LHC end-of-year jamboree

December 17th, 2010

CERN, Geneva, Switzerland

LHC Performance in 2010 and Prospects

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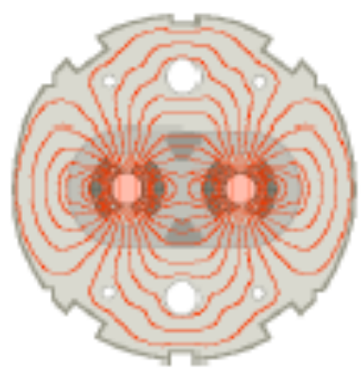
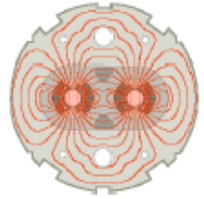
BE department - OP group

CERN Geneva (CH)



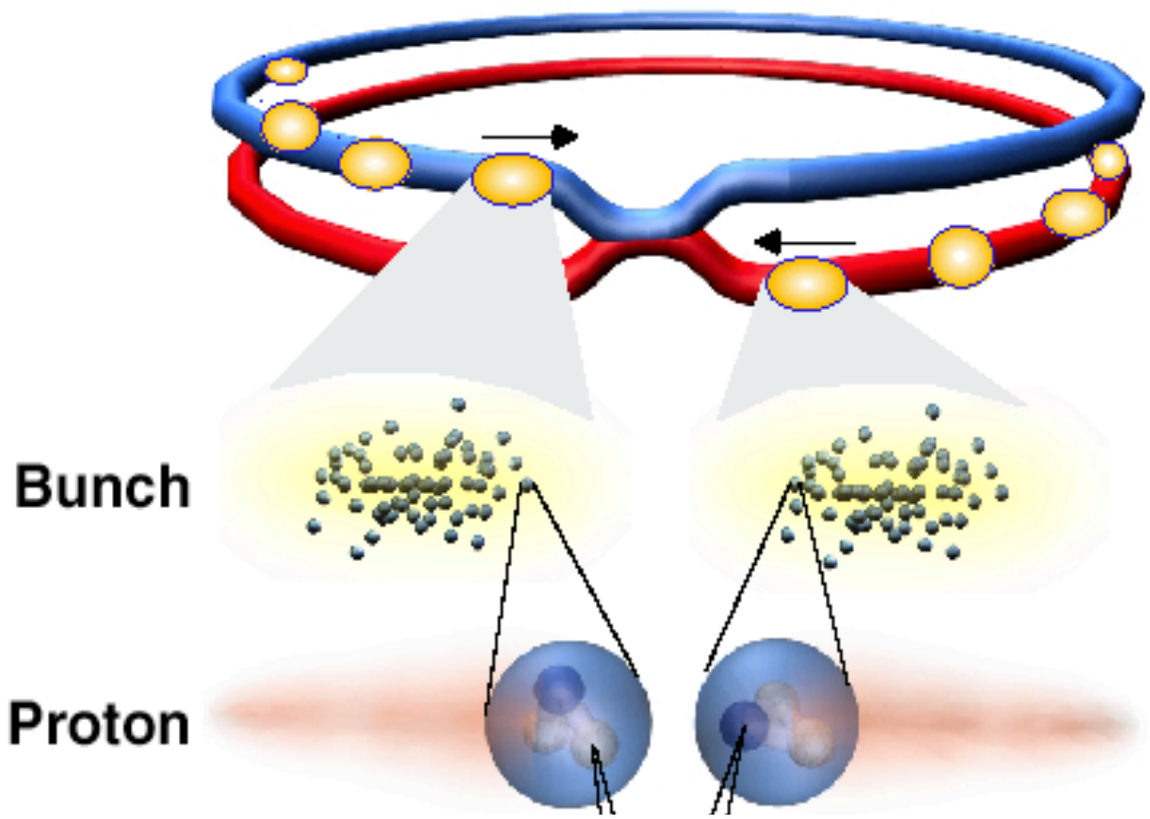
Outline



- ☑ Introduction
- ☑ Performance in 2010
- ☑ 2011 prospects
- ☑ Conclusions

Introduction

Collisions at the LHC: counter-rotating, high-intensity bunches of protons or heavy ions.



The rate of **new particle's production** is proportional to the **luminosity**:

$$\mathcal{L} \propto \frac{N_1 N_2 n_b}{\sigma^2}$$

Key parameters:

N_i = bunch intensity

n_b = number of bunches

σ = colliding beam size

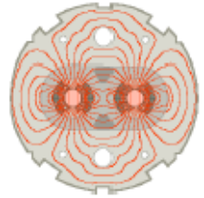
*Nominal LHC parameters (7 TeV): **2808** bunches of **1.1×10^{11}** protons, **0.000016** m size.*

Units for the luminosity:

Peak luminosity given in event rate per unit of area $cm^{-2}s^{-1}$: ***2010 goal = $10^{32} cm^{-2}s^{-1}$***

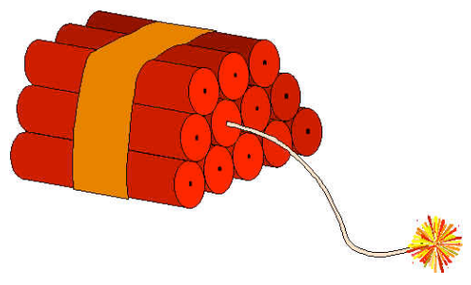
Integral luminosity (prop. to number of collisions) fb^{-1} : ***2011 goal = 1 fb^{-1}***

Goals of 2010 LHC operation

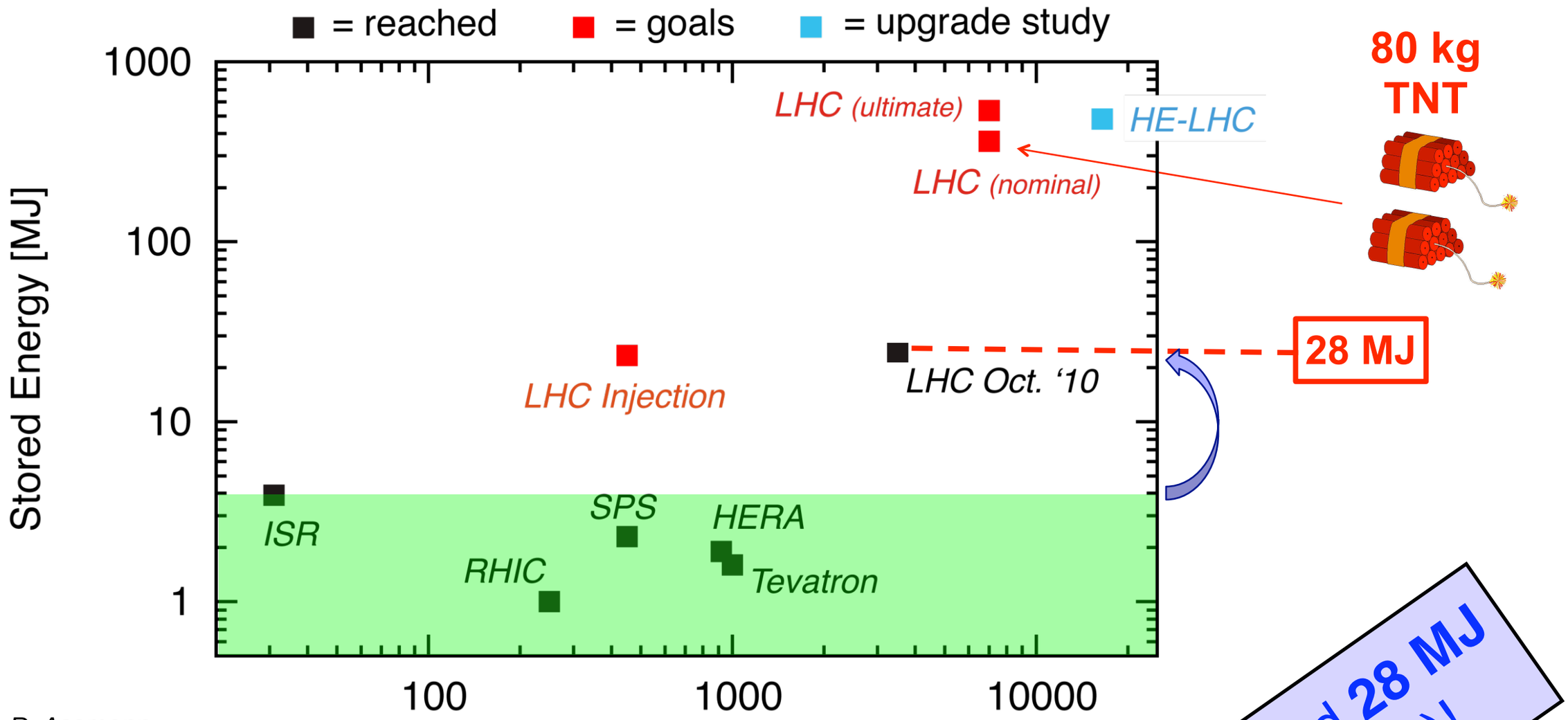


- ☑ **Lay foundations for the 2011 goal of 1 fb^{-1}.**
  2010 target: peak luminosity = 10^{32} cm^{-2} s^{-1}. ✓
- ☑ **Steady run around 1-2 MJ for an extended period of time.** ✓
- ☑ **Safe, phased increase up to ~ 30 MJ.** ✓
- ☑ **Gain a solid operational experience on the critical machine phases** (injection, energy ramp, squeeze, collisions, ...). ✓

30 MJ is equivalent to
~7 kg of TNT



What does this means in practice?



