



Subcooling HEX Contract Kick Off Meeting Introduction to CERN and High Luminosity project

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CERN, 06/10/2023

Outline

- Introduction to CERN
- Introduction to Hi-Lumi project
- Cryogenic system for Hi-Lumi project

The Mission of CERN

- Push forward the frontiers of knowledge
E.g., the secrets of the Big Bang ...what was the matter like within the first moments of the Universe's existence?
- Develop new technologies for accelerators and detectors
- Information technology - the Web and the GRID
- Medicine - diagnosis and therapy
- Train scientists and engineers of tomorrow
- Unite people from different countries and cultures



CERN was founded 1954: 12 European States

“Science for Peace”

Today: 23 Member States

Employees: ~2 700 staff, 800 fellows
Associates: ~11 800 users, 1 300 others
Budget (2019) ~ 1 200 MCHF

Member States: Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Israel, Italy, the Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Spain, Sweden, Switzerland and the United Kingdom

Associate Members in Pre-Stage to Membership: Cyprus, Slovenia

Associate Member States:

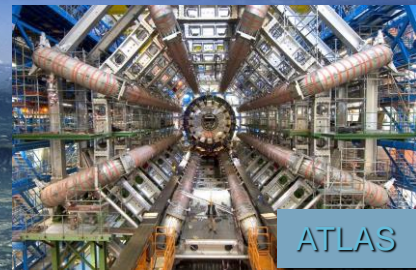
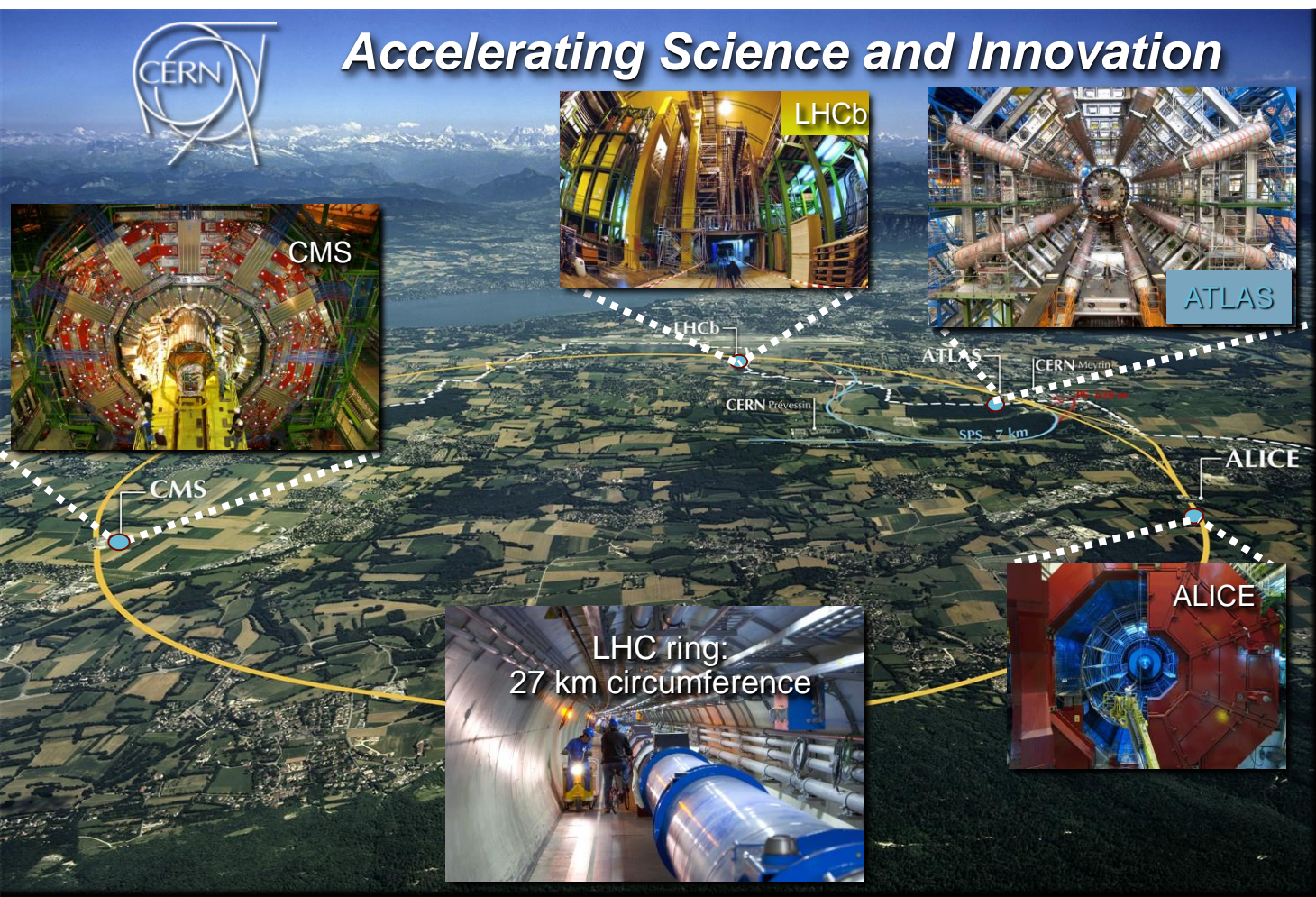
Croatia, India, Lithuania, Pakistan, Turkey and Ukraine

