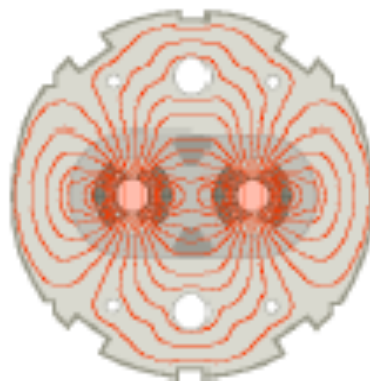


The operation of the LHC accelerator complex

Part 2

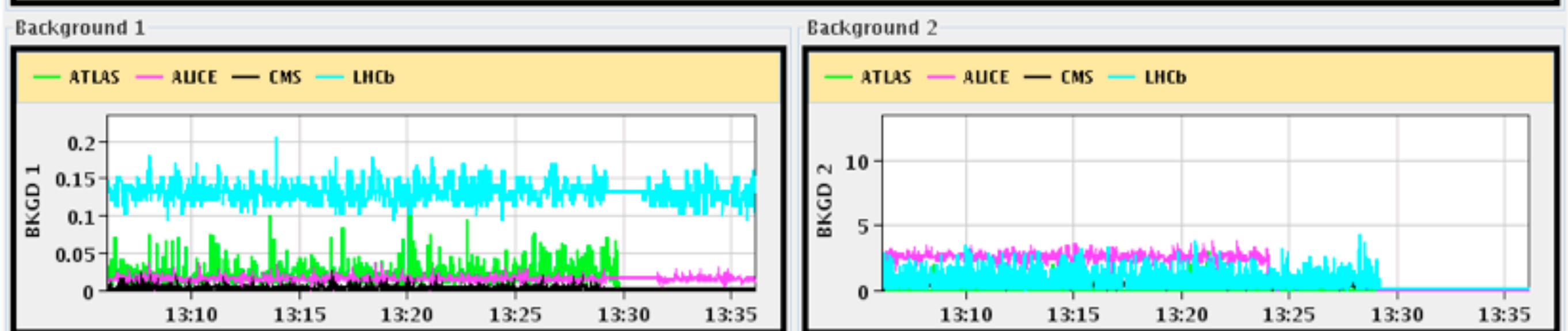
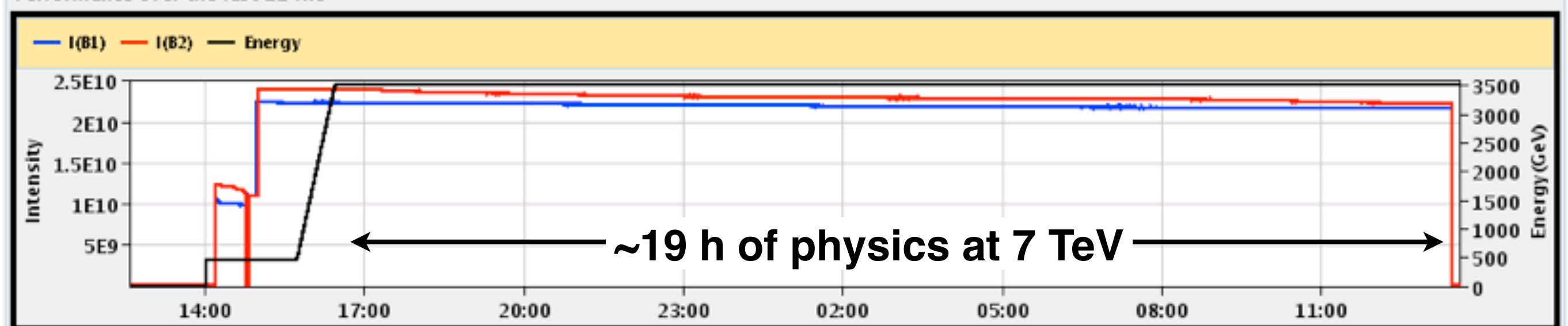
Stefano Redaelli

**CERN Beams Department
Operations Group**

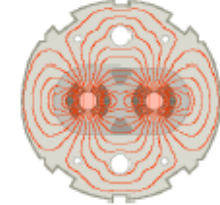


Experiment Status	ATLAS	ALICE	CMS	LHCb
Instantaneous Luminosity	1.052e-05	0.000e+00	0.000e+00	0.000e+00
BRAN Count Rate	2.391e-06	7.884e-04	2.614e-18	1.210e-18
BKGD 1	0.002	0.011	0.002	0.150
BKGD 2	0.000	0.000	0.002	0.002
BKGD 3	0.000	0.006	0.003	0.045
LHCf	MOVING	Count(Hz): 0.000	LHCb VELO Position	Gap: 58.0 ...
TOTEM:	STANDBY			

Performance over the last 12 Hrs

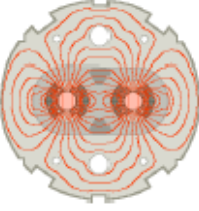


Status ~1h ago

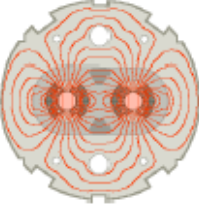


LHC Page1		Fill: 1028		E: 60 GeV		09-04-2010 08:24:45	
BEAM SETUP: CYCLING							
Energy:	60 GeV	I(B1):	0.00e+00	I(B2):	3.86e+07		
Post Mortem Information PM event ID: Thu Apr 08 19:26:12 CEST 2010 PM event category: TIMING_EVENT PM event classification: PM1_EVENT PM BIS Analysis result: No input change detected PM comment: Timing event, no beam.							
Comments 09-04-2010 07:43:25 :				BIS status and SMP flags		B1	B2
staring precycle No beam before 9:00 (at earliest)				Link Status of Beam Permits		false	false
				Global Beam Permit		false	false
				Setup Beam		true	true
				Beam Presence		false	false
				Moveable Devices Allowed In		false	false
				Stable Beams		false	false
LHC Operation in CCC : 77600, 70480				PM Status B1	ENABLED	PM Status B2	ENABLED

Outline - 2st lecture

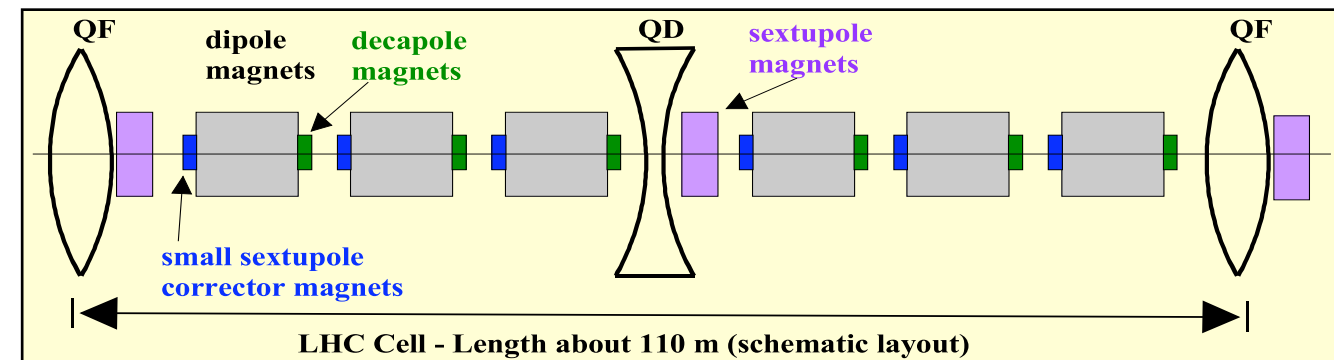


- **Recap. of 1st lecture**
- **Parameters for 2010-11**
- **LHC operational phases**
 - LHC cycle
 - Commissioning: baseline / status
- **Operational tools**
 - Page 1's / fixed displays
 - More applications
- **One shift of LHC operation**
 - How do we operate the LHC



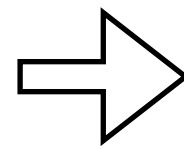
Beam rigidity:

$$B\rho = \frac{p}{e}$$



Equation of motion and its solution:

$$x'' + K(s)x = \frac{1}{\rho} \frac{\Delta p}{p_0}$$



$$x(s) = A \sqrt{\beta_x(s)} \cos[\phi(s) + \phi_0] + D(s) \times \frac{\Delta p}{p}$$

Beta function points to $\beta_x(s)$
Dispersion points to $D(s)$

Betatron tune and chromaticity:

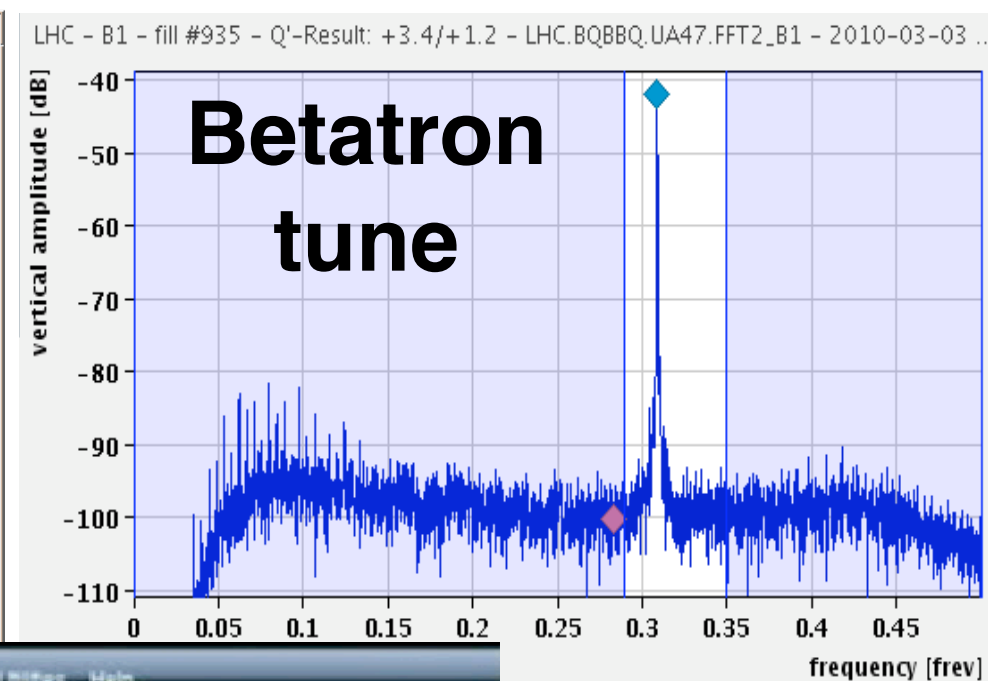
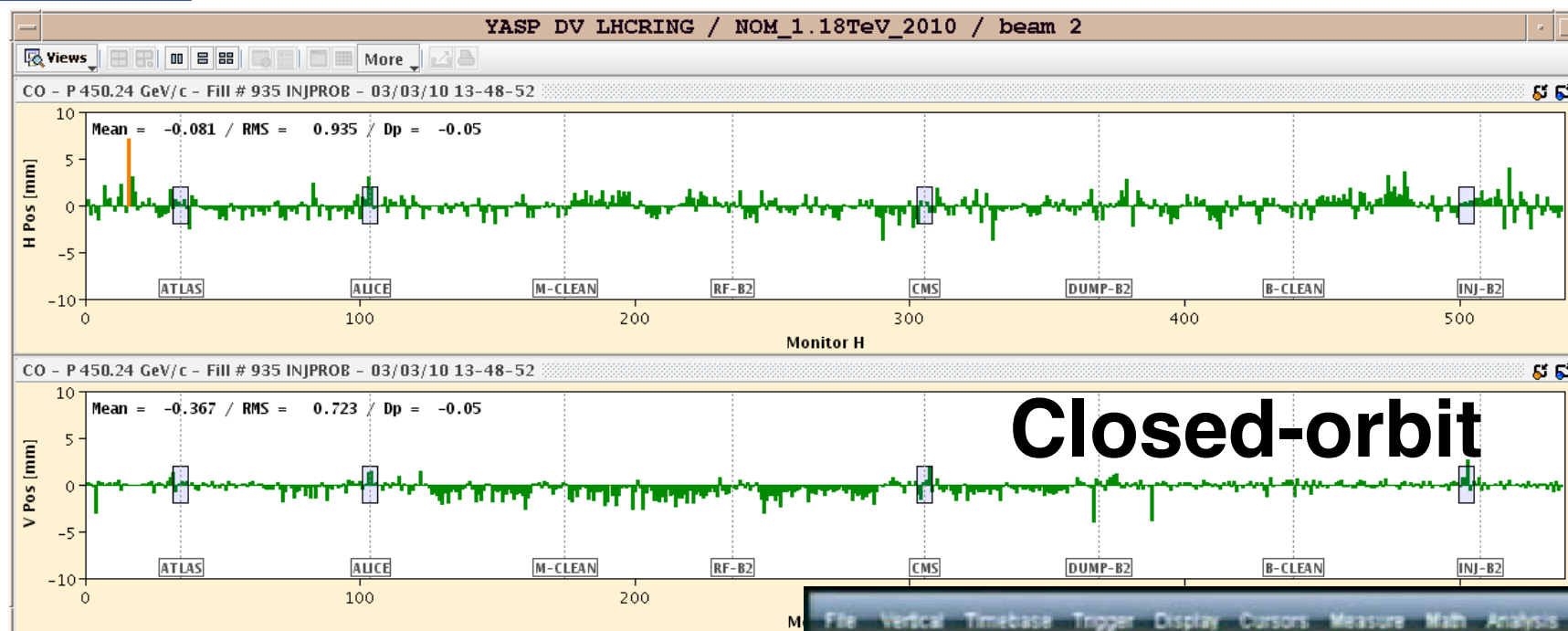
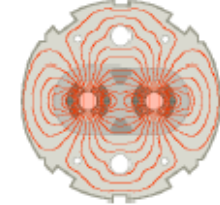
$$Q = \frac{1}{2\pi} \int \frac{ds}{\beta(s)}$$

$$Q' = \frac{\Delta Q}{\Delta p/p}$$

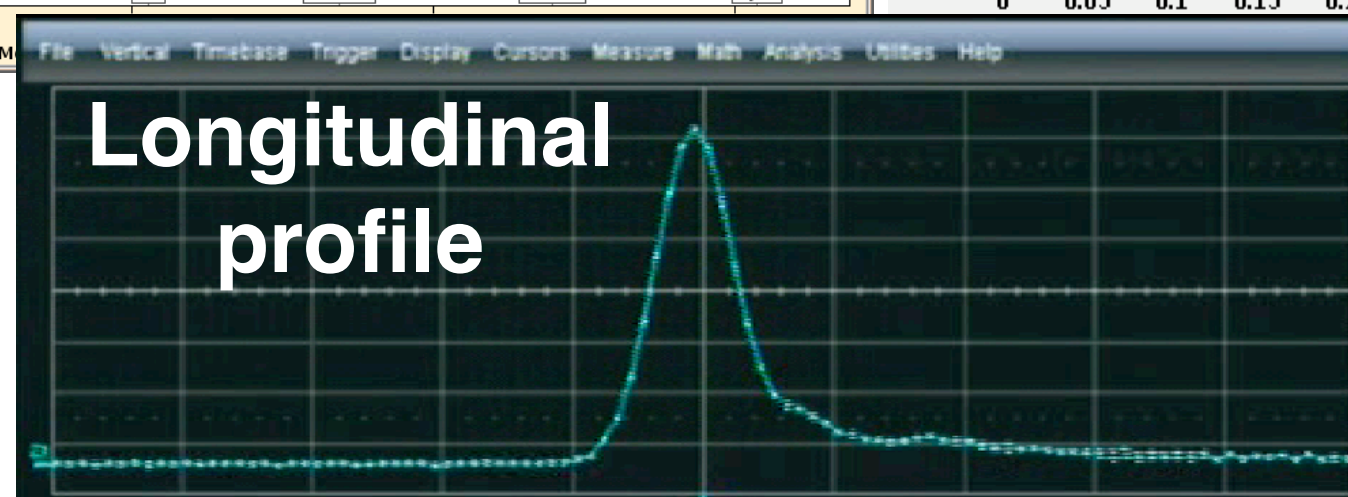
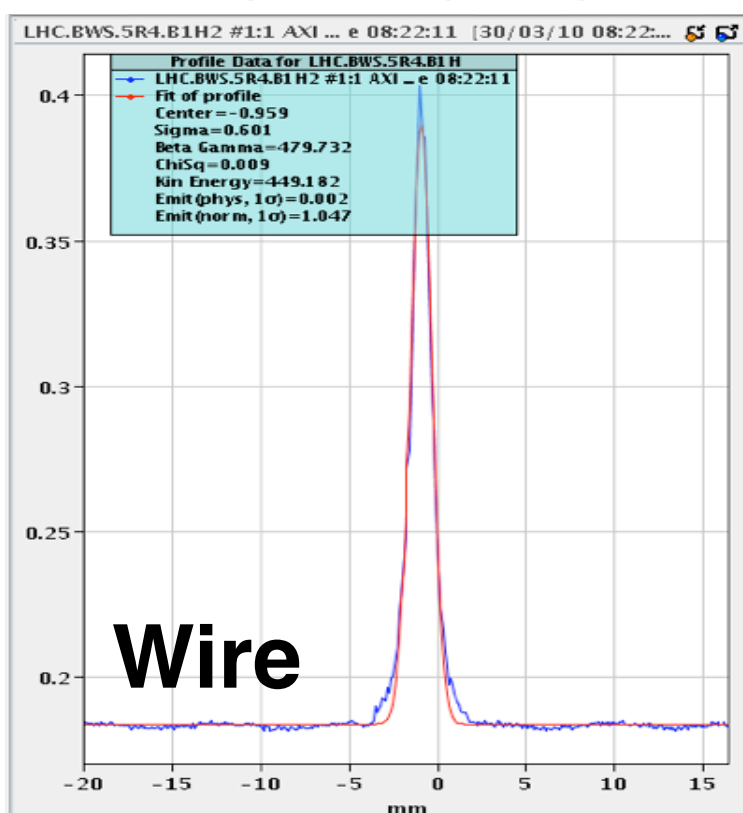
Emittance and beam size:

$$\sigma_x(s) = \sqrt{\epsilon \beta_x(s) + [D_x(s)\delta]^2}$$

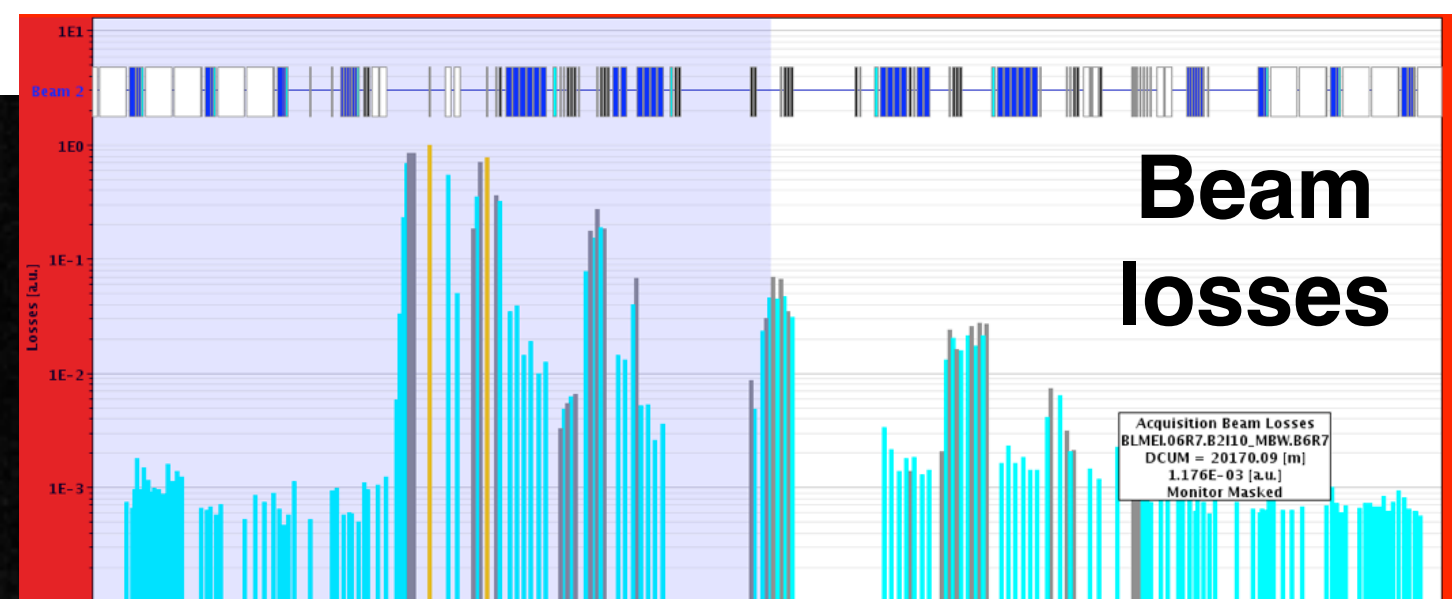
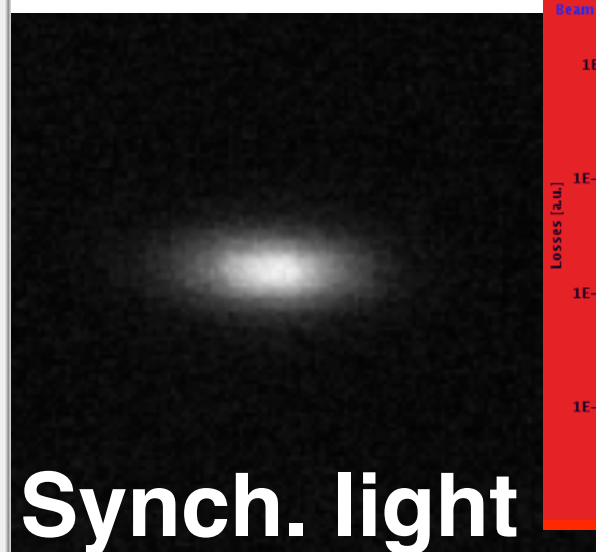
Beam measurements at the LHC



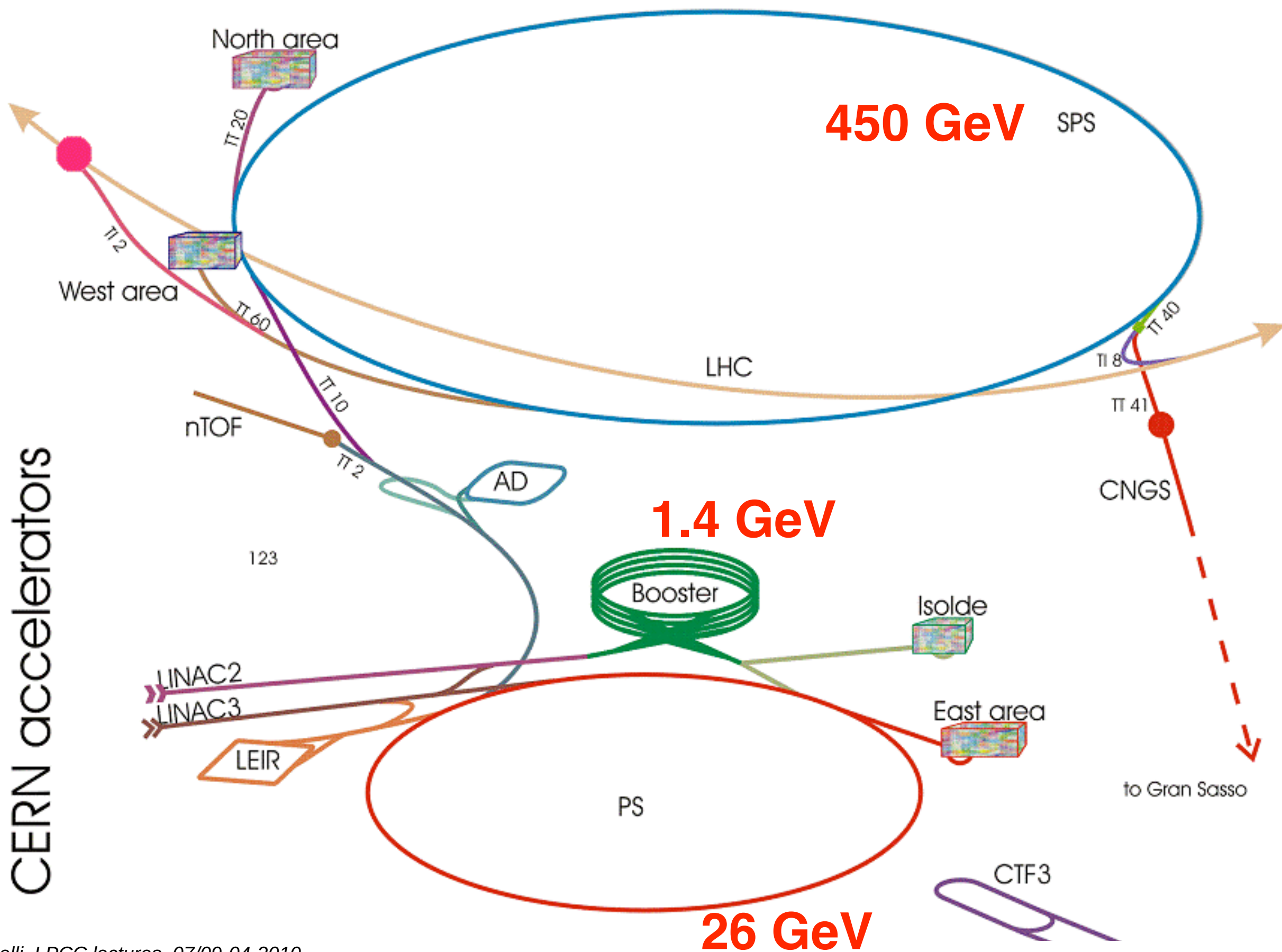
Transverse size



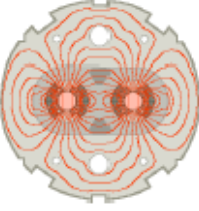
Synch. light



LHC injector complex

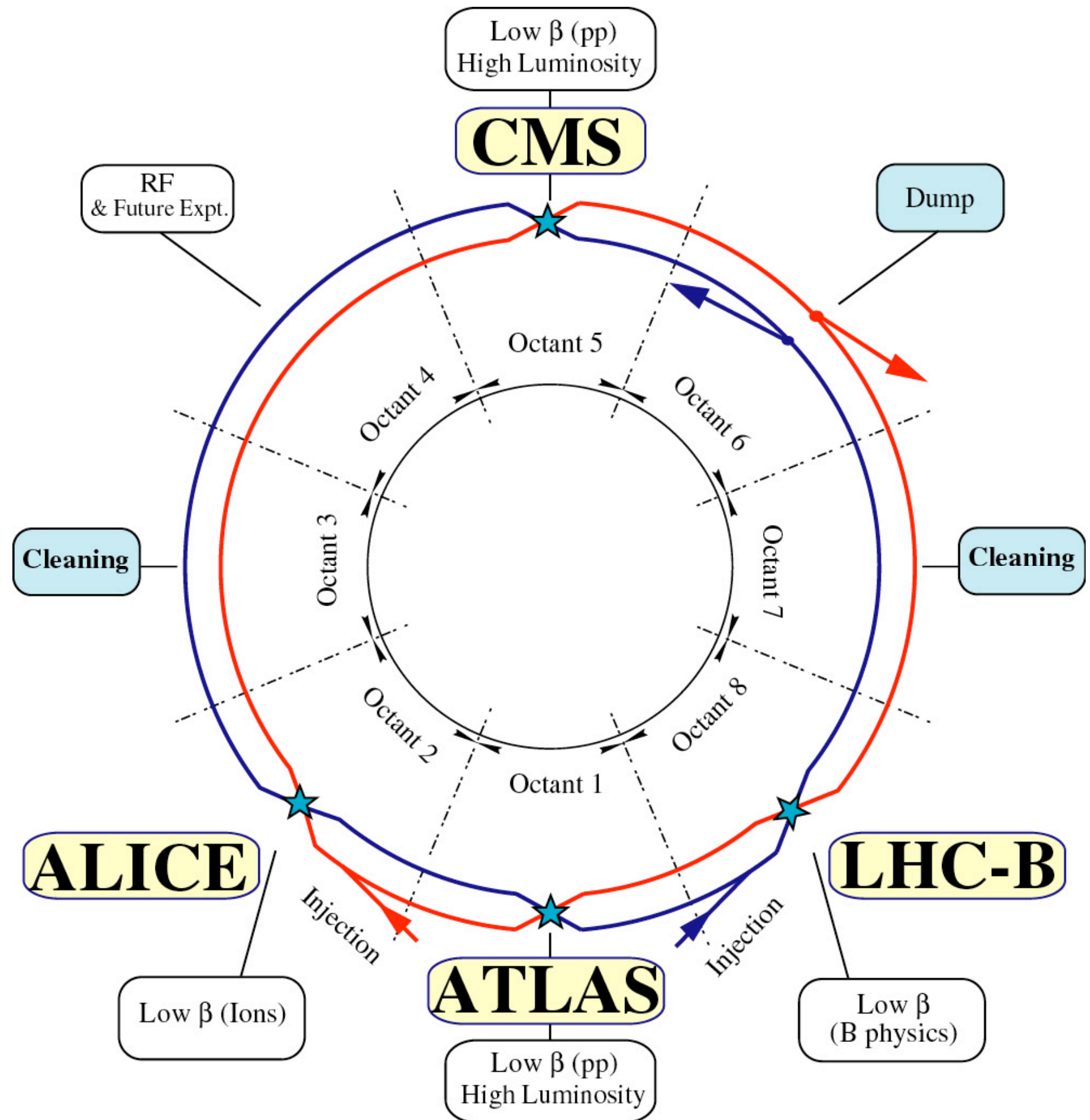


LHC layout and accelerator systems

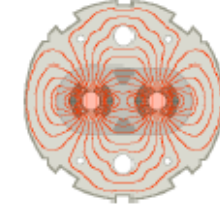


Eight arcs and eight straight sessions:

- Point 1: **Atlas**, **LHCf**
- Point 2: **Alice**, injection
- Point 3: Momentum cleaning
- Point 4: RF
- Point 5: **CMS**, **TOTEM**
- Point 6: Beam Dumps
- Point 7: Betatron cleaning
- Point 8: **LHCb**, injection



LHC design parameters

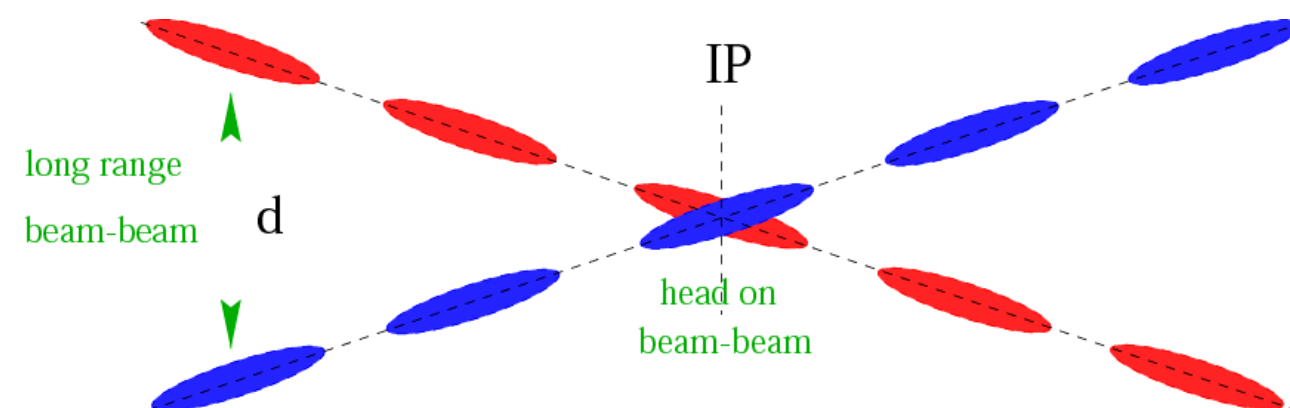
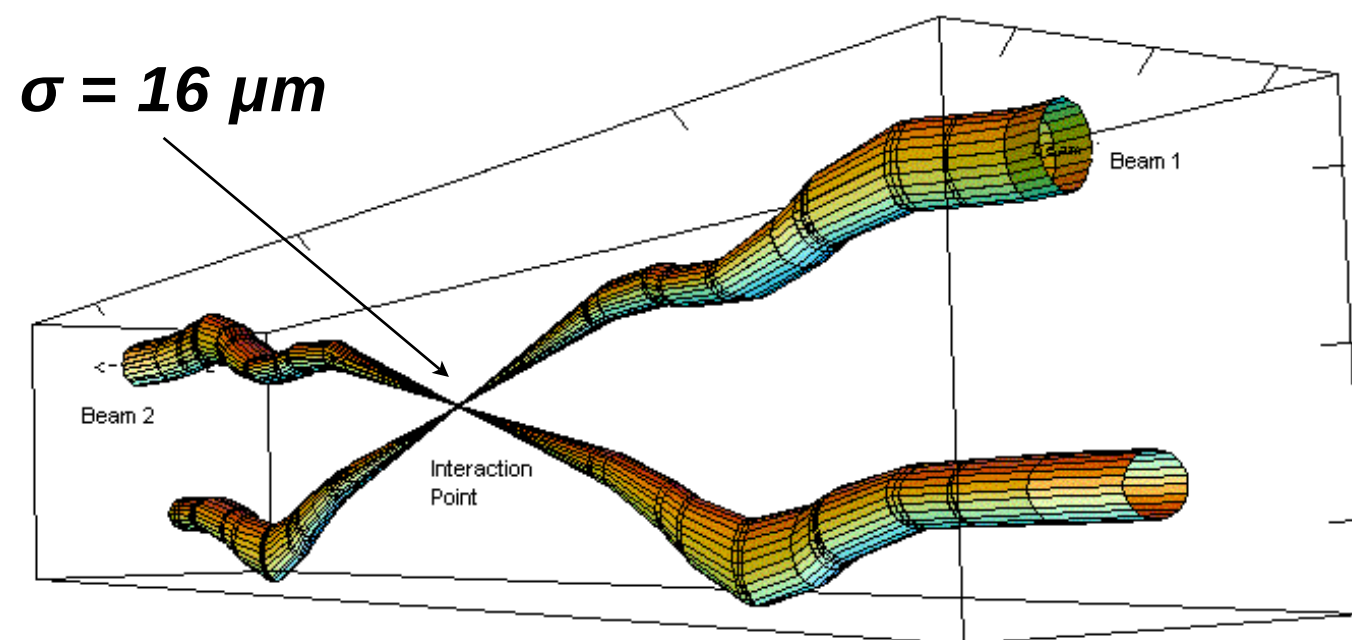


Nominal LHC parameters	
Beam injection energy (TeV)	0.45
Beam energy (TeV)	7.0
Number of particles per bunch	1.15×10^{11}
Number of bunches per beam	2808
Max stored beam energy (MJ)	362
Norm transverse emittance ($\mu\text{m rad}$)	3.75
Colliding beam size (μm)	16
Bunch length at 7 TeV (cm)	7.55

$$L = \frac{N^2 k_b f \gamma}{4\pi \epsilon_n \beta^*} F$$

$$F = 1 / \sqrt{1 + \left(\frac{\theta_c \sigma_z}{2\sigma^*} \right)^2}$$

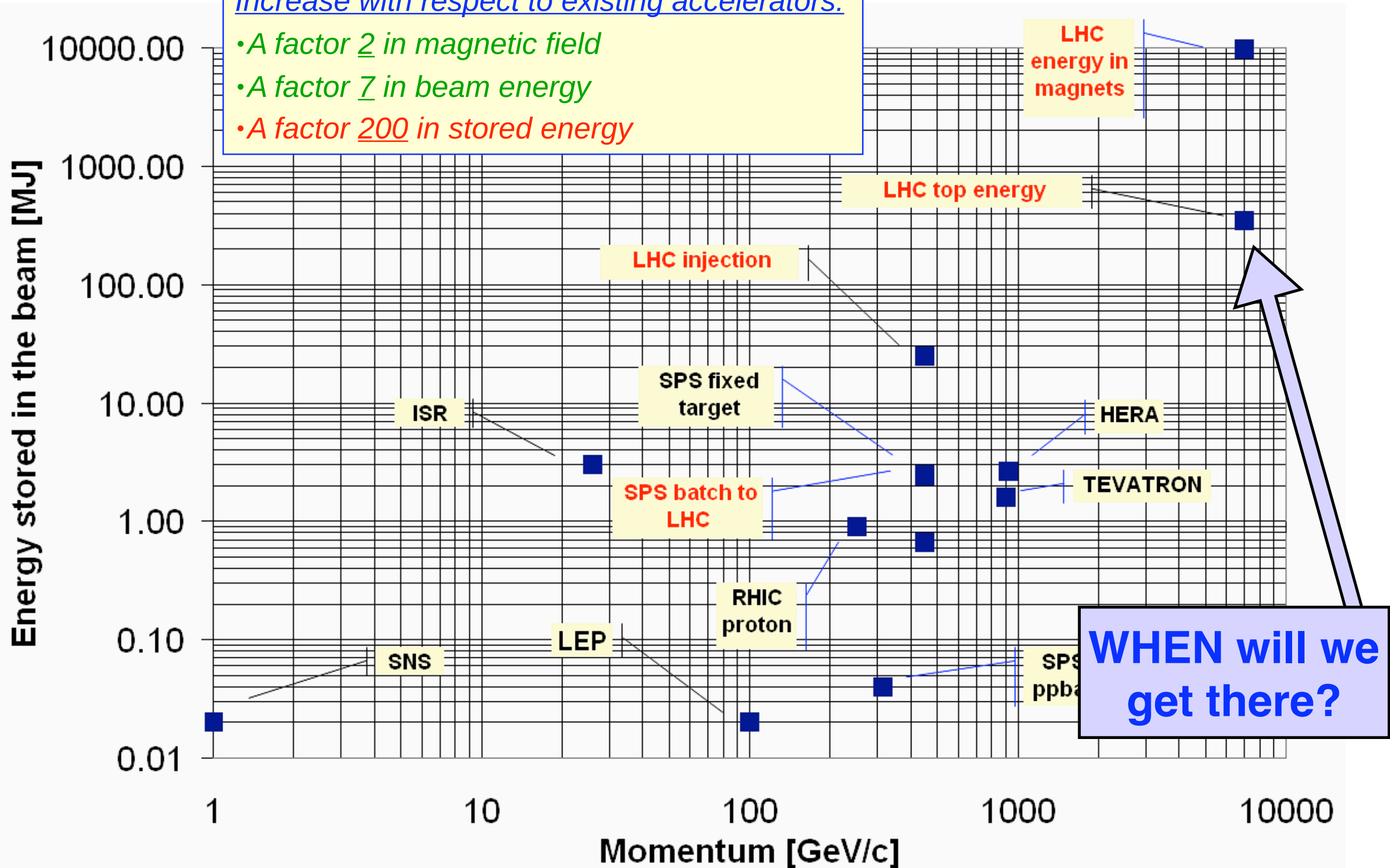
- $\beta^* = 0.55 \text{ m}$
- *Crossing* = $285 \mu\text{rad}$
- $L = 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$



The stored energy challenge

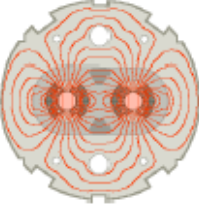
Increase with respect to existing accelerators:

- A factor 2 in magnetic field
- A factor 7 in beam energy
- A factor 200 in stored energy



WHEN will we get there?

LHC energy target - way down



All main magnets commissioned for 7TeV operation before installation

Detraining found when hardware commissioning sectors in 2008

5 TeV poses no problem
Difficult to exceed 6 TeV

Machine wide investigations following S34 incident showed problem with joints

Commissioning of new Quench Protection System (nQPS)

450 GeV

7 TeV

12 kA

5 TeV

9 kA

3.5 TeV

6 kA

1.18 TeV

2 kA

When

2002-2007

Why

Design

Summer 2008

Detraining

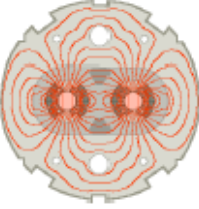
Late 2008
Spring 2009

Joints

Nov. 2009

nQPS

LHC energy target - way up



Train magnets

6.5 TeV is within reach

7 TeV will take time

Repair joints

Complete pressure relief system

Commission nQPS system

450 GeV

1.18 TeV

3.5 TeV

6 TeV

7 TeV

When

What

2014 ?

Training

2013

Stabilizers

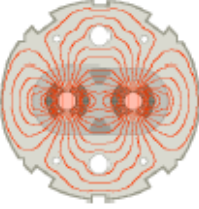
2011

nQPS

2010

2009

Goals for 2010-2011



2009			2010			2011		
Repair of Sector 34	1.18 TeV	nQPS 6kA	3.5 TeV $I_{\text{safe}} < I < 0.2 I_{\text{nom}}$ $\beta^* \sim 2 \text{ m}$		Ions	3.5 TeV $\sim 0.2 I_{\text{nom}}$ $\beta^* \sim 2 \text{ m}$		Ions
No Beam	B		Beam			Beam		

Goal (ambitious!) for the run: collect 1 fb^{-1} of data/exp at 3.5 TeV/beam.

To achieve such this goal the LHC must operate in 2011 with

$L \sim 2 \times 10^{32} \text{ Hz/cm}^2 \sim \text{Tevatron Luminosity}$

which requires ~ 700 bunches of 10^8 p/bunch (stored energy of $\sim 30 \text{ MJ}$ – 10% of nominal)

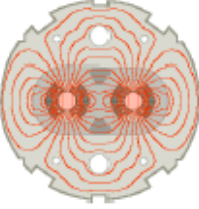
Implications:

Strict and clean machine setup.

Machine protection systems at near nominal performance.

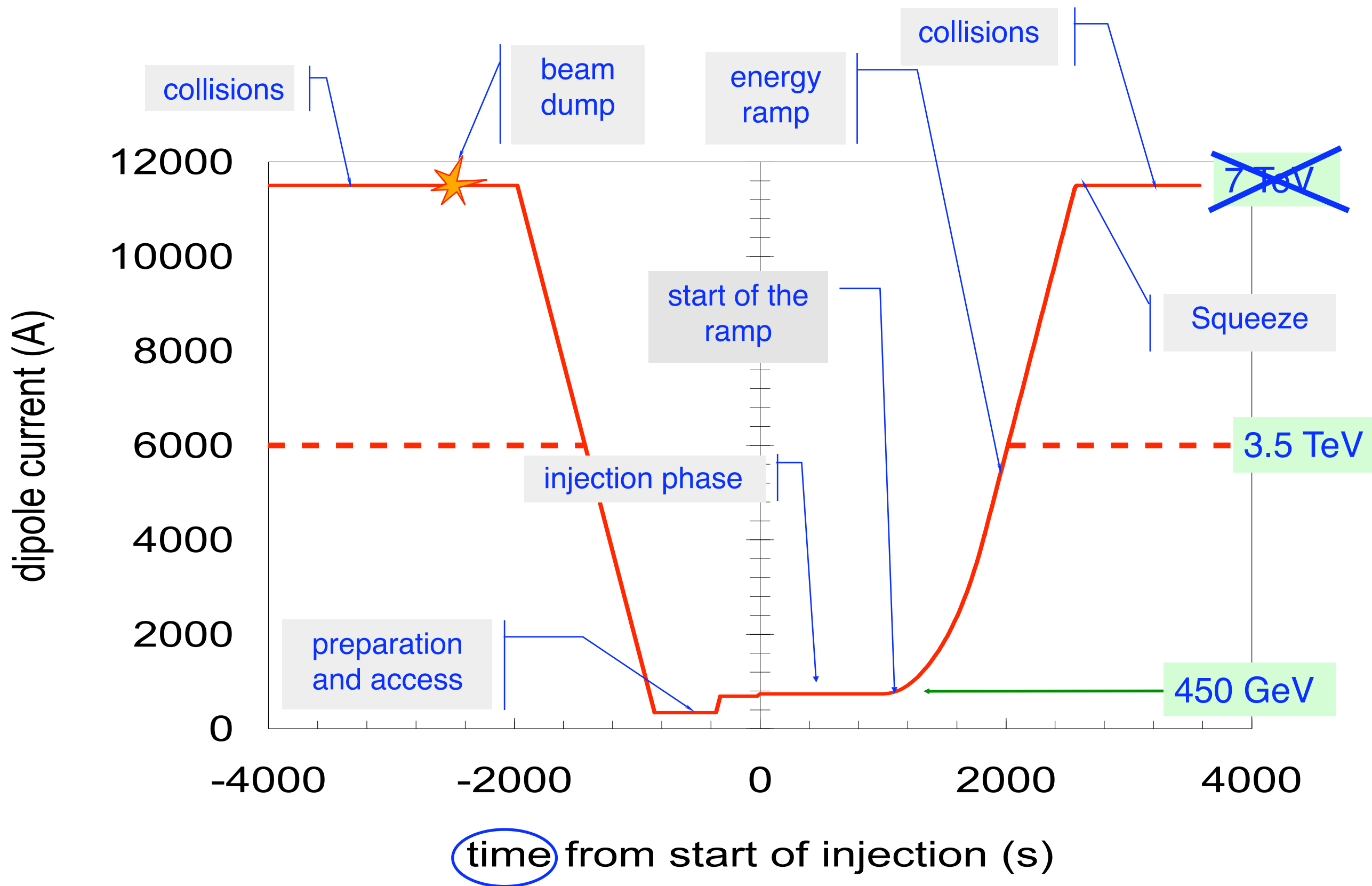
Minimum β^* in various IP's

	β^*_{inj}	β^*_{min}
IP1 / IP5	11 m	2 m
IP2+	10 m	3 m
IP8+	10 m	2 m
IP5-TOTEM	11 m	90 m



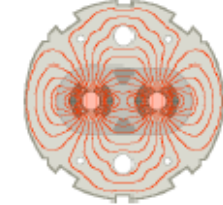
- Recap. of 1st lecture
- Parameters for 2010-11
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 - **The LHC cycle**
 - **Commissioning: baseline / status**
- Operational tools
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 - How do we operate the LHC

LHC cycle



Also ramp time needs an update...

What has to be done in each phase?



- Procedures elaborated within the **LHC Commissioning Working Group** (LHCCWG) in preparation for the 7 TeV operation.
- Updated now for the 3.5 TeV scenario
- Particular careful for machine protection aspects!

Phase A.1	First turn: injection commissioning; threading, commissioning instrumentation. Ring 1, ring 2.
Phase A.2	Circulating pilot: establish circulating beam, closed orbit, ...
Phase A.3	450 GeV initial commissioning: system commissioning beam dump, ...
Phase A.4	450 GeV optics: beta beating, dispersion, coupling, non-aperture, ...
Phase A.5	450 GeV, increasing intensity: prepare the LHC for unsaturated operation
Phase A.6	450 GeV, two beam operation
Phase A.7	450 GeV, collisions
Phase A.8	Snap-back and ramp: single beam/two beams
Phase A.9	Top energy checks
Phase A.10	Top energy, collisions
Phase A.11	Squeeze: Commission the betatron squeeze in all IP's
Phase A.12	Beam commissioning with experimental magnets

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CH-1211 Geneva 23
Switzerland

the **Large Hadron Collider** project

LHC Project Document No.
LHC-OP-BCP-0002 rev 1.0
CERN Div./Group or Supplier/Contractor Document No.

LHC Project Document No.
LHC-OP-BCP-0005 rev 0.2
CERN Div./Group or Supplier/Contractor Document No.

LHC Project Document No.
LHC-OP-BCP-0012 rev 0.2
CERN Div./Group or Supplier/Contractor Document No.
LHCCWG
EDMS Document No.
876869

Date: 2007-11-30

Beam Commissioning Procedure

**LHC COMMISSIONING WITH BEAM:
PHASE A.11 (BETATRON SQUEEZE)**

Abstract

This document describes the LHC beam commissioning procedures for the betatron squeeze at 7 TeV in all IP's without crossing angle. It covers the entry conditions, the commissioning procedures and exit conditions of this phase. Possible problems and open questions are also listed.

Prepared by : R.Aleman Fernandez M. Giovannozzi M. Gruwé V. Kain L. Ponce S. Redaelli W. Venturini On behalf of the LHCCWG	Checked by: LHCCWG	Approved by: R. Bailey O. Bruning P. Collier M. Lamont S. Myers
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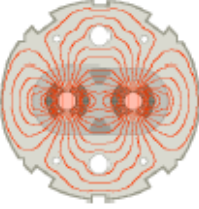
LHCCWG list:

R.Aleman Fernandez, G. Arduini, R. Assmann, R. Bailey, O. Bruning, H. Burkhardt, A. Butterworth, P. Collier, S. Fartoukh, M. Giovannozzi, B. Goddard, J.-J. Gras, M. Gruwé, R. Jones, V. Kain, P. Koutchouk, M. Lamont, A. MacPherson, L. Ponce, S. Redaelli, R. Saban, F. Schmidt, R. Schmidt, R. Steinhagen, E. Todesco, J. Uythoven, W. Venturini Delsolario, J. Wenninger, T. Wijnands, F. Zimmermann

Approval list:

F. Bordry, L. Bottura, T. Camporesi, P. Ciriani, K. Eggert, L. Evans, M. Ferro-Luzzi, R. Garoby, J. Lettry, P. Lebrun, T. Linnekar, S. Maury, V. Mertens, K.-H. Mess, G. Mornacchi, M. Nessi, W. Riegler, G. Roy, H. Schmickler, A. Schopper, F. Strubin, E. Tsismelis, R. VanWeelden

Commissioning vs. “routine” OP



During **beam commissioning**, we want to:

1. Establish for the first time the critical phases
 - First beam threading, RF capture, closed orbit
 - First ramp, first squeeze, ...
2. Verify that all the accelerator system work correctly
 - Beam instrumentation, controls
 - Kickers, RF, collimators, beam dump, ...
3. Bring within tolerance the key machine/beam parameters
 - Orbit, tune, chromaticity, beta-beating, coupling, aperture, ...
4. Establish re-producible **reference** settings for critical systems
 - Orbit and optics; collimator settings
 - Machine protection conditions for given beam configuration
5. Assess **safely** the machine protection aspect before each energy step

Initially,
commissioning and
physics will be
interleaved (“staged”
approach)

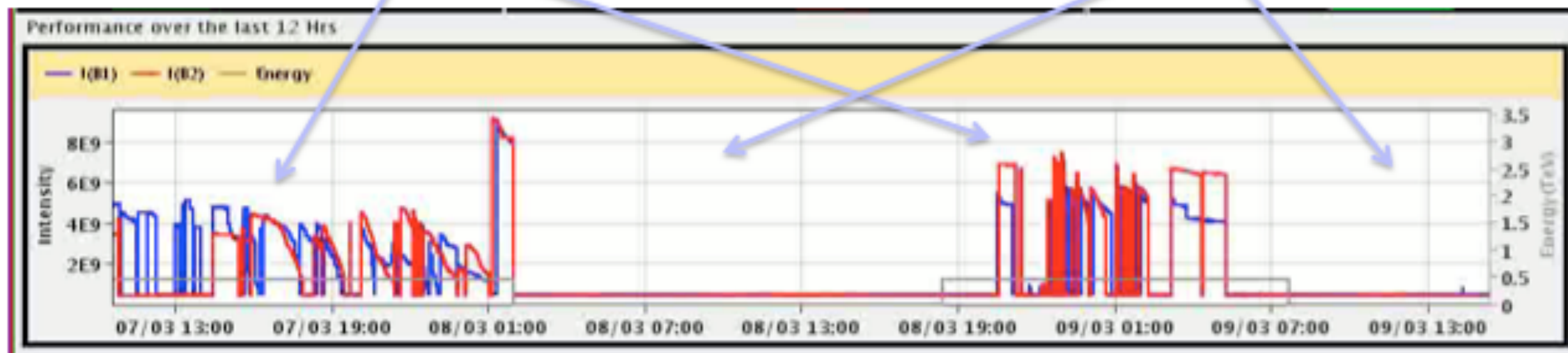
During **beam operation for physics**, we want to:

1. Re-establish the reference conditions with minor changes
2. Optimize the time without beam to improve integrated luminosity

Example of commissioning

Very busy beam work by CCC team
and many experts (single bunch up to $1e10$ p)

Very busy hardware
work by experts: no beam

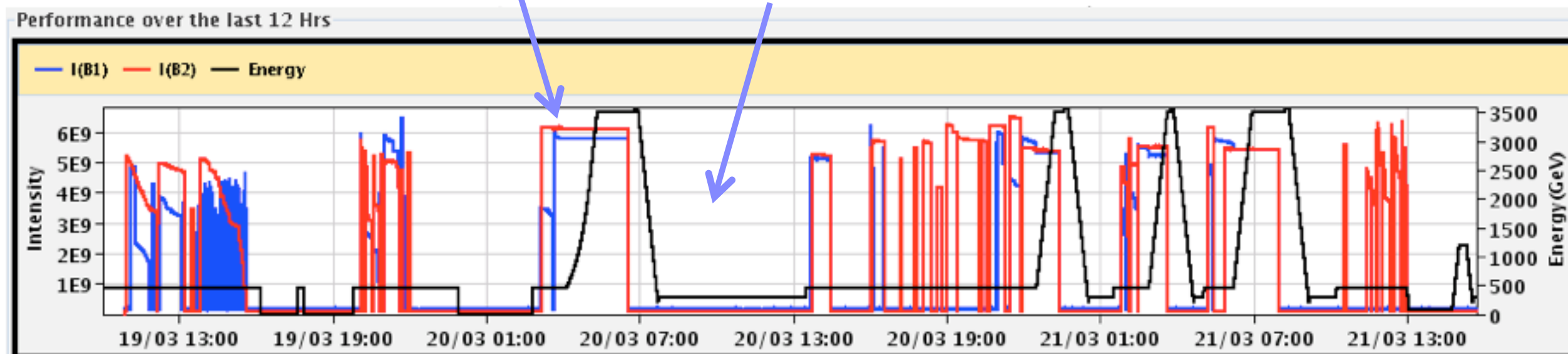


2 days

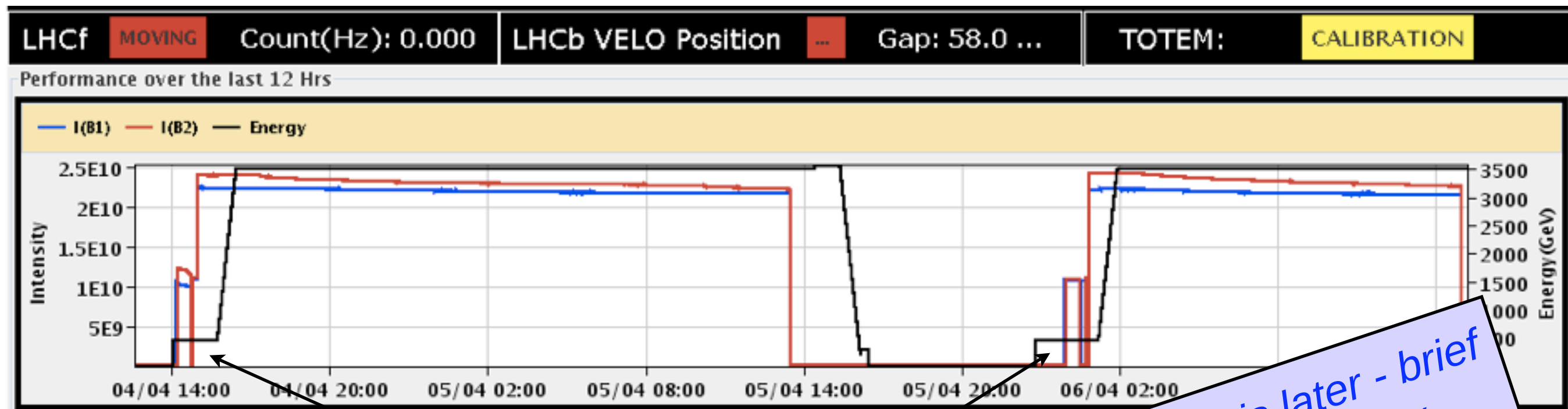
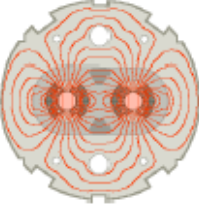
Beam 1
Beam 2

Ramp

Problems



Example of operation for physics

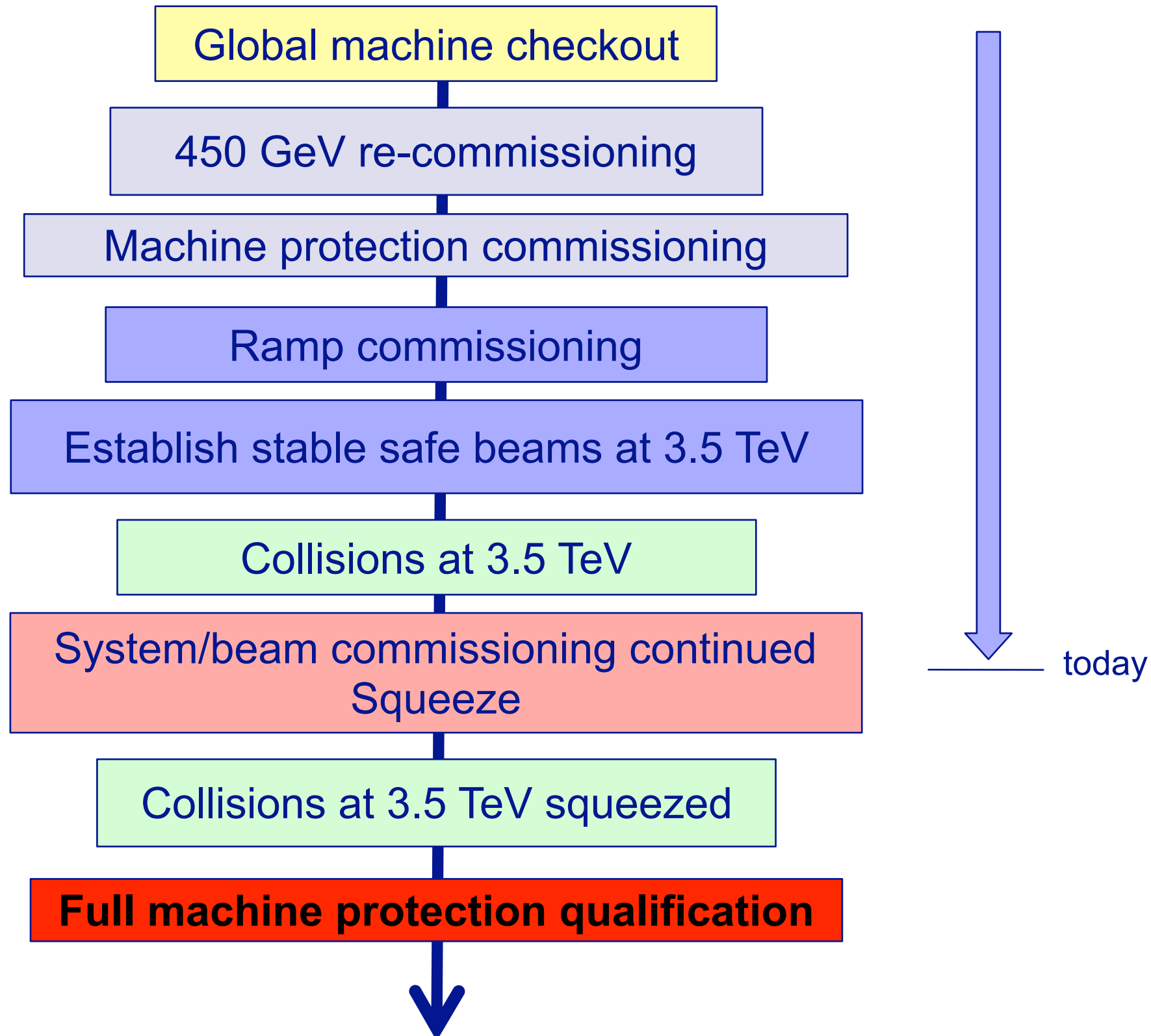


Will come back to this later - brief commissioning status now.

