HL- LHC High-Luminosity LHC

The LHC upgrade ¶

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HL-LHC Configuration, Quality & Sourcing Office
On behalf of the HL-LHC Project team

Portuguese Industry @ CERN, September 2019

The HL-LHC Project

What, when, where, by whom?

LHC; the largest scientific instrument

- 27 km, p-p at 7+7 TeV (6.5+6.5 in 2018)
- 1232 x 15 m Twin Dipoles SC Magnets
- Operational field 8.3 T @11.85 kA (7.7 T 2018)
- HEII cooling, 1.9 K with 3 km circuits (130 tonnes He inventory).
- Other 500 SC magnets (quads) and nearly 8000 SC corrector magnets.
- 400 MHz Standing wave RF
- Cryo : 8 x 18 kW@4.5K
- And so much more

Why HL-LHC

Technical limitation on the istantaneous lumi:
1. **Collider** (cryolimit in the triplet region) at 2×10^{34} $cm^{-2}s^{-1}$ twice the nominal design luminosity)
2. **Experiments** (pile up in the detectors). Designed for PU 40 they are actually dealing with 60 (average)!

Technical limitation on integrated lumi:
1. **Collider** (radiation damage to the IT magnets – correctors and quadrupoles)
2. **Experiments** (radiation damage in the Inner Tracker)

LHC is at 93% of the design energy (now planned for 2021-23)
LHC is 20% above planned luminosity (number of collisions)

Goal of High Luminosity LHC (HL-LHC) as fixed in November 2010

From FP7 HiLumi LHC Design Study application

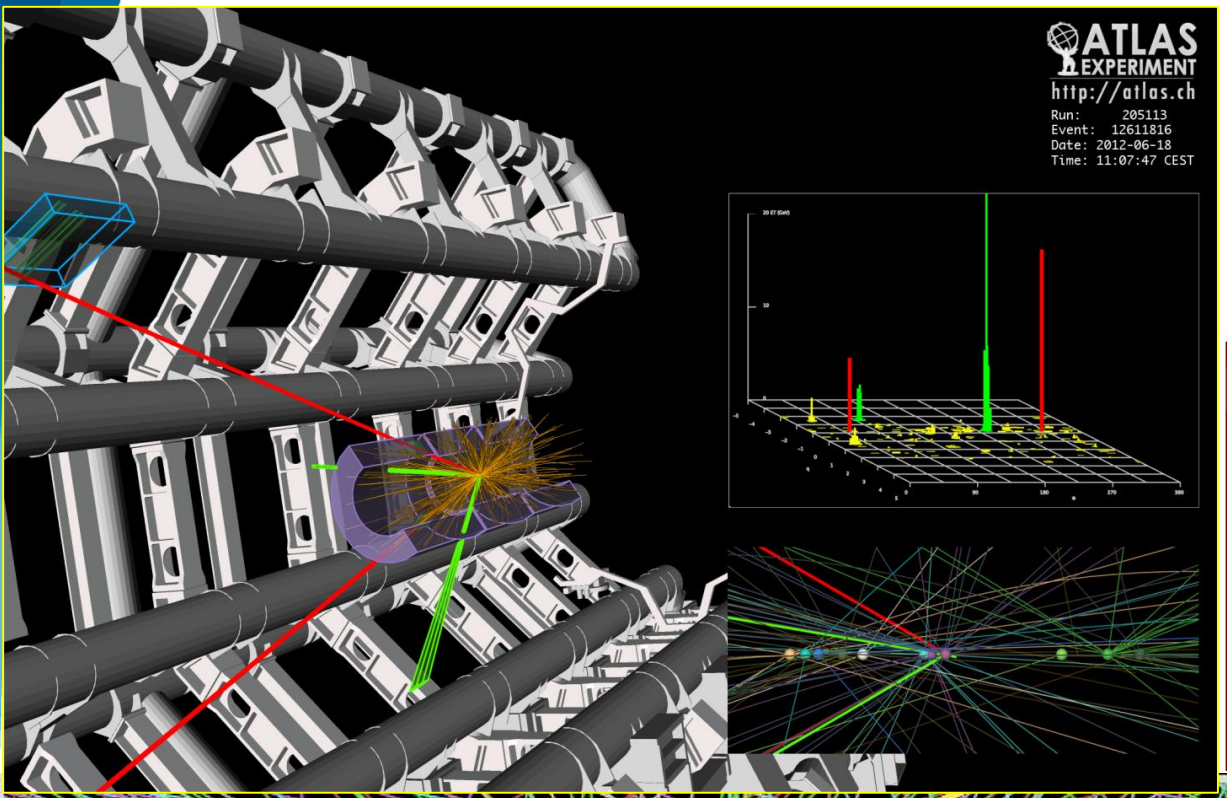
The main objective of HiLumi LHC Design Study is to determine a hardware configuration and a set of beam parameters that will allow the LHC to reach the following targets:

A peak luminosity of L_{peak} = **5×10^{34} $cm^{-2}s^{-1}$ with levelling**, allowing:

An integrated luminosity of **250 fb^{-1} per year**, enabling the goal of **L_{int} = 3000 fb^{-1}** twelve years after the upgrade.
This luminosity is more than ten times the luminosity reach of the first 10 years of the LHC lifetime.

Ultimate performance established 2015-2016: with same hardware and same beam parameters: use of **engineering margins:**
$L_{peak\ ult} \cong 7.5\ 10^{34}$ $cm^{-2}s^{-1}$ and **Ultimate Integrated $L_{int\ ult} \sim 4000$ fb^{-1}**
LHC should not be the limit, would Physics require more…

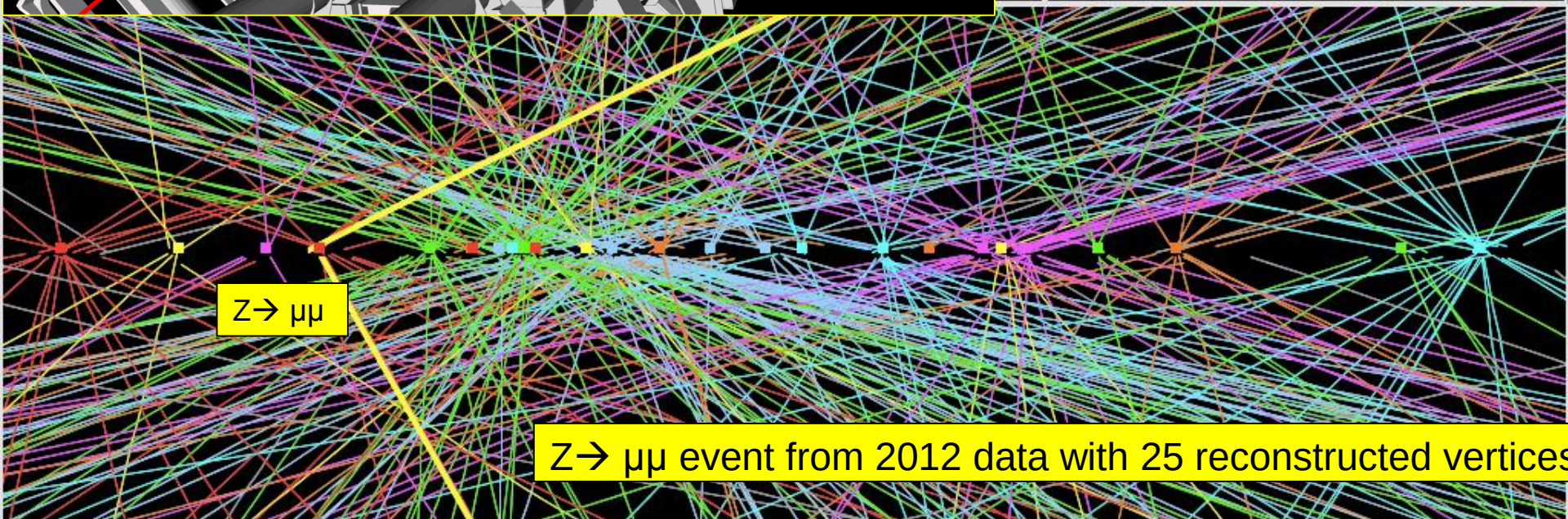
HiLumi HL-LHC PROJECT



More luminosity ⇒ higher the collision rate

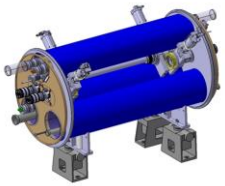
Higgs: the needle in the haystack

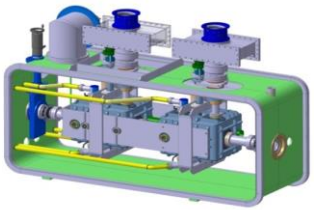
Picture repeated 40 millions times each second

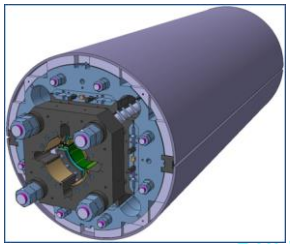


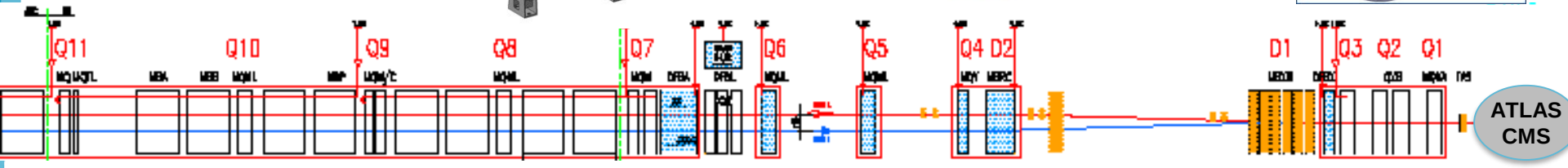
Z→ μμ event from 2012 data with 25 reconstructed vertices

The largest HEP accelerator in construction









Dispersion Suppressor (DS) in P7

Matching Section (MS)

Interaction Region (ITR)

Modifications
1. In IP2: new DS collim. in C.Cryost.
2. In IP7 new DS collimation with 11 T

Cryogenics, Protection, Interface, Vacuum, Diagnostics, Inj/Extr… extension of infrastr.

