

Shot Mechanics

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Main Injector/Recycler Department

Run Coordinator 1 Aug – 1 Dec

Directors Review
D. Johnson

17-18 October 2002

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Shot Mechanics

- # Introduction
- # Operational Planning
- # Description of a Shot
- # How are we doing

Introduction to Collider Shots

The Function

- to prepare the accelerator complex for (re)loading protons and pbars into the Tevatron Collider for producing luminosity

The Goal

- to efficiently load the maximum intensity of protons and pbars,
- bring the protons and pbars into collision at both interaction regions with minimal loss and maximum possible luminosity,
- and minimize dead time between Collider fills.

Operational Planning

- # To provide maximum (initial & integrated) luminosity and maintain the ability for improvement in initial luminosity, lifetime, and reliability the following strategies have been adopted
 - Alternate weeks of “stack ‘n store” and dedicated Collider Studies (3 to 5 shifts)
 - Take advantage of “no stack – no store” periods for accelerator improvement studies
 - Focused studies (aimed toward a specific problem) between store termination and Collider filling
 - Extended periods of “stack ‘n store”
 - M&D periods as needed

Operational Planning, continued

- To accomplish the coordination of the Collider program a series of strategy, planning, and briefing meetings are carried out.
 - Monthly Run II Strategy Meeting (Directorate, CDF, D0, Operations, Beams Div. Head, Run II Project leader, Run coordinator, special guests)
 - Review performance of previous month
 - Determine the running strategy for next month
 - Run II Steering Committee made up the Division management, Run coordination team, and Department Heads
 - Status of outstanding action items
 - Issues inhibiting performance/strategies
 - Plans for the upcoming week
 - Issues requiring discussion, coordination and/or decision

Operational Planning , continued

- Run II Scheduling meeting (9:00 AM M,W,F) with the all Beams Division Departments, the Directorate, local DOE, and Experiment Coordinators
 - the operational status of the accelerator and the experiments is discussed
 - and the operational plan for the day/week is announced.
- Monday morning meeting with the Beams Division Head, Run IIA Project Leader, the Run Coordinator (and Deputy)
 - discuss the previous weekend
 - and the plans for the week prior to Run II Coordination meeting
- Monday Studies Planning meeting with the Run II Coordination team and machine coordinators (open to all)
 - Study plans and requests of each department for the week are discussed
 - A detailed plan (by shifts) is worked out to coordinate the activities of all accelerators

Operational Planning , continued

- All Experimenters Meeting
 - Status Reports from Accelerator Operations, Run Coordinator, and all Experiments
 - Presentation of the Accelerator schedule for the week
- Run II Shot Analysis (Run II Coordination Team, Shot Analysis Team, Machine Coordinators)
 - Discussion of the prior weeks shots
 - Shot analysis issues
 - Presentation of Accelerator Study results
- Department Studies meetings
 - Detailed discussion of individual accelerator issues and studies
 - Develop detailed study plans and priorities

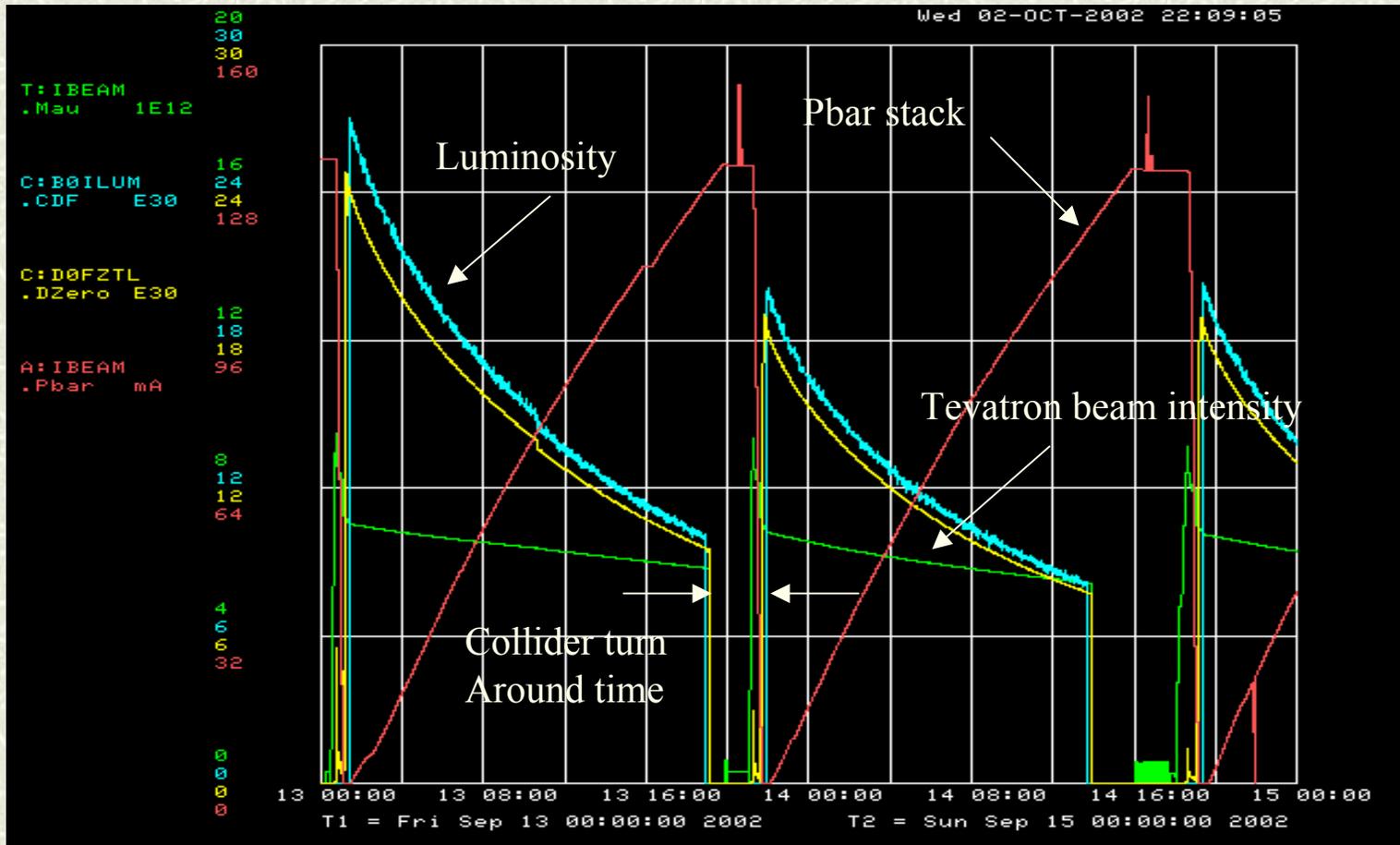
Operational Planning , continued

Run Coordinator:

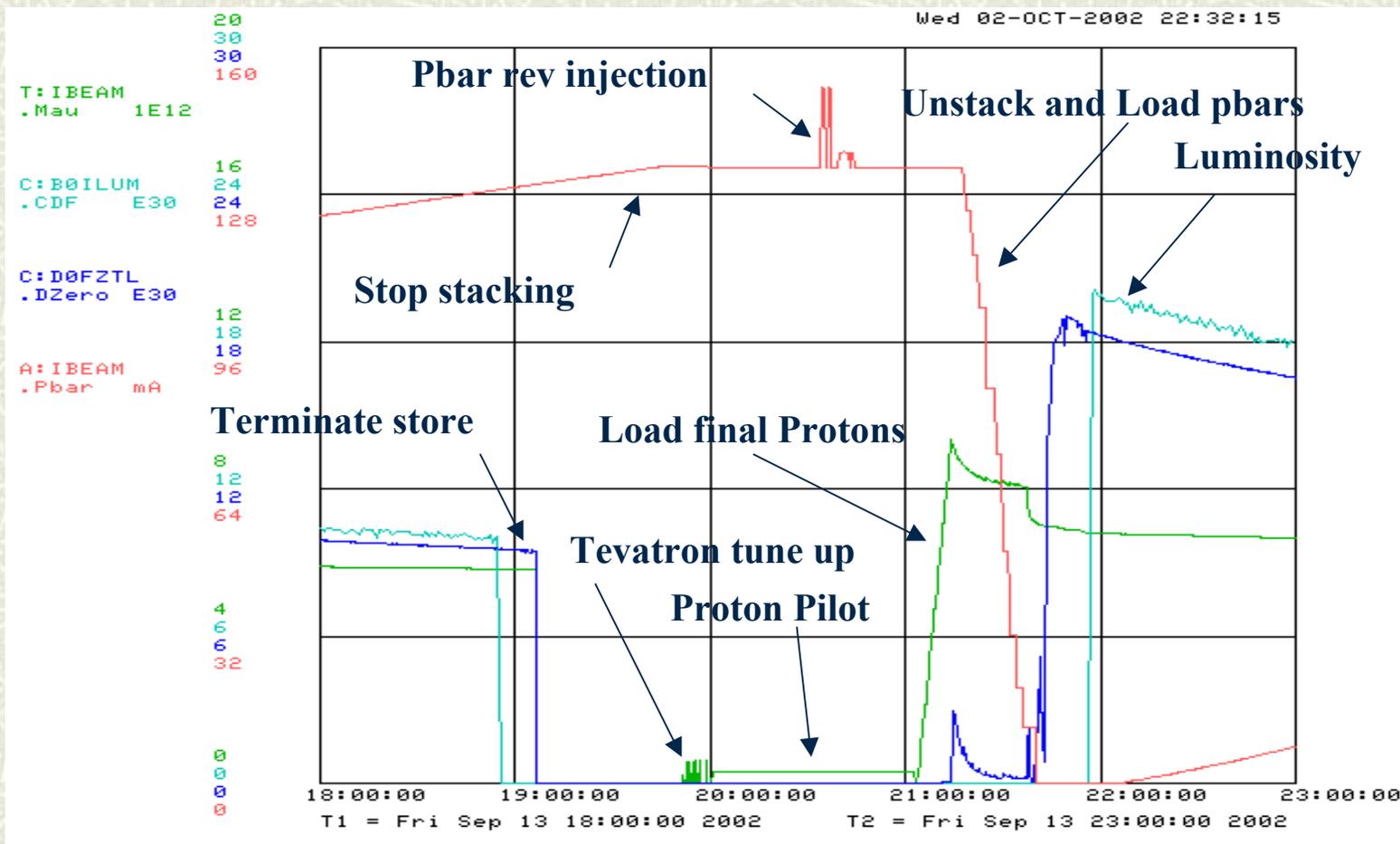
- With consultation of Run II management, Division Head, department heads and machine coordinators.
 - Determines daily/weekly store and studies schedule
 - Shot parameters on a store by store basis
 - Primary interface between Beams Division and Experiment Run coordinators

