Integrated Luminosity Model

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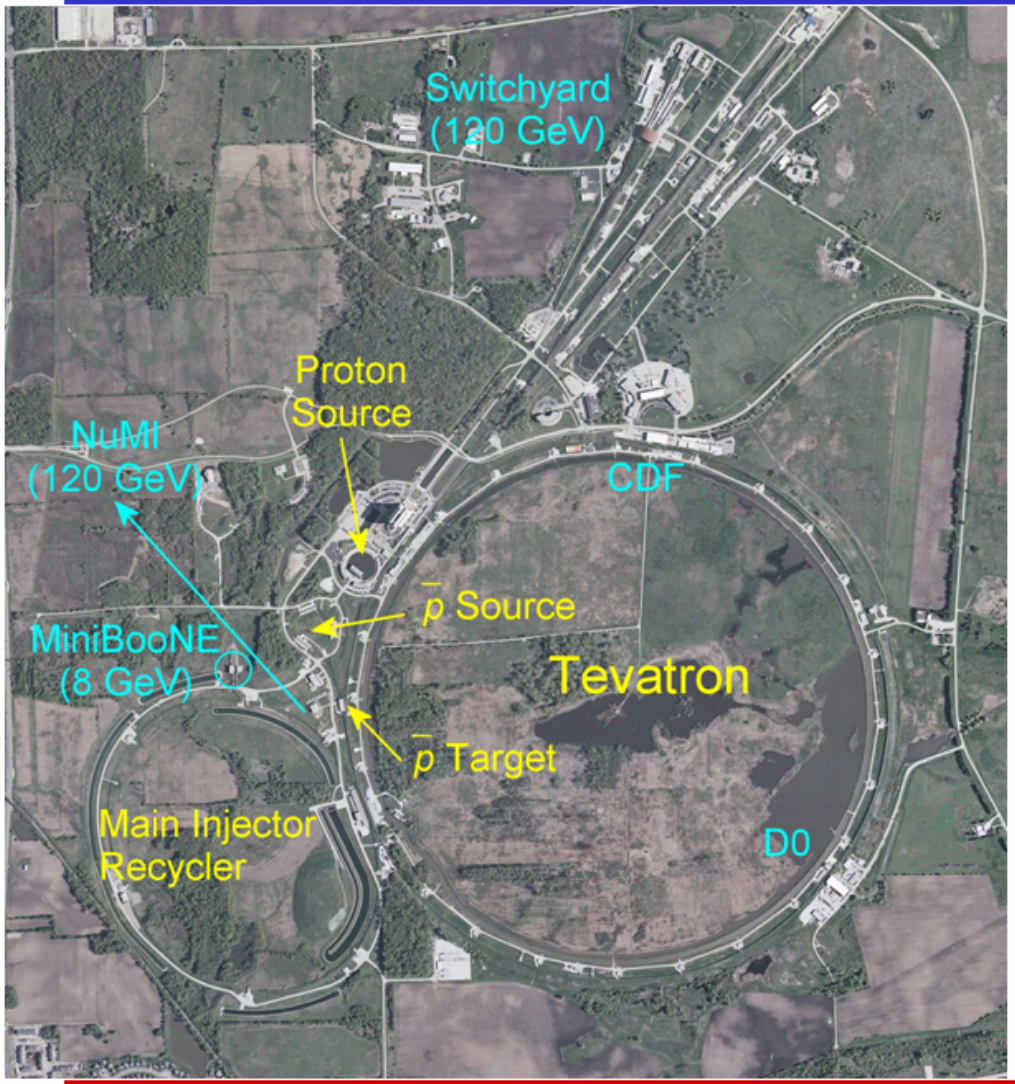
Introduction

- From the beginning of RunII to nearly a year ago
  - Emphasis was placed on Initial Luminosity
    - Availability of Antiprotons (Pbars)
    - Stability of Complex and competition of other experiments
    - Incorporation of upgrades
- Present day
  - Complex is more stable, conditions more reproducible
  - Allows us to use this model to optimize Integrated Luminosity
- How are we optimizing integrated luminosity?
  - Presuming stable beam conditions, the limiting factor becomes Pbar Production rate
  - By using recent historical data to model the accelerator complex performance, we find the optimum Pbar initial conditions for maximizing integrated luminosity

Fermilab Accelerator Complex



Two Collider Experiments
- CDF
- D0

Two neutrino Experiments
- NuMI
- MiniBooNE

120 GeV Fixed Target Experiments

Ongoing program of
- Tevatron,
- $\bar{p}$ source,
- Main Injector, and
- Recycler

