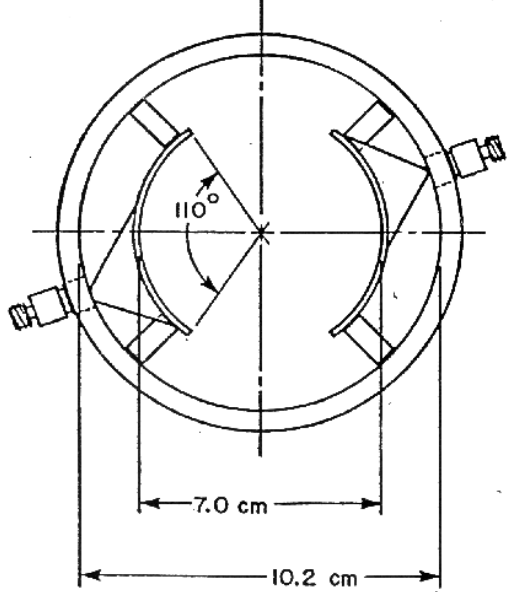


Tevatron BPM Upgrade

Stephen Wolbers
(for the Tevatron BPM Upgrade Project)

All Experimenters Meeting

January 24, 2005

Outline

- Project description and scope.
- Current Status and Upgrade BPM Performance.
- Plan for final installation and commissioning.

TeV Beam Position Monitor (BPM) Upgrade Project

- **Joint CD/AD project.**
  - Began in August 2003.
- **Key contributors and contributions:**
  - Jim Steimel: Technical Coordinator
  - Mike Martens: Specifications and Tevatron requirements, integration.
  - Luciano Piccoli, Margaret Votava: Front-end software
  - Vince Pavlicek, Ken Treptow, Bill Haynes: Engineering
  - Dehong Zhang: Testing, integration
  - Tim Kasza: Hardware testing and acceptance, tracking
  - Rob Kutschke: Analysis, calibration
  - Brian Hendricks: Controls interface, console applications.
  - Bob Webber: Technical guidance and instrumentation experience and project management.
  - Bakul Banerjee: Project assistant

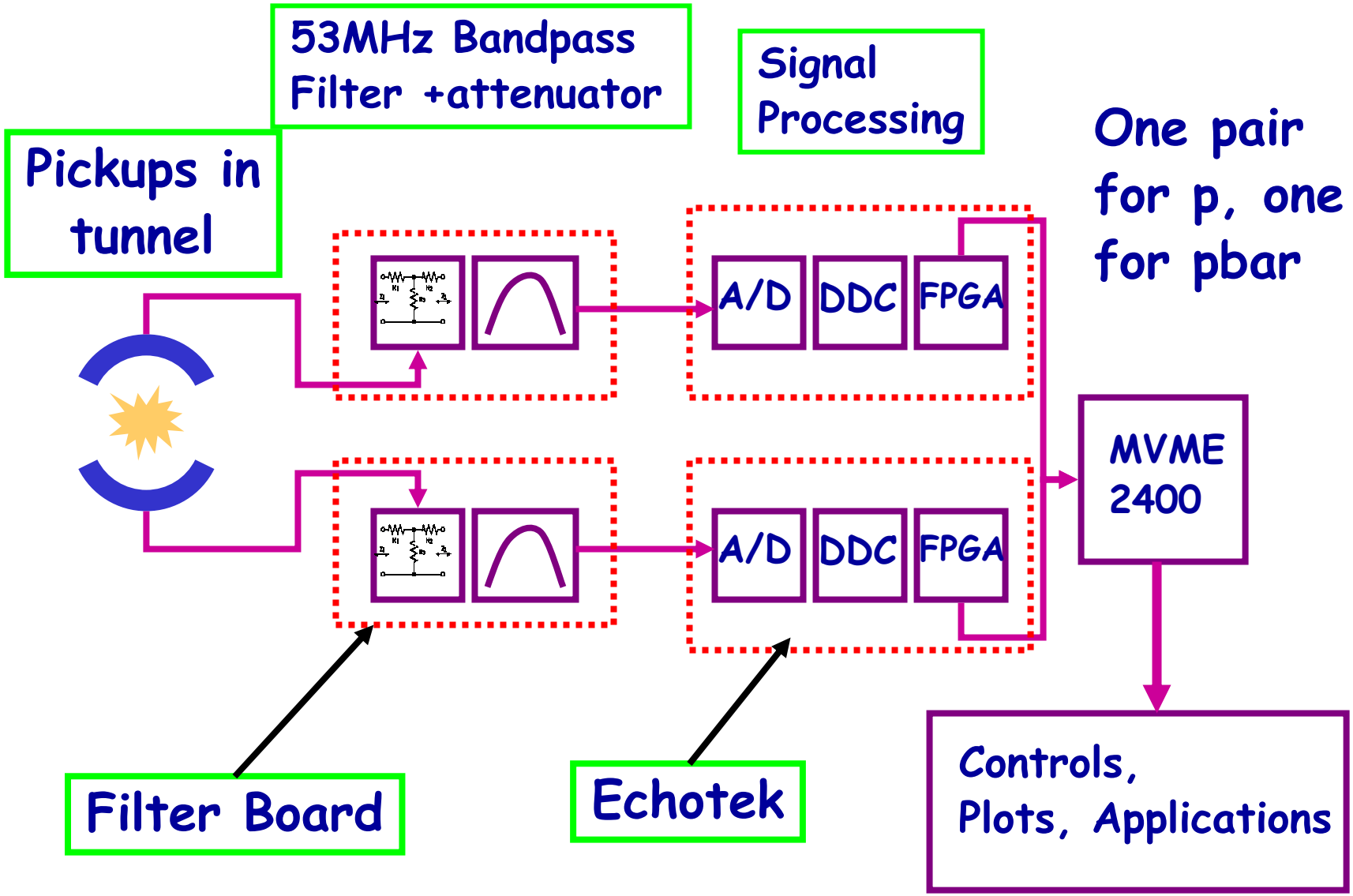
Specifications/Reasons for upgrade

- Old hardware was not accurate, precise or reliable enough for the Tevatron, nor was it able to measure pbar positions.
- New system goals/requirements:
  - Stable, accurate, precise measurements
    - Aiming for <10 micron (1 sigma) precision for best proton position measurement
    - Current system has 150 micron least significant bit
  - Reliable hardware and software
  - Software to collect and use the data.
    - More sophisticated data analysis is not part of the project (e.g., lattice measurements)
  - Measurement of antiproton positions (new capability)
    - Requires twice as many electronics channels

TeV BPM Upgrade Scope

- New electronics.
- Front-end software.
- Data to the online/controls system.
- Modified applications to use the new data.
- The pickups in the accelerator will not be modified!
- Both ends (p and pbar) of the pickups will be instrumented.

Block Diagram – vertical BPM



Hardware Components

- **Echotek Digital Signal Receiver (150)**
  - Commercial 8 channel 80 MHz 14 bit ADC, DDC, FPGA
  - Exact or similar boards are common to Recycler, Transfer Lines, NUMI, MI BPM projects
- **Front-end Filter Board (150)**
  - 53 MHz band-pass filter, 10 or 20 dB attenuator, relays for diagnostic signal
  - Designed by CD
- **Timing Board (38)**
  - Provides clocks and triggers for Echotek
  - Provides 53 MHz diagnostic signals
  - Designed by CD
- **MVME Processors, VME subracks, Crate monitoring, cables, test stands, test signals, controls network.**

Software Overview

- **Front-end**
  - Processes Echotek output to provide
    - Closed orbit
    - Turn by turn
    - First turn
  - Manages data collection and modes of operation
- **Online/console applications**
  - Moves data into controls system and applications, libraries and databases.
- **Offline/calibration**
  - Provides necessary deconvolution (pbar) and corrections to ensure accuracy and precision of the system.
  - pbar measurements are available at the front-end.

