One intensive and fantastic year in 10 minutes !
~ one slide and less than one minute per month !

www.cern.ch

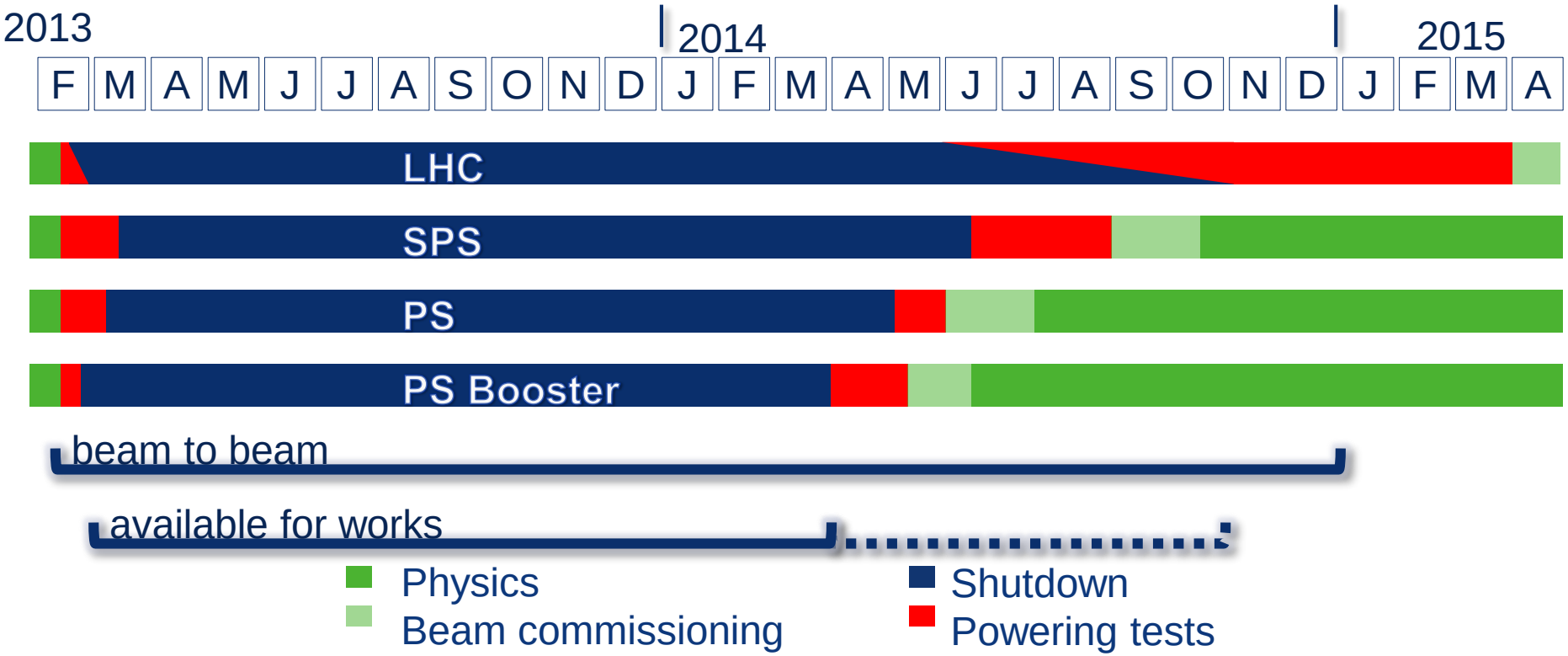
Status Report on the start-up activities
From LS1 to 4fb^{-1} at 13 TeV

Council – Open Session

Frédérick Bordry

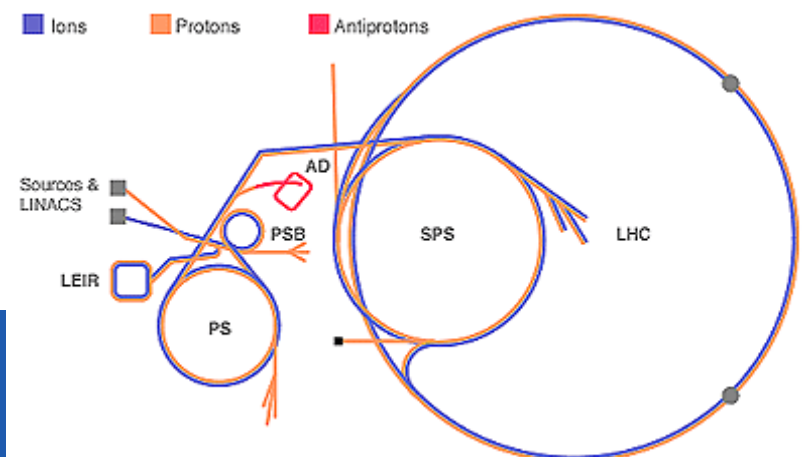
18th December 2015

January to March 2015: End of LS1 for the LHC



Over 1 Million Hours Worked in the LHC Tunnel

Safety First, Quality Second, Schedule Third.



