

There is still time to visit our  
refreshment stand



# Accelerator Division: The Movie

R. Dixon

# Overview

- History/Accomplishments
- Challenges and Issues
  - Operations
  - Projects
  - Safety
- Lessons Learned
- The future

# History

To Understand where we are going  
we must understand where we  
have been and what we have  
accomplished

The Lost Boys

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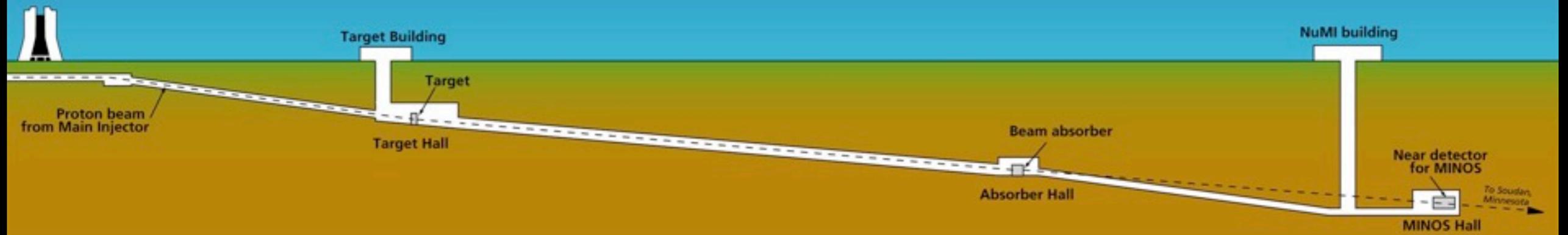
The Lost Boys

Well, they should have said it

# Setting

- 2003
  - Rookie division Head
  - Run II underway without ambitious Goals
  - NuMI beam under Construction
    - Large project with major technical Challenges
  - 8-GeV neutrino program underway (MiniBooNE)
  - Aggressive review committees bearing down upon Us
  - Talented motivated accelerator Division

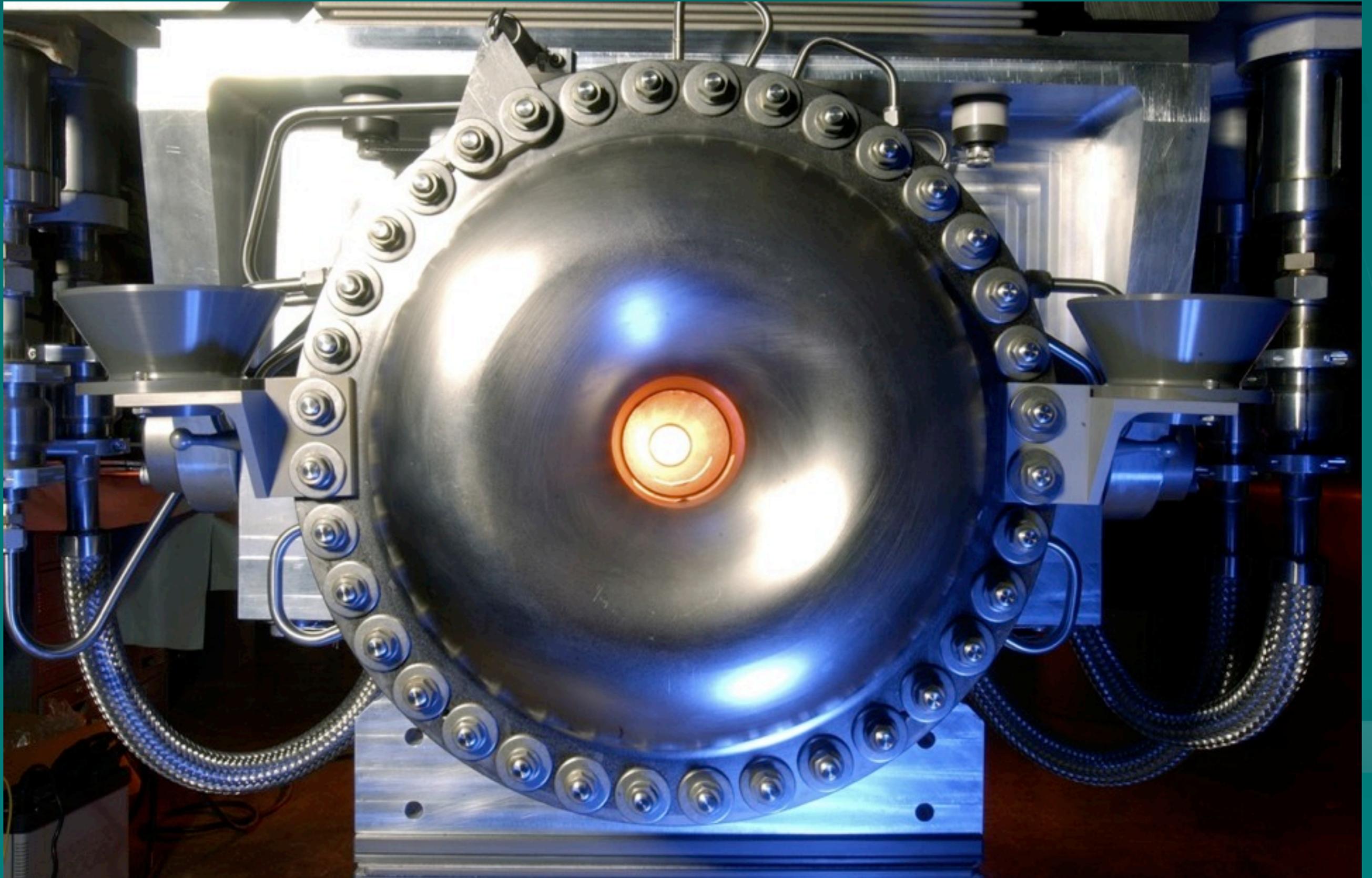
# NuMI Tunnel Project





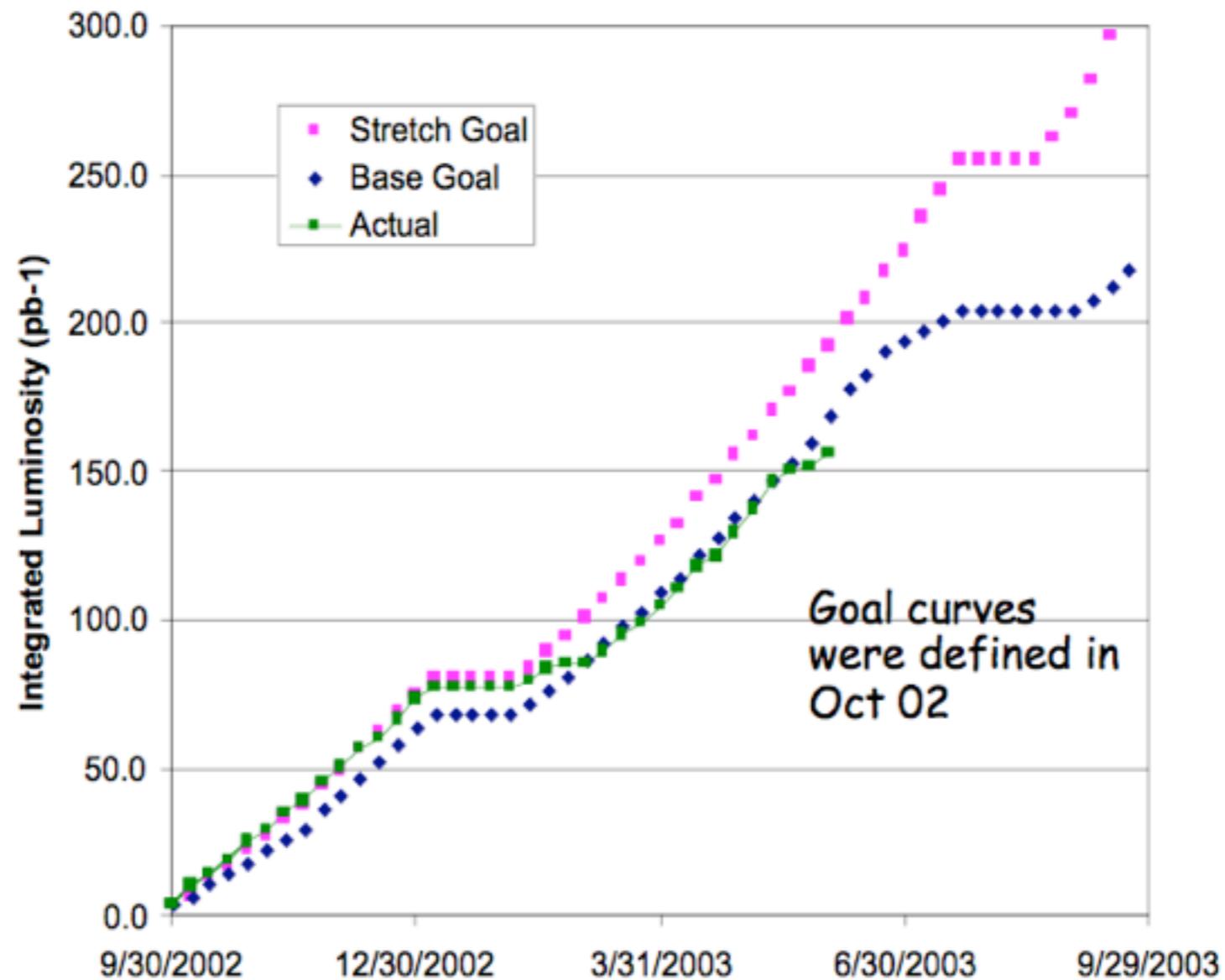
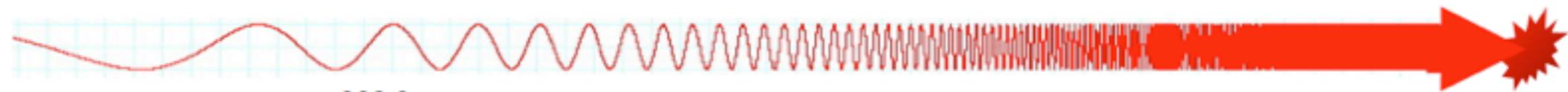
Friday, October 8, 2010

