Status of LHC and HL-LHC

Frédérick Bordry

6th Meeting of the TIARA Collaboration Council

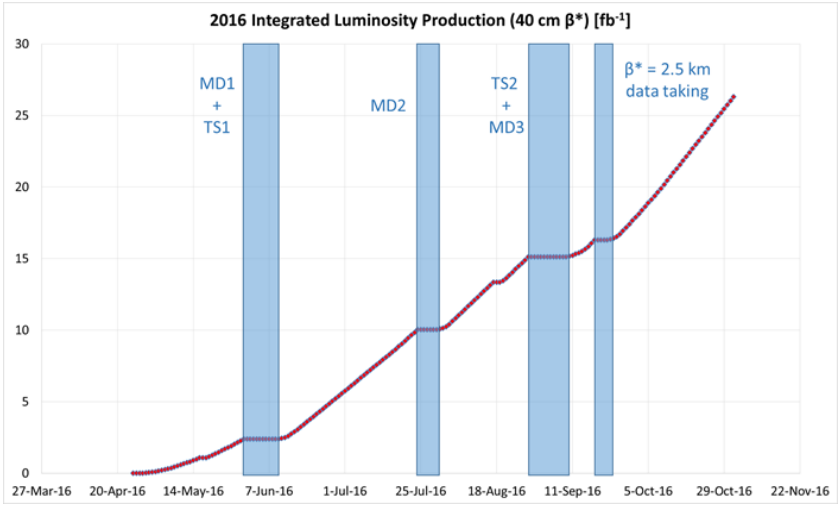
2nd February 2017

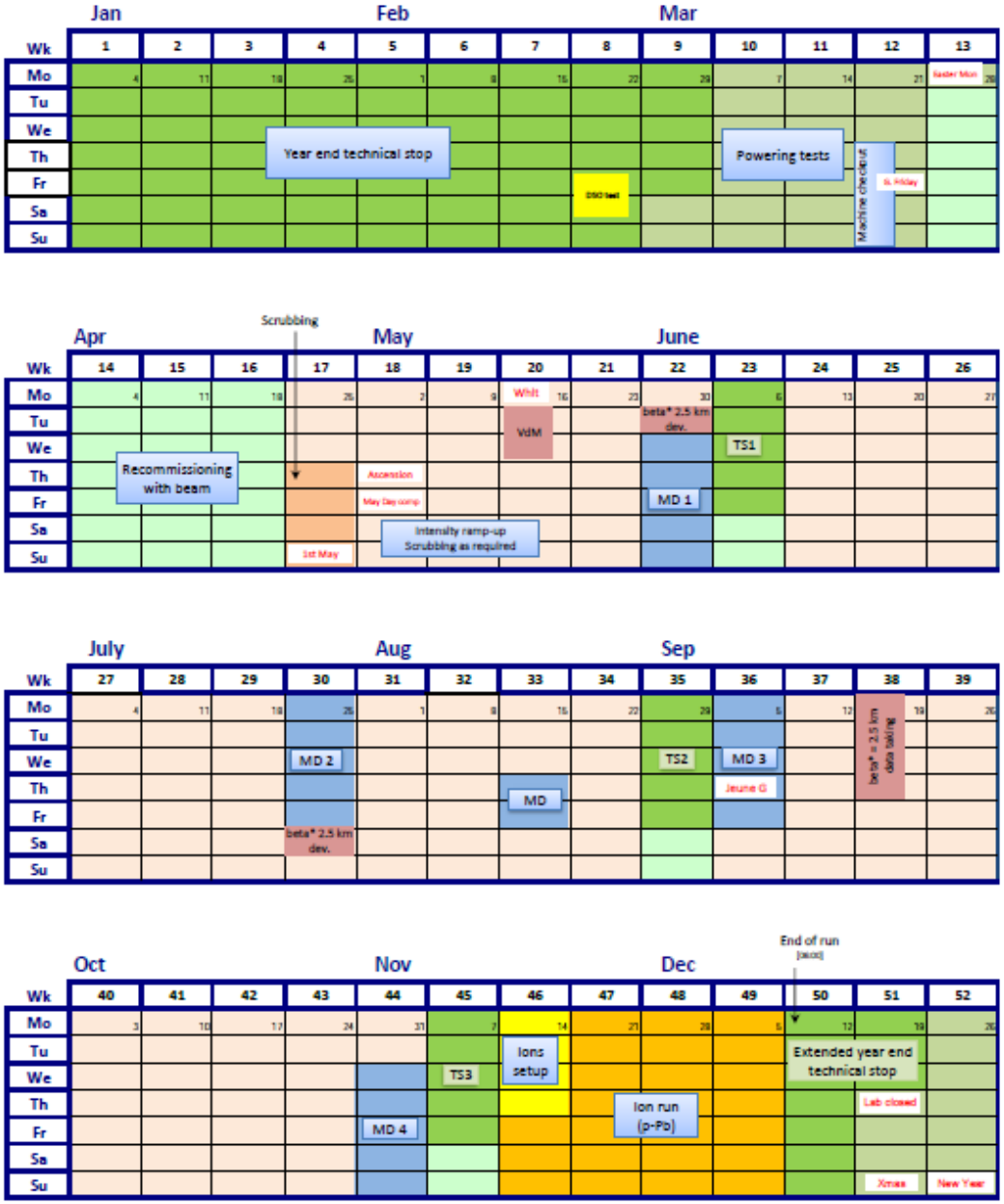
www.cern.ch

LHC schedule 2016

2016: a production year

Integrated luminosity goal:
2016 : ~ 25 fb^{-1} at 13 TeV c.m

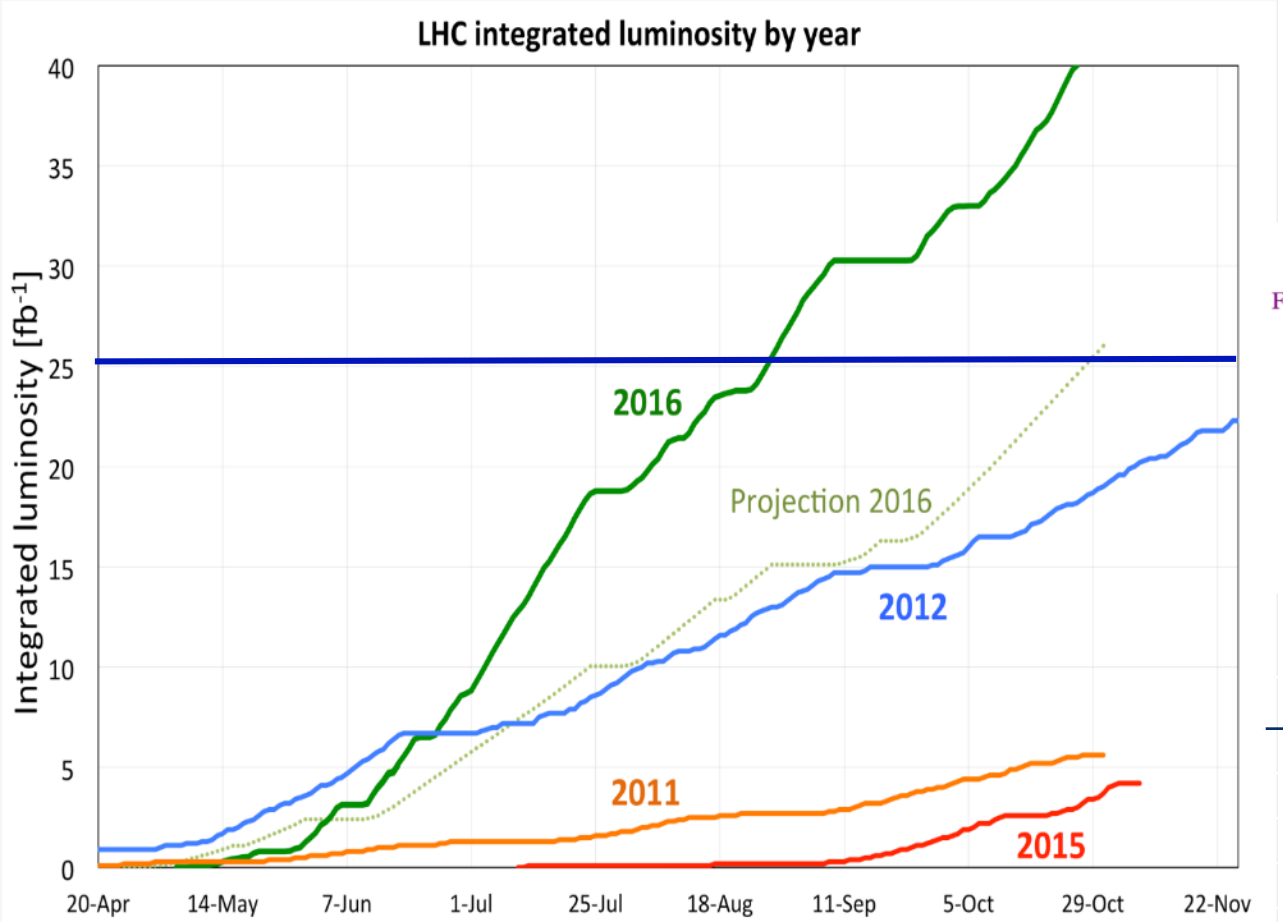


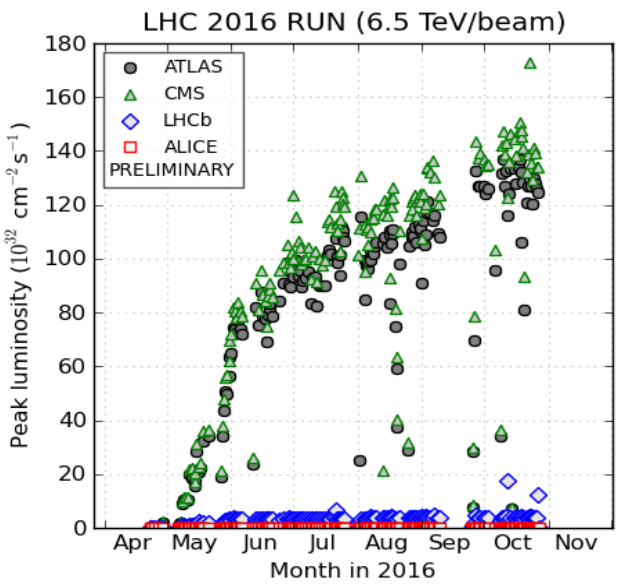


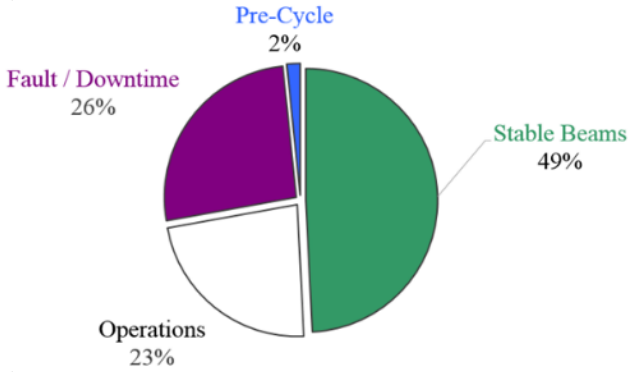
Chamonix'16 conclusion (March 2016)

