LHC progress Report

LHCC

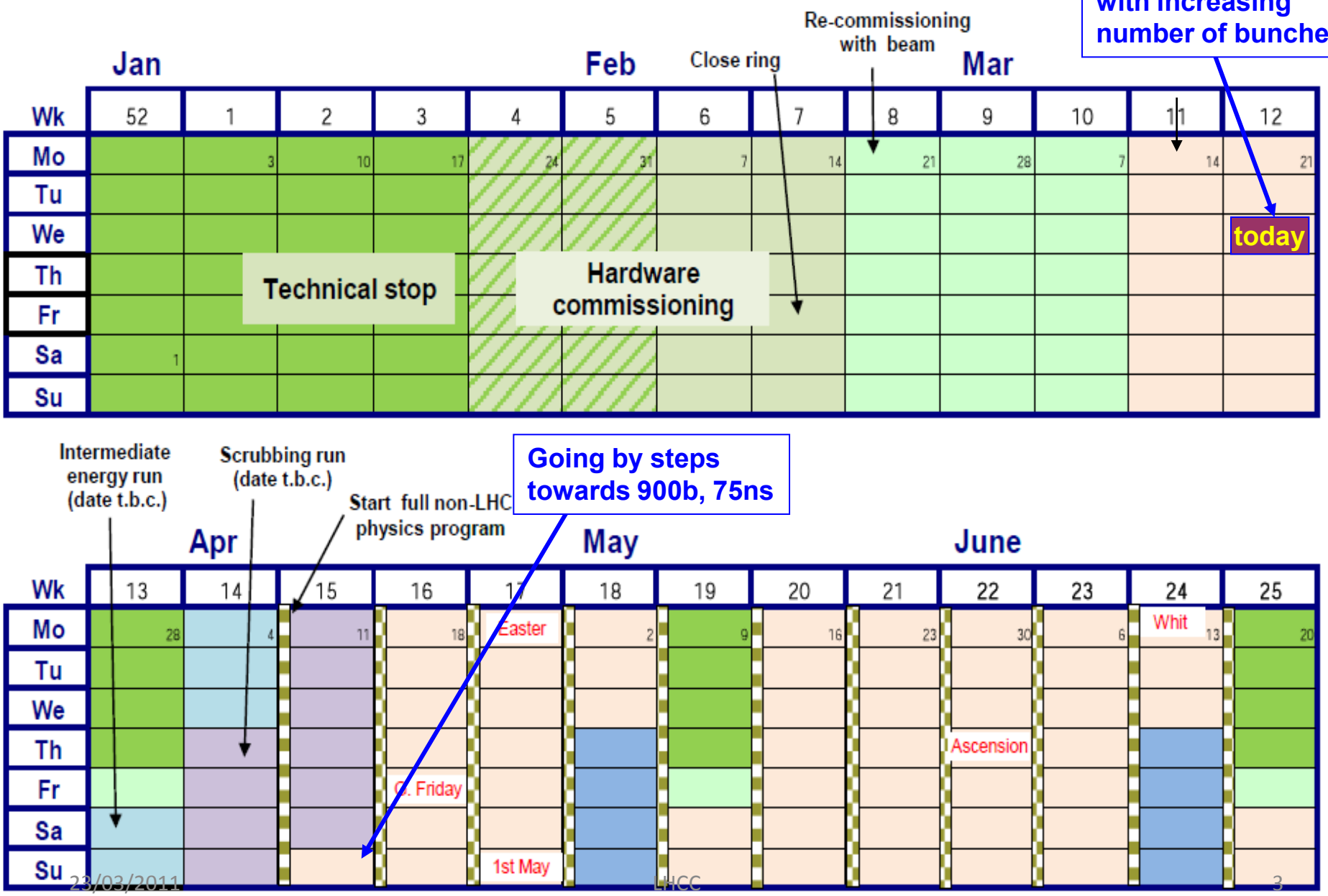
Wednesday 23rd March 2011

Start up scenario

- **75 ns beam re-commissioning – Scrub with 50 ns – 75/50 ns operation**
  - Recommissioning with 75 ns bunch spacing - 3
  - Increase bunch number (~300b?) – 2 w
  - Scrub with 50ns when needed - 1 [illegible]
  - After scrubbing experience [illegible] 50/75 ns
  - 50/75 ns operation and [illegible] bunch number -2.5w 300 – 400 – 600 – 800 – 936 -?? [illegible] and OP qualification –
  - Physics opera[illegible] ns – 936/1404 b
  - (Back u[illegible] 150 ns operation – couple days)
- Other [illegible] start up scenari were discussed

On the planned schedule

2011 LHC schedule



450 GeV

- Injection optics and orbit OK.
- Aperture OK and measured.
- RF system OK.
- Transverse damper OK.
- Feedbacks OK.
- Emittance small now
- Injection ring
- Machi OK.
- Injec nsfer line collimation OK.
- Now: Moving to multi-bunch injection.
  - BLM firmware upgrade done
  - First injection tests

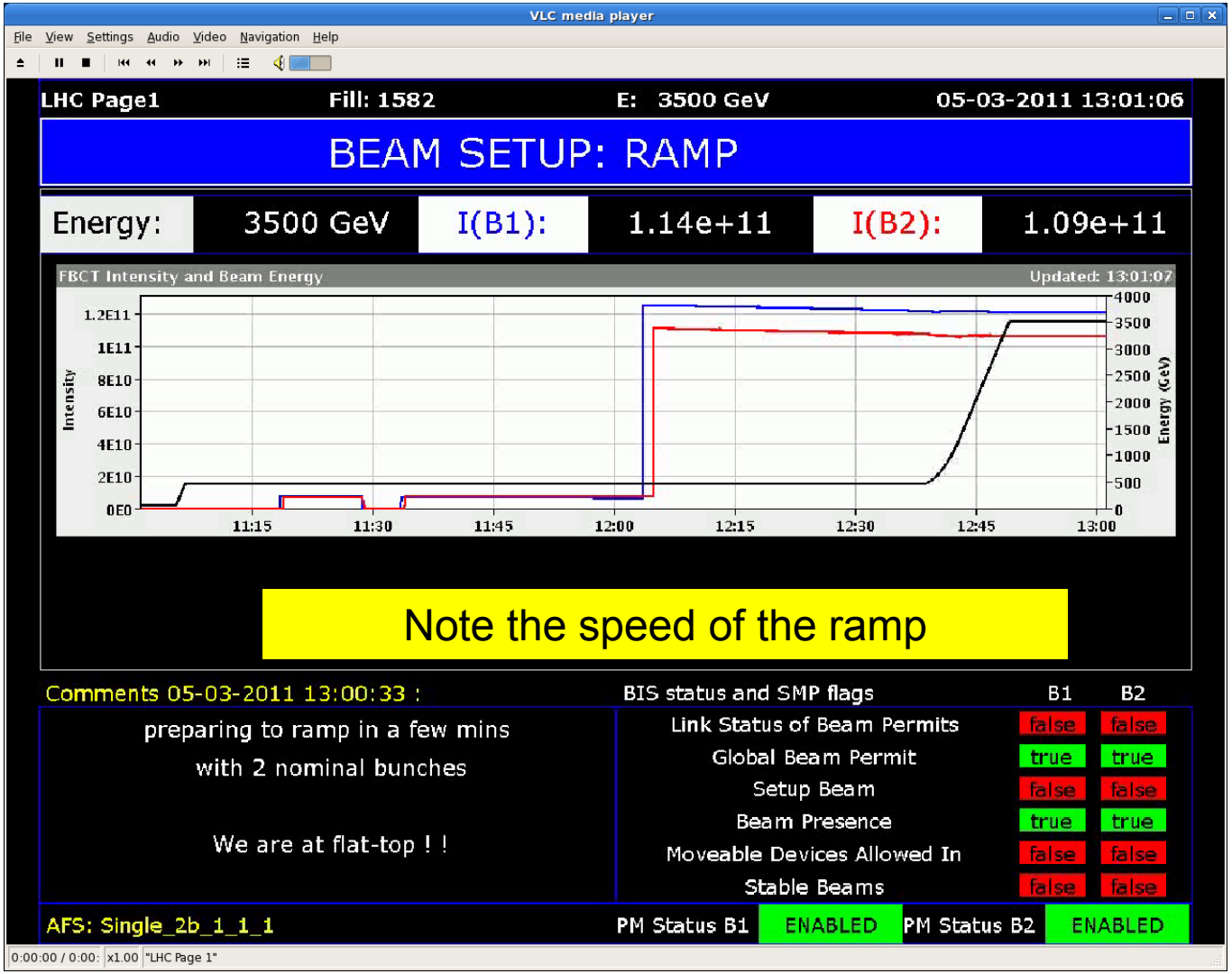
All Ready

Ramp

- Pilot and nominal bunch. OK.
- Chromaticity, tune, orbit OK.
- RF blowup. OK
- Feedbacks OK.
- Transmissio[illegible]times OK.
- Collim[illegible]p: OK