Change/new lay-out
1. TAXN
2. D2
3. CC
4. Q4
5. Correctors
6. Q5
7. Q5@1.9K in P6
8. New collimators

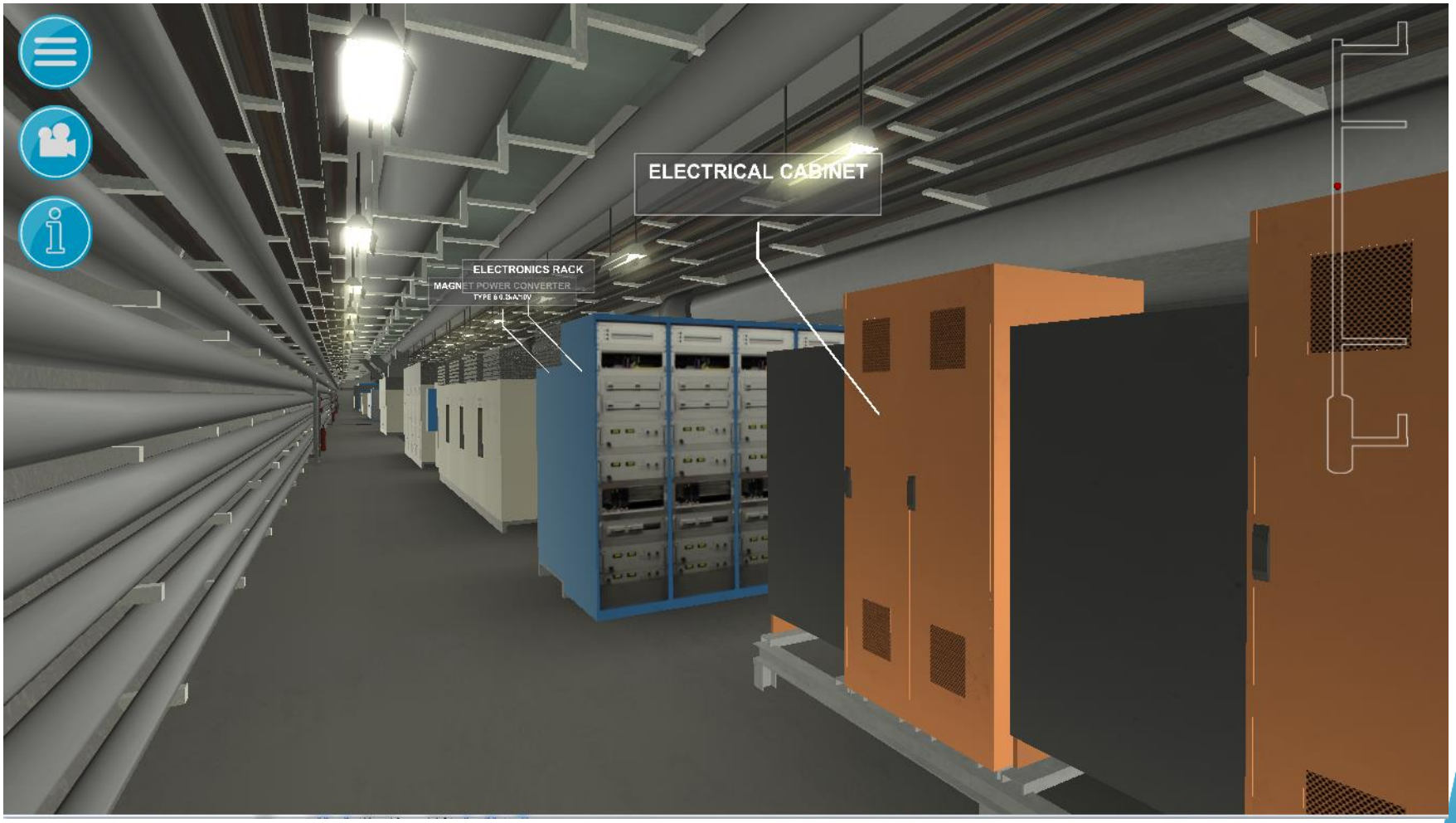
Complete change and new lay-out
1. TAXS
2. Q1-Q2a-Q2b-Q3
3. D1
4. All Correctors Magnets
5. Heavy shielding (W)

> 1.2 km of LHC !!

