June 18, 2007

P5 Update on Tevatron Running in FY09

The charge to the P5 subpanel of HEPAP, sent on June 8, 2005 (attached in the appendix) included a request that we recommend whether the Tevatron collider should continue taking data through FY2009 as well as what factors or considerations might lead to continued running beyond FY2009. Our recent roadmap for the field assumed running through FY2009, with the proviso that this would be evaluated by the summer of 2007. Given the excellent performance of the Tevatron collider, the continued productivity of the CDF and D0 physics groups, and the CERN schedule, the main issue that needs to be evaluated for the FY09 run is the availability of manpower for running the experiments and doing the physics. To evaluate the manpower situation, P5 held a meeting at Fermilab on June 8, 2007 where the collaborations presented their plans. This included status reports, from each collaboration, on the detectors, computing resources, and triggers in light of the increased Tevatron luminosity. At the meeting we also heard an update on planning at Fermilab and a status report and projections for the luminosity at the Tevatron. We note that Fermilab has instituted a very successful visitors program, which has provided a few key individuals for each experiment. Our very positive evaluation of the status of the experiments and the collaborations is presented below. Our strong recommendation is that the Tevatron running should be continued in FY09 at high priority. Both the experimenters and the general particle physics community are very enthusiastic about the program based on the recent exciting physics results (for example B_S mixing, limits on B_S to $\mu+\mu-$, single top production, very precise top and W masses and their implication for the mass of the Higgs boson) and the physics potential of larger data sets.

The issue of what might lead to further running beyond FY09 is very dependent on the status of searches for new physics and the Higgs boson. P5 felt that this could better be evaluated at the end of the summer when many analyses now in progress have reached their conclusion. We therefore have deferred our comments on the possibility of running beyond FY09 till a later date in this year, when the analyses now in progress have been concluded. We anticipate that these analyses will present physics using approximately 2 fb^{-1} of collected data. The running through FY09 would most likely provide an integrated luminosity between 6.3 and 7.3 fb^{-1}. Additional running would likely add between 1.5 and 2 fb^{-1} per year.

Detector Status and Manpower for D0 and CDF

D0 Detector Status

The decision of running the Tevatron collider in FY09 is supported by the excellent performance of the detectors. In fact, the D0 detector is not only performing well but it is expected to continue to do so up to at least 7.5 fb^{-1} of data, assuming no surprises.

There were some concerns about the D0 superconducting solenoid after the FY05 shutdown when the solenoid was warmed to room temperature to fix a leak in a vapor-cooled current lead and it quenched while raising the current to its nominal operating value of 4750 amps. Detailed analyses of the behavior of the solenoid and the cryogenic system indicated that a resistive solder joint on the inner coil of the solenoid was likely the problem, and that the resistance of that joint increased when the coil experienced large thermal cycles. To minimize the risk of additional degradation of the coil joint, controlled access procedures were revised to allow entry to the Collision Hall without ramping down the solenoid in order to minimize the frequency of charging and discharging cycles of the solenoid. Moreover, the operating field and current were reduced from 2 T to 1.9 T and 4750 amps to 4550 amps, respectively. The operation of the solenoid in this new configuration has been very stable over the last few years.

An upgrade to improve the D0 detector performance for the Run IIb of the Tevatron was successfully concluded in 2006. The upgrade included the challenging insertion of an additional layer, L0, of radiation hard silicon detectors designed to fit inside the RunIIa Silicon Microstrip Tracker (SMT). The new layer is performing extremely well with only 19 bad channels out of total of 12,288 channels. L0 provides improvements in tracking precision and it is already in use for first physics results with 2 fb^{-1}. The analysis of the depletion voltage of each SMT layer versus integrated luminosity indicates that even layer 1 would be operational up to 7.5 fb^{-1}. Overall we conclude that the silicon system should remain fully operational through FY09, even if its performance might be degraded by the decreasing signal over background expected at higher doses.

