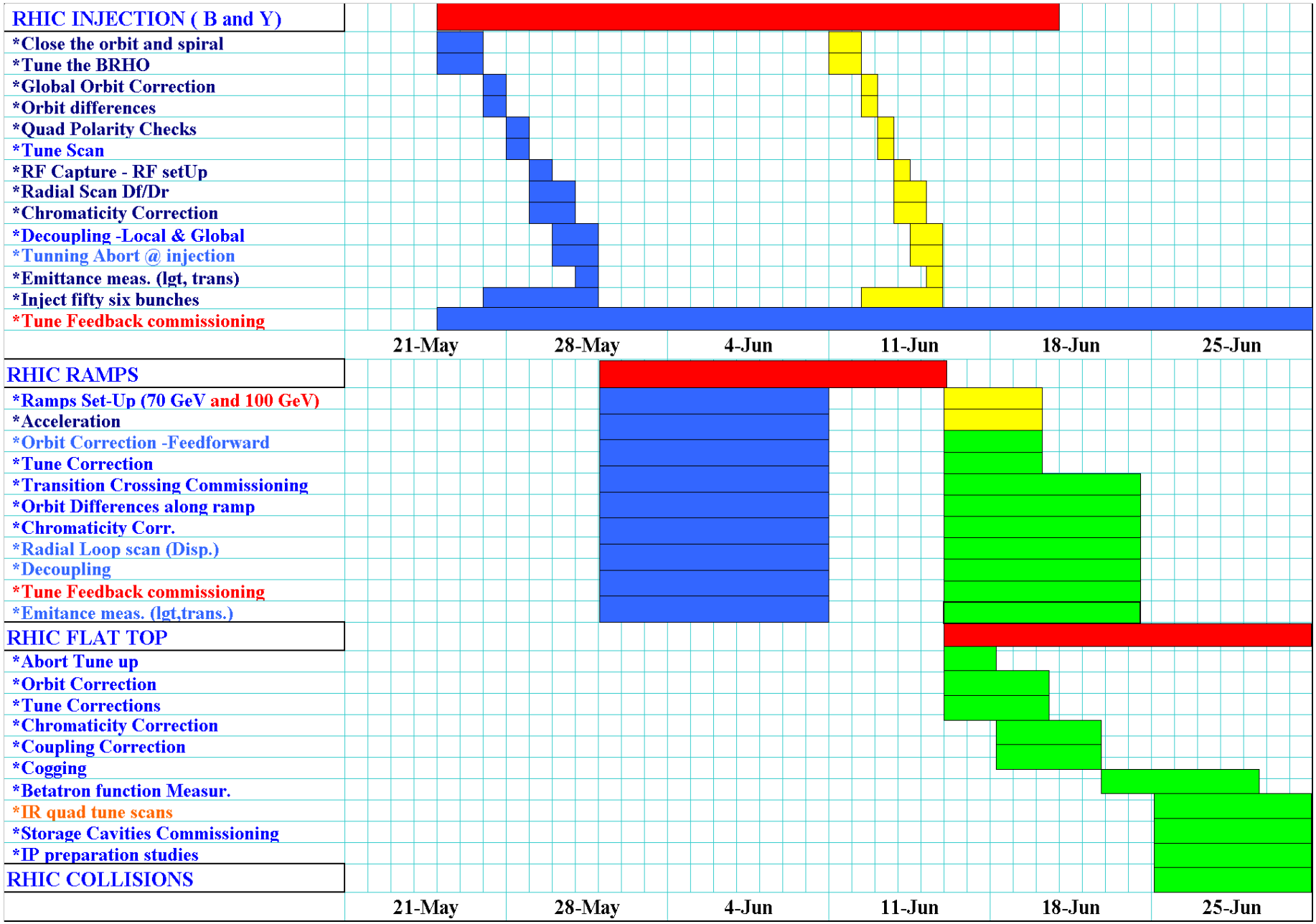
RHIC Gold Run 2001

- Plans/Achievements
- Major Challenges and Steps during the Gold run in 2001
- Systems performances
- Instrumentation performance
- Model/Measured lattice
- Priorities for the next run

Plans/Achievements



Not previously planed but achieved

RHIC RAMPS
PLL - CHROMATICITY measurements
LANDAU Cavities ON
VERTICAL SEPARATION @ IP
OCTUPOLES@TRANSITION
BETA SQUEEZE along the RAMP to 2m
BETA SQUEEZE along the RAMP to 1m
RHIC FLAT TOP-COLLISIONS
GAP CLEANING
CRYSTAL CHANNELING
TUNE BOX from the Schottky data

Challenges during the gold run 2001:

- Limited tune and momentum space at both injection and storage, and the snap-back tune shift.
- Limited radial aperture during the ramp.
- Ramping to the flat top with successful beta squeeze along the ramp (initially problems with the radial loop and DSP code (June 20, 2001).
- Vertical dispersion in the yellow ring (Roll in the triplets – effect magnified @β^*=1m).
- Transition crossing: Timing, strength, tune shift during the γ_t jump, fast instability, zero chromaticity crossing, α_1=–0.35 due to all IP @β^*=5 m. Repeatable successful ramps achieved (July 8, 2001).
- Intensity limitations ($1x10^9$ per bunch). Six bunches design intensity went to the top energy.
- Instabilities: fast instability@ transition (octupoles, beam-beam), resistive wall instability (chromaticity).
- Transverse and longitudinal emittance blow-up (chromaticity correction, Landau cavities).
- **Beam-beam effect : longitudinal separation @ injection, added the vertical separation @ IP's.**
- 110 gold bunches: electron beam instability – vacuum pressure bumps.
- At the stores:
  - Beam life time dives after cogging (beam-beam) or rebucketing (momentum aperture tight). Cures: Orbit correction, chromaticity, correct tune box, local&global decoupling, IR nonlinear corrections.
  - Transverse oscillations 10-14 Hz -> Mechanical vibrations??
  - Gradient Errors – betatron functions waves.

November 8, RHIC operation meeting Agenda:

Beam Life time:

- Orbit correction -V. Ptitsyn
- Chromaticity – S. Tepikian
- Tunes – W. Fischer
- Local and global decoupling (Joanne Beebe-Wang F. Pilat, and V. Ptitsyn)
- IR nonlinear corrections (F. Pilat&V. Pritsyn)

Lattice Problems:

- Betatron function measurements (Mei Bai)
- Errors in the triplet gradient transverse functions?? (V. Ptitsyn&J. van Zeijts)
- Vernier scans results comparison to the β^* (A. Drees)
- Horizontal dispersion mismatch (V. Ptitsyn&J. Van Zeijts)
- Vertical dispersion mismatch (V. Ptitsyn, F. Pilat, S. Tepikian)

Transverse Emittance Blow-up:

- During the ramp (M. Brennan and W. Fischer: Coherence meter, S. Tepikian IPM).
- Landau Cavity (M. Brennan and M. Blaskiewicz)
- At the flat-top 14 Hz noise (M. Brennan, W. Fischer)

Intensity Limitations:

- **Transition Crossing:**
  - Fast Instability - Octupole Strength (J. Kewisch, C. Montag)
  - ¼ Resonance correction (J. Kewisch and F. Schmitt)
  - RF voltage manipulations
  - Transition timing
  - Transition jump tuning
- **Vacuum Problems:**
  - Gap in the bunches (W. Fischer)
  - Measurements of the bunch tune shifts (W. Fischer and mei Bai).
  - Solenoidal fields around the beam pipes (W. Fischer and W. MacKay)
  - 120 Bunch mode (W. Fischer).

Major Steps during the Gold run 2001:

- Agreement with the lattice predictions – quadrupoles' polarity check (May 2001).
- Limited momentum aperture @ injection (On June 21, +/- 7 mm achieved).
- Transition crossing improved: γ_t jump quads tuned, jump and phase jump timing, octupoles, zero chromaticity crossing, tune box correction (July 8, 2001)…
- Longitudinal instabilities along the acceleration by 'Landau cavities' (October 17, 2001).
- The beam-beam tune spread was used to fight the fast instability replaced by OCTUPOLES (October 25, 2001).
- Rebucketing – reducing the bunch length to ~3 ns.
- Design Intensity per bunch – 1 x 10^9 ions (November 19, 2001).
- Emittance blow up along the ramp – coherence signals found.
- **Chromaticity measured along the ramp with the PLL and radial loop oscillations**.
- First gain in luminosity by lowering the β^*=3 m to β^*=2 m (October 6, 2001).
- Beta squeeze along the ramp at PHENIX @IP the β^*=2 m was lowered to β^*=1 m (November 1, 2001)

Systems performances:

- Excellent tools and programs were developed and used:
  - SEQUENCER (excellent)
    - Subsequences:
      - Multiple instrumentation automatic data collection (Rob Michnoff) along the ramp, through transition, at the flat top.
      - Hysteresis ramp.
      - Instrumentation injection set-up…
  - Ramp manager (excellent-although needs easy restore), wfg-manager (excellent – needs a solution for deuterons).
  - PS-compare, PS watch, barshow, SNAP shots.
  - INJECTION program – (excellent it does orbit closure, longitudinal matching, measures tunes, shows losses…).
  - Orbit Correction (excellent).
  - Logging system (excellent).
  - ELOG (excellent – needs few small improvements like shift titles).
- **RF SYSTEM – acceleration and storage system** (excellent – needs integration with the rest of the systems and a final solution with the windows is here!!) and additional 'Landau' – storage cavities used at acceleration.
- **Gamma-t jump quadrupole system** (very good-failed quads needs to be fixed).
- **Abort system** (very good – needs improvements in reliability).
- **GAP cleaning** (very good needs to become operational without experts).
- **Collimation** (very good) nice new program but the BACKGROUNDS need to be reduced!
- **POWER SUPPLIES** – everybody hopes that it will continue to behave as at the end of the run.
- **QUENCH protection and detection system** – excellent (to many quench link events) needs to get integrated to the control system.
- **ALARM system (excellent).**
- **PERMIT link system** (very good needs improvements a possibility to run rings separately).
- **Luminosity monitoring** (excellent – but needs real transverse data not predicted).
- **Decoupling** (excellent – new methods are being proposed).
- **PHASE LOCK LOOP** – very promising.
- **Chromaticity correction** (very good – will improve with PLL working).
- **CONTROL SYSTEM** (excellent).
- **QUAD polarity check** (very good – needs improvements for the triplets check).

Instrumentation performances:

- **ARTUS** very good.
- **IPM** (needs improvements).
- **BPM** very good (small upgrade).
- **AC dipole** (not fully commissioned needs support).
- **Wall current monitors-WCM excellent** (reliable, reconstruction, logged transition).
- **Loss Monitors very good** (need improvement on synchronous data display).
- **PLL** – very promising.
- **Schottky detector** (needs easier accessibility and integration to the controls).
- **Coherence monitor.**
- **Button BPM's ?**
- **PIN diodes** (excellent).

Model/Measured lattice

- **Betatron amplitude functions** showed waves around into the arcs. The **gradient errors** are measured by different methods and we need a task force to correct it.
- **Dispersion function** showed relatively good agreement in the horizontal plane and large vertical values especially in the yellow ring.
- **Very large coupling** was confirmed by measurements and attributed to the error in the **triplet quadrupoles rolls**.
- **Beta squeeze** to different β^* at IP's along the acceleration showed excellent results and **agreement with predictions**. This is a message for the next run: we should pick the most suitable lattice from the beginning!
- **Emittance growth** along the acceleration and at the flat top does not completely agree with the intra beam scattering predictions.
- The down-ramp could not be predicted the magnetic measurement data do not exist.
- **Non-linearities at the IP's** are measured but not completely corrected.
- **Beam- beam effects** behaved as predicted. Very serious limitation during the acceleration and at the storage (life time sometimes got reduced as soon as the collisions were established).
- Betatron resonances ¼ and 1/5 need to be corrected especially around transition.
- Electron cloud effect in the gold run induced vacuum pressure rise.
- The ramp during the gold run had $\beta^*= 5$ m at the transition at each IP, which does not make required value of the $\alpha_1=-1$ but the **$\alpha_1=-0.3$**. **This we should replace in the next run making $\alpha_1=-1$ with the $\beta^*=3$ m at all IP except 6 and 10 o'clock.**

Priorities for the next run

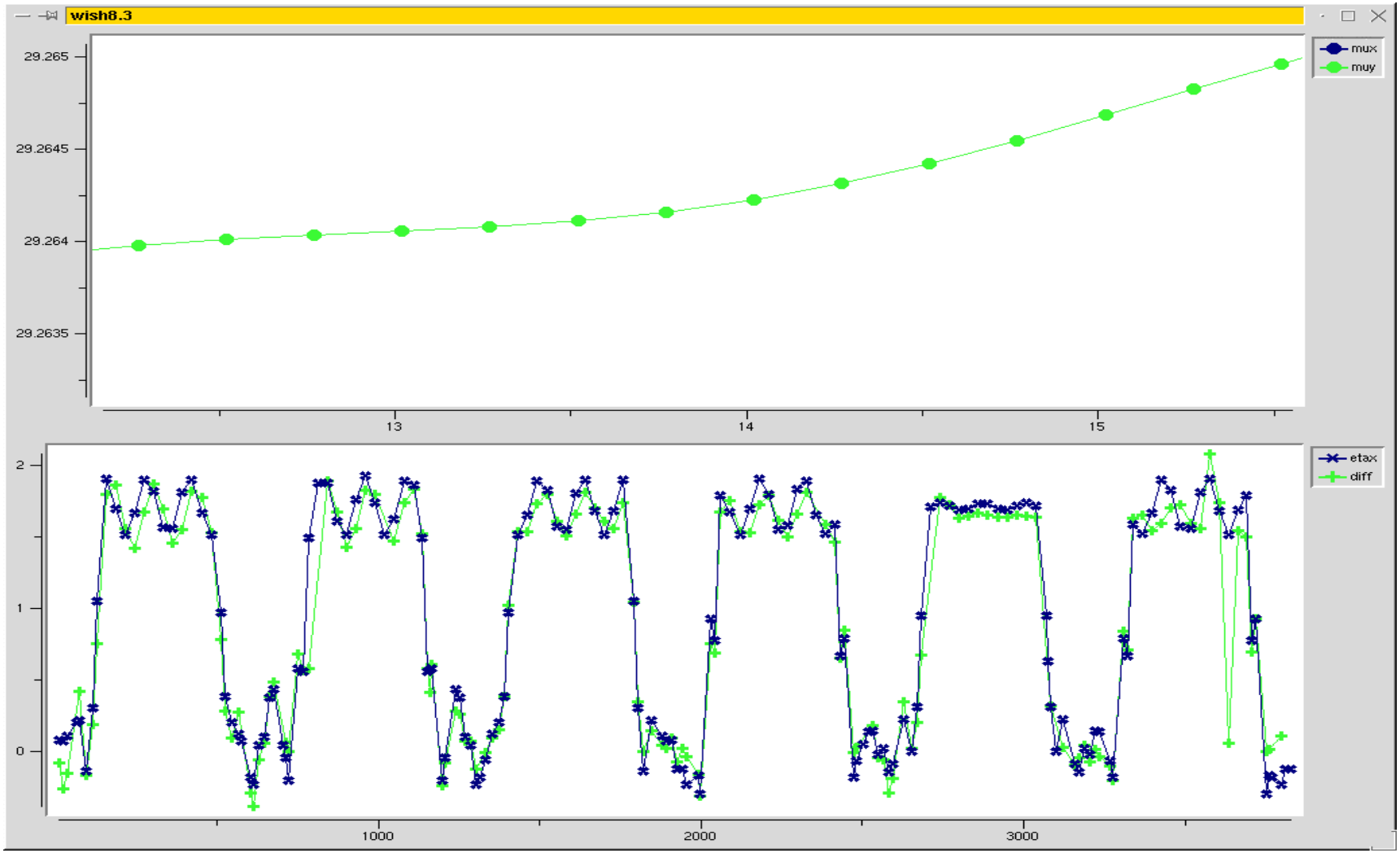
TASKS and COMMISSIONERS

1. AC dipole: Mei Bai
2. RF integration: Johannes van Zeijts and Mike Brennan
3. Open the triplet cryostats? (β^*=1 m?) Fulvia Pilat
4. Transition crossing with gold: Christoph Montag (fast sextupoles,lattice α1, octupoles..)
5. Longitudinal beam instabilities – Mike Blaskiewicz (fast RF-device?,feedback?)
6. Electron Cloud – pressure bump – S. Y. Zhang and Dick Hsueh (solenoids, chambers).
7. 110 bunch operation – Wolfram Fischer (kicker improvements?).
8. Software IMPROVEMENTS: New Programs and existing programs (Todd Satogata and John Morris)
9. Deuteron-Gold preparation – Kip Gardner
10. Transverse damper – Angelika Drees
11. Beam-beam effect: Wolfram Fischer
12. Quadrupoles' gradient errors and fix? Vadim Ptitsyn
13. Mechanical oscillations fix? Christoph Montag
14. Ramp editor update β^*=3&10 m at transition – Johannes van Zeijts
15. Rebucketing – Mike Brennan
16. Beam profile measurements? Roger Connolly
17. IP nonlinear corrections – Fulvia Pilat
18. Decoupling – Fulvia Pilat
19. Tune and chromaticity FEEDBACK – Pete Cameron
20. Permit Link Improvement requests: George Ganetis
21. Collimation and gap cleaning – Angelika Drees
22. Decapoles – for the 0.2 resonance correction- V. Ptitsyn
23. Spin ROTATORS commissioner: Waldo MacKay
24. Aperture problems: Mei Bai
25. RF integration: M. Brennan, Johannes van Zeijts.
26. New instrumentation: (P. Cameron).
27. Magnetic measurements (W. Fischer).
28. Emittance blow up and growth – Steve Tepikian
29. RHIC Accelerator Physics Experiments (F. Pilat)

Agreement with the lattice predictions – Blue beam dispersion function

Agreement with the lattice predictions???

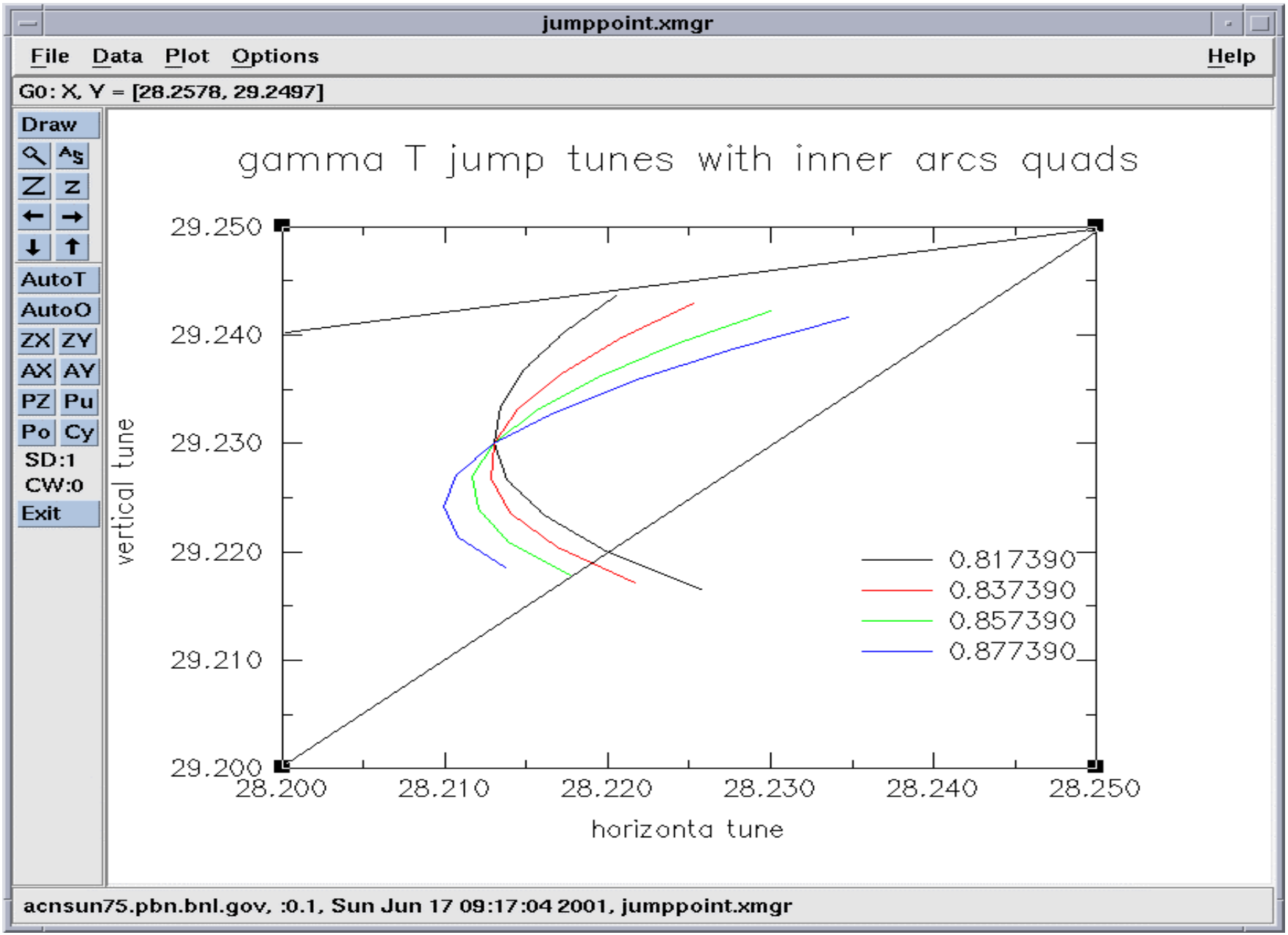
comment by...Johannes -- bi4-qf9-ps bi1-qf9-ps reversed in simulation and tune set to 0.23 0.22 gets this agreement with meas/sim. These ps have -6 amps.



