Tracking Performance

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03/08/2023

Muon Gun Data Selection

- Data from

  /collab/project/snowmass21/data/fmeloni/LegacyProductions/before29Jul23/DataMuC_MuColl_v1/muonGun/reco/ (note: no BIB)

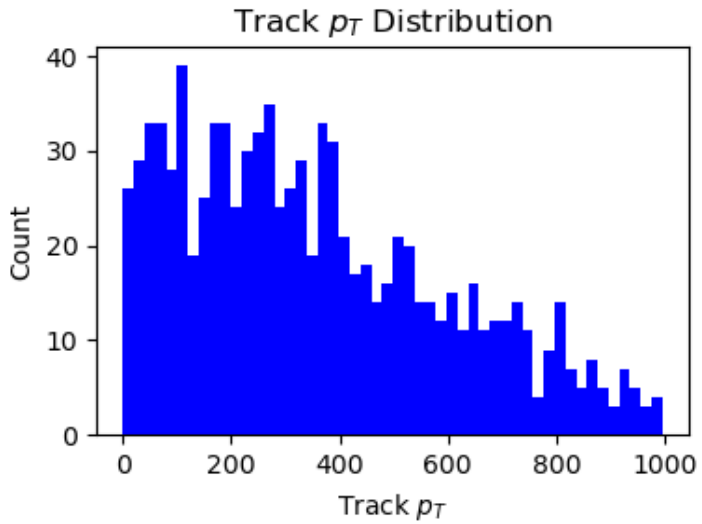
- I matched the reconstructed Muon tracks to truth Muons using only dR matching with dR < 0.1

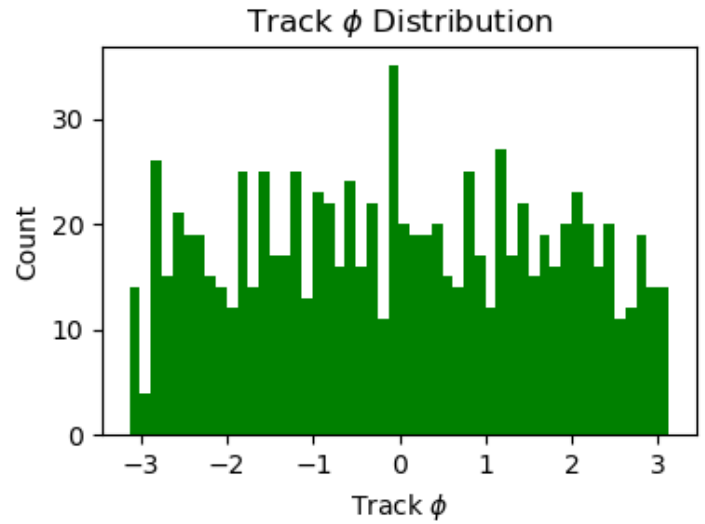
- No requirement on muon pT, nhits, etc.

