Starting with the Future…

- Everything is driven by our *science* roadmap
  - Namely, the European Strategy for Particle Physics
- Future facilities explicitly (though not exclusively) mentioned
  - Completion, commissioning, exploitation of HL-LHC
  - Delivery of LNBF / DUNE
  - Electron-positron Higgs factory
  - Energy frontier proton-proton collider
  - Also increasingly prominent in discussions: muon collider
- Our past achievements rest on substantial technology R&D
  - At least 15-20 years in the case of the LHC / HL-LHC
  - Substantial R&D and industrialisation towards ILC
- Future facilities depend yet more strongly on new technology
  - Fundamental R&D challenges presented by FCChh and MC in particular

European Strategy

- Strategy contains strong and explicit statements on R&D:
  - *The particle physics community should ramp up its R&D effort focused on advanced accelerator technologies […]*
  - *The European particle physics community must intensify accelerator R&D and sustain it with adequate resources.*
  - *A roadmap should prioritise the technology […]*
  - *Deliverables for this decade should be defined in a timely fashion and coordinated among CERN and national laboratories and institutes.*
- Detector R&D, computing R&D, and training also prominent
  - ESPPU is an 'R&D-focussed document', even more so than previous iterations
- This of course was steered by the inputs
  - *Accelerator science and technology be acknowledged as a vital need with the highest priority within the update of the European Strategy of Particle Physics.* (TIARA input)
  - *A vigorous new experimental programme in the long term, requires significant investment in detector and accelerator R&D in the medium term. The case for this investment should be clearly spelt out in the European Strategy*. (STFC input)

LDG Mandate

- Facilitate informal dialogue among the Directors of the LPPLs and CERN
- Provide direct input to the European Strategy for Particle Physics
- Liaise with the European Commission and national funding agencies, research institutes and universities in order to ensure that the LPPLs speak with a single voice
- Maximise the regional and national benefits of investment in fundamental research and in CERN;
- Keep abreast of the activities being undertaken in laboratories outside … as well as by other coordinating groups in particle physics and related areas, and foster dialogue with them;
- Draw up and maintain a prioritised accelerator R&D roadmap towards future large-scale facilities for particle physics
- Oversee the accelerator R&D activities on the roadmap, with the aim of strengthening cooperation and ensuring effective use of complementary capabilities.

- Noting that accelerator R&D is clearly not confined to large laboratories
- LDG and ECFA working closely together on respective roadmaps – see Karl's talk

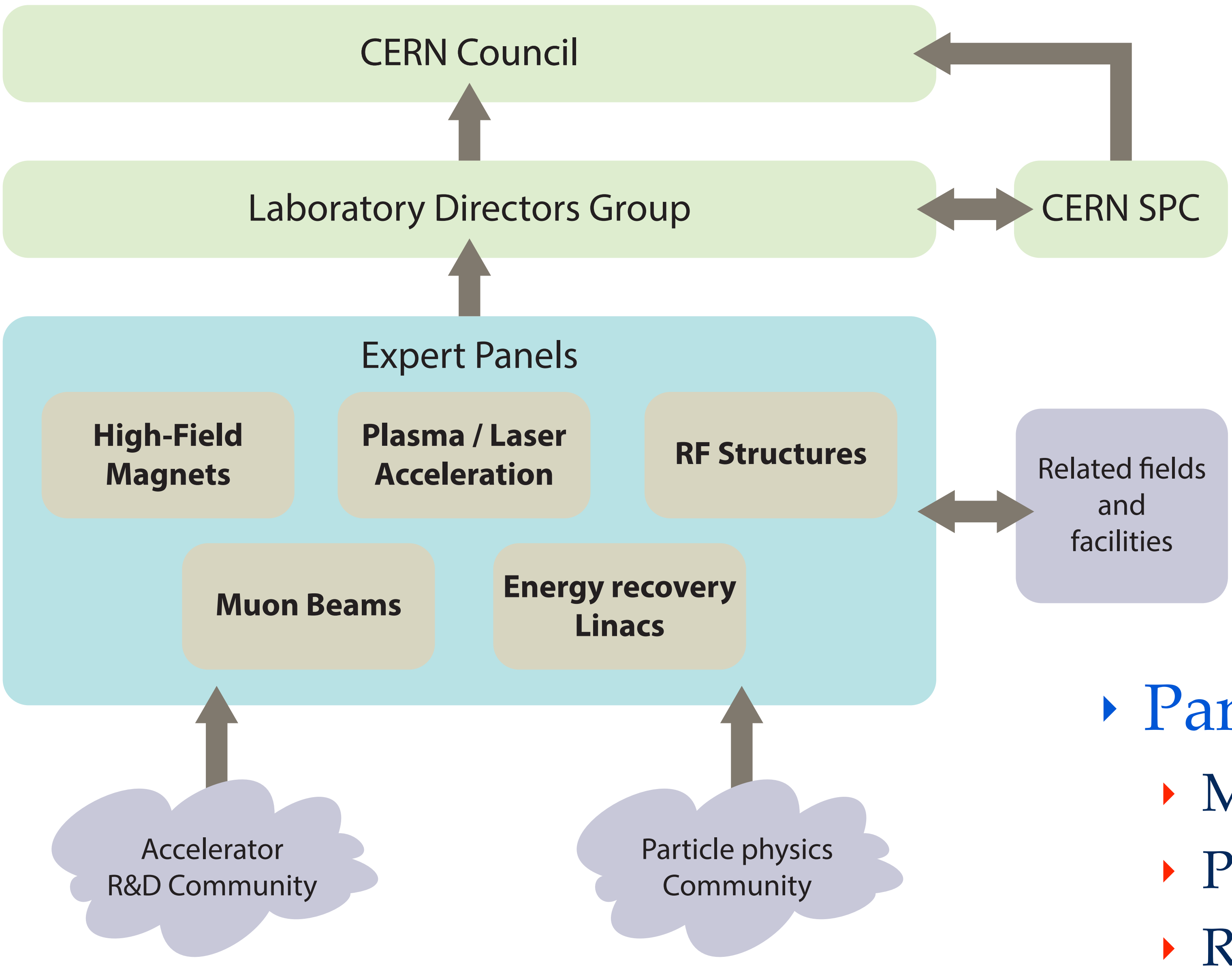
Roadmap Requirements

- Provide an agreed structure for a coordinated and intensified programme of particle accelerator R&D, including into new technologies, to be coordinated across national laboratories
- Be compatible and commensurate with corresponding roadmaps in detectors, computing and other developments, with a compatible timeline and deliverables
- Be based on the goals of the European Strategy, but defined in its implementation through consultation with the community and, where appropriate, through the work of expert panels
- Take into account, and coordinate with, international activities and work being carried out in other related scientific fields, including development of new large-scale facilities
- Specify a series of concrete deliverables, including demonstrators, over the next decade
- Be designed to inform, through its outcomes, subsequent updates to the European Strategy.
- Focus is 5-10 years – set in the context of a longer overarching programme

