LDG Update

- LDG role and remit
- Accelerator R&D progress
- Sustainability assessment
- Open LDG Forum / Workshop
- Changes to LDG composition

Science and Technology Facilities Council

LDG Open Forum @ BNL

- My thanks to the many people involved in the event
  - BNL (Maria Chamizo Llatas) for organising and hosting
  - Speakers and convenors for arranging a high-quality meeting
- Topics discussed
  - European and US strategy processes
  - Labs support for accelerator and detector R&D
  - Sustainability for major facilities
  - Presentations by HEP and non-HEP laboratories (BNL, ESS, SLAC)
  - Community workshop on accelerator R&D progress
- Success?
  - 60 people peak attendance physically / on zoom
  - Feedback from both sides of Atlantic indicates that it was a useful event
  - Clear and significant overlap in interests and opportunities for labs around the world
    - General agreement: convergence in R&D is precursor to collaboration in delivery of next machines
    - The challenges are also in common with (currently) non-PP major laboratories
  - There is no other workshop that covers this territory…
- Continuation?
  - Will aim to keep this 'new tradition' alive post-ESPPU

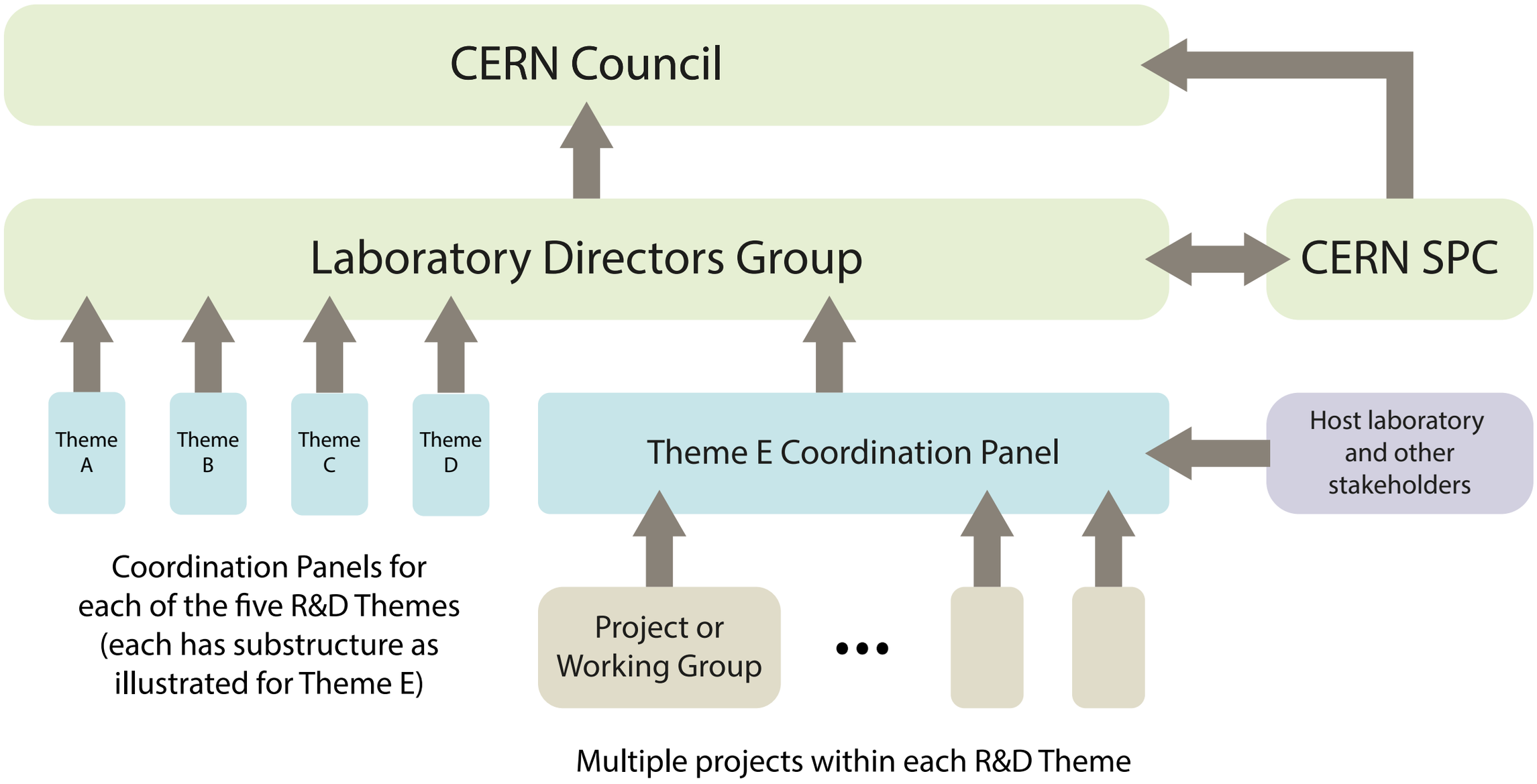
Role of the Major Laboratories

- Focal points for national communities
- Practical support for large-scale HEP projects
  - Engineering, computing, R&D, project and financial management
- Construction / operation of accelerators
  - Including participation in the current and future CERN programme
- Career support for specialists in the above areas
- Exchange of expertise / people between HEP and non-HEP infrastructures
  - Light sources, neutron sources, telescopes, lasers, supercomputing, etc
  - Use of HEP technologies and approaches across other scientific areas is a major generator of impact, and a major justification for continued funding
- The lab mission becomes increasingly diverse, challenging, expensive
  - Labs across the world share similar challenges and need to work together on the solutions
- LDG has a 'built in' role in the European Strategy process,
  - With the responsibility to facilitate the process, but also bring a specific perspective on deliverability of the strategy

