

LHC Status Report

Steve Myers

(on behalf of the LHC team)

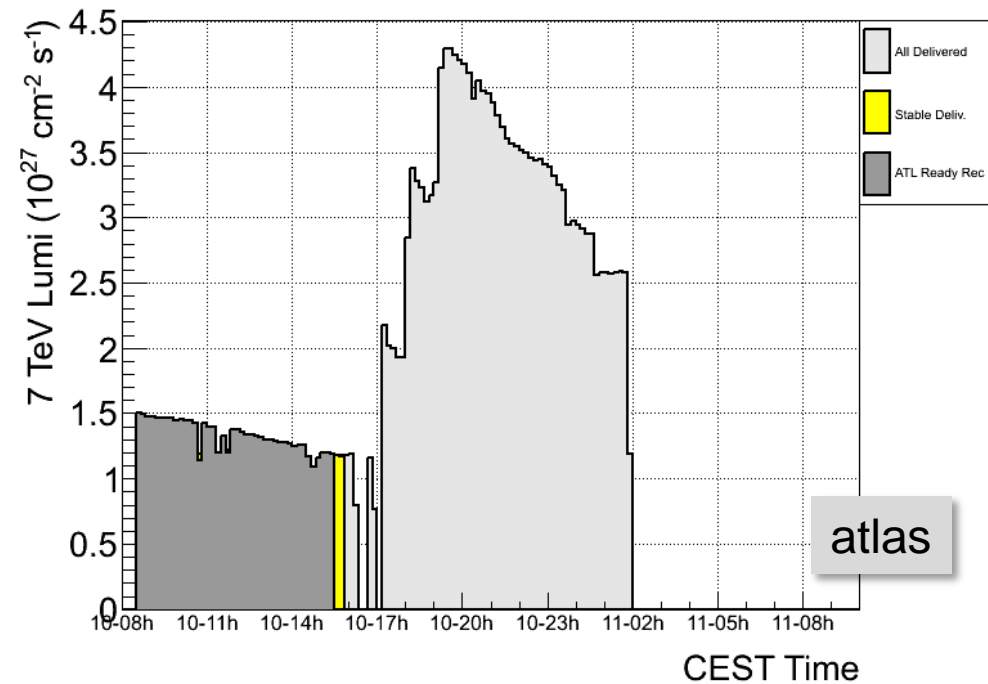
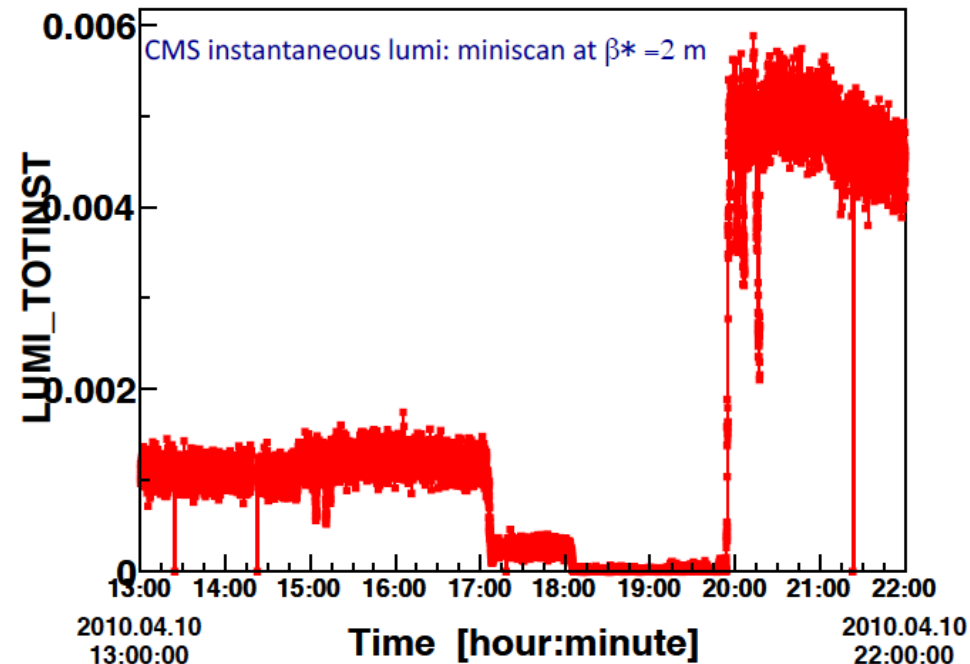
LHCC 7th July, 2010.

Milestones

- 30 March: first collisions at 3.5TeV/beam
- 19 April: order of magnitude increase in luminosity
 - doubling the number of particles/bunch
 - β^* from 11 to 2m (4b/beam) $L \sim 2 \times 10^{28}$.
 - Beam lifetimes of ~ 1000 hours
- 22 May another order of magnitude:
 - 13 bunches in each beam ($L \sim 3 \times 10^{29}$)
- 26 May: Design intensity bunches were brought into collision at 3.5TeV/beam.
- 2nd July peak luminosity of $10^{30} \text{cm}^{-2} \text{s}^{-1}$.

IP1&5 lumi vs squeeze

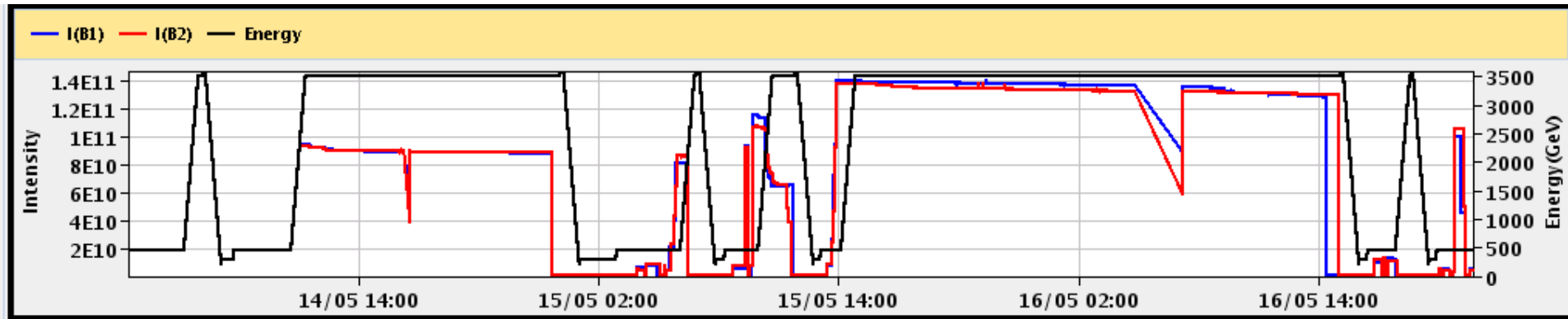
- Raw (online) lumi plots on 10 apr 2010, during the squeeze to 2m in IP1 and IP5
- Factor gained (raw numbers):
 - ~4.5 in Pt5 (after min scan)
 - ~4 in Pt1
- Not corrected for lumi decay over the ~5h of squeeze and mini scans



Pushing Number of $2e10$ Bunches

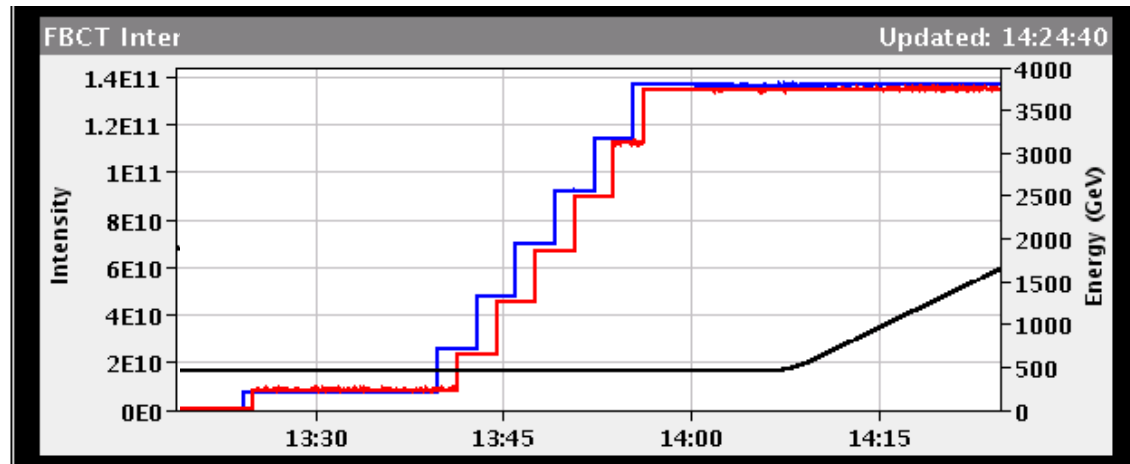
$2 \times 2e10 \rightarrow 4 \times 2e10$

$6 \times 2e10$ per beam



← 48 hours →

Allowed doubling the integrated luminosity for 2010 within 48 hours!



13 bunches: 3×10^{29} !!



Recent progress/Changes

- Until 9 June, machine time shared between physics and machine studies.
 - Physics with $\sim 2 \times 10^{10}$ protons/bunch
 - Machine studies to develop 1×10^{11} protons per bunch
- Beam Stored energy is the metre stick: (Machine Protection)
 - Lost particles must end up on collimator or dump

Following discussions with the 4 spokespersons and the physics coordinator, a decision was unanimously made on 9 June to concentrate on “Machine studies to develop 1×10^{11} protons per bunch” until it was operational. This meant postponing physics data taking for around ~~3~~ weeks. (Minutes LMC 9th June)