The SMT is surrounded by the scintillating fibers tracker (SFT) which is readout by Visible Light Photon Counters (VLPC). The SFT is performing well with a light yield of ~ 7 photoelectrons/mip and with more than 98% operating channels. The new readout electronics (AFEII) installed at the end of 2006 improves significantly the resolution and it shows no saturation up to highest luminosity. Nonetheless, tracking at high luminosity remains challenging because of the small central tracking volume and the high occupancy per fiber. For example, the tracking efficiency in $Z\rightarrow\mu^+\mu^-$ decreases by about 5% when the luminosity increases from 0.5×10^{32} cm^{-2} s^{-1} to 1.5×10^{32} cm^{-2} s^{-1}. D0 should continue to monitor this drop and evaluate its impact on the b-tagging efficiency and other analyses such as the search for the standard model Higgs. P5 is concerned that substantial collaboration resources will need to be directed to understand these effects and to develop new algorithms to recover the tracking performance at high instantaneous luminosity. Doing as much of this work as possible in FY08, focused particularly on discovery physics, will be important to running the experiment and doing physics with reduced staffing in FY09.

The Uranium Liquid Argon calorimeter and muon systems are stable and reliable. D0 observes less than 0.1% of non-working channels in the calorimeter and 0.5% in the muon systems, respectively. No radiation damage issues for these detectors are expected.

The D0 trigger system selects ~100 Hz of events to write to tape out of a 2 MHz interaction rate. The Level 1 trigger operates at ~2 kHz, which is reduced to ~1 kHz at Level 2 and 100 Hz at Level 3. Calorimeter and fiber tracker trigger upgrades were installed during the 2006 summer shutdown. As a result of these upgrades a new L1 "caltrack" trigger was implemented which provides matching between calorimeter objects and tracks. The committee congratulates D0 for the successful implementation of these triggers. The caltrack trigger has a significant impact in reducing the jet, missing energy, and di-electron trigger rates at high luminosity while maintaining a good efficiency for physics.

Regarding computing, P5 expressed some concerns that the D0 collaboration relies on GRID resources for Monte Carlo generation and data reprocessing and that these resources might decrease once the LHC experiments come online next year. Fermilab is aware of these issues and both D0 and CDF seem confident that they will be able to deal with computing resource issues through FY09. The lab has also committed to providing the necessary computing resources for analyzing the data after the Tevatron running is complete.

In conclusion the experiment is operating well and recording great physics quality data. The average data taking efficiency is ≈85% and during a typical week ≈ 40 pb^{-1} are collected. As of today D0 has ~ 2.5 $fb^{-1}$of data on tape and it has already reported physics results from data collected early in 2007 such as the search for $B_S \rightarrow \mu^+\mu^-$ which is sensitive to new physics and uses 2 fb^{-1} of data. The physics program of the collaboration remains clearly of the highest quality and 2006 was the best year in D0 history in term of publications, with many fundamental results already presented such as the first evidence for single top production, and more physics to come in the future.

D0 Manpower Status

Running the Tevatron through FY09 implies another 2 years of data taking and probably at least 4 more years of intensive analysis. We see substantial challenges for the D0 Collaboration in the area of personpower as they will try to fulfill all the tasks connected with that program.

We were impressed with the fact that the Collaboration has made a detailed study of personnel projections through FY09. Numbers presented to us were based on MOU's with the collaborating institutions. So far there has not been a comparably detailed study of available personnel for the subsequent analysis tasks. We want to emphasize that one should not underestimate the amount of effort, and hence number of FTE's, that will be required to bring the various analyses to completion. In addition, significant computer resources will be needed during the post-data taking analysis phase. The Collaboration has made a concerted effort to see how the existing modus operandi could be streamlined to enable operation with fewer people. There are a number of areas where higher efficiency in the use of human resources can be expected in the future.

We applaud the Collaboration for these efforts but want to express simultaneously our concern that some of the projections may be somewhat optimistic and/or do not leave much margin for error. We want to flag several areas where we feel the element of risk is especially high. Fermilab will need to monitor these areas and help, should problems arise.

Part of the argument for fewer personnel needed in the future relies on the assumption that both the data taking and the analysis will be much more stable in the future. That may well turn out to be true but we see several reasons why these hopes may not be realized. Increased luminosity may require additional tuning of different analysis algorithms due to higher occupancy rates and/or possible deterioration of detector performance. In the analysis area, inclusion of additional physics channels in the Higgs search may require significant additional studies before any gain is realized. As mentioned earlier, every effort should be made in FY08 to prepare the way for running in FY09 with fewer personnel.

