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LHC Machine Status
RRB

Frédérick Bordry

23rd October 2017

LHC schedule 2017

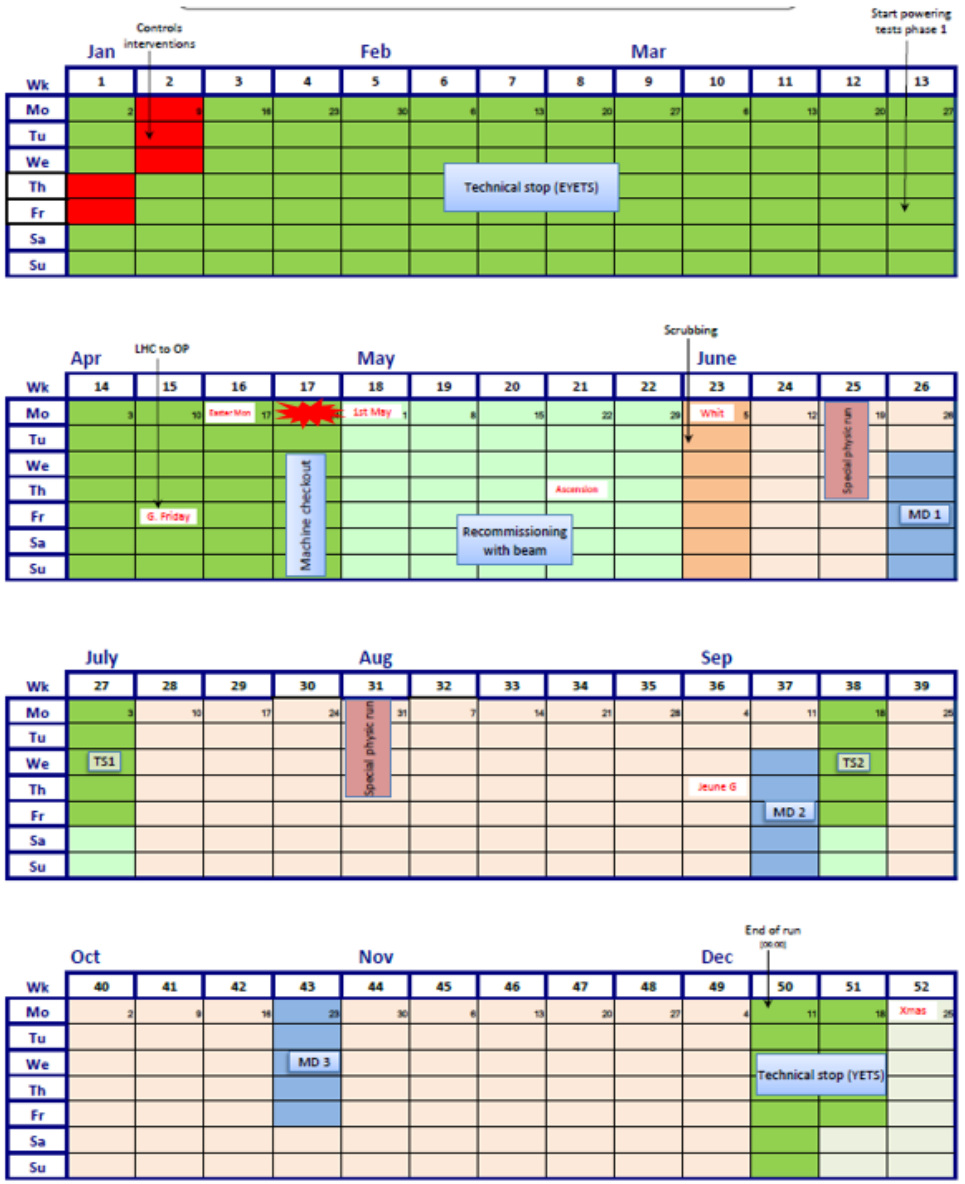
a new p-p production year at 13 TeV

Goal 45fb^{-1}

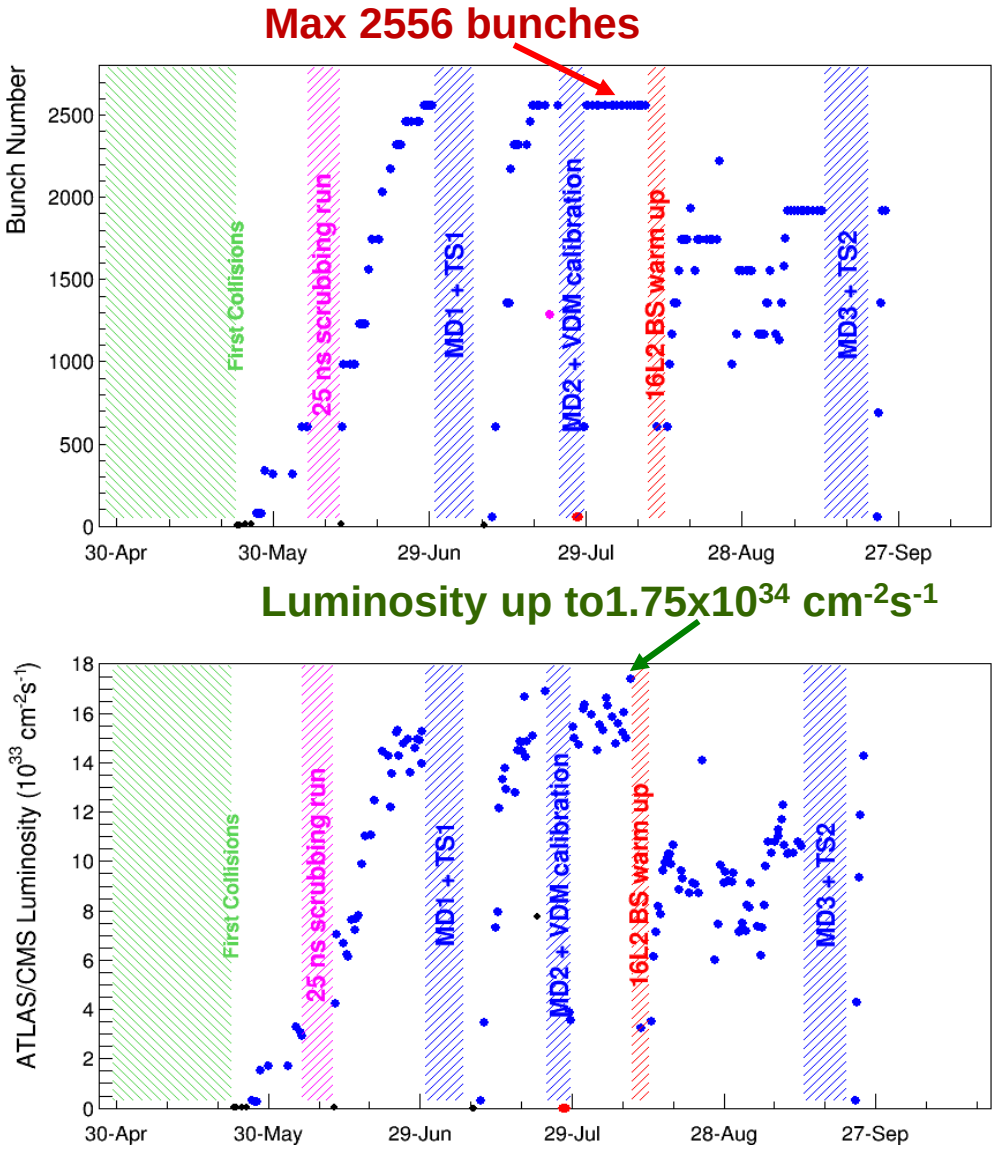
keeping the LHC availability close to 50% (stable beams)

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

Special runs: VdM scans,… and … LHCC recommendations

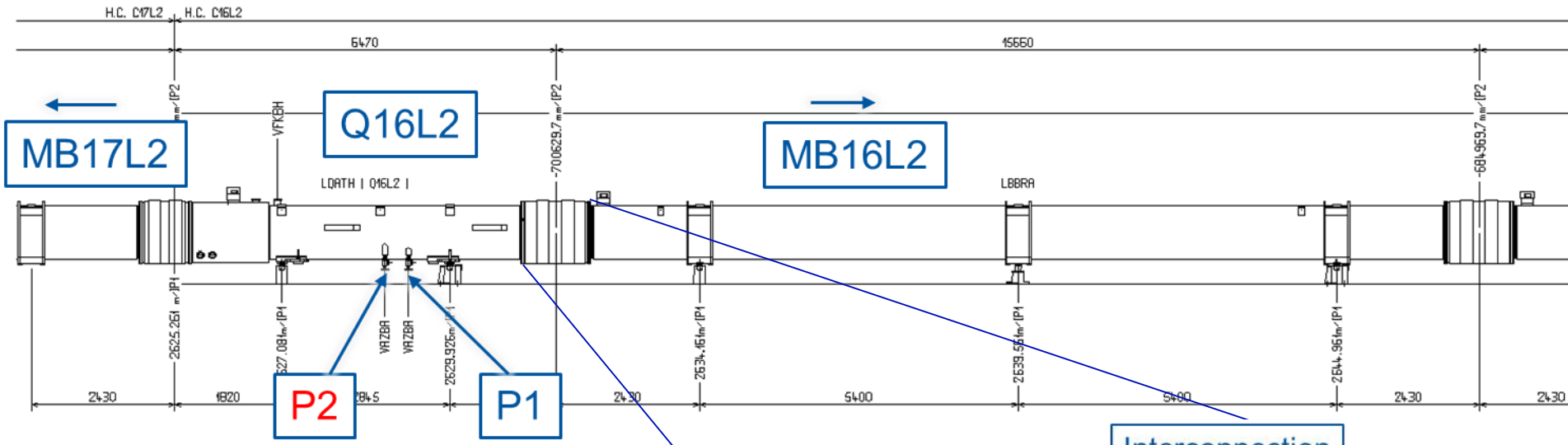


LHC Physics Run 2017 up to TS2: it was not all plain sailing !



