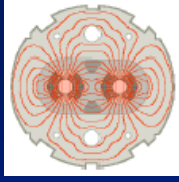
Quark Matters,

Annecy, France

23rd May 2011



The LHC
Status and Performance

Stephen Myers

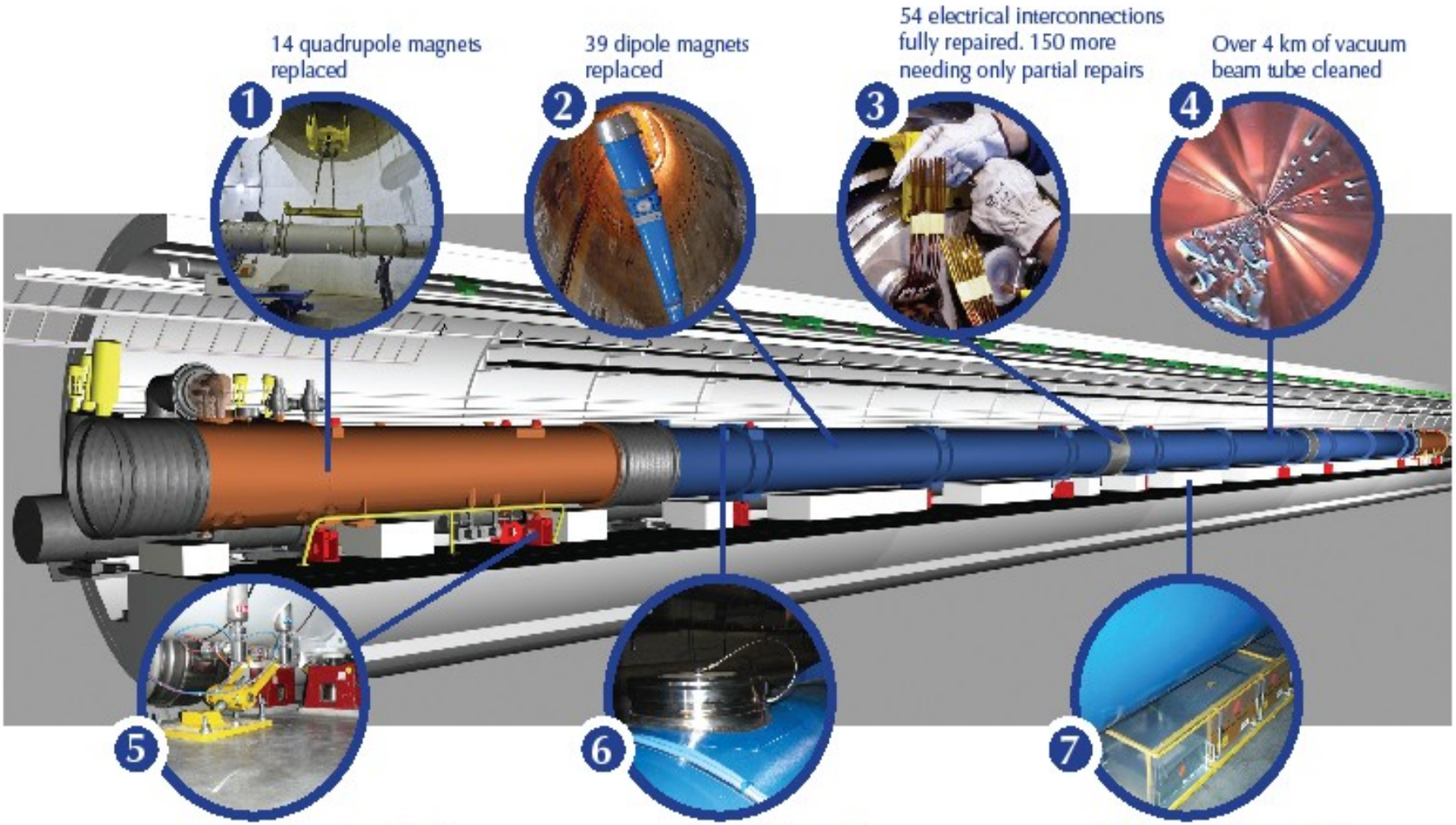
Director for Accelerators and Technology,

CERN Geneva

September 10, 2008; It worked!

Phase 1 +2

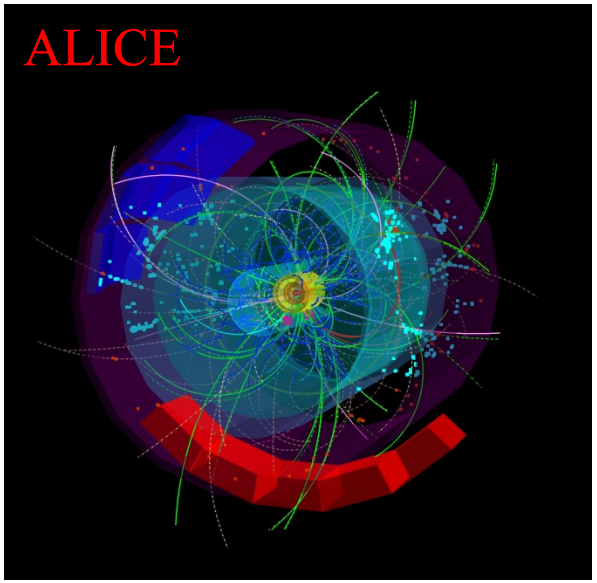
The LHC repairs in detail



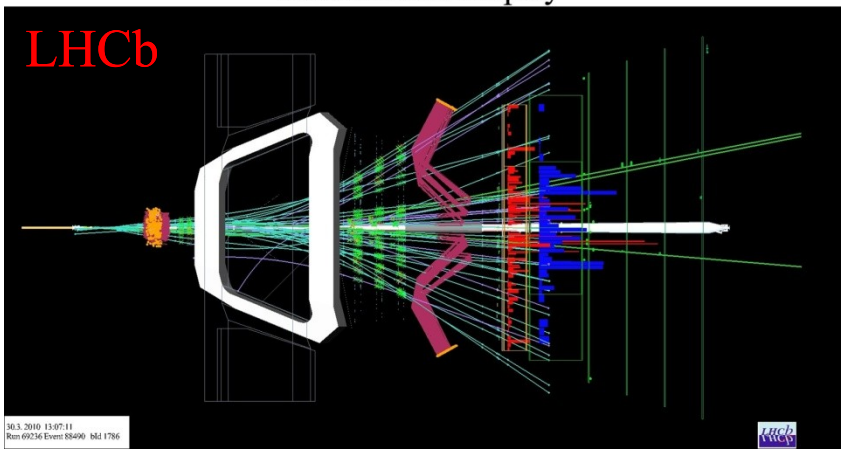
CERN

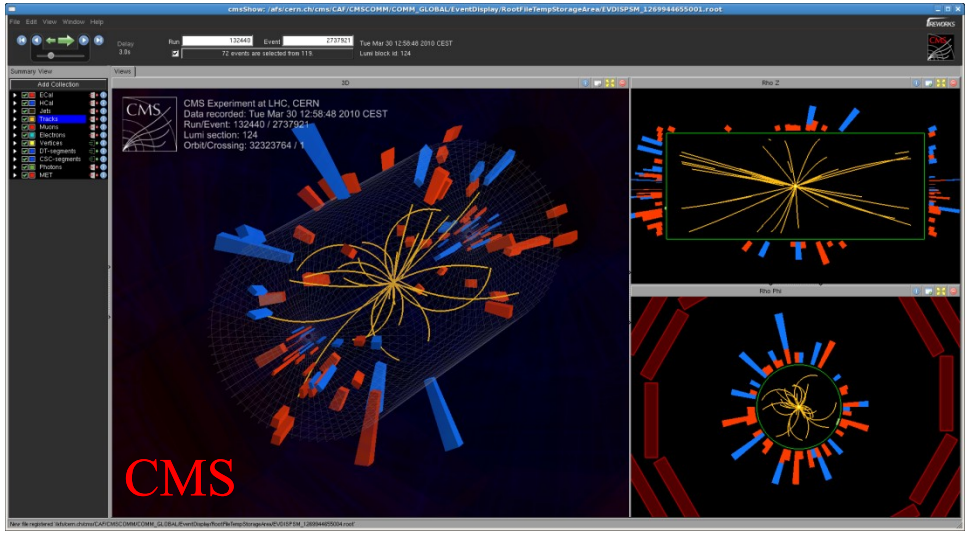
+ 8 cryogenics!

LHC: First collisions at 7 TeV on 30 March 2010



LHCb Event Display





Very Cautious start: low bunch intensity and increasing the number of bunches to 13 with beta* = 2m

calculated

Event	TeV	OEF	β*	Nb	Ib	Itot	MJ	Nc	Peak luminosity	Date
1	3.5	0.2	10	2	1.00E+10	2.0E+10	0.0113	1	8.9E+26	30 March 2010
2	3.5	0.2	10	2	2.00E+10	4.0E+10	0.0226	1	3.6E+27	02 April 2010
3	3.5	0.2	2	2	2.00E+10	4.0E+10	0.0226	1	1.8E+28	10 April 2010
									28	19 April 2010
									28	15 May 2010
6	3.5	0.2	2	13	2.60E+10	3.4E+11	0.1910	8	2.4E+29	22 May 2010
7	3.5	0.2	3.5	3	1.10E+11	3.3E+11	0.1865	2	6.1E+29	26 June 2010
8	3.5	0.2	3.5	6	1.00E+11	6.0E+11	0.3391	4	1.0E+30	02 July 2010
9	3.5	0.2	3.5	8	9.00E+10	7.2E+11	0.4069	6	1.2E+30	12 July 2010
10	3.5	0.2	3.5	13	9.00E+10	1.2E+12	0.6612	8	1.6E+30	15 July 2010
11	3.5	0.2	3.5	25	1.00E+11	2.5E+12	1.4129	16	4.1E+30	30 July 2010
12	3.5	0.2	3.5	48	1.00E+11	4.8E+12	2.7127	36	9.1E+30	19 August 2010

Switch to beta* = 3.5m, design bunch intensity and increase the number of bunches to 48 (2.7MJ)

Maximum reached is 10.7×10^{30} $cm^{-2}s^{-}$

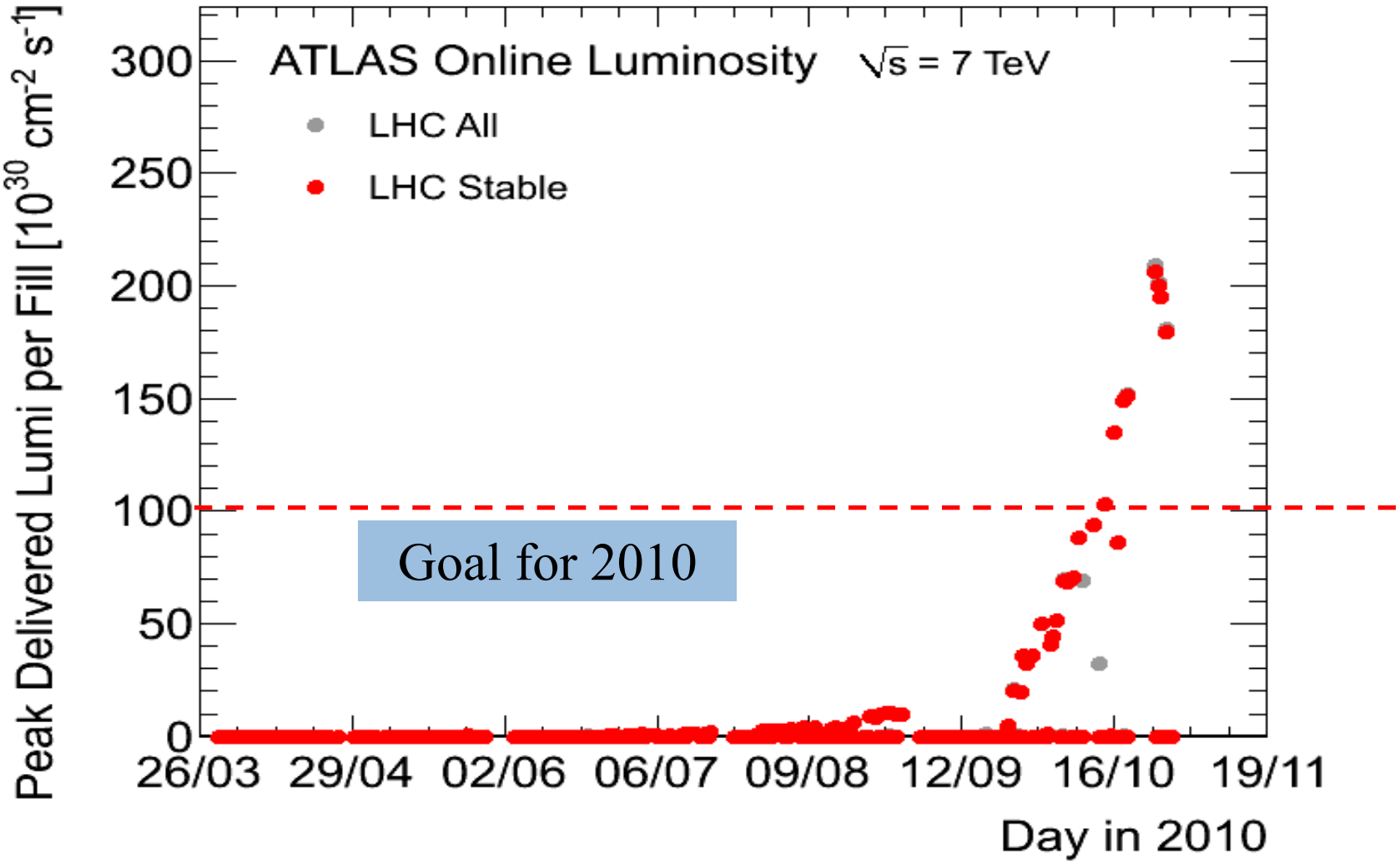
First Operation with trains of bunches; up to 348 still with beta* = 3.5m (3.5TeV/beam, 24MJ)

d

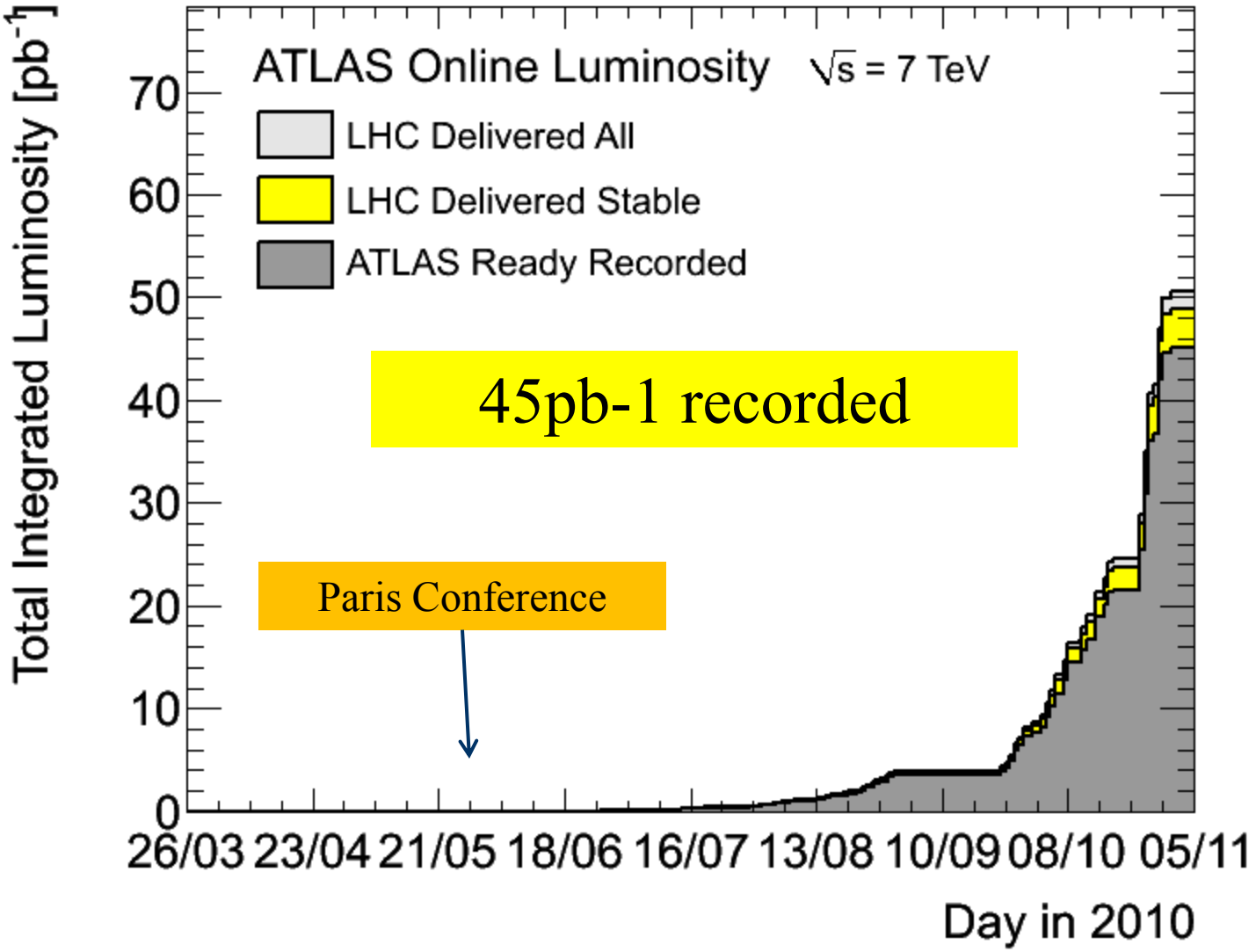
Nb	Ib	MJ	Nc	Peak luminosity (design parameters)	Maximum luminosity (measured)	Pile up (from measured Lumi)	Date
56	1.10E+11	3.5	47	1.203E+31	2.000E+31	1.9054	23/09/2010
104	1.10E+11	6.5	93	2.381E+31	3.500E+31	1.7955	25/09/2010
152	1.10E+11	9.4	140	3.584E+31	5.000E+31	1.7550	29/09/2010
204	1.10E+11	12.7	186	4.762E+31	7.000E+31	1.8307	04/10/2010
248	1.10E+11	15.4	233	5.965E+31	1.030E+32	2.2158	14/10/2010
312	1.10E+11	19.4	295	7.552E+31	1.500E+32	2.5650	16/10/2010
368	1.15E+11	23.9	348	9.737E+31	2.050E+32	2.9721	25/10/2010

Performance Improvement by a factor of 200,000 in 7 months:

