SDA- Shot Data Analysis

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DOE Review

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What's Our Job?

SDA is a system for acquiring, archiving and analyzing data from stores.

- Allows correlation of information from multiple sources at specific times during the stores
- Information for day to day monitoring of stores
- Specialized studies
  - Long term trends
  - Investigate correlations
    - Luminosity vs. emittances, number of protons and anti-protons
  - Accelerator physics questions
    - Pbar Burn rate / total loss rate during HEP
    - Orbit changes
    - ??
- Controls, Computing Division, people from CDF/D0, coordination moving to Accelerator Integration Department

What's Required to Do the Job?

- Is data acquisition reliable?
  - Fine for the current load
- Inputs- are we getting the relevant information?
  - 90% complete
- Is the instrumentation adequate?
  - Relative calibrations between devices and same devices in different machines
  - Systematic and statistical errors
- Do we have adequate tools for exploiting the data?
  - Browser and Report Writer for quick studies,
  - Tables built automatically every store
    - Supertable
    - Derived tables and associated plotting tools
    - Short summary tables
    - Tables use corrected values from OSDA
  - Shots scrapbook
  - OSDA (Offline Shot Data Analysis) - Suite of Java packages to correct raw data and calculate generally useful quantities like lifetimes

Current Set of Inputs

- Intensities
- Beam sigmas and transverse emittances
- Bunch lengths and longitudinal emittances
- Luminosities, losses, beam positions from CDF/DO
- Magnet settings, readbacks – incomplete
- Misc. devices like RF control signals
- Fast Time plots of intensity devices and control settings
- Beams Division Documents 691, 692, 703, 705

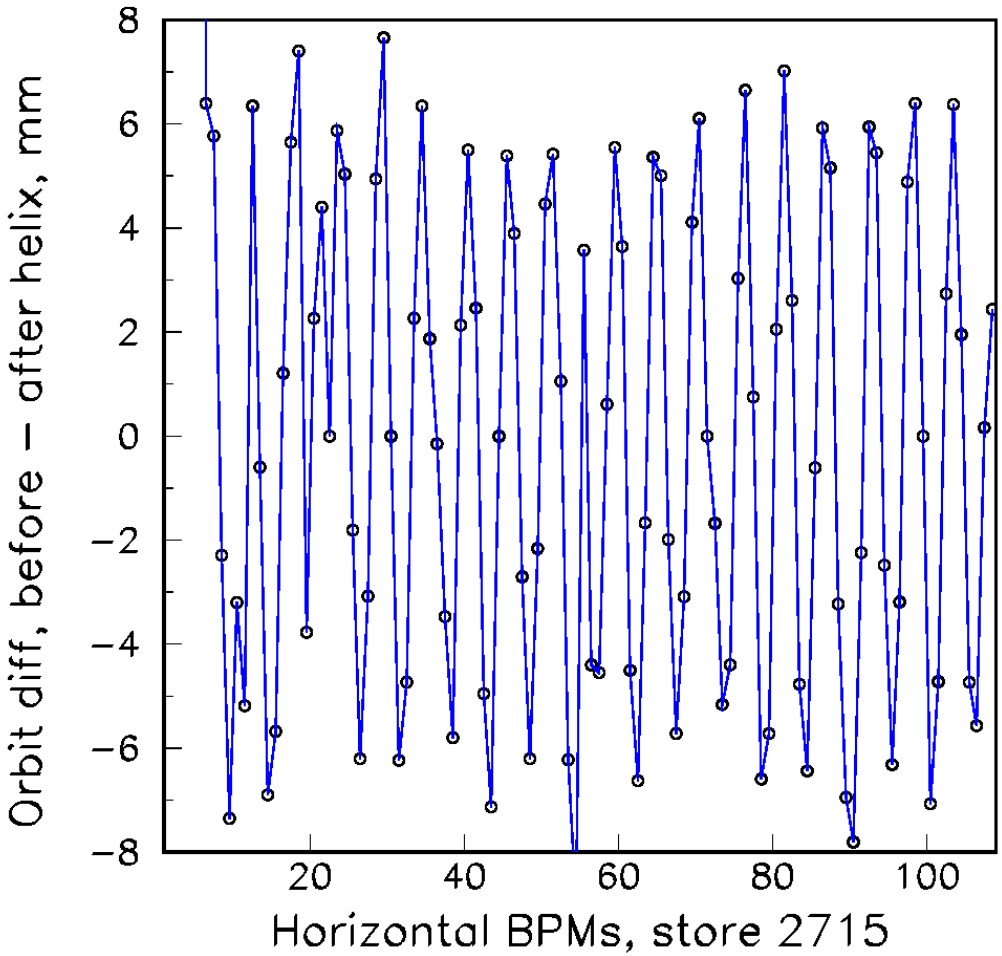
Incomplete and Missing Inputs

- Tev BPM orbits
  - Recently checked/added, BPMs work better than expected on coalesced beam
  - Systematic history of orbits during all phases of the store, including uncoalesced beam during tuneup and with coalesced beam at 150 GEV and every 10 minutes during HEP
  - Need SDA code to unpack the data – underway
  - Orbits already being used with cumbersome access methods
  - Even more valuable once have new BPM system
- Tunes, chromaticities, settings and measured values
  - Need application program upgrades – underway
- Misc. magnet, dampers settings and readbacks
- ???

Examples - Understanding the Instrumentation

- Relative calibration of Toroid, SBD, FBI intensities
  - Tevatron – Alvin Tollstrup - finished
  - MI – Michael Weber (D0) – just started
- Reliability of Tev BPM data with coalesced and uncoalesced beam
  - Better than expected on coalesced beam
- Deriving emittances from bunch sigmas
  - Tev Flying Wires – two horizontal wires, E11, E17, one vertical wire at E11
  - Cross calibrate horizontal emittances from E11 and E17 using SBD for dp/p
  - Cross calibrate SyncLite and FW E11, E17
  - Compare to scraping studies

