Maximum Proton Energy and Intensity in Booster

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July 21, 2015

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 \(15.8 \text{Tm}\). Protons at this rigidity have a kinetic energy of \(3.89 \text{ GeV}\).

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 \(17.3 \text{Tm}\). Protons at this rigidity have a kinetic energy of \(4.33 \text{ GeV}\).

The new extraction septum magnet to be installed this summer (2015) in the D6 straight is designed to transport Fe\(^{24+}\) ions (i.e. helium-like iron) at a kinetic energy of 1.5 GeV per nucleon. This corresponds to a magnetic rigidity of \(17.5 \text{Tm}\). 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 \(4.39 \text{ GeV}\).

2 Maximum Proton Kinetic Energy

Although the BMM power supply can deliver enough current to allow circulation of protons with a kinetic energy of \(4.39 \text{ GeV}\) in Booster, we cannot accelerate protons beyond transition in the present machine. This limits the kinetic energy to approximately \(3.6 \text{ GeV}\). In practice, we have been able to accelerate protons to a kinetic energy of \(2.5 \text{ GeV}\).
3 Maximum Proton Intensity

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

Intensities as high as \(1.2 \times 10^{12}\) 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 \(24 \times 10^{12}\) 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 \(1.054 \times 10^{14}\) GeV-nucleons per Booster cycle. At the rate of one cycle every three seconds this gives \(1.26 \times 10^{17}\) GeV-nucleons per hour, which is well below the Booster Particle Beam Limit (PBL) of \(1.1 \times 10^{18}\) GeV-nucleons/hour [2].

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

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

References


[2] C-A OPM 2.5, Item 5.1.2