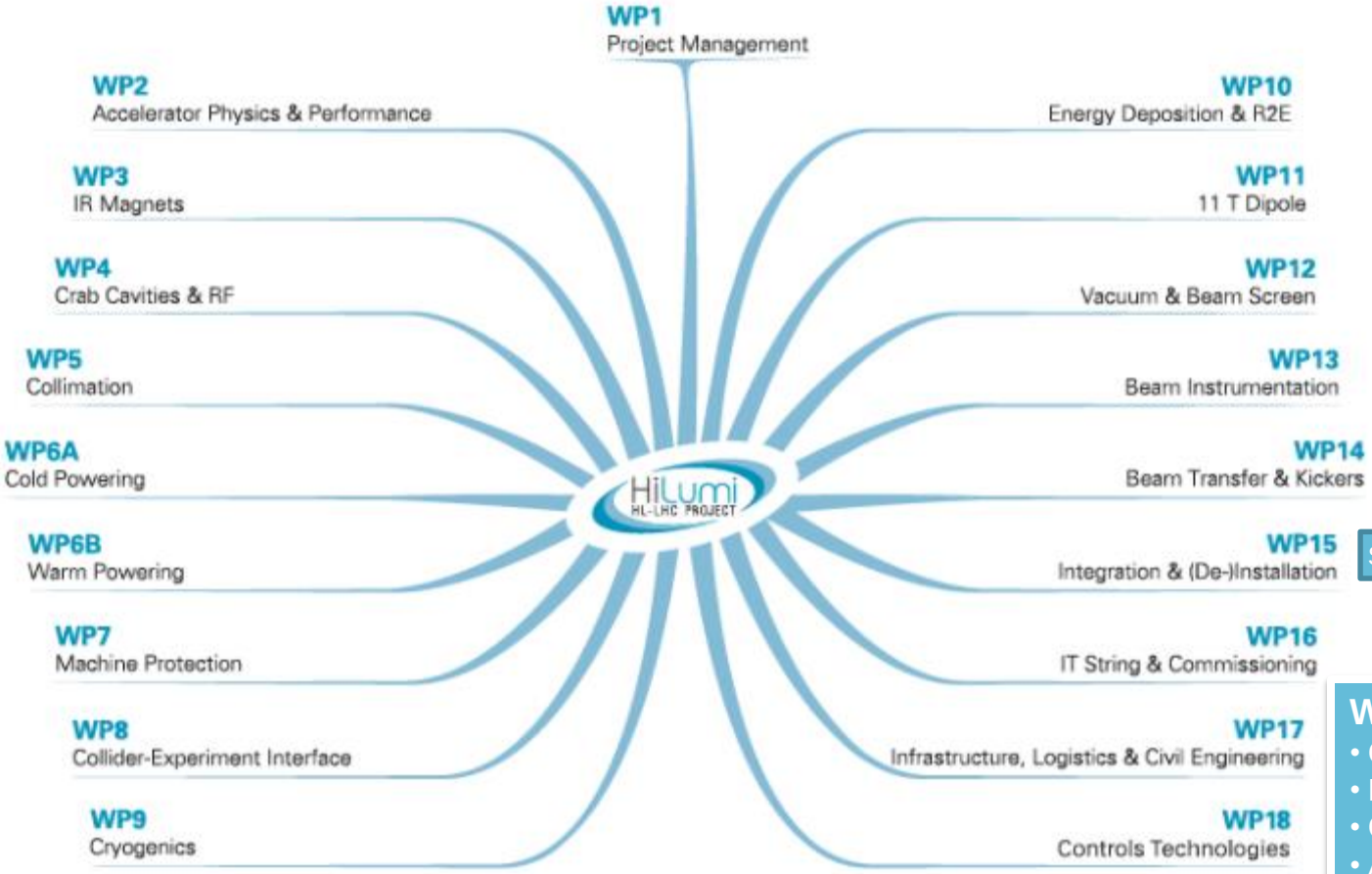
HiLumi HL-LHC PROJECT

Surface infrastructures

Underground infrastructures



Project structure

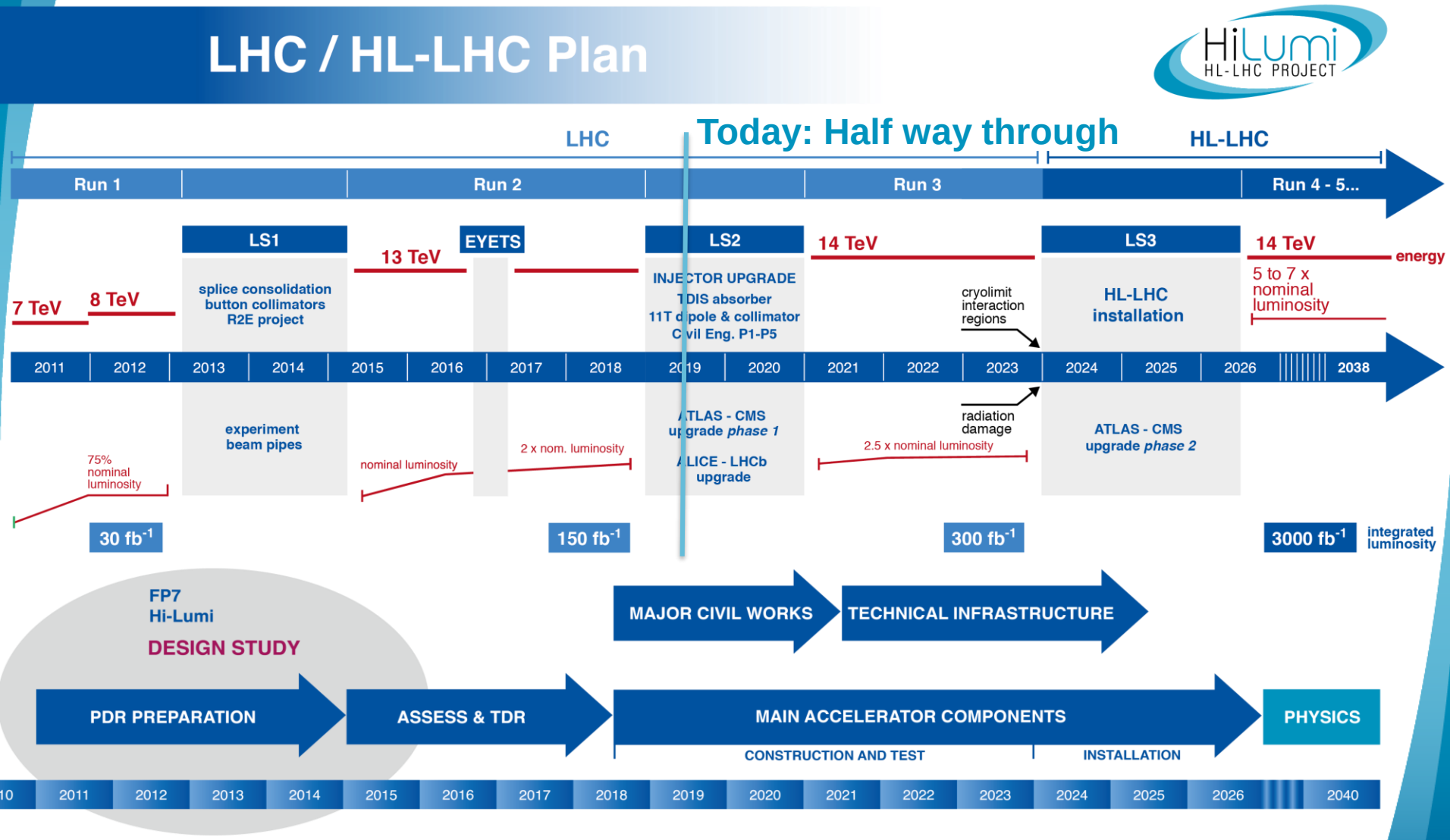


Survey-Align

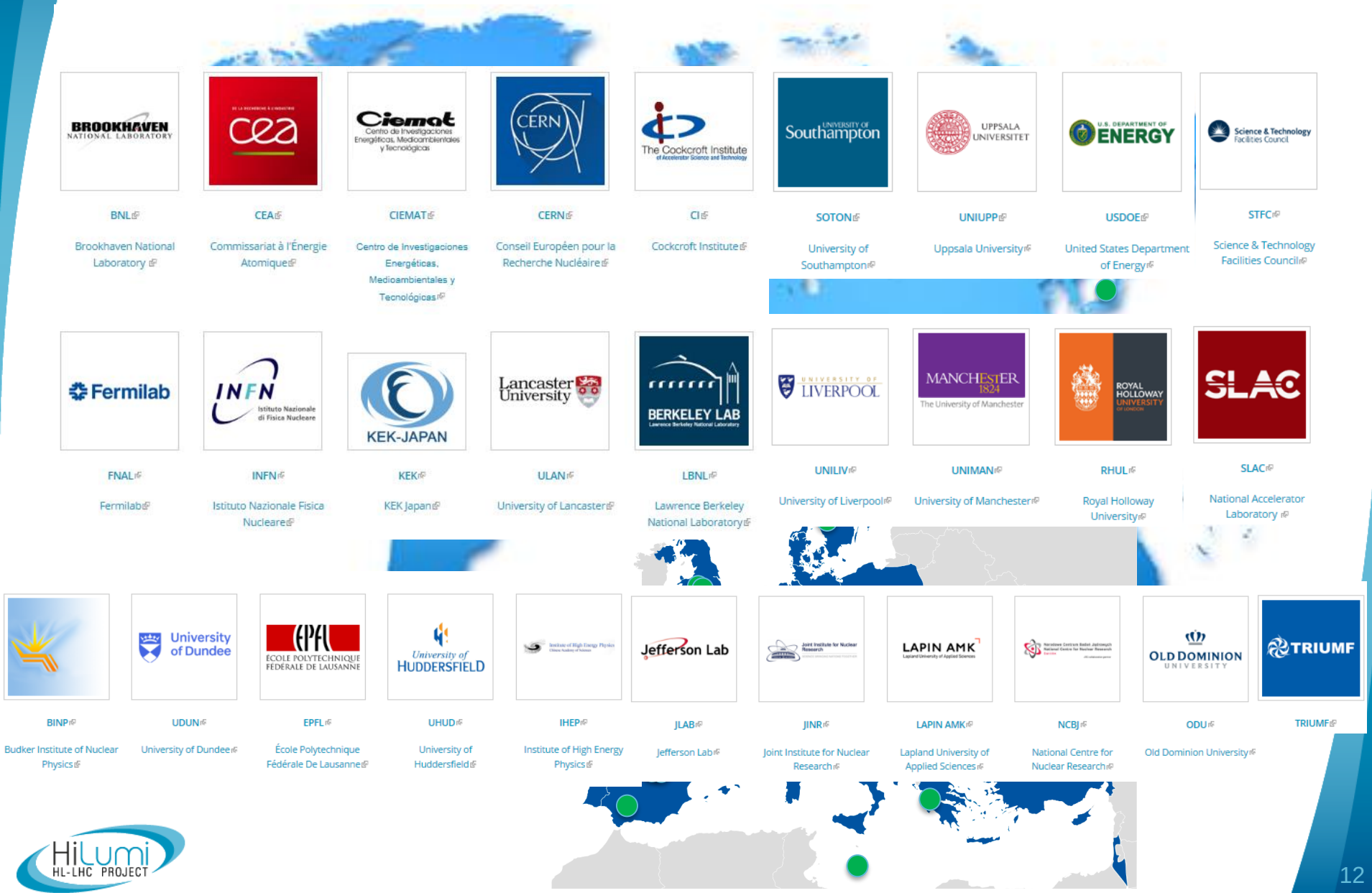
WP17 subWPs:

- Civil Works
- Electrical Engineering
- Cooling & Ventilation
- Access & Alarms
- Tech Monitoring
- Transport
- Logistics & Storage
- Operational Safety

High Luminosity: a luminous future for LHC!