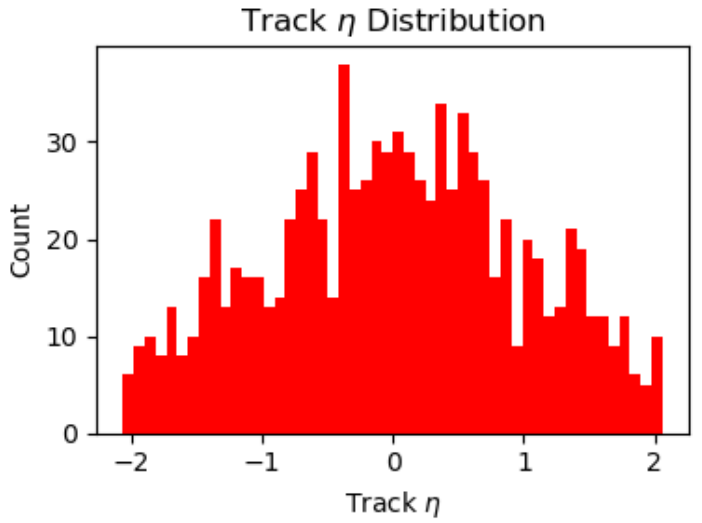
- There are 924 matched tracks in total

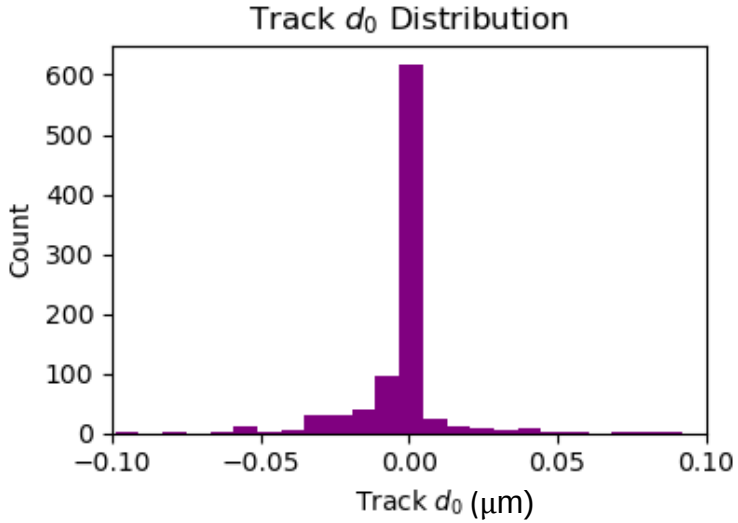
Basic Distributions for Reco

- Quick overview of some basic distributions
- Muons have p_T up to 1000 GeV, decreasing with higher p_T
- ϕ is relatively uniform for all muons
- η is centred around 0, and the counts decrease with higher η (both + and -)
- d_0 is heavily centred around 0, as expected









Single Event Resolutions

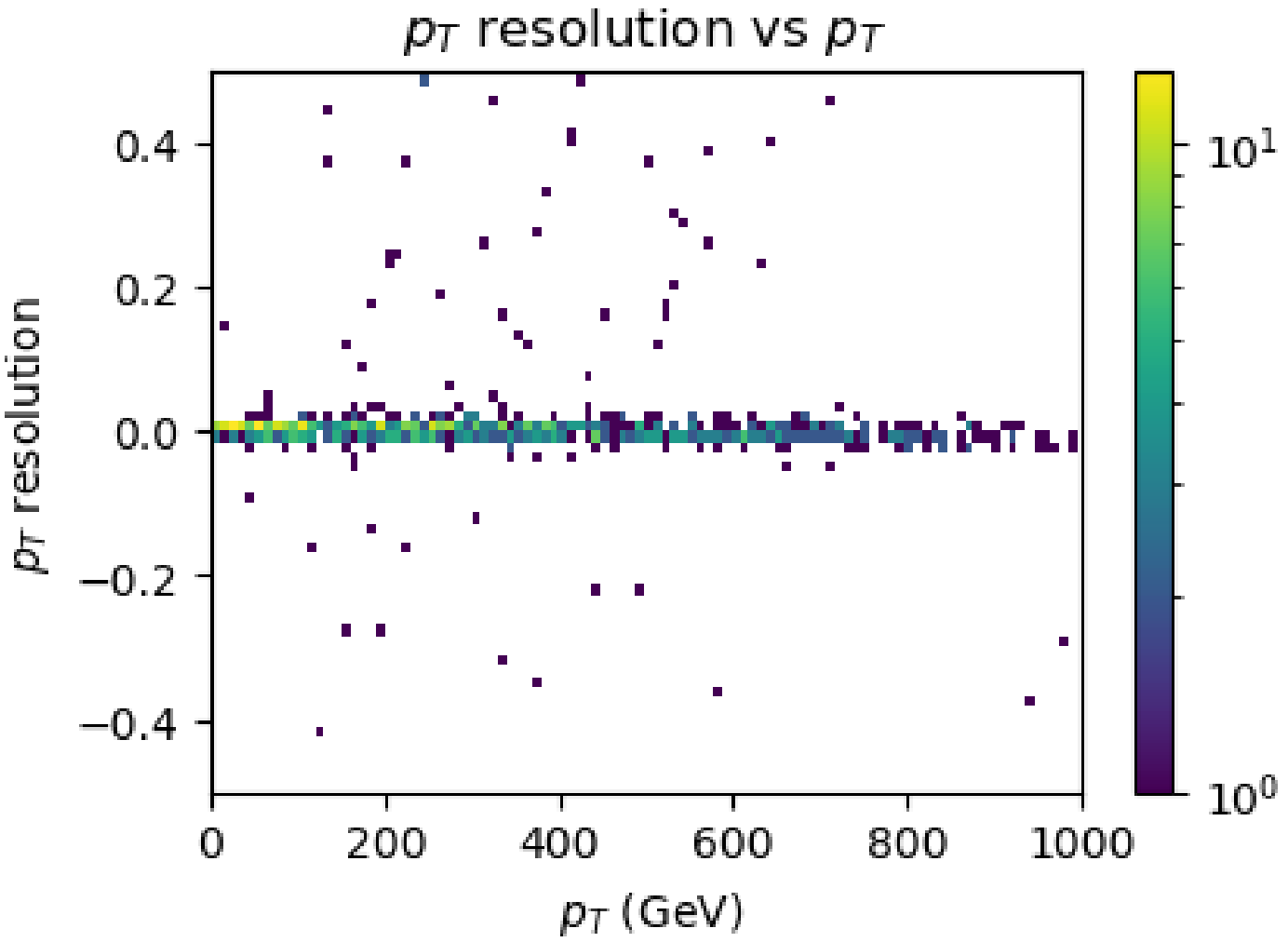
- We define resolution for matched muons as:

  p_T res = truth p_T - reco p_T / truth p_T

- For the impact parameters, the truth impact parameters are 0 (we define them to be created at the origin), so instead of using a formula similar to the above, we can just use the track impact parameters' displacement from the origin

p_T Resolution

- The idea is to make a two histogram of (for example) p_T resolution versus track p_T and then use the y-values in each x bin to compute the resolution
- We do this by taking the σ (std.) of the gaussian within each x bin

