

Welcome to CERN

Cryogenics at CERN

CERN, Tuesday 3rd of September 2019

D. Delikaris

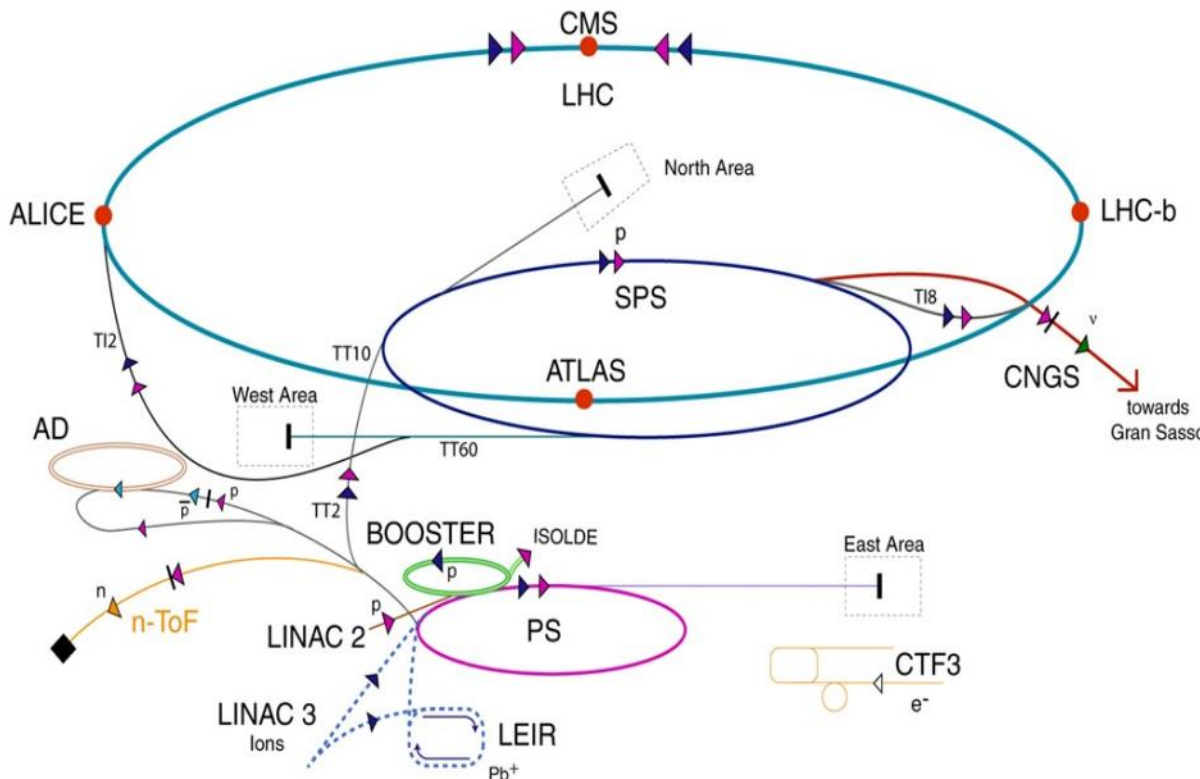
Head of Cryogenics Group (CRG)

Technology Department (TE)

CERN



CERN: Accelerators Complex



- ▶ protons
- ▶ antiprotons
- ▶ ions
- ▶ electrons
- ▶ neutrons
- ▶ neutrinos
- AD Antiproton Decelerator
- PS Proton Synchrotron
- SPS Super Proton Synchrotron
- LHC Large Hadron Collider
- n-ToF Neutron Time of Flight
- CNGS CERN Neutrinos Gran Sasso
- CTF3 CLIC Test Facility 3

