# *LHC*

## *OP DAYS - 26/01/2012*

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# *OUTLOOK*

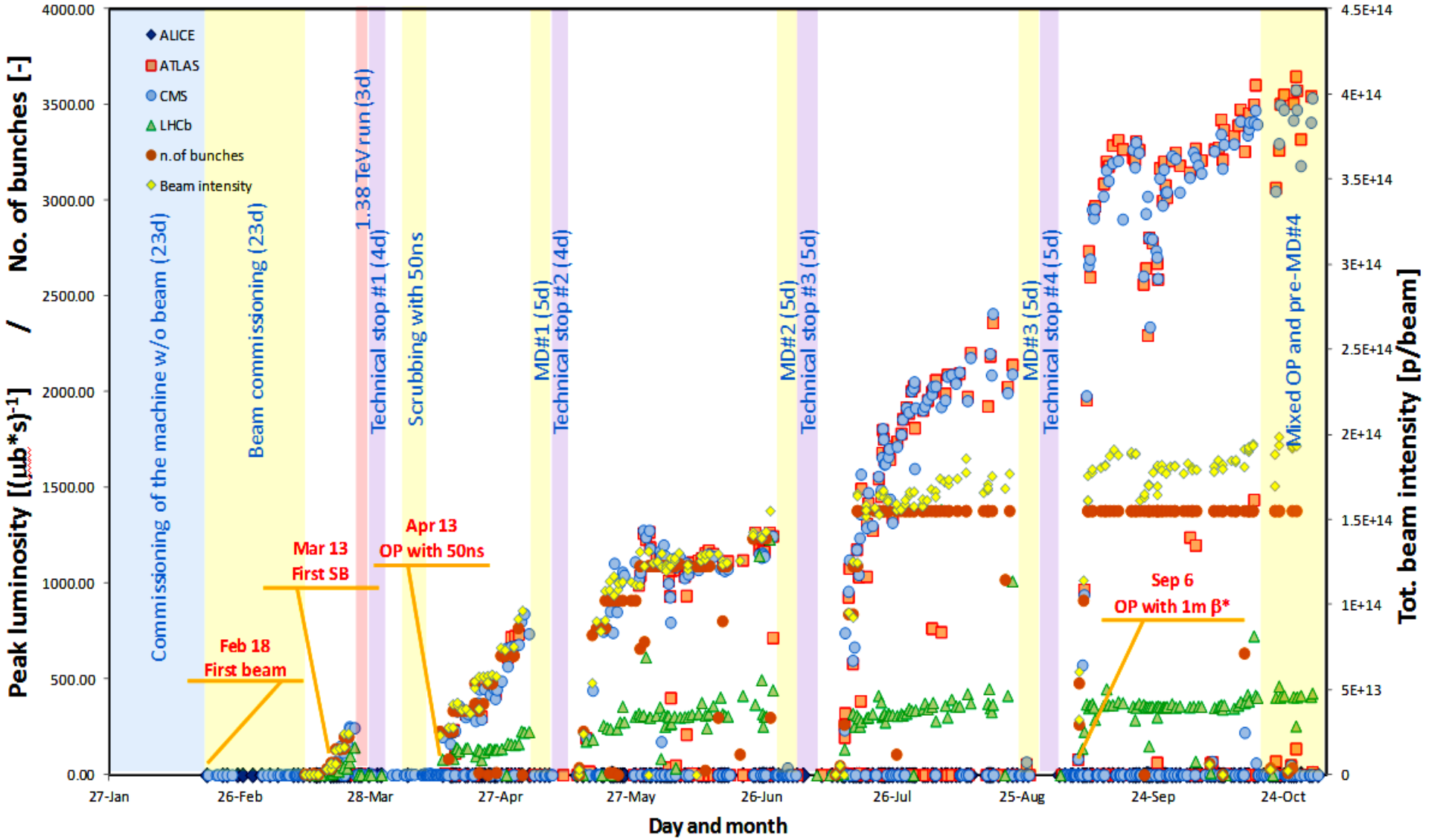
- PROTON RUN
- ION RUN
- LHC WEAKNESS
- 2012

# PROTON RUN: ABOVE ALL EXPECTATIONS

| Beam parameters (50ns) | expected | achieved |
|---|---|---|
| Bunch Intensity [e11 p/b] | 1.2 | 1.4 |
| Normalized emittance [μm] | 2.5 | 2 |
| Colliding bunches | 1404 | 1331 |
| β* [m] | 1.5 | 1 |

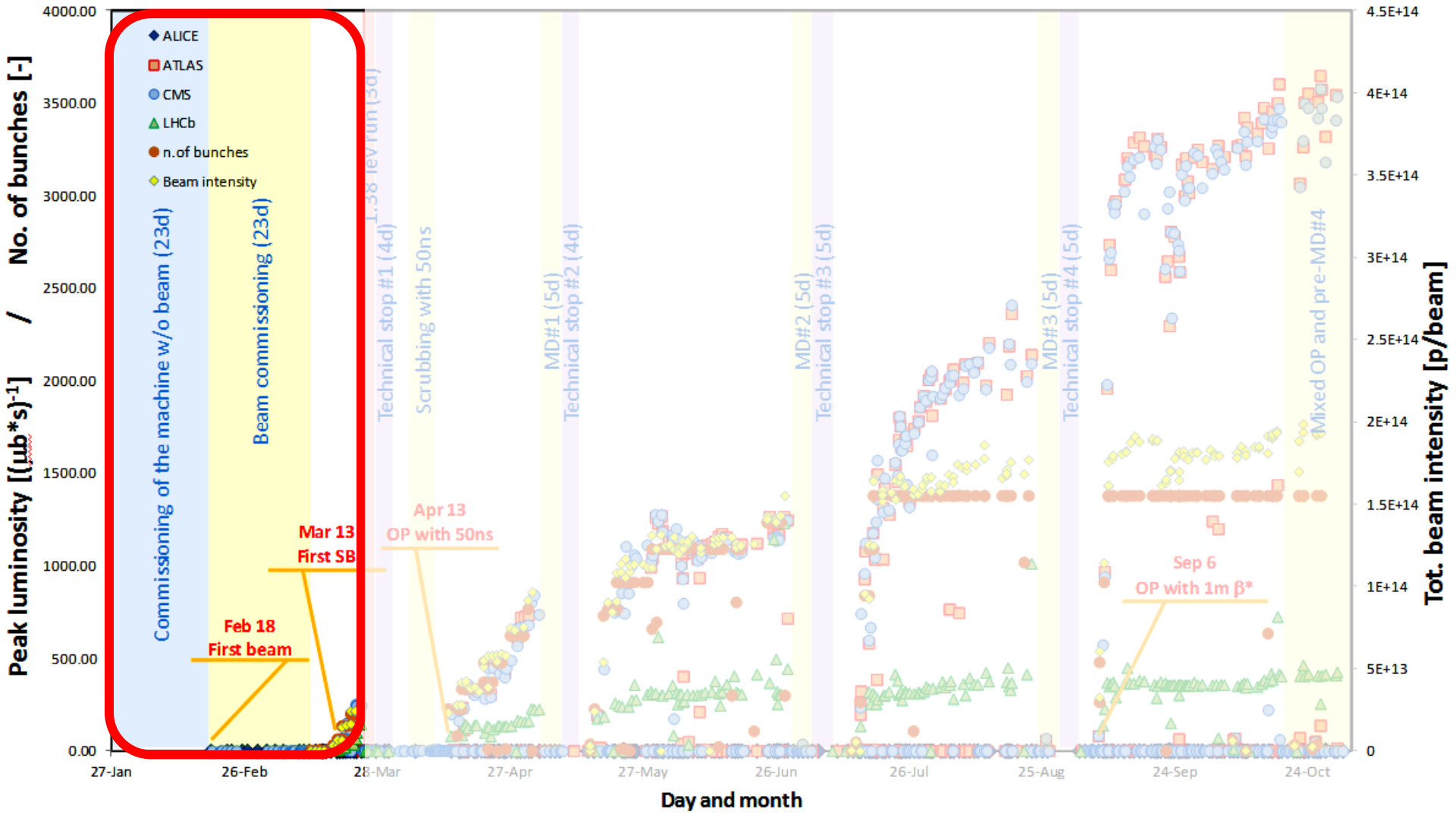
| Luminosity | expected | achieved |
|---|---|---|
| Peak luminosity [Hz/cm$^2$] | 2e33 | 3.5e33 |
| Integrated Luminosity [fb$^{-1}$] | IP1 & IP5 : baseline 1 fb$^{-1}$<br>(but >2fb$^{-1}$ expected)<br>IP8 : 1fb$^{-1}$ (challenging) | IP1 : 5.575 fb$^{-1}$<br>IP5 : 5.725 fb$^{-1}$<br>IP8 : 1.212 fb$^{-1}$ |