LDG Remit

- Remit approved by CERN Council
  - Facilitate informal dialogue among the Directors of the LNLs 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, ensuring that LNLs 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 CERN's Member States, and of other coordinating groups in particle physics and related fields, and foster dialogue with them
  - Draw up and maintain a prioritised accelerator R&D roadmap towards future large-scale facilities for particle physics
  - Coordinate the accelerator R&D activities on the roadmap, with the aim of strengthening cooperation and ensuring effective use of complementary capabilities

Accelerator R&D Coordination



- Vehicle for cooperative, coordinated, focussed R&D towards the future machines
  - Annual workshop on R&D in ~June, annual review of progress by LDG in ~November

High-Field Magnets

Laboratory Directors Group

HFM programme steering board
M. Lamont (chair)
P. Vedrine (co-chair)

HFM programme collaboration board
C. Senatore (chair)
P. Campana (deputy)

High Field Magnet Programme
E. Todesco (Leader), B. Auchmann (Co-leader)

Programme office
G. Riddone

RD1: Nb_3Sn conductor

- 1.1 **Nb_3Sn procurement** T. Boutboul (CERN)
- 1.3 **Nb_3Sn development** C. Senatore (UniGe)
- 1.15 **Nb_3Sn development** T. Nakamoto (KEK)
- 1.17 **Nb_3Sn characterization** A. Kario (U. Twente)
- 1.18 **Studies on oxidation** A. Leineweber (BAF)
- 1.19 **Nb_3Sn characterization** C. Senatore (UniGe)

RD1 line coordinators:
T. Boutboul (CERN)
C. Senatore (UniGe)

Note: completed WPs not shown

RD2:HTS conductor and magnets

- 2.1 **REBCO development** B. Holzapfel (KIT)
- 2.2 **REBCO tapes** A. Ballarino (CERN)
- 2.5 **Demonstrator DI coil** A. Ballarino (CERN)
- 2.6 **Solenoids and MuC** L. Bottura (CERN)
- 2.7, 2.14 **HTS characterization** A. Kario (Twente)
- 2.11 **Demonstrator MI coil** T. Lecrevisse (CEA)
- 2.15 **IBS development** A. Malagoli (CNR-SPIN)
- 2.16 **HTS procurement** A. Ballarino (CERN)
- 2.17 **AC losses and solenoids** Y. Yang (SOTON)

RD2 line coordinators:
A. Ballarino (CERN)
A. Kario (Twente)

RD3: Nb_3Sn magnets

- 3.1 **12 T cosθ CERN** A. Foussat (CERN)
- 3.2 **12 T cosθ FalconD** S. Farinon (INFN)
- 3.4 **Technology development** A. Haziot (CERN)
- 3.5 **14 T block dipole** J. C. Perez (CERN)
- 3.6, 3.12 **14 T R2D2** E. Rochepault (CEA)
- 3.7 **14 T common coil** F. Toral (CIEMAT)
- 3.8, 3.14 **14 T stress managed** D. M. Araujo (PSI)

RD3 line coordinators:
F. Toral (CIEMAT)
A. Haziot, A. Foussat (CERN)

RD4: Modeling

- 4.1 **Model and software** S. Russenschuck (CERN)
- 4.2 **Structural material** C. Garion (CERN)
- 4.3 **Insulation materials** R. Piccin (CERN)
- 4.4 **Impregnation R&D** T. Tervoort (ETHZ)
- 4.5 **Quench D+P** M. Wozniak (CERN)
- 4.6 **Cryogenics and thermal studies** P. Borges de Sousa (CERN)

RD4 line coordinators:
S. Farinon (INFN)
C. Garion (CERN)