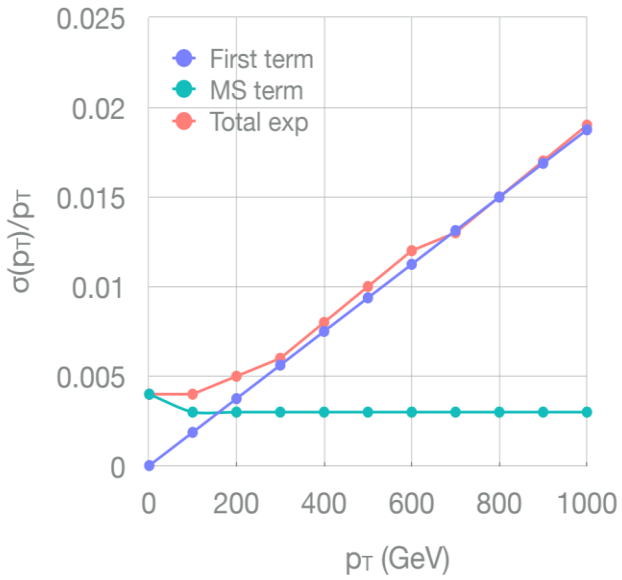


1D Slices for p_T resolution

- We take 1D slices by p_T bins to check if the data is gaussian and if it matches expectations
- For example, for a p_T range 1-100 GeV, we expect $\sigma(p_T)/\,p_T$ to be ~0.003, increasing with higher p_T
- (Credit: Karri DiPetrillo)

Momentum Resolution

	σ(pT) / pT			
pT (GeV)	Sagitta Term	MS Term	Total Exp	Total Obs
1	0.00002	0.004	0.004	0.005
10	0.00019	0.003	0.003	0.003
100	0.00187	0.003	0.004	0.003
1000	0.01874	0.003	0.019	-



Expected results agree with measured resolution @3 TeV
Need to test for pT > 200 GeV to validate first term

