

Run II Luminosity
Director's Review Panel Report
Oct . 18, 2002

Introduction

Fermilab Director Witherell assembled a panel of accelerator experts (See Appendix I) which met at Fermilab Oct. 17 and 18 to review plans and accomplishments for FY03 colliding beam operation. (See Appendix 2 for the detailed charge.) Each of the relevant project heads and the overall managers gave detailed presentations about the current status of the systems , concerns and plans for improvements together with their immediate and longer range goals.

The Panel was very favorably impressed with the progress in peak and integrated luminosity achieved in recent months. It appears highly likely that the base goal for integrated luminosity in FY03 (200 pb^{-1}) can be met or exceeded. The Laboratory has become highly focused on the colliding beam program with human resources drawn from across the Lab to meet the goals. The results of this focusing have been dramatic and the Lab is to be complimented for this accomplishment.

Charge Number One

- 1. The committee is asked to review and comment on the current status of Run IIa luminosity performance and the effectiveness of the current technical and management activities to improve that performance. The committee should comment on the plan presented to increase the peak luminosity and to accumulate integrated luminosity in FY03. The committee is asked to comment on whether or not we have developed a comprehensive understanding of the issues and challenges that must be addressed to achieve these goals. The committee is asked to review our plan for achieving these goals and to comment on whether or not the plan is judged to be comprehensive, realistic and achievable considering the current status and understanding of the collider complex.*

Overall the plan to increase the peak luminosity in FY03 is comprehensive and sound and the organization now in place will be able to carry it out in a timely fashion. By important subsystems we make further comments:

Proton Source (Linac + Booster)

The source is delivering sufficient protons now to meet the base goals of the colliding beam program for this year. The improvement projects planned to enhance stability through additional active damping are important for luminosity and will probably also help in decreasing beam loss and the attendant deposition of radiation. Further reduction of radiation deposition in machine components via the planned collimator system may not be entirely adequate to handle the order of magnitude increase in integrated beam output made necessary by the upcoming

neutrino program. Mitigation of space charge effects may be needed in addition and may be needed for the future of the colliding beam program beyond FY03.

It is to be noted that the neutrino program to be run simultaneously with the colliding beam program will require an order of magnitude more integrated proton flux than the collider program. This will stress the proton source considerably in radiation dose potential and electro-mechanical stress to pulsed elements. Reliability concerns and priorities may demand difficult decisions.

Main Injector

The longitudinal damper planned for the MI is important for further luminosity increase through improved coalescing efficiency. Emittance dilution control is expected to be enhanced by the planned injection damper as well. In addition, the planned BPM improvement is also important in tuning up the system when the 2.5 MHz beam is in use. Of particular note is the collaboration with SLAC on BPM development which has been very beneficial.

Antiproton Source

Recent improvements to the optics and cooling system have brought current performance far enough to support the FY03 goals. Plans for further improvements will support further luminosity improvements in the future. It will be important to continue work on understanding the saturation of the longitudinal emittance, now observed in the debuncher, so that the cycle time can be reduced. When this is accomplished it will be appropriate to review the longer term plan for enhancing the cooling rate based on the knowledge accumulated through the recent and planned improvements.

Tevatron

The Tevatron group has consistently managed to profit from improvements in the injector chain to increase luminosity. The planned emittance and injection dampers are important and will enhance stability and luminosity. The planned aperture increase is also highly likely to bring significant luminosity enhancement. It appears that some local alignment work in areas needing relatively large correctors may bring some profit as well. The planned improvement to the BPM system and other instrumentation are important as well but may have to be deferred.

Beam Transfers

The issues here are well understood and the means for resolving them planned. The institution of improved Beam Line Tuning instrumentation and implementation is planned and will bring useful benefits.

Recycler

The Recycler will not be used in FY03 but preparatory work needs to be done so that it can be available for later luminosity upgrades. Issues in completion of the recycler commissioning are

largely understood. Work on integrating the recycler into the accelerator chain must await a time when stacks of $2E12$ pbars are available for measurement of equilibrium emittance.

Shot Data Analysis

This system and its implementation are a resounding success and the Lab is to be complimented on this achievement which will be a key factor in meeting current and future goals.

Accelerator Physics Issues and Management

Important factors in achieving future luminosity goals will be understanding of beam-beam short range and long range effects in the Tevatron and longitudinal and transverse instabilities in the various accelerator systems in the chain. Space charge effects in the booster may also be a significant factor in future luminosity enhancements. The Panel was pleased to see that most of the Beam Physics group is engaged in some aspects of these challenges. Review of the disposition of these resources may prove useful

The Panel was particularly pleased to see the important collaboration with SLAC physicists in doing simulations of beam-beam effects. Learning to compute these effects will be essential to achieving the ultimate luminosity possible in the Fermilab colliding beam program.

- 2. The committee is asked to comment on the management of the effort considering aspects such as organization, deployment of resources, and talents of the staff. The committee is asked to make recommendations to the director for actions which would improve the probability of success of the laboratory luminosity plan. In the Review Committee's judgment, do the proposed plans and processes give reasonable assurance of meeting the luminosity plan? How might these plans and processes be improved?*

The Panel is pleased to see the great attention to management, organization and prioritization of resource usage that is being paid to Run IIa. We judge that the current organization is capable of meeting the FY03 luminosity goal and perhaps even more. The Panel applauds the decision of the management to merge Run IIa and Run IIb and view the whole as a dynamic system which will need to evolve as the initial system is fully commissioned and the emphasis is on specific luminosity improvements and in maximization of production. The organization and skill set of the subtask leaders will need to evolve along with the program. Now and in the future the integration of the subtasks and particularly in reviewing the necessarily shifting priorities in and among the subtasks are and will be very important indeed. This need should be revisited periodically by the Lab leadership.

