Starting with the Future...

- Everything is driven by our science roadmap
 - Namely, the European Strategy for Particle Physics
- Some future facilities explicitly mentioned:
 - Completion, commissioning, exploitation of HL-LHC
 - Delivery of LNBF / DUNE
 - Electron-positron Higgs factory
 - Energy frontier proton-proton collider

- <image><image><image><image><image><image><image><image><image><image><image><image><image><text><text><text>
- Also increasingly prominent in discussions: muon collider
- Past achievements rest on substantial, sustained technology R&D
 - At least 20 years prior to LHC / HL-LHC
 - Several sequential stages of R&D and industrialisation required
- Future facilities depend yet more strongly on new technology
 - Fundamental R&D challenges presented by long-term machines
 - Efficiency and industrialisation challenges presented by nearer-term machines



R&D in the EPPSU

- 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 should be acknowledged as a vital need with the highest priority within the update. (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)



Dave.Newbold@stfc.ac.uk

Roadmap Requirements

- Provide a structure for a coordinated and intensified programme of 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 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 largescale 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 in the context of a longer overarching programme



Accelerator R&D Panels



 A big thank you to all members of the international accelerator community who have contributed



Informally: The Questions

- What R&D remains to be done towards future facilities?
- What are the priorities?
- How long might it take?
- What is the fastest technically limited schedule?
- How much will it cost?
- What different options and trade-offs exist?
- What are the linkages between activities?
- What science can be done using demonstrators, or intermediate-scale facilities?
- The Roadmap should provide answers: both this year, and in increasing detail for subsequent strategy updates
 - In many cases, the first R&D phase will focus on feasibility / motivation / justification

Dave.Newbold@stfc.ac.uk

Process



- Consultation phase now finished
 - (Literally) dozens of meetings / workshops and hundreds of inputs to the process
 - Symposium in July generated useful feedback from the PP 'user' community
 - Presentations of at EPS-HEP
 - Interim report almost finalised
 - Feedback from SPC and via RECFA now requested
- Next steps
 - 'Closed process' to define delivery plans
 - Late November: formal review of final plans
 - December: endorsement by CERN Council
- Subsequent implementation
 - Community / collaboration driven
 - Seems clear that some formal high-level coordination / governance is also necessary



Objectives: HFM

100000

GOALS OF A HIGH FIELD MAGNETS R&D PROGRAM

- Demonstrate Nb₃Sn magnet technology for large scale 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 in excess of 20 T)

10000 *Robust* Nb₃Sn Total magnet length (m) 1000 HL-LHC QXF 100 Logical step for a next HL-LHC 11T phase (2027-2034) 10 D20 (Fresca2 - Ultimate Nb₃Sn Exploration of 1 MDPCT1 new concepts HTS and technologies 0.1 5 10 15 20 25 Bore field (T)

Dave.Newbold@stfc.ac.uk

Development of robust and

cost-efficient processes

LHC 💧

• Other key parameters:

- Cost of Magnets & R&D
- Timeline of a realistic development

LDG meeting, 19 July 2021

Page 5



Objectives: RF

	Particle sources	Magnet and Vacuum systems	High Field SC magnets	Normal Conducting RF structures	Superconducting RF cavities	RF power sources	Cryogenics	Instrumentation
ILC	•				•	•	•	•
FCC	•	•	•		•		•	•
PIP-II, MYRRHA					•	•	•	•
JLEIC	•		•	•		•		•
eRHIC, LHeC					•		•	•
DIAMOND2, SLS2		•				•		•
LCLS2-HE, SHINE		•			•		•	•
DONES	•	•		•	•	•	•	•
DEMOs	•		•			•	•	
PERLE					•	•		•
BELA, compact neutron sources	•			•				•

- Scope covers both SC and NC RF structures
 - Not only cavities, but couplers, tuning elements, power sources, LLRF
- Main challenges
 - Efficiency and optimisation of the end-to-end system
 - Efficient automation / industrialisation for assembly and tuning
 - Diagnostics and rapid feedback mechanisms
 - Development of sources, materials and structures for new wavebands (mm / THz)





Objectives: Laser / Plasma



Complementary to existing work in other fields

- Address HEP-specific aspects not covered elsewhere, while maintaining close links
- Focussed on feasibility and motivation for large programme in next decade





Objectives: Muons



Focus on feasibility study for the next strategy update

- Goal is to scientifically justify a larger-scale investment in further R&D
- Requires evidence that all key challenges can be met, and that sustainable design is possible
- Parameter choices for 3TeV (2045) and 10TeV machines under study
- Precursor demonstrator beam (with science applications) in nearer term



Objectives: ERL





Final Report

- Interim report now under review by CERN Scientific Policy Committee
- Panels now working towards delivery plans
 - Concrete deliverables, including technology demonstrators, over the next ten years
 - First estimates of the human and capital resources required
 - Specification of the large- and medium-scale facilities required for delivery
 - Links to work planned in other fields or for non-particle-physics facilities
 - Requirements for detector or instrumentation developments
 - Scientific benefits foreseen in the short to medium term
- The R&D plans will be large-scale and long-term in nature
 - Will break down into manageable 'work packages'
 - Could directly form the basis for new RD collaborations in some cases
- Additional content being prepared for the final report
 - Stand-alone summary chapter on sustainability aspects
 - As background, short summaries of work planned towards specific facilities
 - Cross-cutting recommendations, including on future organisation
- Final (public) report to be endorsed by CERN Council in December 2021





Additional Information



Panel Remit and Positioning

• Expert 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 \checkmark
- Propose ambitious but realistic objectives, work plans, and deliverables
- Give options and scenarios for European investment and activity level
- NOT in scope at this stage
 - Detailed discussions of funding or commitments
 - But: must establish a 'credible envelope' for R&D investment to guide plans
- Positioning of R&D in the field
 - R&D is only one aspect of a substantial workload in coming years
 - Preparations for HL-LHC; specific feasibility studies for new machines
 - But: continuity of ongoing R&D, and early feasibility studies are essential to steer and support the long-term future of the field
 - The roadmap cannot make choices on the balance of activities but it must explore the consequences of those choices

Dave.Newbold@stfc.ac.uk