EUROPEAN RESEARCH EXECUTIVE AGENCY (REA)

REA.C – Future Society
C.4 – Reforming European R&I and Research Infrastructures

GRANT AGREEMENT

Project 101094300 — MuCol

PREAMBLE

This **Agreement** ('the Agreement') is **between** the following parties:

on the one part,

the **European Research Executive Agency (REA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and

on the other part,

1. 'the coordinator':

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE (CERN), PIC 999988133, established in ESPLANADE DES PARTICULES 1 PARCELLE 11482 DE MEYRIN BATIMENT CADASTRAL 1046, GENEVE 23 1211, Switzerland,

and the following other beneficiaries, if they sign their 'accession form' (see Annex 3 and Article 40):

2. **DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY (DESY)**, PIC 999986969, established in NOTKESTRASSE 85, HAMBURG 22607, Germany,

3. **TECHNISCHE UNIVERSITAT DARMSTADT (TUDA)**, PIC 999986581, established in KAROLINENPLATZ 5, DARMSTADT 64289, Germany,

4. **UNIVERSITAET ROSTOCK (UROS)**, PIC 999852430, established in UNIVERSITATSPLATZ 1, ROSTOCK 18051, Germany,

5. **COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES (CEA)**, PIC 999992401, established in RUE LEBLANC 25, PARIS 15 75015, France,

6. **ISTITUTO NAZIONALE DI FISICA NUCLEARE (INFN)**, PIC 999992789, established in Via Enrico Fermi 54, FRASCATI 00044, Italy,

7. **UNIVERSITA DEGLI STUDI DI MILANO (UMIL)**, PIC 999995796, established in Via Festa Del Perdono 7, MILANO 20122, Italy,

8. **UNIVERSITA DEGLI STUDI DI PADOVA (UNIPD)**, PIC 999995602, established in VIA 8 FEBBRAIO 2, PADOVA 35122, Italy,

9. **UNIVERSITEIT TWENTE (UTWENTE)**, PIC 999900833, established in DRIENERLOLAAN 5, ENSCHEDE 7522 NB, Netherlands,

10. **LABORATORIO DE INSTRUMENTACAO E FISICA EXPERIMENTAL DE PARTICULAS LIP (LIP)**, PIC 999661534, established in RUA LARGA 4 UNIVERSIDADE DE COIMBRA, COIMBRA 3004 516, Portugal,

11. **EUROPEAN SPALLATION SOURCE ERIC (ESS)**, PIC 919998053, established in ODARSLOVSVAGEN 113, LUND 224 84, Sweden,

12. **UPPSALA UNIVERSITET (UU)**, PIC 999985029, established in VON KRAEMERS ALLE 4, UPPSALA 751 05, Sweden,

Unless otherwise specified, references to 'beneficiary' or 'beneficiaries' include the coordinator and affiliated entities (if any).

If only one beneficiary signs the grant agreement ('mono-beneficiary grant'), all provisions referring to the 'coordinator' or the 'beneficiaries' will be considered — mutatis mutandis — as referring to the beneficiary.

The parties referred to above have agreed to enter into the Agreement.

By signing the Agreement and the accession forms, the beneficiaries accept the grant and agree to implement the action under their own responsibility and in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

The Agreement is composed of:

Preamble

Terms and Conditions (including Data Sheet)

Annex 1	Description of the action[1]
Annex 2	Estimated budget for the action
Annex 2a	Additional information on unit costs and contributions (if applicable)
Annex 3	Accession forms (if applicable)[2]
Annex 3a	Declaration on joint and several liability of affiliated entities (if applicable)[3]
Annex 4	Model for the financial statements
Annex 5	Specific rules (if applicable)

[1] Template published on Portal Reference Documents.
[2] Template published on Portal Reference Documents.
[3] Template published on Portal Reference Documents.

TERMS AND CONDITIONS

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DATA SHEET

1. General data

Project summary:

Project summary
Two facility concepts have been considered as potential pathways to the future of particle physics at the energy frontier in Europe: FCC-hh, a 100 TeV circular hadron collider and CLIC, a 3 TeV linear lepton (i.e. electron-positron) collider. The recent European Accelerator R&D Roadmap includes a novel option, a 10 or more TeV muon collider, which expands the lepton collider energy reach and promises compact dimensions, high efficiency and limited cost. Muons are point-like particles, in contrast to hadrons; a 10 TeV muon collider would have a comparable physics case, for a number of physics processes, to a 100 TeV hadron collider. The muon collider promises high benefit but also faces a significant risk, as it is the first of its kind and uses novel advanced technologies. The MuCol design study will address the core challenges identified in the Roadmap, develop the concept and technologies and demonstrate: • the physics case of the muon collider is sound and detector systems can yield sufficient resolution and rejection of backgrounds; • no principle technological issues will prevent the achievement of a satisfactory performance of the accelerator or the detectors; • the muon collider provides a highly sustainable energy frontier facility compared to other equivalent colliders; and • exploiting synergies with other scientific and industrial R&D projects, can provide Europe a leading edge in discovery potential and development of associated technologies. The final report will include a thorough assessment of benefits and risks of the accelerator and detector complex, including an evaluation of the scientific, industrial and societal return beyond high-energy physics, the cost scale and sustainability of the complex and the impact arising from an implementation on the CERN site. This will allow the next European Strategy for Particle Physics Update (ESPPU) process to make informed choices for the selection of the next large collider to be built in Europe.

Keywords:

– Accelerator Physics and Technology, Particle Physics, Radiofrequency, Magnets

Project number: 101094300

Project name: A Design Study for a Muon Collider complex at 10+ TeV center of mass

Project acronym: MuCol

Call: HORIZON-INFRA-2022-DEV-01

Topic: HORIZON-INFRA-2022-DEV-01-01

Type of action: HORIZON Research and Innovation Actions

Granting authority: European Research Executive Agency

Grant managed through EU Funding & Tenders Portal: Yes (eGrants)

Project starting date: fixed date: 1 March 2023

Project end date: 28 February 2027

Project duration: 48 months

Consortium agreement: Yes

2. Participants

List of participants:

N°	Role	Short name	Legal name	Ctry	PIC	Total eligible costs (BEN and AE)	Max grant amount
1	COO (IO)	CERN	ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE	CH	999988133	210 000.00	210 000.00
2	BEN	DESY	DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY	DE	999986969	50 000.00	50 000.00
3	BEN	TUDA	TECHNISCHE UNIVERSITAT DARMSTADT	DE	999986581	120 270.00	120 000.00

N°	Role	Short name	Legal name	Ctry	PIC	Total eligible costs (BEN and AE)	Max grant amount
4	BEN	UROS	UNIVERSITAET ROSTOCK	DE	999852430	90 000.00	90 000.00
5	BEN	CEA	COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	FR	999992401	422 592.50	385 000.00
6	BEN	INFN	ISTITUTO NAZIONALE DI FISICA NUCLEARE	IT	999992789	510 000.00	510 000.00
7	BEN	UMIL	UNIVERSITA DEGLI STUDI DI MILANO	IT	999995796	300 000.00	300 000.00
8	BEN	UNIPD	UNIVERSITA DEGLI STUDI DI PADOVA	IT	999995602	100 000.00	100 000.00
9	BEN	UTWENTE	UNIVERSITEIT TWENTE	NL	999900833	120 000.00	120 000.00
10	BEN	LIP	LABORATORIO DE INSTRUMENTACAO E FISICA EXPERIMENTAL DE PARTICULAS LIP	PT	999661534	40 000.00	40 000.00
11	BEN	ESS	EUROPEAN SPALLATION SOURCE ERIC	SE	919998053	240 000.00	240 000.00
12	BEN	UU	UPPSALA UNIVERSITET	SE	999985029	30 000.00	30 000.00
13	AP	PSI	PAUL SCHERRER INSTITUT	CH	999994923	0.00	0.00
14	AP	UNIGE	UNIVERSITE DE GENEVE	CH	999974650	0.00	0.00
15	AP	Imperial	IMPERIAL COLLEGE OF SCIENCE TECHNOLOGY AND MEDICINE	UK	999993468	0.00	0.00
16	AP	UKRI	UNITED KINGDOM RESEARCH AND INNOVATION	UK	906446474	0.00	0.00
17	AP	UWAR	THE UNIVERSITY OF WARWICK	UK	999976784	0.00	0.00
18	AP	ULA	UNIVERSITY OF LANCASTER	UK	999840984	0.00	0.00
19	AP	SOTON	UNIVERSITY OF SOUTHAMPTON	UK	999975329	0.00	0.00
20	AP	UOS	THE UNIVERSITY OF SUSSEX	UK	999852721	0.00	0.00
21	AP	SYSU	SUN YAT-SEN UNIVERSITY	CN	999870860	0.00	0.00
22	AP	KIT	KARLSRUHER INSTITUT FUER TECHNOLOGIE	DE	990797674	0.00	0.00
23	AP	CNRS	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	FR	999997930	0.00	0.00
24	AP	ENEA	AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE	IT	999988521	0.00	0.00
25	AP	UNIBO	ALMA MATER STUDIORUM - UNIVERSITA DI BOLOGNA	IT	999993953	0.00	0.00
26	AP	UNIPV	UNIVERSITA DEGLI STUDI DI PAVIA	IT	999893752	0.00	0.00
27	AP	STRATHCLYDE	UNIVERSITY OF STRATHCLYDE	UK	999974068	0.00	0.00
28	AP	HUD	UNIVERSITY OF HUDDERSFIELD	UK	999452208	0.00	0.00
29	AP	RHUL	ROYAL HOLLOWAY AND BEDFORD NEW COLLEGE	UK	999861451	0.00	0.00
30	AP	UOXF	THE CHANCELLOR, MASTERS AND SCHOLARS OF THE UNIVERSITY OF OXFORD	UK	999984350	0.00	0.00
31	AP	ISU	IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY	US	998804733	0.00	0.00
32	AP	BNL	BROOKHAVEN SCIENCE ASSOCIATES LLC	US	983190061	0.00	0.00
Total						2 232 862.50	2 195 000.00

Coordinator:

– ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE (CERN)

3. Grant

Maximum grant amount, total estimated eligible costs and contributions and funding rate:

Total eligible costs (BEN and AE)	Funding rate (%)	Maximum grant amount (Annex 2)	Maximum grant amount (award decision)
2 232 862.50	100	2 195 000.00	2 195 000.00

Grant form: Budget-based

Grant mode: Action grant

Budget categories/activity types:

- A. Personnel costs
  - A.1 Employees, A.2 Natural persons under direct contract, A.3 Seconded persons
  - A.4 SME owners and natural person beneficiaries

- B. Subcontracting costs

- C. Purchase costs
  - C.1 Travel and subsistence
  - C.2 Equipment
  - C.3 Other goods, works and services

- D. Other cost categories
  - D.2 Internally invoiced goods and services

- E. Indirect costs

Cost eligibility options:

- In-kind contributions eligible costs

- Parental leave

- Project-based supplementary payments

- Average personnel costs (unit cost according to usual cost accounting practices)

- Limitation for subcontracting

- Travel and subsistence:
  - Travel: Actual costs
  - Accommodation: Actual costs
  - Subsistence: Actual costs

- Equipment: depreciation only

- Indirect cost flat-rate: 25% of the eligible direct costs (categories A-D, except volunteers costs, subcontracting costs, financial support to third parties and exempted specific cost categories, if any)

- VAT: Yes

- Other ineligible costs

Budget flexibility: Yes (no flexibility cap)

4. Reporting, payments and recoveries

4.1 Continuous reporting (art 21)

Deliverables: see Funding & Tenders Portal Continuous Reporting tool

4.2 Periodic reporting and payments

Reporting and payment schedule (art 21, 22):

Reporting					Payments	
Reporting periods			Type	Deadline	Type	Deadline (time to pay)
RP No	Month from	Month to				
					Initial prefinancing	30 days from entry into force/10 days before starting date – whichever is the latest
1	1	24	Periodic report	60 days after end of reporting period	Interim payment	90 days from receiving periodic report
2	25	48	Periodic report	60 days after end of reporting period	Final payment	90 days from receiving periodic report

Prefinancing payments and guarantees:

Prefinancing payment	
Type	Amount
Prefinancing 1 (initial)	1 756 000.00

Reporting and payment modalities (art 21, 22):

Mutual Insurance Mechanism (MIM): Yes

MIM contribution: 5% of the maximum grant amount (109 750.00), retained from the initial prefinancing

Restrictions on distribution of initial prefinancing: The prefinancing may be distributed only if the minimum number of beneficiaries set out in the call condititions (if any) have acceded to the Agreement and only to beneficiaries that have acceded.

Interim payment ceiling (if any): 90% of the maximum grant amount

Exception for revenues: Yes

No-profit rule: Yes

Late payment interest: ECB + 3.5%

Bank account for payments:

FR7630003001090003726133228

Conversion into euros: Double conversion

Reporting language: Language of the Agreement

4.3 Certificates (art 24):

Certificates on the financial statements (CFS):

Conditions:

Schedule: only at final payment, if threshold is reached

Standard threshold (beneficiary-level):

- financial statement: requested EU contribution to costs ≥ EUR 430 000.00

Special threshold for beneficiaries with a systems and process audit(see Article 24): financial statement: requested EU contribution to costs ≥ EUR 725 000.00

4.4 Recoveries (art 22)

First-line liability for recoveries:

Beneficiary termination: Beneficiary concerned

Final payment: Each beneficiary for their own debt

After final payment: Beneficiary concerned

Joint and several liability for enforced recoveries (in case of non-payment):

Individual financial responsibility: Each beneficiary is liable only for its own debts (and those of its affiliated entities, if any)

5. Consequences of non-compliance, applicable law & dispute settlement forum

Suspension and termination:

Additional suspension grounds (art 31)

Additional termination grounds (art 32)

Applicable law (art 43):

Standard applicable law regime: EU law + law of Belgium

Special applicable law regime:

– ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE (CERN): EU law + law of Switzerland + general principles governing the law of international organisations and the general rules of international law

Dispute settlement forum (art 43):

Standard dispute settlement forum:

EU beneficiaries: EU General Court + EU Court of Justice (on appeal)

Non-EU beneficiaries: Courts of Brussels, Belgium (unless an international agreement provides for the enforceability of EU court judgements)

Special dispute settlement forum:

– ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE (CERN): Arbitration

6. Other

Specific rules (Annex 5): Yes

Standard time-limits after project end:

Confidentiality (for X years after final payment): 5

Record-keeping (for X years after final payment): 5 (or 3 for grants of not more than EUR 60 000)

Reviews (up to X years after final payment): 2

Audits (up to X years after final payment): 2

Extension of findings from other grants to this grant (no later than X years after final payment): 2

Impact evaluation (up to X years after final payment): 5 (or 3 for grants of not more than EUR 60 000)

CHAPTER 1 GENERAL

ARTICLE 1 — SUBJECT OF THE AGREEMENT

This Agreement sets out the rights and obligations and terms and conditions applicable to the grant awarded for the implementation of the action set out in Chapter 2.

ARTICLE 2 — DEFINITIONS

For the purpose of this Agreement, the following definitions apply:

Actions — The project which is being funded in the context of this Agreement.

Grant — The grant awarded in the context of this Agreement.

EU grants — Grants awarded by EU institutions, bodies, offices or agencies (including EU executive agencies, EU regulatory agencies, EDA, joint undertakings, etc.).

Participants — Entities participating in the action as beneficiaries, affiliated entities, associated partners, third parties giving in-kind contributions, subcontractors or recipients of financial support to third parties.

Beneficiaries (BEN) — The signatories of this Agreement (either directly or through an accession form).

Affiliated entities (AE) — Entities affiliated to a beneficiary within the meaning of Article 187 of EU Financial Regulation 2018/1046[4] which participate in the action with similar rights and obligations as the beneficiaries (obligation to implement action tasks and right to charge costs and claim contributions).

Associated partners (AP) — Entities which participate in the action, but without the right to charge costs or claim contributions.

Purchases — Contracts for goods, works or services needed to carry out the action (e.g. equipment, consumables and supplies) but which are not part of the action tasks (see Annex 1).

Subcontracting — Contracts for goods, works or services that are part of the action tasks (see Annex 1).

In-kind contributions — In-kind contributions within the meaning of Article 2(36) of EU Financial

[4] For the definition, see Article 187 Regulation (EU, Euratom) 2018/1046 of the European Parliament and of the Council of 18 July 2018 on the financial rules applicable to the general budget of the Union, amending Regulations (EU) No 1296/2013, (EU) No 1301/2013, (EU) No 1303/2013, (EU) No 1304/2013, (EU) No 1309/2013, (EU) No 1316/2013, (EU) No 223/2014, (EU) No 283/2014, and Decision No 541/2014/EU and repealing Regulation (EU, Euratom) No 966/2012 ('EU Financial Regulation') (OJ L 193, 30.7.2018, p. 1): "**affiliated entities** [are]:
(a) entities that form a sole beneficiary [(i.e. where an entity is formed of several entities that satisfy the criteria for being awarded a grant, including where the entity is specifically established for the purpose of implementing an action to be financed by a grant)];
(b) entities that satisfy the eligibility criteria and that do not fall within one of the situations referred to in Article 136(1) and 141(1) and that have a link with the beneficiary, in particular a legal or capital link, which is neither limited to the action nor established for the sole purpose of its implementation".

Regulation 2018/1046, i.e. non-financial resources made available free of charge by third parties.

Fraud — Fraud within the meaning of Article 3 of EU Directive 2017/1371[5] and Article 1 of the Convention on the protection of the European Communities' financial interests, drawn up by the Council Act of 26 July 1995[6], as well as any other wrongful or criminal deception intended to result in financial or personal gain.

Irregularities — Any type of breach (regulatory or contractual) which could impact the EU financial interests, including irregularities within the meaning of Article 1(2) of EU Regulation 2988/95[7].

Grave professional misconduct — Any type of unacceptable or improper behaviour in exercising one's profession, especially by employees, including grave professional misconduct within the meaning of Article 136(1)(c) of EU Financial Regulation 2018/1046.

Applicable EU, international and national law — Any legal acts or other (binding or non-binding) rules and guidance in the area concerned.

Portal — EU Funding & Tenders Portal; electronic portal and exchange system managed by the European Commission and used by itself and other EU institutions, bodies, offices or agencies for the management of their funding programmes (grants, procurements, prizes, etc.).

CHAPTER 2 ACTION

ARTICLE 3 — ACTION

The grant is awarded for the action **101094300** — **MuCol** ('action'), as described in Annex 1.

ARTICLE 4 — DURATION AND STARTING DATE

The duration and the starting date of the action are set out in the Data Sheet (see Point 1).

CHAPTER 3 GRANT

ARTICLE 5 — GRANT

5.1 Form of grant

The grant is an action grant[8] which takes the form of a budget-based mixed actual cost grant (i.e. a

[5] Directive (EU) 2017/1371 of the European Parliament and of the Council of 5 July 2017 on the fight against fraud to the Union's financial interests by means of criminal law (OJ L 198, 28.7.2017, p. 29).
[6] OJ C 316, 27.11.1995, p. 48.
[7] Council Regulation (EC, Euratom) No 2988/95 of 18 December 1995 on the protection of the European Communities financial interests (OJ L 312, 23.12.1995, p. 1).
[8] For the definition, see Article 180(2)(a) EU Financial Regulation 2018/1046: '**action grant**' means an EU grant to finance "an action intended to help achieve a Union policy objective".

grant based on actual costs incurred, but which may also include other forms of funding, such as unit costs or contributions, flat-rate costs or contributions, lump sum costs or contributions or financing not linked to costs).

5.2 Maximum grant amount

The maximum grant amount is set out in the Data Sheet (see Point 3) and in the estimated budget (Annex 2).

5.3 Funding rate

The funding rate for costs is 100% of the action's eligible costs.

Contributions are not subject to any funding rate.

5.4 Estimated budget, budget categories and forms of funding

The estimated budget for the action is set out in Annex 2.

It contains the estimated eligible costs and contributions for the action, broken down by participant and budget category.

Annex 2 also shows the types of costs and contributions (forms of funding)[9] to be used for each budget category.

If unit costs or contributions are used, the details on the calculation will be explained in Annex 2a.

5.5 Budget flexibility

The budget breakdown may be adjusted — without an amendment (see Article 39) — by transfers (between participants and budget categories), as long as this does not imply any substantive or important change to the description of the action in Annex 1.

However:

- changes to the budget category for volunteers (if used) always require an amendment
- changes to budget categories with lump sums costs or contributions (if used; including financing not linked to costs) always require an amendment
- changes to budget categories with higher funding rates or budget ceilings (if used) always require an amendment
- addition of amounts for subcontracts not provided for in Annex 1 either require an amendment or simplified approval in accordance with Article 6.2
- other changes require an amendment or simplified approval, if specifically provided for in Article 6.2
- flexibility caps: not applicable.

[9] See Article 125 EU Financial Regulation 2018/1046.

ARTICLE 6 — ELIGIBLE AND INELIGIBLE COSTS AND CONTRIBUTIONS

In order to be eligible, costs and contributions must meet the **eligibility** conditions set out in this Article.

6.1 General eligibility conditions

The **general eligibility conditions** are the following:

(a) for actual costs:

(i) they must be actually incurred by the beneficiary

(ii) they must be incurred in the period set out in Article 4 (with the exception of costs relating to the submission of the final periodic report, which may be incurred afterwards; see Article 21)

(iii) they must be declared under one of the budget categories set out in Article 6.2 and Annex 2

(iv) they must be incurred in connection with the action as described in Annex 1 and necessary for its implementation

(v) they must be identifiable and verifiable, in particular recorded in the beneficiary's accounts in accordance with the accounting standards applicable in the country where the beneficiary is established and with the beneficiary's usual cost accounting practices

(vi) they must comply with the applicable national law on taxes, labour and social security and

(vii) they must be reasonable, justified and must comply with the principle of sound financial management, in particular regarding economy and efficiency

(b) for unit costs or contributions (if any):

(i) they must be declared under one of the budget categories set out in Article 6.2 and Annex 2

(ii) the units must:

- be actually used or produced by the beneficiary in the period set out in Article 4 (with the exception of units relating to the submission of the final periodic report, which may be used or produced afterwards; see Article 21)

- be necessary for the implementation of the action and

(iii) the number of units must be identifiable and verifiable, in particular supported by records and documentation (see Article 20)

(c) for flat-rate costs or contributions (if any):

(i) they must be declared under one of the budget categories set out in Article 6.2 and Annex 2

(ii) the costs or contributions to which the flat-rate is applied must:

- be eligible
- relate to the period set out in Article 4 (with the exception of costs or contributions relating to the submission of the final periodic report, which may be incurred afterwards; see Article 21)

(d) for lump sum costs or contributions (if any):

(i) they must be declared under one of the budget categories set out in Article 6.2 and Annex 2

(ii) the work must be properly implemented by the beneficiary in accordance with Annex 1

(iii) the deliverables/outputs must be achieved in the period set out in Article 4 (with the exception of deliverables/outputs relating to the submission of the final periodic report, which may be achieved afterwards; see Article 21)

(e) for unit, flat-rate or lump sum costs or contributions according to usual cost accounting practices (if any):

(i) they must fulfil the general eligibility conditions for the type of cost concerned

(ii) the cost accounting practices must be applied in a consistent manner, based on objective criteria, regardless of the source of funding

(f) for financing not linked to costs (if any): the results must be achieved or the conditions must be fulfilled as described in Annex 1.

In addition, for direct cost categories (e.g. personnel, travel & subsistence, subcontracting and other direct costs) only costs that are directly linked to the action implementation and can therefore be attributed to it directly are eligible. They must not include any indirect costs (i.e. costs that are only indirectly linked to the action, e.g. via cost drivers).

In-kind contributions provided by third parties free of charge may be declared as eligible direct costs by the beneficiaries which use them (under the same conditions as if they were their own, provided that they concern only direct costs and that the third parties and their in-kind contributions are set out in Annex 1 (or approved ex post in the periodic report, if their use does not entail changes to the Agreement which would call into question the decision awarding the grant or breach the principle of equal treatment of applicants; 'simplified approval procedure').

6.2 Specific eligibility conditions for each budget category

For each budget category, the **specific eligibility conditions** are as follows:

Direct costs

A. Personnel costs

A.1 Costs for employees (or equivalent) are eligible as personnel costs if they fulfil the general eligibility conditions and are related to personnel working for the beneficiary under an employment contract (or equivalent appointing act) and assigned to the action.

They must be limited to salaries (including net payments during parental leave), social security contributions, taxes and other costs linked to the remuneration, if they arise from national law or the employment contract (or equivalent appointing act) and be calculated on the basis of the costs actually incurred, in accordance with the following method:

{daily rate for the person

multiplied by

number of day-equivalents worked on the action (rounded up or down to the nearest half-day)}.

The daily rate must be calculated as:

{annual personnel costs for the person

divided by

215}.

The number of day-equivalents declared for a person must be identifiable and verifiable (see Article 20).

The actual time spent on parental leave by a person assigned to the action may be deducted from the 215 days indicated in the above formula.

The total number of day-equivalents declared in EU grants, for a person for a year, cannot be higher than 215, minus time spent on parental leave (if any).

For personnel which receives supplementary payments for work in projects (project-based remuneration), the personnel costs must be calculated at a rate which:

- corresponds to the actual remuneration costs paid by the beneficiary for the time worked by the person in the action over the reporting period
- does not exceed the remuneration costs paid by the beneficiary for work in similar projects funded by national schemes (‘national projects reference’)
- is defined based on objective criteria allowing to determine the amount to which the person is entitled

and

- reflects the usual practice of the beneficiary to pay consistently bonuses or supplementary payments for work in projects funded by national schemes.

The national projects reference is the remuneration defined in national law, collective labour agreement or written internal rules of the beneficiary applicable to work in projects funded by national schemes.

If there is no such national law, collective labour agreement or written internal rules or if the project-based remuneration is not based on objective criteria, the national project reference will be the average

remuneration of the person in the last full calendar year covered by the reporting period, excluding remuneration paid for work in EU actions.

If the beneficiary uses average personnel costs (unit cost according to usual cost accounting practices), the personnel costs must fulfil the general eligibility conditions for such unit costs and the daily rate must be calculated:

- using the actual personnel costs recorded in the beneficiary's accounts and excluding any costs which are ineligible or already included in other budget categories; the actual personnel costs may be adjusted on the basis of budgeted or estimated elements, if they are relevant for calculating the personnel costs, reasonable and correspond to objective and verifiable information

and

- according to usual cost accounting practices which are applied in a consistent manner, based on objective criteria, regardless of the source of funding.

A.2 and **A.3 Costs for natural persons working under a direct contract** other than an employment contract and costs for **seconded persons by a third party against payment** are also eligible as personnel costs, if they are assigned to the action, fulfil the general eligibility conditions and:

(a) work under conditions similar to those of an employee (in particular regarding the way the work is organised, the tasks that are performed and the premises where they are performed) and

(b) the result of the work belongs to the beneficiary (unless agreed otherwise).

They must be calculated on the basis of a rate which corresponds to the costs actually incurred for the direct contract or secondment and must not be significantly different from those for personnel performing similar tasks under an employment contract with the beneficiary.

A.4 The work of **SME owners** for the action (i.e. owners of beneficiaries that are small and medium-sized enterprises[10] not receiving a salary) or **natural person beneficiaries** (i.e. beneficiaries that are natural persons not receiving a salary) may be declared as personnel costs, if they fulfil the general eligibility conditions and are calculated as unit costs in accordance with the method set out in Annex 2a.

B. Subcontracting costs

Subcontracting costs for the action (including related duties, taxes and charges, such as non-deductible or non-refundable value added tax (VAT)) are eligible, if they are calculated on the basis of the costs actually incurred, fulfil the general eligibility conditions and are awarded using the

[10] For the definition, see Commission Recommendation 2003/361/EC: micro, small or medium-sized enterprise (SME) are enterprises

- engaged in an economic activity, irrespective of their legal form (including, in particular, self- employed persons and family businesses engaged in craft or other activities, and partnerships or associations regularly engaged in an economic activity) and

- employing fewer than 250 persons (expressed in 'annual working units' as defined in Article 5 of the Recommendation) and which have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million.

beneficiary's usual purchasing practices — provided these ensure subcontracts with best value for money (or if appropriate the lowest price) and that there is no conflict of interests (see Article 12).

Beneficiaries that are 'contracting authorities/entities' within the meaning of the EU Directives on public procurement must also comply with the applicable national law on public procurement.

Subcontracting may cover only a limited part of the action.

The tasks to be subcontracted and the estimated cost for each subcontract must be set out in Annex 1 and the total estimated costs of subcontracting per beneficiary must be set out in Annex 2 (or may be approved ex post in the periodic report, if the use of subcontracting does not entail changes to the Agreement which would call into question the decision awarding the grant or breach the principle of equal treatment of applicants; 'simplified approval procedure').

C. Purchase costs

Purchase costs for the action (including related duties, taxes and charges, such as non-deductible or non-refundable value added tax (VAT)) are eligible if they fulfil the general eligibility conditions and are bought using the beneficiary's usual purchasing practices — provided these ensure purchases with best value for money (or if appropriate the lowest price) and that there is no conflict of interests (see Article 12).

Beneficiaries that are 'contracting authorities/entities' within the meaning of the EU Directives on public procurement must also comply with the applicable national law on public procurement.

C.1 Travel and subsistence

Purchases for **travel, accommodation** and **subsistence** must be calculated as follows:

- travel: on the basis of the costs actually incurred and in line with the beneficiary's usual practices on travel
- accommodation: on the basis of the costs actually incurred and in line with the beneficiary's usual practices on travel
- subsistence: on the basis of the costs actually incurred and in line with the beneficiary's usual practices on travel .

C.2 Equipment

Purchases of **equipment, infrastructure or other assets** used for the action must be declared as depreciation costs, calculated on the basis of the costs actually incurred and written off in accordance with international accounting standards and the beneficiary's usual accounting practices.

Only the portion of the costs that corresponds to the rate of actual use for the action during the action duration can be taken into account.

Costs for **renting or leasing** equipment, infrastructure or other assets are also eligible, if they do not exceed the depreciation costs of similar equipment, infrastructure or assets and do not include any financing fees.

C.3 Other goods, works and services

Purchases of **other goods, works and services** must be calculated on the basis of the costs actually incurred.

Such goods, works and services include, for instance, consumables and supplies, promotion, dissemination, protection of results, translations, publications, certificates and financial guarantees, if required under the Agreement.

D. Other cost categories

D.2 Internally invoiced goods and services

Costs for internally invoiced goods and services directly used for the action may be declared as unit cost according to usual cost accounting practices, if and as declared eligible in the call conditions, if they fulfil the general eligibility conditions for such unit costs and the amount per unit is calculated:

- using the actual costs for the good or service recorded in the beneficiary's accounts, attributed either by direct measurement or on the basis of cost drivers, and excluding any cost which are ineligible or already included in other budget categories; the actual costs may be adjusted on the basis of budgeted or estimated elements, if they are relevant for calculating the costs, reasonable and correspond to objective and verifiable information

and

- according to usual cost accounting practices which are applied in a consistent manner, based on objective criteria, regardless of the source of funding.

'Internally invoiced goods and services' means goods or services which are provided within the beneficiary's organisation directly for the action and which the beneficiary values on the basis of its usual cost accounting practices.

This cost will not be taken into account for the indirect cost flat-rate.

Indirect costs

E. Indirect costs

Indirect costs will be reimbursed at the flat-rate of 25% of the eligible direct costs (categories A-D, except volunteers costs, subcontracting costs, financial support to third parties and exempted specific cost categories, if any).

Contributions

Not applicable

6.3 Ineligible costs and contributions

The following costs or contributions are **ineligible**:

(a) costs or contributions that do not comply with the conditions set out above (Article 6.1 and 6.2), in particular:

(i) costs related to return on capital and dividends paid by a beneficiary

(ii) debt and debt service charges

(iii) provisions for future losses or debts

(iv) interest owed

(v) currency exchange losses

(vi) bank costs charged by the beneficiary's bank for transfers from the granting authority

(vii) excessive or reckless expenditure

(viii) deductible or refundable VAT (including VAT paid by public bodies acting as public authority)

(ix) costs incurred or contributions for activities implemented during grant agreement suspension (see Article 31)

(x) in-kind contributions by third parties: not applicable

(b) costs or contributions declared under other EU grants (or grants awarded by an EU Member State, non-EU country or other body implementing the EU budget), except for the following cases:

(i) Synergy actions: not applicable

(ii) if the action grant is combined with an operating grant[11] running during the same period and the beneficiary can demonstrate that the operating grant does not cover any (direct or indirect) costs of the action grant

(c) costs or contributions for staff of a national (or regional/local) administration, for activities that are part of the administration's normal activities (i.e. not undertaken only because of the grant)

(d) costs or contributions (especially travel and subsistence) for staff or representatives of EU institutions, bodies or agencies

(e) other :

(i) country restrictions for eligible costs: not applicable

(ii) costs or contributions declared specifically ineligible in the call conditions.

6.4 Consequences of non-compliance

If a beneficiary declares costs or contributions that are ineligible, they will be rejected (see Article 27).

This may also lead to other measures described in Chapter 5.

[11] For the definition, see Article 180(2)(b) of EU Financial Regulation 2018/1046: '**operating grant**' means an EU grant to finance "the functioning of a body which has an objective forming part of and supporting an EU policy".

CHAPTER 4 GRANT IMPLEMENTATION

SECTION 1 CONSORTIUM: BENEFICIARIES, AFFILIATED ENTITIES AND OTHER PARTICIPANTS

ARTICLE 7 — BENEFICIARIES

The beneficiaries, as signatories of the Agreement, are fully responsible towards the granting authority for implementing it and for complying with all its obligations.

They must implement the Agreement to their best abilities, in good faith and in accordance with all the obligations and terms and conditions it sets out.

They must have the appropriate resources to implement the action and implement the action under their own responsibility and in accordance with Article 11. If they rely on affiliated entities or other participants (see Articles 8 and 9), they retain sole responsibility towards the granting authority and the other beneficiaries.

They are jointly responsible for the *technical* implementation of the action. If one of the beneficiaries fails to implement their part of the action, the other beneficiaries must ensure that this part is implemented by someone else (without being entitled to an increase of the maximum grant amount and subject to an amendment; see Article 39). The *financial* responsibility of each beneficiary in case of recoveries is governed by Article 22.

The beneficiaries (and their action) must remain eligible under the EU programme funding the grant for the entire duration of the action. Costs and contributions will be eligible only as long as the beneficiary and the action are eligible.

The **internal roles and responsibilities** of the beneficiaries are divided as follows:

(a) Each beneficiary must:

(i) keep information stored in the Portal Participant Register up to date (see Article 19)

(ii) inform the granting authority (and the other beneficiaries) immediately of any events or circumstances likely to affect significantly or delay the implementation of the action (see Article 19)

(iii) submit to the coordinator in good time:

- the prefinancing guarantees (if required; see Article 23)
- the financial statements and certificates on the financial statements (CFS) (if required; see Articles 21 and 24.2 and Data Sheet, Point 4.3)
- the contribution to the deliverables and technical reports (see Article 21)
- any other documents or information required by the granting authority under the Agreement

(iv) submit via the Portal data and information related to the participation of their affiliated entities.

(b) The coordinator must:

(i) monitor that the action is implemented properly (see Article 11)

(ii) act as the intermediary for all communications between the consortium and the granting authority, unless the Agreement or granting authority specifies otherwise, and in particular:

- submit the prefinancing guarantees to the granting authority (if any)
- request and review any documents or information required and verify their quality and completeness before passing them on to the granting authority
- submit the deliverables and reports to the granting authority
- inform the granting authority about the payments made to the other beneficiaries (report on the distribution of payments; if required, see Articles 22 and 32)

(iii) distribute the payments received from the granting authority to the other beneficiaries without unjustified delay (see Article 22).

The coordinator may not delegate or subcontract the above-mentioned tasks to any other beneficiary or third party (including affiliated entities).

However, coordinators which are public bodies may delegate the tasks set out in Point (b)(ii) last indent and (iii) above to entities with 'authorisation to administer' which they have created or which are controlled by or affiliated to them. In this case, the coordinator retains sole responsibility for the payments and for compliance with the obligations under the Agreement.

Moreover, coordinators which are 'sole beneficiaries'[12] (or similar, such as European research infrastructure consortia (ERICs)) may delegate the tasks set out in Point (b)(i) to (iii) above to one of their members. The coordinator retains sole responsibility for compliance with the obligations under the Agreement.

The beneficiaries must have **internal arrangements** regarding their operation and co-ordination, to ensure that the action is implemented properly.

If required by the granting authority (see Data Sheet, Point 1), these arrangements must be set out in a written **consortium agreement** between the beneficiaries, covering for instance:

- the internal organisation of the consortium
- the management of access to the Portal
- different distribution keys for the payments and financial responsibilities in case of recoveries (if any)
- additional rules on rights and obligations related to background and results (see Article 16)

[12] For the definition, see Article 187(2) EU Financial Regulation 2018/1046: "Where several entities satisfy the criteria for being awarded a grant and together form one entity, that entity may be treated as the **sole beneficiary**, including where it is specifically established for the purpose of implementing the action financed by the grant."

- settlement of internal disputes
- liability, indemnification and confidentiality arrangements between the beneficiaries.

The internal arrangements must not contain any provision contrary to this Agreement.

ARTICLE 8 — AFFILIATED ENTITIES

Not applicable

ARTICLE 9 — OTHER PARTICIPANTS INVOLVED IN THE ACTION

9.1 Associated partners

The following entities which cooperate with a beneficiary will participate in the action as ‘associated partners’:

- **PAUL SCHERRER INSTITUT (PSI)**, PIC 999994923
- **UNIVERSITE DE GENEVE (UNIGE)**, PIC 999974650
- **IMPERIAL COLLEGE OF SCIENCE TECHNOLOGY AND MEDICINE (Imperial)**, PIC 999993468
- **UNITED KINGDOM RESEARCH AND INNOVATION (UKRI)**, PIC 906446474
- **THE UNIVERSITY OF WARWICK (UWAR)**, PIC 999976784
- **UNIVERSITY OF LANCASTER (ULA)**, PIC 999840984
- **UNIVERSITY OF SOUTHAMPTON (SOTON)**, PIC 999975329
- **THE UNIVERSITY OF SUSSEX (UOS)**, PIC 999852721
- **SUN YAT-SEN UNIVERSITY (SYSU)**, PIC 999870860
- **KARLSRUHER INSTITUT FUER TECHNOLOGIE (KIT)**, PIC 990797674
- **CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS (CNRS)**, PIC 999997930
- **AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE (ENEA)**, PIC 999988521
- **ALMA MATER STUDIORUM - UNIVERSITA DI BOLOGNA (UNIBO)**, PIC 999993953
- **UNIVERSITA DEGLI STUDI DI PAVIA (UNIPV)**, PIC 999893752
- **UNIVERSITY OF STRATHCLYDE (STRATHCLYDE)**, PIC 999974068
- **UNIVERSITY OF HUDDERSFIELD (HUD)**, PIC 999452208
- **ROYAL HOLLOWAY AND BEDFORD NEW COLLEGE (RHUL)**, PIC 999861451

- **THE CHANCELLOR, MASTERS AND SCHOLARS OF THE UNIVERSITY OF OXFORD (UOXF)**, PIC 999984350

- **IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY (ISU)**, PIC 998804733

- **BROOKHAVEN SCIENCE ASSOCIATES LLC (BNL)**, PIC 983190061

Associated partners must implement the action tasks attributed to them in Annex 1 in accordance with Article 11. They may not charge costs or contributions to the action and the costs for their tasks are not eligible.

The tasks must be set out in Annex 1.

The beneficiaries must ensure that their contractual obligations under Articles 11 (proper implementation), 12 (conflict of interests), 13 (confidentiality and security), 14 (ethics), 17.2 (visibility), 18 (specific rules for carrying out action), 19 (information) and 20 (record-keeping) also apply to the associated partners.

The beneficiaries must ensure that the bodies mentioned in Article 25 (e.g. granting authority, OLAF, Court of Auditors (ECA), etc.) can exercise their rights also towards the associated partners.

9.2 Third parties giving in-kind contributions to the action

Other third parties may give in-kind contributions to the action (i.e. personnel, equipment, other goods, works and services, etc. which are free-of-charge) if necessary for the implementation.

Third parties giving in-kind contributions do not implement any action tasks. They may not charge costs or contributions to the action, but the costs for the in-kind contributions are eligible and may be charged by the beneficiaries which use them, under the conditions set out in Article 6. The costs will be included in Annex 2 as part of the beneficiaries' costs.