2016 LHC : Production year

Peak luminosity > 1.4 x 10^{34} $cm^{-2}s^{-1}$
OVER 25 fb^{-1} in both ATLAS and CMS





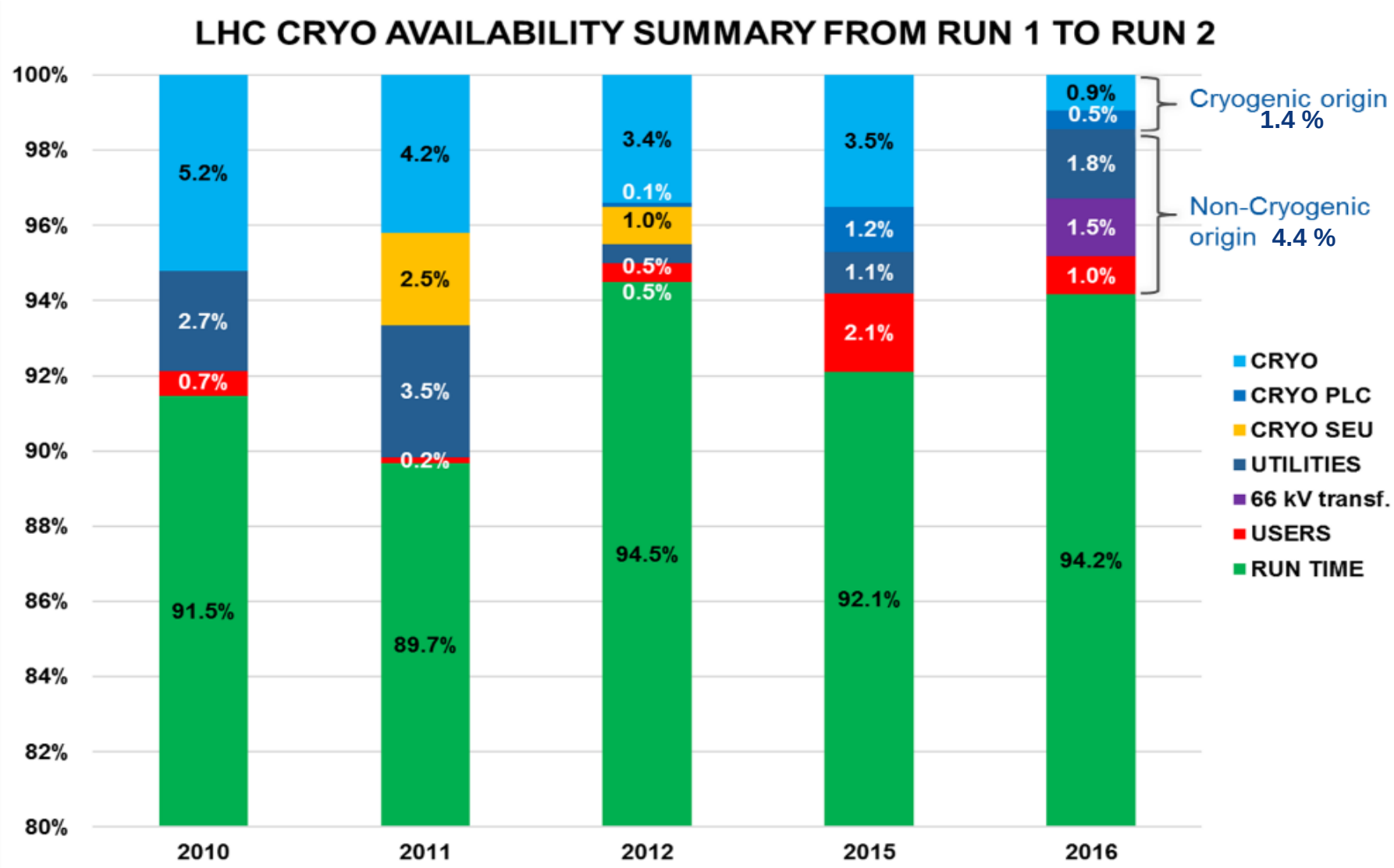


≈153 days physics ≈3738.7 hours

	Duration [h]
Stable Beams	1839.5
Fault / Downtime	980.0
Operations	857.9
Pre-Cycle	61.3

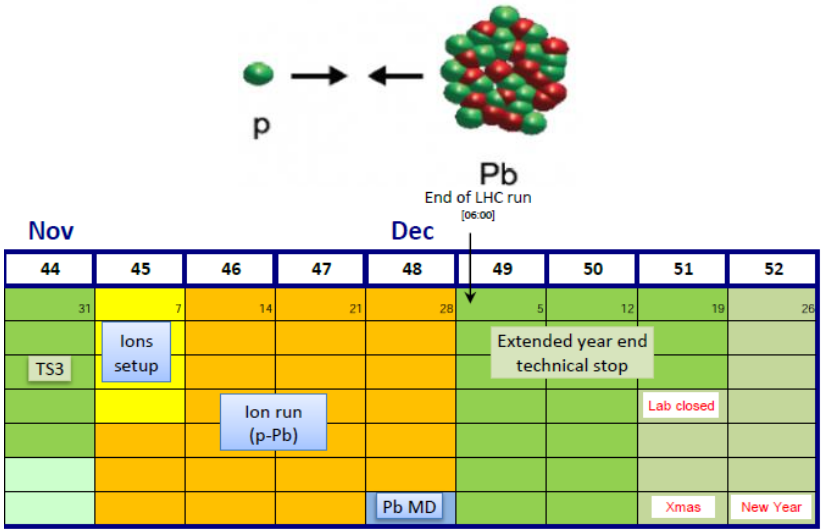
TS1 - TS2 : stable beams 58 %
TS2 - TS3 : stable beams 54 %

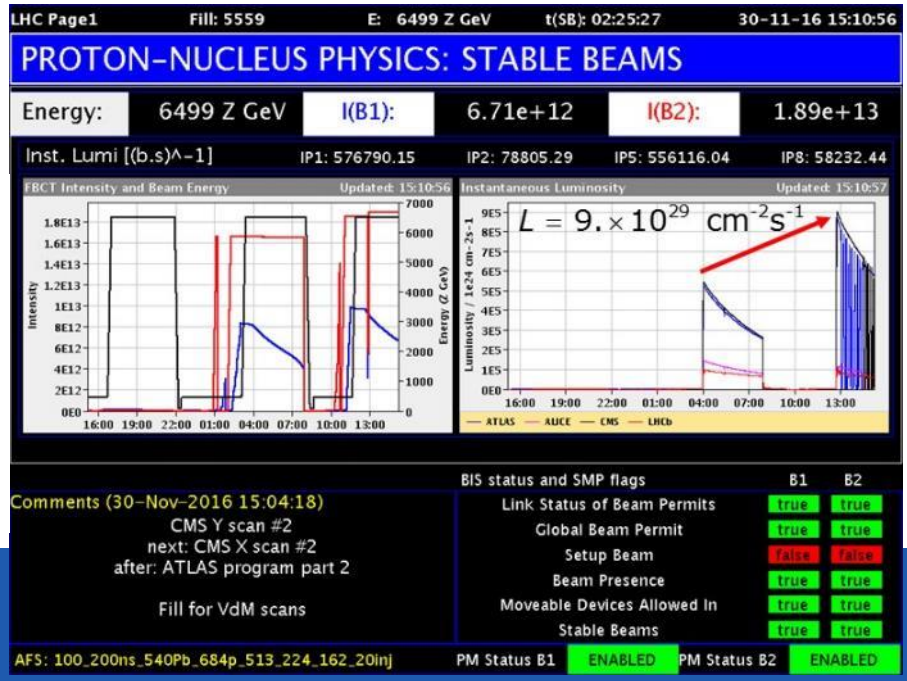
LHC Cryogenics availability (2016): 98.6% (**94.2%**)



LHC Goals of p-Pb run surpassed

Configuration	Goal		Achieved
5 TeV p-Pb (E_{beam}=4 Z TeV)	ALICE	700x10^6 min bias events	**780x10^6**
8 TeV p-Pb (E_{beam}=6.5 Z TeV)	ATLAS - CMS	50 nb^{-1}	**69.5 - 65.5 nb^{-1}**
	LHCb - ALICE	10 nb^{-1}	**14 - 13 nb^{-1}**
	LHCf	9-12 h at 10^{28} $cm^{-2}s^{-1}$	**9.5 h**
8 TeV Pb-p (E_{beam}=6.5 Z TeV)	ATLAS - CMS	50 nb^{-1}	**124 - 118 nb^{-1}**
	ALICE - LHCb	10 nb^{-1}	**25 - 19 nb^{-1}**





