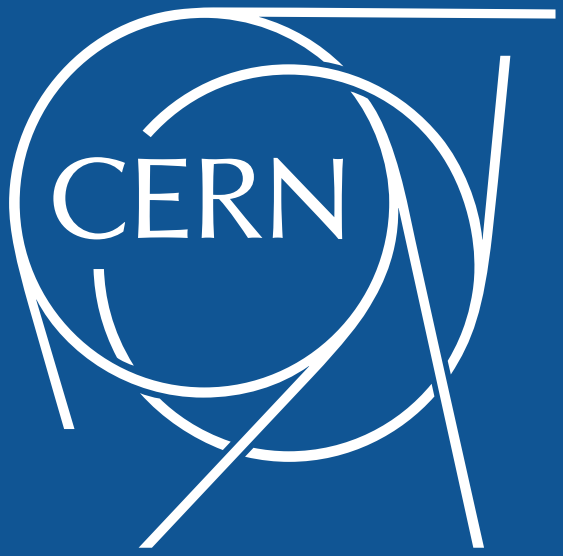
CERN and Astroparticle Physics



Fabiola Gianotti, APPEC, 7 April 2016

CERN scientific strategy: three main pillars

Full exploitation of the LHC:

- ❑ Run 2 started last year
- ❑ building upgrades of injectors, collider and detectors (HL-LHC)

Diversity programme serving a broad community:

- ❑ ongoing experiments and facilities at Booster, PS, SPS and their upgrades (ELENA, HIE-ISOLDE)
- ❑ participation in accelerator-based neutrino projects outside Europe (presently mainly LBNF in the US) through the CERN Neutrino Platform

Preparation of CERN's future:

- ❑ vibrant accelerator R&D programme exploiting CERN's strengths and uniqueness (including superconducting high-field magnets, AWAKE, etc.)
- ❑ design studies for future accelerators: CLIC, FCC (includes HE-LHC*)
- ❑ future opportunities for scientific diversity programme (new)

* HE-LHC:~16 T Nb_3Sn magnets in LHC tunnel (→ $\sqrt{s}$ ~ 30 TeV)

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Important milestone: update of the European Strategy for Particle Physics (~ 2019-2020)

