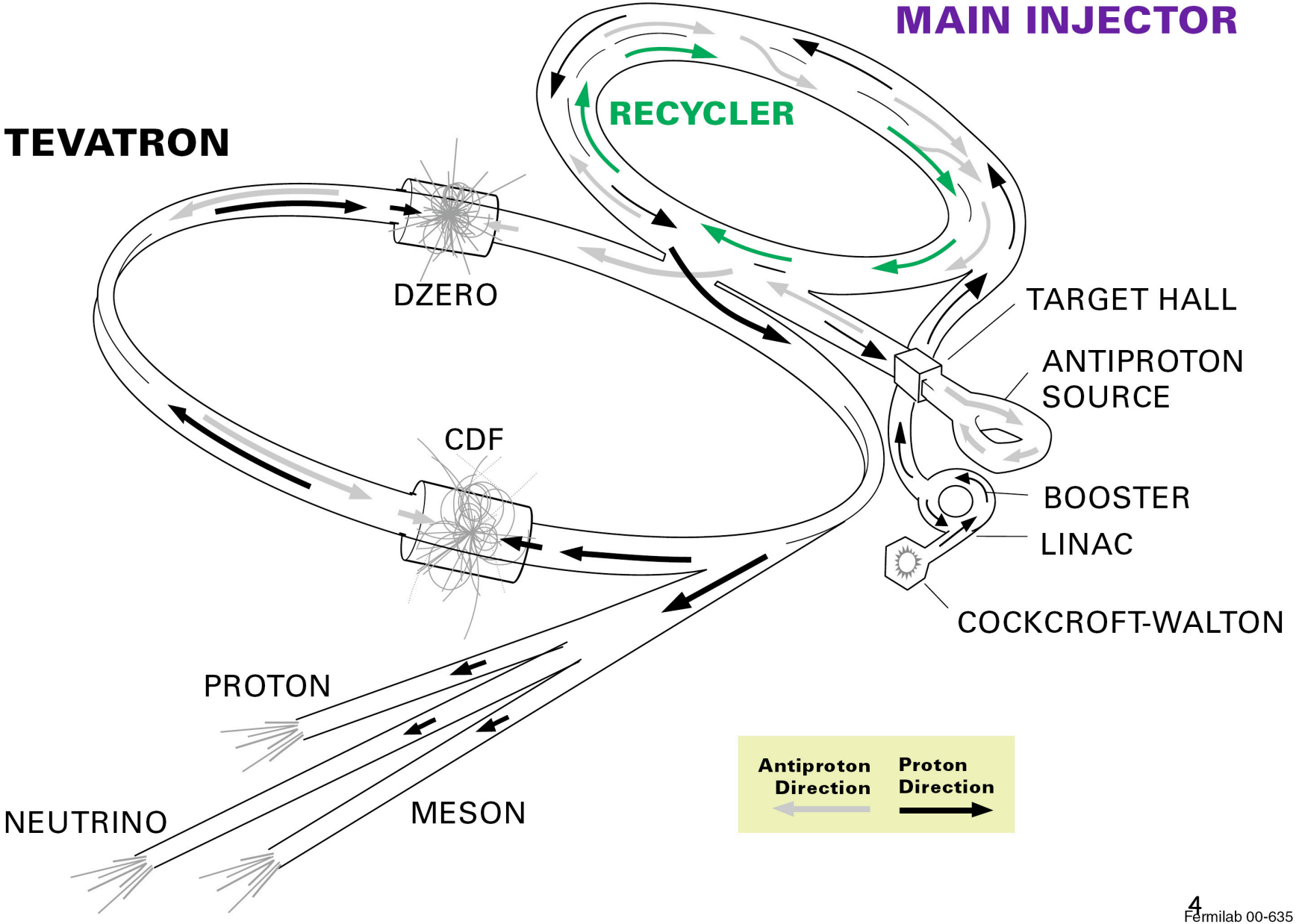
Tevatron Status and Recent Improvements

R. Dixon

Overview

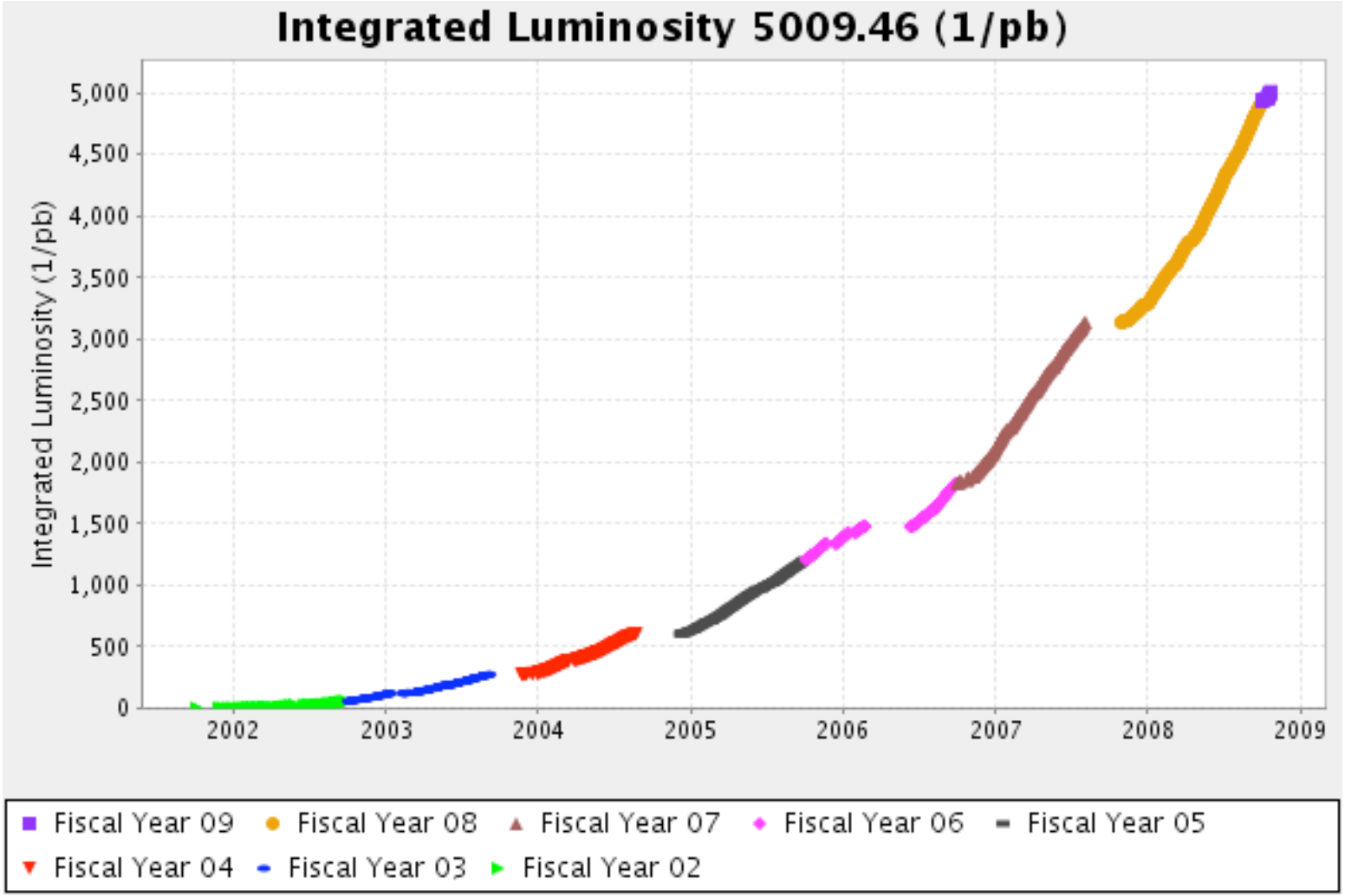
- Overview of Fermilab Accelerator Complex
- Collider Run II Performance
  - Machine Performance
  - Luminosity Summaries
  - Performance Projections
  - Summary of Improvements and Optimizations