Applications for Membership or Associate Membership: Brazil, Estonia, Latvia

Observers to Council: Japan, Russia, United States of America; European Union, JINR and UNESCO



Accelerating Science and Innovation



Why the High Luminosity LHC project ?

Many questions remain !

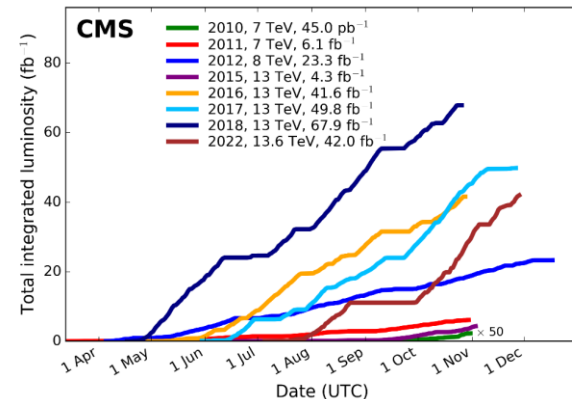
- Higgs properties [coupling]
- More than one Higgs?
- Beyond Standard Model Physics? Dark Matter & Dark Energy?

➔ **Need more Data and Statistics!!**

- ➔ The final focusing magnets will also need to be replaced because of radiation damage.

HL-LHC Goals

- Extend the LHC lifetime by 15+ years
- Prepare the machine for producing in that period 10 times more data as compared to the nominal LHC operation period



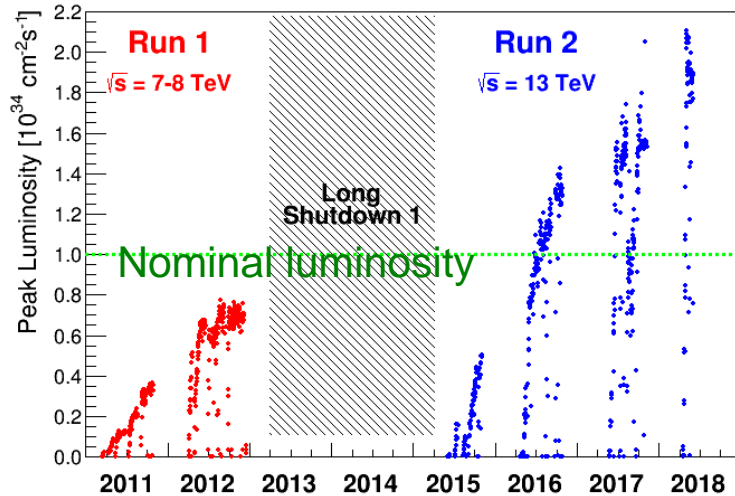
$$\frac{dR}{dt} = L\sigma_p$$

- dR/dt : number of events per second
- L : luminosity
- σ_p : event production cross section

NB: doubling the accuracy for the experiments would require 4 times the data volume (over 20 Years of operation with current peak performance after end of Run 3)

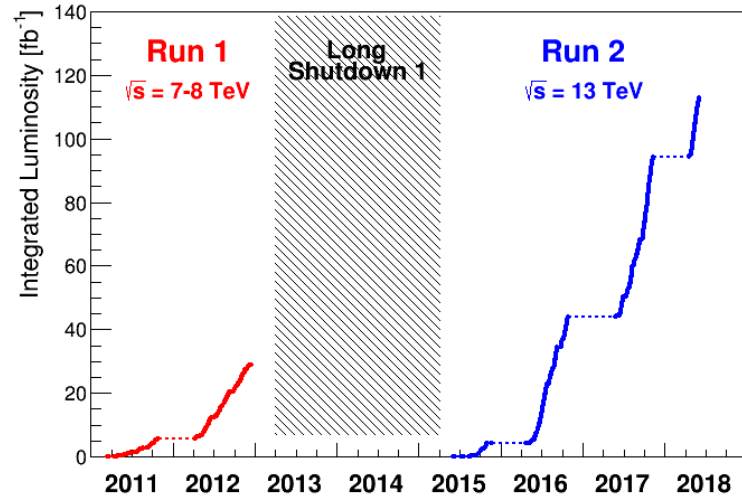
Basic performance indicators of a particle collider

Peak Luminosity
=> Performance



“The potential of the facility”

Integrated Luminosity
=> Qualification – Global availability - Time



“What allows science” (statistics)

