Status of the Accelerator Complex

Ioanis Kourbanis
Main Injector Department
Fermilab Users' Meeting
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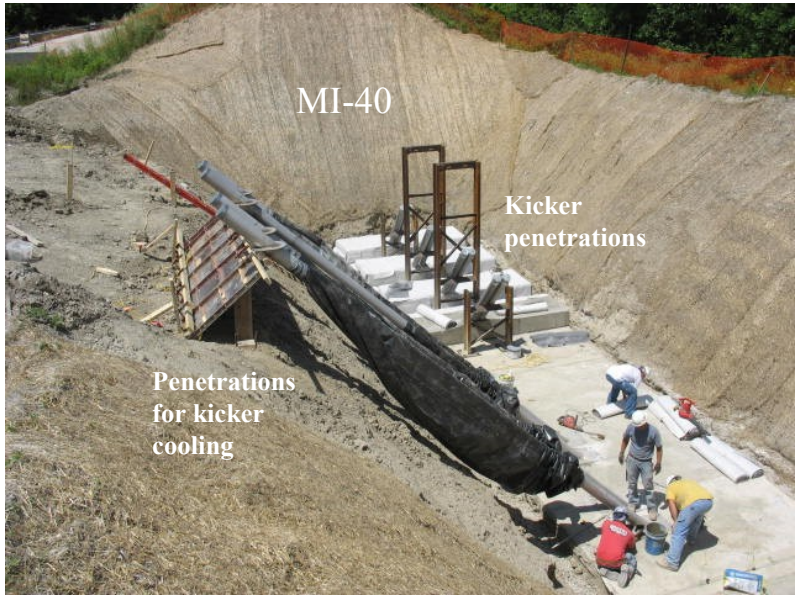
Overview

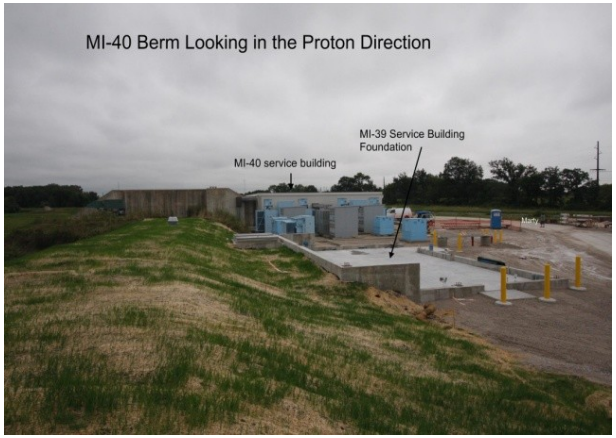
- Summer 09 shutdown.
- Proton Source performance and Issues.
- Main Injector high power operation and NuMI.
- Collider Run Plan and Performance.

Summer 09 shutdown

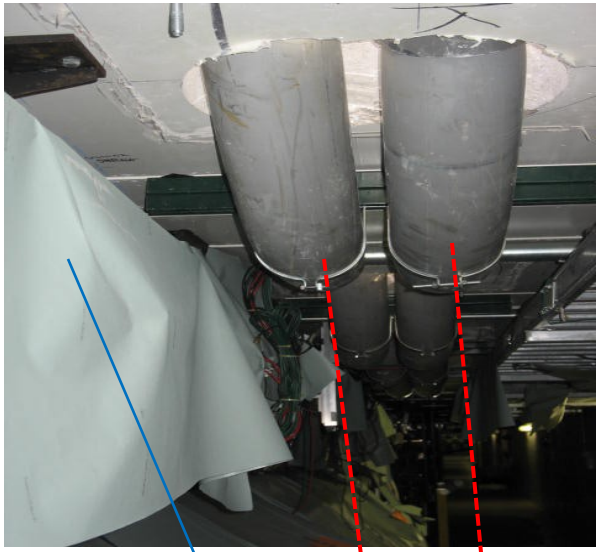
- Successfully completed a 12 week summer shutdown.
- Removed the berm at two MI locations (MI-10, MI-40) in order to install penetrations required for NOvA running.
  - Seven gap clearing kickers were installed in MI that can become operation al after this coming shutdown.
- The rest of the Booster corrector magnets were installed.
- Extensive TeV repairs were performed.
  - 8 housed were warmed at room temperature to fix vacuum leaks
  - 88 TeV magnets were unrolled or moved.
- Pbar fixed a couple of magnets and installed new 4-8GHz kickers in the Accumulator.
- NuMI fixed horn 2 water leak, replaced target and the hadron monitor.