FERMILAB'S ACCELERATOR CHAIN

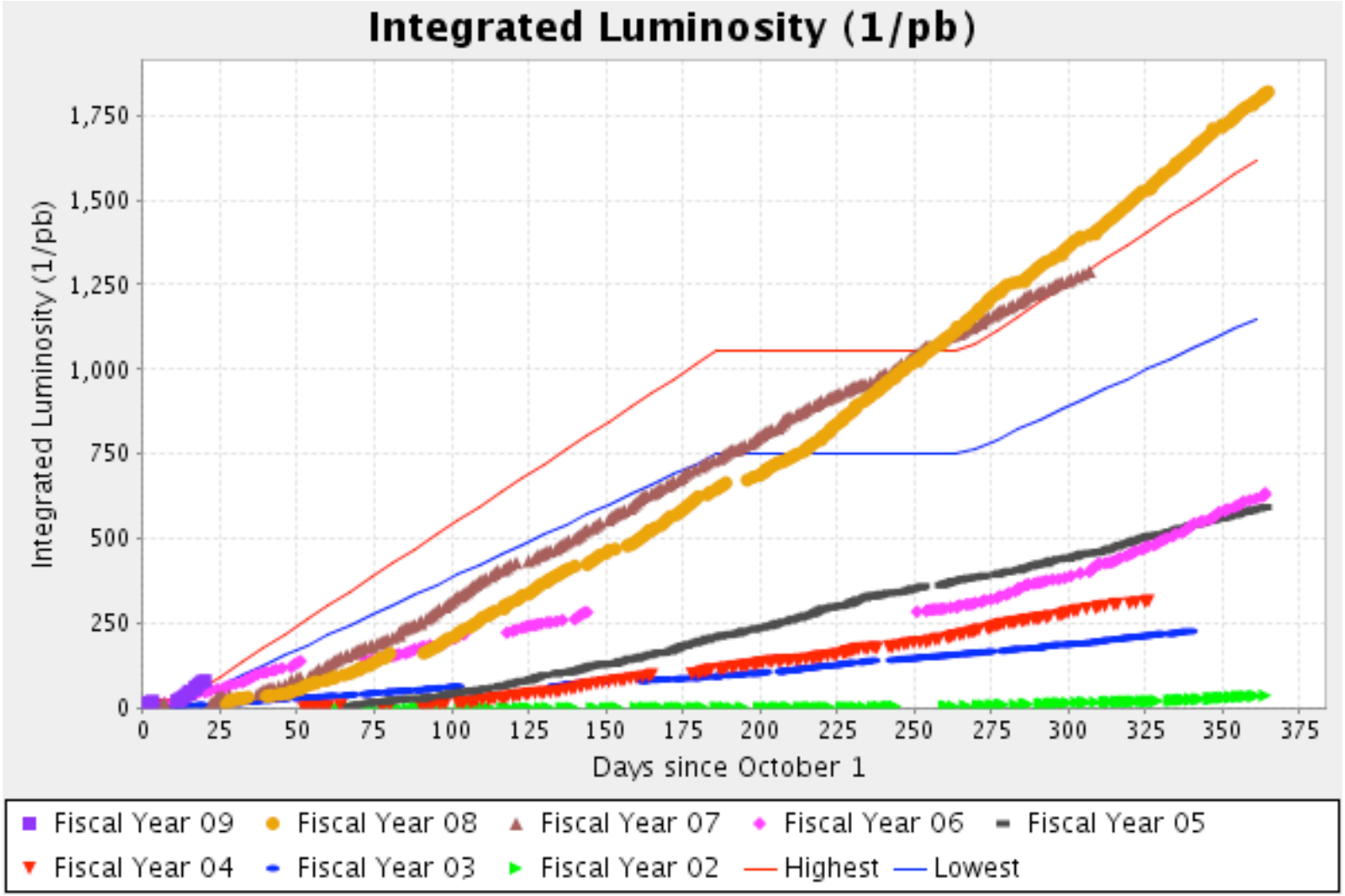


Fermilab 00-635

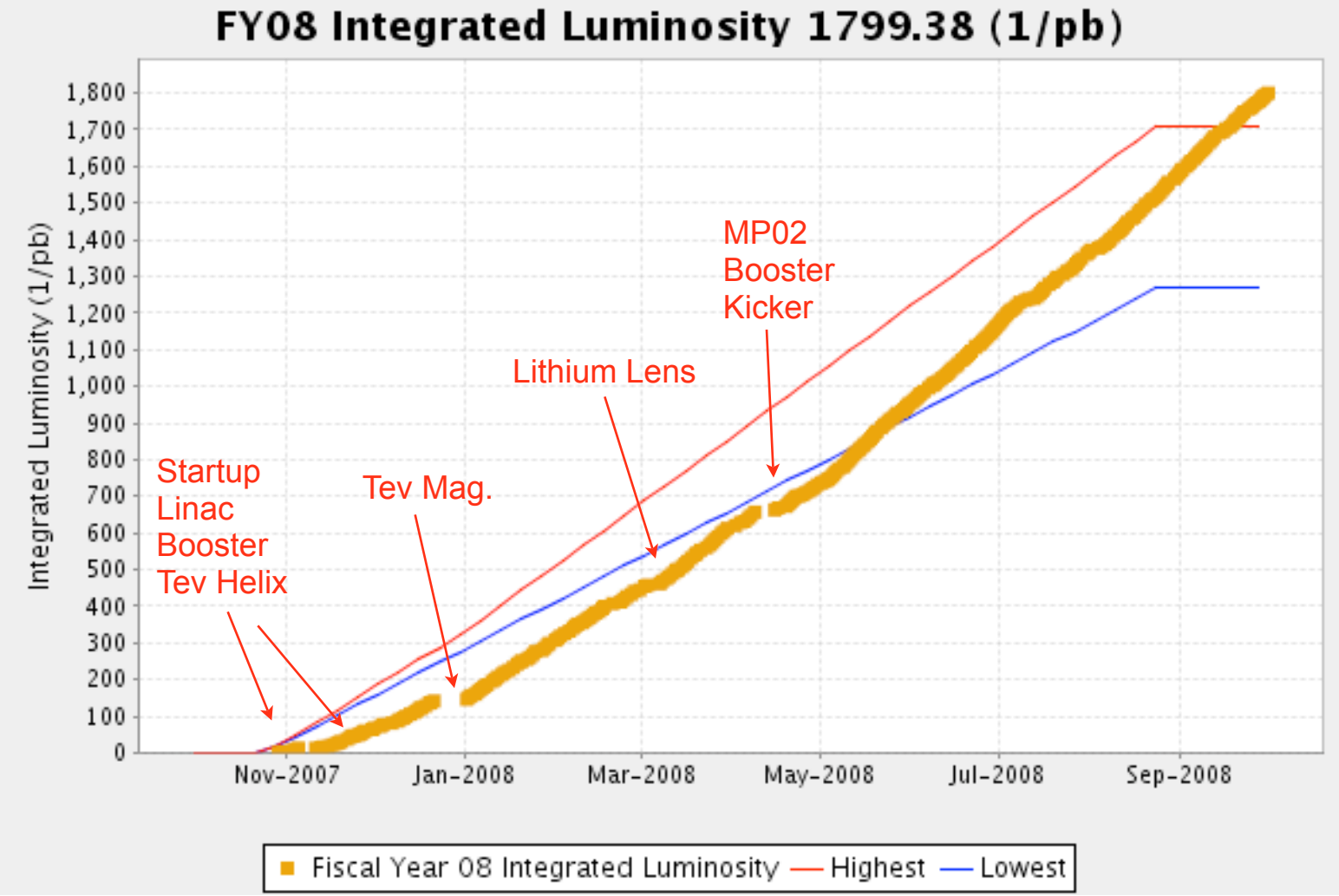
Total Run II Integrated Luminosity



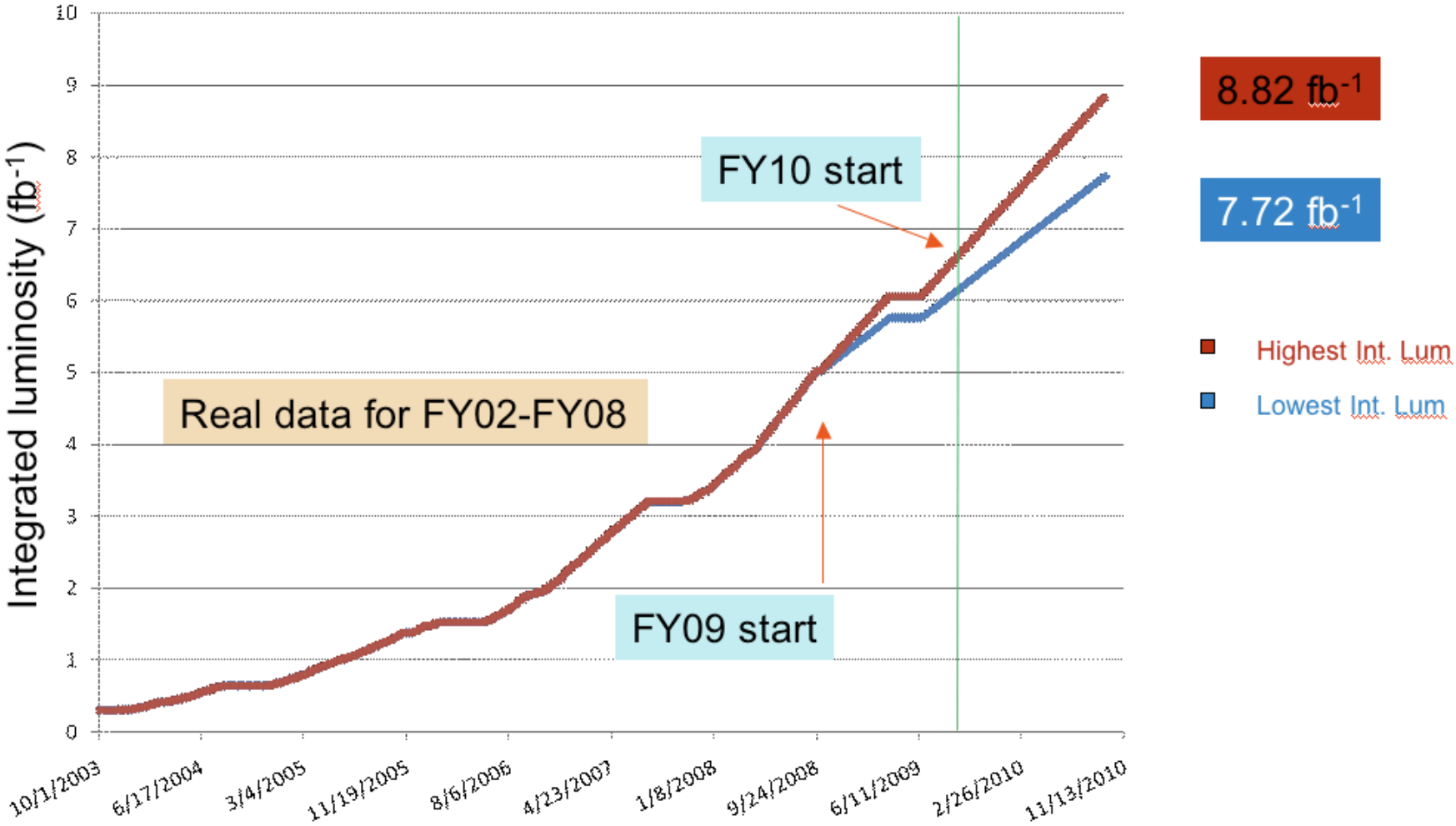