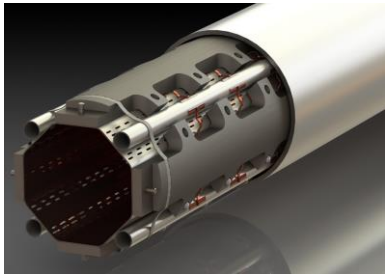
Global collaboration

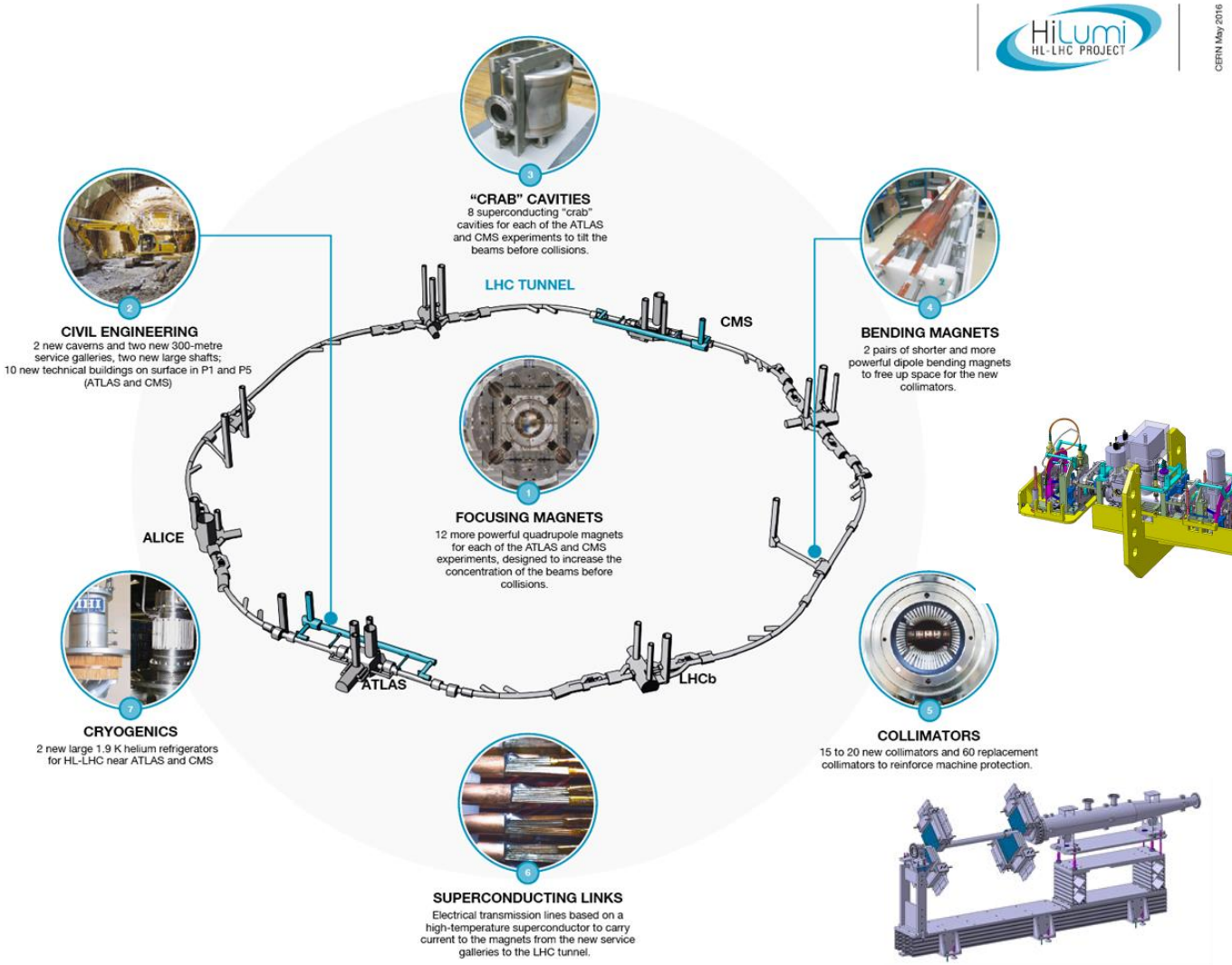


Technology

Landmarks

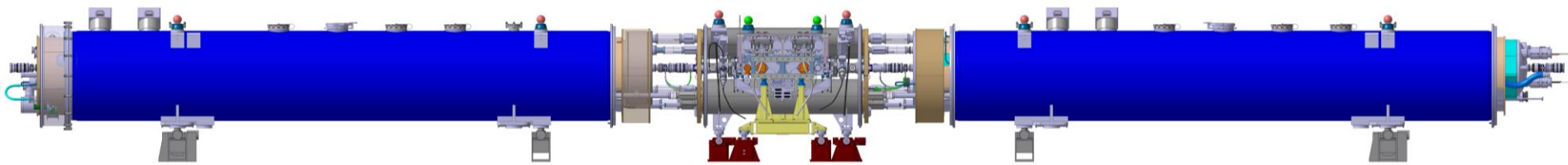
Technology landmarks



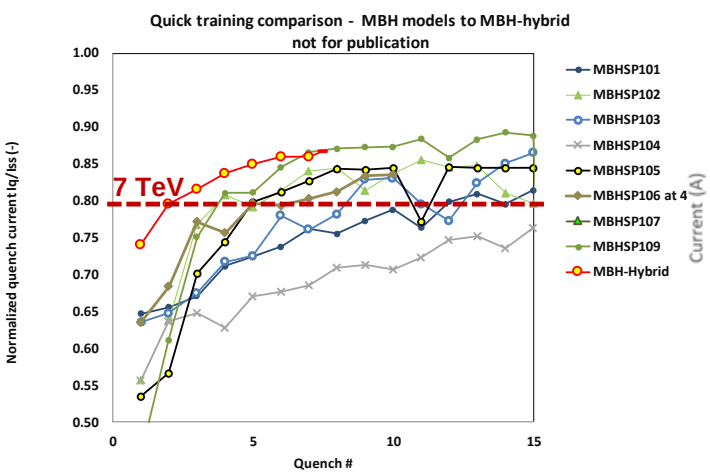


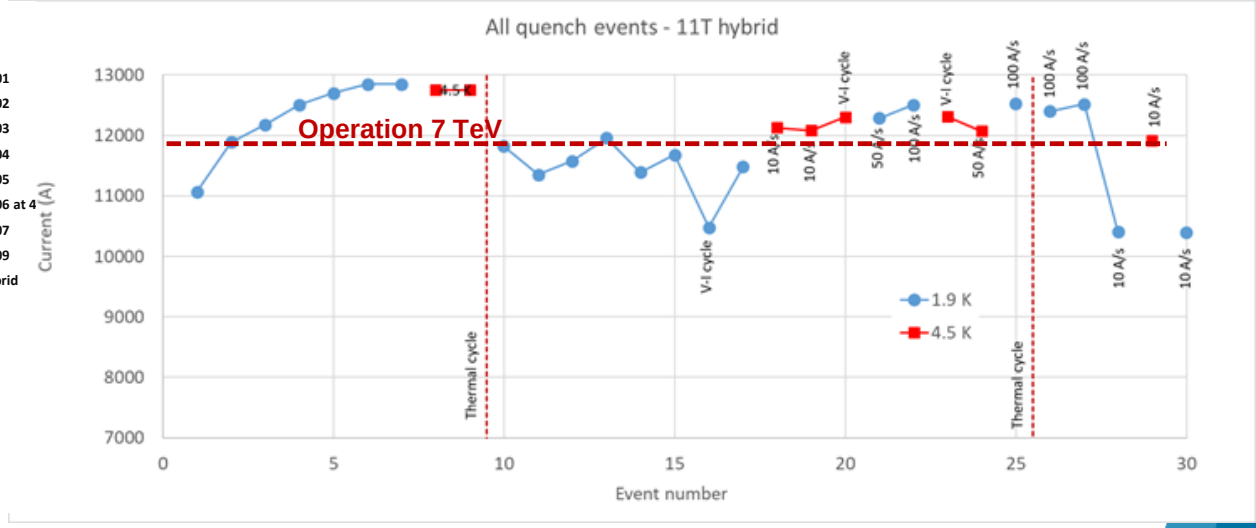
11T Nb_3Sn

LBH_**A (11T)** By-pass cryostat with collimator LBH_**B (11T)**

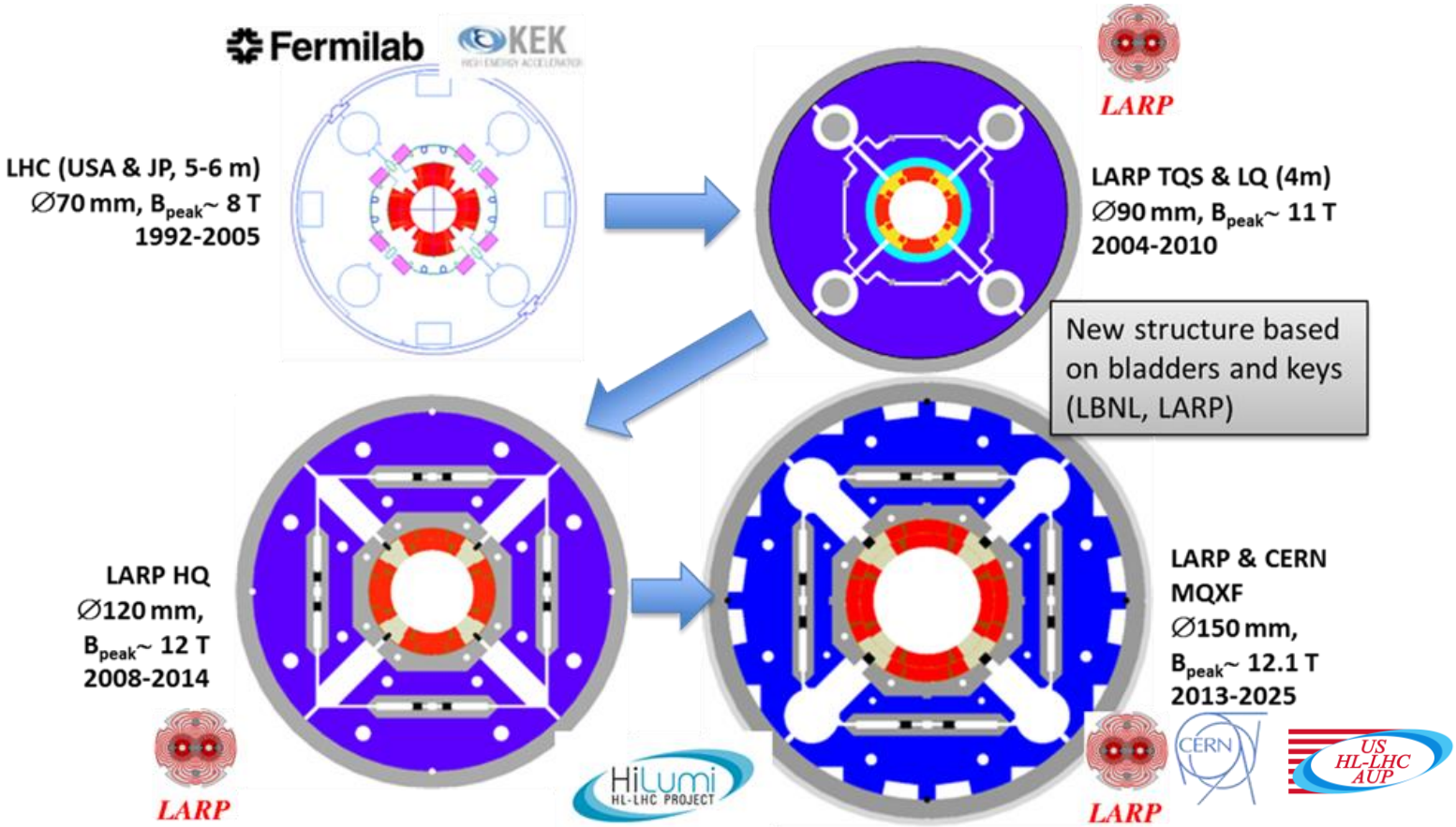


New Magnet Technology in Nb_3Sn: an 11 T dipole replacing an 8.3 T LHC dipole in 2020