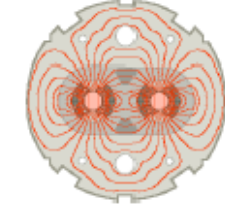
Bunches injected, kept the minimum time needed for tuning and for recovering ref conditions, then ramp, then stable beams!

And then... hands OFF!!!

Where do we stand?



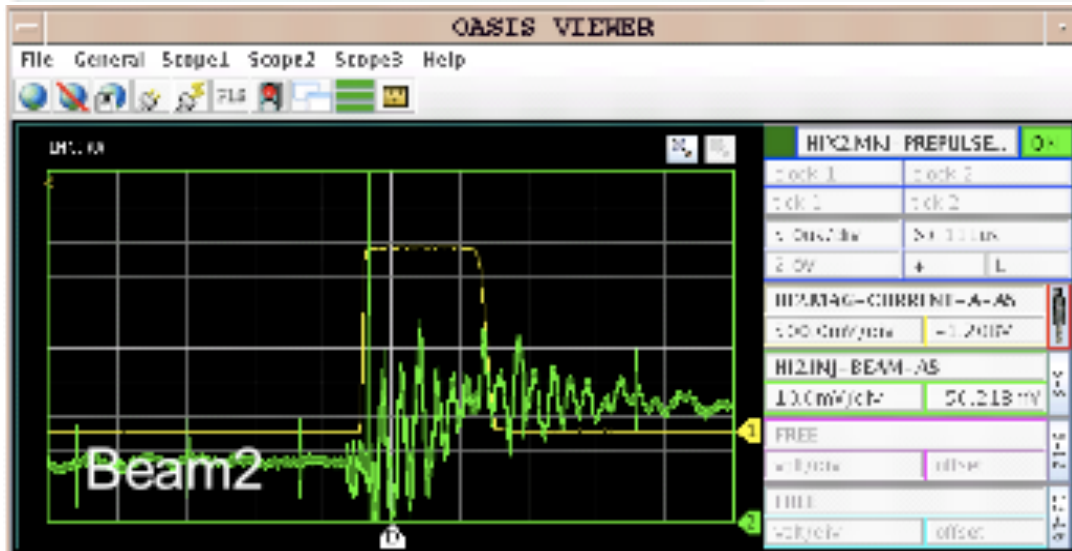
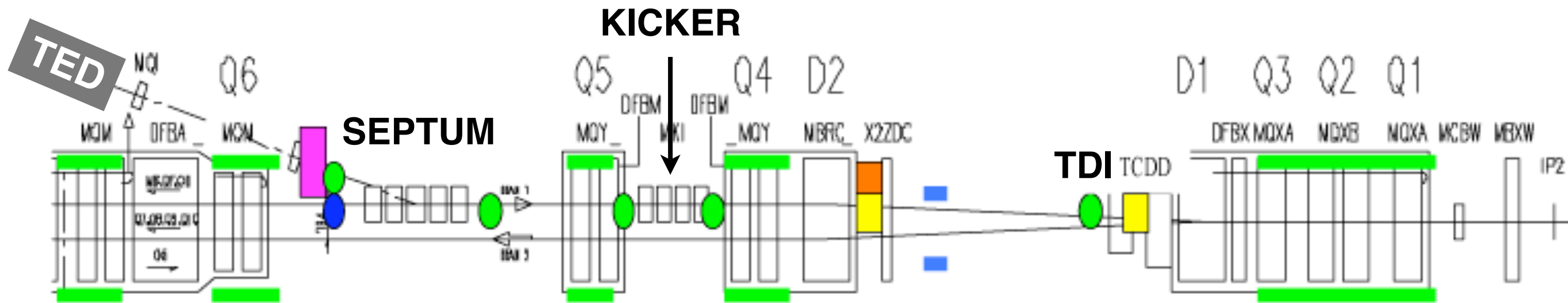
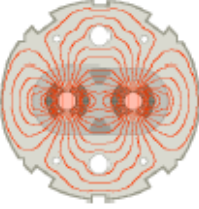
2010 commissioning milestones



27 th Feb	First injection
28 th Feb	Both beams circulating
5 th March	Canonical two beam operation
8 th March	Collimation setup at 450 GeV
12 th March	Ramp to 1.18 TeV
15 th - 18 th March	Technical stop – beam
19 th March	Ramp to 3.5 TeV
26 th - 29 th March	Preparation of ‘stable’
30 th March	First 3.5 TeV collision
1 st April	Betatron squeeze to
4 th - 5 th April	19h-long store with
7 th April	Betatron squeeze to

Can only show a selection of topics:

- injection*
- first beam threading*
- RF capture*
- Q , Q' , orbit adjustment*
- optics and aperture*
- collimator setup*
- 3.5 TeV ramp*
- squeeze*
- beam dump*
- pre-cycle*

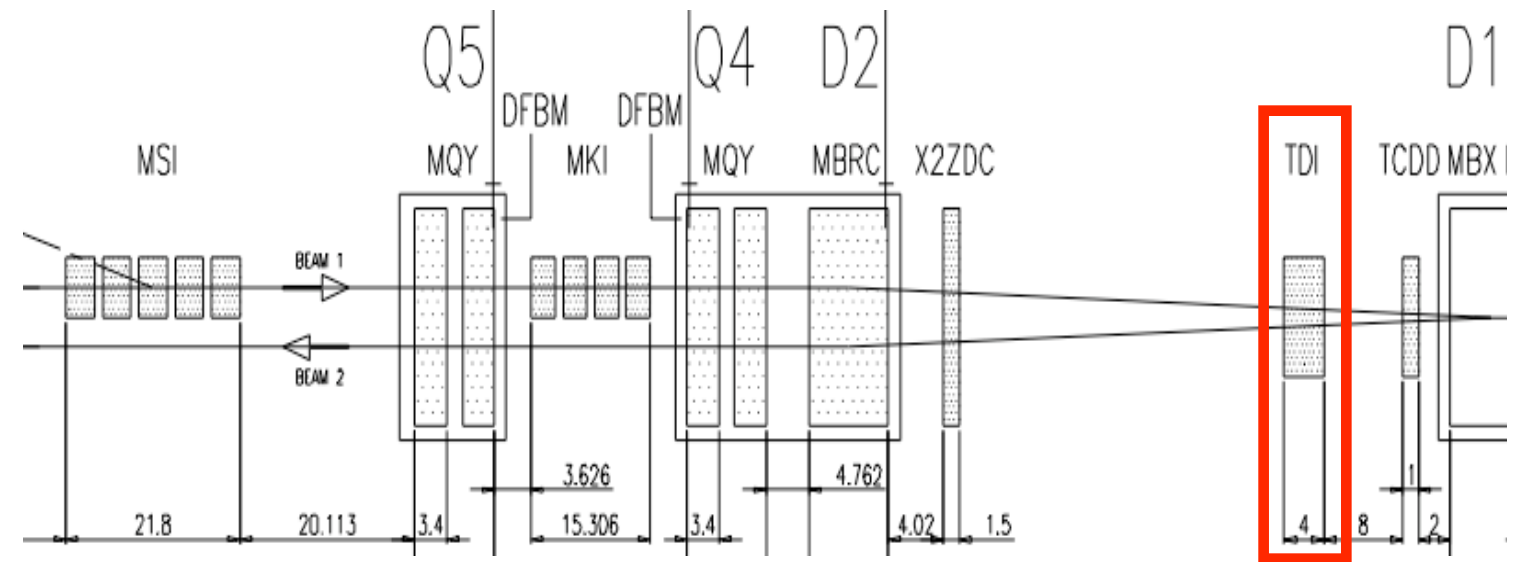
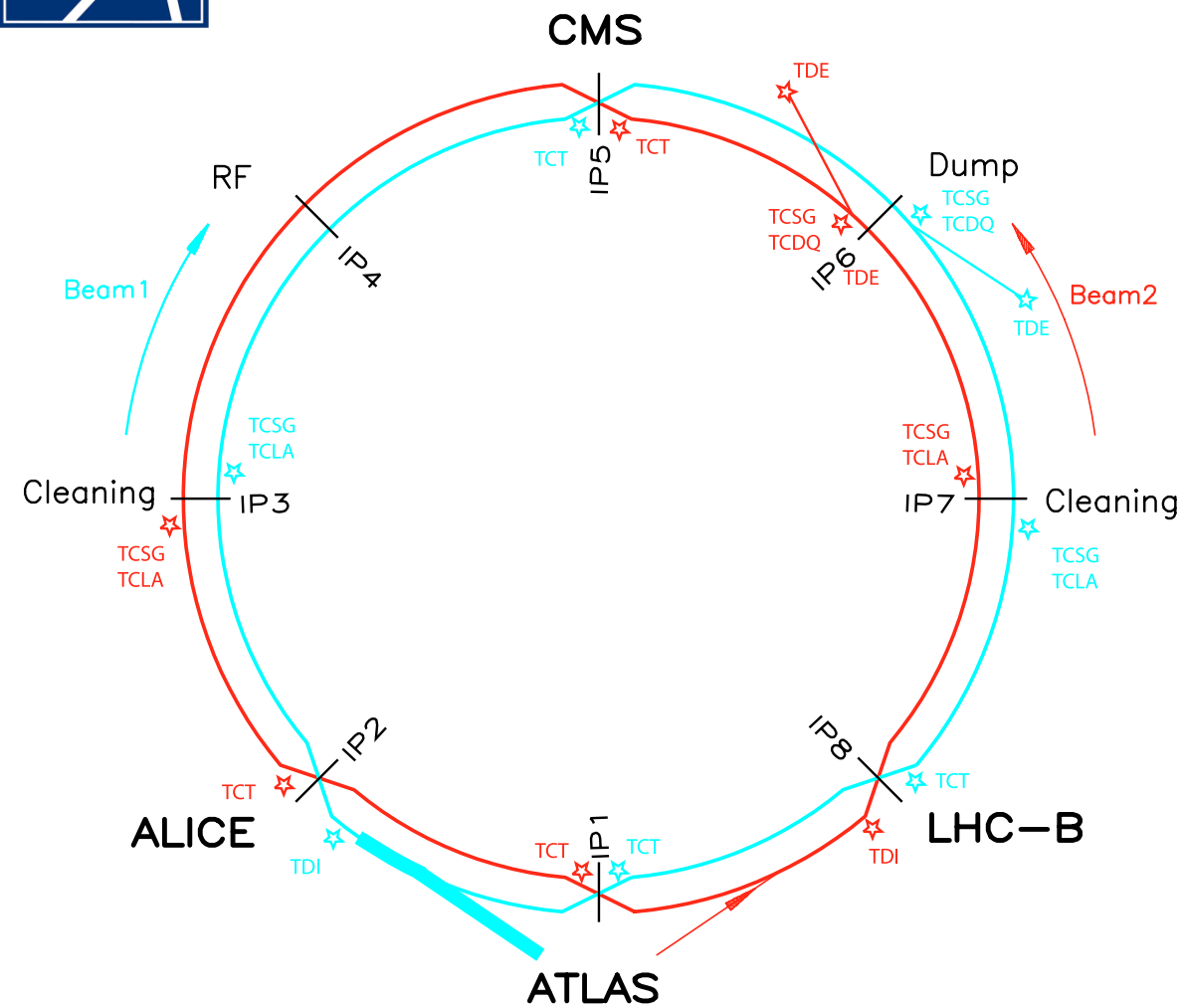
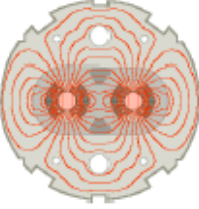


- | | | | | |
|---|-------------------------|---|------|--------------------------------|
|  | BPM and BLM |  | BTPX | timing PU - 0.5 m |
|  | Beam-beam rate monitors |  | BPMW | position PU - 0.5 m |
| | |  | BTv | first turn screen - 0.5 m |
| | |  | BTvI | screen for injection - 0.5 m |
| | |  | BCTI | beam current transformer - 1 m |

**Extensively tested during T12/8
commissioning and sector tests:**

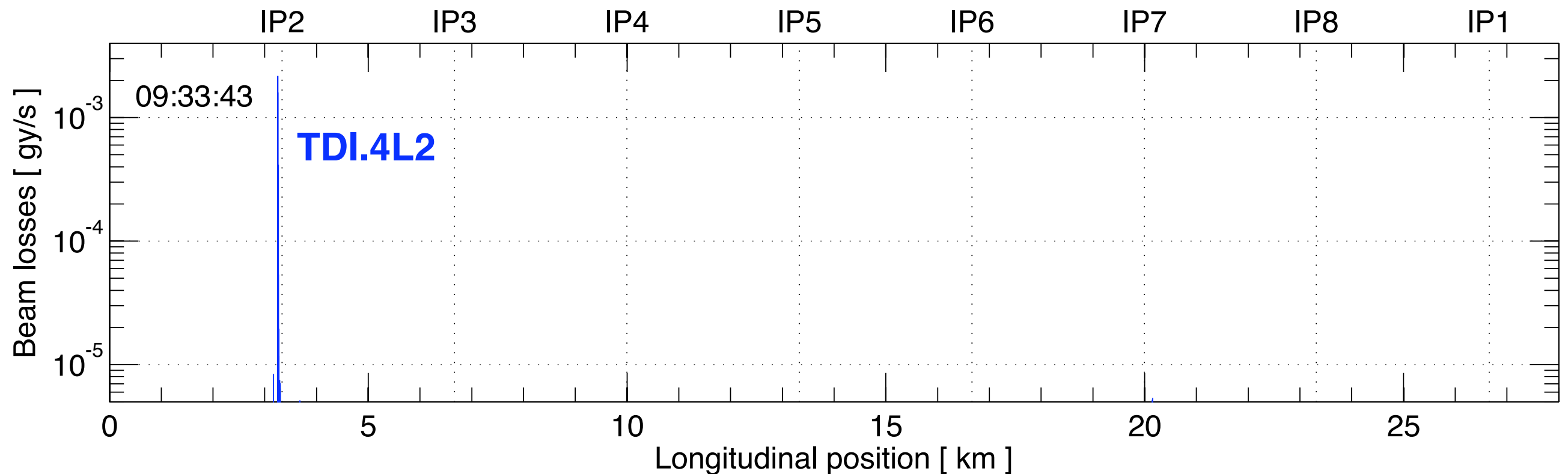
- synchronization of kickers with extracted beam
 - steering of the transfer lines
 - protection settings
 - injection quality checks

Beam threading - Beam1 on TDI

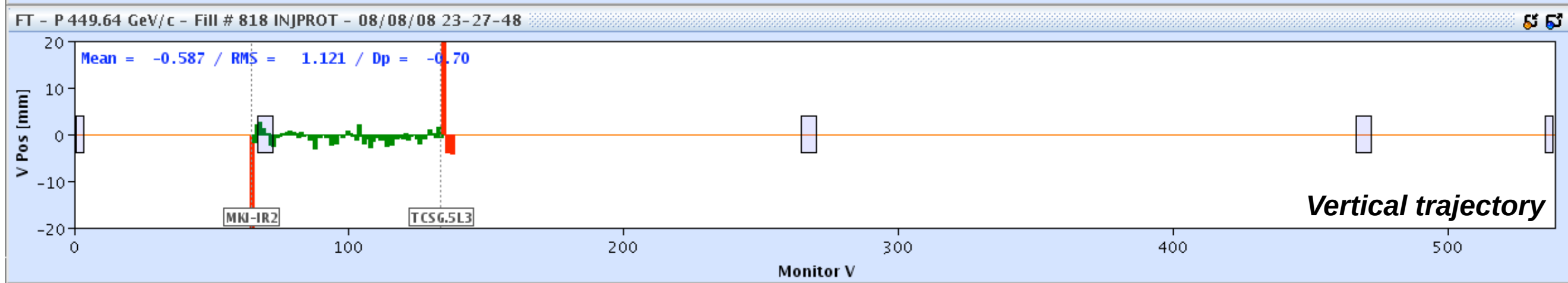
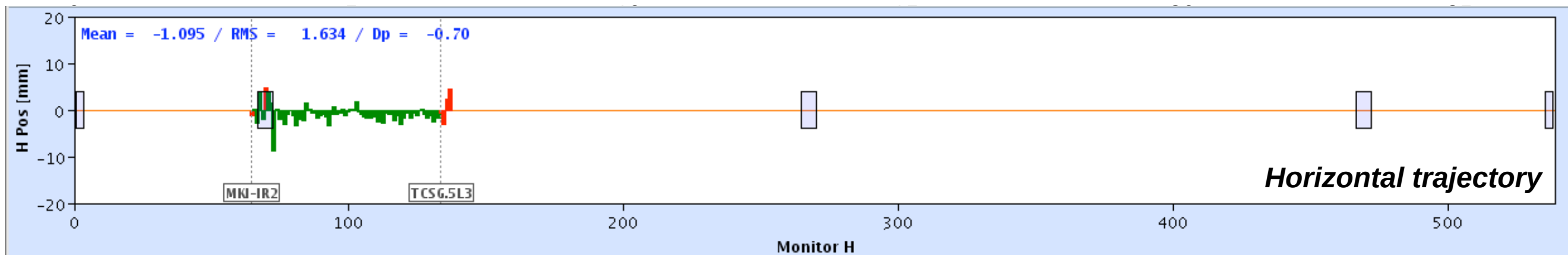
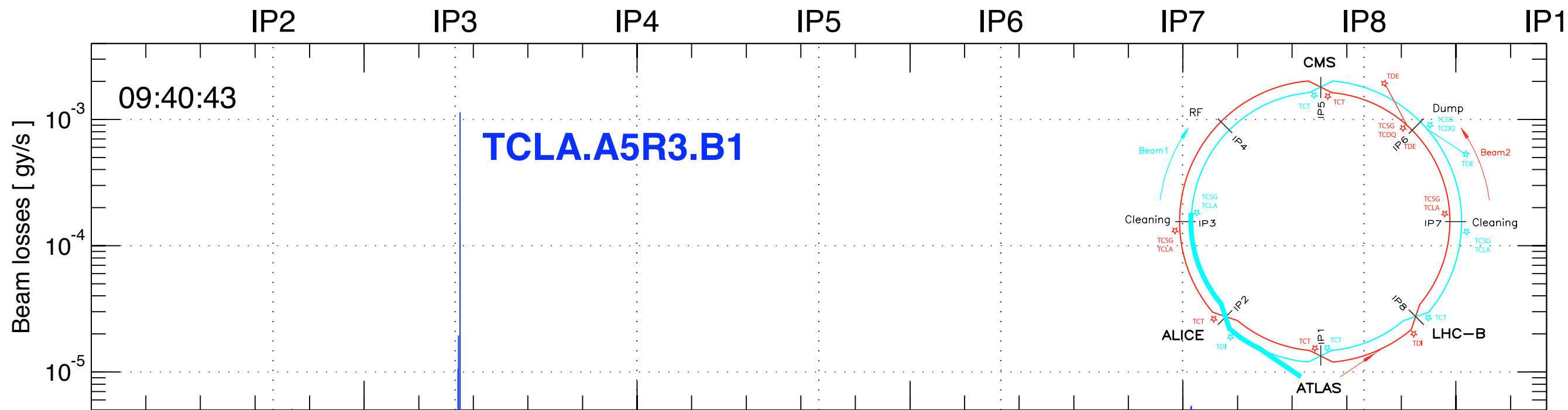
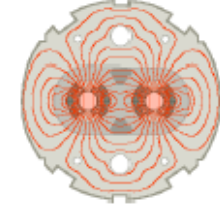


Collimators in all points were used to stop the beam:

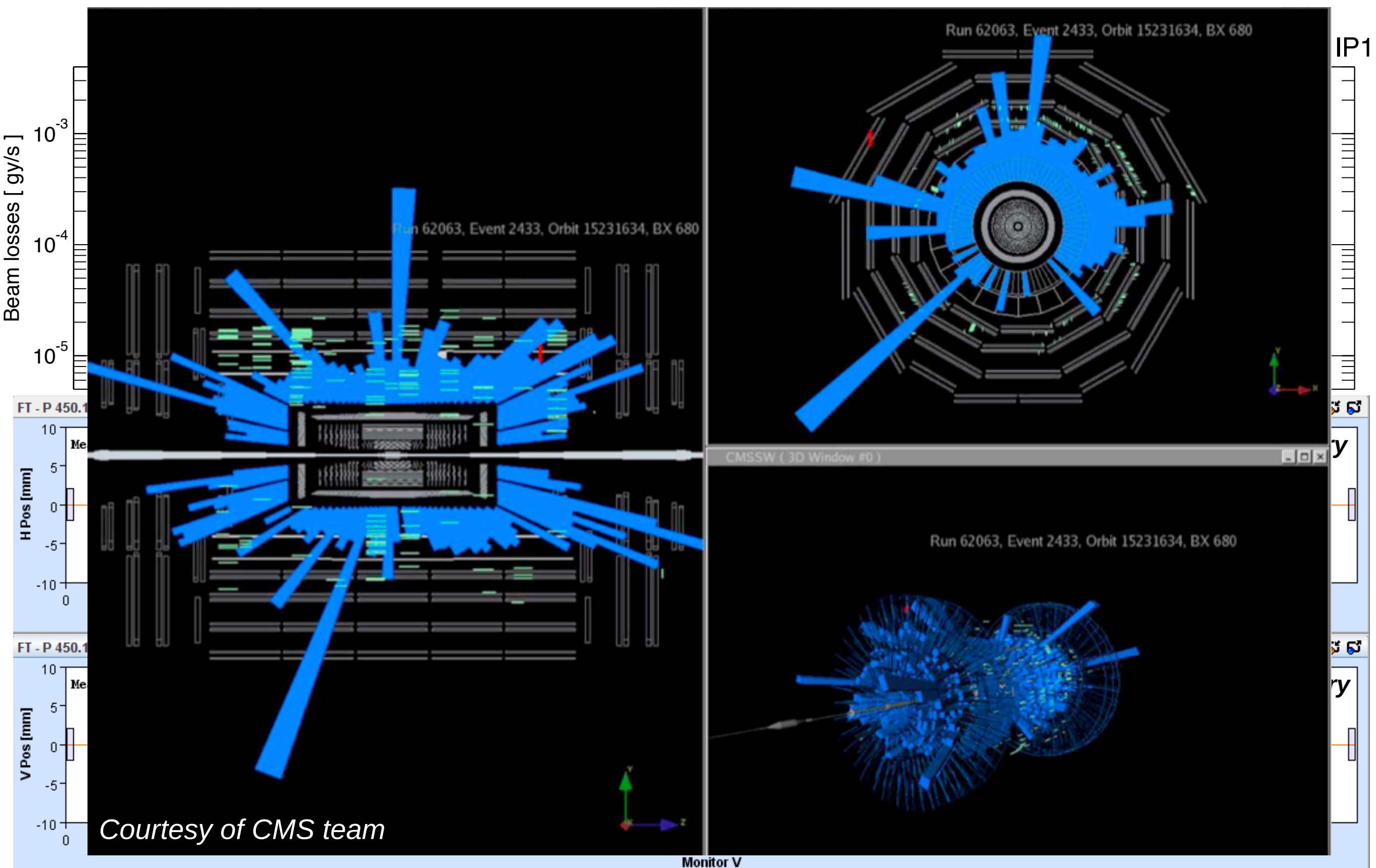
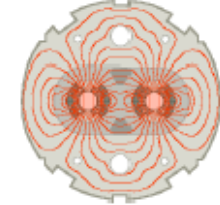
- optimize beam trajectory before going into next sector;
- improve the show!



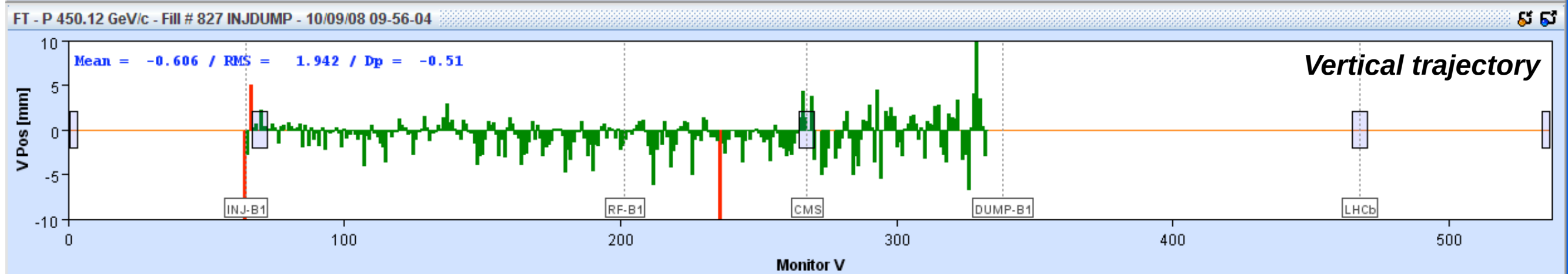
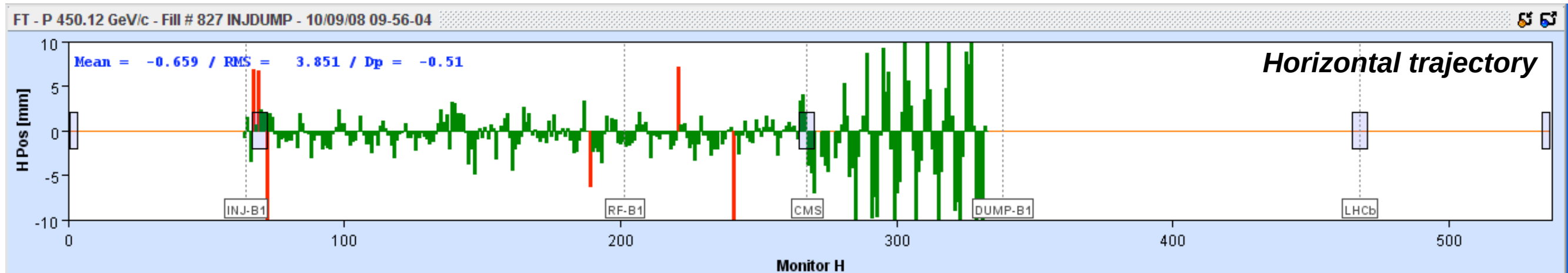
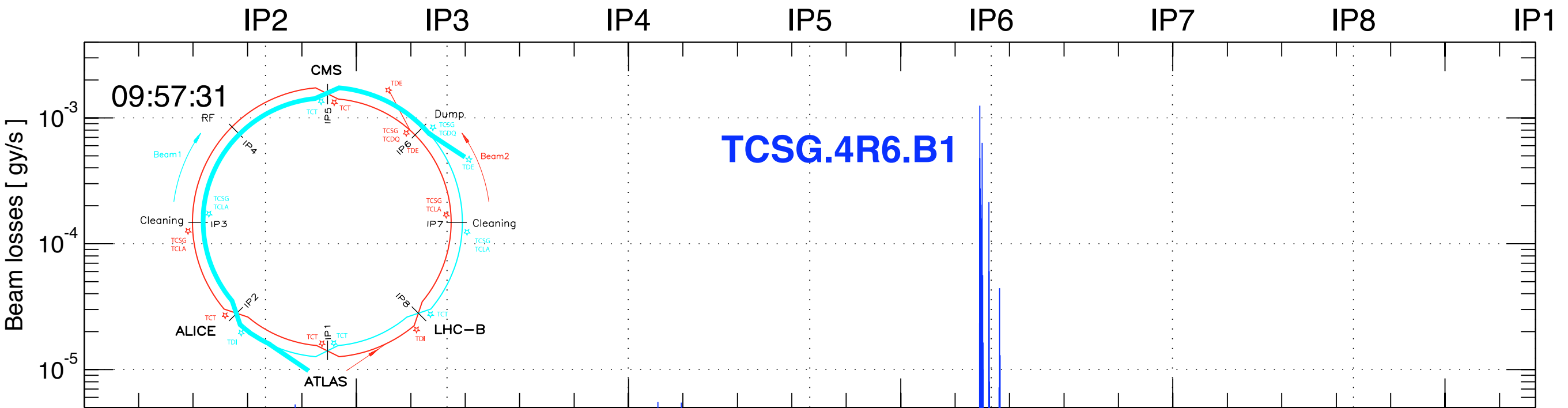
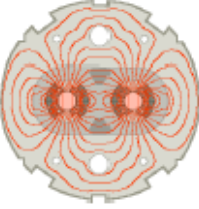
Beam threading - Beam1 to IP3



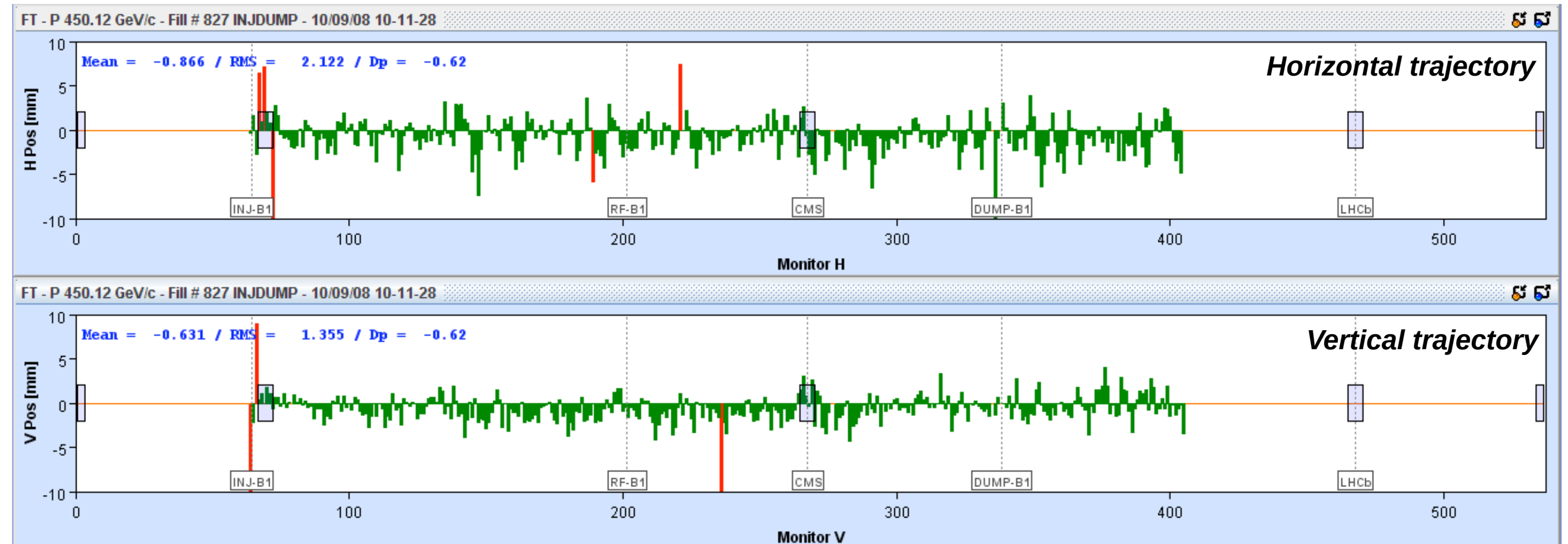
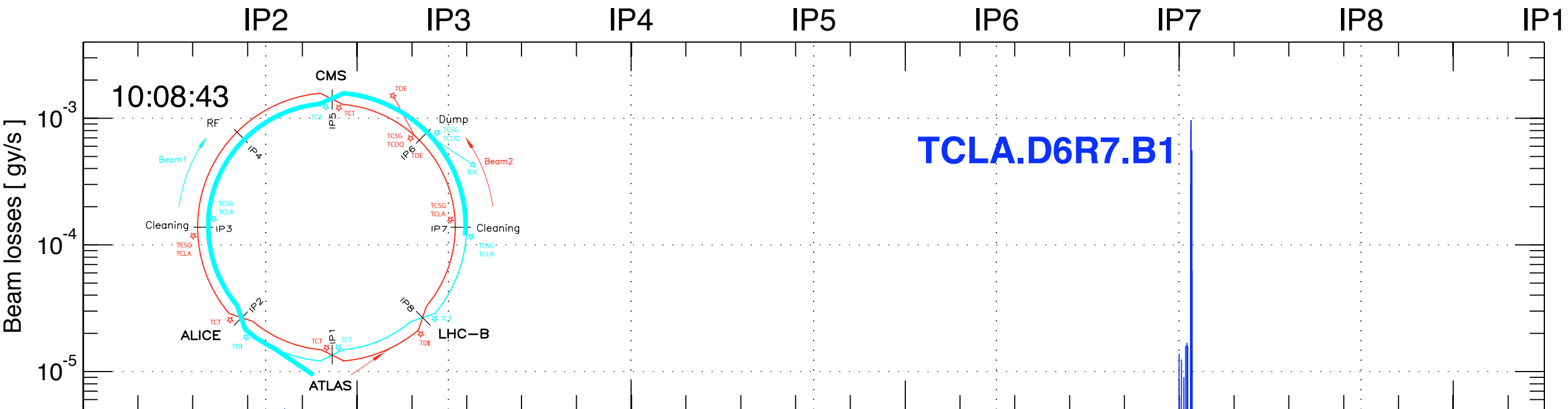
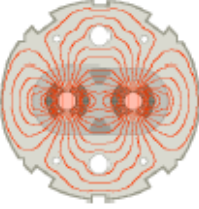
Beam threading - beam to CMS



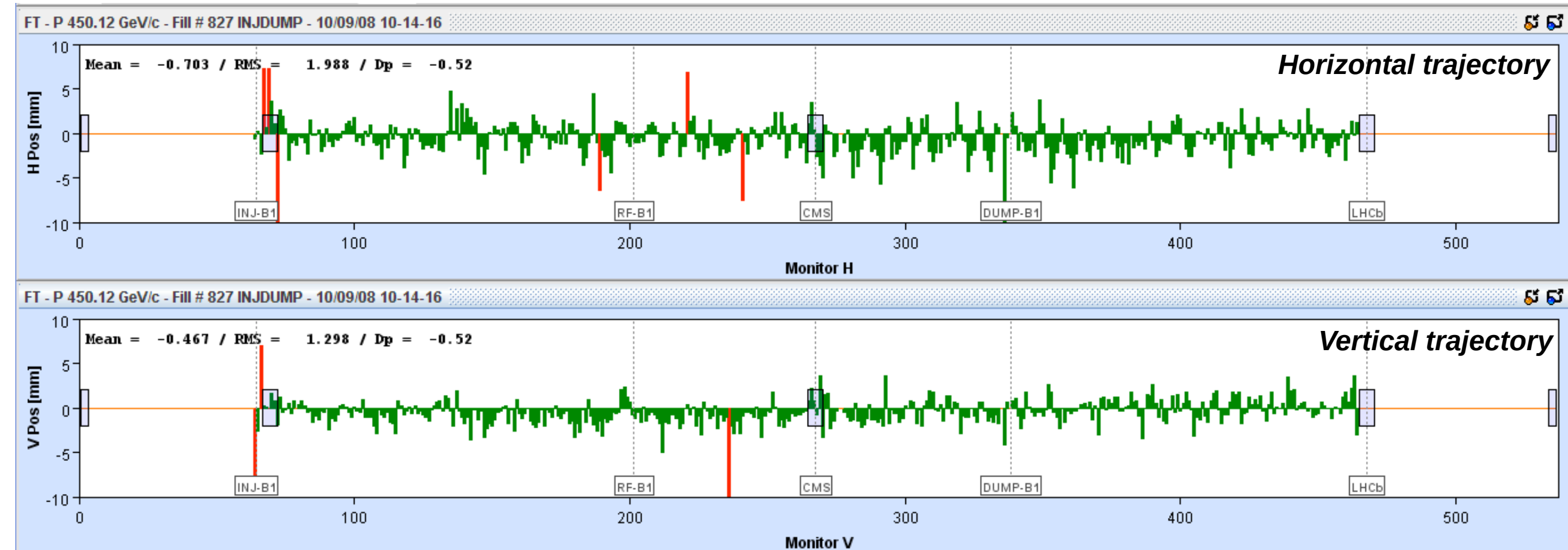
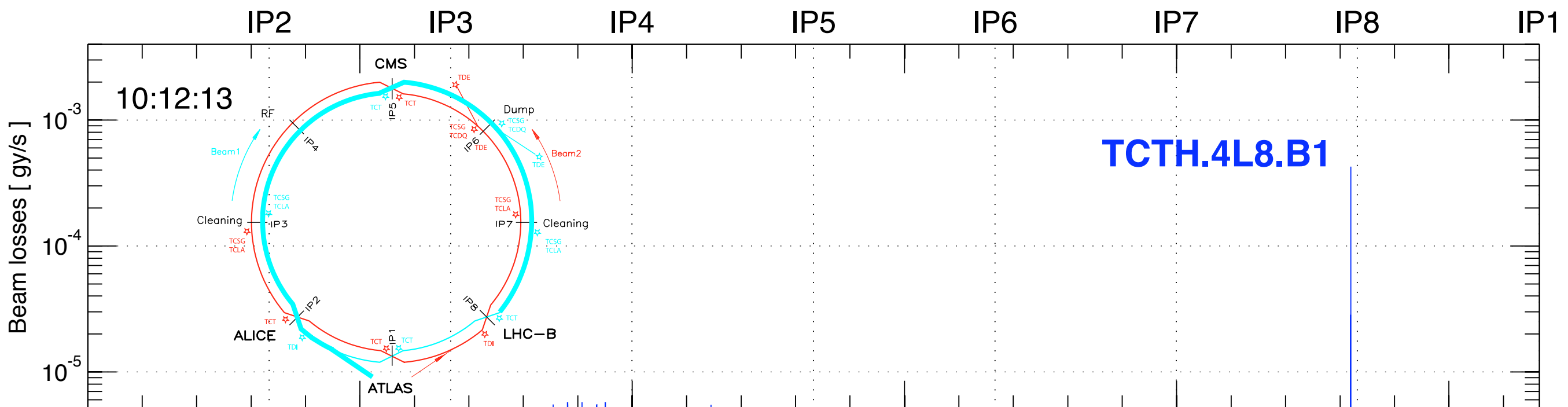
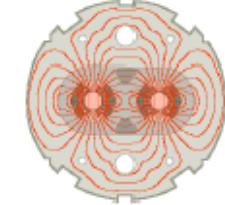
Beam threading - Beam 1 to the dump



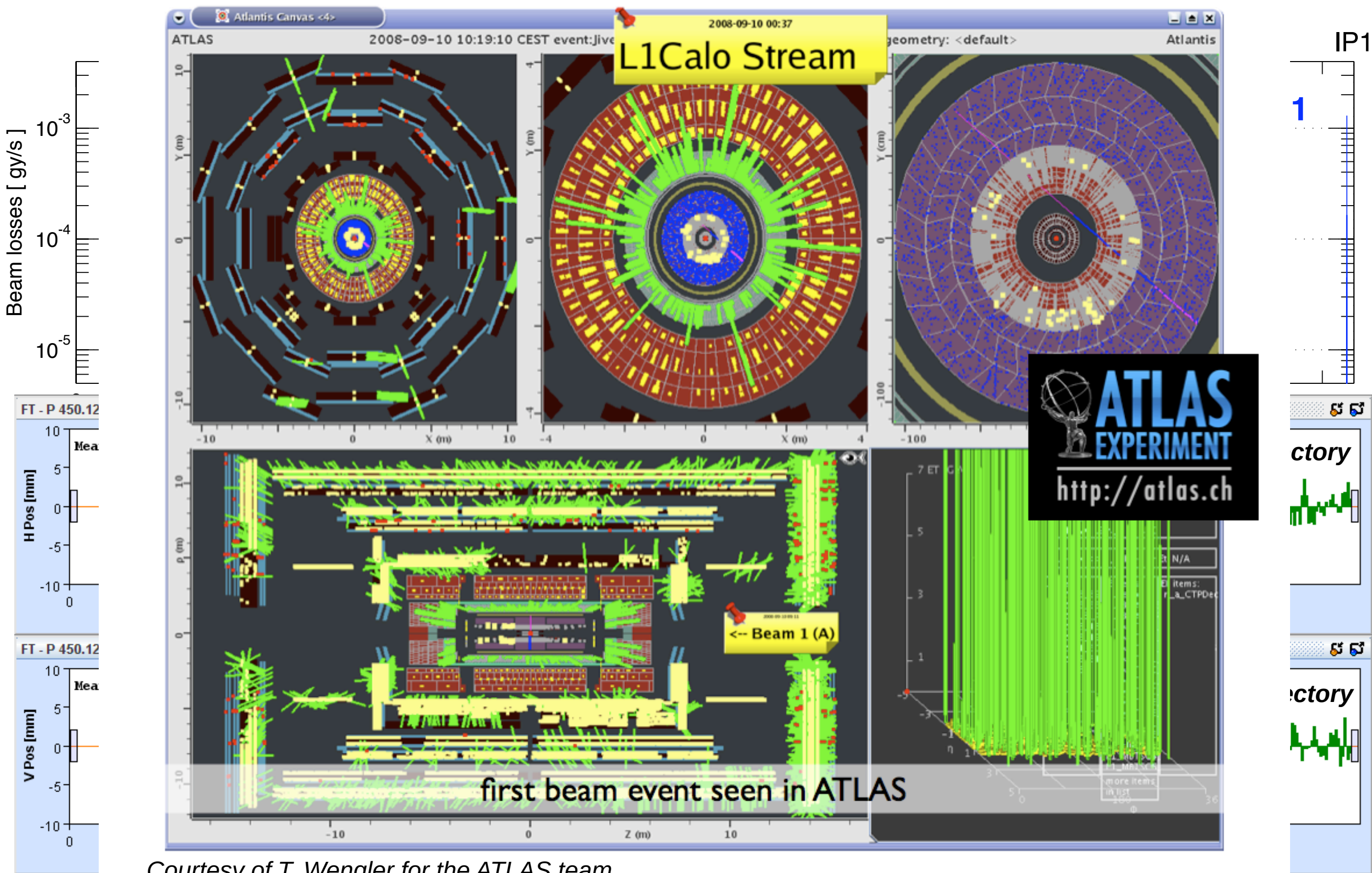
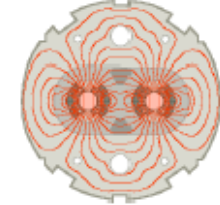
Beam threading - Beam1 to IR7



Beam threading - Beam1 to IR8

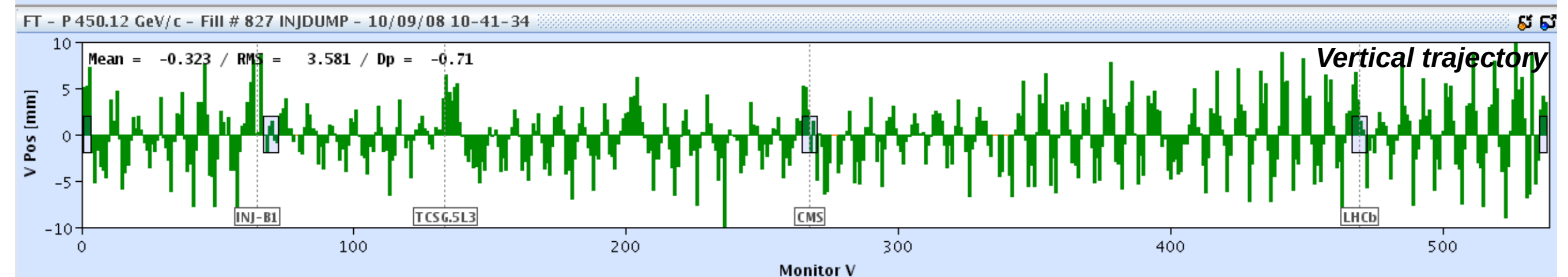
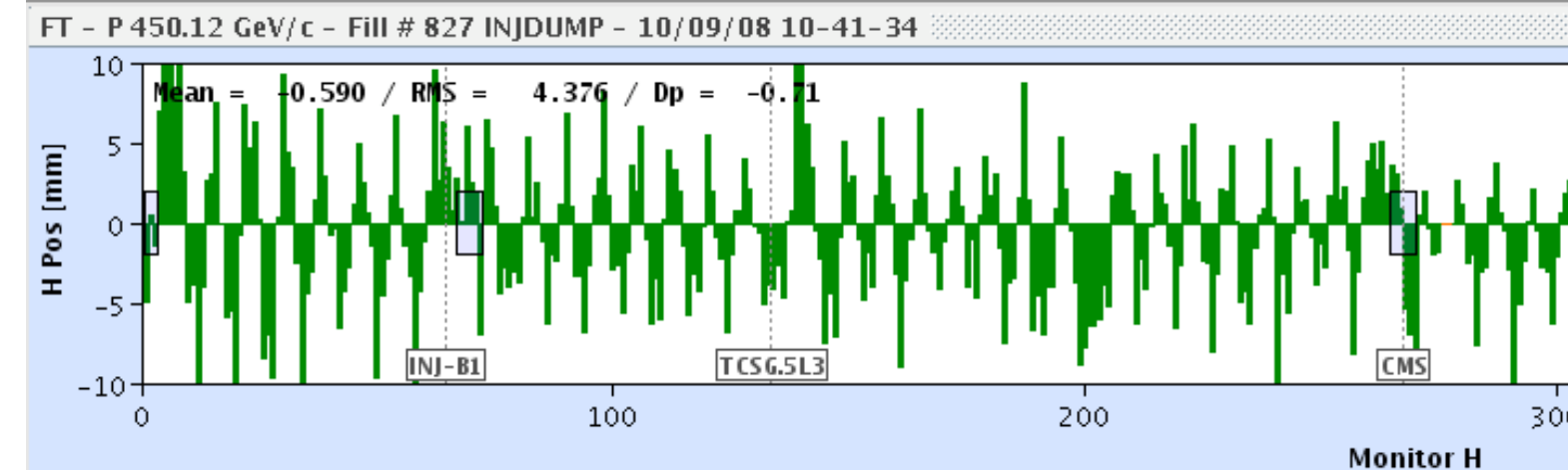
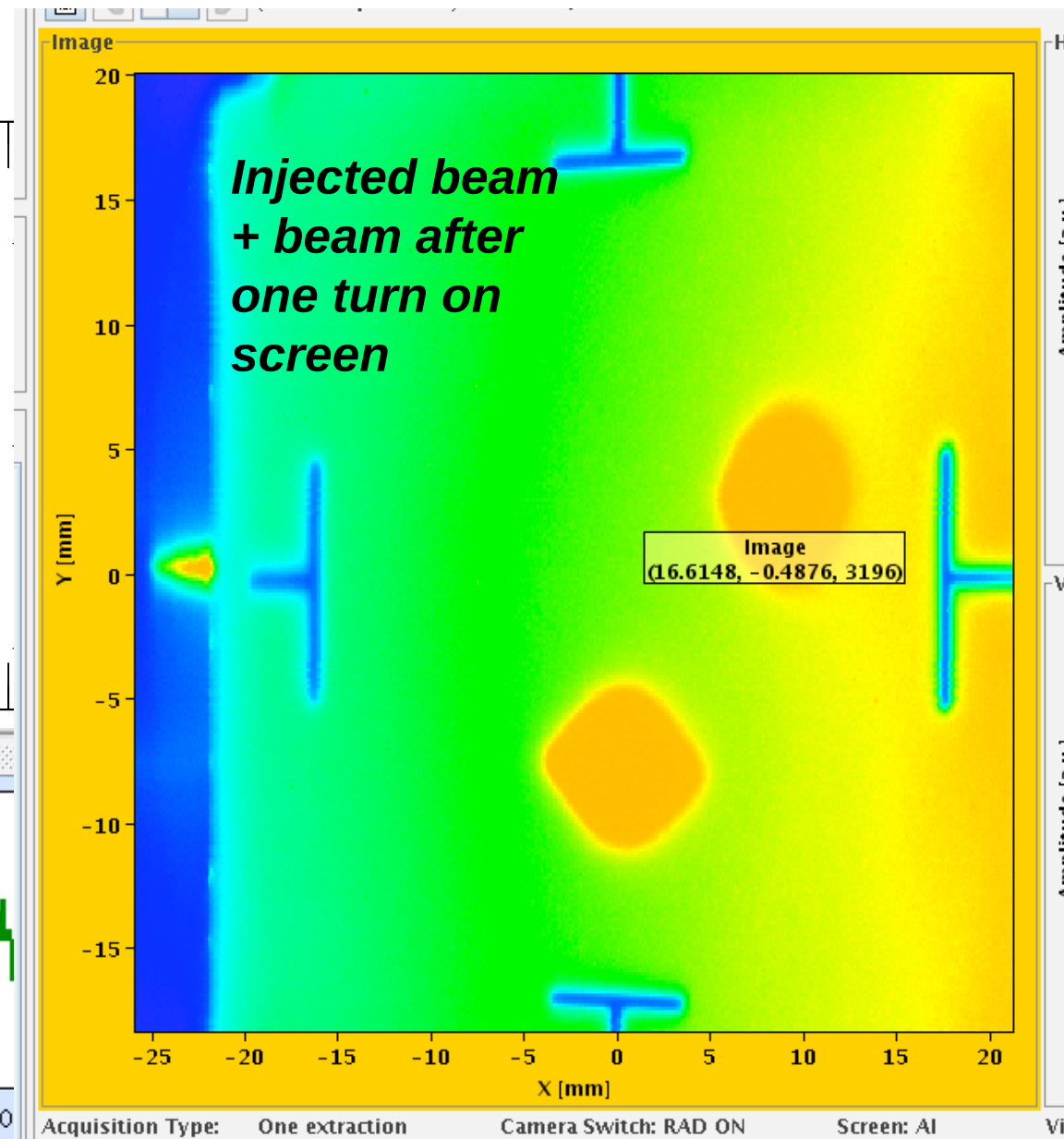
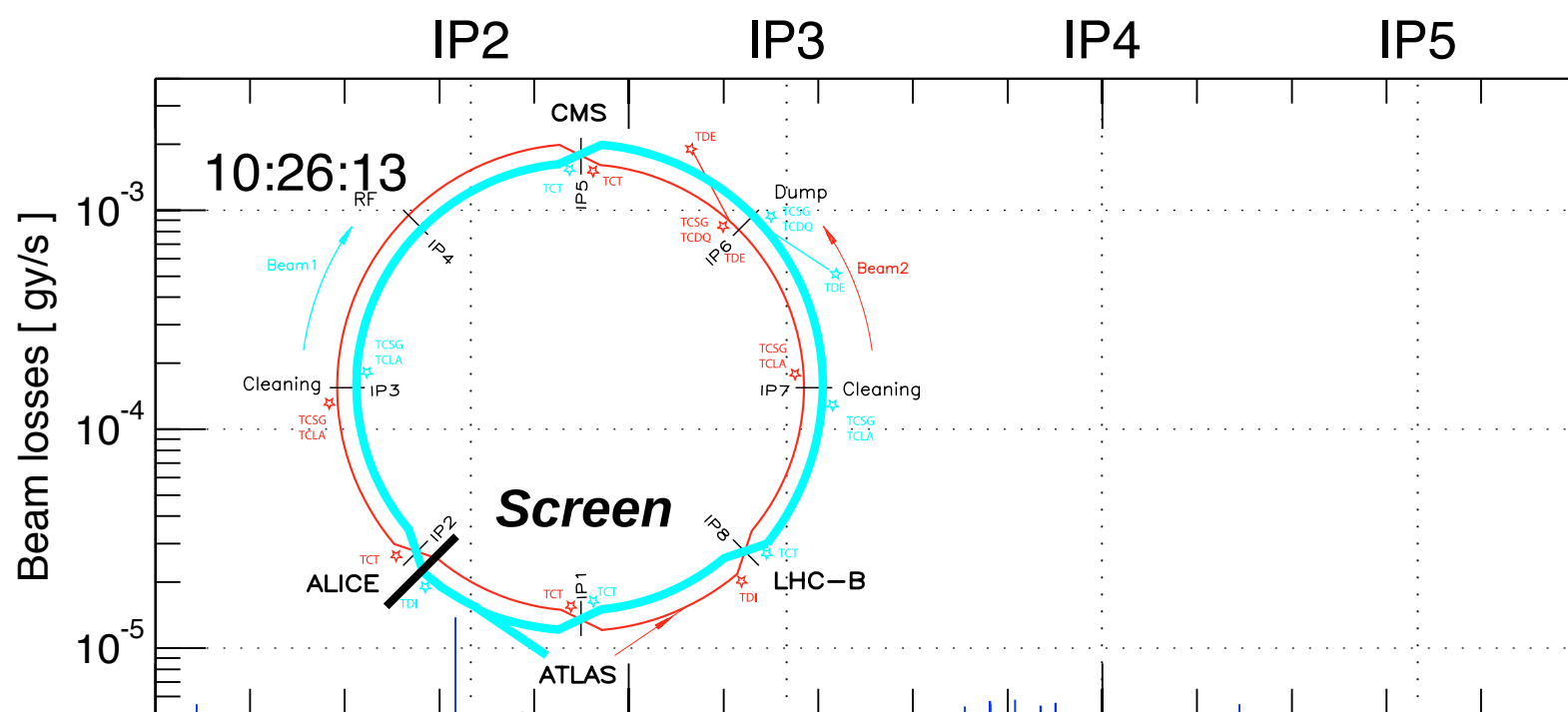
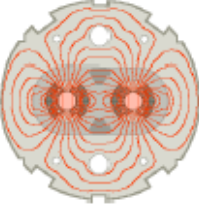