Tev BPM Orbit Data



Difference Orbit
Before Helix-
Before Ramp

Horizontal BPMs

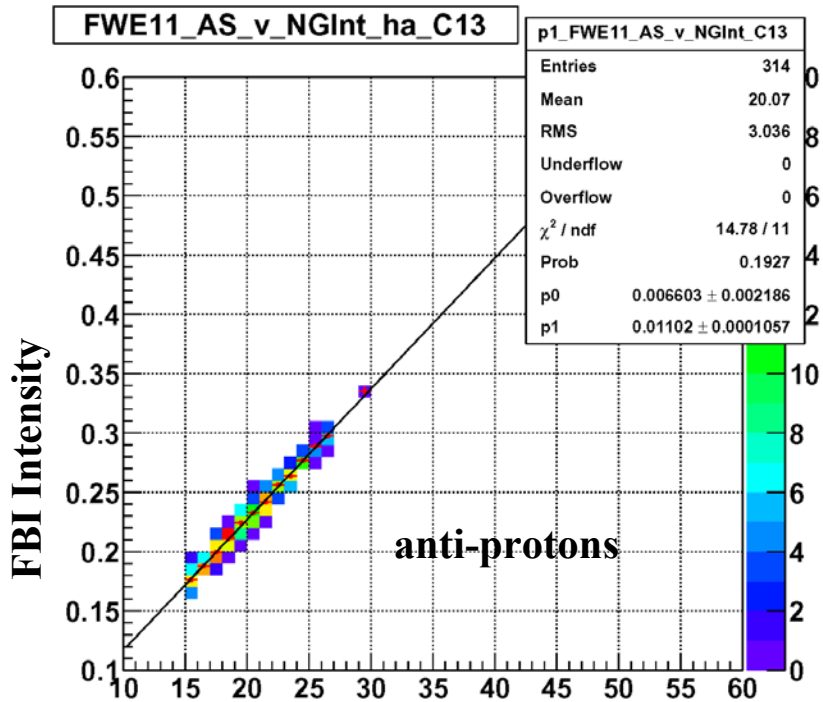
During Store 2715

Helix is clearly
visible

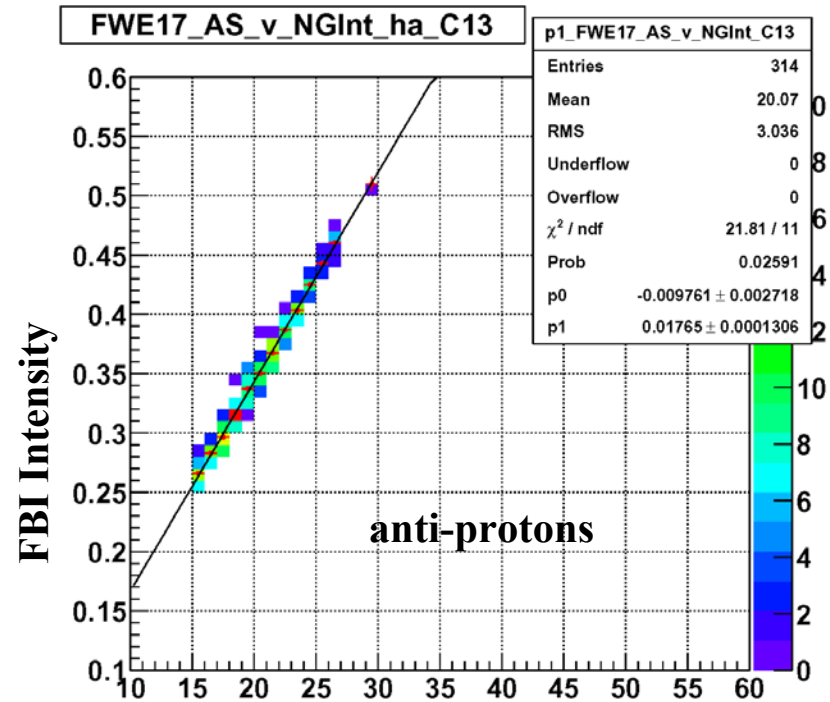
Understanding Flying Wires and SyncLite

- Compare area of FW profile to FBI intensity
  - Very linear
  - Qualitative agreement given differences in gain and acceptance of the paddles
- Compare horizontal emittance as measured at E11 with E17 emittance, using SBD for dp/p
  - Anti-protons – ratio has slope of .97 and intercept of 1.25 – after fixing saturation
  - Protons – poor agreement, slope .41, intercept 14.5
- Compare area of SyncLite profile with FBI intensity
  - Better for anti-protons than for protons
- Compare flying wire emittances with SyncLite emittances
  - HP – slope .97 intercept 12 HA – slope .55 intercept 37
  - VP – slope 1.2 intercept 1.2 VA – slope .92 intercept .92
- Very sensitive to lattice parameters and dp/p
- Store to store variations