April 2015 : First circulating beams in LHC on Easter Sunday

May 2015 : Beam commissioning

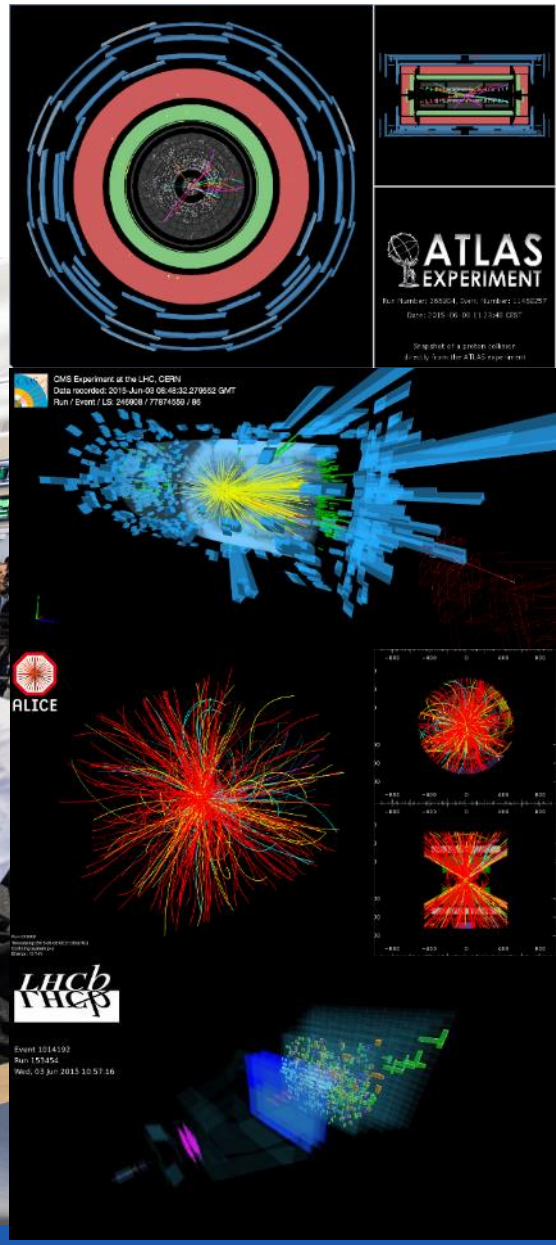
6.5 TeV

- **A lot of lessons learnt and experience from Run 1**
- Excellent and improved system performance (LS1)
  - Beam Instrumentation
  - Transverse feedback
  - RF
  - Collimation
  - Injection and beam dump systems
  - Vacuum
  - Machine protection
- Improved software & analysis tools (LS1)
- Magnetically reproducibility
- Optically good, corrected to excellent
- Behaving well at 6.5 TeV
  - One additional training quench so far
- Operationally well under control
  - Injection, ramp, squeeze, de-squeeze