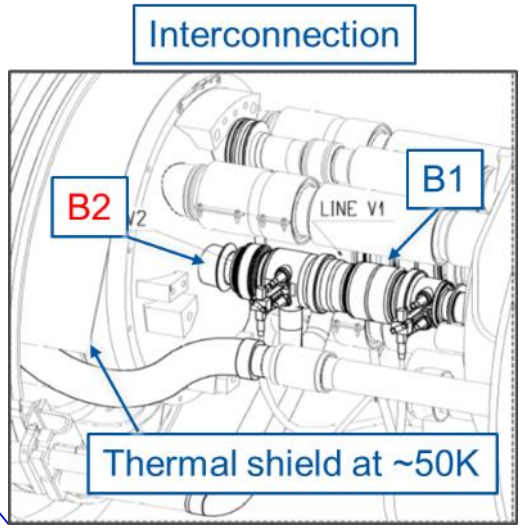
- Initial turn on and scrubbing very successful
- After TS1 started to suffer from fast losses in the cell 16L2 (sector 1-2) leading to beam instabilities and beam dumps
  - **Not understood and limiting luminosity production, but mitigation strategy found**
- In order to try to understand the problem further it was decided to warm-up the beam screen in 16L2 to 80K in order to flush any contamination to the cold-bore
  - **Established procedure, used before**
- During this procedure: much larger pressure rise than expected
  - **10^{-3} mbar compared to 10^{-7}mbar**
- Following this, 16L2 problems much worse
  - **Mitigation strategy no longer found to work and luminosity production much reduced**
  - ***Task force***
- A different bunch configuration reducing the problems found: 8b4e
  - **8 consecutive 25ns slots filled with proton bunches, followed by 4 slots with no bunches**
  - **peak luminosity is ~1.1e34cm^{-2}s^{-1} (PU~40)**
- Shorter TS2 (3 days) and very fast restart
  - **Beta * = 30cm**

LHC “16L2”: Air inlet as “most probable” cause



Air inlet through **both** pumping ports while magnet cold masses, beam screens and thermal shields already at operating cryogenic temperature.

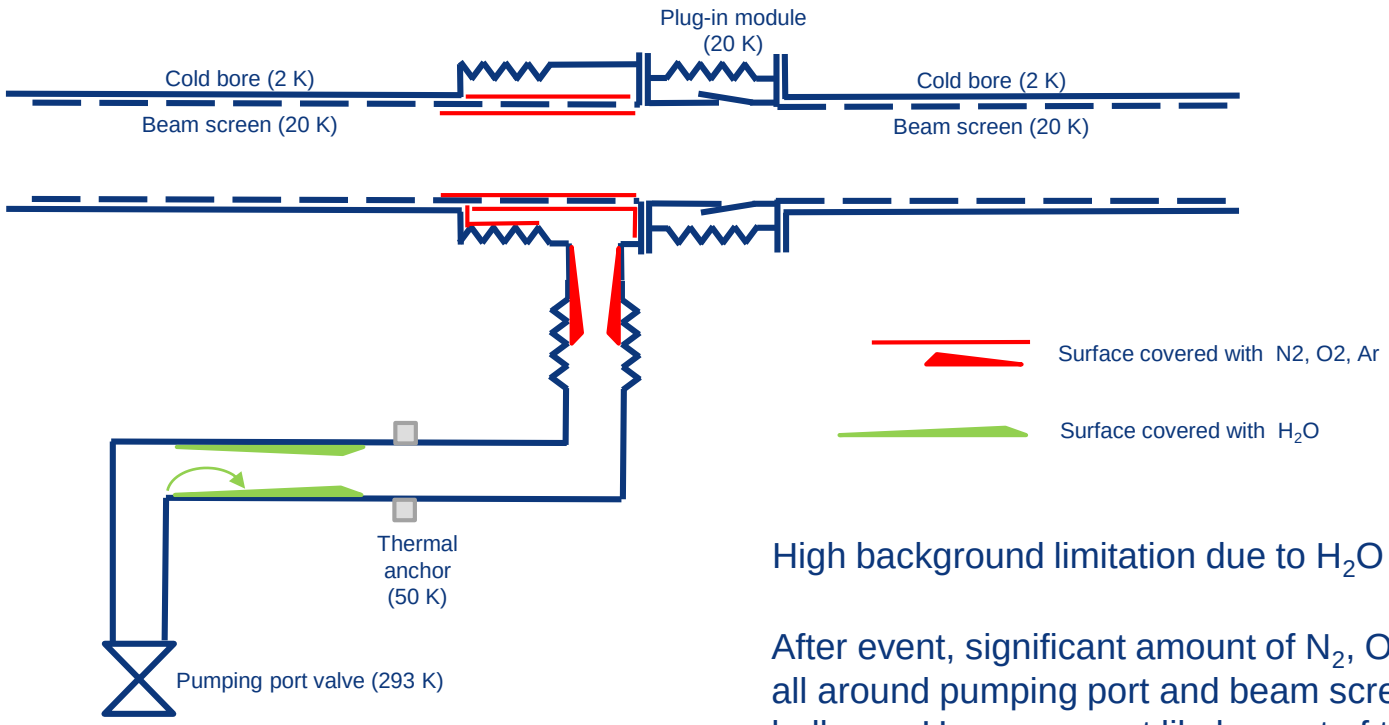
To be noted that gasses have a reduced mobility at those temperatures, explain why was not immediately identified.



LHC “16L2”: Air inlet as “most probable” cause

Event (accidental air inlet with BS at 20 K)

(same pumping group pumping beam 1 and beam 2)

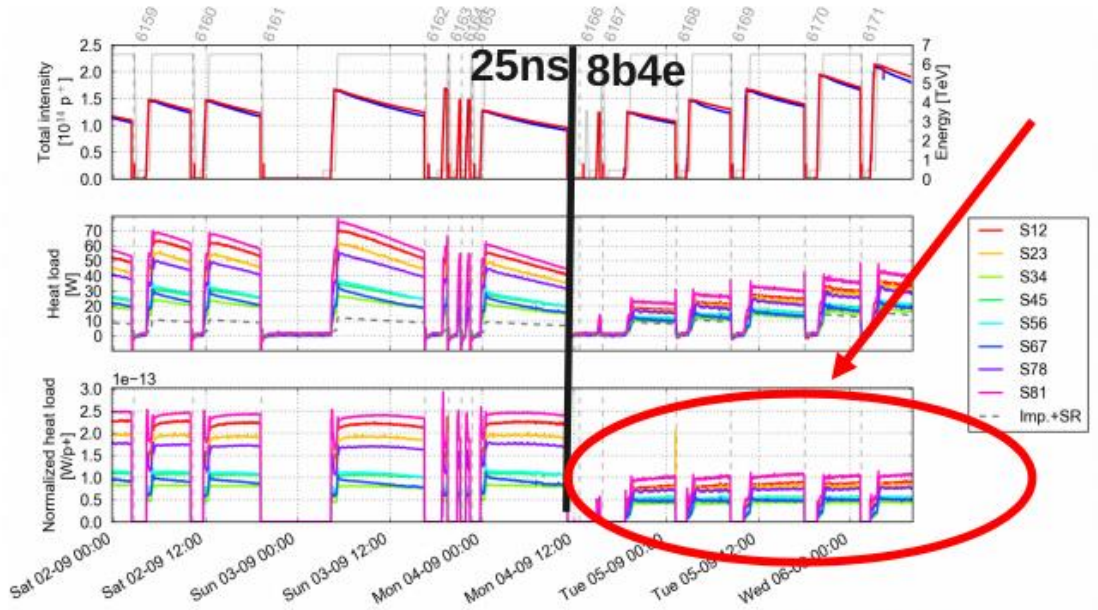


High background limitation due to H_2O from air.