Compare FW Area with FBI Intensity

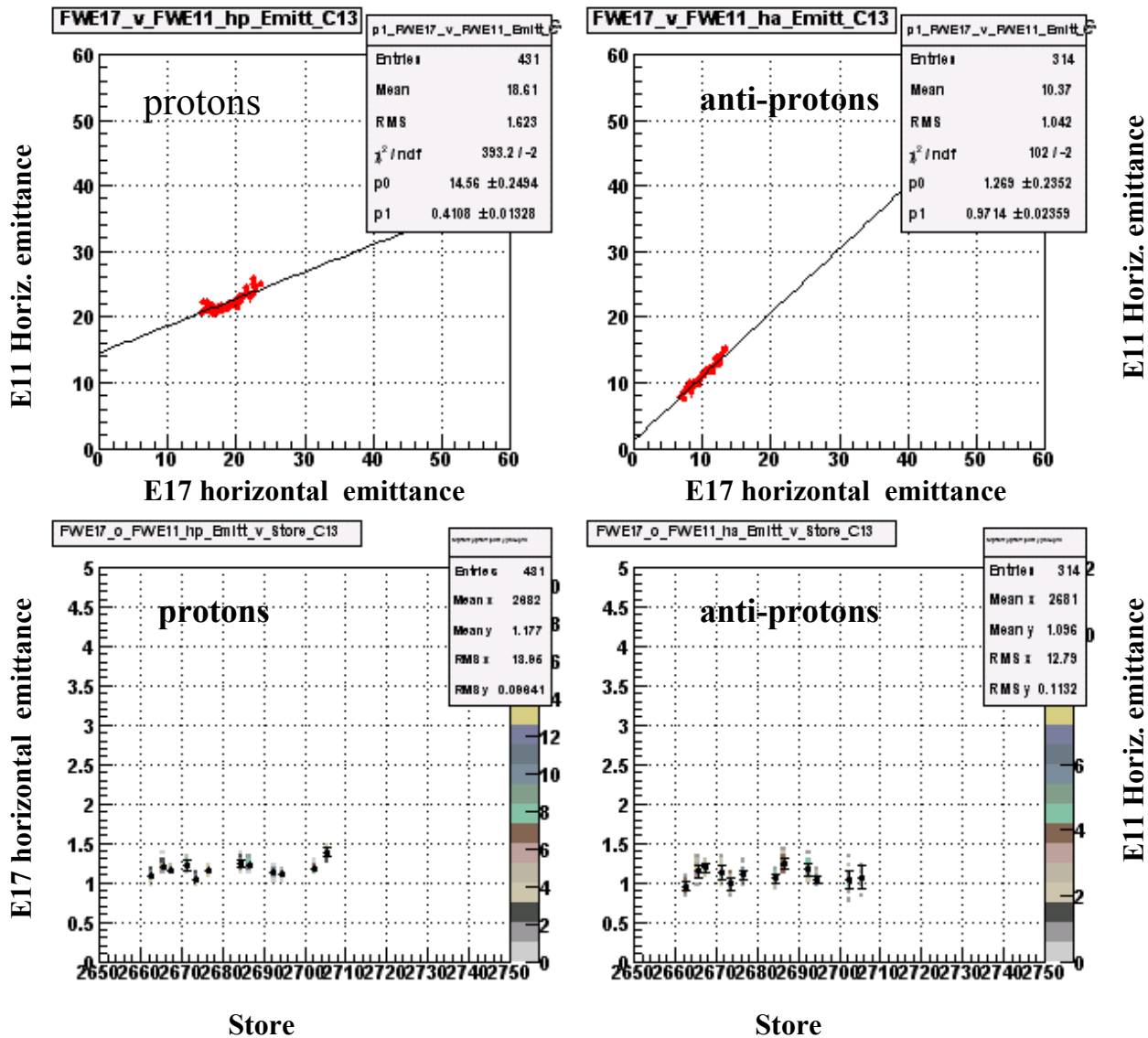


FW E11 horizontal emittance

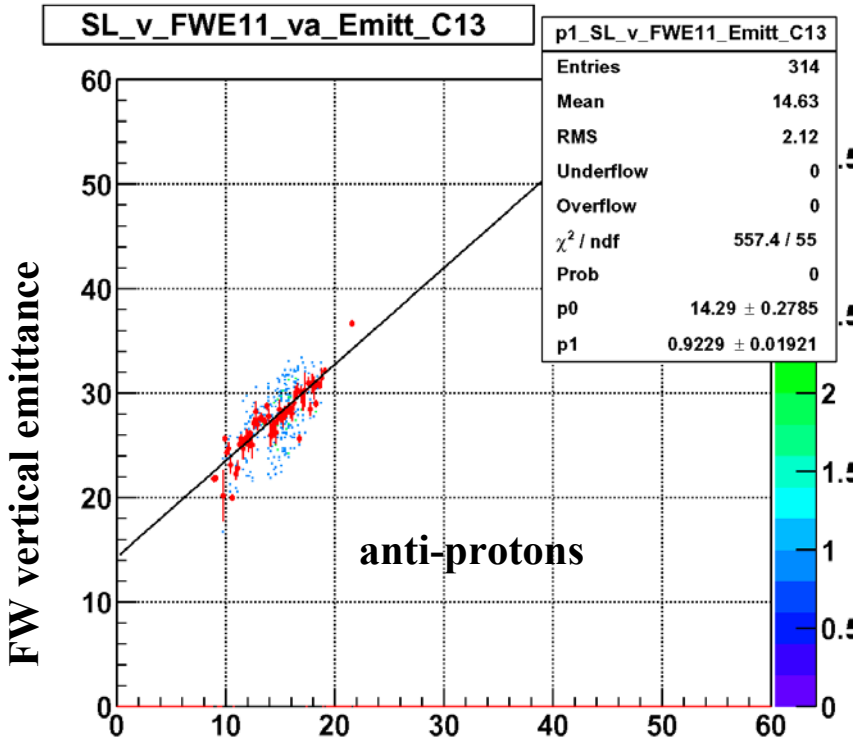


FW E17 Horizontal Emittance

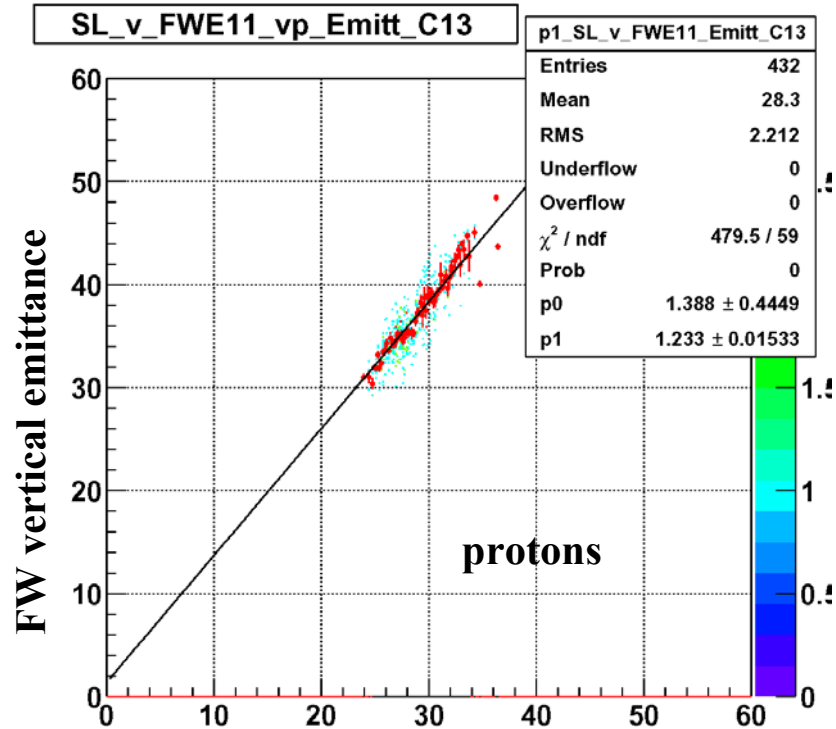
Compare E11 to E17 FW Horizontal Emittances



