Review of Recent Tevatron Operations

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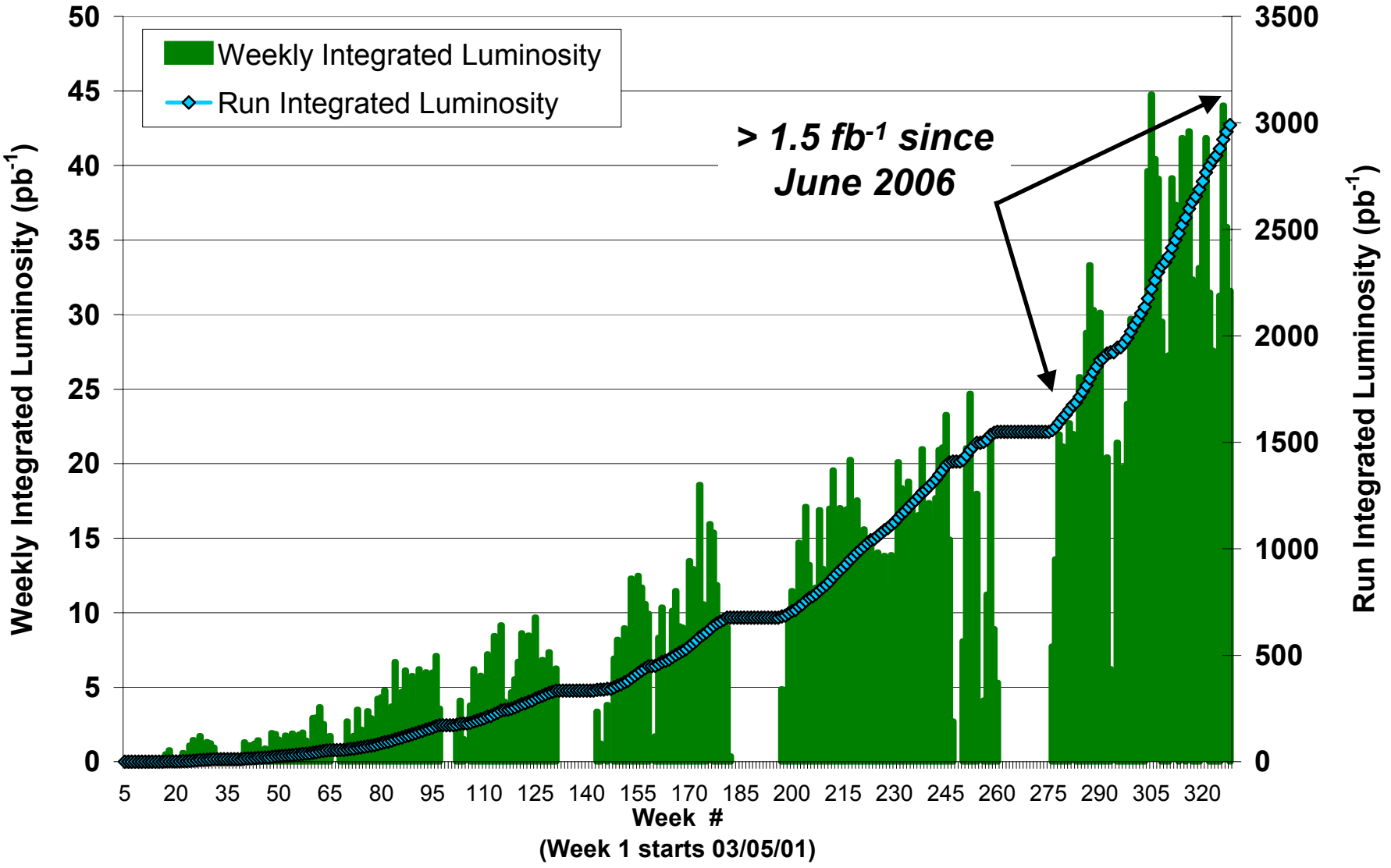
PAC 2007