# PROTON RUN IN DETAILS

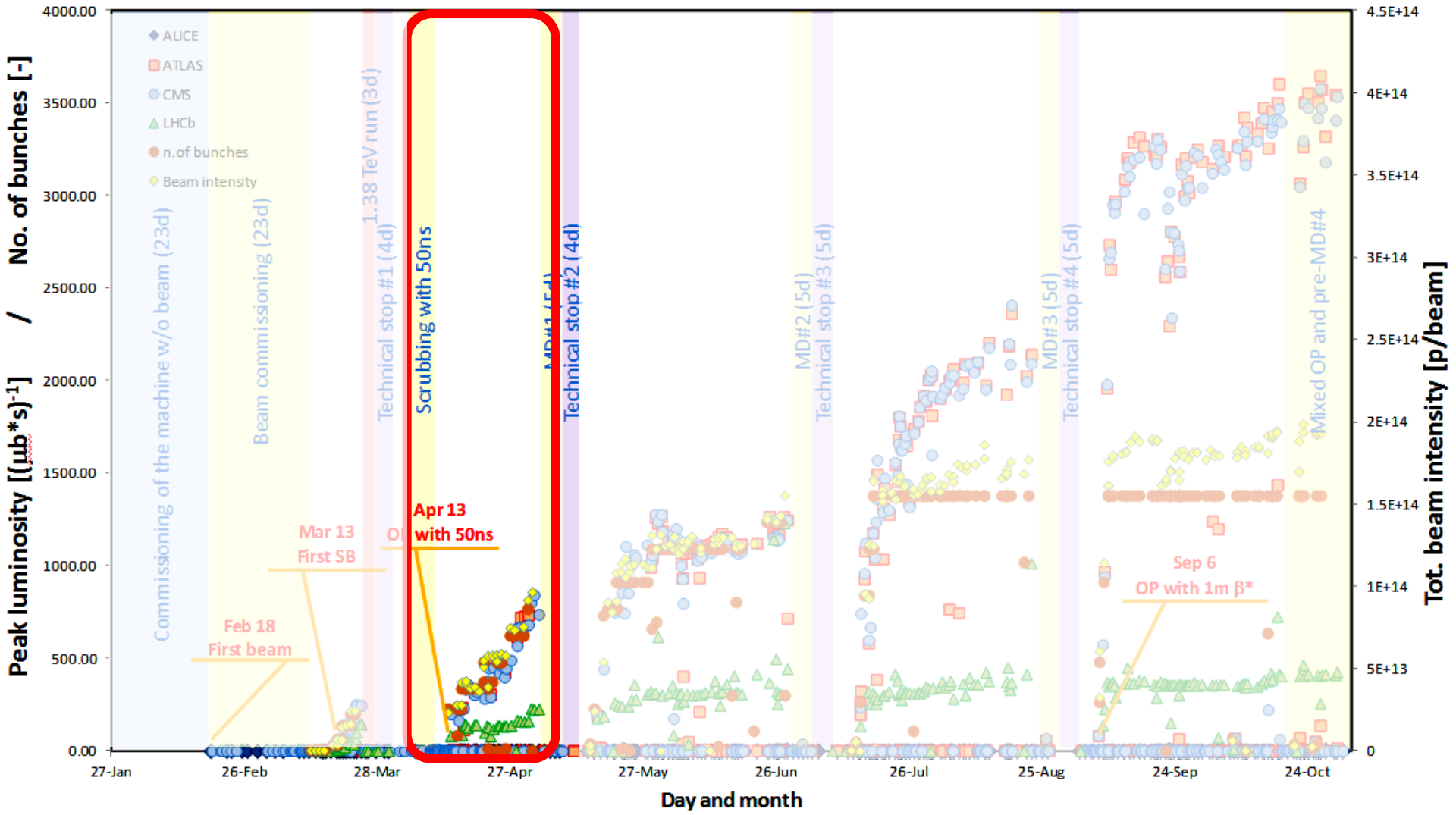



*From Mirko Pojer - Evian workshop 2011*

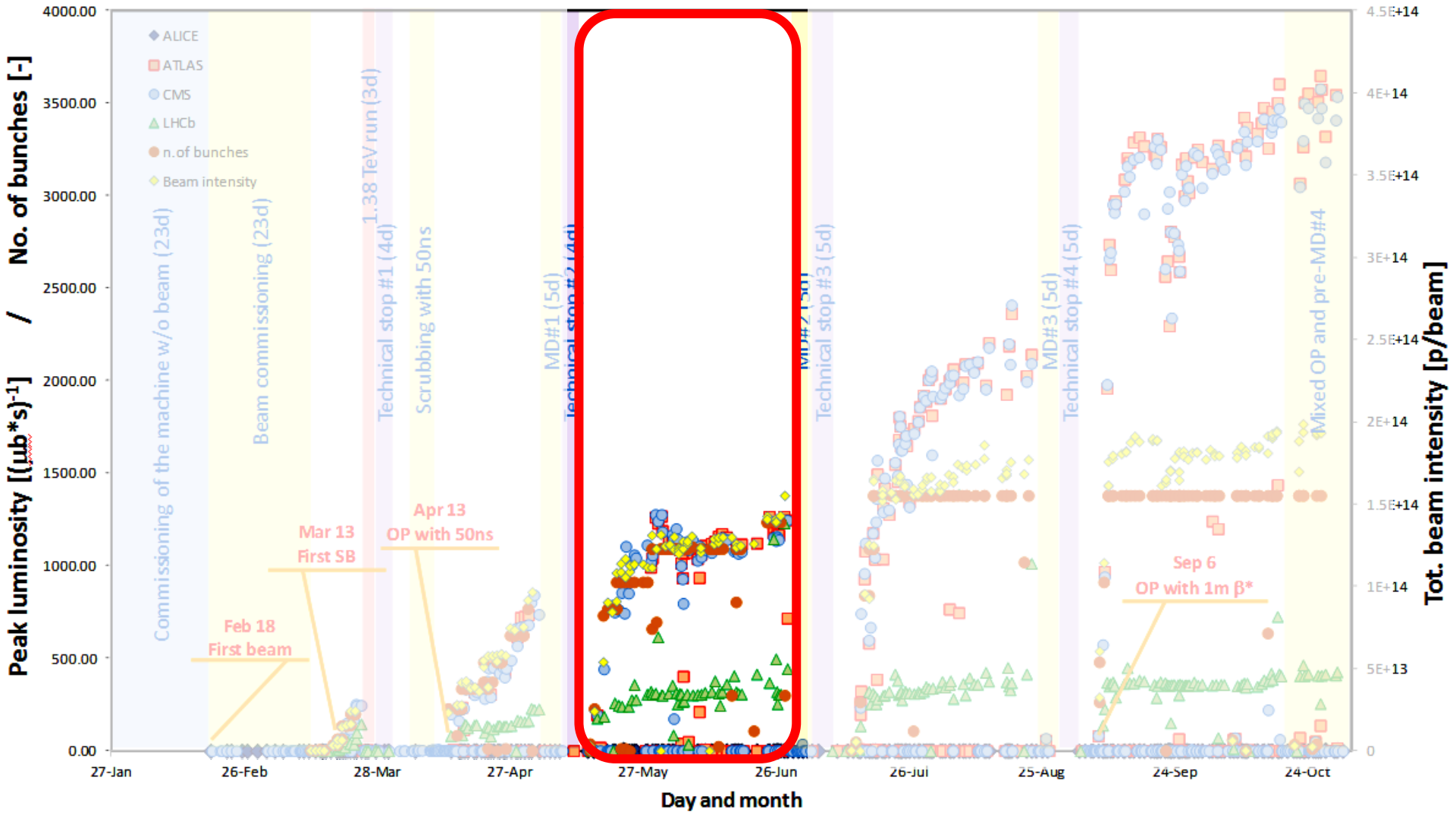
- Hardware commissioning & machine checkout : very efficient, tight planning respected
- Beam commissioning 75ns.
- First stable beam 75ns.