1D Slices for p_T resolution

Slice 0: 0 to 100 GeV

Sigma from Fit: 0.00434 GeV

Slice 1: 100 to 200 GeV

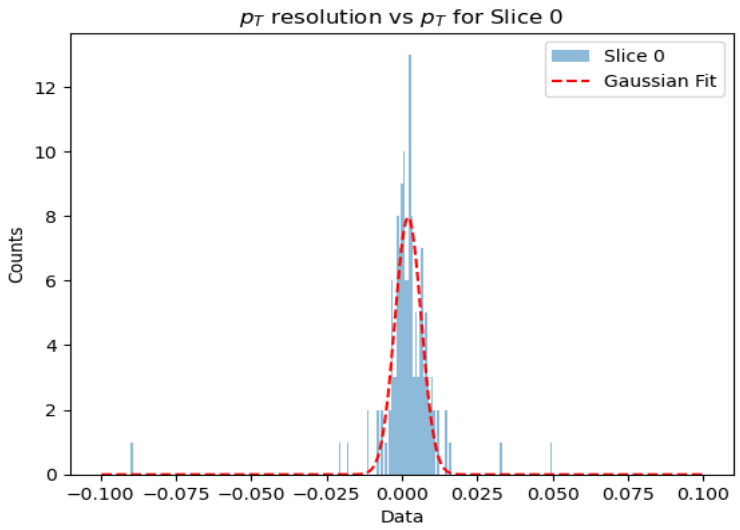
Sigma from Fit: 0.00503 GeV

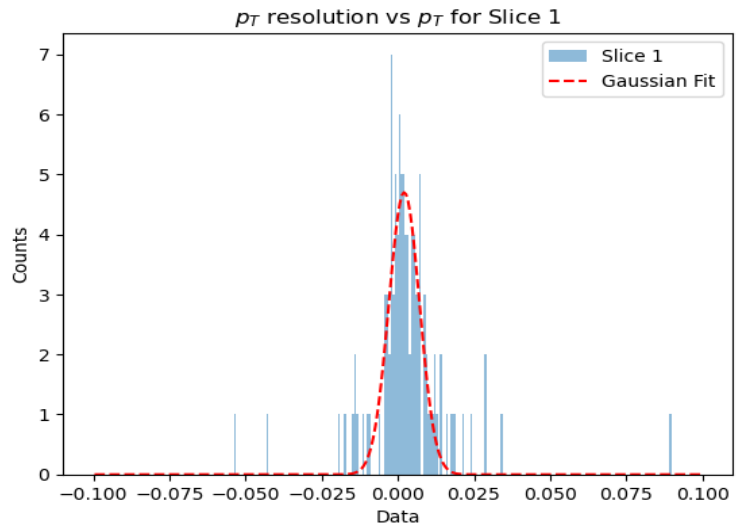
Slice 2: 200 to 400 GeV

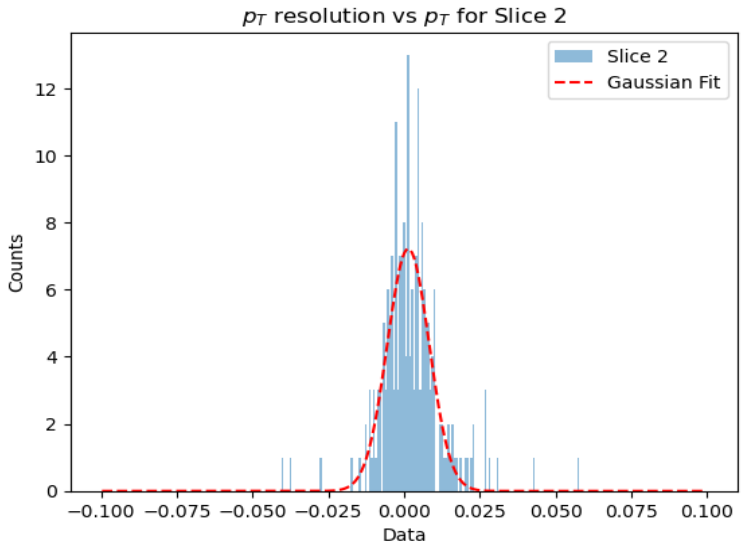
Sigma from Fit: 0.00690 GeV

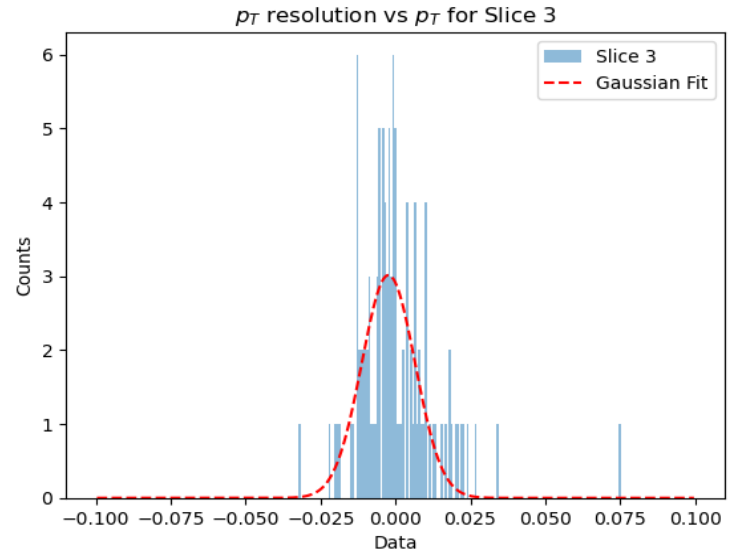
Slice 3: 400 to 600 GeV

Sigma from Fit: 0.00888 GeV









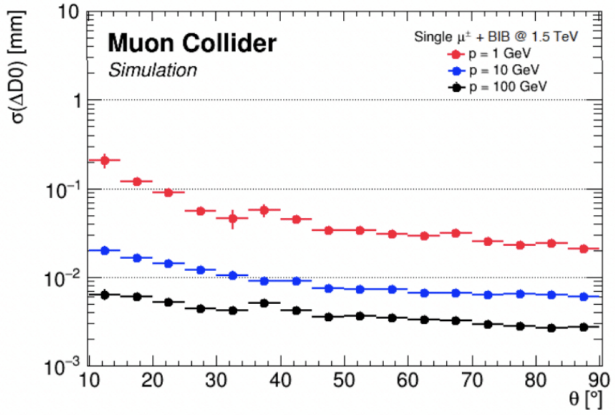
Impact parameter resolution

1D Slices for d_0 resolution

- Let's do the same for d_0
- For example, for a p_T range 1-100 GeV, we expect $\sigma(d_0)$to be ~5µm, decreasing with higher p_T
- (Credit: Karri DiPetrillo)

Agrees fairly well with observed resolution @3 TeV

	σ(d₀) (µm)			
pT (GeV)	First term	MS term	Total exp	Total Obs
1	3.9	37	37	20
10	3.9	3.6	5.4	6
100	3.9	0.36	4.0	3
1000	3.9	0.036	3.9	-