Roadmapping Approach

- Stage 1 (overseen by LDG, mandate from CERN Council):
  - Formal process, continuing the momentum of the strategy groups
  - Mirrors the style of the ESPPU
    - Expert discussion panels
    - Wide consultation with the community (some inputs already in place from ESPPU)
    - Determination of a plan with options for investment
  - Culminates in approval of roadmap by CERN Council – and finishes
  - European process, but with strong international inputs
- Stage 2 (driven by the community, LDG institutes in support):
  - Proposals for activities by accelerator R&D networks / community
  - Explicit discussion of possible funding levels and routes
  - Engagement with funding agencies around specific projects
  - Implement the R&D roadmap
  - Necessarily a programme with a fully international context

SPC Update: Accelerator R&D Roadmap



- Panel chairs
  - Magnets: P. Vedrine (IRFU)
  - Plasma: R. Assmann (DESY)
  - RF: S. Bousson (IJCLab)
  - Muons: D. Schulte (CERN)
  - ERL: M. Klein (Liverpool)
  - Diverse and international panel membership

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Panel Remit

- LDG role (LDG is *not* a panel of experts):
  - Act as steering committee for the roadmap definition process
  - Oversee EPs, receiving reports and providing feedback and direction
  - Produce and present interim and final reports for CERN Council
- Panel remit:
  - Establish key R&D needs, as dictated by the scientific priorities
  - Consult widely with the European and international communities, taking into account the capabilities and interests of stakeholders
  - Take explicitly into account the plans and needs in related scientific fields
  - Propose ambitious but realistic objectives, work plans, and deliverables
  - Give options and scenarios for European investment and activity level
- NOT in scope (part of Stage 2 and beyond)
  - Planning for specific future facilities
  - Planning of funding routes, beyond the overall cost of the proposed R&D programme
  - Statements of institutional or national commitment

Observations so far

- Engagement
  - Success in engaging the (international) accelerator physics community
  - Over 50 meetings / workshops, several hundred people involved
  - Some panels already producing 'long reports' summarising all inputs
- Diversity
  - Clearly, the five areas are at a range of scope and maturity
  - The final roadmap must balance medium- and long-term R&D carefully
  - Keep in mind the focus on informing decisions at the next EPPSU
- Synthesis
  - In the end, we require one roadmap not five – also leaving some 'freedom'
  - The final prioritisation is a matter for Council and its advisors
    - These are long-term strategic questions of science, funding and organisation
  - But: we may wish to provide short-term feedback on the 'level of ambition' / 'level of urgency', with respect to the foreseen programme
    - What are the real technical barriers in the limit of infinite resources?
- In summary: strong progress, and an excellent start by the panels

HFM Progress

DEVELOPMENT OF HIGH FIELD MAGNETS : SCOPE AND CHALLENGES

SCOPE

- Establish the R&D needs to demonstrate Nb3Sn magnet technology for large sacle deployment, pushing it to its practical limits both in terms of maximum performance as well as production scale
  - Demonstrate Nb3Sn full potential in terms of ultimate performance (target 16 T)
  - Develop Nb3Sn magnet technology for collider-scale production, through robust design, industrial manufacturing processes and cost reduction (benchmark 12 T)
- Demonstrate suitability of HTS for accelerator magnet applications providing a proof of principle of HTS magnet technology beyond the reach of Nb3Sn (target around 20 T)
- In addition, propose collaboration schemes and options for EU investment.

GRAND CHALLENGES AND KEY ISSUES

- Need for superconductors with high engineering current density, $J_E \approx 600$ A/mm^2, appropriate to yield a compact and efficient coil design, with requirements for high mechanical strength and good tolerance to stress and strain, associated magnetization, and internal resistance, including production quality, etc..
- Need for new mechanical solutions and stress management concepts to withstand large electromagnetic forces larger by a factor 4 to 6 with respect to the one experienced by the LHC dipoles and mechanical stresses in the range of 150 to 200 MPa.
- Need for new powering systems, detection and protection methods, to handle the increase of stored energy per unit length higher than the LHC by a factor of 4 to 6, including the difference of behavior between LTS and HTS coils.
- Need to set realistic cost targets to be able to move from R&D to industrial-scale production, in order to build a future collider

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HFM Progress

INITIAL FINDINGS - 1

- **Conductors – Nb3Sn**

Nb3Sn is reaching the upper limit of performance.

Advances in composition and architecture need to be consolidated (laboratory), and made practical for large-scale production (industry), including considerations on all performance parameters (mechanics, magnetization – laboratory; homogeneity, unit length, cost – industry).

- **Conductors – HTS**

Spectacular electrical performance, the challenge is now to combine critical current with mechanical and protection properties. This may need some innovative thinking about tapes and cables (tape structuring, no transposition, no insulation), which may bring a revolution in magnet engineering

High temperature operation (20 to 65 K) is an interesting option (cryogenic efficiency, high radiation and thermal loads for muon collider), also driven for other fields (fusion and power machinery).

Industry drive for high-field performance is independent of HEP (fusion and NMR, power applications for motors and generators at 50…65 K) and cost of HTS will decrease because of substantial investment from fusion and power applications.

HFM Progress

INITIAL FINDINGS - 2

- **Magnets Nb3Sn**

Length effects and electro-thermo-mechanics of Nb3Sn magnets are a crucial issue (11T experience), we need to find a way to address them. Model and prototypes developments need to be better integrated and supported by basic R&D. However, length effects can only be investigated with long coils.

An initial tentative to identify suitable design options for the various field levels targeted:

- 2-layer cos-theta suitable up to 12 T
- 4-layers cos-theta or blocks for the 14-16 T range
- Common coils to resolve the issue of the end (to be demonstrated)
- CCT or other stress managed concept beyond 15-16 T

A decision on a feasible, cost-effective and practical operating field will be one of the main outcomes of the development work planned in the coming years.

Industry would welcome early involvement in the R&D phase, participating in the whole process to gain early experience on a potential manufacturing phase and decrease risk. However, as for SC industry, it is unlikely that a large-scale manufacturing of HEP magnets would have direct spin-off to other fields.

Initial findings - 3

- **Magnets HTS**

Non Insulated/Partial Insulated conductors may be a tool to explore the technology on small scale, avoiding the burden of full magnet engineering. Besides the obvious challenges (long time constants, mechanics with current flow not well defined), the predictability of the transverse resistance is an issue

We need a focused study on what is the best HTS cable configuration for magnet applications , targeted at magnet construction (winding of the ends) and operation (transposition)

Field quality is a declared issue, but this should be revisited, possibly transferring a part of the challenges to beam dynamics, diagnostics and controls.