LHC



THE LARGE HADRON COLLIDER

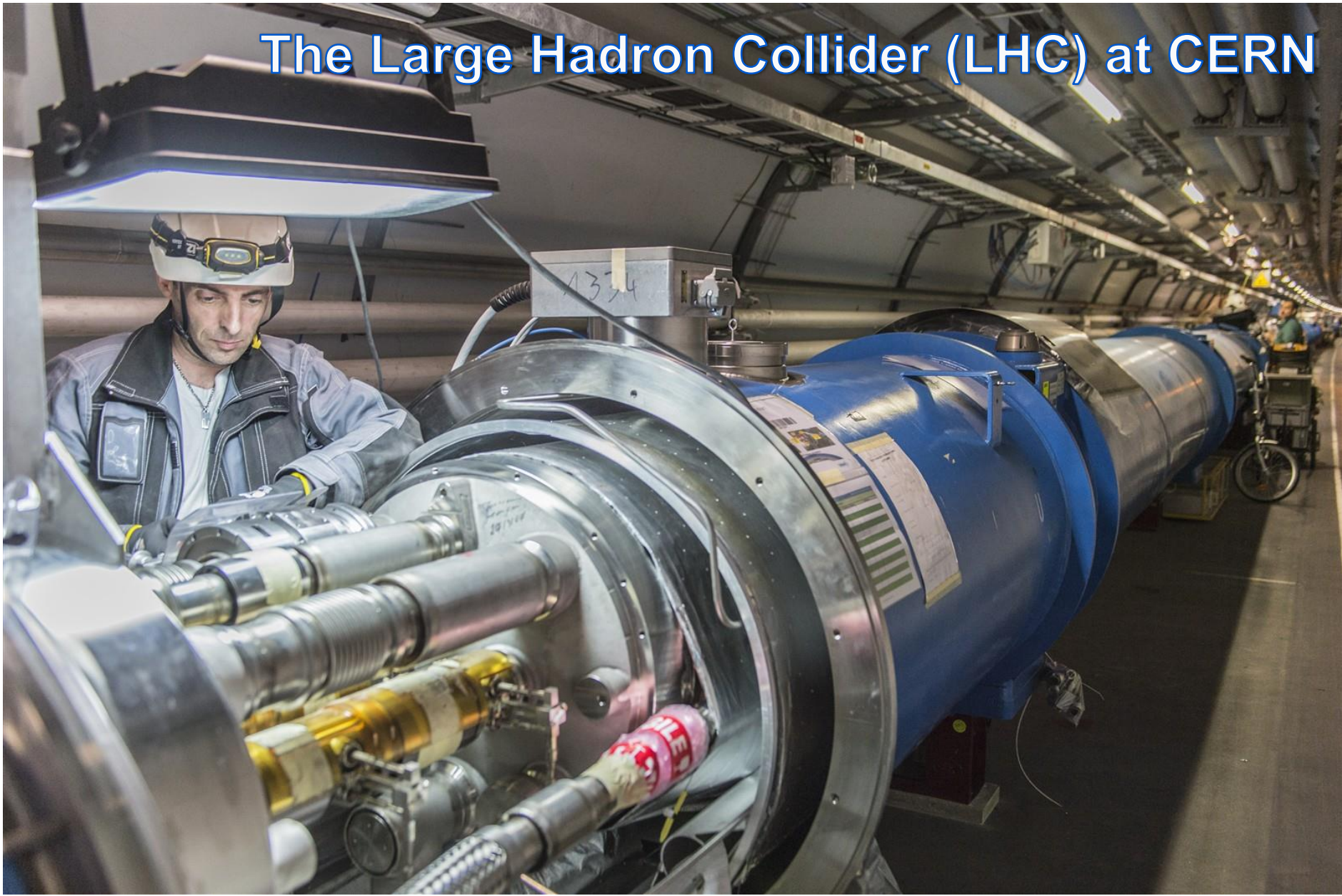


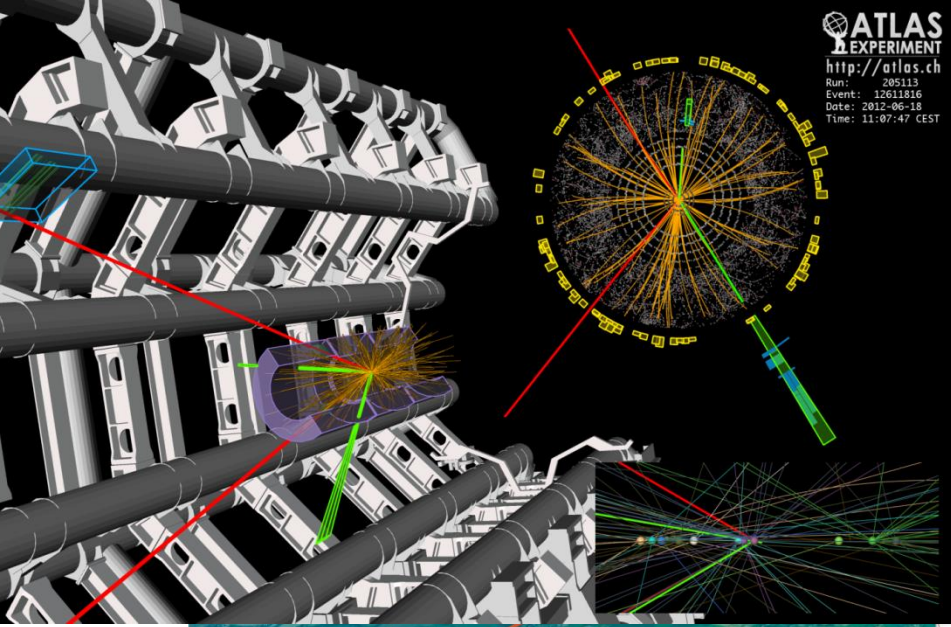
LE GRAND COLLISIONNEUR DE HADRONS

CERN AC - F116

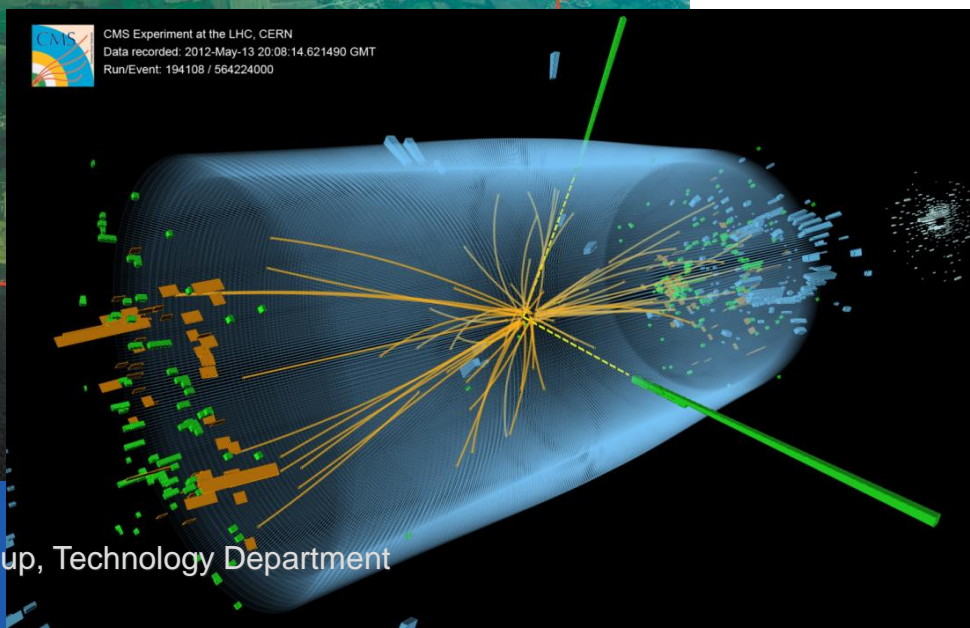


The Large Hadron Collider (LHC) at CERN





The Large Hadron Collider & Higgs events on ATLAS & CMS detectors



The Cryogenics Group

76 Staff members
16 Fellows
1 Doctoral student
5 Project associates
3 Technical students
1 Trainee

Industrial support resources
(service contracts):

General mechanical, electrical,
instrumentation support: 22 FTE

Maintenance & Operation (M&O)
dedicated service contract: 47 FTE

- Cryogenic Laboratory & Instrumentation
- Mechanical Engineering
- Process Controls & Electrical Engineering
- Maintenance Management & Logistics
- Operation

Cryogenics Staff Members

D. DELIKARIS Group Leader

S. CLAUDET Deputy

Secretariat: **C. CAZENOVES**

J. BREMER - Detectors link-person
S. JUNKER - Radiation Safety Support Officer
T. KOETTIG - Safety link-person
O. PIROTTE - Cryogenics Safety Officer

Controls & Electrical Support CE

M. PEZZETTI
TH. BARBE
C. BATAILT
B. D'HULSTER
C. FLUDER
B. IVENS
S. MARTIN
R. ROUZET
A. TOVAR-GONZALEZ
D. VALENCON
A. ZMUDA

Cryolab & Instrumentation CI

J. BREMER
J. CASAS-CUBILLOS
M. CHALIFOUR
P. CHAMBOUVET
L. DUFAY-CHANAT
C. FABRE
T. KOETTIG
J.M. QUETSCH
N. TRIKOUPIIS
A. VACCA
R. VAN WEELDEREN
N. VAUTHIER

Mechanical & Engineering Support ME

A. PERIN
C. BERTHELIER
B. BITZBERGER
F. DHALLA
R. GUEYDAN
S. JUNKER
L. LE MAO
A. LEES
J. METSELAAR
D. MAJOURNAL
E. MONNERET
J. MOULEYRE
O. PIROTTE
G. ROLANDO
M. SISTI
L. STEWART