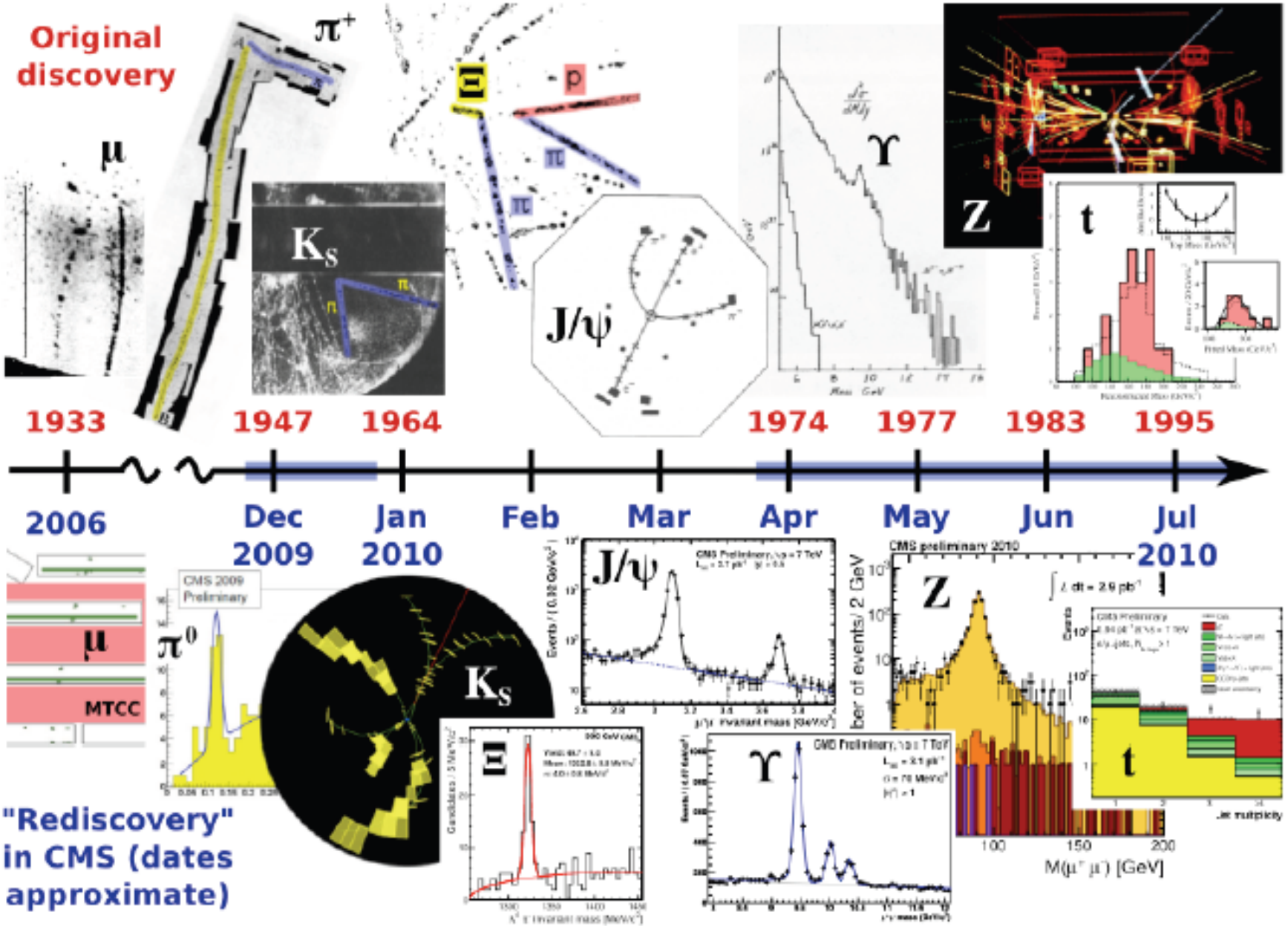
Peak Luminosity



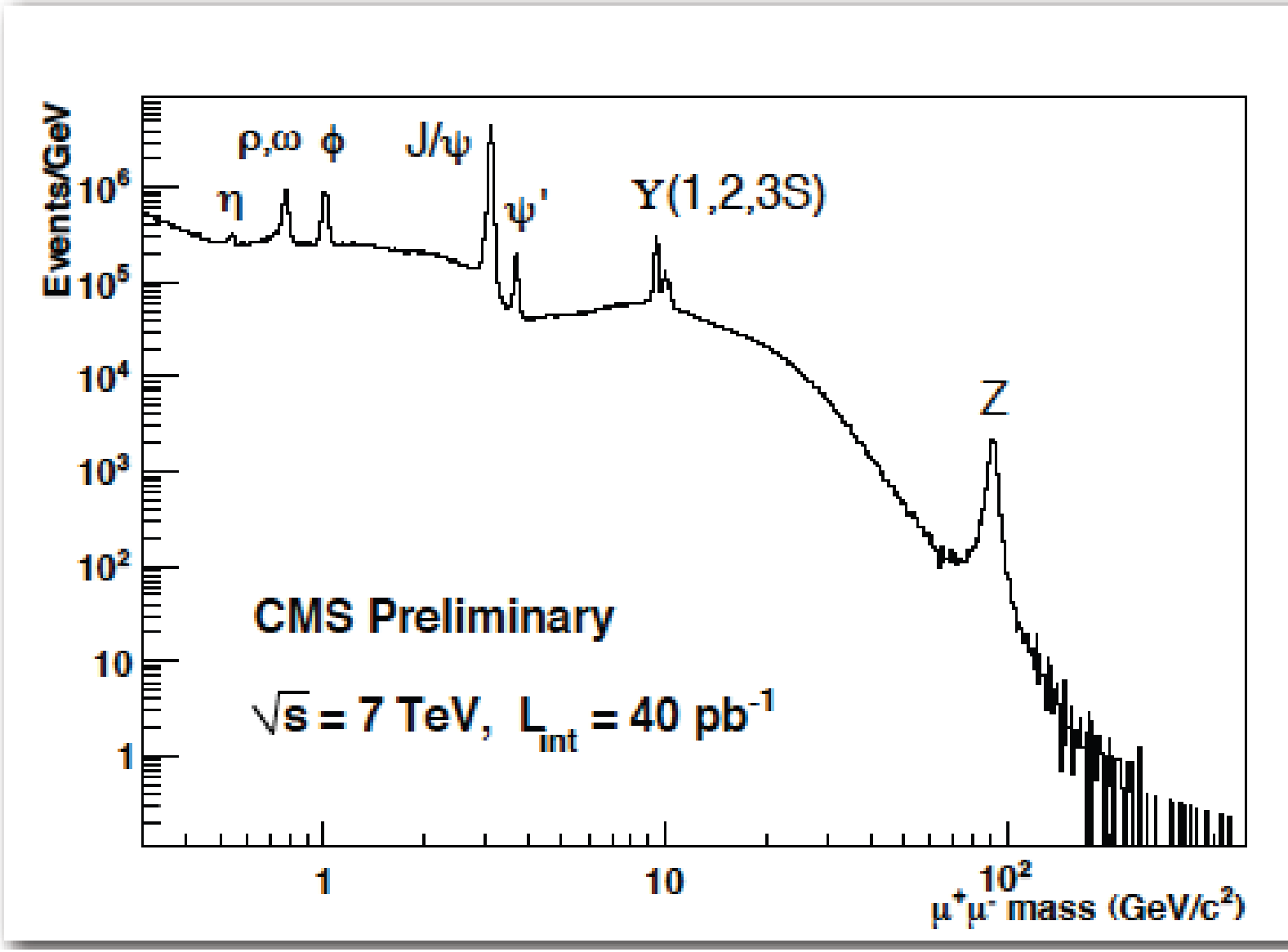
Integrated Luminosity in 2010

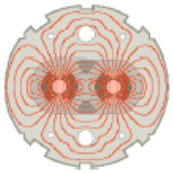


Brief History of the Standard Model



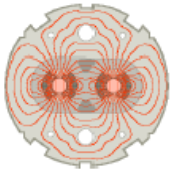
Di-electron and di-muon spectra





End of 2010:
Collisions of lead ions

2010 Ion Run Predictions



The Injectors ready

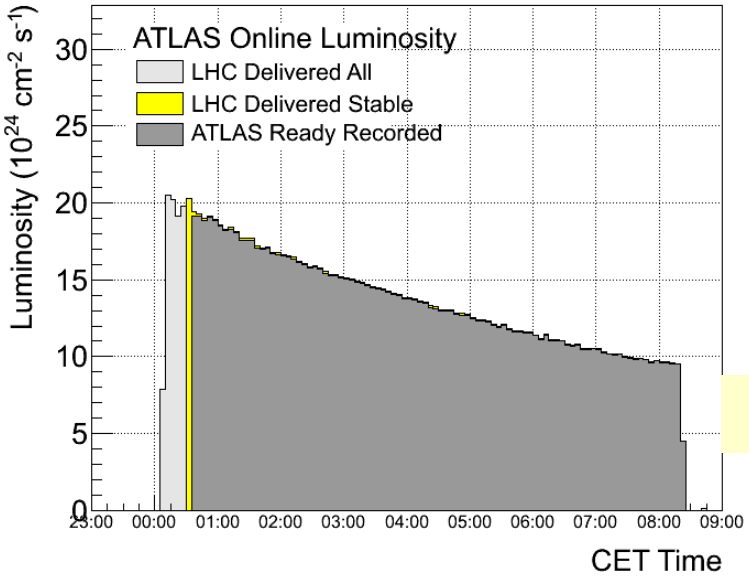
- *The Pb^{82+} beam was injected into the LHC (first beam after the 2008 incident)*

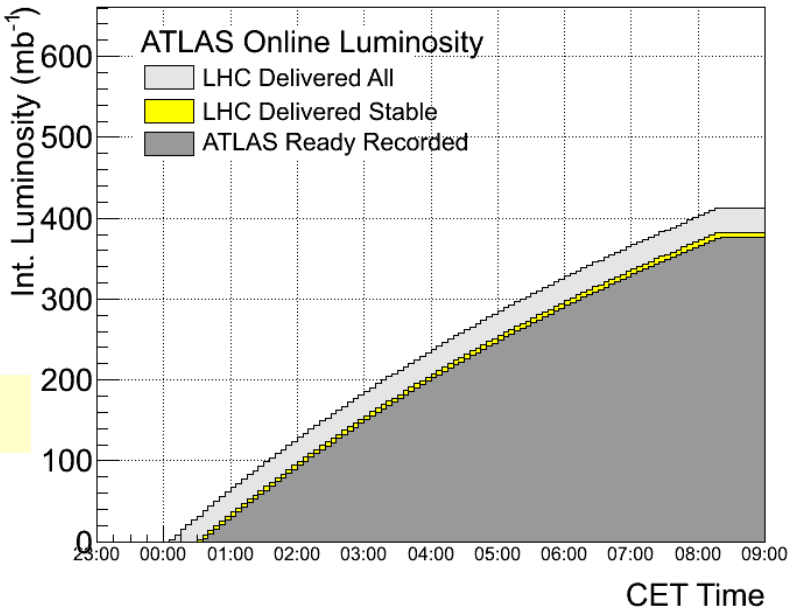
The basic machine parameters are similar

- *But the collimation system needed some setting up*
- *The behavior of the beam instrumentation– the low intensities make life difficult*

It will not look as impressive as protons as far as absolute performance is concerned:

- *Peak Luminosity ~10^{+25} cm^{-2} s^{-1} (c.f. 2x10^{+32} for protons)*
- *Integrated Luminosity ~3-10 μb^{-1} (c.f. 50,000,000 μb^{-1} for protons)*
- *But each collision will look pretty impressive!*

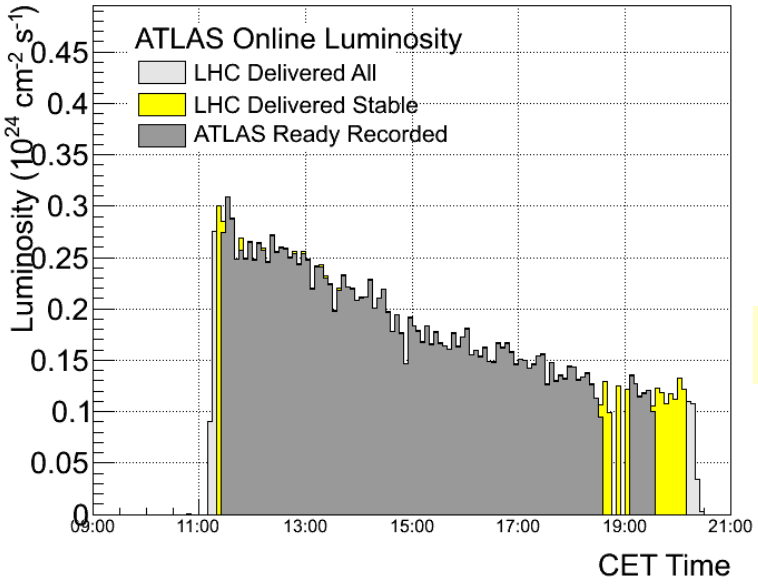


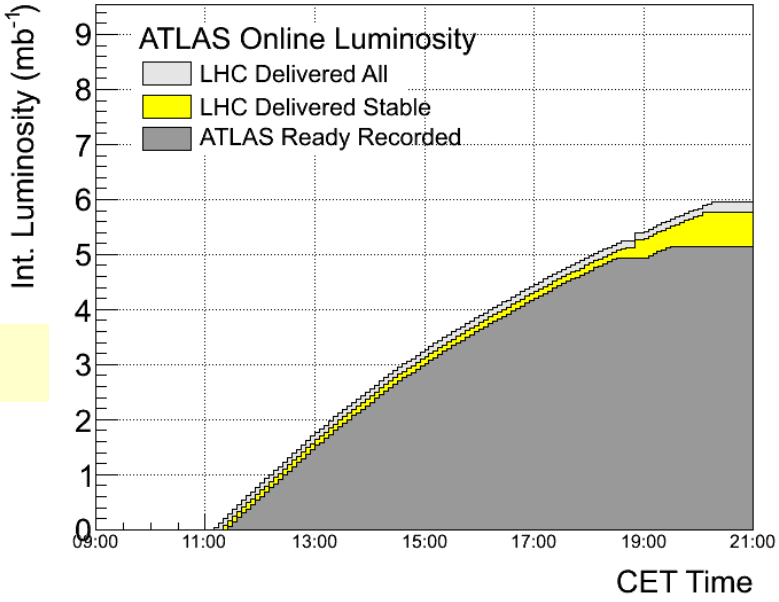


14 Nov

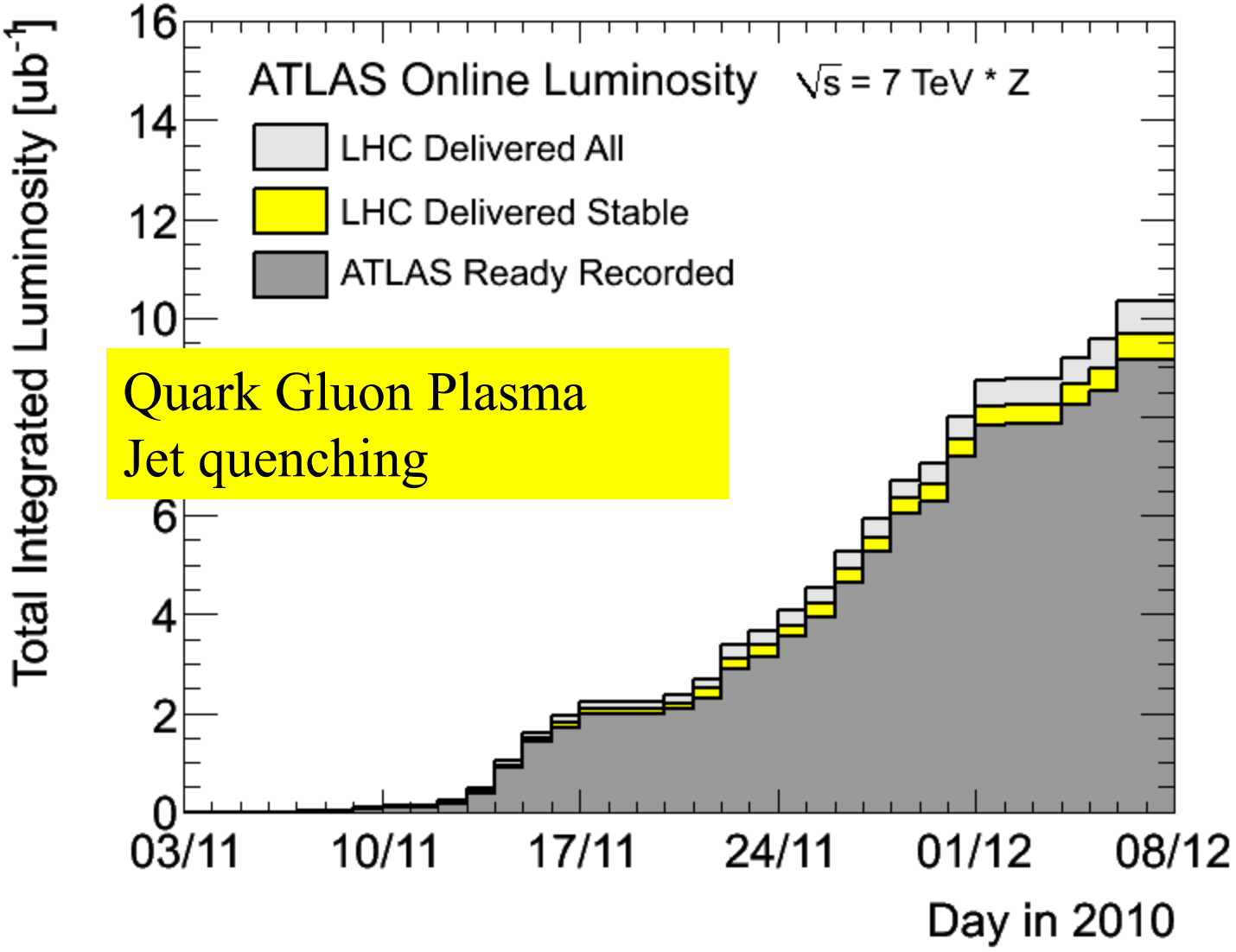
6 days of ion operation (x 100 increase)

8 Nov



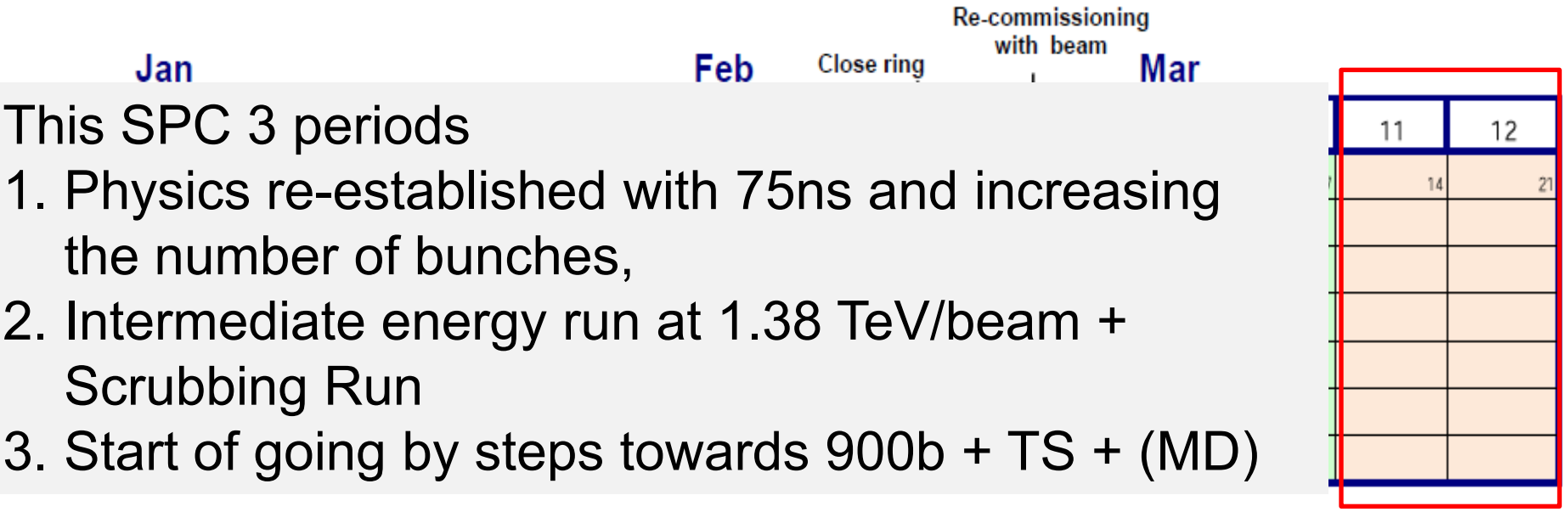


Integrated Luminosity with lead Ions



Quark Gluon Plasma
Jet quenching

2011 LHC schedule



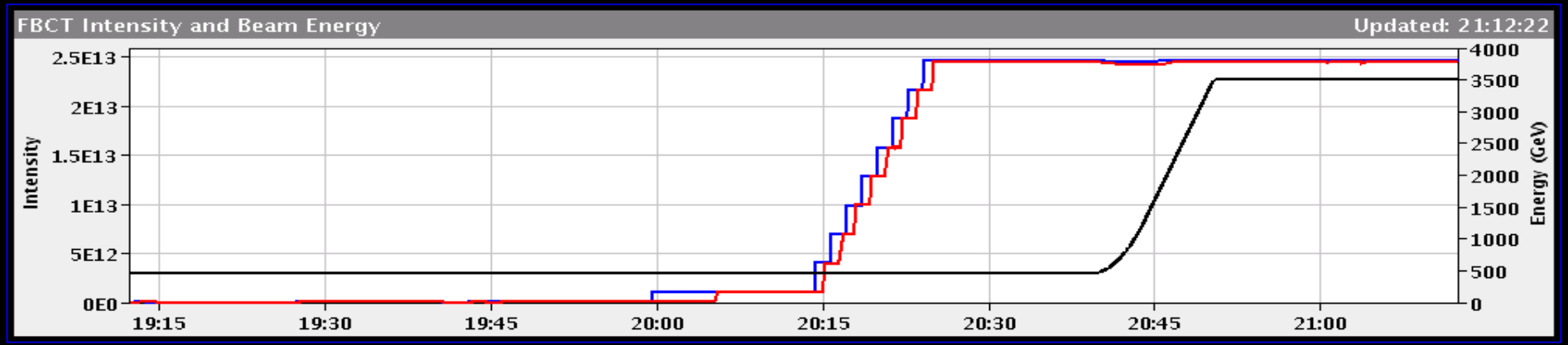
Period 1: Restablishing Physics at 75ns bunch spacing

200 bunches; 75ns; 24bpi

LHC Page1 | Fill: 1645 | E: 3500 GeV | 22-03-2011 21:12:25

PROTON PHYSICS: ADJUST

Energy:	3500 GeV	I(B1):	2.48e+13	I(B2):	2.44e+13



Comments 22-03-2011 20:22:16 :