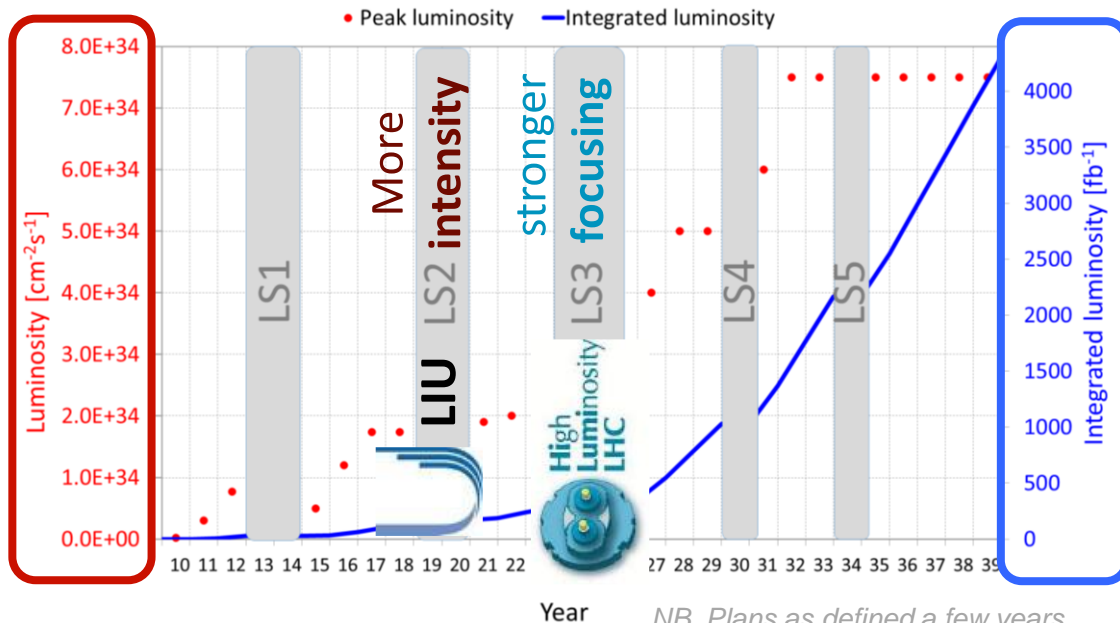
Towards higher collision rates

New discoveries and precision measurements need integrated luminosity !!!

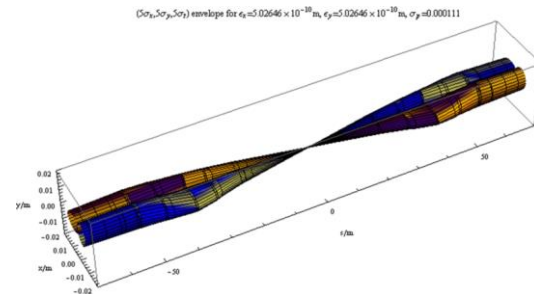
$$\text{Luminosity} = f * N^2 / 4\pi \sigma^2$$



Need for more protons in a smaller cross section !!!



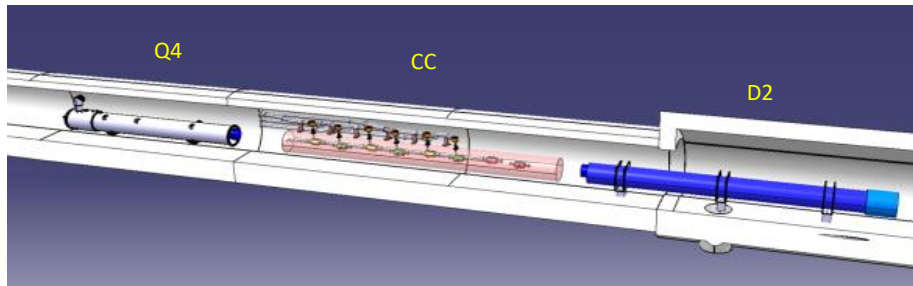
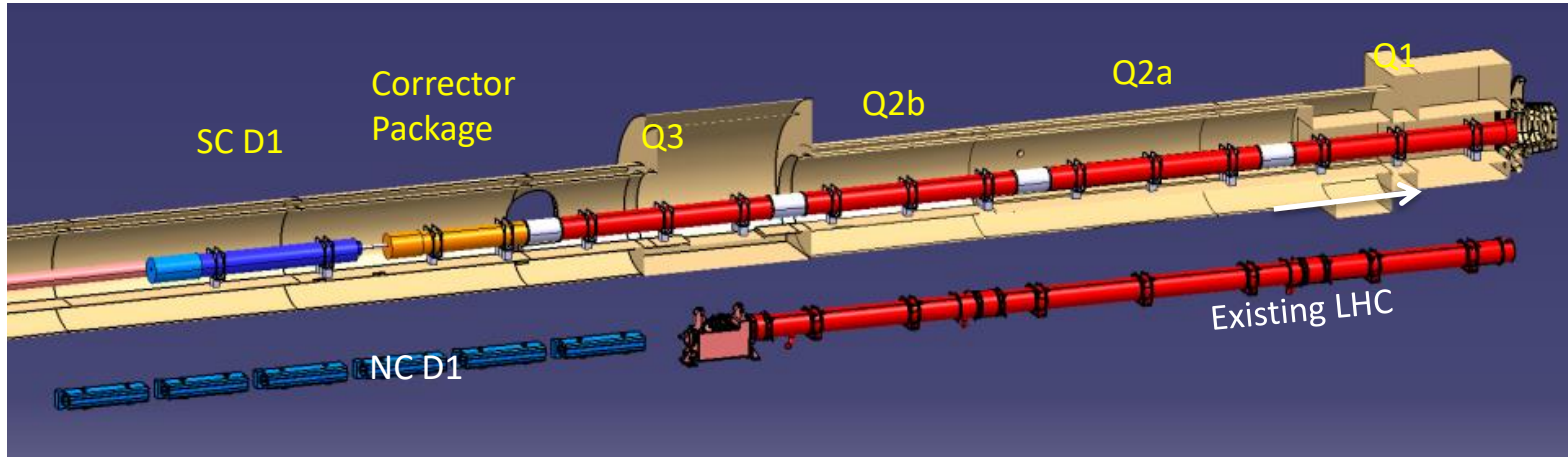
Target for physics: doubling integrated Luminosity for each new run



