MTE Commissioning status

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in collaboration with
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Thanks to P. Freyermuth, H. Genoud, Y. Riva AB-OP
and OP crews

Commissioning phases

Goal: provide the CNGS/SFTPRO beams with MTE by the half of the run

Phase I

1. Beams preparation ⇒ 2 USERS ⇒ PSB(h1-h2), PS(2 bp for studies, 1 bp for extraction)
2. Measurement of nonlinear chromaticity to establish working point for capture
   ⇒ Working Point (Qx,Qy,Xix,Xiy but also Xix')
3. Re-establish capture ⇒ islands formation and capture optimisation ⇒ 2 bp ⇒ prepare 1 bp
4. Tests of CT extraction with bunched beam
5. Preparation of the extraction elements
   ⇒ Kickers with no beam on ZERO Cycle
   ⇒ Optimisation/Calibration of the new bump 16

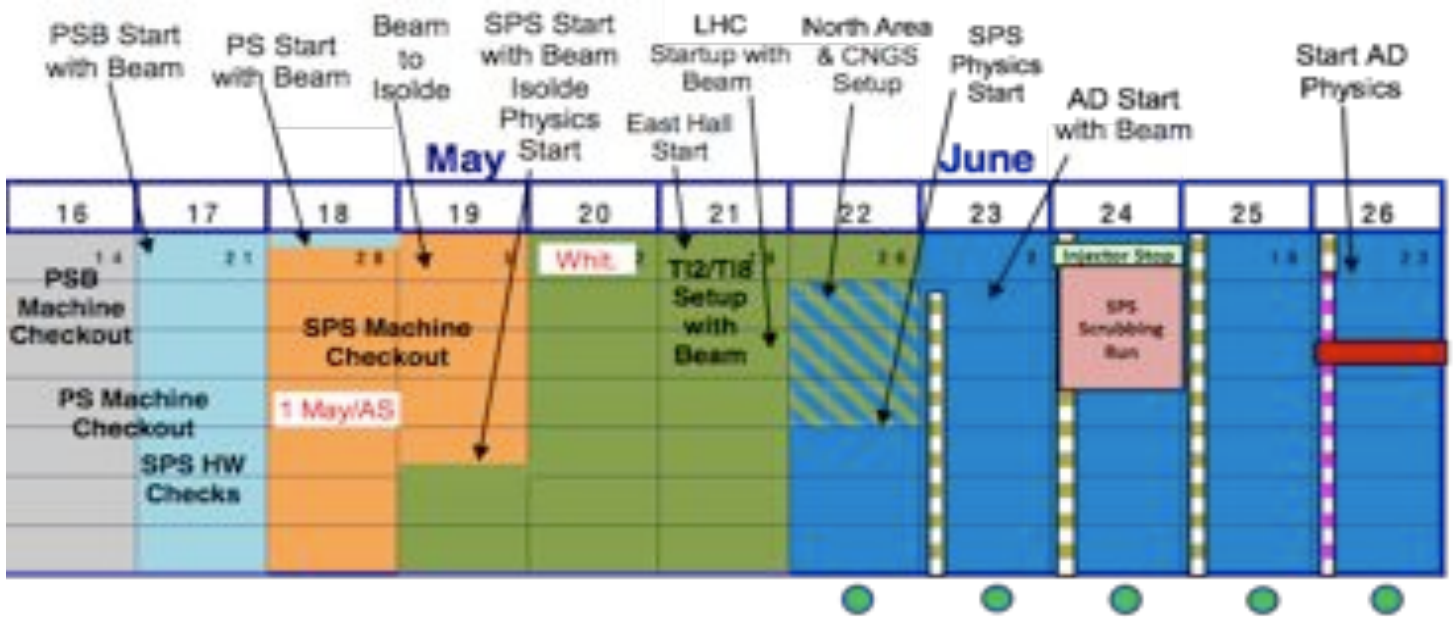
Phase 2

6. Preparation of nominal extraction with moderate intensity for CNGS-SFTPRO operation ⇒ 1 bp
7. Optics study and matching PS-TT2-SPS
8. CNGS-SFTPRO with MTE extraction
9. make a party ...

From APC- 29/02/08

MTE commissioning - Schedule 1st part

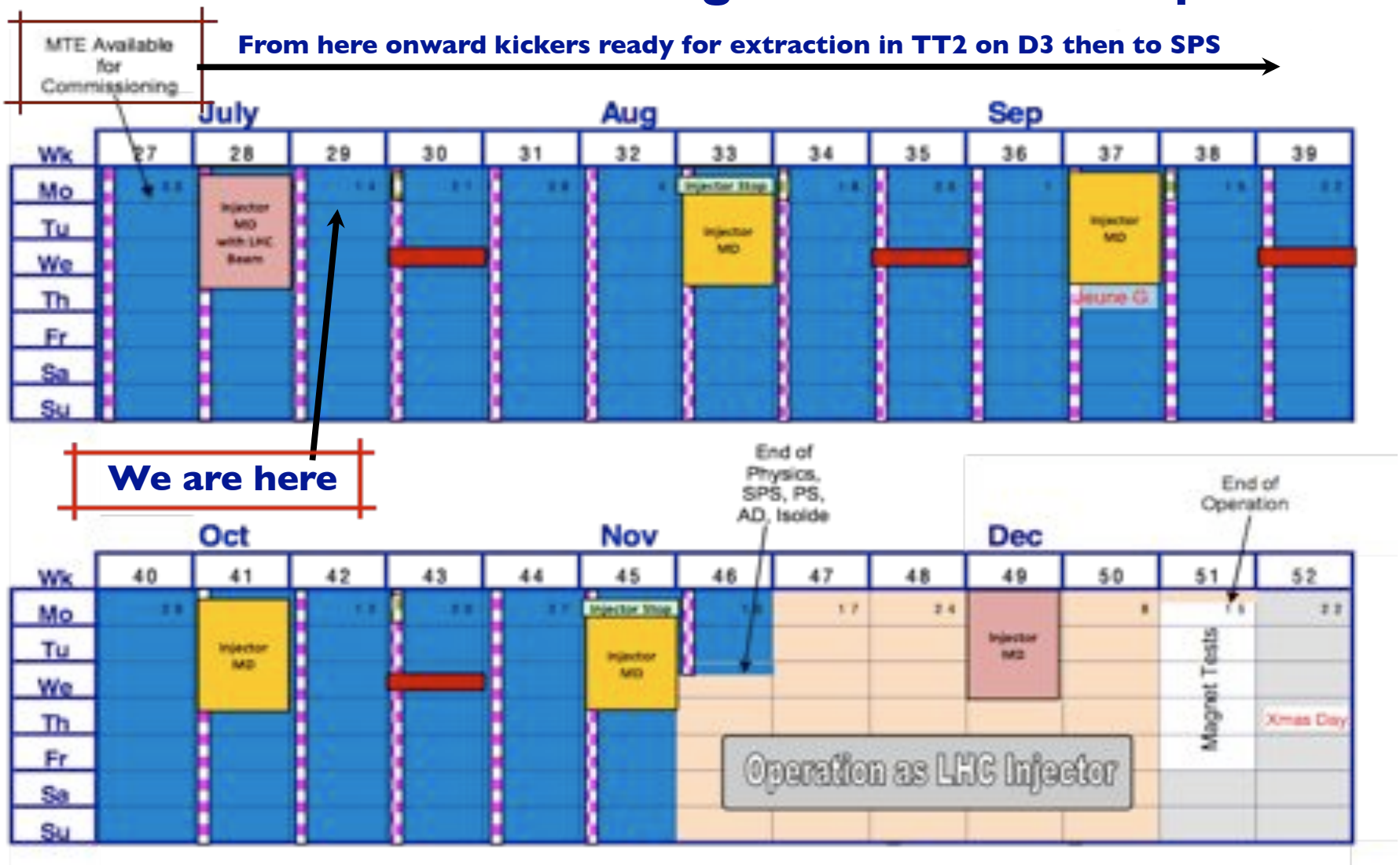
Phase 1: Capture with normal fast extraction on single turn



Weeks with MTE commissioning without extraction

MTE Setup and Development with Beam to LHC

MTE commissioning - Schedule 2nd part



MTE Setup and Development with Beam to LHC

Summary of activities

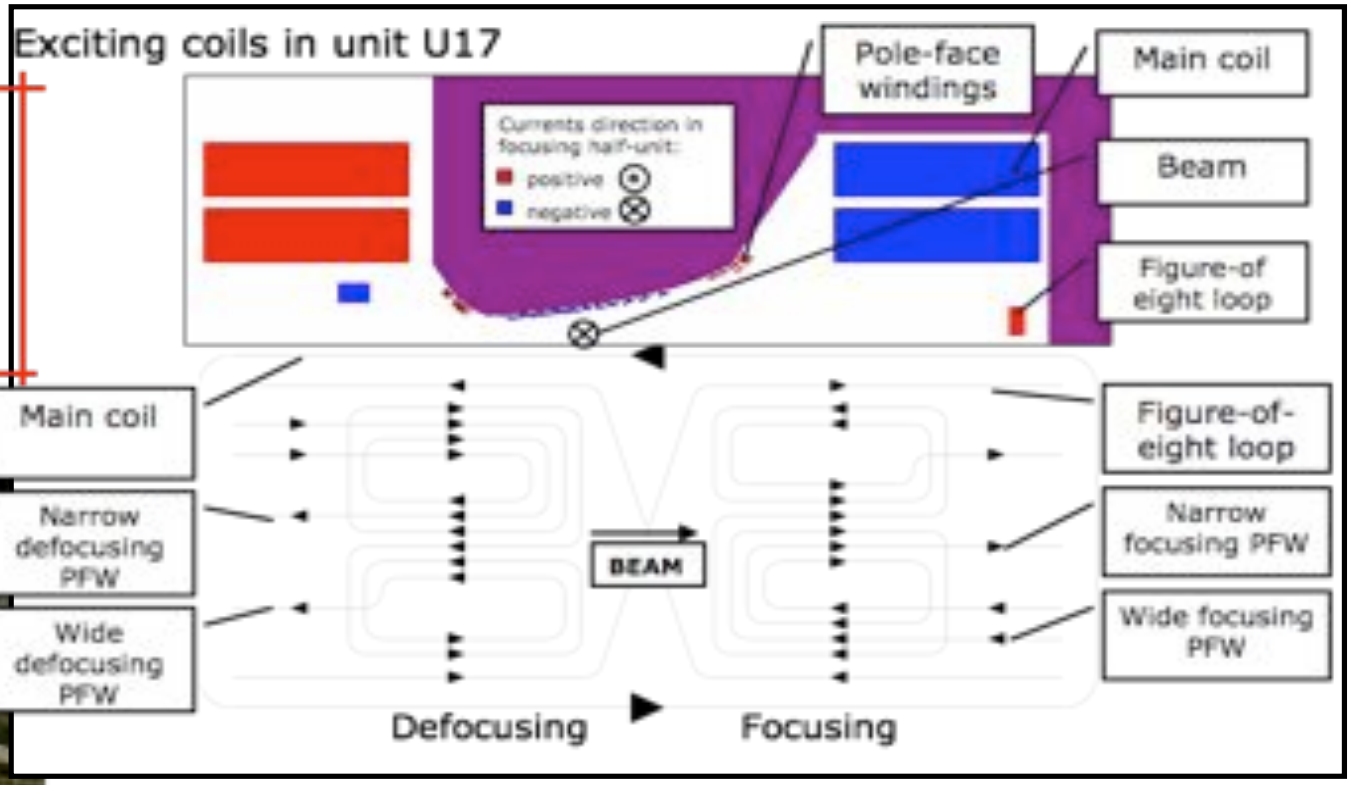
Activitiy	bp	Beam@PSB	Tot. Int.	Bnchs	Exp. Status	Eventual issues	Comments
References of pencil beam	2	Pencil	1.00E+12	2	Done	time available	
Non-linear chrom nominal working point	2	Pencil	1.00E+12	2	Done	Slow radial loop, 50 ms to go to 20 mm	Done with no low energy quad +-20 mm max
Check OMT XMT by Q' meas	2	Pencil	1.00E+12	2	Done	OMT with wrong polarity, one too weak	With no low energy quad, r= +-20 mm max. +100 A, +50 A OMT, 250 XMT
OMT XMT Q' meas	2	Pencil	1.00E+12	2	Done	OMT with wrong polarity, one too weak	With no low energy quad, r= +-20 mm max. +100 A, +50 A OMT, 250 XMT
Bump16 detuning	2	Pencil	1.00E+12	2	Done	Oasis not available to check synchronism	none
Bump16 detuning compensation	2	Pencil	1.00E+12	2	Done	Low energy quad large with time spread	Low quads max dI/dt about 2A/ms
Matrix of low energy quadrupoles	2	Pencil	1.00E+12	2	Done	Some of the quad. Not pulsing correctly	Scan with 0 +-1 A +-2 A. Done twice because of pb low energy quads.
Capture pencil	2	Pencil	1.00E+12	2	Done	none	
References of large emittance beam	2	TOF	3.00E+12	1	ongoing		Longitudinal to check
Capture TOF	2	TOF	3.00E+12	1	Done	losses at c800. No program for W.P.	Still not 20% islands
Capture TOF optimisation	2	TOF	3.00E+12	1	ongoing	No program for W.P.. No CODD	Still not 20% islands. Matrix 5 CM implemented and correction done
Slow Bump16 calibration	2	Pencil	1.00E+12	2	Done	CODD not working.	
Fast bump calibration	2	Pencil	1.00E+12	2	ongoing	KICKER ready in July	KFA4 done, KFA13 and KFA21 prepared last week
1 basic period preparation	1	h1-h2		1--8	not requested	Archives at PSB, risk lose pencil. No W.P.	Cycle preparation with low intensity CNGS or SFTPRO. h8-h16-h420?
1 basic period capture	1	h1-h2		1--8	not done		
1 basic period extraction study, no capture	1	Pencil	1.00E+12	2	not done		Injection of h1 pencil on h2 prepared cycle?
Capture - extraction	1	CNGS		1--8	not done		
TT2-TT10 optics study	1	Pencil	1.00E+12	2	not done	Semfil in TT2 not usable for emitt.	First TT2, then TT10. ERDs not yet used this year
Injection in SPS	1	CNGS		1--8	not done		

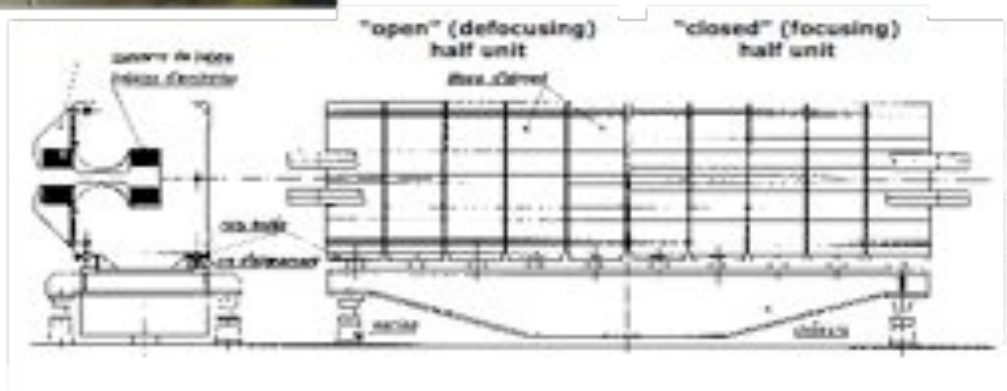
Done
Ongoing
Critical
To be done

Not Done means not done yet because scheduled later in the commissioning

Brief digression on PFW ...