Compare SyncLite to FW – Vertical

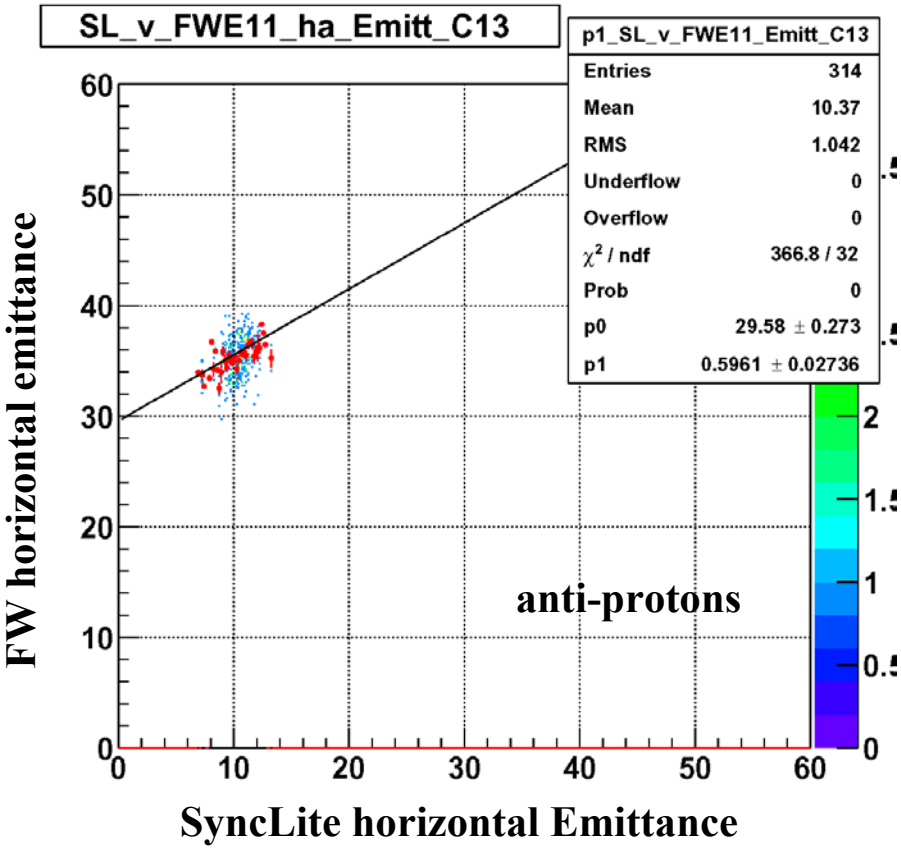


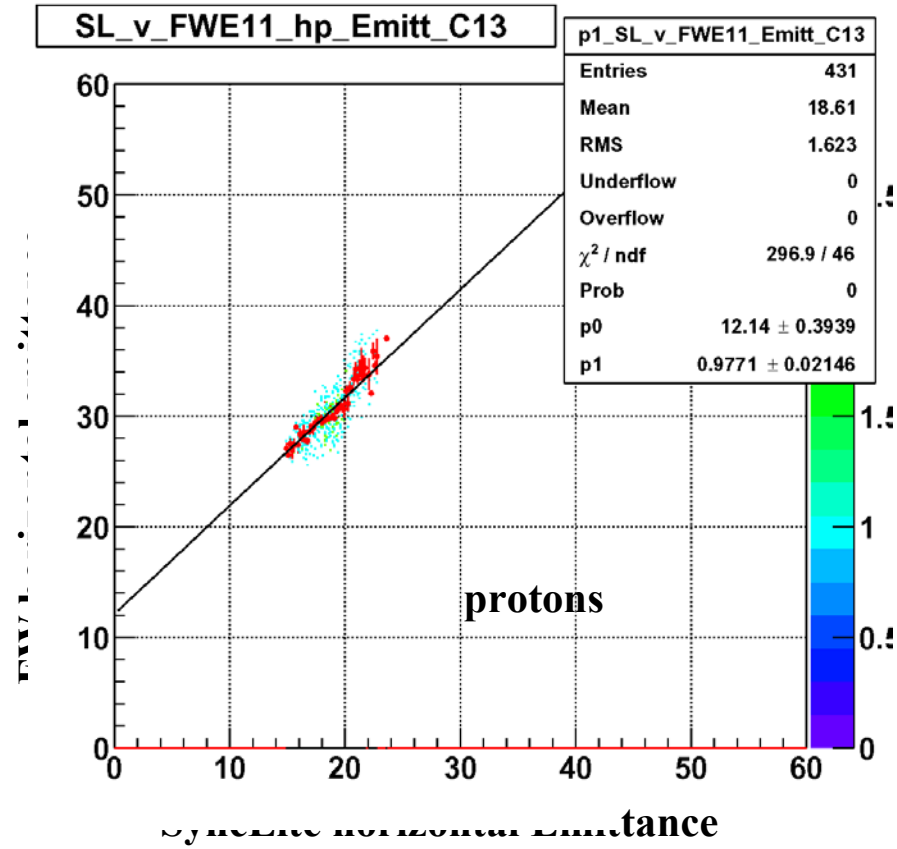
SyncLite vertical Emittance



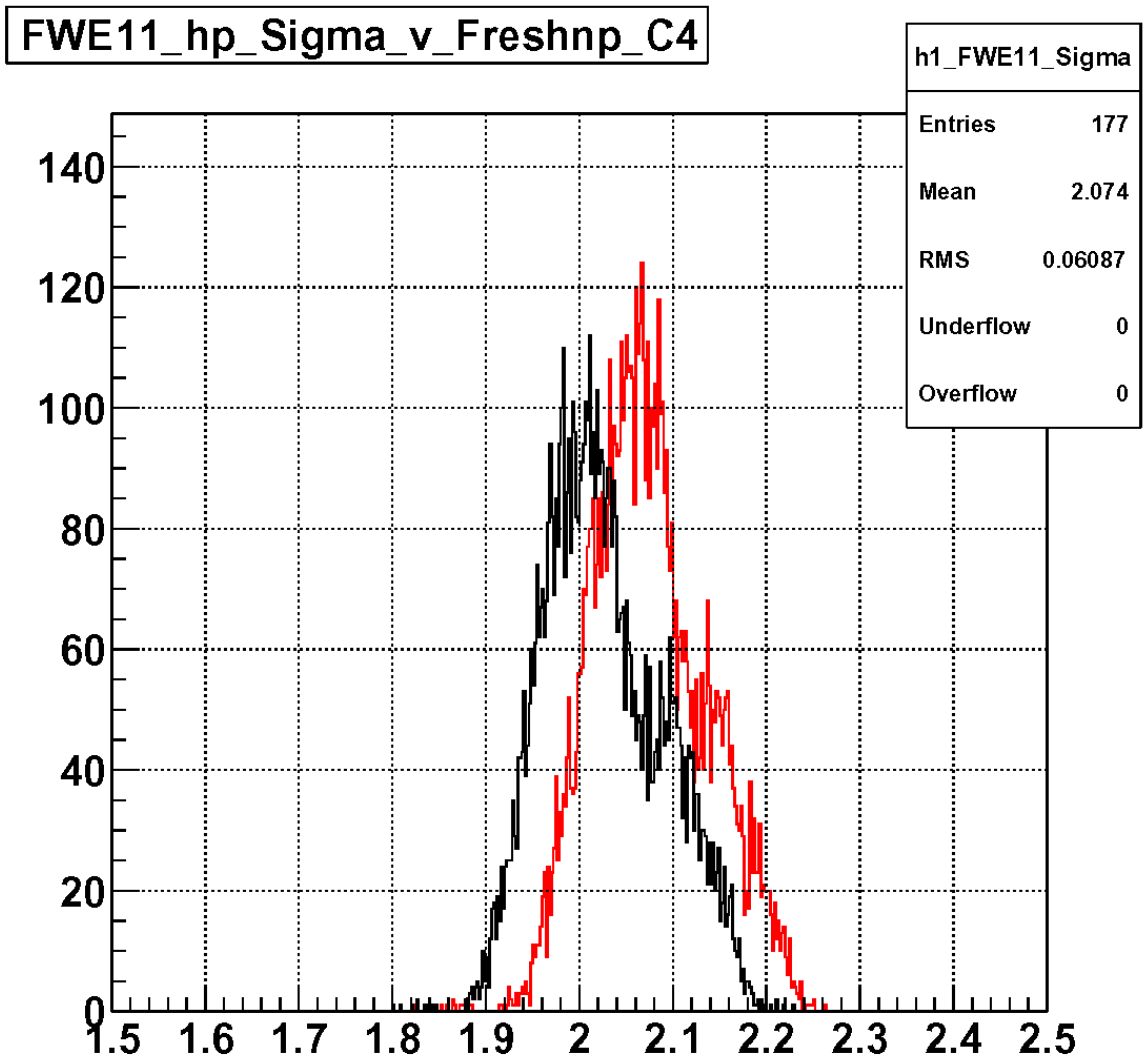
SyncLite vertical Emittance

Compare SyncLite to FW - Horizontal





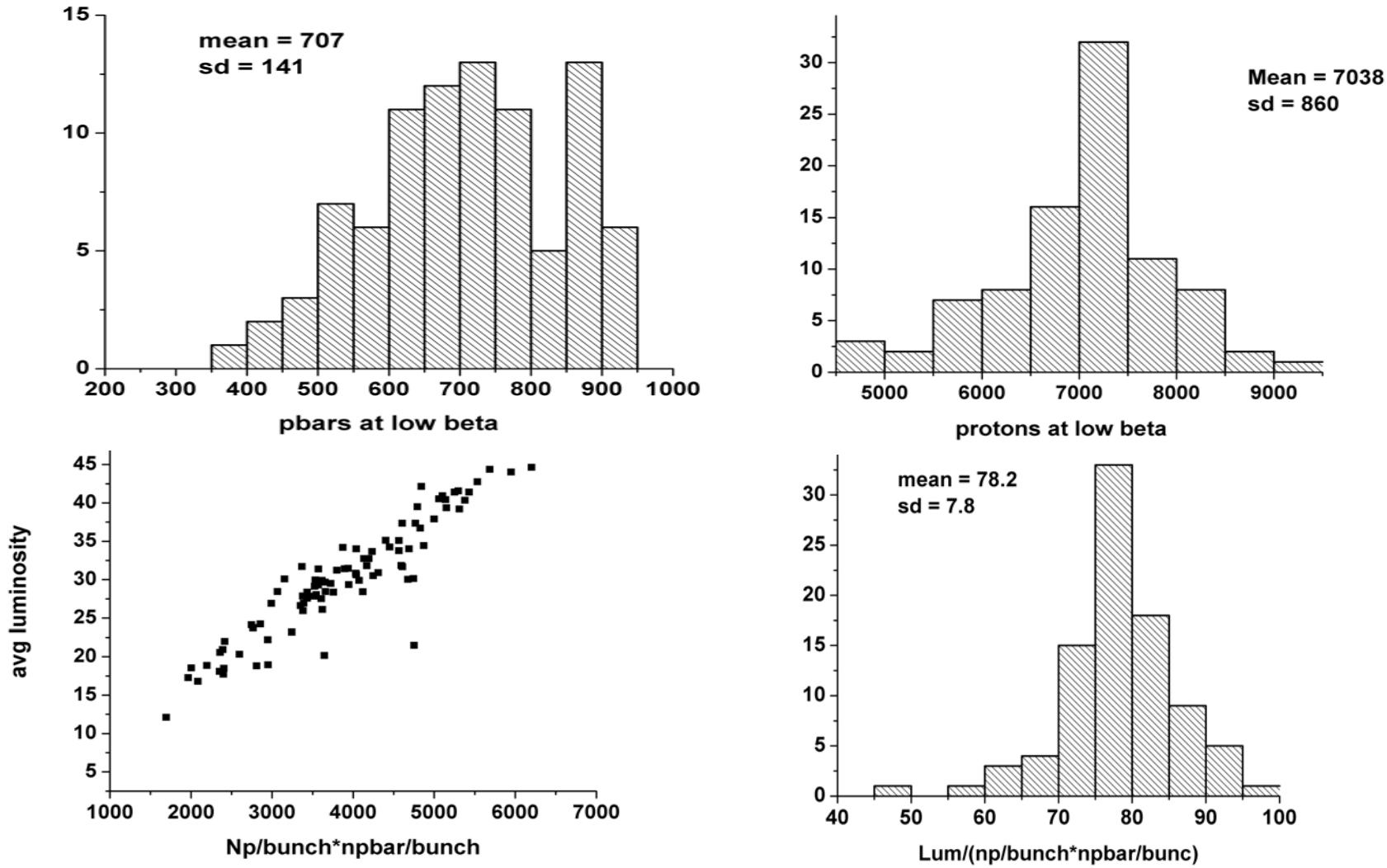
Flying Wires, Pass 1 vs. Pass 2



Supertable

- One line per store
- Built automatically every store
- 90+ quantities of general interest
  - Dates, time on helix, length of store
  - How store ended
  - Luminosities, intensities at collision
  - Efficiencies at each stage from p, pbar sources to HEP
  - Emittances at each stage
  - Peak, average losses
  - Lifetimes, etc.
- Source of tables in Dave McGinnis's plenary talk
- Averages over bunches

Plots From Supertable – Elements of Luminosity



FY03 Collider Parameters

Parameter	Average*	St. Dev.*	Best Integrated	Best Peak	Phase 1	
Initial Luminosity (CDF)	31.2	9.6	42.0	47.4	68.0	$x10^{30}cm^{-2}sec^{-1}$
