Recent Tevatron Operational Experience

A. Valishev, G. Annala, D. Bollinger, B. Hanna, A. Jansson, T. Johnson, R.S. Moore, D. Still, C.Y. Tan, X.L. Zhang

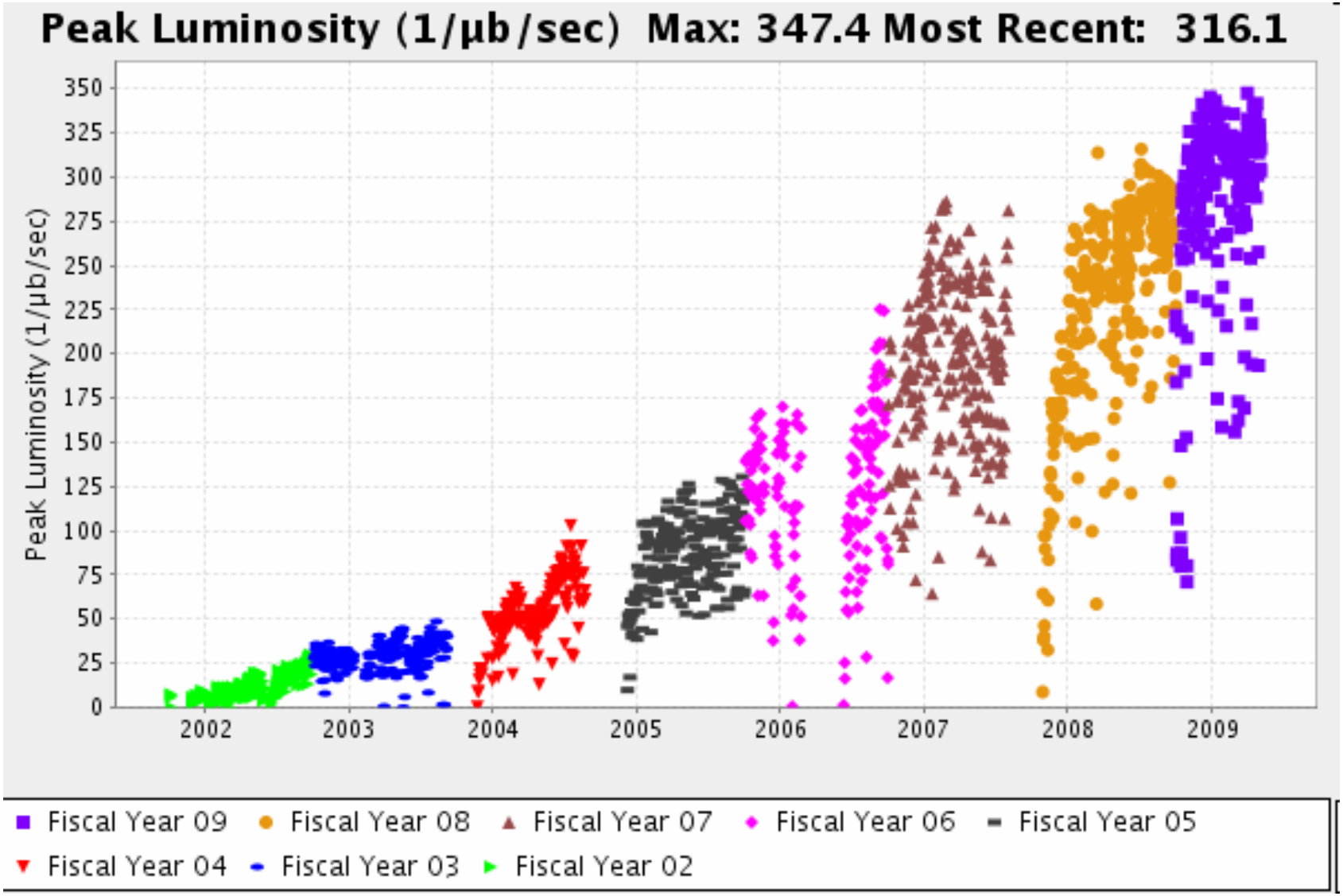
Fermilab, Batavia IL

PAC'09, May 8, 2009

Outline

- Overview of collider operation and issues
- Categorization of quenches
- Orbit stabilization and optics stability
- Losses during low-beta squeeze
  - Aperture at CDF
  - Beam-beam effects and chromaticity
- Summary