# NuMI Horn 1



# First Run II Luminosity Goals

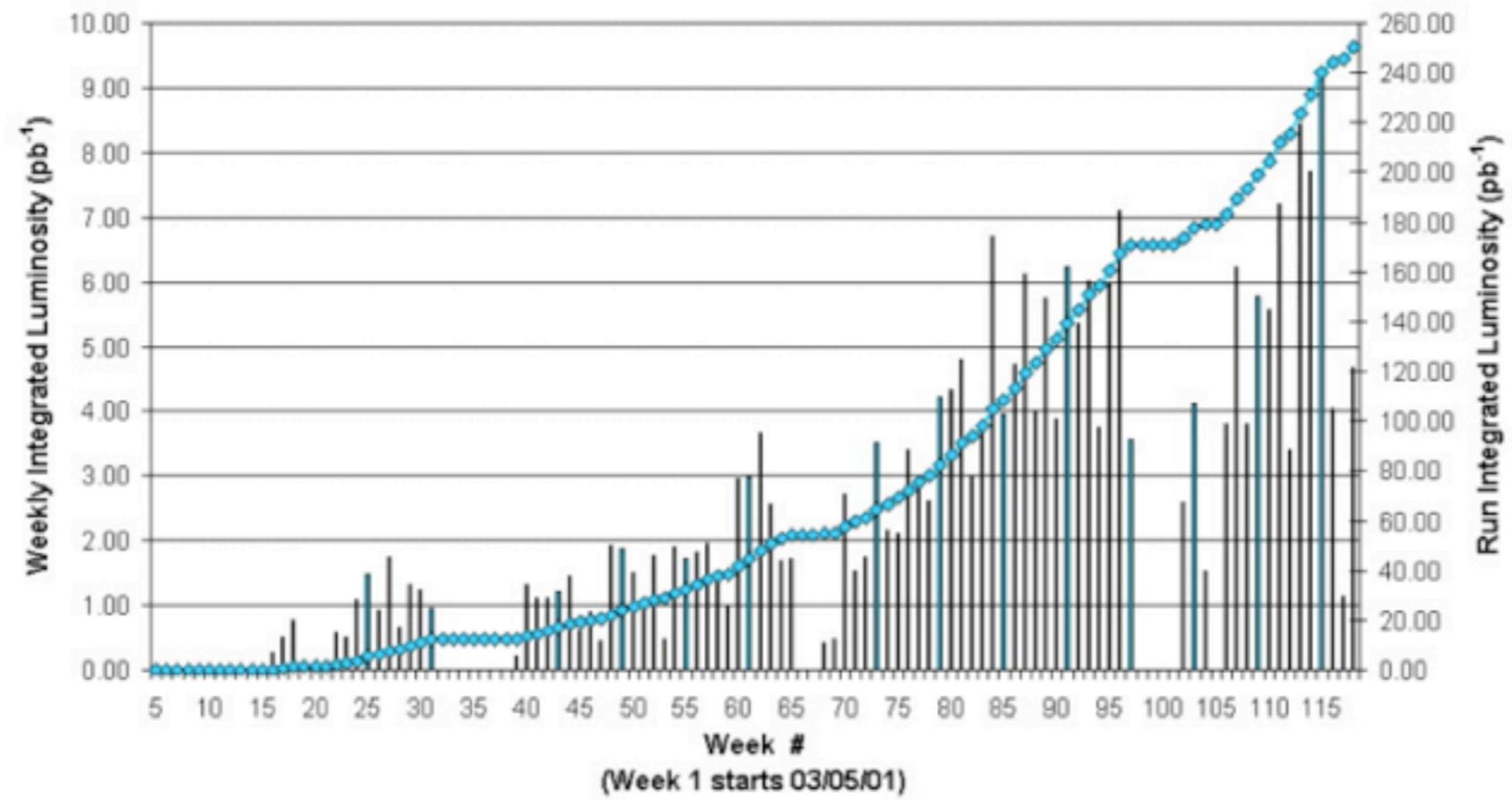
## *Integrated Luminosity & Goals*



30fb<sup>-1</sup>  
15 fb<sup>-1</sup>?

# Run II Performance in 2003

## Run II Integrated Luminosity Progress

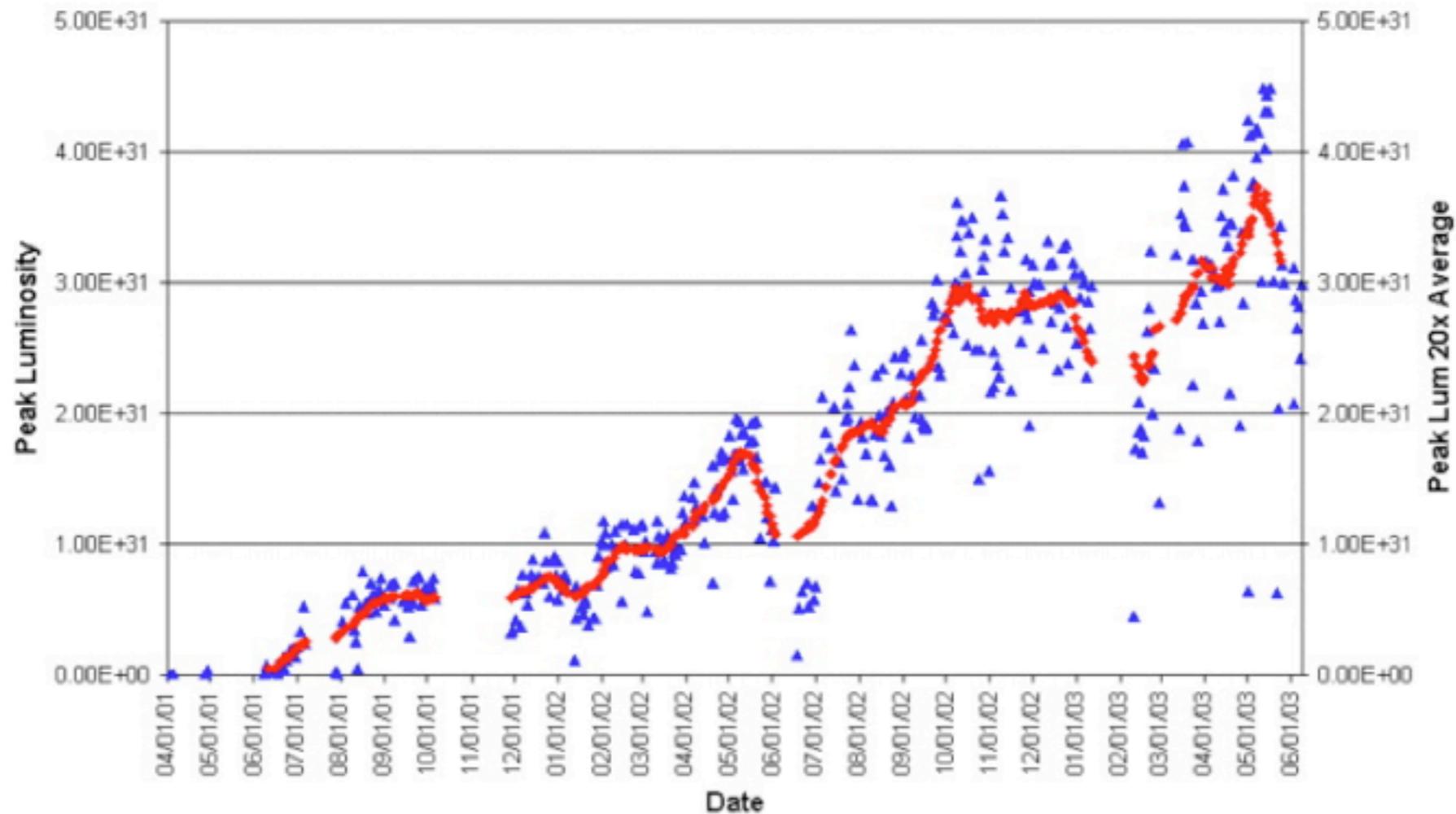
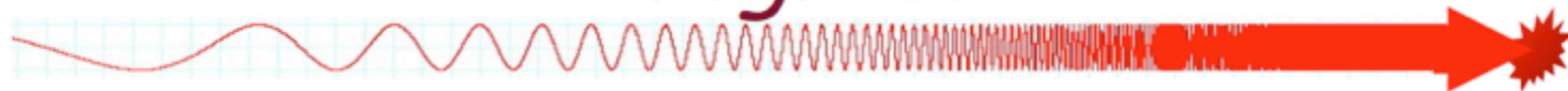


PAC 6-14-03  
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# 2003 Peak Luminosity

## *Run II Peak Luminosity Progress*

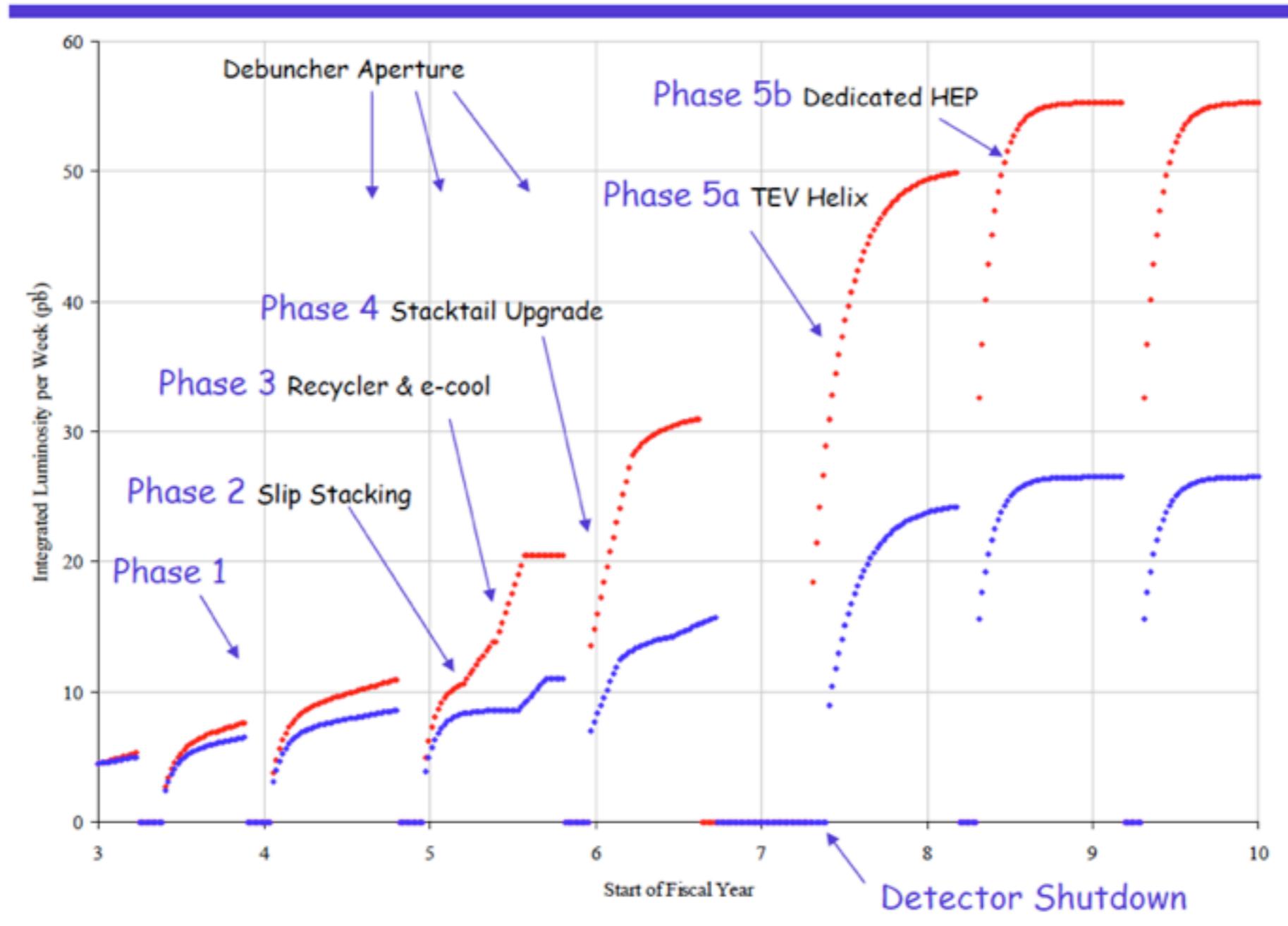


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# 2003 Review

## Weekly Luminosity and Phases



DOE Review, July 21, 2003

Spalding 26

# Proton Source

## *Maintenance and Reliability*



- Linac and Booster are 32 years old
  - Obsolete technology-- spares difficult to come by
  - Many systems depend on a hand full of experts who are loft
- Tevatron is 20 years old and was designed with a 20 year lifetime in mind
- Much of the rest of the infrastructure is old