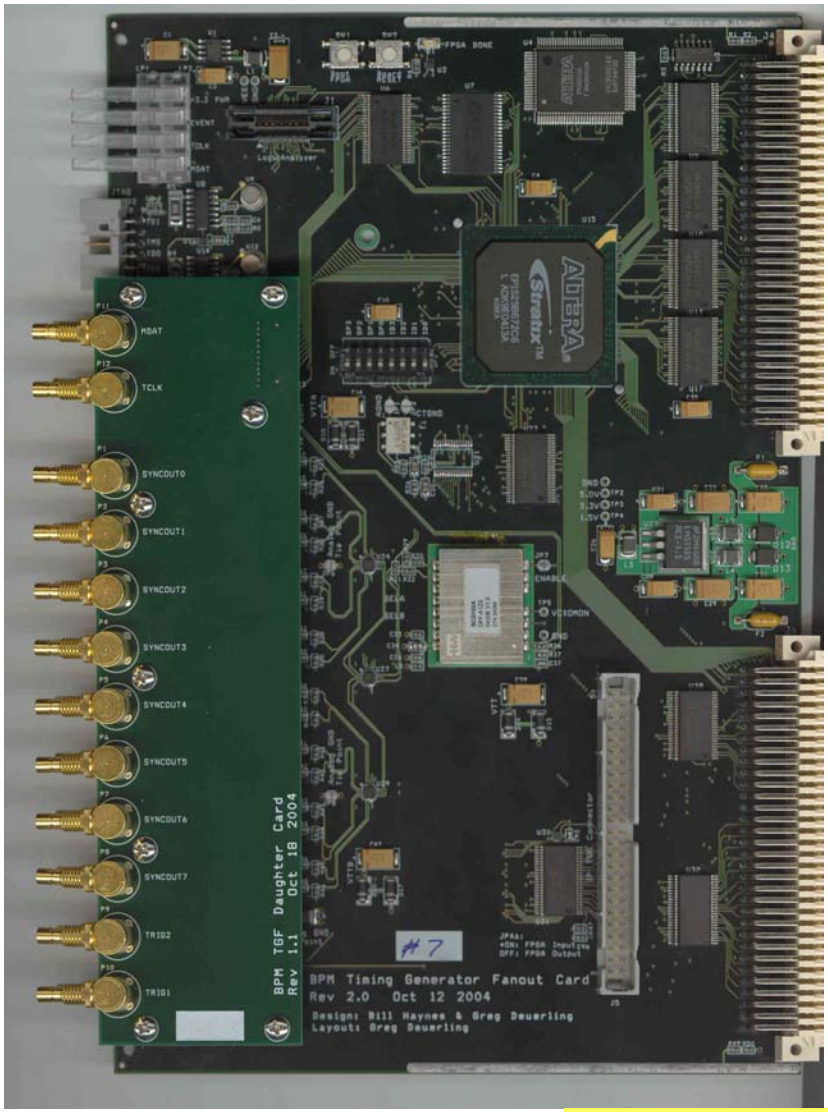
Documentation

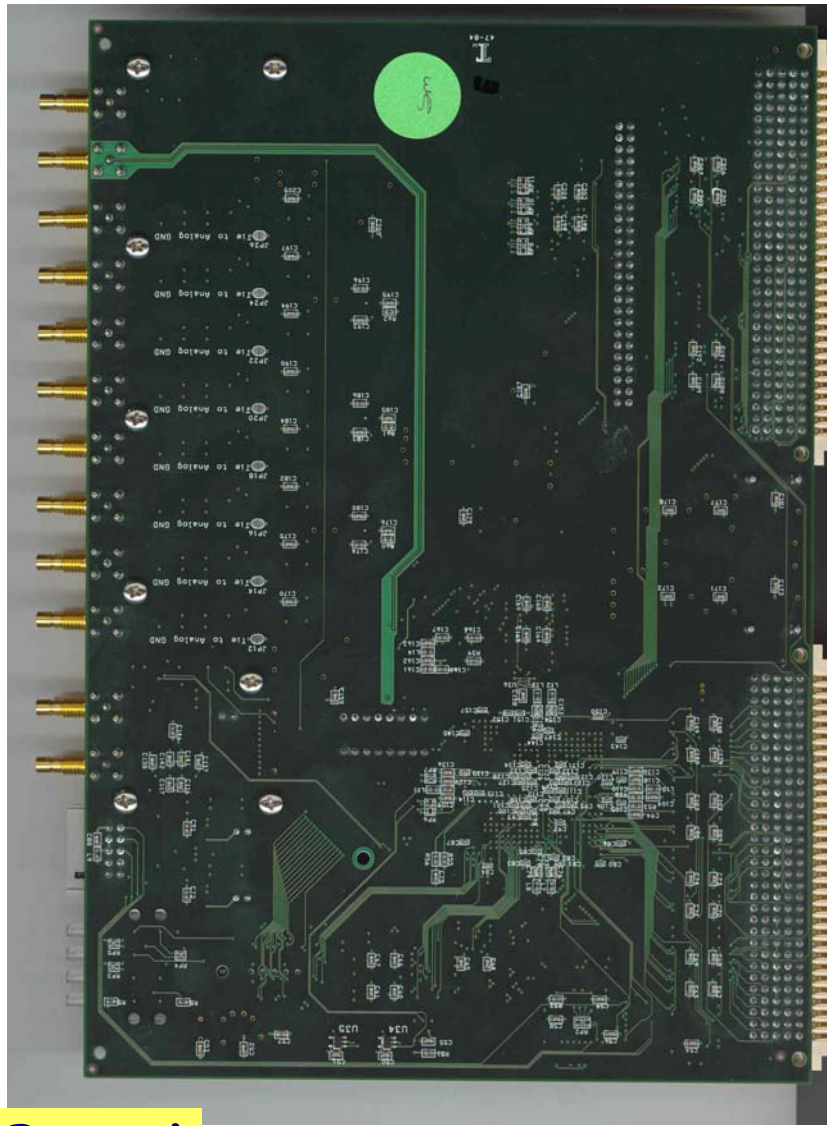
- Requirements, specifications, designs, PRRs, test plans, as-builts, manuals, MOUs
- 183 documents in Beams docDB as of 1/23/05.
  - All of the above, plus:
  - Technical memos
  - Review reports
  - Meeting minutes
  - Talks
  - Data analysis
- Web pages, mailing lists, etc.

Tev BPM Current Status

- Essentially all hardware is hand,including spares:
  - 150 Echotek digital receiver boards.
  - 150 Front-end filter boards.
  - 38 Timing boards.
  - 31 Crate controllers (MVME 2400)
  - Crates, cables, panels.
- All cabling from tunnel to service buildings (27) is in place.
- Space has been identified in all of the service buildings for electronics installation.
  - In a few cases the old system will have to be removed to make room for the new one.
  - The BLM electronics/readout system will remain in place.

Timing Board



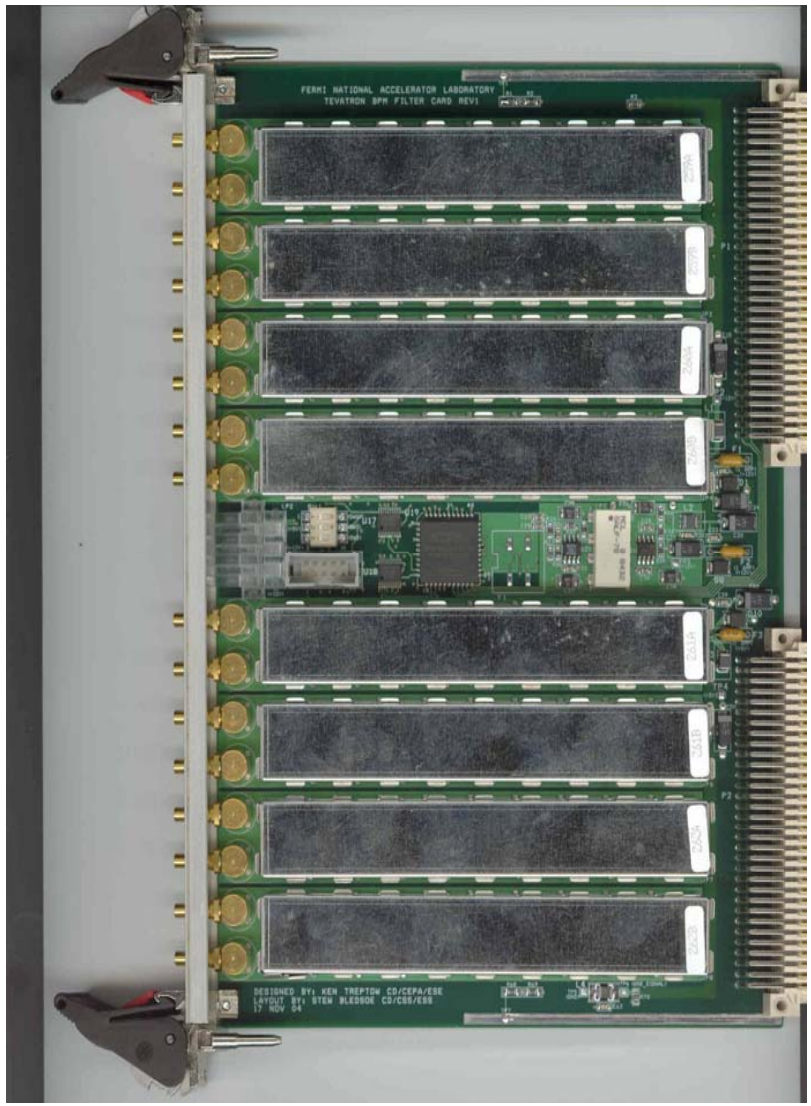


Production Board

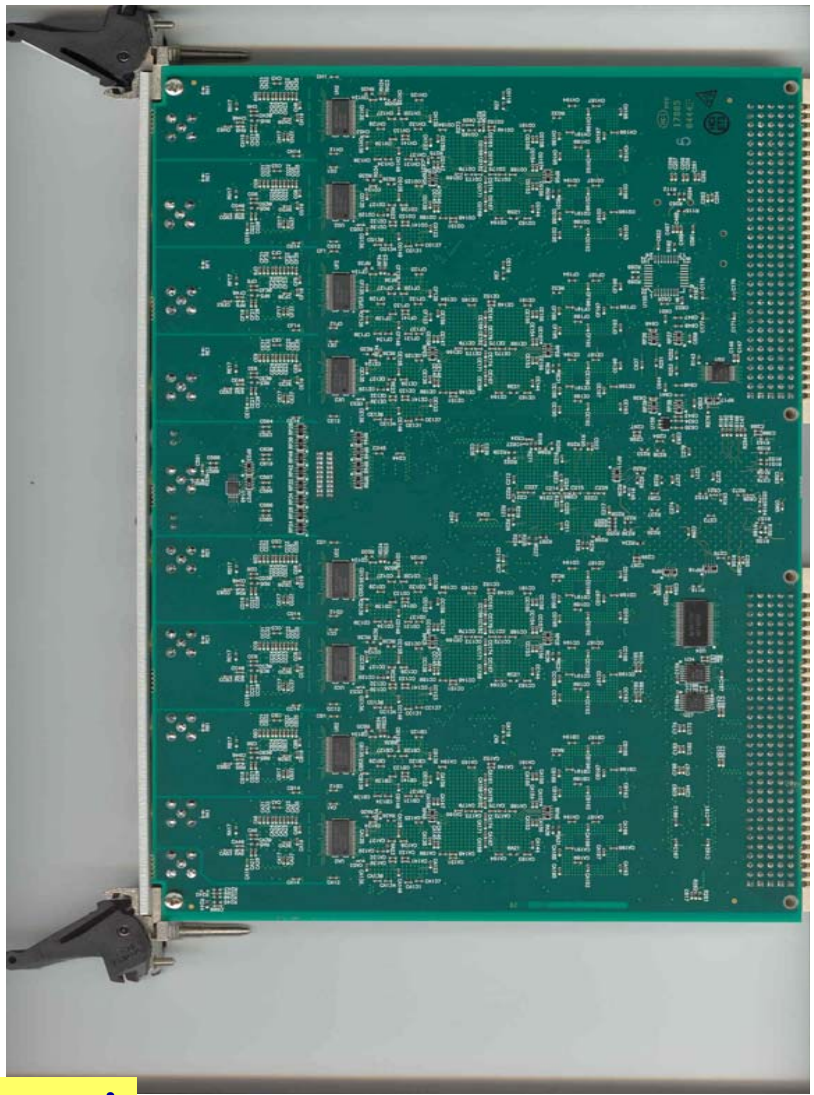
Filter Board

- 8 channels
- 53 MHz band-pass filter
- Attenuation Circuit
- Relays/53 MHz diagnostic signal
- Shielding