Peak Luminosity of the Tevatron

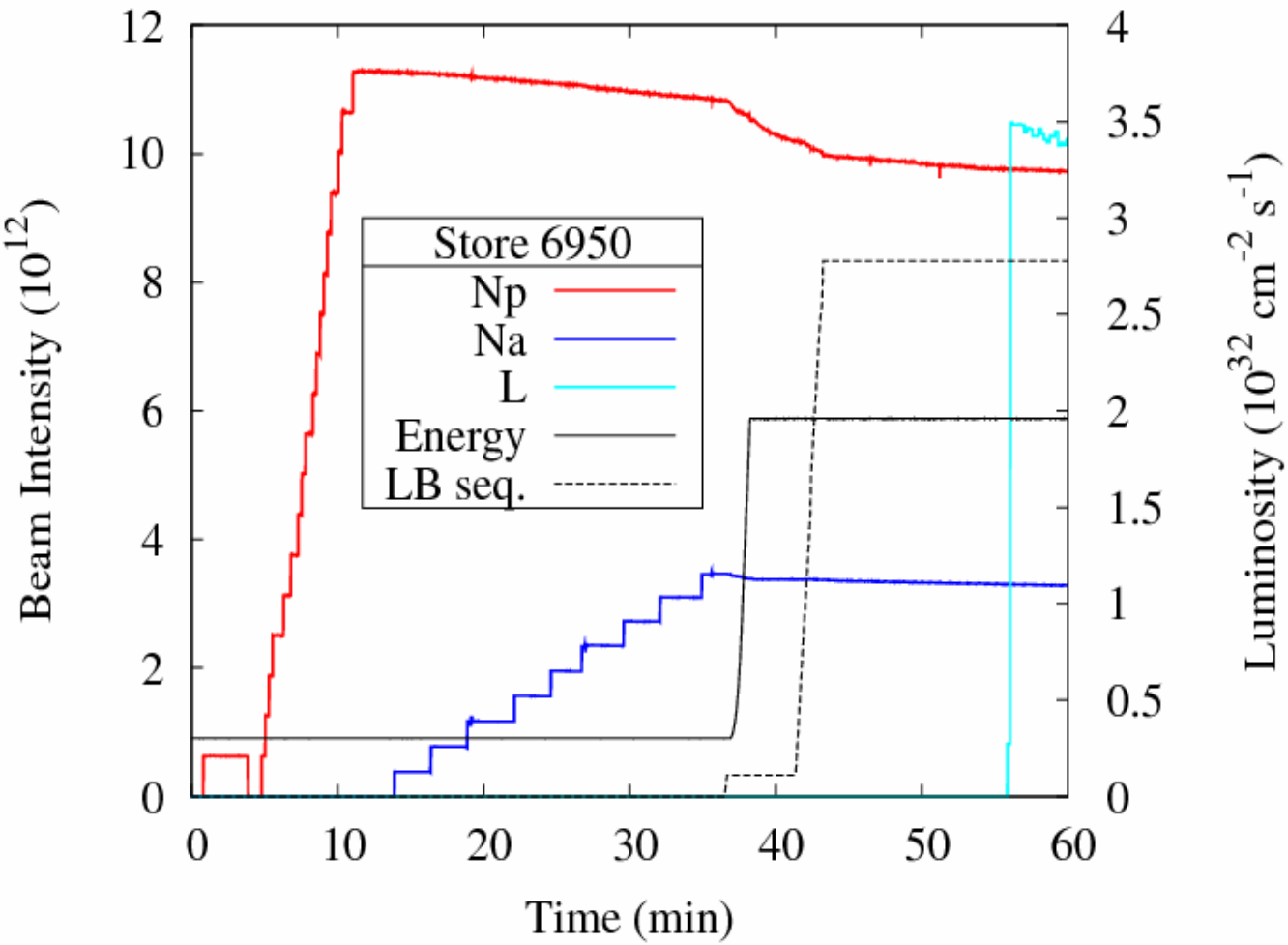


Collider Fill Cycle

Limitations:

- Np=3 10^{11}/bunch
  εp=18 π mm mrad – upstream machines
- Na=1 10^{11}/bunch – accumulation rate
- εa=7 π mm mrad – beam-beam effects *
- L_0 – experiments

