International
MUON Collider
Collaboration

Roadmap

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How the Report has been done

- Based on community meeting and panel expertise spelled out challenges and status

- Identified work to be done and specified scenarios to address them
  - charge from LDG: define a minimum programme and and aspirational programme
  - we decided to spell out the aspirational programme and mark what is missing in the minimum programme

How the Scenarios have been done

We used the input from the community meetings

- scientific input from discussions
- information from the templates
- there has already been priority information in the templates
  - the panel then reviewed the priorities a bit

- The aspirational programme contained basically all that the working groups identified
- Aimed to have a minimum programme to be 2-3 times larger than the CERN contribution
- Hard to define the border
- The minimum is a reduction of our ambition
  - but still do not yet have all the resources

Example Template: HE-Acceleration

Objectives							
Basic: Develop a credible design concept High-energy muon acceleration complex with cost estimate, upgrade path, and demonstration facility requirements based on reasonable assumptions on technology development.							
Complete beamline description with lattices and ideally have start-2-end tracking of full system to demonstrate luminosity performance and bunch compression during the process.							
Identify outstanding challenges with possible mitigation approaches.							
High-level Deliverables							
Priority 1) Overall design parameters							
Priority 1) Rapid Cycling System (RCS) design							
Priority 2) Linac and Recirculating Linac (RLA) design							
Priority 2) Alternative to RCS: FFA							
Resources	**1**	**2**	**3**		**1**	**2**	**3**
Staff	0.5	1	0.3	PhD	3	3	
Postdoc	4	3		Material			
Interested partners							
BNL (FFA + RCS), CEA (RCS), IJCLab-In2p3 (RLA), JLAB (Linac), UKRI-STFC (FFA)							

Resources are given in total number of FTE-years for the whole duration and in kEuro for material

HE-Acceleration

1	Task description	Resource estimate staff [FTEy]	postdoc [FTEy]	PhD [FTEy]	material [kEuro]
	Get a baseline layout and gather all parameters in a table including cost estimation and powering budget.	0.1	1.5		
	Start to end simulations of HEC complex	0.1	0.5	0.5	
	Lattice optics design and single particle dynamics in the RCS	0.2		2.5	
	Tolerance studies (alignment and field quality)	0.1	2		
	Evaluate the collective effects in the RCS	In Beam Dynamics package			
	Radiation mitigation in the arcs	In Radiation protection package			

2	Task description	staff	postdoc	PhD	material
	Assess the key issues of the linac +RLA system (muon decay effects on SRF cavities, injection, alignment, …)	0.1	1		
	Lattice optics and single particle dynamics of the linac and RLA	0.2	2		
	Assess the potential benefits of FFA as an alternative	0.3			
	Lattice optics design and single particle dynamics, in FFA	0.4		3	
	Evaluate the collective effects in the linac system	In Beam Dynamics package			
	Evaluate the collective effects in FFA	In Beam Dynamics package			

3	Task description	staff	postdoc	PhD	material
	Build a synergy around FFAs (spallation sources for instance)	0.3			

HE-Acceleration

Workpackage Description

This work-package is focused on the feasibility and optimization of the muon acceleration complex from the cooling channel to the collider. The main goal is to develop a credible design concept of the high-energy muon acceleration complex with cost estimate, upgrade path, and demonstration facility requirements based on reasonable assumptions on technology development.

In this aim, this work package will completely describe the beamline by gathering all relevant information in a parameter table. This work package will provide a full set of lattices with critical technologies identified and will have start-2-end tracking of full system to demonstrate luminosity performance and to validate the bunch compression and emittance preservation during the acceleration process.
This work package will identify outstanding challenges with possible mitigation approaches.

This work package will have an iterative and collaborative process in the collective effects part with the Beam Dynamics and with the technology work packages like SRF and magnet WPs to validate the feasibility of the machine parameters.

Deliverables

Three main deliverables are foreseen:

- a Project Evaluation Report that assesses the muon collider potential as input to the next ESPPU; (Note since this is a European document, we want to feed into all relevant processes)
- an R&D Plan that describes a path towards the collider;
- an Interim Report by the end of 2023 that documents progress and allows the wider community to update their view of the concept and to give feedback to the collaboration.