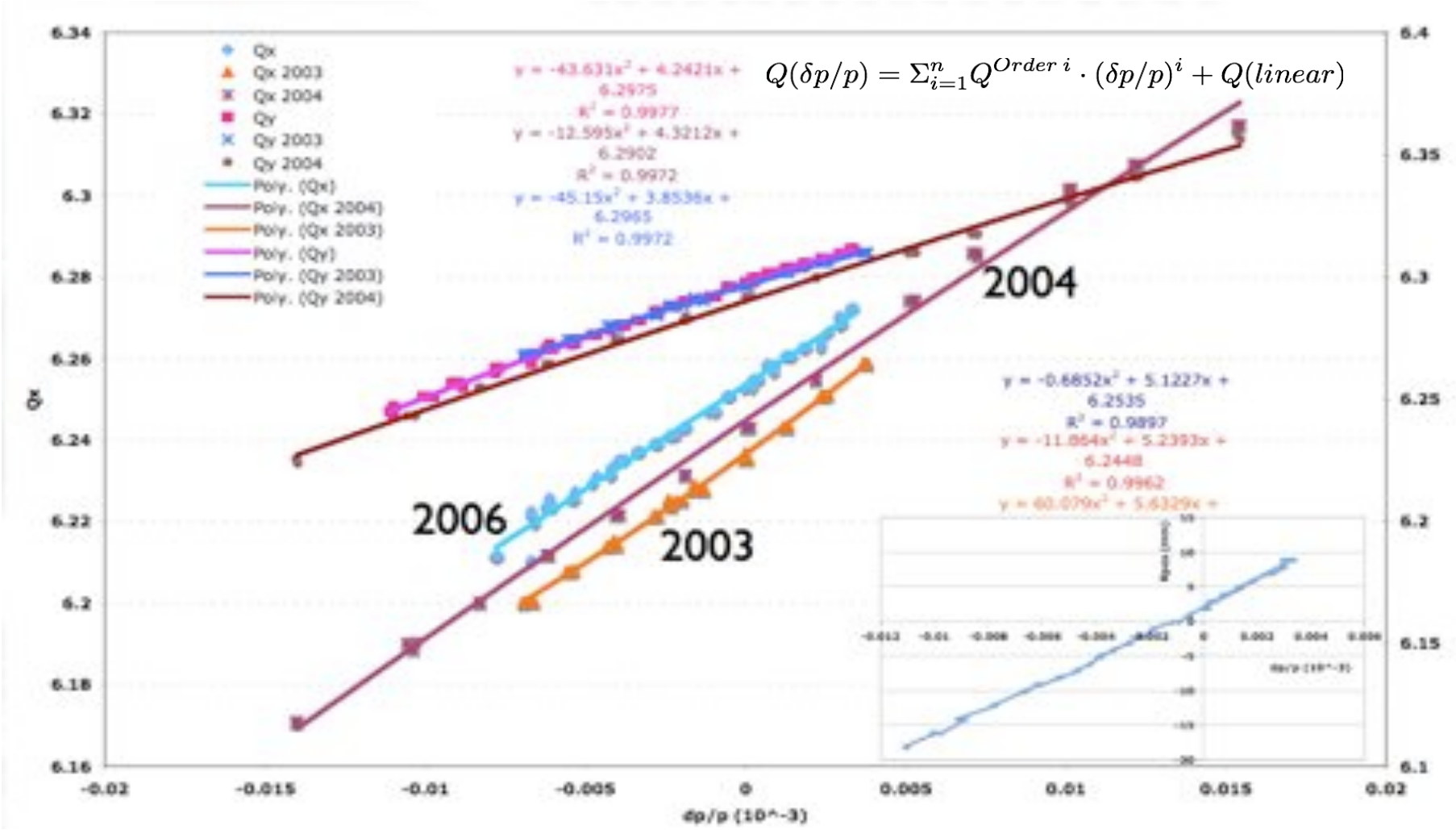
- In 5-CM there are : 4 machine physical parameters
a) to control *5 free currents*
The 5th machine parameter could be: non linear-chromaticity (MTE) minimisation of the RMS F8L current





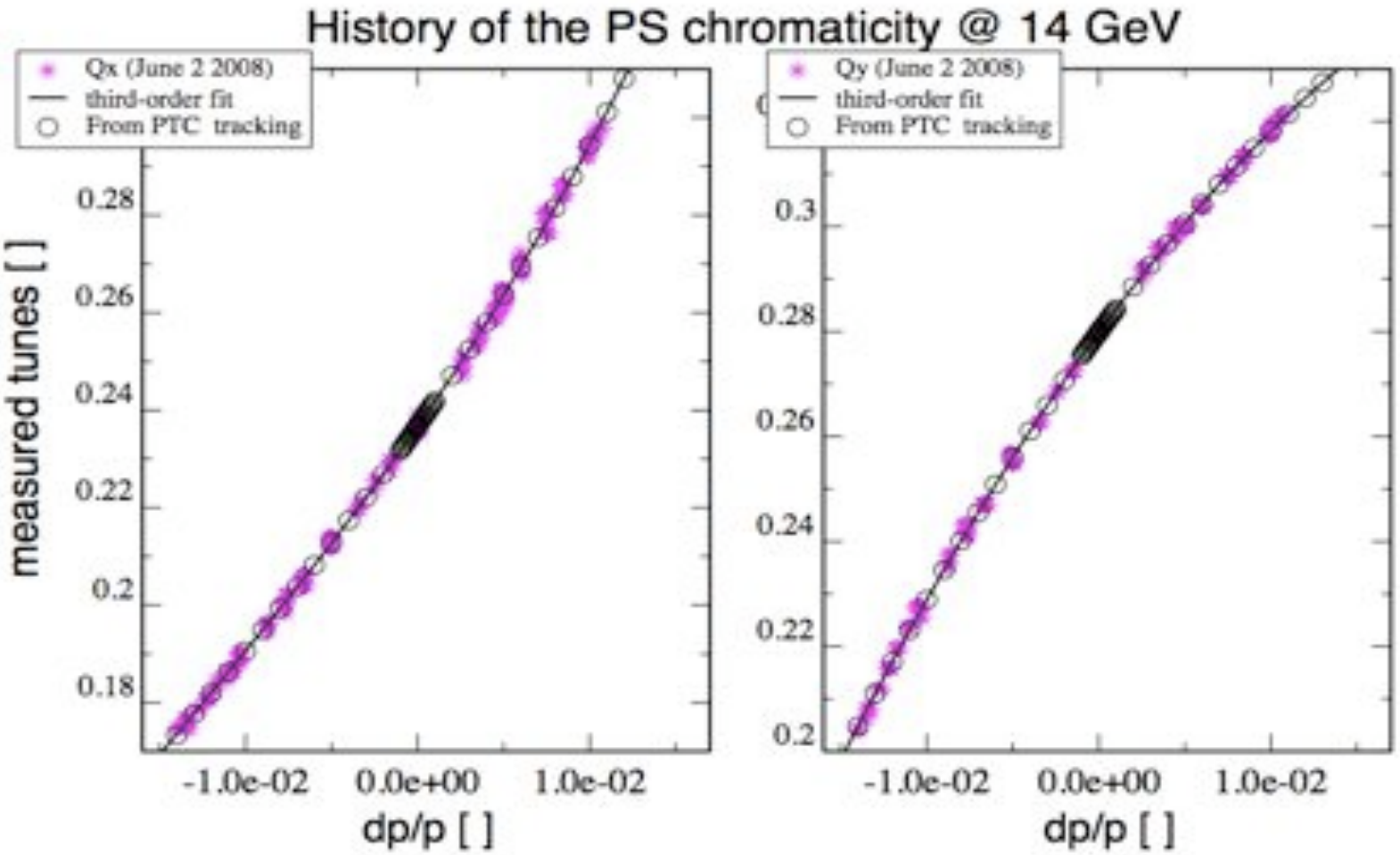
	ΔI FN	ΔI FW	ΔI DN	ΔI DW	ΔI 8L
ΔQh	$f^{FN}_{\Delta Qh}(E)$	$f^{FW}_{\Delta Qh}(E)$	$f^{DN}_{\Delta Qh}(E)$	$f^{DW}_{\Delta Qh}(E)$	$f^{8L}_{\Delta Qh}(E)$
ΔQv	$f^{FN}_{\Delta Qv}(E)$	$f^{FW}_{\Delta Qv}(E)$	$f^{DN}_{\Delta Qv}(E)$	$f^{DW}_{\Delta Qv}(E)$	$f^{8L}_{\Delta Qv}(E)$
ΔXih	$f^{FN}_{\Delta Xih}(E)$	$f^{FW}_{\Delta Xih}(E)$	$f^{DN}_{\Delta Xih}(E)$	$f^{DW}_{\Delta Xih}(E)$	$f^{8L}_{\Delta Xih}(E)$
ΔXiv	$f^{FN}_{\Delta Xiv}(E)$	$f^{FW}_{\Delta Xiv}(E)$	$f^{DN}_{\Delta Xiv}(E)$	$f^{DW}_{\Delta Xiv}(E)$	$f^{8L}_{\Delta Xiv}(E)$

Non-linear chromaticity 1st



The measurement of the non-linear chromaticity is done by measuring the tune with beam displaced radially up to very large amplitudes ⇒ Need a good tune measurement for beam a very large radial displacement with small losses

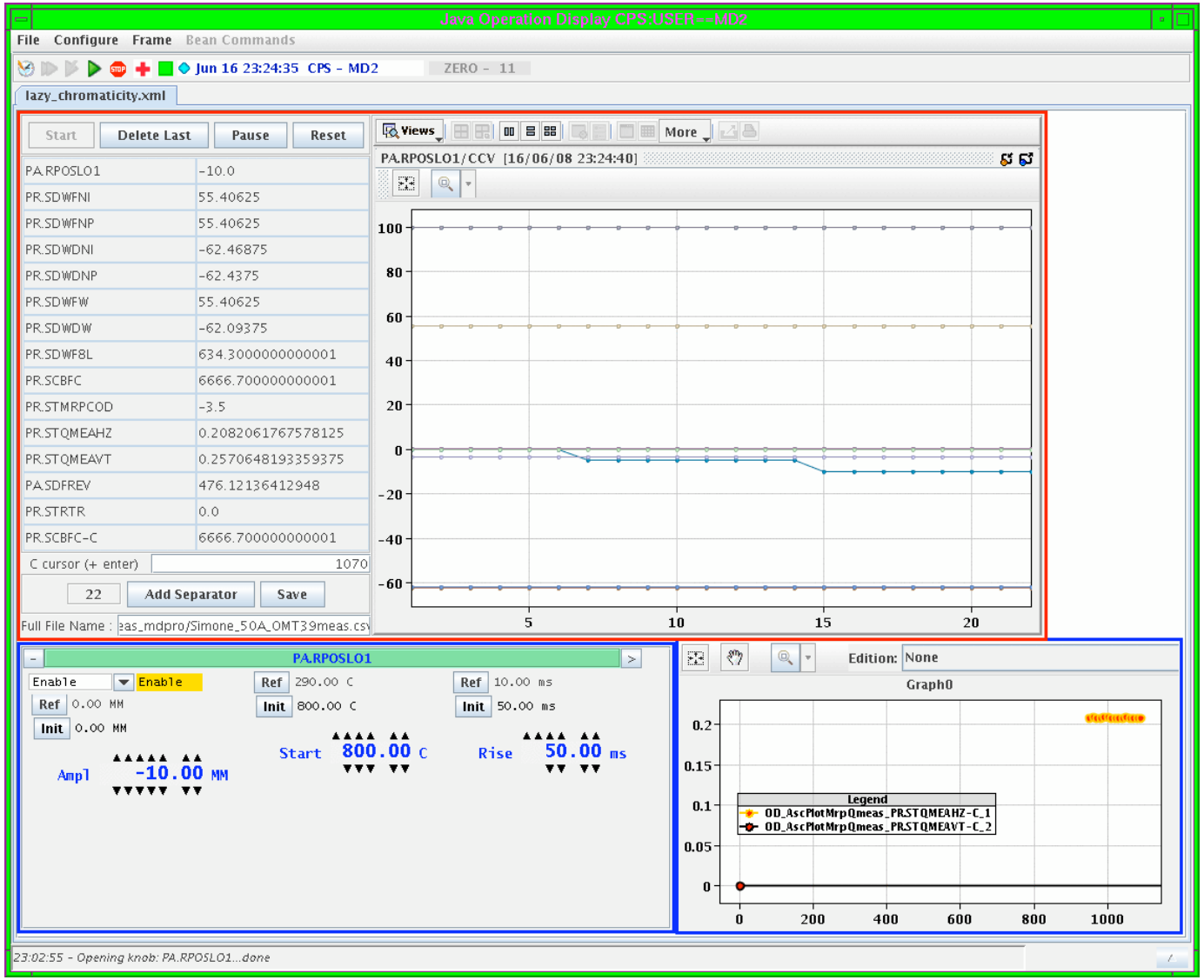
Non-linear chromaticity



Non-linear chromaticity measured with old tune measurement system with max radial displacement of +- 20 mm, as in 2004
Issues encountered:

• radial steering up to 20 mm needed 50 ms, otherwise radial loop cannot follow. (Thanks to H. Demerau AB/RF)
• the phase of the Q-meter kicker cannot be adjusted, 2 bunches opposite in the machine required since the kicker is shorter than 1 machine turn (2.2 mus)

First OP-MTE application

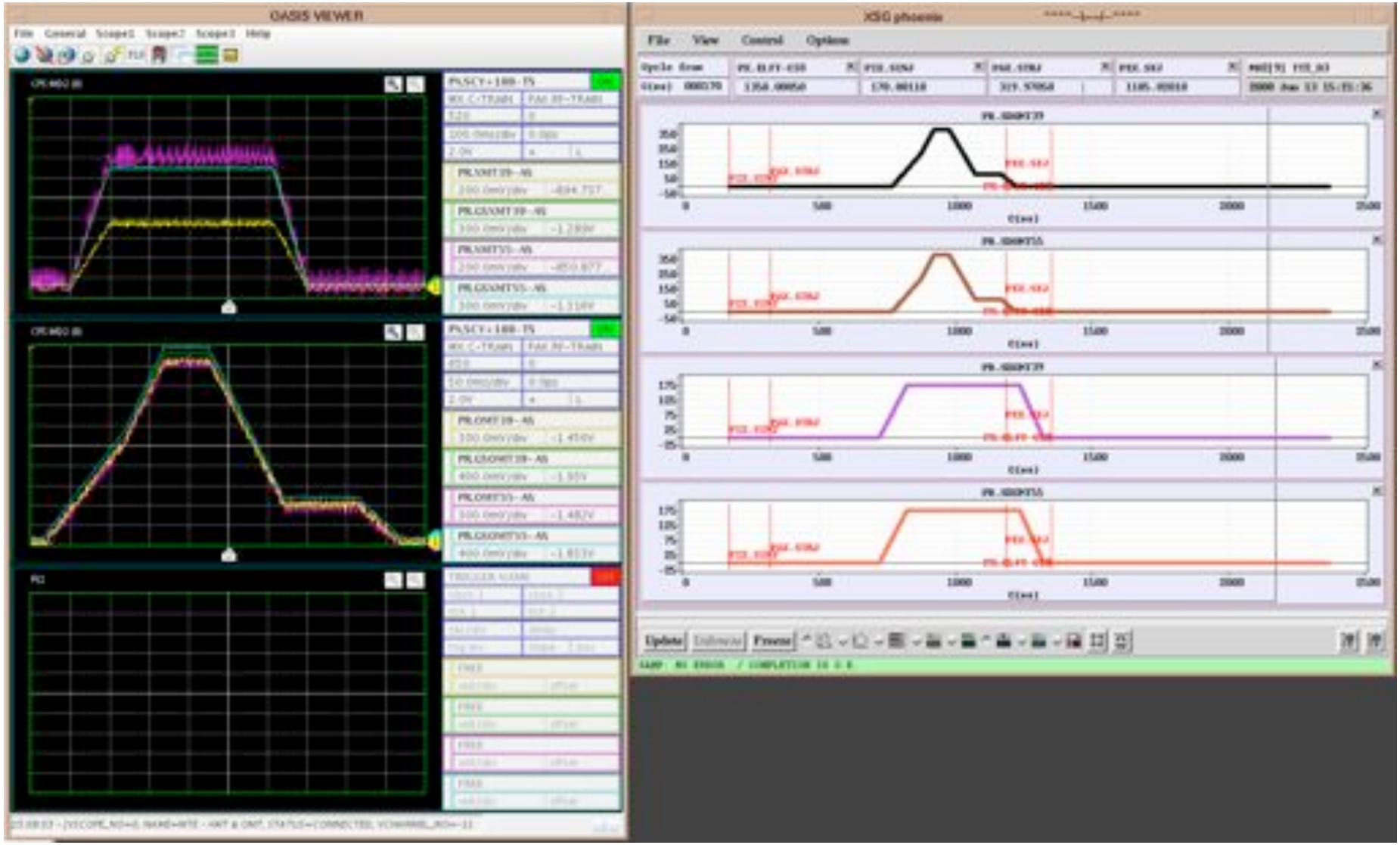


P. FREYERMUTH (AB/OP) adapted an application to measure the linear chromaticity in a semi-automatic tool to measure non-linear chromaticity.

