STATUS OF THE FERMILAB MAIN INJECTOR PROJECT

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Abstract

Fermilab is in the midst of a program to raise the luminosity in the Tevatron proton-antiproton collider by at least a factor of ten above the currently achieved level of 5×10^{30} cm^{-2}sec^{-1}. The centerpiece of this effort is the Fermilab Main Injector, a new 150 GeV synchrotron that will replace the existing Main Ring accelerator. This project is now under construction with completion scheduled for the summer of 1998. Status of the associated R&D program and progress on construction will be discussed.

1. INTRODUCTION

The Fermilab Main Injector (FMI) Project is the centerpiece of Fermilab's initiative for the 1990s, Fermilab III. The goals of Fermilab III are: to produce sufficient quantities of the top quark to allow determination of its fundamental properties; to provide a factor of two increase in the mass scale characterizing possible extensions to the Standard Model; and to support new initiatives in neutral kaon physics, b physics, and neutrino oscillations. In order to attain these goals Fermilab is planning to attain by the end of the decade a luminosity in excess of 5×10^{31} cm^{-2}sec^{-1} in the Tevatron $\bar{p}$-p Collider, supported by a new 150 GeV accelerator, the Fermilab Main Injector.

The Main Injector will be constructed tangent to the Tevatron in a separate tunnel on the southwest corner of the Fermilab site. The FMI will be roughly half the size of the existing Main Ring yet will boast greatly improved performance. The Main Injector will allow the production of about four times as many antiprotons per hour (1.7×10^{11}/hour) as are currently possible using the Main Ring and will have a capability for the delivery of two times as many protons to the Tevatron (at least 3×10^{11} protons/bunch for collider operations). Additionally the Main Injector will support the delivery of very intense proton beams ($>3 \times 10^{13}$ protons every 2.9 seconds with a 33% spill duty factor, or every 1.9 seconds with a few millisecond fast spill) for use in state-of-the-art studies of CP violation and rare kaon decays, and for experiments designed to search for transmutation between different neutrino generations. Low intensity proton beams emanating from the Main Injector will support test beams required for the development and calibration of new experimental detection devices. In contrast to the present situation at Fermilab, simultaneous antiproton production and Main Injector slow spill operation will be possible under normal circumstances. The Main Injector parameter list is given in Table 1.

Table 1: Main Injector Parameters

Circumference	3319.4	m
Injection Energy	8.9	GeV
Peak Energy	150	GeV
Minimum Cycle Time(@120 GeV)	1.5	sec
Number of Protons	3×10^{12}	
Number of Bunches	498	
Protons/Bunch	6×10^{10}	
Horizontal Tune	26.4	
Vertical Tune	25.4	
Transition Gamma	20.4	
Natural Chromaticity (H)	-33.6	
Natural Chromaticity (V)	-33.9	
Transverse Emittance (95%, normalized)	20π	mm-mr
Longitudinal Emmittance	0.4	eV-sec
Transverse Admittance (@8.9 GeV)	40π	mm-mr
Longitudinal Admittance	0.5	eV-sec
β_{max}	57	m
Maximum Dispersion	2.0	m
Number of Straight Sections	8	
RF Frequency (Injection)	52.8	MHz
RF Frequency (Extraction)	53.1	MHz
Harmonic Number	588	
RF Voltage	4	MV
Number of Dipoles	216/128	
Dipole Lengths	6.1/4.1	m
Dipole Field (@150 GeV)	17.2	kG
Number of Quadrupoles	128/32/48	
Quadrupole Lengths	2.1/2.5/2.9	m
Quadrupole Gradient	196	kG/m
Number of Quadrupole Busses	2	

The Fermilab Main Injector Project is in its third year of funding with $52,650,000 appropriated to date. While physical construction was begun in the summer of 1992 with the wetland mitigation project, the first construction of the accelerator facility itself was initiated on February 8, 1993 and

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will continue for several more years. The total estimated cost for the project is $229,600,000. Based on the currently proposed funding profile project completion is scheduled for the summer of 1998.

2. PROJECT STATUS

2.1 R&D Program

A comprehensive R&D program is nearing completion. Two prototype and ten pre-production dipole magnets have been sucessfully constructed and tested. These magnets are conventional iron/copper magnets designed with a a low number of turns (4 turns/pole) in order to support the rapid cycle rate at 120 GeV. Magnetic measurements have verified the field quality of the magnets as being sufficient to support a dynamic aperture at injection in excess of the required 40π mm-mr, and as being of sufficient quality to allow resonant extraction at 120 GeV. Typically the deviation of the magnetic field relative to the central value is less that 1×10^{-4} over an aperture of ±3.8 mm (±1.5").

Prototype quadrupole and sextupole magnets have also been constructed and tested. Each shows acceptable field quality. A prototype model of the 1000V/10,000A supply required to power the dipole magnets has been successfully tested and the first pre-production unit is now under construction. The prototype supply is currently ramping a string of ten of the preproduction dipoles. Twelve of these supplies are required for powering the completed accelerator dipole string. Three prototype 200 kW rf power amplifiers, of eighteen required to accelerate the beam, have been fabricated. One unit is currently in service in the existing Main Ring rf system.

The R&D program will be completed later this year following assembly and testing of the pre-production dipole supply and completion of modulators required to drive the three rf power amplifiers.

2.2 Magnet Production

The focus of the magnet pre-production R&D program over the past eighteen months has been the development of coil and half-core production capability by industrial vendors. This program follows the successful prototype development phase in which the magnet design was finalized and performance specifications were achieved on two prototype magnets. Contracts are now in place with Everson Electric Company to form copper coils for the dipole magnets, with Tesla Engineering LTD for insulating of formed coils, and with SVF Inc. for production of half cores. All three vendors are currently in production. Complete magnets will be assembled at Fermilab utilizing sub-assemblies supplied by these vendors. Magnet assembly should start in late July with a total of 344 dipole magnets to be constructed by the summer of 1997.

2.2 Civil Construction

Following the official groundbreaking on March 22, 1993 the project rapidly awarded contracts for other civil construction activities. Contracts for the underground enclosure housing the rf straight section and the large service building/rf gallery at the point of tangency, and for general site preparation were awarded in the first half of 1993. Work on these projects is now largely complete. The largest single construction package on the project, the underground accelerator ring enclosure, was awarded in January 1994. The overall construction strategy for the project has been established as constructing the northern half of the ring enclosure in 1994 and the southern half in 1995. Work on the ring enclosure was initiated in April 1994. Construction of the beamline connecting the Main Injector to the existing 8 GeV Booster and of the above grade service buildings will be initiated in late 1995 and in 1996.

3. SUMMARY

Construction of the Fermilab Main Injector is now well underway. Construction activities are currently concentrated on civil construction and dipole magnet fabrication. In 1995 construction activities will begin to be visible on a broader front. The project is currently funding limited with respect to its completion date. The current funding profile will allow commissioning of the Main Injector starting in the summer of 1998. Fermilab continues to look forward to the completion of this project and the research opportunities that will become available both during the current decade and into the 21st century.