Methods & Logistics ML

Ph. GAYET
L. ALAUX
N. BONETTI
T. DUPONT
F. FERRAND
N. GUILLOTIN
S. KNOOPS
J.P. LAMBOY
J.J. MINGUILLON ACHA

Operation OP

G. FERLIN
K. BACKMAN
A. BALLI
B. BRADU
K. BRODZINSKI
M. COMBE
R. CONSENTINO
B. CWICKLINSKI
L. DELPRAT
E. DURET BOURGOZ
A. ESCOLEIRA
V. GAHIER
C. GUILLOU
K. HAFI
L. HERBLIN
G. JONES
D. MAJOURNAL
R. MAUNY
P. OWEN
A. PERRIER-CORNET
G. RAKOTONIAINA
A. SURACI
Y. VALSKAR
U. WAGNER
J. WOLFF
T. YTTERDAL

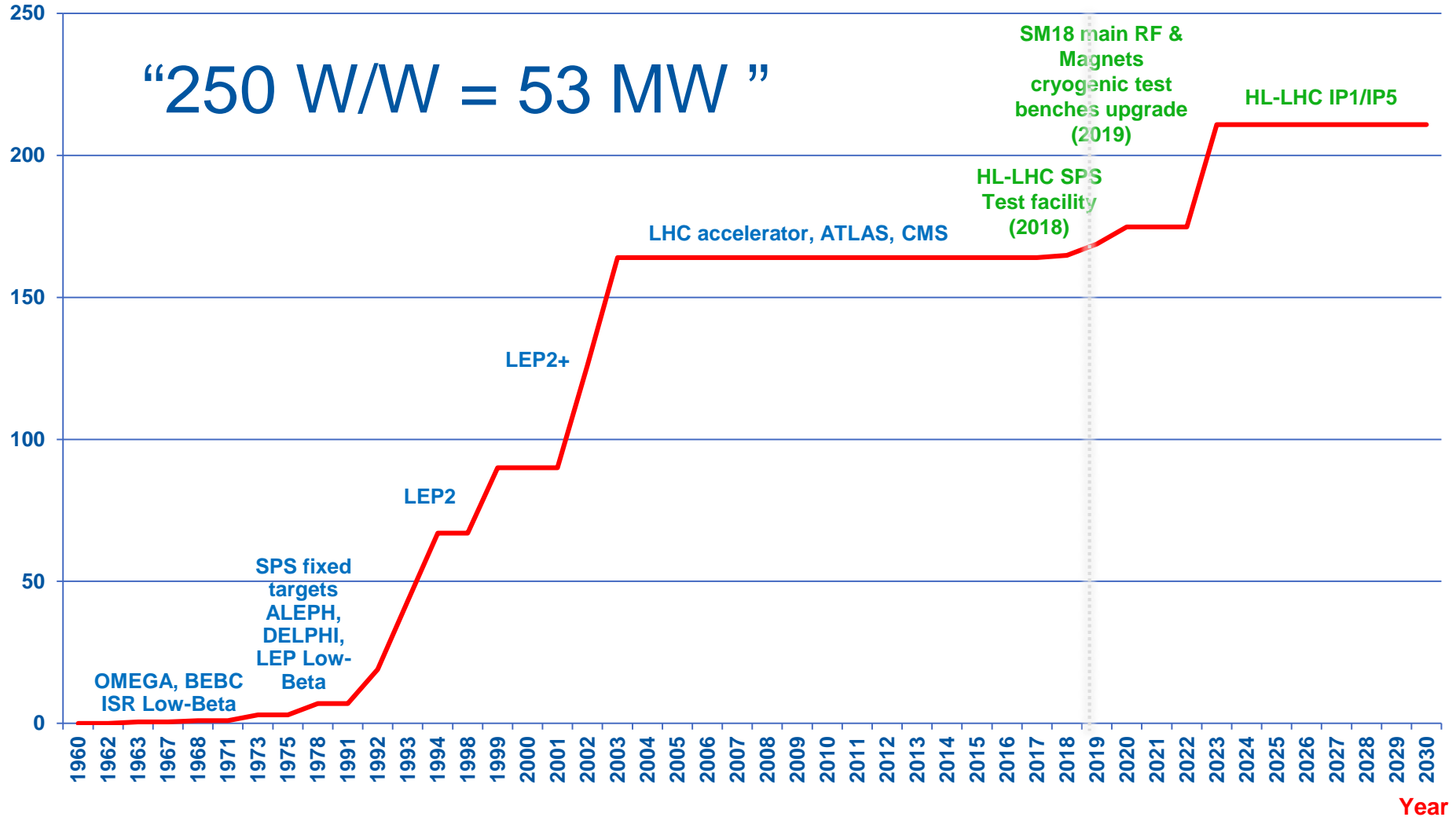
MARCH 2019

Cryogenic power at CERN

kW at 4.5 K

Helium refrigeration capacity at CERN (kW@4.5 K)

“250 W/W = 53 MW”



