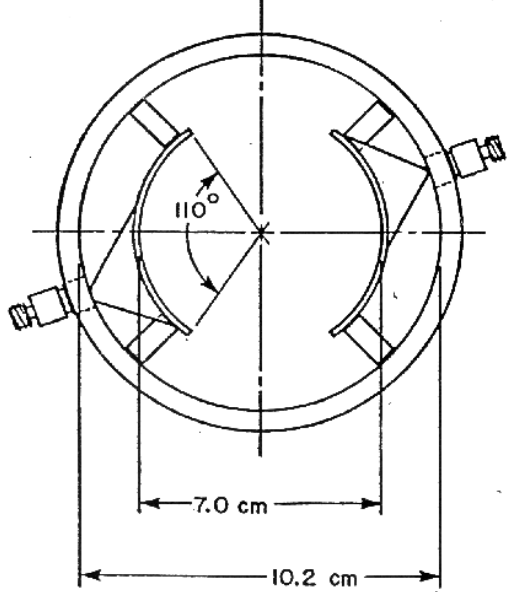


Tevatron BPM Upgrade (+MI/transfer line BPM)

Stephen Wolbers

(for the Tevatron BPM Upgrade Project)

Run 2 Meeting

March 24, 2005

Outline

- Project description and scope.
- Current Status
- Plan for final installation and commissioning.
- Measurement quality : Rob Kutschke in the next talk.
- Short mention of transfer line and MI BPM upgrades.

TeV Beam Position Monitor (BPM) Upgrade Project

- Joint CD/AD project.
  - Officially began in August 2003.
  - Previous to that time work had occurred on requirements and some design ideas.
- Key contributors and contributions: red=AD, purple=CD
  - 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
    - Old 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.

History (1)

- First estimates: ~9 month project, $900K in M&S.
- Probably possible if the project had only accelerator instrumentation experts and no pbar measurements and a well-specified hardware and measurement technique.
- But these things were not true.
  - People needed to learn the language and the techniques of measuring proton positions in the Tevatron.
  - pbar measurements are tricky/difficult because of the contamination of the signal by the large proton signal in the antiproton pickups.
    - This eventually will affect the proton measurement as well.

History (2)

- Learn accelerator instrumentation and accelerator physics.
- Finish requirements and have them reviewed.
  - September 22, 2003
- Compare electronics choices
  - Echotek, Damper board, DSR board.
- Get reviewed (very helpful!)
  - December 19, 2003
- Make design
- By this time the project had grown to about 1 year and $1.76M in M&S costs.

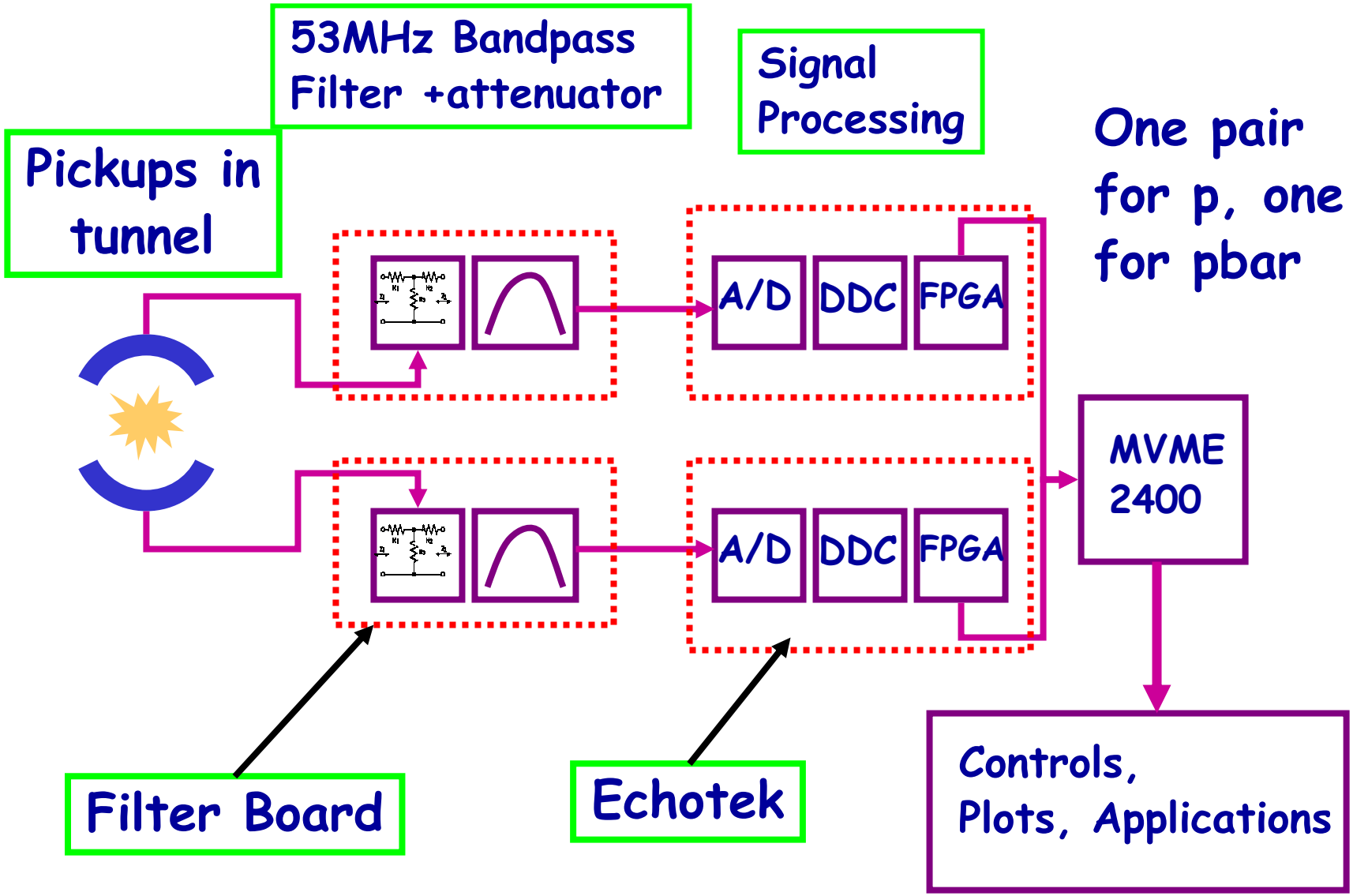
History (3)

- **Next 6 months:**
  - Order Echotek boards.
  - Design analog front-end and have it reviewed
    - May 14, 2004.
  - Plan installation and commissioning.
  - Remove BLM interface from the project.
  - Watch the schedule slide as the inevitable delays in hardware deliveries, etc. occur.
  - Specify and order analog filters.
  - Get teststands in FCC established
    - Big deal – Needed part of the AD network in Feynman.
  - Design and purchase VME crates, MVME processors, cables, panels, etc.

History (4)

- Receive first prototype Echotek boards in June.
- First production boards in August.
- Test crate in accelerator in August, before shutdown.
- Final design and prototypes of front-end boards in the fall.
- First installed crate (A3) November 22, 2004, just before beam startup.

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
    - Injection 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.
- 185 documents in Beams docDB as of 3/14/05.
  - 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.
    - There is already a request to remove part of the old BPM system to make room for BLM prototype.

Applications

- Many applications have been or will be modified to use the new BPM positions, either through modifications to BPMLIB or changes to the applications themselves.
- SDA is being converted to use the new BPMs as they are installed.
- Some new applications are being developed to take advantage of the new systems and new capabilities.