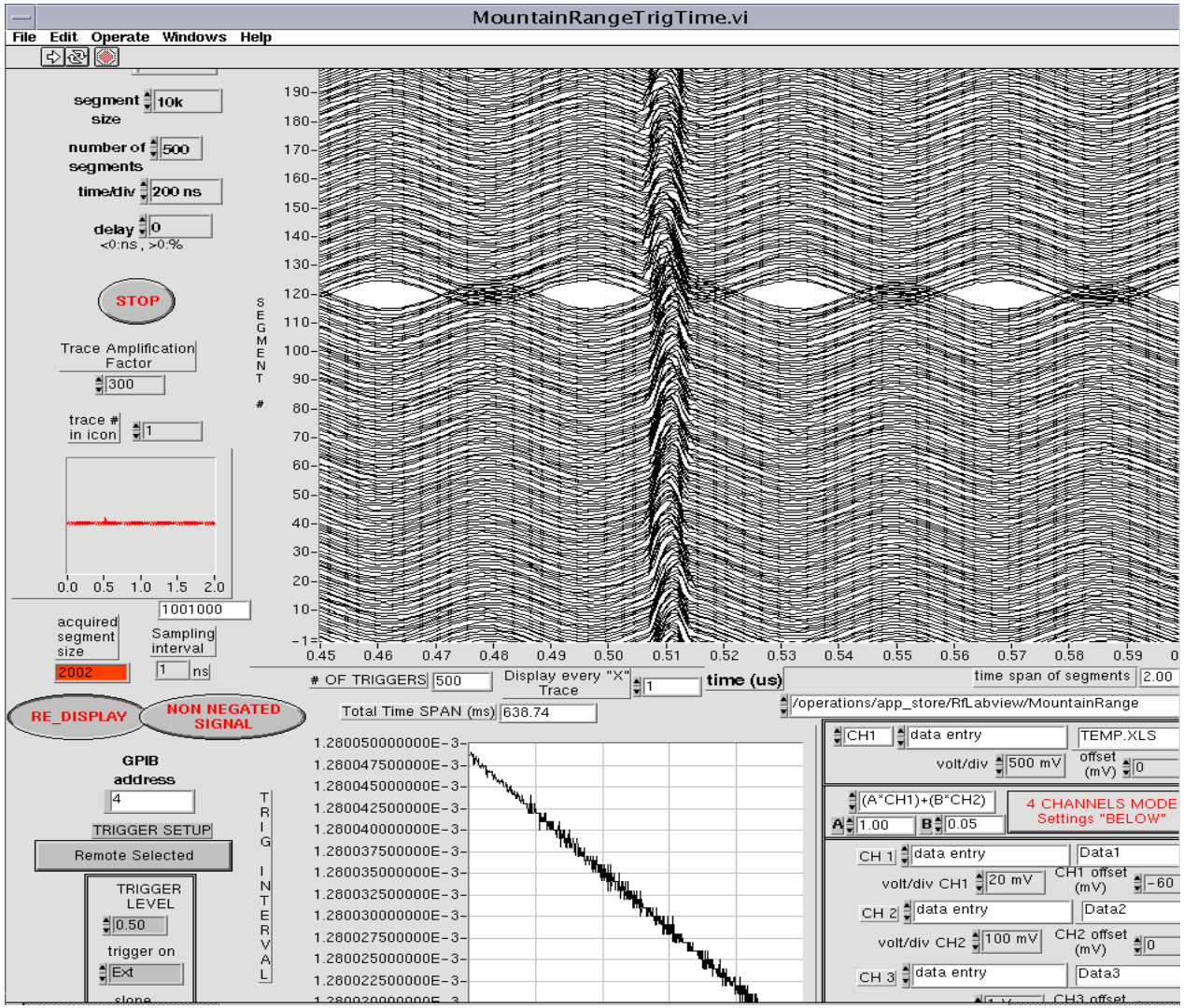
Yellow vertical dispersion

Dispersion in the yellow ring after beta squeeze to 1m

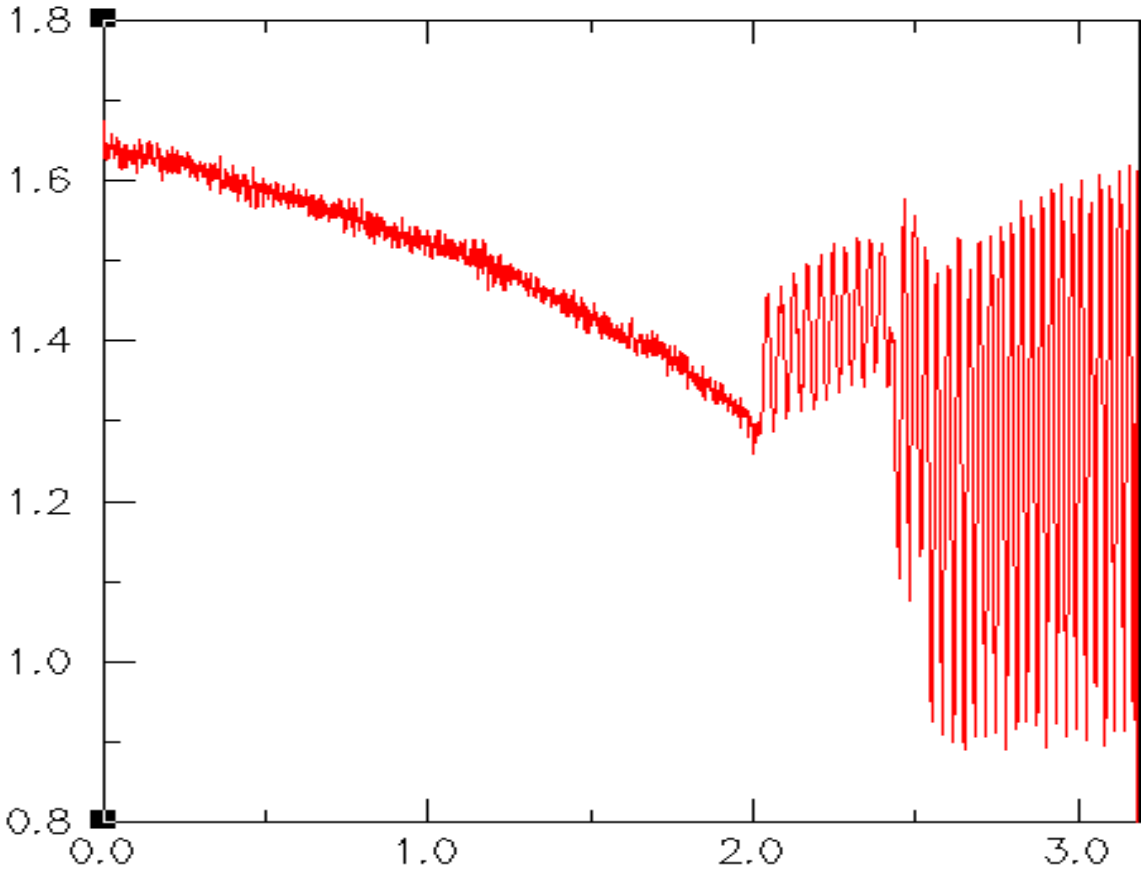
Predictions for the tune changes during the γ_t quad ramping



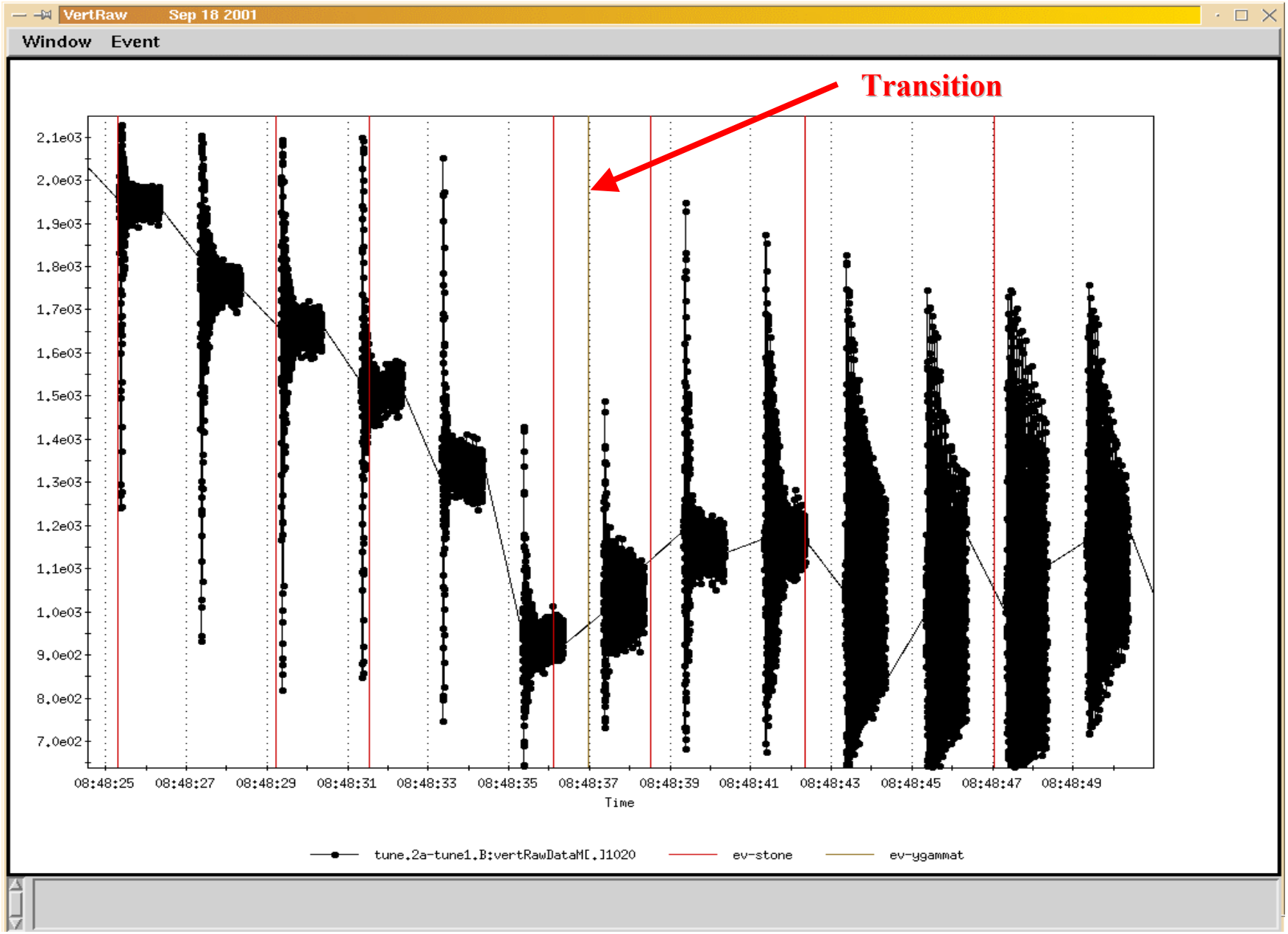
Perfect crossing of a bunch through transition with the γ_t jump