LHC Limitations

SPS beam-dump

Nb of bunches per injection limited to 96

Total number of bunches: 2200

LHC Injection kickers

Outgassing from ceramic

Bunch population limited to around 1.1 x 10^{11}

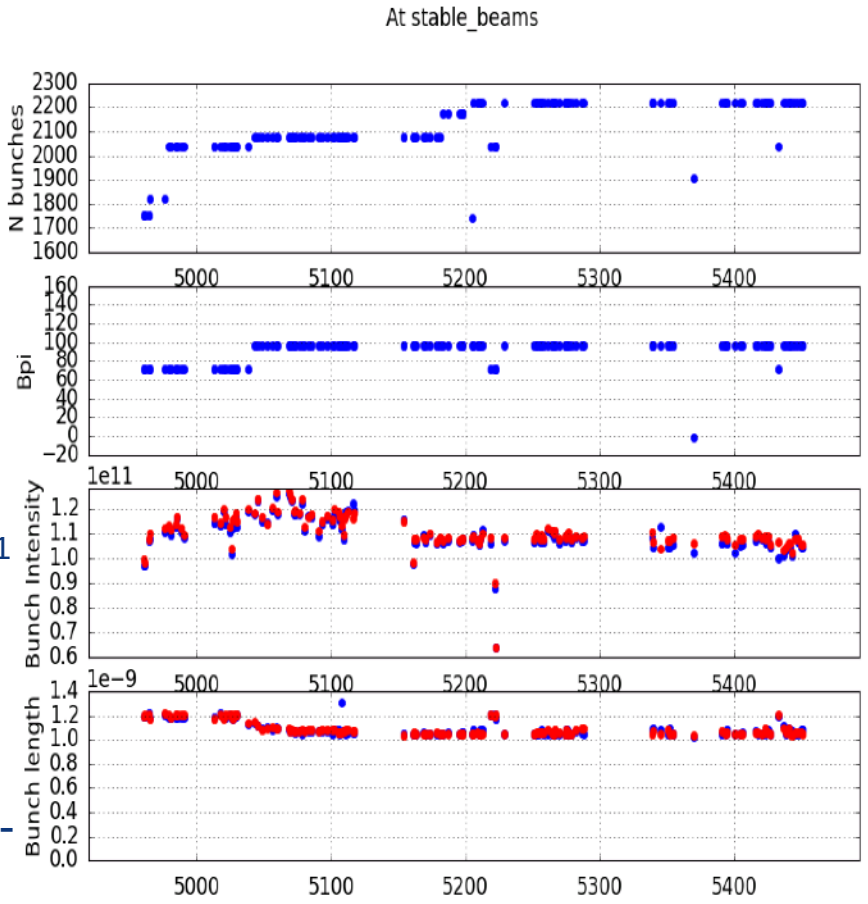
Electron cloud

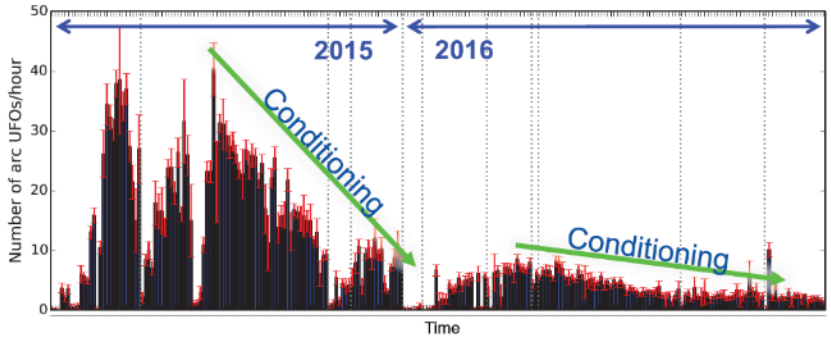
Still significant heat-load within cryogenic limits

Dynamics – well handled by cryogenics feed-forward – no impact on operations in the present conditions

UFOs

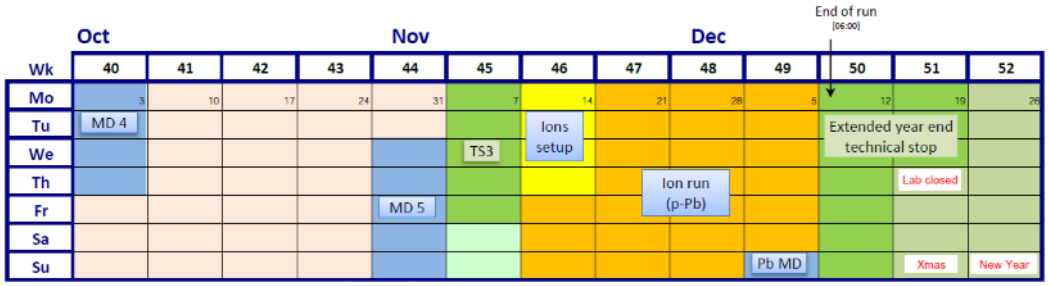
Frequency has happily conditioned down



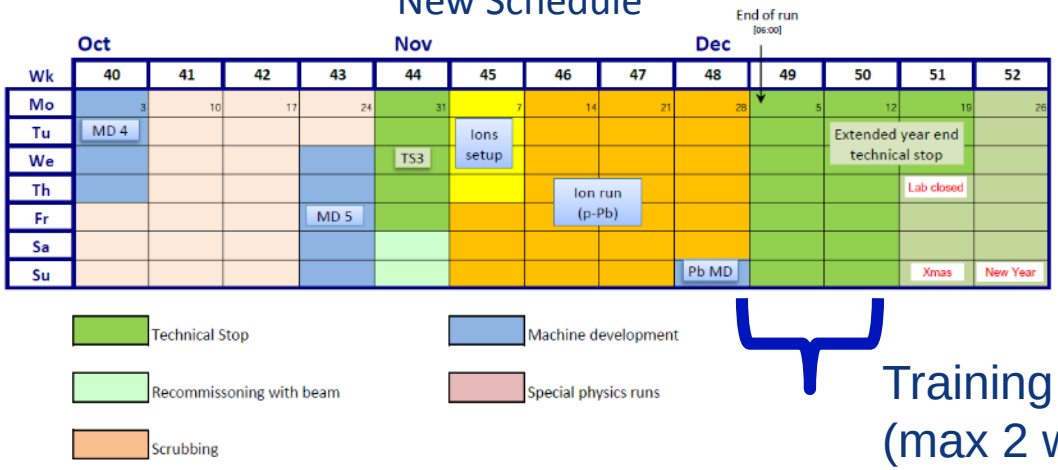


LHC: new schedule approved on 31st August

Initial LHC SCHEDULE



New Schedule

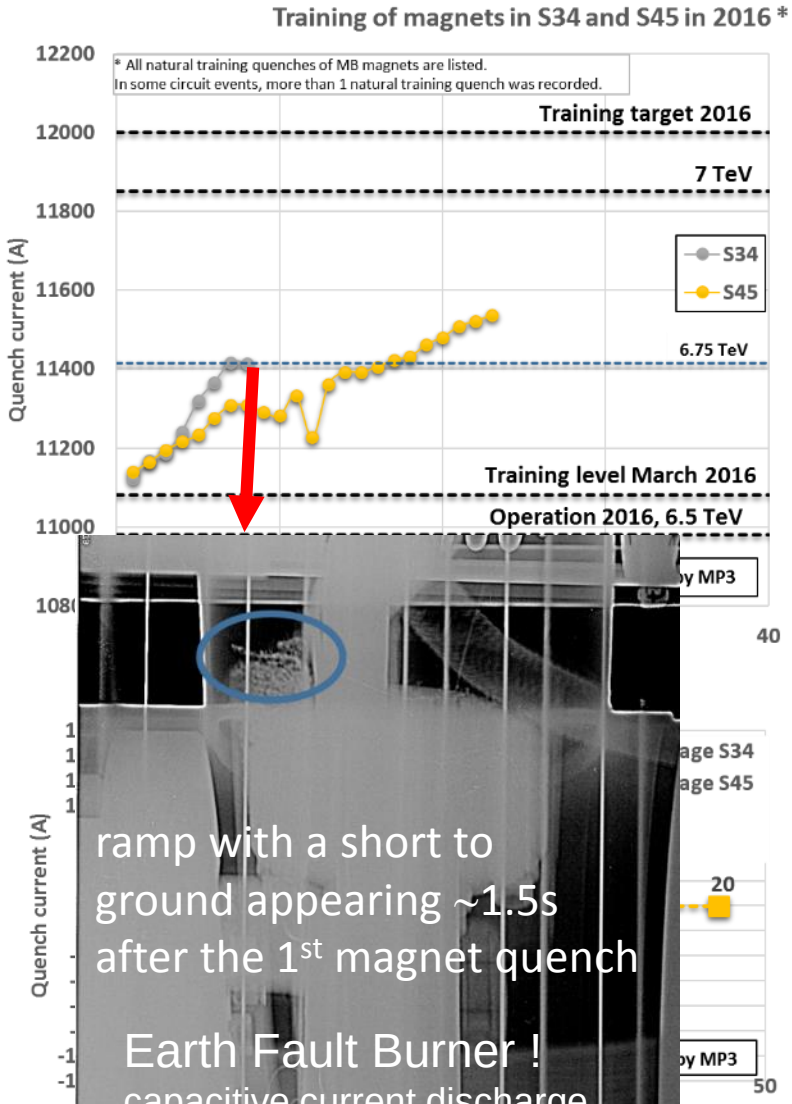


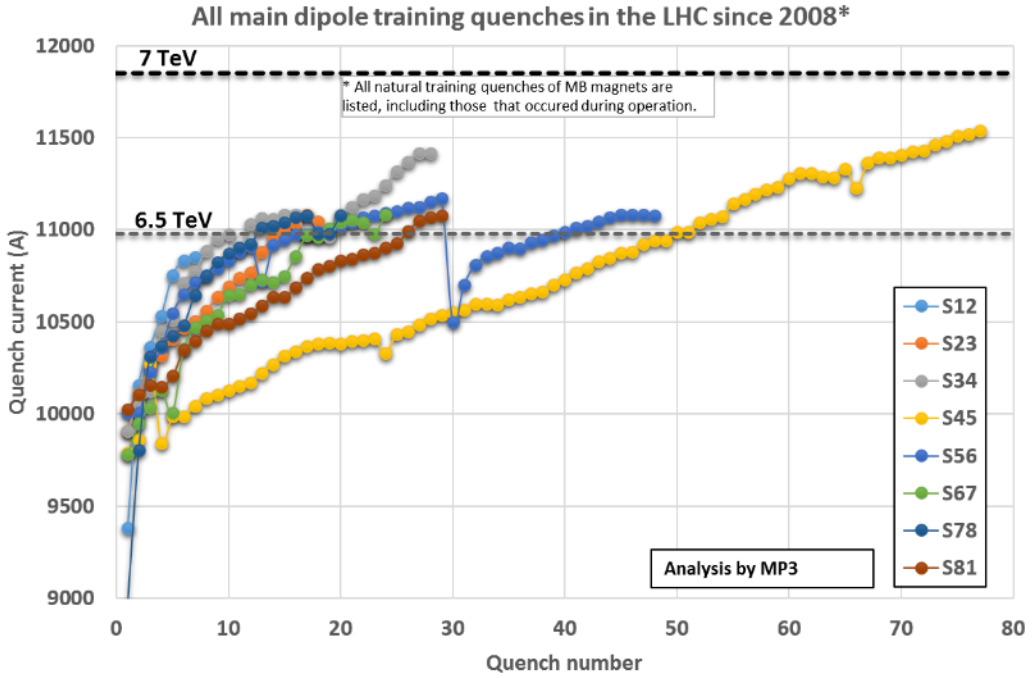
LHC Proton Run 2016 was reduced by one week: one week investment for energy increase

The restart date in 2017 is unchanged

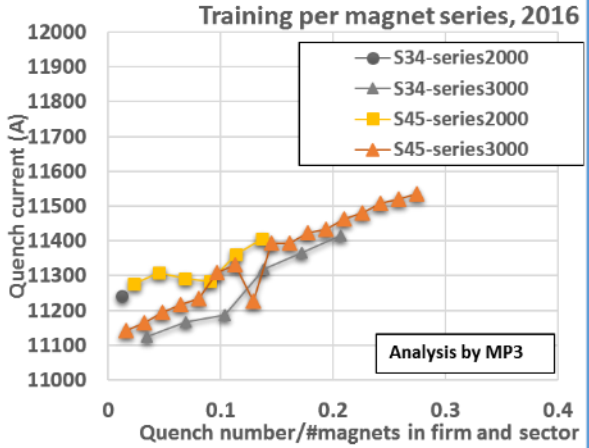
Training of 2 sectors towards 7 TeV (max 2 weeks; finally 10 days)

