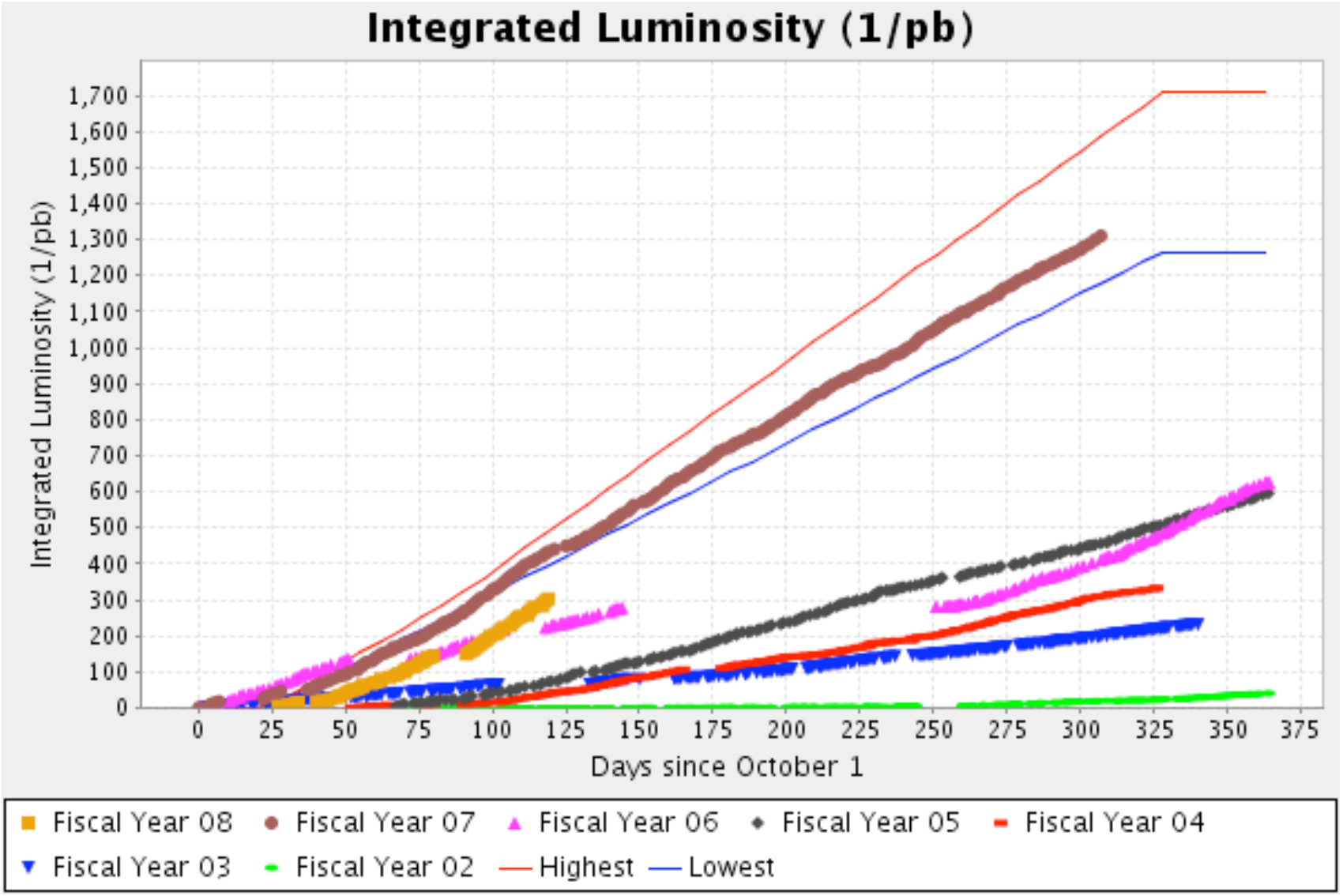
# Tevatron Performance and Prospects

R. Dixon

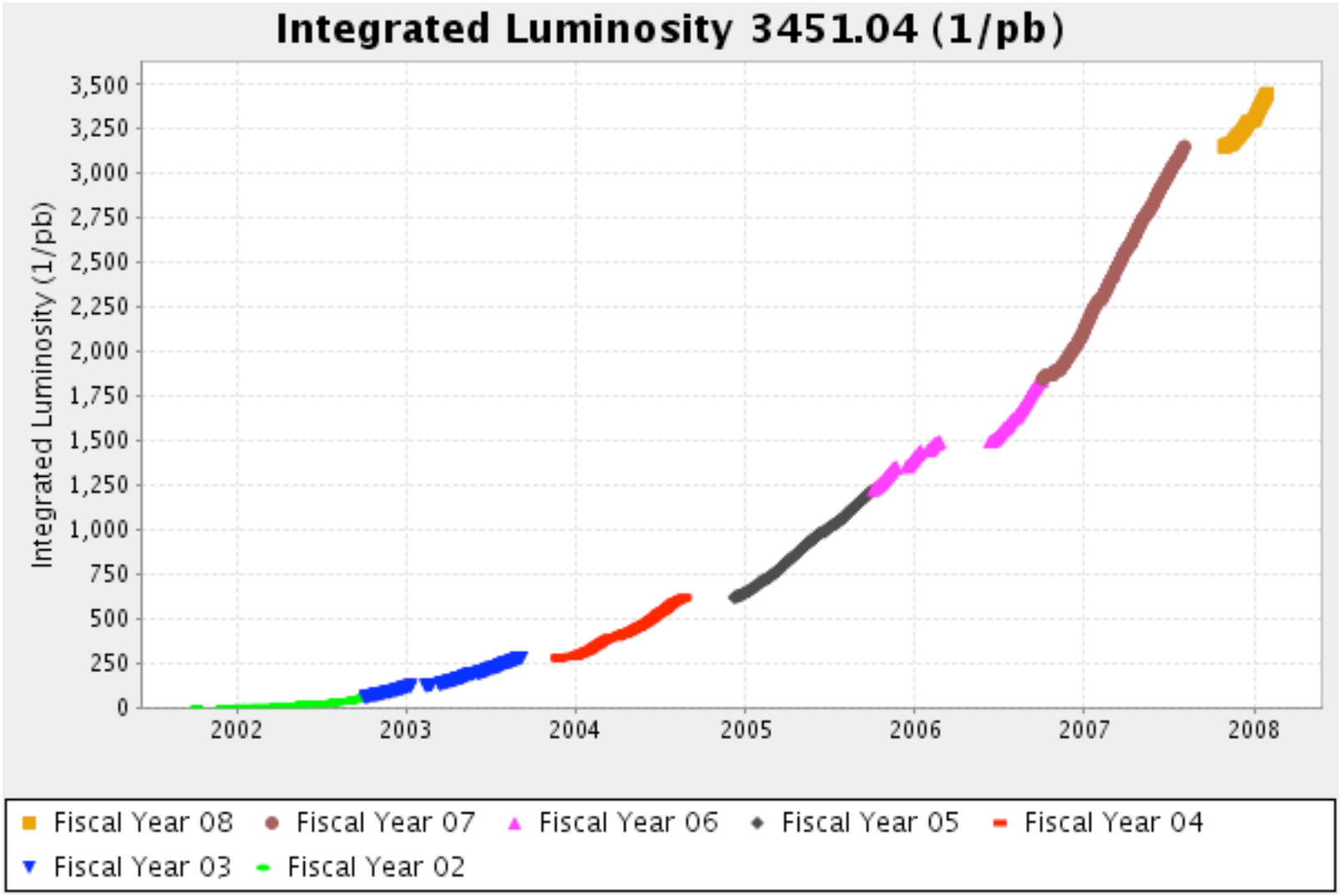
# Overview

- Run II Performance Summary
  - Luminosity Summaries
  - Performance Projections
  - Comparison to Luminosity data
- 2007/2008 Startup
  - Antiproton Stacking Rates
  - Tevatron Helix
  - Antiproton Brightness
  - Reliability
- Strategy