The third parties and their in-kind contributions should be set out in Annex 1.

The beneficiaries must ensure that the bodies mentioned in Article 25 (e.g. granting authority, OLAF, Court of Auditors (ECA), etc.) can exercise their rights also towards the third parties giving in-kind contributions.

9.3 Subcontractors

Subcontractors may participate in the action, if necessary for the implementation.

Subcontractors must implement their action tasks in accordance with Article 11. The costs for the subcontracted tasks (invoiced price from the subcontractor) are eligible and may be charged by the beneficiaries, under the conditions set out in Article 6. The costs will be included in Annex 2 as part of the beneficiaries' costs.

The beneficiaries must ensure that their contractual obligations under Articles 11 (proper implementation), 12 (conflict of interest), 13 (confidentiality and security), 14 (ethics), 17.2 (visibility), 18 (specific rules for carrying out action), 19 (information) and 20 (record-keeping) also apply to the subcontractors.

The beneficiaries must ensure that the bodies mentioned in Article 25 (e.g. granting authority, OLAF, Court of Auditors (ECA), etc.) can exercise their rights also towards the subcontractors.

9.4 Recipients of financial support to third parties

If the action includes providing financial support to third parties (e.g. grants, prizes or similar forms of support), the beneficiaries must ensure that their contractual obligations under Articles 12 (conflict of interest), 13 (confidentiality and security), 14 (ethics), 17.2 (visibility), 18 (specific rules for carrying out action), 19 (information) and 20 (record-keeping)also apply to the third parties receiving the support (recipients).

The beneficiaries must also ensure that the bodies mentioned in Article 25 (e.g. granting authority, OLAF, Court of Auditors (ECA), etc.) can exercise their rights also towards the recipients.

ARTICLE 10 — PARTICIPANTS WITH SPECIAL STATUS

10.1 Non-EU participants

Participants which are established in a non-EU country (if any) undertake to comply with their obligations under the Agreement and:

- to respect general principles (including fundamental rights, values and ethical principles, environmental and labour standards, rules on classified information, intellectual property rights, visibility of funding and protection of personal data)
- for the submission of certificates under Article 24: to use qualified external auditors which are independent and comply with comparable standards as those set out in EU Directive 2006/43/EC[13]
- for the controls under Article 25: to allow for checks, reviews, audits and investigations (including on-the-spot checks, visits and inspections) by the bodies mentioned in that Article (e.g. granting authority, OLAF, Court of Auditors (ECA), etc.).

Special rules on dispute settlement apply (see Data Sheet, Point 5).

10.2 Participants which are international organisations

Participants which are international organisations (IOs; if any) undertake to comply with their obligations under the Agreement and:

- to respect general principles (including fundamental rights, values and ethical principles, environmental and labour standards, rules on classified information, intellectual property rights, visibility of funding and protection of personal data)
- for the submission of certificates under Article 24: to use either independent public officers or external auditors which comply with comparable standards as those set out in EU Directive 2006/43/EC

[13] Directive 2006/43/EC of the European Parliament and of the Council of 17 May 2006 on statutory audits of annual accounts and consolidated accounts or similar national regulations (OJ L 157, 9.6.2006, p. 87).

- for the controls under Article 25: to allow for the checks, reviews, audits and investigations by the bodies mentioned in that Article, taking into account the specific agreements concluded by them and the EU (if any).

For such participants, nothing in the Agreement will be interpreted as a waiver of their privileges or immunities, as accorded by their constituent documents or international law.

Special rules on applicable law and dispute settlement apply (see Article 43 and Data Sheet, Point 5).

10.3 Pillar-assessed participants

Pillar-assessed participants (if any) may rely on their own systems, rules and procedures, in so far as they have been positively assessed and do not call into question the decision awarding the grant or breach the principle of equal treatment of applicants or beneficiaries.

'Pillar-assessment' means a review by the European Commission on the systems, rules and procedures which participants use for managing EU grants (in particular internal control system, accounting system, external audits, financing of third parties, rules on recovery and exclusion, information on recipients and protection of personal data; see Article 154 EU Financial Regulation 2018/1046).

Participants with a positive pillar assessment may rely on their own systems, rules and procedures, in particular for:

- record-keeping (Article 20): may be done in accordance with internal standards, rules and procedures

- currency conversion for financial statements (Article 21): may be done in accordance with usual accounting practices

- guarantees (Article 23): for public law bodies, prefinancing guarantees are not needed

- certificates (Article 24):

    - certificates on the financial statements (CFS): may be provided by their regular internal or external auditors and in accordance with their internal financial regulations and procedures

    - certificates on usual accounting practices (CoMUC): are not needed if those practices are covered by an ex-ante assessment

and use the following specific rules, for:

- recoveries (Article 22): in case of financial support to third parties, there will be no recovery if the participant has done everything possible to retrieve the undue amounts from the third party receiving the support (including legal proceedings) and non-recovery is not due to an error or negligence on its part

- checks, reviews, audits and investigations by the EU (Article 25): will be conducted taking into account the rules and procedures specifically agreed between them and the framework agreement (if any)

- impact evaluation (Article 26): will be conducted in accordance with the participant's internal rules and procedures and the framework agreement (if any)

- grant agreement suspension (Article 31): certain costs incurred during grant suspension are eligible (notably, minimum costs necessary for a possible resumption of the action and costs relating to contracts which were entered into before the pre-information letter was received and which could not reasonably be suspended, reallocated or terminated on legal grounds)

- grant agreement termination (Article 32): the final grant amount and final payment will be calculated taking into account also costs relating to contracts due for execution only after termination takes effect, if the contract was entered into before the pre-information letter was received and could not reasonably be terminated on legal grounds

- liability for damages (Article 33.2): the granting authority must be compensated for damage it sustains as a result of the implementation of the action or because the action was not implemented in full compliance with the Agreement only if the damage is due to an infringement of the participant's internal rules and procedures or due to a violation of third parties' rights by the participant or one of its employees or individual for whom the employees are responsible.

Participants whose pillar assessment covers procurement and granting procedures may also do purchases, subcontracting and financial support to third parties (Article 6.2) in accordance with their internal rules and procedures for purchases, subcontracting and financial support.

Participants whose pillar assessment covers data protection rules may rely on their internal standards, rules and procedures for data protection (Article 15).

The participants may however not rely on provisions which would breach the principle of equal treatment of applicants or beneficiaries or call into question the decision awarding the grant, such as in particular:

- eligibility (Article 6)

- consortium roles and set-up (Articles 7-9)

- security and ethics (Articles 13, 14)

- IPR (including background and results, access rights and rights of use), communication, dissemination and visibility (Articles 16 and 17)

- information obligation (Article 19)

- payment, reporting and amendments (Articles 21, 22 and 39)

- rejections, reductions, suspensions and terminations (Articles 27, 28, 29-32)

If the pillar assessment was subject to remedial measures, reliance on the internal systems, rules and procedures is subject to compliance with those remedial measures.

Participants whose assessment has not yet been updated to cover (the new rules on) data protection may rely on their internal systems, rules and procedures, provided that they ensure that personal data is:

- processed lawfully, fairly and in a transparent manner in relation to the data subject

- collected for specified, explicit and legitimate purposes and not further processed in a manner that is incompatible with those purposes

- adequate, relevant and limited to what is necessary in relation to the purposes for which they are processed

- accurate and, where necessary, kept up to date

- kept in a form which permits identification of data subjects for no longer than is necessary for the purposes for which the data is processed and

- processed in a manner that ensures appropriate security of the personal data.

Participants must inform the coordinator without delay of any changes to the systems, rules and procedures that were part of the pillar assessment. The coordinator must immediately inform the granting authority.

Pillar-assessed participants that have also concluded a framework agreement with the EU, may moreover — under the same conditions as those above (i.e. not call into question the decision awarding the grant or breach the principle of equal treatment of applicants or beneficiaries) — rely on the provisions set out in that framework agreement.

SECTION 2 RULES FOR CARRYING OUT THE ACTION

ARTICLE 11 — PROPER IMPLEMENTATION OF THE ACTION

11.1 Obligation to properly implement the action

The beneficiaries must implement the action as described in Annex 1 and in compliance with the provisions of the Agreement, the call conditions and all legal obligations under applicable EU, international and national law.

11.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 28).

Such breaches may also lead to other measures described in Chapter 5.

ARTICLE 12 — CONFLICT OF INTERESTS

12.1 Conflict of interests

The beneficiaries must take all measures to prevent any situation where the impartial and objective implementation of the Agreement could be compromised for reasons involving family, emotional life, political or national affinity, economic interest or any other direct or indirect interest (‘conflict of interests’).

They must formally notify the granting authority without delay of any situation constituting or likely to lead to a conflict of interests and immediately take all the necessary steps to rectify this situation.

The granting authority may verify that the measures taken are appropriate and may require additional measures to be taken by a specified deadline.

12.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 28) and the grant or the beneficiary may be terminated (see Article 32).

Such breaches may also lead to other measures described in Chapter 5.

ARTICLE 13 — CONFIDENTIALITY AND SECURITY

13.1 Sensitive information

The parties must keep confidential any data, documents or other material (in any form) that is identified as sensitive in writing ('sensitive information') — during the implementation of the action and for at least until the time-limit set out in the Data Sheet (see Point 6).

If a beneficiary requests, the granting authority may agree to keep such information confidential for a longer period.

Unless otherwise agreed between the parties, they may use sensitive information only to implement the Agreement.

The beneficiaries may disclose sensitive information to their personnel or other participants involved in the action only if they:

(a) need to know it in order to implement the Agreement and

(b) are bound by an obligation of confidentiality.

The granting authority may disclose sensitive information to its staff and to other EU institutions and bodies.

It may moreover disclose sensitive information to third parties, if:

(a) this is necessary to implement the Agreement or safeguard the EU financial interests and

(b) the recipients of the information are bound by an obligation of confidentiality.

The confidentiality obligations no longer apply if:

(a) the disclosing party agrees to release the other party

(b) the information becomes publicly available, without breaching any confidentiality obligation

(c) the disclosure of the sensitive information is required by EU, international or national law.

Specific confidentiality rules (if any) are set out in Annex 5.

13.2 Classified information

The parties must handle classified information in accordance with the applicable EU, international or national law on classified information (in particular, Decision 2015/444[14] and its implementing rules).

Deliverables which contain classified information must be submitted according to special procedures agreed with the granting authority.

Action tasks involving classified information may be subcontracted only after explicit approval (in writing) from the granting authority.

Classified information may not be disclosed to any third party (including participants involved in the action implementation) without prior explicit written approval from the granting authority.

Specific security rules (if any) are set out in Annex 5.

13.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 28).

Such breaches may also lead to other measures described in Chapter 5.

ARTICLE 14 — ETHICS AND VALUES

14.1 Ethics

The action must be carried out in line with the highest ethical standards and the applicable EU, international and national law on ethical principles.

Specific ethics rules (if any) are set out in Annex 5.

14.2 Values

The beneficiaries must commit to and ensure the respect of basic EU values (such as respect for human dignity, freedom, democracy, equality, the rule of law and human rights, including the rights of minorities).

Specific rules on values (if any) are set out in Annex 5.

14.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 28).

Such breaches may also lead to other measures described in Chapter 5.

ARTICLE 15 — DATA PROTECTION

15.1 Data processing by the granting authority

[14] Commission Decision 2015/444/EC, Euratom of 13 March 2015 on the security rules for protecting EU classified information (OJ L 72, 17.3.2015, p. 53).

Any personal data under the Agreement will be processed under the responsibility of the data controller of the granting authority in accordance with and for the purposes set out in the Portal Privacy Statement.

For grants where the granting authority is the European Commission, an EU regulatory or executive agency, joint undertaking or other EU body, the processing will be subject to Regulation 2018/1725[15].

15.2 Data processing by the beneficiaries

The beneficiaries must process personal data under the Agreement in compliance with the applicable EU, international and national law on data protection (in particular, Regulation 2016/679[16]).

They must ensure that personal data is:

- processed lawfully, fairly and in a transparent manner in relation to the data subjects
- collected for specified, explicit and legitimate purposes and not further processed in a manner that is incompatible with those purposes
- adequate, relevant and limited to what is necessary in relation to the purposes for which they are processed
- accurate and, where necessary, kept up to date
- kept in a form which permits identification of data subjects for no longer than is necessary for the purposes for which the data is processed and
- processed in a manner that ensures appropriate security of the data.

The beneficiaries may grant their personnel access to personal data only if it is strictly necessary for implementing, managing and monitoring the Agreement. The beneficiaries must ensure that the personnel is under a confidentiality obligation.

The beneficiaries must inform the persons whose data are transferred to the granting authority and provide them with the Portal Privacy Statement.

15.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 28).

Such breaches may also lead to other measures described in Chapter 5.

ARTICLE 16 — INTELLECTUAL PROPERTY RIGHTS (IPR) — BACKGROUND AND RESULTS —ACCESS RIGHTS AND RIGHTS OF USE

[15] Regulation (EU) 2018/1725 of the European Parliament and of the Council of 23 October 2018 on the protection of natural persons with regard to the processing of personal data by the Union institutions, bodies, offices and agencies and on the free movement of such data, and repealing Regulation (EC) No 45/2001 and Decision No 1247/2002/EC (OJ L 295, 21.11.2018, p. 39).

[16] Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (‘GDPR’) (OJ L 119, 4.5.2016, p. 1).

16.1 Background and access rights to background

The beneficiaries must give each other and the other participants access to the background identified as needed for implementing the action, subject to any specific rules in Annex 5.

'Background' means any data, know-how or information — whatever its form or nature (tangible or intangible), including any rights such as intellectual property rights — that is:

(a) held by the beneficiaries before they acceded to the Agreement and

(b) needed to implement the action or exploit the results.

If background is subject to rights of a third party, the beneficiary concerned must ensure that it is able to comply with its obligations under the Agreement.

16.2 Ownership of results

The granting authority does not obtain ownership of the results produced under the action.

'Results' means any tangible or intangible effect of the action, such as data, know-how or information, whatever its form or nature, whether or not it can be protected, as well as any rights attached to it, including intellectual property rights.

16.3 Rights of use of the granting authority on materials, documents and information received for policy, information, communication, dissemination and publicity purposes

The granting authority has the right to use non-sensitive information relating to the action and materials and documents received from the beneficiaries (notably summaries for publication, deliverables, as well as any other material, such as pictures or audio-visual material, in paper or electronic form) for policy, information, communication, dissemination and publicity purposes — during the action or afterwards.

The right to use the beneficiaries' materials, documents and information is granted in the form of a royalty-free, non-exclusive and irrevocable licence, which includes the following rights:

(a) **use for its own purposes** (in particular, making them available to persons working for the granting authority or any other EU service (including institutions, bodies, offices, agencies, etc.) or EU Member State institution or body; copying or reproducing them in whole or in part, in unlimited numbers; and communication through press information services)

(b) **distribution to the public** (in particular, publication as hard copies and in electronic or digital format, publication on the internet, as a downloadable or non-downloadable file, broadcasting by any channel, public display or presentation, communicating through press information services, or inclusion in widely accessible databases or indexes)

(c) **editing or redrafting** (including shortening, summarising, inserting other elements (e.g. meta-data, legends, other graphic, visual, audio or text elements), extracting parts (e.g. audio or video files), dividing into parts, use in a compilation)

(d) **translation**

(e) **storage** in paper, electronic or other form

(f) **archiving**, in line with applicable document-management rules

(g) the right to authorise **third parties** to act on its behalf or sub-license to third parties the modes of use set out in Points (b), (c), (d) and (f), if needed for the information, communication and publicity activity of the granting authority

(h) **processing**, analysing, aggregating the materials, documents and information received and **producing derivative works**.

The rights of use are granted for the whole duration of the industrial or intellectual property rights concerned.

If materials or documents are subject to moral rights or third party rights (including intellectual property rights or rights of natural persons on their image and voice), the beneficiaries must ensure that they comply with their obligations under this Agreement (in particular, by obtaining the necessary licences and authorisations from the rights holders concerned).

Where applicable, the granting authority will insert the following information:

"© – [year] – [name of the copyright owner]. All rights reserved. Licensed to the [name of granting authority] under conditions."

16.4 Specific rules on IPR, results and background

Specific rules regarding intellectual property rights, results and background (if any) are set out in Annex 5.

16.5 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 28).

Such a breach may also lead to other measures described in Chapter 5.

ARTICLE 17 — COMMUNICATION, DISSEMINATION AND VISIBILITY

17.1 Communication — Dissemination — Promoting the action

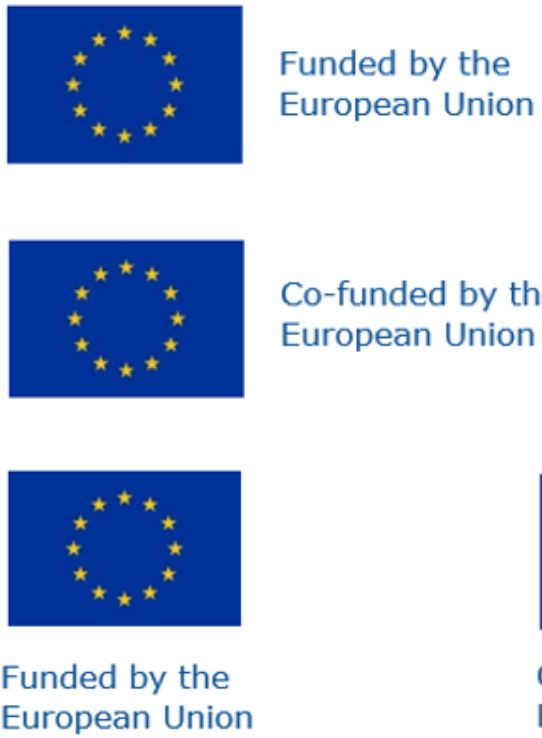
Unless otherwise agreed with the granting authority, the beneficiaries must promote the action and its results by providing targeted information to multiple audiences (including the media and the public), in accordance with Annex 1 and in a strategic, coherent and effective manner.

Before engaging in a communication or dissemination activity expected to have a major media impact, the beneficiaries must inform the granting authority.

17.2 Visibility — European flag and funding statement

Unless otherwise agreed with the granting authority, communication activities of the beneficiaries related to the action (including media relations, conferences, seminars, information material, such as brochures, leaflets, posters, presentations, etc., in electronic form, via traditional or social media, etc.), dissemination activities and any infrastructure, equipment, vehicles, supplies or major result funded

by the grant must acknowledge EU support and display the European flag (emblem) and funding statement (translated into local languages, where appropriate):



The emblem must remain distinct and separate and cannot be modified by adding other visual marks, brands or text.

Apart from the emblem, no other visual identity or logo may be used to highlight the EU support.

When displayed in association with other logos (e.g. of beneficiaries or sponsors), the emblem must be displayed at least as prominently and visibly as the other logos.

For the purposes of their obligations under this Article, the beneficiaries may use the emblem without first obtaining approval from the granting authority. This does not, however, give them the right to exclusive use. Moreover, they may not appropriate the emblem or any similar trademark or logo, either by registration or by any other means.

17.3 Quality of information — Disclaimer

Any communication or dissemination activity related to the action must use factually accurate information.

Moreover, it must indicate the following disclaimer (translated into local languages where appropriate):

> "Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or [name of the granting authority]. Neither the European Union nor the granting authority can be held responsible for them."

17.4 Specific communication, dissemination and visibility rules

Specific communication, dissemination and visibility rules (if any) are set out in Annex 5.

17.5 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 28).

Such breaches may also lead to other measures described in Chapter 5.

ARTICLE 18 — SPECIFIC RULES FOR CARRYING OUT THE ACTION

18.1 Specific rules for carrying out the action

Specific rules for implementing the action (if any) are set out in Annex 5.

18.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 28).

Such a breach may also lead to other measures described in Chapter 5.

SECTION 3 GRANT ADMINISTRATION

ARTICLE 19 — GENERAL INFORMATION OBLIGATIONS

19.1 Information requests

The beneficiaries must provide — during the action or afterwards and in accordance with Article 7 — any information requested in order to verify eligibility of the costs or contributions declared, proper implementation of the action and compliance with the other obligations under the Agreement.

The information provided must be accurate, precise and complete and in the format requested, including electronic format.

19.2 Participant Register data updates

The beneficiaries must keep — at all times, during the action or afterwards — their information stored in the Portal Participant Register up to date, in particular, their name, address, legal representatives, legal form and organisation type.

19.3 Information about events and circumstances which impact the action

The beneficiaries must immediately inform the granting authority (and the other beneficiaries) of any of the following:

(a) **events** which are likely to affect or delay the implementation of the action or affect the EU's financial interests, in particular:

(i) changes in their legal, financial, technical, organisational or ownership situation (including changes linked to one of the exclusion grounds listed in the declaration of honour signed before grant signature)

(ii) linked action information: not applicable

(b) **circumstances** affecting:

(i) the decision to award the grant or

(ii) compliance with requirements under the Agreement.

19.4 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 28).

Such breaches may also lead to other measures described in Chapter 5.

ARTICLE 20 — RECORD-KEEPING

20.1 Keeping records and supporting documents

The beneficiaries must — at least until the time-limit set out in the Data Sheet (see Point 6) — keep records and other supporting documents to prove the proper implementation of the action in line with the accepted standards in the respective field (if any).

In addition, the beneficiaries must — for the same period — keep the following to justify the amounts declared:

(a) for actual costs: adequate records and supporting documents to prove the costs declared (such as contracts, subcontracts, invoices and accounting records); in addition, the beneficiaries' usual accounting and internal control procedures must enable direct reconciliation between the amounts declared, the amounts recorded in their accounts and the amounts stated in the supporting documents

(b) for flat-rate costs and contributions (if any): adequate records and supporting documents to prove the eligibility of the costs or contributions to which the flat-rate is applied

(c) for the following simplified costs and contributions: the beneficiaries do not need to keep specific records on the actual costs incurred, but must keep:

(i) for unit costs and contributions (if any): adequate records and supporting documents to prove the number of units declared

(ii) for lump sum costs and contributions (if any): adequate records and supporting documents to prove proper implementation of the work as described in Annex 1

(iii) for financing not linked to costs (if any): adequate records and supporting documents to prove the achievement of the results or the fulfilment of the conditions as described in Annex 1

(d) for unit, flat-rate and lump sum costs and contributions according to usual cost accounting practices (if any): the beneficiaries must keep any adequate records and supporting documents to prove that their cost accounting practices have been applied in a consistent manner, based on

objective criteria, regardless of the source of funding, and that they comply with the eligibility conditions set out in Articles 6.1 and 6.2.

Moreover, the following is needed for specific budget categories:

(e) for personnel costs: time worked for the beneficiary under the action must be supported by declarations signed monthly by the person and their supervisor, unless another reliable time-record system is in place; the granting authority may accept alternative evidence supporting the time worked for the action declared, if it considers that it offers an adequate level of assurance

(f) additional record-keeping rules: not applicable

The records and supporting documents must be made available upon request (see Article 19) or in the context of checks, reviews, audits or investigations (see Article 25).

If there are on-going checks, reviews, audits, investigations, litigation or other pursuits of claims under the Agreement (including the extension of findings; see Article 25), the beneficiaries must keep these records and other supporting documentation until the end of these procedures.

The beneficiaries must keep the original documents. Digital and digitalised documents are considered originals if they are authorised by the applicable national law. The granting authority may accept non-original documents if they offer a comparable level of assurance.

20.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, costs or contributions insufficiently substantiated will be ineligible (see Article 6) and will be rejected (see Article 27), and the grant may be reduced (see Article 28).

Such breaches may also lead to other measures described in Chapter 5.

ARTICLE 21 — REPORTING

21.1 Continuous reporting

The beneficiaries must continuously report on the progress of the action (e.g. **deliverables, milestones, outputs/outcomes, critical risks, indicators,** etc; if any), in the Portal Continuous Reporting tool and in accordance with the timing and conditions it sets out (as agreed with the granting authority).

Standardised deliverables (e.g. progress reports not linked to payments, reports on cumulative expenditure, special reports, etc; if any) must be submitted using the templates published on the Portal.

21.2 Periodic reporting: Technical reports and financial statements

In addition, the beneficiaries must provide reports to request payments, in accordance with the schedule and modalities set out in the Data Sheet (see Point 4.2):

- for additional prefinancings (if any): an **additional prefinancing report**
- for interim payments (if any) and the final payment: a **periodic report**.

The prefinancing and periodic reports include a technical and financial part.

The technical part includes an overview of the action implementation. It must be prepared using the template available in the Portal Periodic Reporting tool.

The financial part of the additional prefinancing report includes a statement on the use of the previous prefinancing payment.

The financial part of the periodic report includes:

- the financial statements (individual and consolidated; for all beneficiaries/affiliated entities)
- the explanation on the use of resources (or detailed cost reporting table, if required)
- the certificates on the financial statements (CFS) (if required; see Article 24.2 and Data Sheet, Point 4.3).

The **financial statements** must detail the eligible costs and contributions for each budget category and, for the final payment, also the revenues for the action (see Articles 6 and 22).

All eligible costs and contributions incurred should be declared, even if they exceed the amounts indicated in the estimated budget (see Annex 2). Amounts that are not declared in the individual financial statements will not be taken into account by the granting authority.

By signing the financial statements (directly in the Portal Periodic Reporting tool), the beneficiaries confirm that:

- the information provided is complete, reliable and true
- the costs and contributions declared are eligible (see Article 6)
- the costs and contributions can be substantiated by adequate records and supporting documents (see Article 20) that will be produced upon request (see Article 19) or in the context of checks, reviews, audits and investigations (see Article 25)
- for the final periodic report: all the revenues have been declared (if required; see Article 22).

Beneficiaries will have to submit also the financial statements of their affiliated entities (if any). In case of recoveries (see Article 22), beneficiaries will be held responsible also for the financial statements of their affiliated entities.

21.3 Currency for financial statements and conversion into euros

The financial statements must be drafted in euro.

Beneficiaries with general accounts established in a currency other than the euro must convert the costs recorded in their accounts into euro, at the average of the daily exchange rates published in the C series of the *Official Journal of the European Union* (ECB website), calculated over the corresponding reporting period.

If no daily euro exchange rate is published in the *Official Journal* for the currency in question, they must be converted at the average of the monthly accounting exchange rates published on the European Commission website (InforEuro), calculated over the corresponding reporting period.

Beneficiaries with general accounts in euro must convert costs incurred in another currency into euro according to their usual accounting practices.

21.4 Reporting language

The reporting must be in the language of the Agreement, unless otherwise agreed with the granting authority (see Data Sheet, Point 4.2).

21.5 Consequences of non-compliance

If a report submitted does not comply with this Article, the granting authority may suspend the payment deadline (see Article 29) and apply other measures described in Chapter 5.

If the coordinator breaches its reporting obligations, the granting authority may terminate the grant or the coordinator's participation (see Article 32) or apply other measures described in Chapter 5.

ARTICLE 22 — PAYMENTS AND RECOVERIES — CALCULATION OF AMOUNTS DUE

22.1 Payments and payment arrangements

Payments will be made in accordance with the schedule and modalities set out in the Data Sheet (see Point 4.2).

They will be made in euro to the bank account indicated by the coordinator (see Data Sheet, Point 4.2) and must be distributed without unjustified delay (restrictions may apply to distribution of the initial prefinancing payment; see Data Sheet, Point 4.2).

Payments to this bank account will discharge the granting authority from its payment obligation.

The cost of payment transfers will be borne as follows:

- the granting authority bears the cost of transfers charged by its bank
- the beneficiary bears the cost of transfers charged by its bank
- the party causing a repetition of a transfer bears all costs of the repeated transfer.

Payments by the granting authority will be considered to have been carried out on the date when they are debited to its account.

22.2 Recoveries

Recoveries will be made, if — at beneficiary termination, final payment or afterwards — it turns out that the granting authority has paid too much and needs to recover the amounts undue.

Each beneficiary's financial responsibility in case of recovery is in principle limited to their own debt and undue amounts of their affiliated entities.

In case of enforced recoveries (see Article 22.4), affiliated entities will be held liable for repaying debts of their beneficiaries, if required by the granting authority (see Data Sheet, Point 4.4).

22.3 Amounts due

22.3.1 Prefinancing payments

The aim of the prefinancing is to provide the beneficiaries with a float.

It remains the property of the EU until the final payment.

For **initial prefinancings** (if any), the amount due, schedule and modalities are set out in the Data Sheet (see Point 4.2).

For **additional prefinancings** (if any), the amount due, schedule and modalities are also set out in the Data Sheet (see Point 4.2). However, if the statement on the use of the previous prefinancing payment shows that less than 70% was used, the amount set out in the Data Sheet will be reduced by the difference between the 70% threshold and the amount used.

The contribution to the Mutual Insurance Mechanism will be retained from the prefinancing payments (at the rate and in accordance with the modalities set out in the Data Sheet, see Point 4.2) and transferred to the Mechanism.

Prefinancing payments (or parts of them) may be offset (without the beneficiaries' consent) against amounts owed by a beneficiary to the granting authority — up to the amount due to that beneficiary.

For grants where the granting authority is the European Commission or an EU executive agency, offsetting may also be done against amounts owed to other Commission services or executive agencies.

Payments will not be made if the payment deadline or payments are suspended (see Articles 29 and 30).

22.3.2 Amount due at beneficiary termination — Recovery

In case of beneficiary termination, the granting authority will determine the provisional amount due for the beneficiary concerned. Payments (if any) will be made with the next interim or final payment.

The **amount due** will be calculated in the following step:

Step 1 — Calculation of the total accepted EU contribution

Step 1 — Calculation of the total accepted EU contribution

The granting authority will first calculate the 'accepted EU contribution' for the beneficiary for all reporting periods, by calculating the 'maximum EU contribution to costs' (applying the funding rate to the accepted costs of the beneficiary), taking into account requests for a lower contribution to costs and CFS threshold cappings (if any; see Article 24.5) and adding the contributions (accepted unit, flat-rate or lump sum contributions and financing not linked to costs, if any).

After that, the granting authority will take into account grant reductions (if any). The resulting amount is the 'total accepted EU contribution' for the beneficiary.

The **balance** is then calculated by deducting the payments received (if any; see report on the distribution of payments in Article 32), from the total accepted EU contribution:

{total accepted EU contribution for the beneficiary

minus

{prefinancing and interim payments received (if any)}}.

If the balance is **positive**, the amount will be included in the next interim or final payment to the consortium.

If the balance is **negative**, it will be **recovered** in accordance with the following procedure:

The granting authority will send a **pre-information letter** to the beneficiary concerned:

- formally notifying the intention to recover, the amount due, the amount to be recovered and the reasons why and
- requesting observations within 30 days of receiving notification.

If no observations are submitted (or the granting authority decides to pursue recovery despite the observations it has received), it will confirm the amount to be recovered and ask this amount to be paid to the coordinator (**confirmation letter**).

If payment is not made to the coordinator by the date specified in the confirmation letter, the granting authority may call on the Mutual Insurance Mechanism to intervene, if continuation of the action is guaranteed and the conditions set out in the rules governing the Mechanism are met.

In this case, it will send a **beneficiary recovery letter**, together with a **debit note** with the terms and date for payment.

The debit note for the beneficiary will include the amount calculated for the affiliated entities which also had to end their participation (if any).

If payment is not made by the date specified in the debit note, the granting authority will **enforce recovery** in accordance with Article 22.4.

The amounts will later on also be taken into account for the next interim or final payment.

22.3.3 Interim payments

Interim payments reimburse the eligible costs and contributions claimed for the implementation of the action during the reporting periods (if any).

Interim payments (if any) will be made in accordance with the schedule and modalities set out the Data Sheet (see Point 4.2).

Payment is subject to the approval of the periodic report. Its approval does not imply recognition of compliance, authenticity, completeness or correctness of its content.

The **interim payment** will be calculated by the granting authority in the following steps:

Step 1 — Calculation of the total accepted EU contribution

Step 2 — Limit to the interim payment ceiling

Step 1 — Calculation of the total accepted EU contribution

The granting authority will calculate the 'accepted EU contribution' for the action for the reporting period, by first calculating the 'maximum EU contribution to costs' (applying the funding rate to the accepted costs of each beneficiary), taking into account requests for a lower contribution to costs, and CFS threshold cappings (if any; see Article 24.5) and adding the contributions (accepted unit, flat-rate or lump sum contributions and financing not linked to costs, if any).

After that, the granting authority will take into account grant reductions from beneficiary termination (if any). The resulting amount is the 'total accepted EU contribution'.

Step 2 — Limit to the interim payment ceiling

The resulting amount is then capped to ensure that the total amount of prefinancing and interim payments (if any) does not exceed the interim payment ceiling set out in the Data Sheet (see Point 4.2).

Interim payments (or parts of them) may be offset (without the beneficiaries' consent) against amounts owed by a beneficiary to the granting authority — up to the amount due to that beneficiary.

For grants where the granting authority is the European Commission or an EU executive agency, offsetting may also be done against amounts owed to other Commission services or executive agencies.

Payments will not be made if the payment deadline or payments are suspended (see Articles 29 and 30).

22.3.4 Final payment — Final grant amount — Revenues and Profit — Recovery

The final payment (payment of the balance) reimburses the remaining part of the eligible costs and contributions claimed for the implementation of the action (if any).

The final payment will be made in accordance with the schedule and modalities set out in the Data Sheet (see Point 4.2).

Payment is subject to the approval of the final periodic report. Its approval does not imply recognition of compliance, authenticity, completeness or correctness of its content.

The **final grant amount for the action** will be calculated in the following steps:

Step 1 — Calculation of the total accepted EU contribution

Step 2 — Limit to the maximum grant amount

Step 3 — Reduction due to the no-profit rule

Step 1 — Calculation of the total accepted EU contribution

The granting authority will first calculate the 'accepted EU contribution' for the action for all reporting periods, by calculating the 'maximum EU contribution to costs' (applying the funding rate to the total accepted costs of each beneficiary), taking into account requests for a lower contribution to costs, CFS threshold cappings (if any; see Article 24.5) and adding the contributions (accepted unit, flat-rate or lump sum contributions and financing not linked to costs, if any).

After that, the granting authority will take into account grant reductions (if any). The resulting amount is the 'total accepted EU contribution'.

Step 2 — Limit to the maximum grant amount

If the resulting amount is higher than the maximum grant amount set out in Article 5.2, it will be limited to the latter.

Step 3 — Reduction due to the no-profit rule

If the no-profit rule is provided for in the Data Sheet (see Point 4.2), the grant must not produce a profit (i.e. surplus of the amount obtained following Step 2 plus the action's revenues, over the eligible costs and contributions approved by the granting authority).

'Revenue' is all income generated by the action, during its duration (see Article 4), for beneficiaries that are profit legal entities (— with the exception of income generated by the exploitation of results, which are not considered as revenues).

If there is a profit, it will be deducted in proportion to the final rate of reimbursement of the eligible costs approved by the granting authority (as compared to the amount calculated following Steps 1 and 2 minus the contributions).

The **balance** (final payment) is then calculated by deducting the total amount of prefinancing and interim payments already made (if any), from the final grant amount:

{final grant amount

minus

{prefinancing and interim payments made (if any)}}.

If the balance is **positive**, it will be **paid** to the coordinator.

The amount retained for the Mutual Insurance Mechanism (see above) will be released and **paid** to the coordinator (in accordance with the rules governing the Mechanism).

The final payment (or part of it) may be offset (without the beneficiaries' consent) against amounts owed by a beneficiary to the granting authority — up to the amount due to that beneficiary.

For grants where the granting authority is the European Commission or an EU executive agency, offsetting may also be done against amounts owed to other Commission services or executive agencies.

Payments will not be made if the payment deadline or payments are suspended (see Articles 29 and 30).

If — despite the release of the Mutual Insurance Mechanism contribution — the balance is **negative**, it will be **recovered** in accordance with the following procedure:

The granting authority will send a **pre-information letter** to the coordinator:

- formally notifying the intention to recover, the final grant amount, the amount to be recovered and the reasons why

- requesting a report on the distribution of payments to the beneficiaries within 30 days of receiving notification and

- requesting observations within 30 days of receiving notification.

If no observations are submitted (or the granting authority decides to pursue recovery despite the observations it has received) and the coordinator has submitted the report on the distribution of payments, it will calculate the **share of the debt per beneficiary**, by:

(a) identifying the beneficiaries for which the amount calculated as follows is negative:

{{{total accepted EU contribution for the beneficiary

divided by

total accepted EU contribution for the action}

multiplied by

final grant amount for the action},

minus

{prefinancing and interim payments received by the beneficiary (if any)}}

and

(b) dividing the debt:

{{amount calculated according to point (a) for the beneficiary concerned

divided by

the sum of the amounts calculated according to point (a) for all the beneficiaries identified according to point (a)}

multiplied by

the amount to be recovered}.

and confirm the amount to be recovered from each beneficiary concerned (**confirmation letter**), together with **debit notes** with the terms and date for payment.

The debit notes for beneficiaries will include the amounts calculated for their affiliated entities (if any).

If the coordinator has not submitted the report on the distribution of payments, the granting authority will **recover** the full amount from the coordinator (**confirmation letter** and **debit note** with the terms and date for payment).

If payment is not made by the date specified in the debit note, the granting authority will **enforce recovery** in accordance with Article 22.4.

22.3.5 Audit implementation after final payment — Revised final grant amount — Recovery

If — after the final payment (in particular, after checks, reviews, audits or investigations; see Article 25) — the granting authority rejects costs or contributions (see Article 27) or reduces the grant (see Article 28), it will calculate the **revised final grant amount** for the beneficiary concerned.

The **beneficiary revised final grant amount** will be calculated in the following step:

Step 1 — Calculation of the revised total accepted EU contribution

Step 1 — Calculation of the revised total accepted EU contribution

The granting authority will first calculate the 'revised accepted EU contribution' for the beneficiary, by calculating the 'revised accepted costs' and 'revised accepted contributions'.

After that, it will take into account grant reductions (if any). The resulting 'revised total accepted EU contribution' is the beneficiary revised final grant amount.

If the revised final grant amount is lower than the beneficiary's final grant amount (i.e. its share in the final grant amount for the action), it will be **recovered** in accordance with the following procedure:

The **beneficiary final grant amount** (i.e. share in the final grant amount for the action) is calculated as follows:

{{total accepted EU contribution for the beneficiary

divided by

total accepted EU contribution for the action}

multiplied by

final grant amount for the action}.

The granting authority will send a **pre-information letter** to the beneficiary concerned:

- formally notifying the intention to recover, the amount to be recovered and the reasons why and
- requesting observations within 30 days of receiving notification.

If no observations are submitted (or the granting authority decides to pursue recovery despite the observations it has received), it will confirm the amount to be recovered (**confirmation letter**), together with a **debit note** with the terms and the date for payment.

Recoveries against affiliated entities (if any) will be handled through their beneficiaries.

If payment is not made by the date specified in the debit note, the granting authority will **enforce recovery** in accordance with Article 22.4.

22.4 Enforced recovery

If payment is not made by the date specified in the debit note, the amount due will be recovered:

(a) by offsetting the amount — without the coordinator or beneficiary's consent — against any amounts owed to the coordinator or beneficiary by the granting authority.

In exceptional circumstances, to safeguard the EU financial interests, the amount may be offset before the payment date specified in the debit note.

For grants where the granting authority is the European Commission or an EU executive

agency, debts may also be offset against amounts owed by other Commission services or executive agencies.

(b) financial guarantee(s): not applicable

(c) joint and several liability of beneficiaries: not applicable

(d) by holding affiliated entities jointly and severally liable (if any, see Data Sheet, Point 4.4)

(e) by taking legal action (see Article 43) or, provided that the granting authority is the European Commission or an EU executive agency, by adopting an enforceable decision under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 100(2) of EU Financial Regulation 2018/1046.

If the Mutual Insurance Mechanism was called on by the granting authority to intervene, recovery will be continued in the name of the Mutual Insurance Mechanism. If two debit notes were sent, the second one (in the name of the Mutual Insurance Mechanism) will be considered to replace the first one (in the name of the granting authority). Where the MIM intervened, offsetting, enforceable decisions or any other of the above-mentioned forms of enforced recovery may be used mutatis mutandis.

The amount to be recovered will be increased by **late-payment interest** at the rate set out in Article 22.5, from the day following the payment date in the debit note, up to and including the date the full payment is received.

Partial payments will be first credited against expenses, charges and late-payment interest and then against the principal.

Bank charges incurred in the recovery process will be borne by the beneficiary, unless Directive 2015/2366[17] applies.

For grants where the granting authority is an EU executive agency, enforced recovery by offsetting or enforceable decision will be done by the services of the European Commission (see also Article 43).