Average Instantaneous Luminosity (CDF)	19.4	6.8	22.3	27.0	37.9	$x10^{30}cm^{-2}sec^{-1}$
Integrated Luminosity per Store (CDF)	985.7	450.5	1713.0	1650.0	2251.3	nb^{-1}
Luminosity per week (CDF)	4.7	2.6	4.6	7.0	10.9	pb^{-1}
Number of Stores per Week	4.7	-	-	-	4.8	
Store Length	14.4	5.5	21.3	17.0	14.5	Hours
Intentional Store Length	16.6	3.4	21.3	17.0	14.5	Hours
Aborted Store Length	10.6	6.4	-	-	-	Hours
Store Hours per week	68.6	31.9	46.3	91.6	70.3	Hours
Time spent stacking per store	14.6	3.4	19.5	20.9	14.5	Hours
Shot Setup Time	2.8	2.6	1.8	2.0	2.0	Hours
Store Lifetime	13.6	3.8	14.9	13.6	10.8	Hours
Protons per bunch	192.1	29.0	203.8	242.0	240.0	$x10^{9}$
Start Stack	135.3	25.1	166.0	173.0	174.3	$x10^{10}$
End Stack	11.2	13.6	12.0	11.0	0.0	$x10^{10}$
Zero Stack Stack Rate	11.7	1.6	11.7	11.7	18.0	$x10^{10}$/Hour
Zero Stacking Rate Stack Size	303.7	1.7	303.7	303.7	300.0	$x10^{10}$
Pbar Transfer efficiency to Low Beta	57.9	7.5	57.7	56.7	75.0	%
HourGlass Factor	0.64	0.03	-	0.65	0.65	