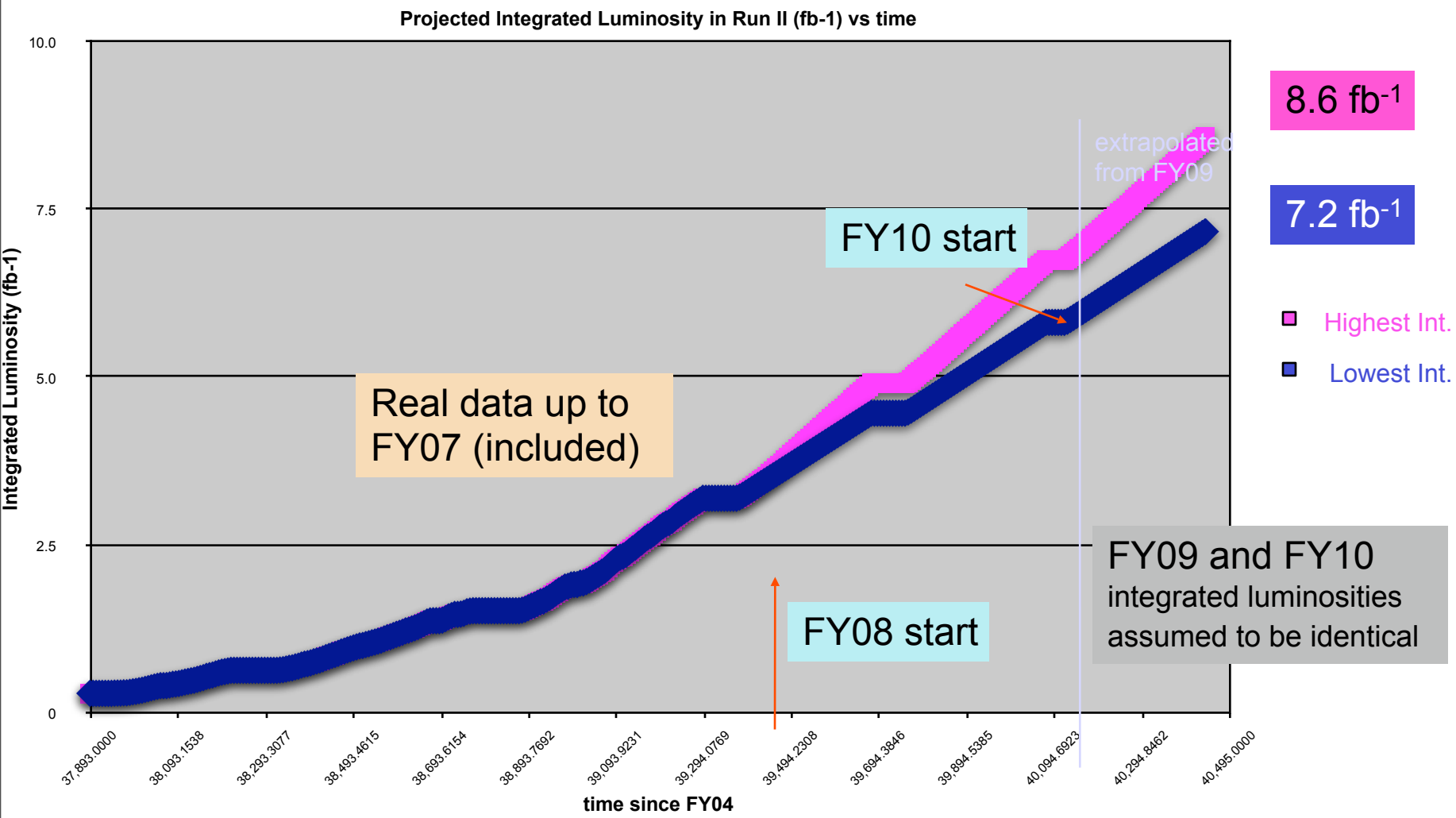
# Luminosity Summary



# Total Integrated Luminosity



# Luminosity projection curves for Run II



# Inputs for FY08 and FY09 – Sc. I (pesimistic)

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

- Number of protons per bunch 256, 256, 256, 256, 260, 260, 260, 260 x $10^9$
- Luminosity Density @ 100 x $10^{10}$ 90.32 $\mu b^{-1}$ / sec
- Luminosity Density @ 300 x $10^{10}$ 190.34 $\mu b^{-1}$ / sec
- Init Tevatron Lifetime @ 80 $\mu b^{-1}$/sec 7.07 hours
- Init Tevatron Lifetime @ 160 $\mu b^{-1}$/sec 6.59 hours
- HEP store hours per week 100 hours
- Acc-Rec Transfer Efficiency @ 0x$10^{10}$ 87.4%
- Acc-Rec Transfer Efficiency @ 300x$10^{10}$ 87%
- Acc-Rec transfer time 0.19 hours
- Recycler lifetime 500 hours
- Recycler mining efficiency 93.8%
- Peak stacking rate 22, 22, …, 22 x$10^{10}$/hour
- Half rate stack size 210x$10^{10}$
- Maximum stack size 420x$10^{10}$
- Timeline Utililization Factor 74,74,74,74,75,75,75,75%
- Accumulator leftover factor 10%

With above inputs we should expect ~ 2619 $pb^{-1}$ in 2 years

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# 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 $\mu b^{-1}$ / sec
- Luminosity Density @ 300 x $10^{10}$ 190.34, 194.147,…,194.147 $\mu b^{-1}$ / sec
- Init Tevatron Lifetime @ 80 $\mu b^{-1}$/sec 7.07, 7.14 hours
- Init Tevatron Lifetime @ 160 $\mu b^{-1}$/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 @ 0x$10^{10}$ 90, 92,…92%
- Acc-Rec Transfer Efficiency @ 300x$10^{10}$ 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 x$10^{10}$/hour
- Half rate stack size 210, 250, …,250x$10^{10}$
- Maximum stack size 420, 500,…,500x$10^{10}$
- Timeline Utililization Factor 80, 83, …,83%
- Accumulator leftover factor 10%