NB. Plans as defined a few years ago, timing not up-to-date

more powerful final focusing !

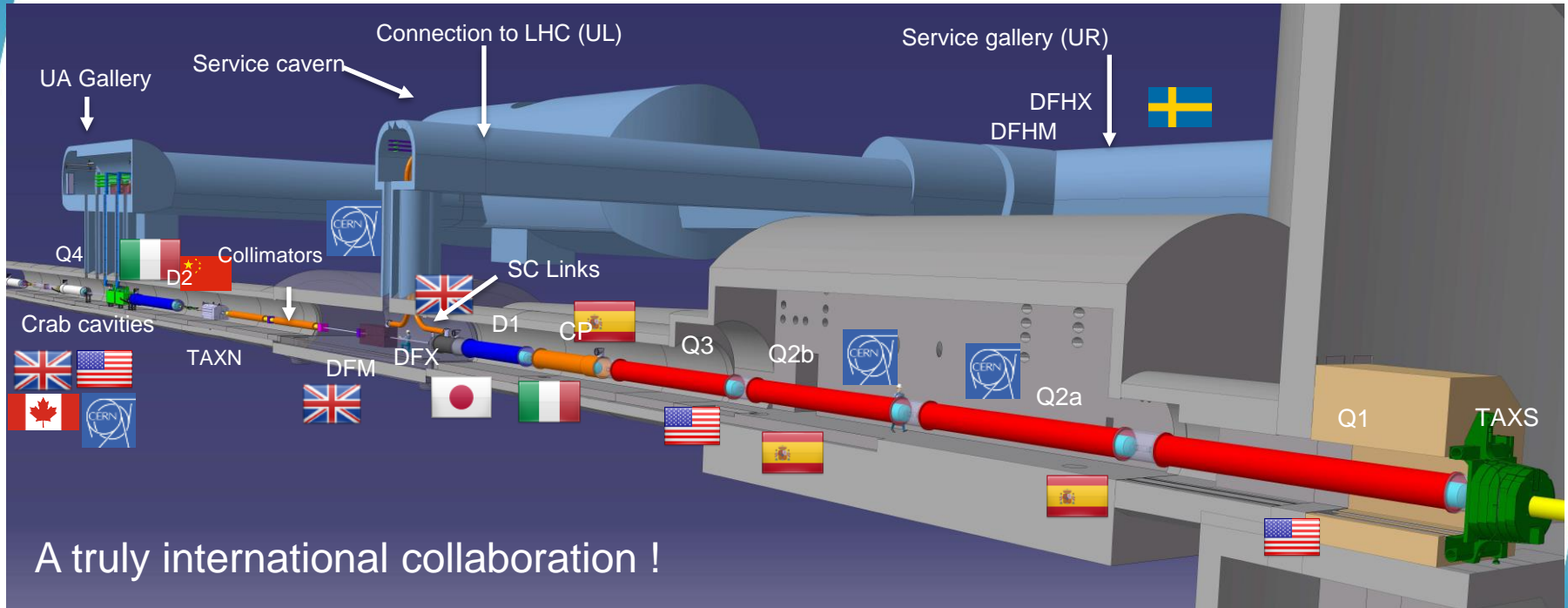
Final focussing at P1 and P5: from LHC to HL-LHC



HL-LHC relies on more powerful final focussing quadrupoles, associated recombination dipoles and crab cavities.