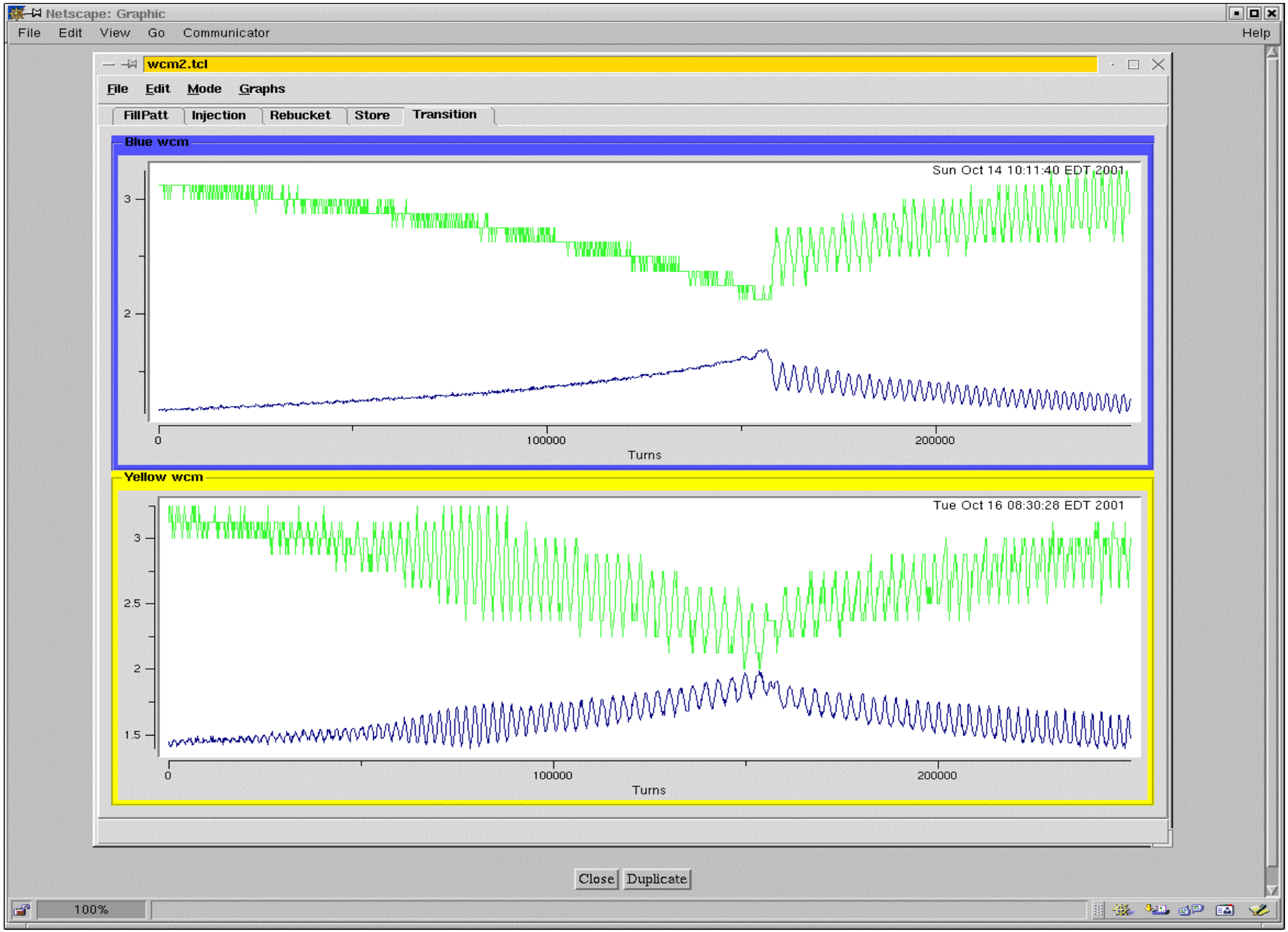
Fast Instability after transition



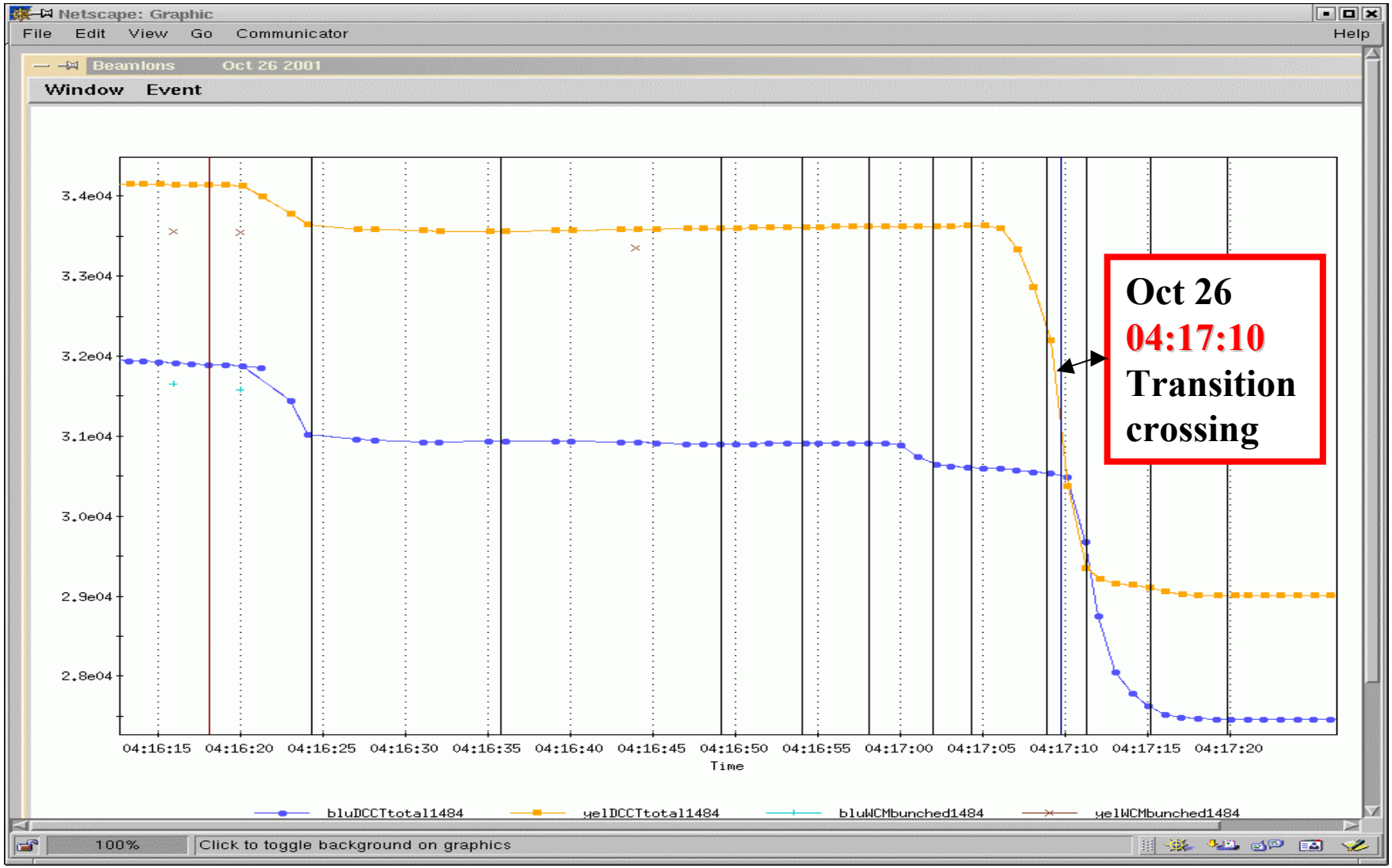
Coherent signal after transition



Longitudinal oscillations of the blue bunch before transition

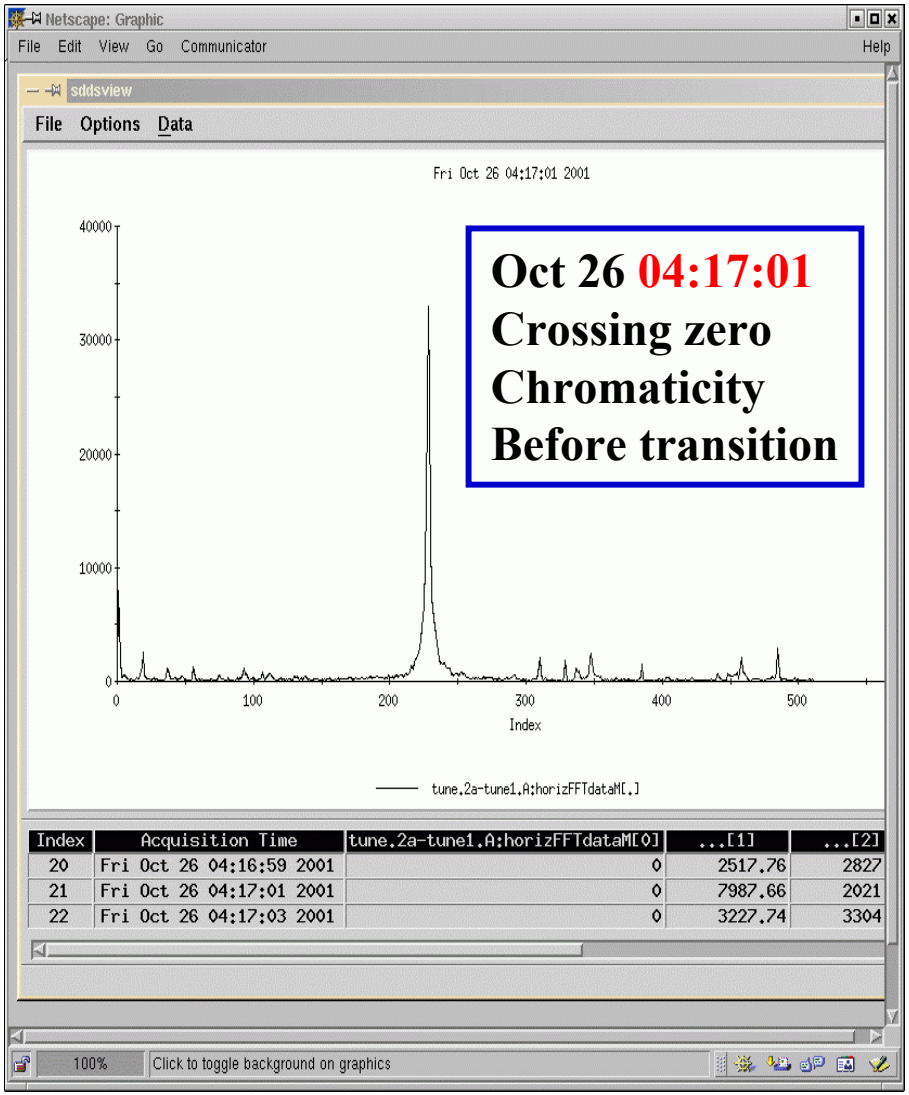


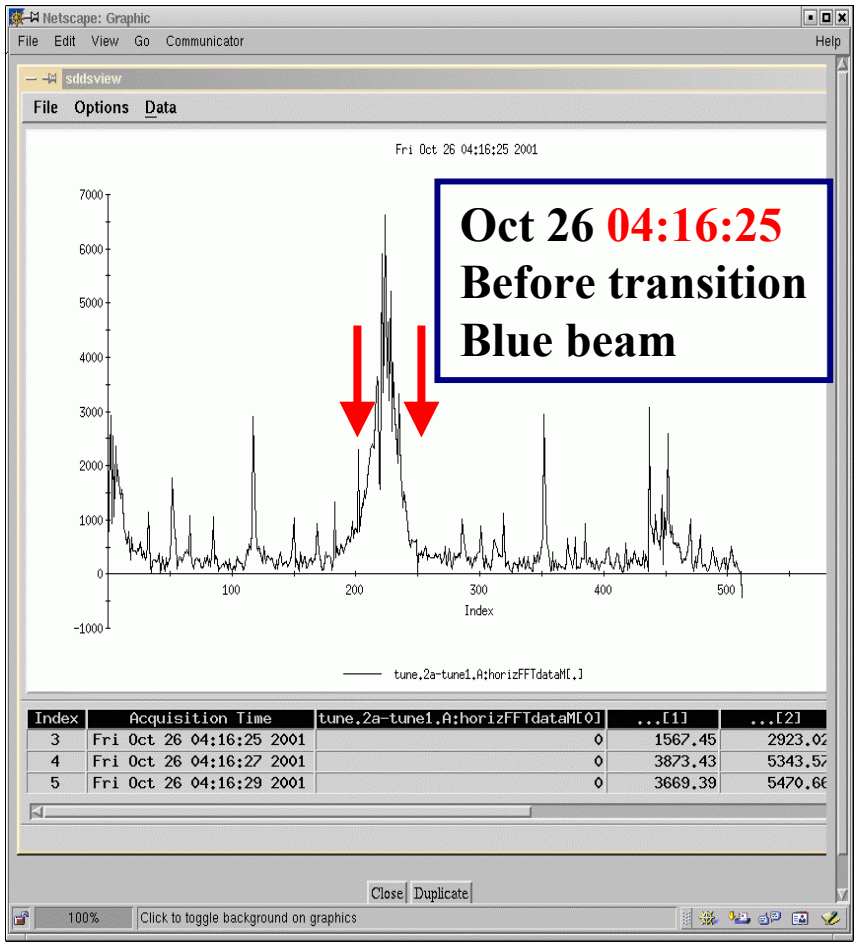
Magnified losses at transition



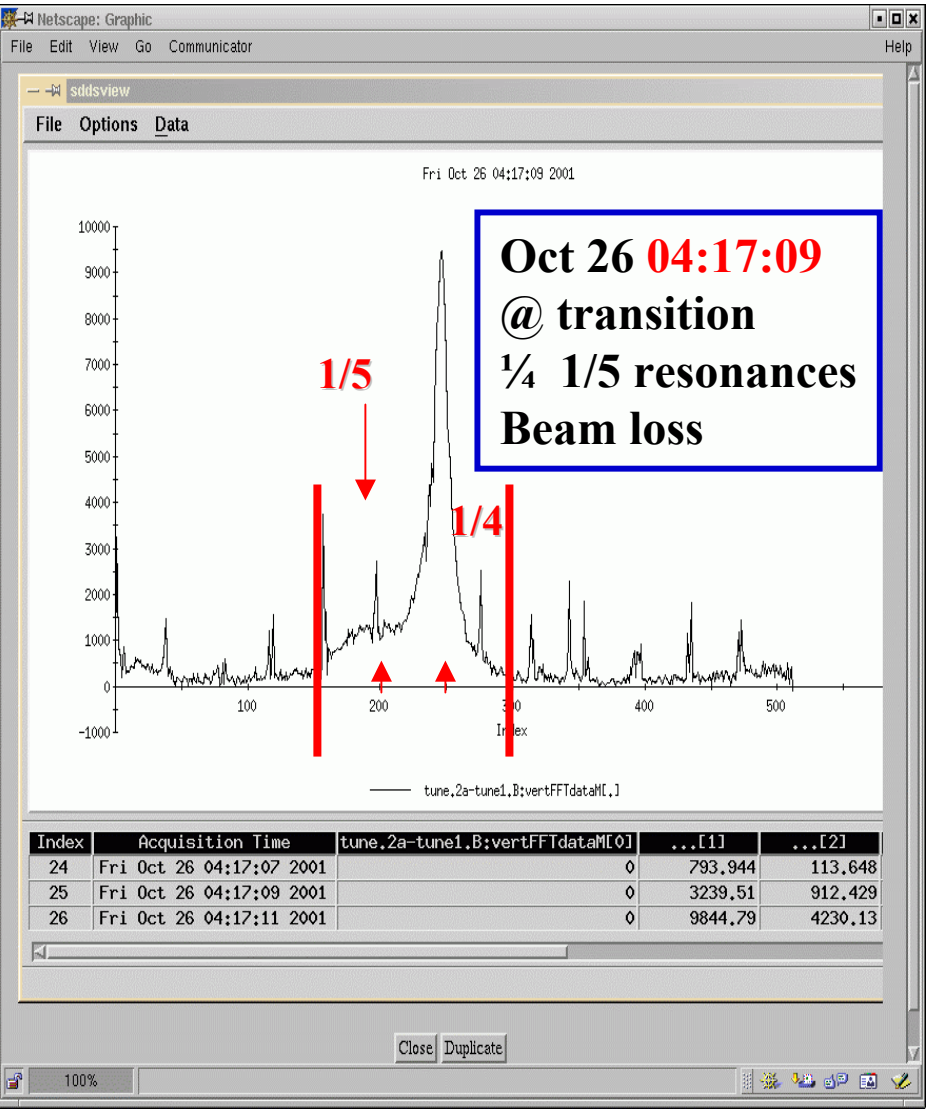
Analysis of the transition crossing - tunes