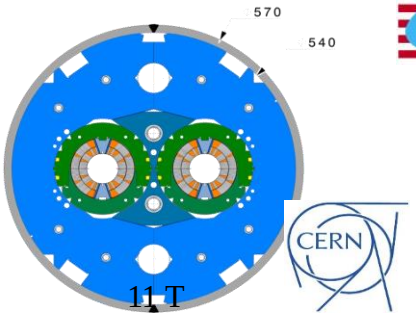




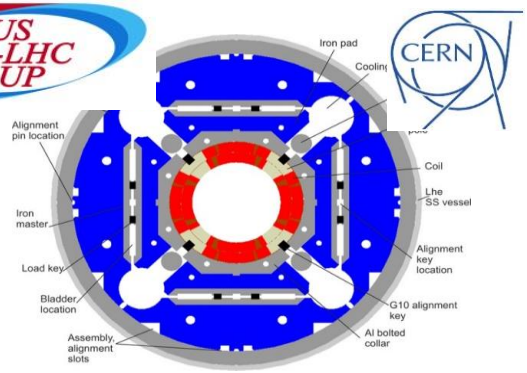
IT quadrupole. Increase in field but also in size wrt LHC. Very relevant also for FCC magnets



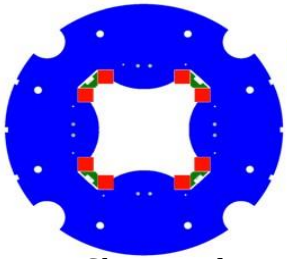
New generation of Magnets (~130)



11 T

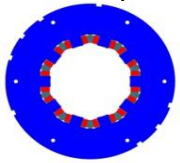


IT Quads



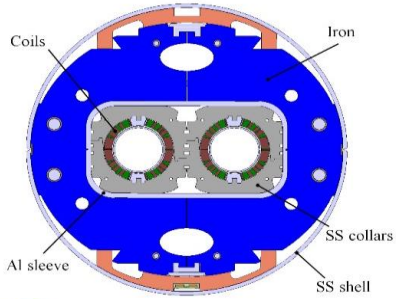
Skew quad

Dodecapole

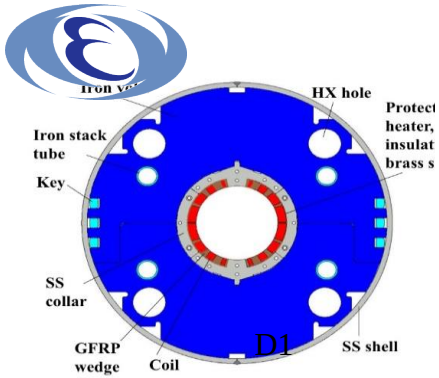


Decapole

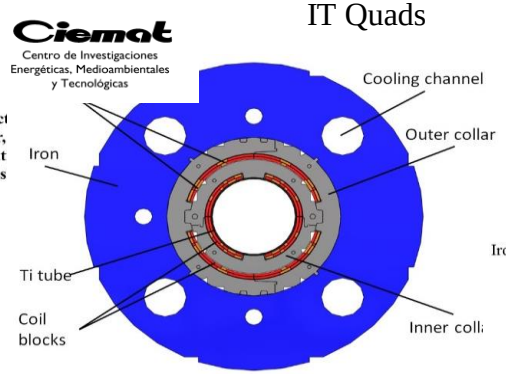
Octupole



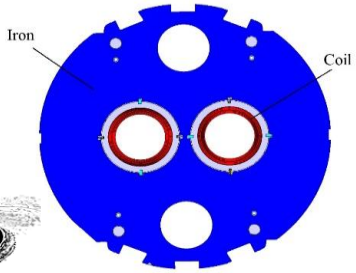
D2



D1

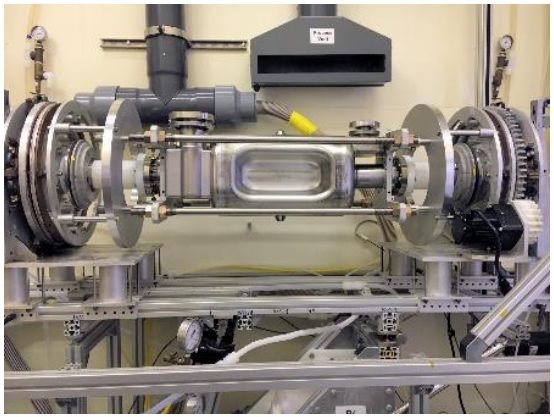


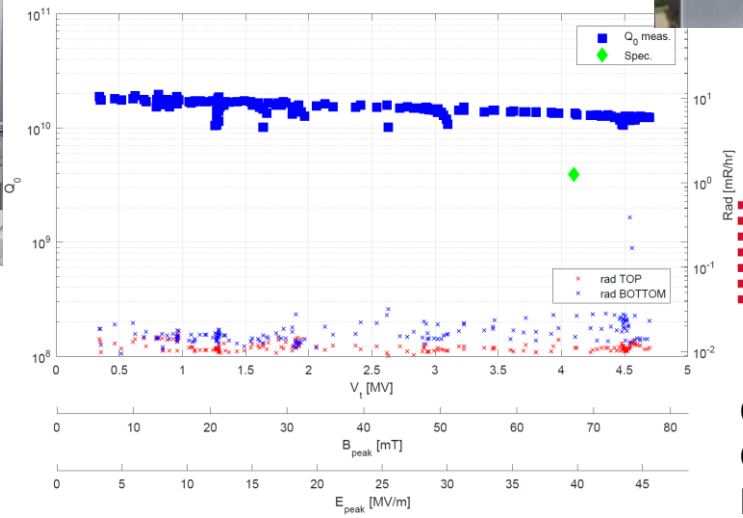
MCBXF



D2 orbit corrector

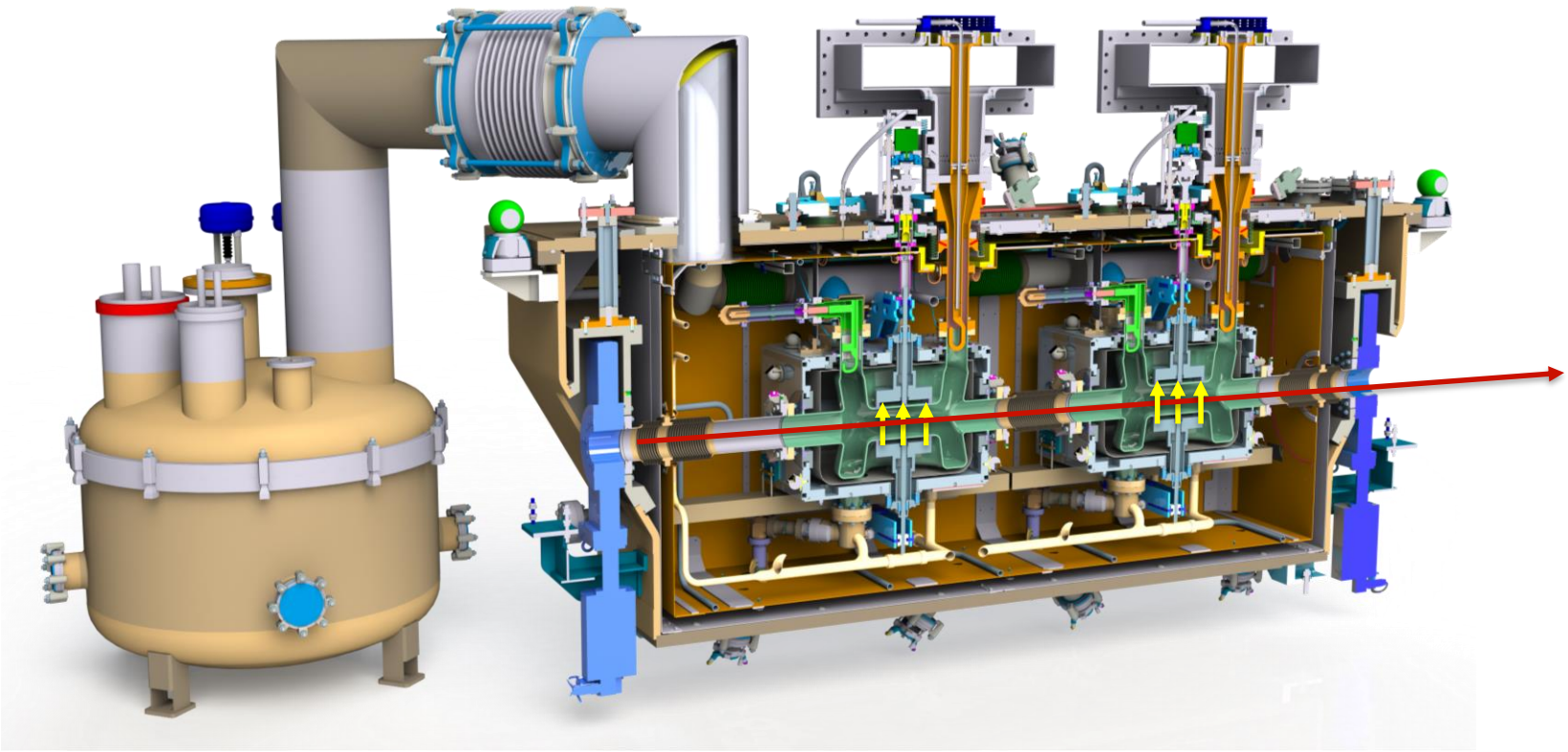
Crab Cavity





CERN DQW prototype for SPS test
Collaboration with UNILANC & STFC - C.I. Daresbury (UK)

