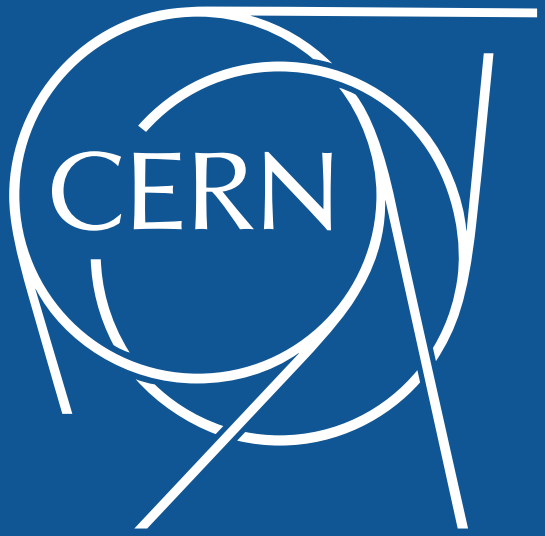
The European Strategy for Particle Physics



Discussion with staff and fellows of IR Sector, FHR Sector, HSE, DG units

Purpose of this meeting

- To inform CERN's employees (staff, fellows) about the goals and process of the European Strategy for Particle Physics (ESPP).
- To discuss the main questions and aspects to be addressed by the ESPP
- To collect your input, comments, questions

Remarks:

- CERN's scientific programme is based on the recommendations of the ESPP, and CERN's long-term future depends primarily on the scientific motivations
  → ESPP is important for all CERN's employees (not only for the physicists)
- Similar meetings are being organised with staff and fellows of the other sectors
  → may call for one/more common meeting/s after this first round
- MPA (users and other associated members of personnel) are involved in most cases in similar discussions in their countries → they are not involved here.
- We thank The Nine for their useful input on these matters

Introduction

The ESPP is the process by which every ~ 7 years the European particle physics community updates the priorities and strategy of the field.
It also makes recommendations on related activities: education, communications and outreach, technology transfer, organisational aspects, etc.

First ESPP in 2006; first update in 2013; next update 2020.

Bottom-up process involving the community. Driven by physics*, with awareness of financial and technical feasibility.

ESPP produces the European roadmap in the worldwide context of the field.
Note: particle physics requires global coordination, given the number, size and complexity of the projects → alignment of the European, US and Japanese roadmaps in recent years to optimise the use of resources

The Strategy is adopted by the CERN Council.
Individual (major) projects require dedicated approval: e.g. HL-LHC

* The scientific input includes: physics results from current facilities from all over the world; physics motivations, design studies and technical feasibility of future projects; results of R&D work, etc.

2013 ESPP update

17 “recommendations”:

3 : general issues

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3 : general issues

4 : high-priority large-scale scientific projects

3 : other essential scientific activities

CERN/3092/RA/Rev. (March 2014):

“… since the Director-General has the mandate to execute all the Council’s decisions, it follows
CERN/3092/RA/Rev. (March 2014):

Examples of recommendations from 2013 ESPP

European organisational model for

and of the national institutes, laboratories and universities closely collaborating with CERN. *Europe should preserve this model in order to keep its leading role, sustaining the success of particle physics and the benefits it brings to the wider society.*

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, by around 2030.

→ Approved by Council 2016

for accelerator projects in a global context, with emphasis on proton-proton and electron-positron high-energy frontier machines. These design studies should be coupled to a vigorous accelerator R&D programme …

→ FCC started 2014

in future long-baseline experiments. Europe should explore the possibility of major participation in leading long-baseline neutrino projects in the US and Japan.

→ Neutrino Platform started 2014

continue supporting and further develop coordinated programmes of education and training.

Expected input from the CERN community

Physics results from LHC (Run2!) **and other ongoing experiments**

Design studies for future facilities and projects:
CLIC (Compact LInear Collider: ee) Project Implementation Plan
FCC (Future Circular Collider: ee, hh, eh) Conceptual Design Report (includes HE-LHC)
Physics Beyond Colliders Report

Results of R&D work: superconducting high-field magnets, AWAKE, etc.

