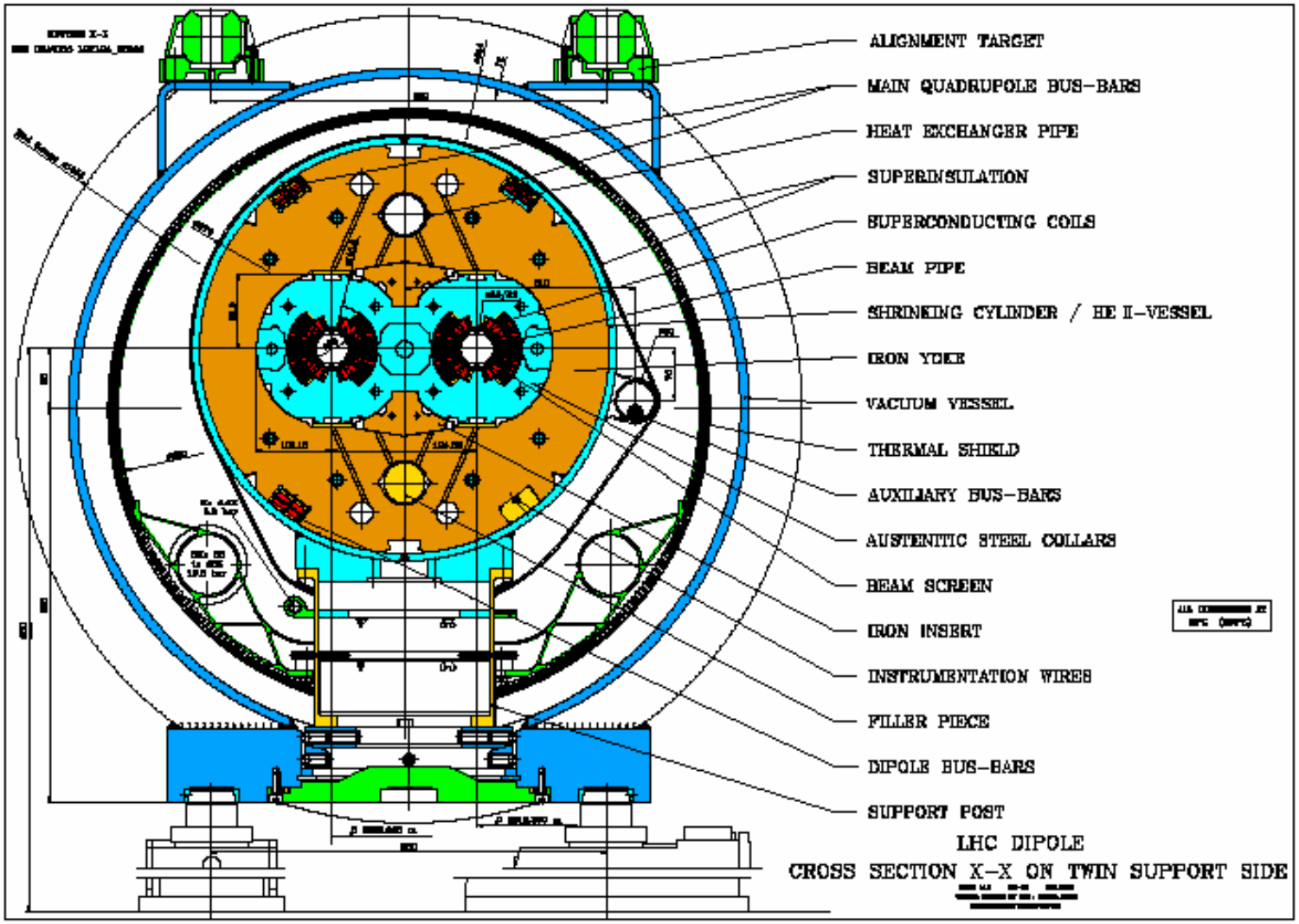
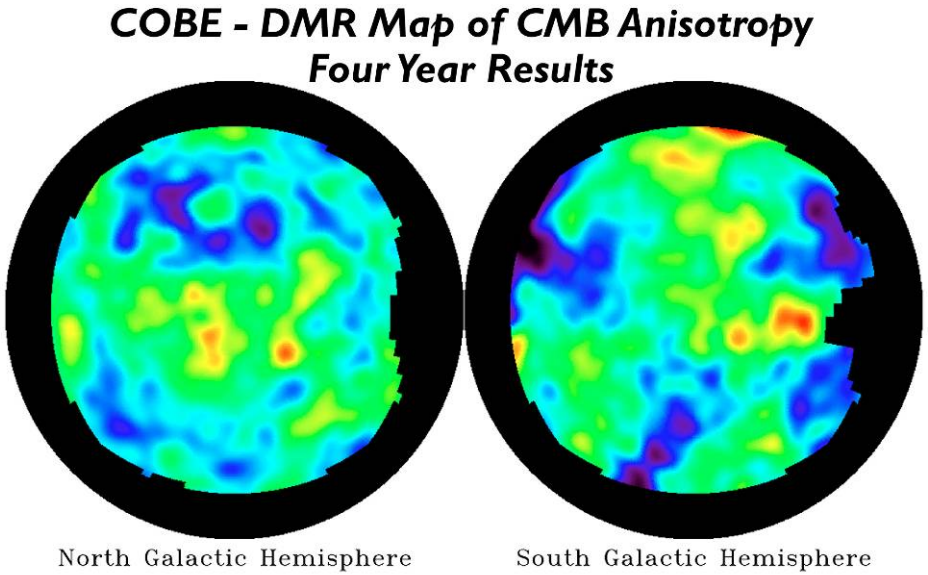
Status of the LHC

Lyn Evans

Cross-section of LHC cryodipole

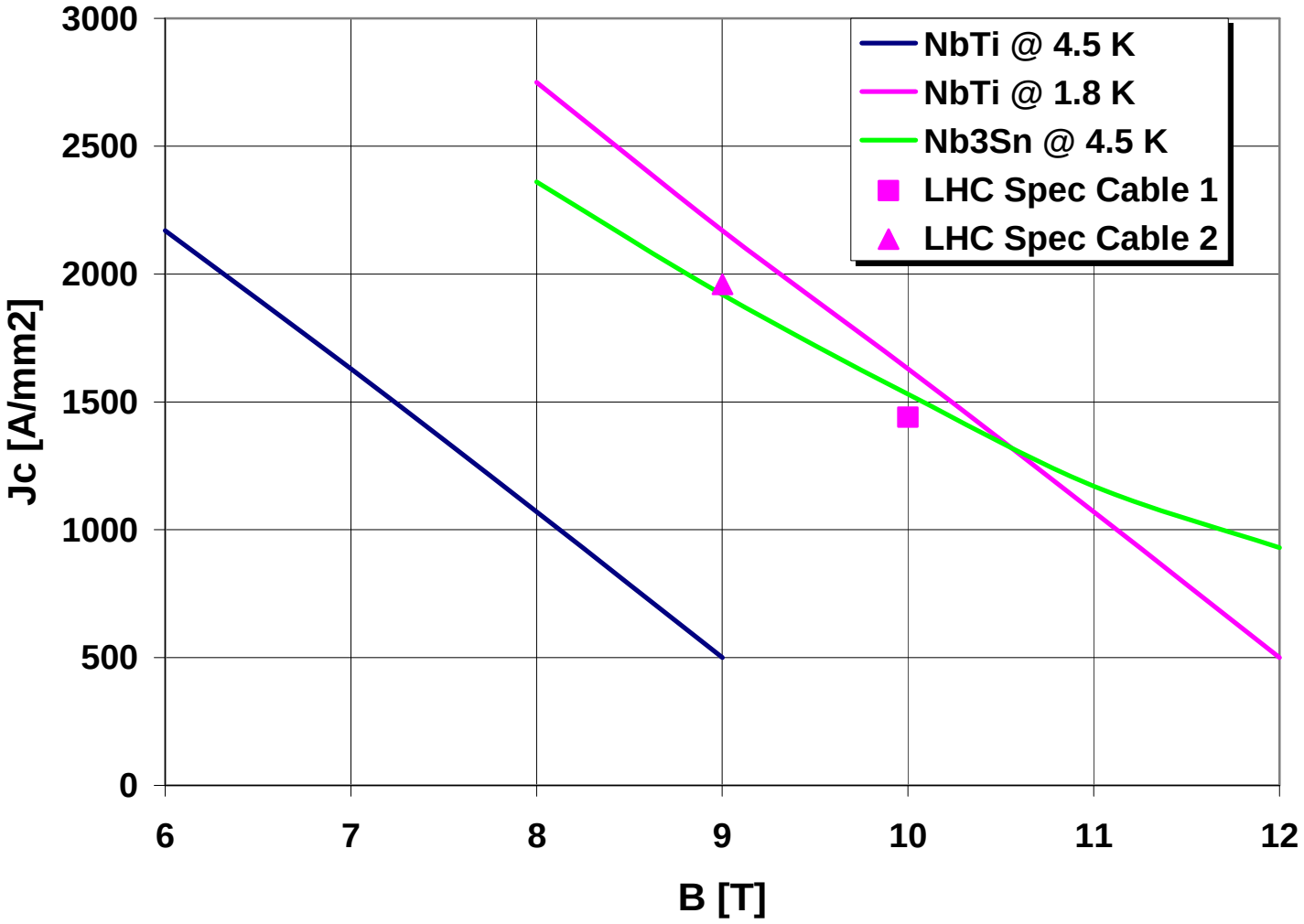


The Large Hadron Collider

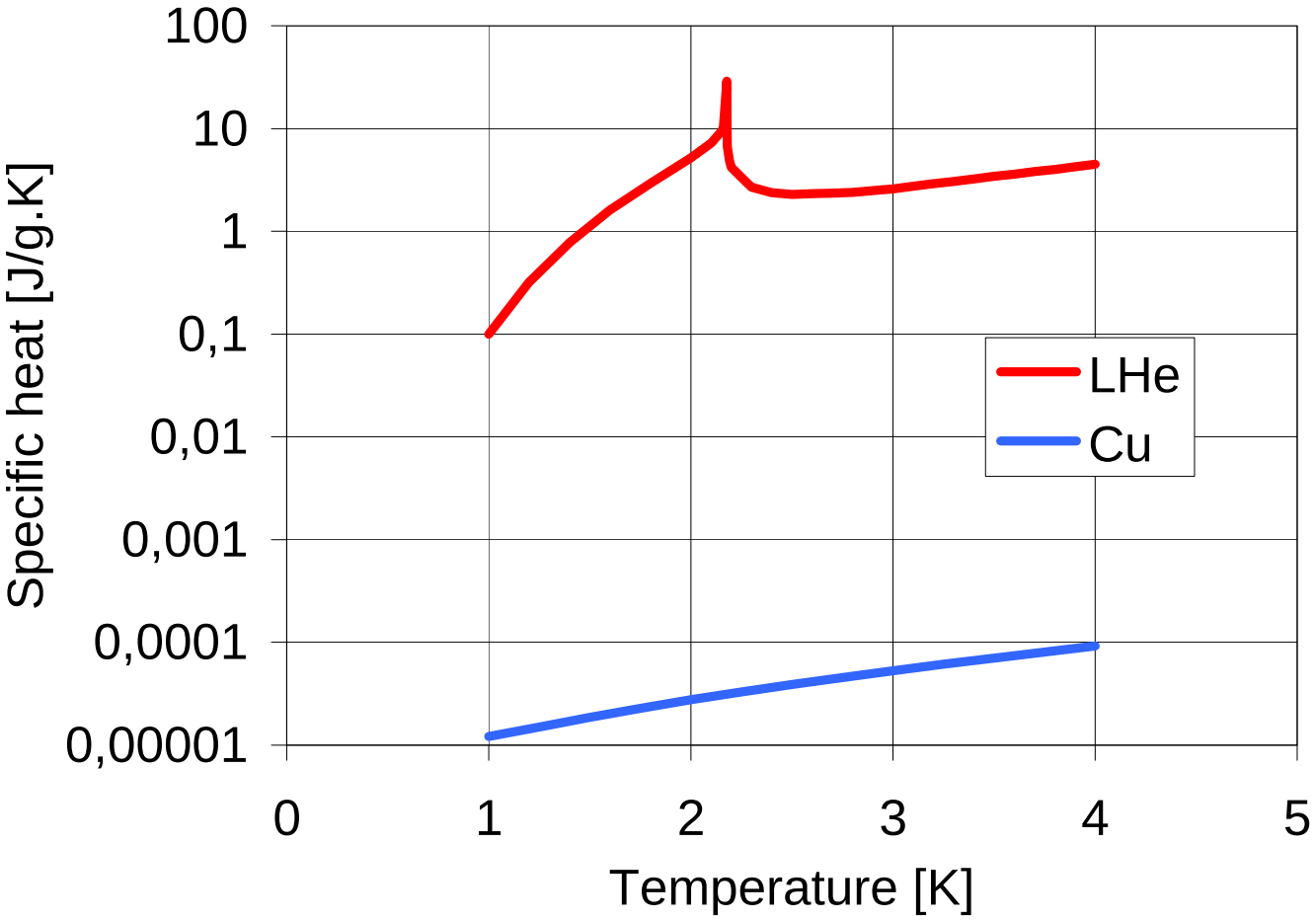


The coldest ring in the universe!