Accelerator Operations (and Accelerator Physicists) execute the plans

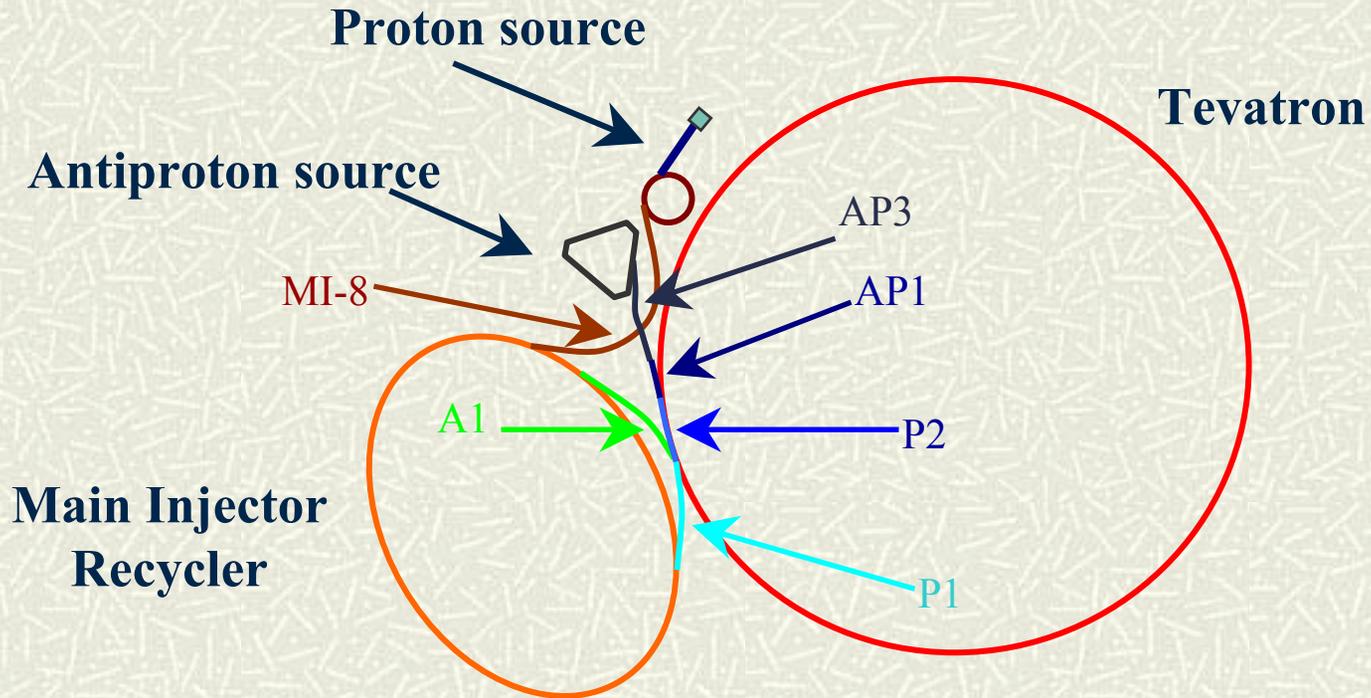
Stack 'n Store



Anatomy of a Shot



Shot Set-Up – the Lay of the Land



Resources

Manpower

- Operations
- Machine Specialist
- Machine Physicists
- Support systems

Software Sequencers

Accelerator Modes / state devices

- Used to communicate between sequencers
- Annunciation of Machine/Transfer states

Sequencers

- # The preparation of the accelerators to “supply”, “prepare” and “accept” and “deliver to collisions” are controlled by Operations using “Sequencer” application programs.
 - Provide a structured way to perform the same task in identical fashion
 - Provide instruction and feedback to Operators
 - Integrate “special purpose” application programs
 - Communication between accelerators via special “state variables”

Pbar Sequencer

```
P64      P-BAR SEQUENCER      02-OCT-02 00:22:42  ♦Pgm_Tools♦
mode     edit     log     status     files     help
-----
aggregate commands  Run II Start Shot set up
---Collider Operation-----
Run II Start Shot set up
-> Run II Start Reverse Protons
Run II Switch to Shot Lattice
Run II Finish Reverse Protons
Run II Continue Shot set up
Run II Prepare to Load Pbars
Run II Load Collider Pbars
Run II Revert to Stack Lattice
Run II Return to Stacking
Run II Dry Shots

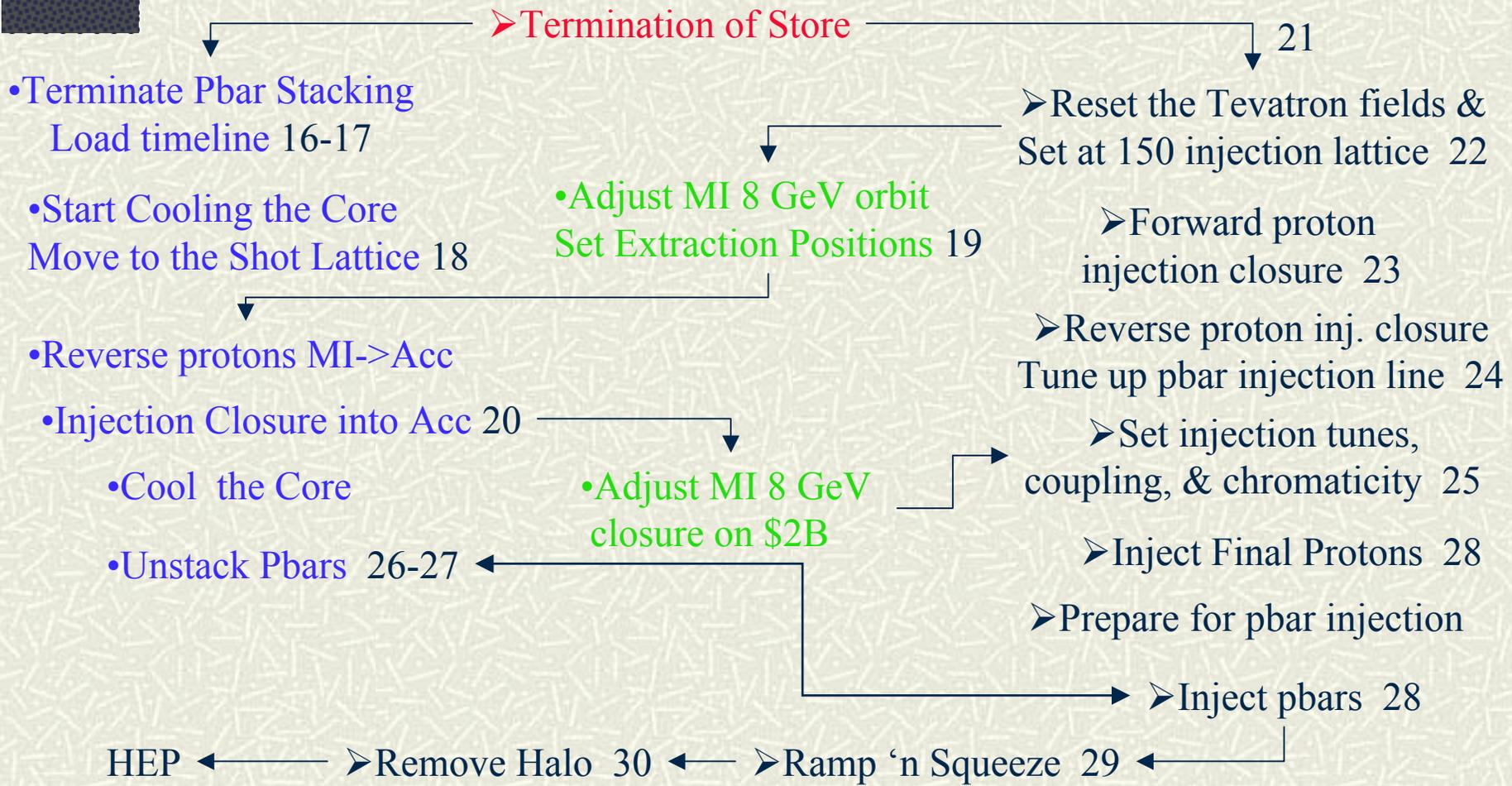
---Collider Development/Studies---
Square Up Core Studies
Load Collider Pbars Studies
New Recycler Skimming
Recycler Skim Pbars before Tev
Run II Unstack & Transfer
Run II Square Up Core

1: 20 of 103
+
Messages
SEQUENCER: (mode 2) begins on console 259 slot PB

Run II Start Shot set up
INSTRUCT 200
BEAM_SWITCH Pbar_Source Off
NOTIFY Start
CTLIT_DEVICE D:Q731 OFF
START_PGM SA0082
INSTRUCT 202
START_PGM SA1127
START_PGM P162
WAIT_FOR SECS 30
SETIT_DEVICE V:PSHOOT =1
SET_ENUMERATED V:APSMOD
SET_DEVICE V:APSMOD =9
SET_DEVICE A:APSHOT +=1
ACL WAIT_FOR_READING_MATCH
SET_DEVICE A:SHTNUM =0
SET_DEVICE V:CASPBT =1
SET_DEVICE V:SETPBT =1
CHECK_DEVICE A:APSHOT READING
CTL_DEVICE A:ISHUTO OFF
CTL_DEVICE A:ESHUTO OFF

1: 20 of 91
+
```