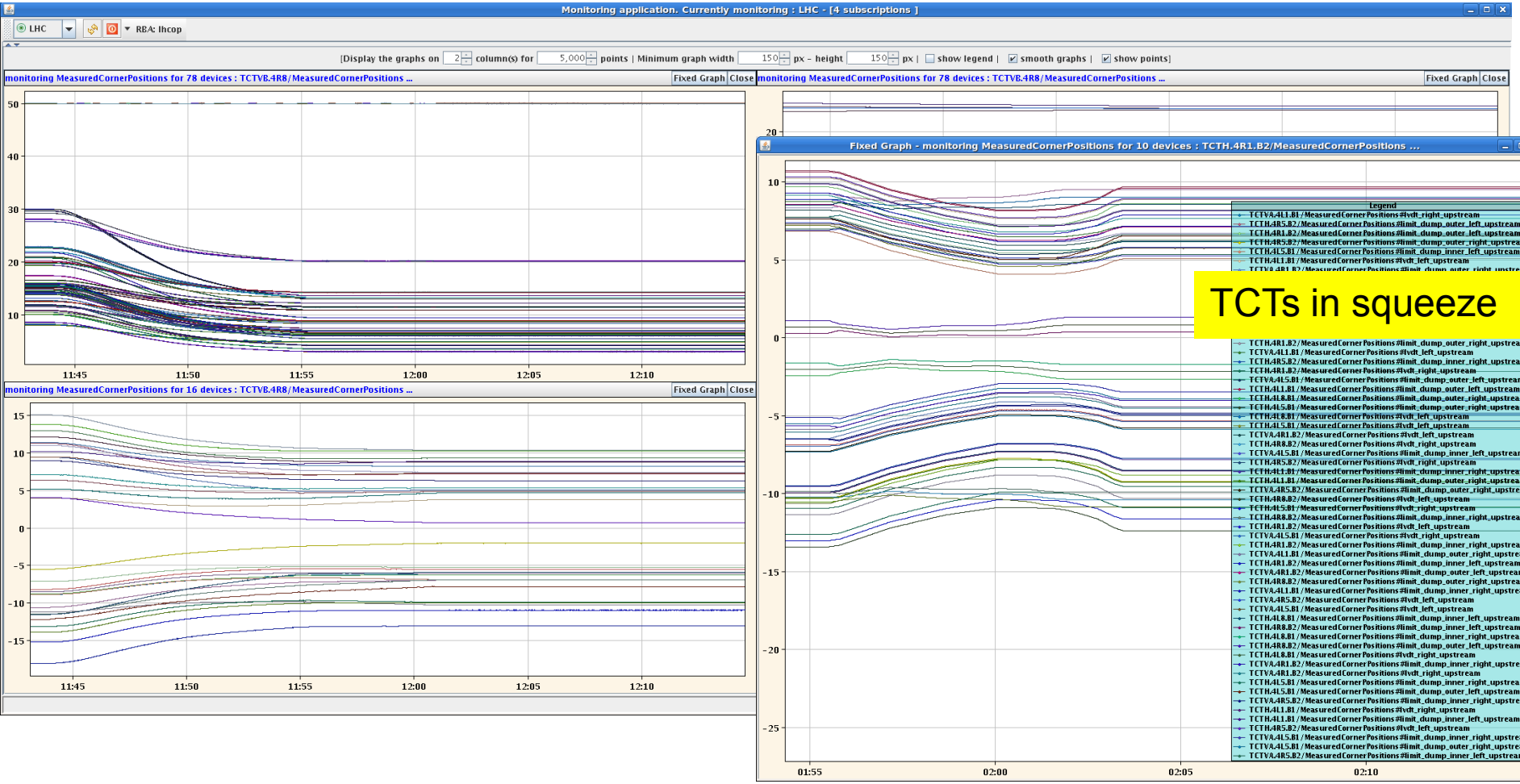
All Ready

First ramp with nominal bunch…

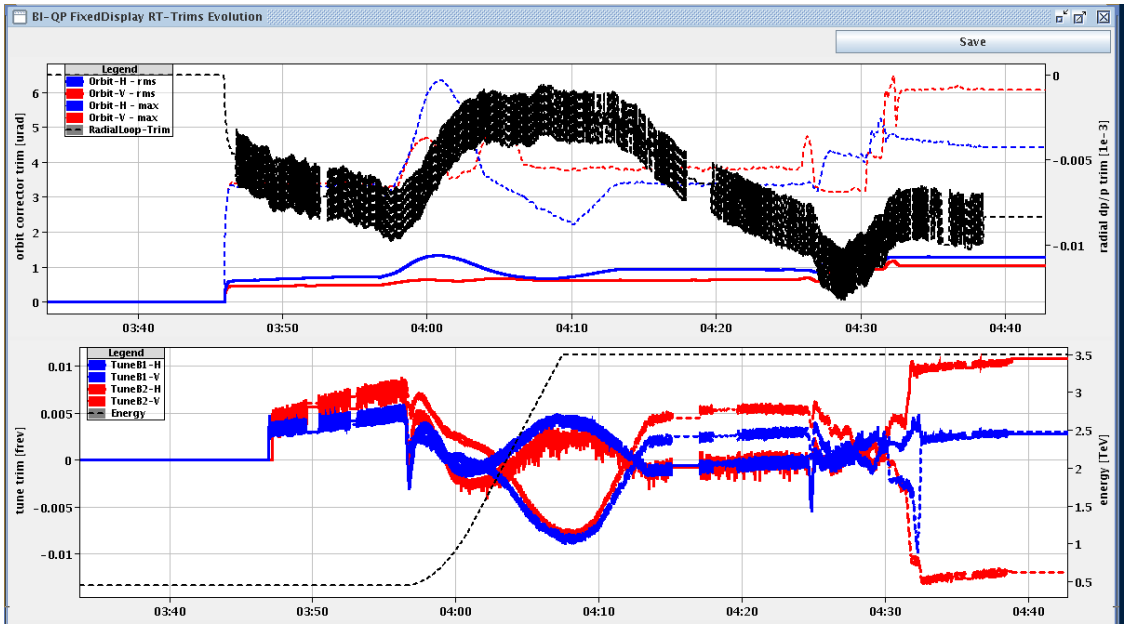


Collimators in ramp & squeeze

Ramp functions of the collimation system

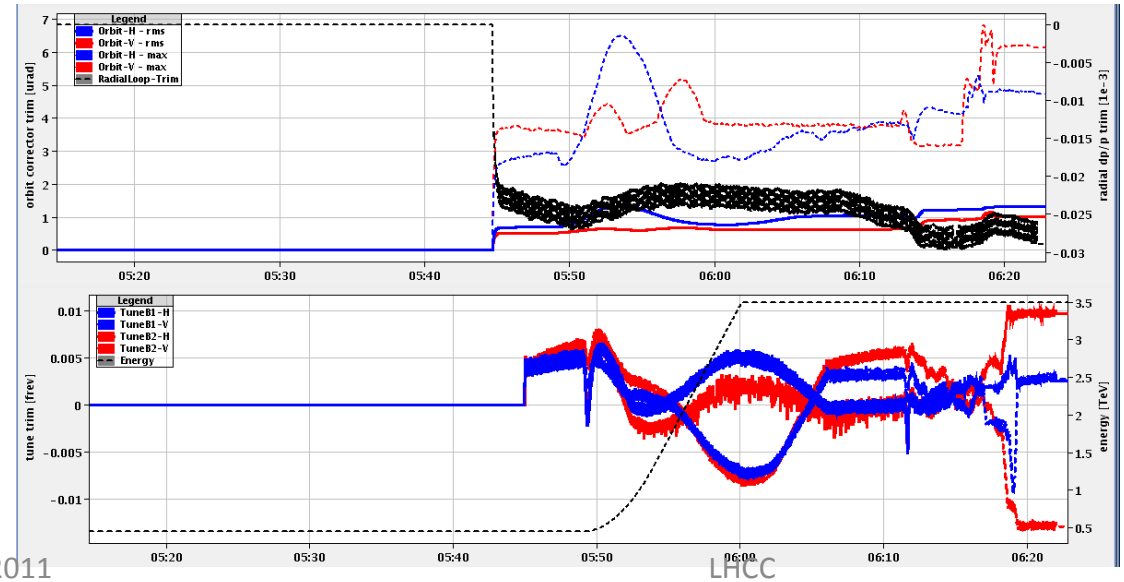


Ramp /squeeze (one step) for Q/Q'/coupling



Orbit trims

Tune trims



Orbit trims

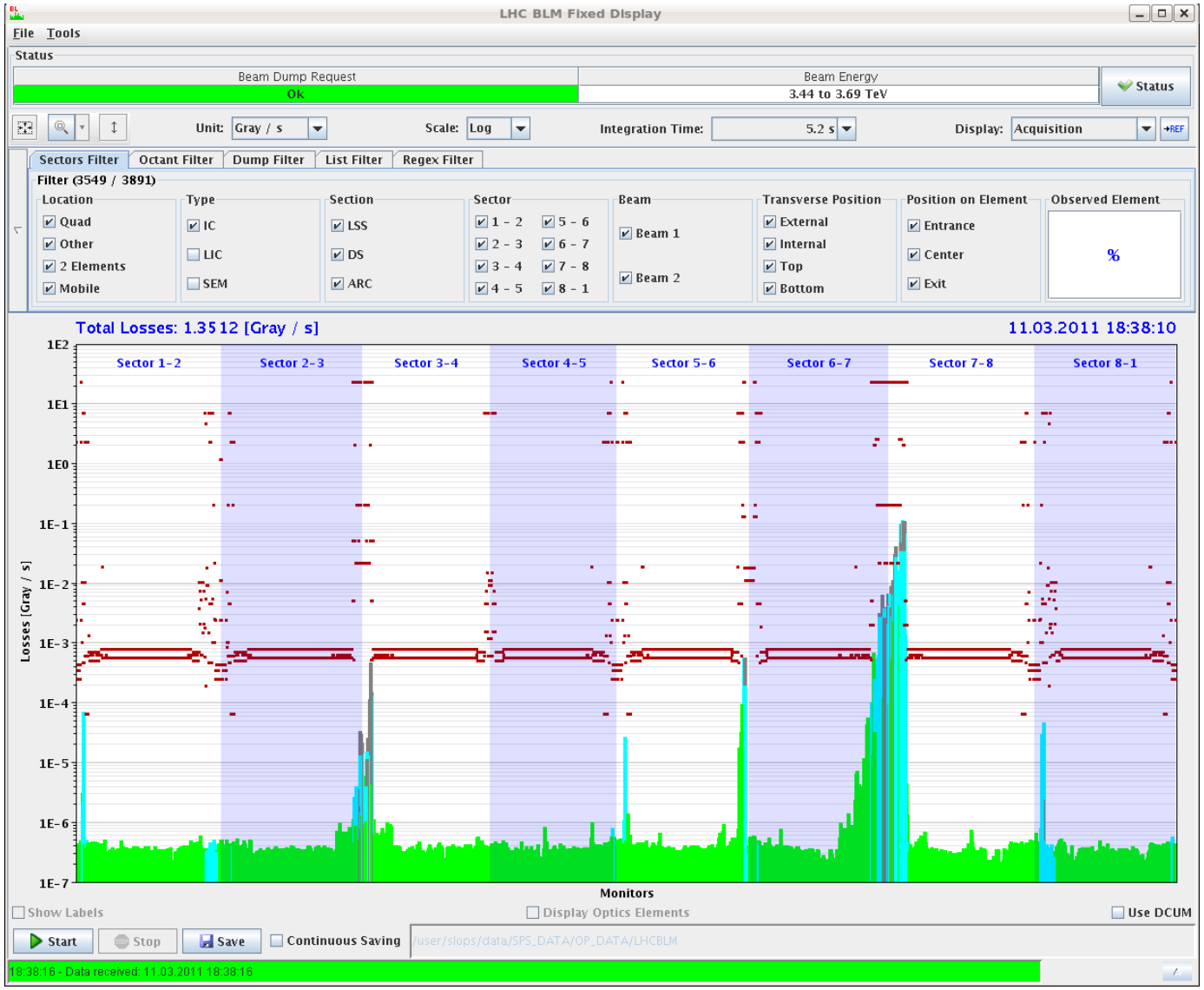
Tune trims

VERY reproducible from ramp to ramp!

3.5 TeV/beam

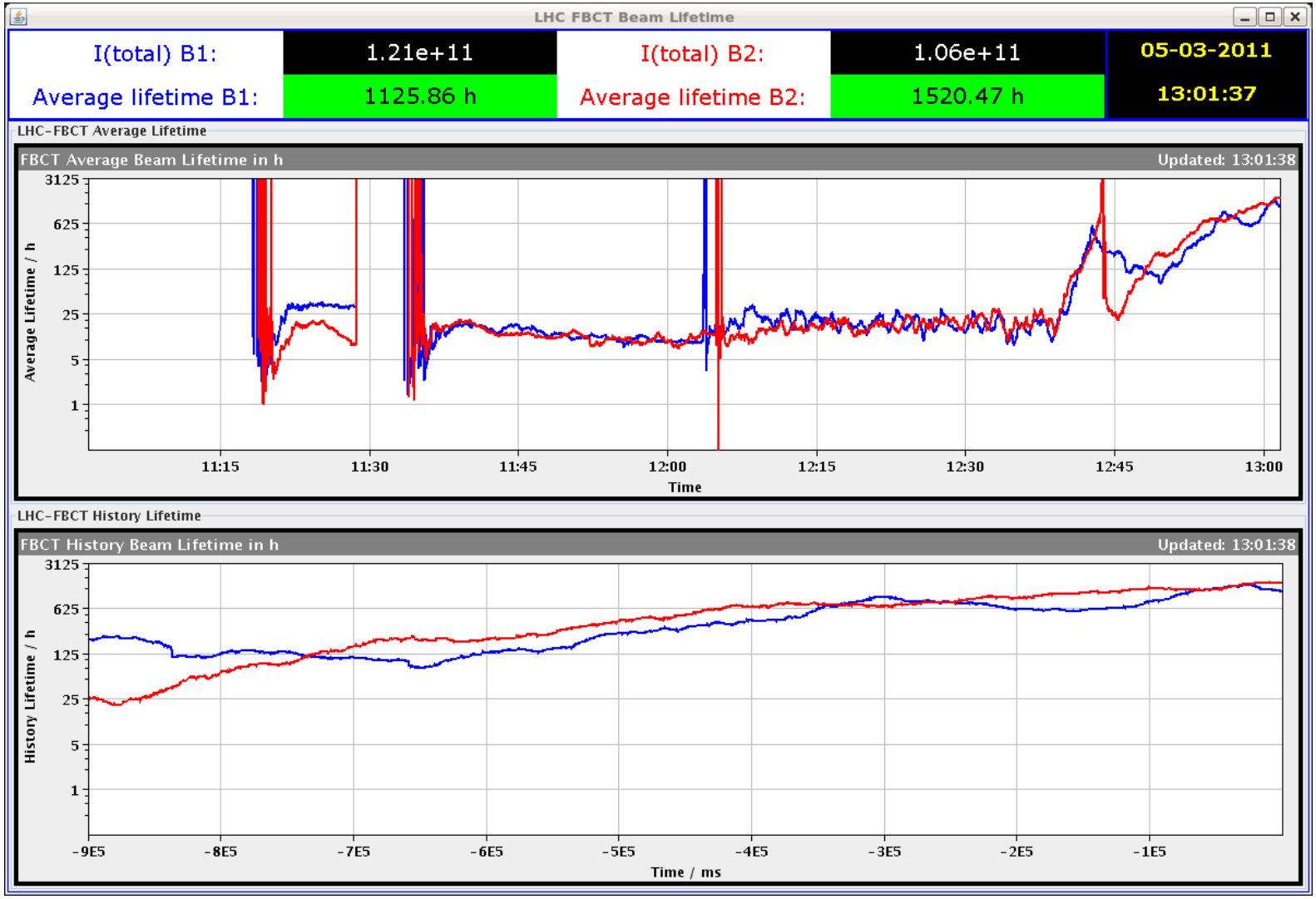
- Chromaticity and tunes OK.
- Beta beat and coupling through squeeze OK.
  - Beta* correction redone with k-modulation.
- Squeeze with dynamic orbit reference OK.
- Sequence with feedbacks OK.
- Pilot collisions and vernier scans OK.
- Final 3.5 TeV reference orbit defined (nominal bunch).
- All collimators calibrated for flat top.
- Dump protection setup and check.
- Loss maps for qualification. Asynchronous dump tests.