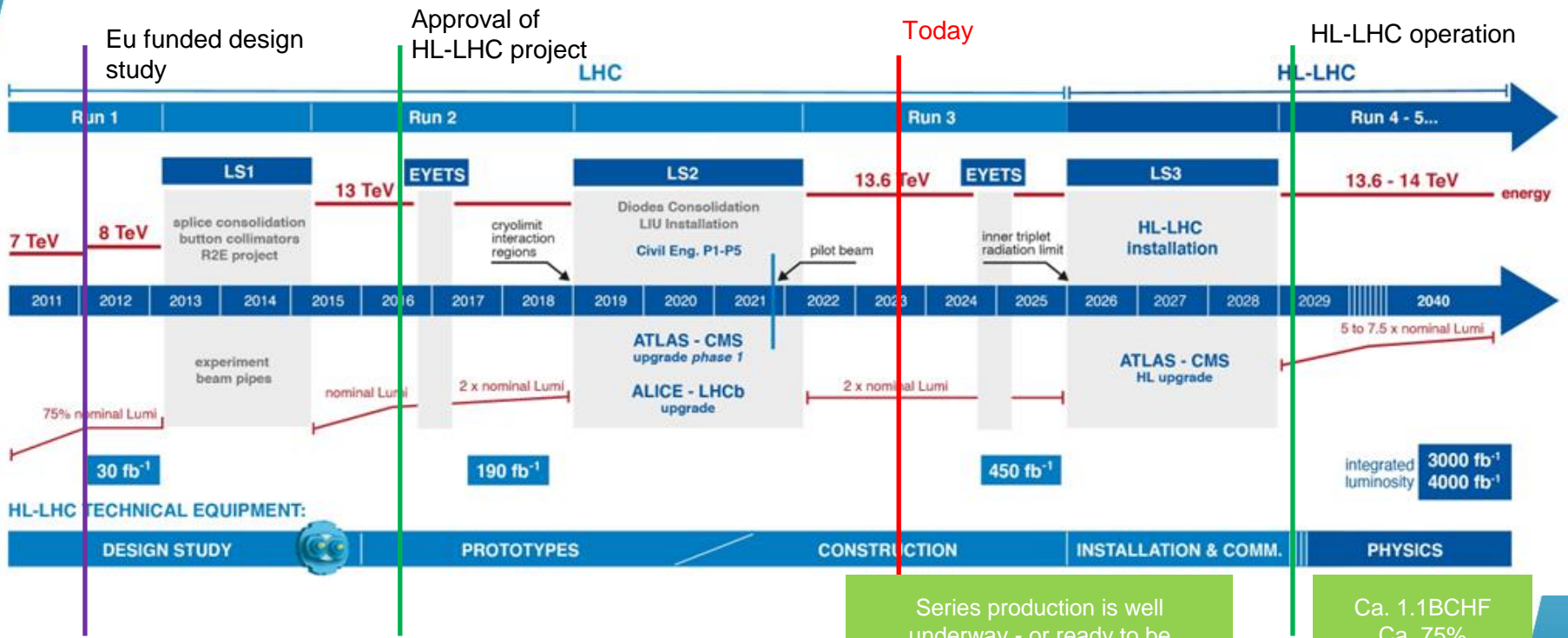
Local heat loads expected x5 w.r.t LHC

View of underground configuration at IP5



A truly international collaboration !