# 2003 Goals

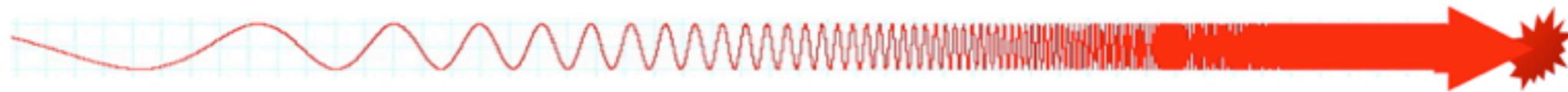
## *Goals for Division*



- Maximize integrated luminosity for collider program between now and the beginning of the LHC era
  - Short term improvements
  - Run II Upgrade Plan
- Continue to increase the number of protons delivered to MiniBooNE
- Install and commission NUMI beam line and run the program
- Improve the operations reliability for the entire program
- Mitigate major vulnerabilities

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Thought to begin in 2007

# Movie

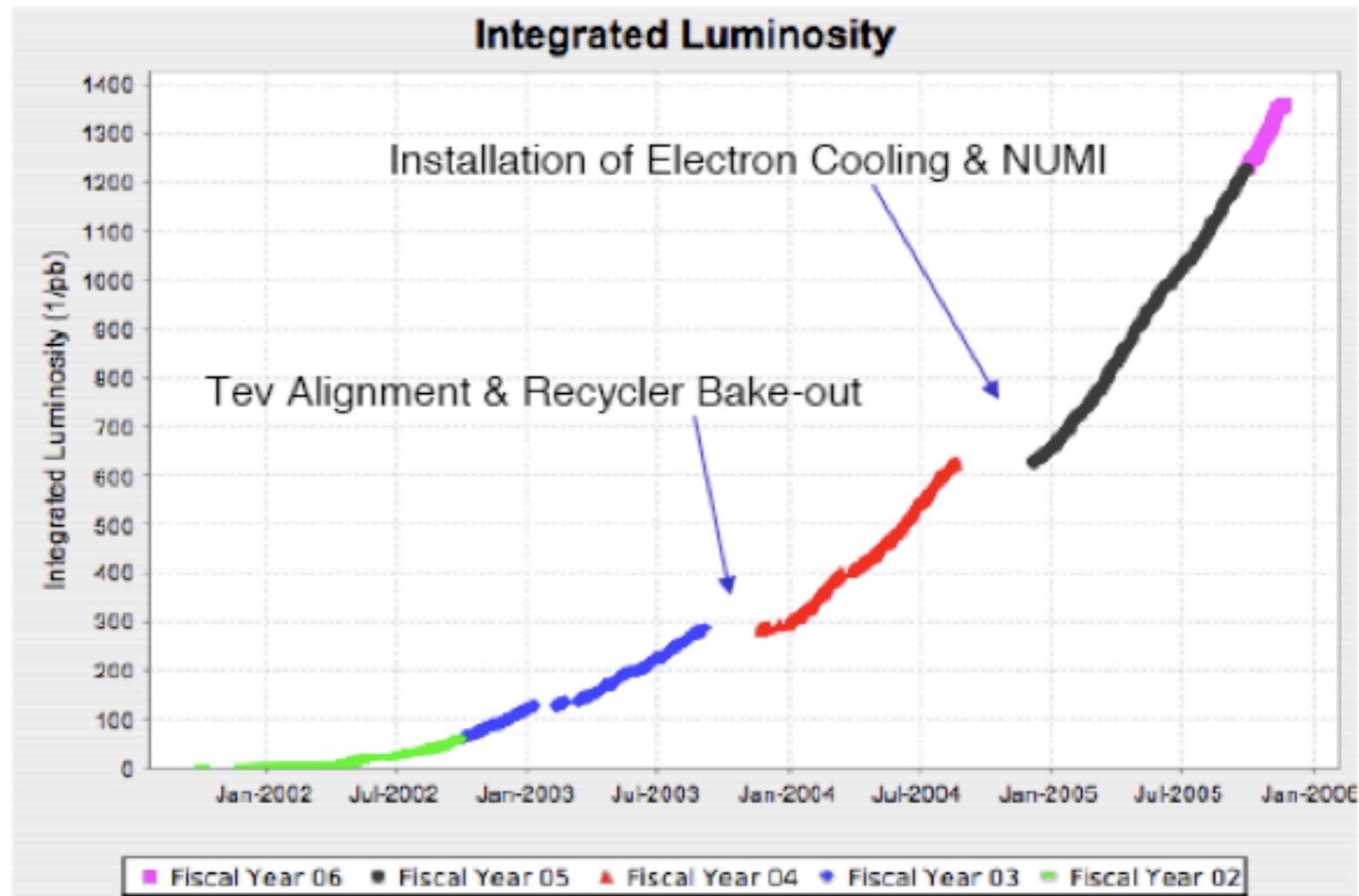


# What Happened

- Tevatron BPMs
- Tevatron Alignment
- Fixed Smart Bolts
- Many stacking improvements
- Main Injector Collimators
- Many other improvements
- Major steps in 2005
  - Slip Stacking in MI for antiproton stacking
  - Electron Cooling
  - NuMI beam turns on



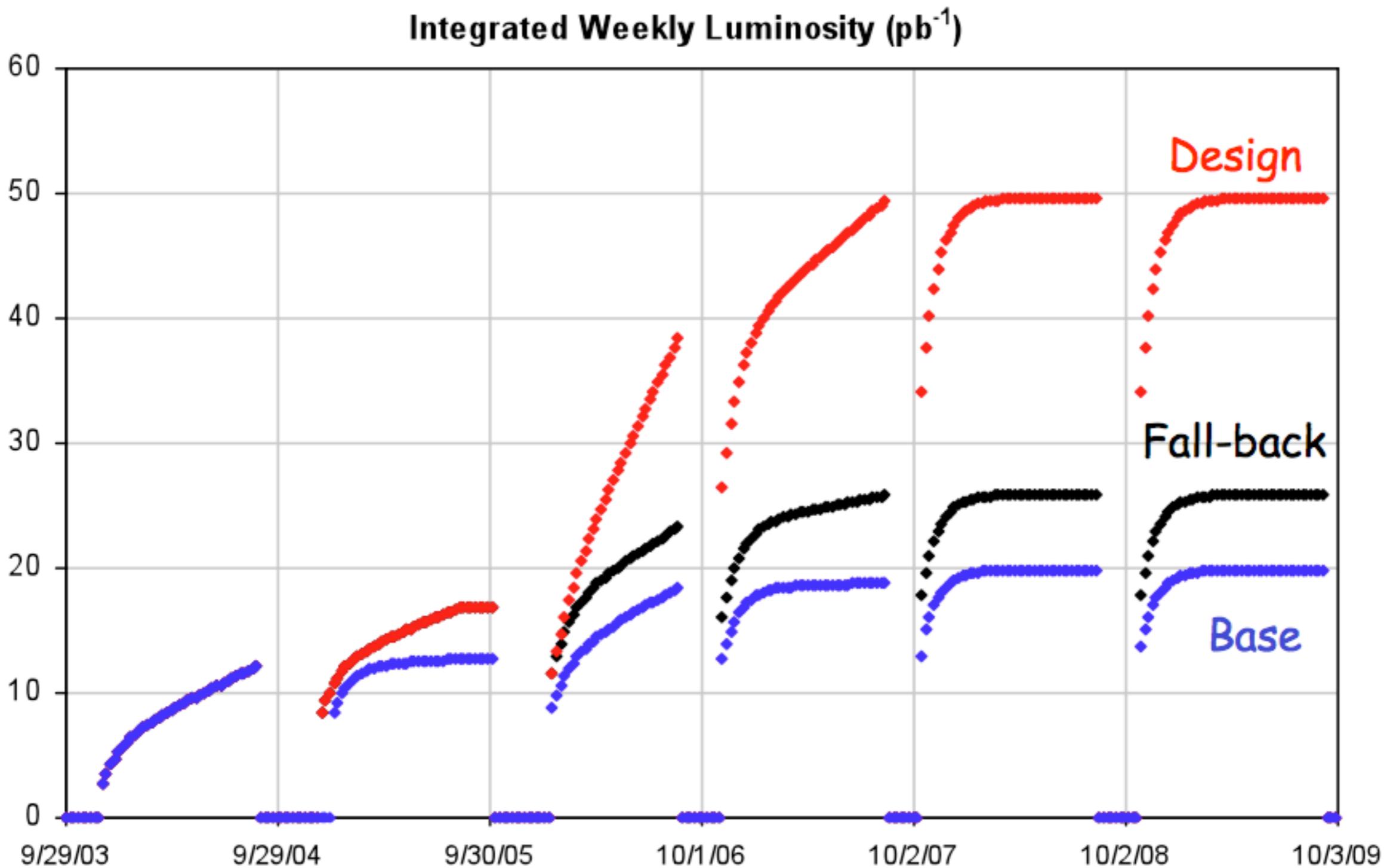
# Integrated Luminosity



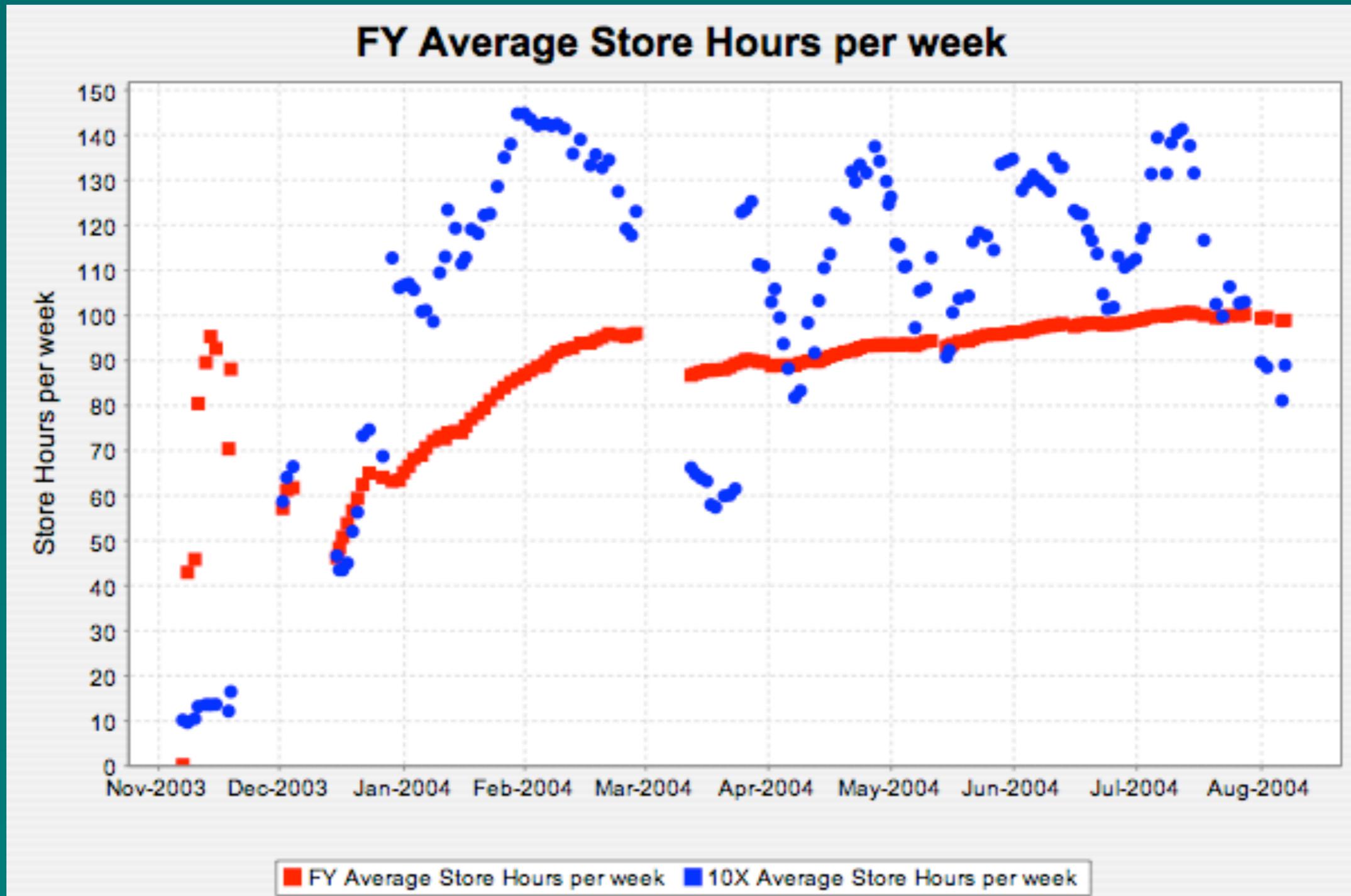
- Since June 2003, the Tevatron has seen a 3-fold increase in
  - Peak luminosity
  - Integrated luminosity per week
  - Total integrated luminosity