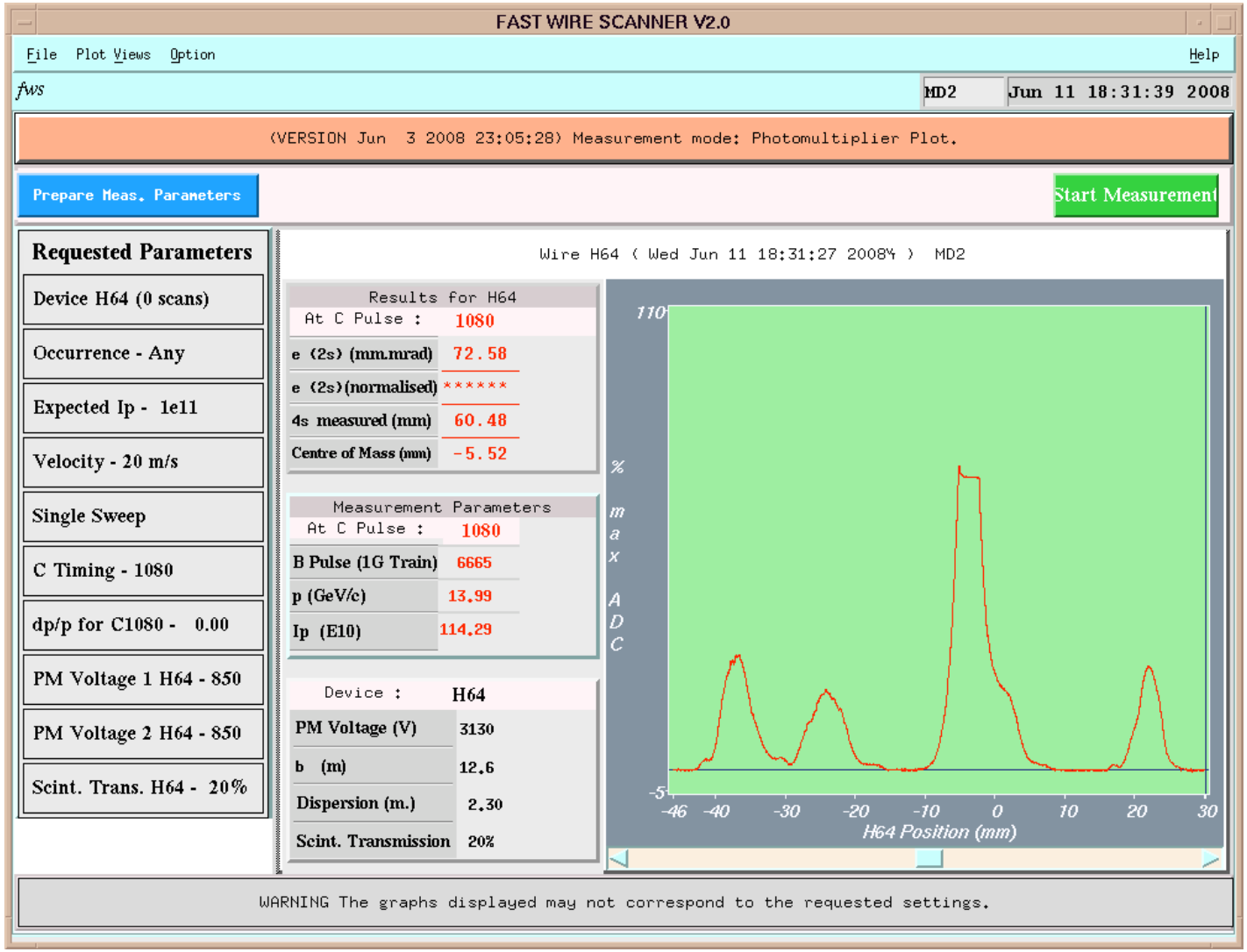
Important tool for the commissioning but also to debug the capture during normal operation.

Program already embedded in the control system.

OASIS signals available



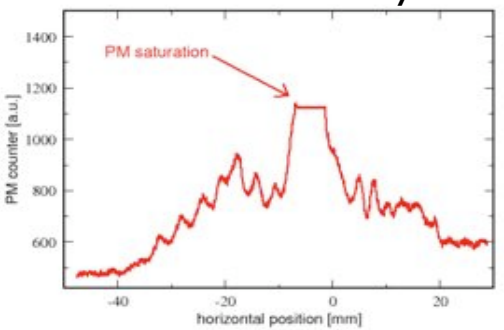
First island of the year



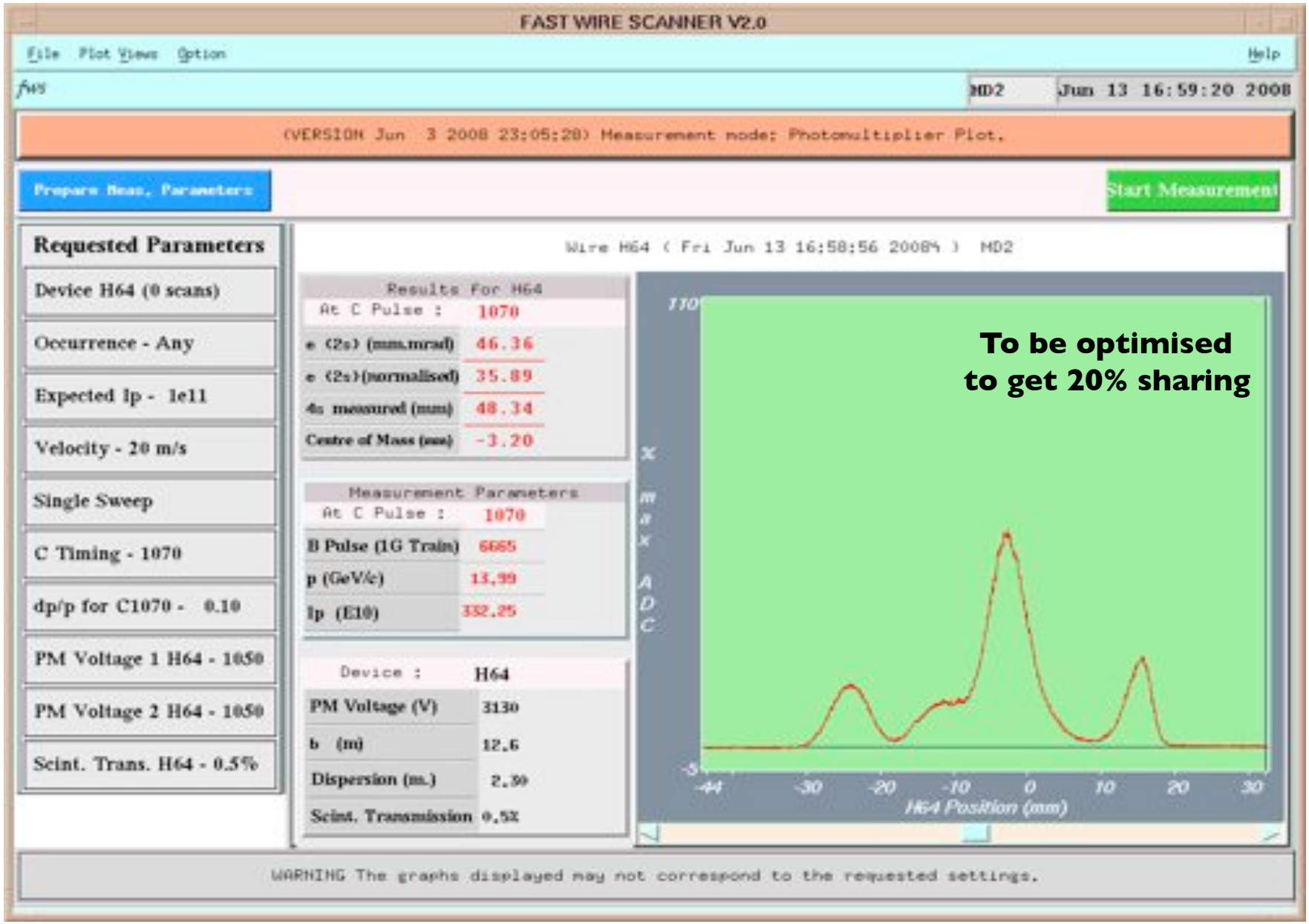
First Capture realised with
2 bunches
small emittance beam
since the large emittance beam could not be properly injected due to the CODD problem with the GATE

Capture very stable, problem of possible noise coming from PFW or MPS not yet observed this year

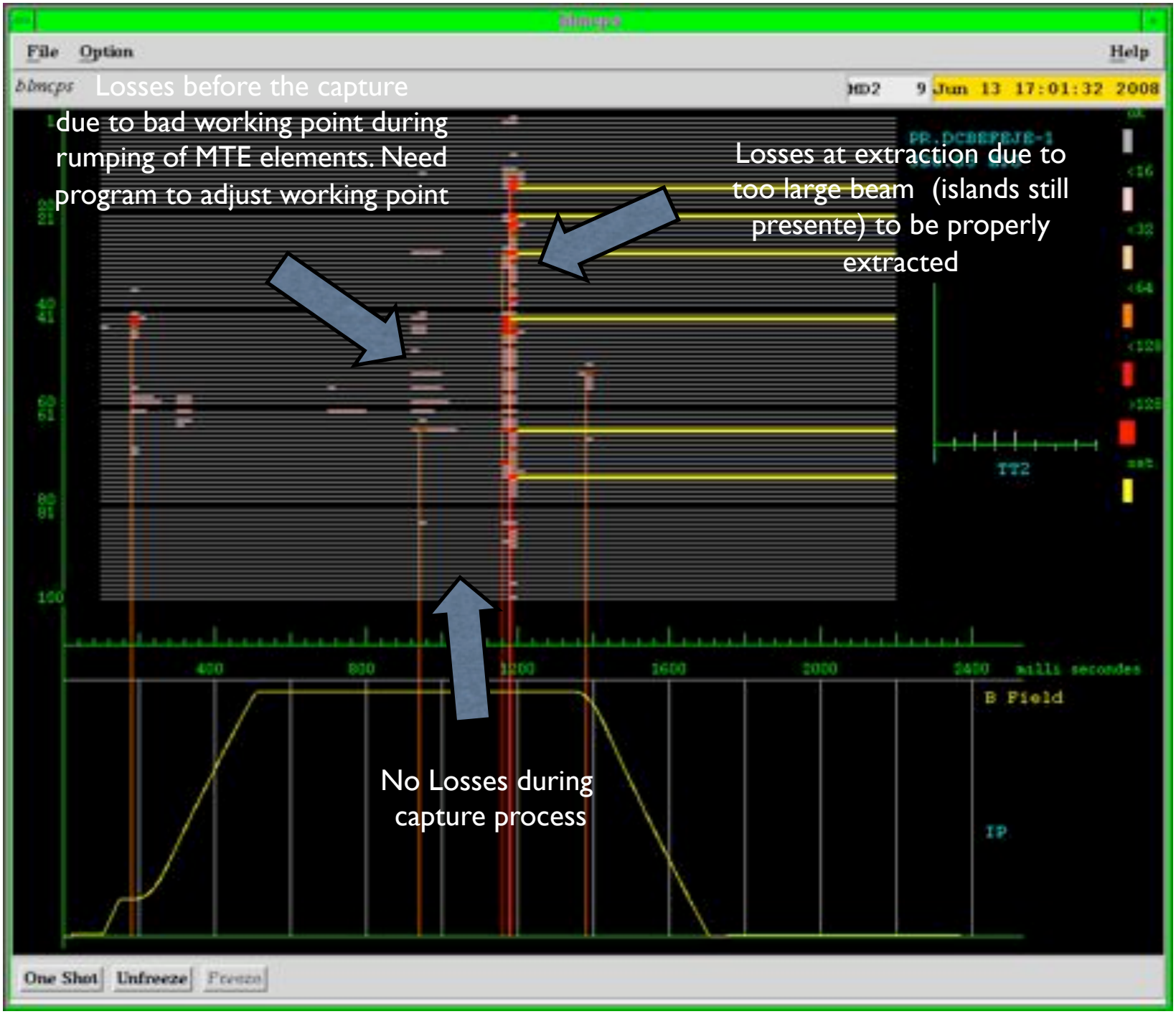
Early 2007



First Single bunch-large emittance capture



Capture loss-less

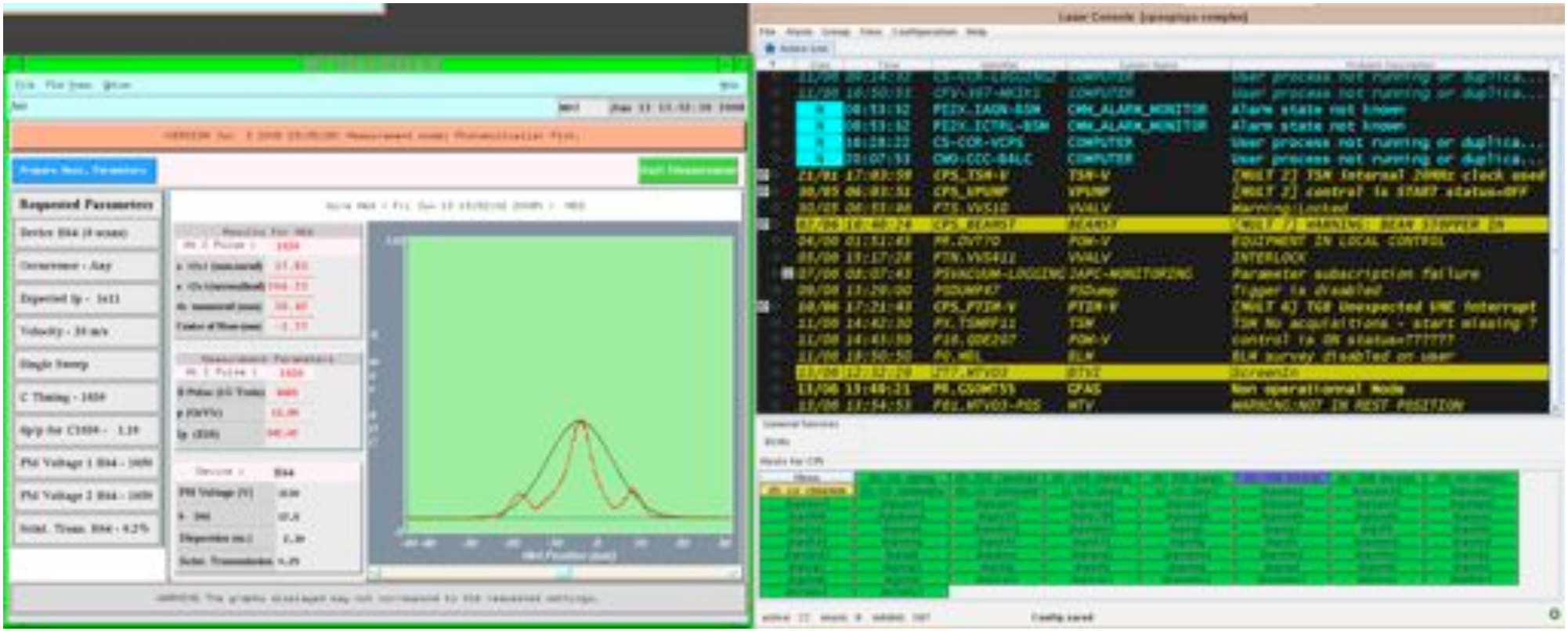


Since the first capture

- Working point before capture optimised with 5 current mode correction matrix measured for MTE -> reduce losses before capture
- Capture done without the use of the low energy quadrupoles by recomputing the current of the PFW with the new measured matrices