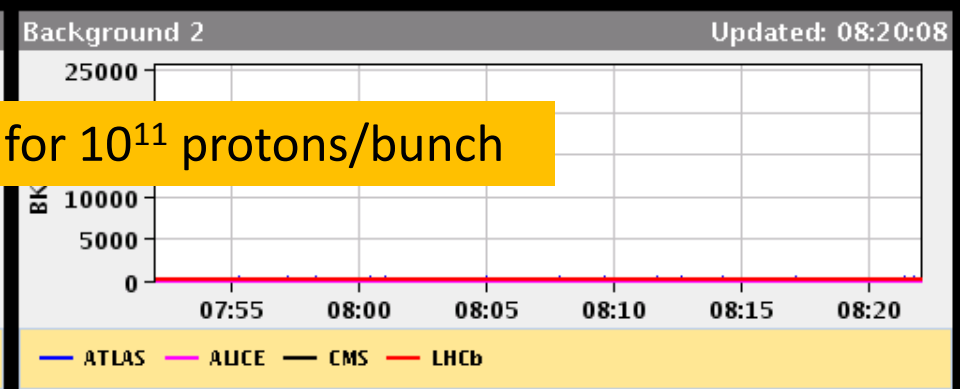
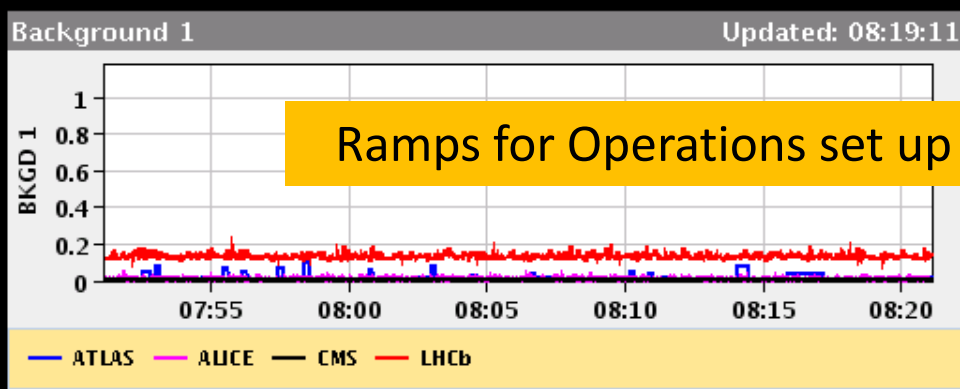
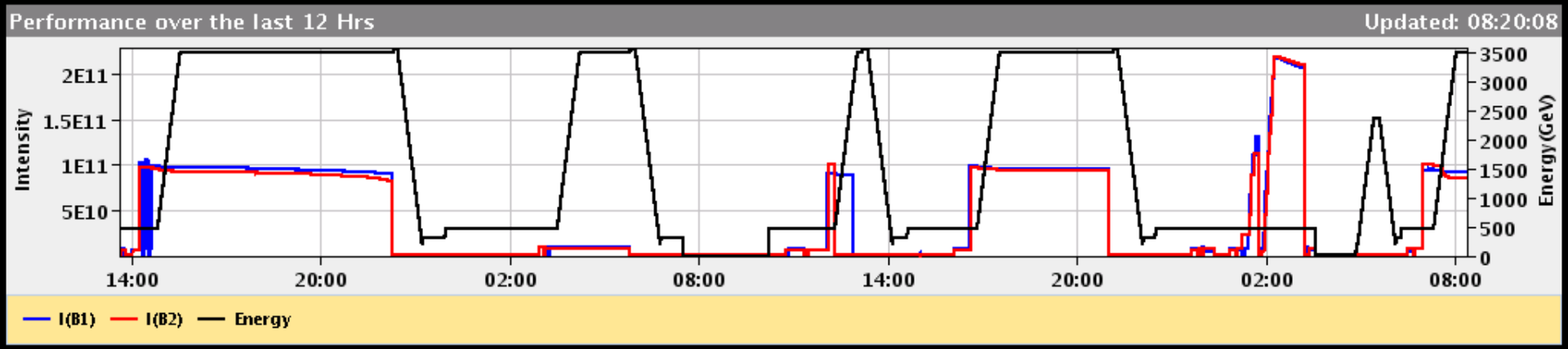
Getting to Stable beams at 1.1×10^{11} .

Instabilities in Collision at 3.5TeV/beam

- longitudinal emittance control
 - In the SPS
 - During the ramp in the LHC
- Transverse damper working
- Collimators set up
- Injection set up for new high intensity
- Beam dump set up for higher intensity
- Started physics data taking under these conditions on Saturday 26th June (almost a week ahead of estimates)

	ATLAS	ALICE	CMS	LHCb
Experiment Status	STANDBY	CALIBRATION	STANDBY	STANDBY
Instantaneous Lumi (ub.s) ⁻¹	0.000	0.000	0.000	0.000
BRAN Count Rate (Hz)	2.000e+00	0.000e+00	1.000e+00	4.000e+01
BKGD 1	0.002	0.004	0.002	0.122
BKGD 2	0.000	0.000	0.004	1.727
BKGD 3	0.000	0.001	0.003	0.037

LHCf STANDBY Count(Hz): 0.000 | LHCb VELO Position OUT Gap: 58.0 mm | TOTEM: STANDBY



Ramps for Operations set up for 10¹¹ protons/bunch

26th June: 5×10^{29} with 3 bunches/beam; $10^{11}/b$

VLC media player

File View Settings Audio Video Navigation Help

26-Jun-2010 20:22:09 Fill #: 1182 Energy: 3500 GeV I(B1): 2.73×10^{11} I(B2): 2.84×10^{11}

	ATLAS	ALICE	CMS	LHCb
Experiment Status	PHYSICS	PHYSICS	PHYSICS	PHYSICS
Instantaneous Lumi (ub.s) ⁻¹	0.500	0.275	0.516	0.444
BRAN Count Rate (Hz)	5.395×10^3	3.675×10^3	7.550×10^3	8.960×10^3
BKGD 1	0.022	0.014	1.178	0.131
BKGD 2	3.000	755.420	0.002	1.238
BKGD 3	0.000	0.006	0.003	0.054

LHCf: PHYSICS Count(Hz): 565.500 | LHCb VELO Position: OFF | Gap: 58.0 mm | TOTEM: CALIBRATION

Performance over the last 12 Hrs Updated: 20:22:09

Background 1 Updated: 20:22:09

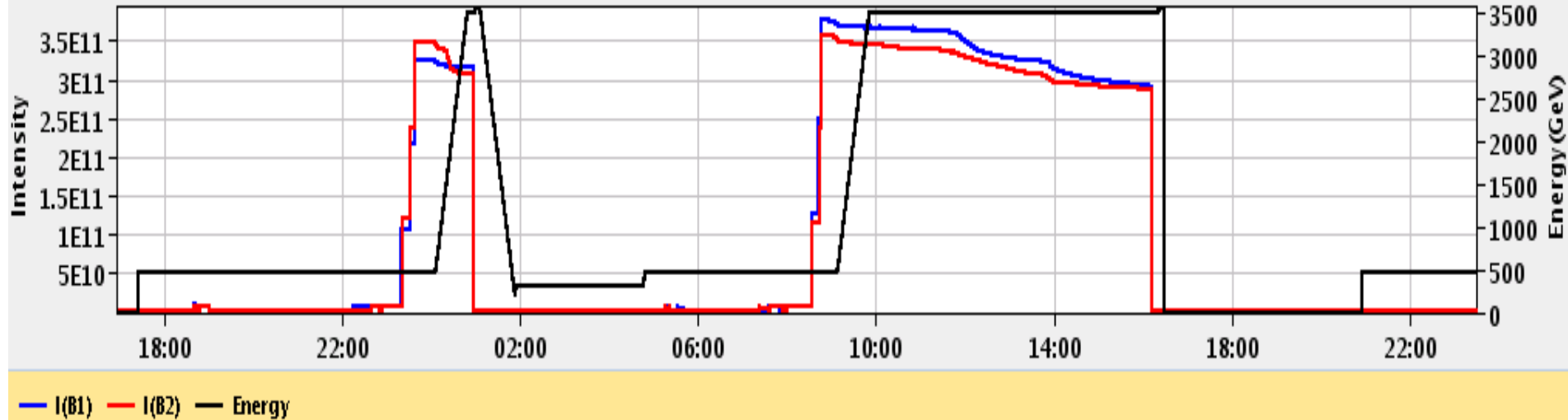
Background 2 Updated: 20:22:09

0:00:00 / 0:00: x1.00 "LHC Operation"

$6-8 \times 10^{29} \text{cm}^{-2} \text{s}^{-1}$ with 3 bunches per beam; $10^{11}/\text{b}$