# Weekly Luminosity Projection



# Reliability

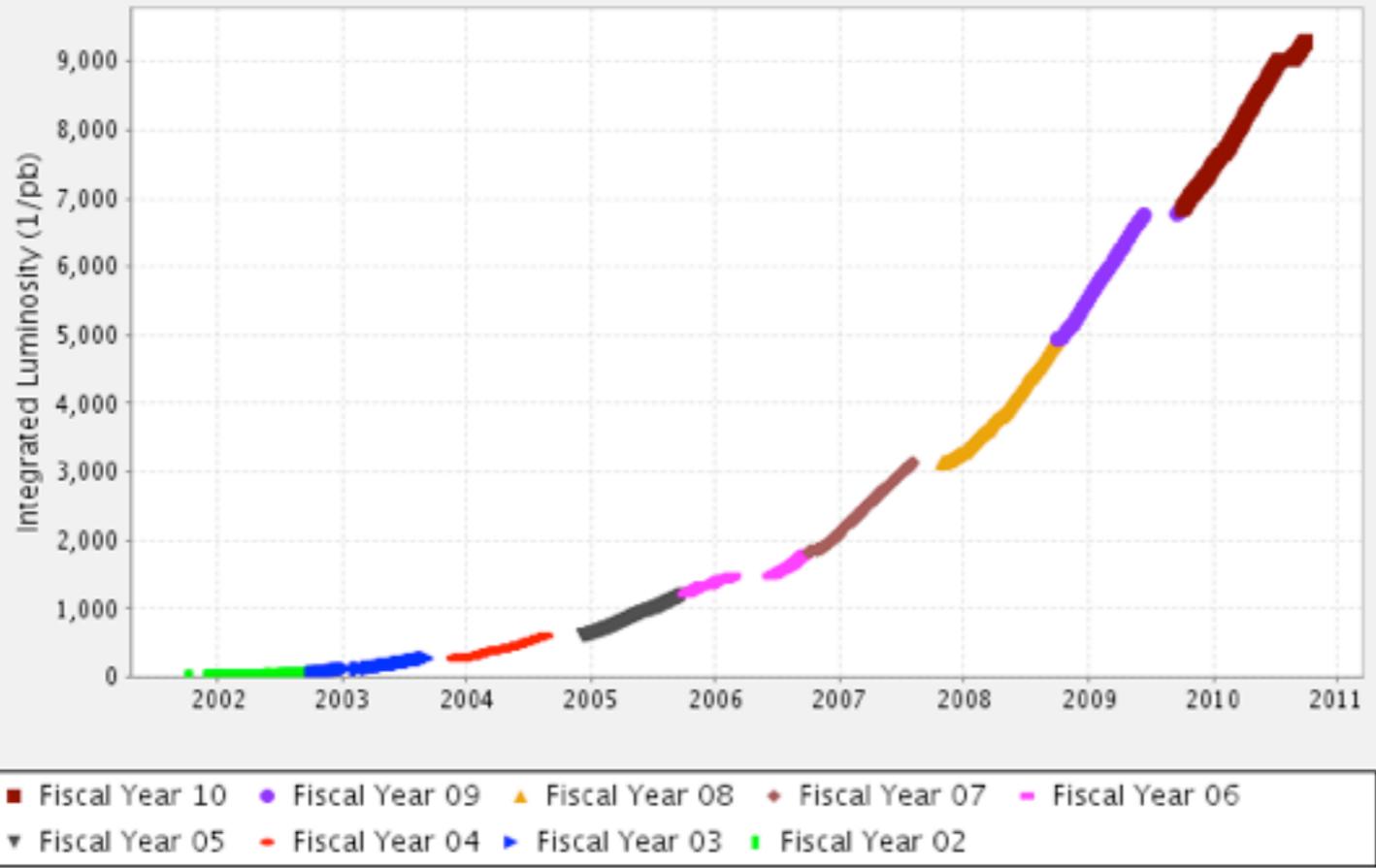


# Fast Forward to 2010

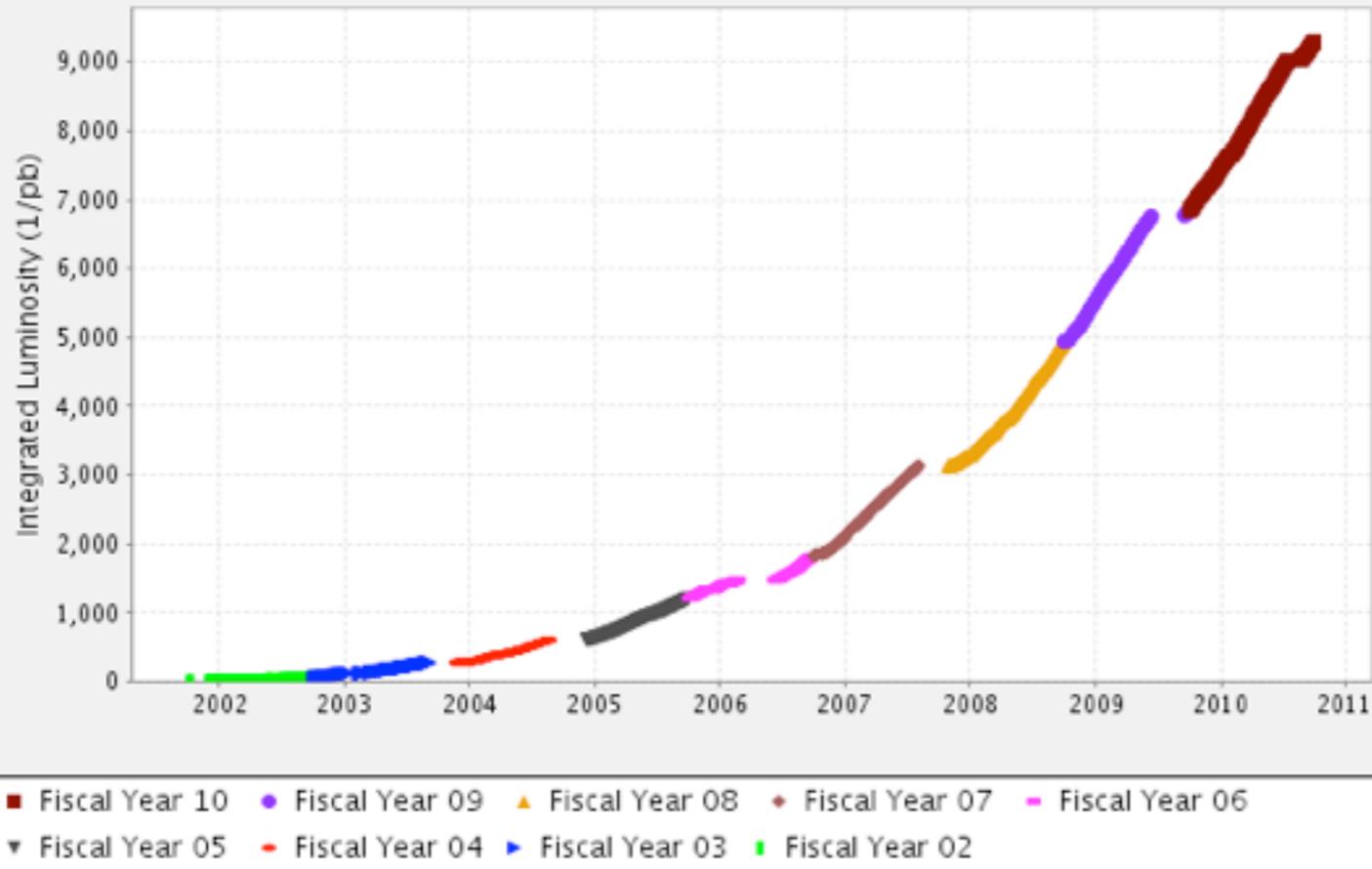




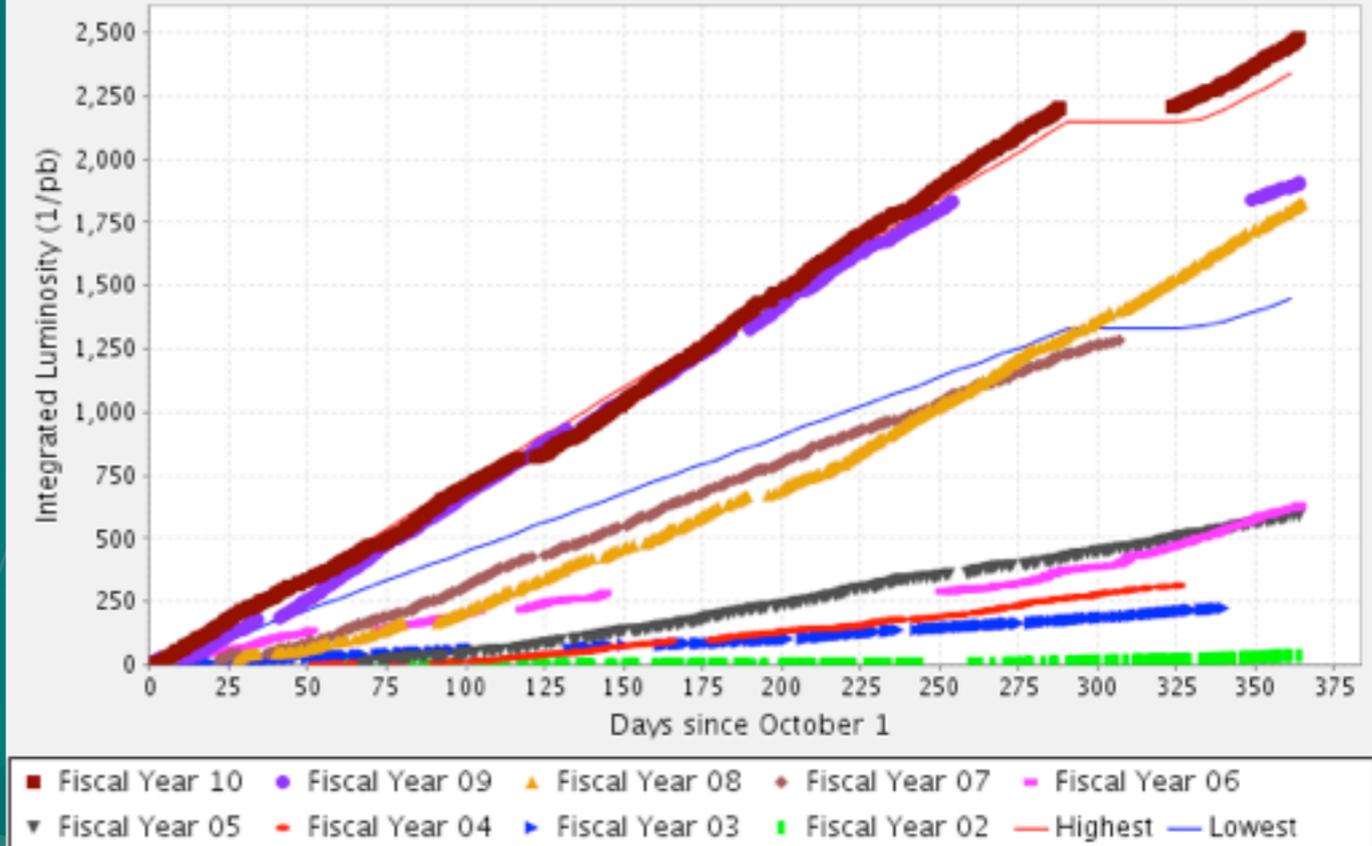
# Integrated Luminosity 9305.47 (1/pb)