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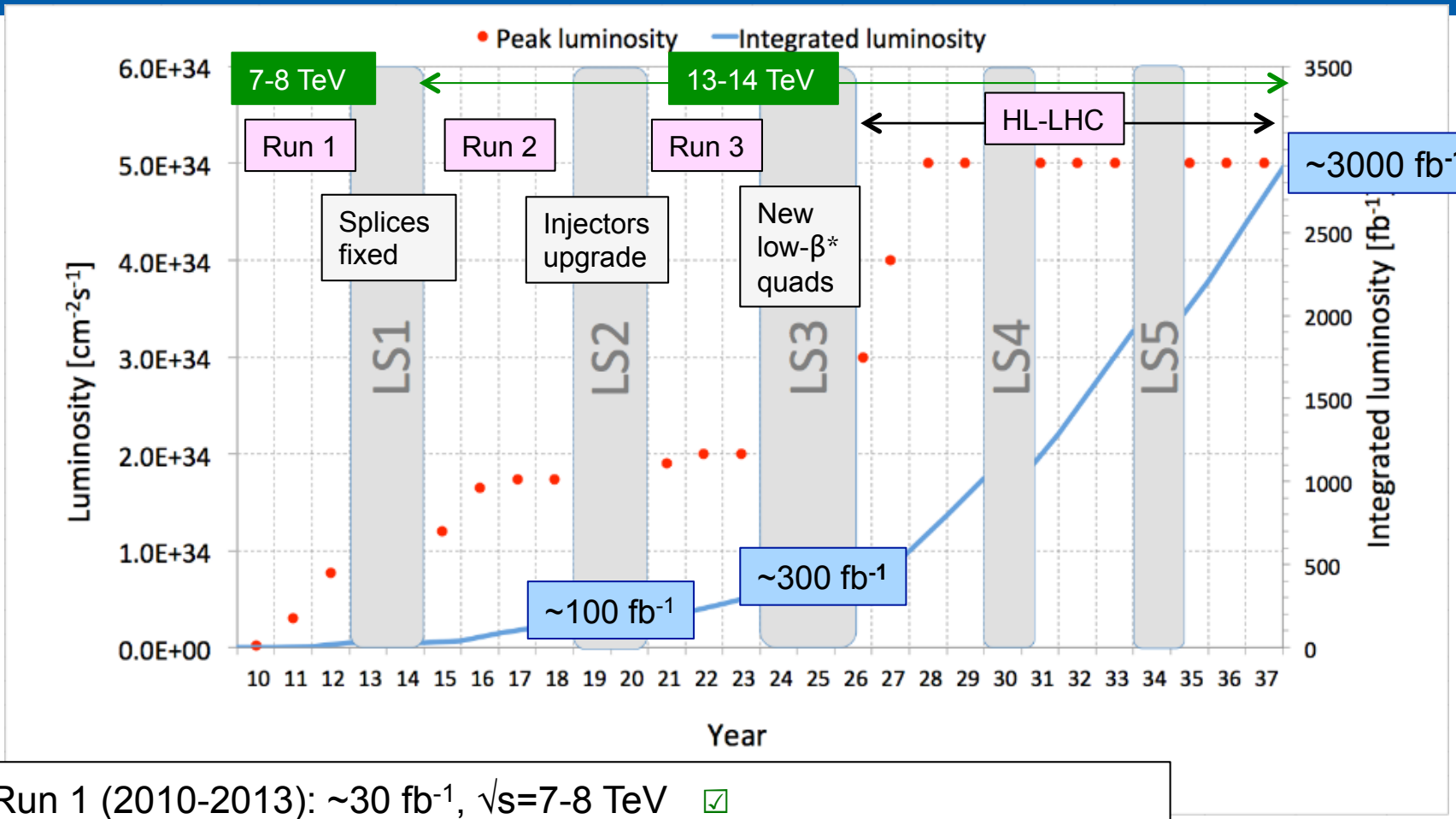
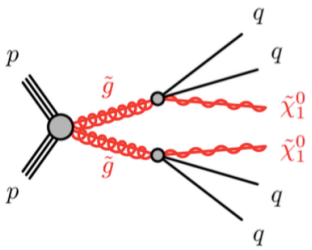
1) LHC and HL-LHC



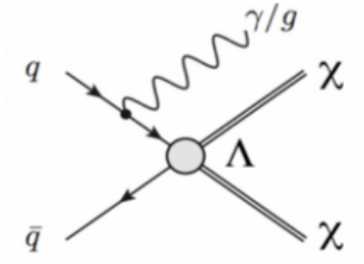
- Run 1 (2010-2013): ~30 fb^{-1}, √s=7-8 TeV ☑
- Run 2 (2015-2018): ~100 fb^{-1}, √s ~ 13 TeV
  - -- 2015: ~4 fb^{-1} √s=13 TeV ☑
  - -- 2016: reach design luminosity L=10^{34} ,√s =13 TeV, ~25 fb^{-1}
- Run 3 (2021-2023): 300 fb^{-1}, √s ~ 14 TeV
- HL-LHC (~2027→ ~2037): ~3000 fb^{-1}, √s ~ 14 TeV
  - -- extend direct discovery potential by ~ 20-30% (up to m ~ 10 TeV)
  - -- measure H couplings to few percent (including 2nd generation: Hμμ)