Beam threading - Beam 1 to ATLAS

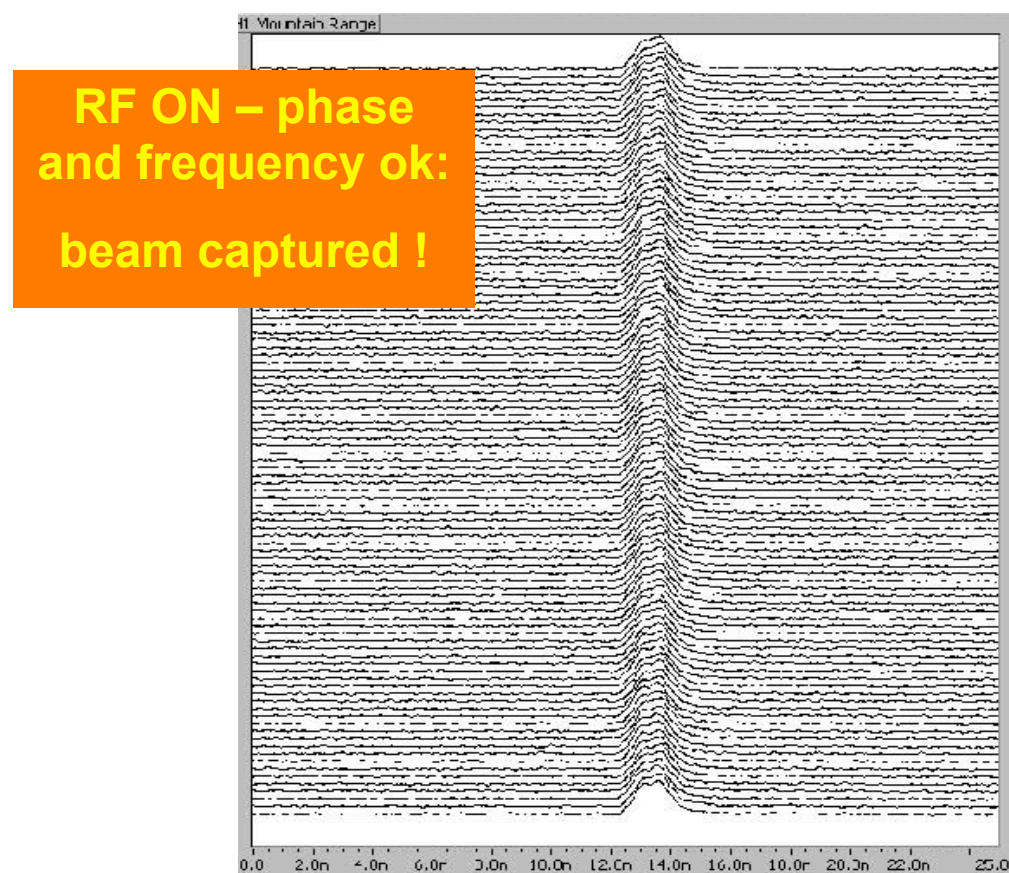
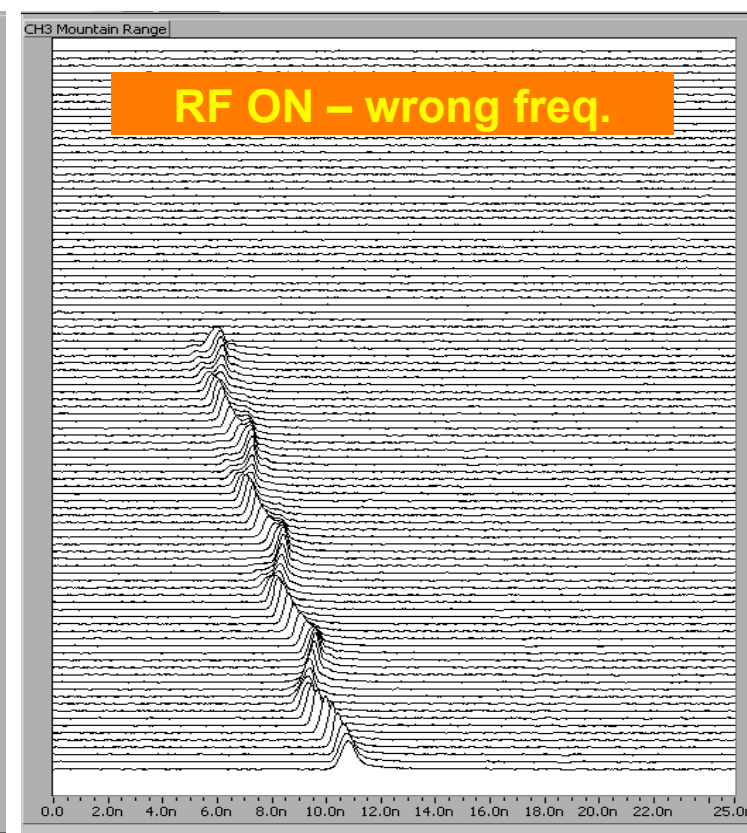
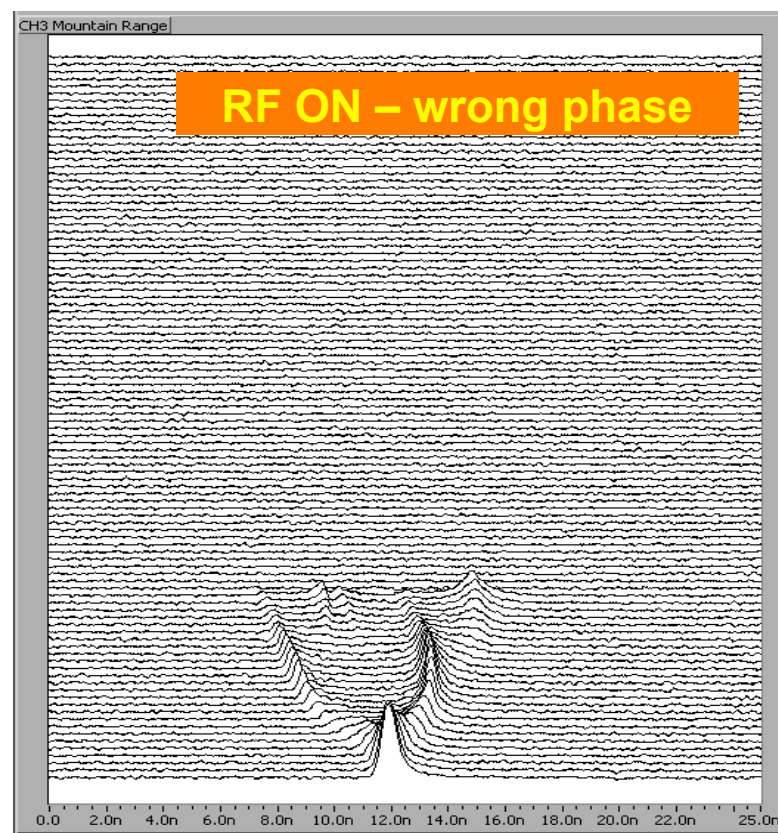
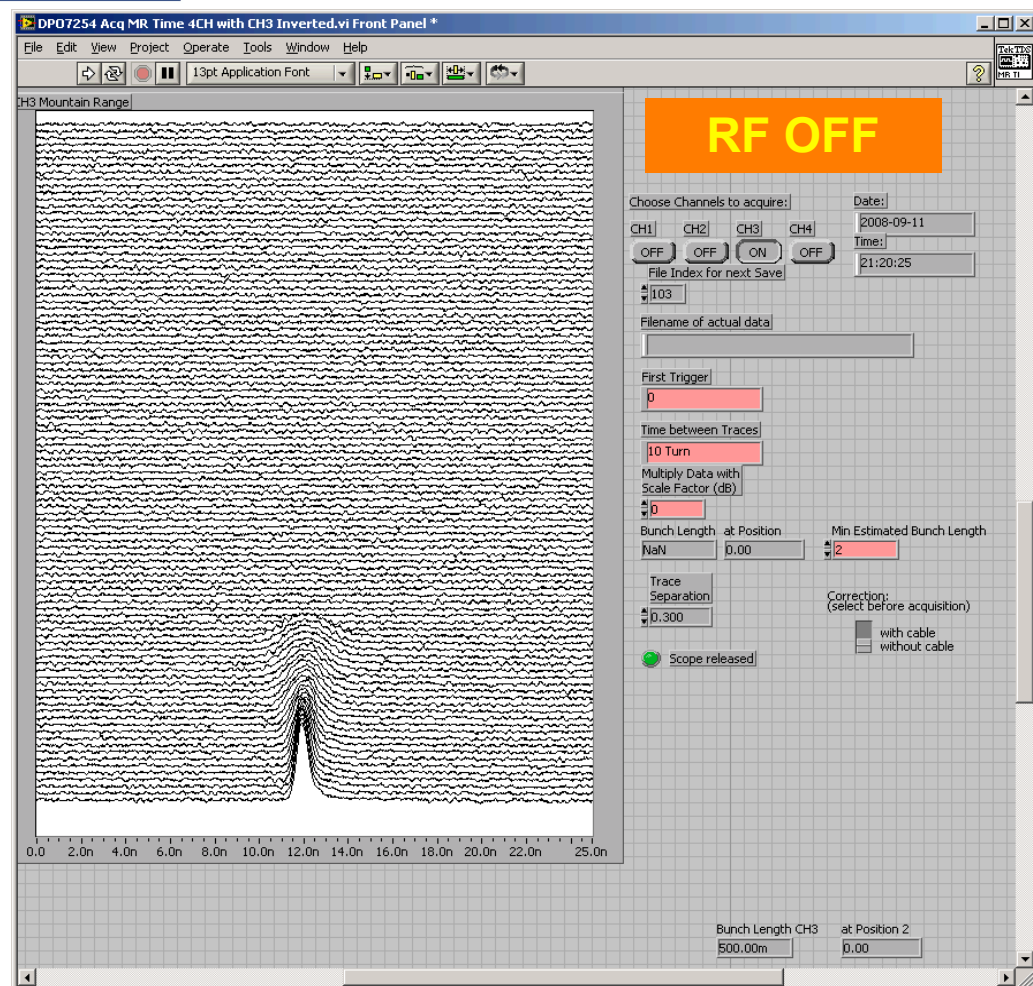
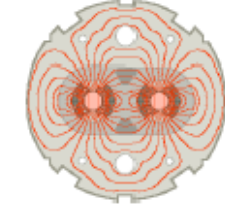


Courtesy of T. Wengler for the ATLAS team

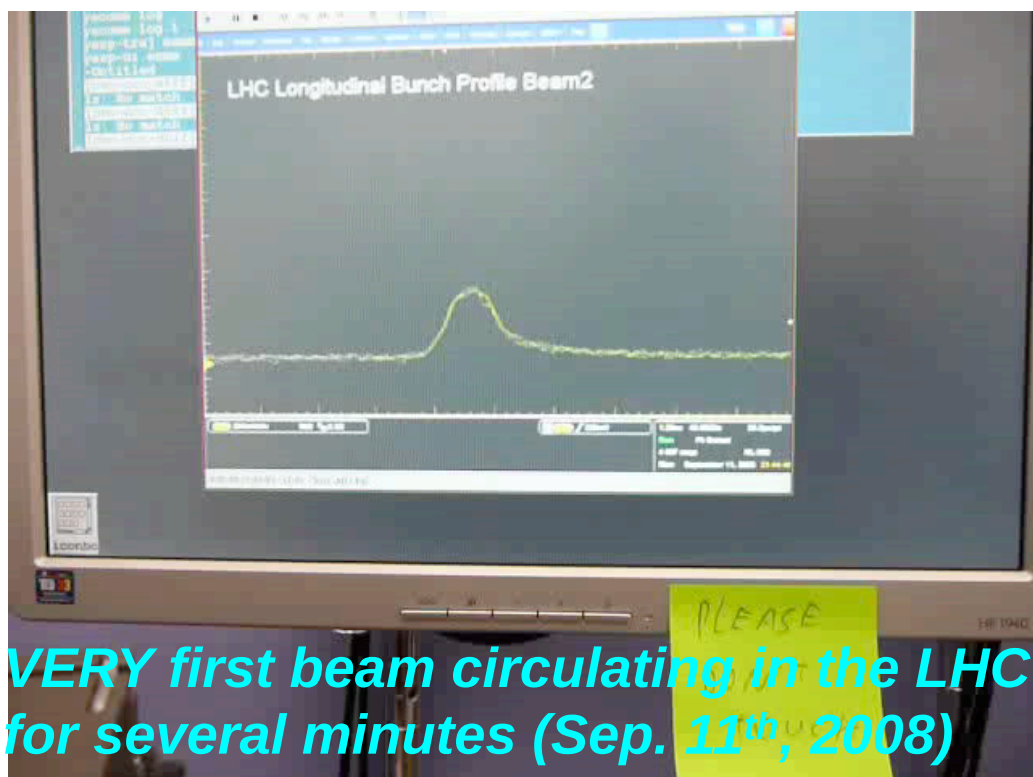
Closure of first turn for beam 1



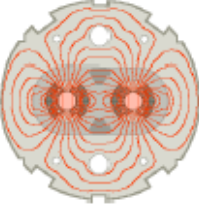
RF capture



Initial commissioning in 2008 for B2



Optimization at injection



```
LHC - B1 - Fill#1020.0
2010-04-03 15:40:28
RAW&FFT: 8192 turns@2.0Hz
no excitation
Q1 = .279645      Qx = .280389
Q2 = .310450      Qy = .309705
|C-| = .009462    E = 450.2 GeV
```

```
LHC - B2 - Fill#1020.0
2010-04-03 15:40:37
RAW&FFT: 8192 turns@2.0Hz
no excitation
Q1 = .279884      Qx = .280118
Q2 = .309541      Qy = .309307
|C-| = .005246    E = 450.2 GeV
```

- Tunes to nominal injection values (H / V = 0.28 / 0.31)
- Chromaticity under control
- Coupling under control
- Repeat with experiment magnets on
- Establish reproducibility fill after fill (with pre-cycle)

...

Work of weeks!

LHC FBCT Beam Lifetime

I(total) B1:

4.91e+09

I(total) B2:

4.14e+09

13-03-2010

Average lifetime B1:

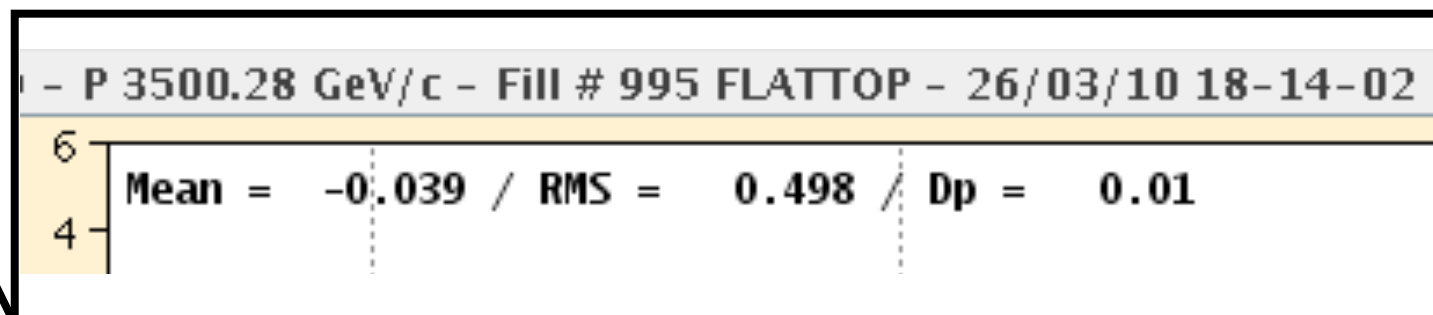
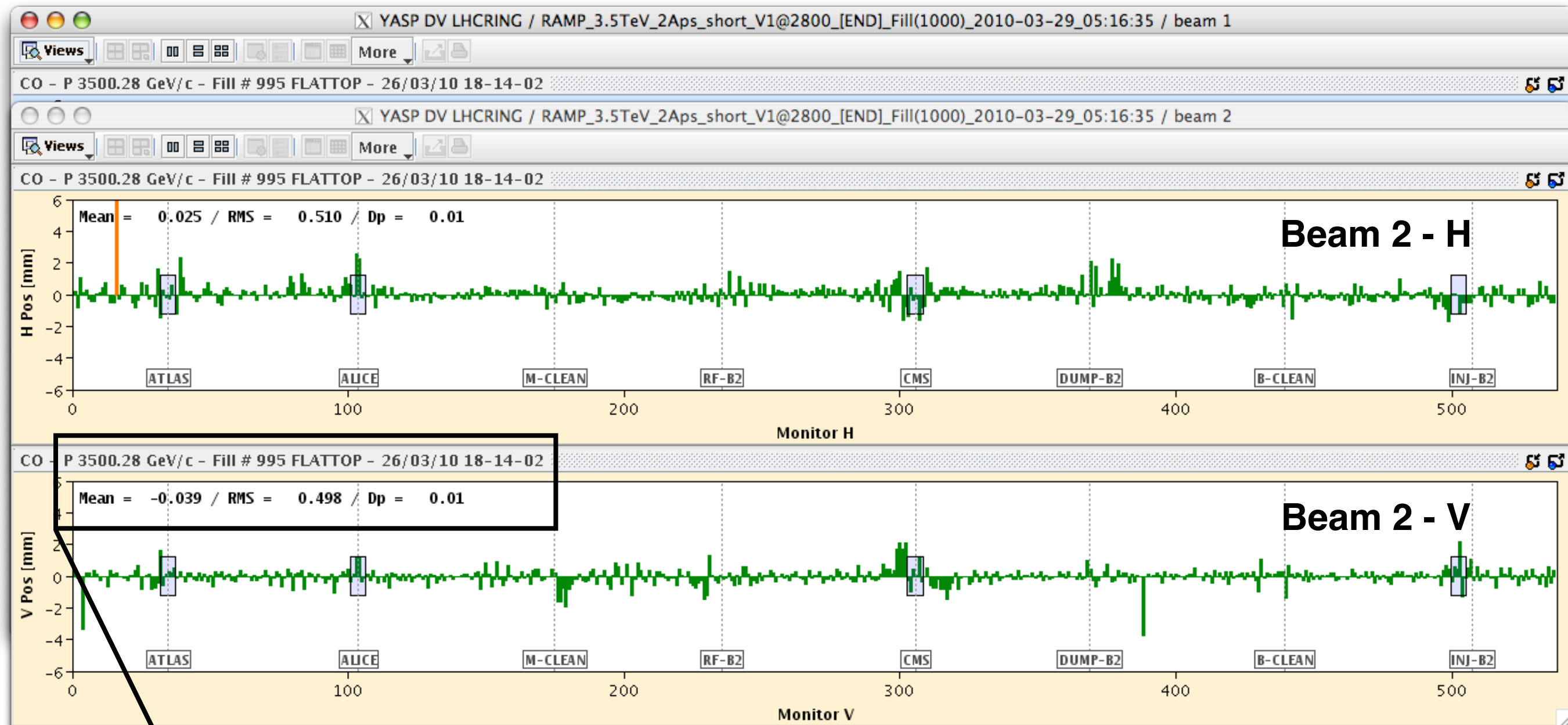
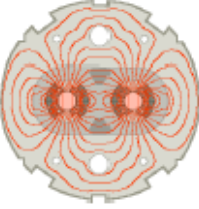
100.00 h

Average lifetime B2:

88.32 h

16:42:34

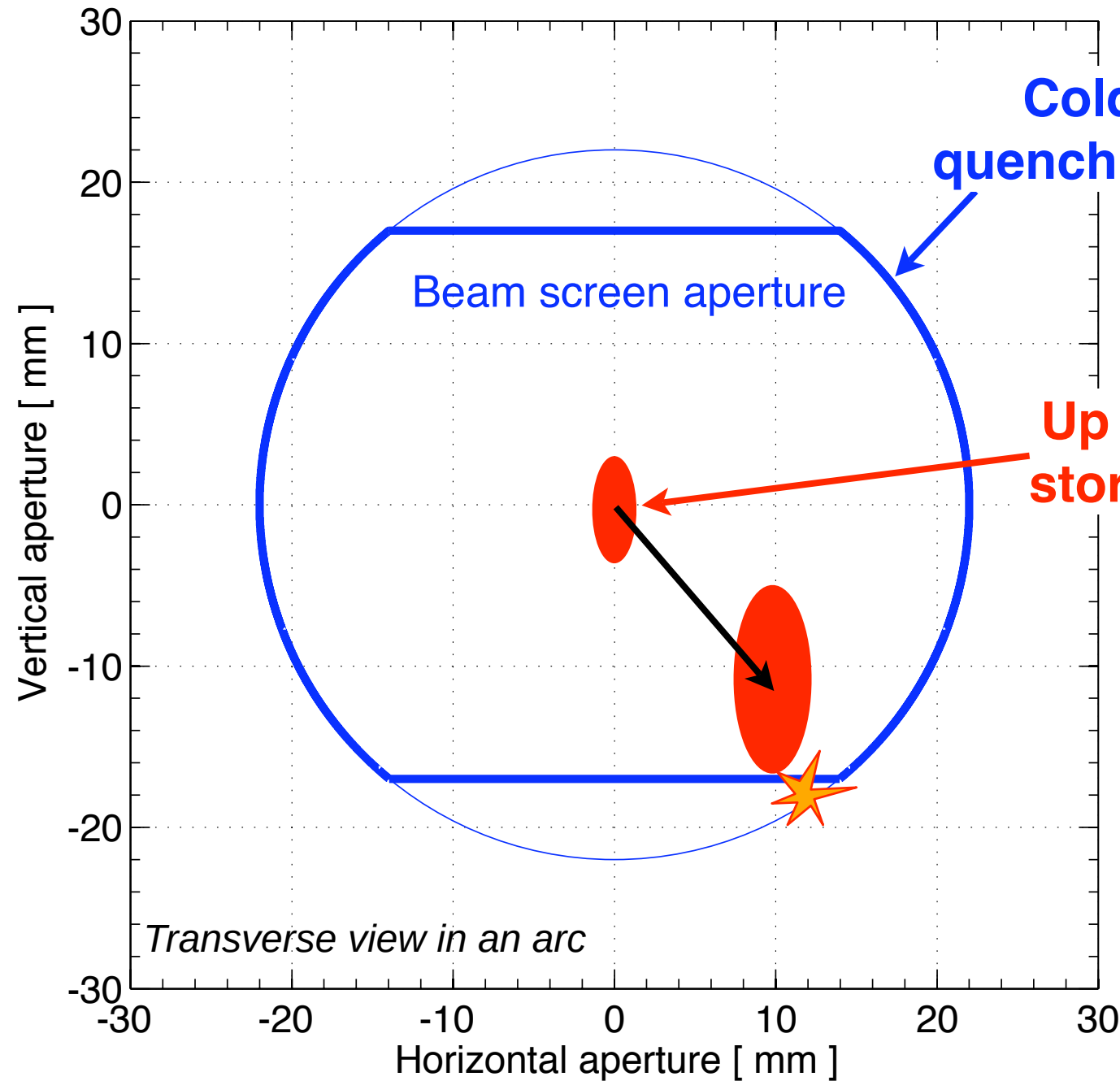
2010 reference “golden” orbit



Is this good or bad??

J. Wenninger

One word on references and tolerances



Orbit, beam size and alignment must be controlled well and kept constant to avoid problems!

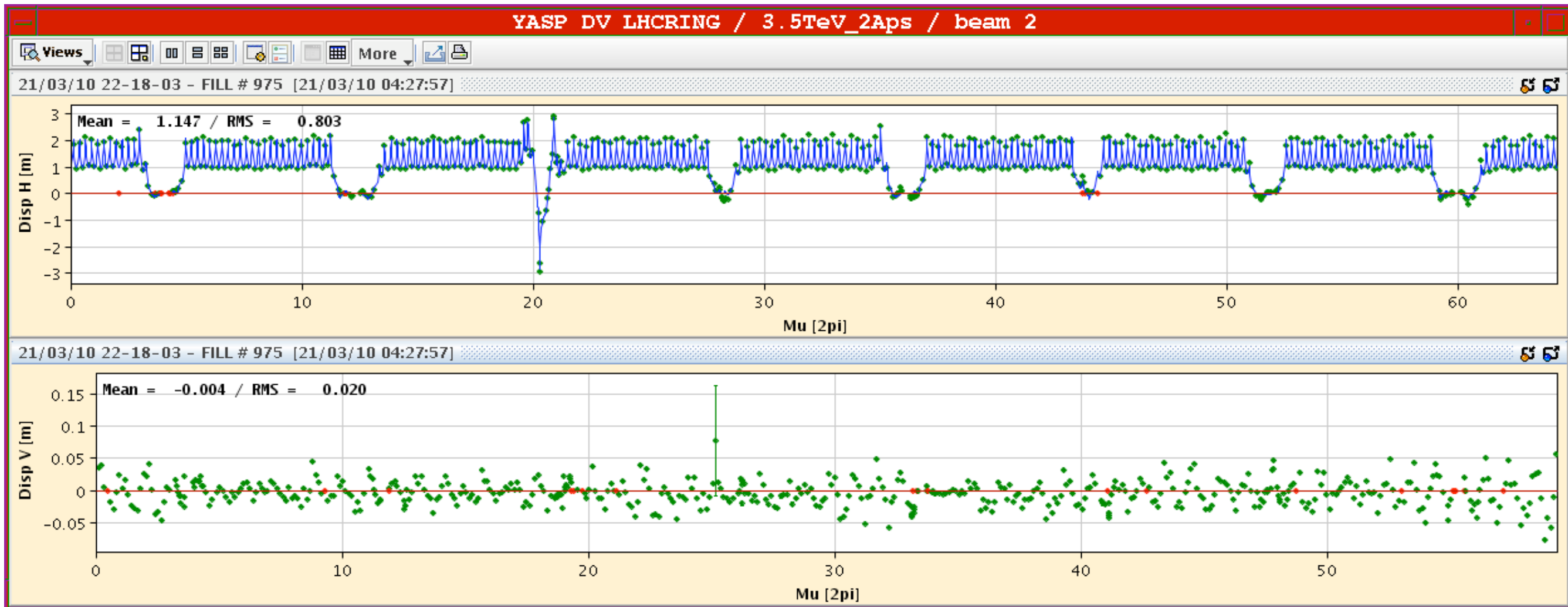
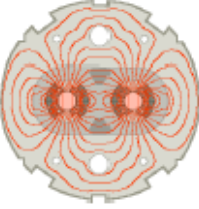
Tolerance table

Closed orbit	$\pm 4 \text{ mm}$
Beta-beat	$\pm 20 \%$
Spurious dispersion	$27\% D_{\text{nom}}^{\text{Arc}}$
Mechanical tolerance	1-2.5 mm
Alignment	1.0.-1.6 mm

In addition, collimators gaps are set with respect to reference orbit and beam size (remember Spain/Italy on euro coin ! !).

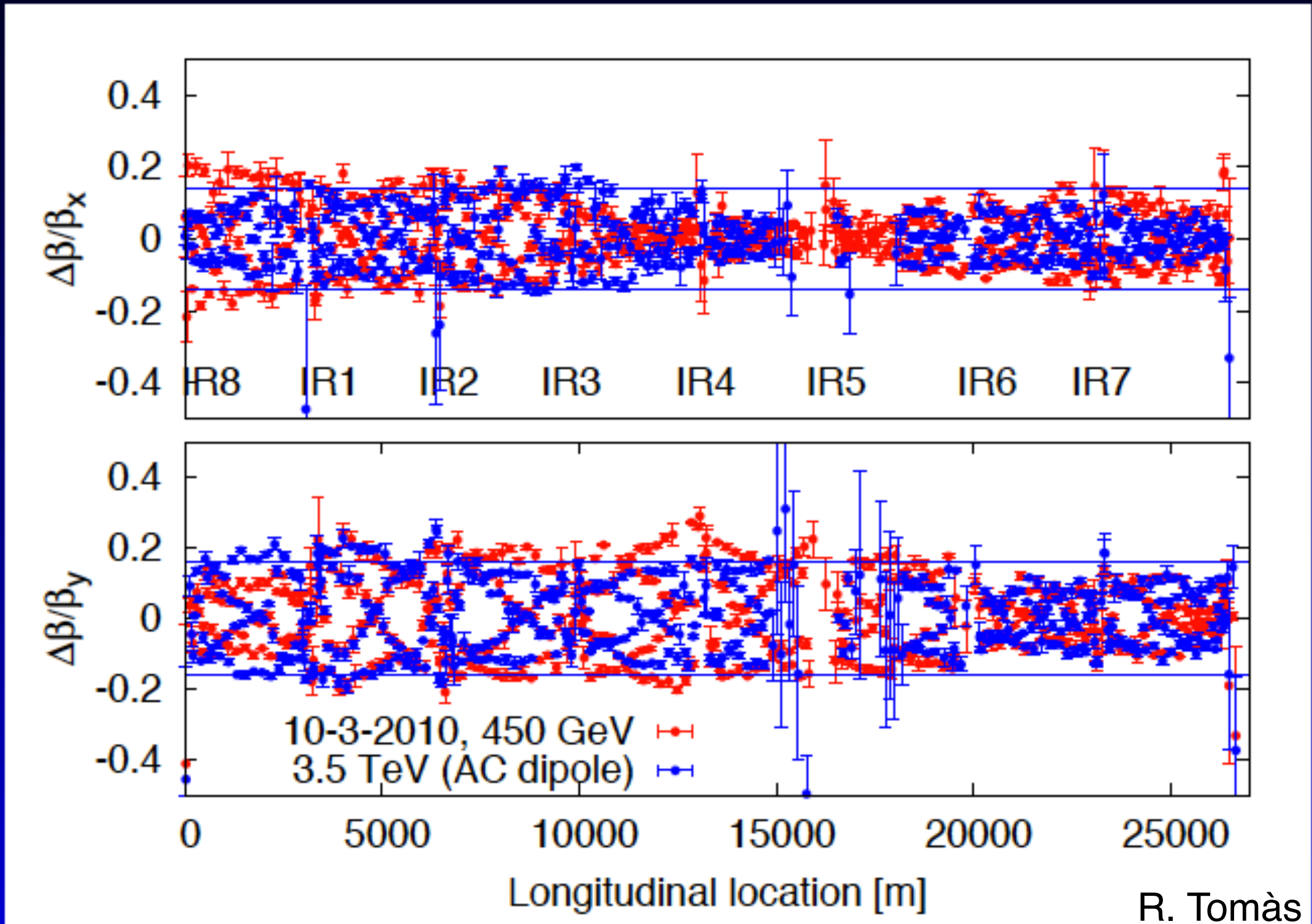
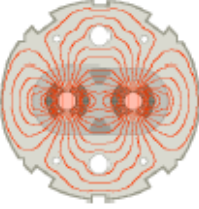
A new collimator alignment campaign (several hours) needed if reference changes!

Optics: dispersion



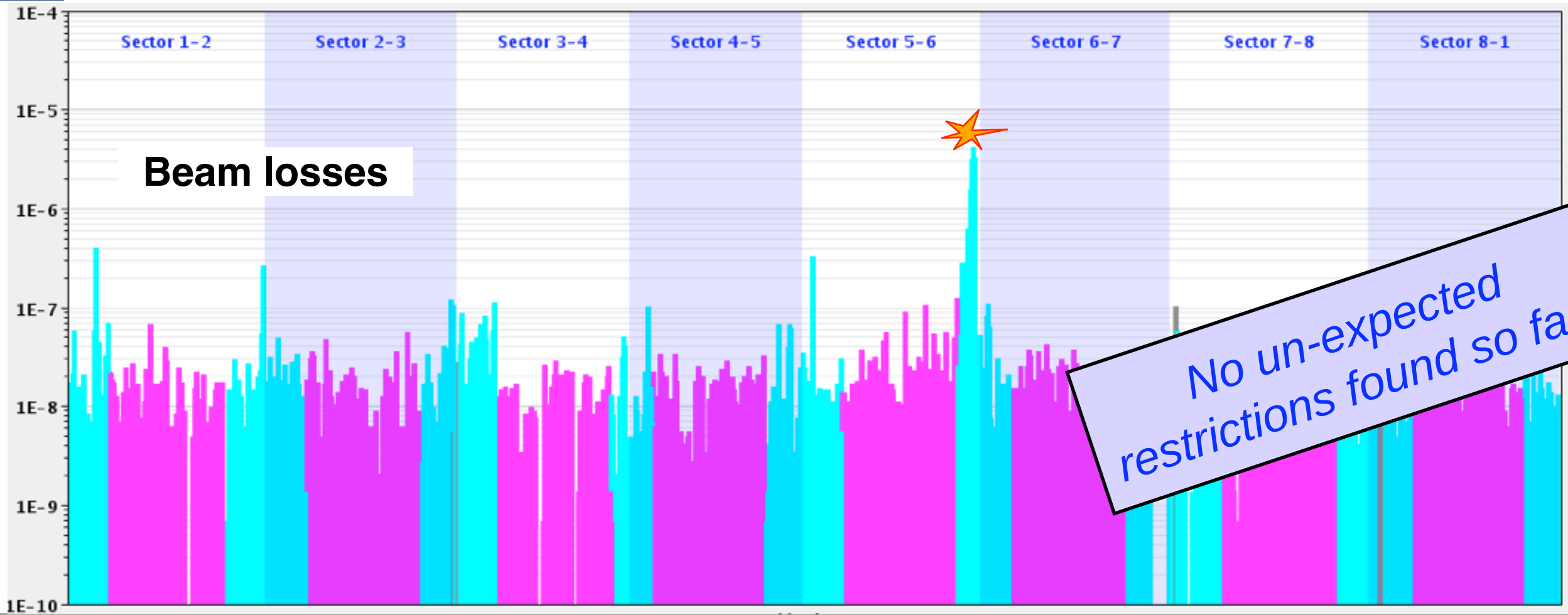
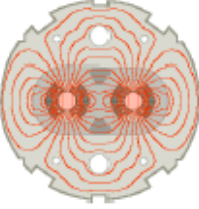
J. Wenninger

Optics: correction of β functions

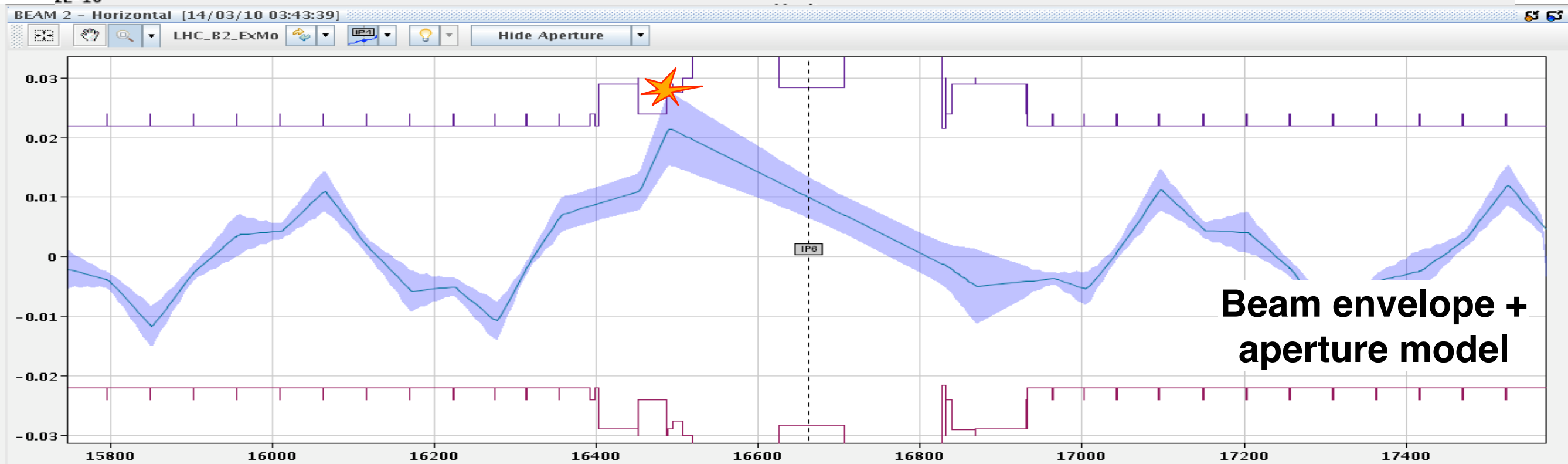


20% beating!

Aperture measurements

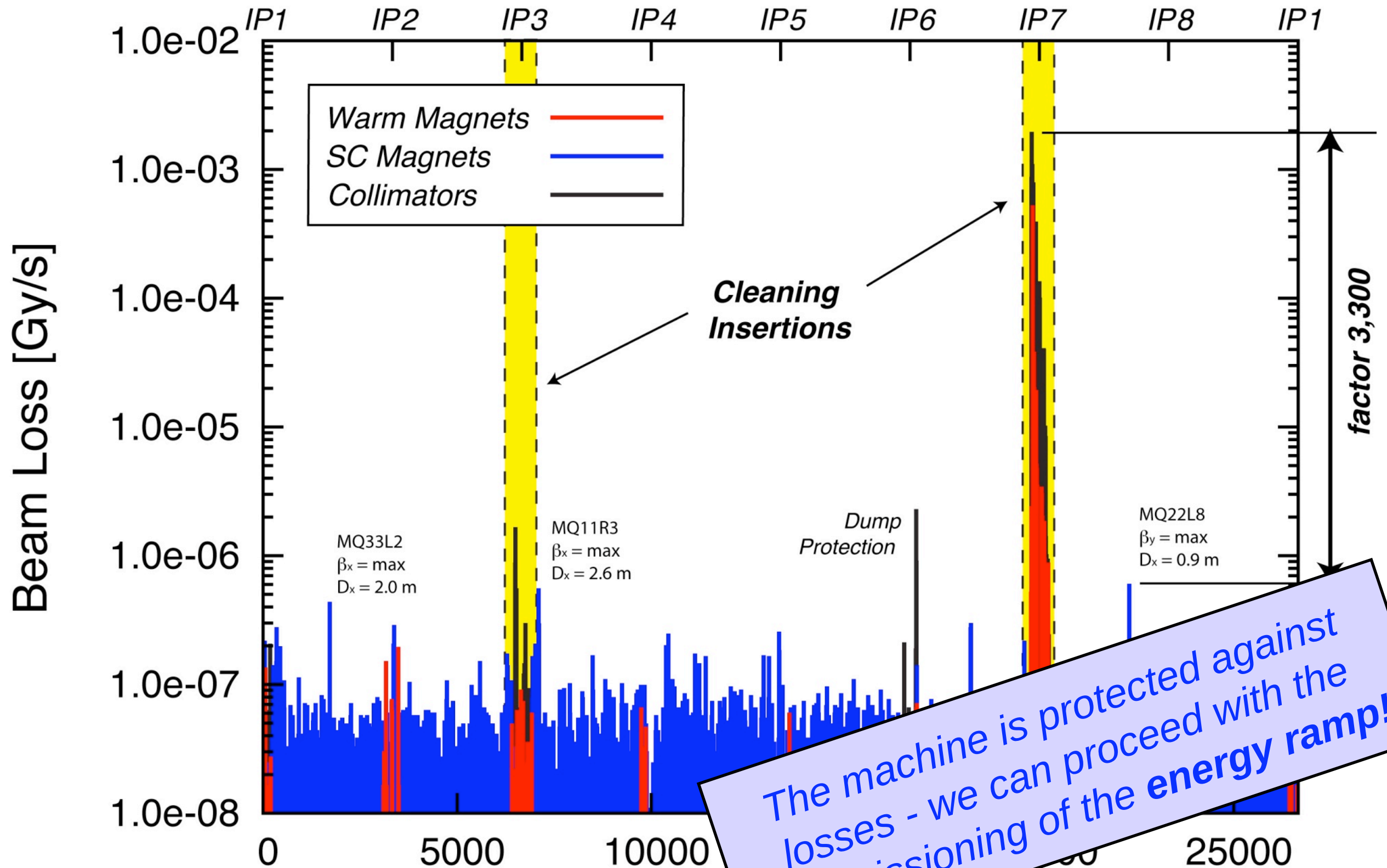


No un-expected restrictions found so far..



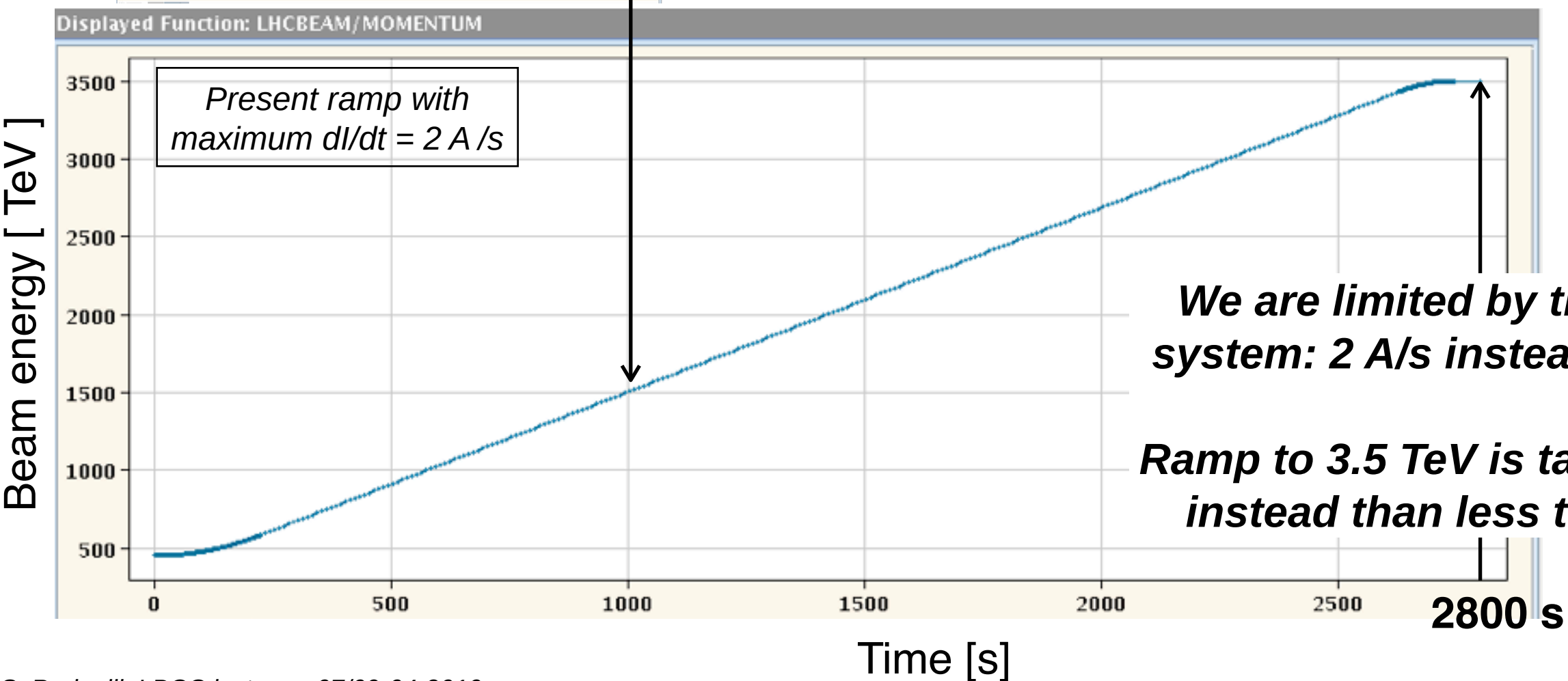
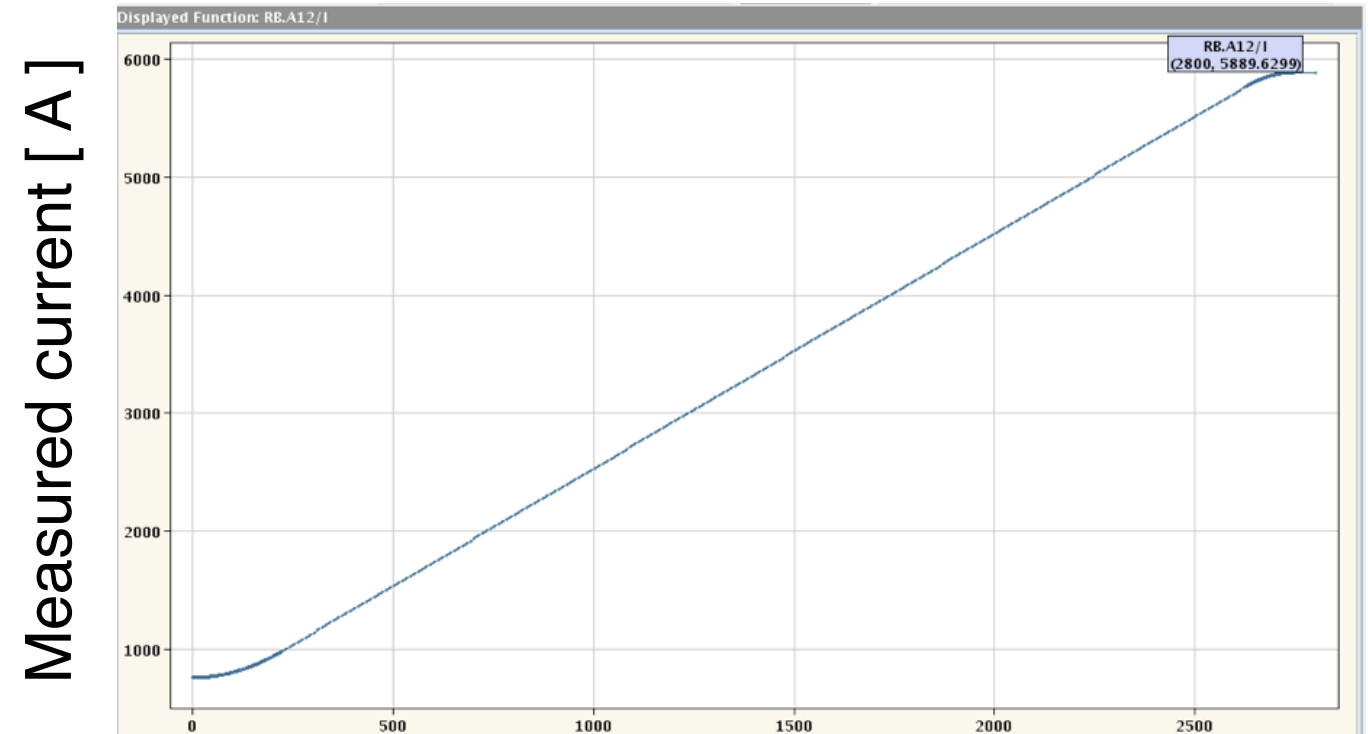
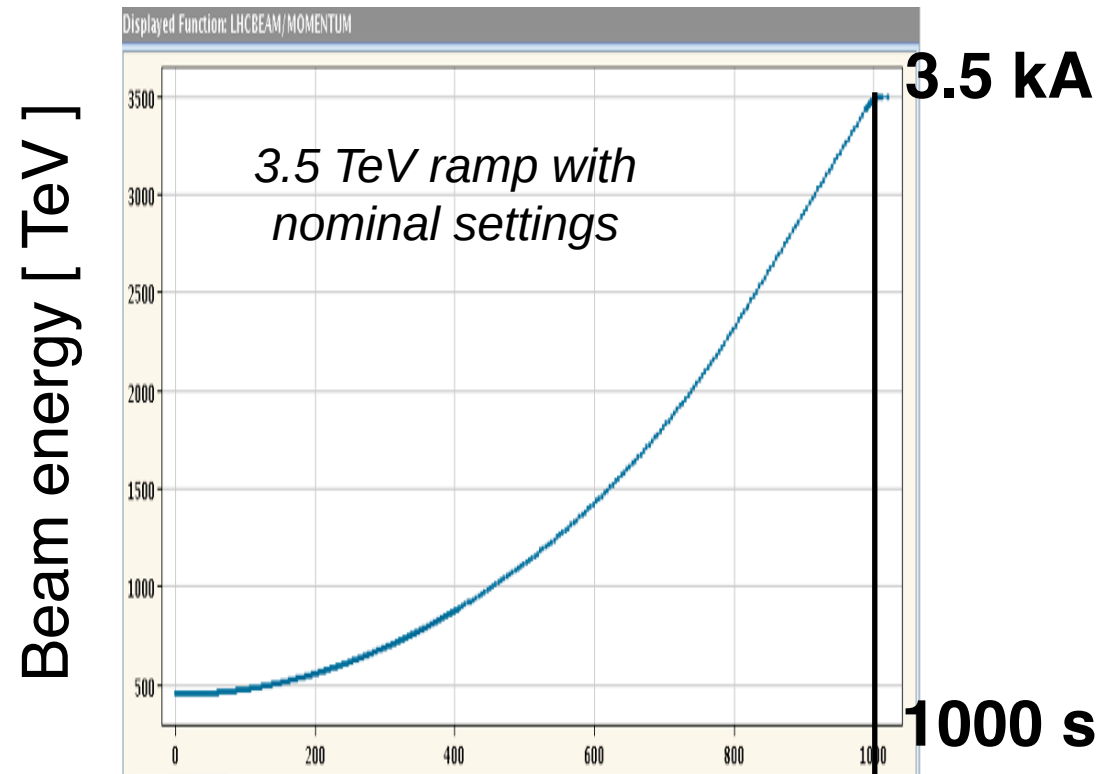
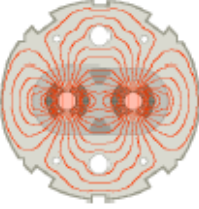


Cleaning efficiency



The machine is protected against losses - we can proceed with the commissioning of the **energy ramp!**

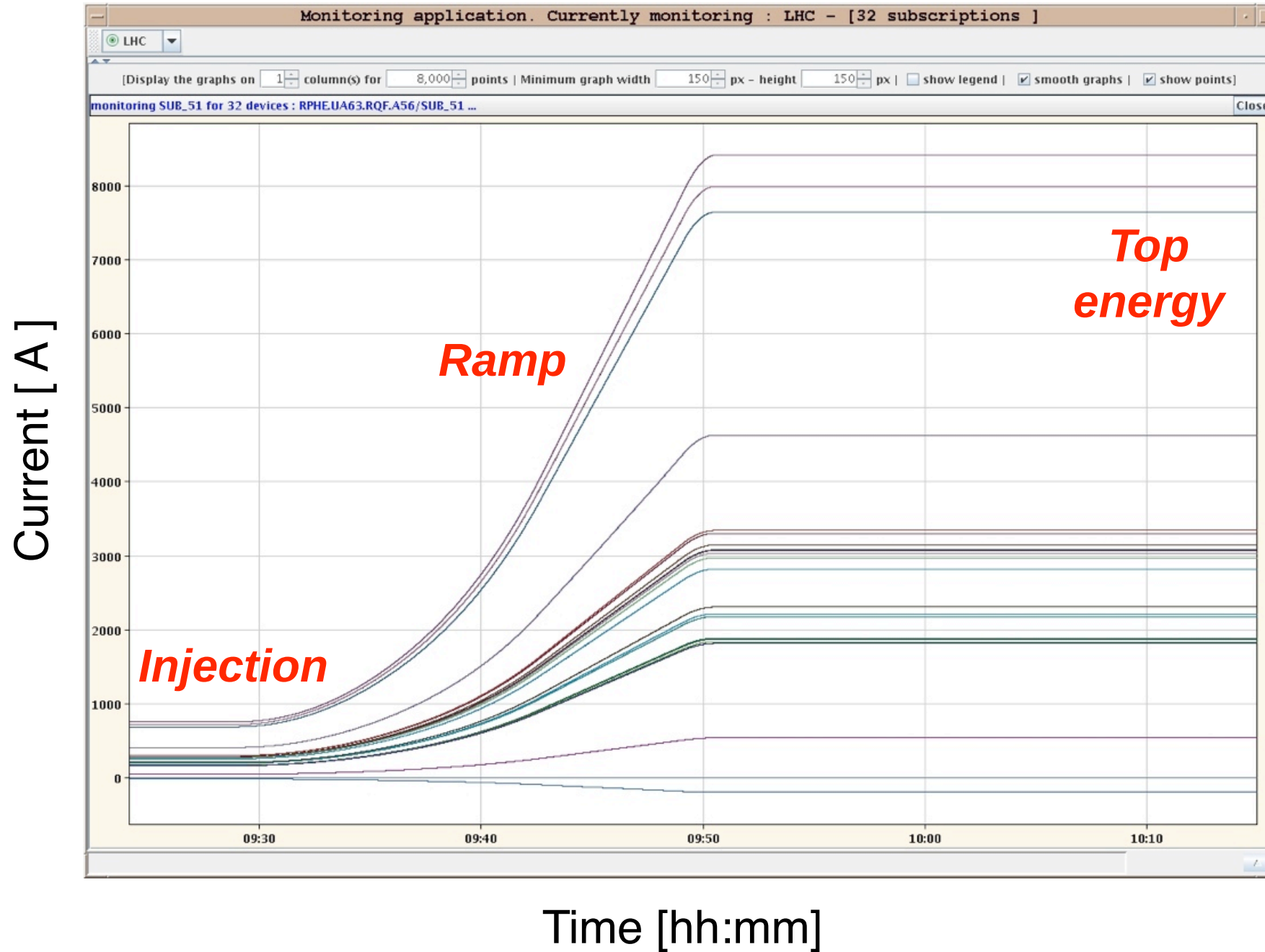
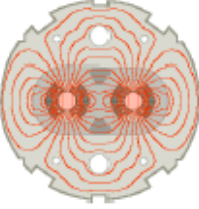
Ramp functions - dipoles



We are limited by the new QPS system: 2 A/s instead than 10 A/s

Ramp to 3.5 TeV is taking ~ 45 min instead than less than 20 min.

Scaling of currents with energy



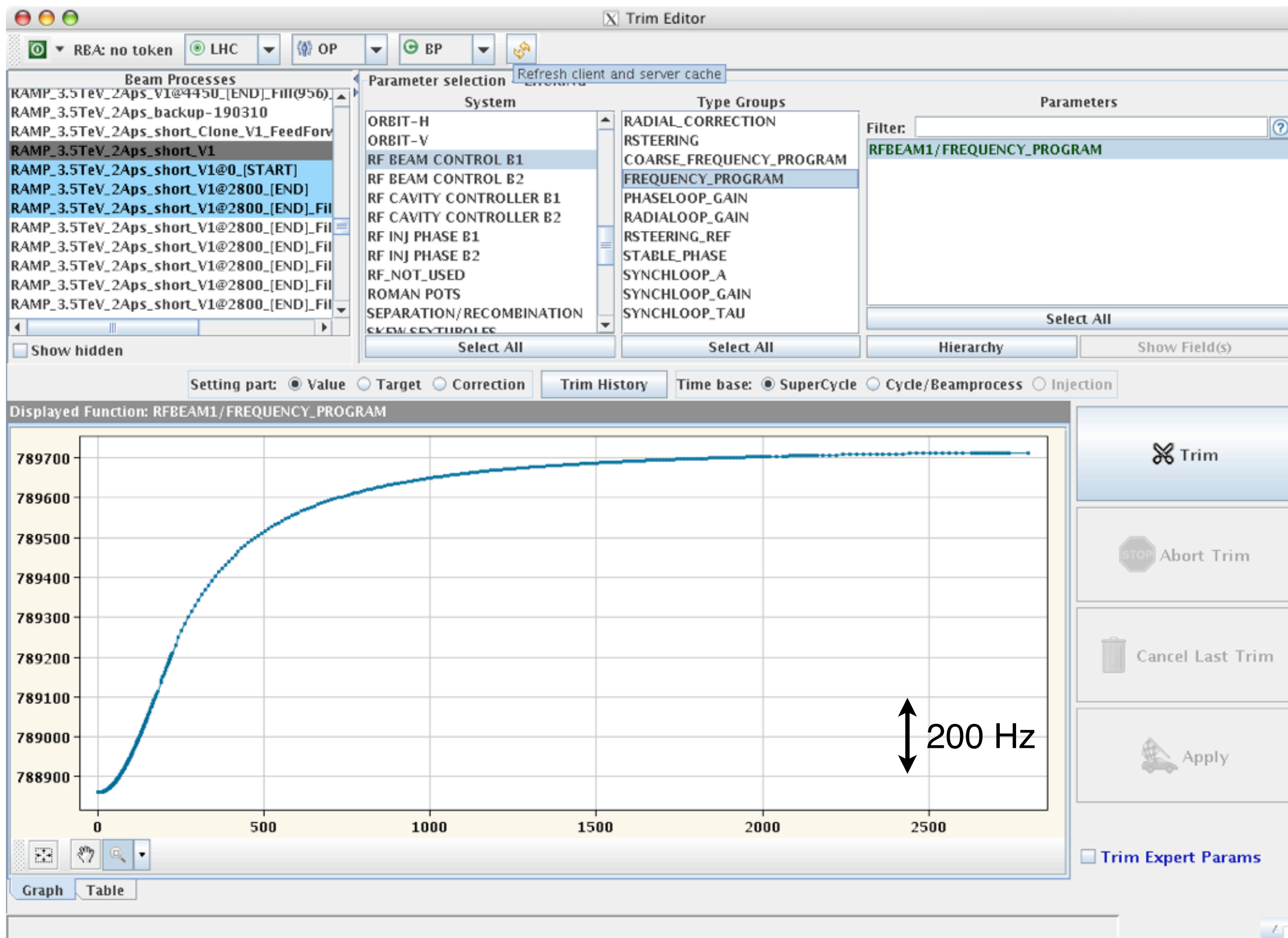
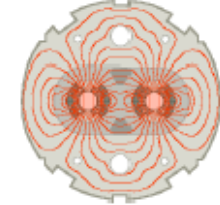
$$B\rho = \frac{p}{e}$$

The magnetic fields must match the beam energy!

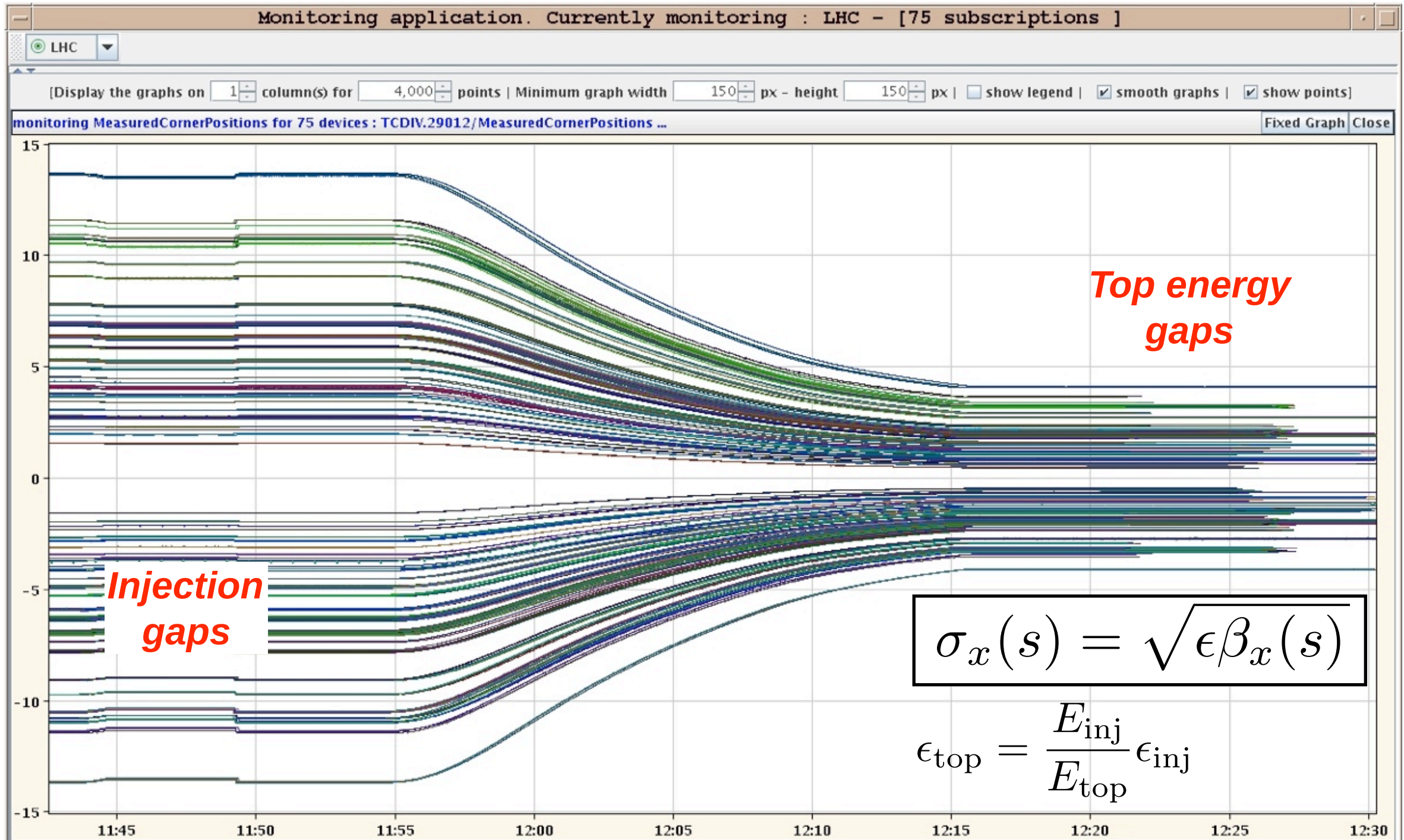
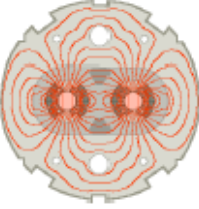
Pre-generated **functions** are loaded into the power converters and are triggered simultaneously by timing events. Need to be updated after corrections and injection (“incorporation”).