Production Board



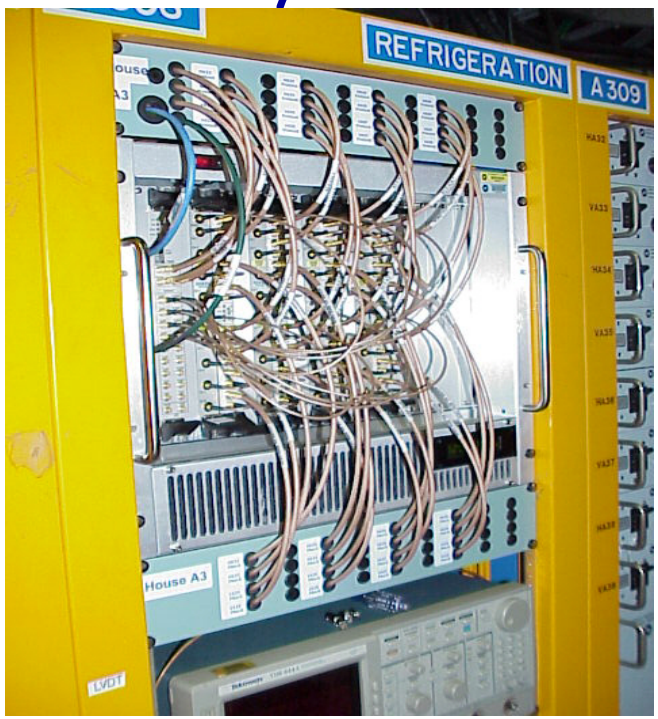
Echotek Board



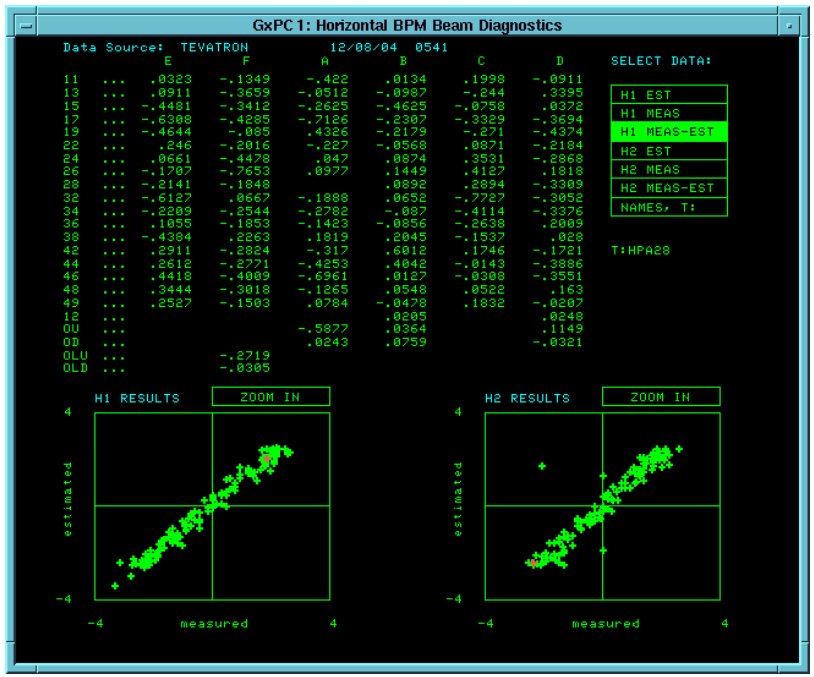
Production Board

Current Status

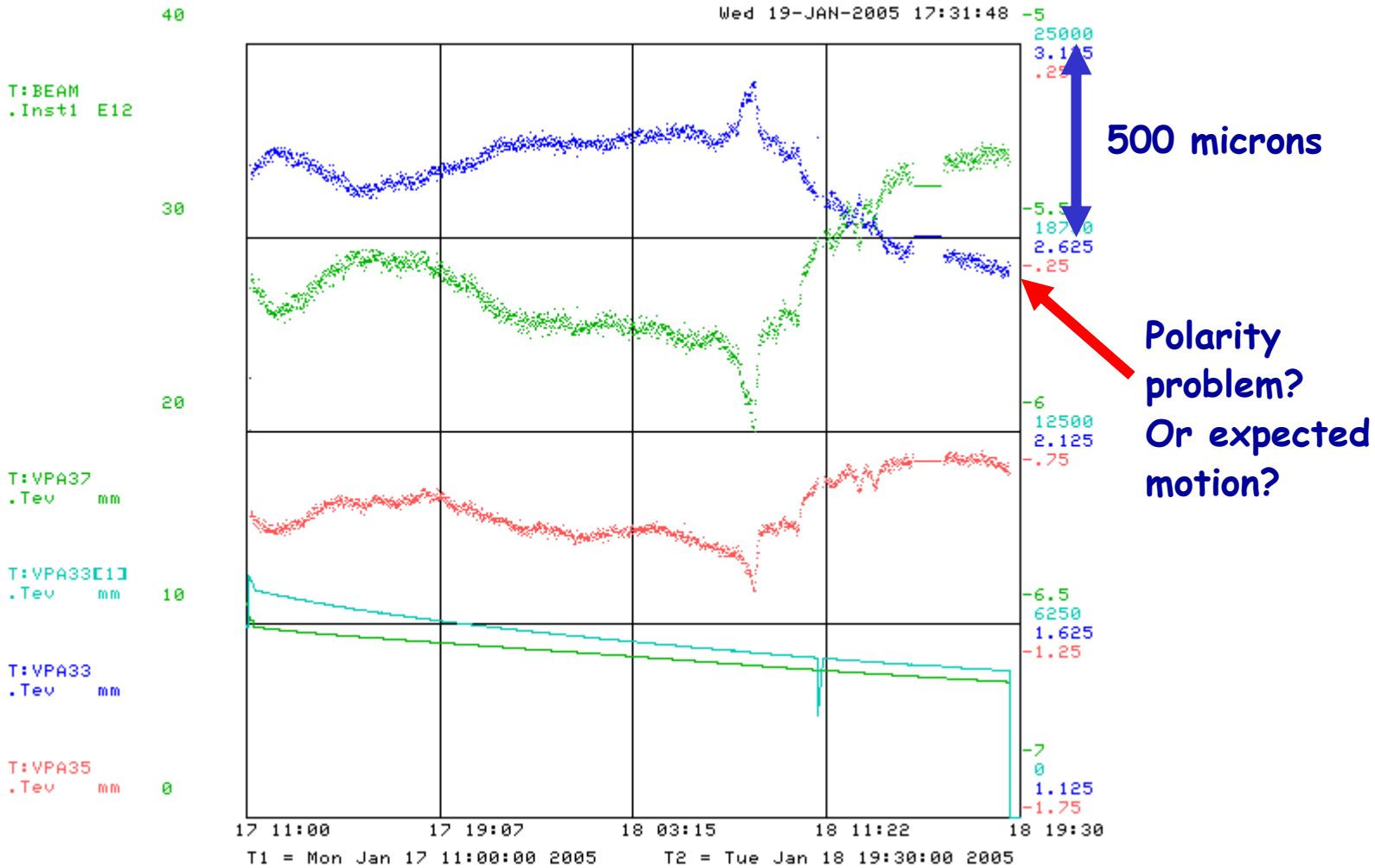
- A3 system was constructed in FCC3 and installed in A3 on November 23.
- Currently commissioning closed orbit, TBT, first turn and pbar measurements.
  Many things have been checked, including scale, polarity, resolutions, pbar measurements, system reliability and stability.