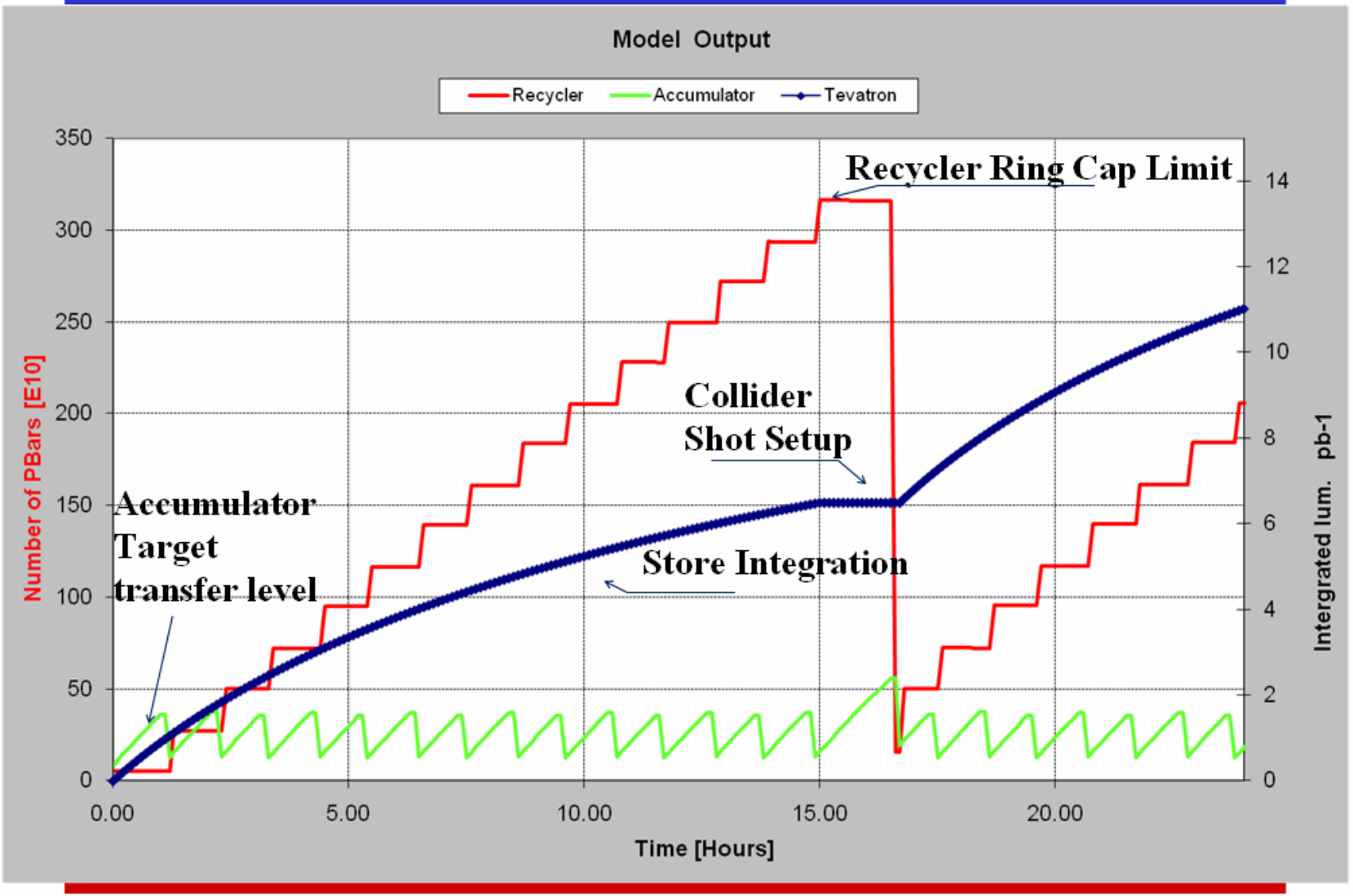
Definitions

- Stack/Stacking
  - The antiprotons are stored in the Accumulator storage ring. Fermilab produces antiprotons by bombarding the Nickel alloy target with protons, collecting the antiprotons into the Accumulator, and then they are stochastically cooled prior to being transferred to the Recycler Ring.
- Store:
  - A collection of Proton and Antiproton that are brought to in collisions in the Tevatron.
- HEP Shot Setup:
  - The Process of loading a store into the Tevatron
- Stash/Stashing
  - The process of accepting antiprotons from the Accumulator and cooling them in preparation for additional transfers, and eventually once the stash is large enough to begin HEP shot setup
- Pbar Transfers:
  - The act of transfer of Antiprotons from the Accumulator to the Recycler.