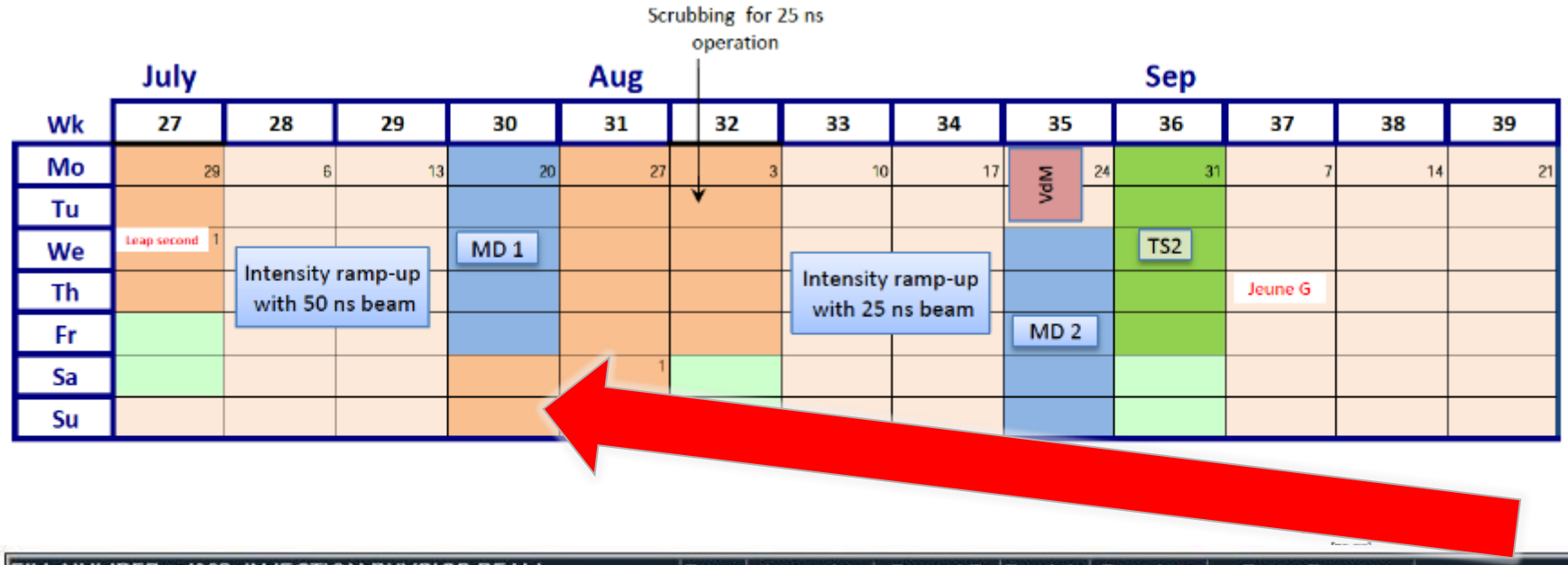
Terrific team work

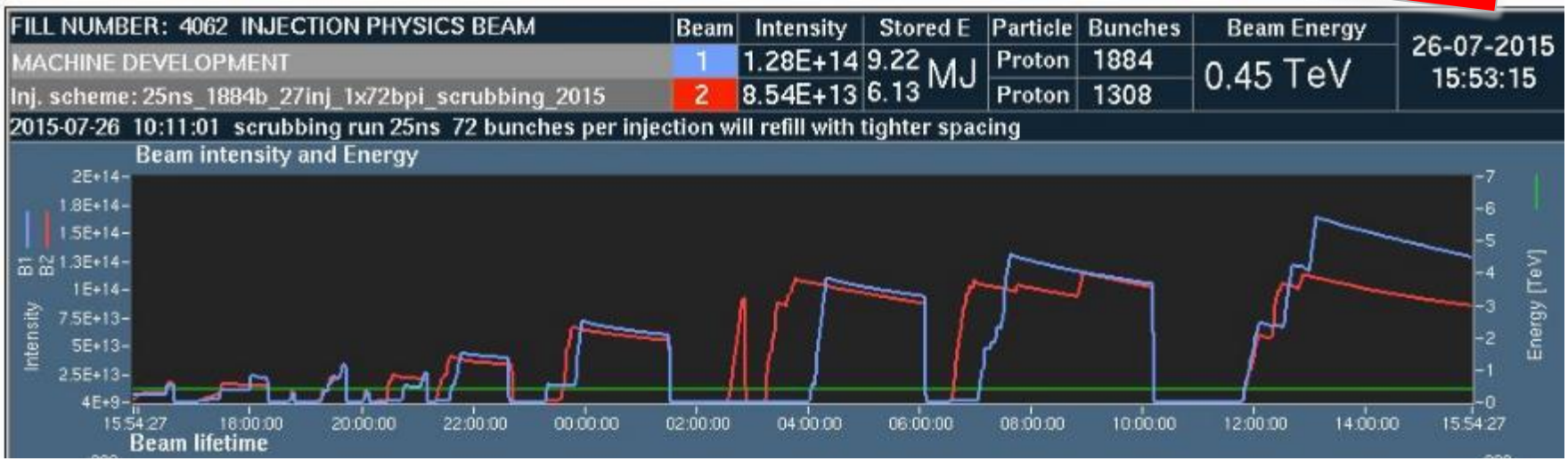
Beam commissioning in two months ☺

June 2015 : LHC experiments are back in business at a new record energy 13 TeV

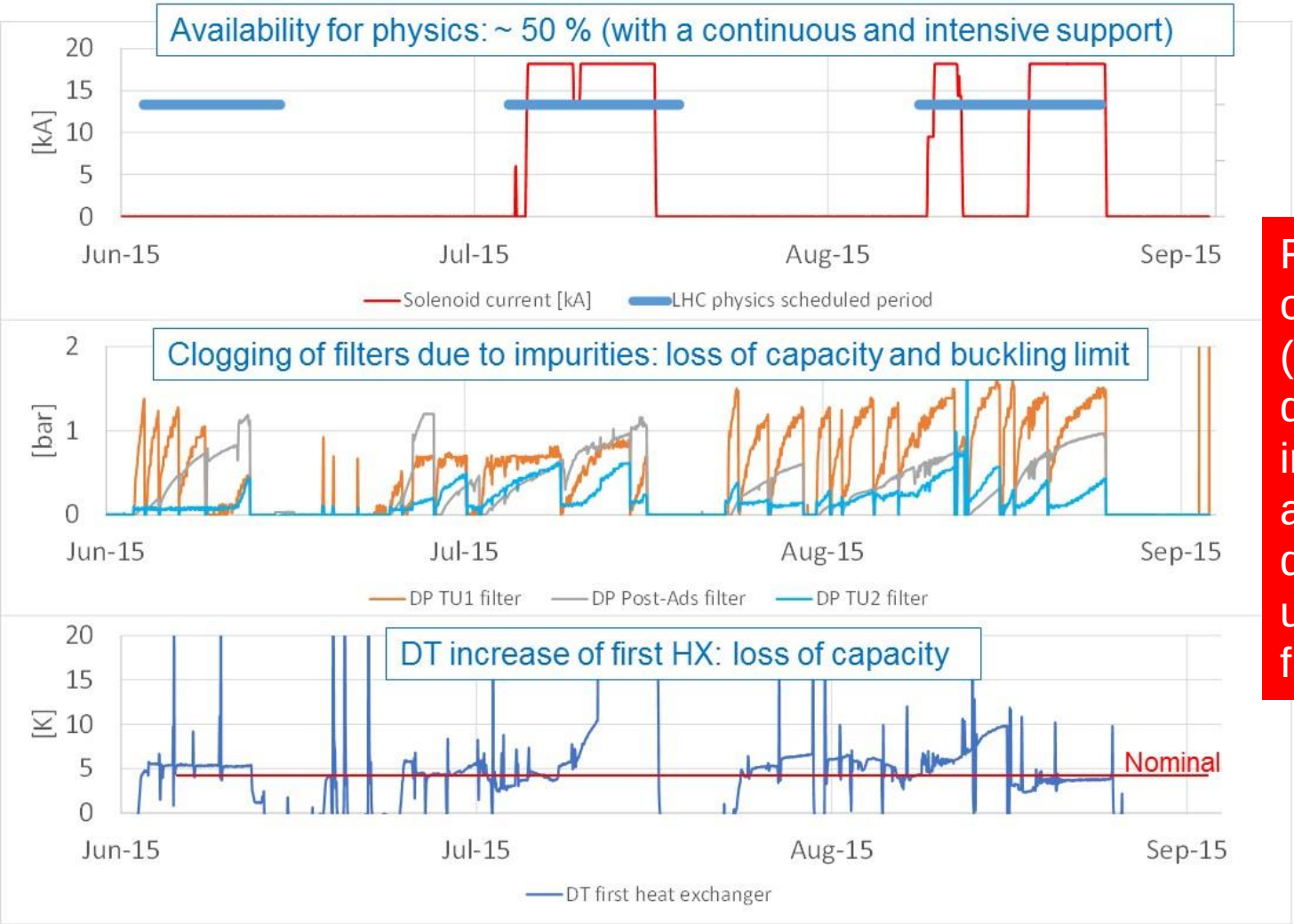


July 2015 : 50 ns Intensity ramp-up and 25 ns Scrubbing