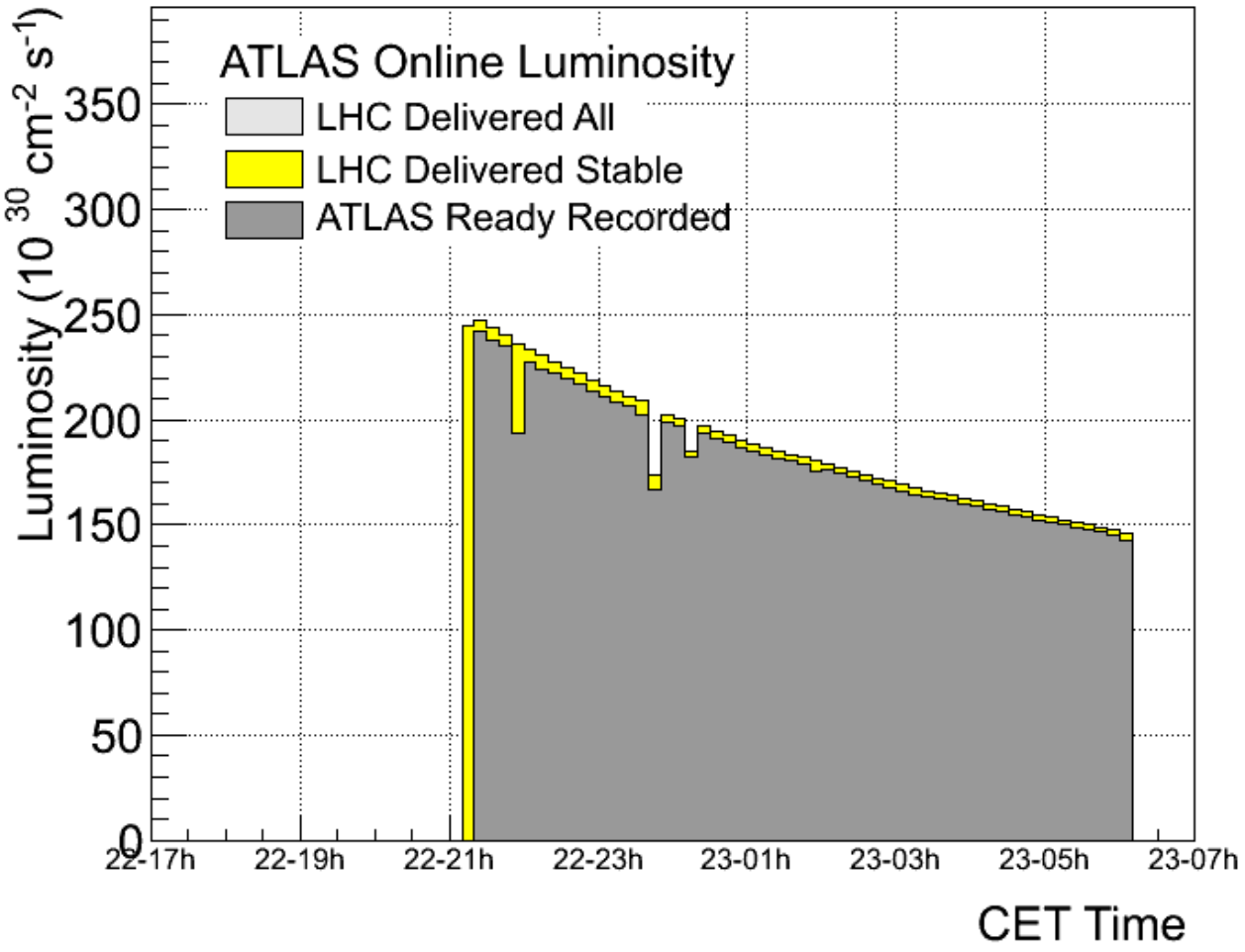
filling

next fill with 200 bunches

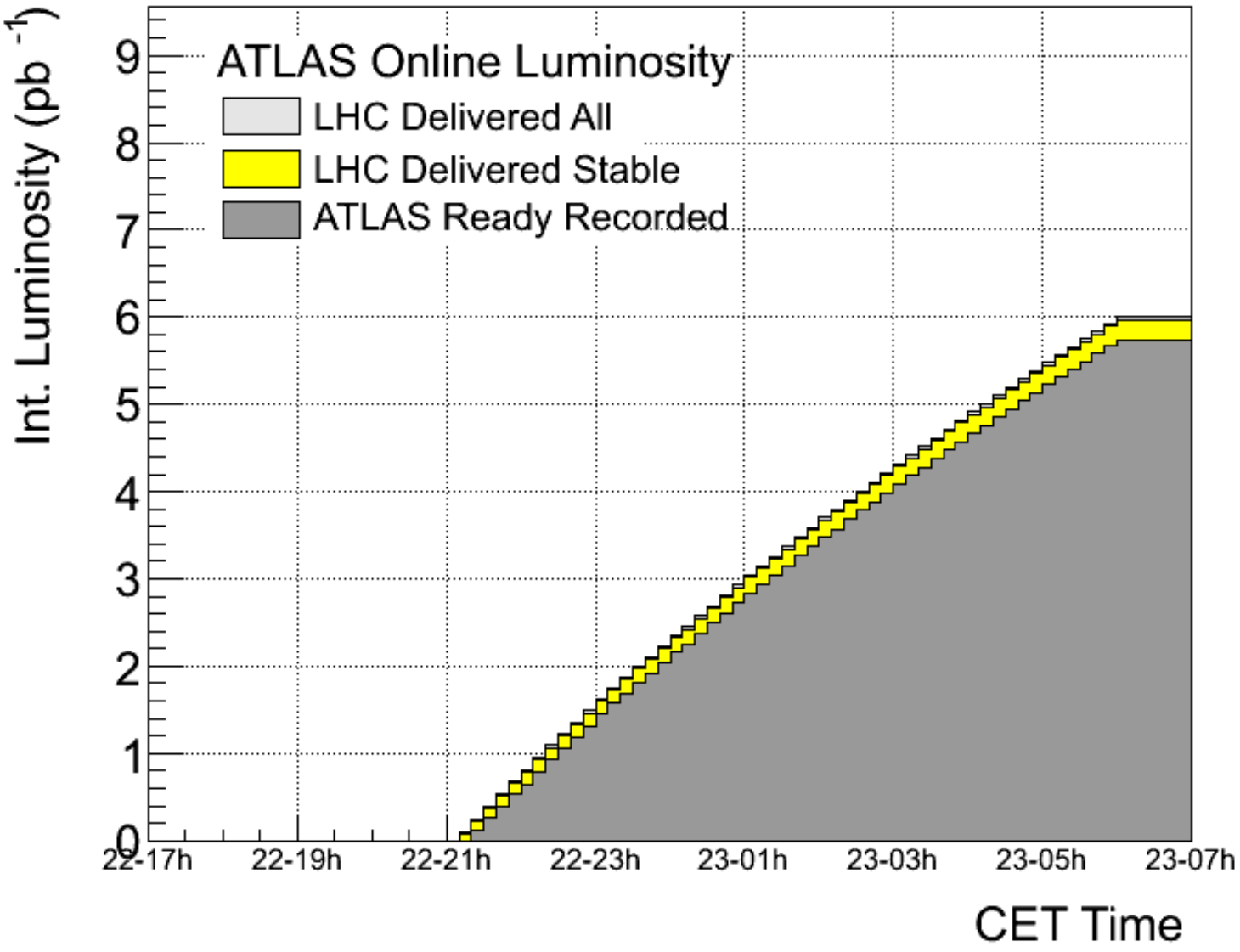
BIS status and SMP flags	B1	B2
Link Status of Beam Permits	true	true
Global Beam Permit	true	true
Setup Beam	false	false
Beam Presence	true	true
Moveable Devices Allowed In	false	false
Stable Beams	false	false

AFS: 75ns_200b_194_178_188_24bpi9inj | PM Status B1: ENABLED | PM Status B2: ENABLED

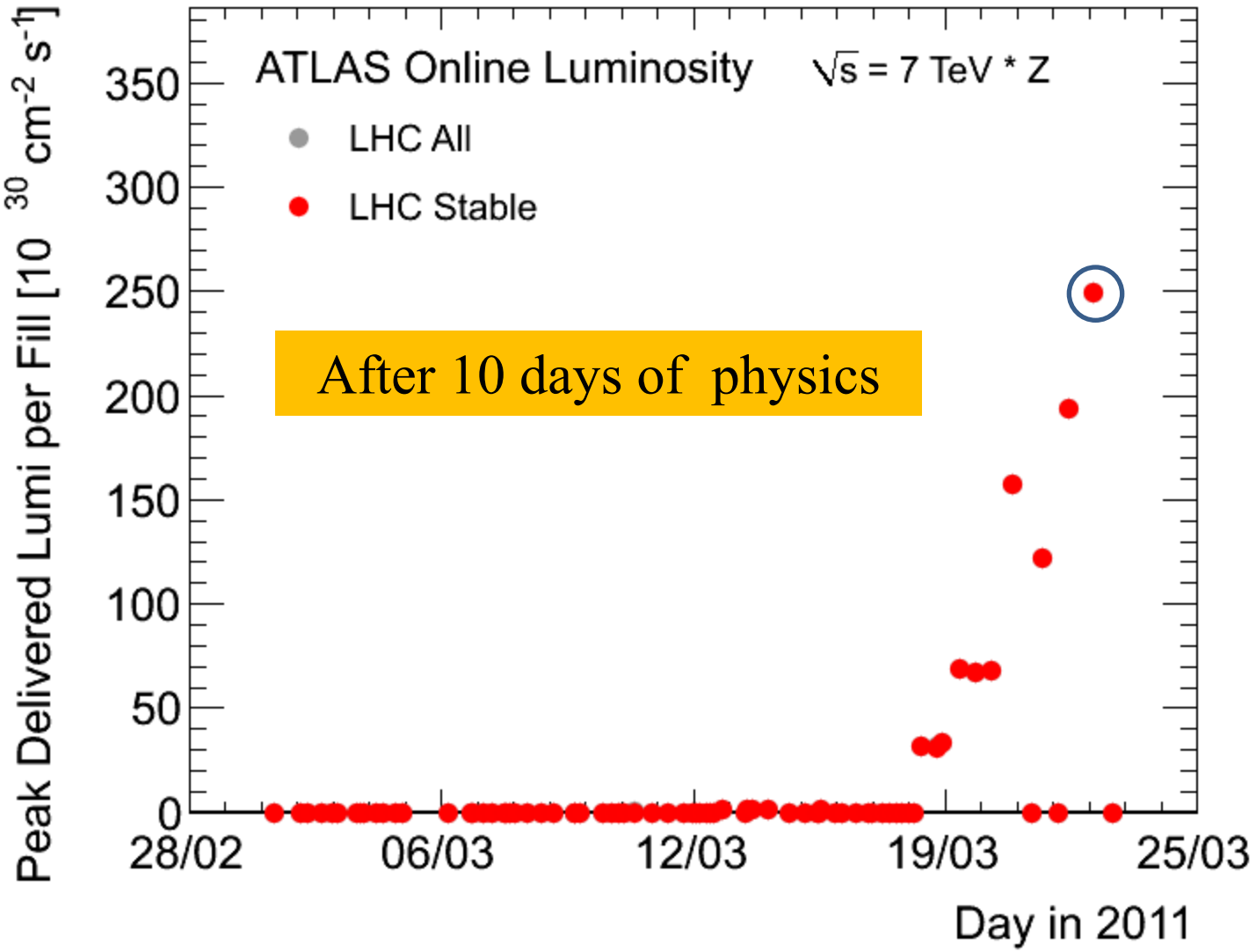
Best fill 1st Period; Luminosity with time



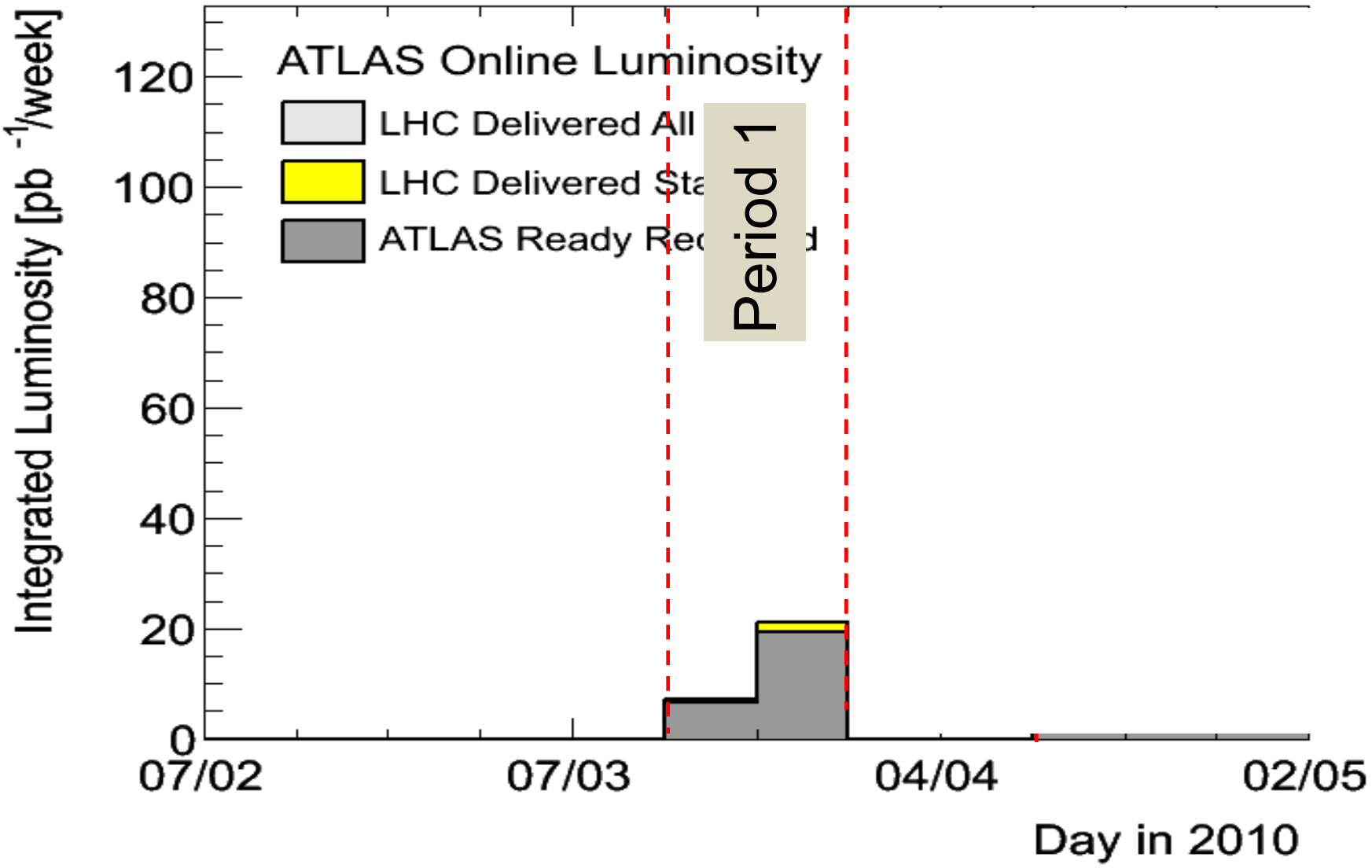
1st Period: Best Integrated Luminosity



First Record Fill of 2011 (on March 23)



1st Period


ATLAS Online Luminosity
LHC Delivered All
LHC Delivered Sta
ATLAS Ready Rec d
Period 1
Integrated Luminosity [pb -1/week]
120
100
80
60
40
20
0
07/02
07/03
04/04
02/05
Day in 2010

2nd Period (a) Intermediate Energy Run at 1.38TeV/beam

Accomplished without too much bother;

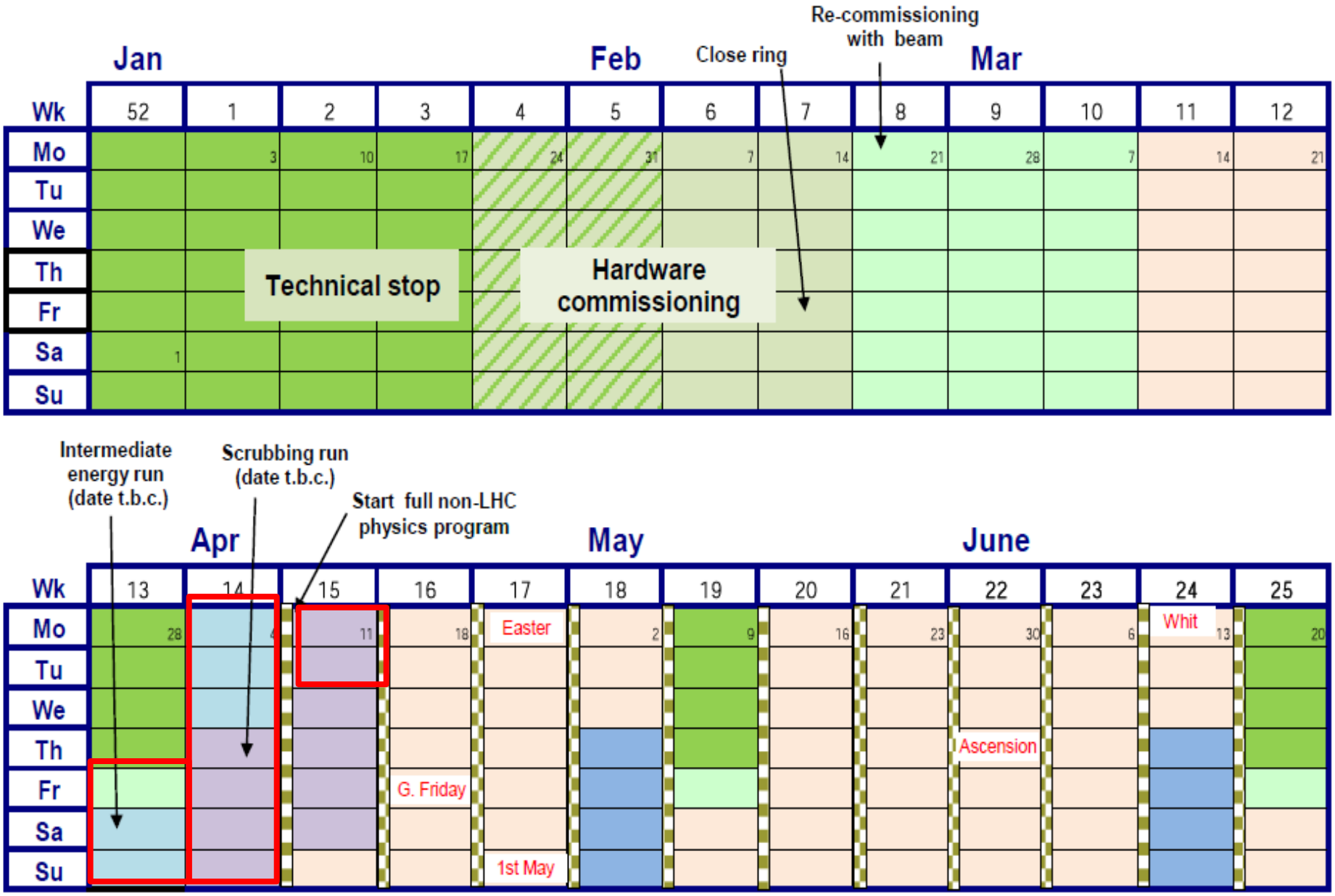
Done in 4 days 25th March – 28th March
BEFORE the Technical stop

2nd Period (b)

Scrubbing Run at 450 GeV/beam.

10 days or real scrubbing foreseen, but because of technical hiccups took 12 days of calendar time

2011 LHC schedule



Scrubbing: only 5 effective days

- Intensity progression – 50 ns
  - Above 600 bunches beam stability became an issue an slowed down temporarily (many dumps) the progression.
    - Tune shifts with intensity, RF tuning…
  - All dumps well captured by MPS.
  - No issues with HOM power for RF.

Date	Bunches B1+B2
Tue 5th April	300+300
Wed 6th April	408+336
Sat 8th April	588+588
Sun 9th April	804+804
Mon 10th April	1020+1020

Summary of week 14 & part of 15

ubbing run

hoven, J. Wenninger,

ni

r, R. Assmann

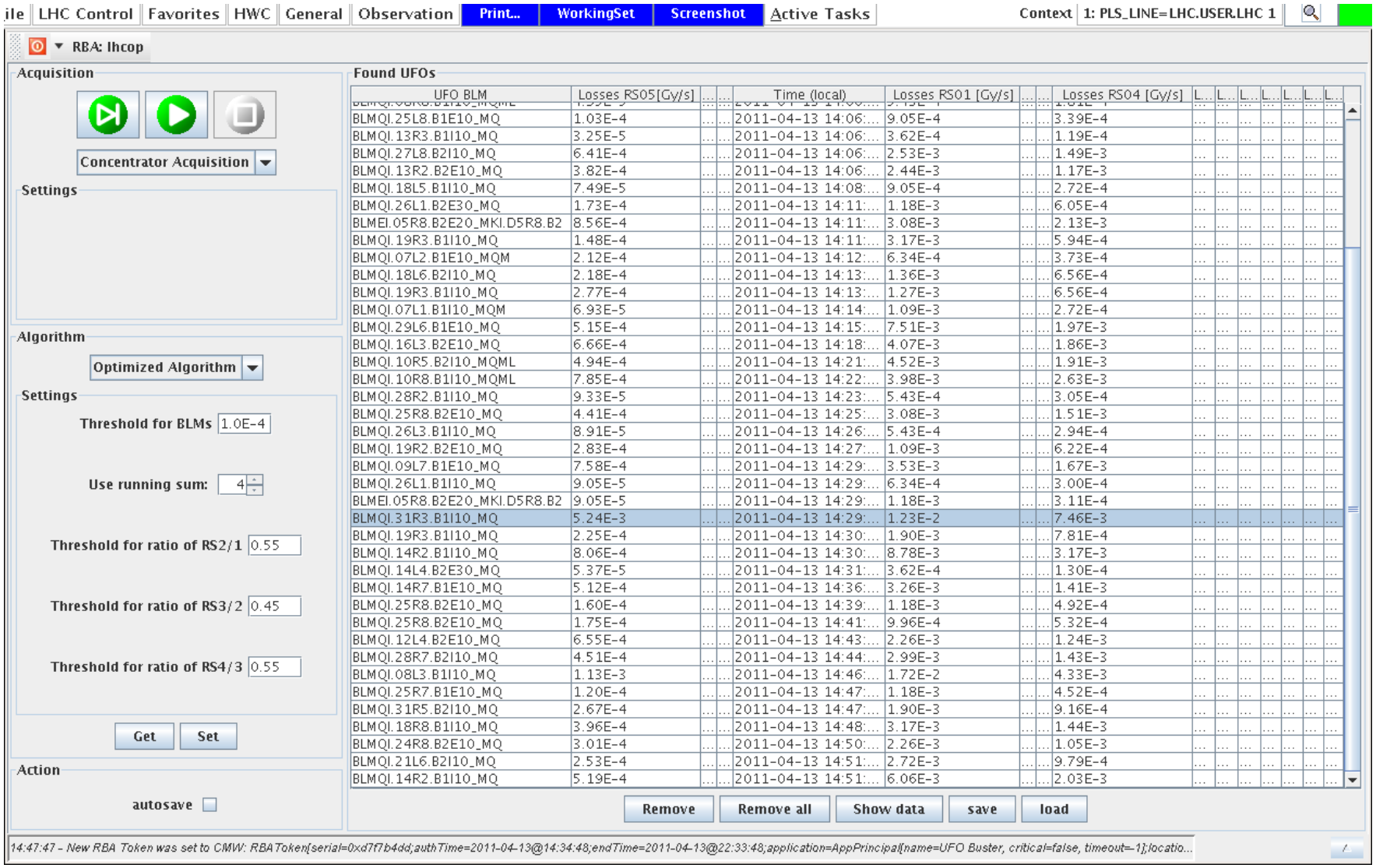
Decision: Continue physics with 50ns

3rd Period: Increasing the number of bunches

Issues encountered with Higher Intensities

- Requires much finer control of the beam parameters
  - Chromaticity, gain of feedback and use of Landau octupoles
  - Injection quality
- Many more UFOs: not yet serious