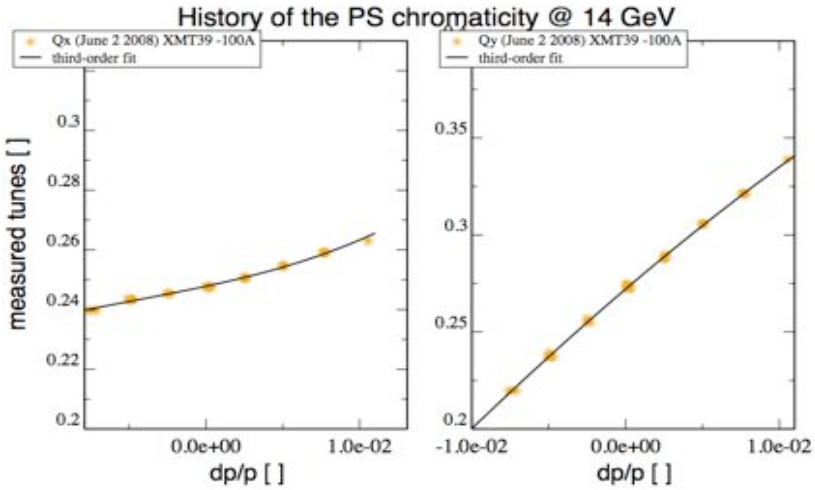
Operators training also started

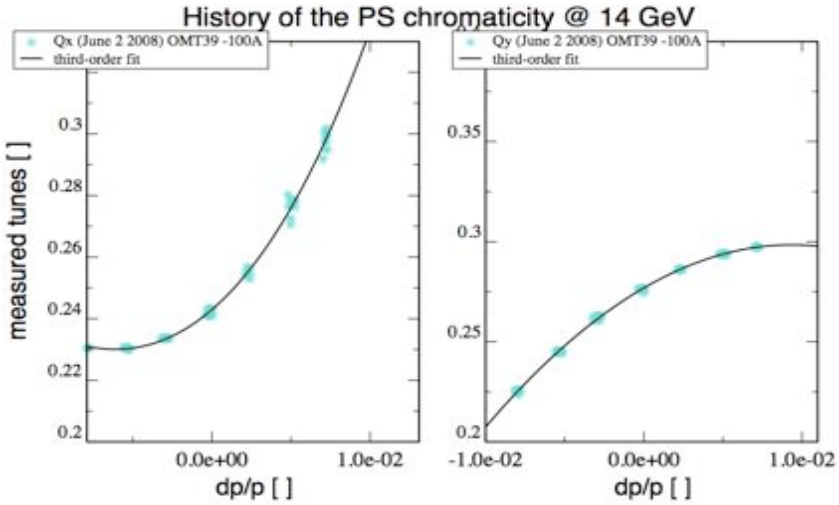
From logbook 13-Jun-2008:
MTE - OMT55 "GFA - Non operational Mode" on Alarm tree.
We have only 2 Islands, PICO is contacted to change the GFA.

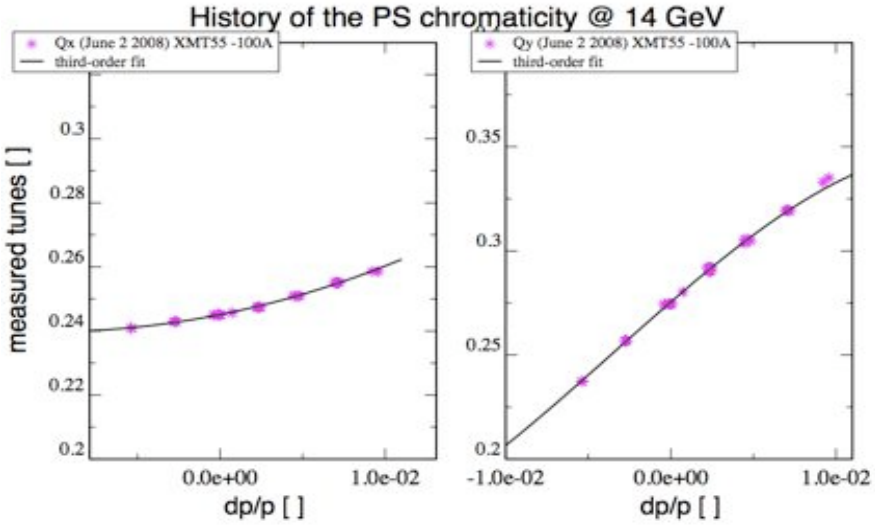


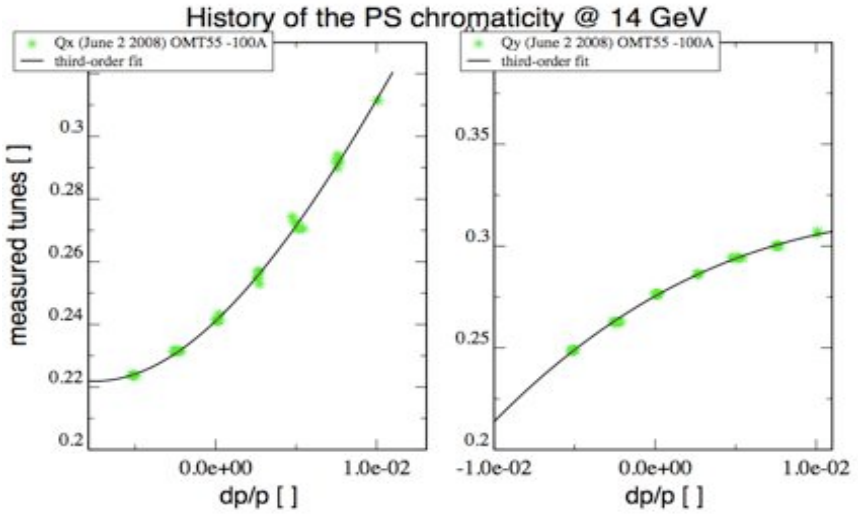
GFA of OMT55 not working correctly was recognised by the operator, by the alarm system and exchanged as for an operative GFA equipment by the Piquet CO

Chromaticity measurements for MTE-Multipoles



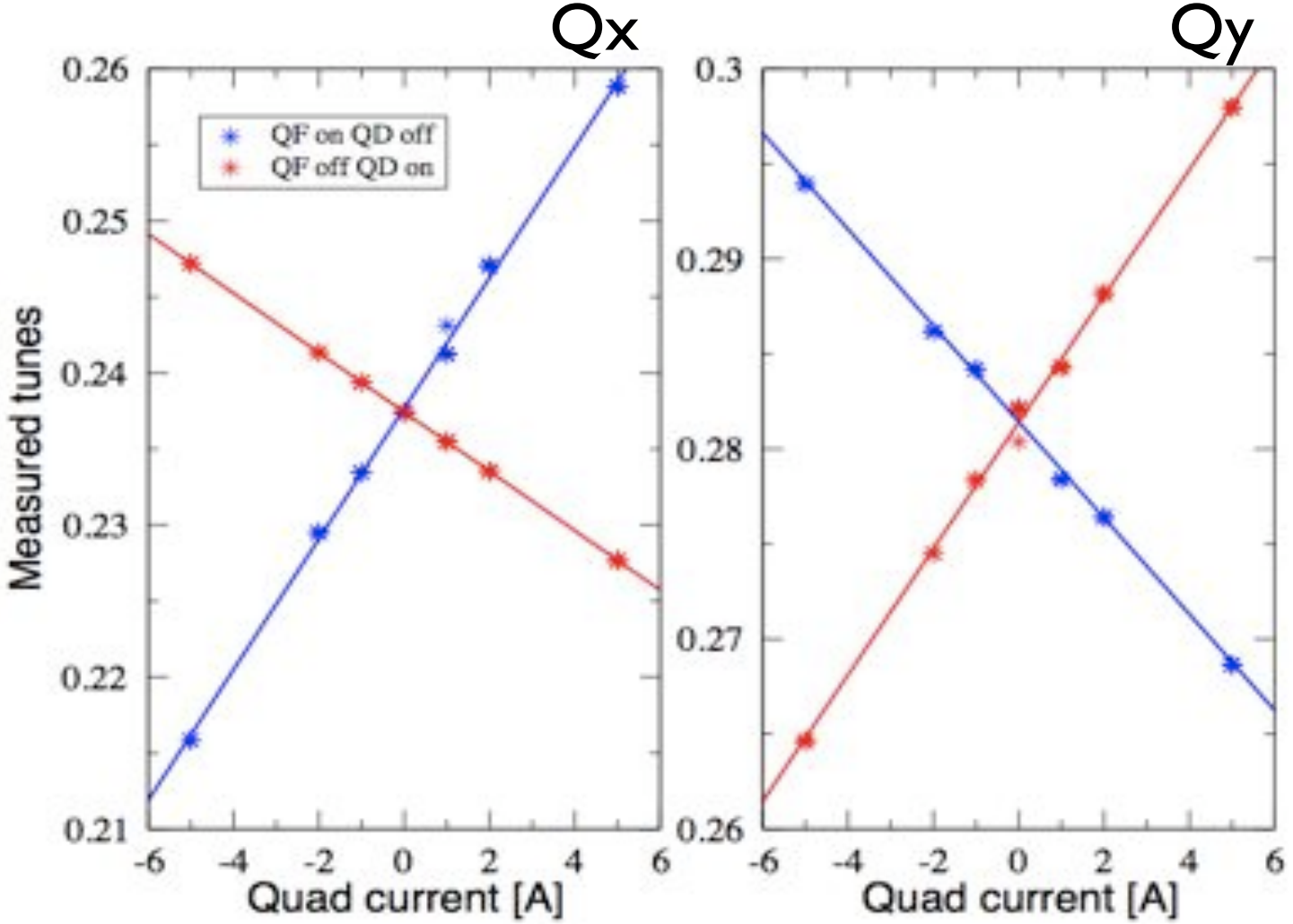






Low energy quadrupole matrix re-measured

$$\begin{pmatrix} \Delta Qx \\ \Delta Qy \end{pmatrix} = \begin{pmatrix} 0.0042984 & -0.0019526 \\ -0.002532 & 0.0033237 \end{pmatrix} \begin{pmatrix} \Delta Iqf \\ \Delta Iqd \end{pmatrix}$$



New Bump 16 studies

Extraction bump16 (BSW16):
the new bump16 have five independent power converters, plus the DHZ15 which is bipolar

Studies:

- measurement of detuning with amplitude
- correction of detuning
- calibration of the bump

```
PE.BSW16-12   (1st bumper in SS12)
PE.BSW16-14   (2nd bumper in SS14)
PE.BSW16-18   (4th bumper in SS18)
PE.BSW16-20   (5th bumper in SS20)
PE.BSW16-22   (6th bumper in SS22)

PR.DHZ15      (3rd bumper in SS15)
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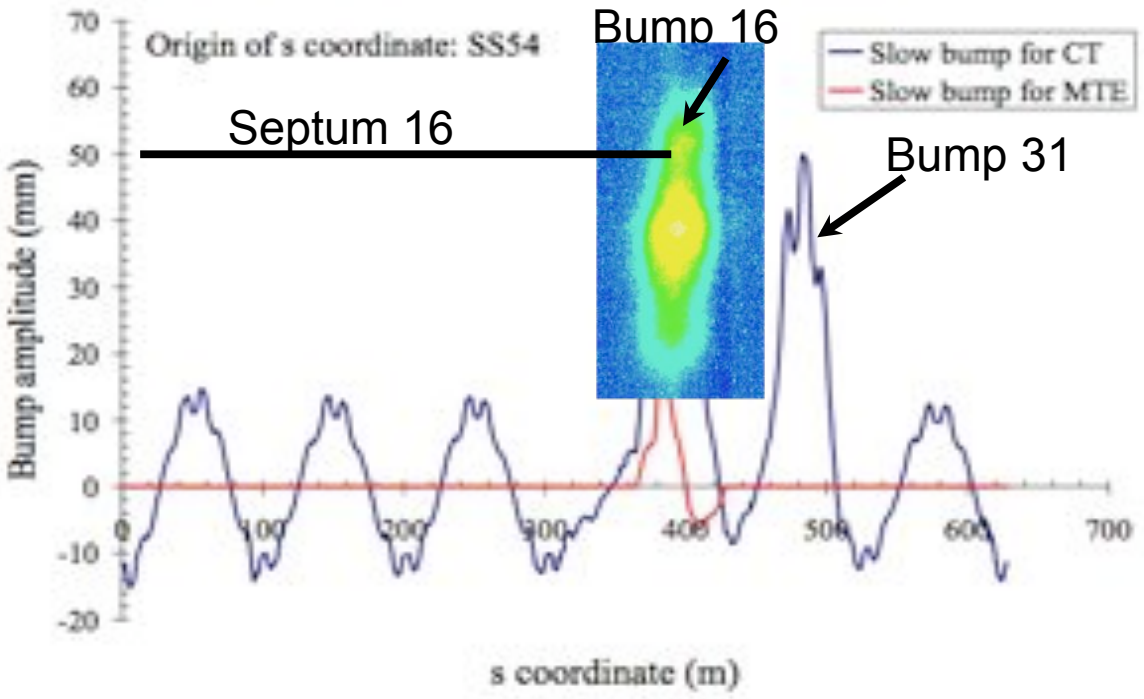
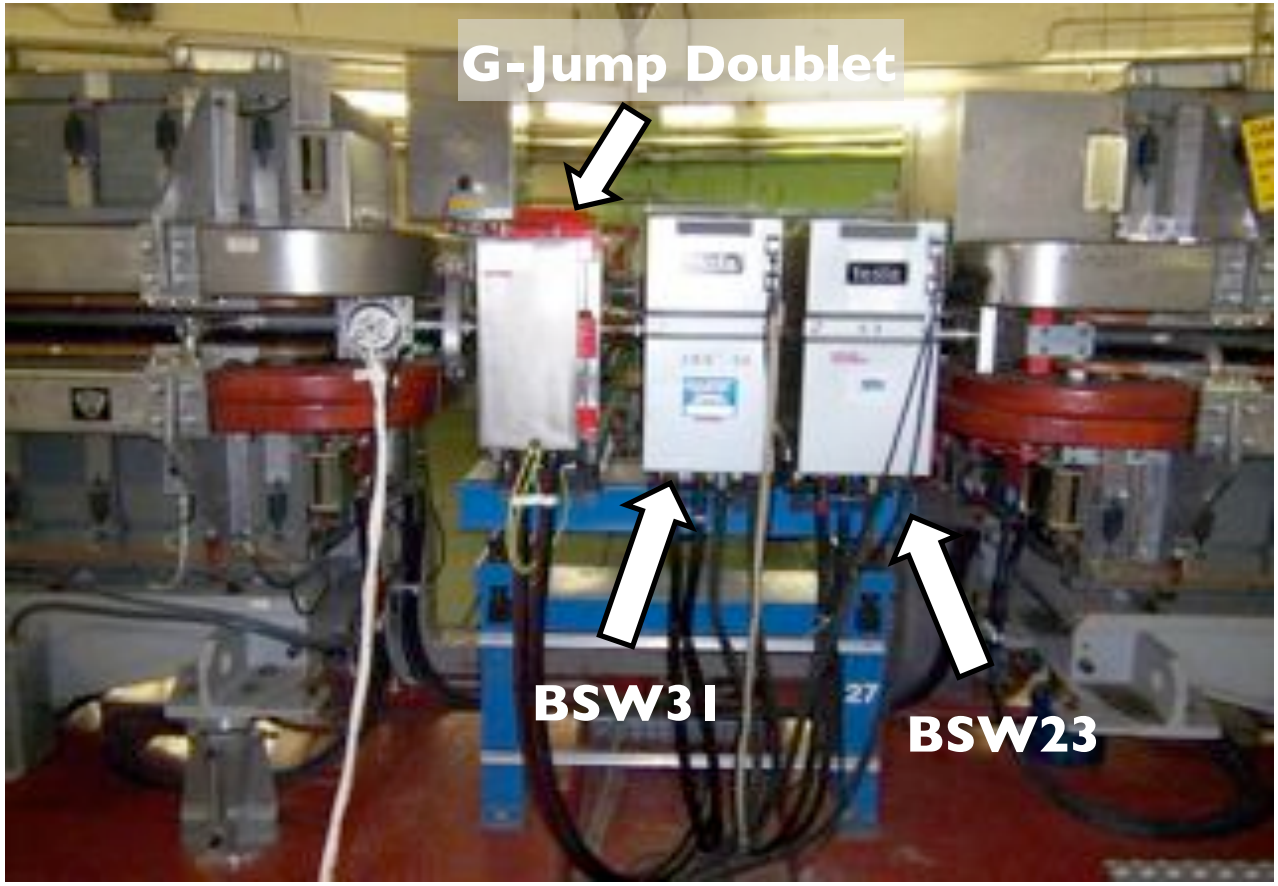


Bump 18 sacrificed….

Leaking connection

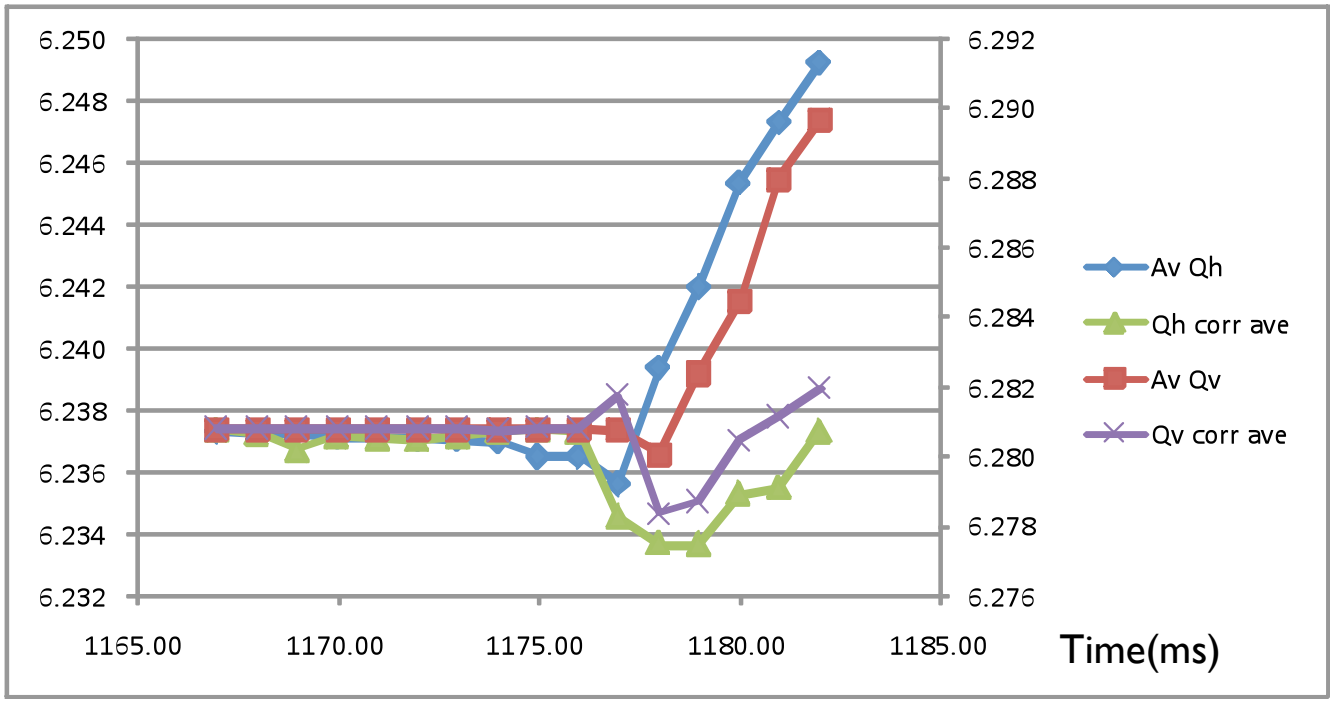


During the technical stop 9th of June, the dipole of the BSW23 – slow extraction found with a water leak.

Since the **spare exists but is not available for installation**, the PSS suggested in agreement with the MTE Beam Commissioning Coordinator (myself&myself) to remove the MTE dipole in SS18 and avoid a 10 days stop of the EAST HALL physics.

The MTE refurbished magnet has been reinstalled on Wednesday 25th June –
but **no spare available for a total of 10 magnets** - Fast & MTE extraction, slow extraction, CT extraction

Bump16 detuning correction



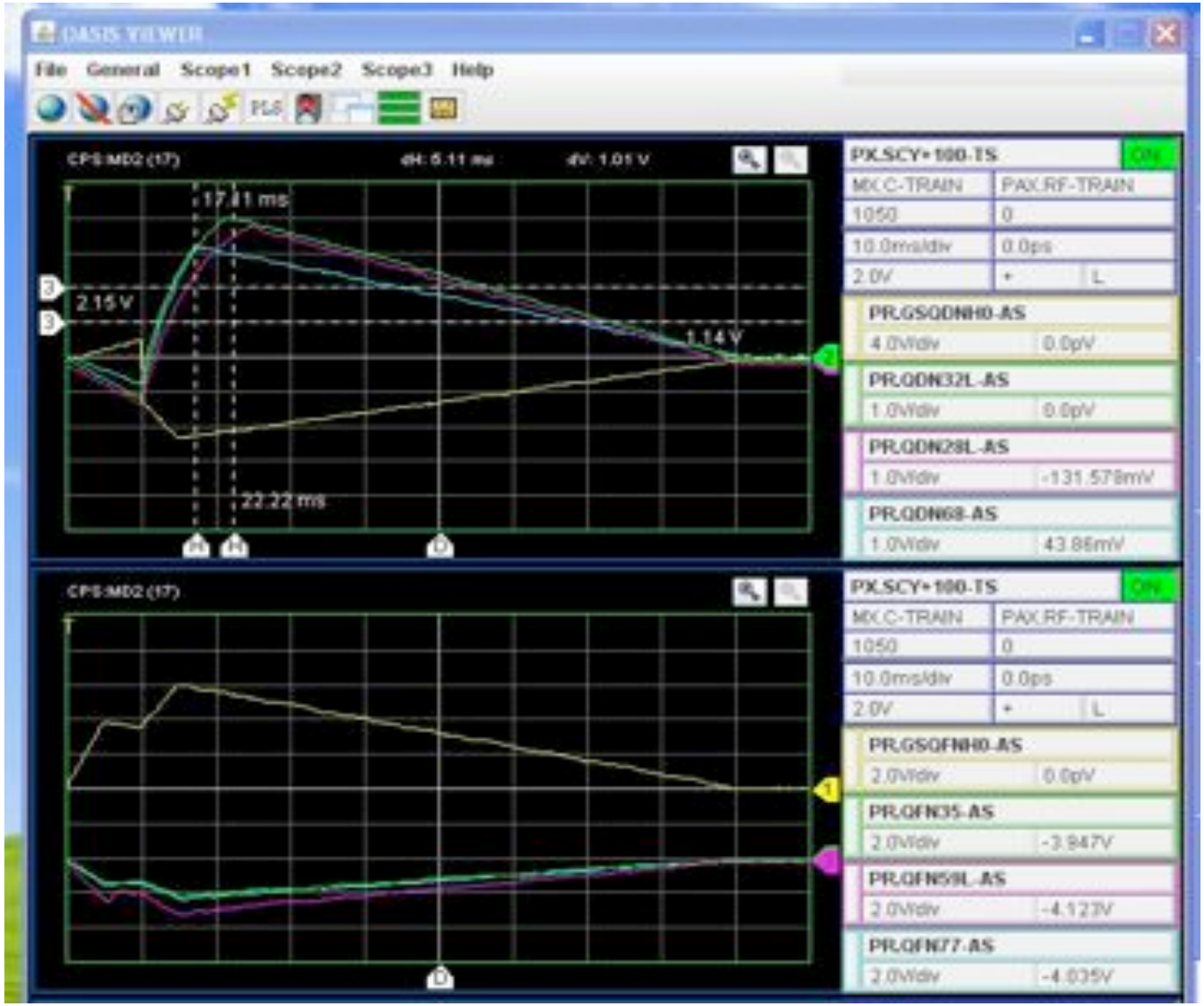
Detuning of the extraction bump16 with only four bumpers tested successfully.

Compensation done with low energy quadrupoles.

The compensation is not exactly flat for this case due to a too large dI/dt for large quadrupole types.

In case of need a further compensation can be done using either the F8L or by programming a smaller tune during the capture and let the tune drifting during the 5 ms duration of the bump.

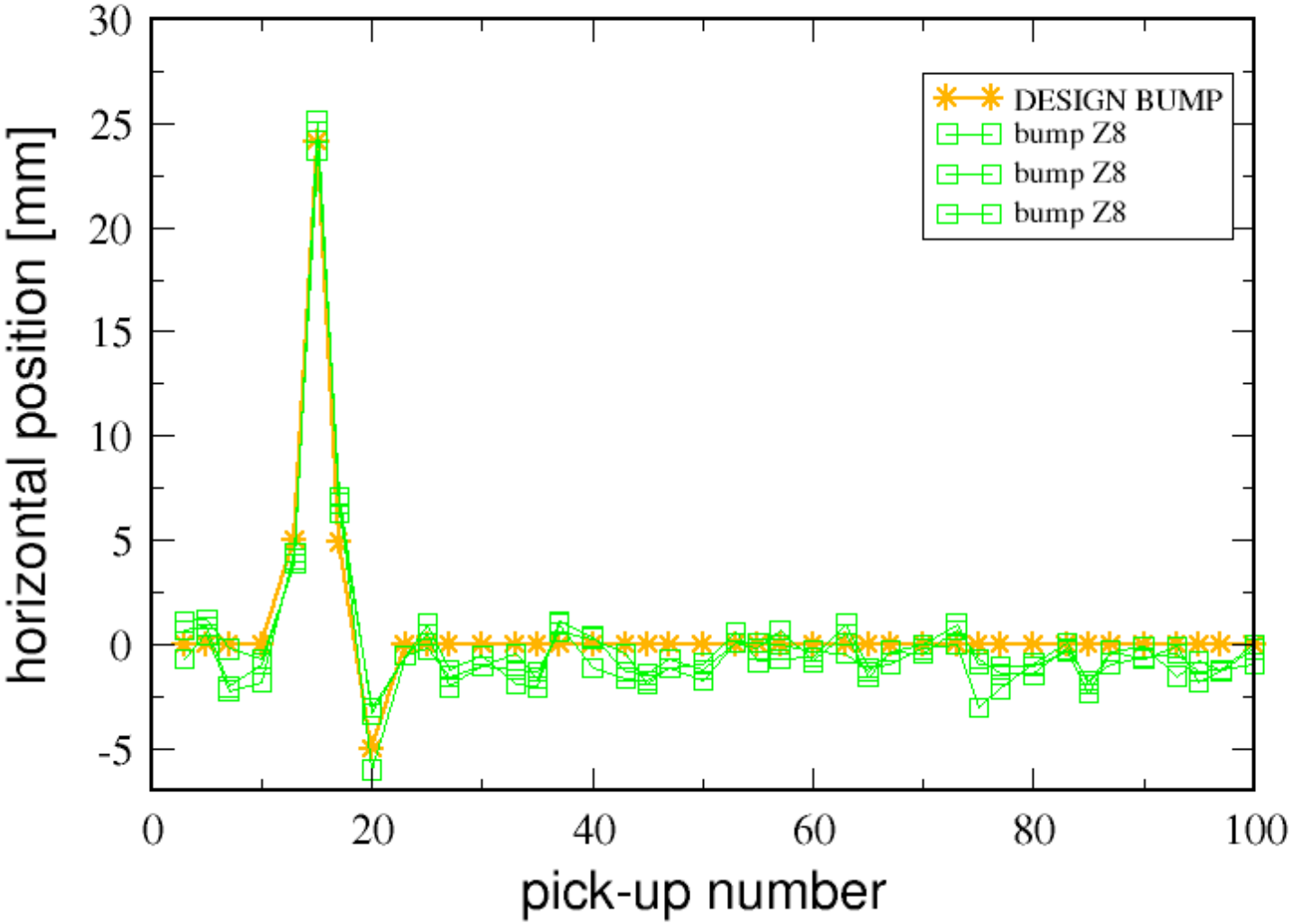
Limitation on dI/dt of low energy quads



For a dI/dt larger than 2 A/ms the large quadrupoles cannot follow the GFA. Investigation ongoing to understand if at least the spread of max current vs time can be reduced.

A certain instability in the pulsing for a too charged supercycle has been observed for the low energy quads.
Capture has been done last week without the quadrupoles and needs to be optimised.

Bump16 calibration

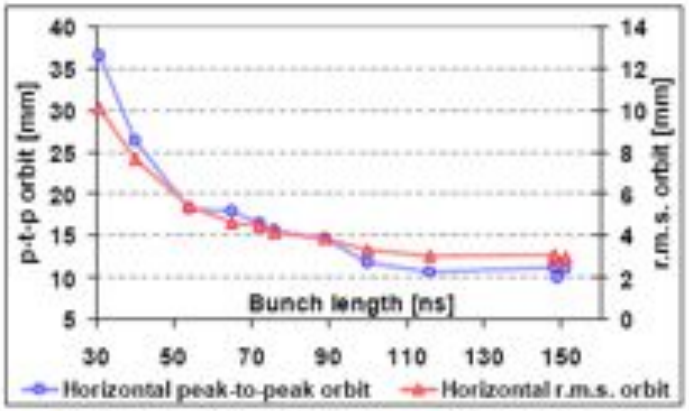


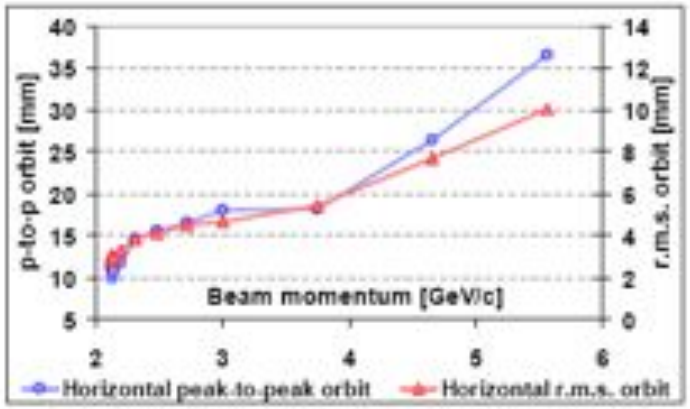
CODD issue 1/2

Since the beginning of the year, CODD not working during acceleration due to a saturation of the SUM signal of the pickup used to normalise the difference signal -> Solved
For two weeks the CODD was not available at all due to a problem of the triggering time used to synchronize the CODD with the injection timing

Closed orbit measurement work

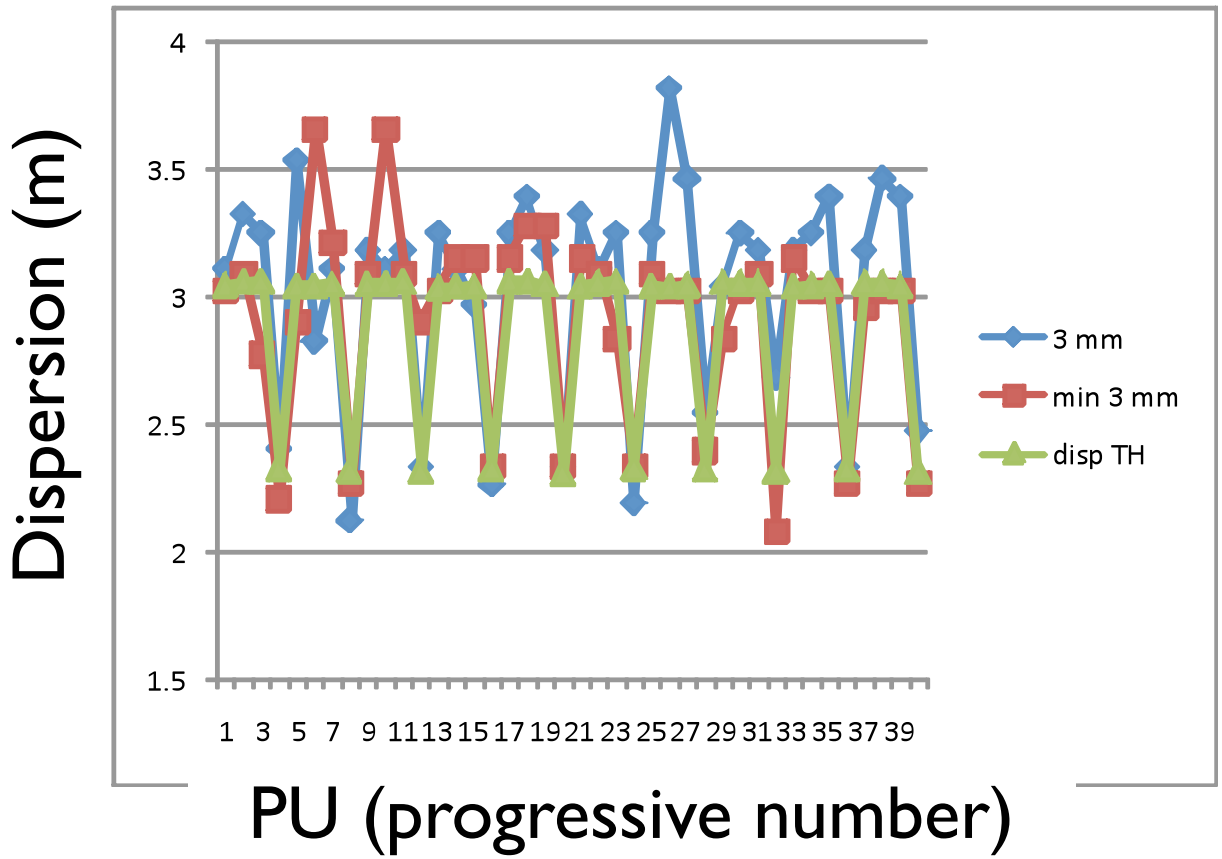
- The orbit acquisition system (CODD) in the PS at the moment does not work suitably along the energy ramping
- In these conditions it will be very difficult to work mainly on
  - Optimizing transition
  - High-energy orbit correction and bump 16 closure
- **SYMPTOMS**
  - Pick-up signals saturate due to a modification of the pick-up amplifiers yielding enlarged measured orbit amplitudes along the acceleration cycle, i.e. with raising momentum and bunch height (decreasing bunch length)





CODD issue 2/2

After a series of measurements, now CODD is giving a peak-to-peak of about 15 mm.
Dispersion measurements confirms that in relative measurement CODD can be trusted-> measurement of the calibration of the bump16 possible.