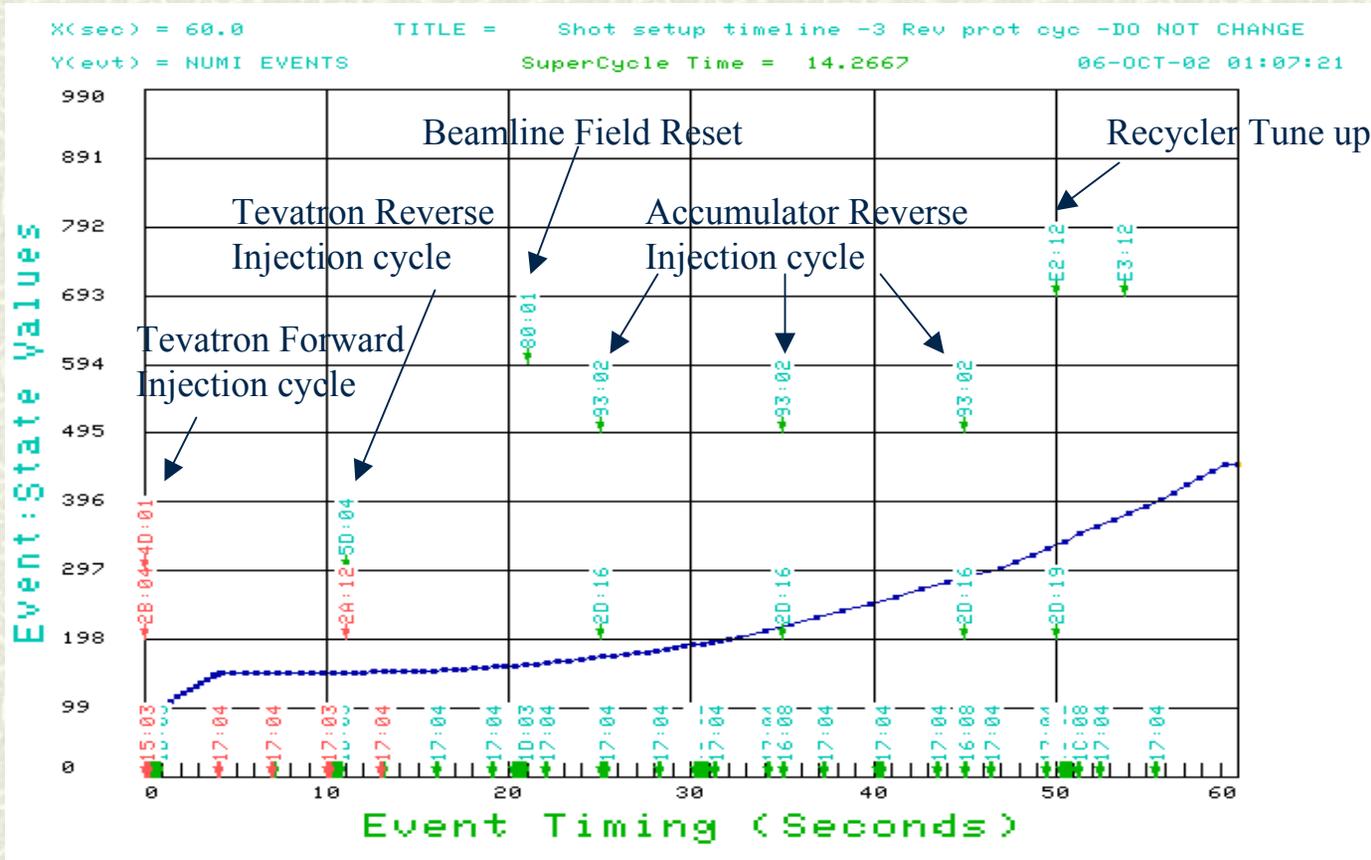
Mechanics of Shot set up



Time Lines

- # Accelerator cycles are clock event driven from a master “Time Line Generator”
- # Standard Time Lines
 - Stacking
 - Forward/Reverse injection tune up
 - Loading final protons
 - Unstacking and loading pbars

TLG module for Forward/Reverse Injection Tune up



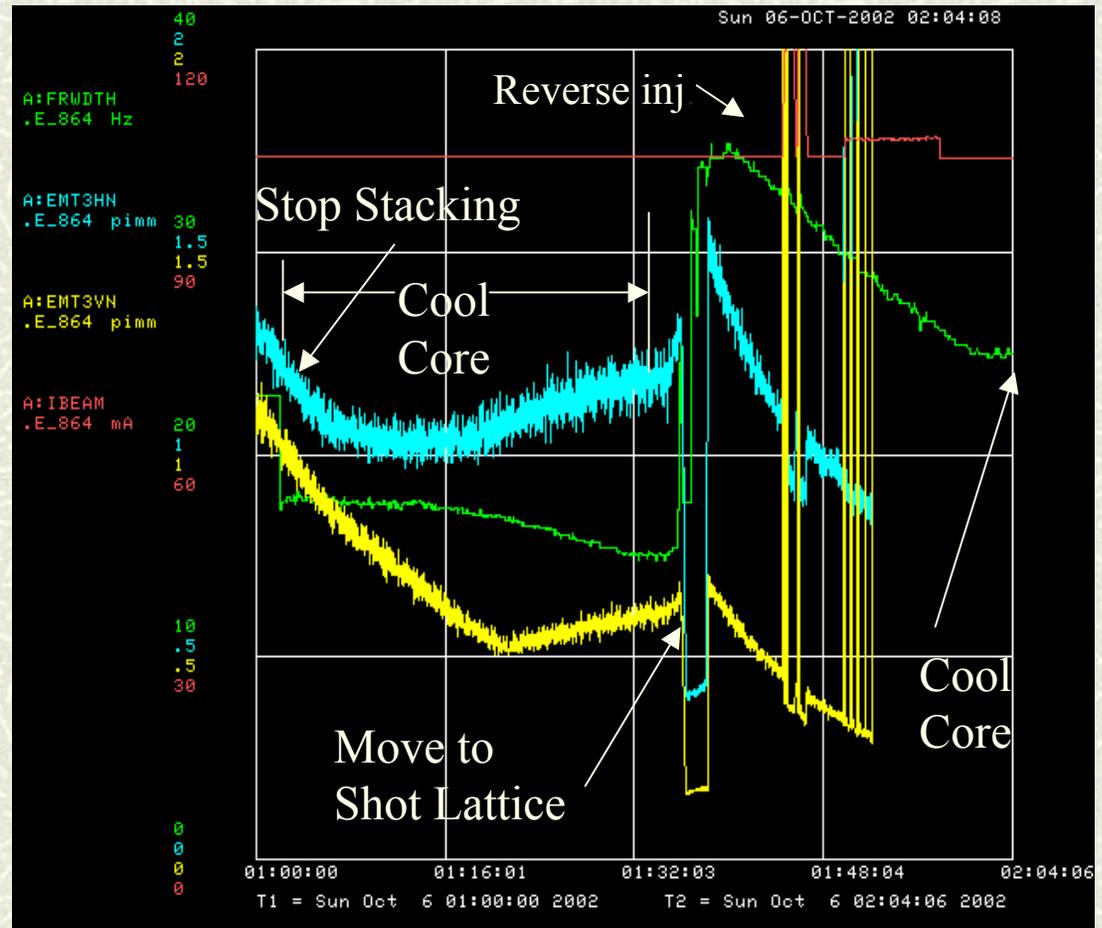
Cool Core and Move to Shot Lattice

Stacking Lattice

Upgraded for Run II
2-4 Gz cooling upgrade
(reduced eta)

