February 2005 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:

In February the project began to install BPM electronics in additional Tevatron service buildings, once the A3 service building system was declared to be "commissioned" on February 7, 2005. This followed from showing that the A3 system was able to provide essentially all of the functionality and satisfied the requirements provided by Mike Martens before we could call a BPM house "commissioned". This does not imply that all work on the system is complete, that all measurements are working properly all the time, nor that no improvements are possible. However, it was a big step for the project and allowed us to move on to install two houses in February – B3 on February 10 and C3 on February 23.

A great deal of work was done during the month to study the performance of the systems and to make modifications or fixes to correct any problems or improve the systems. The Echotek boards were all in the process of being modified to add a 50 ohm resistor to the SYNC input. This was necessary to match the impedance of the Timing board, and to avoid noise and cross-talk. This decision was made after discussions with Craig McClure and others to ensure that the 50 ohm impedance is acceptable for other timing systems that might be used for these Echotek boards. All filters and filter boards were tested for matching/mismatching and after some discussion a criteria for failure was established in both phase and attenuation. All failed filter pairs will be returned to Lark for replacement. All Timing boards were tested and ready for use by the project.

A test stand short in late January caused by loose parts on a Filter board (as delivered by the vendor) affected 2 filter boards, 2 Echotek boards, 1 MVME processor, 1 Timing board, and the VME backplane. Repairs were made to both filter boards, the Timing board, the backplane, and one Echotek board. One Echotek board is not repairable (after being evaluated by Echotek) and will be returned to Fermilab. The MVME processor awaits a proper chip for replacement to effect a repair.

The performance of the A3, B3 and C3 systems were examined in some detail during February. This includes the reliability and stability of the systems, problem debugging and solving, analyzing the data and reporting on the features seen, enabling use of the system by application programs and SDA and others. By the end of the month the systems were running fairly reliably and remaining problems were being actively pursued.

A problem with the signal size uniformity of the 53 MHz diagnostic signal was discovered in February. Installation was held until this problem could be investigated and understood and a fix found and tested.

A meeting was held with the Run 2 Coordinator (Jim Morgan), the Tevatron coordinator at that time (Ron Moore), the Tevatron Department Head (Vladimir Shiltsev), and others to discuss the proper procedure for new BPM house installation. A satisfactory process was agreed upon and installation should proceed smoothly.

Resources Used in February 2005:

The total number of FTE-months devoted to the project in calendar February 2005 from the Computing Division was reported to be 10.9 FTE-months with 23 people contributing. The total number of FTE-months devoted to the project from the Accelerator Division was 2.5 FTE-months with 9 people contributing. The total effort from both Divisions was 13.4 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	9.7
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
January, 2005	1.1	10.0	11.1
February, 2005	2.5	10.9	13.4
SUM (through Feb, 2005)	35.5	139.2	174.7

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 February, 2005:

Req #/PO	Date	Item	Estim. Cost
PRN60505	2/21/05	T Jack+ BNC Jack/SMB T Jack	$173.70
PRN60509	2/21/05	T Jack+ BNC Jack/SMB T Jack	$151.40
PRN59669	2/1/05	RJ12/DB9Male Rs232 Cable 30	$211.50
PRN60158	2/14/05	Optologic model OL4054 15	$2,275.00
PRN60222	2/15/05	Optologic Power supply 15	$385.00
Monthly Total			$3,196.60

Milestones:

No DOE milestones in February, 2005.

The March milestones will not be achieved due to the delay in installation and commissioning. All milestones will be achieved by the end of May, 2005. The old and new proposed dates are:

1.4.5.4.4.1.7 All Tev BPM crates functionally available (except for F bldg.) or Installed:

Old date: 3/4/05 New date: 5/16/05

1.4.5.4.5.1.4 Tev BPM Electronics commissioning complete

Old date: 3/30/05 New date: 5/16/05

1.4.5.4.6.8 Tev BPM Upgrade Operational

Old date: 3/30/05 New date: 5/31/05

Meetings held, Reports Given:

Meetings were held in February on the following dates:

Project Meetings: February 2,7,9,16,21,23,28

Documents:

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

1593-v3 The Envelope Filter Gustavo Cancelo 28 Feb 2005

1592-v1 The phase shift problem in the Tevatron BPM signals Gustavo Cancelo 25 Feb 2005

1591-v1 The CIC filter Gustavo Cancelo 25 Feb 2005

1590-v1 Some models of the BPM signal Gustavo Cancelo 25 Feb 2005

1586-v1 Timing Generator Fanout (TGF) Diagnostic Signals Bill Haynes 22 Feb 2005

1383-v4 TeV BPM Analog Board PRR Bob Forster *et. al.* 18 Feb 2005

1583-v2 A Survey of TBT Capabilities of the Upgraded TeV BPMs Robert K Kutschke 18 Feb 2005

1584-v1 Collection of BPM Related Papers from the Tev Commissioning Era Alan Baumbaugh *et. al.* 18 Feb 2005

1582-v1 TBT in mid HEP Store Using the Upgrade TeV BPM Electronics Robert K Kutschke 17 Feb 2005

