



LHC Machine Status Report

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for the LHC team

126th LHCC meeting - 25 May 2016

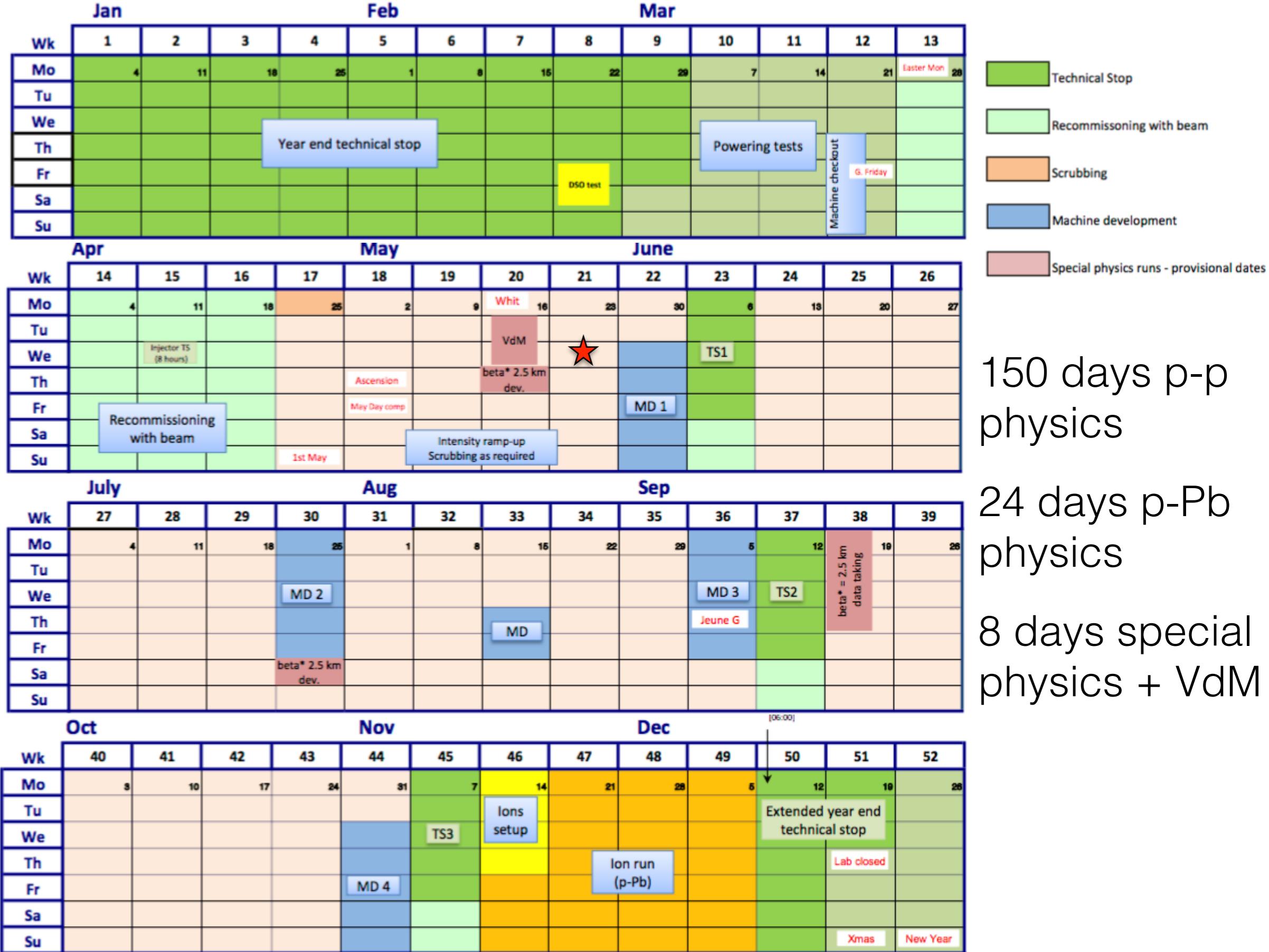
Outline

- Objectives for 2016
- Changes w.r.t. 2015
- Summary of the machines commissioning
- Status of the operation
- Plan for 2016

Objectives for 2016

- 2015 has been a recommissioning year after LS1
- 2016 will be the first production year of run 2
 - Increase the total number of bunches (288b trains)
 - Reduce the beam size at the IPs (β^* 40cm)
 - Shorter and faster intensity ramp-up (more luminosity)
- 2015: $\sim 4 \text{ fb}^{-1}$ integrated luminosity
- 2016: target is 25 fb^{-1} integrated luminosity

LHC Schedule for 2016



Main changes w.r.t. 2015

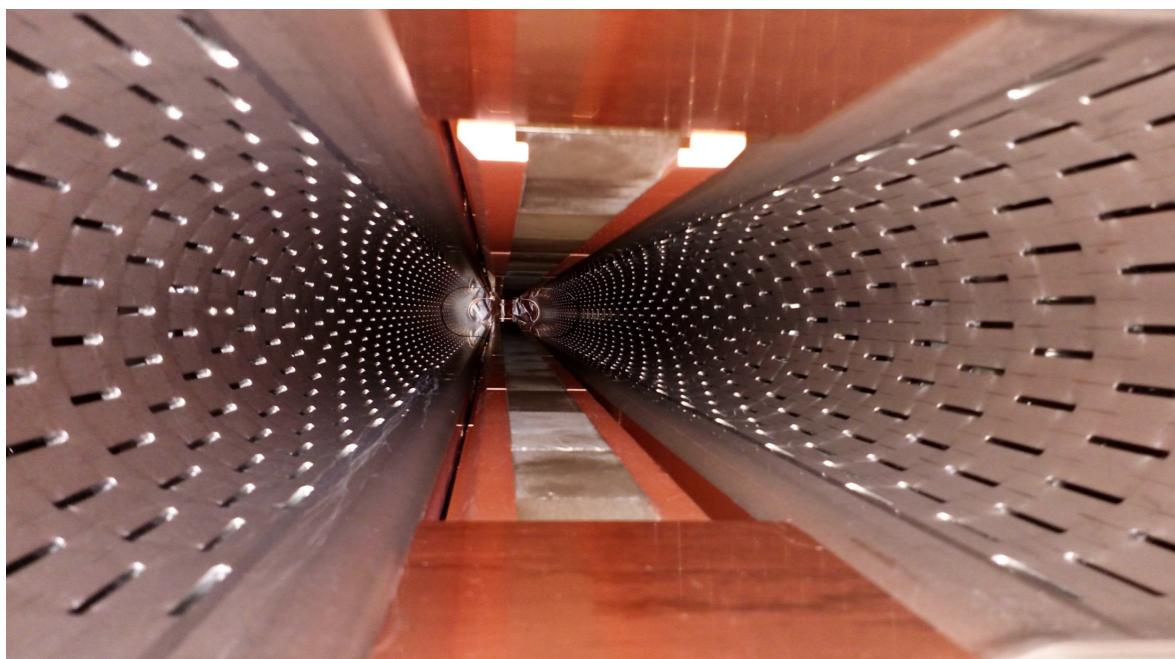
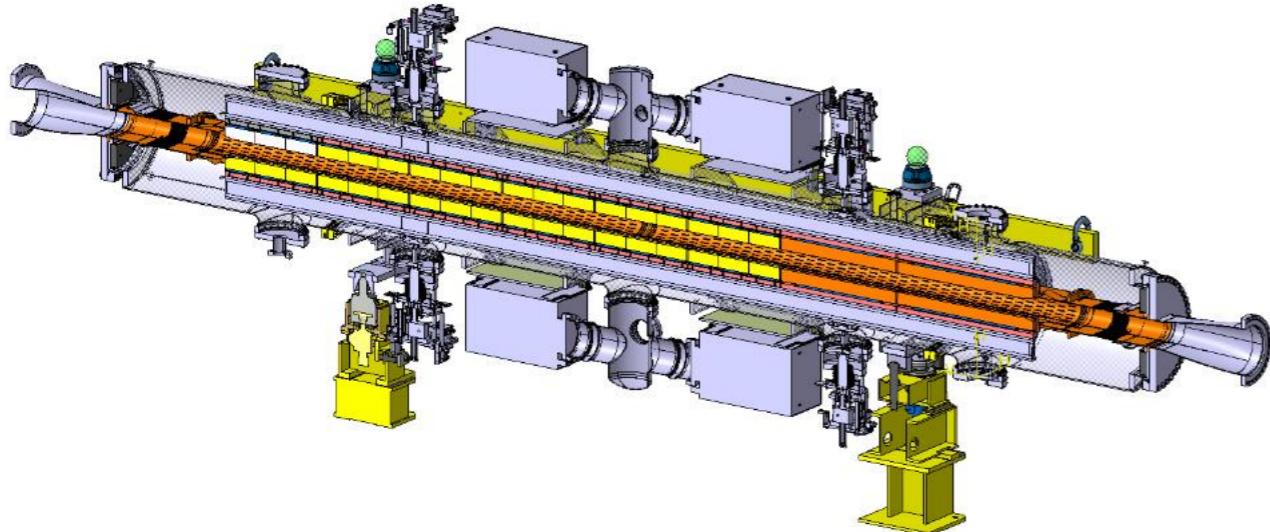
- Smaller beta* from 80cm to 40cm → Higher luminosity
- New combined ramp & squeeze → Shorter squeeze
- Better handling of e-cloud effects → Mitigate transients, reduced movement of triplet in IR8
- New TDIs → more bunches per injection from SPS → more bunches in the machine
- Changed BLM thresholds → Minimise dumps due to UFOs

