

European Strategy for Particle Physics Update

Tracey Berry on behalf of PPAP



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European Strategy for PP Update - context!



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European Strategy for Particle Physics Update



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- ESPP is cornerstone of Europe's **decision-making process for long-term future of field**
- Mandated by the CERN Council: initiated in 2005
resulting document adopted by Council in 2006.
- Formed through **broad consultation of the grass-roots particle physics community**
Actively solicits opinions of physicists from **around the world**
- **Coordination** with similar processes in US & Japan for optimal use of resources **globally**
- **Regular updates** to account for evolution of field
- Next was prepared in 2012 and adopted in 2013 (post Higgs)

2016
2019
Now preparing 2024/5

2018
2020
2026



Now preparing 2024/5

**We would like
your input!**



European Strategy for Particle Physics Updates



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Introduction: LHC and its High Luminosity upgrade

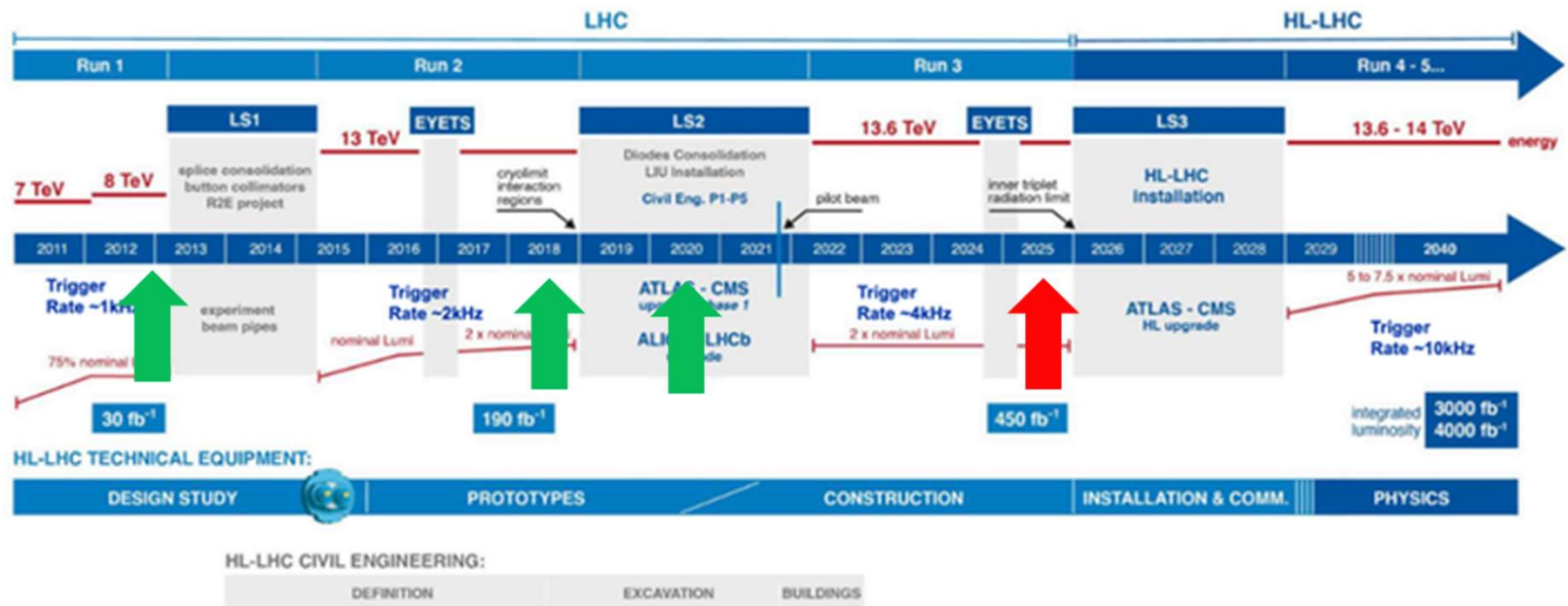


Figure adapted from: Zerlauth, Markus & Bruning, Oliver. (2024). Status and prospects of the HL-LHC project. DOI: 615. 10.22323/1.449.0615.