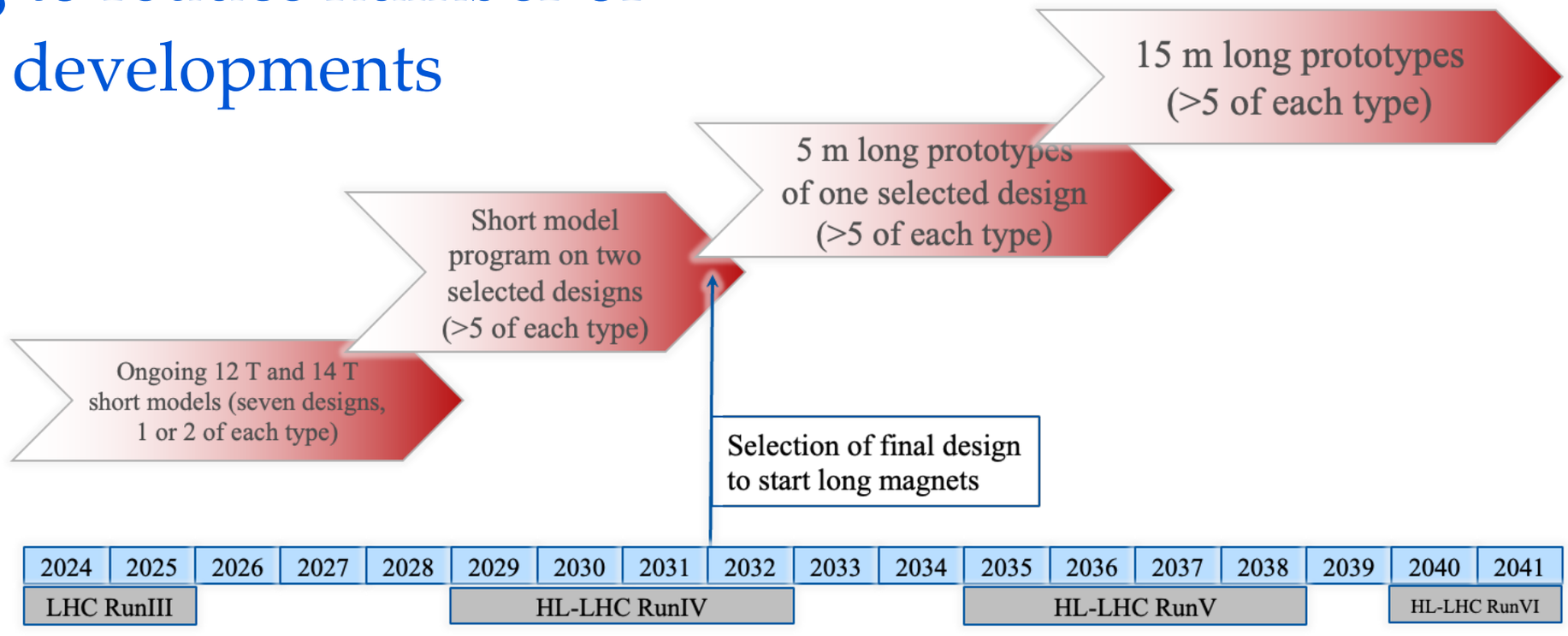
RD5: Infrastructures

- 5.1 **Test** F. Mangiarotti (CERN)
- 5.2 **Conductors** T. Boutboul (CERN)
- 5.3 **Short model** J. C. Perez (CERN)
- 5.4 **Full scale** S. I. Bermudez (CERN)
- 5.5 **Instrumentation** L. Fiscarelli (CERN)

RD6: Scientific and societal impact forum
E. Chesta (CERN)
L. Kretzschmar

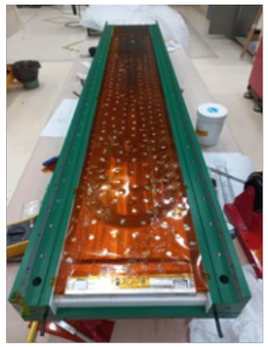
HFM: Key Goals

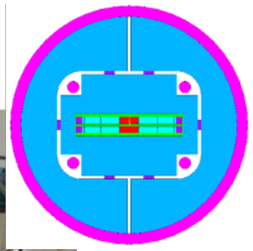
- Goals
  - Develop Nb3Sn dipole at 14T field
    - Sufficient to deliver 80TeV FCChh
  - Explore HTS technology for up to 20T field
    - Compatible with FCChh target of 120TeV
  - Promote common required developments for both technologies
  - Explore implications outside HEP and for society
- Re-planning to reduce number of parallel LTS developments



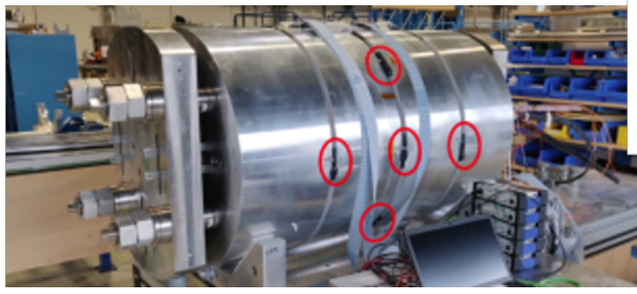
HFM in the Lab!