Applications

Green : done or working, Brown: working on, Red: old only

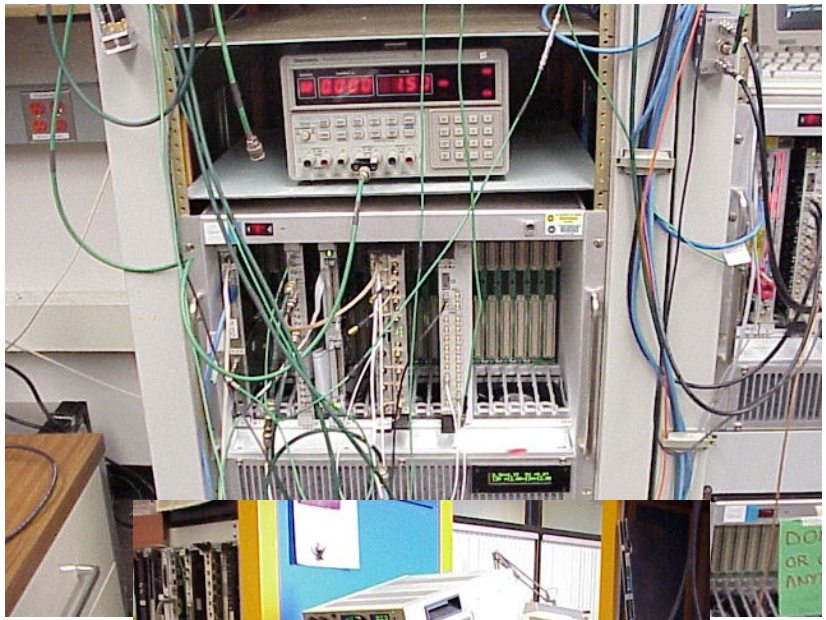
- T37, BPM Control Parameters (not needed)
- T38, BPM/BLM tests (being specified)
- T39, BPM/BLM plots (done)
- T41, BPM beam diagnostic (done)
- T42*, Tevatron TBT display (done)
- T117, T121*, TeV orbit closure (done)
- C45, extract BPM profile frames (done)
- C50*, TOP (done)
- C48, sequencer (old system only)
- W25, Diagnostics (up to date)
- W68, TBT application (done)
- W136, TBT application (in development)
- C10*, Collimator scraping control
- Calibrations (in development)
- P163*, differential orbit measurements
- W132, BPM library test program

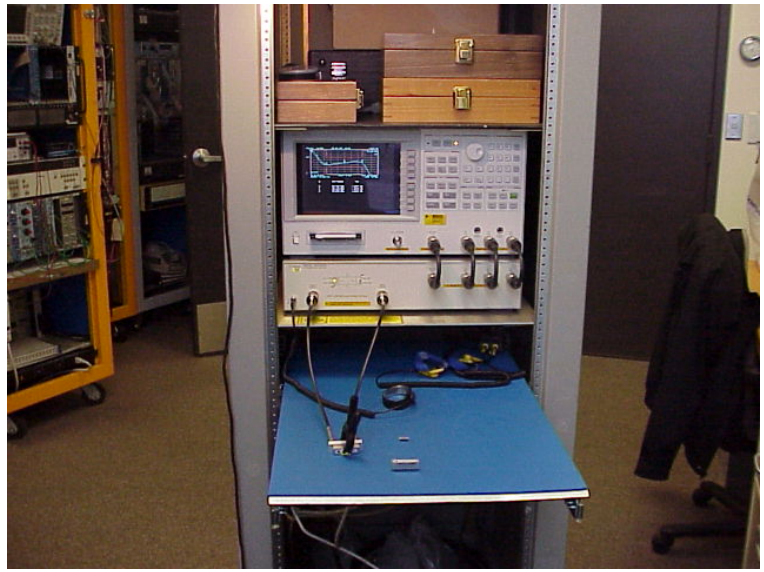
*=relinked with new BPMLIB

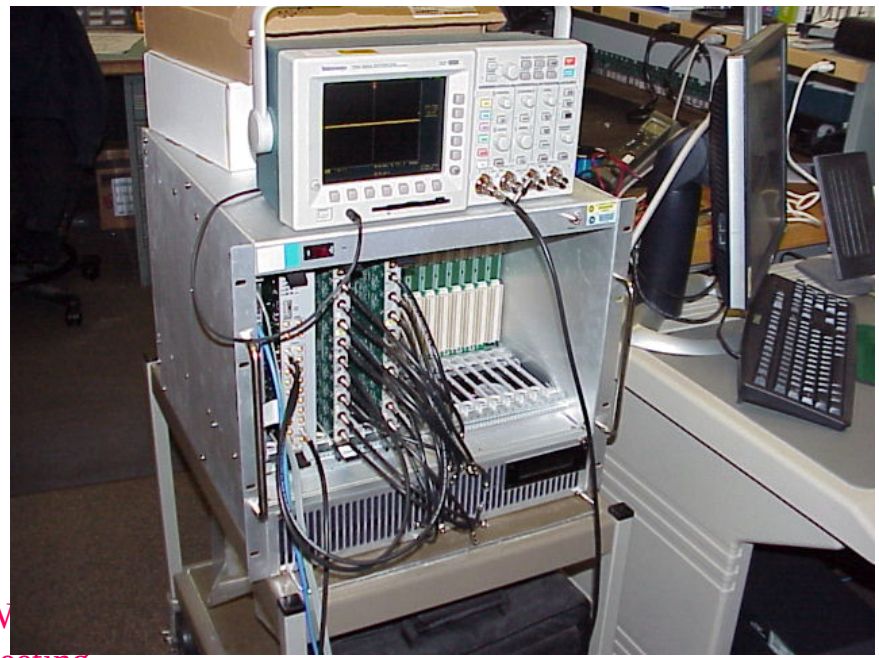
Test stands

- Test stands have been essential for:
  - Testing hardware
  - Debugging software
  - Studying Echotek behavior
  - Hardware acceptance for timing, filter and Echotek boards
- In the end we used 4 or more teststands to carry out the project.