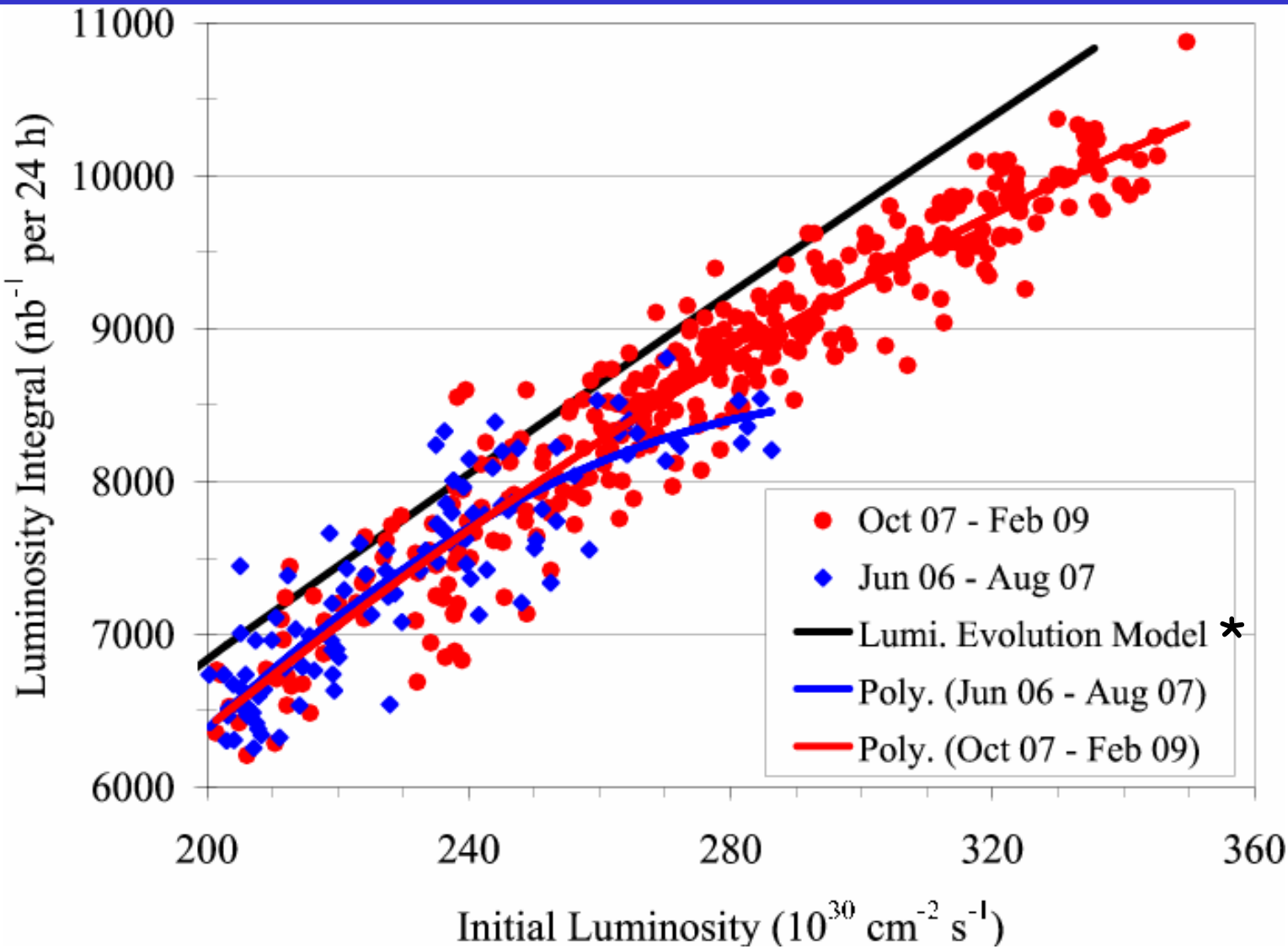
Concentrate on repeatability**



* C.Y.Tan, TU6RFP053
** C.Gattuso, MO4RAC03

Store 6950 L_0=3.5x10^{32}

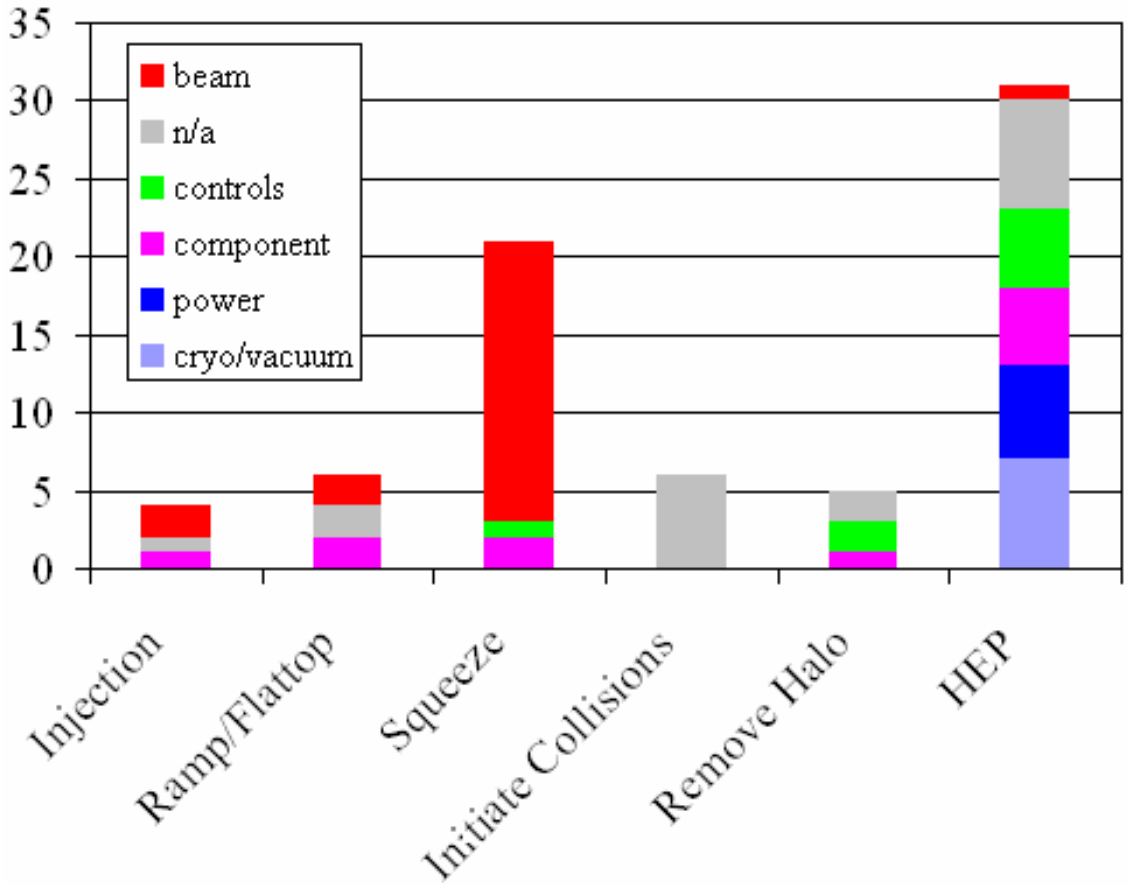
Integrated Luminosity Performance



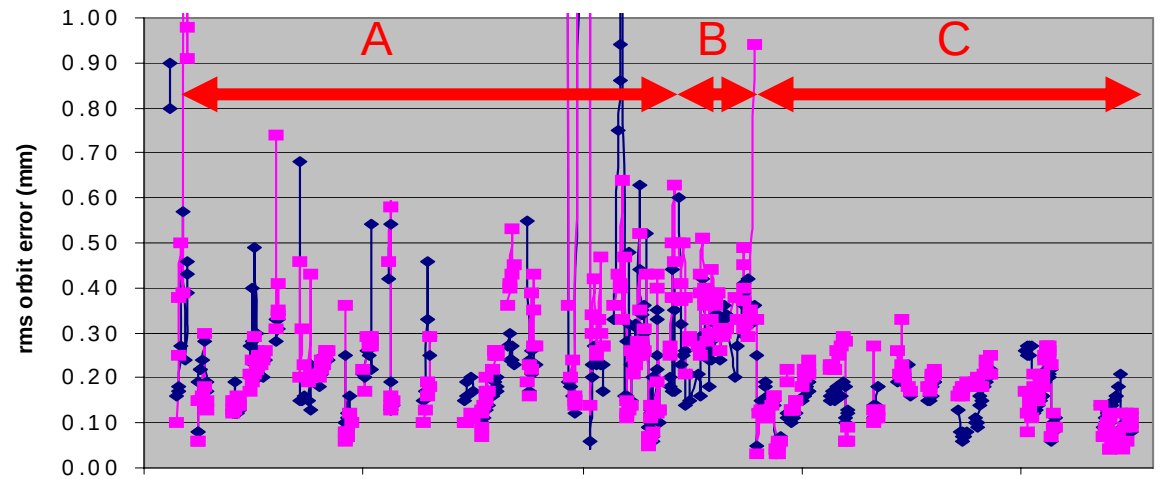
* V.Lebedev, MO1BCI02

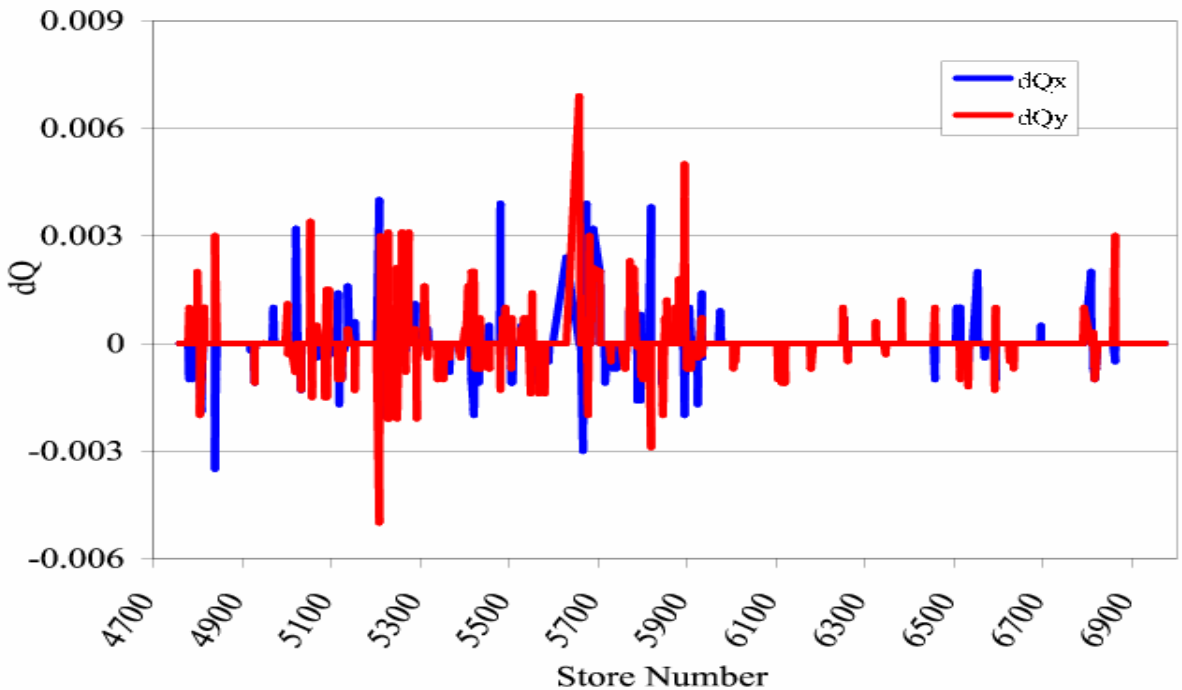
Categorization of Quenches

- Total quenches since Oct. 2007 - 73
- Distribution
  - Injection: 4
  - Ramp/Flattop: 6
  - Squeeze: 21
  - Initiate Collisions: 6
  - Remove Halo: 5
  - HEP: 31
- Most quenches in squeeze (18) were caused by a combination of beam-beam and orbit issues.
- Only 1 beam related quench in HEP