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

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

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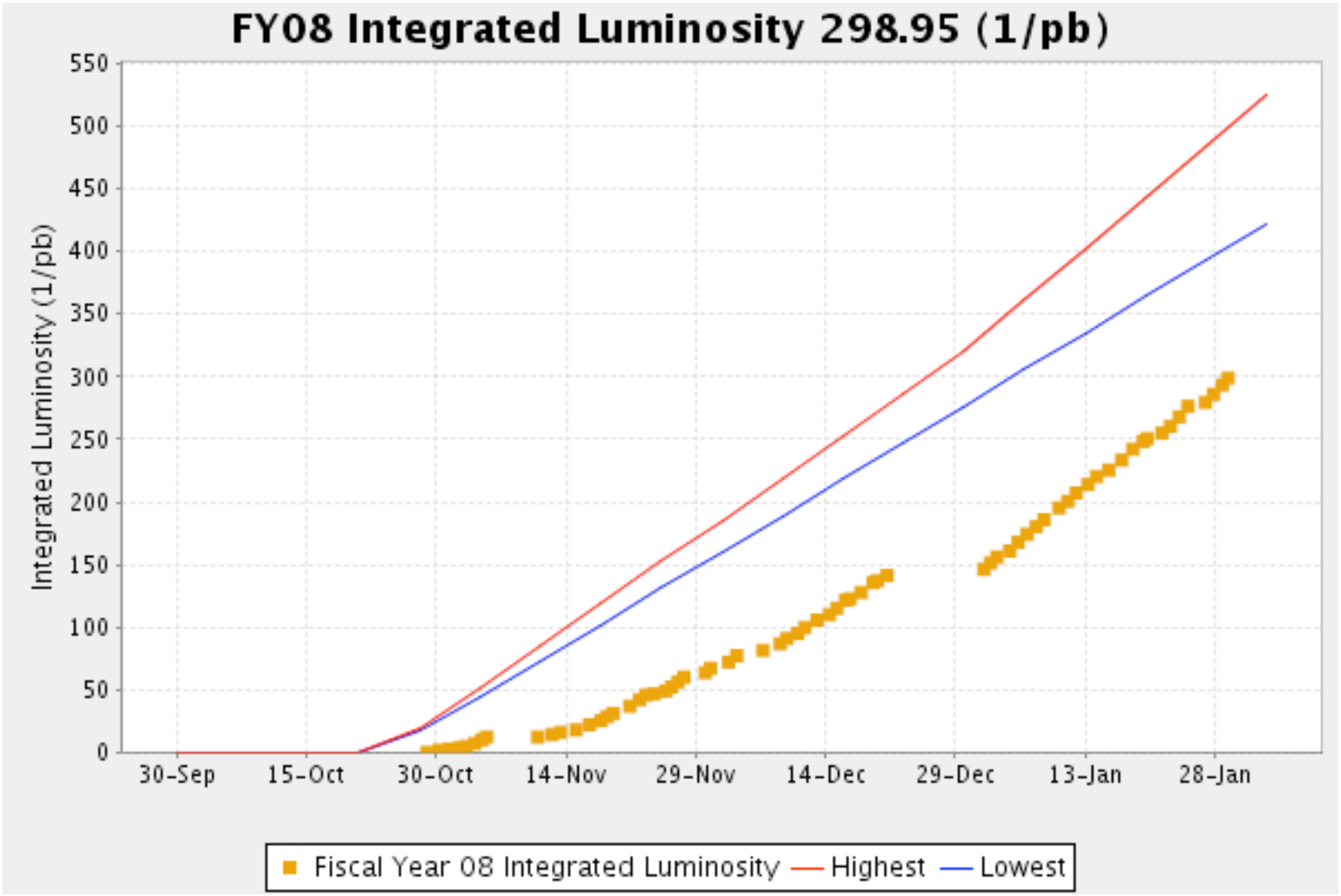
