

CERN report

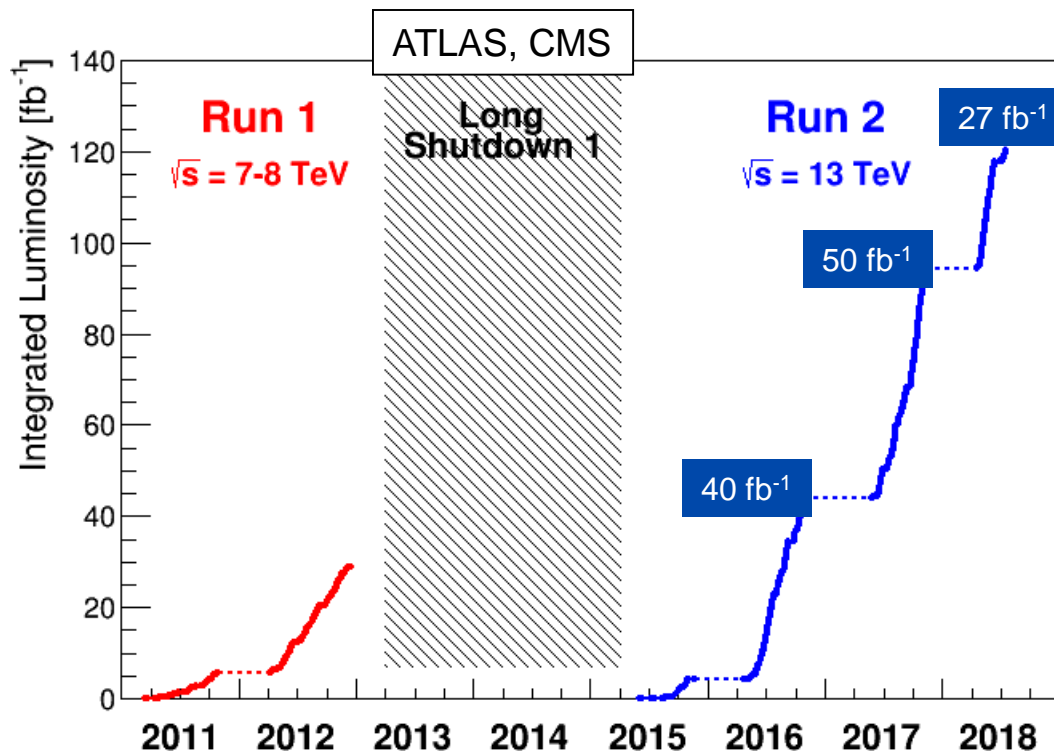
Fabiola Gianotti, Plenary ECFA, Alba Synchrotron, 19 July 2018

- ❑ Scientific programme
- ❑ Geographical enlargement
- ❑ The Science Gateway project
- ❑ Other news



LHC continues to break new records

- **Peak luminosity:** $\sim 2 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ (design: 1.0×10^{34}): thanks to brightness of beams from injectors and squeezing ($\beta^*=30 \text{ cm}$; design value was $\beta^*=55 \text{ cm}$).
Crossing angle anti-leveling ($160 \rightarrow 130 \mu\text{rad}$) and β^* anti-leveling ($30 \rightarrow 25 \text{ cm}$) at end of fill.
- **Integrated luminosity:**
 - goal for 2018: $\sim 60 \text{ fb}^{-1}$ ATLAS and CMS; $\sim 2 \text{ fb}^{-1}$ LHCb
 - Run 2 so far: $\sim 120 \text{ fb}^{-1}$ ATLAS and CMS; $\sim 5 \text{ fb}^{-1}$ LHCb, $\sim 49 \text{ pb}^{-1}$ ALICE