MI Penetrations





MI Tunnel Penetrations



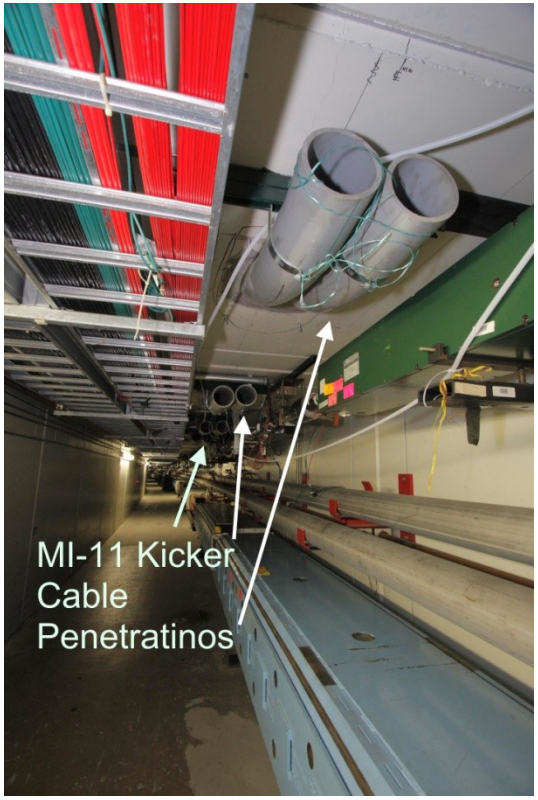
Recycler magnets

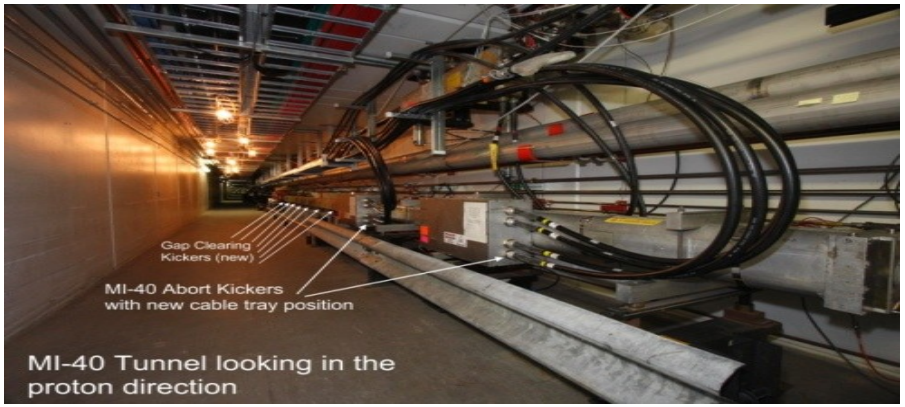
MI penetrations

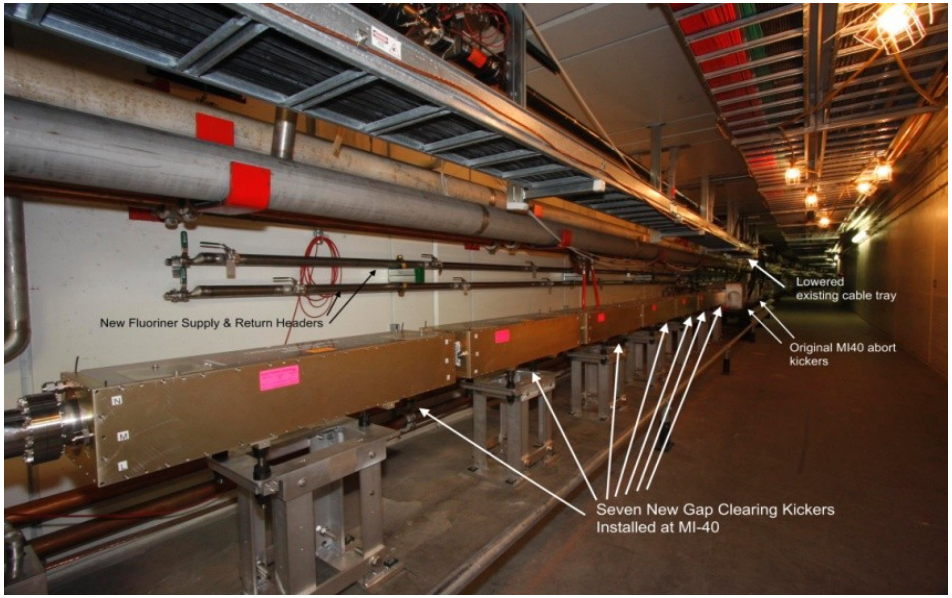
Recycler

MI Magnets at MI-10 covered with lead blankets for personnel protection

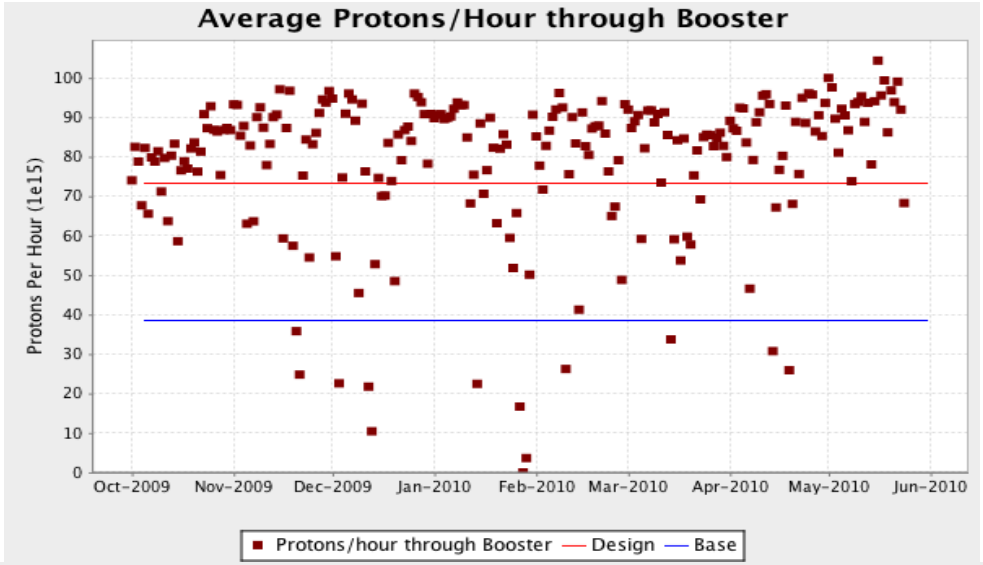
MI-40 Gap Clearing Kickers

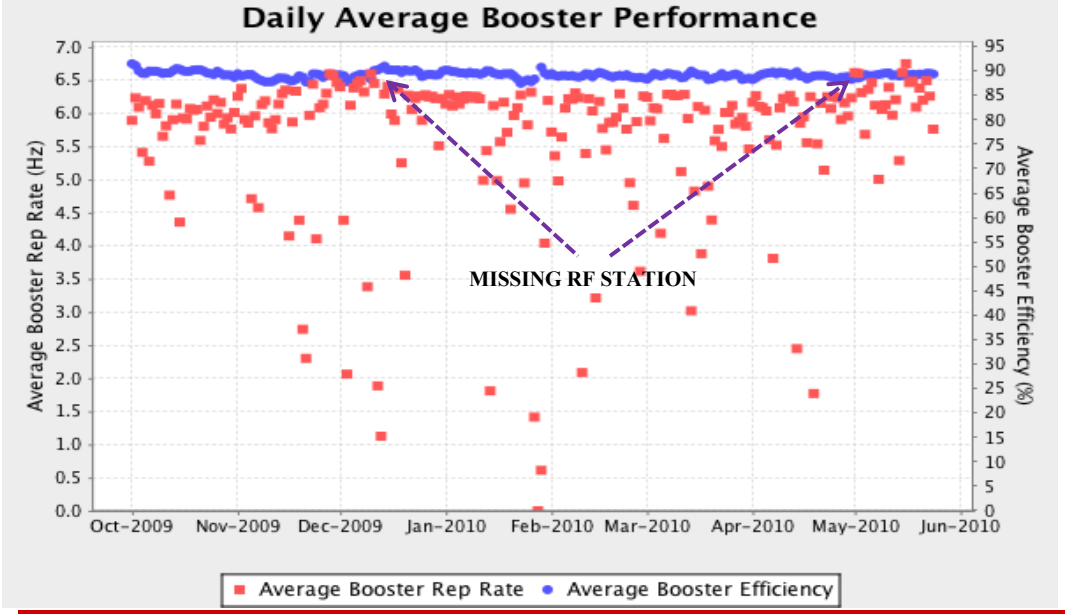






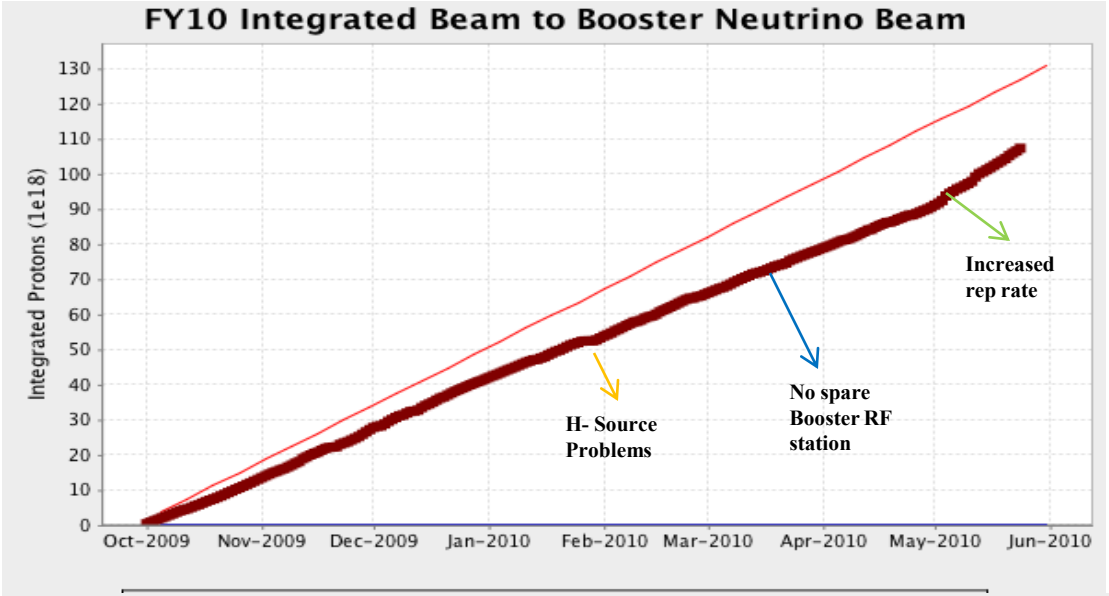
Proton Source Performance

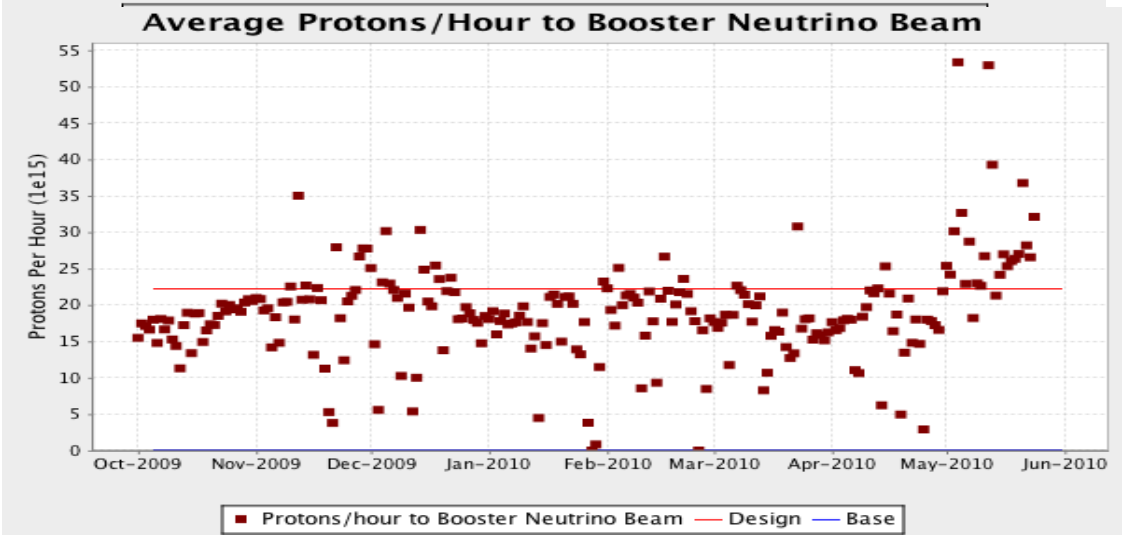




- For pbar stacking and NuMI we need 5Hz and 7.7E16 P/h.
- RF and beam losses is limiting the rep rate and the total protons per hour.
- Had to reduce the rep rate while running without spare rf station.
- Problems with the proton source affected both the protons per hour and the beam quality out of Booster.
- We have started to see the effect of the Booster correctors.
  - More stable conditions for tuning
  - Better working point
- For NOvA we will need 9Hz rep rate and 1.4E7P/h.