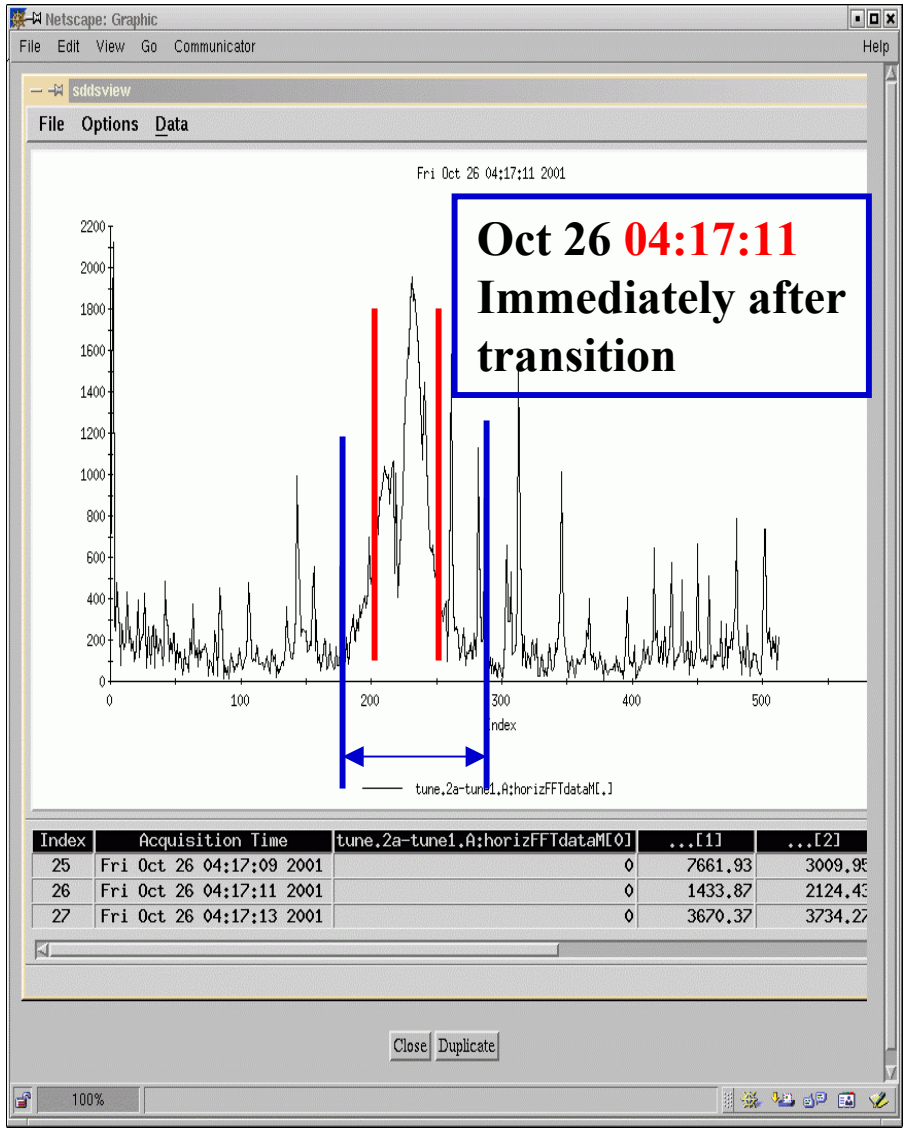
Oct 26 04:17:01





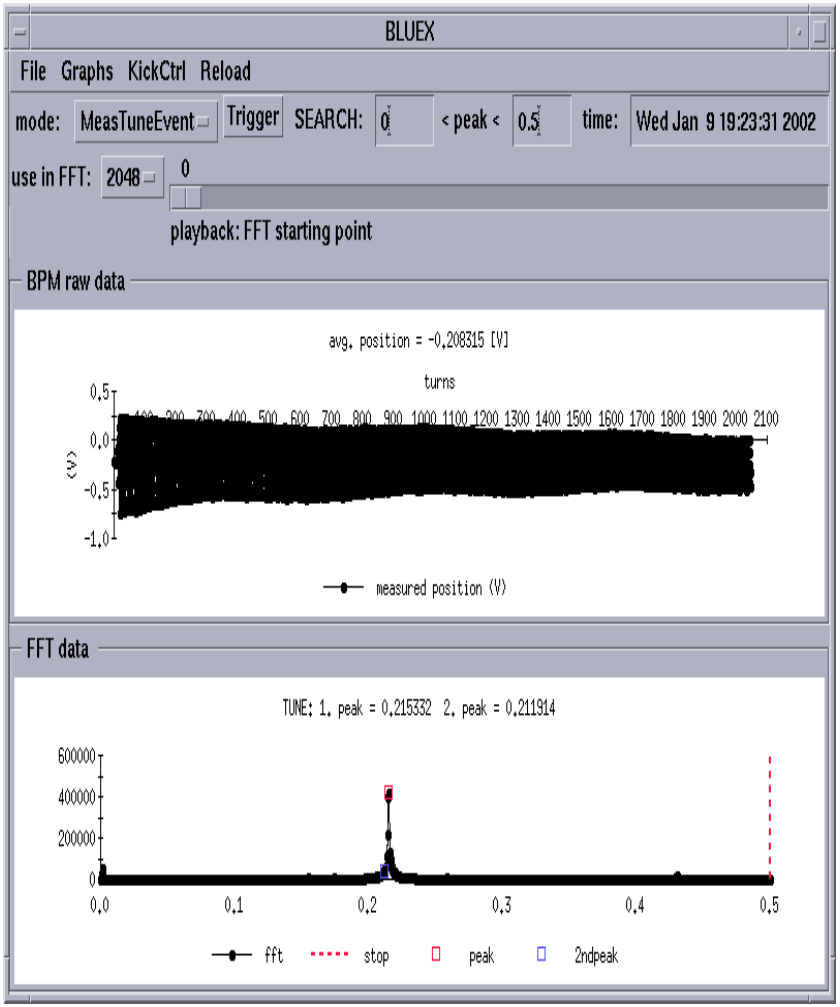
Tunes at transition





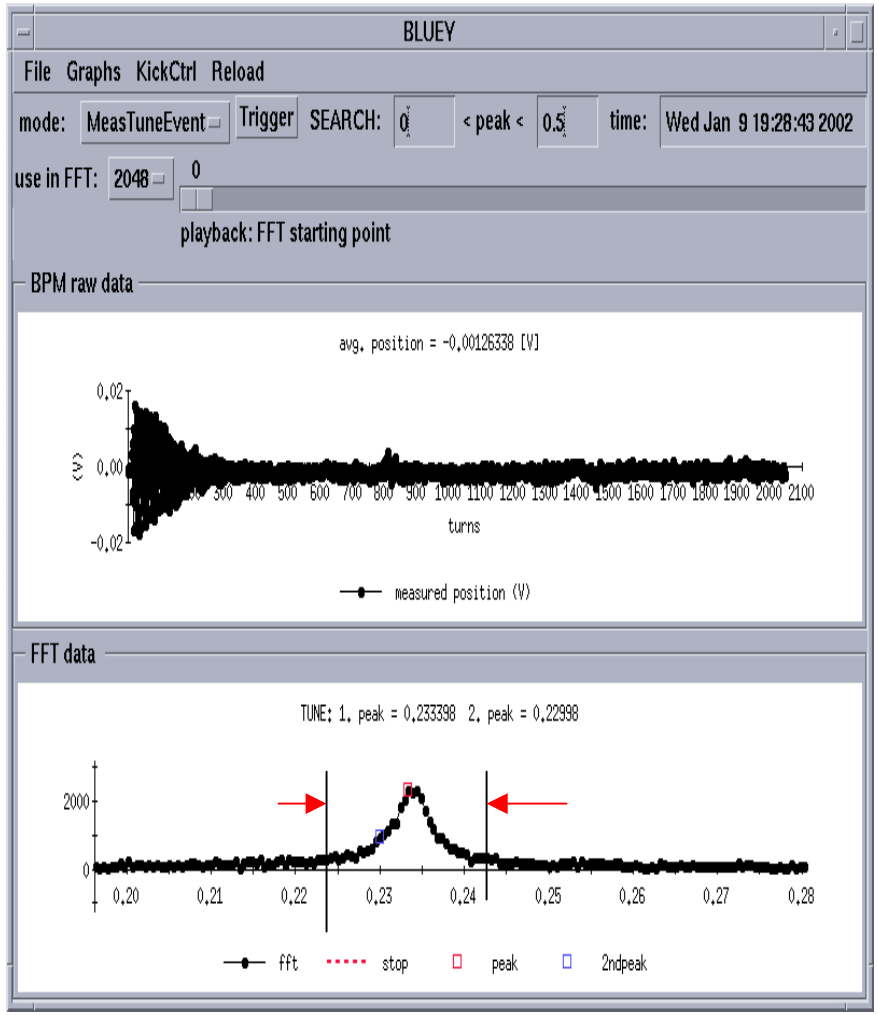
Octupole correction

Octupoles are at zero current
Chromaticity very close to zero

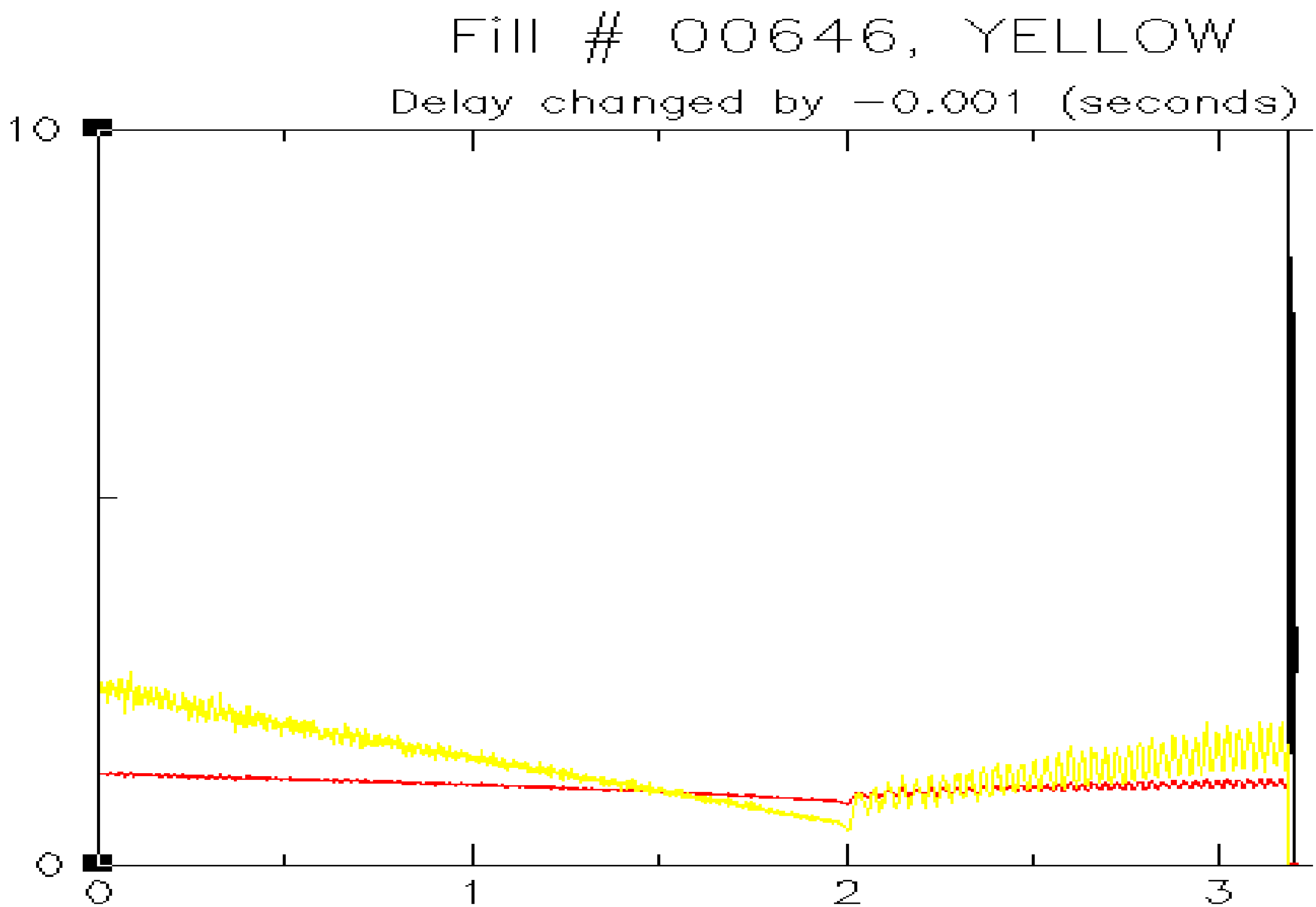


Octupoles are at set at k=–6

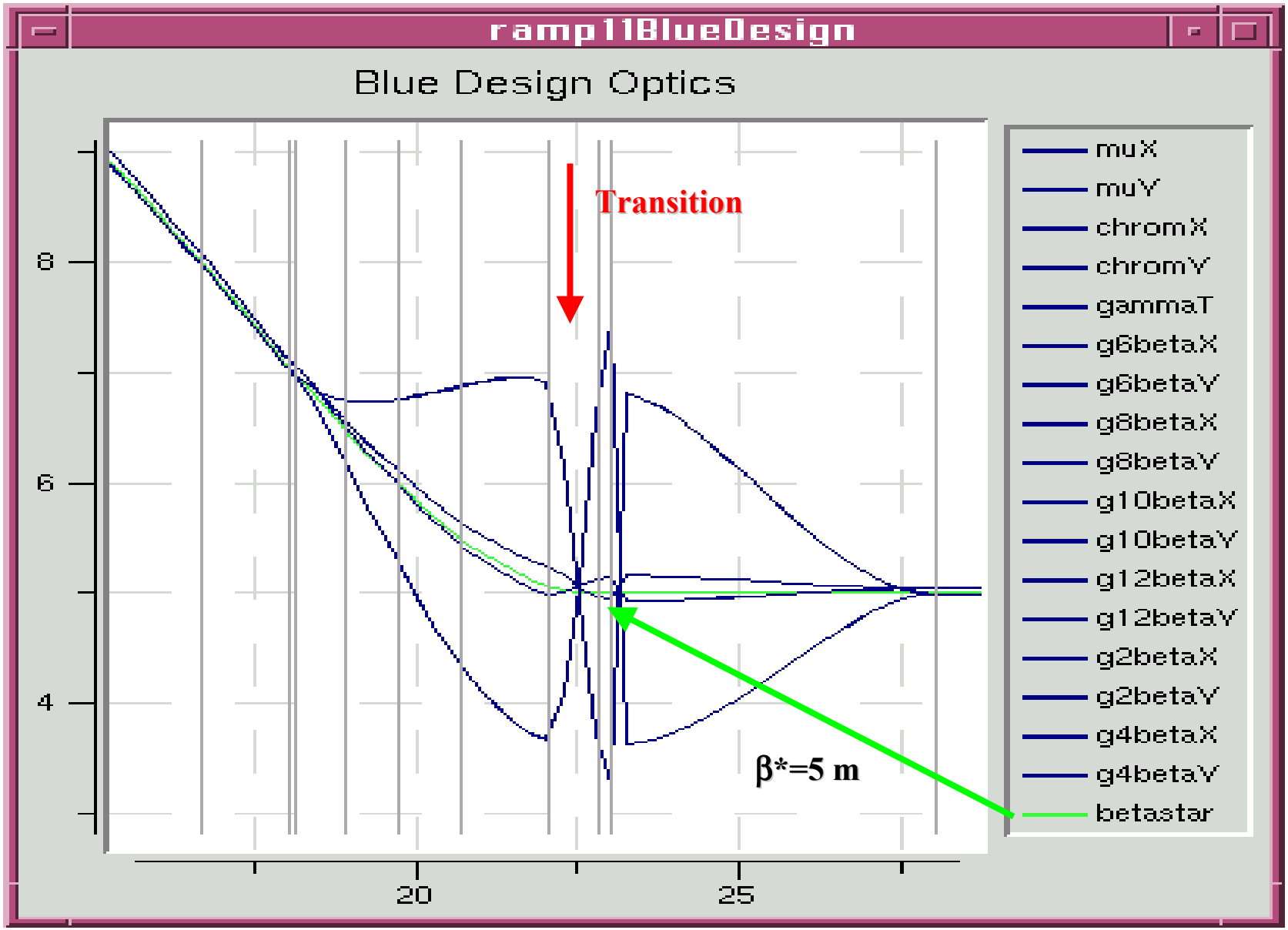
Chromaticity very close to zero



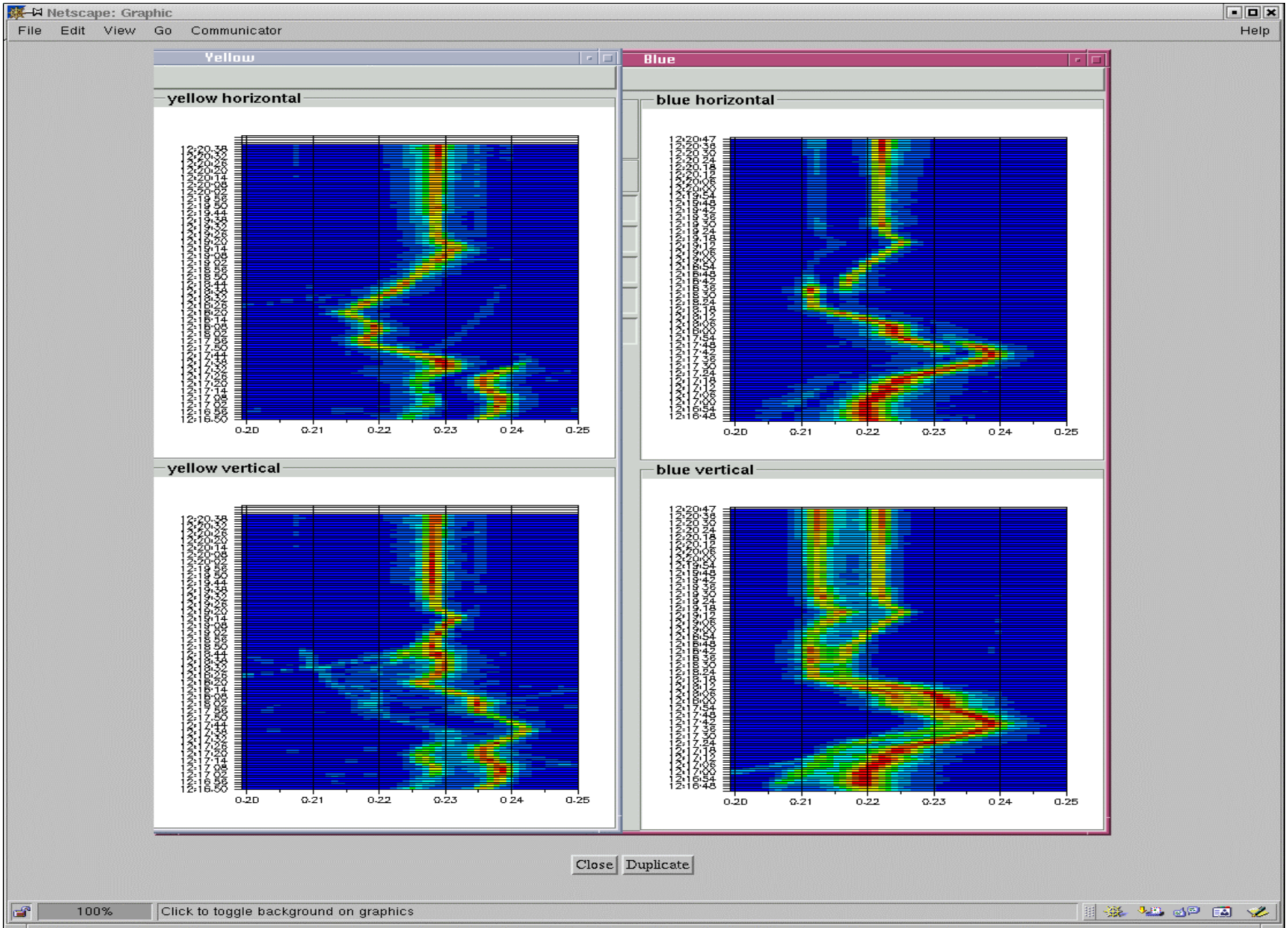
Best matched transition crossing



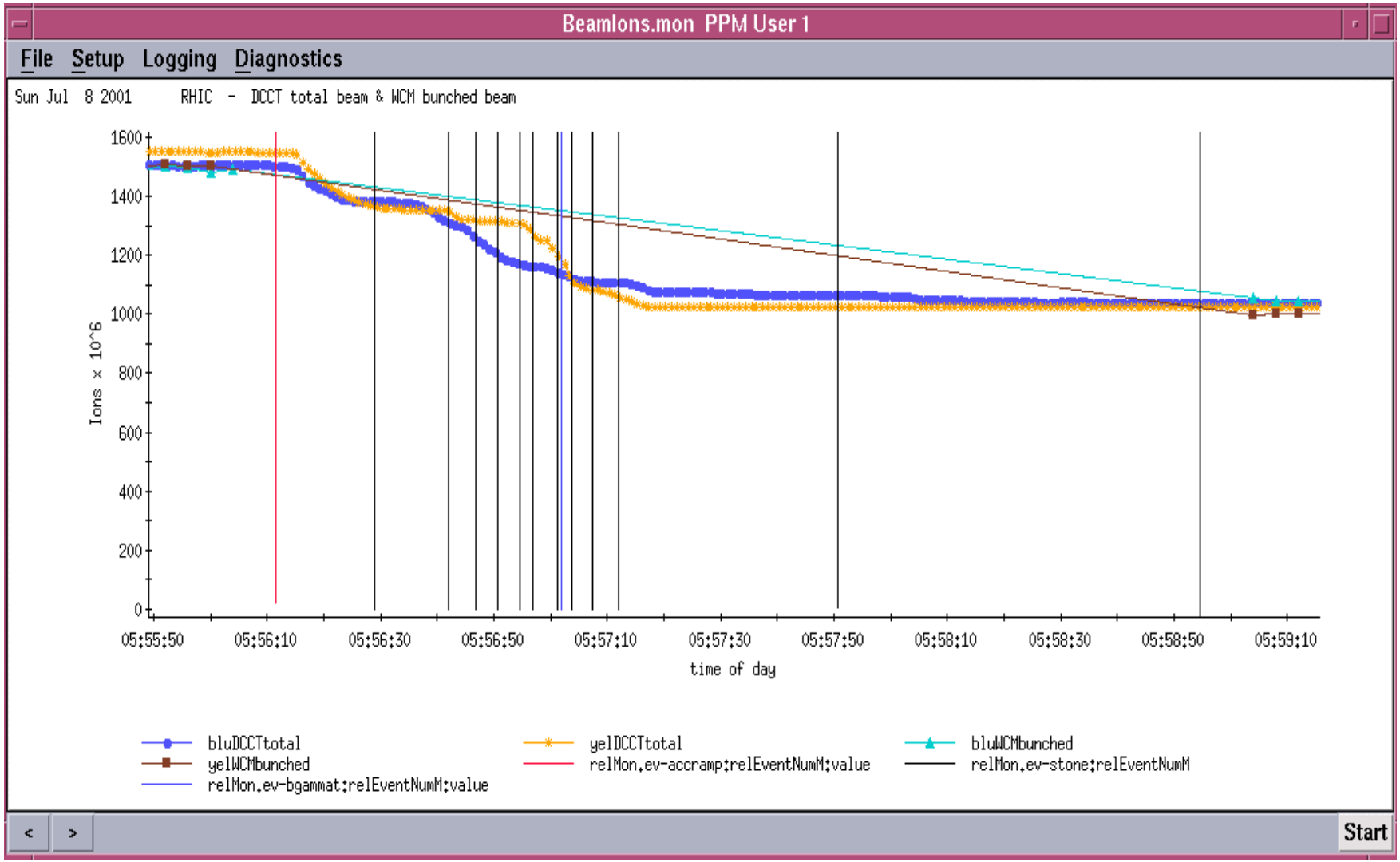
Model Predictions for a transition crossing



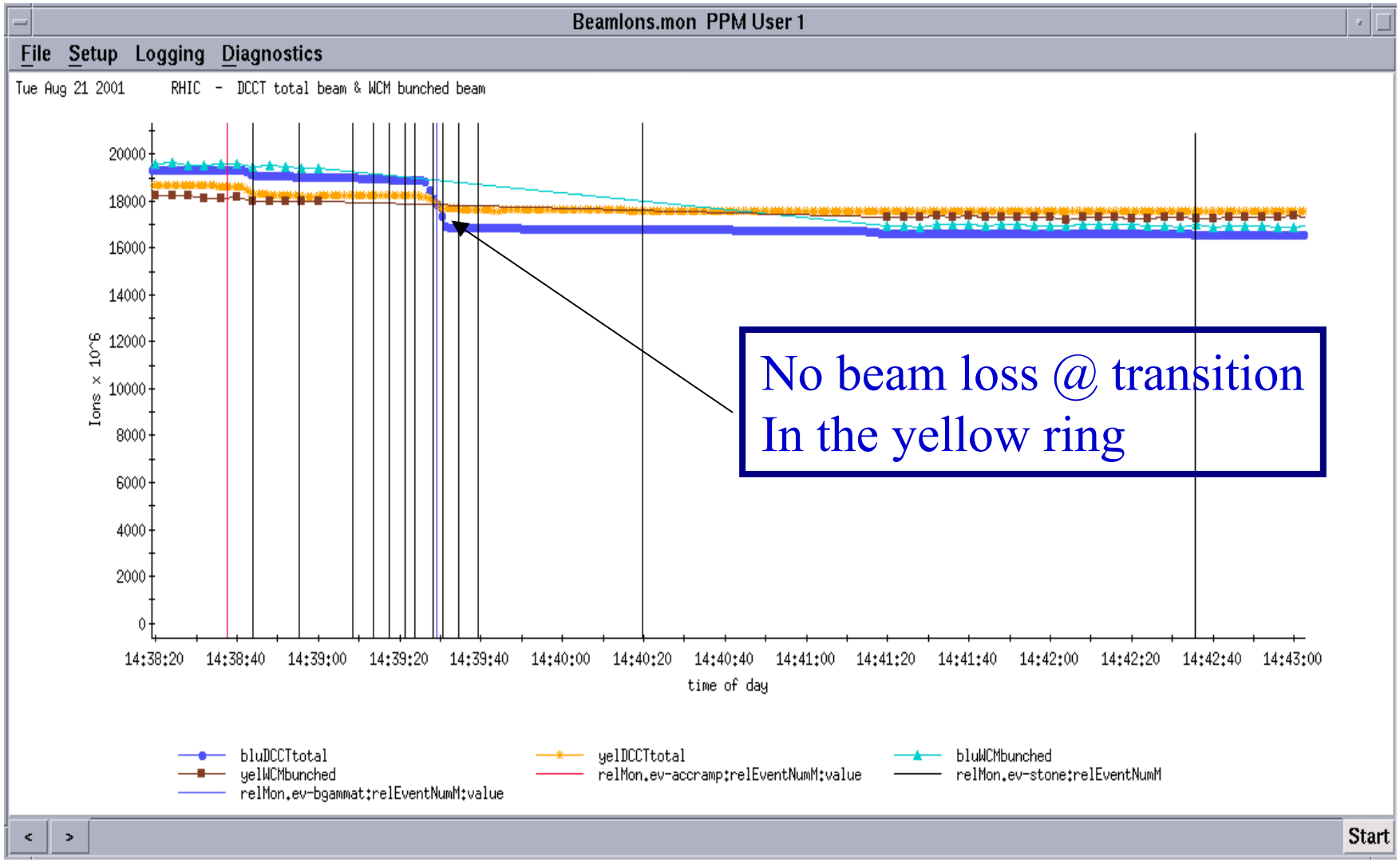
Successful ramp – betatron tunes along the ramp



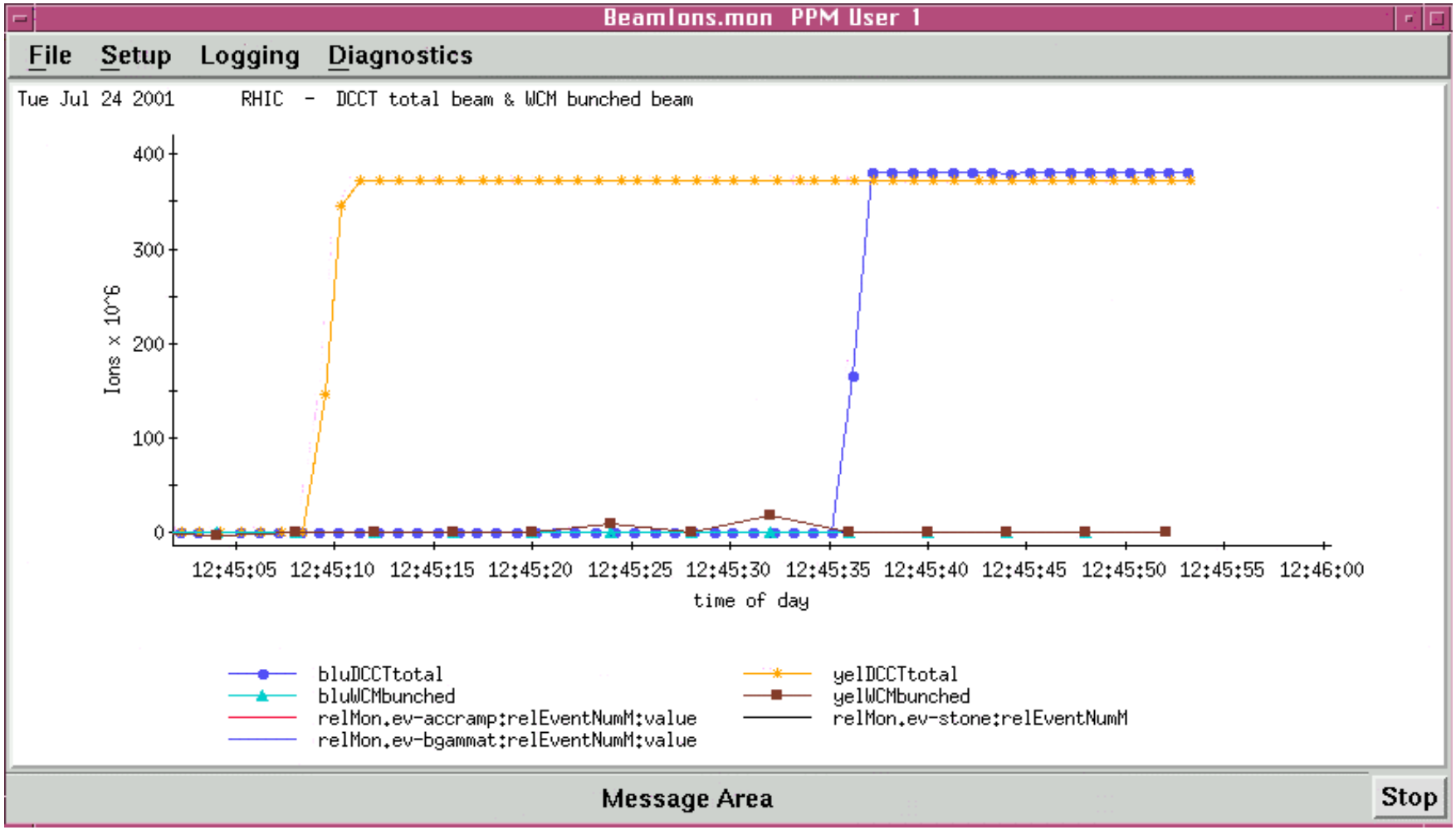
First successful ramp with both beams : July 8, 2001