- **Technologies**

Running programs should be supported in priority. In particular the characterization and development of insulation systems, the development of advanced diagnostics and material analysis and multiscale and multi-physics modelling.

A prioritized program for the upgrade of test infrastructure shall be defined to accompany the needs for high field characterization of conductors and cables, and fast turnaround on magnet sub-scale and full-scale demonstrators and models.

Thermal management of high field magnets (both internal, heat transfer to coolant, and external, heat transfer to cryoplant) will require new engineering solutions that need to be integrated from the start.

HFM Report Outline

- Executive Summary
  - Reference to Remit
  - Summary of work
- Main conclusions and top-level roadmap
- Abstract
- Motivation for a High Field Magnet R&D Program
  - Historical perspective
  - Highest Field Attained
  - Discussion
- Objectives of a High Field Magnets R&D Program
- Challenges of High Field Magnets
  - Superconductor
  - Forces and stresses (electromechanical induced stresses)
  - Stored energy
  - Cost
- High Field Magnets R&D Program Drivers
- Proposed Program Structure and Deliverables
  - Nb3Sn conductor
  - HTS conductor
  - Nb3Sn accelerator magnet development
  - Nb3Sn magnet technology
  - HTS magnet technology
  - Materials and insulation technology
  - Magnet protection
  - Infrastructure for development, manufacture, test and measurement
- Roadmap, Work Plan and Timeline
  - Nb3Sn Roadmap
  - HTS Roadmap
  - Impact of a High Field Magnet R&D Program
  - Applications to Other Fields and Society
  - Industrial Ecosystem
  - Training and Education
- Scenario of Engagement and Investments
- Sustainability

HGPLA Progress

Expert Panel HGPL "High Gradient Acceleration (Plasma/Laser)"

Expert Panel – Panel chairs:
Chair: Ralph Assmann (DESY/INFN)
Deputy Chair: Edda Gschwendtner (CERN)

Panel members:
Kevin Cassou (IN2P3/IJCLab), Sebastien Corde (IP Paris), Laura Corner (Liverpool), Brigitte Cros (CNRS UPSay), Massimo Ferarrio (INFN), Simon Hooker (Oxford), Rasmus Ischebeck (PSI), Andrea Latina (CERN), Olle Lundh (Lund), Patric Muggli (MPI Munich), Phi Nghiem (CEA/IRFU), Jens Osterhoff (DESY), Tor Raubenheimer (SLAC), Arnd Specka (IN2PR/LLR), Jorge Vieira (IST), Matthew Wing (UCL).

Panel associated members:
Cameron Geddes (LBNL), Mark Hogan (SLAC)), Wei Lu (Tsinghua U.) , Pietro Musumeci (UCLA)

OPEN CONSULTATION PROCESS – WORK FLOW

Expert Panel: 18 experts - 4 associated - 11 meetings Retreat 23/6

Email list
231 scientists registered to roadmap process

Townhall 30/3
Setting the scene, explaining the process, **HEP goals and targets**

Parameters
Parameters of interest, proposal of **2 common study cases**

Townhall Meetings 21/5 and 31/5
Input presented by **48 SPEAKERS FROM COMMUNITY**
Up to **130 simultaneous participants**

Draft R&D Roadmap, deliverables: July

Townhall #4 feedback

LDG, SPC, … feedback

FINAL REPORT
October

R. Assmann, E. Gschwendtner

2

HGPLA Progress

High Gradient Acceleration (Plasma/Laser): Input to Panel

State of field: Rapidly progressing (e.g. first FEL SASE lasing) – low energy RI's planned (outside HEP) – national, European, international efforts – wish to **advance HEP concepts**

MAIN CHALLENGES

Electron beam with collider quality

1-10 GV/m acceleration, 15,000 nC/s charge delivered, sub-micron transverse emittances, 10^{-4} rel. energy spread, spin polarization.
Deliverables on injectors, numerical simulations, repetition rate, efficiency, beam loading, emittance preservation, energy spread control, polarization, staging, … were proposed.

Solution for positron acceleration

with parameters similar to electron bunches.
Deliverables on numerical simulations, proof-of-principle experiments were proposed.

Conceptual design advanced collider

with physics case, self-consistent machine parameter set, realistic assessment of feasibility issues, performance, size and cost.
Deliverables on a coordinated international design study, including beam delivery, luminosity and interaction region design, were proposed.

Intermediate steps towards a particle physics collider and synergy

with progress in photon science and lower energy applications.
Deliverables for intermediate implementation steps were proposed.

R. Assmann, E. Gschwendtner 3

HGPLA Progress

First Thoughts Future Strategic Development I

- **Various important milestones** in field of plasma and laser accelerators have been achieved or will be achieved over the next years and has reached the stage of providing first user facilities in the European research landscape. This **should be complemented by early HEP targeted tests and R&D activities.**
- Given that funding for ongoing activities is mostly from non-HEP sources**, several HEP aspects are, however, neglected,** for example staging to high energy, efficiency, positrons and polarization.
- Detailed technical **deliverables, milestones and funding options** for the next decade will be a crucial part of our roadmap and will be detailed further in our interim and final reports.
- The community in large majority agrees that **a conceptual design study on high energy aspects is a required step.** The expert panel fully endorses this.

R. Assmann, E. Gschwendtner 4

HGPLA Progress

First Thoughts Future Strategic Development II

- CERN hosts AWAKE and is a member of the EuPRAXIA consortium. **CERN's support is important and highly appreciated.** Covers only selected aspects and driver technologies.
- An additional development of the CERN involvement could include **CERN to host, initially at least, an International Design Study** to be completed by the next European strategy update**.** CERN would need to provide **seed funding** and M&P(~2 MCHF/year).
- CERN's strong involvement should be leveraged by **increased funding and HEP commitments in ongoing European and national R&D program**s and projects.
- After successful demonstration of various milestones and successful completion of ongoing major programs (AWAKE, EuPRAXIA, national programs), **a dedicated HEP test facility will very likely become necessary** and should be operational in the mid 2030's. At this time the effort could evolve to develop a plasma & laser accelerator test facility at CERN or another suitable location.