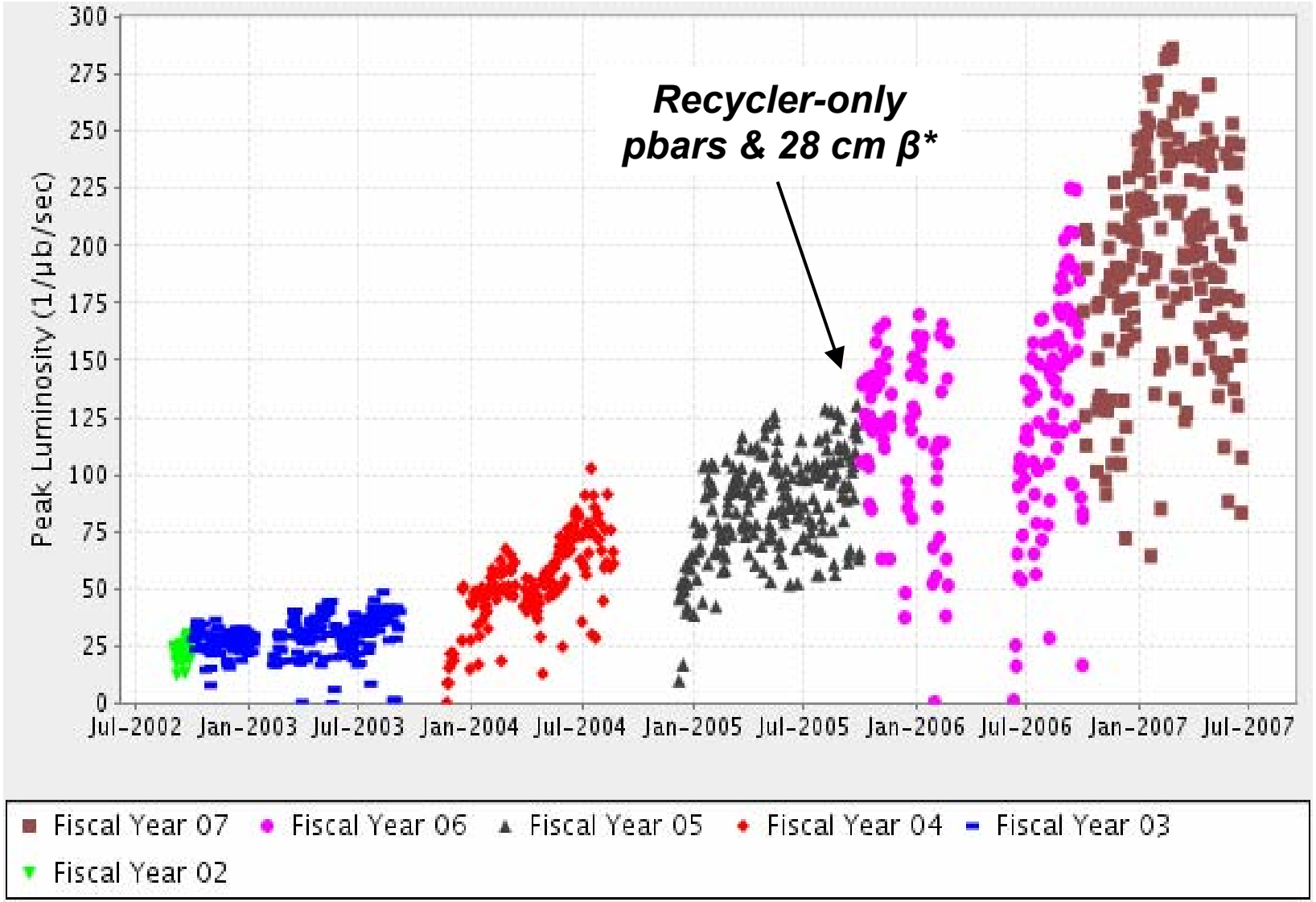
Overview

- Tevatron
  - 1 km radius superconducting synchrotron at 980 GeV beam energy
  - Tevatron 36×36 proton-antiproton collisions to CDF & D0 experiments
  - 3 trains of 12 bunches each with 396 ns separation
  - Protons and antiprotons circulate in single beam pipe
    - Electrostatic separators keep beams apart except where/when desired
    - Beam-beam interactions (head-on & long range) play major role

Tevatron Delivered Luminosity



Tevatron Run 2 Peak Luminosities



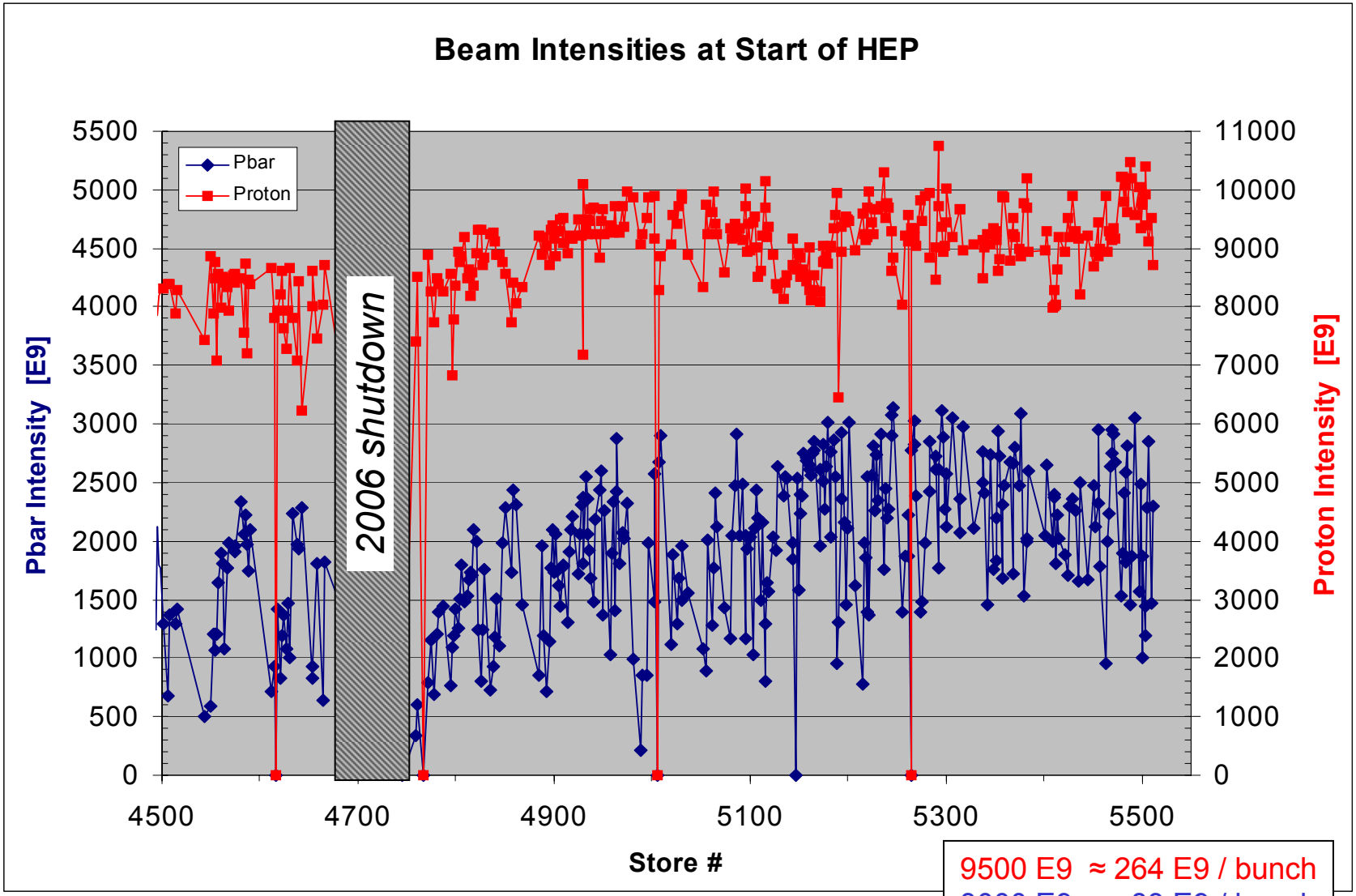
2006 Tevatron Shutdown Tasks

- Fixed known cold leaks in E2, A3, B4; replace failed dipole in F4
- Installed 2 new separators (B48, A17), replace 3 separators (A49)
- Completed reshimming on remaining 228 dipoles
- Replaced all ≈1200 helium relief valves (Kautzky) on magnets
- Repaired TEL-1 and installed TEL-2 (electron lenses)
- Pulled cables for new sextupole circuits (2^{nd} order chromaticity correction)
- Unrolled quads in A3 (~10 mrad); unroll ~60 magnets with small rolls
- Completed IPM detector installation
- Completed ring-wide hydrostatic level sensor installation
- Many smaller tasks, lots of maintenance…
- ***Tevatron Run II upgrades effectively complete!***

