FNAL Accelerator Complex Status

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Contents

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- Progress on Protons for Neutrino Production
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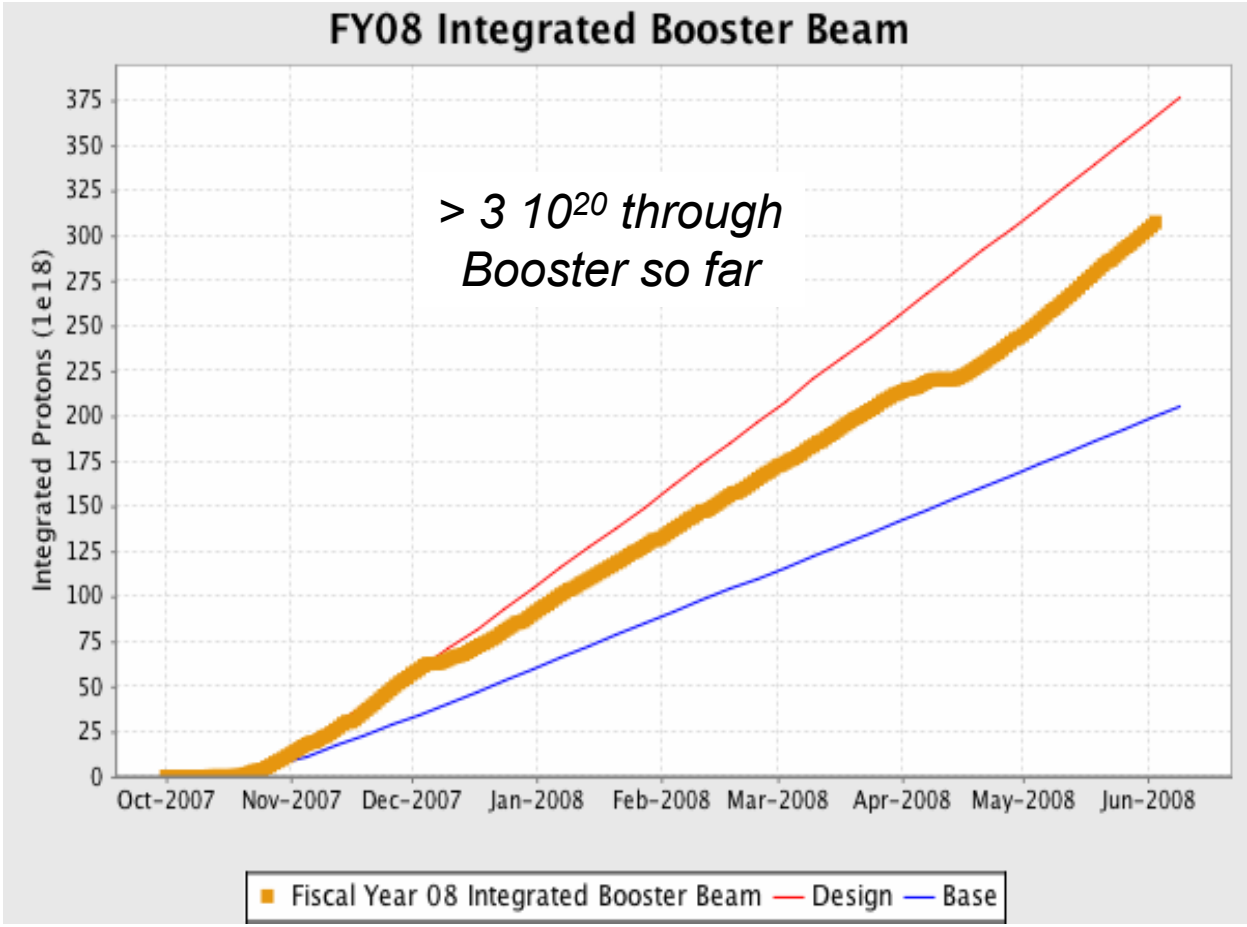
- Planning Ahead
- Summary

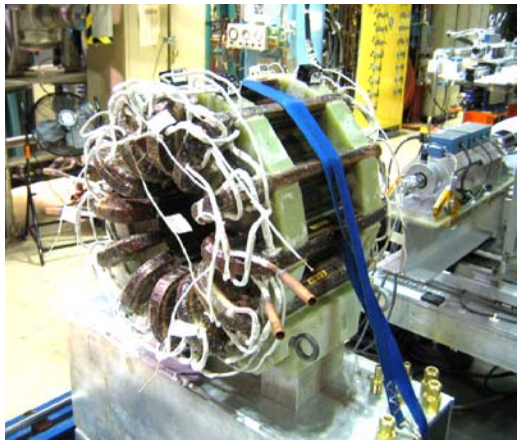
Activity Overview

- Shutdown: August - October 2007
  - Booster correctors, Main Injector collimators, Tevatron maintenance
- Neutrino Production
  - 8 GeV p for BNB (Booster Neutrino Beam): MiniBoone + SciBoone
  - 120 GeV protons for NuMI: MINOS
- Collider (Tevatron, Antiproton Source, Recycler)
  - Run 2: Now > 4 fb^{-1} delivered to both CDF and D0
  - Records in antiproton production and delivered luminosity
  - Several operational improvements
- SY120 – Meson Test Beam Facility
  - One spill (1 sec / 4 sec) from MI every 60 s up to 12 hr/day
  - Pushing secondary beam energies down to 1 GeV

Booster Highlights

- Installed ¼ of the new corrector system during 2007 shutdown
  - Stronger dipoles + ramped quadrupoles and sextupoles

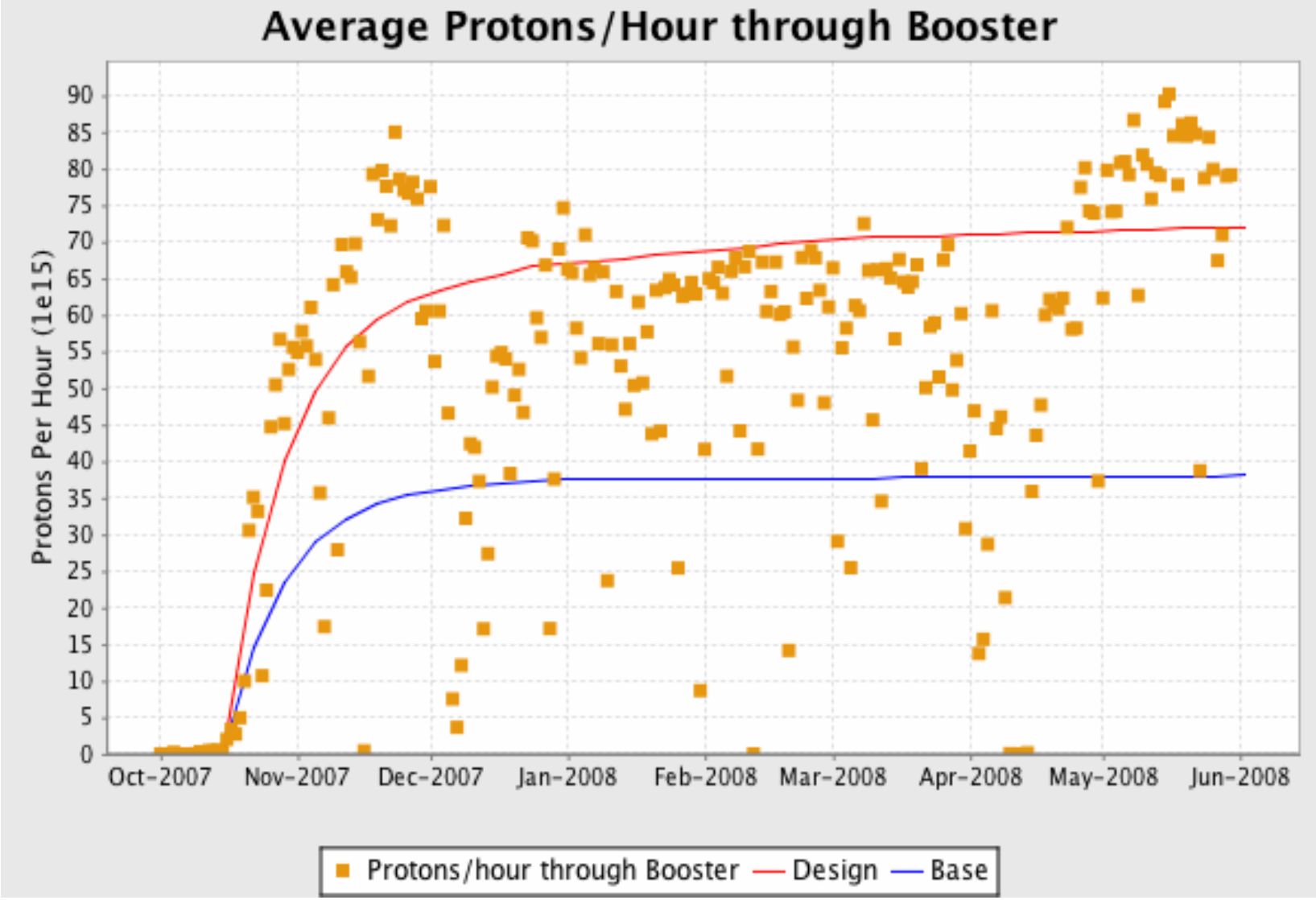


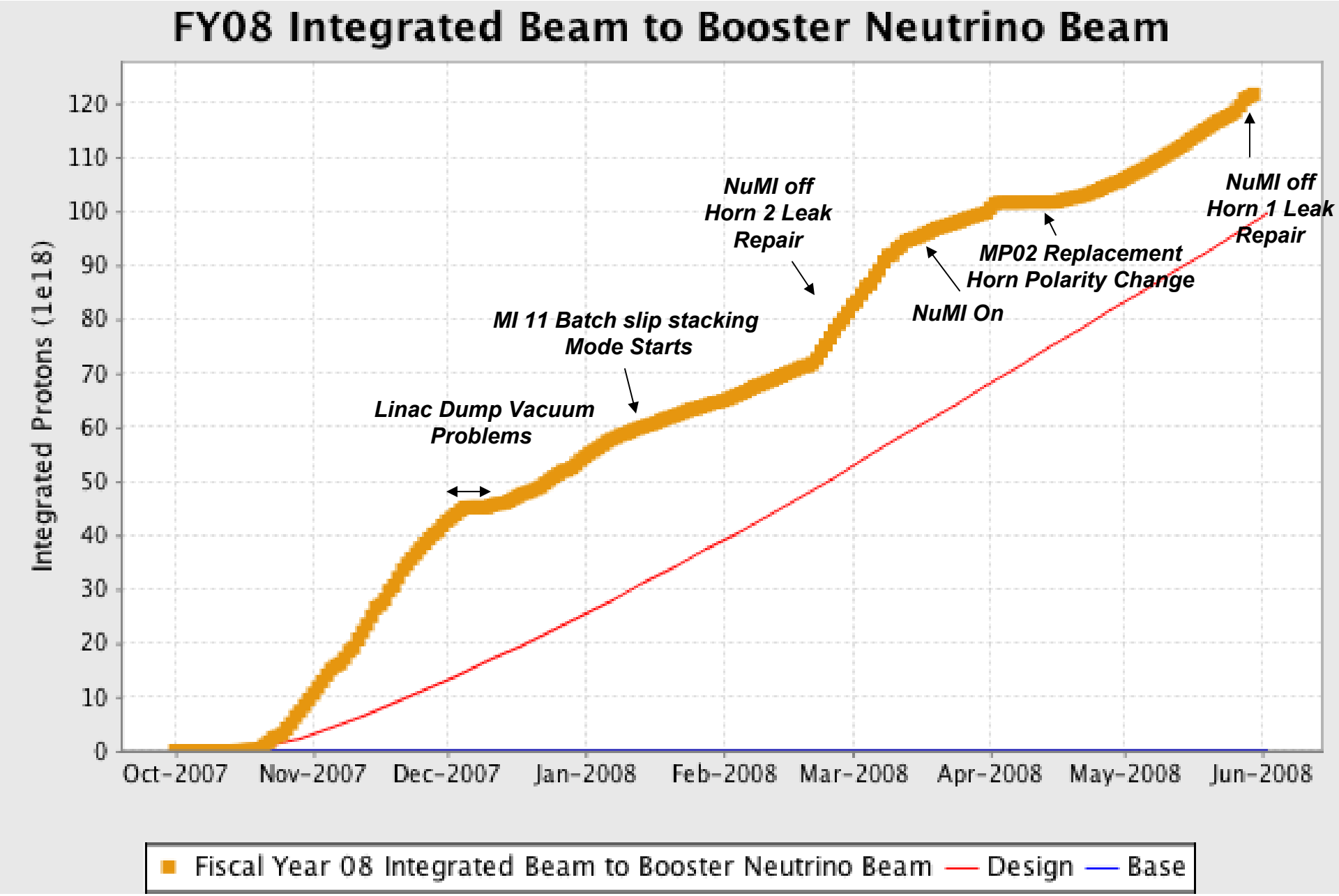


corrector coil package

- Delivering high quality beam to support combined pbar / NuMI slip-stacking operation *and* MiniBooNE / SciBooNE at record total rate