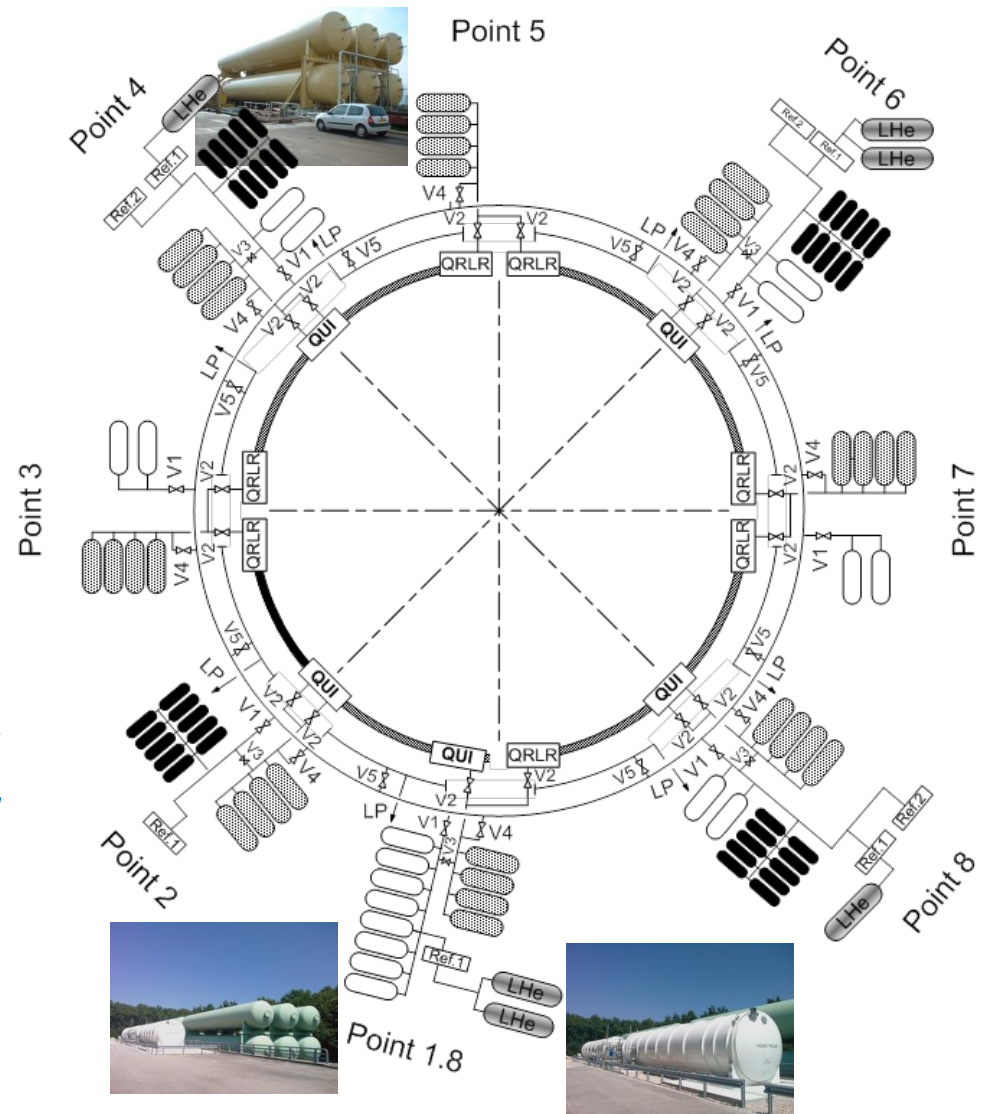
Year



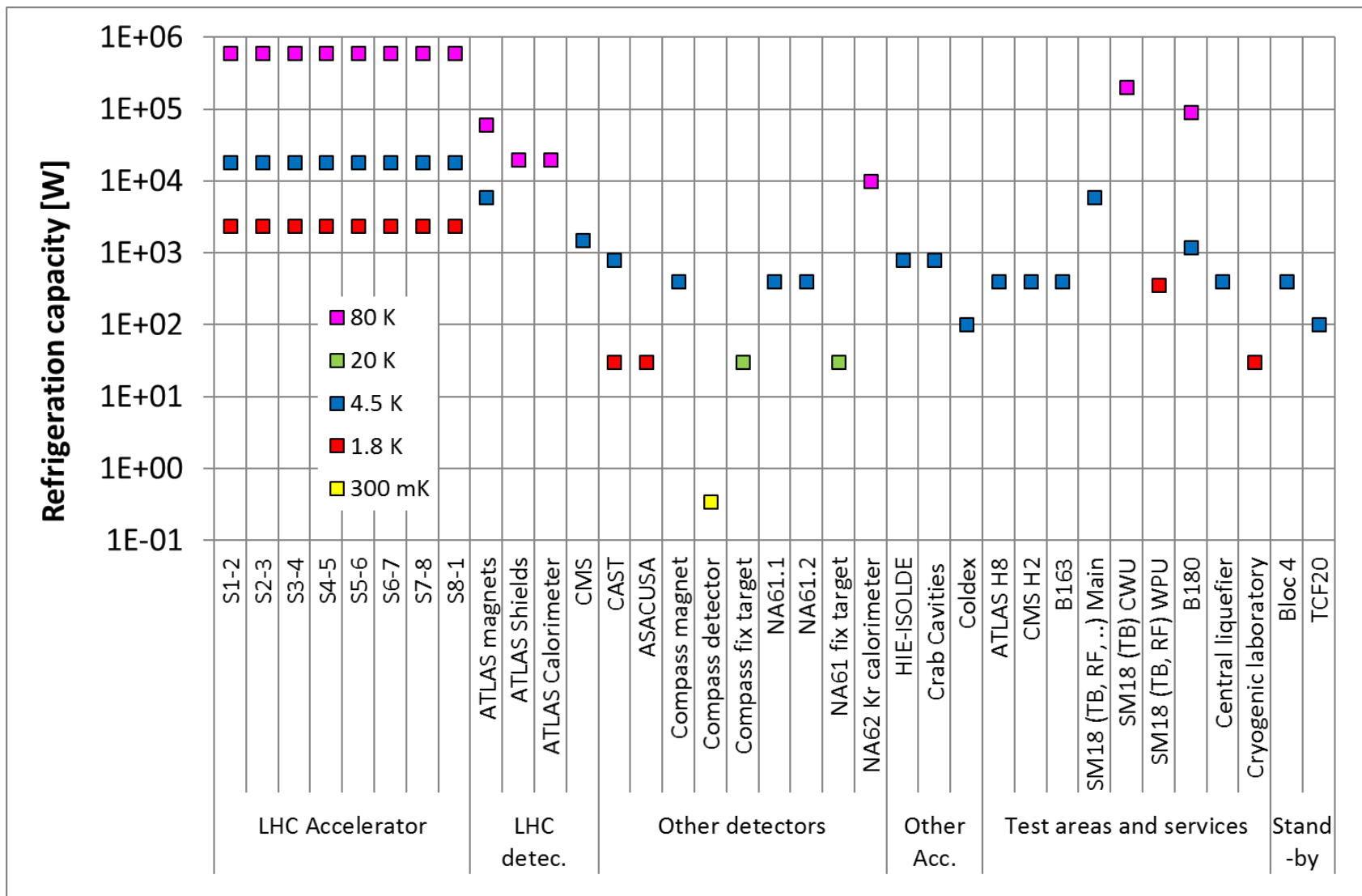
Helium Storage & Distribution

LHC helium storage & distribution (high grade helium ring line, 2 MPa, 27 km long, for LHC operation)