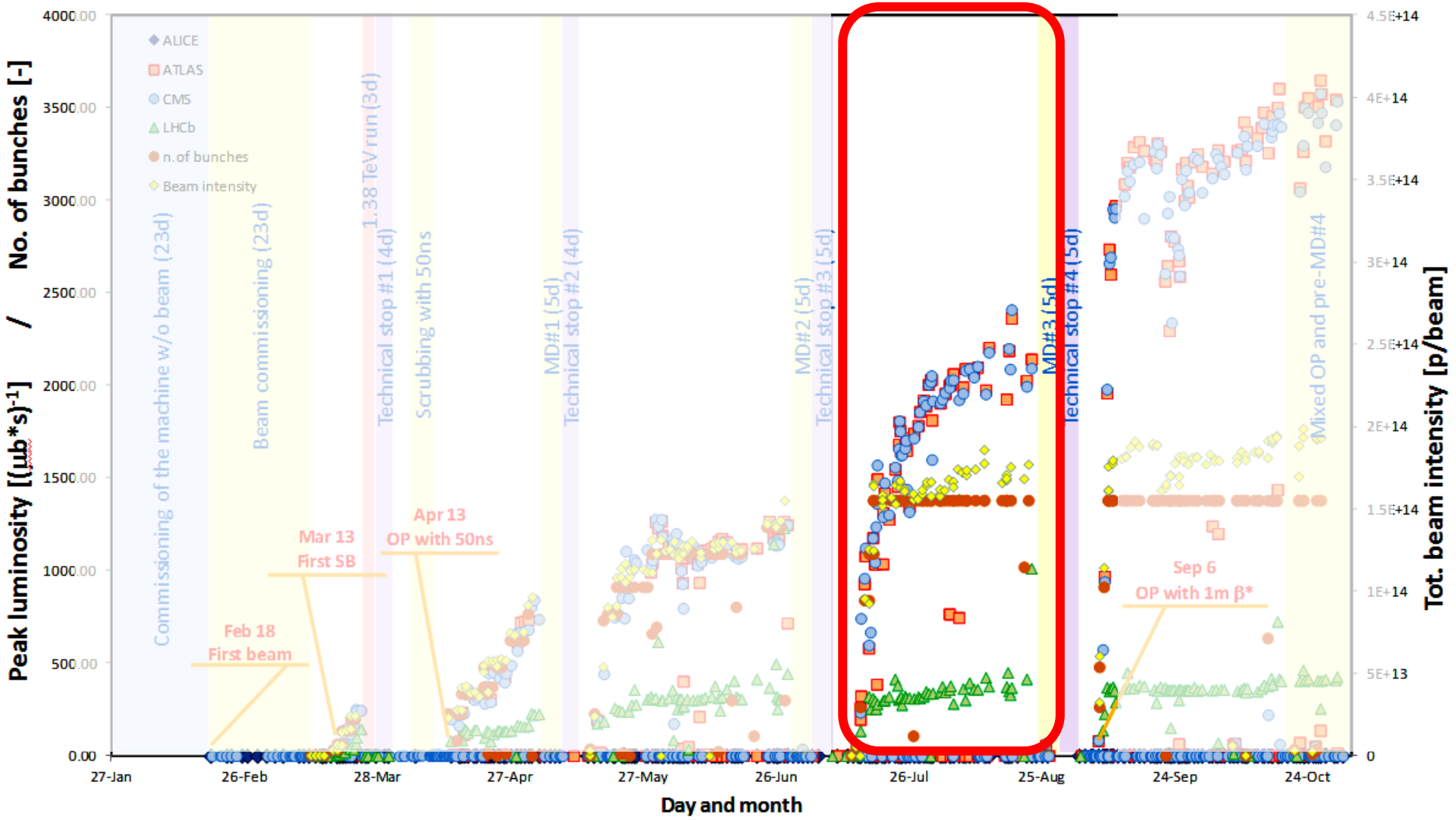
- Scrubbing run necessary before 50ns beam
- Fast commissioning of 50ns beam
- Intensity ramp-up (steps defined by machine protection panel)



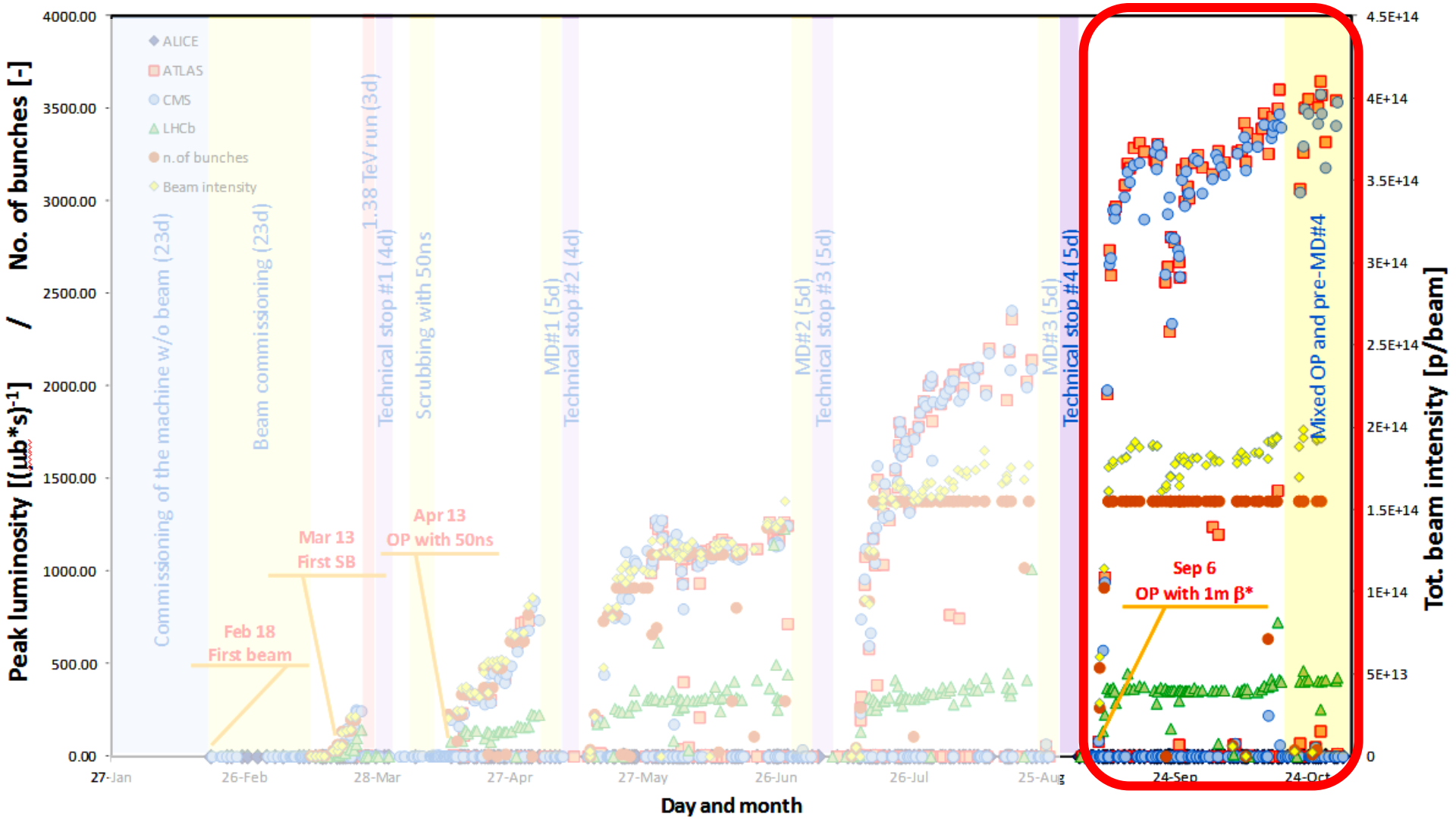
- Continue intensity ramp-up
- Stabilise and consolidate