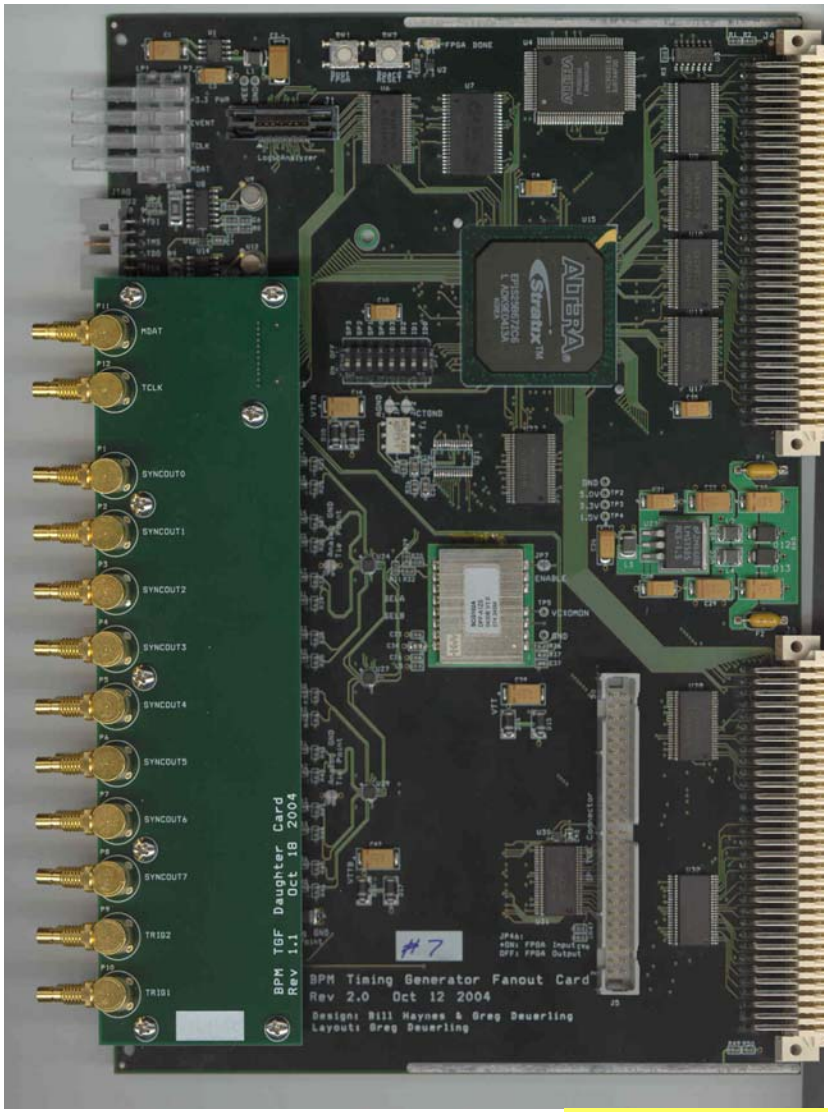
Test stands

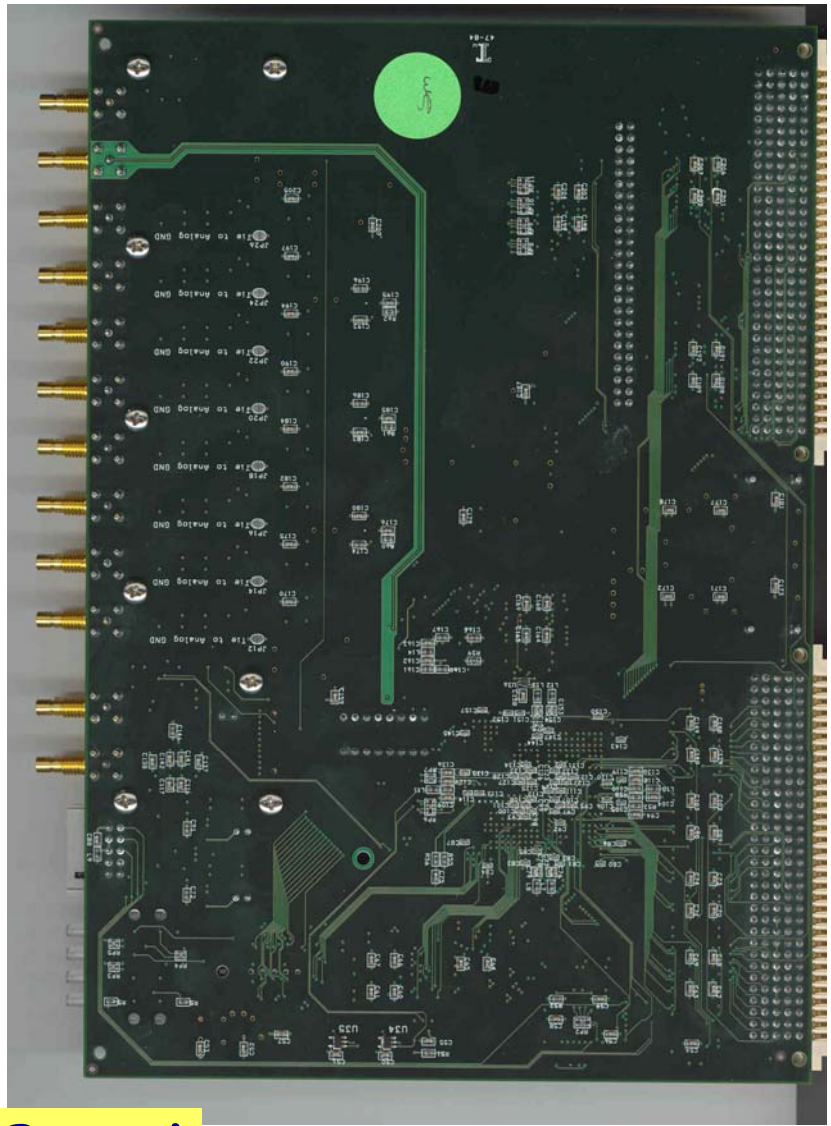






Timing Board



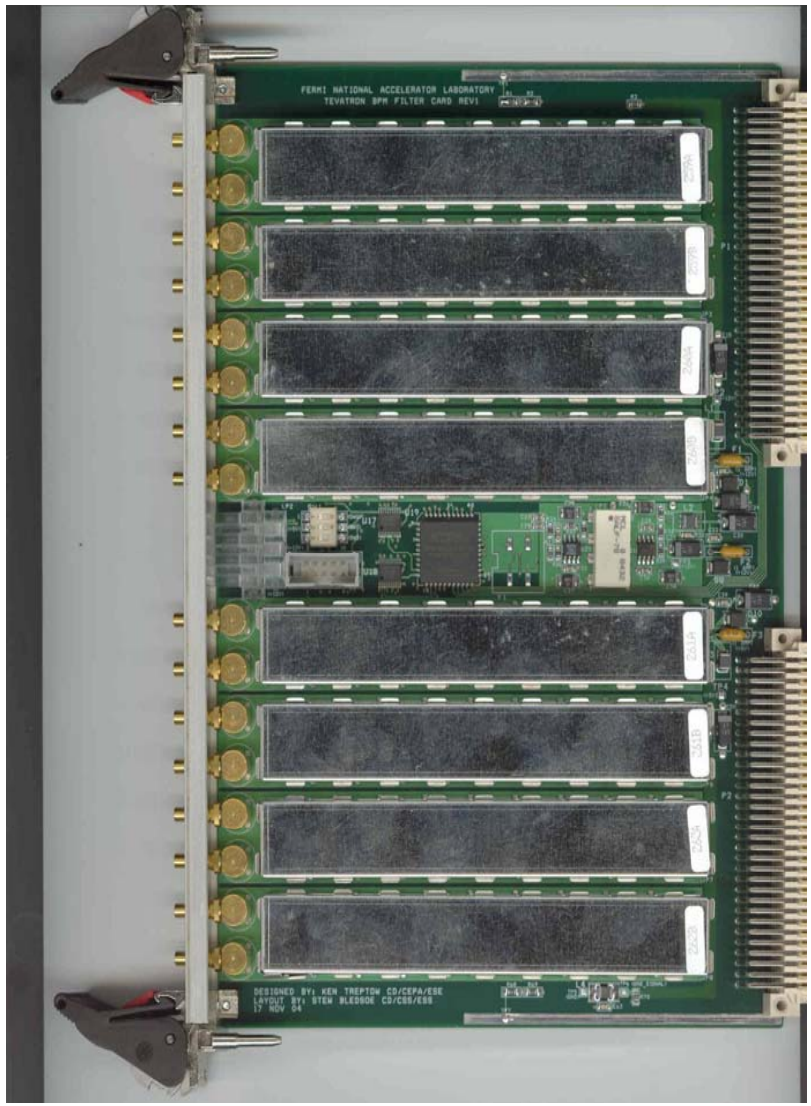


Production Board

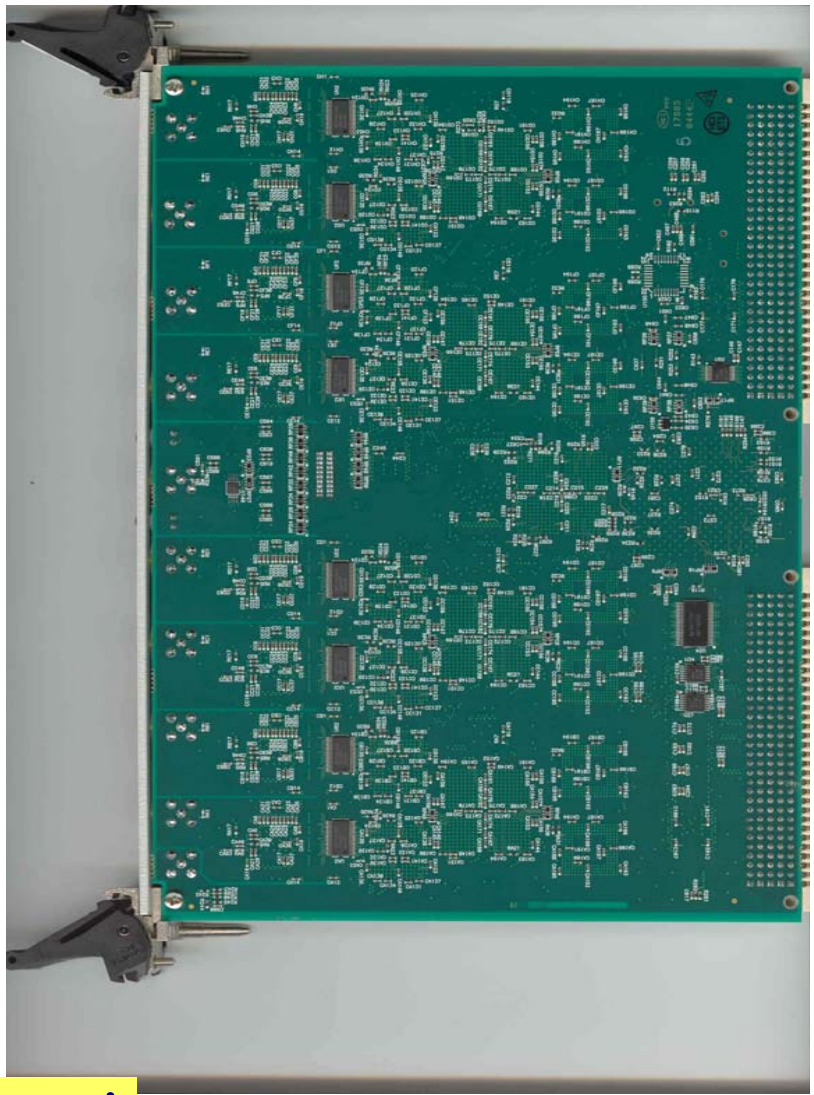
Filter Board

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

Production Board



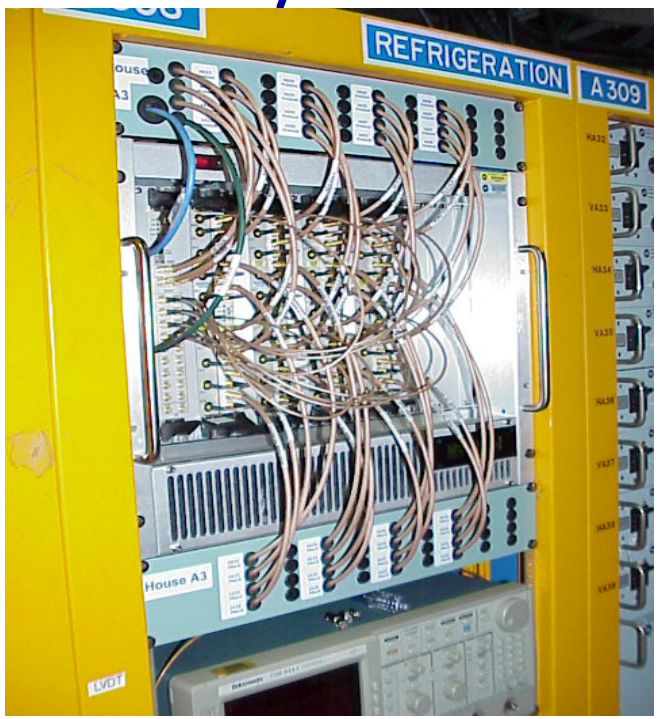
Echotek Board



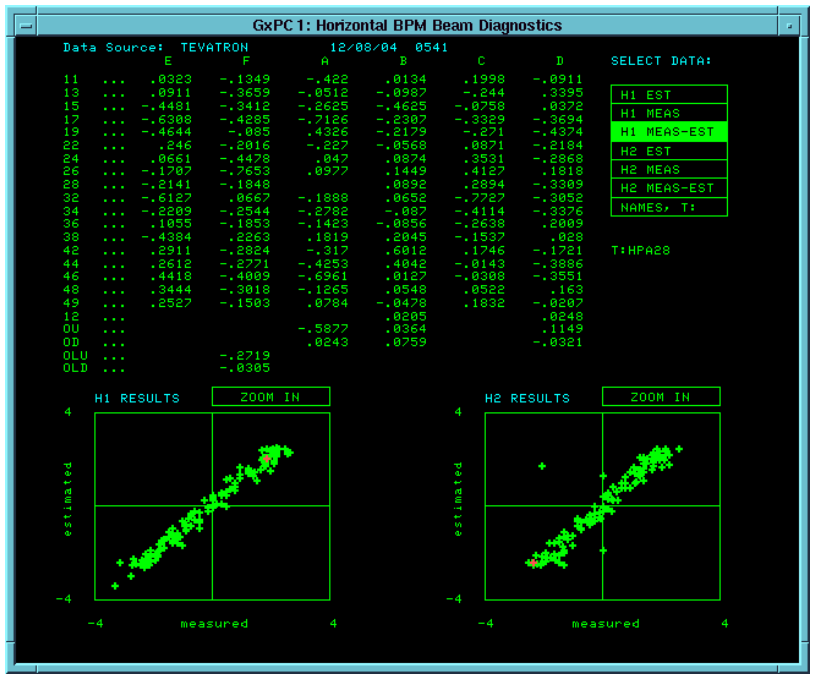
Production Board