22.5 Consequences of non-compliance

22.5.1 If the granting authority does not pay within the payment deadlines (see above), the beneficiaries are entitled to **late-payment interest** at the rate applied by the European Central Bank (ECB) for its main refinancing operations in euros (‘reference rate’), plus the rate specified in the Data Sheet (Point 4.2). The reference rate is the rate in force on the first day of the month in which the payment deadline expires, as published in the C series of the *Official Journal of the European Union*.

If the late-payment interest is lower than or equal to EUR 200, it will be paid to the coordinator only on request submitted within two months of receiving the late payment.

Late-payment interest is not due if all beneficiaries are EU Member States (including regional and local government authorities or other public bodies acting on behalf of a Member State for the purpose of this Agreement).

[17] Directive (EU) 2015/2366 of the European Parliament and of the Council of 25 November 2015 on payment services in the internal market, amending Directives 2002/65/EC, 2009/110/EC and 2013/36/EU and Regulation (EU) No 1093/2010, and repealing Directive 2007/64/EC (OJ L 337, 23.12.2015, p. 35).

If payments or the payment deadline are suspended (see Articles 29 and 30), payment will not be considered as late.

Late-payment interest covers the period running from the day following the due date for payment (see above), up to and including the date of payment.

Late-payment interest is not considered for the purposes of calculating the final grant amount.

22.5.2 If the coordinator breaches any of its obligations under this Article, the grant may be reduced (see Article 28) and the grant or the coordinator may be terminated (see Article 32).

Such breaches may also lead to other measures described in Chapter 5.

ARTICLE 23 — GUARANTEES

Not applicable

ARTICLE 24 — CERTIFICATES

24.1 Operational verification report (OVR)

Not applicable

24.2 Certificate on the financial statements (CFS)

If required by the granting authority (see Data Sheet, Point 4.3), the beneficiaries must provide certificates on their financial statements (CFS), in accordance with the schedule, threshold and conditions set out in the Data Sheet.

The coordinator must submit them as part of the periodic report (see Article 21).

The certificates must be drawn up using the template published on the Portal, cover the costs declared on the basis of actual costs and costs according to usual cost accounting practices (if any), and fulfil the following conditions:

(a) be provided by a qualified approved external auditor which is independent and complies with Directive 2006/43/EC[18] (or for public bodies: by a competent independent public officer)

(b) the verification must be carried out according to the highest professional standards to ensure that the financial statements comply with the provisions under the Agreement and that the costs declared are eligible.

The certificates will not affect the granting authority's right to carry out its own checks, reviews or audits, nor preclude the European Court of Auditors (ECA), the European Public Prosecutor’s Office (EPPO) or the European Anti-Fraud Office (OLAF) from using their prerogatives for audits and investigations under the Agreement (see Article 25).

If the costs (or a part of them) were already audited by the granting authority, these costs do not need to be covered by the certificate and will not be counted for calculating the threshold (if any).

[18] Directive 2006/43/EC of the European Parliament and of the Council of 17 May 2006 on statutory audits of annual accounts and consolidated accounts or similar national regulations (OJ L 157, 9.6.2006, p. 87).

24.3 Certificate on the compliance of usual cost accounting practices (CoMUC)

Not applicable

24.4 Systems and process audit (SPA)

Beneficiaries which:

- use unit, flat rate or lump sum costs or contributions according to documented (i.e. formally approved and in writing) usual costs accounting practices (if any) or
- have formalised documentation on the systems and processes for calculating their costs and contributions (i.e. formally approved and in writing), have participated in at least 150 actions under Horizon 2020 or the Euratom Research and Training Programme (2014-2018 or 2019-2020) and participate in at least 3 ongoing actions under Horizon Europe or the Euratom Research and Training Programme (2021-2025 or 2026-2027)

may apply to the granting authority for a systems and process audit (SPA).

This audit will be carried out as follows:

Step 1 – Application by the beneficiary.

Step 2 – If the application is accepted, the granting authority will carry out the systems and process audit, complemented by an audit of transactions (on a sample of the beneficiary's Horizon Europe or the Euratom Research and Training Programme financial statements).

Step 3 – The audit result will take the form of a risk assessment classification for the beneficiary: low, medium or high.

Low-risk beneficiaries will benefit from less (or less in-depth) ex-post audits (see Article 25) and a higher threshold for submitting certificates on the financial statements (CFS; see Articles 21 and 24.2 and Data Sheet, Point 4.3).

24.5 Consequences of non-compliance

If a beneficiary does not submit a certificate on the financial statements (CFS) or the certificate is rejected, the accepted EU contribution to costs will be capped to reflect the CFS threshold.

If a beneficiary breaches any of its other obligations under this Article, the granting authority may apply the measures described in Chapter 5.

ARTICLE 25 — CHECKS, REVIEWS, AUDITS AND INVESTIGATIONS — EXTENSION OF FINDINGS

25.1 Granting authority checks, reviews and audits

25.1.1 Internal checks

The granting authority may — during the action or afterwards — check the proper implementation of the action and compliance with the obligations under the Agreement, including assessing costs and contributions, deliverables and reports.

25.1.2 Project reviews

The granting authority may carry out reviews on the proper implementation of the action and compliance with the obligations under the Agreement (general project reviews or specific issues reviews).

Such project reviews may be started during the implementation of the action and until the time-limit set out in the Data Sheet (see Point 6). They will be formally notified to the coordinator or beneficiary concerned and will be considered to start on the date of the notification.

If needed, the granting authority may be assisted by independent, outside experts. If it uses outside experts, the coordinator or beneficiary concerned will be informed and have the right to object on grounds of commercial confidentiality or conflict of interest.

The coordinator or beneficiary concerned must cooperate diligently and provide — within the deadline requested — any information and data in addition to deliverables and reports already submitted (including information on the use of resources). The granting authority may request beneficiaries to provide such information to it directly. Sensitive information and documents will be treated in accordance with Article 13.

The coordinator or beneficiary concerned may be requested to participate in meetings, including with the outside experts.

For **on-the-spot visits**, the beneficiary concerned must allow access to sites and premises (including to the outside experts) and must ensure that information requested is readily available.

Information provided must be accurate, precise and complete and in the format requested, including electronic format.

On the basis of the review findings, a **project review report** will be drawn up.

The granting authority will formally notify the project review report to the coordinator or beneficiary concerned, which has 30 days from receiving notification to make observations.

Project reviews (including project review reports) will be in the language of the Agreement.

25.1.3 Audits

The granting authority may carry out audits on the proper implementation of the action and compliance with the obligations under the Agreement.

Such audits may be started during the implementation of the action and until the time-limit set out in the Data Sheet (see Point 6). They will be formally notified to the beneficiary concerned and will be considered to start on the date of the notification.

The granting authority may use its own audit service, delegate audits to a centralised service or use external audit firms. If it uses an external firm, the beneficiary concerned will be informed and have the right to object on grounds of commercial confidentiality or conflict of interest.

The beneficiary concerned must cooperate diligently and provide — within the deadline requested — any information (including complete accounts, individual salary statements or other personal data)

to verify compliance with the Agreement. Sensitive information and documents will be treated in accordance with Article 13.

For **on-the-spot** visits, the beneficiary concerned must allow access to sites and premises (including for the external audit firm) and must ensure that information requested is readily available.

Information provided must be accurate, precise and complete and in the format requested, including electronic format.

On the basis of the audit findings, a **draft audit report** will be drawn up.

The auditors will formally notify the draft audit report to the beneficiary concerned, which has 30 days from receiving notification to make observations (contradictory audit procedure).

The **final audit report** will take into account observations by the beneficiary concerned and will be formally notified to them.

Audits (including audit reports) will be in the language of the Agreement.

25.2 European Commission checks, reviews and audits in grants of other granting authorities

Where the granting authority is not the European Commission, the latter has the same rights of checks, reviews and audits as the granting authority.

25.3 Access to records for assessing simplified forms of funding

The beneficiaries must give the European Commission access to their statutory records for the periodic assessment of simplified forms of funding which are used in EU programmes.

25.4 OLAF, EPPO and ECA audits and investigations

The following bodies may also carry out checks, reviews, audits and investigations — during the action or afterwards:

- the European Anti-Fraud Office (OLAF) under Regulations No 883/2013[19] and No 2185/96[20]
- the European Public Prosecutor's Office (EPPO) under Regulation 2017/1939
- the European Court of Auditors (ECA) under Article 287 of the Treaty on the Functioning of the EU (TFEU) and Article 257 of EU Financial Regulation 2018/1046.

If requested by these bodies, the beneficiary concerned must provide full, accurate and complete information in the format requested (including complete accounts, individual salary statements or

[19] Regulation (EU, Euratom) No 883/2013 of the European Parliament and of the Council of 11 September 2013 concerning investigations conducted by the European Anti-Fraud Office (OLAF) and repealing Regulation (EC) No 1073/1999 of the European Parliament and of the Council and Council Regulation (Euratom) No 1074/1999 (OJ L 248, 18/09/2013, p. 1).

[20] Council Regulation (Euratom, EC) No 2185/96 of 11 November 1996 concerning on-the-spot checks and inspections carried out by the Commission in order to protect the European Communities' financial interests against fraud and other irregularities (OJ L 292, 15/11/1996, p. 2).

other personal data, including in electronic format) and allow access to sites and premises for on-the-spot visits or inspections — as provided for under these Regulations.

To this end, the beneficiary concerned must keep all relevant information relating to the action, at least until the time-limit set out in the Data Sheet (Point 6) and, in any case, until any ongoing checks, reviews, audits, investigations, litigation or other pursuits of claims have been concluded.

25.5 Consequences of checks, reviews, audits and investigations — Extension of results of reviews, audits or investigations

25.5.1 Consequences of checks, reviews, audits and investigations in this grant

Findings in checks, reviews, audits or investigations carried out in the context of this grant may lead to rejections (see Article 27), grant reduction (see Article 28) or other measures described in Chapter 5.

Rejections or grant reductions after the final payment will lead to a revised final grant amount (see Article 22).

Findings in checks, reviews, audits or investigations during the action implementation may lead to a request for amendment (see Article 39), to change the description of the action set out in Annex 1.

Checks, reviews, audits or investigations that find systemic or recurrent errors, irregularities, fraud or breach of obligations in any EU grant may also lead to consequences in other EU grants awarded under similar conditions (‘extension to other grants’).

Moreover, findings arising from an OLAF or EPPO investigation may lead to criminal prosecution under national law.

25.5.2 Extension from other grants

Results of checks, reviews, audits or investigations in other grants may be extended to this grant, if:

(a) the beneficiary concerned is found, in other EU grants awarded under similar conditions, to have committed systemic or recurrent errors, irregularities, fraud or breach of obligations that have a material impact on this grant and

(b) those findings are formally notified to the beneficiary concerned — together with the list of grants affected by the findings — within the time-limit for audits set out in the Data Sheet (see Point 6).

The granting authority will formally notify the beneficiary concerned of the intention to extend the findings and the list of grants affected.

If the extension concerns **rejections of costs or contributions**: the notification will include:

(a) an invitation to submit observations on the list of grants affected by the findings

(b) the request to submit revised financial statements for all grants affected

(c) the correction rate for extrapolation, established on the basis of the systemic or recurrent errors, to calculate the amounts to be rejected, if the beneficiary concerned:

(i) considers that the submission of revised financial statements is not possible or practicable or

(ii) does not submit revised financial statements.

If the extension concerns **grant reductions**: the notification will include:

(a) an invitation to submit observations on the list of grants affected by the findings and

(b) the **correction rate for extrapolation**, established on the basis of the systemic or recurrent errors and the principle of proportionality.

The beneficiary concerned has **60 days** from receiving notification to submit observations, revised financial statements or to propose a duly substantiated **alternative correction method/rate**.

On the basis of this, the granting authority will analyse the impact and decide on the implementation (i.e. start rejection or grant reduction procedures, either on the basis of the revised financial statements or the announced/alternative method/rate or a mix of those; see Articles 27 and 28).

25.6 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, costs or contributions insufficiently substantiated will be ineligible (see Article 6) and will be rejected (see Article 27), and the grant may be reduced (see Article 28).

Such breaches may also lead to other measures described in Chapter 5.

ARTICLE 26 — IMPACT EVALUATIONS

26.1 Impact evaluation

The granting authority may carry out impact evaluations of the action, measured against the objectives and indicators of the EU programme funding the grant.

Such evaluations may be started during implementation of the action and until the time-limit set out in the Data Sheet (see Point 6). They will be formally notified to the coordinator or beneficiaries and will be considered to start on the date of the notification.

If needed, the granting authority may be assisted by independent outside experts.

The coordinator or beneficiaries must provide any information relevant to evaluate the impact of the action, including information in electronic format.

26.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the granting authority may apply the measures described in Chapter 5.

CHAPTER 5 CONSEQUENCES OF NON-COMPLIANCE

SECTION 1 REJECTIONS AND GRANT REDUCTION

ARTICLE 27 — REJECTION OF COSTS AND CONTRIBUTIONS

27.1 Conditions

The granting authority will — at beneficiary termination, interim payment, final payment or afterwards — reject any costs or contributions which are ineligible (see Article 6), in particular following checks, reviews, audits or investigations (see Article 25).

The rejection may also be based on the extension of findings from other grants to this grant (see Article 25).

Ineligible costs or contributions will be rejected.

27.2 Procedure

If the rejection does not lead to a recovery, the granting authority will formally notify the coordinator or beneficiary concerned of the rejection, the amounts and the reasons why. The coordinator or beneficiary concerned may — within 30 days of receiving notification — submit observations if it disagrees with the rejection (payment review procedure).

If the rejection leads to a recovery, the granting authority will follow the contradictory procedure with pre-information letter set out in Article 22.

27.3 Effects

If the granting authority rejects costs or contributions, it will deduct them from the costs or contributions declared and then calculate the amount due (and, if needed, make a recovery; see Article 22).

ARTICLE 28 — GRANT REDUCTION

28.1 Conditions

The granting authority may — at beneficiary termination, final payment or afterwards — reduce the grant for a beneficiary, if:

(a) the beneficiary (or a person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) has committed:

  (i) substantial errors, irregularities or fraud or

  (ii) serious breach of obligations under this Agreement or during its award (including improper implementation of the action, non-compliance with the call conditions, submission of false information, failure to provide required information, breach of ethics or security rules (if applicable), etc.), or

(b) the beneficiary (or a person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) has committed — in other EU grants

awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant (see Article 25).

The amount of the reduction will be calculated for each beneficiary concerned and proportionate to the seriousness and the duration of the errors, irregularities or fraud or breach of obligations, by applying an individual reduction rate to their accepted EU contribution.

28.2 Procedure

If the grant reduction does not lead to a recovery, the granting authority will formally notify the coordinator or beneficiary concerned of the reduction, the amount to be reduced and the reasons why. The coordinator or beneficiary concerned may — within 30 days of receiving notification — submit observations if it disagrees with the reduction (payment review procedure).

If the grant reduction leads to a recovery, the granting authority will follow the contradictory procedure with pre-information letter set out in Article 22.

28.3 Effects

If the granting authority reduces the grant, it will deduct the reduction and then calculate the amount due (and, if needed, make a recovery; see Article 22).

SECTION 2 SUSPENSION AND TERMINATION

ARTICLE 29 — PAYMENT DEADLINE SUSPENSION

29.1 Conditions

The granting authority may — at any moment — suspend the payment deadline if a payment cannot be processed because:

(a) the required report (see Article 21) has not been submitted or is not complete or additional information is needed

(b) there are doubts about the amount to be paid (e.g. ongoing audit extension procedure, queries about eligibility, need for a grant reduction, etc.) and additional checks, reviews, audits or investigations are necessary, or

(c) there are other issues affecting the EU financial interests.

29.2 Procedure

The granting authority will formally notify the coordinator of the suspension and the reasons why.

The suspension will **take effect** the day the notification is sent.

If the conditions for suspending the payment deadline are no longer met, the suspension will be **lifted** — and the remaining time to pay (see Data Sheet, Point 4.2) will resume.

If the suspension exceeds two months, the coordinator may request the granting authority to confirm if the suspension will continue.

If the payment deadline has been suspended due to the non-compliance of the report and the revised report is not submitted (or was submitted but is also rejected), the granting authority may also terminate the grant or the participation of the coordinator (see Article 32).

ARTICLE 30 — PAYMENT SUSPENSION

30.1 Conditions

The granting authority may — at any moment — suspend payments, in whole or in part for one or more beneficiaries, if:

(a) a beneficiary (or a person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) has committed or is suspected of having committed:

(i) substantial errors, irregularities or fraud or

(ii) serious breach of obligations under this Agreement or during its award (including improper implementation of the action, non-compliance with the call conditions, submission of false information, failure to provide required information, breach of ethics or security rules (if applicable), etc.), or

(b) a beneficiary (or a person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) has committed — in other EU grants awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant.

If payments are suspended for one or more beneficiaries, the granting authority will make partial payment(s) for the part(s) not suspended. If suspension concerns the final payment, the payment (or recovery) of the remaining amount after suspension is lifted will be considered to be the payment that closes the action.

30.2 Procedure

Before suspending payments, the granting authority will send a **pre-information letter** to the beneficiary concerned:

- formally notifying the intention to suspend payments and the reasons why and
- requesting observations within 30 days of receiving notification.

If the granting authority does not receive observations or decides to pursue the procedure despite the observations it has received, it will confirm the suspension (**confirmation letter**). Otherwise, it will formally notify that the procedure is discontinued.

At the end of the suspension procedure, the granting authority will also inform the coordinator.

The suspension will **take effect** the day after the confirmation notification is sent.

If the conditions for resuming payments are met, the suspension will be **lifted**. The granting authority will formally notify the beneficiary concerned (and the coordinator) and set the suspension end date.

During the suspension, no prefinancing will be paid to the beneficiaries concerned. For interim payments, the periodic reports for all reporting periods except the last one (see Article 21) must not contain any financial statements from the beneficiary concerned (or its affiliated entities). The coordinator must include them in the next periodic report after the suspension is lifted or — if suspension is not lifted before the end of the action — in the last periodic report.

ARTICLE 31 — GRANT AGREEMENT SUSPENSION

31.1 Consortium-requested GA suspension

31.1.1 Conditions and procedure

The beneficiaries may request the suspension of the grant or any part of it, if exceptional circumstances — in particular *force majeure* (see Article 35) — make implementation impossible or excessively difficult.

The coordinator must submit a request for **amendment** (see Article 39), with:

- the reasons why
- the date the suspension takes effect; this date may be before the date of the submission of the amendment request and
- the expected date of resumption.

The suspension will **take effect** on the day specified in the amendment.

Once circumstances allow for implementation to resume, the coordinator must immediately request another **amendment** of the Agreement to set the suspension end date, the resumption date (one day after suspension end date), extend the duration and make other changes necessary to adapt the action to the new situation (see Article 39) — unless the grant has been terminated (see Article 32). The suspension will be **lifted** with effect from the suspension end date set out in the amendment. This date may be before the date of the submission of the amendment request.

During the suspension, no prefinancing will be paid. Costs incurred or contributions for activities implemented during grant suspension are not eligible (see Article 6.3).

31.2 EU-initiated GA suspension

31.2.1 Conditions

The granting authority may suspend the grant or any part of it, if:

(a) a beneficiary (or a person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) has committed or is suspected of having committed:

(i) substantial errors, irregularities or fraud or

(ii) serious breach of obligations under this Agreement or during its award (including improper implementation of the action, non-compliance with the call conditions,

submission of false information, failure to provide required information, breach of ethics or security rules (if applicable), etc.), or

(b) a beneficiary (or a person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) has committed — in other EU grants awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant

(c) other:

(i) linked action issues: not applicable

(ii) the action has lost its scientific or technological relevance, for EIC Accelerator actions: the action has lost its economic relevance, for challenge-based EIC Pathfinder actions and Horizon Europe Missions: the action has lost its relevance as part of the Portfolio for which it has been initially selected

31.2.2 Procedure

Before suspending the grant, the granting authority will send a **pre-information letter** to the coordinator:

- formally notifying the intention to suspend the grant and the reasons why and
- requesting observations within 30 days of receiving notification.

If the granting authority does not receive observations or decides to pursue the procedure despite the observations it has received, it will confirm the suspension (**confirmation letter**). Otherwise, it will formally notify that the procedure is discontinued.

The suspension will **take effect** the day after the confirmation notification is sent (or on a later date specified in the notification).

Once the conditions for resuming implementation of the action are met, the granting authority will formally notify the coordinator a **lifting of suspension letter**, in which it will set the suspension end date and invite the coordinator to request an amendment of the Agreement to set the resumption date (one day after suspension end date), extend the duration and make other changes necessary to adapt the action to the new situation (see Article 39) — unless the grant has been terminated (see Article 32). The suspension will be **lifted** with effect from the suspension end date set out in the lifting of suspension letter. This date may be before the date on which the letter is sent.

During the suspension, no prefinancing will be paid. Costs incurred or contributions for activities implemented during suspension are not eligible (see Article 6.3).

The beneficiaries may not claim damages due to suspension by the granting authority (see Article 33).

Grant suspension does not affect the granting authority's right to terminate the grant or a beneficiary (see Article 32) or reduce the grant (see Article 28).

ARTICLE 32 — GRANT AGREEMENT OR BENEFICIARY TERMINATION

32.1 Consortium-requested GA termination

32.1.1 Conditions and procedure

The beneficiaries may request the termination of the grant.

The coordinator must submit a request for **amendment** (see Article 39), with:

- the reasons why
- the date the consortium ends work on the action ('end of work date') and
- the date the termination takes effect ('termination date'); this date must be after the date of the submission of the amendment request.

The termination will **take effect** on the termination date specified in the amendment.

If no reasons are given or if the granting authority considers the reasons do not justify termination, it may consider the grant terminated improperly.

32.1.2 Effects

The coordinator must — within 60 days from when termination takes effect — submit a **periodic report** (for the open reporting period until termination).

The granting authority will calculate the final grant amount and final payment on the basis of the report submitted and taking into account the costs incurred and contributions for activities implemented before the end of work date (see Article 22). Costs relating to contracts due for execution only after the end of work are not eligible.

If the granting authority does not receive the report within the deadline, only costs and contributions which are included in an approved periodic report will be taken into account (no costs/contributions if no periodic report was ever approved).

Improper termination may lead to a grant reduction (see Article 28).

After termination, the beneficiaries' obligations (in particular Articles 13 (confidentiality and security), 16 (IPR), 17 (communication, dissemination and visibility), 21 (reporting), 25 (checks, reviews, audits and investigations), 26 (impact evaluation), 27 (rejections), 28 (grant reduction) and 42 (assignment of claims)) continue to apply.

32.2 Consortium-requested beneficiary termination

32.2.1 Conditions and procedure

The coordinator may request the termination of the participation of one or more beneficiaries, on request of the beneficiary concerned or on behalf of the other beneficiaries.

The coordinator must submit a request for **amendment** (see Article 39), with:

- the reasons why
- the opinion of the beneficiary concerned (or proof that this opinion has been requested in writing)

- the date the beneficiary ends work on the action ('end of work date')

- the date the termination takes effect ('termination date'); this date must be after the date of the submission of the amendment request.

If the termination concerns the coordinator and is done without its agreement, the amendment request must be submitted by another beneficiary (acting on behalf of the consortium).

The termination will **take effect** on the termination date specified in the amendment.

If no information is given or if the granting authority considers that the reasons do not justify termination, it may consider the beneficiary to have been terminated improperly.

32.2.2 Effects

The coordinator must — within 60 days from when termination takes effect — submit:

(i) a **report on the distribution of payments** to the beneficiary concerned

(ii) a **termination report** from the beneficiary concerned, for the open reporting period until termination, containing an overview of the progress of the work, the financial statement, the explanation on the use of resources, and, if applicable, the certificate on the financial statement (CFS; see Articles 21 and 24.2 and Data Sheet, Point 4.3)

(iii) a second **request for amendment** (see Article 39) with other amendments needed (e.g. reallocation of the tasks and the estimated budget of the terminated beneficiary; addition of a new beneficiary to replace the terminated beneficiary; change of coordinator, etc.).

The granting authority will calculate the amount due to the beneficiary on the basis of the report submitted and taking into account the costs incurred and contributions for activities implemented before the end of work date (see Article 22). Costs relating to contracts due for execution only after the end of work are not eligible.

The information in the termination report must also be included in the periodic report for the next reporting period (see Article 21).

If the granting authority does not receive the termination report within the deadline, only costs and contributions which are included in an approved periodic report will be taken into account (no costs/ contributions if no periodic report was ever approved).

If the granting authority does not receive the report on the distribution of payments within the deadline, it will consider that:

- the coordinator did not distribute any payment to the beneficiary concerned and that

- the beneficiary concerned must not repay any amount to the coordinator.

If the second request for amendment is accepted by the granting authority, the Agreement is **amended** to introduce the necessary changes (see Article 39).

If the second request for amendment is rejected by the granting authority (because it calls into question the decision awarding the grant or breaches the principle of equal treatment of applicants), the grant may be terminated (see Article 32).

Improper termination may lead to a reduction of the grant (see Article 31) or grant termination (see Article 32).

After termination, the concerned beneficiary's obligations (in particular Articles 13 (confidentiality and security), 16 (IPR), 17 (communication, dissemination and visibility), 21 (reporting), 25 (checks, reviews, audits and investigations), 26 (impact evaluation), 27 (rejections), 28 (grant reduction) and 42 (assignment of claims)) continue to apply.

32.3 EU-initiated GA or beneficiary termination

32.3.1 Conditions

The granting authority may terminate the grant or the participation of one or more beneficiaries, if:

(a) one or more beneficiaries do not accede to the Agreement (see Article 40)

(b) a change to the action or the legal, financial, technical, organisational or ownership situation of a beneficiary is likely to substantially affect the implementation of the action or calls into question the decision to award the grant (including changes linked to one of the exclusion grounds listed in the declaration of honour)

(c) following termination of one or more beneficiaries, the necessary changes to the Agreement (and their impact on the action) would call into question the decision awarding the grant or breach the principle of equal treatment of applicants

(d) implementation of the action has become impossible or the changes necessary for its continuation would call into question the decision awarding the grant or breach the principle of equal treatment of applicants

(e) a beneficiary (or person with unlimited liability for its debts) is subject to bankruptcy proceedings or similar (including insolvency, winding-up, administration by a liquidator or court, arrangement with creditors, suspension of business activities, etc.)

(f) a beneficiary (or person with unlimited liability for its debts) is in breach of social security or tax obligations

(g) a beneficiary (or person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) has been found guilty of grave professional misconduct

(h) a beneficiary (or person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) has committed fraud, corruption, or is involved in a criminal organisation, money laundering, terrorism-related crimes (including terrorism financing), child labour or human trafficking

(i) a beneficiary (or person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) was created under a different jurisdiction with the intent to circumvent fiscal, social or other legal obligations in the country of origin (or created another entity with this purpose)

(j) a beneficiary (or person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) has committed:

(i) substantial errors, irregularities or fraud or

(ii) serious breach of obligations under this Agreement or during its award (including improper implementation of the action, non-compliance with the call conditions, submission of false information, failure to provide required information, breach of ethics or security rules (if applicable), etc.)

(k) a beneficiary (or person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) has committed — in other EU grants awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant (extension of findings from other grants to this grant; see Article 25)

(l) despite a specific request by the granting authority, a beneficiary does not request — through the coordinator — an amendment to the Agreement to end the participation of one of its affiliated entities or associated partners that is in one of the situations under points (d), (f), (e), (g), (h), (i) or (j) and to reallocate its tasks, or

(m) other:

(i) linked action issues: not applicable

(ii) the action has lost its scientific or technological relevance, for EIC Accelerator actions: the action has lost its economic relevance, for challenge-based EIC Pathfinder actions and Horizon Europe Missions: the action has lost its relevance as part of the Portfolio for which it has been initially selected

32.3.2 Procedure

Before terminating the grant or participation of one or more beneficiaries, the granting authority will send **a pre-information letter** to the coordinator or beneficiary concerned:

- formally notifying the intention to terminate and the reasons why and
- requesting observations within 30 days of receiving notification.

If the granting authority does not receive observations or decides to pursue the procedure despite the observations it has received, it will confirm the termination and the date it will take effect (**confirmation letter**). Otherwise, it will formally notify that the procedure is discontinued.

For beneficiary terminations, the granting authority will — at the end of the procedure — also inform the coordinator.

The termination will **take effect** the day after the confirmation notification is sent (or on a later date specified in the notification; 'termination date').

32.3.3 Effects

(a) for **GA termination**:

The coordinator must — within 60 days from when termination takes effect — submit a **periodic report** (for the last open reporting period until termination).

The granting authority will calculate the final grant amount and final payment on the basis of the report submitted and taking into account the costs incurred and contributions for activities implemented before termination takes effect (see Article 22). Costs relating to contracts due for execution only after termination are not eligible.

If the grant is terminated for breach of the obligation to submit reports, the coordinator may not submit any report after termination.

If the granting authority does not receive the report within the deadline, only costs and contributions which are included in an approved periodic report will be taken into account (no costs/contributions if no periodic report was ever approved).

Termination does not affect the granting authority's right to reduce the grant (see Article 28) or to impose administrative sanctions (see Article 34).

The beneficiaries may not claim damages due to termination by the granting authority (see Article 33).

After termination, the beneficiaries' obligations (in particular Articles 13 (confidentiality and security), 16 (IPR), 17 (communication, dissemination and visibility), 21 (reporting), 25 (checks, reviews, audits and investigations), 26 (impact evaluation), 27 (rejections), 28 (grant reduction) and 42 (assignment of claims)) continue to apply.

(b) for **beneficiary termination**:

The coordinator must — within 60 days from when termination takes effect — submit:

(i) a **report on the distribution of payments** to the beneficiary concerned

(ii) a **termination report** from the beneficiary concerned, for the open reporting period until termination, containing an overview of the progress of the work, the financial statement, the explanation on the use of resources, and, if applicable, the certificate on the financial statement (CFS; see Articles 21 and 24.2 and Data Sheet, Point 4.3)

(iii) a **request for amendment** (see Article 39) with any amendments needed (e.g. reallocation of the tasks and the estimated budget of the terminated beneficiary; addition of a new beneficiary to replace the terminated beneficiary; change of coordinator, etc.).

The granting authority will calculate the amount due to the beneficiary on the basis of the report submitted and taking into account the costs incurred and contributions for activities implemented before termination takes effect (see Article 22). Costs relating to contracts due for execution only after termination are not eligible.

The information in the termination report must also be included in the periodic report for the next reporting period (see Article 21).

If the granting authority does not receive the termination report within the deadline, only costs and contributions included in an approved periodic report will be taken into account (no costs/contributions if no periodic report was ever approved).

If the granting authority does not receive the report on the distribution of payments within the deadline, it will consider that:

- the coordinator did not distribute any payment to the beneficiary concerned and that
- the beneficiary concerned must not repay any amount to the coordinator.

If the request for amendment is accepted by the granting authority, the Agreement is **amended** to introduce the necessary changes (see Article 39).

If the request for amendment is rejected by the granting authority (because it calls into question the decision awarding the grant or breaches the principle of equal treatment of applicants), the grant may be terminated (see Article 32).

After termination, the concerned beneficiary's obligations (in particular Articles 13 (confidentiality and security), 16 (IPR), 17 (communication, dissemination and visibility), 21 (reporting), 25 (checks, reviews, audits and investigations), 26 (impact evaluation), 27 (rejections), 28 (grant reduction) and 42 (assignment of claims)) continue to apply.

SECTION 3 OTHER CONSEQUENCES: DAMAGES AND ADMINISTRATIVE SANCTIONS

ARTICLE 33 — DAMAGES

33.1 Liability of the granting authority

The granting authority cannot be held liable for any damage caused to the beneficiaries or to third parties as a consequence of the implementation of the Agreement, including for gross negligence.

The granting authority cannot be held liable for any damage caused by any of the beneficiaries or other participants involved in the action, as a consequence of the implementation of the Agreement.

33.2 Liability of the beneficiaries

The beneficiaries must compensate the granting authority for any damage it sustains as a result of the implementation of the action or because the action was not implemented in full compliance with the Agreement, provided that it was caused by gross negligence or wilful act.

The liability does not extend to indirect or consequential losses or similar damage (such as loss of profit, loss of revenue or loss of contracts), provided such damage was not caused by wilful act or by a breach of confidentiality.

ARTICLE 34 — ADMINISTRATIVE SANCTIONS AND OTHER MEASURES

Nothing in this Agreement may be construed as preventing the adoption of administrative sanctions (i.e. exclusion from EU award procedures and/or financial penalties) or other public law measures, in addition or as an alternative to the contractual measures provided under this Agreement (see,

for instance, Articles 135 to 145 EU Financial Regulation 2018/1046 and Articles 4 and 7 of Regulation 2988/95[21]).

SECTION 4 FORCE MAJEURE

ARTICLE 35 — FORCE MAJEURE

A party prevented by force majeure from fulfilling its obligations under the Agreement cannot be considered in breach of them.

'Force majeure' means any situation or event that:

- prevents either party from fulfilling their obligations under the Agreement,
- was unforeseeable, exceptional situation and beyond the parties' control,
- was not due to error or negligence on their part (or on the part of other participants involved in the action), and
- proves to be inevitable in spite of exercising all due diligence.

Any situation constituting force majeure must be formally notified to the other party without delay, stating the nature, likely duration and foreseeable effects.

The parties must immediately take all the necessary steps to limit any damage due to force majeure and do their best to resume implementation of the action as soon as possible.

CHAPTER 6 FINAL PROVISIONS

ARTICLE 36 — COMMUNICATION BETWEEN THE PARTIES

36.1 Forms and means of communication — Electronic management

EU grants are managed fully electronically through the EU Funding & Tenders Portal ('Portal').

All communications must be made electronically through the Portal, in accordance with the Portal Terms and Conditions and using the forms and templates provided there (except if explicitly instructed otherwise by the granting authority).

Communications must be made in writing and clearly identify the grant agreement (project number and acronym).

Communications must be made by persons authorised according to the Portal Terms and Conditions. For naming the authorised persons, each beneficiary must have designated — before the signature of this Agreement — a 'legal entity appointed representative (LEAR)'. The role and tasks of the LEAR are stipulated in their appointment letter (see Portal Terms and Conditions).

[21] Council Regulation (EC, Euratom) No 2988/95 of 18 December 1995 on the protection of the European Communities financial interests (OJ L 312, 23.12.1995, p. 1).

If the electronic exchange system is temporarily unavailable, instructions will be given on the Portal.

36.2 Date of communication

The sending date for communications made through the Portal will be the date and time of sending, as indicated by the time logs.

The receiving date for communications made through the Portal will be the date and time the communication is accessed, as indicated by the time logs. Formal notifications that have not been accessed within 10 days after sending, will be considered to have been accessed (see Portal Terms and Conditions).

If a communication is exceptionally made on paper (by e-mail or postal service), general principles apply (i.e. date of sending/receipt). Formal notifications by registered post with proof of delivery will be considered to have been received either on the delivery date registered by the postal service or the deadline for collection at the post office.

If the electronic exchange system is temporarily unavailable, the sending party cannot be considered in breach of its obligation to send a communication within a specified deadline.

36.3 Addresses for communication

The Portal can be accessed via the Europa website.

The address for paper communications to the granting authority (if exceptionally allowed) is the official mailing address indicated on its website.

For beneficiaries, it is the legal address specified in the Portal Participant Register.

ARTICLE 37 — INTERPRETATION OF THE AGREEMENT

The provisions in the Data Sheet take precedence over the rest of the Terms and Conditions of the Agreement.

Annex 5 takes precedence over the Terms and Conditions; the Terms and Conditions take precedence over the Annexes other than Annex 5.

Annex 2 takes precedence over Annex 1.

ARTICLE 38 — CALCULATION OF PERIODS AND DEADLINES

In accordance with Regulation No 1182/71[22], periods expressed in days, months or years are calculated from the moment the triggering event occurs.

The day during which that event occurs is not considered as falling within the period.

'Days' means calendar days, not working days.

ARTICLE 39 — AMENDMENTS

[22] Regulation (EEC, Euratom) No 1182/71 of the Council of 3 June 1971 determining the rules applicable to periods, dates and time-limits (OJ L 124, 8/6/1971, p. 1).

39.1 Conditions

The Agreement may be amended, unless the amendment entails changes to the Agreement which would call into question the decision awarding the grant or breach the principle of equal treatment of applicants.

Amendments may be requested by any of the parties.

39.2 Procedure

The party requesting an amendment must submit a request for amendment signed directly in the Portal Amendment tool.

The coordinator submits and receives requests for amendment on behalf of the beneficiaries (see Annex 3). If a change of coordinator is requested without its agreement, the submission must be done by another beneficiary (acting on behalf of the other beneficiaries).

The request for amendment must include:

- the reasons why
- the appropriate supporting documents and
- for a change of coordinator without its agreement: the opinion of the coordinator (or proof that this opinion has been requested in writing).

The granting authority may request additional information.

If the party receiving the request agrees, it must sign the amendment in the tool within 45 days of receiving notification (or any additional information the granting authority has requested). If it does not agree, it must formally notify its disagreement within the same deadline. The deadline may be extended, if necessary for the assessment of the request. If no notification is received within the deadline, the request is considered to have been rejected.

An amendment **enters into force** on the day of the signature of the receiving party.

An amendment **takes effect** on the date of entry into force or other date specified in the amendment.

ARTICLE 40 — ACCESSION AND ADDITION OF NEW BENEFICIARIES

40.1 Accession of the beneficiaries mentioned in the Preamble

The beneficiaries which are not coordinator must accede to the grant by signing the accession form (see Annex 3) directly in the Portal Grant Preparation tool, within 30 days after the entry into force of the Agreement (see Article 44).

They will assume the rights and obligations under the Agreement with effect from the date of its entry into force (see Article 44).

If a beneficiary does not accede to the grant within the above deadline, the coordinator must — within 30 days — request an amendment (see Article 39) to terminate the beneficiary and make any changes

necessary to ensure proper implementation of the action. This does not affect the granting authority's right to terminate the grant (see Article 32).

40.2 Addition of new beneficiaries

In justified cases, the beneficiaries may request the addition of a new beneficiary.

For this purpose, the coordinator must submit a request for amendment in accordance with Article 39. It must include an accession form (see Annex 3) signed by the new beneficiary directly in the Portal Amendment tool.

New beneficiaries will assume the rights and obligations under the Agreement with effect from the date of their accession specified in the accession form (see Annex 3).

Additions are also possible in mono-beneficiary grants.

ARTICLE 41 — TRANSFER OF THE AGREEMENT

In justified cases, the beneficiary of a mono-beneficiary grant may request the transfer of the grant to a new beneficiary, provided that this would not call into question the decision awarding the grant or breach the principle of equal treatment of applicants.

The beneficiary must submit a request for **amendment** (see Article 39), with

- the reasons why
- the accession form (see Annex 3) signed by the new beneficiary directly in the Portal Amendment tool and
- additional supporting documents (if required by the granting authority).

The new beneficiary will assume the rights and obligations under the Agreement with effect from the date of accession specified in the accession form (see Annex 3).

ARTICLE 42 — ASSIGNMENTS OF CLAIMS FOR PAYMENT AGAINST THE GRANTING AUTHORITY

The beneficiaries may not assign any of their claims for payment against the granting authority to any third party, except if expressly approved in writing by the granting authority on the basis of a reasoned, written request by the coordinator (on behalf of the beneficiary concerned).

If the granting authority has not accepted the assignment or if the terms of it are not observed, the assignment will have no effect on it.

In no circumstances will an assignment release the beneficiaries from their obligations towards the granting authority.

ARTICLE 43 — APPLICABLE LAW AND SETTLEMENT OF DISPUTES

43.1 Applicable law

The Agreement is governed by the applicable EU law, supplemented if necessary by the law of Belgium.

Special rules may apply for beneficiaries which are international organisations (if any; see Data Sheet, Point 5).

43.2 Dispute settlement

If a dispute concerns the interpretation, application or validity of the Agreement, the parties must bring action before the EU General Court — or, on appeal, the EU Court of Justice — under Article 272 of the Treaty on the Functioning of the EU (TFEU).

For non-EU beneficiaries (if any), such disputes must be brought before the courts of Brussels, Belgium — unless an international agreement provides for the enforceability of EU court judgements.

For beneficiaries with arbitration as special dispute settlement forum (if any; see Data Sheet, Point 5), the dispute will — in the absence of an amicable settlement — be settled in accordance with the Rules for Arbitration published on the Portal.