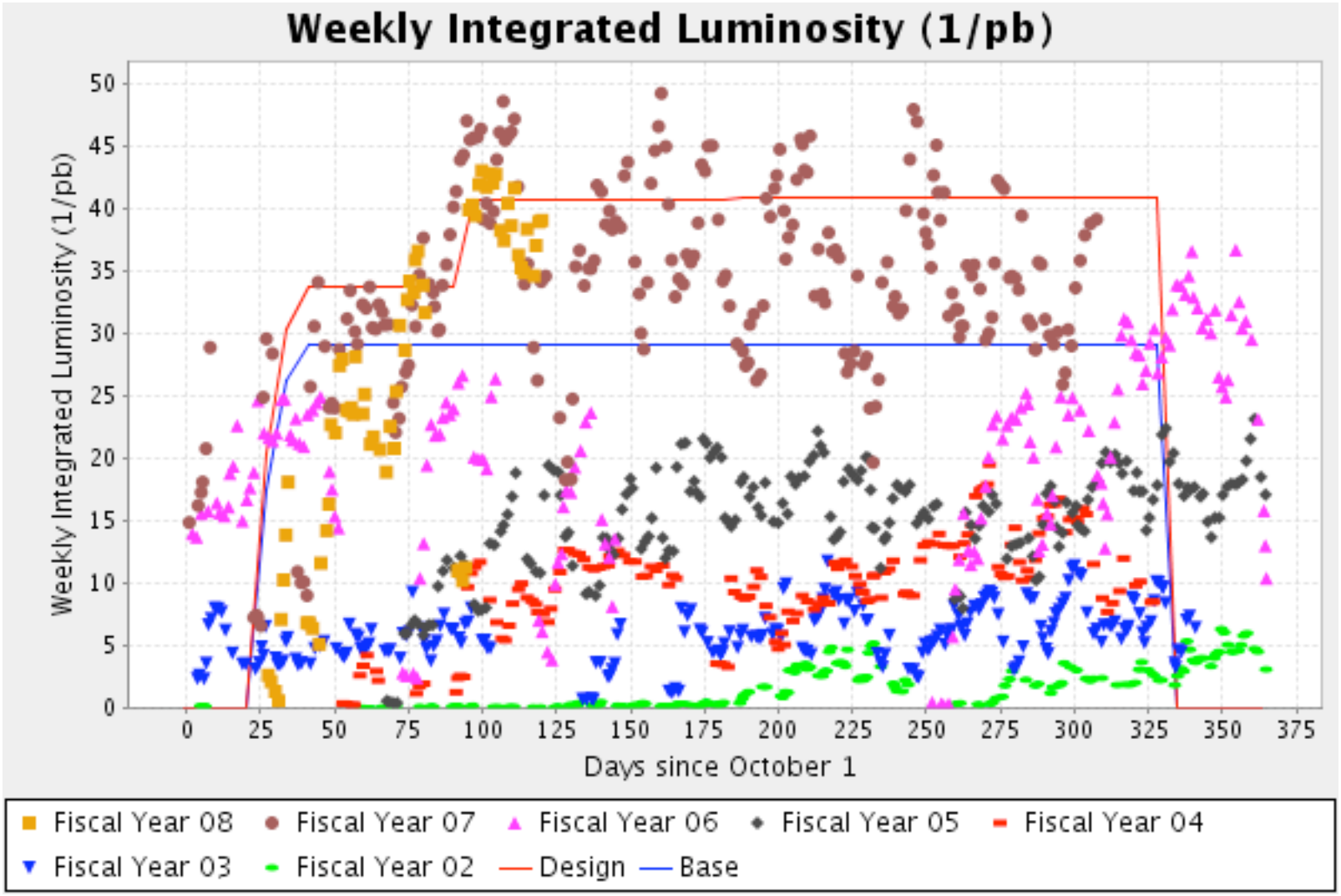
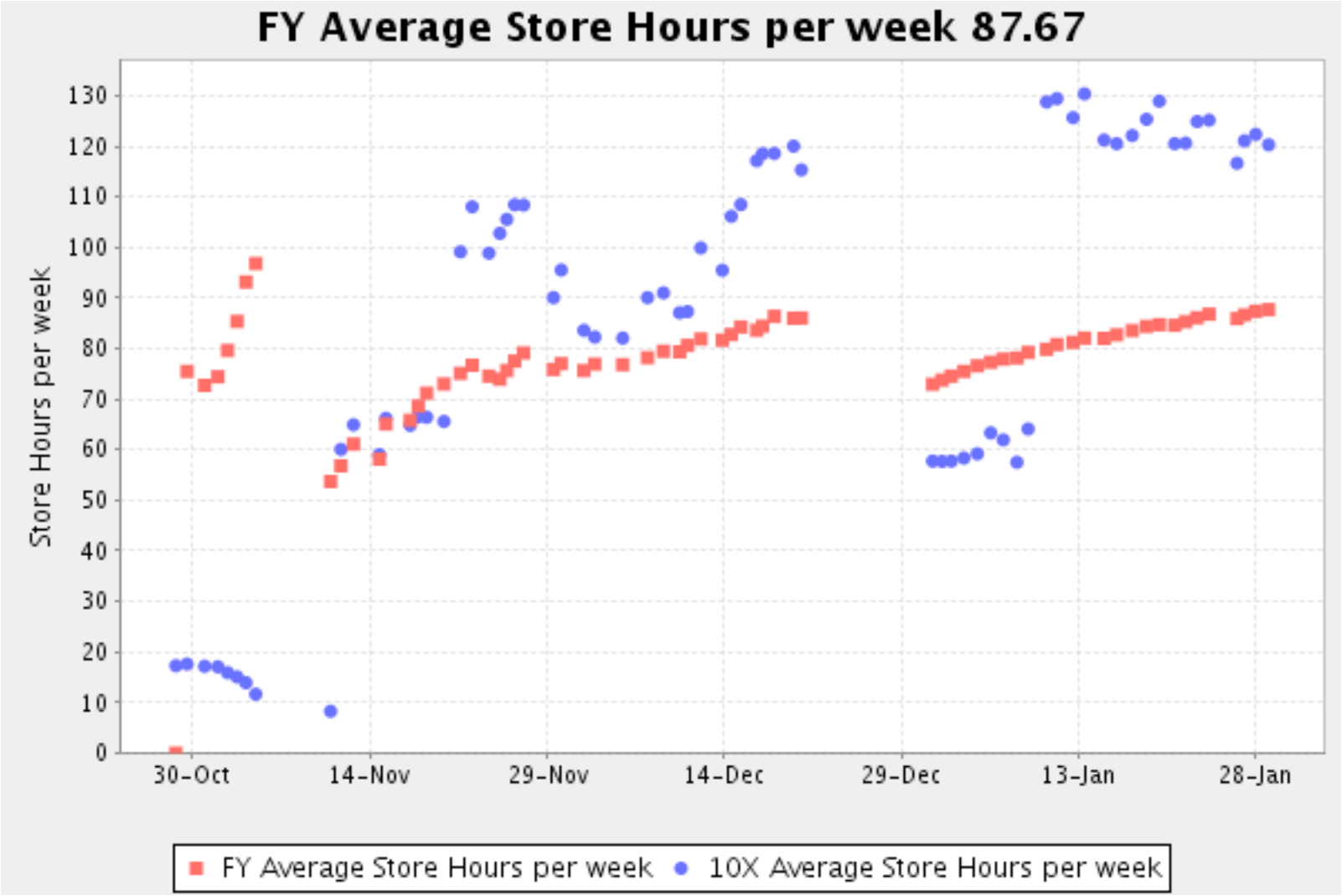
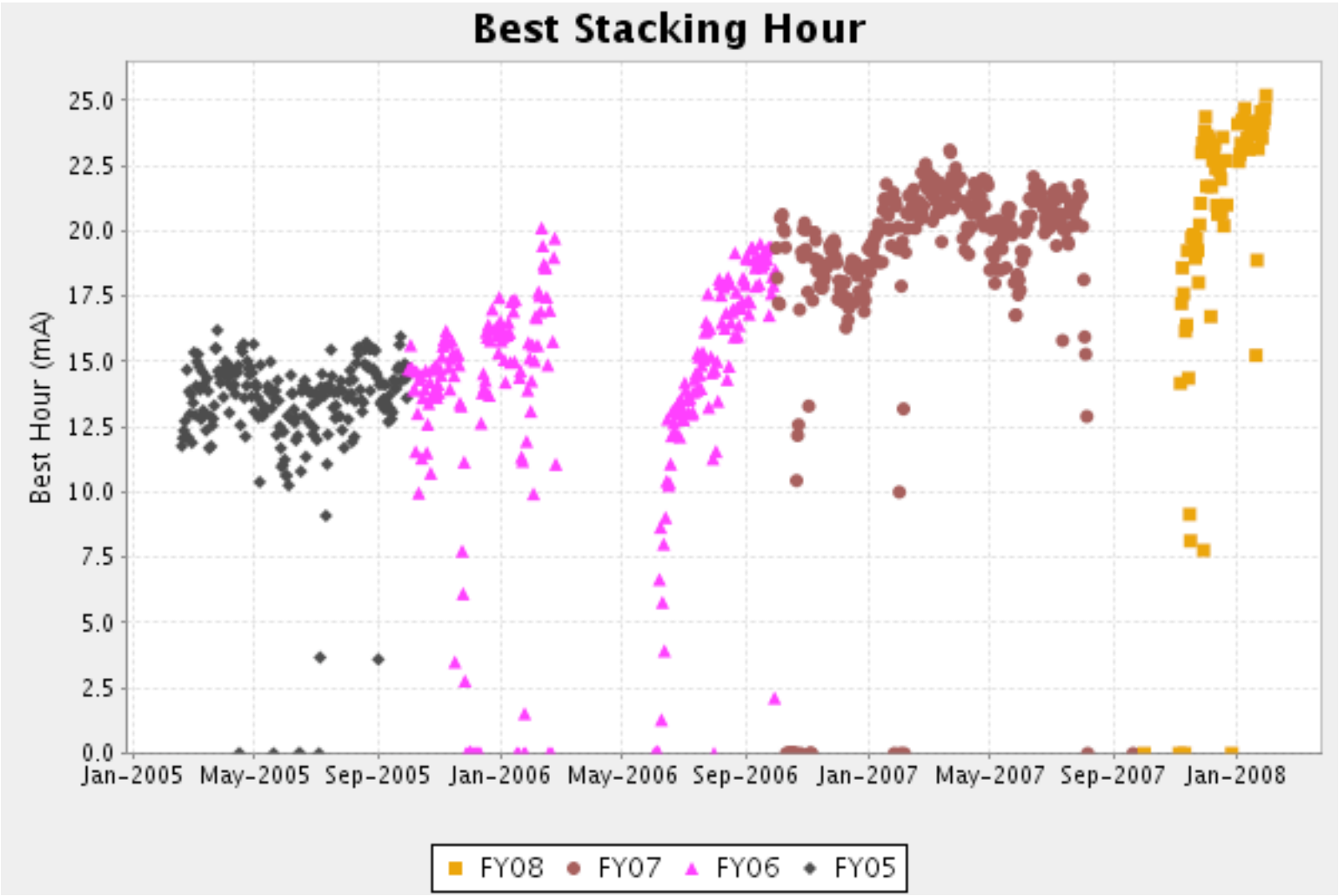