1581-v1 Anti-protons in the A3 and B3 Houses Robert K Kutschke 17 Feb 2005

1577-v1 Proton Position Resolutions Using the Upgraded TeV BPM Electronics in B3 Robert K Kutschke 14 Feb 2005

1571-v2 Seeing HV Coupling with the Upgraded TeV BPMs Robert K Kutschke 11 Feb 2005

1565-v2 Injection Turn by Turn From February 6, 2005 Robert K Kutschke 09 Feb 2005

1566-v2 Injection Turn by Turn From February 7, 2005 Robert K Kutschke 09 Feb 2005

907-v2 Monthly Reports of the Tevatron BPM Upgrade Project Steve Wolbers 09 Feb 2005

860-v31 Tevatron BPM Software Specifications Jim Steimel *et. al.* 08 Feb 2005

1504-v2 Tevatron BPM Electronic Support MOU Steve Wolbers 08 Feb 2005

1503-v2 Tevatron BPM Software Support MOU Steve Wolbers 08 Feb 2005

1562-v3 Confirmation of BPM Signal Amplitudes through BPM System Filter Boards - Proton, Antiproton, and Un-coalesced Bunches Bob Webber 06 Feb 2005

1276-v3 Tevatron BPM Front End Software User's Guide Margaret E Votava *et. al.* 04 Feb 2005

1552-v2 A Second Look at Injection Turn by Turn Robert K Kutschke 03 Feb 2005

1067-v22 Tevatron BPM Software Design Luciano Piccoli *et. al.* 02 Feb 2005

Subproject Leader Reports:

Electronics: Vince Pavlicek

The electronics group supported the system debugging and exploration of system issues at the test crates in FCC. The installation process continued to be high priority with the installation of B3 and C3 crates. The ESS techs continue to provide assembled crates well ahead of the installation process.

The filter card differential phase acceptance specifications were widened to approximately double the original value. This is still less than half of the phase difference that is expected to be detectable in the data processing. This new value puts 98% if the filter pairs in the accepted group. The outlier filter pairs are being evaluated individually. Four pairs have been confirmed to be out of specification and less than ten remain to be evaluated.

All components and accessories for the project have been received. The diagnostic signal was found to be of low quality and possibly variable amplitude during system evaluations. Diagnostics revealed that the mismatch of the filter card input impedance and the backplane trace impedance was causing reflections that contaminated the diagnostic signal distributed on the backplane. The filter card firmware did little more than receiving this signal from the backplane so the firmware was improved to make it less sensitive to noise and the backplane impedance was lowered by adjusting the termination resistances to reduce and damp the reflections. Also the distributed frequency on the backplane was cut in half and the firmware designed to reconstruct the original signal from the distributed signal. At the end of the month the quality was dramatically improved and the final design of the firmware and the details of the hardware changes were still being determined.

Hardware Tracking/Testing: Tim Kasza

During the month of February, we concluded our initial efforts in acceptance testing production Echotek, Filter and Timing boards.

Significant progress was made installing an Engineering Change Order (ECO) to all but a few of the 250 TeV-BPM style Echotek boards. This ECO involved changing the Sync input termination resistor from 1K to 50 ohm. Currently, we are in the process of shipping 2 boards back to Echotek for evaluation of an issue with loading firmware. To-date, this issue has been observed on approximately 11 Echotek boards.

Testing was concluded on 62 pairs of Lark filters that were previously untested. The test results are currently being evaluated to determine the full set of filter pairs that do not meet acceptance limits. Filters that fail to meet the acceptance criteria will be sent back to Lark for exchange.

All of the Motorola MVME crate processors were cycled through and have been upgraded to VxWorks 5.5.

Our efforts supported the installation of 2 new TeV-BPM system crates in service buildings at B3 and C3. In order to keep pace with the projected installation schedule, we have setup and assembled complete systems crates for the next 6 service buildings (D3, E3, F2, B0, D0, and A2).

Front-end/DAQ software: Margaret Votava

The effort during the month of February was concentrated on the following subjects: B3 and C3 commissioning, missing TCLK problem, software bug fixes, resolution of diagnostic issues, improvement on alarm capabilities, addition of survey offsets, help on resolving the timing card generated diagnostic signals and working with Echotek on the firmware loading problem.

During this month the B3 and C3 houses were commissioned. Problems were detected during startup at both locations. At B3 the front-end software failed to start leaving the processor to a state where remote sessions could not be opened. That required debugging on site, which revealed that the TCLK signal was present according to the timing card. The software was modified to exit gracefully if signals are not detected at startup time. The procedure to verify the cause of the failure is to check the TRACE buffer. After the signals were fixed the software was able to start taking data.

At C3, also during startup time, the Echotek driver failed to set the delay for the last channel of the last digitizer board. That failure caused the front-end to ignore ACNET settings, which include setting the diagnostic mode and modifying delays. The Echotek card was replaced and the system was able receive settings again.