If a dispute concerns administrative sanctions, offsetting or an enforceable decision under Article 299 TFEU (see Articles 22 and 34), the beneficiaries must bring action before the General Court — or, on appeal, the Court of Justice — under Article 263 TFEU.

For grants where the granting authority is an EU executive agency (see Preamble), actions against offsetting and enforceable decisions must be brought against the European Commission (not against the granting authority; see also Article 22).

ARTICLE 44 — ENTRY INTO FORCE

The Agreement will enter into force on the day of signature by the granting authority or the coordinator, depending on which is later.

SIGNATURES

For the coordinator

Mike Lamont with ECAS id n003m7pt signed in the Participant Portal on 23/02/2023 at 07:52:25 (transaction id SigId-47972-fqYYrkwk3KYrzaLp9i1hnKAzXFtpNIu8FwDqME4JqoNanbGDL86CwxXkEHU0NVGVAhC9UYs5krzb1rJi9jDLu1m-jpJZscgsw0KcAcndKkXAma-TjzTHbLcTkrkzbIPdkJnC4hSiOrGW3ouZCMa2aO43RZghvdUUhNfzQ1KwYGb51HSA8LQ8GfI5aBMuMVNvtyPTAG). Timestamp by third party at 2023.02.23 07:52:32 CET

For the granting authority

Signed by Sari VARTIAINEN-MATHIEU with ECAS id vartisi as an authorised representative on 23-02-2023 12:17:00 (transaction id SigId-52585-kNPUuQSzJQyfUhAAZ05zhozMZVoadyFGfJGmWVinTzOHvPcKVhbGuHDU2zQUXPfzXCS92lwq8ubzsuo9cJBbOPJC-jpJZscgsw0KcAcndKkXAma-9EpM0OXgSNQX8fQHAymW0BydcQ4ceM4pVD7TaZDvCruC3hx8IHYShMhnjwBRRNsMSiRYECQOqqGA4nDmhh0D90)
2023.02.23 12:17:04 CET

ANNEX 1

Horizon Europe (HORIZON)

Description of the action (DoA)

Part A

Part B

DESCRIPTION OF THE ACTION (PART A)

COVER PAGE

Part A of the Description of the Action (DoA) must be completed directly on the Portal Grant Preparation screens.

PROJECT *Grant Preparation (General Information screen) — Enter the info.*	
Project number:	101094300
Project name:	A Design Study for a Muon Collider complex at 10+ TeV center of mass
Project acronym:	MuCol
Call:	HORIZON-INFRA-2022-DEV-01
Topic:	HORIZON-INFRA-2022-DEV-01-01
Type of action:	HORIZON-RIA
Service:	REA/C/04
Project starting date:	fixed date: 1 March 2023
Project duration:	48 months

TABLE OF CONTENTS

PROJECT SUMMARY

Project summary

Grant Preparation (General Information screen) — Provide an overall description of your project (including context and overall objectives, planned activities and main achievements, and expected results and impacts (on target groups, change procedures, capacities, innovation etc)). This summary should give readers a clear idea of what your project is about.

Use the project summary from your proposal.

Two facility concepts have been considered as potential pathways to the future of particle physics at the energy frontier in Europe: FCC-hh, a 100 TeV circular hadron collider and CLIC, a 3 TeV linear lepton (i.e. electron-positron) collider. The recent European Accelerator R&D Roadmap includes a novel option, a 10 or more TeV muon collider, which expands the lepton collider energy reach and promises compact dimensions, high efficiency and limited cost.
Muons are point-like particles, in contrast to hadrons; a 10 TeV muon collider would have a comparable physics case, for a number of physics processes, to a 100 TeV hadron collider.
The muon collider promises high benefit but also faces a significant risk, as it is the first of its kind and uses novel advanced technologies.
The MuCol design study will address the core challenges identified in the Roadmap, develop the concept and technologies and demonstrate:
• the physics case of the muon collider is sound and detector systems can yield sufficient resolution and rejection of backgrounds;
• no principle technological issues will prevent the achievement of a satisfactory performance of the accelerator or the detectors;
• the muon collider provides a highly sustainable energy frontier facility compared to other equivalent colliders; and
• exploiting synergies with other scientific and industrial R&D projects, can provide Europe a leading edge in discovery potential and development of associated technologies.
The final report will include a thorough assessment of benefits and risks of the accelerator and detector complex, including an evaluation of the scientific, industrial and societal return beyond high-energy physics, the cost scale and sustainability of the complex and the impact arising from an implementation on the CERN site. This will allow the next European Strategy for Particle Physics Update (ESPPU) process to make informed choices for the selection of the next large collider to be built in Europe.

LIST OF PARTICIPANTS

PARTICIPANTS

Grant Preparation (Beneficiaries screen) — Enter the info.

Number	Role	Short name	Legal name	Country	PIC
1	COO	CERN	ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE	CH	999988133
2	BEN	DESY	DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY	DE	999986969
3	BEN	TUDA	TECHNISCHE UNIVERSITAT DARMSTADT	DE	999986581
4	BEN	UROS	UNIVERSITAET ROSTOCK	DE	999852430
5	BEN	CEA	COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	FR	999992401
6	BEN	INFN	ISTITUTO NAZIONALE DI FISICA NUCLEARE	IT	999992789
7	BEN	UMIL	UNIVERSITA DEGLI STUDI DI MILANO	IT	999995796

PARTICIPANTS

Grant Preparation (Beneficiaries screen) — Enter the info.

Number	Role	Short name	Legal name	Country	PIC
8	BEN	UNIPD	UNIVERSITA DEGLI STUDI DI PADOVA	IT	999995602
9	BEN	UTWENTE	UNIVERSITEIT TWENTE	NL	999900833
10	BEN	LIP	LABORATORIO DE INSTRUMENTACAO E FISICA EXPERIMENTAL DE PARTICULAS LIP	PT	999661534
11	BEN	ESS	EUROPEAN SPALLATION SOURCE ERIC	SE	919998053
12	BEN	UU	UPPSALA UNIVERSITET	SE	999985029
13	AP	PSI	PAUL SCHERRER INSTITUT	CH	999994923
14	AP	UNIGE	UNIVERSITE DE GENEVE	CH	999974650
15	AP	Imperial	IMPERIAL COLLEGE OF SCIENCE TECHNOLOGY AND MEDICINE	UK	999993468
16	AP	UKRI	UNITED KINGDOM RESEARCH AND INNOVATION	UK	906446474
17	AP	UWAR	THE UNIVERSITY OF WARWICK	UK	999976784
18	AP	ULA	UNIVERSITY OF LANCASTER	UK	999840984
19	AP	SOTON	UNIVERSITY OF SOUTHAMPTON	UK	999975329
20	AP	UOS	THE UNIVERSITY OF SUSSEX	UK	999852721
21	AP	SYSU	SUN YAT-SEN UNIVERSITY	CN	999870860
22	AP	KIT	KARLSRUHER INSTITUT FUER TECHNOLOGIE	DE	990797674
23	AP	CNRS	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	FR	999997930
24	AP	ENEA	AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE	IT	999988521
25	AP	UNIBO	ALMA MATER STUDIORUM - UNIVERSITA DI BOLOGNA	IT	999993953
26	AP	UNIPV	UNIVERSITA DEGLI STUDI DI PAVIA	IT	999893752
27	AP	STRATHCLYDE	UNIVERSITY OF STRATHCLYDE	UK	999974068
28	AP	HUD	UNIVERSITY OF HUDDERSFIELD	UK	999452208
29	AP	RHUL	ROYAL HOLLOWAY AND BEDFORD NEW COLLEGE	UK	999861451
30	AP	UOXF	THE CHANCELLOR, MASTERS AND SCHOLARS OF THE UNIVERSITY OF OXFORD	UK	999984350
31	AP	ISU	IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY	US	998804733
32	AP	BNL	BROOKHAVEN SCIENCE ASSOCIATES LLC	US	983190061

LIST OF WORK PACKAGES

Work packages

Grant Preparation (Work Packages screen) — Enter the info.

Work Package No	Work Package name	Lead Beneficiary	Effort (Person-Months)	Start Month	End Month	Deliverables
WP1	Coordination and Communication	1 - CERN	0.10	1	48	D1.1 – Data-management plan D1.2 – Preliminary ESPPU report No. 1 D1.3 – Preliminary ESPPU report No. 2 D1.4 – Intermediate ESPPU report D1.5 – Consolidated ESPPU report
WP2	Physics and Detector Requirements	8 - UNIPD	84.00	1	48	D2.1 – Beam-induced background and detector configuration D2.2 – Detector performance by using physics processes
WP3	Proton Complex	11 - ESS	26.00	1	48	D3.1 – Final report on parameters and initial study for the Proton Complex
WP4	Muon Production & cooling	16 - UKRI	72.10	1	48	D4.1 – Development of BDSIM simulation D4.2 – Preliminary Report on key subsystems for ESPPU input D4.3 – Consolidated Report on key subsystems
WP5	High Energy Complex	5 - CEA	36.00	1	48	D5.1 – Report on the collider ring design D5.2 – Report on the design of the HEC
WP6	RadioFrequency Systems	5 - CEA	106.00	1	48	D6.1 – Report on design of high power and high efficiency RF power sources D6.2 – Report on RF for MCC and HEC
WP7	Magnet Systems	1 - CERN	189.00	1	48	D7.1 – Preliminary report on muon collider magnets

Work packages

Grant Preparation (Work Packages screen) — Enter the info.

Work Package No	Work Package name	Lead Beneficiary	Effort (Person-Months)	Start Month	End Month	Deliverables
						D7.2 – Consolidated report on muon collider magnets
WP8	Cooling cell Integration	7 - UMIL	62.00	1	48	D8.1 – Presentation of cooling cell conceptual design D8.2 – Final report on cooling cell design

Associated with document Ref. Ares(2023)1315812 - 22/02/2023

Work package WP1 – Coordination and Communication

Work Package Number	WP1	Lead Beneficiary	1. CERN
Work Package Name	Coordination and Communication		
Start Month	1	End Month	48

Objectives

WP1 will coordinate both the scientific and administrative tasks of MuCol. All participants will participate to the decision making through the Collaboration Board.

The objectives of WP1 are:

Provide scientific coordination of the work
Setup and ensure a quality assurance process for peer review of all the results
Provide technical coordination
Ensure compliance with requirements from EU rules for the project (financial reporting, notification of the achievement of milestones and deliverables etc…)
Organisation of Collaboration meetings and workshops, harmonization of events across the workpackages
Editing of common reports, ensuring the respect of deadlines for deliverables and milestones
Coordination of Communication and Dissemination activities
Monitoring of gender dimension issues

Description

CERN will coordinate WP1 and provide the Study Leader (SL) and the Technical Coordinator. The SL will propose a Deputy from the researchers of the Consortium for appointment by the Governing Board. All Institutes, both Beneficiaries and Associates, will contribute to this workpackage with participation to the relevant committees and Boards, and by providing candidates for transversal roles, such as Gender Advisor and Communication and Dissemination Officer. The resources are coming from own resources of each Institute, not claimed to EU.

Task 1.1 Study Coordination (CERN)
This task will ensure a coherent development of the design and parameters. It will ensure the implementation of the workprogramme, coordinate the scope of the project and propose design choices; it will organise the Governing Board and Advisory Committee meetings in collaboration with the respective chairs. It will ensure the integration of the effort within the international collaboration established at CERN and provide a link to other bodies.

Task 1.2 Technical Coordination (CERN)
The Technical Coordinator will ensure the timely delivery of milestones and deliverables. It will prepare the periodic and final reports as well as follow the use of resources. CERN will also establish an infrastructure to store the relevant project data, in particular parameters, specifications and layouts and make them available to all partners and the IMCC. The Technical Coordinator will also coordinate the establishment and follow-up of the Data Management Plan and ensure the monitoring of the gender dimension issues with the help of the Gender Advisor.

Task 1.3 Quality Management (CERN)
The task will implement a peer-review process for the publications of results and make reports available.

Task 1.4 Communication and Dissemination(CERN, INFN)
CERN and INFN will ensure the communication of scientific results to relevant communities and scientific committees, as well as funding agencies. Also, it will organize and streamline the dissemination to general public. It will be led by the Communication and Dissemination Officer. The task will organize , with support from all the WPs, a session on synergies with other fields, and dedicated topical workshops if the opportunity arises.

Task 1.5 Implementation Scenarios (CERN)
CERN will develop a scenario towards the construction of a muon collider. It will identify the main cost and power consumption drivers to determine the cost and power-consumption scales of the collider. It will assess the impact on the environment and the constraints for an implementation at CERN. The reuse of existing infrastructure will be considered.

Associated with document Ref. Ares(2023)1315812 - 22/02/2023

Work package WP2 – Physics and Detector Requirements

Work Package Number	WP2	Lead Beneficiary	8. UNIPD
Work Package Name	Physics and Detector Requirements		
Start Month	1	End Month	48

Objectives
WP2 will study the beam-induced background effects on the detector with different interaction region design to define its optimal configuration which will include the shielding. Event reconstruction algorithms will be developed to exploit 5D information in order to additionally mitigate the beam-induced background effects, in particular the irreducible part. The last objective is the detector performance evaluation by using the most relevant SM measurements and New Physics reaches.

Description
WP2 will be coordinated by UNIPD, with the participation of INFN, CEA, DESY, UOS, LIP, CERN, ISU, SYSU, UNIPV. Task 2.1 Design of detector configurations at √s=3 TeV and √s=10 TeV with the optimised interaction regions (UNIPD,) This task will study the beam-induced background effects on the detector components produced with different interaction region configurations. Feedbacks will be given to WP5, high energy complex , where the IR is designed to optimise background fluxes and the shielding configuration. This will be done in an iterative way until an optimised IR is defined and the relative detector configuration proposed. Task 2.2 Design and implementation of event reconstruction algorithms in 5D at √s=3 TeV and √s=10 TeV (DESY) This task will focus on developing reconstruction algorithms exploiting 3D position, energy, and timing measurements to mitigate beam-induced background and perform tracking and calorimetry clustering. Leveraging on the developments made for future colliders, this task will explore machine learning solutions and parallel computing, both for real-time event processing and for offline analysis, taking into account the specific challenges of a muon collider (e.g., particle tracking in the forward region). Task 2.3 Evaluate detector performance at different collision energies by using major physics processes (INFN) This task will explore the detector performance of a muon collider operating at different collision energies. Exploiting an optimal design of the interaction region (Task1) and advances in event reconstruction (Task2), the detector performance will be determined by evaluating the reach of major physics processes for Standard Model measurements, and for searches for physics beyond the Standard Model.

Work package WP3 – Proton Complex

Work Package Number	WP3	Lead Beneficiary	11. ESS
Work Package Name	Proton Complex		
Start Month	1	End Month	48

Objectives
This work package aims to define the most promising scheme for the linac, accumulator and compressor rings and prepare a comprehensive summary of the current technology and possible R&D topics of importance for the proton complex. A self-consistent parameter set will be developed to determine the input beam conditions for the muon complex, based on known technological limitations.

Description
ESS will coordinate the Workpackage, and will provide the overall coordination of the activity and the communication

of its results. It will monitor work progress and inform the project management and work package participants (UU and CERN), monitor the WP budget and use of resources and prepare internal and deliverable reports.

Task 3.1 – High power linac (CERN)
The goal of this task is to collect the parameters that can be used for a future design of a high-power H- Linac to be used as the driver of the proton complex. This collection will be based on inputs from ESS and the SPL/LINAC4 designs and may include: source type, preliminary acceleration layout, beam dynamics and stability considerations and chopping schemes. Consideration will be given of the need for additional acceleration after the linac in order to reach the required beam power. The parameters will be used to provide input on final beam parameters for task 3.2. CERN will be leader of this task bringing its experience in the design of the CERN LINAC4 and SPL and H- sources. ESS will bring expertise in high power hadron linac design.

Task 3.2 – Compressor ring design (ESS)
The goal of this task is to provide a self-consistent collection of parameters to be used in the design of a future compressor ring. The ring will create the high intensity short bunches that will be delivered to the target for muon production. With the input of WP4 (target and cooling) and task 3.1, a set of beam parameters will be defined. A preliminary design of the rings will be developed including accumulation and compression strategy, preliminary lattice and injection and extraction considerations. Further R&D needs will be outlined and eventually beam measurements at CERN or other facilities might be proposed. Preliminary study of intensity-based effects such as space charge, single-bunch and impedance effects will be carried out for the compressor ring. ESS will lead this task and bring expertise in lattice design and beam dynamics. UU will bring expertise in lattice design and RF. CERN will provide further lattice design expertise. ESS will hire a postdoc for this task and share the supervision with UU.

Work package WP4 – Muon Production & cooling

Work Package Number	WP4	**Lead Beneficiary**	16. UKRI
Work Package Name	Muon Production & cooling		
Start Month	1	**End Month**	48

Objectives
The muon cooling work package aims to establish a baseline for the muon target and cooling system in the light of known technological limits and identify areas where further R&D is required to deliver a satisfactory system conceptual design.

Description
The target and ionisation cooling work package will develop the muon source from the proton target through to the beginning of the acceleration system. A principle challenge for the muon collider is to deliver a beam having suitable luminosity so that the probability of a collision at the detector is significant. This WP will study the specific issues generated by the impact of a high brightness proton beam ona solid, liquid or fluidised powder target. It will then advance the understanding of the Ionisation cooling technique, whose principle has been recently demonstrated by the Muon Ionisation Cooling Experiment (MICE) collaboration, and design a configuration capable of delivering a muon beam compressed into a minimum phase-speace volume, such as to satisfy the requirements in terms of luminosity production at the experiements. WP4 will explore the technologies necessary to cool the beam in collaboration with WP6, WP7 and WP8, and will provide specificatins and input to WP3 and WP5. This WP will be led by UKRI, that will bring in its experience gained within the MICE collaboration. Other participants are Imperial, UWAR, CERN, INFN, UMIL, ENEA. Task 4.1 Cooling system development (UKRI) The cooling system uses a system of magnets, RF cavities and energy absorbing materials, to compress the beam both transverse and parallel to the direction of travel of the muon beam. This key system has to deliver a compression in the phase-space volume occupied by the beam by five orders of magnitude. A preliminary design for such a cooling system was developed within the MAP, assuming solenoids limited to 13 T and RF cavities limited to 30 MV/m. Subsequent experimental work demonstrated RF cavities having fields up to 50 MV/m, while exposed to significant magnetic fields. In collaboration with WP6 and WP7, the lattice optimisation will be extended to include these new parameter sets. The lattices will be made more realistic, with appropriate consideration of space for alignment equipment, beam instrumentation and due consideration of requirements for the magnet and RF system, also in liaison with WP6 and 7.

The lattices will be assessed for integration into a cooling test, in close collaboration with WP8. Appropriate interfaces with the surrounding accelerator subsystems will be considered.

Task 4.2 Target system development (CERN)
In order to reach high luminosity, a high muon beam current must be delivered into the cooling system. This is achieved by impacting high energy protons onto a target, where pions are created and collected in a high field solenoid or a magnetic horn system. The pions decay to muons and are then delivered into the cooling systems. The proton beam proposed would be one of the highest power proton beams delivered. The proton beam pulse is proposed to be extremely short so that the resultant pion beam is also as short as possible. This would make the instantaneous proton power orders of magnitude higher than the state of the art. In this work package the impact of such a beam on the target systems and supporting infrastructure will be investigated. The pion yield will be assessed. The impact of the beam on target lifetime will be considered and mitigating strategies such as novel target concepts will be assessed. The heat load on the surrounding magnets will be studied and, in close collaboration with the Magnets WP7, the required shielding and associated magnet aperture requirements for the capture of pions will be studied.

Task 4.3 Code development (Imperial)
The BDSIM code has been developed in Europe in order to enable simulation of accelerator equipment in the presence of beam intersecting devices. BDSIM has been used to study several major proposed accelerator facilities including FCC-hh, CLIC and the ILC. BDSIM provides a unique combination of accelerator-style mapping techniques and particle physics-style tracking based on the Geant4 physics library. Previous simulations of ionisation cooling have been performed using G4Beamline, developed in the US. However G4Beamline has not been updated for more than 2 years despite a number of issues in the code. Imperial College, London will develop BDSIM in close collaboration with the BDSIM project leaders at Royal Holloway University of London so that it is fully integrated and capable of delivering simulations of the full cooling system.

Work package WP5 – High Energy Complex

Work Package Number	WP5	**Lead Beneficiary**	5. CEA
Work Package Name	High Energy Complex		
Start Month	1	**End Month**	48

Objectives

WP5 will perform a design of the pulsed synchrotrons of the acceleration complex and will explore an alternative based on fixed-field alternating gradients. Another objective is the design of the collider to get the target luminosity in the interaction region taking into account the limitations due to collective effects, the machine detector interface and the background to experiment. WP5 will optimize the shielding design of the interaction region and magnets to handle the radiation due to muon decay and other beam losses.

Description

CEA will provide the overall coordination of the activity and of the communication of its results. It will monitor work progress and inform the project management and work package participants, monitor the WPbudget and use of resources and prepare internal and deliverable reports. Other Participants are INFN, CERN, HUD, RHLU, BNL.

Task 5.1 Collider design (CERN). This task focuses on study of the feasibility and optimization of the muon collider. The main goal is to develop a credible design concept of the muon collider with a cost estimate. It will develop a consistent lattice for a 3 TeV and 10 TeV com collider. Particular challenges are chromatic effects due to the small beta* and large momentum spread and their correction, control of linear and non-linear momentum compaction to keep small bunch length, acceptable beam induced background levels, control of the neutrino radiation issue, beam operation with moving beam lines and, possibly, non-linear effects.

Task 5.2 Pulsed synchrotron and FFA design (CEA). This task addresses the feasibility and optimization of the muon acceleration complex with upgrade path based on reasonable assumptions on technology development. This task will address two technical solutions: pulsed synchrotrons and FFA. This task will describe the beamline in a parameter table, provide a full set of lattices and have start-2-end tracking to validate luminosity performance, bunch compression and emittance preservation during the acceleration process. CEA will lead this task and perform the design study of

the accelerator complex based on pulsed synchrotrons whereas STFC will focus on FFA. CERN will contribute to the longitudinal dynamics studies and bring expertise in synchrotrons.

Task 5.3 Beam dynamics (CERN). This task focuses on the transverse collective effects all along the muon accelerator chain and in particular, the ones linked to impedances. This task will study impedance effects to check that the very quick acceleration phase is feasible when high-intensity effects taken into account. The detailed proposed work plan is: i) Compute and store the resistive-wall impedance and wakefield. ii) Perform simulations of transverse beam stability assuming with a single bunch and scan the relevant parameters to
set limits on the performance reach. iii) Choose the RF cavity impedance models and extend the previous parameters scan. v) Re-do the same analysis with the 2 counter-rotating bunches. vi) Propose possible mitigation measures and study in particular if pulsed synchrotrons need sextupoles.

Task 5.4 MDI design and background to experiment (CERN). This task will develop a conceptual interaction region design, which integrates a detector shielding together with the detector envelope and the final focus system and incorporates requirements from other activities. It will quantify particle fluxes for different source terms and study the time dependence with respect to the bunch passage: i) muon decay, ii) incoherent electron-positron pair production at the IP, and iii) beam halo losses. This task will optimize the shielding design with respect to different contributions and explore other possible background mitigation techniques on the machine side. It will assess the need of a halo-removal system for background reduction. It will provide estimates of the long-term radiation damage in the detector. CERN will lead this task. INFN and STFC will bring their expertise in machine-detector interface.

Task 5.5 Radiation studies for the accelerators (CERN). This task will address the simulation and mitigation of radiation-related effects including the neutrino hazard. This task will quantify the heat load distribution and long-term radiation damage in superconducting magnets due to muon decay and beam halo losses. It will develop a shielding design for arc magnets, in order to: i) avoid quenches, ii) sustain the thermal load, and iii) prevent magnet failures. This task will quantify the radiation environment in the tunnel and caverns and assess the need of machine protection systems including a beam extraction system and input for a beam loss monitoring system. This task will assess the effect of the lattice design on the neutrino distribution, and perform optimizations. It will refine the dose kernel for assessing the surface dose arising from neutrino-induced particle showers.

Work package WP6 – RadioFrequency Systems

Work Package Number	WP6	**Lead Beneficiary**	5. CEA
Work Package Name	RadioFrequency Systems		
Start Month	1	**End Month**	48

Objectives
The objective of this work package is to assess crucial feasibility issues and technological challenges of the RF systems. The study will concentrate on the two most challenging sections, the Muon Cooling Complex (MCC), and the muon acceleration stage of the High Energy Complex (HEC), for which a baseline concept of most critical RF components will be outlined.

Description
This workpackage will be led by CEA, supported in some tasks by INFN that will provide the deputy WP leader. Apart from the coordination of the work inside the WP, CEA and INFN will ensure proper integration of the work of this work package with the studies done in WP4, WP5 and WP8. Other Participants to this WP are UROS, CERN, ULA, Strathclyde. Task 6.1 Baseline concept of the RF system for acceleration to the High Energy Complex (HEC) (UROS) This task, led by the University of Rostock, aims to provide a preliminary design concept for the SRF cavities for acceleration in the Rapid Cycling Synchrotrons (RCS) of the HEC of the muon collider. For the acceleration stage of the HEC, the short muon lifetime requires the highest possible acceleration rate to reach energy gains on the order of 10 GeV per turn. This is foreseen to be provided with very high voltage SRF cavities. A suitable cavity technology, including the accelerating cavity type and shape, the cavity material, and the main RF frequency, will be determined for this system. Strong transient beam loading effects, as well as strong wake field effects due to the very high intensity

of the muon bunches will also have to be addressed in the cavity optimisation. In cooperation with WP5, a full set of parameters for the RF cavities that address longitudinal beam dynamics and stability will be established (R/Q, Vmax, …) for the fundamental mode and HOMs' suppression. This will provide input specifications for the design concept of the RCSs cavities.

Task 6.2 Baseline concept of the RF system for the Muon Cooling Complex (MCC) (CEA and INFN)
The focus of this task, led in conjunction by CEA and INFN, is to lay out a conceptual design of the RF systems for the MCC, based on a consistent set of parameters for all RF cavities and associated systems to be integrated into the cooling cells of the MCC obtained from inputs given by WP4 and WP8. For the muon cooling section, one challenge already pointed out in the preliminary MAP study, is to achieve gradients of at least 30 MV/m in RF cavities that will be placed in magnetic fields of 13 T, and explore whether it is possible to push these values at the light of the latest developments in RF and magnet technology. At first, specifications for the design of all RF cavities will be collected (frequency, gradient, length, B-field, aperture). Then, based on the guidance given by WP4, full set of parameters for the cavities will be calculated, serving as a base for their conceptual design and integration in the cooling cells. The impact of beam loading on the muon energy spread will also be assessed at this stage and appropriate mitigating actions will be recommended.

Task 6.3 Break down mitigation studies for cavities of the muon cooling cells (CEA)
The goal of this task, led by CEA, is to study and enhance the present comprehension of the intrinsic concepts that influence the break down rate of RF cavities submitted to strong magnetic fields. We plan to extend existing theoretical studies, and with additional inputs from previous experimental studies at CERN for CLIC and FermiLab for MAP, as well as from additional tests performed in the scope of this task, realistic solutions to mitigate the breakdown and provide guidance for the design and the fabrication of high gradient RF cavities that stand strong magnetic fields in the MCC will be proposed.

Task 6.4 Baseline concept of high efficiency and high-power RF sources for the muon collider (ULA)
The aim of this task, led by University of Lancaster, is to provide a baseline concept for the RF sources needed for the muon collider that will require higher RF power than is currently possible with commercially available sources. Recent studies at CERN and Lancaster have shown that using novel two-stage klystrons can significantly increase their efficiency and thus reduce their power consumption. At first, the requirements in terms of frequencies, peak power and efficiency for all RF sources that provide RF to the muon collider cavities will be collected. Then, conceptual studies to improve by design the intrinsic energy efficiency of the most power-demanding RF sources in order to ensure sustainability over the long term will be presented.

Work package WP7 – Magnet Systems

Work Package Number	WP7	**Lead Beneficiary**	1. CERN
Work Package Name	Magnet Systems		
Start Month	1	**End Month**	48

Objectives
The objective of this work package is to address feasibility and technology limits of the magnet and powering systems, assess technology readiness and R&D timeline. The leading topics are: (i) the value of the maximum field and free bore of the solenoids for the target, capture and cooling complex, (ii) the concept and feasibility of the fast accelerator chain, and (iii) design options for the magnets of the collider complex. We address the above topics through a combination of conceptual design work, targeted tests and specific characterization measurements. We also plan to exploit synergies with on-going developments in other fields (high magnetic field science, NMR, fusion) and programs (EU High-Field Magnets R&D, US-MDP).

Description
WP7 will be coordinated by CERN. Other participants are CEA, INFN, SOTON, TUDa, UTWENTE, UMIL, PSI, UNIGE, KIT, CNRS, UNIBO. Task 7.1 Technical Coordination and Integration (CERN) We will establish within this task a magnet catalogue, including a set of target specifications, baseline concepts and technology options, and identification of leading drivers for the power consumption and cost. The catalogue

Associated with document Ref. Ares(2023)1315812 - 22/02/2023

will include the results from the other three tasks in this work package, and will complete it for the whole collider complex. This task also provides the interface for magnet energy deposition and radiation studies, magnet cooling studies, as well as safety and environmental aspects of the magnet system. CERN (Task Leader) will provide the resources and technical support, in collaboration with CEA, polling actively the demands from accelerator physics (WP2, WP3, WP4, WP5, WP8), and interfacing to the other aspects of the study, including the contribution to power and cost model.

Task 7.2 Target, Capture and Cooling Magnets (INFN)
This task covers the conceptual design work required to establish performance limits, assess feasibility, and identify outstanding R&D for the target, capture and final cooling solenoids, in close collaboration with the activities on beam capture and cooling, target and absorber design (WP4), and RF (WP6). Specific focus will be put on (i) the target solenoid, which requires high field (20 T) in a large bore (150 mm), subjected to substantial energy deposition (100 kW) and radiation, and (ii) the final cooling solenoid, where the required
field (40 T minimum to 60 T target) in a small bore (50 mm) is well beyond the present state of the art. The task will maintain a close interface with the engineering design and integration of the solenoid for the test module (WP8). The task provides coordination for a limited Technology Performance Limits (TPL) experimental activity devoted to establishing material and technology limits, towards the identification of priority R&D. The work will be performed by INFN (Task Leader), CEA, CERN, CNRS, KIT, PSI, SOTON, UNIGE and TWENTE, in collaboration with KEK and US-MDP.
PSI involvement: participation in conceptual design, in particular quench protection and mechanics, and experimental activities on intelligent electrical insulation and instrumentation for solenoids for the target and cooling area.
UNIGE involvement: experimental activity on HTS material in support to magnet conceptual design, including tailored experiments to determine the electrical performance at high field and the mechanical limits of commercial conductors.

Task 7.3 Fast Cycled Accelerators (CERN)
The aim of this task is to propose concepts and evaluate realistic performance targets for the fast-ramping accelerators, in close collaboration with beam physics (WP5) and RF (WP6). The main challenge is the management of the large energy stored in the magnet system (of the order of 100 MJ), the power flow required for ramping (in excess of 50 GW reactive power), and the quality of the fast field ramp (0.5 ms for the shortest cycle time). This task includes the integrated development and optimization of concepts for the power storage, conversion and distribution in normal-conducting fast ramping magnets. The focus will be on the present baseline scheme, i.e. a Hybrid Cycled Synchrotron (HCS) consisting of a combination of DC dipoles (superconducting, up to 16 T) and AC dipoles (resistive, bipolar, ± 2 T). Alternative schemes will be considered at the level of conceptual study, and in particular HTS fast ramped magnets, to see whether performance can be improved and consumption reduced. The work will be performed by CERN (Task Leader), CNRS (within the Laboratoire National des Champs Magnétiques Intenses), TUDa, UNIBO and TWENTE, in collaboration with Kyoto University (HTS RCS) that will collaborate externally without formally joining the Consortium.

Task 7.4 Collider Ring Magnets (INFN)
This task aims at assessing realistic performance targets for the large bore (range of 150 mm) collider magnets, in close collaboration with beam optics (WP5), machine-detector interface, and energy deposition studies (WP2). The design activity will be focused on the combined functions dipoles in the arc, 10 to 16 T, which are a good sample of the magnet challenges. The study will consider LTS and HTS materials, adopting a stress management mechanical system, which is an innovative approach for accelerator magnets. We finally plan to address the effects of the expected heat and radiation load, up to 0.5 kW/m linear power density in the coils, considering aspects such as thermal stability, heat removal and radiation-induced damage. The work will be performed by INFN (Task Leader) and UNIMI in collaboration with KEK, PSI and US-MDP.
PSI involvement: sharing of stress managed concepts and technology for the design of collider dipoles.

Work package WP8 – Cooling cell Integration

Work Package Number	WP8	**Lead Beneficiary**	7. UMIL
Work Package Name	Cooling cell Integration		
Start Month	1	**End Month**	48

Objectives
The first objective of this workpackage is to select the technologies that are more suitable for a construction of a cooling cell that will demonstrate the feasibility of the concept including: absorbers that will decrease the emittance in both the longitudinal and transvers plane Superconducting solenoids, to limit the transverse blow-up of the beam. RadioFrequency

Cavities, that will accelerate the beam providing back longitudinal momentum The second objective is to design each component of the cooling cell and integrate them in a single assembly to demonstrate that there is no showstopper for such systems.

Description

This Workpackage will be led by UMIL, that will ensure that the individual designs of each component are performed taking into account the integration within a single mechanical assembly. To this purpose, UMIL will ensure the publication of clear functional specifications and will animate regular meeting among the different Institutes and across the various tasks. UMIL will also coordinate the preparation of reports and communication in general, and liaise with the rest of the project, in particular WP1, WP4, WP6 and WP7.
Other participants are CERN, INFN, Imperial, UKRI.

Task 8.1: Absorbers and Windows (CERN)
Coordinated by CERN, with studies on possible absorbers to be used in a cooling cells. Studies on windows will be necessary for the case of a liquid absorber, and in case that the RF task concludes that a high-pressure gas-filled cavity has to be used. This task will liaise with WP4.

Task 8.2: Solenoids: (UMIL)
Coordinated by UMIL, will as well resort to the experience of past projects and will propose, with the support of INFN a solenoid configuration compatible with all constraints. UMIL will design the solenoids to be integrated in the cell and liaise with the relevant task of WP7.

Task 8.3: RadioFrequency (INFN)
Coordinated by INFN. This workpackage will critically review the experience built by the muon collider community mainly through projects in the US over the last 20 years (Muon factory, Neutrino factory, MAP)and the experience of the MICE experiment. INFN LASA will design a cavity for the cooling cell liaising directly with WP6.

Task 8.4: Cooling cell performance: (UKRI)
Coordinated by UKRI, has the goal of selecting the type of cooling cell that represents better the difficulties of integration. This task will specify the main parameters for each component and will ensure that the overall cooling efficiency is preserved during the detailed design of the cell. This task will liaise with WP4

Task 8.5: Integration (UMIL)
Coordinated by UMIL, will make sure that the design of every single component in the other tasks is performed having in mind the integration in an assembly and will provide at the end a full 3D model of the cooling cell including all services (fluids, electrical connections etc…). All other participants to the Workpackage will contribute to this task, In particular CERN will make sure the 3D model respects the CERN quality manual in order to allow a future integration on a test facility on the CERN site.

STAFF EFFORT

Staff effort per participant

Grant Preparation (Work packages - Effort screen) — Enter the info.

Participant	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	Total Person-Months
1 - CERN	0.10								0.10
2 - DESY		12.00							12.00
3 - TUDA							15.00		15.00
4 - UROS						12.00			12.00
5 - CEA		12.00			24.00	22.00	18.00		76.00
6 - INFN		12.00			12.00	36.00	32.00	18.00	110.00
7 - UMIL							8.00	32.00	40.00
8 - UNIPD		24.00							24.00
9 - UTWENTE							14.00		14.00
10 - LIP		12.00							12.00
11 - ESS			24.00						24.00
12 - UU			2.00						2.00
13 - PSI							36.00		36.00
14 - UNIGE							24.00		24.00
15 - Imperial				22.50				12.00	34.50
16 - UKRI				28.60					28.60
17 - UWAR				21.00					21.00
18 - ULA						36.00			36.00
19 - SOTON							42.00		42.00

Staff effort per participant

Grant Preparation (Work packages - Effort screen) — Enter the info.

Participant	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	Total Person-Months
20 - UOS		12.00							12.00
Total Person-Months	0.10	84.00	26.00	72.10	36.00	106.00	189.00	62.00	575.20

LIST OF DELIVERABLES

Deliverables

Grant Preparation (Deliverables screen) — Enter the info.

The labels used mean:

Public — fully open (⚠ automatically posted online)
Sensitive — limited under the conditions of the Grant Agreement
EU classified —RESTREINT-UE/EU-RESTRICTED, CONFIDENTIEL-UE/EU-CONFIDENTIAL, SECRET-UE/EU-SECRET under Decision 2015/444

Deliverable No	Deliverable Name	Work Package No	Lead Beneficiary	Type	Dissemination Level	Due Date (month)
D1.1	Data-management plan	WP1	1 - CERN	DMP — Data Management Plan	PU - Public	5
D1.2	Preliminary ESPPU report No. 1	WP1	1 - CERN	R — Document, report	PU - Public	12
D1.3	Preliminary ESPPU report No. 2	WP1	1 - CERN	R — Document, report	PU - Public	24
D1.4	Intermediate ESPPU report	WP1	1 - CERN	R — Document, report	PU - Public	36
D1.5	Consolidated ESPPU report	WP1	1 - CERN	R — Document, report	PU - Public	48
D2.1	Beam-induced background and detector configuration	WP2	8 - UNIPD	DATA — data sets, microdata, etc	PU - Public	30
D2.2	Detector performance by using physics processes	WP2	2 - DESY	R — Document, report	PU - Public	36
D3.1	Final report on parameters and initial study for the Proton Complex	WP3	11 - ESS	R — Document, report	PU - Public	45
D4.1	Development of BDSIM simulation	WP4	16 - UKRI	OTHER	PU - Public	24
D4.2	Preliminary Report on key subsystems for ESPPU input	WP4	16 - UKRI	R — Document, report	PU - Public	33
D4.3	Consolidated Report on key subsystems	WP4	16 - UKRI	R — Document, report	PU - Public	45

Deliverables

Grant Preparation (Deliverables screen) — Enter the info.