UFO's: 90 in 90 minutes

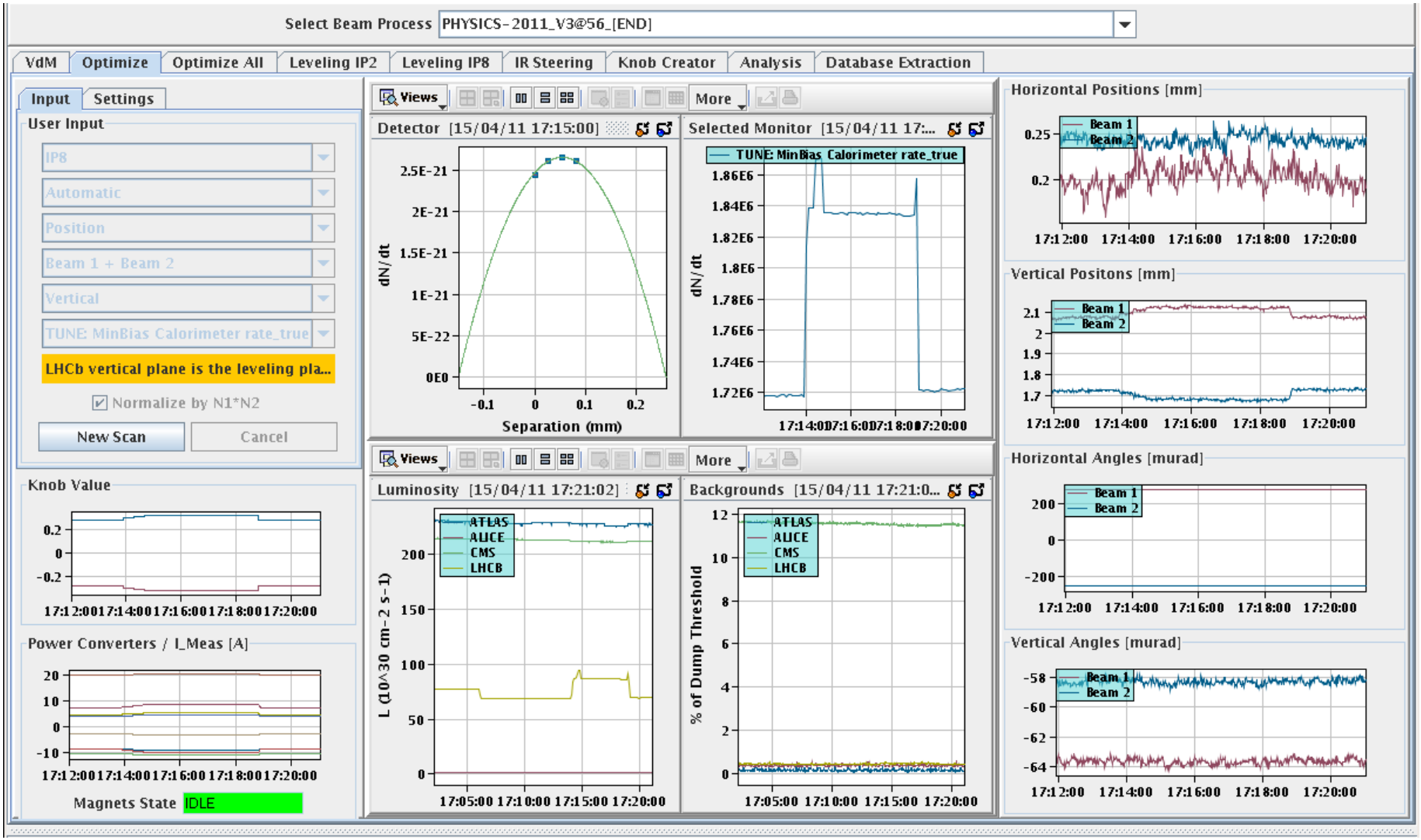


3rd Period: Increasing the number of bunches

Issues with Machine Protection

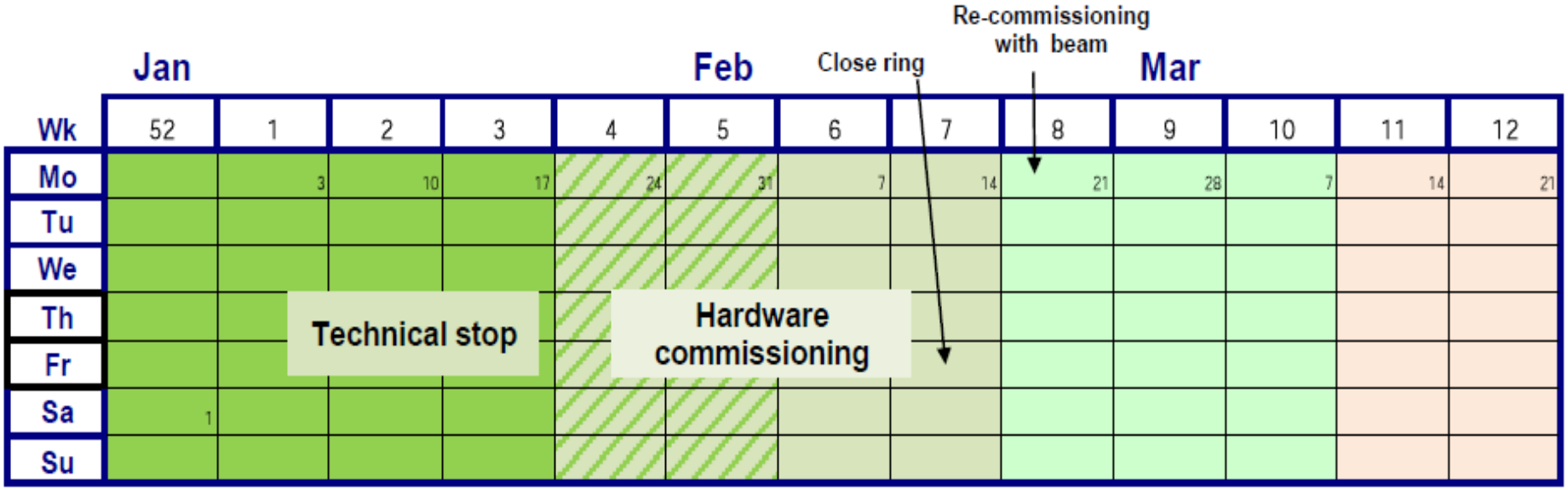
1. Collimation loss of hierarchy at 450 GeV
   - Due to order in which the loss maps were performed
2. 72 bunches
   - Last bunch of previous injection got kicked; low intensity and higher emittance
   - BPMs position calibration is sensitive to bunch intensity
   - Dump interlock measures local position of all bunches
3. **HTS quench (7th April)**
4. **Injection Kicker Flashover (18th April)**

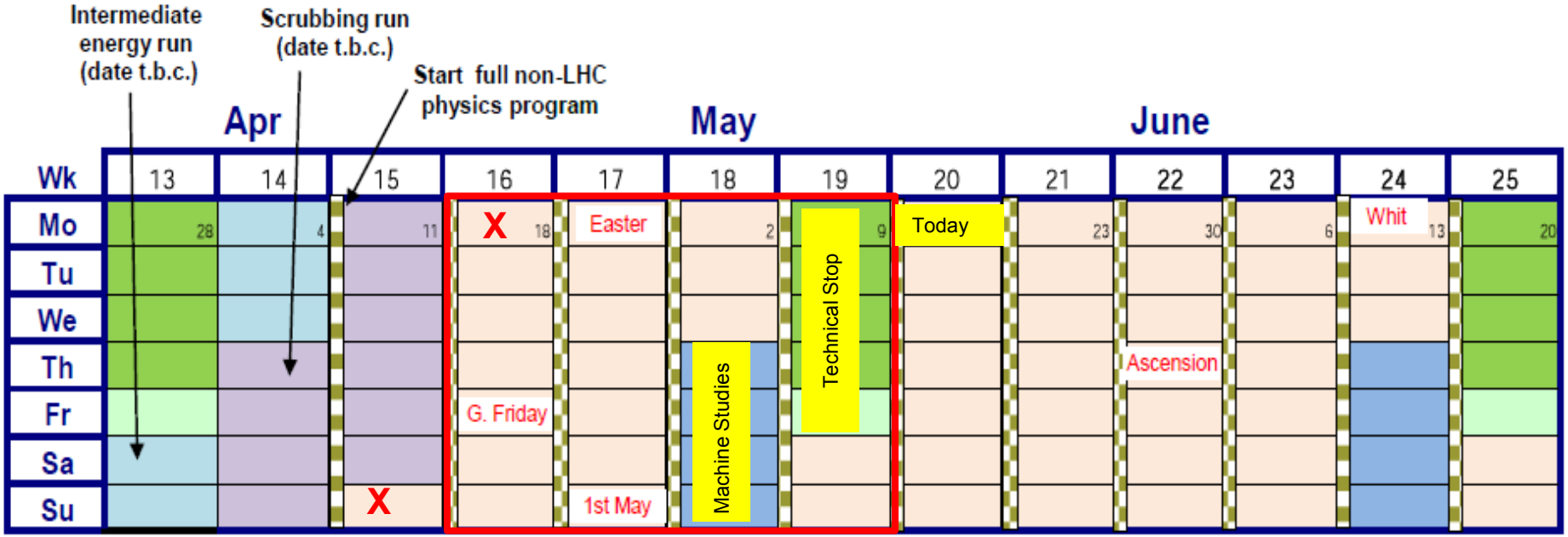
Lumi leveling test 15th April: now operational



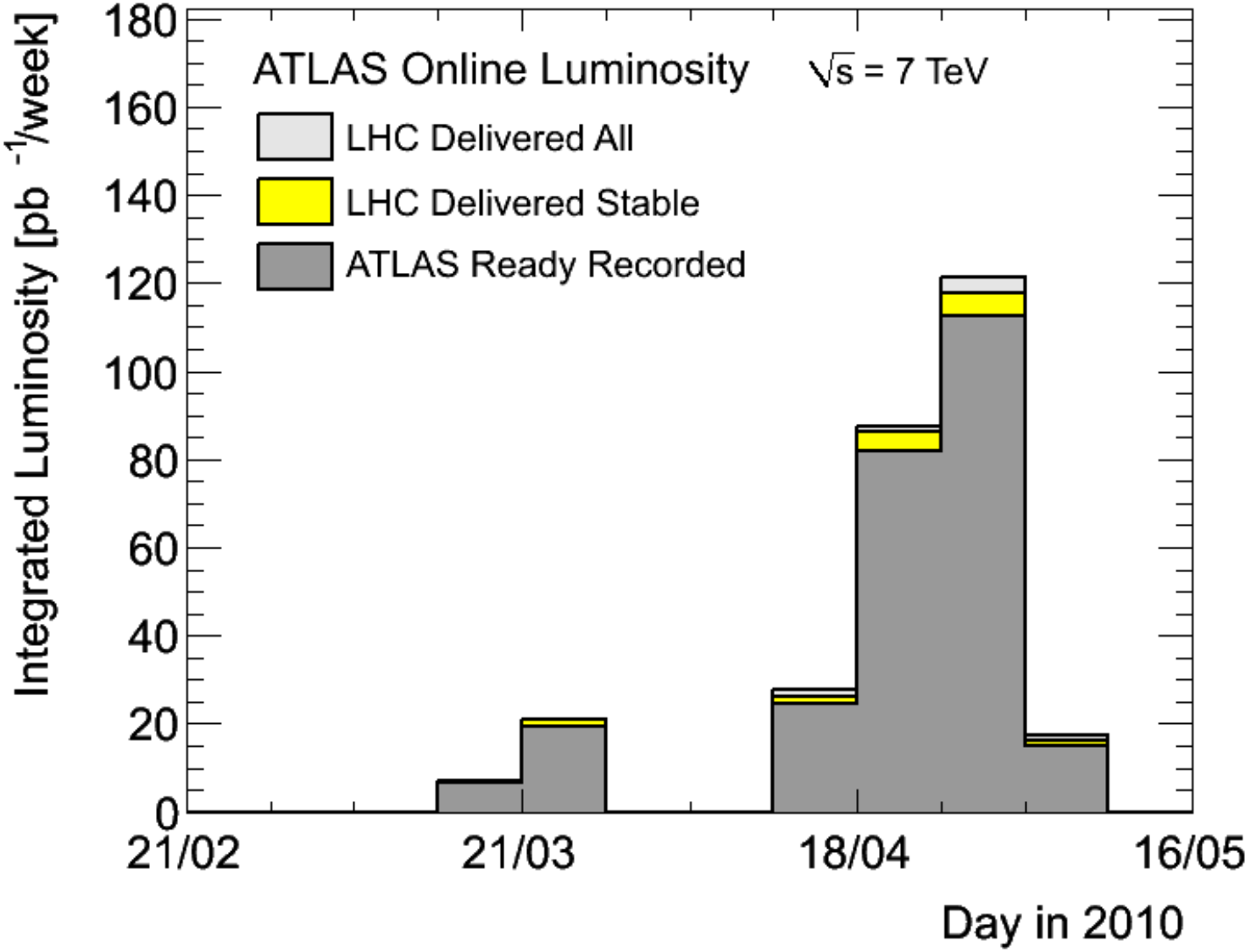
LHCb

2011 LHC schedule

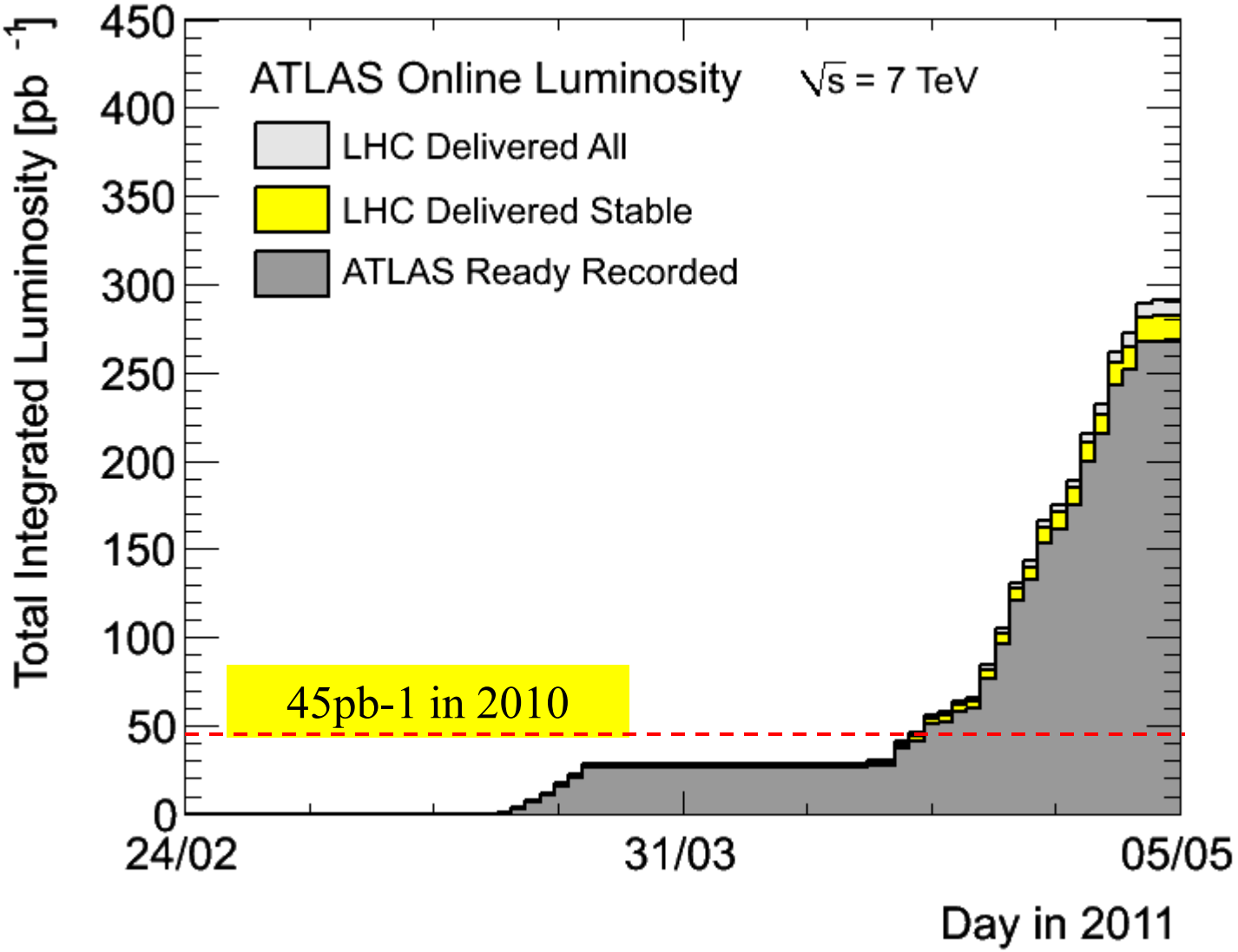




2011: Weekly summary of Integrated Luminosity

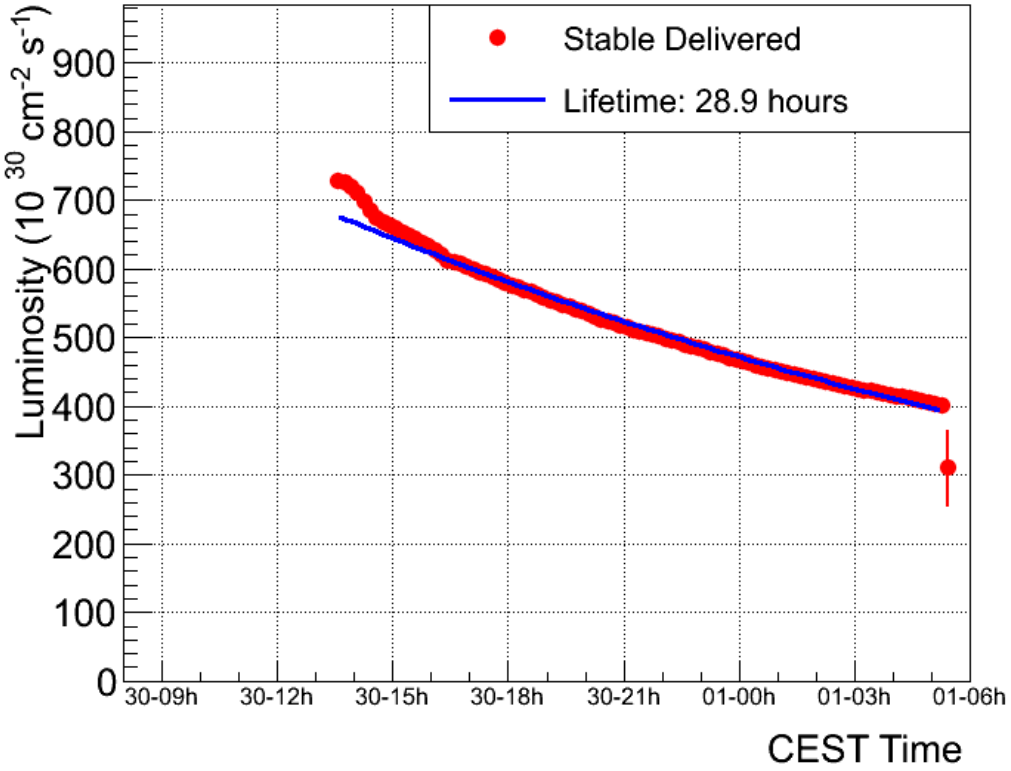


2011: Evolution of Integrated (to 2nd May)



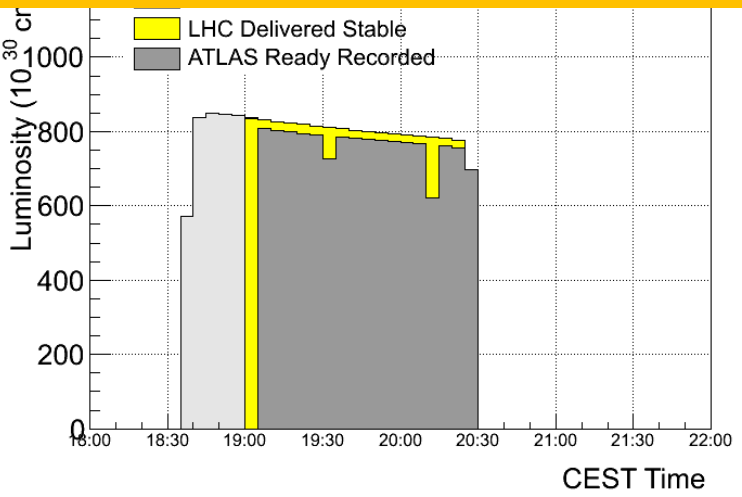
Fill 1749 – overnight (1—2 May)

Peak luminosity	~6.9 e32
Integrated luminosity	~29.7 pb-1
Stable beams	15 hours 53 minutes
Colliding bunches	598
Average emittance from luminosity	~2.5 micron