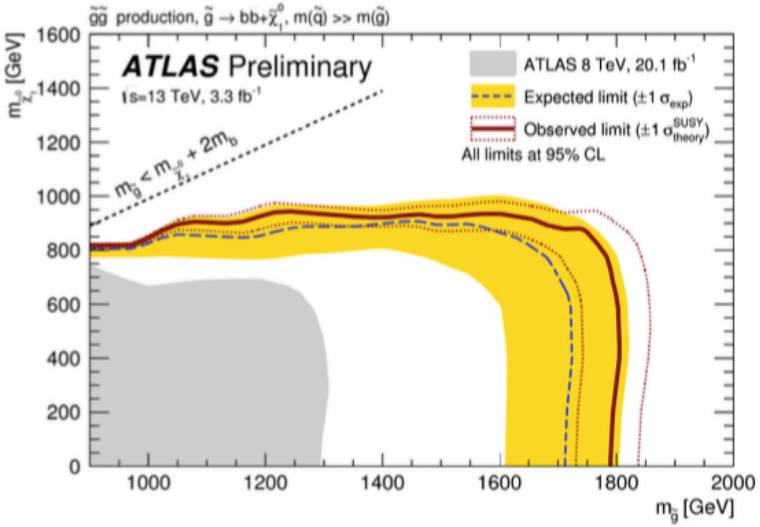
Integrated luminosities are for each of ATLAS and CMS

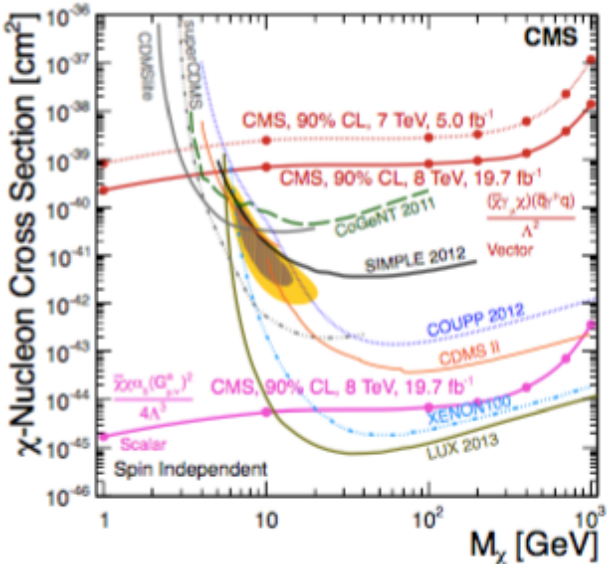
Common physics interests between LHC and astroparticle (few examples)



