Update on (the updated) European Strategy for Particle Physics

Latin American Strategy Forum For Research Infrastructures
July 7th 2020

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CERN Council (double) role
The European Strategy for Particle Physics (ESPP)
The ESPP ‘05-’0) process and 2013 update
The ESPP update process (‘18-’20)
Highlights from the 2020 ESPP update
Founded in 1954 by 12 European States - “Science for Peace”
~ 2’500 staff, ~ 1’800 other paid personnel, ~ 14’000 scientific users
Budget (2018) ~ 1’2 bnCHF

Governance: CERN Council (Member States)

23 Member States: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Israel, Italy, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Spain, Sweden, Switzerland and United Kingdom
2 Associate Member States in the Pre-Stage to Membership: Cyprus, Slovenia
6 Associate Member States: Croatia, India, Lithuania, Pakistan, Turkey, Ukraine
2 Current Applications for (Associate) Membership: Brazil, Estonia
Observers to Council: Japan, Russia, United States of America; EU, JINR and UNESCO

International co-operation agreements & other instruments with 62 more countries
There is a fundamental need for an ongoing process to define and update the European Strategy for Particle Physics; Council [...] shall assume this responsibility, acting as a council for European Particle Physics

CERN-Council-S/002, July 2006
https://council.web.cern.ch/en/content/mandate-espp
European Strategy for Particle Physics - ESPP

- Process for European particle physics community to update the scientific priorities of the field.
- Adopted by the CERN Council and basis of CERN’s scientific program.
- First ESPP in 2006; first update in 2013
- Last update approved June 2020 (started in late 2018)
- Physics-driven, bottom-up, process involving the community, with awareness of financial/technical feasibility. Also includes recommendations on education, outreach, technology transfer, organizational aspects.
- Produces the European roadmap in the worldwide context of the field. Alignment of the European, US and Japanese roadmaps optimizes resources.
European Strategy for Particle Physics - ESPP

• The 2006 ESPP exercise (see back-up slides):
  • Before the LHC era
  • Established a community-driven process
  • Defined the role of Council
  • Affirmed the priority at the time
  • Spawned global Outreach and Knowledge Transfer initiatives

• The 2013 ESPP update (see back-up slides):
  • Against the Higgs discovery background
  • Large scale community-driven process and input
  • Set foundations for the High Luminosity LHC program and funding for the machine and experiments’ upgrades
  • Defined the involvement and support of CERN to neutrino physics programs
European Particle Physics Strategy Update

PPG – Physics Preparatory Group: 17 representatives from communities, laboratories, other bodies (including 4 from Americas/Asia)

ESG – European Strategy Group: CERN Member States, European laboratories, invitees from Associate/Observer States and other fields
ESPP - Roles and Responsibilities

**PPG**: Scientific input to the Strategy Update
- Call for community input (Through 2018): 160 contributions
- Open symposium (Granada, May 2019): 600 attendees
- Briefing book (September 2019): 100 pages

**ESG**: Drafts Strategy Update document *(by March 2020)*
- Recommendation of future facility in Europe
- Ensure dynamism in the field to complement energy frontier
- Balance of timescale, career path, academia priorities
- Complementary, synergic, role of National Laboratories

**CERN Council**: approves Strategy Update *(June 2020)*
- CERN governance and budget, long-term planning

PPG – Physics Preparatory Group: 17 members from community and labs (4 from Americas/Asia)
ESG – European Strategy Group: CERN Members/Associates/Observers, European labs, others
CERN Council – CERN Member States representatives. One country one vote.
Possible scenarios of future colliders

Japan
- 20km tunnel
  - ILC: 250 GeV
    - 5.5 B/9 years
    - 2 ab⁻¹
    - ±2.5 B/7 years
    - 31 km tunnel
  - 500 GeV
    - 4 ab⁻¹
    - 40 km tunnel
  - 1 TeV
    - ≈ 4.54 ab⁻¹
- CepC: 90/160
  - 5.5 B/7 years
  - 6 B/8 years
  - 16/2.6 ab⁻¹
- SppC: ≈ FCC-hh
- 11 km tunnel
  - CLIC: 380 GeV
    - 5.1 B/5 y
    - 1.5 TeV
    - 2.5 ab⁻¹
    - 29 km tunnel
  - 7.3 B/5 y
  - 50 km tunnel
- 8 years
  - 10.5 B/10 year
  - 100km tunnel
  - FCC-ee: 90/160/250 GeV
    - 1.7 ab⁻¹
  - 17 B/11 years
  - 350-365 GeV
  - 0.25-1 ab⁻¹
  - FCC hh: 150 TeV ≈ 20-30 ab⁻¹
- 8 years
  - 248/15 years
  - 100km tunnel
  - FCC hh: 100 TeV 20-30 ab⁻¹