Yearly Luminosity Curves



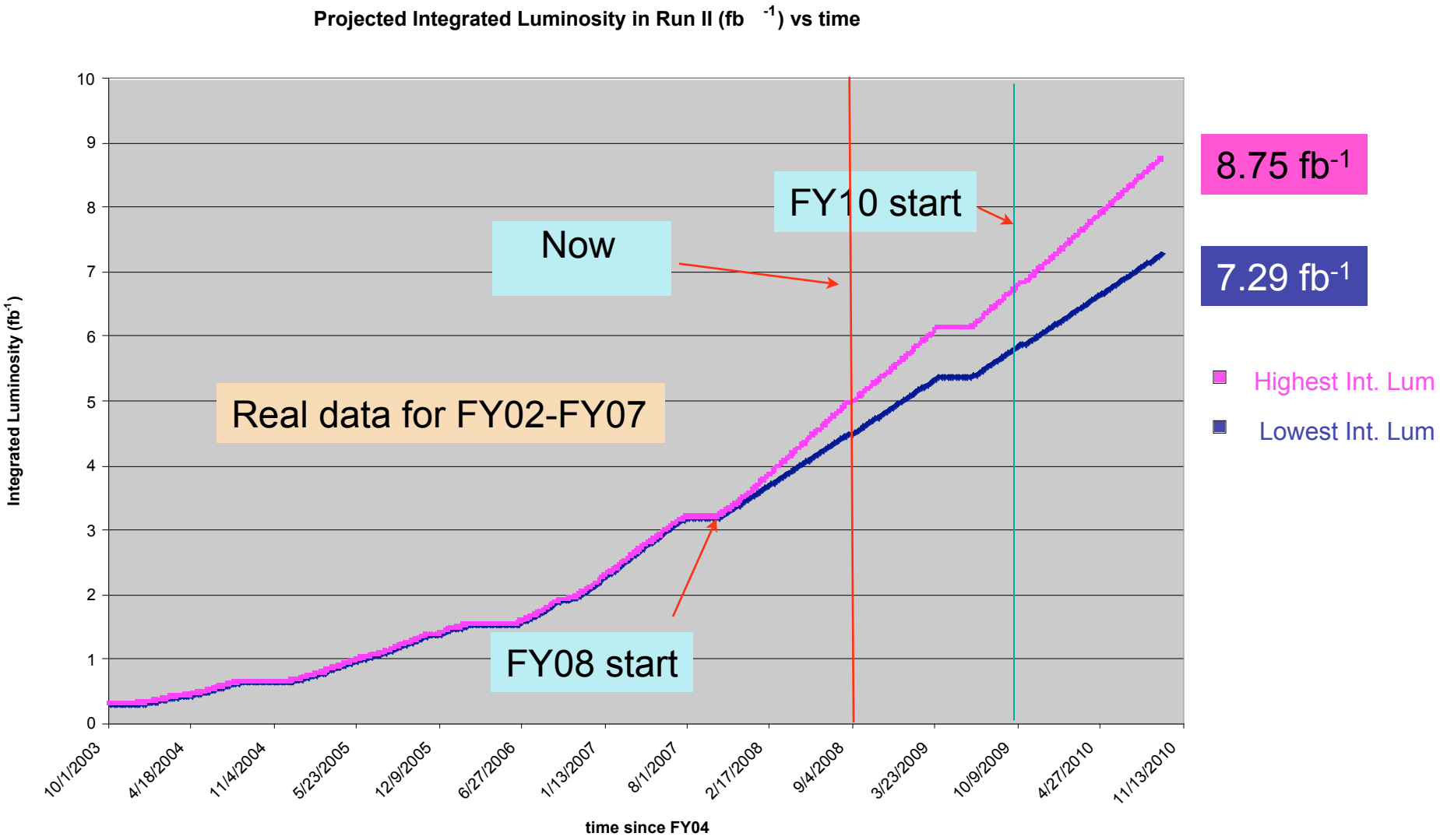
Typical Reliability Issues



Run II Luminosity Projection Curves



Luminosity Projection Curves for Run II



Inputs for FY08 and FY09 – Sc. IV (optimistic1)