Current Status

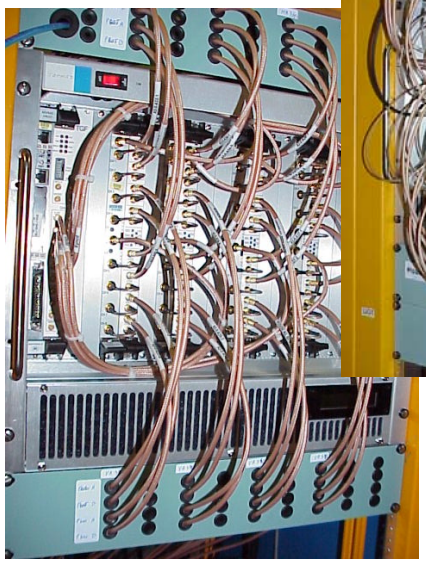
- A3 system was constructed in FCC3 and installed in A3 on November 23.
- Currently commissioning closed orbit, TBT, first turn and pbar measurements.
  Many things have been checked, including scale, polarity, resolutions, pbar measurements, system reliability and stability.



Scale Check

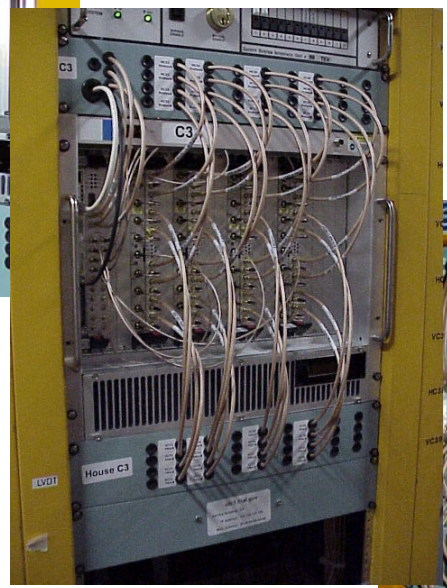


Systems are going in!

