STATUS OF AND PROSPECTS FOR THE 150 ns BEAM IN INJECTORS

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(presented by Rende Steerenberg. Many thanks!)
Thanks to many colleagues from OP, Steve Hancock and Thomas Bohl

Bunch spacing defined in the PS

- **Introduction**
- **PSB-PS**
- **SPS**
- **Conclusion and possible next step**

INTRODUCTION

- **Email from P. Collier on 13/05/2010 => Look into the feasibility of providing such a beam for the LHC with NOMINAL bunch intensity through the MSWG**

- **There were some discussions already in the past on the 150 ns beam but this was for a "new request from ALICE" (https://ab-mgt-md-users.web.cern.ch/ab-mgt-md-users/2009/StrategyForMachineDevelopmentStudiesIn2009_IEFC_17-04-09.pdf) and only ~ 1/3 or ~ 1/2 of the nominal intensity was requested => In the new request above, the ~ nominal intensity is required!**

- **MDs foreseen in the PSB-PS in week 23 starting on 07/06/2010 (https://ab-mgt-md-users.web.cern.ch/ab-mgt-md-users/2010/pmd23.htm)**

- **MDs foreseen in the SPS in week 24 starting on 14/06/2010 (https://ab-mgt-md-users.web.cern.ch/ab-mgt-md-users/2010/pmd24.htm)**

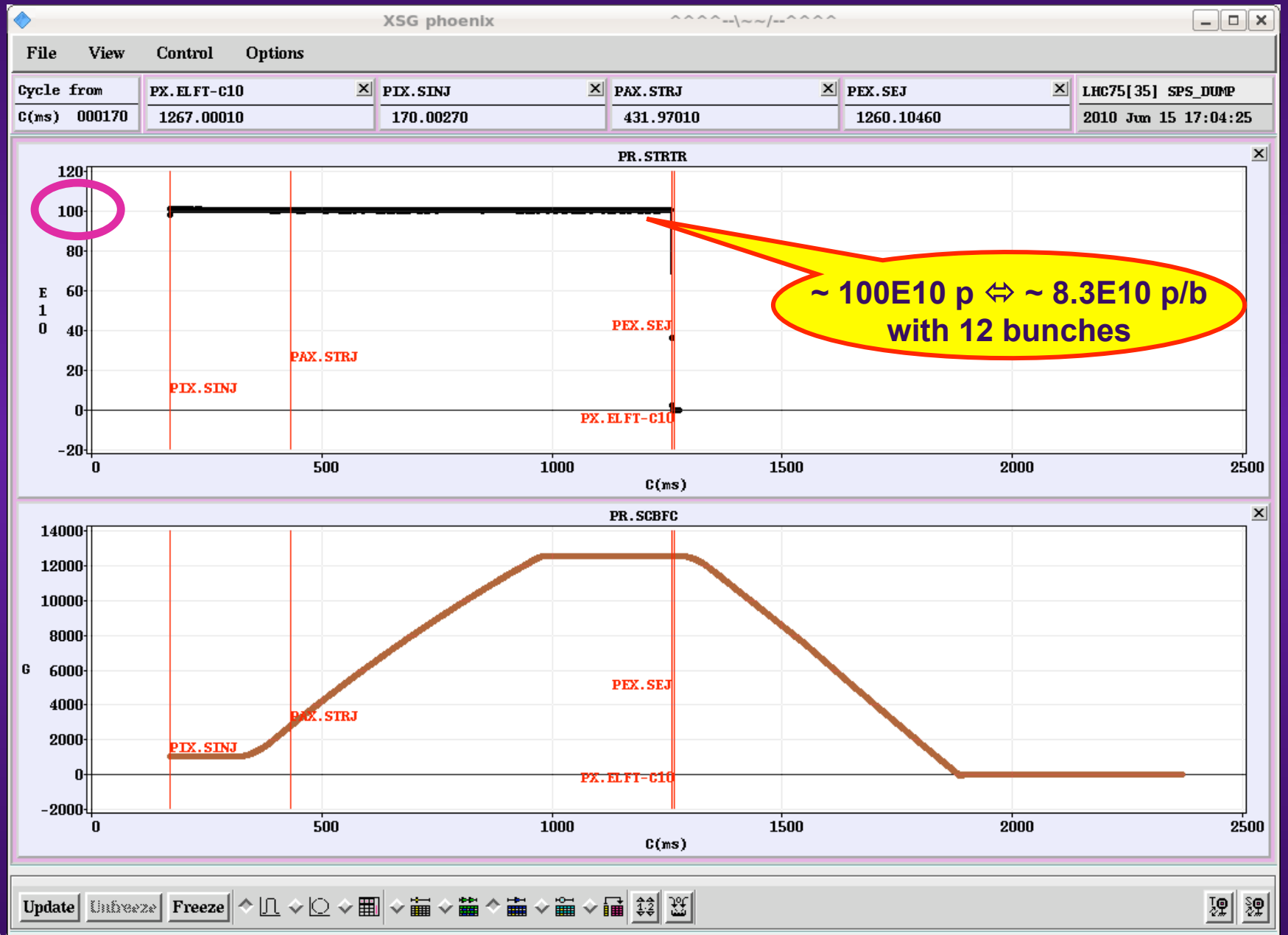
PSB-PS (1/5)

- MDs done on PSB user = LHC75 and PS user = LHC75
- 3 PSB rings with 2 bunches
- 1-batch mode (this beam profited from the 1-batch transfer developed last year)
- 0.6 eVs (instead of the nominal 0.9 eVs) => This beam requires very small longitudinal emittance from the PSB. Indeed, to maintain equidistant bunches, the splitting (to obtain 12 bunches spaced by 150 ns in the PS, starting from 6 bunches in the PSB) can only be done while consecutive buckets are filled. This limits splitting to low-energy and raises concerns about splitting such small bunches, about crossing transition, and about keeping them stable (competing against longitudinal coupled-bunch instabilities when the longitudinal emittance is already, at most, the final one of 0.35eVs)