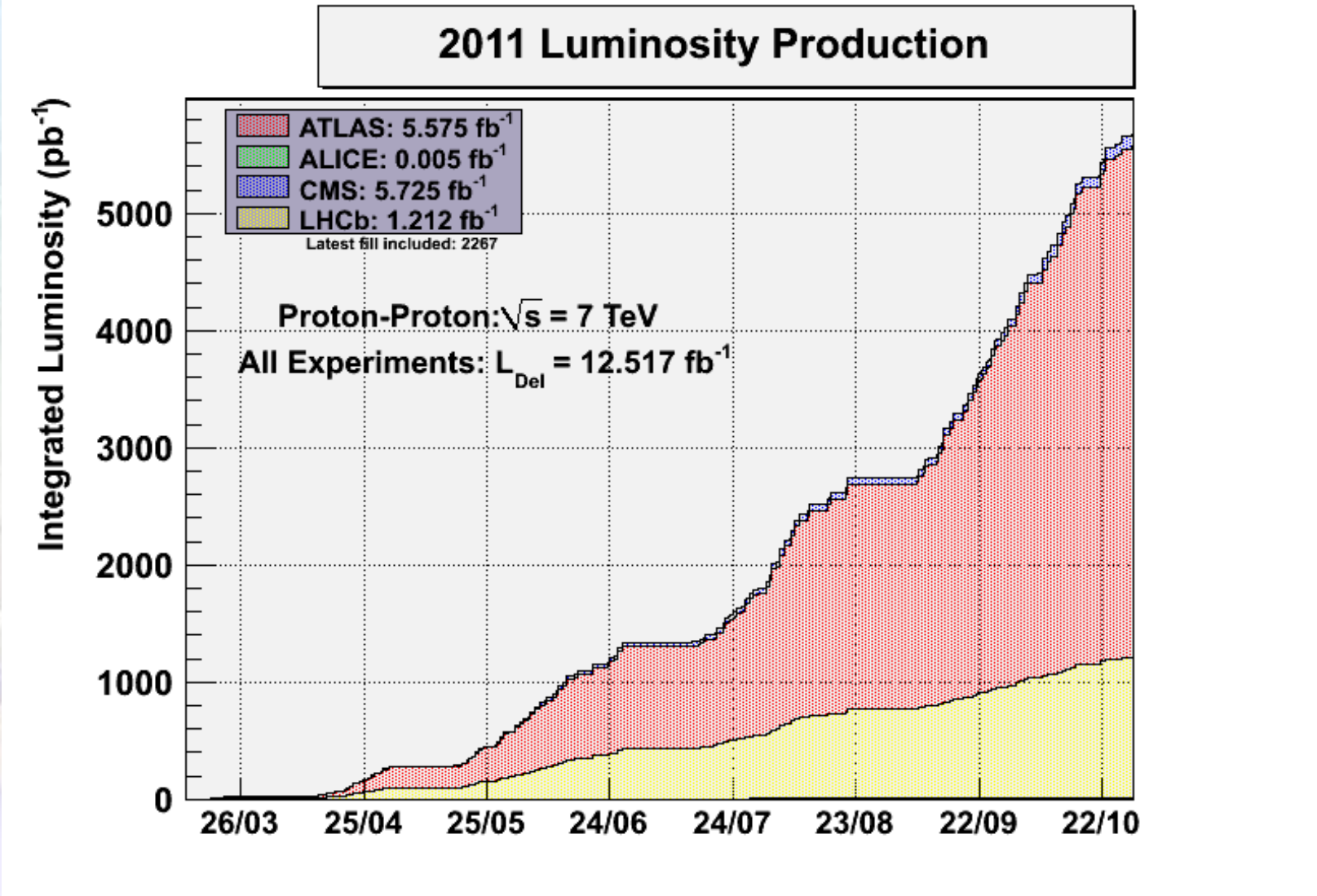
- Difficult restart after technical stop: major electrical network failure
- Intensity ramp up to 1380 bunches
- Increase peak luminosity : I/bunch ↗, emittance↘ in the injectors. Start to see vacuum effects.



- Commissioning of 1m β* squeeze.(4 days only to get to 1380b)
- Vacuum activity: beam losses in collision, 2 beam dumps. Get better with cleaning effects.
- 1st stable beam with 25ns beam at 3.5TeV