80 kg TNT

28 MJ

We made it! Achieved **28 MJ** (24 MJ with collisions)!

In the first year of operation we needed to achieve:

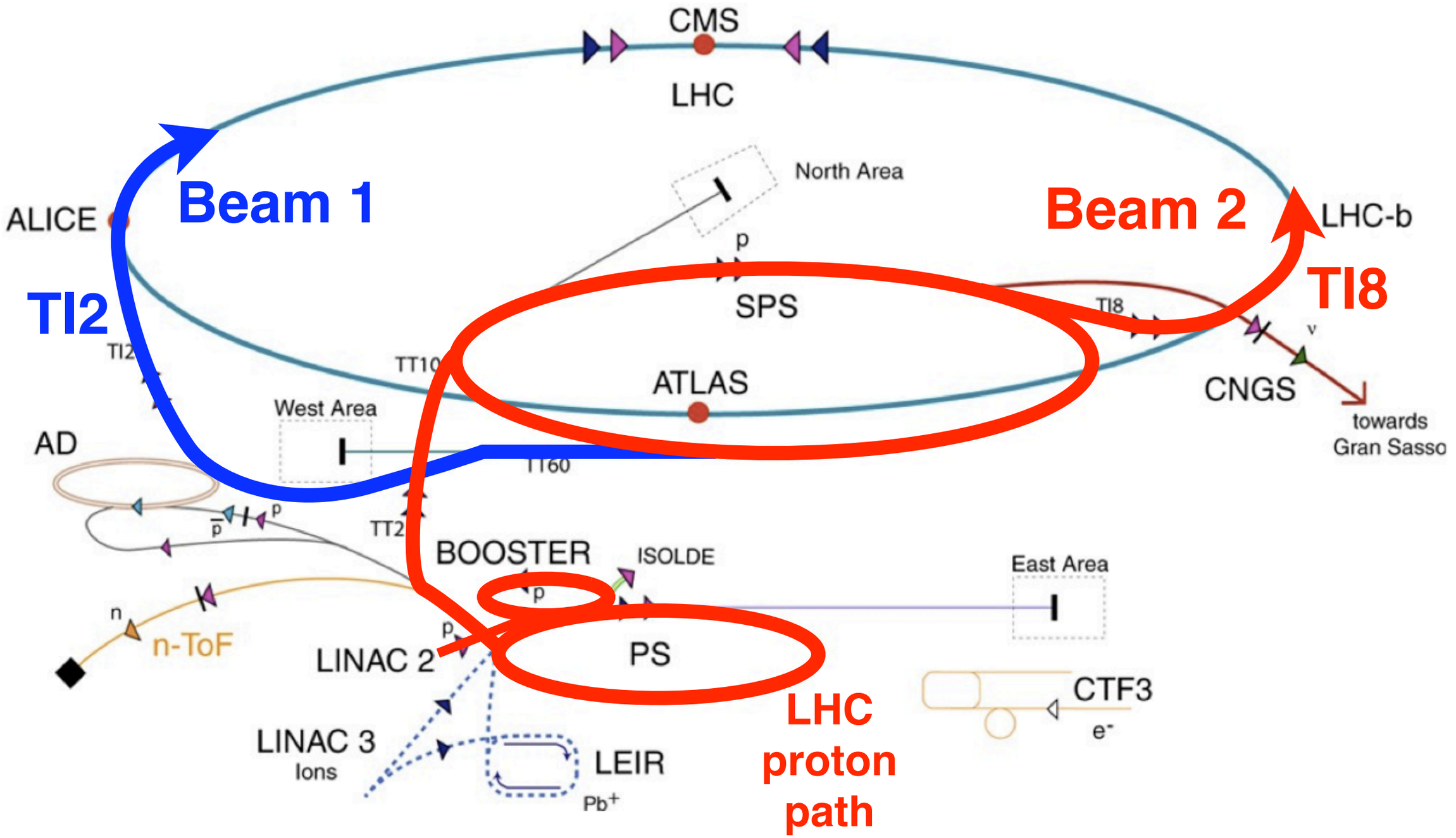
Factor ~10 above state-of-the-art.

Factor ~15 above the Tevatron.

Outline

- Introduction
- **Performance in 2010**
  - **Luminosity with protons**
  - **Ion run highlights**
  - **Mention some problems**
- 2011 prospects
- Conclusions

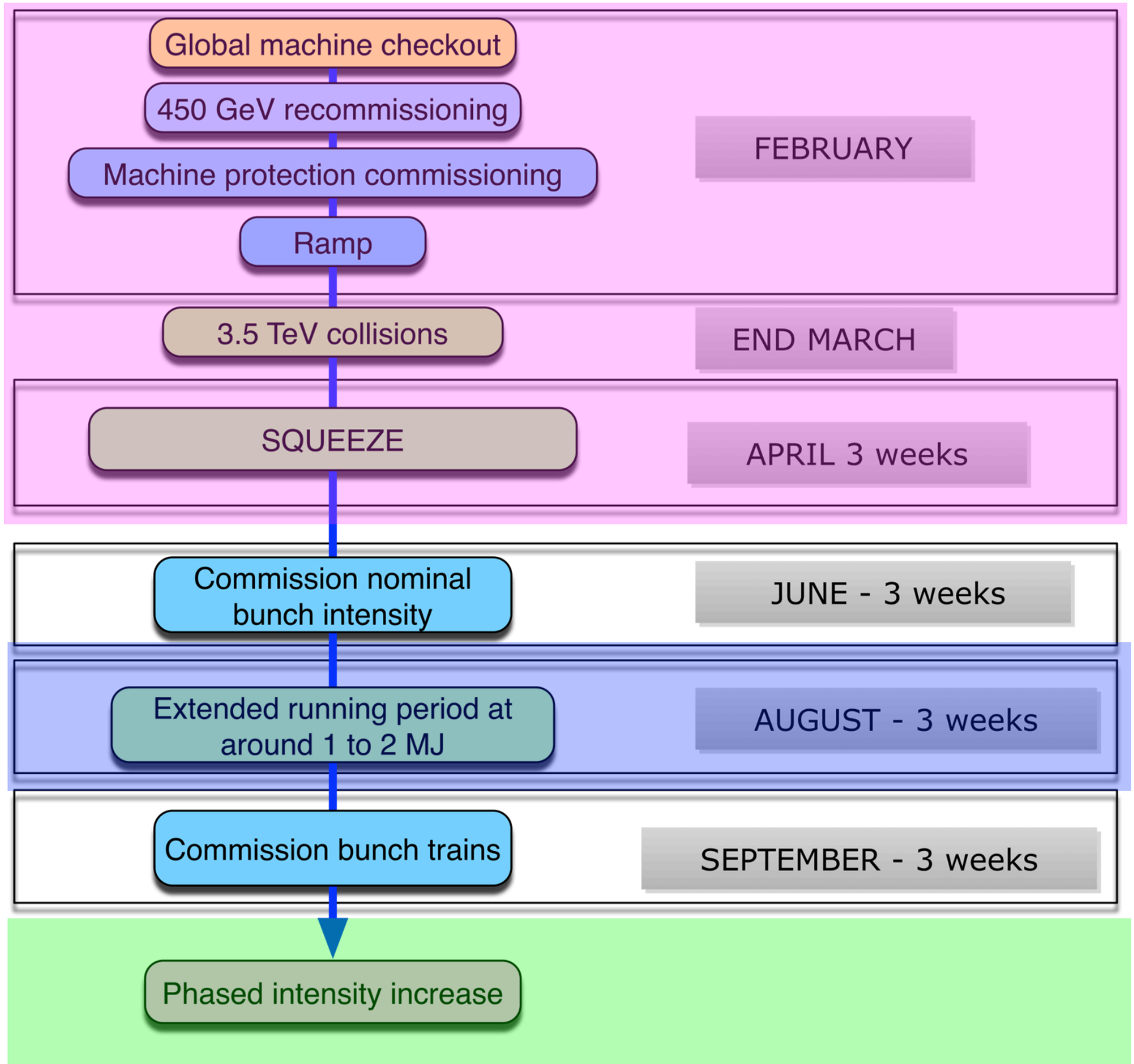
LHC injectors: excellent performance!



Excellent performance of the LHC injection chain:

- Provided the variety of beams needed for commissioning and physics;
- Bunch intensities and beam sizes better than nominal.