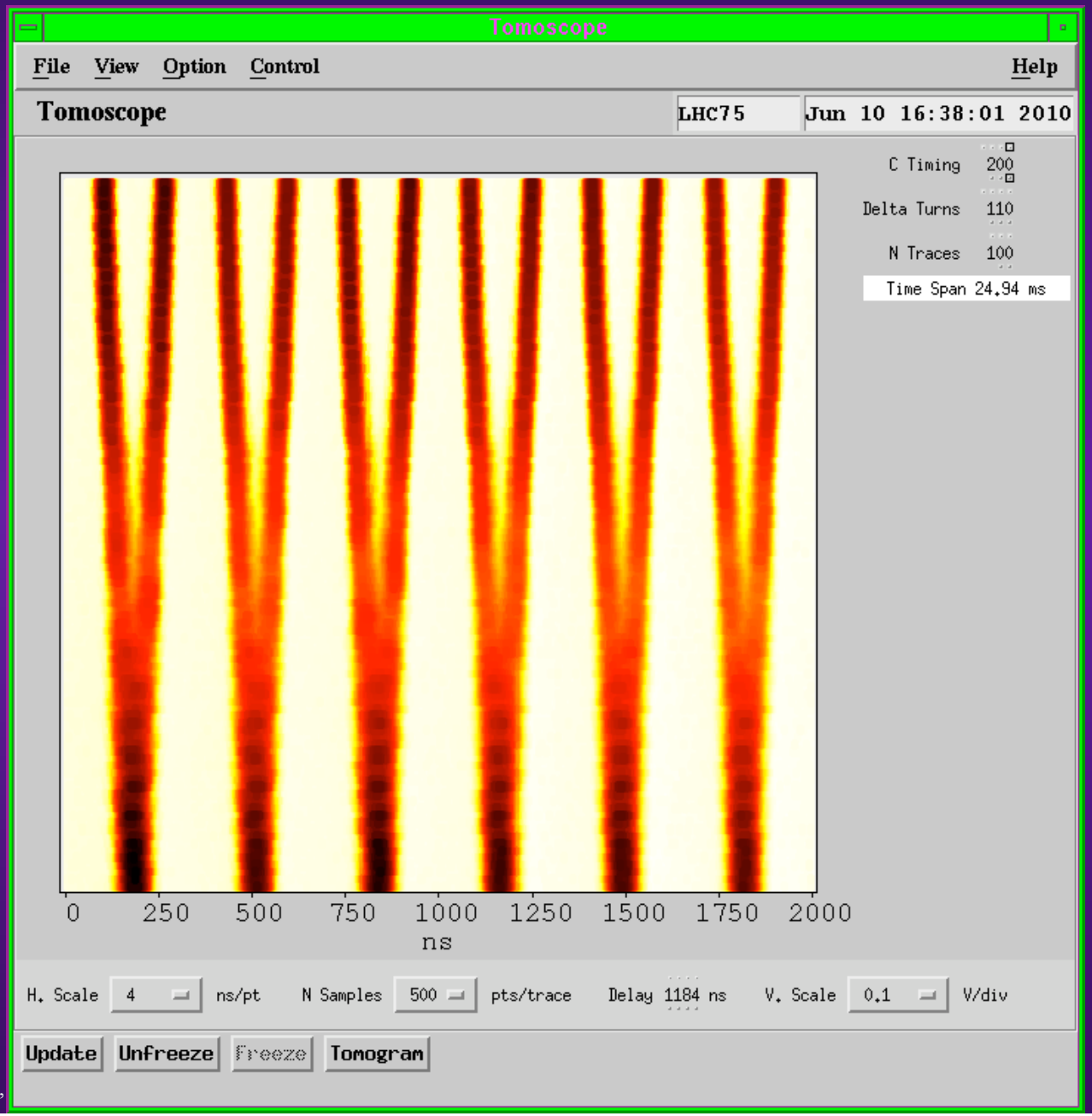
PSB-PS (2/5)

- The single splitting at low energy was acceptable and transition crossing proved straightforward, but quadrupolar coupled-bunch instabilities developed during acceleration
- We have no direct means to fight these
- We have strong evidence to suspect they are driven by the 40 and 80MHz cavities, which explains why the "bricolage" one-turn-delay feedback around the 10MHz system had no effect
- Nevertheless, the beam (12 bunches at ejection) is OK up to ~ 2/3 of the nominal intensity. Thereafter it degrades due to the coupled-bunch instabilities. We did not go further than nominal intensity