Example of a betatron loss map @ 1.5 m beta*

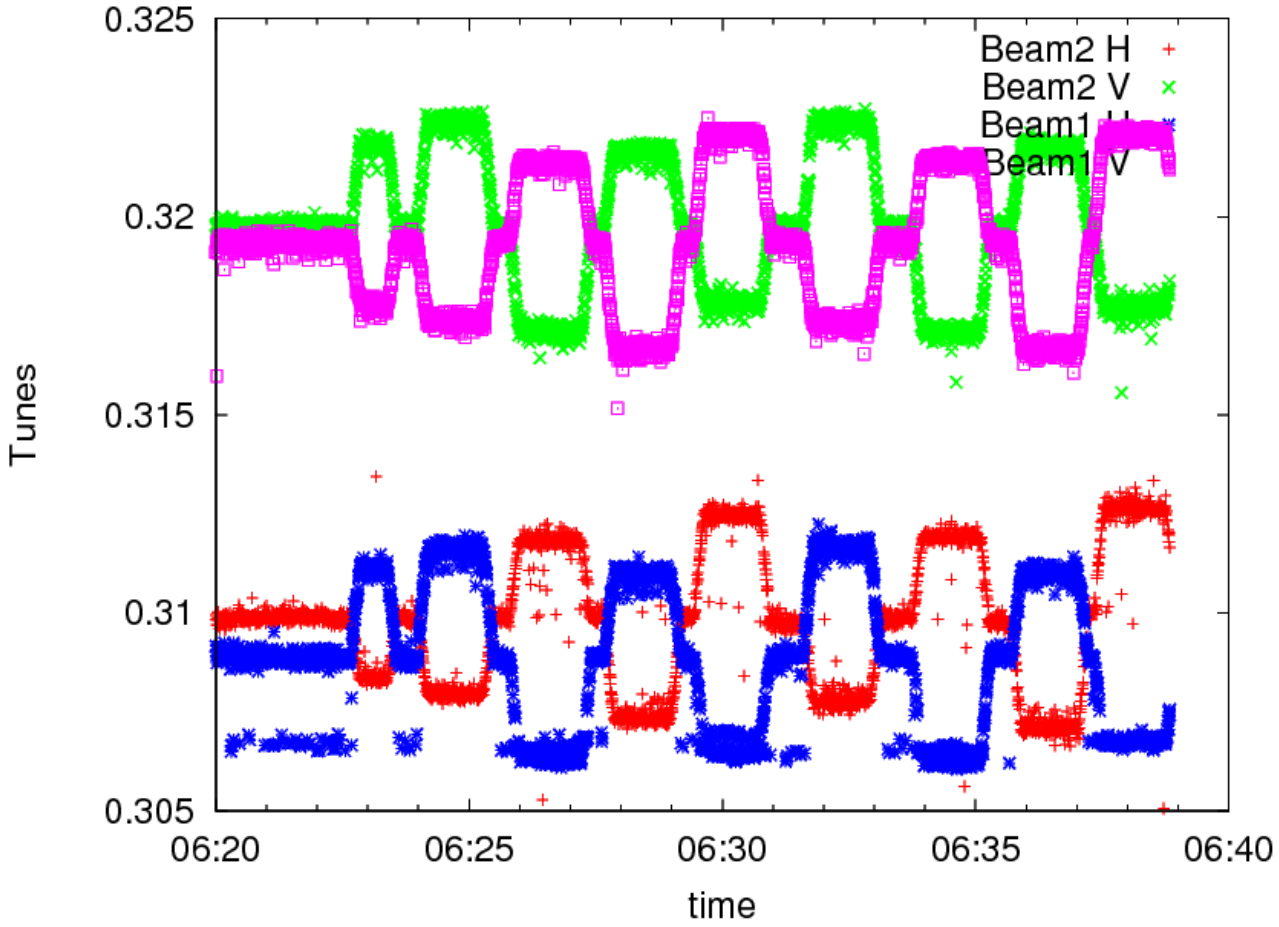


No losses on inner triplets all on TCTs

Single Beam Lifetimes.. amazing



K-modulation measurement



β^* is calculated from the amplitude of the tune modulation when changing the gradient of triplet quadrupoles.

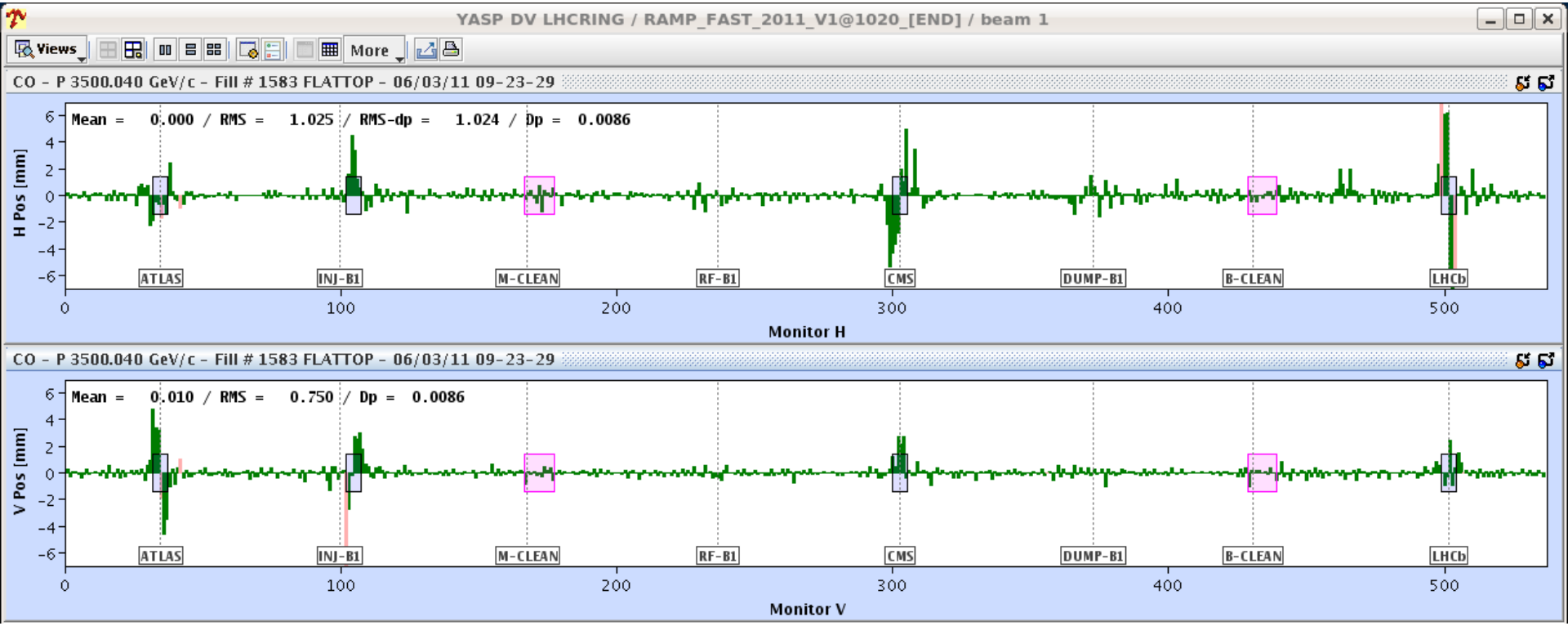
beta* from K modulation

- ‘Final’ values from K-modulation:

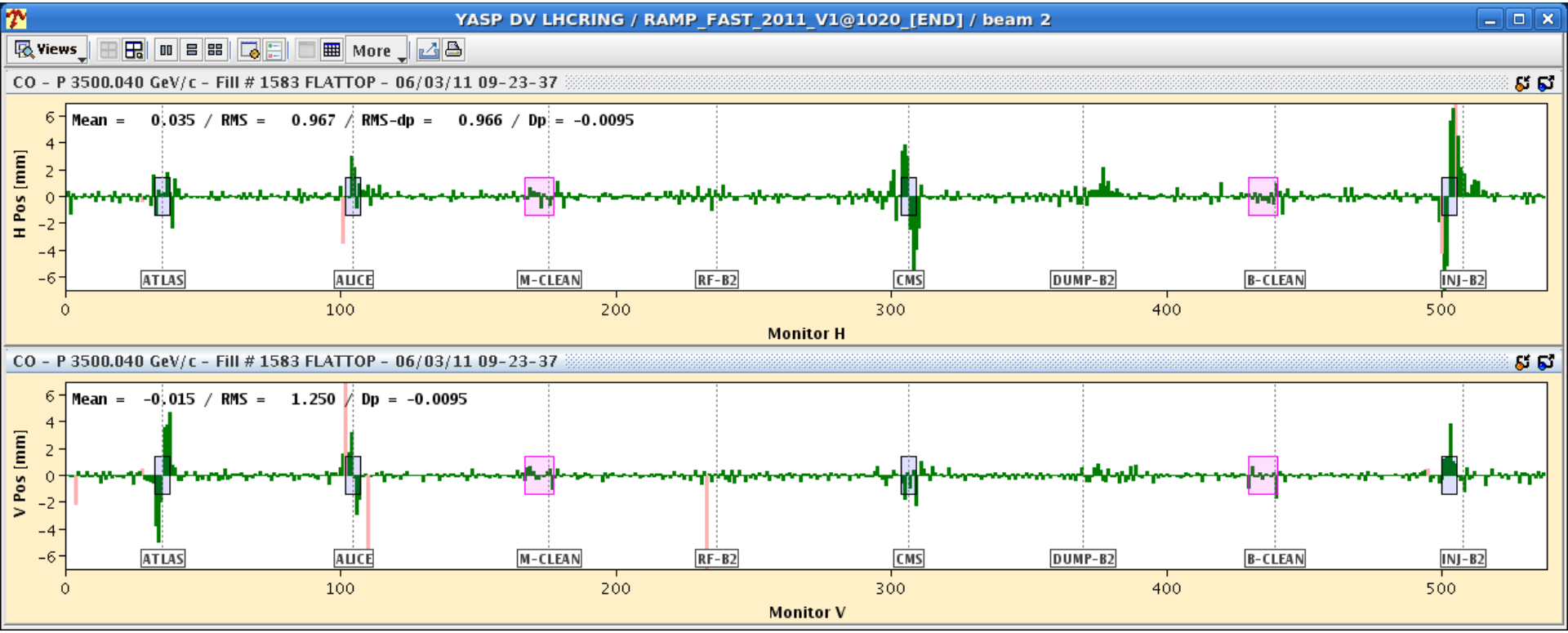
Beam/plane	IR1	IR5
B1H	1.50	1.53
B2H	1.48	1.57
B1V	1.52	1.50
B2V	1.52	1.57