Overview of 2010 operation



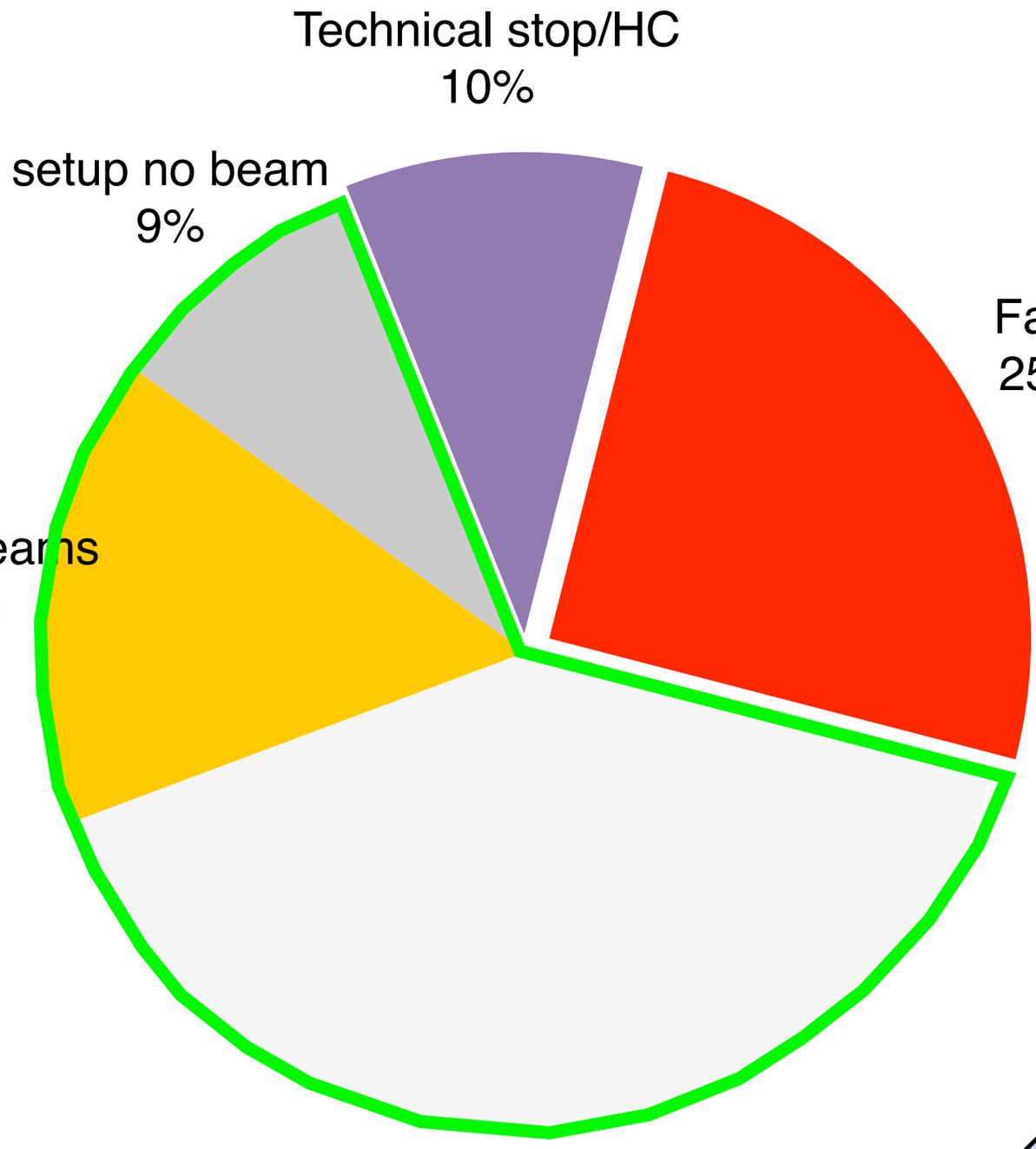
Initial luminosity run

Very fast!!

Nominal bunch intensity

Performance ramp-up

Overall LHC efficiency in 2010

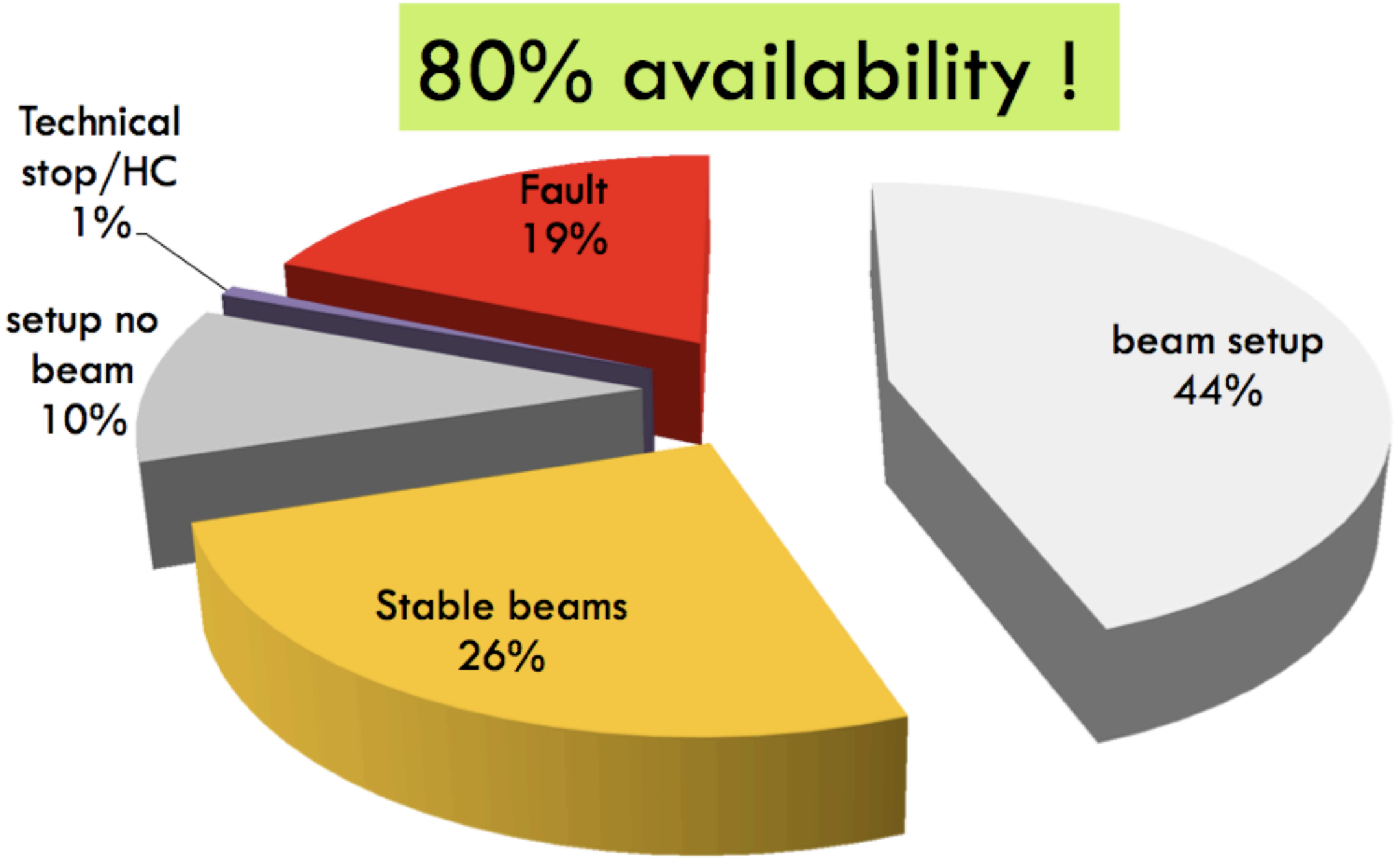


65% availability!

Great achievement for the first year of operation!

W. Venturini

Best month: November (with ions)