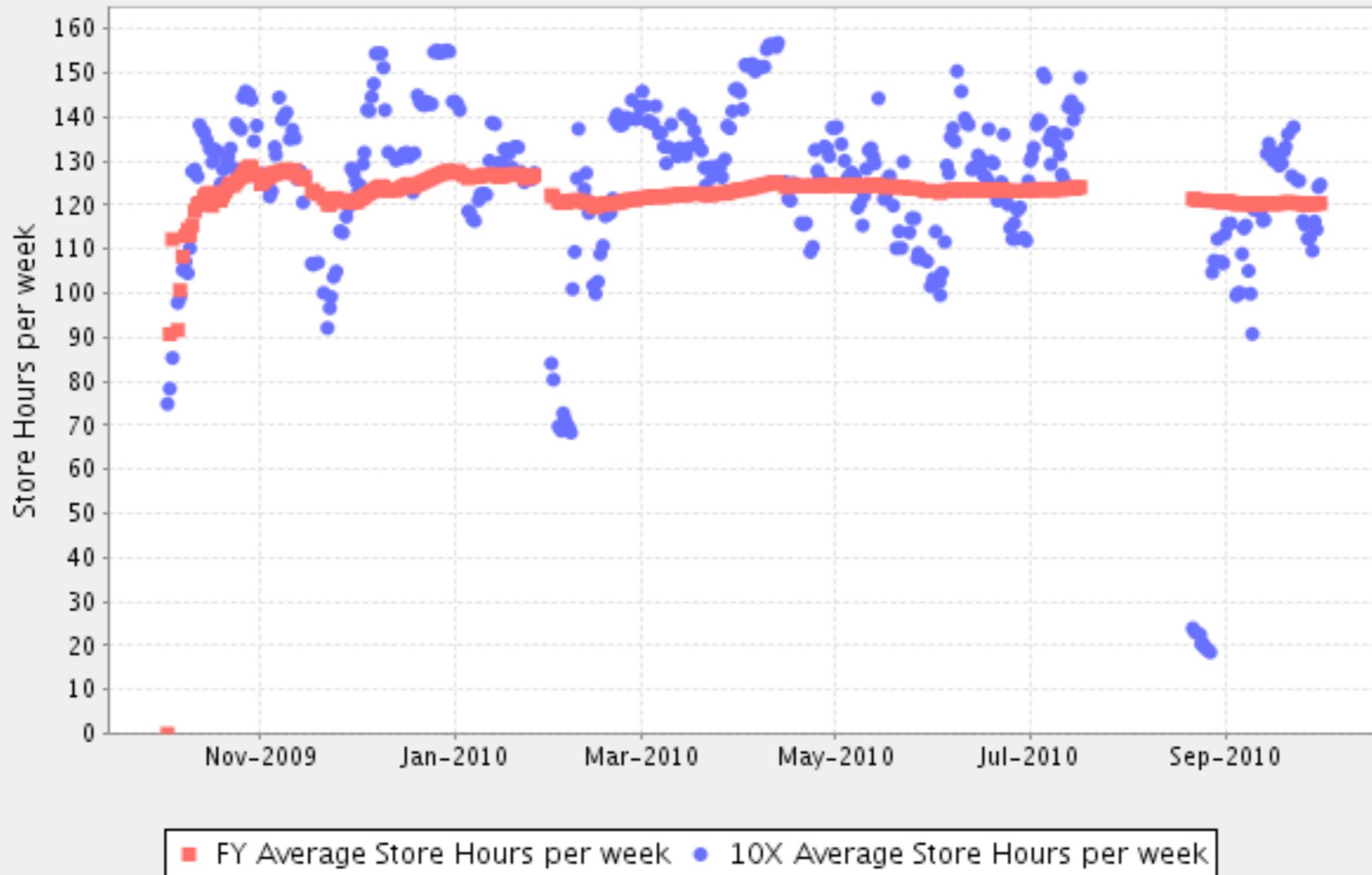
**Integrated Luminosity 9305.47 (1/pb)**



**Integrated Luminosity (1/pb)**



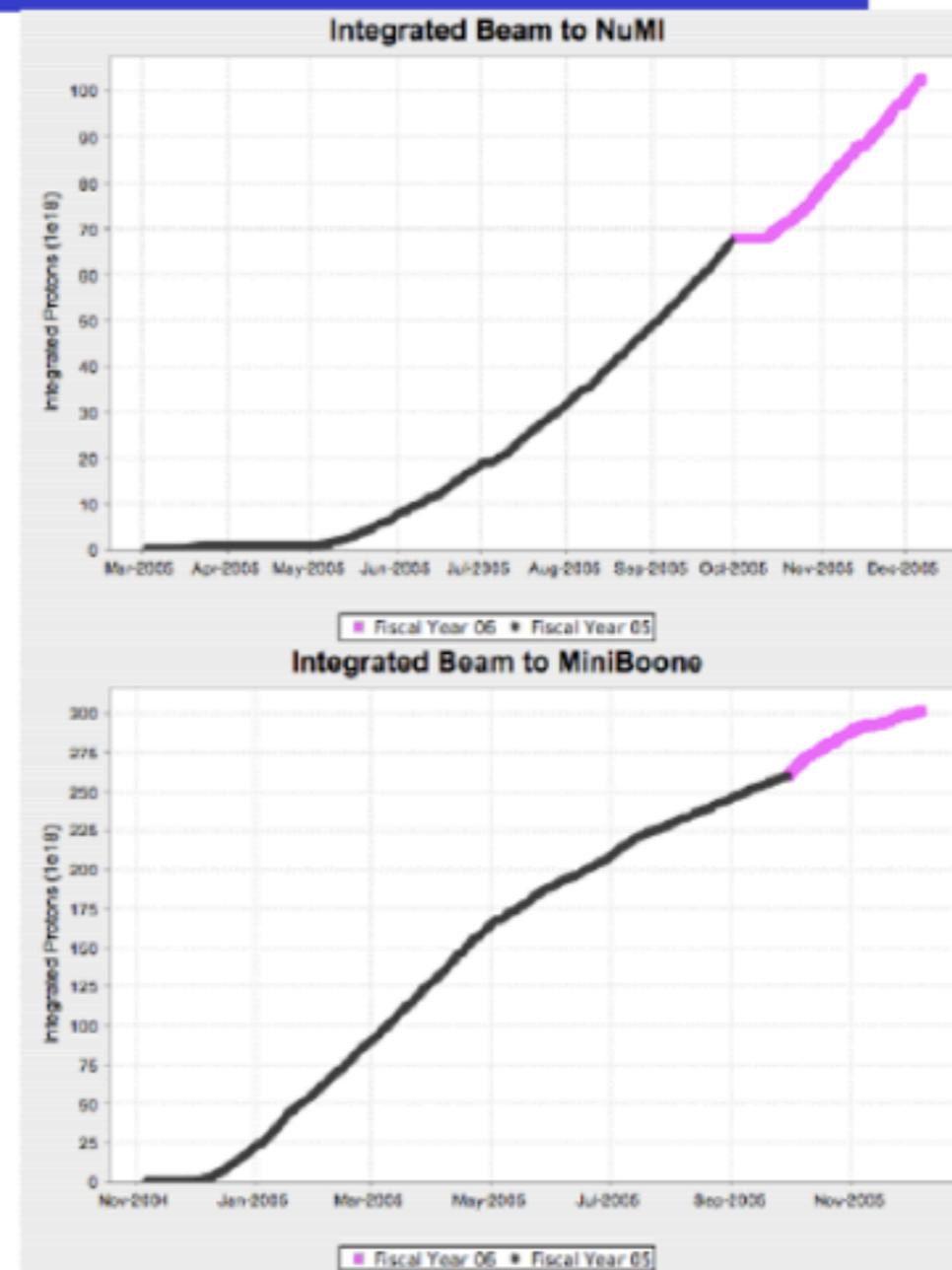
## FY Average Store Hours per week 120.41