*Based on 75 Stores between 2/10/03 – 6/5/03

FY03 Collider Emittances

Emittance (measured)	Average*	St. Dev.*	Best Integrated	Best Peak	Phase 1	
Accumulator (Pbar)	5.0	1.5	6.6	7.0	7.0	π-mm-mrad
MI 8 GeV (Pbar)	7.4	1.6	8.9	9.4	9.0	π-mm-mrad
MI 150 GeV (Pbar)	8.5	1.8	10.1	10.5	11.0	π-mm-mrad
TEV 150 GeV (Pbar)	17.6	2.4	21.9	19.9	18.0	π-mm-mrad
TEV 980 GeV (Pbar)	21.2	3.2	-	24.0	19.0	π-mm-mrad
TEV Low Beta GeV (Pbar)	20.9	4.1	22.7	25.1	20.0	π-mm-mrad

Emittance (measured)	Average*	St. Dev.*	Best Integrated	Best Peak	Phase 1	
MI 8 GeV (Proton)	15.2	1.3	14.8	15.5	15.0	π-mm-mrad
MI 150 GeV (Proton)	18.1	1.2	17.5	18.3	18.0	π-mm-mrad
TEV 150 GeV (Proton)	24.5	2.4	22.3	25.9	19.0	π-mm-mrad
TEV 980 GeV (Proton)	25.9	2.0	-	26.6	20.0	π-mm-mrad
TEV Low Beta GeV (Proton)	23.4	2.6	21.9	24.1	20.0	π-mm-mrad

*Based on 75 Stores between 2/10/03 – 6/5/03

FY03 Collider Efficiencies

Cumulative Efficiency	Average*	St. Dev.*	Best Integrated	Best Peak	Phase 1	
MI Injection (Pbar)	94.5	4.2	96.0	96.0	96.0	%
MI Acceleration (Pbar)	93.3	5.7	96.0	96.0	96.0	%
Coalescing (Pbar)	81.9	8.7	82.6	87.4	86.4	%
Tev Injection (Pbar)	73.8	8.8	76.8	78.6	82.1	%
TEVAcceleration (Pbar)	66.4	8.3	65.3	65.3	78.0	%
Initiate Collisions (Pbar)	62.0	9.7	60.0	59.4	75.6	%

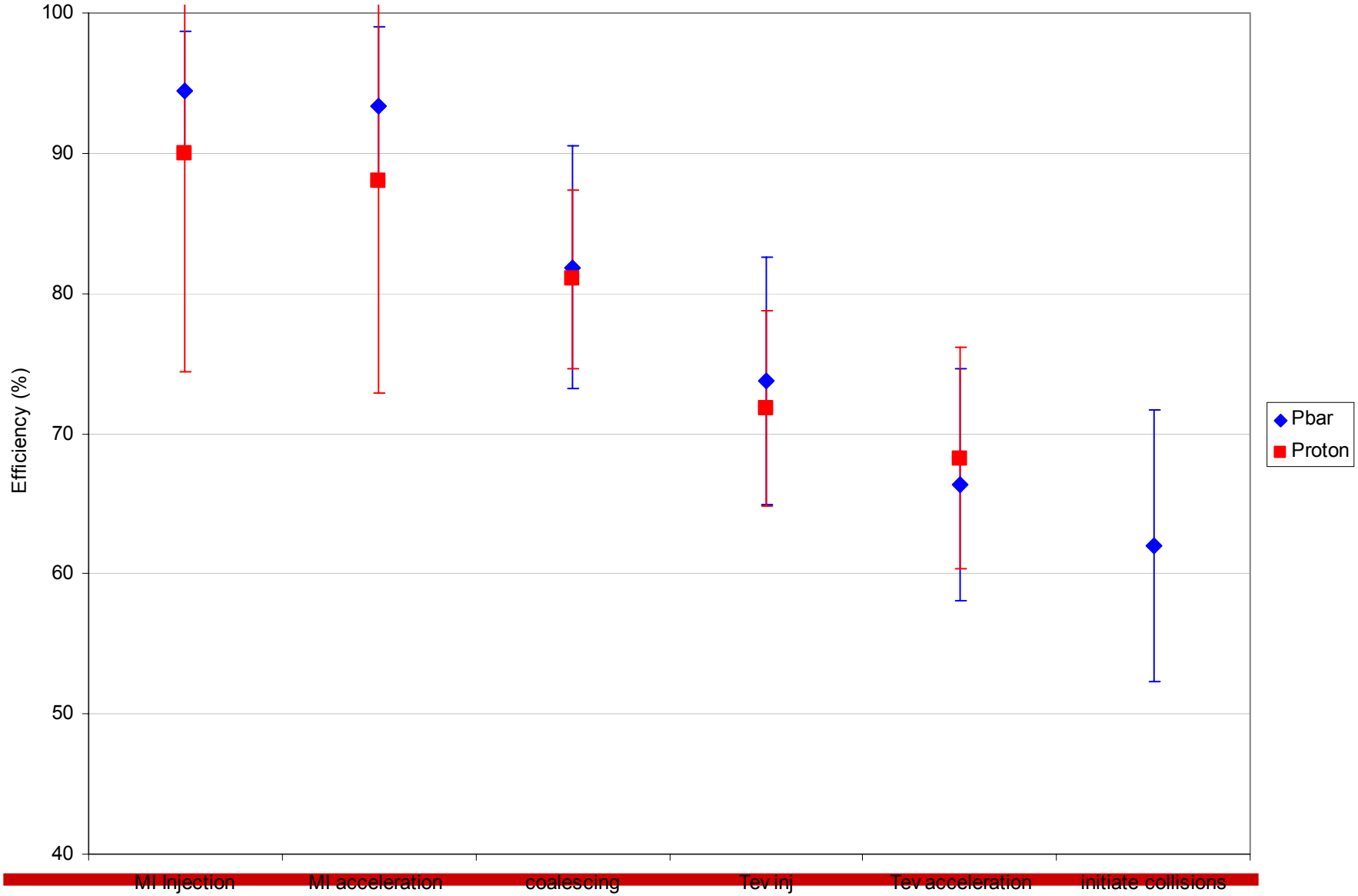
Efficiency	Average*	St. Dev.*	Best Integrated	Best Peak	Phase 1	
MI Injection (Pbar)	94.5	4.2	96.0	96.0	96.0	%
MI Acceleration (Pbar)	98.8	3.5	100.0	100.0	100.0	%
Coalescing (Pbar)	87.6	5.9	86.0	91.0	90.0	%
Tev Injection (Pbar)	90.2	5.7	93.0	90.0	95.0	%
TEVAcceleration (Pbar)	89.9	3.6	85.0	83.0	95.0	%
Initiate Collisions (Pbar)	92.7	8.3	92.0	91.0	97.0	%