1D Slices for d_0 resolution

Slice 0: 0 to 100 GeV

Sigma from Fit: 3.05μm

Slice 1: 100 to 200 GeV

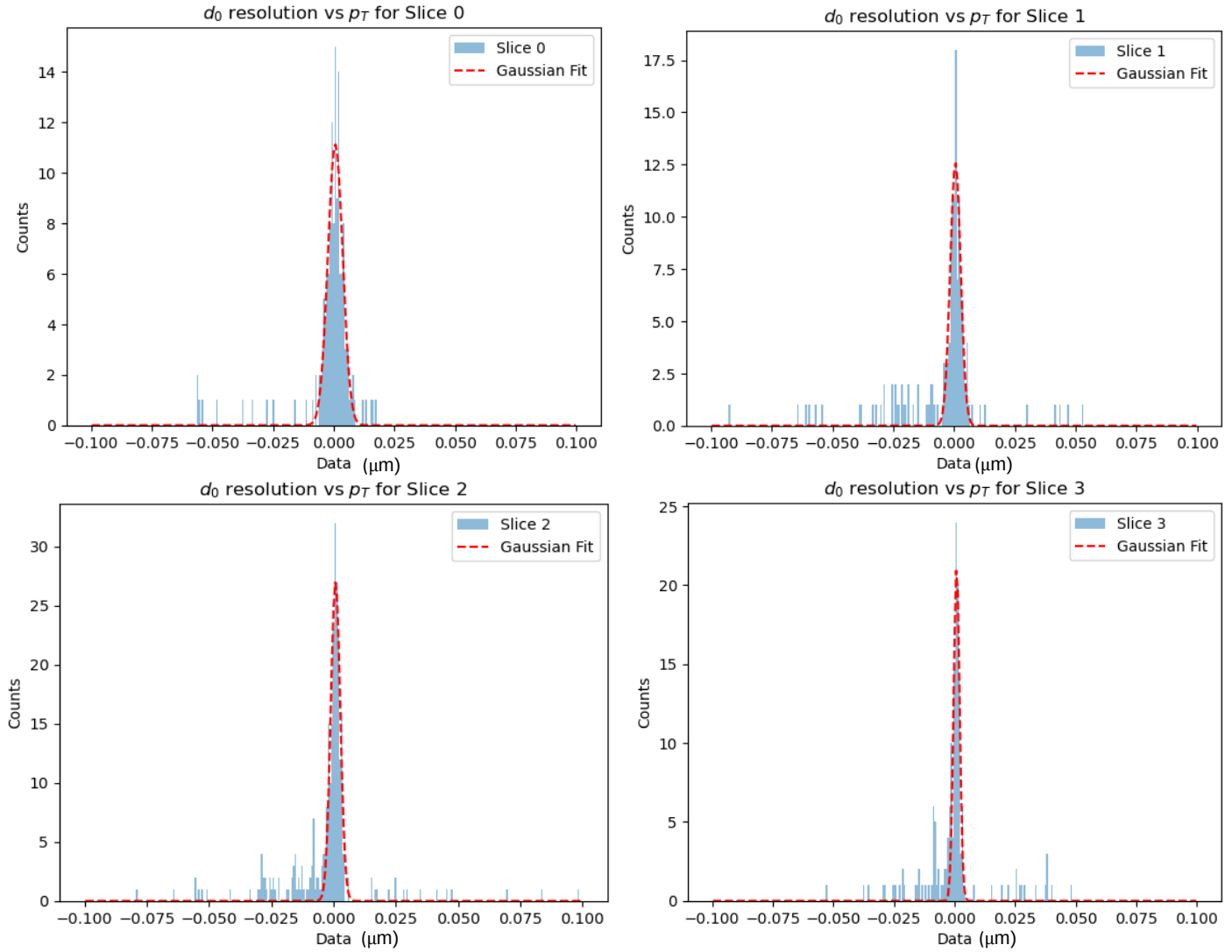
Sigma from Fit: 2.15μm

Slice 2: 200 to 400 GeV

Sigma from Fit: 1.91μm