FY08 Booster Proton Delivery




FY08 Integrated Beam to Booster Neutrino Beam
Integrated Protons (1e18)
0
10
20
30
40
50
60
70
80
90
100
110
120
Oct-2007
Nov-2007
Dec-2007
Jan-2008
Feb-2008
Mar-2008
Apr-2008
May-2008
Jun-2008
Linac Dump Vacuum Problems
MI 11 Batch slip stacking Mode Starts
NuMI off Horn 2 Leak Repair
NuMI On
MP02 Replacement Horn Polarity Change
NuMI off Horn 1 Leak Repair
Fiscal Year 08 Integrated Beam to Booster Neutrino Beam
Design
Base

Main Injector Collimators

- Collimate uncaptured beam left over from high-intensity slip-stacking
  - Essential for going up to 400 kW operation
  - Localize radiation to reduce impact on personnel and components
- Scatter off-momentum particles with thin primary target (.25 mm W)
- Capture scattered beam in 20 t steel blocks covered with marble
- Installed 4 secondary collimators during 2007 shutdown
  - Tricky! Dipole and quadrupole busses had to be relocated
- Now operational with collimator efficiency >90%

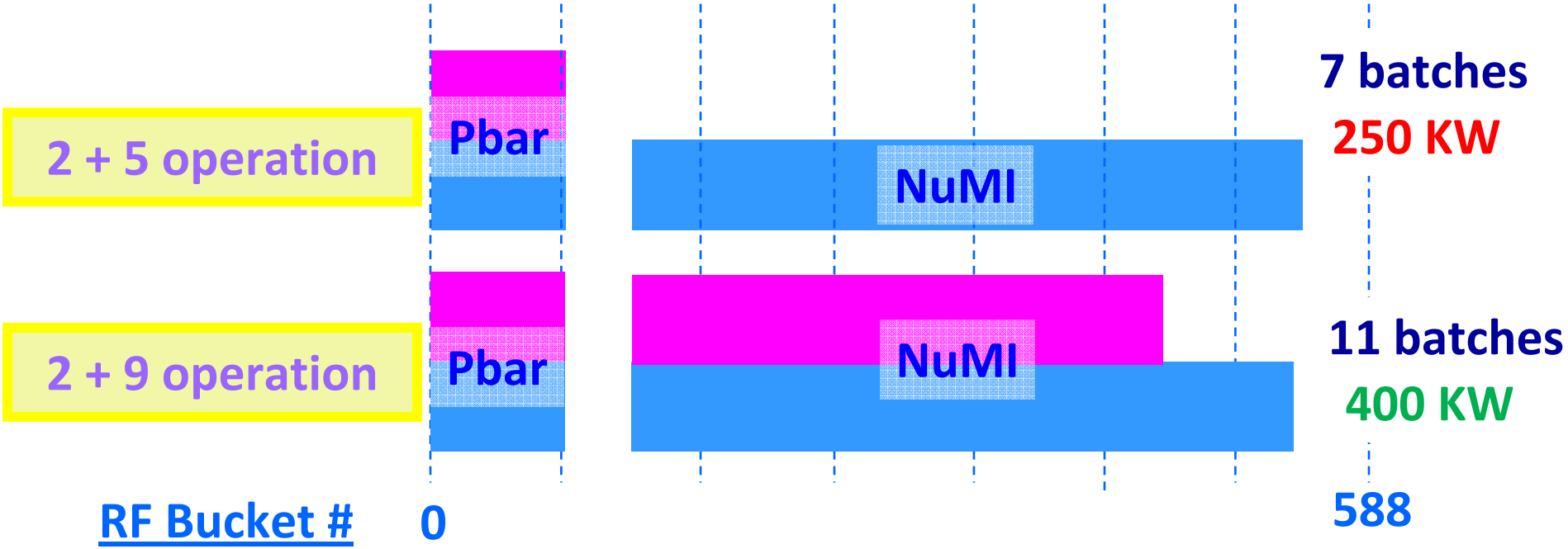
20 Ton Secondary Collimator in MI

Includes precise radial and vertical motion

How big? --- Fill up the available space!

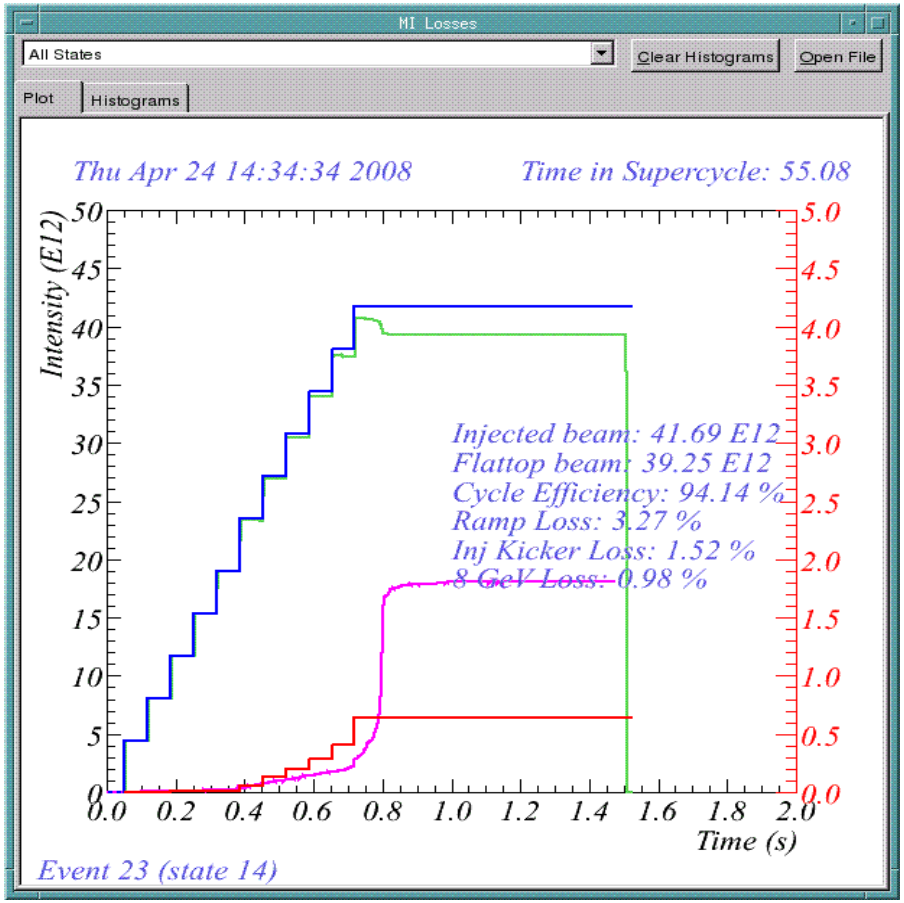
Multi-Batch Slip-Stacking in MI

- Inject multiple Booster batches around MI – captured by different RF systems
- Merge together – “slip-stacking” – accelerate all in same cycle

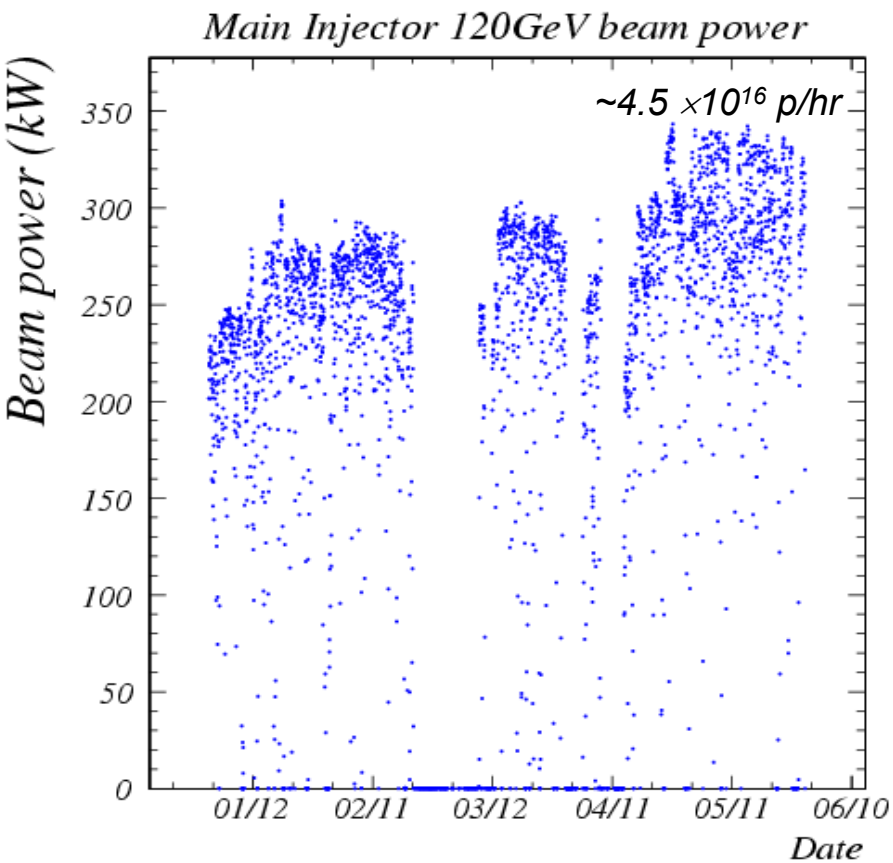


- Prior to 2007 shutdown “2+5” was standard procedure
- “2+9” became operational in Jan 2008 - allows higher beam power for NuMI