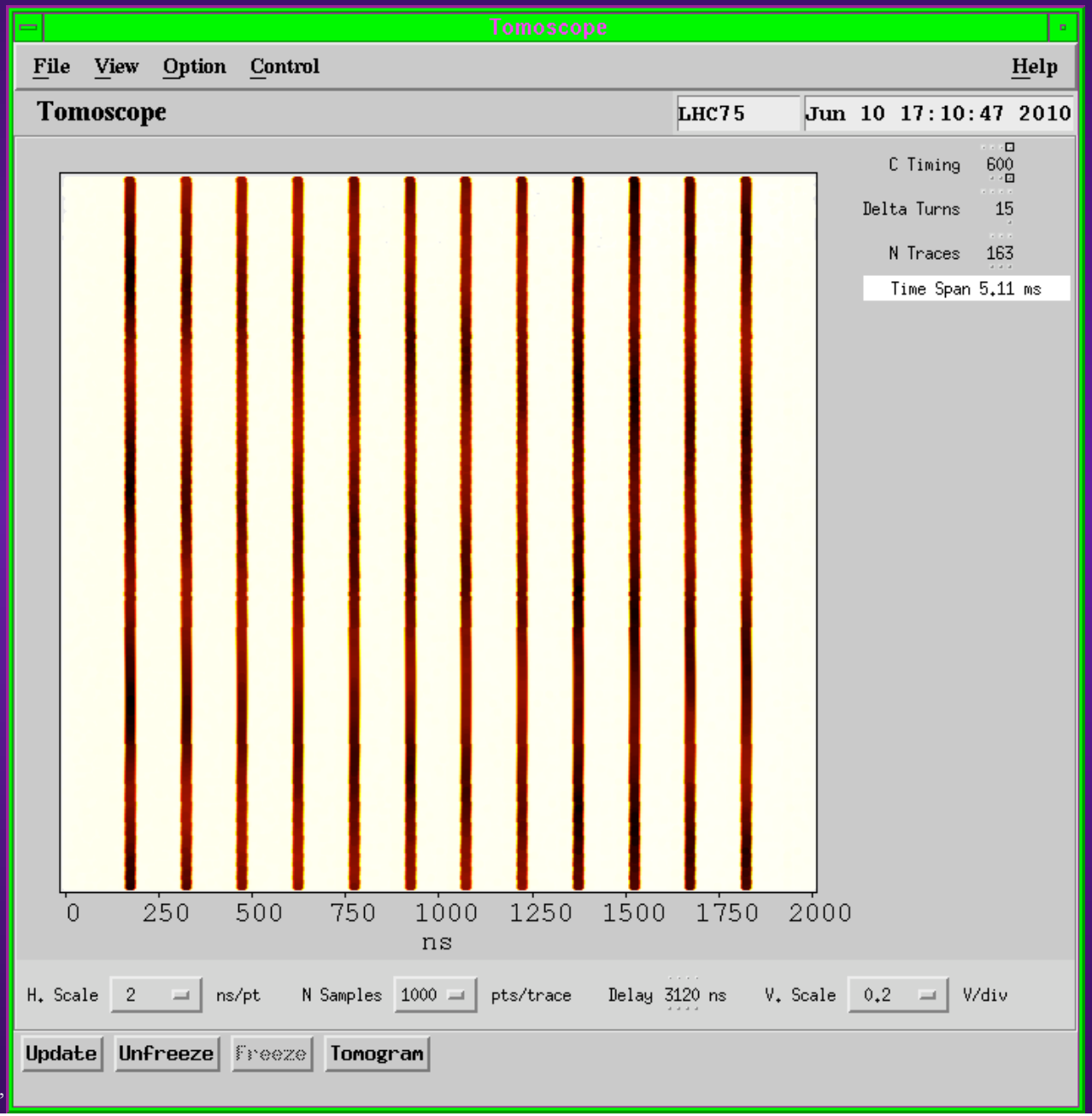
PSB-PS (3/5)


XSG phoenix
File
View
Control
Options
Cycle from
C(ms) 000170
PX.ELFT-C10
1267.00010
PIX.SINJ
170.00270
PAX.STRJ
431.97010
PEX.SEJ
1260.10460
LHC75[35] SPS_DUMP
2010 Jun 15 17:04:25
PR.STRTR
E 1 0
PEX.SEJ
PAX.STRJ
PIX.SINJ
PX.ELFT-C10
C(ms)
~ 100E10 p ⇔ ~ 8.3E10 p/b
with 12 bunches
PR.SCBFC
G
PEX.SEJ
PAX.STRJ
PIX.SINJ
PX.ELFT-C10
C(ms)
Update
Unfreeze
Freeze

PSB-PS (4/5)