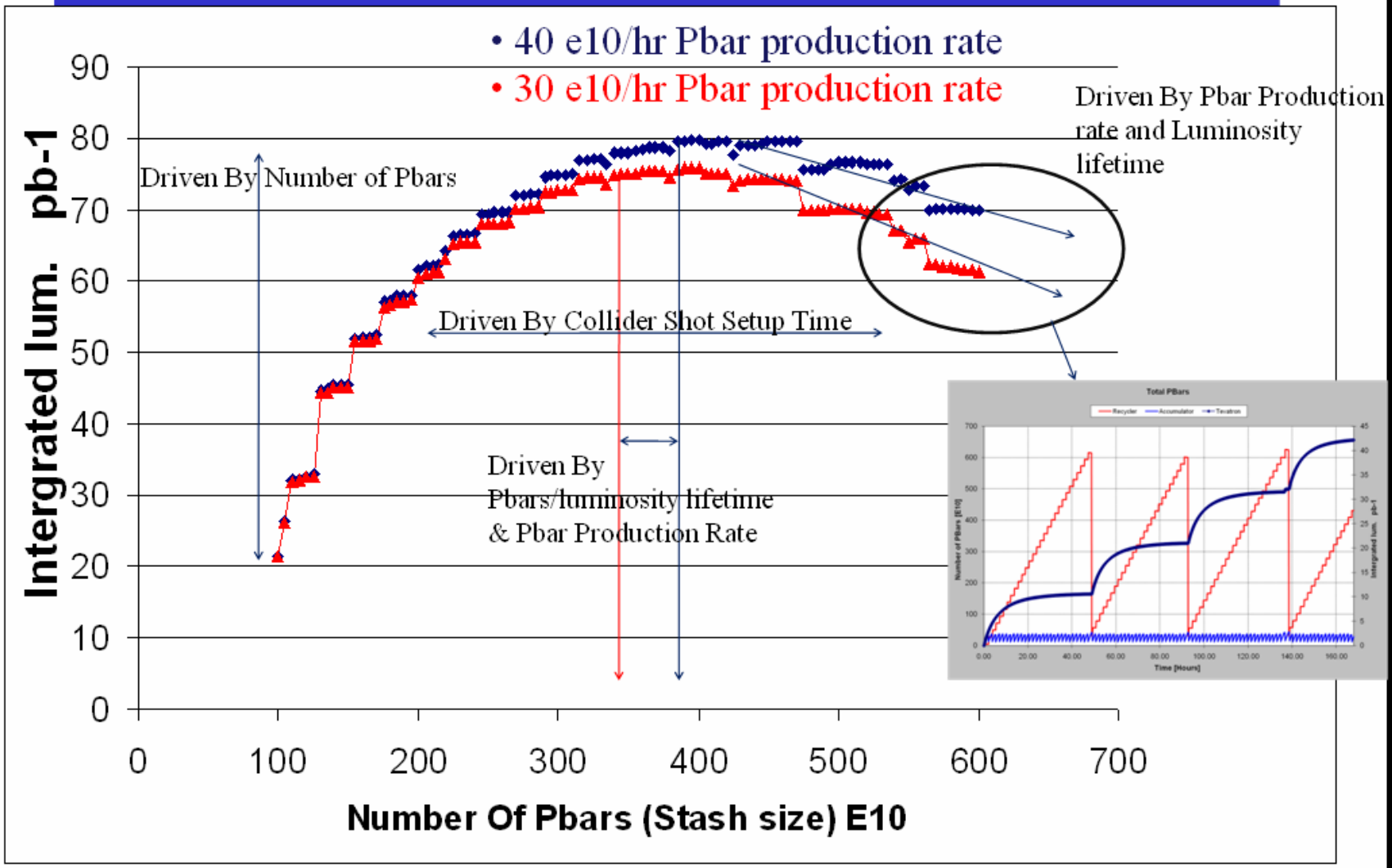
Model Assumptions /Parameters

- Proton Parameters are kept fixed (small leverage)
  - Proton Beam conditions are reproducible
    - Intensity ~320 E9 per bunch
    - Emittances ~16-17 π mm-mr @ 8 GeV
- Luminosity Parameters
  - Using historic data to obtain
    - Initial Luminosity dependence on the number of Pbars
    - Typical luminosity lifetime behavior
- Pbar Parameters
  - Effective Production Rate
    - Stacking rate
    - Transfer Efficiency
    - Lifetimes in Both Recycler and Accumulator
  - Interruption to stacking
    - Shot Setup Transfer Times (interruption to Pbar production)
    - Down Time (typically not used)
  - Tevatron Transfer Efficiency