# 2005

## Major Expansion of the Neutrino Program

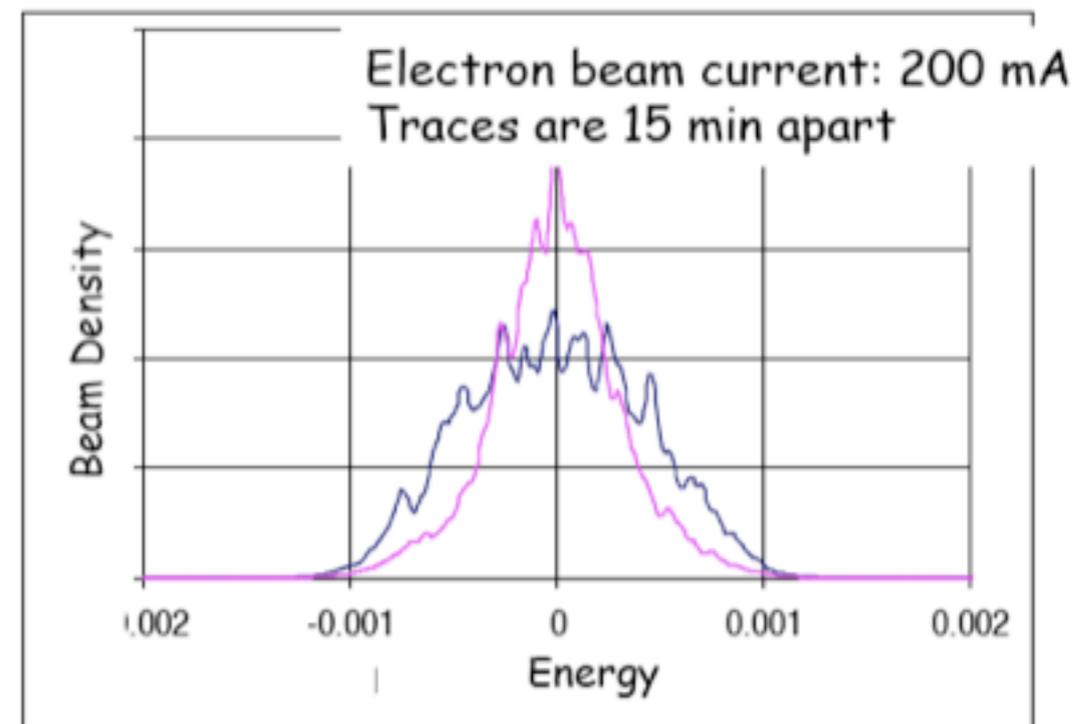
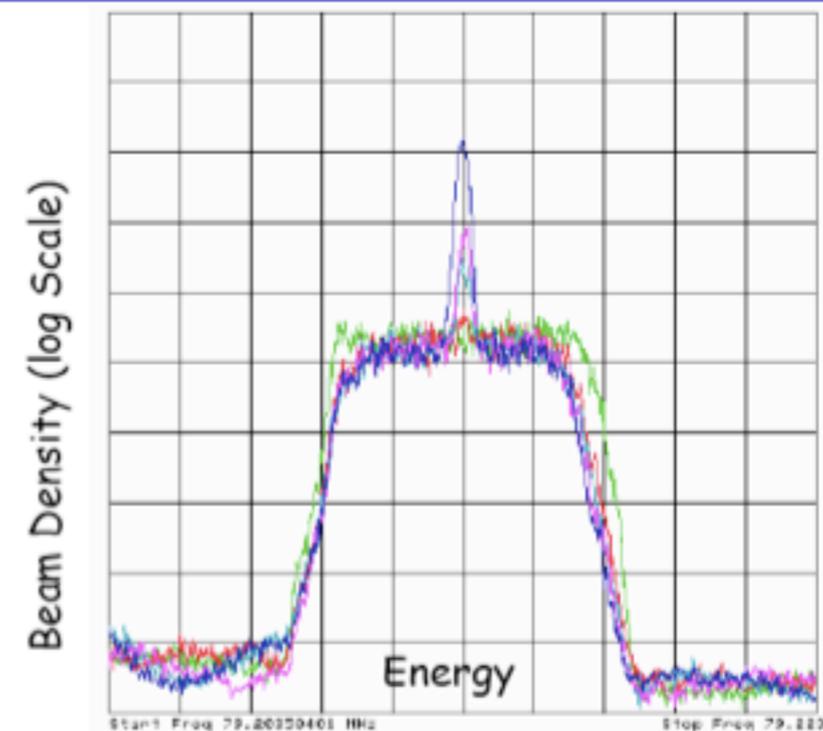
- **NUMI commissioned**
  - First beam on Dec. 4, 2004
  - Around the clock operations on March 14, 2005
  - Operations in Mixed-Mode antiproton stacking cycles
  - Target problems April 2005
  - Horn Problems September 2005
  - Running on average at 175-200kW of beam power
  - Reached  $1 \times 10^{20}$  protons in December 2005
  - Major issues:
    - Targeting component reliability and availability - Engineering!
    - Pulses per second - tied to pbar stacking
- **Record throughput for MiniBoone**
  - $8.0 \times 10^{16}$  protons/hour
  - Delivered a over  $6 \times 10^{20}$  protons in three years of running
- **Routine running of SY120**
  - Developed mixed mode which achieved a factor of 7 more spill seconds than originally allocated
  - Now with NUMI absorbing all the mixed mode cycles, a long flattop ramp keeps most of the spill-seconds intact.



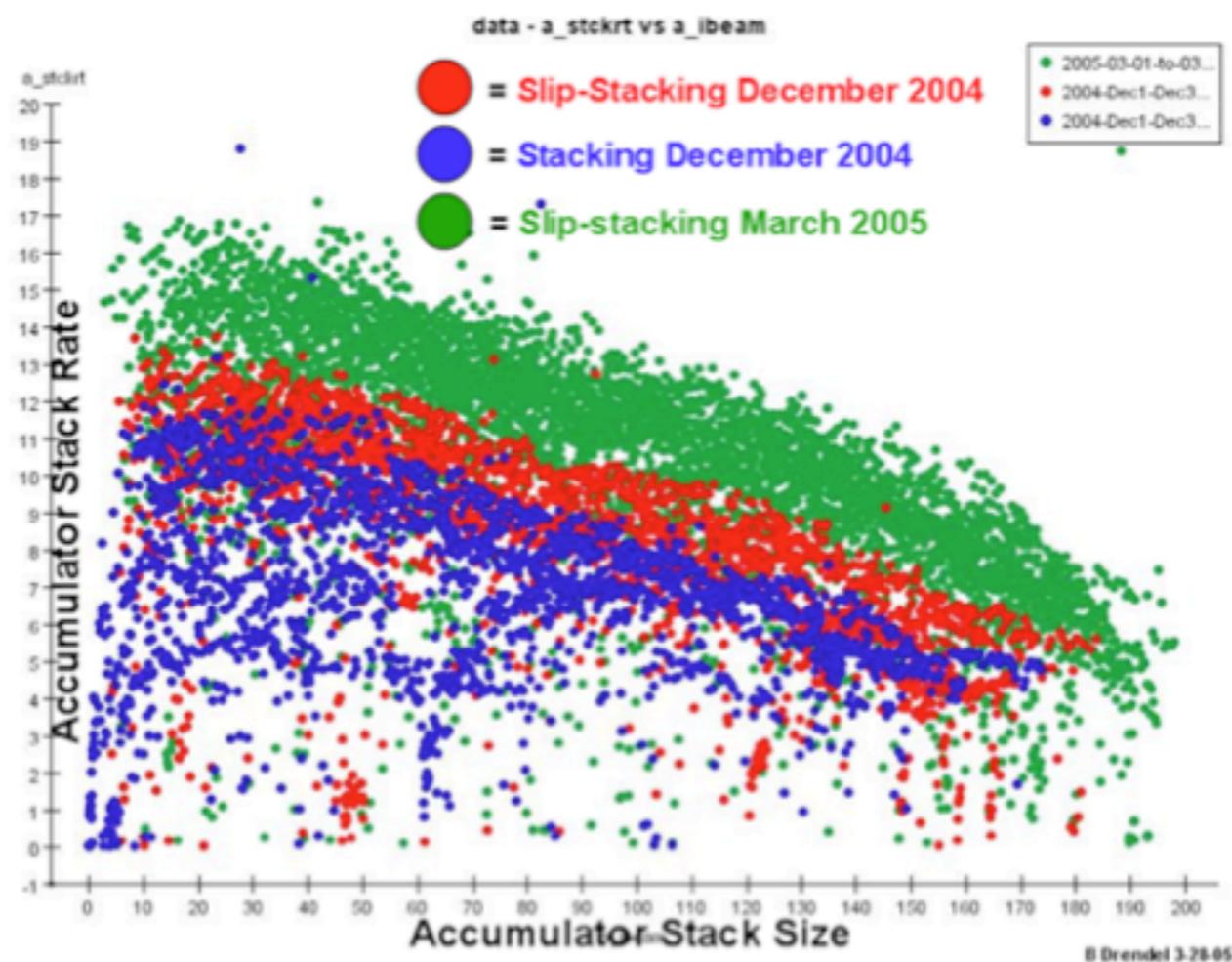
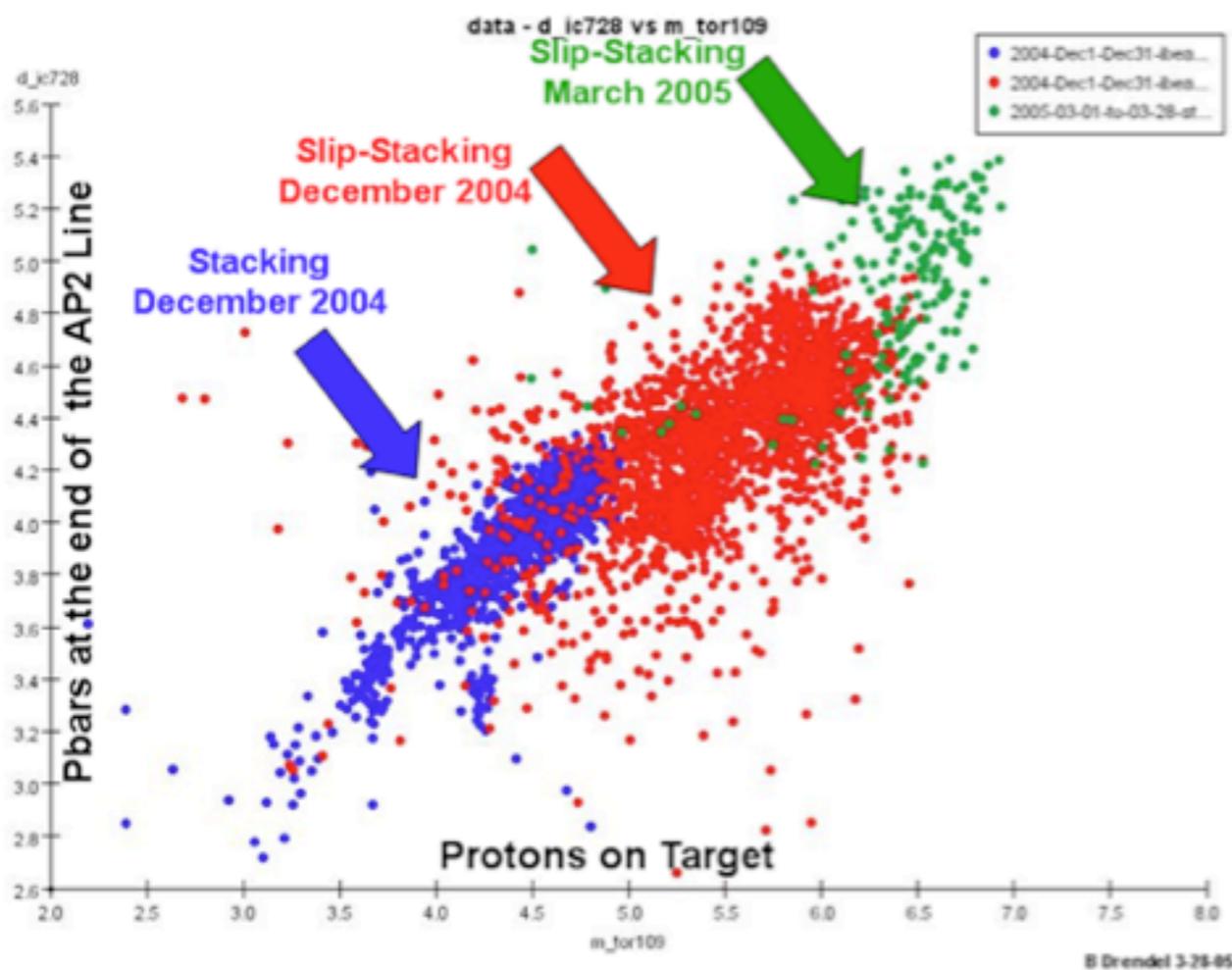


## Recycler Electron Cooling

- Electron cooling commissioning
  - Electron cooling was demonstrated in July 2005 two months ahead of schedule.
  - By the end of August 2005, electron cooling was being used on every Tevatron shot
- Electron cooling goals
  - Can presently support final design goal of rapid transfers (30eV-Sec/2hrs)
  - Can presently reliably support stacks of  $250 \times 10^{10}$  (FY06 design goal)
  - Have achieved 500 mA of electron beam which is the final design goal.