Smaller beta*

$$\mathcal{L} \propto \frac{1}{\beta^*}$$

- Beta* limited by aperture in the focusing triplets
 - 40cm is the lower limit for a long range beam-beam separation of 11 sigma
- Increase in squeeze time
 - Compensated by combined ramp & squeeze
- Tighter collimators setting
 - Modified phase advance between IP6 and TCTs IP1&5

TDIs replacement



- Damaged BN ceramic tiles replaced with Cu coated graphite
- New TDI can cope with the injection of trains of 288 bunches

Commissioning milestones

YETS - Many interventions
on many systems

Ended on
March 4

Powering tests

Start March 4
End March 21

HW check out

BIS loop closed
March 23

Low intensity injection

First beam
March 25

Low intensity combined
ramp and squeeze

First CR&S
March 26

Low intensity squeeze

First squeeze
March 26

Corrections of
Optics, Q, Q[‘], C⁻

Nominal intensity

Injection

Combined ramp and
squeeze

Squeeze

First collisions

Collimators setup

First stable beams

Bunch trains injection

Physics
Intensity ramp-up

Started operation with
nominals March 29

CR&S on April 6

First collisions April 8

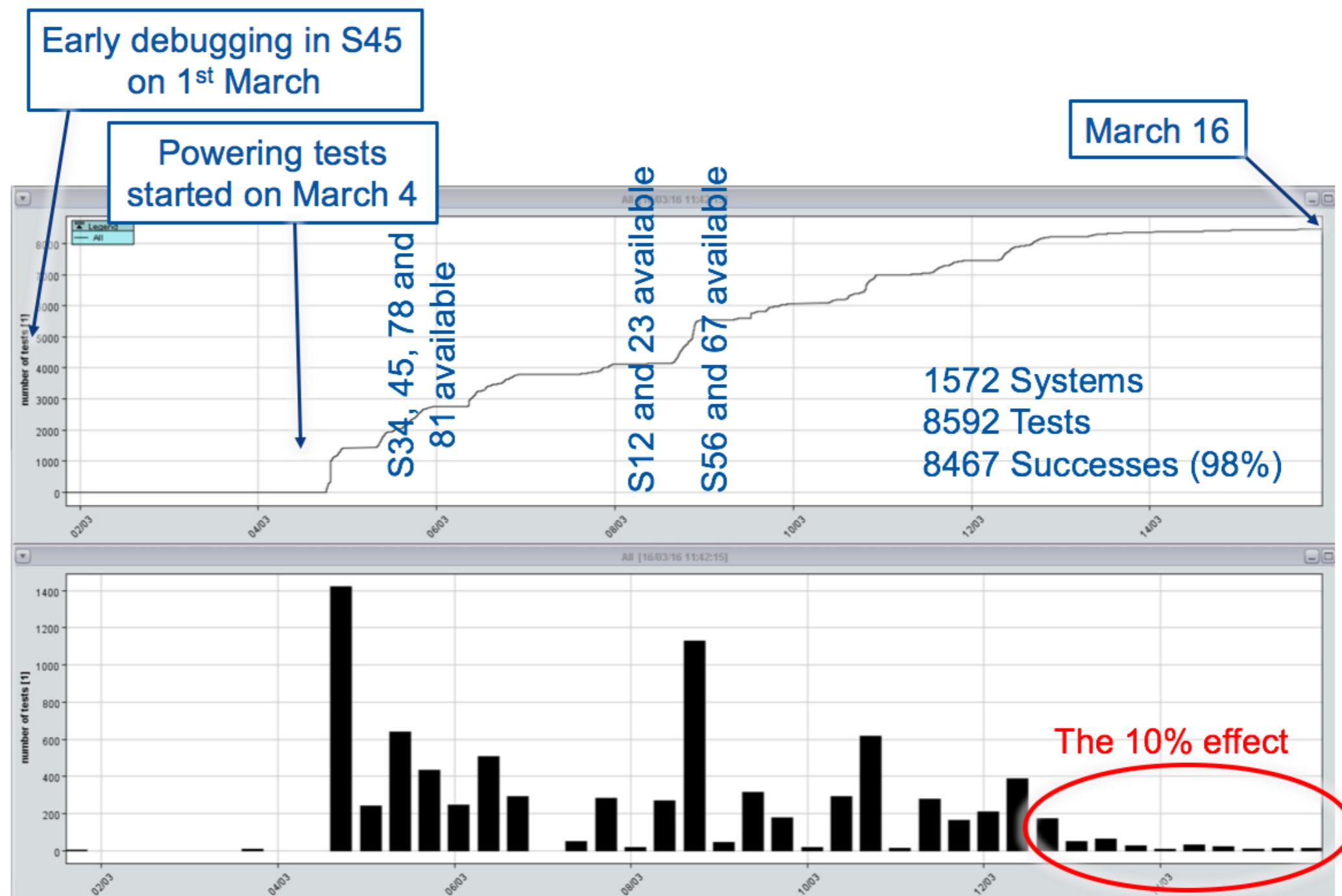
April 23 3b+3b
April 24 12b+12b

72b April 21

1177b May 18

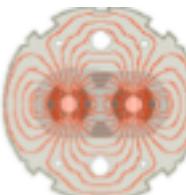
Included special bump in IP5 to
increase dispersion in TOTEM

Powering tests

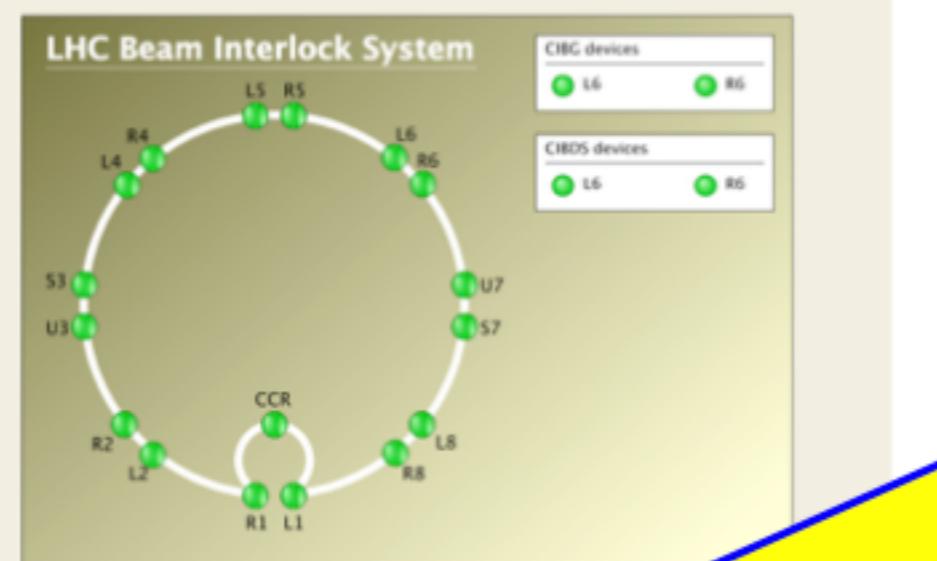




Successful completion of cold checkout



25 March Morning



23:27:32

5L5.B2	-20.01	19.99	TCSGA5R7.B2	-20
4L5.B2	-19.98	19.98	TCSGB5R7.B2	-19
7.4R5.B2	-15	20	TCSGA6R7.B2	-19
1.4R5.B2	-14.98	19.99	TCP.B6R7.B2	-20
76		20	TCP.C6R7.B2	-19
4A4L6.B2	-20.01	20	TCP.D6R7.B2	-20
4A4L6.B2			IP8	
77		19.98	TCLIB.6L8.B2	-20
A7L7.B2	-19.98	19.93	TCLIA.4L8	-20
D6L7.B2	-19.98	10.02	TDI.4R8	-1
C6L7.B2	-20.01	25	TCTPV.4R8.B2	-24
B6L7.B2	-19.98	15	TCTPH.4R8.B2	-1
A6L7.B2	-19.98		TI8	
6L7.B2	-20	10	TCDIH.87441	-1
E5L7.B2	-19.98	10	TCDIV.87645	-1
D5L7.B2	-19.98	9.98	TCDIH.87804	-1
B5L7.B2	-19.97	9.99	TCDIH.87904	-9.
A4L7.B2	-19.98	10	TCDIH.88121	-9.
A4R7.B2	-19.98	10.01	TCDIV.88123	-9.
B4R7.B2	-19.96			
D4R7.B2	-20			
OFFMOMENTUM_POS_DP				
OFFMOMENTUM_NEG_DP				