MB Training campaign 2016, December 5 - 14

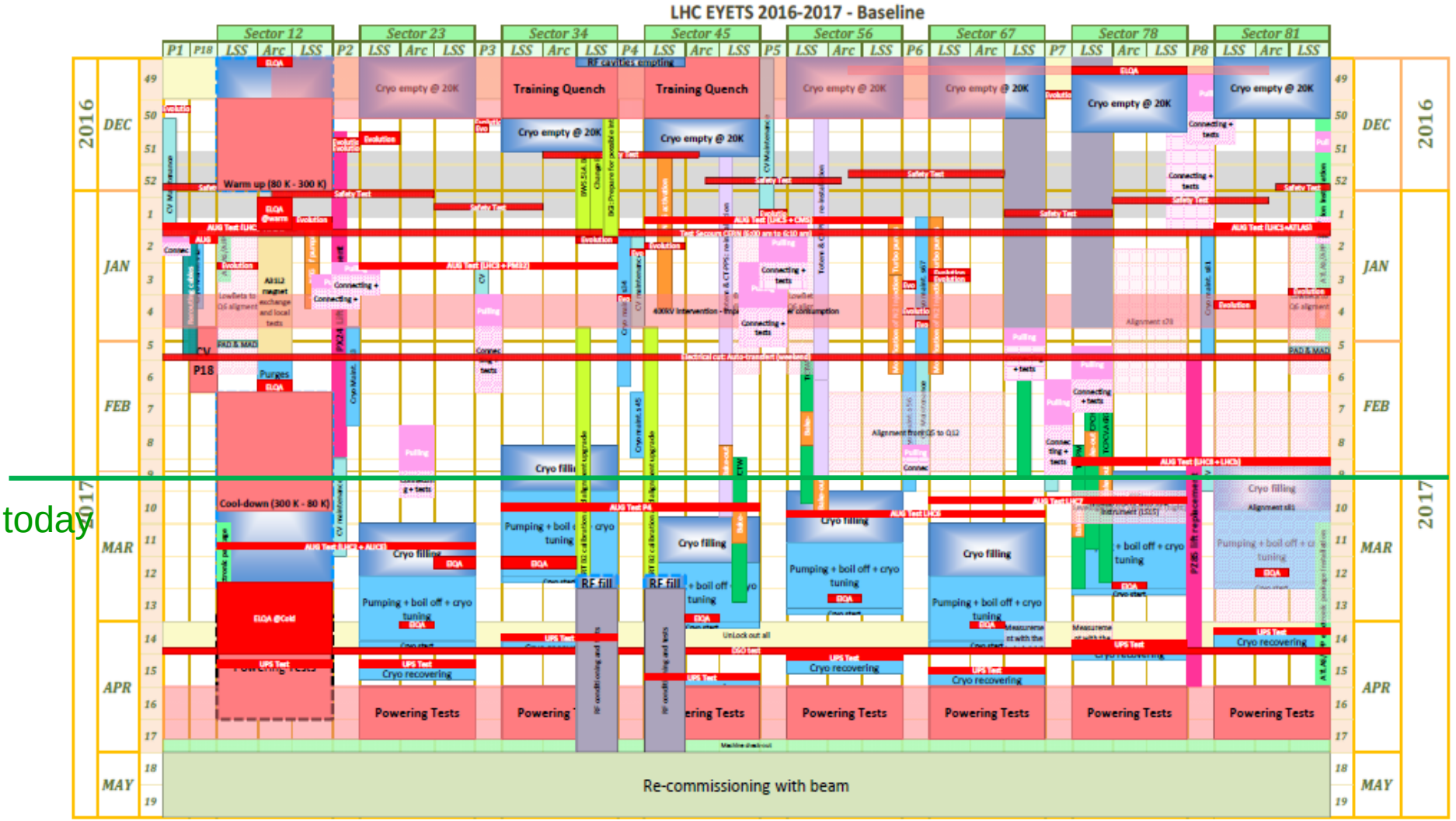




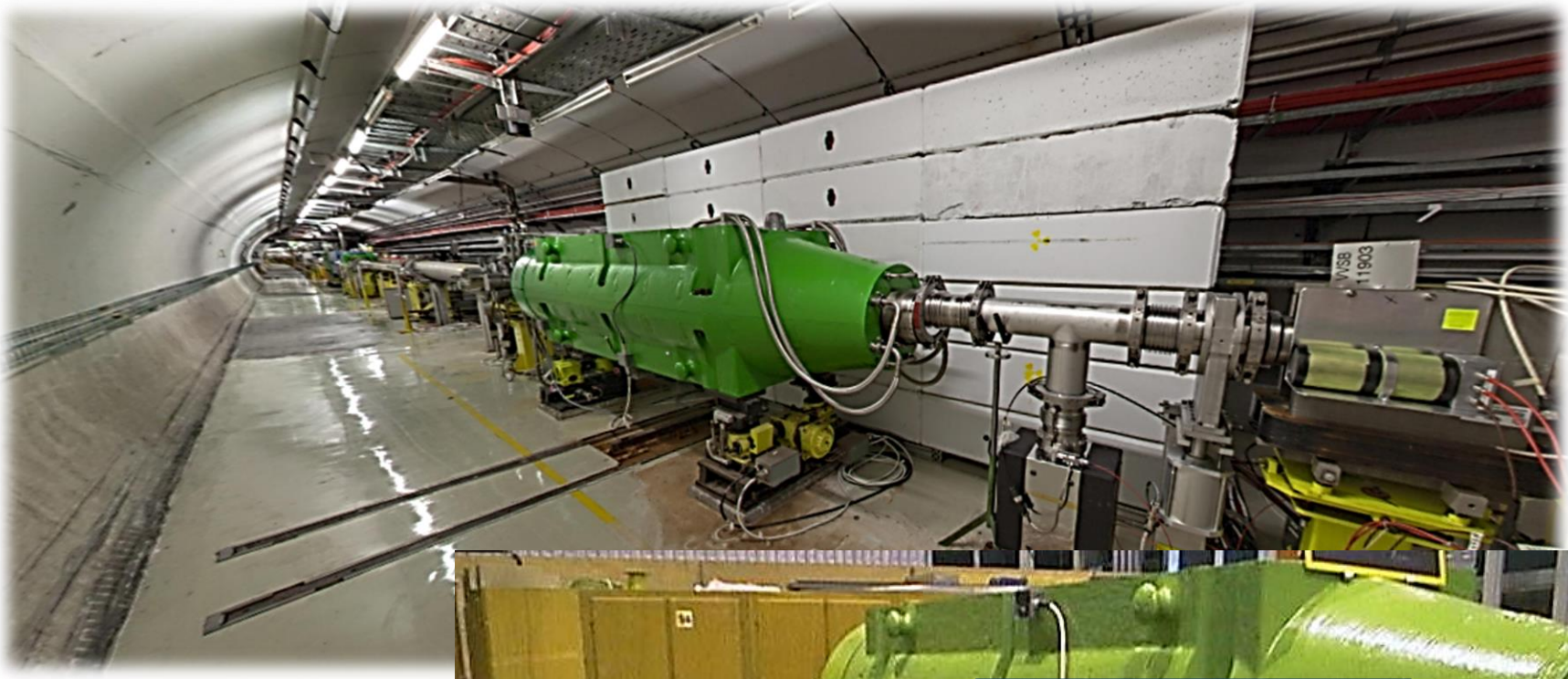
	Training quenches December 2016		
	Series 1000	Series 2000	Series 3000
RB.A34	1	1	6
RB.A45	0	6	17
total	1	7	23

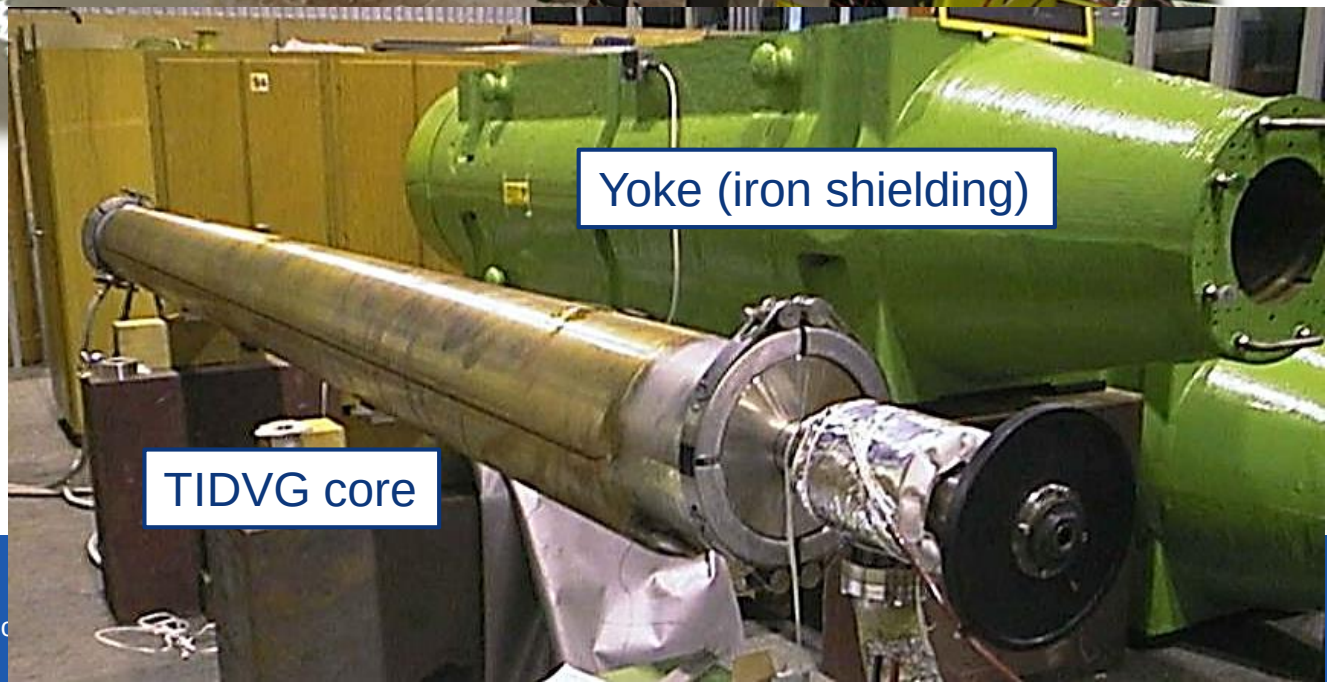


LHC EYETS Overview



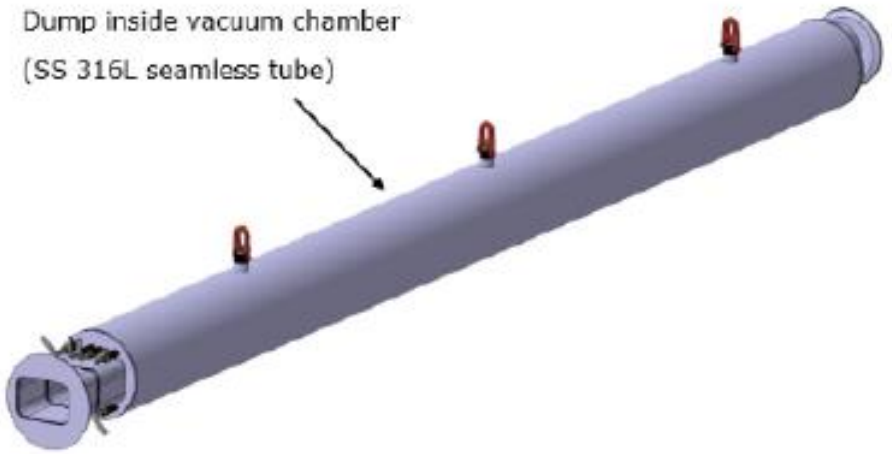
SPS tunnel: internal beam dump (TIDVG#3)