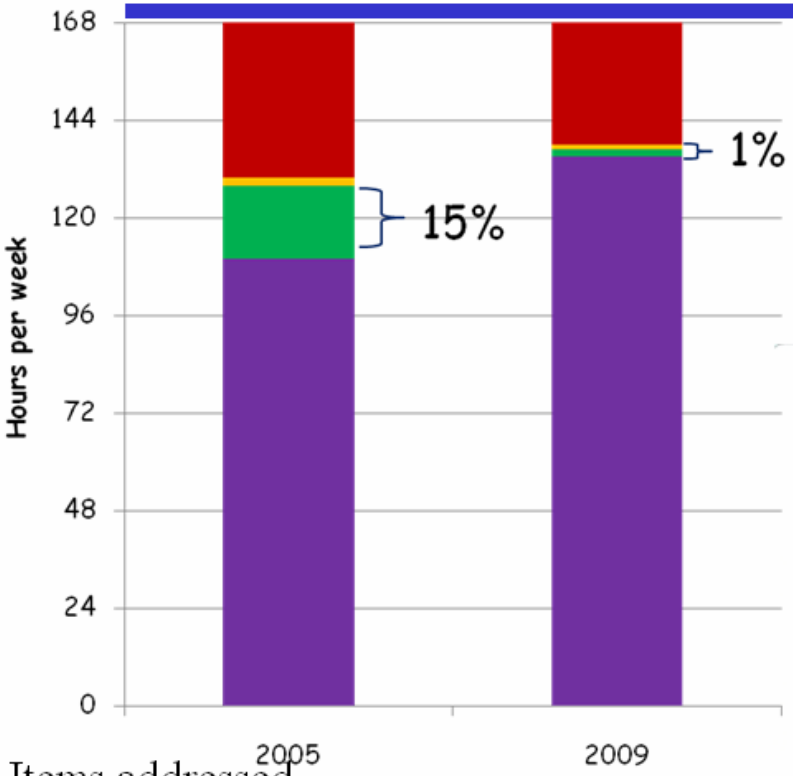
Modeled Production



Response of the model



Maximizing Pbar Production



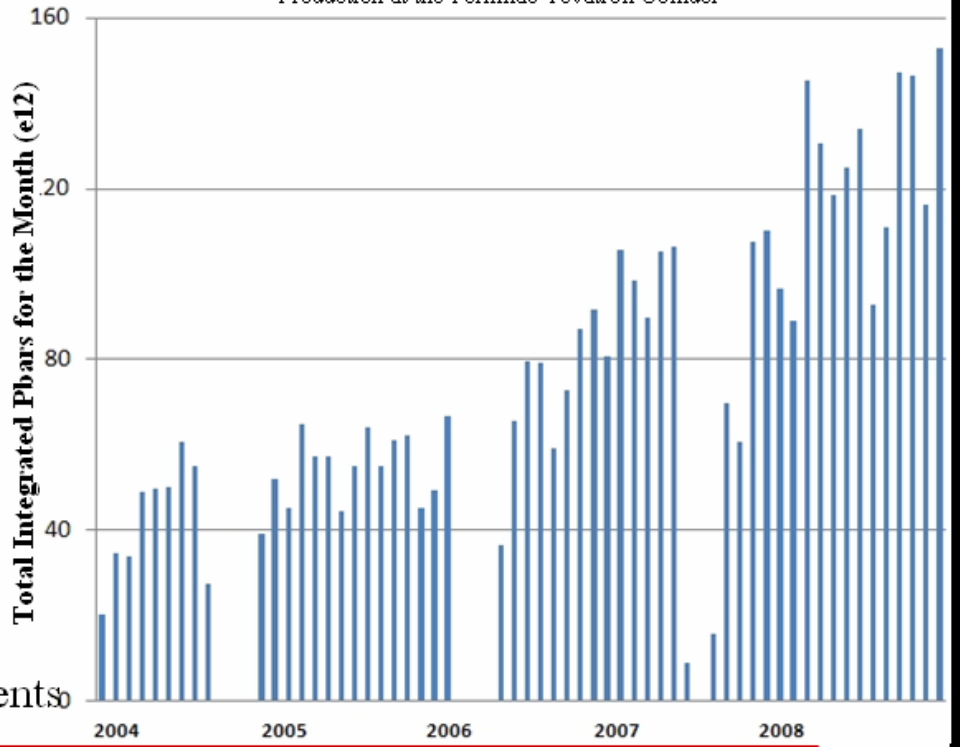
Downtime Hours
Study Hours
Set-up Hours
Stacking Hours

Detailed explanation of improvements to the Fermilab Antiproton Source:

TU6PFP075, "Progress in Antiproton Production at the Fermilab Tevatron Collider "(

TU6RFP032, "Improvements to Antiproton Accumulator to Recycler Transfers at the Fermilab Tevatron Collider "

FR5REP030, "Operating Procedure Changes to Improve Antiproton Production at the Fermilab Tevatron Collider "