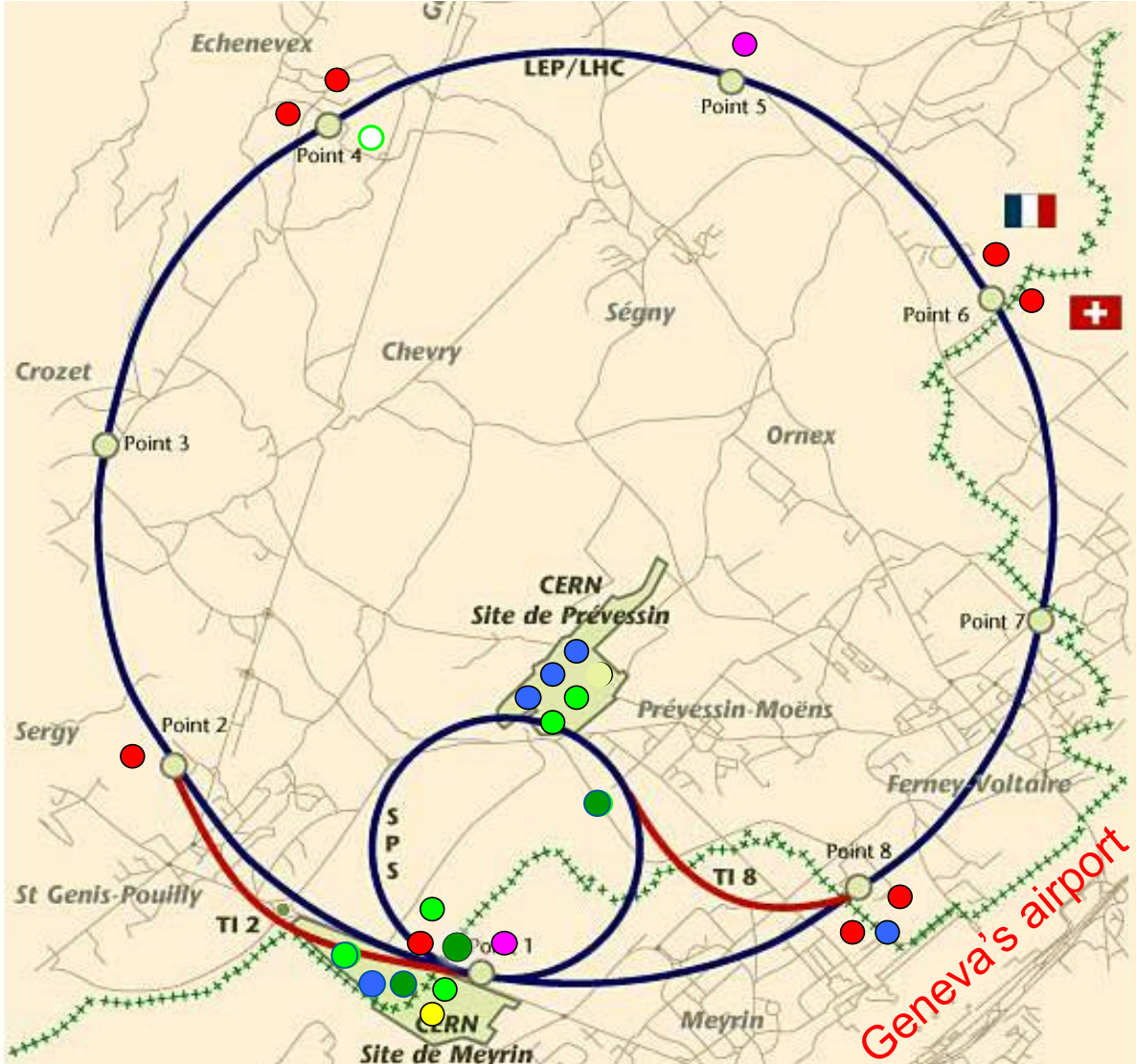
[Completing the existing CERN helium recovery system: high grade, 20 MPa, 5 km long and low grade, 3 kPa & 20 MPa, 3 km long each]



Cryogenic power at CERN



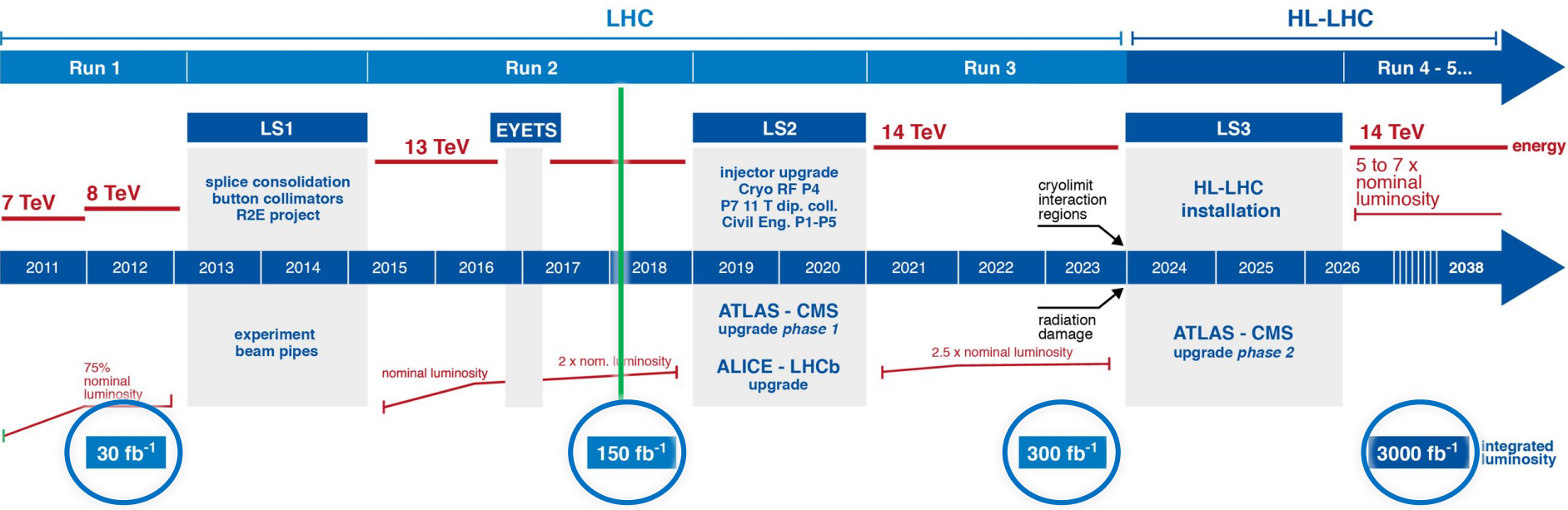
Cryogenic Plants at CERN



- LHC accelerator
- LHC detectors
- Other detectors
- Other accelerators
- Test areas
- Central services
- Standby