Assuming 21 hour long stores and 6 pbar transfer shots between stores

- Number of protons per bunch 260, 270, 270, 270, 270, 270, 270, 270 x 10^9
- Luminosity Density @ 100 x 10^{10} 90.32, 92.126,…,92.126 μb^{-1} / sec
- Luminosity Density @ 300 x 10^{10} 190.34, 194.147,…,194.147 μb^{-1} / sec
- Init Tevatron Lifetime @ 80 μb^{-1}/sec 7.07, 7.14 hours
- Init Tevatron Lifetime @ 160 μb^{-1}/sec 6.59, 6.65, …,6.65 hours
- HEP store hours/week 110, 120,120, 120, 110, 120, 120, 120 hours
- Acc-Rec Transfer Efficiency @ 0x10^{10} 90, 92,…92%
- Acc-Rec Transfer Efficiency @ 300x10^{10} 90, 91,…91%
- Acc-Rec transfer time 0.19, 0.16, …, 0.16 hours
- Recycler lifetime 500 hours
- Recycler mining efficiency 93.8%
- Peak stacking rate 22, 25, 27,…, 27 x10^{10}/hour
- Half rate stack size 210, 250, …,250x10^{10}
- Maximum stack size 420, 500,…,500x10^{10}
- Timeline Utililization Factor 80, 83, …,83%
- Accumulator leftover factor 10%

With above inputs we should expect ~ 3545 pb^{-1} in 2 years

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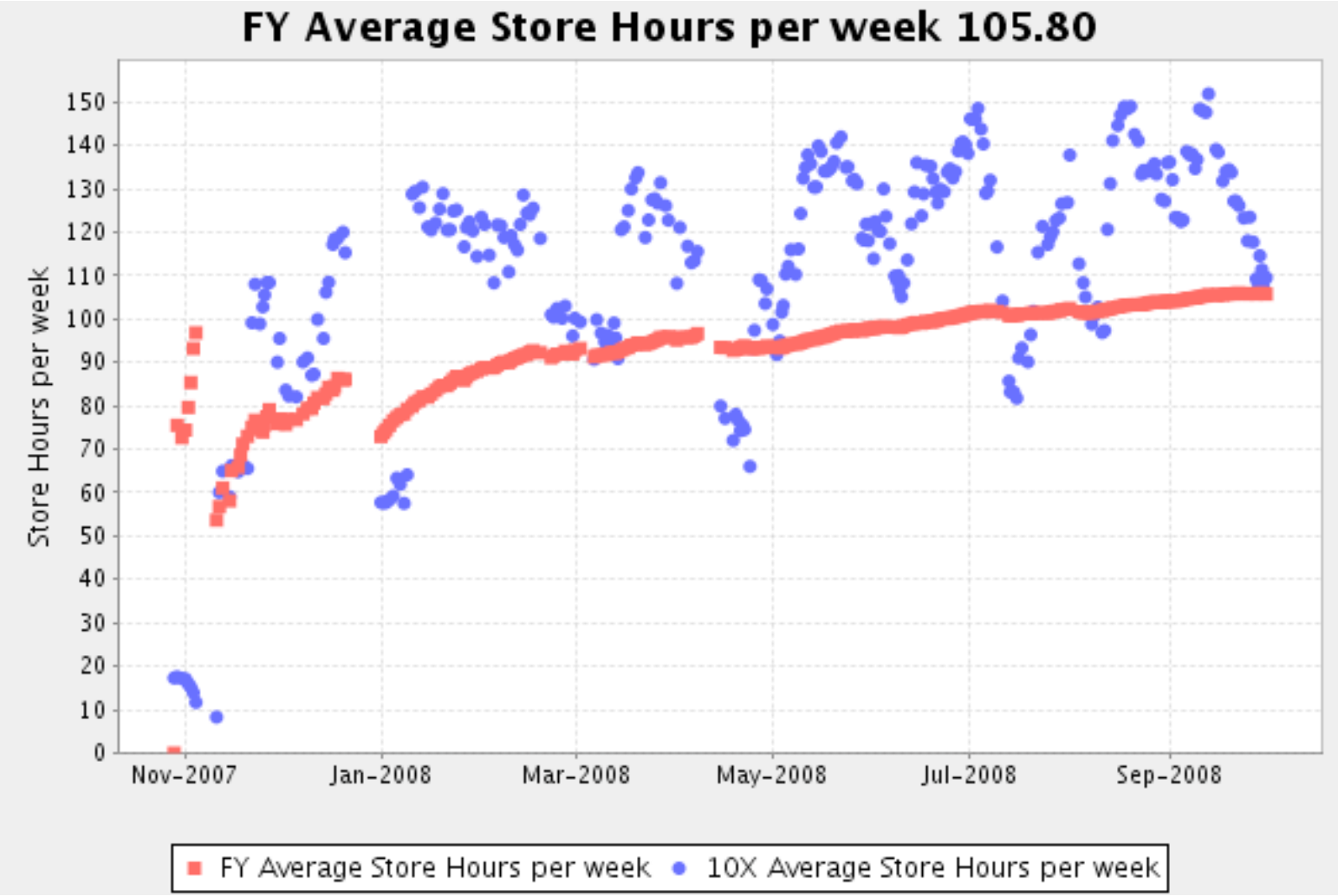
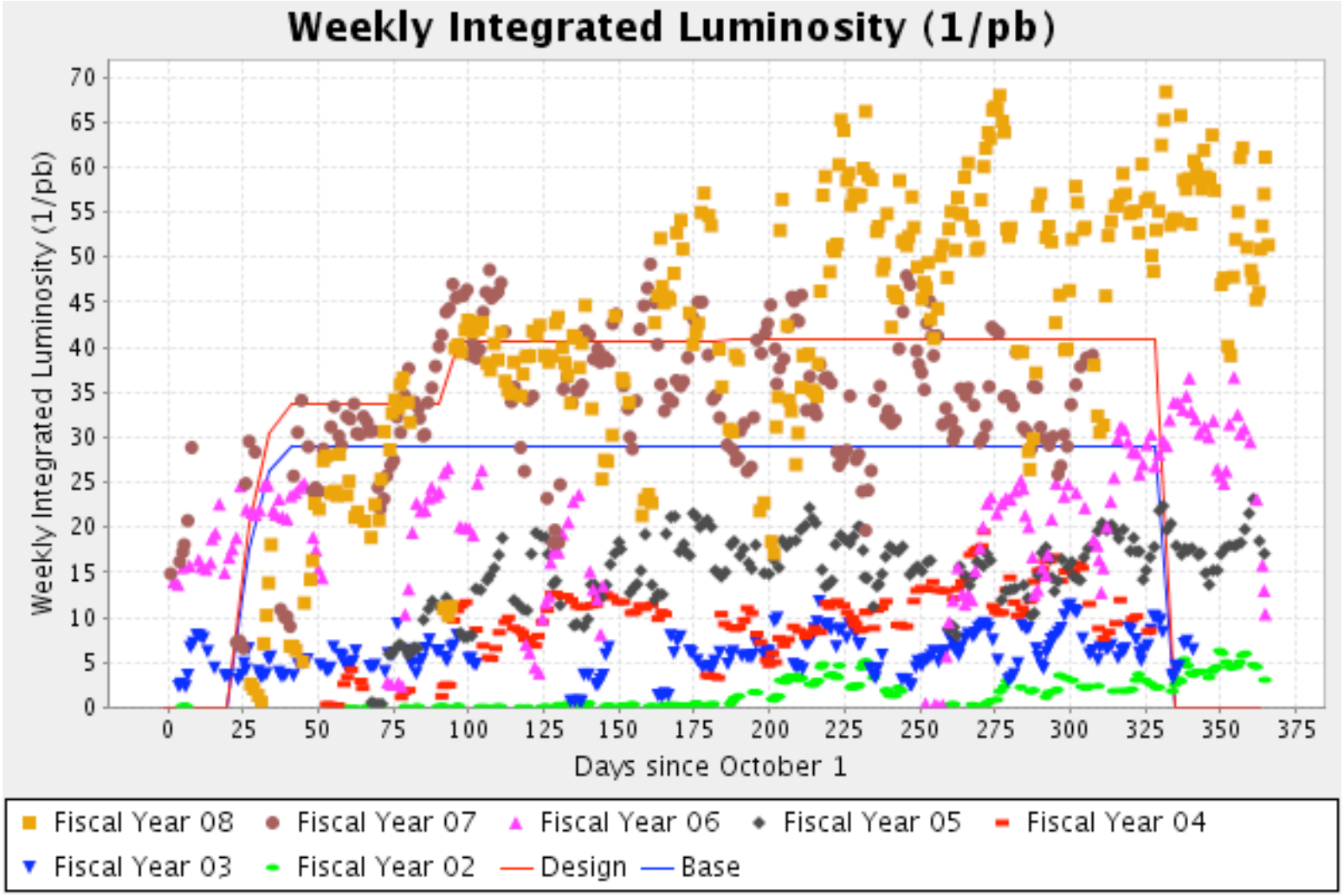
Average Store Hours FY08