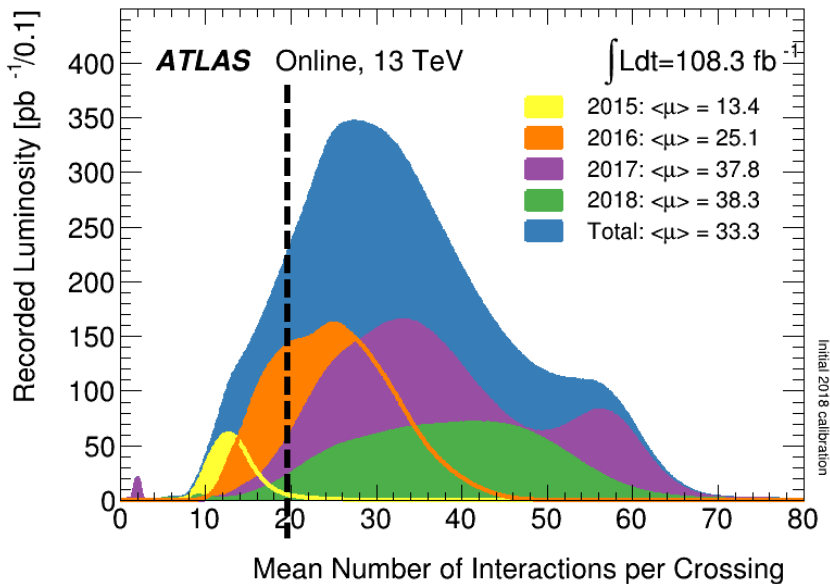


Run 1+2 goal of 150 fb⁻¹ achieved already

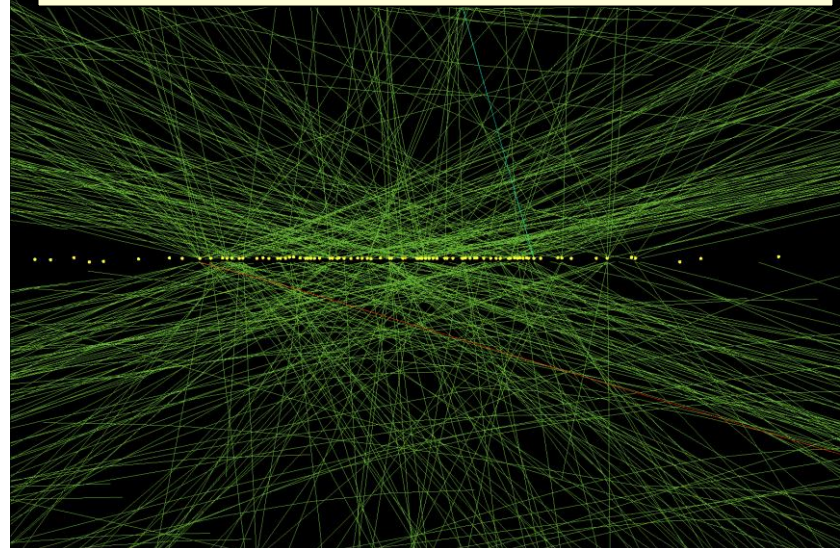


Excellent performance of the experiments

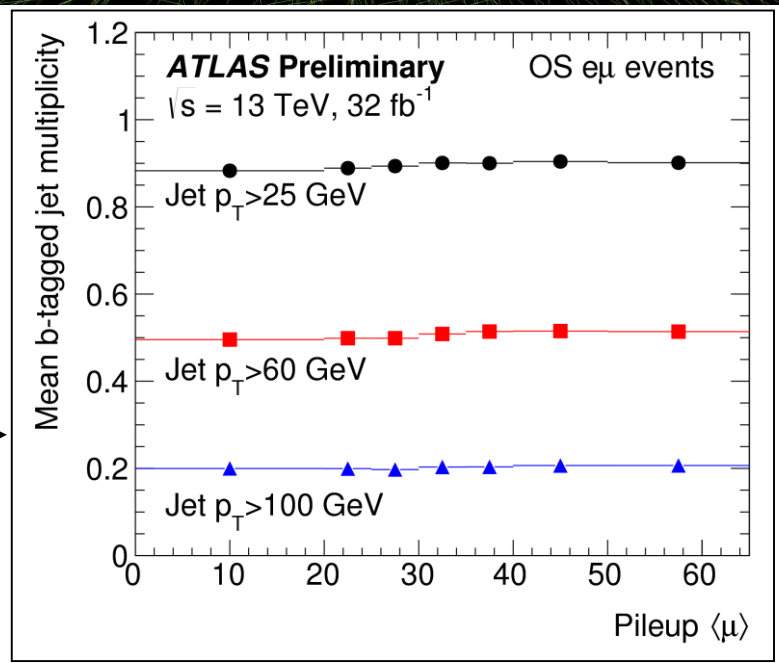
ATLAS and CMS designed for pile-up of ~ 20 interactions/x-ing