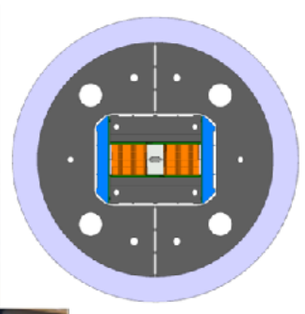
Laboratory Directors Group



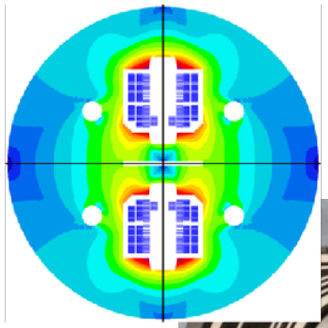


CEA



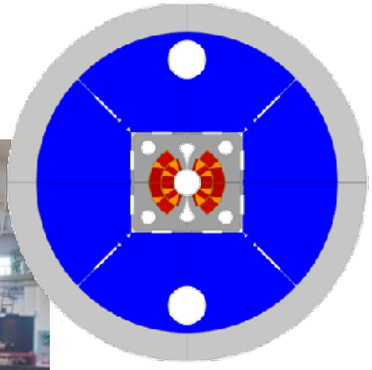


CERN



PSI

LTS

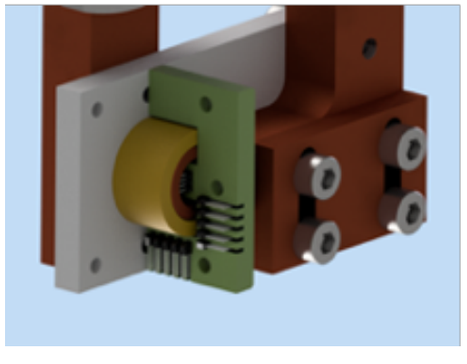


HTS

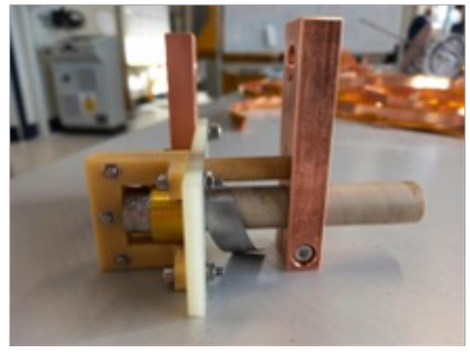
CERN

KIT

INFN



PSI

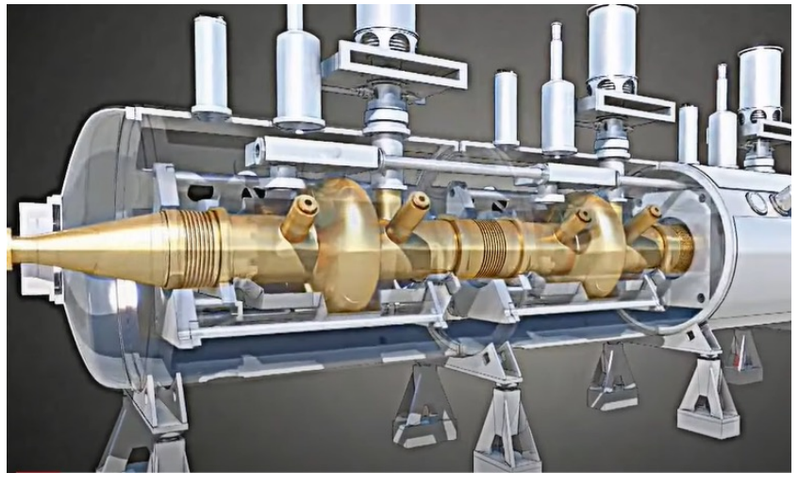


Science and Technology Facilities Council

RF

RF = increase beam energy efficiently and reliably

https://ldg-rfcp.com/



RF Panel coordination	G. Bisoffi INFN-I, P. McIntosh STFC-UK
WG1 **Bulk Nb**	M. Baylac CNRS-F, C. Madec CEA-F, L. Monaco INFN-I
WG2 **Thin films**	C. Antoine CEA-F, O. Malyshev STFC-UK
WG3 **Couplers**	F. Gerick CERN, E. Montesinos CERN, A. Neumann HZB-D
WG4 **NC High gradient**	W. Wünsch CERN, D. Alesini INFN-I
WG5 **RF Power sources**	I. Syratchev CERN, G. Burt STFC-UK, M. Jensen ESS-S
WG6 **LLRF, AI, ML**	Z. Geng PSI-CH, W. Cichalewski U-Lodz-P

= cavities

RF in EC Projects

Running and proposed EU projects with RF content

IFIGENIA: linear accelerators fon novel methods/tools for RI production for medical applications

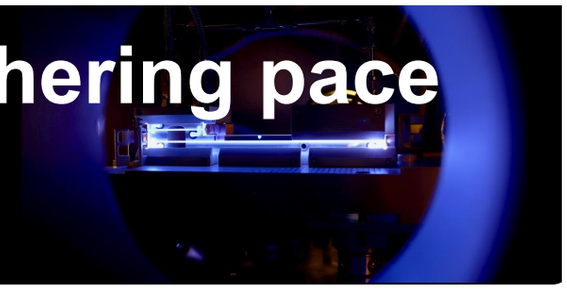
ARTIFACT: ARTificial Intelligence For Accelerators, user Communities and associated Technologies

Including RF items

J.M. Perez-TIARA, at IFAST Annual meeting, Paris April 16-19, 2024

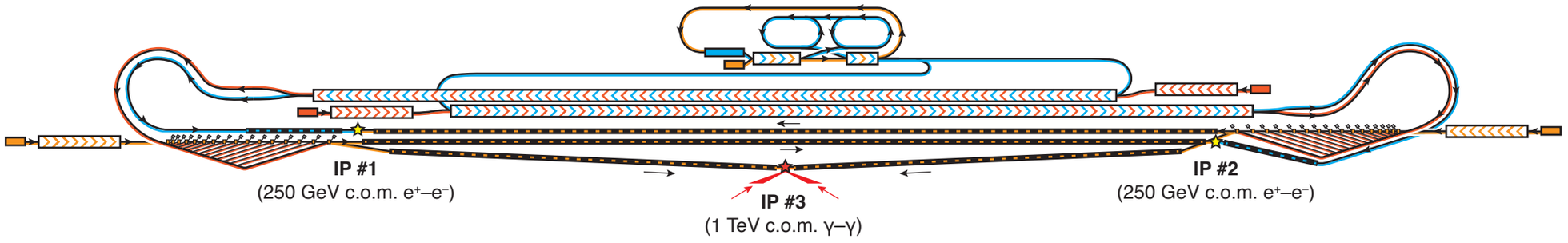
Plasma: HALHF

Progress towards a pre-CDR ‘HALHF 2.0’ is gathering pace



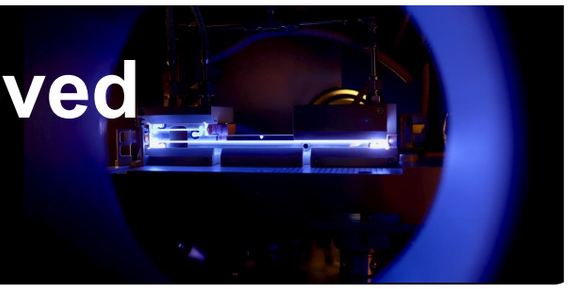
WP1.1: Overall Collider Concepts (R. D’Arcy, C.A. Lindstrøm, B. Foster)

- **Recent progress:**
  - *Collaboration*
    - A group of scientists (plasma, RF, detector/physics, positrons, etc.) meet monthly to discuss crucial themes, including other collider concepts (e.g. proton-driven)
  - *Optimisation*
    - Community engagement has made progress in answering some questions (RF, plasma parameters, etc.) but posed some more (flat beams)
  - *Upgrades*
    - Upgrade paths for polarised positrons, higher energies (380 GeV, 1 TeV), multiple IPs, & γ–γ collisions
  - *Towards a pre-CDR*
    - ‘Experts meeting’ at Erice, Sicily from Oct 3-8 (funded by INFN) to solidify the pre-CDR design



Reference: Lindstrøm, D'Arcy, Foster, arXiv:2312.04975 (2024)

AWAKE Measurement Milestones in 2023 Achieved



WP3.2: Proton-beam-driven experiments (Edda Gschwendtner, Patric Mugli)