R. Assmann, E. Gschwendtner 5

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HGPLA Report Outline

Expert Panel HGPL – Roadmap Report Structure

- *~40 page report*
- *Structure adopted in discussion with chair of expert panel HFM (PV)*
- *Focusing space-wise on challenges, program structure and deliverables for developing roadmap*
- *Embedding into larger context, including synergy (applications)*

• Executive Summary	2 p
• Abstract	0,5 p
• Motivation for a Plasma and Laser Accelerator R&D Program	1 p
• State of the Art	2 p
• Objectives of a Plasma and Laser Accelerator R&D Program	2 p
• Challenges of Plasma and Laser Accelerators	6 p
• Plasma and Laser Accelerator R&D Program Drivers	2 p
• Proposed Program Structure and Deliverables	12 p
• Roadmap, Work Plan and Timeline	4 p
• Impact of a Plasma and Laser Accelerator R&D Program	4 p
• Applications to Other Fields and Society	2 p
• Scenario of Engagement and Investments	2 p
• Sustainability	1 p

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HGRF Progress

High gradient RF Structures

Goal : **define the roadmap of required R&D for pushing accelerating gradients on RF structures, in the view of future large-scale facilities for particle physics**

Organization :

- **Coordinators:** S. Bousson (IJCLab), Hans Weise (DESY)
- **Panel members:**
  Alessandro Gallo (INFN LNF), Guillaume Devanz (CEA), Thomas Proslier (CEA), David Longuevergne (IJCLab), Guillaume Olry (IJCLab), Franck Gerigk (CERN), Alexej Grudiev (CERN), Graeme Burt (Lancaster University)
- **Other persons** will also largely participate to the report as contributors (community experts)
- **Panel meetings** every 2 weeks – Thursday afternoon

Links with other panels

- **Muon colliders**
- **ERLs**

Strong links with the already well organized community

- **SRF :** TTC (Tesla Technology Collaboration), chaired by Hans Weise - Last TTC meeting was in January 2021
- **Normal conducting :** recurrent workshops: "International Workshop on Breakdown Science and High Gradient Technology" - 13rd edition happened (virtualy) on 19-21 April 2021
- **General** : Snowmass 21 process, in particular with the group AF7-RF (RF Accelerator Technology R&D)

June 2021 *1*

HGRF Progress

SCOPE

The scientific and technical scope is covering 3 main topics and is addressing overall performances (accelerating gradients, RF power generation, cost and energy efficiency)

- **Superconducting RF Acceleration :**

RF structure design (optimization of existing structure type and new ideas), surface treatment (doping, infusion, heat treatments), thin films (high Tc material, multilayers) and corresponding substrate material and preparation, power couplers, frequency tuners, HOM suppression (dampers, couplers), cryogenic, in-situ conditioning.

- **Normal conducting RF Acceleration**

RF structure design, advanced concepts (distributed coupling accelerator structures, multi-frequency accelerator structures), high precision fabrication and new fabrication methods (additive manufacturing, assembled structures), tuning during operation (advanced cooling), surface quality (preparation and control)

- **RF power generation and control**

High efficiency klystrons, high frequency RF source, high power RF components (loads, circulator, directional couplers, windows), simulation tools for RF source design

RF control: hardware for LLRF systems, machine learning

In addition, questions linked to industrialization should be taken into account, as large scale system production is a major challenge of future accelerators. Dedicated programs related to technology transfer to industry are absolutely required prior to launch mass production if we want to insure reliability in performances achievement over a large number of components.

June 2021 *2*

HGRF Progress

High gradient RF Structures

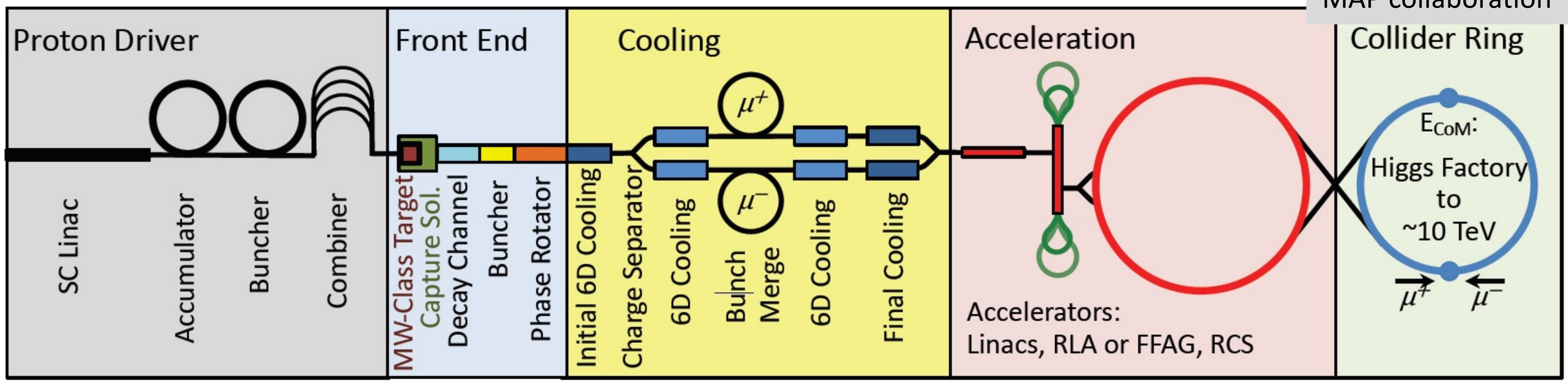
Timeline:

- Define the detailed scope of the panel : **Done**
- **"State of the art" workshop will happen on the second week of July (**
  - **Format: 2 half-days in the same week**
  - **Several sessions organized corresponding to the different topics identified by the panel -** Speakers are being invited for overview talks
  - **One large session kept fully open** to address topics not covered or forgotten
- **Establishing the roadmap:**
  - First skeleton produced during summer based on subject/discussion originated during the workshop and on the expert knowledge
  - Non-formal interaction with the community
  - Drafting the report and first organized interaction with the community – format and exact time not yet decided
- **July: interim report**
- **September: first draft report**
- **November: final report**

June 2021 *3*

Muons Progress

Baseline Muon Collider Concept



Short, intense proton bunches produce pions that decay into muons that can be captured

Muon are captured, bunched and then cooled by ionisation cooling in matter

Acceleration to collision energy

Collision

Past work has been mainly performed in US (MAP Collaboration), Test of muon cooling in UK

No CDR exists, no coherent baseline of machine, no cost estimate
US activity very much reduced after last P5
But many parts designed and tested
At this stage no showstoppers identified by panel