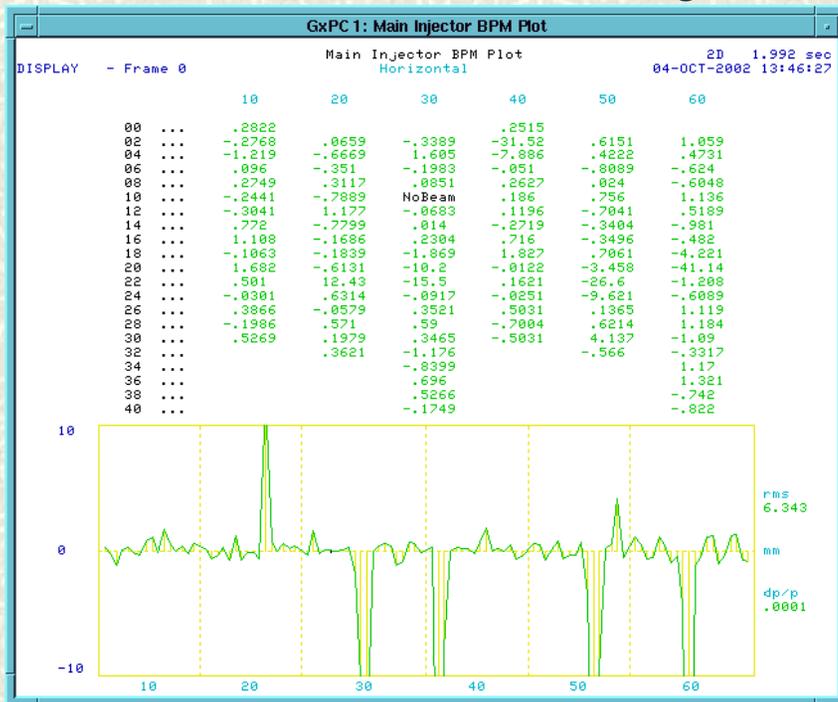
Shot Lattice

Similar to Run I lattice
Lower transverse emittance
Reduced Dispersion and
increased eta to reduce
intra-beam scattering

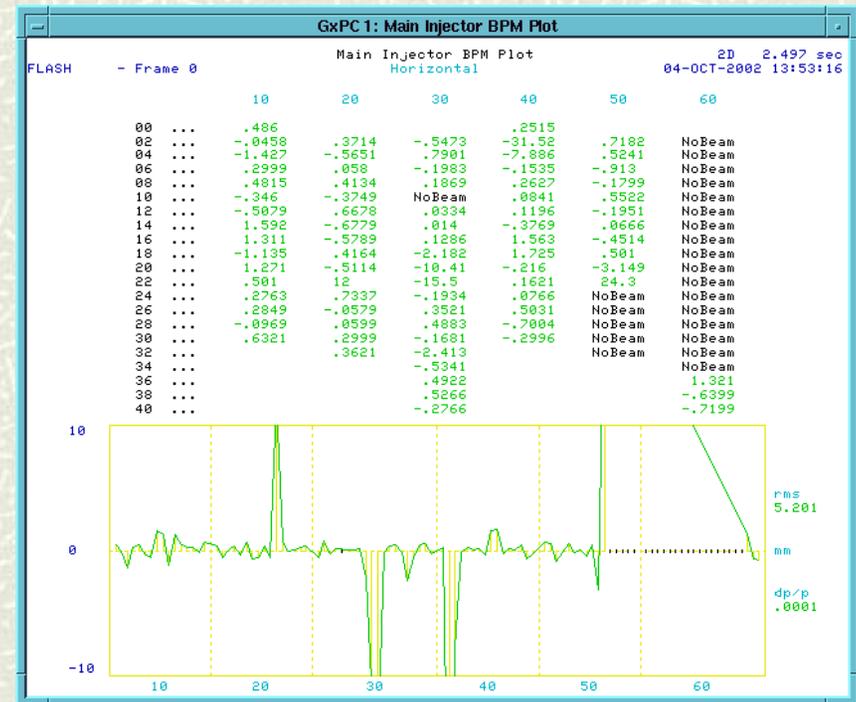


Check/Adjust MI Orbit Positions

> Once the Tevatron is at 150 GeV and while the Core is being cooled and moved to Shot Lattice



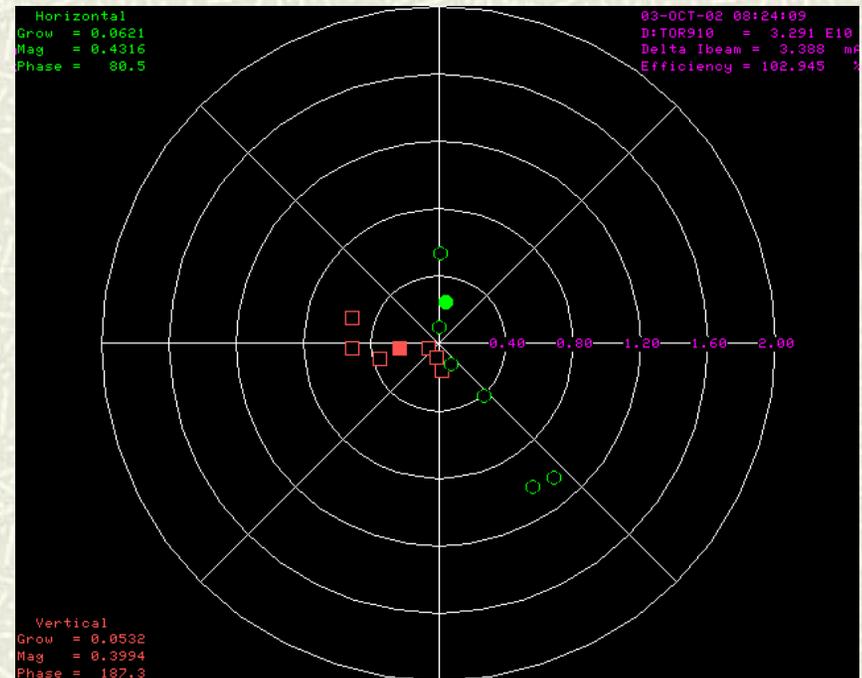
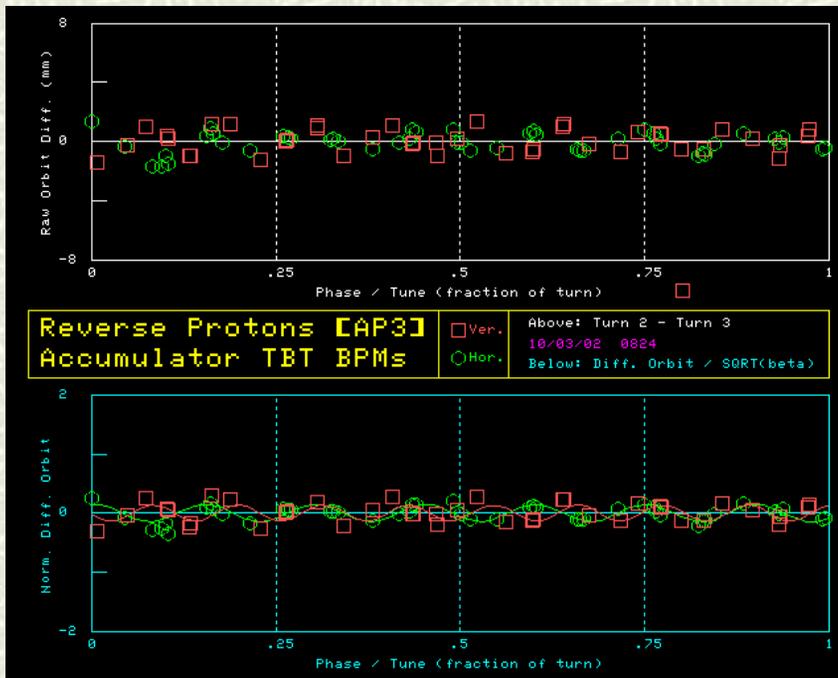
The MI closed orbit is checked / adjusted



The MI extraction positions are checked / adjusted

Injection Closure into the Accumulator

> Final tune up procedure before cooling the core and unstacking pbars.