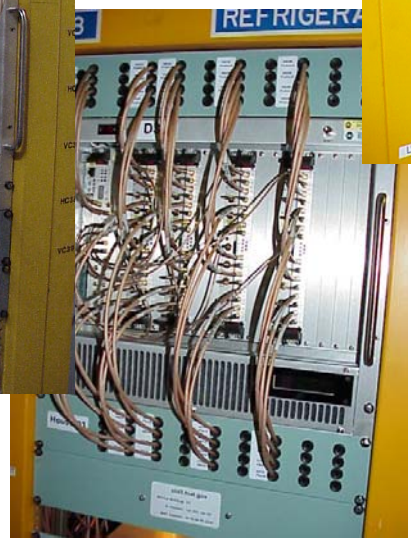


A3
11/22/04

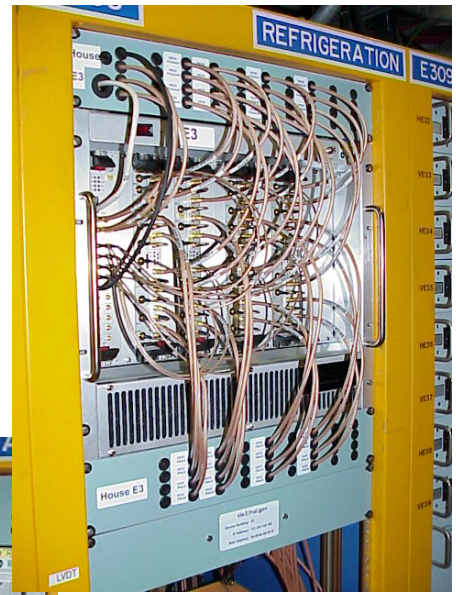
B3
2/10/05



C3
2/23/05



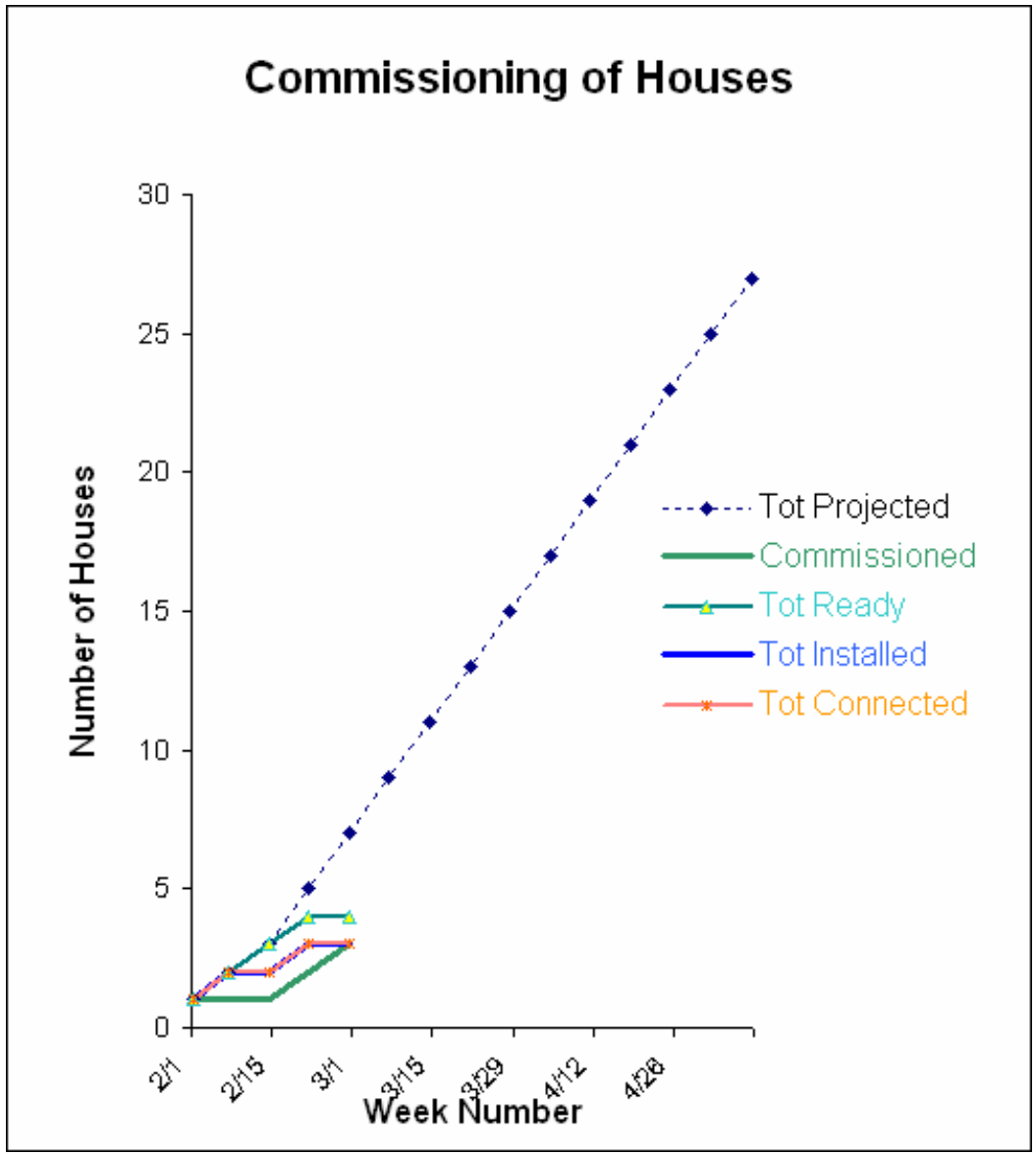
D3
3/08/05



E3
3/11/05

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
- Two or three houses per week
- Finish in May, 2005.


Commissioning of Houses
Number of Houses
30
25
20
15
10
5
0
2/1
2/15
3/1
3/15
3/29
4/12
4/26
Week Number
Tot Projected
Commissioned
Tot Ready
Tot Installed
Tot Connected

What's Left

- Install all the hardware.
- Fix problems
  - Injection first turn (phase/timing problem)
- Finish all functionality
  - "Safe" mode
  - Pbar measurements
  - Time-dependent calibrations, calibration database
- As built's
- MOU-> operations
- Project closeout

Transfer line/MI BPM

- Transfer line BPM is Nathan Eddy/Elvin Harms/Bob Webber responsibility
  - Shared with TeV BPM:
    - Clock fanout
    - Echotek modules
- MI BPM system also needs upgrading
  - Essentially the same reasons as for the TeV BPM
  - AND the MI will be around for quite some time
- A MI BPM upgrade project has not yet formally begun
  - People are very busy with TeV BPM, transfer line BPM projects, NUMI commissioning

MI BPM

- First step: Update MI BPM requirements
  - Old version dates from early 2003
  - Update to take into account operational changes
  - Think about proton intensity increases coming from proton project and/or proton driver
- Form a project
  - CD and AD participation is likely
  - Develop project plan, cost estimates, schedule, etc.