Dark matter searches



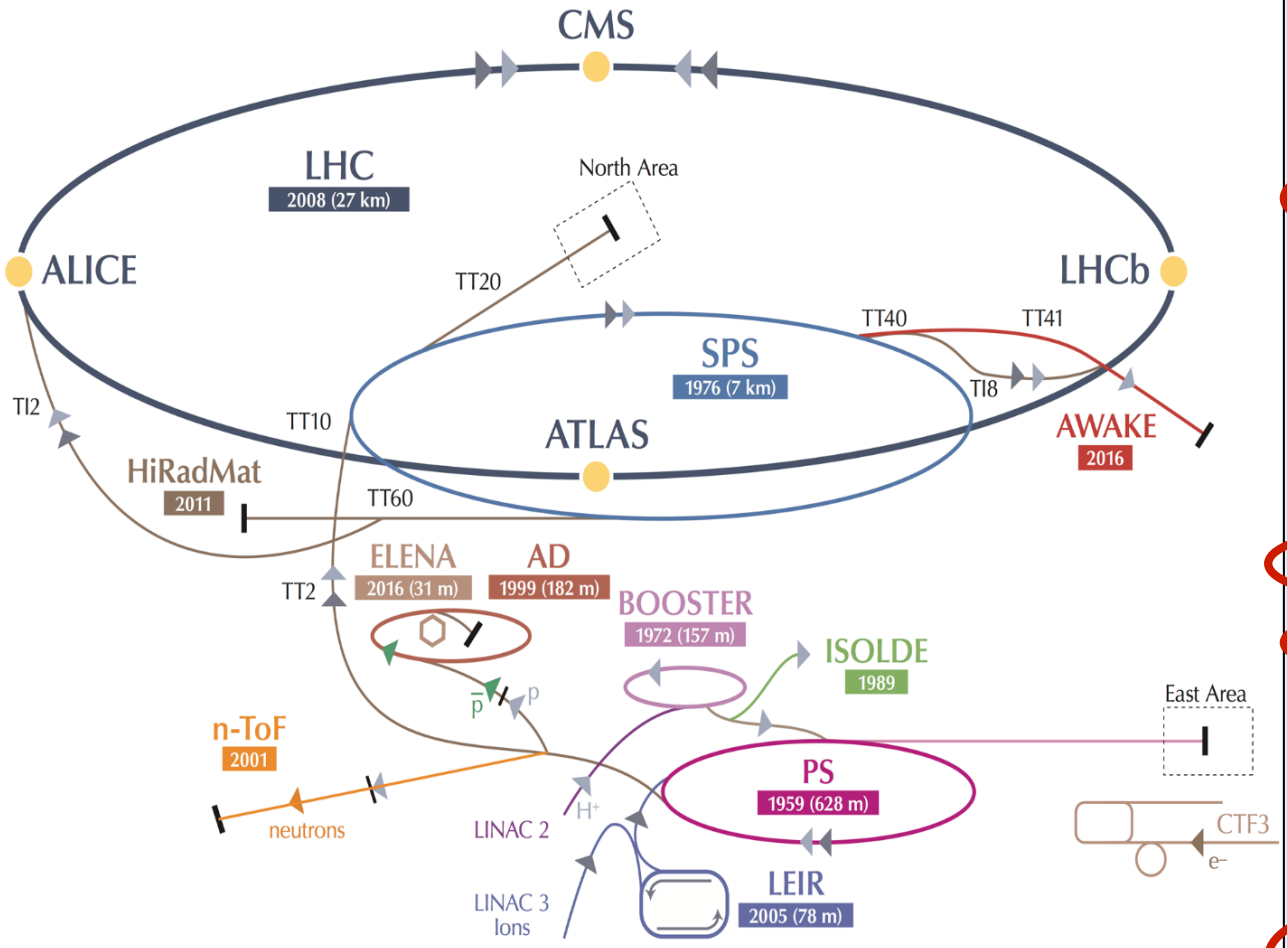




In addition:

- ❑ general searches for new physics will have impact on astroparticle
- ❑ measurements of cross-sections and particle spectra at very high energies using forward detectors (e.g. LHCf) and special techniques (e.g. LHCb SMOG gas target)
  → useful input for cosmic rays MC modeling
- ❑ etc.

2) Scientific diversity: a compelling programme beyond the LHC



~20 experiments > 1200 physicists

AD: Antiproton Decelerator for antimatter studies

AWAKE: proton-induced plasma wakefield acceleration

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: ions and neutrino targets

NA62: rare kaon decays

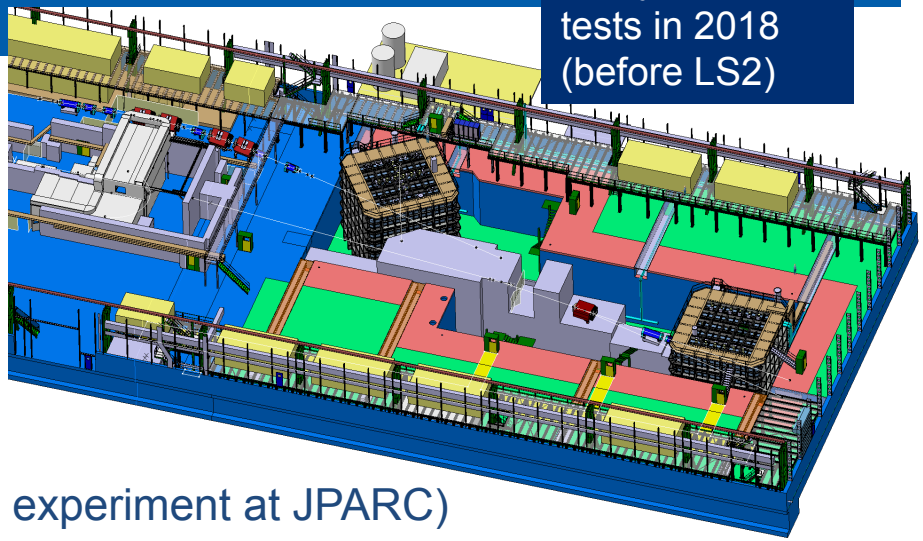
NA63: radiation processes in strong EM fields