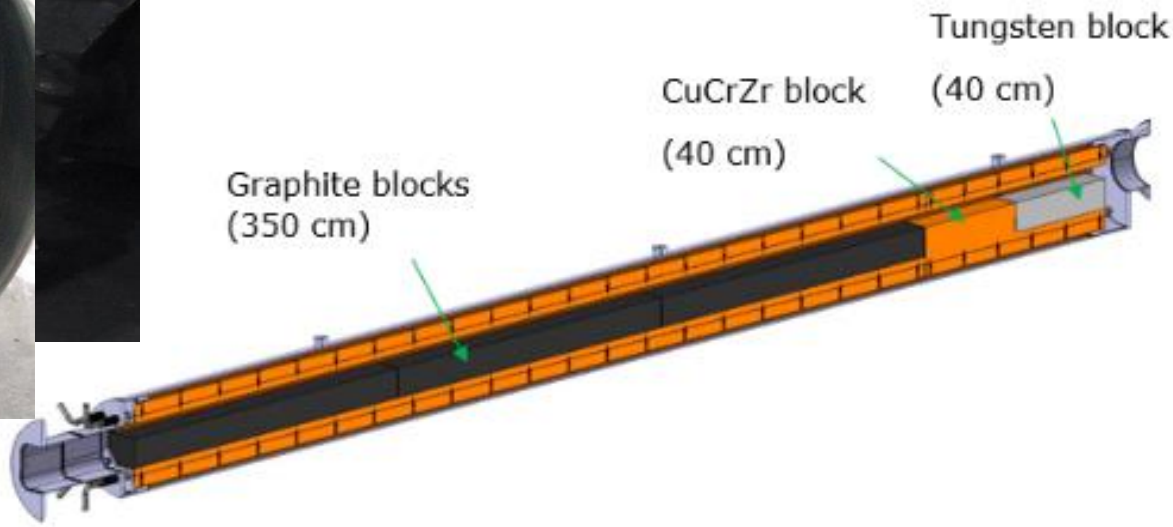




SPS beam dump: new design (TIDVG#4) ; **crash program**

Vacuum tightness is ensured by a seamless 316L tube – no welds inside the shielding





Courtesy Simone Gilardoni

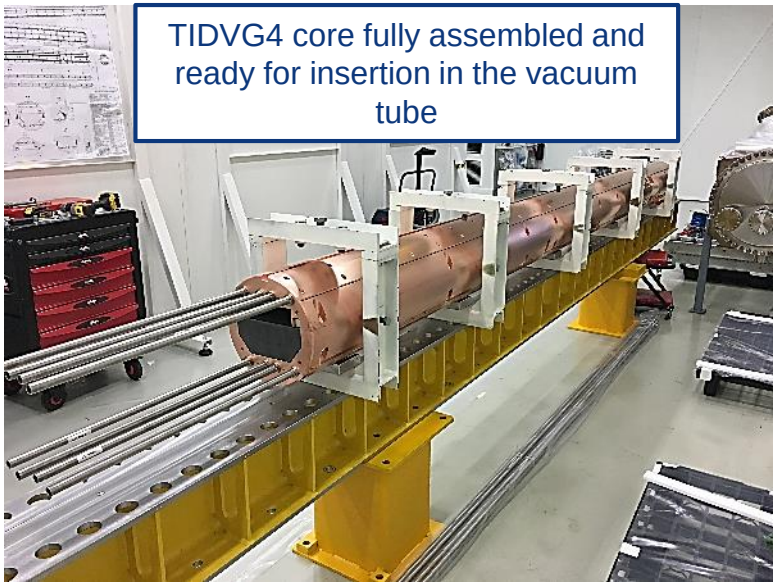
SPS new beam dump: assembly (TIDVG#4)

- The dump core has been successfully assembled at CERN in January 2017
- 3.5 m graphite, 40 cm CuCrZr and 40 cm Inermet

Graphite inside the CuCrZr core

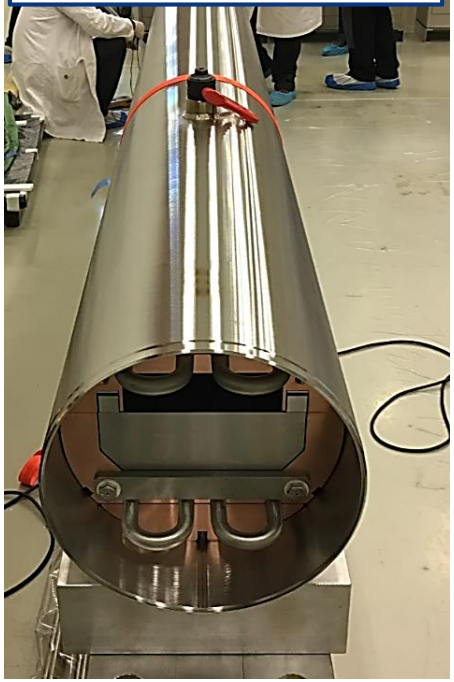
Medium/high-Z absorber

TIDVG4 core fully assembled and ready for insertion in the vacuum tube

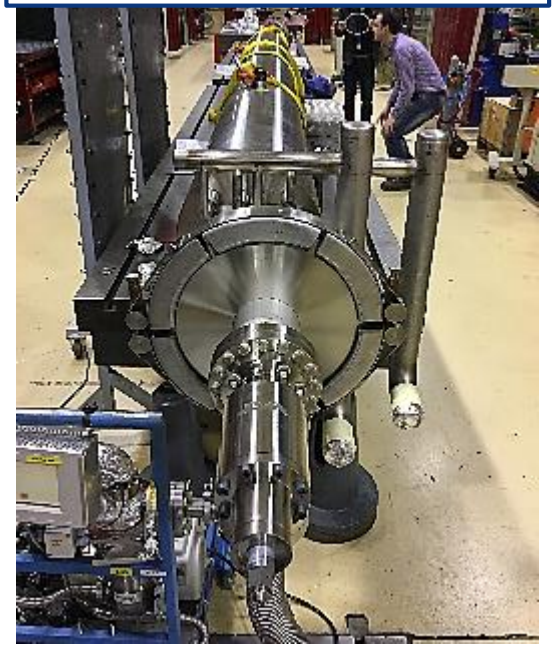


SPS new beam dump: insertion, final assembly and bake-out

TIDVG4 core fully inserted (downstream)



Final leak detection (downstream)



Beginning of the bake-out

So far so good … ☺

TIDVG#4 installation (and TIDVG#3 removal) decision to be taken today at LMC

Bake-out in tunnel foreseen to be finished by early April 2017 (ready for beam operation)

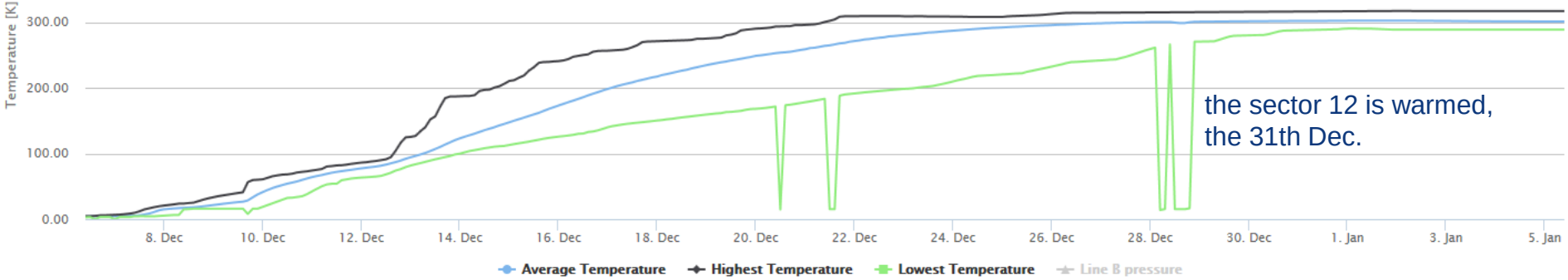
LHC : Magnet Exchange during eYETS

7 interconnections must be opened for the re-connection and the validation of the auxiliary circuits (correctors)

21 weeks required for the warm-up, exchange of the magnet, cool-down and the re-commissioning of the sector