The DQW CC in cryomodule for the SPS test



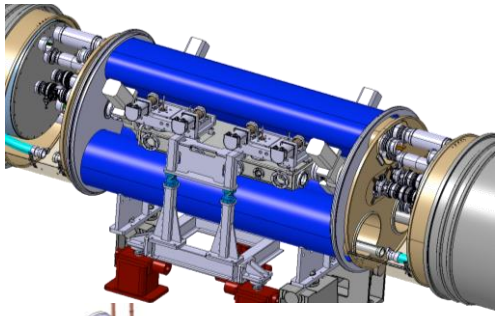
Collimators low-Z : special MoGR Mo-coated upgrade partly in 2020 and then in 2025

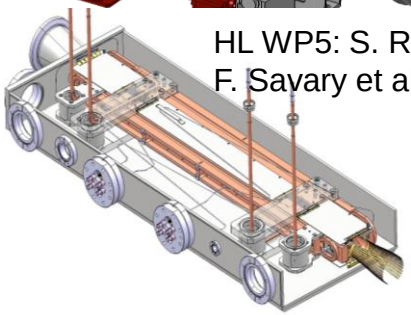
Samples of MoGr (Molybdenum-Graphite) from producer (CERN EN/MME/STI)

CINEL, Pd, Italy)

HL WP5: S. Redaelli, R. Bruce, S. Gilardoni, M. Calviani, A. Bertrelli, R. Carra et al.

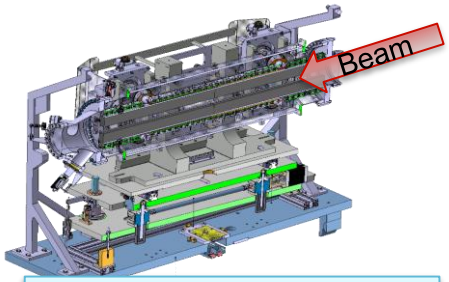
Cold-Warm-Cold bypass to host Collimators in the DS region



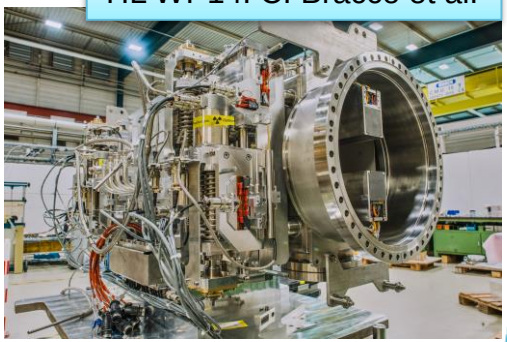


HL WP5: S. Redaelli, F. Savary et al.

New injection protection absorber



HL WP14: C. Bracco et al.

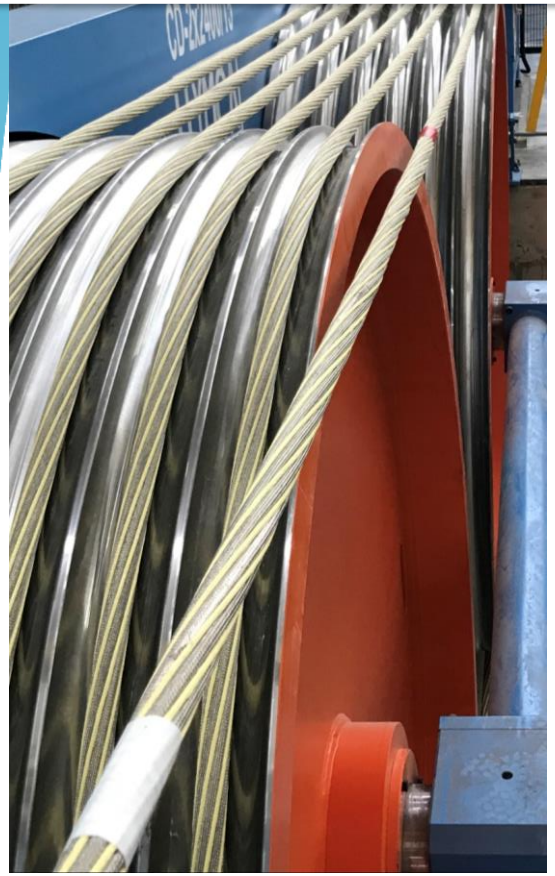


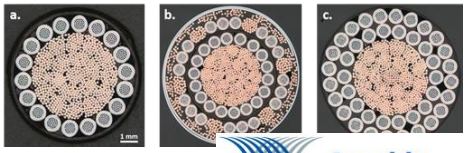
In total some 40 new absorber and collimators devices in LS2 (2020) and LS3 (2025)

SC Links

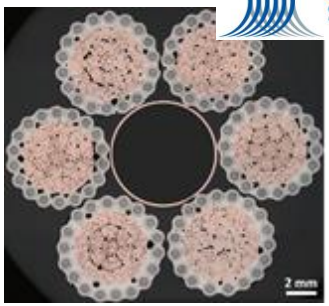
SC Links inside flexible cryostat: first 60 m long prototype 20 kA cable tested at CERN

First long length of 20 kA **MgB_2 cable** (IT Quad circuit)