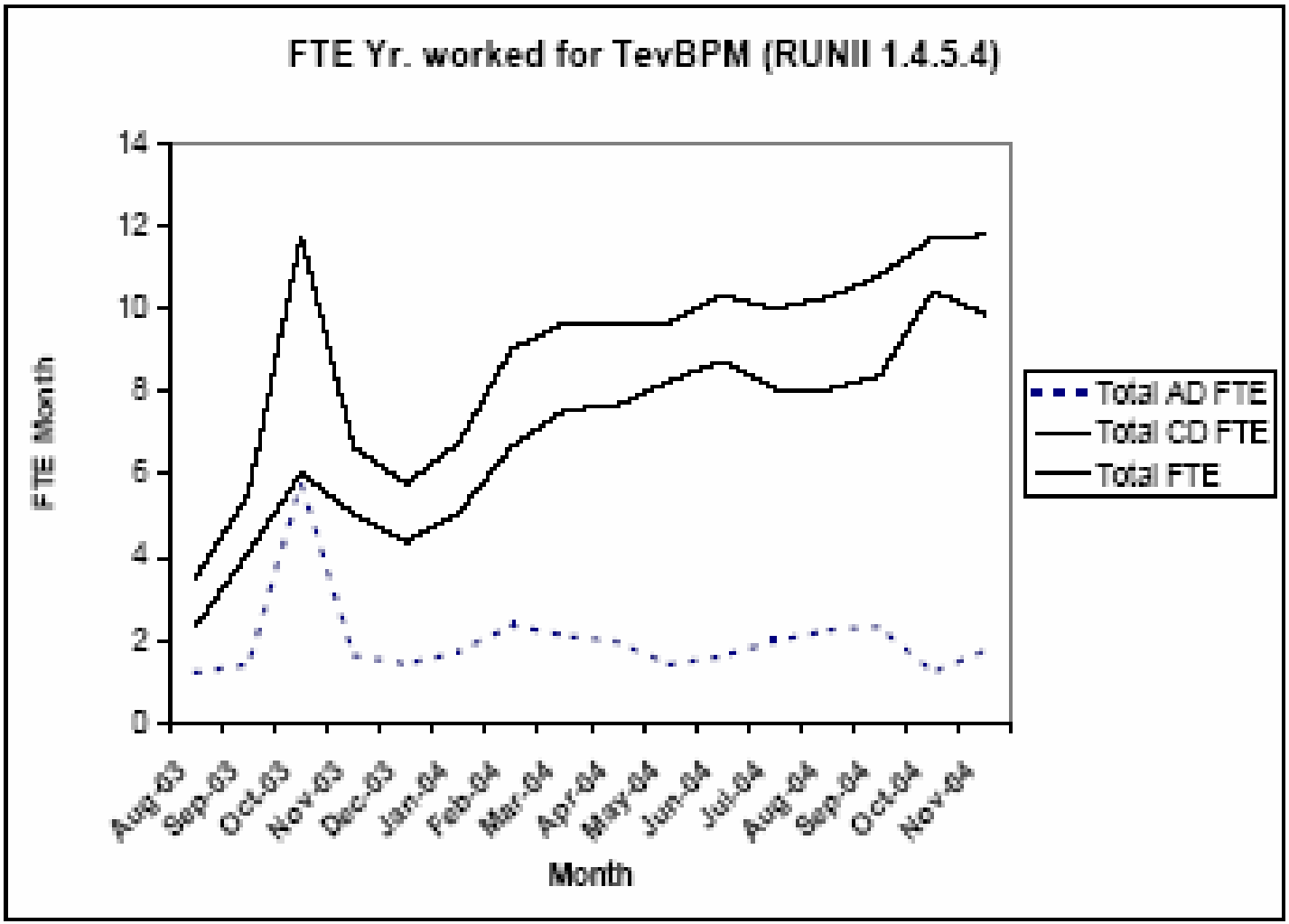
Summary of today's Part I

- 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.

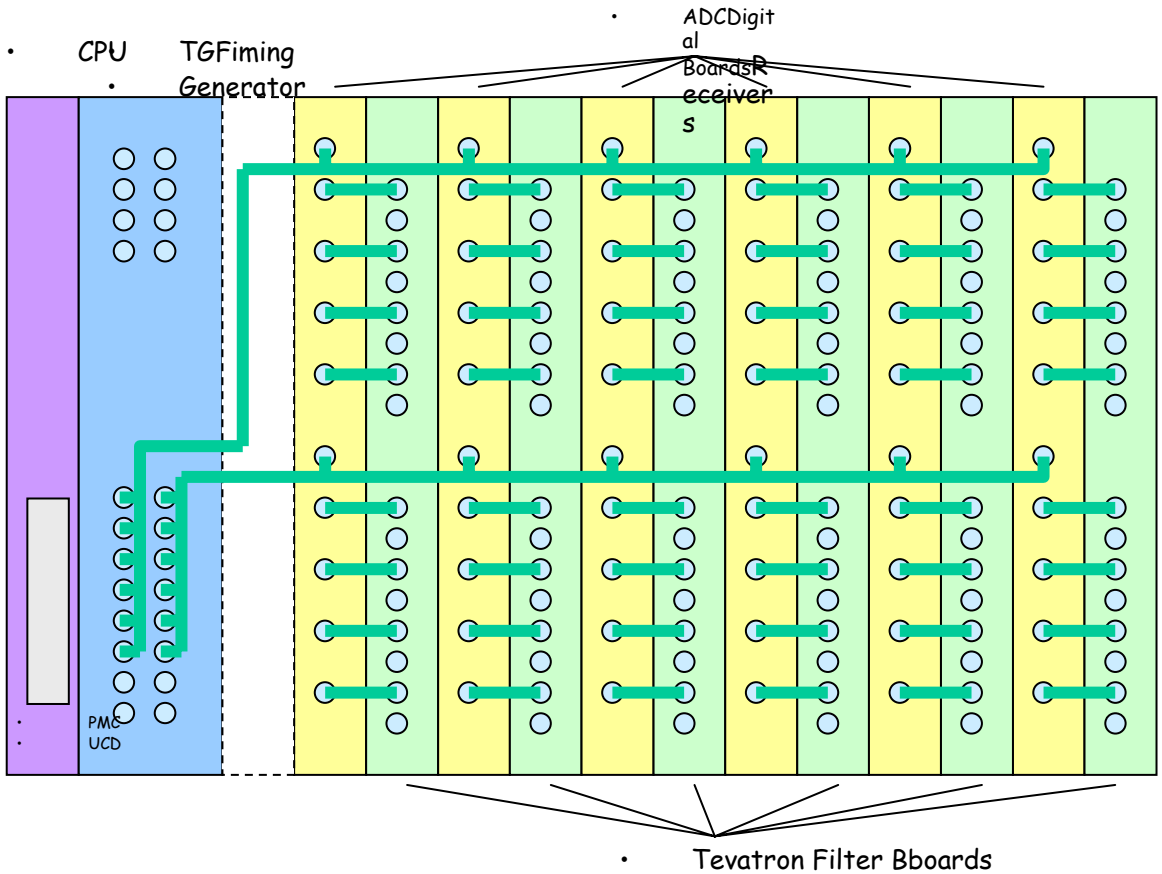
Rob Kutschke will show how well the system works…