Cryogenics for the HL-LHC project

LHC / HL-LHC Plan

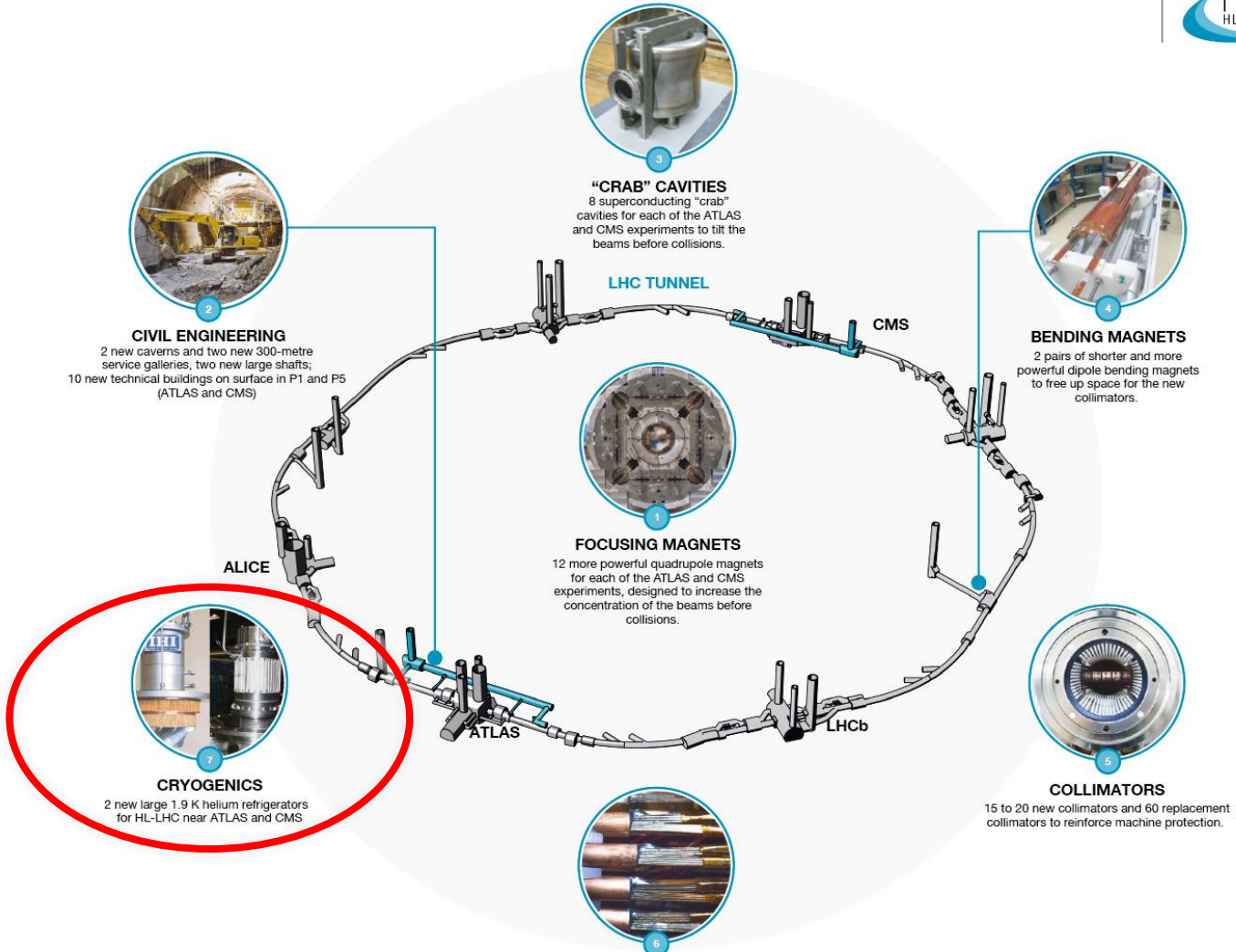


Cryogenics for the HL-LHC project

for physics by means of a technology advancement



CERN May 2016



CIVIL ENGINEERING
 2 new caverns and two new 300-metre service galleries, two new large shafts; 10 new technical buildings on surface in P1 and P5 (ATLAS and CMS)

"CRAB" CAVITIES
 8 superconducting "crab" cavities for each of the ATLAS and CMS experiments to tilt the beams before collisions.

FOCUSING MAGNETS
 12 more powerful quadrupole magnets for each of the ATLAS and CMS experiments, designed to increase the concentration of the beams before collisions.

BENDING MAGNETS
 2 pairs of shorter and more powerful dipole bending magnets to free up space for the new collimators.

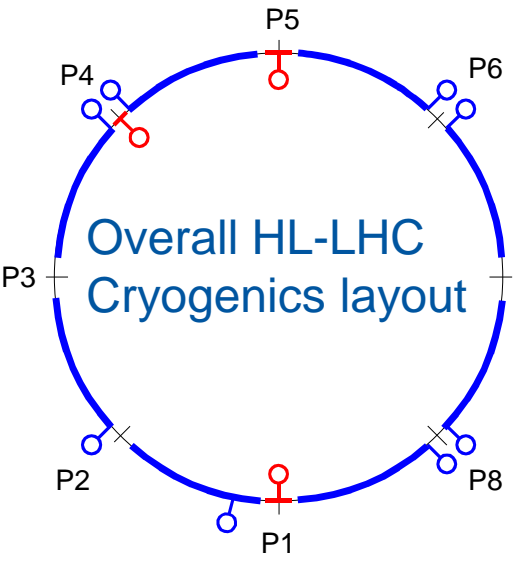
COLLIMATORS
 15 to 20 new collimators and 60 replacement collimators to reinforce machine protection.

CRYOGENICS
 2 new large 1.9 K helium refrigerators for HL-LHC near ATLAS and CMS

SUPERCONDUCTING LINKS
 Electrical transmission lines based on a high-temperature superconductor in carry current to the magnets from the new service galleries to the LHC tunnel.

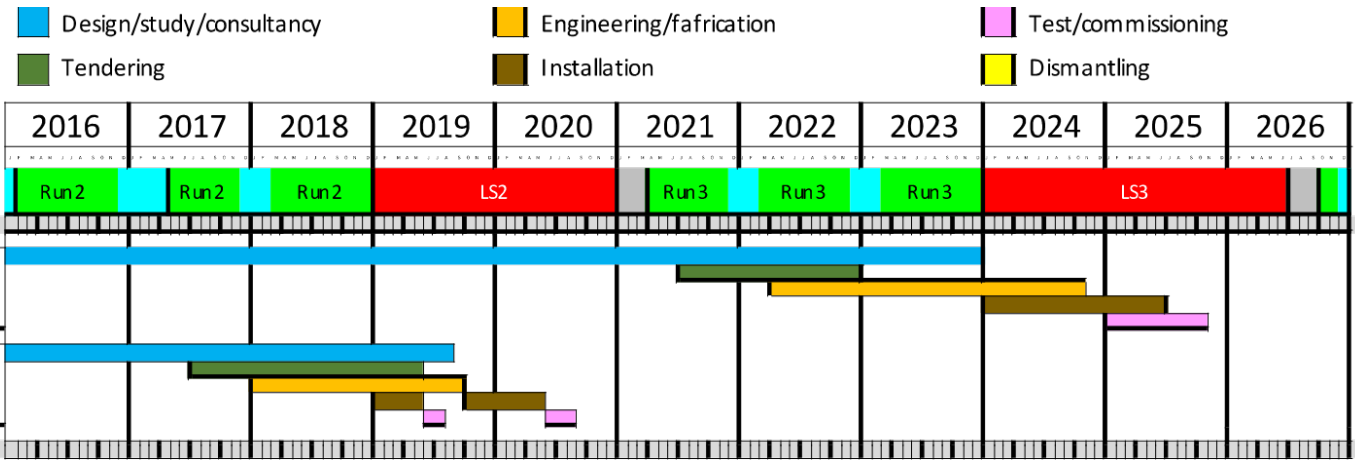


Cryogenics for the HL-LHC project



- 2 new cryogenic plants (18 kW @ 4.5 K) at P1 and P5 for high-luminosity insertions
- 1 new cryogenic plant (4 kW @ 4.5 K) at P4 for RF cryogenic modules; (retained alternative: upgrade of 1 existing LHC cryogenic plant)
- 1 new cryogenic plant (0.8 kW @ 4.5 K) as RF cold test facility with LHC beam type at SPS-BA6 (Crab-Cavities program): successfully commissioned, crab cavities at 2 K

