December 2004 Report of the Tevatron BPM Upgrade
wbs item 1.4.5.4 of the Run 2 Luminosity Upgrade Project

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Project Manager's Summary:

The main efforts in December were the commissioning of the first production crate in the A3 service building and the beginning of deliveries of production timing and filter boards. Associated software, diagnostics, calibration and application efforts also were pursued.

The TeV BPM A3 crate instruments 8 BPMs (4 vertical and 4 horizontal). Great progress was made in December to measure closed-orbit proton and anti-proton positions using the upgraded electronics and software. By Christmas the system was able to provide stable closed-orbit measurements of proton positions. Turn-by-turn and first-turn measurements were being actively commissioned at the end of December. Anti-proton position measurements could be made offline and work had begun to understand how to provide anti-proton positions in real time.

All of the Echotek boards for the Tevatron BPM Upgrade (150 boards) and the transfer line and Main Injector BPM projects (100 boards) have been delivered and are in the process of being tested. Failed boards were returned to Echotek for repair. Five boards have been returned to Echotek at this time.

The first items of the production filter and timing boards arrived in December and were tested. The timing board had one incorrect part and once it was replaced the board tested successfully. The filter board showed phase mis-match which was traced to a probably change in the filter response probably caused by the use of wave-soldering of the filters to the board. A decision was made to hand-solder all future boards and a delivery of 22 boards was received by the end of December. Test procedures for the filter and timing boards were developed and documented.

Work continues to investigate alternative schemes of making measurements by using different filtering and averaging in the Echotek and the front-end. It is expected that these techniques will be further investigated as the commissioning continues.

Four abstracts about the Tevatron BPM Upgrade were submitted to the 2005 Particle Accelerator Conference.

During the next few months the project will continue to install and commission the systems around the Tevatron ring.

Resources Used in December 2004:

The total number of FTE-months devoted to the project in calendar December 2004 from the Computing Division was reported to be 7.5 FTE-months with 22 people contributing. The total number of FTE-months devoted to the project from the Accelerator Division was 1.1 FTE-months with 7 people contributing. The total effort from both Divisions was 8.6 FTE-months. The following table gives the estimated or reported effort for both divisions (in FTE-months) since August of 2003.

Month	AD Effort	CD Effort	Total Effort
August, 2003	1.2	2.3	3.5
September, 2003	1.4	4.1	5.5
October, 2003	5.4	6.0	11.4
November, 2003	1.6	5.0	6.6
December, 2003	1.4	4.4	5.8
January, 2004	1.7	5.1	6.8
February, 2004	2.3	6.7	9.0
March, 2004	2.1	7.6	9.7
April, 2004	2.0	7.7	9.4
May, 2004	1.4	8.3	9.7
June, 2004	1.6	8.7	10.3
July, 2004	2.0	8.1	10.1
August, 2004	1.5	8.0	9.5
September, 2004	2.3	8.4	10.7
October, 2004	1.1	10.5	11.6
November, 2004	1.8	9.9	11.7
December, 2004	1.1	7.5	8.6
SUM (through Dec)	31.9	118.3	150.4

The effort is consistent with the wbs estimates of approximately 10-12 FTE per month during this period and the effect of the holidays and vacation period in December. The effort listed here is time worked and does not include vacation, sick leave, holidays, etc.

Purchase requisitions/procard obligations in December, 2004:

Req #/PO/Fermi PO	Date	Item	QTY	Estim. Cost
PRN57612	12/3/04	OptiLogic model OL405	15	$2,500.00
PRN57611	12/4/04	Optologic Accessories	15	$162.75
PRN57798	12/3/04	RG58 Cables	2	$727.60
PO560996	12/8/04	RG316 Replacement Cables	300	$4,764.00
Monthly Total				**$3,390.35**

Milestones:

No DOE milestones in December, 2004.

Meetings held, Reports Given:

Meetings were held in December on the following dates:

Project Meetings: December 1,2,6,8,15.

Documents:

The following documents were written and added to the Accelerator Division Document Database in December:

860-v27 Tevatron BPM Software Specifications Jim Steimel *et. al.* 30 Dec 2004

1516-v1 Beam Position Scan of Tev VPA33 BPM with Upgraded Electronics. Michael A. Martens 29 Dec 2004

1512-v3 Tevatron BPM Upgrade Test Stand Setup Dehong Zhang 27 Dec 2004

1511-v1 Tevatron BPM Upgrade Commissioning Steve Wolbers 17 Dec 2004

1498-v2 BPM Sub Rack Address maps Vince Pavlicek *et. al.* 16 Dec 2004

1499-v2 BPM Electronics Production Test Plan Timothy J. Kasza 16 Dec 2004

1381-v13 Echotek Board and Other Hardware Testing Status Timothy J. Kasza 16 Dec 2004