Highlights since 2006 shutdown…

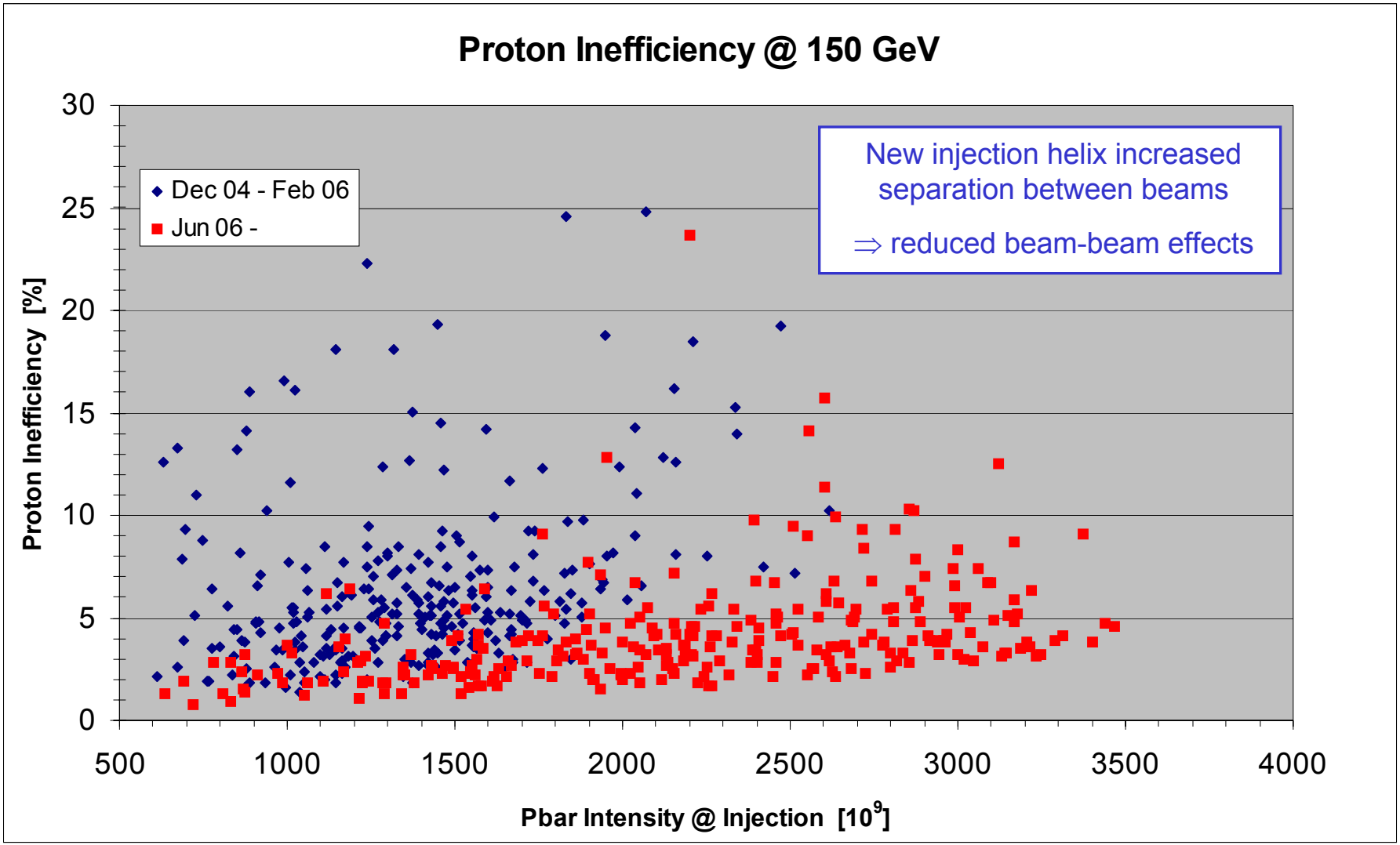
- Record delivered luminosity / week 24.4 → 44.9 pb^{-1}
- Record peak luminosity 180 → 292 10^{30} cm^{-2} s^{-1}
- Delivered > 1.5 fb^{-1} to CDF and D0 (Run 2 total delivered now > 3 fb^{-1})
- More antiprotons with smaller emittances to HEP
  - Thanks to Antiproton Source and Recycler
  - See K. Gollwitzer's talk tomorrow afternoon (WEZAKIO1)
- More protons to HEP
  - Injecting ≈10% more protons
  - Better lifetime @ 150 GeV from new helical orbit, reduced beam-beam
- Improved luminosity lifetime
  - Additional separators increase separation (up to 20% at parasitic crossings)
  - Beam-beam effects reduced
- Commissioned TEL-2 and demonstrated beam-beam compensation on protons
  - See V. Shiltsev's talk later this session (TUOCKI04)