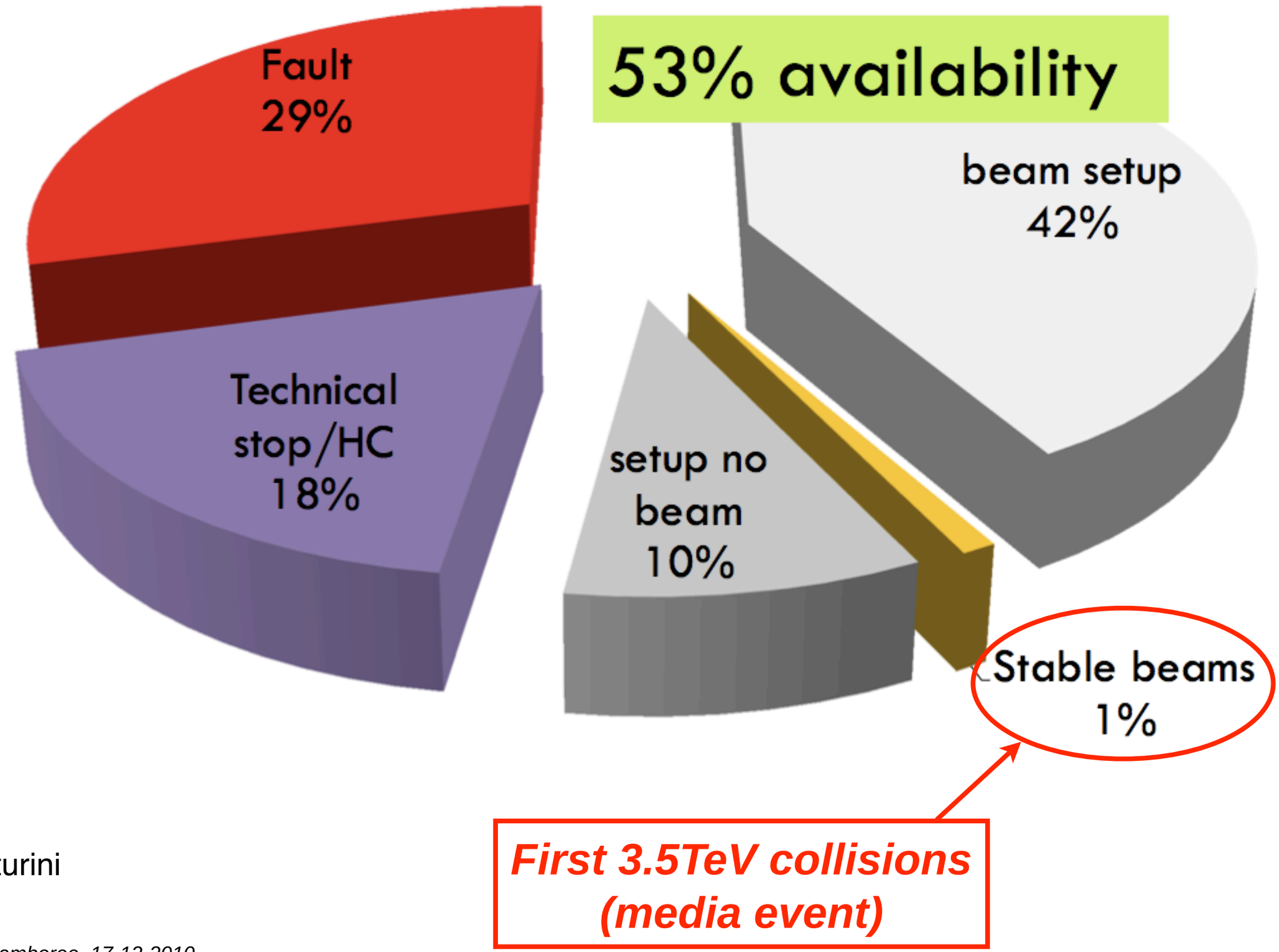


W. Venturini

Well-trained ion operation at the end of the proton run!

Worst month: March

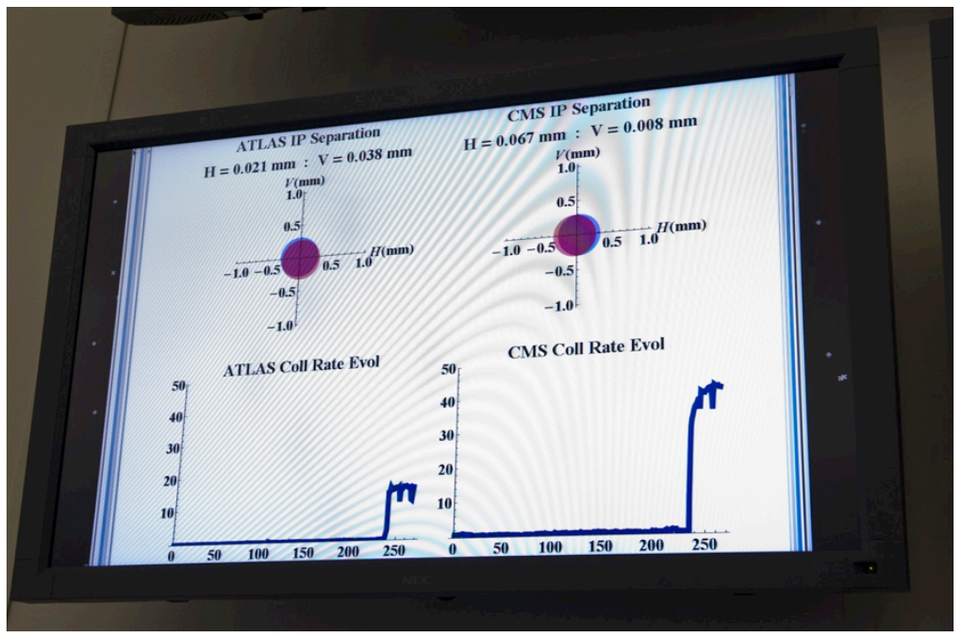
(initial commissioning phase)



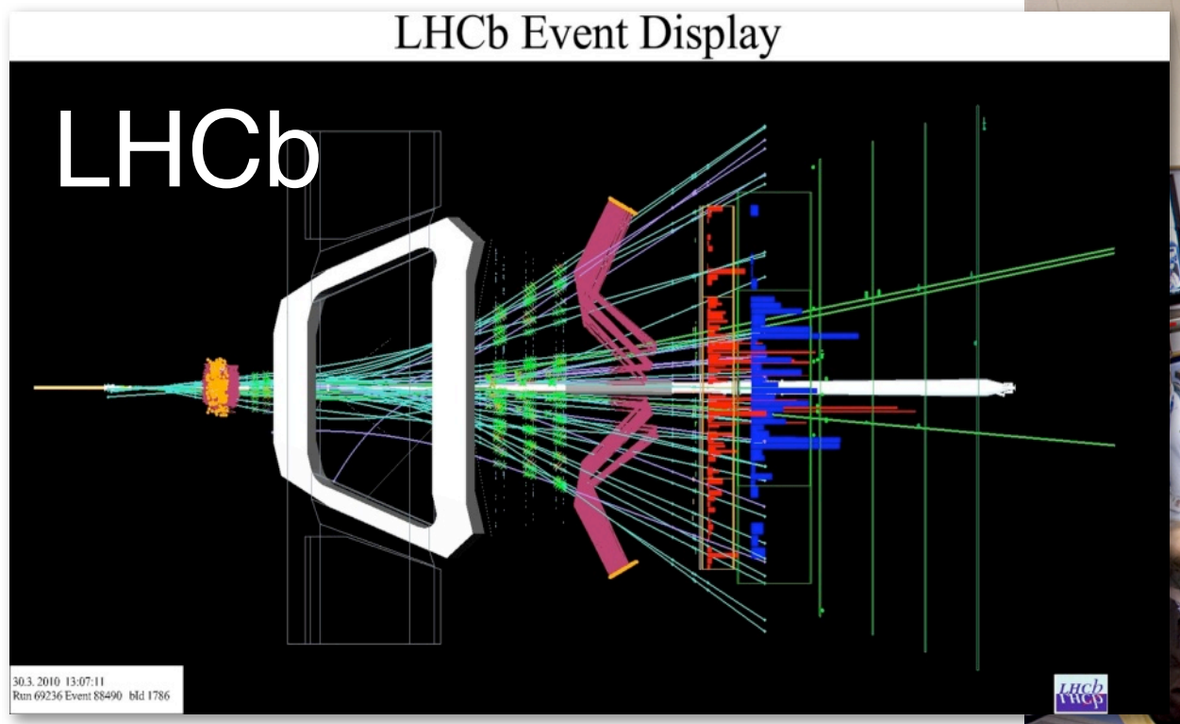
W. Venturini

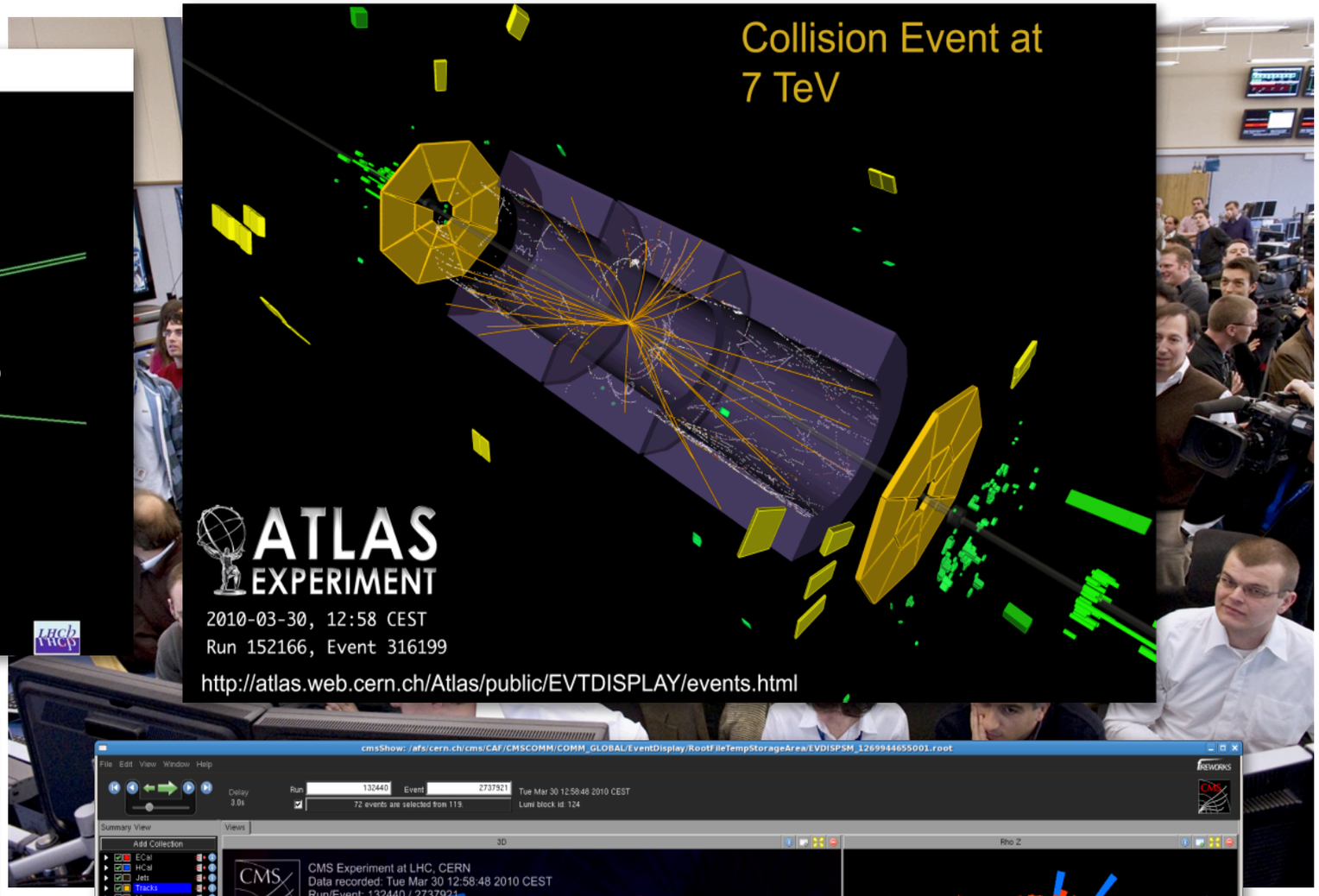
First 7 TeV collisions (March 30th)