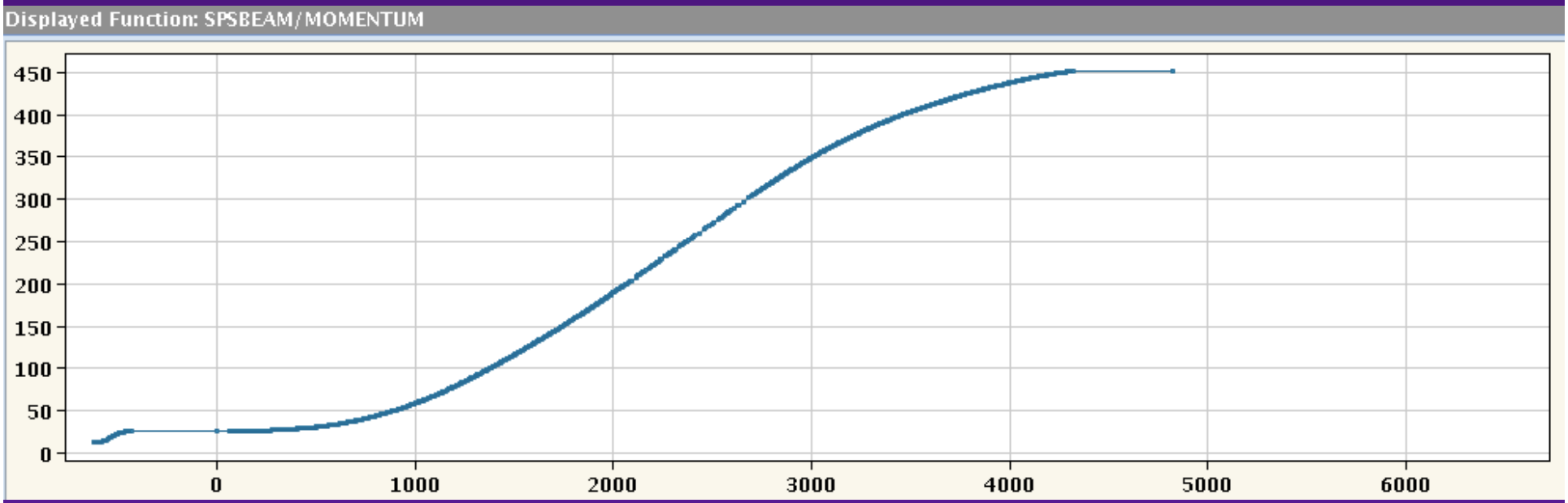

Tomoscope
File View Option Control Help
Tomoscope
LHC75
Jun 10 16:38:01 2010
C Timing 200
Delta Turns 110
N Traces 100
Time Span 24.94 ms
0 250 500 750 1000 1250 1500 1750 2000
ns
H. Scale 4 ns/pt
N Samples 500 pts/trace
Delay 1184 ns
V. Scale 0.1 V/div
Update
Unfreeze
Freeze
Tomogram

PSB-PS (5/5)

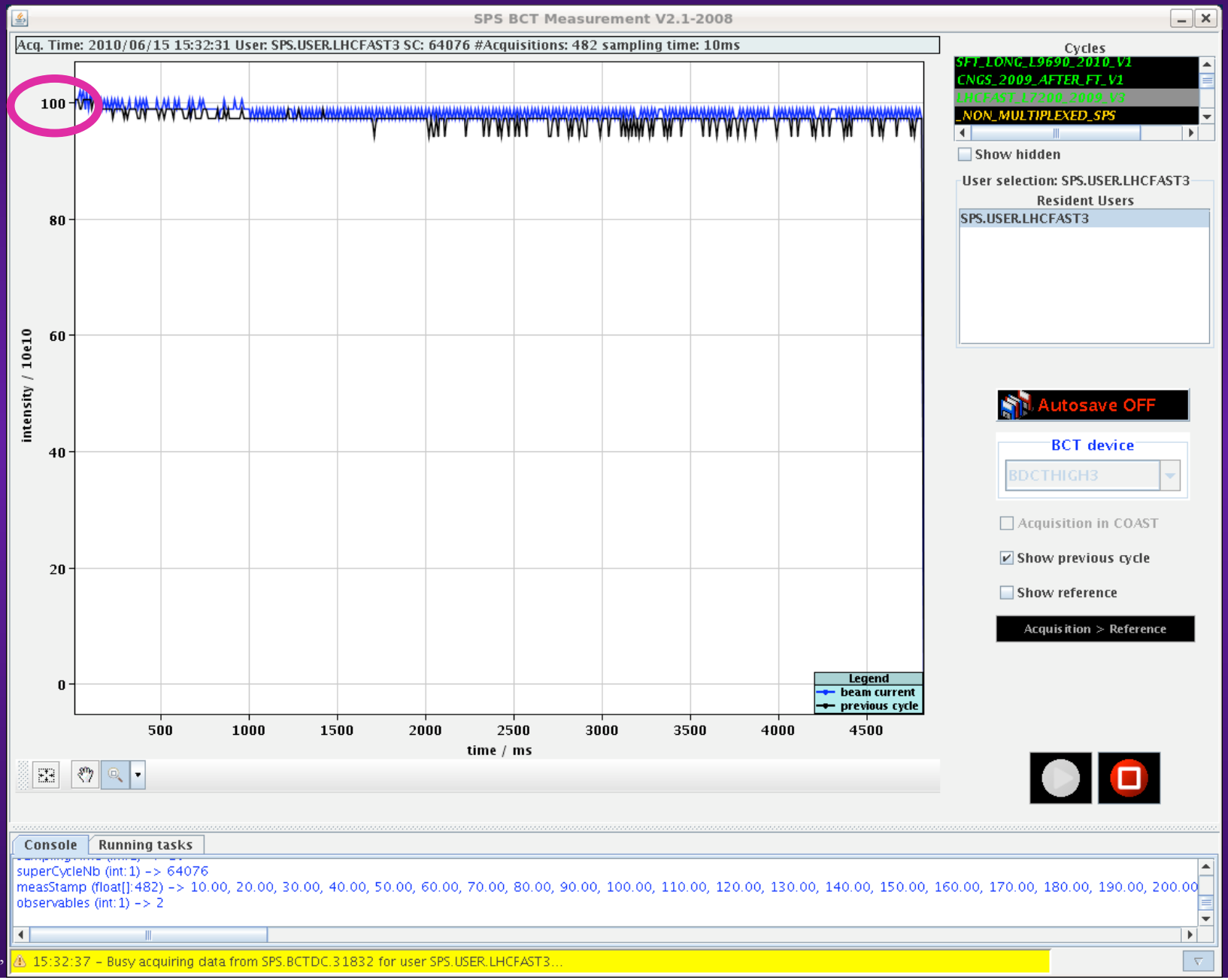

Tomoscope
File
View
Option
Control
Help
Tomoscope
LHC75
Jun 10 17:10:47 2010
C Timing 600
Delta Turns 15
N Traces 163
Time Span 5.11 ms
0
250
500
750
1000
1250
1500
1750
2000
ns
H. Scale 2 ns/pt
N Samples 1000 pts/trace
Delay 3120 ns
V. Scale 0.2 V/div
Update
Unfreeze
Freeze
Tomogram

SPS (1/8)

