Particle-Techniques

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January 2021

1 Assignment 1 (Computer Issues)

1.1 Revised Method

Using the the hits from the drift chamber and the fact the geometry of the magnet is a cube, a revised method for calculating the momentum was done. (see the code Tracker.py for details).

- First, the direction vector of the particle exiting drift chamber 1 and entering drift chamber 2 are found by using the hits in the drift chamber to trace a line through the points, and then the direction vector is found by normalising the vector.
- The entry and exit points of the particle is found by extrapolating the direction vector of the hits of drift chambers 1 and 2 (1 for the entry point and 2 for the exit point), using the real distance between the drift chambers and the magnet. As a result the direction vector of the entry and exit points are the same as the direction vectors of the tracks.
- The deflection angle θ is found by seeing how much the direction vector of the particle changes as it exits the magnetic field. This is done by calculating the angle of the direction vectors of the particle entry and exit points and taking the difference.
- The distance between the entry and exit point of the magnet d is found using $d^2 = h^2 + l^2$, where l is the length of the magnet along z and h is the difference in the x position for the particle entry and exit points of the magnet.
- The bending radius r is found using the equation $d/\arcsin(\theta)$.
- Calculate the momentum using $p = qBr$ (need to switch to relativistic equation).

mean (GeV): 100.0948 +- 0.0005 standard deviation (GeV): 1.41 +- 0.0005 Amplitude: 900.0 +- 100.0 Average momentum resolution (GeV): 19.0+-2.0

mean (GeV): 100.09236 +- 3e-05 standard deviation (GeV): 0.33947 +- 3e-05 Amplitude: 143.0 +- 4.0 Average momentum resolution (GeV): 7.0+-5.0

mean (GeV): 50.03878 +- 3e-05 standard deviation (GeV): 0.35178 +- 3e-05 Amplitude: 239.0 +- 9.0 Average momentum resolution (GeV): 3.0+-4.0 50 GeV has significantly more outliers than the rest

mean (GeV): 200.211 +- 0.001 standard deviation (GeV): 1.433 +- 0.001 Amplitude: 600.0 +- 200.0 Average momentum resolution (GeV): 38.0+-4.0

1.2 Part 1:

Beam Momentum is 100 GeV and the magnetic field is set to 0.5T. The beam angle (also all other parts) is zero. 1000 events are generated (same for subsequent parts). x precision is 10^{-4}m and y precision is 10^{-2}m.

Momentum is estimated using the deflection of the charged particle as it travels through the magnetic field. the equation for the momentum of a charged particle travelling through a magnetic field is

$$p = qBr, \tag{1}$$

where q is the charge, B is the Field strength and r is the radius of deflection. The radius can be determined by seeing ho much the direction vector of the particle changes as it passes through the magnetic field. Particles in this experiment will be moving considerably fast, so the amount the trajectory bends is very small. Hence we can approximate the arc length as the length of the magnet, hence

$$r = \frac{L}{\Delta\theta} \tag{2}$$

where L is the magnet length.

The resolution (I think) is dependant on how well the deflection radius can be calculated, so its relative uncertainty scales proportionally:

$$\frac{\sigma_r}{r} = \frac{\sigma_p}{p}. \tag{3}$$

To determine σ_r, propagation of uncertainties in the tracking is done. The trajectories before and after the magnetic field are $\vec{r}_1$ and $\vec{r}_2$ respectively. $\Delta\theta$ found using the trajectories:

$$\Delta\theta = \frac{x_2}{r_2} - \frac{x_1}{r_1} \tag{4}$$

so the uncertainty in $\Delta\theta$ is

$$\sigma_\theta = \sigma_x \sqrt{\frac{1}{r_2} + \frac{1}{r_2}}. \tag{5}$$

From equation 2 σ_r is given by:

$$\sigma_r = \frac{r}{\Delta\theta}\sigma_\theta \tag{6}$$

so the momentum resolution is:

$$\sigma_p = \frac{p\sigma_x}{\Delta\theta}\sqrt{\frac{1}{r_2} + \frac{1}{r_2}}. \tag{7}$$

Here, σ_x is the uncertainty in x which I take as the precision in x i.e. 10^{-4}m. Note it is the only uncertainty in the equation because all other parameters are dependant on the x precision (z is assumed to be perfectly known as it is part of the detector geometry).

These methods were implemented in python to generate the momentum distribution, the average momentum and the momentum resolution.

If the trajectory is perfectly known, σ_x will be zero, so following equation 7, σ_p will be zero so you can perfectly determine the resolution (not sure?).

1.3 Results(Momentum)

All plots have around 1000 events (outliers excluded). Particles are μ^+.