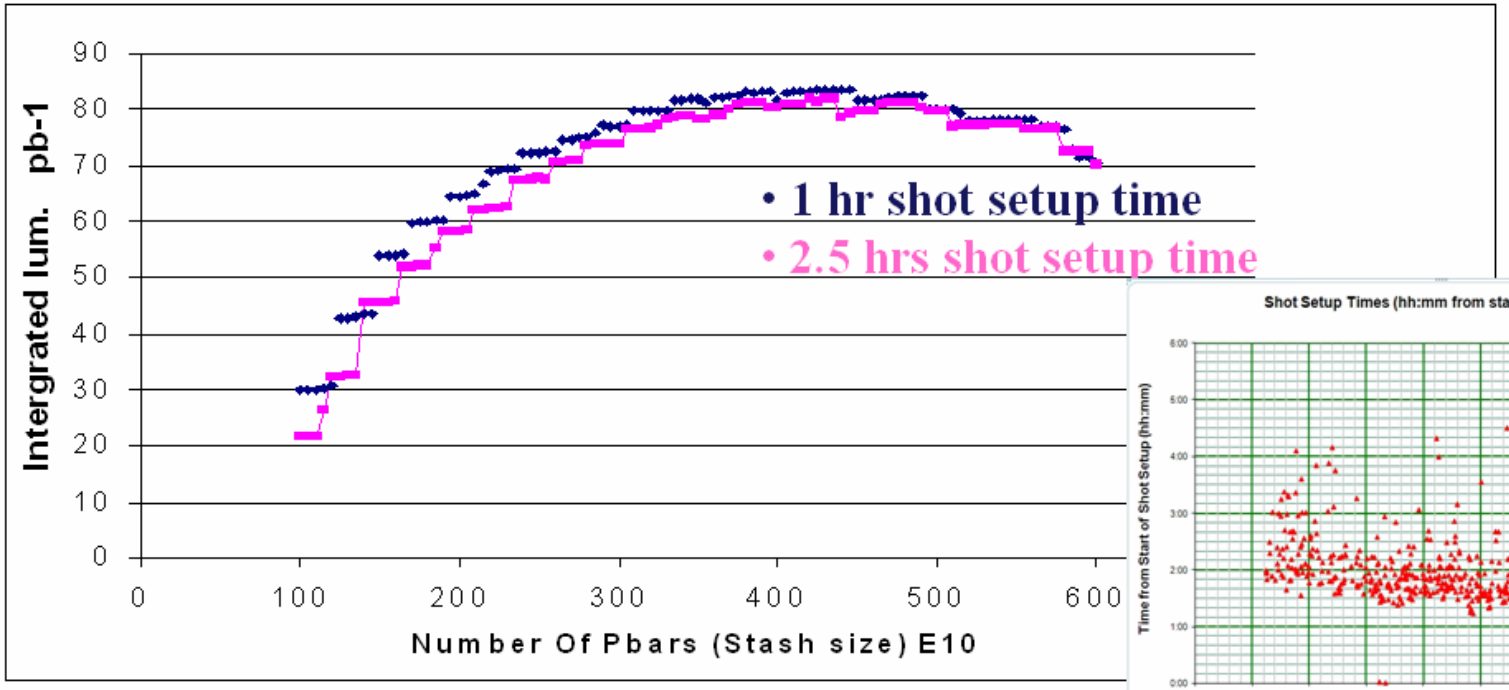


Items addressed

- Reduced Shot setup time (beam transf time)
- Optimize number of stacking cycles
- Increased Proton on Target

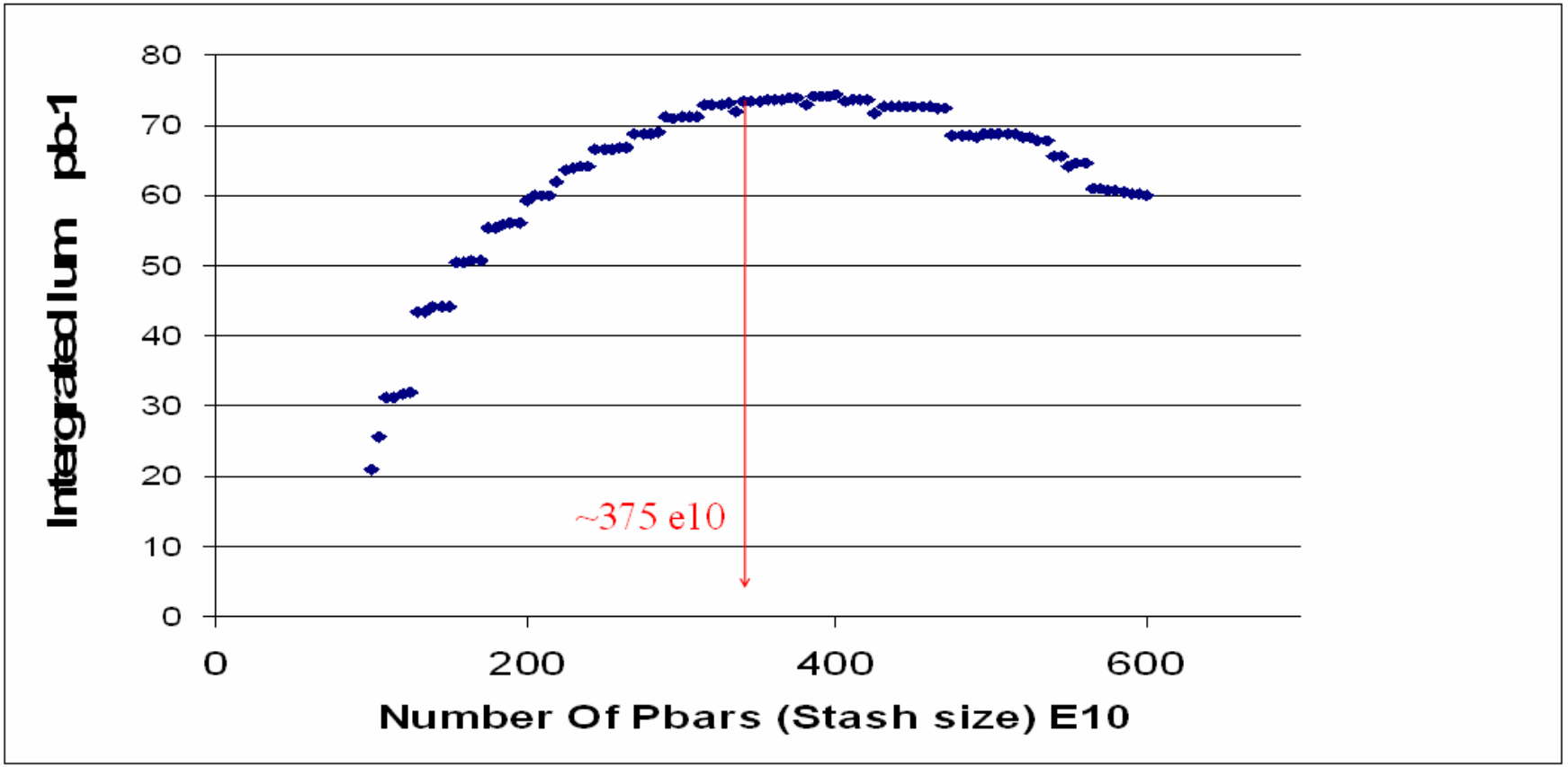
Along with a long list of machine improvements