- Errors around 4-10%.
- Imbalance is 2.5 +- 8%.
- No correction at present until we get feedback from the experiments

3.5 TeV Orbit High Intensity B1



3.5 TeV Orbit High Intensity B2



Summary of validations

Saturday 12th March

	Betatron loss maps	+ off momentum	- off momentum	async dump
450 GeV	Done	Done	Done	Done
Flat top	Done	Done		Done
1.5 m before collisions				
Collisions	Done	Done		

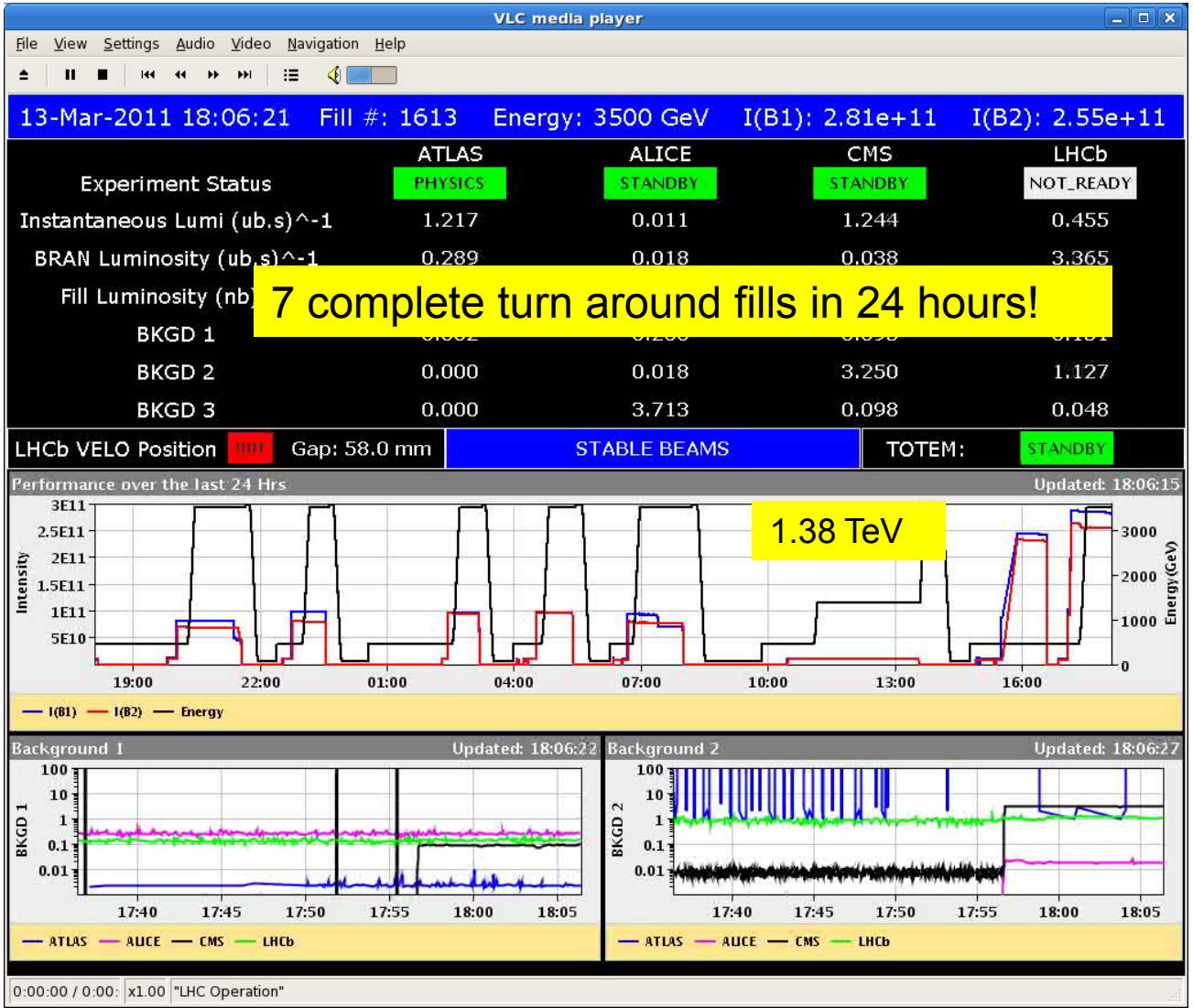
Sunday 13th March

Condition	Betatron H	Betatron V	Dp/p +	Dp/p -	Dump
Injection	X	X	X	X	X
Flat top	X	X	X	X	X
Squeezed	X	X	X	X	X
Collisions	X	X	X	X	X

7 complete energy ramps and squeezes in less than 24 hours

End for week 10

- Protection validation ‘factory’, 1.38 TeV ramp & collisions, and finally stable beams at 3.5 TeV.



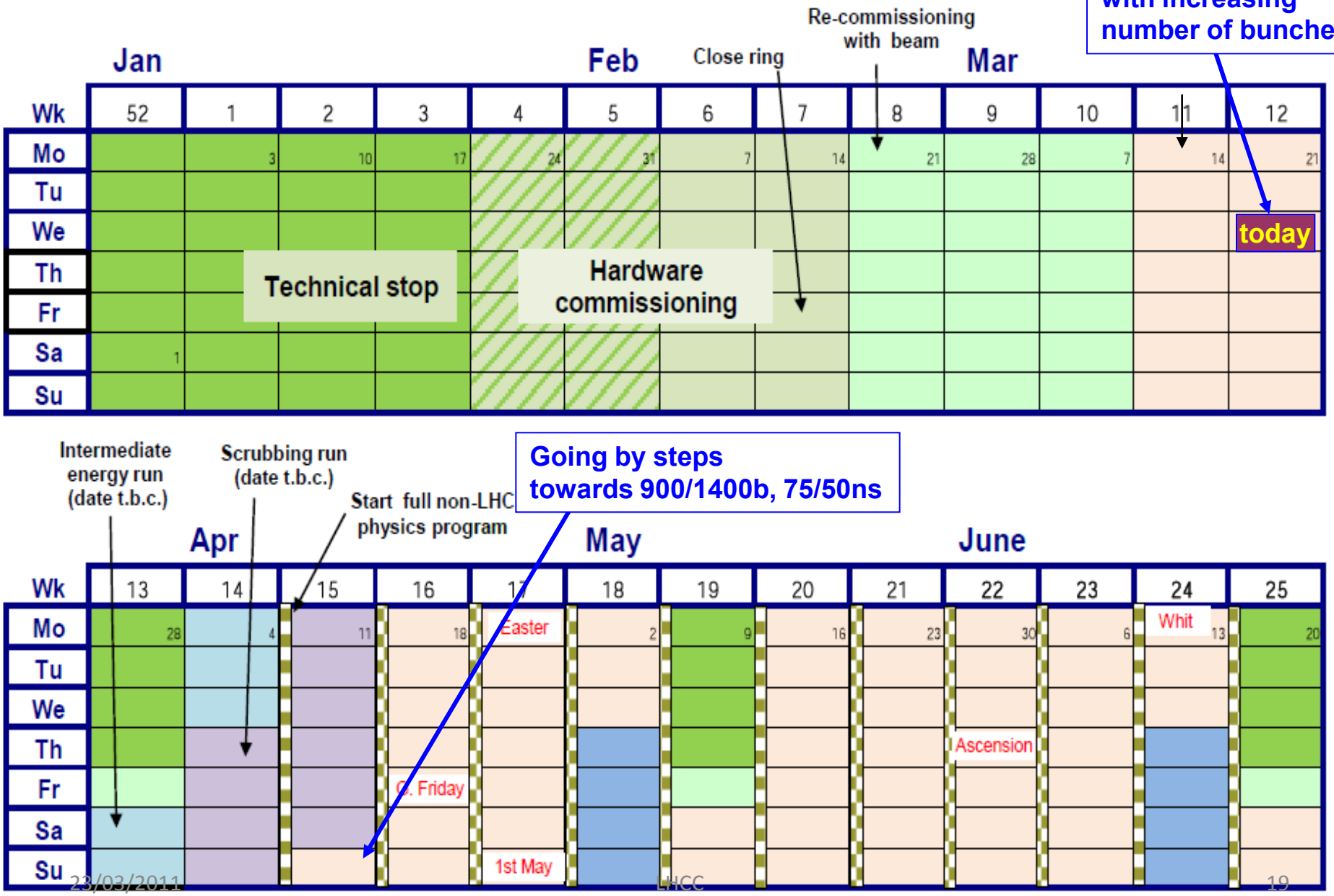
Intensity ramp-up, first phase

Intensity ramp-up

- 32 bunches
- 64 bunches
- 136 bunches
- 200 bunches

Baseline is three fills per step, in total 20h

2011 LHC schedule



Fills of Last week

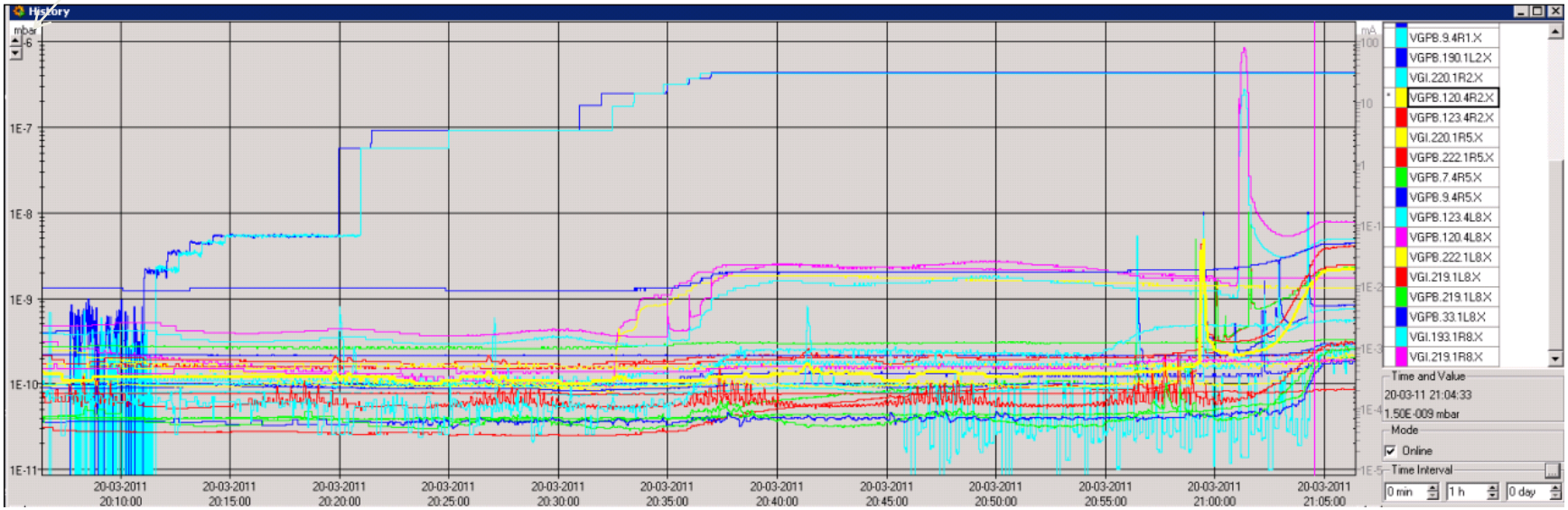
Fill	# bunches	Average bunch population @coll [10^{11} p]	Initial luminosity [10^{30} cm^{-2}s^{-1}]	ε_{HV} @coll (from init. Lumi)	Integrated luminosity [pb^{-1}]	Coast duration [hours]	Turn-around to next fill [hours]
1634	32	1.18/1.12	30	2.8	0.51	06:00	02:25
1635	32	1.18/1.17	33	2.7	0.009	00:06	05:00 (RF)
1636	32	1.16/1.15	32	2.7	0.56	06:00	02:41
1637	64	1.18/1.15	66	2.7	1.3	06:40	02:45 (Inj)
1638	64	1.14/1.14	66	2.6	1.34	07:05	05:50 (CRYO)
1639	64	1.14/1.14	65	2.7	1.21	06:20	02:30 (MPS)
1640	136	1.18/1.18	148	2.6	3.7	08:30	

