



Main Injector Beam Position Monitor Upgrade: Status and Plans

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All Experimenters' Meeting April 3, 2006

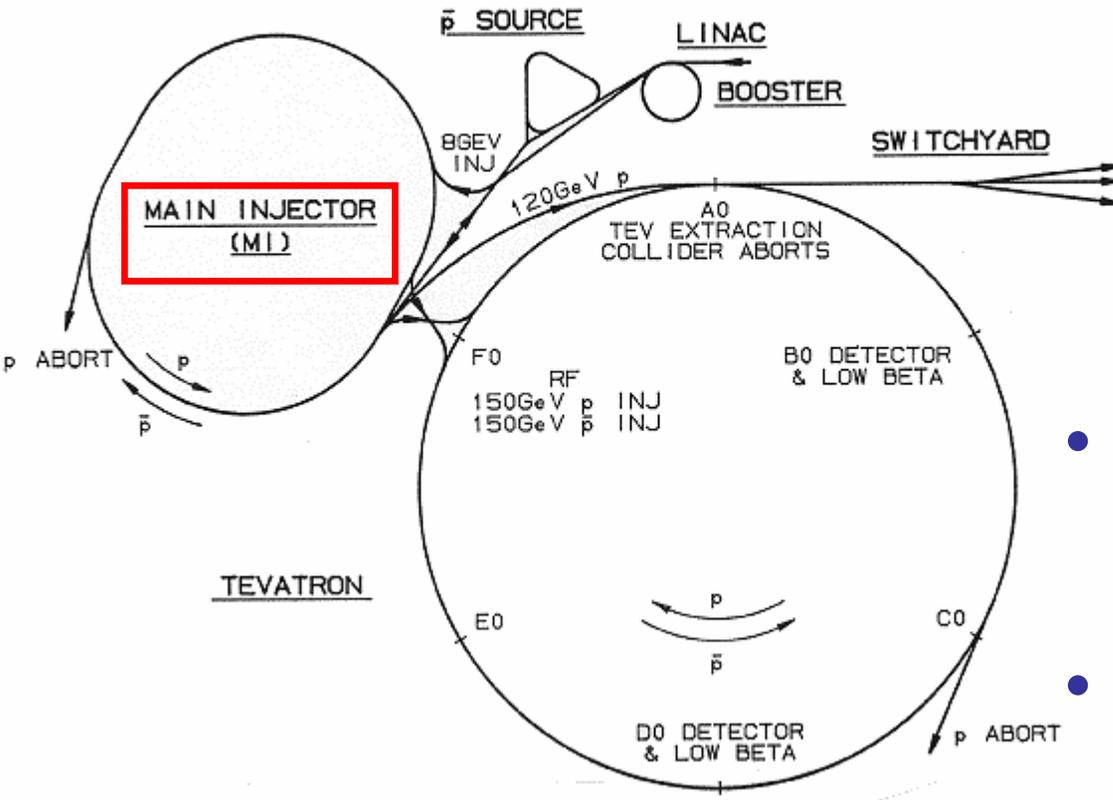
Project Overview

- Goals: Improved functionality, reliability.
 - Improved position resolution.
 - Measurement of pbar positions. **New capability in MI.**
 - Highly configurable. **New capability in MI.**
- Joint project: AD/CD.
- Core technology:
 - Commercial digital receiver board (Echotek).
 - Now a standard: RR, TeV, transfer line and MI BPMs.
- Evolution of previous Echotek-based designs.
- 208 BPM locations
 - Including 7 new wide aperture BPMs.

Major Modes

- Closed orbit (CO):
 - Average over all bunches for ~40 turns.
 - Averages out betatron motion (not synchrotron motion; by design).
- Turn by Turn (TbT):
 - Average position over ~44 buckets (~1/13 of circumference).
 - Usually triggered by injection/extraction TCLK events.
 - Can be hand triggered at an arbitrary time, eg. pinger.
- Safe mode:
 - Failsafe operation when high accuracy timing is not available.
 - Average position over ~44 buckets.
 - Report updated position every ~22 buckets.
 - Continuous for about ~470 turns.
- CO and TbT: implemented for both 2.5 MHz and 53 MHz.