We see a number of worrisome features in the personnel projections. The total number of FTE's is projected to decrease by almost a factor of 2 over the next two years. The number of students is decreasing rather rapidly and the data shown indicates that the graduating students are not being fully replaced by new ones. That does not bode well for speedy completion of analysis. The fraction of time that an average D0 collaborator will have to spend in FY09 on service tasks is projected to be 67%. That significantly decreases the attractiveness of participation in the experiment and may lead to speedier exodus of physicists, thus aggravating this particular situation. In addition, it obviously will decrease the pace of the analysis. Another concern is to what extent some of the subsystems will be losing key personnel in the near future. We were not shown data on this point and thus cannot assess how serious a problem that might be.

We urge the Collaboration to continue their investigation of these potential difficulties and of ways to alleviate them. Intensive recruiting of new personnel, and especially new students, is one avenue that should be pursued. Different subsystems, in both software and hardware, need to be examined to see if there will be sufficient expertise to maintain them till the end of the experiment. We urge additional streamlining of the physics program through more focused emphasis on a limited number of topics with the highest discovery potential, particularly in FY09.

The Fermilab visitor and guest scientist program provides a mechanism for alleviation of some of the personnel problems. We urge the Collaboration and the Laboratory to work together to see how this program could be optimized during the next 3 or 4 years so as to help assure maximum physics productivity.

CDF Detector Status

If the CDF detector were to continue to function as it has to date, there would be little worry about the ability of CDF to operate that detector through 2009. The detector has now logged 2.2 fb^{-1} with an efficiency of 85% (with the silicon detector turned on).

The calorimetry and the muon system appear to have no problems worth mentioning. The questions arise in the tracking and triggering systems. For tracking CDF has a large advantage over D0 in that the central outer tracker has larger radius, more detection layers, and hence lower occupancy. The drift chamber, after an incident with reducing gain, has stabilized operation by adding oxygen to the gas mix, resulting in cleaned wires.

The inner silicon tracking might present a problem in FY09. The innermost layer is nearing type inversion and a plausible extrapolation indicates that it can remain fully depleted and functional for tracking through 2009 running. This prediction is not completely solid in that the one standard deviation contours intercept the maximum voltage before breakdown at about 6 fb^{-1}. The data at the end of the present run should, however, allow a much better extrapolation of the performance through FY09.

The most worrisome problem at present is the leak in the ISL cooling system. It is not known if this is a one of a kind problem or a systemic problem. CDF have created a task force to address the leak and more information will become available after the August-September 2007 shutdown when repairs will be made.

The triggers must keep pace with any further increases in luminosity. A variety of recent trigger upgrades allow CDF to preserve the physics menu up to a luminosity of $3x10^{32}$ cm^{-2} sec^{-1}. At this luminosity, reconstruction efficiencies appear to only suffer modest reductions. The data acquisition bandwidth will also be increased. In addition, CDF have taken the decision to focus on their Higgs search, improving trigger efficiencies on specific channels related to Higgs searches with different production mechanisms and different Higgs decay modes. This focus is quite appropriate as the manpower available to do analysis begins to fall off and will likely yield significantly more events in which to search for new physics. We were impressed with the very significant strides in triggering.

A plan is in place to secure sufficient computing resources to analyze data taken through 2009 in a timely manner. After data taking is complete, the CDF online computing farm becomes available as a potential additional computing resource.

CDF Manpower Status

CDF conducted a survey of available human resources and required effort in 2005 by polling the collaborating institutions and establishing MOU's with each. The exercise was repeated in 2007 using the same methodology and the previous results were used to validate the current survey. For example, the 2005 survey indicated that by 2007, 132 FTE's would be required to operate the detector and 320 FTE's would be available. (In this context, "operate" includes running the detector, processing the data, developing the algorithms, and management). The 2007 "actuals" are 124 FTE's required for operations with 392 FTE's available. The fact that these numbers are comparable validates the methodology and gives confidence in the 2009 projections based on the 2007 survey. The 2009 projections are that 102 FTE's will be needed for operations and that 236 FTE's will be available. One way of interpreting these numbers is that 236-102= 134 FTE's will be available for physics analysis prior to the end of FY09. These numbers indicate that we can expect that CDF will have adequate human resources to run through the end of 2009 and get the high priority physics from that data analyzed and published.

It is interesting to look at the (relatively small) differences between the 2005 projections and the 2007 actuals. CDF needs fewer people for operations and has more people available. They attribute the former to a concerted effort to streamline and automate operations and the latter to the physics becoming more attractive due to new opportunities and LHC delays.