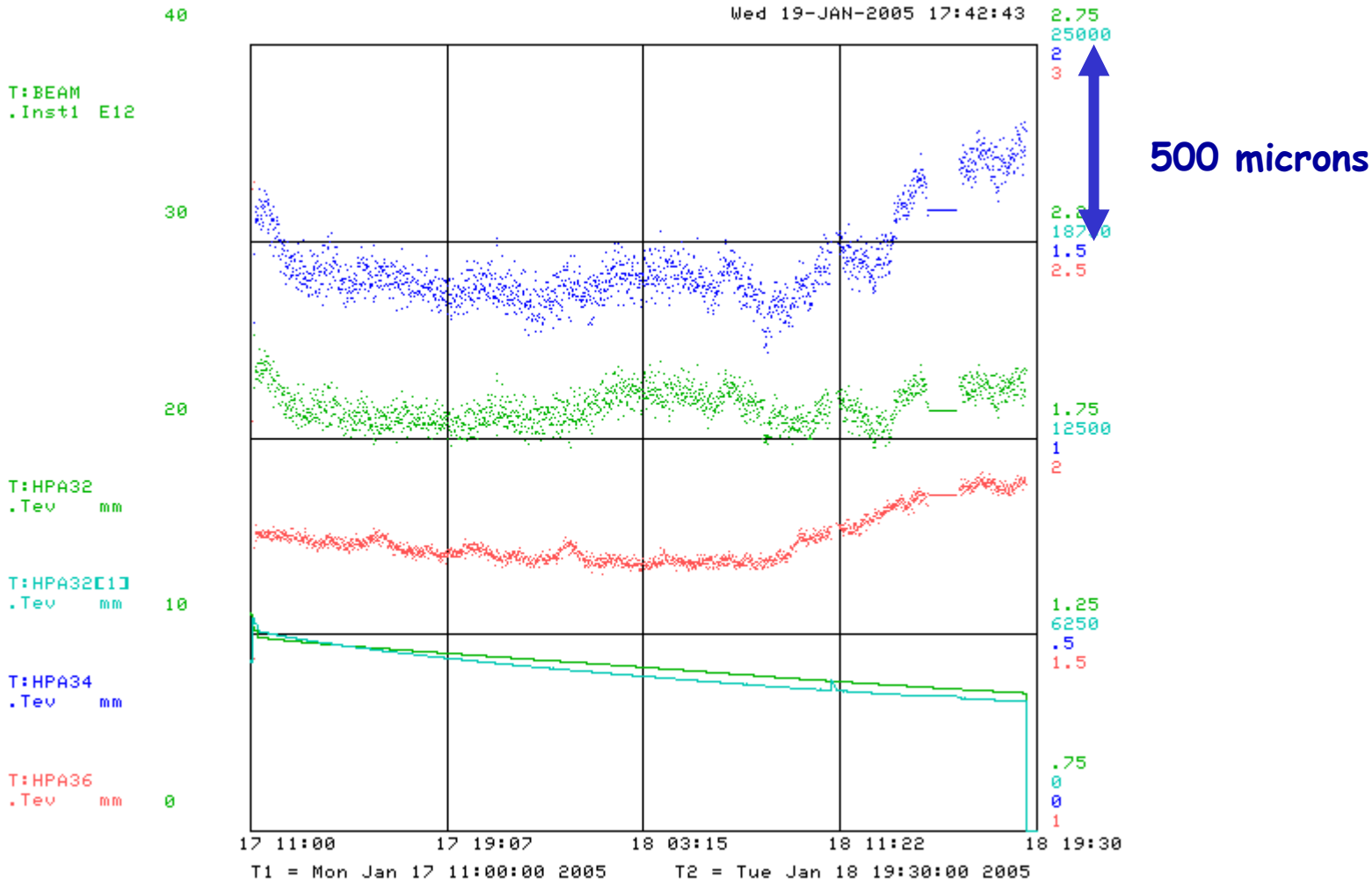
Scale Check



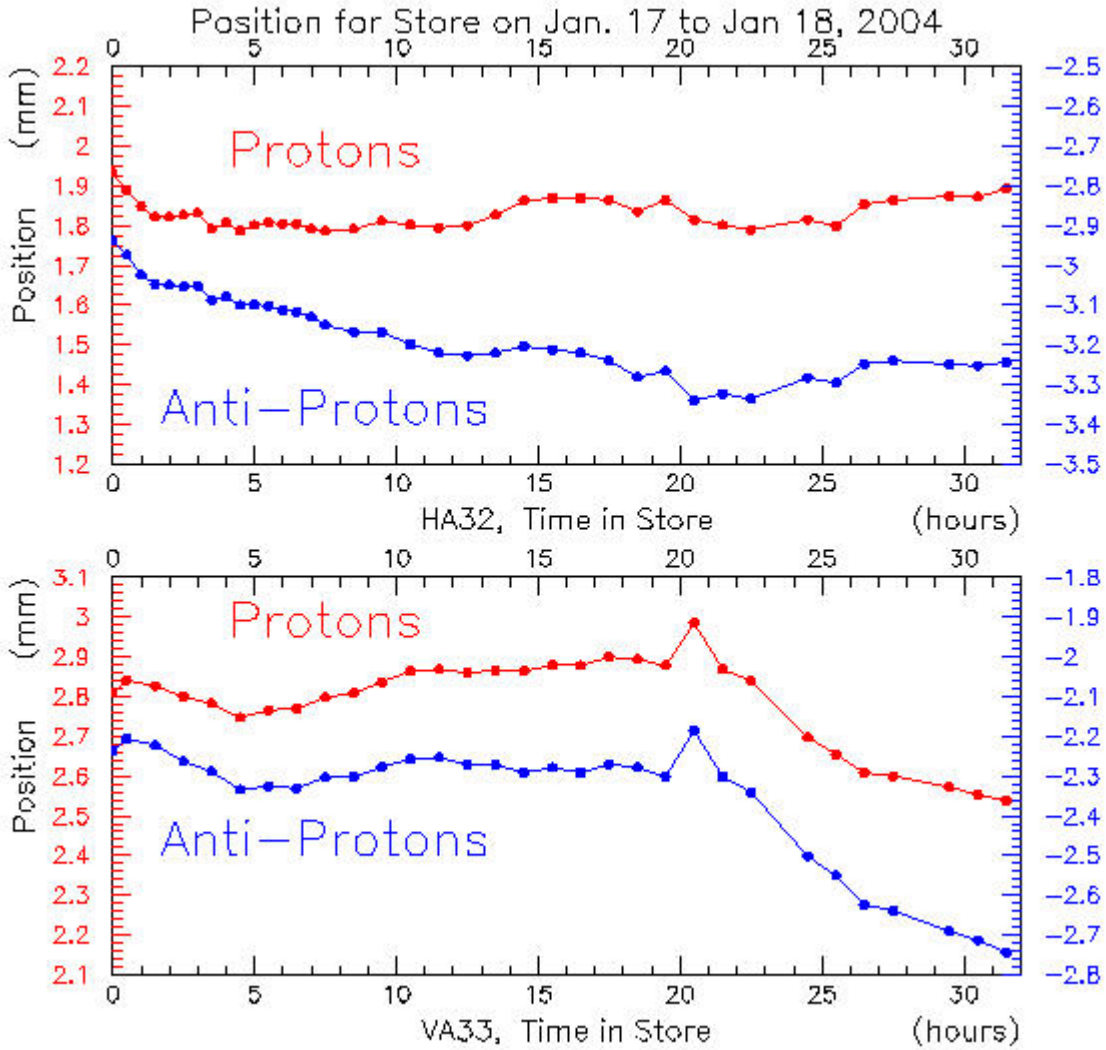
Recent Store (Monday 1/17/05) Vertical



Same store - horizontal

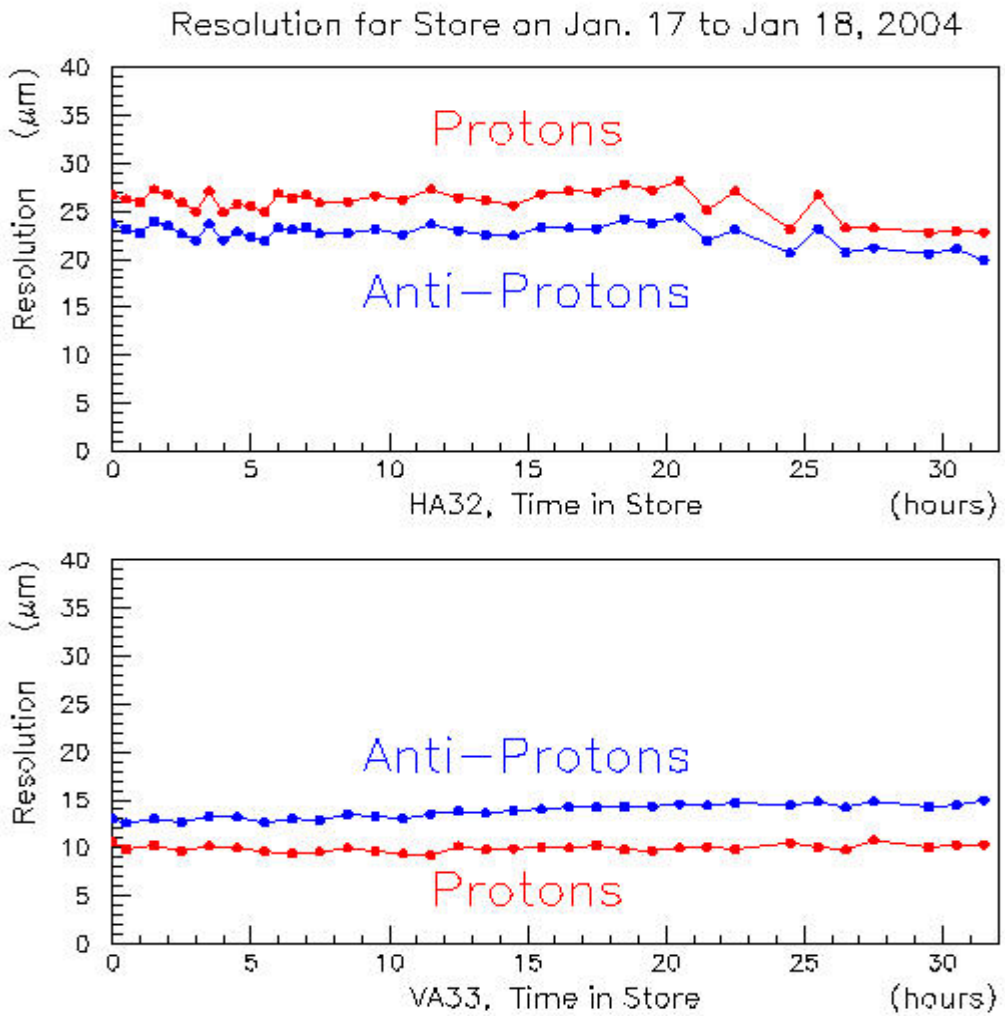


p and pbar positions during 1/17/05 store



Early results- Still need to Analyze to see If it makes Sense.