Schedule

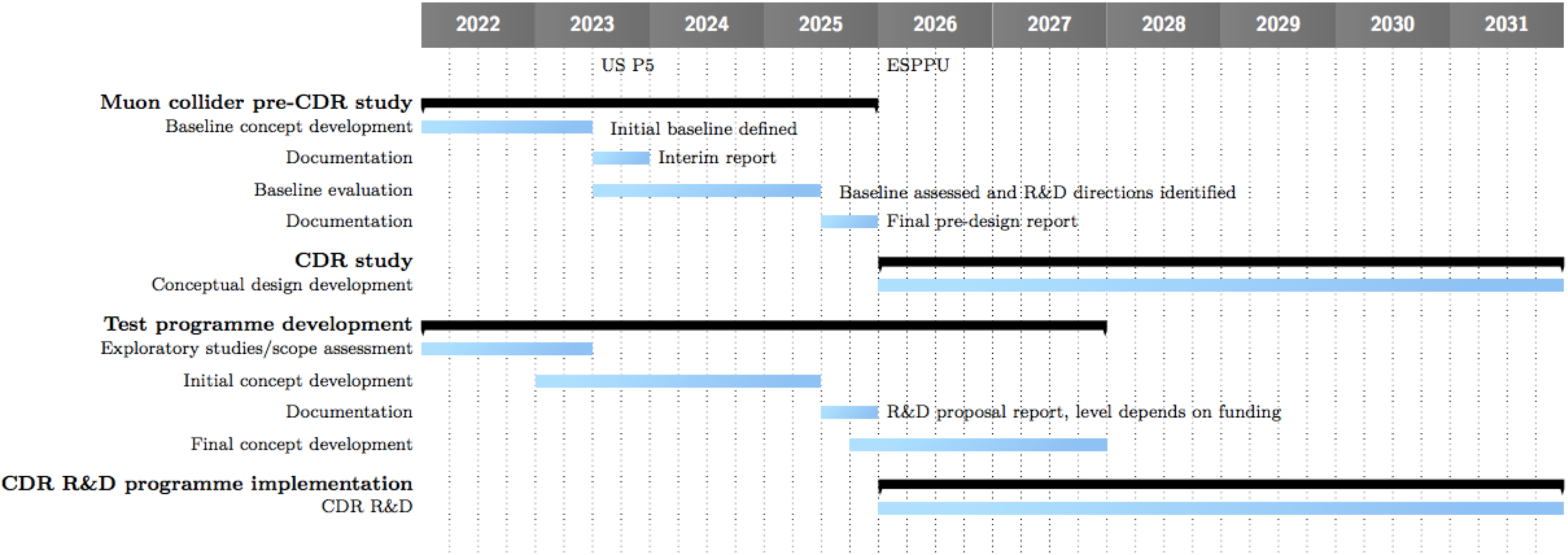

Fig. 5.4: Overall timeline for the R&D programme.

Project Evaluation Report

5.7.1.1 Project evaluation report

The project evaluation report will contain an assessment of whether the 10 TeV muon collider is a promising option and identify the required compromises to realise a 3 TeV option by 2045. In particular the questions below would be addressed.

- What is a realistic luminosity target?
- What are the background conditions in the detector?
- Can one consider implementing such a collider at CERN or other sites, and can it have one or two detectors?
- What are the key performance specifications of the components and what is the maturity of the technologies?
- What are the cost drivers and what is the cost scale of such a collider?
- What are the power drivers and what is the power consumption scale of the collider?
- What are the key risks of the project?

Workpackage Overview

SITE: Site choice, civil engineering etc. high-level neutrino flux mitigation

NF: Neutrino mitigation technology

MDI: Machine detector interface

ACC: Accelerator design across the whole complex, beam dynamics

HFM: High-field magnets

FR: Fast-ramping magnet systems

RF: RF systems

TAR: Target and target complex

MOD: Muon cooling module design

DEM: Demonstrator design and test programme development

INT: Integration, parameters, coordination

Workpackage Overview

Label	Begin	End	Description	Aspirational [FTEy]	Aspirational [kCHF]	Minimal [FTEy]	Minimal [kCHF]
MC.SITE	2021	2025	Site and layout	15.5	300	13.5	300
MC.NF	2022	2026	Neutrino flux mitigation system	22.5	250	0	0
MC.MDI	2021	2025	Machine-detector interface	15	0	15	0
MC.ACC.CR	2022	2025	Collider ring	10	0	10	0
MC.ACC.HE	2022	2025	High-energy complex	11	0	7.5	0
MC.ACC.MC	2021	2025	Muon cooling systems	47	0	22	0
MC.ACC.P	2022	2026	Proton complex	26	0	3.5	0
MC.ACC.COLL	2022	2025	Collective effects across complex	18.2	0	18.2	0
MC.ACC.ALT	2022	2025	High-energy alternatives	11.7	0	0	0
MC.HFM.HE	2022	2025	High-field magnets	6.5	0	6.5	0
MC.HFM.SOL	2022	2026	High-field solenoids	76	2700	29	0
MC.FR	2021	2026	Fast-ramping magnet system	27.5	1020	22.5	520
MC.RF.HE	2021	2026	High Energy complex RF	10.6	0	7.6	0
MC.RF.MC	2022	2026	Muon cooling RF	13.6	0	7	0
MC.RF.TS	2024	2026	RF test stand + test cavities	10	3300	0	0
MC.MOD	2022	2026	Muon cooling test module	17.7	400	4.9	100
MC.DEM	2022	2026	Cooling demonstrator design	34.1	1250	3.8	250
MC.TAR	2022	2026	Target system	60	1405	9	25
MC.INT	2022	2026	Coordination and integration	13	1250	13	1250
			Sum	445.9	11875	193	2445

Table 5.5: The resource requirements for the two scenarios. The personnel estimate is given in full-time equivalent years and the material in kCHF. It should be noted that the personnel contains a significant number of PhD students. Material budgets do not include budget for travel, personal IT equipment and similar costs. Colours are included for comparison with the resource profile Fig. 5.7.

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Workpackage Overview

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Conclusion

Best to give time to read the document before discussing the workpackages individually

Minimal programme contains the work that has to start as soon as possible because it provides input to the overall design

For aspirational programme some delay might be acceptable

- did not define finer priorities (or rather removed the finer grading)

Some work might be addressed for contributions from other regions, inp articular the US after the Snowmass process

The proposals for EU co-funded studies will be good to get going

But need volunteers for the whole programme

- including expression of interest outside of Europe

Need to be clear about the level of support each partner can provide and what is required in addition

- we should be proactive for the Roadmap

Project Meeting

Afternoons of February 14, 15 and 17

Goal is to discuss drafts of
- overall work programme
- EU co-funding
- white papers

Some scientific content to see actual progress
- 3 TeV physics case
- US site filler discussions
- muon-ion collider
- regional views (Americas, Asia)
- neutrino flux studies
- …

All (in particular conveners) are invited to suggest contributions

Andrea and Donatella will lead the organisation of the physics part
A small group should help to organise the accelerator part