FY08 Integrated Luminosity 298.95 (1/pb)
Integrated Luminosity (1/pb)
550
500
450
400
350
300
250
200
150
100
50
0
30-Sep
15-Oct
30-Oct
14-Nov
29-Nov
14-Dec
29-Dec
13-Jan
28-Jan
Fiscal Year 08 Integrated Luminosity
Highest
Lowest

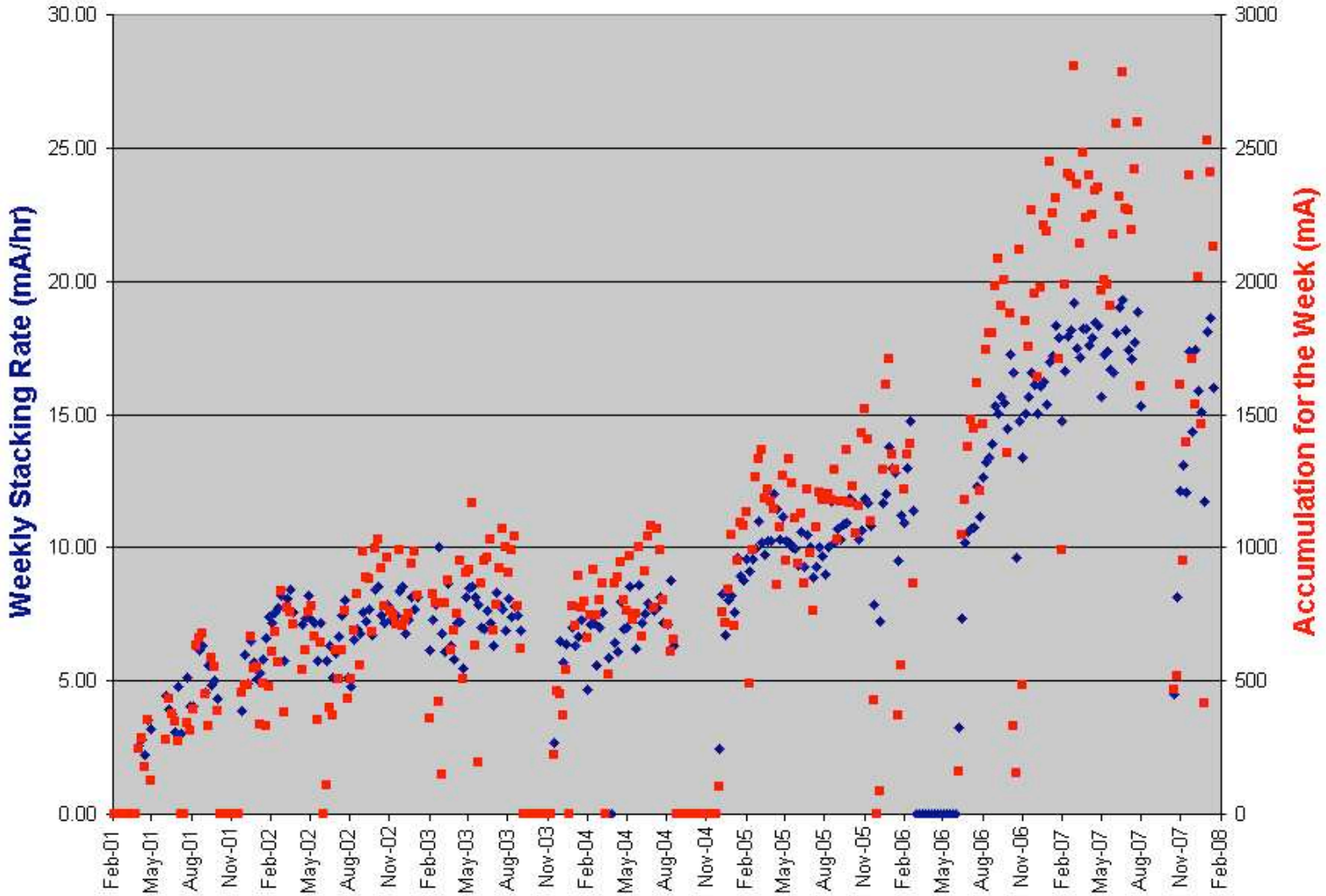
# Integrated Luminosity per Week

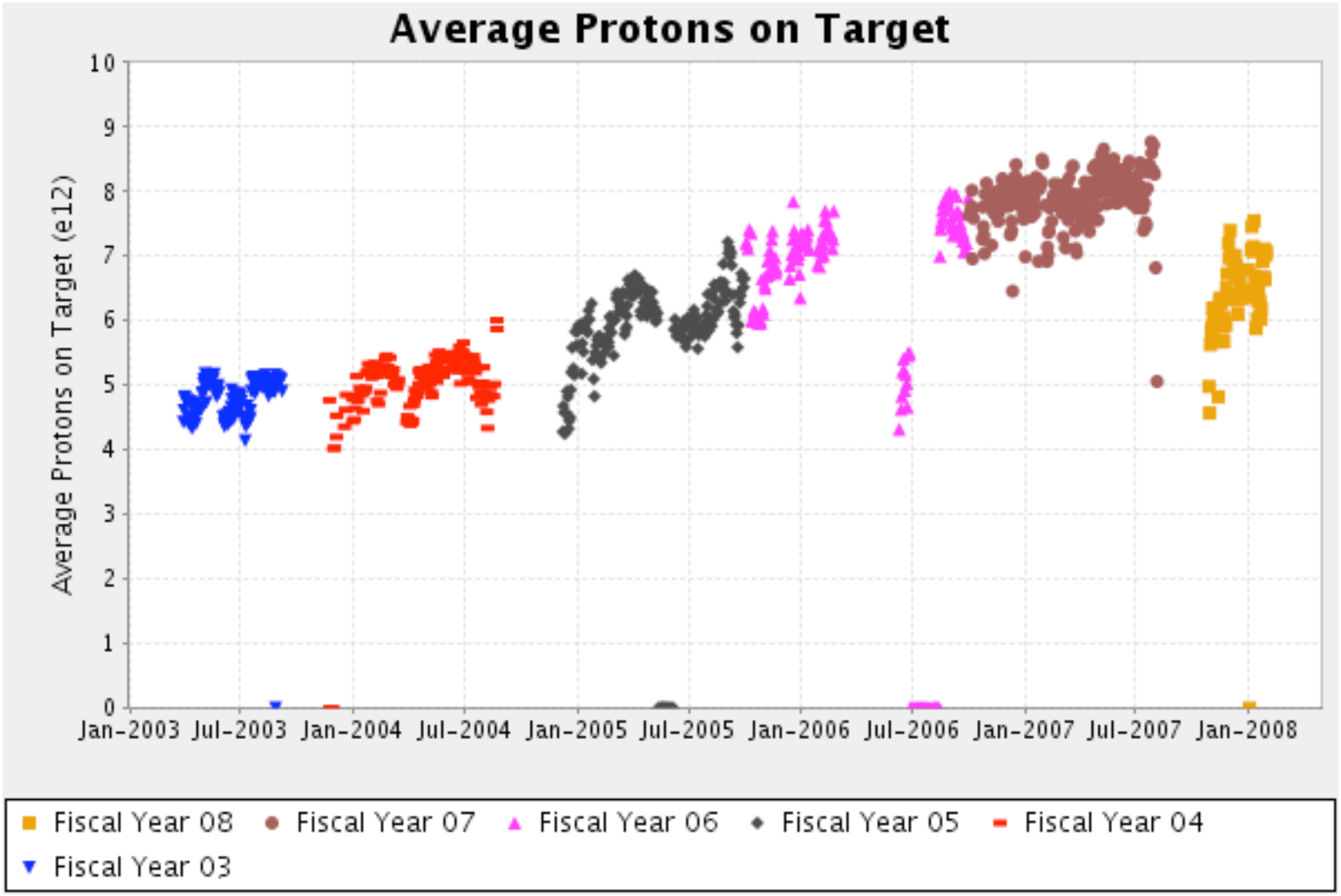



FY Average Store Hours per week 87.67
Store Hours per week
130
120
110
100
90
80
70
60
50
40
30
20
10
0
30-Oct
14-Nov
29-Nov
14-Dec
29-Dec
13-Jan
28-Jan
FY Average Store Hours per week
10X Average Store Hours per week

