

Physical Aperture and Beamline Matching Criteria for the Main Injector

S. Holmes, P. Martin, S. Peggs

Physical Aperture

The primary design goal of the Main Injector is the ability to accommodate the largest transverse beam emittance which we can conceive of ever being delivered from either the Booster or Antiproton Accumulator. Currently this number is believed to be 30π mm-mr (95%, normalized emittance). In accordance with this goal the specification on the required physical aperture available in the Main Injector and associated beamlines shall be as follows:

1. All physical apertures shall encompass an ellipse whose half-axes are given by:

$$\Delta_{H,V} = \sqrt{\frac{40\beta_{H,V}}{\gamma}} + \eta_{H,V}(\sigma_p/p).$$

2. Additionally all physical apertures shall encompass an ellipse whose half-axes are given by:

$$\Delta_{H,V} = \sqrt{\frac{30\beta_{H,V}}{\gamma}} + \eta_{H,V}(\sigma_p/p) + 3\text{mm} \times \sqrt{\frac{8.9\text{GeV}/c}{p}}.$$

Here the lattice functions, β and η , are given in meters, σ_p/p is in units of 10^{-3} , and $\Delta_{H,V}$ are thus in mm. Criteria 1. and 2. shall be met for all momenta in the range 8.9 to 150 GeV/c. Note that criterion 1. is only relevant if $\beta > 112$ m.

Beamline Matching

Scenarios for use of the Main Injector in support of Tevatron Collider operations call for transverse emittances of $>20\pi$ mm-mr (95%, normalized). We will establish a goal of limiting emittance dilution due to optical and steering mismatches to 1π mm-mr for design purposes and 2π operationally during beam transfers of 20π beams.. In accordance with these goals:

Design Specification

1. Design horizontal and vertical dispersion will be matched through the beam transfer lines to a level such that emittance dilution is less than or equal to 1π mm-mr. The criterion is as given in MI-0001:

$$\frac{\Delta\eta^2 + (\beta\Delta\eta' + \alpha\Delta\eta)^2}{\beta} < .0088\text{m} \times \left(\frac{150 \text{ GeV}/c}{p} \right) \times \left(\frac{.049\%}{\sigma_p/p} \right)$$

2. Design beta functions will be matched through the beam transfer lines to a level such that the contribution to emittance dilution is small compared to that of the momentum mismatch, i.e. 2% of 20π mm-mr:

$$\left(\frac{\Delta\beta}{\beta} \right)^2 (1 + \alpha^2) + (\Delta\alpha)^2 < .0004$$

For the above exercises the lattice functions shall be for the current lattice as maintained by Al Russell. The momentum spread, σ_p/p , as a function of energy will be as given in the most recent revision of MI-27 (author-Phil Martin).

Operations

1. The cumulative effect of steering errors at injection, dispersion mismatches, and beta function mismatches shall be kept less than 2π mm-mr.