Adjust Horizontal and Vertical trims in AP3 to minimize injection oscillations on to the Accumulator extraction orbit

Tevatron Sequencer

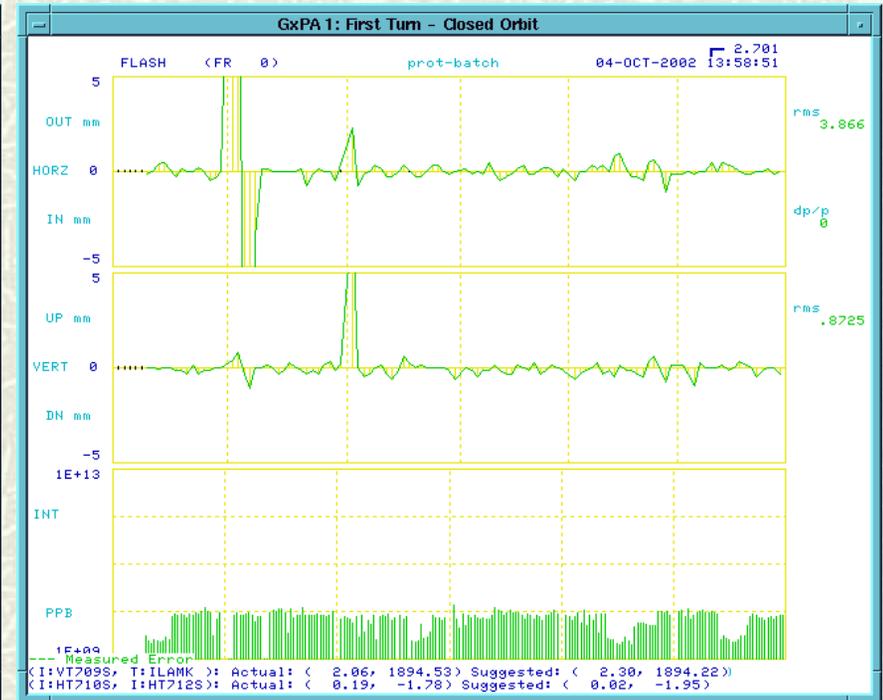
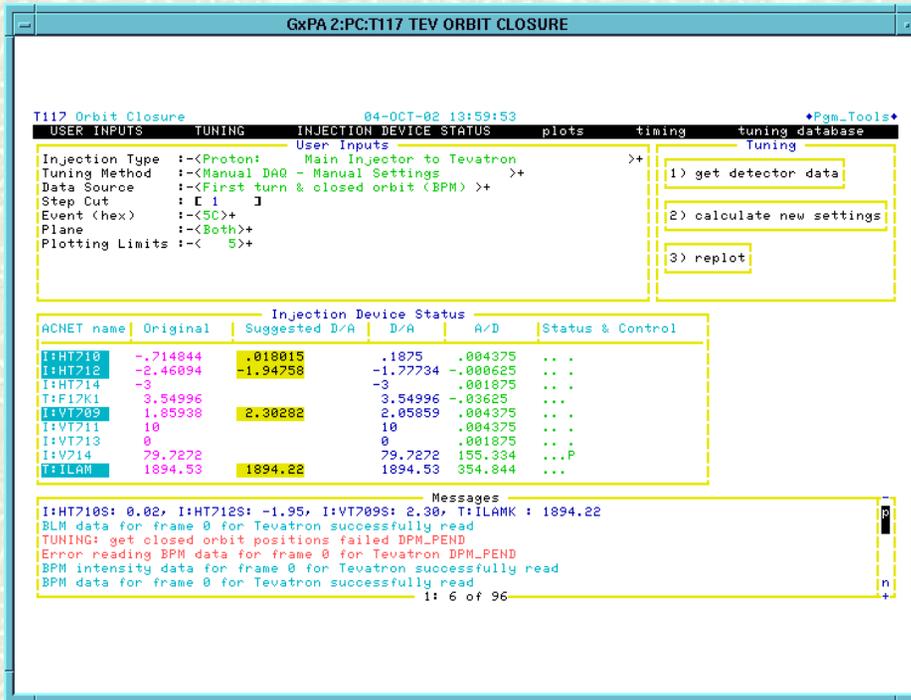
- Tune Up
- Injection
- Ramping
- Squeeze and Initiate Collisions

```
T48 COLLIDER SEQUENCER LOCKED 02-OCT-02 00:24:43 Pgm_Tools
mode edit log status files help
aggregate commands Set up Pbar Injection
::: Proton Injection tune up p
::: Reverse Injection tune up p
::: Proton Pilot
::: Inject Final Protons
ERR Set up Pbar Injection
::: Inject Pbars
ERR Prepare to Ramp
ERR Accelerate
ERR Goto Low Beta
-> Initiate Collisions
::: Remove Halo
::: HEP store
::: Turn off HEP
::: Un-Squeeze
::: Decelerate
ERR Goto Proton Inj Porch
::: -----
::: Recovery
ERR Stop at Flattop n
1:20 of 28 + 1:20 of 22 +
Messages
SEQUENCER: (mode 1) begins on console 259 slot PB in READ-ONLY access
SEQUENCER: mode 1 locked by console 7 slot PA
SEQUENCER: (mode 8) ends on console 259 slot PB
SEQUENCER: (mode 8) begins on console 259 slot PB
1:4 of 9 +
```

Reset Tevatron Fields sit at injection lattice

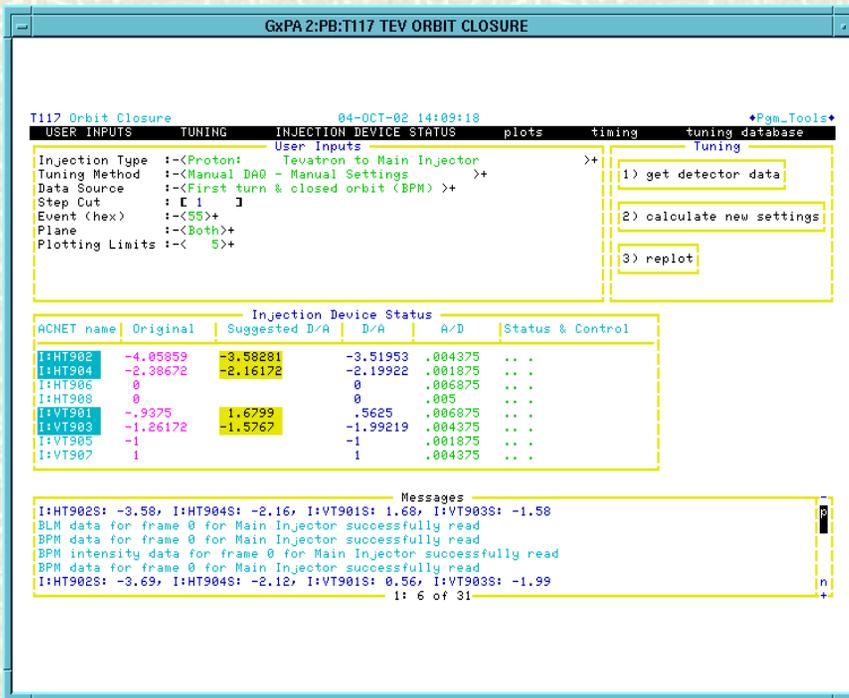
- Store is terminated
- Un-squeeze , *Low beta supplies are ramped to injection lattice*
- Tevatron bus current is ramped to 150 GeV injection level.
- Operators perform a “dry squeeze”
 - Ramp to flattop
 - Ramp low beta to collision lattice and sit for 15 min
- Un-squeeze and ramp down to 150 GeV injection lattice
 - ✓ Tune and coupling drift auto compensation
 - ✓ Sextupole (b2) due to persistent currents compensation
- ✓ Now ready for forward injection tune up

Tevatron Forward Proton Closure



Tevatron Reverse Proton Closure

Adjust the proton trajectory from the Tevatron through the A1 beamline back into the MI
 Adjust closure back into the MI by matching the first turn orbit (flash) with the MI closed orbit.