FERMILAB TEVATRON ACCELERATOR
WITH MAIN INJECTOR



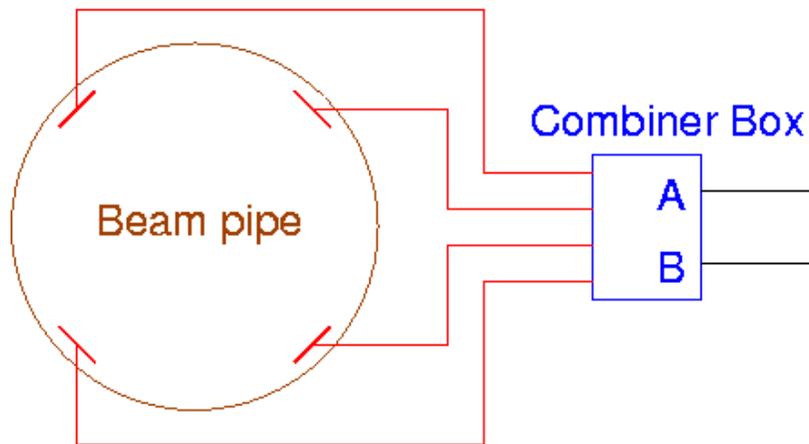
- Sources of beam:
 - Booster, ACC, RR
 - TeV (tuneup)!
- Beam destinations:
 - TeV, RR, NUMI, SY120
 - Pbar production target
 - ACC (tuneup)!

Main Injector Cycles

- Cartoon definition:
 - Inject beam (one or many times).
 - Do something with it:
 - Slip position
 - Ramp to new energy
 - Change RF structure
 - Send beam to one or more destination(s).
 - Typical duration: a few seconds.
- Many tens of possible cycles.
- Timeline generator “plays” a long sequence of interleaved cycles.
- **Bookkeeping complexity:**
 - Different combination of measurements for each type of cycle.
 - Detailed TbT timing is different for each cycle.
 - Separate data buffers for each type of cycle.

Cartoon of the Hardware

In Tunnel: replace cominber box



BPM pickup has 4 electrodes

Combiner box:

Old: Blocks 2.5 MHz; H/V switchable.

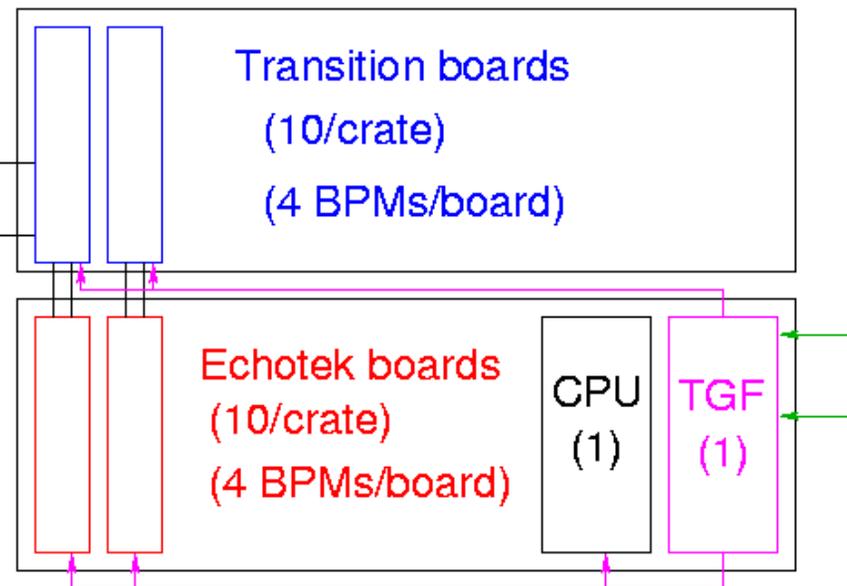
New: Passes 2.5 MHz; H/V fixed.