Booster Neutrino Beam

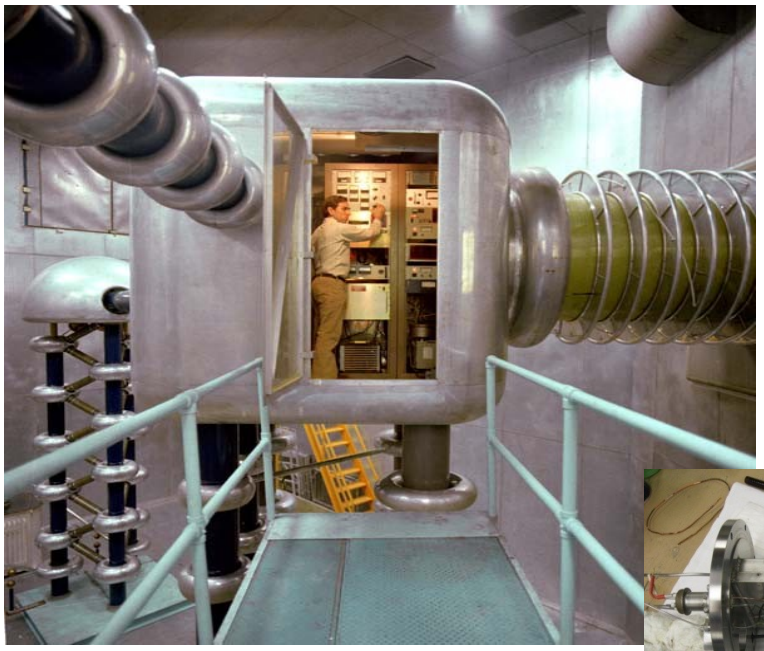


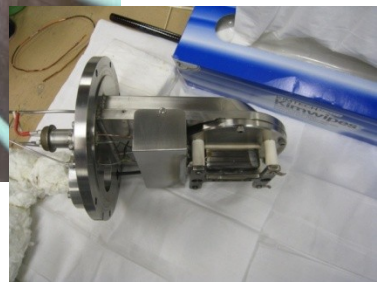


Fermilab Pre-Injectors

I-

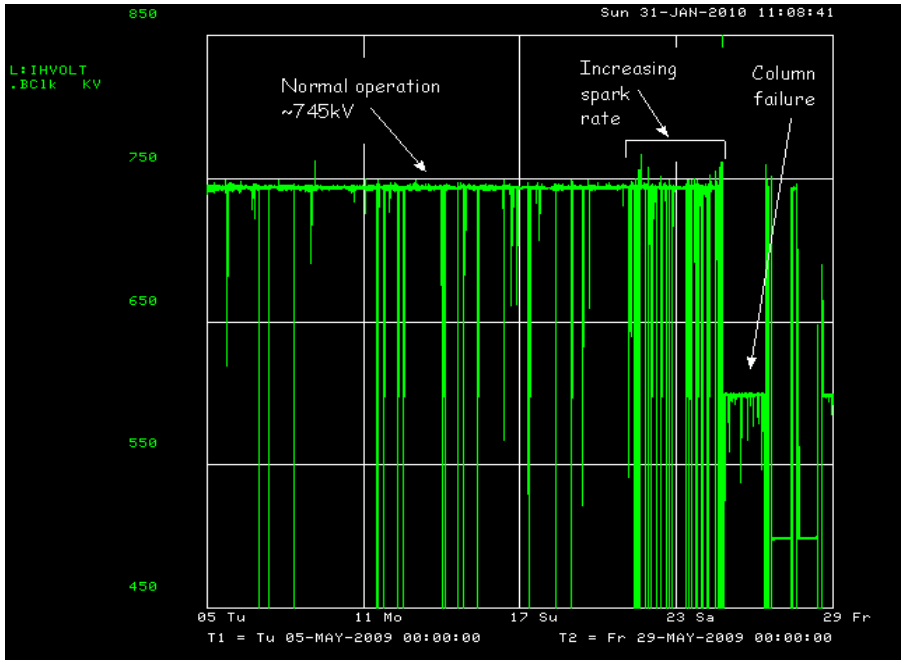
H-

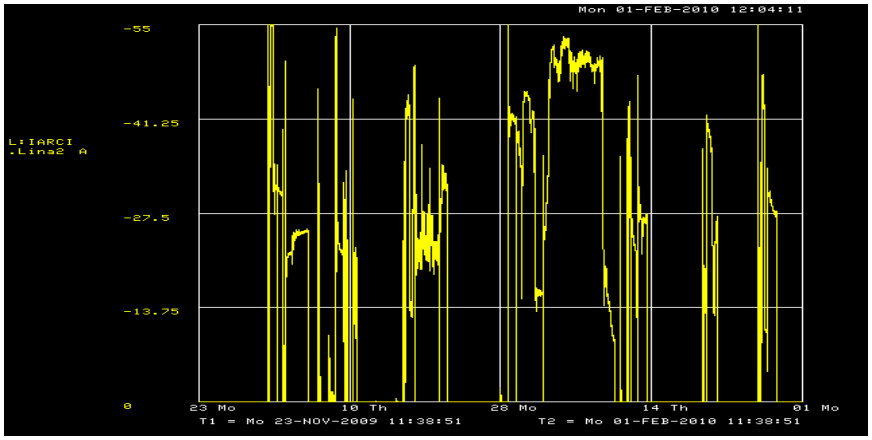


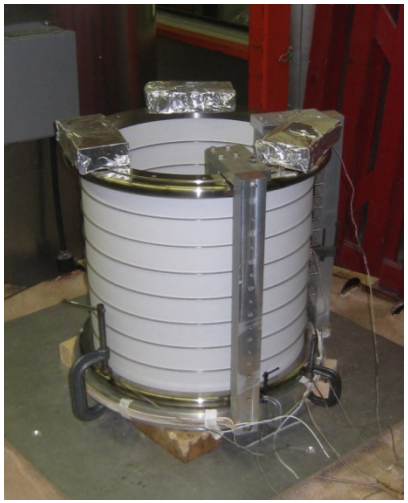


- Two Cockroft-Walton pre-injectors each with a magnetron H- source.
- Only one source and one Cockcroft-Walton operational at any one time.
- We have been operating with one pre-Injector for almost a year.

I- Source Problems

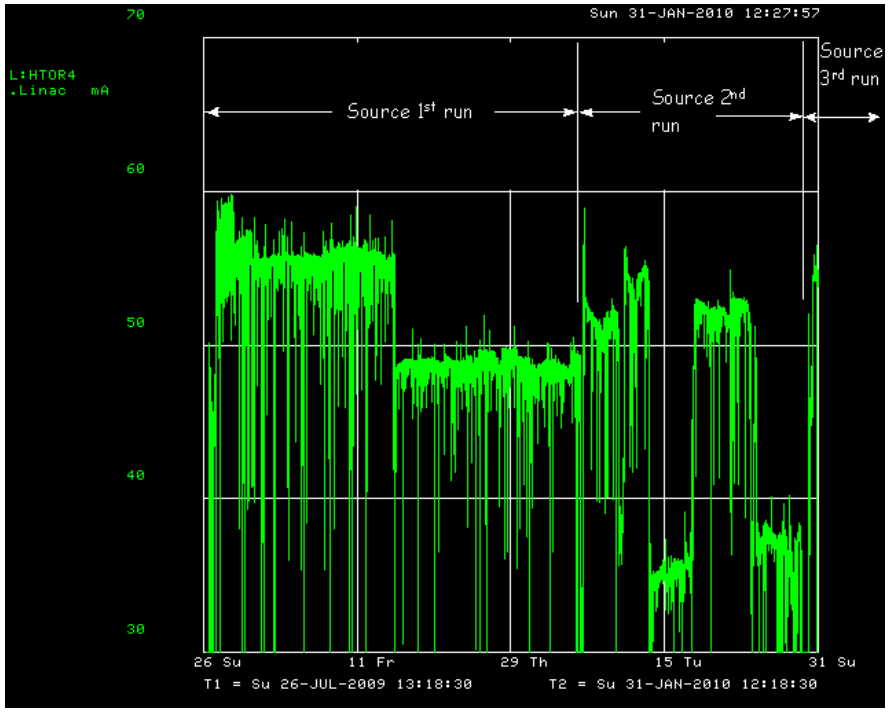


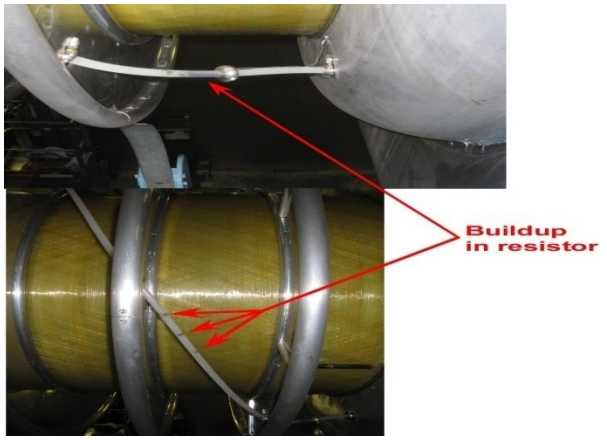




- Had to build a new accelerating column.
- Problems with die off of sources after that.
- Spend almost a year without it.
- It now up and running (run with it the last 21/2 months)

H- Source Problems

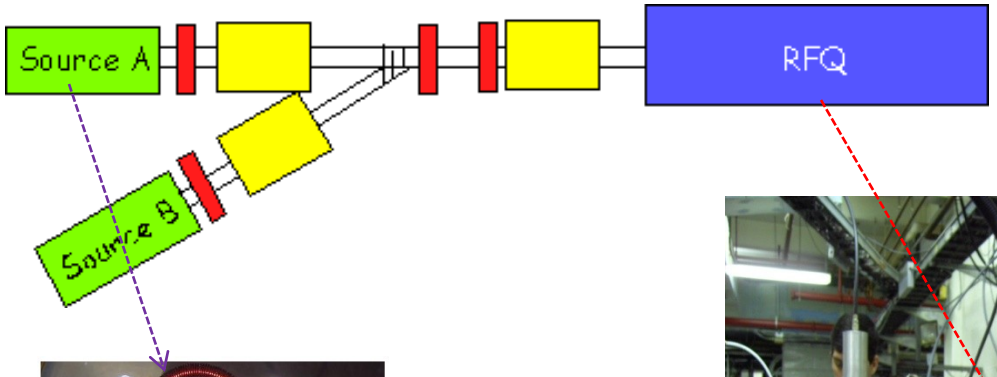


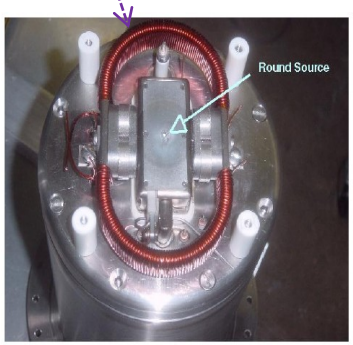


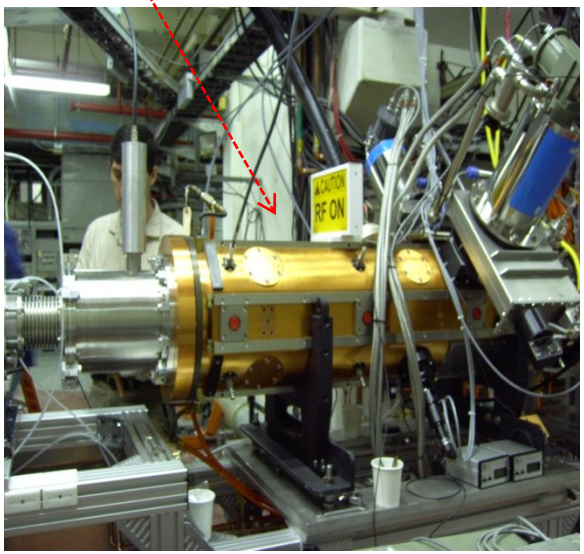
- H- source has been un-stable since start-up
- The source has been taken out and rebuilt twice.
- The ion pump has been replaced
- Improved regulation
- It is running better since March