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Deliverable No	Deliverable Name	Work Package No	Lead Beneficiary	Type	Dissemination Level	Due Date (month)
D5.1	Report on the collider ring design	WP5	5 - CEA	R — Document, report	PU - Public	44
D5.2	Report on the design of the HEC	WP5	5 - CEA	R — Document, report	PU - Public	45
D6.1	Report on design of high power and high efficiency RF power sources	WP6	5 - CEA	R — Document, report	PU - Public	42
D6.2	Report on RF for MCC and HEC	WP6	5 - CEA	R — Document, report	PU - Public	45
D7.1	Preliminary report on muon collider magnets	WP7	1 - CERN	R — Document, report	PU - Public	33
D7.2	Consolidated report on muon collider magnets	WP7	1 - CERN	R — Document, report	PU - Public	45
D8.1	Presentation of cooling cell conceptual design	WP8	7 - UMIL	OTHER	PU - Public	15
D8.2	Final report on cooling cell design	WP8	7 - UMIL	R — Document, report	PU - Public	42

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Deliverable D1.1 – Data-management plan

Deliverable Number	D1.1	Lead Beneficiary	1. CERN
Deliverable Name	Data-management plan		
Type	DMP — Data Management Plan	Dissemination Level	PU - Public
Due Date (month)	5	Work Package No	WP1

Description
D1.1 Data-management plan - M5

Deliverable D1.2 – Preliminary ESPPU report No. 1

Deliverable Number	D1.2	Lead Beneficiary	1. CERN
Deliverable Name	Preliminary ESPPU report No. 1		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	12	Work Package No	WP1

Description
Preliminary ESPPU report No. 1

Deliverable D1.3 – Preliminary ESPPU report No. 2

Deliverable Number	D1.3	Lead Beneficiary	1. CERN
Deliverable Name	Preliminary ESPPU report No. 2		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	24	Work Package No	WP1

Description
Preliminary ESPPU report No. 2

Deliverable D1.4 – Intermediate ESPPU report

Deliverable Number	D1.4	Lead Beneficiary	1. CERN
Deliverable Name	Intermediate ESPPU report		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	36	Work Package No	WP1

Description
Intermediate ESPPU report

Associated with document Ref. Ares(2023)1315812 - 22/02/2023

Deliverable D1.5 – Consolidated ESPPU report

Deliverable Number	D1.5	**Lead Beneficiary**	1. CERN
Deliverable Name	Consolidated ESPPU report		
Type	R — Document, report	**Dissemination Level**	PU - Public
Due Date (month)	48	**Work Package No**	WP1

Description
Consolidated ESPPU report

Deliverable D2.1 – Beam-induced background and detector configuration

Deliverable Number	D2.1	**Lead Beneficiary**	8. UNIPD
Deliverable Name	Beam-induced background and detector configuration		
Type	DATA — data sets, microdata, etc	**Dissemination Level**	PU - Public
Due Date (month)	30	**Work Package No**	WP2

Description
Beam-induced background and detector configuration

Deliverable D2.2 – Detector performance by using physics processes

Deliverable Number	D2.2	**Lead Beneficiary**	2. DESY
Deliverable Name	Detector performance by using physics processes		
Type	R — Document, report	**Dissemination Level**	PU - Public
Due Date (month)	36	**Work Package No**	WP2

Description
Detector performance by using physics processes

Deliverable D3.1 – Final report on parameters and initial study for the Proton Complex

Deliverable Number	D3.1	**Lead Beneficiary**	11. ESS
Deliverable Name	Final report on parameters and initial study for the Proton Complex		
Type	R — Document, report	**Dissemination Level**	PU - Public
Due Date (month)	45	**Work Package No**	WP3

Description
Final report on parameters and study of the preliminary scenario for the Proton Complex

Deliverable D4.1 – Development of BDSIM simulation

Deliverable Number	D4.1	Lead Beneficiary	16. UKRI
Deliverable Name	Development of BDSIM simulation		
Type	OTHER	Dissemination Level	PU - Public
Due Date (month)	24	Work Package No	WP4

Description
Development of BDSIM simulation

Deliverable D4.2 – Preliminary Report on key subsystems for ESPPU input

Deliverable Number	D4.2	Lead Beneficiary	16. UKRI
Deliverable Name	Preliminary Report on key subsystems for ESPPU input		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	33	Work Package No	WP4

Description
Preliminary Report on key subsystems for ESPPU input

Deliverable D4.3 – Consolidated Report on key subsystems

Deliverable Number	D4.3	Lead Beneficiary	16. UKRI
Deliverable Name	Consolidated Report on key subsystems		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	45	Work Package No	WP4

Description
Consolidated Report on key subsystems

Deliverable D5.1 – Report on the collider ring design

Deliverable Number	D5.1	Lead Beneficiary	5. CEA
Deliverable Name	Report on the collider ring design		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	44	Work Package No	WP5

Description
Report on the collider ring design

Deliverable D5.2 – Report on the design of the HEC

Deliverable Number	D5.2	Lead Beneficiary	5. CEA
Deliverable Name	Report on the design of the HEC		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	45	Work Package No	WP5

Description
Report on the design of the HEC

Deliverable D6.1 – Report on design of high power and high efficiency RF power sources

Deliverable Number	D6.1	Lead Beneficiary	5. CEA
Deliverable Name	Report on design of high power and high efficiency RF power sources		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	42	Work Package No	WP6

Description
Report on design of high power and high efficiency RF power sources

Deliverable D6.2 – Report on RF for MCC and HEC

Deliverable Number	D6.2	Lead Beneficiary	5. CEA
Deliverable Name	Report on RF for MCC and HEC		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	45	Work Package No	WP6

Description
Report on RF for MCC and HEC

Deliverable D7.1 – Preliminary report on muon collider magnets

Deliverable Number	D7.1	Lead Beneficiary	1. CERN
Deliverable Name	Preliminary report on muon collider magnets		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	33	Work Package No	WP7

Description
Preliminary report on muon collider magnets

Associated with document Ref. Ares(2023)1315812 - 22/02/2023

Deliverable D7.2 – Consolidated report on muon collider magnets

Deliverable Number	D7.2	**Lead Beneficiary**	1. CERN
Deliverable Name	Consolidated report on muon collider magnets		
Type	R — Document, report	**Dissemination Level**	PU - Public
Due Date (month)	45	**Work Package No**	WP7

Description
Consolidated report on muon collider magnets

Deliverable D8.1 – Presentation of cooling cell conceptual design

Deliverable Number	D8.1	**Lead Beneficiary**	7. UMIL
Deliverable Name	Presentation of cooling cell conceptual design		
Type	OTHER	**Dissemination Level**	PU - Public
Due Date (month)	15	**Work Package No**	WP8

Description
Presentation of cooling cell conceptual design

Deliverable D8.2 – Final report on cooling cell design

Deliverable Number	D8.2	**Lead Beneficiary**	7. UMIL
Deliverable Name	Final report on cooling cell design		
Type	R — Document, report	**Dissemination Level**	PU - Public
Due Date (month)	42	**Work Package No**	WP8

Description
Final report on cooling cell design

LIST OF MILESTONES

Milestones

Grant Preparation (Milestones screen) — Enter the info.

Milestone No	Milestone Name	Work Package No	Lead Beneficiary	Means of Verification	Due Date (month)
1	Website Available	WP1	1-CERN	Website online	2
2	Kick-off meeting	WP1	1-CERN	Indico site	3
3	Tentative parameters available	WP1	1-CERN	Database	6
4	First annual meeting	WP1	1-CERN	Indico site	15
5	Preliminary parameters	WP1	1-CERN	Database	18
6	Second annual meeting	WP1	1-CERN	Indico site	27
7	Consolidated parameters	WP1	1-CERN	Database	30
8	Third annual meeting	WP1	1-CERN	Indico site	39
9	Training on detector design and physics performance tools	WP2	8-UNIPD	Training material	6
10	Workshop on MDI and IR design	WP2, WP5	8-UNIPD	Indico site	13
11	Release of simplified detector performance model (DELPHES card or/and similar format)	WP2	8-UNIPD	Model published on the website	18
12	Workshop on detector design and physics performance with a public lecture on Muon Collider	WP2	8-UNIPD	Indico site	25
13	Publication of report of detector performance with major physics process at several ECM	WP2	8-UNIPD	Article ready for submission	48
14	Mini-Workshop on pulsed magnets	WP7, WP5	5-CEA	Indico site	15
15	Tentative design of the interaction region	WP2, WP5	1-CERN	Optics files	18

Milestones

Grant Preparation (Milestones screen) — Enter the info.

Milestone No	Milestone Name	Work Package No	Lead Beneficiary	Means of Verification	Due Date (month)
16	Tentative optics of the collider ring and pulsed synchrotrons	WP5	5-CEA	Optics files	19
17	Tentative design of the FFA	WP5	5-CEA	Optics files	25
18	Tentative impedance budget in the collider and pulsed synchrotron	WP5	5-CEA	Dataset	26
19	Workshop on ultra-high-field solenoids	WP7	1-CERN	Indico site	30
20	Workshop on high-field collider magnets	WP7, WP5	1-CERN	Indico site	42
21	Cooling cell design 3D model	WP8	7-UMIL	3D model completed & Report	33

LIST OF CRITICAL RISKS

Critical risks & risk management strategy

Grant Preparation (Critical Risks screen) — Enter the info.

Risk number	Description	Work Package No(s)	Proposed Mitigation Measures
1	Hiring difficulty (i) likelihood: medium, (ii) severity: high	WP7, WP3, WP6, WP1, WP2, WP4, WP8, WP5	To exploit hiring strategies (websites, Professional networks, socials etc…) of all the participating Institutes to enlarge as much as possible the platform of publication of open positions.
2	Unilateral withdrawal of a Partner (i) likelihood: low (ii) severity: medium	WP1	The Consortium has a wide coverage of every necessary competence. Withdrawal for any reason of one of the partners will be mitigated with the reassignment of resources to another partner having the necessary competences. The decision will be taken at the Governing Board level.

Critical risks & risk management strategy

Grant Preparation (Critical Risks screen) — Enter the info.

Risk number	Description	Work Package No(s)	Proposed Mitigation Measures
3	Significant delay on deliverables (i) likelihood: low, (ii) severity: medium	WP7, WP3, WP6, WP1, WP2, WP4, WP8, WP5	Progress will be regularly monitored via the Management Board and achievement of Milestones and Deliverables. Appropriate measures, if necessary will be addressed by the Governing Board.
4	Failure to achieve performance goals with realistic component performance specifications (i) likelihood: medium, (ii) severity: high	WP1	Rebalance parameters to relax the requirements on the section that does not fulfil the specifications. Identify R&D necessary to improve performance for final report. Adjust performance goals, if unavoidable
5	Additional challenges are identified that require unforeseen efforts (i) likelihood: low, (ii) severity: medium	WP1	Discussion at the Governing board level. Participants will make additional resources available or reprioritisation of efforts.
6	Delay in the availability of 10 TeV centre-of-mass energy IR lattice (i) likelihood: low, (ii) severity: high	WP2	Study a procedure to scale the 3 TeV centre-of-mass results to high energy with much less accuracy
7	Lack of computing resources to fully simulate the beam-induced background for all the IR configurations (i) likelihood: low, (ii) severity: medium	WP2	Discussion at the Governing Board. Members (including associates) will be requested to contribute with more computing resources.
8	In the course of the study we find that a certain parameter required by the target (WP4) cannot be achieved by the Proton Complex (i) likelihood: Medium, (ii) severity: high.	WP3, WP4	The two WPs will have regular common meetings. Tradeoffs on performances may be analysed and discussed in the management committee for the evaluation of the overall impact.
9	Complexity or cost of Technology Performance Limits (TPL) experiments beyond the scope of the work planned (i) likelihood: medium (ii) severity: low	WP7	Resort to basic electro-mechanical characterization measurements to identify design limits, postponing full TPL experiments to the R&D phase.
10	Selected components of the cooling cell do not fit within the specified space (i) likelihood: medium, (ii) severity: high.	WP8	Additional iteration on components design, and cooling cell architecture. Organisation of a dedicated workshop open to international experts. Check the impact on downstream sections of the complex.

PROJECT REVIEWS

Project Reviews

Grant Preparation (Reviews screen) — Enter the info.

Review No	**Timing** (month)	**Location**	**Comments**
RV1	26	TBC	MTR
RV2	50	TBC	Final Project Review

Description of the action (DoA)

Part B

MuCol – A Design Study for a Muon Collider complex at 10 TeV center of mass

History of changes

Part A		
Date	Page / Section	Nature of change and reason / Justification of change proposed (if applicable)
August, 2022	Table 3.1b WP description	Typo correction: the text in the Proposal skips Task 6.4. It goes from Task 6.3 to Task 6.5. Therefore, "Task 6.5" was replaced by "Task 6.4"
August, 2022	Deliverables and Milestones tabs	Update of Milestones and Deliverables as requested by the Project Officer
October, 2022	Beneficiaries / Associated Partners tabs	UK institutes switched from Beneficiaries to Associated Partners
October, 2022	WP effort	ESS (WP3) update of PM from 33 to 24. UMIL (WP8) update of PM from 38 to 32
January, 2023	Start date	Updating start date from Jan. 1st to March 1st
February, 2023	WP tab	Update of WP7 description to mention PSI and UNIGE involvements in Task 7.2 (PSI, UNIGE) and 7.4 (PSI)
February, 2023	Deliverables tab	Correction of WP linked to Deliverable D14 "Report on design of high power and high efficiency RF power sources" from WP5 to WP6
Part B		
Date	Page / Section	Nature of change and reason / Justification of change proposed (if applicable)
August, 2022	26 / 3.1	Gant chart updated
August, 2022	29 / 3.1	Addition of Table 3.1 k – Associated Partners resources
October, 2022	27/ 3.1	Addition of "*Regarding WP1, the work will be performed mainly on CERN own resources, with an estimated of 35PM of existing personnel for high level coordination tasks.*"
October, 2022	28/ 3.1	Deletion of "Consumables, software licenses for other labs (36000)." from CERN table
October, 2022	29-30/ 3.1	Addition of UK institutes as Associated Partners resources
January, 2023	26 / 3.1	Gant chart updated
February, 2023	28 / 3.1	Addition of comments in "Table 3.1h: 'Purchase costs' items" regarding CERN services costs

Abstract

Two facility concepts have been considered in the past years as pathways to the future of particle physics at the energy frontier in Europe: FCC-hh, a 100 TeV circular hadron collider and CLIC, a 3 TeV linear lepton (i.e. electron-positron) collider. They are improved versions of projects realized in the past. The expected cost and power consumption are 24 GCHF and 580 MW for FCC-hh and 18 GCHF and 590 MW for CLIC.

The recent European Accelerator R&D Roadmap (https://arxiv.org/abs/2201.07895) includes a 10 or more TeV Muon Collider. This novel interest is based on two considerations:

- *The recognition of the physics potential of a lepton collider with a centre-of-mass energy of 10 TeV or more.*
- *The recent advances in technology that make the realisation of a muon collider plausible.*

The Muon collider promises to expand the lepton collider energy reach. Muons are much heavier than electrons and with a much reduced synchrotron radiation, allowing acceleration and collision of the beam in rings, even at multi-TeV energies. This results in compact dimensions and promises high efficiency and limited cost. The tunnel length of a 10 TeV muon collider is expected to be similar to the 3 TeV CLIC and significantly smaller than FCC-hh. Because muons are point-like particles, in contrast to the composite hadrons, a muon collider may have a physics case of comparable interest than a 100 TeV hadron collider.

Past work has demonstrated several key muon collider technologies and concepts, and gives confidence that the facility concept is viable. Component designs have been developed that can cool the initially diffuse beam and accelerate it to multi-TeV energy on a time scale compatible with the muon lifetime. Relevant technologies, e.g., superconducting magnets, have recently progressed.

While the muon collider promises high benefits it also poses a significant risk. No muon collider has yet been built. The facility is based on advanced concepts and technologies. The Roadmap identifies remaining key challenges that require to be addressed by the next ESPPU so that the High Energy Physics community may make informed choices.

MuCol will address the core of these key challenges. It will develop the baseline design and assess the physics performance based on realistic performance goals for the collider components. The identification of the cost and power consumption drivers will enable determination of the cost and power consumption scale. This will allow the next European Strategy for Particle Physics Update (ESPPU) process to seriously consider also Muon Colliders for the selection of the next large collider to be built in Europe.

1. Excellence

1.1. Objectives and ambition

The MuCol study will produce a coherent description of a novel particle accelerator complex that will collide muons of opposite charge at the energy frontier. The study will target a centre-of-mass energy (E_{CM}) of 10 TeV with 3 TeV envisaged as a first stage.

The main outcome of MuCol will be a report documenting the facility design that should demonstrate that:

- the physics case of the muon collider is sound and detector systems can yield sufficient resolution and rejection of backgrounds;
- there are no principle technology showstoppers that will prevent the achievement of a satisfactory performance from the accelerator or from the detectors side;
- the muon collider provides a highly sustainable energy frontier facility as compared to other equivalent colliders;
- exploiting synergies with other scientific and industrial R&D projects, it is a valuable platform to provide Europe a leading edge not only in terms of discovery potential, but also for the development of associated technologies.

The final report will include a thorough assessment of benefits and risks of the accelerator and detector complex, including an evaluation of the scientific, industrial and societal return beyond high-energy physics, the cost scale and sustainability of the complex and the impact arising from an implementation on the CERN site.

Introduction

Muons, like electrons, are point-like particles (leptons) so that their nominal centre-of-mass collision energy E_{CM} is entirely available to produce high-energy reactions. By contrast, the relevant energy for proton (hadron) colliders is the centre-of-mass energy of the collisions between the partons that constitute the protons. The partonic collision energy is distributed statistically, and represents hence only a fraction of the proton collider nominal energy. A muon collider with a given nominal energy and luminosity is thus more effective than a proton collider with comparable energy and luminosity. Fig. 1 shows the centre-of-mass energy, $\sqrt{s_p}$ that a proton collider must have to be considered *equivalent* to a muon collider of a centre-of-mass energy $\sqrt{s_\mu}$. The *equivalence* definition is not trivial and depends on the physics channel, and it is related to the production cross section of the particles under study. A detailed discussion can be found in [https://doi.org/10.48550/arXiv.2203.07261]. As a reference, a 100 TeV centre-of-mass proton collider, representative of the design efforts for a hadron-hadron Future Circular Collider (FCC-hh) at CERN, is shown to be *equivalent* to a muon collider with E_{CM} in the range of 7 to 14 TeV. MuCol will therefore study a collider at E_{CM} of 10 TeV being in the middle of the range of the *equivalence* to FCC-hh.

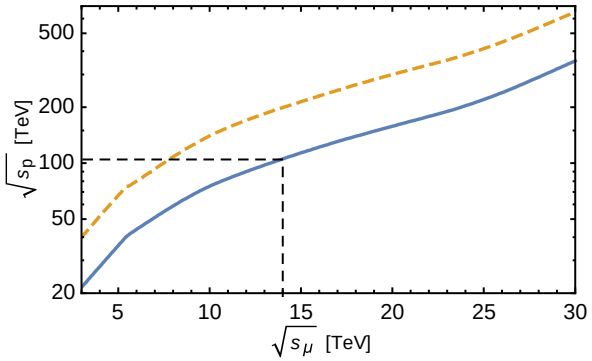

Fig. 1. The centre-of-mass energy at which the proton collider cross-section equals that of a muon collider. The dashed line assumes comparable Feynman amplitudes for the muon and the proton production processes. A factor of ten enhancement could possibly be considered as the continuous line due to QCD production.

The above considerations clearly point to the competitive advantage of lepton colliders at the energy frontier. Still accelerating leptons to such high energy poses very significant challenges. Specifically, the energy reach of circular electron and positron colliders is limited due to the energy loss by synchrotron radiation. The highest energy circular e^+e^- collider under design at CERN, the FCC-ee, will be limited to a maximum collision energy of 365 GeV for a circumference of about 90 km, i.e. much below the range of E_{CM} discussed here.

Linear e^+e^- colliders are an alternative configuration, as they do not suffer from synchrotron radiation, but they are inherently less efficient than circular colliders since the particles collide only once, and the collision energy is proportional to the length of the collider. Therefore, higher energies require longer and longer colliders. As an example, the Compact Linear Collider (CLIC) studied at CERN, would have a total length of nearly 50 km to achieve a collision energy of 3 TeV, with an estimated power consumption of 590 MW, while the estimated consumption for a 3 TeV Muon Collider is of the order of 250 MW (although this last number needs to be confirmed by more detailed studies).

Synchrotron radiation is strongly reduced in heavy particles, such as hadrons, which is why proton circular colliders are the preferred and most efficient option to reach high E_{CM}. In this case the main limitation comes from the maximum magnetic field in the dipoles to keep an affordable collider circumference. As an example, FCC-hh, with a total circumference of about 90 km, requires magnetic fields up to 16 T to get a collision energy of 100 TeV, which is at the limit of the technology of superconducting dipoles and will be an important cost driver.

Muons are heavy leptons, with a mass that is 207 times that of electrons, and synchrotron radiation in a circular accelerator is largely suppressed. They are hence ideal candidate particles for acceleration and collision in circular accelerators. A muon collider, if proven feasible, would outperform by far any electron-positron collider. The reason why this has not been realized already is that muons decay spontaneously with a lifetime of 2.2 □s at rest. This exceedingly short time is expanded in the laboratory frame by relativistic time dilation, remaining however orders of magnitude shorter than the typical acceleration and collision times of high-energy physics collider facilities built so far. Specific technologies are needed to ensure a satisfactory performance for the entire complex.

Indeed while the necessary technologies for electron-positron and proton-proton colliders are either readily available or within proven reach, a comprehensive and self-consistent study of Muon Colliders is not available. The US Muon Accelerator Program (MAP) has studied the concepts at the basis of a muon collider facility, producing a preliminary design of machines at different centre-of-mass energies up to 6 TeV [M-H. Wang *et al* 2016 *JINST* **11** P09003]. While the MAP study was seminal to our proposal, it focused only on selected areas of the whole accelerator complex, missing an integrated view of the whole facility. Also, the study identified several technological issues that, a decade later, we believe can be tackled and overcome.

MuCol will address the design of the Muon Collider facility using a holistic approach, from muon generation to collision, including the study of the interaction regions and the background to the experimental detectors, and will explore the associated technologies.

Physics Motivations

Interest in the potential of a muon collider was greatly revived in the past years, as demonstrated by a large number of theoretical and phenomenological papers culminated in the “Muon Smasher Guide” (Al Ali, Hind et al - arXiv:2103.14043, accepted for publication)

The current proposal of a muon collider at 10 TeV centre-of-mass energy foresees a first phase at 3 TeV, and both collision energies provide compelling physics opportunities. The physics potential at 3 TeV is similar to the potential of CLIC at its highest energy, with the bonus of the unique possibilities offered by collisions of muons instead of electrons. As discussed in [https://doi.org/10.48550/arXiv.2203.07261], muon and anti-muon collision at the TeV energy scale offer a tremendous opportunity in the search for new physics. Indeed, both the *g-2* and *b-physics* observed anomalies with respect to the Standard Model (SM) predictions involve muon coupling. This supports the importance of investing now in a muon collider feasibility study.

The second phase, a muon collider with a centre-of-mass energy of 10 TeV or more, would open entirely new opportunities for the exploration of fundamental physics. The “Muon Smasher’s Guide” analyses physics potential in all the high energy physics sectors and illustrates how the muon collider can be

complementary to other experiments that are probing for new physics like the study of electric dipole moments and gravitational waves. MuCol will show whether a high energy option can be envisaged, and within a practical technology reach.

The detector design for a 3 TeV collider could be similar to the CLIC one, with significant modifications of the inner (tracker) region needed to cope with the background distribution induced by the muon beams decays. A detector for physics studies at centre-of-mass energy of 10 TeV or higher on the other hand has never been designed. MuCol offers the unique opportunity to deal with novel detector designs to quantify the challenges and explore new experimental concepts for high energy physics, integrating sub-detectors R&D with innovative event reconstruction algorithms. MuCol will study the beam-induced background by varying the accelerator Interaction Region (IR) and will design an efficient background shielding, thus providing the best experimental conditions. Detector optimization and evaluation of their final performance are the main objectives of WP2.

Accelerator Physics and Technology Motivations

MuCol will have to deal with the difficulty inherent with the very short lifetime of muons, of the order of 2.2 μsec in the particle reference frame, requiring all processes of muon generation and acceleration to be significantly faster than what is normally done with hadrons or electrons.

The second major challenge of a muon collider is the emission of neutrinos by natural decay of muons. Neutrinos penetrate the earth at long distance and therefore showering arising from neutrino interactions may appear on the surface, even for a collider constructed underground, e.g. 200 m as presently considered at CERN. The proposed techniques to reduce the flux to a negligible level need to be studied to ensure that the effect remains at a level consistent with existing facilities on the CERN site. This is required in order to prove the feasibility of construction, and ensure the required public acceptance.

To address the two issues above we will use as a starting point the conceptual layout of the chain of accelerators elaborated by the Muon Accelerator Program (MAP) that has coordinated US efforts on muon collider R&D, documented, among other articles, in a JINST Special Issue. The layout proposed by MAP is shown in Fig. 2, and described briefly below.

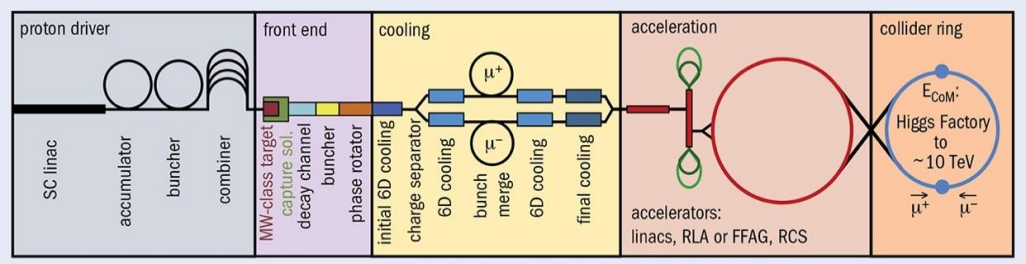

Fig. 2: Layout of the Muon Collider complex as elaborated by the MAP

The proton complex produces a short, high intensity proton pulse that hits a target and produces pions. The decay channel guides the pions and collects the muons produced by their decay into a buncher and phase rotator system to form a muon beam. A high muon beam brightness is mandatory to deliver the largest number of particle collisions. This implies that a large proton beam power is driven onto the pion production target to make the largest possible number of pions and, following decay of the pions, muons. The muon collider design foresees a state-of-the-art proton complex, capable of delivering up to 5MW of proton beam power at less than 5 GeV. These parameters are in line or only slightly beyond existing or approved pulsed proton driver facilities but crucially, the muon collider requires protons to be delivered at the target in an extremely short pulse, around 1 ns long, so that the resultant muon beam is also very short and can be subsequently captured in a suitable RF system. Compression of the proton bunch in such a short pulse will require an advanced arrangement of RF cavities. The overall efficacy of such a system is constrained by the self-repulsion of the protons due to space charge.

The following cooling section reduces the volume of the resultant muons in position-momentum space, a process called *ionisation cooling*. This process is shown schematically in fig. 3.

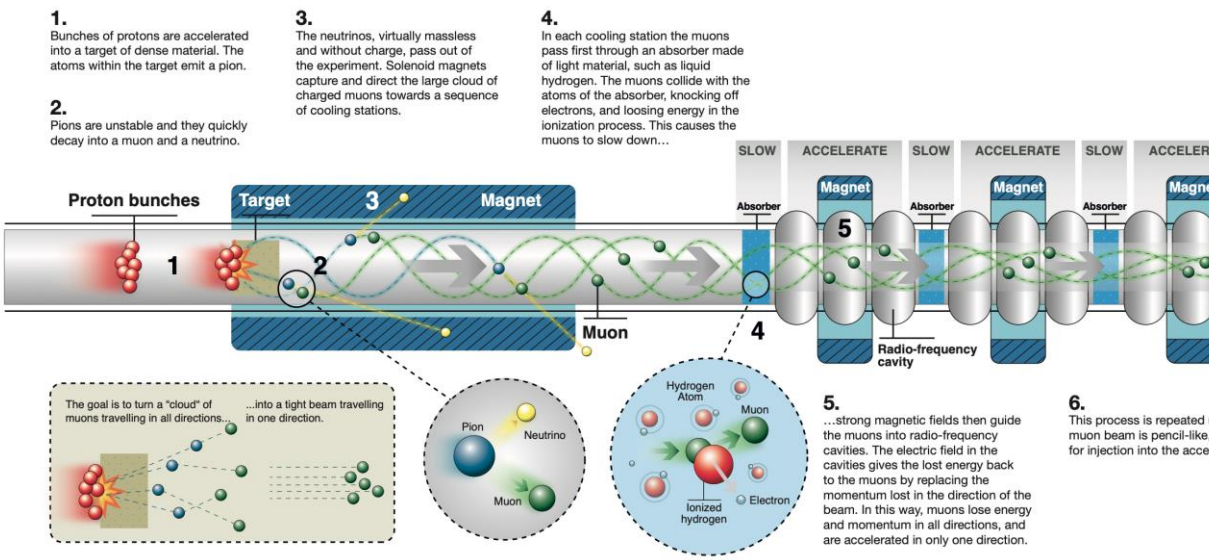

Fig. 3: Principle of the Muon Ionisation Cooling

A pair of approximately kilometre-long muon cooling linacs reduce the six-dimensional volume of the positively- and negatively-charged muon beams by five orders of magnitude. Within each linac, muons are continuously decelerated and re-accelerated to provide the muon cooling. Muon ionisation cooling requires very tight focusing and high-gradient RF cavities to reach the lowest emittance. The whole lattice must be extremely compact to properly contain the beam. A design for such a lattice was shown by MAP to almost reach the required performance. Since the end of MAP, advances have been made in RF and magnet technology that suggest that the lattice design can be improved. On the other hand further work must be performed to understand constraints arising from engineering and integration challenges, such as the need to maintain a thermal barrier between cryogenic magnets and room temperature RF cavities.

A sequence of a linac and two recirculating linacs receive the cooled muon beams and accelerate them to 60 GeV. One or more rings then accelerate the beams to the final energy of 1.5 TeV (E_{CM} of 3 TeV) or 5 TeV (E_{CM} of 10 TeV). As the beam is accelerated, the lifetime in the lab frame increases due to relativistic time dilation so later stage accelerators have proportionally more time for the acceleration process, making Rapid-Cycling Synchrotrons (RCS) a possible option. Fixed-field alternating-gradient accelerators (FFAs) are an interesting alternative that avoids pulsing the magnets of a synchrotron. Finally the two single bunch beams of opposite charge are injected at full energy into the collider ring to produce collisions at two interaction points.

The MAP study laid out the basic concept and examined the feasibility of some of the key components. Still, several important elements were not studied, including:

- **Muon source** – The individual elements of the muon source were studied separately, but an integrated system design and optimization was not performed. In addition, MAP studies considered gallium, graphite and mercury as options for the production target material. MuCol will assess the expected performances of different alternatives taking into account eventual technical limitations. Some of the options, such as mercury targets, are not suitable in the European context and will not be studied further in MuCol.
- **Muon cooling** – Cooling studies assumed limits in solenoid and RF fields that appear to be too conservative in the light of the recent progress in superconducting magnet and RF technology. For instance in 2021 a solenoid based on HTS technology has reached 32 T. The MAP missed the target luminosity by a factor two due to technology limitations which constrained the expected performance of the cooling elements. MuCol will revise estimates based on the present state of the art.
- **High collision energy E_{CM}** – The highest collision energy studied by MAP was 6 TeV, and technical limitations such as beam-induced backgrounds or neutrino dose have not been studied in detail at higher energies.

- **Radiological impact** – MuCol will evaluate the Neutrino flux at the surface in the region of the CERN site ensuring that the level of radiation stays within or below the levels of the LHC, ensuring that eventual mitigation measures are compatible with requirements from beam operation.
- **Technology impact** – Beyond the interest of the HEP community for the physics case of a muon collider, the technologies that are crucial to its success are directly related to advances in other fields of scientific and societal applications. As an example, the HTS superconducting solenoids for a muon collider resemble very closely ultra-high-field NMR magnets (life science application), magnets for high-field science (solid-state, material and life science applications), and magnets for fusion (energy applications). Research on technology relevant to a muon collider can hence be conducive to significant advances in other fields.

Sustainability Motivations and site specific considerations

Another important motivation for MuCol is the possibility that the next collider might have comparable (slightly larger) size and energy consumption with respect to the High-Luminosity LHC. This stems directly from the fact that muons can be accelerated to high energy in a circular collider, because of their sizeable mass, and that the centre-of-mass energy is fully available to produce clean events. The first consequence of these two properties is that a muon collider has the smallest footprint with respect to alternatives with comparable physics reach (Fig. 4 right). The largest circular muon collider, for E_{CM} of 10 TeV, will have a diameter of approximately 10 km, to be compared with about 30 km diameter for the FCC and 50 km linear length for the 3 TeV CLIC. The second implication of the above properties is that the electricity consumption is expected to be significantly lower than alternatives. Moreover, several machines in the layout will be pulsed, with a low average power consumption. MuCol will aim at estimating with more precision the energy consumption based on defined technological choices, and provide paths for optimization, for instance with studies on pulsed power and Energy Storage Systems that may accumulate energy during the pulse of the machines of the complex and give it back when necessary, thus reducing dramatically the energy pulled from the network. Energy performance over the operating lifetime will be established as one of the main design criteria.

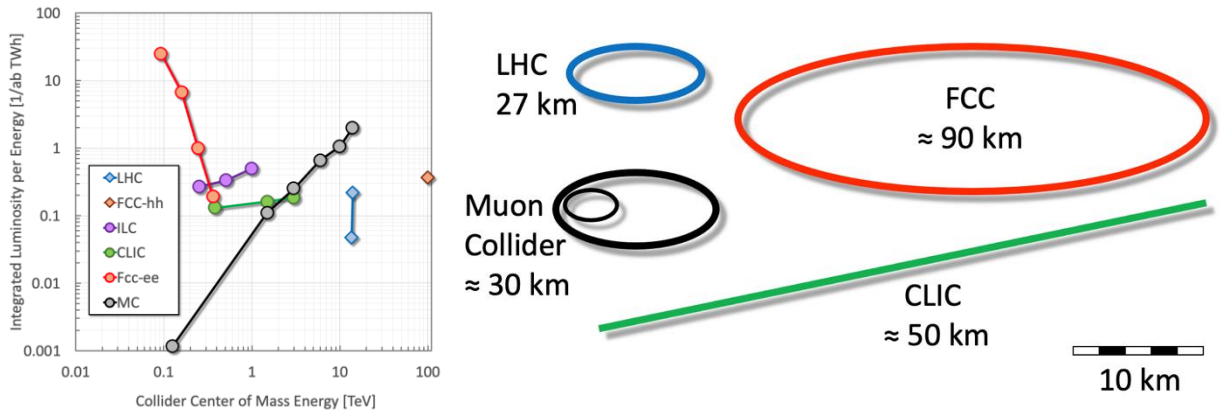

Fig. 4: Integrated luminosity of several collider options per TWh of energy consumption, as a function of Centre-of-mass collision energy (left). Comparison of footprint of the muon collider complex, FCC and CLIC. The LHC is shown for comparison (right).

A Muon Collider on the CERN site embeds intrinsically the “do not significantly harm” principle as the installations to be built are only slightly larger (20%) than the existing installations used for the LHC programme. It is therefore natural to expect that most of the existing technical infrastructure can be re-used for the project and only a very limited amount of additional installations will need to be added.

Moreover, 70% of CERN’s energy consumption is already produced with sources within the EU taxonomy and CERN plans to be ISO 50001 certified by the end of 2022. This will imply establishing clear resource optimisation and key performance indicators to monitor and optimise the use of resources in general and of electrical power in particular. A Muon Collider facility at CERN will therefore inscribe itself in a virtuous framework aimed at becoming a fully sustainable Science Facility.

Synergies

MuCol will explore synergies with other fields of science that may provide further motivations for its construction. Due to its modularity and staging possibility, the muon collider may serve as an ideal platform to associate other facilities such as advanced Neutrino Factories and radioactive beam facilities downstream of the production target. As an example, the present conceptual design of the facility could unfold towards a possible parallel implementation of nuStorm [DOI 10.17181/CERN.FQTB.O8QN]. Target technology challenges are shared with the progress sought in other fields of physics, e.g. neutrino factories, radioactive ion beams and nuclear and neutron physics, as well as for energy applications, e.g. studies of compatibility between liquid metals and metallic containment vessels.

A number of technologies to be developed for a muon collider are directly relevant to fields other than physics and societal applications. Progress in high field solenoids bears potential for significant advancement in medical applications, material science and energy applications. Energy optimisation techniques, which are mandatory for a muon collider and included in MuCol, find natural application in any other project requiring large, pulsed power sources, and may profit from or benefit research on energy storage systems (e.g. supercapacitors and batteries).

MuCol plans to identify these prospected synergies, build long term collaboration links on the subjects identified, and exploit them to leverage the impact of the study.

Financial Plan

MuCol will provide an analysis of the main cost drivers in order to identify R&D topics on which it may be useful to invest to reduce the total cost, and an estimate of the order of magnitude of the cost of the Facility. The possibility to re-use the LHC tunnel will be explored and will depend on the availability of high field magnets, and on the impact of neutrino flux at the surface.

A complete financial plan however is not in the scope of MuCol, and will be developed at the request of CERN Council during the next R&D phase. A good basis for such a financial plan will be the experience on construction of the LHC, that is comparable in size, and of ESS.

The LHC has been built using CERN's normal operation budget with a modest amount of in-kind contributions from other regions. A muon Collider at CERN might have to rely on a somewhat higher level of in-kind contribution. This amount might have to be slightly increased for a muon collider if the LHC tunnel cannot be re-used, however ESS, is within reach if the next ESPPU provides a clear choice foe European States to invest into it. The remaining 60% to 80% is comparable to the effort done for the construction of the LHC.

Technology Readiness level

MuCol does not address the construction of a single technology or a product, but rather to advance the understanding of how to design such a complex facility, integrating a number of disciplines and technologies. It is therefore difficult, if not inappropriate, to express the progress expected in terms of a unique TRL number. Overall, we can say that we intend to move from a level of Basic principles Observed and Reported, to Proof-of-Concept validated analytically.

1.2. Methodology

MuCol will be structured as a project, resorting to previous successful experiences in the accelerator community, such as the EuroCirCol and the HI-LUMI projects. For the sake of conciseness, we will not detail here the responsibilities and the roles of each partner, as they are quite standard and similar to other projects. The Governance including the precise definition of all roles in the project, in-kind resources provided by each Institute, publication policies etc… have been discussed among the participants and will be detailed, before the start of the project, in a Consortium Agreement Document that all participants will be required to sign. This kind of organization of the consortium (including a Study leader and a Technical coordinator, an advisory Committee, a Governing Board and a management committee) is quite common in the communities of particle accelerators and particle physics. A sketch of the organization is shown in Fig. 5.

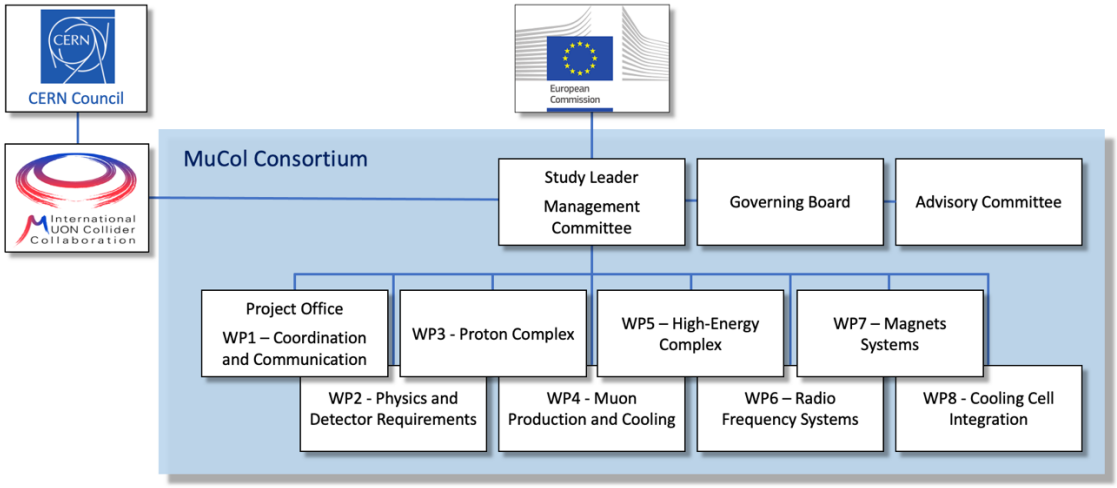

Fig. 5: Proposed organisation of MuCol

The activities are grouped in work-packages, with the first one dedicated to coordination and communication activities, that have an important role in such a large consortium and with the variety of activities to be developed. Scientific and Technical activities in each work package have been specifically selected to address the challenges that are most critical to the feasibility of a muon collider, based on the analysis performed within the scope of the European Accelerator R&D Roadmap exercise [https://arxiv.org/abs/2201.07895], endorsed by CERN Council on behalf of its member States. This document clearly defines prioritised R&D scenarios. The medium term goal (five years, by the next ESPPU) is to provide the elements required by the European particle physics community, the CERN Council as well as other funding agencies to make informed choices on the future direction of HEP. The MuCol study inscribes itself perfectly and seamlessly in this process, and shall make key contributions to the implementation of the R&D in the Roadmap by delivering and updating a Muon Collider Assessment Report (D1.2 and D1.3 of WP1).

The MuCol study described in this proposal will also be an integral part of the effort of the International Muon Collider Collaboration, hosted at CERN. MuCol is key to encourage and support participation of European Institutes to the collaborative efforts, allowing them to take responsibility for key parts of the collider design. This empowering process will build critical know-how at all participating parties, it will give them impact on the decisions within the scope of the International Muon Collider Collaboration, as well as the next ESPPU process. Finally, also of paramount importance, MuCol will prepare the future of all participating institutes by forming them in a solid community, ready for the design and construction of a future collider.

In the following we will clarify the scientific and technical measures, the methods as well as the organisation that we will adopt to achieve the objectives and unfold the potential mentioned in the previous paragraph.