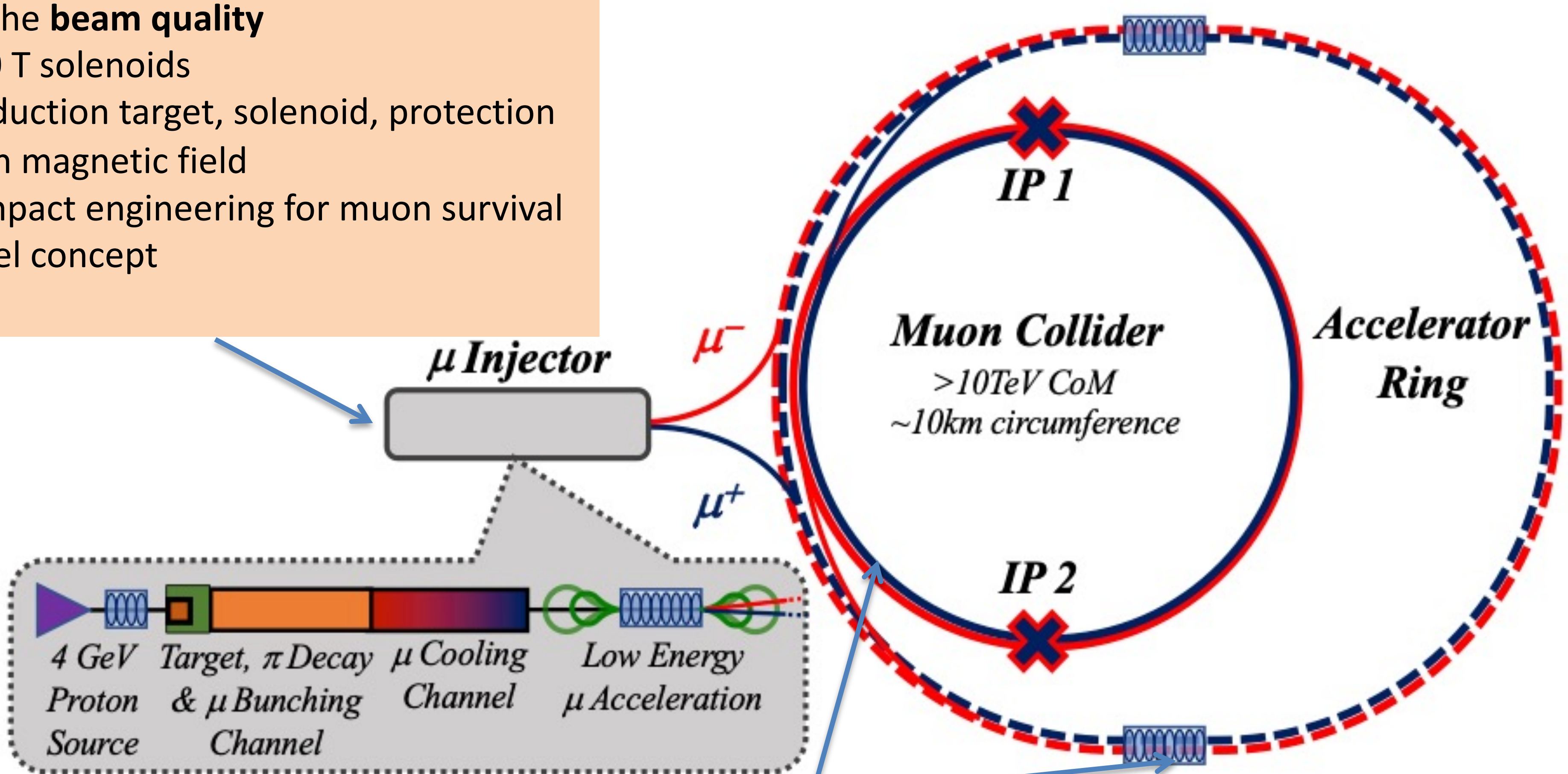
Note: Effort mainly in INFN on alternative positron-driven scheme, but needs inventions

Muon Collider Physics and Detector Meeting, June, 2021

Muons Progress

R&D Challenges

Drives the **beam quality**
- > 30 T solenoids
- Production target, solenoid, protection
- RF in magnetic field
- Compact engineering for muon survival
- novel concept
- …



Cost and **power** consumption limit energy reach
- Superconducting collider ring magnets
- Fast ramping magnets with energy recovery
- Efficient RF for high bunch charge
- FFA
- Protection of collider magnets from muon decays

Neutrino flux and **MDI** limit energy reach
- Machine detector interface
- Neutrino flux on Earth surface (have mitigation idea)

Integrated coherent concept/parameters

Muon Beam Panel, June 2021

Science and Technology Facilities Council

Muons Progress

International Muon Collider Collaboration

Objective:

In time for the next European Strategy for Particle Physics Update, the study aims to **establish whether the investment into a full CDR and a demonstrator is scientifically justified**.

It will provide a baseline concept, well-supported performance expectations and assess the associated key risks as well as cost and power consumption drivers. It will also identify an R&D path to demonstrate the feasibility of the collider.

Deliverable: Report assessing muon collider potential and describing R&D path to CDR

Scope:

- Focus on two energy ranges:
  - **3 TeV**, if possible with technology ready for construction in 10-20 years
  - **10+ TeV**, with more advanced technology, **the reason to chose muon colliders**
- Explore synergy with other options (neutrino/higgs factory)
- Define **R&D path**

Panel works closely with collaboration and endorses goal: establish muon collider is realistic option so that next ESPPU can make fully informed choices

Muon Beam Panel, June 2021

Muons Progress

Tentative target parameters
Scaled from MAP parameters

Comparison:
CLIC at 3 TeV: 28 MW

Parameter	Unit	3 TeV	10 TeV	14 TeV
L	10^{34} cm^{-2}s^{-1}	1.8	20	40
N	10^{12}	2.2	1.8	1.8
f_r	Hz	5	5	5
P_{beam}	MW	5.3	14.4	20
C	km	4.5	10	14
<B>	T	7	10.5	10.5
ε_L	MeV m	7.5	7.5	7.5
σ_E / E	%	0.1	0.1	0.1
σ_z	mm	5	1.5	1.07
β	mm	5	1.5	1.07
ε	µm	25	25	25
$\sigma_{x,y}$	µm	3.0	0.9	0.63