10 m Rb vapour source with a density step in AWAKE in 2023/2024

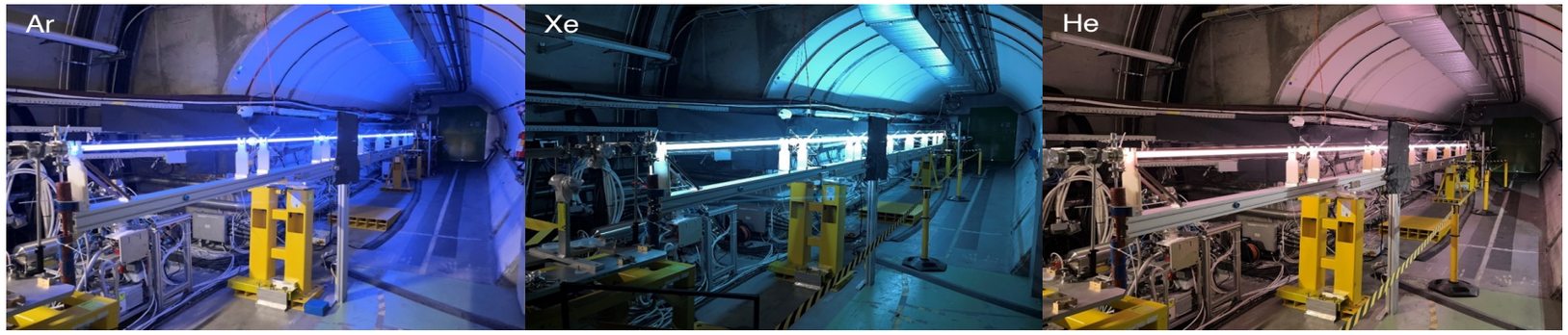
AWAKE Run 2023/24: ***Stabilization:*** New 10 m long rubidium vapour source with a density step

➔ density step allows to **maintain a large amplitude of the wakefields**.

➔ **Clear effects** of the density step seen in 2023 Run!

➔ **Complete the *Stabilization* experiment in 2024!**

10m Discharge Plasma Source: Unique opportunity during May 2023 Proton Run

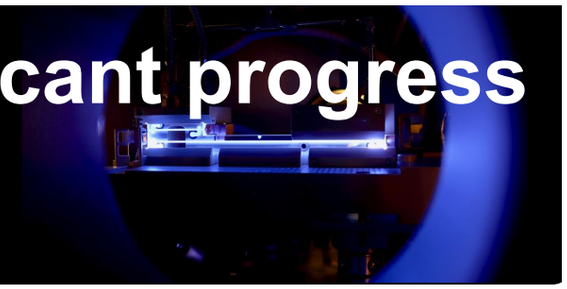


Successfully installed, commissioned and operated a 10m long discharge prototype plasma source during the May 2023 Run

➔ **Physics papers** on current filamentation instability, ion motion, …

Plasma: Positrons

Plasma-based acceleration of positrons: significant progress

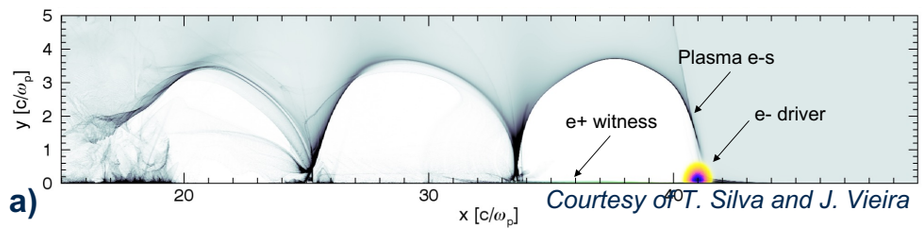


A titanic task, but with new exciting and promising results

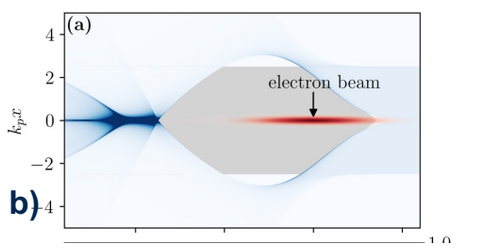
WP 1.4: Positron acceleration (Gianluca Sarri, Severin Diederichs)

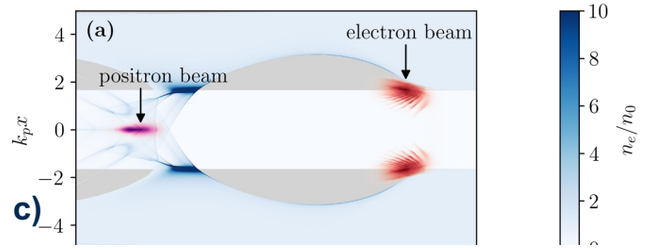
NUMERICAL / THEORETICAL WORK

- GPU-capable PIC codes with mesh refinement allow modeling of positron acceleration with collider-relevant parameters.
- Several acceleration schemes numerically identified, such as hollow plasma channels[1] and finite plasma columns[2].
- Temperature effects shown to enable emittance preservation of collider-relevant positron beams[3].