CERN
- HL-LHC: 13 TeV
  - 7 B/8 years
  - 3-4 ab⁻¹
- HE-LHC: 27 TeV
  - 10 ab⁻¹
- LHeC: 1.2 TeV
  - 1.7 B/6 year
  - 0.25-1 ab⁻¹
- FCC-eh: 3.5 TeV
  - 2 ab⁻¹
- FCC hh: 100 TeV 20-30 ab⁻¹

From U. Bassler

[Image]
Strategy brochure

Deliberation document

Briefing book

Some highlights in the next slides
The successful completion of the high-luminosity upgrade of the machine and detectors should remain the focal point of European particle physics, together with continued innovation in experimental techniques. The full physics potential of the LHC and the HL-LHC, including the study of flavour physics and the quark-gluon plasma, should be exploited.

Europe, and CERN through the Neutrino Platform, should continue to support long baseline experiments in Japan and the United States. In particular, they should continue to collaborate with the United States and other international partners towards the successful implementation of LBNF and DUNE.
An electron-positron Higgs factory is the highest-priority next collider. For the longer term, the European particle physics community has the ambition to operate a proton-proton collider at the highest achievable energy.
The particle physics community should ramp up its R&D effort focused on advanced accelerator technologies, in particular that for high-field superconducting magnets, including high-temperature superconductors;

Europe, together with its international partners, should investigate the technical and financial feasibility of a future hadron collider at CERN with a centre-of-mass energy of at least 100 TeV and with an electron-positron Higgs and electroweak factory as a possible first stage. Such a feasibility study of the colliders and related infrastructure should be established as a global endeavour and be completed on the timescale of the next Strategy update.
The European particle physics community must **intensify** accelerator R&D and sustain it with adequate resources. A **roadmap** should prioritise the technology, taking into account synergies with international partners and other communities such as photon and neutron sources, fusion energy and industry. Deliverables for this decade should be defined in a timely fashion and **coordinated among** CERN and national laboratories and institutes.
Experiments in diverse areas that offer potential high-impact particle physics programmes at laboratories in Europe should be supported, as well as participation in such experiments in other regions of the world.

Europe should continue to vigorously support a broad programme of theoretical research covering the full spectrum of particle physics from abstract to phenomenological topics.

Detector R&D programmes and associated infrastructures should be supported at CERN, national institutes, laboratories and universities. Synergies between the needs of different scientific fields and industry should be identified and exploited to boost efficiency in the development process and increase opportunities for more technology transfer benefiting society at large. The community should define a global detector R&D roadmap that should be used to support proposals at the European and national levels.
CERN should initiate discussions with potential major partners as part of the feasibility study for a next generation collider being hosted at CERN.

In the case of a global facility outside Europe in which CERN participates, CERN should act as the European regional hub, providing strategic coordination and technical support.
Back-up slides:
The First ESPP process (‘05-‘06)
The 2013 ESPP update
The European strategy for particle physics

Particle physics stands on the threshold of a new and exciting era of discovery. The next generation of experiments will explore new domains and probe the deep structure of space-time. They will measure the properties of the elementary constituents of matter and their interactions with unprecedented accuracy, and they will uncover new phenomena such as the hierarchy of mass and the physics of the Standard Model. Supplementing the hitherto dominant attempts to test the Standard Model, this next generation of experiments will aim to answer questions such as: What are the origins of mass? What is the nature of the dark matter and energy that permeate the cosmos? How will these measure the insights that new measurements will bring, together, the results will have a profound impact on the way we view our Universe. European particle physics should thoroughly exploit its current exciting and diverse research programme, as it should position itself to stand ready to address the challenges that will emerge from exploration of the new frontier, and it should participate fully in an increasingly global adventure.

General issues

1. European particle physics is founded on strong national institutes, universities, and laboratories and the CERN Organisation. Eureope stands at the center of the global effort in particle physics.