BI –ABP-OP experts still working to understand if the measuremets are correct and actually the PS orbit is really the one observed by the CODD.
Not clear why the orbit at injection would be so good and then so poor during acceleration.
Tested that it cannot be a PFW-F8L issue.

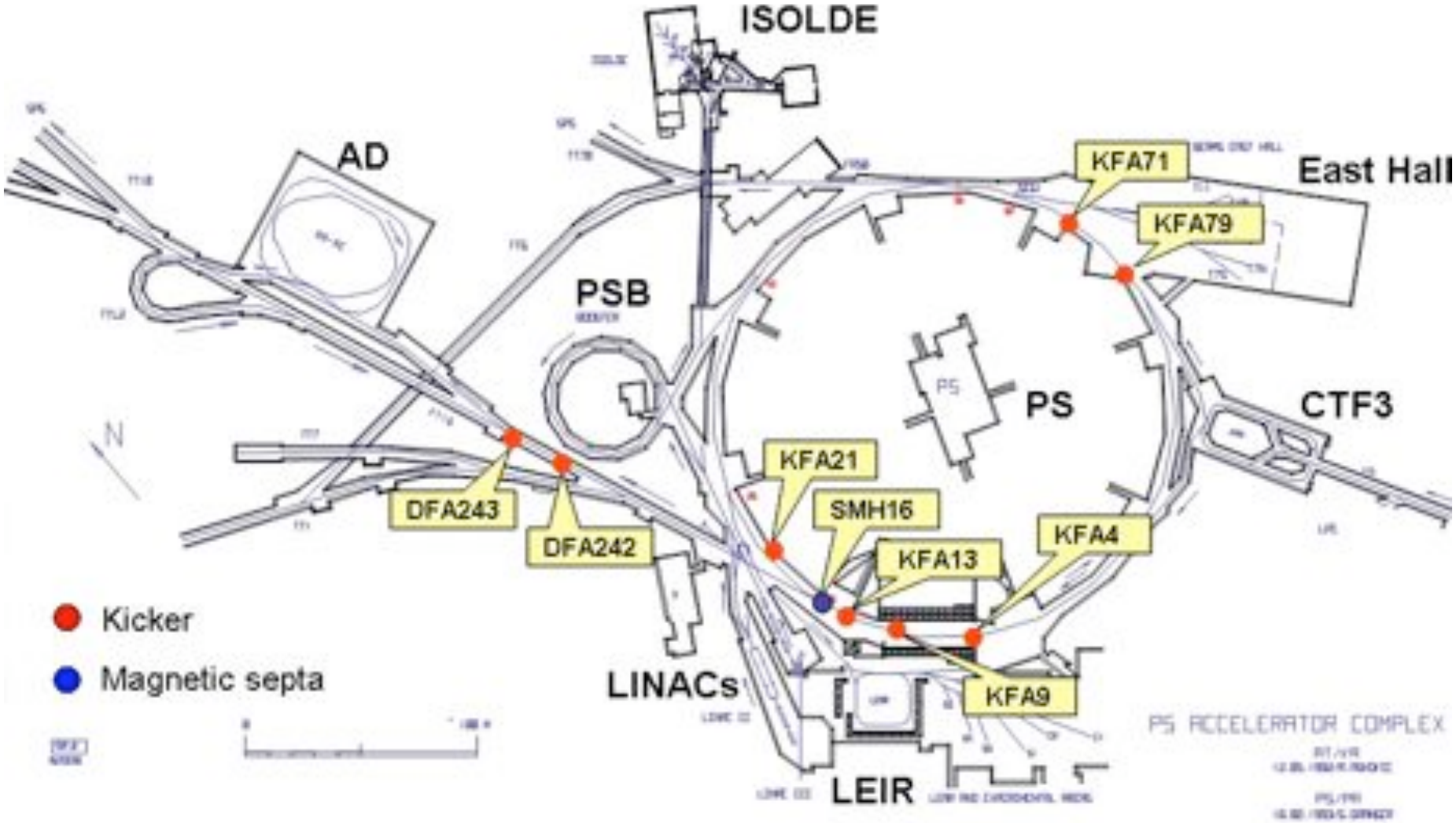
A fraction of the MTE commissioning time and man-power has been spent to help solving the CODD problem.

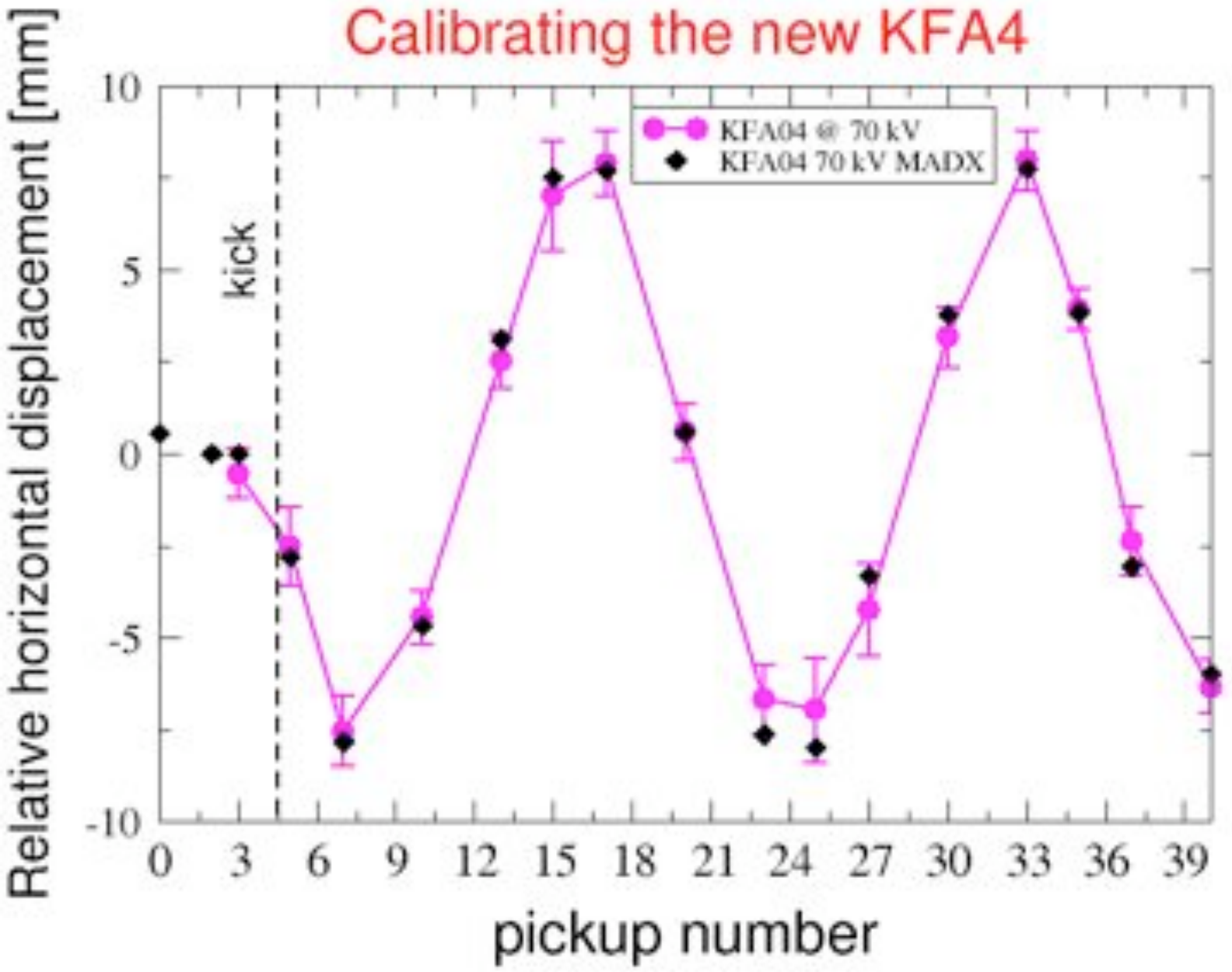
Tested that, in case the orbit would be really poor as observed, an effective correction could be implemented by using the DHZ15-60, newly installed as bipolar (thanks to AB-PO).
An eventual bad orbit cannot be produced by the missing induced current compensation cards since the orbit distortion should decrease with B, which is not the case

A possible reason for the bad orbit, MU25

KICKER status

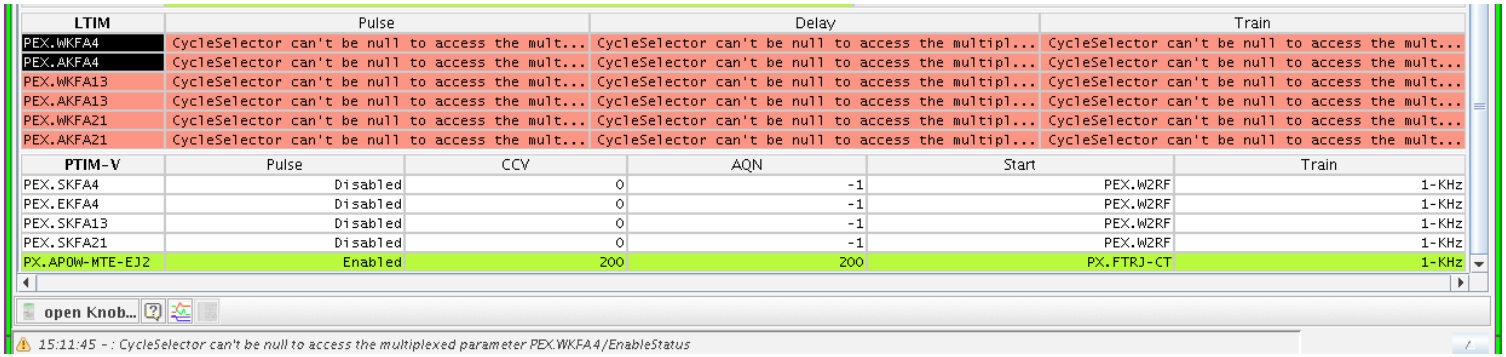
The KFA4 has been calibrated and ready for operation. KFA13 and KFA21 ready by this week.
To avoid possible interference between operation beam CT extract and the use of the BFA9p, new timings were installed to double pulse the fast CT kicker twice during the MTE cycle.




Calibrating the new KFA4
Relative horizontal displacement [mm]
pickup number
kick
KFA04 @ 70 kV
KFA04 70 kV MADX
10
5
0
-5
-10
0
3
6
9
12
15
18
21
24
27
30
33
36
39

Typical PS control problem

JAVA CM cannot acquire, at first ,the KFA4 timing status

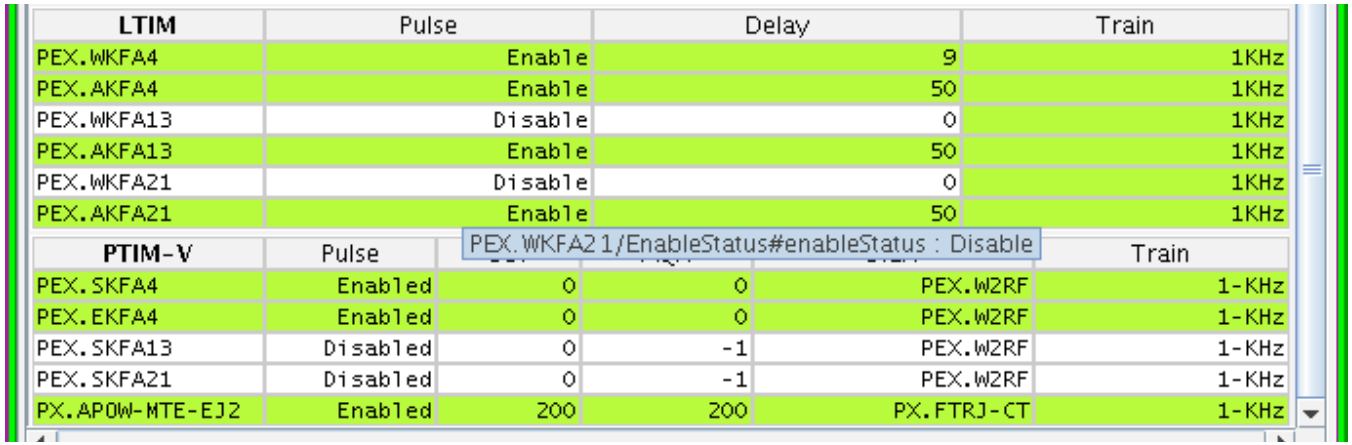


LTIM	Pulse	Delay	Train
PEX.WKFA4	CycleSelector can't be null to access the mult...	CycleSelector can't be null to access the multipl...	CycleSelector can't be null to access the mult...
PEX.AKFA4	CycleSelector can't be null to access the mult...	CycleSelector can't be null to access the multipl...	CycleSelector can't be null to access the mult...
PEX.WKFA13	CycleSelector can't be null to access the mult...	CycleSelector can't be null to access the multipl...	CycleSelector can't be null to access the mult...
PEX.AKFA13	CycleSelector can't be null to access the mult...	CycleSelector can't be null to access the multipl...	CycleSelector can't be null to access the mult...
PEX.WKFA21	CycleSelector can't be null to access the mult...	CycleSelector can't be null to access the multipl...	CycleSelector can't be null to access the mult...
PEX.AKFA21	CycleSelector can't be null to access the mult...	CycleSelector can't be null to access the multipl...	CycleSelector can't be null to access the mult...

PTIM-V	Pulse	CCV	AQN	Start	Train
PEX.SKFA4	Disabled	0	-1	PEX.W2RF	1-KHz
PEX.EKFA4	Disabled	0	-1	PEX.W2RF	1-KHz
PEX.SKFA13	Disabled	0	-1	PEX.W2RF	1-KHz
PEX.SKFA21	Disabled	0	-1	PEX.W2RF	1-KHz
PX.APOW-MTE-EJ2	Enabled	200	200	PX.FTRJ-CT	1-KHz

open Knob...

15:11:45 - : CycleSelector can't be null to access the multiplexed parameter PEX.WKFA4/EnableStatus



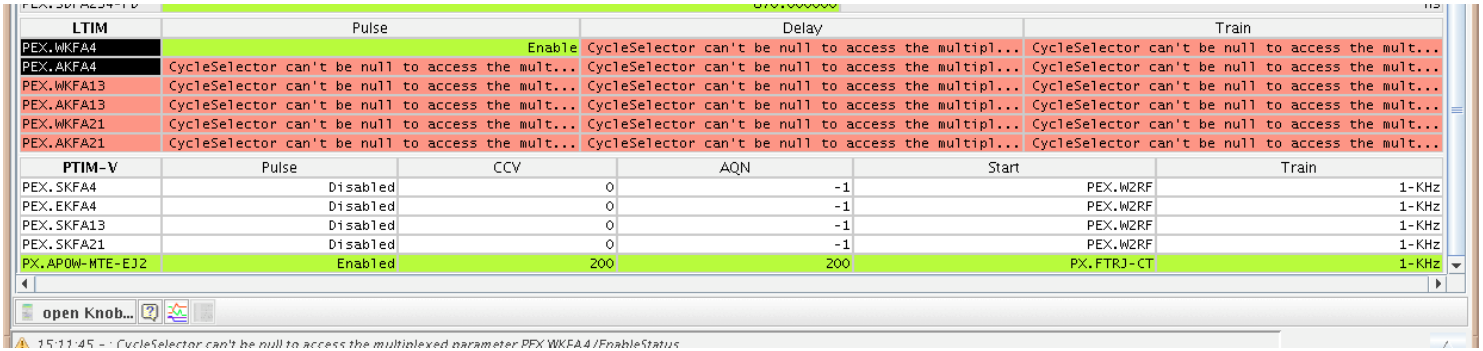
LTIM	Pulse	Delay	Train
PEX.WKFA4	Enable	9	1KHz
PEX.AKFA4	Enable	50	1KHz
PEX.WKFA13	Disable	0	1KHz
PEX.AKFA13	Enable	50	1KHz
PEX.WKFA21	Disable	0	1KHz
PEX.AKFA21	Enable	50	1KHz

PEX.WKFA21/EnableStatus#enableStatus : Disable

PTIM-V	Pulse				Train
PEX.SKFA4	Enabled	0	0	PEX.W2RF	1-KHz
