Maximum Proton Energy and Intensity in Booster

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1 Maximum Magnetic Rigidities

The highest current used routinely in the Booster Main Magnet (BMM) is 5000 A, which corresponds to a magnetic rigidity of 15.8 Tm. Protons at this rigidity have a kinetic energy of 3.89 GeV.

Calculations done by Ioannis Marneris and recent experience [1] show that (with certain restrictions) the BMM power supply can deliver 5500 A. Extrapolation of measured field-versus-current data shows that 5500 A corresponds to a magnetic rigidity of 17.3 Tm. Protons at this rigidity have a kinetic energy of 4.33 GeV.

The new extraction septum magnet to be installed this summer (2015) in the D6 straight is designed to transport Fe24+ ions (i.e. helium-like iron) at a kinetic energy of 1.5 GeV per nucleon. This corresponds to a magnetic rigidity of 17.5 Tm. The expectation is that the BMM power supply will be able to deliver the current necessary to get to this rigidity. Protons at this rigidity have a kinetic energy of 4.39 GeV.

2 Maximum Proton Kinetic Energy

Although the BMM power supply can deliver enough current to allow circulation of protons with a kinetic energy of 4.39 GeV in Booster, we can not accelerate protons beyond transition in the present machine. This limits the kinetic energy to approximately 3.6 GeV. In practice, we have been able to accelerate protons to a kinetic energy of 2.5 GeV.

3 Maximum Proton Intensity

Intensities as high as 24×10^{12} protons per Booster cycle at a kinetic energy of 1.91 GeV have been achieved.

Intensities as high as 1.2×10^{12} protons per Booster cycle are possible with the present polarized proton source.

4 GeV-Nucleons per Hour under Various Conditions

1. Assume **one Booster cycle every three seconds** with 24×10^{12} protons accelerated per cycle to the maximum Booster magnetic rigidity of 17.5 Tm. The kinetic energy of protons at this rigidity is 4.39 GeV. This gives 1.054×10^{14} GeV-nucleons per Booster cycle. At the rate of one cycle every three seconds this gives 1.26×10^{17} GeV-nucleons per hour, which is well below the Booster Particle Beam Limit (PBL) of 1.1×10^{18} GeV-nucleons/hour [2].

2. Assume **one Booster cycle every three seconds** with 24×10^{12} protons accelerated per cycle to a kinetic energy of 3.6 GeV. This gives 8.64×10^{13} GeV-nucleons per Booster cycle. At the rate of one cycle every three seconds this gives 1.037×10^{17} GeV-nucleons per hour, which is well below the Booster PBL.

3. Assume 7.5 **Booster cycles per second** with 24×10^{12} protons accelerated per cycle to a kinetic energy of 2 GeV. This gives 4.8×10^{13} GeV-nucleons per Booster cycle. At 7.5 cycles per second this gives 1.3×10^{18} GeV-nucleons per hour, which is slightly above the Booster PBL.

References

[1] K. Zeno and N. Kling, NSRL-2014 elog, July 8, 2014, entries 14:11 and 15:54

[2] C-A OPM 2.5, Item 5.1.2