Luminosity Data



Records During the Past Year

Stacking: 27.01 X 10^{10}/hour on June 3, 2008

Record Initial Luminosity:

3.18 X 10^{32} cm^{-2} sec^{-1} on July 5, 2008

Record Delivered Luminosity for one week:

57.5 pb^{-1} on June 30, 2008

Record Delivered Luminosity for one month:

221 pb^{-1} May 2008 (Fourth best month = 217)

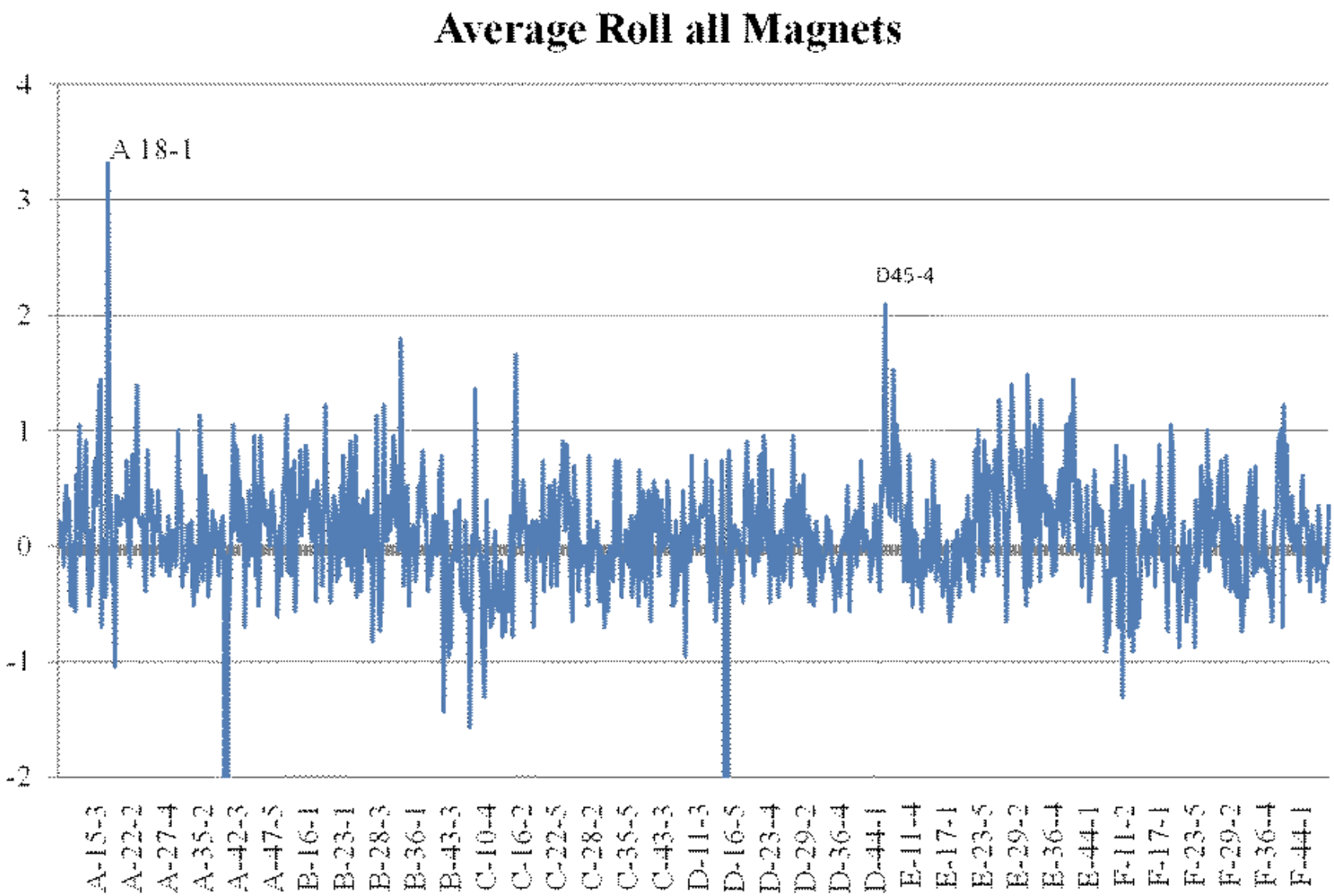
Improvements

- Reliability
  - Overall Machine Reliability-- weaknesses continue to be found and mitigated
- Tevatron reliability
  - Quench Protection
  - Fewer quenches
- Better instrumentation
  - Beam Position Monitors all around
- Careful alignment and realignment of the Tevatron
- Increased antiproton stacking rate
  - 15 ma/hr --> 27 ma/hr peak
- Electron cooling of antiprotons in the Recycler
  - Single largest luminosity gain
- Optimizing Running Conditions
  - Improve transfer efficiencies, transfer times, shot setup times
  - Optimize store length and initial luminosities
  - Optimize beam brightness

Store Terminations

Year	Stores	Normal Terminations	%Normal Terminations
2003	186	55	30%
2004	166	110	66%
2005	243	170	69%
2006	171	107	63%
2007	220	177	80%
2008	304	262	86%