1504-v1 Tevatron BPM Electronic Support MOU Steve Wolbers 14 Dec 2004

1503-v1 Tevatron BPM Software Support MOU Steve Wolbers 14 Dec 2004

1496-v1 Using Time Separation of Signals to Obtain Independent Proton and Antiproton Beam Position Measurements Around the Tevatron Bob Webber 09 Dec 2004

1381-v12 Echotek Board and Other Hardware Testing Status Timothy J. Kasza 09 Dec 2004

1493-v1 A Look at New Data from VA33 Robert K Kutschke 08 Dec 2004

1490-v1 Tevatron Beam Position Monitor Upgrade Steve Wolbers 07 Dec 2004

860-v26 Tevatron BPM Software Specifications Jim Steimel *et. al.* 07 Dec 2004

1451-v2 BPM Calibration Discussion Robert K Kutschke 06 Dec 2004

1483-v1 Progress Report Eric James 03 Dec 2004

1482-v1 Analysis of the phase shift error between A and B signals in BPMs Gustavo Cancelo 03 Dec 2004

1480-v1 TeV BPM Upgrade (Talk at CD Accelerator Activities Mtg 11/30/04) Steve Wolbers 02 Dec 2004

1381-v11 Echotek Board and Other Hardware Testing Status Timothy J. Kasza 02 Dec 2004

1479-v1 A Quick Look at the BPMs in A3 Robert K Kutschke 01 Dec 2004

Subproject Leader Reports:

Technical Coordinator: Jim Steimel

The technical coordination efforts have focused on commissioning the A3 system. Priorities were focused on debugging front-end and online software for reliable proton closed orbit readings during all Tevatron operations. This was achieved before the end of the year. Next, studies began in earnest for commissioning turn-by-turn and first turn data aquisition. Application programs were modified to handle the new data structures for turn by turn, and filter parameters were optimized for Tevatron single bunch or uncoalesced bunch operation. Commissioning of a second house (B3) will commence once Tevatron operation specialists are satisified with the performance of the BPM system for proton closed orbit, turn by turn, and first turn measurements.

Electronics: Vince Pavlicek

The electronics group supported the expansion of module testing into the ESS testing areas and the test crate operation in the A3 service building as necessary. Also, data acquisition tests began at a dedicated test stand in FCC to collect data to ground truth the simulations of the Echotek signal processing. Planned are comparisons between existing algorithms and several proposals for the final Echotek algorithm.

Timing card and Filter card production was started. One unit of each arrived and was used to debug the test plan that is being refined.

The first timing card had an incorrect part installed. When it was swapped with the correct part the board passed all tests and assisted with refining the test procedure. The board matched or bettered the operation of the pilot module.

The first Filter card failed the incoming characterization tests in several channels. Investigation revealed that the bandpass filters did not meet acceptance specifications including one pair of filters that passed when tested off the board, before assembly. The heat of the wave soldering process was suspected so a second unit was requested from the board house with the change that the filters be hand-soldered. That unit passed all tests and a subsequent batch of 22 hand-soldered modules was delivered. These units are under test and are also mostly passing so production of the full order was released.

Hardware Tracking/Testing: Tim Kasza

During the month of December, the final quantities of Echotek boards were delivered. All 250 boards for the Tevatron/Main Injector/Transfer Line BPM projects have arrived at Fermilab. In order to determine if upgrading firmware on Echotek boards that previously passed acceptance testing would have any effect on channel gains, we retested a small sample of boards after upgrading the firmware. We concluded that the gains remained the same to within 1 or 2 parts in a thousand. After completing this exercise,

the determination was made to upgrade firmware on the remaining boards without retesting. This effort is nearly completed except for a small number of boards mostly located in test stands. In addition, 5 Echotek boards that were sent back to Echotek for warranty repair have come back. The repair information reported back on each board indicated that solder bridges (shorts) were found across IC pins. All 5 boards have been retested, and now test fine. We have completed testing ~150 of the 250 Tevatron type Echotek boards.

As the month progressed, our efforts focused on setting up new stand alone test stands and writing test procedures in preparation for testing the production TGF and Filter boards. The first quantities of production TGF and Filter boards began to arrive in December. The 1st TGF board was delivered and tested by the project's engineering group. A total of 24 Filter boards also arrived in December. A change in phase matching characteristics was discovered with filters that were installed on the 1st Filter board. This was attributed to the high temperature used in the wave soldering technique used to solder filters to the PCB. Testing has proceeded with minor issues after a decision was made to hand solder each filters. The remaining quantities of TGF and Filter boards are expected to be assembled and delivered in January. We anticipate that our testing efforts will keep pace with the projected installation schedule.

Front-end/DAQ software: Margaret Votava

In December the DAQ group worked on the following items: turn-by-turn mode of operation, A3 house commissioning problems, integration with online software, improvement of front-end diagnostic tools, and preparation of the B3 crate for commissioning and timing board production test stand setup.