P and pbar resolutions (closed orbit) during 1/17/05 store



Horizontal ~20-25 μm (thought to be due to beam motion)

Vertical ~10-15 μm

Schedule/Plan

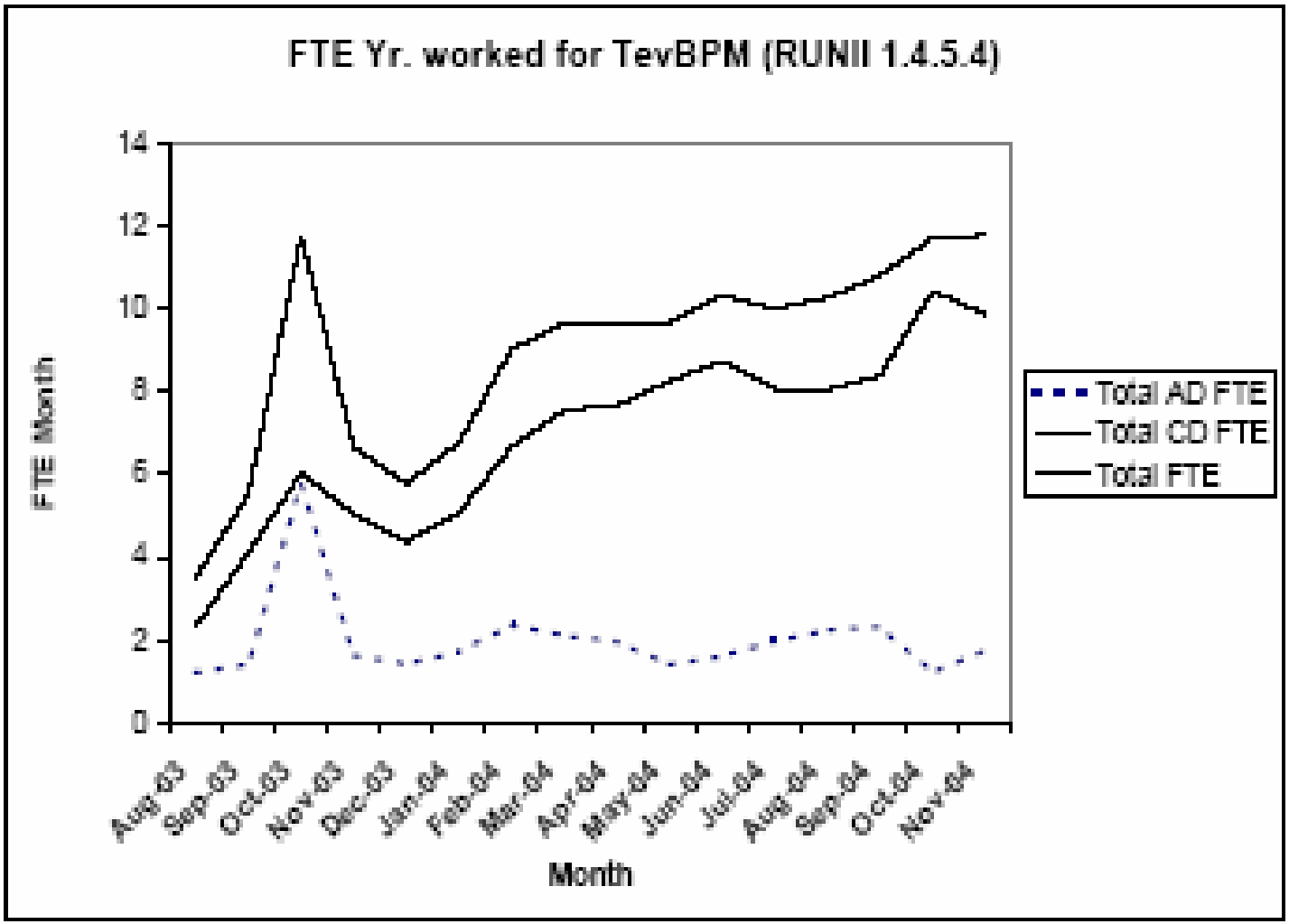
- The plan is to commission houses one at a time (so as not to interfere with Tevatron operations) and to do so as quickly as possible.
  - Proposal for commissioning order:
    - A3,B3,C3,D3,E3,F2,B0,D0,A2,B2,C2,D2,E2,A4,B4,C4,D4,E4,A1,B1,C1,D1,E1,A0,F3,F4,F1
- Step 1: Finish commissioning A3 and get sign-off from Tevatron Department
- Week 1: B3
- Week 2: C3
- Two or three houses per week after that
- Finish in April, 2005.

Summary

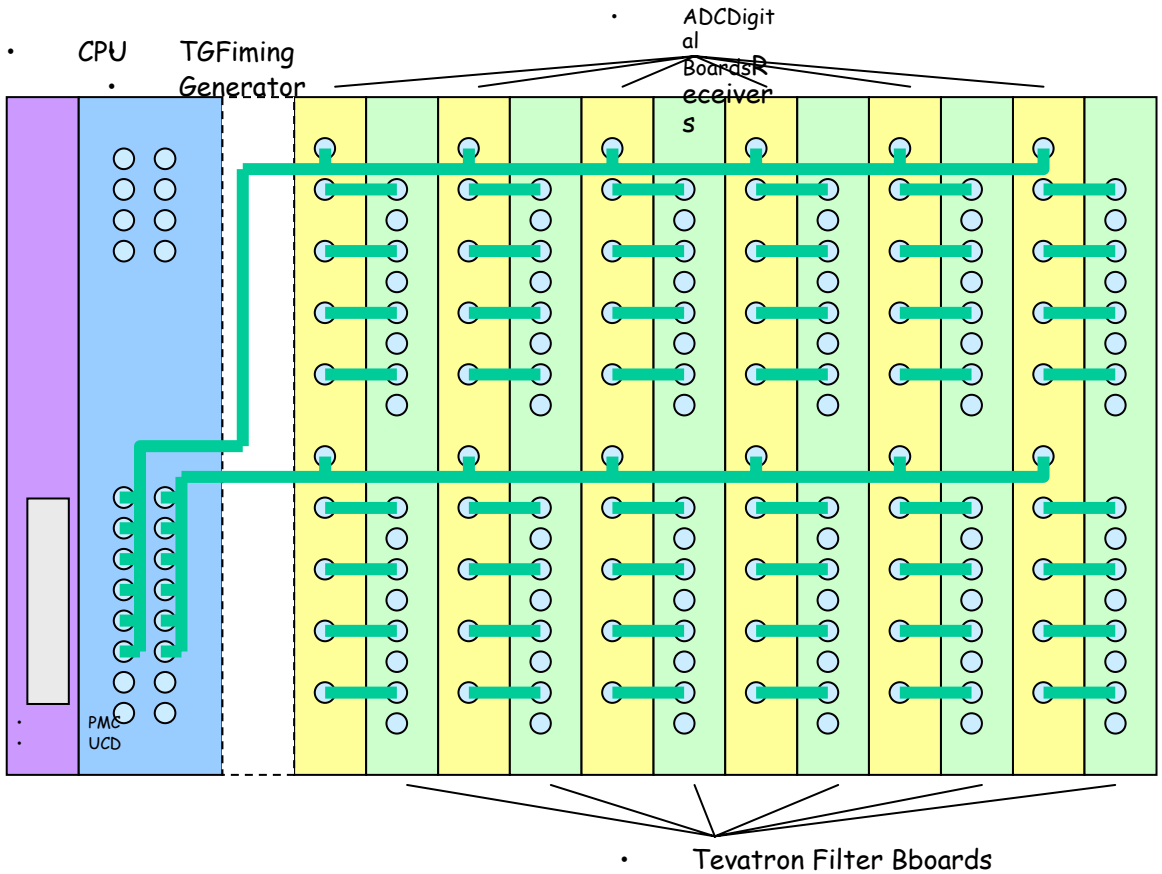
- The TeV BPM Upgrade project is moving to final commissioning of all 27 houses, replacing the old system with a more modern, reliable, and precise system.
- This has been made possible by the efforts of many people (~35 individuals) from CD and AD who contributed over the past 1.5 years.

Backup Slides

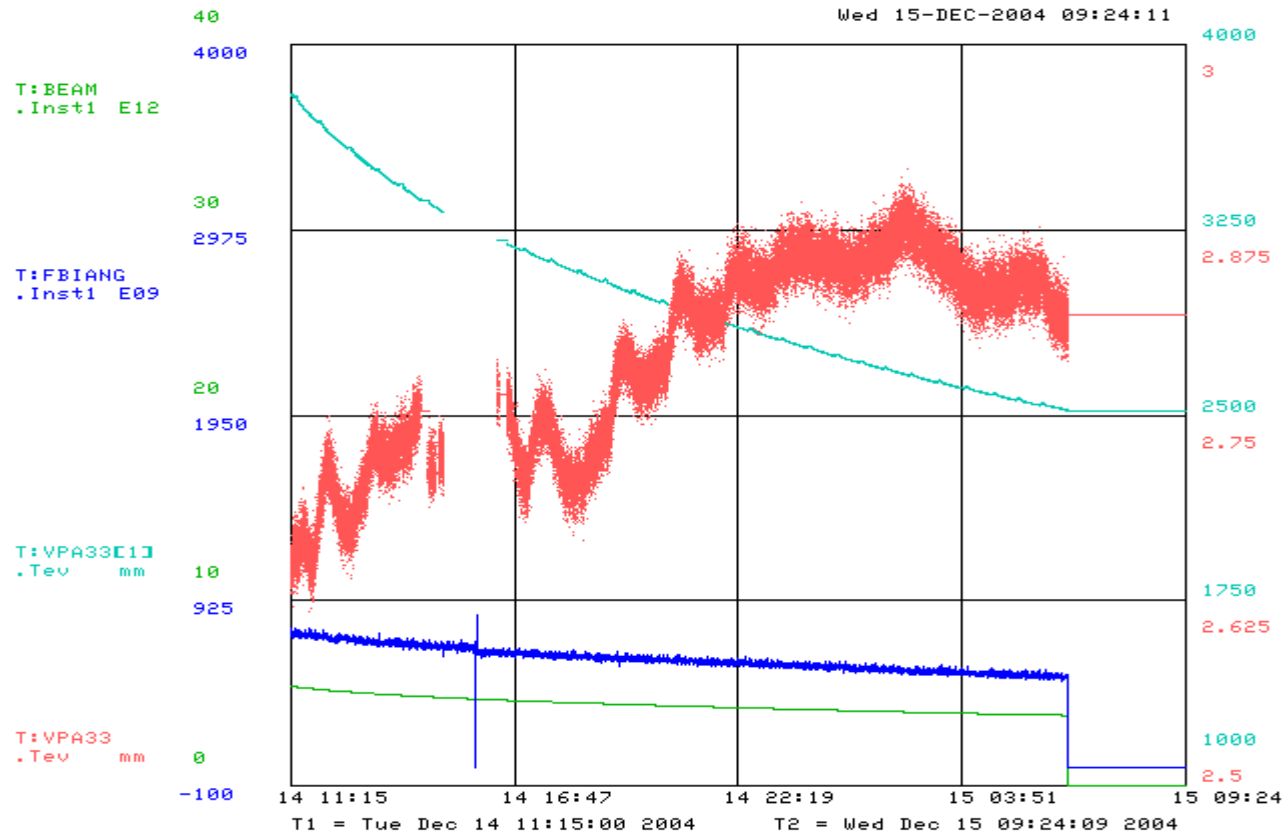
Effort


FTE Yr. worked for TevBPM (RUNII 1.4.5.4)
FTE Month
14
12
10
8
6
4
2
0
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04
Oct-04
Nov-04
Month
Total AD FTE
Total CD FTE
Total FTE