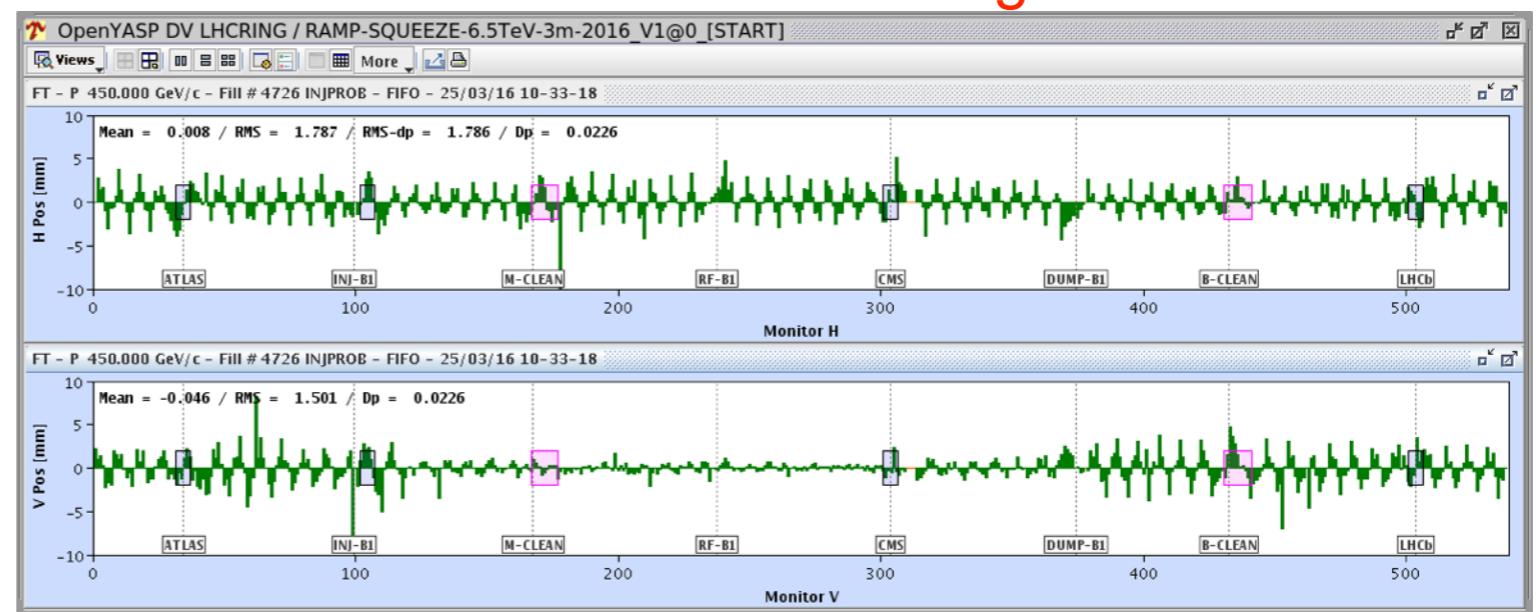
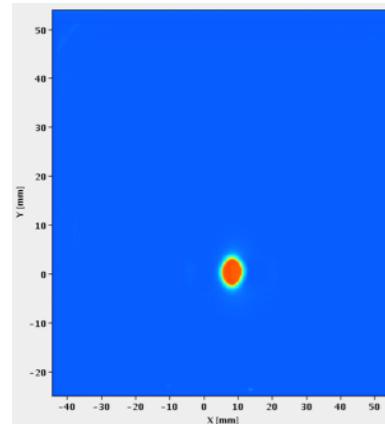
LHC is ready for beam