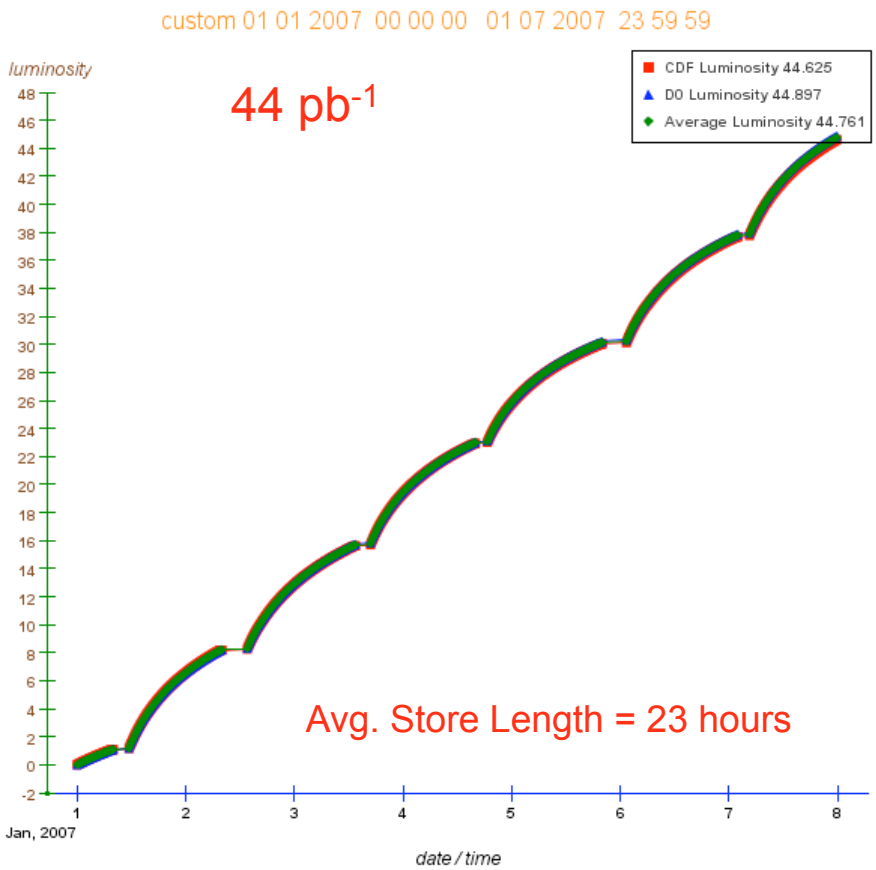
Tevatron Magnet Rolls

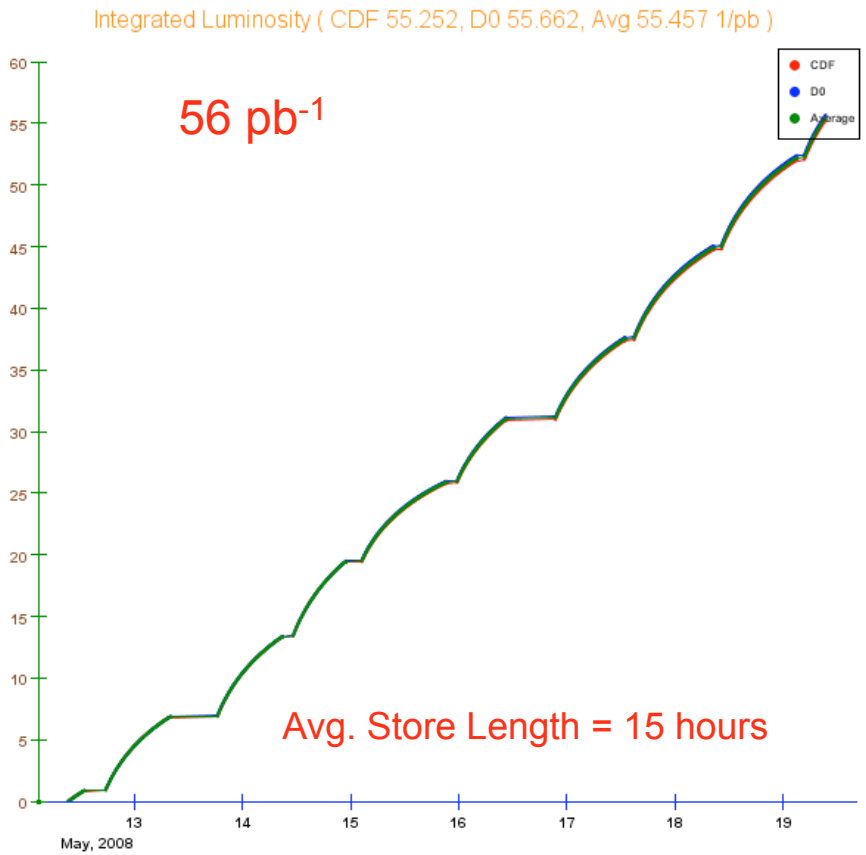


Optimizing Run Conditions

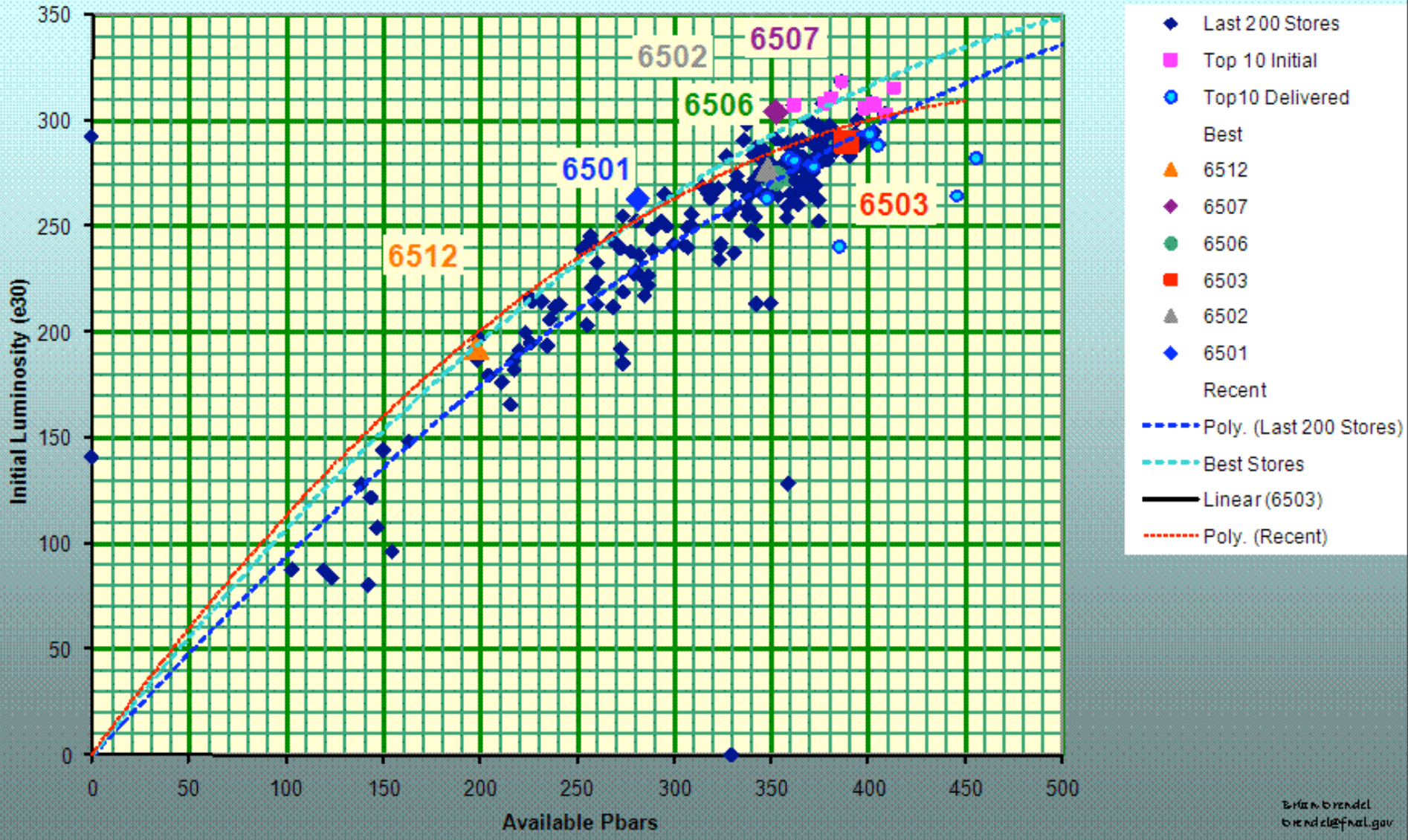
- Run Coordinators
  - Report directly to me
  - All have operations backgrounds/work closely with operations department
  - Live with machine 24 hours per day
  - Make all decisions
    - Meet with me everyone morning for guidance
    - Meet with AD machine coordinators and Experiment coordinators every morning to make a plan for the day
- Run Coordination Support
  - Theory support
    - Mike Syphers (Assist. Div Head)
    - APC personnel as needed
  - Shot Data Analysis Group (in Headquarters)
    - Vaia Papadimitriou
    - Mary Convery
    - Software support from Controls Department
  - Rest of the Accelerator Division as needed