Crucial input will come also from facilities, projects and experiments across the world.
For instance: Japan's decision to build (or not) an International Linear Collider (ILC), expected by end 2018, will have an impact on which future high-E accelerators CERN should build

2020 ESPP update: timeline and structures

- The strategy update will be adopted by CERN's Council in May 2020
- It will be drafted by the European Strategy Group (ESG)
- The draft will be based on input from the community (physics results, new projects, national roadmaps, individuals, etc.), to be submitted by end 2018
- Input collected by Physics Preparatory Group (PPG): they will organize an Open Symposium (May 2019) involving the community and summarize the physics input in a "Briefing Book".
- Organizational matters will be handled by Strategy Secretariat

- **September 2017: Strategy Secretariat appointed by Council**
  H. Abramowicz (Chair; also chair of PPG and ESG), J. D'Hondt (ECFA Chair), K. Ellis (SPC Chair), L. Rivkin (Chair of LDG=Laboratory Directors Group)

- **September 2018: appointment of PPG and ESG by Council** → formal start of the ESPP update
  PPG: Strategy Secretariat, 4 members proposed by SPC and 4 by ECFA, 1 CERN representative, 2 representatives from Asia and 2 from Americas
  ESG: Strategy Secretariat, CERN DG, 1 representative per CERN Member State, LDG
  Invited: Council President, 1 rep per Associate Member State and Observer State, PPG, EC representative, Chairs of ApPEC, NuPECC, FALC, ESFRI

- **May 2019: Open Symposium**

- January 2020: Drafting of strategy update by ESG

- **May 2020: approval of the ESPP update by Council**

A very exciting (and puzzling …) time for particle physics

Main results from LHC so far:
- ❑ discovery of the Higgs boson → Standard Model completed, it works beautifully
- ❑ no sign of physics beyond the Standard Model (yet!)

⬇

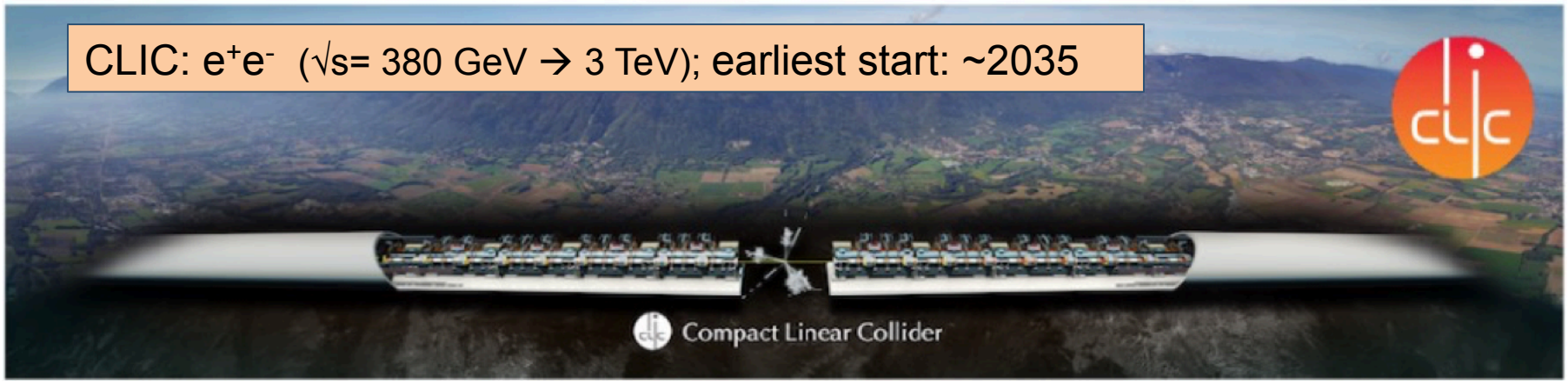
PUZZLING: the SM is not a complete theory of particle physics, as several outstanding questions remain that cannot be explained within the SM