Timeline of LHC and HL-LHC

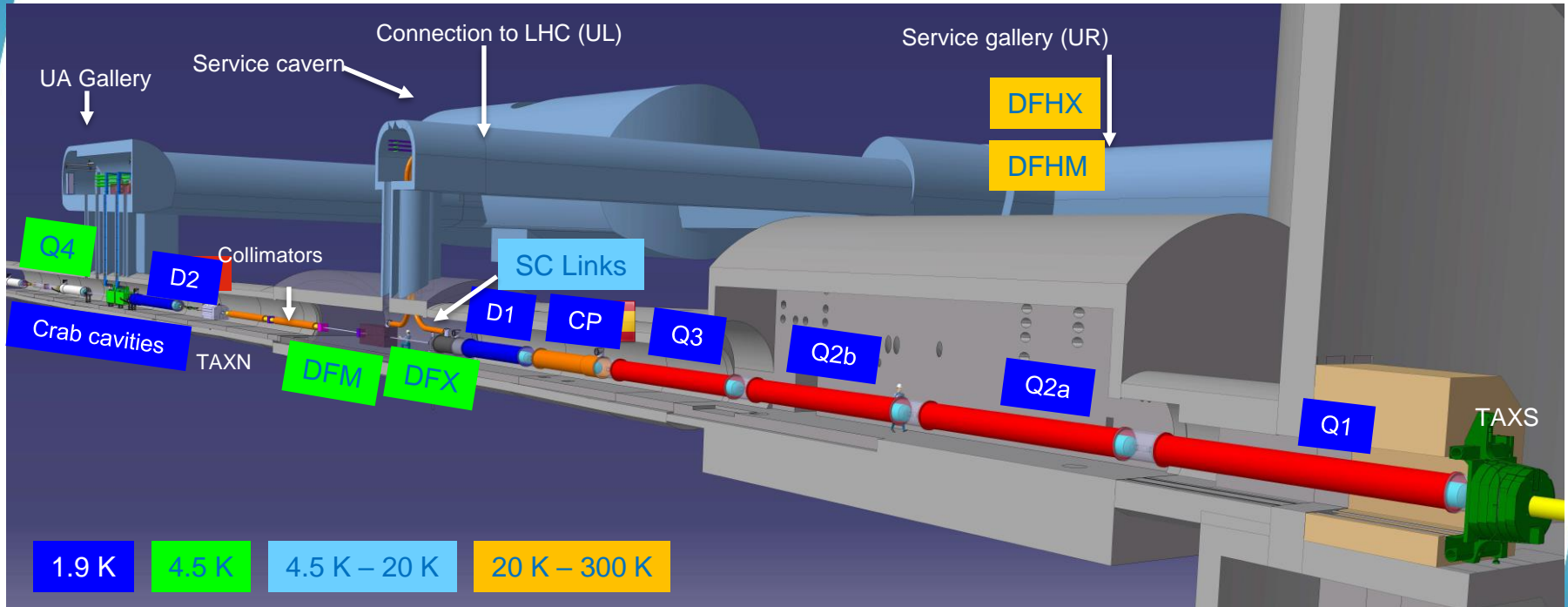


Series production is well underway - or ready to be launched - for all components!

Ca. 1.1BCHF
Ca. 75% committed



What needs to be cooled



SC magnets beam screens are cooled at 60-80 K

HL-LHC P1/P5 Cryogenic architecture

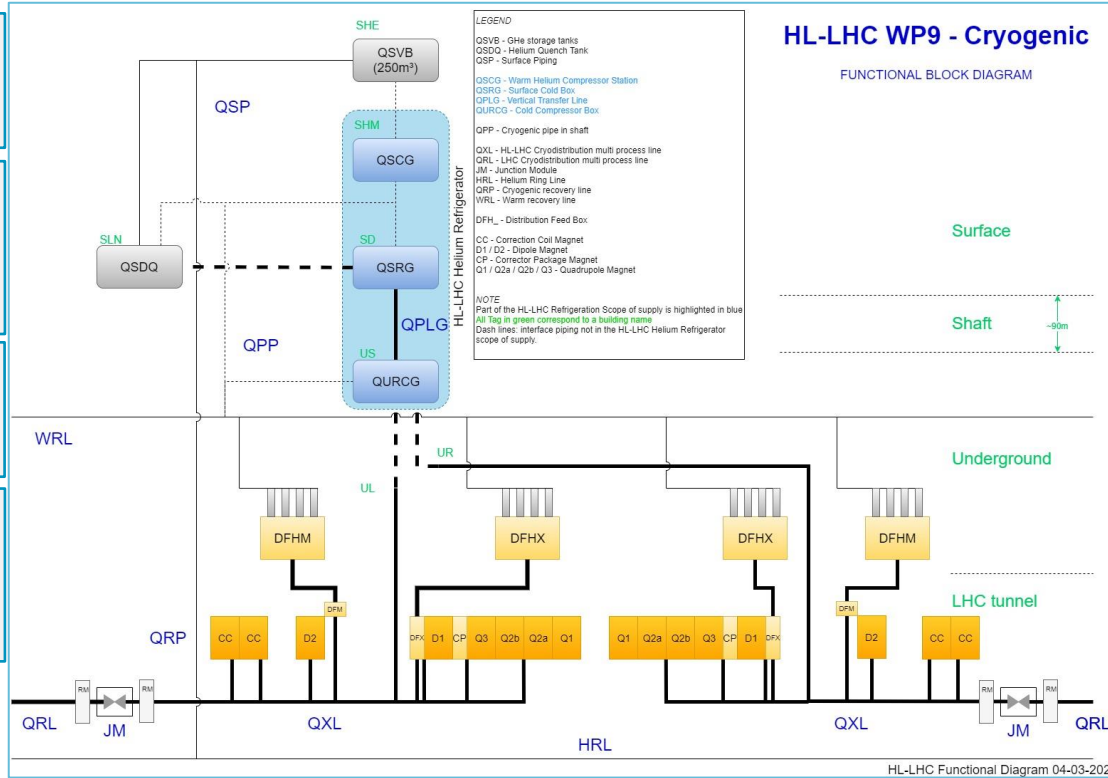
QSRG : Compressor station providing gaseous helium **20 B**

QSRG : 4.5K refrigerator providing supercritical helium at **3 bara** and **4.6 K**