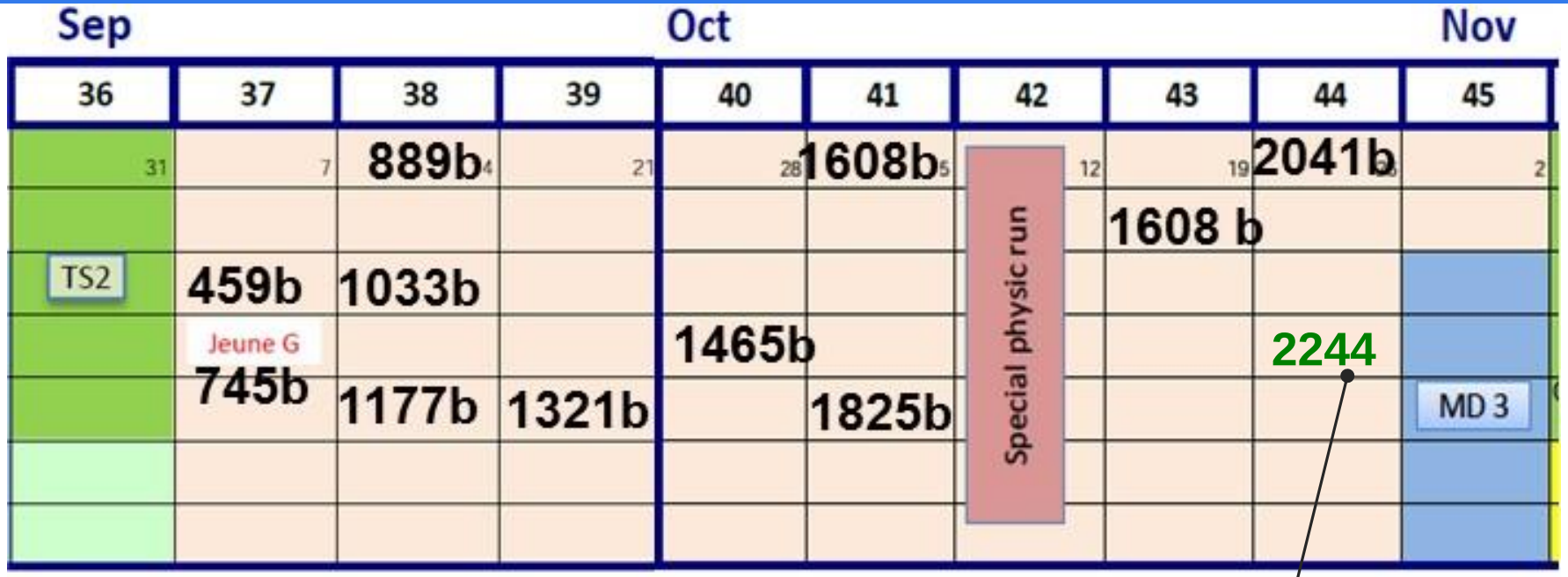


August 2015 : heroic fight against the CMS cold-box oil contamination

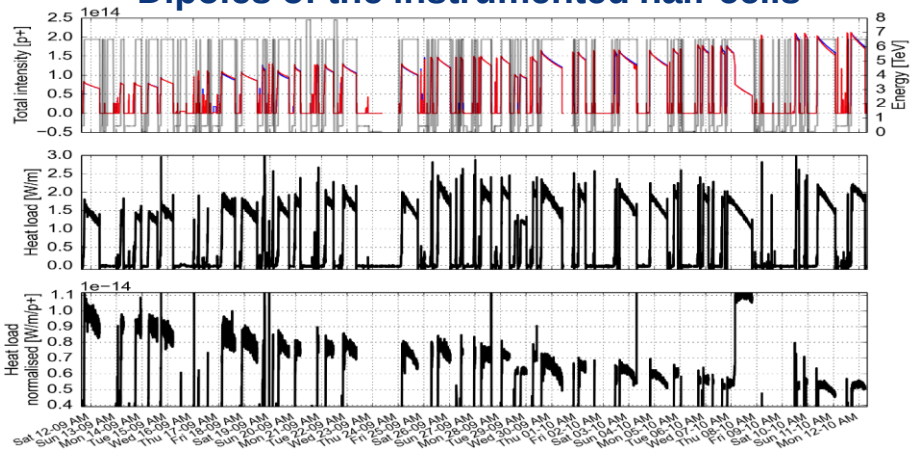


Finally in 2015: of the integrated (p-p) luminosity delivered to CMS in 2015, about 75% of the data is taken under nominal field conditions.

September and October 2015 : 25ns intensity ramp up



Dipoles of the instrumented half-cells



- Resume of the intensity ramp up after TS2
  - *First driven by machine protection validation*
  - *Then driven by cryo system operation*
- Special physics run (90 m optics)

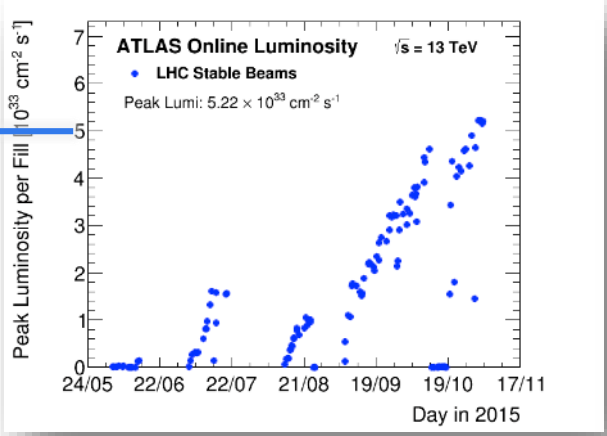
2015 LHC Luminosity (p-p)