Key Topics

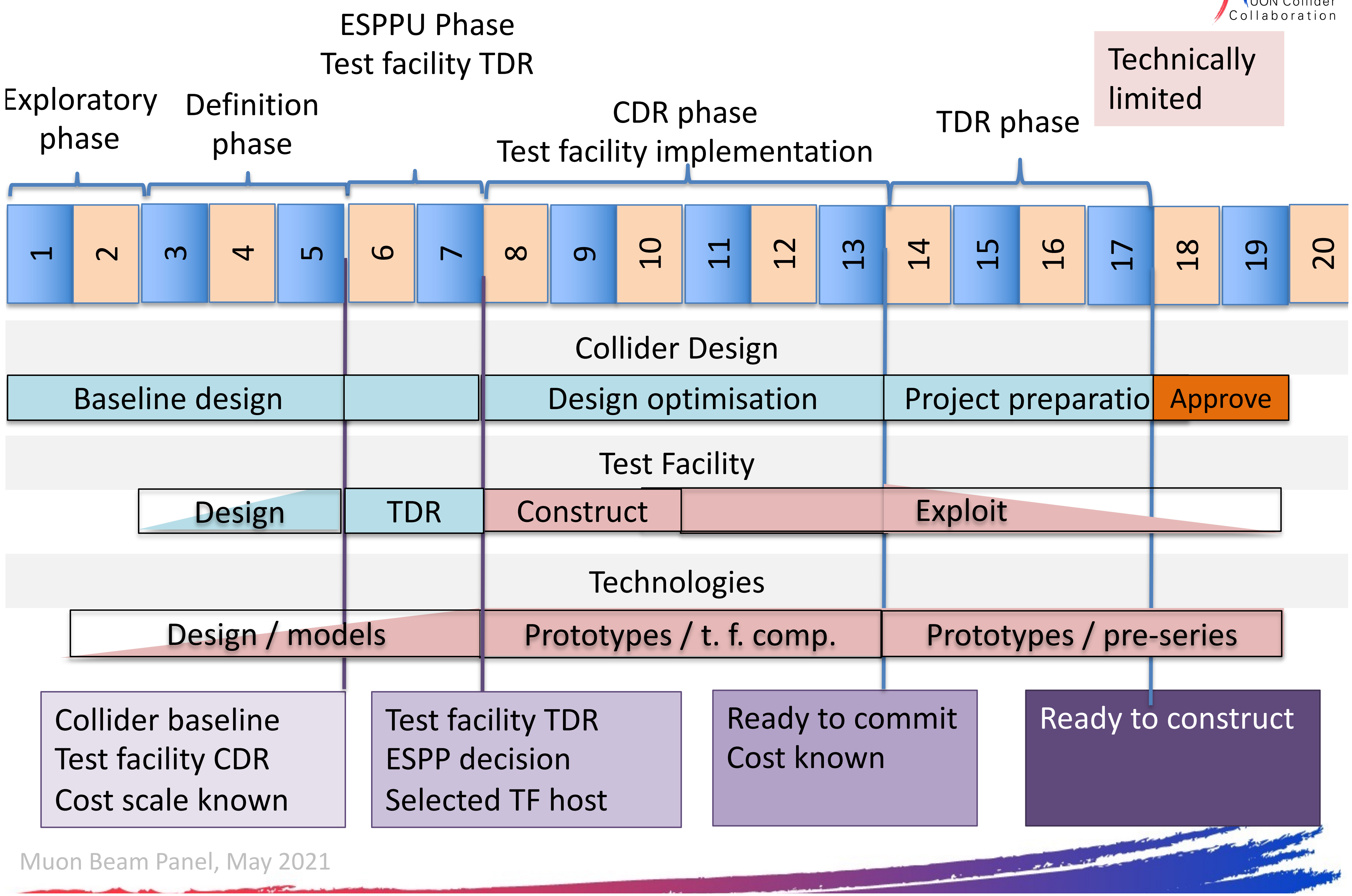
10+ TeV is uncharted territory

- **Physics potential** evaluation
- Impact on the environment
  - The **neutrino radiation** and its impact on the site
- The impact of **machine induced background** on the detector, as it might limit the physics reach.
- **High-energy systems** after the cooling (acceleration, collision, …)
  - This can limit the energy reach via cost, power and beam quality
- **High-quality beam production** of cooled muon beam
  - MAP did study this in detail
  - Need to optimise and prepare test facility

Muon Beam Panel, June 2021

Muons Progress

Scope and Potential Long-Term Timeline



Muons Report Outline

- Introduction
- Executive summary
- Muon collider motivation
  - Physics
  - Potential cost and power efficiency
- Sustainability
  - Power efficiency
  - Cost efficiency
- Muon collider design overview
- Status of design (and history)
- Muon collider challenges
  - Overall project
    - Parameters
    - Layout
    - Power, cost and risk drivers
    - Radiation protection and site considerations
    - Other project challenges
  - Proton complex
  - Target area and source system
  - Muon cooling
  - Muon acceleration
  - Muon collider ring
  - MDI
  - Magnets
  - RF
- Work programme (deliverables)
  - Project
    - parameters and layout
    - cost and power
    - choices and trade-offs
  - Accelerator design
    - Proton complex
    - Muon production and cooling
    - High-energy acceleration
    - Collider ring
    - Beam dynamics
- MDI
- Systems design
  - Magnets and power converters
  - RF
  - Target and shielding
  - Neutrino flux mitigation
  - Other technologies
- Test facility preparation
- Synergies
  - Technologies
    - Magnets
    - RF
    - Targets
  - Facilities
    - Proton complex
    - Neutrino facility
- Scenarios and impact

ERL (Long) Report Outline

Contents

Figure 3: Draft table of contents of the about 250 pages paper in preparation describing the ERL developments and prospects [1]. A similar order of topics will be used for the shorter roadmap input, complemented by chapters on milestones, cost and options for the ERL future.

Very recent:
$e\gamma \rightarrow e\mu/\mu$
concept of
100 GeV eERL
with X ray FEL
as base for
muon collider
10pmrad emittance