Tot. L = 8.7 pb-1

Vacuum Experimental Areas 136 bunches

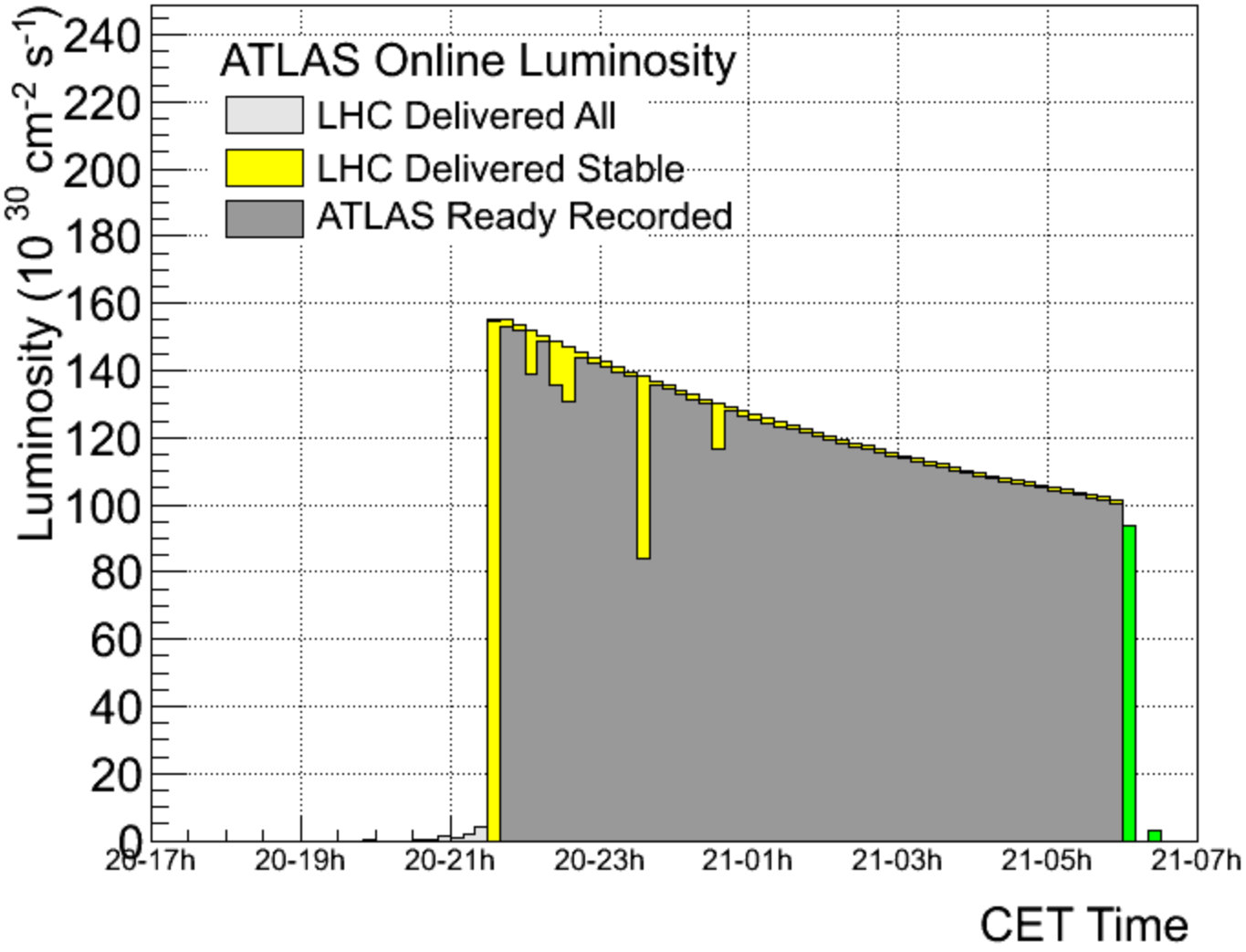
1e-6 mbar !!!

ATLAS had vacuum spikes at about 21:00... until 21:15 it went up by a couple of orders of magnitude, by now recovered 10%.

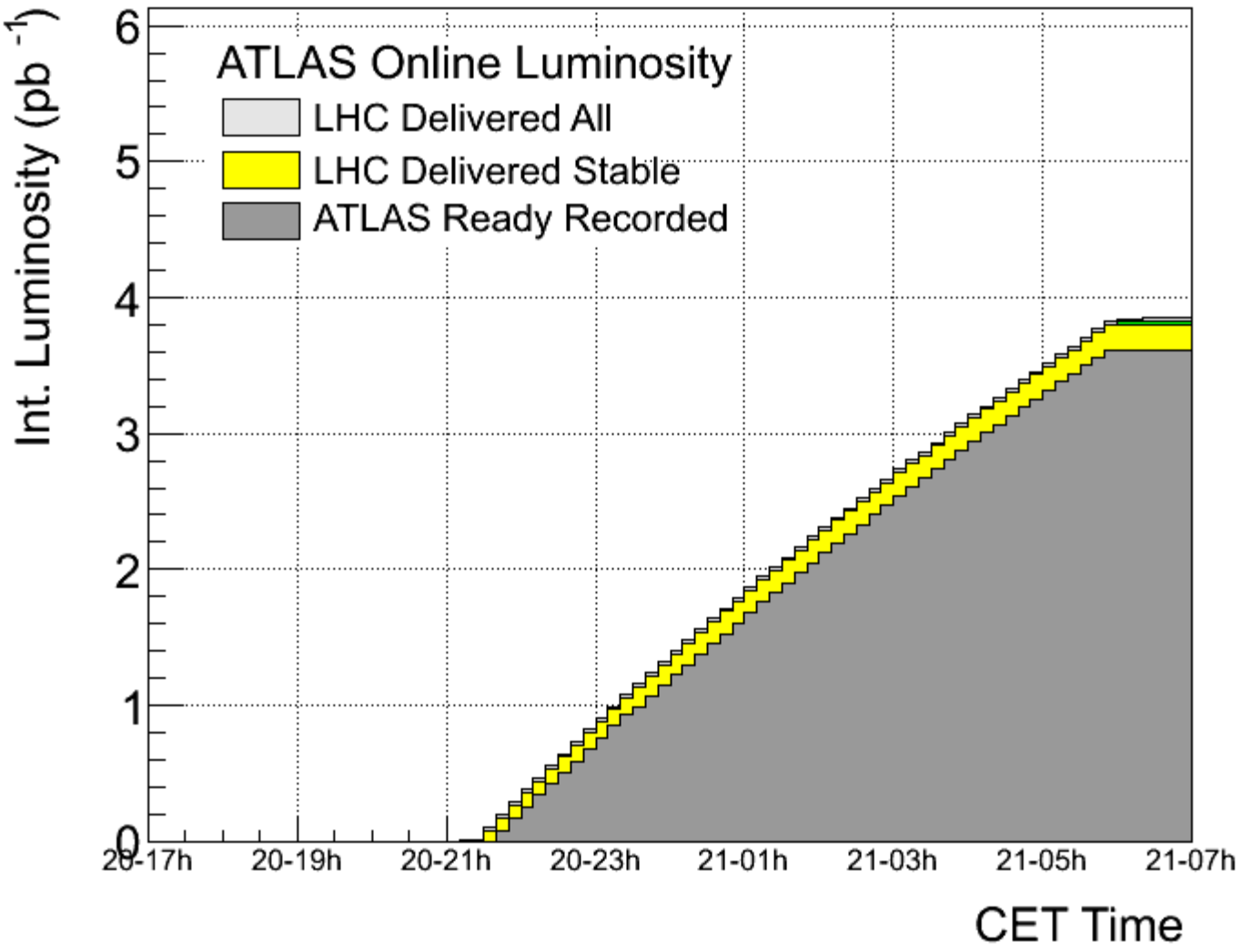


M.Jimenez

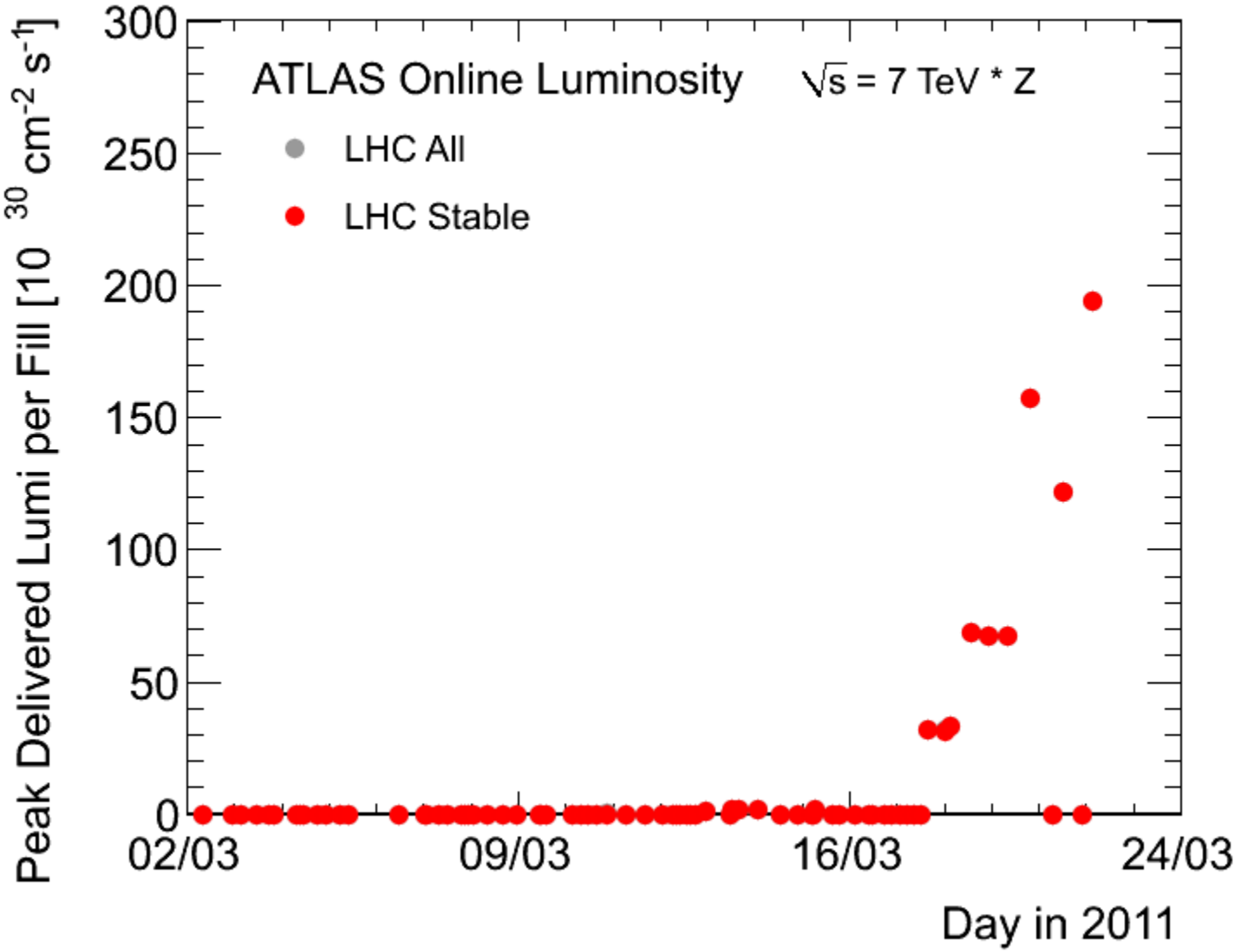
Best Fill


ATLAS Online Luminosity
LHC Delivered All
LHC Delivered Stable
ATLAS Ready Recorded
Luminosity (10^{30} cm^{-2} s^{-1})
240
220
200
180
160
140
120
100
80
60
40
20
0
20-17h
20-19h
20-21h
20-23h
21-01h
21-03h
21-05h
21-07h
CET Time