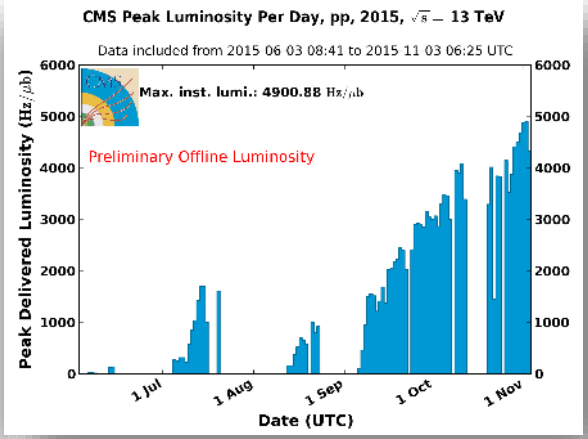
ATLAS | CMS

Peak

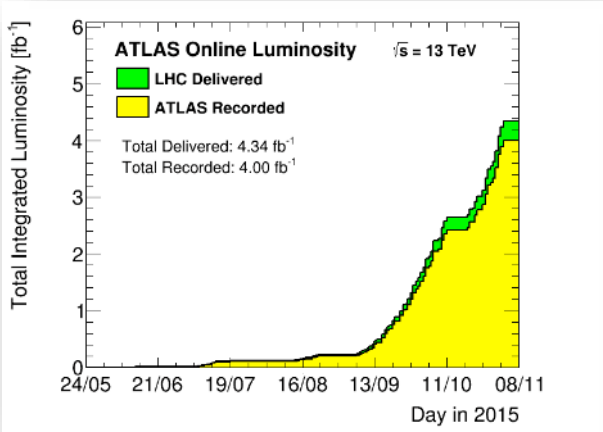
5 x 10^{33} cm^{-1} s^{-1}

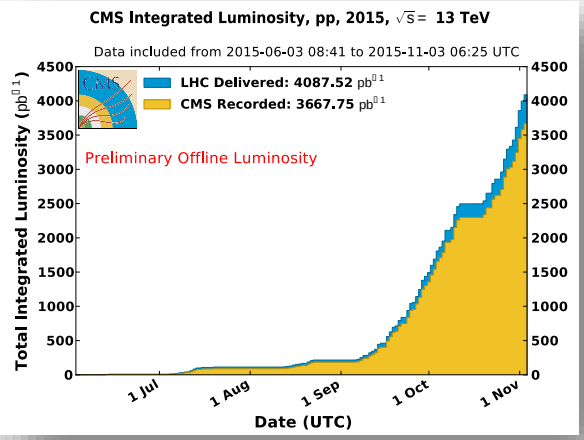
Design 10^{34} cm^{-1} s^{-1}





Integrated





2015 LHC Integrated Luminosity

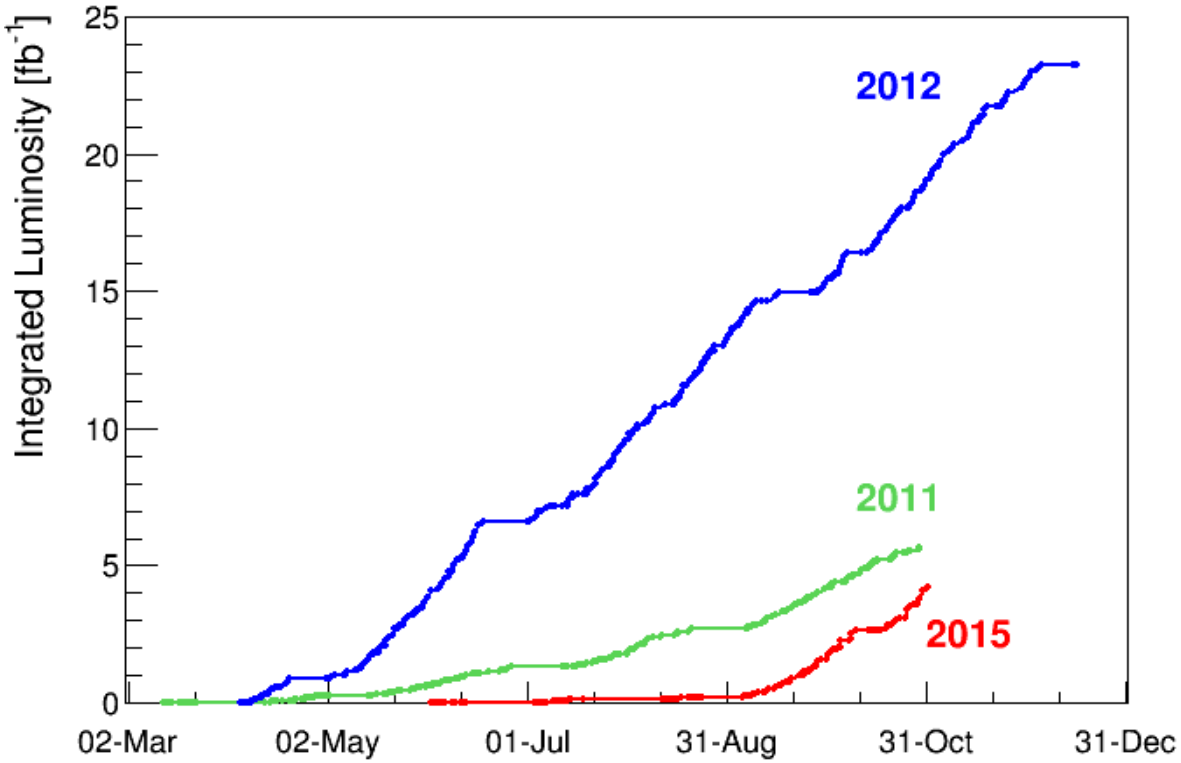
- The initial projections of integrated luminosity for 2015 were ~ 8-10 fb^{-1}.
- **Achieved ~ 4.3 fb^{-1}.**
- Slope at the end of the run better than in 2011, and close to 2012 slope

  (last week of operation > 1 fb^{-1})

The main reasons for the lower value:

- Start-up delays (~ 4 weeks),

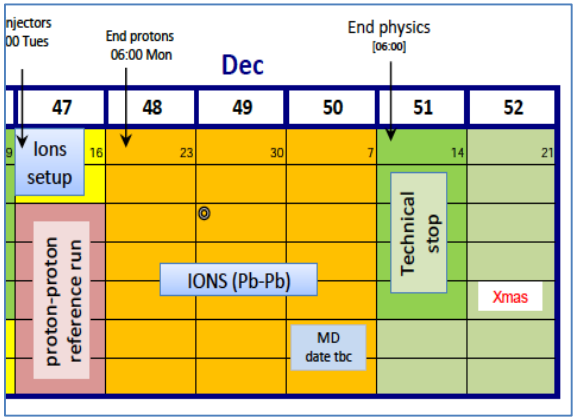
- Availability issues:
  radiation failures on the quench protection tunnel electronics; solved after TS2
- Electron clouds mitigation