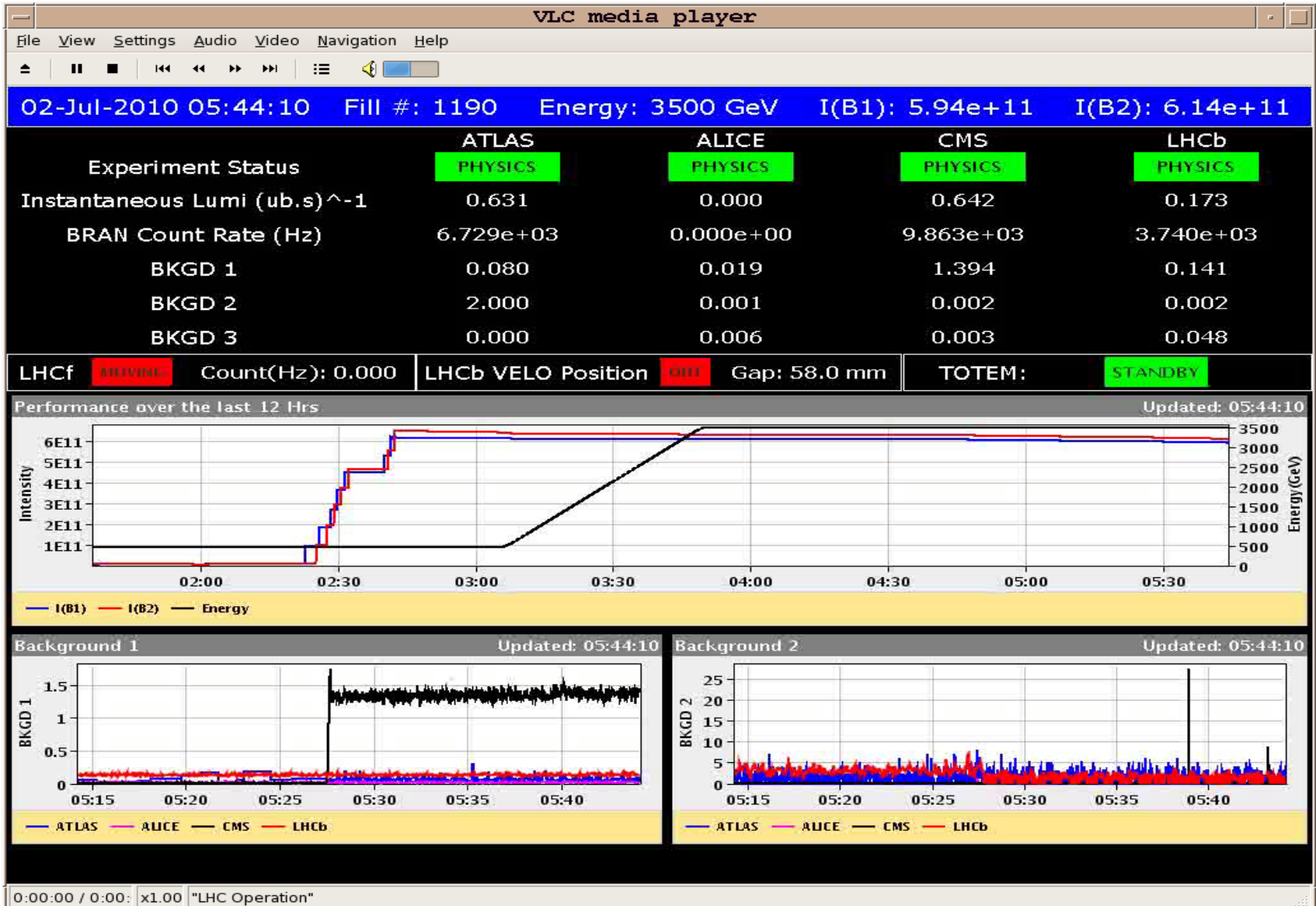
Performance over the last 12 Hrs

Updated: 23:28:17



29th June, new record

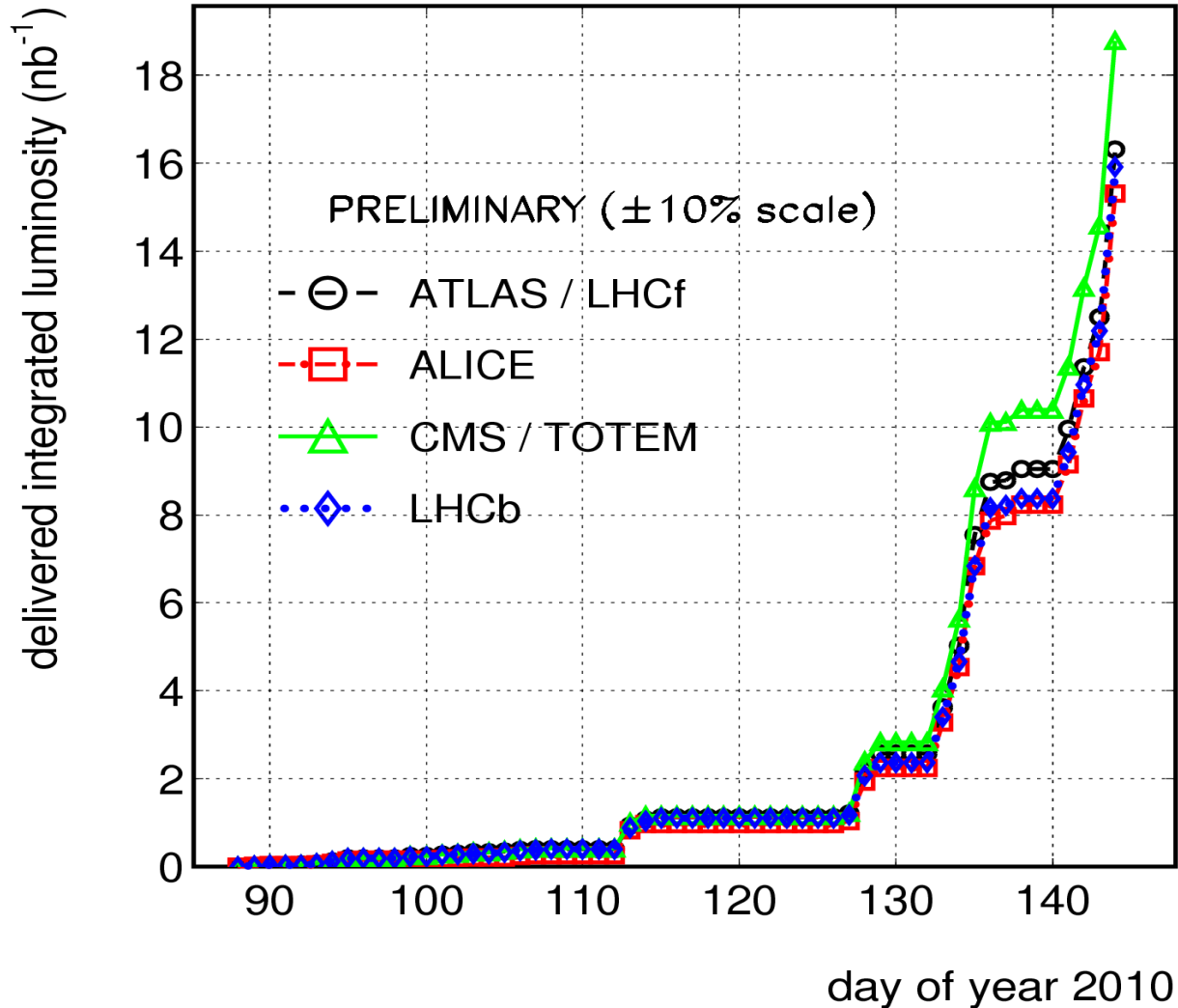
2nd July: Colliding 6 bunches per beam; $10^{11}/b$



Integrated Luminosity (Linear Scale)

2010/05/27 08.08

LHC 2010 RUN (3.5 TeV/beam)



Look back over week 26 (28/6/10)

- Goals of the week:
 - Reach peak luminosity of $10^{30} \text{ cm}^{-2} \text{ s}^{-1}$
 - Improve operational procedures (squeeze and collision sequences)
- Number of accesses: 6
- Number of ramps: 12
- Number of fills declared for physics: 7
- Fastest turnaround: 4h48 (*end stable beams to start stable beams*)

End of fills

- Reason for end of 6 physics fills:
 - End of fill study and planned dump: x 2
 - Electrical glitch: x 2
 - Instability-induced losses
 - Internal beam dump interlock
- Beam dumps on 5 ramps not making it into physics:
 - Losses from WS above threshold
 - LSA software problems
 - QPS trip
 - Single collimator not ramping
 - No longitudinal blowup during ramp

Friday 2/7/10

- Went to 7 bunch scheme: 6 colliding, 1 not colliding
- Bunch intensity: $\sim 9e10$
- Used separation to limit ALICE luminosity
- Achieved $> 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$ in all experiments (except ALICE)
- Stable for 16 min, then instabilities (mainly bunch 1)
- Lost after 34 min due to beam losses

New Record Lumi > 1e30 cm-2 s-1

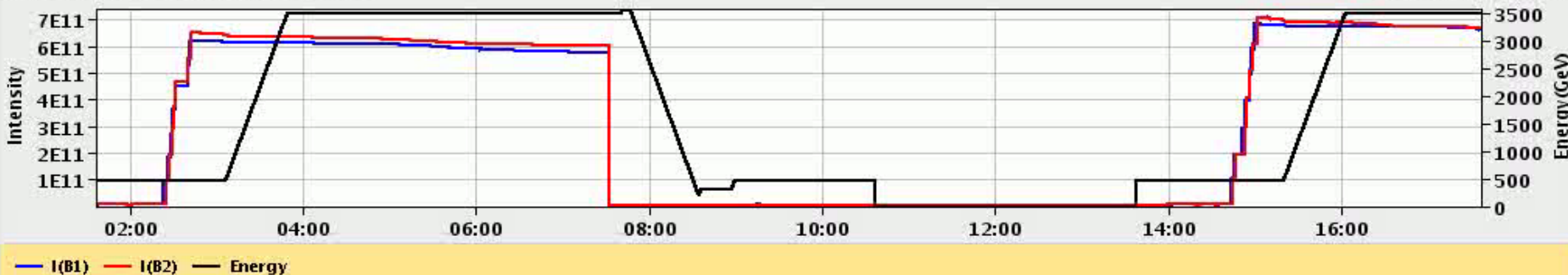
02-Jul-2010 17:36:21 Fill #: 1192 Energy: 3500 GeV I(B1): 6.65e+11 I(B2): 6.70e+11

	ATLAS	ALICE	CMS	LHCb
Experiment Status	PHYSICS	PHYSICS	PHYSICS	PHYSICS
Instantaneous Lumi (ub.s) ⁻¹	1.054	0.004	1.172	1.047
BRAN Count Rate (Hz)	1.098e+04	3.100e+01	1.657e+04	2.124e+04
BKGD 1	0.028	0.016	2.416	0.169
BKGD 2	0.000	0.008	0.002	1.974
BKGD 3	0.000	0.005	0.003	0.060

LHCf **MOVING** Count(Hz): 0.114 LHCb VELO Position **OUT** Gap: 58.0 mm TOTEM: **STANDBY**

Performance over the last 12 Hrs

Updated: 17:36:20



Emittances before ramp :

- B1 H: 2.5
- B1 V: 2.5
- B2 H: 2.5
- B2 V: 3.0 (measure not so good)

Emittances meas during the ramp

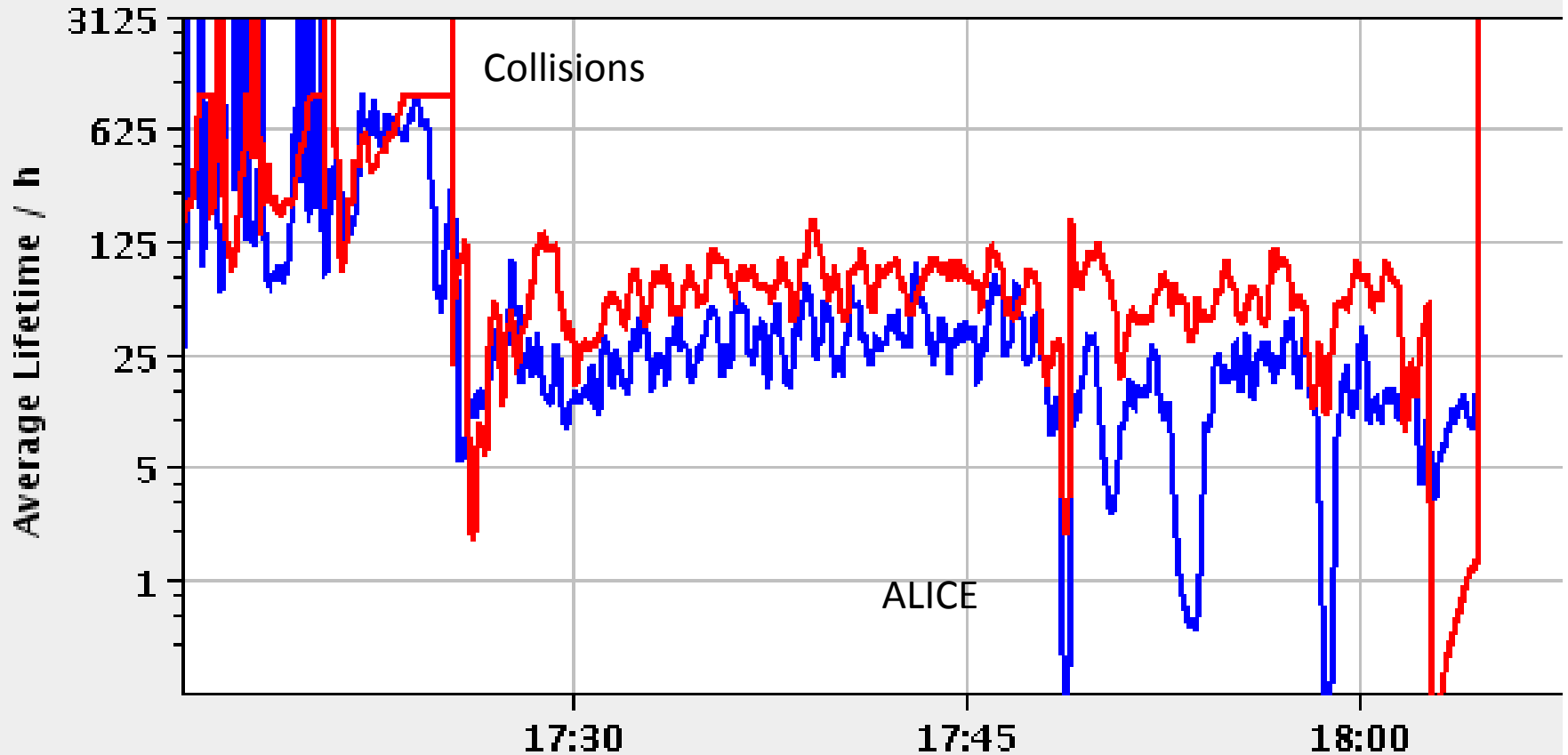
- B1 H: 4.2
- B1 V: 5.1
- B2 H: 2.3
- B2 V: 2.9