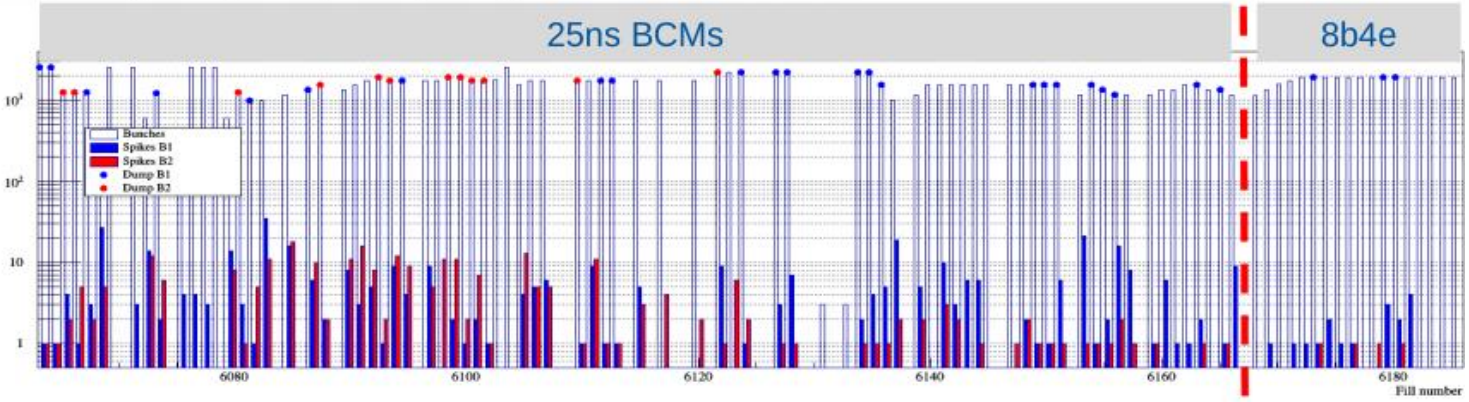
After event, significant amount of N_2, O_2 and Ar all around pumping port and beam screen bellows. However most likely most of those gases stick on the pumping port bellows.

Effect of 8b4e on16L2

Important reduction of heat load and loss spikes in 16L2

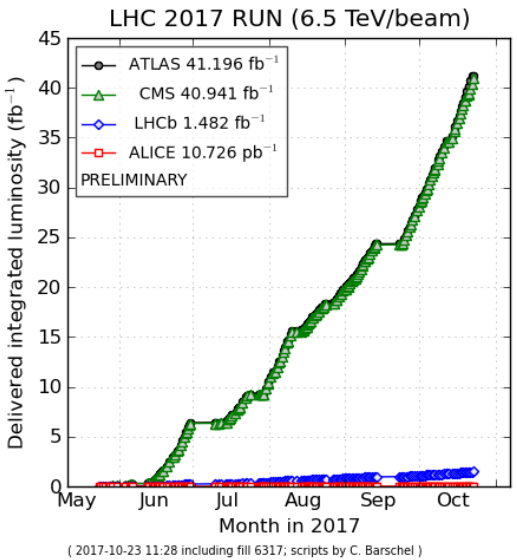


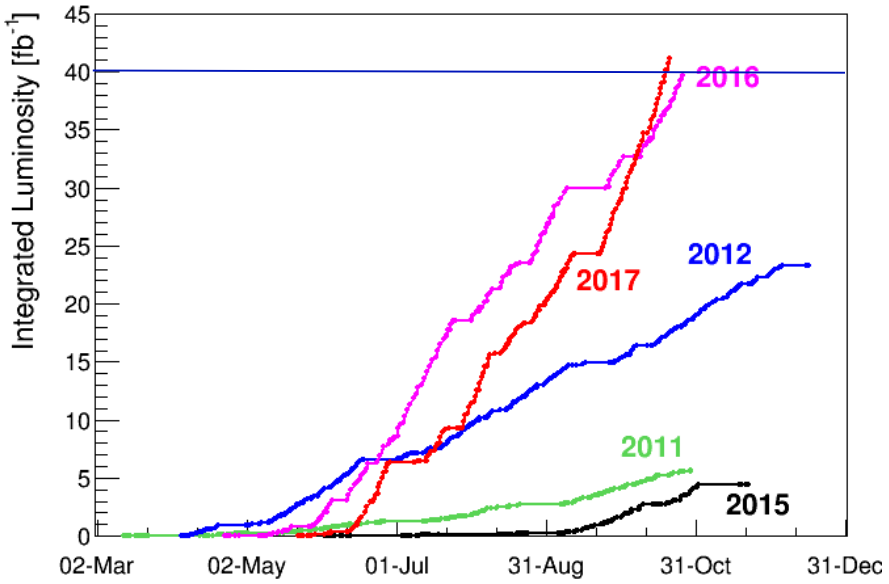
Big reduction in the heat load

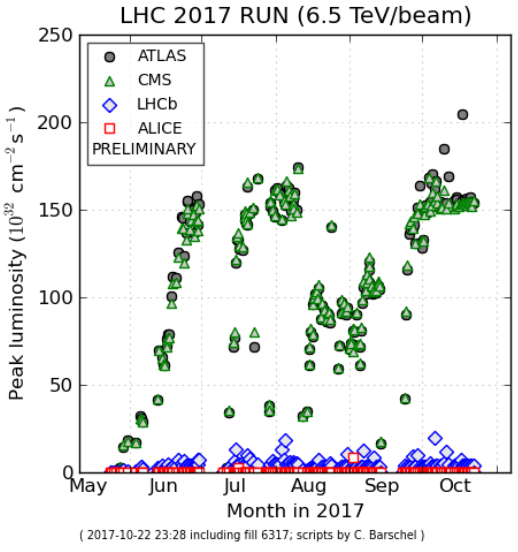


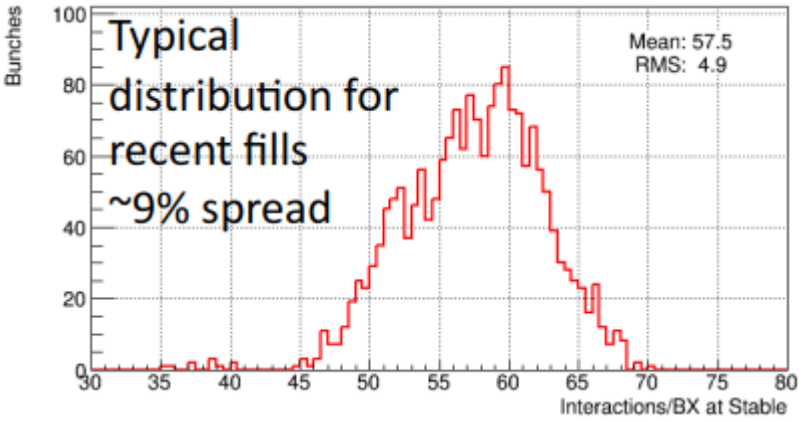
LHC 2017 : Integrated Performance (up to 23rd October)

> 41 fb^{-1}









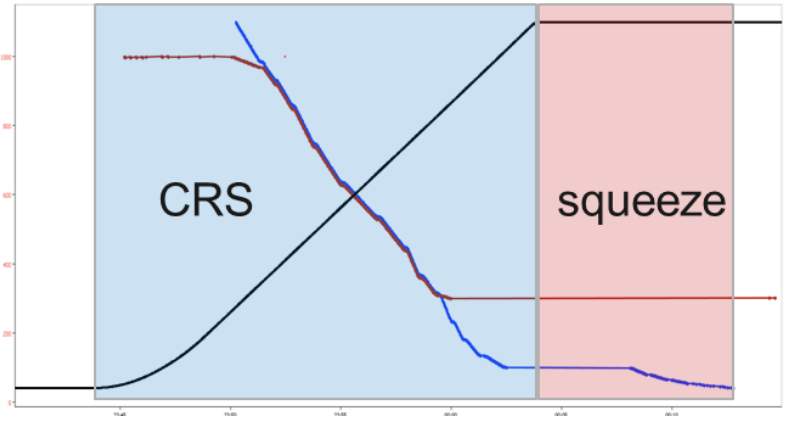
BBLR studies and possible reduction of the crossing angles in the LHC

J. Barranco, X. Buffat, M. Crouch, T. Pieloni, C. Tambasco, B. Salvachua, M. Solfaroli, G. Trad, A. Gorzawski, G. Valentino,

J. Wenninger, S. Redaelli, R. Tomas, E. Metral, R. Bruce, M. Giovannozzi, Y. Papaphilippou, E. Hamish Maclen, R. De Maria, G. Arduini, S. Fartoukh, D. Pellegrini, E. Bravin, H. Bartoski, G. Iadarola