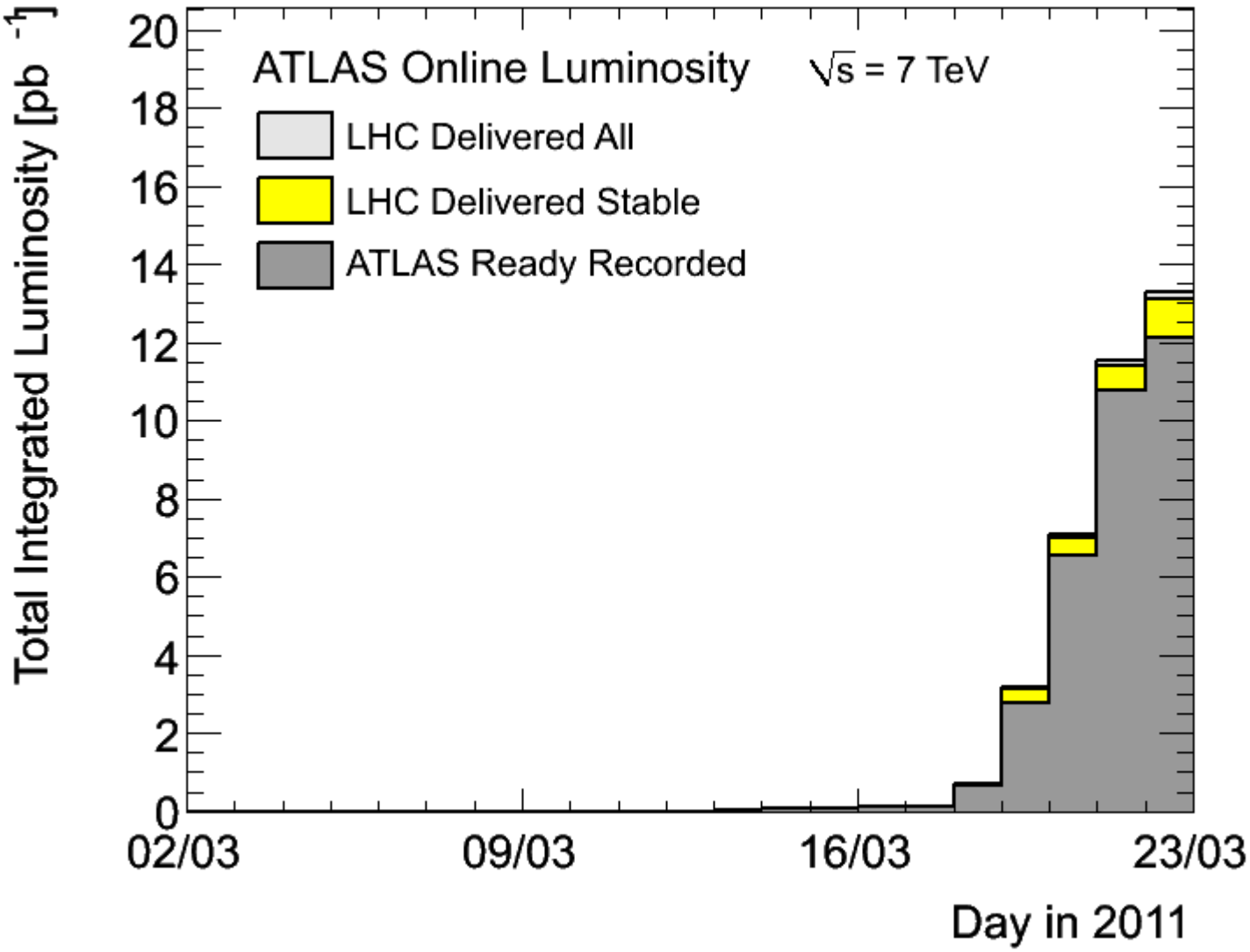
Best Fill


ATLAS Online Luminosity
LHC Delivered All
LHC Delivered Stable
ATLAS Ready Recorded
Int. Luminosity (pb -1)
0
1
2
3
4
5
6
20-17h
20-19h
20-21h
20-23h
21-01h
21-03h
21-05h
21-07h
CET Time

Peak Luminosity



Integrated Luminosity



Plans Up to the Technical Stop

- Tu am: Fix controls issues. Last 136b fill.
- Tu pm: Go to 200 bunches.
- Tu – Wed: Perform 2 fills with 200 bunches.
  End of fill test of IR8 separation (tbc).
- Wed pm: Complete commissioning 1.38 TeV.
- Wed pm – Fri: Stable beams at 1.38 TeV. 80b.
- Sat am: Switch back to 3.5 TeV
  Test ramp nominal bunch.
  Third fill with 200b.
- Weekend: Commissioning (3h for TL tests,
  8h injection test with 96b, ...)
  Intensity step to 250b if time left
- Monday 6am: Beam stop for TS

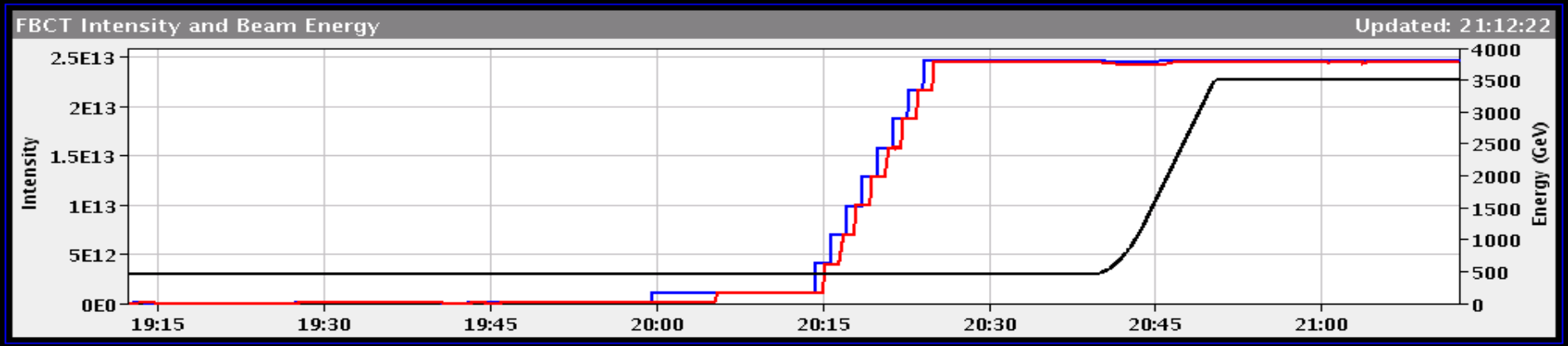
BUT late last night

200 bunches

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

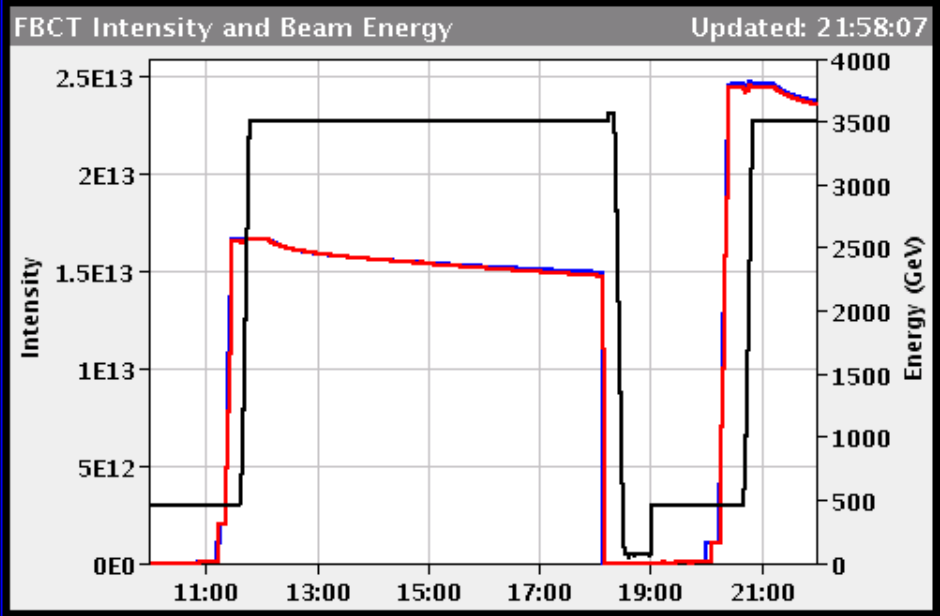
BIS status and SMP flags	B1	B2
Link Status of Beam Permits	true	true
Global Beam Permit	true	true
Setup Beam	false	false
Beam Presence	true	true
Moveable Devices Allowed In	false	false
Stable Beams	false	false

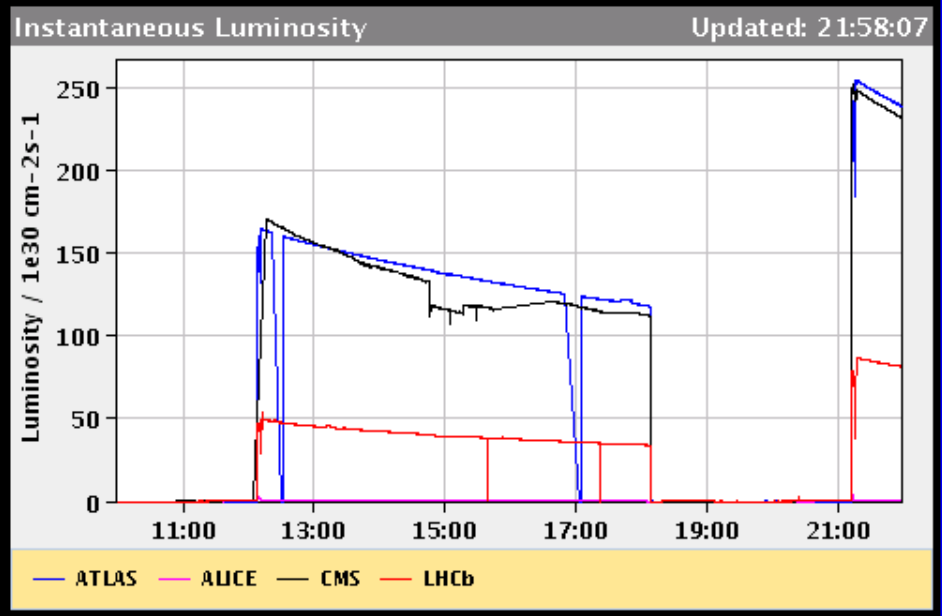
AFS: 75ns_200b_194_178_188_24bpi9inj | PM Status B1: ENABLED | PM Status B2: ENABLED

LHC Page1 | Fill: 1645 | E: 3500 GeV | 22-03-2011 21:58:06

PROTON PHYSICS: STABLE BEAMS

Energy:	3500 GeV	I(B1):	2.38e+13	I(B2):	2.35e+13





Comments 22-03-2011 21:21:07 :