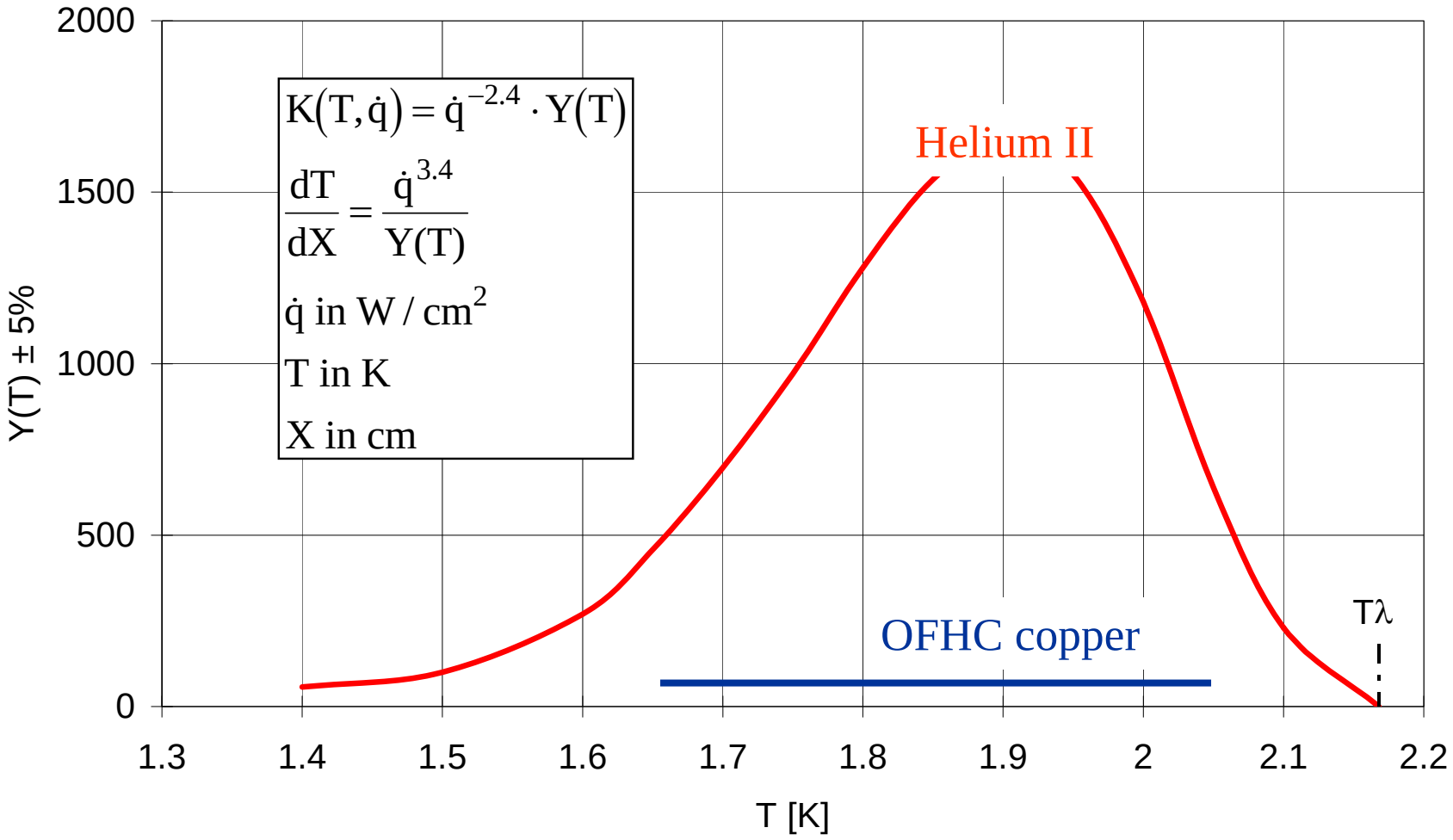
Critical current density of technical superconductors



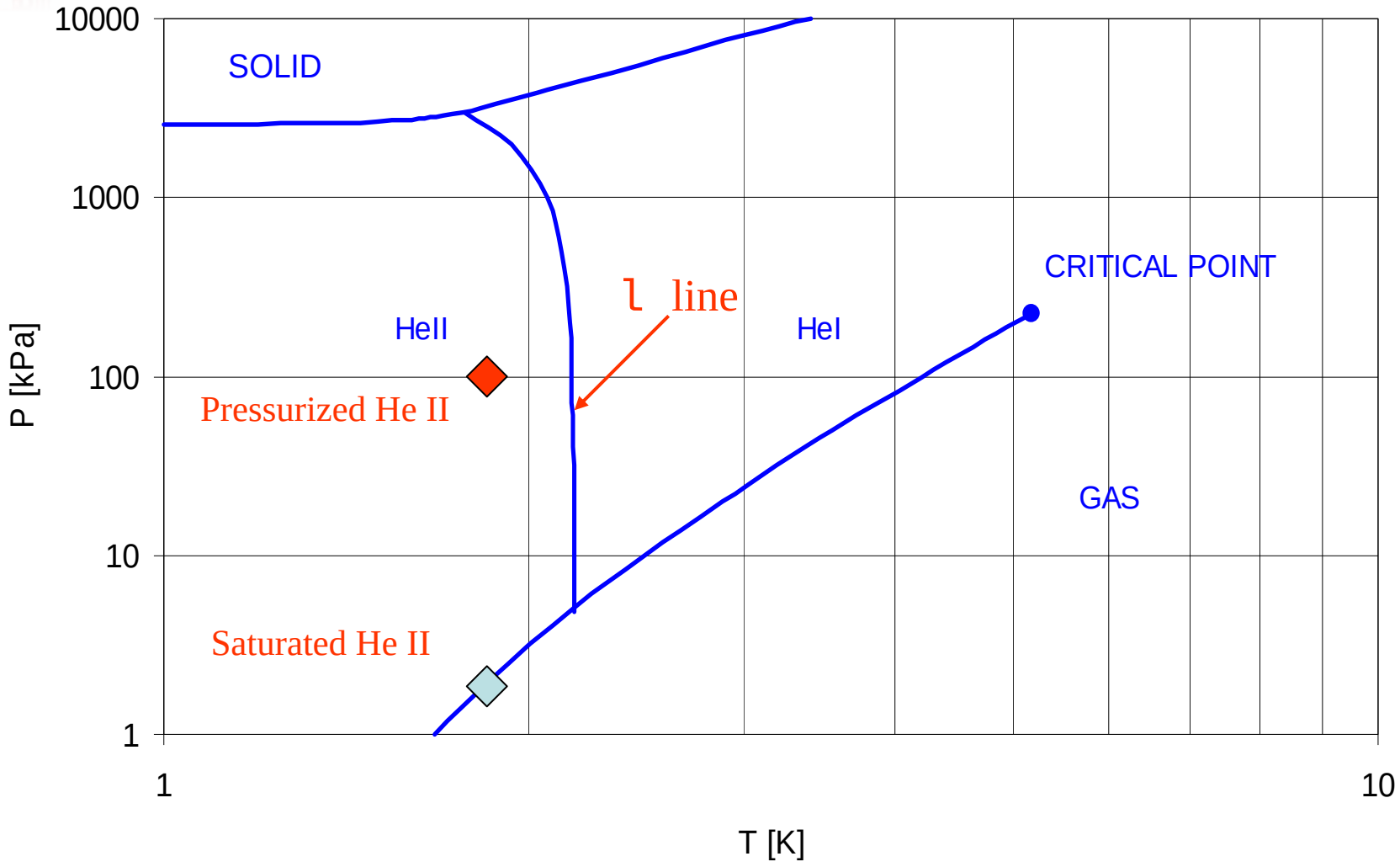
Specific heat of LHe and Cu



Equivalent thermal conductivity of He II

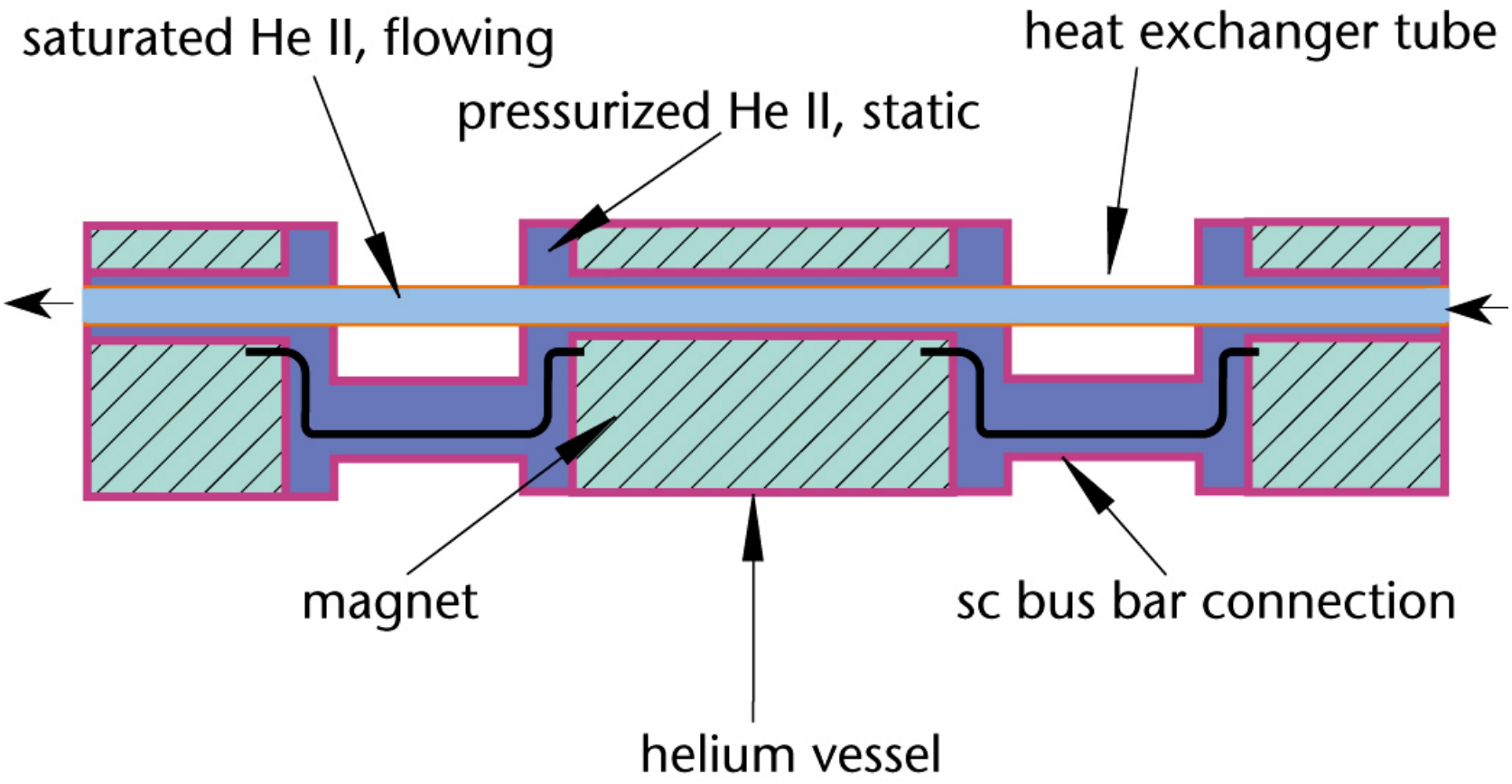


Phase diagram of Helium



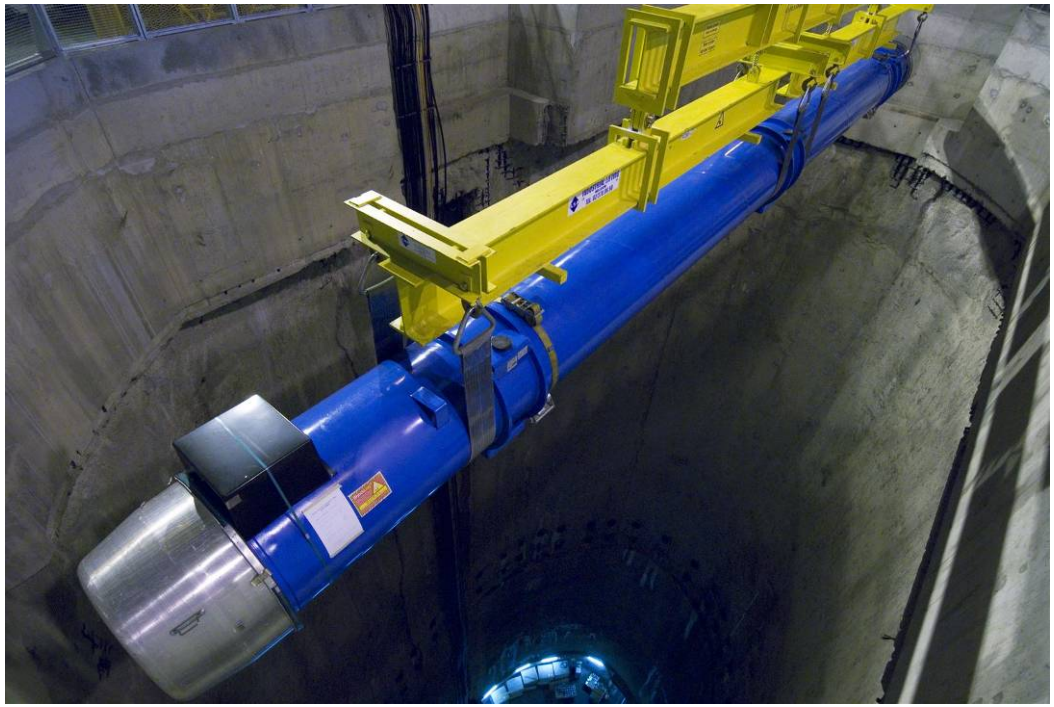
Linear heat exchanger

LHC magnet string cooling scheme



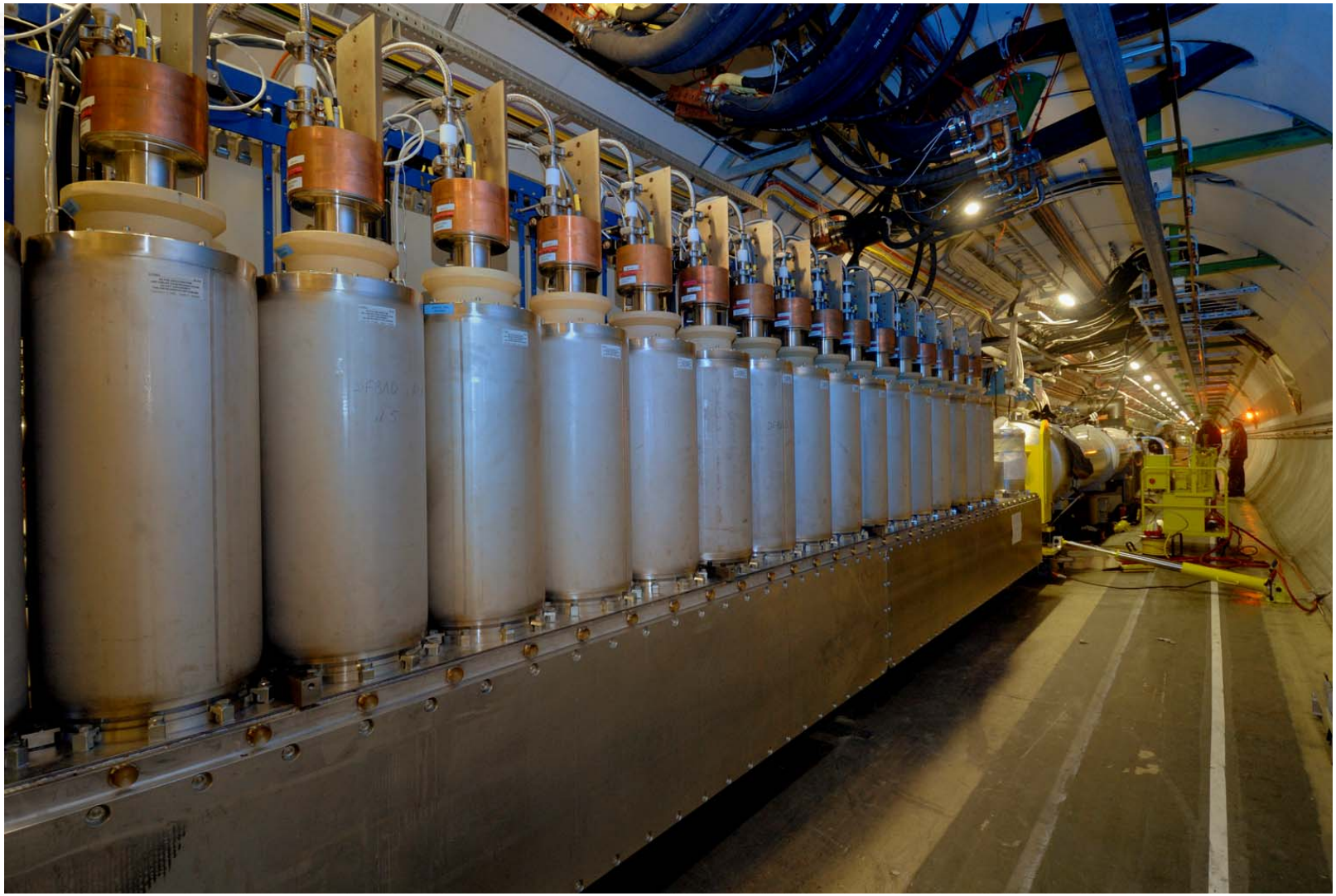
CERN AC _ EI2-12 VE _ V9/9/1997

Descent of the last magnet, 26 April 2007



30’000 km underground at 2 km/h!