Beam Intensities in HEP Stores

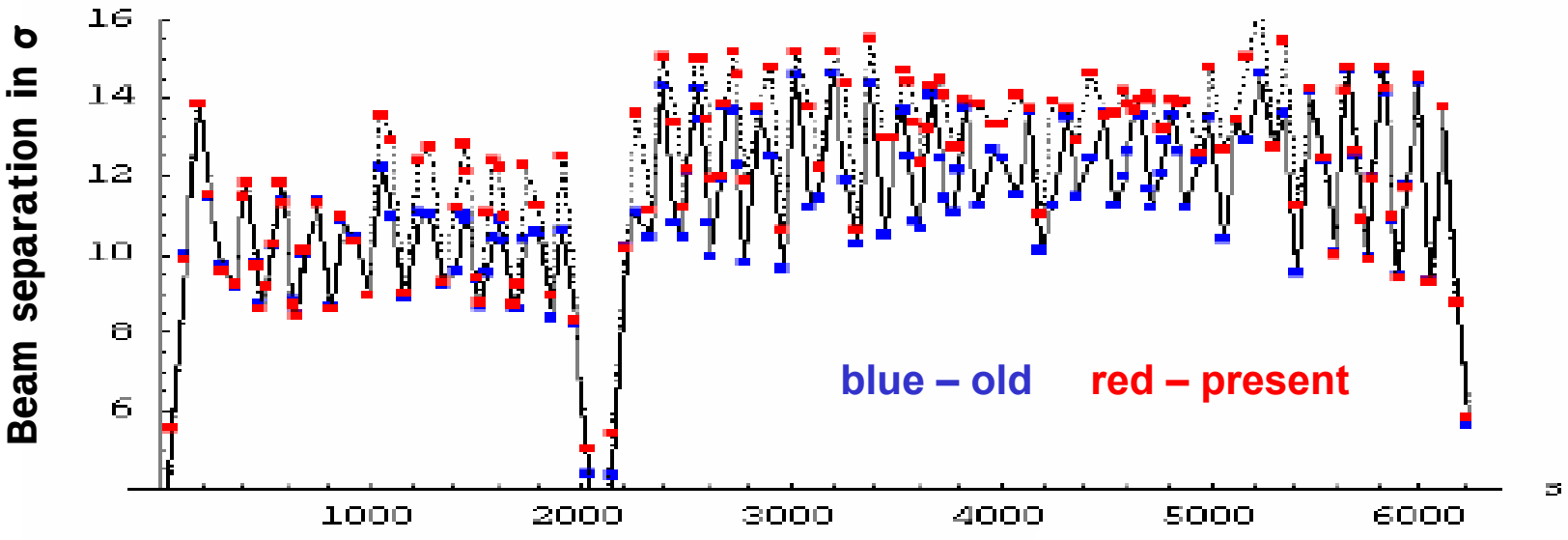


9500 E9 ≈ 264 E9 / bunch
3000 E9 ≈ 83 E9 / bunch

Improved Proton Efficiency vs Pbar Intensity



Larger Separation with New Collision Helix

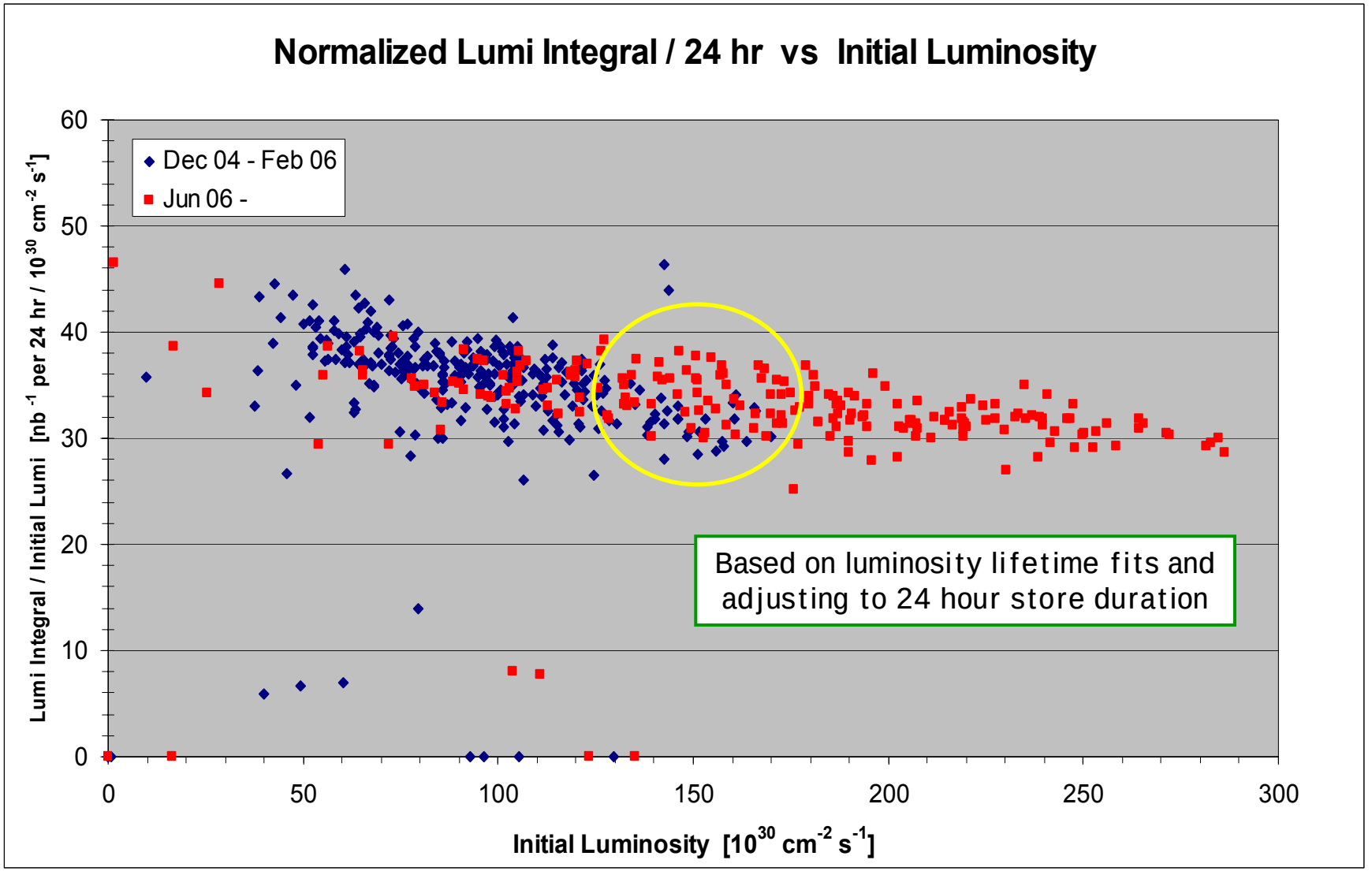


Beam separation near IPs (in σ's)