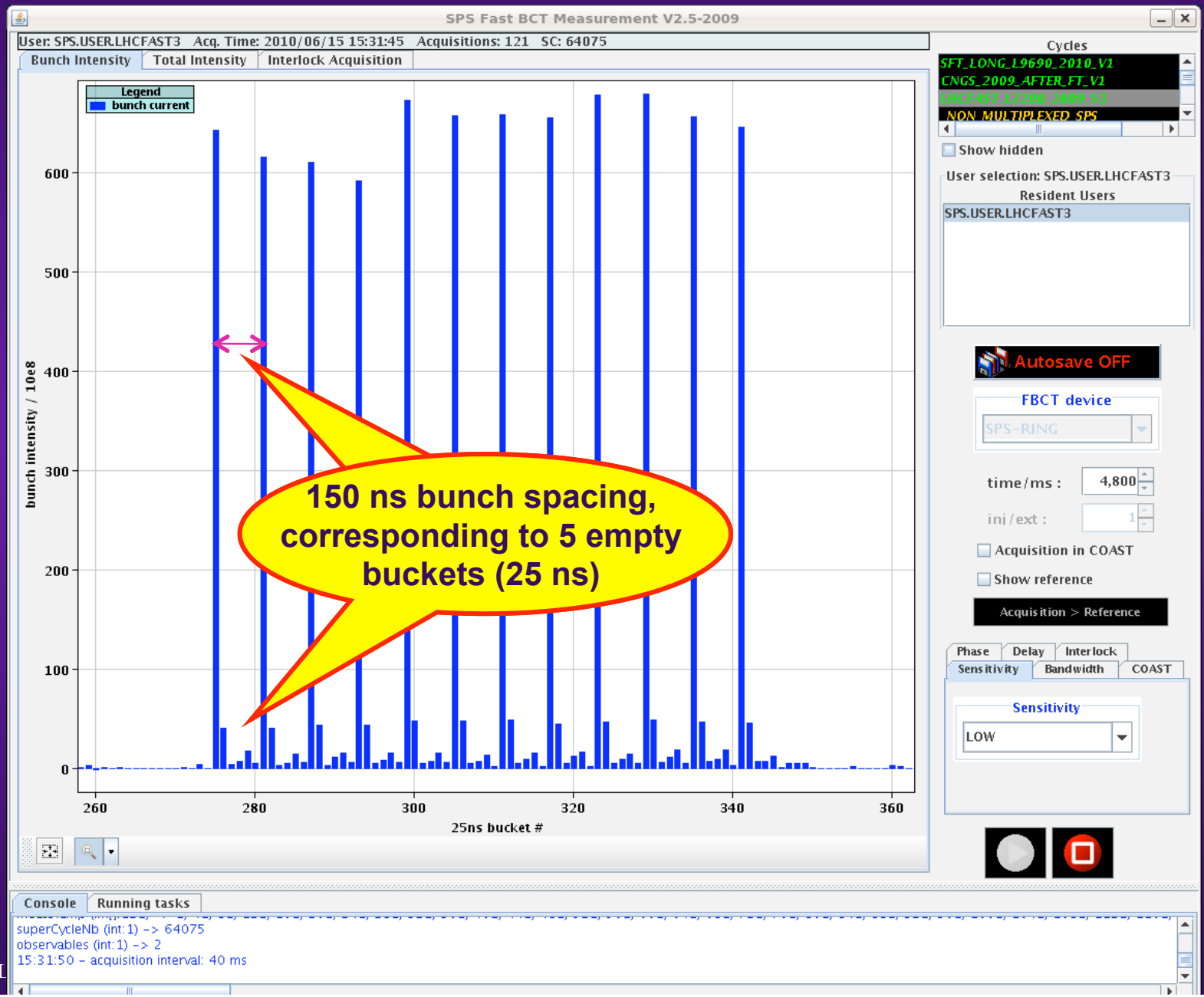
- MDs done on SPS user = LHCFAST3



SPS (2/8)


SPS BCT Measurement V2.1-2008
Acq. Time: 2010/06/15 15:32:31 User: SPS.USER.LHCFAST3 SC: 64076 #Acquisitions: 482 sampling time: 10ms
intensity / 10e10
time / ms
Legend
beam current
previous cycle
Cycles
SFT_LONG_L9690_2010_V1
CNGS_2009_AFTER_FT_V1
LHCFAST_17200_2009_V3
_NON_MULTIPLEXED_SPS
Show hidden
User selection: SPS.USER.LHCFAST3
Resident Users
SPS.USER.LHCFAST3
Autosave OFF
BCT device
BDCTHIGH3
Acquisition in COAST
Show previous cycle
Show reference
Acquisition > Reference
Console
Running tasks
superCycleNb (int:1) -> 64076
measStamp (float[]:482) -> 10.00, 20.00, 30.00, 40.00, 50.00, 60.00, 70.00, 80.00, 90.00, 100.00, 110.00, 120.00, 130.00, 140.00, 150.00, 160.00, 170.00, 180.00, 190.00, 200.00
observables (int:1) -> 2
15:32:37 - Busy acquiring data from SPS.BCTDC.31832 for user SPS.USER.LHCFAST3...

SPS (3/8)


SPS Fast BCT Measurement V2.5-2009
User: SPS.USER.LHCFAST3 Acq. Time: 2010/06/15 15:31:45 Acquisitions: 121 SC: 64075
Bunch Intensity
Total Intensity
Interlock Acquisition
Legend
bunch current
bunch intensity / 10e8
25ns bucket #
150 ns bunch spacing, corresponding to 5 empty buckets (25 ns)
Cycles
SFT_LONG_L9690_2010_V1
CNGS_2009_AFTER_FT_V1
LHCFAST_17200_2009_V3
NON_MULTIPLEXED_SPS
Show hidden
User selection: SPS.USER.LHCFAST3
Resident Users
SPS.USER.LHCFAST3
Autosave OFF
FBCT device
SPS-RING
time/ms :
4,800
inj/ext :
Acquisition in COAST
Show reference
Acquisition > Reference
Phase
Delay
Interlock
Sensitivity
Bandwidth
COAST
Sensitivity
LOW
Console
Running tasks
superCycleNb (int:1) -> 64075
observables (int:1) -> 2
15:31:50 - acquisition interval: 40 ms