DFBAO in Sector 7-8



Dipole-dipole interconnect: electrical splices

Cooldown of Sectors

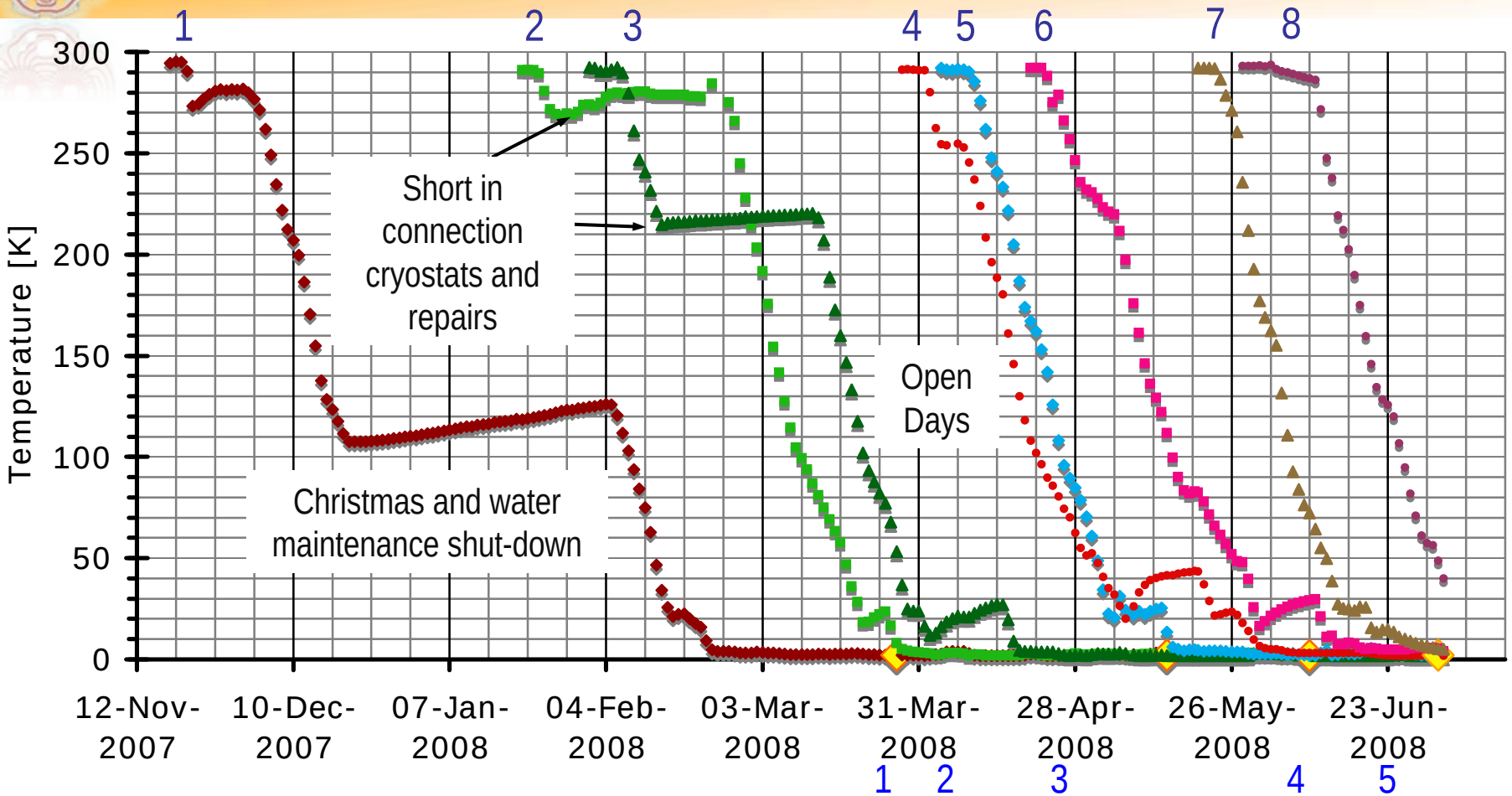
- From RT to 80K precooling with LN2. 1200 tons of LN2 (64 trucks of 20 tons). Three weeks for the first sector.
- From 80K to 4.5K. Cooldown with refrigerator. Three weeks for the first sector. 4700 tons of material to be cooled.
- From 4.2K to 1.9K. Cold compressors at 15 mbar. Four days for the first sector.

Large helium refrigerator for cooling down to 4.5 K

33 kW @ 50 K to 75 K
23 kW @ 4.6 K to 20 K
41 g/s liquefaction

600 kW precooling to 80 K with
LN2 (up to ~5 tons/h)

Cool-down of LHC sector

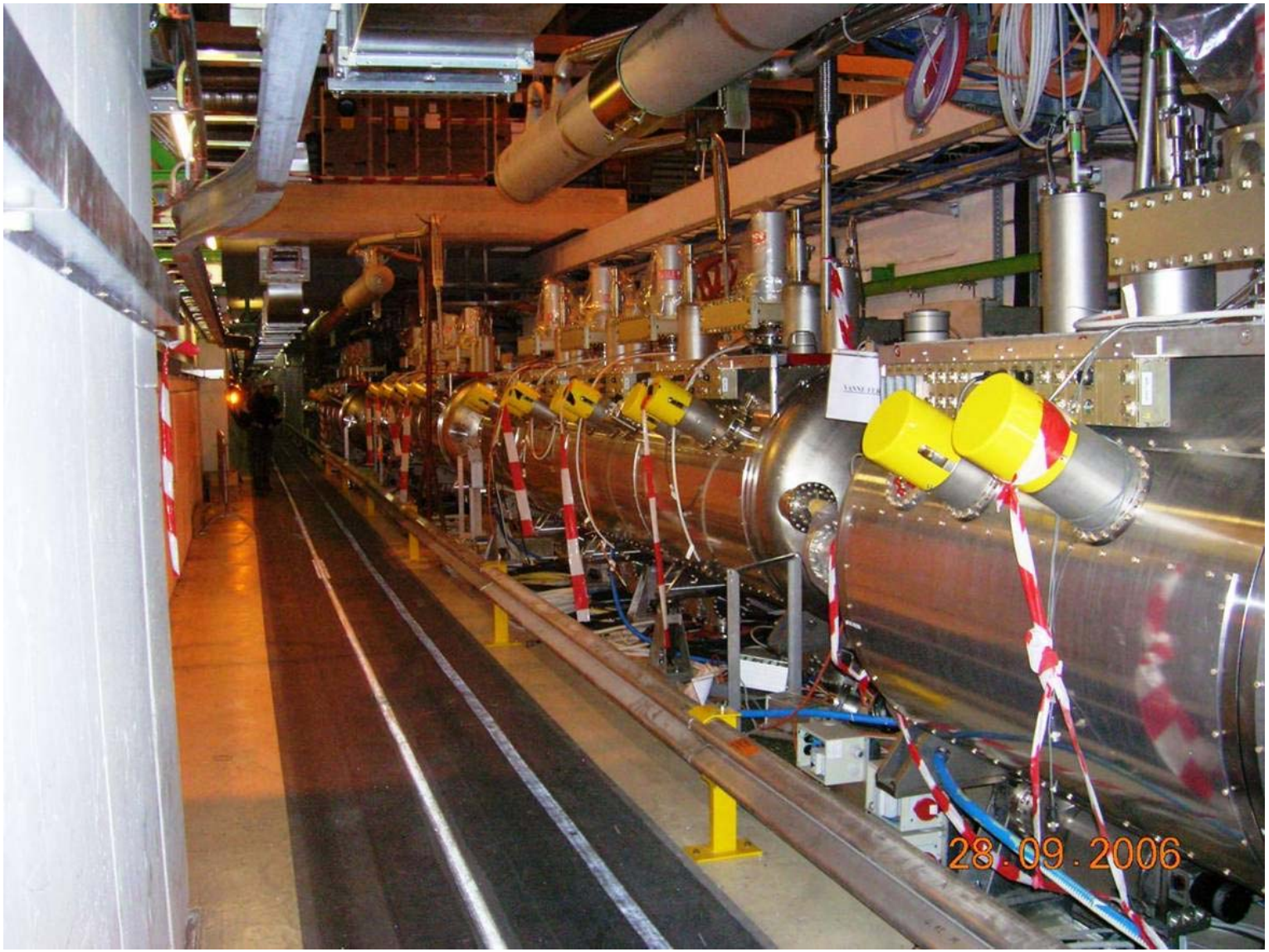


Sectors
< 2 K
+ 2 < 5 K

Cooling sectors + Cryo tuning + Powering activities

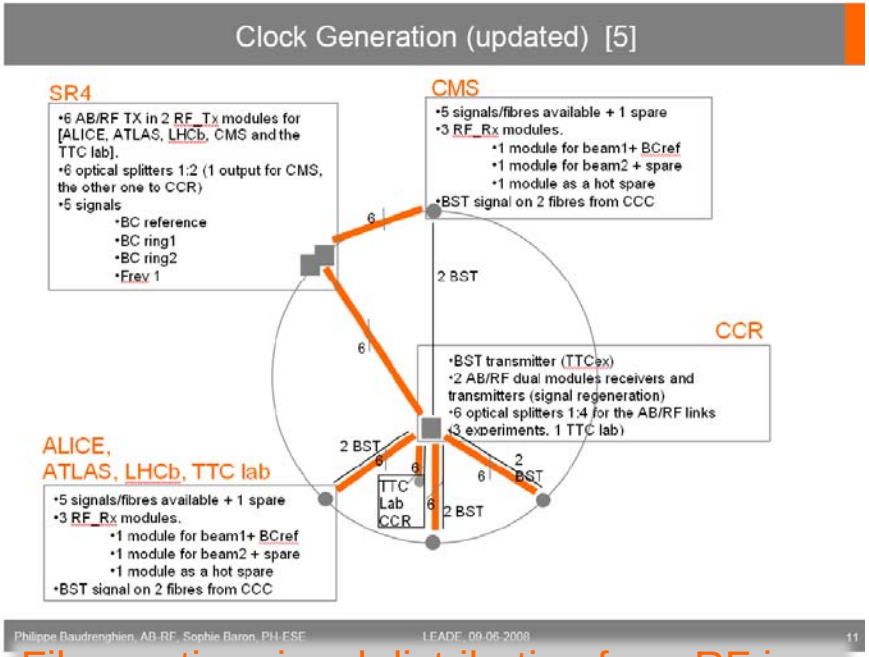
Lyn Evans – EDMS document no. 969889

RF cavities



Two 300 kW klystrons with circulators and loads

the RF cavities and transverse dampers



Fibre-optics signal distribution from RF in SR4 to Experiments, BT & BI equipment and to CCC.

40 MHz bunch clocks, revolution frequencies,
40 MHz 7TeV reference. Injection & dump kicker pulses

Preparation for Beam

RF synchronization in place – clocks and timing now going from SR4 to all users. Recent successful *dry run tests* with all users and OP group, including basic software.

Cavity Beam Control systems in advanced state but some items on critical path.

Transverse Damper electronics being tested.

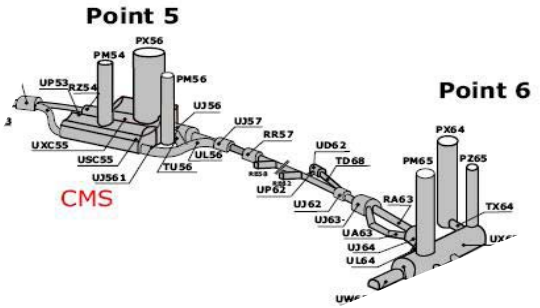
Software for beam control also critical, but basic functionality will be available for this run.

Procedures for beam commissioning well defined.

Longitudinal diagnostics in good shape to study and commission first beams….

Courtesy Edmond Ciapala

the superconducting circuits of an LHC sector



XR5			LR5			A56							ML6	
IT	600A	80 120A	IPQ	IPD	80 120A	RB	QD	QF	IP	80 120A	600A	60A	IPQ	80 120A
1	7	5	3	1	10	1	1	1	7	14	39	94	2	4
1.9 K			4.5 K			1.9 K							4.5 K	