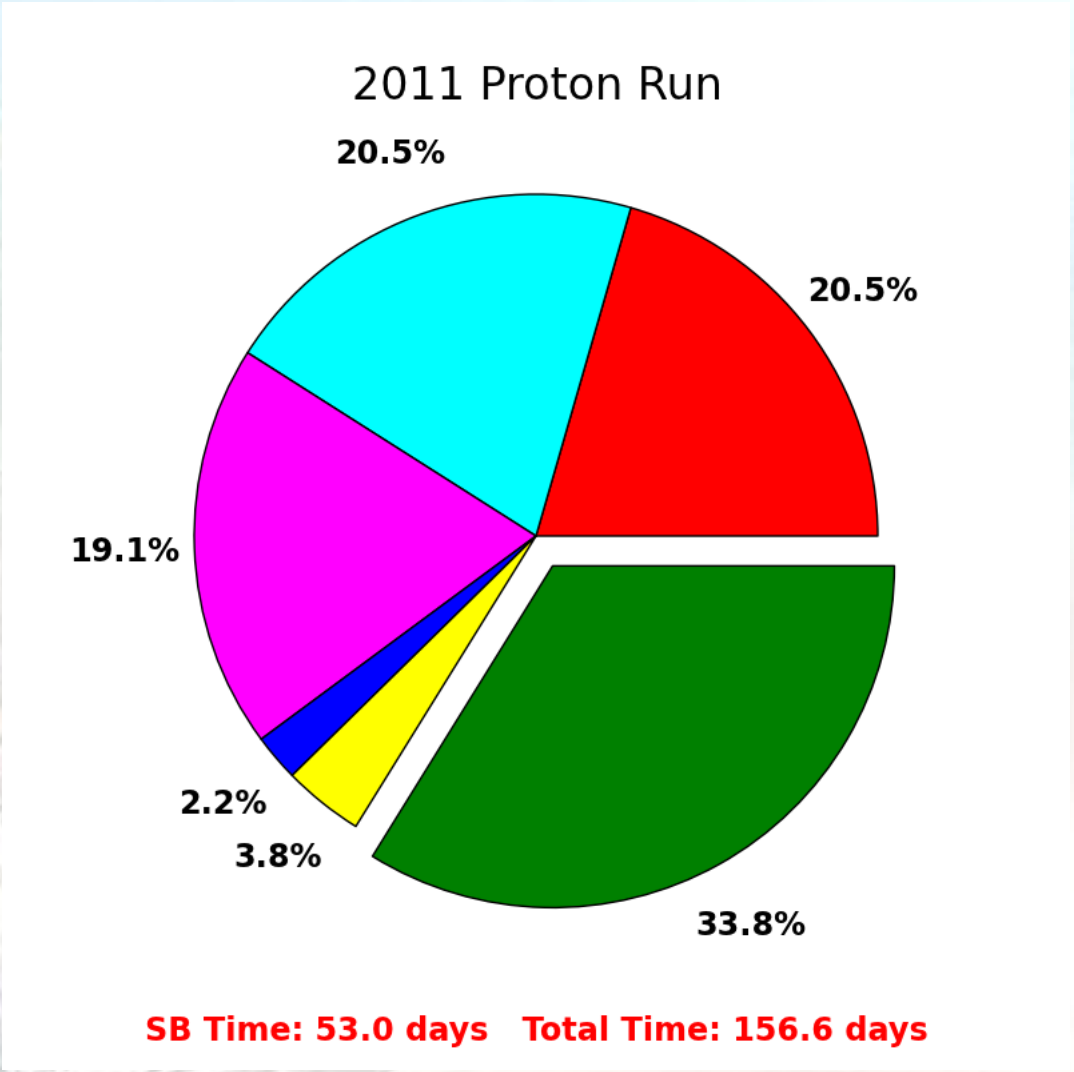
# PROTON RUN : LUMINOSITY PRODUCTION



# PROTON RUN: MACHINE MODE STATISTICS

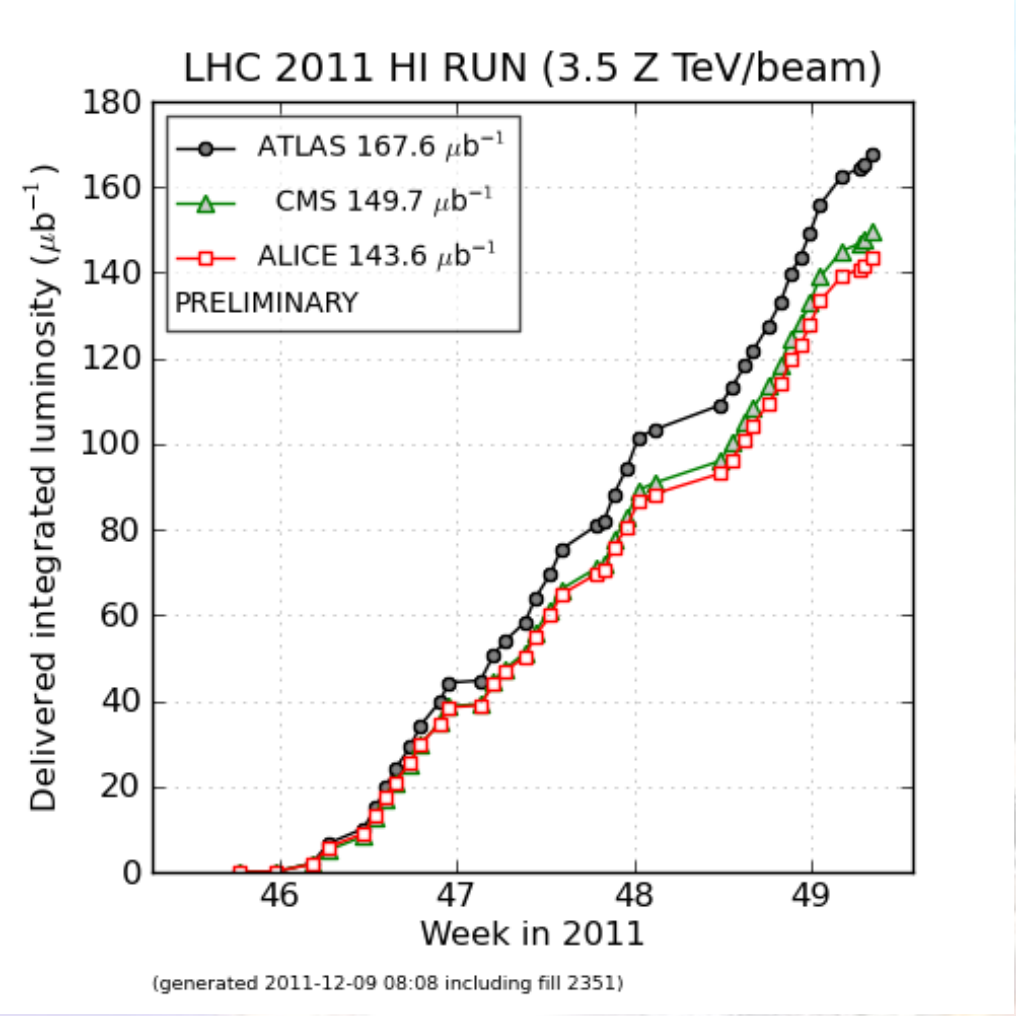

Total Time: 156.6 days

Stable beam: 33.8%




*From Alick McPherson - Evian workshop 2011*

# ION RUN : HAPPY CLIENTS




5 times the promised peak luminosity:

- Peak Luminosity ~ 5e26 Hz/cm$^2$
- Twice the design value at this energy.
- In 2010 it was ~2e25 Hz/cm$^2$