Core challenges and Interdisciplinarity

We list below the key challenges for the muon collider identified and prioritized in the European Accelerator R&D Roadmap. They have been retained as high-priority in the R&D Roadmap process, as they may limit the performance or drive the cost, power consumption and risk. MuCol will address the core challenges, identified explicitly below:

- The **production of a high-charge, high-quality muon beam**, which is required to achieve the desired luminosity. Optimisation of the cooling process and close integration of the technical components are required to reach the performance goal, while maintaining low power consumption and cost. The performance of the source also impacts the design of the high-energy part of the collider complex. Particular challenges addressed in MuCol are:
    - The *production of high-charge proton beams*, combining a very large number of protons into the short pulses required for the muon production.
    - The *effect of proton beam impact* on the pion production target and the *effect of hadronic*

showers on the surrounding solenoid, as a consequence of the production of high charge muon beams.

- The achievement of small final beam emittance in the muon beam ionisation cooling system.

- The **collider ring and the acceleration system** that follows the muon cooling can limit the energy reach. These systems have never been studied for 10 TeV or higher energy. The collider ring design impacts the neutrino flux and the background to the detectors. Particular challenges addressed in MuCol are:
  - The *cost and power effective muon beams acceleration*, in particular in the RCSs.
  - The *design of the collider ring*, and in particular the focusing of the beam in the collision point to obtain high luminosity.
  - The *impact of muon beam decay and loss* on the facility, in particular for the collider ring.
  - Intensity dependent *collective effects* of the beam can create bottlenecks in the design of the complex that need to be mitigated and could potentially lead to important cost increase or performance loss.
- The **Machine Detector Interface** (MDI) might limit the physics reach due to beam-induced background, and the detector and machine need to be simultaneously optimised. These issues will be addressed integrally in MuCol.
- **The environmental impact**. The foreseen methods to reduce the impacts of the **neutrino flux** to negligible levels have to be verified. Other aspects that will be studied in MuCol are the overall collider footprint and required power, mandatory information towards a **sustainable science** case. Other site dependent studies, such the geology of the site, will not be addressed by MuCol, but will be conducted by CERN within the framework of the International Collaboration.

MuCol will finally put the accent on the availability of the core technologies, and the required R&D that will enable meeting the challenges. The magnet and RF technologies are the most important drivers of performance, cost and power consumption. Their tight integration in the muon cooling cell is unprecedented and needs dedicated studies.

Workpackages

To address the core challenges, MuCol has to draw from a wide spectrum of different competences and closely integrate them. The work is organised in seven technical workpackages to cover the physics requirements (WP2), the accelerator chain (WP3, WP4, WP5) and the most critical technologies (WP6, WP7, WP8):

- **WP2: Physics and Detector Requirements** provides the link to the physics and detector studies. It will make available a database with Beam-Induced Background (BIB) to the physics community and maintain a simplified model of the detector for physics studies. Based on feedback from the physics community, it will provide feedback and guidance to the accelerator design.
- **WP3: The Proton Complex** will address the key challenge of the accumulation of the protons in very high-charge bunches, by addressing in details the proton complex design, and will provide the basic parameters of the complex and the characteristics of the beam impacting on the production target.
- **WP4: The Muon Production and Cooling** will address the production of the muons by the proton beam hitting a target and the subsequent cooling, including some of the specific technologies, such as for the production target and the absorbers that reduce the beam phase space volume.
- **WP5: The High-energy Complex** will study the acceleration and collision complex of the muons.
- **WP6: Radio Frequency Systems** will address the Radio Frequency (RF) systems of the muon cooling ensuring coherence in frequency choice and synchronization among the various stages. It will contribute to sustainability studies by studying high efficiency RF Power sources.
- **WP7: Magnet Systems** will establish a complete inventory of the necessary magnets to optimize and standardise the design, and address the most critical ones. In particular it will focus on the solenoids of the muon production and cooling, which are specific to the muon collider, and the fast-ramping magnet system, which have ambitious requirements on power flow and power efficiency and limits the energy reach of the collider.

- **WP8: Cooling Cell Integration** will address the design of the muon cooling cell, which is a unique and novel design and which faces integration challenges.

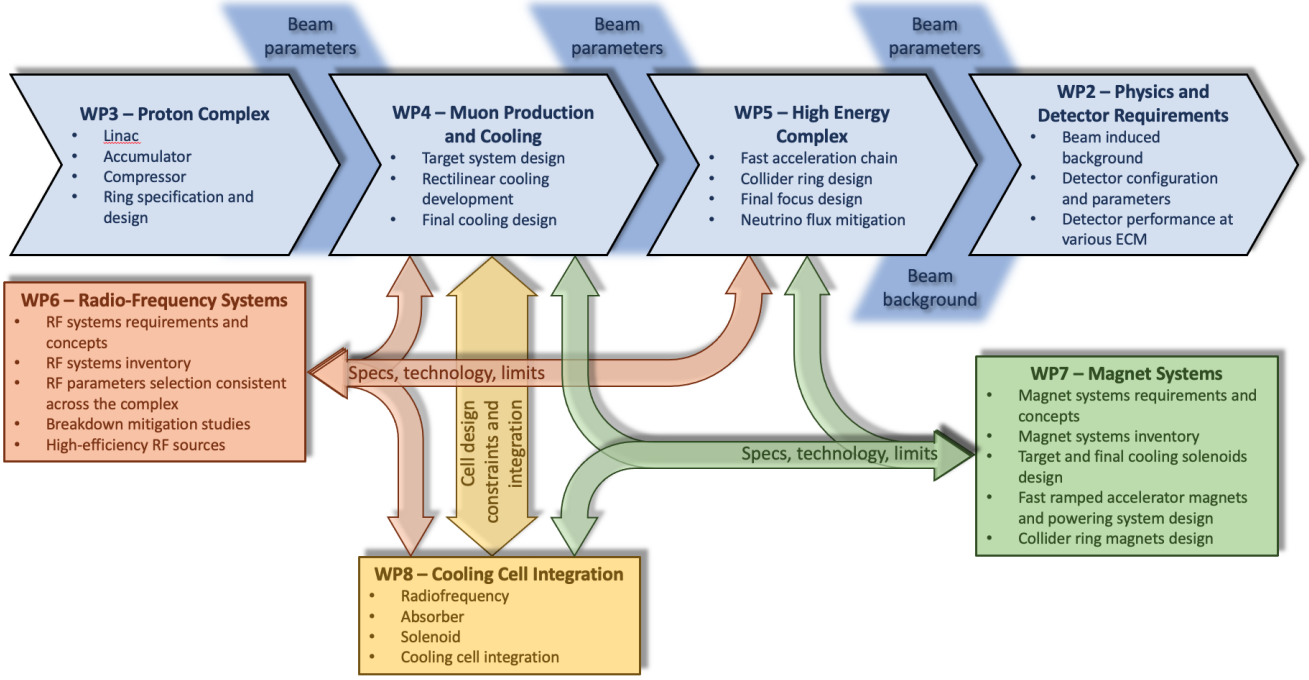

Fig. 6: Schematic diagram of interactions among workpackages

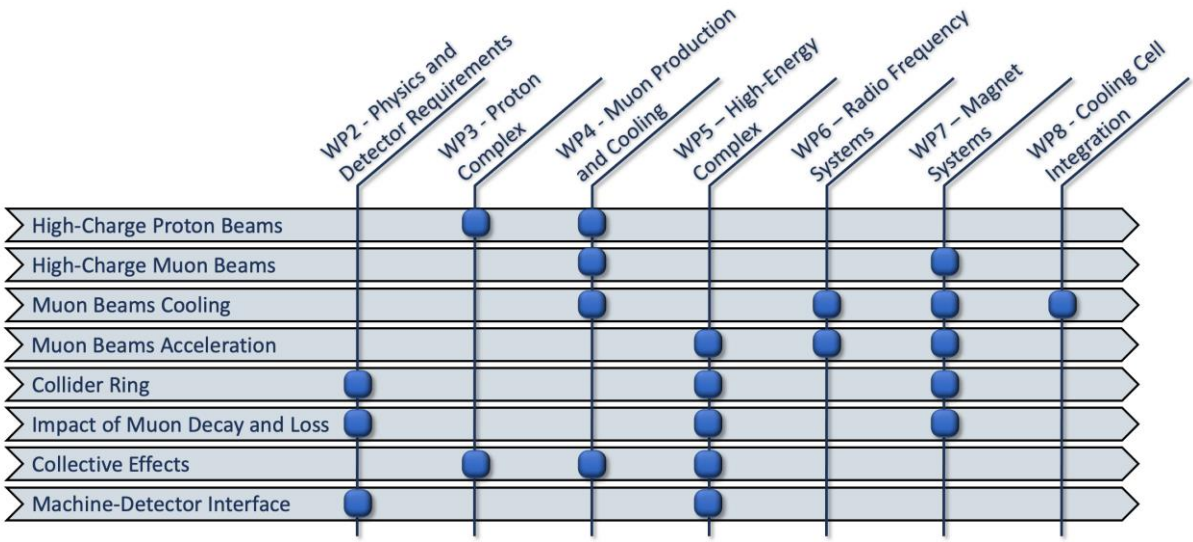

Fig. 7: Responsibility Assignment Matrix

These workpackages will closely interact to face the core challenges of the muon collider concept. In particular all WPleaders, and as required task leaders, will be invited regularly to participate in a Management Committee to exchange information and specifications, will have to report on the advancement of the work and will receive clear actions to implement. We show in Fig. 6 a schematic representation of the grouping of the technical workpackages, their inter-relation, while the overall coordination will be provided by WP1 (Coordination and Communication).

In Fig. 7 we detail the Responsibility Assignment Matrix of the project, showing how the single core challenges will be addressed jointly by the workpackages. ***Close integration is an important element of novelty introduced by MuCol in a feasibility the study of a muon collider.*** In the following paragraphs we provide a detailed description of the challenges and the methodology to address them. Specifically, we expand on how the workpackages address the core challenges, and through which challenge they will be required to interact and integrate results.

High-charge Proton Beam Production

The proton complex has to deliver a high-power beam consisting of a few short pulses (*O(1ns)*) per second in order to produce a sufficiently large number of muons. The compression of the large number of protons ($O(10^{15})$) into the short pulses is unprecedented. WP3 will develop a design for the combination and evaluate the limit arising from the repelling force between the protons. This has direct impact on the muon production, taken as input for the work of WP4.

High-charge Muon Beam Production

The proton beam will be sent into a target where it produces pions, which decay into muons. These are then compressed into a bunch. The proton target is beyond the state of the art, with an anticipated power of 2 MW. The beam consists of 5 pulses of about one ns and 400 kJ each and will induce shock waves in the target, lead to strong heating and, in the long run, induce radiation damage. WP4 will assess the performance of different target technology options, including graphite and fluidised tungsten, and determine the most promising solutions. The target is embedded in a high-field hybrid resistive and superconducting solenoid to efficiently collect the produced pions. The proton beam produces hadronic showers in the target that irradiate the solenoid. This is mitigated, in the MAP approach, by using a large aperture superconducting solenoid (O(1 m) radius) that allows to place nuclear shielding inside. The combination of high field and large aperture results in mechanical stresses that limit the performance of the superconductor. The second performance limit is the considerable amount of radiation leaking through the shield, and deposited in the coil, affecting radiation sensitive components (e.g. resins) as well as the cryogenic power and operation costs. WP4 and WP7 will evaluate the radiation, shielding and magnet design, and develop an overall configuration that balances the different requirements. Both existing (LTS) and emerging (HTS) magnet technology will be considered in this evaluation, possibly taking advantage from the energy efficiency associated with an operation temperature higher than liquid helium. Concerning the target, Studies will benefit of the recent studies in the HiRadMat facility at CERN where different materials are exposed to intense pulsed beams of protons at 400 GeV to benchmark dynamic and hydrodynamic codes for the simulation of energy deposition and instantaneous heating generating shock waves in the materials.

Muon Beam Ionisation Cooling

Even with a high muon flux, the beam must be tightly focused at the interaction point in the collider. To reach the desired luminosity, the volume of the beam in position and momentum space, known as beam emittance, must be reduced by five orders of magnitude. Ionisation cooling is the technique proposed to reduce the muon beam emittance. This consists in continuously decelerate and re-accelerate the muons in a linac consisting of tightly integrated superconducting solenoids, normal-conducting RF systems, absorbers and other components. The initial parts of the system are optimised to transport the initially large, diffuse beam, while the final parts of the system are optimised for small emittance yielding a high brightness, extremely short pulse of muons. The ionisation cooling is a novel concept and unique to muons. No previous experience with cooling an intense beam of muons exist. To prove that the concept delivers the required emittance, WP4 will explore performance and study limits of compact lattices, containing high-gradient RF cavities, studied in detail by WP6, and tightly focusing high field solenoids, studied in WP7. The integration of RF, Magnets and absorbers will be studied and modelled in WP8. A design for such a lattice was shown by MAP to almost reach the required performance (about a factor 2 was missing). Since the end of MAP, advances have been made in RF and magnet technology that suggest that the lattice design can be significantly improved. Specifically, WP6 will investigate the compatibility of the required high gradients and high magnetic fields, and mitigation measures to improve RF performance, such has cryogenically cooled resistive cavities. On the side of WP7, the recent successes in HTS magnet technology applied to user facilities and commercial NMR systems have greatly enlarged the landscape. WP7 will provide a realistic evaluation of performance limits and perspectives to go beyond the state of the art to feed the cooling lattice optimization. WP8 will consider the fully engineered integration of a complete cooling cell, providing crucial feedback on the single technology workpackages on matter such as required structures, access for services such as vacuum, powering and cooling, the necessity of thermal barriers, clearances for assembly and operation. These inputs will be the technology basis of the overall assessment and optimization of the rectilinear muon cooling system, done within WP4.

Cost and Power-effective Muon Beam Acceleration

After cooling, the muons have to be rapidly accelerated to full energy before they are injected into the

collider ring to limit the fraction of the beam that is lost. The lion share of this acceleration is performed in the RCSs, which have a critical impact on the cost, performance and power consumption of the complex and are a main limitation of the energy reach. The design of the RCSs requires close integration of the optics design and the two technology components, the accelerating RF systems and the fast-ramping magnet system, as they impact each other. WP5, WP6 and WP7 will closely collaborate to design the RCS.

The currently proposed RCS design consists of cells that combine a sequence of fast-ramping normal-conductive magnets and static superconducting magnets. The superconducting magnets bend the beam to the inside of the ring. The fast-raping magnets are used to adjust the bending force of the cell to the increasing beam energy. When the beam is injected they are powered to bend the beam to the outside canceling most of the bending force of the superconducting magnets. While the beam energy is increasing by acceleration these magnets are ramped down and then up with the opposite magnetic field to increase the bending force of the cells. This system halves the amount of fast-ramping magnets required but lead to a challenging optics design to mitigate the impact of the path length and position changes during the ramp. WP5 will design the optics and devise the solutions to compensate the orbit changes. It will identify the ratio between injection and extraction energy that can be achieved in each ring.

The fast-ramping dipoles in these rings store a large magnetic energy, which needs to be rapidly extracted and re-injected several times per second. The total peak power flow into and from the fast-ramping dipoles is of the order of tens of GW and the average power of the order of GW; it is critical to minimise the losses associated with this power flow and to recover the magnetic energy almost completely to avoid excessive power use. WP7 will develop efficient magnet and power converter concepts to achieve this goal.

Each muon beam pulse consists of one short high-charge bunch to obtain high luminosity. When it passes through the RF cavities in the acceleration complex it extracts a significant fraction of the energy in the cavity and induces important parasitic fields, so-called wakefields. Both effects have to be mitigated to ensure the preservation of the beam quality that is essential for the luminosity. WP5 and WP6 will address this together.

Collider Ring

WP5 will be responsible to create a consistent optics for the 10 TeV collider. Compared to the MAP study at 3 TeV, the higher beam energy makes the ring significantly more challenging. This is especially true for the focusing system at the collision point, which may actually limit the energy reach of the collider. A concept for the interaction region is required to establish the validity of the 10 TeV design, including the interface to the experiments and measures to reduce background, in collaboration with WP2, as well as limits for magnet performance, with WP7. Neutrino flux from muons decay is one of the major issues identified for a muon collider. WP5 will devise configuration to minimize the effects, including an evaluation of energy and radiation dose, which affects the required shielding and aperture of the collider magnets. Based on the results of WP5, WP7 will consider magnet configurations compatible with the aperture request (e.g. stress-managed) and heat removal (e.g. open midplane).

Impact of Muon Beam Decay and Loss

During the acceleration and in particular in the collider ring muons decay into two neutrinos and an electron or positron, depending on the charge of the muon. The electrons and positrons carry on average one third of the muon energy and will be lost inside of the ring. This is particularly critical in the collider ring since one lets the muons circulate until the largest part has decayed. The superconducting magnets of the ring have to be shielded from the losses, which requires larger aperture; this in turn limits the magnetic field due to stress. In addition, the removal of the heat through a cryogenic plant is one of largest power consumers of the collider. Workpackages 5 and 7 will address this challenge and iterate on the design to find the optimum solution. The shielding must fulfill different purposes, like preventing beam-induced quenches, reducing the thermal load to the cryogenic system, and avoiding magnet failures due to the cumulative dose in insulators and atomic displacements in superconductors.

The work will use simulation tools that are well established in the community (e.g. BDSIM, MADx, FLUKA, GEANT4 etc…). It is anticipated that extensions to those tools will be necessary in some cases. Where applicable, new models will be made available to the community through the mechanisms of the Open Access policy of CERN. Input files for simulations will be stored in public repositories such as the CERN Github.

Collective Effects

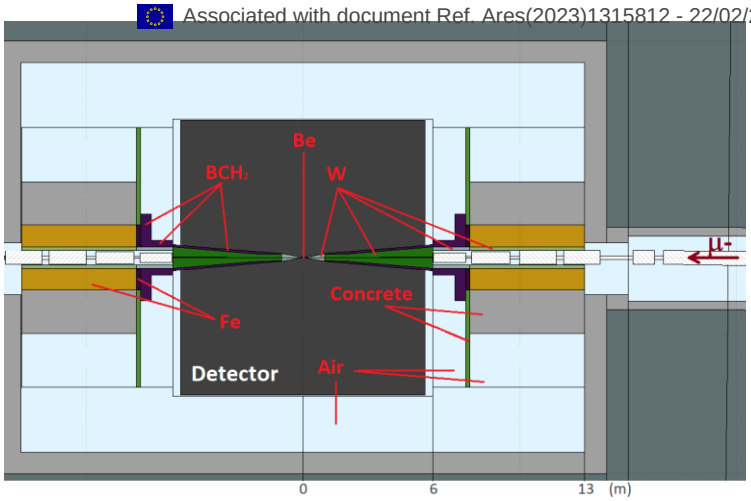

*Figure 8: Interaction region layout with the passive elements labels. In green the two nozzles connected to the beam-pipe [JINST **16** P11009, 2021].*

Collective effects can create important bottlenecks along the collider, in particular in view of the very large bunch charge, that is about one order of magnitude above the one planned for HL-LHC. Particular concerns are the impedance effects arising from the wall around the beam and from the accelerating cavities, that need to be simulated and the performance of mitigation methods needs to be assessed. Important parameters for the facility such as the aperture of the beam pipe and the choice of cavity frequency and design will be impacted by those results. The beam pipe size will feed back into the aperture of the magnets. This has an important impact on the magnetic energy in the fast-ramping magnets and drive the cost and power consumption of these systems. It also drives the aperture of the collider ring magnets, combined with the shielding needs, and thus the stress in these magnets, their main challenge. We will assess collective effects as part of the machine workpackages (WP 3, WP 4 and WP 5)

Machine-detector Interface

A multi-TeV Muon Collider needs to deliver high instantaneous luminosity to be able to exploit the diverse physics potential opportunities. To reach this goal high intense muon beams, with about 2×10^{12} muons per bunch, are necessary. A fraction of the muons continually decay, each producing two neutrinos and a high-energy electron or positron. The latter will be lost at the aperture of the beam guiding magnets and produce showers of secondaries and tertiaries. At the Interaction Point (IP), where the two muon bunches collide, these showers produce Beam-Induced Background (BIB). The flux of these particles is very high, at 10 TeV about 50,000 muons per meter decay per beam passage. Hence the background can strongly affect the detector performance and needs to be efficiently mitigated. The current solution, initially proposed by MAP, consists of two tungsten cone-shaped shielding (nozzles) around the beampipe, with the origin in proximity of the interaction point, to be accurately designed and optimized for each specific beam energy. In addition a robust detector with high granularity and good time resolution will be designed to cut in the time and direction of the tracks to further suppress the background.

Fig. 8 illustrates the current design of the IR at $\sqrt{S} = 1.5$ TeV with the nozzles (green conical shape) entering the detector represented here by a cylindrical black box.

Workpackage 2 will assess whether the physics potential of a Muon Collider at 10 TeV centre-of-mass energy can be realised with a proper detector design. As a starting point and also as a basis to understand the scaling with energy, it will study the 3 TeV configuration for which initial IR designs exist.

WP2 will provide performance specifications for detectors at 3 TeV and 10 TeV centre-of-mass energies and determine its performance by assessing its sensitivity to major physics processes beyond the Standard Model and precision Standard Model measurements.

The activities will be developed in three tasks, focusing on different aspects. The effects of the beam-induced background - one of the main challenges in detector design - will be studied comparing different configurations of the interaction region (IR) and shielding around it. The studies will proceed in close collaboration with WP5, (high energy complex)), which will provide time-dependent distributions of beam-induced background particles entering the detector envelope. These distributions will then be propagated into the detector components and studied in detail. Feedback will be given to WP5, where experts will modify the IR configuration to optimise the beam-induced background level and the shielding volume. The process will continue iteratively until an effective compromise is found. The final data will be made available by using an appropriate format and location depending on the size..

At the same time, new algorithms for event reconstruction in each sub-detector will be developed by exploiting 5D event reconstruction - including 3D position, time and energy information - in order to mitigate the effect of the irreducible beam-induced background. Events produced by the primary muon interactions will be overlaid with the machine background to have a realistic description of the detector performance.

State of the art machine learning algorithms will be used as base for the algorithms leveraging on the large experience the group has developed on the LHC experiments. Finally, the detector and algorithms performance will be determined by measuring the reach on the most challenging physics cases. Standard Model precision measurements and New Physics searches with discovery potential will be evaluated. The results will be used to define a simplified detector performance model in the form of a DELPHES card or/and similarly, which will be made publicly available on the project web site and continuously updated as new studies will be available. This format allows a wider community to study the impact of the detector on the physics performance in a simplified and slightly approximated fashion, without having to resort to full detector simulations taking into account also the effect of the beam-induced background.

The beam-induced background generation will be performed with a dedicated software package (FLUKA). The detector simulation and event reconstruction will be done by exploiting the ILCSoft package which is based on GEANT. The software used to simulate detector response and the reconstruction algorithms will be publicly available on the CERN github.

Core technologies

Significant progress in the muon collider will be possible only by advancing accelerator technology well beyond state of the art. MuCol puts a strong emphasis on this, dedicating three workpackages to RF (WP6), magnets (WP7) and the ionisation cooling cell (WP8).

*Figure 9: HTS solenoid (non-insulated) generating 14.4 T in the bore of a 31.1 resistive background, reaching record fields of 45.5 T [Nature **570**, 496-499, 2019].*

The main challenges for the **RF system** that are addressed in WP6 are the effect of a large background magnetic field, efficient high-power klystrons, and effective energy transfer to the beam. The RF system of the muon ionisation cooling is integrated into the strong magnetic field of the solenoids that surrounds the absorbers and guide the beam. The magnetic field strongly increases the tendency to RF breakdown, which limits the cavity electric field. This is due to the effect of magnetic field on the electrons emitted at one location on the cavity surface, which may be focussed in their trajectory and cause local damage at the cavity surface. Two approaches have been tested to mitigate this effect: using beryllium instead of copper, less prone to damage, and filling the cavity with high pressure gas, limiting the energy gain of the electrons. WP6 will develop theoretical models to improve our capability to predict the effect and devise an experimental strategy to verify the theory. The normal-conducting cavities of the muon cooling system need to be filled with short high-power RF power pulses to avoid excessive power losses in the walls. This requires cost effective and efficient high-power klystrons. WP6 will develop the concept of these klystrons to minimise the cost and establish realistic performance targets. The RF system in the RCS is an important factor for the design of the ring and for the cost and power consumption of the facility. Currently, superconducting cavities are the baseline to accelerate the beam. Just before the beam arrives, they are filled with energy to establish the accelerating gradient. During each of the repeated passages the beam will extract a fraction of the energy, which is refilled by the next passage. Once the beam has been accelerated, the energy in the cavity will be dumped. For efficient operation one has to maximise the fraction of the energy in the cavity that is extracted by the beam compared to the energy that is required to establish the field, while maintaining the beam quality. In addition, the beam generates unwanted fields that can lead to instabilities.

The **magnets** required for a muon collider, within the scope of WP7, span a very broad range of technologies, from ultra-high field superconducting solenoids to very fast resistive pulsed dipoles and quadrupoles. They are grouped in WP7 by complex. The target and cooling area magnets are solenoids, where we will profit from advances in HTS technology. We will study HTS based options priming a reduction in size and power consumption, and an increase in field performance. A HTS target solenoid could produce the desired field requiring less shield and operating at temperature higher than liquid helium, i.e. improved energy efficiency. For the final cooling, where the objective is maximum bore field, we will consider magnet designs either based on cables, or using the novel partial-insulation technique, so to

extend the present reach of HTS solenoids from 32 T (user facility), beyond 45.5 T (present highest field reached in an HTS winding, see Fig. 9), aiming at the 60 T target required to reach the emittance specification. Accelerator magnets will be designed as an integrated effort with energy storage and power management, striving for a true system optimum. The goal is to achieve the highest practical field performance and ramp quality at minimum stored magnetic energy, so to reduce the overall energy storage and power flow. HTS windings will be studied as an alternative, mainly to see whether it could be possible to increase the field swing, thus at the same time reducing the accelerator dimension and stored energy, and increasing the useful lifetime of the muons. Finally, the collider magnets will profit from synergy with the recently initiated EU High Field Magnet R&D Program (HFM), and the on-going US Magnet Development Program (US-MDP). HFM and US-MDP are considering stress management concepts for Nb3Sn magnets, as well as HTS dipole magnets for accelerators. MuCol WP7 will profit from these developments, focusing on specific designs and features, based on LTS and HTS, meeting the muon collider specifications. Of particular importance for the collider magnets will be energy deposition and radiation dose. WP6 will seek and design geometry and material alternatives that could minimize the heat load (e.g. open midplane) and maximise lifetime (e.g. rad-hard insulation).

The **ionization cooling cells**, which are the object of WP8, are unique to the muon collider and have never been designed. They pose specific challenges not only for the components but also for the integration. The cells have to be compact to minimise the length and the muon decay rate. They have to tightly integrate superconducting solenoids with normal-conducting RF, absorbers, beam instrumentation and auxiliary system, such as vacuum and cryogenics. The MAP study did not produce a detailed cooling cell design that is required to identify and mitigate limitations arising from the integration. WP8 will develop a full design of a representative cooling cell. It will investigate the state of the art for the components, select the most promising technologies for each component, and then cooperate to build a full 3D technical model of a cell. Phenomena such as increased breakdown in RF cavities, radiation load to superconducting solenoids, extreme energy deposition in absorber materials and vacuum windows will be taken into account to mitigate the risk that they may limit the performance of such a system. The participants will study the available literature on the subject, and provide new simulations and a full 3D mechanical model designed using CATIA or Inventor to confirm the feasibility. Reduced scale plastic models will be produced by additive manufacturing to double check the mechanical integration

Implementation Scenarios

The cost and power drivers of the facility will be identified and the cost and power scale be determined. We will assess whether a muon collider could be implemented at CERN considering environmental and geological factors. A scenario with a staged implementation will be considered with particular emphasis on minimising the time between the end of HL-LHC and the first stage. The required R&D path toward the construction of the collider will be laid out.

Gender dimension

MuCol will not involve any research linked to the gender dimension. The promotion of gender balance is a constant preoccupation of the High Energy physics community and will be promoted as well in this project, both from the point of view of hiring of students and in the different management and scientific bodies.

Concretely, a ***Gender Advisor*** will be appointed among the participants to enforce gender equality. She/He will regularly report to the Collaboration Board and will be available to the Participating Institutes of MuCol and to all the staff members and the students for suggestions and confidential contacts. The Gender Advisor will remain in contact with social services of the participating Institutes, in particular at CERN, to address eventual issues arising in the project. The presence of family services inside the main hosting laboratories (housing, kindergarten, summer camps for children, recreation services) will provide all personnel with the same opportunities for travelling, will reduce the impact of family duties on careers and will improve the work/life balance. On the Communication and Outreach side, particular attention will be dedicated to events aiming to attract young women to STEM careers.

Open Science and Data Management

MuCol brings together a diverse range of institutions and researchers who will produce research products of different complexity, sizes, formats serving different research communities and of course the public. Participating researchers are already practicing Open Science in their daily routine building on decades of Open Science experience in High-Energy Physics. CERN, a global leader in Open Science, is

coordinating the consortium and, by autumn 2022, will publish its institutional Open Science policy (OSP). This will gather the already published Open Access and Open Data policies, and will have paragraphs related to Open Source Software, Open Hardware, Research Integrity and Reproducibility, Citizen Science and Research Assessment - as well as Training and Outreach. Once published, the CERN's OSP, that collects also input from other European institution, will become the de-facto standard for Open Science in the field of High Energy and Accelerator Physics.

MuCol will build by M6 its Data Management Plan on CERN OSP and taking into account the diversity of the different participating Institutes, uniting the Muon Collider community to further its Open Science practices with the goal to maximize the impact of its research/project outputs.

As part of the proposal a thorough identification of expected outputs is already considered, e.g. data and public reports will be released with the appropriate open science and FAIR practices for those.

2. Impact

MuCol will assess whether the muon collider is a viable option by the next ESPPU. So far, all the approaches to a future ESFRI in particle physics were based on the improvement of previously employed concepts: linear and circular electron-positron colliders as well as circular hadron colliders. The muon collider is a novel concept, such an infrastructure has never been realised up to date. It promises a path to lepton collision energies well beyond other particles accelerator and combines the precision of a lepton collider with a discovery potential associated with future hadron colliders. Hence it presents a disruption option where the presently high risk is balanced by the high benefit for the field.

This project lays the groundwork for a new ESFRI infrastructure proposal on a multi-TeV muon collider facility.

MuCol will develop concepts of the key collider systems that are based on realistic performance targets for the technologies and allow estimation of the physics capabilities through simulation studies. It will advance the understanding of the whole infrastructure, including the muon collider complex and the detector operations with the new accelerator well beyond the present state of the art. MuCol will reach a status where the facility is expected to deliver the desired physics outcome, the most important-challenges have been identified, and either solutions are proposed, or the necessary R&D is defined. The main **requirements and potential barriers** are centered around the fact MuCol requires the availability of a solid team of experts to address challenges in beam physics, in accelerator engineering and in detector design, not only to build on past experience, but also to guide young researchers towards the solution of complex problems of accelerator and detector physics.

Through its activities, MuCol will have significant impact on three of the outcomes defined in the scope of this call.

- **The future of a new ESFRI Infrastructure** – The study will establish a path to mitigate critical risks in the muon collider facility and support a robust assessment of cost, risk and performance, enabling it to be proposed as the next ESFRI infrastructure in particle physics at the energy frontier. In particular an initial stage with a centre-of-mass energy around 3 TeV could be constructed after the planned end of HL-LHC operations in the 2040s. The results of the MuCol study will be the foundation for an informed decision.

- **Aligning the scientific landscape** –The 2020 ESPPU identified several potential facilities for further R&D, including various options for electron positron colliders and a future very large proton-proton collider, however a decision on the construction of the future facility is expected to take place at the next exercise in 2026-2027. If the muon collider were shown to be a viable route for particle physics, MuCol would dramatically change the decision landscape.

- **A strong technology drive** – The MuCol study will identify and evaluate challenges that go clearly beyond the state of the art in most of the domains of accelerator physics and technology and detectors development. Several of these challenges are shared with other research areas like medicine, material science, life sciences, and energy. The richness of these connections makes MuCol particularly attractive, especially because a direct impact on the ability to tackle scientific and societal challenges can be expected already on the scale of the technology R&D, rather than on the longer time scale of facility construction and operation.

In the next section we describe how we address the above outcomes.

2.1. Project's pathways towards impact

The future of a new ESFRI Infrastructure

MuCol will deliver a preliminary assessment report at the start of the next ESPPU process, foreseen in 2026, and contribute to the final report for the executive strategy decisions, to be endorsed by CERN Council in 2027.

The ambition of MuCol is to develop the concept to a level that allows the physicists' community and the funding agencies to make informed decisions. To be confident that the significant challenges of the muon collider can be successfully addressed with a well-defined R&D program . that one can commit to this path toward the next facility

The project is the framework for a well-founded decision-making process with two key elements. Every work package of MuCol is explicitly addressing topics that could not be studied or that have not been studied in detail by previous projects (such as MAP), aiming either at realistic and pragmatic solutions, or identifying the R&D programme necessary to confirm the hypothesis behind design solutions that go beyond the state of the art. This is witnessed by the workplan, milestones and deliverables identified, strongly linking the WPactivities. The second key element is the integrated approach that we have defined for MuCol, aiming at a coherent and self-consistent baseline design of the whole facility, from physics case to the technology relevant to its construction.

Aligning the landscape

The solid support from the physics community that we are witnessing through the participation of several major institutions active in High Energy physics to MuCol, since its inception, is the path towards a successful completion of the project. Thanks to this wide support, the muon collider has been introduced already in 2020 in the ESPPU, and was identified as a promising alternative to other colliders. MuCol is now part of the ongoing coordinated accelerator R&D in Europe, and it received a strong community support in the Snowmass process in the US.

The analysis of the options for a next collider machine is a complex process, and it involves the world-wide high energy physics community. The result depends on a balance among (i) physics case, (ii) technology readiness, (iii) sustainable science and (iv) societal return. MuCol is the first project being able to quantify on a sound basis each of the four items above, which will be crucial for striking the proper balance in the decision.

The muon collider will be the game changer in the panorama if, as the studies done until now demonstrate, it will prove to be feasible. In the unlikely case the outcome of MuCol should find that a muon collider is not advantageous on a practical scale of time and investment, such result would nonetheless bring crucial elements in a future decision of a next collider, clearing scenarios and options, and thus would help aligning the high energy physics community.

The muon collider could represent the perfect choice for the next accelerator at CERN, giving to Europe the leadership on the energy frontier physics, in case the decision of building an electron-positron collider to be built in China or Japan to study the Higgs properties is taken.

In case no electron-positron collider will be built due to the international scenario, the first phase of the muon collider at low energy (around 3 TeV centre-of-mass energy) may be considered as the better alternative. The legacy brought by MuCol will help in keeping the European leadership in the high energy physics research with accelerators.

A strong technology drive

A crucial element of impact for MuCol is the technology fall-out that we expect from the design study. Even if the size of the project will not allow the construction of prototypes or beam facilities that may validate concepts and finalize technologies, the proposed design and limited experimental effort have a definite potential to induce significant responses. We list below the main elements of novelty that could have measurable impact.

The work on the **Proton Complex** (WP3) will provide scenarios to achieve a single, very intense and stable pulse of protons that hits the production target. Although the techniques to achieve this goal are known, beam instabilities at the required intensity remain a challenge. This work has impact and synergies with proton sources for spallation sources for material research and life sciences.

The beam target which is part of the muon production (WP4) is a specific technology item whose challenges and results will be shared with other fields of science, e.g. spallation neutron sources, as well as energy, e.g. liquid metals moderators for fission and breeders for fusion.

Finally, in the domain of **Magnets** (WP7) the proposed conceptual design and R&D bears multiple

implications to other fields of science, industrial and societal applications. The superconducting outer magnet of the target solenoid is in the range of field and geometry relevant for full-body MRI for neuroscience, or solenoid magnets for thermonuclear fusion. In addition, the work proposed here will consider large current HTS cables as an option to wind such solenoid, which bears direct connection and potential impact for the on-going research on compact tokamaks, such as those performed by MIT and Commonwealth Fusion Systems. The ultra-high field solenoids required in the final cooling stage are conceptually similar, but well beyond the performance of present magnets for high-field science, as well as solenoids for NMR spectroscopy. The challenges to be mastered for a fast-ramped acceleration stage are relevant to the development of rapid cycled synchrotrons for the generation of intense proton beams, for accelerator-driven reactors and transmutation systems and material science, synchrotron for particle therapy applications, as well as nuclear physics. Finally, energy and power management for the fast ramped magnets in the accelerator complex share challenges with energy storage, power conversion and pulse forming networks for high-field pulsed magnets user facilities. In short, conceptual development in any of the magnet systems of a muon collider will bring advances in the above adjacent fields, by providing concepts and design solutions fostering significant progress.

The scale of the impact of MuCol is the largest. The entire worldwide community of Particle Physics will be impacted as only one Facility of this kind will be built in the world.

The significance of the impact is also of the highest relevance on only for the European community, but also for the other regions (US, Asia). If the next European Strategy recommends the Muon Collider as the next Collide on which European States should invest, also the other Regions (US, Asia) will participate, and update their strategy accordingly.

2.2. Measures to maximise impact - Dissemination, exploitation and communication

Scientific dissemination and communication activities will be the main instruments through which the community will build the knowledge basis and foster the approval of a muon collider project in Europe. The main goal will be a plan to inform and engage the wide community over time. MuCol will provide a strong driver within the wider scope of the International Muon Collider Collaboration. This action will generate the required momentum towards the next ESPPU, whose process relies heavily on a bottom-up scientific community approach to reach a consensus on the submitted plans. The same community will play a major role in the **exploitation** of results, and in particular when national groups will lobby at political level to receive support from the national and international funding agencies (e.g. single laboratories and research institutes, scientific councils, ministries, etc…) to endorse the ESPPU.

We also recognize that communication to the general public will be essential throughout the study. The approval of a large project such as a muon collider will have to rely on a solid public acceptance, in recognition of the investment of a significant budget for a scientific project, its return, but also the practical consequences of its construction and exploitation. Moreover we are convinced that it is important to leverage on the synergies identified, not only in terms of science, but also putting the accent on the societal implications such as advance of HTS technology for applications to medicine and energy production.

The plan devised is based on three main pillars:

- **Dissemination and communication of a sound and convincing physics programme** – The first requirement for a successful approval of a muon collider project is that the community of High Energy Physics (HEP) in Europe and beyond must be convinced, based on credible simulation studies and extrapolations, that the physics programme of the Muon Collider is competitive with the alternatives and achievable in a reasonable time frame. Besides scientific publications on the physics case, planned as a result of WP2, the MuCol community plans to participate and present to the major conferences in the field (ICHEP, IPAC) in order to engage an increasingly wider community around the muon collider study. Community meetings, in the form of yearly workshops, are planned during MuCol as an opportunity to communicate and discuss progress and plans., with dedicated funds allocated. The physics case will be also presented to the CERN Scientific Policy Committee, to build political support, and finally the project will take a leading role during the ESPPU process to lead the discussion on muon colliders, providing a convincing proposal document and representation at strategy meetings. ***The goal is to achieve recognition in the final document of the ESPPU, with a high level of priority among R&D projects in Europe***.

- **A credible and consistent description of the facility**, from the proton source to the collision regions of the entire accelerator chain, including the devised solutions and a perspective development plan. The goal is to convince that the conceptual design parameters are appropriate to build the facility and run a strong scientific programme in a period of about five to ten years at each energy stage (3 TeV and 10 TeV). A fundamental part of the description shall point to uncertainties and critical issues that are left unresolved, by showing that they are understood, and establishing a credible R&D programme to address them. The MuCol design study, including the facility description and development plan will be internally reviewed at each step and phase by an independent advisory committee of experts in accelerator physics and technology to be established at the beginning of the project. In order to make sure that the design is sound and realistic, recommendations from the advisory committee will be considered in the MuCol reports. The majority of milestones and deliverables in the proposed workplan have scope and content suitable for publication in scientific journals. This will provide a wide scope peer review, and visibility for the work performed within the MuCol design study. In particular, we plan the final report of MuCol to appear as a special issue of a scientific journal to be identified in the course of year 2 of the project. As for the physics case, the achievements of each work package will be presented in general conferences, such as the IPAC series, as well as the yearly workshops planned within the scope of MuCol. Finally, participation and presentation at specialists conferences (e.g. MT, ASC) is planned, to get targeted feedback of the community of accelerator and technology experts.
- **Establish contact with synergic projects and activities** – As we have detailed above, MuCol has strong connection to on-going or perspective developments in other fields of science, medicine, energy and societal applications. We plan to reinforce them by reaching-out to those companion fields, bring the attention to the case, present progress, and discuss practical terms of collaboration. The work planned within the scope of WP1 involves an analysis of the scientific and technology potential of MuCol beyond the muon collider, and support to participation to conferences and workshops in associated fields such as magnet technology and applied superconductivity, high-field magnet science, radio-frequency, nuclear energy. Once the analysis of WP1 complete, we plan to call for topical workshops within the scope of selected work packages (e.g. Target and cooling, WP4, or Magnets, WP7) joined with participants from other communities. The expected result will be to expose the technology challenges and advances, profiting from a wider knowledge basis, gaining further support from companion communities, and eventually conduct common studies on specific subjects by leveraging on shared interest.