13 circuits

14 circuits

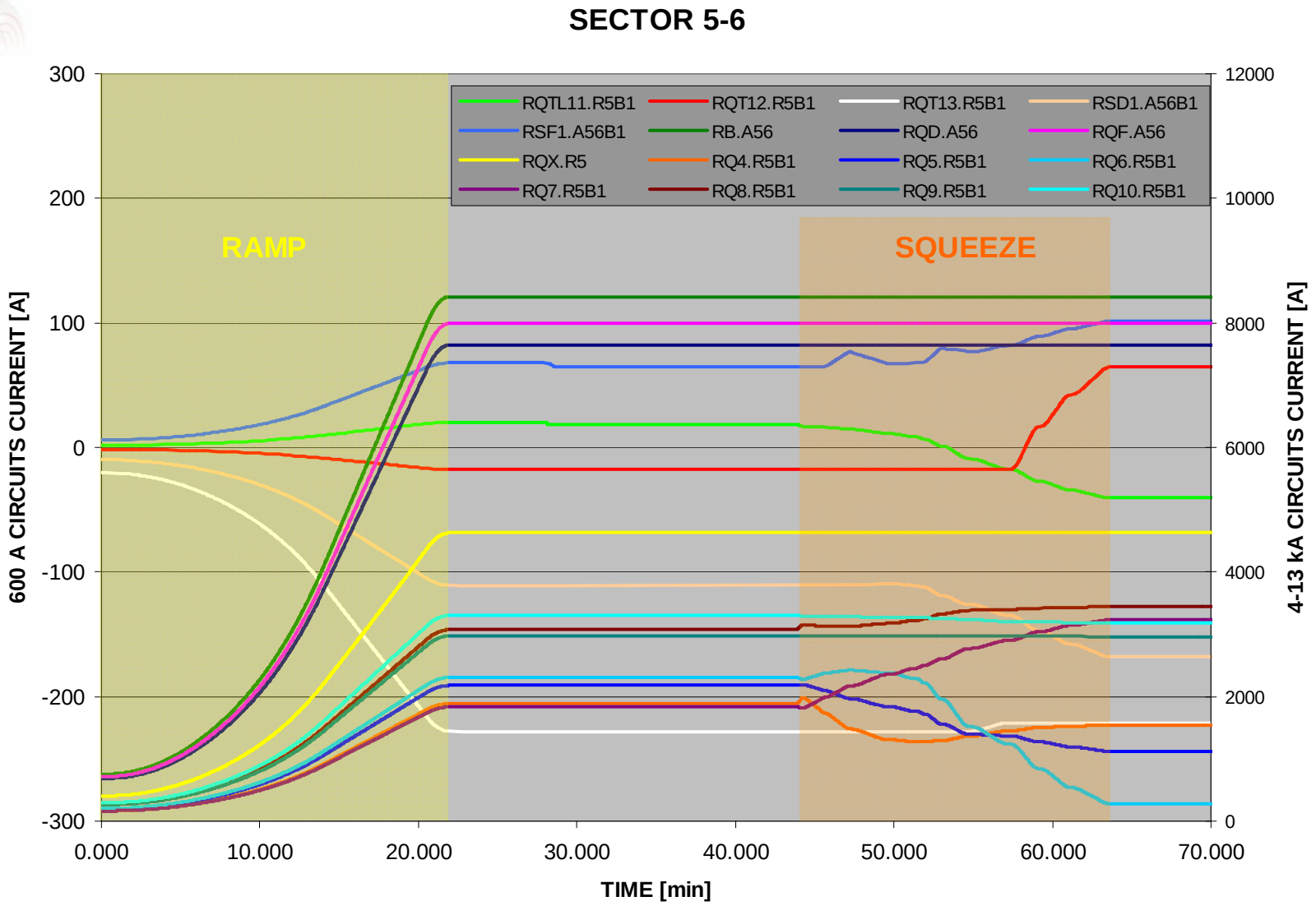
157 circuits

6 circuits

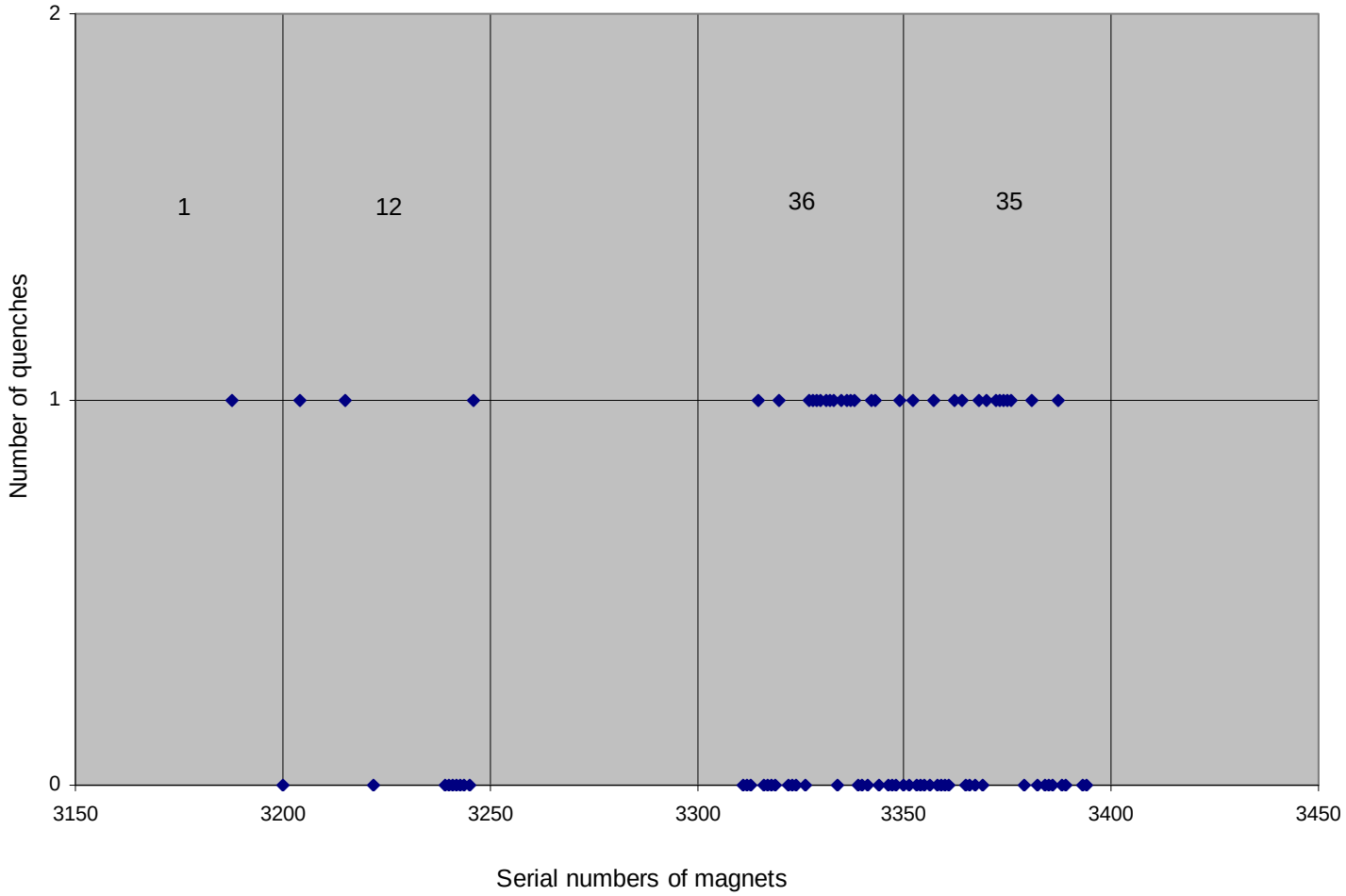
Totalling 190 circuits

Courtesy Roberto Saban

Ramp and squeeze of main circuits

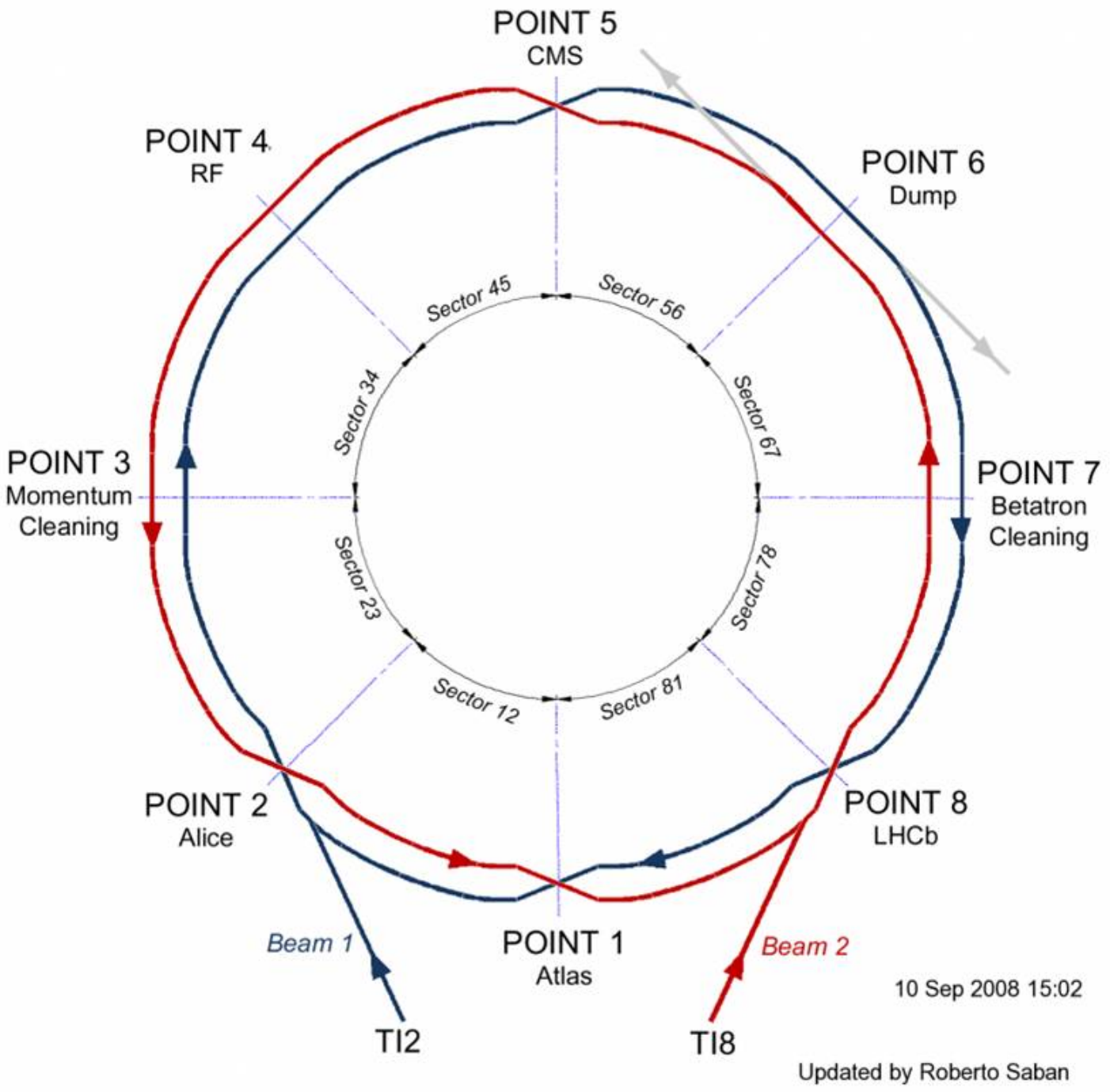


re-training of dipoles in Sector 5-6



Situation on 10th September

- 7 out of 8 sectors fully commissioned for 5 TeV operation and 1 sector (3-4) commissioned up to 1 TeV.


POINT 5
CMS
POINT 4
RF
POINT 6
Dump
POINT 3
Momentum
Cleaning
POINT 7
Betatron
Cleaning
POINT 2
Alice
POINT 8
LHCb
POINT 1
Atlas
Sector 45
Sector 56
Sector 34
Sector 67
Sector 23
Sector 78
Sector 12
Sector 81
Beam 1
Beam 2
TI2
TI8
10 Sep 2008 15:02
Updated by Roberto Saban