The turn-by-turn mode was tested on the A3 house. During the tests a few problems were uncovered and fixed. The turn-by-turn ACNET devices were defined with the wrong length, preventing the online software from reading out the data. The position and intensities for the various turns were the same due to a bug in the position algorithm. It was developed for the closed orbit mode and reused in turn-by-turn mode. After resolving the problems the turn-by-turn plots showed that some points had unreasonable values. The injection turn-by-turn measurements are currently ignoring the value of the state device variable that indicates the machine status.

Further tests at A3 showed possible cross-talk between timing board sync outputs. During the tests a bad filter board channel was detected. Also it was noticed that data from the bpms HA36 and VA37 were read out by the front-end as if they were HA38 and VA39 and vice-versa. The cause of the confusion was the swapping of two EchoTek board addresses.

Online applications were failing to retrieve display and profile data from the front-end node. A bug on the TCLK handling code was found, it was preventing the timing board interrupts from reaching the processor (wrong interrupt level was enabled). During the investigation of the TCLK problem it was found that the upper eighth timing board

TCLK registers were not working properly. The hardware group quickly fixed the board firmware.

The T39 and W25 applications had some problems communicating with the front-end software. The positions and intensities reported by T39 did not agree with the values at the front-end. The online application was using a bad offset that was fixed. Profile frames requested by the same application returned always data from the frame zero, even when the user requested other frames. The trace messages on the front-end showed that the online software was indeed requesting frame zero. There was a minor problem on the W25 page where the timing delays were sent to the wrong ACNET device. This was quickly fixed by the online group.

There were several improvements on the diagnostics tools on the front-end software. More options for displaying data locally were added as well as a history of received TCLKs was implemented. This helped catching TCLK sequencing problems.

Additionally, preparations were started for the B3 house commissioning by creating the ACNET devices and configuring the system to run the front-end software. The A3 and B3 timing devices were added to the download list, allowing the system to retrieve delay values after a reboot. The timing board production test stand (at FCC3) was configured to run the timing board diagnostics software.

Online software: Brian Hendricks

During the past month several bugs were found and fixed in the BPMUTI library. Also, some bugs were fixed in the T39 display program, and work continued on supporting pbar data in that program. Work also continued on Roger Tokarek's new turn by turn diagnostic program including adding support for setting up arm and trigger timing.

Offline software: Rob Kutschke

December was a short month due to a holidays and time conflict with the BTeV CD2/3a Lehman review. Following the start of Tevatron operations I collected data samples from the six new BPMs which were logged in the lumberjack data logger. I collected the shot set up for most shots until Dec 22 and I have also recorded some of the reverse proton tuneups done before each store. A few teething problems were seen in this data and reported to the hardware and daq teams; see, for example, Beams-doc-1479 and Beams-doc-1493. Most of the reported problems were quickly resolved but an issue with the transition of accelerator states remains. Otherwise, a preliminary the data looks much like the data recorded with the prototype boards.

I continued discussions with Gustavo Cancelo about the effect of differences of phase along the signal paths of the A and B signals. My first, simple calculations, reported last month, had predicted a significant effect but they did not include a simulation of the CIC filter. Gustavo's calculations included a simulation of the CIC filter and a more detailed simulation of the other filters; these calculations show that the effect is negligible.

Requirements: Mike Martens

The upgraded BPM system in the A3 house of the Tevatron has been used during routine operations and several tests of the system have been performed. Overall much progress has been made and the system is maturing as the bugs are located and fixed. At this time the closed orbit measurements are behaving as expected (although there remain several minor bugs in the reporting of the positions taken during the profile frames.) So far we have not been able to make sense of the TBT data reported by the BPM system but it is likely that this is related to timing and software issues.

As a test we measured the response of the BPM system to changes in the closed orbit. The results are documented in "Beam Position Scan of Tev VPA33 BPM with Upgraded Electronics", Beams-Doc-1516-v1, available at http://beamdocs.fnal.gov/cgi-bin/DocDB/ShowDocument?docid=1516. A summary of the results are given in the next two paragraphs.

The BPMs in the A3 house of the Tevatron are outfitted with the Tev BPM upgrade electronics. As a test we measured the response of the BPM system to changes in the closed orbit. The results are presented and compared to a rudimentary model of the Tev stripline BPMs. The upgraded BPM electronics performed as expected and, with minimal beam intensity, provided closed orbit measurements with about 0.04 mm rms resolution. The position changes reported by the BPM system are only 95% of the calculated orbit changes, but it is not clear if this is related to the BPM scale factor or to inaccuracies in the calculation of the orbit bumps. The results of the measurement are in qualitative agreement with the simple model of the BPMs, but differ in magnitude. Compared to the model the BPM response (defined as the change in reported position divided by the actual position change) is 25% less than expected. The measured change in intensity as a function of beam intensity is also less than predicted by the simple model. (Probably the model is too simple to accurately predict the actual response of the stripline pickups.)