1st European Strategy for Particle Physics (0th update)



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2006 document:

- Placed the **LHC** at the top of European particle physics' scientific priorities,
- with a significant **luminosity upgrade** already being mooted.
- A ramp-up of **R&D into future accelerators** also featured high on the priority list,
- followed by coordination with a **potential International Linear Collider**, and
- participation in a **global neutrino programme**.
- original Strategy also foresaw **increased collaboration** with neighbouring fields such as **astroparticle and nuclear physics**, and
- recognised the importance of complementary issues such as **communications and technology transfer**

Introduction: LHC and its High Luminosity upgrade



1st European Strategy for Particle Physics Update



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Next Update: prepared in 2012, adopted in 2013

PP had evolved! **Higgs discovered...**

- **LHC** topped the list of scientific priorities
- with the **high-luminosity upgrade** increasing in importance, and
- preparations for the **post-LHC future** taking shape.
“Europe needs to be in a position to propose an **ambitious post-LHC accelerator project at CERN** by the time of the next Strategy update.”
- Remainder of the updated recommendations represented logical and evidence-based evolutions of those contained in the initial European Strategy
- *All have been, or are in the process of being, implemented*

Introduction: LHC and its High Luminosity upgrade



Figure adopted from:
Zorfaoui, Mariani & Stawing, Oliver. (2024). Status and prospects of the
HL-LHC. DOI: 10.22323/1.449.0615.

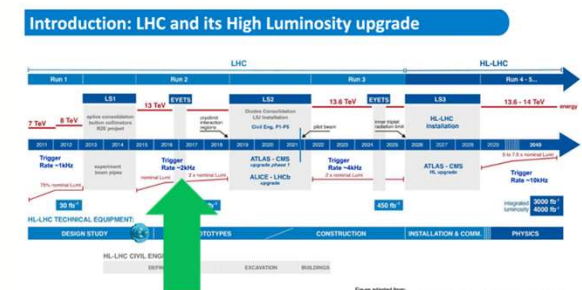
2nd European Strategy for Particle Physics Update



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2nd update of European Strategy started in 2016: *“the stakes were high”*

- Europe, in collaboration with worldwide partners was **engaged in R&D projects for a range of ambitious post-LHC facilities at CERN** under the CLIC and FCC umbrellas.
- **Compare to other projects being considered beyond Europe:**
International Linear Collider (ILC) in Japan, and
Circular Electron-Positron Collider (CEPC) in China
decision on whether ILC to go forward eagerly anticipated!
check progress, matching their expected performance to physics needs
- *impressive results from the LHC, as well as from technological and resourcing considerations*
- Europe, through CERN, contributing fully to a **globally-coordinated neutrino programme with experiments to be carried out in the USA and Japan**
- A study to investigate the potential for physics beyond colliders, maximising the potential for CERN’s unique accelerator complex, was launched in 2016

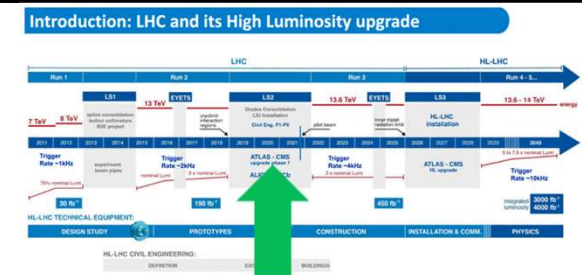




Structure for Strategy Update

- 3rd update of the European Strategy for PP formally got under way in September 2018,
- when CERN Council, comprising representatives from CERN's Member and Associate Member States, established a **European Strategy Group (ESG)** to coordinate the process.
 - ESG worked in **close consultation with the scientific community**:
 - **call for input** from the entire physics community in March 2018 (200 submissions)
 - Discussed in an **Open Symposium in Granada, May 2019** and summary of community's input distilled into **Physics Briefing Book**, by Physics Prep. Grp.
 - Final recommendations, ESG converged on, in **week drafting session, Germany, Jan 2020**

A year & half+



2020 Update



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2020 strategy update:

