Simulation of Momentum Spread in the Meson Test Beamline

M. Backfish

May 14, 2015

1 Introduction

The purpose of this document is to describe two methods for determining the momentum spread or $\frac{dP}{P}$ for the beam delivered to the Meson Test experiments. The Meson Test, henceforward MTest, beamline layout can be seeen in figure 1. Momentum selection in the MTest beamline is initially done with the Westward bending magnets MT4W-1 and MT4W-2. Initial momentum collimation occurs after these two dipoles with F:MT4CH1 and F:MT4CH2. These collimators are both fully extracted at around 90 mm. MT5E, a five dipole string, then bends the beam back East in order to better cancel dispersion from the first bend magnets. After this second group of dipoles off momentum beam lands on the 76.2 mm aperture of MT5Q1 which with collimators fully extracted determines the momentum spread, or momentum bite, delivered to the experiments.

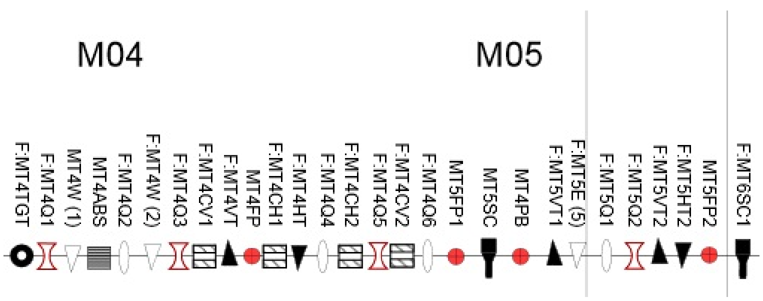

Figure 1: MTest secondary beamline components

2 Simplified Model for $2\ \frac{GeV}{c}$ Beam

With momentum collimators fully extracted, 90 mm gap, the smallest momentum aperture becomes the first quadrupole after the MT5E bend string, MT5Q1. This is illustrated in figure 2.

To simplify the geometrical model, the total integrated field from all 5 magnets can be considered as one magnet as shown in figure 3. This is reasonable because the distance between the magnets is small in comparison to the length of the magnets. To account for some of the error caused by this assumption, the distance in between the magnets is then added to the final length of travel after the MT5E bend to the aperture at MT5Q1. Using the geometry outlined in figure 3 we find $\frac{dp}{P}$ to be ± 4.5 %. This estimate is bigger than the actual as it neglects the momentum dependent position shift on the upstream end of MT5E as a result of MT4W (see figure 1 for beamline details).

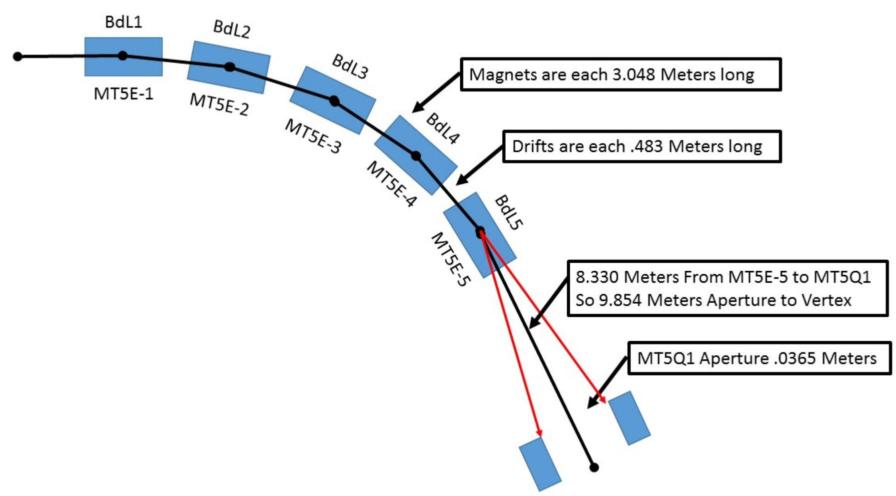

Figure 2: Off momentum particles will be bent more or less through the MT5E magnet string and ultimately deposited on the aperture of MT5Q1. It should be noted that each MT5E magnet bends the beam 8.5 mR or about .5 degrees. The angles are depicted larger in the image.