Injection & Threading

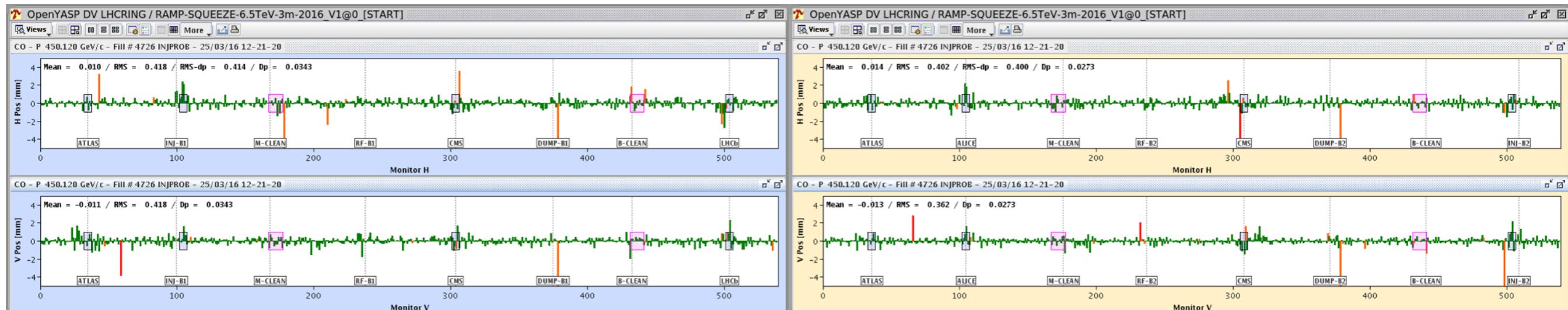
25 March Morning

10:34 B1Circulating

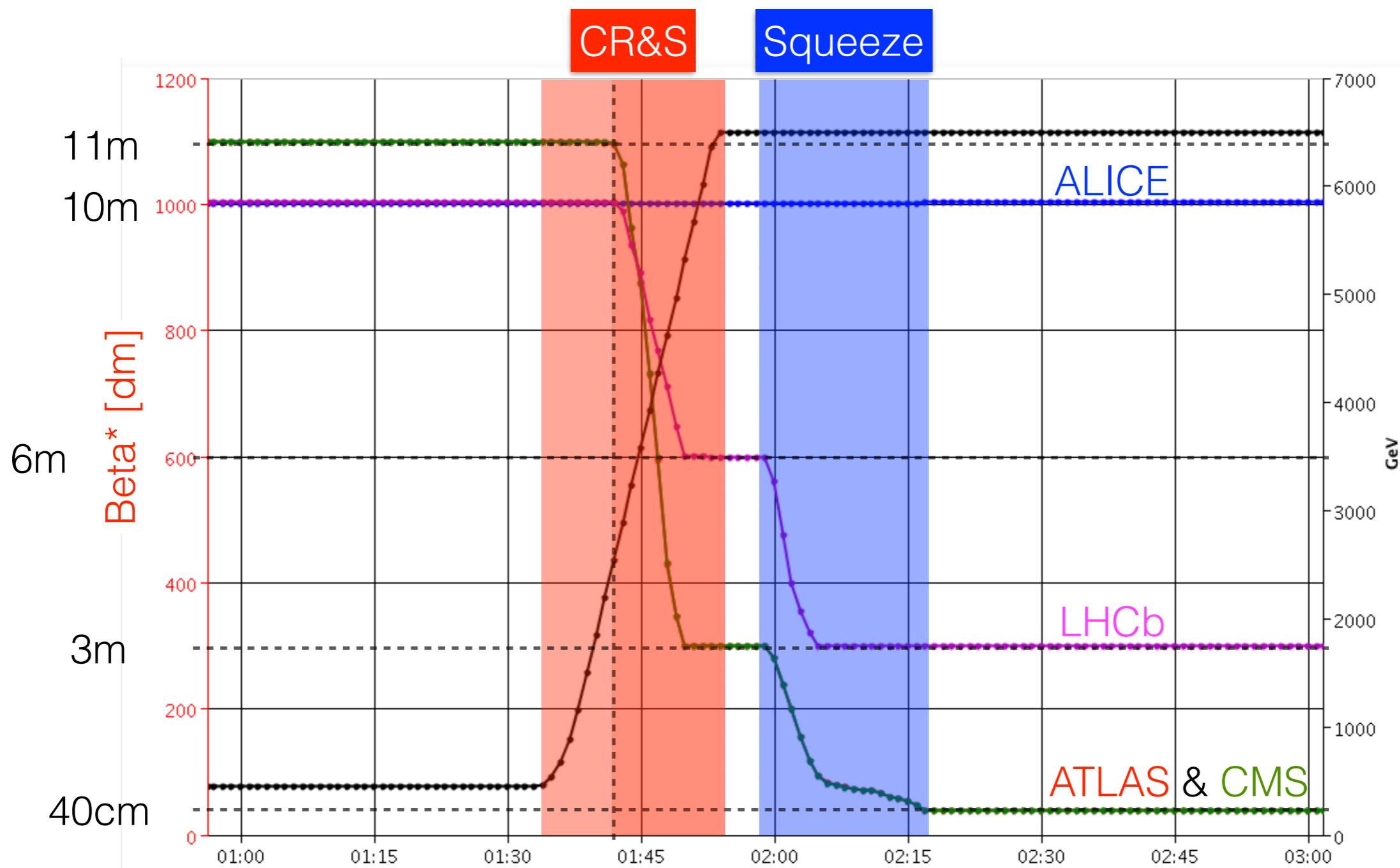
10:13 B1Injected



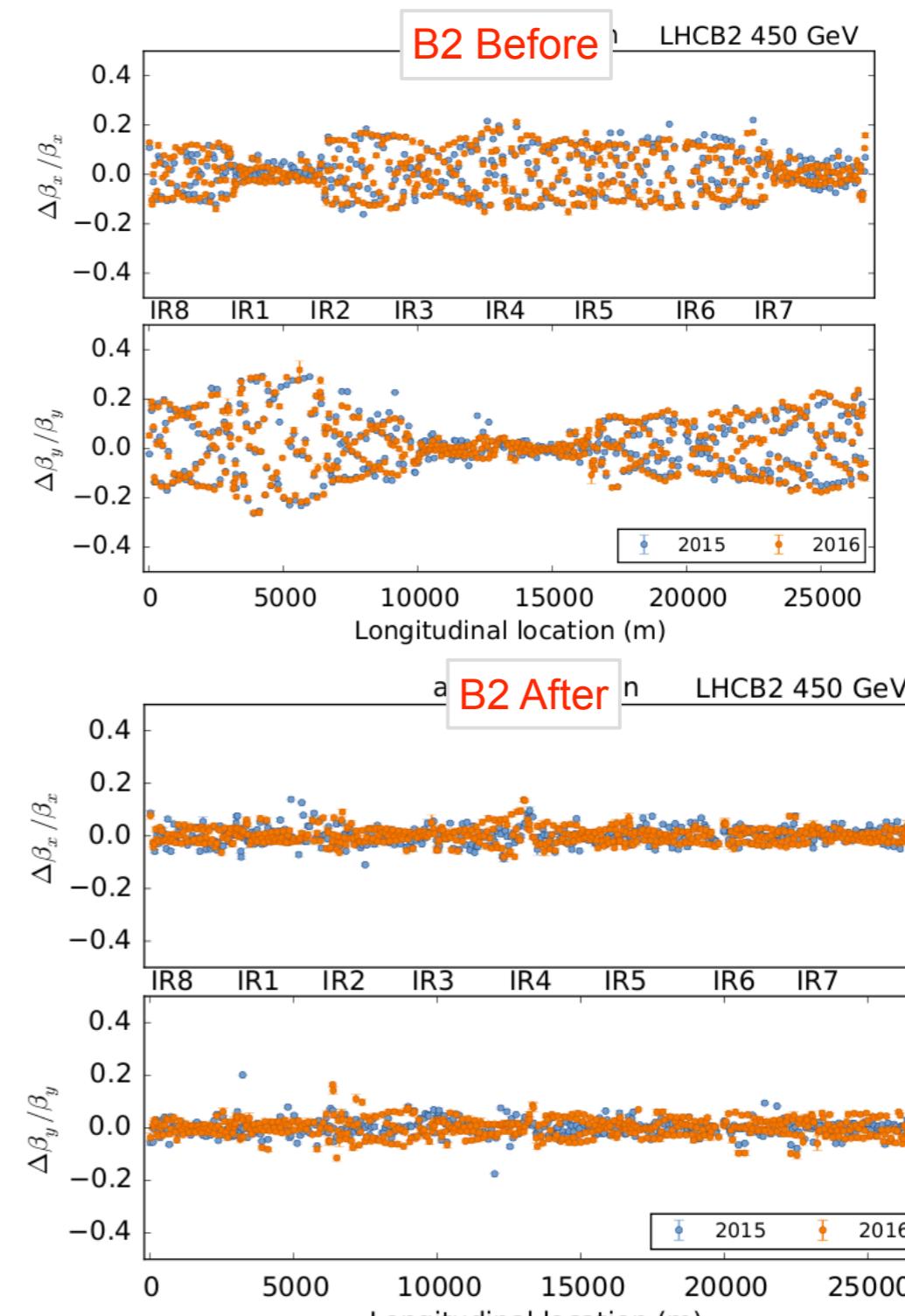
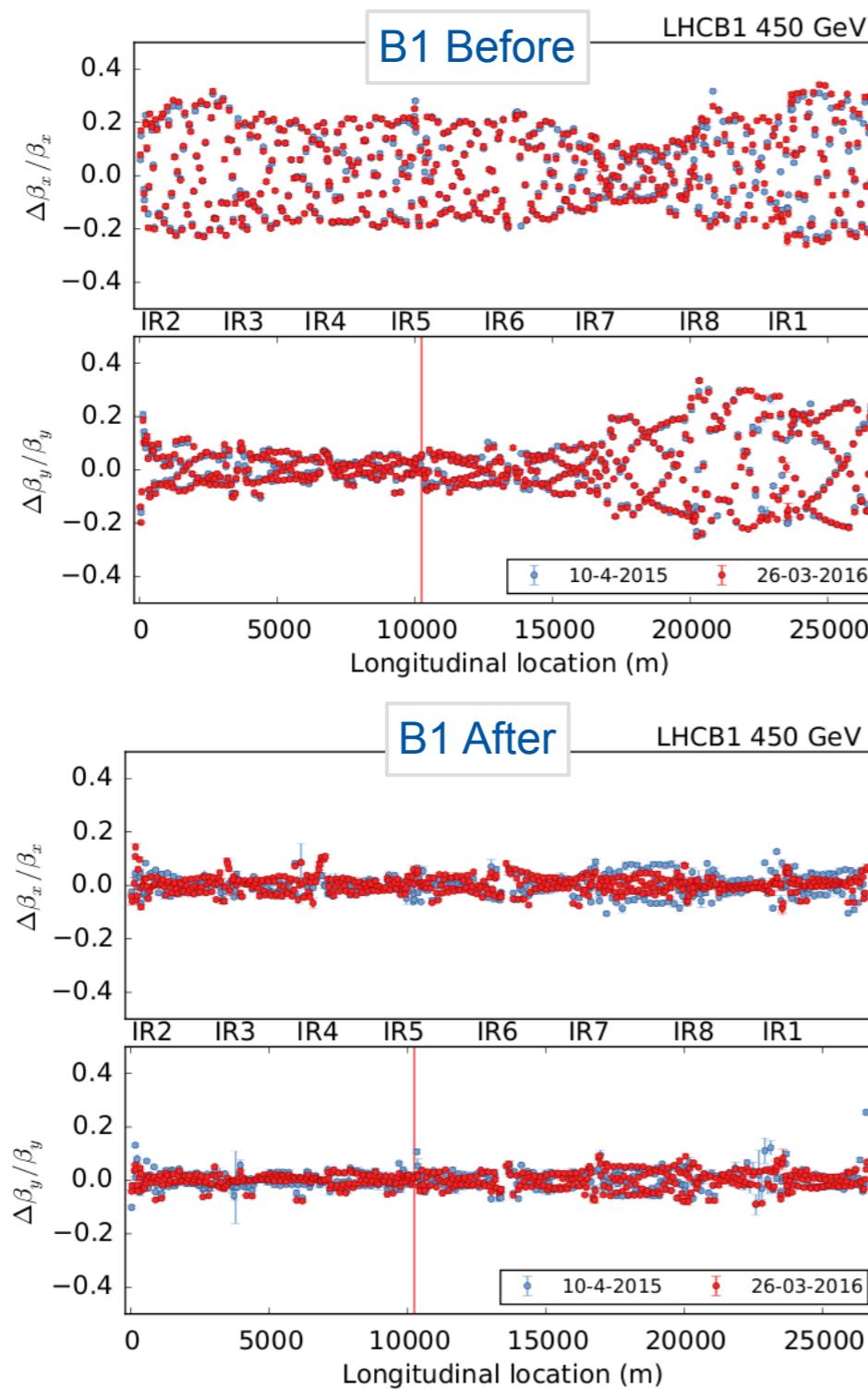
12:22 B1 and B2 circulating and orbit corrected