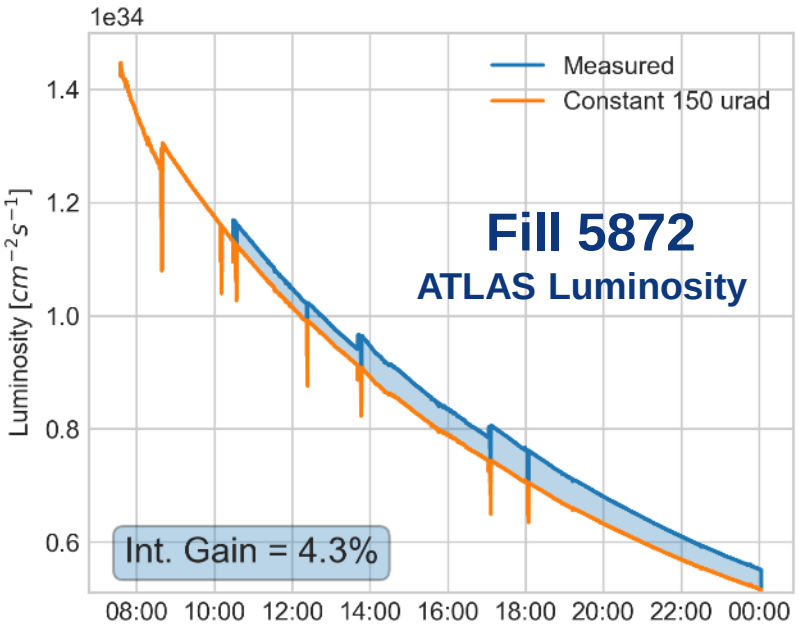
LMC, 31st August 2016

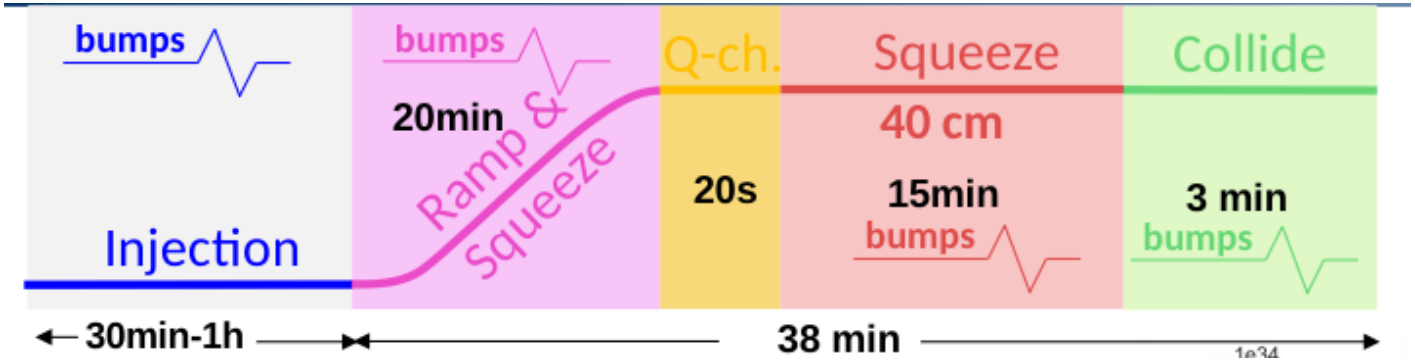
Energy vs β* in IP1/5/8



Crossing angle anti-levelling operational

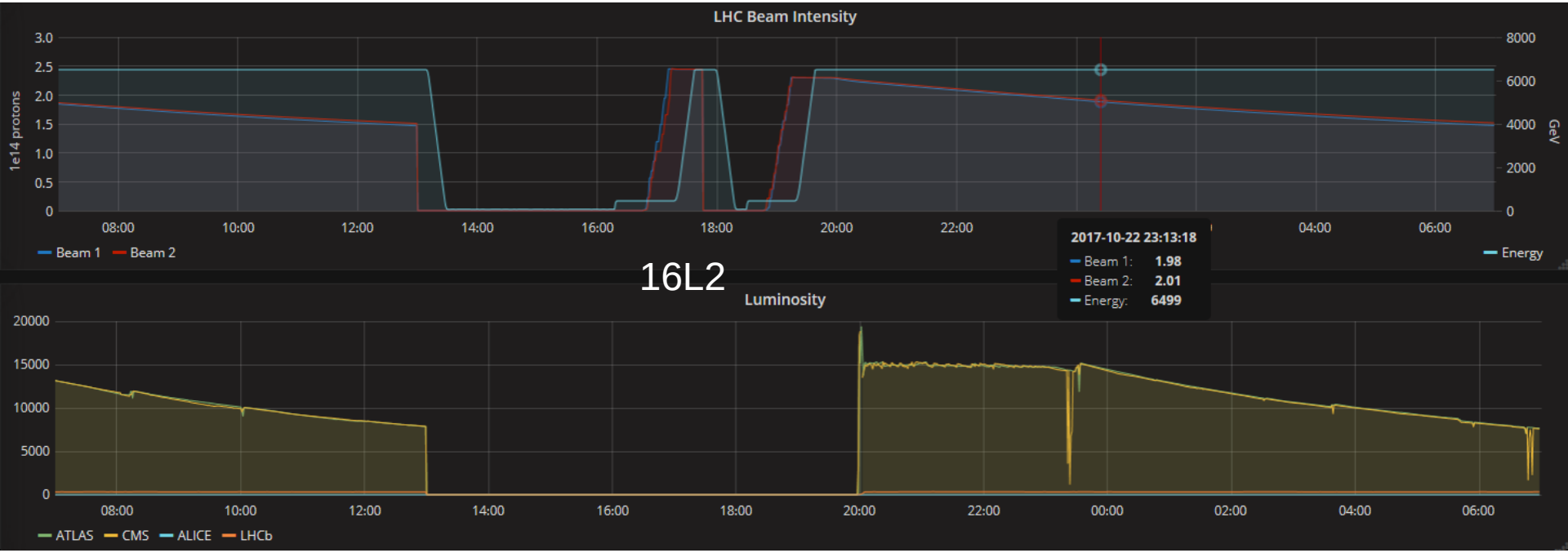
- Observed luminosity gain of **3-4 %**
- Steps of -10 μrad at stable beams
  after 2h, 4h, 8h
  150 → 140 → 130 → 120 μrad





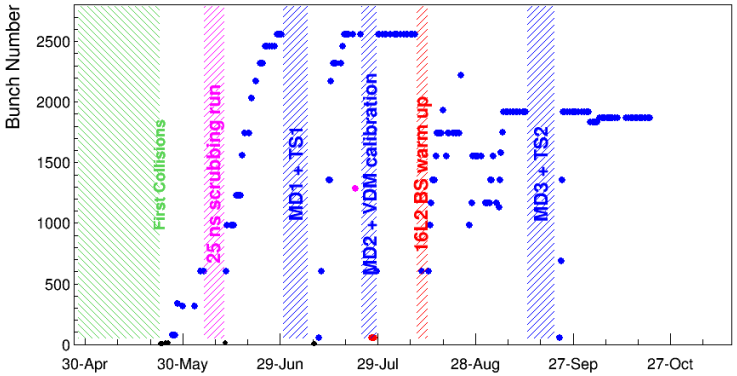
Minimum time from stable beams to stable beams = 2h

1.3E11 proton per bunch is not; **1.25E11 ppb is OK**,



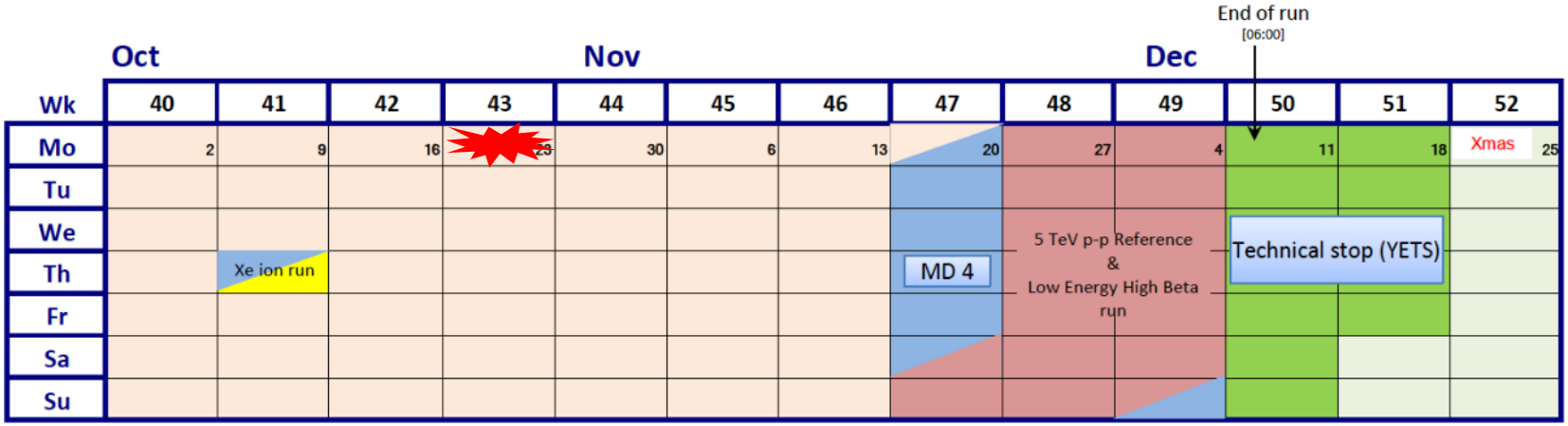
LHC plans

- p-p runs with 8b+4e (number of bunches limited to 1868 bunches) but with **Beta * = 30 cm** (ATLAS and CMS), crossing angle reduction during the fill and luminosity levelling at 1.5 10^{34} cm^{-2} s^{-1}