2007 vs 2008 Running





Average Initial Luminosity vs Available Pbars

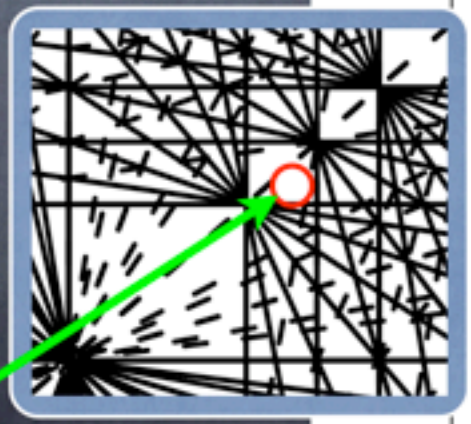


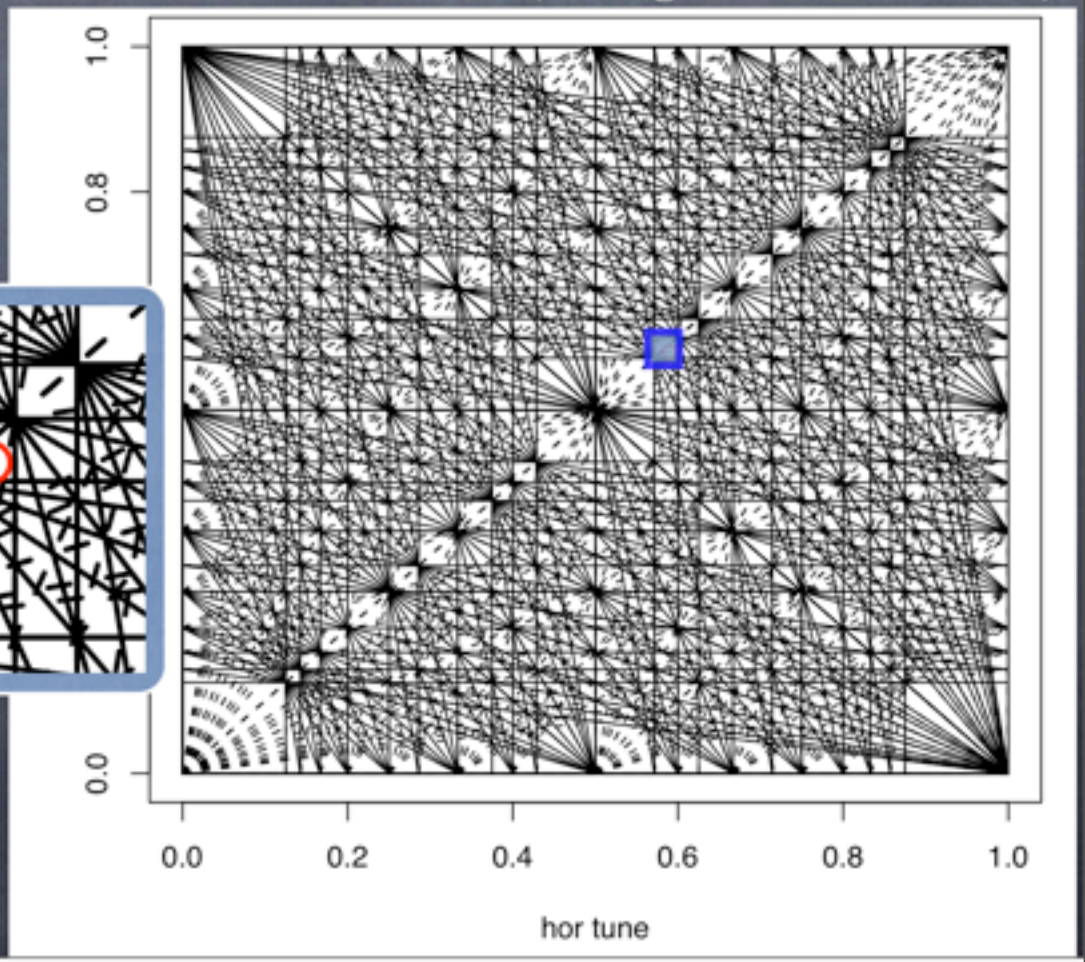
Tune Diagram

- Resonance Lines in tune space indicate potential problem spots for operation

(through 8th order shown)