Combined Ramp & Squeeze

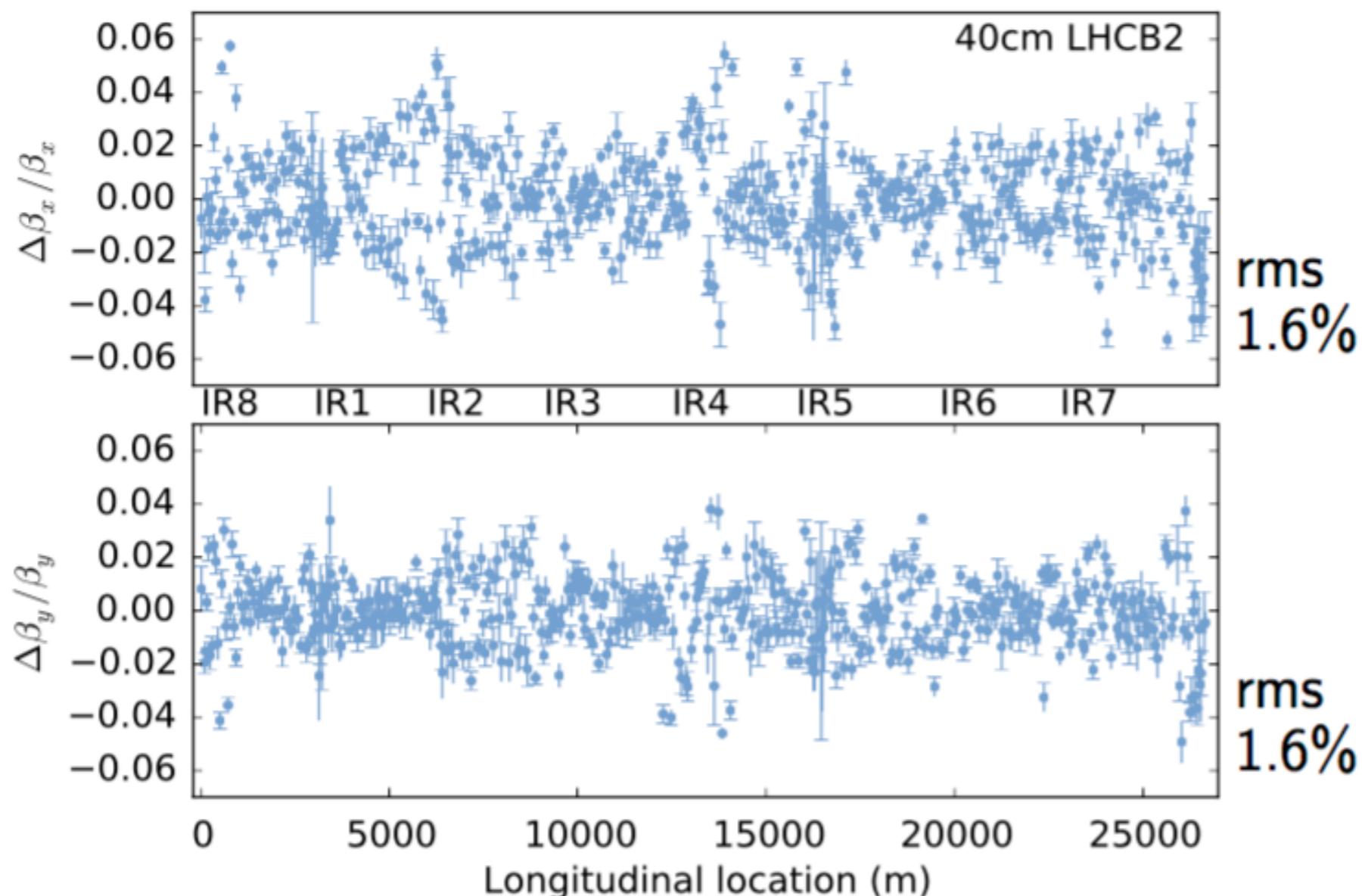


Optics corrections at 450 GeV

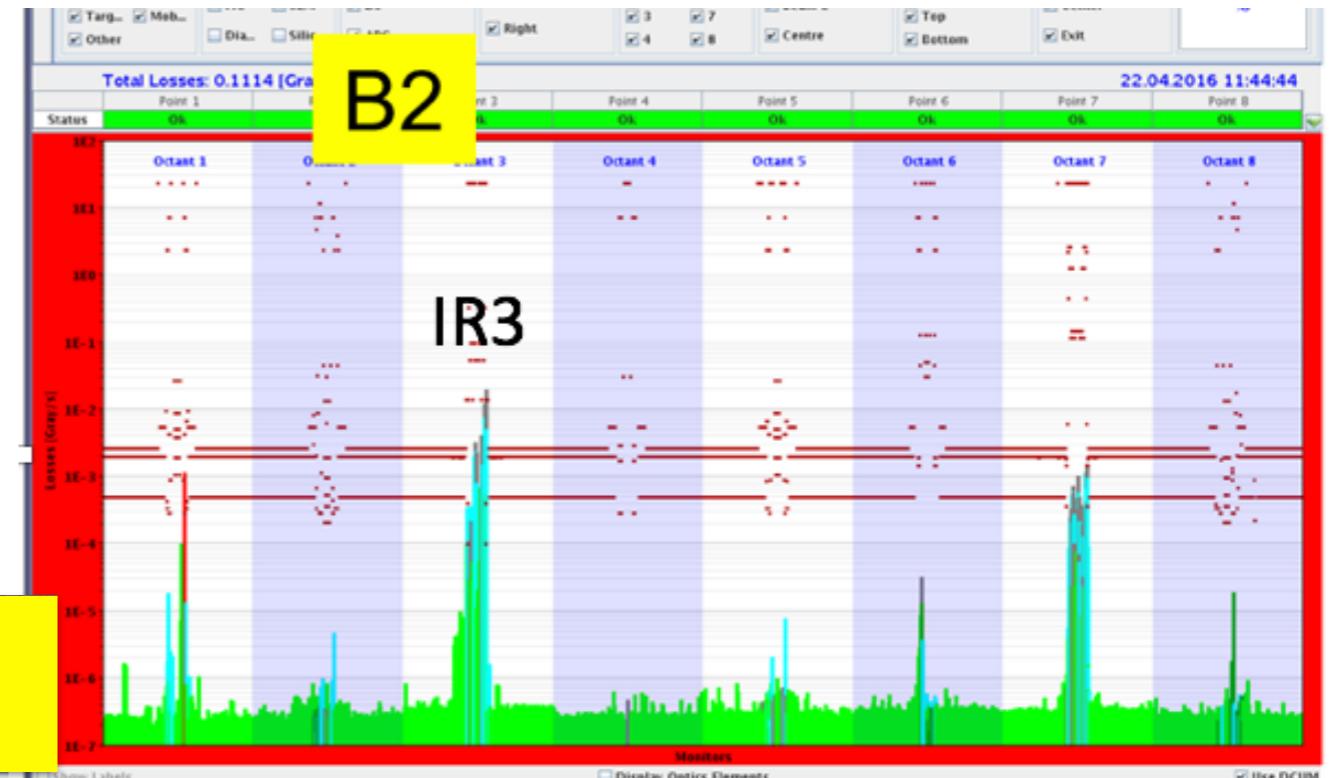
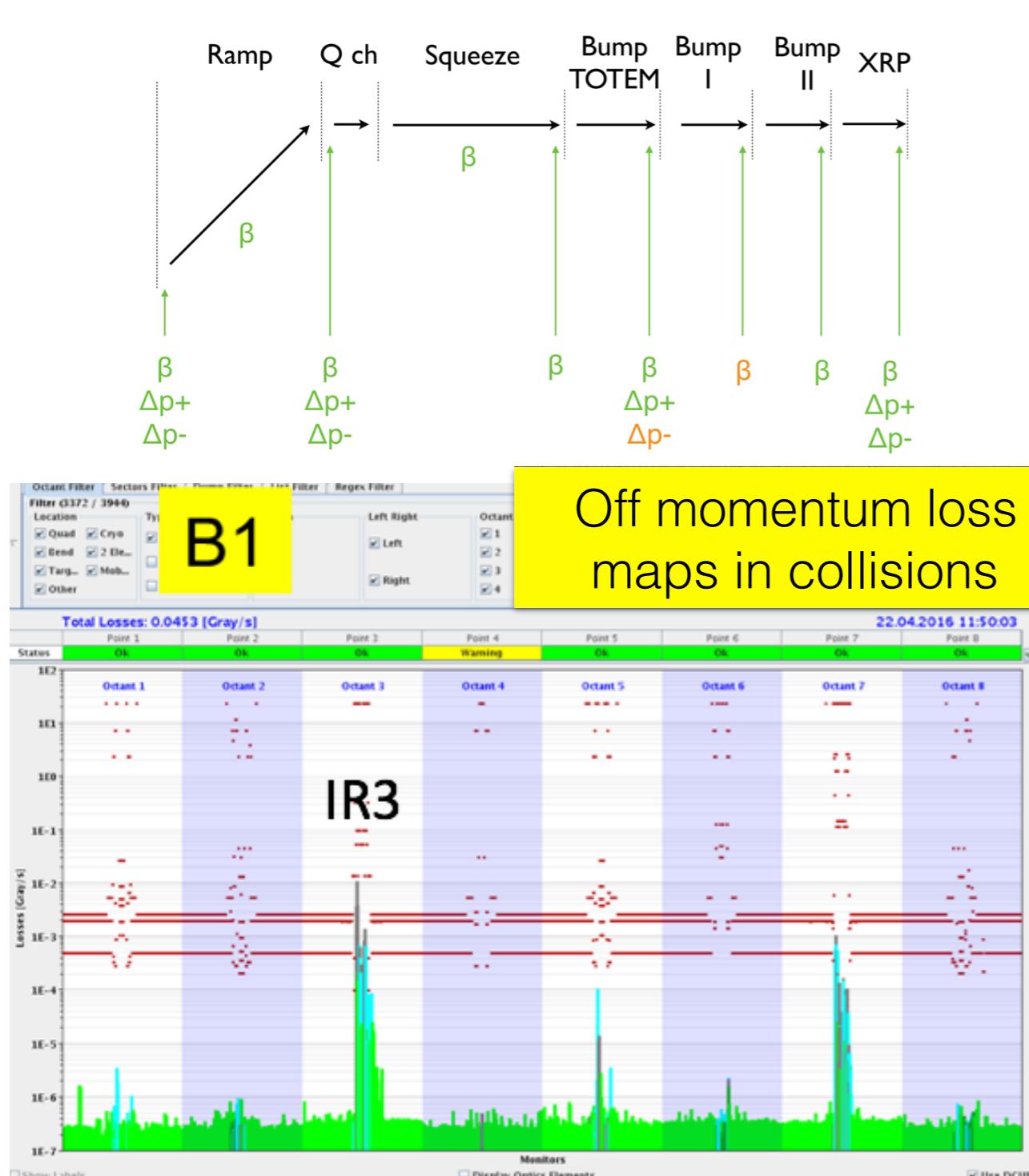


Optics corrections

Squeeze: 40cm, Beam 2



Loss maps



Loss maps need to be performed for all different cycles!