VME Crate Layout



Results from A3 system – closed orbit, complete store



A3 Result – Turn-by-turn and closed orbit comparison

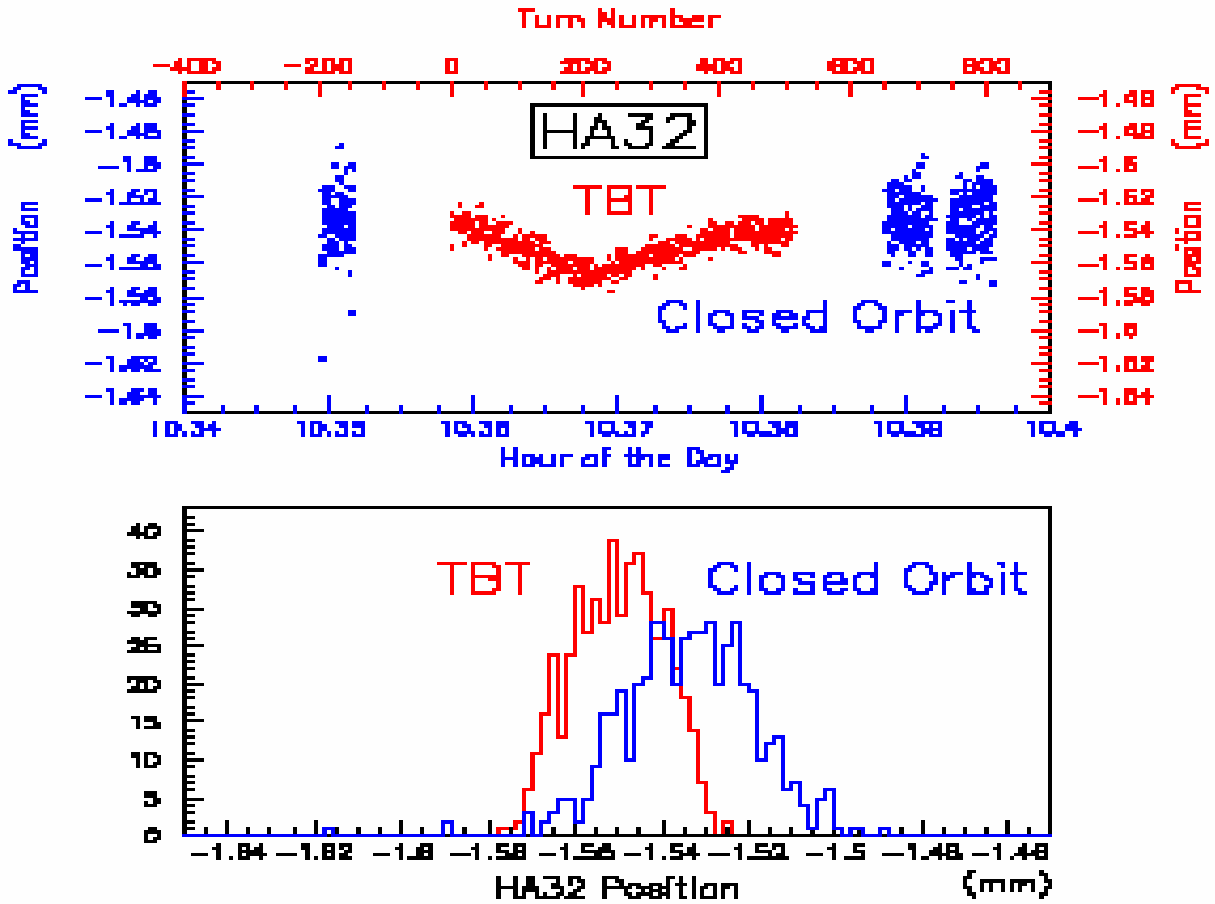


Figure 7: cc

A3 Results-TBT resolution

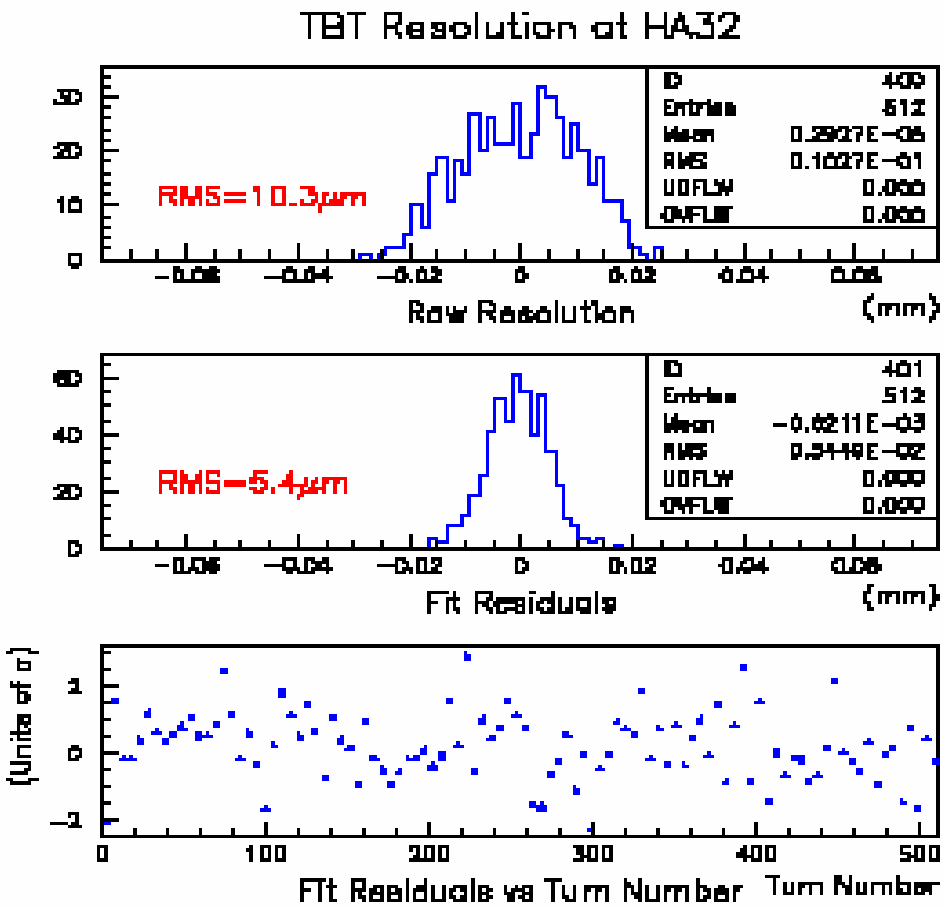


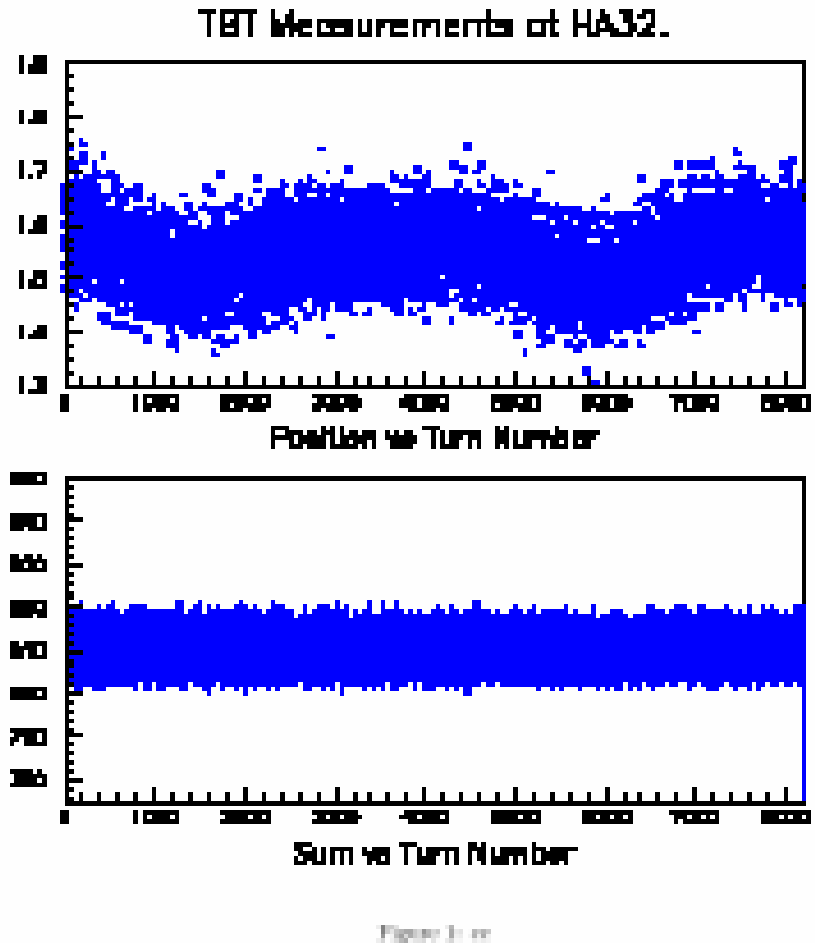
Figure 2: cc

Problems/Issues/Recent Progress

- We must commission the A3 BPM system before moving into commissioning of the other 27 houses.
- Major work to debug and solve issues related to:
  - Timing and triggers
  - Echotek board processing
  - Front-end software
  - Applications "seeing" new data