To ensure that the plan is implemented effectively, we will nominate a Dissemination and Communication Officer, chosen among the partners of MuCol and working within the scope of WP1. The Officer will follow the dissemination and communication plan based on the following concrete scientific actions, which are foreseen in the MuCol budget to allow travel to conferences and workshops where the physics case and accelerator design may be presented:

- Presentation to international conferences in particle and accelerator physics (ICHEP, IPAC);
- Organization of yearly community meeting for the whole study, expected duration of one week, with parallel sessions dedicated to each work package;
- Participation to international conferences and workshops in companion fields of science and technology (MT, ASC, SRF);
- Organization of a topical workshop on cross-cutting and companion fields of science and societal applications (i.e. high-field magnet science and NMR applications, energy and power management), eventually joined with the EU project I-FAST on technology R&D, enhancing the industry's engagement
- Scientific publications from each work package in international, peer reviewed journals, associated with milestone and delivery reports;
- Publication of a special issue on MuCol, in an international journal of relevance in the field.

The scientific community, as well as the general public, will be informed through a dedicate project website, managed by a responsible for communication within MuCol, in charge of preparing posts on social media. This activity will be in collaboration with the outreach services of CERN and other institutions. On

top of scientific publications, a communication strategy will be established by the communication officer, to properly advert on the results through social media.

Finally since the next accelerator project will still be a global endeavor, even beyond the LHC, we have invited institutions form outside Europe to be associate members or collaborating institutes, and count on impacting decisional processes outside Europe. The contribution of MuCol to the Snowmass Strategy process in the US is important for the European community in order to remain at the forefront of the development of muon colliders. Should a decision to build a muon collider be taken by other regions (US or Asia), European Institutes will be considered as strategic partners to collaborate on the project. At the same time, should European countries decide to build it at CERN or another site in Europe, communities from other regions may obtain resources to participate to a EU project. Non-European colleagues will help with determining communication means and tools towards communities and at political level as appropriate to their specific processes.

Research data management and management of other research outputs:

The consortium will produce predominantly textual reports for internal and external consumption, as well as presentations in standard formats. As part of WP2, simulated data, the beam-induced background in the detector at different centre-of-mass energies, will be produced. Additional simulated data will be used and produced in the consortium as part of WP3, WP4, WP5. The expected size of these datasets is in the range of few terabytes and they will be made available as open data at CERN. WP6, WP7 and WP8 will produce Engineering simulations and mechanical drawings that will be stored in Engineering databases with open access to the muon collider community, and to general public when relevant.

The MuCol research and data outputs will follow the FAIR principles:

Findability of research outputs: public reports will be published via established document repositories, such as the CDS, arXiv, Zenodo and other institutional repositories of consortium partners if needed. Both CDS and Zenodo use persistent identifiers (DOIs) to identify the reports and are considered trusted repositories. Whenever possible, the research outputs will be linked e.g. to an article, further documentation, auxiliary measurements/datasets etc.

Accessibility of research outputs: public reports and presentations will be made available through the repositories and the web sites. Detailed data and documents access provisions will be discussed as part of the Open Science Principles in the Data Management Plan.

Interoperability of research outputs: the repositories currently identified for publishing the research outputs, use standardized metadata schemas (e.g. Datacite Metadata Standard) that enable easy discovery. Whenever possible and applicable, community standards will be used, e.g. to submit data to the HEPData repository.

Reusability of research outputs: the consortium will preserve its assets at CERN, by using the standard and trusted storage facilities and software tools already developed for the LHC machine and experiments. To further the reusability of research outputs, the consortium will aim at linking its research outputs to provide more context to the individual assets, e.g. datasets on HEPdata and articles are linked, software components are linked to datasets or articles as well.

2.3. Summary

KEY ELEMENT OF THE IMPACT SECTION

SPECIFIC NEEDS	EXPECTED RESULTS	D & E & C MEASURES
What are the specific needs that triggered this project?	*What do you expect to generate by the end of the project?*	*What dissemination, exploitation and communication measures will you apply to the results?*
• A comprehensive assessment of the feasibility, benefits, risks, cost and sustainability of a muon collider, requested by the last ESPPU (2020). The assessment will provide the next ESPPU (2026-27) with crucial elements for an informed decision towards the next ESFRI infrastructure for European and worldwide particle physics. • A thorough evaluation of the technical challenges of a muon collider, identified within the European Accelerator R&D Roadmap (2022) recently endorsed by CERN Council. Solutions beyond the state-of-the-art are clearly required, and a detailed resource loaded R&D plan towards the muon collider has to be submitted to the next ESPPU.	• A coherent description of the muon collider, a novel particle accelerator complex at the energy frontier, summarized in an assessment report that will be delivered to the next ESPPU for decision on the further steps. • The definition of a core R&D plan, necessary to access the technologies that are critical to a muon collider, and tightly connected to research of relevance for industrial and societal applications (e.g. HTS solenoids for NMR spectroscopy and high magnetic field science). Realizing the potential for a dramatic change in the landscape of high energy physics, allowing down-selection among the present collider options, and providing clear guidance to the community-driven strategy process even in case that the evaluation of feasibility of a muon collider reveals issues beyond present technology reach. • The confirmation that a Muon Collider can be built as a sustainable facility. • Sharing expertise among the participant laboratories and universities, training of young researchers and students, and forming the core team that will take the conceptual design of the facility forwards.	• The assessment and consolidated reports will be disseminated to the science community as part of the European strategy processes and through scientific publication. • Major results will be presented at international conferences. • Workshops will be organised to promote community participation, with sessions devoted to establishing connections and collaborations with companion programs, institutions and industry. • The International Muon Collider Collaboration has direct oversight from major national funding agencies and CERN management, enabling the results to be disseminated to the funding organisations. • Communication to the public will be achieved through the collaboration's website, social media, professional networks, and in liaison with other Accelerator EU programems such as IFAST, and committees like TIARA. CERN's and other Institutes' communication departments will be involved.

TARGET GROUPS	OUTCOMES	IMPACTS
Who will use or further up-take the results of the project? Who will benefit from the results of the project?	*What change do you expect to see after successful dissemination and exploitation of project results to the target group(s)?*	*What are the expected wider scientific, economic and societal effects of the project contributing to the expected impacts outlined in the respective destination in the work programme?*
• The high energy physics and Accelerator physics communities. The key aim of the project is to impact the conclusions of the next Update to the European Strategy for Particle Physics, which is a community-led strategy process. • Decision-making and advisory bodies such as CERN Scientific Policy Committee, CERN Council, the Laboratories Directors Group and the European and International Committees on Future Accelerators will be informed directly. • Technology developments in beam targets, RF and magnet technologies will benefit the accelerator community in general, and will have direct impact on other communities such as high magnetic field science, NMR spectroscopy and MRI, fusion power. • Synergies with other fields of science will impact the communities of Spallation Neutron Sources and Neutrino Physics.	• We expect the high energy physics community to invest in the muon collider, to progress beyond the study proposed here, ultimately leading to construction and exploitation. • To convince CERN member States through CERN Council to recommend a Muon Collider at CERN as the next collider to become an ESFRI • Build a solid and cognizable community in Europe so that EU Institutes can keep a leading role in a muon collider construction project. • Broaden the collaboration scope, enlarging participation to the International Muon Collider Collaboration, and engaging other communities whose expertise and activities are relevant to muon collider technologies .	• The detailed science case, including the understanding of technical risks, will enable the European high-energy physics community to align on a future ESFRI infrastructure at the next European strategy update. Reaching consensus and clarity, also thanks to the outcome of MuCol, will be important to maintain the EU leading role in this field. • MuCol shall point to a way to explore the energy frontier of particle physics in a more sustainable way, with a facility that uses lower power and reduced footprint when compared to other options. We expect savings by approximately a factor two vs. alternatives with equivalent physics reach. • The technologies that will be explored in the scope of MuCol, and in particular ultra-high field HTS magnets, could be directly conducive to significant progress in NMR spectroscopy and high magnetic field material and life science beyond 40 T.

3. Quality and efficiency of the implementation

3.1. Work plan and resources

The Workplan of MuCol is organised in view of providing input on the next Upgrade of the European Strategy for Particle Physics that will occur in years 2026/2027. In this respect the most important milestones are the general reports to be published at the end of 2025 and at the end of the project, the first to be submitted as kick-off information at the start of the ESPPU process, the second will document all the latest studies and will be published before the final decisions.

The first 6 months will be used to set-up the project structure, hire students (most of the budget will be used for postdocs and PhD students), and start the initial training. At the same time expert researchers within the team will explore the available literature and results from MAP and other previous muon accelerator programmes in order to select the most promising configurations/solutions to be studied further. ***A tentative scenario*** will be selected at the end by month 6, also implying an initial selection of technologies, layouts and tools to be used for detailed studies.

From month 6 (or earlier in some cases) to month 39 we will conduct a collaborative and iterative process that will involve detailed design of the accelerators, of some of the most critical components, and we will animate an intense exchange among different workpackages that will allow cross-fertilisation of ideas and will highlight the need of further re-optimisation. During this period ***a preliminary scenario*** will be established, by month 18. Results will be presented in major conferences in the different field to receive feedback also from a wider community with a final report to be issued by month 36 that will be used as input to the ESPPU (Muon Collider assessment report). Adjacent fields will also be contacted and informed to build collaborations where synergies look promising.

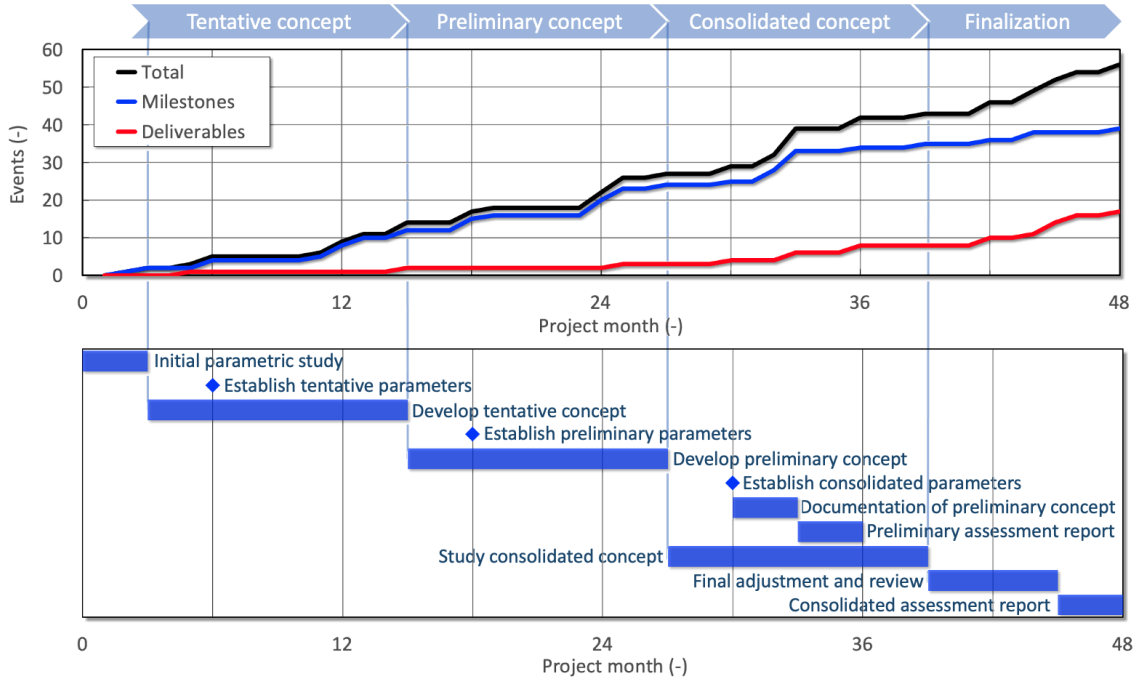

Fig. 10: Dashboard of Milestones and Deliverables of MuCol (top). High-level Gantt chart of MuCol (bottom).

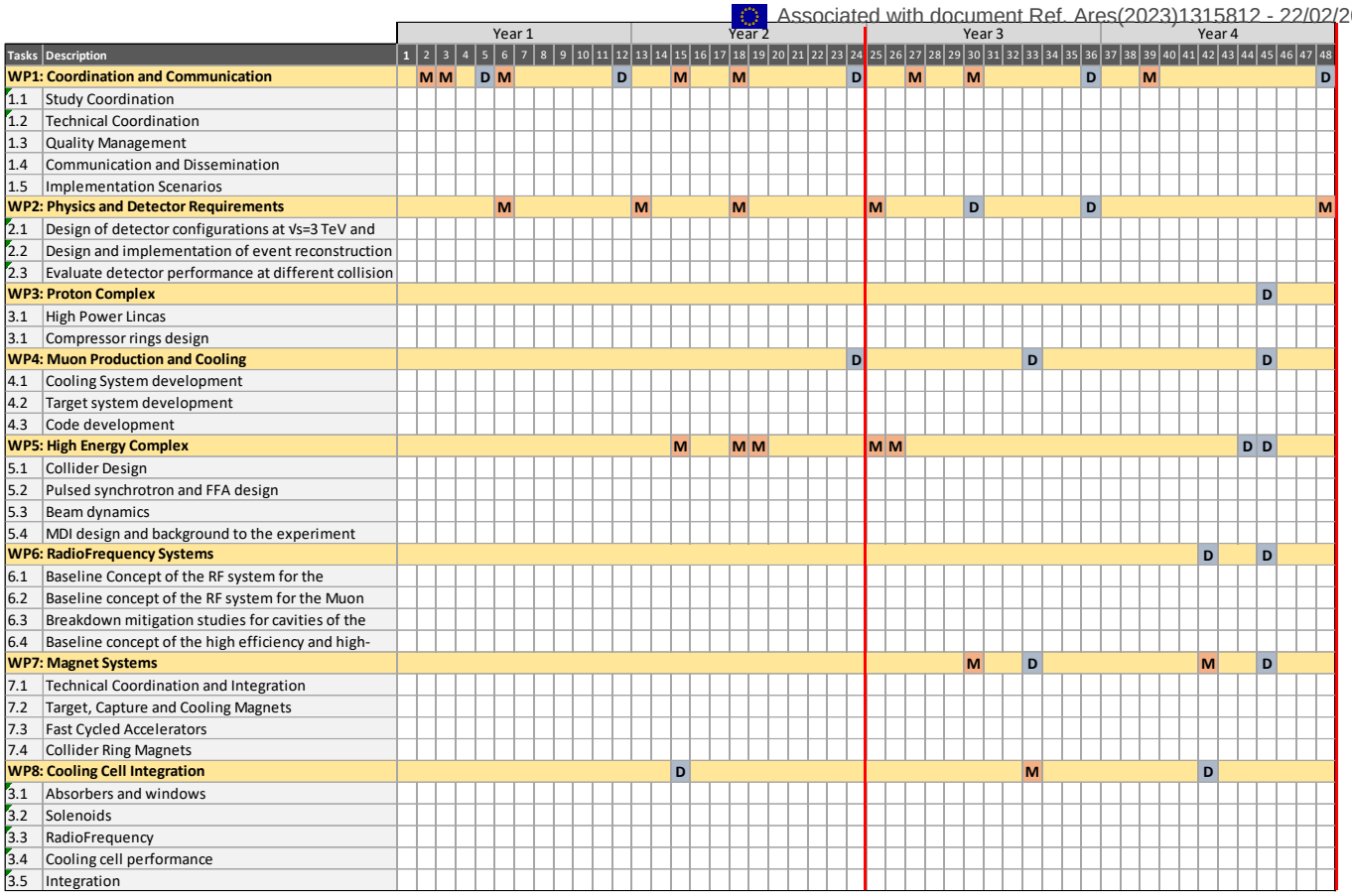

*Fig. 11: Gantt chart of MuCol (**D**: Deliverable, **M**: Milestone, vertical red line: planned review)*

The study of a consolidated scenario will be launched at month 30, and all studies will be reviewed and finalised with a consolidated set of parameters. In the same period publications and participation to events relevant to the ESPPU process will be encouraged. A final report, in the form of an update of the Muon Collider assessment report will be published.

MuCol will be instrumental to train a new generation of young researchers to Muon Collider specificities. Having such a reserve of young and motivated researchers, will be a necessary condition to start the next phase of R&D on the muon Collider. This is the reason why we reserved almost 90% of the budget requested to EU for hiring students and young researchers. The infrastructure necessary for the studies (e.g. computing facilities, workshops for any prototyping activities, facilities for tests, some travel budget etc…), will be mostly provided in kind by the participating Institutes. In total we plan to hire about 30 among PhD students and post-doc fellows either on EU funds or on the Institutes funds. All participating Institutes, whether Beneficiaries or Associated, will provide as an in-kind contribution the necessary time of expert researchers to train and guide the students. In total about 500 PM will be made available in-kind by the Institutes, matching the 500 PM funded by MuCol EU funds for a total of ~1000 PM for the whole MuCol project.

Table 3.1f: Summary of staff effort

The detail of beneficiaries PM per WP is given in Part A. Here, the cells in green show participation of the Institution based on own funds that will not be claimed to EU, but that will be committed to the Consortium for monitoring by each institute in signing the Collaboration agreement if MuCol is selected for funding. The total value of the project is estimated to about 10 MCHF, with the following share: 30% EU (claimed funds), 30% CERN, 40% all other Institutes. In particular all Institutes will ensure funds to provide PhD and PostDoc contracts in line with at least the minimal legal duration (typically 3 years for PhD students, 2 years for PostDocs). CERN will invest PMs in all the Technical WPs, and will ensure availability of Senior Scientists for Scientific, Technical and Administrative Coordination as required by the project. Regarding WP1, the work will be performed mainly on CERN own resources, with an estimated of 35PM of existing personnel for high level coordination tasks.
The table shows visually that for every WP there is sufficient availability of partners that can work on each topic and eventually compensate the sudden withdrawal of one of the partners.

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8
CERN	x	x	x	x	x	x	x	x
DESY	x	x						
TUDa	x						x	
UROS	x					x		
CEA	x	x			x	x	x	
INFN	x	x		x	x	x	x	x
UMIL	x			x			x	x
UNIPD	x	x						
UT-WENTE	x						x	
LIP	x	x						
ESS	x		x					
UU	x		x					
Imperial	x			x				x
UKRI	x			x				x
UWAR	x			x				
ULA	x					x		
SOTON	x						x	
UOS	x	x						
PSI	x						x	
UNIGE	x						x	
SYSU	x	x						
KIT	x						x	
CNRS	x						x	
ENEA	x			x				
UNIBO	x						x	
UNIPV	x	x						
Strath-clyde	x					x		
HUD	x				x			
RHLU	x				x			
UOXF	x				x			
ISU	x	x						
BNL	x				x			

Table 3.1g: 'Subcontracting costs' items

No partner has foreseen Subcontracting

Table 3.1h: 'Purchase costs' items (travel and subsistence, equipment and other goods, works and services)

Participant Number/Short Name 1/CERN		
	Cost (€)	**Justification**
Travel and subsistence	40,000.00	Participation to projects meetings and events., visit to partners
Equipment		
Other goods, works and services	128,000.00	Administrative support to CERN. *We consider the administrative support as being a service and not subcontracting as we do not subcontract specific tasks, but we have a fraction of a person dedicated to generic administrative tasks such as support to the organisation of meetings and workshops, follow-up of deliverables and milestones (intended as the person who collects and integrates in a single file parts of reports in due time from different contributors), formatting of documents, storage of documents in our Document Management Systems etc…*
Remaining purchase costs (<15% of pers. Costs)		
Total	168,000.00	

Participant Number/Short Name 8/UNIPD		
	Cost (€)	**Justification**
Travel and subsistence	20,000	Participation to projects meetings and events., and to invite experts
Equipment		
Other goods, works and services		
Remaining purchase costs (<15% of pers. Costs)		
Total	20,000.00	

Participant Number/Short Name 12/UU		
	Cost (€)	**Justification**
Travel and subsistence	5,000.00	Participation to projects meetings and events.
Equipment		
Other goods, works and services		
Remaining purchase costs (<15% of pers. Costs)		
Total	5,000.00	

Table 3.1i: 'Other costs categories' items (e.g. internally invoiced goods and services)

No partner has foreseen any other cost categories

Table 3.1j: 'In-kind contributions' provided by third parties

No In-kind contribution is foreseen at this stage.

Table 3.1 k: Associated Partners resources

Participant Number/Short Name 13/PSI		
	Cost (€)	**Manpower (Person/Month)**
A. Personnel costs	209,565.00	36
B. Subcontracting costs	0.00	
C. Purchase costs	12,000.00	
D. Other direct costs	0.00	
E. Indirect costs	55,391.25	
Total costs	**276,956.25**	

Participant Number/Short Name 14/UNIGE		
	Cost (€)	**Manpower (Person/Month)**
A. Personnel costs	175,200.00	24
B. Subcontracting costs	0.00	
C. Purchase costs	40,000.00	
D. Other direct costs	0.00	
E. Indirect costs	53,800.00	
Total costs	**269,000.00**	

Participant Number/Short Name 15/Imperial		
	Cost (€)	**Manpower (Person/Month)**
A. Personnel costs	246,000.00	34.5
B. Subcontracting costs	0.00	
C. Purchase costs	1,200.00	
D. Other direct costs	0.00	
E. Indirect costs	61,800.00	
Total costs	**309,000.00**	

Participant Number/Short Name 16/UKRI		
	Cost (€)	**Manpower (Person/Month)**
A. Personnel costs	147,800.00	28.6
B. Subcontracting costs	0.00	
C. Purchase costs	9,000.00	
D. Other direct costs	0.00	
E. Indirect costs	39,200.00	
Total costs	**196,000.00**	

Participant Number/Short Name 17/UWAR		
	Cost (€)	**Manpower (Person/Month)**
A. Personnel costs	37,800.00	21
B. Subcontracting costs	0.00	
C. Purchase costs	2,200.00	
D. Other direct costs	0.00	
E. Indirect costs	10,000.00	
Total costs	**50,000.00**	

Participant Number/Short Name 18/ULA		
	Cost (€)	**Manpower (Person/Month)**
A. Personnel costs	80,000.00	36
B. Subcontracting costs	0.00	
C. Purchase costs	0.00	
D. Other direct costs	0.00	
E. Indirect costs	20,000.00	
Total costs	**100,000.00**	

Participant Number/Short Name 19/SOTON		
	Cost (€)	**Manpower (Person/Month)**
A. Personnel costs	80,000.00	42
B. Subcontracting costs	0.00	
C. Purchase costs	0.00	
D. Other direct costs	0.00	
E. Indirect costs	20,000.00	
Total costs	**100,000.00**	

Participant Number/Short Name 20/UOS		
	Cost (€)	**Manpower (Person/Month)**
A. Personnel costs	40,000.00	12
B. Subcontracting costs	0.00	
C. Purchase costs	0.00	
D. Other direct costs	0.00	
E. Indirect costs	10,000.00	
Total costs	**50,000.00**	

3.2. Capacity of participants and consortium as a whole

The consortium comprises 32 Institutes out of which 18 are Beneficiaries and 14 Associates. The idea to setup a European Project to perform a design study of a Muon Collider has raised a lot of interest in several scientific communities, and the Consortium that has been setup has already reached the goal of enlarging the scope of the Muon Collider Collaboration to new Institutes and different fields of science. The Consortium will comprise in fact Laboratories and Universities from the following fields:

- High Energy Physics
- Accelerator Physics
- Spallation Neutron Sources
- Fission/fusion nuclear technologies
- High Field Magnets for medical applications and material studies

CERN will coordinate the project, in line with its mandate to coordinate at European level the efforts of R&D in accelerator physics and Technology. The goal of CERN's coordination will be to ensure coherence with the goals of the European R&D roadmap, in order to ensure that MuCol will deliver results that will critically impact the next ESPPU. CERN will also participate with in-kind resources in almost all the workpackages, and will serve as a host for the consortium for general meetings and events. CERN has a long experience in managing complex studies of Accelerator physics and technology, and has developed over the years tools for collaborative work that will be put at the disposal of the consortium.

The Consortium will comprise a balanced mix of Laboratories, some of them with specific competencies such as ENEA for liquid metal loops, and LNCMI for high field solenoids. Other laboratories have a vast experience and spectrum of competences in Accelerator physics and technology (e.g. INFN, CEA, UKRI, ESS). Finally the Consortium is complemented with Universities, that will provide the link to academia, will bridge the gap towards young generation of researchers, providing opportunities for direct dissemination through public lectures and seminars, and providing high level scientific support to the studies in MuCol, but also a platform to hire the required PhD students and PostDocs.

This large consortium will provide opportunities for discussion and exchange of know-how among experts, ensuring that all results will be peer-reviewed already internally because of the nature of the consortium itself. The contiguity with the larger International Muon collaboration, comprising also other universities and laboratories, and in particular institutes from US and Japan, will ensure that the progress and the results of MuCol will be of the highest quality standards.

Every institute has promised resources to MuCol and those resources will be committed through a Consortium agreement to be signed by every participant, to secure a sufficient level of Person Months to achieve the goals of Mucol and supervise the young researchers. Every workpackage is covered by more than one institution, this structure will ensure also a low level of risk since every Institute will be ready to take over more responsibilities in the unlikely case that one of the institutions will have to withdraw from MuCol.

ANNEX 2

ESTIMATED BUDGET FOR THE ACTION

	Estimated eligible[1] costs (per budget category)										Estimated EU contribution[2]			
	Direct costs								Indirect costs	Total costs	EU contribution to eligible costs			Maximum grant amount[6]
	A. Personnel costs			B. Subcontracting costs	C. Purchase costs			D. Other cost categories	E. Indirect costs[3]		Funding rate %[4]	Maximum EU contribution[5]	Requested EU contribution	
	A.1 Employees (or equivalent) A.2 Natural persons under direct contract A.3 Seconded persons		A.4 SME owners and natural person beneficiaries	B. Subcontracting	C.1 Travel and subsistence	C.2 Equipment	C.3 Other goods, works and services	D.2 Internally invoiced goods and services	E. Indirect costs					
Forms of funding	Actual costs	Unit costs (usual accounting practices)	Unit costs[7]	Actual costs	Actual costs	Actual costs	Actual costs	Unit costs (usual accounting practices)	Flat-rate costs[8]					
	a1	a2	a3	b	c1	c2	c3	d2	e = 0,25 * (a1 + a2 + a3 + c1 + c2 + c3)	f = a + b + c + d + e	U	g = f * U%	h	m
1 - CERN	0.00	0.00	0.00	0.00	40 000.00	0.00	128 000.00	0.00	42 000.00	210 000.00	100	210 000.00	210 000.00	210 000.00
2 - DESY	40 000.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10 000.00	50 000.00	100	50 000.00	50 000.00	50 000.00
3 - TUDA	96 216.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24 054.00	120 270.00	100	120 270.00	120 000.00	120 000.00
4 - UROS	72 000.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18 000.00	90 000.00	100	90 000.00	90 000.00	90 000.00
5 - CEA	332 074.00	0.00	0.00	0.00	6 000.00	0.00	0.00	0.00	84 518.50	422 592.50	100	422 592.50	385 000.00	385 000.00
6 - INFN	362 000.00	0.00	0.00	0.00	18 000.00	0.00	28 000.00	0.00	102 000.00	510 000.00	100	510 000.00	510 000.00	510 000.00
7 - UMIL	230 000.00	0.00	0.00	0.00	10 000.00	0.00	0.00	0.00	60 000.00	300 000.00	100	300 000.00	300 000.00	300 000.00
8 - UNIPD	60 000.00	0.00	0.00	0.00	20 000.00	0.00	0.00	0.00	20 000.00	100 000.00	100	100 000.00	100 000.00	100 000.00
9 - UTWENTE	84 000.00	0.00	0.00	0.00	4 000.00	0.00	8 000.00	0.00	24 000.00	120 000.00	100	120 000.00	120 000.00	120 000.00
10 - LIP	30 000.00	0.00	0.00	0.00	2 000.00	0.00	0.00	0.00	8 000.00	40 000.00	100	40 000.00	40 000.00	40 000.00
11 - ESS	184 320.00	0.00	0.00	0.00	7 680.00	0.00	0.00	0.00	48 000.00	240 000.00	100	240 000.00	240 000.00	240 000.00
12 - UU	19 000.00	0.00	0.00	0.00	5 000.00	0.00	0.00	0.00	6 000.00	30 000.00	100	30 000.00	30 000.00	30 000.00
13 - PSI														
14 - UNIGE														
15 - Imperial														
16 - UKRI														
17 - UWAR														
18 - ULA														
19 - SOTON														
20 - UOS														
21 - SYSU														
22 - KIT														
23 - CNRS														
24 - ENEA														
25 - UNIBO														
26 - UNIPV														
27 - STRATHCLYDE														
28 - HUD														
29 - RHUL														
30 - UOXF														
31 - ISU														
32 - BNL														

	Estimated eligible[1] costs (per budget category)										Estimated EU contribution[2]			
	Direct costs								Indirect costs	Total costs	EU contribution to eligible costs			Maximum grant amount[6]
	A. Personnel costs			B. Subcontracting costs	C. Purchase costs			D. Other cost categories	E. Indirect costs[3]		Funding rate %[4]	Maximum EU contribution[5]	Requested EU contribution	
	A.1 Employees (or equivalent) A.2 Natural persons under direct contract A.3 Seconded persons		A.4 SME owners and natural person beneficiaries	B. Subcontracting	C.1 Travel and subsistence	C.2 Equipment	C.3 Other goods, works and services	D.2 Internally invoiced goods and services	E. Indirect costs					
Forms of funding	Actual costs	Unit costs (usual accounting practices)	Unit costs[7]	Actual costs	Actual costs	Actual costs	Actual costs	Unit costs (usual accounting practices)	Flat-rate costs[8]					
	a1	a2	a3	b	c1	c2	c3	d2	e = 0,25 * (a1 + a2 + a3 + c1 + c2 + c3)	f = a + b + c + d + e	U	g = f * U%	h	m
Σ consortium	1 509 610.00	0.00	0.00	0.00	112 680.00	0.00	164 000.00	0.00	446 572.50	2 232 862.50		2 232 862.50	2 195 000.00	2 195 000.00

[1] See Article 6 for the eligibility conditions. All amounts must be expressed in EUR (see Article 21 for the conversion rules).
[2] The consortium remains free to decide on a different internal distribution of the EU funding (via the consortium agreement; see Article 7).
[3] Indirect costs already covered by an operating grant (received under any EU funding programme) are ineligible (see Article 6.3). Therefore, a beneficiary/affiliated entity that receives an operating grant during the action duration cannot declare indirect costs for the year(s)/reporting period(s) covered by the operating grant, unless they can demonstrate that the operating grant does not cover any costs of the action. This requires specific accounting tools. Please immediately contact us via the EU Funding & Tenders Portal for details.
[4] See Data Sheet for the funding rate(s).
[5] This is the theoretical amount of the EU contribution to costs, if the reimbursement rate is applied to all the budgeted costs. This theoretical amount is then capped by the 'maximum grant amount'.
[6] The 'maximum grant amount' is the maximum grant amount decided by the EU. It normally corresponds to the requested grant, but may be lower.
[7] See Annex 2a 'Additional information on the estimated budget' for the details (units, cost per unit).
[8] See Data Sheet for the flat-rate.

ANNEX 2a

ADDITIONAL INFORMATION ON UNIT COSTS AND CONTRIBUTIONS

SME owners/natural person beneficiaries without salary (Decision C(2020) 7115[1])

Type: unit costs

Units: days spent working on the action (rounded up or down to the nearest half-day)

Amount per unit (daily rate): calculated according to the following formula:

{EUR 5 080 / 18 days = **282,22**}
multiplied by
{country-specific correction coefficient of the country where the beneficiary is established}

The country-specific correction coefficients used are those set out in the Horizon Europe Work Programme (section Marie Skłodowska-Curie actions) in force at the time of the call (see Portal Reference Documents).

HE and Euratom Research Infrastructure actions[2]

Type: unit costs

Units[3]: see (for each access provider and installation) the unit cost table in Annex 2b

Amount per unit*: see (for each access provider and installation) the unit cost table in Annex 2b

* Amount calculated as follows:

For trans-national access:

$$\frac{\text{average annual total trans-national access costs to the installation (over past two years[4])}}{\text{average annual total quantity of trans-national access to the installation (over past two years[5])}}$$

For virtual access:

$$\frac{\text{total virtual access costs to the installation (over the last year[6])}}{\text{total quantity of virtual access to the installation (over the last year[7])}}$$

Euratom staff mobility costs[8]

Monthly living allowance

Type: unit costs

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1 Commission Decision of 20 October 2020 authorising the use of unit costs for the personnel costs of the owners of small and medium-sized enterprises and beneficiaries that are natural persons not receiving a salary for the work carried out by themselves under an action or work programme (C(2020)7715).

2 Decision of 19 April 2021 authorising the use of unit costs for the costs of providing trans-national and virtual access in Research Infrastructure actions under the Horizon Europe Programme (2021-2027) and the Research and Training Programme of the European Atomic Energy Community (2021-2025).

3 Unit of access (e.g. beam hours, weeks of access, sample analysis) fixed by the access provider in proposal.

4 In exceptional and duly justified cases, the granting authority may agree to a different reference period.

5 In exceptional and duly justified cases, the granting authority may agree to a different reference period.

6 In exceptional and duly justified cases, the granting authority may agree to a different reference period.

7 In exceptional and duly justified cases, the granting authority may agree to a different reference period.

8 Decision of 15 March 2021 authorising the use of unit costs for mobility in co-fund actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025).

Units: months spent by the seconded staff member(s) on research and training in fission and fusion activities (person-month)

Amount per unit*: see (for each beneficiary/affiliated entity and secondment) the unit cost table in Annex 2b

* Amount calculated as follows from 1 January 2021:
{**EUR 4 300** multiplied by
country-specific correction coefficient** of the country where the staff member is seconded}[9]

**Country-specific correction coefficients as from 1 January 2021[10]

EU-Member States[11]

Country / Place	Coefficient (%)
Bulgaria	59,1
Czech Rep.	85,2
Denmark	131,3
Germany Bonn Karlsruhe Munich	101,9 95,8 98 113,9
Estonia	82,3
Ireland	129
Greece	81,4
Spain	94,2
France	120,5
Croatia	75,8
Italy Varese	95 90,7
Cyprus	78,2
Latvia	77,5
Lithuania	76,6
Hungary	71,9
Malta	94,7
Netherlands	113,9
Austria	107,9
Poland	70,9
Portugal	91,1
Romania	66,6
Slovenia	86,1

[9] Unit costs for living allowances are calculated by using a method of calculation similar to that applied for the secondment to the European Commission of seconded national experts (SNEs).

[10] ⚠ For the financial statements, the amount must be adjusted according to the actual place of secondment.
The revised coefficients were adopted in the Decision authorising the use of unit costs for the Fusion Programme co-fund action under the Research and training Programme of the European Atomic Energy Community 2021-2025. They are based on the 2020 Annual update of the remuneration and pensions of the officials and other servants of the European Union and the correction coefficients applied thereto (OJ C 428, 11.12.2020) to ensure purchasing power parity. The revised coefficient are applied as from 1 January 2021 through an amendment to the grant agreement.

[11] No correction coefficient shall be applicable in Belgium and Luxembourg.

Slovakia	80,6
Finland	118,4
Sweden	124,3

Third countries

Country/place	Coefficient (%)
China	82,2
India	72,3
Japan	111,8
Russia	92,7
South Korea	92,3
Switzerland	129.2
Ukraine	82.3
United Kingdom	97.6
United States	101,4 (New-York) 90,5 (Washington)

Mobility allowance

Type: Unit costs

Units: months spent by the seconded staff member(s) on research and training in fission and fusion activities (person-month)

Amount per unit: **EUR 600** per person-month; see (for each beneficiary/affiliated entity and secondment) the unit cost table in Annex 2b

Family allowance

Type: unit costs

Units: months spent by the seconded staff member(s) on research and training in fission and fusion activities (person-month)

Amount per unit: **EUR 660** per person-month; see (for each beneficiary/affiliated entity and secondment) the unit cost table in Annex 2b

Education allowance

Type: Unit costs

Units: months spent by the seconded staff member(s) on research and training in fission and fusion activities (person-month)

Amount per unit*: see (for each beneficiary/affiliated entity and secondment) the unit cost table in Annex 2b

*Amount calculated as follows from 1 January 2021:
{EUR 283.82 x number of dependent children[12]**}**

[12] For the estimated budget (Annex 2): an average should be used. (⚠ For the financial statements, the number of children (and months) must be adjusted according to the actual family status at the moment the secondment starts.)