Beam 2 first beam – D-Day

YASP DV LHCRING / INJ-TEST-NB / beam 2

YASP DV LHCRING / INJ-TEST-NB / beam 2

YASP DV LHCRING / INJ-TEST-NB / beam 2

YASP DV LHCRING / INJ-TEST-NB / beam 2

YASP DV LHCRING / INJ-TEST-NB / beam 2

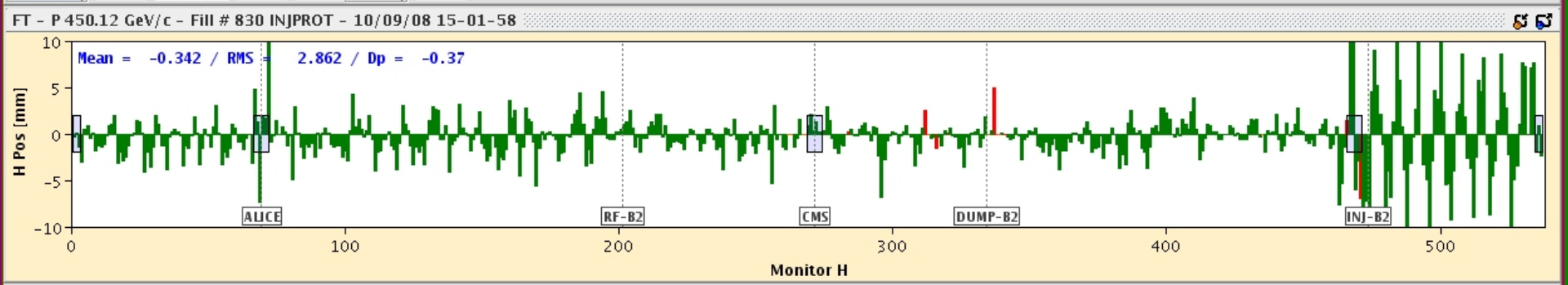
YASP DV LHCRING / INJ-TEST-NB / beam 2

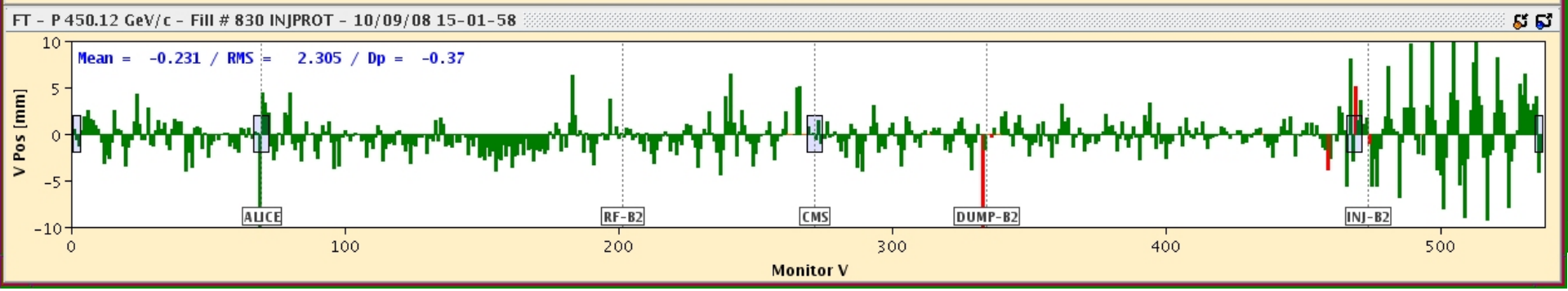
YASP DV LHCRING / INJ-TEST-NB / beam 2

YASP DV LHCRING / INJ-TEST-NB / beam 2

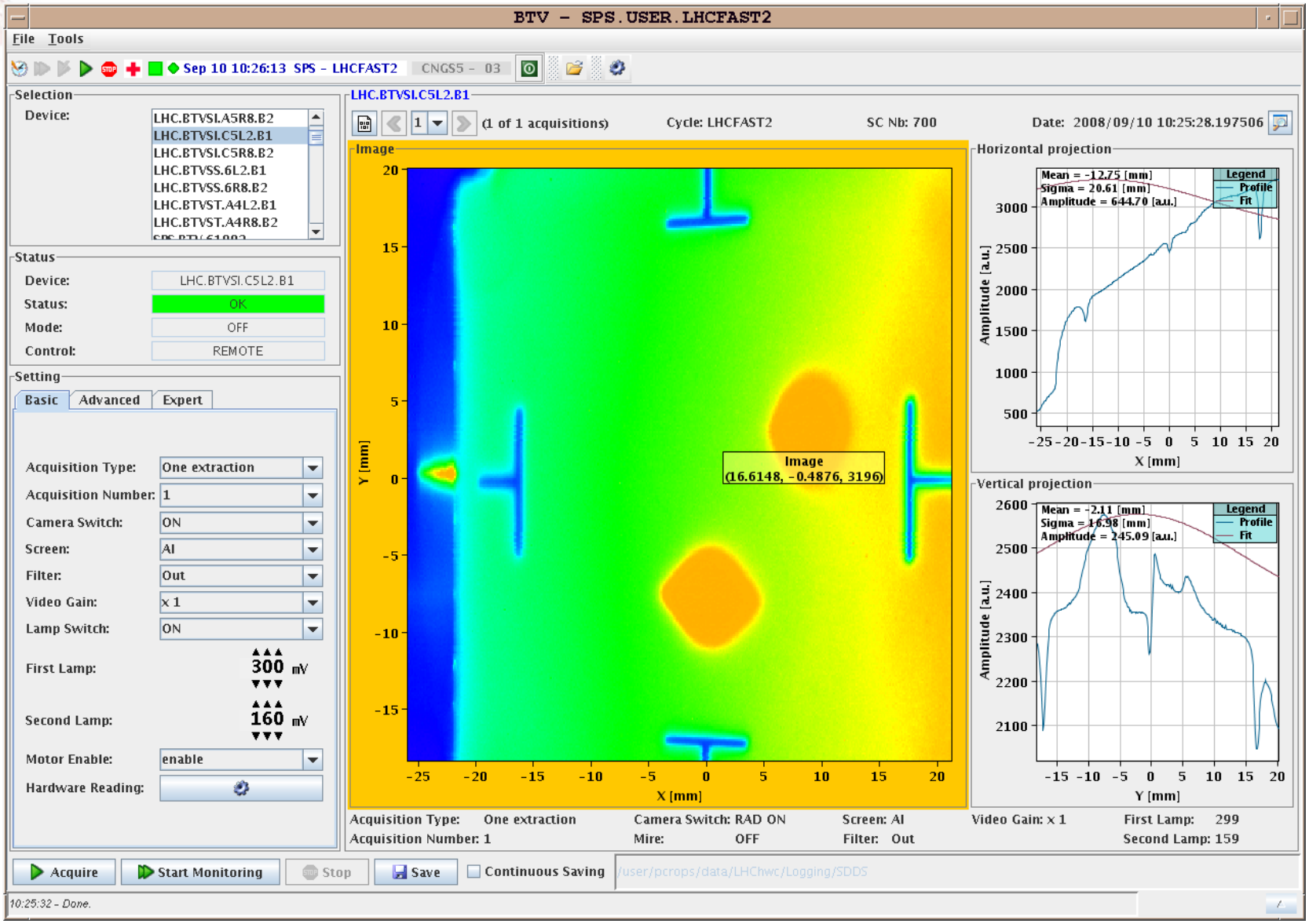
YASP DV LHCRING / INJ-TEST-NB / beam 2

Views More

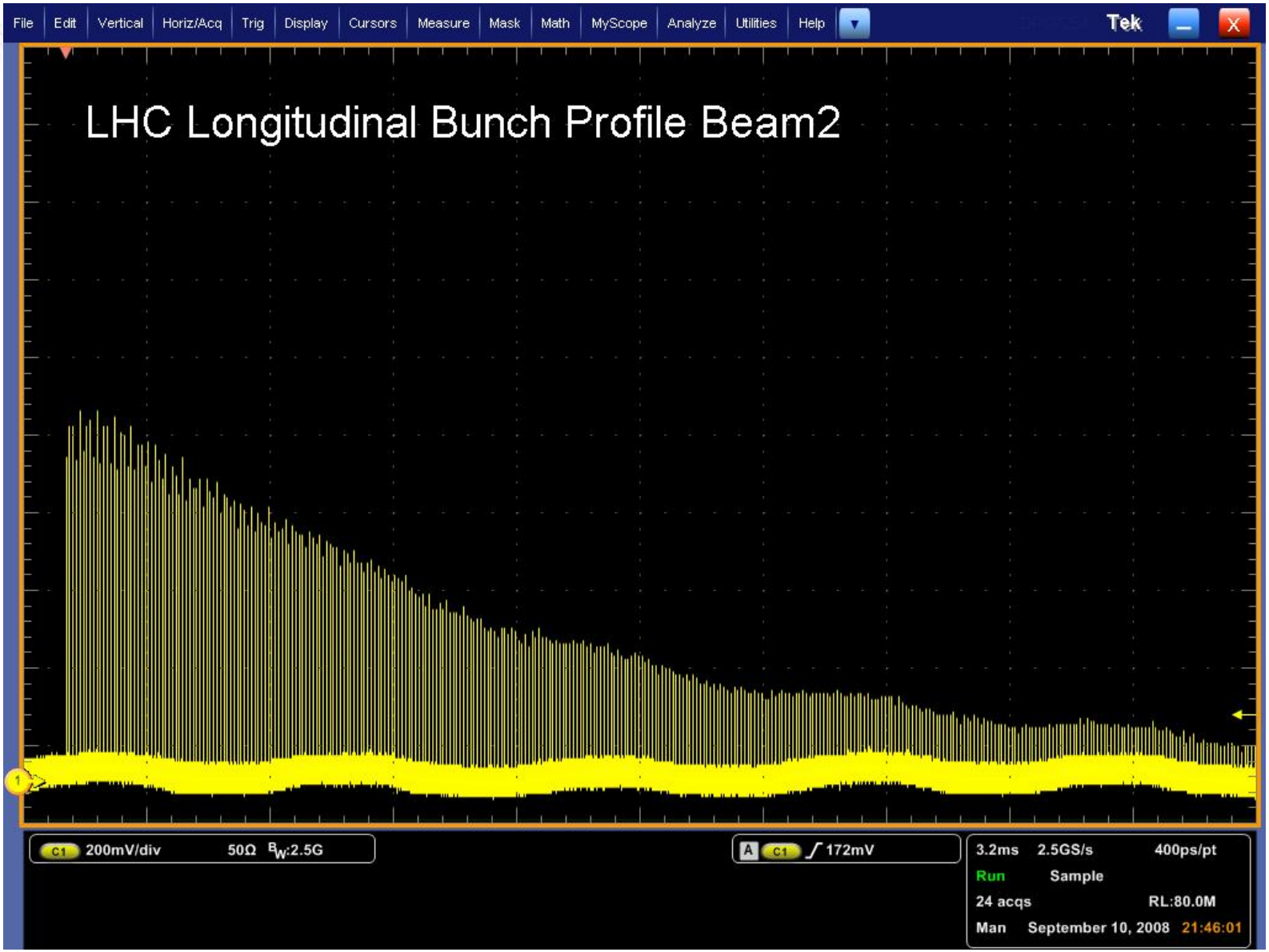




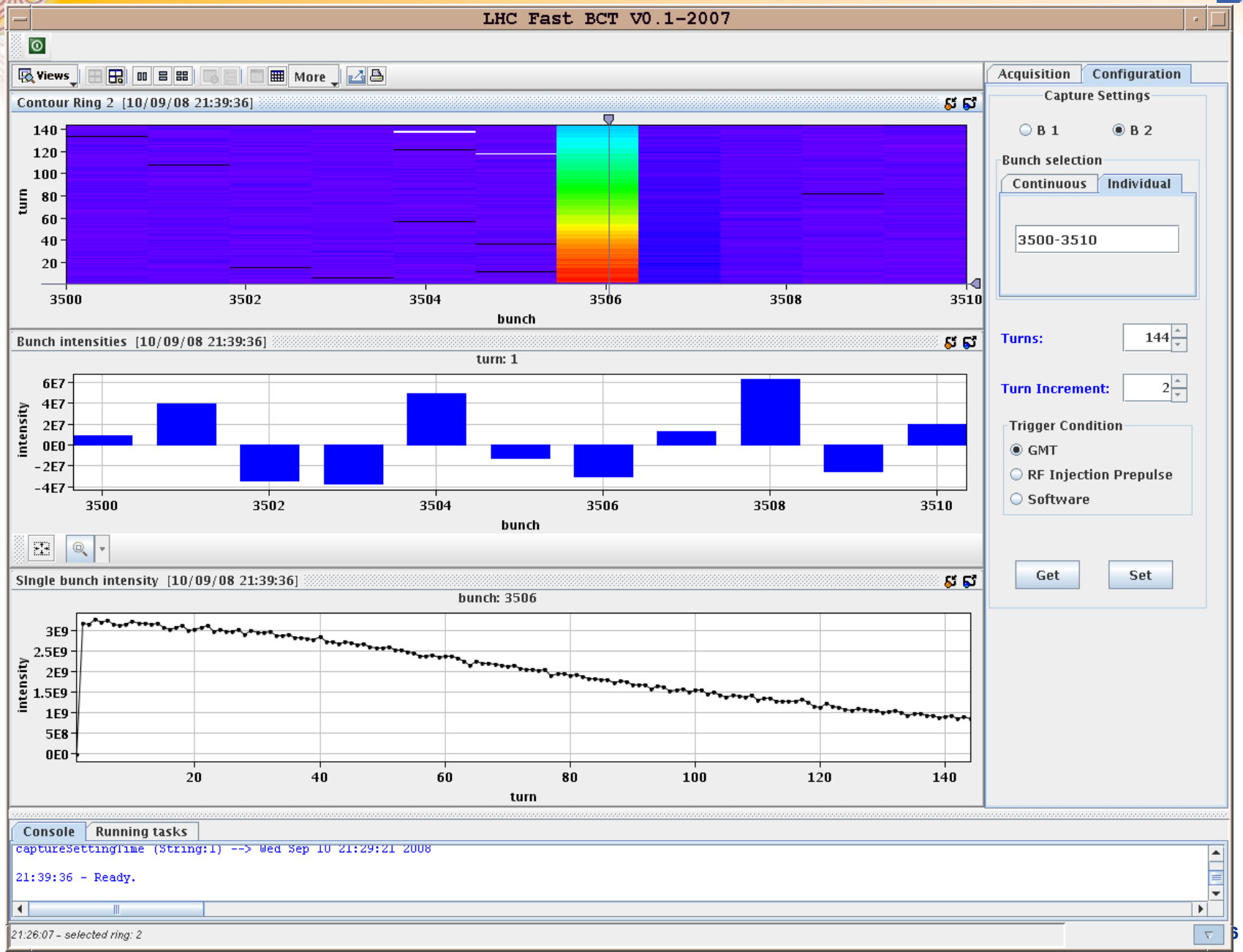
Beam on turns 1 and 2



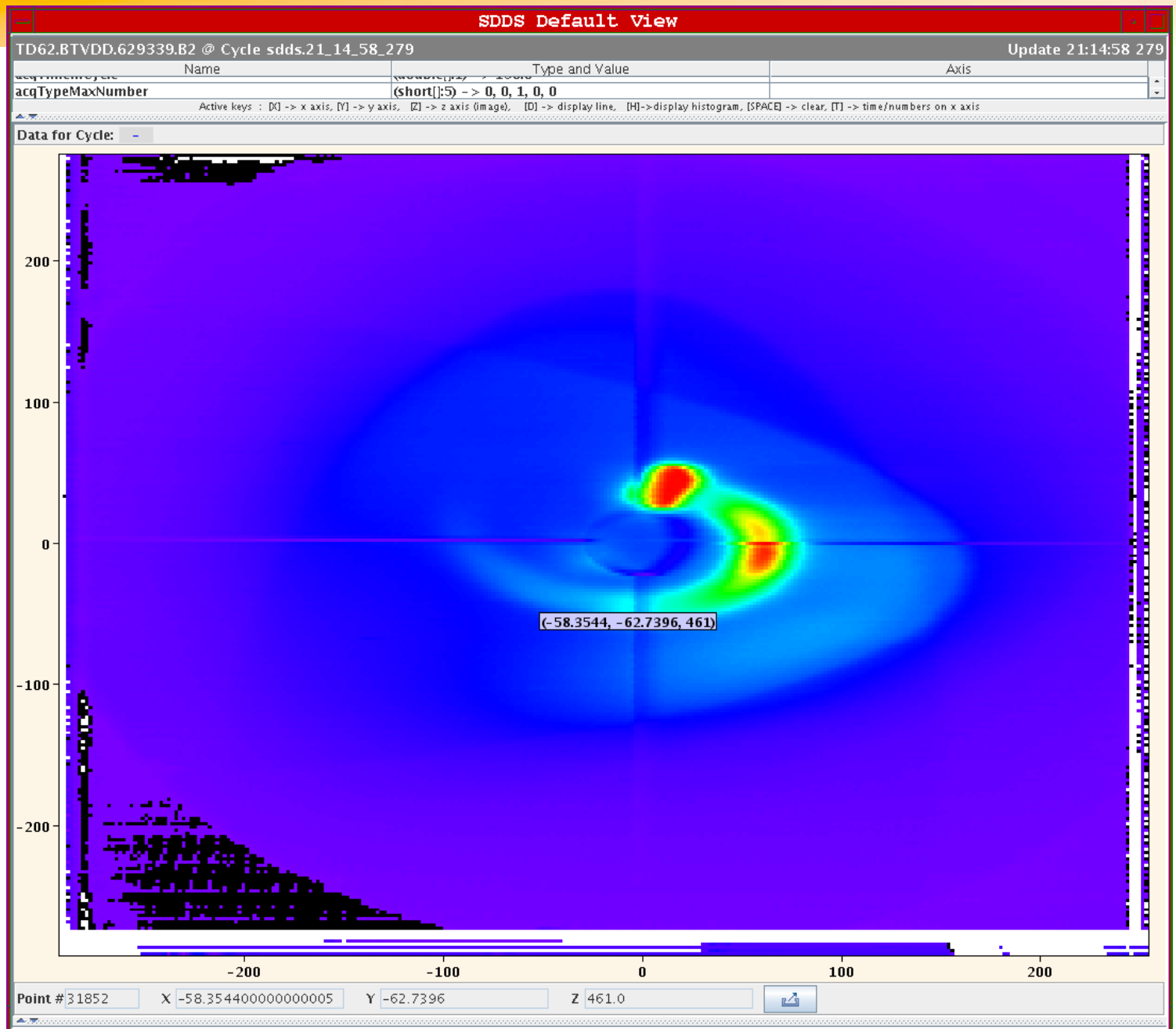
Few 100 turns



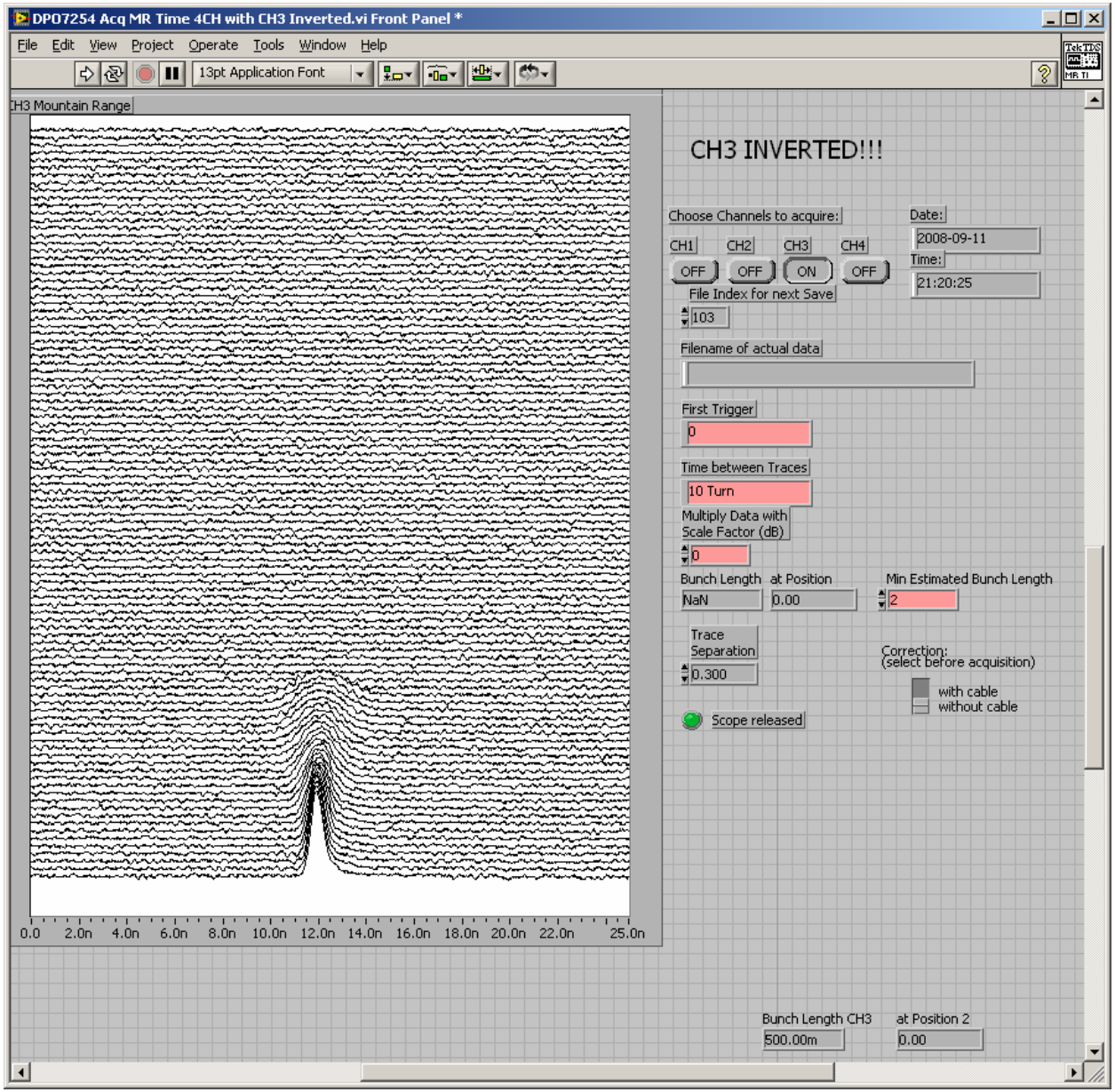
Fast BCT


LHC Fast BCT V0.1-2007
Views
More
Acquisition
Configuration
Capture Settings
B 1
B 2
Bunch selection
Continuous
Individual
3500-3510
Contour Ring 2 [10/09/08 21:39:36]
turn
bunch
Turns:
144
Turn Increment:
2
Trigger Condition
GMT
RF Injection Prepulse
Software
Get
Set
Bunch intensities [10/09/08 21:39:36]
turn: 1
intensity
Single bunch intensity [10/09/08 21:39:36]
bunch: 3506
Console
Running tasks
captureSettingTime (String:1) --> Wed Sep 10 21:29:21 2008
21:39:36 - Ready.
21:26:07 - selected ring: 2