In this context it is appropriate to comment on the available resources as well. These resources are tightly circumscribed by current conditions in the US HEP program and are not likely to change in the near future. Thus the Panel is particularly pleased to see the successful effort to encourage and benefit from collaborations among the various Lab Divisions and with other laboratories in the US and abroad. There remain manpower needs in the Beams Division and the Panel hopes that further intra-laboratory recruitments will be possible. The panel hopes that further, carefully arranged and well matched inter laboratory collaborations can also be made.

3. *The achievement of high luminosity performance is dependent on reliable machine operation. Consequently, the committee is also asked to be sensitive to infrastructure issues in each subsystem of the Tevatron complex that may be impacting performance and how these are being or should be addressed.*

The Panel finds that the Lab managers and leaders are very sensitive to this issue and have taken means to address the concerns of reliability. Reliability statistics are routinely collected and analyzed for patterns. A study of vulnerabilities has been made and is being evaluated for priority setting in the purchase of spares and the redesign of equipment that will be more highly stressed in the future than it is at present. While there may be surprises when the full system is operating as envisioned, a great part of the system is now in operation and its reliability statistics well known so that there is a solid basis for designing and implementing reliability improvements.

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APPENDIX 1

Director's Review of Run II Luminosity Plan

REVIEW PARTICIPANTS

Director's Review Committee

Swapam Chattopadhyay, Jefferson Laboratory
Mike Harrison, Brookhaven National Laboratory
Phil Martin, Fermilab (ret.)
Joseph Rogers, Cornell University
Marc Ross, SLAC
Peter Tenenbaum, SLAC
Maury Tigner, Cornell University (Chair)
Ferdinand Willeke, DESY

Observers

John Staples, Lawrence Berkeley National Laboratory
Mike Zisman, Lawrence Berkeley National Laboratory

Presenters

Mike Church
Jim Crisp
Paul Czarapata
Steve Holmes
Dave Johnson
Valeri Lebedev
Dave McGinnis
Shekhar Mishra
Vladimir Shiltsev
Jean Slaughter
Mike Syphers
Bob Webber

Directorate

Hugh Montgomery
Ken Stanfield
Mike Witherell

Department of Energy

Jim Miller
Dennis Parzyck
Paul Philp

APPENDIX 2

Charge to the Review Committee

Fermilab Run II Luminosity Director's Review

October 17-18, 2002

The Fermilab Tevatron facility has been in operation colliding protons and antiprotons since March of 2001, following a five-year period to complete the Tevatron Fixed Target program, complete construction of a new 120 GeV Main Injector synchrotron and upgrades to the rest of the accelerator complex and to the CDF and D-Zero detectors. In the period prior to the five-year shutdown, known as Run Ib, the Tevatron performance set world records for peak, average, and integrated luminosity in a proton-antiproton (P-bar) collider. In the present run, Run IIA, the Tevatron has in July, August, and September of this year exceeded its Run Ib records and is again operating at world record peak, average, and integrated luminosity, exceeding those of Run Ib. However, the start-up of operations for Run IIA has not progressed according to plan. The integrated luminosity is about a factor of two behind its original, planned time line.

The Run II Tevatron collider program is anticipated to be an important extension of the productive physics program of Run I, which included the discovery of the top quark. With the successful commissioning of the Main Injector and the Recycler, the Tevatron in Run II is planned to run at luminosities an order of magnitude higher than it has in the past, and at the higher center-of-mass energy of 2 TeV. The degree to which the Tevatron achieves this performance in Run II will determine the physics reach. For this reason, it is vital to the U.S. program in high energy physics to maximize the performance of the Tevatron and, therefore, the scientific output of the Collider experiments in this critical period before LHC turn-on.

Presentations to the committee will provide an overview of Run II goals, current performance and issues. The goals and strategic approach for the coming year will be presented. We will discuss with the committee, accelerator physics issues, a summary of current performance, comparison with Run IIA goals, identification of major issues needing resolution in order to achieve peak luminosity of $(5 - 8) \times 10^{31}$, performance goals for FY03, major tasks for the coming year, schedule, and resource requirements.

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issues and challenges that must be addressed to achieve these goals. The committee is asked to review our plan for achieving these goals and to comment on whether or not the plan is judged to be comprehensive, realistic and achievable considering the current status and understanding of the collider complex.

2. The committee is asked to comment on the management of the effort considering aspects such as organization, deployment of resources, and talents of the staff. The committee is asked to make recommendations to the director for actions which would improve the probability of success of the laboratory luminosity plan. In the Review Committee's judgment, do the proposed plans and processes give reasonable assurance of meeting the luminosity plan? How might these plans and processes be improved?
3. The achievement of high luminosity performance is dependent on reliable machine operation. Consequently, the committee is also asked to be sensitive to infrastructure issues in each subsystem of the Tevatron complex that may be impacting performance and how these are being or should be addressed.