Optimizing Tevatron Shot Setup Length

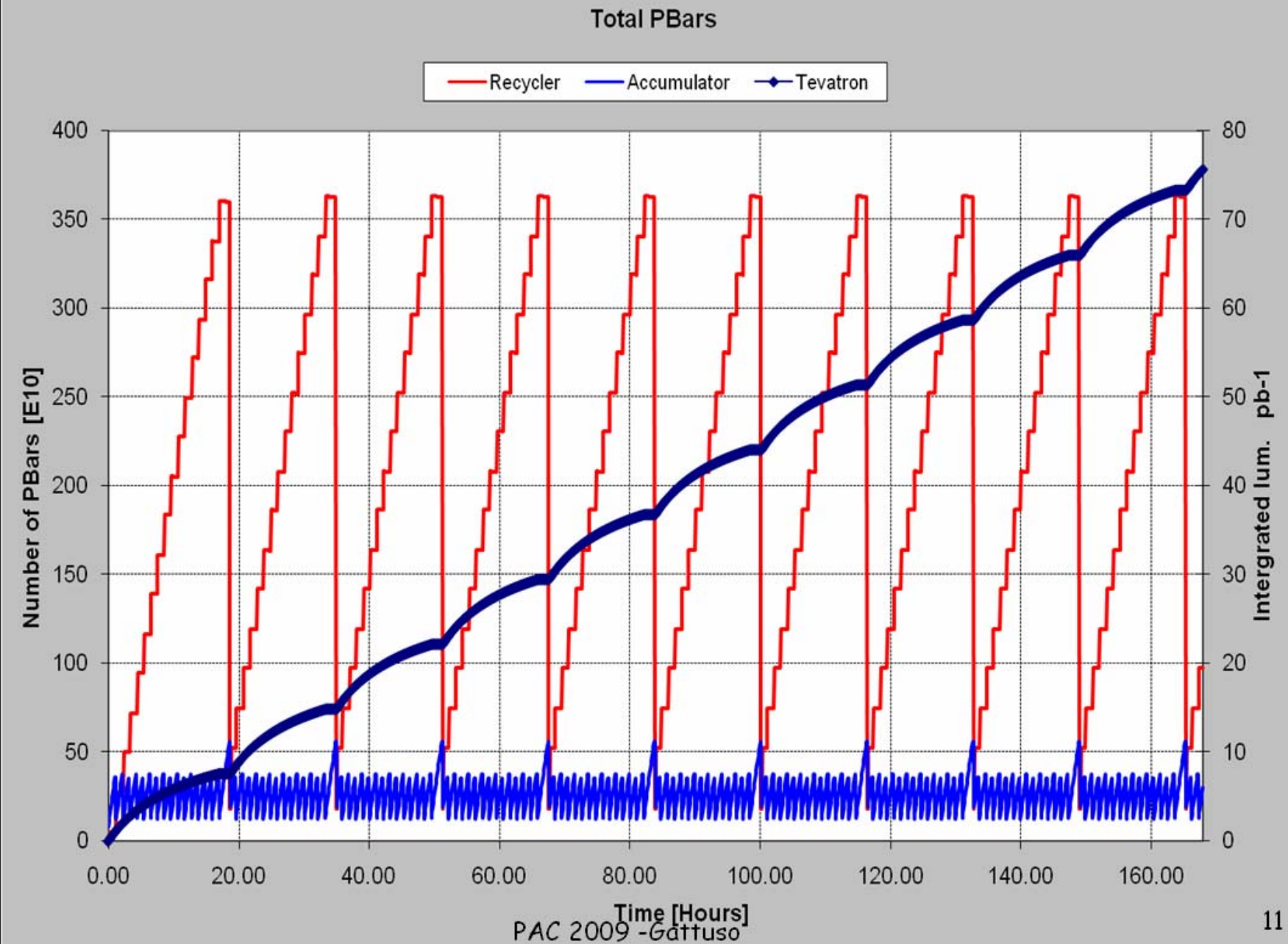


- By shortening the shot setup time, greatest improvement when shooting from a smaller Stash.
- Collider Shot Setup Time has been Reduced from 2.5 to 1 hour.