New wide aperture BPMS:

Traditional H/V electrode placement

Read out both (separate channels)

Service buildings: all new
(2 VME crates / building)

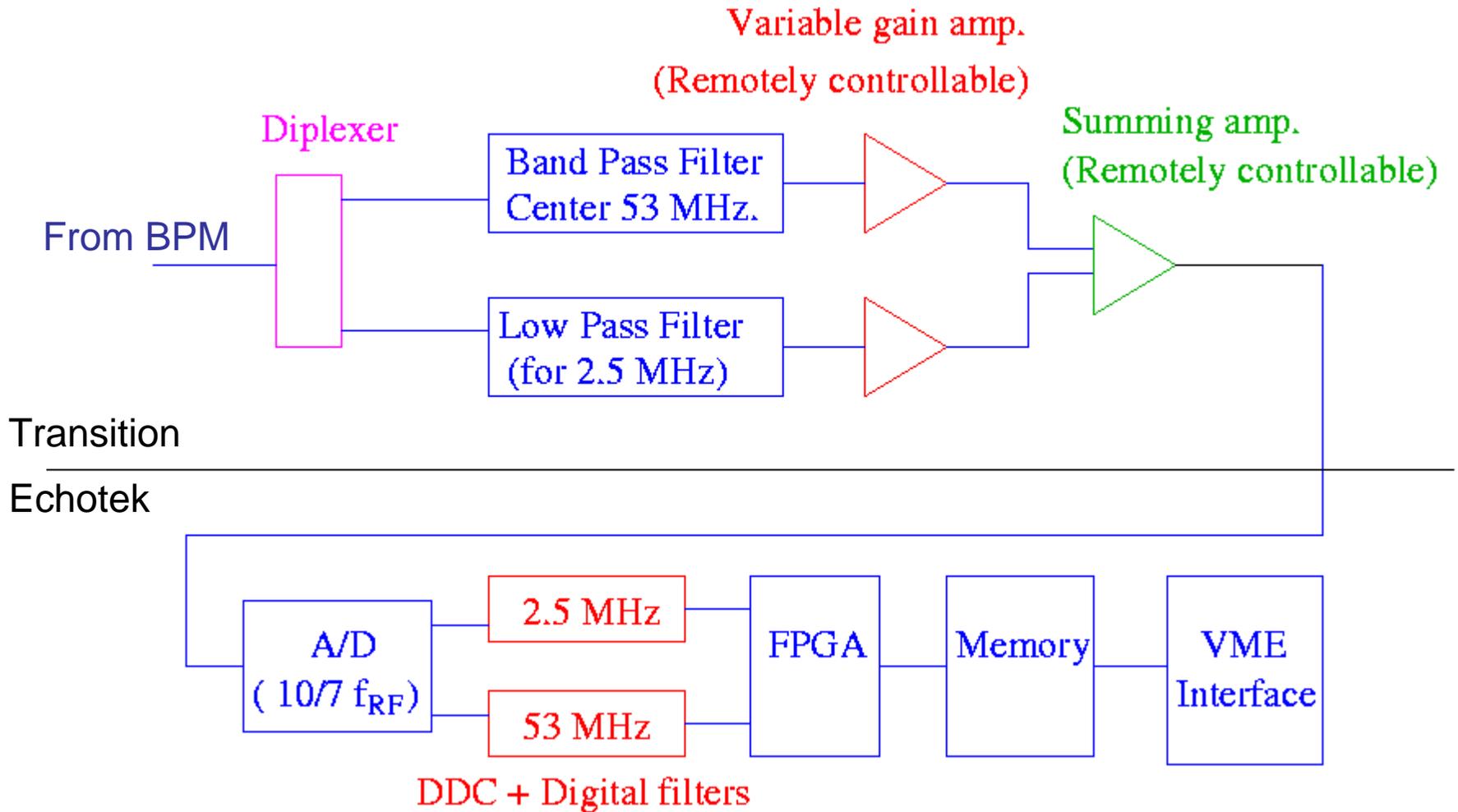


TGF = Timing Generator and Fan-out

