DOE RUN II Review
July 21-23, 2003
Instrumentation Breakout
Breakout Schedule with Links to Presentations
Questions and Answers Below

Monday	
15:45 – 16:45	Response to questions 1 and 2 from the instrumentation specialists 1) Bob Webber – Responses to and progress since October Review 2) Bob Webber – Instrumentation –The Plan– 3) James Patrick – Controls System
Tuesday	
8:00 – 9:00	Tevatron Instrumentation.Response to questions 1, 2 and 3 from instrumentation specialists and Tevatron systems physicists 1) Jean Slaughter – SDA 2) Mike Martens – BPM Applications and Requirements 3) Jim Steimel – Other Tevatron Instrumentation
9:00 – 10:30	Recycler and Electron Cooling Instrumentation.Response to questions 1, 2 and 3 from instrumentation specialists and Recycler and Electron Cooling systems physicists 1) Bob Webber – RR BPM status 2) John Marriner – Beam Instrumentation in RR Commissioning 3) Alexander Shemyakin - Electron Cooling Instrumentation
10:30 – 11:15	Linac, Booster and Main Injector Instrumentation.Response to questions 1, 2 and 3 from instrumentation specialists and Linac, Booster and Main Injector systems physicists 1) Alberto Marchionni - MI BPM Requirements Specification 2) Eric Prebys – Instrumentation in the Proton Source
11:15 – 12:00	Anti-Proton Source Instrumentation.Response to questions 1, 2 and 3 from instrumentation specialists and Anti-Proton Source systems physicists 1) KeithGollwitzer – Debuncher and AP2 BPMs 2) Elvin Harms – P1, 2, AP1, 3 BPMs and Rapid Transfer –automation–
13:00 – 14:00	Joint discussion with Accelerator Physics subcommittee on the questions 2 and 3 1) Mike Martens – Tevatron Instrumentation 2) Paul LeBrun – Determination of Pbar Burn Rate in Collisions

June 23, 2003 Memo
from Bob Siemann and Massimo Placidi

We have been asked to supply questions to you as the point of contact for the Instrumentation subcommittee prior to the upcoming review of the Tevatron luminosity upgrades.Reference is made below to the "upgrade plan".These references refer to the June 15, 2003 document "The Run II Luminosity Upgrade at the Fermilab Tevatron – Project Plan and Resource-Loaded Schedule".

We would like responses to questions 1 – 3 below from instrumentation specialists and from accelerator physicists working on the individual machines, and we would like presentations from both groups during the breakout sessions.The Recycler and Electron Cooling are particularly important in the upgrade, and they would seem to deserve special attention when responding to these questions.

1) What instrumentation is planned to support each of the principal elements of the upgrade plan given starting of page 9?What are the costs, manpower requirements and schedule for each of the instrumentation projects?What are the relative priorities of the different projects?

Instrumentation included in the Upgrade Plan to support the principal plan elements is identified in the WBS sections cited below (See attached file Instrumentation_Table.xls for more details):

1.3.1.3 Main Injector Upgrades
- 1.3.1.3.1 Main Injector Dampers in support of longitudinal emittance control
- 1.3.1.3.2 Main Injector BPM System upgrade in support of all Main Injector operations

1.3.2.2.3 AP2 and Debuncher Acceptance Improvement Instrumentation
- 1.3.2.2.3.1.1 AP2 BPM data acquisition and software upgrade in support of AP2 and Debuncher acceptance improvements
- 1.3.2.2.3.1.2 Reinstall Debuncher horizontal collimator in support of acceptance improvement measurements
- 1.3.2.2.3.1.3 AP2 Large Aperture Toroid in support of AP2 and Debuncher acceptance improvements
- 1.3.2.2.3.2.1 Debuncher BPM electronics and software upgrade in support of AP2 and Debuncher acceptance improvements
- 1.3.2.2.3.3 Development of unspecified new instrumentation in support of antiproton source Antiproton production improvements

1.3.3.4.9.1 Recycler Ring Injection Dampers in support of Recycler integration

1.3.3.6 Rapid Transfers (antiprotons from Accumulator to Recycler)
- 1.3.3.6.3 Rapid Transfer Software in support of reliable and automated Accumulator to Recycler Antiproton transfers
- 1.3.3.6.4 Oscillation Feedback and Control
  - 1.3.3.6.4.1 Main Injector injection dampers in support of Accumulator to Recycler Antiproton transfers
  - 1.3.3.6.4.2 Accumulator Quad pickup in support of Accumulator to transfer line matching improvements and monitoring
- 1.3.3.6.5.1 P1, P2, AP1, and AP3 BPM upgrade in support of reliable and automated Accumulator to Recycler Antiproton transfers