	B0 US	B0 DS	D0 US	D0 DS
Before	5.4	5.6	5.0	5.2
After	6.4	5.8	6.2	5.6

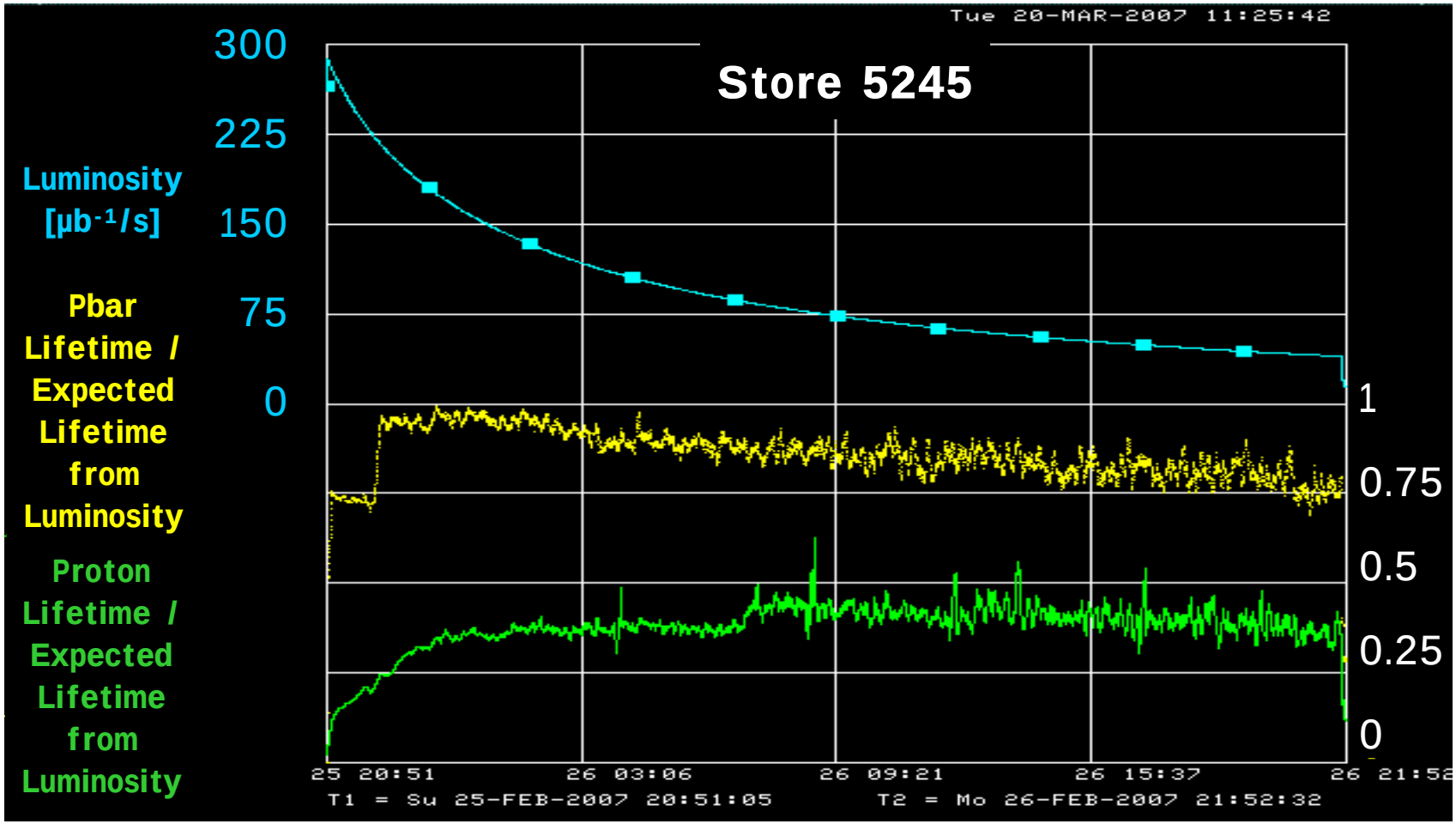
- Installed 2 additional separators during 2006 shutdown
- Luminosity lifetime improved ~20% compared to pre-shutdown
  - Increased integrated luminosity per store (for similar luminosities and duration)