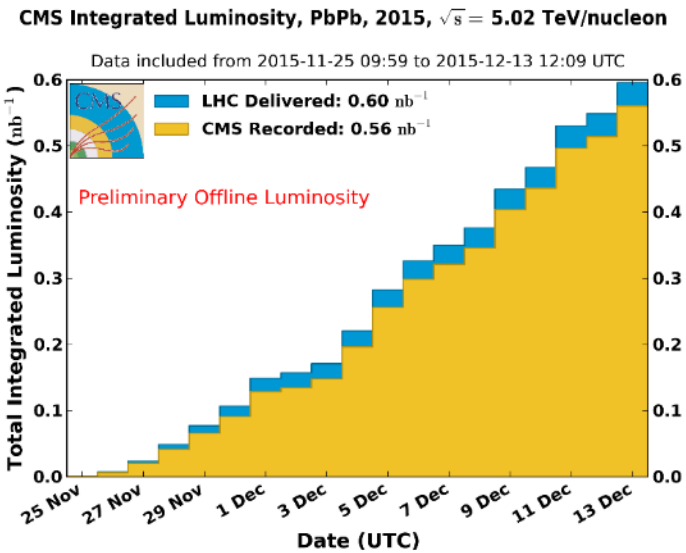


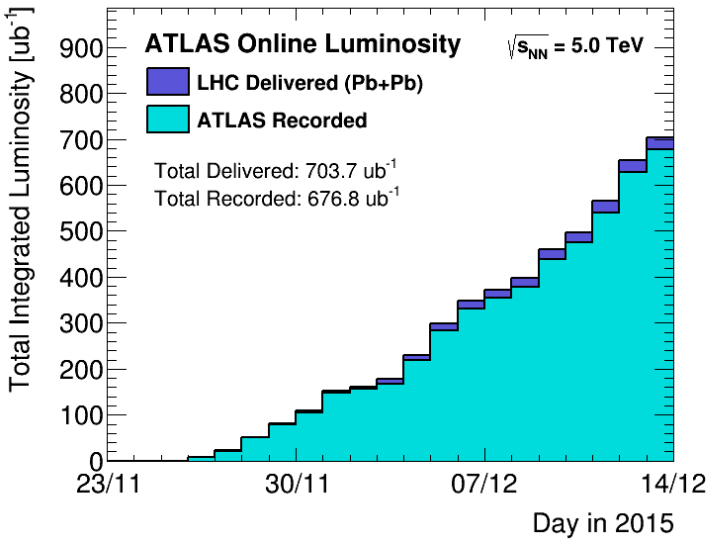
November and December: Lead-Lead physics run

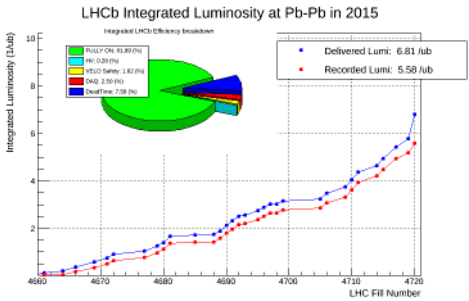
- Design peak lumi: 1×10^{27} $cm^{-2}s^{-1}$:
  - *ALICE leveled at design luminosity*
  - *ATLAS/CMS already beyond (up to 3.5×10^{27} $cm^{-2}s^{-1}$)*

- Delivered luminosity(3 weeks of physics):
  - *Target for 2015 ions run :300 - 500 μb^{-1}*
  - ***ALICE 430 μb^{-1}*** *; ATLAS/CMS ~700/600 μb^{-1}*