n-TOF: n-induced cross-sections

UA9: crystal collimation

Neutrino Platform: collaborating with experiments in US and Japan → see later

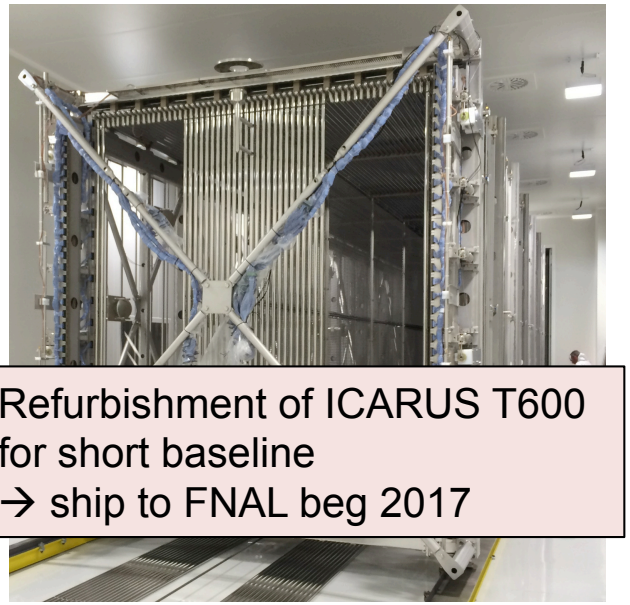
CERN neutrino activities



Mission:

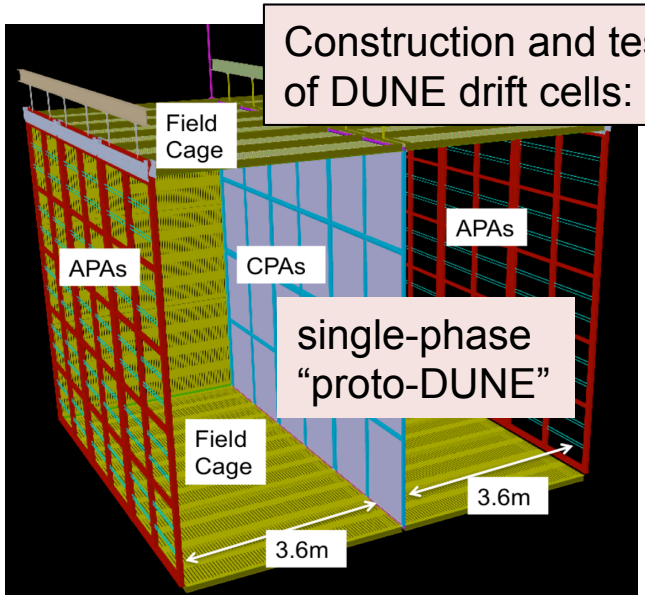
- ❑ Provide charged beams and test space to neutrino community → North Area extension
- ❑ R&D to demonstrate large-scale LAr technology (cryostats, cryogenics, detectors)
- ❑ Construction of first cryostat for DUNE
- ❑ Support neutrino experiments in US and Japan (e.g. BabyMIND: muon spectrometer for WAGASCI experiment at JPARC)

A Neutrino physics group recently established at CERN (few experimentalists and theorists) to capitalize (in terms of physics return) on the technical and financial investment and to help foster collaboration in the European accelerator-based neutrino community