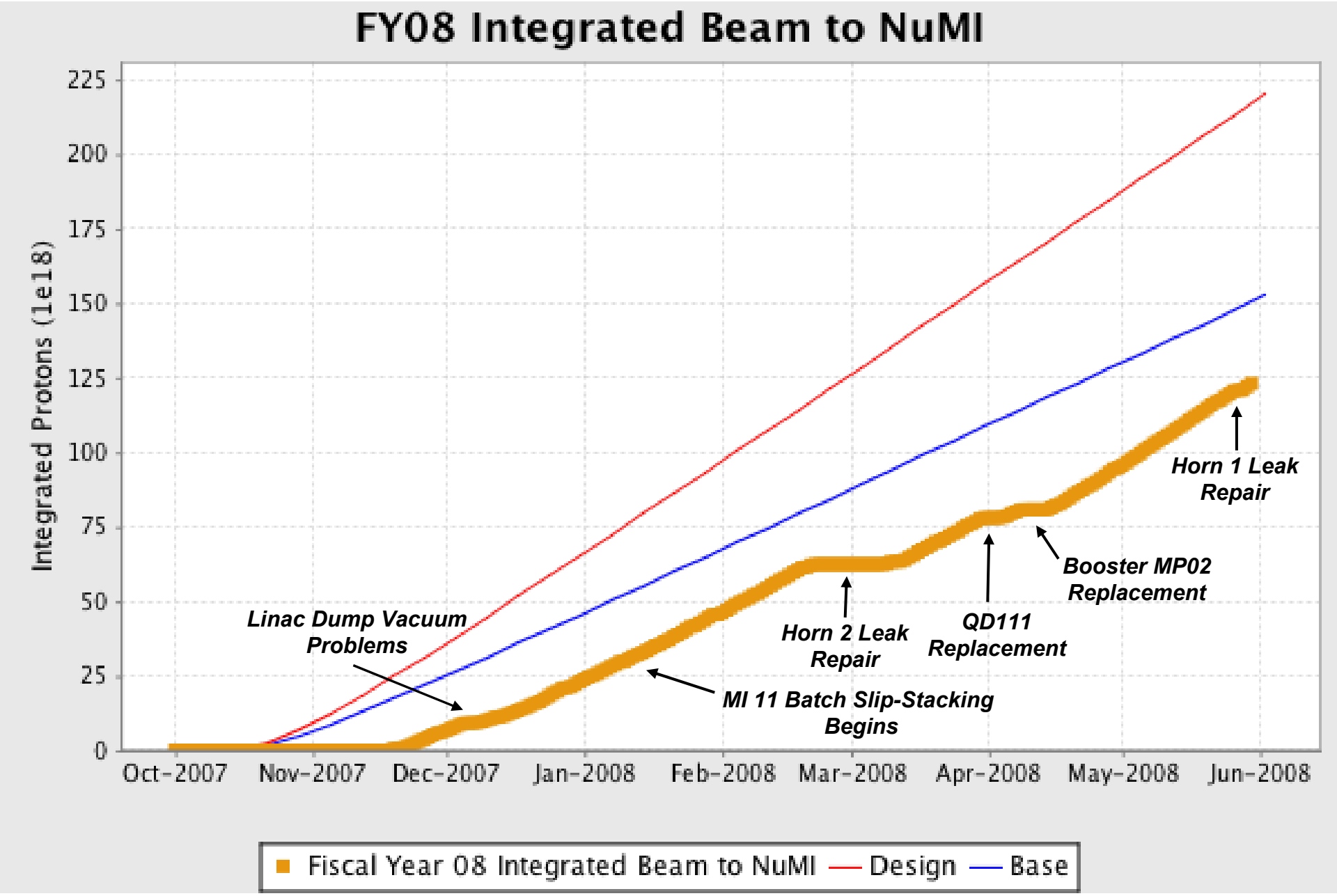
Multi-Batch Slip-Stacking in Operation



Typical MI intensity and efficiency during mixed mode operation



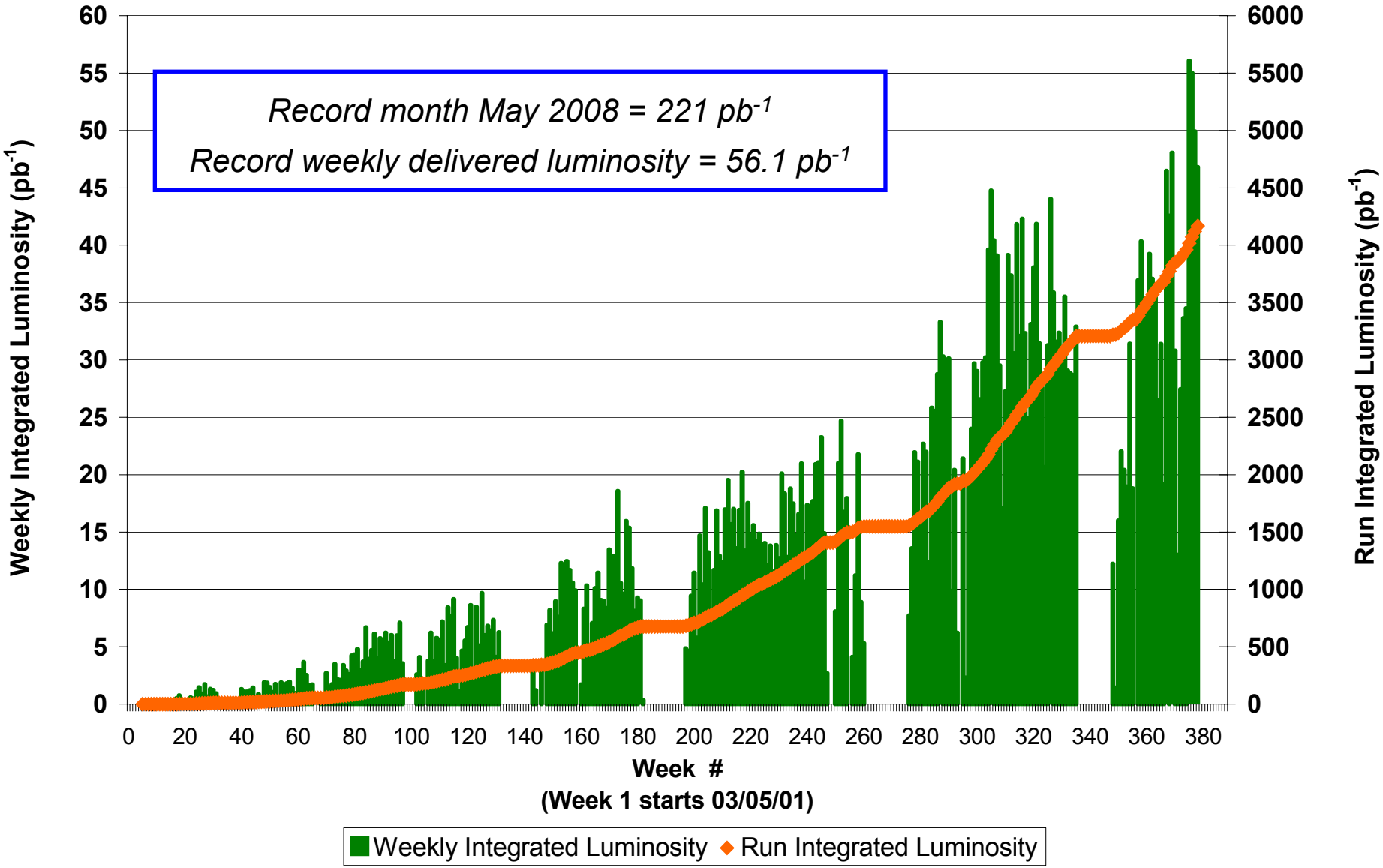
MI beam power at 120 GeV since multi-batch slip stacking become operational


FY08 Integrated Beam to NuMI
Integrated Protons (1e18)
225
200
175
150
125
100
75
50
25
0
Oct-2007
Nov-2007
Dec-2007
Jan-2008
Feb-2008
Mar-2008
Apr-2008
May-2008
Jun-2008
Linac Dump Vacuum Problems
MI 11 Batch Slip-Stacking Begins
Horn 2 Leak Repair
QD111 Replacement
Booster MP02 Replacement
Horn 1 Leak Repair
Fiscal Year 08 Integrated Beam to NuMI
Design
Base