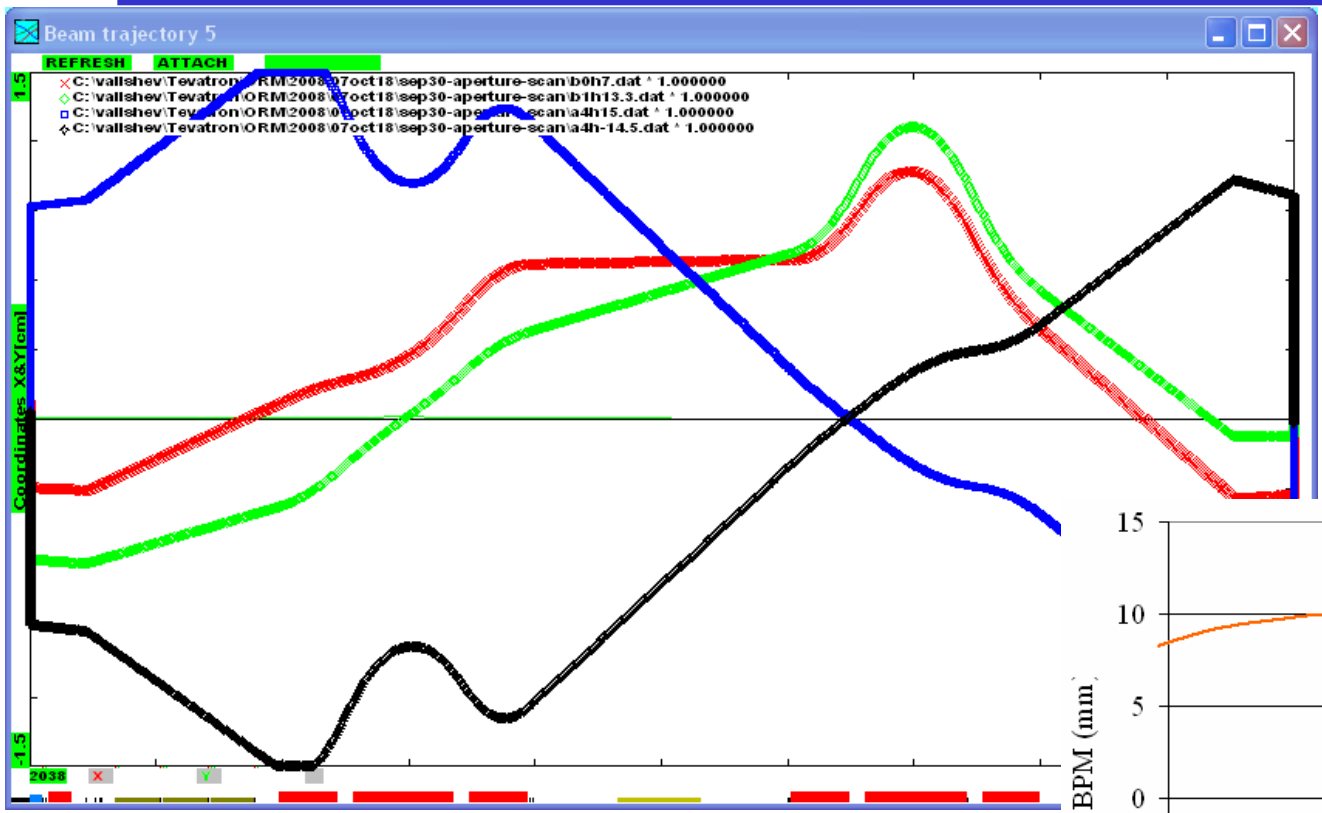
Orbit and Tune Stability

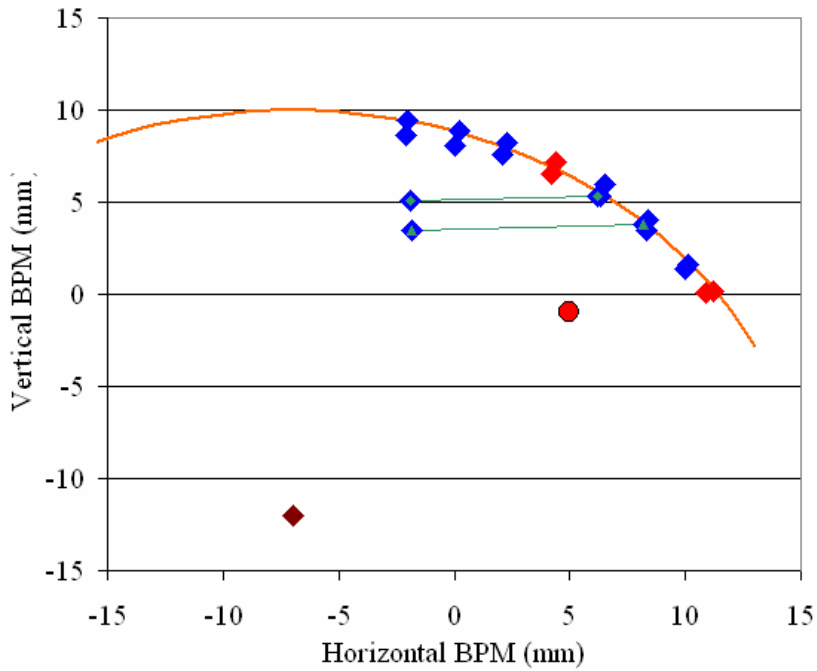




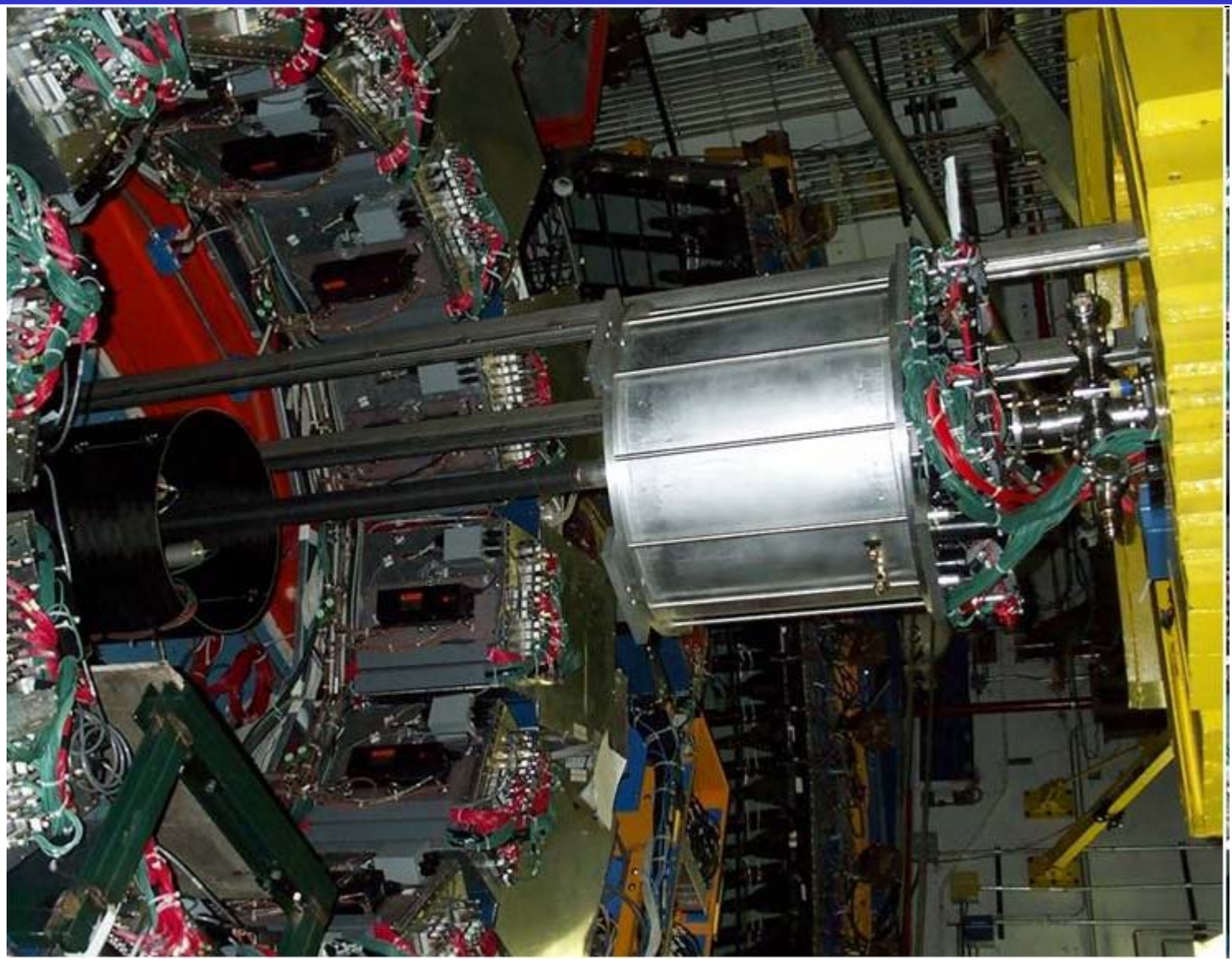
zone	Hor ave (mm)	Hor sigma (mm)
A	.29	.35
B	.29	.09
C	.15	.05