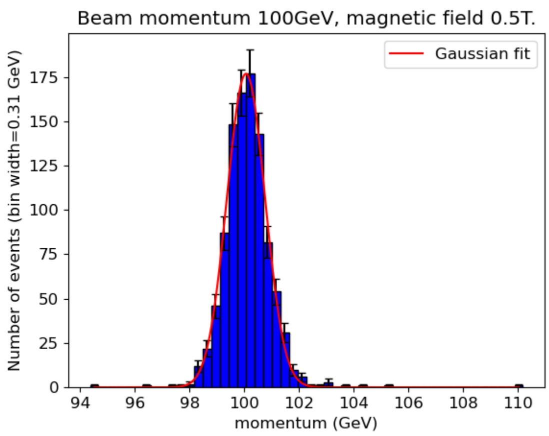

Figure 1: Momentum distribution for part 1

Mean (GeV)	100.06215 ± 8e-05
Standard deviation (GeV)	0.69766 ± 8e-05
Amplitude	310.0 ± 10.0
Average momentum resolution (GeV)	9.5 ± 0.5

Table 1: Table of fitted Gaussian parameters for figure 1.

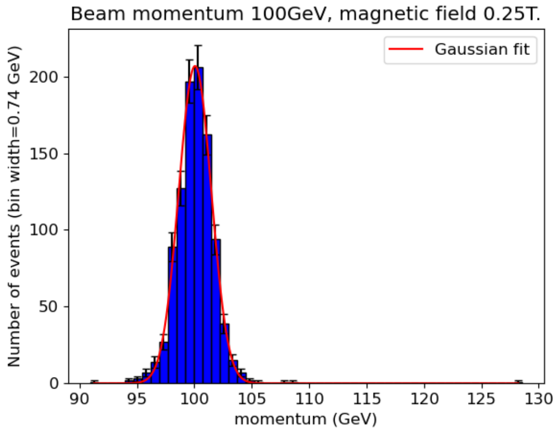

Figure 2: Momentum distribution for part 2a.

Mean (GeV)	100.0948 ± 0.0005
Standard deviation (GeV)	1.41 ± 0.0005
Amplitude	900.0 ± 100.0
Average momentum resolution (GeV)	19.0 ± 2.0

Table 2: Table of fitted Gaussian parameters for figure 2.

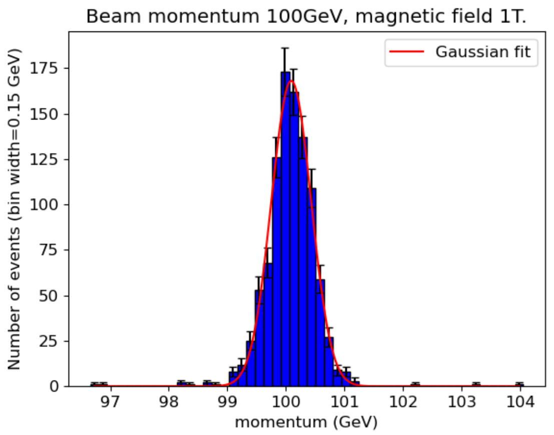

Figure 3: Momentum distribution for part 2b.

Mean (GeV)	100.09236 ± 3e-05
Standard deviation (GeV)	0.33947 ± 3e-05
Amplitude	143.0 ± 4.0
Average momentum resolution (GeV)	7.0 ± 5.0

Table 3: Table of fitted Gaussian parameters for figure 3.

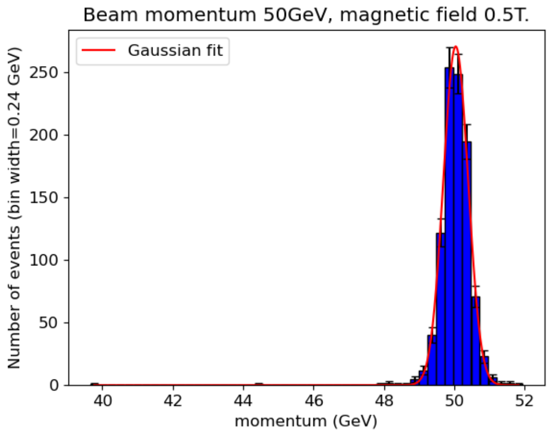

Figure 4: Momentum distribution for part 3a.

Mean (GeV)	50.03878 ± 3e-05
Standard deviation (GeV)	0.35178 ± 3e-05
Amplitude	239.0 ± 9.0
Average momentum resolution (GeV)	3.0 ± 4.0

Table 4: Table of fitted Gaussian parameters for figure 4.

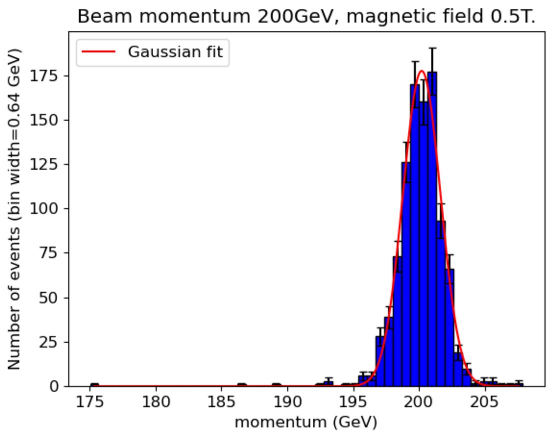

Figure 5: Momentum distribution for part 3b.

Mean (GeV)	200.211 ± 0.001
Standard deviation (GeV)	1.433 ± 0.001
Amplitude	600.0 ± 200.0
Average momentum resolution (GeV)	38.0 ± 4.0

Table 5: Table of fitted Gaussian parameters for figure 5.