1.3.4.6 TeV Improve Control and Diagnostics
- 1.3.4.6.1 Abort gap monitor in support of diagnosing and monitoring un-bunched beam in the abort gap
- 1.3.4.6.2 Tevatron Longitudinal Dampers in support of longitudinal emittance improvements to Collider beams
- 1.3.4.6.3 Proton/Antiproton Tune Meter/Tracker in support of Collider beam transverse tune control at injection and up the ramp
- 1.3.4.6.4 Tevatron BPM upgrade in support of stabilizing orbits in the Tevatron
- 1.3.4.6.5 Tevatron Ionization Profile Monitor in support of achieving and monitoring transverse matching into Tevatron
- 1.3.4.6.6 B-field diagnostics (not beam instrumentation)
- 1.3.4.6.7 1.7 GHz Schottky Detector electronics and software in support of measurement and monitoring transverse and longitudinal beam parameters (even bunch-by-bunch) throughout a Collider cycle
- 1.3.4.6.8 Pingers for head-tail monitor in support of chromaticity measurements and bunch instability investigations

The costs, manpower, and schedule for each of these projects can be found in the resource loaded

Plan charts in the attached files Inst_Cost_Run_IIu_Freeze3.2_2003-07-14.pdf and Inst_Dates_Run_IIu_Freeze3.2_2003-07-14.pdf.
--- NOTE: Date headers on the Gantt chart within these files are confusing. The Quarters are numbered as fiscal year quarters and the year above identifies the calendar year in which the new fiscal year begins; so October 1, 2003 appears as 2003 Quarter 1 when in fact that is the beginning of FY04.---
Except where there is low-resource level R&D effort with decision points identified in the future (e.g. Tevatron IPM) or parallel efforts by different resource organizations (e.g. Tevatron BPMs and Debuncher BPMs), the relative priorities of the tasks are consistent with their temporal order in the Plan schedule.
Beam instrumentation for Electron Cooling, not specifically identified in the Plan, is largely already in place, operational, and integrated into ACNET at the Wideband Lab development facility.The plan is to simply relocate this equipment and software as the electron cooling systems are installed in the Recycler.
In addition, there is considerable instrumentation effort included in the plan, though be it implicitly, under the global Operations and Operational Maintenance and Upgrades WBS 1.1.This includes commissioning and utilization optimization of recently installed instrumentation systems as well as ongoing improvements to better integrate existing systems into daily operations.Example areas include the Recycler BPM system, global intensity monitoring, Tevatron synchrotron light monitor, Tevatron BPM applications and automation software, signal processing electronics and software for Recycler 1.7 GHz Schottky monitor, Booster beam loss monitoring, Booster hardware performance monitoring, and Linac beam energy and momentum spread monitoring and feedback control.

2) Instrumentation has a variety of functions including meeting day-to-day needs for operations and providing tools for accelerator physics studies.Describe the functions of the instrumentation projects addressed in question 1 above.To what extent will the day-to-day needs be met by the planned instrumentation? To what extent will the accelerator physics needs met?Both of these should be addressed from end-to-end of the accelerator chain.Are the limitations, if any, in either category budgetary or technical?

Budgetary limitations are reflected in the estimates and scheduling of the various projects as found in the resource loaded Plan. From the Upgrade Plan overview document, The Plan is constrained by available M&S funding in FY03 and the expected funding level for FY04.This results in deferring some maintenance items until FY05-FY-07, and delays some of the early work on the luminosity upgrade by about three months.Among the instrumentation components of the Plan, the BPM systems (Tevatron, Main Injector, Debuncher and transfer lines) are the most costly and the power systems for the various beam dampers come in second.All of these costs are included in the Plan within the constraints above and with identified contingency; however, the reality of actual budgets and the expediencies of daily operational maintenance may force changes and compromises as the Plan is being executed.
Technical limitations are noted as appropriate in the functional descriptions that follow.

Main Injector Upgrades

The Main Injector longitudinal dampers will serve in day-to-day operations to preserve the longitudinal emittance of beams in the Main Injector at injection and during acceleration. For accelerator physics purposes, these dampers with permit measurement of machine longitudinal impedance parameters and instability growth rates.