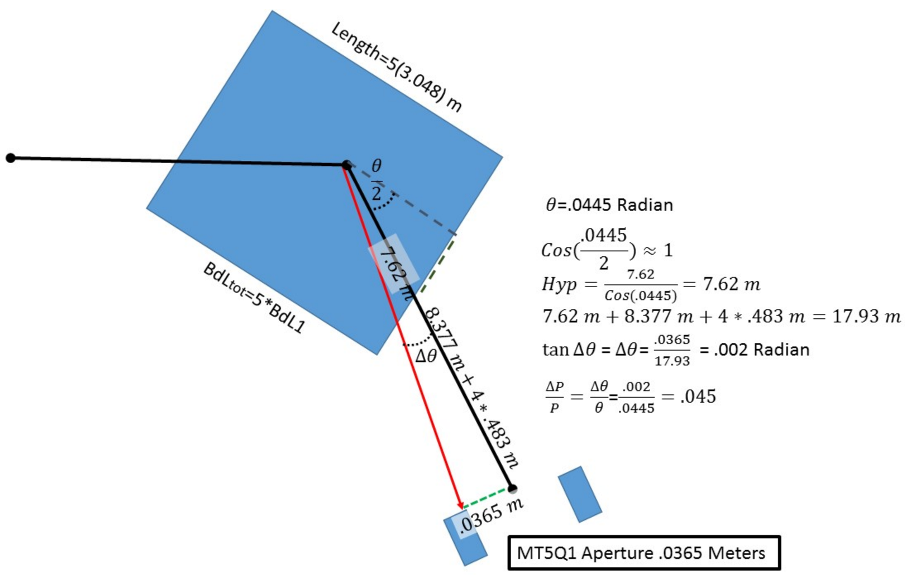

Figure 3: To simplify the model the total integrated field from all 5 magnets is considered as one magnet.

3 Simulation in Turtle

A detailed Transport/Turtle simulation was used to better understand how momentum selection occurs within the MTest beamline. Tracks were created with horizontal and vertical positions and angles equal to 0. Momentum spread, $\frac{dP}{P}$, was simulated from -10.000 to 10.000 in .001 increments. These vectors were propogated through the MTest beamline using Turtle and a 2 $\frac{GeV}{c}$ beam momentum. The results are displayed with a label of the component that caused the momentum restriction in figure 4. The simulations were performed with momentum collimators set to 90 mm or fully extracted from the beam. These results show that while momentum collimation occurs upstream, the ultimate determination of momentum spread, or momentum bite, at the the MTest experiments is a result of the quadrupole aperture following the MT5E dipole string which was geometrically simulated in the first section of this document. Figure 5 is a more detailed simulation which used initial particle vectors with $\frac{dP}{P}$ from $-.1$ to .1 in increments of .00001. The momentum spread is simulated 72.5 meters downstream of the downstream end of the second cherenkov detector. The momentum spread was found to be ± 1.9 %.

4 Conclusion

The rough geometrical calculation of momentum spread at the Fermi Test Beam Facility was ± 4.5 % from section 1. This estimate should be larger than the actual momentum spread as upstream momentum dependent factors are assumed constant. The detailed simulation using Turtle found ± 1.9 % using a 2 $\frac{GeV}{c}$ beam. The Fermi Test Beam Facility quotes ± 2.7 % for the 2 $\frac{GeV}{c}$ beam momentum [3]. These simulations will be used and improved to better understand and control the Meson Test beam used at the Fermi Test Beam Facility.

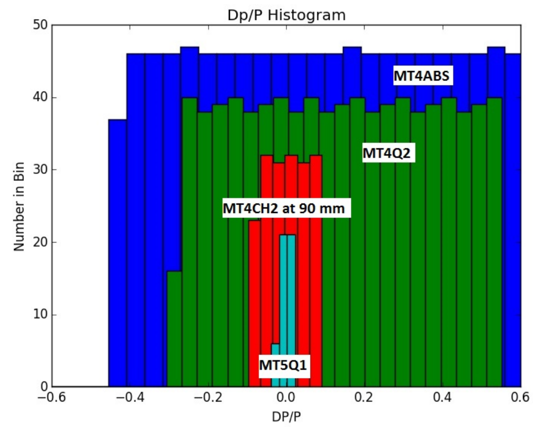

Figure 4: Momentum spread as,simulated after each labeled device.

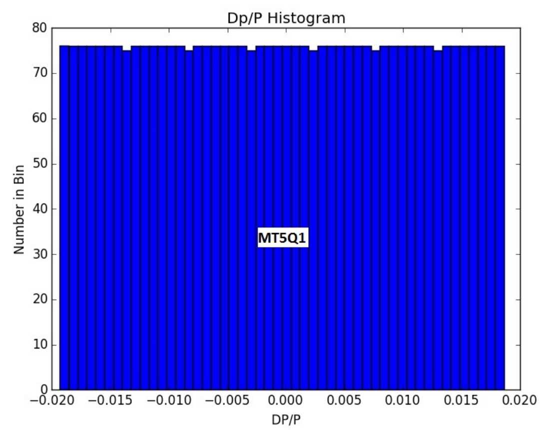

Figure 5: The first quad downstream of MT5Q1 ultimately determines the momentum spread at the experiment with upstream collimators fully extracted.

References

[1] D.A. Edwards and M.J. Syphers, “An Introduction to the Physics of High Energy Accelerators”, Wiley Series in Beam Physics and Accelerator Technology, SSC laboratory, Dallas, Texas, 1993 pp. 61.

[2] Eric Prebys, “Basic EM and Relativity”,USPAS, Austin, Tx 2012

[3] A. Soha, http://ppd.fnal.gov/ftbf/beam/energies.html