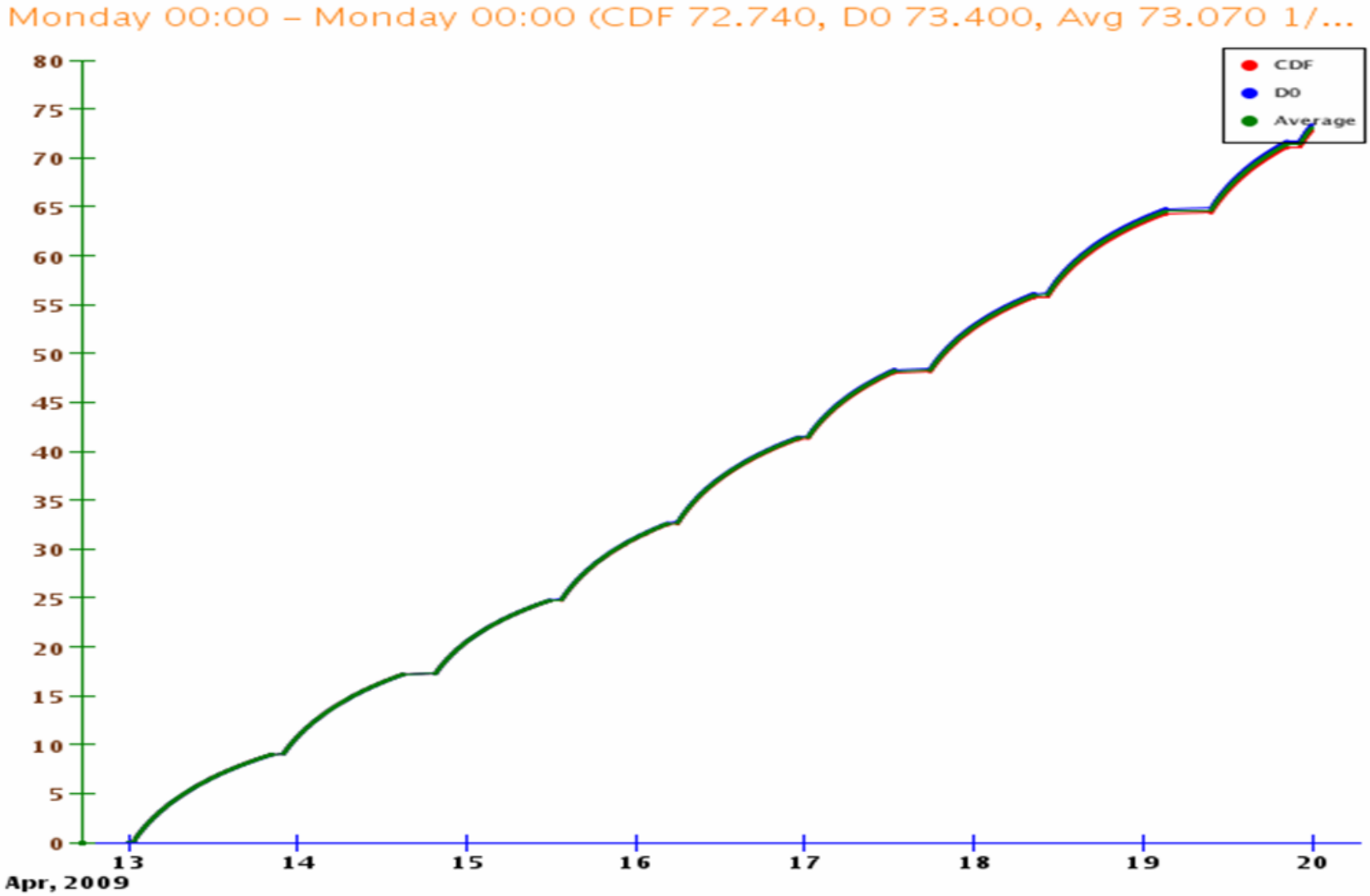
For a Pbar Production Rate of 30 e10/hr



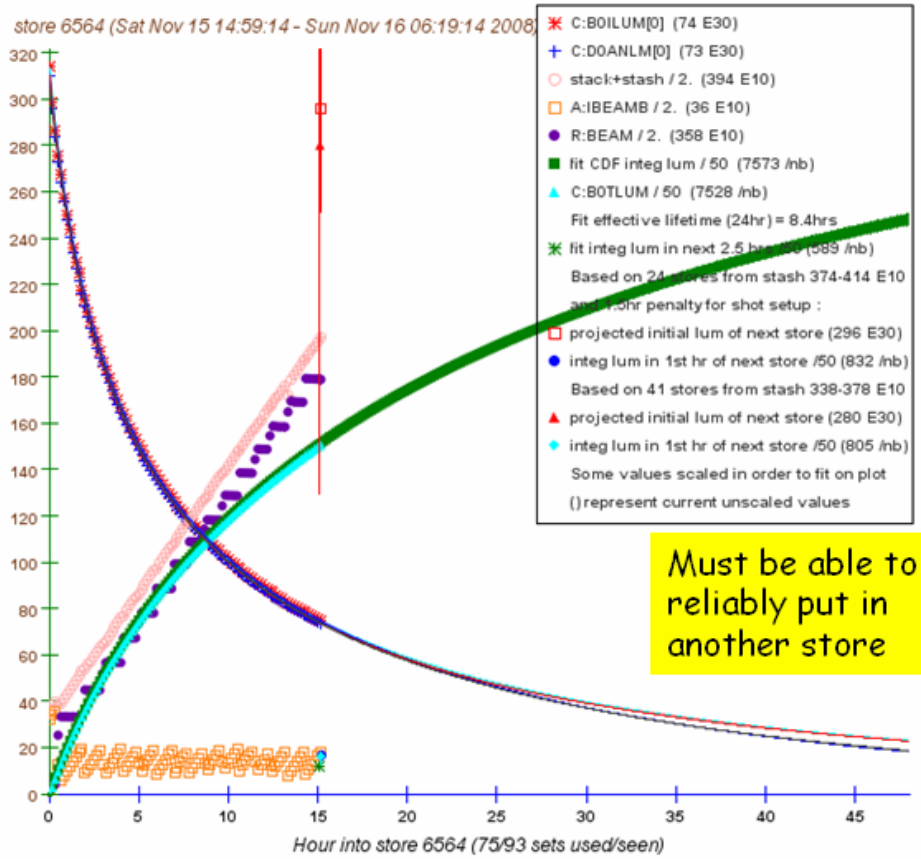
- Collider Shot setup = 1.5 hours
- Gives Target Stash:375 e10