arXiv:2106.03255
Curatolu, Serafini

ERL concepts now
for ep, e^+e^-, γγ
+ muon colliders

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ERL Progress

A selection of past, present and proposed ERL facilties vs energy and current

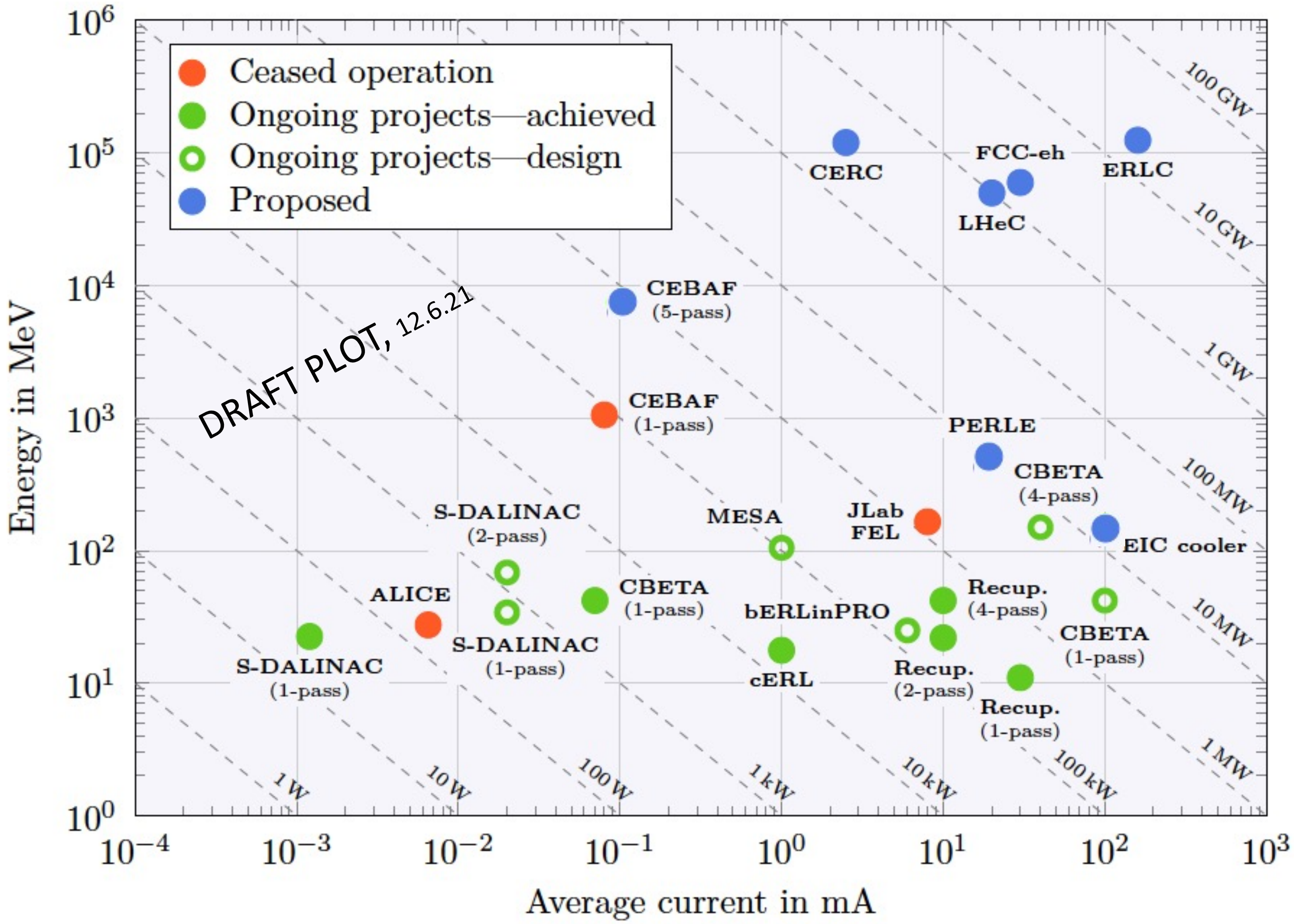

Figure 1: Electron energy vs current for ERL facilities, draft plot from long write-up [1].

ERL Features:

Very high luminosity through high electron current and small preserved injector emittance. Economic use of power $P_o/(1-\eta)$ through recovery in multiple linac passing (recirculator or head-on). Non-radiative beam dump at injection energy. → orders of magnitude improved performance at same or reduced power, **a new era for accelerator, HEP, NP and applications**

"The ERL concept is well proven and the technology is well developed. Many demonstrator facilities exist worldwide with increasing sophistication. It needs a facility comprising all essential features simultaneously: high-current, multi-pass, optimised cavities and cryo-modules and a physics quality beam eventually for experiments". (Bob Rimmer)

ERL Recent Developments

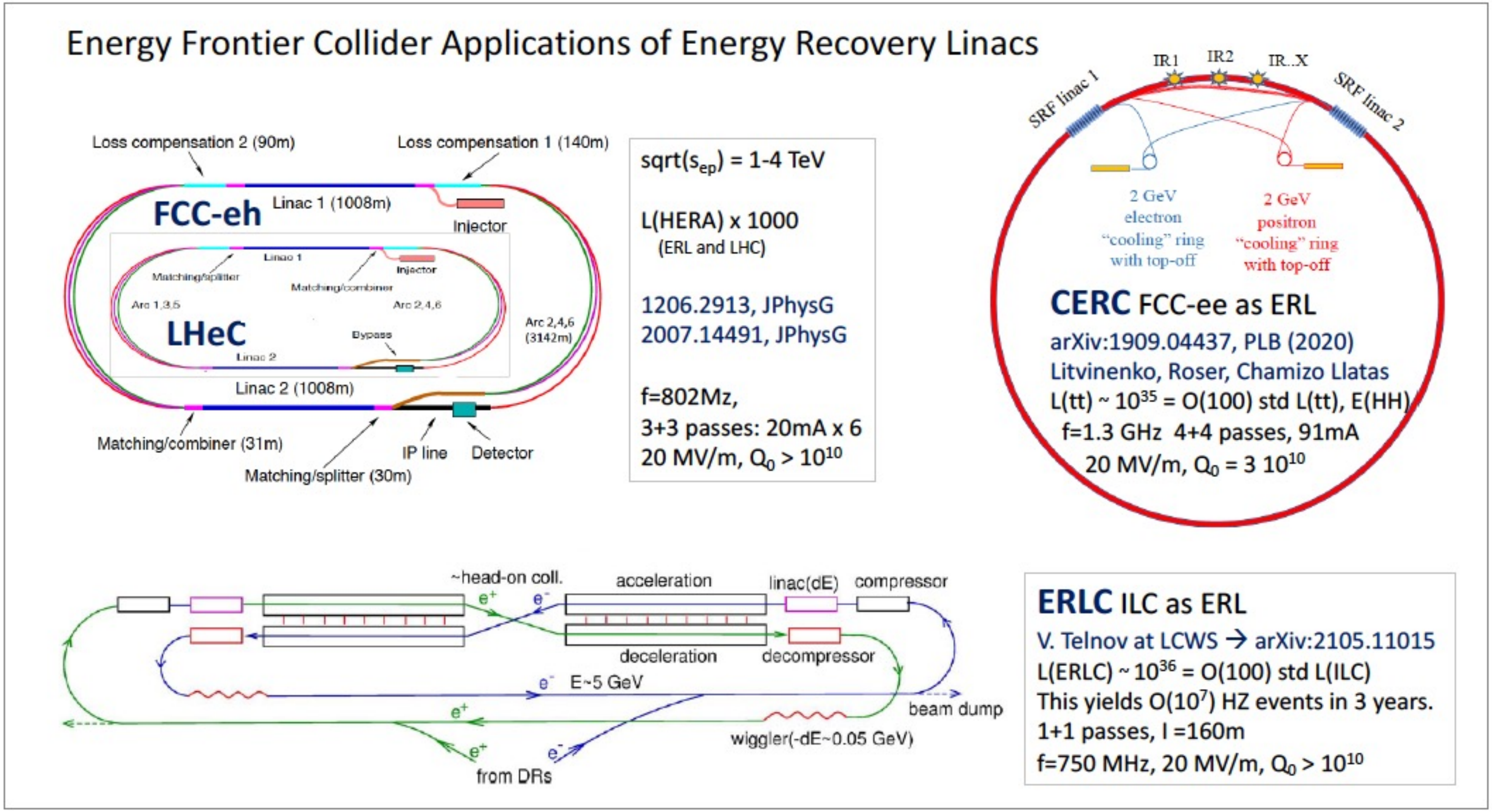

Figure 2: Sketch of possible future colliders based on ERLs: left top: LHeC and FCC-eh; right top: CERC; bottom: ERLC. For more information see the arXiv references displayed.