Synchronous movements of **power converters**, **radio-frequency** and **collimators**!

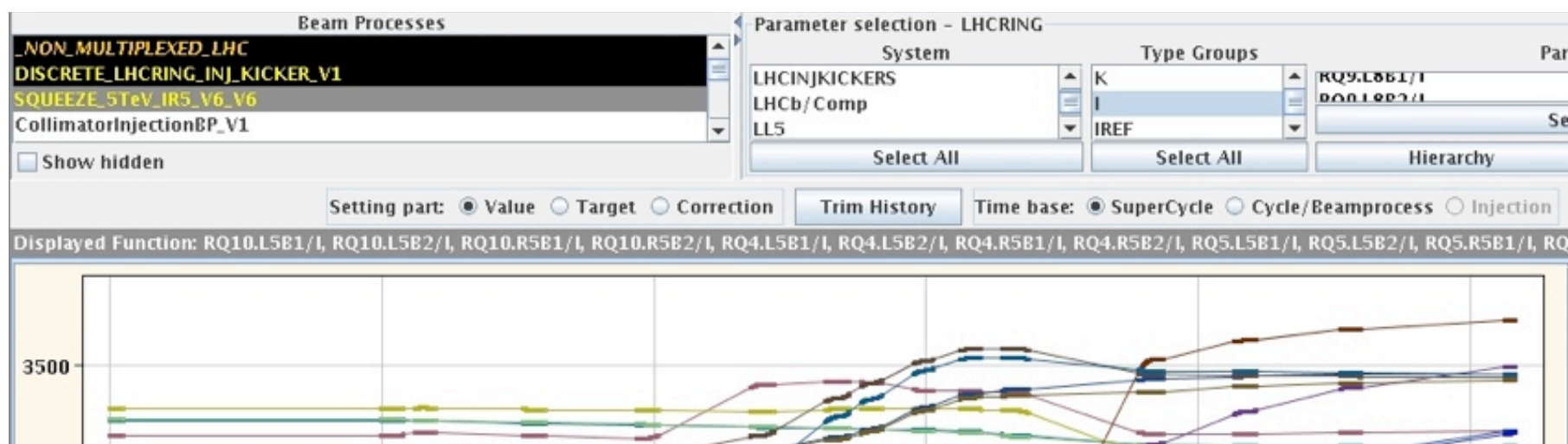
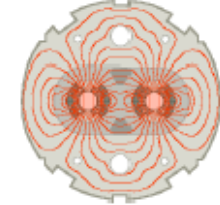
Frequency change during ramp



Collimator ramp functions



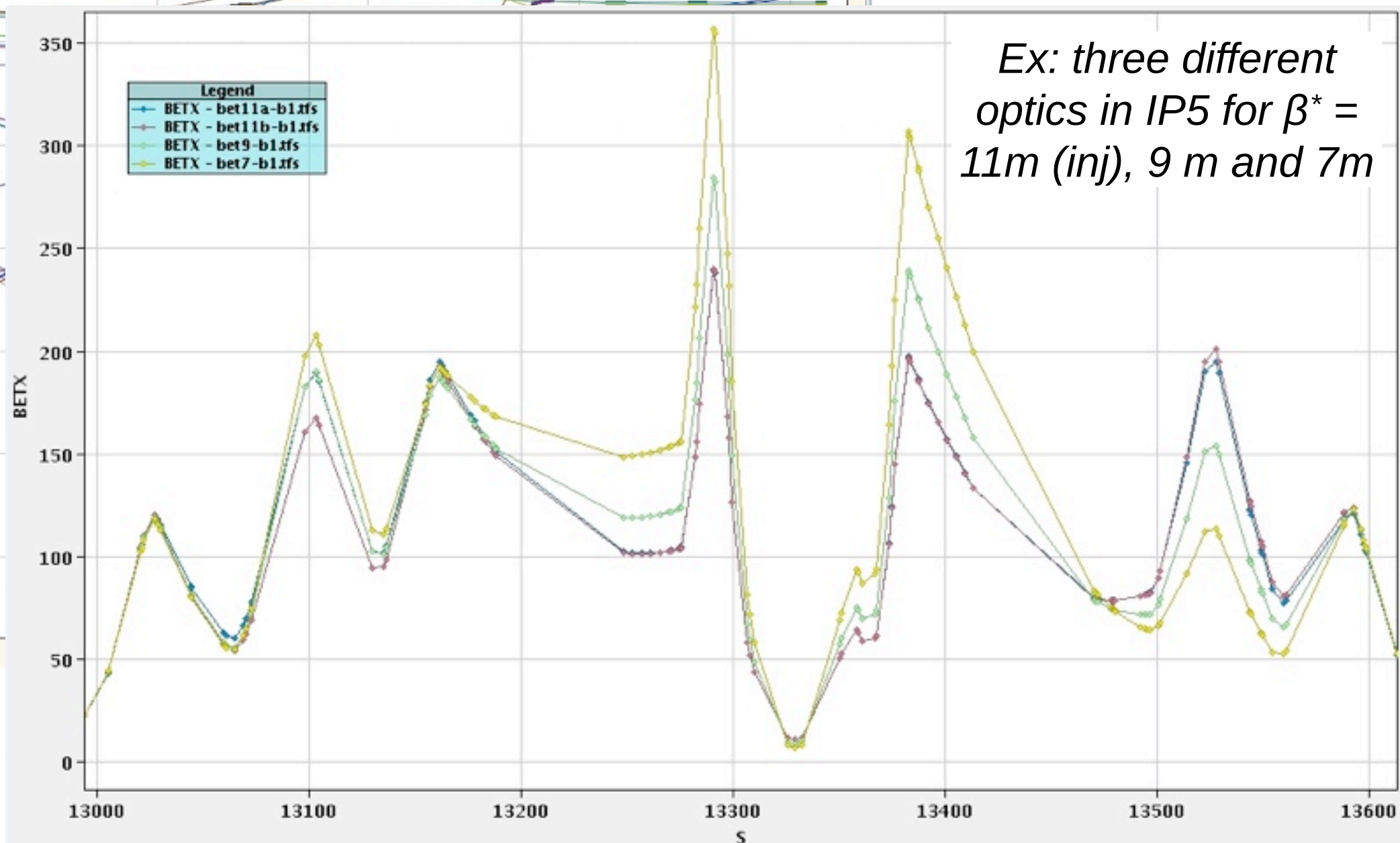
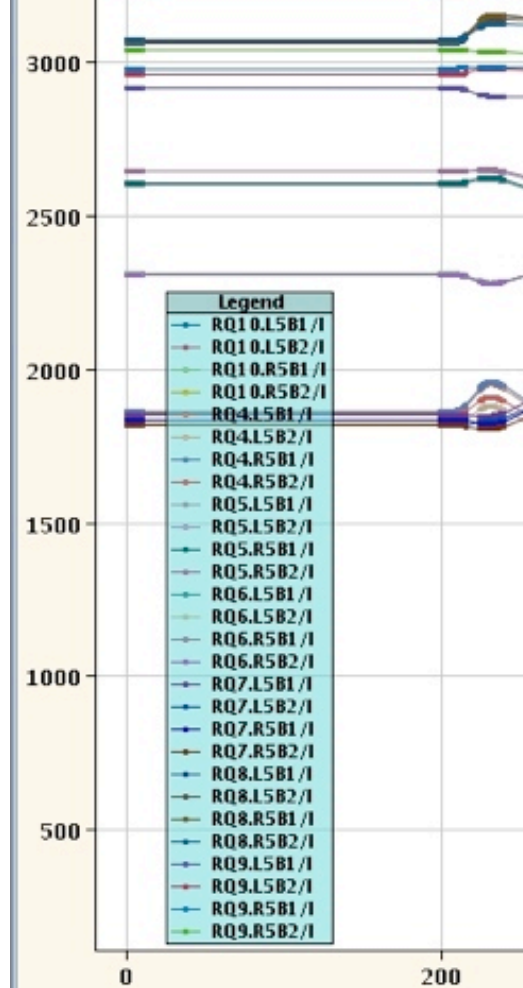
Betatron squeeze



$$L = \frac{N^2 k_b f \gamma}{4\pi \epsilon \beta^*} F$$

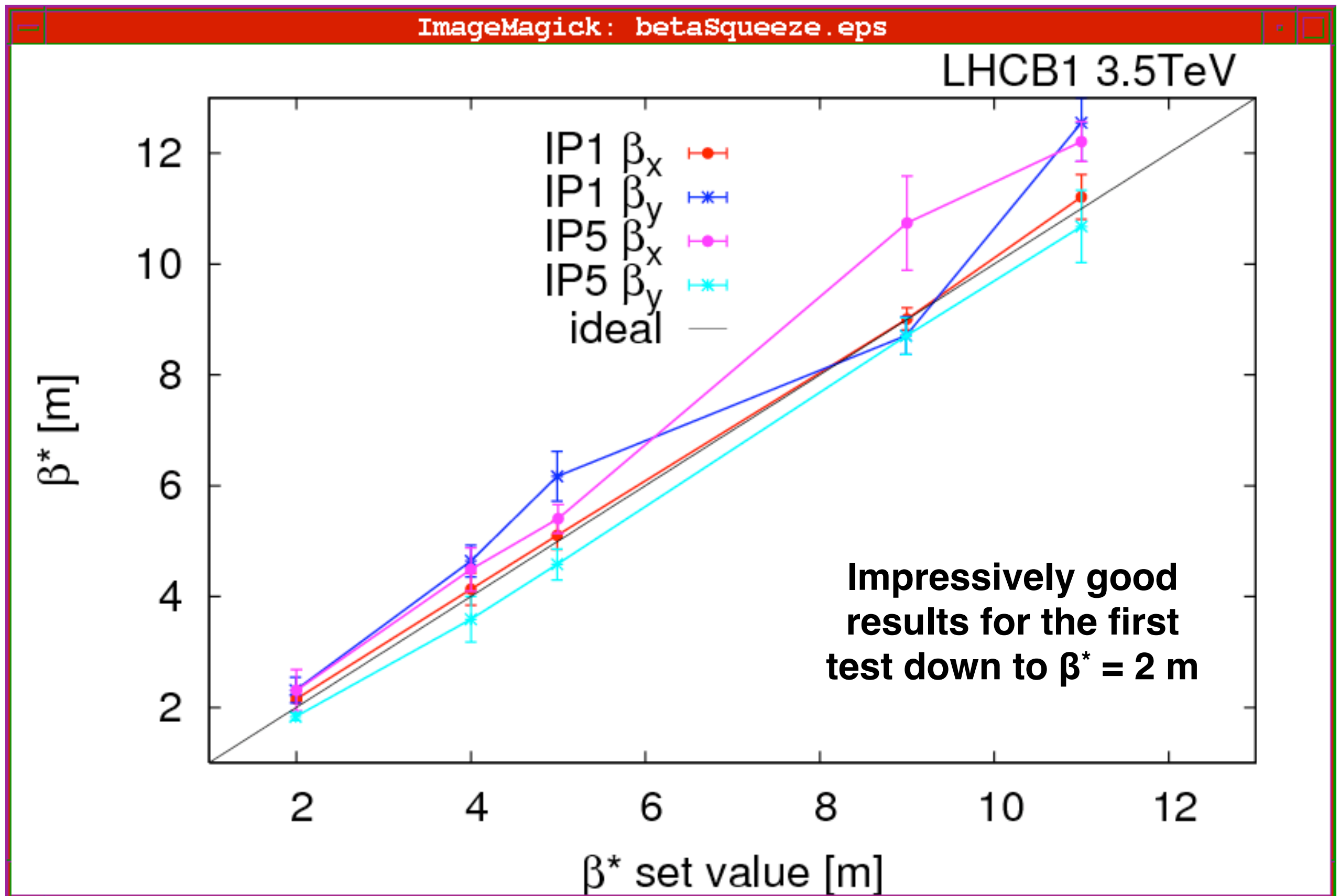
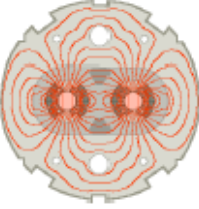
Gain luminosity without increasing the stored energy!!!

Current [A]

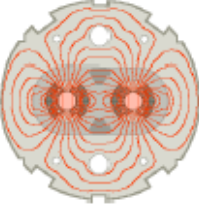


Ex: three different optics in IP5 for $\beta^ = 11m$ (inj), 9 m and 7m*

Results from YESTERDAY night

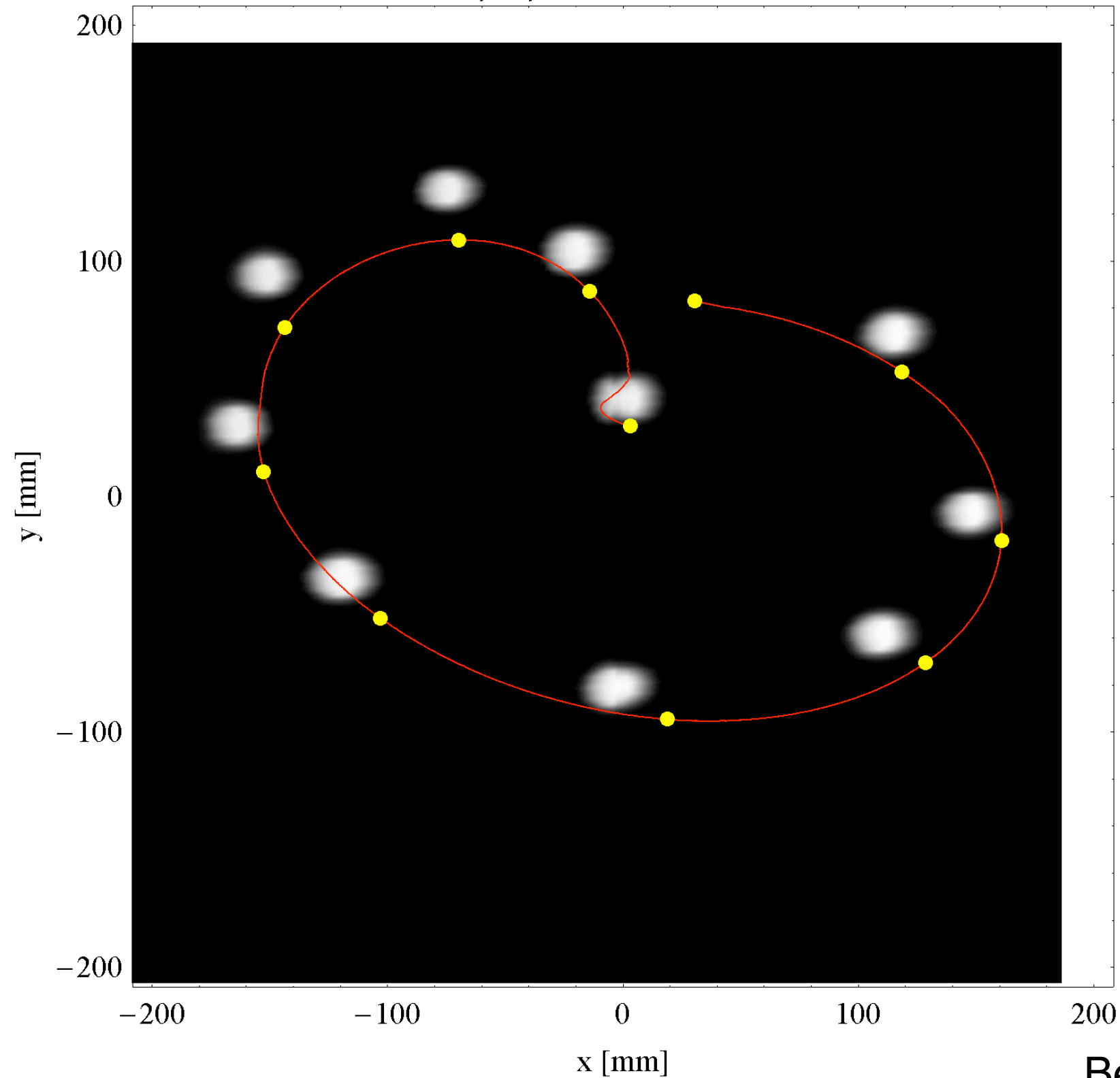


Beam dump

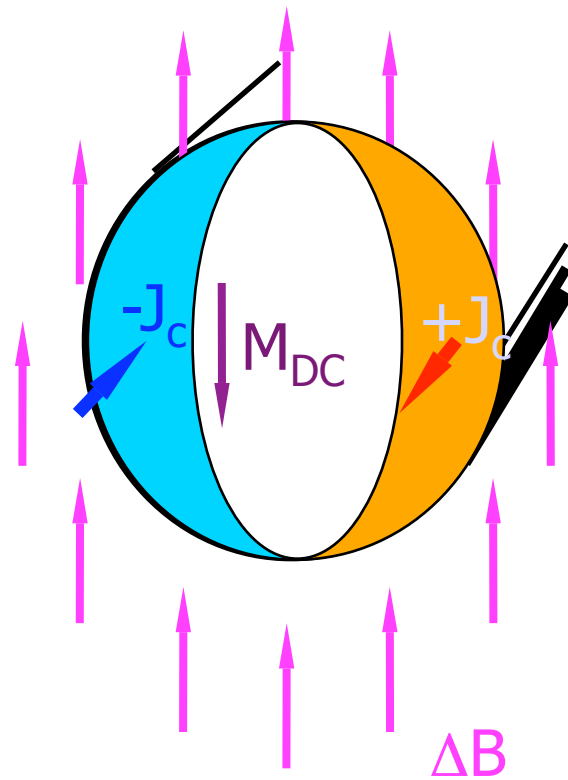
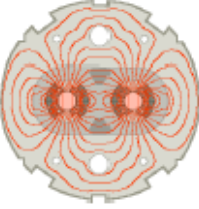


TD68.BTVDD.689339.B1

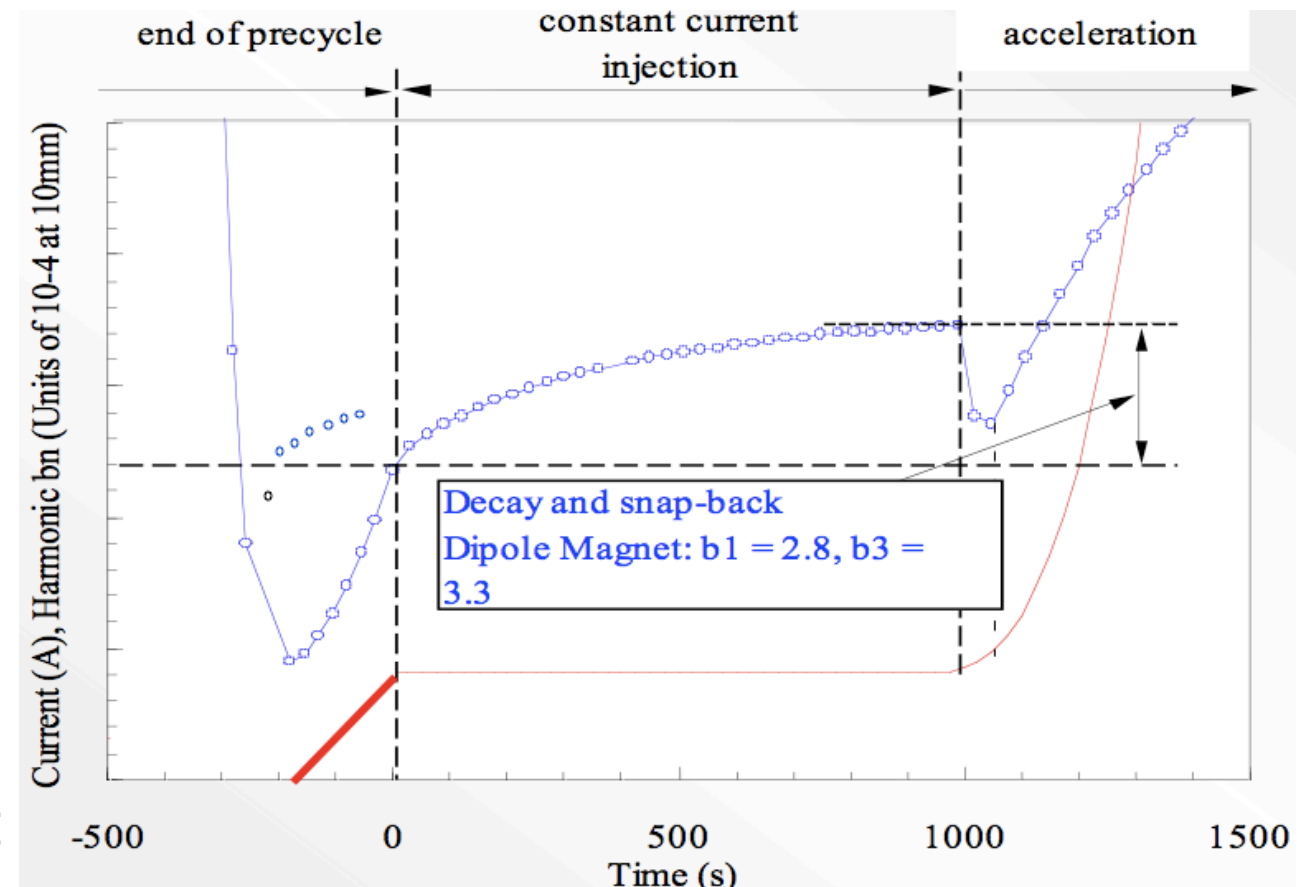
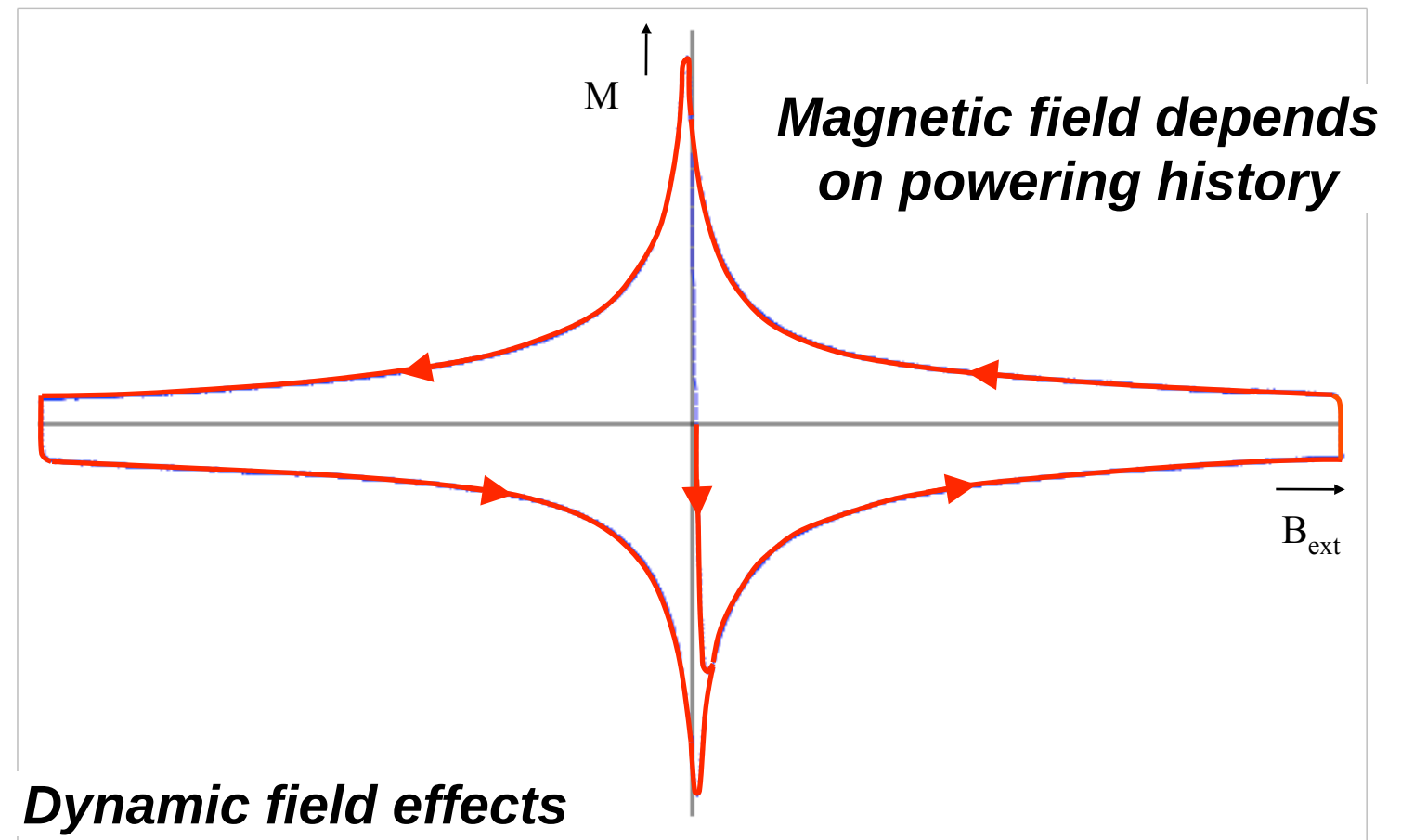
2010/03/24 03:23:34.600000



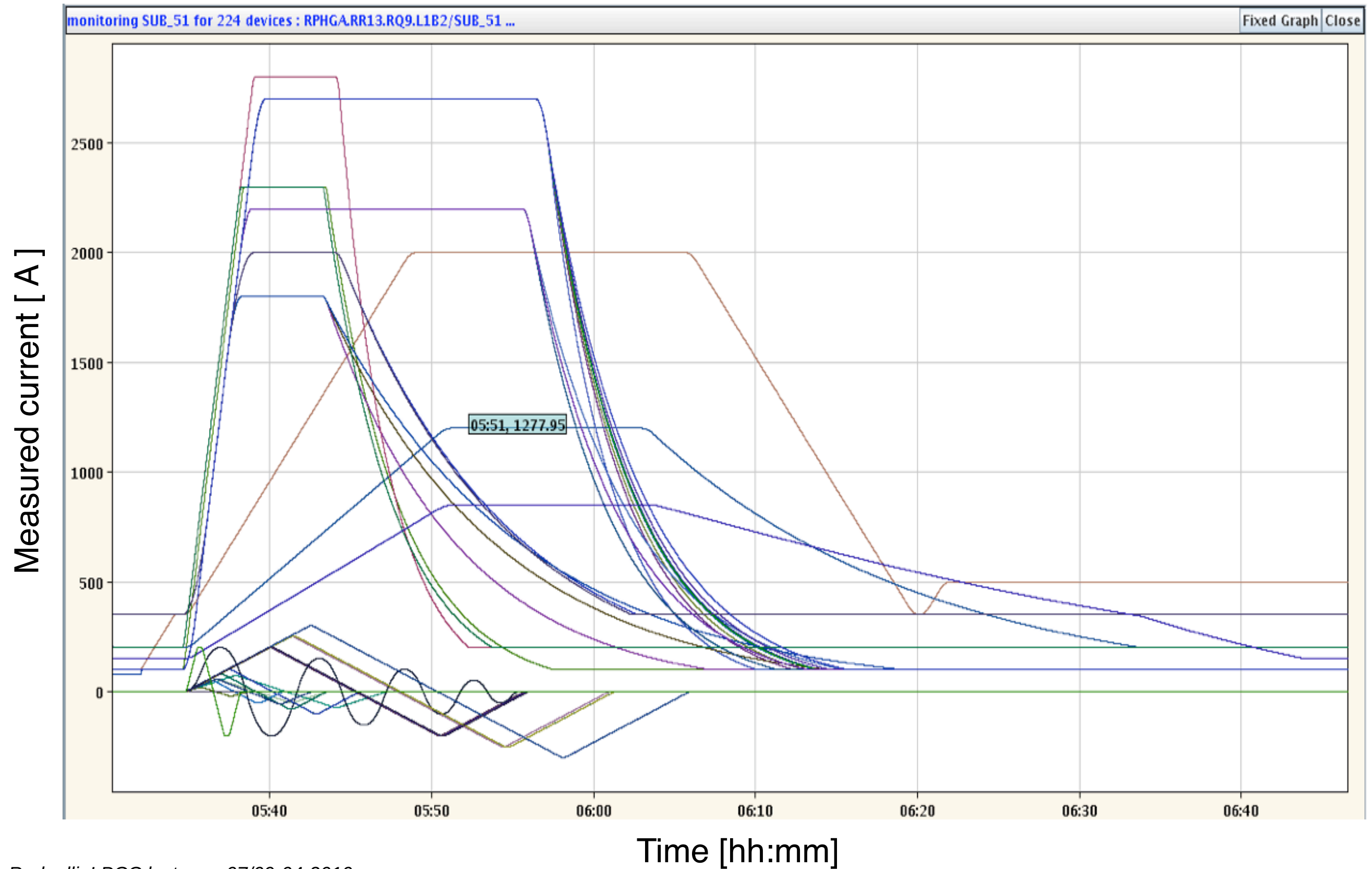
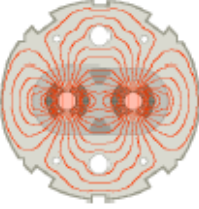
Superconducting features



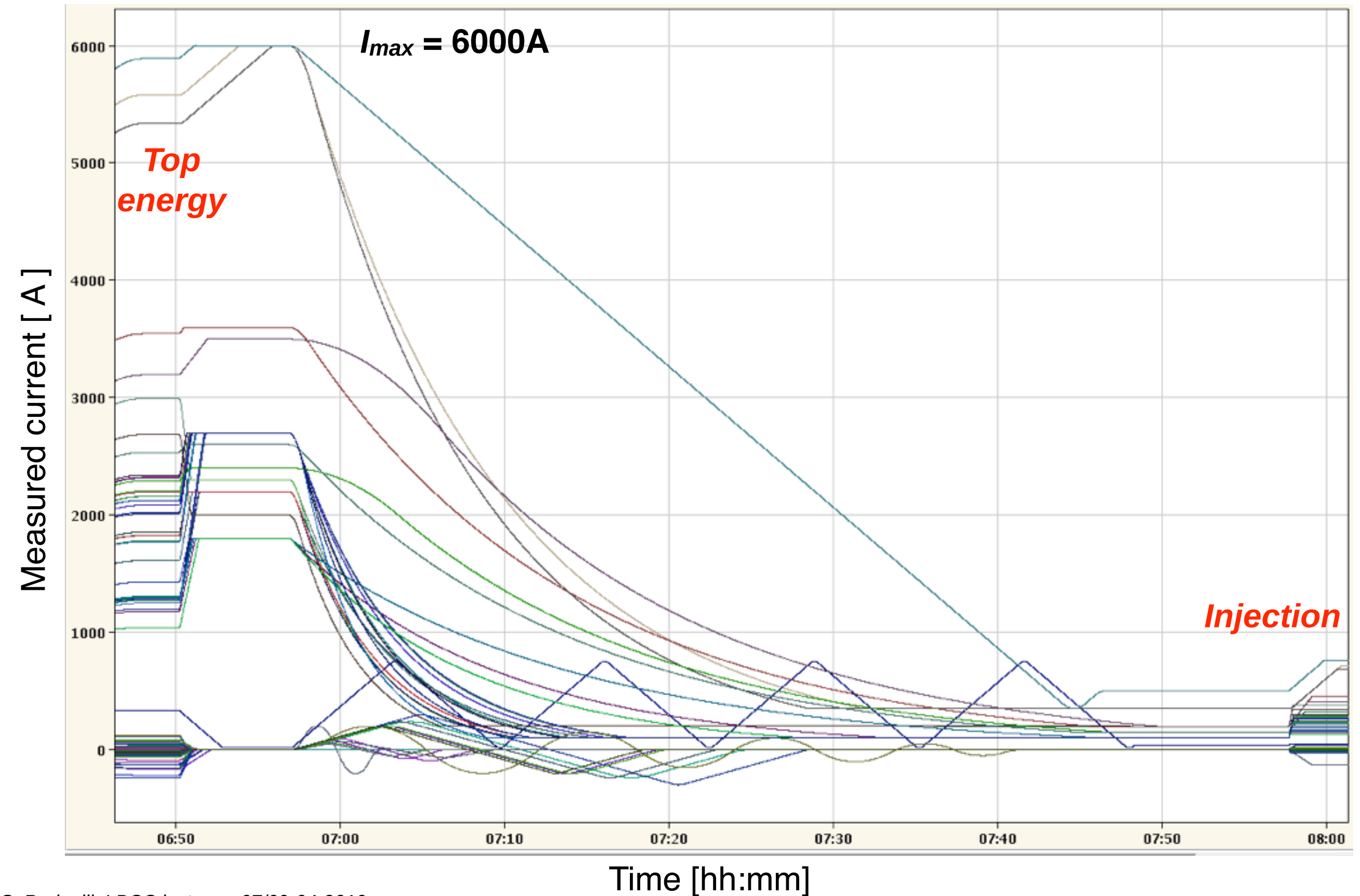
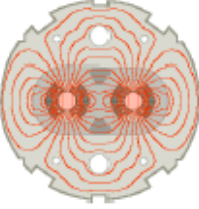
These effects can be dangerous for the beam. A tight control requires to pre-cycle the SC magnets to re-establish the same magnetic history before each new fill.

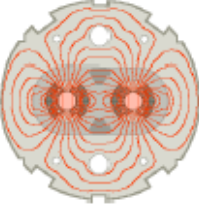


Pre-cycle



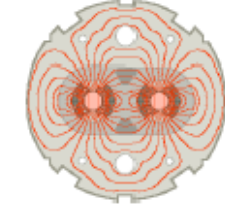
Pre-cycle combined to ramp-down





- Recap. of 1st lecture
- Parameters for 2010-11
- Operational phases
 - Commissioning: baseline / status
 - Operation routine
- **Operational tools**
 - **Page 1's / fixed displays**
 - **More applications**
- One shift of LHC operation
 - How do we operate the LHC

The LHC page1



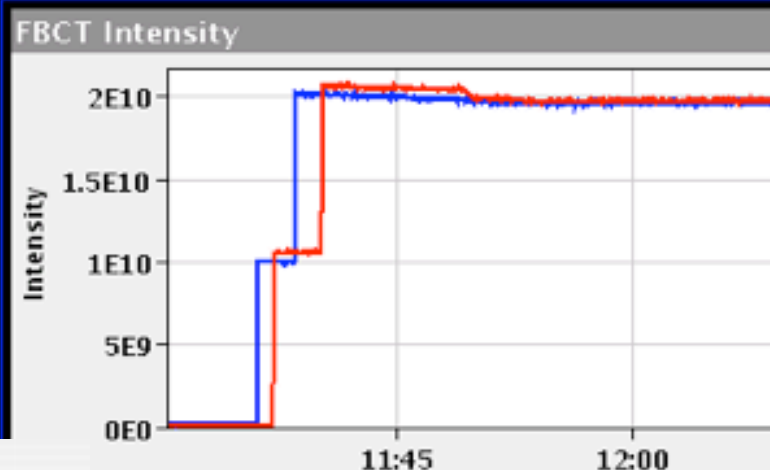
Fill number

LHC Page1 **Fill: 1005** **E: 3500 GeV** 30-03-2010 13:30:26

PROTON PHYSICS: STABLE BEAMS

Machine: beam mode

Energy: 3500 GeV



CHANGE BEAM MODES (RED = RF SYNCHO NOT ALLOWED / GREEN = RF SYNCHO ALLOWED):

SETUP	INJECTION PROBE BEAM	INJECTION SETUP BEAM
INJECTION PHYSICS BEAM	PREPARE RAMP	RAMP
FLAT TOP	ADJUST	SQUEEZE
STABLE BEAMS	UNSTABLE BEAMS	BEAM DUMP
RECOVERY	RAMP DOWN	CYCLING
ABORT	NO BEAM	INJECT AND DUMP
CIRCULATE AND DUMP		

CHANGE ACCELERATOR MODES (RED = OPERATIONAL / GREEN = NON_OPERATIONAL):

PROTON PHYSICS	ION PHYSICS	TOTEM PHYSICS
MACHINE DEVELOPMENT	MACHINE TEST	RECOVERY
BEAM SETUP	ACCESS	MACHINE CHECKOUT
SECTOR DEPENDENT	SHUTDOWN	COOLDOWN
WARMUP		

Operation crew's comment

Comments 30-03-2010 13:22:57 :

Stable beams!

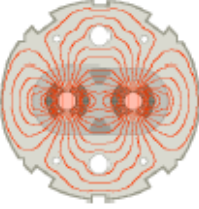
LHC Operation in CCC : 77600, 70480

Global Beam Permit	true	true
Setup Beam	true	true
Beam Presence	true	true
Moveable Devices Allowed In	true	true
Stable Beams	true	true

PM Status B1 **ENABLED** PM Status B2 **ENABLED**

<http://op-webtools.web.cern.ch/op-webtools/vistar/vistars.php?usr=LHC1>

Interlock / SMP panel on page1

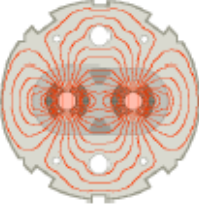


BIS status and SMP flags		B1	B2
Link Status of Beam Permits		true	true
Global Beam Permit		false	false
Setup Beam		true	true
Beam Presence		false	false
Moveable Devices Allowed In		false	false
Stable Beams		false	false
PM Status B1	ENABLED	PM Status B2	ENABLED

SMP = safe
machine
parameters

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

Allows experiments to
take data with sensitive
components: all safety
conditions are met!

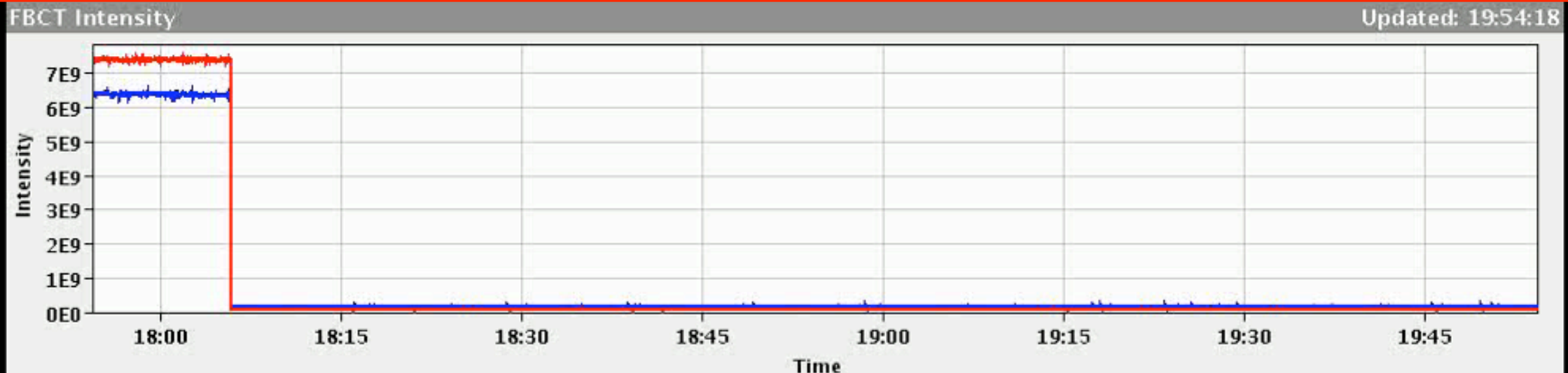


LHC Page1 Fill: 979 E: 450 GeV 23-03-2010 19:54:18

BEAM SETUP: INJECTION PROBE BEAM

BCT TI2: 0.00e+00 **I(B1):** 0.00e+00 **BCT TI8:** 0.00e+00 **I(B2):** 0.00e+00

TED TI2 position:	BEAM	TDI P2 gaps/mm	up: 9.06	down: 9.03
TED TI8 position:	BEAM	TDI P8 gaps/mm	up: 8.32	down: 8.36



Comments 23-03-2010 19:52:12 :

Pre-cycle completed, preparing
for injections.

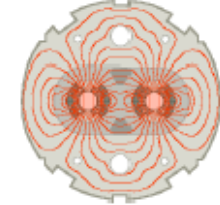
BIS status and SMP flags

	B1	B2
Link Status of Beam Permits	true	true
Global Beam Permit	false	false
Setup Beam	true	true
Beam Presence	false	false
Moveable Devices Allowed In	false	false
Stable Beams	false	false

LHC Operation in CCC : 77600, 70480

PM Status B1 **ENABLED** PM Status B2 **ENABLED**

Inject&Dump or Circulate&Dump



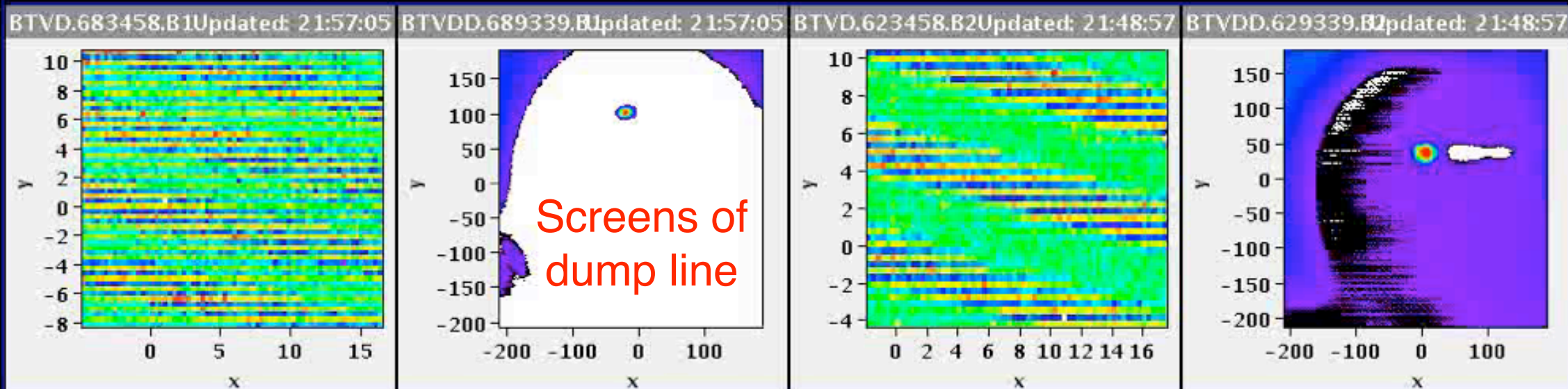
LHC Page1 Fill: 981 E: 450 GeV 23-03-2010 21:57:43

BEAM SETUP: INJECT AND DUMP

BCT TI2: 0.00e+00 I(B1): 0.00e+00 BCT TI8: 0.00e+00 I(B2): 0.00e+00

TED TI2 position: **BEAM** TDI P2 gaps/mm up: 9.06 down: 9.03

TED TI8 position: **BEAM** TDI P8 gaps/mm up: 8.32 down: 8.36



Comments 23-03-2010 21:30:00 :

Beam dump studies

Both beams in, but still synchro problem

RF experts are investigating

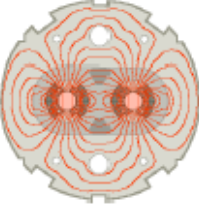
BIS status and SMP flags

	B1	B2
Link Status of Beam Permits	false	false
Global Beam Permit	true	false
Setup Beam	true	true
Beam Presence	false	false
Moveable Devices Allowed In	false	false
Stable Beams	false	false

LHC Operation in CCC : 77600, 70480

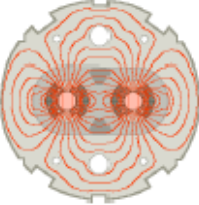
PM Status B1 **ENABLED** PM Status B2 **ENABLED**

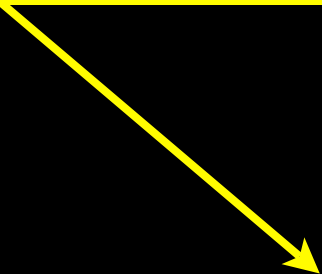
Page1 during energy ramp



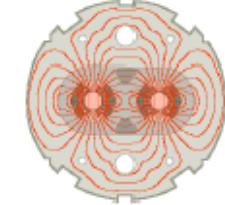
?

Ramp Down / Recovery

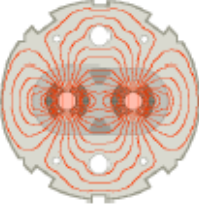


LHC Page1		Fill: 1024		E: 7864 GeV		07-04-2010 00:41:22	
PROTON PHYSICS: RAMP DOWN							
Energy:	7864 GeV	I(B1):	1.32e+09	I(B2):	0.00e+00		
Post Mortem Information PM event ID: Tue Apr 06 22:07:18 CEST 2010 PM event category: EMERGENCY_DUMP PM event classification: MULTIPLE_SYSTEM_DUMP PM BIS Analysis result: First input change detected: USER_PERMIT: Ch 12(PIC_MSK): A T -> F on CIB.UA87. PM comment:							
 Info on the last <i>post-mortem</i> event, with comment by the EiC.							
Comments 07-04-2010 00:36:48 :			BIS status and SMP flags		B1	B2	
Access needed to fix a EE switch problem in RQTD.A81B1			Link Status of Beam Permits		false	false	
			Global Beam Permit		false	false	
			Setup Beam		true	true	
			Beam Presence		false	false	
Next fill for physics			Moveable Devices Allowed In		false	false	
			Stable Beams		false	false	
LHC Operation in CCC : 77600, 70480			PM Status B1		ENABLED	PM Status B2	
						ENABLED	

Access → a bit sad...



LHC Page1	Fill: 1028	E: 7864 GeV	08-04-2010 21:03:21
ACCESS: NO BEAM			
</			



LHC Page1
Fill: 924.0
E: 450 GeV
08-02-2010 11:24:46

SECTOR DEPENDENT: NO BEAM

Sector 12:	PO PHASE 2
Sector 23:	PO PHASE 2
Sector 34:	PO PHASE 2
Sector 45:	PO PHASE 2
Sector 56:	PO PHASE 2
Sector 67:	PO PHASE 2
Sector 78:	PO PHASE 2
Sector 81:	PO PHASE 2

Powering phase
for the different
sectors

Comments 08-02-2010 11:14:49 :

changing LHC modes for software tests
Expts: Switch to internal clock, as we
stop the RF clock until further notice

Clelia is born! @9:28 2.97 Kg and 51 cm

LHC ACCESS: An ADI # is obligatory

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

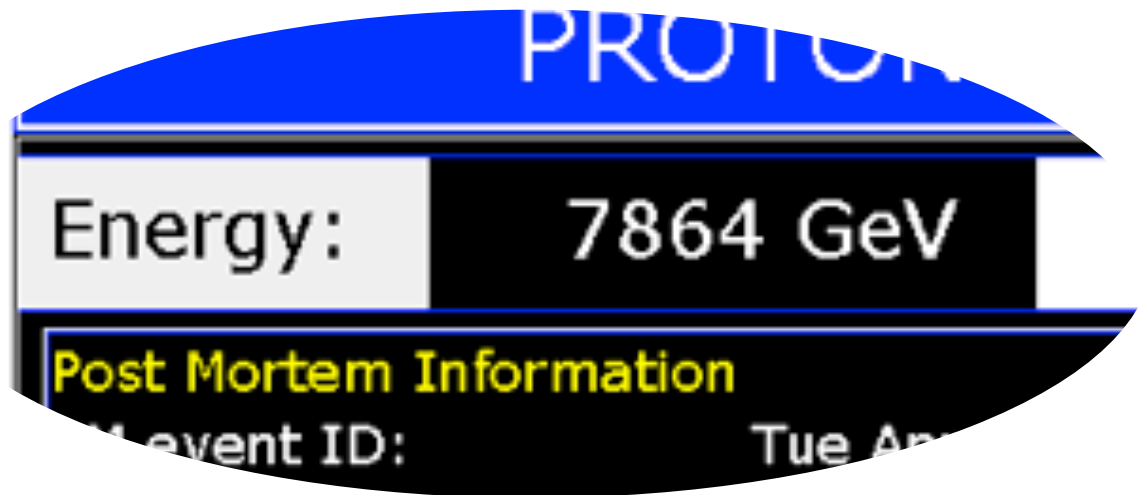
LHC Operation in CCC : 77600, 70480

PM Status B1
DISABLED

PM Status B2
ENABLED

My daughter

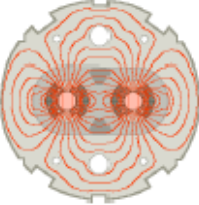
Very high energy...



Flags and SMP flags	B1	B2
Link Status of Beam Permits	false	false
Global Beam Permit	false	false
Setup Beam	true	true
Beam Presence	false	false
Services Allowed In	false	false

Don't panic! Easy way to see if there is beam or not...
*Distributed energy info goes to the maximum (safest settings for machine protection) in case of errors of the **beam energy measurement** based on dipole current reading.*

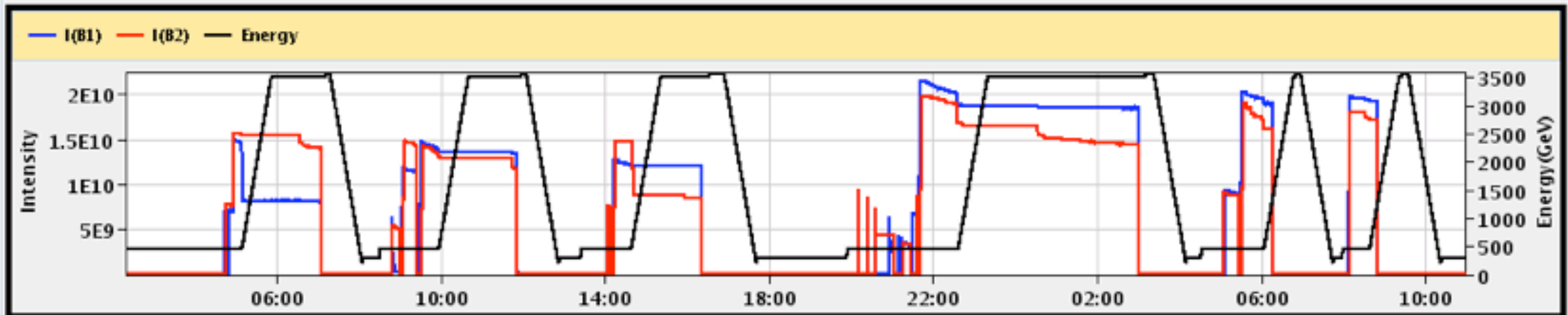
We would tell you in advance - probably - if we tried higher energies...