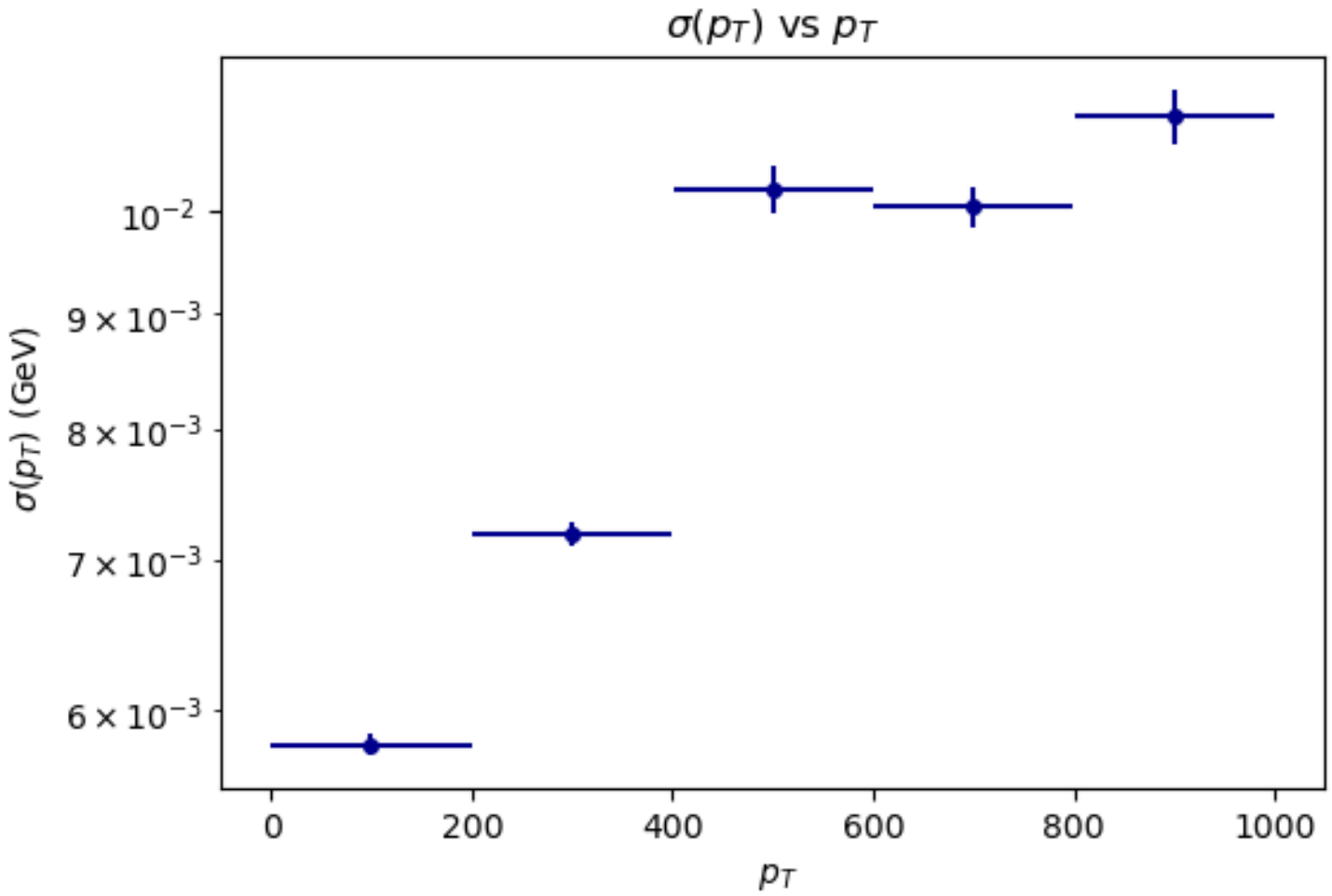
Slice 3: 400 to 600 GeV

Sigma from Fit: 1.24μm



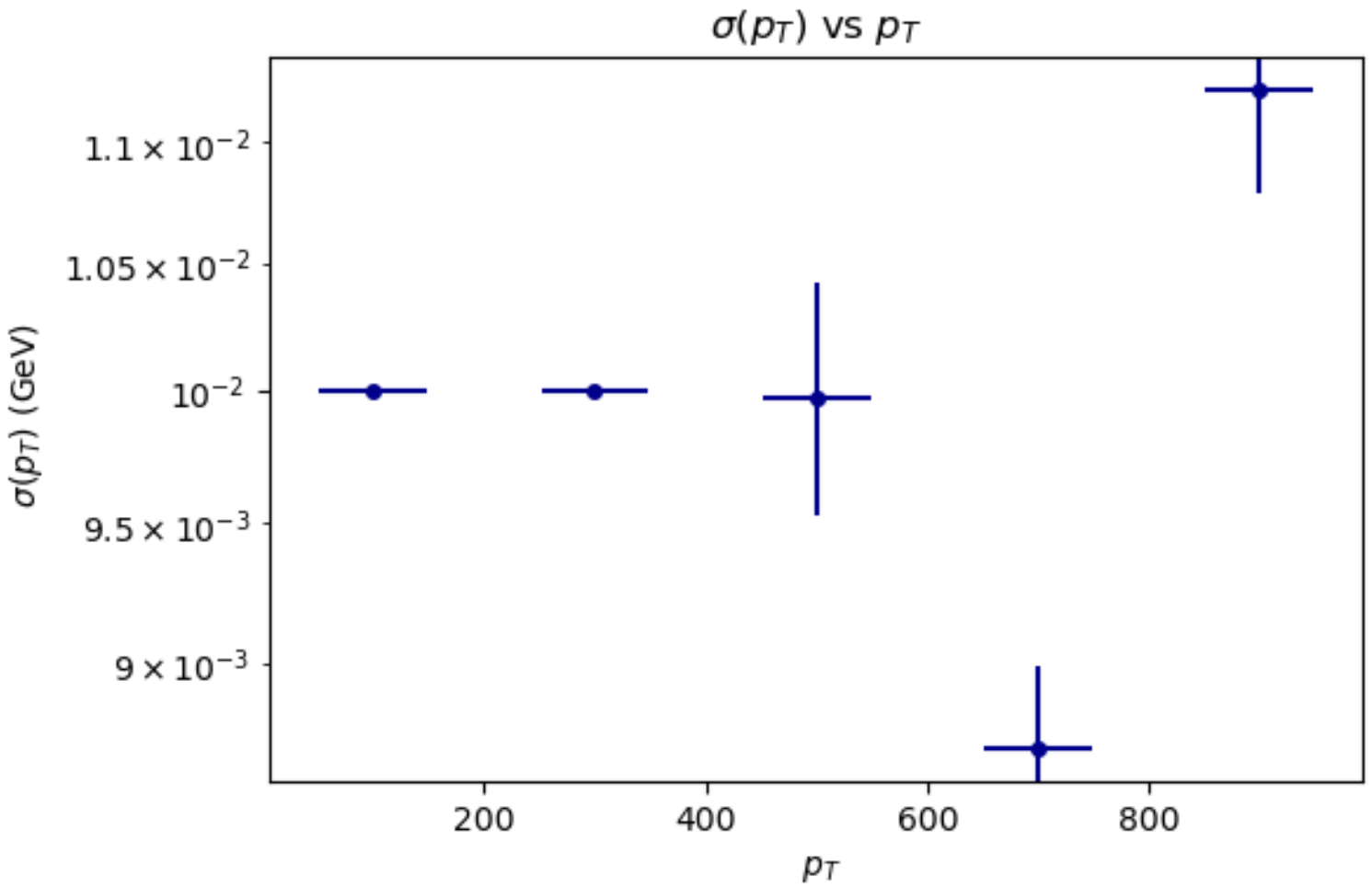
p_T Resolution

- $\sigma(p_T)$ against matched track p_T
- No selection on d_0
- No selection on θ