4 ½ weeks (7days/7) will be necessary to disconnect and re-connect the dipole

Magnet temperature of sector 1-2



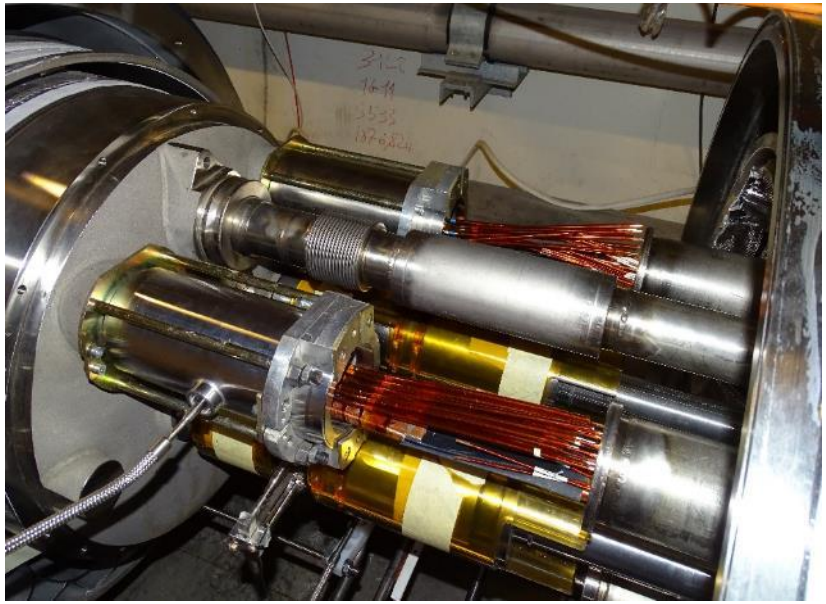
LHC : Magnet Exchange during eYETS

Magnet exchange on January 16th

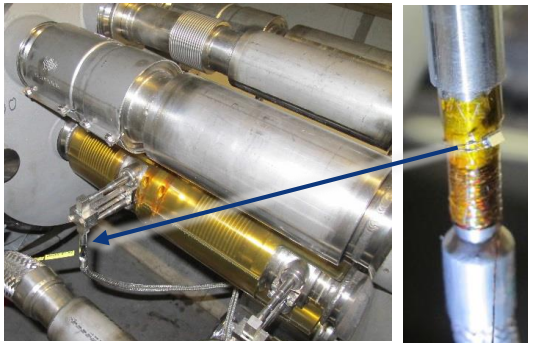

New A31L2 magnet installation

3 weeks for magnet re-connection and local qualification

- Constant quality control validation by TE/MSC
- Electrical continuity by ElQA (for correctors)
- Welding visual inspection by EN/MME
- Leak test by TE/VSC
- Additional instrumentation installed by TE/CRG


Re-connection in progress (All but M lines)


13kA splices and shunts soldered


Additional temperature sensors

LHC : Magnet Exchange during eYETS

Ready for closure (February 6th).

Successful global test :

- ElQA test
- Validation of the re-welding by a controlled pressurisation
- Leak test and vacuum insulation pumping

Cool down started February 15th

LHC Performance Workshop 2017 - 23-26 January 2017

A great workshop after a great year 2016 to prepare 2017,

Run 2, LS2, Run3,… LIU and HL-LHC

2017 plans

- Keep pushing performance and **availability (~50%)**
- BCMS beams (Smaller emittance though cycle; lower electron cloud heat load; faster intensity ramp-up; lower total beam current; lower losses; better for R2E... pile-up ?) **=> maximize integrated luminosity**
- Starting with ATS optics; β^* = 40 cm and later towards 33 cm

  (would deploy HL-LHC optics and open up the exploration of its possibilities)

  => expect to reach 1.7 to 1.9 10^{34} cm^{-2} s^{-1} (inner triplet cooling limit ?)

- Look forward to HL-LHC without compromising present performance: ATS, beta* levelling, RF full de-tuning, electron cloud,...
- Look forward to the post-LS2 LIU era and how to exploit the potential

2017 special runs ?

- 5 TeV pp reference run (for Pb-PB and p-Pb physics analysis)
  - LHCC should take a decision if to do at end of 2017 or end of 2018 just before the ion run
  - LHCC should define the duration: 7-10 days or 4-5 days of stable days

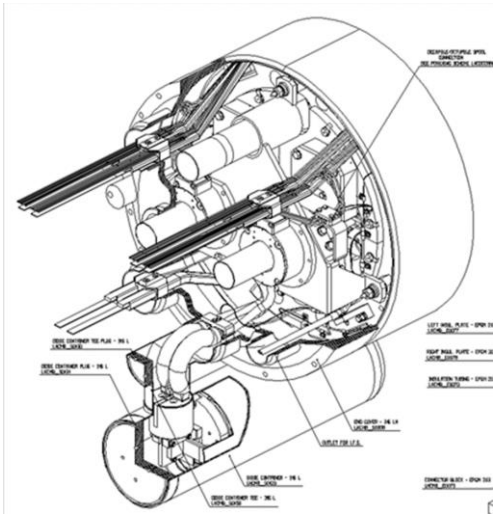
- High β* run at low energy (900 GeV/2 TeV ?)
  (TOTEM and ATLAS(ALFA)
  - 2018 or Run 3 ?
  - To schedule 1 day of machine time in 2017 to investigate possibilities ?

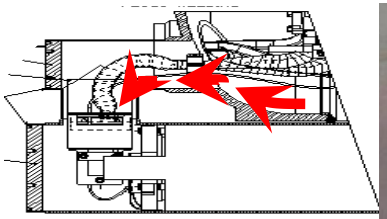
- 90 m-like β* run with maximum luminosity
  (TOTEM and ATLAS(ALFA)
  - LHCC: 2018 ? Duration : ~1-2 weeks including setup

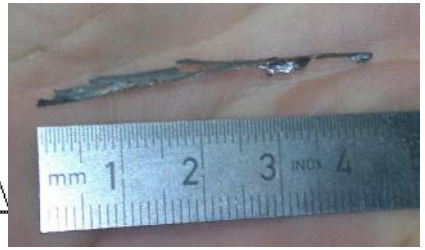
Beam energy : **Run 2 @ 13 TeV c.m.**

NO change of beam energy in 2017 and 2018

Goal is to prepare the LHC to run at 14 TeV during Run 3.







Study how to reinforce the insulation (and to clean) during LS2 the electrical part connecting the dipole bypass diode.
Powering tests before and during LS2 should be defined

Working group was set up after Chamonix workshop:
How ?, How long ?, How much ?

LHC schedule 2017

a new production year at 13 TeV

Goal 45fb^{-1}

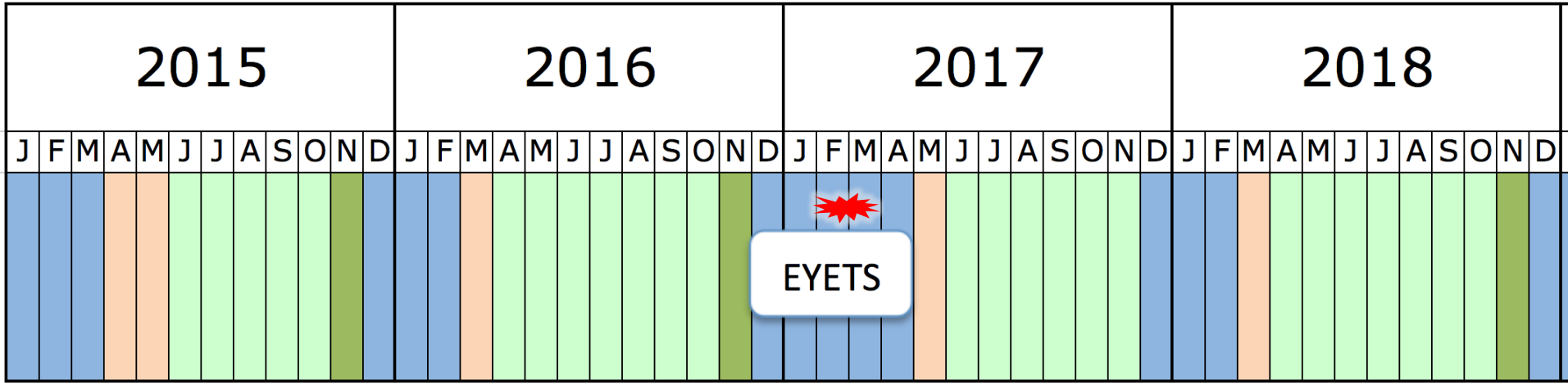
keeping the LHC availability close to 50% (stable beams)

Initially 15 days of MD; later during 2017 according integrated luminosity : + 3 days ?

Special runs: VdM scans,… and … LHCC recommendations

Run 2 and Run 3

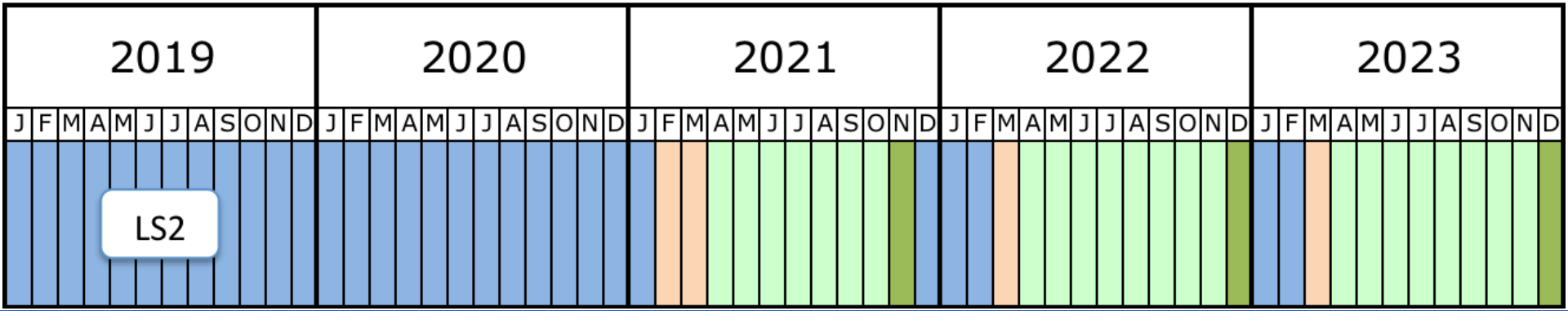
Ion runs end of 2018 (Pb-Pb)



Shutdown/Technical stop
Protons physics
Commissioning
Ions

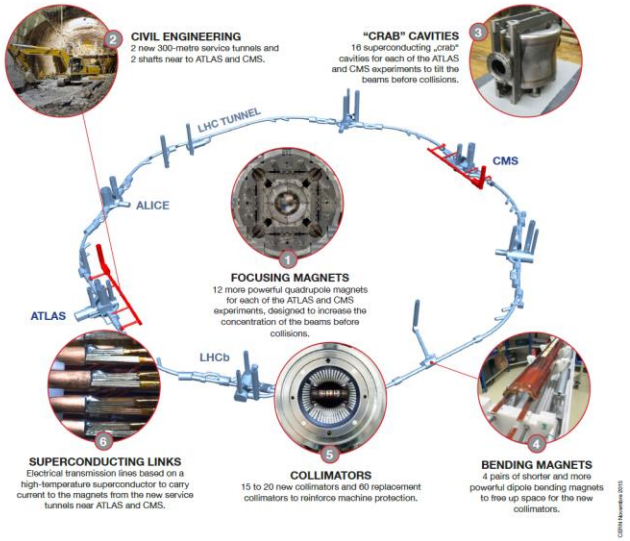
>120 fb^{-1} (13 TeV)

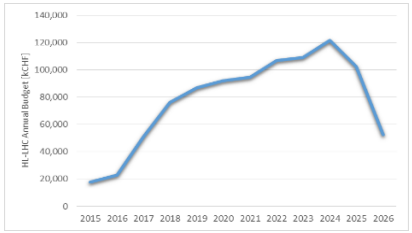
Σ 300 fb^{-1} (14 TeV ?)