PEX.EKFA4	Enabled	0	0	PEX.W2RF	1-KHz
PEX.SKFA13	Disabled	0	-1	PEX.W2RF	1-KHz
PEX.SKFA21	Disabled	0	-1	PEX.W2RF	1-KHz
PX.APOW-MTE-EJ2	Enabled	200	200	PX.FTRJ-CT	1-KHz

X-Motif tells that everything is fine. (Checked with the expert afterwards)

JAVA CM acquires only a status change



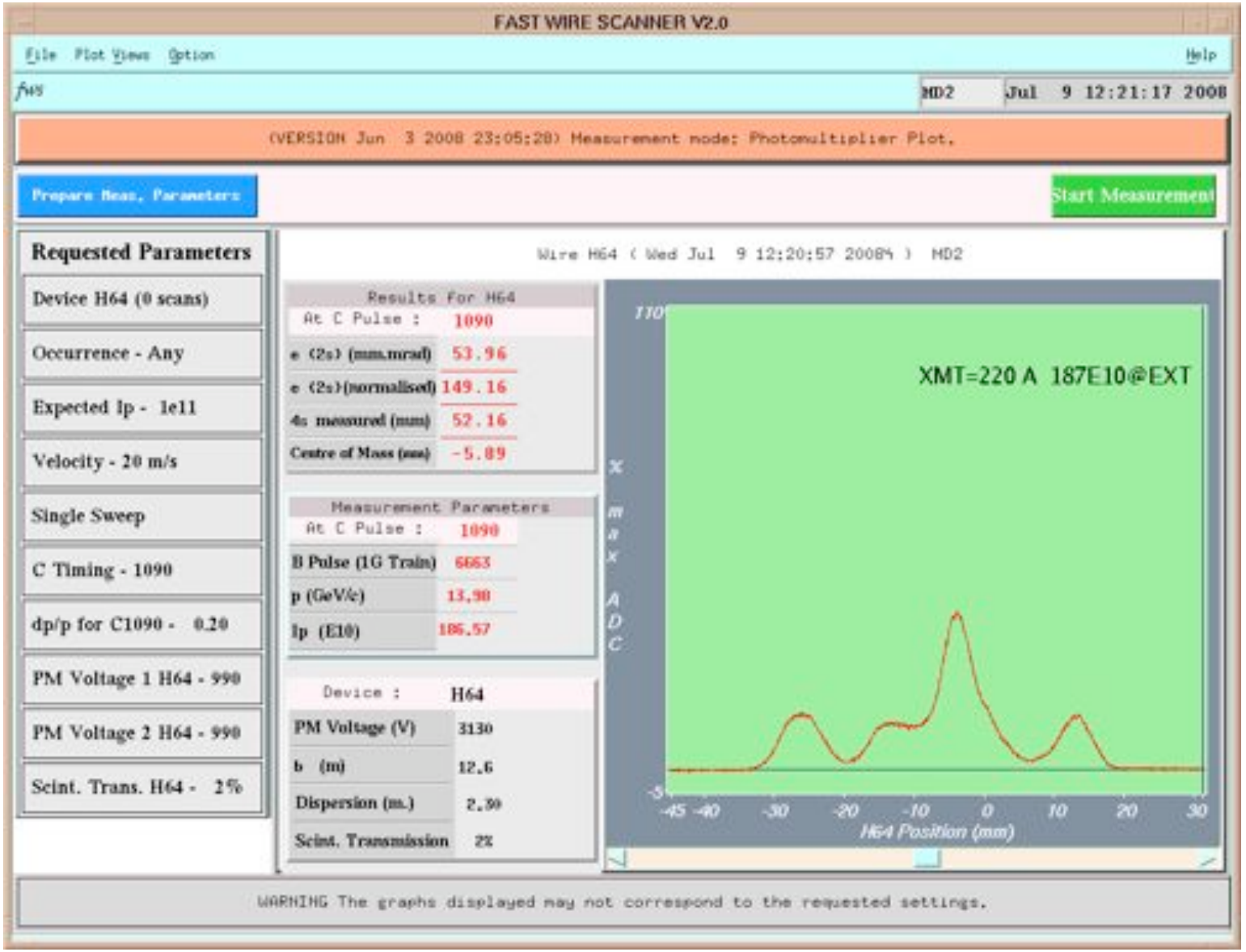
LTIM	Pulse	Delay	Train
PEX.WKFA4	Enable	CycleSelector can't be null to access the multipl...	CycleSelector can't be null to access the mult...
PEX.AKFA4	CycleSelector can't be null to access the mult...	CycleSelector can't be null to access the multipl...	CycleSelector can't be null to access the mult...
PEX.WKFA13	CycleSelector can't be null to access the mult...	CycleSelector can't be null to access the multipl...	CycleSelector can't be null to access the mult...
PEX.AKFA13	CycleSelector can't be null to access the mult...	CycleSelector can't be null to access the multipl...	CycleSelector can't be null to access the mult...
PEX.WKFA21	CycleSelector can't be null to access the mult...	CycleSelector can't be null to access the multipl...	CycleSelector can't be null to access the mult...
PEX.AKFA21	CycleSelector can't be null to access the mult...	CycleSelector can't be null to access the multipl...	CycleSelector can't be null to access the mult...

PTIM-V	Pulse	CCV	AQN	Start	Train
PEX.SKFA4	Disabled	0	-1	PEX.W2RF	1-KHz
PEX.EKFA4	Disabled	0	-1	PEX.W2RF	1-KHz
PEX.SKFA13	Disabled	0	-1	PEX.W2RF	1-KHz
PEX.SKFA21	Disabled	0	-1	PEX.W2RF	1-KHz
PX.APOW-MTE-EJ2	Enabled	200	200	PX.FTRJ-CT	1-KHz

open Knob...

15:11:45 - : CycleSelector can't be null to access the multiplexed parameter PEX.WKFA4/EnableStatus

Optimising the capture, now at about 15%

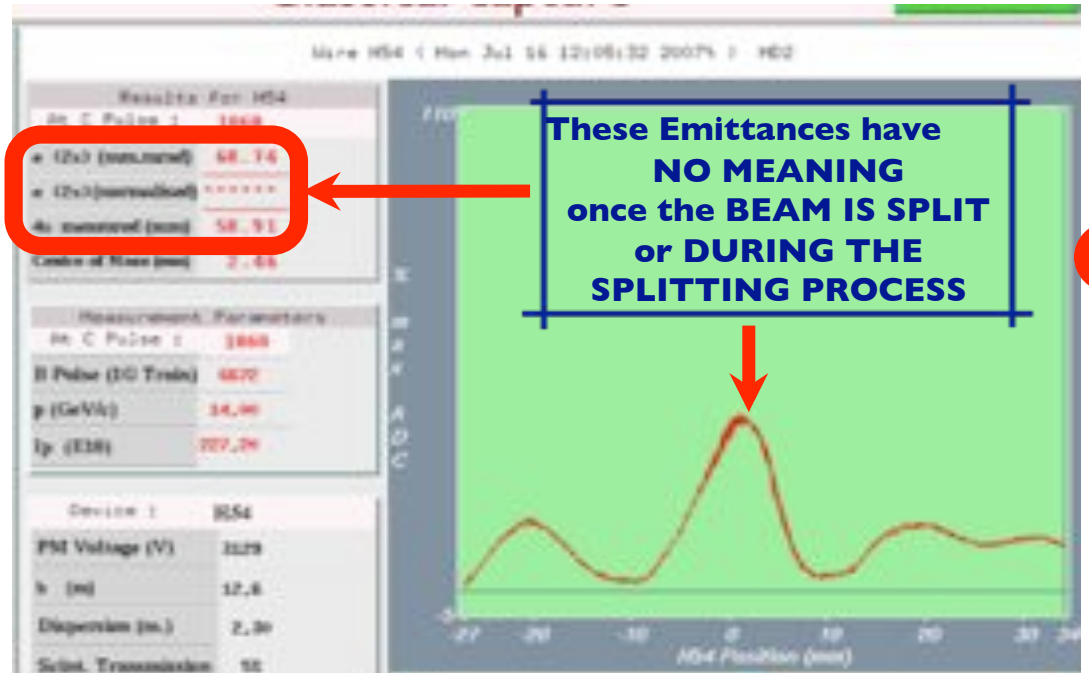


Conclusions

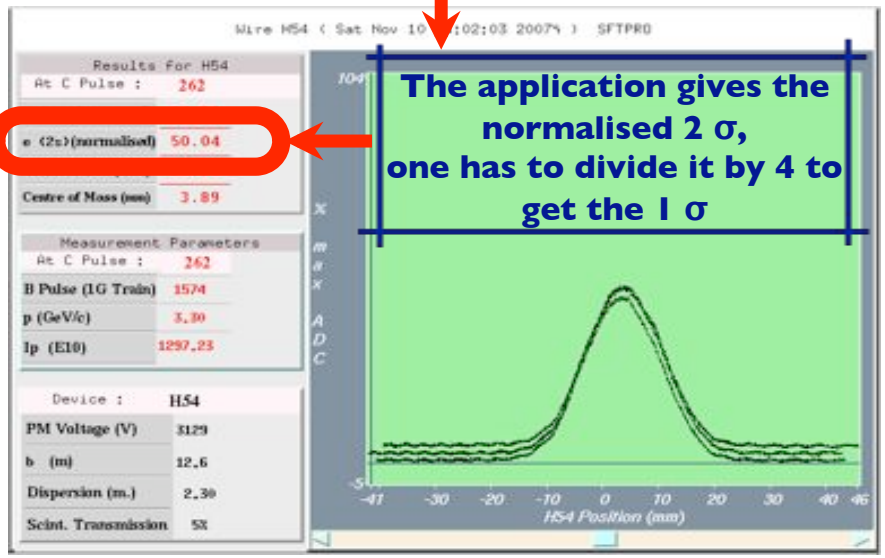
- **Program for next weeks (short term):**
  - **KFAs commissioning**
  - **Capture optimisation**
  - **Extraction tests**
- **Main issues encountered so far, none of them MTE-specific but common to normal operation:**
  - **CODD availability – no orbit measurement for extraction bump studies, multipoles feed-down studies**
  - **Application for working-point control still in development**
  - **General status of the control system**
  - **MU25 down**

Different Beams for different purposes...

Beam type	Intensity per bunch	Emittance* H/V	Harmonic	Total intensity	Number PSB rings	Aim	PS bp
Pencil	50 10^{10}	~2/~1	1	50 10^{10}	1	Xix' meas.	2
Moderate intensity	300 10^{10}	~9/~6	1	300 10^{10}	1-4	Capture study	1-2
Operational	300 10^{10}	~9/~6	2	2400 10^{10}	4	CNGS SFTPRO	1
High intensity	600 10^{10}	~9/~6	1	600 10^{10}	1	Capture studies	2



***Emittance: 1 σ normalised of the beam BEFORE capture i.e. from PSB**

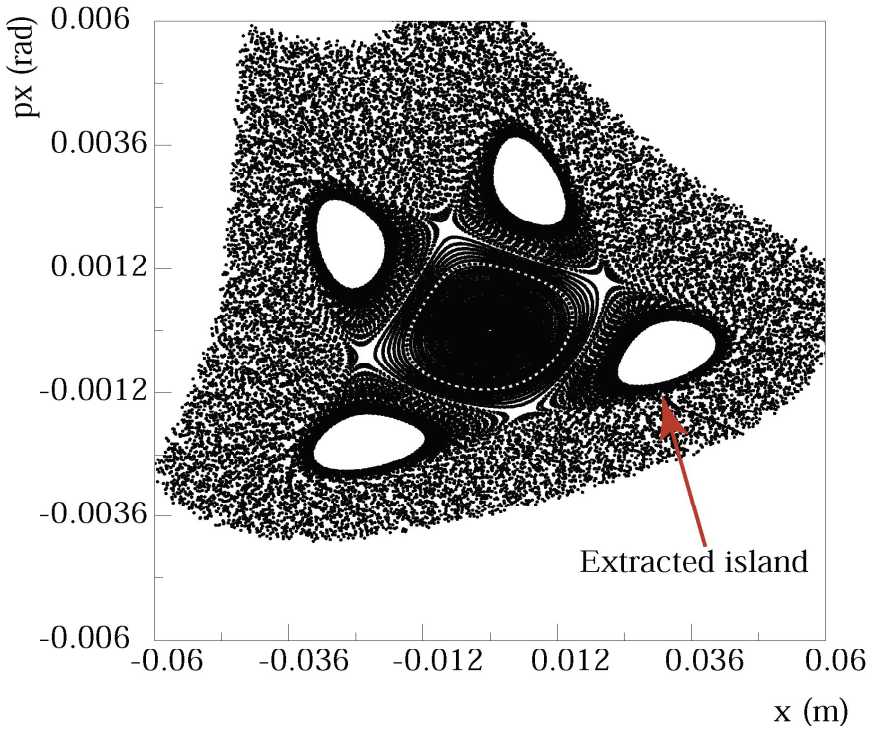


Beams for MTE commissioning and operation

	Booster	PS	Aim
During commissioning	MD1	MD1 (1 bp)	Extraction setting up
	TOF	MD2 (2 bp)	Capture preparation & optimisation
	SFTPRO/CNGS	SFTPRO/CNGS	Normal CT extraction
Operation*	SFTPRO/CNGS	SFTPRO/CNGS	MTE extraction
	MD1	MD1 (1 bp)	Settings ready for SFTPRO/ CNGS *CT extraction* *switch in case of problems with MTE*
	TOF	MD2 (2 bp)	Further studies

***proposal under discussion to be confirmed by the end of the commissioning**

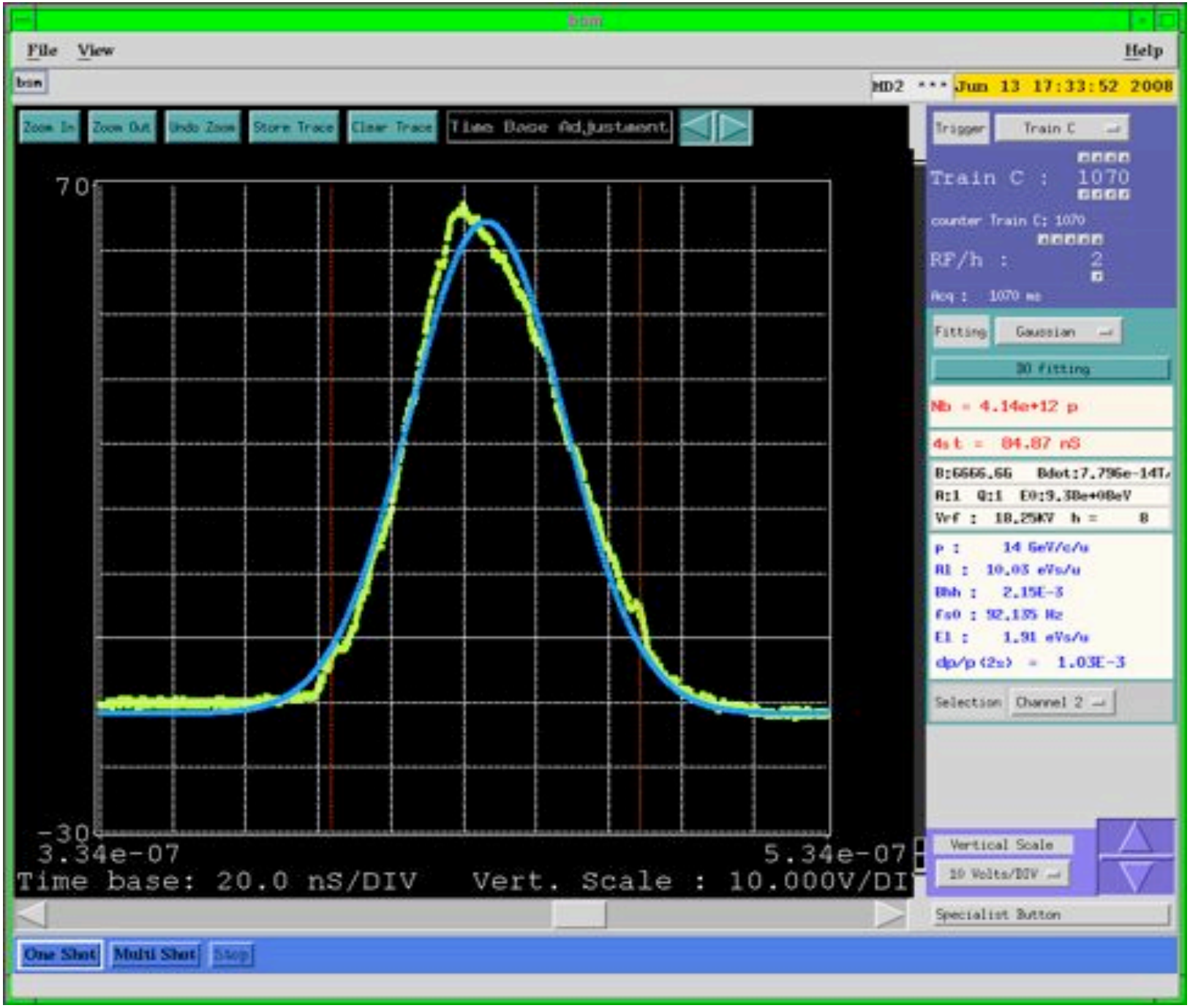