The Main Injector BPM System upgrade will serve both day-to-day operations and accelerator physics concerns by facilitating accurate, high resolution closed orbit and turn-by-turn position

measurements of the beam structures that play central roles in present and future Main Injector operations in support of Run II.The current system offers accurate measurements only for trains of sequential 53 MHz bunches, poor resolution even for that beam, and is nearly un-maintainable due to both hardware and software obsolescence. The large signal level dynamic range presented by the bunch structures in the Main Injector, ranging from low intensity 2.5 MHz antiproton bunches to high intensity coalesced proton bunches, offers a significant technical challenge and be a technical limitation.

AP2 and Debuncher Acceptance Improvement Instrumentation

The AP2 and Debuncher Ring BPM data acquisition and software upgrades will provide the facility for beam position measurements with the accuracy and resolution required for the accelerator physics investigations necessary to identify the critical elements for improvement of the Antiproton acceptance of the AP2 beamline and the Debuncher ring.

The AP2 Large Aperture Toroid is a physical necessity to increase the phase space acceptance in the AP2 beamline.

The development of unspecified new instrumentation item is a placeholder for yet to be identified instrumentation required to support the increased Antiproton production rates in the Upgrade Plan.

Recycler Ring Instrumentation

Injection dampers will serve the day-to-day need to preserve antiproton beam emittance at injection into the Recycler in the presence of residual, random variations due to kickers and/or transfer line power supplies.

The new Recycler Ring BPM system does not appear in the Plan, as it is expected to be fully operational by October. It is currently about half installed and is being commissioned at this time.

Rapid Transfers

Items in this category address improvements needed to support frequent antiproton transfers from the Accumulator through Main Injector into the Recycler Ring.

Antiprotons must be injected into the Main Injector on their way to the Recycler.Injection dampers are needed in the Main Injector to serve the day-to-day requirement of preserving antiproton beam emittance at injection here just as do the respective injection dampers in the Recycler.

The Accumulator beam quadrupole moment pickup functions to observe and measure transverse beam envelope oscillations that exist in the presence of Accumulator to transfer line optics mismatch.This device primarily serves accelerator physics needs to study the quality of matching, but will be available to be incorporated into automatic daily operations.

The P1, P2, AP1, and AP3 BPM upgrade covers the transport lines through which antiprotons pass on route to the Recycler. This upgrade will provide the hardware and software to support reliable, fast, and automated beamline tune-up necessary for regular and efficient antiproton transfers.

Tevatron Improved Control and Diagnostics

The abort gap monitor is an additional and enhanced mode of operation of the Tevatron synchrotron light monitor system to detect, measure and monitor particles the ◆leak◆ into the abort gap and can be the cause of magnet quenches during beam aborts. This system is expected to serve both accelerator physics and operational needs by facilitating study of the development of beam in the gap and offering the ability to quantify the un-bunched beam intensity to determine the extent of ◆cleaning◆ that must be maintained to assure safe aborts.

In day-to-day operations, the Tevatron longitudinal dampers will serve to preserve the longitudinal emittance of beams in the Tevatron. For accelerator physics purposes, these dampers with permit measurement of machine longitudinal impedance parameters and instability growth rates

that may lead for better understanding of the machine and further performance improvements.

Tune control at injection, up the ramp, and in collision is known to be a sensitive parameter in Tevatron beam stability. The Proton/Antiproton Tune Meter/Tracker represents a dedicated effort to improve and automate measurement of both proton and antiproton tunes throughout the cycle.This functionality will offer benefits to accelerator physics understanding of the sensitivities and time-varying nature of the tunes and offer the possibility of real-time tune feedback in day-to-day operations.

The Tevatron BPM upgrade will replace the existing BPM electronics systems to facilitate accurate, high-resolution measurement of beam orbits during normal Collider operations. The overlapping in time of proton and antiproton signals coupled with the directionality of the existing BPM pick-up electrodes (which will not be replaced) present a technical limitation to getting unambiguous position information at all pick-up locations when both protons and antiprotons are present. An inter-divisional organization (Beams and Computing Divisions) is in place to carry out this project.

Transverse emittance blow-up at injection into the Tevatron is currently a problem limiting luminosity performance.At this time there is no instrument that can observe betatron frequency beam envelope oscillations at 150 GeV in the Tevatron; flying wires are too slow and there is insufficient synchrotron light.The ionization profile monitor is the device of choice to address this problem. IPM installations in numerous machines have manifested technical limitations in providing quantitatively understood beam profile measurements; useful relative measurements can reasonably be expected.