Efficiency	Average*	St. Dev.*	Best Integrated	Best Peak	Phase 1	
MI Injection (Proton)	90.0	15.6	100.0	85.0	95.0	%
MI Acceleration (Proton)	97.8	2.2	98.0	100.0	100.0	%
Coalescing (Proton)	86.5	4.3	85.0	90.0	90.0	%
Tev Injection (Proton)	89.1	4.6	88.0	91.0	95.0	%
TEVAcceleration (Proton)	95.7	5.8	96.0	95.0	95.0	%

Cumulative Efficiency	Average*	St. Dev.*	Best Integrated	Best Peak	Phase 1	
MI Injection (Proton)	90.0	15.6	100.0	85.0	95.0	%
MI Acceleration (Proton)	88.0	15.1	98.0	85.0	95.0	%
Coalescing (Proton)	81.0	6.4	83.3	76.5	85.5	%
Tev Injection (Proton)	71.8	7.0	73.3	69.6	81.2	%
TEVAcceleration (Proton)	68.3	7.9	70.4	66.1	77.2	%

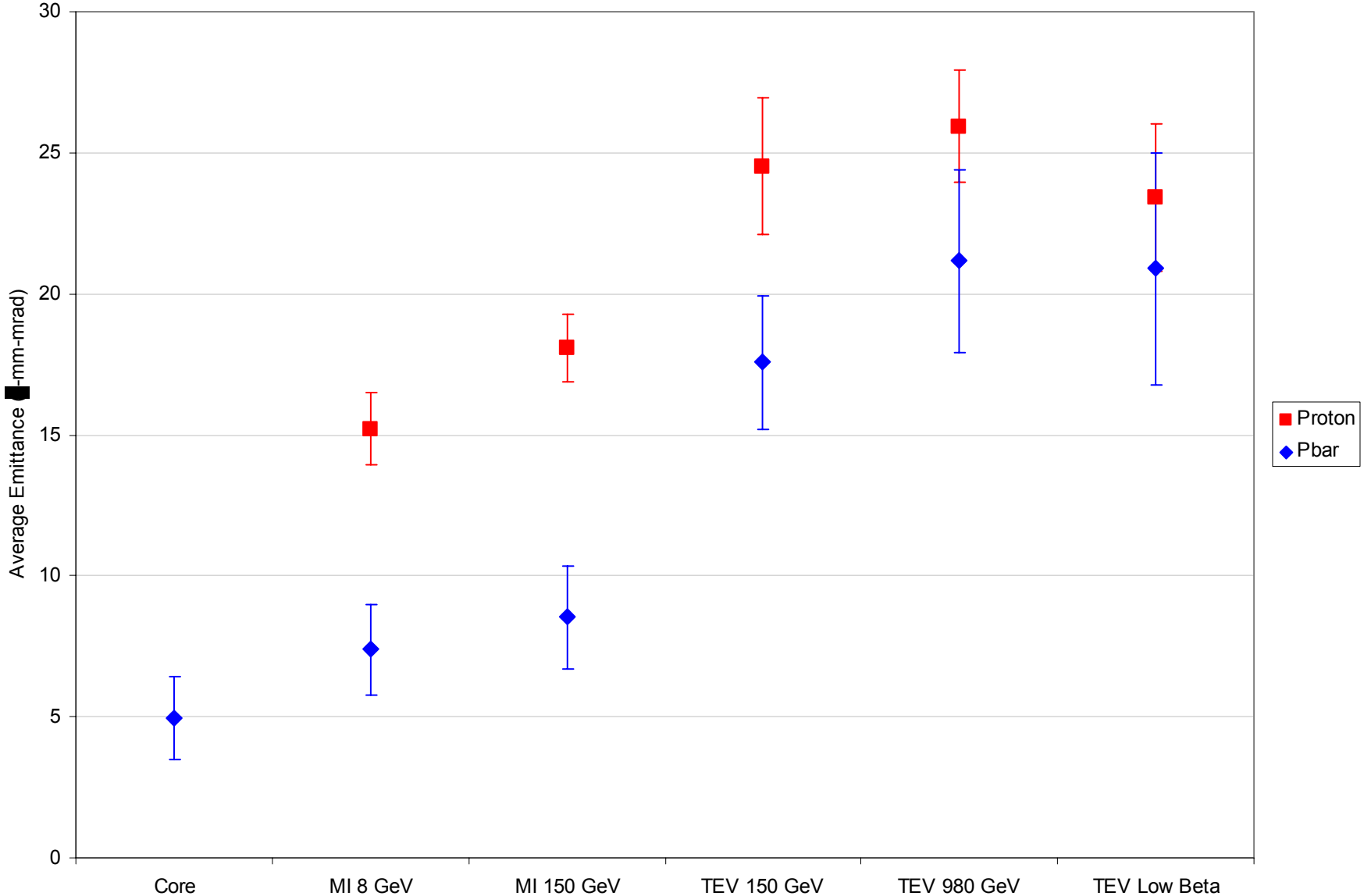
*Based on 75 Stores between 2/10/03 – 6/5/03

