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

Status Report on the start-up activities

*From LS1 to 4fb⁻¹ at 13 TeV*

Council – Open Session
Frédérick Bordry
18th December 2015
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
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

May 2015: Beam commissioning

Terrific team work
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

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

- **Availability for physics:** ~ 50 % (with a continuous and intensive support)

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.
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

Peak
$5 \times 10^{33} \text{ cm}^{-1} \text{s}^{-1}$
Design $10^{34} \text{ cm}^{-1} \text{s}^{-1}$

Integrated

CMS

CMS Peak Luminosity Per Day, pp, 2015, $\sqrt{s} = 13 \text{ TeV}$

CMS Integrated Luminosity, pp, 2015, $\sqrt{s} = 13 \text{ TeV}$

Data included from 2015-06-03 08:41 to 2015-11-03 06:25 UTC

Preliminary Offline Luminosity

ATLAS Online Luminosity

CMS Peak Luminosity Per Day, pp, 2015, $\sqrt{s} = 13 \text{ TeV}$

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Data included from 2015-06-03 08:41 to 2015-11-03 06:25 UTC

Preliminary Offline Luminosity
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

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)
November and December: Lead-Lead physics run

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

![Graph showing CMS Integrated Luminosity, PbPb, 2015, $\sqrt{s} = 5.02$ TeV/nucleon]

![Graph showing ATLAS Online Luminosity at $\sqrt{s_{NN}} = 5.0$ TeV]

![Graph showing LHCb Integrated Luminosity at Pb-Pb in 2015]
2015 a solid year for LHC injectors

One illustration: Intensity Accelerated in the PS

Total $4.67 \times 10^{19}$ charges, of which:

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

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
- $\beta^* = 40$ cm in ATLAS and CMS
- Rapid intensity ramp up should be possible
  - Nominal design luminosity $1\times10^{34}$ 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

"May the Force be with you"

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