Dump dilution sweep

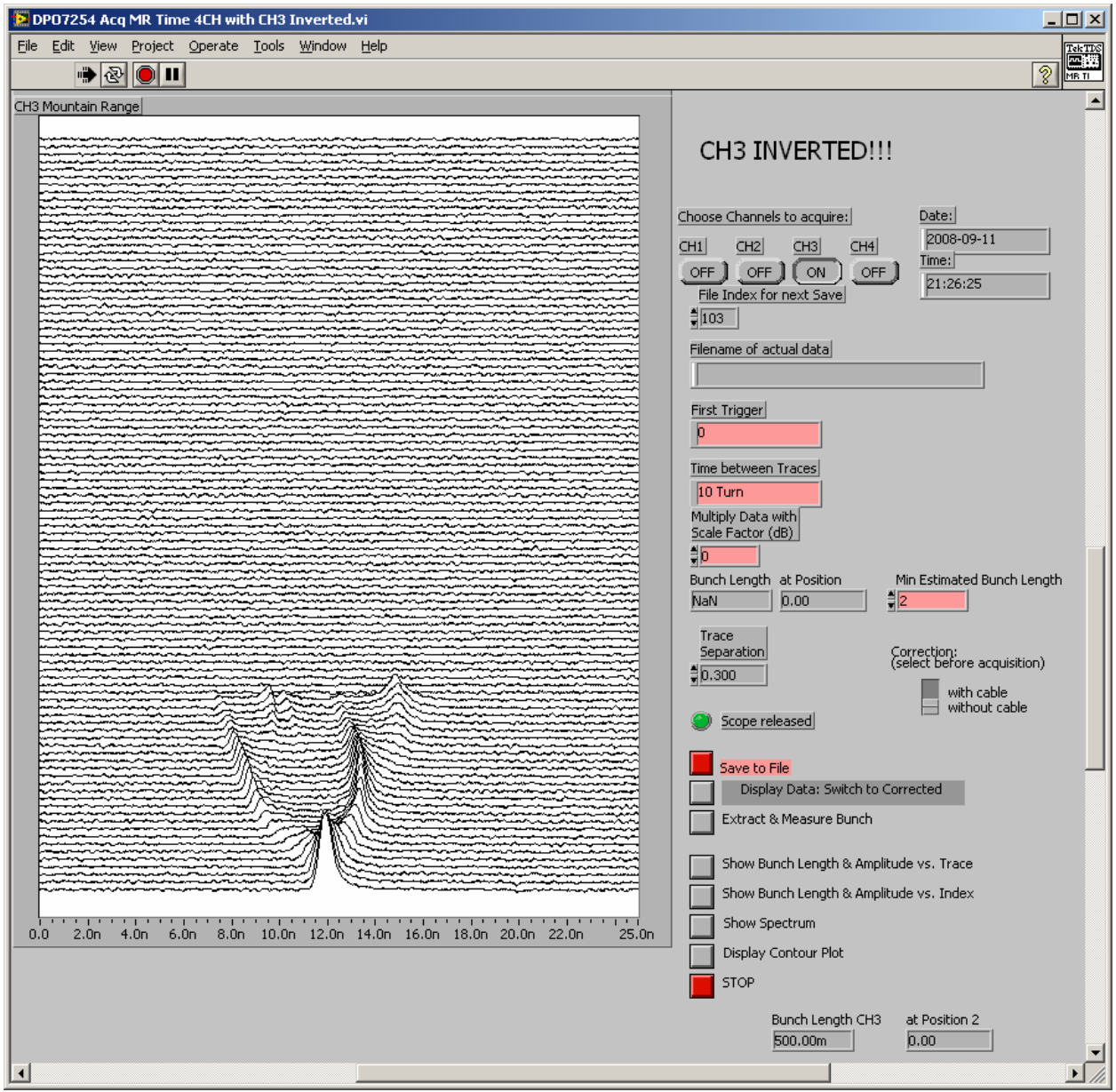


No RF, debunching in ~ 25*10 turns, i.e. roughly 25 mS



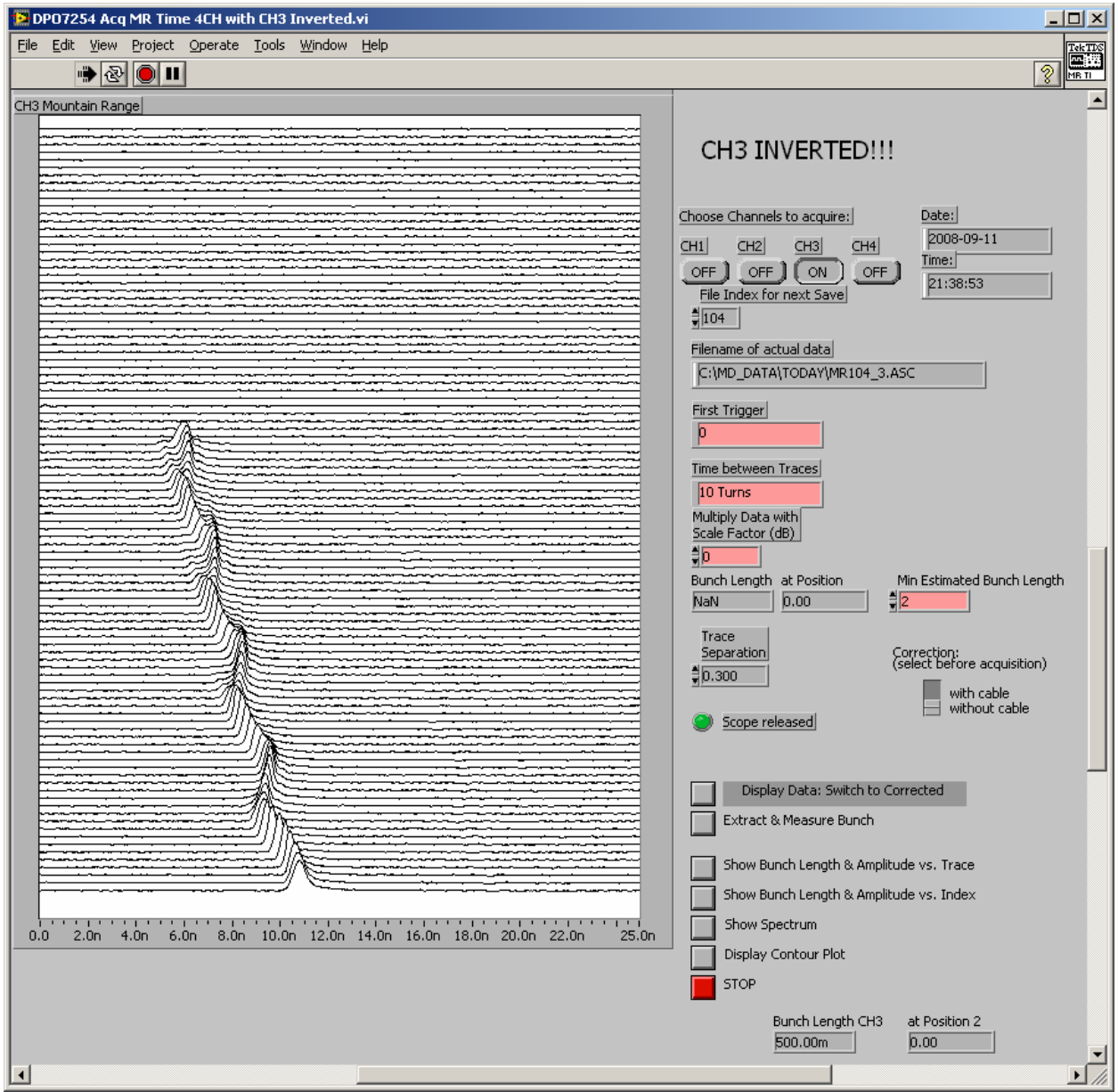
Courtesy E. Ciapala

First attempt at capture, at exactly the wrong injection phase…



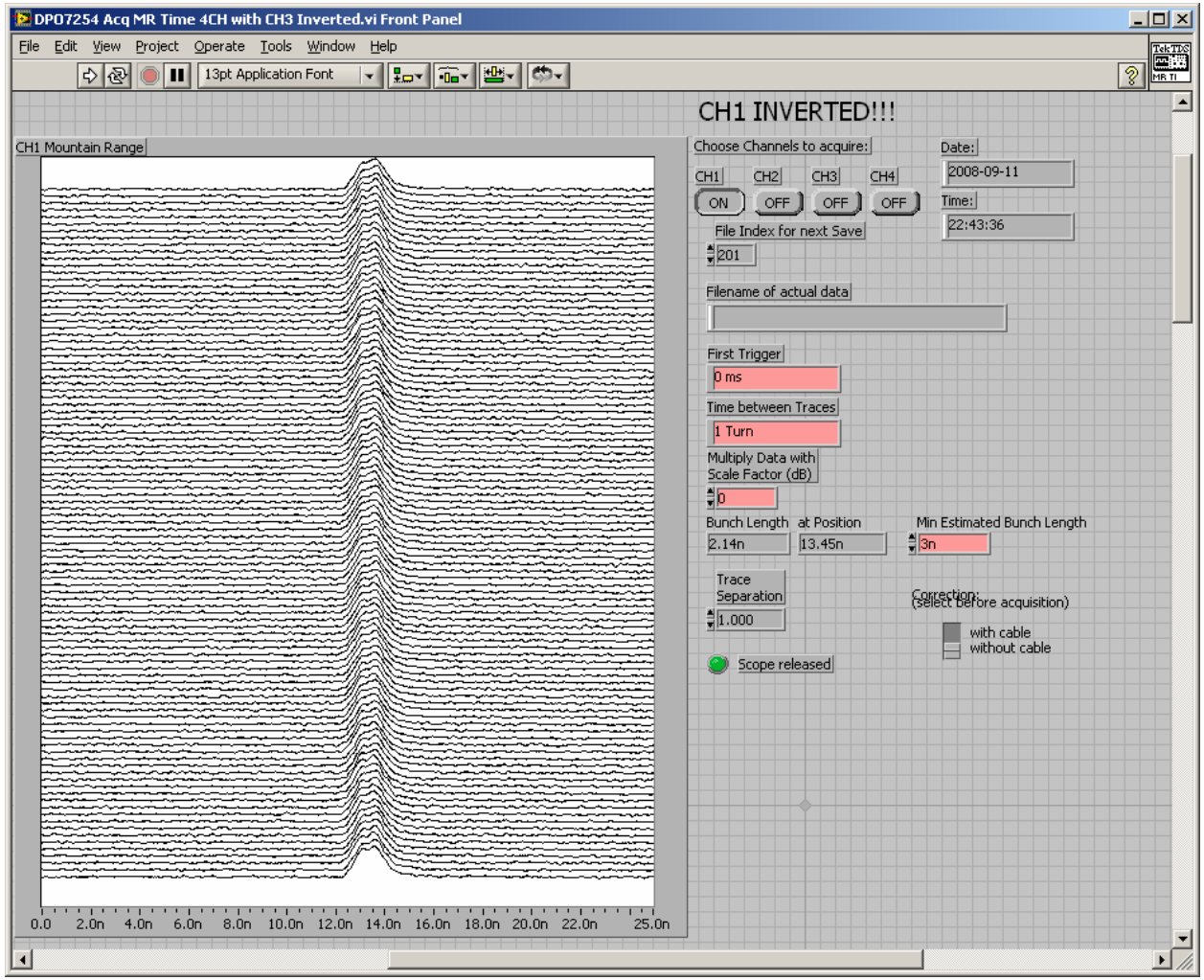
Courtesy E. Ciapala

Capture with corrected injection phasing



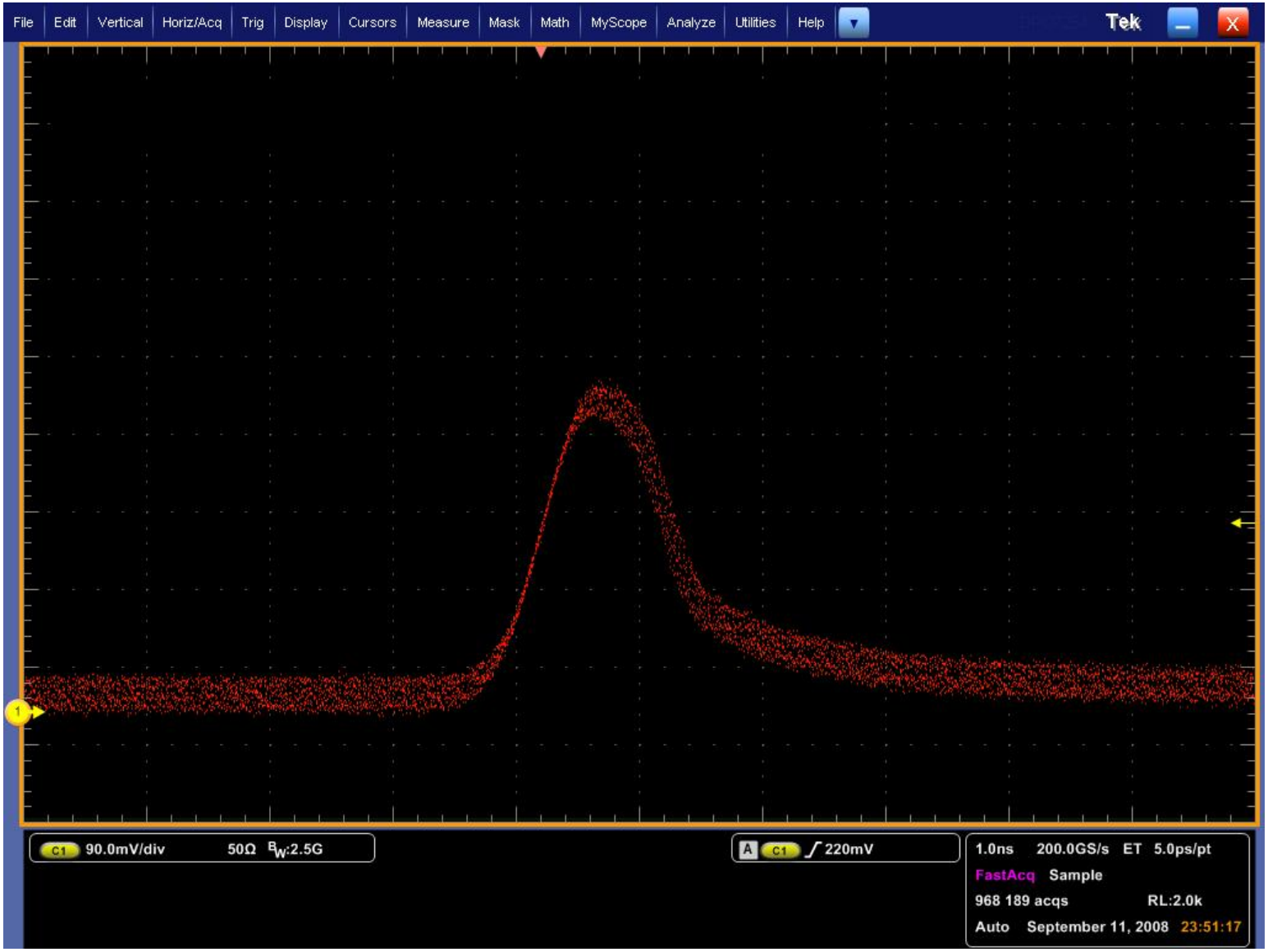
Courtesy E. Ciapala

Capture with optimum injection phasing, correct reference

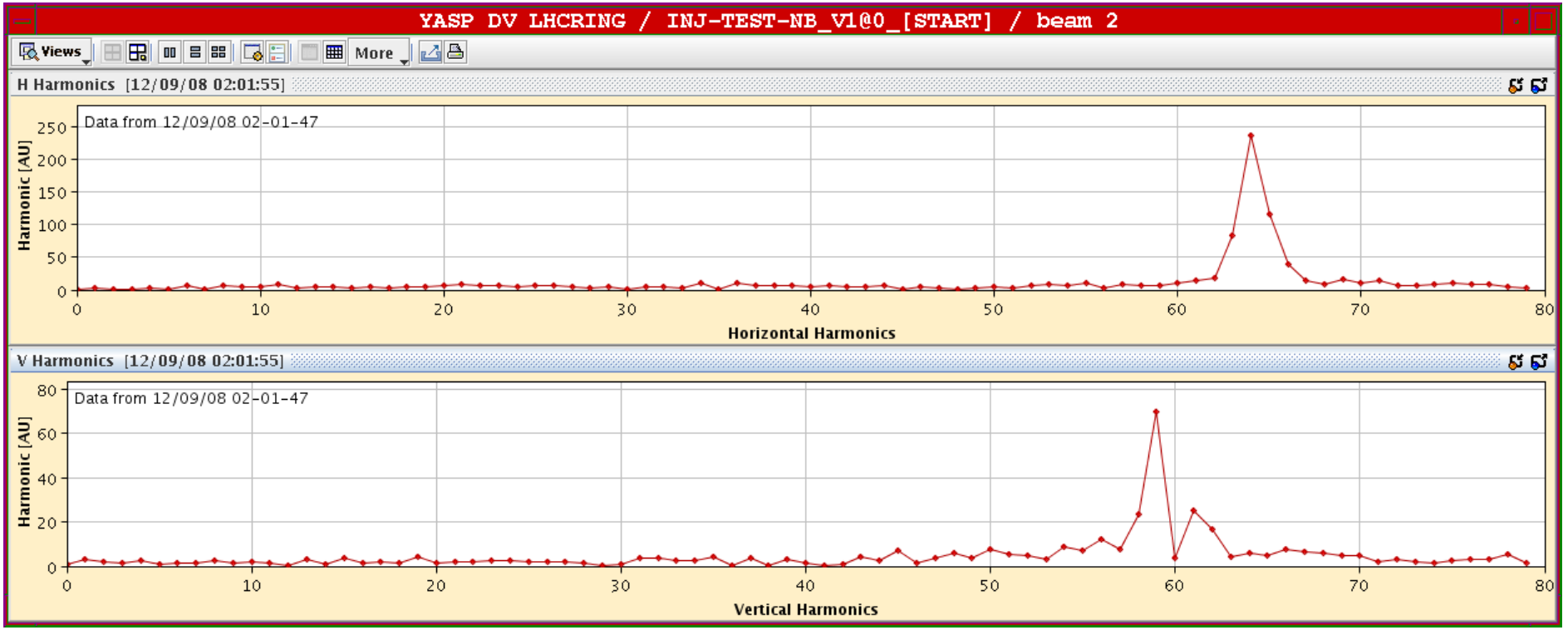


Courtesy E. Ciapala

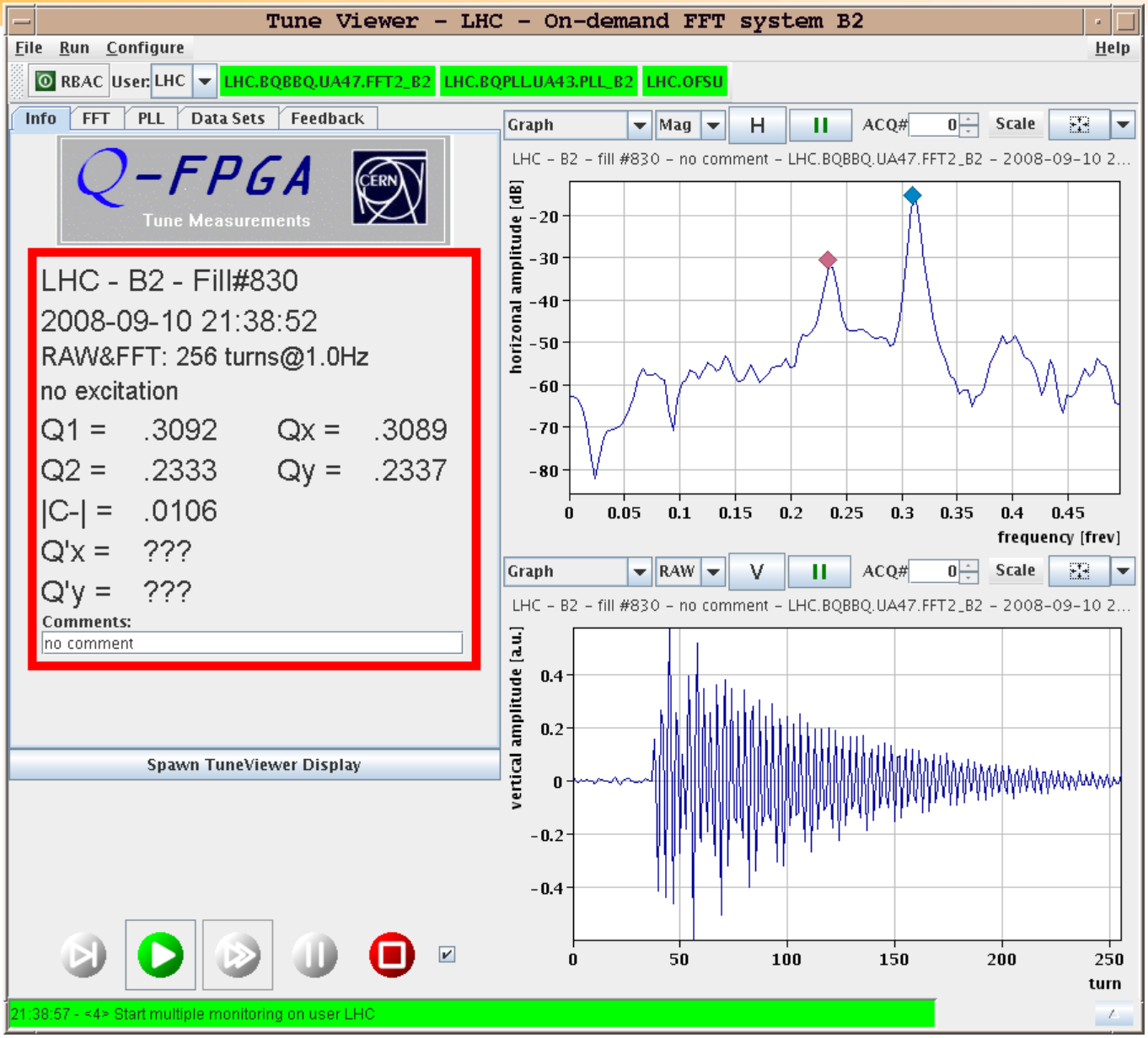
LHC longitudinal bunch profile Beam 2



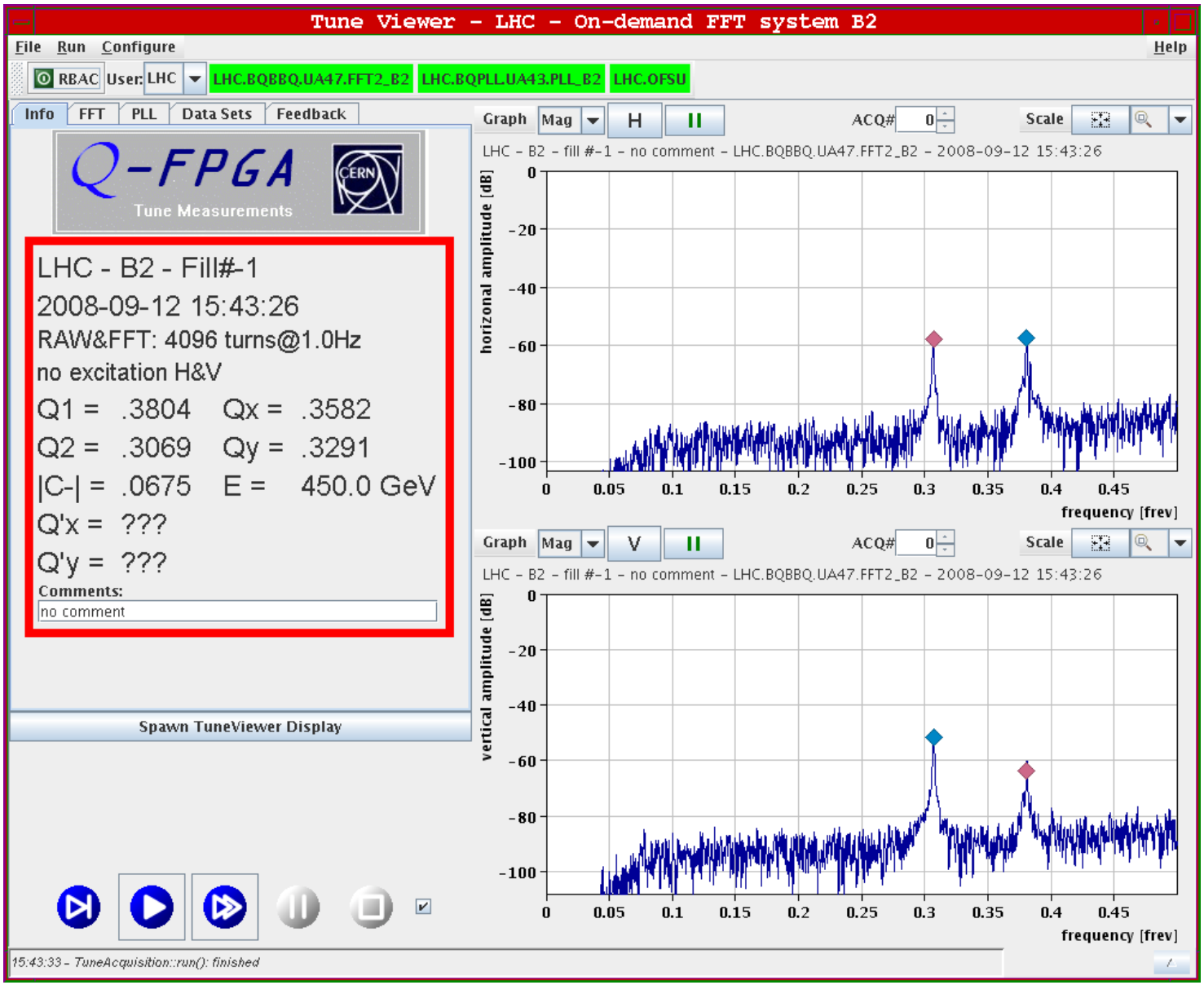
Integer tunes



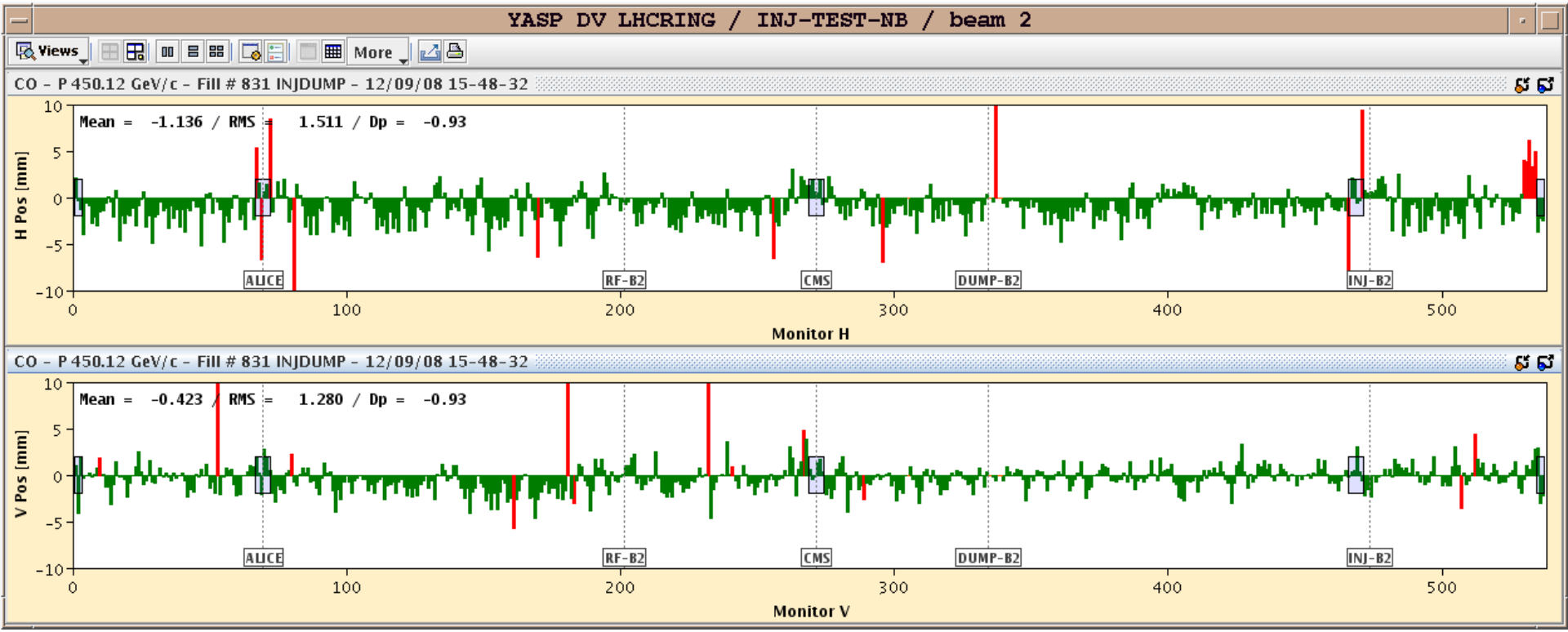
Tune measurements



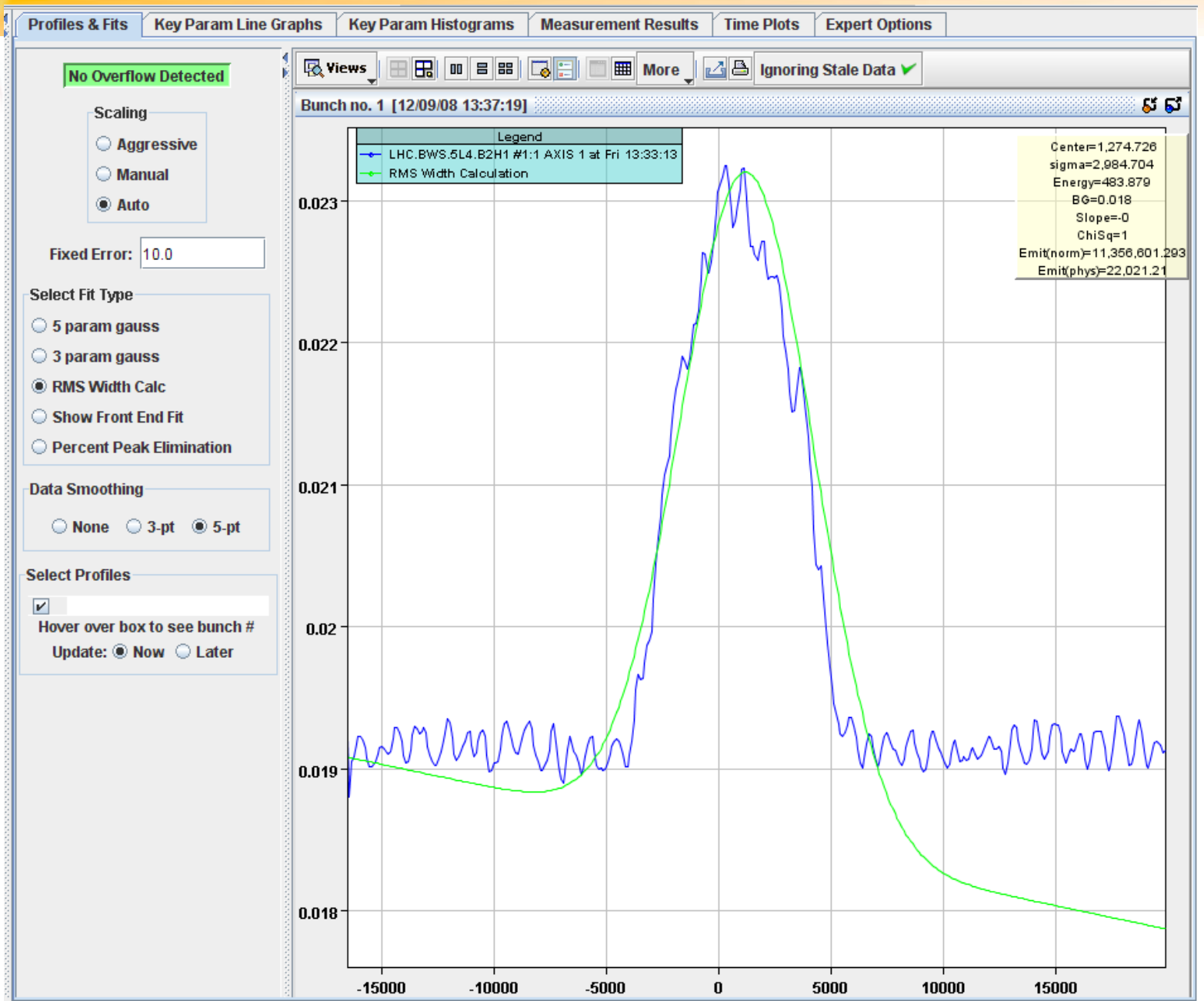
Fractional tune spectrum H & V (Beam2) – closest Q approach ~ 0.06 due to coupling



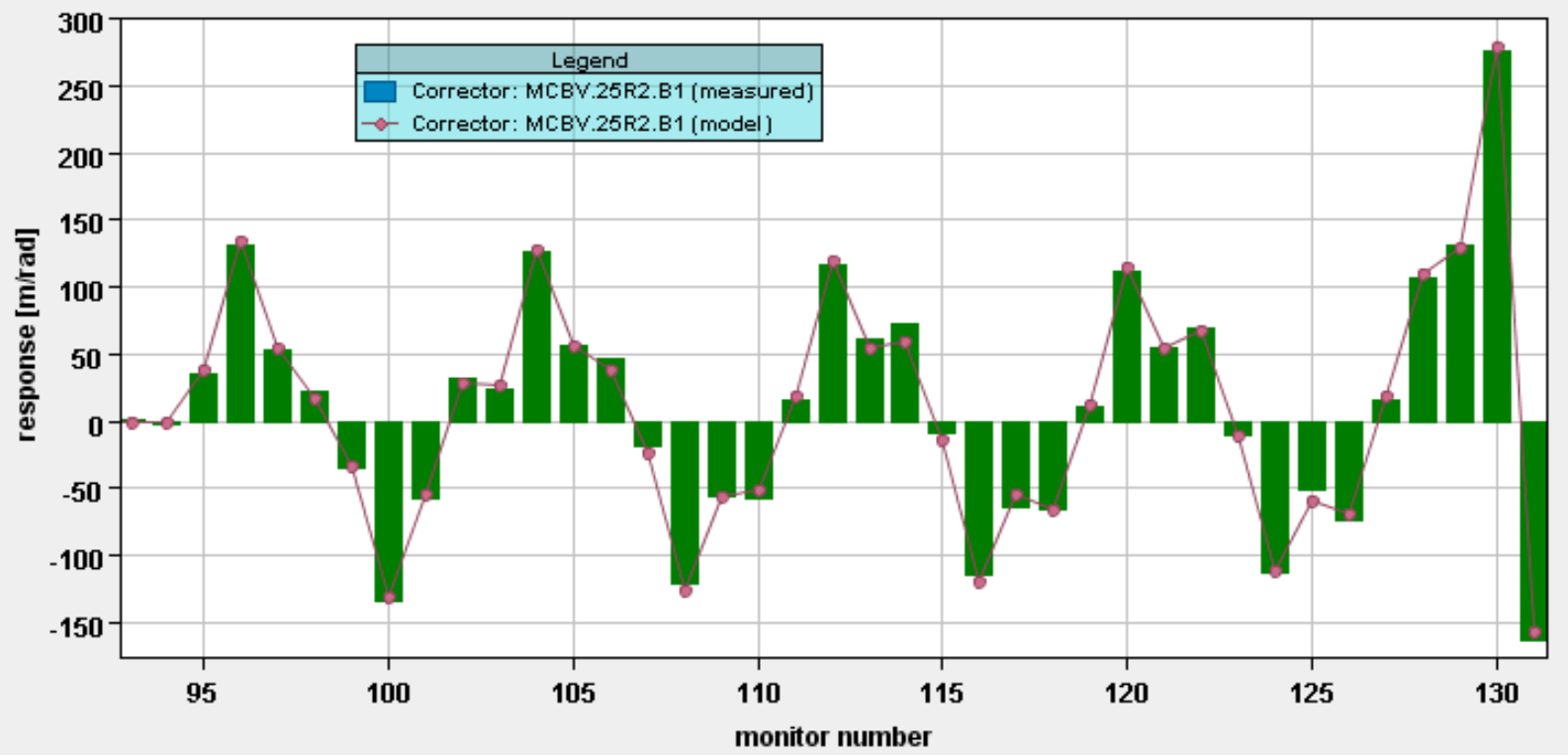
Corrected closed orbit on B2.
Energy offset of ~ -0.9 permill due to the capture frequency.