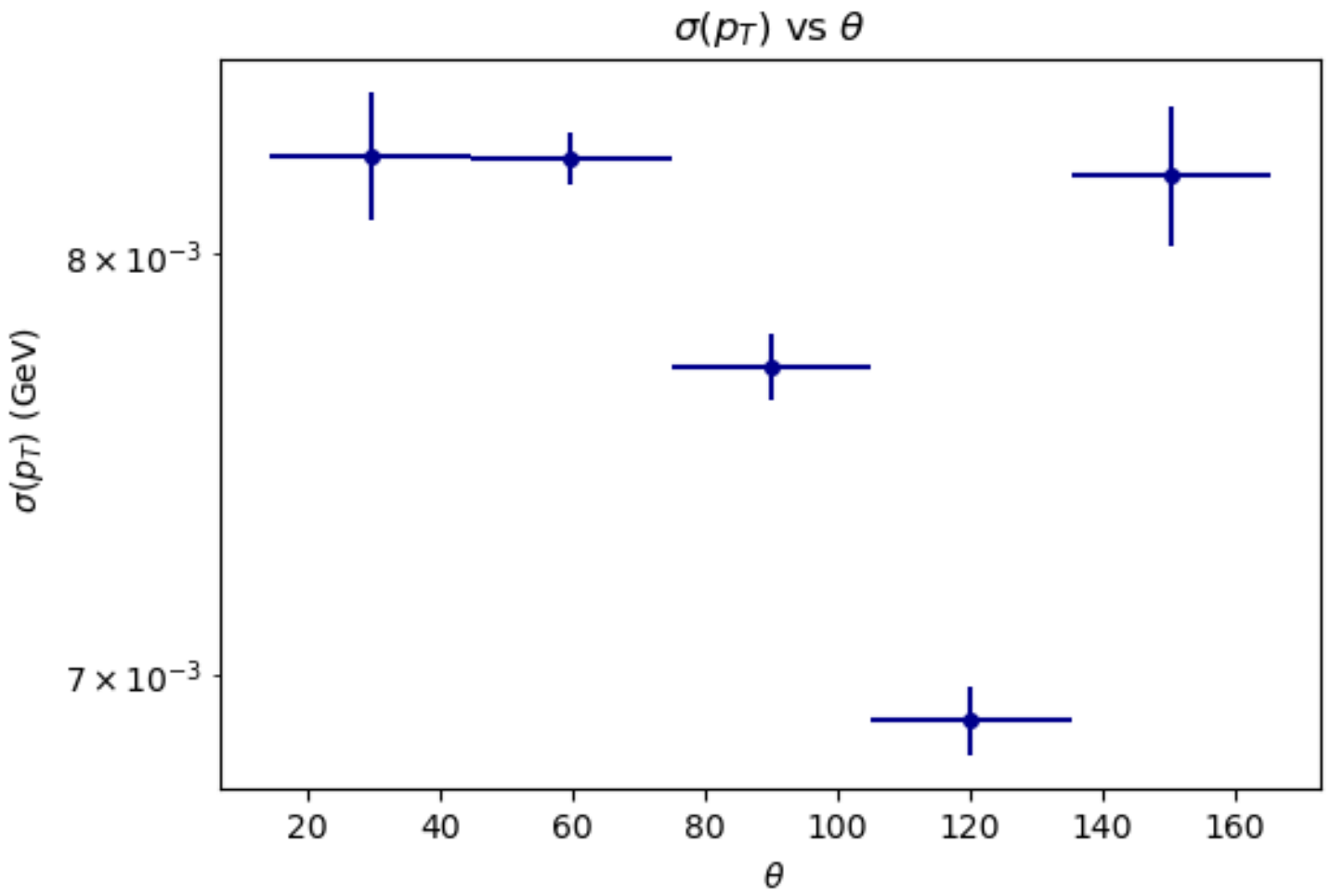
p_T Resolution

- $\sigma(p_T)$ against matched track p_T
- Using pT_d0_cutoffs = [0.8, 0.7, 0.6, 0.5]