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ERL Recent Developments

Evaluation of ERL concepts for FCC-ee [CERC] and the ILC [ERLC]

Vladimir Litvinenko+ https://doi.org/10.1016/j.physletb.2020.135394 ;
Valery Telnov, https://arxiv.org/abs/2105.11015

The Sub-Panel should evaluate the technical and financial implications of the two novel concepts compared to the FCC-ee and ILC projects:

What are the technical advances, specifically in luminosity?

What are the technical solutions + obstacles requiring R&D?

How much time would that additionally require?

What is the rough cost implication (to about 10%)

Sub-Panel members

Chris Adolphsen (SLAC)	Reinhard Brinkmann (DESY)
Oliver Brüning (CERN)	Andrew Hutton (JLab) – Chair
Sergei Nagaitsev (Fermilab)	Max Klein (Liverpool)
Peter Williams (STFC)	Akira Yamamoto (KEK)
Kaoru Yokoya (KEK)	Frank Zimmermann (CERN)

The e^+e^- ERL Sub-Panel

Dates for the sub-Panel

Kick-off meeting held June 9, 2021

Completion by September 3, 2021

Deliverable:

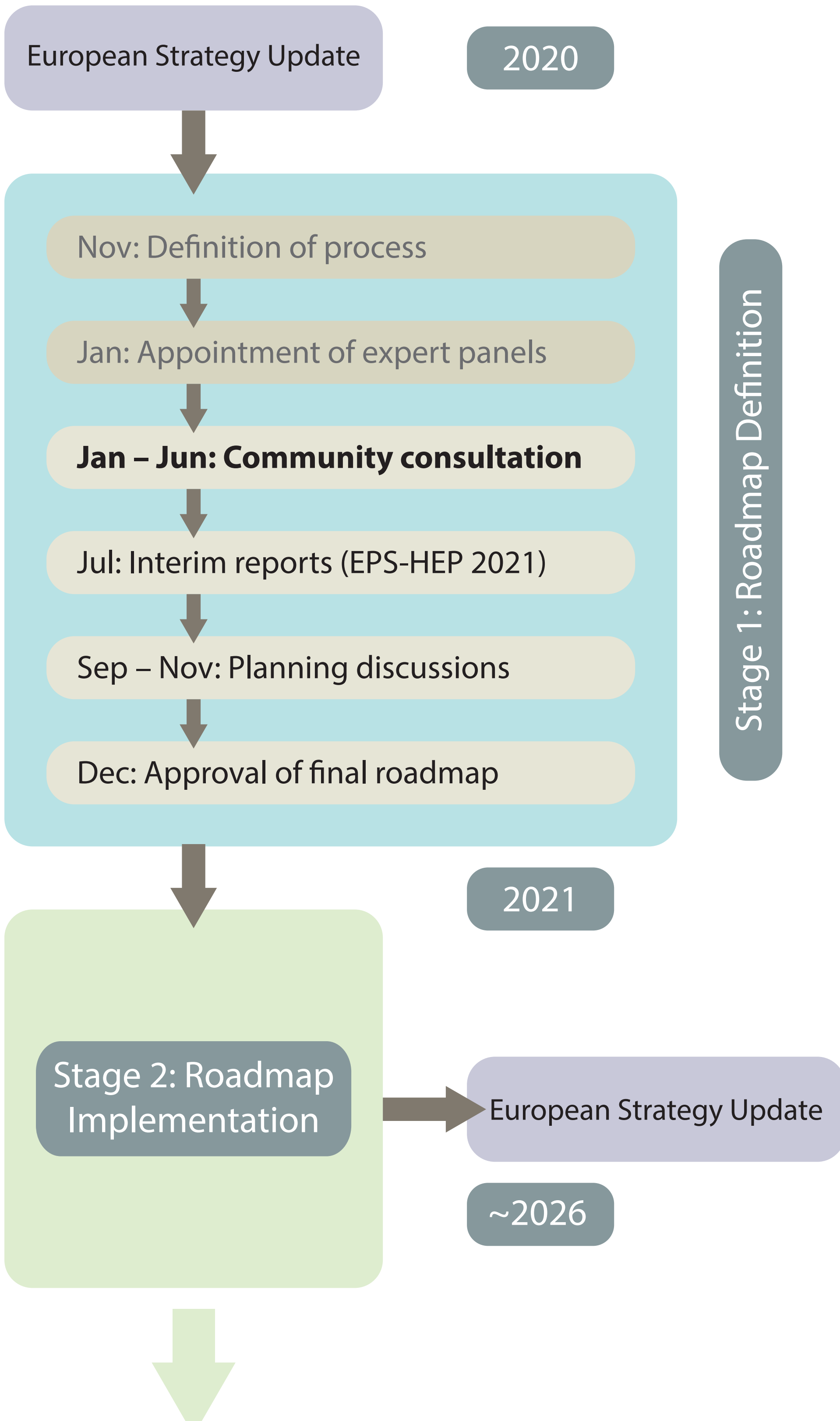
A short report (~20 pages) detailing the conclusions of the evaluation, which should be agreed and supported by the entire sub-Panel and published as Appendix B to the full Panel report.

Methodology: Sessions with proponents to begin with. Sessions open to other ERL panel members

Procedure agreed with the proponents

Valeri Telnov and Vladimir Litvinenko, Tomas Roser

Timeline



- Key dates
  - 9th July: Open workshop for PP community to seek input / feedback
  - July EPS-HEP: reports by panels, summary report
    - Key findings; 'roadmap planning' is next stage
  - September Council: presentation of interim report
  - September – October: 'closed process' to define draft roadmap, scoped plans
  - November: Review and feedback by SPC subcommittee
  - December Council: approval of roadmap
    - Corresponding time line for ECFA detector R&D roadmap

Conclusion

- The end product
  - Report for Council (200pp; panel reports plus synthesis)
  - Summary report in 'glossy' format for funding agencies etc (10pp)
    - To be produced in a consistent style with ECFA – 'companion volumes'
  - Long reports from panels, possibly published
- From January 2021, the 'implementation phase' begins
- Questions for the FCC community
  - Are there R&D requirements from the FCC programme not yet captured?
  - Are anticipated time scales for deliverables compatible with FCC planning?
  - What is the optimal balance between 'generic' long term R&D, medium-term R&D, and near term concrete preparations for new machines?
- All feedback is welcome
  - Public presentation of current findings over the next month
    - Symposium for HEP community: https://indico.cern.ch/event/1053889
  - Please feel free to contact panel chairs directly