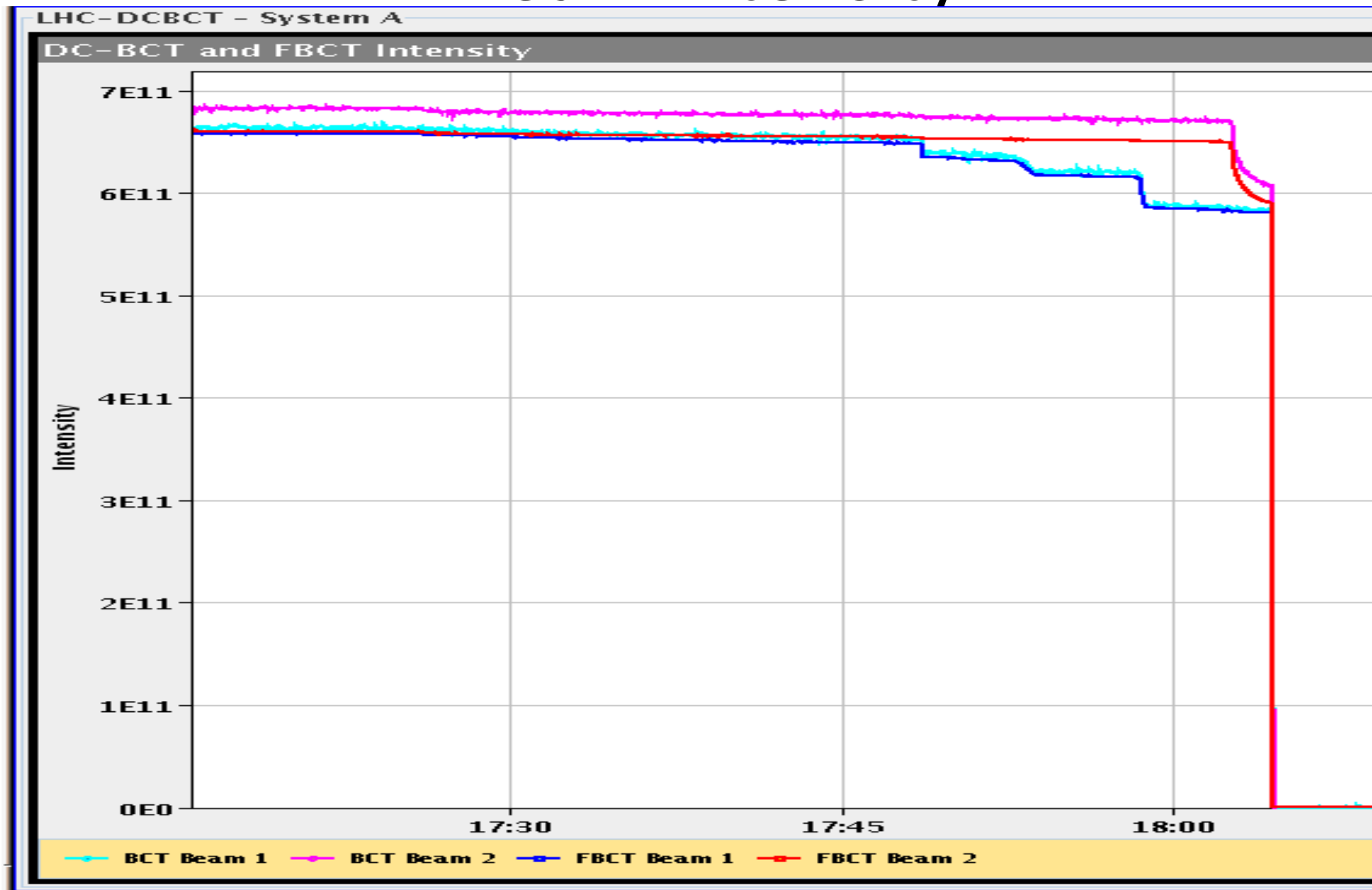
Beam Lifetime

LHC-FBCT Average Lifetime

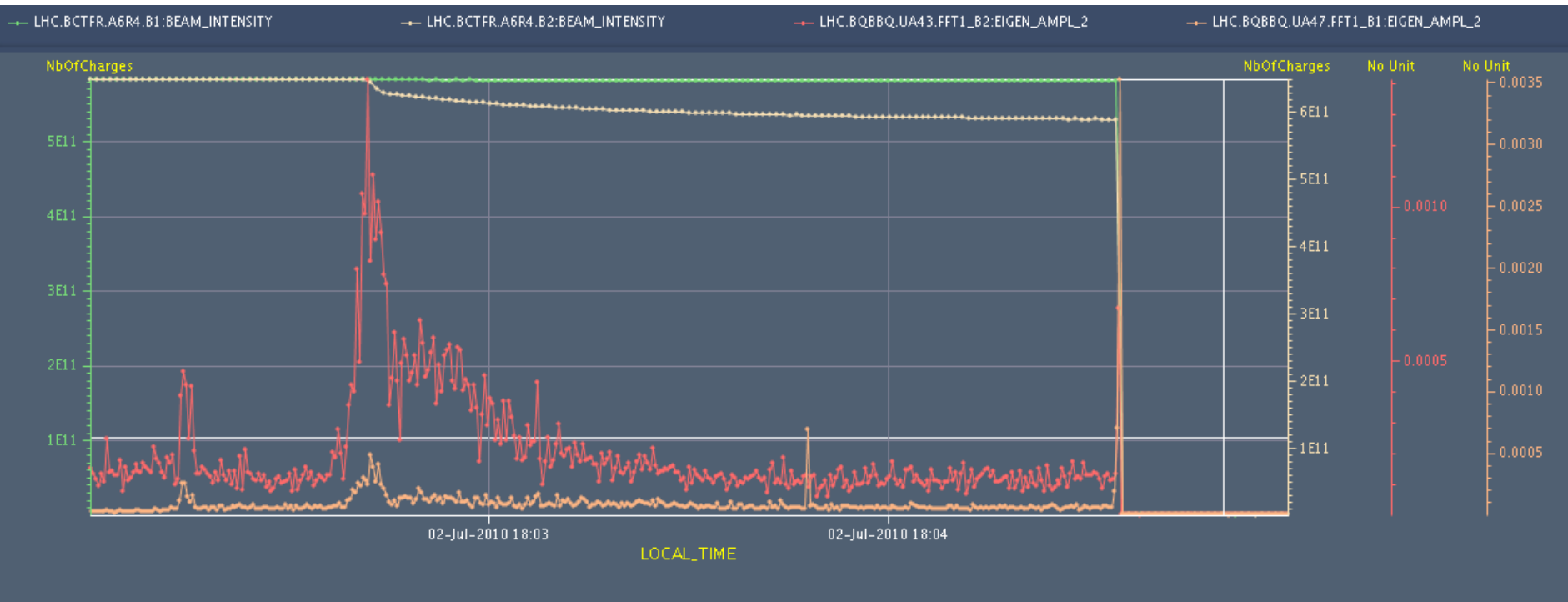
FBCT Average Beam Lifetime in h



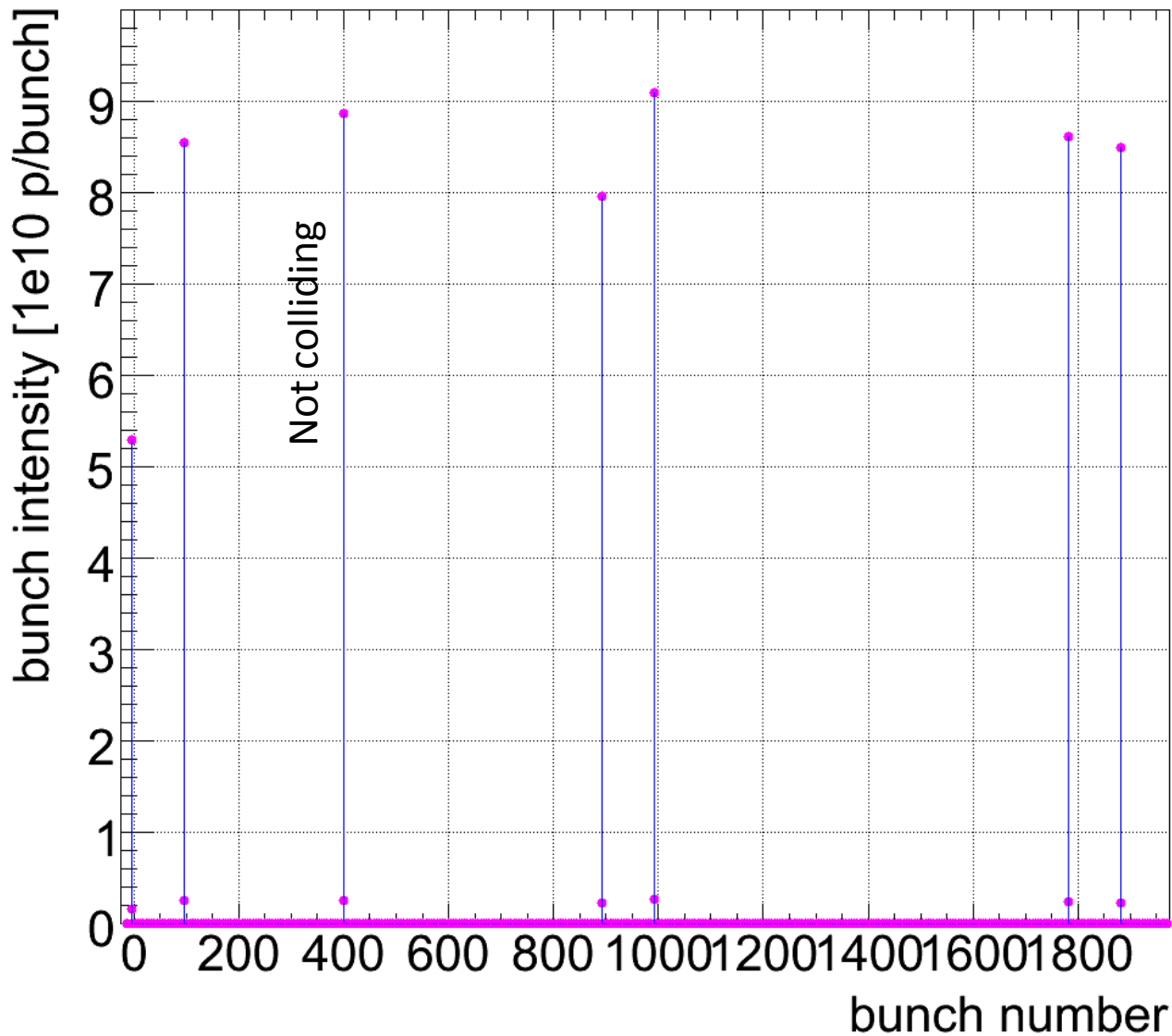
Beam Intensity



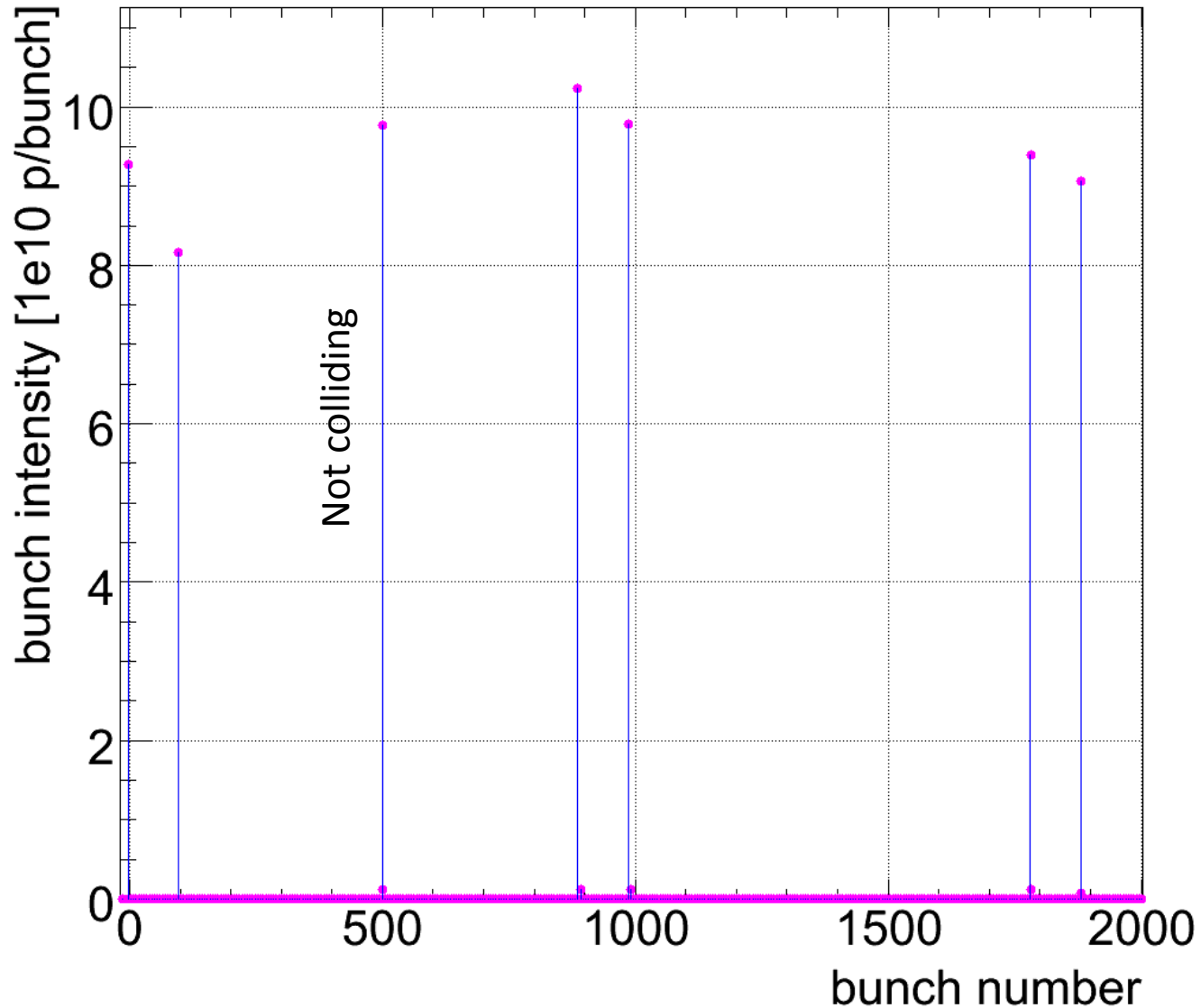
Tune: Coherent Excitation



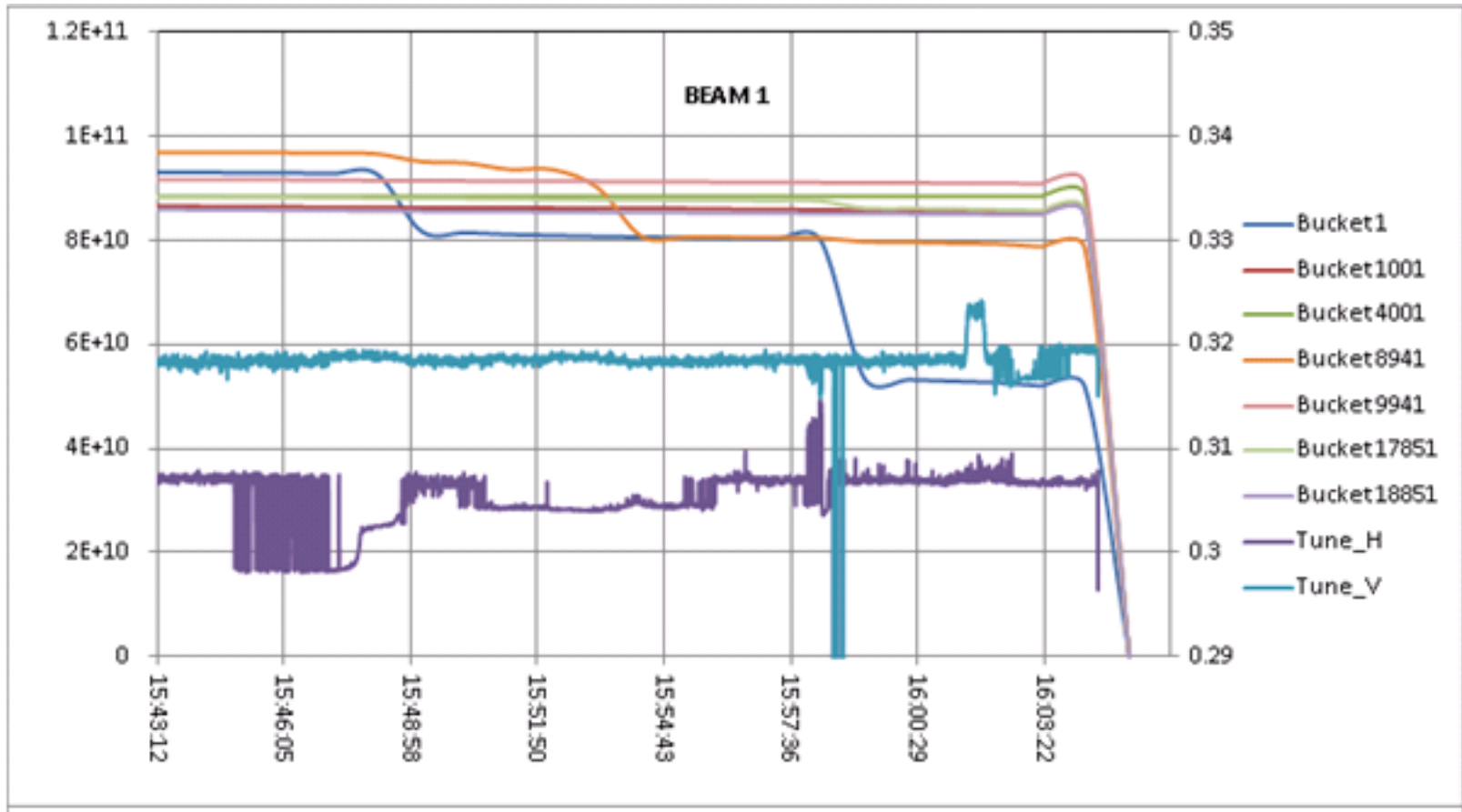
Bunch Intensity B1



Bunch Intensity B2

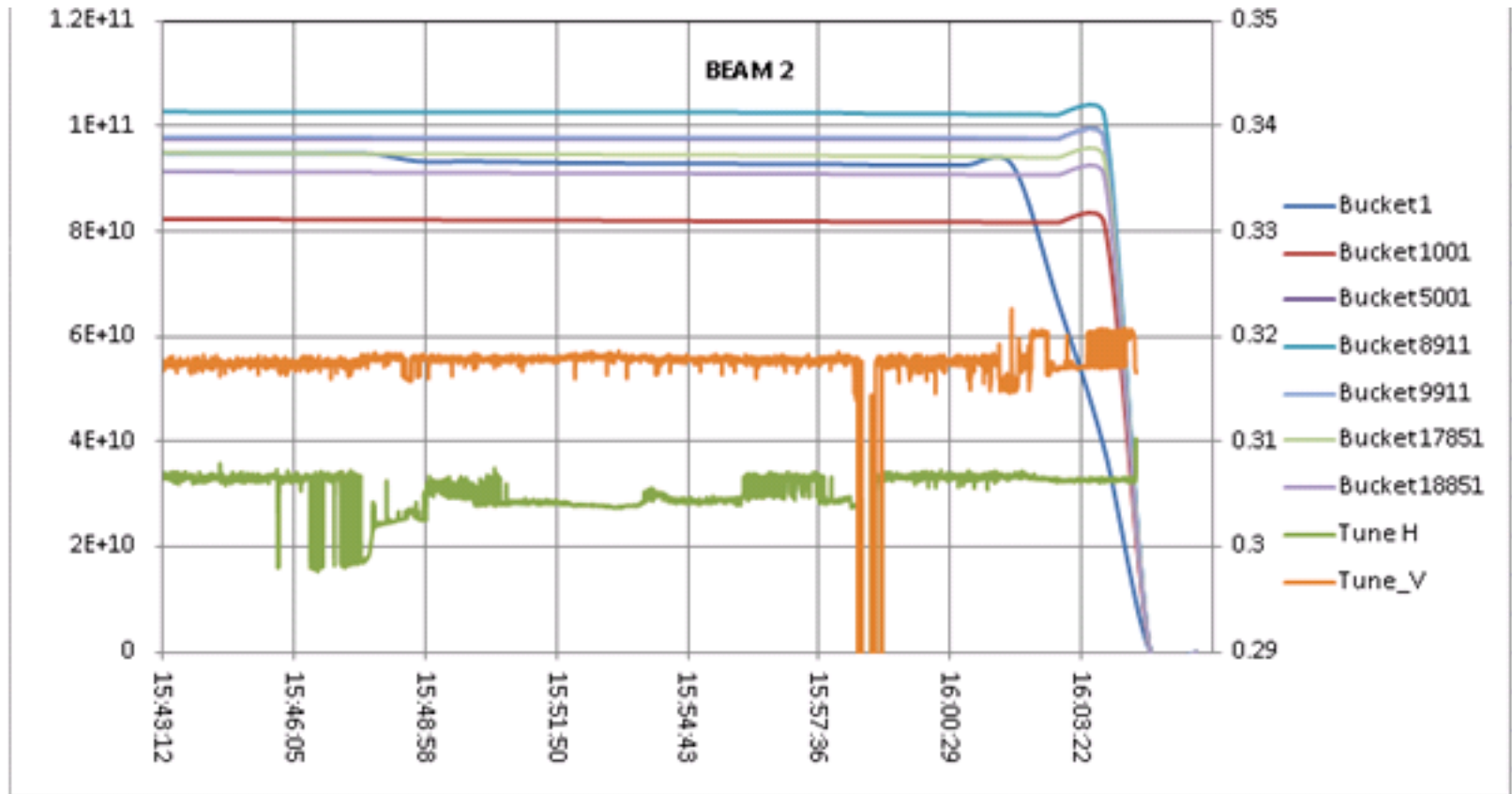