Future Source

- Replace the Cockcroft-Walton with a 200MHz RFQ.
- Replace the present magnetron source with a new one with a circular aperture.
- Similar to the BNL current per-accelerator

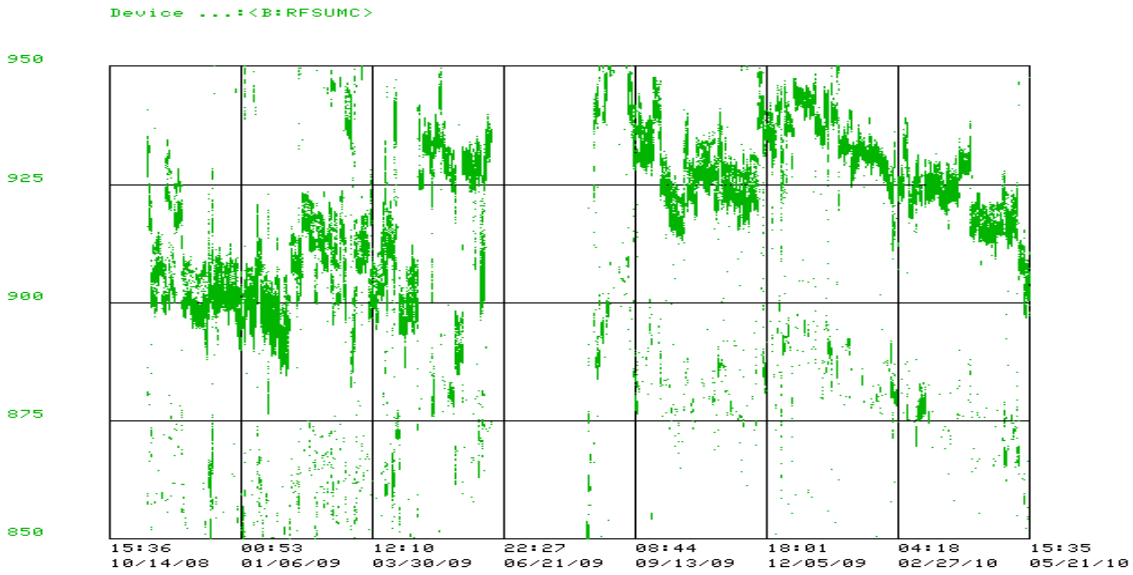






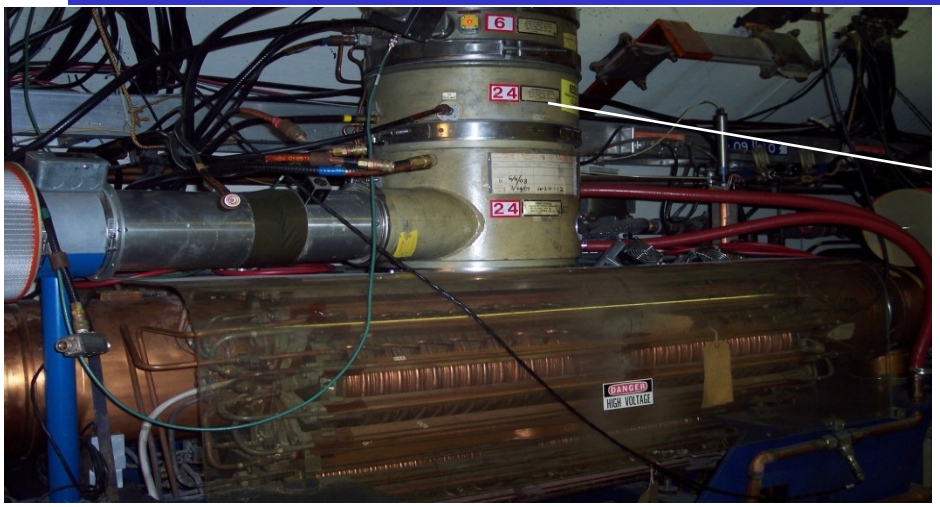
Booster RF

- Booster is currently RF limited.
- We are still using the original Booster cavities.
- Currently we have one of the spare RF cavities installed in the tunnel as a "hot spare" (cavity 19).
- A ceramic leak on cavity 19 forced us to have no "hot spare" for almost 3 months.
- We are working on improving the reliability of the Booster RF cavities with the Solid State Upgrade.

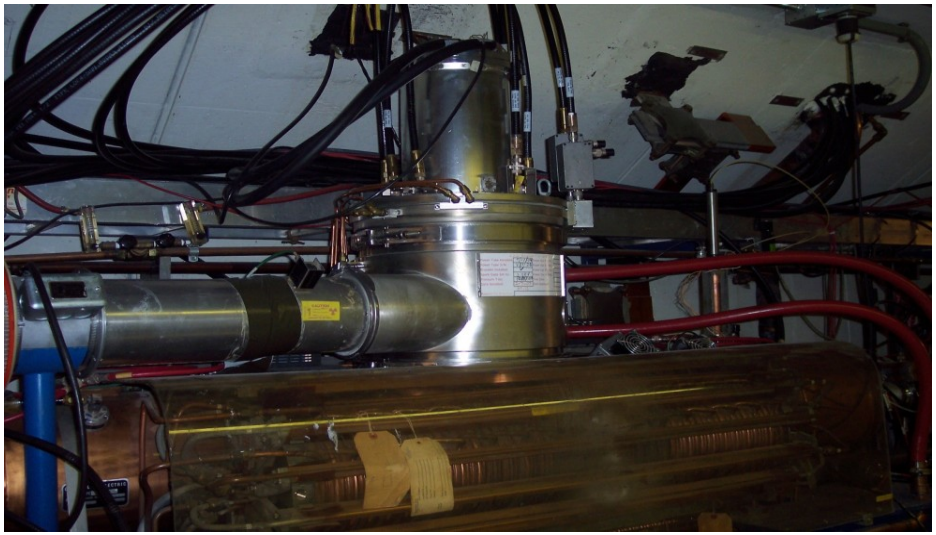


•History of the Booster rf voltage. The voltage varies depending how many rf stations are ON.

Booster RF Cavities

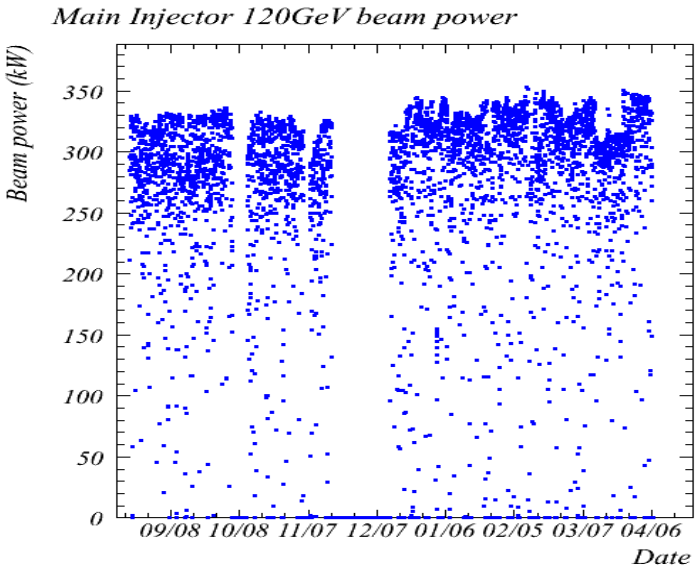


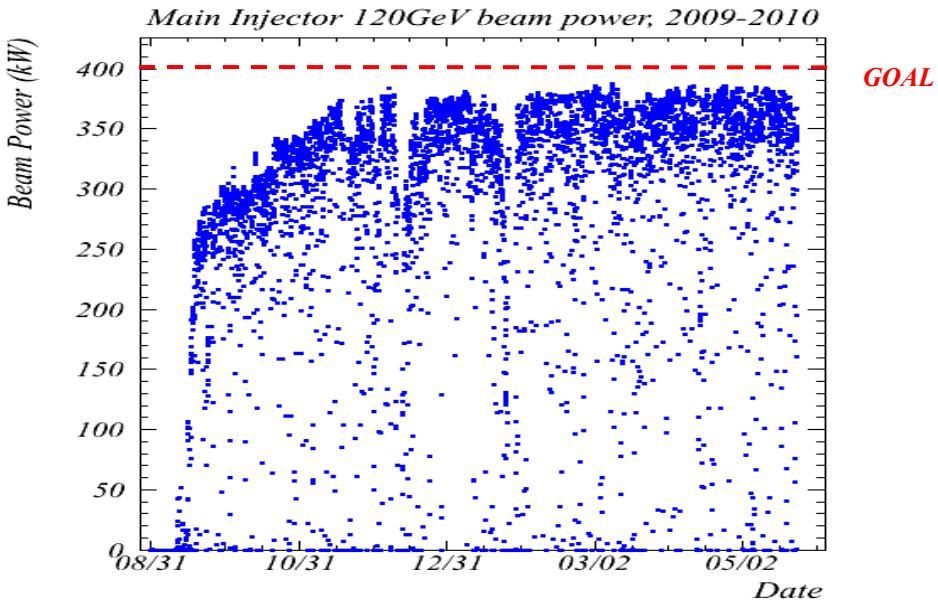
•Original Booster rf station. The whole driver section of the final tetrode is in the tunnel. It includes 14 parallel connected tetrodes with water cooling.