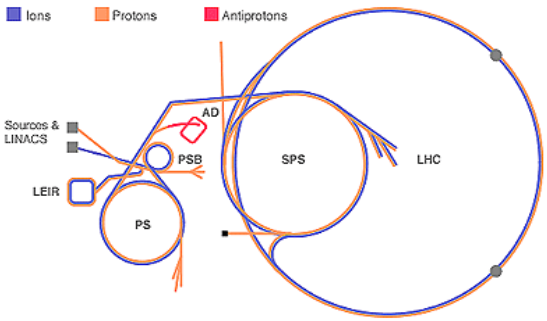






Courtesy John Jowett

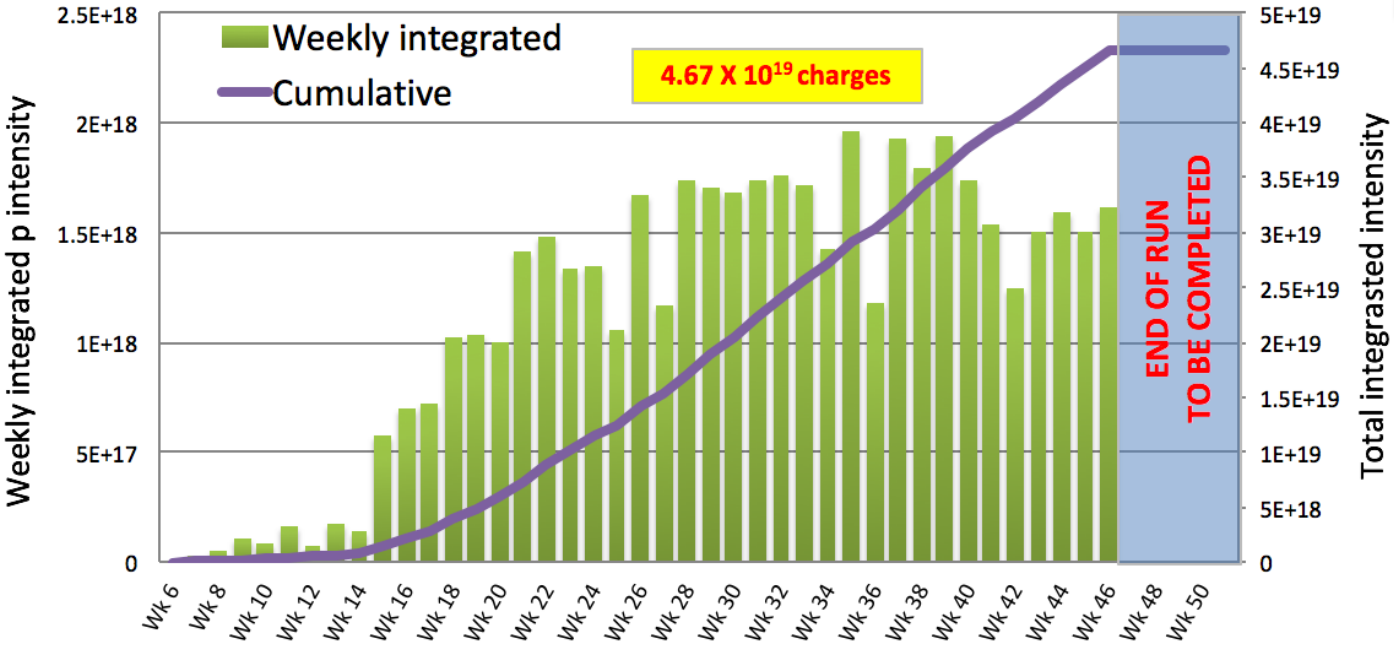
2015 a solid year for LHC injectors



One illustration: Intensity Accelerated in the PS

Total **4.67x10^{19}** charges, of which :

- 1.9 x 10^{19} for SPS fixed target beam (CT/MTE) setting up and physics → 41%
- 1.9 x 10^{19} for nTOF → 41%
- 1.7 x 10^{18} for LHC beams in PS, SPS and LHC (setting up, studies and physics) → 4%



The PS executed ~ 16 million cycles

Conclusions

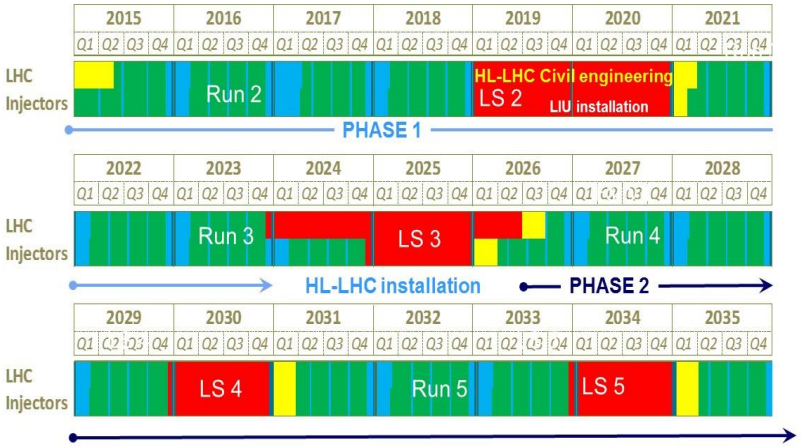
LHC is operational at 13 TeV c.m. and with 25ns beams (2x2244 nominal bunches)

From 2016 in production mode

- **6.5 TeV, machine scrubbed for 25 ns operation**
- **β^* = 40 cm in ATLAS and CMS**
- **Rapid intensity ramp up should be possible**
  - **Nominal design luminosity $1x10^{34}$ cm^{-2} s^{-1} should be reached**

RUN 2 goal : 100 fb^{-1} and to reach 300 fb^{-1} at the end of RUN 3

LHC Injector Upgrade (LIU => LS2) and High Luminosity LHC (HL-LHC =>LS3) well defined and now in construction phase



Full exploitation of the LHC with optimised planning out to 2035.

Thanks to the whole Injectors & LHC Team, Contractors and International Collaborators

Disclaimer: Impossible to mention everything in 10 minutes
Please forgive me if I forget your favourite topic
Mea Culpa …

"May the Force be with you"