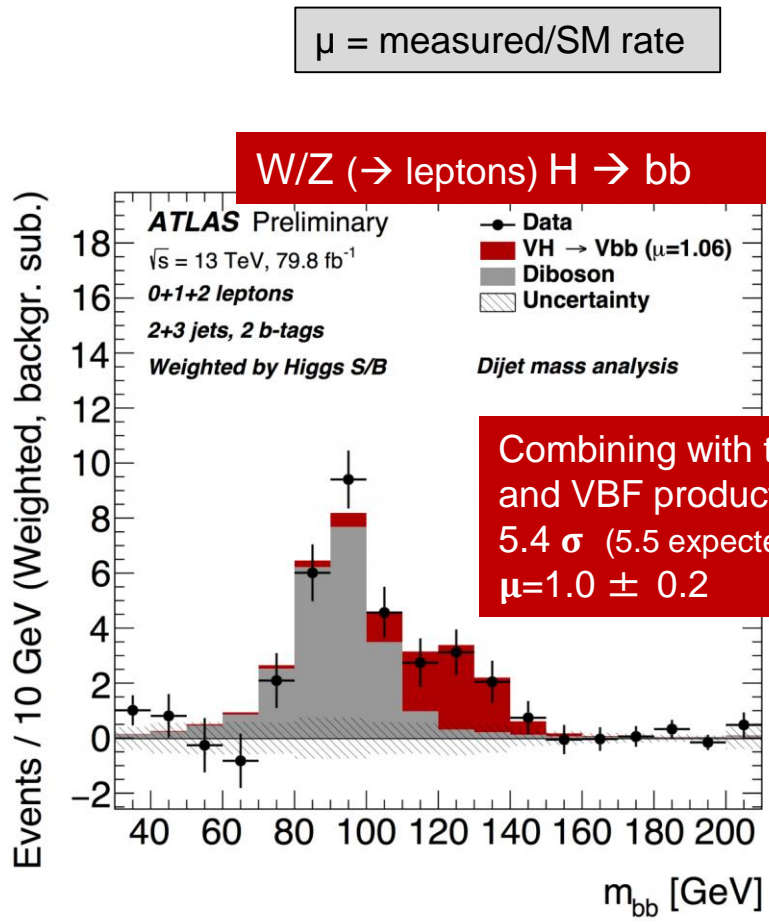
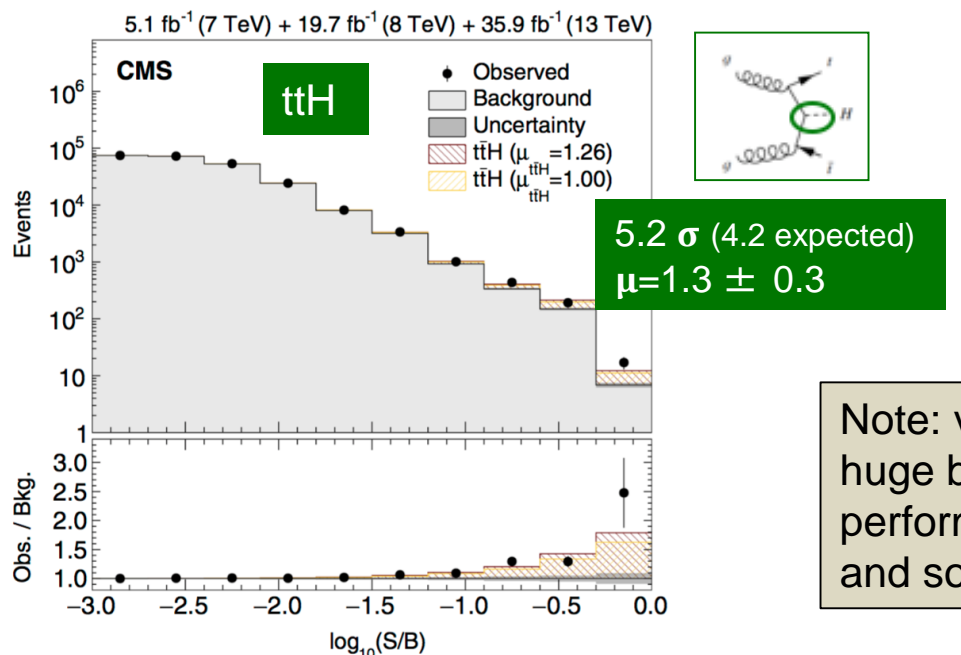
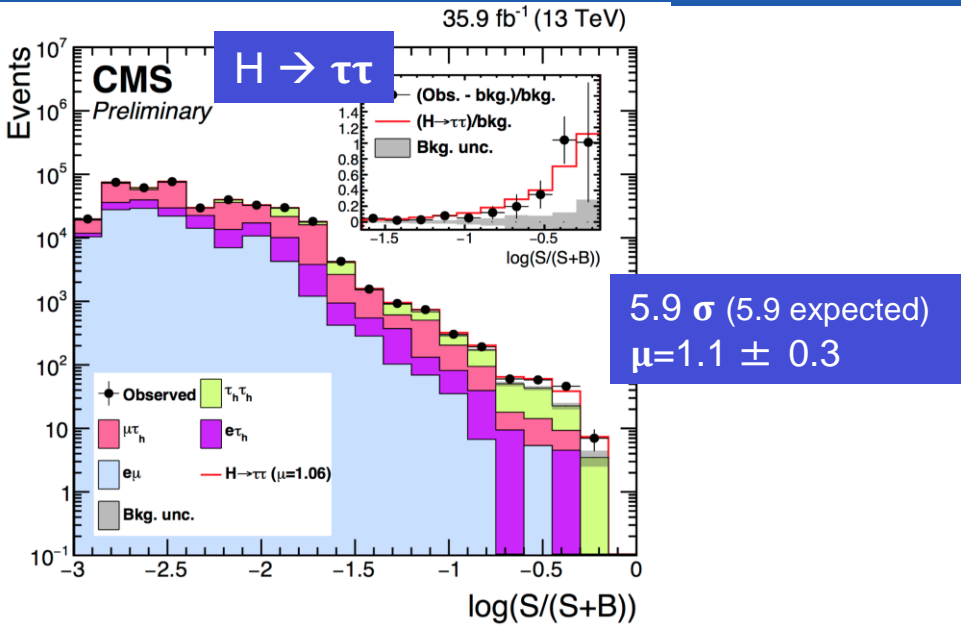
CMS: event with 78 reconstructed vertices