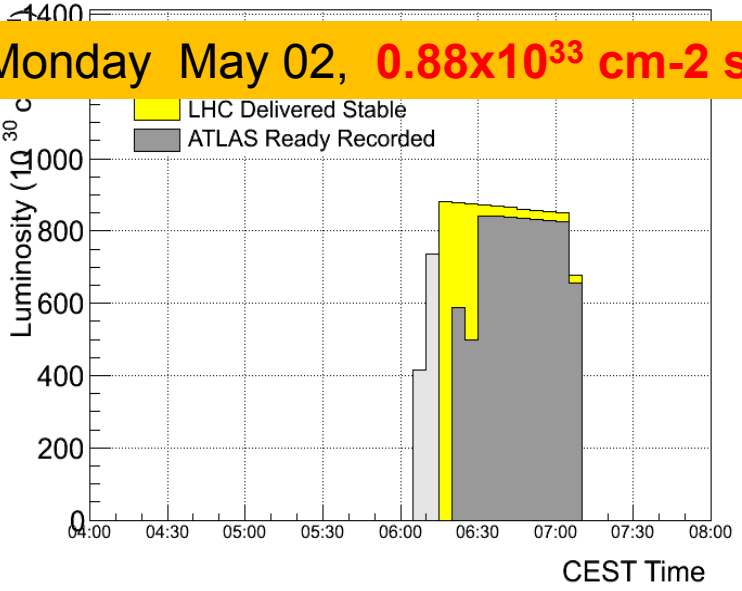


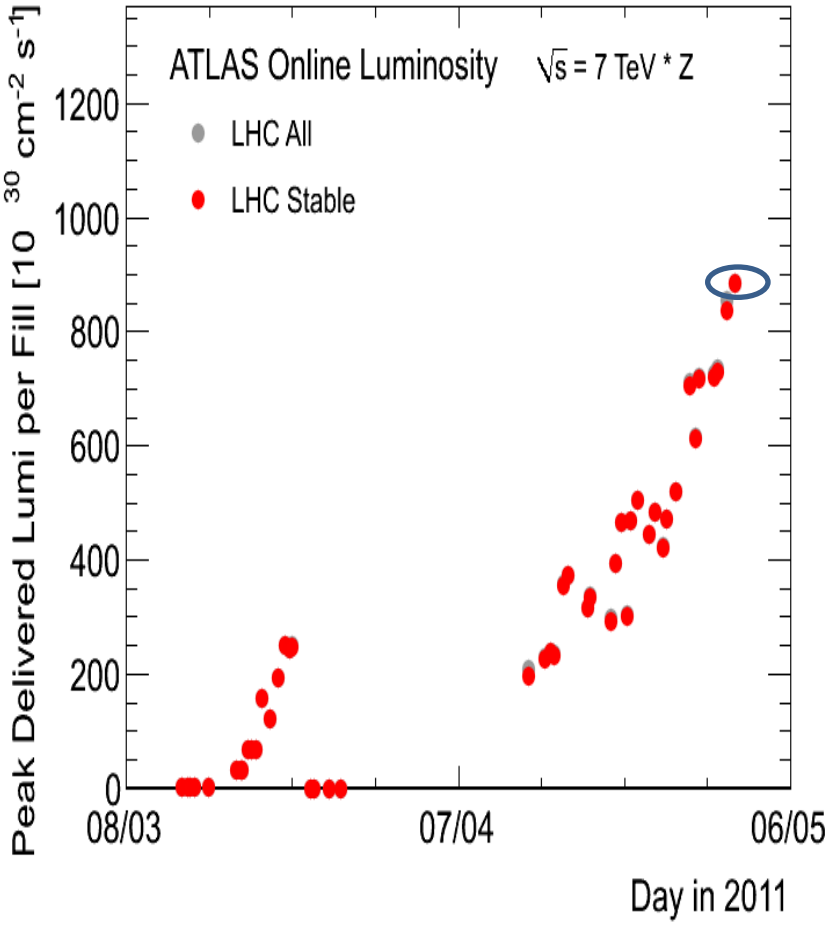
2 fills with 768 bunches/beam

Sunday May 01; 0.84x10^{33} cm^{-2} s^{-1}



Monday May 02, 0.88x10^{33} cm-2 s-1





MD1

Some highlight …

- MDs prove excellent performance potential of LHC:
  - No head-on beam-beam limit encountered with 3 times nominal brightness. Total tune shift: 0.03 with ATLAS/CMS collisions.
  - ATS injection optics with different integer tunes fine to 3.5 TeV.
  - Collimation system reached tighter settings with better cleaning efficiency.
  - Impedance and instabilities under control.
- Operational improvements:
  - 90m optics for ALFA and TOTEM works fine.

Beam-beam limit

43% of design

50% above design

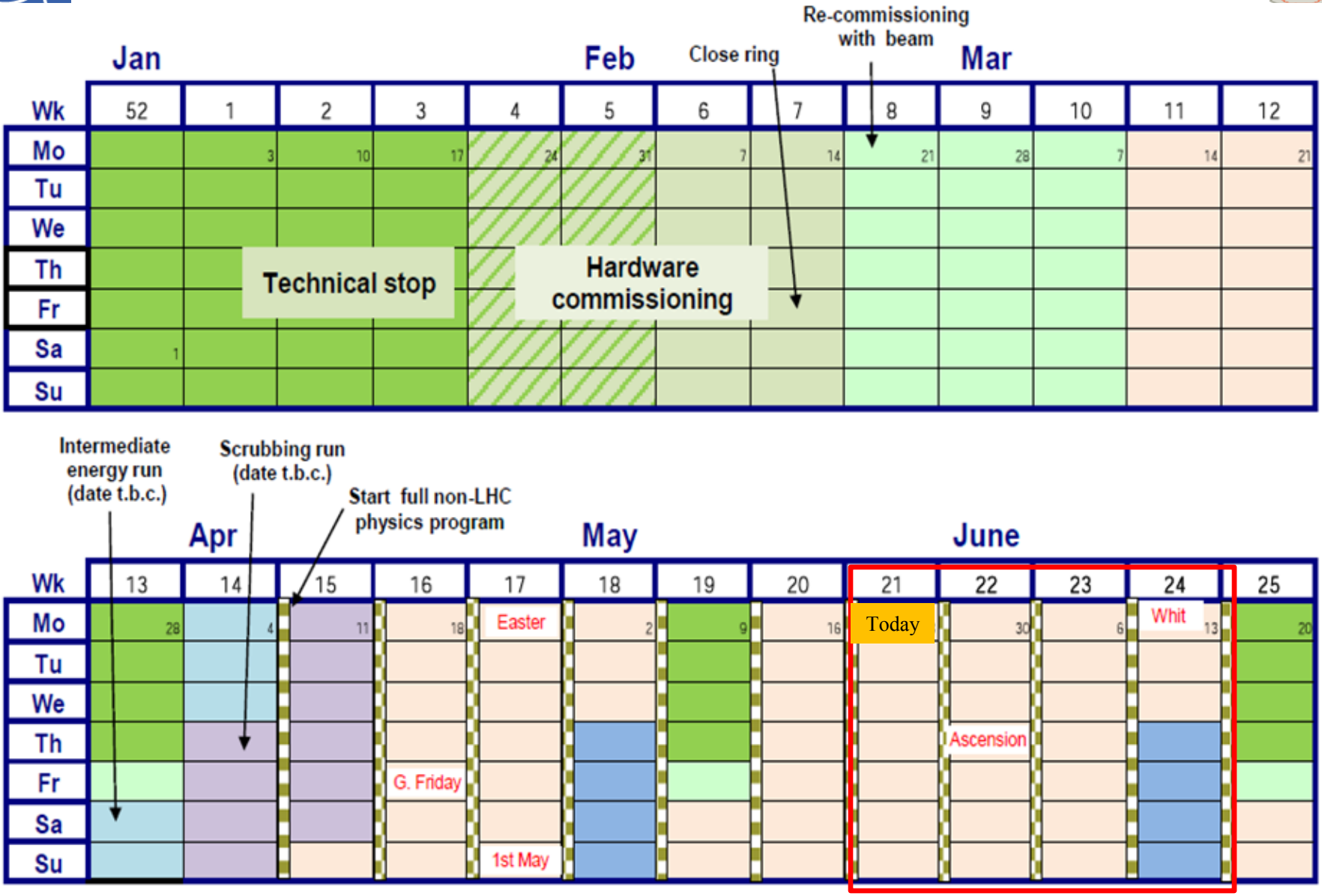
- Collided high intensity beams (1.7 E11) and small emittances (smaller than 1.5 um) in IP1 and IP5.
- First attempt achieved tune shifts 0.01 per IP, vertical blowup of emittance.
  - Blowup most likely due to 10th order resonance.
- In final attempt reduced vertical tune to end up below 10th order after putting beams in collision. No more blowup observed, tune shifts per IP in excess of 0.015 (with initial emittance below 1.2 um).

Factor of 4.5 above design

- Collisions in IP1 and IP5, optimized and no more blowup.
- No limit found for head-on beam-beam effects for the intensities investigated so far (no long range yet).

Next Period 4.5 weeks of physics before the summer conferences

Next Period: Physics + MD2

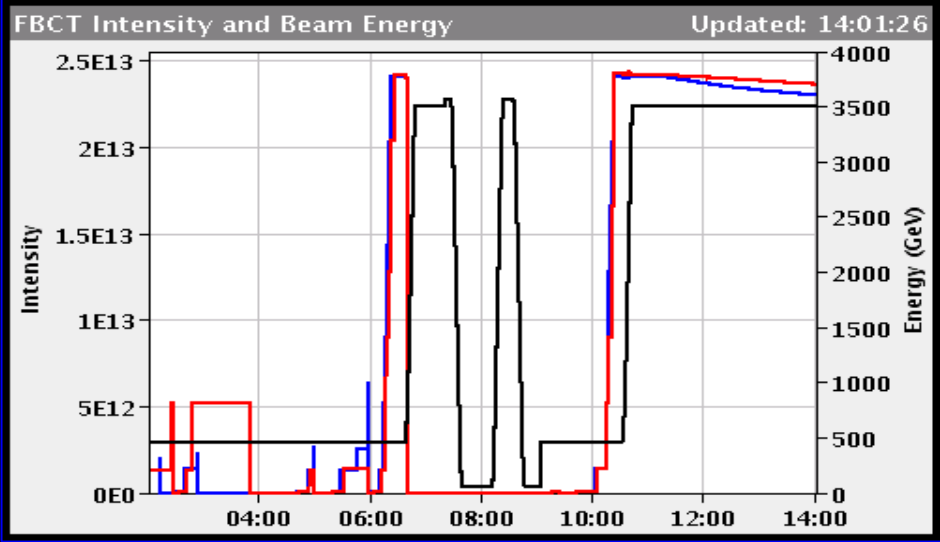


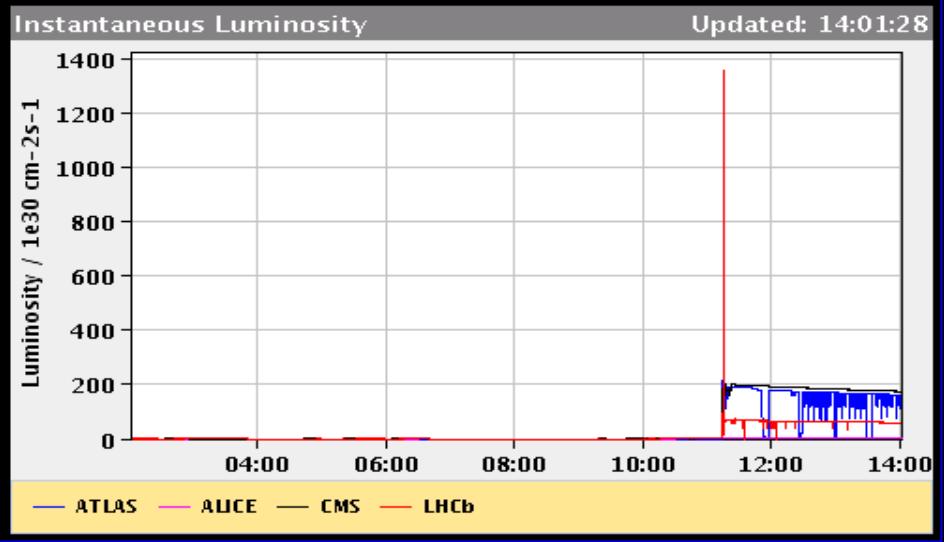
First Stable Beams 2xE32, 228 bunches

LHC Page1 | Fill: 1785 | E: 3500 GeV | 16-05-2011 14:01:29

PROTON PHYSICS: STABLE BEAMS

Energy:	3500 GeV	I(B1):	2.32e+13	I(B2):	2.38e+13





Comments 16-05-2011 12:18:53 :

STABLE BEAMS

IP1 length scale calibration on-going

fill with 50ns for PHYSICS (228b)

BIS status and SMP flags	B1	B2
Link Status of Beam Permits	true	true
Global Beam Permit	true	true
Setup Beam	false	false
Beam Presence	true	true
Moveable Devices Allowed In	true	true
Stable Beams	true	true

AFS: 50ns_228b+1small_214_12_180_36bpi_8inj

PM Status B1: ENABLED | PM Status B2: ENABLED

Next Years

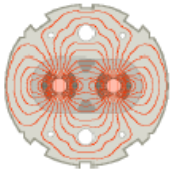
Physics data-taking until end of 2012

- Start taking advantage of the performance possibilities arising from the machine studies (July 2011 performance review, following MD2)
  - beam beam, aperture, emittance, intensity (pile-up)
- Following measurements of the copper stabilizers during the Christmas stop we will re-evaluate the maximum energy for 2012 (Chamonix 2012)

Long Shutdown in 2013

- repair/upgrade the magnet interconnects for operation at 6.5-7 TeV/beam
- install new collimation system in DS zone?

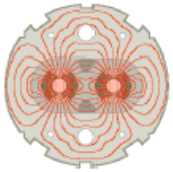
Longer Term



HL-LHC: Luminosity Upgrade (x5 with “levelling”)

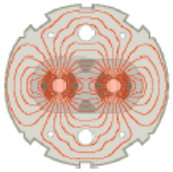
HE-LHC: Possible energy increase of the LHC

Luminosity Upgrade Scenario



- For LHC high luminosities, the luminosity lifetime becomes comparable with the turn round time ⇒ Low efficiency
- Preliminary estimates show that the useful integrated luminosity is greater with
  - a peak luminosity of 5×10^{34} cm^{-2} s^{-1} and a longer luminosity lifetime (by luminosity levelling)
  - than with 10^{35} and a luminosity lifetime of a few hours
- Luminosity Levelling by
  - Beta*, crossing angle, crab cavities, and bunch length
  - ??? Off steering

Hardware for the Upgrade



- New high field insertion quadrupoles
- Upgraded cryo system for IP1 and IP5
- Upgrade of the intensity in the Injector Chain
- Crab Cavities to take advantage of the small beta*
- Single Event Upsets
  - SC links to allow power converters to be moved to surface
- Misc
  - Upgrade some correctors
  - Re-commissioning DS quads at higher gradient
  - Change of New Q5/Q4 (larger aperture), with new stronger corrector orbit, displacements of few magnets
  - Larger aperture D2

First Thoughts on an Energy Upgrade

Very Long Term Objectives: Higher Energy LHC

Preliminary HE-LHC - parameters

	nom	HE-LHC
beam energy [TeV]		16.5
dipole field [T]		20
dipole coil aperture [mm]		40-45
#bunches / beam		1404
bunch population [10^{11}]		1.29
initial transverse normalized em [μm]		3.75 (x), 1.84 (y)
number of IPs contribut	3	2
maximum total bea	0.01	0.01
IP beta function	0.55	1.0 (x), 0.43 (y)
full crossing	285 (9.5 $\sigma_{x,y}$)	175 (12 σ_{x0})
stored b	362	479
SR p	3.6	62.3
longitu amping time [h]	12.9	0.98
events pe	19	76
peak lumin cm^{-2}s^{-1}]	1.0	2.0
beam lifetime	46	13
integrated luminosity over 10 h [fb^{-1}]	0.3	0.5

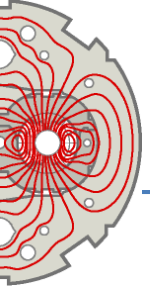
Very preliminary with large error bars

HE-LHC – main issues and R&D

- ***high-field 20-T dipole*** *magnets based on Nb_3Sn, Nb_3Al, and HTS*
- ***high-gradient quadrupole magnets*** *for arc and IR*
- ***fast cycling SC magnets*** *for 1-TeV injector*
- ***emittance control*** *in regime of strong SR damping and IBS*
- *cryogenic handling of* ***SR heat load*** *(first analysis; looks manageable)*
- *dynamic* ***vacuum***

Thu 19/5

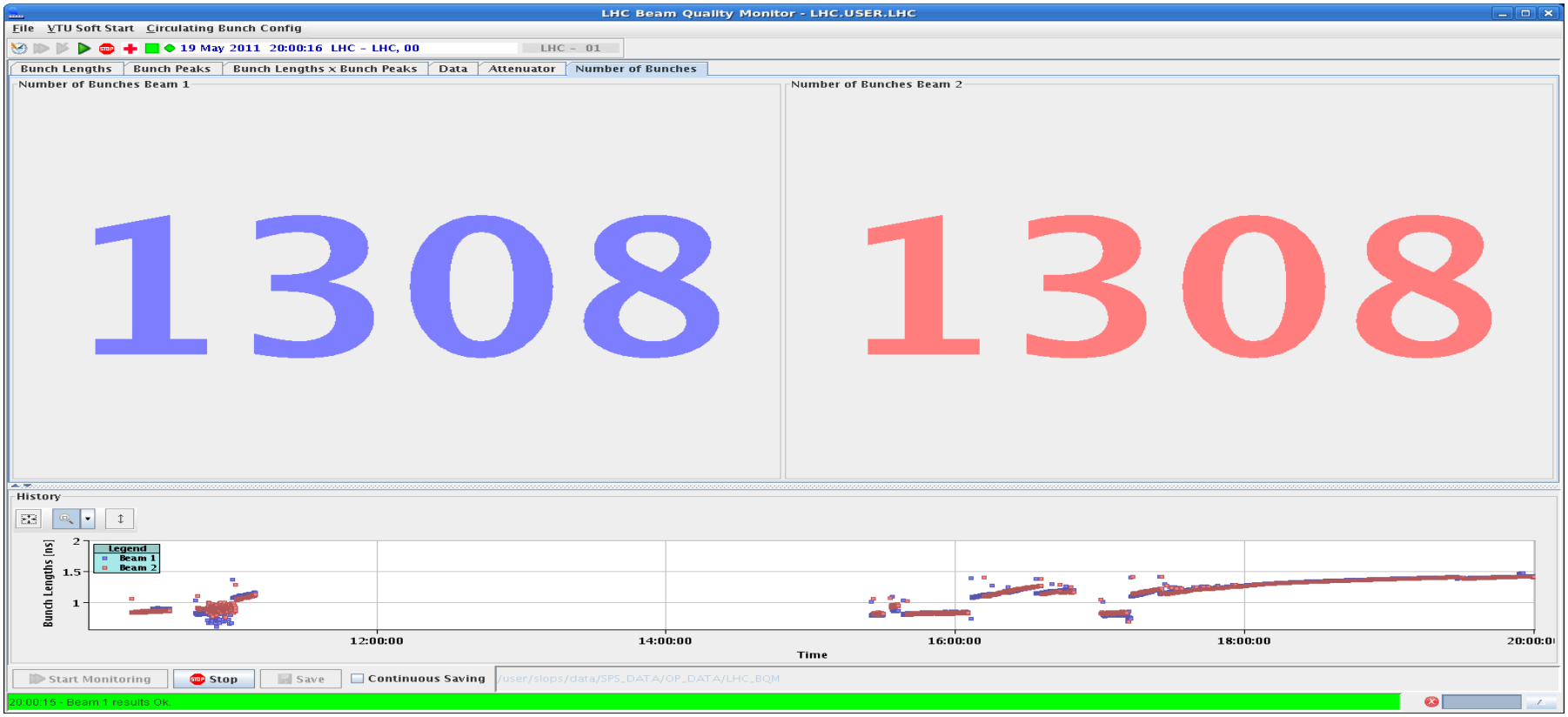
- 17:00-20:00 Injection of large number of bunches (verification of vacuum, cryogenics and RF in parallel)
- **20:00 1308 bunch/beam injected**
- 21:20 Beam dump due to vacuum spike close to D1.R2
- 23:35 STABLE BEAMS 1795: Initial luminosity: 7.7×10^{32} $cm^{-2}s^{-1}$ – delivered so far ~ 18 pb^{-1} in 8 h
- Beam dump due to cryo control card for current leads

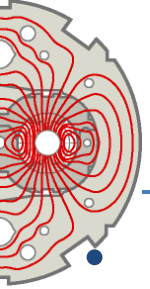


Up to the Minute News

Filling with trains of 108 bunches

- While RF, cryo, vacuum monitoring
- 1.5×10^{14} p in the machine ~half nominal intensity