Total PBars
Recycler
Accumulator
Tevatron
Number of PBars [E10]
Intergrated lum. pb-1
Time [Hours]
0
50
100
150
200
250
300
350
400
0
10
20
30
40
50
60
70
80
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00

"Perfect" week
April 13th-20th 2009



Tool used for Daily Decision Making



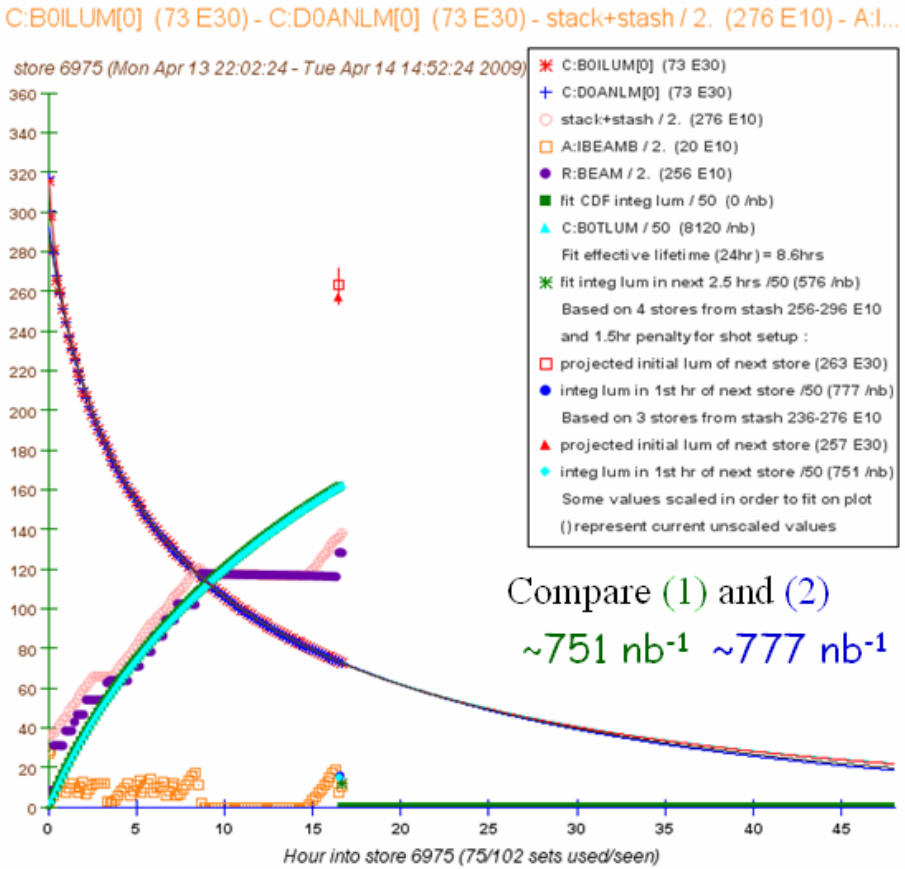
- Fit luminosity decay of current store
- Predict integrated luminosity of next 2.5 hours of current store (1)
- Predict initial luminosity of new store from current stash based on historical data
- Predict integrated luminosity in first hour of new store (1.5 hrs shot setup) based on historical data (2)
- Compare (1) and (2)

Must be able to reliably put in another store

~600 nb^{-1} ~800 nb^{-1}

- When we reach the optimal target stash size based on the model, this tool confirms that we will be integrating more by terminating the existing store and putting in a new one
- Also use this tool when significant stacking downtime

Tool used for Daily Decision Making



Compare (1) and (2)

~751 nb^{-1} ~777 nb^{-1}

- Fit luminosity decay of current store
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Conclusion

- Tools are in place for
  - Weekly optimization of Integrated Luminosity
  - Store by Store Operational Decisions
- Gives us insight as to what areas to attack to improve integrated luminosity
- Directs our response to interruptions of our standard operating conditions
- As improvements have been made to the complex the Model parameters are revisited to insure that we are optimized.