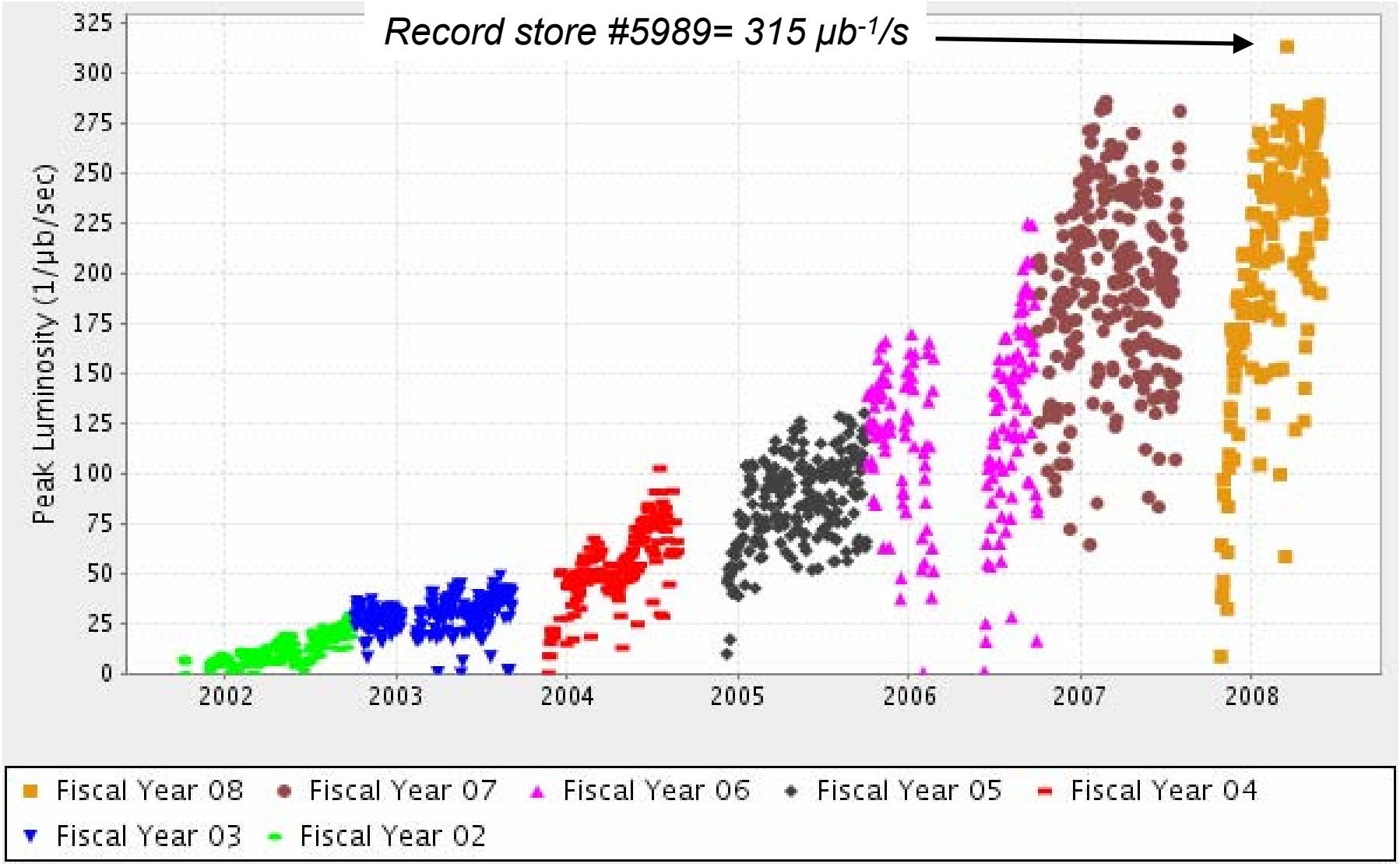
Collider Run 2

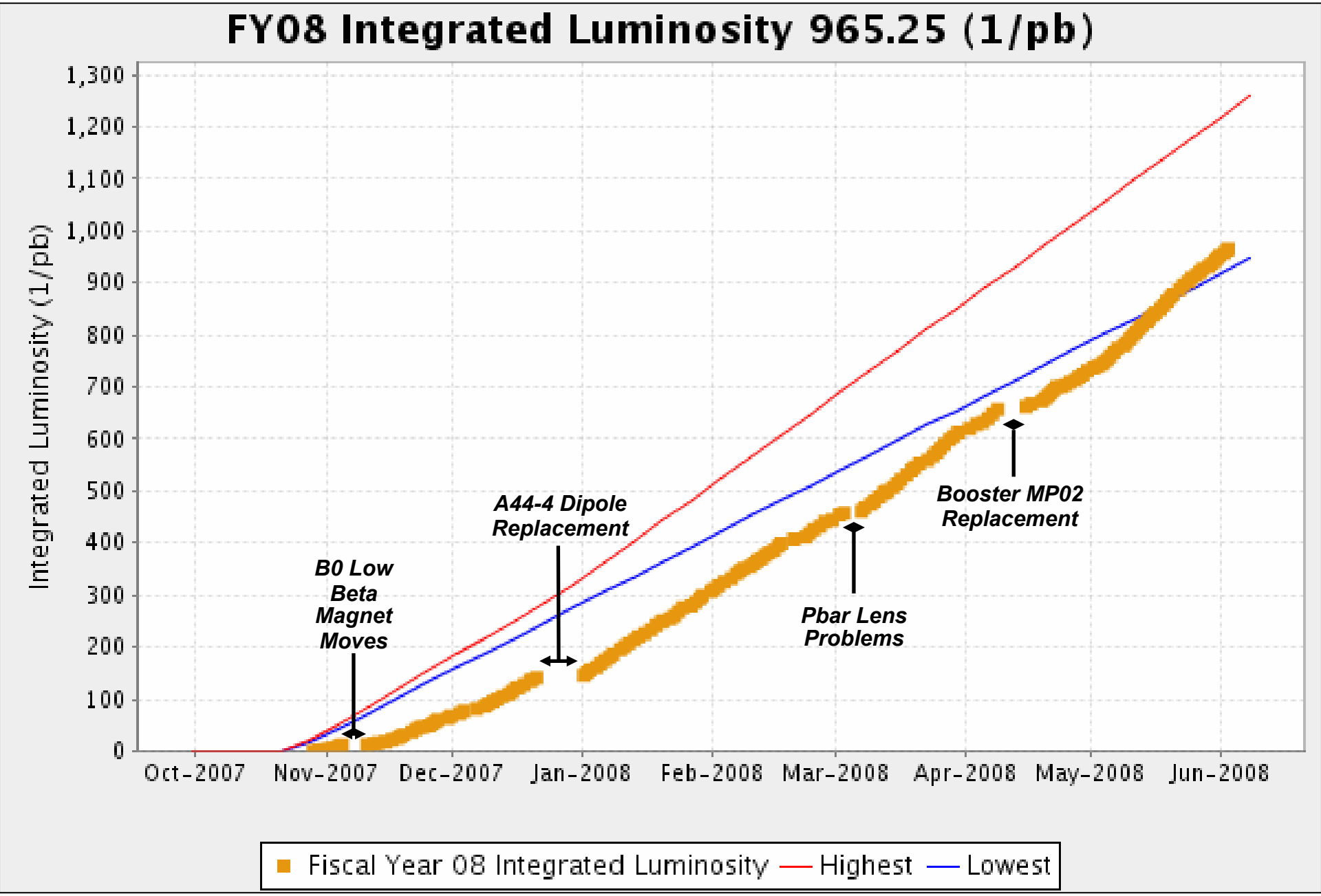
- No major upgrades during 2007 shutdown – all done!
  - Tevatron: maintenance – find/fix leaks – several components replaced
  - Pbar Source: rearrange Accumulator components, new beam tube for Debuncher extraction kicker
- Pbar progress
  - Higher gradient Li lens, new stochastic cooling equalizers
  - Improving mechanics of transfers to Recycler
  - Record stack rate, maximum stack size, # stacked in week
- Recycler + Electron Cooling delivering very bright pbars
  - Tevatron deliberately blowing-up pbar emittances to help protons survive!

Collider Run II Integrated Luminosity

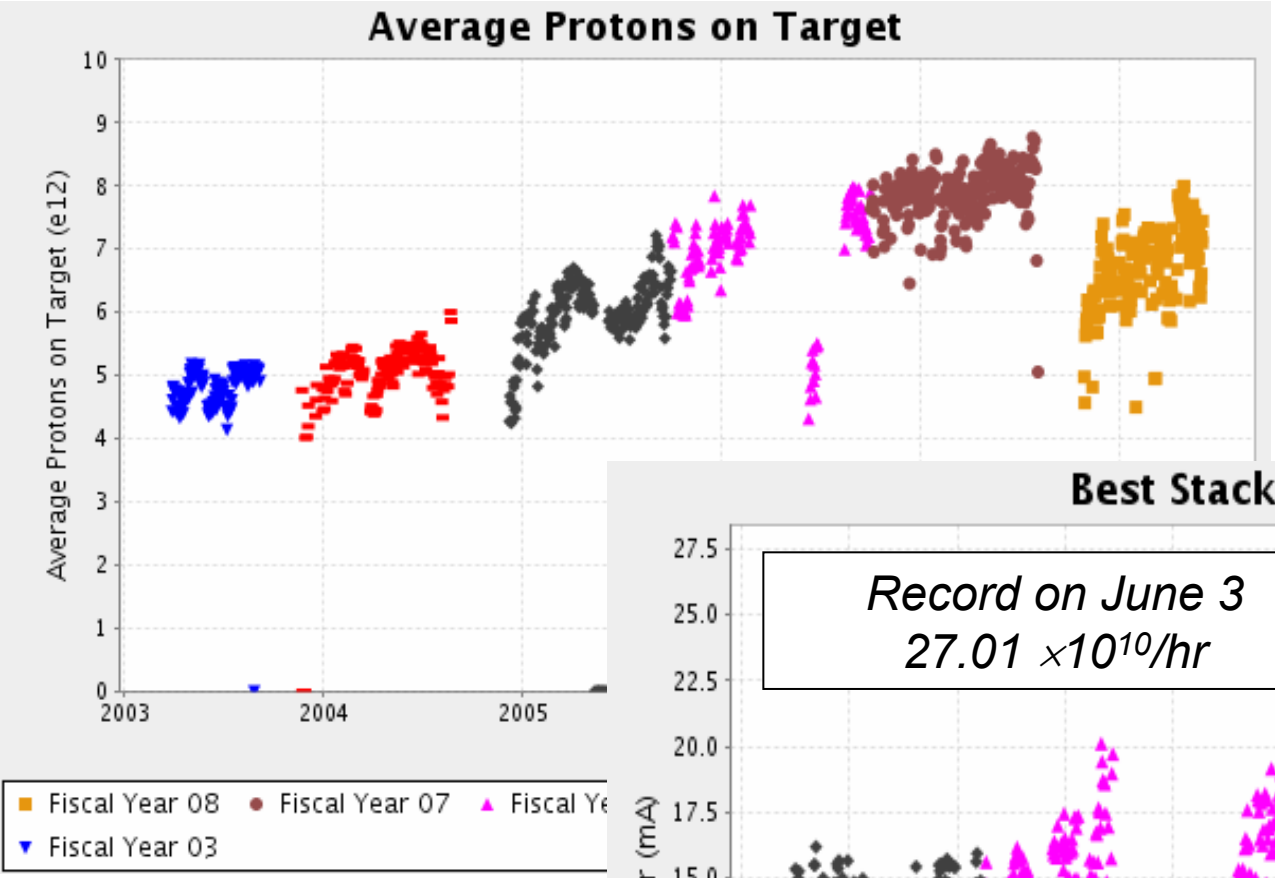


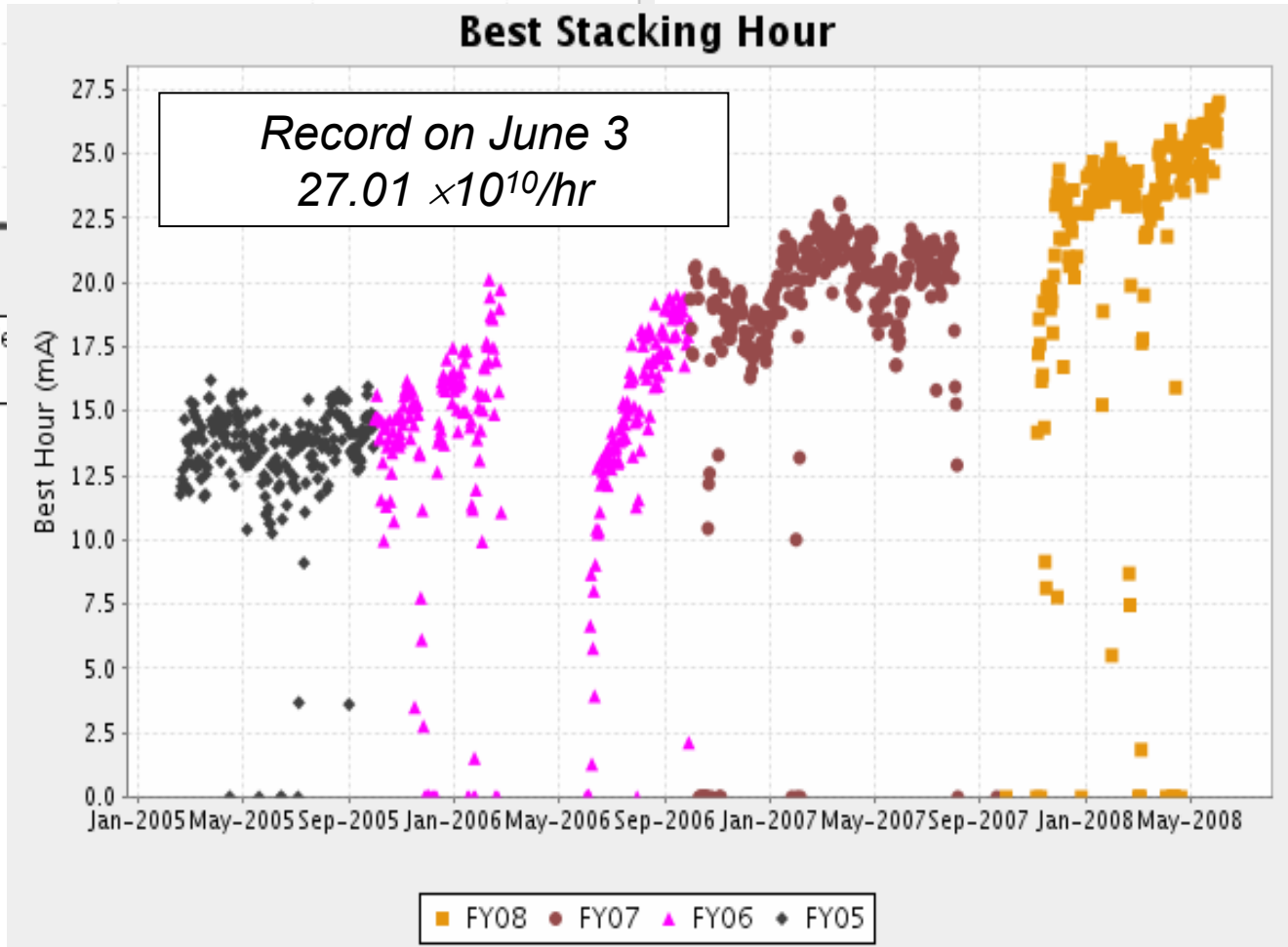
Tevatron Peak Luminosity




FY08 Integrated Luminosity 965.25 (1/pb)
Integrated Luminosity (1/pb)
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
Oct-2007
Nov-2007
Dec-2007
Jan-2008
Feb-2008
Mar-2008
Apr-2008
May-2008
Jun-2008
B0 Low Beta Magnet Moves
A44-4 Dipole Replacement
Pbar Lens Problems
Booster MP02 Replacement
Fiscal Year 08 Integrated Luminosity
Highest
Lowest