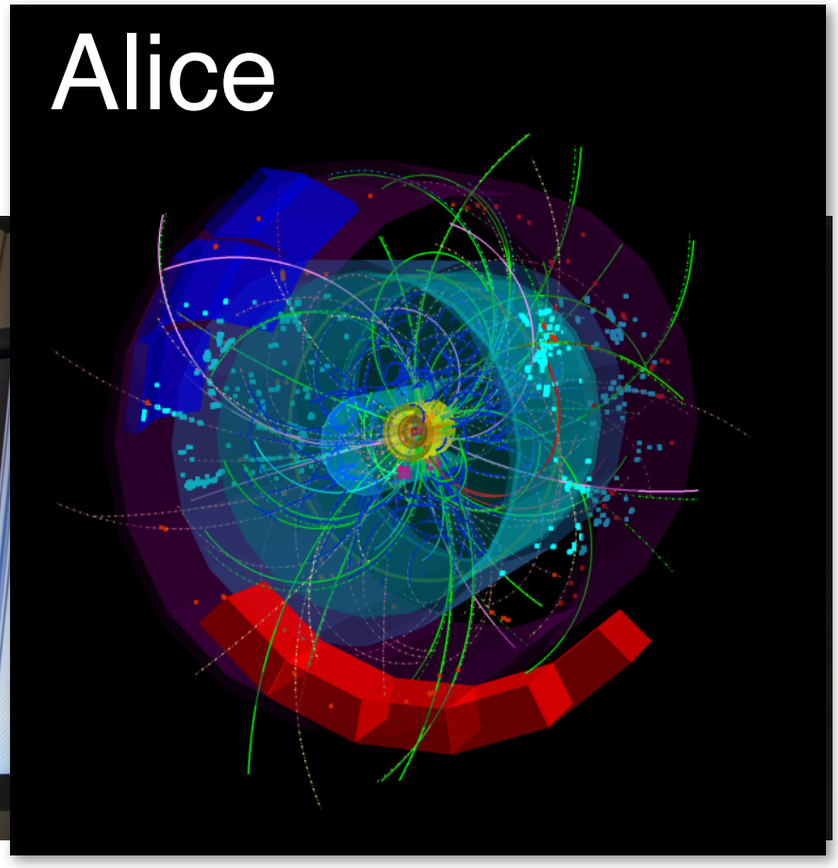
Worried until we managed to steer the beams in collision for the first time...

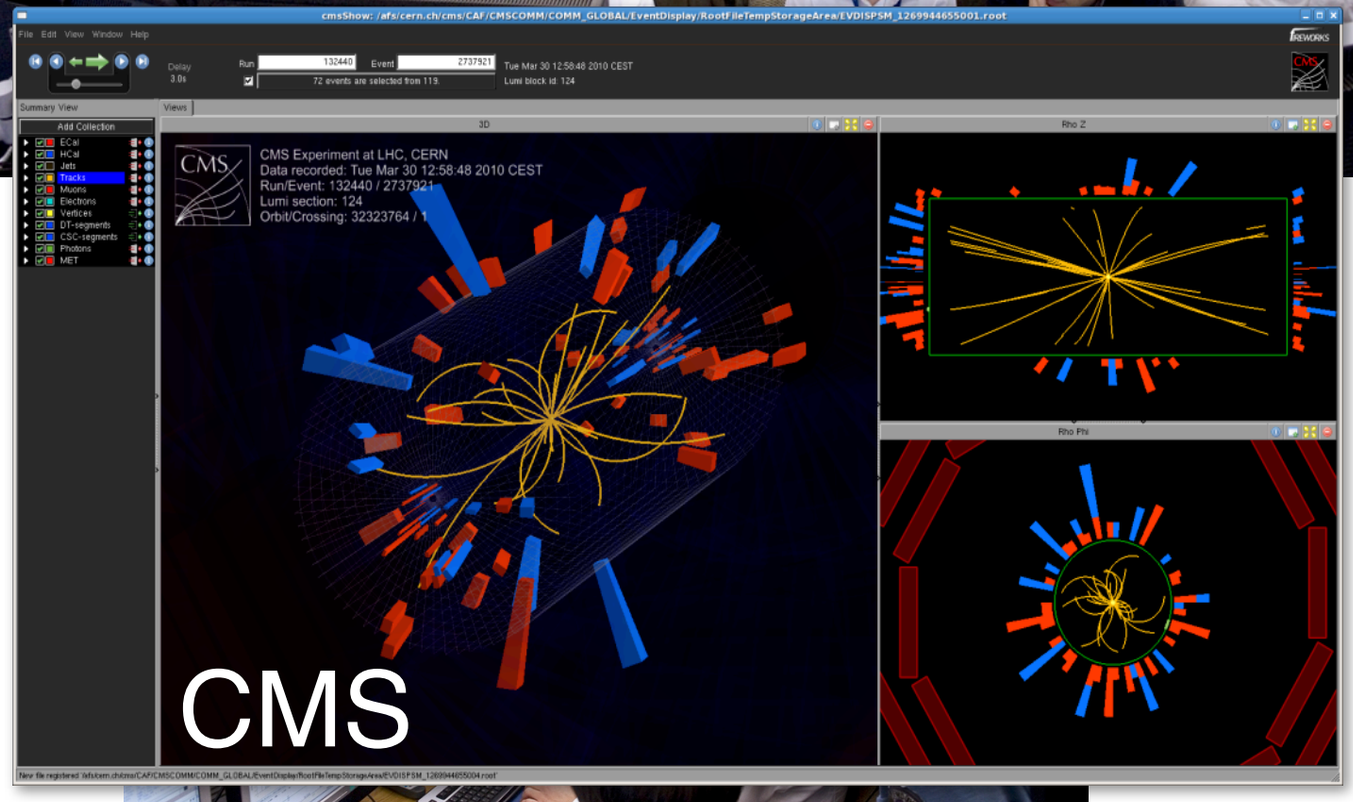


First 7 TeV collisions (March 30th)