Efficient ramps in August 2001– Moderate intensitiy 0.33 x 10^9 per bunch

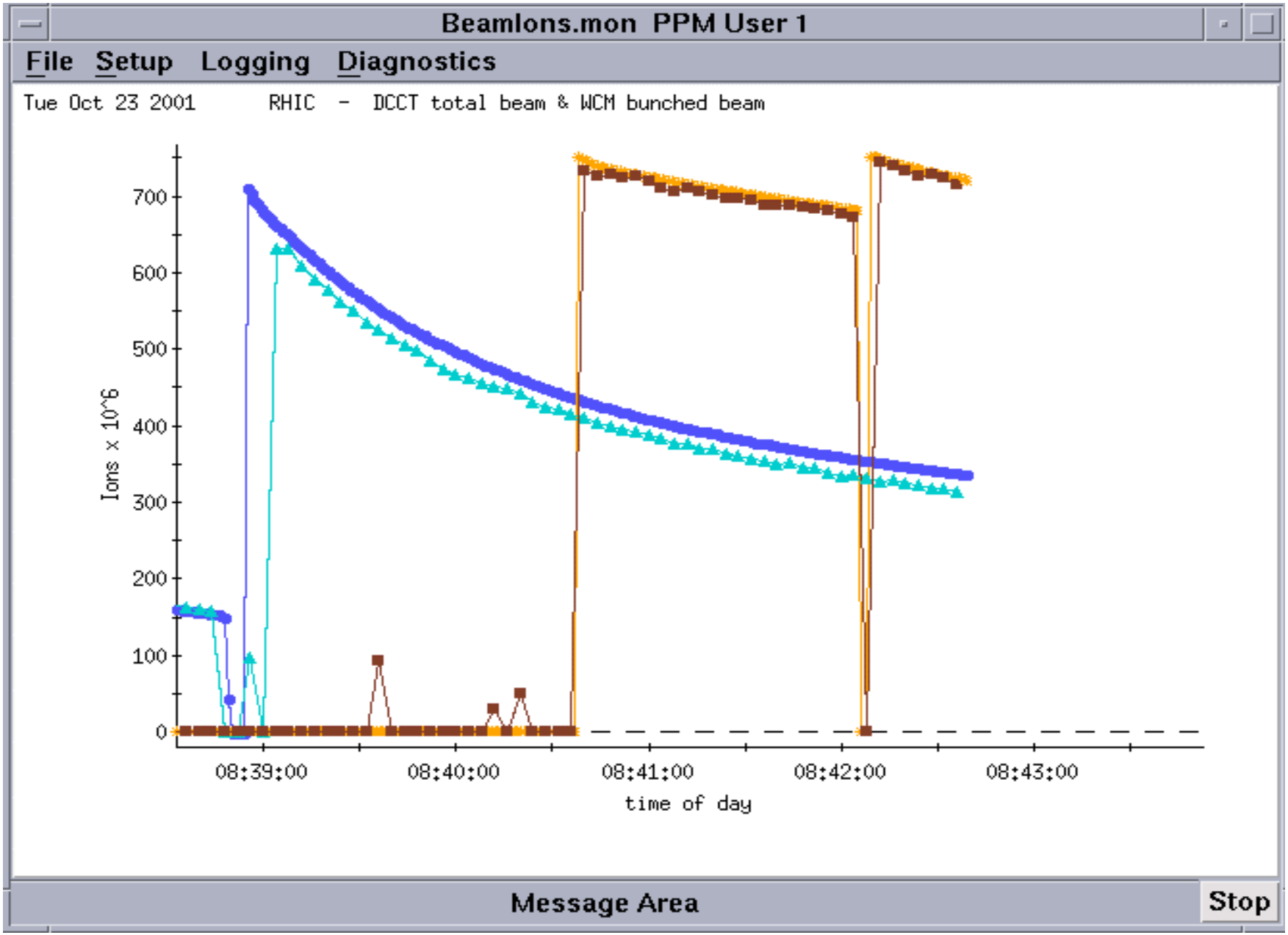


Beams in the blue and yellow beams @ injection – beginning of the run

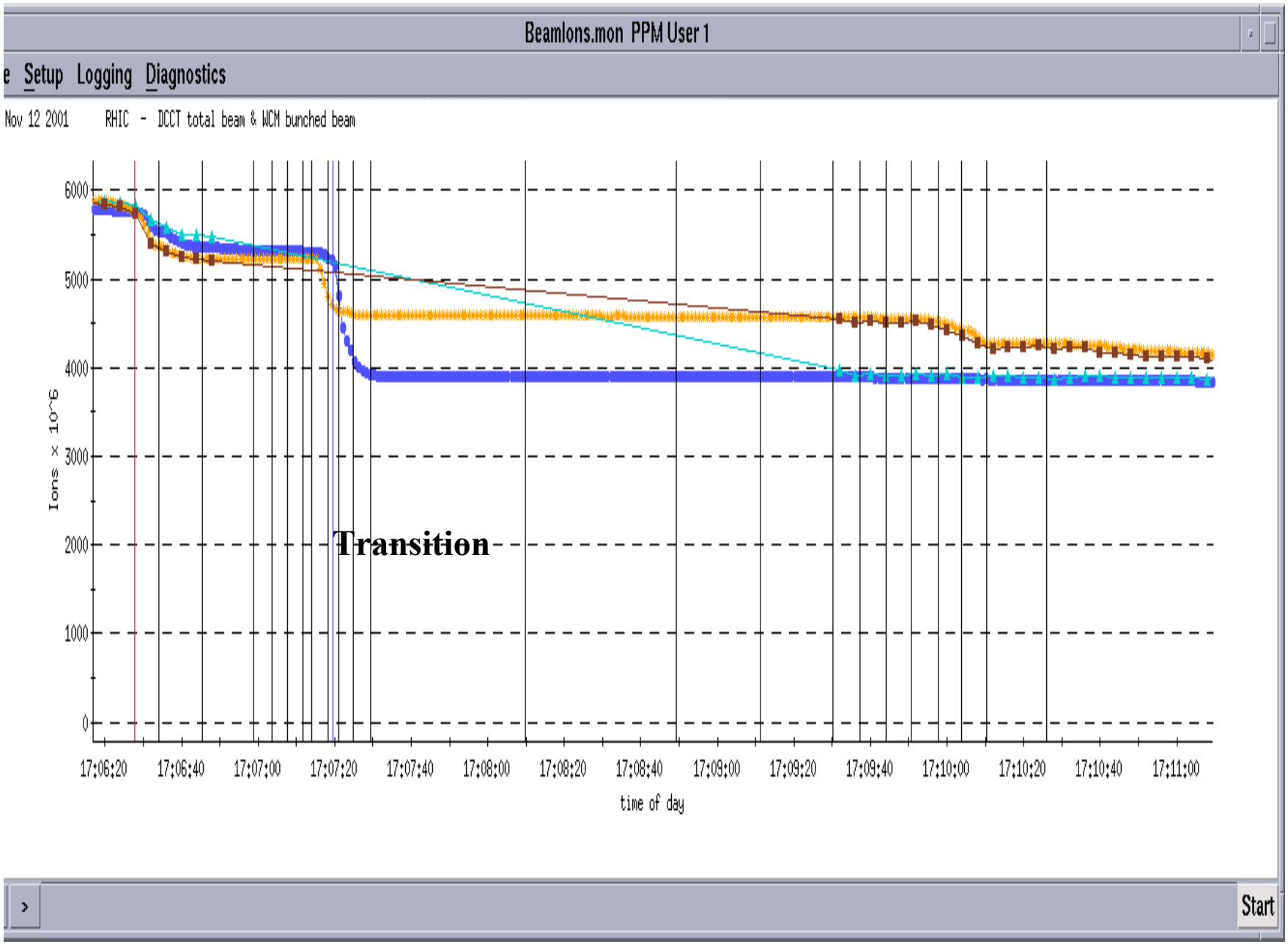


A current per bunch = 40% of the design (July 24, 2001)

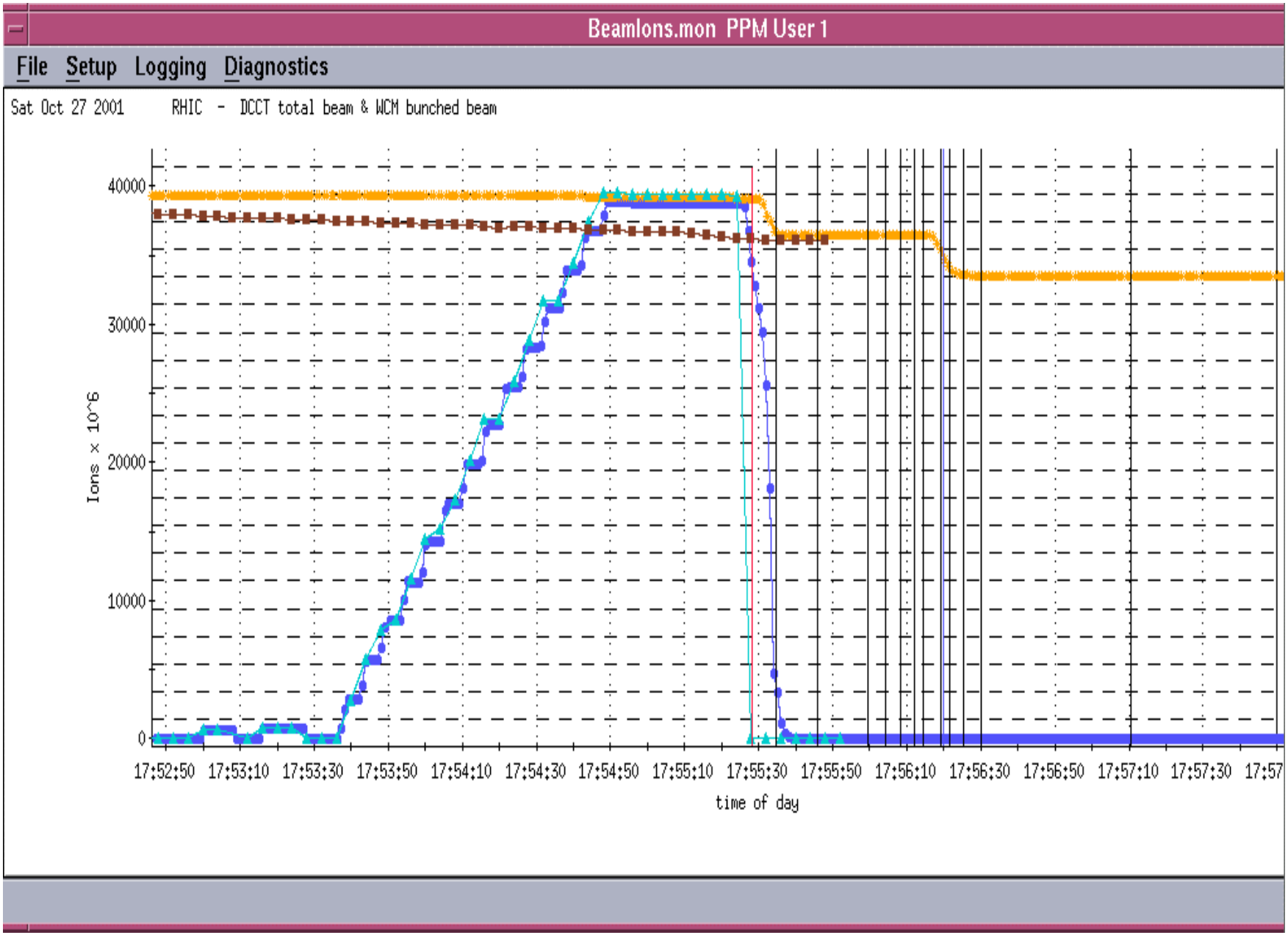
Correcting chromaticities @ injection with 0.7 x 10^9 ions per bunch



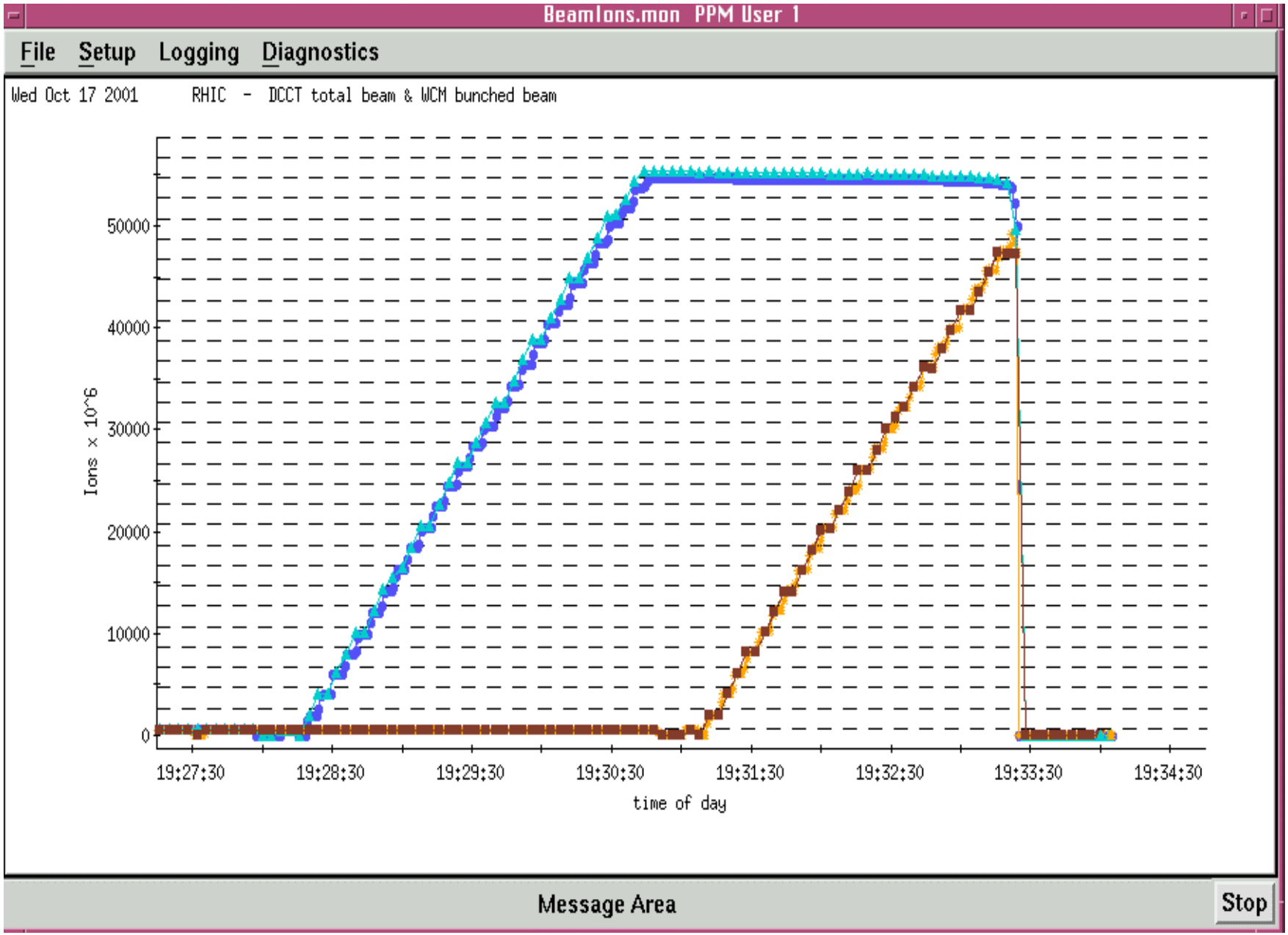
Six Bunch Design Intensity ramp 60 x 10^9 –> 1.0 x 10^9 per bunch



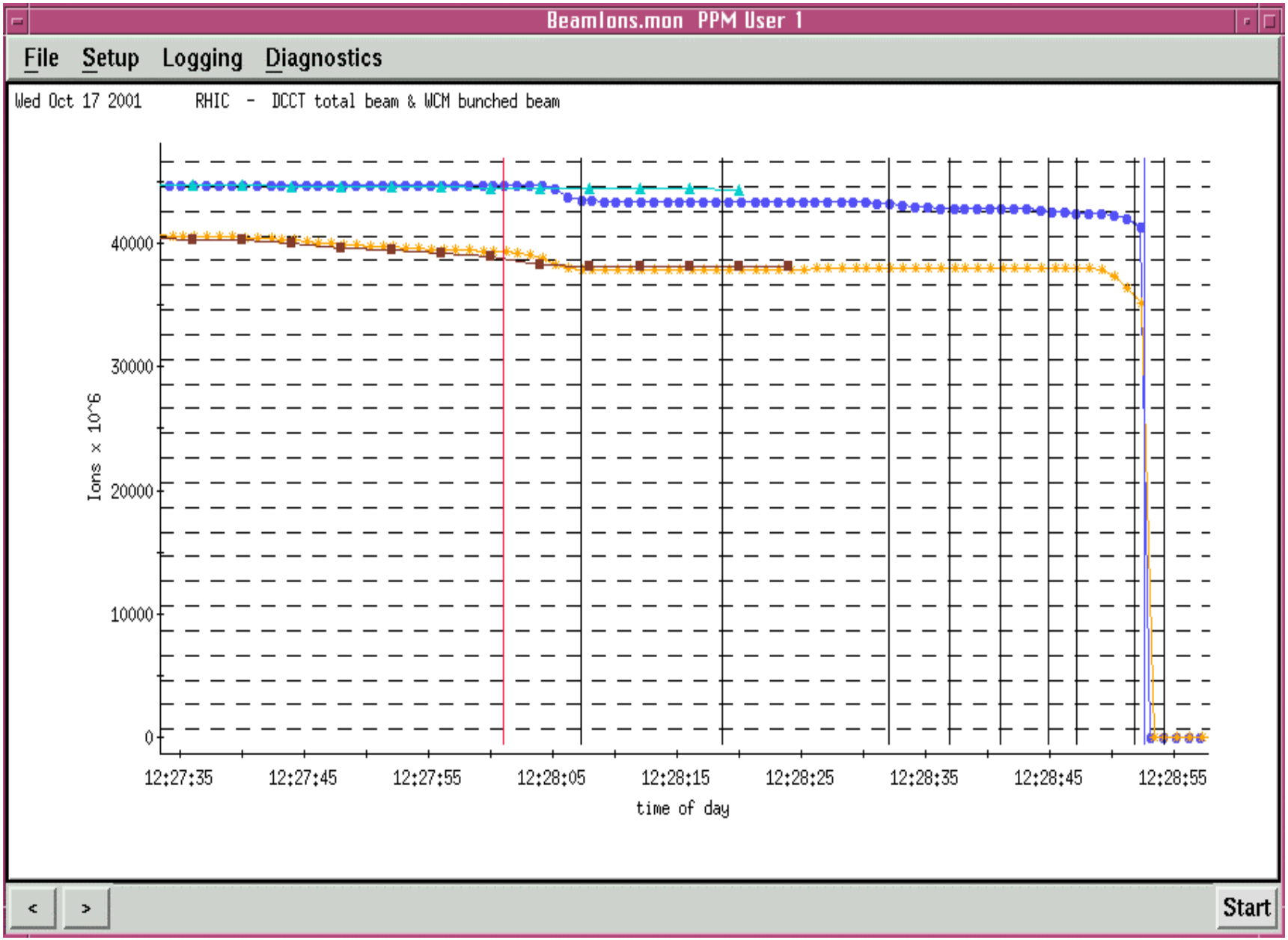
First attempt with $40x10^9$ ions = 0.73×10^9 per bunch