Backup Slides

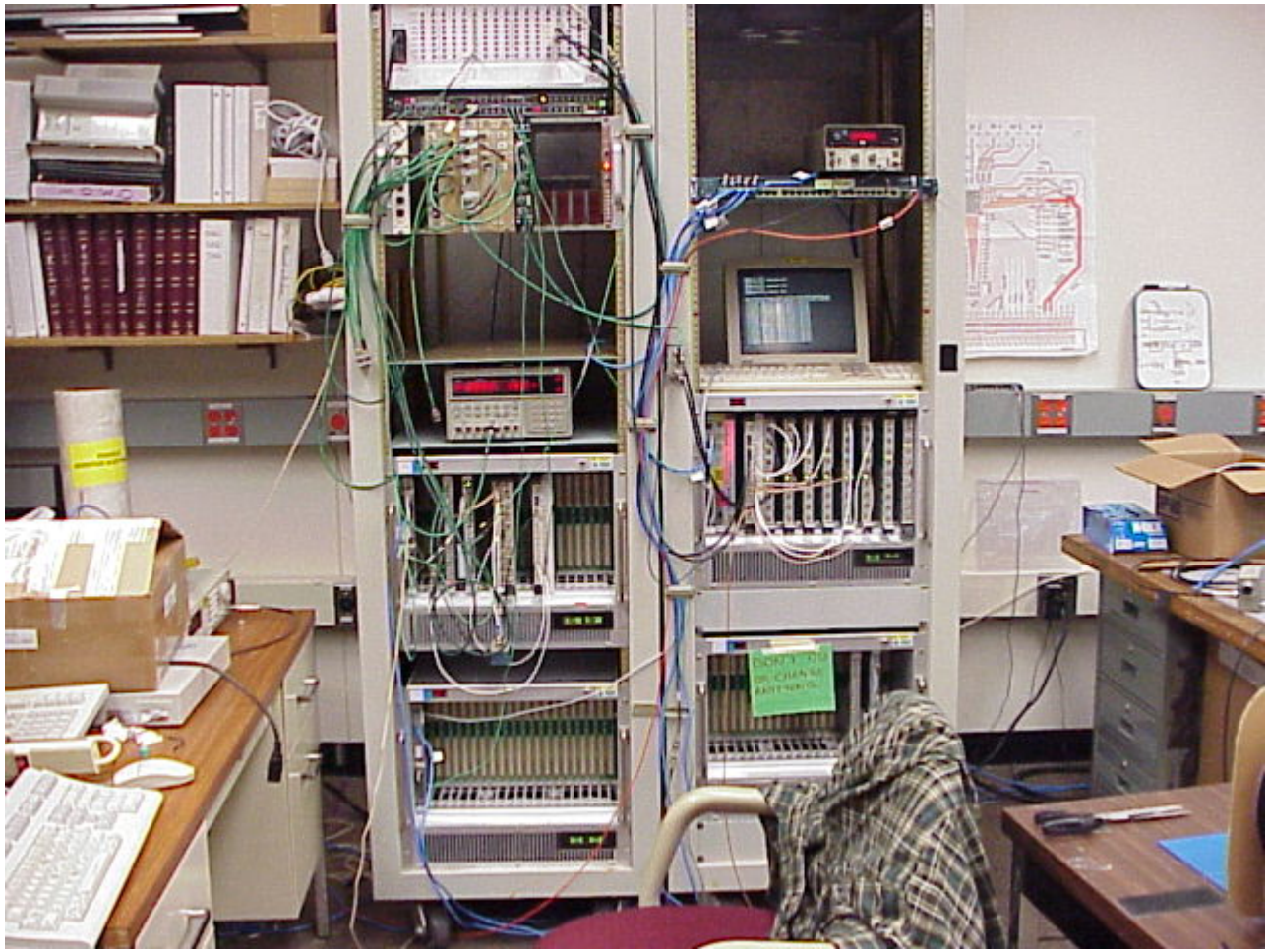
Effort


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

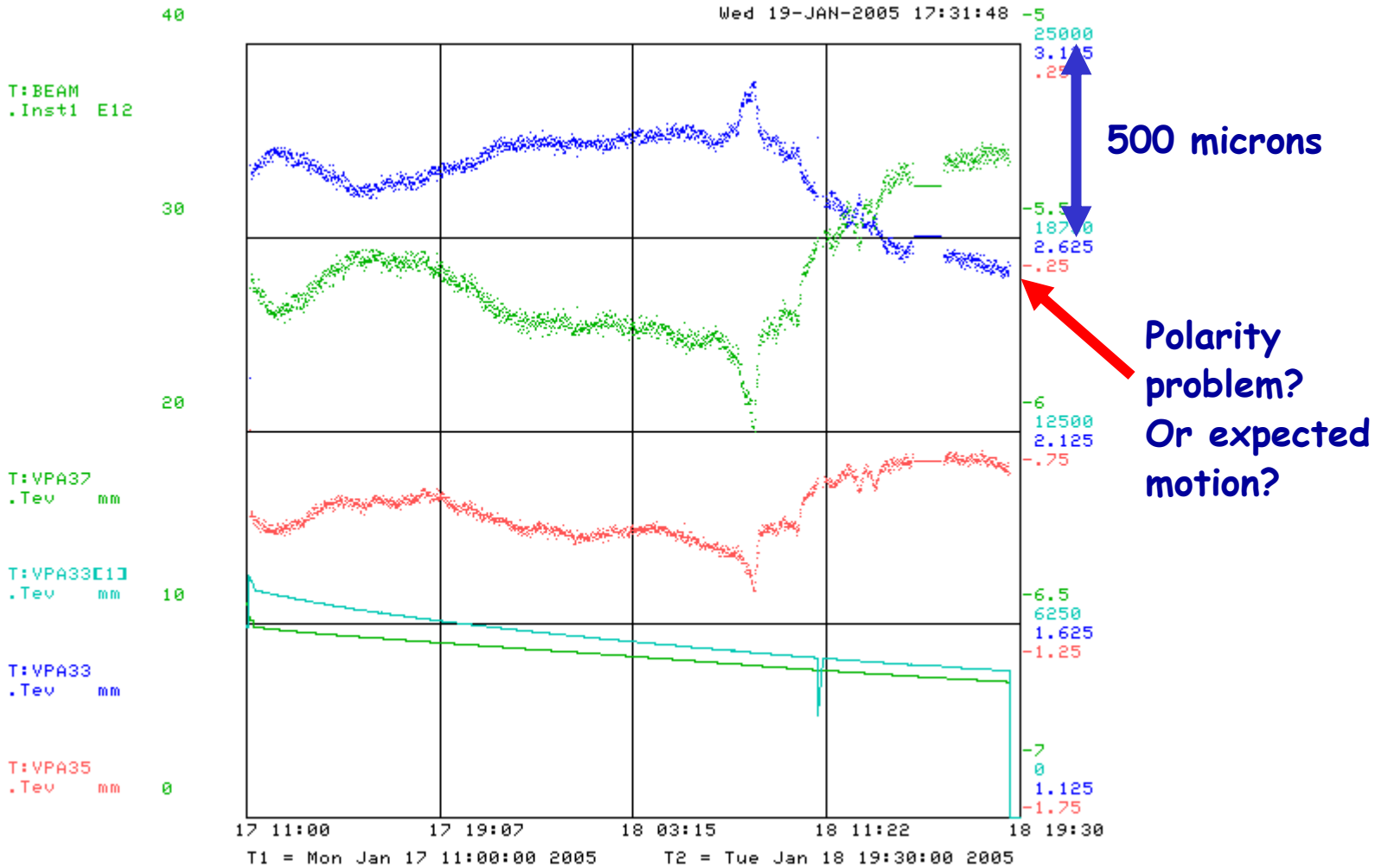
VME Crate Layout



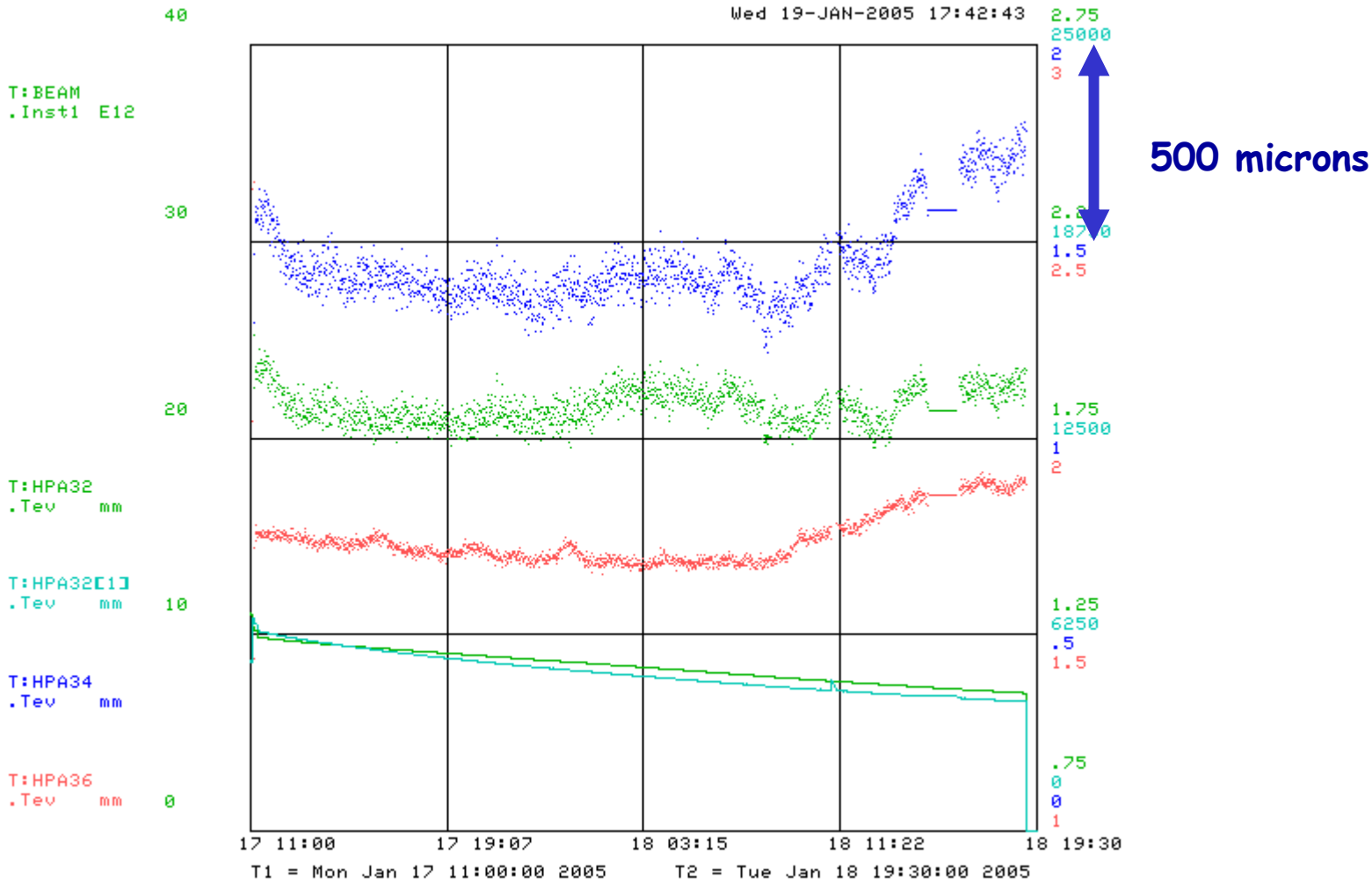