QPLG : Vertical transfer line (~100 m height)

QURCG : Cold compressor box providing cooling capacity at **1.8 K**

Users at tunnel level



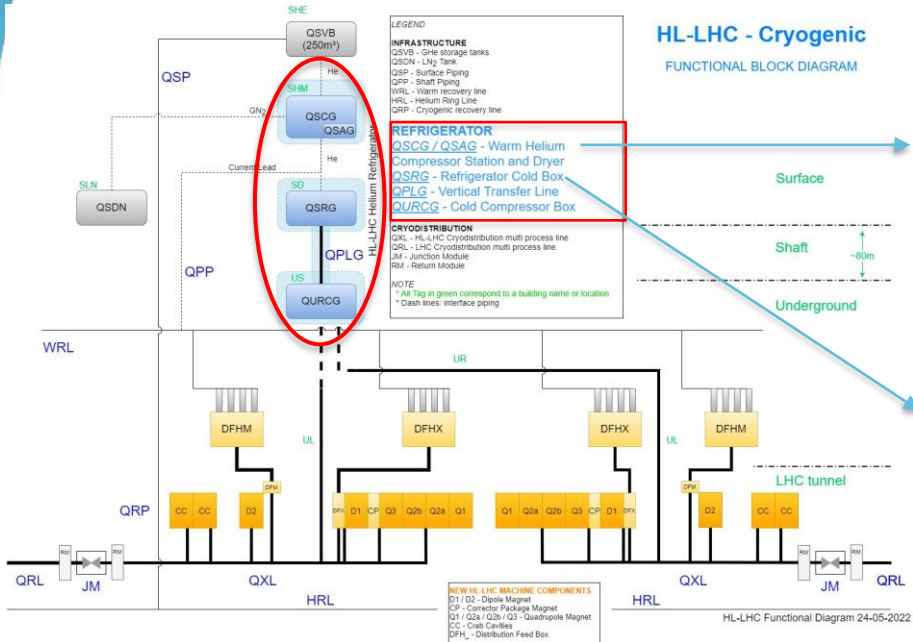
QXL : Distribution line distributing C,E and returning B,D,F

- 70 m for the common branch
- 270 m for the long branch
- 60 m for the short branch

RM/JM : Return module and junction module at extremities for transient handling and back-up

Helium Refrigerators at LHC P1 and P5 for HL-LHC

P1-P5 Cryogenic Architecture



Helium Refrigerators

2 x 14kW @4.5K, including 3.25kW @1.9K



LHC Helium Refrigerators similar capacity required for P1 and for P5, in addition to 8 existing

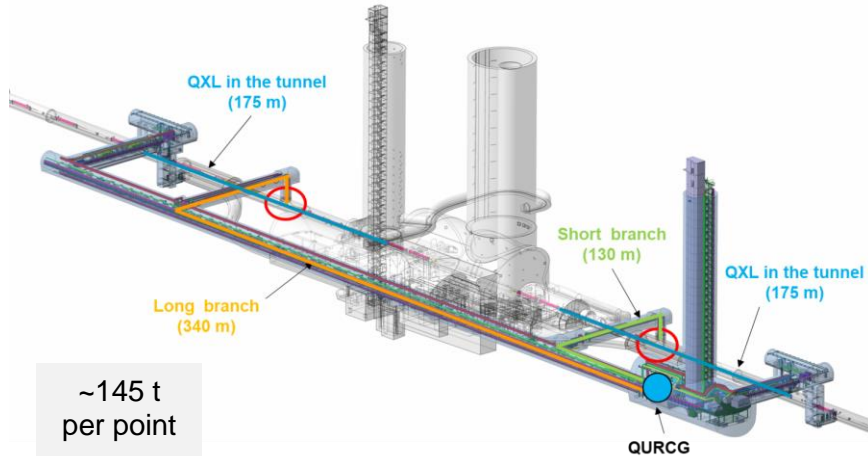
Compressor station (100t, 4MW input power)



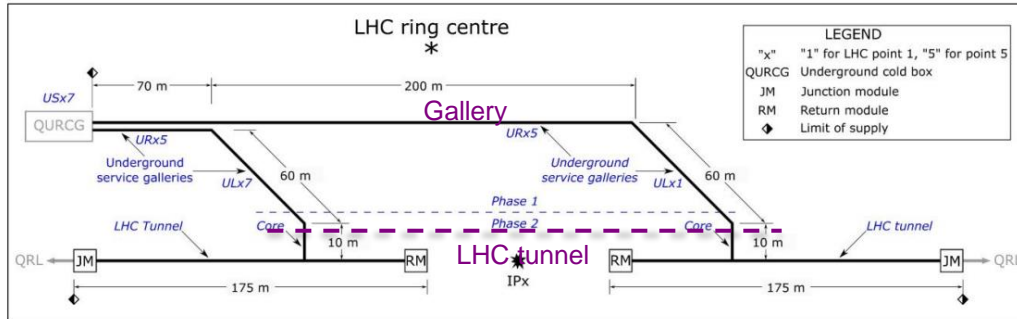
Cold boxes from world wide leading industries (>100t, Heat exchangers, expansion turbines, valves, controls)