Courtesy of T. Silva and J. Vieira

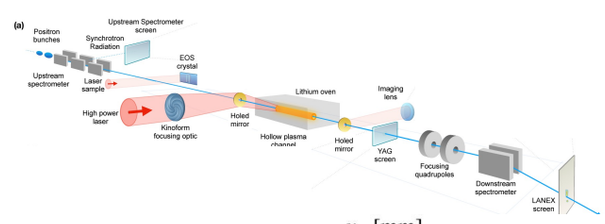


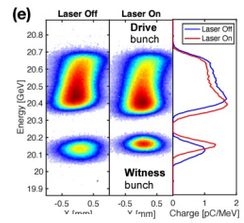


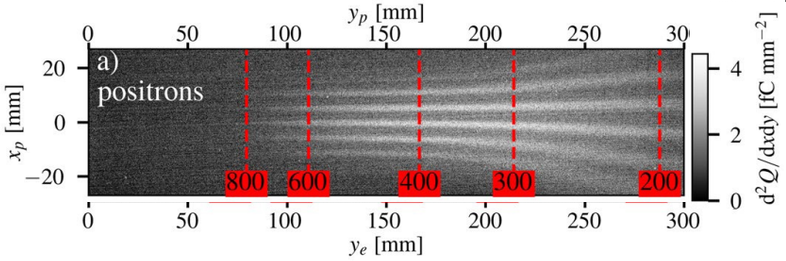
EXPERIMENTAL WORK

- To date, only SLAC can perform meaningful studies of positron acceleration[4]

- Promising results in the generation of high-quality laser-driven positron beams have been obtained[5]







[1] Phys. Rev. Lett. 127, 104801 (2021)
[2] Phys. Rev. Accel. Beams 23, 121301 (2020)
[3] Phys. Plasmas 30, 073104 (2023)
[4] ArXiv:2304.01700 (2023)
[5] Sci. Rep. 10.1038/s41598-024-56281-1 (2024)

Muons: International Progress

US P5: The Muon Shot

Particle Physics Project Prioritisation Panel (P5) endorses muon collider R&D: ”This is our muon shot”

Recommend joining the IMCC
Consider FNAL as a host candidate

The New York Times

Particle Physicists Agree on a Road Map for the Next Decade

A “muon shot” aims to study the basic forces of the cosmos. But meager federal budgets could limit its ambitions.

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AUGUST 28, 2023 | 10 MIN READ

Particle Physicists Dream of a Muon Collider

After years spent languishing in obscurity, proposals for a muon collider are regaining momentum among particle physicists

nature

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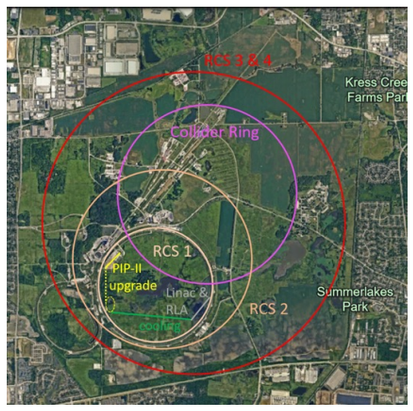
EDITORIAL | 17 January 2024

US particle physicists want to build a muon collider — Europe should pitch in

A feasibility study for a muon smasher in the United States could be an affordable way to maintain particle physics unity.



We welcome the US community

Already participation, also in leadership
- Will increase and reorganise in 2024

Consider also US stated wishes:
- Want to reach 10 TeV parton level collisions
- Timeline around 2050
- Fermilab option for demonstator and hosting
- Reference design in a “few” years

- US - CERN agreement/addendum to be prepared

Muons: Scenarios and Interim Report

Laboratory Directors Group

MuCol

International MUON Collider Collaboration

Interim Report

Executive Summary

Overview of Collaboration Goals and R&D programme

Physics Opportunities

Physics, Detector and Accelerator Interface

Detector

Accelerator design

Accelerator technologies

Synergies

Development of the R&D programme

Implementation Considerations

Contents

MuCol

Target integrated luminosities

$\sqrt{s}$	$\int \mathcal{L} dt$
3 TeV	$1\ \mathrm{ab}^{-1}$
10 TeV	$10\ \mathrm{ab}^{-1}$
14 TeV	$20\ \mathrm{ab}^{-1}$

Need to spell out scenarios

Need to integrate potential performance limitations for technical risk, cost, power, …

Initial Staged Target Parameters

International MUON Collider Collaboration

Parameter	Unit	3 TeV	10 TeV	10 TeV	10 TeV
L	**10^{34} cm^{-2}s^{-1}**	**1.8**	**20**	**6?**	**13**
N	10^{12}	2.2	1.8	1.8	1.8
f_r	Hz	5	5	5	5
P_{beam}	**MW**	**5.3**	**14.4**	**14.4**	**14.4**
C	km	4.5	10	15	15
<B>	T	7	10.5	10.5	7
ε_L	MeV m	7.5	7.5	7.5	7.5
σ_E / E	%	0.1	0.1	0.05?	0.1
σ_z	mm	5	1.5	3?	1.5
β	mm	5	1.5	3?	1.5
ε	μm	25	25	25	25
$\sigma_{x,y}$	μm	3.0	0.9	1.3	0.9