Aperture Restriction in CDF IR

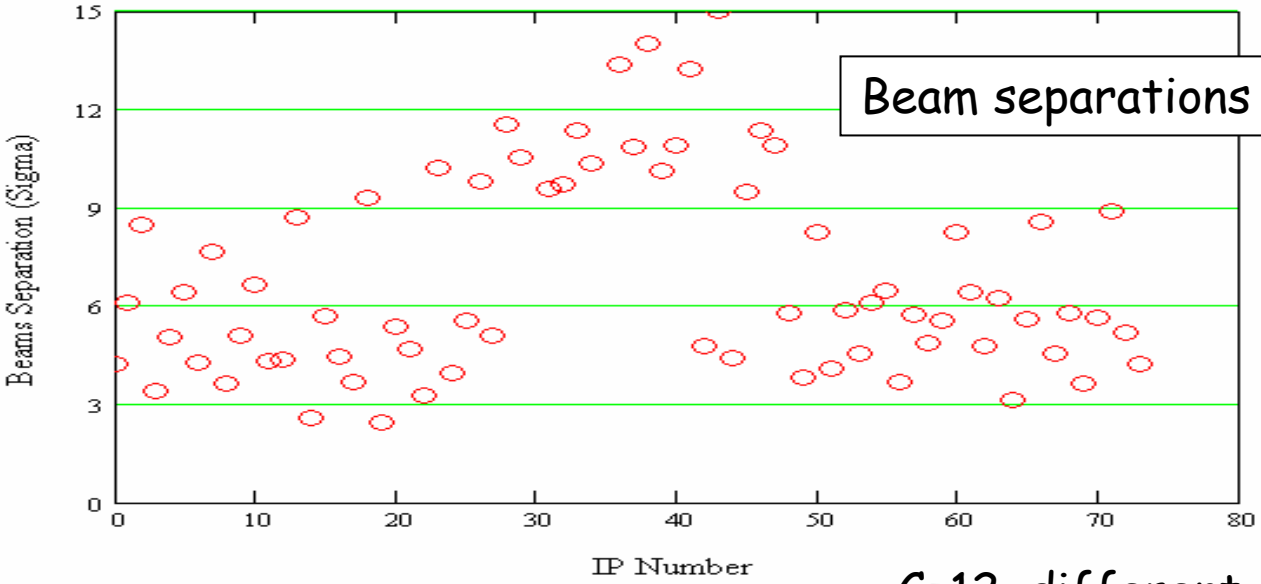




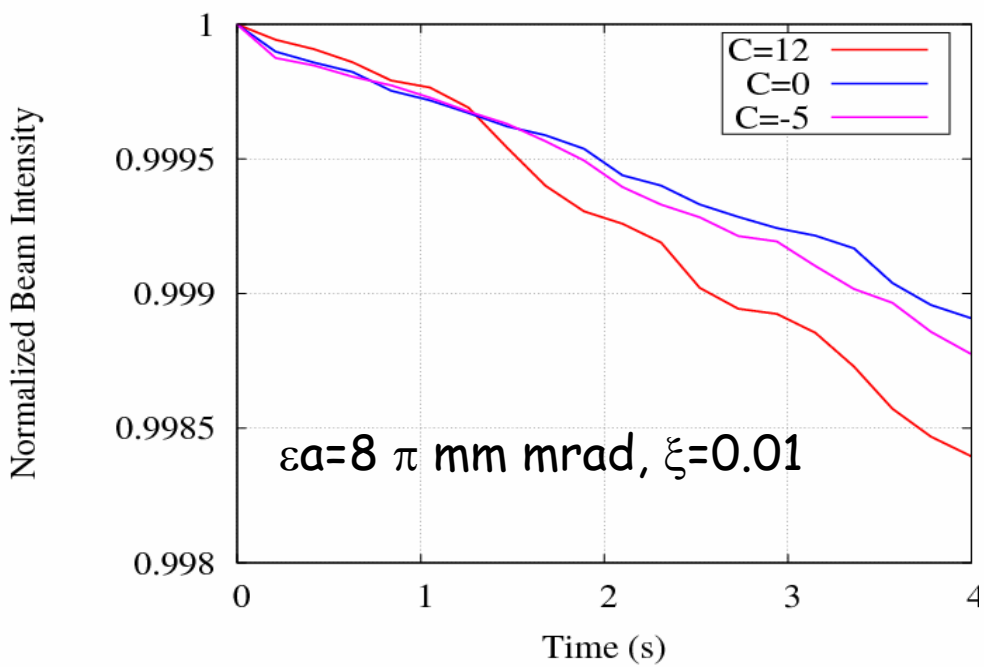
Aperture Restriction in CDF IR

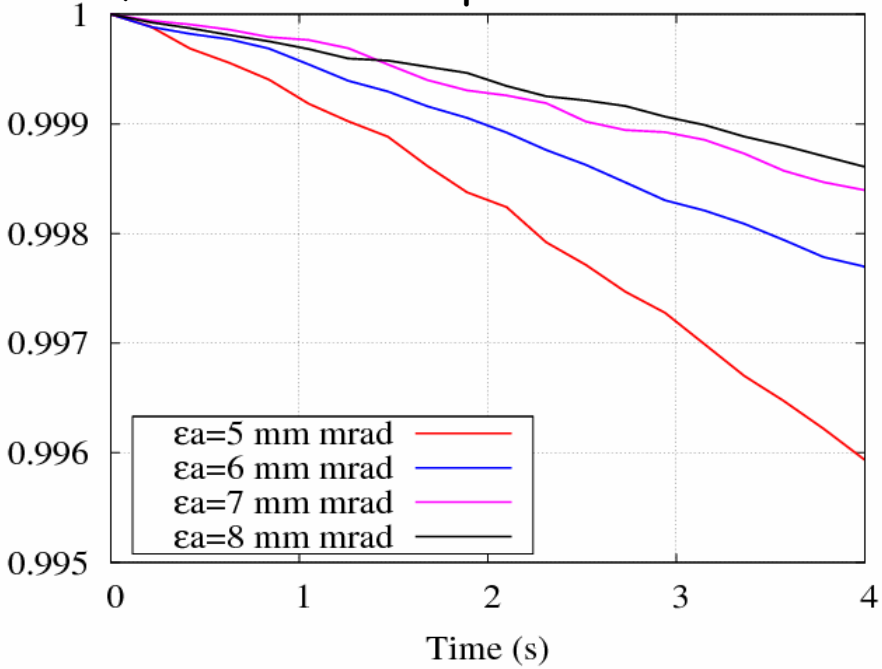


Beam-Beam Effects at Low-Beta Sequence 14

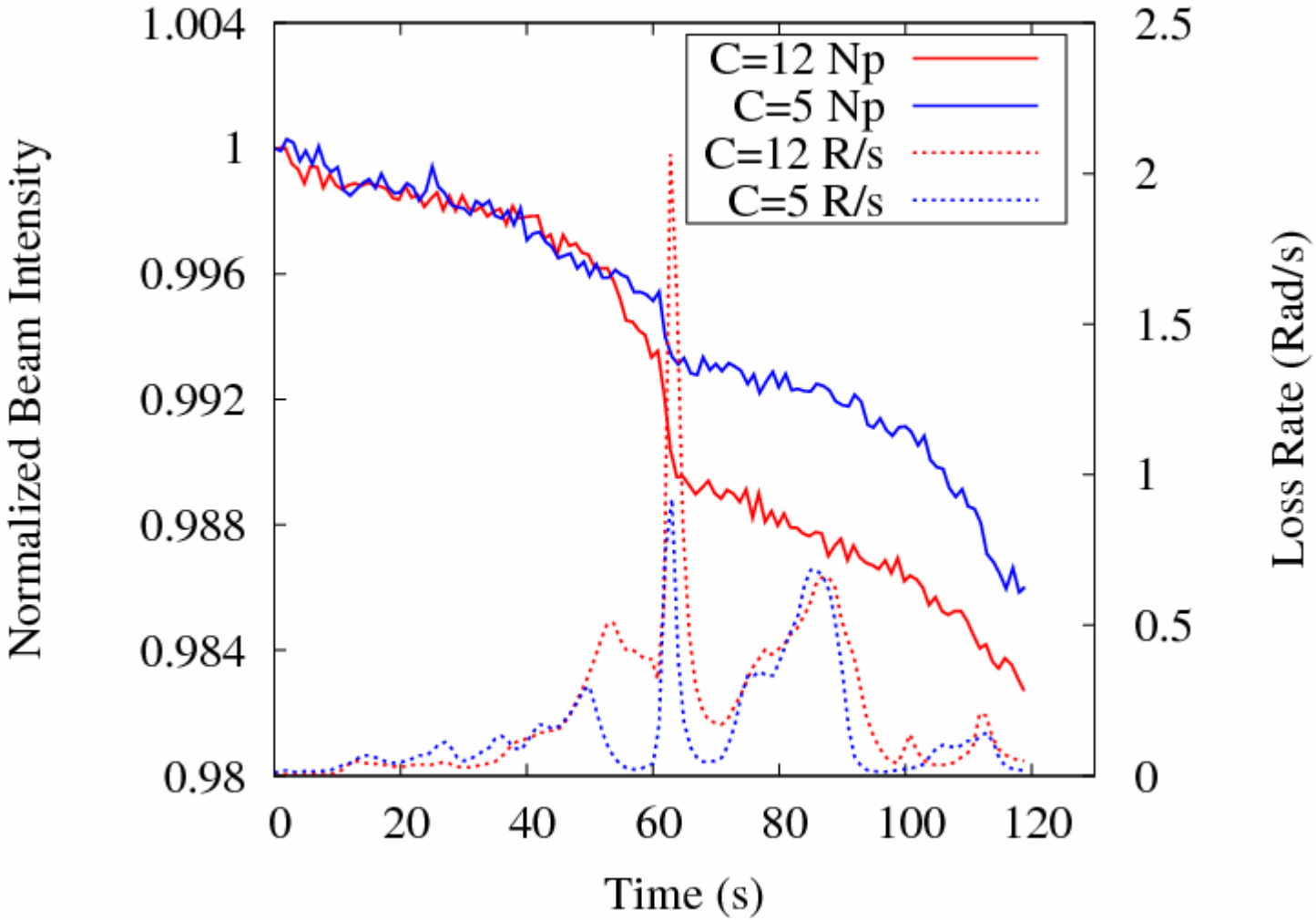


C=12, different antiproton emittances



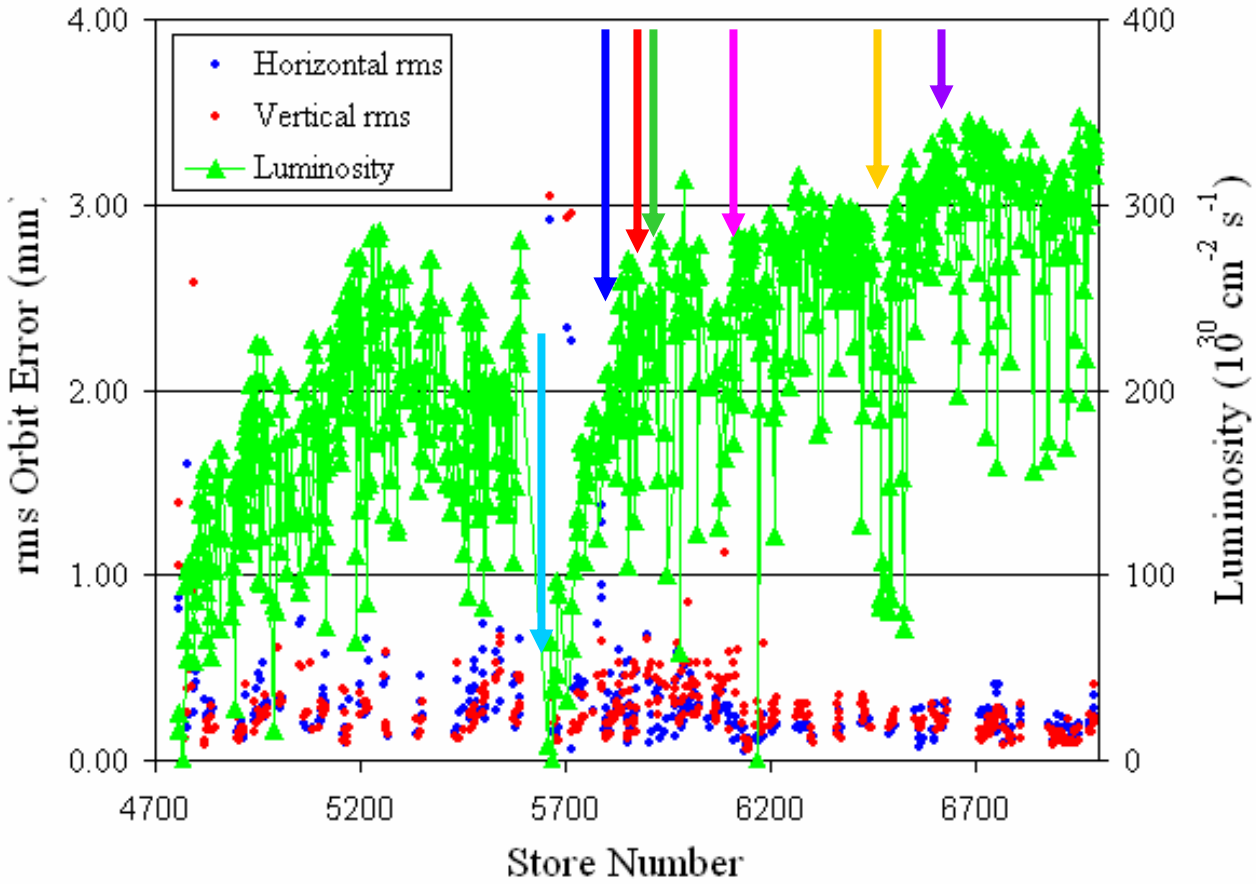


Normalized Proton Loss During Low-Beta Squeeze



Red traces – before chromaticity change at sequence 14, blue - after

Luminosity and Timeline of Events



store	date	comment
5657	10/28 2007	End of 2007 shutdown
5813	12/20 2007	Tune adjustment based on Na
5871	1/17 2008	Implemented antiproton blowup
5891	2/7 2008	D0 optics correction
5903	2/12 2008	fixing orbit stabilization
6099	4/29 2008	Orbit stab. to reference
6489	10/11 2008	Fixed CDF aperture.
6625	12/6 2008	Lowered C in squeeze