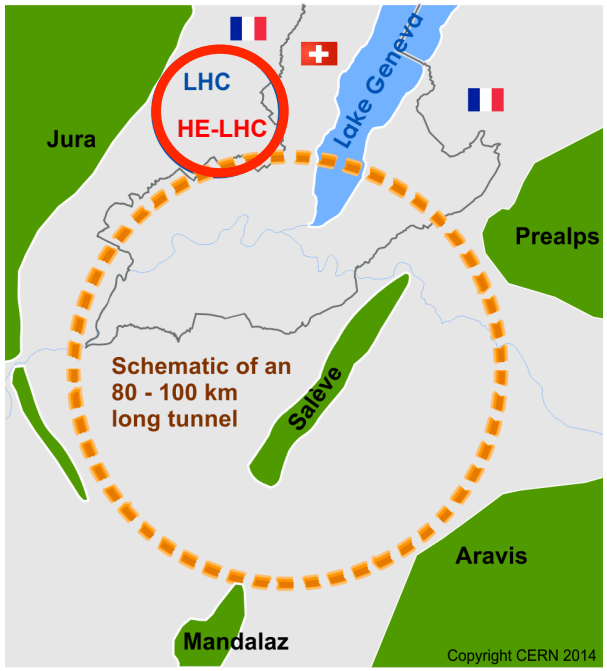
What is the composition of dark matter (~25% of the Universe) ?
What is the origin of neutrino masses and oscillations ?
Why 3 fermion families ? Why do neutral leptons, charged leptons and quarks behave differently?
What is the origin of the matter-antimatter asymmetry in the Universe ?
Why is the Higgs boson so light (so-called “naturalness” or “hierarchy” problem) ?
Why is Gravity so weak ? Etc. etc.

These questions require NEW PHYSICS → where is it ???

The breadth and complexity of the outstanding questions, and **the lack of clear indications of where new physics might be** require a variety of approaches: **particle colliders**, neutrino experiments, dark matter direct and indirect searches, **measurements of rare processes, dedicated searches,** cosmic surveys → **scientific diversity** is crucial.