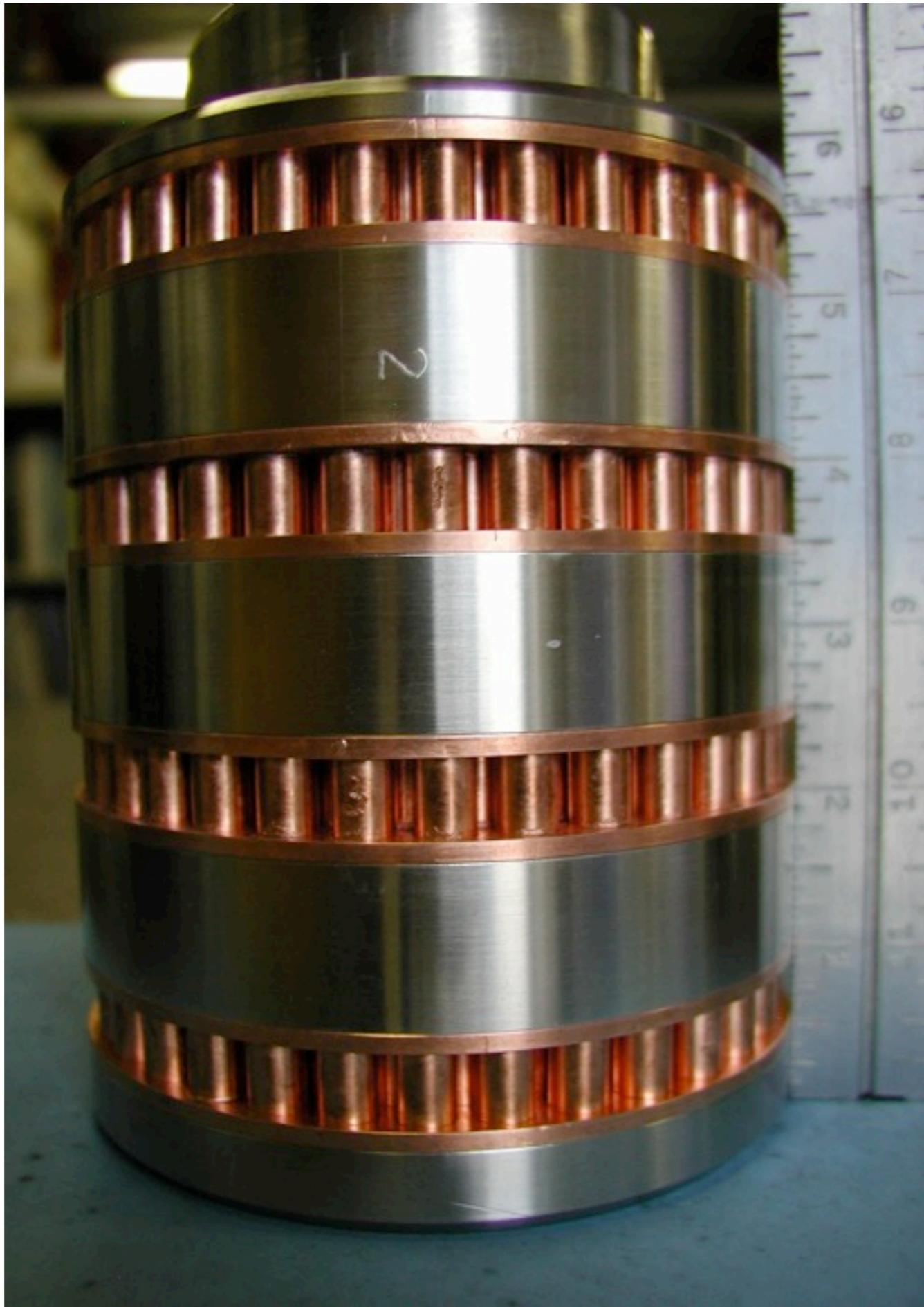
## Antiproton Production - Slip Stacking

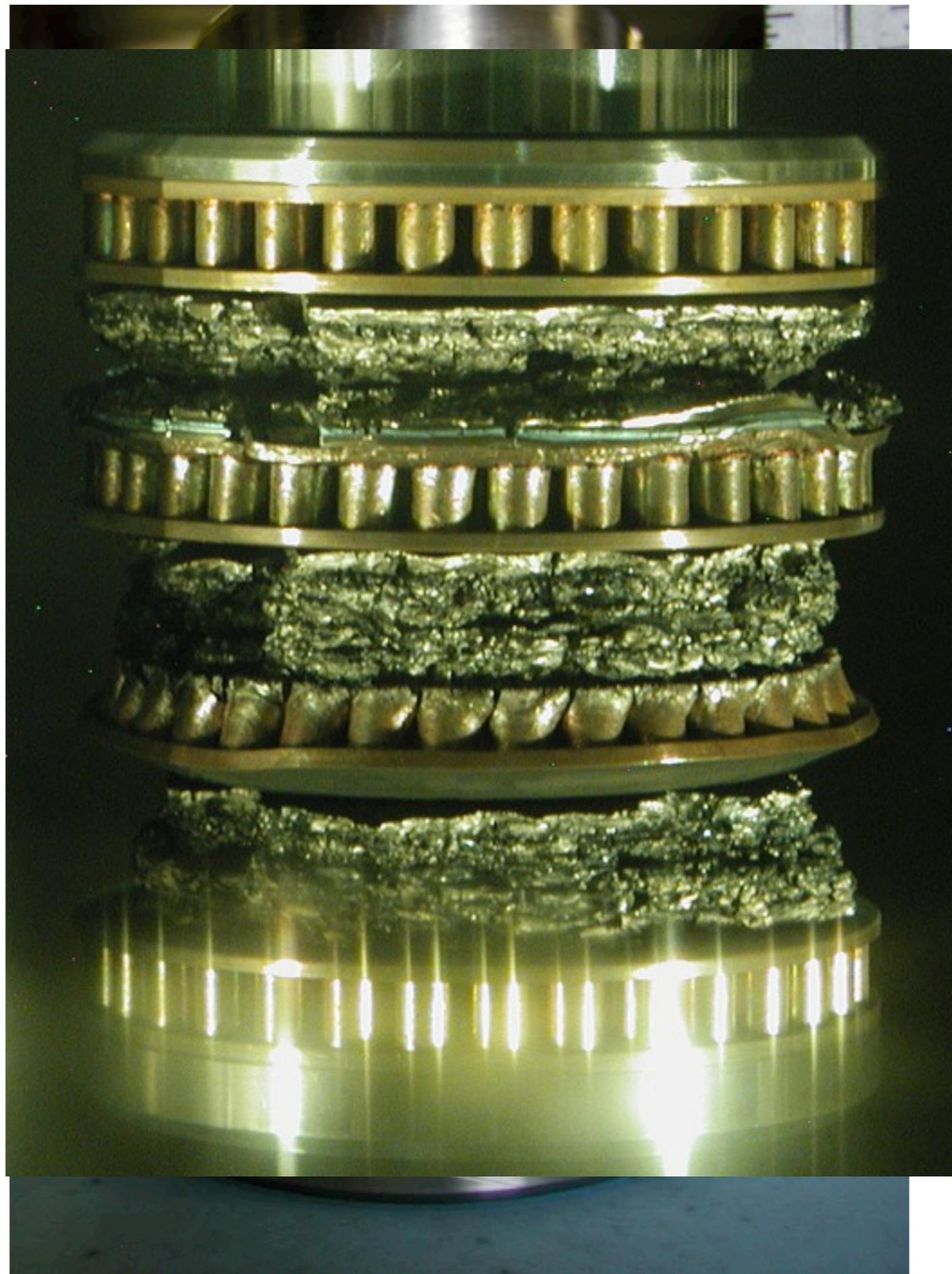


Tevatron Machine Performance and Perspectives - McGinnis

# Main Injector Collimators







## Tevatron Beam Power

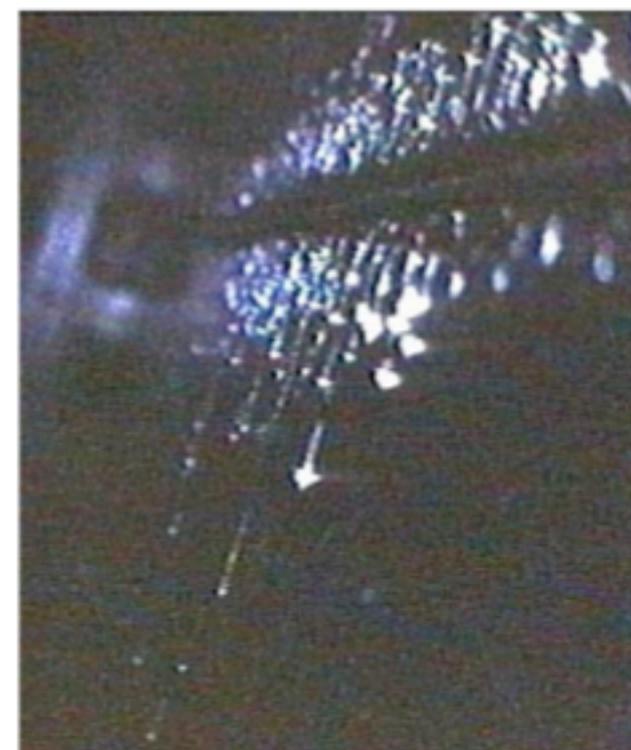
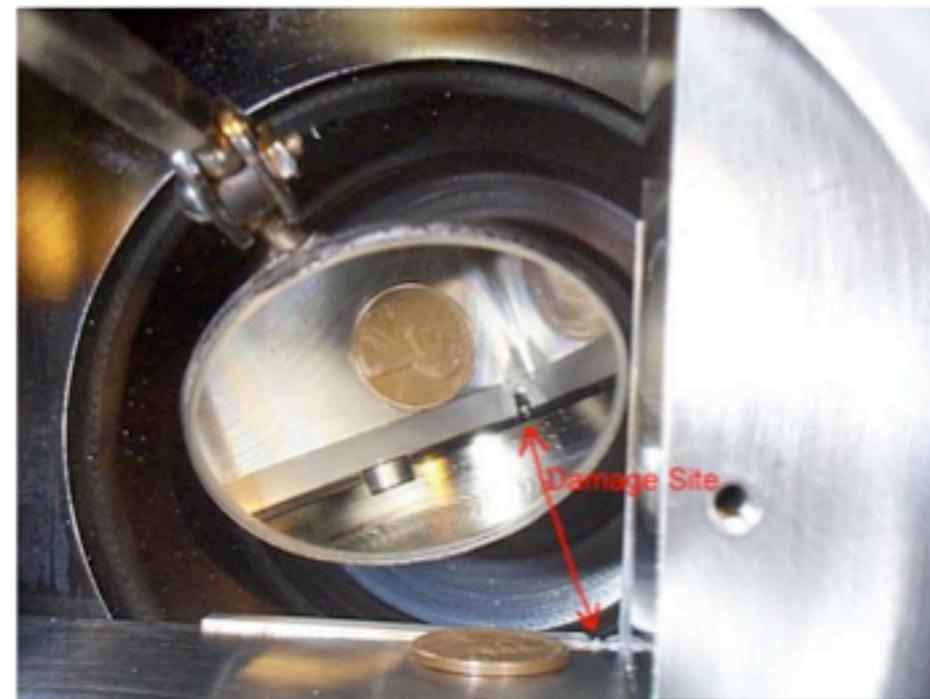
$$L = \frac{3\gamma f_0}{\beta^*} (BN_p) \left( \frac{N_p}{\epsilon_p} \right) \frac{F(\beta^*, \theta_{x,y}, \epsilon_{p,\bar{p}}, \sigma_{p,\bar{p}}^L)}{(1 + \epsilon_{\bar{p}}/\epsilon_p)}$$