110 bunches vacuum pressure @ injection

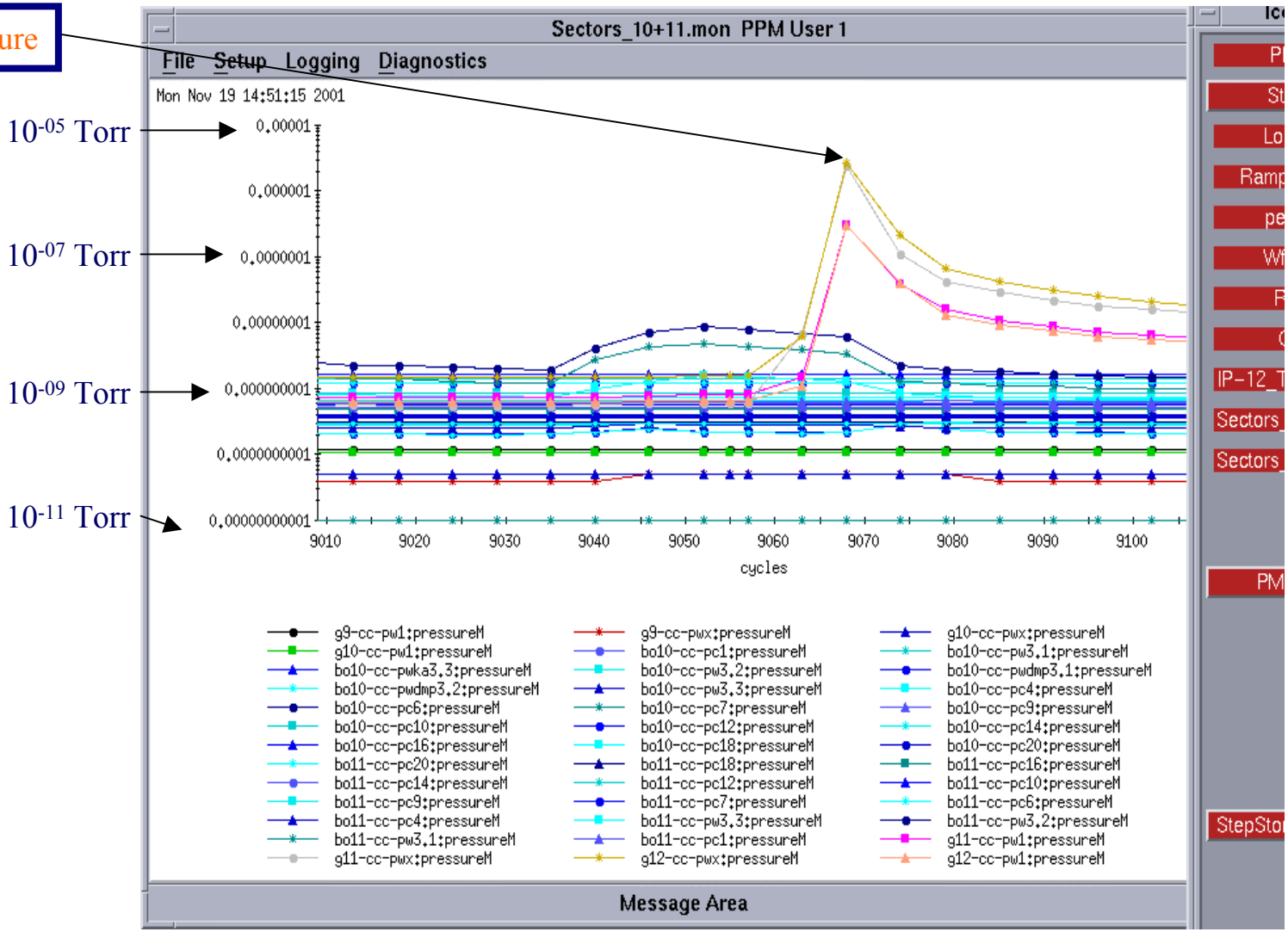


110 Bunches accelerated up to transition

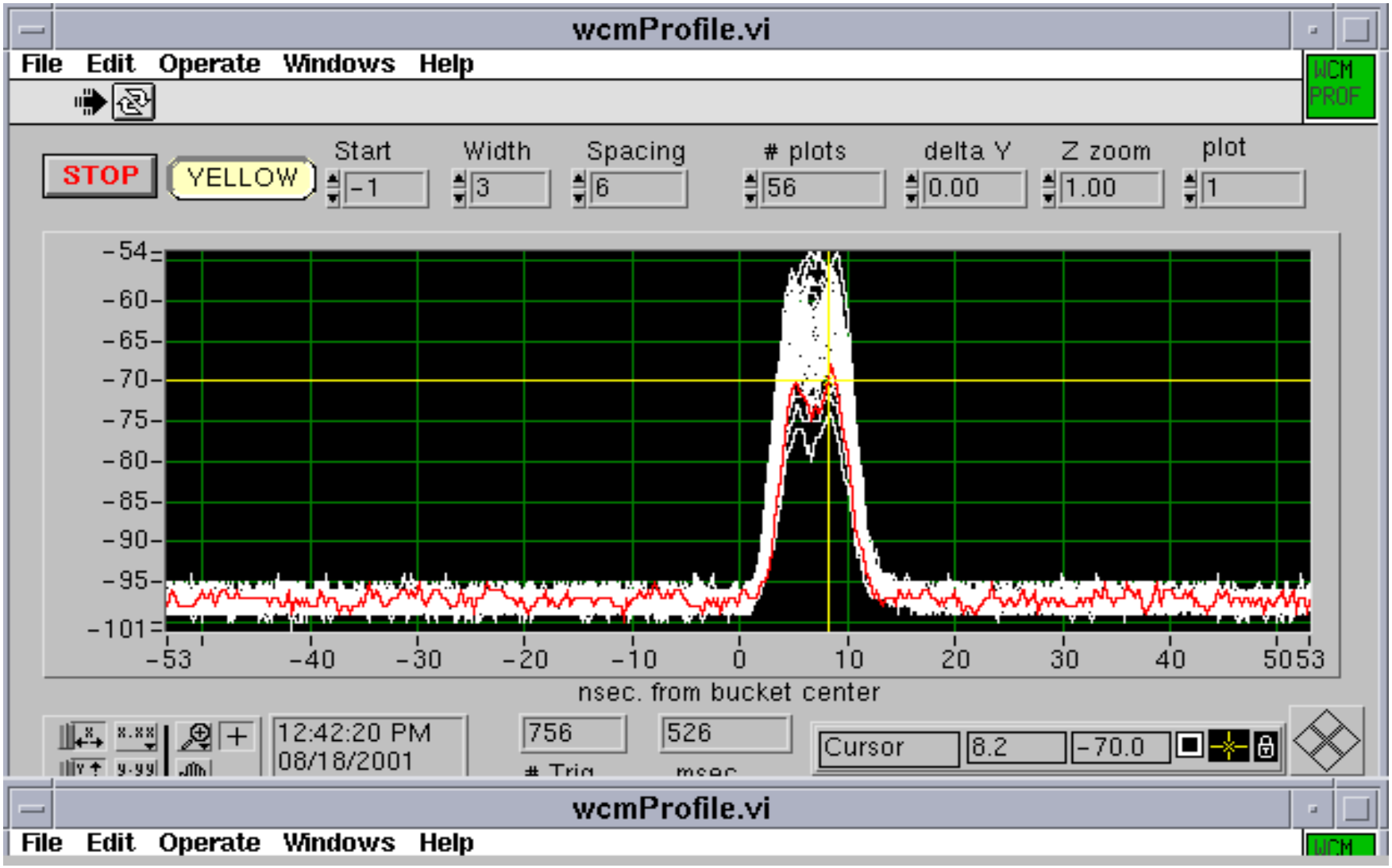


110 Bunches vacuum break-out

G12-cc-pw1:pressure

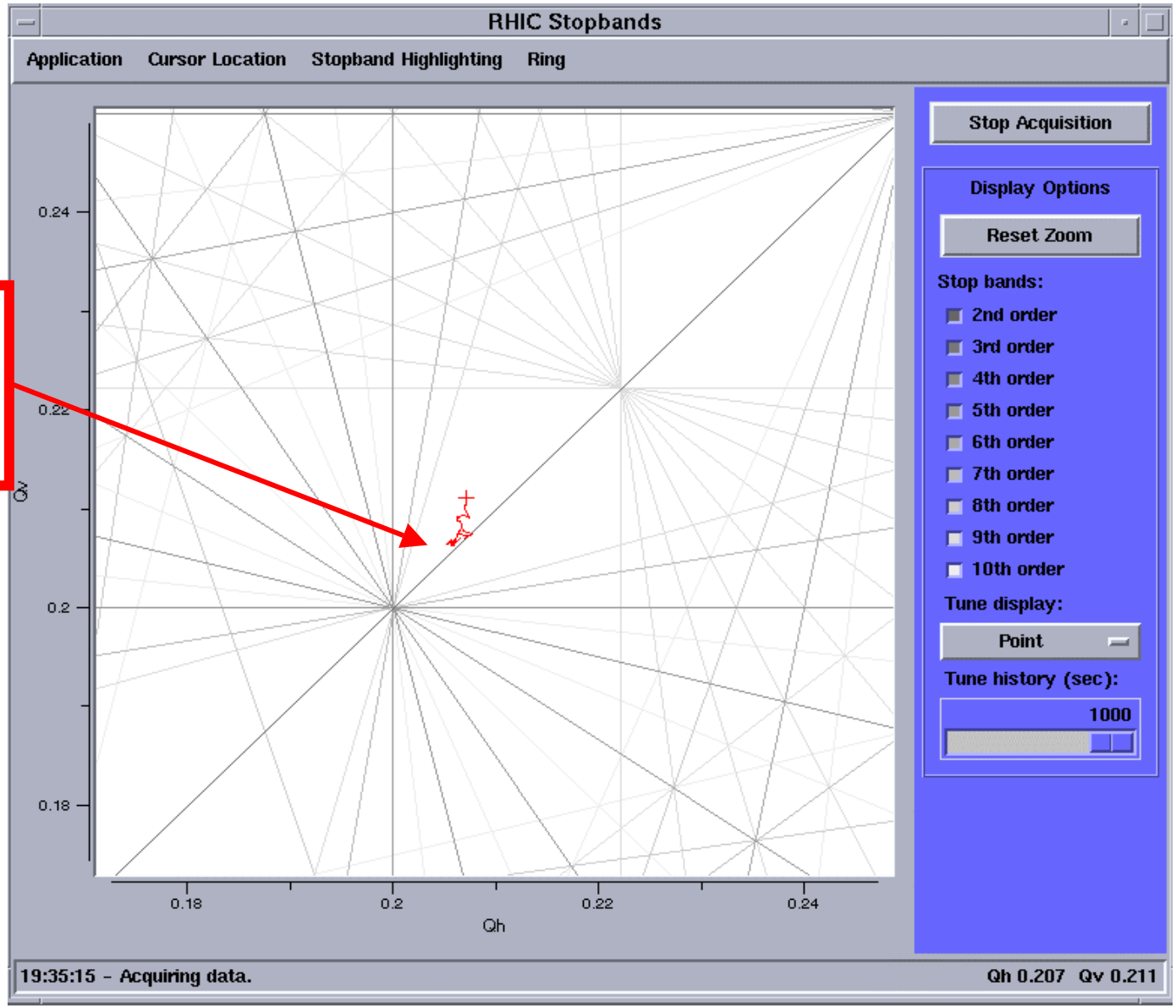


Longitudinal oscillations at injection (avoided later by ‘injection’ matching)

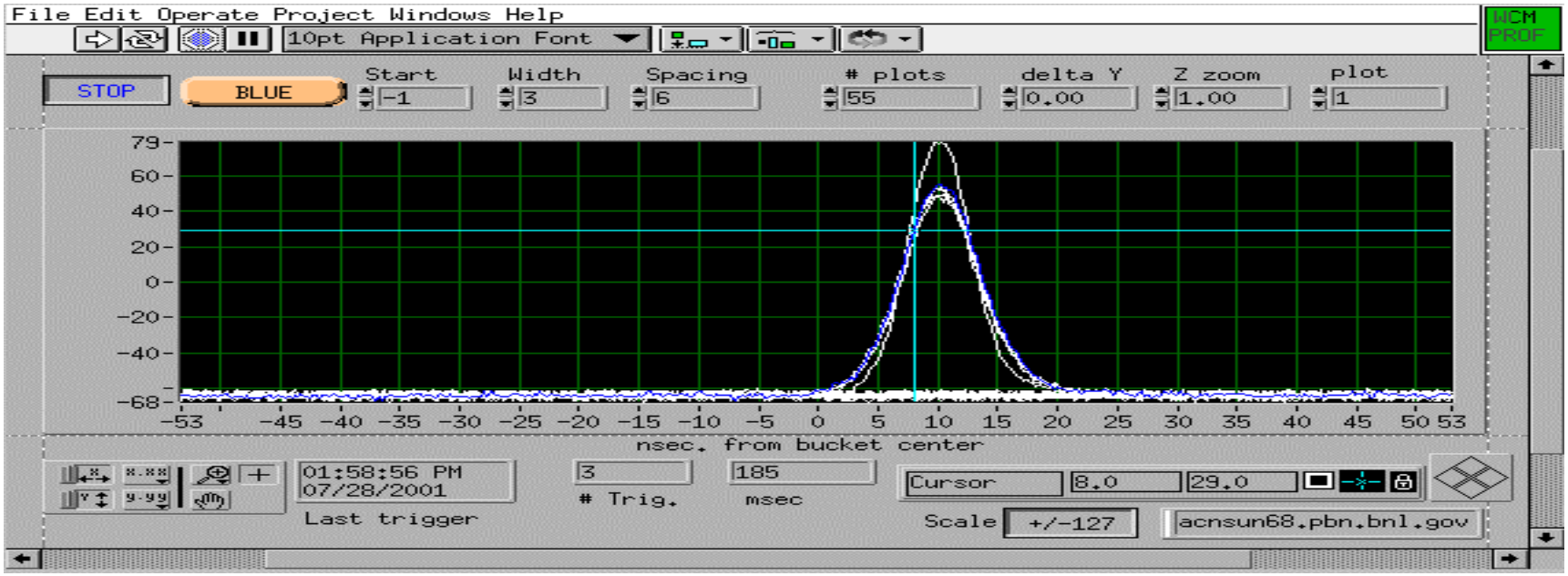


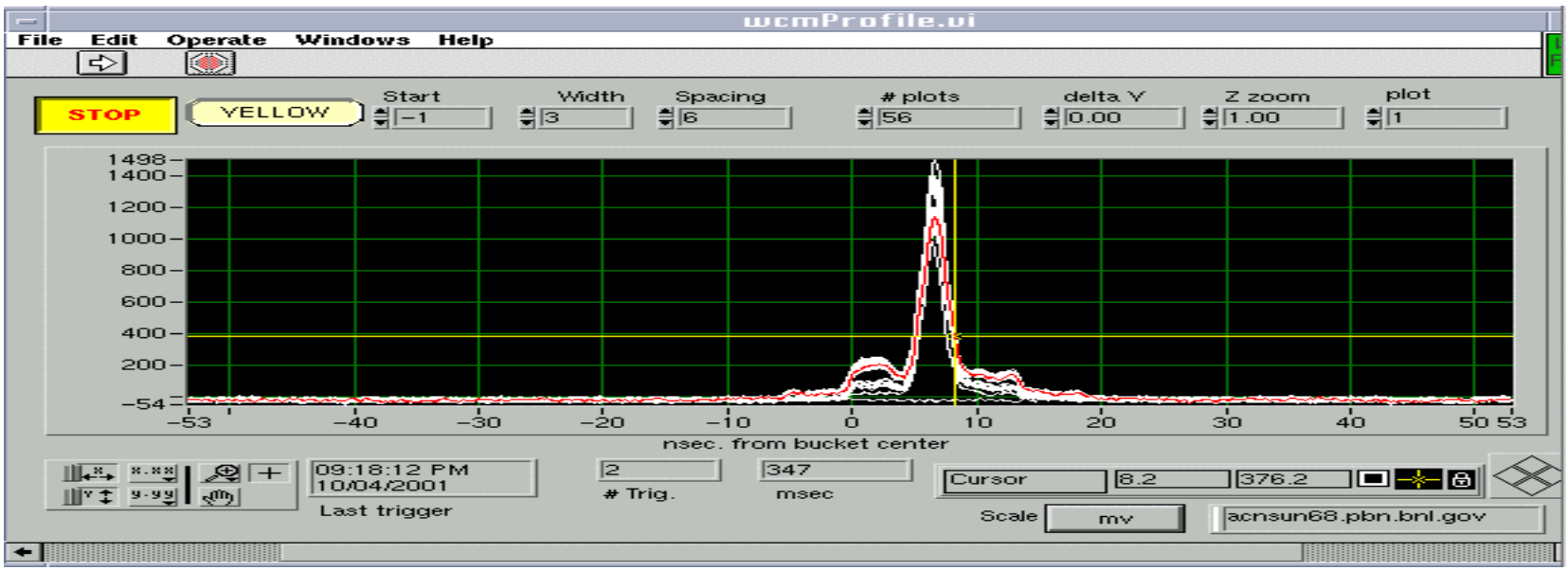
Schottky monitor used @ store to improve the lifetime

The beam life
Time improved
Going away from
The ‘diagonal”



Rebucketing – reducing the bunch length to ~3 ns.





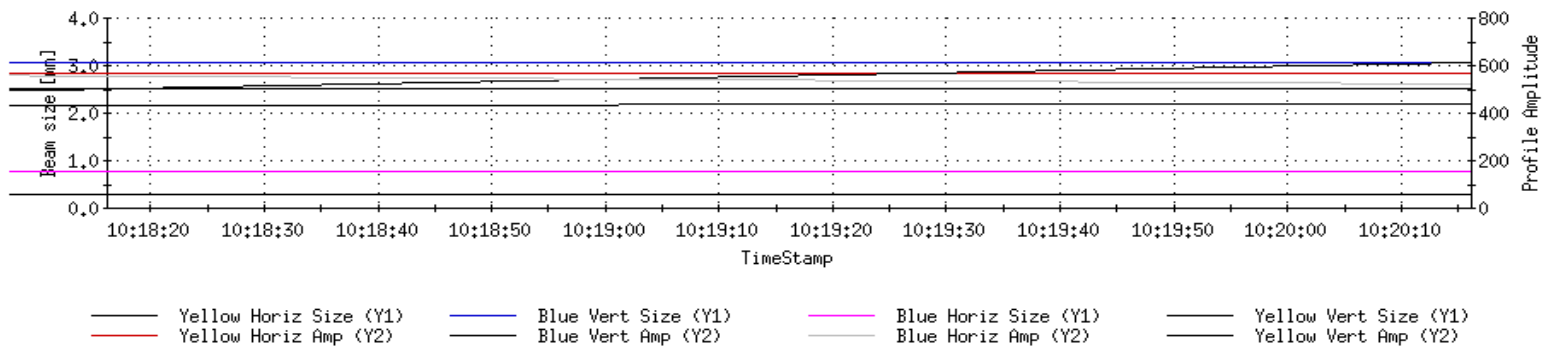
IPM results after steering beams around them

Rhic Ionization Profile Monitor

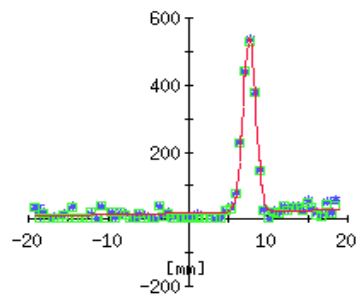
File View Setup Help

Function	Horizontal	Vertical	Horizontal	Vertical
Time-stamp	Nov 02, 10:20:16	Nov 02, 10:20:16	Nov 02, 10:20:16	Nov 02, 10:20:16
Turns Interval	1	1	1	1
Emittance [pi*mm-mrad]	0.0643754	0.0368784	0.00887613	0.0247637
Norm-Emit [pi*mm-mrad]	41.4802	23.7626	5.71932	15.9565
Sigma [mm]	0.785381	3.05156	0.288163	2.50059
Center [mm]	7.68615	-3.69371	-0.764872	-1.17202
Amplitude	520.027	613.092	567.066	441.298