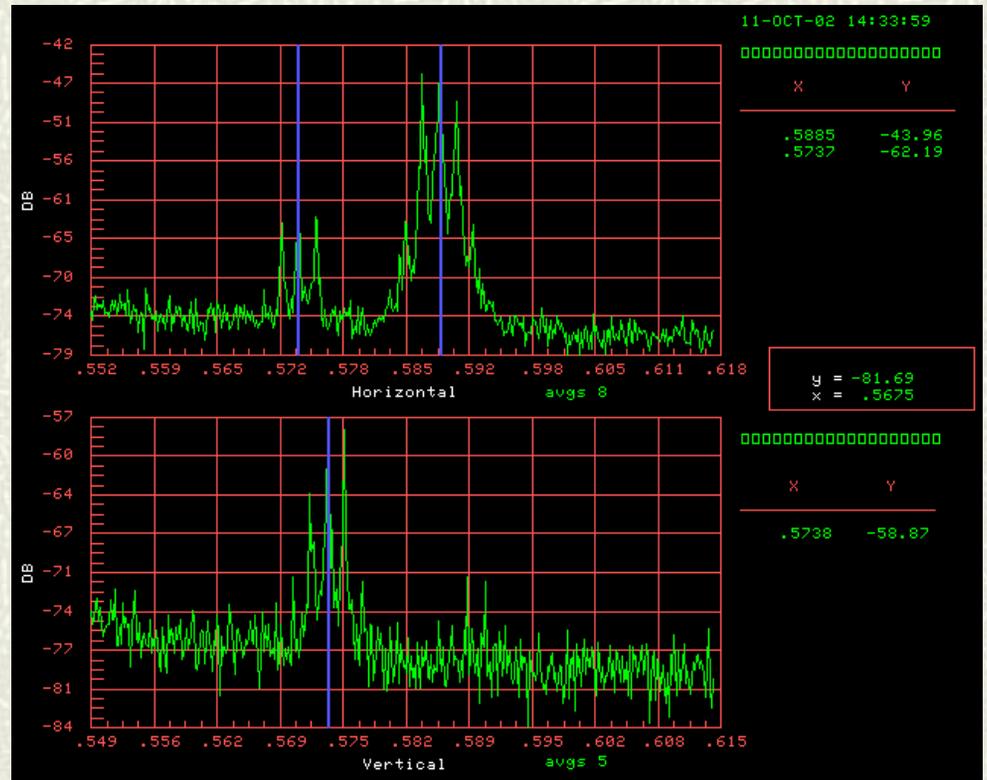
Program to read orbits and calculate/send corrections

MI difference orbit between first turn and closed orbit

Proton Pilot

Adjustment of proton tunes, chromaticity, and coupling on central orbit,

Setting nominal tunes on the central orbit
 $Q_h = .583$ and $Q_v = .574$



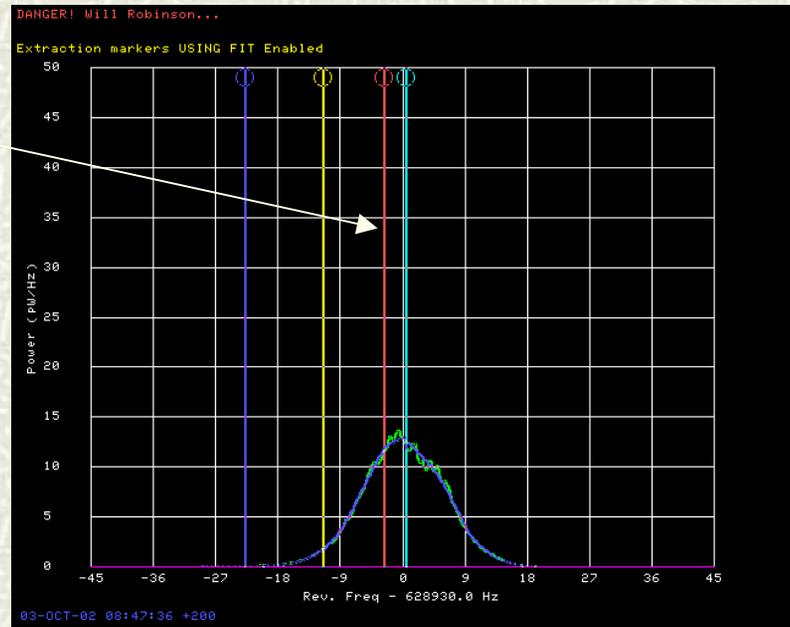
Once final protons are loaded, Tevatron is prepared for pbar injection

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Unstacking Pbars from the Accumulator

- >Once final protons are loaded, Tevatron is prepared for pbar injection
- The Tevatron Mode state variable is set to “ready for pbars”
- The Tevatron transfer state variable, *Next bunch*, is set for each transfer.
- Using the Pbar sequencer the operator requests a the number of pabrs to un-stack
- The proper RF curves are calculate and downloaded

Markers indicating the part of the core to be un-stacked defined by the amount of beam being requested.



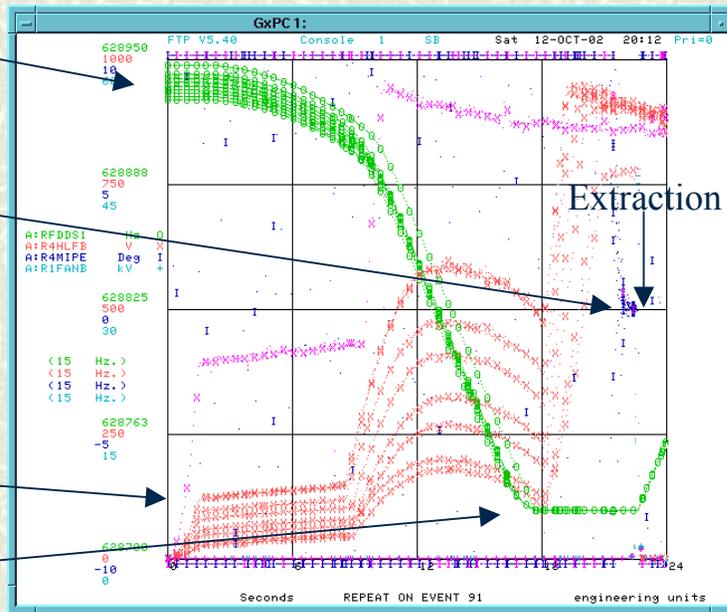
Unstacking Pbars from the Accumulator, con't

Capture freq.

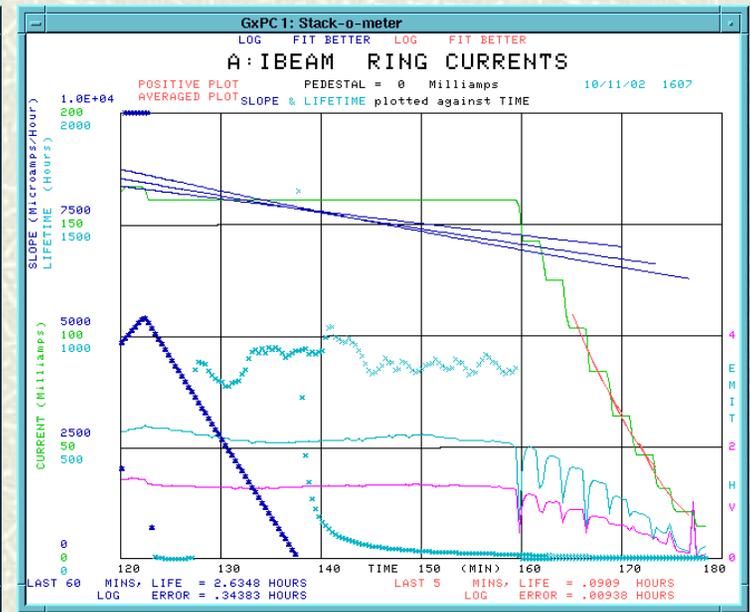
Phase locking to MI

Capture voltage

Extraction orbit freq

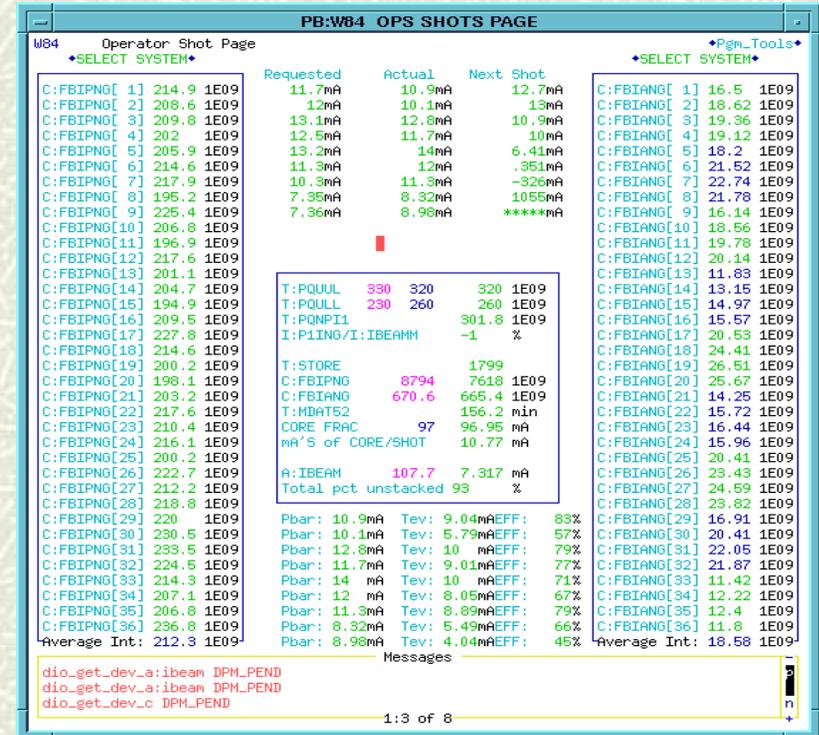
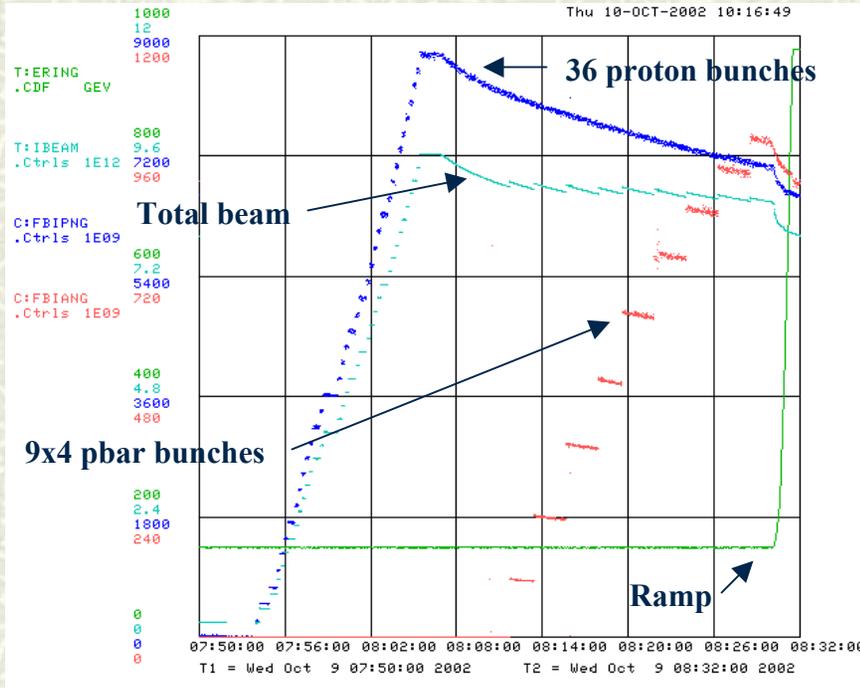


