CERN and Astroparticle Physics

Fabiola Gianotti, APPEC, 7 April 2016
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- 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)

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1) LHC and HL-LHC

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

Integrated luminosities are for each of ATLAS and CMS.
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

AD: Antiproton Decelerator for antimatter studies
AWAKE: proton-induced plasma wakefield acceleration
CAST, OSQAR: axions
CLOUD: impact of cosmic rays on aerosols 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

~20 experiments > 1200 physicists
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 m³, ~ 700 tons

-ready for beam tests in 2018 (before LS2)
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

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)