Control signals: MDAT, TCLK, BSync, BES

CPU talks to ACNET

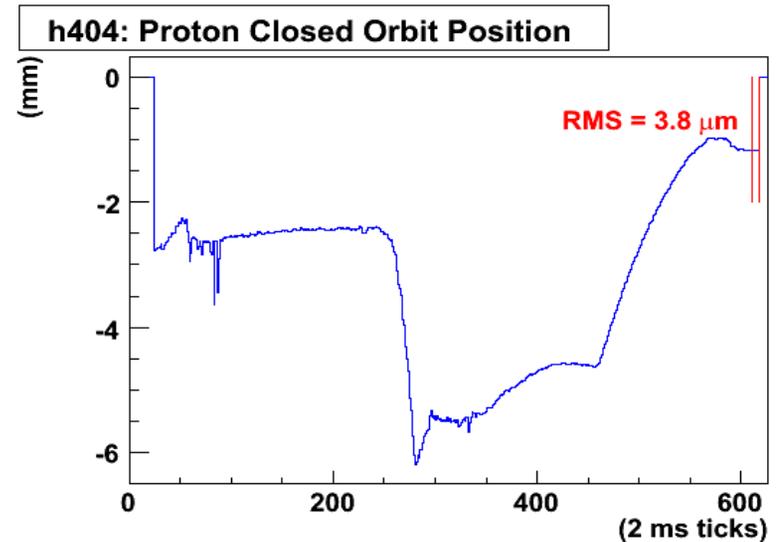
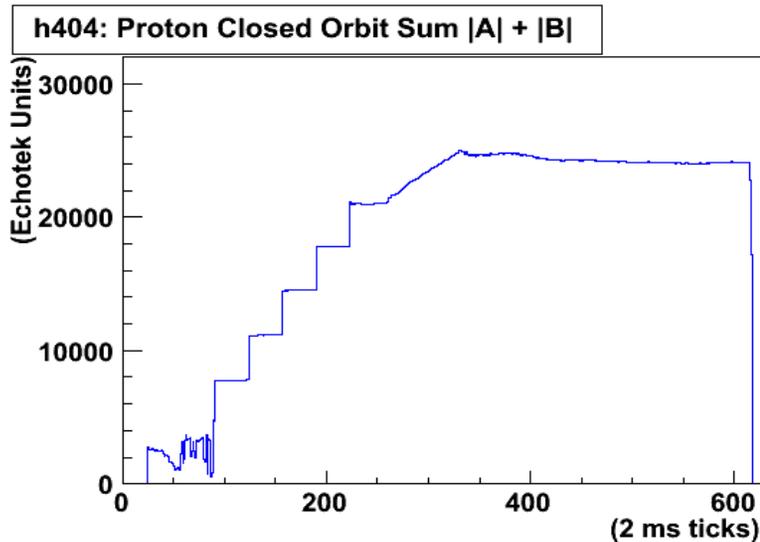
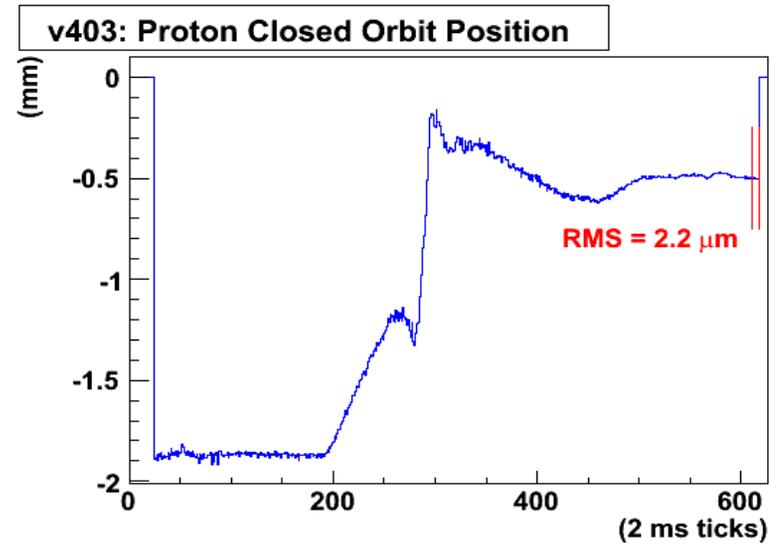
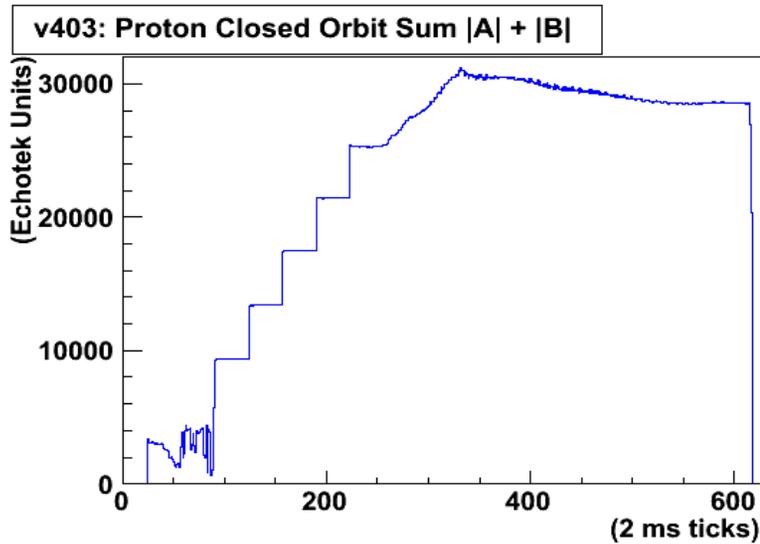
Cartoon of Transition and Echotek Boards