- Places priority on the successful **completion of High-Luminosity LHC** over coming decade
- begins to map out potential landscape in Europe in post LHC (near- and long-term future)
- recommends a **Higgs factory** as the highest priority to follow the LHC
- while pursuing a technical and financial feasibility study for a **next-generation hadron collider in parallel**, in preparation for the long-term
- maintaining the existing European **support for neutrino physics in the USA and Japan** is also strongly recommended
- also covers areas of **synergy** with neighbouring fields e.g., **astroparticle & nuclear physics**
- includes societal aspects ranging from **training and knowledge transfer** to
- **minimising the environmental footprint of future facilities**

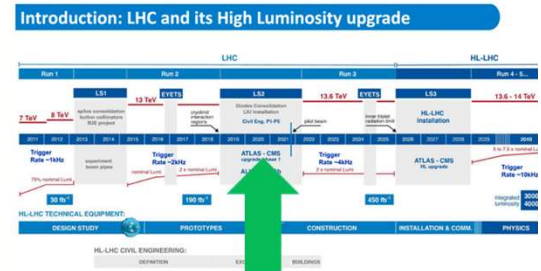
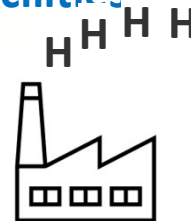
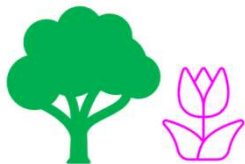


Figure adapted from:
Zohar, M. & Shuang, C. (2020). Status and prospects of the HL-LHC.
DOI: 10.1088/1361-6470/ab8d8d

European Strategy for PP Update - Plan this time!



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Structure for Strategy Update

This time...

1 May: virtual kick-off meeting, by ECFA-UK, inform community on ES process
and encourage inputs to physics briefing book

May/June: kick-off meetings accelerator/detector communities

April/May: PPAP survey to input to Science Board (PPAN) Roadmapping

 **25-26 June: PPAP community meeting** -input for PPAN long-range PP Roadmap &
discussion on UK input to the European Strategy for Particle Physics Update

23-26 September: IPPP, Durham: **Workshop**, by ECFA-UK and IPPP,
physics, detector and accelerator opportunities/challenges
inputs to physics briefing book, UK technical input ESPPU detector R&D

October: **Drafting Day:** community consensus building,
pulling technology and physics aspects together for UK input

in coordination with Science Board (PPAN) prioritised roadmap process, PPAP gathering input

What does ECFA do (in the UK)



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Sinead Farrington

European Strategy Particle Physics Update:

Workshop at IPPP, Durham in September organised by ECFA-UK

<https://conference.ippp.dur.ac.uk/event/1357/> please register!

- Organised by ECFA-UK and IPPP, Durham
- Bring the community together for a physics (rather than strategic) focused workshop
- Discuss the major physics goals of the next decades of particle physics and encourage UK contributions to analysis studies which can be submitted to the strategy process, either as individual studies, or as submissions by already-established consortia, or as inputs to the ECFA e+e- study (as an example).
- Provide talks on opportunities and challenges in detector R&D and accelerator physics.
- Workshop is open to all, with participation across **all particle physics scientific interests - theorists and experimentalists - and across the community demographic.**
- It is not intended to discuss preferences for facilities at this meeting, rather to inform the next steps in our national discussion.

What does ECFA do (in the UK)



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European Strategy Particle Physics Update:
Workshop at IPPP, Durham in September organised by ECFA-UK

Sinead Farrington

**If you have topics to contribute please contact the session chairs
(in each case the last one is the ECFA-UK member helping with that area):**

- **Detector R&D:** Chris Parkes, Daniela Bortoletto
- **Accelerator R&D:** Phil Burrows, Jim Clarke, Stewart Boogert, Matthew Wing, Haroon Rafique
- **Theory cross-cutting the below areas:** Michael Spannowsky, Sinead Farrington
- **e+e-:** Guy Wilkinson, Aidan Robson
- **eh:** Uta Klein, Matthew Wing
- **10 TeV pCM colliders:** Andy Pilkington, Karol Krizka and Sarah Williams
- **HL-LHC:** Jon Butterworth, Sinead Farrington, Daniela Bortoletto
- **Neutrinos:** Kirsty Duffy, Sarah Williams
- **Direct Dark Matter:** Sally Shaw, Sarah Williams
- **Non-collider experiments:** Carl Gwilliam, Mark Lancaster, Sarah Williams
- **Quantum technologies:** Ian Shipsey, Sarah Williams