•Booster rf station with Solid State Upgrade. Only the final power tube is in the tunnel.
•Plan to upgrade the rest of the 16 Booster stations.

MI Beam Power

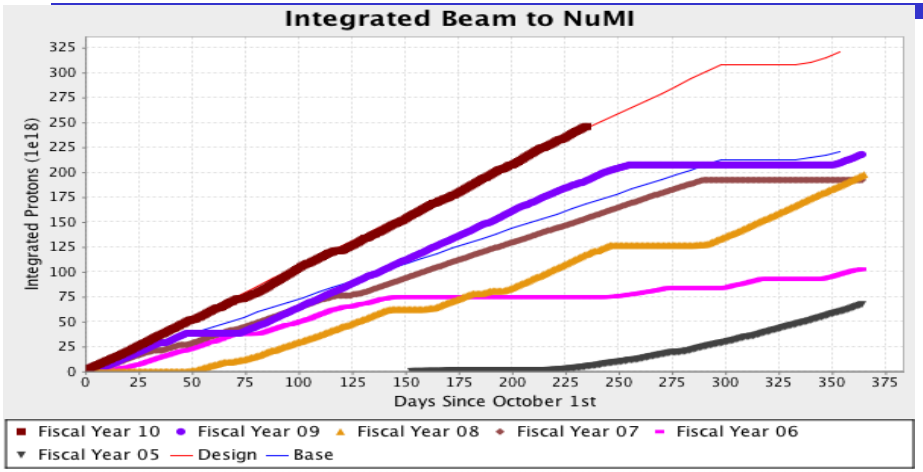




MI Beam Power from 08/2008-04/09

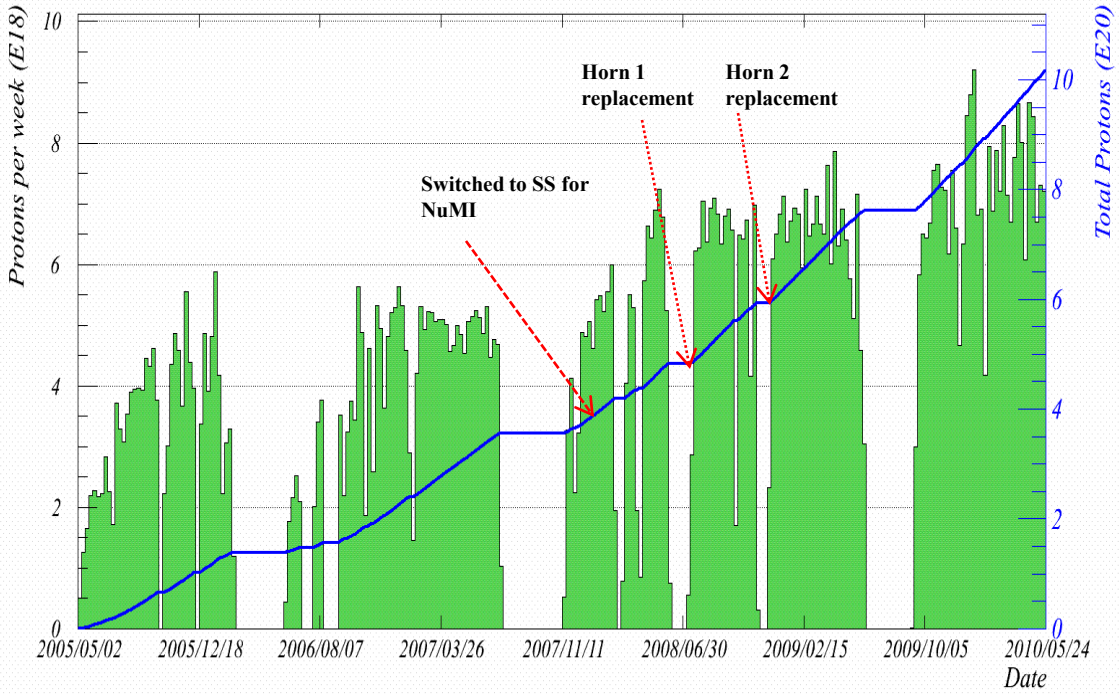
- **We have achieved 95% of the design MI power at 120 GeV.**
- **Losses in MI are currently preventing us of achieving 400KW.**
- **To address the losses we need the clearing gap kickers to become operational.**
- **MI uptime is 95%.**
- **RF Cavity water leaks are a source of concern.**

Beam to NuMI



- Have delivered more that 2.2E20 protons this year and more than 1E21P so far!
- No component failures in the NuMI beam line and better MI performance.

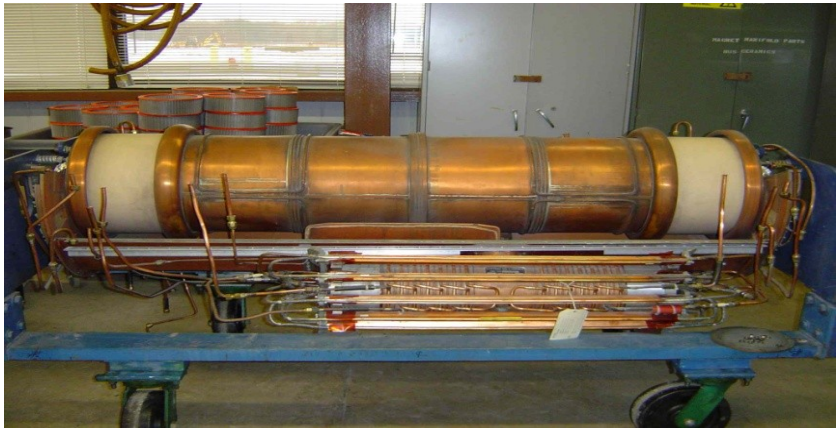
Total NuMI protons to 00:00 Monday 24 May 2010



MI RF water leaks

- MI is using the old Main Ring RF cavities.
- The driver section of all the MI cavities has been replaced with solid state drivers (Solid State Upgrade) greatly increasing the reliability.
- Lately we dealing with more and more water leaks in the RF cavities.
- For the first time in MI we had to take a cavity out of the tunnel in order to replace a water leak.
  - One of the spare MI cavities that has been re-furbished for NOvA replaced the leaking cavity.
- We plan to proactively address the cavity cooling problems.
- We are working on a new RF cavity prototype for MI (Project X).