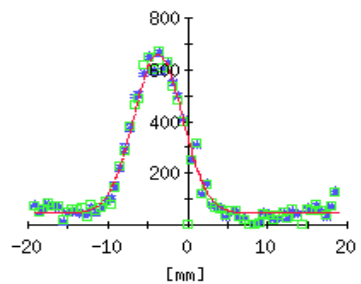
Beam Sizes [mm] and Profile Amplitude



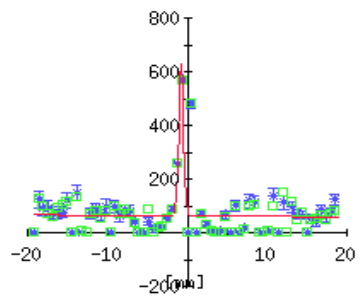
Blue Horizontal



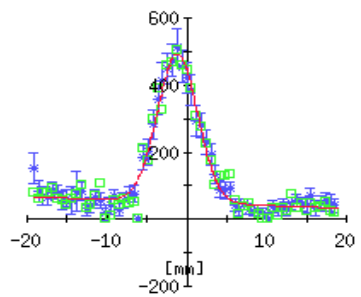
Blue Vertical



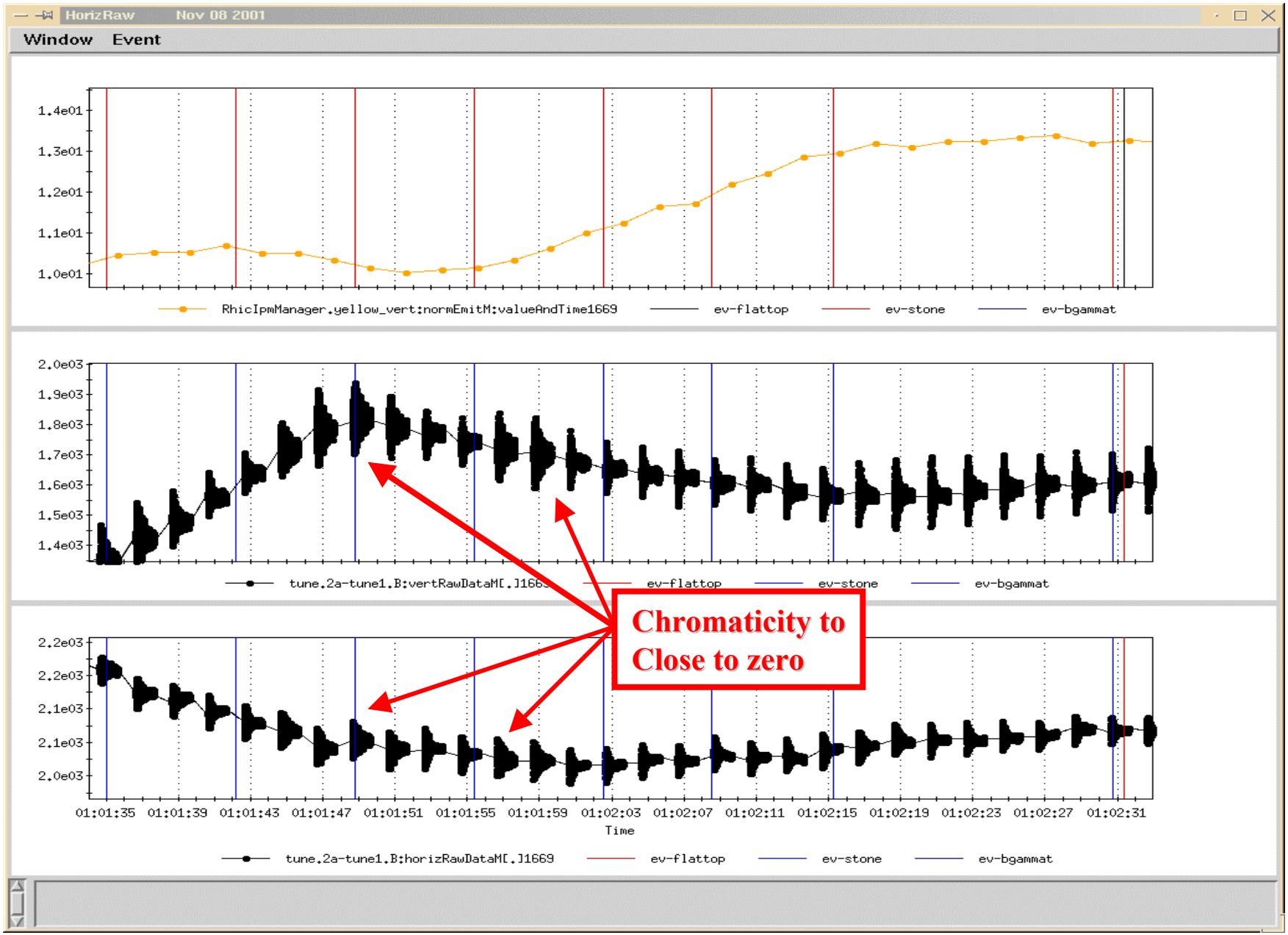
Yellow Horizontal



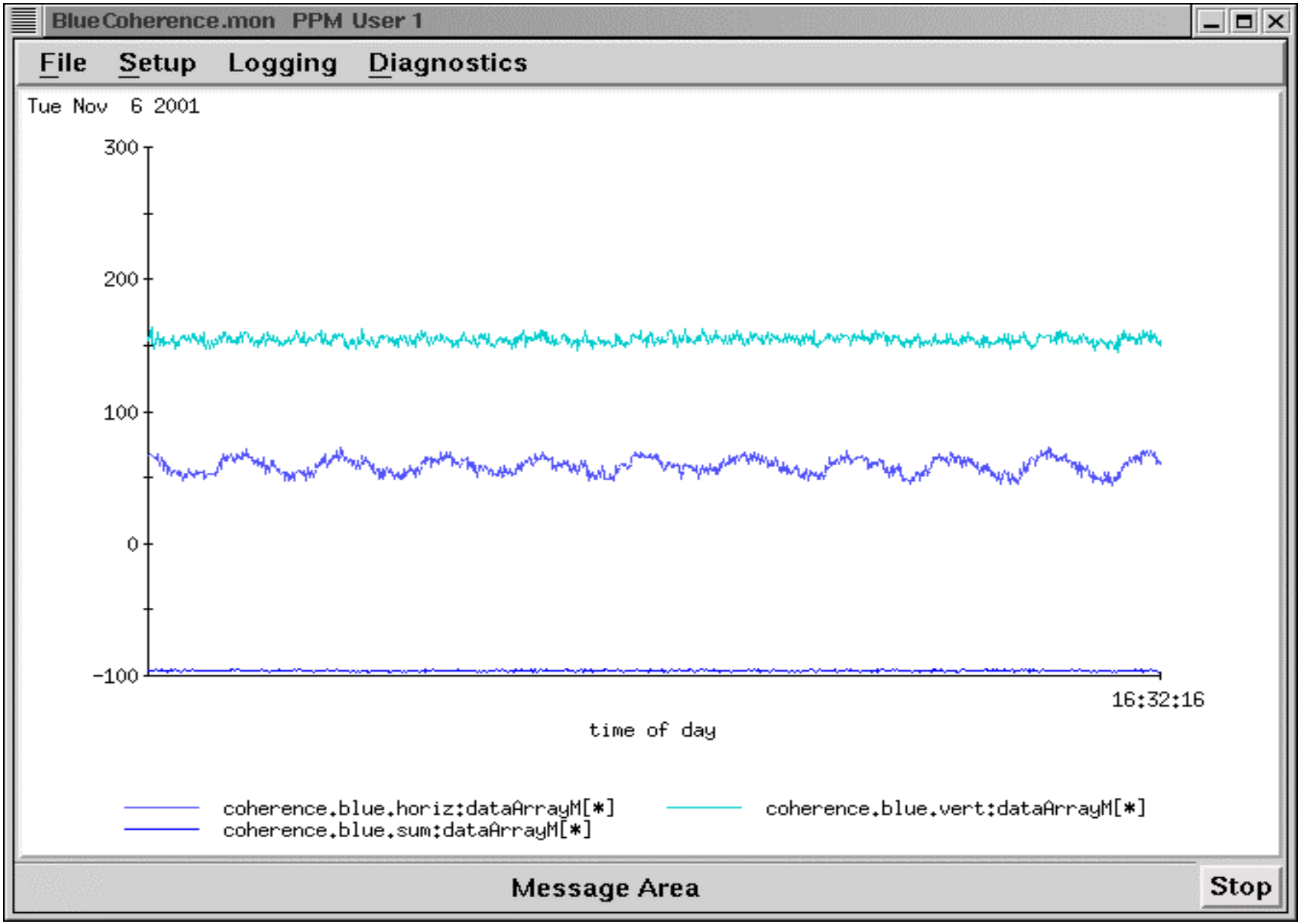
Yellow Vertical



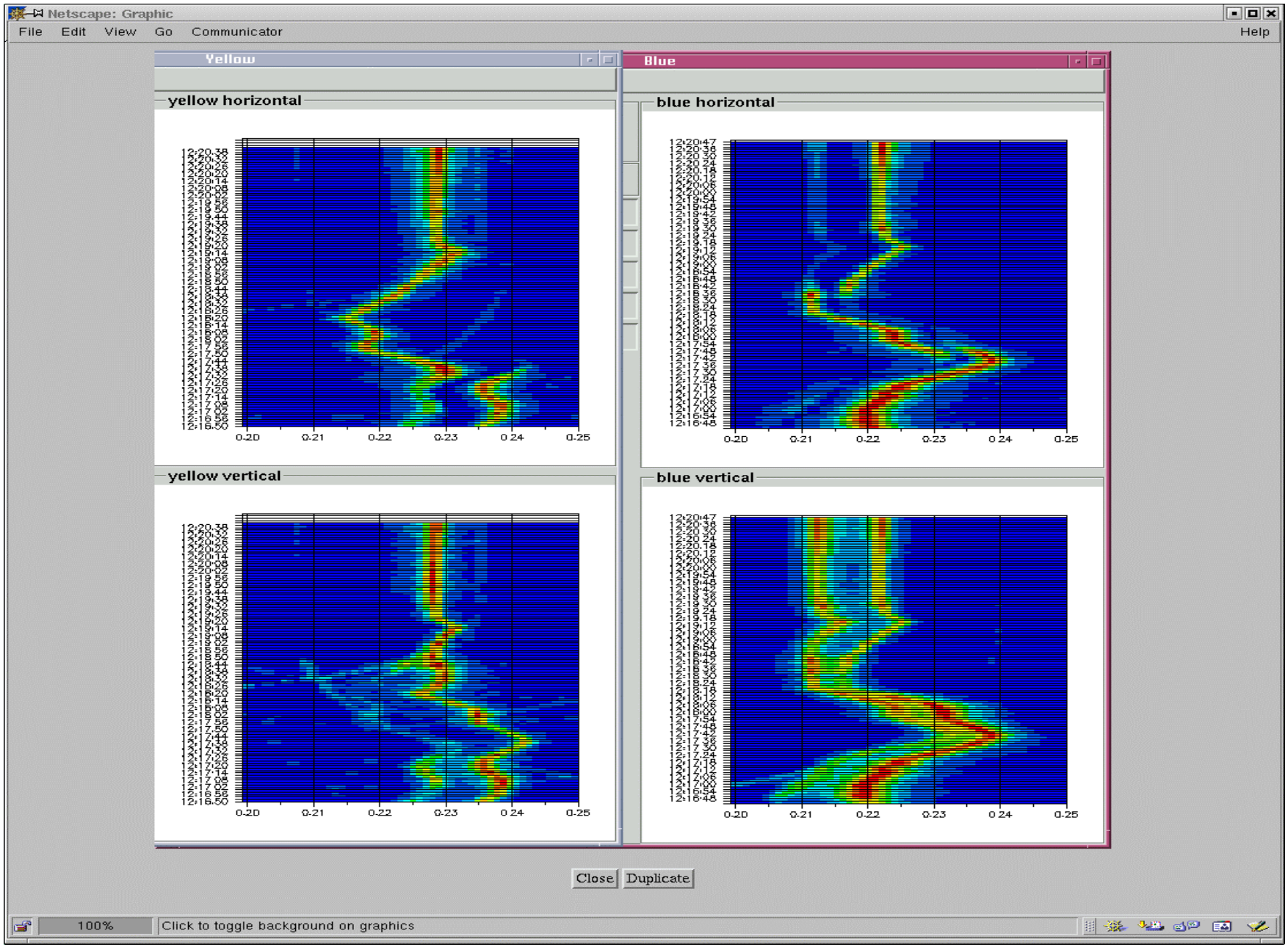
Transverse beam blow up at the end of the ramp