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY (DESY), PIC 999986969, established in NOTKESTRASSE 85, HAMBURG 22607, Germany,

hereby agrees

to become beneficiary

in Agreement No 101094300 — MuCol ('the Agreement')

between ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE (CERN) **and** the **European Research Executive Agency (REA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Susanne Hummel with ECAS id n007012z signed in the Participant Portal on 28/02/2023 at 18:02:43 (transaction id SigId-96417-azk5D RHzJy4rlCOZfuv2Bzf0Tb7nE0ZAN4zI5GkXYDEZZfUYOOkAdiZEwJGtZ ft0w3OV9yUDcaRg2EXewiLED8m-jpJZscgsw0KcAcndKkXAma-0QxG jlzgnmgbRcM5h3uzrZme0sT50N2mH6Msd0JzsnMP3wsXnTzlP9ZyJf c5jYG3KwzmVCE5vIRzSSs7Jr8679x0). Timestamp by third party at 2023.02.28 18:02:50 CET

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

TECHNISCHE UNIVERSITAT DARMSTADT (TUDA), PIC 999986581, established in KAROLINENPLATZ 5, DARMSTADT 64289, Germany,

hereby agrees

to become beneficiary

in Agreement No 101094300 — MuCol ('the Agreement')

between ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE (CERN) **and** the **European Research Executive Agency (REA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Manfred EFINGER with ECAS id nefimanf signed in the Participant Portal on 24/02/2023 at 14:57:46 (transaction id SigId-66731-tP67Do03L3PEACdmN3fPbnvO5jFpRRontd74Aawl2vzhuaH0oPMsRxv5M99yazvCmVBZjvAzlf9mdzWozJCELK4-jpJZscgsw0KcAcndKkXAma-N9EExGeAv4izzvisJm9OZdvziCppE2Q7snXVJNSLsqXtT9ulzzq6JiG2y5vRtkp7kGbPpUlzRPpN923gnCs8Di9m). Timestamp by third party at 2023.02.24 14:57:52 CET

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

UNIVERSITAET ROSTOCK (UROS), PIC 999852430, established in UNIVERSITATSPLATZ 1, ROSTOCK 18051, Germany,

hereby agrees

to become beneficiary

in Agreement No 101094300 — MuCol ('the Agreement')

between ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE (CERN) **and** the **European Research Executive Agency (REA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Tim Joppke with ECAS id n007w8do signed in the Participant Portal on 23/02/2023 at 12:24:45 (transaction id SigId-52735-KQzGr5zbdz TA0E8kfE8f0zsfrpr8enxuffSOn7ibhywvrjFJB1nFhOrzK9zRF1zSXCfYC PICjq6vmOxcDB5usvWi-jpJZscgsw0KcAcndKkXAma-zezmLsDAnRQ NT25PWChhqNrDI9qFGdl8HUAmUnfrHBxMmdgUuq0BfZLRhuGzz yXf7aBfzhuIla0zGfP3BizmgszP). Timestamp by third party at 2023.02.23 12:24:51 CET

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES (CEA), PIC 999992401, established in RUE LEBLANC 25, PARIS 15 75015, France,

hereby agrees

to become beneficiary

in Agreement No 101094300 — MuCol ('the Agreement')

between ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE (CERN) **and** the **European Research Executive Agency (REA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Gaelle DECROIX with ECAS id ndecroga signed in the Participant Portal on 28/02/2023 at 17:19:05 (transaction id SigId-95869-nqcc nRH7KHEhd2lczUog9u0rFBAEc1O1i3Y68qzIlpXS6IKa8j1Lft4KhdJ9x MXrr16bqPGtGPlQM3Aj8XoknE-jpJZscgsw0KcAcndKkXAma-NWd6 VGke4WaaMlBhdezHf4EuZ29lyUEXqDauljsVzQHQZ9Ap5jrRtCczM9 OrrlwgXZJbAzkAw3OGdJlQtiQy1sC). Timestamp by third party at 2023.02.28 17:19:14 CET

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

ISTITUTO NAZIONALE DI FISICA NUCLEARE (INFN), PIC 999992789, established in Via Enrico Fermi 54, FRASCATI 00044, Italy,

hereby agrees

to become beneficiary

in Agreement No 101094300 — MuCol ('the Agreement')

between ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE (CERN) **and** the **European Research Executive Agency (REA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Angelo RIVETTI with ECAS id nriettan signed in the Participant Portal on 27/02/2023 at 18:29:39 (transaction id SigId-83669-XVzVB WRrXAovrcw8nCywnrn4KwLzGgOPHTV9eDyy2h0fqhCYwgChrUcIs6 1yP2XPh2GuMO8o2jJ5DxJcx2YVNZ-jpJZscgsw0KcAcndKkXAma-6LDG agrzuqg248BGWuCwd0mUBfzsiW8EZ2H3SwAzL3zVXVYXSBsmVKkK f3aAUlT71BuiGIcSE2AVJGzNzdviQ0j0). Timestamp by third party at 2023.02.27 18:29:44 CET

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

UNIVERSITA DEGLI STUDI DI MILANO (UMIL), PIC 999995796, established in Via Festa Del Perdono 7, MILANO 20122, Italy,

hereby agrees

to become beneficiary

in Agreement No 101094300 — MuCol ('the Agreement')

between ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE (CERN) **and** the **European Research Executive Agency (REA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Elio FRANZINI with ECAS id nvagganl signed in the Participant Portal on 27/02/2023 at 10:52:49 (transaction id SigId-75177-CmUD75lzSoeB4xtOk4OszrQcMK972B0TcHQRAfGhMHnlvPin4CyTNdPDqcH41QK2FqpnUS2rDYSZIKaFRft3VJ-jpJZscgsw0KcAcndKkXAma-jzZSkxsYT7HWsxszMgqLKwWP199hbORuSCTqYR1dIeA5BsnAzWhCTt1IgARNxNxUL9rzGfQ10pZtjLn6RBALvi4). Timestamp by third party at 2023.02.27 10:52:53 CET

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

UNIVERSITA DEGLI STUDI DI PADOVA (UNIPD), PIC 999995602, established in VIA 8 FEBBRAIO 2, PADOVA 35122, Italy,

hereby agrees

to become beneficiary

in Agreement No 101094300 — MuCol ('the Agreement')

between ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE (CERN) **and** the **European Research Executive Agency (REA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Flavio Seno with ECAS id n002xv7o signed in the Participant Portal on 23/02/2023 at 16:54:02 (transaction id SigId-57553-IJTU7BriCumhWddMJX2GMYk6Kqkj4Is0ITYv9HbxErpZC20pVl3r725HOYEHR1K2TrSHnr3AcggemsoLGElFVW-jpJZscgsw0KcAcndKkXAma-B06tfZe0j5dyujy806zWWZvmYGXtgxi78GphM7pOWIFxZMwmvznRGx3pM9YWH6we3tAMxGtJ6AWdhuPmdAURry). Timestamp by third party at 2023.02.23 16:54:09 CET

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

UNIVERSITEIT TWENTE (UTWENTE), PIC 999900833, established in DRIENERLOLAAN 5, ENSCHEDE 7522 NB, Netherlands,

hereby agrees

to become beneficiary

in Agreement No 101094300 — MuCol ('the Agreement')

between ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE (CERN) **and** the **European Research Executive Agency (REA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Jan-Willem TIMMERMAN with ECAS id ntimmejm signed in the Participant Portal on 23/02/2023 at 15:38:11 (transaction id SigId-55952-65vrzLHQZSAgYvgzzXBgzOM2xqHUGi3JLrLHrrZPVhLSMmYqqNCIMDMbA2yYwcZzZ31957oyodtr2QwZy1D1H5r-jpJZscgsw0KcAcndKkXAma-XBnDzHBWrFBu7zHBbQCc1Xn6mXCfoNQtkzkG1zHcamBeLMHx5rUAGZVjn4Kx2lepoCHfeV7DqIEHNYsHztfJuwj). Timestamp by third party at 2023.02.23 15:38:17 CET

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

LABORATORIO DE INSTRUMENTACAO E FISICA EXPERIMENTAL DE PARTICULAS LIP (LIP), PIC 999661534, established in RUA LARGA 4 UNIVERSIDADE DE COIMBRA, COIMBRA 3004 516, Portugal,

hereby agrees

to become beneficiary

in Agreement No 101094300 — MuCol ('the Agreement')

between ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE (CERN) **and** the **European Research Executive Agency (REA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Mário PIMENTA with ECAS id npimenmr signed in the Participant Portal on 23/02/2023 at 13:02:17 (transaction id SigId-53236-qs4iEBfKzVwpHPHkinso1MSKYG5PpiYbtK384k0QlZuynV48c4dZvzwtMpDaWiezK8wanAzk0SDEav5O63zK8p5-jpJZscgsw0KcAcndKkXAma-2Ekr7uM6rziH4S2r1CIxN3gbzzaDKgeDcbjdztZzJ0stqtelsWZysQTopJupRXZnN1EsclqAgiV6TX47QUAyXXD). Timestamp by third party at 2023.02.23 13:02:24 CET

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

EUROPEAN SPALLATION SOURCE ERIC (ESS), PIC 919998053, established in ODARSLOVSVAGEN 113, LUND 224 84, Sweden,

hereby agrees

to become beneficiary

in Agreement No 101094300 — MuCol ('the Agreement')

between ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE (CERN) **and** the **European Research Executive Agency (REA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Helmut Schober with ECAS id n008h35v signed in the Participant Portal on 27/02/2023 at 12:38:52 (transaction id SigId-77479-Lx1AM BH5T2BxXqpM6kFmFFkIvpzzPJQ54MioGGqlAHffn2B0zJMt4zVbcjLn1 zQrddq4YfES0flqMKvn4n1dvQc-jpJZscgsw0KcAcndKkXAma-HGxTLT 5NTRCZ4mamOBsDyQiTeF527x4T0ysGILx0CzPzx5a6lEL4Qx5EnNje WjL5xpJzdoA0ifSWzWrU42zzUuMG). Timestamp by third party at 2023.02.27 12:38:56 CET

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

UPPSALA UNIVERSITET (UU), PIC 999985029, established in VON KRAEMERS ALLE 4, UPPSALA 751 05, Sweden,

hereby agrees

to become beneficiary

in Agreement No 101094300 — MuCol ('the Agreement')

between ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE (CERN) **and** the **European Research Executive Agency (REA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Per ABRAHAMSSON with ECAS id nabrahap signed in the Participant Portal on 23/02/2023 at 15:06:46 (transaction id SigId-55208-iQvvbLVX2vv3befW3FzSzV5jq7lMSWmy1ImuqwjWl5FUf1WPr60cJyh8Zw6MQlzdRCYCpzzXyD5XzzZolqSWlXne-jpJZscgsw0KcAcndKkXAma-fqMq2cNCE2MZTvZ0OWkHqZPykRKXC8ftLG6y3Nn9HpXl891Tk7pkEdpGZxNBwckAmoozv1qSdj9gXy6GDeJ7Iu). Timestamp by third party at 2023.02.23 15:06:54 CET

FINANCIAL STATEMENT FOR [PARTICIPANT NAME] FOR REPORTING PERIOD [NUMBER]

	Eligible[1] costs (per budget category)																	EU contribution[2]				Revenues
	Direct costs															Indirect costs	Total costs	EU contribution to eligible costs			Total requested EU contribution	Income generated by the action
	A. Personnel costs			B. Subcontracting costs	C. Purchase costs			D. Other cost categories								E. Indirect costs[2]		Funding rate %[3]	Maximum EU contribution[4]	Requested EU contribution		
	A.1 Employees (or equivalent) A.2 Natural persons under direct contract A.3 Seconded persons		A.4 SME owners and natural person beneficiaries	B. Subcontracting	C.1 Travel and subsistence	C.2 Equipment	C.3 Other goods, works and services	[D.1 Financial support to third parties]	D.2 Internally invoiced goods and services	[D.3 Transnational access to research infrastructure unit costs]	[D.4 Virtual access to research infrastructure unit costs]	*[OPTION for HE PCP/PPI:* D.5 PCP/PPI procurement costs*]*	*[OPTION for Euratom Programme Cofund Actions:* D.6 Euratom Cofund staff mobility costs*]*	*[OPTION for HE ERC Grants:* D.7 ERC additional funding*]*	*[OPTION for HE ERC Grants:* D.8 ERC additional funding (subcontracting, FSTP and internally invoiced goods and services)*]*	E. Indirect costs						
Forms of funding	Actual costs	Unit costs (usual accounting practices)	Unit costs[5]	Actual costs	Actual costs	Actual costs	Actual costs	[Actual costs]	Unit costs (usual accounting practices)	[Unit costs[5]]	[Unit costs[5]]	[Actual costs]	[Unit costs[5]]	[Actual costs]	[Actual costs]	Flat-rate costs[6]						
	a1	a2	a3	b	c1	c2	c3	[d1a]	d2	[d3]	[d4]	[d5]	[d6]	[d7]	[d8]	e = 0,25 * (a1 + a2 + a3 ~~+b+~~ c1 +c2 + c3 ~~+d1a + d2 + d3 + d4 [+ d5][+ d6]~~ [+d7] ~~[+ d8]~~)	f = a+b+c+d+e	U	g = f*U%	h	m	n
XX – [short name beneficiary/affiliated entity]																						

The beneficiary/affiliated entity hereby confirms that:

The information provided is complete, reliable and true.

The costs and contributions declared are eligible (see Article 6).

The costs and contributions can be substantiated by adequate records and supporting documentation that will be produced upon request or in the context of checks, reviews, audits and investigations (see Articles 19, 20 and 25).

For the last reporting period: that all the revenues have been declared (see Article 22).

① Please declare all eligible costs and contributions, even if they exceed the amounts indicated in the estimated budget (see Annex 2). Only amounts that were declared in your individual financial statements can be taken into account lateron, in order to replace costs/contributions that are found to be ineligible.

[1] See Article 6 for the eligibility conditions. All amounts must be expressed in EUR (see Article 21 for the conversion rules).

[2] If you have also received an EU operating grant during this reporting period, you cannot claim indirect costs - unless you can demonstrate that the operating grant does not cover any costs of the action. This requires specific accounting tools. Please contact us immediately via the Funding & Tenders Portal for details.

[3] See Data Sheet for the reimbursement rate(s).

[4] This is the *theoretical* amount of EU contribution to costs that the system calculates automatically (by multiplying the reimbursement rates by the costs declared). The amount you request (in the column 'requested EU contribution') may be less.

[5] See Annex 2a 'Additional information on the estimated budget' for the details (units, cost per unit).

[6] See Data Sheet for the flat-rate.

ANNEX 5

SPECIFIC RULES

CONFIDENTIALITY AND SECURITY (— ARTICLE 13)

Sensitive information with security recommendation

Sensitive information with a security recommendation must comply with the additional requirements imposed by the granting authority.

Before starting the action tasks concerned, the beneficiaries must have obtained all approvals or other mandatory documents needed for implementing the task. The documents must be kept on file and be submitted upon request by the coordinator to the granting authority. If they are not in English, they must be submitted together with an English summary.

For requirements restricting disclosure or dissemination, the information must be handled in accordance with the recommendation and may be disclosed or disseminated only after written approval from the granting authority.

EU classified information

If EU classified information is used or generated by the action, it must be treated in accordance with the security classification guide (SCG) and security aspect letter (SAL) set out in Annex 1 and Decision 2015/444[1] and its implementing rules — until it is declassified.

Deliverables which contain EU classified information must be submitted according to special procedures agreed with the granting authority.

Action tasks involving EU classified information may be subcontracted only with prior explicit written approval from the granting authority and only to entities established in an EU Member State or in a non-EU country with a security of information agreement with the EU (or an administrative arrangement with the Commission).

EU classified information may not be disclosed to any third party (including participants involved in the action implementation) without prior explicit written approval from the granting authority.

ETHICS (— ARTICLE 14)

Ethics and research integrity

The beneficiaries must carry out the action in compliance with:

- ethical principles (including the highest standards of research integrity)

[1] Commission Decision 2015/444/EC, Euratom of 13 March 2015 on the security rules for protecting EU classified information (OJ L 72, 17.3.2015, p. 53).

and

- applicable EU, international and national law, including the EU Charter of Fundamental Rights and the European Convention for the Protection of Human Rights and Fundamental Freedoms and its Supplementary Protocols.

No funding can be granted, within or outside the EU, for activities that are prohibited in all Member States. No funding can be granted in a Member State for an activity which is forbidden in that Member State.

The beneficiaries must pay particular attention to the principle of proportionality, the right to privacy, the right to the protection of personal data, the right to the physical and mental integrity of persons, the right to non-discrimination, the need to ensure protection of the environment and high levels of human health protection.

The beneficiaries must ensure that the activities under the action have an exclusive focus on civil applications.

The beneficiaries must ensure that the activities under the action do not:

- aim at human cloning for reproductive purposes
- intend to modify the genetic heritage of human beings which could make such modifications heritable (with the exception of research relating to cancer treatment of the gonads, which may be financed)
- intend to create human embryos solely for the purpose of research or for the purpose of stem cell procurement, including by means of somatic cell nuclear transfer, or
- lead to the destruction of human embryos (for example, for obtaining stem cells).

Activities involving research on human embryos or human embryonic stem cells may be carried out only if:

- they are set out in Annex 1 or
- the coordinator has obtained explicit approval (in writing) from the granting authority.

In addition, the beneficiaries must respect the fundamental principle of research integrity — as set out in the European Code of Conduct for Research Integrity[2].

This implies compliance with the following principles:

- reliability in ensuring the quality of research reflected in the design, the methodology, the analysis and the use of resources
- honesty in developing, undertaking, reviewing, reporting and communicating research in a transparent, fair and unbiased way

[2] European Code of Conduct for Research Integrity of ALLEA (All European Academies).

- respect for colleagues, research participants, society, ecosystems, cultural heritage and the environment

- accountability for the research from idea to publication, for its management and organisation, for training, supervision and mentoring, and for its wider impacts

and means that beneficiaries must ensure that persons carrying out research tasks follow the good research practices including ensuring, where possible, openness, reproducibility and traceability and refrain from the research integrity violations described in the Code.

Activities raising ethical issues must comply with the additional requirements formulated by the ethics panels (including after checks, reviews or audits; see Article 25).

Before starting an action task raising ethical issues, the beneficiaries must have obtained all approvals or other mandatory documents needed for implementing the task, notably from any (national or local) ethics committee or other bodies such as data protection authorities.

The documents must be kept on file and be submitted upon request by the coordinator to the granting authority. If they are not in English, they must be submitted together with an English summary, which shows that the documents cover the action tasks in question and includes the conclusions of the committee or authority concerned (if any).

VALUES (— ARTICLE 14)

Gender mainstreaming

The beneficiaries must take all measures to promote equal opportunities between men and women in the implementation of the action and, where applicable, in line with the gender equality plan. They must aim, to the extent possible, for a gender balance at all levels of personnel assigned to the action, including at supervisory and managerial level.

INTELLECTUAL PROPERTY RIGHTS (IPR) — BACKGROUND AND RESULTS — ACCESS RIGHTS AND RIGHTS OF USE (— ARTICLE 16)

Definitions

Access rights — Rights to use results or background.

Dissemination — The public disclosure of the results by appropriate means, other than resulting from protecting or exploiting the results, including by scientific publications in any medium.

Exploit(ation) — The use of results in further research and innovation activities other than those covered by the action concerned, including among other things, commercial exploitation such as developing, creating, manufacturing and marketing a product or process, creating and providing a service, or in standardisation activities.

Fair and reasonable conditions — Appropriate conditions, including possible financial terms or royalty-free conditions, taking into account the specific circumstances of the request for access, for example the actual or potential value of the results or background to which access is requested and/or the scope, duration or other characteristics of the exploitation envisaged.

FAIR principles — ‘findability’, ‘accessibility’, ‘interoperability’ and ‘reusability’.

Open access — Online access to research outputs provided free of charge to the end-user.

Open science — An approach to the scientific process based on open cooperative work, tools and diffusing knowledge.

Research data management — The process within the research lifecycle that includes the organisation, storage, preservation, security, quality assurance, allocation of persistent identifiers (PIDs) and rules and procedures for sharing of data including licensing.

Research outputs — Results to which access can be given in the form of scientific publications, data or other engineered results and processes such as software, algorithms, protocols, models, workflows and electronic notebooks.

Scope of the obligations

For this section, references to ‘beneficiary’ or ‘beneficiaries’ do not include affiliated entities (if any).

Agreement on background

The beneficiaries must identify in a written agreement the background as needed for implementing the action or for exploiting its results.

Where the call conditions restrict control due to strategic interests reasons, background that is subject to control or other restrictions by a country (or entity from a country) which is not one of the eligible countries or target countries set out in the call conditions and that impact the exploitation of the results (i.e. would make the exploitation of the results subject to control or restrictions) must not be used and must be explicitly excluded from it in the agreement on background — unless otherwise agreed with the granting authority.

Ownership of results

Results are owned by the beneficiaries that generate them.

However, two or more beneficiaries own results jointly if:

- they have jointly generated them and
- it is not possible to:
    - establish the respective contribution of each beneficiary, or
    - separate them for the purpose of applying for, obtaining or maintaining their protection.

The joint owners must agree — in writing — on the allocation and terms of exercise of their joint ownership (‘**joint ownership agreement**’), to ensure compliance with their obligations under this Agreement.

Unless otherwise agreed in the joint ownership agreement or consortium agreement, each joint owner may grant non-exclusive licences to third parties to exploit the jointly-owned results (without any right to sub-license), if the other joint owners are given:

- at least 45 days advance notice and
- fair and reasonable compensation.

The joint owners may agree — in writing — to apply another regime than joint ownership.

If third parties (including employees and other personnel) may claim rights to the results, the beneficiary concerned must ensure that those rights can be exercised in a manner compatible with its obligations under the Agreement.

The beneficiaries must indicate the owner(s) of the results (results ownership list) in the final periodic report.

Protection of results

Beneficiaries which have received funding under the grant must adequately protect their results — for an appropriate period and with appropriate territorial coverage — if protection is possible and justified, taking into account all relevant considerations, including the prospects for commercial exploitation, the legitimate interests of the other beneficiaries and any other legitimate interests.

Exploitation of results

Beneficiaries which have received funding under the grant must — up to four years after the end of the action (see Data Sheet, Point 1) — use their best efforts to exploit their results directly or to have them exploited indirectly by another entity, in particular through transfer or licensing.

If, despite a beneficiary's best efforts, the results are not exploited within one year after the end of the action, the beneficiaries must (unless otherwise agreed in writing with the granting authority) use the Horizon Results Platform to find interested parties to exploit the results.

If results are incorporated in a standard, the beneficiaries must (unless otherwise agreed with the granting authority or unless it is impossible) ask the standardisation body to include the funding statement (see Article 17) in (information related to) the standard.

Additional exploitation obligations

Where the call conditions impose additional exploitation obligations (including obligations linked to the restriction of participation or control due to strategic assets, interests, autonomy or security reasons), the beneficiaries must comply with them — up to four years after the end of the action (see Data Sheet, Point 1).

Where the call conditions impose additional exploitation obligations in case of a public emergency, the beneficiaries must (if requested by the granting authority) grant for a limited period of time specified in the request, non-exclusive licences — under fair and reasonable conditions — to their results to legal entities that need the results to address the public emergency and commit to rapidly and broadly exploit the resulting products and services at fair and reasonable conditions. This provision applies up to four years after the end of the action (see Data Sheet, Point 1).

Additional information obligation relating to standards

Where the call conditions impose additional information obligations relating to possible standardisation, the beneficiaries must — up to four years after the end of the action (see Data Sheet, Point 1) — inform the granting authority, if the results could reasonably be expected to contribute to European or international standards.

Transfer and licensing of results

Transfer of ownership

The beneficiaries may transfer ownership of their results, provided this does not affect compliance with their obligations under the Agreement.

The beneficiaries must ensure that their obligations under the Agreement regarding their results are passed on to the new owner and that this new owner has the obligation to pass them on in any subsequent transfer.

Moreover, they must inform the other beneficiaries with access rights of the transfer at least 45 days in advance (or less if agreed in writing), unless agreed otherwise in writing for specifically identified third parties including affiliated entities or unless impossible under the applicable law. This notification must include sufficient information on the new owner to enable the beneficiaries concerned to assess the effects on their access rights. The beneficiaries may object within 30 days of receiving notification (or less if agreed in writing), if they can show that the transfer would adversely affect their access rights. In this case, the transfer may not take place until agreement has been reached between the beneficiaries concerned.

Granting licences

The beneficiaries may grant licences to their results (or otherwise give the right to exploit them), including on an exclusive basis, provided this does not affect compliance with their obligations.

Exclusive licences for results may be granted only if all the other beneficiaries concerned have waived their access rights.

Granting authority right to object to transfers or licensing — Horizon Europe actions

Where the call conditions in Horizon Europe actions provide for the right to object to transfers or licensing, the granting authority may — up to four years after the end of the action (see Data Sheet, Point 1) — object to a transfer of ownership or the exclusive licensing of results, if:

- the beneficiaries which generated the results have received funding under the grant
- it is to a legal entity established in a non-EU country not associated with Horizon Europe, and
- the granting authority considers that the transfer or licence is not in line with EU interests.

Beneficiaries that intend to transfer ownership or grant an exclusive licence must formally notify the granting authority before the intended transfer or licensing takes place and:

- identify the specific results concerned
- describe in detail the new owner or licensee and the planned or potential exploitation of the results, and
- include a reasoned assessment of the likely impact of the transfer or licence on EU interests, in particular regarding competitiveness as well as consistency with ethical principles and security considerations.

The granting authority may request additional information.

If the granting authority decides to object to a transfer or exclusive licence, it must formally notify the beneficiary concerned within 60 days of receiving notification (or any additional information it has requested).

No transfer or licensing may take place in the following cases:

- pending the granting authority decision, within the period set out above
- if the granting authority objects
- until the conditions are complied with, if the granting authority objection comes with conditions.

A beneficiary may formally notify a request to waive the right to object regarding intended transfers or grants to a specifically identified third party, if measures safeguarding EU interests are in place. If the granting authority agrees, it will formally notify the beneficiary concerned within 60 days of receiving notification (or any additional information requested).

Granting authority right to object to transfers or licensing — Euratom actions

Where the call conditions in Euratom actions provide for the right to object to transfers or licensing, the granting authority may — up to four years after the end of the action (see Data Sheet, Point 1) — object to a transfer of ownership or the exclusive or non-exclusive licensing of results, if:

- the beneficiaries which generated the results have received funding under the grant
- it is to a legal entity established in a non-EU country not associated to the Euratom Research and Training Programme 2021-2025 and
- the granting authority considers that the transfer or licence is not in line with the EU interests.

Beneficiaries that intend to transfer ownership or grant a licence must formally notify the granting authority before the intended transfer or licensing takes place and:

- identify the specific results concerned
- describe in detail the results, the new owner or licensee and the planned or potential exploitation of the results, and
- include a reasoned assessment of the likely impact of the transfer or licence on EU interests, in particular regarding competitiveness as well as consistency with

ethical principles and security considerations (including the defence interests of the EU Member States under Article 24 of the Euratom Treaty).

The granting authority may request additional information.

If the granting authority decides to object to a transfer or licence, it will formally notify the beneficiary concerned within 60 days of receiving notification (or any additional information requested).

No transfer or licensing may take place in the following cases:

- pending the granting authority decision, within the period set out above
- if the granting authority objects
- until the conditions are complied with, if the granting authority objection comes with conditions.

A beneficiary may formally notify a request to waive the right to object regarding intended transfers or grants to a specifically identified third party, if measures safeguarding EU interests are in place. If the granting authority agrees, it will formally notify the beneficiary concerned within 60 days of receiving notification (or any additional information requested).

Limitations to transfers and licensing due to strategic assets, interests, autonomy or security reasons of the EU and its Member States

Where the call conditions restrict participation or control due to strategic assets, interests, autonomy or security reasons, the beneficiaries may not transfer ownership of their results or grant licences to third parties which are established in countries which are not eligible countries or target countries set out in the call conditions (or, if applicable, are controlled by such countries or entities from such countries) — unless they have requested and received prior approval by the granting authority.

The request must:

- identify the specific results concerned
- describe in detail the new owner and the planned or potential exploitation of the results, and
- include a reasoned assessment of the likely impact of the transfer or license on the strategic assets, interests, autonomy or security of the EU and its Member States.

The granting authority may request additional information.

Access rights to results and background

Exercise of access rights — Waiving of access rights — No sub-licensing

Requests to exercise access rights and the waiver of access rights must be in writing.

Unless agreed otherwise in writing with the beneficiary granting access, access rights do not include the right to sub-license.

If a beneficiary is no longer involved in the action, this does not affect its obligations to grant access.

If a beneficiary defaults on its obligations, the beneficiaries may agree that that beneficiary no longer has access rights.

Access rights for implementing the action

The beneficiaries must grant each other access — on a royalty-free basis — to background needed to implement their own tasks under the action, unless the beneficiary that holds the background has — before acceding to the Agreement —:

- informed the other beneficiaries that access to its background is subject to restrictions, or

- agreed with the other beneficiaries that access would not be on a royalty-free basis.

The beneficiaries must grant each other access — on a royalty-free basis — to results needed for implementing their own tasks under the action.

Access rights for exploiting the results

The beneficiaries must grant each other access — under fair and reasonable conditions — to results needed for exploiting their results.

The beneficiaries must grant each other access — under fair and reasonable conditions — to background needed for exploiting their results, unless the beneficiary that holds the background has — before acceding to the Agreement — informed the other beneficiaries that access to its background is subject to restrictions.

Requests for access must be made — unless agreed otherwise in writing — up to one year after the end of the action (see Data Sheet, Point 1).

Access rights for entities under the same control

Unless agreed otherwise in writing by the beneficiaries, access to results and, subject to the restrictions referred to above (if any), background must also be granted — under fair and reasonable conditions — to entities that:

- are established in an EU Member State or Horizon Europe associated country

- are under the direct or indirect control of another beneficiary, or under the same direct or indirect control as that beneficiary, or directly or indirectly controlling that beneficiary and

- need the access to exploit the results of that beneficiary.

Unless agreed otherwise in writing, such requests for access must be made by the entity directly to the beneficiary concerned.

Requests for access must be made — unless agreed otherwise in writing — up to one year after the end of the action (see Data Sheet, Point 1).

Access rights for the granting authority, EU institutions, bodies, offices or agencies and national authorities to results for policy purposes — Horizon Europe actions

In Horizon Europe actions, the beneficiaries which have received funding under the grant must grant access to their results — on a royalty-free basis — to the granting authority, EU institutions, bodies, offices or agencies for developing, implementing and monitoring EU policies or programmes. Such access rights do not extend to beneficiaries' background.

Such access rights are limited to non-commercial and non-competitive use.

For actions under the cluster 'Civil Security for Society', such access rights also extend to national authorities of EU Member States for developing, implementing and monitoring their policies or programmes in this area. In this case, access is subject to a bilateral agreement to define specific conditions ensuring that:

- the access rights will be used only for the intended purpose and
- appropriate confidentiality obligations are in place.

Moreover, the requesting national authority or EU institution, body, office or agency (including the granting authority) must inform all other national authorities of such a request.

Access rights for the granting authority, Euratom institutions, funding bodies or the Joint Undertaking Fusion for Energy — Euratom actions

In Euratom actions, the beneficiaries which have received funding under the grant must grant access to their results — on a royalty-free basis — to the granting authority, Euratom institutions, funding bodies or the Joint Undertaking Fusion for Energy for developing, implementing and monitoring Euratom policies and programmes or for compliance with obligations assumed through international cooperation with non-EU countries and international organisations.

Such access rights include the right to authorise third parties to use the results in public procurement and the right to sub-license and are limited to non-commercial and non-competitive use.

Additional access rights

Where the call conditions impose additional access rights, the beneficiaries must comply with them.

COMMUNICATION, DISSEMINATION, OPEN SCIENCE AND VISIBILITY (— ARTICLE 17)

Dissemination

Dissemination of results

The beneficiaries must disseminate their results as soon as feasible, in a publicly available format, subject to any restrictions due to the protection of intellectual property, security rules or legitimate interests.

A beneficiary that intends to disseminate its results must give at least 15 days advance notice to the other beneficiaries (unless agreed otherwise), together with sufficient information on the results it will disseminate.

Any other beneficiary may object within (unless agreed otherwise) 15 days of receiving notification, if it can show that its legitimate interests in relation to the results or background would be significantly harmed. In such cases, the results may not be disseminated unless appropriate steps are taken to safeguard those interests.

Additional dissemination obligations

Where the call conditions impose additional dissemination obligations, the beneficiaries must also comply with those.

Open Science

Open science: open access to scientific publications

The beneficiaries must ensure open access to peer-reviewed scientific publications relating to their results. In particular, they must ensure that:

- at the latest at the time of publication, a machine-readable electronic copy of the published version or the final peer-reviewed manuscript accepted for publication, is deposited in a trusted repository for scientific publications

- immediate open access is provided to the deposited publication via the repository, under the latest available version of the Creative Commons Attribution International Public Licence (CC BY) or a licence with equivalent rights; for monographs and other long-text formats, the licence may exclude commercial uses and derivative works (e.g. CC BY-NC, CC BY-ND) and

- information is given via the repository about any research output or any other tools and instruments needed to validate the conclusions of the scientific publication.

Beneficiaries (or authors) must retain sufficient intellectual property rights to comply with the open access requirements.

Metadata of deposited publications must be open under a Creative Common Public Domain Dedication (CC 0) or equivalent, in line with the FAIR principles (in particular machine-actionable) and provide information at least about the following: publication (author(s), title, date of publication, publication venue); Horizon Europe or Euratom funding; grant project name, acronym and number; licensing terms; persistent identifiers for the publication, the authors involved in the action and, if possible, for their organisations and the grant. Where applicable, the metadata must include persistent identifiers for any research output or any other tools and instruments needed to validate the conclusions of the publication.

Only publication fees in full open access venues for peer-reviewed scientific publications are eligible for reimbursement.

Open science: research data management

The beneficiaries must manage the digital research data generated in the action ('data') responsibly, in line with the FAIR principles and by taking all of the following actions:

- establish a data management plan ('DMP') (and regularly update it)

- as soon as possible and within the deadlines set out in the DMP, deposit the data in a trusted repository; if required in the call conditions, this repository must be federated in the EOSC in compliance with EOSC requirements

- as soon as possible and within the deadlines set out in the DMP, ensure open access — via the repository — to the deposited data, under the latest available version of the Creative Commons Attribution International Public License (CC BY) or Creative Commons Public Domain Dedication (CC 0) or a licence with equivalent rights, following the principle 'as open as possible as closed as necessary', unless providing open access would in particular:

    - be against the beneficiary's legitimate interests, including regarding commercial exploitation, or

    - be contrary to any other constraints, in particular the EU competitive interests or the beneficiary's obligations under this Agreement; if open access is not provided (to some or all data), this must be justified in the DMP

- provide information via the repository about any research output or any other tools and instruments needed to re-use or validate the data.

Metadata of deposited data must be open under a Creative Common Public Domain Dedication (CC 0) or equivalent (to the extent legitimate interests or constraints are safeguarded), in line with the FAIR principles (in particular machine-actionable) and provide information at least about the following: datasets (description, date of deposit, author(s), venue and embargo); Horizon Europe or Euratom funding; grant project name, acronym and number; licensing terms; persistent identifiers for the dataset, the authors involved in the action, and, if possible, for their organisations and the grant. Where applicable, the metadata must include persistent identifiers for related publications and other research outputs.

Open science: additional practices

Where the call conditions impose additional obligations regarding open science practices, the beneficiaries must also comply with those.

Where the call conditions impose additional obligations regarding the validation of scientific publications, the beneficiaries must provide (digital or physical) access to data or other results needed for validation of the conclusions of scientific publications, to the extent that their legitimate interests or constraints are safeguarded (and unless they already provided the (open) access at publication).

Where the call conditions impose additional open science obligations in case of a public emergency, the beneficiaries must (if requested by the granting authority) immediately deposit any research output in a repository and provide open access to it under a CC BY licence, a Public Domain Dedication (CC 0) or equivalent. As an exception, if the access would be against the beneficiaries' legitimate interests, the beneficiaries must grant non-exclusive licenses — under fair and reasonable conditions — to legal entities that need the research output to address the public emergency and commit to rapidly and broadly exploit the resulting products and services at fair and reasonable conditions. This provision applies up to four years after the end of the action (see Data Sheet, Point 1).

Plan for the exploitation and dissemination of results including communication activities

Unless excluded by the call conditions, the beneficiaries must provide and regularly update a plan for the exploitation and dissemination of results including communication activities.

SPECIFIC RULES FOR CARRYING OUT THE ACTION (— ARTICLE 18)

Implementation in case of restrictions due to strategic assets, interests, autonomy or security of the EU and its Member States

Where the call conditions restrict participation or control due to strategic assets, interests, autonomy or security, the beneficiaries must ensure that none of the entities that participate as affiliated entities, associated partners, subcontractors or recipients of financial support to third parties are established in countries which are not eligible countries or target countries set out in the call conditions (or, if applicable, are controlled by such countries or entities from such countries) — unless otherwise agreed with the granting authority.

The beneficiaries must moreover ensure that any cooperation with entities established in countries which are not eligible countries or target countries set out in the call conditions (or, if applicable, are controlled by such countries or entities from such countries) does not affect the strategic assets, interests, autonomy or security of the EU and its Member States.

Recruitment and working conditions for researchers

The beneficiaries must take all measures to implement the principles set out in the Commission Recommendation on the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers[3], in particular regarding:

- working conditions
- transparent recruitment processes based on merit, and
- career development.

The beneficiaries must ensure that researchers and all participants involved in the action are aware of them.

Specific rules for access to research infrastructure activities

Definitions

Research Infrastructures — Facilities that provide resources and services for the research communities to conduct research and foster innovation in their fields. This definition includes the associated human resources, and it covers major equipment or sets of instruments; knowledge-related facilities such as collections, archives or scientific data infrastructures; computing systems, communication networks, and any other infrastructure, of a unique nature and open to external users, essential to achieve excellence in research and innovation. Where relevant, they may be used beyond research, for example

[3] Commission Recommendation 2005/251/EC of 11 March 2005 on the European Charter for Researchers and on a Code of Conduct for the Recruitment of Researchers (OJ L 75, 22.3.2005, p. 67).

for education or public services, and they may be 'single-sited', 'virtual' or 'distributed'[4]:

When implementing access to research infrastructure activities, the beneficiaries must respect the following conditions:

- for transnational access:
  - access which must be provided:

    The access must be free of charge, transnational access to research infrastructure or installations for selected user-groups.

    The access must include the logistical, technological and scientific support and the specific training that is usually provided to external researchers using the infrastructure. Transnational access can be either in person (hands-on), provided to selected users that visit the installation to make use of it, or remote, through the provision to selected user-groups of remote scientific services (e.g. provision of reference materials or samples, remote access to a high-performance computing facility).

  - categories of users that may have access:

    Transnational access must be provided to selected user-groups, i.e. teams of one or more researchers (users).

    The majority of the users must work in a country other than the country(ies) where the installation is located (unless access is provided by an international organisation, the Joint Research Centre (JRC), an ERIC or similar legal entity).

    Only user groups that are allowed to disseminate the results they have generated under the action may benefit from the access (unless the users are working for SMEs).

    Access for user groups with a majority of users not working in a EU Member State or Horizon Europe associated country is limited to 20% of the total amount of units of access provided under the grant (unless a higher percentage is foreseen in Annex 1).

  - procedure and criteria for selecting user groups:

    The user groups must request access by submitting (in writing) a description of the work that they wish to carry out and the names, nationalities and home institutions of the users.

    The user groups must be selected by (one or more) selection panels set up by the consortium.

[4] See Article 2(1) of the Horizon Europe Framework Programme Regulation 2021/695.

The selection panels must be composed of international experts in the field, at least half of them independent from the consortium (unless otherwise specified in Annex 1).

The selection panels must assess all proposals received and recommend a short-list of the user groups that should benefit from access.

The selection panels must base their selection on scientific merit, taking into account that priority should be given to user groups composed of users who:

- have not previously used the installation and
- are working in countries where no equivalent research infrastructure exist.

It will apply the principles of transparency, fairness and impartiality.

Where the call conditions impose additional rules for the selection of user groups, the beneficiaries must also comply with those.

- other conditions:

The beneficiaries must request written approval from the granting authority for the selection of user groups requiring visits to the installations exceeding 3 months (unless such visits are foreseen in Annex 1).

In addition, the beneficiaries must:

- advertise widely, including on a their websites, the access offered under the Agreement
- promote equal opportunities in advertising the access and take into account the gender dimension when defining the support provided to users
- ensure that users comply with the terms and conditions of the Agreement
- ensure that its obligations under Articles 12, 13, 17 and 33 also apply to the users
- keep records of the names, nationalities, and home institutions of users, as well as the nature and quantity of access provided to them

- for virtual access:
  - access which must be provided:

The access must be free of charge, virtual access to research infrastructure or installations.

'Virtual access' means open and free access through communication networks to digital resources and services needed for research, without selecting the users to whom access is provided.

The access must include the support that is usually provided to external users.

Where allowed by the call conditions, beneficiaries may in justified cases define objective eligibility criteria (e.g. affiliation to a research or academic institution) for specific users.

- other conditions:

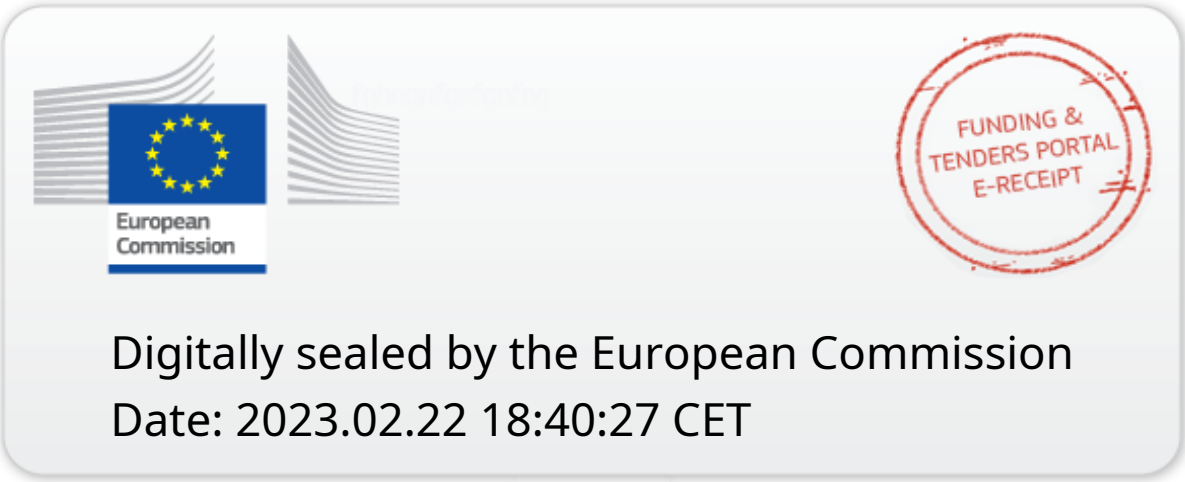
  The beneficiaries must have the virtual access services assessed periodically by a board composed of international experts in the field, at least half of whom must be independent from the consortium (unless otherwise specified in Annex 1). For this purpose, information and statistics on the users and the nature and quantity of the access provided, must be made available to the board.

  The beneficiaries must advertise widely, including on a dedicated website, the access offered under the grant and the eligibility criteria, if any.

  Where the call conditions impose additional traceability[5] obligations, information on the traceability of the users and the nature and quantity of access must be provided by the beneficiaries.

These obligations apply regardless of the form of funding or budget categories used to declare the costs (unit costs or actual costs or a combination of the two).

[5] According to the definition given in ISO 9000, i.e.: "Traceability is the ability to trace the history, application, use and location of an item or its characteristics through recorded identification data." The users can be traced, for example, by authentication and/or by authorization or by other means that allows for analysis of the type of users and the nature and quantity of access provided.



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