SPS (4/8)

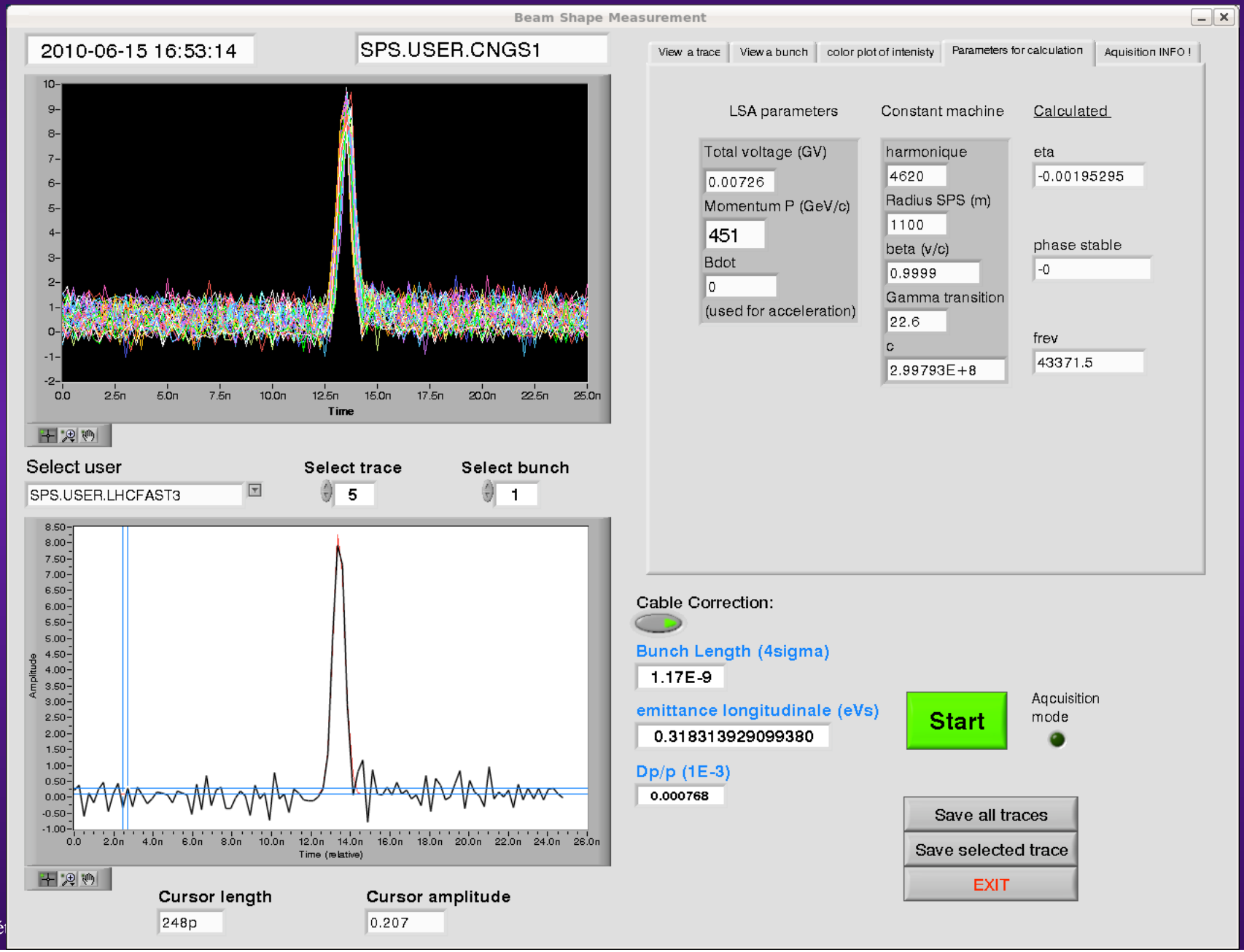
- If we look at the FBCT it seems we had a lot of bunches in between and it gave lower values of ~ 6-6.5E10 p/b (instead of ~ 8E10 p/b)

- In fact this was due to the FBCT, which needed to be re-adjusted (confirmed also by T. Bohl, who did not see satellite bunches in between the main bunches) => Indeed, the acquisition is done during 25 ns but the integration time is 20 ns. Therefore, if the pulse is coming too late the intensity will be underestimated. In the FBCT application, there is a knob called "Phase" allowing to scan the position of the integration window (each step corresponds to 1.5 ns). The idea is to scan and maximize the signal

SPS (5/8)