Bunch Intensity versus Time



→ Beam-beam effects

Bunch Intensity versus Time



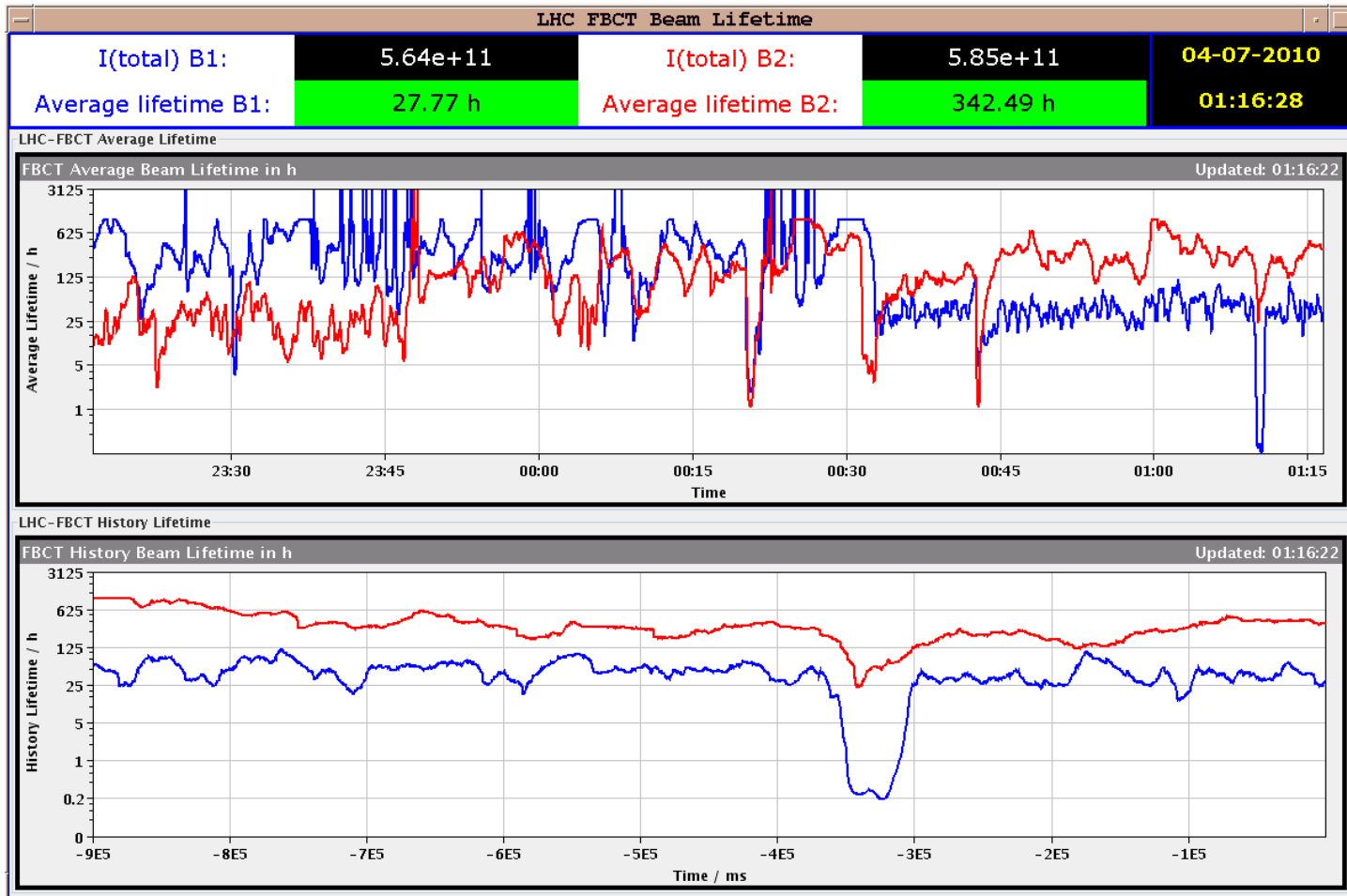
→ Beam-beam effects

Saturday 3/7/10

- Decided to go towards nominal emittance (3.5 μm) for limiting beam-beam effects to nominal values.
- Standard emittances below 2 μm at injection.
- Attempt to blow-up emittance with transverse feedback – really needs additional software