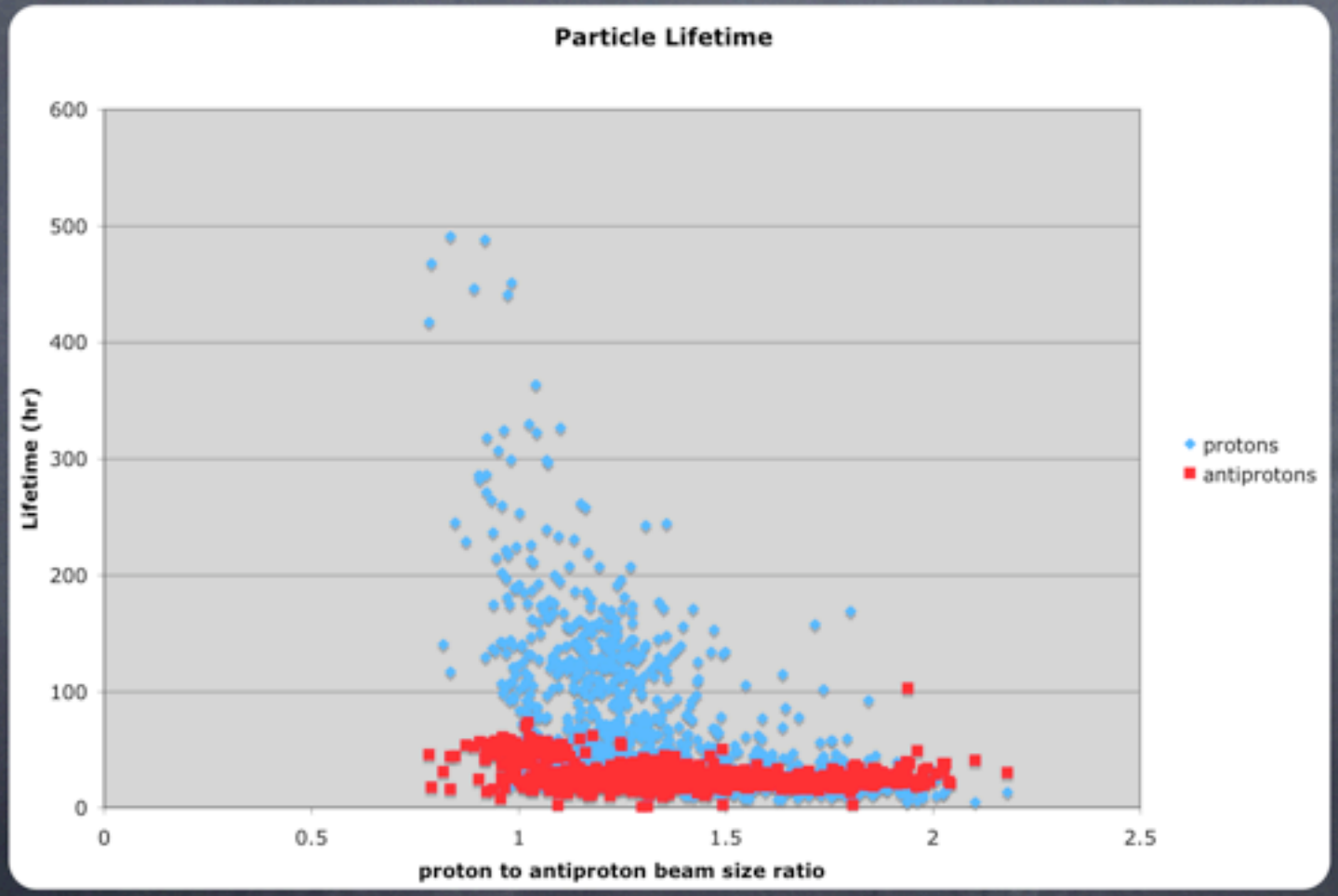
- Tev operation:
  - ~ 20.59, 20.58





width ~ 0.025

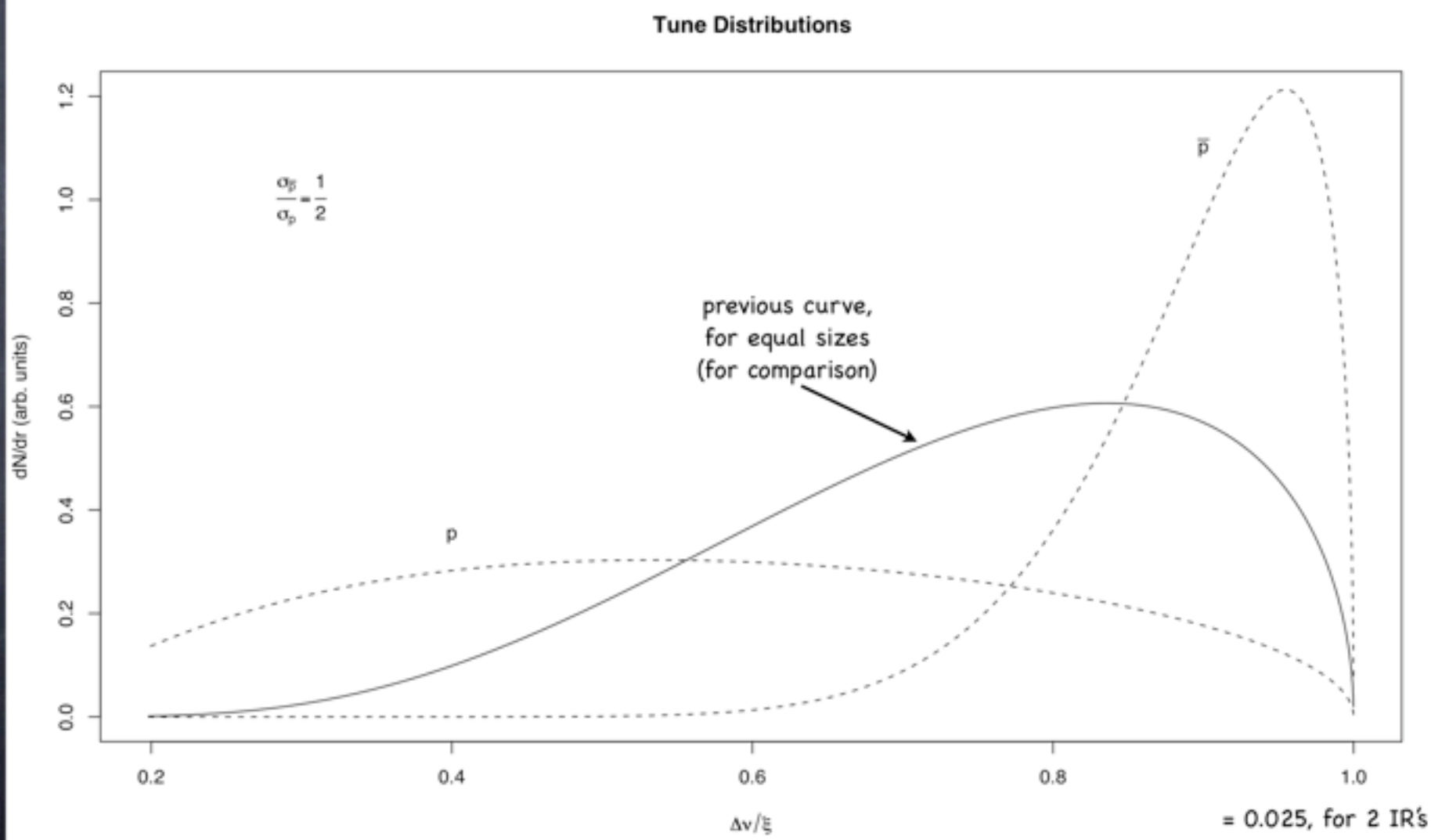
Lifetimes during 1st two hours



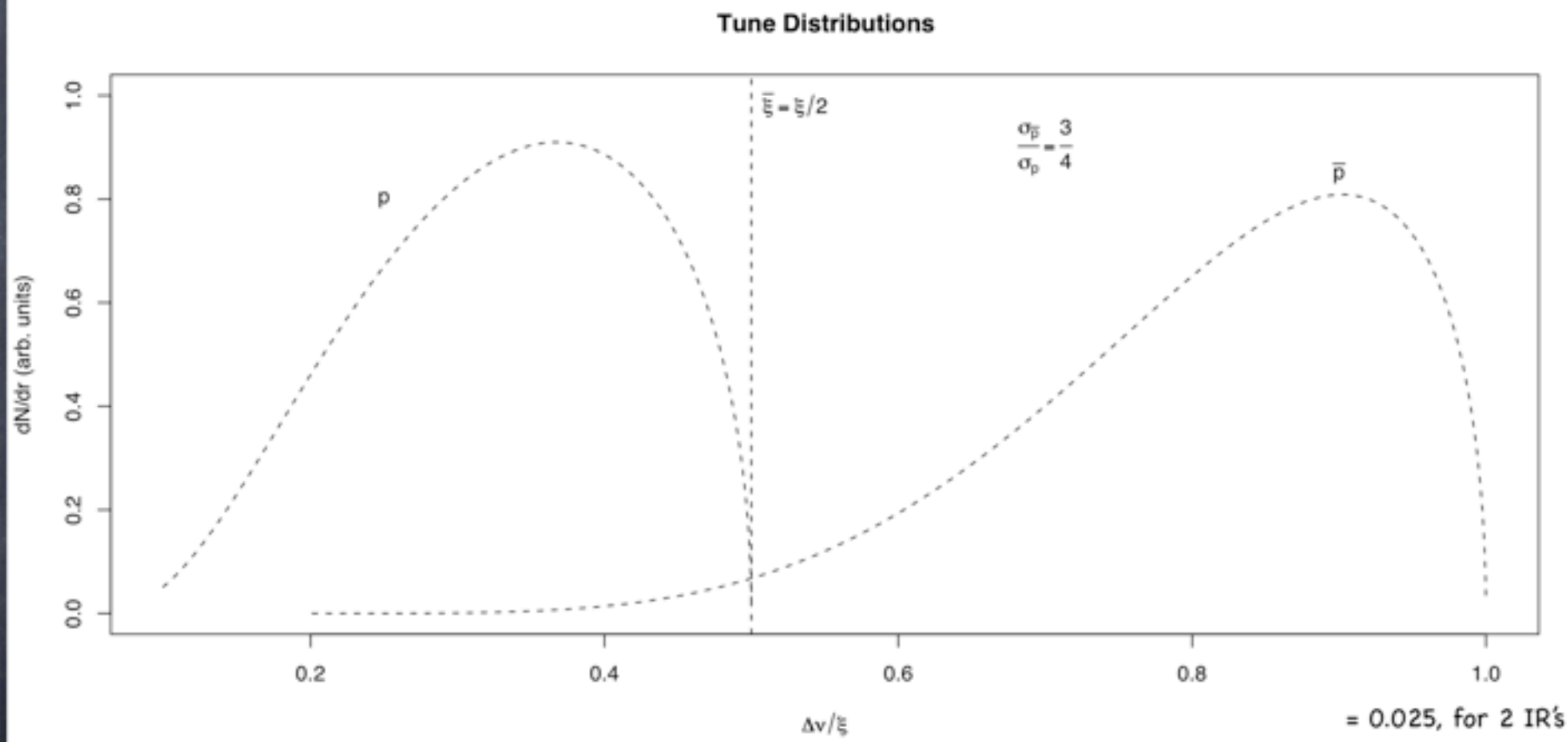
Data available thru SDA;
thanks -- J. Annala

~1000 stores

Cold Pbars...


Tune Distributions
dN/dr (arb. units)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0.2
0.4
0.6
0.8
1.0
Δν/ξ
$\frac{\sigma_{\xi}}{\sigma_{p}} = \frac{1}{2}$
p
$\bar{p}$
previous curve,
for equal sizes
(for comparison)
= 0.025, for 2 IR's

Optimal?



Roughly equal tune spreads in both beams
--> does this optimize lumi lifetime??

Controlling the Brightness of the Beams

- Antiprotons and "jacked" by PBJ after injection into the Tevatron to increase their emittance (decrease brightness
- Now experimenting with proton brightness
  - Better quality beam from Booster
  - More intense beam from Booster that is scraped in the Main Injector resulting in beam with smaller emittance
  - This led to record store and a number of other stores above the curves

Ongoing Improvements

- Stacking Rate
  - Equalizer to mitigate core heating √
  - Debuncher notch filter
  - ~12 equalizers on the Debuncher, stacktail, and core
- Improve transfer efficiencies and times √
- Decreasing shot setup time by loading protons 2 bunches at a time
- Orbit stabilization in theTevatron √
- Controlling Antiproton brightness in the Tevatron due to improvements in the Recycler √
  - Antiprotons emittances are blown up slightly to improve proton lifetimes during the store
- Improving proton brightness
  - Improve beam quality coming out of Booster
  - Scraping in Main Injector
- Optimizing Running Conditions
  - Store Length
  - Proton/Antiproton brightness

Run II Strategy

- Maximize the delivered luminosity
  - Continue
    - to make small improvements with short payback times
    - to Optimize Running Conditions to take advantage of improvements
    - to increase overall machine reliability reliability

Summary

- Collider Performance continues to improve
  - Making small improvements to stacking
  - Improving efficiencies, transfer times, and shot setup times
  - Improving reliability
  - Optimizing running modes