CDF should be commended for carrying the needs/available analysis one step further by checking specific expertise requirements and availability for each sub-system. They refer to this as a “gap” analysis. As an example, we were shown the Central Outer Tracker (COT) analysis where the COT experts were categorized as “committed”, “likely available”, or “unavailable” quarter-by-quarter through the end of FY09. The resulting small “unavailable” gap was flagged as a management action item. The Committee feels that D0 could benefit from a similar exercise.

Appendix:

P5 Charge
P5 membership list

U.S. Department of Energy
and the
National Science Foundation

JUN 0 8 2005

Professor Abraham Seiden
Chair, P5 Subpanel of HEPAP
University of California, Santa Cruz
1156 High Street
Santa Cruz, California 95064

Dear Professor Seiden:

As you know, the role of the P5 Subpanel is to advise and prioritize specific projects, at the request of the Department of Energy (DOE) and National Science Foundation (NSF), and to maintain the roadmap for the field. We would like P5 to begin the task of making a new roadmap for the next decade. This roadmap should be based on input from the various HEPAP subpanels, formed over the last few months, looking at specific sub-areas of particle physics. The roadmap should integrate the various projects into a coherent plan based on scientific promise, cost, and technical and budgetary constraints. There are major opportunities ahead of us – the Large Hadron Collider will soon be producing data, there is a consensus among high energy physicists worldwide towards an International Linear Collider, and a number of study groups and subpanels have laid out the opportunities in such other areas as neutrino physics, dark matter and dark energy.

Of course, the U.S. high energy physics program already has a suite of highly productive accelerator-based efforts at Fermilab, SLAC, and Cornell, and is now reaping the scientific output of the world-leading user facilities that were built in the 1990's. The particle physics community has been aggressive in trying to exploit these investments, and the payoff has been and continues to be a rich and diverse set of physics results. Now is the time to begin considering the next phase: a plan for the Tevatron Collider and PEP-II B-factory that also makes room for other initiatives important to realizing the grand opportunities of elementary particle physics. While the opportunities are great, the budgetary environment is difficult at best. Like all experimental programs, the Tevatron and B-factory will eventually reach the point where the scientific returns diminish, or are eclipsed by other facilities. The immediate question on which we ask your advice is: when would the significant resources that are now invested in operations of these facilities have a greater scientific impact if they were to be deployed otherwise.

Current planning calls for PEP-II to be operated until the end of FY2008 at the latest, and the Tevatron collider to be operated until the end of FY2009. What factors or considerations might lead to stopping B-factory operations one year, or two years earlier than planned? When would we be in a position to make such a determination and what information would be needed? Similarly, for the Tevatron collider, what factors or considerations might lead to stopping operations one year, or two years earlier than now planned? What might lead to running longer than now planned? Again, when would we be in a position to make such a determination and what information would be needed?

In considering and commenting on these issues, you should understand these questions within the international context of HEP and what is planned at KEK-B and the LHC. For definiteness, you may assume a constant funding level for the overall US HEP program; do not assume that the geographic or programmatic distribution of those funds must remain as now. For the purposes of this exercise you should understand that there would likely be no funding for any new initiatives in neutrinos, dark matter and/or dark energy, and no significant ramp-up in ILC R&D until the operations of these facilities are completed. Again, for this exercise, you should assume the availability of redirected resources will strongly impact our ability to carry out smaller initiatives within the roadmap (for example in neutrino physics, dark matter, and dark energy), but will likely impact only weakly the start date for ILC construction, which will largely be determined by other factors.

The DOE and the NSF would like a draft recommendation regarding the two major facilities, in the context of an initial roadmap, by the end of October 2005, with a final report by the end of November. A separate request to construct a final roadmap will be made after the conclusion of the work being done by the various HEPAP subpanels addressing the sub-areas of particle physics.

Thank you in advance for your dedication to addressing these important and challenging questions.

Sincerely,

Dr. Robin Staffin
Associate Director
Office of High Energy Physics
Office of Science
Department of Energy

Dr. Michael Turner
Assistant Director
Mathematical and Physical Sciences
National Science Foundation

cc: Fred Gilman

Membership List

Particle Physics Project Prioritization Panel (P5)

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