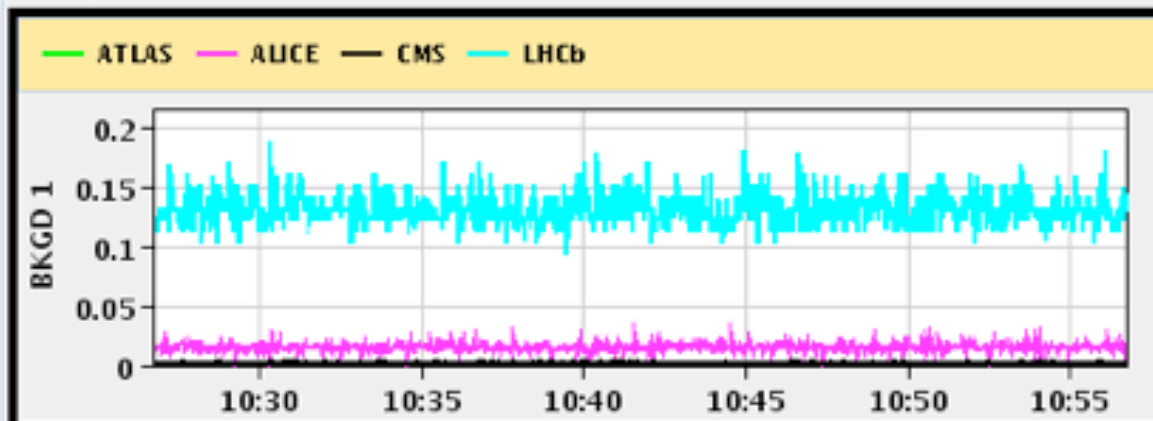
30-Mar-2010 10:56:45 Fill #: 1004 Energy: 297.4 GeV I(B1): 1.55e+08 I(B2): 6.79e+07

Experiment Status	ATLAS	ALICE	CMS	LHCb
Instantaneous Luminosity	0.000e+00	0.000e+00	0.000e+00	-1.000e+00
BRAN Count Rate	0.000e+00	1.960e-01	2.855e+00	1.123e-02
BKGD 1	0.002	0.013	0.002	0.131
BKGD 2	0.000	0.000	0.000	0.002
BKGD 3	0.000	0.005	0.000	0.038
LHCf	STANDBY	Count(Hz): 0.000	LHCb VELO Position	OUT
			Gap: 58.0 mm	TOTEM:
				CALIBRATION

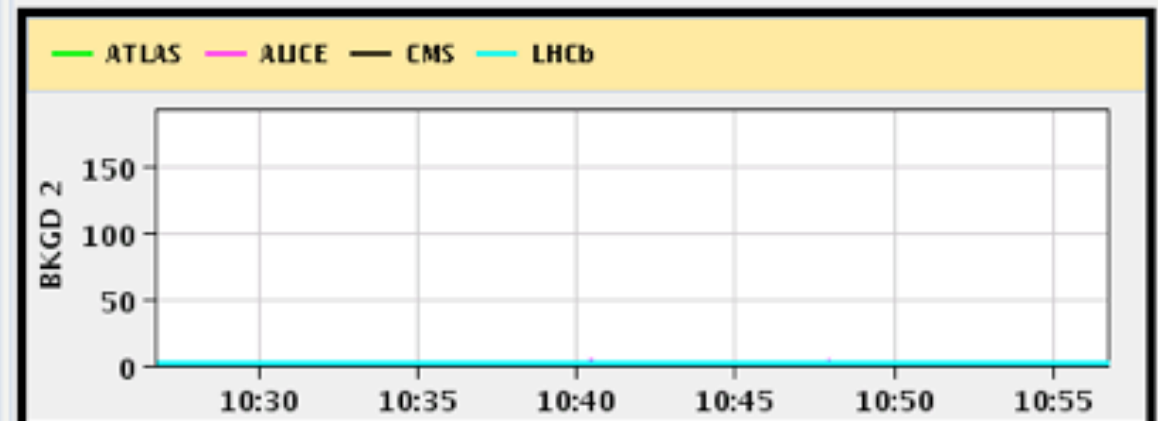
Performance over the last 12 Hrs



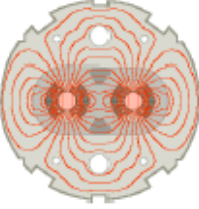
Background 1



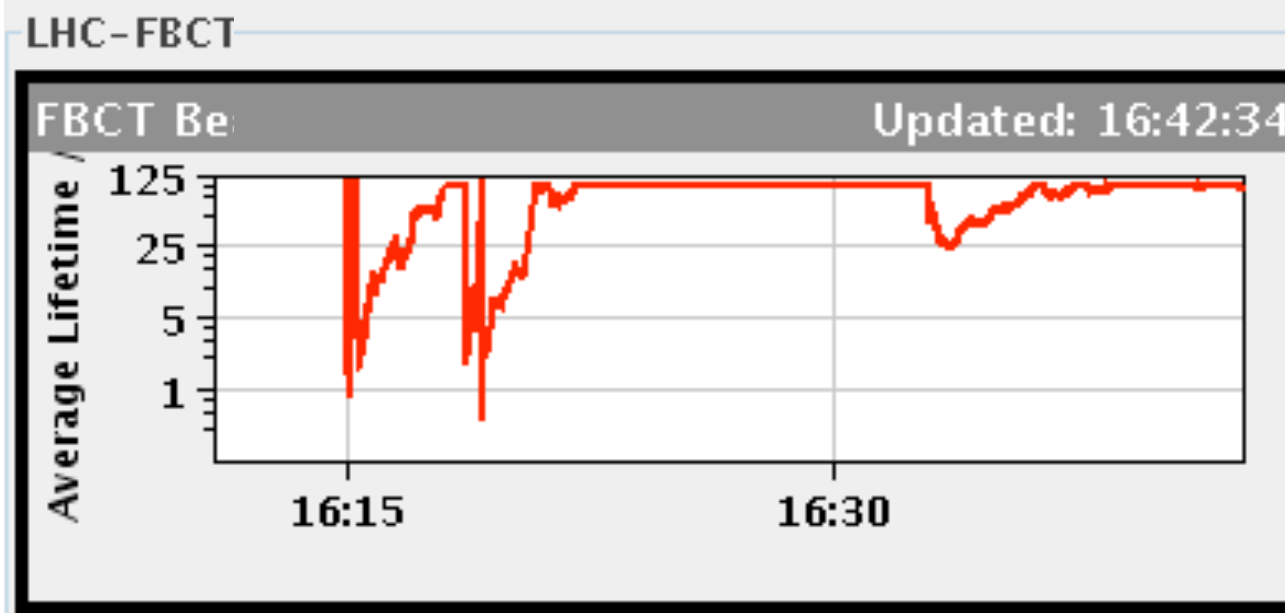
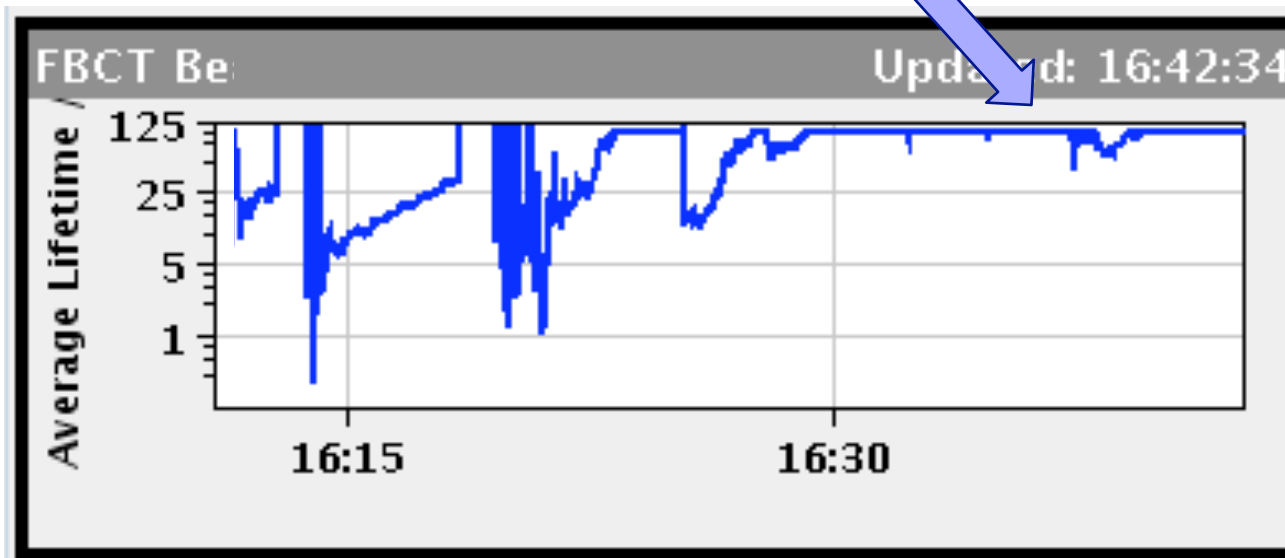
Background 2

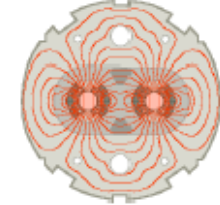


Beam current / lifetime display



LHC FBCT Beam Lifetime				
I(total) B1:	4.91e+09	I(total) B2:	4.14e+09	13-03-2010
Average lifetime B1:	100.00 h	Average lifetime B2:	88.32 h	16:42:34





LHC Cryogenics Page1
25-03-2010 01:38:03

BEAM SETUP: CYCLING

S 12	CM ITR1	CS ITR1	CM MSR1	CS MSR1	CM AR12	CS AR12	CM MSL2	CS MSL2	CM AML3	CS AML3
S 23	CM ITR2	CS ITR2	CM MSR2	CS MSR2	CM AML3	CS AML3				
S 34	CM AMR3	CS AMR3	CM MSL4	CS MSL4						
S 45	CM MSR4	CS MSR4	CM AR45	CS AR45	CM MSL5	CS MSL5				
S 56	CM ITR5	CS ITR5	CM MSR5	CS MSR5	CM AR56	CS AR56				
S 67	CM MSR6	CS MSR6	CM AML7	CS AML7						
S 78	CM AMR7	CS AMR7	CM MSL8	CS MSL8	CM ITL8	CS ITL8				
S 81	CM ITR8	CS ITR8	CM MSR8	CS MSR8	CM AR81	CS AR81	CM MSL1	CS MSL1	CM ITL1	CS ITL1

RF : CM 1L4 CS 1L4 CM 2L4 CS 2L4 CM R4 CS 1R4 CM 2R4 CS 2R4

Average Temperatures (in K):

ARC12: 1.93	ARC23: 1.96	LSS12:
ARC34: 1.94	ARC45: 1.94	LSS34:
ARC56: 1.97	ARC67: 1.99	LSS56:
ARC78: 1.95	ARC81: 1.94	LSS78:

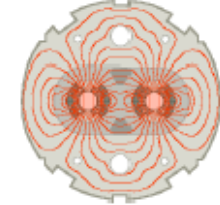
60A Power Permit:

S12
S23
S34
S45
S56
S67
S78
S81

Cryo MAINTAIN and START
for each cryogenics sector

The message here is:
all GREEN → good
some CRYO-START RED → bad
some CRYO-MAINT RED → VERY bad

Power converter status displays



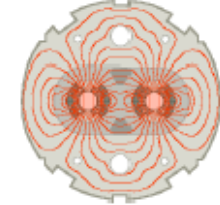
Monitoring set: SECTOR23

25 March, 2010, 02:37:

RB.A23	RCBCH10.L3B1	RCBCH10.R2B1	RCBCH5.R2B2	RCBCH6.L3B1	RCBCH6.R2B1	RCBCH7.L3B2	RCBCH7.R2B2	RCBCH8.L3B1
RCBCH8.R2B1	RCBCH9.L3B2	RCBCH9.R2B2	RCBCH55.R2B1	RCBCH55.R2B2	RCBCV			
RCBCV6.R2B2	RCBCV7.L3B1	RCBCV7.R2B1	RCBCV8.L3B2	RCBCV8.R2B2	RCBC			
RCBH11.L3B2	RCBH11.R2B2	RCBH12.L3B1	RCBH12.R2B1	RCBH13.L3B2	RCBH			
RCBH15.R2B2	RCBH16.L3B1	RCBH16.R2B1	RCBH17.L3B2	RCBH17.R2B2	RCBH18.L3B1	RCBH18.R2B1	RCBH19.R2B2	RCBH20.L3B1
RCBH20.R2B1	RCBH21.L3B2	RCBH21.R2B2	RCBH22.L3B1	RCBH22.R2B1	RCBH23.L3B2	RCBH23.R2B2	RCBH24.L3B1	RCBH24.R2B1
RCBH25.L3B2	RCBH25.R2B2	RCBH26.L3B1	RCBH26.R2B1	RCBH27.L3B2	RCBH27.R2B2	RCBH28.L3B1	RCBH28.R2B1	RCBH29.L3B2
RCBH29.R2B2	RCBH30.L3B1	RCBH30.R2B1	RCBH31.L3B2	RCBH31.R2B2	RCBH32.L3B1	RCBH32.R2B1	RCBH33.L3B2	RCBH33.R2B2
RCBH34.L3B1	RCBV11.L3B1	RCBV11.R2B1	RCBV12.L3B2	RCBV12.R2B2	RCBV13.L3B1	RCBV13.R2B1	RCBV14.L3B2	RCBV14.R2B2
RCBV15.L3B1	RCBV15.R2B1	RCBV16.L3B2	RCBV16.R2B2	RCBV17.L3B1	RCBV17.R2B1	RCBV18.L3B2	RCBV18.R2B2	RCBV19.R2B1
RCBV20.L3B2	RCBV20.R2B2	RCBV21.L3B1	RCBV21.R2B1	RCBV22.L3B2	RCBV22.R2B2	RCBV23.L3B1	RCBV23.R2B1	RCBV24.L3B2
RCBV24.R2B2	RCBV25.L3B1	RCBV25.R2B1	RCBV26.L3B2	RCBV26.R2B2	RCBV27.L3B1	RCBV27.R2B1	RCBV28.L3B2	RCBV28.R2B2
RCBV29.L3B1	RCBV29.R2B1	RCBV30.L3B2	RCBV30.R2B2	RCBV31.L3B1	RCBV31.R2B1	RCBV32.L3B2	RCBV32.R2B2	RCBV33.L3B1
RCBV33.R2B1	RCBV34.L3B2	RCBWH4.L3B1	RCBWH5.L3B2	RCBWV4.L3B2	RCBWV5.L3B1	RCBXH1.R2	RCBXH2.R2	RCBXH3.R2
RCBXV1.R2	RCBXV2.R2	RCBXV3.R2	RCBYH4.R2B1	RCBYHS4.R2B1	RCBYHS4.R2B2	RCBYV4.R2B2	RCBYVS4.R2B1	RCBYVS4.R2B2
RCD.A23B1	RCD.A23B2	RCO.A23B1	RCO.A23B2	RCS.A23B1	RCS.A23B2	RD1.R2	RD2.R2	ROD.A23B1
ROD.A23B2	ROF.A23B1	ROF.A23B2	RQ10.R2B1	RQ10.R2B2	RQ4.R2B1	RQ4.R2B2	RQ5.R2B1	RQ5.R2B2
RQ6.L3B1	RQ6.L3B2	RQ6.R2B1	RQ6.R2B2	RQ7.R2B1	RQ7.R2B2	RQ8.R2B1	RQ8.R2B2	RQ9.R2B1
RQ9.R2B2	RQD.A23	RQF.A23	RQS.A23B1	RQS.L3B2	RQS.R2B2	RQT12.L3B1	RQT12.L3B2	RQT12.R2B1
RQT12.R2B2	RQT13.L3B1	RQT13.L3B2	RQT13.R2B1	RQT13.R2B2	RQT4.L3	RQT5.L3	RQTD.A23B1	RQTD.A23B2
RQTF.A23B1	RQTF.A23B2	RQTL10.L3B1	RQTL10.L3B2	RQTL11.L3B1	RQTL11.L3B2	RQTL11.R2B1	RQTL11.R2B2	RQTL7.L3B1
RQTL7.L3B2	RQTL8.L3B1	RQTL8.L3B2	RQTL9.L3B1	RQTL9.L3B2	RQX.R2	RSD1.A23B1	RSD1.A23B2	RSD2.A23B1
RSD2.A23B2	RSF1.A23B1	RSF1.A23B2	RSF2.A23B1	RSF2.A23B2	RSS.A23B1	RSS.A23B2	RTQX1.R2	RTQX2.R2

YELLOW = Executing functions (OK)

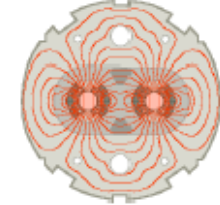
RED = BAD



RB.A81	RCBCH10.L1B1	RCBCH10.R8B1	RCBCH5.L1B2	RCBCH6.L1B1	RCBCH6.R8B1	RCBCH7.L1B2	RCBCH7.R8B2	RCBCH8.L1B1
RCBCH8.R8B1	RCBCH9.L1B2	RCBCH9.R8B2	RCBCV10.L1B2	RCBCV10.R8B2	RCBCV5.L1B1	RCBCV6.L1B2	RCBCV6.R8B2	RCBCV7.L1B1
RCBCV7.R8B1	RCBCV8.L1B2	RCBCV8.R8B2	RCBCV9.L1B1	RCBCV9.R8B1	RCBH11.L1B2	RCBH11.R8B2	RCBH12.L1B1	RCBH12.R8B1
RCBH13.L1B2	RCBH13.R8B2	RCBH14.L1B1	RCBH14.R8B1	RCBH15.L1B2	RCBH15.R8B2	RCBH16.L1B1	RCBH16.R8B1	RCBH17.L1B2
RCBH17.R8B2	RCBH18.L1B1	RCBH18.R8B1	RCBH19.L1B2	RCBH19.R8B2	RCBH20.L1B1	RCBH20.R8B1	RCBH21.L1B2	RCBH21.R8B2
RCBH22.L1B1	RCBH22.R8B1	RCBH23.L1B2	RCBH23.R8B2	RCBH24.L1B1	RCBH24.R8B1	RCBH25.L1B2	RCBH25.R8B2	RCBH26.L1B1
RCBH26.R8B1	RCBH27.L1B2	RCBH27.R8B2	RCBH28.L1B1	RCBH28.R8B1	RCBH29.L1B2	RCBH29.R8B2	RCBH30.L1B1	RCBH30.R8B1
RCBH31.L1B2	RCBH31.R8B2	RCBH32.L1B1	RCBH32.R8B1	RCBH33.L1B2	RCBH33.R8B2	RCBH34.L1B1	RCBV11.L1B1	RCBV11.R8B1
RCBV12.L1B2	RCBV12.R8B2	RCBV13.L1B1	RCBV13.R8B1	RCBV14.L1B2				B2
RCBV16.R8B2	RCBV17.L1B1	RCBV17.R8B1	RCBV18.L1B2	RCBV18.R8B2				B2
RCBV21.L1B1	RCBV21.R8B1	RCBV22.L1B2	RCBV22.R8B2	RCBV23.L1B1				B1
RCBV25.R8B1	RCBV26.L1B2	RCBV26.R8B2	RCBV27.L1B1	RCBV27.R8B1				B1
RCBV30.L1B2	RCBV30.R8B2	RCBV31.L1B1	RCBV31.R8B1	RCBV32.L1B2				B2
RCBXH1.L1	RCBXH1.R8	RCBXH2.L1	RCBXH2.R8	RCBXH3.L1				1
RCBXV2.R8	RCBXV3.L1	RCBXV3.R8	RCBYH4.L1B1	RCBYH4.R8B1				B1
RCBYHS4.R8B2	RCBYHS5.R8B1	RCBYHS5.R8B2	RCBYV4.L1B2	RCBYV4.R8B2	RCBYV5.R8B1	RCBYVS4.L1B1	RCBYVS4.L1B2	RCBYVS4.R8B1
RCBYVS4.R8B2	RCBYVS5.R8B1	RCBYVS5.R8B2	RCD.A81B1	RCD.A81B2	RCO.A81B1	RCS.A81B1	RCS.A81B2	RD1.R8
RD2.L1	RD2.R8	ROD.A81B1	ROD.A81B2	ROF.A81B1	ROF.A81B2	RQ10.L1B1	RQ10.L1B2	RQ10.R8B1
RQ10.R8B2	RQ4.L1B1	RQ4.L1B2	RQ4.R8B1	RQ4.R8B2	RQ5.L1B1	RQ5.L1B2	RQ5.R8B1	RQ5.R8B2
RQ6.L1B1	RQ6.L1B2	RQ6.R8B1	RQ6.R8B2	RQ7.L1B1	RQ7.L1B2	RQ7.R8B1	RQ7.R8B2	RQ8.L1B1
RQ8.L1B2	RQ8.R8B1	RQ8.R8B2	RQ9.L1B1	RQ9.L1B2	RQ9.R8B1	RQ9.R8B2	RQD.A81	RQF.A81
RQS.A81B1	RQS.L1B2	RQS.R8B2	RQT12.L1B1	RQT12.L1B2	RQT12.R8B1	RQT12.R8B2	RQT13.L1B1	RQT13.L1B2
RQT13.R8B1	RQT13.R8B2	RQTD.A81B1	RQTD.A81B2	RQTF.A81B1	RQTF.A81B2	RQTL11.L1B1	RQTL11.L1B2	RQTL11.R8B1
RQTL11.R8B2	RQX.L1	RQX.R8	RSD1.A81B1	RSD1.A81B2	RSD2.A81B1	RSD2.A81B2	RSF1.A81B1	RSF1.A81B2
RSF2.A81B1	RSF2.A81B2	RSS.A81B1	RSS.A81B2	RTQX1.L1	RTQX1.R8	RTQX2.L1	RTQX2.R8	

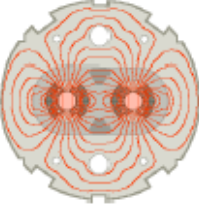
Candidate sources:
Cryo
Power converters
Quench protection system

Colorful combinations are possible...



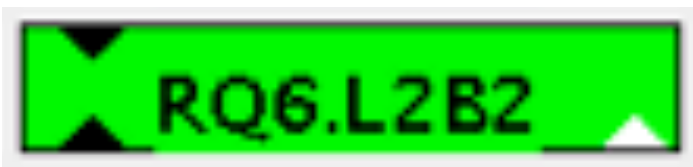
RB.A12	RCBCH10.L2B2	RCBCH10.R1B2	RCBCH5.R1B1	RCBCH6.L2B2	RCBCH6.R1B2	RCBCH7.L2B1	RCBCH7.R1B1	RCBCH8.L2B2
RCBCH8.R1B2	RCBCH9.L2B1	RCBCH9.R1B1	RCBCV10.L2B1	RCBCV10.R1B1	RCBCV5.R1B2	RCBCV6.L2B1	RCBCV6.R1B1	RCBCV7.L2B2
RCBCV7.R1B2	RCBCV8.L2B1	RCBCV8.R1B1	RCBCV9.L2B2	RCBCV9.R1B2	RCBH11.L2B1	RCBH11.R1B1	RCBH12.L2B2	RCBH12.R1B2
RCBH13.L2B1	RCBH13.R1B1	RCBH14.L2B2	RCBH14.R1B2	RCBH15.L2B1	RCBH15.R1B1	RCBH16.L2B2	RCBH16.R1B2	RCBH17.L2B1
RCBH17.R1B1	RCBH18.L2B2	RCBH18.R1B2	RCBH19.L2B1	RCBH19.R1B1	RCBH20.L2B2	RCBH20.R1B2	RCBH21.L2B1	RCBH21.R1B1
RCBH22.L2B2	RCBH22.R1B2	RCBH23.L2B1	RCBH23.R1B1	RCBH24.L2B2	RCBH24.R1B2	RCBH25.L2B1	RCBH25.R1B1	RCBH26.L2B2
RCBH26.R1B2	RCBH27.L2B1	RCBH27.R1B1	RCBH28.L2B2	RCBH28.R1B2	RCBH29.L2B1	RCBH29.R1B1	RCBH30.L2B2	RCBH30.R1B2
RCBH31.L2B1	RCBH31.R1B1	RCBH32.L2B2	RCBH32.R1B2	RCBH33.L2B1	RCBH33.R1B1	RCBH34.L2B2	RCBV11.L2B2	RCBV11.R1B2
RCBV12.L2B1	RCBV12.R1B1	RCBV13.L2B2	RCBV13.R1B2	RCBV14.L2B1	RCBV14.R1B1	RCBV15.L2B2	RCBV15.R1B2	RCBV16.L2B1
RCBV16.R1B1	RCBV17.L2B2	RCBV17.R1B2	RCBV18.L2B1	RCBV18.R1B1	RCBV19.L2B2	RCBV19.R1B2	RCBV20.L2B1	RCBV20.R1B1
RCBV21.L2B2	RCBV21.R1B2	RCBV22.L2B1	RCBV22.R1B1	RCBV23.L2B2	RCBV23.R1B2	RCBV24.L2B1	RCBV24.R1B1	RCBV25.L2B2
RCBV25.R1B2	RCBV26.L2B1	RCBV26.R1B1	RCBV27.L2B2	RCBV27.R1B2	RCBV28.L2B1	RCBV28.R1B1	RCBV29.L2B2	RCBV29.R1B2
RCBV30.L2B1	RCBV30.R1B1	RCBV31.L2B2	RCBV31.R1B2	RCBV32.L2B1	RCBV32.R1B1	RCBV33.L2B2	RCBV33.R1B2	RCBV34.L2B1
RCBXH1.L2	RCBXH1.R1	RCBXH2.L2	RCBXH2.R1	RCBXH3.L2	RCBXH3.R1	RCBXV1.L2	RCBXV1.R1	RCBXV2.L2
RCBXV2.R1	RCBXV3.L2	RCBXV3.R1	RCBYH4.L2B2	RCBYH4.R1B2	RCBYH5.L2B1	RCBYHS4.L2B1	RCBYHS4.L2B2	RCBYHS4.R1B1
RCBYHS4.R1B2	RCBYHS5.L2B1	RCBYHS5.L2B2	RCBYV4.L2B1	RCBYV4.R1B1	RCBYV5.L2B2	RCBYVS4.L2B1	RCBYVS4.L2B2	RCBYVS4.R1B1
RCBYVS4.R1B2	RCBYVS5.L2B1	RCBYVS5.L2B2	RCD.A12B1	RCD.A12B2	RCO.A12B1	RCO.A12B2	RCS.A12B1	RCS.A12B2
RD1.L2	RD1.LR1	RD2.L2	RD2.R1	ROD.A12B1	ROD.A12B2	ROF.A12B1	ROF.A12B2	RQ10.L2B1
RQ10.L2B2	RQ10.R1B1	RQ10.R1B2	RQ4.L2B1	RQ4.L2B2	RQ4.R1B1	RQ4.R1B2	RQ5.L2B1	RQ5.L2B2
RQ5.R1B1	RQ5.R1B2	RQ6.L2B1	RQ6.L2B2	RQ6.R1B1	RQ6.R1B2	RQ7.L2B1	RQ7.L2B2	RQ7.R1B1
RQ7.R1B2	RQ8.L2B1	RQ8.L2B2	RQ8.R1B1	RQ8.R1B2	RQ9.L2B1	RQ9.L2B2	RQ9.R1B1	RQ9.R1B2
RQD.A12	RQF.A12	RQS.A12B2	RQS.L2B1	RQS.R1B1	RQT12.L2B1	RQT12.L2B2	RQT12.R1B1	RQT12.R1B2
RQT13.L2B1	RQT13.L2B2	RQT13.R1B1	RQT13.R1B2	RQTD.A12B1	RQTD.A12B2	RQTF.A12B1	RQTF.A12B2	RQTL11.L2B1
RQTL11.L2B2	RQTL11.R1B1	RQTL11.R1B2	RQX.L2	RQX.R1	RSD1.A12B1	RSD1.A12B2	RSD2.A12B1	RSD2.A12B2
RSF1.A12B1	RSF1.A12B2	RSF2.A12B1	RSF2.A12B2	RSS.A12B1	RSS.A12B2	RTQX1.L2	RTQX1.R1	RTQX2.L2

Summary of circuit states



*Colors we like
(no faults)*

*Colors we do NOT like
(faults!)*



ON, IDLE



OFF



ARMED



EXECUTING



STAND_BY



ERROR

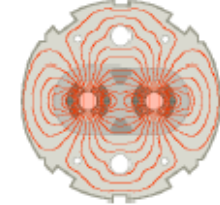


**NO_
CONN.**



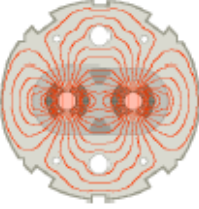
**SLOW_
ABORT**

Collimators

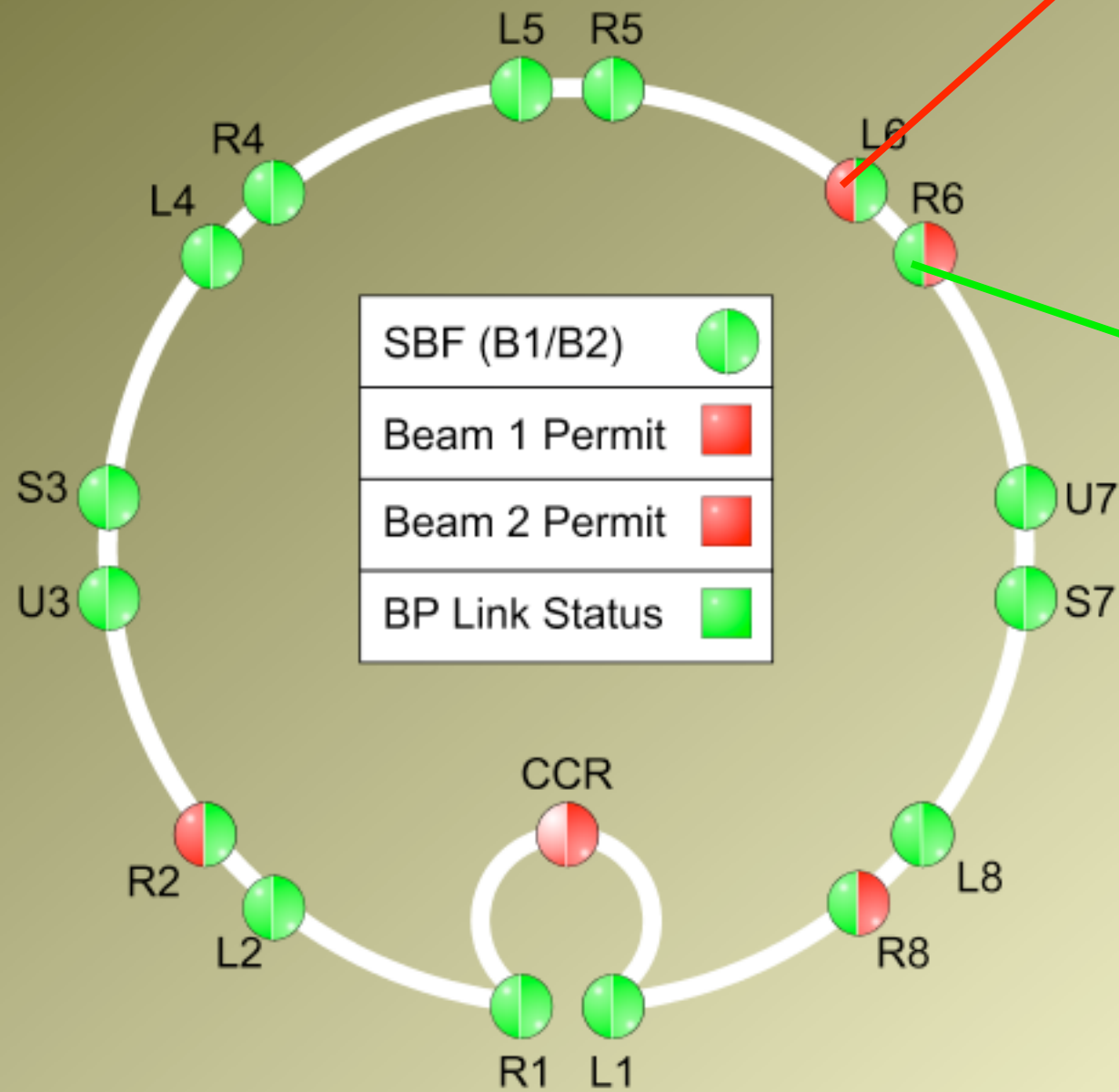


LHC Collimators Beam: B1 Set: HW Group:LHC COLLIMATORS					
LHC Collimators Beam: B1 Set: HW Group:LHC COLLIMATORS					
25-03-2010 01:18:13					
Collimators in IP1/IP5	Collimators in IP2/IP8	Collimators in IP3	Collimators in IP6	Collimators in IP7	Collimators in TI2
● TCTH.4L5.B1 ●	● TCLIB.6R2.B1 ●	● TCSG.5L3.B1 ●	● TCSG.4R6.B1 ●	● TCSG.B5L7.B1 ●	● TCDIH.29205 ●
● TCL.5R1.B1 ●	● TCTH.4L2.B1 ●	● TCSG.B5R3.B1 ●	● TCDQA.A4R6.B1 ●	● TCSG.A4R7.B1 ●	● TCDIV.29012 ●
● TCTVA.4L5.B1 ●	● TCTVB.4L8 ●	● TCLA.7R3.B1 ●		● TCLA.A7R7.B1 ●	● TCDIV.29234 ●
● TCTH.4L1.B1 ●	● TDI.4L2 ●	● TCLA.A5R3.B1 ●		● TCLA.C6R7.B1 ●	● TCDIV.20607 ●
● TCTVA.4L1.B1 ●	● TCTVB.4L2 ●	● TCLA.B5R3.B1 ●		● TCLA.D6R7.B1 ●	● TCDIH.29050 ●
● TCL.5R5.B1 ●	● TCTH.4L8.B1 ●	● TCLA.6R3.B1 ●		● TCSG.D4L7.B1 ●	● TCDIV.29465 ●
	● TCLIA.4R2 ●	● TCSG.A5R3.B1 ●		● TCP.B6L7.B1 ●	● TCDIH.29509 ●
	● TCDD.4L2 ●	● TCP.6L3.B1 ●		● TCSG.B5R7.B1 ●	
		● TCSG.4R3.B1 ●		● TCLA.A6R7.B1 ●	
				● TCP.D6L7.B1 ●	
				● TCSG.A6L7.B1 ●	
				● TCSG.B4L7.B1 ●	
				● TCSG.A5L7.B1 ●	
				● TCSG.E5R7.B1 ●	
				● TCSG.6R7.B1 ●	
				● TCSG.A4L7.B1 ●	
				● TCSG.D5R7.B1 ●	
				● TCLA.B6R7.B1 ●	

Beam interlock status



LHC Beam Interlock System



BIC Overview

CIB.UA63.L6.B1 X

SHOW VIEW MASK/UNMASK COMMAND

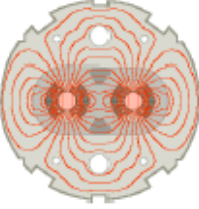
SAFE BEAM FLAG: TRUE

SOFTWARE	INPUT	DISABLED	MASK SET	MATRIX	PERMIT
INIT	TRUE			TRUE	
1	TRUE			TRUE	
2					
3					
4					
5	TRUE			TRUE	
6	TRUE			TRUE	
7	Vacuum b2	NO		TRUE	
8	not used	YES			
9	LBDS-b2	NO		TRUE	
10	not used	YES			
11	PIC_UNM	NO		TRUE	
12	not used	YES			
13	not used	YES			
14	Beam-2 Excur...	NO	YES	TRUE	
15	FMCM_RMSD-...	NO	NO	TRUE	
16	BTV-b2	NO	NO	TRUE	
17	not used	YES	NO		
18	PIC_MSK	TRUE	NO	TRUE	
19	not used	YES	NO		
20	not used	YES	NO		

PERMIT: TRUE

Can ONLY put beam if all is green!

Outline - 2st lecture



- **Recap.**

- **Parameters**

- **LHC operation**

- The

- Commissioning: baseline / status

- **Operational tools**

- Page 1's / fixed displays

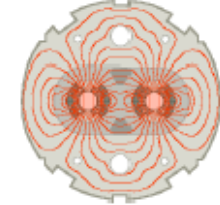
- More applications

- **One shift of LHC operation**

- **How do we operate the LHC**

Assume that:
we have the target parameters for the beam
the experiments have decided the running config
the machine protection is validated for the specified intensities
All injector chain is up and ready

One day of the LHC . . .



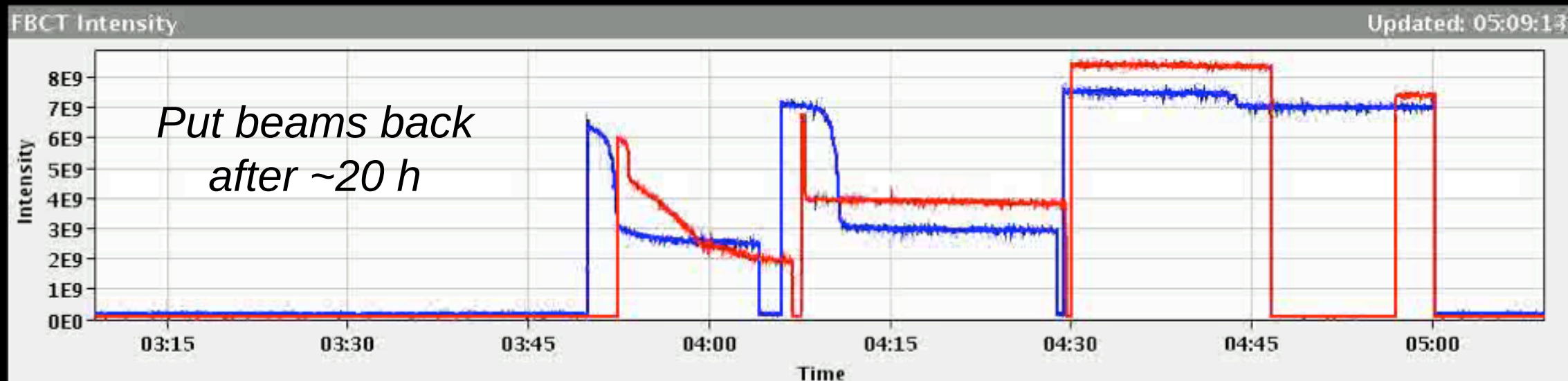
LHC Page1 Fill: 993 E: 450 GeV 25-03-2010 05:09:14

BEAM SETUP: INJECTION PROBE BEAM

BCT TI2: 0.00e+00 I(B1): 0.00e+00 BCT TI8: 0.00e+00 I(B2): 0.00e+00

TED TI2 position: **BEAM** TDI P2 gaps/mm up: 9.05 down: 9.04

TED TI8 position: **BEAM** TDI P8 gaps/mm up: 8.32 down: 8.36



Comments 25-03-2010 05:05:33 :

Lost cryo conditions in 81

No beam for at least 2 h

BIS status and SMP flags

B1 B2

Link Status of Beam Permits

false false

Global Beam Permit

false false

Setup Beam

true true

Beam Presence

false false

Moveable Devices Allowed In

false false

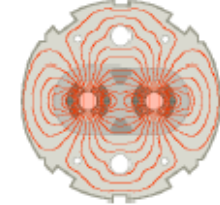
Stable Beams

false false

LHC Operation in CCC : 77600, 70480

PM Status B1 **ENABLED** PM Status B2 **ENABLED**

... starts waiting for cold-down.



March 24th, 23:50

LHC Cryogenics Page1									
24-03-2010 23:51:32									
BEAM SETUP: CYCLING									
S 12	CM ITR1	CS ITR1	CM MSR1	CS MSR1	CM AR12	CS AR12	CM MSL2	CS MSL2	CM ITL2 CS ITL2
S 23	CM ITR2	CS ITR2	CM MSR2	CS MSR2	CM AML3	CS AML3			
S 34	CM AMR3	CS AMR3	CM MSL4	CS MSL4					
S 45	CM MSR4	CS MSR4	CM AR45	CS AR45	CM MSL5	CS MSL5	CM ITL5	CS ITL5	
S 56	CM ITR5	CS ITR5	CM MSR5	CS MSR5	CM AR56	CS AR56	CM MSL6	CS MSL6	
S 67	CM MSR6	CS MSR6	CM AML7	CS AML7					
S 78	CM AMR7	CS AMR7	CM MSL8	CS MSL8	CM ITL8	CS ITL8			
S 81	CM ITR8	CS ITR8	CM MSR8	CS MSR8	CM AR81	CS AR81	CM MSL1	CS MSL1	CM ITL1 CS ITL1
RF :	CM 1L4	CS 1L4	CM 2L4	CS 2L4	CM R4	CS 1R4	CM 2R4	CS 2R4	
Average Temperatures (in K):									
ARC12:	1.93	ARC23:	2.08	LSS12:	3.13	LSS23:	3.59	DFB12:	4.41
DFB23:	4.49	ARC34:	1.94	ARC45:	1.94	LSS34:	4.14	LSS45:	3.94
DFB34:	5.84	DFB45:	5.59	ARC56:	1.97	ARC67:	1.98	LSS56:	3.62
LSS67:	4.49	DFB56:	5.57	DFB67:	3.88	ARC78:	1.95	ARC81:	1.94
LSS78:	3.08	LSS81:	3.19	DFB78:	4.44	DFB81:	4.44		
60A Power Permit:									
	S12	S23	S34	S45	S56	S67	S78	S81	

March 25th, 01:38

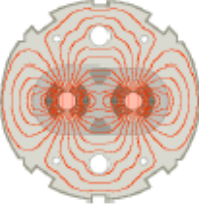
LHC Cryogenics Page1									
25-03-2010 01:38:03									
BEAM SETUP: CYCLING									
S 12	CM ITR1	CS ITR1	CM MSR1	CS MSR1	CM AR12	CS AR12	CM MSL2	CS MSL2	CM ITL2 CS ITL2
S 23	CM ITR2	CS ITR2	CM MSR2	CS MSR2	CM AML3	CS AML3			
S 34	CM AMR3	CS AMR3	CM MSL4	CS MSL4					
S 45	CM MSR4	CS MSR4	CM AR45	CS AR45	CM MSL5	CS MSL5	CM ITL5	CS ITL5	
S 56	CM ITR5	CS ITR5	CM MSR5	CS MSR5	CM AR56	CS AR56	CM MSL6	CS MSL6	
S 67	CM MSR6	CS MSR6	CM AML7	CS AML7					
S 78	CM AMR7	CS AMR7	CM MSL8	CS MSL8	CM ITL8	CS ITL8			
S 81	CM ITR8	CS ITR8	CM MSR8	CS MSR8	CM AR81	CS AR81	CM MSL1	CS MSL1	CM ITL1 CS ITL1
RF :	CM 1L4	CS 1L4	CM 2L4	CS 2L4	CM R4	CS 1R4	CM 2R4	CS 2R4	
Average Temperatures (in K):									
ARC12:	1.93	ARC23:	1.96	LSS12:	3.12	LSS23:	3.56	DFB12:	4.41
DFB23:	4.48	ARC34:	1.94	ARC45:	1.94	LSS34:	4.14	LSS45:	3.94
DFB34:	5.84	DFB45:	5.59	ARC56:	1.97	ARC67:	1.99	LSS56:	3.62
LSS67:	4.49	DFB56:	5.57	DFB67:	3.88	ARC78:	1.95	ARC81:	1.94
LSS78:	3.08	LSS81:	3.19	DFB78:	4.44	DFB81:	4.44		
60A Power Permit:									
	S12	S23	S34	S45	S56	S67	S78	S81	

March 25th, 01:57

LHC Cryogenics Page1									
25-03-2010 01:57:16									
BEAM SETUP: CYCLING									
S 12	CM ITR1	CS ITR1	CM MSR1	CS MSR1	CM AR12	CS AR12	CM MSL2	CS MSL2	CM ITL2 CS ITL2
S 23	CM ITR2	CS ITR2	CM MSR2	CS MSR2	CM AML3	CS AML3			
S 34	CM AMR3	CS AMR3	CM MSL4	CS MSL4					
S 45	CM MSR4	CS MSR4	CM AR45	CS AR45	CM MSL5	CS MSL5	CM ITL5	CS ITL5	
S 56	CM ITR5	CS ITR5	CM MSR5	CS MSR5	CM AR56	CS AR56	CM MSL6	CS MSL6	
S 67	CM MSR6	CS MSR6	CM AML7	CS AML7					
S 78	CM AMR7	CS AMR7	CM MSL8	CS MSL8	CM ITL8	CS ITL8			
S 81	CM ITR8	CS ITR8	CM MSR8	CS MSR8	CM AR81	CS AR81	CM MSL1	CS MSL1	CM ITL1 CS ITL1
RF :	CM 1L4	CS 1L4	CM 2L4	CS 2L4	CM R4	CS 1R4	CM 2R4	CS 2R4	
Average Temperatures (in K):									
ARC12:	1.93	ARC23:	1.95	LSS12:	3.12	LSS23:	3.55	DFB12:	4.41
DFB23:	4.48	ARC34:	1.94	ARC45:	1.94	LSS34:	4.14	LSS45:	3.94
DFB34:	5.84	DFB45:	5.59	ARC56:	1.97	ARC67:	1.99	LSS56:	3.62
LSS67:	4.48	DFB56:	5.57	DFB67:	3.88	ARC78:	1.95	ARC81:	1.94
LSS78:	3.08	LSS81:	3.19	DFB78:	4.44	DFB81:	4.44		
60A Power Permit:									
	S12	S23	S34	S45	S56	S67	S78	S81	

March 25th, 02:00 → Ready for powering

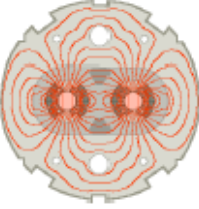
LHC Cryogenics Page1									
23-03-2010 12:44:18									
BEAM SETUP: INJECTION PROBE BEAM									
S 12	CM ITR1	CS ITR1	CM MSR1	CS MSR1	CM AR12	CS AR12	CM MSL2	CS MSL2	CM ITL2 CS ITL2
S 23	CM ITR2	CS ITR2	CM MSR2	CS MSR2	CM AML3	CS AML3			
S 34	CM AMR3	CS AMR3	CM MSL4	CS MSL4					
S 45	CM MSR4	CS MSR4	CM AR45	CS AR45	CM MSL5	CS MSL5	CM ITL5	CS ITL5	
S 56	CM ITR5	CS ITR5	CM MSR5	CS MSR5	CM AR56	CS AR56	CM MSL6	CS MSL6	
S 67	CM MSR6	CS MSR6	CM AML7	CS AML7					
S 78	CM AMR7	CS AMR7	CM MSL8	CS MSL8	CM ITL8	CS ITL8			
S 81	CM ITR8	CS ITR8	CM MSR8	CS MSR8	CM AR81	CS AR81	CM MSL1	CS MSL1	CM ITL1 CS ITL1
RF :	CM 1L4	CS 1L4	CM 2L4	CS 2L4	CM R4	CS 1R4	CM 2R4	CS 2R4	
Average Temperatures (in K):									
ARC12:	1.93	ARC23:	1.94	LSS12:	3.13	LSS23:	3.45	DFB12:	4.43
DFB23:	4.43	ARC34:	1.94	ARC45:	1.94	LSS34:	4.14	LSS45:	3.93
DFB34:	5.84	DFB45:	5.58	ARC56:	1.97	ARC67:	1.99	LSS56:	3.62
LSS67:	4.49	DFB56:	5.57	DFB67:	3.88	ARC78:	1.95	ARC81:	1.95
LSS78:	3.08	LSS81:	3.18	DFB78:	4.43	DFB81:	4.43		
60A Power Permit:									
	S12	S23	S34	S45	S56	S67	S78	S81	



No Cryo = No powering

[illegible]

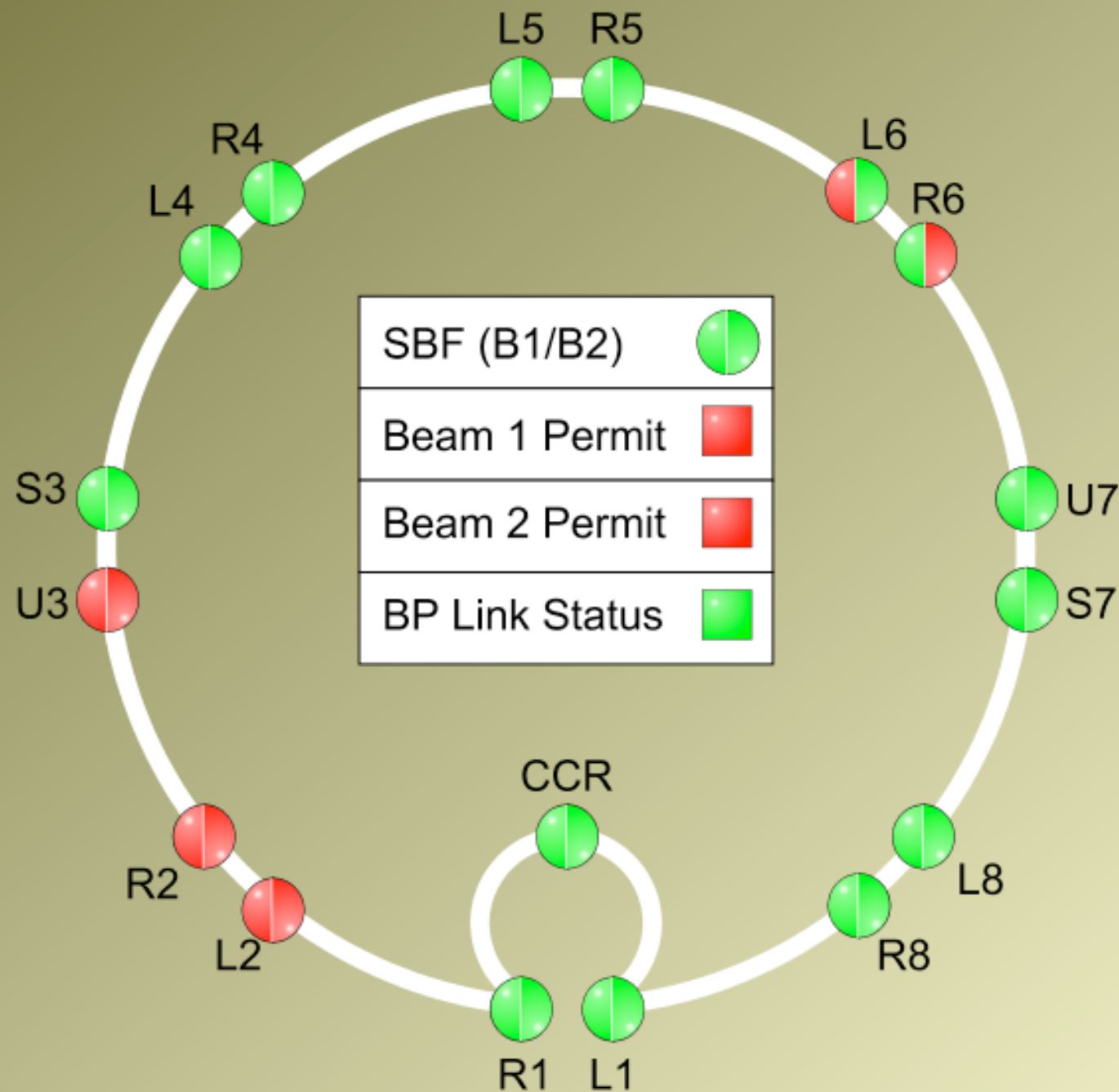
No powering = no beam



Configuration Version: 1.11

Time: Wed Mar 24 23:58:37 CET 2010

LHC Beam Interlock System

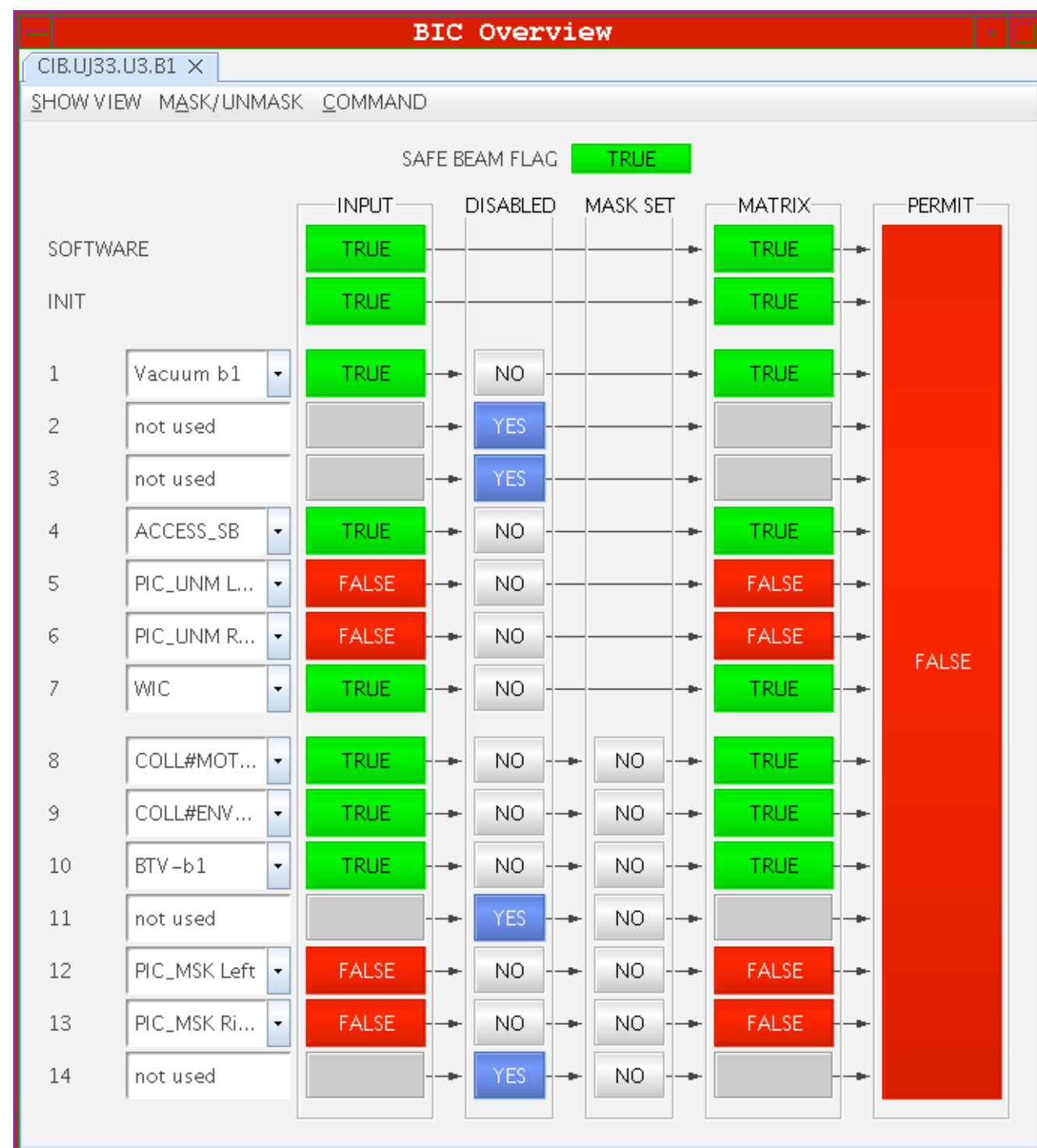


Injection Permits

	ALICE		ATLAS
	CMS		LHCb
	ALICE_ZDC		TOTEM
	B1		B2
OP Injection Switches			

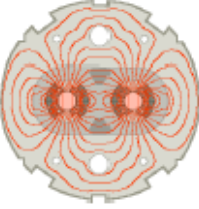
BIS Operation Overview

	PM OK		Pre-OP
	B1		B2
Beam Presence			
	Movables Allowed In		
	Stable Beams		
	Interlocking channels		
	CIBG: Beam Permit Loop		
	BIS Logging Overview		
	Expert Overview		



Maskable and un-maskable channels of powering sub-sector with no cryo conditions prevent ARMING the beam dump system.

Preparing for beam: RF



LHC RF CONTROL

RB/A: lhcop

ACSMModuleM1B1

LINE 1B1

POWER ON

LINE 2B1

POWER ON

LINE 3B1

POWER ON

LINE 4B1

POWER ON

Power Converter

IDLE

50.198 KV

31.138 A

RF LL ON

1 MV

RF LL ON

1 MV

RF LL ON

1 MV

RF LL ON

1 MV

Show/Hide

Select/Unselect

ACSMModuleM2B1

LINE 5B1

POWER ON

LINE 6B1

POWER ON

LINE 7B1

POWER ON

LINE 8B1

POWER ON

Power Converter

IDLE

50.505 KV

31.378 A

RF LL ON

1 MV

RF LL ON

1 MV

RF LL ON

1 MV

RF LL ON

1 MV

Show/Hide

Select/Unselect

ACSMModuleM1B2

LINE 1B2

POWER ON

LINE 2B2

POWER ON

LINE 3B2

POWER ON

LINE 4B2

POWER ON

Power Converter

IDLE

49.993 KV

31.255 A

RF LL ON

1 MV

RF LL ON

1 MV

RF LL ON

1 MV

RF LL ON

1 MV

Show/Hide

Select/Unselect

ACSMModuleM2B2

LINE 5B2

POWER ON

LINE 6B2

POWER ON

LINE 7B2

POWER ON

LINE 8B2

POWER ON

Power Converter

IDLE

49.737 KV

31.17 A

RF LL ON

1 MV

RF LL ON

1 MV

RF LL ON

1 MV

RF LL ON

1 MV

Show/Hide

Select/Unselect

LINE NAME	POWER STATUS	POWER MODE	POWER DETAILED MODE	POWER DETAILED STATUS	Maximum time Left	RF VETO	RF LL STATUS	RF LL MODE	RF LL DETAILED	RF LL DETAILED STATUS
ACSLine1B1	OK	ON	ON	no info	1600	OK	OK	ON	ON	no info
ACSLine2B1	OK	ON	ON	no info	1600	OK	OK	ON	ON	no info
ACSLine3B1	OK	ON	ON	no info	1600	OK	OK	ON	ON	no info
ACSLine4B1	OK	ON	ON	no info	1600	OK	OK	ON	ON	no info
ACSLine5B1	OK	ON	ON	no info	1600	OK	OK	ON	ON	no info
ACSLine6B1	OK	ON	ON	no info	1600	OK	OK	ON	ON	no info
ACSLine7B1	OK	ON	ON	no info	1600	OK	OK	ON	ON	no info
ACSLine8B1	OK	ON	ON	no info	1600	OK	OK	ON	ON	no info
ACSLine1B2	OK	ON	ON	no info	1600	OK	OK	ON	ON	no info
ACSLine2B2	OK	ON	ON	no info	1600	OK	OK	ON	ON	no info
ACSLine3B2	OK	ON	ON	no info	1600	OK	OK	ON	ON	no info
ACSLine4B2	OK	ON	ON	no info	1600	OK	OK	ON	ON	no info
ACSLine5B2	OK	ON	ON	no info	1600	OK	OK	ON	ON	no info
ACSLine6B2	OK	ON	ON	no info	1600	OK	OK	ON	ON	no info
ACSLine7B2	OK	ON	ON	no info	1600	OK	OK	ON	ON	no info
ACSLine8B2	OK	ON	ON	no info	1600	OK	OK	ON	ON	no info

18KV ON

RESET BIC INTERLOCK B1

BIC B1

RESET BIC INTERLOCK B2

BIC B2

POWER & RF COMMANDS

READY

send

RF ON

RF OFF

Select All

01:00:43 - RF ON command correctly sent to hardware for ACSLine7B2; waiting for RF LL status ON

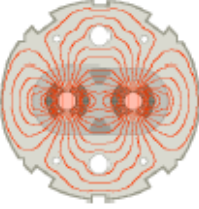
16 Klystrons

One Power Converter feeds 4 klystrons

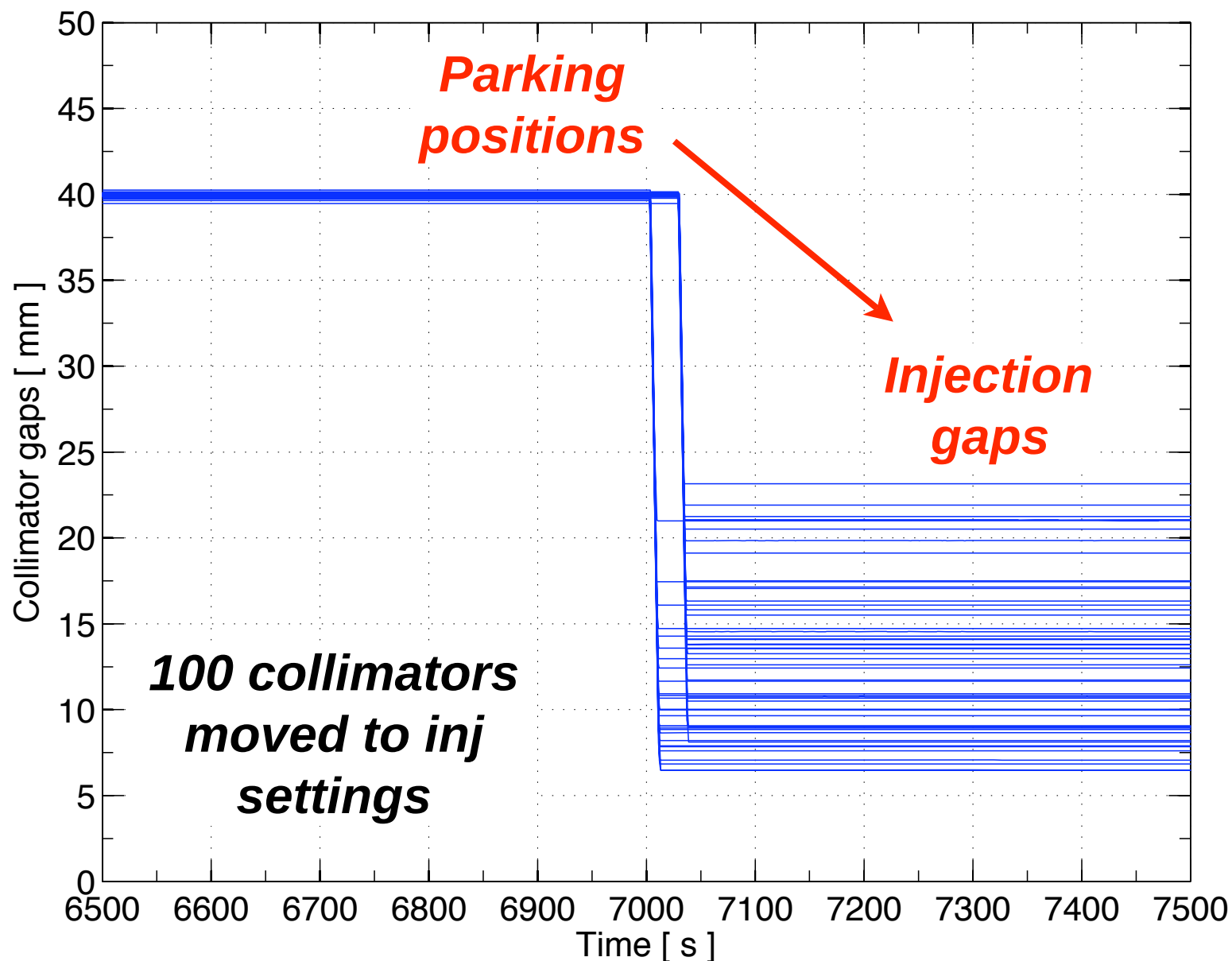
Cavity Controller LLRF

Injection settings:
8 MV per beam
=
1 MV x 8 cavities per beam

Preparing for beam: Collimators

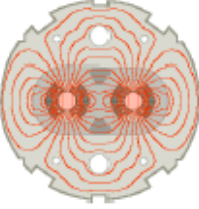


TED T12 position:	BEAM	TDI P2 gaps/mm	up: 9.05	down: 9.04
TED T18 position:	BEAM	TDI P8 gaps/mm	up: 8.32	down: 8.36



- TED's open ("beam")
- TDI's to "protect" settings
- Cleaning collimators to injection settings

Preparing for beam: injection kickers

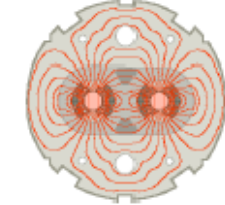


LHC Injection Kickers		
MKI - B1	Control: REMOTE	State: ON
Conditioning	Validity: true	Remaining time: 87 min.
MKI - B2	Control: REMOTE	State: ON
Conditioning	Validity: true	Remaining time: 88 min.