Drafting Day



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Sinead Farrington

- **October**, date to be advised:
- **UK national EPPSU submission Drafting Day**: here the work begins on a community-wide draft.
- Try to converge around UK positions on some key questions.
- We may have a set of questions by then for national inputs to the European Strategy Update.
- This drafting day will aim to write down, from day one, statements that the UK community can agree on for submission. Later drafting days will iterate on this - the suggestion is 1-2 further drafting days before the deadline in March 2025.

The editors will be drawn from ECFA-UK and co-opted PPAP members, to provide expertise across the full range of areas.

ESPPU Context



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Formulating Europe's strategy for particle physics

Sinead Farrington

Five stages:

1. Community provides input by 31/3/25

2. Physics Preparatory Group (PPG) produces a Briefing Book

3. Open community meeting, June/July 2025

**4. European Strategy Group (ESG) meets to draft the text;
expected UK ESG members:**

Mark Lancaster (Manchester, UK CERN Council Scientific Delegate)

Jim Clarke (AsTeC)

Sinead Farrington (RAL-PPD) – UK national lab representatives

5. Proposal goes to CERN Council, late 2025/ early 2026.

All coordinated by Strategy Secretary,
appointed last week by CERN Council: Karl Jakobs

European Strategy for PP Update - Your Input!



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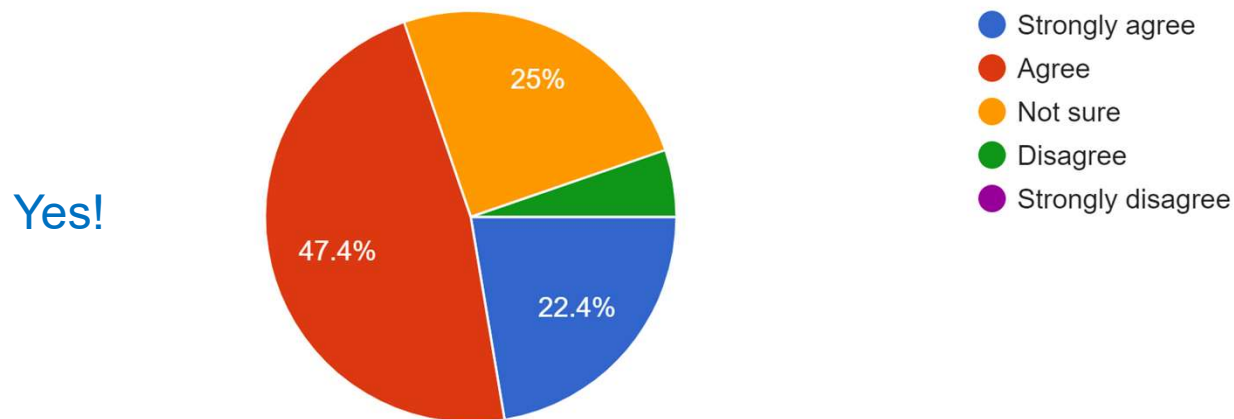
70 % - UK should prioritise input to ESPPU



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Should the UK prioritise science areas in the national input to ESPPU?

76 responses



- **European subset of PPAN prioritisation** should be baseline input, for coherence
- Need **Plan B** priorities for eventuality of no FCC:
what is the STFC approach if CepC is the only e+e- machine?
- Mix of calls to **balance** away from big expts (incl FCC, feeling ESPP is too CERN-centric), vs. calls for full exploitation of LHC and Higgs sector
- Split calls for **push UK strategic areas of expertise/leadership vs "pure science"***
view on priorities [*] subjective!
- Contextual: **climate and ECR welfare** raised in a few submissions

European Strategy for PP Update - Your Priorities



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2 main discussion points

- What are the **top scientific challenges** that the European Strategy for Particle Physics should address in the next 10 to 20 years?
- Please identify which of these may **require any major investment** in new capability?