Better Lifetime ⇒ More Delivered Luminosity

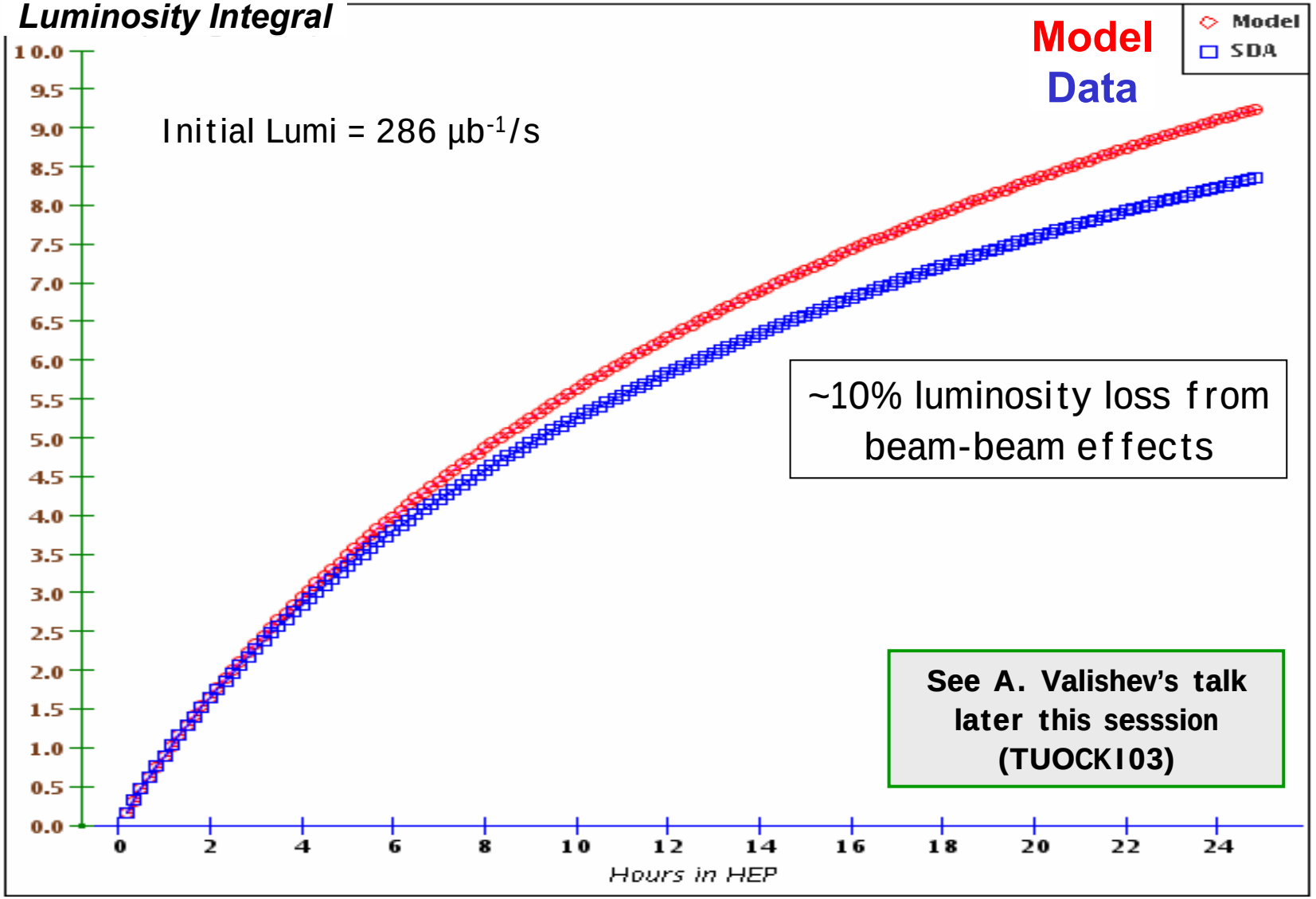


Beam Lifetimes during HEP

- Pbar lifetime dominated by luminosity – good
- Most protons lost in non-luminous processes – not so good
  - Head-on beam-beam effects from smaller emittance pbars on protons



Store 5245 – Comparison to Model w/o Beam-Beam



Reliability

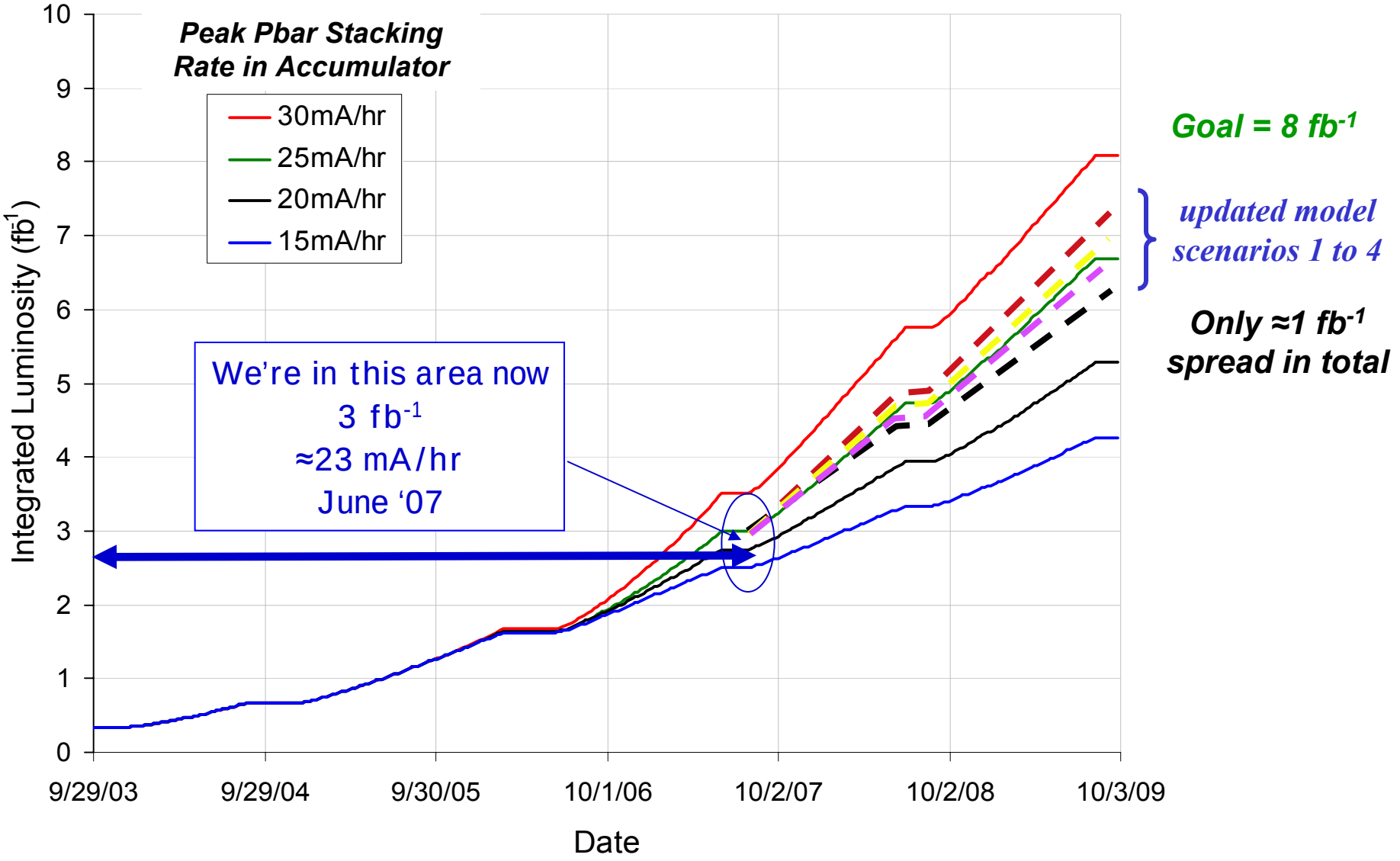
- Over 280 HEP stores since June 2006 – 75% terminated intentionally
  - Slightly better than the 72% Run 2 historical average
  - Causes: power supplies ≈ 24%, cryo ≈ 11%, Mother Nature ≈ 10%, controls ≈ 9% , separators ≈ 7%
- Averaging ≈105 HEP store hours per week since October 2006
  - Includes few weeks of downtime to repair failed Tevatron components
  - Weeks of 130 store hours not uncommon
- Reliability
  - Replaced all ≈1200 LHe Kautzky valves (cause of 2 FY06 dipole failures)
  - Modifying quench protection system to allow faster beam aborts
  - Cog pbars out of abort gap for acceleration – prevent needless quenches

Looking Ahead in Tevatron

- Implement 2nd order chromaticity correction @ low β – in progress
  - Simulations show improved lifetimes during HEP
  - Also prerequisite to pursue possible new working point near ½ integer
  - See A. Valishev poster (FRPMS015)

- Pursue other minor improvements (few % each) – they all add up!
  - Scrape (higher intensity) protons @ 150 GeV
    - Can reduce losses up ramp and through squeeze? Need to resume
  - Investigating new cogging between antiproton injections
    - Reduce beam-beam effects by changing locations of long-range crossings
  - Use TELs (electron lenses) on protons for beam-beam compensation
    - Raise tunes of individual bunches away from resonance to improve lifetime
  - Better helices, improved transfer line matching, faster shot-setups, etc.