STABLE BEAMS

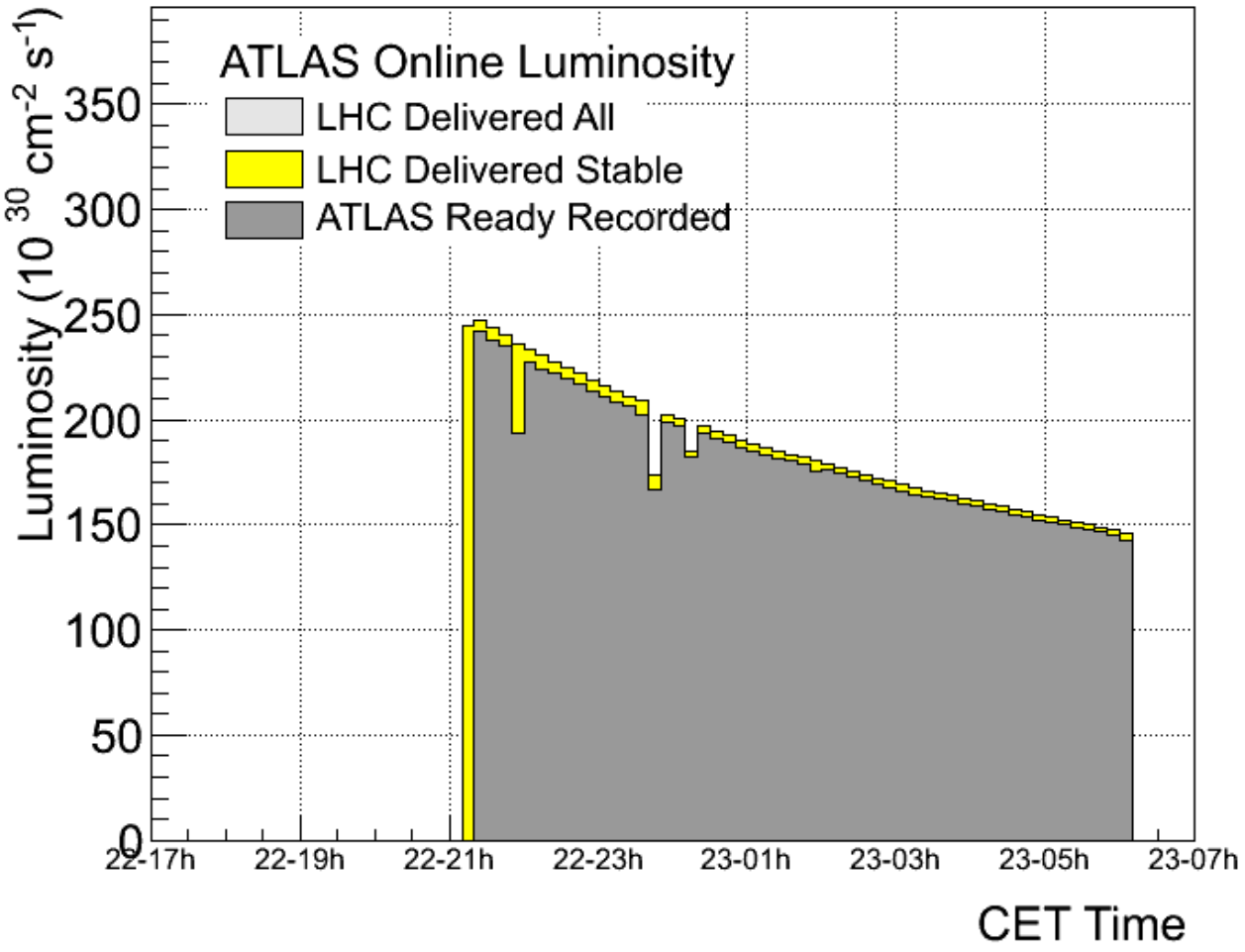
2010 record passed !!!!