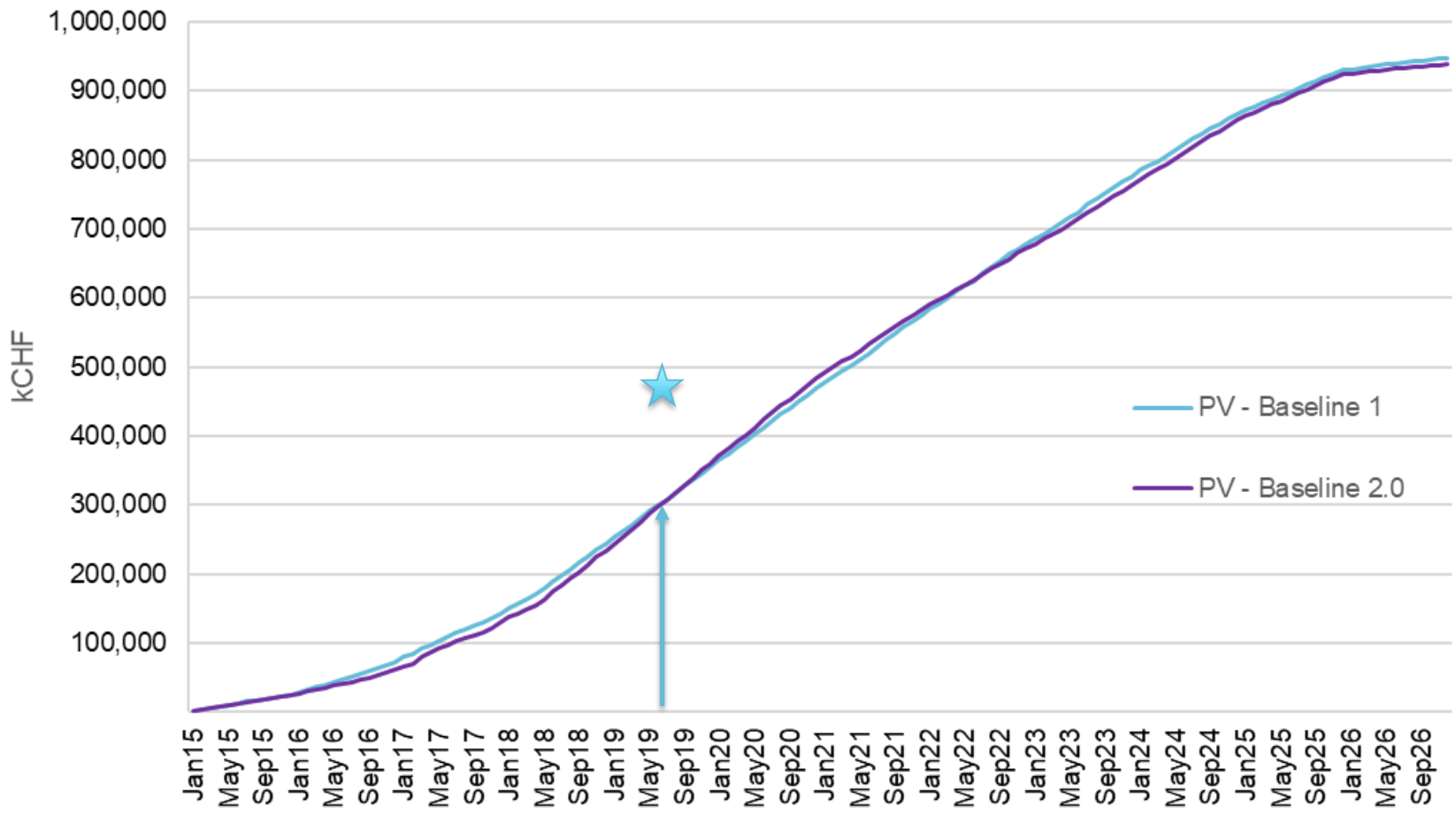
Ansaldo Superconduttori



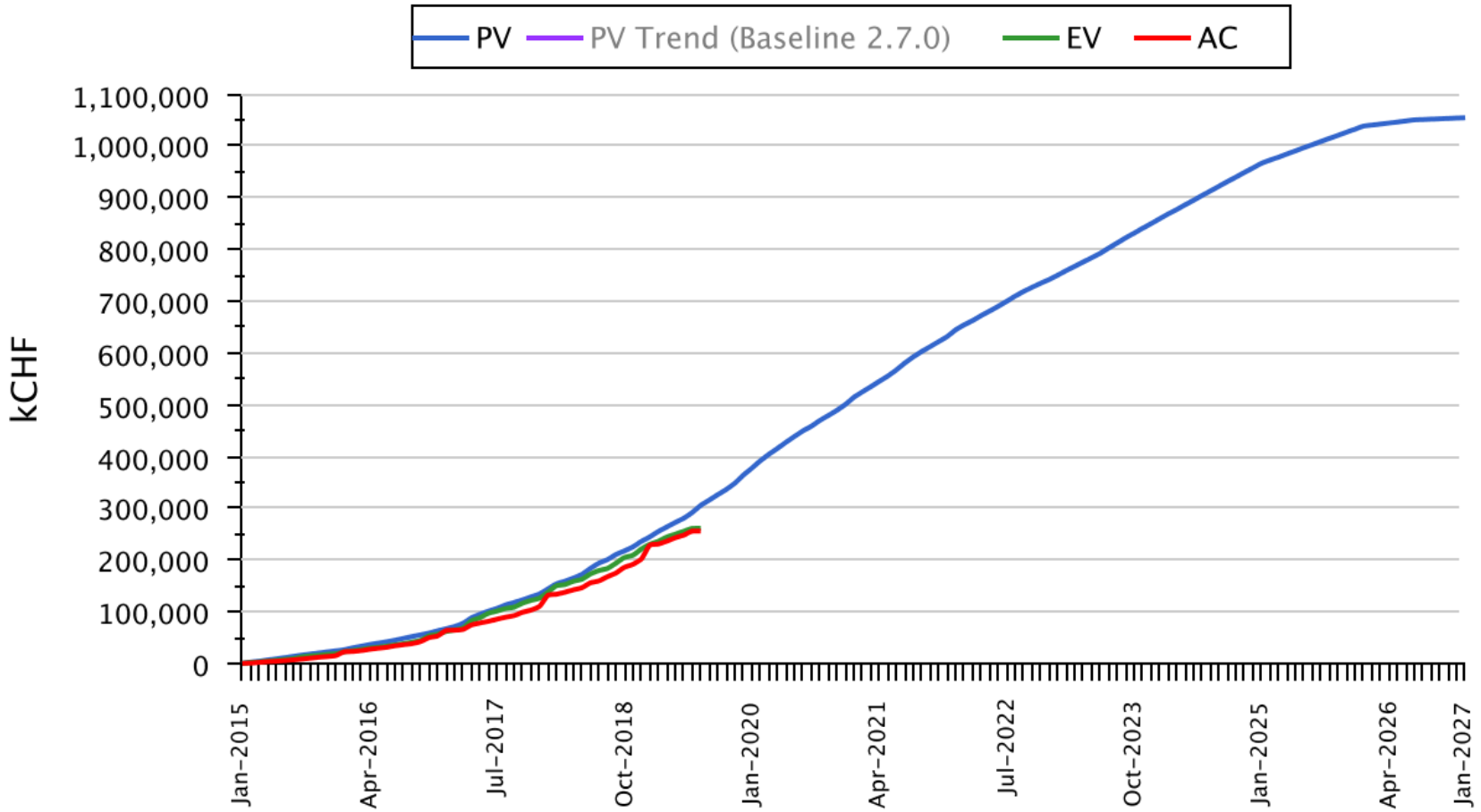
Industry

Procurement for HL-LHC

COST: 950 MCHF for materials slightly less than 2000 Staff-year



How we are doing? (Plan versus Actual)

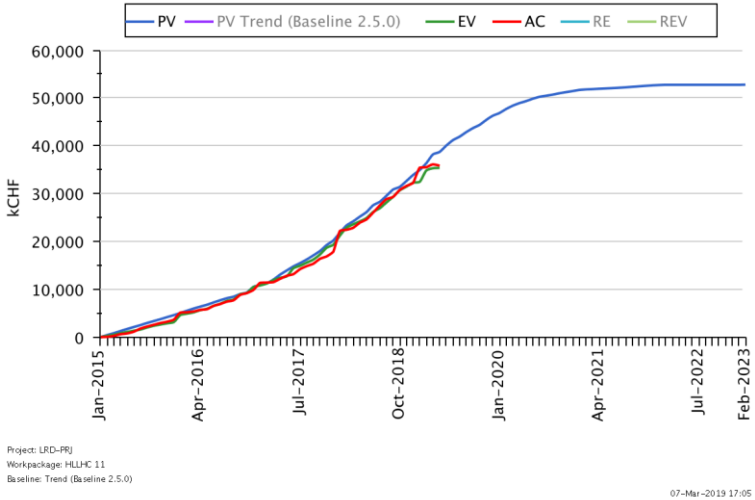


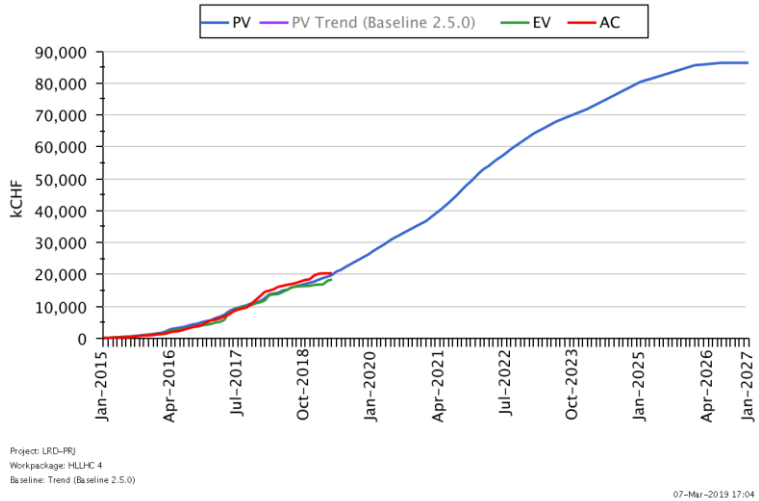
Project: LRD-PRJ

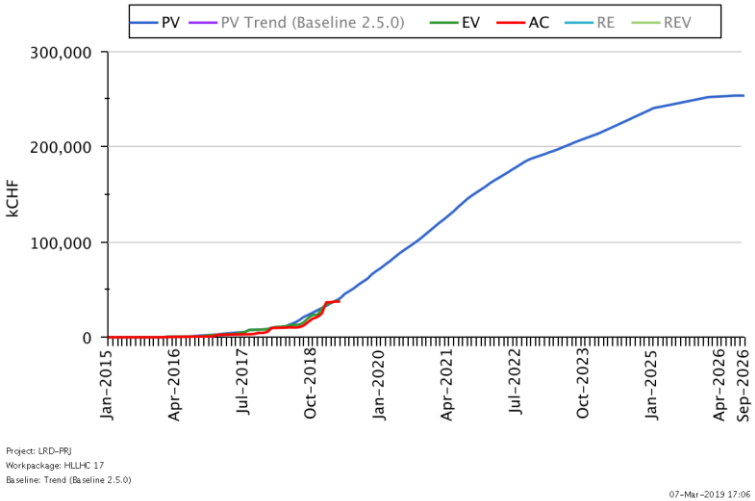
Baseline: Baseline 2.7.0

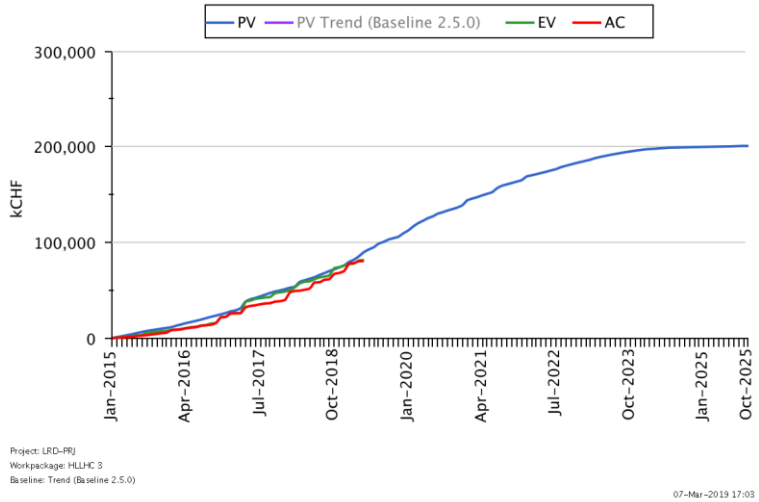
03-Jun-2019 10:49

On track for all WPs









The HL-LHC Project

Main components, technical services and infrastructure

Tendering on-going or already open and checking

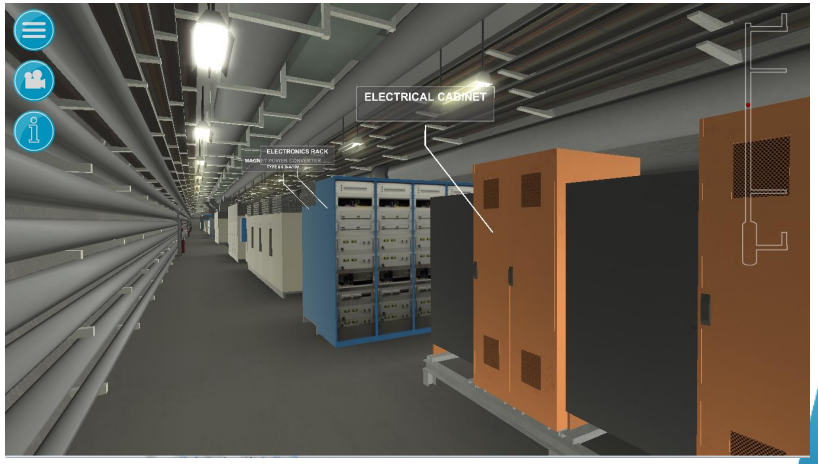
- MS-4514:Design and Manufacture of high precision 18kA and 14kA (class 0) DC Current Transformers
- MS-4513:Design and Manufacture of high precision 2kA (class 2) DC Current Transformers
- MS-4512: MLI for cryomagnets
- MS-4500: IPOC Digitizers
- Manufacture of Pumping Slot Shields for beam screen (high-precision thin walled beryllium-cooper components)

Still to come as components

- Bladders for the Quadrupoles series production
- Cold-warm Transitions
- Expansion Bellows
- Studs to maintain the absorbers on the beam screens
- Semi-rigid, radio frequency cables
- Laser to be used in the FSI (Frequency Scanning Interferometry
- Hydrostatic Levelling Sensors and Wire Positioning Sensors
- Manufacturing of the Thermal Shields in Al. for cryomagnets
- VAX Supports – Metallic structures
- Mechanical Switches for Energy Extraction Systems
- Electronics for beam instrumentation
- Overhead cranes for P1 and P5 (25t and 20t capacity)
- D2 magnet components (wedges, end spacers, Al ring)
- Service modules for magnets cryostats
- 1 Vacuum vessel for RFD prototype
- Faraday Cage for RF services
- ….and of course we will always need raw materials, tooling and small hardware…

Still to come as service contracts or material/installation….