Refinement of HW and tool has reduced the time from days to hours

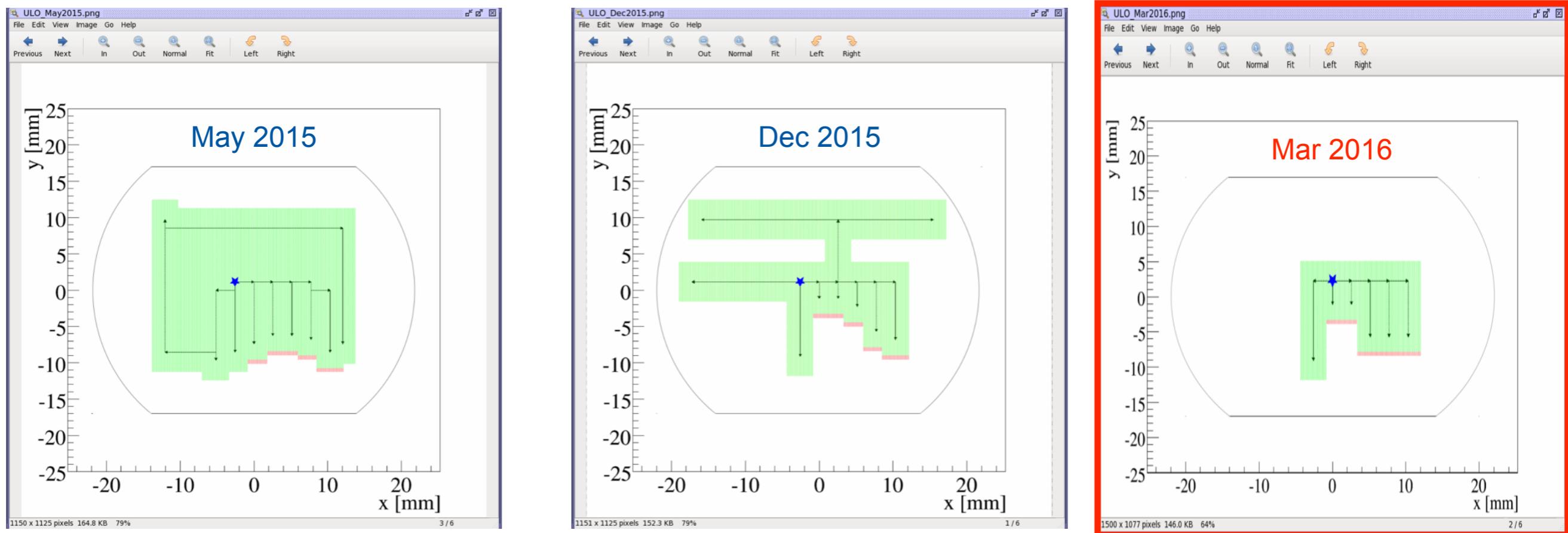
Special cycles

- Van der Meer scans for luminosity calibration
 - Scheduled early in the run
 - Completed for ATLAS, ALICE and LHCb
 - Need to be completed/repeated for CMS
- Large beta* run
 - Scheduled later in the year
- Proton-Lead physics

Possible performance limitations

- Unidentified laying object (ULO)
 - Reduces available aperture
- Unidentified falling objects (UFO)
 - Trigger beam dumps and magnet quenches
- Electron cloud
 - Limits number of bunches and degrades beam quality
- Hardware faults rate
 - Fault tracking tools (identify critical systems)
 - Consolidations (using fault tracking as input)
 - R2E project (SEU almost gone)

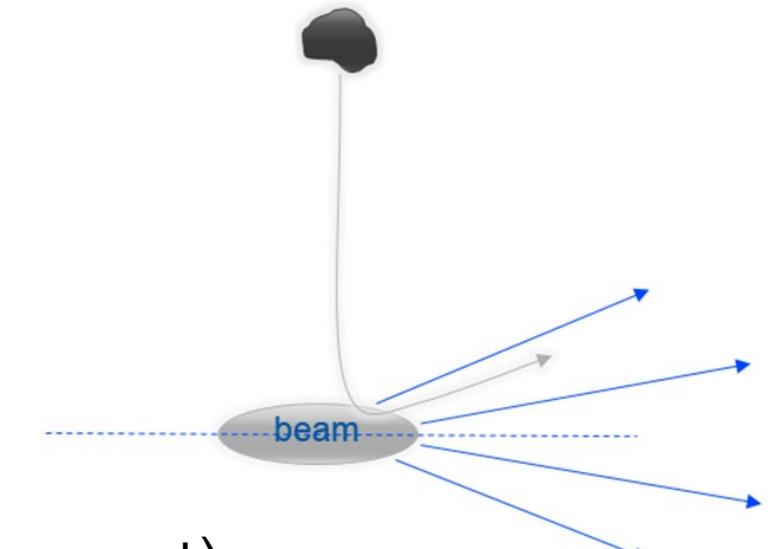
ULO in 15R8



The unidentified laying object in cell 15R8 causes an aperture restriction

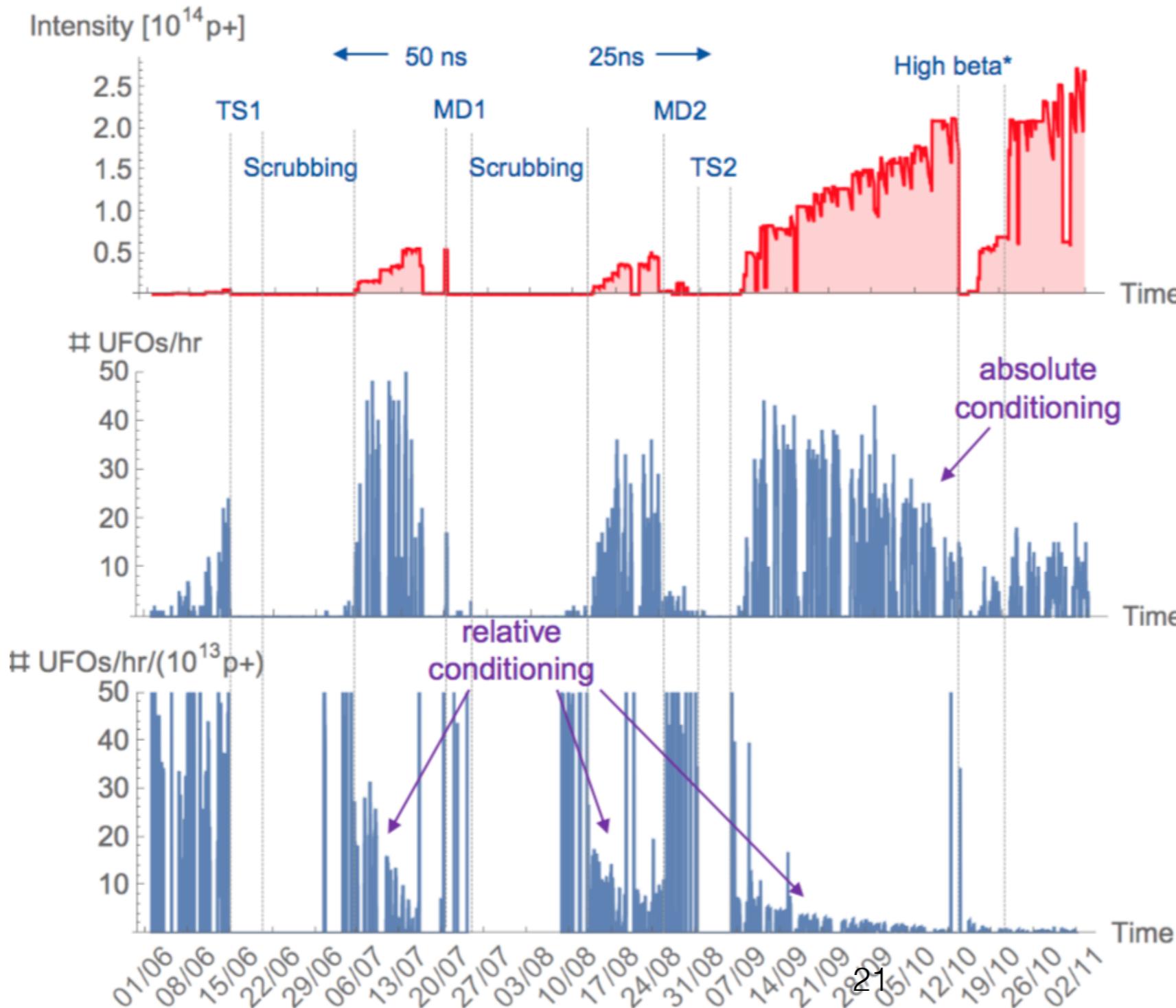
A scan was performed early on during commissioning and the restriction was found to be similar to 2015