○ Existing cryoplant
○ New HL-LHC cryoplant



Cryogenics at CERN

forthcoming procurement

Activities / Year	2019	2020	2021	2022	2023
Supply of 40'000 t of liquid nitrogen for the 2019-2023 operational period (renewal)	Red	Green	Green	Green	Green
Supply of 240 t of liquid helium for the 2021-2025 operational period (renewal)	Yellow	Red	Green	Green	Green
Maintenance & Operation industrial support services for the 2022-2026 period (renewal)	Yellow	Yellow	Red	Green	Green
HL-LHC: -Procurement of two 18 kW @ 4.5 K cryogenic plants and cold compressors units -Procurement of the 1.5 km cryogenic distribution infrastructure (multiple-lines)	White	White	Red	Red	Green



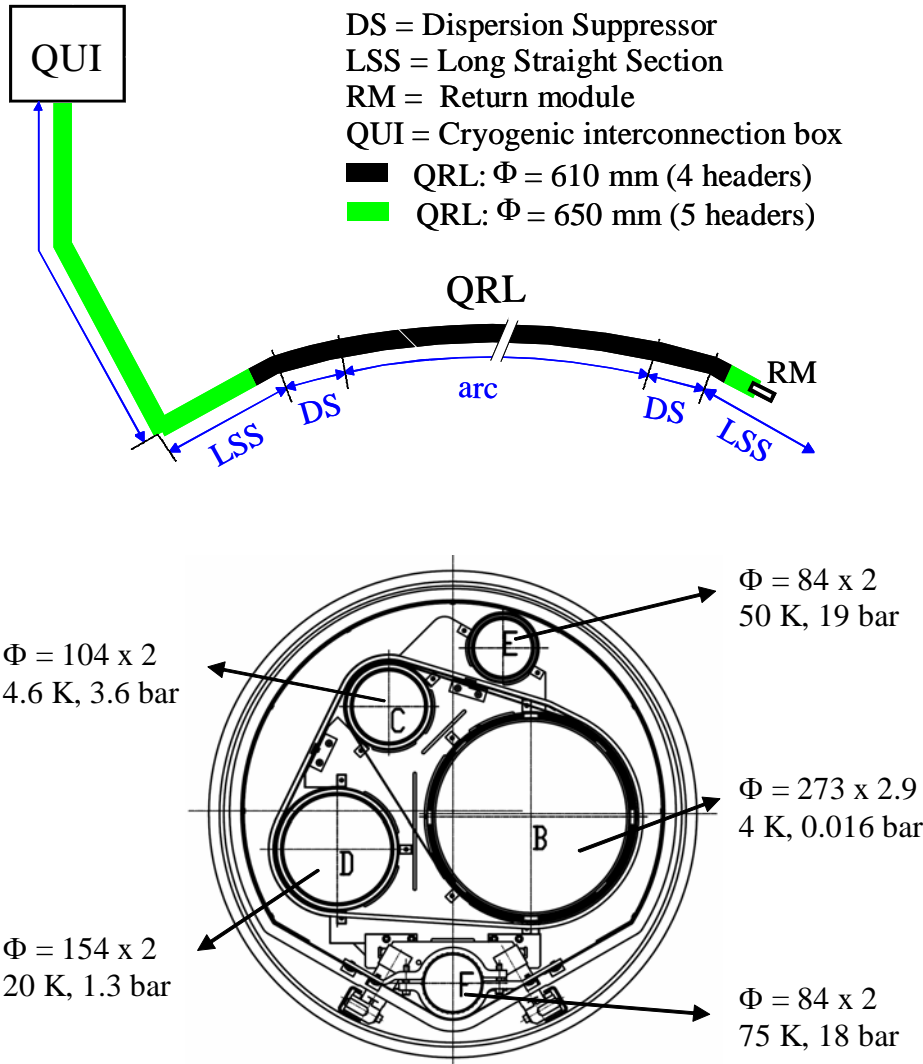
Invitation to tender



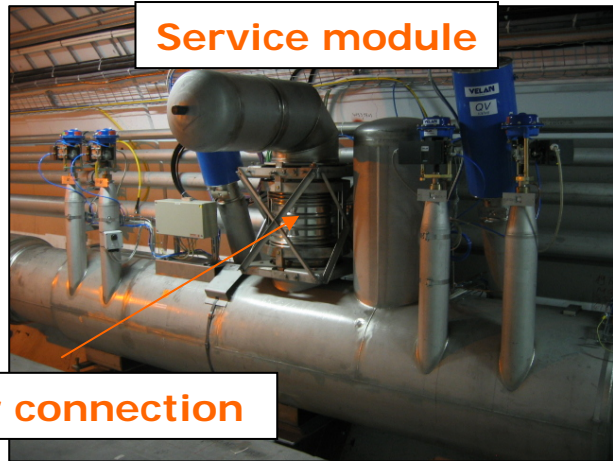
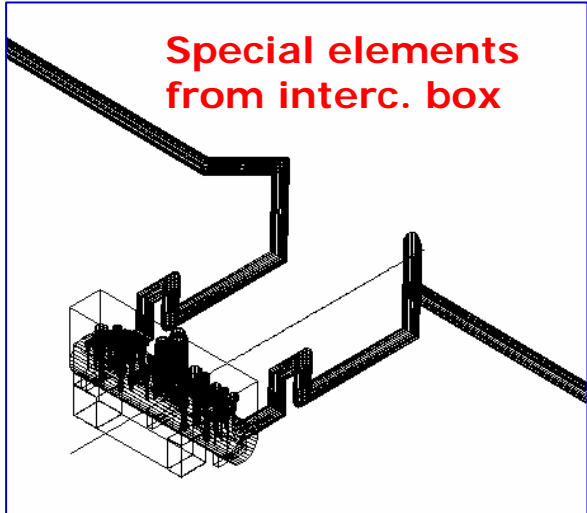
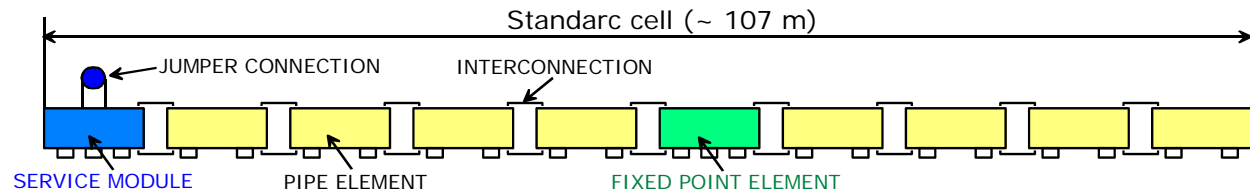
Existing contract