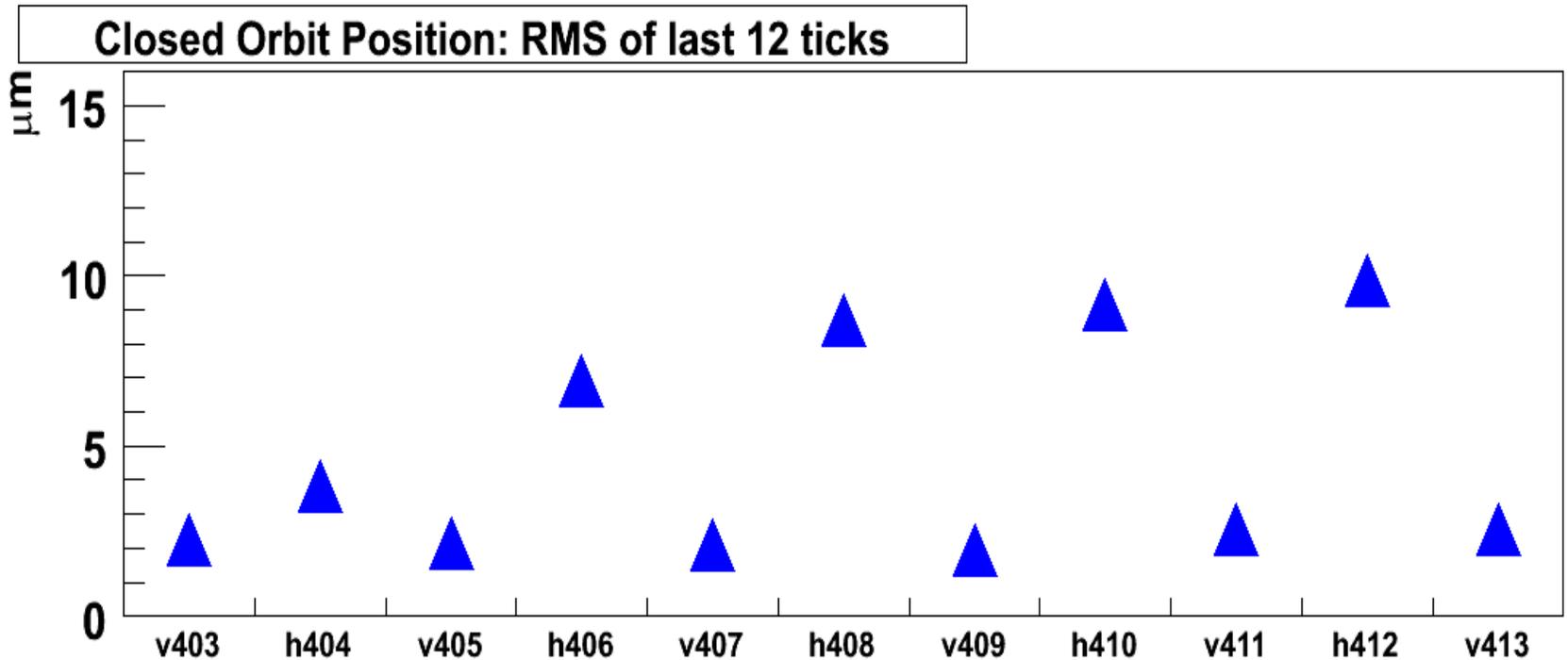


Notes on Cartoon Figures

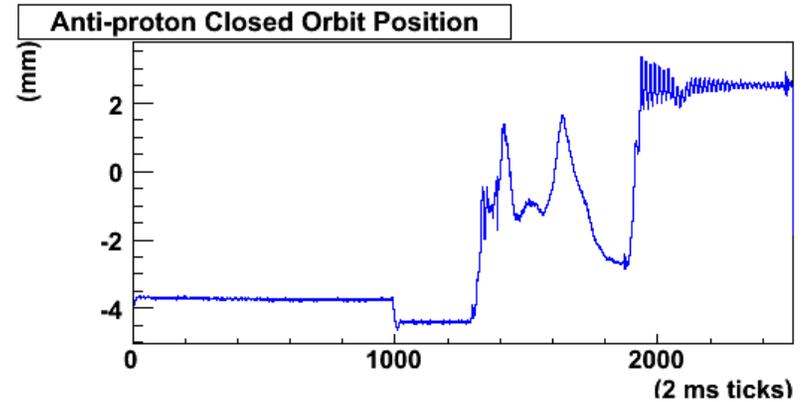
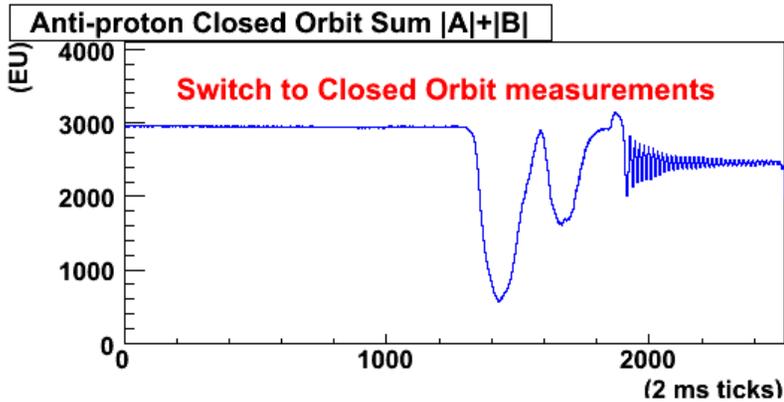
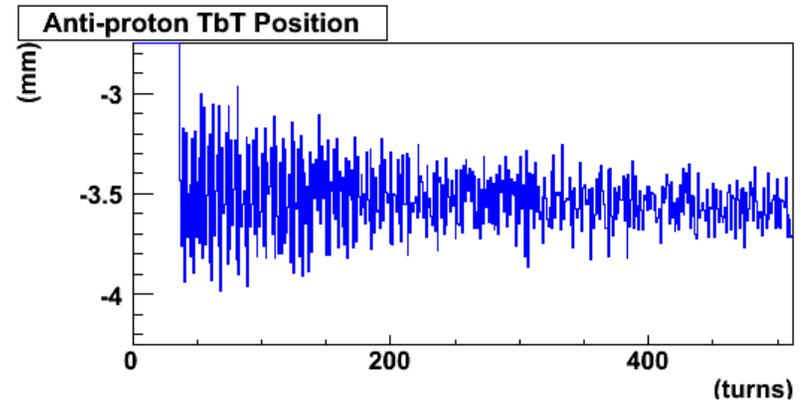
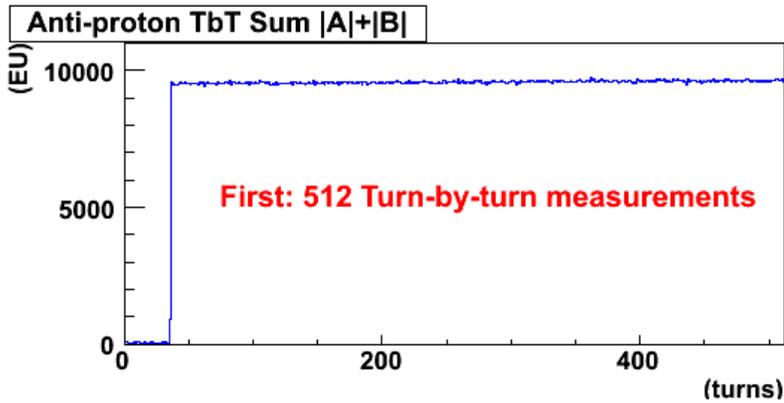
- TGF, Combiner and Transition boards: in-house designs.
- Combiner board:
 - Old boxes contained a band pass filter to select only the 53 MHz component:
 - Anti-protons are usually bunched at 2.5 MHz so the old system was blind to anti-protons (most of the time).
 - New system allows both 53 MHz and 2.5 MHz components to pass.
 - Can see anti-protons now.
 - Old system was H/V switchable:
 - Rarely used.
 - Now fixed H or V. Reduces points of failure by removing unnecessary complexity.
 - New style BPMs at large aperture quads:
 - 4 electrodes in traditional H/V style.
 - Will read out both H and V.
- Transition Board:
 - Two pass bands: 53 MHz and 2.5 MHz.
 - Gain in each band separately controllable.
 - Output can be one, other or sum.