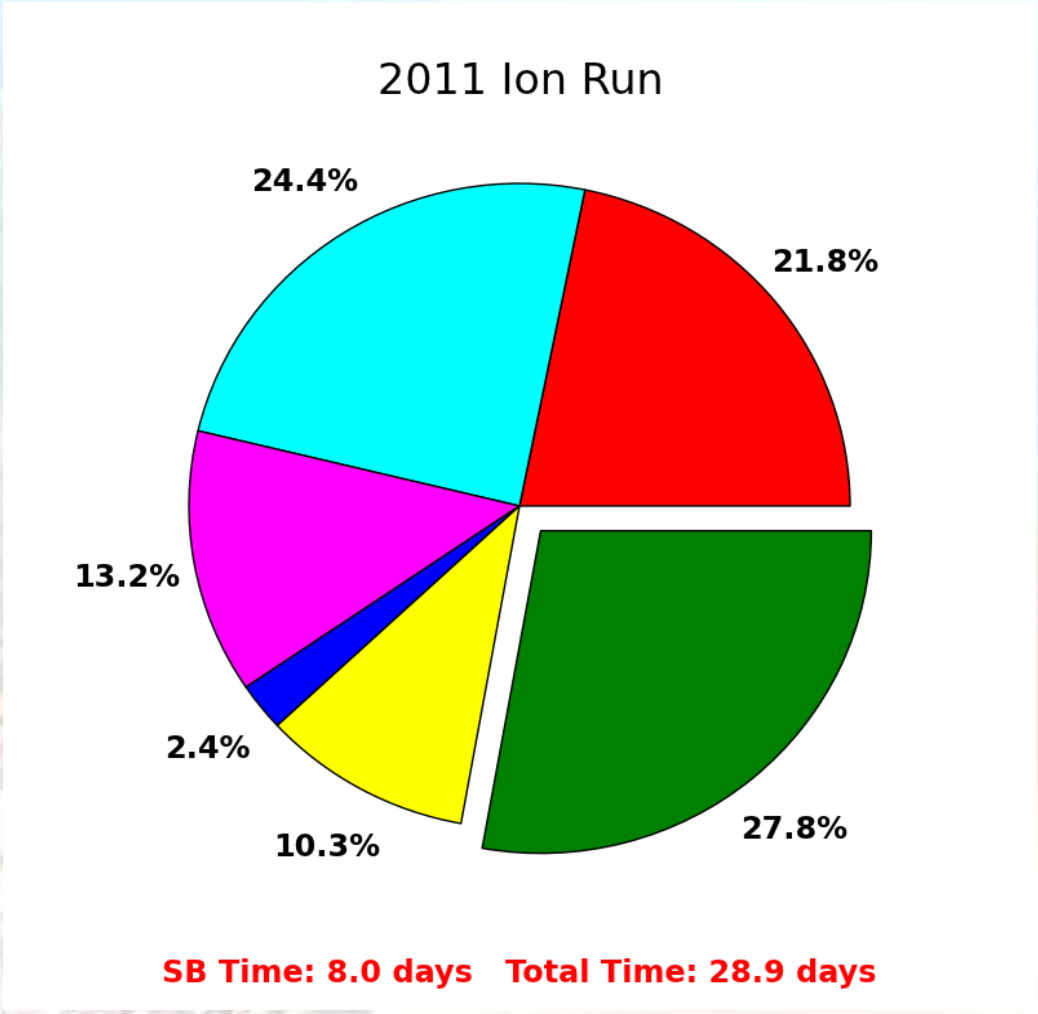
Integrated luminosity :
15 times 2010

*From Paolo Giubellino (Alice)- Evian workshop 2011*

# ION RUN: MACHINE MODE STATISTICS

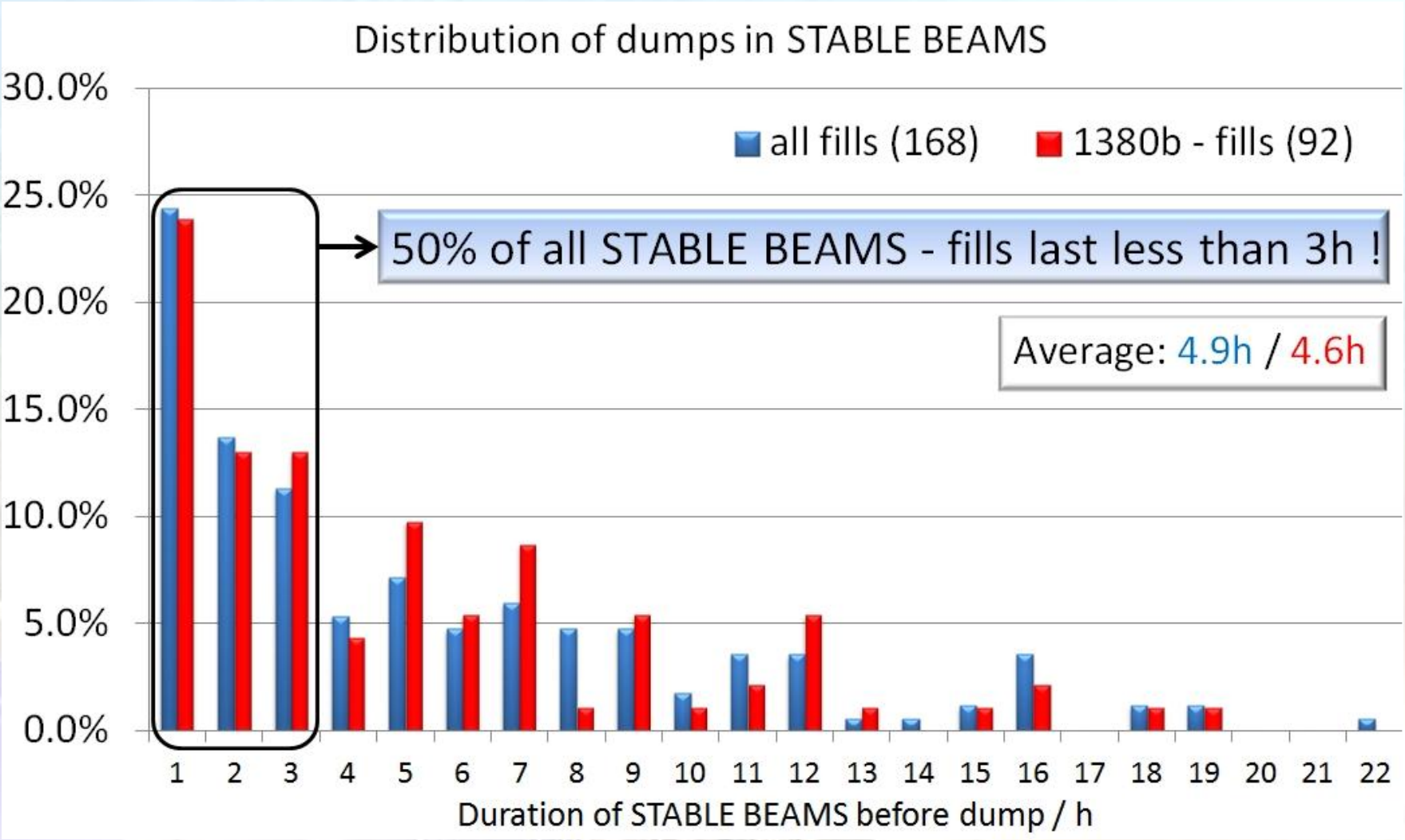

Total Time : 28.9 days

Stable beam: 27.8%



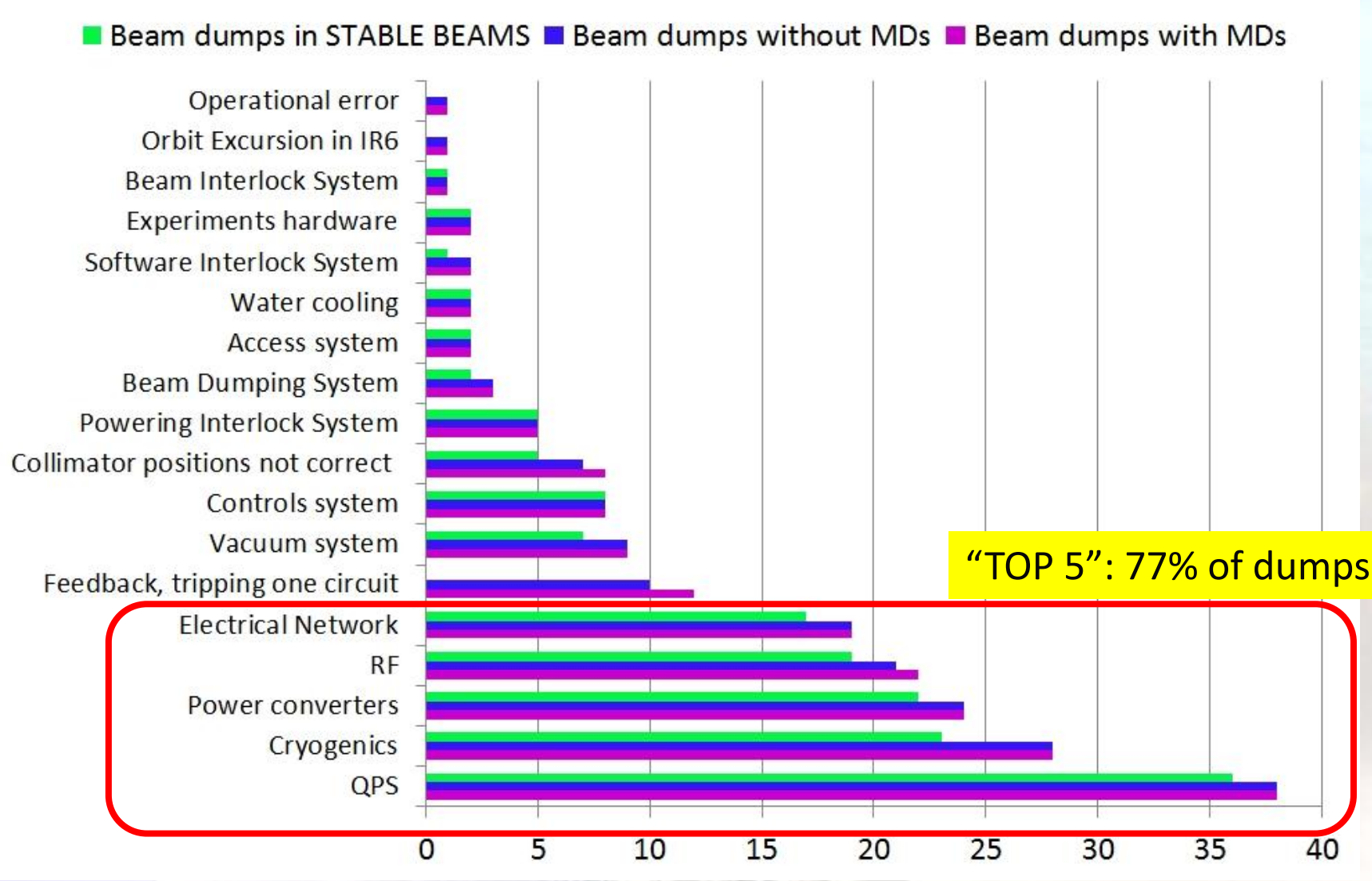

*From Alick McPherson - Evian workshop 2011*

# *LHC WEAKNESS: "keep the beams in!"*




*From Markus Albert- Evian workshop 2011*

# LHC WEAKNESS: BEAM DUMP CAUSES




"TOP 5": 77% of dumps in SB

*From Markus Albert- Evian workshop 2011*

# LHC WEAKNESS: Single Event Upset

- Single event upset : radiation on the electronic causes equipment failure (mainly on QPS and Cryo) : at least 69 dumps in 2011.
  → From Markus Albert in Evian workshop : 22% of stable beams dumped by SEU.

- In 2012, the number of dumps could go down if mitigation actions are taken during the shutdown :

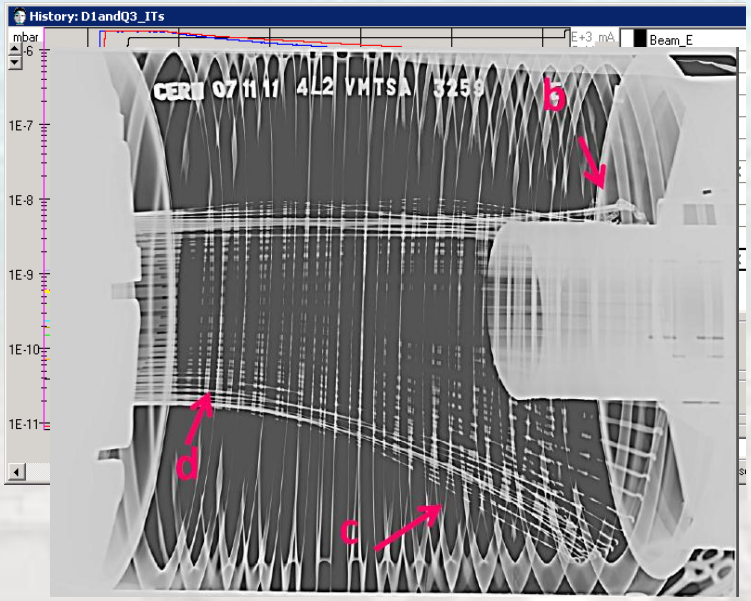
| Equipment | Failures 2011 | 2012 Expectation | |
|---|---|---|---|
| | Dump | Without mitigation | With mitigation actions |
| B/P/WIC | | 0 | 0 |
| Collimation | 1 | 0.5 | 1 |
| | 3 | 4 | 1 |
| Cryo | 7 | 21 | 0 |
| | 12 | 16 | 0 |
| | 11 | 33 | 1 |
| EN/EL | 2 | 6 | 1 |
| EPC | 7 | 15 | 15 |
| | 4 | 9.5 | 0 |
| QPS | 10 | 17 | 20 mitigation actions will allow a gain of 2.5 |
| | 6 | 10 | |
| | 6 | 18 | |
| **Other** | | | 5 |
| TOTAL | 69 | 150 | 45 |