HL-LHC project

formal approval by CERN Council (June 2016)



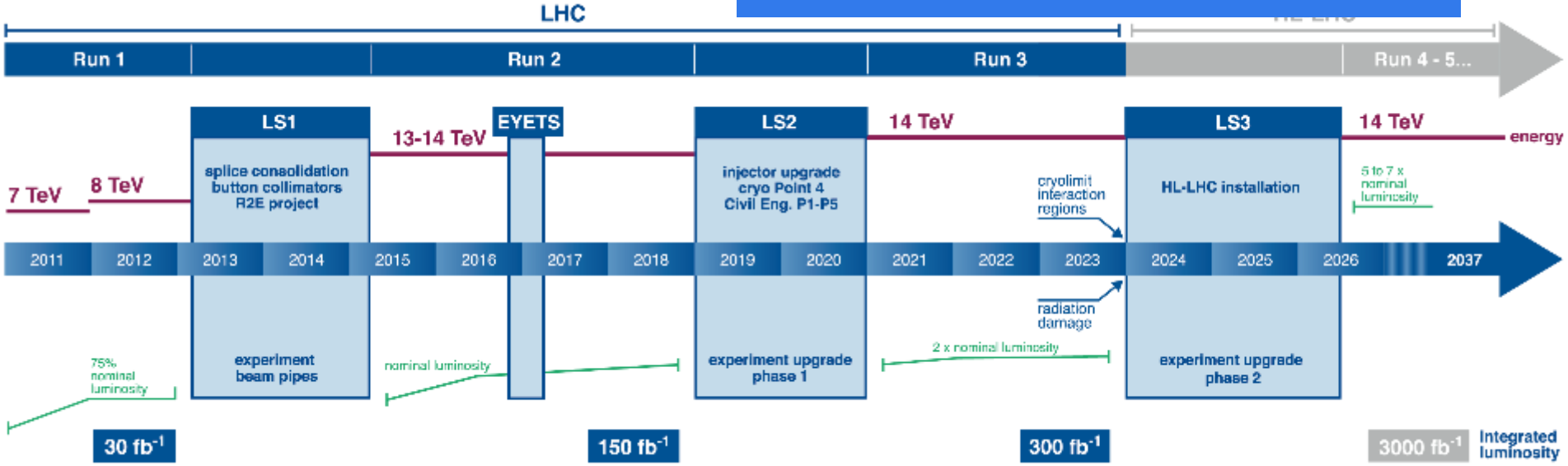


Cost to Completion
Material : 950 MCHF
Personnel: 1600 FTE-years

Major intervention on more than 1.2 km of the LHC

with new technologies:

Nb_3Sn magnets, Crab cavities,…



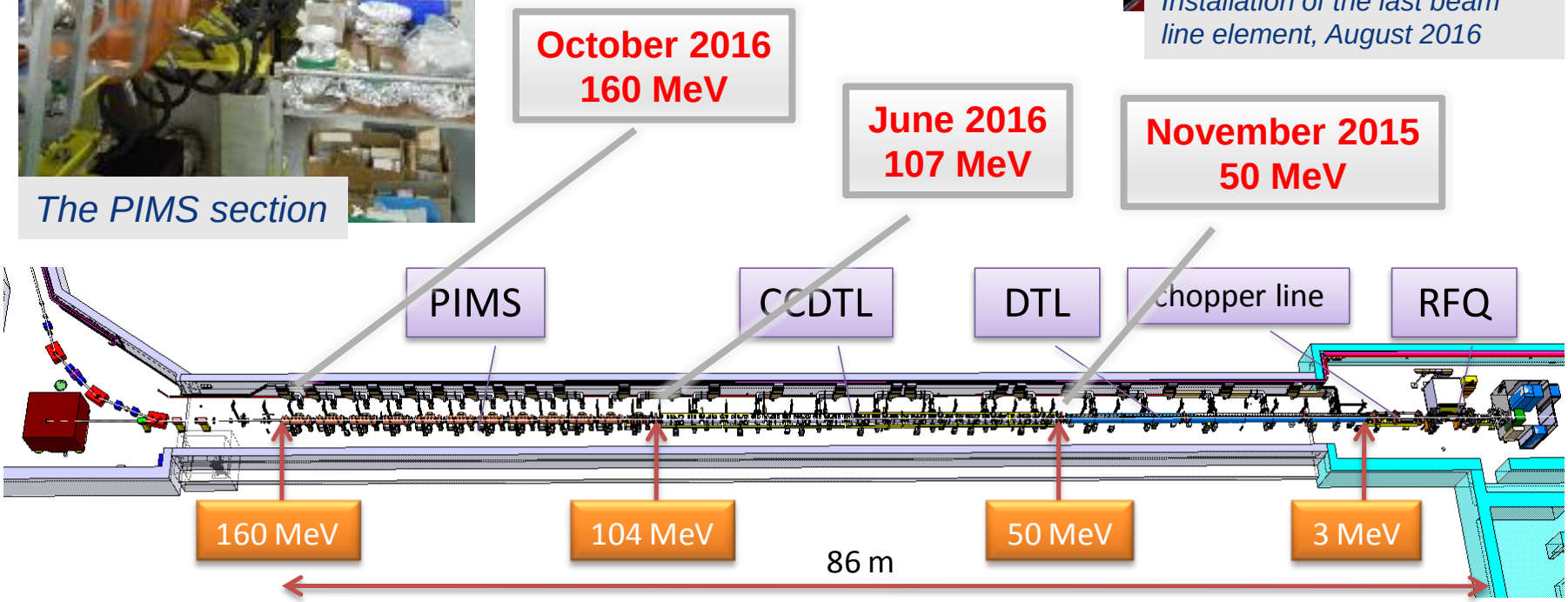
Linac4 reached its energy goal – October 2016

The PIMS section

September-November 2016: Commissioning with beam of 12 PIMS accelerating structures (built in collaboration CERN-NCBJ-FZJ).

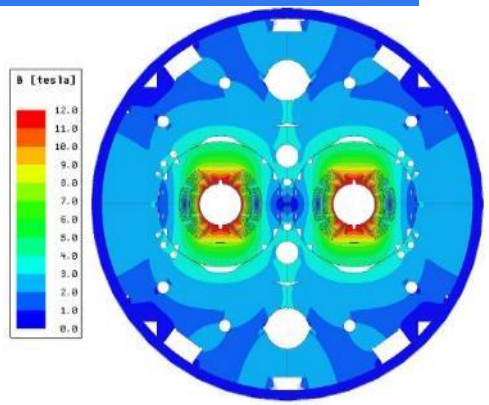
160 MeV design energy reached on 25.10. 2016

Installation of the last beam line element, August 2016



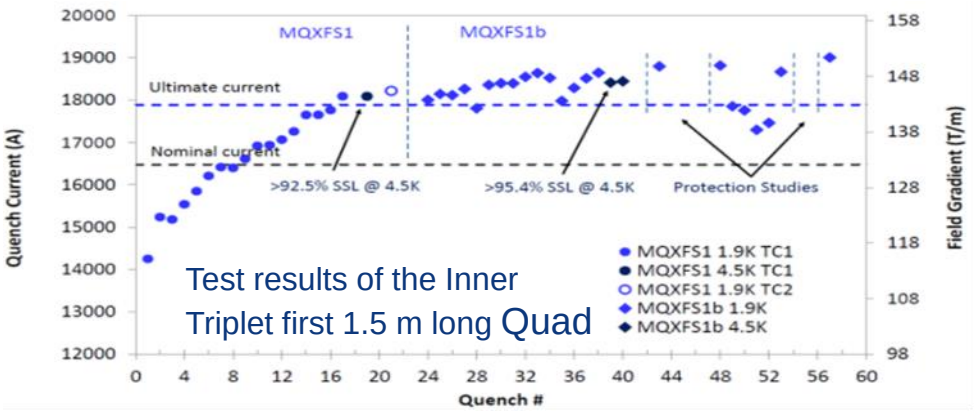
HL-LHC Main achievement 2016

The 11 T dipole 2 m long model reached a B_{max} of 12.5 T



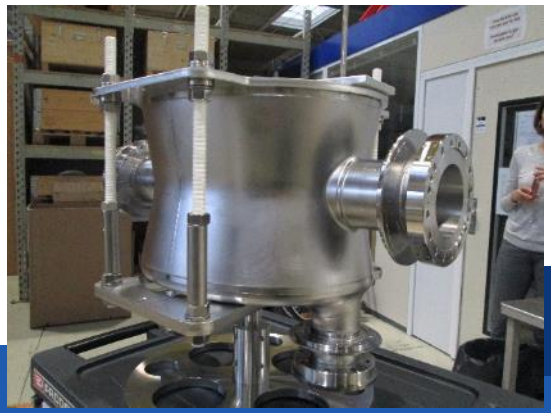
Cross section of the 11 T dipole

Test of the first full cross-section (150 mm aperture) Triplet Quadrupole, 1.5 m long, half CERN, half USA: it went beyond ultimate ($B_{max\ eq.}$ of 12.5 T)



Test results of the Inner Triplet first 1.5 m long Quad

Completion of the first Crab Cavity, type Double Quarter Wave at CERN just before Christmas!



First Crab Cavity produced at CERN

2017 Main Objectives of HL-LHC

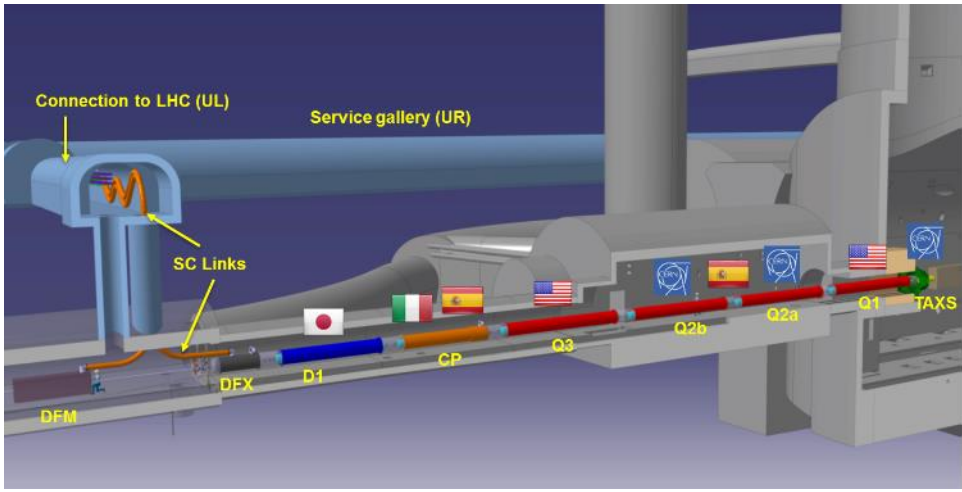
Construction and test of first prototypes (full length) of both 11 T dipole and Inner Triplet Quadrupole; mass production of Nb_3Sn cables

Construction of first complete cryo-module of the Crab Cavity, test in SM18. Cryogenics and infrastructure for testing in SPS.