Monitoring Un-stacking ARF4 frequency and cavity voltage



Monitoring the transverse emittance and Accumulator ring beam current

Tevatron Injection Protons/Pbars

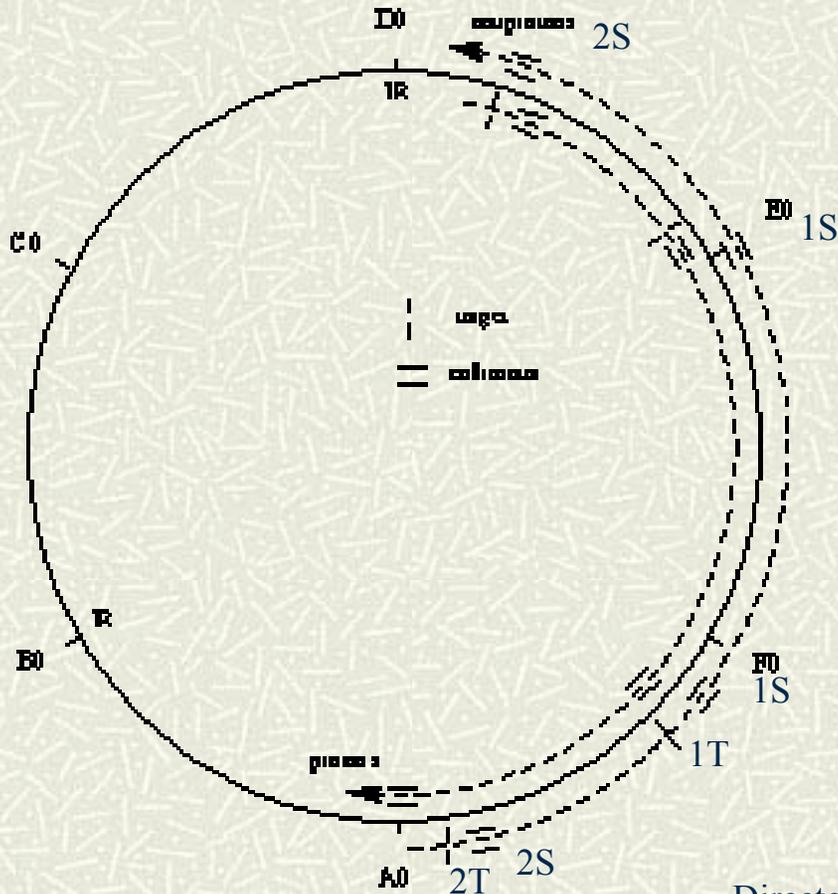


Plot showing proton and pbar bunch intensity and total beam intensity

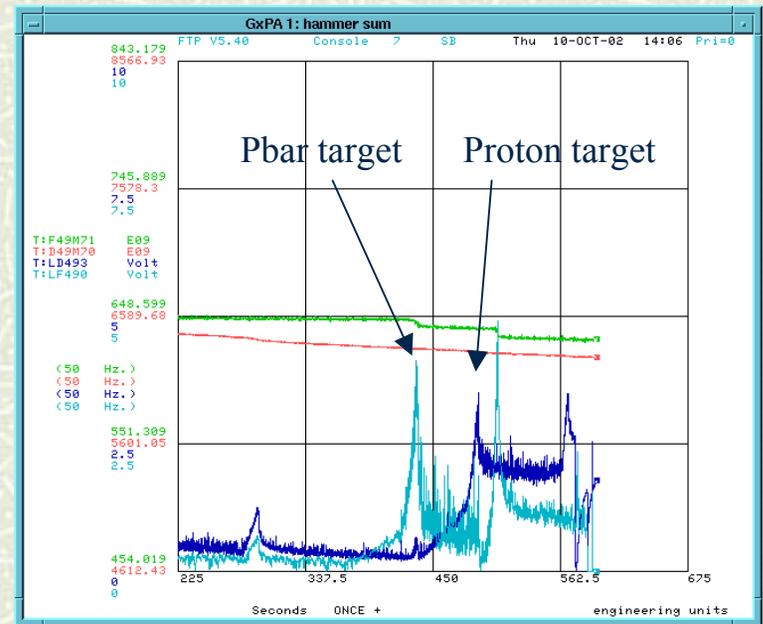
Program used to monitor (and set qualifier) Proton Intensity and monitor pbar injection process

Remove Halo

> Last step before HEP



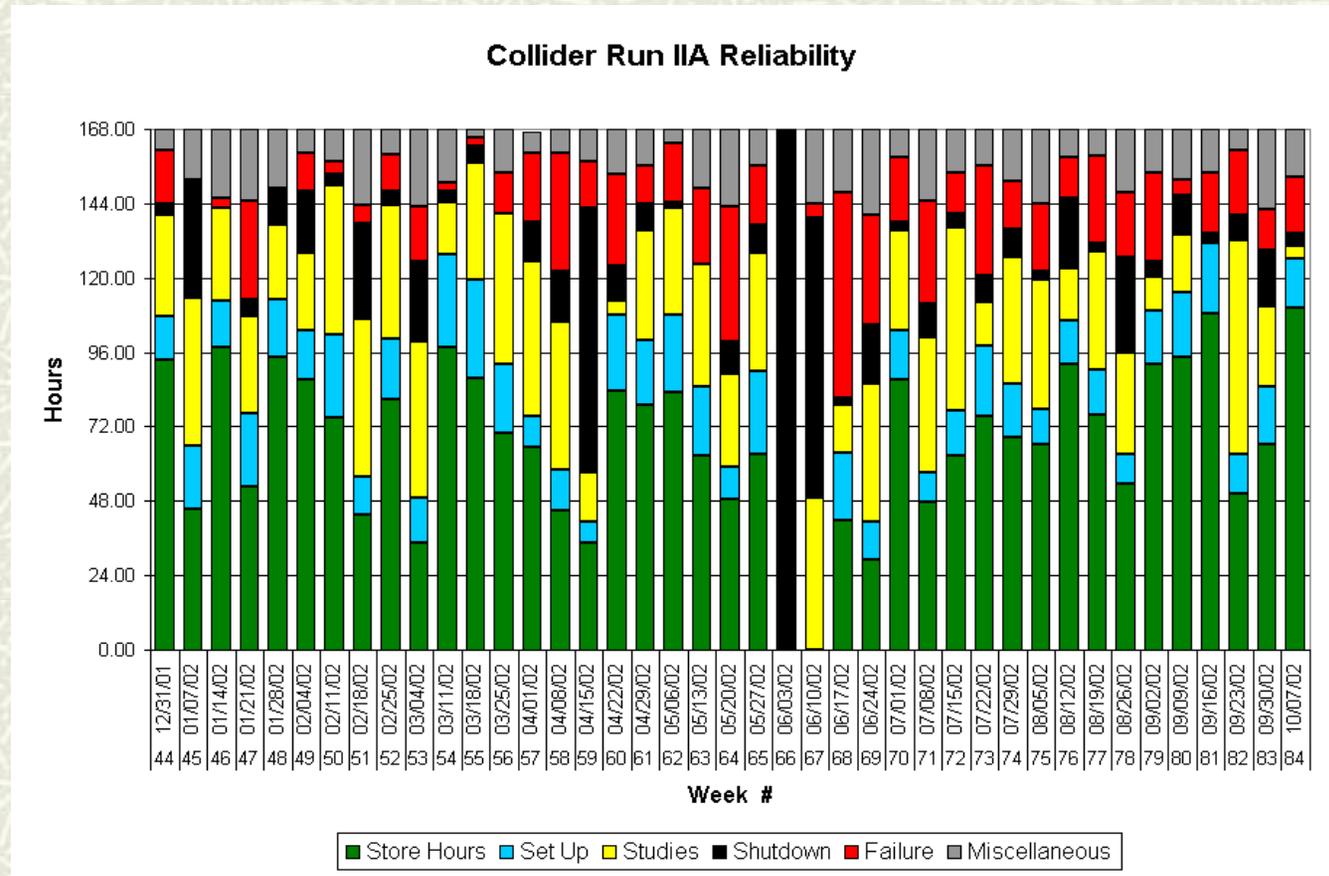
- One set of proton and pbar collimators.
- Each set contains a single target and two secondary collimators.
- Two stage Halo removal
- Automated with beam loss feedback