FY03 Collider Efficiencies



*Based on 75 Stores between 2/10/03 – 6/5/03

FY03 Collider Emittances



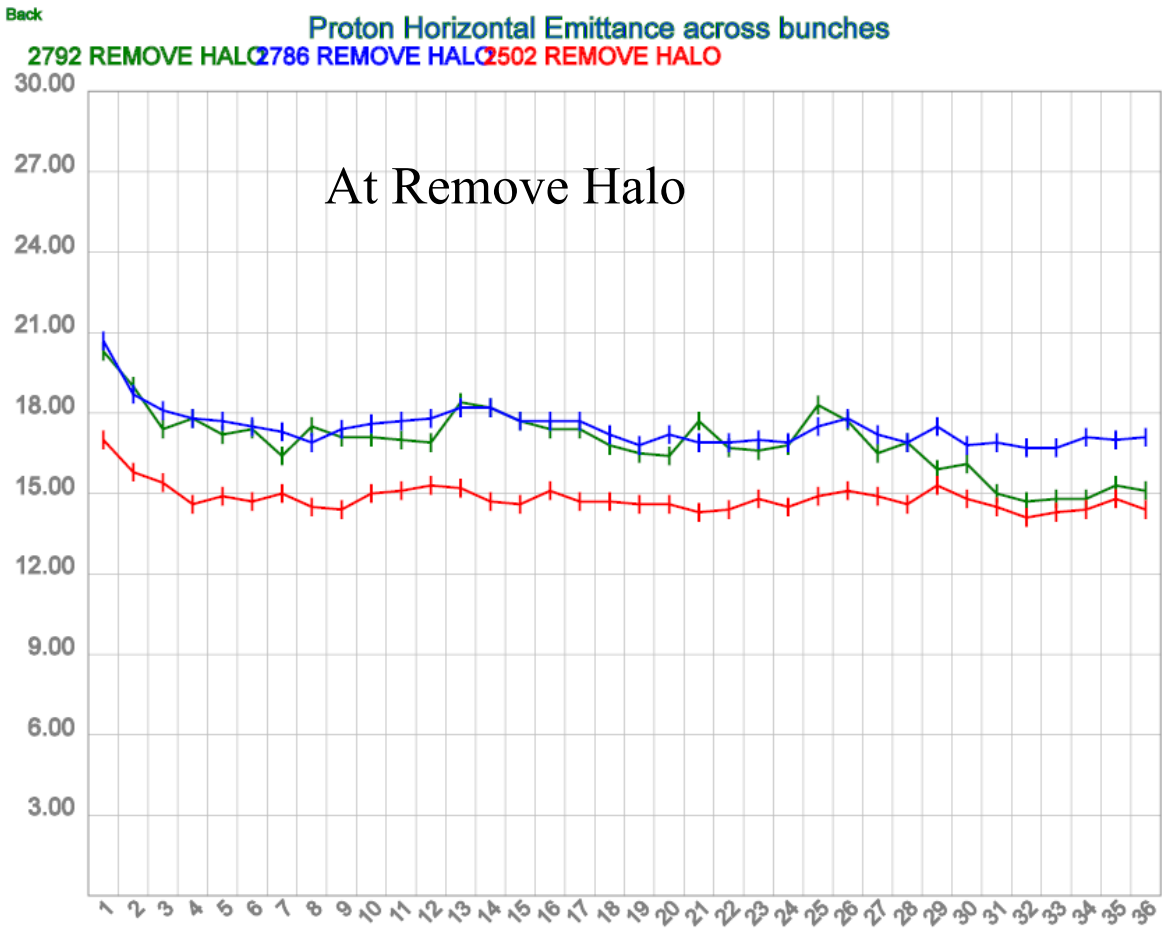
*Based on 75 Stores between 2/10/03 – 6/5/03

Derived Tables- Detailed Information on each Store

- Table per store – built automatically
  - All 6 emittances
  - Intensities
- Average and bunch by bunch information
- Use best algorithms to get physics quantities
  - Not always available directly from front-end.

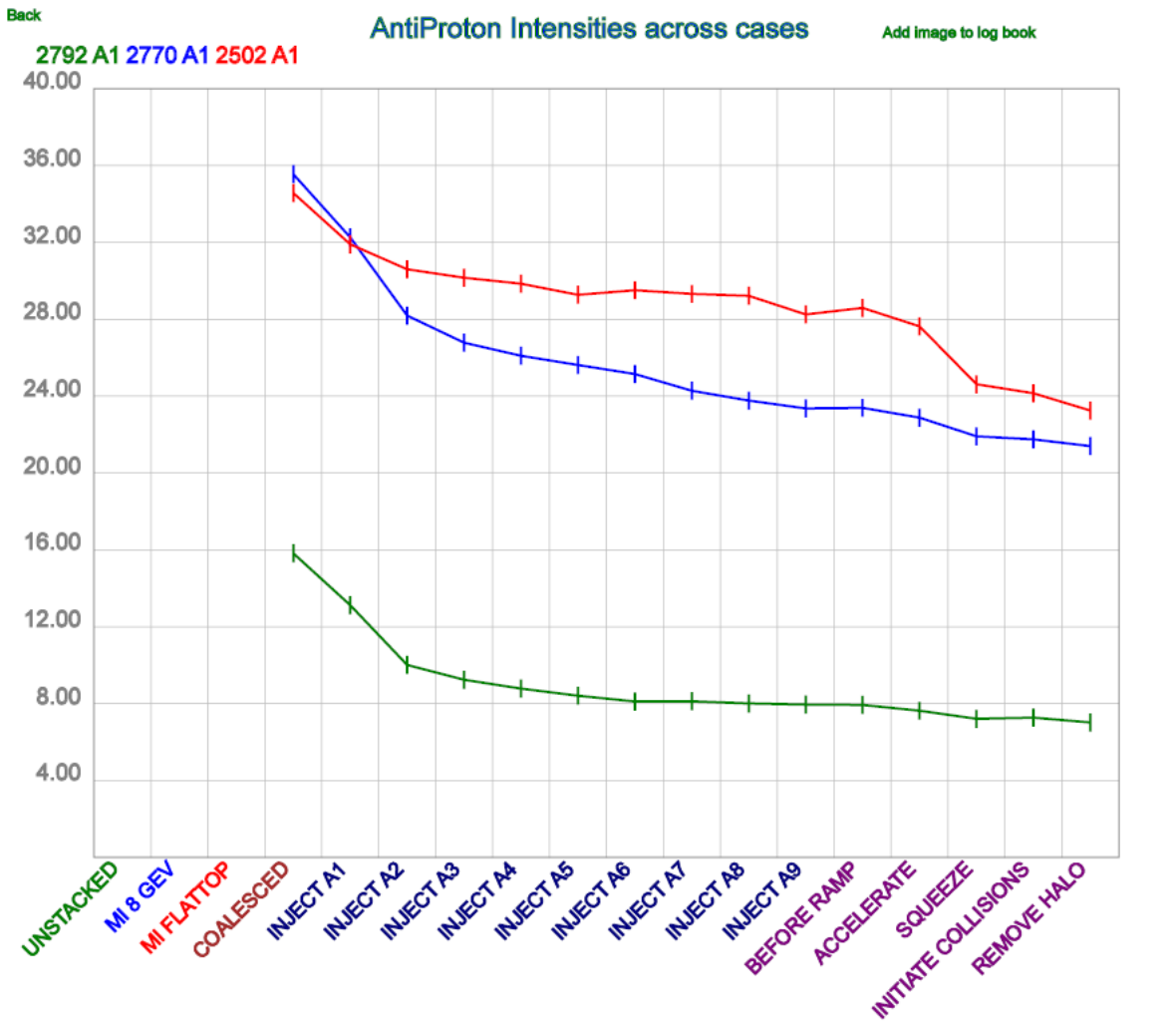
Example – Bunch by Bunch Comparison for 3 Stores

emittance



Bunch number

Intensity for the 1st pbar bunch



Special Analyses

- Different Methods
  - Extract data using Report Writer, Interactive Viewer, tables
  - Write a simple Java program using data extraction and physics classes – OSDA library

- Examples
  - Paul Lebrun's talk in joint session on the pbar burn rate
  - K. Genser's work on understanding flying wires and sync light d
  - PAC 2003 papers on
    - Computed vs. measured luminosity
    - Luminosity lifetime and emittance growth during HEP

Summary

- SDA allows the correlation of information from all different sources to look for correlations
- Much progress in the past 6 months
- Effort is now in the Accelerator Integration Department and is being expanded