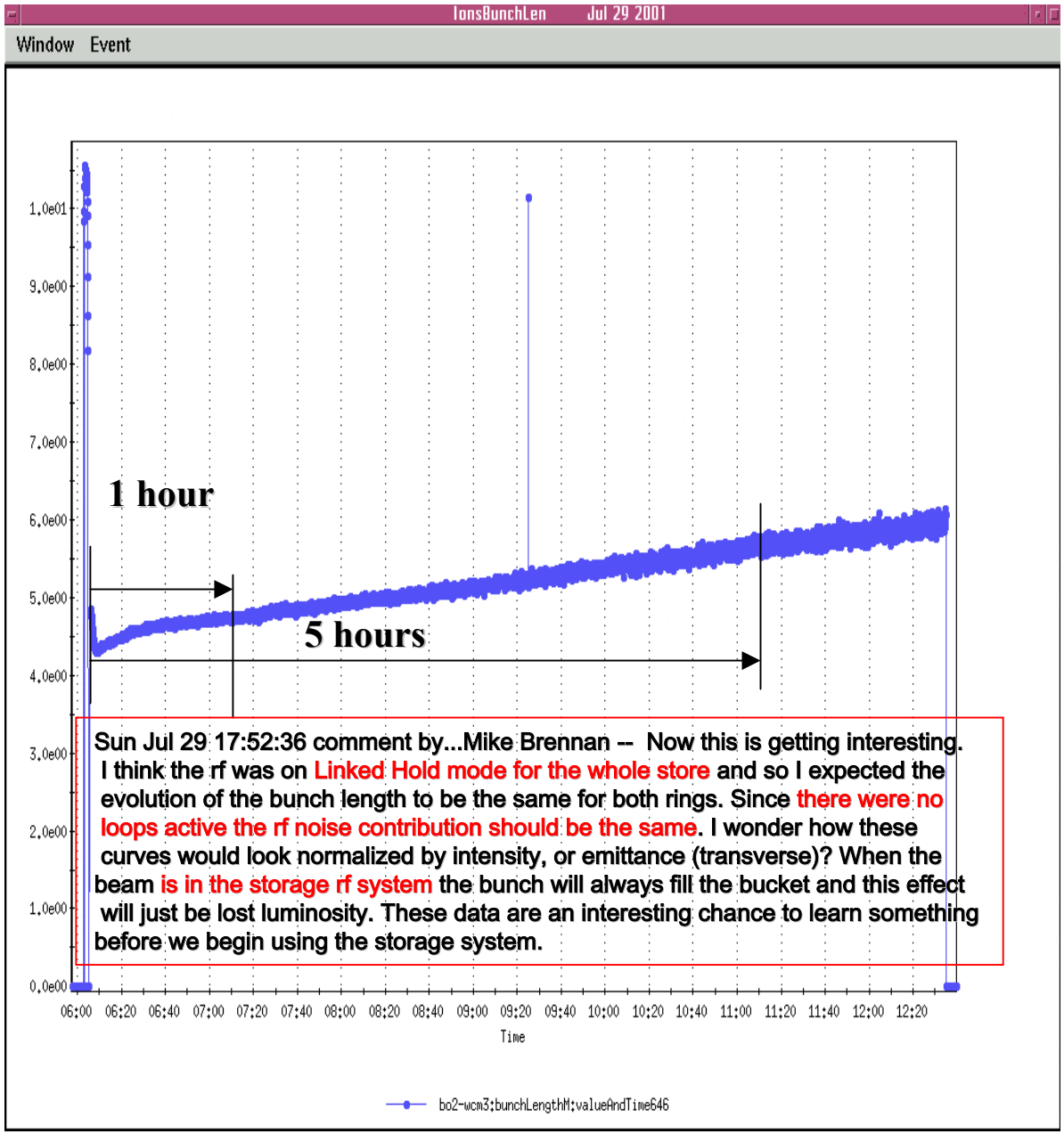
Coherence detector results

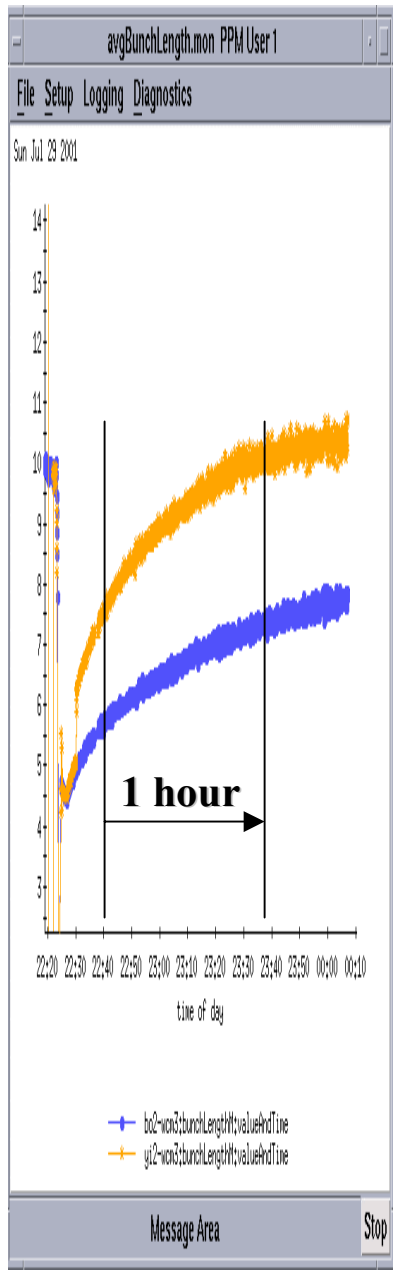


Tunes along very well adjusted ramp

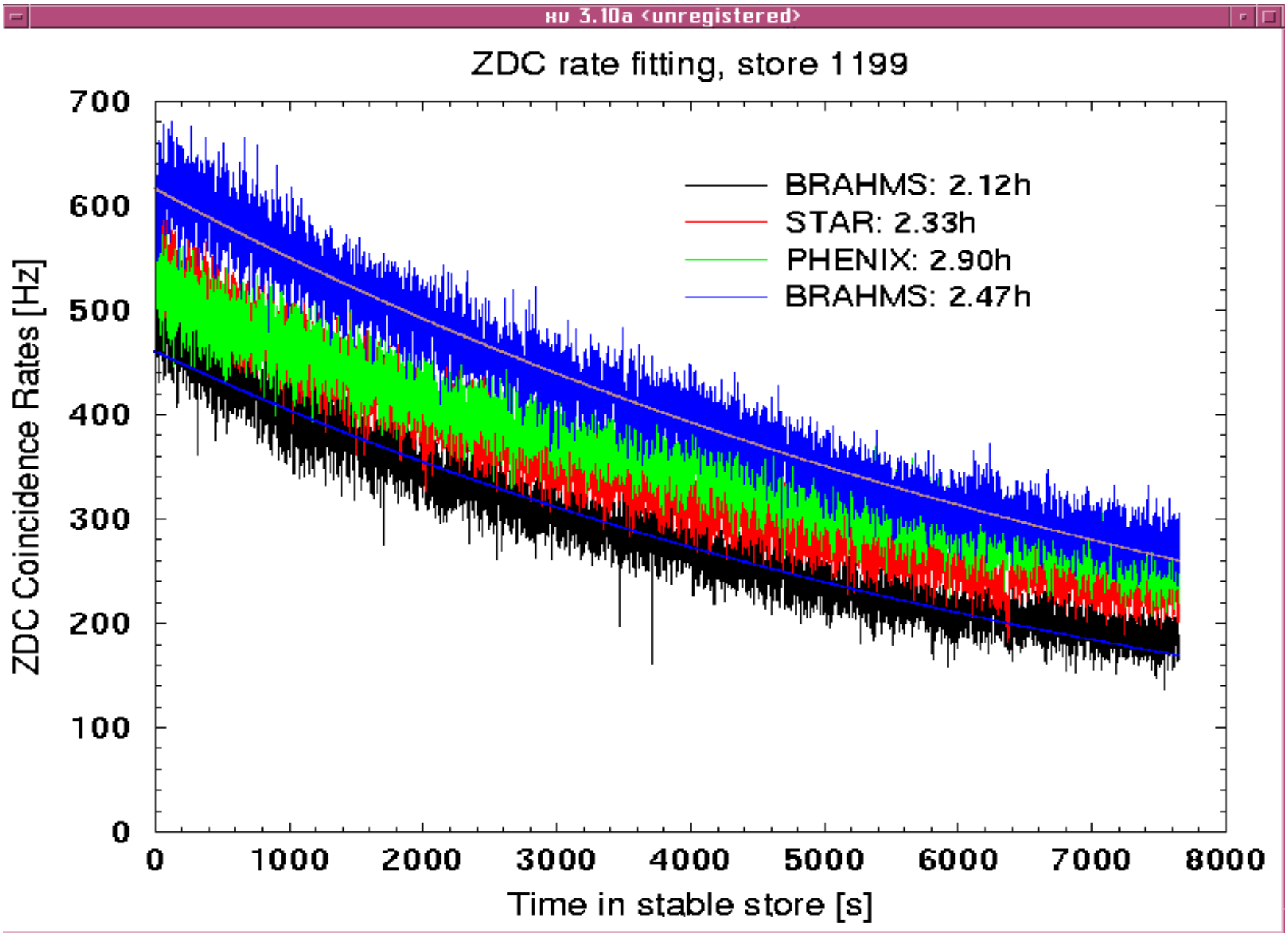


Longitudinal beam growth

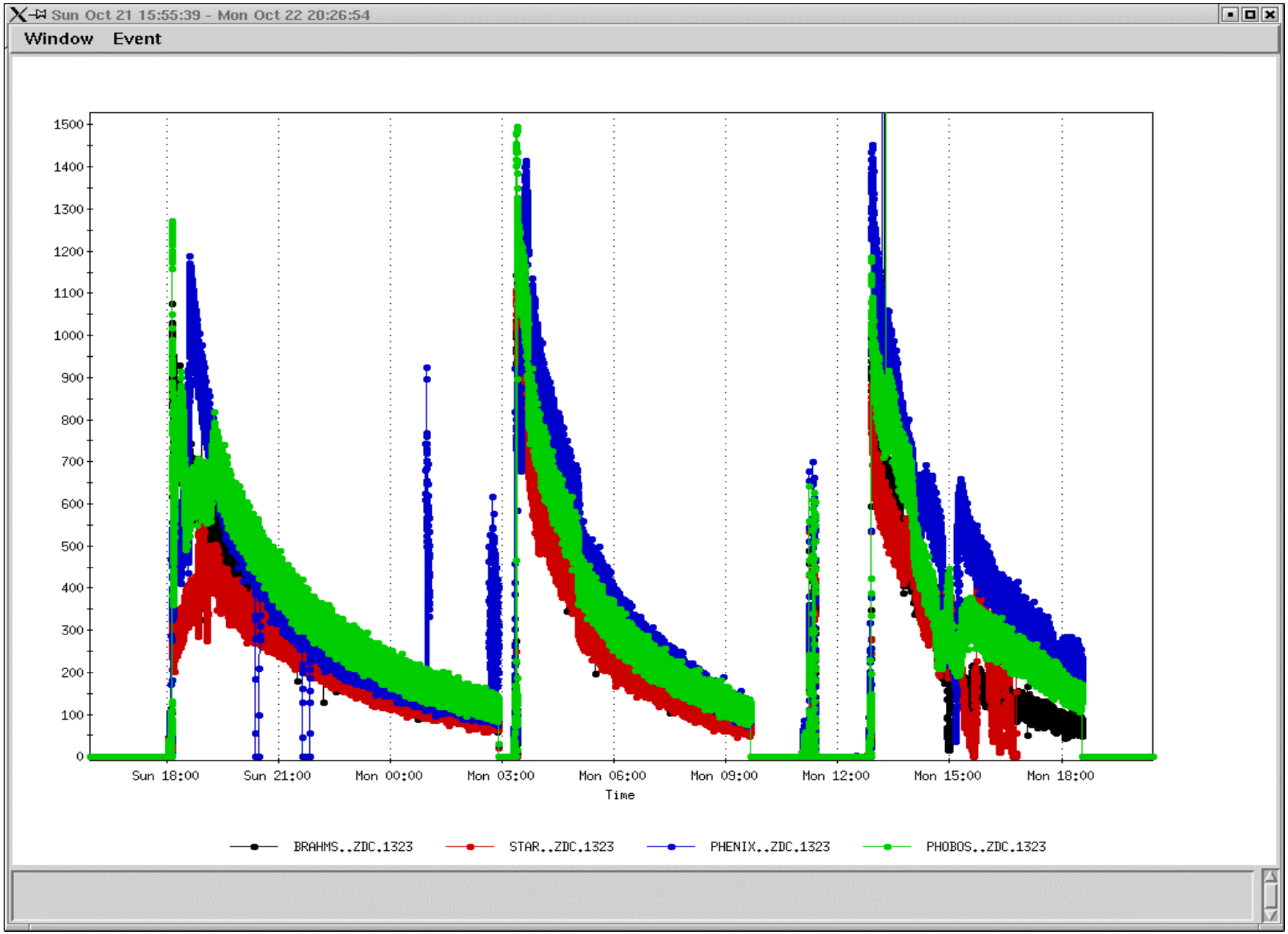




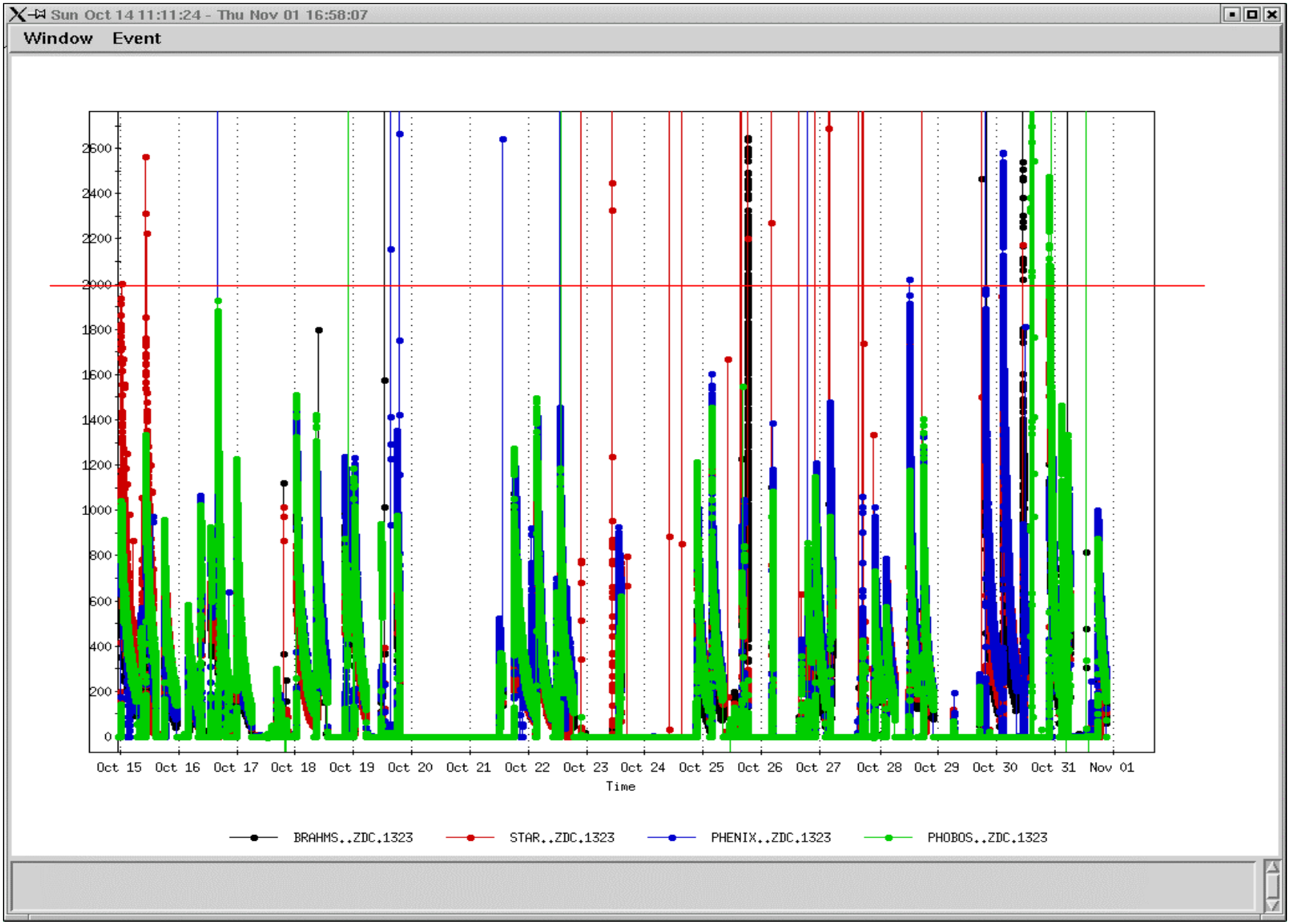
Luminosities lifetimes @ β*=3 m at each IP



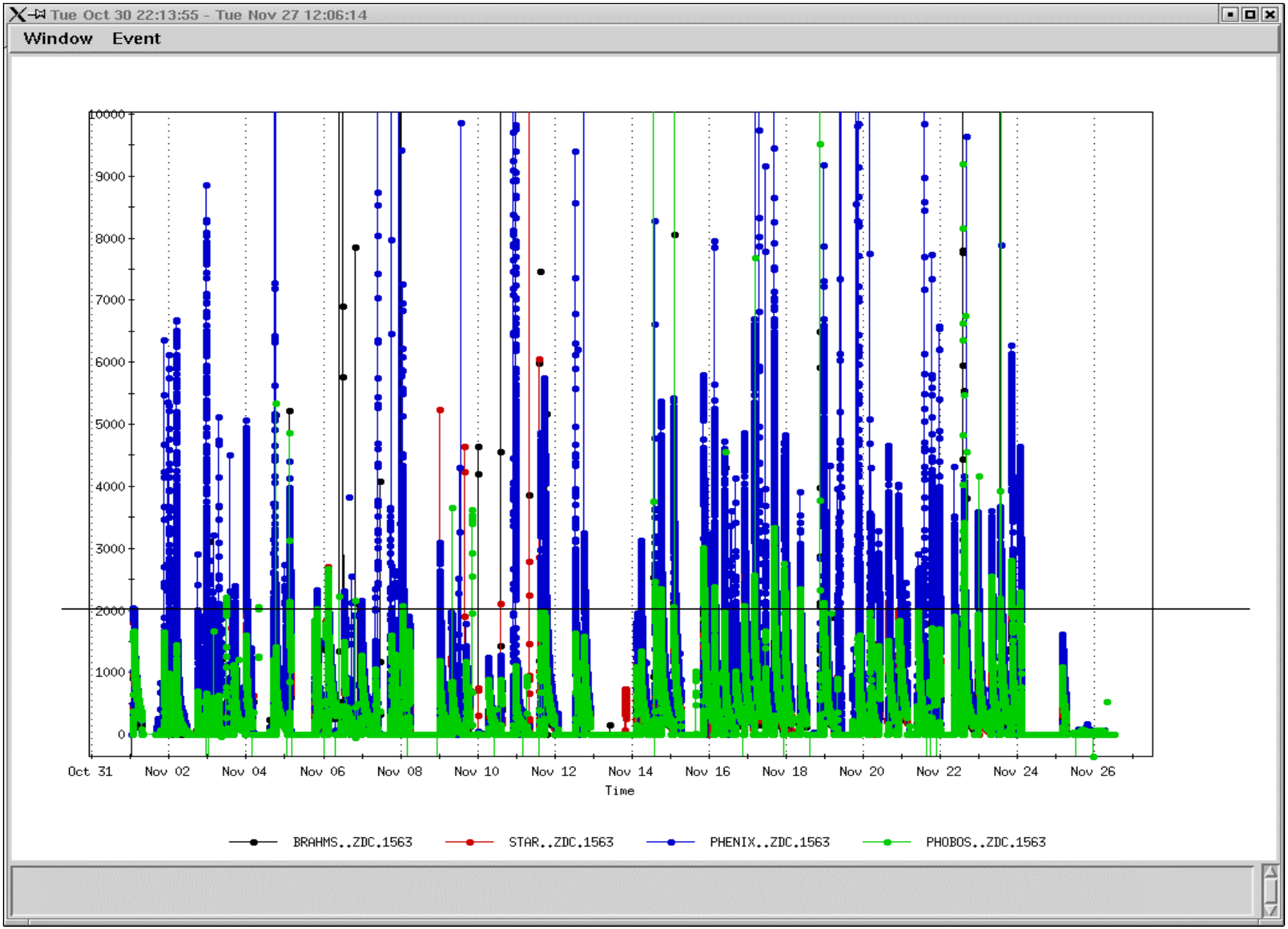
Luminosities during @ β*=2 m @ each IP



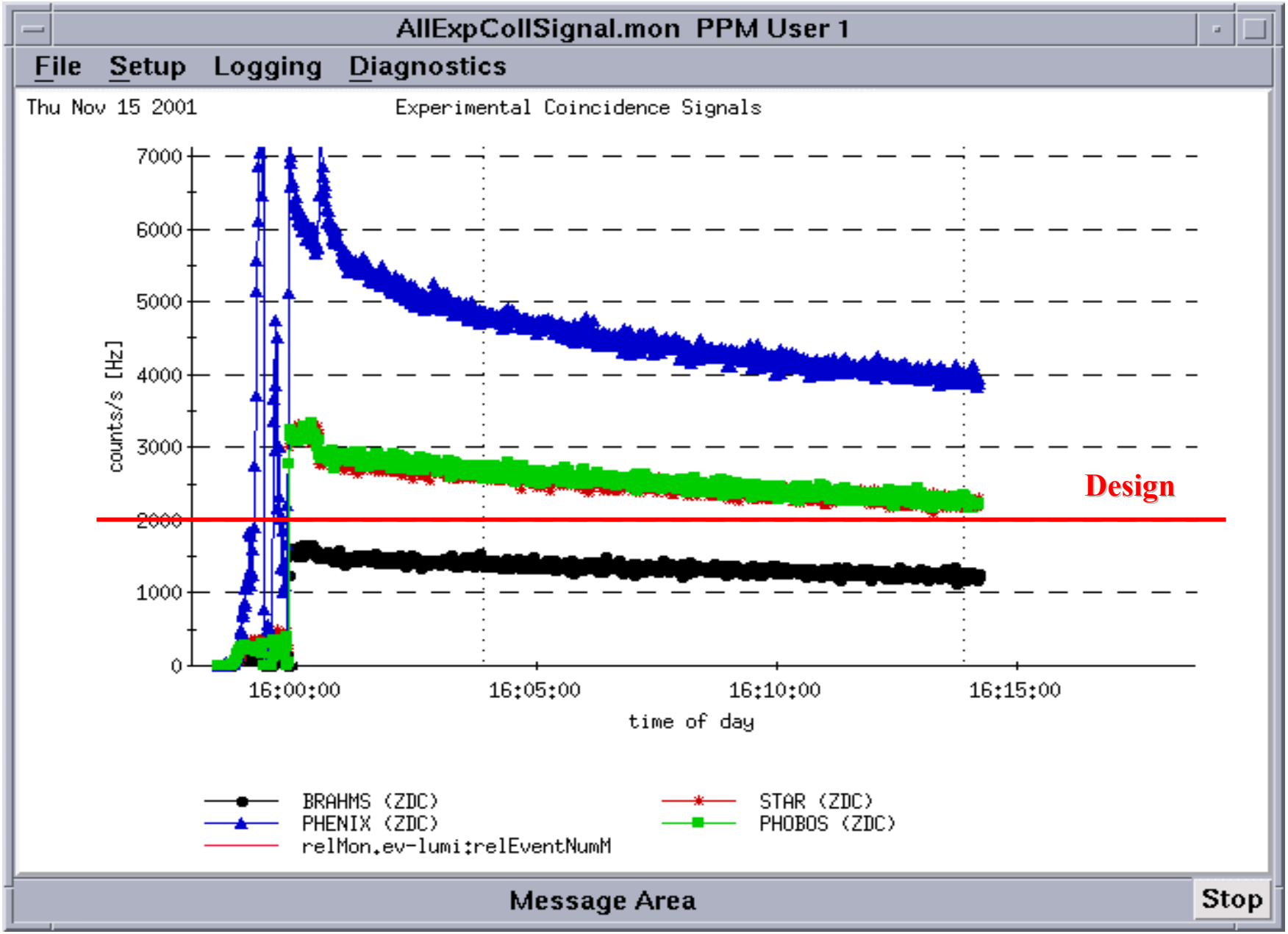
Luminosities during the last two weeks in October 2001, β*=2 m



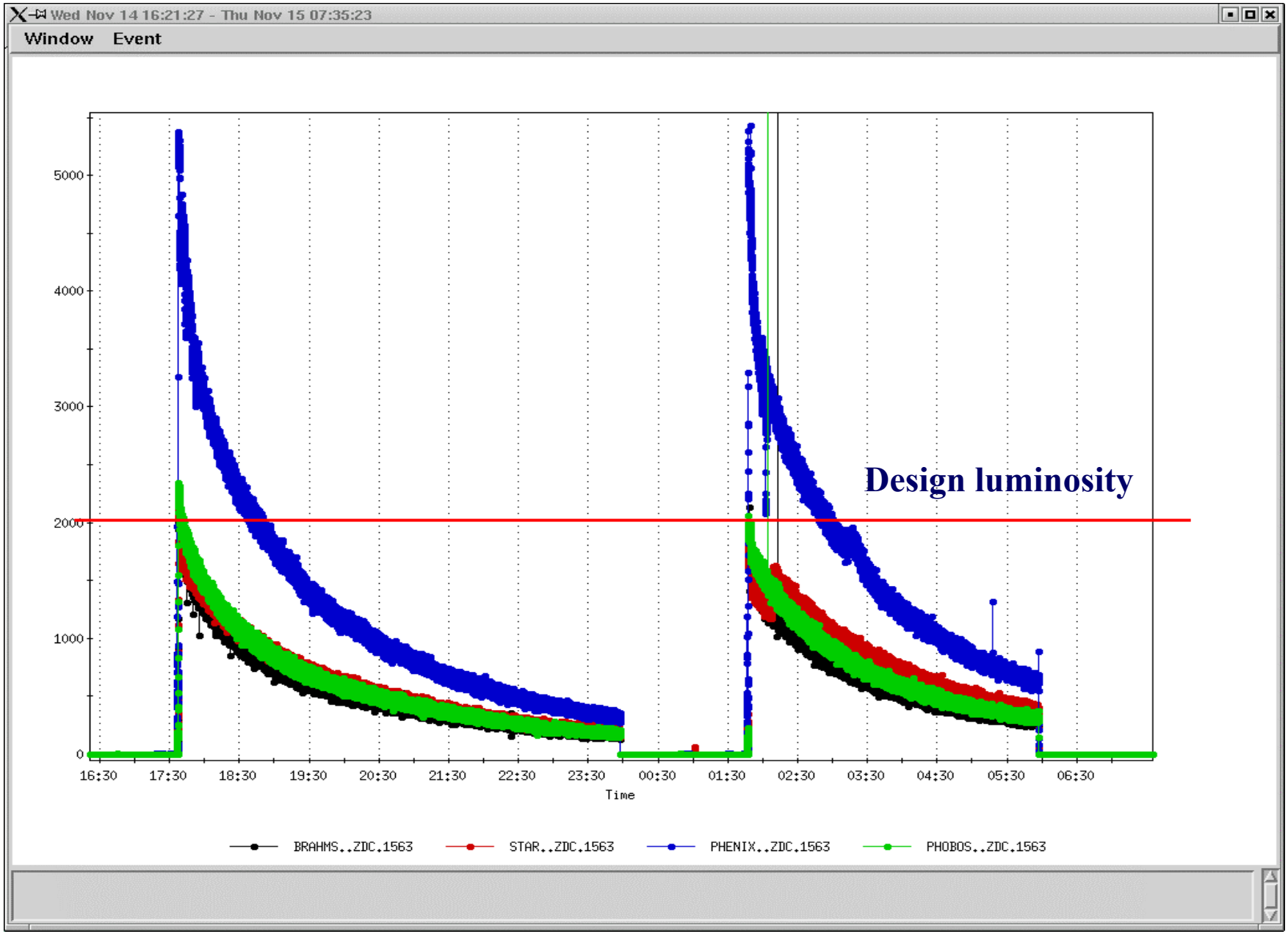
Luminosities during the month of November (β*= 1m @ PHENIX)



Luminosities at the end of the gold run – November 15, 2001



Two stores in November 2001



An Example of the PS-COMPARE: bad board in yo8-qf2