- Switch off TFB – not effective
- Blow up emittances in SPS via screens in TT10
 - 3.6/4.4 μm on offer
 - TFB back on in LHC
 - Too high losses on transfer line collimators
 - different screens - OK

B1H	B1V	B2H	B2V
2.8	2.5	3.1	4.2

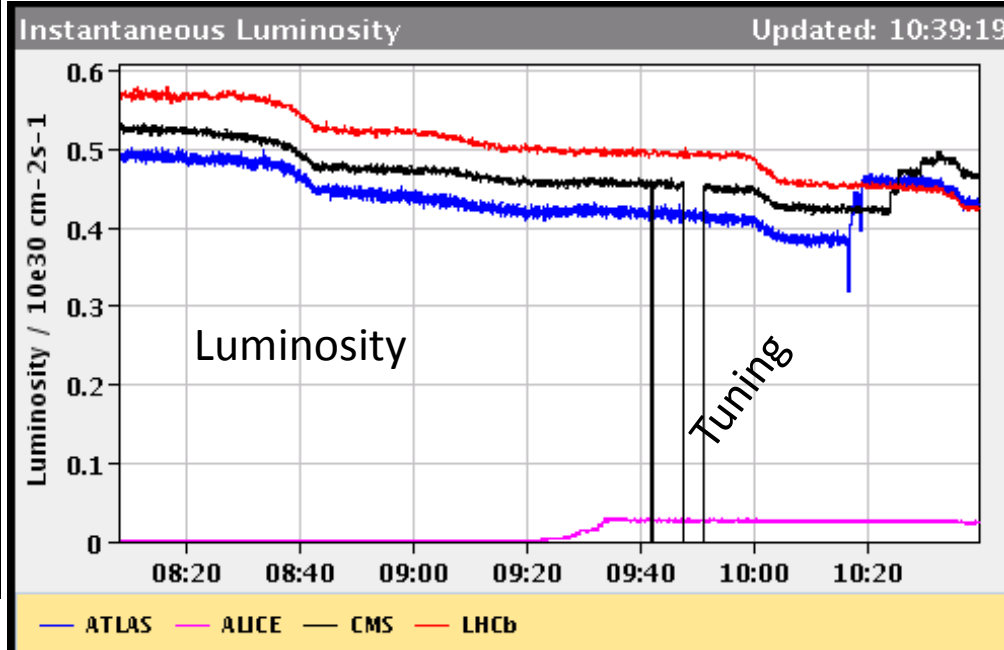
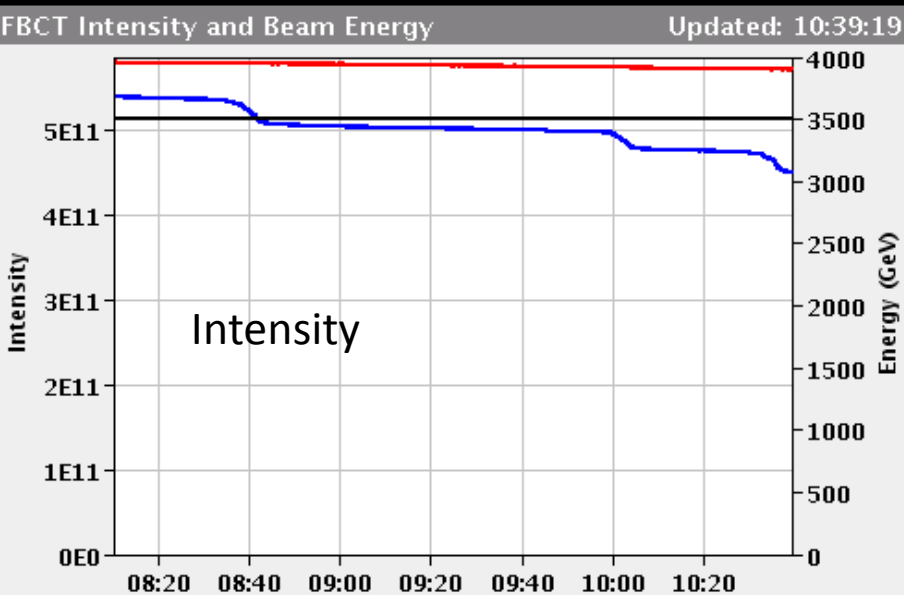
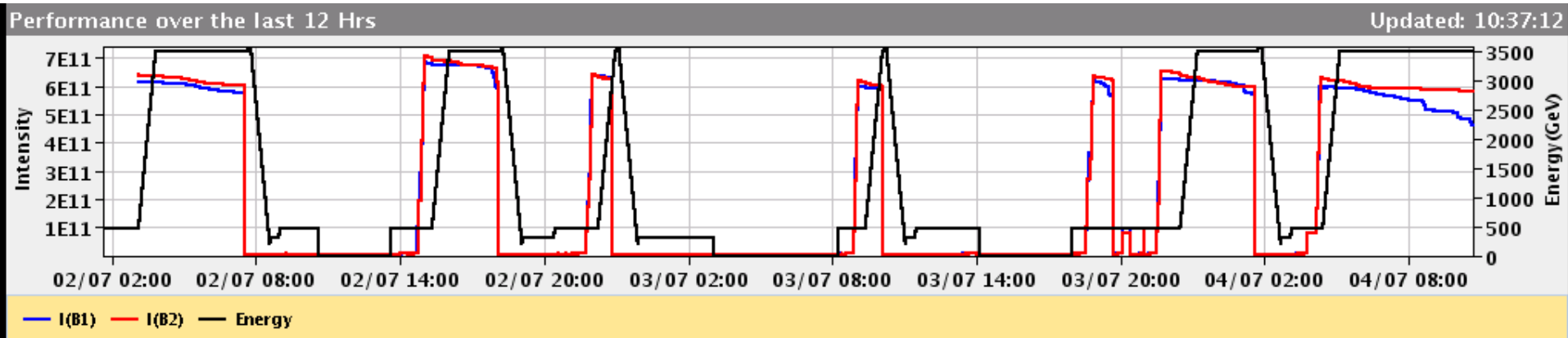
Lifetime