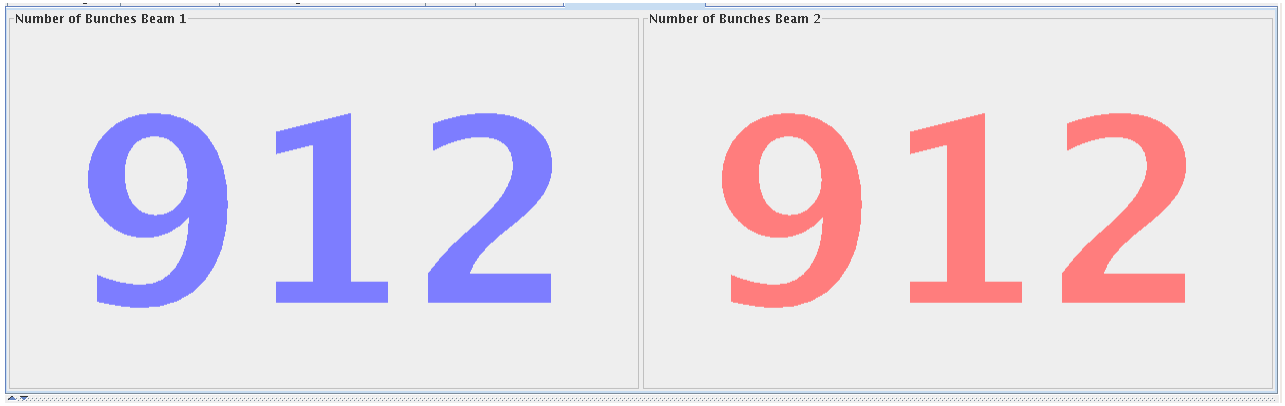


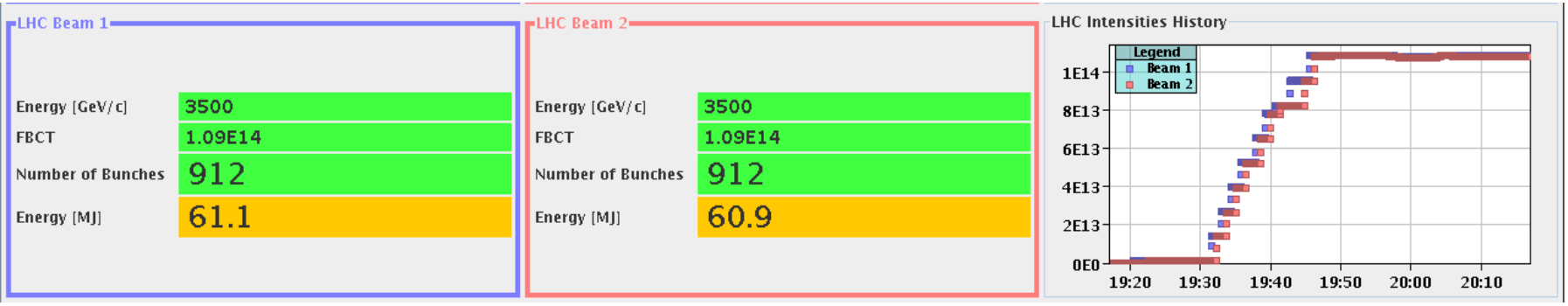


Last Weekend Sat-Sun 21-22 May

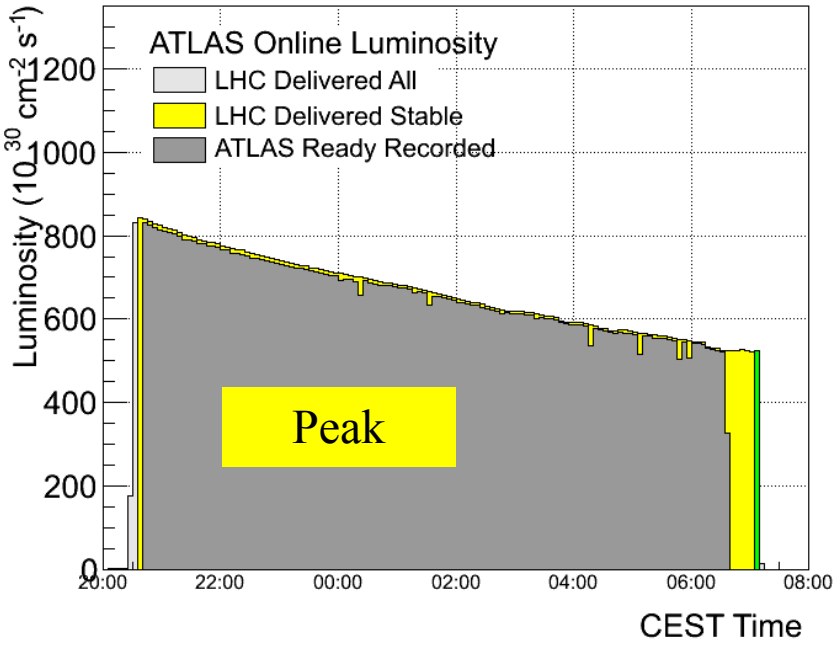
- 12:00 End of STABLE BEAMS 1798: 18.8 pb-1 in 9 h
- 12:00-14:00: RF tests – study of transient during klystron switch off
- 14:00-18:00: ramp down and access for ATLAS and QPS controller reset.
- OK from rMPP to go ahead with 912 bunches
- 20:34 STABLE BEAMS #1799 - 912 bunches/train - Initial luminosity 8.5×10^{32} $cm^{-2}s^{-1}$. **More than 10^{14} p/beam in collision**
- 07:00 Beam dump: end of STABLE BEAMS #1799: 25 pb^{-1}. **Record integrated luminosity in 24 hours: 33.33 pb^{-1}**

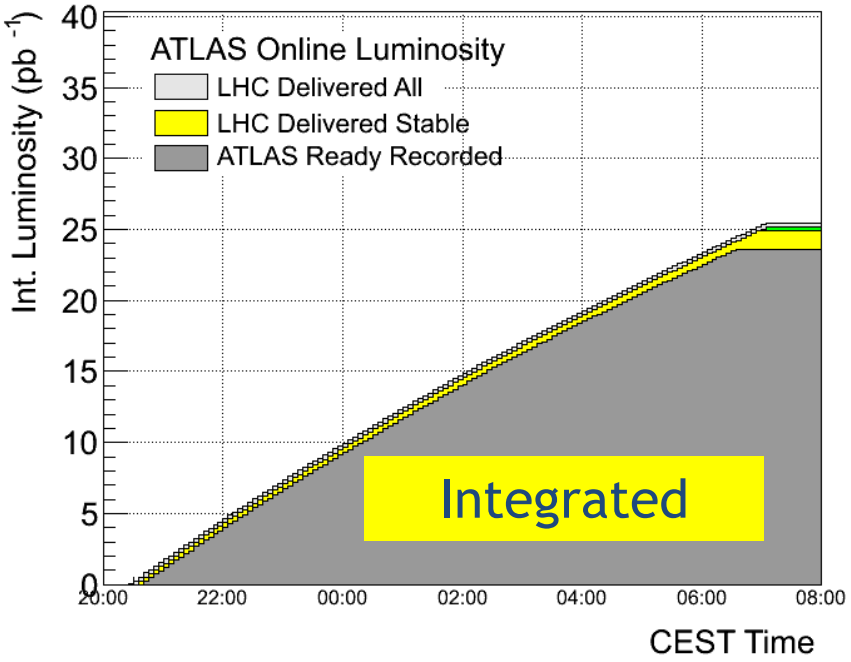
912 bunches


Number of Bunches Beam 1
912
Number of Bunches Beam 2
912

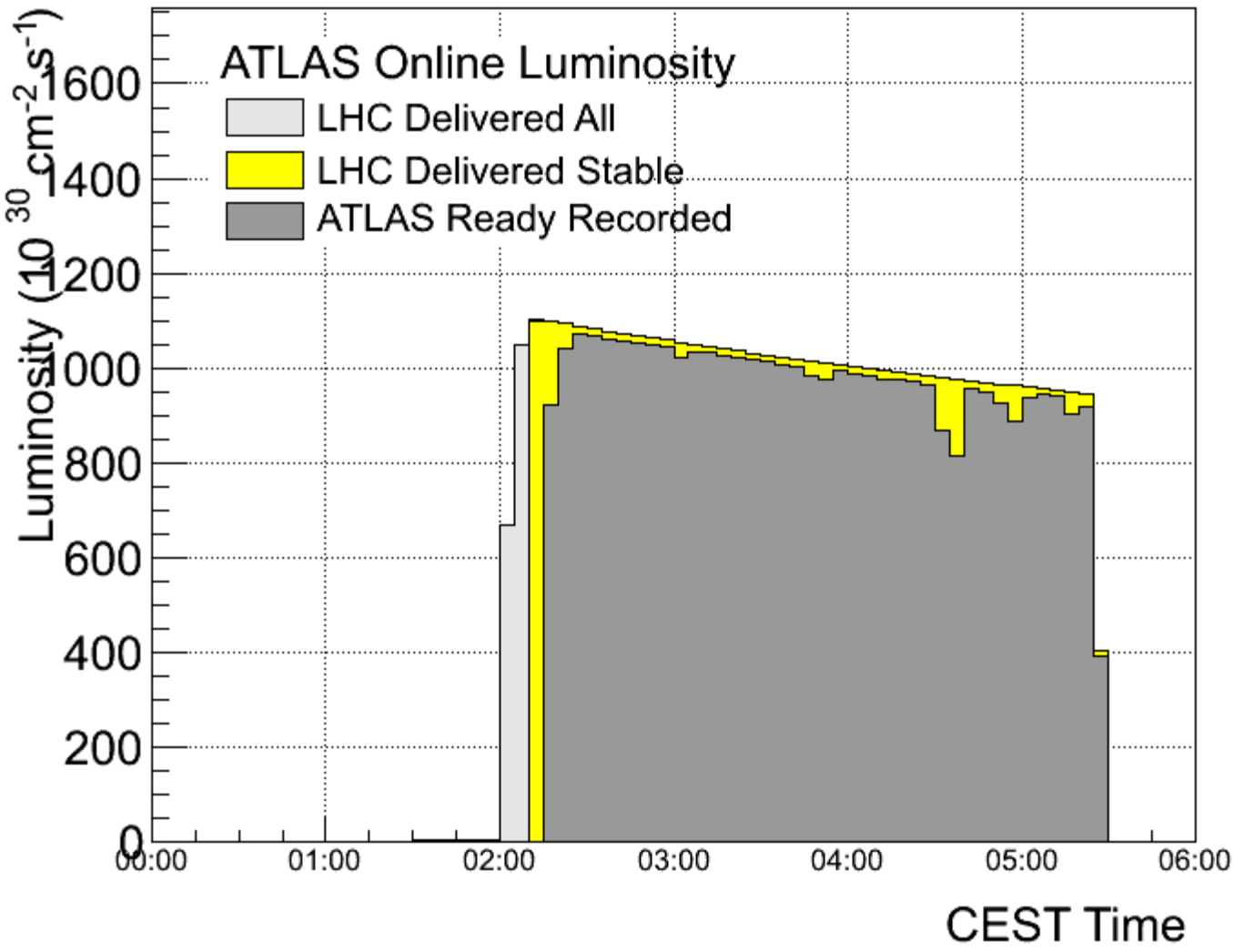

LHC Beam 1
Energy [GeV/c] 3500
FBCT 1.09E14
Number of Bunches 912
Energy [MJ] 61.1
LHC Beam 2
Energy [GeV/c] 3500
FBCT 1.09E14
Number of Bunches 912
Energy [MJ] 60.9
LHC Intensities History
Legend
Beam 1
Beam 2
1E14
8E13
6E13
4E13
2E13
0E0
19:20
19:30
19:40
19:50
20:00
20:10

Sat-Sun Good Fill

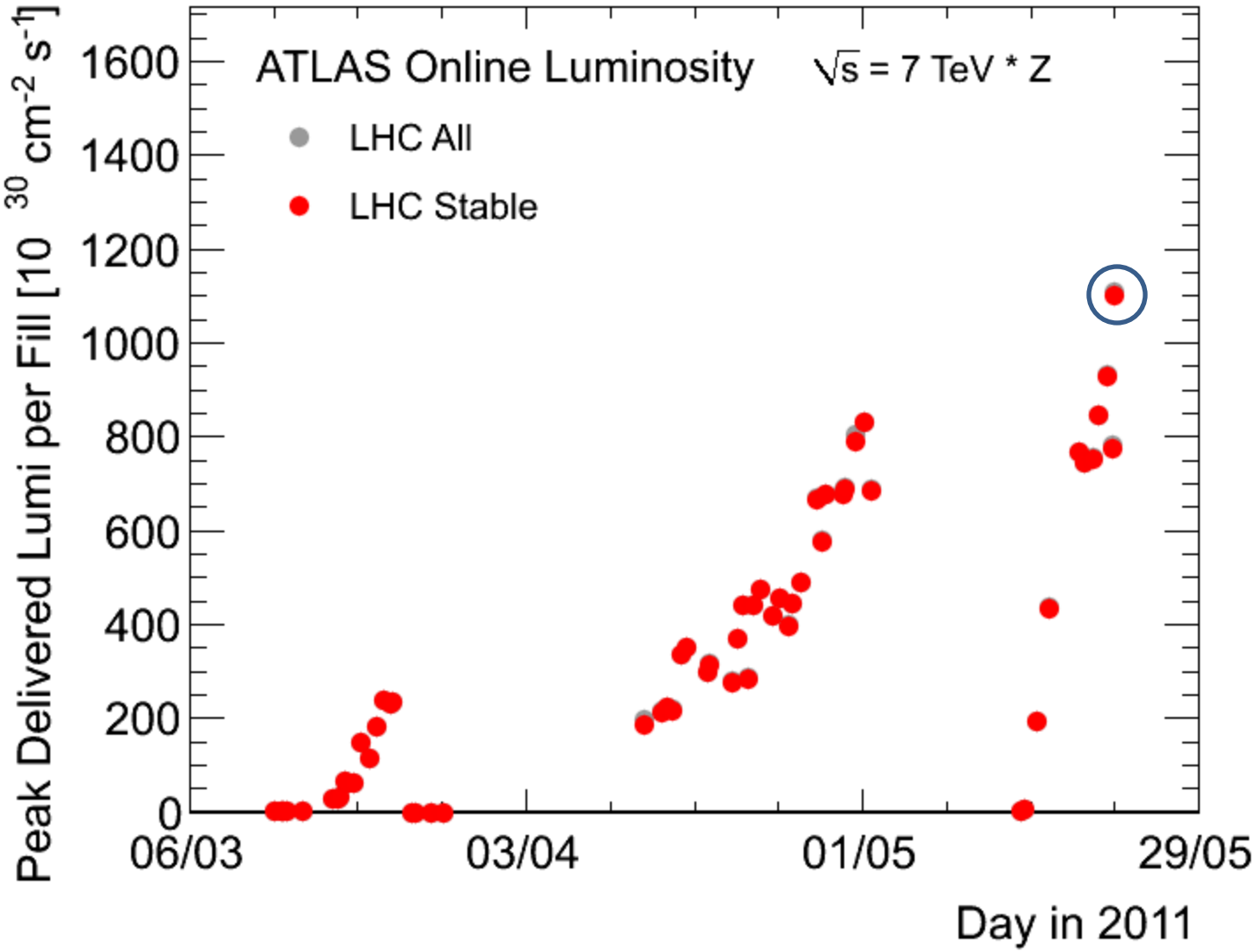




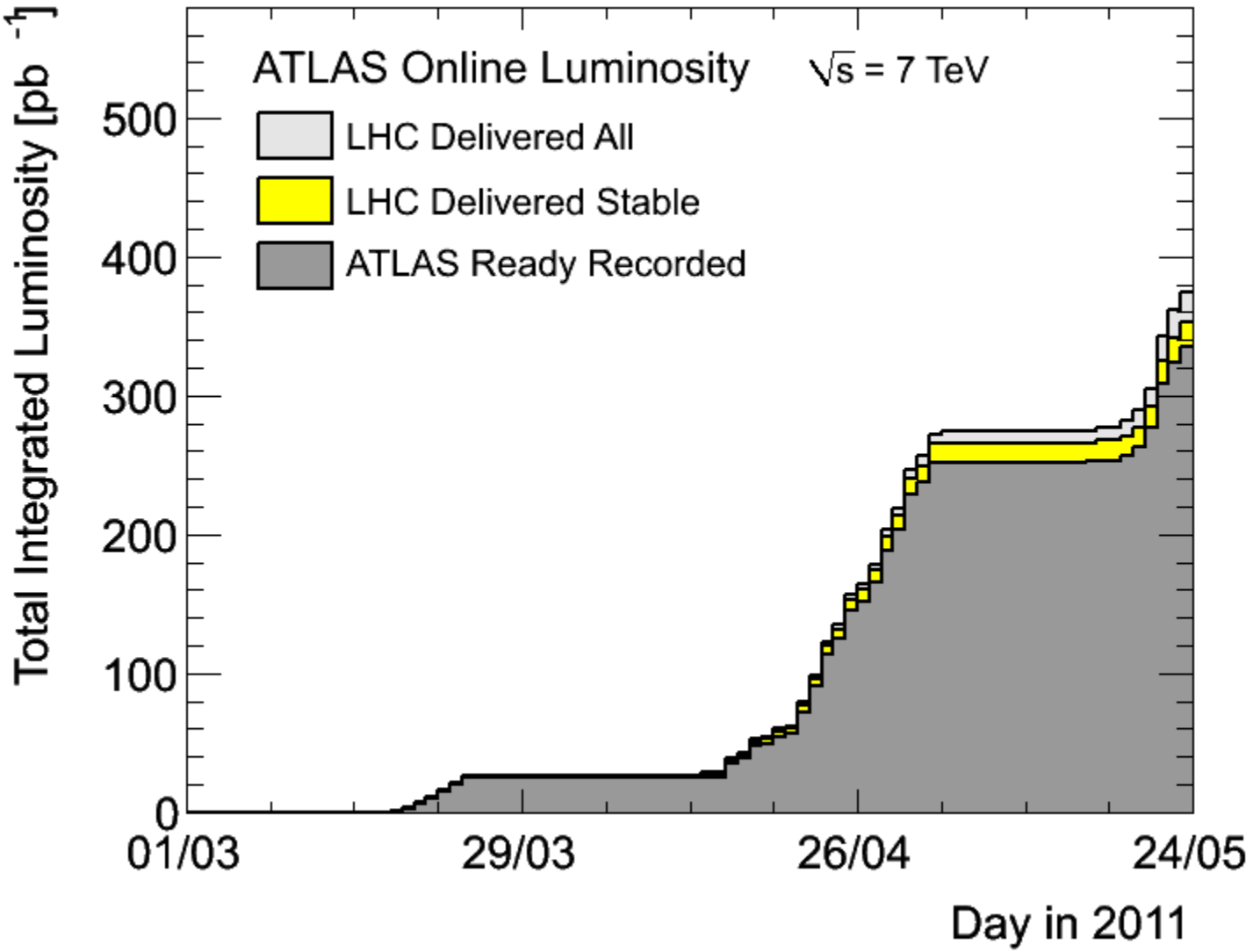
02:15 this morning: $1.1 \times 10^{33} cm^{-2} s^{-1}$



2011 Peak


ATLAS Online Luminosity
√s = 7 TeV * Z
LHC All
LHC Stable
Peak Delivered Lumi per Fill [10^30 cm^-2 s^-1]
1600
1400
1200
1000
800
600
400
200
0
06/03
03/04
01/05
29/05
Day in 2011

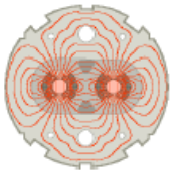
2011 Update


ATLAS Online Luminosity
√s = 7 TeV
LHC Delivered All
LHC Delivered Stable
ATLAS Ready Recorded
Total Integrated Luminosity [pb -1]
500
400
300
200
100
0
01/03
29/03
26/04
24/05
Day in 2011

Summary

- Right on Track
- Intensity, peak and Integrated luminosity g
  very rapidly
- Successfully implemented luminosity leveling for LHCb
- Recently a few “near misses” causing sleepless nights
  - HTS protection fault for DFBs
  - Injection kicker flashover
- We must remain vigilant!!
- How to continue for the rest of 2

Warning Shots

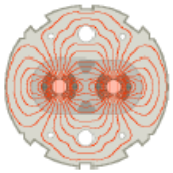


Thank you for your attention

Event of 7th April

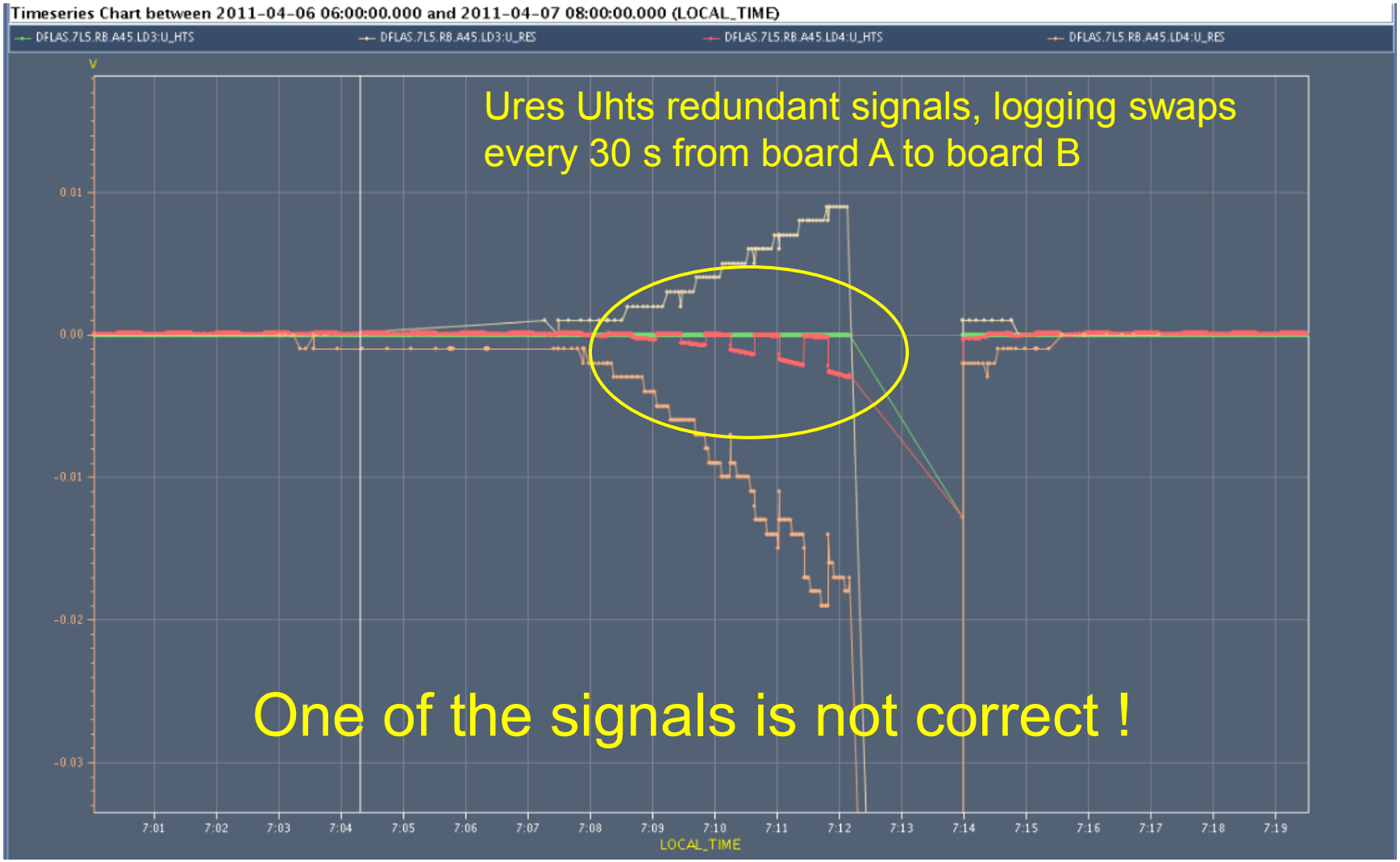
- Thursday afternoon (7th April) all powering was stopped in the LHC following the discovery of a worrying cabling problem affecting the QPS system protecting the HTS current leads.
- Followed by an extensive verification campaign.
- Lost about 2 days.