*From G.Spieza- Evian workshop 2011*

**Mitigation :**
shielding, relocation, software patch.

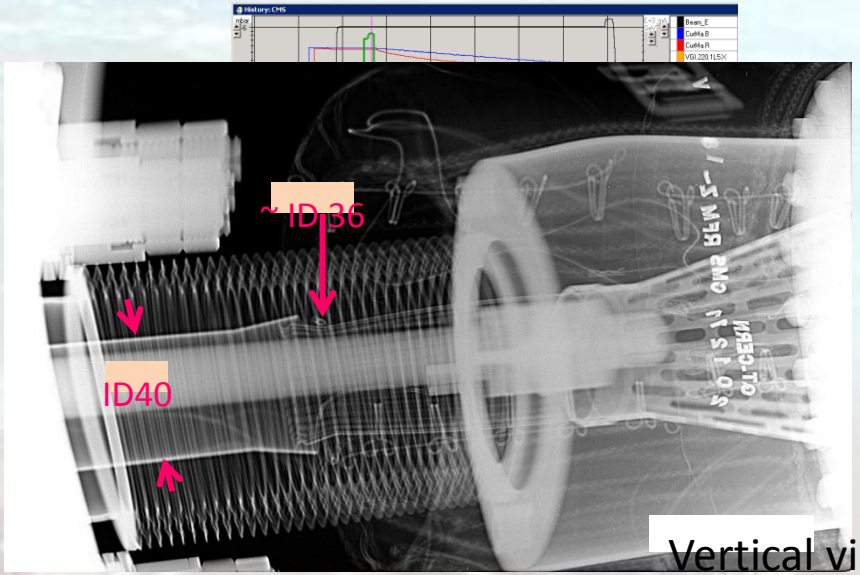
# LHC WEAKNESS : VACUUM & RF FINGERS

**Pressure spikes at injection and stable beam in LSS2 and LSS8**




NC found last November : falling RF fingers due to broken springs in VAMTF components, induced by beam heating

**Pressure increase around IR5 -> background for CMS**



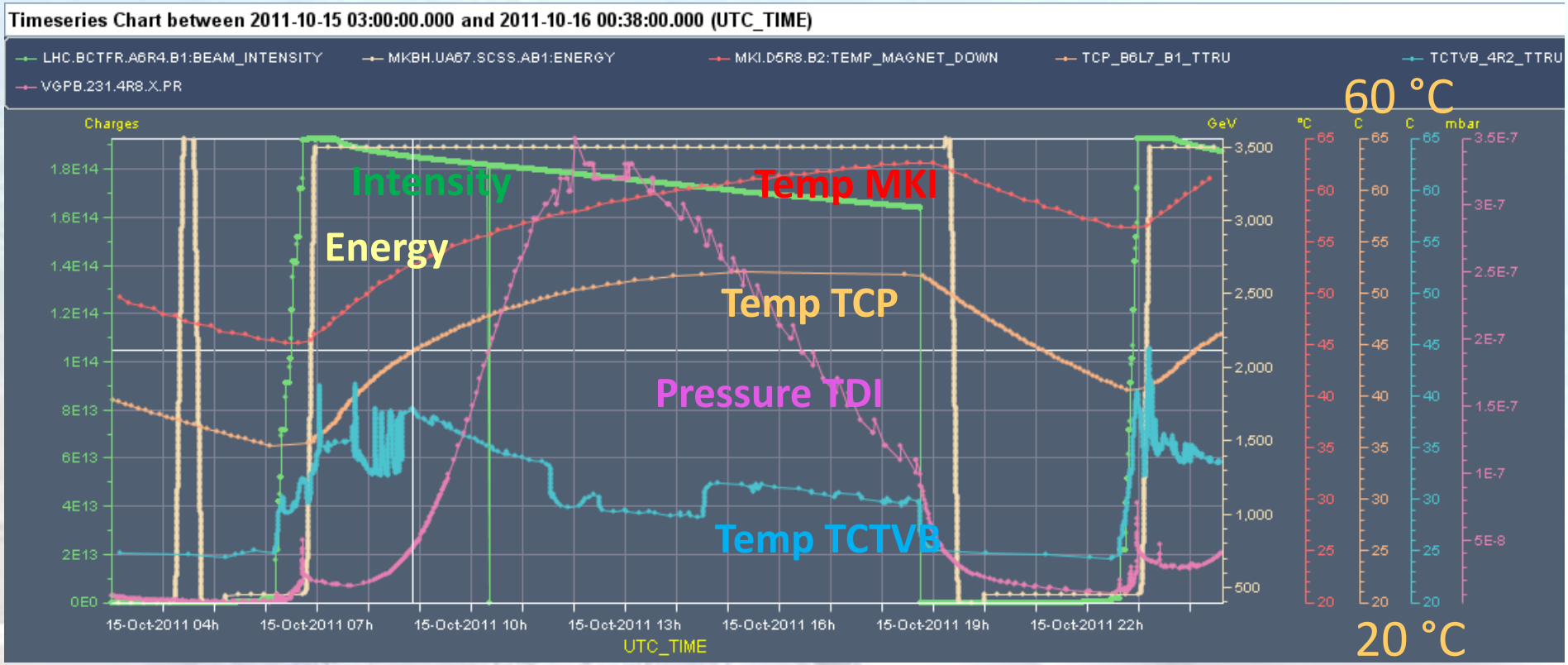

Vertical view

NC found during Xmas shut down:
RF fingers overlap of ~ 6 mm inside RF insert exactly where the pressure increase had been observed

All NCs should be addressed before next start-up

*From V.Baglin – LBOC 17/01/2012*

# LHC WEAKNESS: TEMPERATURE EFFECTS




Main expected beam induced heating limitations in 2012:

**MKI-8D** and **maybe MKI-8B** → will need to wait for cooldown before injection

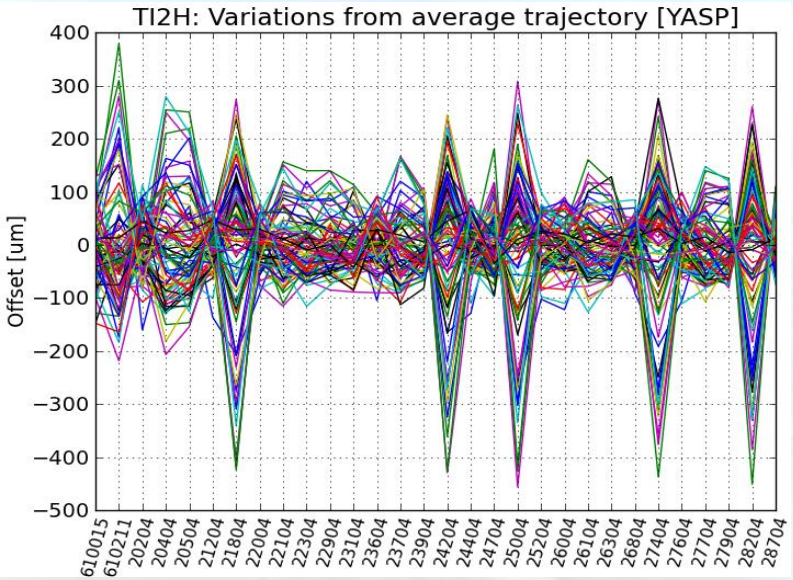
**Beam screen in stand alone Q6R5** → not much cooling margin left

**double bellow module VMTSA** ***(should be resolved during shutdown)***

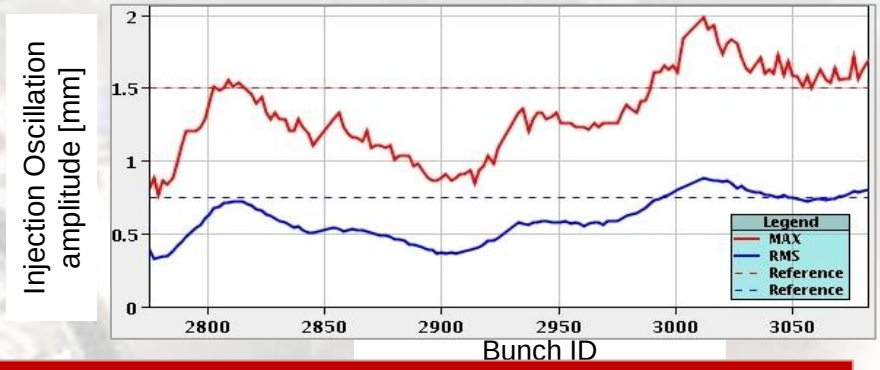
*From Benoit Salvant- Evian workshop 2011*

# LHC WEAKNESS: INJECTION STABILITY

Large shot-by-shot variations are observed for both lines in the horizontal plane
– sources identified as the MSE and possibly MKE4




Bunch-by-bunch variations on beam in horizontal plane
- caused by a ripple on MKE4




Estimate 2012 if stability is not improved:
1h steering x 0.5/days x 120 days = 60h!