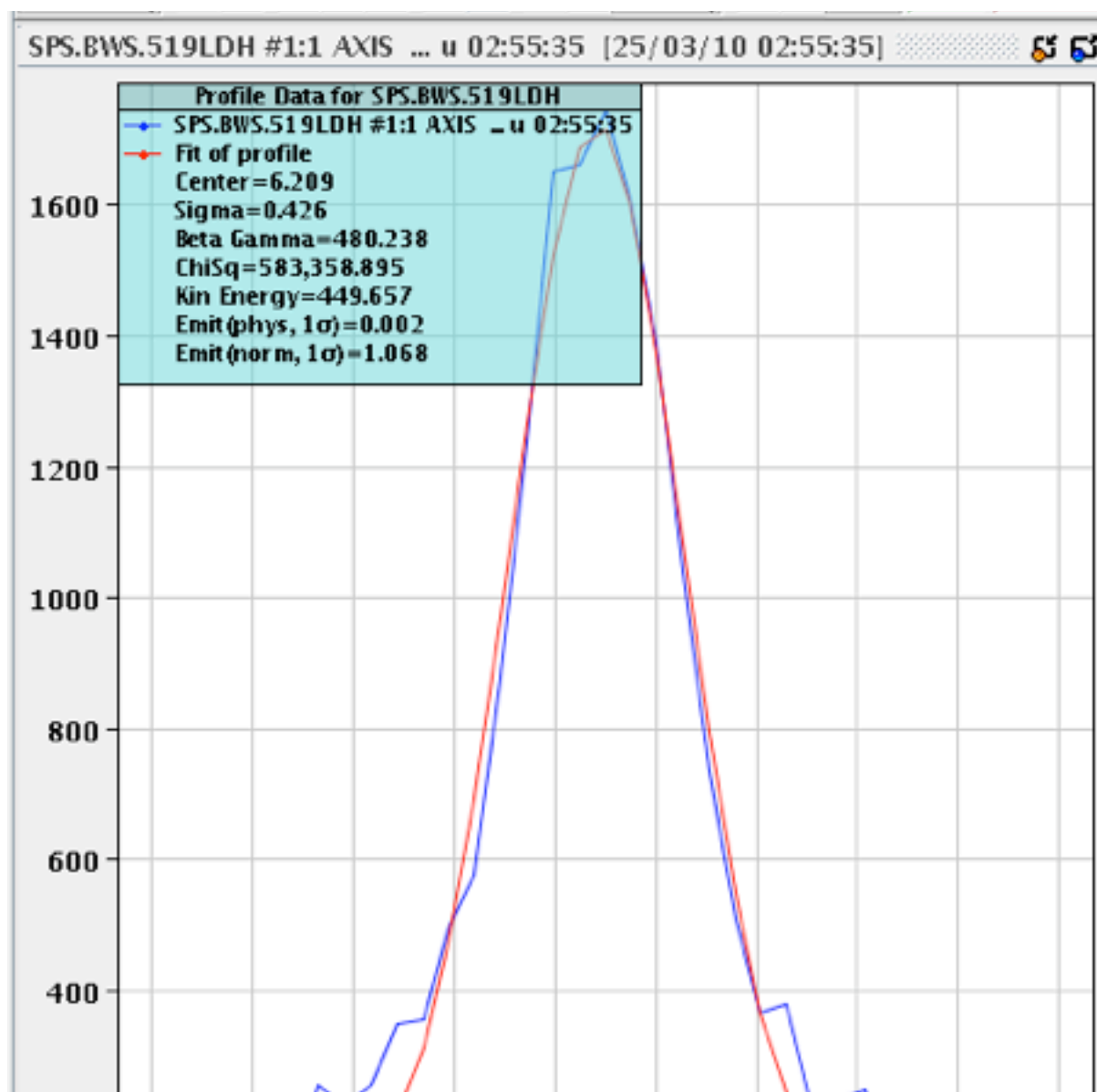
Kickers need to be conditioned.

Conditioning (“soft-start”) takes 10-15 minutes and lasts 1h30

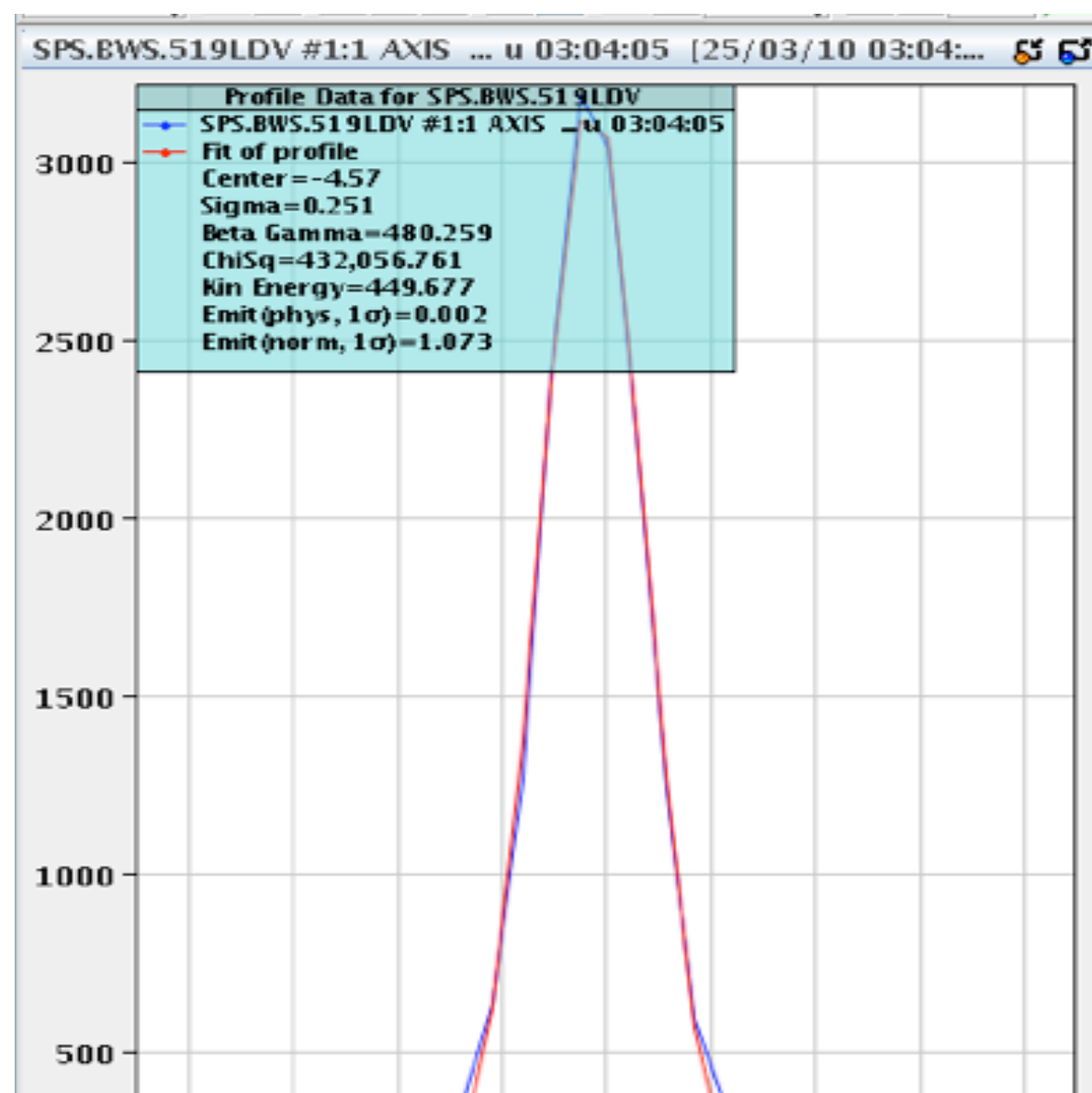
Preparing for beam: SPS emittances



Horizontal beam size



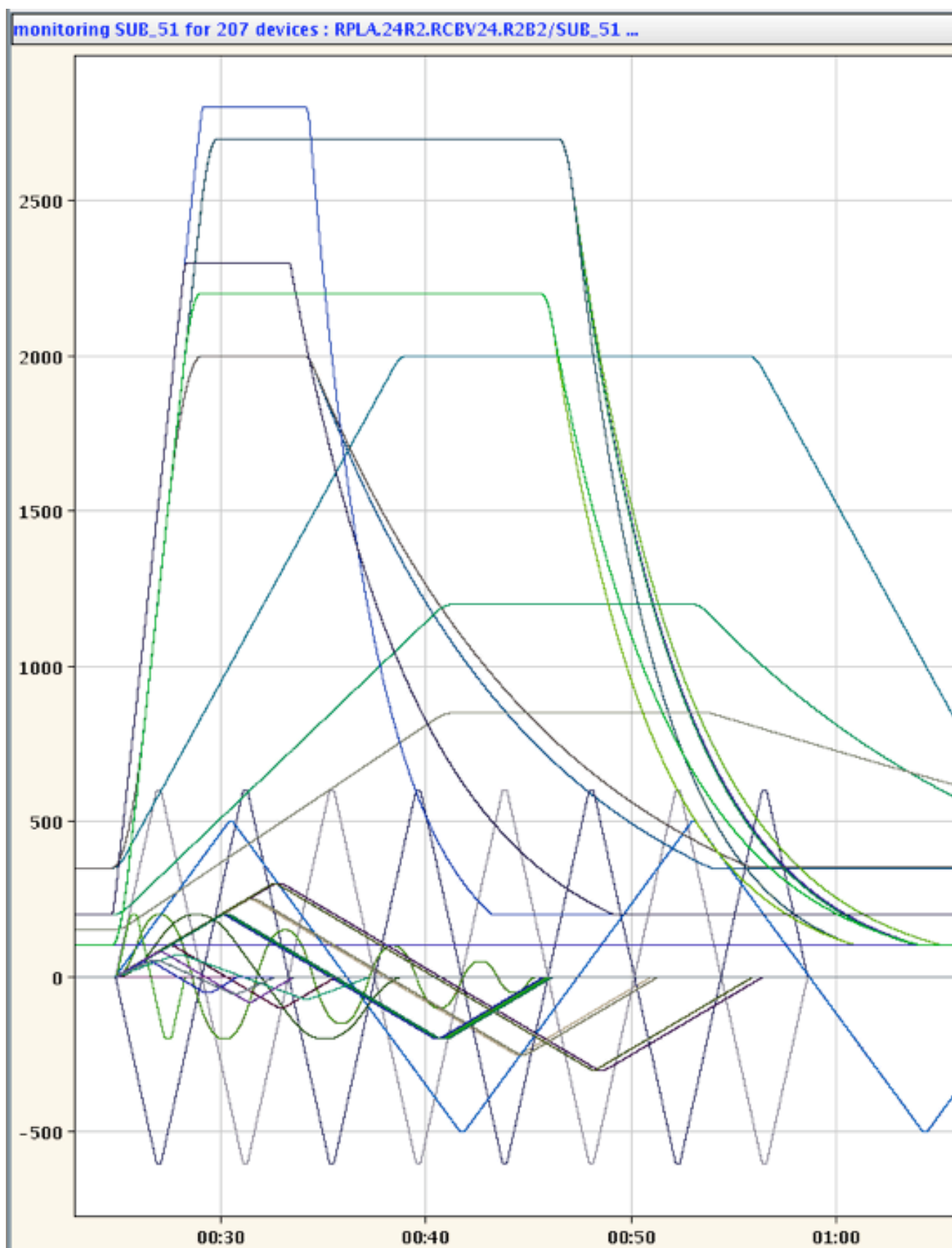
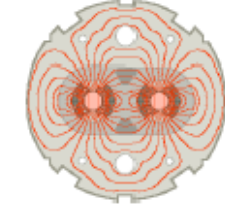
Vertical beam size



TED T12 position:	DUMP	TDI P2 gaps/mm	up: 9.12	down: 9.07
TED T18 position:	DUMP	TDI P8 gaps/mm	up: 8.34	down: 8.35

Could also verify steering of transfer lines with TED closed...

Finally, pre-cycling the sectors



LHC Cryogenics Page1 23-03-2010 12:44:18

BEAM SETUP: INJECTION PROBE BEAM

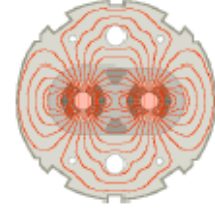
S 12	CM ITR1	CS ITR1	CM MSR1	CS MSR1	CM AR12	CS AR12	CM MSL2	CS MSL2	CM ITL2	CS ITL2
S 23	CM ITR2	CS ITR2	CM MSR2	CS MSR2	CM AML3	CS AML3				
S 34	CM AMR3	CS AMR3	CM MSL4	CS MSL4						
S 45	CM MSR4	CS MSR4	CM AR45	CS AR45	CM MSL5	CS MSL5	CM ITL5	CS ITL5		
S 56	CM ITR5	CS ITR5	CM MSR5	CS MSR5	CM AR56	CS AR56	CM MSL6	CS MSL6		
S 67	CM MSR6	CS MSR6	CM AML7	CS AML7						
S 78	CM AMR7	CS AMR7	CM MSL8	CS MSL8	CM ITL8	CS ITL8				
S 81	CM ITR8	CS ITR8	CM MSR8	CS MSR8	CM AR81	CS AR81	CM MSL1	CS MSL1	CM ITL1	CS ITL1
RF :	CM 1L4	CS 1L4	CM 2L4	CS 2L4	CM R4	CS 1R4	CM 2R4	CS 2R4		

Average Temperatures (in K):

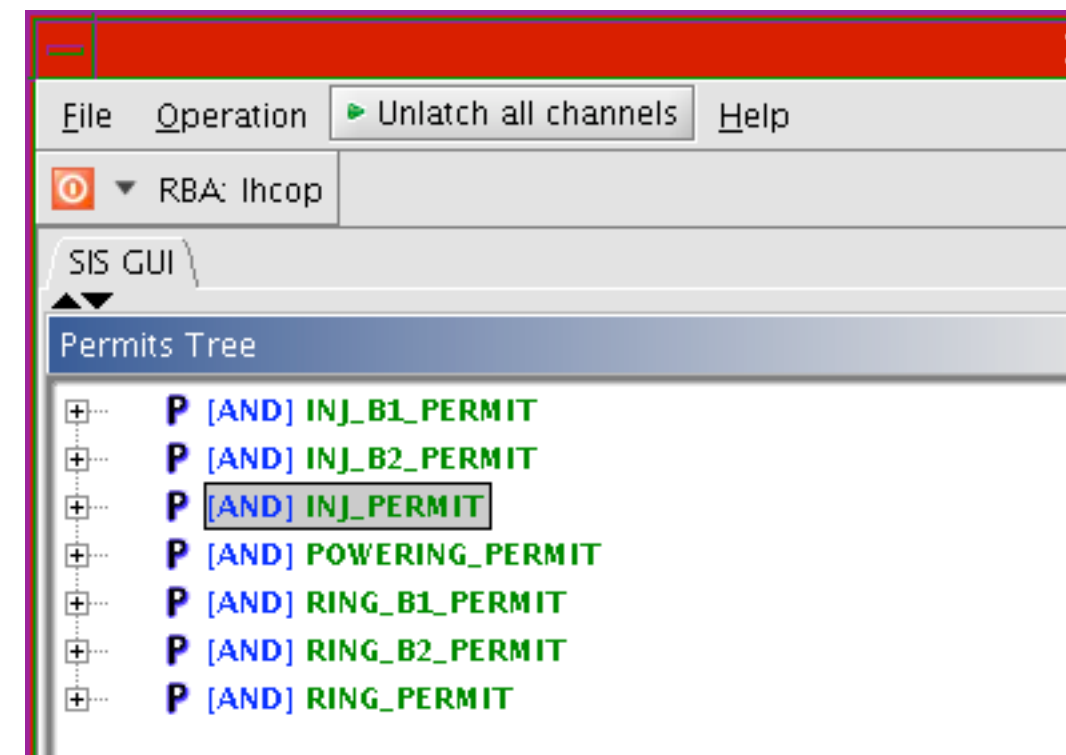
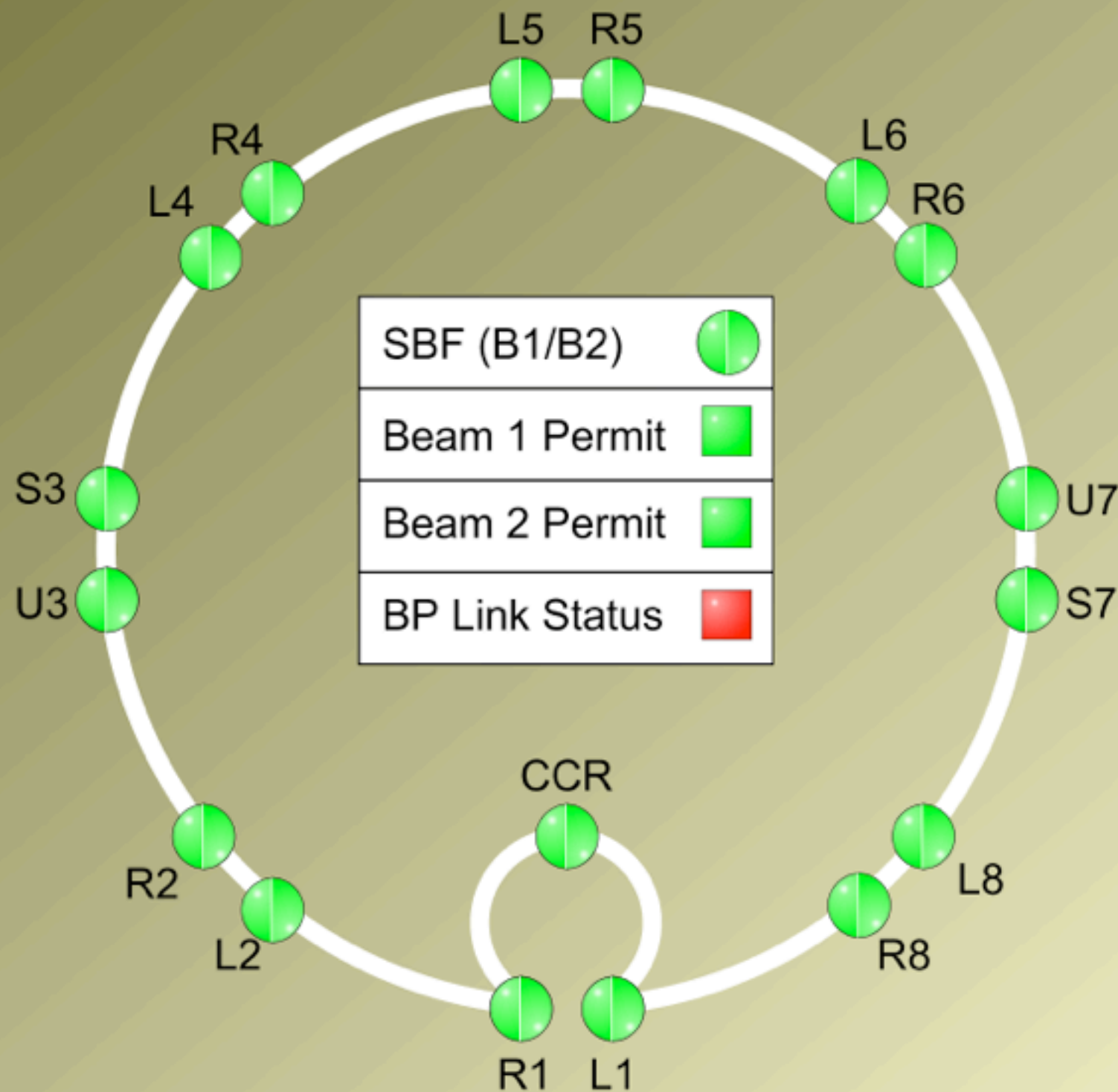
ARC12: 1.93	ARC23: 1.94	LSS12: 3.13	LSS23: 3.45	DFB12: 4.43	DFB23: 4.43
ARC34: 1.94	ARC45: 1.94	LSS34: 4.14	LSS45: 3.93	DFB34: 5.84	DFB45: 5.58
ARC56: 1.97	ARC67: 1.99	LSS56: 3.62	LSS67: 4.49	DFB56: 5.57	DFB67: 3.88
ARC78: 1.95	ARC81: 1.95	LSS78: 3.08	LSS81: 3.18	DFB78: 4.43	DFB81: 4.43

60A Power Permit: S12 S23 S34 S45 S56 S67 S78 S81

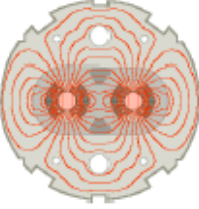
Machine is ready for injection!



LHC Beam Interlock System



Need to inform the experiments...

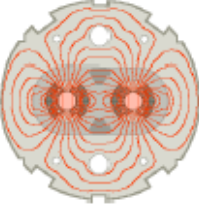


Injection hand-shake performed with appropriate sequences

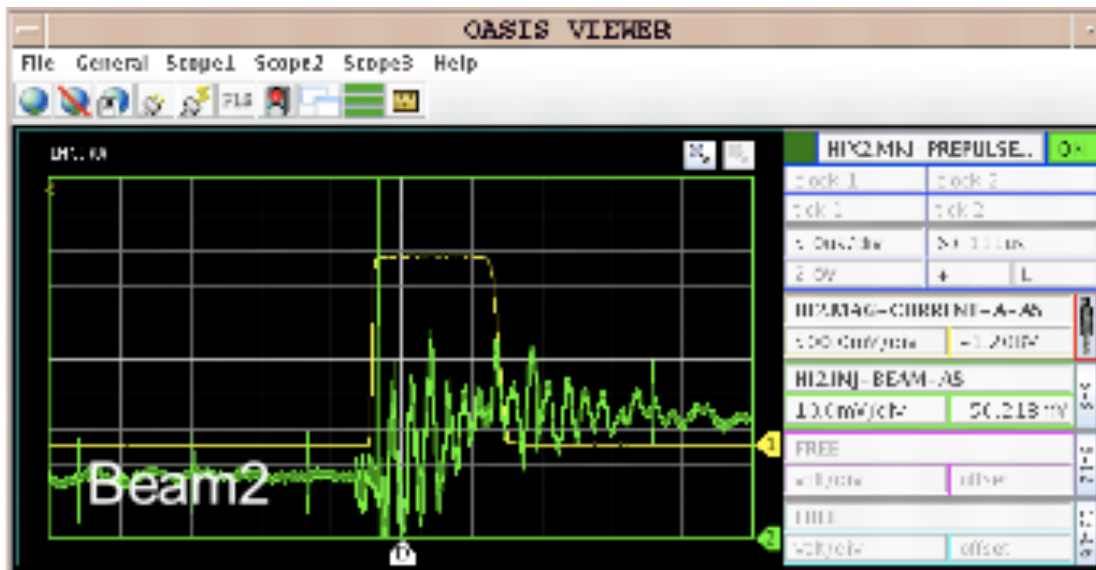
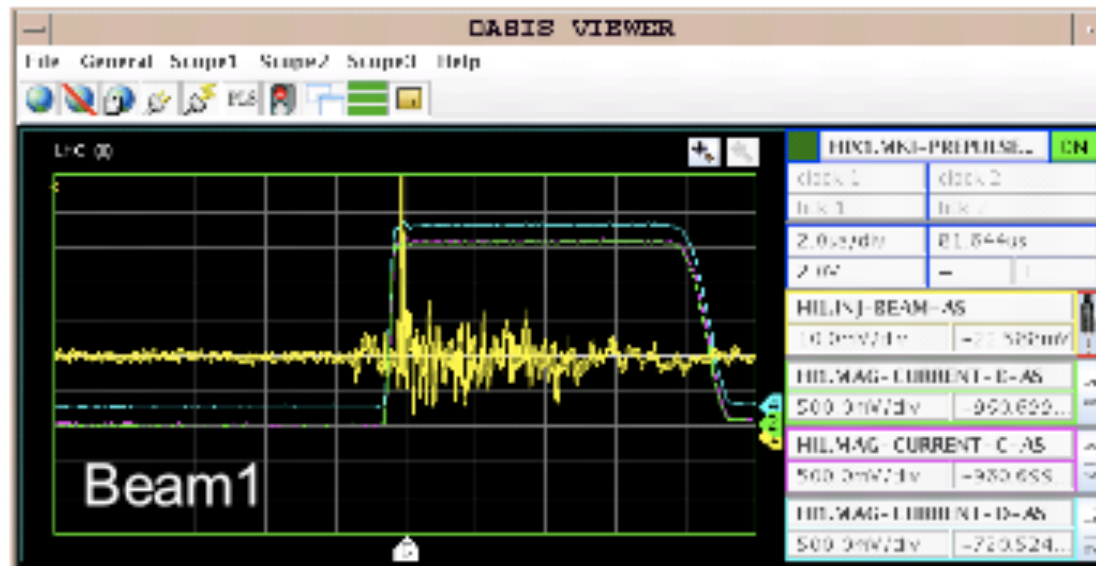
LHC-EXPTS Handshakes			
23-Mar-2010 21:57:27		Beam Mode: INJECT AND DUMP	
	INJECTION	ADJUST	BEAM DUMP
LHC Handshakes	READY	STANDBY	STANDBY
ATLAS Handshakes	READY	VETO	VETO
ALICE Handshakes	READY	VETO	VETO
CMS Handshakes	READY	VETO	VETO
LHCb Handshakes	READY	VETO	VETO
TOTEM Handshakes	READY	VETO	VETO
LHCf Handshakes	READY	VETO	VETO

Then we can request the beams from the injectors!!

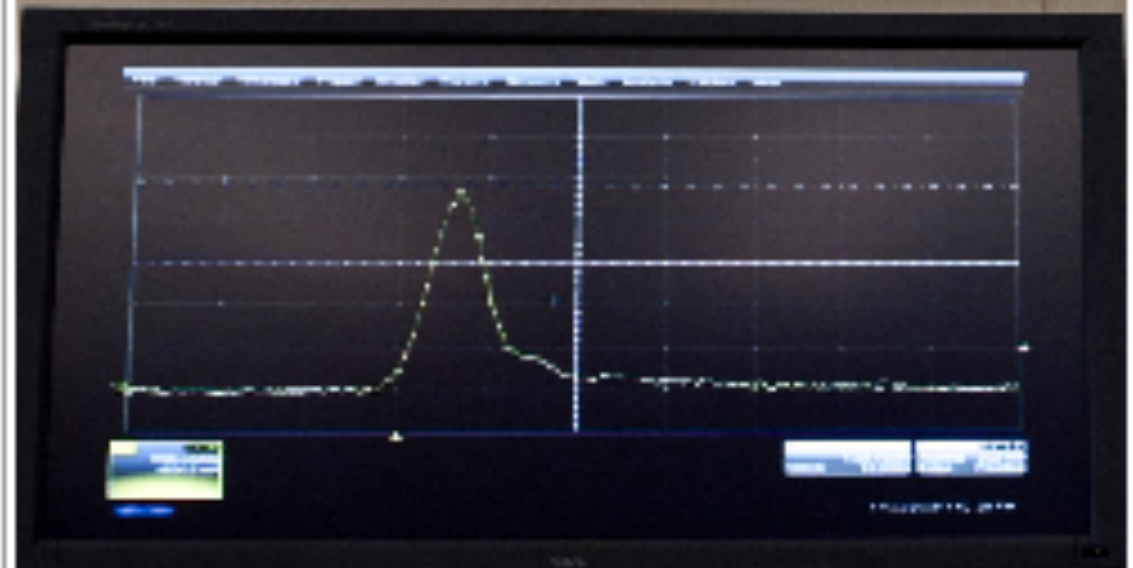
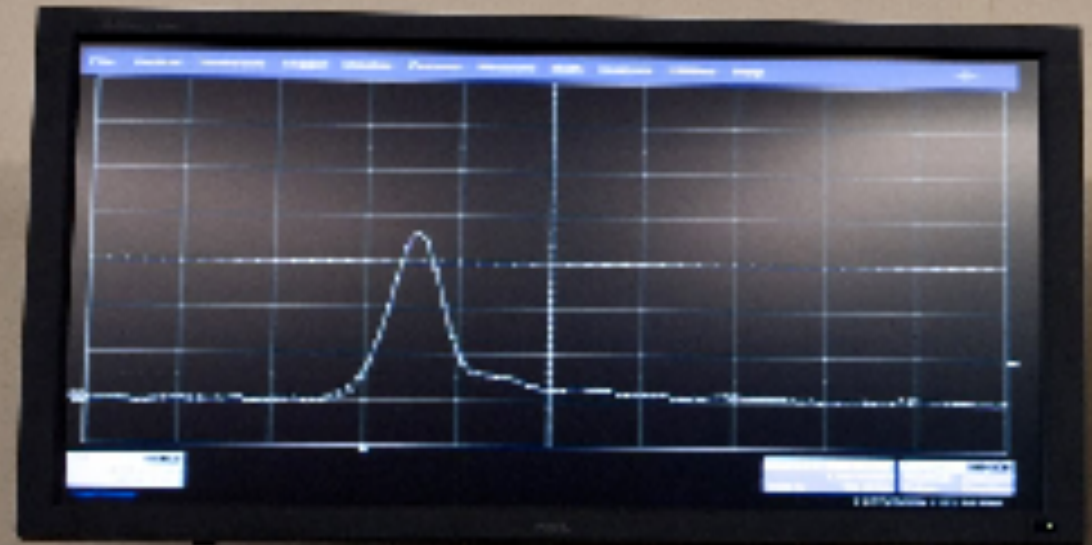
Both beams are back - what a relief!



Scopes at the end of TI2/8

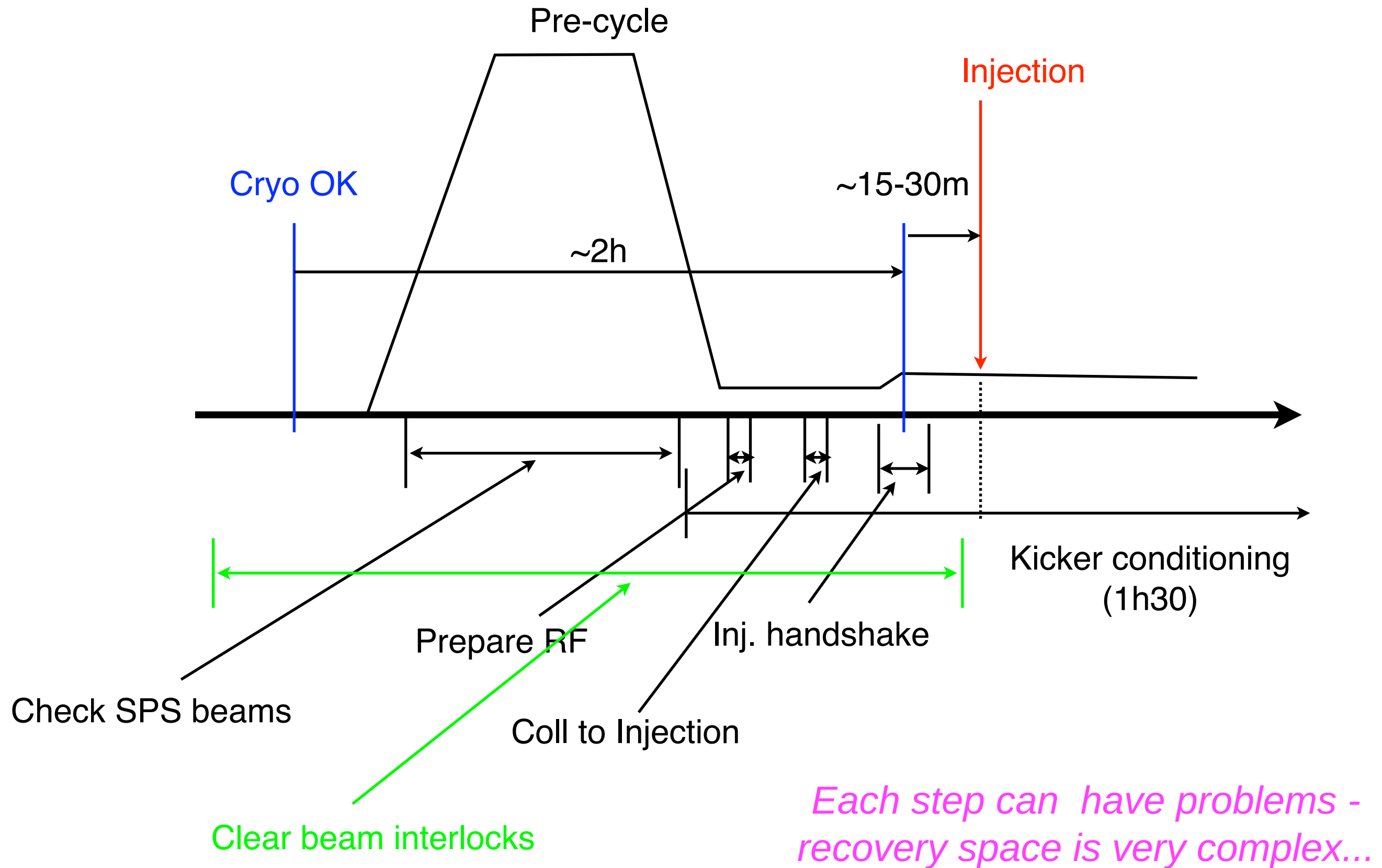


Longitudinal pickups in the LHC

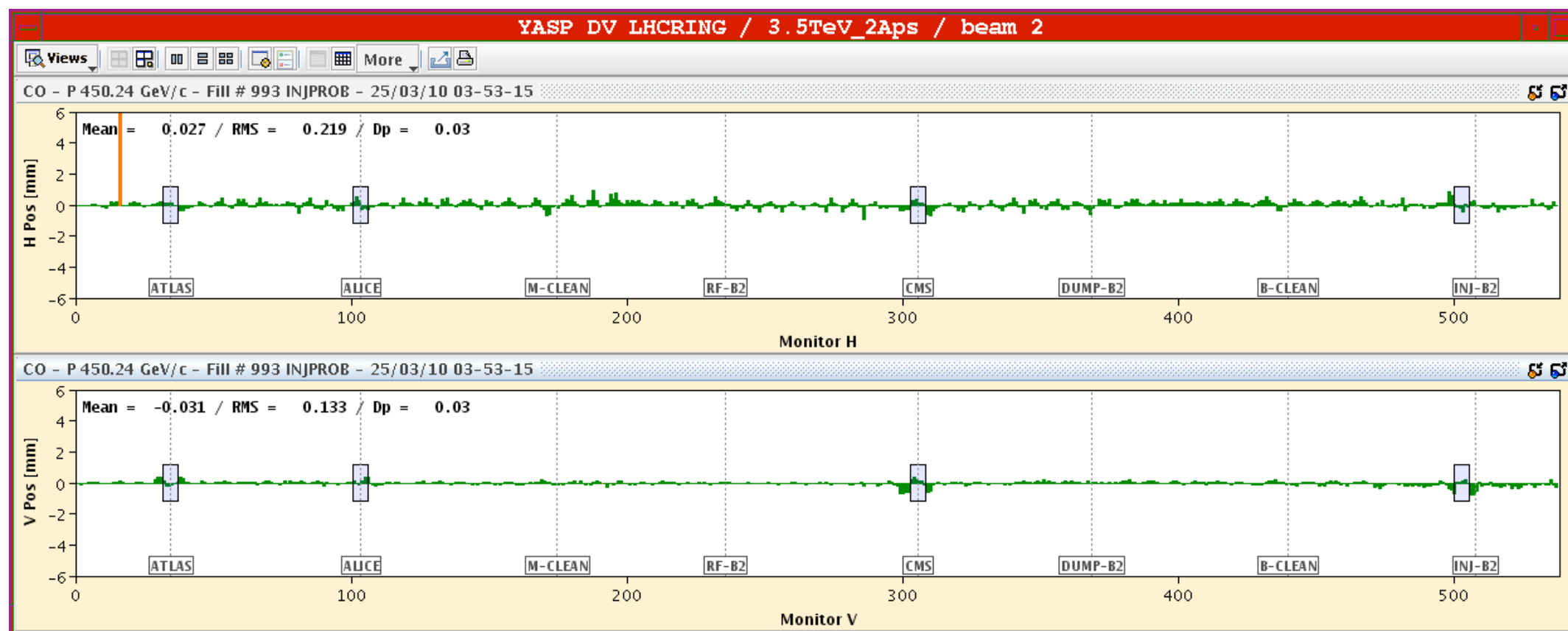
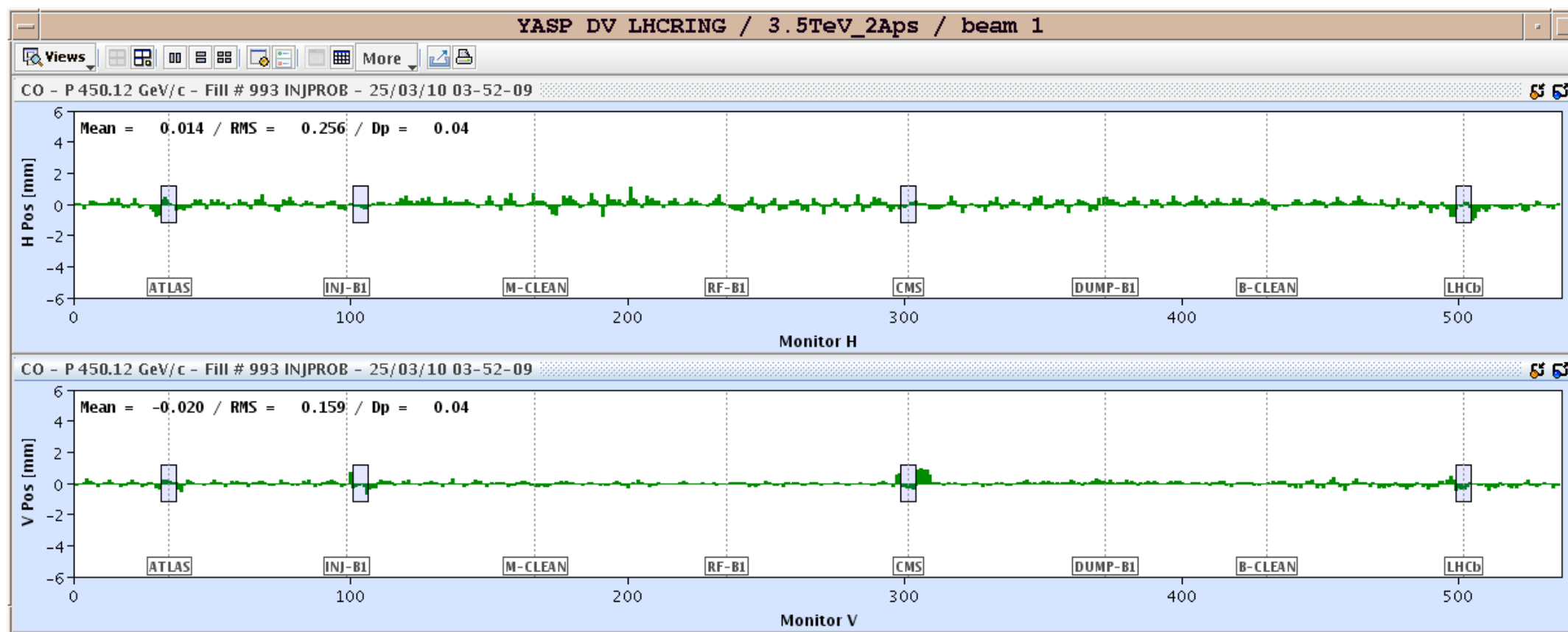
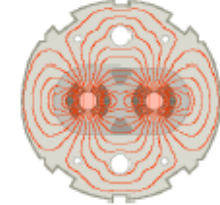


Screens showing two beams in the LHC

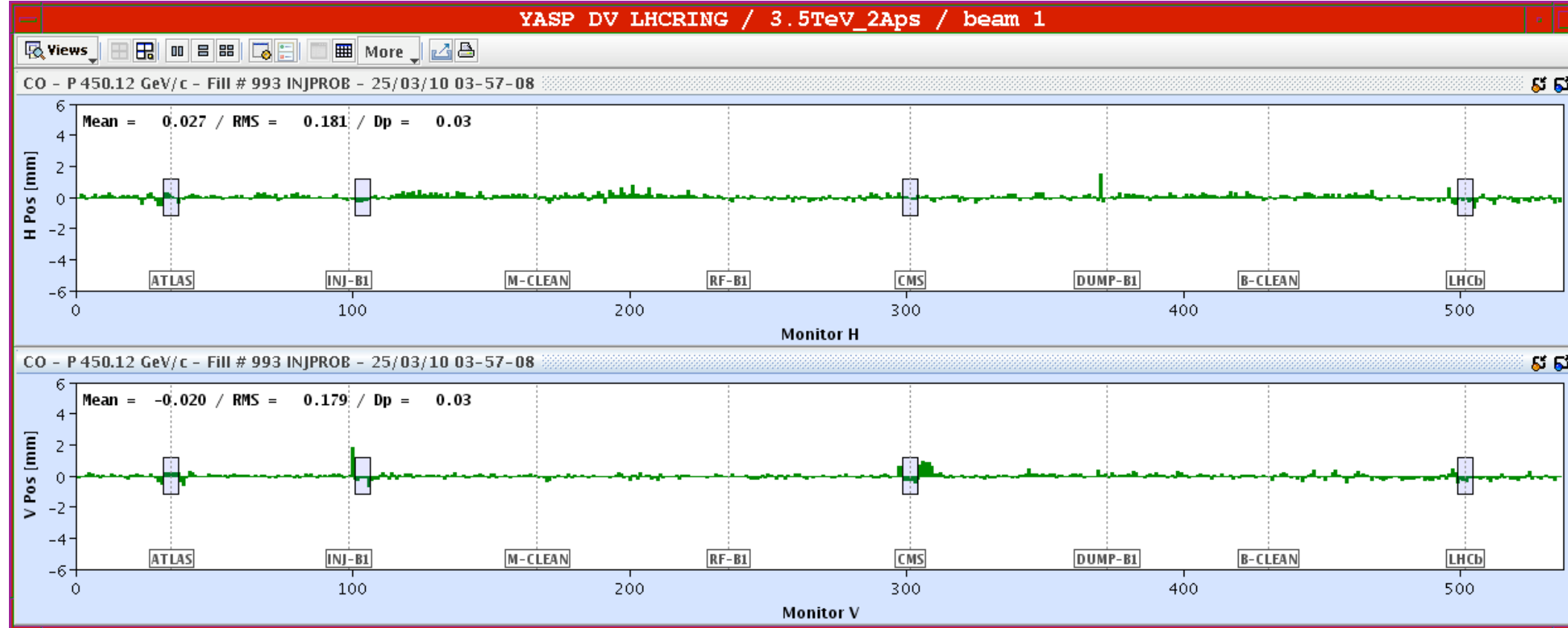
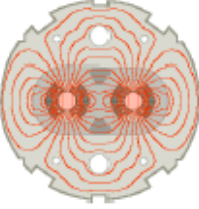
Time-line



Injection and first orbit

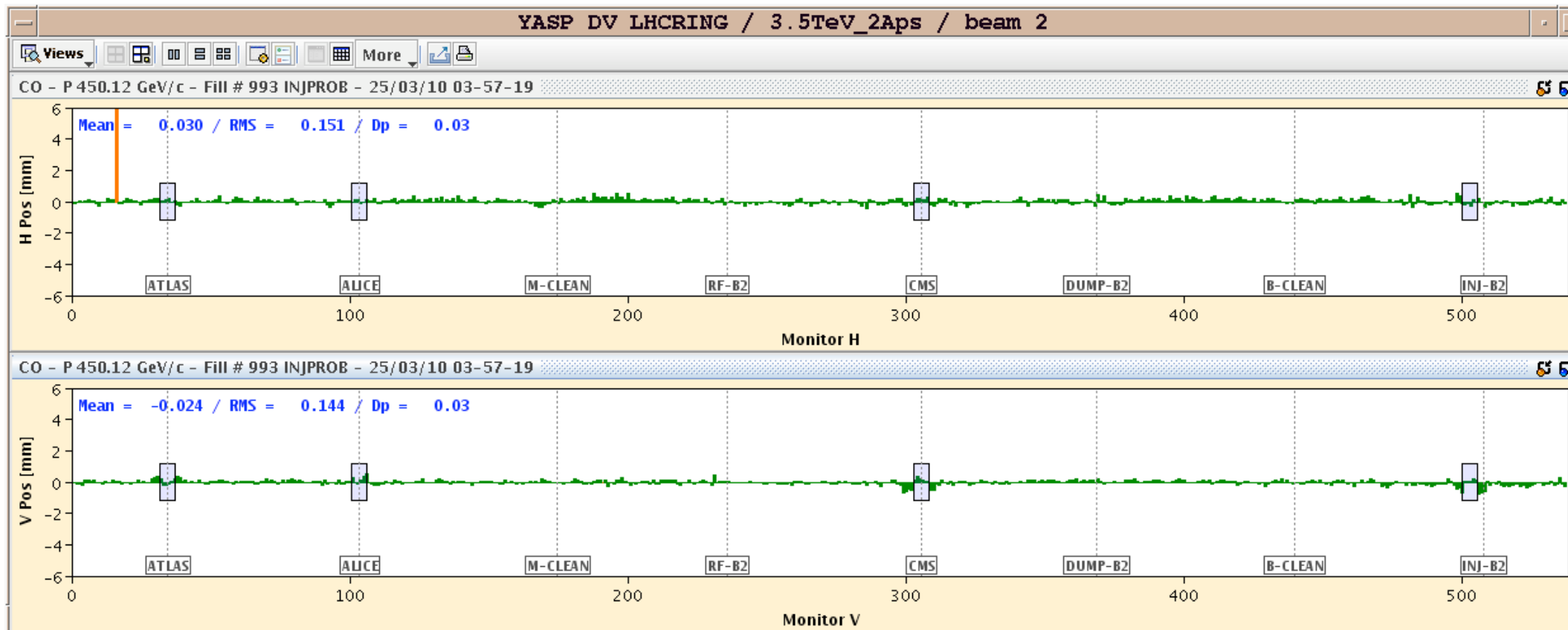


Orbit corrected to golden

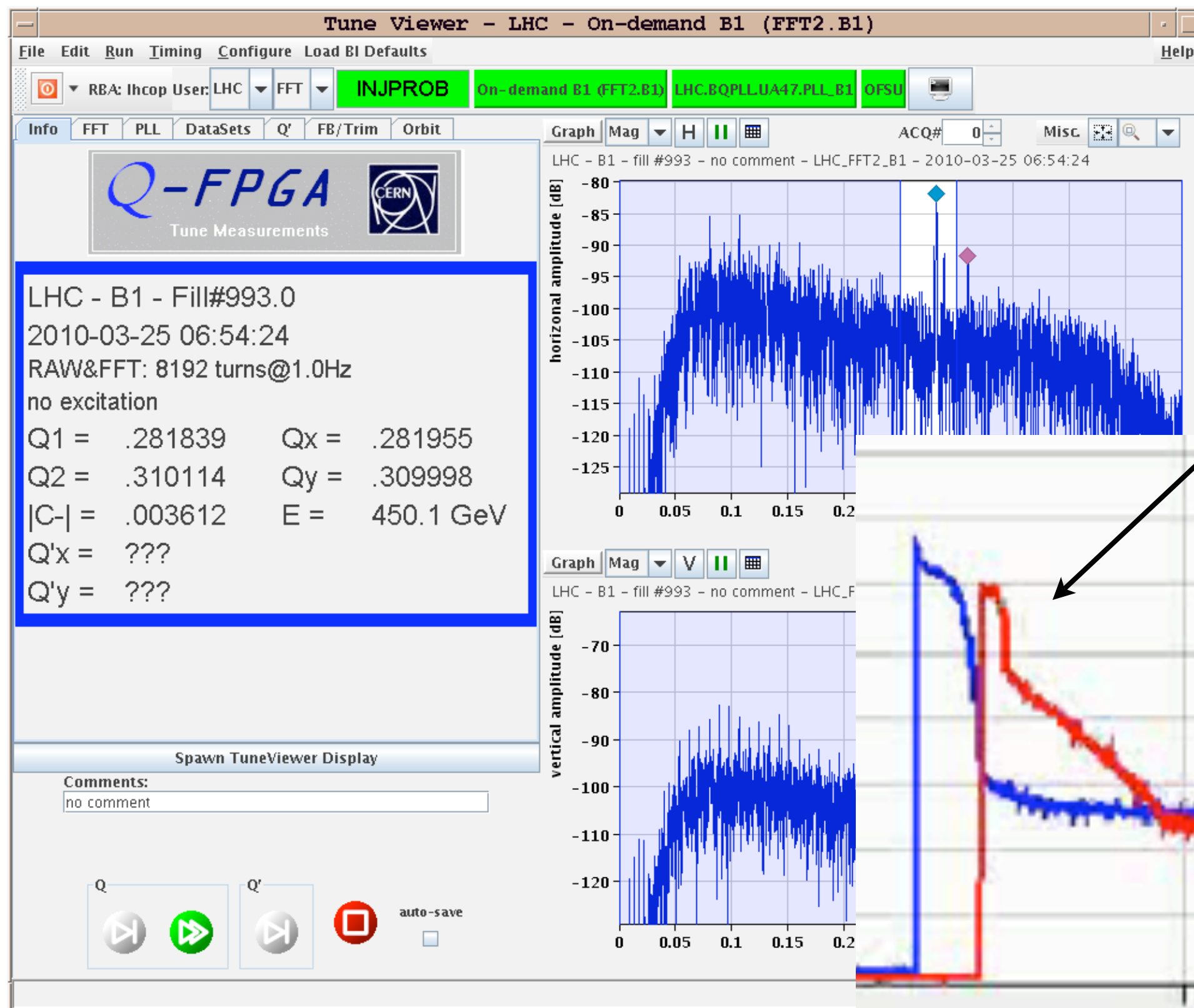
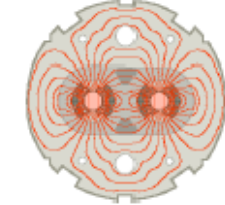


Correct RMS
difference to
golden to below
150-200 μm

Collimation
regions: absolute
difference below
 $\sim 200 \mu\text{m} = 20\%$
of σ

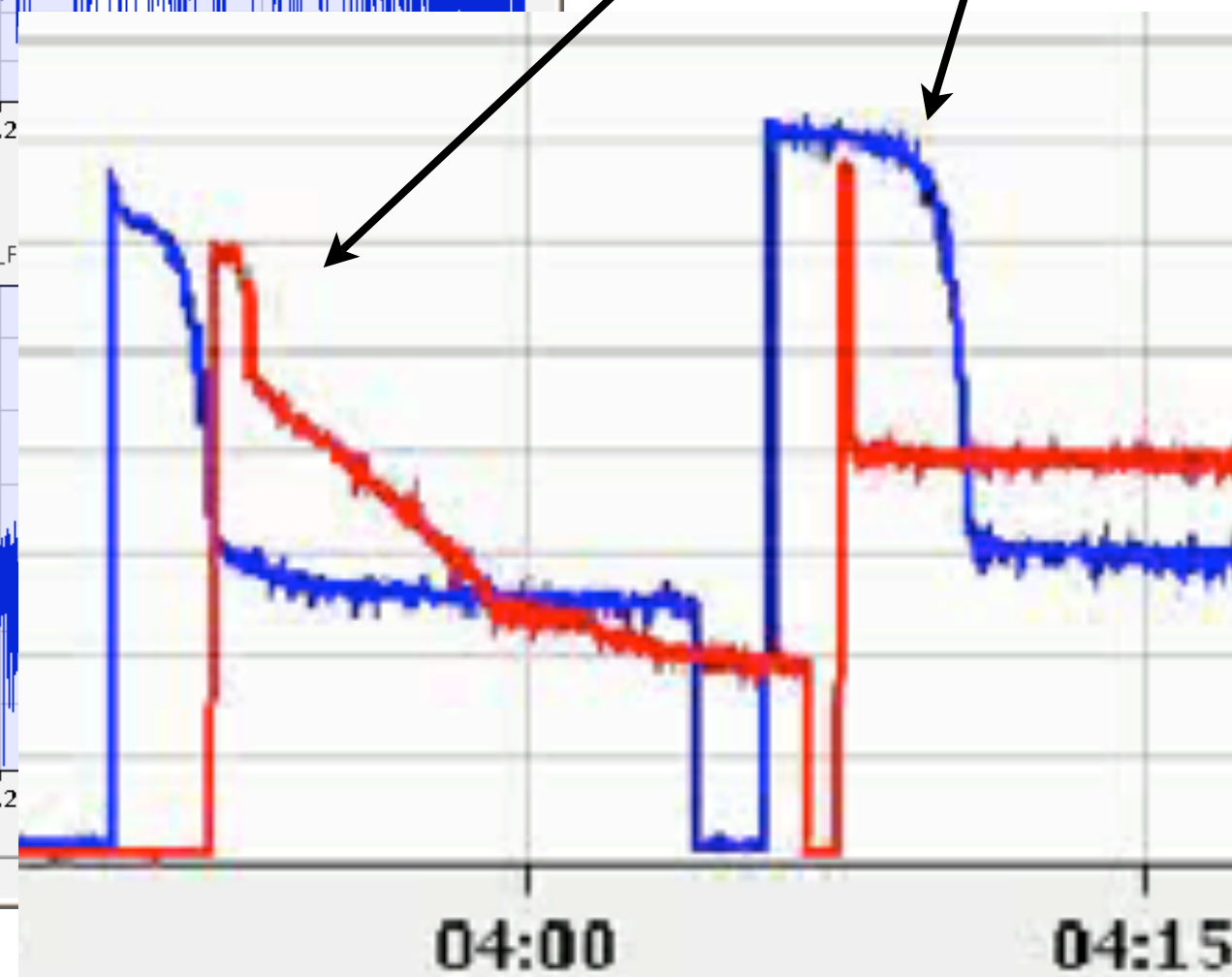


Tune correction - B1

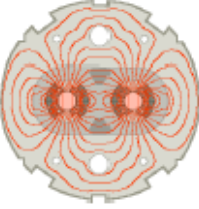


Tunes are also good.

BUT: lifetime VERY bad!



Chromaticity adjustment



04:12 Vertical tunes are on the hump and we have poor
We also check the chromaticity.

Chroma B1-h ~ -4 -> trimmed by +10
Chroma B2-h ~ 0 -> trimmed by +5

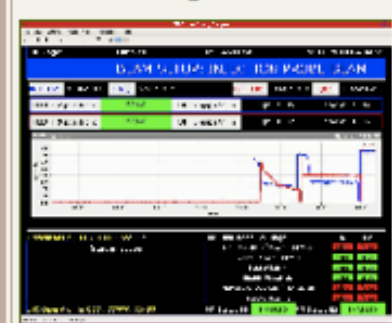
04:20 Chroma B1-V ~ 19 -> trimmed by -14
Chroma B2-V ~ 14 -> trimmed by -9

Tune values after chromaticity adjustments.