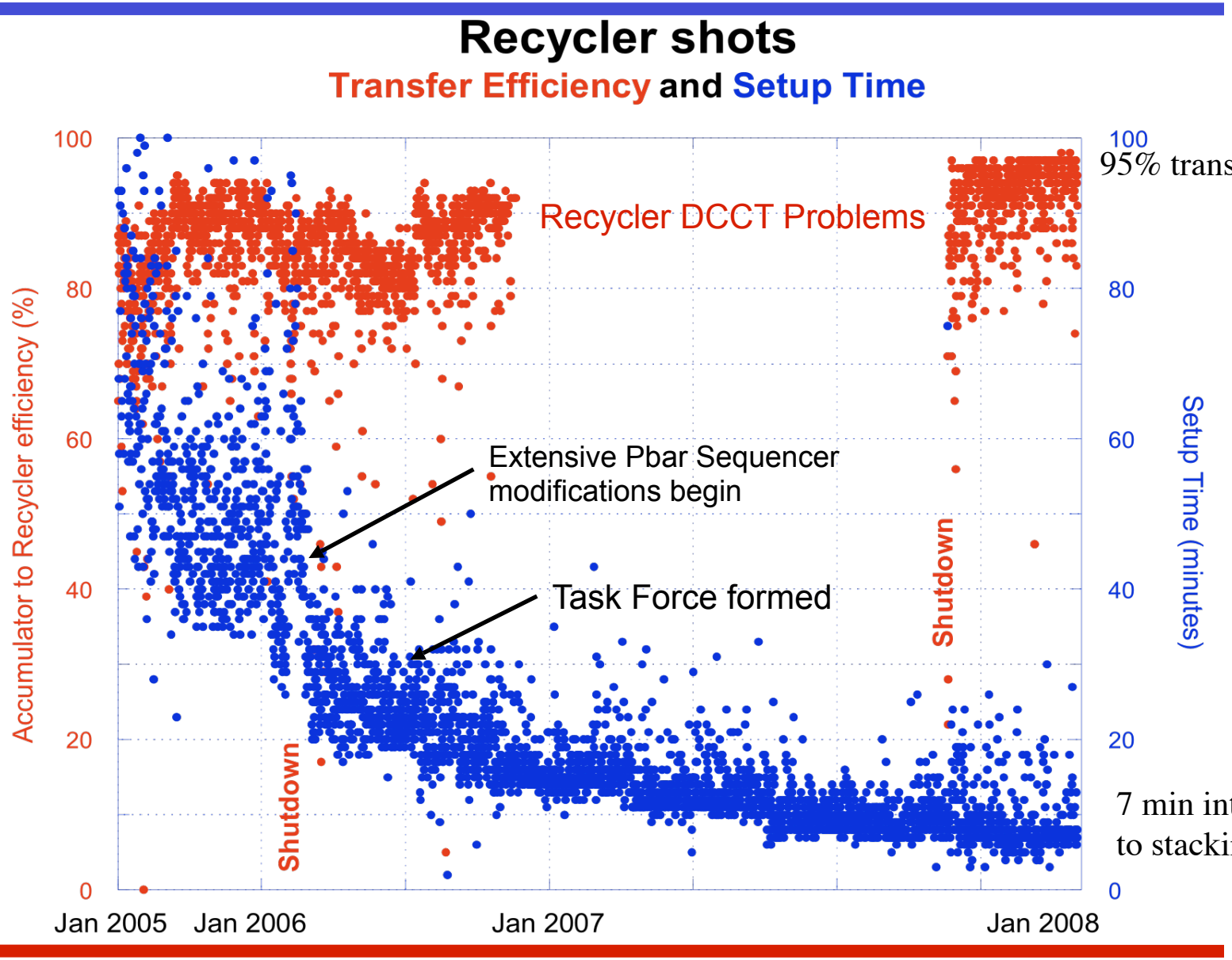

Best Stacking Hour
Best Hour (mA)
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Jan-2005
May-2005
Sep-2005
Jan-2006
May-2006
Sep-2006
Jan-2007
May-2007
Sep-2007
Jan-2008
FY08
FY07
FY06
FY05

# Weekly Stacking Rate




Average Protons on Target
Average Protons on Target (e12)
10
9
8
7
6
5
4
3
2
1
0
Jan-2003
Jul-2003
Jan-2004
Jul-2004
Jan-2005
Jul-2005
Jan-2006
Jul-2006
Jan-2007
Jul-2007
Jan-2008
Fiscal Year 08
Fiscal Year 07
Fiscal Year 06
Fiscal Year 05
Fiscal Year 04
Fiscal Year 03