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

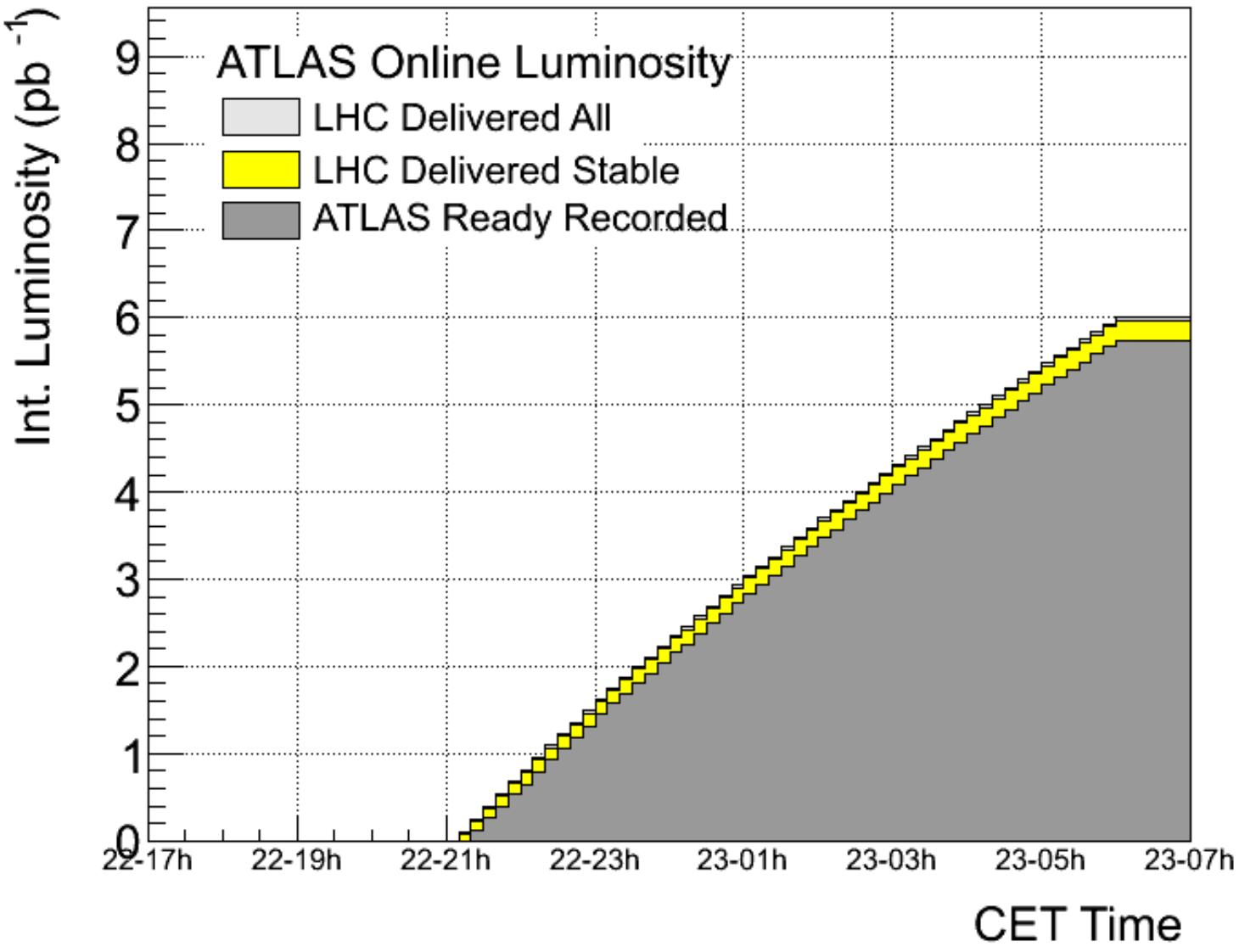
AFS: 75ns_200b_194_178_188_24bpi9inj

PM Status B1: ENABLED | PM Status B2: ENABLED

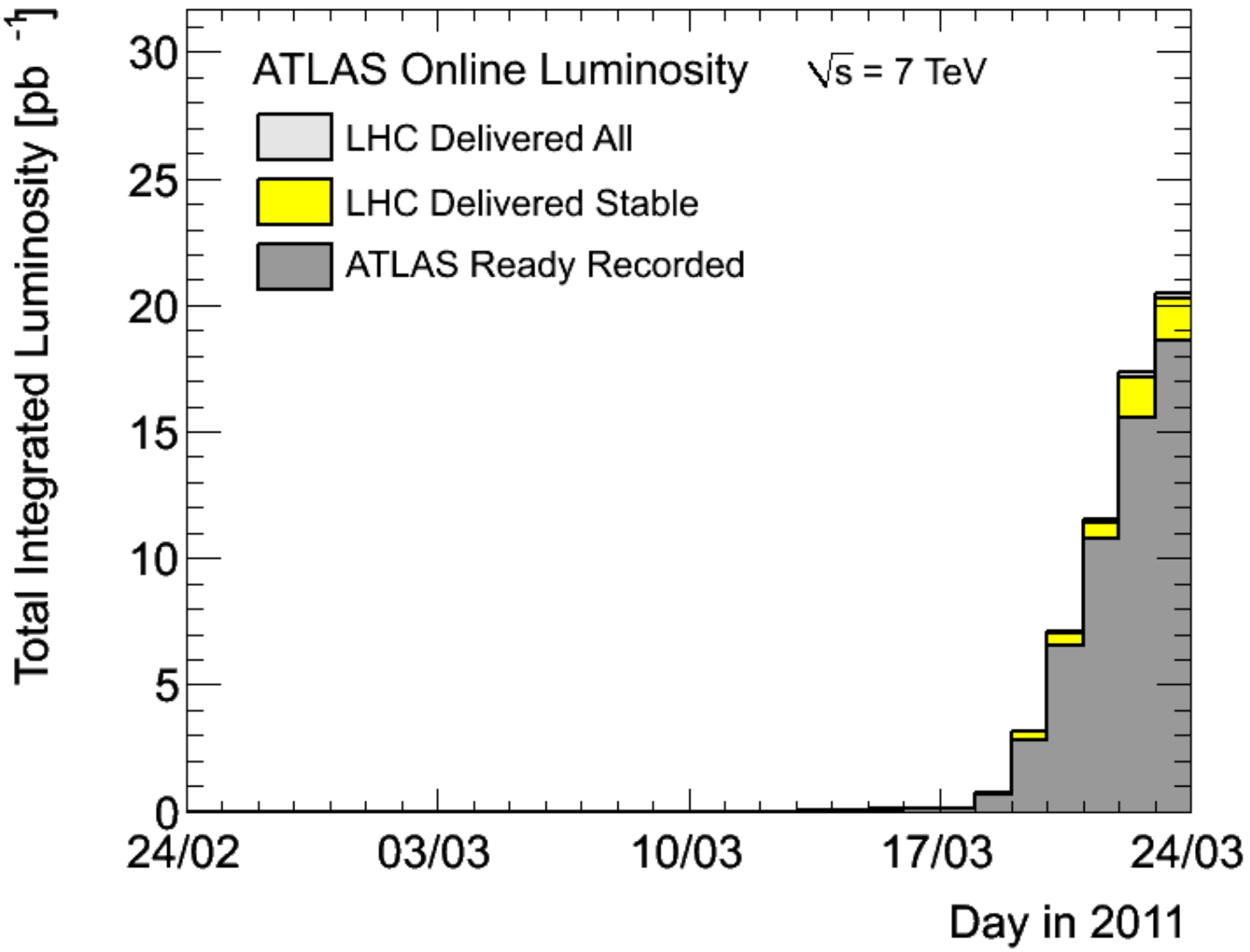
Best best fill

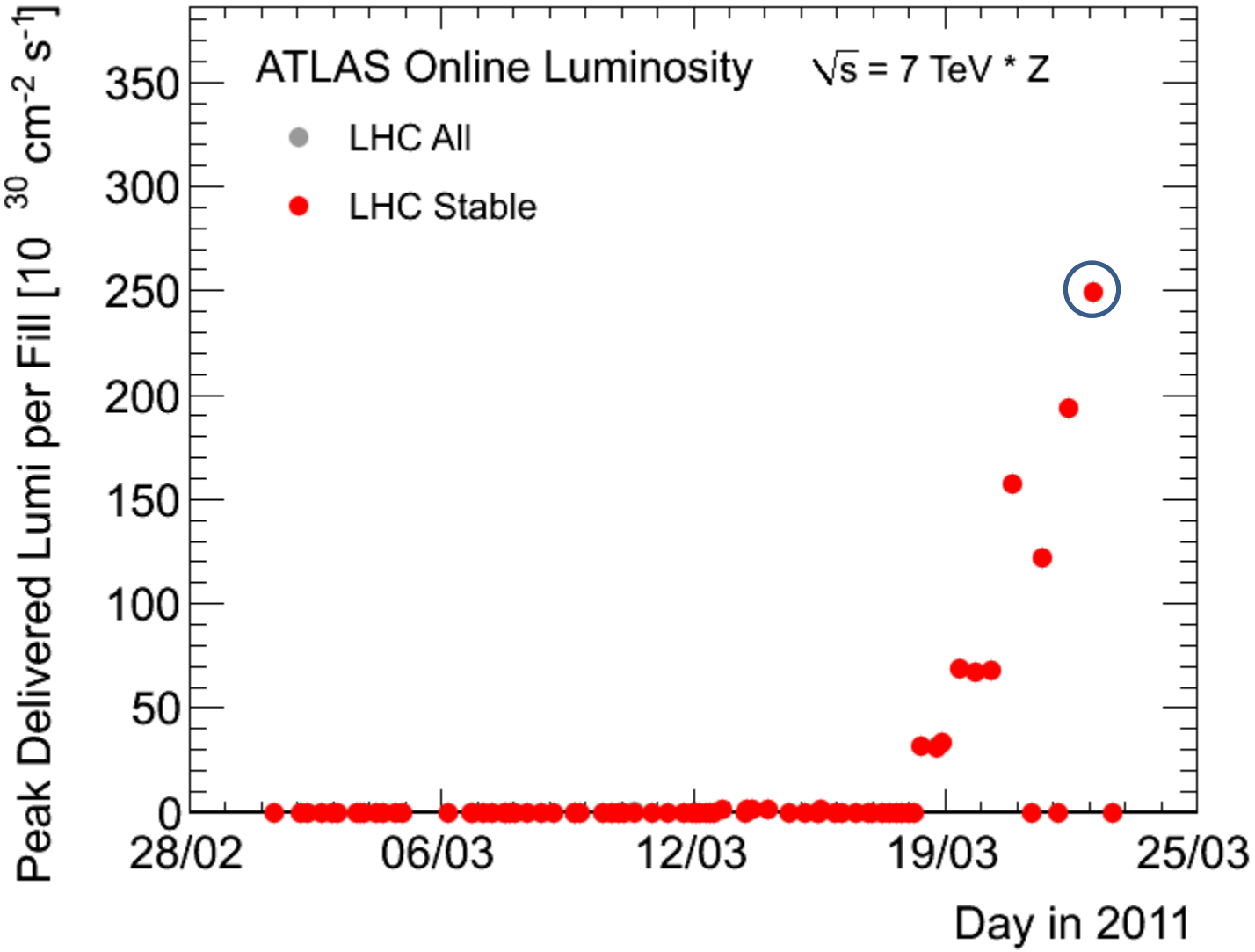


Best best fill



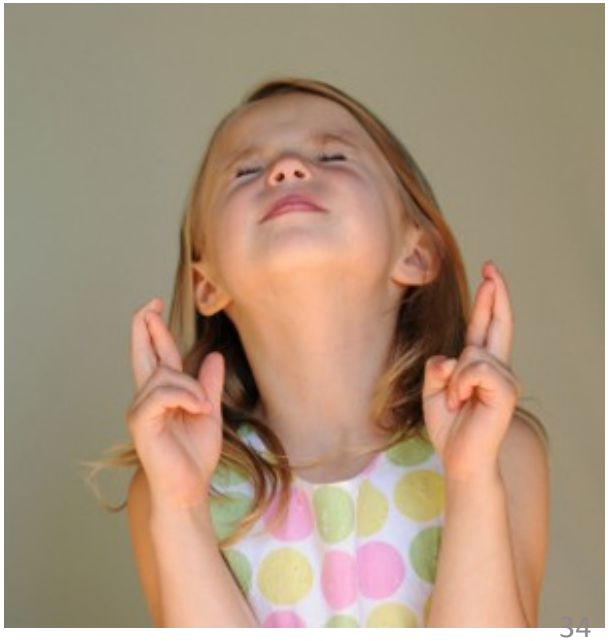
+6pb-1 onto integrated




ATLAS Online Luminosity
√s = 7 TeV * Z
LHC All
LHC Stable
Peak Delivered Lumi per Fill [10 30 cm-2 s-1]
350
300
250
200
150
100
50
0
28/02
06/03
12/03
19/03
25/03
Day in 2011

Summary

- Right on Track
- Many operational improvements from Evian and Chamonix have already been implemented
- LHC is behaving very reproducibly
- Recommissioning very fast
- Ramping up the intensity
- For the rest of 2011



Thank you for your attention

Tuesday 0830

Still Outstanding

- Injection of 96 bunches (→ weekend)
- Timing distribution (→ technical stop)
- ~~FGC firmware update~~
- ~~Collimation system controls fix~~
- 1.38 TeV setting-up (→ Wednesday onwards)
  - Crossing angle all zero: OK
  - TCTs to set up & loss maps
- Interlock tests for the roman pot (→ parasitic or TS)
- ~~RF voltage limit interlock~~
- Longitudinal blow-up (→ if needed)
- Wire scanners
- Abort gap cleaning (→ with high intensity injection)
- Injection gap cleaning (→ with high intensity injection)

Running in 2011; Distribution of Days

Protons

Item	Days
Total p OP - 37 ½ weeks	262
11 MDs (2 days)	-22
6 TS (4+1 days)	-30
Special requests	-10
Commissioning	-28
Intensity ramp up	-40
Scrubbing run	-8
Total HIGH INTENSITY	**124**

Beam parameters 2011

@ exit SPS

Beam parameters	150 ns	75 ns	50 ns
Bunch intensity [e11 p/b]	1.2	1.2 (1-batch) 1.2 (2-batch) tbc	1.2 (1-batch) 1.6 (1-batch) 1.2 (2-batch)
Normalised Emittance [μm]	2 (1.6 achieved)	2 ~1. to 1.5 – tbc	2 3.5 ~1.5

Retained for L calculation (LHC):

Beam parameters	150 ns	75 ns	50 ns
Bunch intensity [e11 p/b]	1.2	1.2	1.2
Normalised Emittance [μm]	2.5	2.5	2.5
Colliding bunches	368*	936	1404

*assume 368 b as proven from 2010 - should be able to go to ~424 b

Estimated Peak and Integrated Luminosity

- Baseline is 2E32 Peak and 1fb-1 (integrated) (expectation management)
- But following 2010, we are confident we will do better

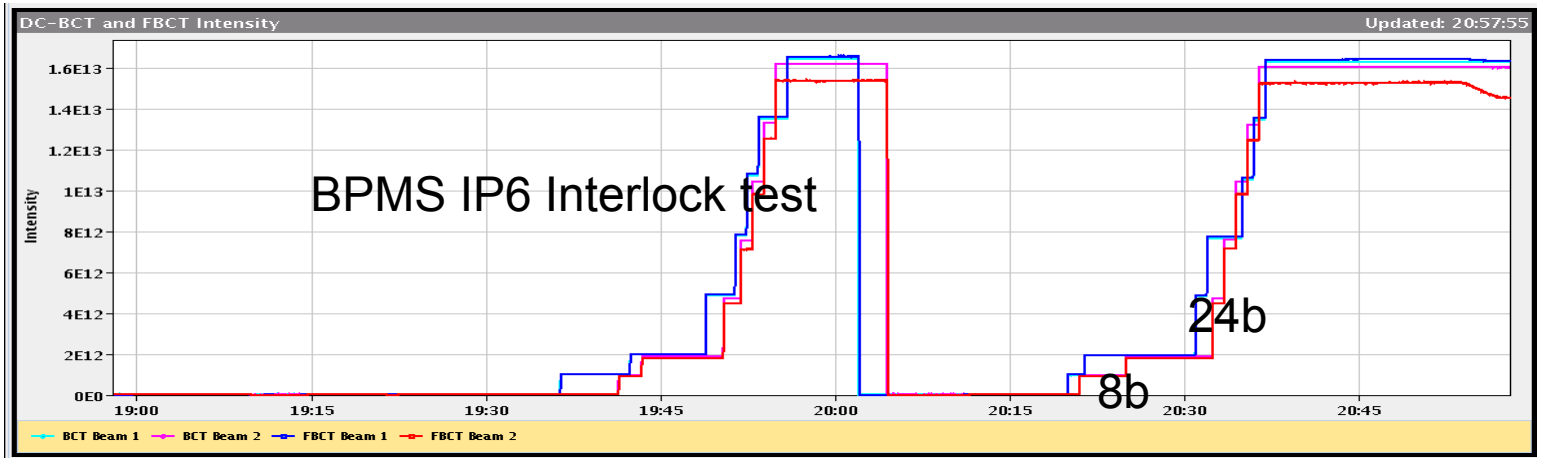
$\beta^* = 1.5m$

days	H.F	Comm with	Fills with	kb	Nb e11	ε μm	ξ/IP	L Hz/cm^2	Stored energy MJ	L Int fb^{-1} 4 TeV	L Int fb^{-1} 3.5 TeV
160	0.3	150 ns	150 ns	368	1.2	2.5	0.006	~5.2e32	~30	~2.1	~1.9
135	**0.2**	**75 ns**	**75 ns**	**936**	**1.2**	**2.5** **2** **1.8**	**0.006** **0.007** **0.008**	**~1.3e33** **~1.6e33** **~1.8e33**	**~75**	**~3** **~3.8** **~4.2**	**~2.7** **~3.3** **~3.7**
125	0.15	50 ns	50 ns	1404	1.2	2.5	0.006	~2e33	~110	~3.2	~2.8

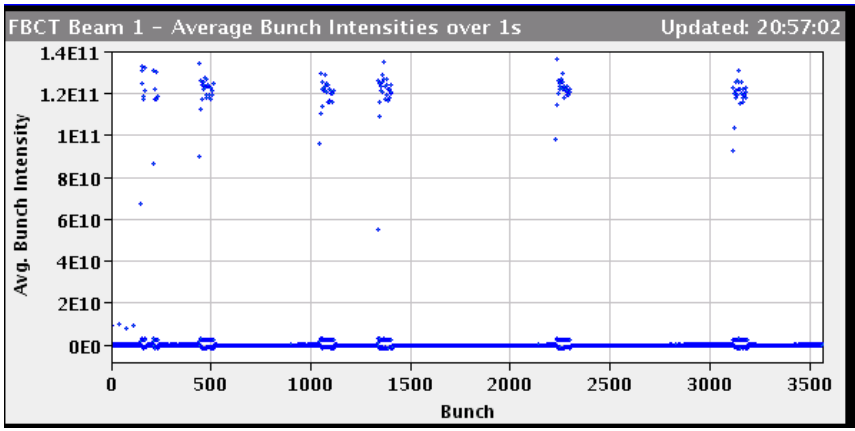
Possible integrated Luminosity of 1-3 fb-1

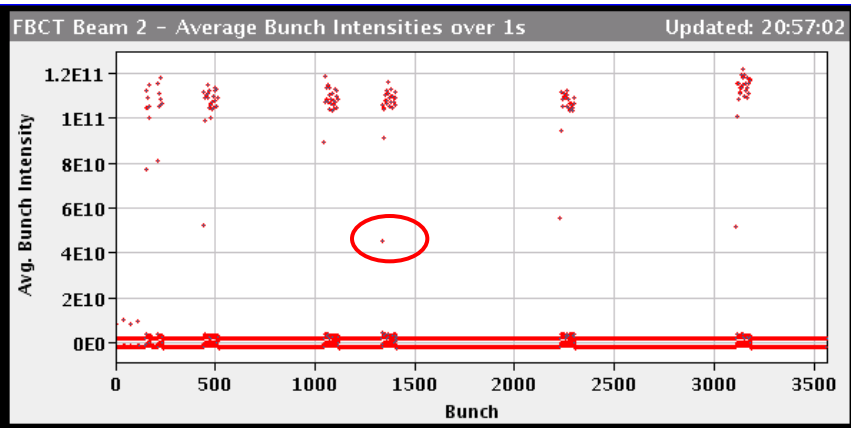
Injecting pilot + trains of 8 + trains of 24

- Great job from the injector shift crews who changed settings from 8 to 24 bunches (75 ns) in 5 minutes!



- But bunches could be a bit more equal…





136 bunches - Vacuum activity starting

Vacuum around the injection kickers MKI IP2 and IP8