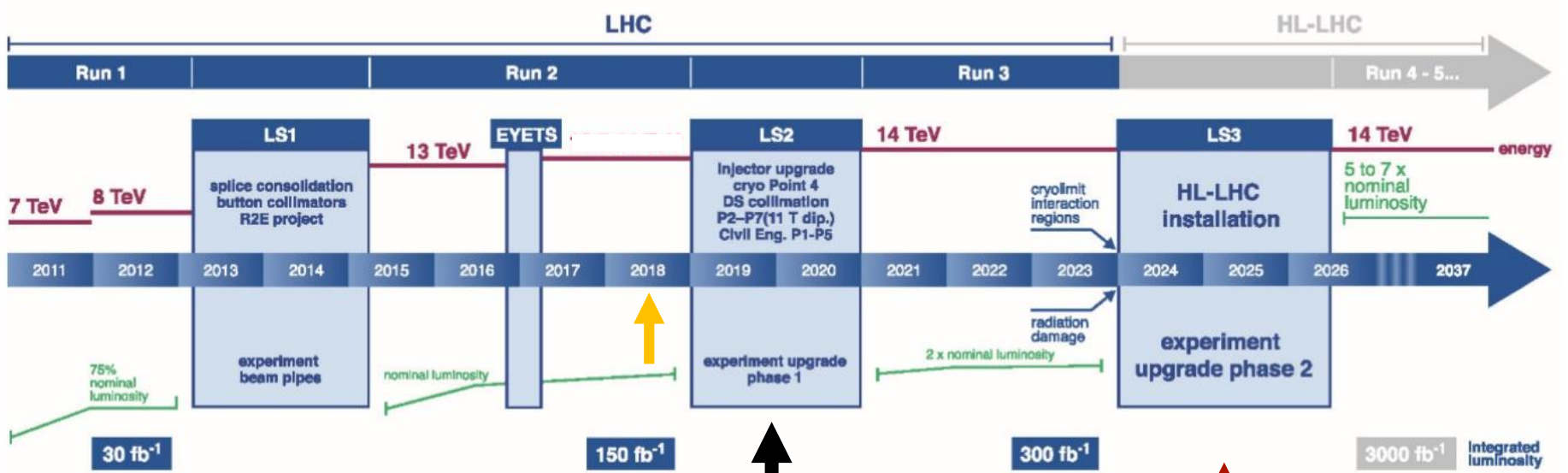
Multiplicity of b-tagged jets in tt events is constant versus number of pile-up events



Higgs couplings to 3rd generation fermions observed recently



Note: very complex final state topologies, huge backgrounds → excellent detector performance, exquisite control of the backgrounds and sophisticated analysis techniques required



LS2 (2019-2020):

- LHC Injectors Upgrade (LIU)
- Civil engineering for HL-LHC equipment @ P1, P5
- 11 T dipoles at P7
- Phase-1 upgrade of LHC experiments

LS3 (2024-2026):

- HL-LHC installation**
- Phase-2 upgrade of ATLAS and CMS

LIU: provide beams with brightness and intensity required for HL-LHC:

2.3×10^{11} p/bunch, $\epsilon \sim 2.1 \mu\text{m}$

→ Linac4 (160 MeV H^+), PSB (1.4 → 2 GeV), PS (new injection and feedback systems), SPS (new 200 MHz RF system, e^- cloud mitigation)