Sunday 4/7/10

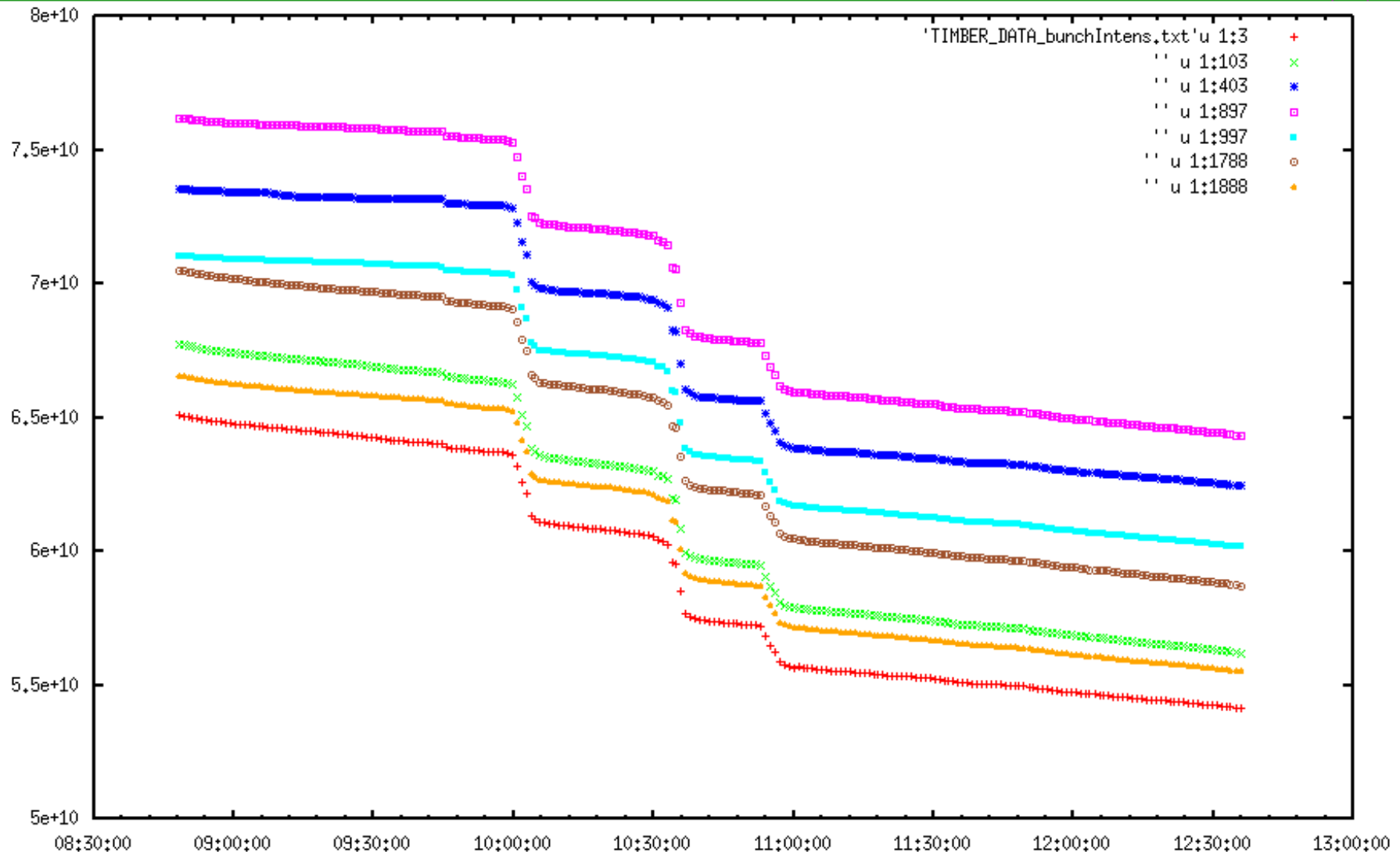
- Again emittance blow-up at injection.
- Long physics fill started at 6h27.
- Longitudinal losses for B1.
- End of fill studies:
 - Transverse damper: Too high gain broadens the tune peak (probably need to work on improving signal/noise in the damper) Observed about 8 dB reduction of the vertical beam 2 tune peak; little change in the tune spectra for the other beams/planes.
 - Wire scanner: measurements at 3.5 TeV.

Better but not perfect stability...



Losses in All Bunches: Not Beam-Beam

Gnuplot

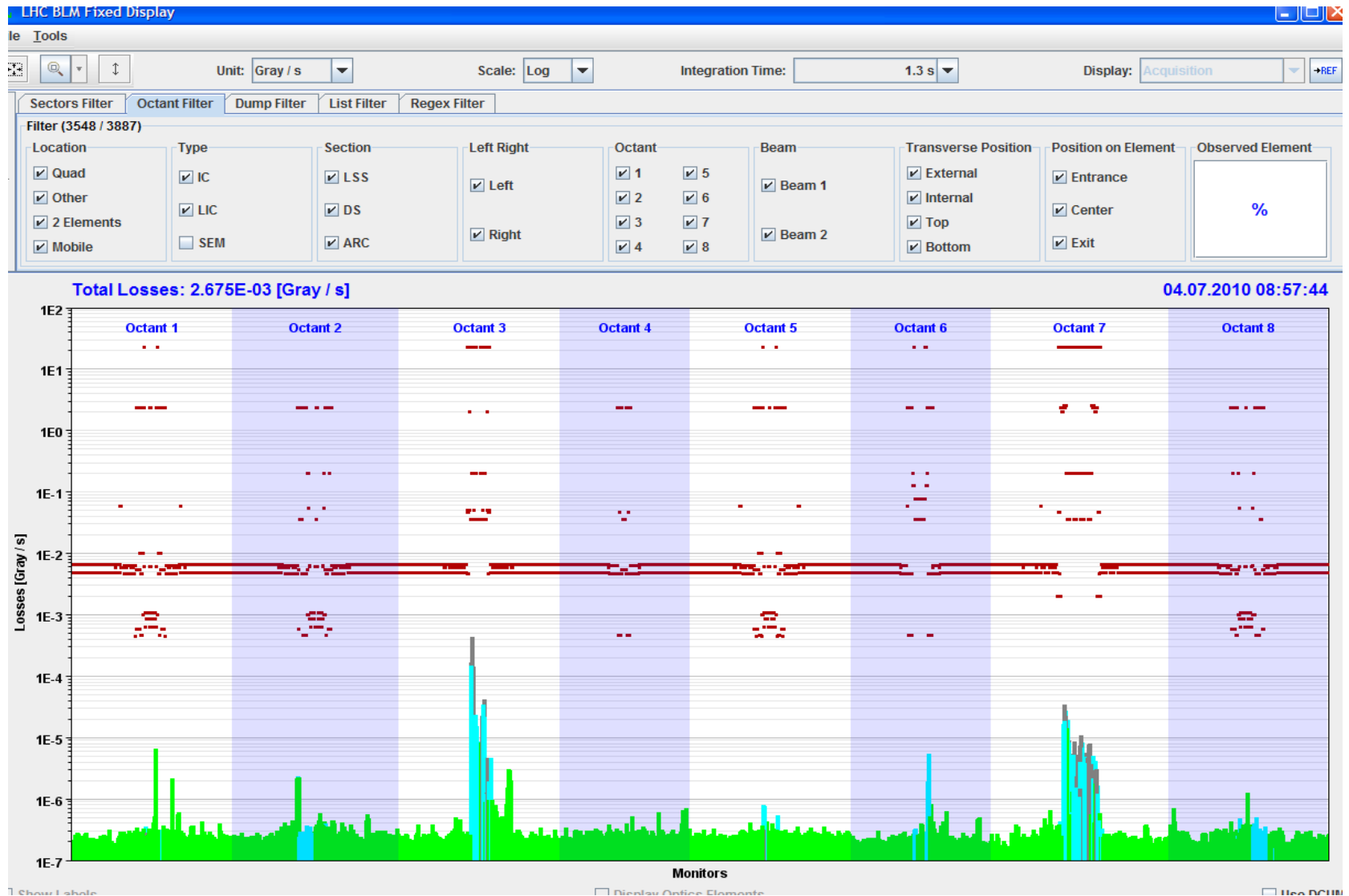


3.31564×10^8 , 7.06131×10^{10}

LHC status

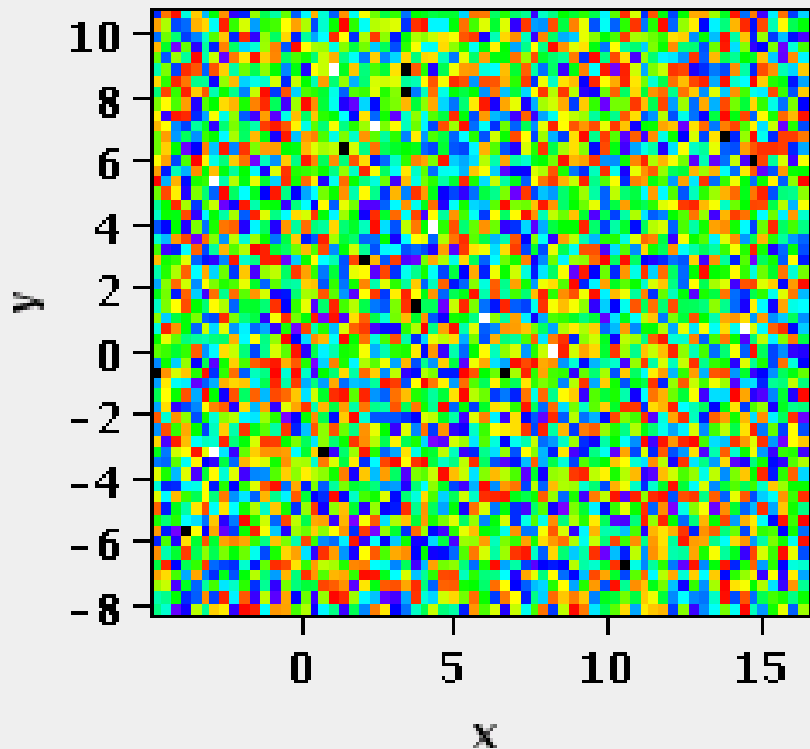
7/7/2010

Momentum Cleaning Very Active: RF Issue

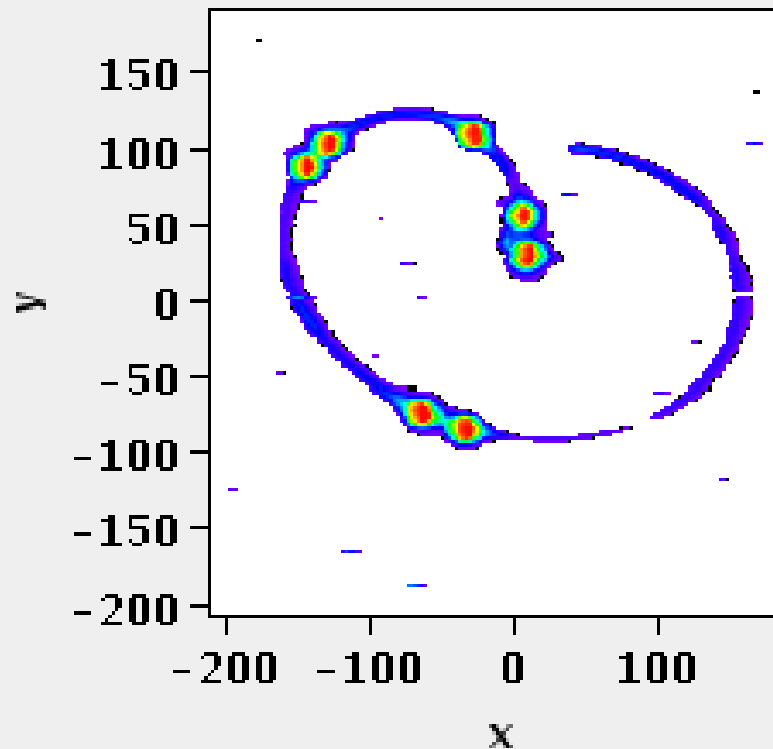


Dump of B1 Uncaptured Beam

BTVD.683458.B1Updated: 19:51:40



BTVDD.689339.B1updated: 19:51:40



Tuesday 6 July

Injection: TDI studies:

In parallel with SPS controlled transverse blowup setting-up used the LHC circulating beams to make some checks of LHC injection protection

Made scans of TDI settings with +/-1000 urad angles applied to jaws, for B1, as a function of TCP setting.