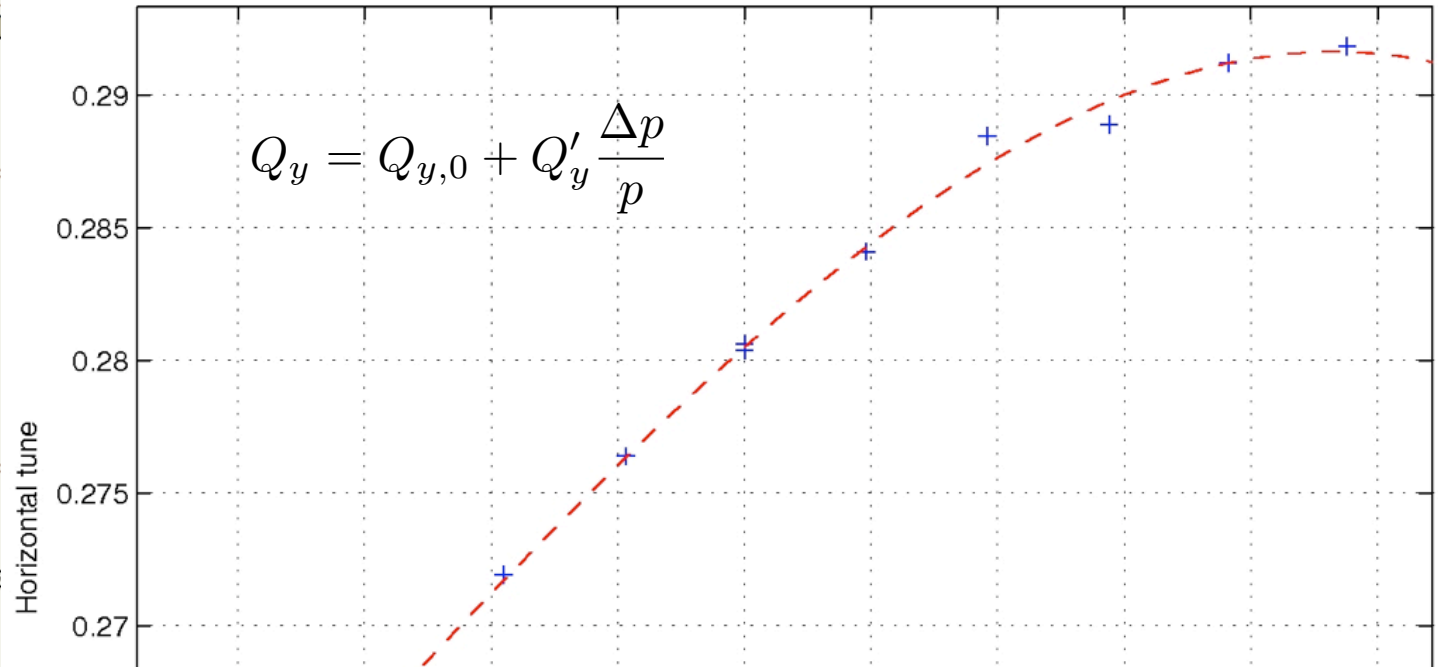
TuneViewer B1 : LHC 2010-03-25_04:30:35 (450.1 GeV)
Eigenmodes : .280715 .310197
Tunes : .280733 .310179 vs. 0.0 0.0
Coupling |C-| : .001433

04:30 TuneViewer B2 : LHC 2010-03-25_04:30:35 (450.1 GeV)
Eigenmodes : .280584 .310197
Tunes : .280944 .309551
Coupling |C-| : .006460

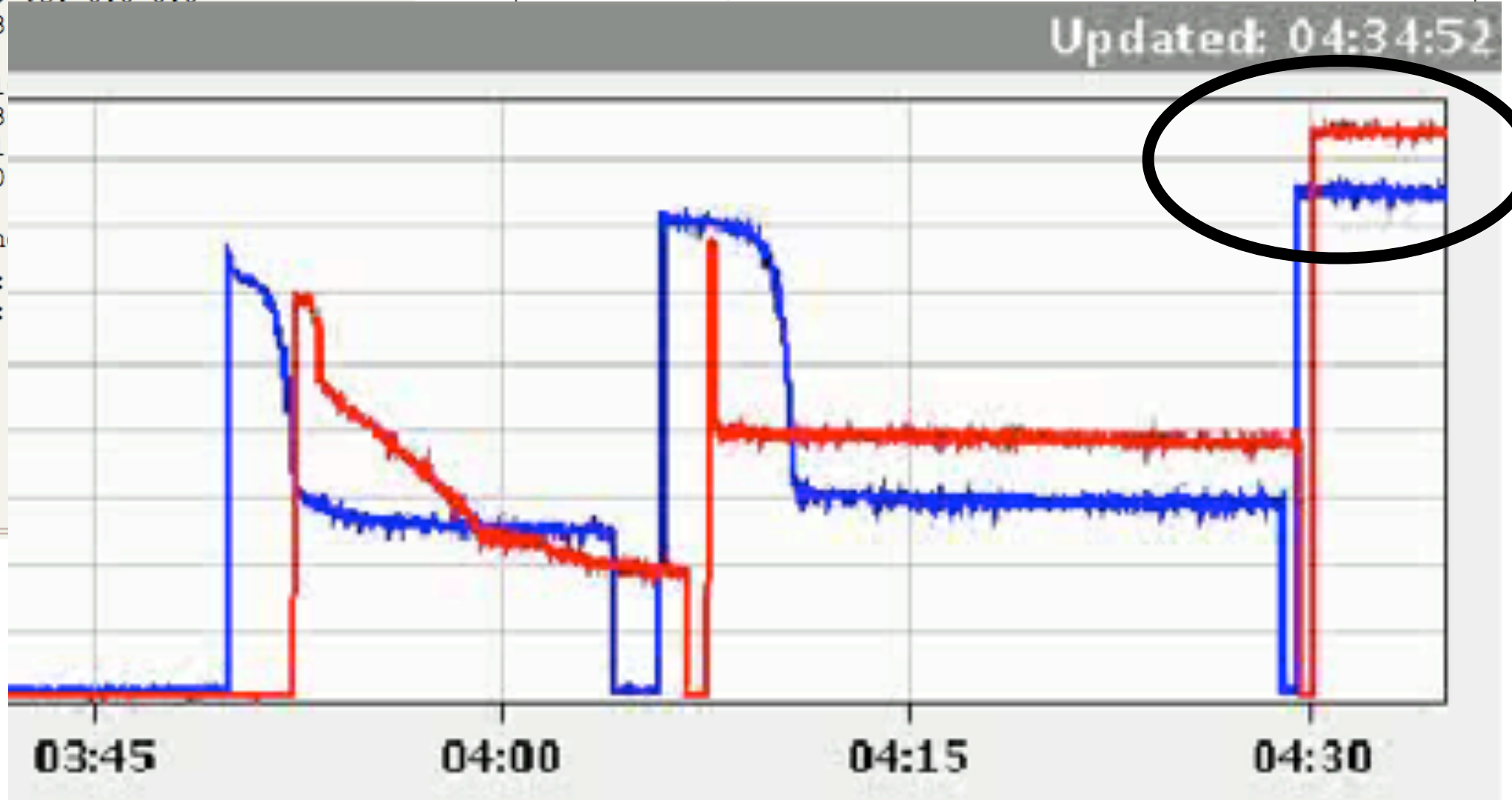
Clear improvement of the



name:
desc:

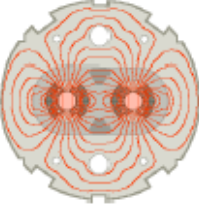


Updated: 04:34:52

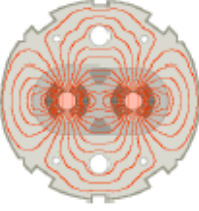


*We are finally ready
for a RAMP!
But . . .*

Another “cold” shower at 05h00

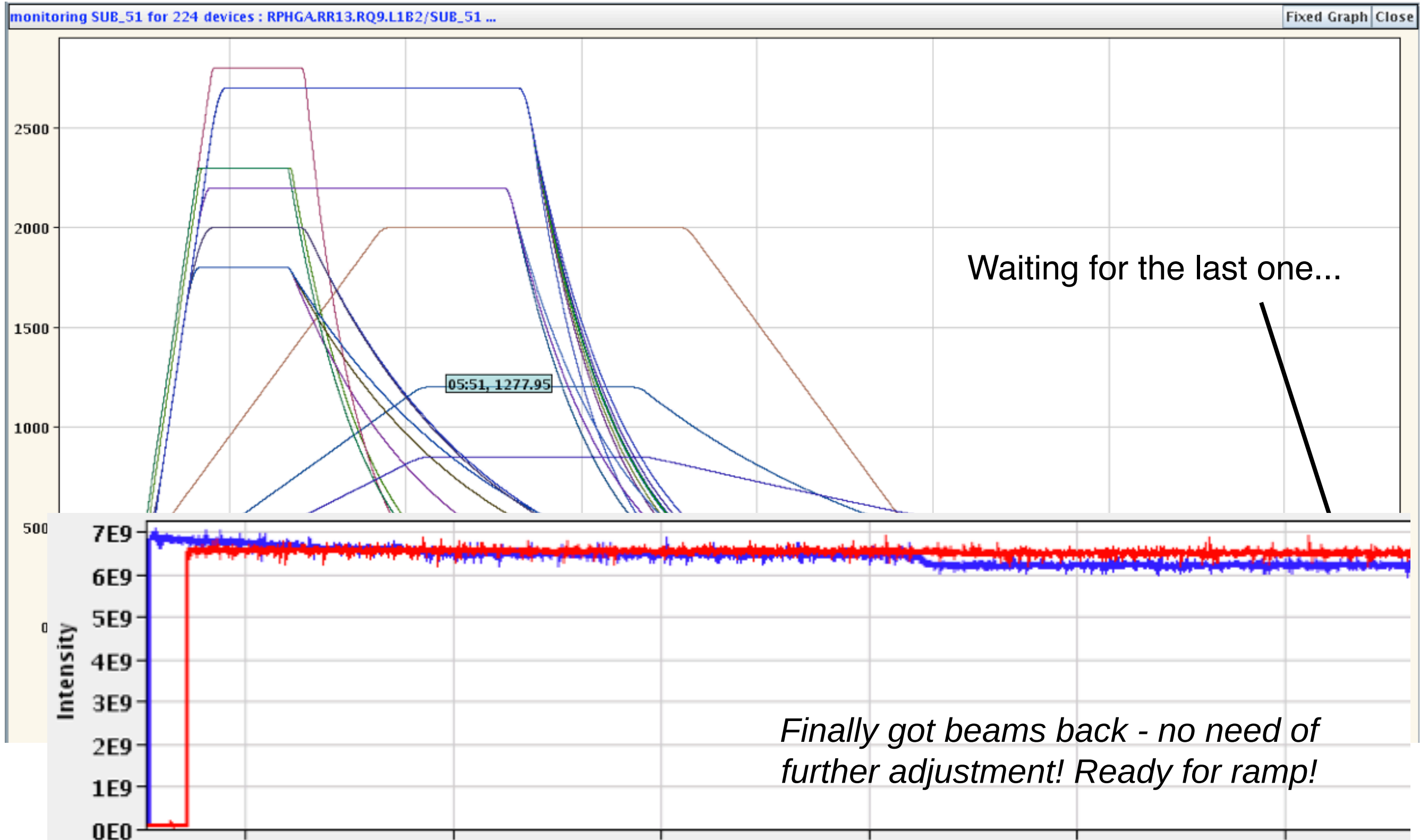
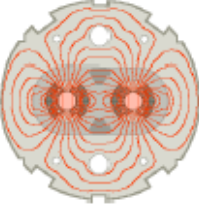


RB.A81	RCBCH10.L1B1	RCBCH10.R8B1	RCBCH5.L1B2	RCBCH6.L1B1	RCBCH6.R8B1	RCBCH7.L1B2	RCBCH7.R8B2	RCBCH8.L1B1
RCBCH8.R8B1	RCBCH9.L1B2	RCBCH9.R8B2	RCBCV10.L1B2	RCBCV10.R8B2	RCBCV5.L1B1	RCBCV6.L1B2	RCBCV6.R8B2	RCBCV7.L1B1
RCBCV7.R8B1	RCBCV8.L1B2	RCBCV8.R8B2	RCBCV9.L1B1	RCBCV9.R8B1	RCBH11.L1B2	RCBH11.R8B2	RCBH12.L1B1	RCBH12.R8B1
RCBH13.L1B2	RCBH13.R8B2	RCBH14.L1B1	RCBH14.R8B1	RCBH15.L1B2	RCBH15.R8B2	RCBH16.L1B1	RCBH16.R8B1	RCBH17.L1B2
RCBH17.R8B2	RCBH18.L1B1	RCBH18.R8B1	RCBH19.L1B2	RCBH19.R8B2	RCBH20.L1B1	RCBH20.R8B1	RCBH21.L1B2	RCBH21.R8B2
RCBH22.L1B1	RCBH22.R8B1	RCBH23.L1B2	RCBH23.R8B2	RCBH24.L1B1	RCBH24.R8B1	RCBH25.L1B2	RCBH25.R8B2	RCBH26.L1B1
RCBH26.R8B1	RCBH27.L1B2	RCBH27.R8B2	RCBH28.L1B1	RCBH28.R8B1	RCBH29.L1B2	RCBH29.R8B2	RCBH30.L1B1	RCBH30.R8B1
RCBH31.L1B2	RCBH31.R8B2	RCBH32.L1B1	RCBH32.R8B1	RCBH33.L1B2	RCBH33.R8B2	<i>Lost the cryogenics sector 81!!</i>		
RCBV12.L1B2	RCBV12.R8B2	RCBV13.L1B1	RCBV13.R8B1	RCBV14.L1B2	RCBV14.R8B2			
RCBV16.R8B2	RCBV17.L1B1	RCBV17.R8B1	RCBV18.L1B2	RCBV18.R8B2	RCBV19.L1B1			
RCBV21.L1B1	RCBV21.R8B1	RCBV22.L1B2	RCBV22.R8B2	RCBV23.L1B1	RCBV23.R8B1	RCBV24.L1B2	RCBV24.R8B2	RCBV25.L1B1
RCBV25.R8B1	RCBV26.L1B2	RCBV26.R8B2	RCBV27.L1B1	RCBV27.R8B1	RCBV28.L1B2	RCBV28.R8B2	RCBV29.L1B1	RCBV29.R8B1
RCBV30.L1B2	RCBV30.R8B2	RCBV31.L1B1	RCBV31.R8B1	RCBV32.L1B2	RCBV32.R8B2	RCBV33.L1B1	RCBV33.R8B1	RCBV34.L1B2
RCBXH1.L1	RCBXH1.R8	RCBXH2.L1	RCBXH2.R8	RCBXH3.L1	RCBXH3.R8	RCBXV1.L1	RCBXV1.R8	RCBXV2.L1
RCBXV2.R8	RCBXV3.L1	RCBXV3.R8	RCBYH4.L1B1	RCBYH4.R8B1	RCBYH5.R8B2	RCBYHS4.L1B1	RCBYHS4.L1B2	RCBYHS4.R8B1
RCBYHS4.R8B2	RCBYHS5.R8B1	RCBYHS5.R8B2	RCBYV4.L1B2	RCBYV4.R8B2	RCBYV5.R8B1	RCBYVS4.L1B1	RCBYVS4.L1B2	RCBYVS4.R8B1
RCBYVS4.R8B2	RCBYVS5.R8B1	RCBYVS5.R8B2	RCD.A81B1	RCD.A81B2	RCO.A81B1	RCS.A81B1	RCS.A81B2	RD1.R8
RD2.L1	RD2.R8	ROD.A81B1	ROD.A81B2	ROF.A81B1	ROF.A81B2	RQ10.L1B1	RQ10.L1B2	RQ10.R8B1
RQ10.R8B2	RQ4.L1B1	RQ4.L1B2	RQ4.R8B1	RQ4.R8B2	RQ5.L1B1	RQ5.L1B2	RQ5.R8B1	RQ5.R8B2
RQ6.L1B1	RQ6.L1B2	RQ6.R8B1	RQ6.R8B2	RQ7.L1B1	RQ7.L1B2	RQ7.R8B1	RQ7.R8B2	RQ8.L1B1
RQ8.L1B2	RQ8.R8B1	RQ8.R8B2	RQ9.L1B1	RQ9.L1B2	RQ9.R8B1	RQ9.R8B2	RQD.A81	RQF.A81
RQS.A81B1	RQS.L1B2	RQS.R8B2	RQT12.L1B1	RQT12.L1B2	RQT12.R8B1	RQT12.R8B2	RQT13.L1B1	RQT13.L1B2
RQT13.R8B1	RQT13.R8B2	RQTD.A81B1	RQTD.A81B2	RQTF.A81B1	RQTF.A81B2	RQTL11.L1B1	RQTL11.L1B2	RQTL11.R8B1
RQTL11.R8B2	RQX.L1	RQX.R8	RSD1.A81B1	RSD1.A81B2	RSD2.A81B1	RSD2.A81B2	RSF1.A81B1	RSF1.A81B2
RSF2.A81B1	RSF2.A81B2	RSS.A81B1	RSS.A81B2	RTOX1.L1	RTOX1.R8	RTOX2.L1	RTOX2.R8	



RB.A81	RCBCH10.L1B1	RCBCH10.R8B1	RCBCH5.L1B2	RCBCH6.L1B1	RCBCH6.R8B1	RCBCH7.L1B2	RCBCH7.R8B2	RCBCH8.L1B1
RCBCH8.R8B1	RCBCH9.L1B2	RCBCH9.R8B2	RCBCV10.L1B2	RCBCV10.R8B2	RCBCV5.L1B1	RCBCV6.L1B2	RCBCV6.R8B2	RCBCV7.L1B1
RCBCV7.R8B1	RCBCV8.L1B2	RCBCV8.R8B2	RCBCV9.L1B1	RCBCV9.R8B1	RCBH11.L1B2	RCBH11.R8B2	RCBH12.L1B1	RCBH12.R8B1
RCBH13.L1B2	RCBH13.R8B2	RCBH14.L1B1	RCBH14.R8B1	RCBH15.L1B2	RCBH15.R8B2	RCBH16.L1B1	RCBH16.R8B1	RCBH17.L1B2
RCBH17.R8B2	RCBH18.L1B1	RCBH18.R8B1	RCBH19.L1B2	RCBH19.R8B2	RCBH20.L1B1	RCBH20.R8B1	RCBH21.L1B2	RCBH21.R8B2
RCBH22.L1B1	RCBH22.R8B1	RCBH23.L1B2	RCBH23.R8B2	RCBH24.L1B1	RCBH24.R8B1	RCBH25.L1B2	RCBH25.R8B2	RCBH26.L1B1
RCBH26.R8B1	RCBH27.L1B2	RCBH27.R8B2	RCBH28.L1B1	RCBH28.R8B1	RCBH29.L1B2	RCBH29.R8B2	RCBH30.L1B1	RCBH30.R8B1
RCBH31.L1B2	RCBH31.R8B2	RCBH32.L1B1	RCBH32.R8B1	RCBH33.L1B2	RCBH33.R8B2	RCBH34.L1B1	RCBV11.L1B1	RCBV11.R8B1
RCBV12.L1B2	RCBV12.R8B2	RCBV13.L1B1	RCBV13.R8B1	RCBV14.L1B2	RCBV14.R8B2	RCBV15.L1B1	RCBV15.R8B1	RCBV16.L1B2
RCBV16.R8B2	RCBV17.L1B1	RCBV17.R8B1	RCBV18.L1B2	RCBV18.R8B2	RCBV19.L1B1	RCBV19.R8B1	RCBV20.L1B2	RCBV20.R8B2
RCBV21.L1B1	RCBV21.R8B1	RCBV22.L1B2	RCBV22.R8B2	RCBV23.L1B1	RCBV23.R8B1	RCBV24.L1B2	RCBV24.R8B2	RCBV25.L1B1
RCBV25.R8B1	RCBV26.L1B2	RCBV26.R8B2	RCBV27.L1B1	RCBV27.R8B1	RCBV28.L1B2	RCBV28.R8B2	RCBV29.L1B1	RCBV29.R8B1
RCBV30.L1B2	RCBV30.R8B2	RCBV31.L1B1	RCBV31.R8B1	RCBV32.L1B2	RCBV32.R8B2	RCBV33.L1B1	RCBV33.R8B1	RCBV34.L1B2
RCBXH1.L1	RCBXH1.R8	RCBXH2.L1	RCBXH2.R8	RCBYH1.L1	RCBYH1.R8	RCBYH2.L1	RCBYH2.R8	RCBYH3.L1
RCBYH3.R8	RCBYH3.L1	RCBYH3.R8	RCBYH3.L1	RCBYH4.L1	RCBYH4.R8	RCBYH5.L1	RCBYH5.R8	RCBYH6.L1
RCBYH6.R8	RCBYH6.L1	RCBYH6.R8	RCBYH6.L1	RCBYH7.L1	RCBYH7.R8	RCBYH8.L1	RCBYH8.R8	RCBYH9.L1
RCBYH9.R8	RCBYH9.L1	RCBYH9.R8	RCBYH9.L1	RCBYH10.L1	RCBYH10.R8	RCBYH11.L1	RCBYH11.R8	RCBYH12.L1
RCBYH12.R8	RCBYH12.L1	RCBYH12.R8	RCBYH12.L1	RCBYH13.L1	RCBYH13.R8	RCBYH14.L1	RCBYH14.R8	RCBYH15.L1
RCBYH15.R8	RCBYH15.L1	RCBYH15.R8	RCBYH15.L1	RCBYH16.L1	RCBYH16.R8	RCBYH17.L1	RCBYH17.R8	RCBYH18.L1
RCBYH18.R8	RCBYH18.L1	RCBYH18.R8	RCBYH18.L1	RCBYH19.L1	RCBYH19.R8	RCBYH20.L1	RCBYH20.R8	RCBYH21.L1
RCBYH21.R8	RCBYH21.L1	RCBYH21.R8	RCBYH21.L1	RCBYH22.L1	RCBYH22.R8	RCBYH23.L1	RCBYH23.R8	RCBYH24.L1
RCBYH24.R8	RCBYH24.L1	RCBYH24.R8	RCBYH24.L1	RCBYH25.L1	RCBYH25.R8	RCBYH26.L1	RCBYH26.R8	RCBYH27.L1
RCBYH27.R8	RCBYH27.L1	RCBYH27.R8	RCBYH27.L1	RCBYH28.L1	RCBYH28.R8	RCBYH29.L1	RCBYH29.R8	RCBYH30.L1
RCBYH30.R8	RCBYH30.L1	RCBYH30.R8	RCBYH30.L1	RCBYH31.L1	RCBYH31.R8	RCBYH32.L1	RCBYH32.R8	RCBYH33.L1
RCBYH33.R8	RCBYH33.L1	RCBYH33.R8	RCBYH33.L1	RCBYH34.L1	RCBYH34.R8	RCBYH35.L1	RCBYH35.R8	RCBYH36.L1
RCBYH36.R8	RCBYH36.L1	RCBYH36.R8	RCBYH36.L1	RCBYH37.L1	RCBYH37.R8	RCBYH38.L1	RCBYH38.R8	RCBYH39.L1
RCBYH39.R8	RCBYH39.L1	RCBYH39.R8	RCBYH39.L1	RCBYH40.L1	RCBYH40.R8	RCBYH41.L1	RCBYH41.R8	RCBYH42.L1
RCBYH42.R8	RCBYH42.L1	RCBYH42.R8	RCBYH42.L1	RCBYH43.L1	RCBYH43.R8	RCBYH44.L1	RCBYH44.R8	RCBYH45.L1
RCBYH45.R8	RCBYH45.L1	RCBYH45.R8	RCBYH45.L1	RCBYH46.L1	RCBYH46.R8	RCBYH47.L1	RCBYH47.R8	RCBYH48.L1
RCBYH48.R8	RCBYH48.L1	RCBYH48.R8	RCBYH48.L1	RCBYH49.L1	RCBYH49.R8	RCBYH50.L1	RCBYH50.R8	RCBYH51.L1
RCBYH51.R8	RCBYH51.L1	RCBYH51.R8	RCBYH51.L1	RCBYH52.L1	RCBYH52.R8	RCBYH53.L1	RCBYH53.R8	RCBYH54.L1
RCBYH54.R8	RCBYH54.L1	RCBYH54.R8	RCBYH54.L1	RCBYH55.L1	RCBYH55.R8	RCBYH56.L1	RCBYH56.R8	RCBYH57.L1
RCBYH57.R8	RCBYH57.L1	RCBYH57.R8	RCBYH57.L1	RCBYH58.L1	RCBYH58.R8	RCBYH59.L1	RCBYH59.R8	RCBYH60.L1
RCBYH60.R8	RCBYH60.L1	RCBYH60.R8	RCBYH60.L1	RCBYH61.L1	RCBYH61.R8	RCBYH62.L1	RCBYH62.R8	RCBYH63.L1
RCBYH63.R8	RCBYH63.L1	RCBYH63.R8	RCBYH63.L1	RCBYH64.L1	RCBYH64.R8	RCBYH65.L1	RCBYH65.R8	RCBYH66.L1
RCBYH66.R8	RCBYH66.L1							

Another pre-cycle



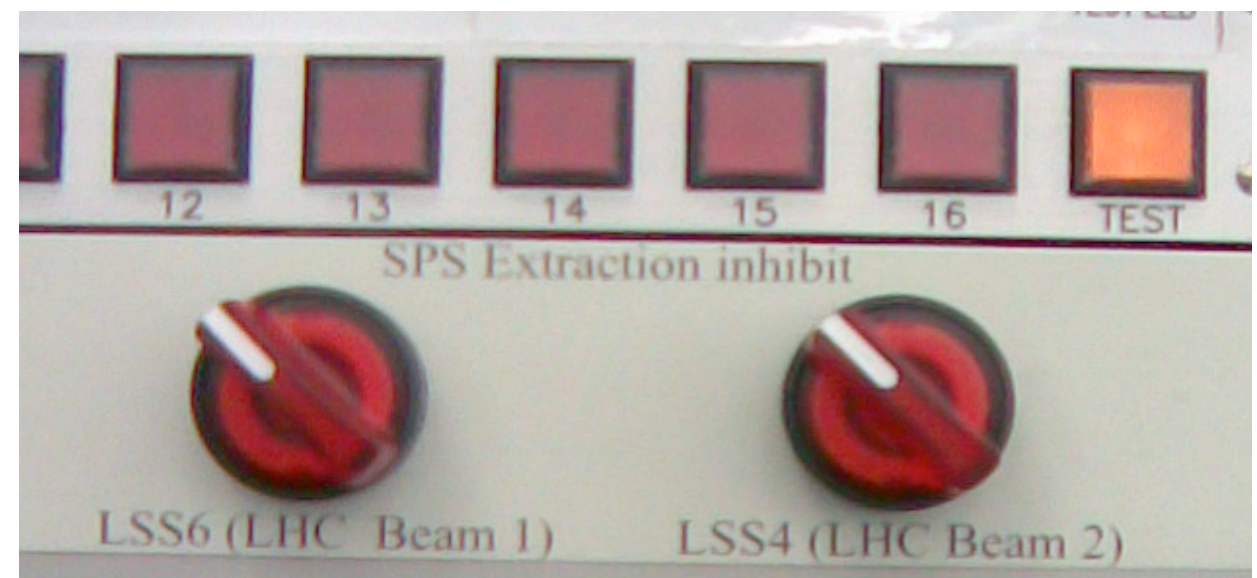
Preparing for ramp

✓ End of injection:

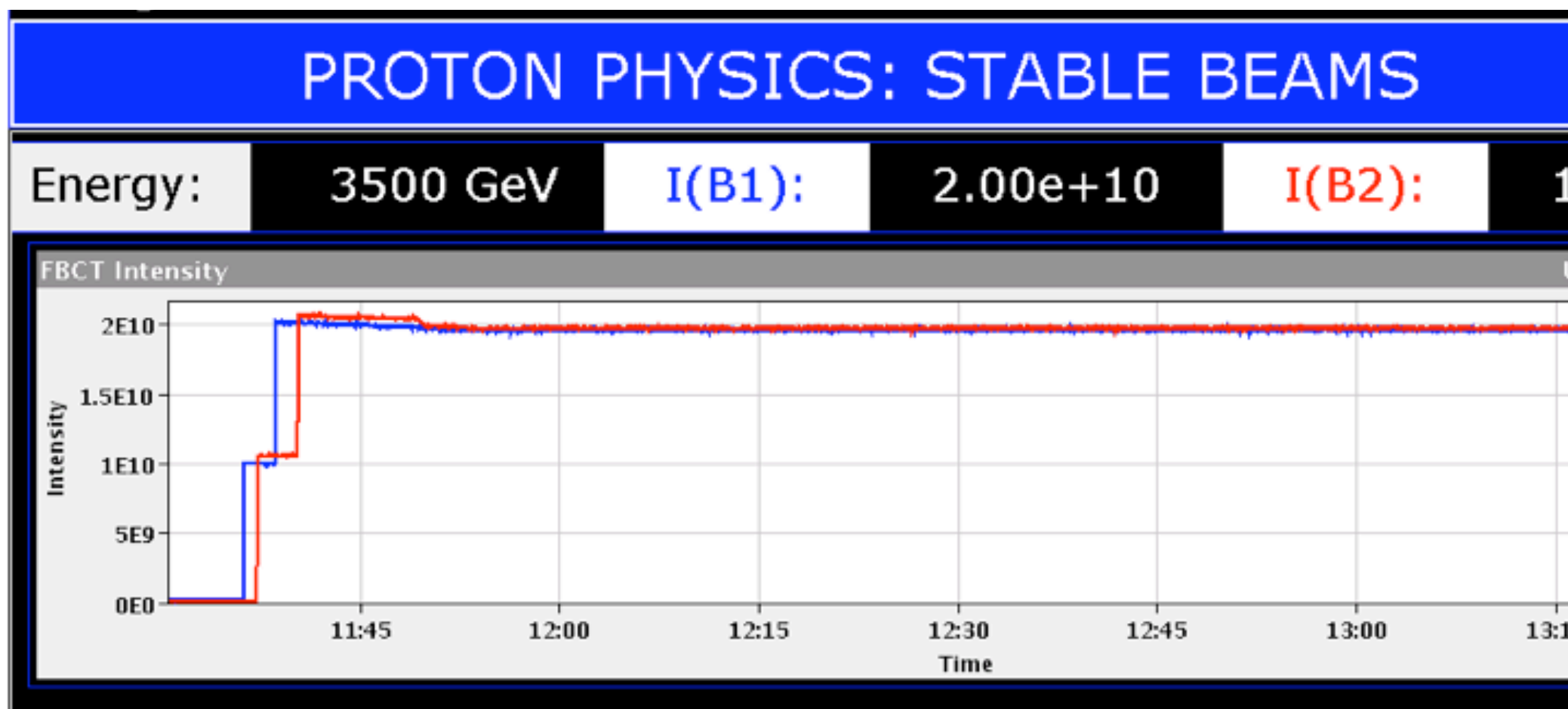
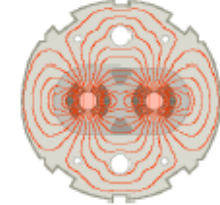
1. Switch the injection kickers to stand-by
2. Disable SPS extraction / inhibit injection in to LHC
3. Move out the injection protection devices

✓ Preparation of the ramp

1. “Incorporate” injection setting into the ramp functions
2. Set-up feedback and feed-forward corrections
3. Load functions to the key systems:
 - power converters, RF, collimators
4. Tell the experiments → close injection handshake
5. Send timing event
6. Only then, start praying.



Ramp to 3.5 TeV / stable beams



Collimators in IP7

●	TCP.D6L7.B1	●
●	TCP.C6L7.B1	●
●	TCP.B6L7.B1	●
●	TCSG.A6L7.B1	●
●	TCSG.B5L7.B1	●
●	TCSG.A5L7.B1	●
●	TCSG.D4L7.B1	●
●	TCSG.B4L7.B1	●
●	TCSG.A4L7.B1	●
●	TCSG.A4R7.B1	●
●	TCSG.B5R7.B1	●
●	TCSG.D5R7.B1	●
●	TCSG.E5R7.B1	●
●	TCSG.6R7.B1	●

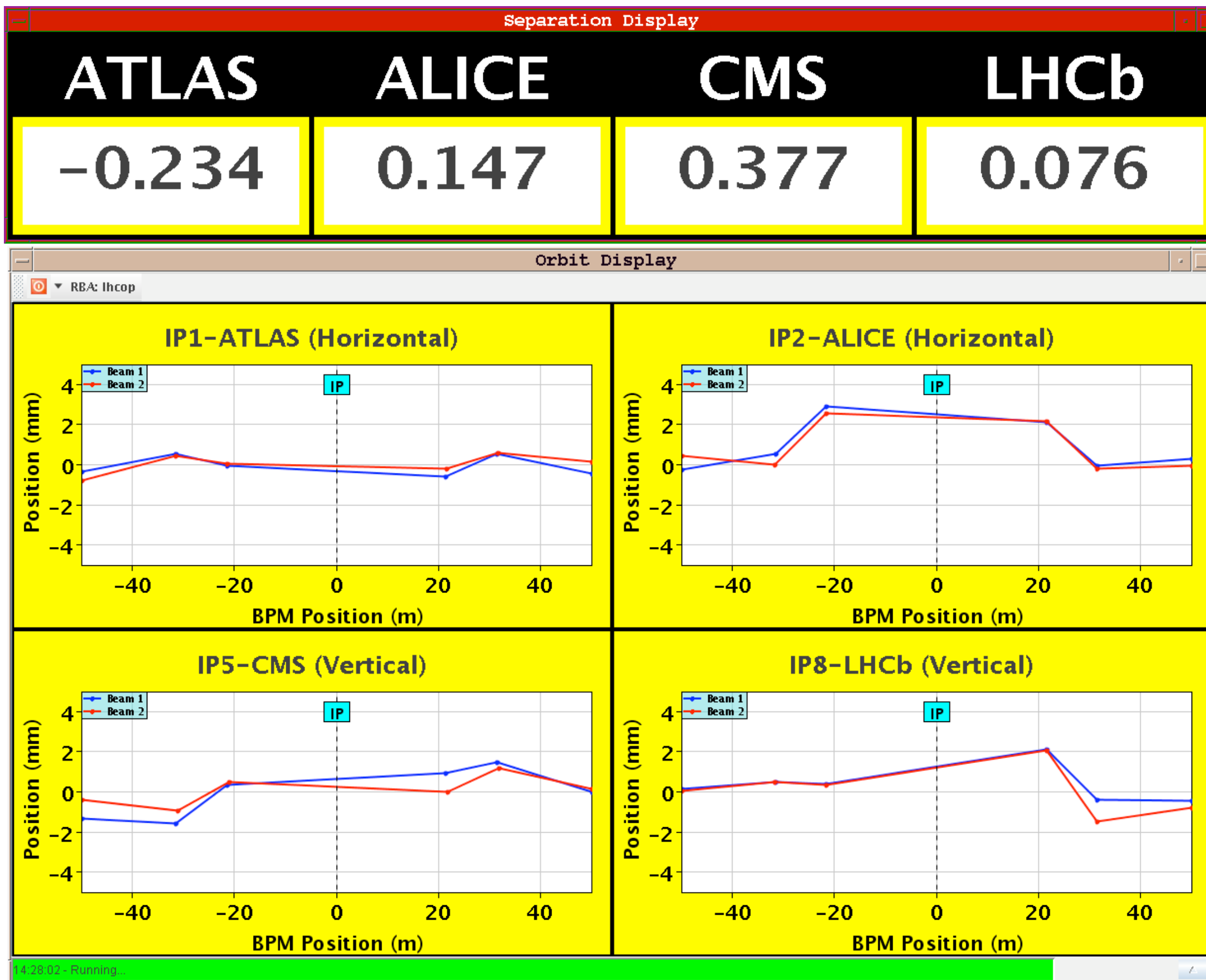
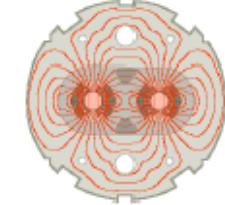
✓ Preparation for stable beams

1. Change tune working point (0.28, 0.31) → (0.31, 0.32)
2. Collapse the separation bumps
3. Move collimator to protection settings for physics
4. Un-mask all the maskable interlocks
5. Link beam permits
6. Change the mode to stable beams. Hands OFF!

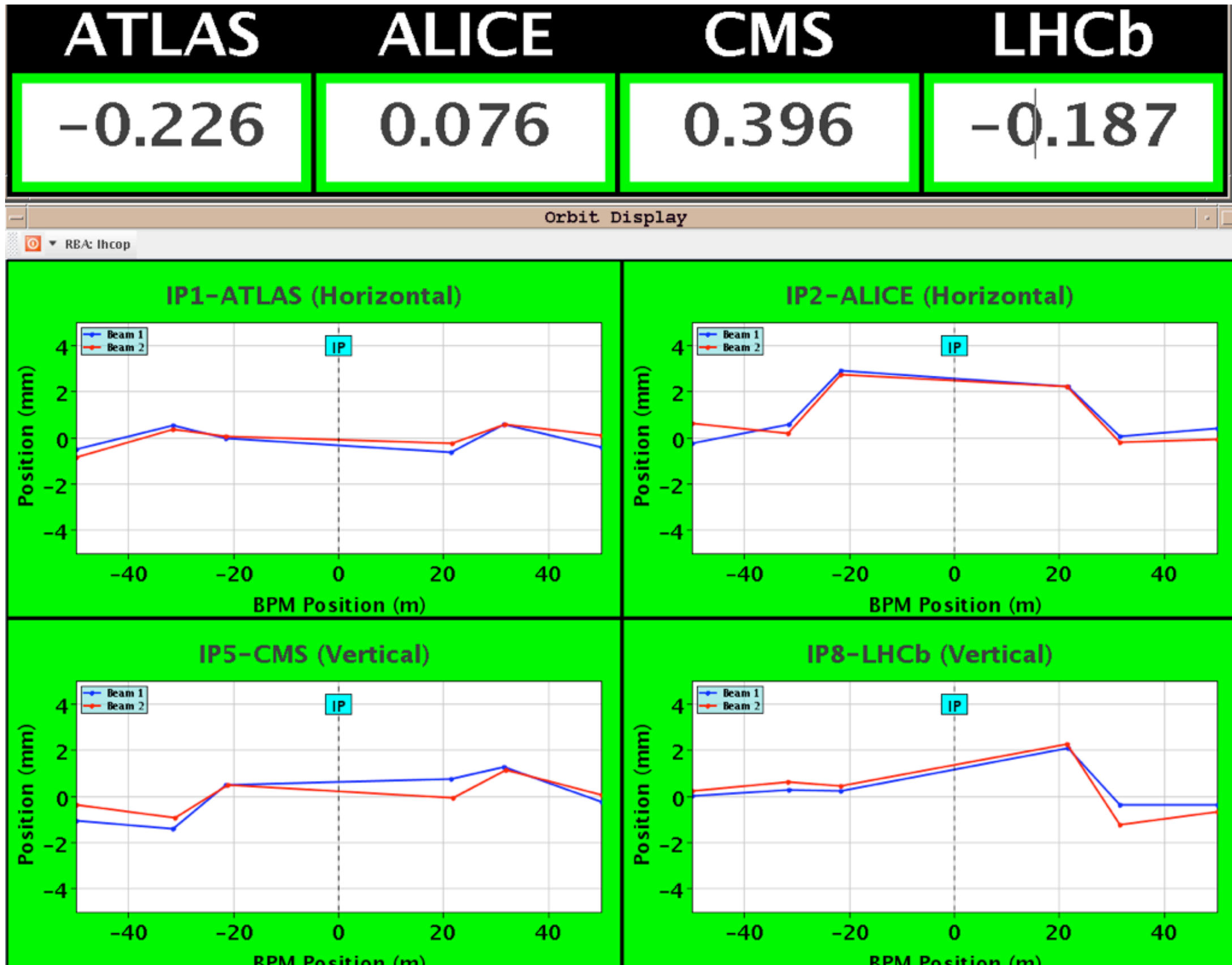
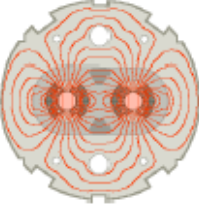
CLOSED

OPEN

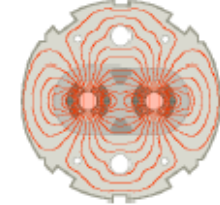
Collapsing the separation bumps



Colliding beams

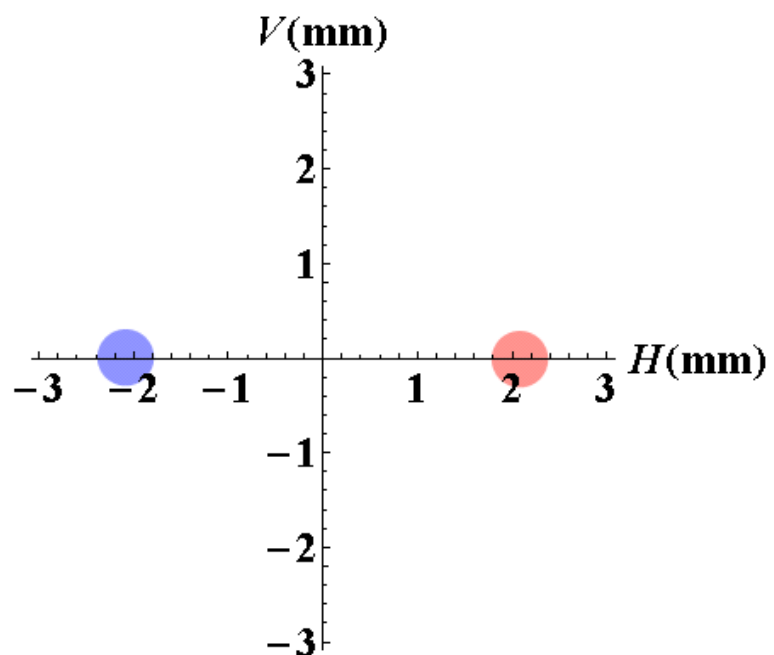


Movie from March the 30th



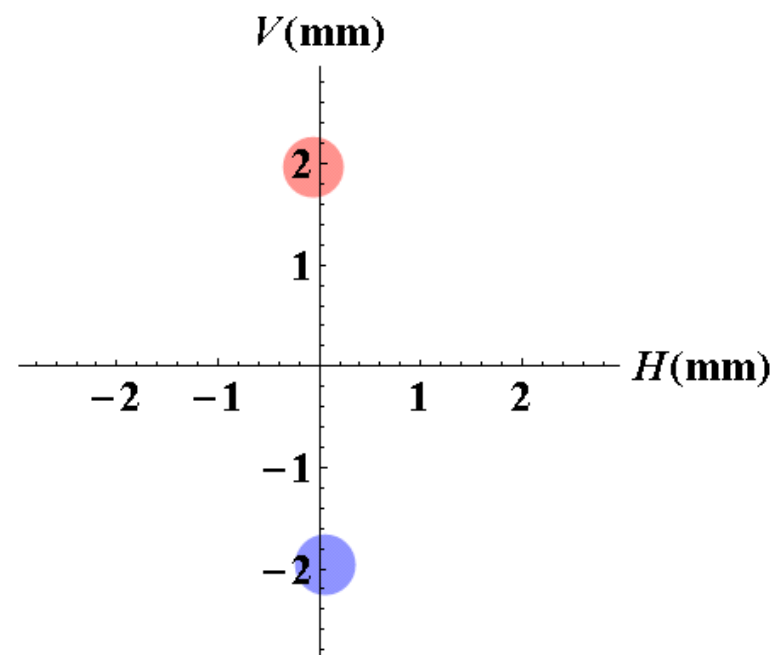
ATLAS IP Separation

$H = 4.173 \text{ mm} : V = 0.035 \text{ mm}$

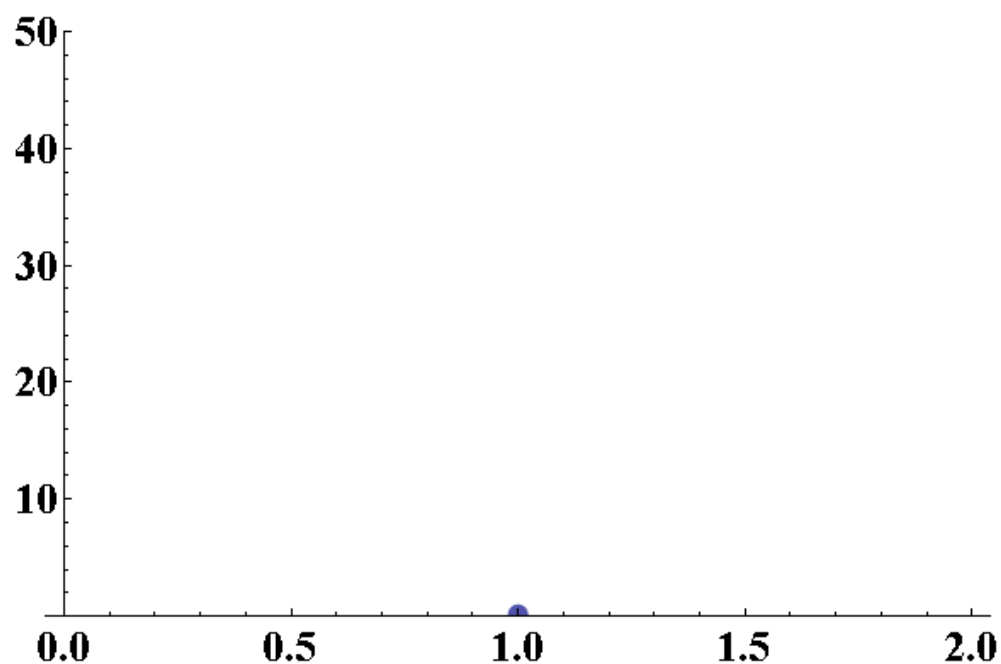


CMS IP Separation

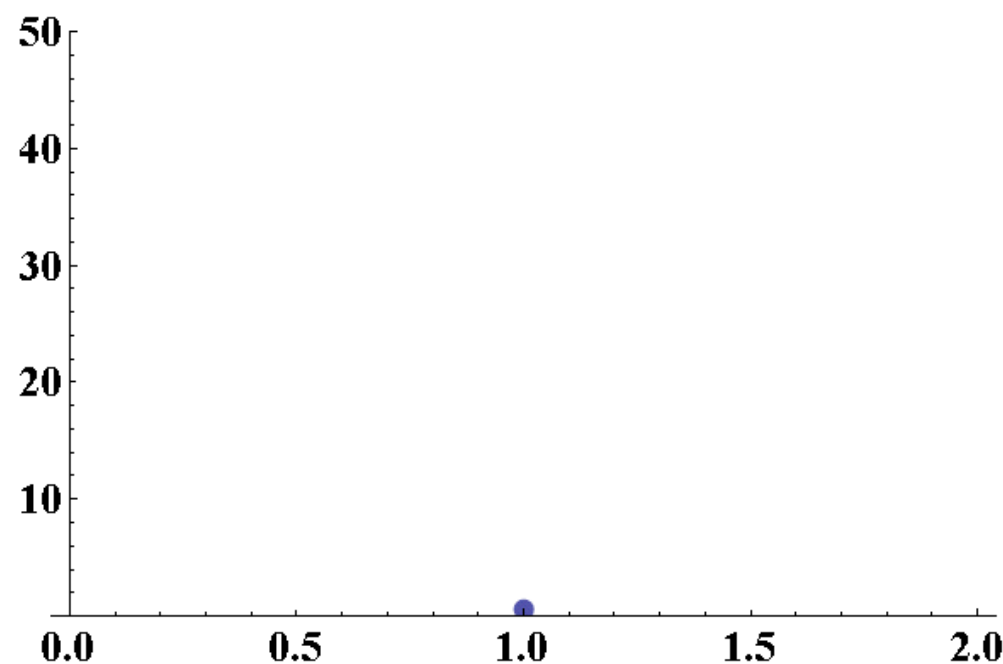
$H = 0.130 \text{ mm} : V = 3.925 \text{ mm}$



ATLAS Coll Rate Evol

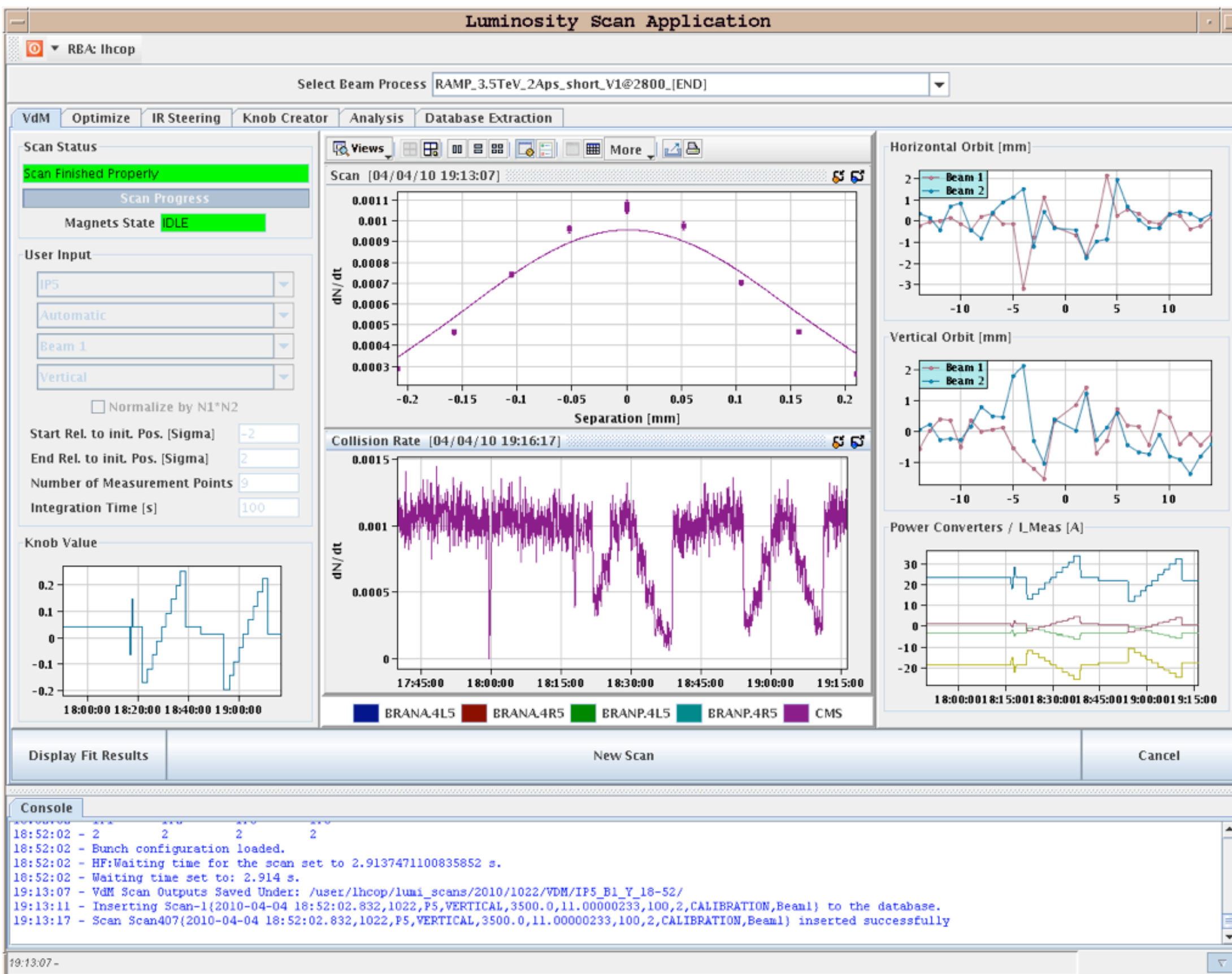
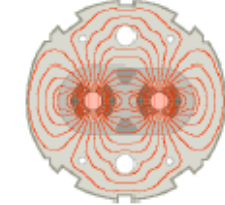


CMS Coll Rate Evol

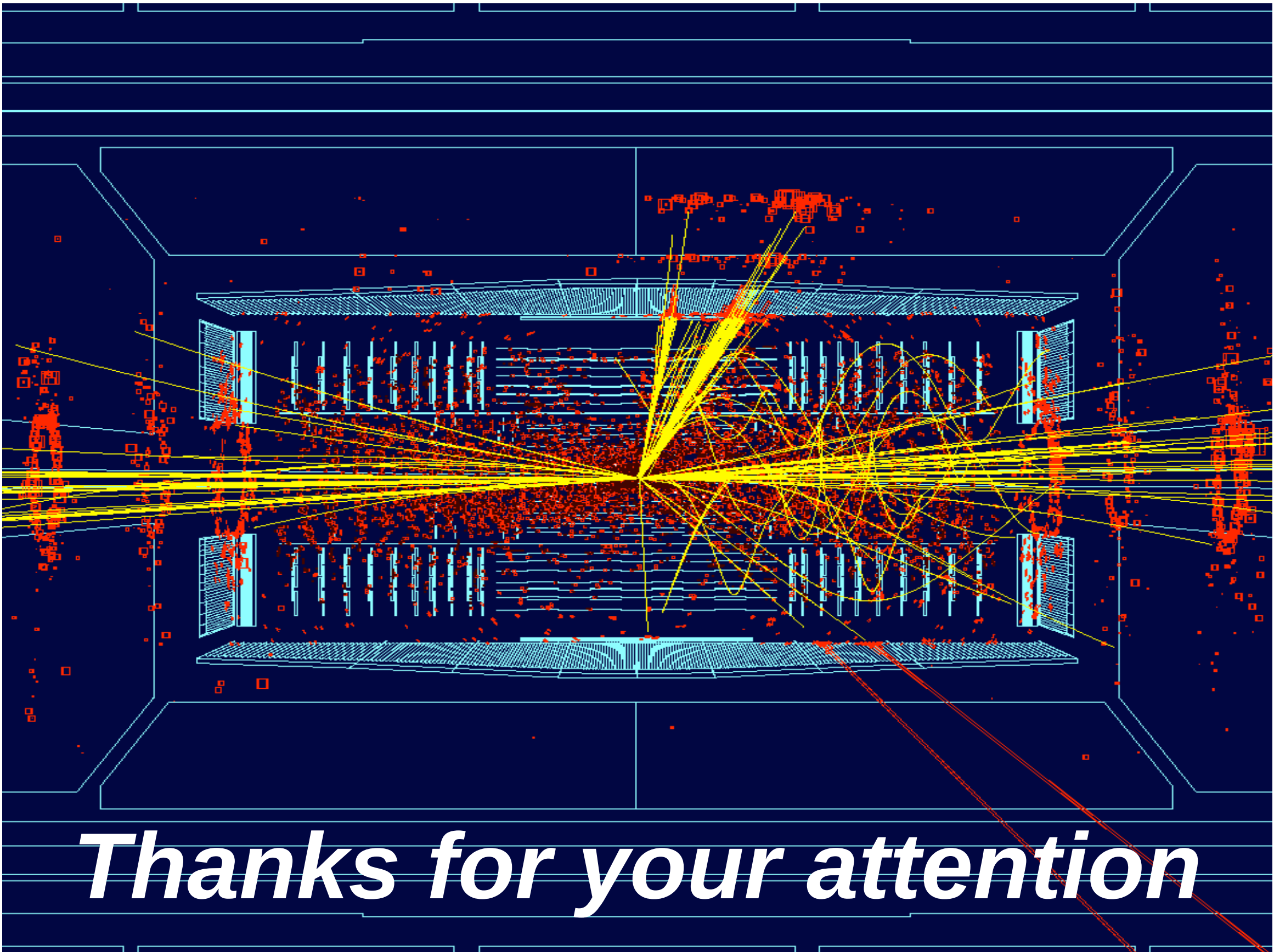


Courtesy of BI

Luminosity scans



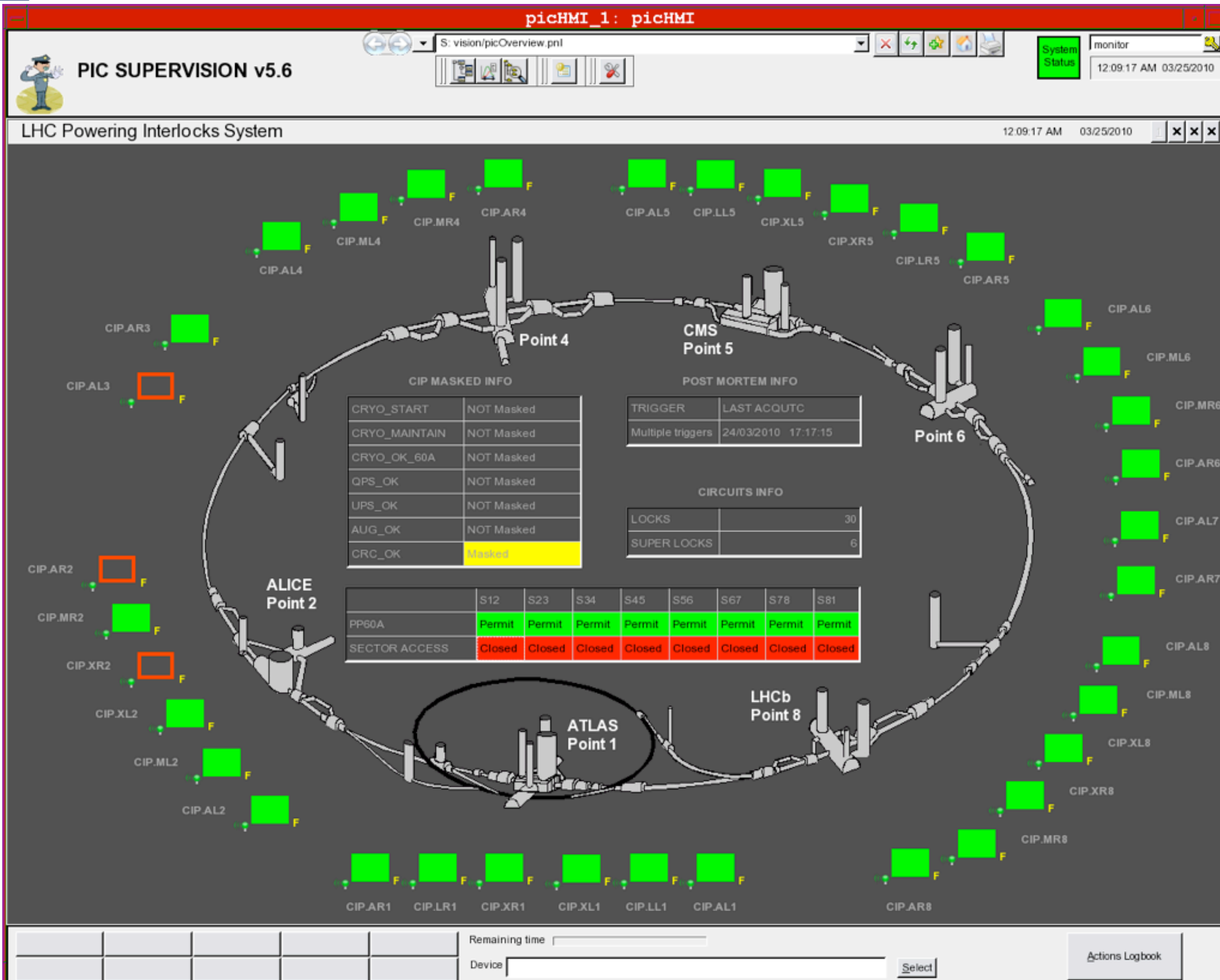
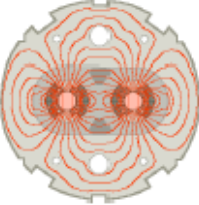
Can you then make sense out of that?