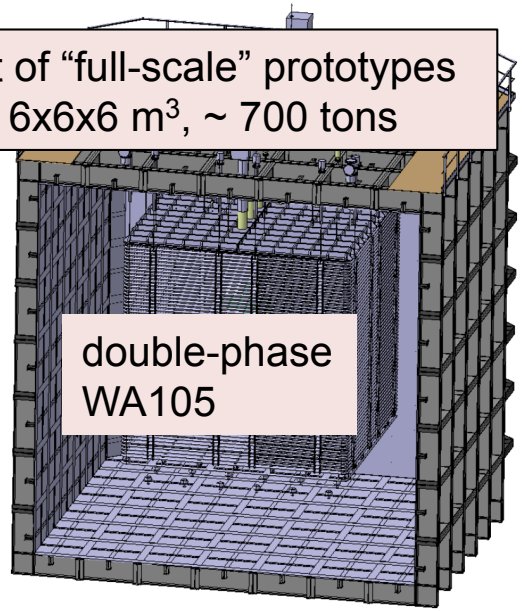


Refurbishment of ICARUS T600 for short baseline
→ ship to FNAL beg 2017

Construction and test of "full-scale" prototypes of DUNE drift cells: ~ 6x6x6 m^3, ~ 700 tons



single-phase "proto-DUNE"



double-phase WA105

3) Future opportunities other than high-energy colliders

A “Physics Beyond Colliders" Study Group has been put in place

Mandate
Explore opportunities offered by CERN accelerator complex and infrastructure to address outstanding questions in particle physics through projects:

- ❑ complementary to future high-energy colliders (HE-LHC, CLIC, FCC)
- ❑ exploiting unique capabilities of CERN accelerator complex and infrastructure
- ❑ complementary to other efforts in the world → optimise resources of the discipline globally

Examples: searches for rare processes and very-weakly interacting particles, electric dipole moments, etc.

→ Enrich and diversify CERN’s future scientific programme

- ❑ Overall coordinators: Joerg Jaeckel (Heidelberg; theory), Mike Lamont (CERN; accelerator), Claude Vallée (CPPM, Marseille; experimental physics)
- ❑ Will be structured in thematic sub-groups with conveners
- ❑ Kick-off meeting in Summer
- ❑ Final report end 2018 → in time for European Strategy

Goal is to involve interested worldwide community, and to create synergies with other laboratories and institutions in Europe (and beyond)

In addition: CERN Recognized Experiments

Experiments from particle particle physics or nearby fields (e.g. astroparticle)

Requirements:

- ❑ substantial participation of physicists from several CERN Member States
- ❑ approved by relevant agencies and reasonably funded

Process:

- ❑ requests scrutinized by dedicated CERN committee and approved by Research Board (once a year, usually in March) → MoU signed after approval
- ❑ status lasts up to 3 years (renewable)

Benefits:

- ❑ CERN user registration for members of Collaboration; visiting team accounts opened;
- ❑ some office space and meeting facilities on best effort basis
- ❑ computing resources, test beams, laboratory equipment, and additional services on best effort basis with proviso that cost to CERN must be marginal (otherwise charged to Collaboration) and CERN projects and activities always have priority

Examples of Recognized Experiments: AMS, Antares, Auger, Belle II, Borexino, CTA-PP, Fermi, IceCube, katrin, LIGO, Magic, MEG, Pamela, T2K, VIRGO, etc.

Possible future joint actions ?

Stronger mutual participation in the respective strategies: update of European Strategy for Particle Physics in ~ 2019-2020 → APPEC will be invited to contribute

Strengthen relations in domains of common interest, e.g.:

- Theory: CERN TH Department welcomes every year astrophysicists and cosmologists among the ~ 700 visiting scientists and organises astroparticle workshops

- Detector R&D (example of common requirements: low power-consumption, reliability, affordable cost): e.g. rad hard Si/Pixel sensors, SiPMT, fast electronics, TDAQ systems, etc. Common applications to EU funds ? E.g. ATTRACT (submission March 2017 to INFRAINNOV-1-2017 call by DG-RTD) for R&D on sensors, electronics, data-acquisition. CERN and ESO are among the partners
- Infrastructure: big cryogenic systems; test-beam facilities
- Technology Transfer: common networks (e.g. HEPTech) ?

- Computing: big data storage, distribution and processing; as for the Grid in the past, future infrastructure, likely based on hybrid cloud model (commercial cloud services, public e-infrastructure, in-house IT resources), will serve different communities

- Communications and Outreach: APPEC is member of EPPCN=European Particle Physics Communication Network (network of experts); recently invited to IPPOG= International Particle Physics Outreach Group (network of enthusiastic physicists)