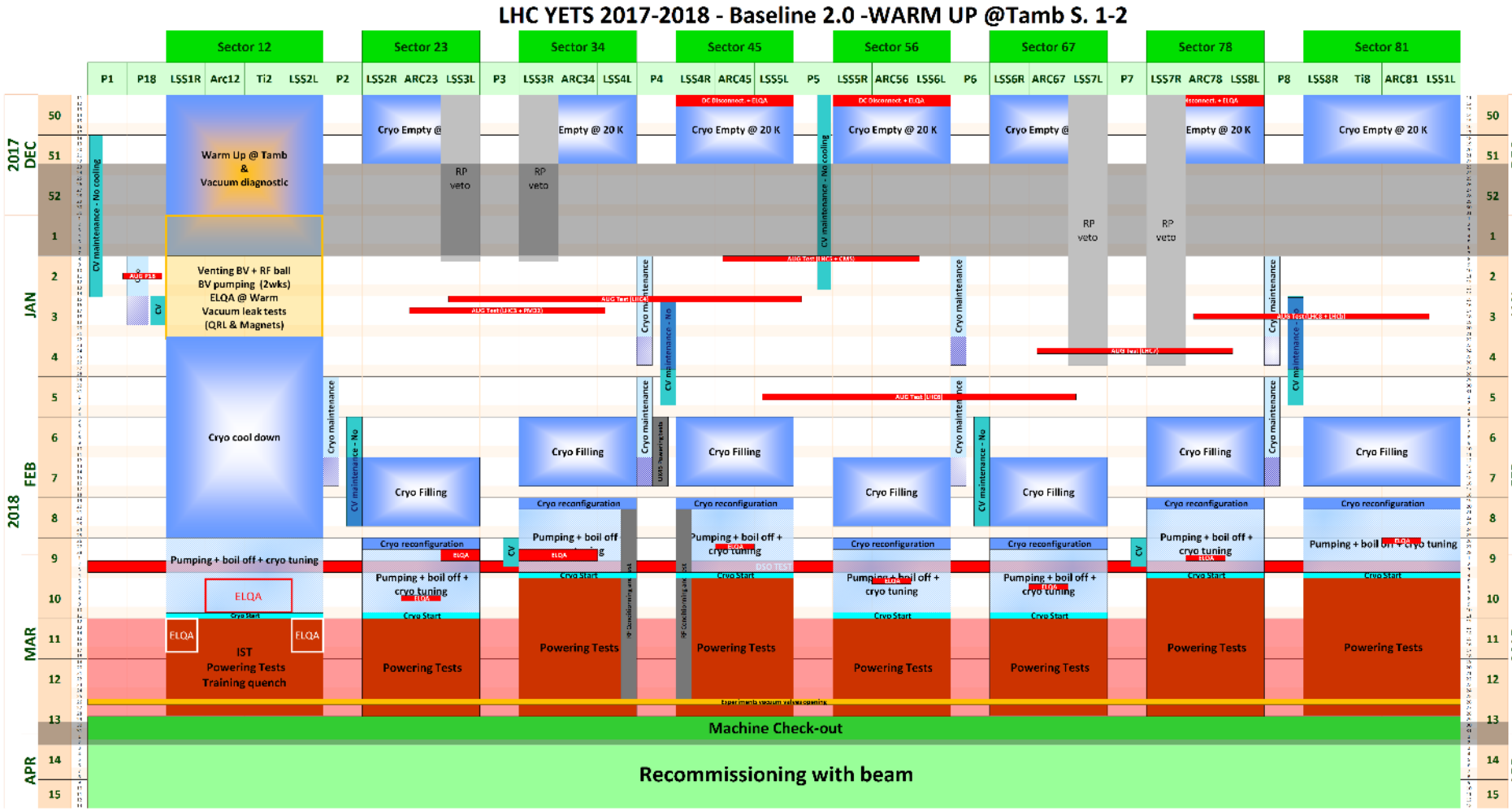
- Special runs: 5 TeV p-p reference and Low Energy High Beta run (following LHCC recommendations: ~15 days):

- Preparing intervention (sector 1-2 warm-up) during the YETS ***(18 weeks "physics" to "physics")***

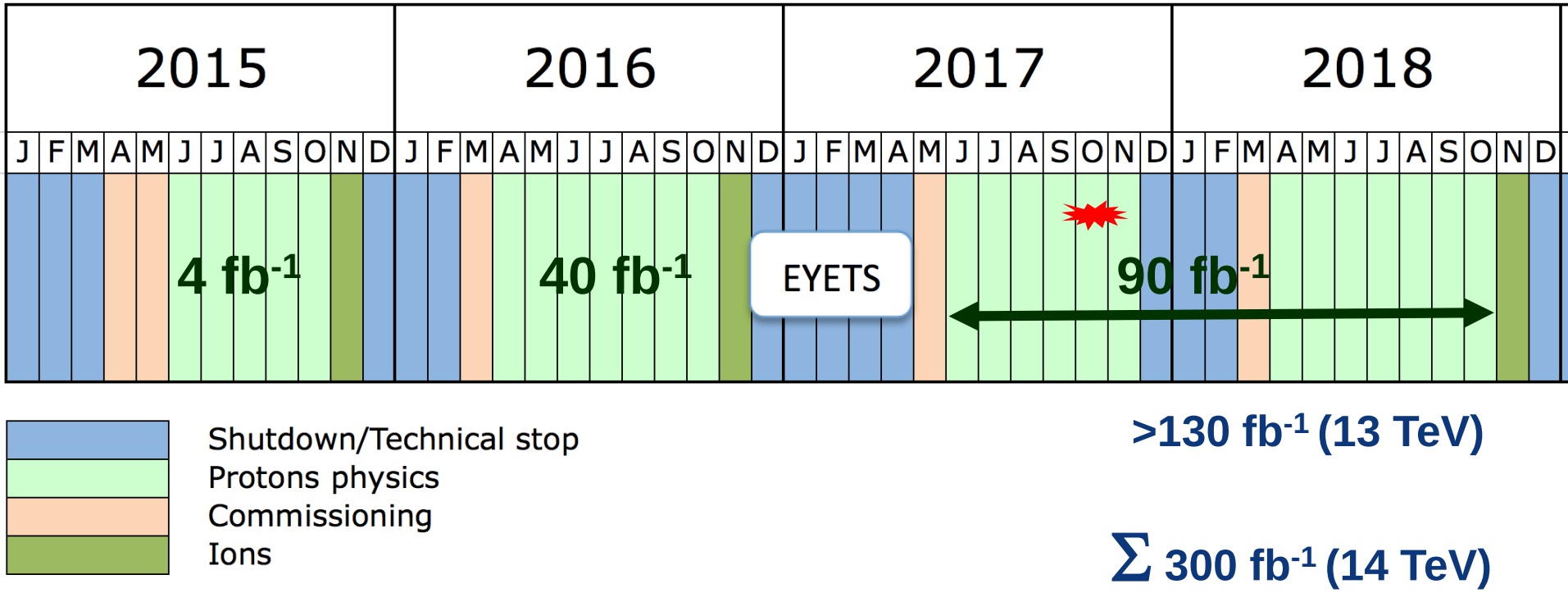


YETS 2017-2018: impact of warm up sector 1-2 @ T amb

Goal to keep 18 weeks “physics to physics”