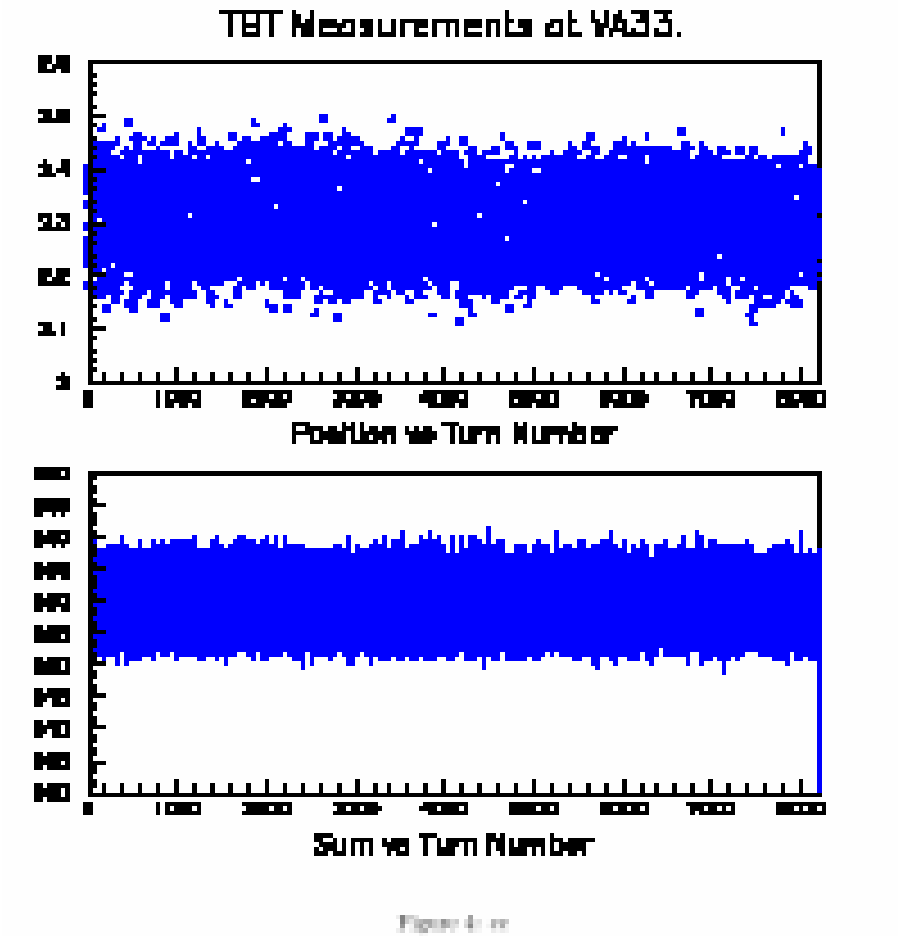
A3 Results-TBT resolution
Caveat: still being debugged

Bob Webber:
Presentation of TBT measurements is OK, but should be qualified as data from a system not yet well tested, characterized, or optimized even in controlled conditions.

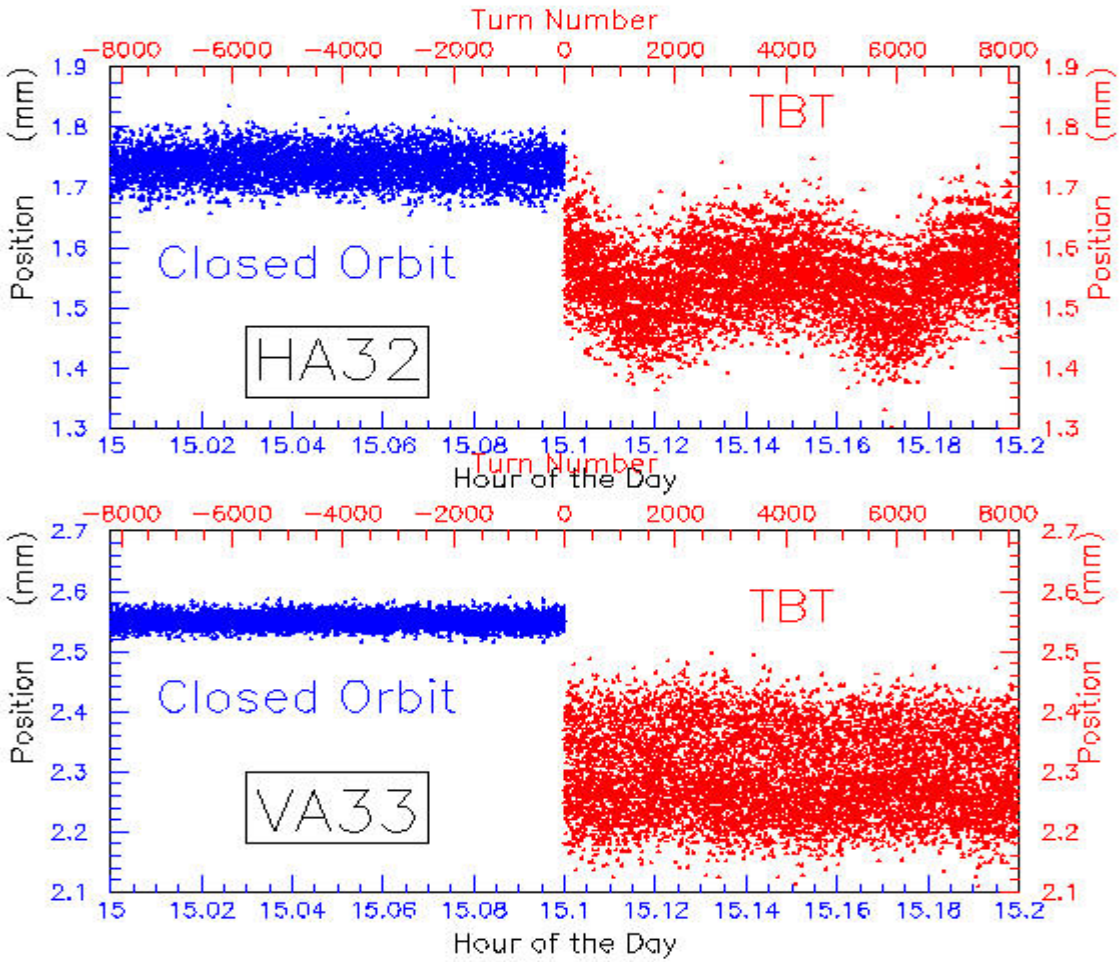


A3 Results-TBT resolution
Caveat: still being debugged

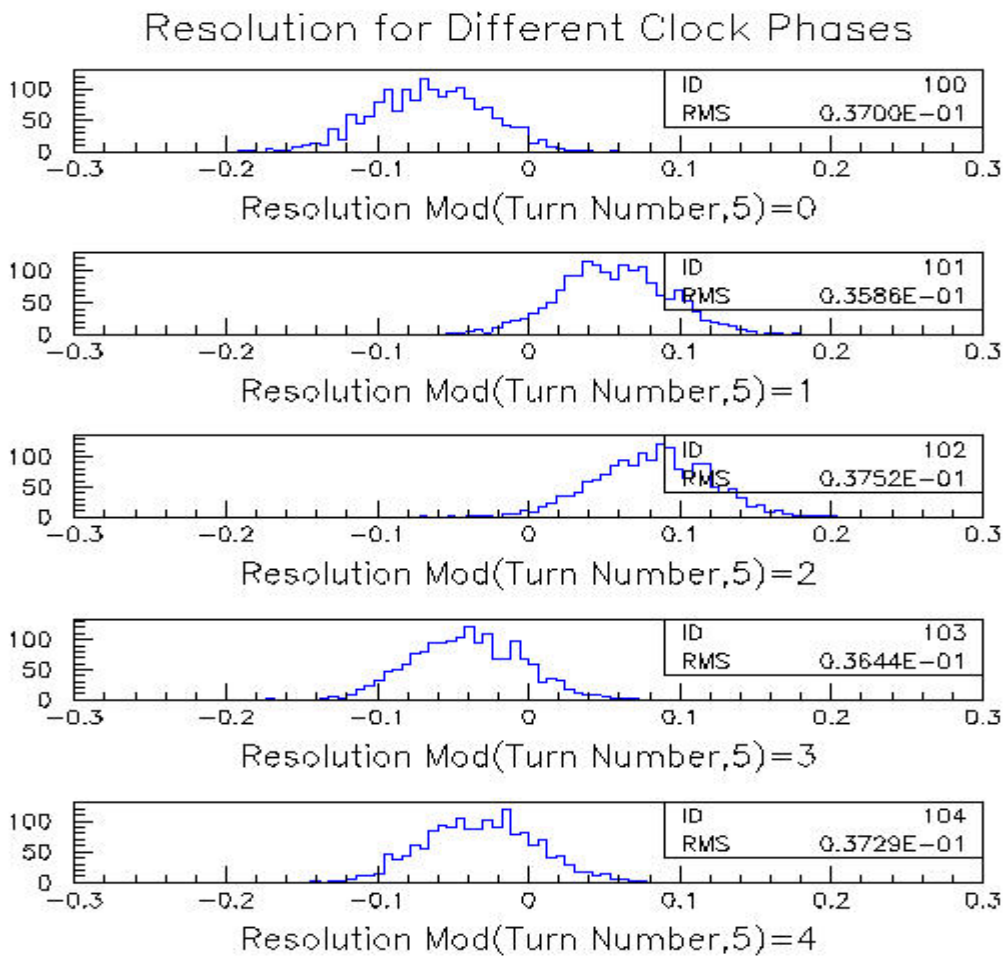
- **Good:**
  - 8000 turns
  - Not completely crazy
- **Bad:**
  - Still some phase/timing issues
  - Position correct?