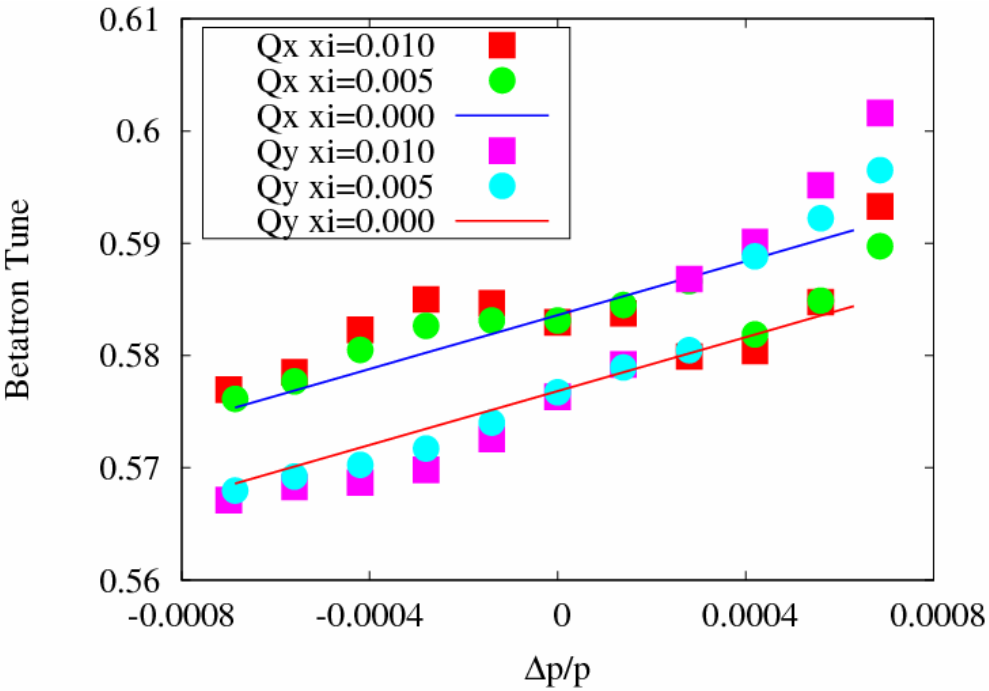
Summary

- Stability is the key to successful running in FY08 an FY09
  - Orbit stabilization
  - Controlled antiproton emittance (or $\varepsilon a/\varepsilon p$ ratio)
  - Controlled proton tune
- With stable machine and beam parameters beam-beam effects are no problem up to 3.5×10^{32}
- Low-beta squeeze is the most demanding stage of the collider cycle
  - Losses are caused by long range beam-beam effects
  - Increase of aperture in the CDF IR improved situation
  - Chromaticity is a strong factor
- Further (though not large) improvements are possible to achieve

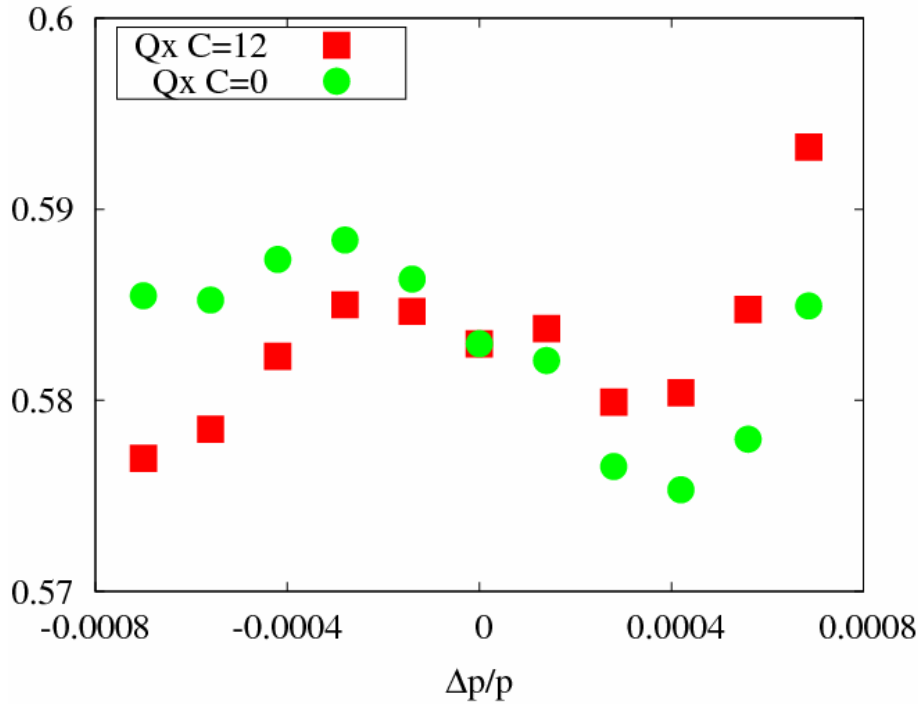
Backup Slides

Calculated Tune Chromaticity with Beam-Beam

Constant C=12, different beam-beam



ξ=0.01, two chromaticities



Quenches After Oct. 6 2008

- Total quenches since Oct. 6 2008 - 22
- Distribution
  - Injection: 0
  - Ramp/Flattop: 2
  - Squeeze: 5
  - Initiate Collisions: 0
  - Remove Halo: 1
  - HEP: 14