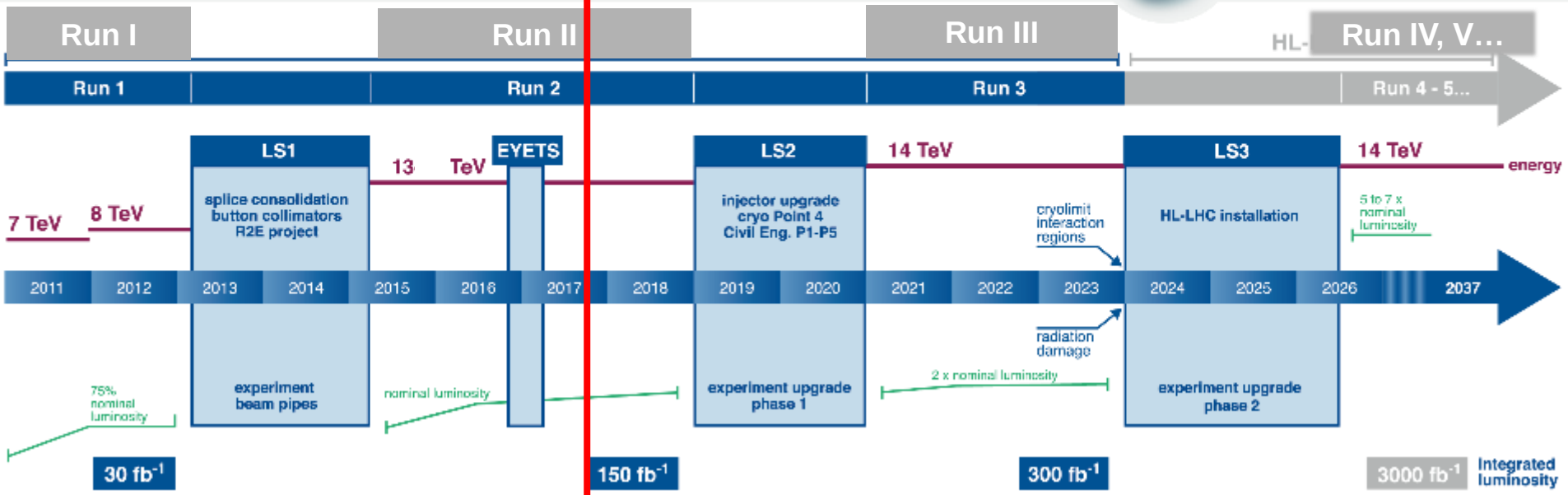


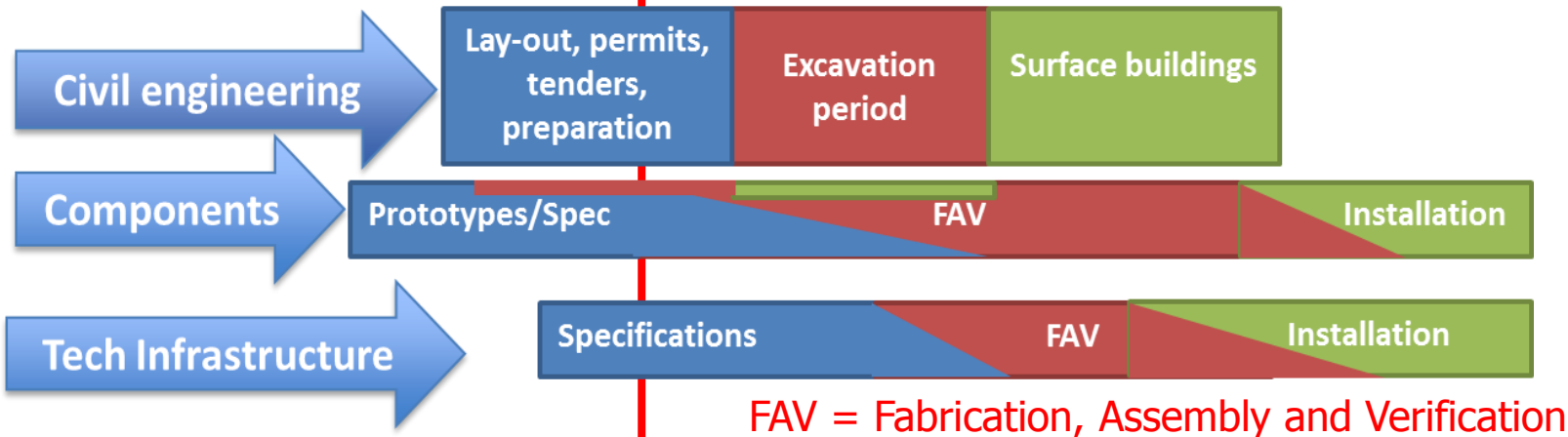
Run 2 and Run 3



today

LHC / HL-LHC Plan





FAV = Fabrication, Assembly and Verification

HL-LHC Nb3Sn magnets plan

Activity	Begin	End
11 T Models Mark I	01.01.2012	31.12.2016
11 T Models Mark II	30.06.2016	30.06.2018
11 T Prototype	12.06.2015	20.01.2017
11 T Production	03.04.2017	14.03.2021

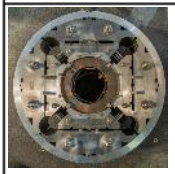
2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026

today

LHC Run II | LS2 | LHC Run III | LS3

LARP

CERN



Activity	Begin	End
QXF Models CERN/US	26.05.2014	31.12.2017
QXF Prototypes US	30.06.2015	30.06.2019
QXF Prototypes CERN	30.06.2016	30.06.2019
QXF Production US	30.06.2018	31.12.2024
QXF Production CERN	30.06.2018	31.12.2023

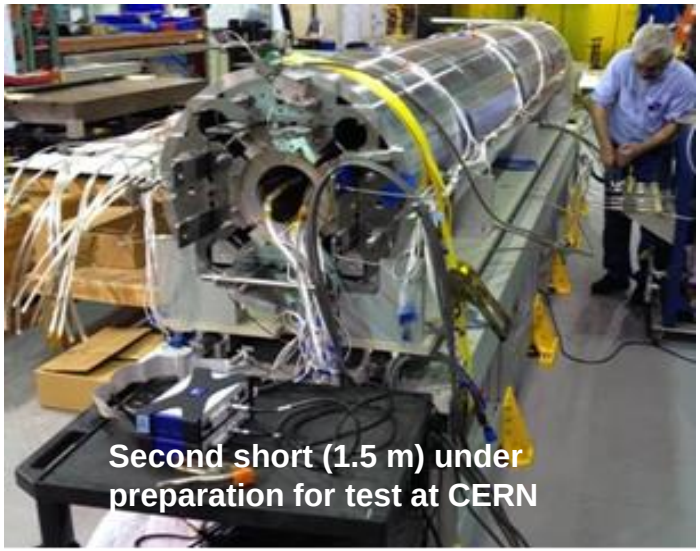
2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026

Opportunity for **first industry experience** on Nb_3Sn accelerator magnets

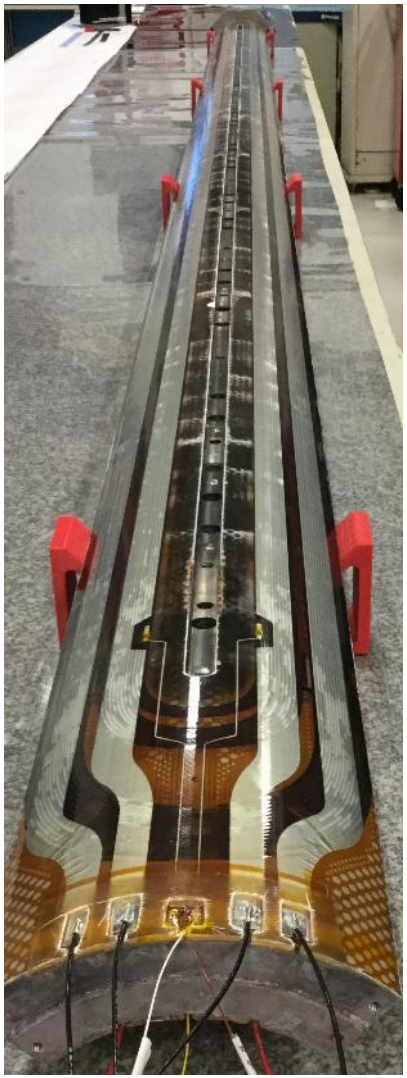
MS-4282/TE/HL/LHC - Manufacturing of Collared Coils for the 11 T Dipole Magnet of HL-LHC