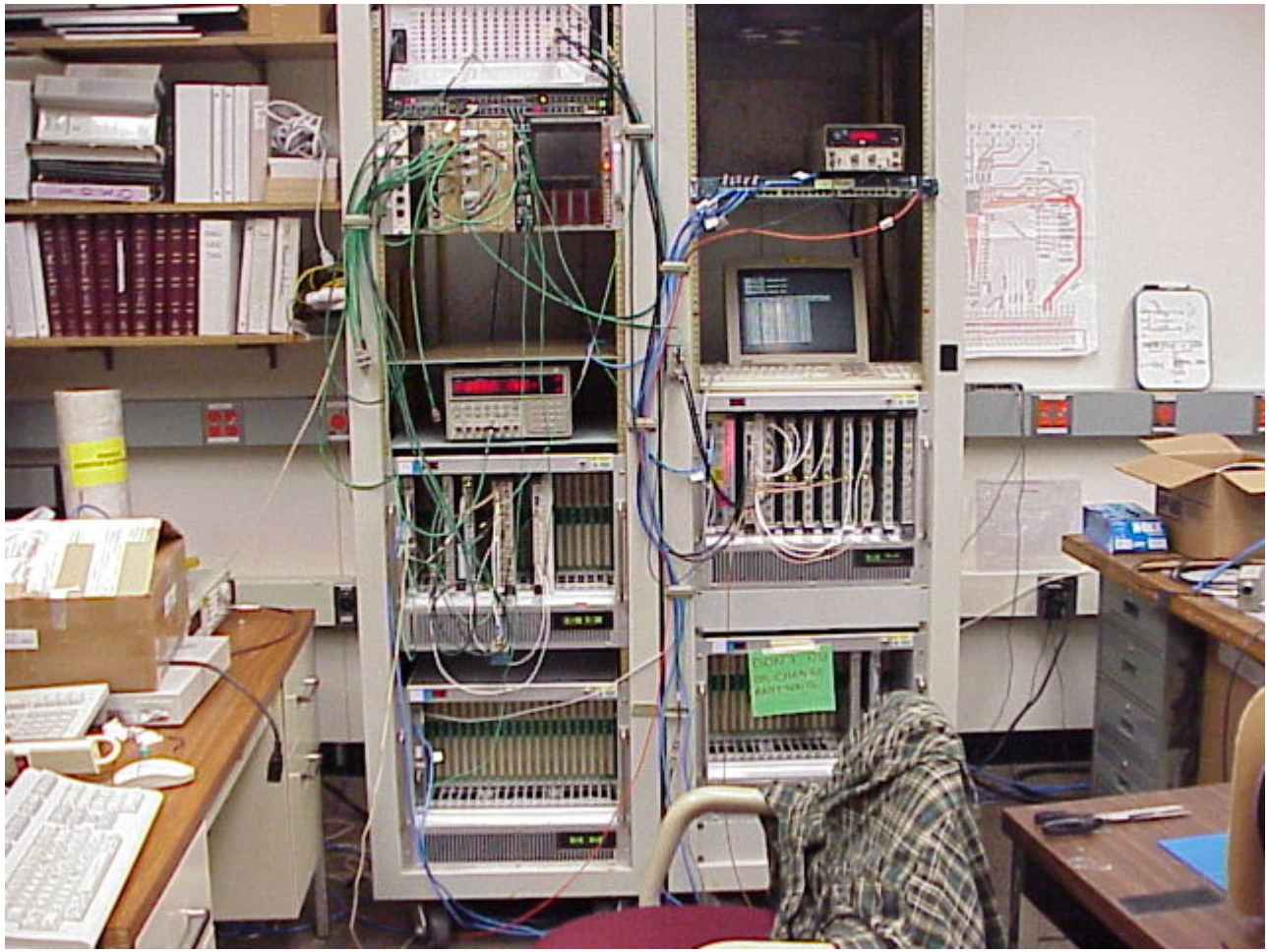
A3 Results-TBT resolution
Caveat: still being debugged



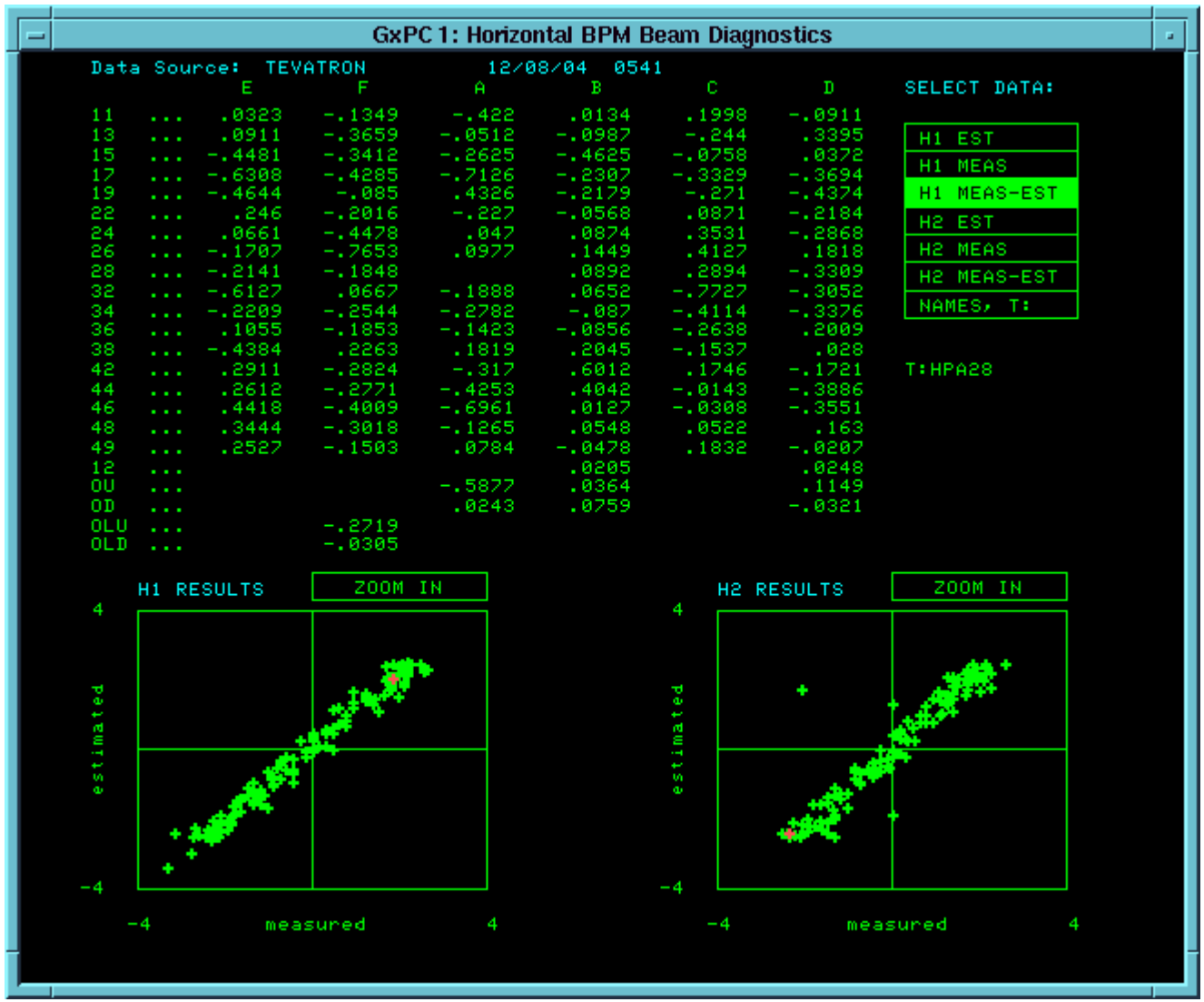
TBT Resolution



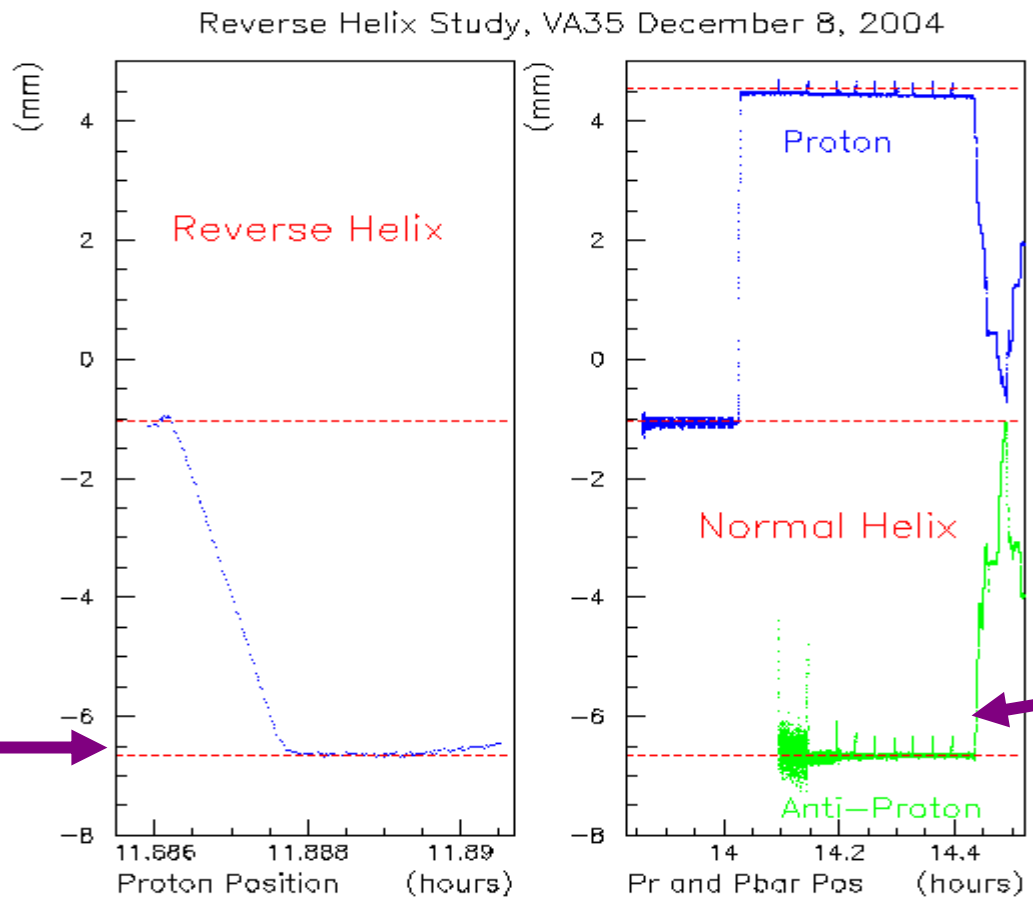
FCC Teststand



Scale check of BPM using bumped beam



A3 result – pbar, injection



Predicted Pbar position

Measured pbar position