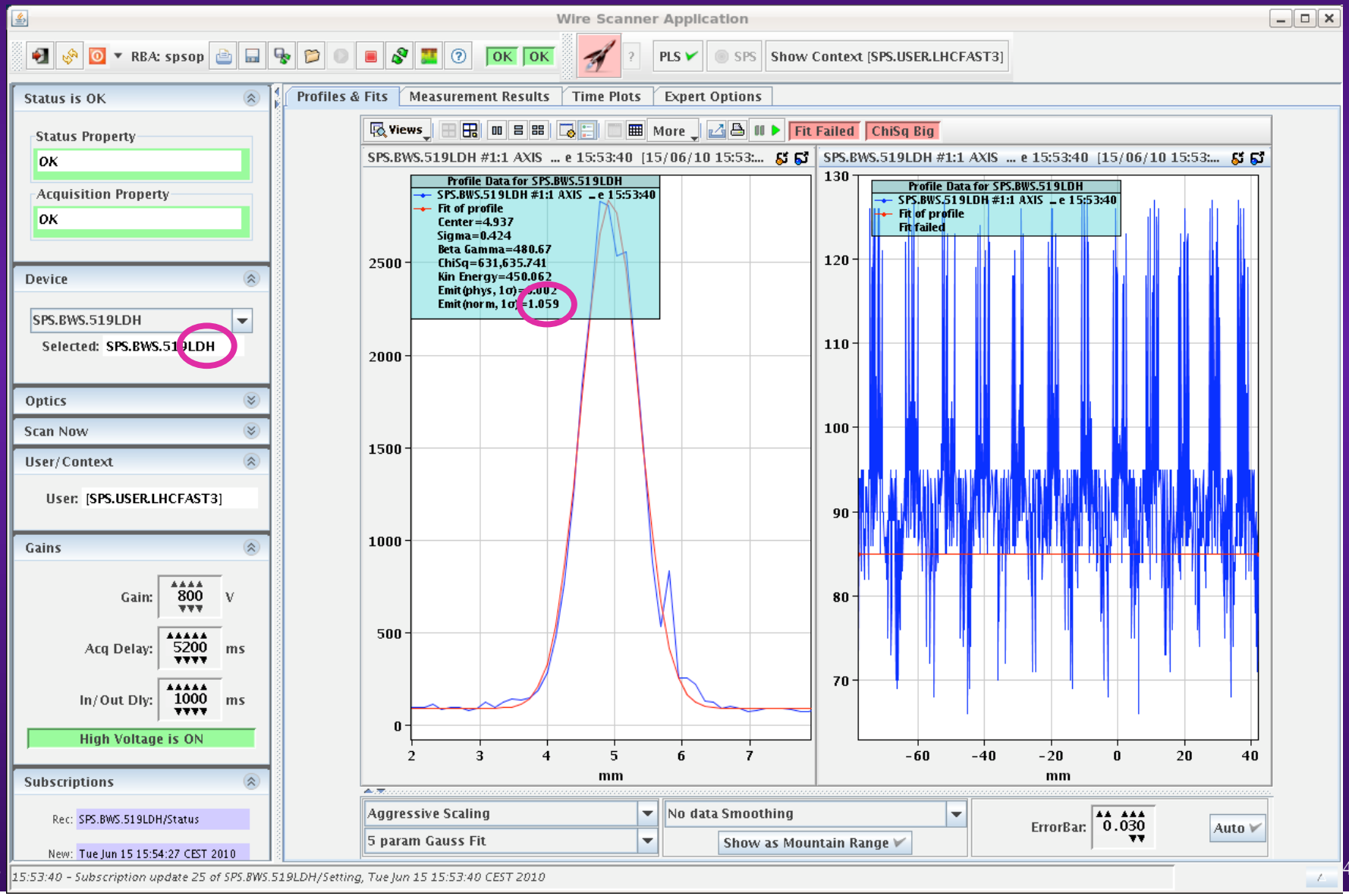
- **Results concerning the longitudinal parameters:**
  - **2010-06-14**
    - **Nq(t=0): 100E10 / 12 = 8.3E10**
    - **bl(t=0): 3.5 ns - 3.8 ns**
    - **bl(t=50ms): 2.8 ns - 3.0 ns**
  - **2010-06-15**
    - **Nq(t=0): 95E10 / 12 = 7.9E10**
    - **Nq(t=4500ms): 90E10 / 12 = 7.5E10**
    - **bl(t=4500ms): most reproducible conditions with TWC800 on and blow-up off/on**
      - **a) blow-up off, TWC800 on: min: 1.2 ns, max: 1.3 ns - 1.4 ns**
      - **b) blow-up on, TWC800 on: min: 1.55 ns, max: 1.65 ns - 1.70 ns**

SPS (6/8)