Data to be fully analysed - scale offsets seen with both angles, unlike B2. Find 0.4 mm for downstream end and 1.1 mm for upstream end.

B2 TDI scan repeated with the offsets found in previous measurements: results coherent with earlier findings.

Tuesday 6 July

Emittance measurements in TL: Chiarra Bracco

SPS Beam blown up to emittance of $>3\mu\text{m}$.

Emittance was then measured in the TL by means of the BTV finding the following results:

TI 8: $E_H = 2.6\mu\text{m}$ (SPS: $3\mu\text{m}$) - $E_V = 2.8\mu\text{m}$ (SPS: $3\mu\text{m}$)

TI 2: $E_H = 3.4\mu\text{m}$ (SPS: $3.2\mu\text{m}$) - $E_V = 2.2\mu\text{m}$ (SPS: $2.9\mu\text{m}$)

Emittance in vertical plane was blown again in order to have $> 3\mu\text{m}$ and new measurements were done in TI 2:

TI 2: $E_H = 3.4\mu\text{m}$ (SPS: $3.5\mu\text{m}$) - $E_V = 2.5\mu\text{m}$ (SPS: $3.5\mu\text{m}$)

Vertical plane show controversial results --> measure beam in the LHC and more to be done to understand the results.

Tuesday 6 July

Transverse blowup studies for LHCINDIV on LHCFAST2 in the SPS -

Octupoles are used in combination with an excitation by the damper around the tune frequency (small frequency modulation).

Tuned the system for providing emittances of 3 μm in H and 3.5 μm in V with SPS WS. Transfer lines indicate about 3 μm in both planes, both beams.

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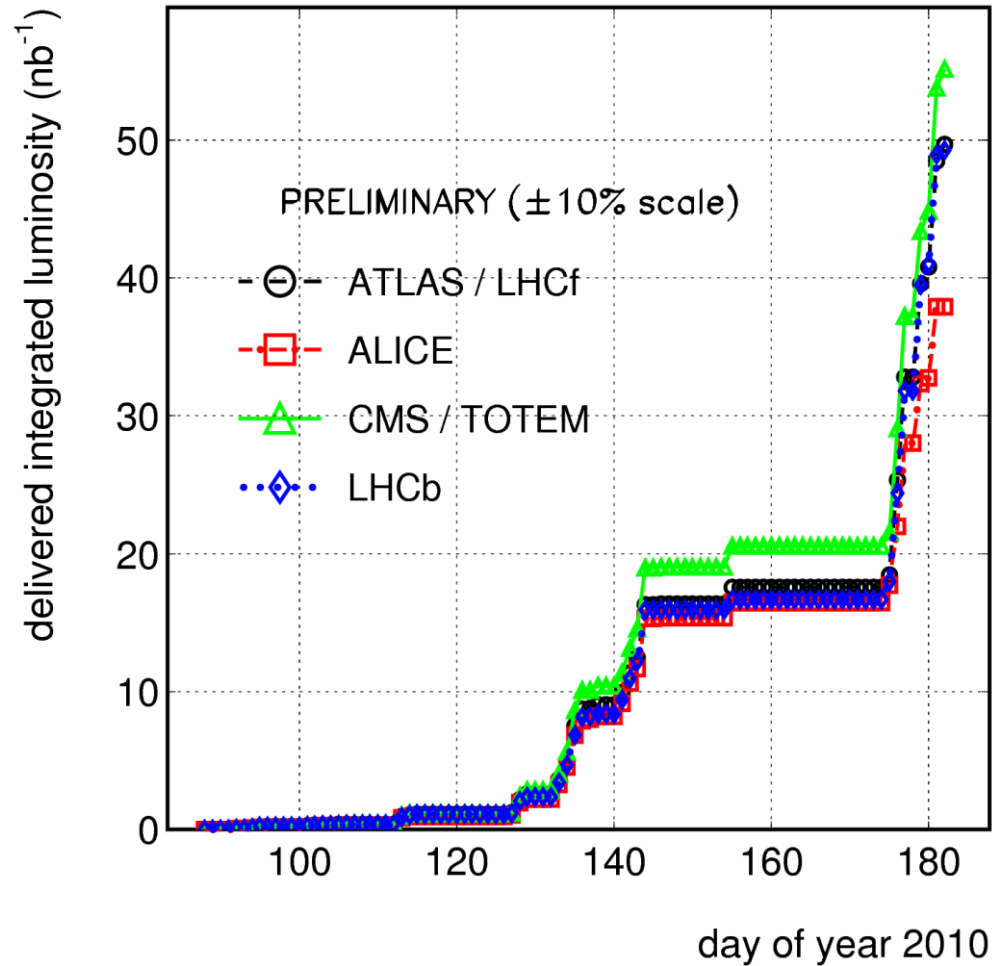
Transverse blowup studies for LHCINDIV on LHCFAST2 in the SPS

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- Tuned the system for providing emittances of 3 μm in H and 3.5 μm in V with SPS WS. Transfer lines indicate about 3 μm in both planes, both beams.

Integrated Luminosity on 2nd July

2010/07/02 11.20

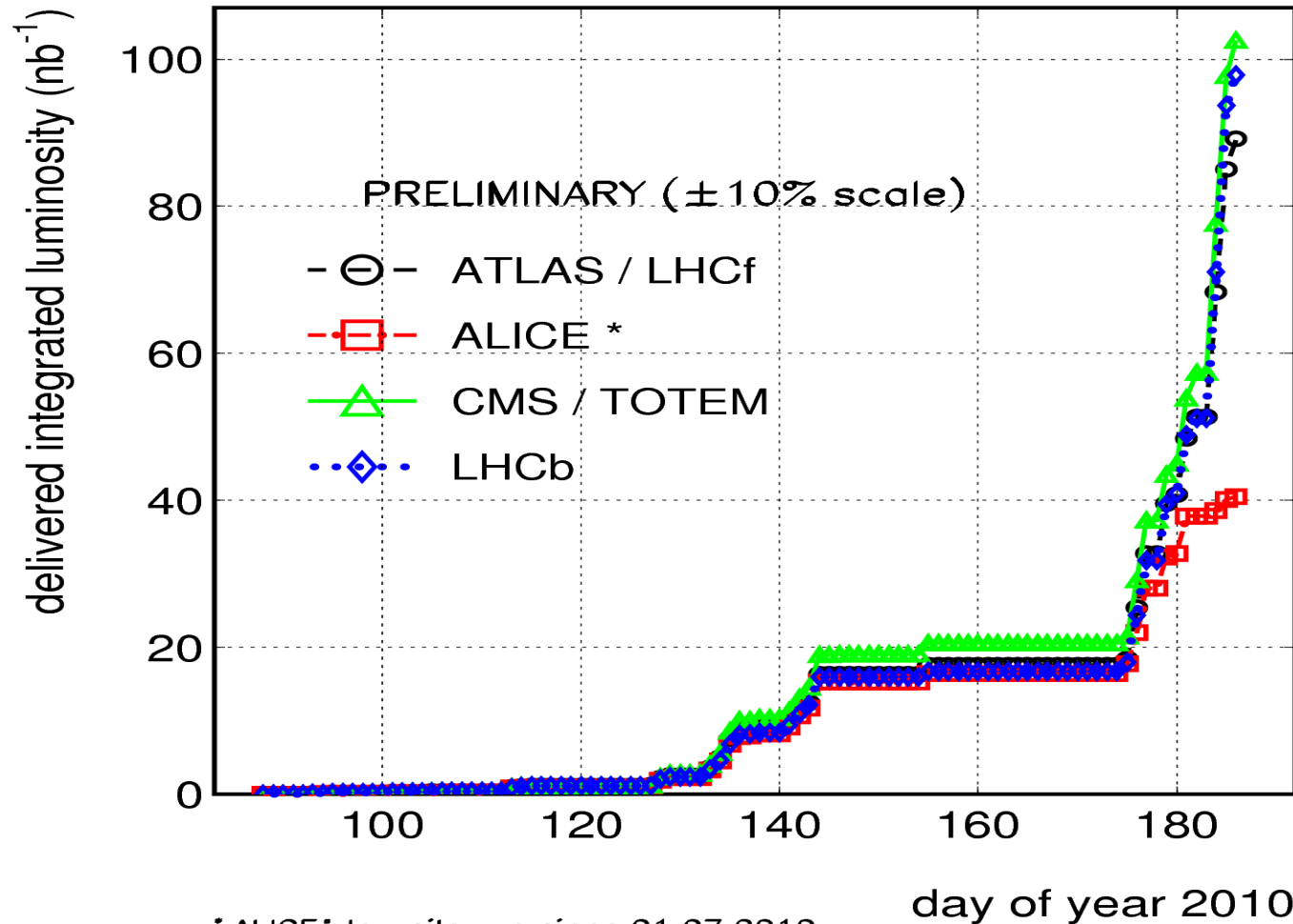
LHC 2010 RUN (3.5 TeV/beam)



Integrated Luminosity on 7th July

2010/07/07 08.08

LHC 2010 RUN (3.5 TeV/beam)



Presently

- More physics for 100 nb^{-1} goal (ICHEP)
- From experience so far
 - No fundamental issue for $1e30$ lumi (16 min OK).
 - Further equalize beam parameters (emittance, intensity, ...) while delivering luminosity. Try to get nominal beam and bunch parameters, including variations.
 - As stability is improved, push up again towards $1e30$ lumi.
 - If problems persist, try simpler collision scheme with 2 collisions per IP. Bunches with 2 collisions seem less affected.
- In addition:
 - Cross calibrate emittance measurement devices.
 - Push transverse damper into full operation in collision, however, possibly needs noise reduction.