TEVATRON II - FIXED-TARGET FACILITIES AT 1 TEV

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Introduction

There are many different aspects of the major construction programs now under way at Fermilab. The Energy Saver (**Fermilab Report**, April 1979 and January 1980), which is already approved, allows for the construction of magnets and refrigeration for a superconducting ring in the Main-Ring tunnel. Tevatron Phase I (**Fermilab Report**, November 1979), a line-item construction project which the Department of Energy has submitted to Congress for approval in FY 1981, includes raising the energy of the superconducting ring to 1 TeV and the construction of a proton-antiproton colliding-beam facility based on the 1-TeV ring.

The existence of a 1-TeV accelerator also opens the possibility of an exciting program of fixed-target physics in the three external laboratories. With the increased energy and intensity of secondary beams produced by 1-TeV protons on fixed targets, it will be possible to extend weak-interaction experiments and measurements of quark and gluon spectroscopy and dynamics into significant new ranges. Work is progressing on conceptual designs to provide the facilities for these experiments. The construction project needed to accomplish these goals is called Tevatron Phase II. Fermilab has submitted this to the Department of Energy for funding in FY 1982.

There are many advantages that arise from the fact that this is an expansion program and not a completely new experimental area or laboratory. First, there is the obvious one that there are large savings because so much of the existing facilities can be adapted to 1 TeV and need not be rebuilt. Second, there is considerable experience in using the facilities at lower energies that will necessarily influence the design at 1 TeV. There is even experience in upgrading the energy of an experimental area; the Meson Area was originally designed for 200 GeV and has already been expanded to 400. Finally, there is the advantage that with the areas in place and with other yearly improvement funds available, we can choose those improvements of the 400-GeV program that enable us to continue operating the external areas at 500 GeV during the Saver commissioning and that are compatible with our conceptual plans for Tevatron II. This report will discuss the improvements and upgrading contemplated in the Tevatron II proposal without going into the details of the funding.

Accelerator Improvements

The Tevatron I project will provide a superconducting synchrotron (and storage ring) capable of sustained operation at 1 TeV. Tevatron II will need to provide for beam extraction at 1

TeV and improvement of the Switchyard to transport 1-TeV beams to the targets. Conventional bump magnets, electrostatic septa, and Lambertson magnets will be built for the extraction channel from the 1-TeV accelerator. The extracted 1-TeV protons will intersect the existing 400-GeV extracted beam line near the end of the Transfer Hall. The large dipole strings in the Switchyard will be upgraded by replacing the existing EPB dipoles with Energy Saver superconducting magnets. A bending string of 3 Energy Saver magnets has already been run successfully for many months in the Meson Area M6 beam line.

In the three external areas, conceptual plans have been developed for a 1-TeV Fixed Target Physics Program through a series of summer studies, workshops, and informal meetings with users. None of the plans below are final nor have final priorities been decided. Forthcoming workshops and PAC meetings are expected to influence both our plans and priorities. We present our current thinking here to encourage users to continue to contribute their ideas.

Neutrino Area

In the Neutrino Area, the spectrum of secondary mesons and hence the decay neutrinos produced from the production target will be increased in both intensity and energy. Since additional decay flight path for the higher energy mesons produced at 1 TeV is needed, Nuhall will be extended 100 m upstream to provide this space, all the way to the present location of the G3 manhole. This will enable us to move the primary proton target upstream. In addition, the first 150 meters of the earth shield in the N0 line will be replaced by steel to absorb the higher-energy muons produced by 1-TeV protons. Dichromatic neutrino beams will be possible up to an energy of 750 GeV.

Muon experiments at Fermilab have always been limited by the energy and intensity limitations of the present N1 beam. It is planned to build a totally new muon beam and Muon Experimental Building with an independent primary beam. It is estimated that the intensity will increase by two orders of magnitude, making it possible to probe the structure of nucleons down to 10^{-16} cm at an energy of 750 GeV.

A number of other smaller improvements are planned for the Neutrino Area, including a new Neutrino Experimental Hall and improvements of the hadron calibration beam lines.

Proton Area

An immediate gain in the intensity and energy of the secondary-particle beams is realized in the Proton Laboratory when the Switchyard and Enclosure H proton triple split are upgraded to 1-TeV capability. In both the P-West high-intensity secondary beam and the P-Center hyperon channel, the gain in intensity is immediate. The secondary-beam and the experimental-

detector energy capabilities will be increased as the physics proposals received dictate.

Presently P-East houses both the Tagged-Photon Laboratory and the broad-band photon beam. A major shortcoming of the present design is the inability to operate both of these beams simultaneously. It is planned to introduce an additional split of the P-East primary proton beam in Enclosure H, creating two independent targeting stations in P-East. One of these two stations will produce the existing electron beam to the Tagged-Photon Laboratory. The 1-TeV incident proton energy will result in a factor of 500 increase in the electron yield at 270 GeV, the present limit of the secondary-beam energy delivered to the Tagged-Photon Laboratory.

The other P-East primary beam will be used to produce a broad-band charged or neutral beam feeding a completely new Broad-Band Laboratory. In this beam it will be possible to generate a high-energy, high-intensity electron beam of wide momentum acceptance up to an energy of 600 GeV. The beam can also be used as a high-intensity charged-pion beam or a neutral hadron or photon beam because its unique "double dog-leg" design returns the final beam to the incident primary beam centerline.

Meson Area

The new Meson two-way split and plans for its improvement to a 400 GeV three-way split were discussed in **Fermilab Report** in November 1979. By upgrading the triple split to 1 TeV, immediate intensity increases will be gained in all the Meson Area secondary-beam lines. It is currently planned to rebuild the target box, adding an overhead target service building to enable more flexibility in adding and handling active targeting magnets for the present primary proton targets. Magnets and magnetized shielding immediately downstream of the primary targets are expected to alleviate the background muon problem that will arise when 1-TeV proton beams are targeted.

The upgrading of the major bend points in the Meson Area secondary-beam lines by substituting Energy Saver dipoles for the existing Main-Ring dipoles has already begun. It is expected that the secondary beam line energy capabilities will keep pace with experimental proposals for physics with the Tevatron. It is planned to modify the experimental detector stations in the M6 line to optimize the handling of the higher energy and intensity secondary fluxes produced at 1 TeV. The modification includes building a detector enclosure downstream of the Meson Detector Building and rearranging the existing Wonder Building enclosures in the M6 area.

Other projects under discussion include modification of the present M2 beam line to include a Polarized-Proton Beam Facility, being constructed in collaboration with Argonne National Laboratory. Studies indicate that the 200-GeV M4 secondary beam

line will become a very useful test beam at Tevatron energies, because its large production angle and both charged and neutral particle capabilities, give it a large range of secondary-particle possibilities but a limited intensity.

Conclusion

Although the detailed design of a 1-TeV fixed-target program for the external laboratory facilities will continue to evolve during the next three years, it is clear from the conceptual plans that many exciting technical projects and physics opportunities exist in these areas. The Research Division has announced a workshop to be held on May 1, 1980, to discuss the "Physics Opportunities at 1 TeV" to explore the physics questions and experimental techniques relevant to a 1-TeV fixed-target physics program.

The Fermilab experimental areas have developed to an advanced state of flexibility and utility at 400 GeV and have hosted some outstanding physics experiments. It is our aim to devlop the external areas and a physics program that will make the Tevatron era at least as productive as the first decade of fixed-target research at Fermilab.

Chuck Schmidt inspects a new ion source.
(Photograph by Fermilab Photo Unit)