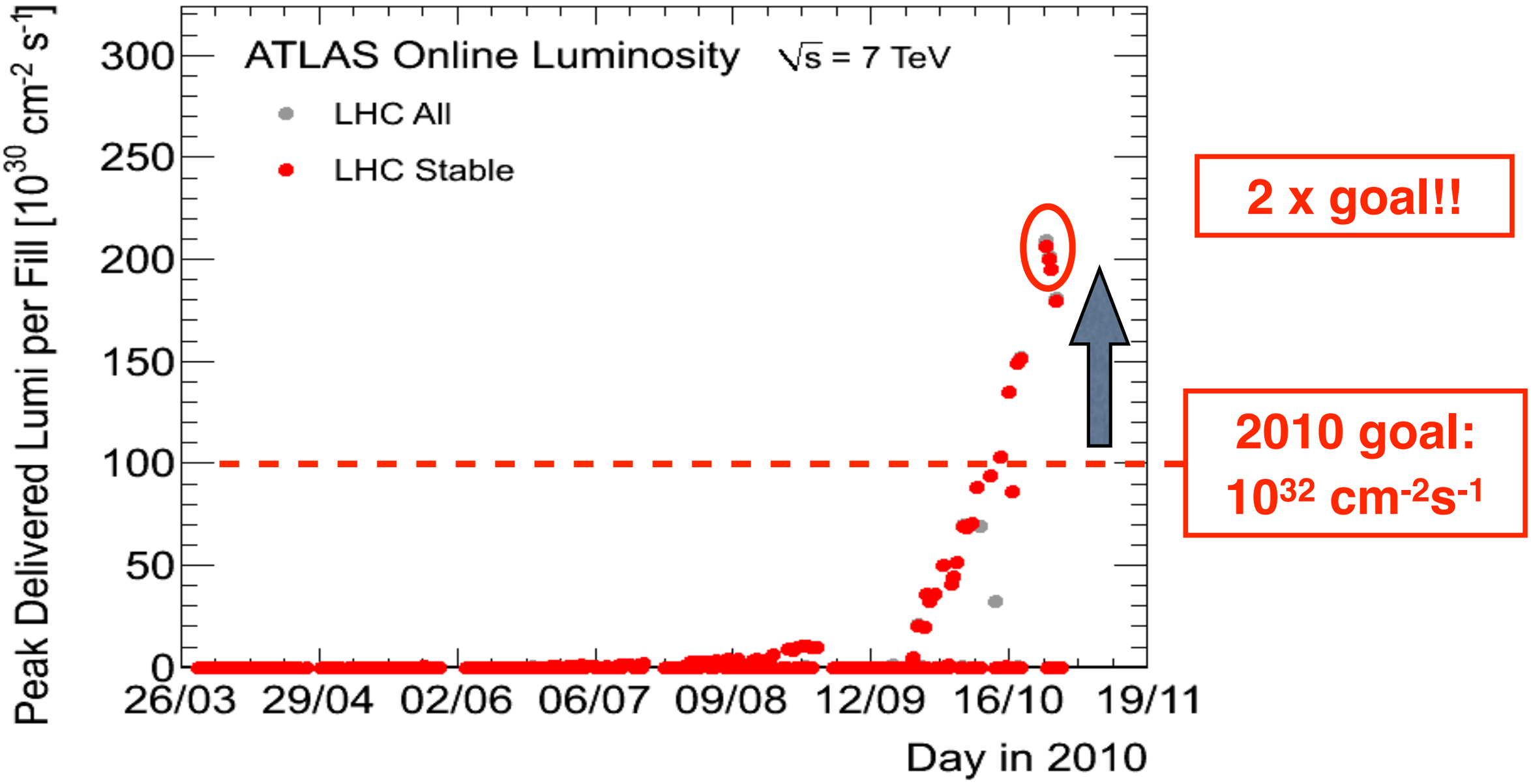






First 7 TeV collisions (March 30th)

Peak luminosity performance



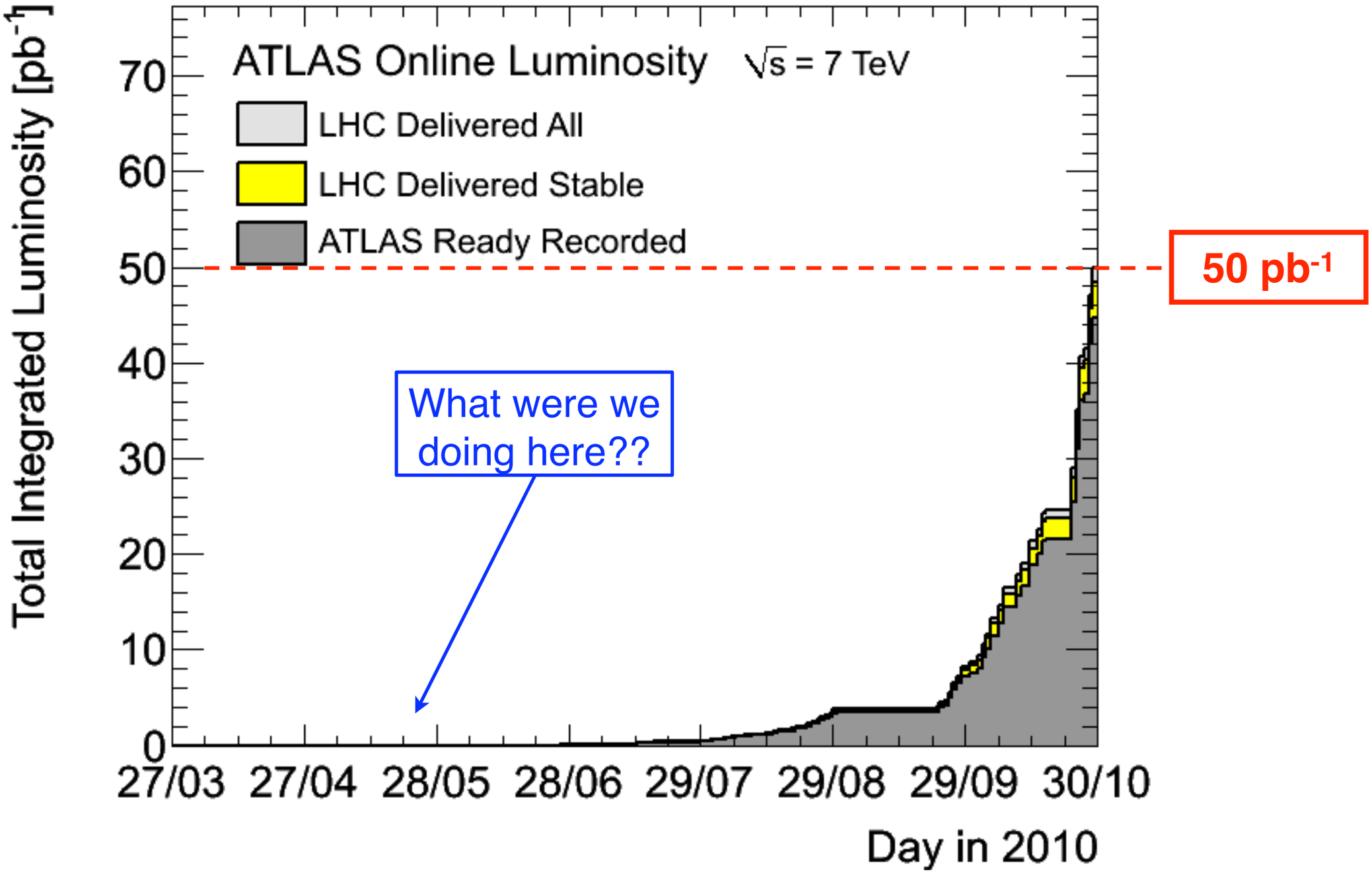
2 x goal!!

2010 goal: 10^{32} cm^{-2}s^{-1}

Main parameters: 368 bunches of 1.2×10^{11} protons.

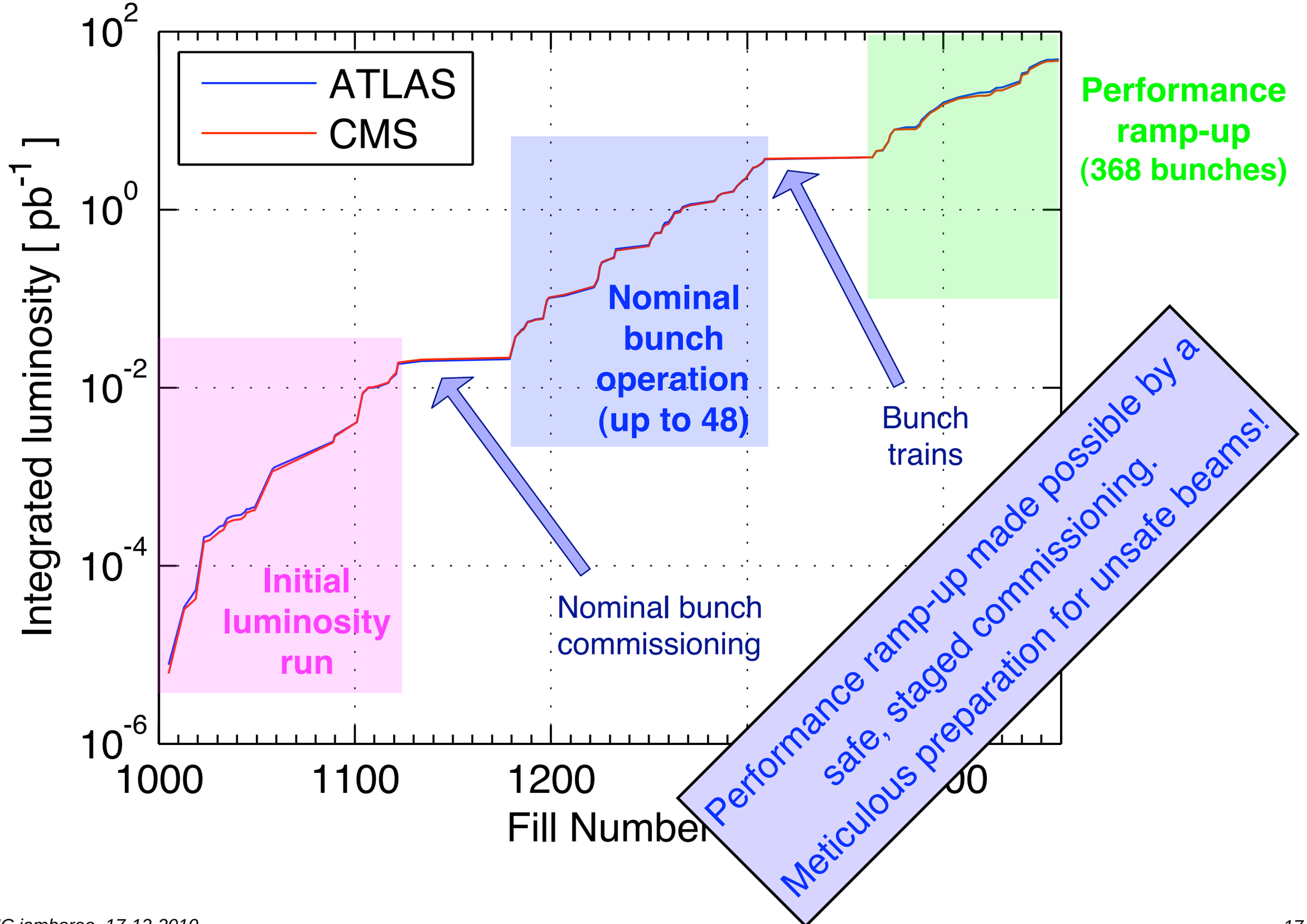
Colliding beam sizes = 0.00004 metres.