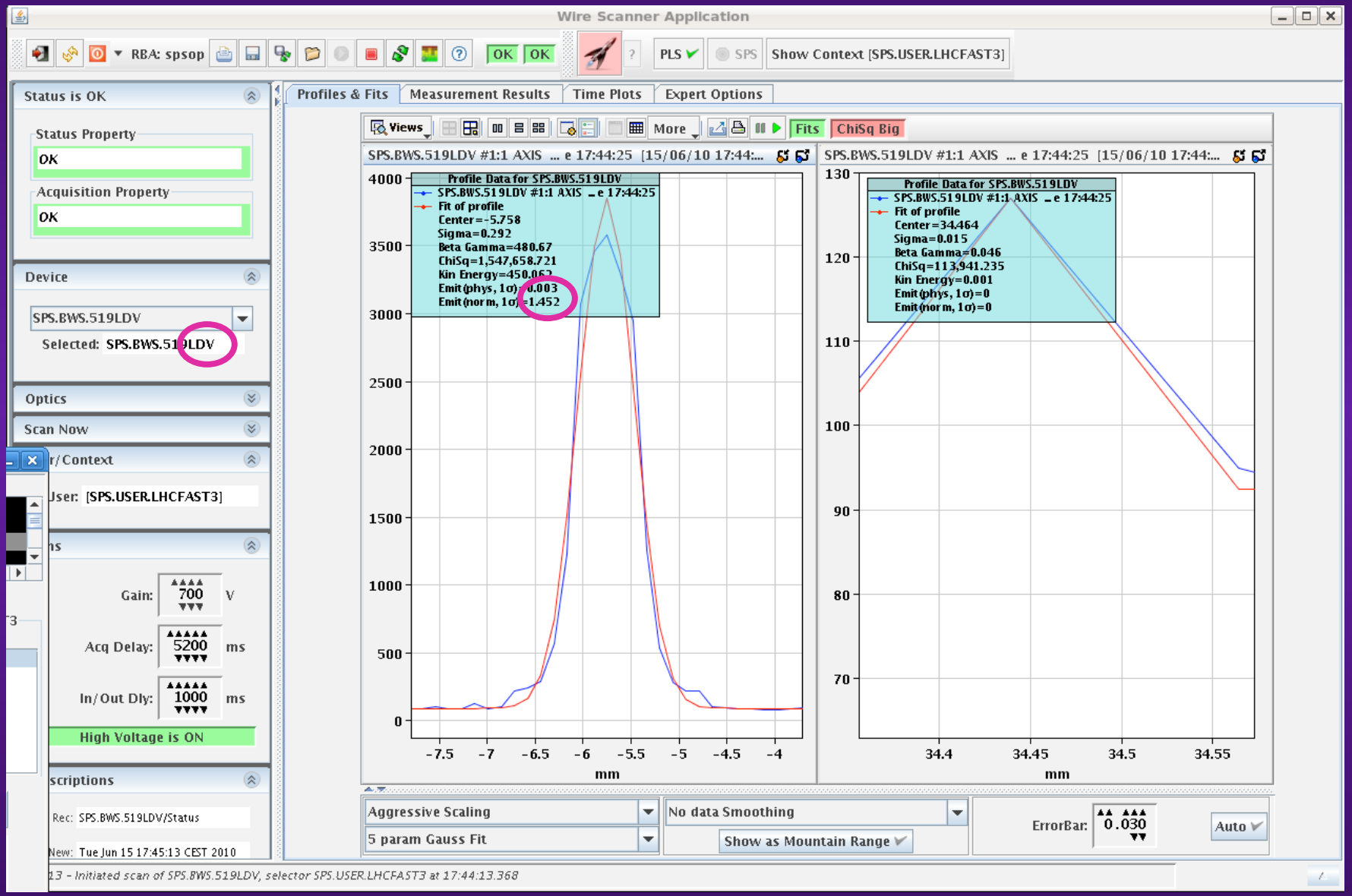

Beam Shape Measurement
2010-06-15 16:53:14
SPS.USER.CNGS1
Time
Select user
SPS.USER.LHCFAST3
Select trace
5
Select bunch
1
Amplitude
Time (relative)
Cursor length
248p
Cursor amplitude
0.207
View a trace
View a bunch
color plot of intenisty
Parameters for calculation
Aquisition INFO !
LSA parameters
Constant machine
Calculated
Total voltage (GV)
0.00726
Momentum P (GeV/c)
451
Bdot
0
(used for acceleration)
harmonique
4620
Radius SPS (m)
1100
beta (v/c)
0.9999
Gamma transition
22.6
c
2.99793E+8
eta
-0.00195295
phase stable
-0
frev
43371.5
Cable Correction:
Bunch Length (4sigma)
1.17E-9
emittance longitudinale (eVs)
0.318313929099380
Dp/p (1E-3)
0.000768
Start
Aqcuisition mode
Save all traces
Save selected trace
EXIT

SPS (7/8)

- **The transverse emittances at top energy were ~ 1-1.5 microm (rms, norm)**



SPS (8/8)


Wire Scanner Application
RBA: spsop
OK
OK
PLS
SPS
Show Context [SPS.USER.LHCFAST3]
Status is OK
Status Property
OK
Acquisition Property
OK
Device
SPS.BWS.519LDV
Selected: SPS.BWS.519LDV
Optics
Scan Now
Gain: 700 V
Acq Delay: 5200 ms
In/Out Dly: 1000 ms
High Voltage is ON
Rec: SPS.BWS.519LDV/Status
New: Tue Jun 15 17:45:13 CEST 2010
Profiles & Fits
Measurement Results
Time Plots
Expert Options
Views
More
Fits
ChiSq Big
SPS.BWS.519LDV #1:1 AXIS ... e 17:44:25 [15/06/10 17:44:...
Profile Data for SPS.BWS.519LDV
SPS.BWS.519LDV #1:1 AXIS _e 17:44:25
Fit of profile
Center=-5.758
Sigma=0.292
Beta Gamma=480.67
ChiSq=1,547,658.721
Kin Energy=450.063
Emit(phys, 1σ)=0.003
Emit(norm, 1σ)=1.452
mm
Profile Data for SPS.BWS.519LDV
SPS.BWS.519LDV #1:1 AXIS _e 17:44:25
Fit of profile
Center=34.464
Sigma=0.015
Beta Gamma=0.046
ChiSq=113,941.235
Kin Energy=0.001
Emit(phys, 1σ)=0
Emit(norm, 1σ)=0
mm
Aggressive Scaling
5 param Gauss Fit
No data Smoothing
Show as Mountain Range
ErrorBar: 0.030
Auto
13 - Initiated scan of SPS.BWS.519LDV, selector SPS.USER.LHCFAST3 at 17:44:13.368

CONCLUSION AND POSSIBLE NEXT STEP

- **12 bunches spaced by 150 ns have been produced in the PS with ~ 2/3 of the nominal intensity (i.e. ~ 8E10 p/b) and kept in the SPS until extraction:**
  - **Concerning the longitudinal plane, the most reproducible conditions at top energy with TWC800 on and blow-up off/on were**
    - **a) blow-up off, TWC800 on: min: 1.2 ns, max: 1.3 ns - 1.4 ns**
    - **b) blow-up on, TWC800 on: min: 1.55 ns, max: 1.65 ns - 1.70 ns**
  - **The transverse emittances at top energy were ~ 1-1.5 microm (rms, norm)**

- **POSSIBLE NEXT STEP: Since the SPS anyway will need to blow up this beam, we should have a joint MD to see what level of beam quality degradation can be tolerated (with a larger longitudinal emittance in the PS the beam intensity can be increased but then we have to check the injection process in the SPS…)**