*From Lene* Drøsdal *Evian workshop 2011*

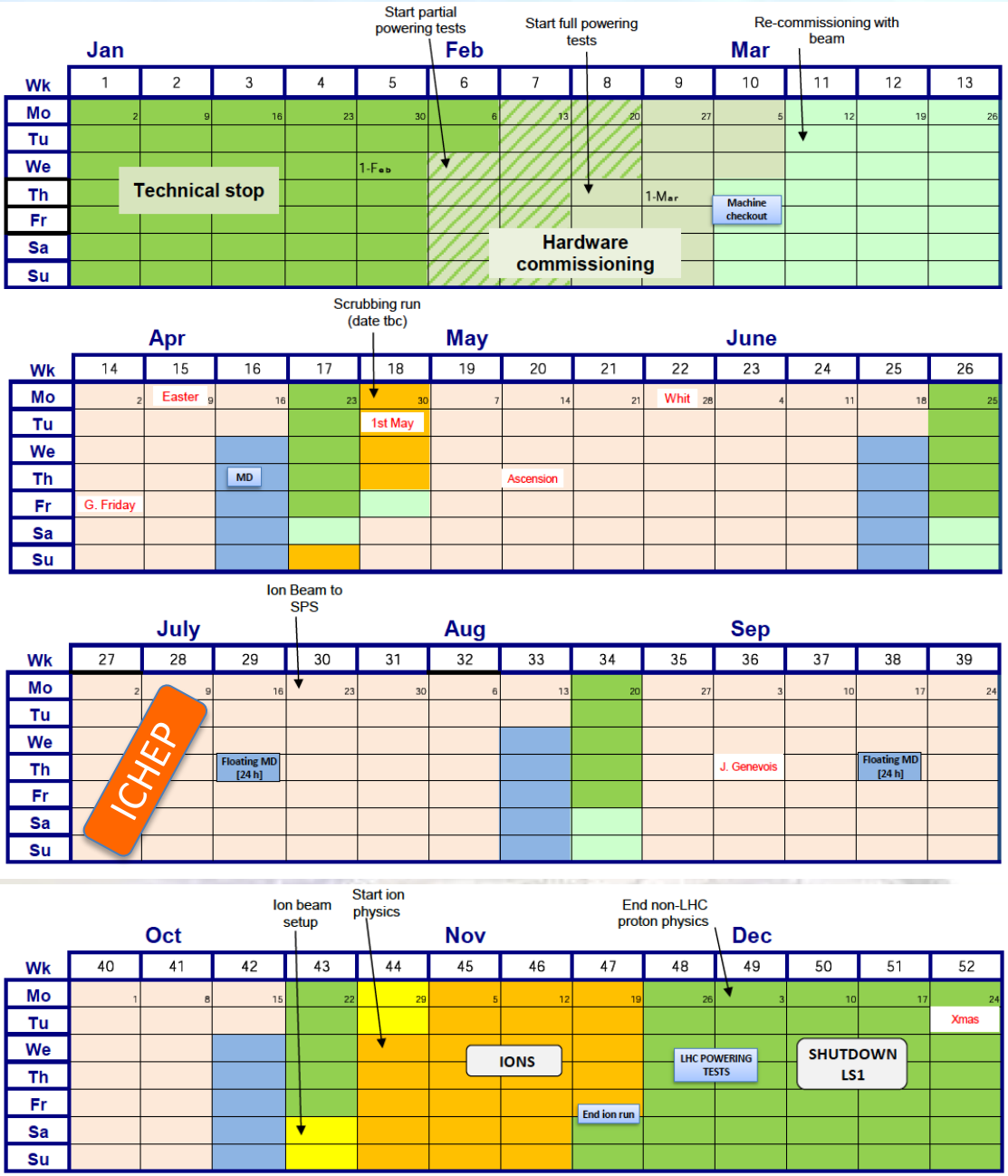
# 2012: EXPECTED BEAM PARAMETERS

- **Proton run**
  - Emittance : 2µm
  - Bunch spacing : 50ns beam, double batch extraction from PSB
  - Intensity per bunch 1.6e11 (max 1.45e11 in 2011)
  - β* : 0.7m in IP1/IP5, aim for 0.6m
  - Energy : 4Tev/beam (t.b.c. at Chamonix).

→ Expected peak luminosity : 6e33 $Hz/cm^2$
→ Expected integrated luminosity :
reasonable : 16 $fb^{-1}$ (IP8: 1.5 $fb^{-1}$)
ideal : 20 $fb^{-1}$

- **Heavy Ion run**
  - p-Pb physics
  - Goal for luminosity : min 10 $nb^{-1}$, expected 30 $nb^{-1}$ by Alice

# 2012: SCHEDULE




Priority to **luminosity production**

Experiments would like to catch the Higgs before ICHEP in July. (first MD block may be rescheduled)


Number of technical stops can't be reduced.

# PREVENTIVE MAINTENANCE IN CCC

Obsolete EIC's

To be replaced

New EIC With operational Hard disk

+

Motivated engineers To be upgraded With EIC software

Spare operational EIC

# CONCLUSION

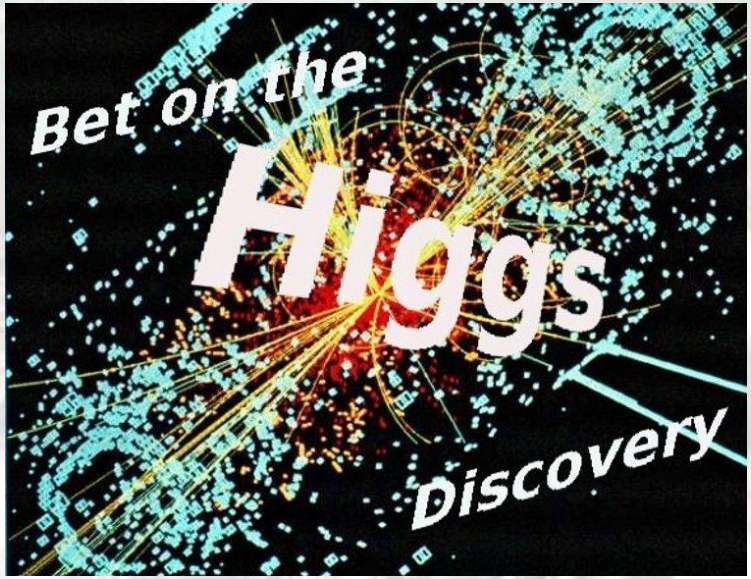
- **LHC performance was above all expectations**
  - Beam quality from the injectors : (high intensity, low emittance)
  - Lower β*
  - Reliable equipments, involvement of the teams

- In addition to the luminosity production, **MDs and special runs**
  - 1.38TeV run, 90m β* run, Van der Meer scans, p-Pb, 25ns stable beam…

- **Was not as easy as it looks**
  - SEUs, UFOs , temperature and vacuum perturbation
  - unstable injection lines
  - Tune feedback tripping the RQTF/RQTD
  - noisy cavities, RF line trips
  - QPS trips
  - 2 major electrical network failures, Cryogenic failures (long recovery time)

# CONCLUSION

- **2012, Higgs year?**
  - new energy (4TeV)
  - new β* (0.7m or 0.6m)
  - Priority to luminosity production.
  - New challenge from the experiments: 20 $fb^{-1}$ for the proton run




http://www.bet-on-the-higgs.com/index.html