Integrated luminosity



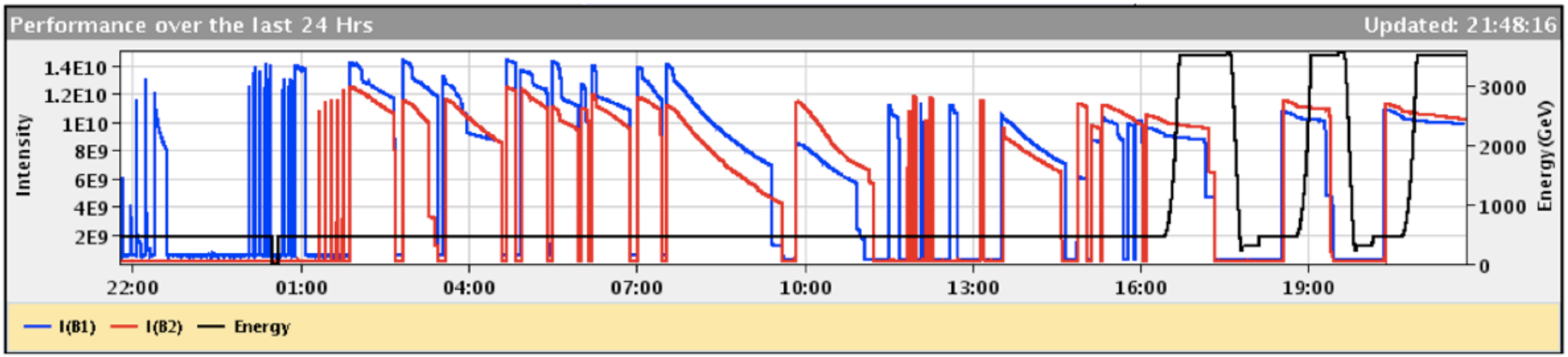
See talks from experiments to see what they could do with this...

Luminosity: 3 running periods



2010 Pb ion run - commissioning

1 day



Beam 1 Inj., Circ. & Capture

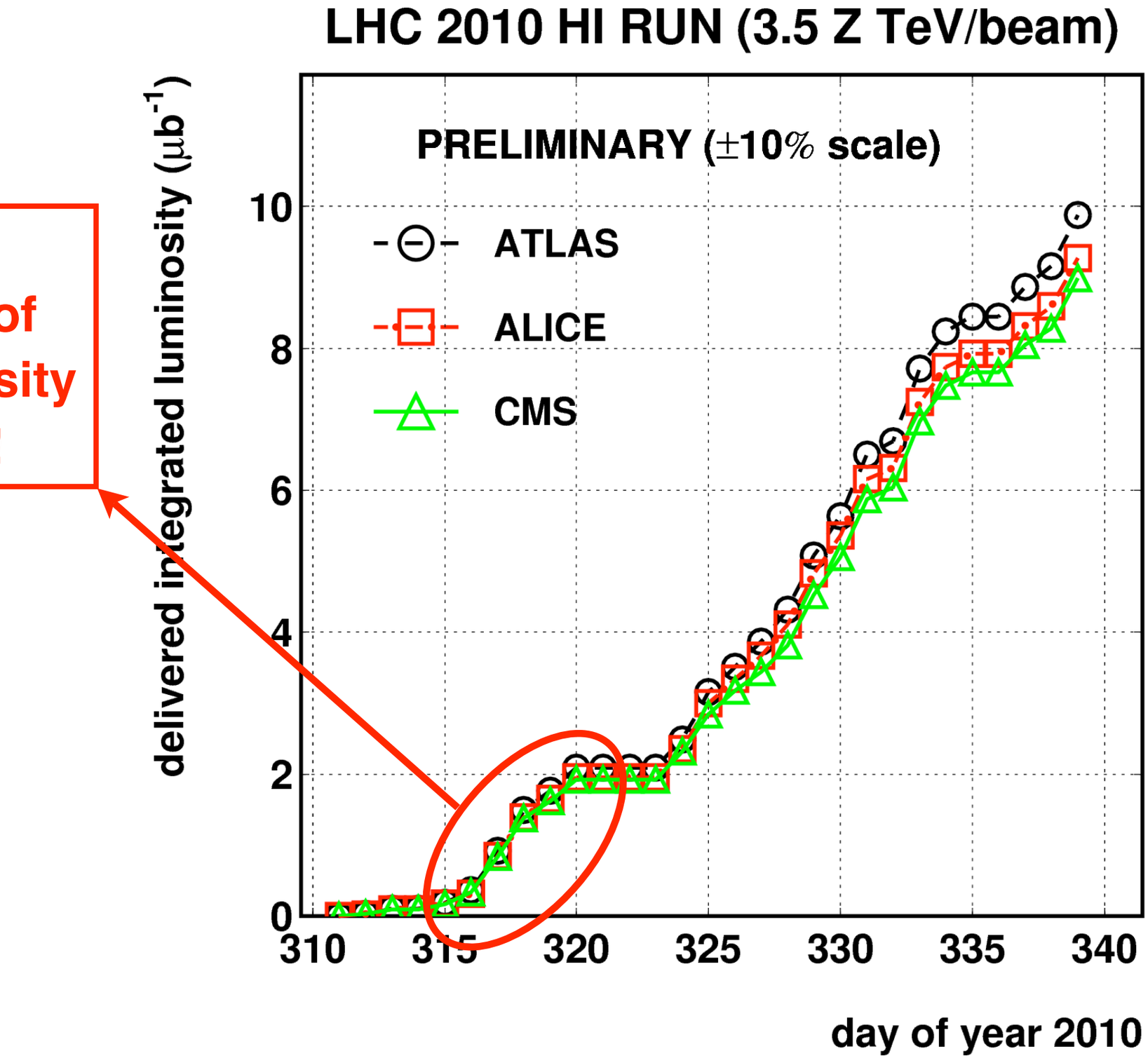
Beam 2 Inj., Circ. & Capture

Optics Checks
BI Checks
Collimation Checks

First Ramp
Collimation Checks
Squeeze

Achieved ion collisions after **3 days** of commissioning (impressively fast)!
This indicates the remarkable maturity and performance of controls, instrumentation, operational experience.

Ion luminosity performance



Gained a factor 100 of peak luminosity in 6 days!

M. Ferro-Luzzi

1 month

Outstanding problems encountered

(only mention potential performance limits for 2011)

☑ UFOs - Unidentified FALLING objects

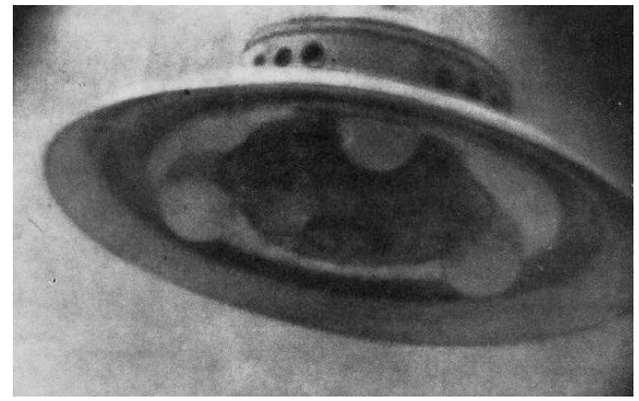
Sudden fast losses ($t < 0.001$s).

Potentially caused by falling dust particles.

No danger for the super-conducting magnets,

but trigger preventive beam dumps;

More frequent with larger beam intensities!



☑ Electron cloud

"Clouds" of electrons generated in the vacuum pipe if

the bunches are too close longitudinally.

Can limit the total intensity (bunch num.):

vacuum problems; instabilities;

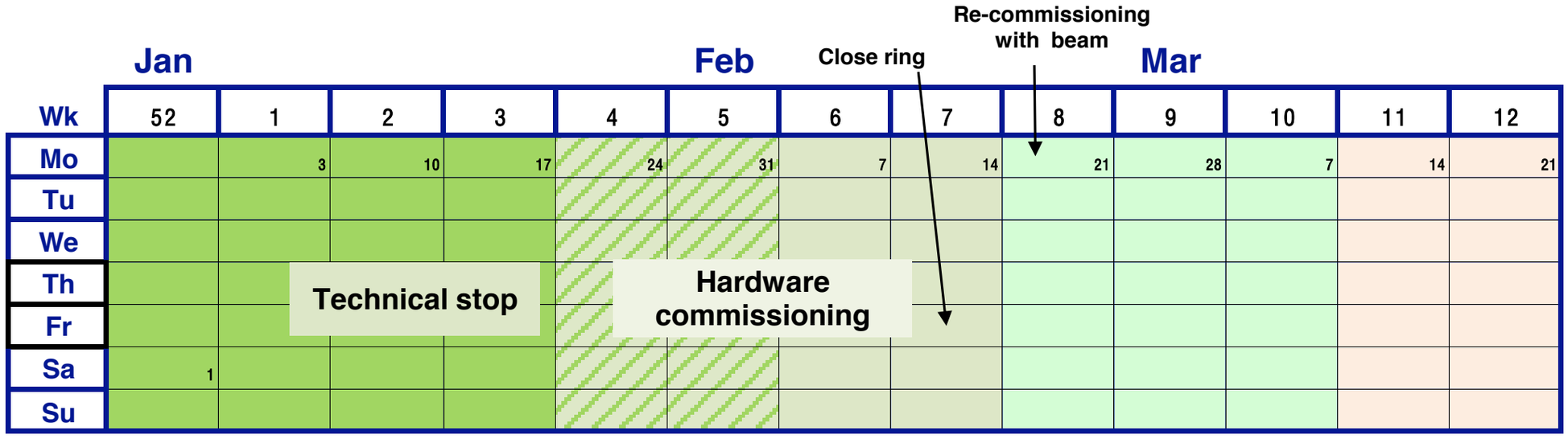
growth of the beam size.