1. What are the top scientific challenges that the European Strategy for Particle Physics should address in the next 10 to 20 years?



- 55 responses
 - 10 = groups
 - 45 = individual

Individual responses are broken down as follows

Career stage	Responses	University	National lab
PhD	0	0	0
Postdoc	5	5	0
Research Fellow	5	4	1
Lecturer	10	10	0
Professor	22	21	0 (1 "other")
Other	3	2	1

Only 5 theorists answered individually

- Concerning that no PhD students answered
- ECR events do include PhD students, include PhD more? they are the future!

1. What are the top scientific challenges that the European Strategy for Particle Physics should address in the next 10 to 20 years?



(Full) exploitation of the (HL-)LHC”

55 responses
10 from groups

Same as UK
[14]

Risk management
Plan B (without FCC)
(and potentially C
(CEPC while HL-LHC)
and D (neither FCC or
CEPC approved) = 1

Keeping CERN
alive &
worldleading in
Europe

Climate
Crisis

Maintaining Skills
ECR engagement =
support during long
timelines

Higgs

Dark Matter

Neutrinos

BSM

Strategy for Facility
beyond
HL-LHC & CERN,
support global
projects

Realistic path to
future colliders
R&D

New accelerator
technologies

Break-through
future collider:
muon or wakefield
plasma

double-beta
decay

Flavour
anomalies

Theory

Baryon asymmetry
confirm lepton CP
violation

machine
learning
advances

1. What are the top scientific challenges that the European Strategy for Particle Physics should address in the next 10 to 20 years?



Individual Trends that emerge:

- Decision on the next collider (post LHC era) is needed
- R&D resources are limited and must be directed appropriately
- Post-LHC plans for CERN should be clarified as soon as possible
- Higgs characterisation
- “Solve” the dark matter problem
- Important to include neutrinos in ESPPU update even though main experiments are outside Europe
- CP-violation in neutrino sector and precision measurement of PMNS matrix
- Full exploitation of LHC upgrades
- Balanced flavour physics programme

**Same themes from
individuals as from groups**

Group submissions:

- Precision studies of Higgs properties
- Find BSM physics
- Discover nature of dark matter
- Important for CERN to invest in experiments outside CERN e.g. neutrino programme. Has been successful with strong contributions to DUNE & T2K ND280 upgrade
- Maintain a diverse and engaging programme in the post-LHC era

1. What are the top scientific challenges that the European Strategy for Particle Physics should address in the next 10 to 20 years?



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Additional drivers:

- Consider impact of research on our climate
- Help solve the climate crisis
- Decreasing interest from younger generations?
- Machine learning will be important irrespective of future programme.

1. What are the top scientific challenges that the European Strategy for Particle Physics should address in the next 10 to 20 years?



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➤ Discussion!

European Strategy for PP Update

- Your views: major investments?



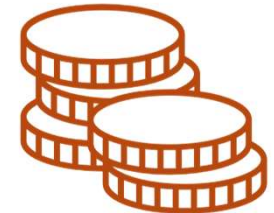
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2. Please identify which of these may require any major investment in new capability?



- **Detector R&D for accelerators and detectors** for a future
 - energy-frontier hadron machine
 - e+ e- Higgs factory
 - FCC
 - muon collider
 - linear collider
 - neutrino & infrastructure

(RF and magnet test stands and a prototyping activity)
(need strong participation for the UK to take a leadership role)
- **AION and XLZD (technology)/Boulby, Dark Matter**
- **BDF/SHiP**
- **Neutrino physics**, phase II of DUNE and potentially HK over the 10 to 20 years
- **Flavour**
- **Analysis facility**
- large-scale **Machine Learning computing** capabilities
- Facilities for fabricating experimental/prototype **quantum sensors**, but may already exist within **EPSRC**.



Please identify which of these may require any major investment in new capability?



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➤ Any missing?

➤ ?



Thanks for participating

Next steps... workshops.....

23-26 September: IPPP, Durham: **Physics, Detector & Accelerator Workshop,**
ECFA-UK/IPPP
<https://conference.ippp.dur.ac.uk/event/1357/>

October: **Drafting Day**

Safe travels home!