Pbar Stacking

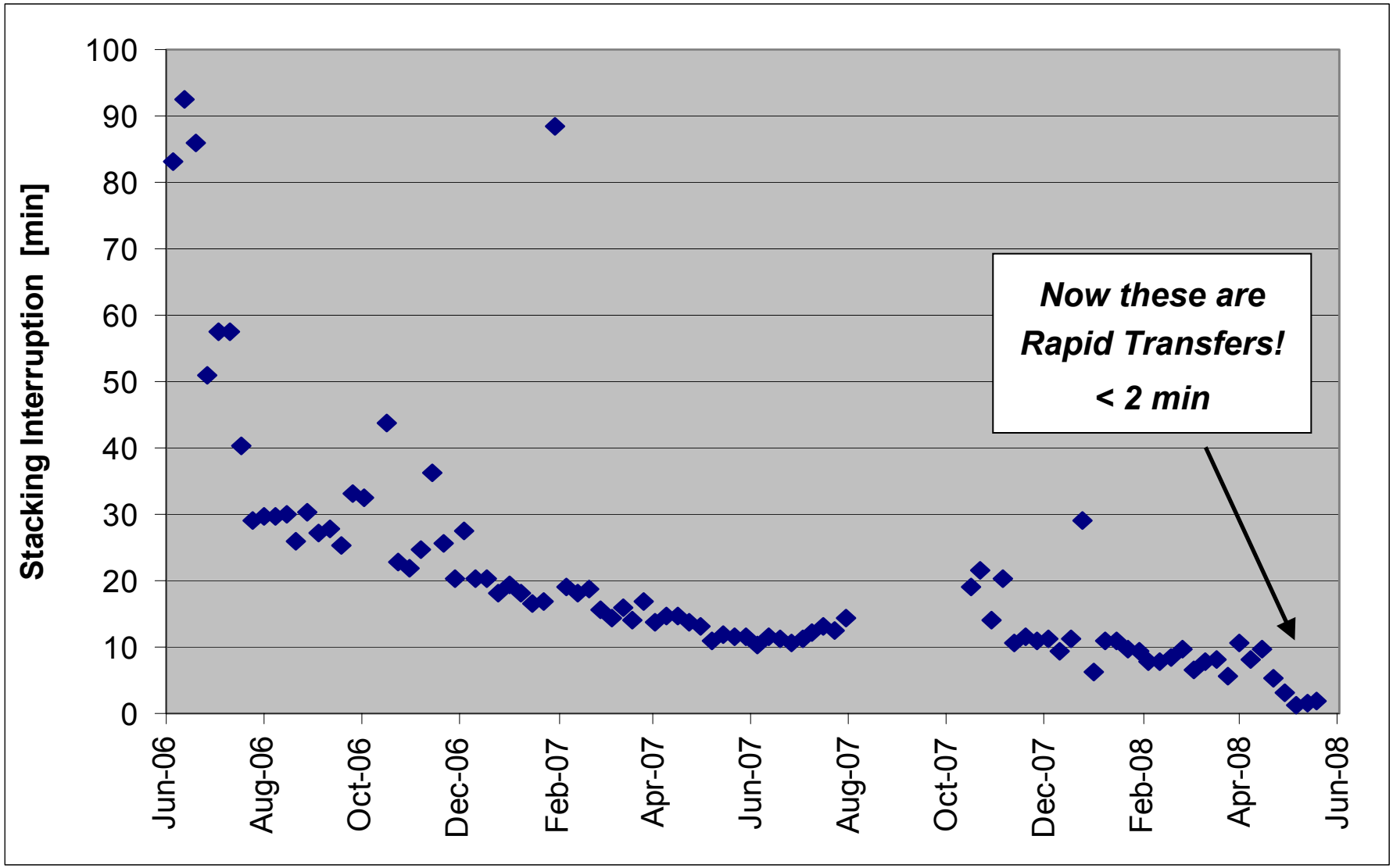


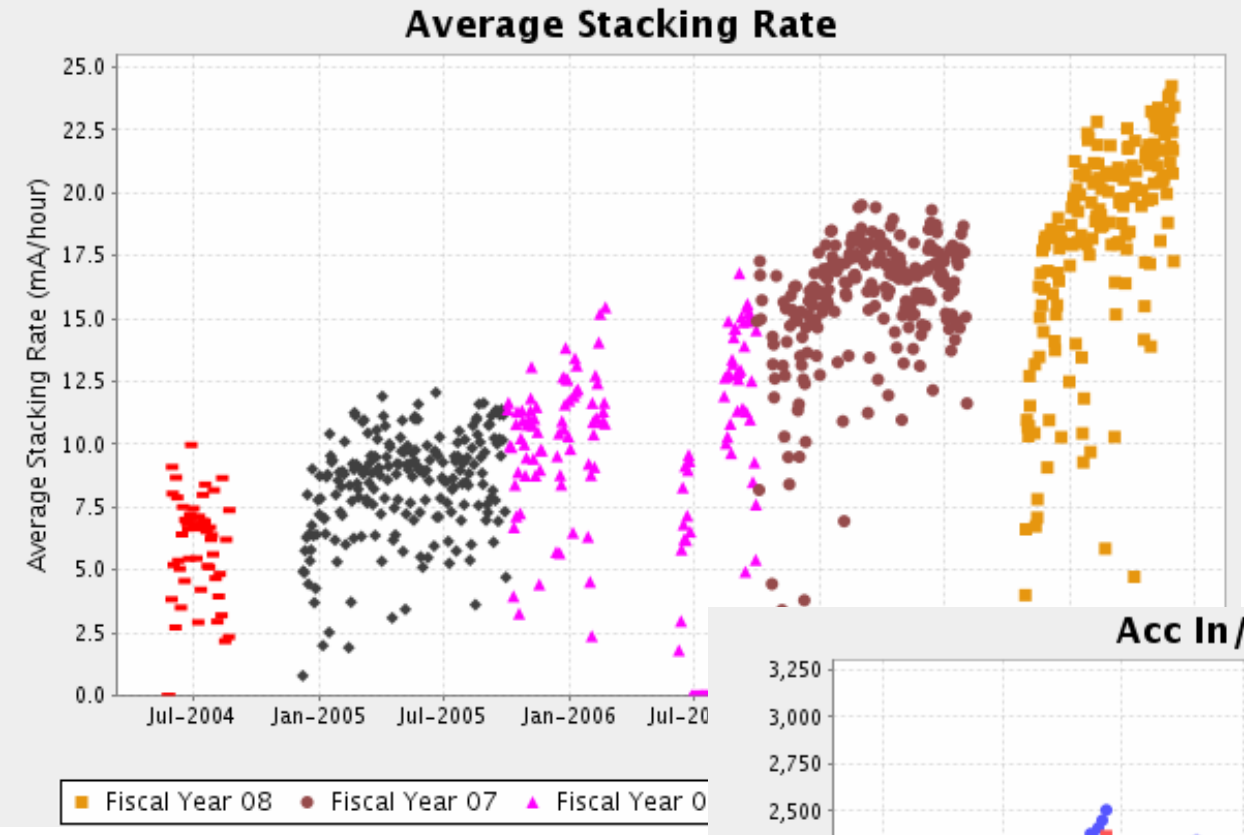


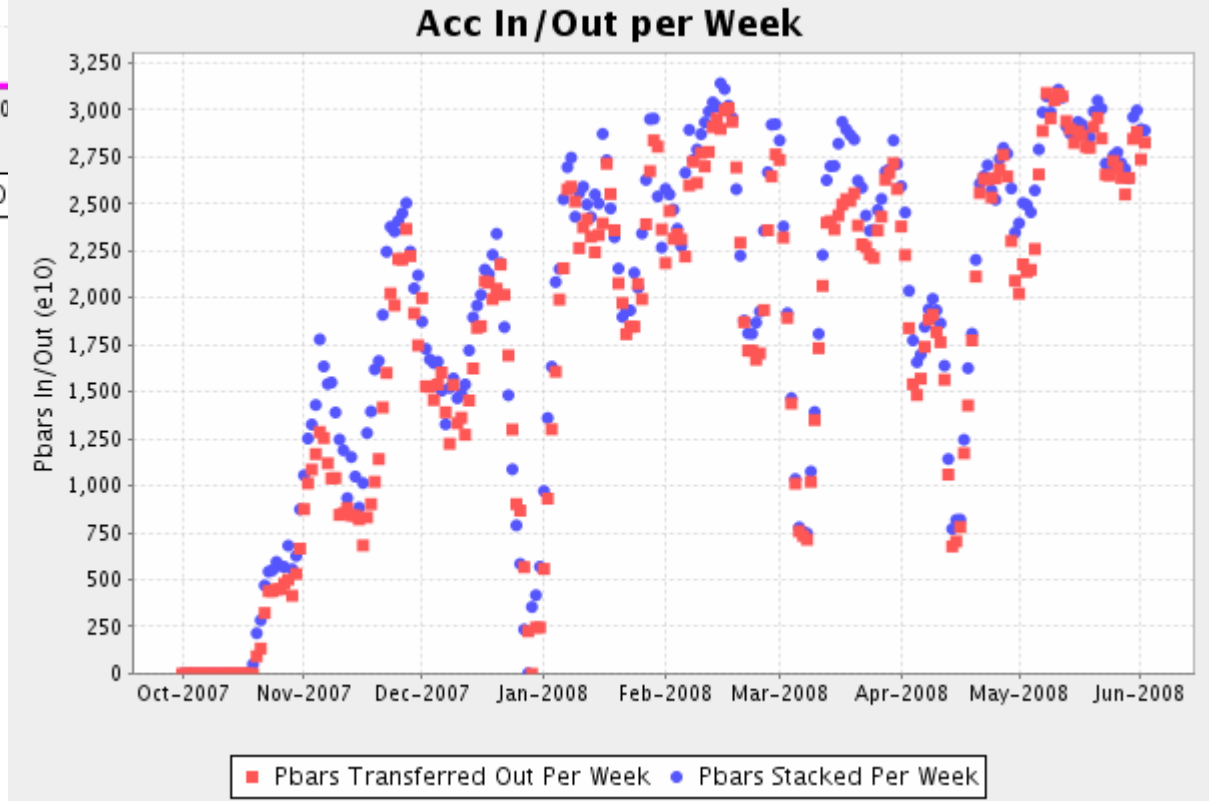
Strategy: Be Efficient, Be Consistent

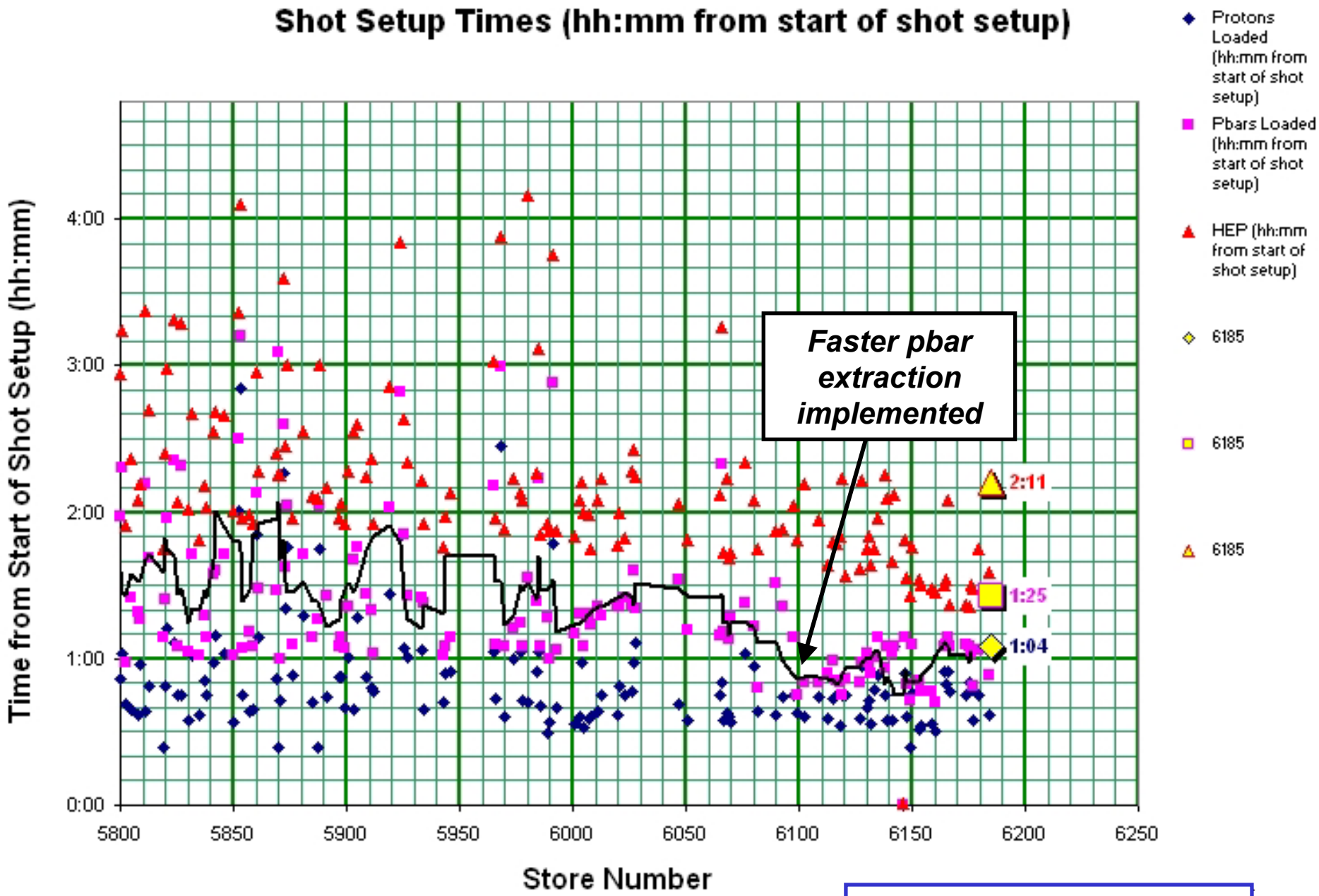
- Big upgrades are done → Make the most of what we've got
- Reduce time not stacking pbars to increase average stacking rate
  - Reduce time for Accumulator→Recycler transfers
  - Stack while doing transfers
- Make HEP shot-setup more efficient
  - "One-shots" for Tevatron when needed – allows more stacking cycles
  - Speed up Recycler pbar mining and extraction - saves ≈15 min!
  - Considering faster proton injection → 2 bunches per shot instead of 1
- Shorter HEP stores
  - Higher average pbar stacking rate → shorter stores for ≈ same initial lumi
  - More stores with higher average luminosity over store duration

Accumulator → Recycler Shot Times

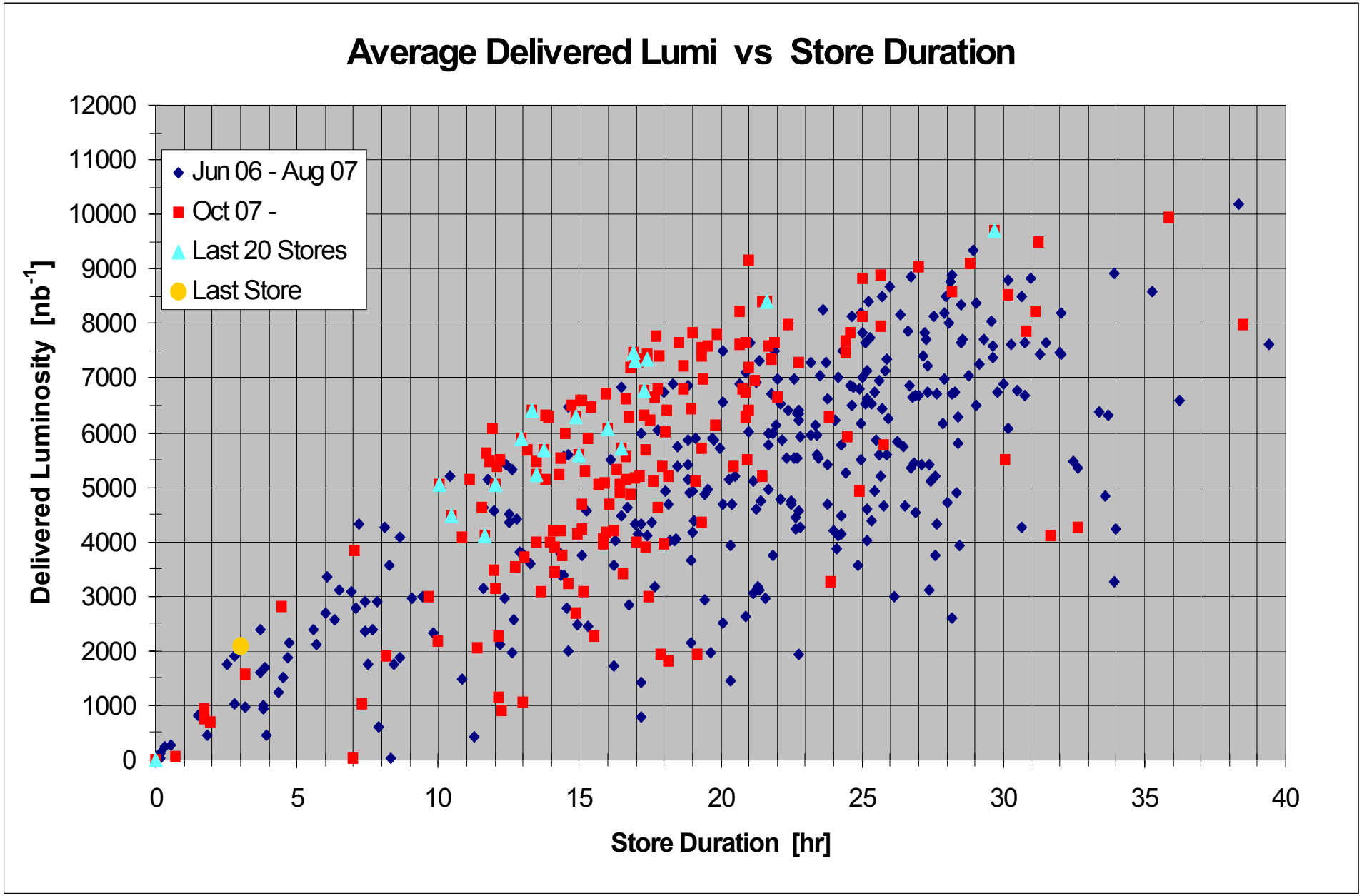



Average Stacking Rate
Average Stacking Rate (mA/hour)
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Jul-2004
Jan-2005
Jul-2005
Jan-2006
Jul-20
Fiscal Year 08