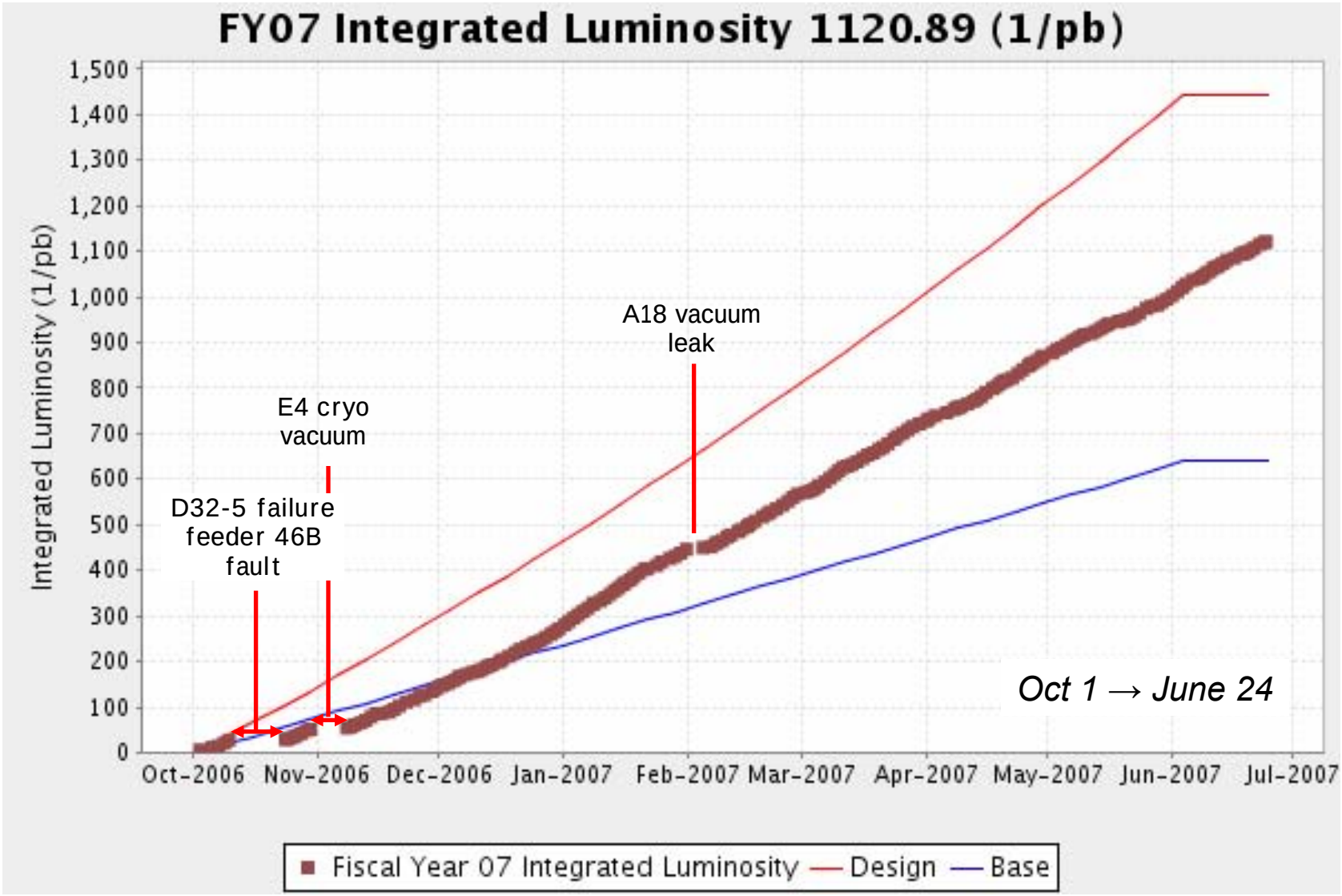
Luminosity Projections with Updated Model Scenarios