HTS quench (sc link)- what happened



- QPS tripped the RB circuit in sector 45 on Thursday around 07:00. *First time ever quench of HTS current lead*
- The HTS quenched due to a lack of cooling in the DFB
  - Faulty electronics board corrupted the temperature feedback loop
- Protection by the QPS monitoring the current leads.
  - Logging of the two HTS signals showed that only one of the two measurements was correct, the other was measuring a short circuit
- An identical fault on the redundant signal would have left the system unprotected and could lead to beyond repair damage to the DFB. No spares
- Decided to stop powering magnets
  - To validate other circuits

QPS signals monitoring the HTS

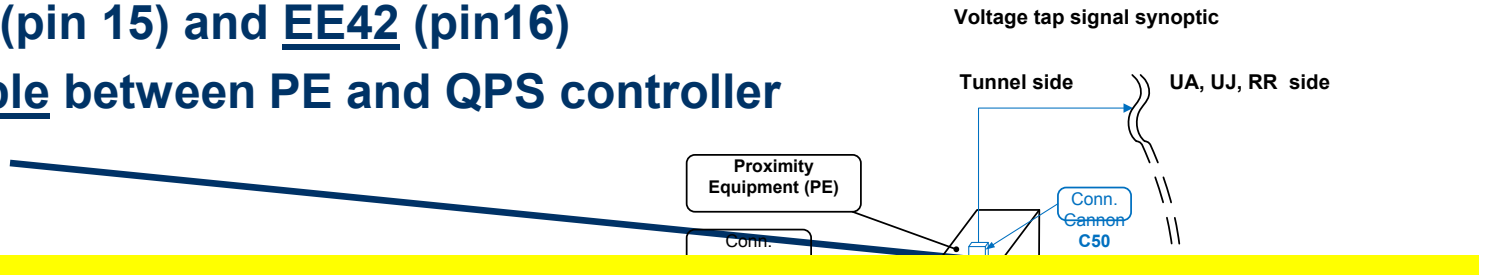


What was swapped…?

- **What was found swapped in RB.A45, Lead#2 on DFBAI (L5)?**

  EE22 (pin 15) and EE42 (pin16)

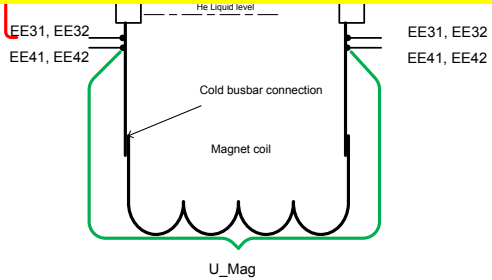
  of cable between PE and QPS controller



This connection had been like this since 2005

Are all connections like this?

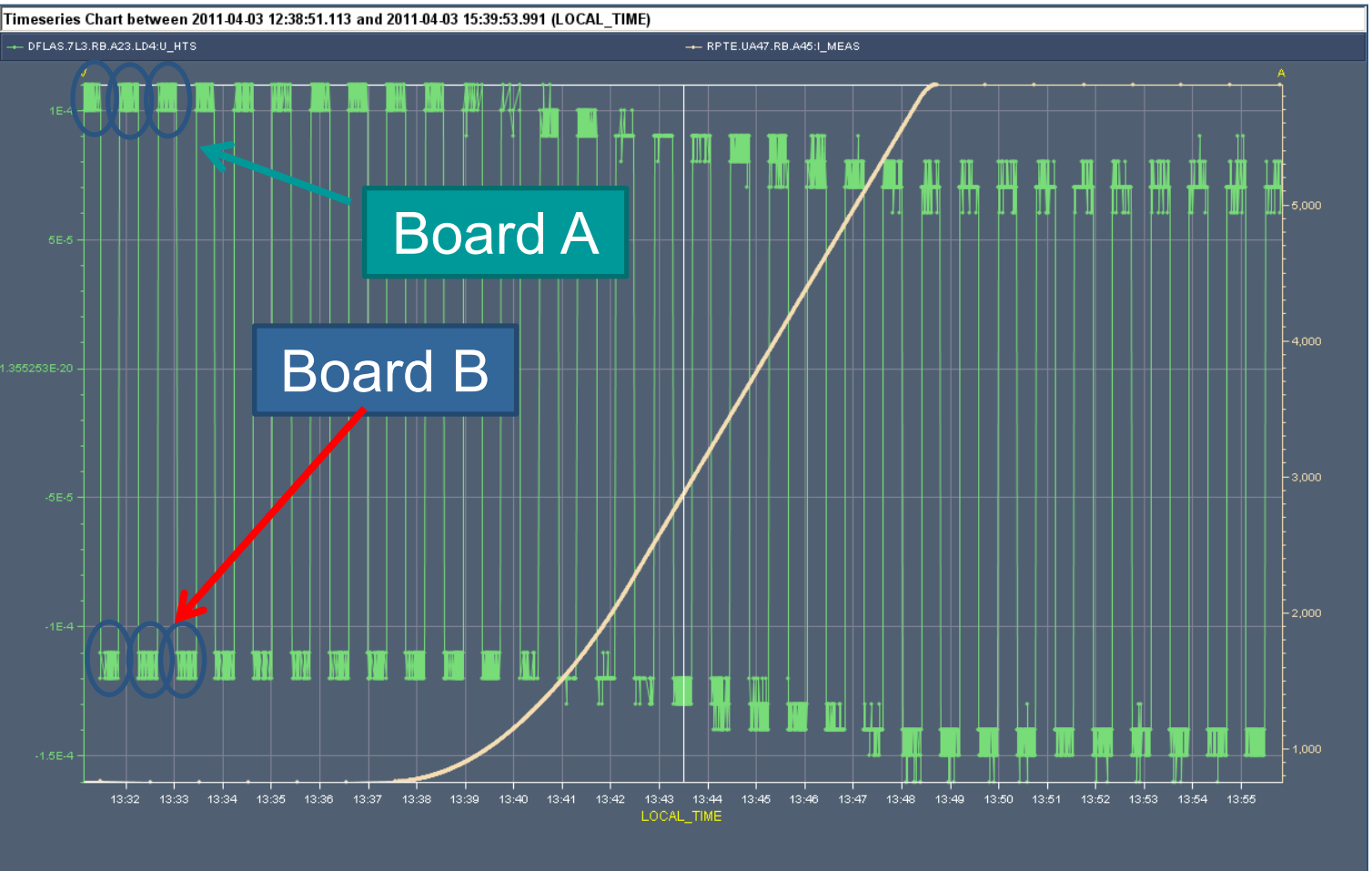
Stop operation until all connections are verified



Giorgio D'Angelo
Vtaps standard DFBs.vsd

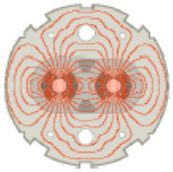
From the logging

- Analysis of the logging data from old ramps allowed the QPS team to verify the correctness of the signals for other 13 kA circuits
- Verification of U_RES & U_HTS on all IPQs, IPDs, ITs using dedicated powering cycles by the QPS team
  - Verification of boards A & B



Example of a healthy channel: both boards move in unison during a ramp

Verification - Friday 8th April



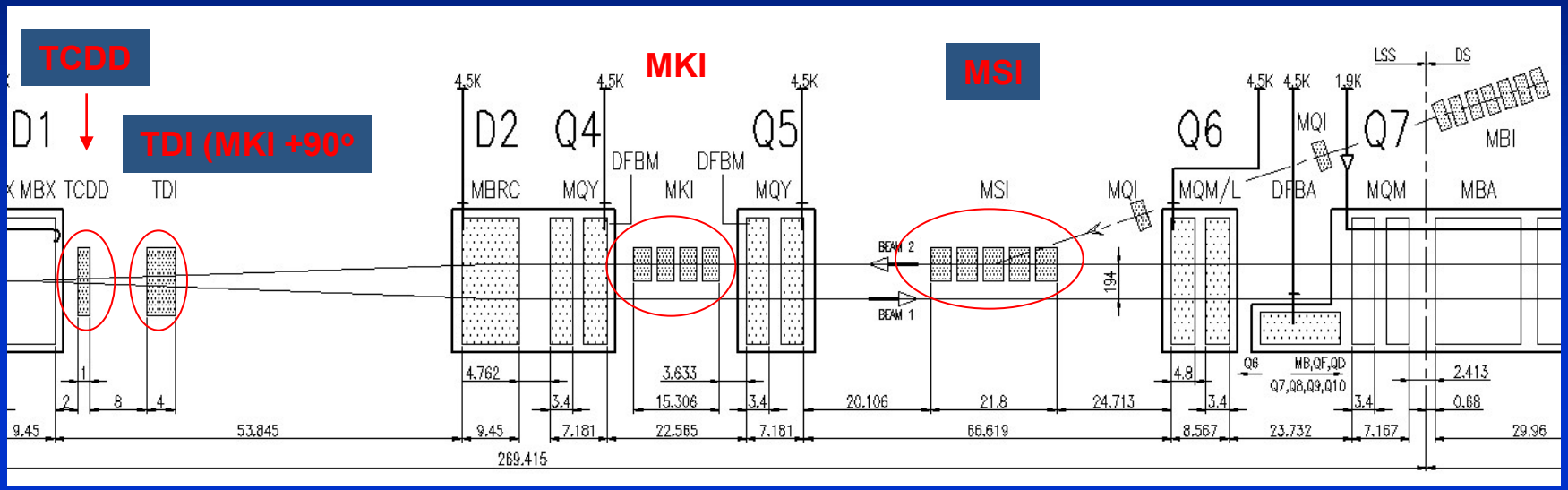
- In the late afternoon all high current circuits except the 600 A circuits had been checked.
  - Acceptable risk for 600 A circuits.
- All tests showed the presence of the expected signals.
- Green light for powering from TE/MPE in the evening.

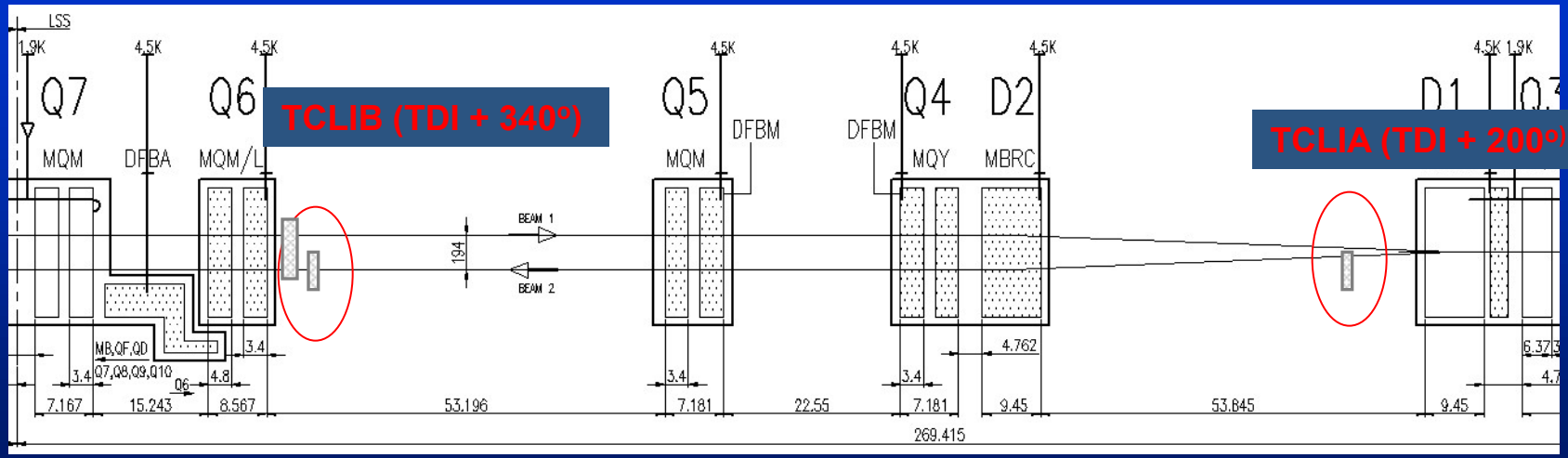
Among all the high current circuits we happen to quench exactly the one circuit with a cabling problem !!

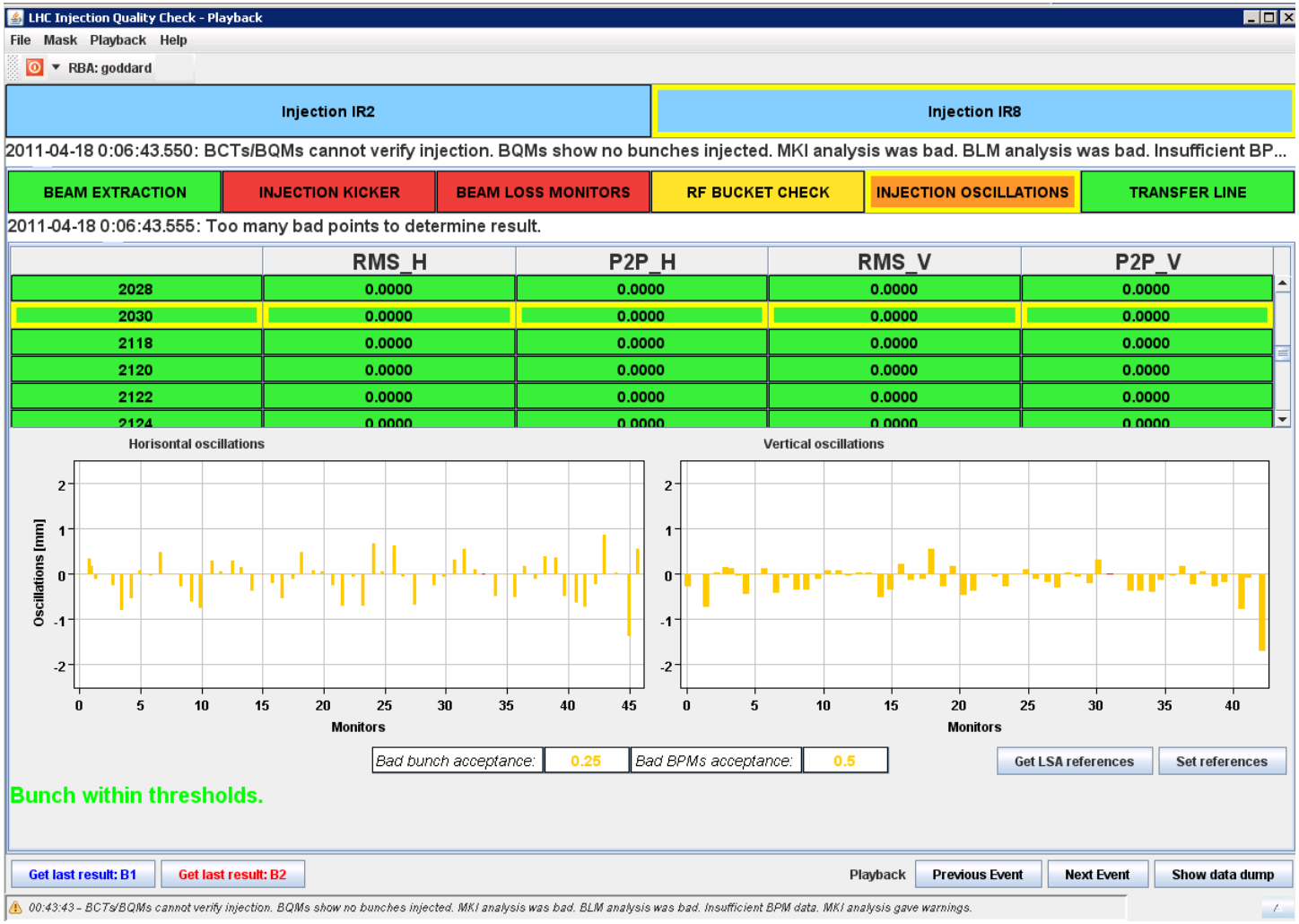
Event of 18th April

- Flashover (high voltage breakdown) on B2 MKI magnet D (first one seen by the beam) while injecting 72b
- Extensive beam losses through P8 and arc 78: result
  - Kicker interlocked off
  - Quench heaters fired on 11 magnets
  - Vacuum valves closed
  - Several very anxious hours....

Overview of injection region (IR8)