2. Increased internationalization, concentration, and scale of particle physics make it a well-established, international strategy for future accelerators and detector development. A science program that is coordinated and internationally accepted will be more effective in meeting the challenges of the future.

Scientific activities

3. The LHC will be the energy frontier machine for the foreseeable future, maintaining European leadership in the field. The LHC has a large potential for further exploitation, and the R&D necessary for its full exploitation is ongoing. The LHC, with its associated detector, will provide a unique scientific opportunity to study the universe at the highest energy and precision at which it can be explored.

4. In order to be in the position to push the energy and luminosity frontier, it is vital to strengthen the advanced accelerator R&D. A coordinated R&D programme should be intensified to develop the high-energy and high-luminosity physics at the future LHC. R&D is needed to exploit the full potential of the LHC and its associated detectors.

5. It is fundamental to complement the results of the LHC with measurements at lower energies. The HERA accelerator will provide an important tool for the exploration of new physics beyond the Standard Model. A well-coordinated programme of measurements at lower energies is essential to exploit the full potential of the LHC.

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Complementary issues

7. The technical advances necessary for particle physics benefit many other sectors, and stimulate the technological development in European industry. Collaboration and exchange of knowledge, by ensuring that the new generation of large-scale experiments is designed to the best advantage, will provide a unique opportunity for these technological developments.

8. European physicists and experimenters are involved in a wide range of different experiments. The involvement of European experimenters is essential to exploit the full potential of the LHC and its associated detectors.

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10. Strong theoretical research and collaboration with experimentalists are essential for the advancement of particle physics and to take full advantage of experimental progress, the forthcoming LHC results will open new opportunities for theoretical developments, and these will be made for theoretical calculations, which should be strongly supported.

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Unanimously approved by the CERN Council at the special Session held in Lisbon on 14 July 2006

http://council-strategygroup.web.cern.ch/council-strategygroup/
Selected highlights from 2006:

- Europe should maintain and strengthen its central position in particle physics.
- Strategy will be defined and updated by CERN Council.
- The highest priority is to fully exploit the LHC, resources for completion of the initial program have to be secured.
- R&D for machine and detectors has to be vigorously pursued now and centrally organized towards a [LHC] upgrade.
- Develop the CLIC technology and high performance magnets for future accelerators.
- Council will play an active role in promoting a coordinated European participation in a global neutrino program.

http://council-strategygroup.web.cern.ch/council-strategygroup/
Council will establish a network of closely cooperating professional communication officers

http://council-strategygroup.web.cern.ch/council-strategygroup/

International Particle Physics Outreach Group

The International Particle Physics Outreach Group (IPPOG)

IPPOG is a network of scientists, science educators and communication specialists working across the globe in informal science education and outreach for particle physics. Particle physics is the science of matter, energy, space and time. IPPOG brings new discoveries in this exciting field to young people and conveys to the public that the beauty of nature is indeed becoming understandable from the interactions of its most fundamental parts - the elementary particles.

The IPPOG collaboration comprises 29 members: 23 countries, 5 experiments and CERN as an international laboratory.

Hans Peter Beck (University of Bern) and Steven Goldfarb (University of Melbourne), IPPOG Chairs

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In memory of our colleague Daniel Lellouch (1957-2019)

"As a scientist I feel I have a responsibility to pass on that sense of awe"

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The relevant technology transfer representatives [...] should create a technology transfer forum to further promote the impact of the spin-offs of particle physics

http://council-strategygroup.web.cern.ch/council-strategygroup/
The 2013 ESPP Update (end 2011 – mid 2013)

- Against the background of the Higgs-boson discovery
- Best-lessons from 2006 incorporated in a solid process
- Representatives of community (Preparatory Group) gathered written input, prepared 500-attendees open symposium, collated a briefing book.
- European Strategy Group (CERN Member-States and national lab representatives, invitees from Associate/Observer states and other bodies) drafted strategy
- Approved by CERN Council in May 2013
Europe’s top priority should be the exploitation of the full potential of the LHC, including the high-luminosity upgrade of the machine and detectors with a view to collecting ten times more data than in the initial design.
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CERN should develop a neutrino programme to pave the way for a substantial European role in future long-baseline experiments. Europe should explore the possibility of major participation in leading long-baseline neutrino projects in the US and Japan.