UFOs



- In 2015 14 UFO-related beam dumps
 - 3 UFO-induced quenches (BLM could not prevent)
 - 9 BLM trigger after UFO event already over.
 - 1 BLM trigger may have shortened the UFO but there was no risk of quenching.
 - 1 BLM trigger potentially avoided a quench.
- Decided to increase threshold of BLM for 2016
 - Number of UFO-induced quenches slightly higher (in 2015 +1)
 - Number of unnecessary dumps decreased (in 2015 -10)

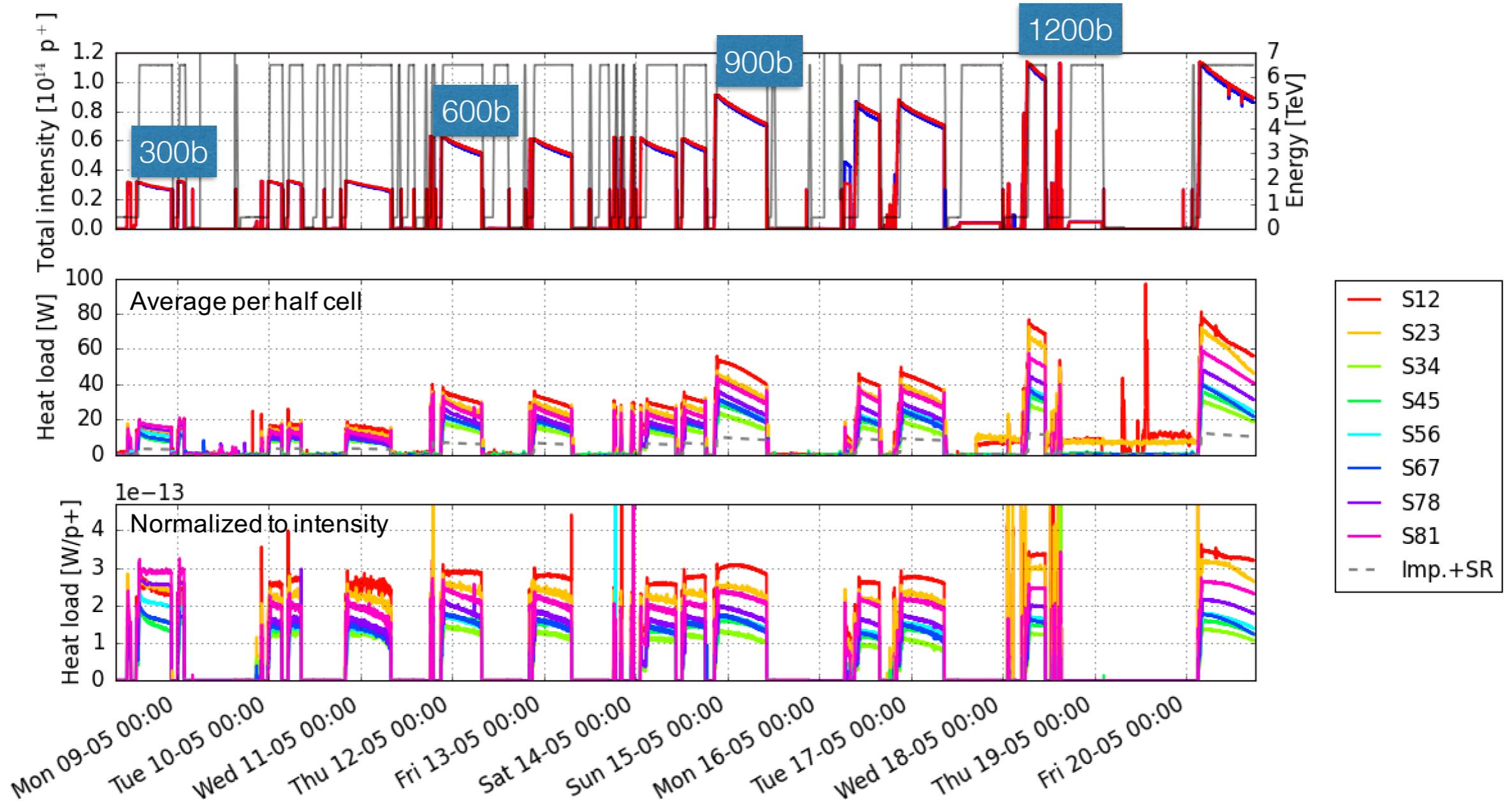
UFO conditioning in 2015



For 2016

- Statistics and intensity still low, too early to quantify the situation
- For the time being one event of UFO-induced quench

Present e-cloud status



No dedicated scrubbing time, will happen during physics

Long faults

- SPS dump (TIDVG) developed a small leak in the vacuum vessel
 - Limit bunch trains to 72b to prevent increase of leak
 - Spare being prepared
- 66kV transformer fault caused by small animal
 - 6 days of down time
- PS main power supply
 - Back-up system failed while main system under repaired. 5 days downtime