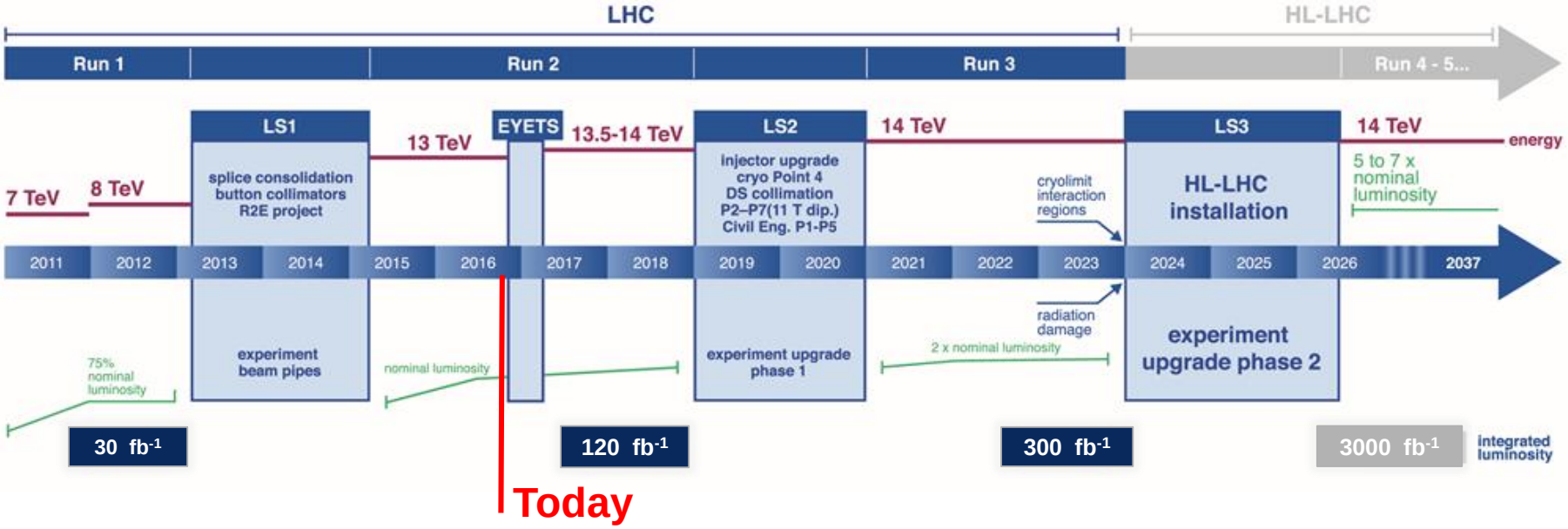
Finalize Technical Specifications and launch of the tender of the large C.E. construction for HL-LHC in P1 and P5 to meet adjudication in March 2018.

2nd Cost & Schedule review of LIU and HL-LHC
(17-19th October 2016)

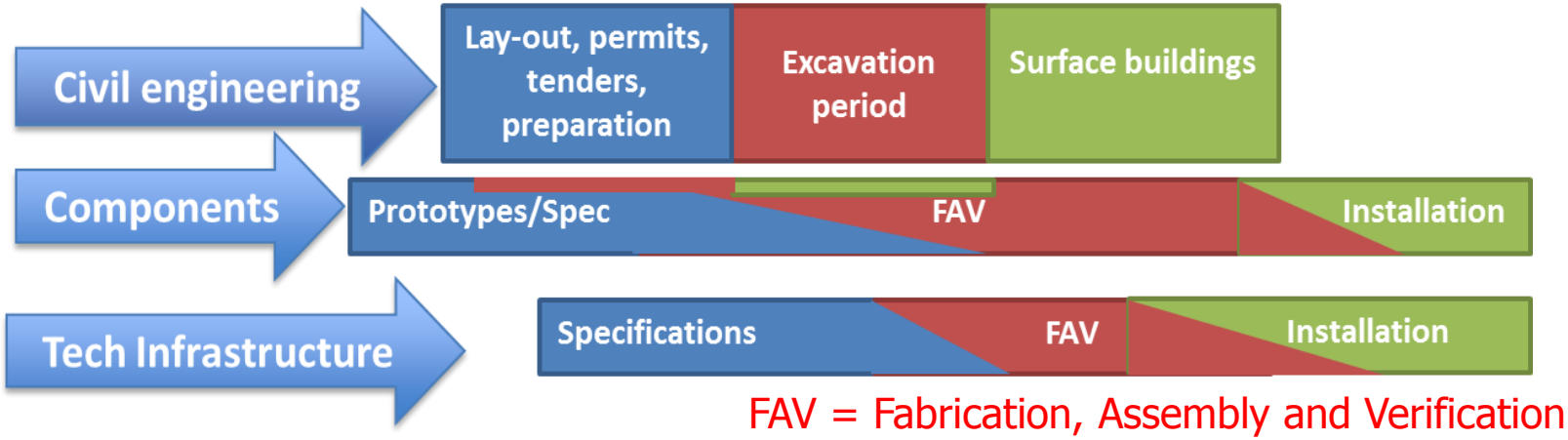
Inner Triplet Region



LHC / HL-LHC Plan

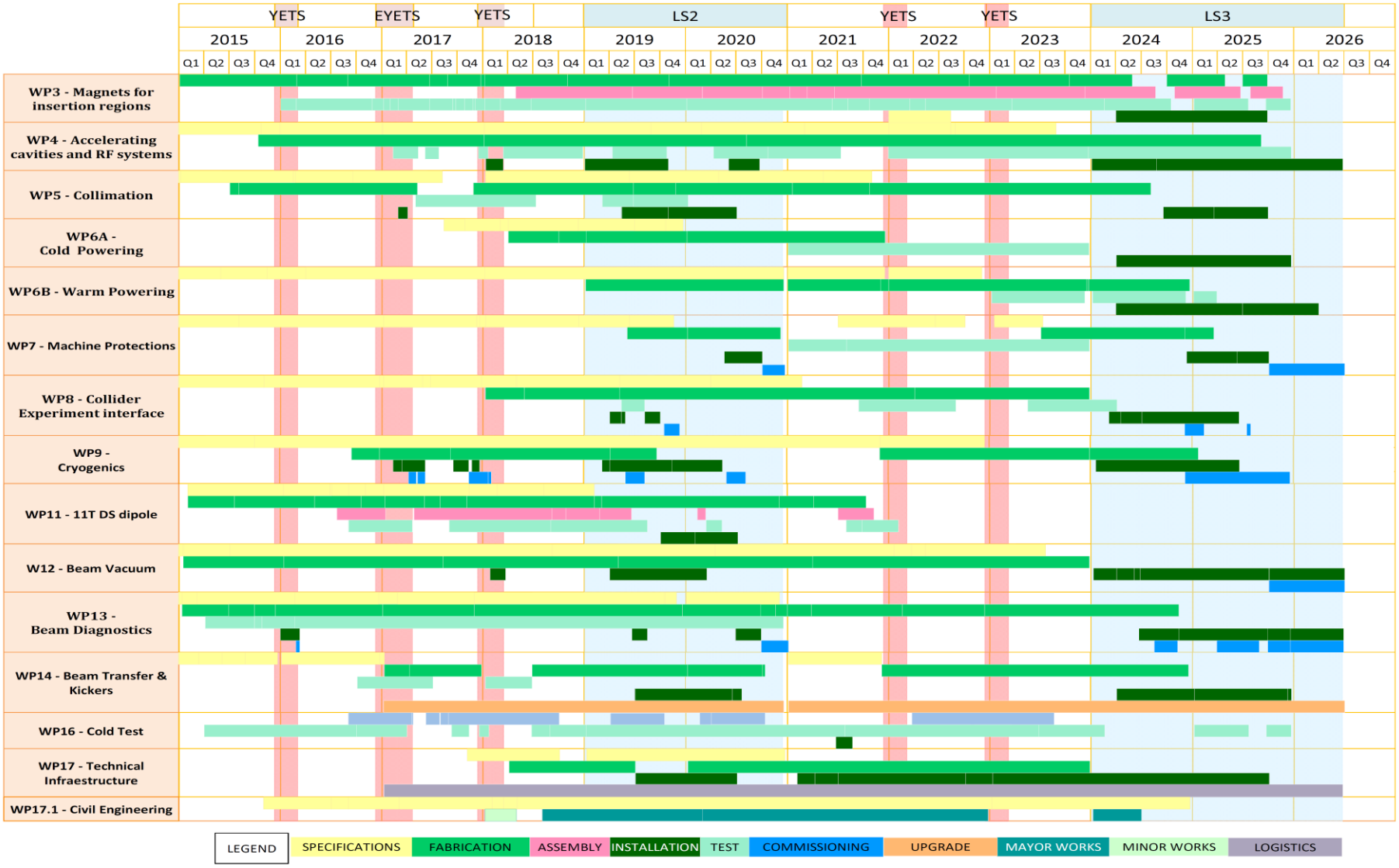


Today



FAV = Fabrication, Assembly and Verification

HL-LHC master schedule



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

WORK PACKAGES & PROCUREMENT INFO

- WP1 - Project Management & Technical Coordination
- WP2 - Acceleratos Physics and Performance
- WP3 - Insertion Regions Magnets
- WP4 - Crab Cavities & RF
- WP5 - Collimation
- WP6A - Cold Powering
- WP6B - Warm Powering
- WP7 - Machine Protection
- WP8 - Collider-Experiment Interface
- WP9 - Cryogenics
- WP10 - Energy Deposition & Absorber Coordination
- WP11 - 11T Dipole
- WP12 - Vacuum
- WP13 - Beam Diagnostics
- WP14 - Beam Transfer & Kickers
- WP15 - Integration & (De-)Installation
- WP16 - Hardware Commissioning
- WP17 - Infrastructure, Logistics and Civil Engineering

WP9 - Cryogenics

WP Leader: Serge Claudet

Main WP Engineers: Daniel Berkowitz, Krzyztof Brodzinski, Laurent Delprat, Gerard Ferlin, Lionel Herblin, Rob Van Weelderen

Technologies: Cryogenics systems for HL-LHC, Electronic, electrical equipment and instrumentation for accelerators

Main materials:

Key external factors: Radiation, 1.9 K

WP9 in a nutshell (Please note that info provided in this document is subject to be changed. Mentioned quantities, materials, parameters, etc. may change along the design and/or manufacturing process of the equipment)

WP9 Main Activities

Next 18 months procurements needs (Access restricted to ILOs)

Thanks for your attention

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