Fiscal Year 07
Fiscal Year 0


Acc In/Out per Week
Pbars In/Out (e10)
3,250
3,000
2,750
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
250
0
Oct-2007
Nov-2007
Dec-2007
Jan-2008
Feb-2008
Mar-2008
Apr-2008
May-2008
Jun-2008
Pbars Transferred Out Per Week
Pbars Stacked Per Week



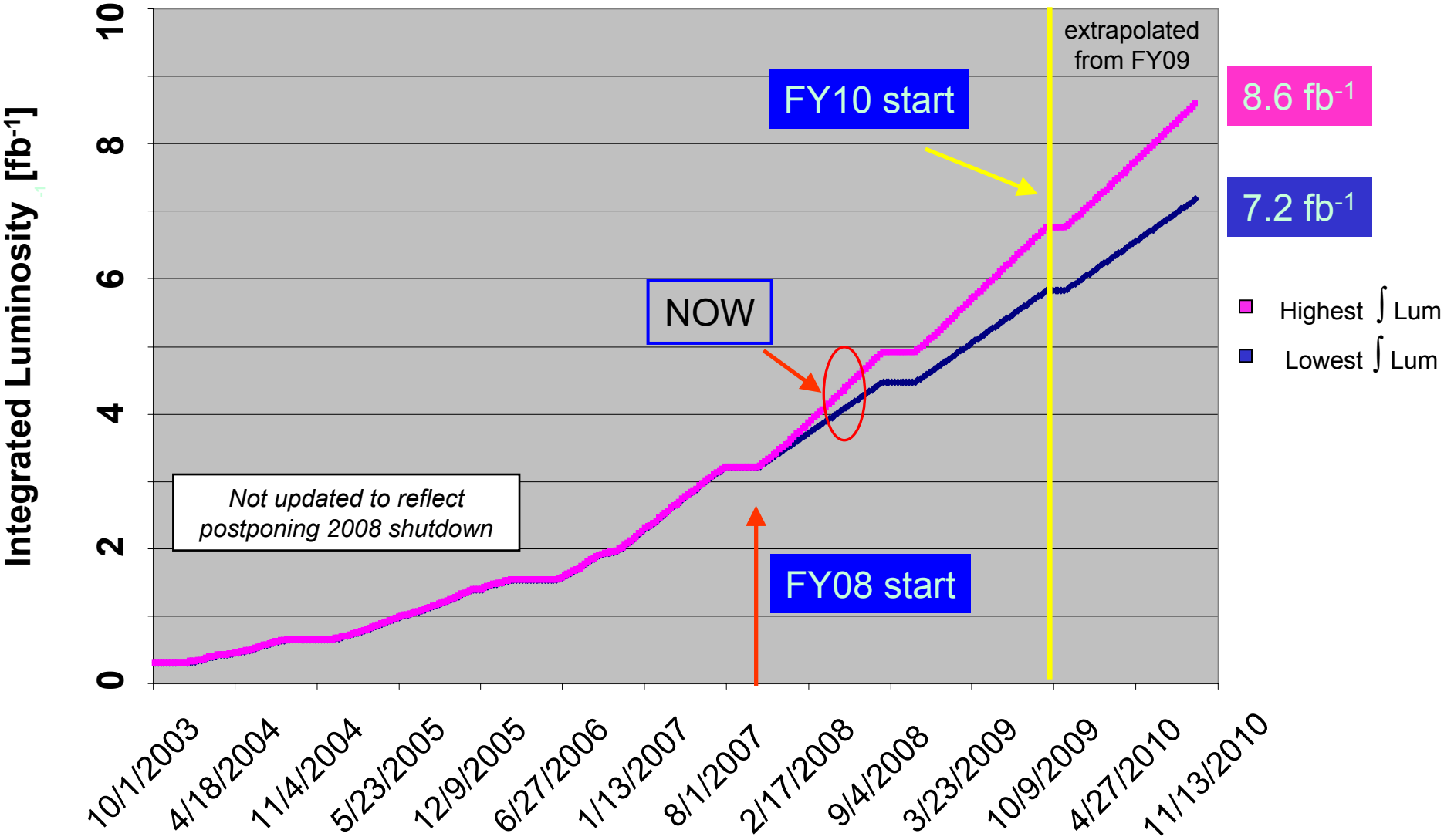
Average HEP shot-setup now ~1:45


Average Delivered Lumi vs Store Duration
Jun 06 - Aug 07
Oct 07 -
Last 20 Stores
Last Store
Delivered Luminosity [nb-1]
Store Duration [hr]
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
0
5
10
15
20
25
30
35
40

Planning Ahead

- No long shutdown in 2008 → push to spring 2009
  - Still need ≈1 week shutdown in 2008 for maintenance
- Could be last long shutdown before Run 2 ends?
  - Tevatron maintenance, Booster correctors, MI work for ν program
- Otherwise, just run, run, run…
  - Continue efforts to improve slip-stacking to reach 400 kW in MI
  - Improvements in Linac LLRF, too
  - Keep pushing on pbar stacking rate
  - Maximize delivered luminosity to CDF and D0
  - Maintenance as needed around the complex