During some injection cycles it was noticed that A3 did not report getting the correct number of profile frames. Instead the front-end was claiming that only 5 profile frames were requested (through TCLK 0x75) during injection. The TCLK history list at A3 showed that during injection the front-end was receiving 32 TCLKs 0x00, and after that event the house was out of sync with the TCLK events. During a brief time when the machine was not operating the TCLK sequencer was configured to provide the injection sequence every minute and the test stands configured to log the events. The problem could not be reproduced. However it helped to catch a few problems that could be related to the missing TCLK problem. The software was disabling the TCLK decoding between the reception of the injection TCLK (0x4D) and the injection BSYNC (0x7C). The setup also helped to find a dead lock situation if the buffers had no data. The firmware was also updated during the tests. A3 was loaded with fixed firmware and software versions, and for several injection cycles the problem has not appeared.

A couple of other software bugs were resolved. They were related to the data transfer between the front-end and the online software. First the FLASH frame (first injection

turn) was returning zero data. However, in the current setup only the 16th turn contains useful data. The first turns have intensity below the acceptable threshold. A configuration parameter was added to allow the choice of the FLASH frame position. It is currently set to be the 16th frame. While implementing this option it was detected that the data packaging for any closed orbit data was not performing as expected. The front-end keeps the data in a different order than the online software, and when it is packed the order must be inverted. The algorithm was incorrect and would send data out of order to the online applications. The algorithm was fixed and verified with test data.

The communication protocol between the W25 application (diagnostics) and the front-end software was better understood. Now the front-end disables the diagnostics correctly when the application is closed.

Work on reporting alarms to the online applications was started. Basic digital alarms can now be issued from the front-end. Some alarms that are currently being implemented are checking for the presence of the TCLK, BSYNC and 53MHz signals.

A list of survey offsets have been added to the front-end. It is a hard-coded list and every house defines which is the correct set of offsets to use based on the node name (e.g. tbpma3). The latest version contains the offsets for the A3, B3, C3, D3 and E3 houses. Other houses contain zero offsets. Zero offsets are also used if the software fails to identify in which house it is running.

For helping define whether it is possible to calculate the pbar correction coefficients on the front-end, a state device history list was implemented. The goal is to provide time stamps of the reception of the V:HELIX state change and define whether the front-end is capable of knowing exactly when the helix opens in order to take beam measurements at distinct positions at the same intensity.

Help was provided on the effort to understand and correct the timing/filter card diagnostic signal variation. Modifications on the test software were made in order to generate an output report containing the values read for every channel for different diagnostic setup.

Echotek was contacted regarding a problem when loading firmware on the digitizer board. The FPGA load process is failing for some of the boards.

Online software: Brian Hendricks

During the past month, minor changes were made to the BPMUTI library support including the addition of a raw turn by turn data routine and the combining of display frame data from old houses into the injection closed orbit data in order to facilitate access by closure programs. There were also some minor bug fixes. Also, the B3 and C3 houses were configured to access new nodes, and SDA data was successfully collected for them. The W68 turn by turn display program was modified to display intensity data as well as raw I and Q data. The W136 turn by turn display was modified to display raw

I and Q data as well, and its user interface was totally reworked. The W25 diagnostic program added crate reboot and power supply control, and several bugs were fixed.

Offline software: Rob Kutschke

I continued to monitor the data which was produced by the upgraded BPM systems in A3, B3 and C3. This included closed orbit measurements, turn by turn (TBT) measurements and injection turn by turn (ITBT) measurements. This month produced the first high quality data for TBT and ITBT. The ITBT studies include both coalesced and uncoalesced beam.

The TBT and ITBT studies uncovered several problems with the system, most of which have been understood and fixed. The one significant outstanding problem, intermittent outliers in the position measurement, has been traced to the system loosing phase lock with the 53 MHZ RF clock. This loss of phase lock was first shown in Beams-doc-1552. A candidate explanation for how the phase lock can be lost is being investigated by Jim Steimel.

The beam physics features which can be seen in the ITBT data include: synchrotron oscillations, quadrupole oscillations of the bunch in the bucket, betatron oscillations, Horizontal vertical coupling, and a set of instrumental artifacts, at 0.2 and 0.4 times the rotational frequency of the Tevatron. The studies of these features were written up in Beams-doc-1565, 1566 and 1571. A status report on this work, Beams-doc-1583, was presented at the Tevatron department meeting on February 18.

TBT data, triggered by hand in mid HEP store, was also studied. In these data there is clear evidence for oscillations in the horizontal positions at about 15 Hz, as was shown in Beams-doc-1582. These oscillations are much smaller in the vertical position data. They also vary in magnitude among the horizontal BPMS and this variation explains the observed differences in closed orbit position resolution among the BPMS (Beams-doc-1577).

I have continued studies of the cancellation of the proton contamination on the anti-proton cables. A new class of problems was discovered and was presented in Beams-doc-1581: at some BPM locations, the helix opens almost entirely in the unmeasured transverse coordinate and only a little in the measured coordinate. For these BPMs the method of using the opening of the helix to calibrate the cancellation fails. Other methods are currently under investigation.

I have begun a study of how the cancellation coefficients vary with time and from BPM to BPM. The infrastructure software for this study is complete and the physics studies are underway. Part of this study is an alternate parameterization of the cancellation.

Along with Marc Mengel and Brian Hendricks I have started plans for the calibration database.