A 1.7 GHz Schottky detector was installed in the Tevatron in January and has been demonstrated to offer the possibility of tune and chromaticity measurements (even bunch-by-bunch) throughout the Tevatron cycle. This project is to develop electronics and software to automate those measurements.

The Pinger project is to fabricate and install both horizontal and vertical beam pingers, fast enough to select a single bunch within the Collider, to permit parasitic machine studies. Differential head-tail motion within a beam bunch offers insight to chromaticity and various beam stability parameters and may facilitate on-line chromaticity measurement.

3) Describe accelerator applications programs, controls hardware and programming, and automation considerations that went into the luminosity upgrade planning.How important were these issues in formulating the plan?Are the costs and manpower for these included in the upgrade plan?

The arena of applications programs, controls, and integration of instrumentation into daily operations is extremely dynamic and multi-faceted one at this time. Concise, summarizing documentation for this broad field of interest is not available. Existing software applications range from machine specific applications such as a Linac beam steering program, a Recycler Ring BPM engineering diagnostics program and a Tevatron orbit smoothing program to nearly generic, common-code based applications like the closed orbit display program and the multi-wire profile monitor display program. Automation programs, including beam-line tuners that compute injection steering corrections, the sequencer that steps through shot set-up for loading the Collider, and the Shot Data Acquisition and Analysis (SDA) programs that collect and serve beam data for performance trending and post-shot analysis are in continual evolution and the Plan assumes that this will continue, largely within WBS 1.1, Operational Upgrades.

The breakout talks will touch upon these issues in much more detail than it is possible and profitable to do here.On Monday afternoon, James Patrick will describe the vision of control system migration from the present VAX based environment to a more modern, flexible, and extendable environment. In the Tevatron Instrumentation breakout, 8:00-9:00 AM Tuesday, Jean Slaughter will describe the significant advances made in the last six months, the informational power provided by, and the future plans for the SDA software. Mike Martens, in the same session, will speak to applications software improvements particularly related to Tevatron orbit control. Eric Prebys will describe controls/software initiatives in the Proton Source in the 10:30-11:15 AM time slot and Elvin Harms will outline the Antiproton Rapid Transfer automation plans in the following session.

Costs and manpower for data acquisition and applications software are identified for nearly every instrumentation system in the Plan (see last column in attached spreadsheet file Instrumentation_Table.xls for easy to read version).In some cases, the identification is clearly apparent and rather detailed, for example, the whole of WBS section 1.3.3.6.3 is for Rapid Transfer software. In other cases, the consideration for software and controls resources captured in the Plan appears only as identified manpower effort, either a named individual or a generic computer professional.

4) Clarify the statement of page 17 of the upgrade plan that there is a shortage of expertise in electrical engineering, control system programming and instrumentation.

The statement is ◆Some specific skills are oversubscribed within the Beams Division, including expertise in beamline optimization, electrical engineering, control system programming and instrumentation.◆

The Run II Upgrade Plan is understood to demand more resources with these specific skills than are currently available from within the Beams Division for dedication to the WBS 1.2 and 1.3 Upgrade projects. The bulk of Division manpower is expended on WBS 1.1, Operations and Operational Maintenance and Upgrades. The Luminosity Upgrade depends on leveraging Beam Division expertise to manage and direct engineering and programming resources that will be made available from other divisions at Fermilab and in some cases from other institutions.

An example of current success in this area is the Recycler Ring BPM system upgrade. A concentrated effort by a project organization relying heavily on Computing Division electronic engineering and technician resources and to a lesser extent on CD programming support has, since the October review, realized a new BPM signal processing system now installed in nearly half of the Recycler.Completion of the system is presently constrained by limited tunnel access availability for installation of signal preamplifier modules.Tests of the systems that are installed are showing outstanding performance.

A second example is the production of machined pieces for the prototype large aperture Booster RF cavities.Under the guidance of the Beams Division RF and Mechanical Support Departments, several universities, including Cal Tech, Columbia, Indiana, Princeton, Texas, and Tufts, have provided machined copper components that are now being assembled here for vacuum and power testing.

A multi-divisional project organization charged with design and implementation of a new BPM system for the Tevatron has just recently been established. The Particle Physics Division is actively involved in Main Injector beam damper electronics and the Tevatron synchrotron light monitor.

In summary, the plan is to utilize to the fullest extent possible, resources outside the Beams Division where the internal resources would otherwise be oversubscribed.As noted in the Upgrade Plan overview, there ◆is concern for schedule contingency◆ where availability and utilization of outside resources might fall short.