Options and time scale for future high-E colliders at CERN

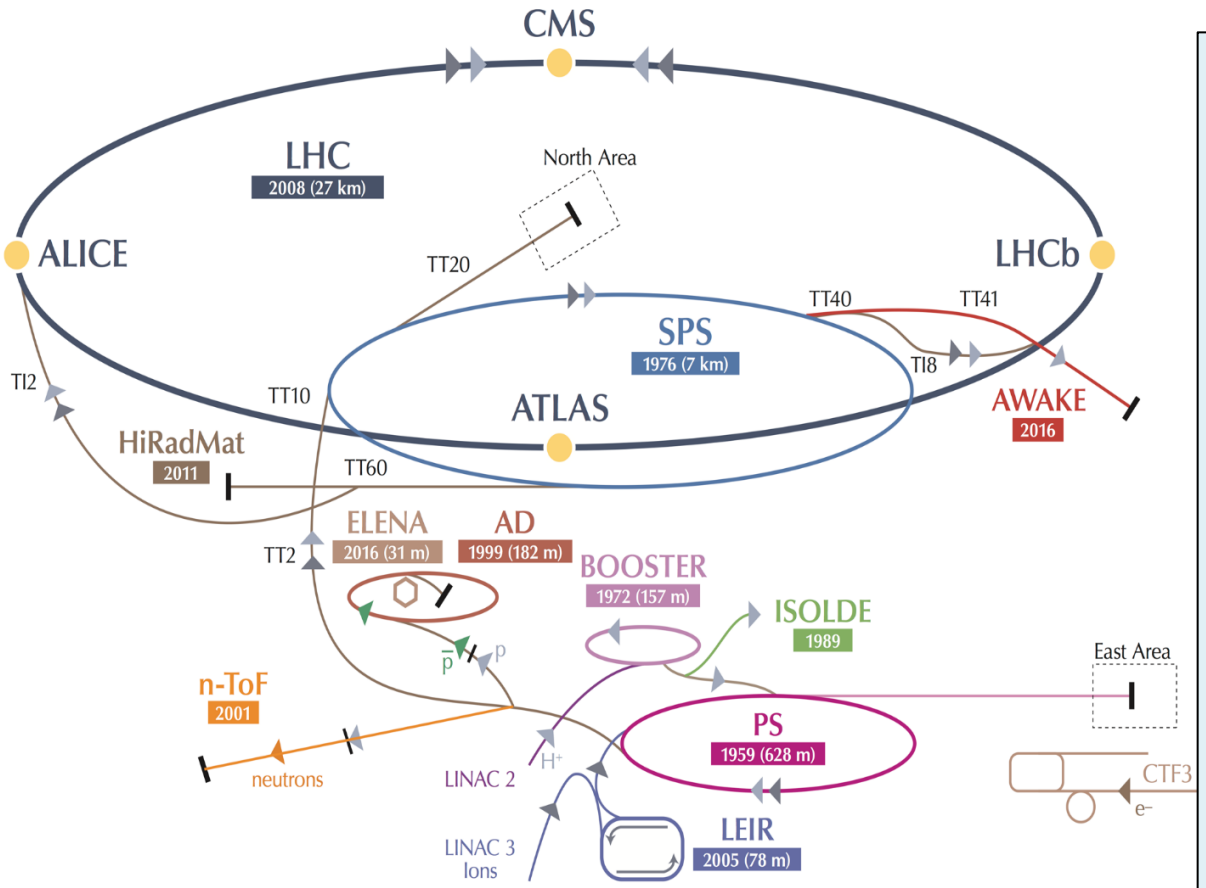




Future Circular Colliders: earliest start:
HE-LHC (√s=27 TeV)**: ~2040**
FCC-ee (√s= 90-350 GeV): **~2039**
FCC-hh (√s=100 TeV): **~2043**

Above schedule gives earliest, purely technical dates: it assumes decision to build the project taken in 2026 and all needed funding available

CERN scientific programme other than LHC



Projects at the injectors.
They exploit unique capabilities of CERN's accelerator complex; ~20 projects, > 1200 physicists.
Future opportunities being studied by "Physics Beyond Colliders" Study Group.

AD: Antiproton Decelerator for antimatter studies

CAST, OSQAR: axions

CLOUD: impact of cosmic rays on aeorosols and clouds → implications on climate

COMPASS: hadron structure and spectroscopy

ISOLDE: radioactive nuclei facility

NA61/Shine: heavy ions and neutrino targets

NA62: rare kaon decays

NA63: interaction processes in strong EM fields in crystal targets

NA64: search for dark photons

Neutrino Platform: ν detectors R&D for experiments in US, Japan

n-TOF: n-induced cross-sections

UA9: crystal collimation

Questions to be addressed by the ESPP (examples …)

How to prepare for a decision about the next big accelerator at CERN in ~2026 (time of next-but-one ESPP update)? Needed accelerator R&D work, physics input, etc.

What would the next accelerator at CERN be if an ILC is built in Japan or if a 100 km circular accelerator is built in China?

What non-collider projects have the highest priorities at CERN and other labs in Europe?

In what projects outside Europe should CERN and Europe participate?

Should CERN contribute to astroparticle physics projects and to which extent?

Education, Communications and Outreach in the ESPP

Education, communications and outreach part of the strategy's recommendations on the "wider impact of particle physics"

- "Outreach and communication in particle physics should receive adequate funding and be recognised as a central component of the scientific activity. EPPCN (European Particle Physics Communication Network) and IPPOG (International Particle Physics Outreach Group) should both report regularly to the Council "
  - CERN coordinates the work of EPPCN → two meetings annually
  - CERN is a member of IPPOG and provides support
  - Rich programme of communications and outreach to many different audience groups through ECO

- "CERN, together with national funding agencies, institutes, laboratories and universities, should continue supporting and further develop coordinated programmes for education and training"
  - CERN maintains and develops and extensive programme of training for teachers, students at different levels and schools (globally)

- CERN can feed ideas on these topics into the process based on the experience of new programmers, different approaches and initiatives over the past five years
- Input on these topics will be coordinated through the IR Sector