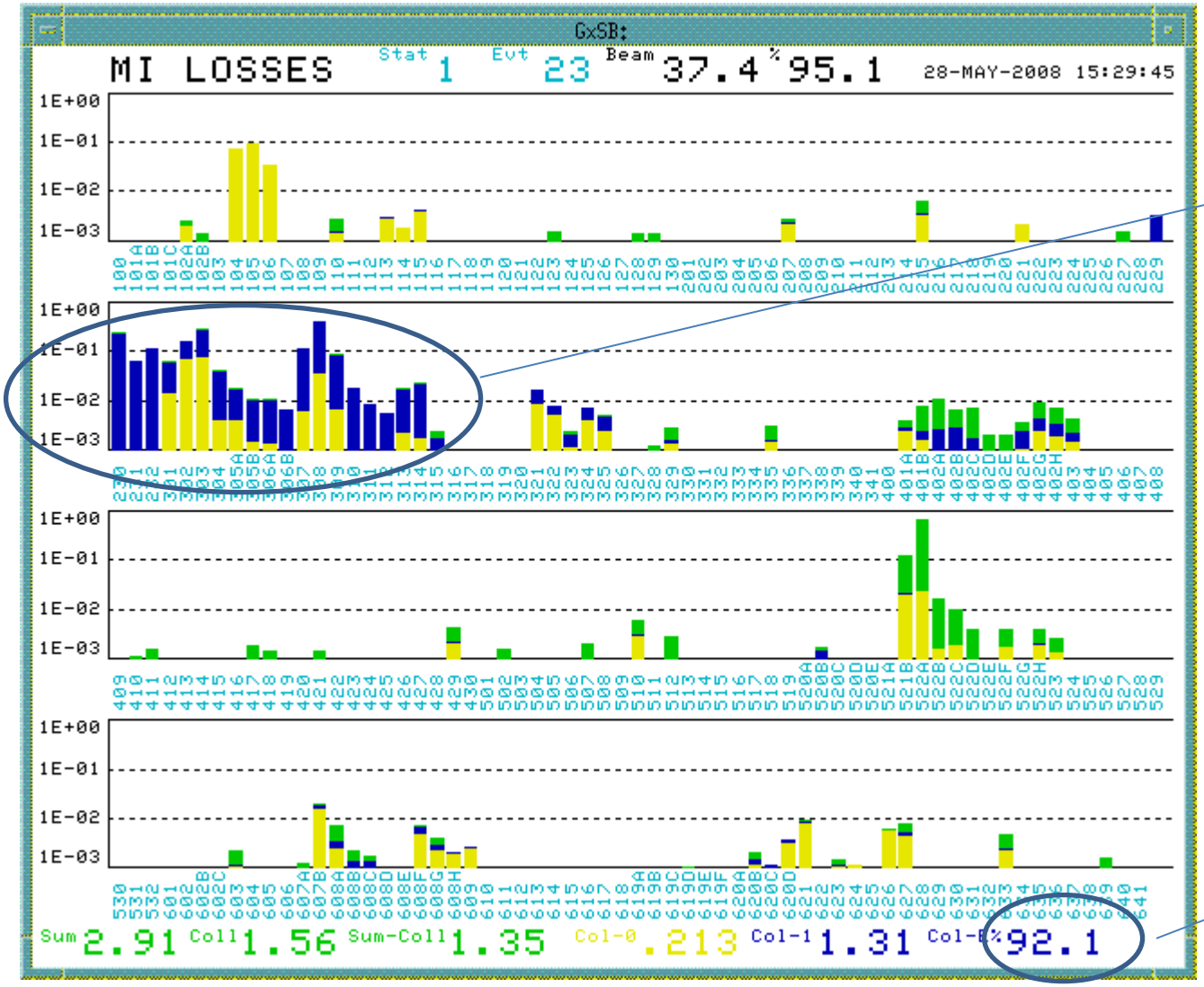
Luminosity Projection



Summary

- Reaping benefits of past upgrades and recent operational improvements
  - Booster correctors
  - MI collimators and multi-batch slip-stacking
  - Pbar stochastic cooling upgrades
  - Improvements in pbar and HEP shot-setups
- Record proton rates through Booster to BNB and up to 350 kW in MI
- Antiproton Source setting records almost every week
  - Peak now > 27 mA/hr – can deliver > 3000×10^{10} per week
- Collider Run 2 now > 4 fb^{-1} and delivering at record rates
  - Tevatron delivered 221 pb^{-1} in May 08!
- Maximize CDF & D0 delivered luminosity while working on proton plan
  - Run, run, run…
  - Push next long shutdown to spring 2009
  - Tevatron maintenance, rest of Booster correctors, improve MI slip-stacking