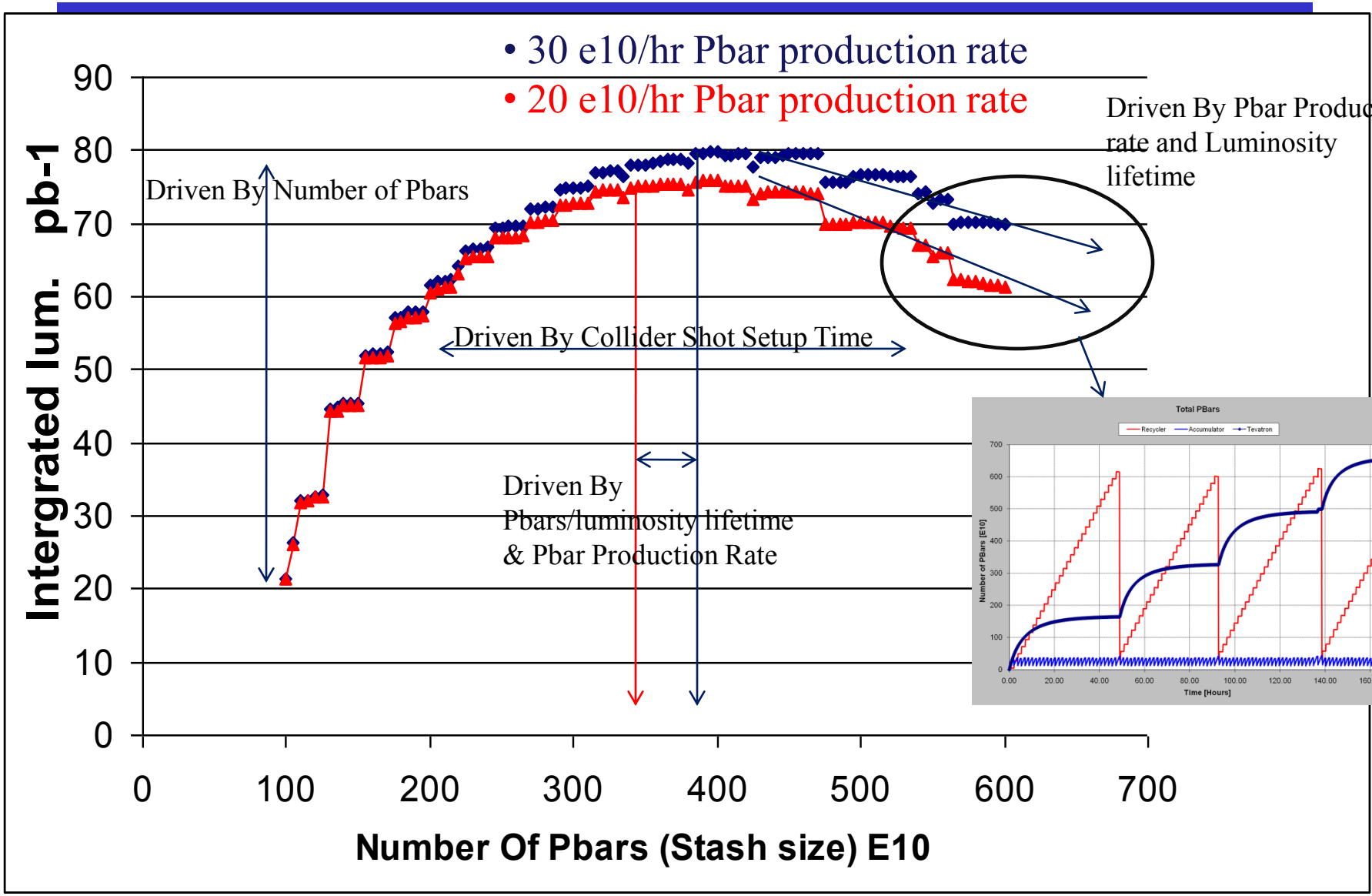
MI RF Cavity water leak



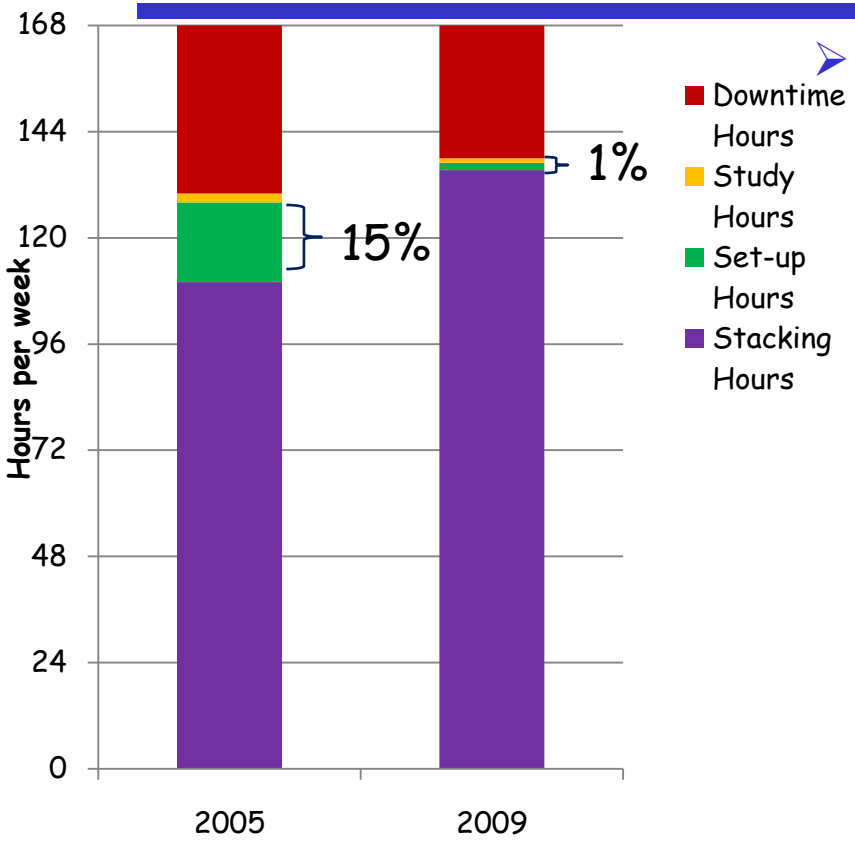
Collider Run Plan

- Emphasis is placed on optimizing Integrated Luminosity.
  - All major upgrades have been completed
  - Complex is more stable, conditions are more reproducible.
- Use operational model based on recent data to model the Accelerator performance and find the optimum Pbar initial conditions for maximizing integrated Luminosity.
- We are working on 3 major improvements
  - Maximize Pbar production
  - Reduction of the time we spend in HEP shot set-up
  - Increase of the proton Brightness

Response of the model



Maximizing Pbar Production

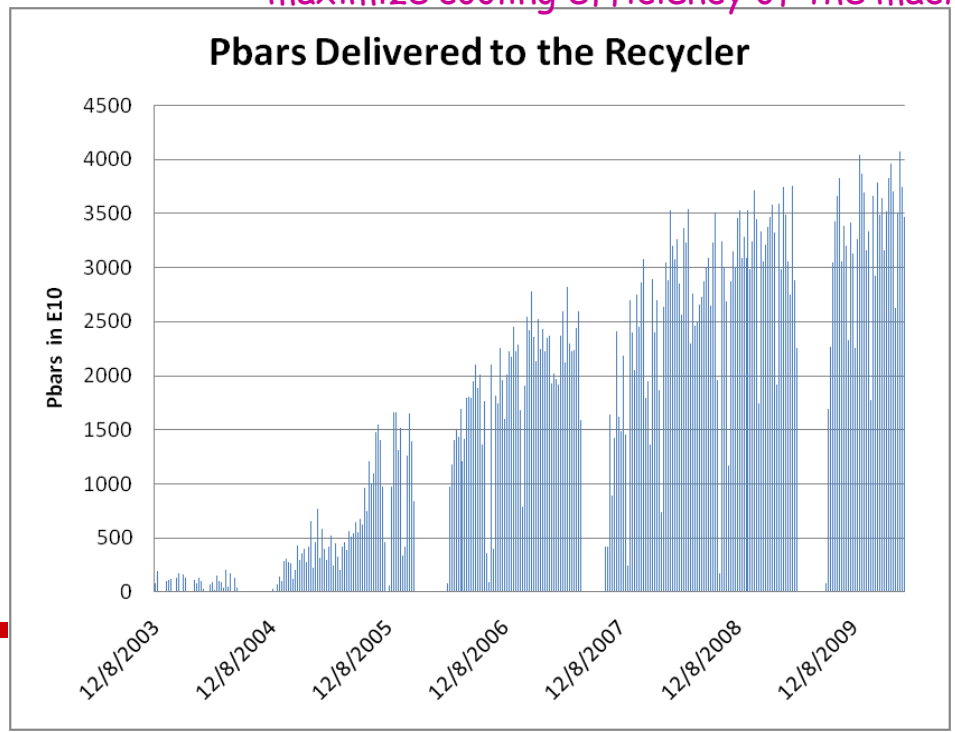


- Maximize Pbar production
  - Shorting Pbar transfer to Recycler (maximizing effective stacking rate)
    - TLG modification
    - Reducing interruption to stacking
      - » Interruption to stack was ~1 hour a 1.5 year ago now it 15 sec
    - Improving Recycler Lifetime
      - » Adjusted the incoming beam parameter to maximize cooling efficiency of the machine

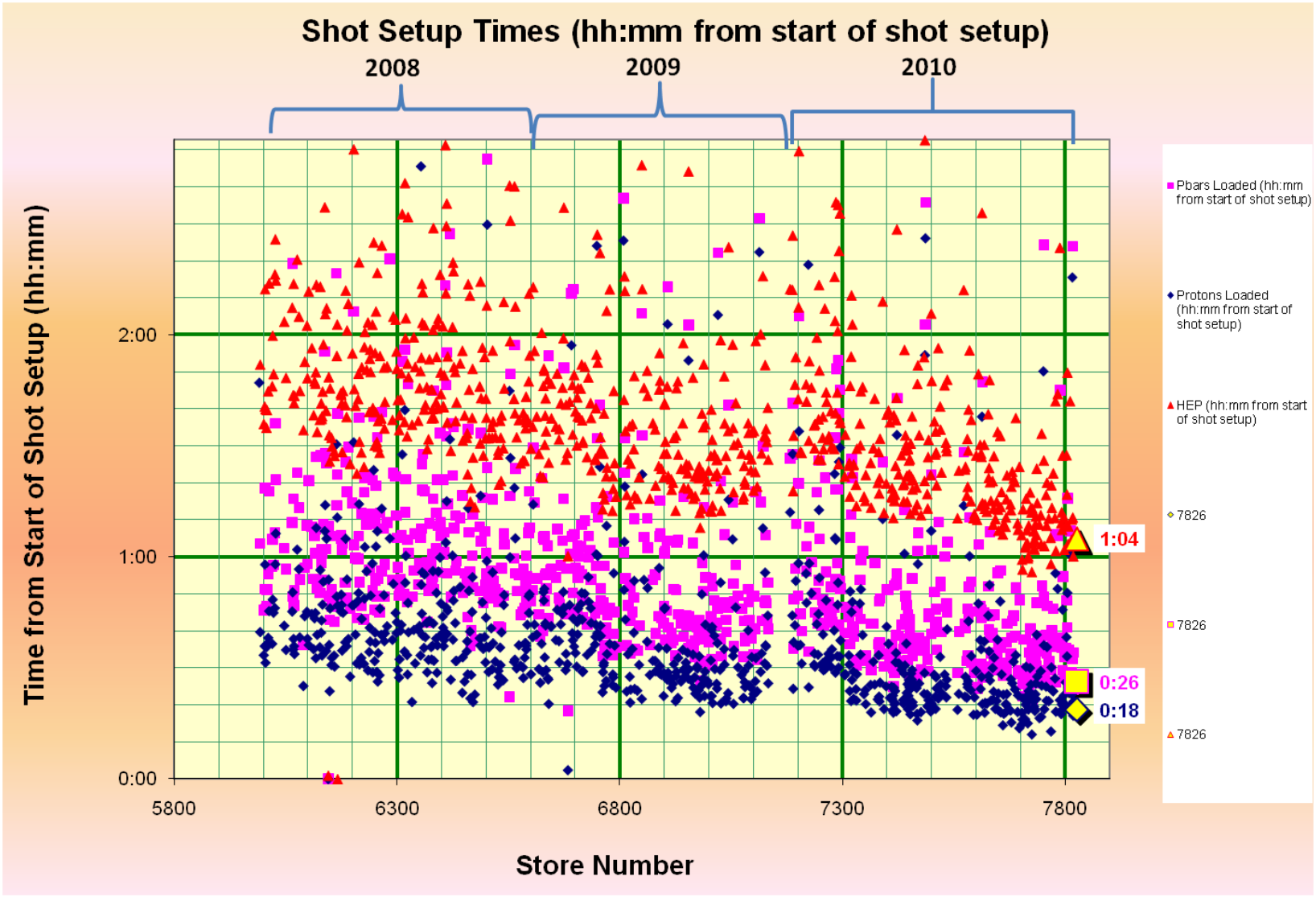
Items addressed

- •Reduced Shot setup time
- •Optimize number of stacking cycles
- •Increased Proton on Target