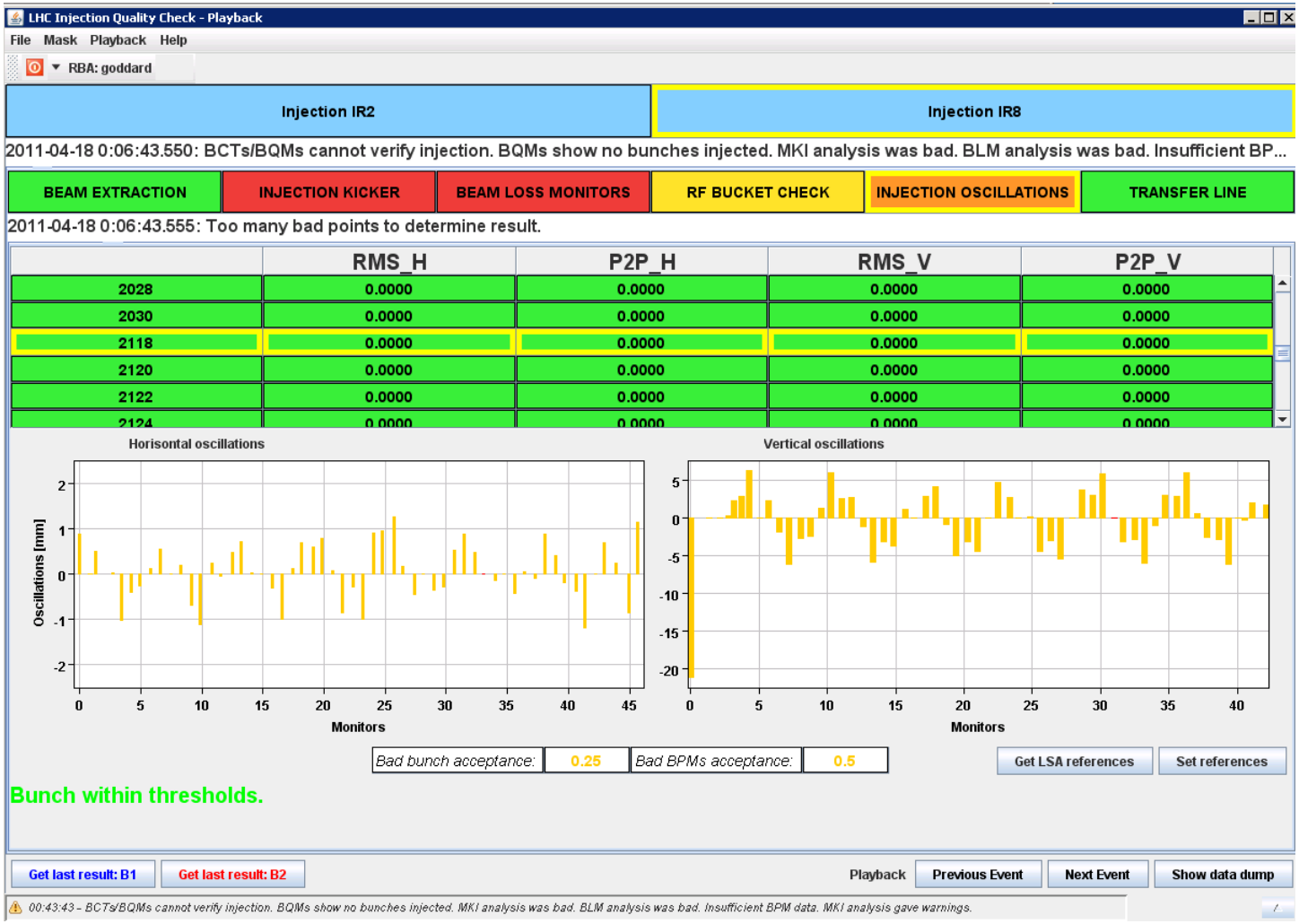






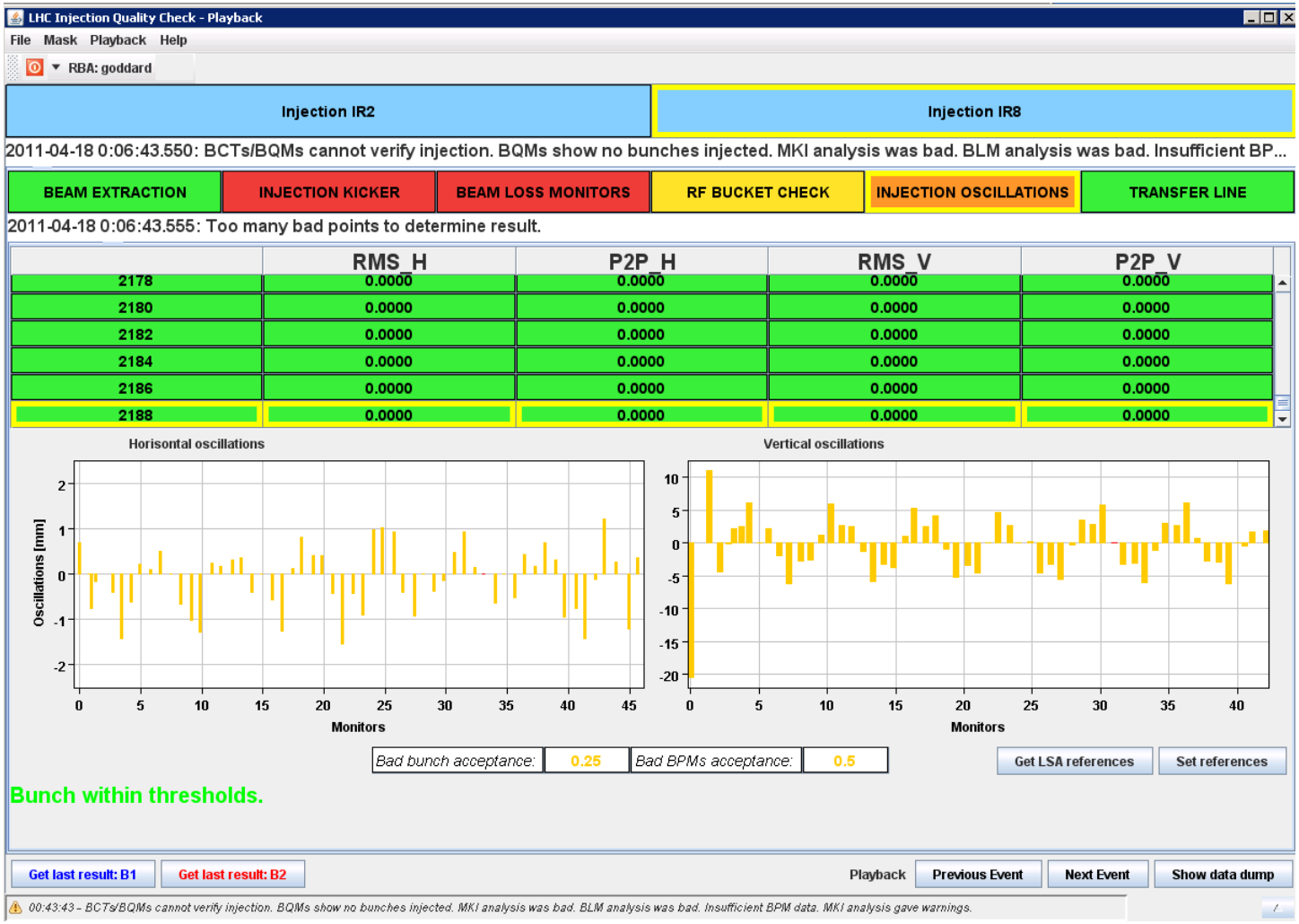
Bunch 36 in first injected batch OK -> breakdown after 1.8 us

From IQC



Bunch 1 in 2nd injected 36b batch +/-5 mm oscillations -> breakdown before 4 us

From IQC



All 36b of 2nd batch were badly kicked

From the trajectory, can say that the beam was on LOWER TDI jaw and overkicked, i.e. breakdown in second half of magnet (LHCb signals support this)

Grazing incidence – BPMs triggering in arc mean that more than 2e10 p+/b transmitted

From IQC

XPOC : XPOC_B2 : 18.04.2011 00:06:43 (1303078003551363525)

Final analysis is finished

XPOC | Modules graph | Results

Session: BEAM 2 E: 450.12 GeV I: 2.58E13 p+ #b: 229 Time: 18.04.2011 - 00:06:43.550'691'300

- XPOC
- CONTEXT
- MKD
- MKB
- TSU
- BLM
- VAC
- BTVDD
- BPMD
- BCT
- BSRA
- TCDQ_BPMS

Module results | Module journal

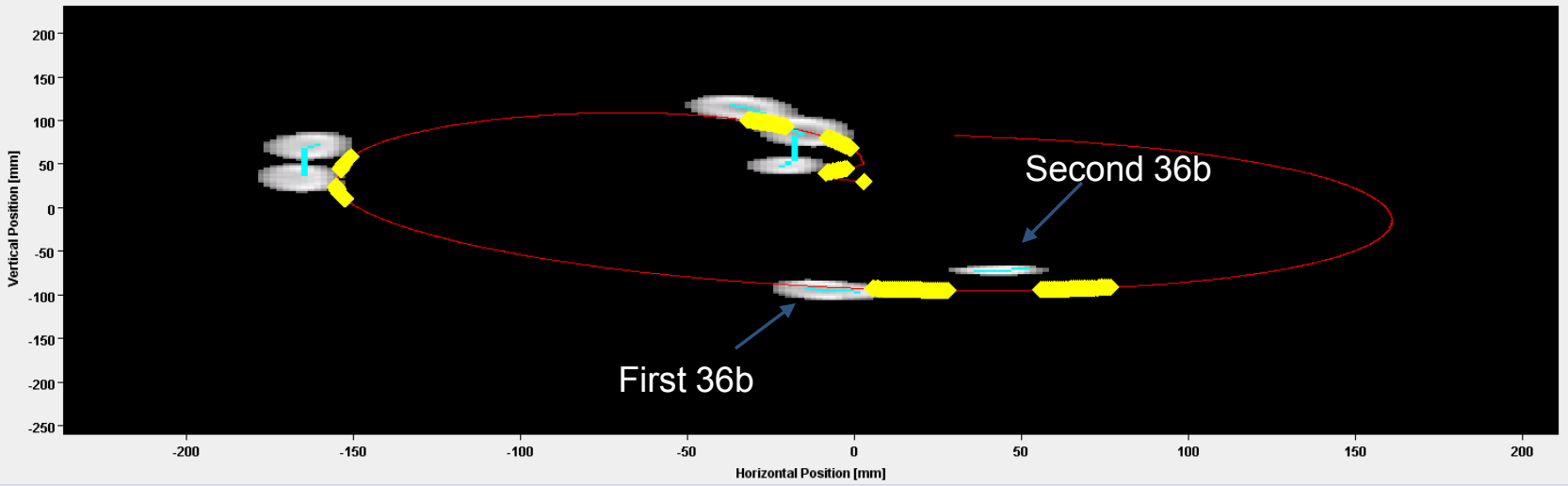
Module: BTVDD — Ignored: YES — Analysis: OK — Check: OK

Checks | Measures | References

CHECKS

Property	Value	Min.Value	Ref.Value	Max.Value	Diff.	Units	Check
isSkeletonDetected	TRUE		TRUE		0	-	OK
height	1.968E2	1.554E2	1.954E2	2.354E2	1.360E0	mm	OK
centerV	6.865E0	-3.744E1	2.557E0	4.256E1	4.308E0	mm	OK
centerH	-5.565E1	-7.920E1	-3.920E1	8.037E-1	-1.646E1	mm	OK
width	2.170E2	1.816E2	2.316E2	2.816E2	-1.465E1	mm	OK
isDumpFillingPatternValid	TRUE		TRUE		0	-	OK

IMAGE

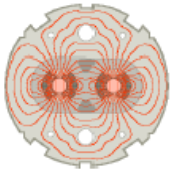


See the two batches clearly on the BTVDD – 2nd batch with lower intensity and vertically offset

FBCT in bump line records 2.58e13 p+ dumped – 'missing' about 2e12 p+, almost exactly half of 36b batch – perfect grazing

From XPOC

Measures proposed and taken

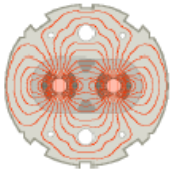


- New SIS to prevent injection if MKI pressure >1e-9 (will have to get some experience with this)
- Checked carefully TDI alignments in P2 and P8, especially with respect to TCLI openings
  - No anomalies found
- New Fixed Display in CCC with MKI pressures
- Vacuum sublimation made on MKI2 and MKI8
- Production of 2nd spare MKI speeded up

Conclusion

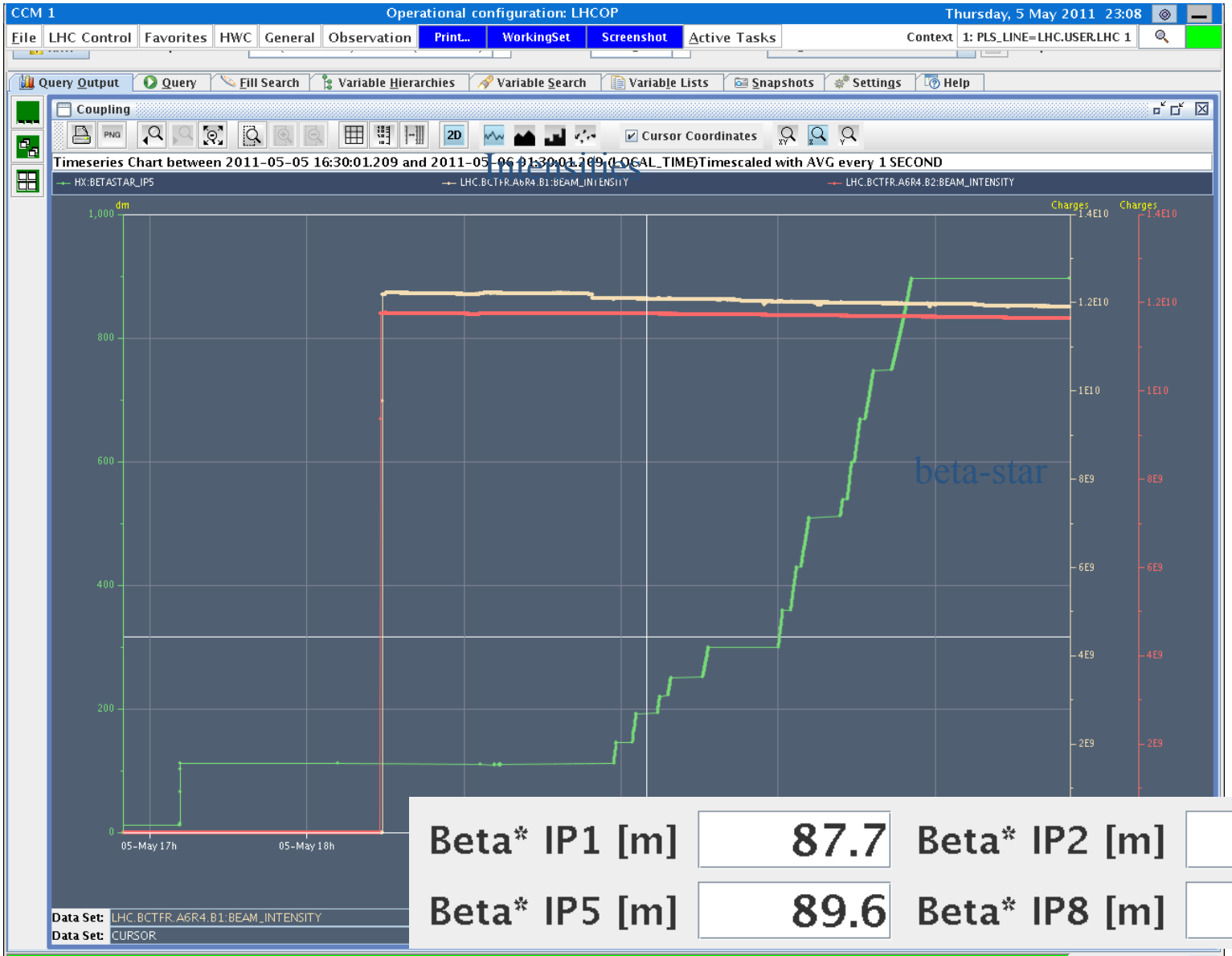
- Had a real breakdown in MKI8.D, between two 36b trains in a 72b batch
- 36b overkicked and grazed lower jaw of TDI/TCLI
  - About half of this intensity was transmitted into LHC (2e12)
- Known worst case scenario for injection protection
  - Showers caused quenches and LHCb trips
  - No damage (magnets, MKI, LHCb, TDI)
  - Protection works – factor 8 to go to real worst-case
  - Setting up and positioning of these devices critical
  - BLMs need more dynamic range
- Production of 2nd new spare MKI accelerated

90 m Unsqueeze



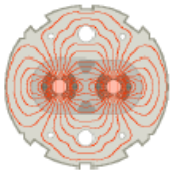
- Demonstrate feasibility of simultaneous un-squeeze of IPs 1 & 5 with external tune compensation using main quads.
  - Orbit and tune feedbacks were kept ON for all the beta* changes.
  - Coupling measurements, corrections, incorporated into functions.
  - Chromaticity & orbit adjusted (real-time trims into the LSA).
- Everything worked as expected. Few minor hiccups.
- B-beat measurements with AC dipole carried out at flat-top, at 30m and (more extensively) at 90m.
- Primary collimators were closed to 10 sigma's as a safety measure prior to the AC dipole measurements.
- At flattop local & global coupling corrections: local

90 m: Intensities and Beta*



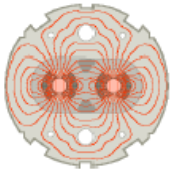
Beta* IP1 [m]	87.7	Beta* IP2 [m]	10.0
Beta* IP5 [m]	89.6	Beta* IP8 [m]	10.0

New ATS Optics



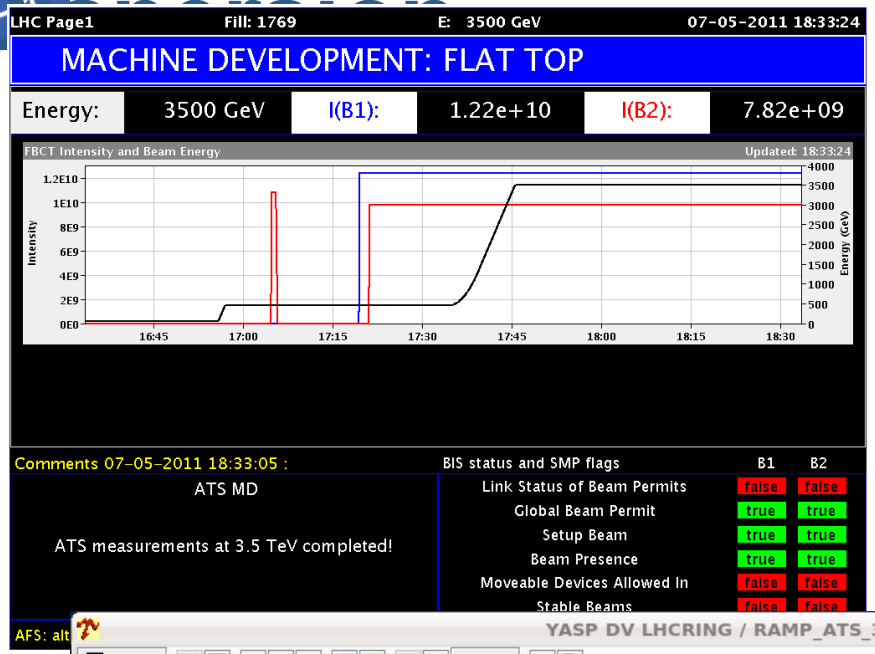
- New injection optics (ATS optics) tested and ramped successfully up to 3.5 TeV
  - crossing scheme off (TCT, TDI, TCLI opened with probe beam
  - successful injection and dump test
  - damper new settings OK (with new phases of the ATS optics)
  - no emittance blow up during the ramp
  - new integer tunes measured at injection 62/60 (instead of 64/59)
  - CO, tune, coupling, chromaticity measured and corrected at injection and flat top
    - new tune, chroma and coupling knobs operational
    - orbit and tune feed-back successfull during the ramp.
  - beta-beat measurement
    - 30% at injection, 10-15% at flat top w/o any specific correction
  - H and V dispersion measured
    - H: +/- 50 cm (compared to 2 m) for Dx at injection, +/- 20 cm at flat top.
    - V: 15-20 cm peak at injection, about 10 cm at flat top.

New ATS Optics



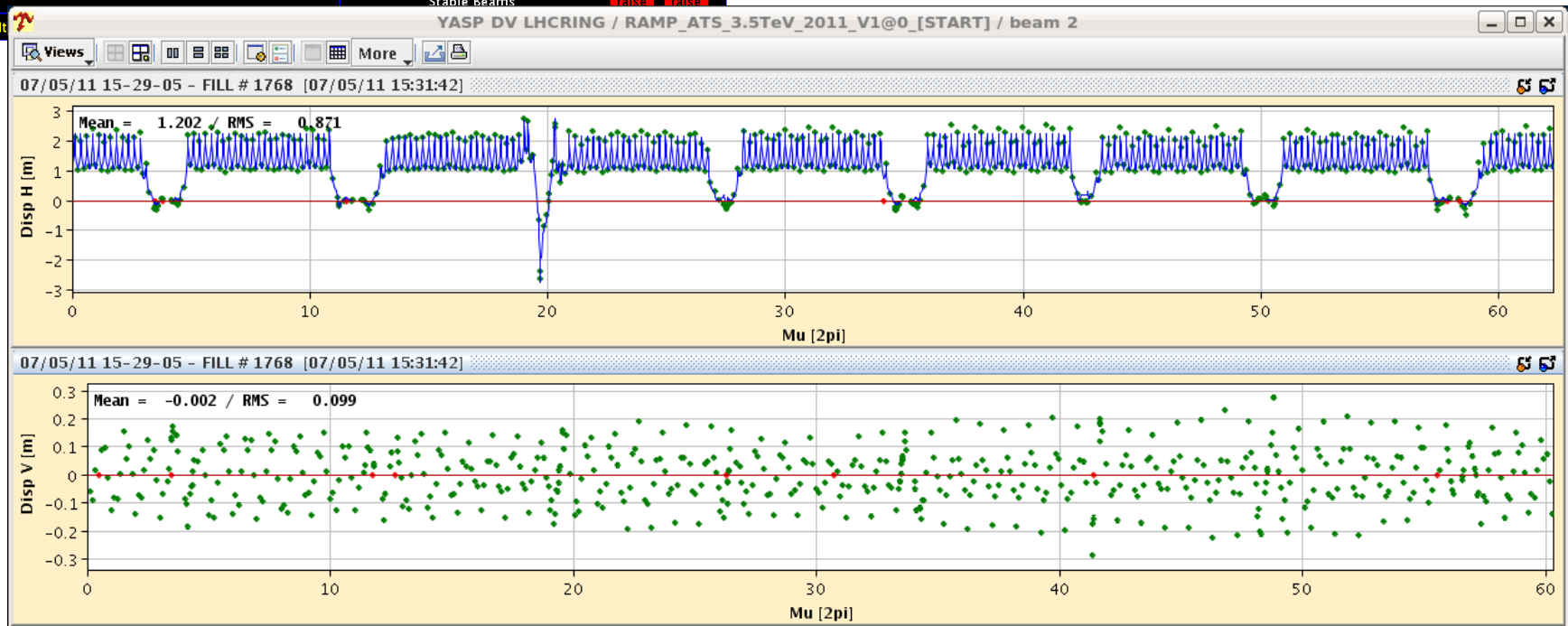
- **Next steps:**
  - **inject and ramp with crossing scheme (170 murad, 2 mm in all IP's kept constant during the ramp).**
  - **pre-squeeze to bstar=1.2 m w/o crossing scheme.**
  - **measure/correct the off-momentum beta-beating, and non-linear chromaticity.**
  - **switch on the crossing scheme at bstar=1.2 m and measure/correct the spurious dispersion.**

ATS New Injection Orbit – Ramp, Dispersion

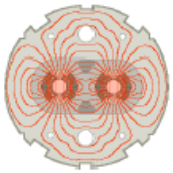


Excellent transmission of intensity through the ramp.

Dispersion B2.



Nominal collimation, single b tune shift (Coll, Imp.)



- Initial blow-up tests with transverse damper.
- Injection scraping during short delay from injectors.
- Nominal 3.5 TeV collimation settings achieved for b1 &b2:
  - TCP = 5.7 sigma (nom), TCSG = 6.7 sigma (nom)
  - TCLA = 9.7 sigma (nom), IP6 = 7.2/7.7 sigma (nom)
- Octupoles trimmed to 350A for beam 1.
- For b1 moved towards nominal 7 TeV settings. Limited by TCSG losses close to IP7. Valid setup reached:
  - TCP = 4.0 sigma (nom), TCSG = 6.0 sigma (nom)
  - TCLA = 8.0 sigma (nom), IP6 = 7.0/7.5 sigma (nom)
  - Smallest gap: 2.2 mm
  - Beam lifetime: > 100 hours
  - Tune shift measured: ~2e-4
  - Efficiency measured: 3e-5 – 1e-4

Settings b1 first loss-maps

Reminder: Start up scenario

- **75 ns beam re-commissioning – Scrub with 50 ns – 75/50 ns operation**
  - Recommissioning with 75 ns bunch spacing - 3 w
  - Increase bunch number (~300b?) – 2 w
  - Scrub with 50ns when needed - 1.5 w

    After scrubbing experience, decide on 50/75 ns
  - 50/75 ns operation and increase bunch number -2.5w 300 – 400 – 600 – 800 – 936 -??1404 MP and OP qualification –
  - Physics operation 50/75 ns – 936/1404 b
  - (Back up: restore 150 ns operation – couple days)
- Other possible start up scenari were discussed