MS-4263/TE/HL/LHC - Supply of Q2 Quadrupole Series Magnets

Nb_3Sn quadrupole: 1st long prototype under construction



Second short (1.5 m) under preparation for test at CERN



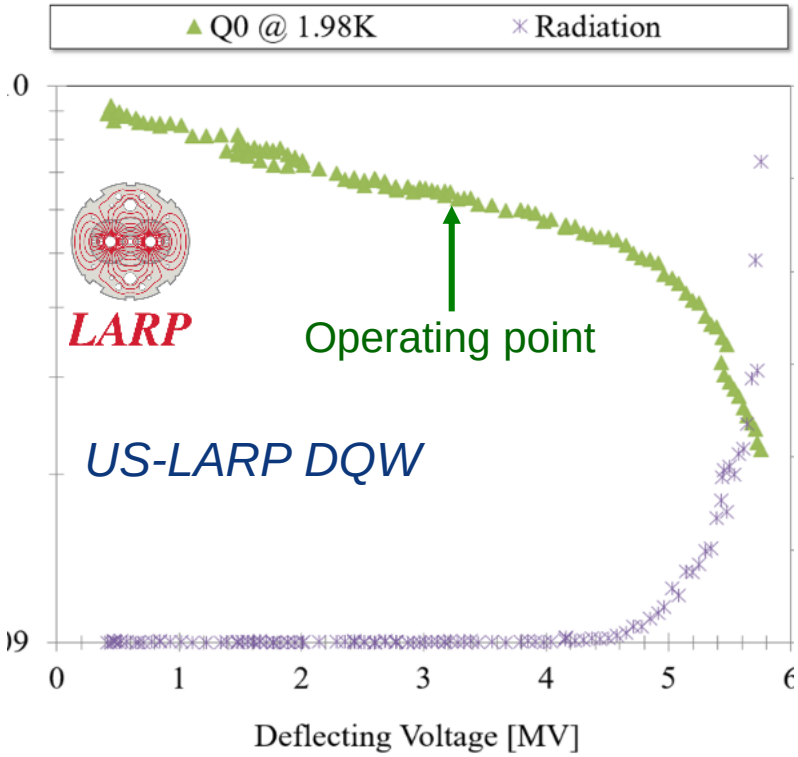
Insertion of coil package inside mechanical structure of the first IT quad prototypes (4.2 m long) in LBNL-USA

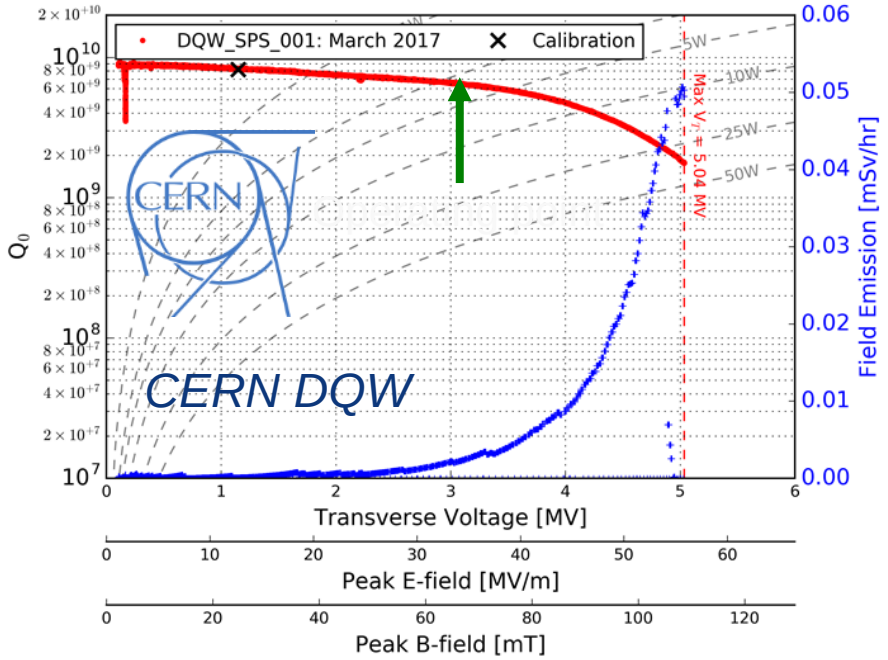
Courtesy of Frédéric Savary

11T dipole (Nb_3Sn): constructing the first prototype at CERN

Milestone:
Magnet prototype (5.5m)
by December 2017

Superconducting RF Crab Cavity first prototypes





February 2017 three (naked) Crab Cavities were tested: all went well beyond the operating voltage of 3.4 MV

- One US-LARP DQW (tested at JLab) went up to 5.4 MV
- One US-LARP RFD (tested at Jlab) reached 4.03 MV.
- One CERN DQW (test at SM18) went up to 5.04 MV

Good results for the CC testing in the SPS in 2018

Crab Cavity construction for SPS test at CERN (DQW type)

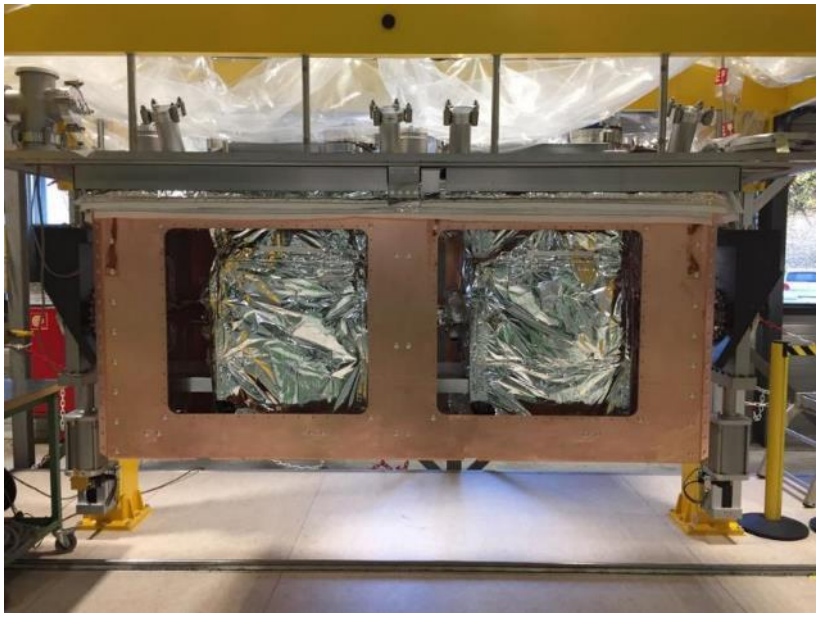
FPC on in Conditioning
Test box & installation of DT

FPC installation onto cavity

String assembly completed Aug 18, 2017

1st complete Cryomodule Oct 2017.

Crab Cavity cryomodule for SPS test in 2018



Thermal shield mounted

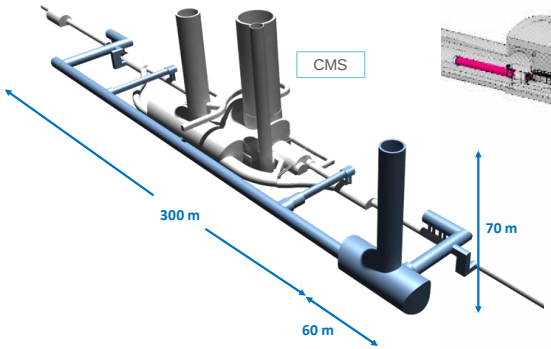
Magnetic shield mounted

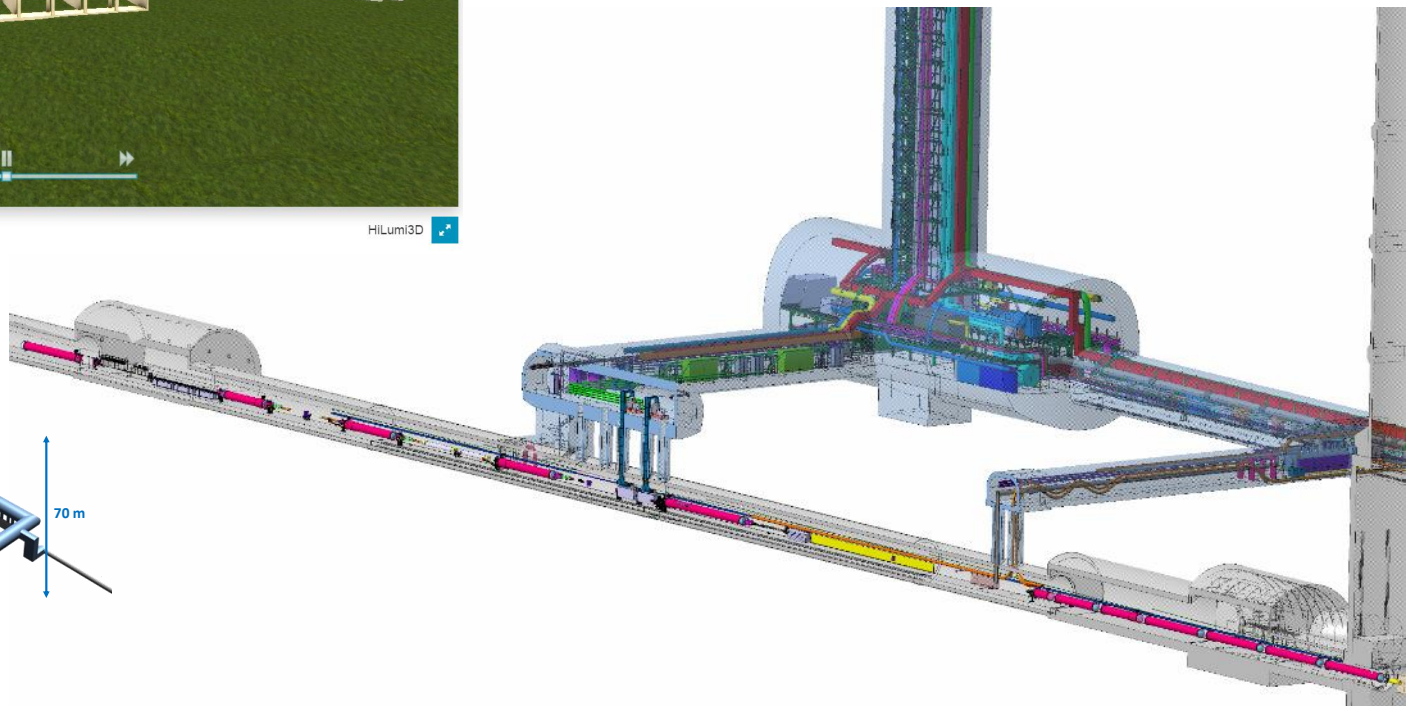
Progressing smoothly: week 42.
On time to install in the SPS during YETS2017-18!