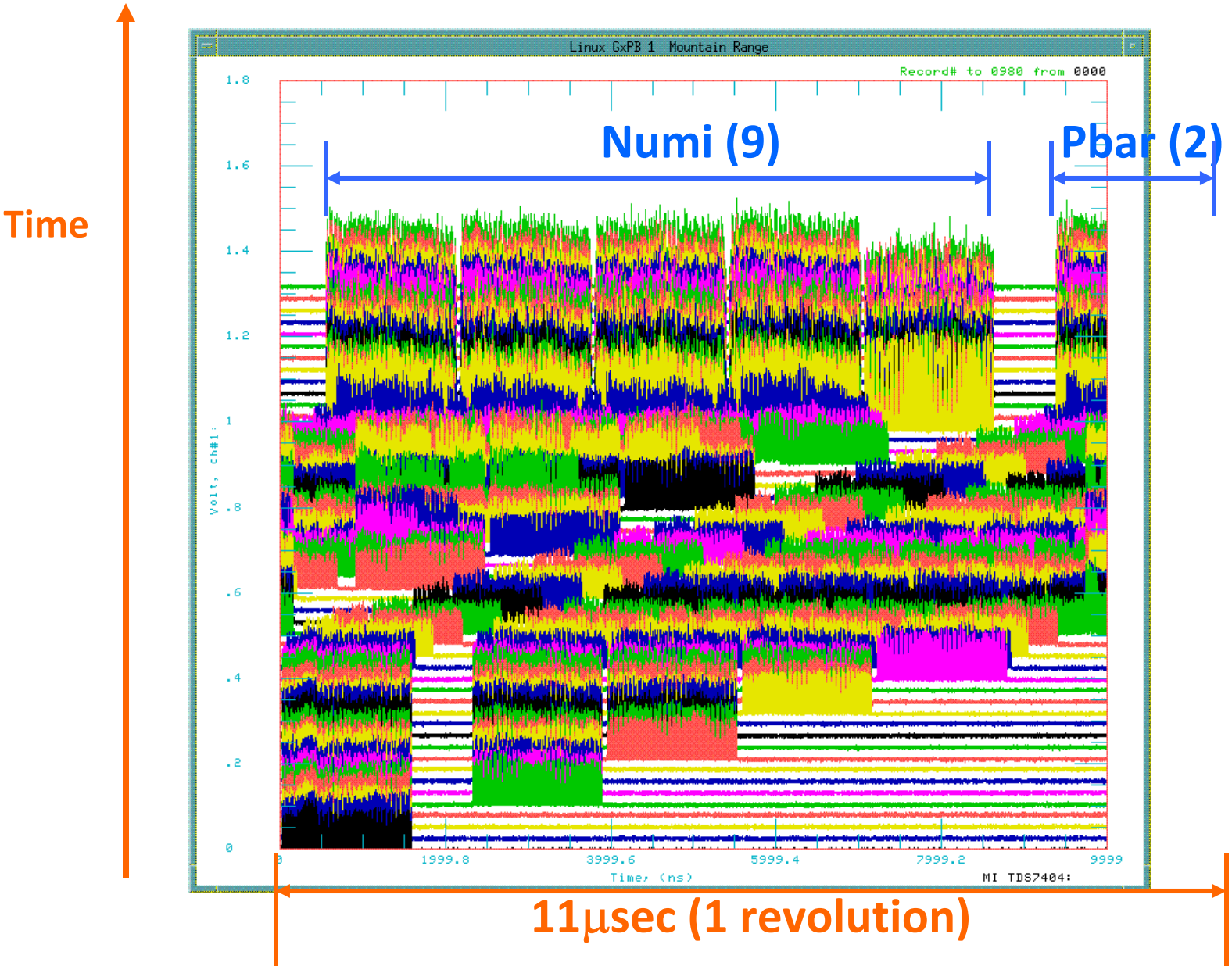
MI Collimator Efficiency



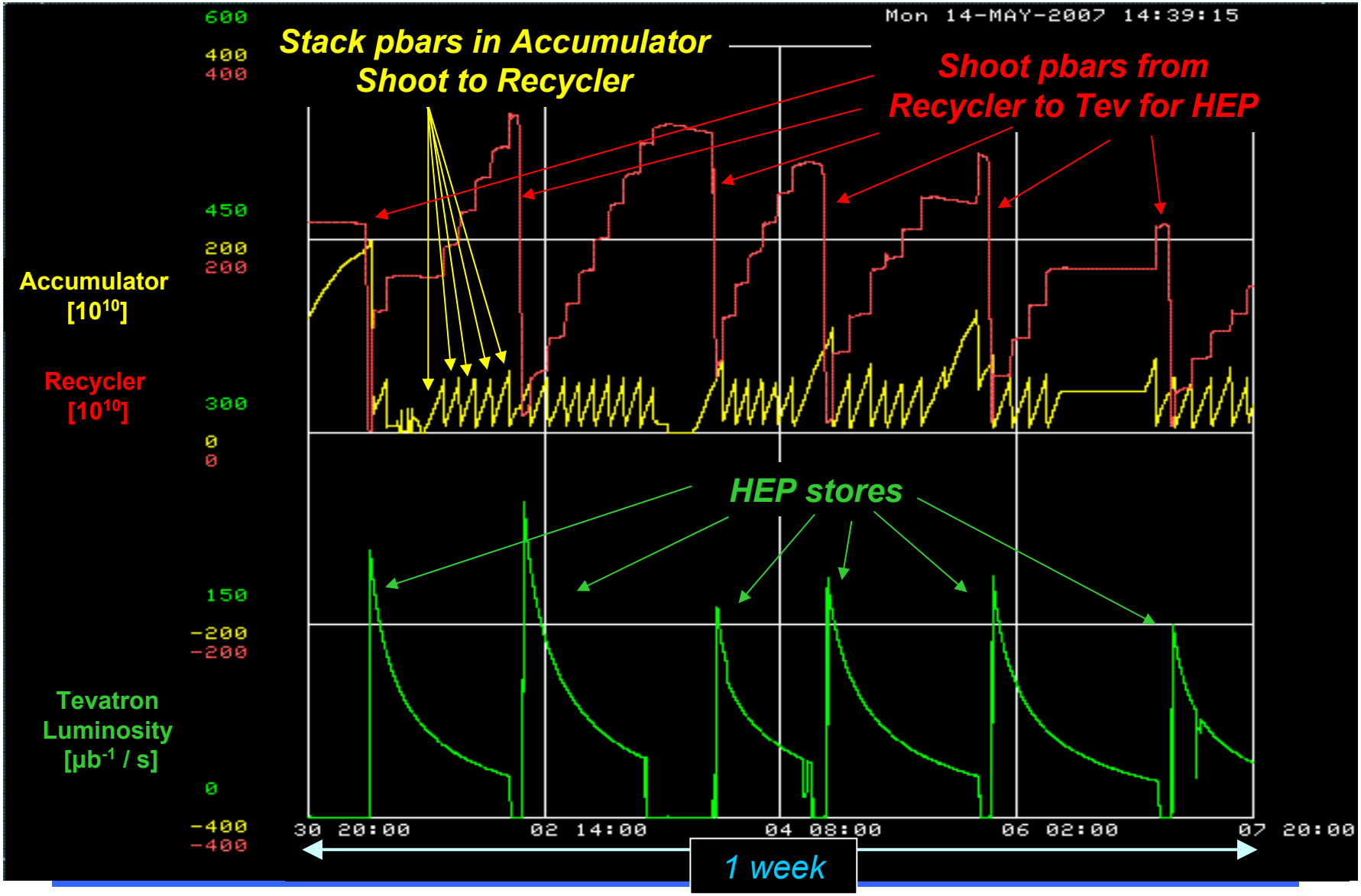
Collimator Region

Coll. Efficiency

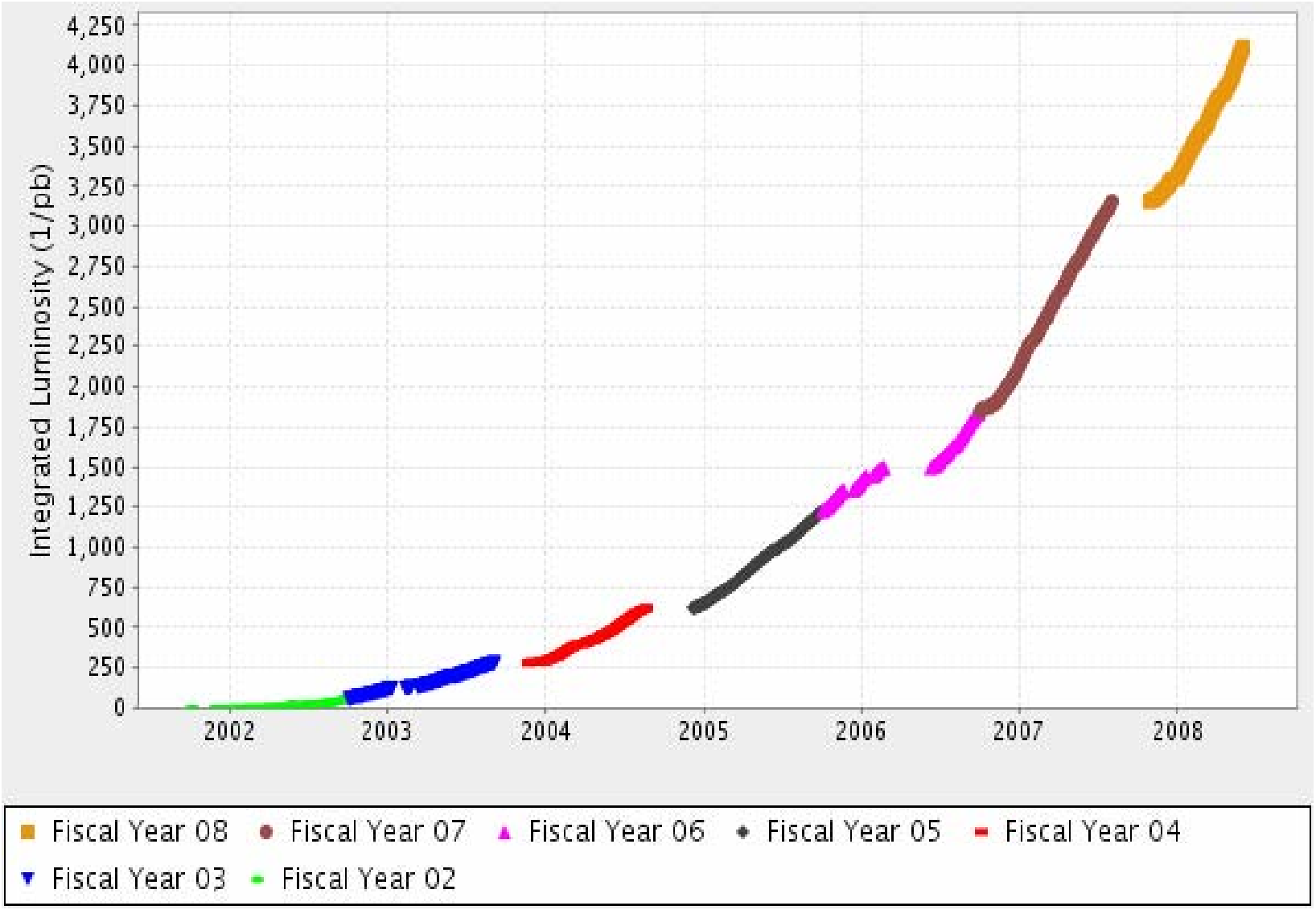
11 batch slip stacking on mixed mode cycle



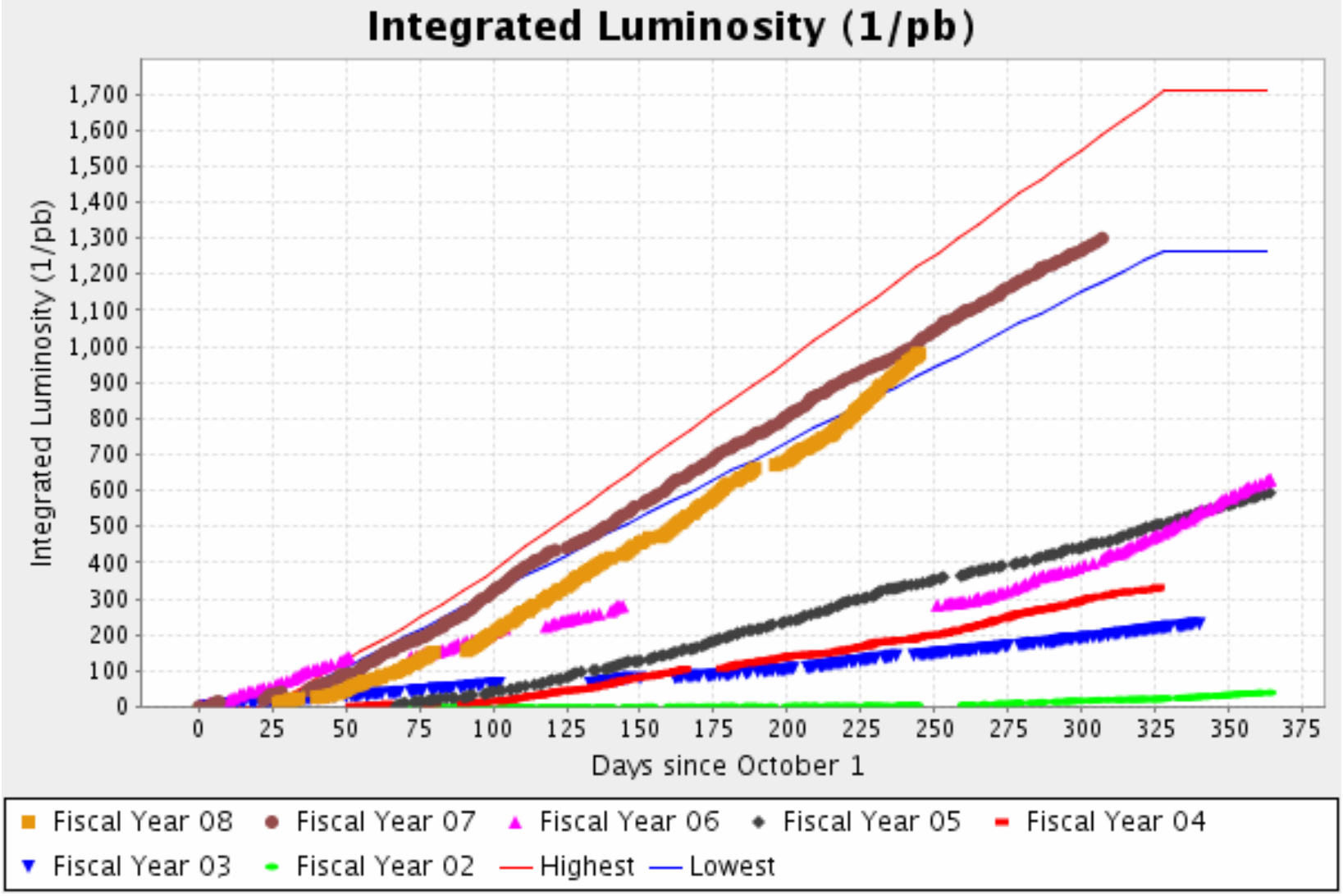
Antiproton Production Flow

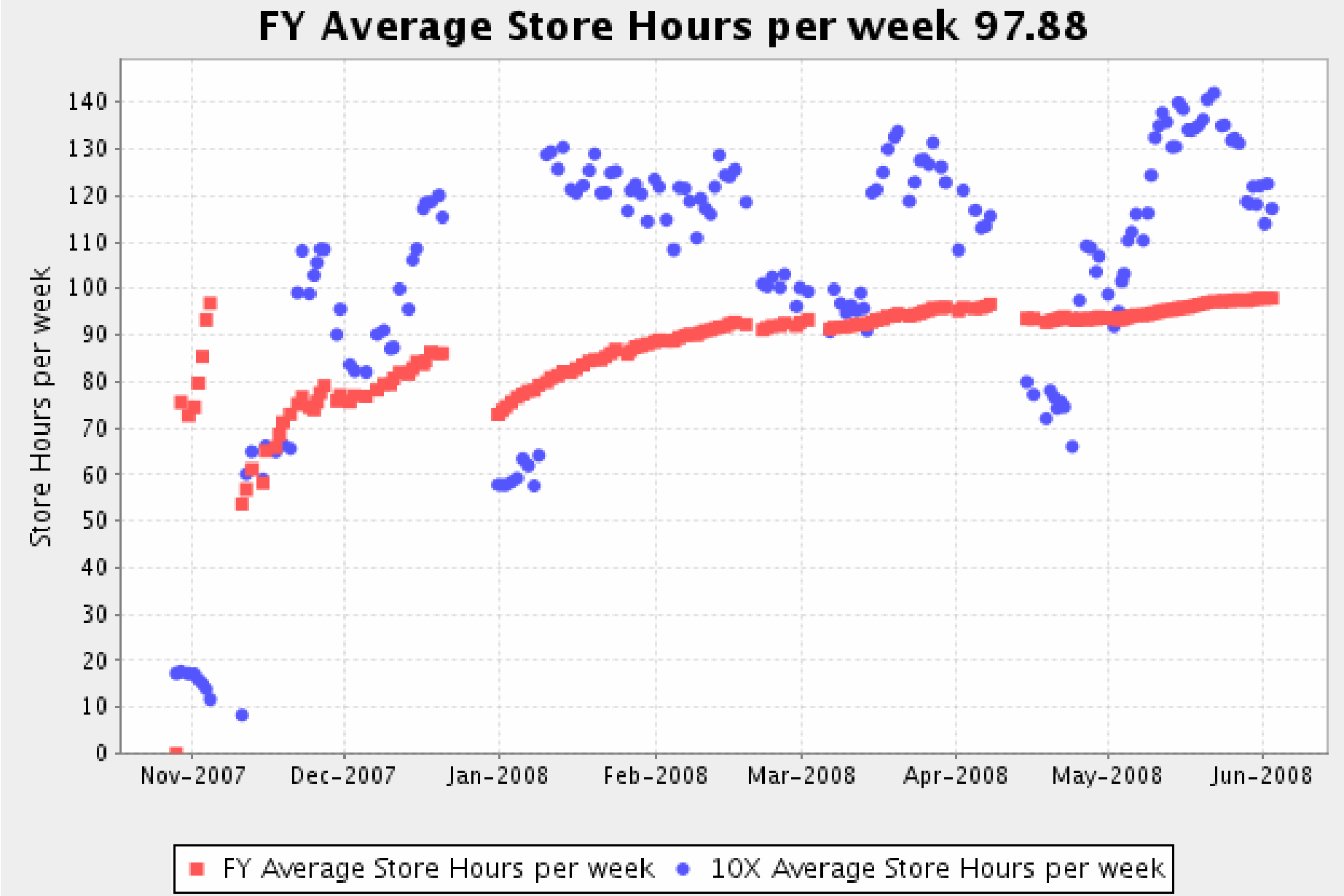


Tevatron Run 2 Integrated Luminosity



Delivered Luminosity by Year




FY Average Store Hours per week 97.88
Store Hours per week
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
Nov-2007
Dec-2007
Jan-2008
Feb-2008
Mar-2008
Apr-2008
May-2008
Jun-2008
FY Average Store Hours per week
10X Average Store Hours per week