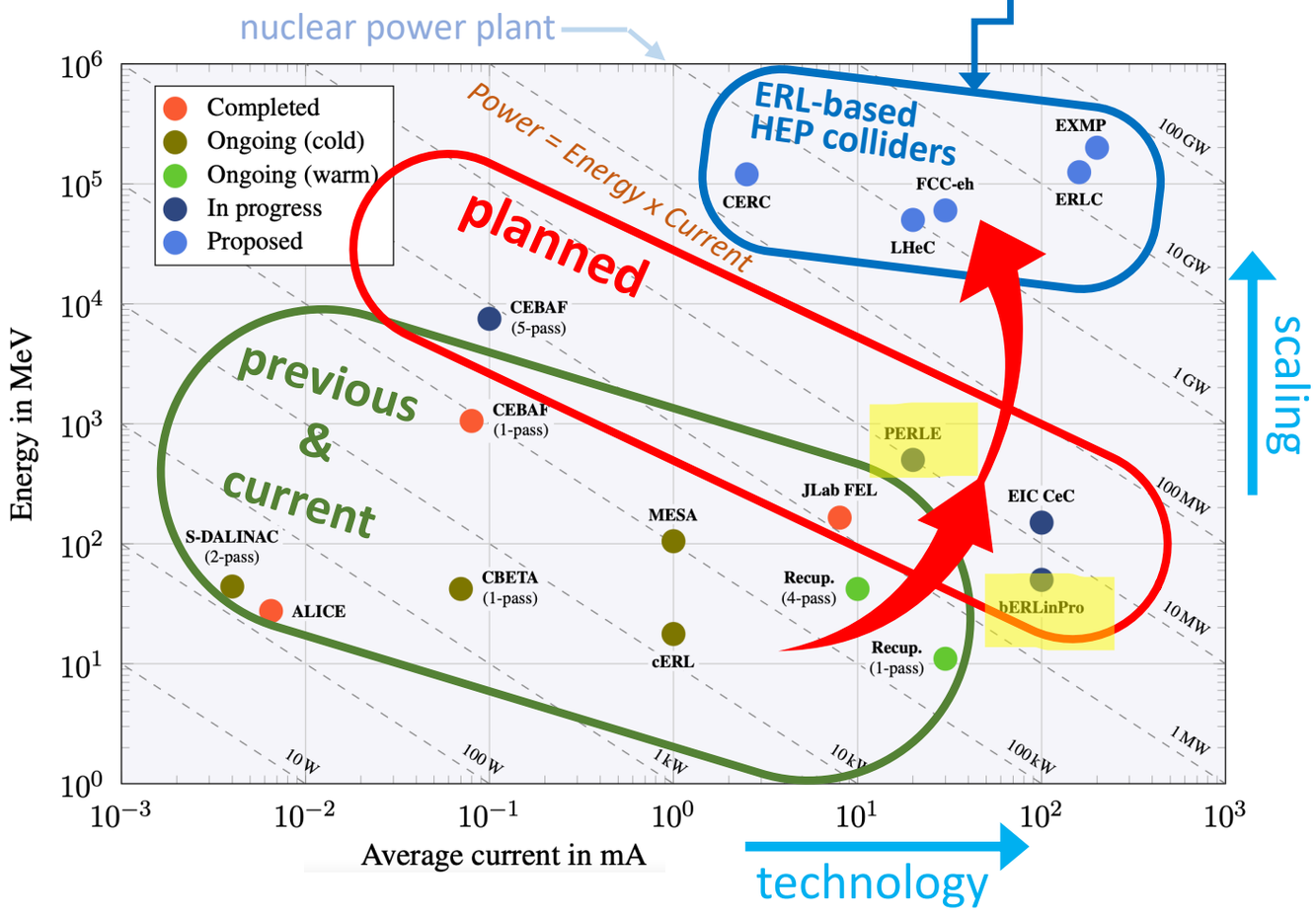
Examples as discussion basis
Numbers will change

D. Schulte Muon Collider, CERN, March 2024

Science and Technology Facilities Council

ERL

ERL to enable high-power beams that would otherwise require one or more nuclear power plants



Future ERL-based Colliders

H, HH, ep/eA, muons, …

R&D Roadmap

bERLinPro & PERLE

essential accelerator R&D labs with ambitions overlapping with those of the particle physics community

towards high energy & high power

Energy Recovery demonstrated

great achievements on all aspects and large research infrastructures based on Energy Recovery systems have been operated successfully

Energy Recovery Linacs (ERL): reaching higher luminosities with less power requirements

Science and Technology Facilities Council

ERL: Progress and Future Impact

Laboratory Directors Group

Innovate for Sustainable Accelerating Systems (iSAS) is a Horizon Europe project

project started on March 1, 2024

Spread over 4 years: ~1000 person-months of researchers and ~12.6M EUR

(of which 5M EUR was requested to Horizon Europe)

DESY. · INFN · UK Research and Innovation · HZB Helmholtz Zentrum Berlin · ESS European Spallation Source · Lancaster University · EPFL École Polytechnique Fédérale de Lausanne · cea · VUB Vrije Universiteit Brussel · cnrs · IJCLab Irène Joliot-Curie · CERN

+ industrial companies: *ACS Accelerators and Cryogenic Systems* (France), *RI Research Instruments GmbH* (Germany), *Cryoelectra GmbH* (Germany), *TFE Thin Film equipment srl* (Italy), *Zanon Research* (Italy), *EuclidTechLab* (USA)

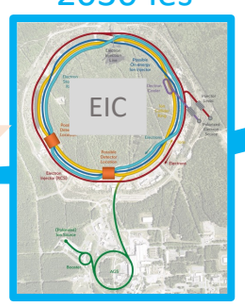
t of ERL technology

demonstrate (multi-turn) high-power ERL

2020'ies

high-power ERL demonstrated

2030'ies



ERL application electron cooling

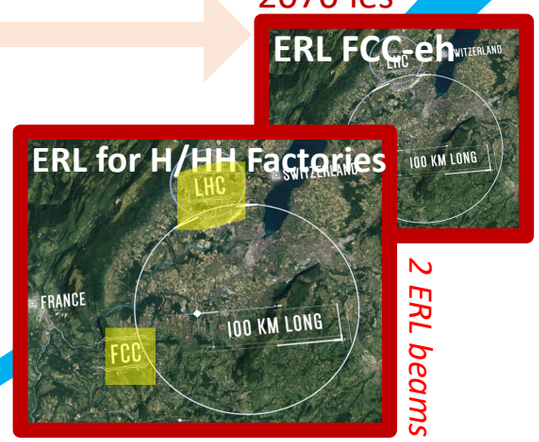
enables the ultimate upgrades of the LHC/FCC programs

2030-2040'ies

high-power ERL
e⁻ beam in collision
(ep/eA @ LHC program)

1 ERL beam

2070'ies



reuse ERL

2 ERL beams

high-power ERL for
e⁺e⁻ Higgs Factories
(Z/W/H/top/HH program)

increases the performance of the next major colliders

Science and Technology Facilities Council

Sustainability WG

- LDG Working Group on "Objective sustainability assessment of accelerators"
  - Working closely with ICFA panel on sustainability
  - Covering technical / organisational angles respectively