HL-LHC: Civil Engineering design finalized

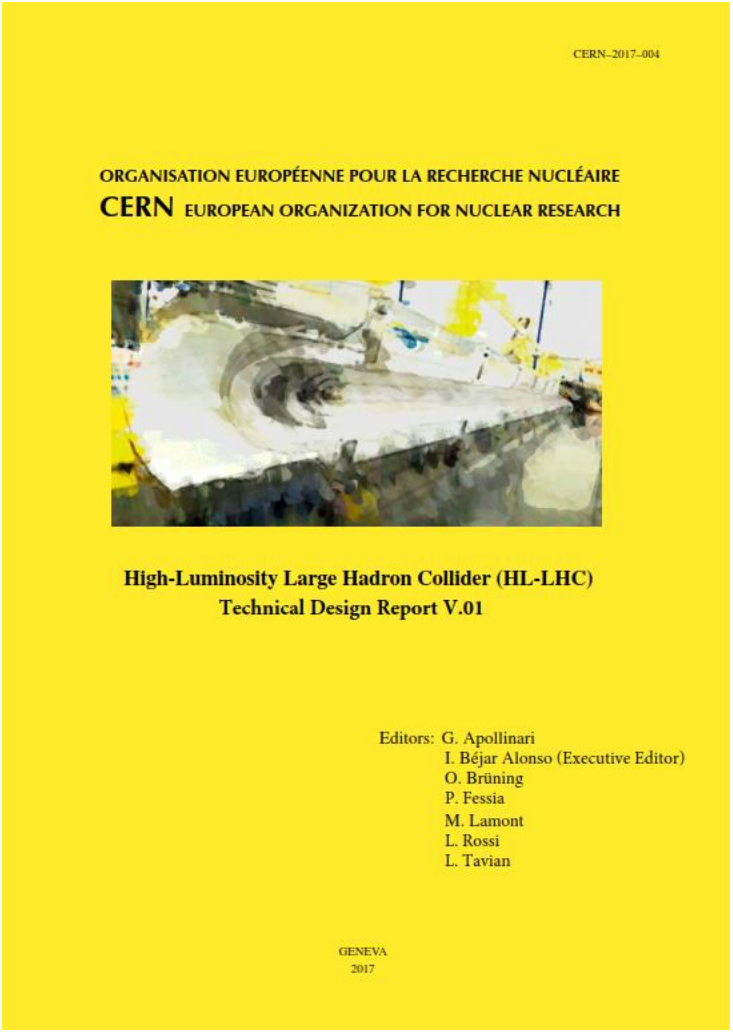
Civil engineering

- Invitation for Tenders (IT) issued by mid July 2017
- Offer assessment: Nov-Dec 2017 (double envelope system).
- adjudication of two contracts (one for Point 1 and one for Point 5) by FC in March 2018.





HL-LHC: TDR V0.1 (TDR V0, August 2016)



Printable Version on EDMS 183344 (565 pages)

https://edms.cern.ch/ui/file/1833445/0.1/HL-LHC_TDR_V.01.2017.08.04.h18.030.pdf

TDR V1 after the Cost &Schedule Review (March 2018).

LHC is not a walk in the park !

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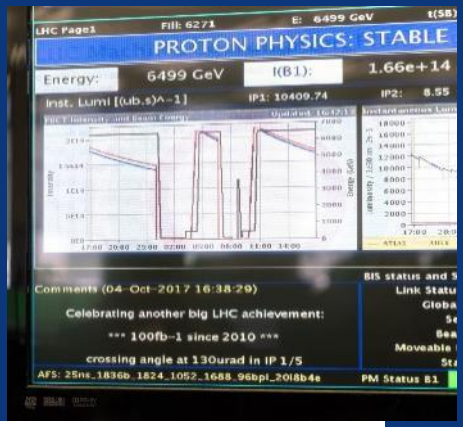
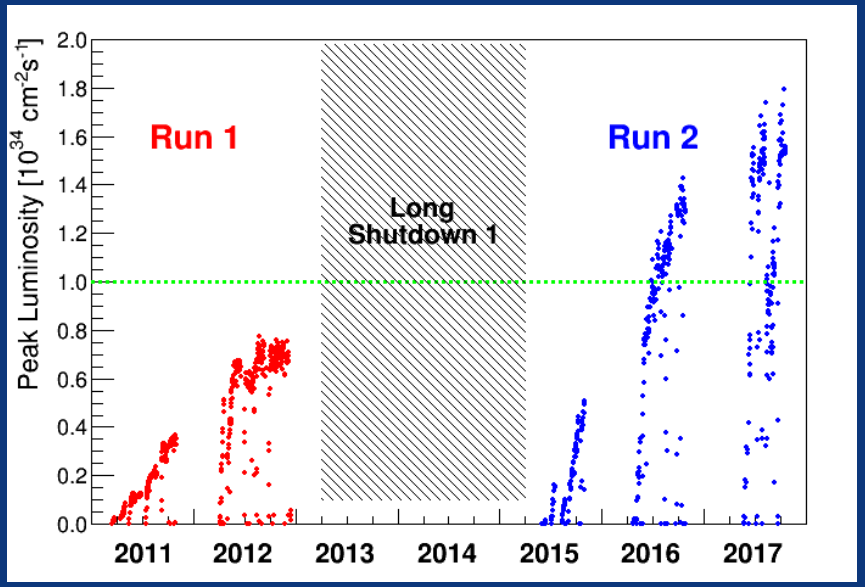
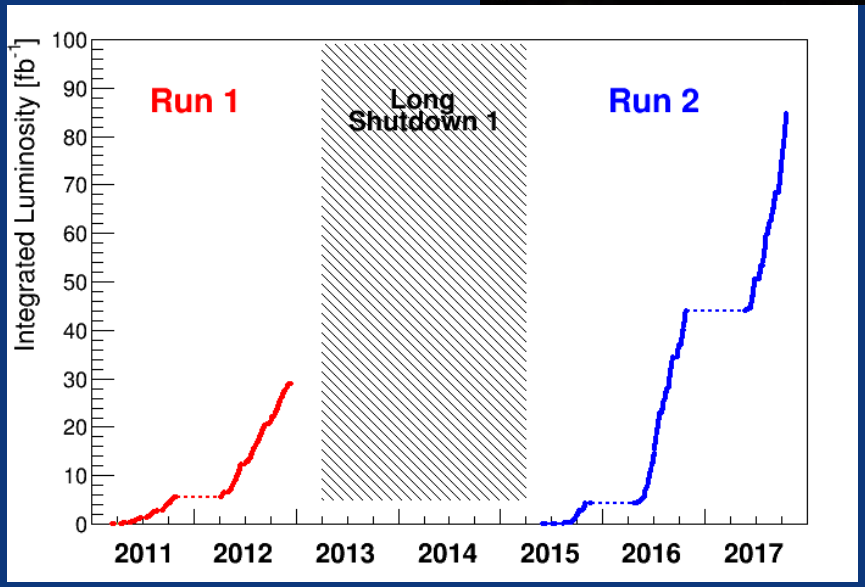
Thanks to a collective effort, numerous ideas and innovations:

- Operation with 8b4e with beta* = 30 cm
- Peak 2.2 10^{34} cm^{-2} s^{-1} but lumi levelling 1.5 10^{34} cm^{-2} s^{-1}
- Integrated luminosity > 41 fb^{-1}
- Sector 1-2 to ambient temperature during next YETS
- > 90 fb^{-1} goal maintained for 2017+2018

- Run 1 + Run 2 : over 100 fb^{-1} on 4th October 2017







Thanks for your attention