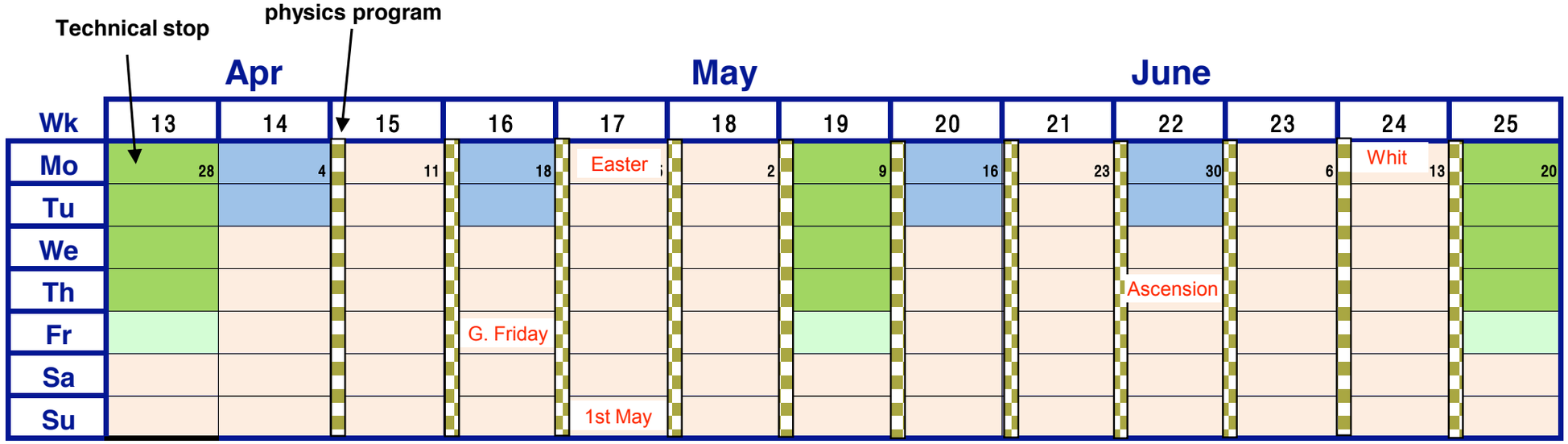
Can be cured by "scrubbing" the chamber.

Outline

- Introduction
- Performance in 2010
- **2011 prospects**
  - **Draft schedule**
  - **Performance reach**
- Conclusions

Draft LHC schedule Q1 & Q2



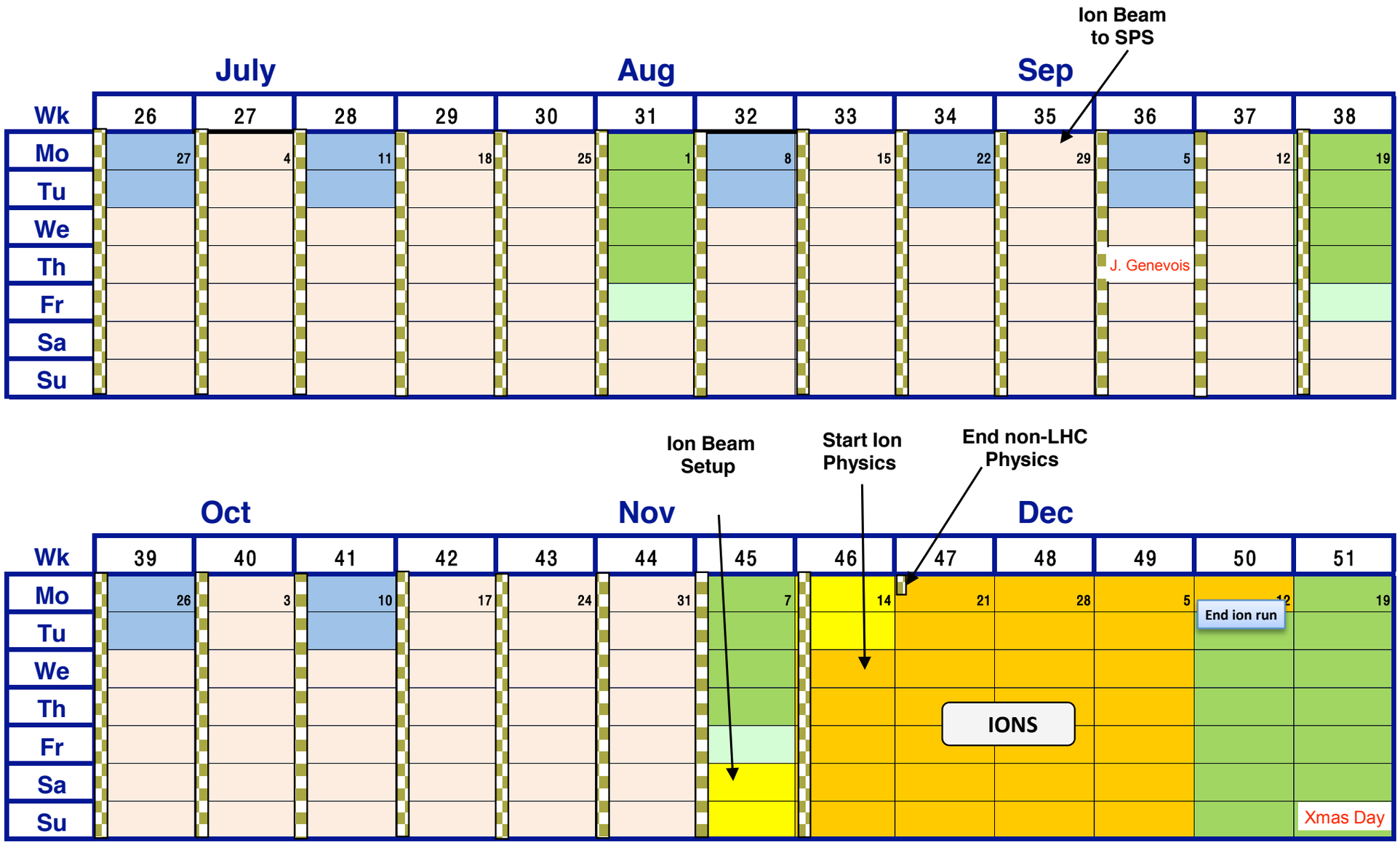


M. Lamont

Re-start in February - Physics start: mid-March
Continuous physics production except for necessary technical stops/machine studies

- Technical Stop
- Recommisssoning with beam
- Machine development
- Ion run
- Ion setup

Draft LHC schedule Q3 & Q4

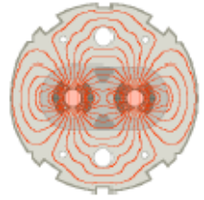


M. Lamont

Proton run followed by 4 weeks of ion physics!

- Technical Stop
- Recommisssoning with beam
- Machine development
- Ion run
- Ion setup

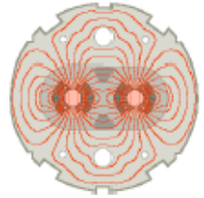
Potential performance range



Goal: 1 fb^{-1}

- **Energy: 3.5 TeV to 4 TeV**
  To be decided at the Chamonix workshop in Jan. 2011.
- **Bunch intensity**
  Baseline 1.2x10^{11} protons, higher possible from injectors.
- **Number of bunches**
  450 to 930 bunches (75 ns spacing): potential **factor 2**.
- **Colliding beam sizes**
  Maintain excellent beams from injectors: **50% smaller** than nominal
  Possible to “squeeze” beams further: another **50% gain**!
- **Peak luminosities in the range of 6 to 16 x 10^{32} cm^{-2}s^{-1} could be possible.**
  At least 3 times more than what we have seen in 2010!
- **Integrated luminosity between 1 and 3 fb^{-1} would appear feasible.**

Conclusions



- ☑ **Excellent first year of operation for the LHC!**
- ☑ **We achieved a peak luminosity twice the target for the year.**
- ☑ **Smooth transition to ion operation (collisions in 3d!)**
- ☑ **Excellent performance of key accelerator systems and injector chain.**
- ☑ **Very good machine availability (65%).**
- ☑ **Solid foundation for 2011 operation: the target for the next year is very much within reach.**
- ☑ **Potential improvements from smaller colliding beam size and more bunches.**