LDG Sustainability WG Composition

People with expertise in evaluation of research infrastructure sustainability and representatives of projects for future accelerators

Wide spectrum of experience and skills from

- sustainability panels established at CERN, DESY, ESS, NIKHEF, STFC
- R&D and operation of accelerators
- Projects for future Higgs factories

to elaborate on the mandate

Development of Guidelines and a minimum set of Key Indicators pertaining to methodology and scope of reports on sustainability in future HEP projects

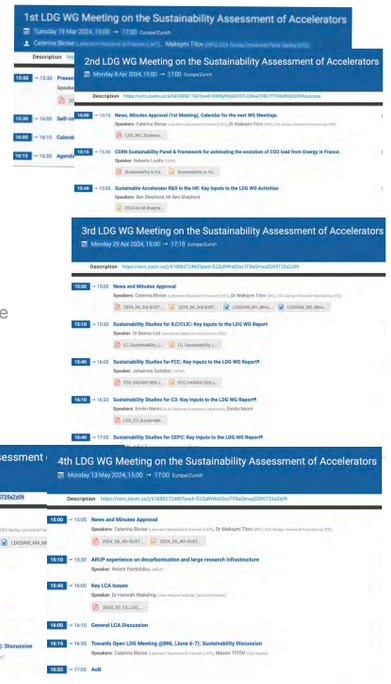
• Walib Kaabi	iSAS, PERLE
• Mats Lindroos	ESS (deceased May 2, 2024)
• Roberto Losito	CERN sust. panel
• Ben Shepherd	STFC sust. Task Force
• Andrea Klumpp	DESY sust. panel
• Hannah Wakeling	ISIS-II Neutron & Muon Source
• Patrick Koppenburg	NIKHEF sust. panel
• Johannes Gutleber	FCC
• Yuhui Li	CePC
• Benno List	ILC
• Emilio Nanni	ICFA and CCC
• Vladimir Shiltsev	LHeC, FCC-eh
• Steinar Stapnes	CLIC, Muon collider
• Caterina Bloise	Co-Chair
• Maxim Titov	Co-Chair, EU-EAJADE

Working Group Activity

Broad range of topics shared

- Reports from CERN and STFC sustainability panels, ESS, Snowmass ITF
- Evaluations carried out for future Higgs factories, FCC, ILC, C3 and CePC
- On key LCA issues
- Invited contributions on Decarbonisation for Large RI, H.Pantelidou (ARUP), Eu-Horizon Project RF2.0, G. DeCarne (KIT), Reduction of GHGs in particle detectors, B. Mandelli (CERN)

Elaboration of WG Report started



Sustainability WG

Laboratory Directors Group

Working Group Report

Overleaf area created

Structure and basic content suggested by reports to the WG and follow-up discussions

Draft report is expected by end of 2024

Report as an input document to the ESPPU due by March 2025

An homogeneous evaluations of all issues will probably need more time to develop and deserves a strategy to be pursued

Science and Technology Facilities Council

LDG Strategy Input

- In-depth international 'mid-term' review of R&D proposed for November
  - Detailed reports needed as basis of LDG ESPPU input
    - We assume accelerator panels and other players will make detailed technical submissions
  - We are mid-way through the roadmap programme
  - Key decisions to be made in the coming year on technology choices
- Charge to review panel
  - Determine current status of the R&D in comparison to original planning
    - Including areas where an increase / redistribution of resources is needed
  - Identify key decisions for the coming period, and input needed for those decisions
  - Determine key future R&D topics and themes for the next phases of R&D
  - Comment on an appropriate project structure and governance mechanism for future R&D
- Other common interests where labs may wish to input to ESPPU ('how' not 'what').
  - Sustainability of computing and non-accelerator infrastructure
  - Use of 'non-HEP' facilities for particle physics
  - Provision of engineering and support facilities (-> LDG / ECFA WG)
  - Model for cross-Europe and global engagement in technical delivery of major projects
    - And making that model efficient and effective
  - The technology pipeline from HEP into science and society
  - Support for recruitment, careers, training, mobility
- Beate / Franck will lead a focussed discussion in September on an LDG submission

LDG Composition

- Laboratory representatives
  - S. Bentvelsen (NIKHEF)
    - Will be replaced during 2024
  - F. Bossi (LNF)
    - -> Paola Gianotti from August 2024
  - J. Clarke (DL)
  - N. Colino (CIEMAT)
  - F. Gianotti (CERN)
  - B. Heinemann (DESY)
    - Will be replaced during 2025
  - D. Newbold (RAL)
    - -> Sinead Farrington from January 2025
  - E. Previtali (LNGS)
  - F. Sabatie (IRFU)
  - M. Seidel (PSI)
  - A. Stocchi (IJCLab)
- Standing observers
  - P. Sphicas (ECFA Chair)
  - M. Lamont (CERN Directorate)
  - J. Mnich (CERN Directorate)
  - H. Montgomery (SPC Chair)
- Secretary
  - E. Tsemelis (CERN)
- Extended LDG members
  - G. Bisoffi (RF) + P. Macintosh
  - W. Leemans (LPA) + R. Patahill
  - S. Stapnes (Muons) + D. Schulte
  - J. D'Hondt (ERL) + M. Klein
  - P. Vedrine (HFM)
  - C. Bloise + M. Titov (Sust. panel)

Election of LDG Chair

- At it last meeting, LDG elected its new chair for 2025–26
- Unanimous support for Professor Mike Seidel
  - Mike is Director of Large Research Facilities at PSI and chair of accelerator physics at EPFL

- Congratulations!
  - Mike will take over the duties of LDG chair, including on the ESG secretariat, ECFA, and CERN SPC, in January 2025