Along with a long list of machine improvements



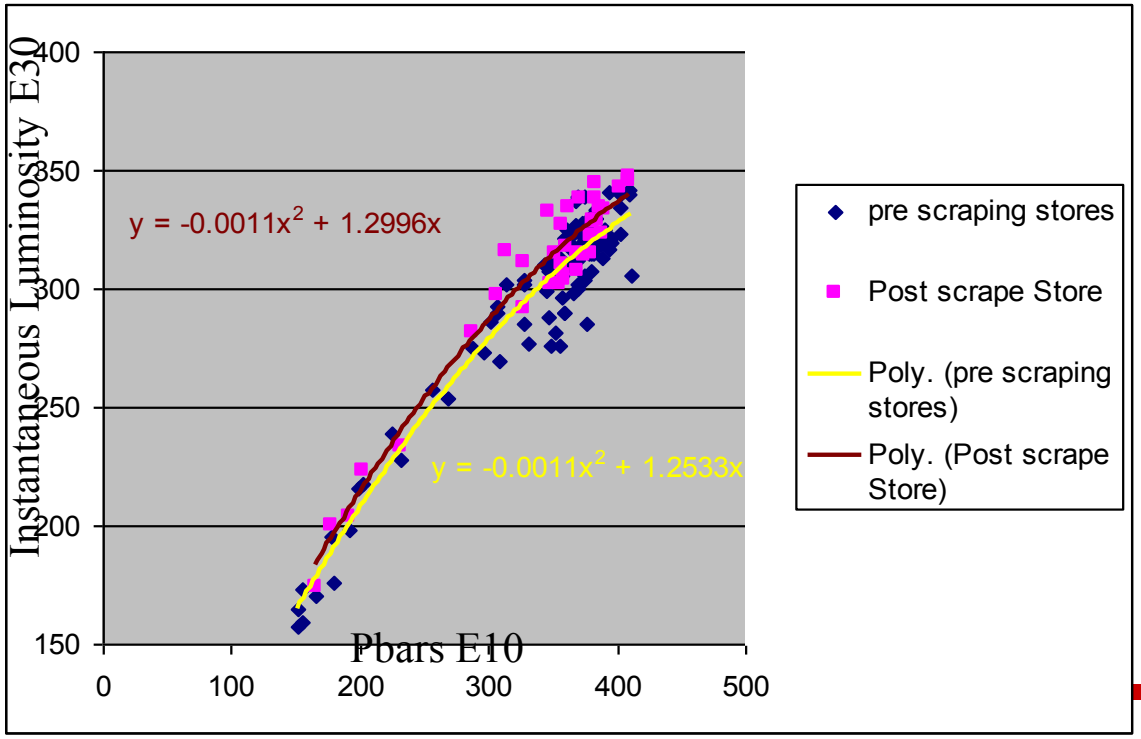
Shot Setup Time Reduction



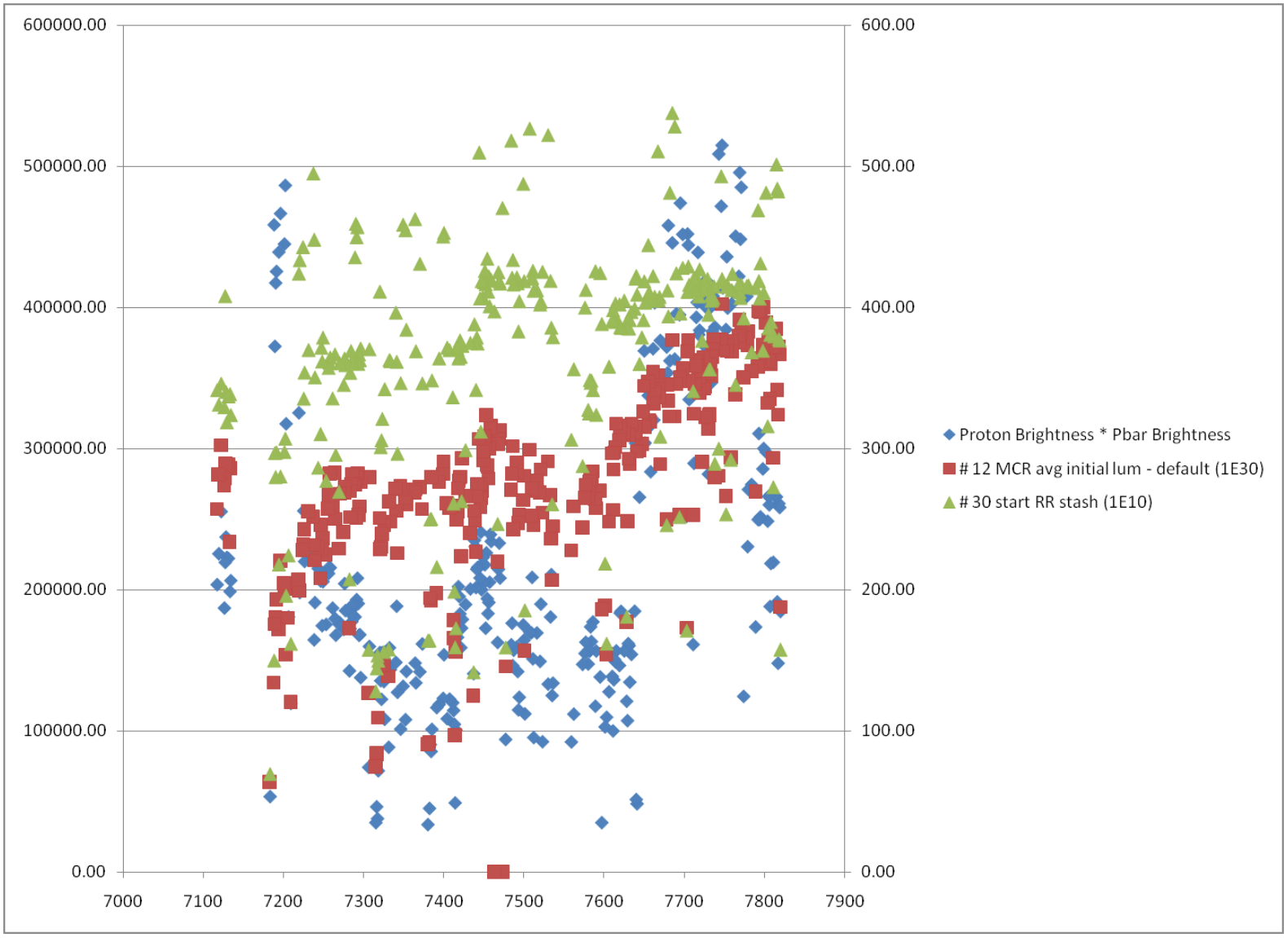
Optimizing Proton Brightness

- Done by scraping the Proton halo in the Main Injector at 8 GeV
- Improved Initial Luminosity ~3-4%
- Transfer/Acceleration efficiency improvement
- Improves Tevatron dynamic aperture of the machine, reduced quenching
- Defined as:

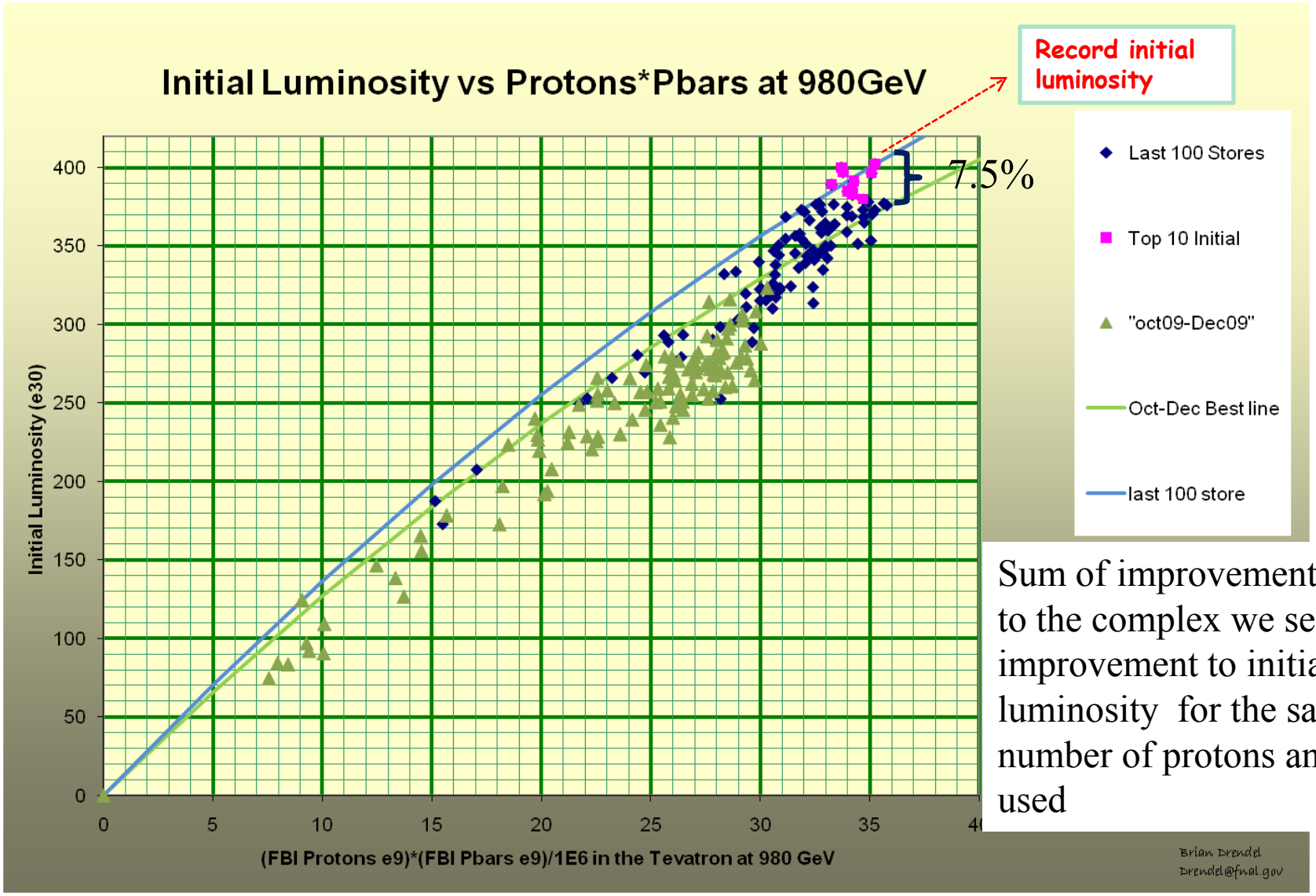
Bunch Intensity/ (Avg. Transverse Emittance X Longitudinal emittance)