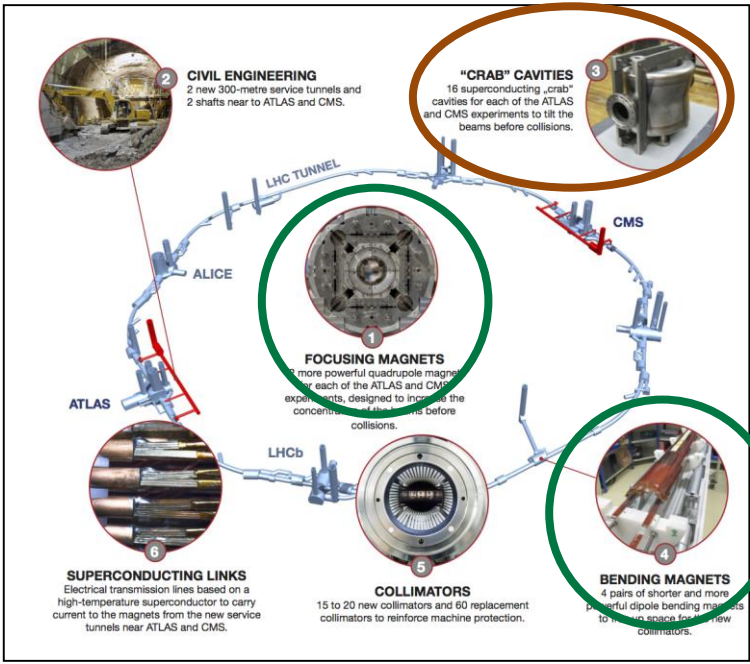
Linac4 commissioned in 2017



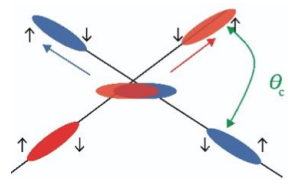
HL-LHC main components (and challenges ...)

Major intervention on 1.2 km of accelerator: Nb₃Sn focusing quadrupoles and 11 T dipoles (tests of full-size prototypes of both in 2018); collimators; crab cavities; cryogenics; etc.

Nb₃Sn focusing magnet: full-size (4.2 m) prototype being tested in the US



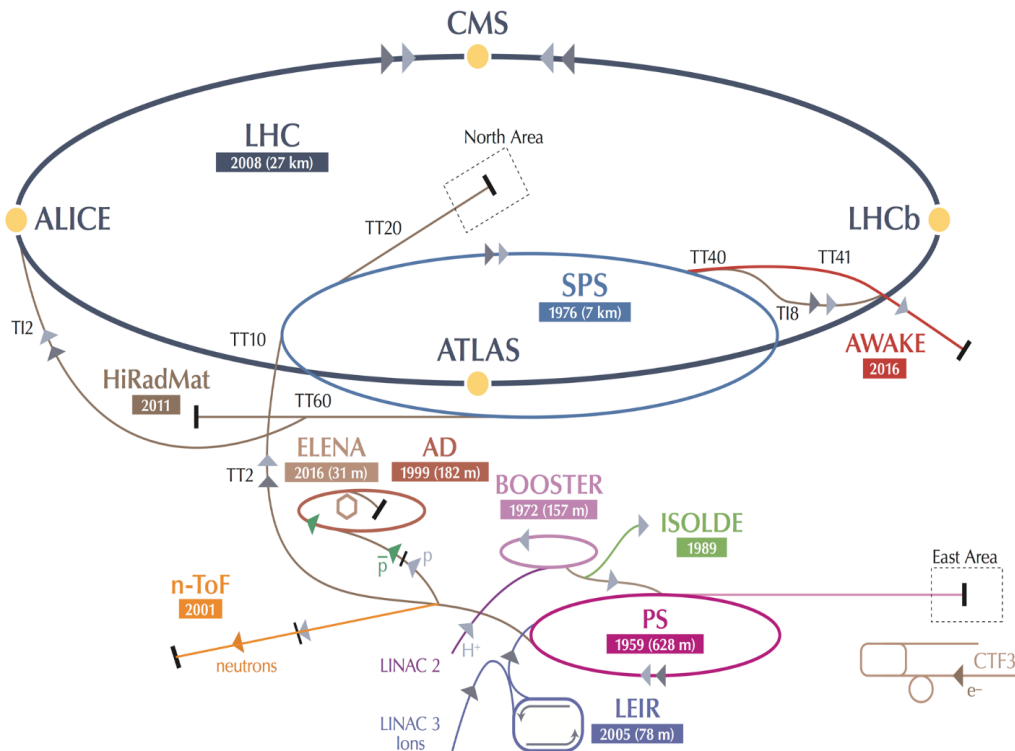
One of most crucial challenges: new-generation superconducting magnets (Nb₃Sn) → fundamental milestone also for future colliders (HE-LHC, FCC)



Cryomodule with 2 crab cavities installed in SPS for tests with p beams in 2018



~20 projects, > 1200 physicists. Future opportunities being studied by "Physics Beyond Colliders" Study Group



- 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:** 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

Recent accomplishments:

- ❑ 4th (last!) cryomodule for HIE-ISOLDE installed
- ❑ commissioning of (new) ELENA ring at AD with pbar reached 100 keV target
- ❑ AWAKE: first e^- acceleration: 18 MeV → 2 GeV (paper submitted to Nature)



Current plan is to start at $\sqrt{s} = 380$ GeV for Higgs and top studies and upgrade up to 3 TeV
→ working on cost and power optimization, key R&D items, industrialization