Why non-linear chomaticity is so important



Islands dimension, separation and formation depend on the sextupoles and octupoles installed for MTE, but also on the sextupolar and octupolar fields already present in the machine ⇒ Pole Face Windings (PFW)

The sextupolar and octupolar component generated by the PFW are inferred from beam based measurement, i.e. non-linear chromaticity.

Knowledge fundamental to compute the current of the MTE non-linear elements.


File View
Help
bsm
MD2 *** Jun 13 17:33:52 2008
Zoom In
Zoom Out
Undo Zoom
Store Trace
Clear Trace
Time Base Adjustment
70
-30
3.34e-07
5.34e-07
Time base: 20.0 nS/DIV
Vert. Scale : 10.000V/DI
Trigger
Train C
Train C : 1070
counter Train C: 1070
RF/h : 2
Acq : 1070 ms
Fitting
Gaussian
3D fitting
Nb = 4.14e+12 p
4s t = 84.87 nS
B:6666.66 Bdot:7.796e-14T/
R:1 Q:1 E0:9.38e+08eV
Vrf : 18.25KV h = 8
p : 14 GeV/c/u
Rl : 10.03 eVs/u
Bbk : 2.15E-3
fs0 : 92.135 Hz
El : 1.91 eVs/u
dp/p (2s) = 1.03E-3
Selection
Channel 2
Vertical Scale
10 Volts/DIV
Specialist Button
One Shot
Multi Shot
Stop

Eventual issues during the commissioning

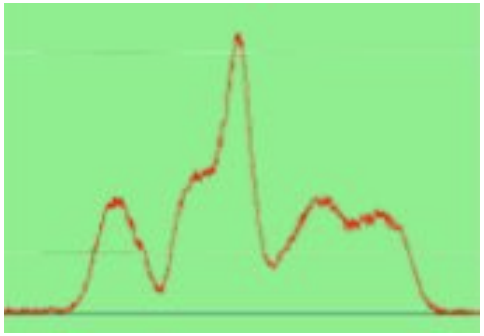
- **Working point has to precisely tuned**, both for the tune variation vs time for the capture, as for the non-linear chromaticity:
  - **5 current matrices needed**
  - program to control the working point
- **Particular care to the longitudinal structure**:
  - degraded longitudinal structure can spoil the capture (coupling longitudinal plane with transverse plane via chromaticity $\frac{\Delta Q}{Q} = \xi \frac{\delta p}{p}$)
- **Noise on the power converters** can spoil completely the capture
- **Availability of the Fast-Wire Scanners**, only instrument to monitor the capture process

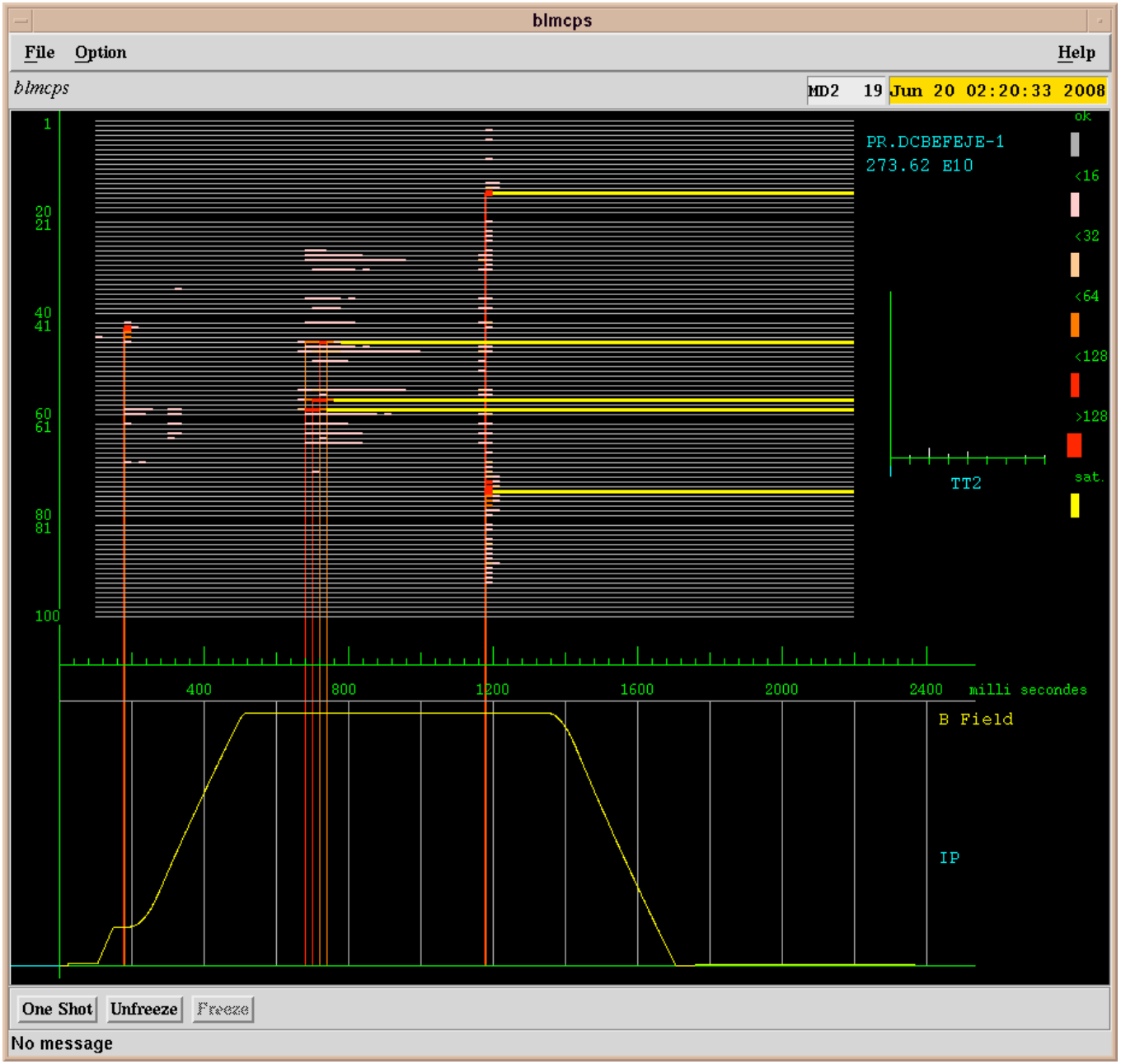
  Noise on the PS main power supply

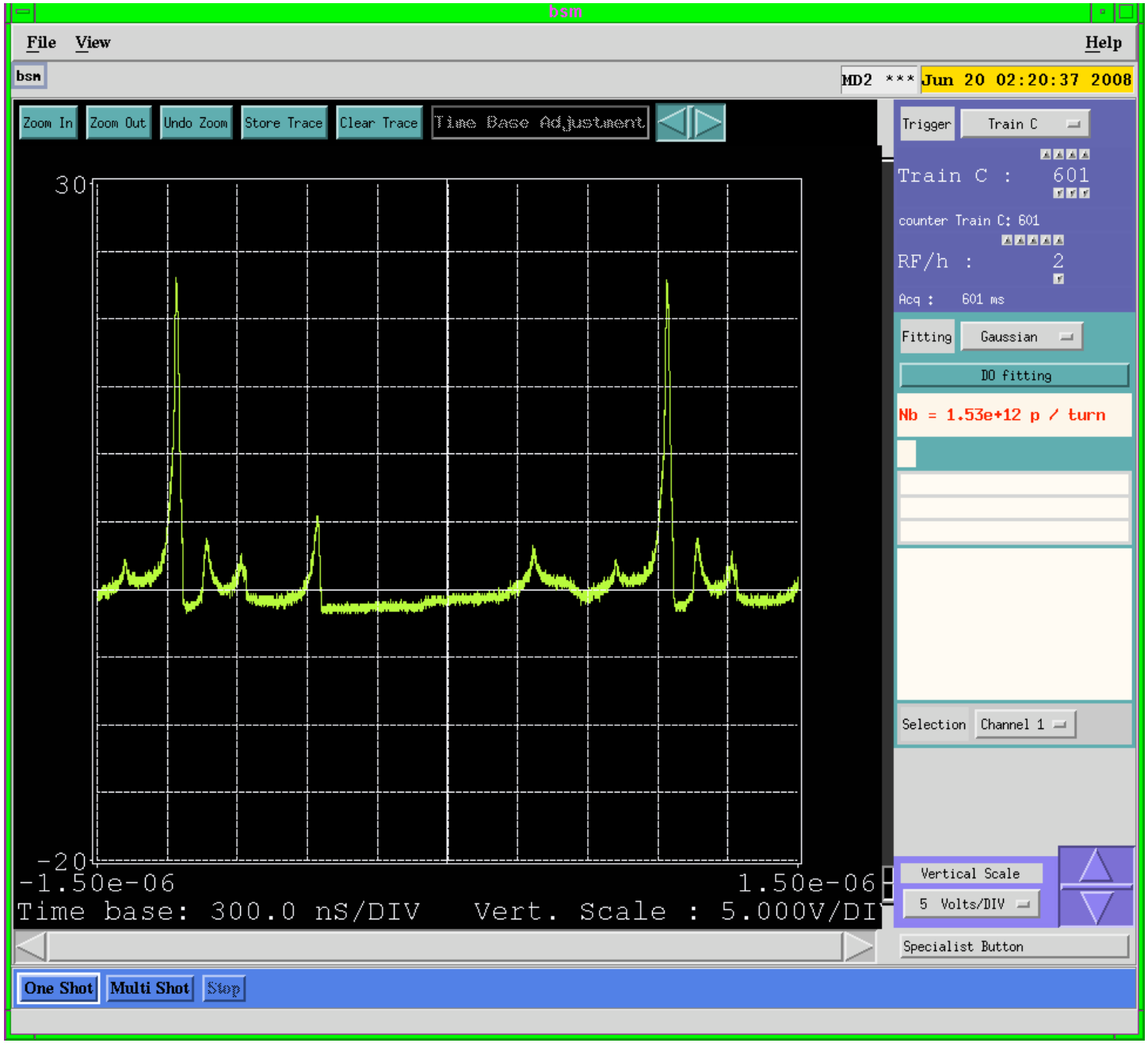
PFW, F8L, MTE-XCT, MTE-OCT, Low-energy quadrupoles should be stable all along the capture process ~ 100 ms (Similar to slow extraction issue during 2007 run)

An eventual noise can destroy completely the island structure

Normal capture




blmcps
File
Option
Help
blmcps
MD2 19 Jun 20 02:20:33 2008
1
20
21
40
41
60
61
80
81
100
PR.DCBEFEJE-1
273.62 E10
TT2
ok
<16
<32
<64
<128
>128
sat.
400
800
1200
1600
2000
2400
milli secondes
B Field
IP
One Shot
Unfreeze
Freeze
No message

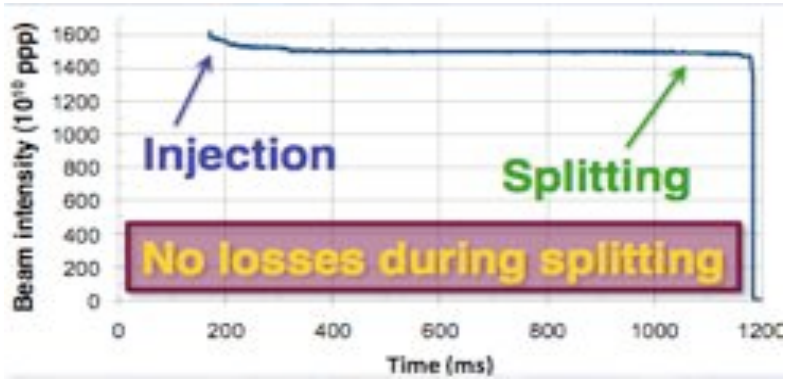

bsm
File
View
Help
bsm
MD2 *** Jun 20 02:20:37 2008
Zoom In
Zoom Out
Undo Zoom
Store Trace
Clear Trace
Time Base Adjustment
30
-20
-1.50e-06
1.50e-06
Time base: 300.0 nS/DIV
Vert. Scale : 5.000V/DI
Trigger
Train C
Train C : 601
counter Train C: 601
RF/h : 2
Acq : 601 ms
Fitting
Gaussian
DO fitting
Nb = 1.53e+12 p / turn
Selection
Channel 1
Vertical Scale
5 Volts/DIV
Specialist Button
One Shot
Multi Shot
Stop

Re-establish the capture

New capture elements: until 2007 XCT OCT in SS21.

Now in SS39 (XCT-OCT) and SS55 (XCT-OCT)


```
PR.OMT39   (octupole in SS39)
PR.OMT55   (octupole in SS55)
PR.XMT39   (2 sextupoles in SS39)
PR.XMT55   (2 sextupoles in SS55)
```



Capture to be trimmed on the 2 bp first, on single bunch with 3×10^{12} p/b and then with multi-bunches