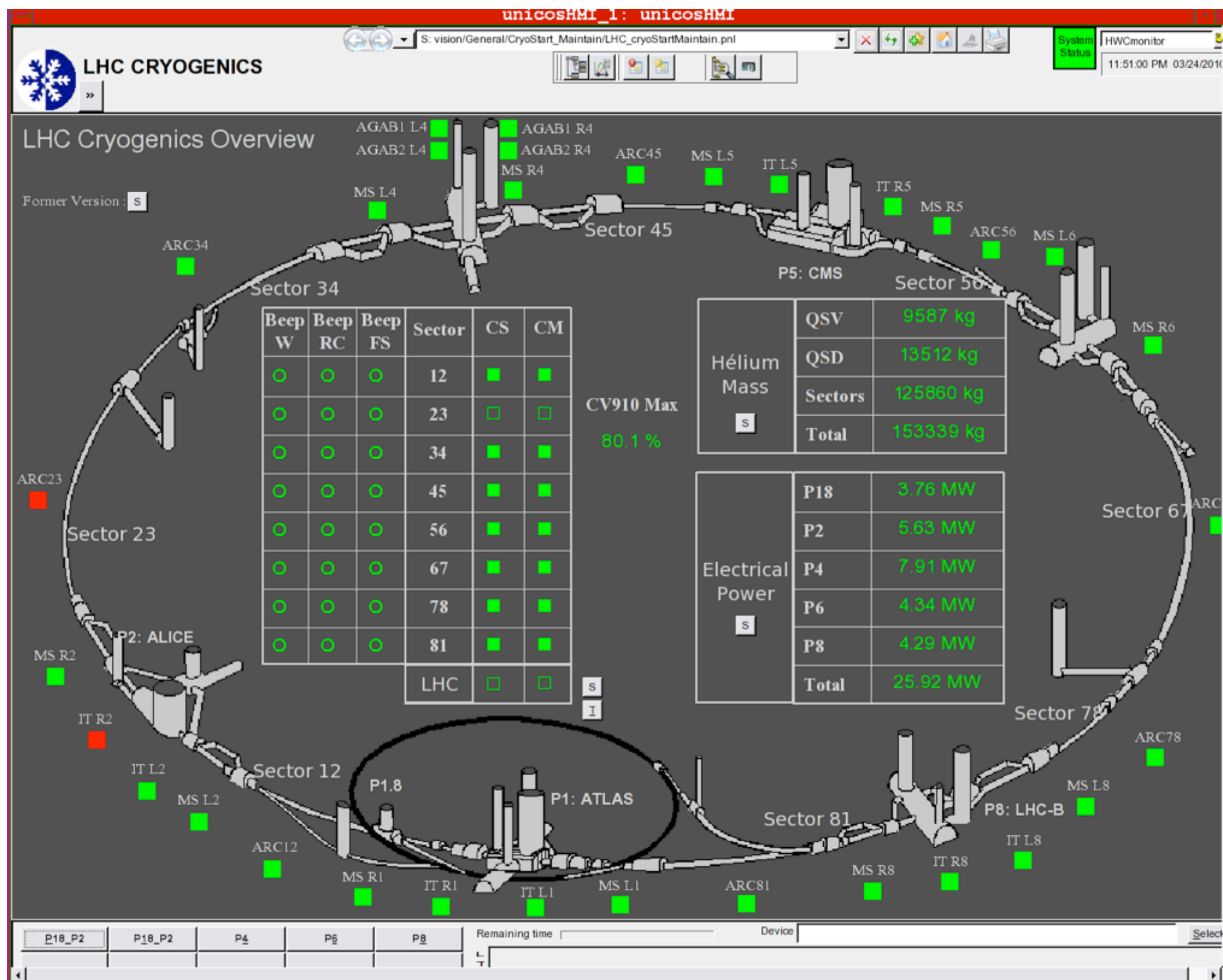
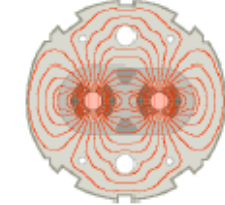
Thanks for your attention

Reserve slides

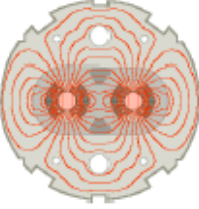
Powering permit per sector



Cryogenics conditions



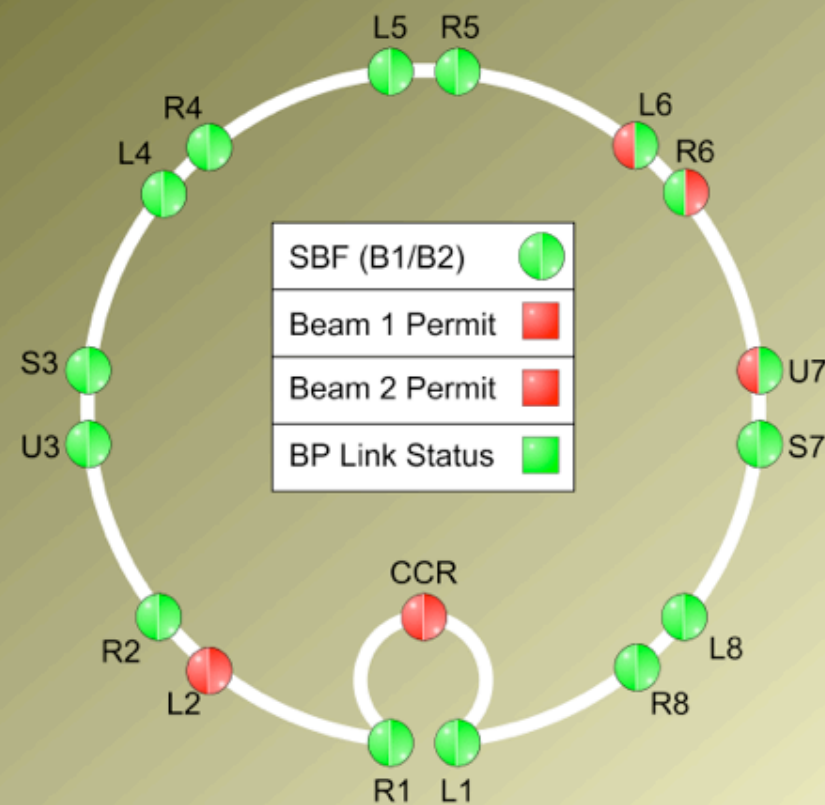
Extended with injection permit



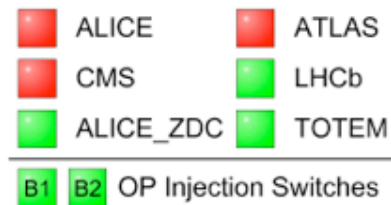
Configuration Version: 1.11

Time: Fri Mar 26 00:45:33 CET 2010

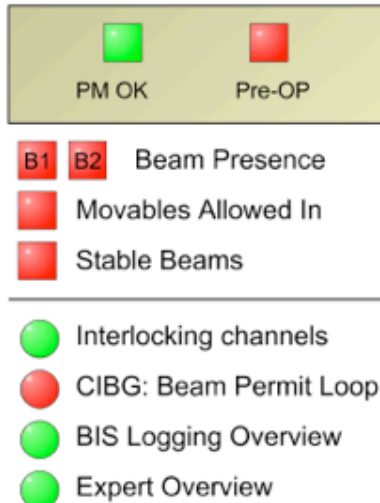
LHC Beam Interlock System



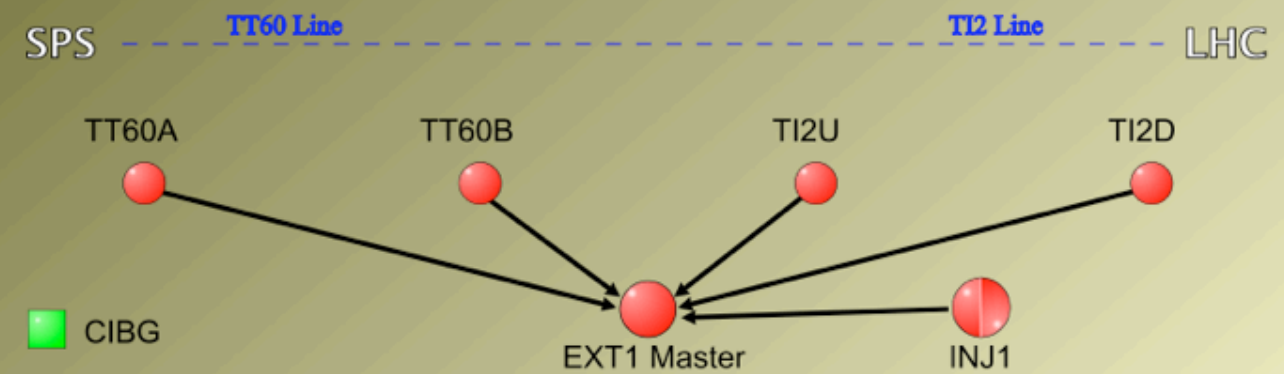
Injection Permits



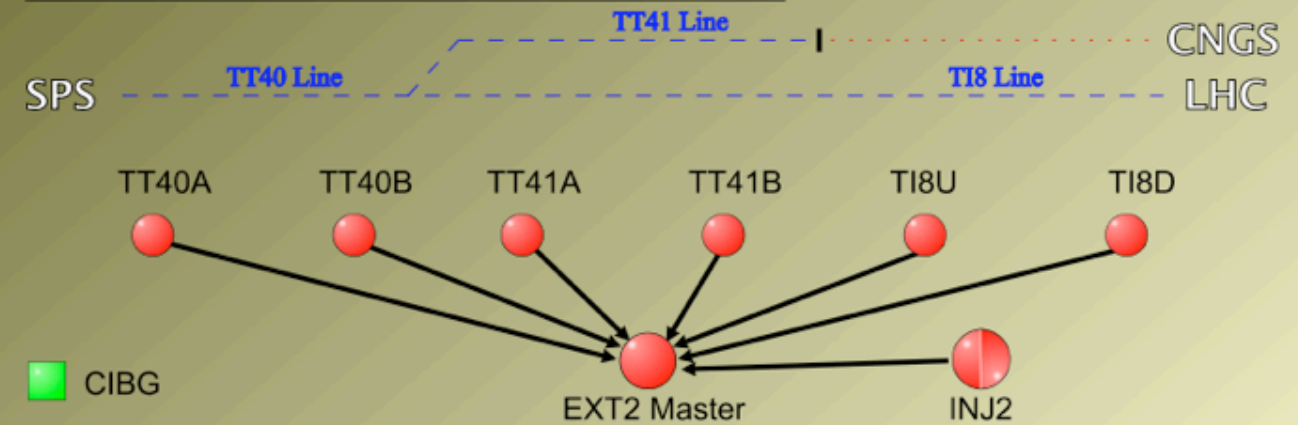
BIS Operation Overview



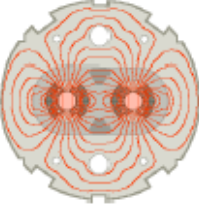
West Extraction: LHC Beam 1



East Extraction: LHC Beam 2



Software interlocks



SIS GUI

Filtering

Filtering Parameters

Pattern:

Search:

Extra Parameters

OR ☐ Masked ☐ Latched ☐ Valid ☐ Invalid ☐ Invalid for beam

Filtering Options

☐ Use RegExps ☐ Invert filtering ☐ 'Flat' view

Filter! Clear

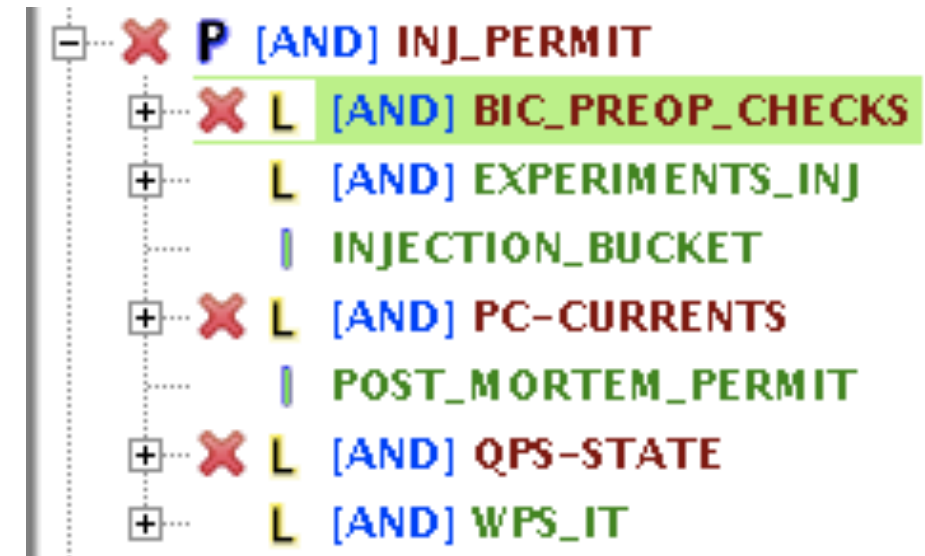
Permits Tree

- + ☒ P [AND] INJ_B1_PERMIT
- + ☒ P [AND] INJ_B2_PERMIT
- + ☒ P [AND] INJ_PERMIT
- + ☐ P [AND] POWERING_PERMIT
- + ☒ P [AND] RING_B1_PERMIT
- + ☒ P [AND] RING_B2_PERMIT
- + ☐ P [AND] RING_PERMIT

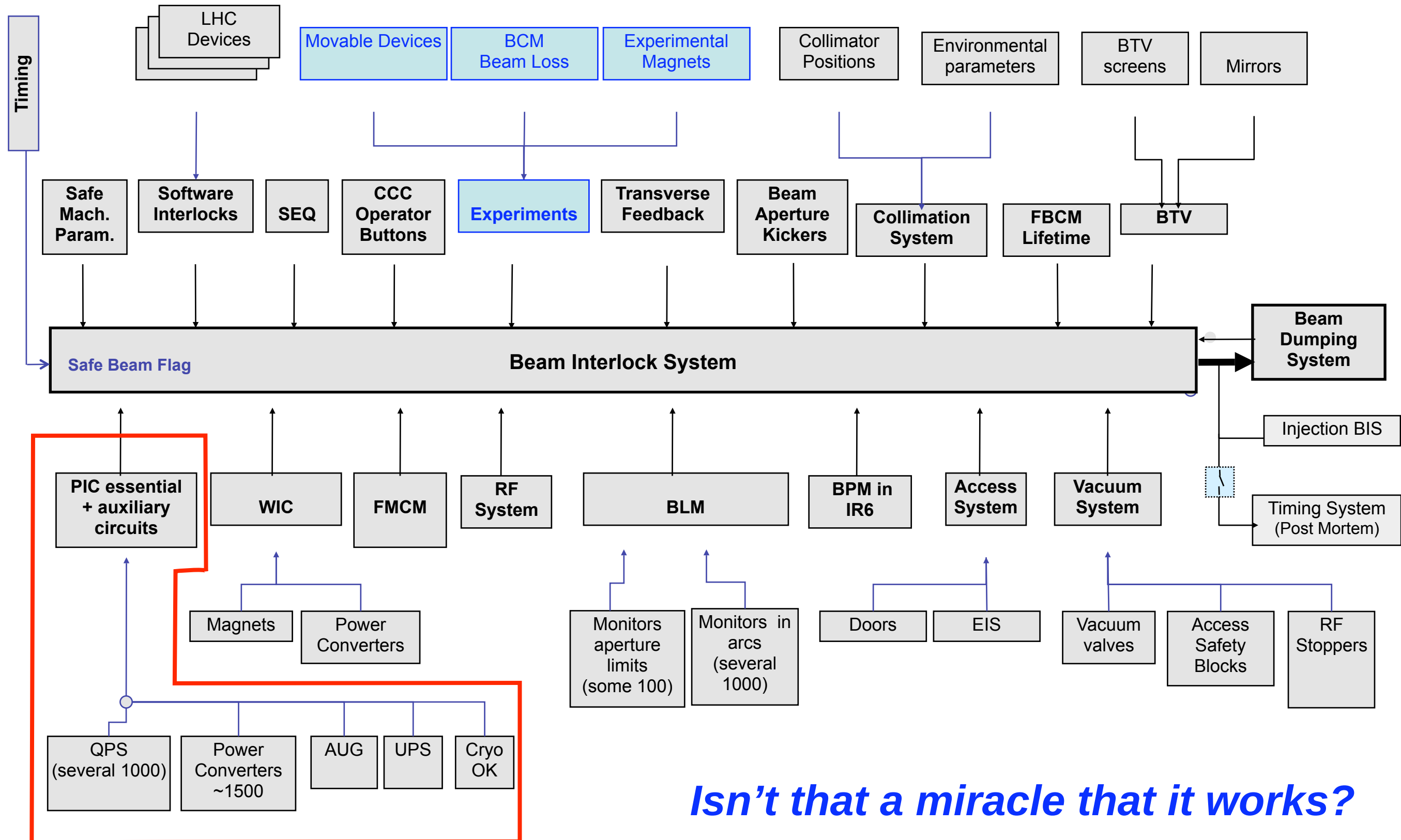
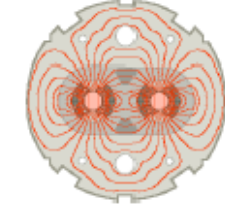
Depth: Show

Expand All Collapse all

Font size: +1 -1 Reset

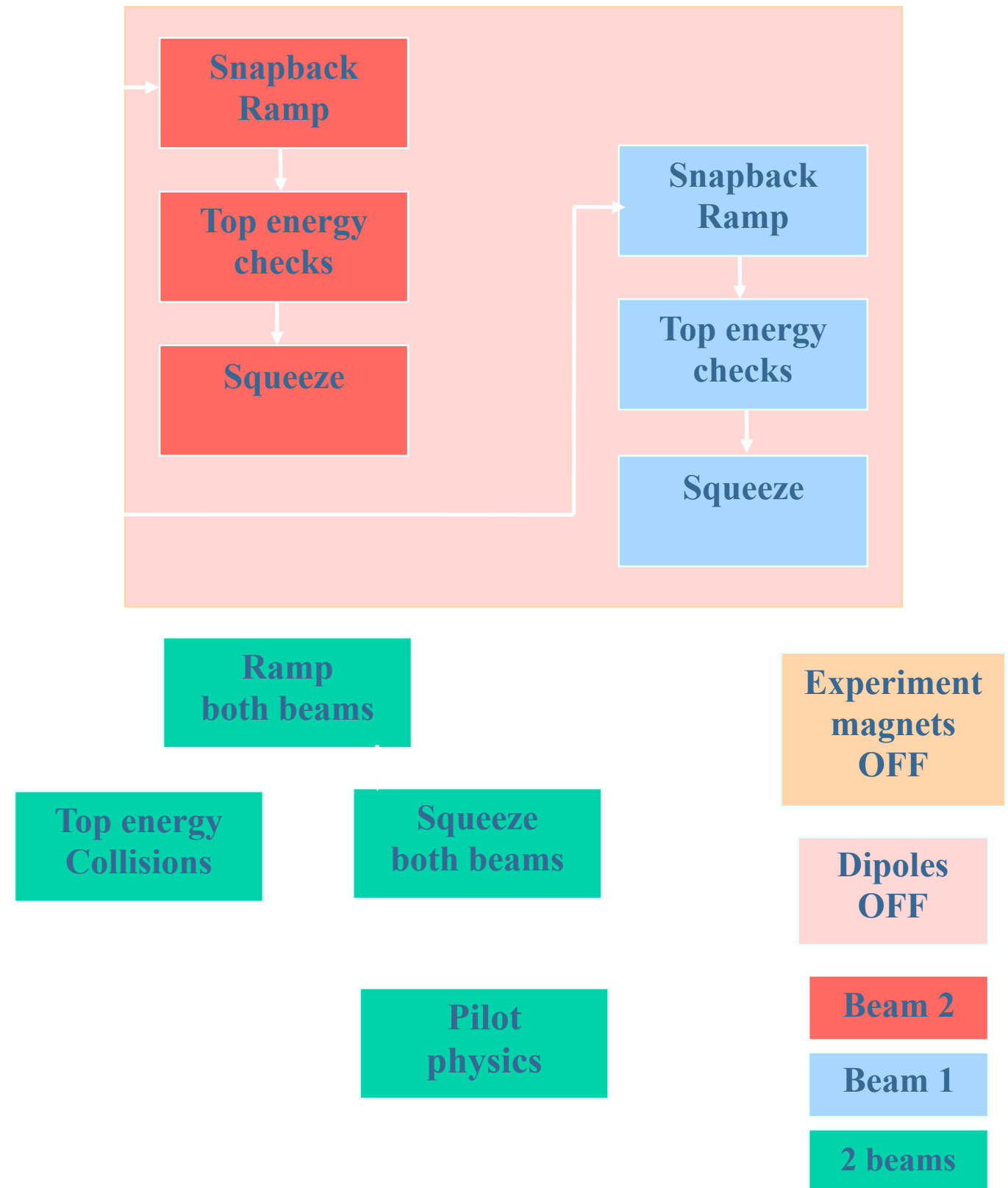
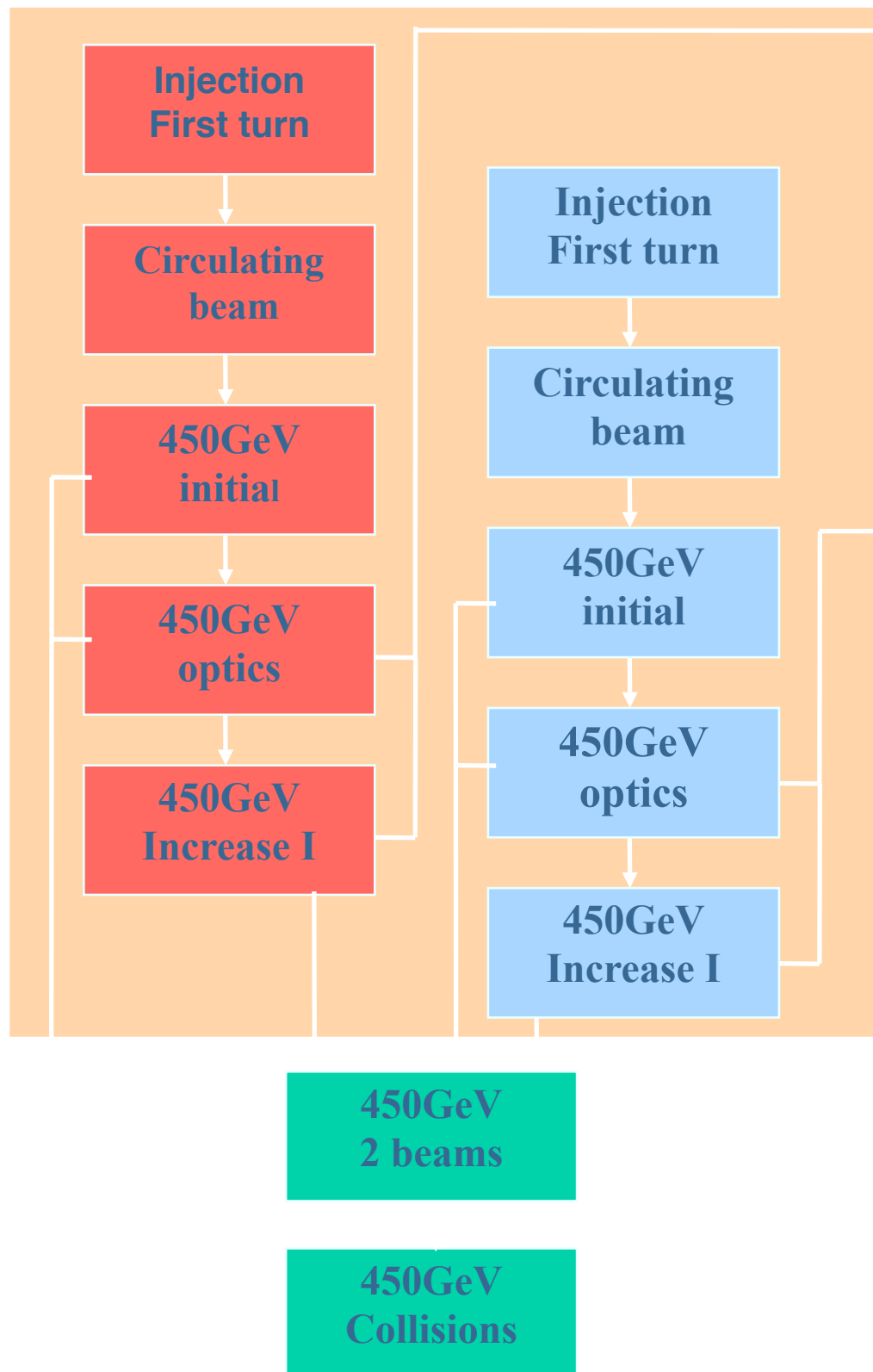
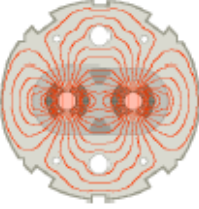


Beam permits



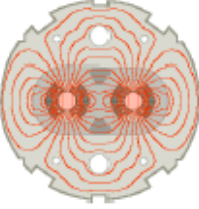
Isn't that a miracle that it works?

Commissioning flow chart



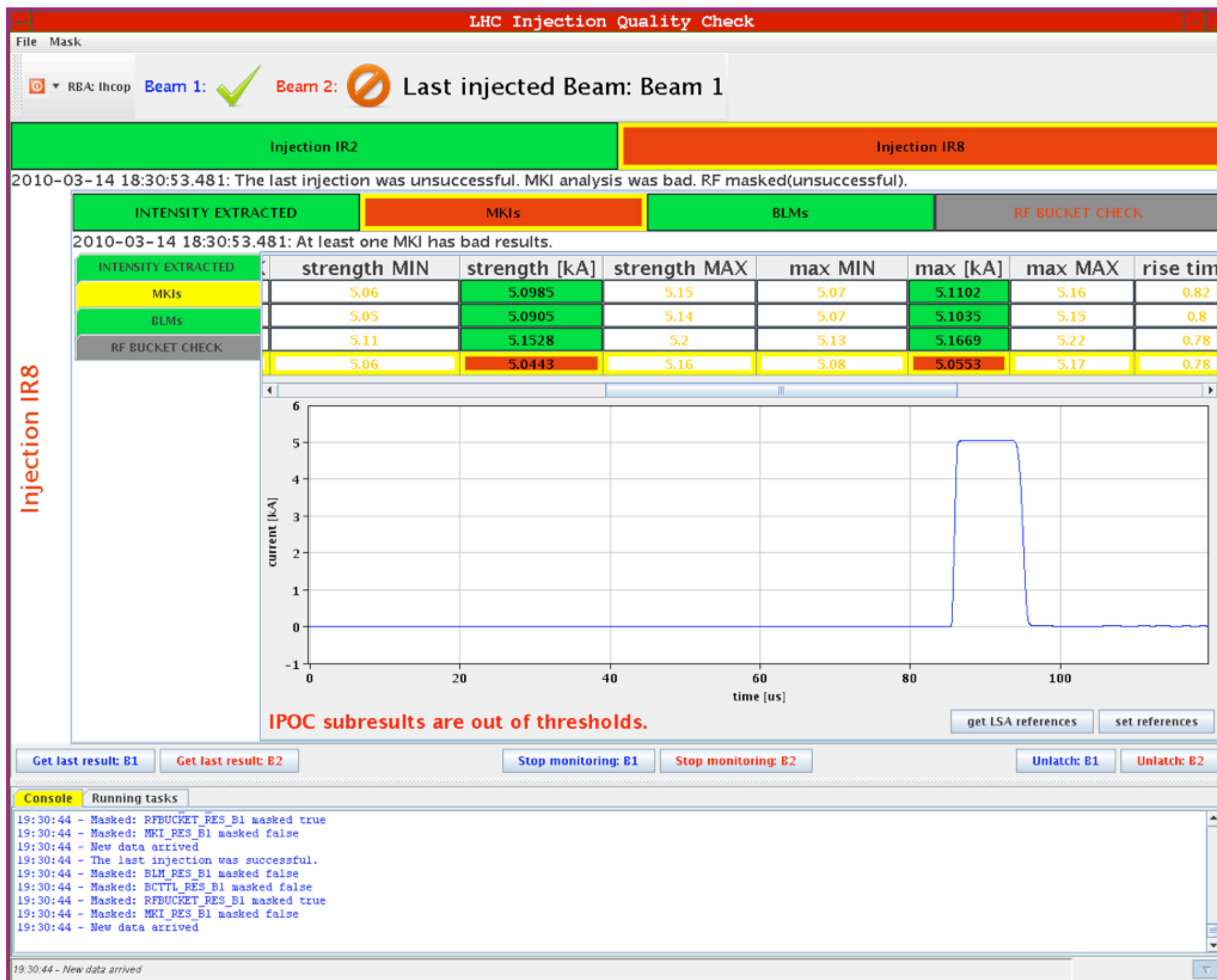
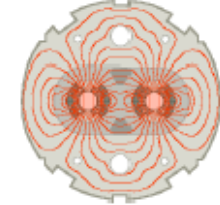


Fast 2009 commissioning

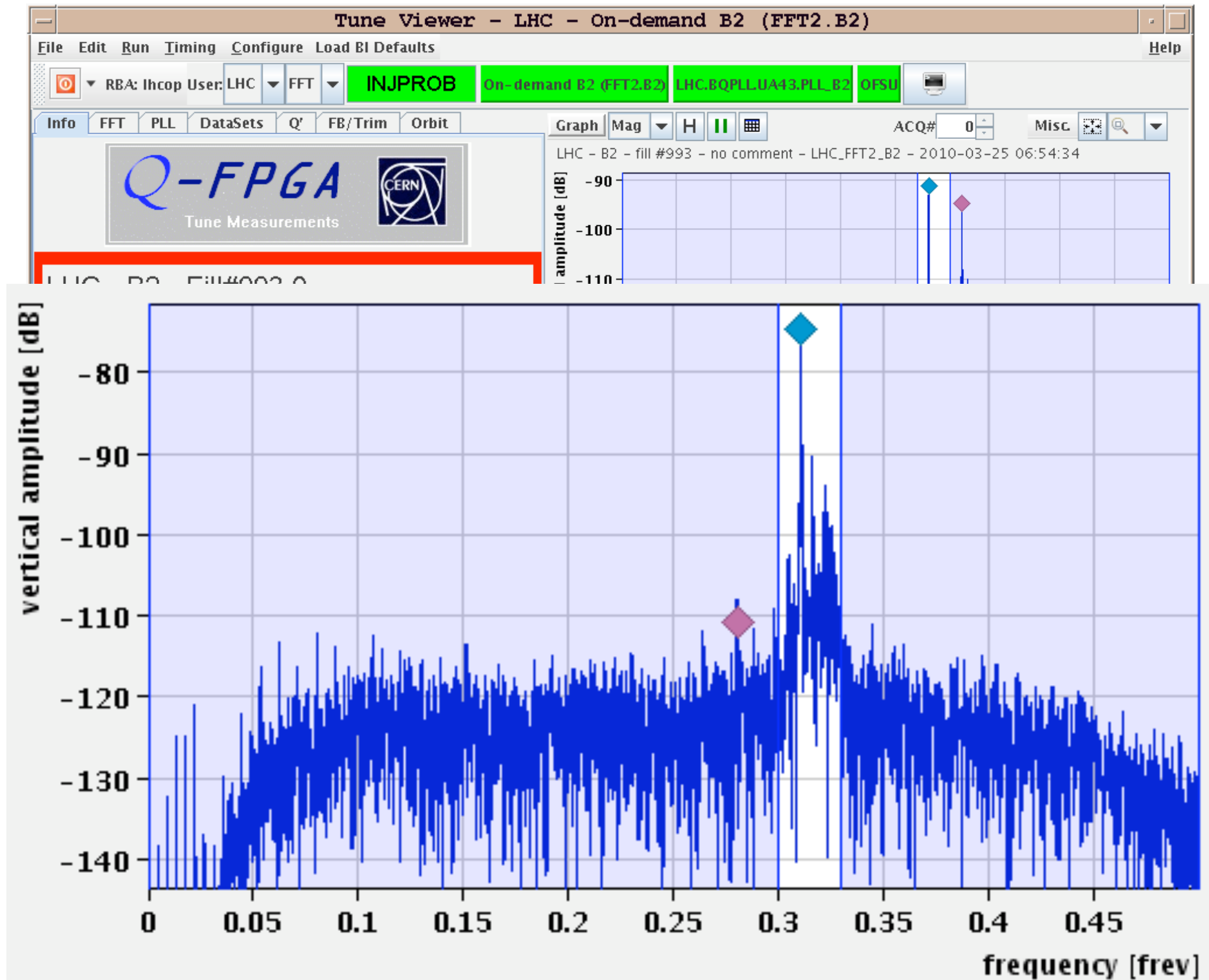
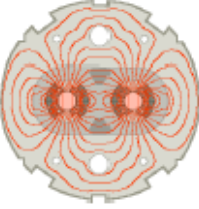


Date	Day	Achieved
Nov 20	1	Each beam circulating. Key beam instrumentation working.
Nov 23	4	First collisions at 450 GeV. First ramp (reached 560 GeV).
Nov 26	7	Magnetic cycling established (reproducibility).
Nov 27	8	Energy matching done.
Nov 29	10	Ramp to 1.18 TeV.
Nov 30	11	Experiment solenoids on.
Dec 04	15	Aperture measurement campaign finished. LHCb and ALICE dipoles on.
Dec 05	16	Machine protection (Injection, Beam dump, Collimators) ready for safe operation with pilots.
Dec 06	17	First collisions with STABLE BEAMS, 4 on 4 pilots at 450 GeV, rates around 1Hz.
Dec 08	19	Ramp colliding bunches to 1.18 TeV
Dec 11	22	Collisions with STABLE BEAMS, 4 on 4 at 450 GeV, $> 10^{10}$ per bunch, rates around 10Hz.
Dec 13	24	Ramp 2 bunches per beam to 1.18 TeV. Collisions for 90mins.
Dec 14	25	Collisions with STABLE BEAMS, 16 on 16 at 450 GeV, $> 10^{10}$ per bunch, rates around 50Hz.
Dec 16	27	Ramp 4 on 4 to 1.18 TeV. Squeeze to 7 m. Collisions.

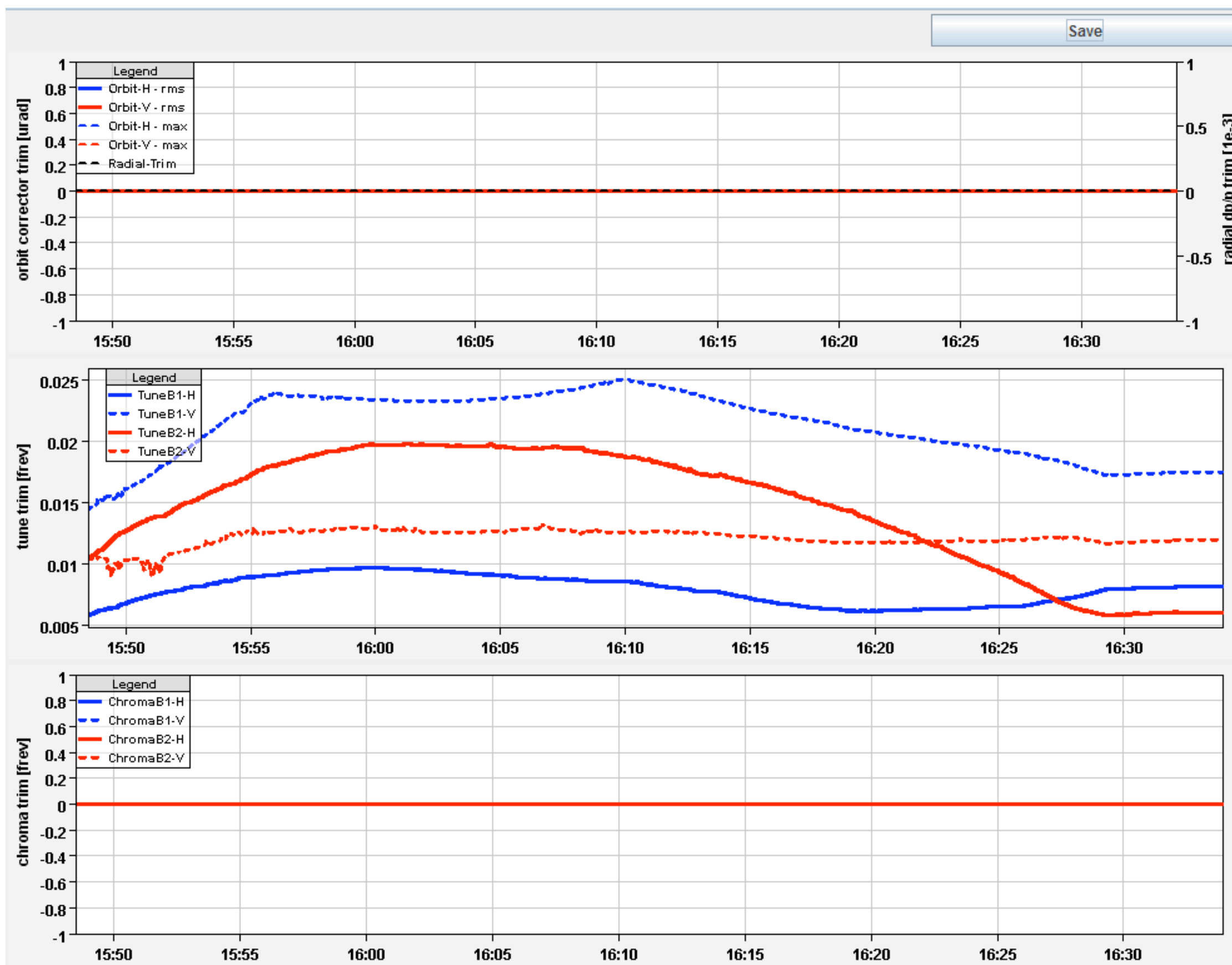
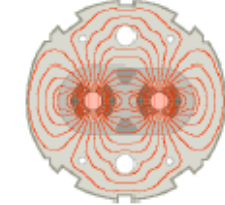
Injection quality control



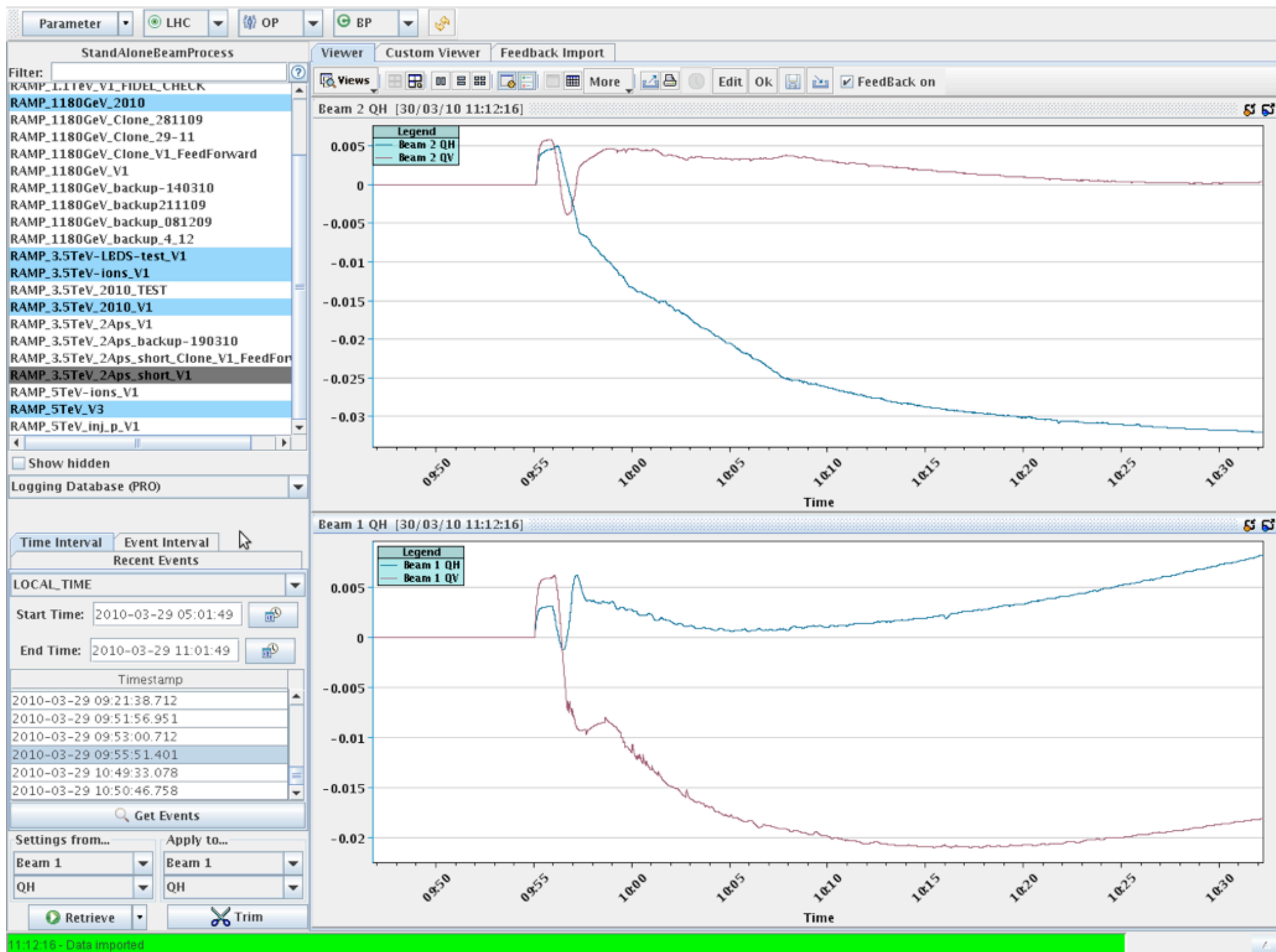
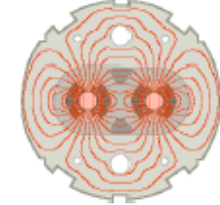
Tune correction - B2



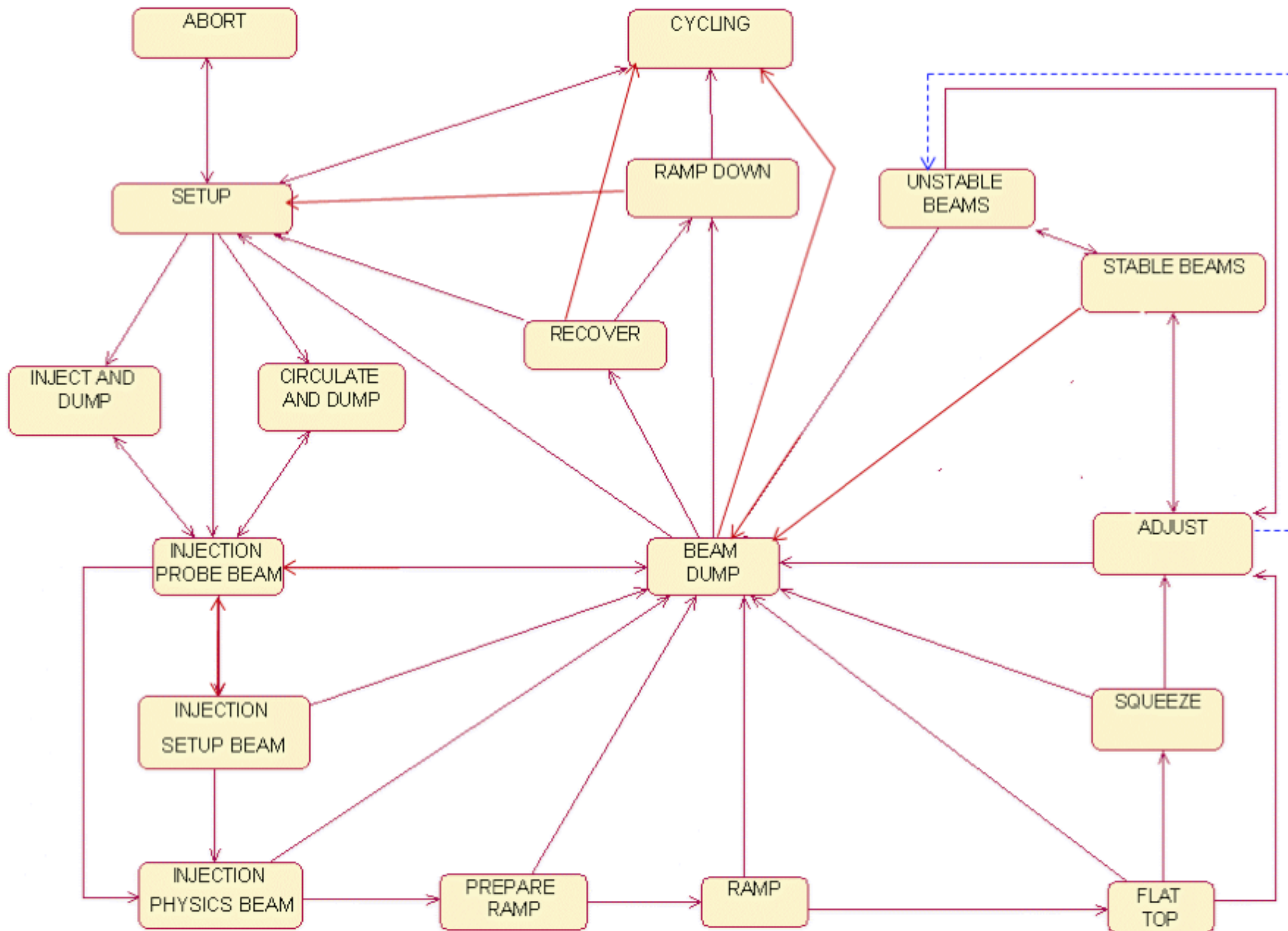
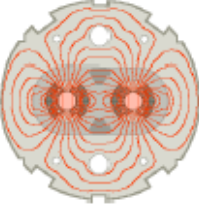
Tune feedback



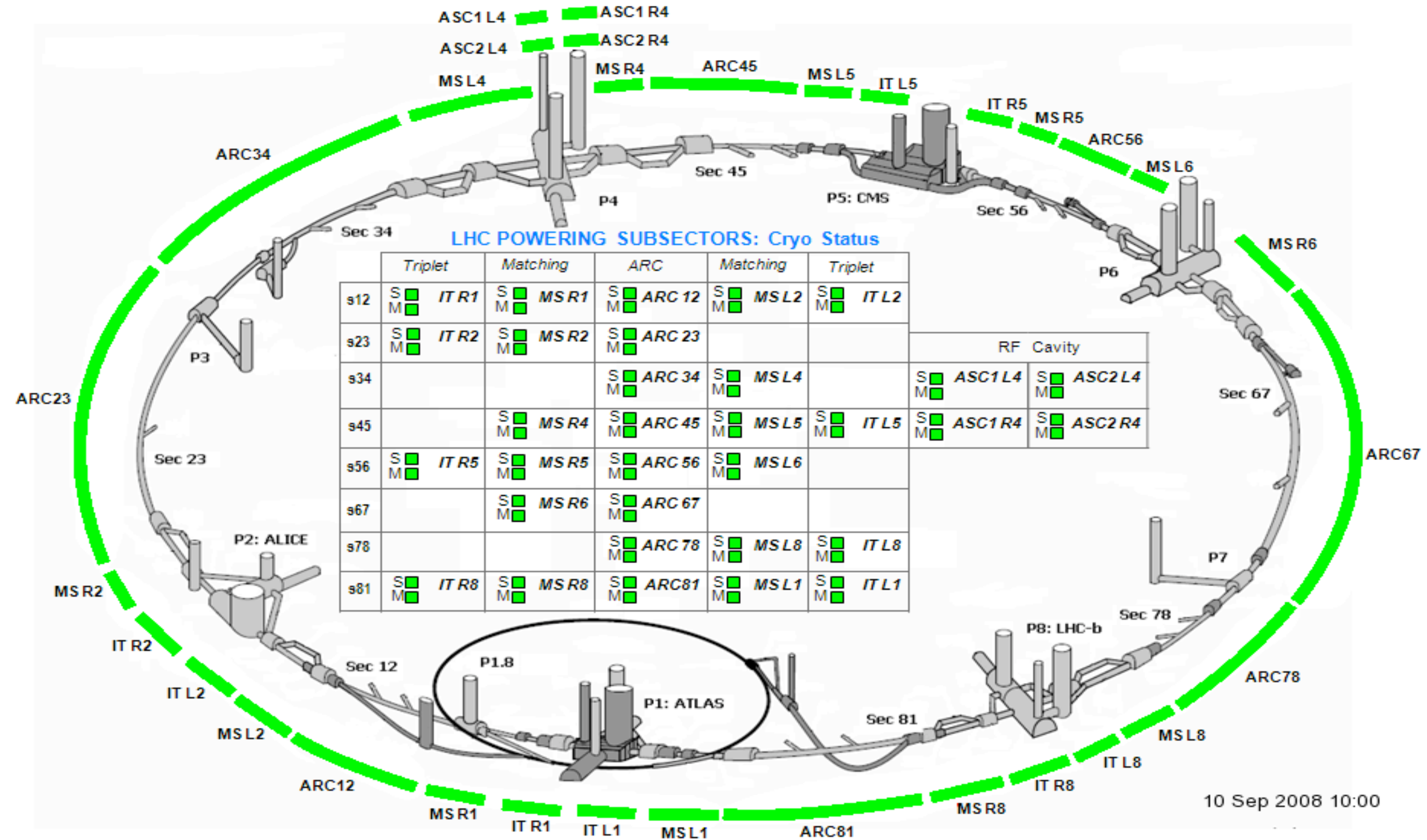
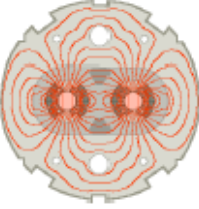
Tune feed-forward



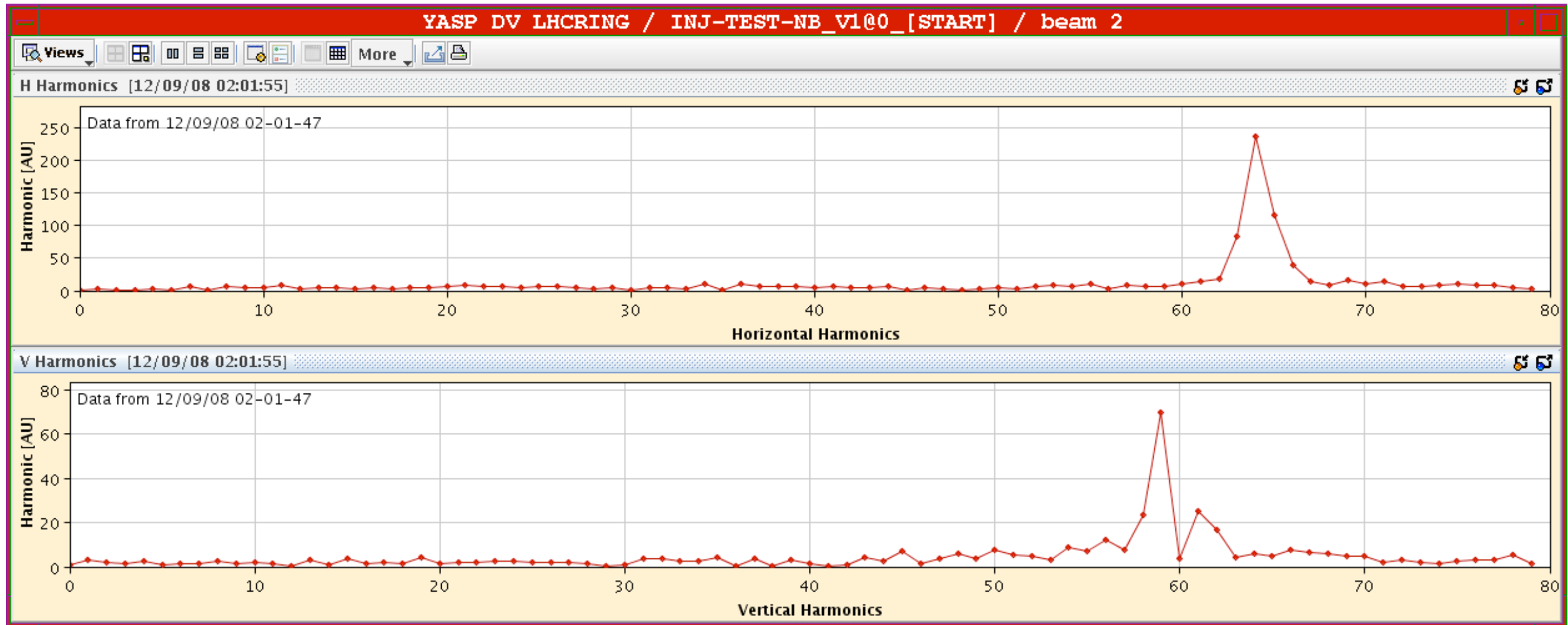
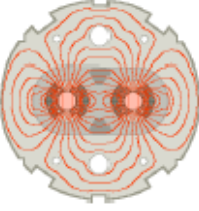
LHC beam modes



Cryo - all green

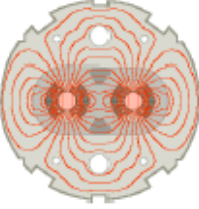


Machine integer tunes



Nominal integer tunes:
 $Q_h = 64$; $Q_v = 59$

Kicker statuses

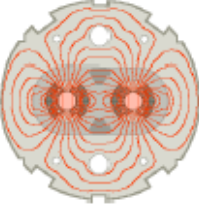


LHC Injection Kickers		
MKI - B1	Control: REMOTE	State: ON
Conditioning	Validity: true	Remaining time: 87 min.
MKI - B2	Control: REMOTE	State: ON
Conditioning	Validity: true	Remaining time: 88 min.

LHC Injection Kickers		
MKI - B1	Control: REMOTE	State: STANDBY
Conditioning	Validity: true	Remaining time: 75 min.
MKI - B2	Control: REMOTE	State: STANDBY
Conditioning	Validity: true	Remaining time: 76 min.

LHC Injection Kickers		
MKI - B1	Control: REMOTE	State: ON
Conditioning	Validity: true	Remaining time: 29 min.
MKI - B2	Control: REMOTE	State: ON
Conditioning	Validity: true	Remaining time: 30 min.

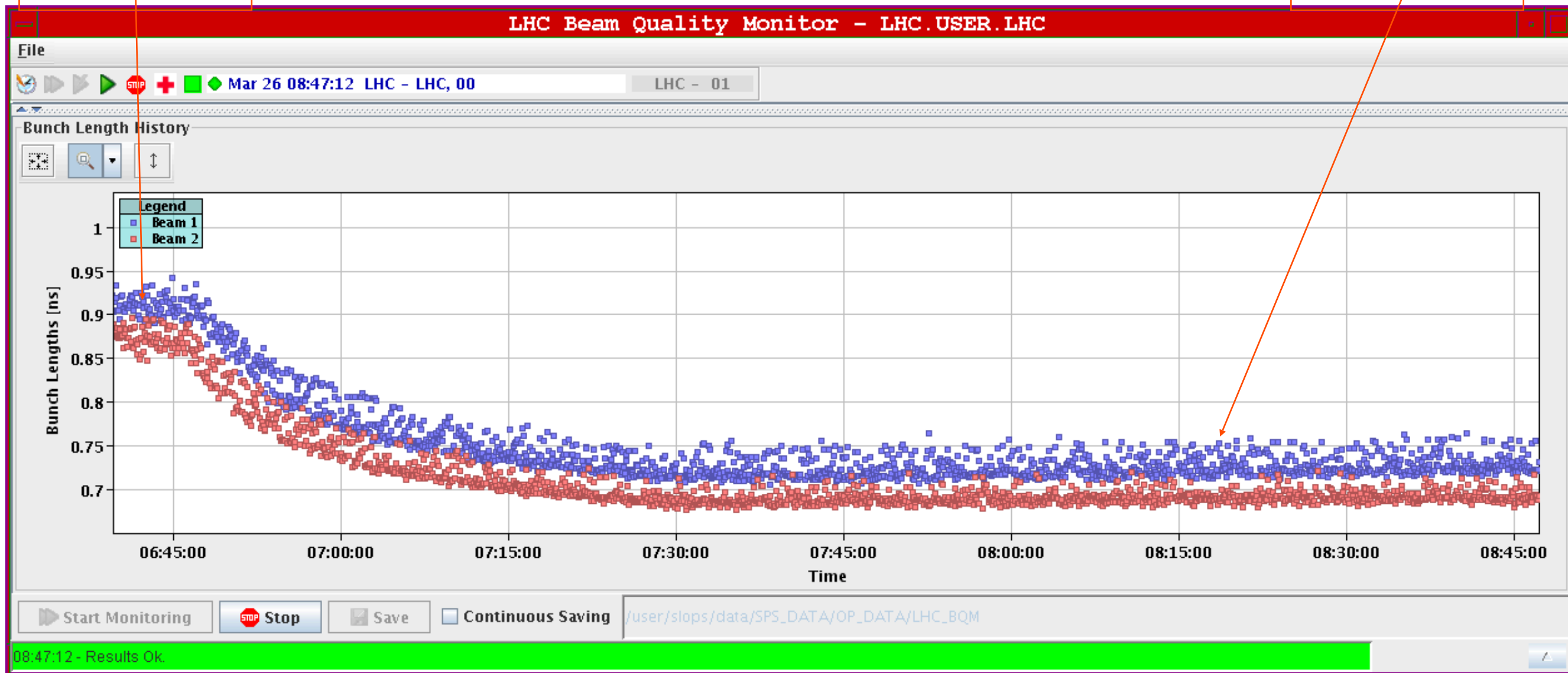
Bunch length measurements



At 450 GeV
bunch length
increases by
~ 30 ps/h

$$L \propto \frac{|\eta|}{(\gamma \cdot V)^{1/4}}$$

At 3.5 TeV
bunch length
increases by
~ 6 ps/h



Single bunch pilot in both rings, ~ 0.4-0.5 eVs. Constant 12 MV during ramp.