- Proton Beam Current

- Luminosity is proportional to the number of protons per bunch ( $N_p$ )
- The proton beam current is proportional to  $BN_p$

- Fast Beam Loss - can cause serious damage to the detector or the accelerator

- Run II example: fast beam loss incident initiated by misbehavior of roman pot → losses → fast trip of correctors → beam miss-steer
- Each proton/pbar bunch is a bullet - in Russian roulette
- Add collimator protection where possible
- Assertions:
  - Every serious beam incident should be fully diagnosed
  - Implication digested by the experiments.
  - Any corrective action will likely involve work on the accelerator
- Unmasking of inputs for protection
- New BLM system as abort input
- Kicker Pre-fires
  - Collimator design
  - Abort block reconfiguration





# What is the Key to Our Success?

## • AD Personnel

- Talented
- Dedicated
- Focused
- Tough
- Together

R. Dixon AD Seminar 12-13-05



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**We developed a reasonable set of challenging goals that brought expectations under control**

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# AD Activities and Projects

## ■ Projects

- NOvA (18)
- HINS (14)
- Project X (7)
- SRF (38)
  - ILC?
- mu2e (2)
- g-2 (Small effort--not approved)
- LBNE (7)
- LARP/LAFS (~0)
- LHC Splices (~0)
- MTA
- Proton Source Upgrade? Task Force Report
- Run II Extension?

# Proton Source Upgrade

- RFQ Source
- Low Energy Linac?
- Booster RF Upgrades
  - Booster Solid State Upgrade
  - Booster 15 Hz Upgrade
  - New RF Cavities
- Shielding
- Utilities

# Proton Source Upgrade

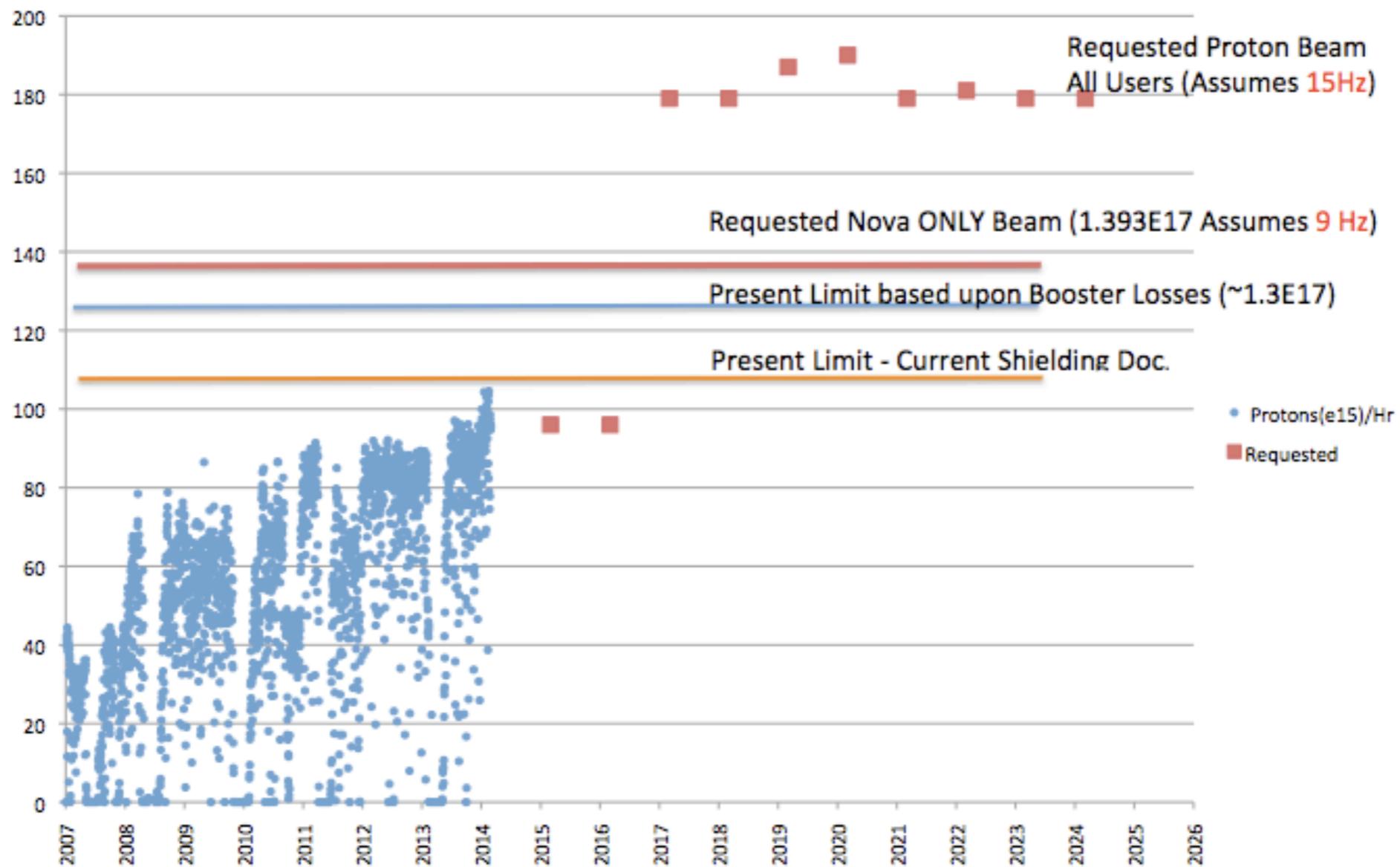
- Reliability of the complex
- Throughput required to satisfy experiments on the books

# Possible Program

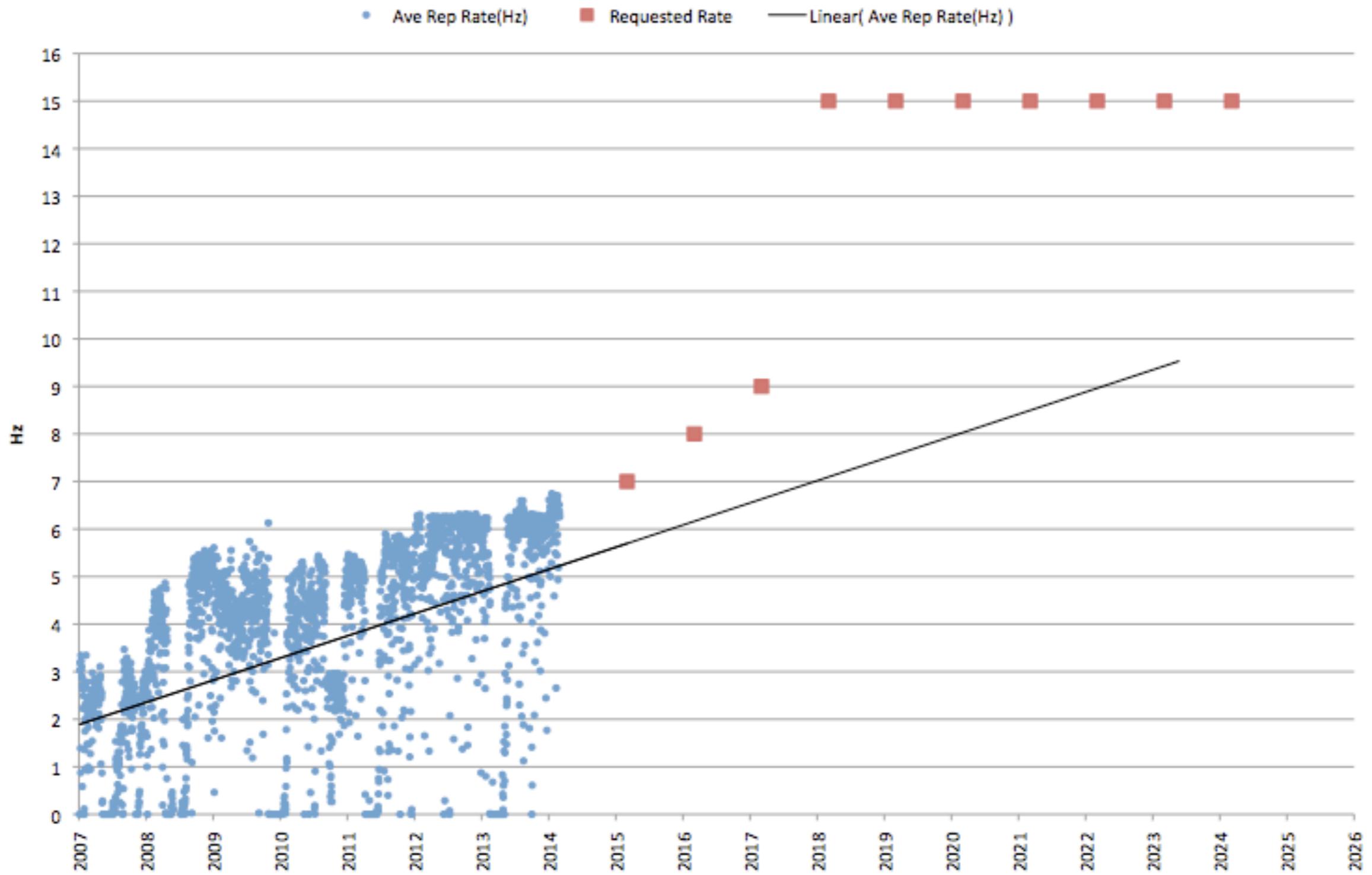
## Required Proton Throughput

Proton Numbers – Jeff Appel

Nova Era plan - Average Protons/Hr (e15)



# Booster Cycle Rate



# Major Issues

- Manpower to support the projects
  - Engineering
- Funding for Proton Source
- Protons for the program
- Targets and horns for the neutrino program
- Run II extension
  - Uncertainty in the program for next year and beyond
- Safety
- Average Age of AD staff
- Office and Work Space for AD Staff



# Pseudo Science

0011 0010 1010 1

Dear Dr. Dixon,

So far, these postulations have been presented to the world of science for some 30 years without any refutation of the conclusions based on the extension of the General Theory of Relativity by Willem de Sitter. Should we continue with this line of investigation, we should have empirical verification of the highly energetic conditions resident in de Sitter space with the generation of a Type Ia Supernova. The question we must ponder is do we as individuals and as a species really wish to do this? Such then is the tragic nature of our species.

... [32 pages]

Your kind thoughts and understanding in all these matters are most gratefully appreciated.

All Best Wishes, Your friend,

With greatest respect,

Paul W. Dixon, Ph.D.  
Professor of psychology

R. Dixon AD Seminar 12-13-05

# Lessons Learned

- Create reasonable goals that create reasonable expectations for our customers
- A motivated and dedicated staff will find a way to exceed expectations
- Don't attempt to jump too far in one leap
  - Bridge the river with carefully placed stones that don't require big steps or risks

# The Future

- The intensity Frontier
  - Project X
  - Neutrinos and Stuff
- the Cosmic frontier
- The energy Frontier
- the Chaos frontier
- Accelerator fission or other practical Applications?