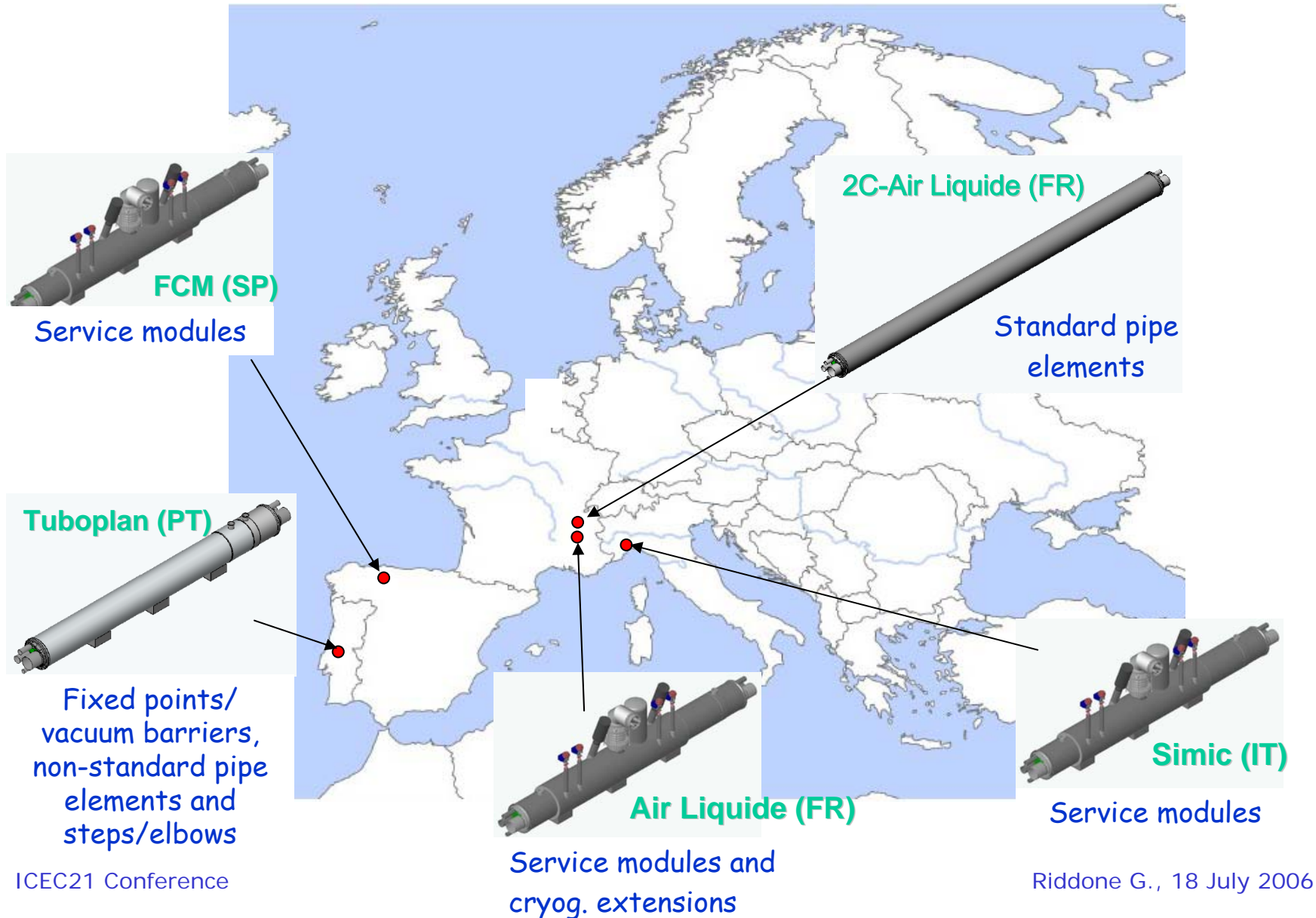
Operational



- 8 QRL sectors
- each QRL sector
 - continuous cryostat of ~3.2 km length: from the cryogenic interconnection box to the return module
 - no header (4 or 5) sectorization
 - 9 vacuum sub-sectors
 - repetitive pattern of straight pipe elements and service modules
 - connection to the superconducting magnets every 107 m



Air Liquide Industrial Organization



SIMIC: 168 standard and
special service modules



FCM: 106 standard
service modules



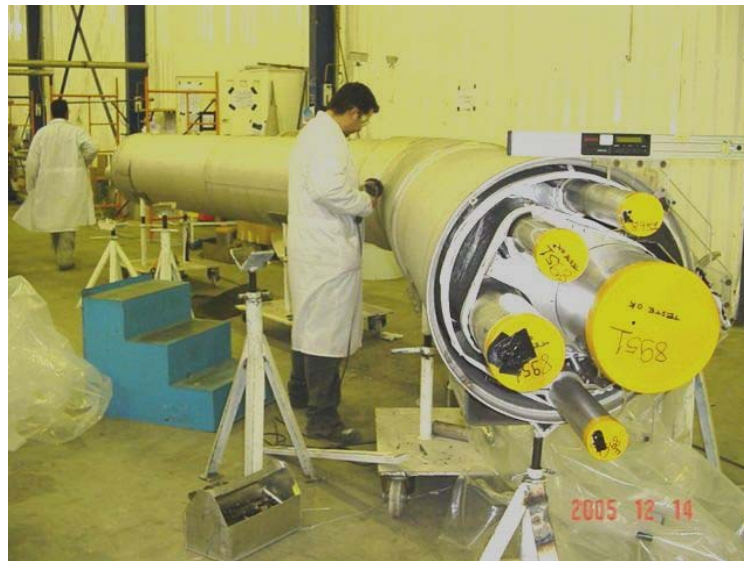
$L = \sim 6.6$ m, vacuum
vessel in stainless steel



Production of Fixed Points/Vacuum Barriers, Special Pipe Elements and Steps/Elbows at Tuboplan



- 239 fixed point/vacuum barrier elements ($L = \sim 6.6$ m)
- 204 special pipe elements ($L = \sim 3-13$ m)



- 70 singularities: steps and elbows