2013 - 2019 Development Phase

Development of a Project Plan for a staged CLIC implementation in line with LHC results; technical developments with industry, performance studies for accelerator parts and systems, detector technology demonstrators

2020 - 2025 Preparation Phase

Finalisation of implementation parameters, preparation for industrial procurement, Drive Beam Facility and other system verifications, Technical Proposal of the experiment, site authorisation

2026 - 2034 Construction Phase

Construction of the first CLIC accelerator stage compatible with implementation of further stages; construction of the experiment; hardware commissioning

DRAFT, purely technical, schedule: assumes decision taken at 2020 ESPP and funding available

2019 - 2020 Decisions

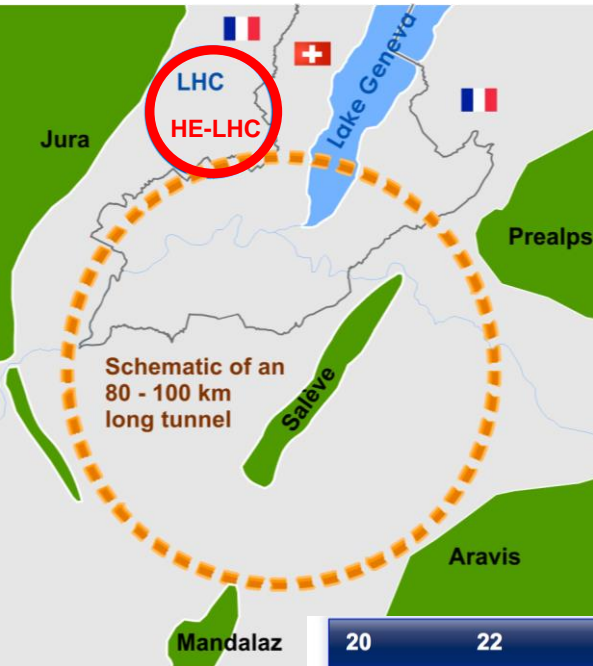
Update of the European Strategy for Particle Physics; decision towards a next CERN project at the energy frontier (e.g. CLIC, FCC)

2025 Construction Start

Ready for construction; start of excavations

2035 First Beams

Getting ready for data taking by the time the LHC programme reaches completion



DRAFT, purely technical, schedule: assumes decision taken at 2026 ESPP and political support and funding available on that time scale

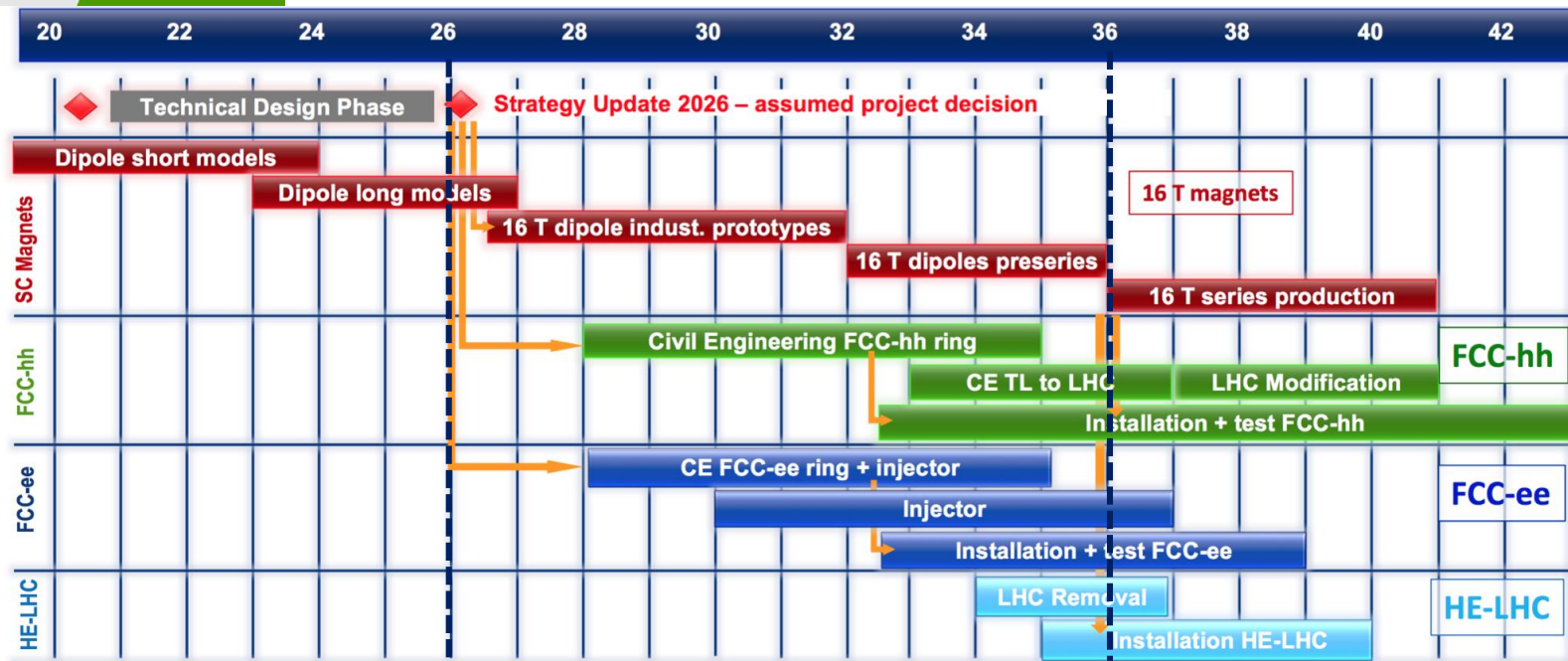
→ gives earliest possible dates for first beams:

FCC-ee: 2039 $\sqrt{s}=90-365$ GeV

HE-LHC: 2040 $\sqrt{s}=27$ TeV

FCC-hh: 2043 $\sqrt{s}=100$ TeV

Note: ep collisions (FCC-eh) at $\sqrt{s}\sim 3.5$ TeV also being studied



22 Member States:

Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Israel, Italy, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom

8 Associate Member States:

Cyprus*, India, **Lithuania (8/1/2018)**, Pakistan, Serbia*, Slovenia*, Turkey, Ukraine

* in the pre-stage to Membership

6 Observers:

Japan, Russia, USA, European Union, JINR, UNESCO

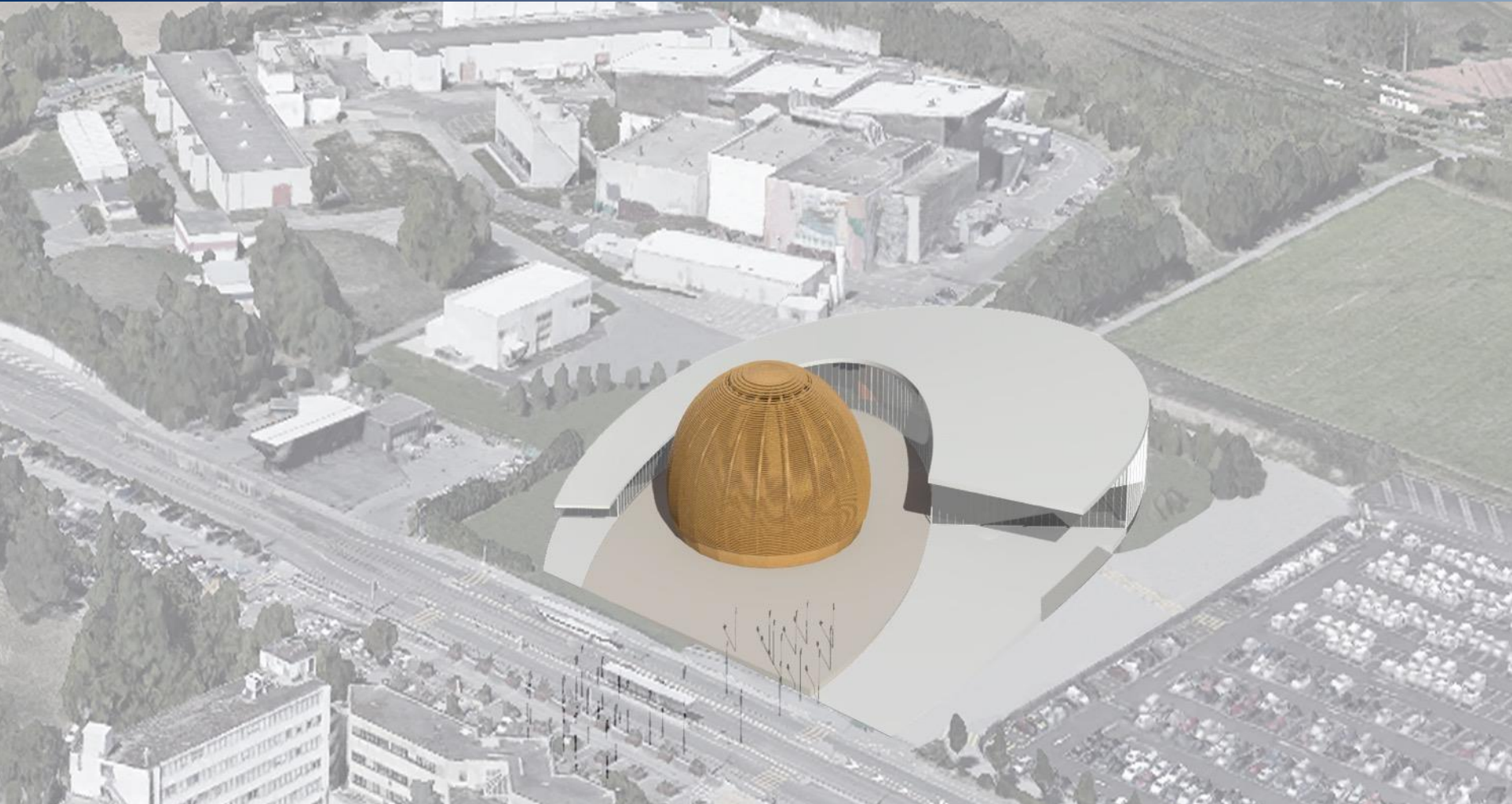
In addition:

~50 ICA (International Cooperation Agreements)

- Croatia is in the process of becoming an Associate Member.
Estonia will soon submit an application for Membership.
- In June the Council established a working group to review some aspects of the geographical enlargement, based on the experience gained since 2010



Science Gateway



A new hub for education and outreach, located near the Globe. It will be an integral part of CERN's site and a component of the visit circuit. Activities will target the general public of all ages. It will also include a 1000-seater Auditorium.



Motivations and goals

CERN attracts every year ~120 000 visitors (> 60% are high-school students) worldwide.

But we receive > 300 000 requests and all our education/training activities are over-subscribed.

- A clear sign of the great interest in science and in CERN's unique research facilities
- CERN is an ideal location for a **dedicated scientific learning and outreach centre open to the general public**, with the goal in particular of encouraging young people to choose careers in Science, Technology, Engineering and Mathematics (STEM).

Note: <20% in Europe today.



The Science Gateway will allow us to:

- ❑ **expand and diversify CERN's** portfolio of education, communication and outreach actions aimed at the general public.
- ❑ satisfy the **> 300 000 visit requests received every year**
- ❑ **cover all ages (~5 to 100+ years!)** with targeted initiatives (currently minimum age for education activities on site: 16 years)
- ❑ **engage more with similar initiatives in CERN's Member States and beyond**



Educational programme, funding, timeline

Activities will be tailored to specific age groups, e.g. primary-school children, high-school students, families, senior people. Preliminary ideas:

- ❑ Mini-workshops and labs for hands-on educational activities (from ages of ~5 years)
- ❑ Interactive screens to explore physics (e.g. the smallest constituents of matter, the fundamental forces, the concept of space-time) in a simple and entertaining way
- ❑ Virtual visits of CERN
- ❑ Temporary and permanent exhibitions, highlighting e.g.:
 - science personalities and the figureheads of particle physics
 - societal impact of CERN's scientific discoveries and technological innovations
 - when science meets the arts (*Arts@CERN* programme)
- ❑ Live connections with other science centres or international partners (universities, museums, etc.) for interesting scientific events
- ❑ > 1000-seater auditorium (divisible) for Collaboration meetings, public lectures and science events organised in the Geneva area (desperate need for it at CERN and in the region).

Total project cost (for building size ~ 7000 m²): **50-70 MCHF**

Project will be financed by **private and/or public donations**, i.e. from outside CERN's budget.

12 MCHF secured so far.

Optimistic schedule: **opening to the public second half 2022**

CERN Environmental Protection Steering (CEPS) board established in 2016 to mitigate impact of CERN on environment, propose prioritized objectives for each of 11 environmental domains and follow up on their implementation → first high-priority recommendations issued end 2017 (e.g. plan to reduce leak/use of fluorinated gases in experiments' detectors)
→ resources secured in the 2019-2023 Medium Term Plan

Mini-ATTRACT project granted 20 M€ from H2020: project led by CERN to help develop next generation detection and imaging technologies, bringing together research community and industry (especially SMEs). Partners include EMBL, ESO, ESRF, European XFEL, ILL, EIRMA (European Industrial Research Management Association), etc.
~170 projects will be funded, 100k€ each → call for proposals to be issued 1st August 2018.

Europe is becoming increasingly more attentive to data privacy issues, including content, use, access, safeguard, retention of personal data → new EU regulation (GDPR) entered into force in May 2018 → **Office of Data Privacy Protection established at CERN** in 2017 to align with best regulations and practices.

An aerial photograph of a rural landscape with fields and a small town. Overlaid on the image is a white line representing a particle accelerator track, which forms a large loop around the town and extends into the distance. The sky is blue with scattered white clouds.

Conclusions

- ❑ 2018 is last year of operation of the accelerator complex before LS2 → on track to deliver (more than) the expected luminosity to the LHC experiments and number of protons to the rest of the scientific programme.
- ❑ Preparation for LS2 and LHC upgrades is progressing on schedule
- ❑ Major focus in coming months: finalise input to the European Strategy → results from current experiments and facilities, physics and design studies for future projects (CLIC, FCC, Physics Beyond Colliders), R&D work, etc.