- Service contract for Q2 magnet production
- Service contract for cryostating and cold mass production
- Cryogenic Plants for P1 and P5 Cooling and ventilation material + installation
- Electrical distribution material + installation
- Access systems material + installation
- Power converters

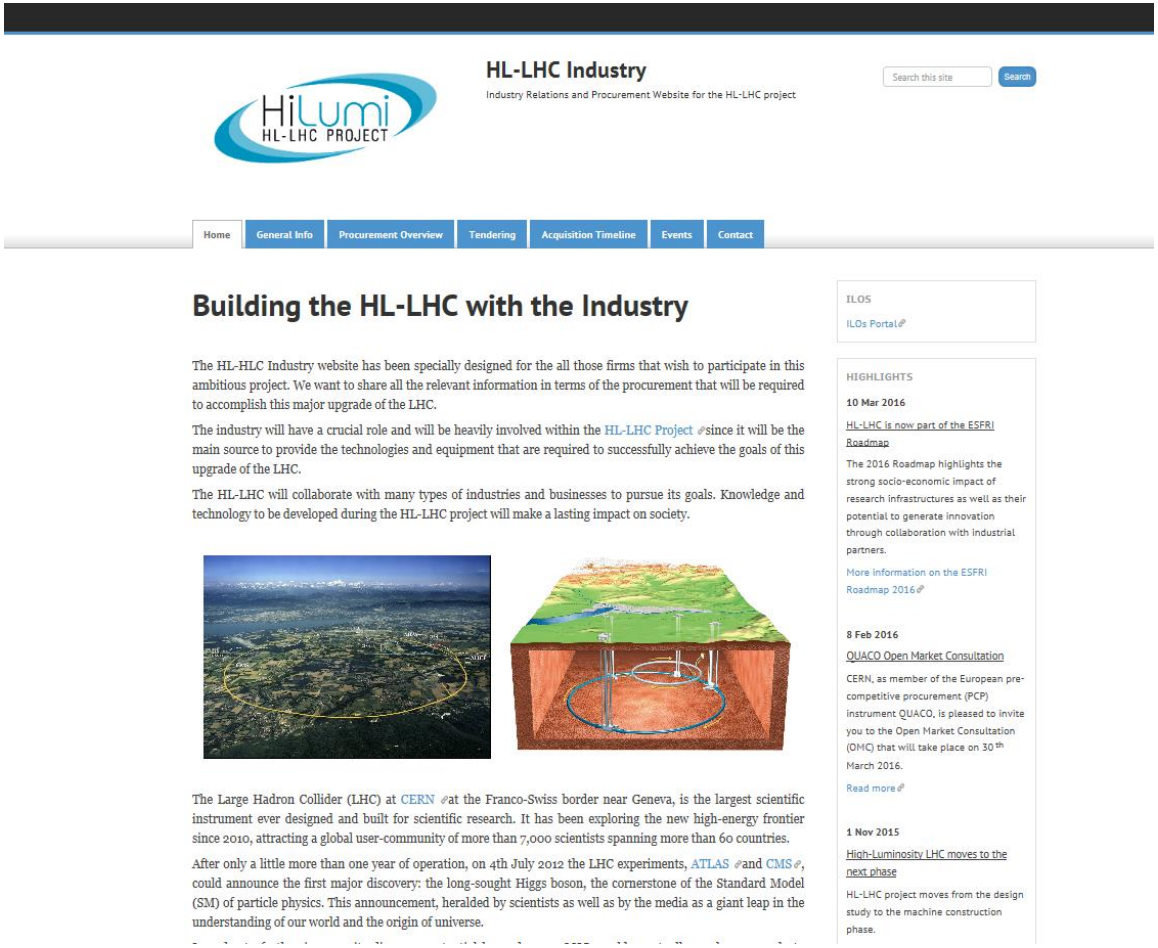


Industry

Tools to communicate and to get informed

Information must be dynamic …

https://project-hl-lhc-industry.web.cern.ch/



HL-LHC Industry

Industry Relations and Procurement Website for the HL-LHC project

Search this site | Search

Home | General Info | Procurement Overview | Tendering | Acquisition Timeline | Events | Contact

Building the HL-LHC with the Industry

The HL-HLC Industry website has been specially designed for the all those firms that wish to participate in this ambitious project. We want to share all the relevant information in terms of the procurement that will be required to accomplish this major upgrade of the LHC.

The industry will have a crucial role and will be heavily involved within the HL-LHC Project since it will be the main source to provide the technologies and equipment that are required to successfully achieve the goals of this upgrade of the LHC.

The HL-LHC will collaborate with many types of industries and businesses to pursue its goals. Knowledge and technology to be developed during the HL-LHC project will make a lasting impact on society.

The Large Hadron Collider (LHC) at CERN at the Franco-Swiss border near Geneva, is the largest scientific instrument ever designed and built for scientific research. It has been exploring the new high-energy frontier since 2010, attracting a global user-community of more than 7,000 scientists spanning more than 60 countries.

After only a little more than one year of operation, on 4th July 2012 the LHC experiments, ATLAS and CMS, could announce the first major discovery: the long-sought Higgs boson, the cornerstone of the Standard Model (SM) of particle physics. This announcement, heralded by scientists as well as by the media as a giant leap in the understanding of our world and the origin of universe.

ILOS

ILOs Portal

HIGHLIGHTS

10 Mar 2016

HL-LHC is now part of the ESFRI Roadmap

The 2016 Roadmap highlights the strong socio-economic impact of research infrastructures as well as their potential to generate innovation through collaboration with industrial partners.

More information on the ESFRI Roadmap 2016

8 Feb 2016

QUACO Open Market Consultation

CERN, as member of the European pre-competitive procurement (PCP) instrument QUACO, is pleased to invite you to the Open Market Consultation (OMC) that will take place on 30th March 2016.

Read more

1 Nov 2015

High-Luminosity LHC moves to the next phase

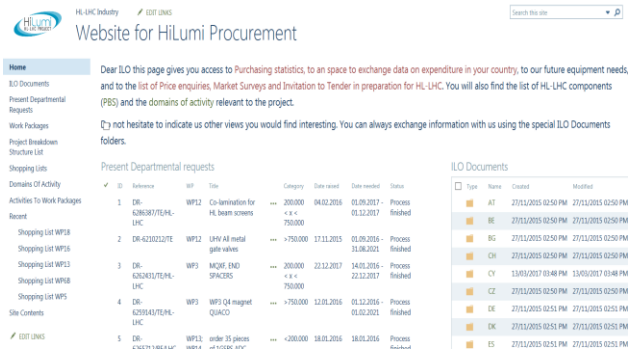
HL-LHC project moves from the design study to the machine construction phase.

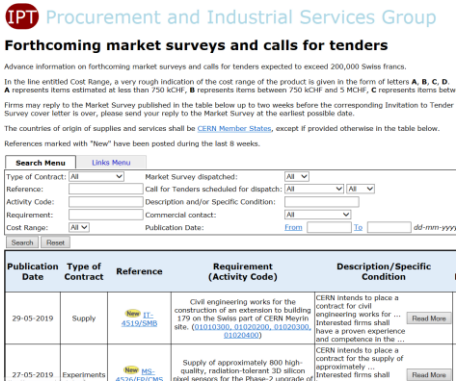
Information must be dynamic …

- Get in touch with your ILO – He is the key contact between CERN and the Industry of each country
  https://ilo.infn.it/index.php

- HL-LHC ILOs Portal (ILOs only)
  HL-LHC Procurement Plan provided since 2015.
  What's coming the next (next 18 months.
  Next revision soon!!!

- CERN Procurement Website
  All MSs & ITs are announced
  (Not only HL)
  https://found.cern.ch/java-ext/found/CFTSearch.do





Our objective

- The High Luminosity project seeks industrial suppliers and collaborations for the current construction phase and make the High Luminosity upgrade.
- CERN aims at fostering R&D collaborations and knowledge exchange also with SMEs, a perfect opportunity to match their capacity with the requirements of HiLumi.
- Understanding our needs is the first step to tender successfully.
- Understanding your capabilities and the know how that could come from industry is the best way to specify equipment that can be built by industry
- Industrial events are always profitable for both parties

Ready for the challenge?

Become a CERN supplier to built future accelerators

Visit us on

https://project-hl-lhc-industry.web.cern.ch

Thank you for your attention

Special Thanks to all HL-LHC WP Leaders