Proton Beam: Anti-proton Production (slip stacking) + NUMI

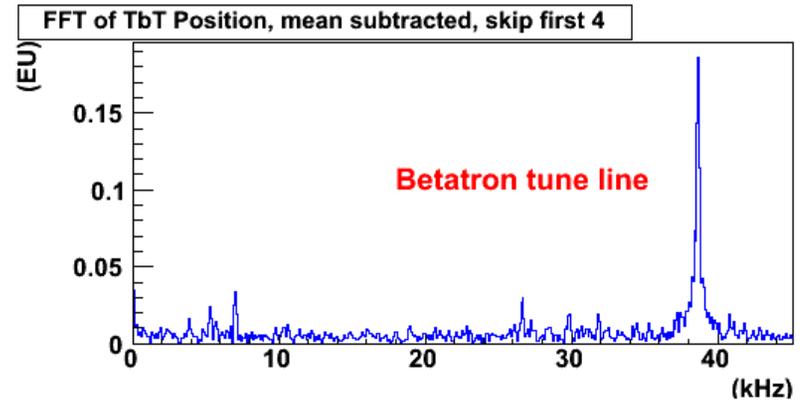




- Observed RMS includes resolution of the instrument plus real beam motion.
 - Almost certainly dominated by real beam motion, especially for the horizontal BPMs.
 - Resolution $< \sim 3 \mu\text{m}$.
- Meets required CO position resolution of $50 \mu\text{m}$ (3σ).



Transfer of anti-protons from
Recycler to TeV.
(Mode switch on the fly!)



Looking Ahead

- April 2006:
 - Receive production transition boards and crate backplanes.
 - Most other components in hand.
 - Assemble and test complete crates in the lab.
- Late May 2006:
 - Restart MI using the BPM system as it existed at shutdown:
 - 11 upgraded BPMs, remainder old.
 - Continue commissioning of existing house during this time.
- Once operations have been re-established, install remaining BPMs.
 - Details of timing to be negotiated with MI operations and MI BLM upgrade project.
 - Can be performed while MI is operation.
- Completion goal: summer 2006.
- Anticipated effort: 7 to 10 FTEs / month.

Summary and Conclusions

- Design is complete and well tested.
- Commissioning of first house advanced.
 - Will be completed during the restart phase.
- Will be ready to install all new hardware before the restart.
 - Last components (transition boards) due during shutdown.
- Expect to complete installation and commissioning within a month of getting the go ahead.
- This talk is Beams-doc-2217.

Backup Slides

Cycle Dependent Configuration

- MI State 5:
 - Two batches from booster. Slip stack to form one batch.
 - Five more batches from booster.
 - Ramp to extraction energy.
 - Deliver slip stacked batch to anti-proton production target.
 - Deliver 5 remaining batches to NUMI.
 - Repeat about every 2 seconds (may interleave with other cycles).
- BPM Configuration:
 - For each of 7 injections, measure the leading half of the newly injected batch, TbT by turn for 512 turns.
 - After last injection, make CO measurements; report at 500 Hz.
 - Just before extraction change back to TbT mode and measure the last few turns before one of the extractions.
 - Not enough time between extractions to reconfigure the system to get both.
 - Store all information until the next instance of state 5.

Timeline to Date

- December 2004 – first organizational meetings.
- Summer 2005 – Project started.
- December 2005 – First measurements using prototype transition and TGF boards.
- February 2006 – One “house” (11 BPMS) instrumented using preproduction transition boards and production TGF.
 - Used operationally for about 1 week before shutdown.
- All major capabilities have been demonstrated at least once.
 - Many capabilities have been routinely used for about 2 weeks.
 - Commissioning of the first house is nearing completion.
- Effort: typically 7 to 10 FTEs / month