Cryogenic distribution line at P1 and P5



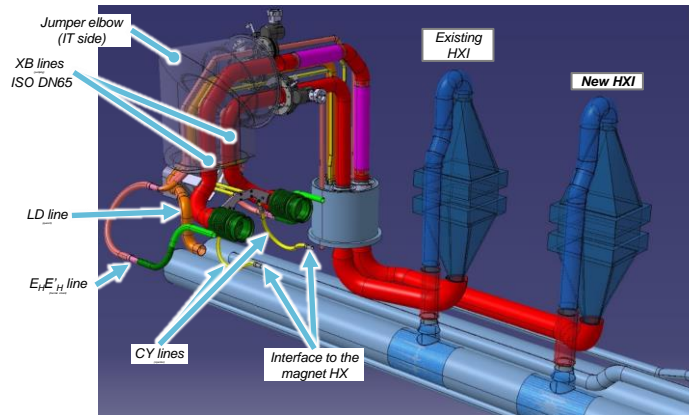
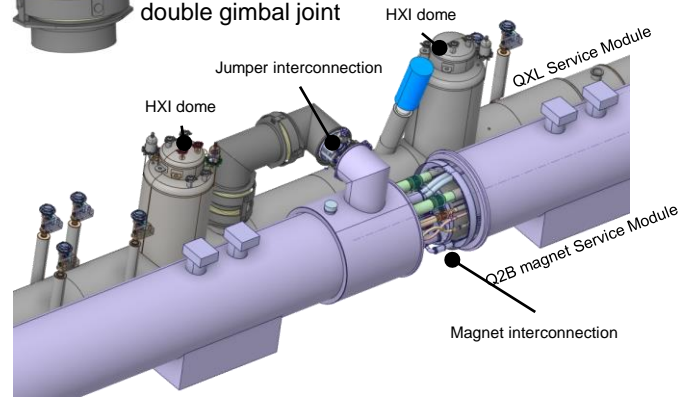
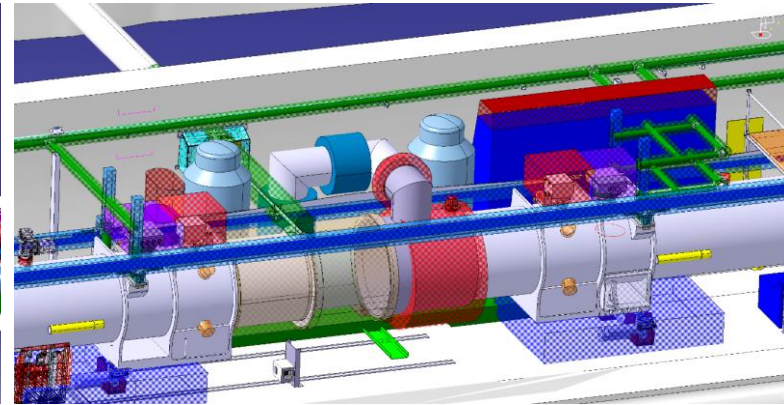
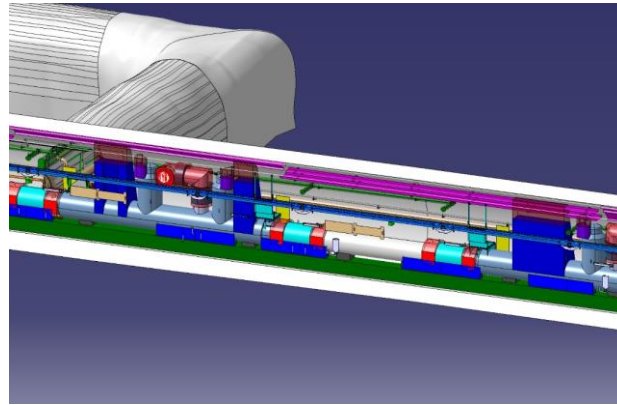
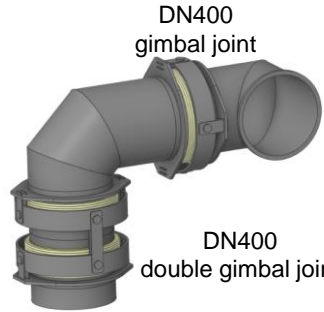
- 2 x 750 m, 5 process pipes, vacuum insulated lines
- Lines diam. 40 - 273 mm, 650 mm - 800 mm



- Tendering process Q1-Q2_2022
- Contract signed Dec'22 with KrioSystem (PL)



Cryogenic distribution line at P1 and P5: some details





Thank you for your attention