# Transfers to the Recycler



# Summary of Antiproton Accumulations rates

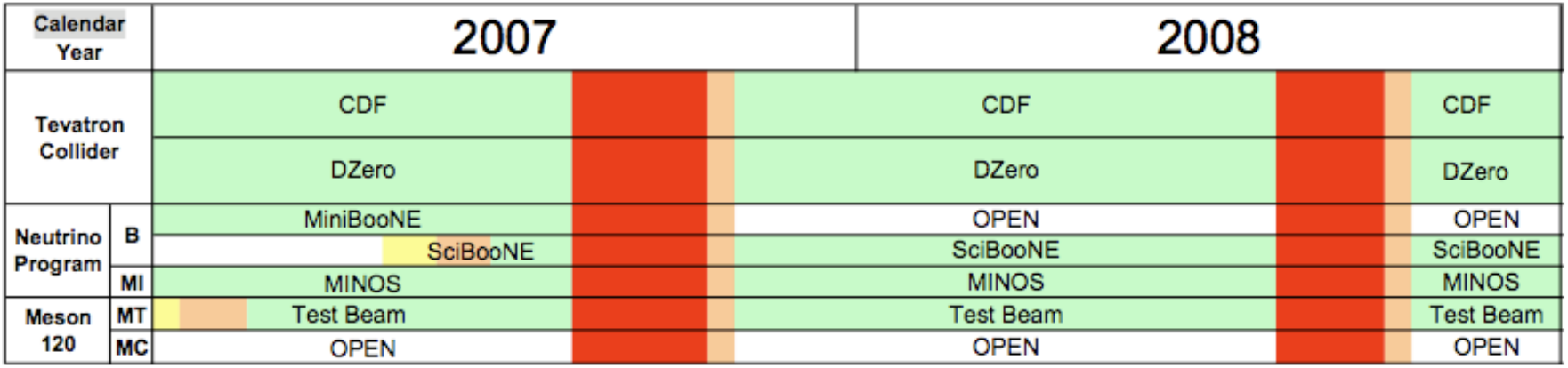
- Stacking Rate Improvements
- Faster transfer times
- Better efficiencies
- Shorter shot setups

==>More Antiprotons available per week

# Schedules and Shutdowns

## 2007-8 Fermilab Accelerator Experiments Schedule

**This Schedule will be updated regularly, as plans change.**




The FY2007 Summer Shutdown is now scheduled to begin on Monday, August 6, with a duration of 10 weeks.
The FY2008 Summer Shutdown is now scheduled for July and August.
This draft schedule will be updated as more precise information is made available.

RUN or DATA

STARTUP/COMMISSIONING

INSTALLATION

M&D (SHUTDOWN)

6/1/2007

# 2007 Shutdown

- Major Shutdown Jobs
  - Booster
    - Correctors
  - Main Injector
    - Collimators
  - Recycler
    - Stochastic cooling changes (longitudinal to transverse for brighter antiproton beams)
  - Tevatron
    - Maintenance
      - Warmed up 4 houses
      - Replaced 5 bad Tevatron Magnets and spools and repaired 2 in place
      - Unrolled magnets (~60)
      - Moved CDF and D0 Ips (moved tripletts)
    - Implemented new helix on startup for Proton losses during squeeze

# 2007/2008 Startup Issues

- Linac vacuum
- Linac stability
- Booster tuning with new correctors
- Tevatron magnet replacement over the holidays
  - Dedication crews worked around the clock during the holidays to replace (except for Christmas)
- Tevatron Helix
- Antiproton brightness

# Losses During the Squeeze

- Proton Loss driven by beam-beam effects
- New helix more complicated than initially thought
  - Flip horz collision helix in short arc to eliminate B17H separator polarity change
  - Also had to flip vertical helix
- Result: Lost ~ 1/3 of the antiprotons during the new helix transition in the squeeze
  - Phase changes of the helix resulted in horizontal and vertical minimum distances to coincide
  - This resulted in nearly head on collisions and beam-beam loss
  - Bottom line-- reverted to old helix

# Beam Lifetime During Physics

- Antiproton lifetime has improved and brightness has increased due to improvements in Recycler
- Proton lifetime suffering from small pbar emittances
  - Antiprotons 3-4 times smaller than protons
  - Greater fraction of proton bunch sees strongest beam-beam force
  - Highest head-on tune shifts for protons > 0.024
  - Tried to blow-up antiprotons using an injection mismatch--worked
- Solution
  - Jacker in Tevatron to blow up antiproton emittance slightly and improve proton lifetime
    - Results in slightly lower peak luminosities
    - Improved integrated luminosities due to better proton lifetimes

# Reliability Improvements

- Better stability in the Tevatron
  - Alignment of the Tevatron
  - Better instrumentation in the Tevatron
  - Improved quench detection
  - Better separation of beams
- Constant improvements in all areas of operations
  - Systematic problems fixed
    - Systematic if it happens twice
  - Linac Power Tube solved

# Store Terminations

| Year | Stores | Normal Terminations | %Normal Terminations |
|---|---|---|---|
| 2003 | 186 | 55 | 30% |
| 2004 | 166 | 110 | 66% |
| 2005 | 243 | 170 | 69% |
| 2006 | 171 | 107 | 63% |
| 2007/8 | 247 | 197 | 80% |

# Tevatron Spares

| Device type | number installed | good spares |
|---|---|---|
| TC dipole | 377 | 15 |
| TB dipole | 395 | 8 |
| TQD quads | 90 | 3 |
| TQF quads | 90 | 4 |

# Magnet Failure History

| Year | Mag. Failures | Other Device Fail. |
|---|---|---|
| 2003 | 1 | 2 |
| 2004 | 0 | 0 |
| 2005 | 2 | 0 |
| 2006 | 2 | 2 |
| 2007 | 0 | 0 |
| 2008 | 1 | 0 |

# Strategy

- Continue to make small improvements with short payback times
- Strive to increase reliability
- Maximize delivered luminosity
- Integrate Luminosity
  - Integrate Luminosity
    - Integrate Luminosity
      - Integrate Luminosity
        - Integrate Luminosity
          - Integrate Luminosity
      - Integrate Luminosity
    - Integrate Luminosity
  - Integrate Luminosity
- Integrate Luminosity

# Summary

- Tevatron is running well
- Tevatron reliability has improved dramatically
- We continue to make small improvements
  - Improve efficiencies to make better use of antiprotons
  - Constantly work on reliability
- We continue to work on reliability in all systems
- Tevatron Spares is not an issue