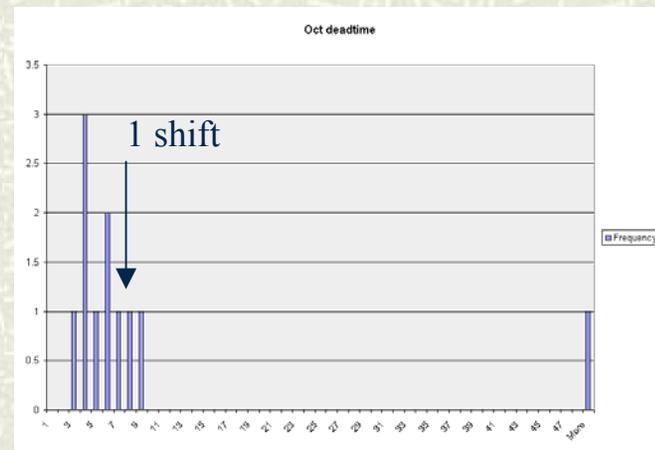
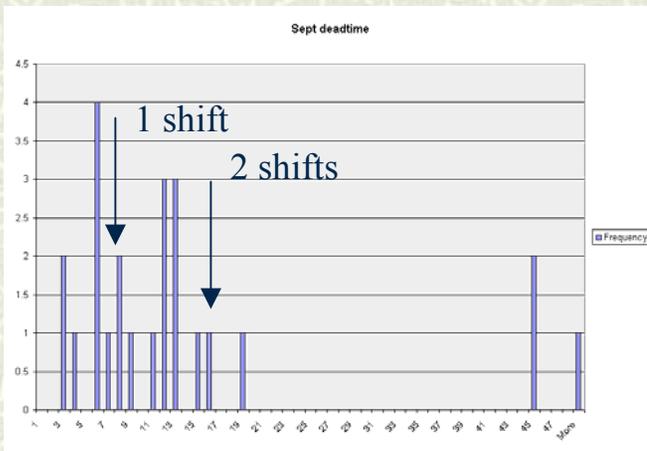
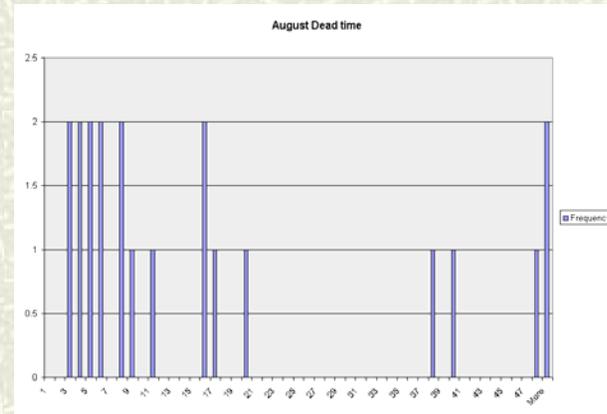
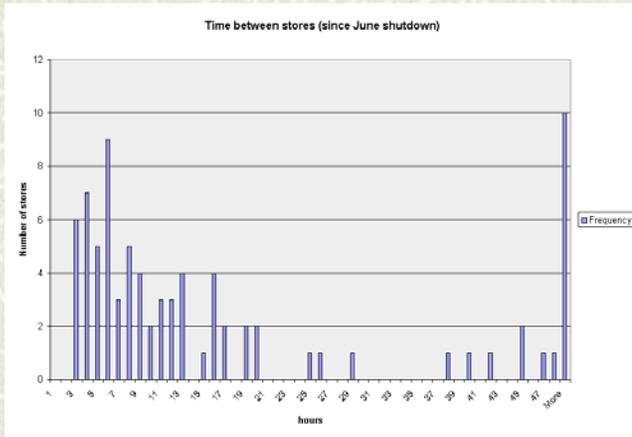
Stores, Studies, Set-up, etc...

Since August 5th

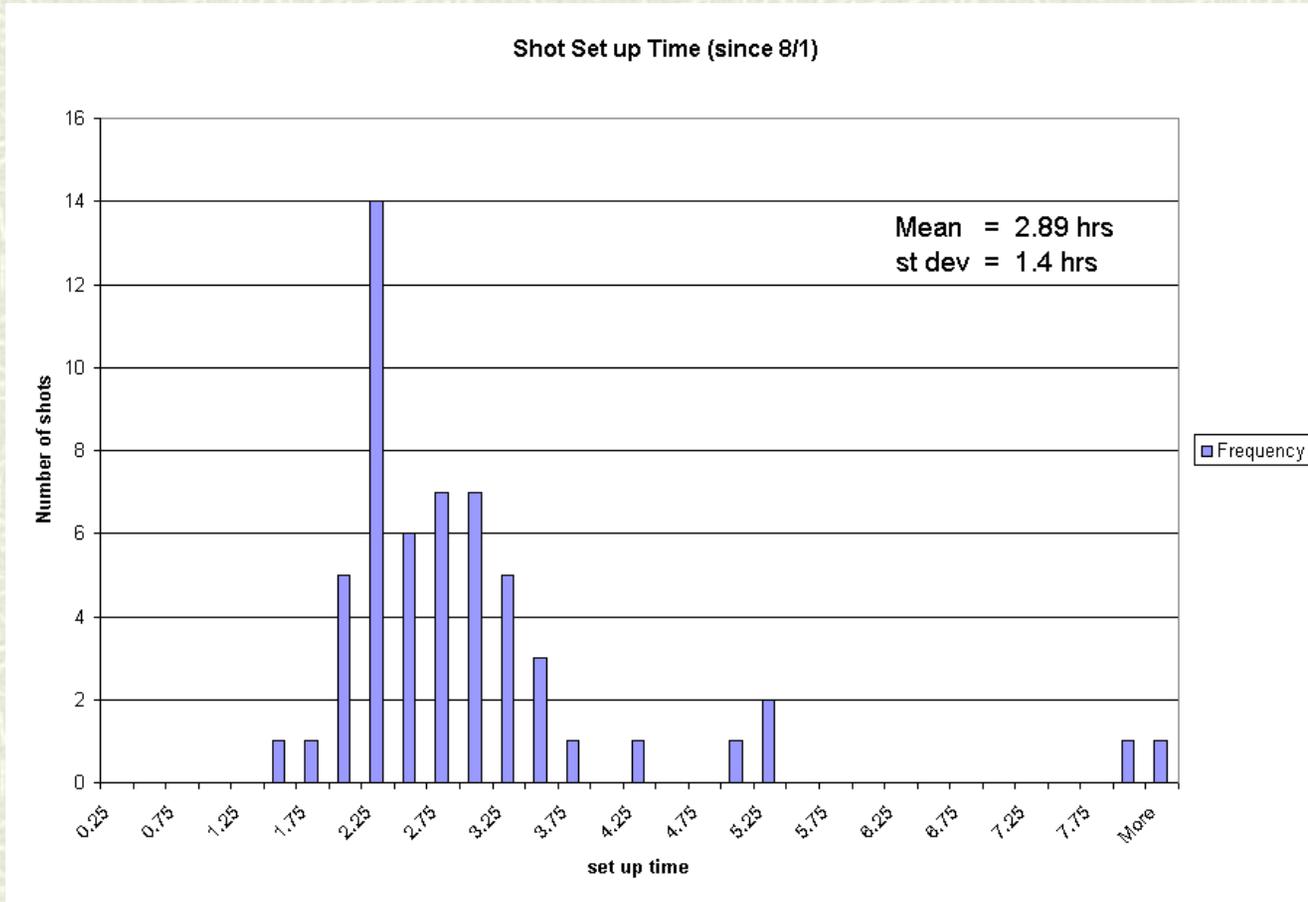
Store Hours 48%
 Set up 10%
 Studies 15%
 Shutdown 7%
 Failures 11%
 Misc 9%



Time Between Stores



Shot Set-up time



Luminosity, etc...

Integrated Luminosity for Week of 10/07/02