FCC Teststand



Recent Store (Monday 1/17/05) Vertical

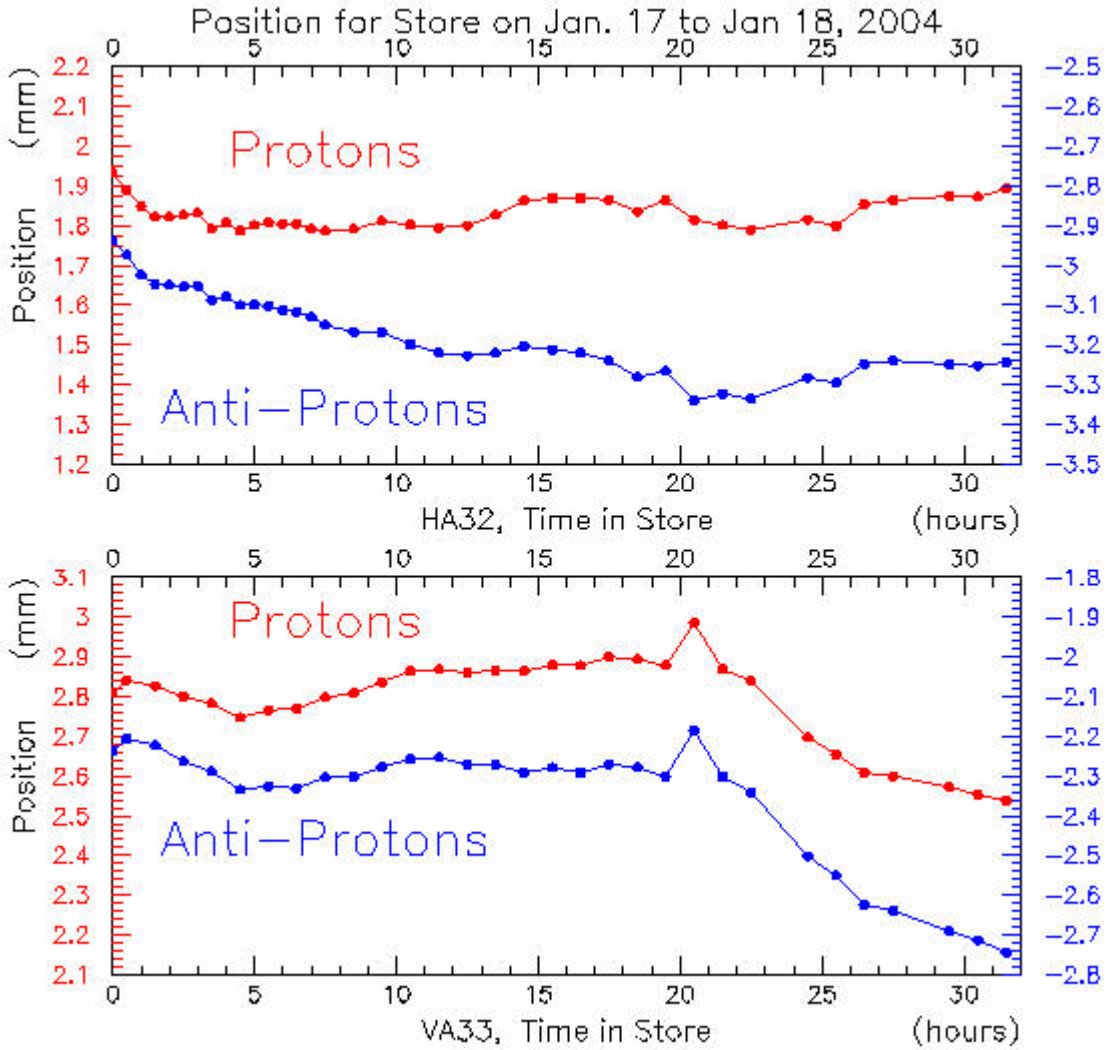


Same store - horizontal



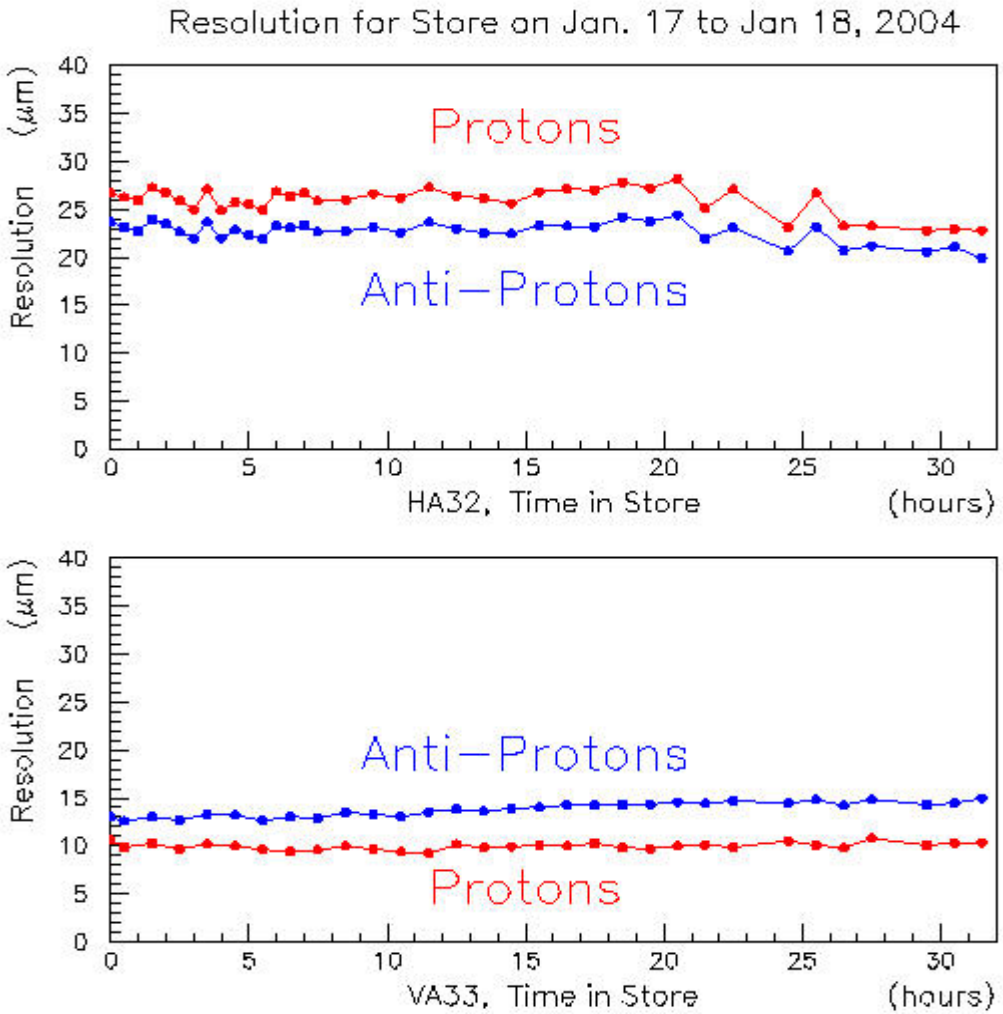
500 microns

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