Effects of the Source problems



Results to the improvements



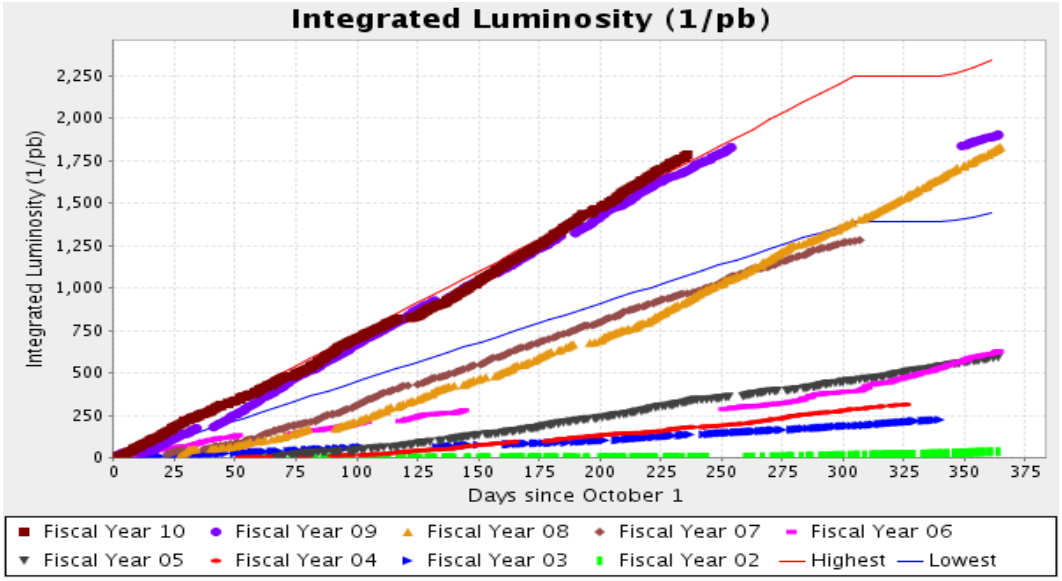
Sum of improvements made to the complex we see 7.5% improvement to initial luminosity for the same number of protons and pbars used

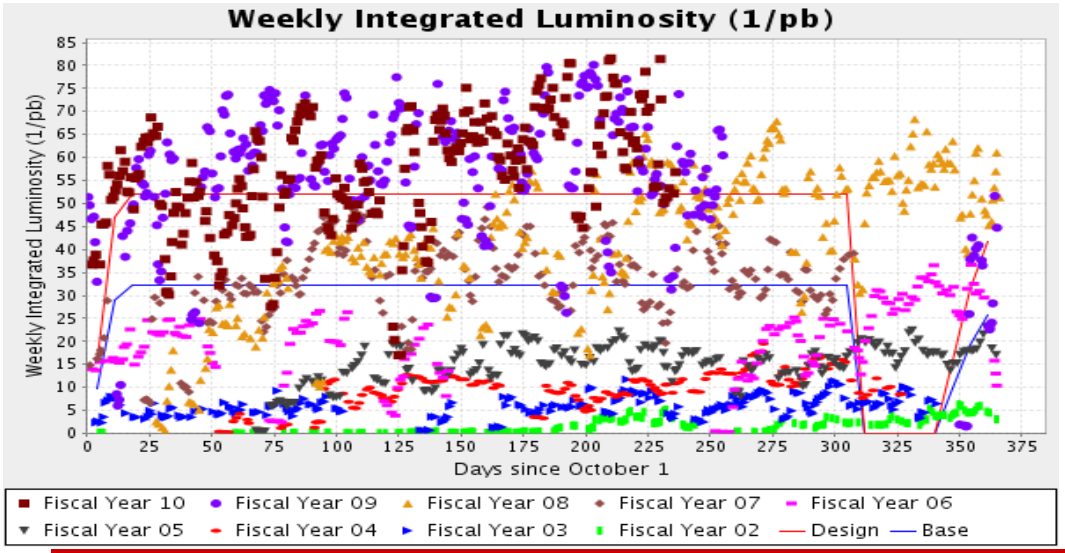
TeV Reliability

Year	Stores	Normal Terminations	%Normal Terminations	Avg Store Hrs/Week (outside of planned shutdowns)
2003	186	55	30%	-
FY04	162	106	65%	100
FY05	211	145	69%	110
FY06	163	101	62%	100
FY07	235	187	80%	110
FY08	304	242	80%	106
FY09	293	253	86%	108
FY10	272	234	86%	124

Improving Reliability

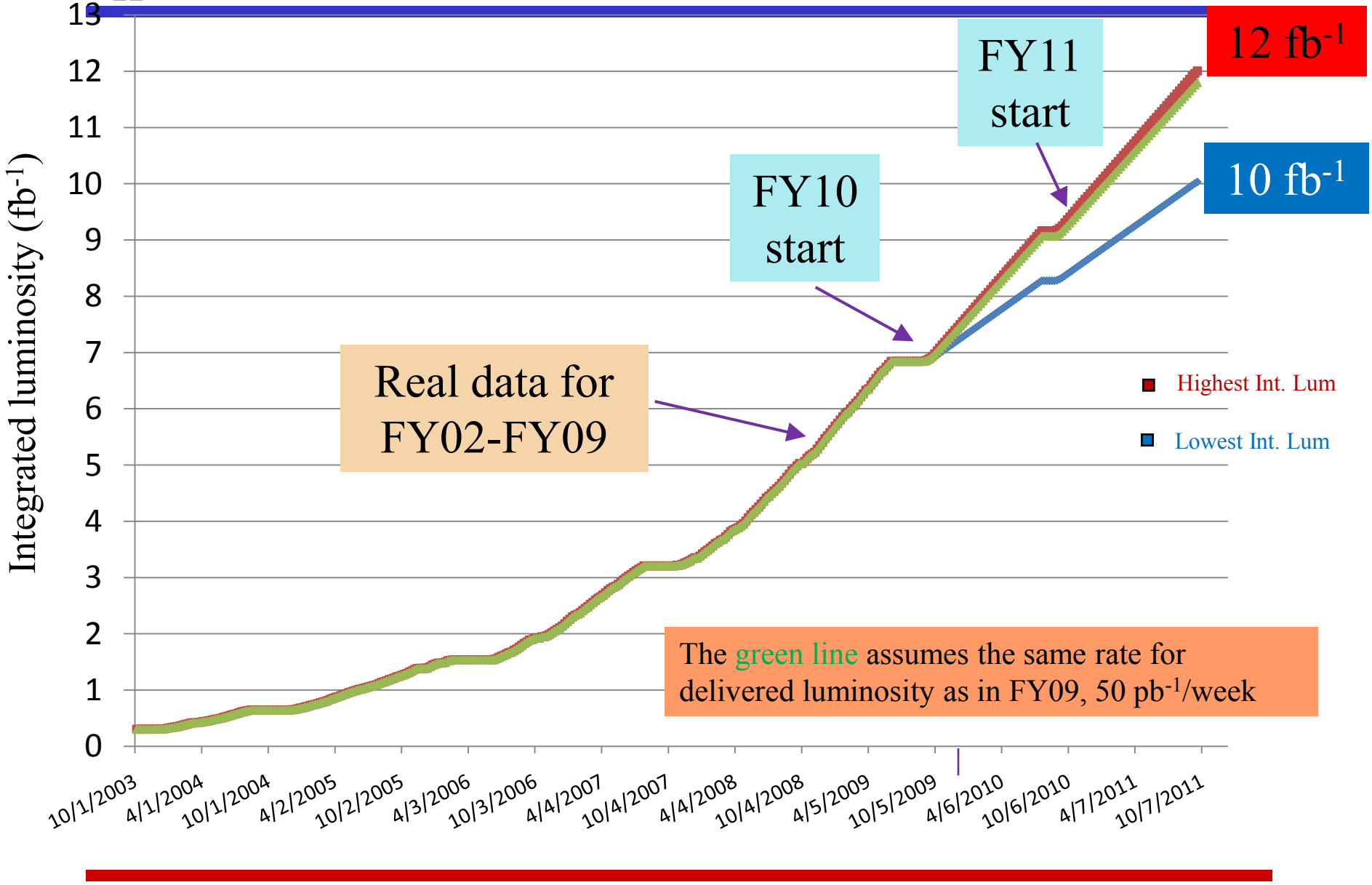
Collider Performance





- **Integrated Luminosity above the red line.**
- **Averaging 58 1/pb per week.**

Luminosity Projection through FY11



Summary

- Successfully completed a 12 week long shutdown.
  - Finished the installation of the Booster correctors.
  - Finished the MI penetrations for NOvA and installed the Gap Clearing Kickers.
- Very good overall performance of the accelerator complex despite problems with aging systems.
  - Record beam delivered to NuMI target.
  - Record integrated and initial luminosity for Collider.
- We are developing a plan to upgrade our proton source in order to meet the increasing proton demands.