LHC Schedule for 2016

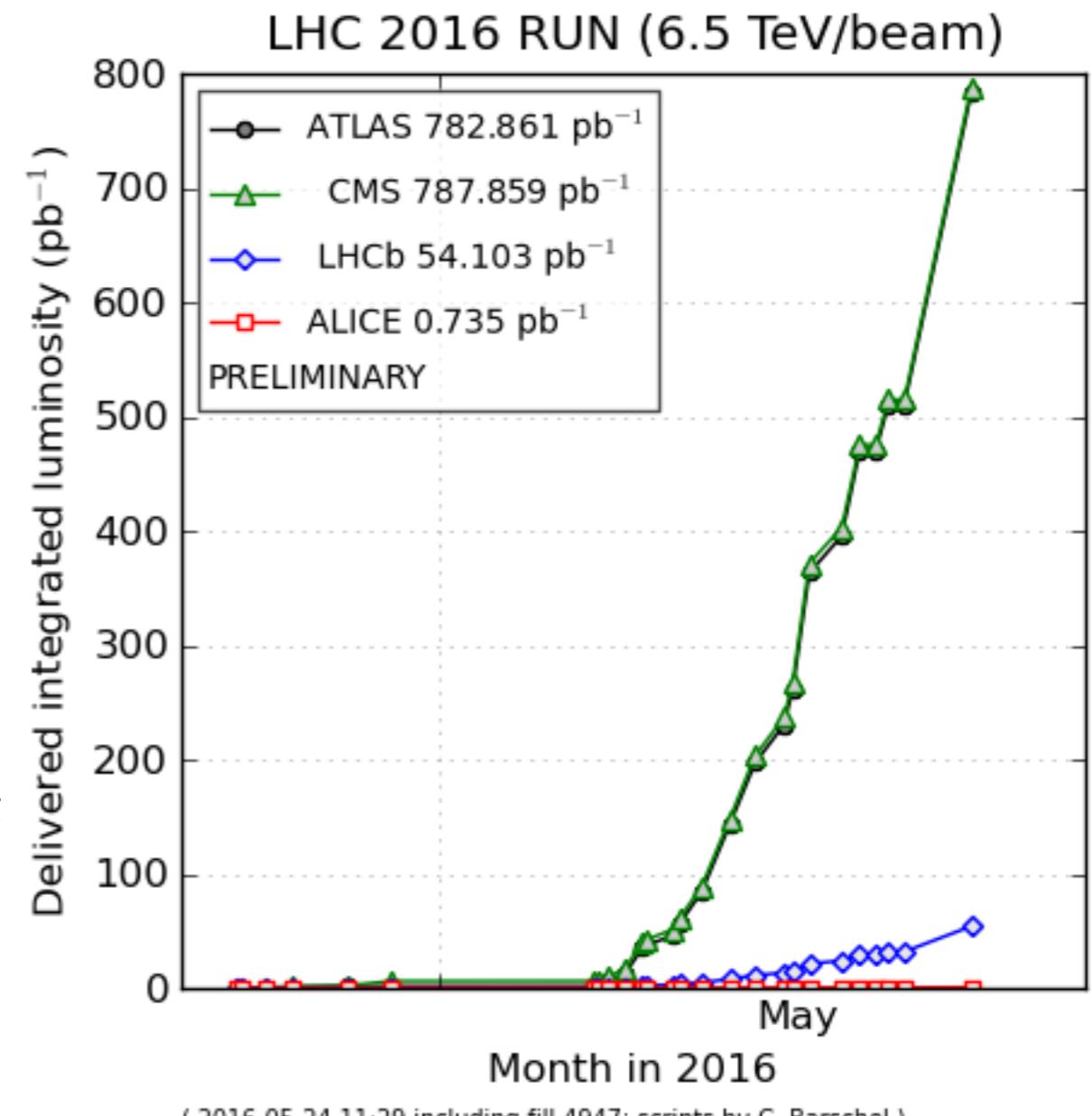
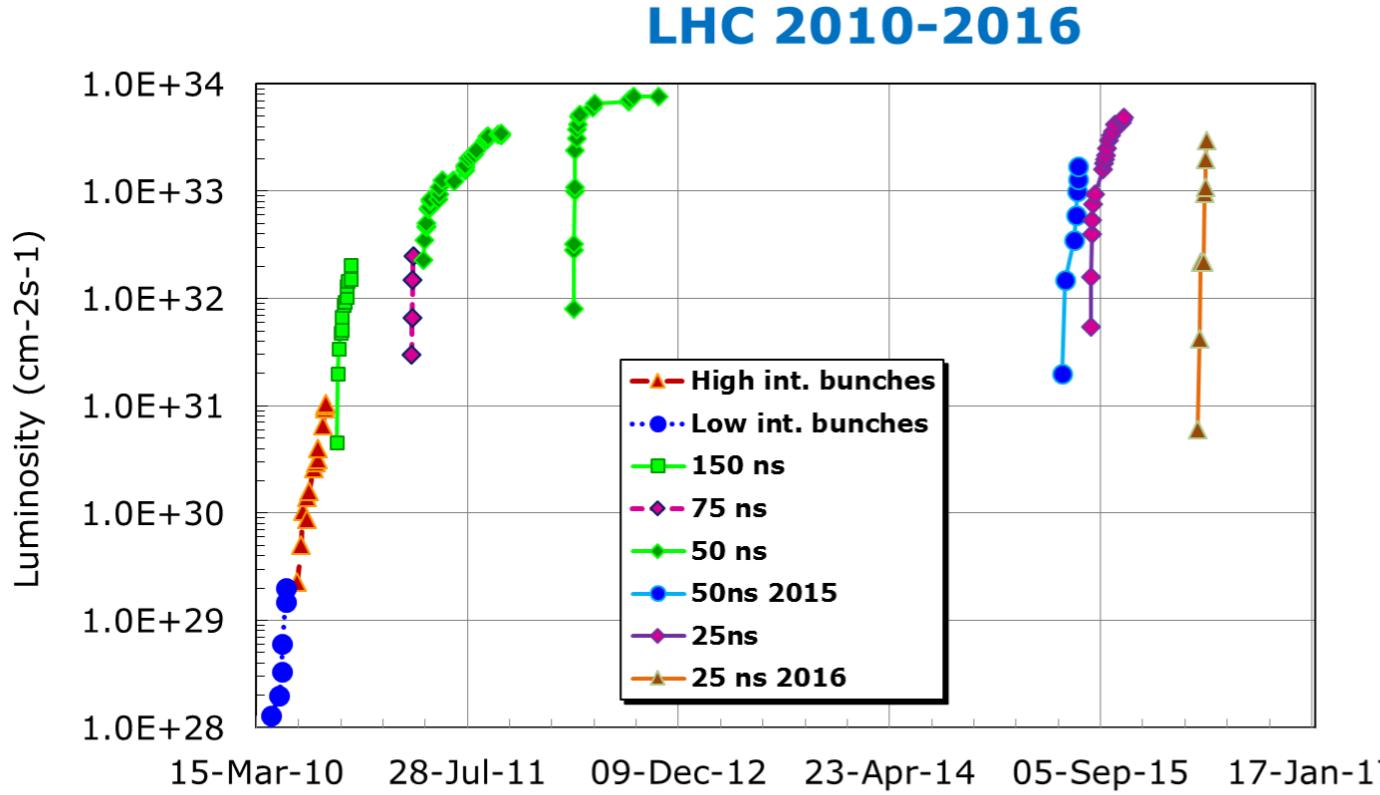


14 days lost
already due to
long faults

136 days p-p
physics

24 days p-Pb
physics

Advancement with luminosity production



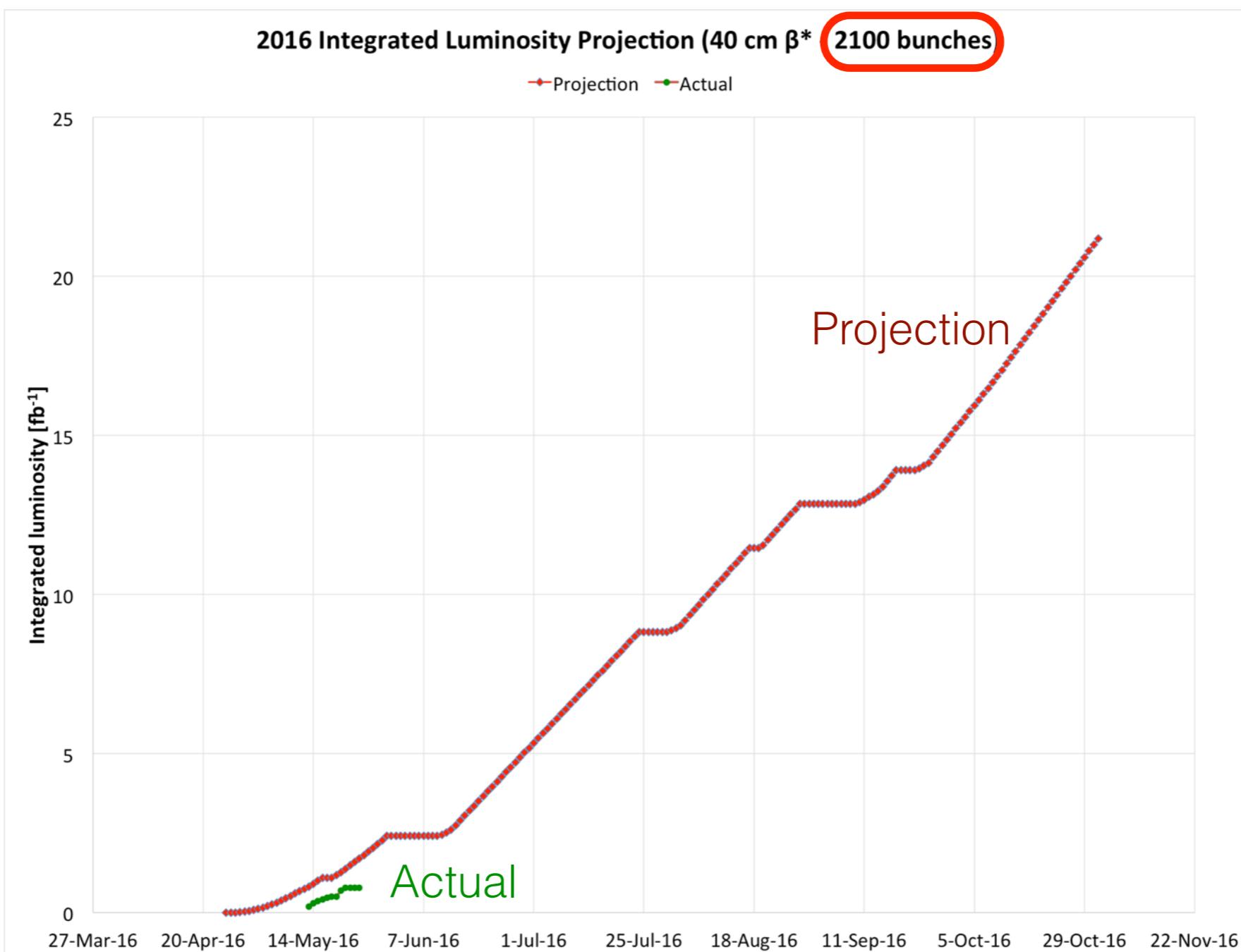
Record length fill 21.05



35h28m stable beams - integrated luminosity ~270 pb⁻¹ !

- Luminosity performance looks good
- Excellent luminosity lifetime
- Long fills
- Availability hit by the extended stops.

Projection for 2016



Conclusions

- The work done during LS1 to improve hardware and tools has allowed for a very efficient startup and commissioning
- LHC in good shape
- Optics and orbit have never been corrected so well
- Significant downtime from important faults in injectors and infrastructure
 - lost around two weeks
 - impact on peak performance from SPS beam dump limitations
- Still early days - 2016 has the potential to be a productive year!

