Chapter 19. R&D Program

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19.1. Introduction

The R&D required to build the Proton Driver has been discussed in some detail in the last section of each relevant chapter. This Chapter is a brief summary of these items. For each item, the reader is referred to the original section for more information. The components of the R&D program are divided into three categories:

- Category A includes those items that are not only needed by the Proton Driver but will also be useful for improving the performance of the present proton source. Therefore, they have the highest priority.
- Category B is the R&D work that is critical to the Proton Driver and is currently underway.
- Category C lists other R&D items that are necessary to the Proton Driver but may have to wait until more resources can be made available.

There is a US-Japan Accord for joint R&D on high intensity proton facilities. A number of the R&D items are part of this collaboration.

19.2. Category A

- High intensity high brightness H^- source development. Develop three different types of sources: an improved magnetron, a noiseless planatron and a Dudnikov Type Source (DTS). The goal is to increase the beam intensity by a factor of two and the brightness by a factor of four. This would help the present Linac and Booster in high intensity operations. (Section 13.11.1)
- Linac front-end improvement. Reassemble hardware left from the PET project (solenoid, 200 MHz RFQ, double alpha magnet and several quadrupoles) and retune it for the H^- operation. A charge neutralization experiment for reducing the space charge effect would also be carried out. If additional resources can be devoted to this item, the solenoid will be replaced by an Einzel lens and new rods will replace the existing ones in the RFQ (Sections 13.11.2 and 13.11.3)
- Booster 53 MHz rf cavity modification. Enlarge the central pipe aperture from 2-1/4" to 5" and increase the voltage per cavity from 55 kV to 66 kV. These modifications would also benefit the present Booster. (Section 5.4.1)
- Finemet 7.5 MHz rf cavity development. As part of the US-Japan Accord, a cavity using Finemet cores from Japan has been constructed at Fermilab. It has been installed in the Main Injector for a 132 ns bunch spacing coalescing experiment. Seven 53 MHz bunches in the Main Injector have been successfully coalesced to form a single 7.5 MHz bunch by using one Finemet cavity. This cavity is 0.5 m long and provides more than 12 kV accelerating voltage. The 132 ns bunch spacing is a critical parameter of Tevatron Run IIb.

- Beam loading compensation system development. This system also helps the Main Injector operation. In particular, when the slip-stacking scheme is implemented, this system would play a crucial rule. (Section 5.4.2)
- Inductive insert study in the present Booster. From the experience at the PSR at Los Alamos National Laboratory and simulations on the Proton Driver as well as on the Booster, it is expected that inductive inserts would effectively reduce the potential well distortion due to space charge and thus reduce beam losses at high intensity. The proposal is to install several ferrite modules at two long straight sections (about 10-m long total) in the Booster. (Section 5.4.4)
- Booster magnet study. This has two parts. One is to install metallic strips and/or a metallic liner in the magnet and measure the coupling impedance. The goal is to reduce the impedance from the laminations seen by the beam. The other is to carry out dynamic measurements of the magnetic field during the cycle. Both would be useful to the present Booster. (Section 6.2)

19.3. Category B

- Stranded conductor coil study. This type of coil is necessary for the Proton Driver magnets. Fermilab has no experience with these coils and there are no U.S. vendors that have this product. However, there are two Japanese companies (Hitachi and Toshiba) that can manufacture the coils made of stranded conductor (copper or aluminum) with a cooling pipe (stainless steel) in the center. We are expecting to receive samples from Toshiba soon. (Section 6.7) (Section 6.6)
- Material outgassing rate test. Because the magnets are canned, the outgassing rate of the laminations and coils will determine the vacuum. In particular, the outgassing rate of the coil made of stranded conductor must be measured carefully. (Section 8.6)
- Chopper development. This is also part of the US-Japan Accord. A new type of chopper based on modulating the energy of the beam from the ion source has been designed and built by a KEK-Fermilab team and installed on the Linac at the HIMAC in Chiba, Japan. The beam test was successful but further improvement is needed and this study should continue. (Section 13.11.4)
- High gradient, low frequency rf system for burst mode operation. Develop an rf cavity with 0.5 - 1 MV/m average accelerating voltage at 7.5 MHz. This cavity would be important for bunch compression operation at the end of the cycle of the Proton Driver. This is part of a US-Japan collaboration. (Section 5.1.3)

19.4. Category C

- Prototyping of a large aperture dipole and quadrupole. The challenges are: high voltage to ground stranded conductor coil and vacuum. (Sections 6.7 and 7.8).
- Prototyping of a complete resonant cell of the dual resonance power supply, and investigation of high power IGBT technology. (Section 7.8)
- Prototyping of a quadrupole tracking error correction system. (Section 7.8)
- Vacuum chamber made of fiber-reinforced epoxy with a continuous metal foil lining. (Section 8.6)

- Laser beam chopping. (Section 13.11.5)
- Two VME bus cards, an 8-channel waveform generator and an 8-channel quick digitizer. (Section 16.13)
- Fast rise- and fall-time kicker. (Section 12.2.1)
- Active feedback systems. (Section 15.4.8)
- TRIUMF rf cavity study. This is a backup as well as a future improvement of the modified Booster cavity. (Section 5.4.3)
- Long pulse test of the Linac klystron. Although this is not mentioned in Chapter 13, it would provide a useful technical contingency in case the H^- source cannot meet its design goal of 115 mA. The bottleneck for the Linac beam pulse length is the klystron stations in the Side-Coupled Linac (SCL) section. If the test shows a 200 μs pulse can be achieved reliably, then the required H^- beam intensity could be reduced by a factor of two.