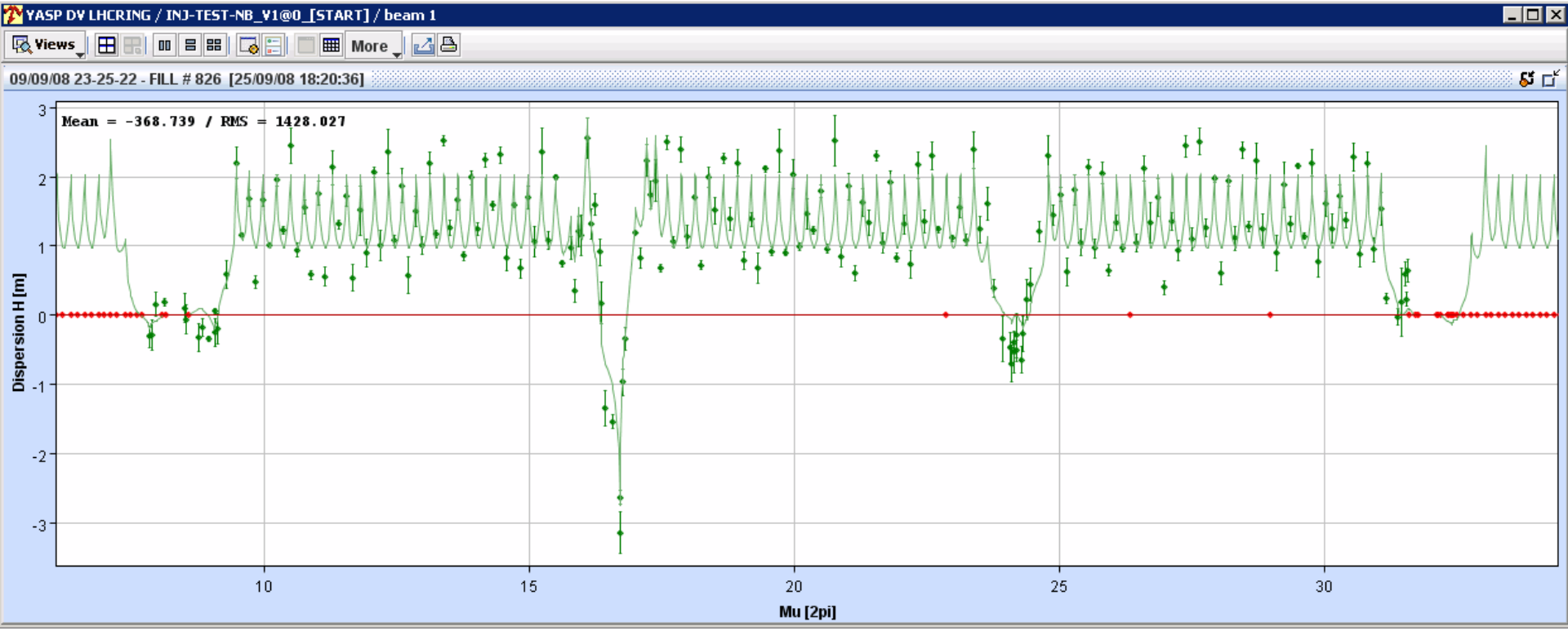
H wire scan


Profiles & Fits
Key Param Line Graphs
Key Param Histograms
Measurement Results
Time Plots
Expert Options
No Overflow Detected
Scaling
Aggressive
Manual
Auto
Fixed Error: 10.0
Select Fit Type
5 param gauss
3 param gauss
RMS Width Calc
Show Front End Fit
Percent Peak Elimination
Data Smoothing
None
3-pt
5-pt
Select Profiles
Hover over box to see bunch #
Update: Now Later
Views
More
Ignoring Stale Data
Bunch no. 1 [12/09/08 13:37:19]
Legend
LHC.BWS.5L4.B2H1 #1:1 AXIS 1 at Fri 13:33:13
RMS Width Calculation
Center=1,274.726
sigma=2,984.704
Energy=483.879
BG=0.018
Slope=-0
ChiSq=1
Emit(norm)=11,356,601.293
Emit(phys)=22,021.21
0.023
0.022
0.021
0.02
0.019
0.018
-15000
-10000
-5000
0
5000
10000
15000

Kick response compared with theoretical optics



Beam 1 H dispersion on first turn
Injection to beam dump



Courtesy J. Wenninger

Transformer failure

- At 23:30 on Friday a 12 MVA transformer at Point 8 failed.
- There is no spare unit but CMS has 2 similar transformers and a lot of over-capacity.
- The cryogenics at point 8 (7-8 and 8-1) was lost.
- The CMS transformer was installed on Saturday and Sunday.

Incident on 19th September

- During commissioning of the last main bend circuit to 5 TeV an incident occurred resulting in the triggering of quench heaters of about 100 magnets and a large He discharge into the tunnel.
- The most probable cause is a faulty electrical connection between two magnets. The sector is being brought to room temperature for repair.
- The time needed for warmup, repair and cooldown precludes a restart before CERN's obligatory winter shutdown.
- The shutdown schedule is being modified to gain ~ 1 month of LHC operation in 2009.

Dipole-dipole interconnect: electrical splices

Thanks

- To all our Russian colleagues who have put such an effort into building the LHC. Your equipment worked perfectly
- Once we can assess the full extent of the repair work, we may gladly accept your offers to help.