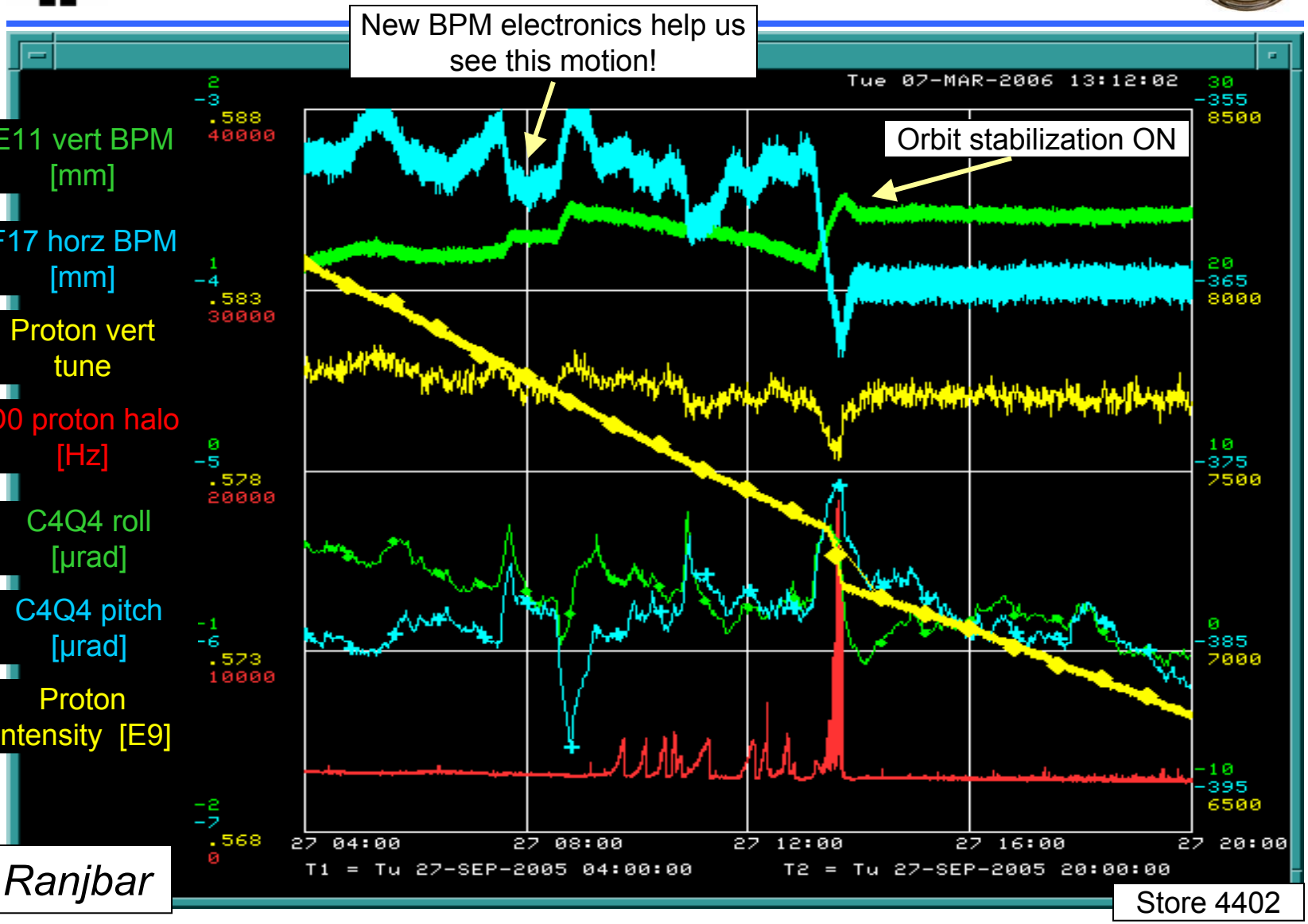
Summary

- Tevatron luminosity made great progress over past year
  - Doubled the delivered luminosity to > 3 fb^{-1}
  - Higher antiproton intensities with smaller emittances
  - Improved luminosity lifetime from increased separation
- Tevatron upgrades complete, still reaping benefits
  - Continue pursuing smaller operational improvements
- On track for 6-7 fb^{-1} total through October 2009
  - 8 fb^{-1} is still the goal
  - Need increased antiproton stacking rates for higher luminosity
- Make the most of the Tevatron before the end of Run 2!

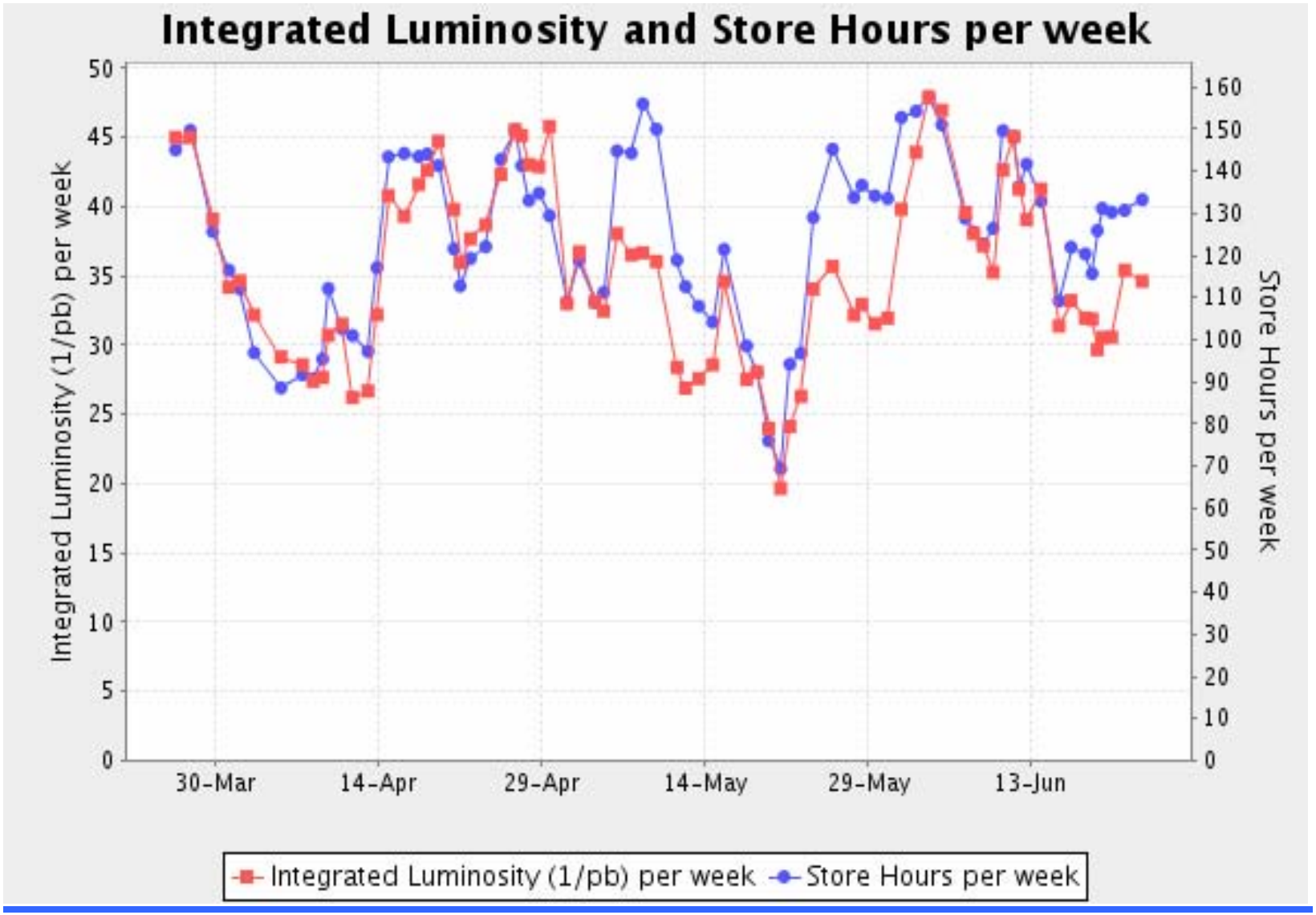
FY07 Tevatron Performance



Magnet Motion / Orbit Stabilization



V. Ranjbar


Integrated Luminosity and Store Hours per week
Integrated Luminosity (1/pb) per week
Store Hours per week
0
5
10
15
20
25
30
35
40
45
50
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
30-Mar
14-Apr
29-Apr
14-May
29-May
13-Jun
Integrated Luminosity (1/pb) per week
Store Hours per week