- 70° <= θ < 110°



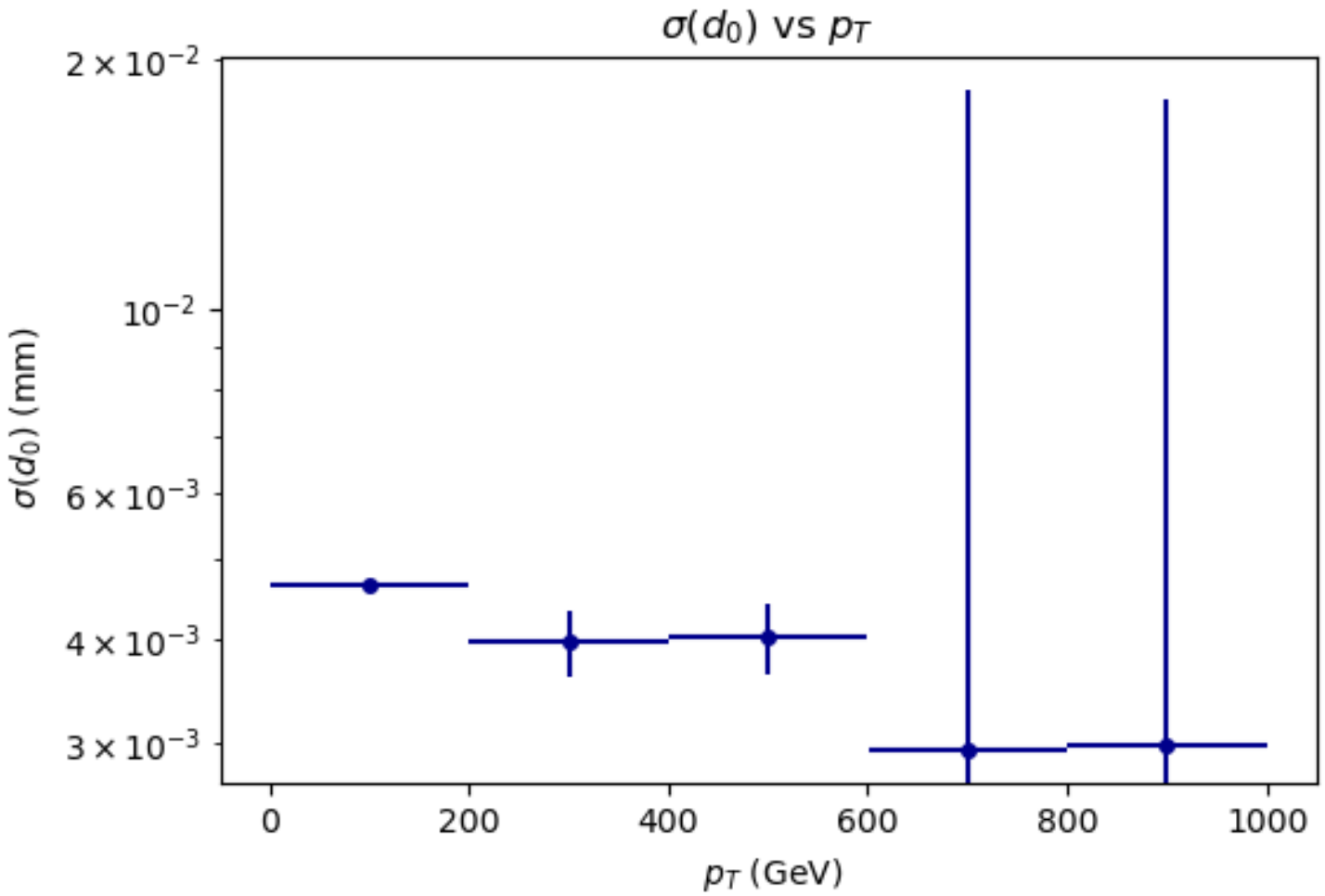
p_T Resolution

- $\sigma(p_T)$ against matched track θ
- No selection on d_0
- No selection on θ



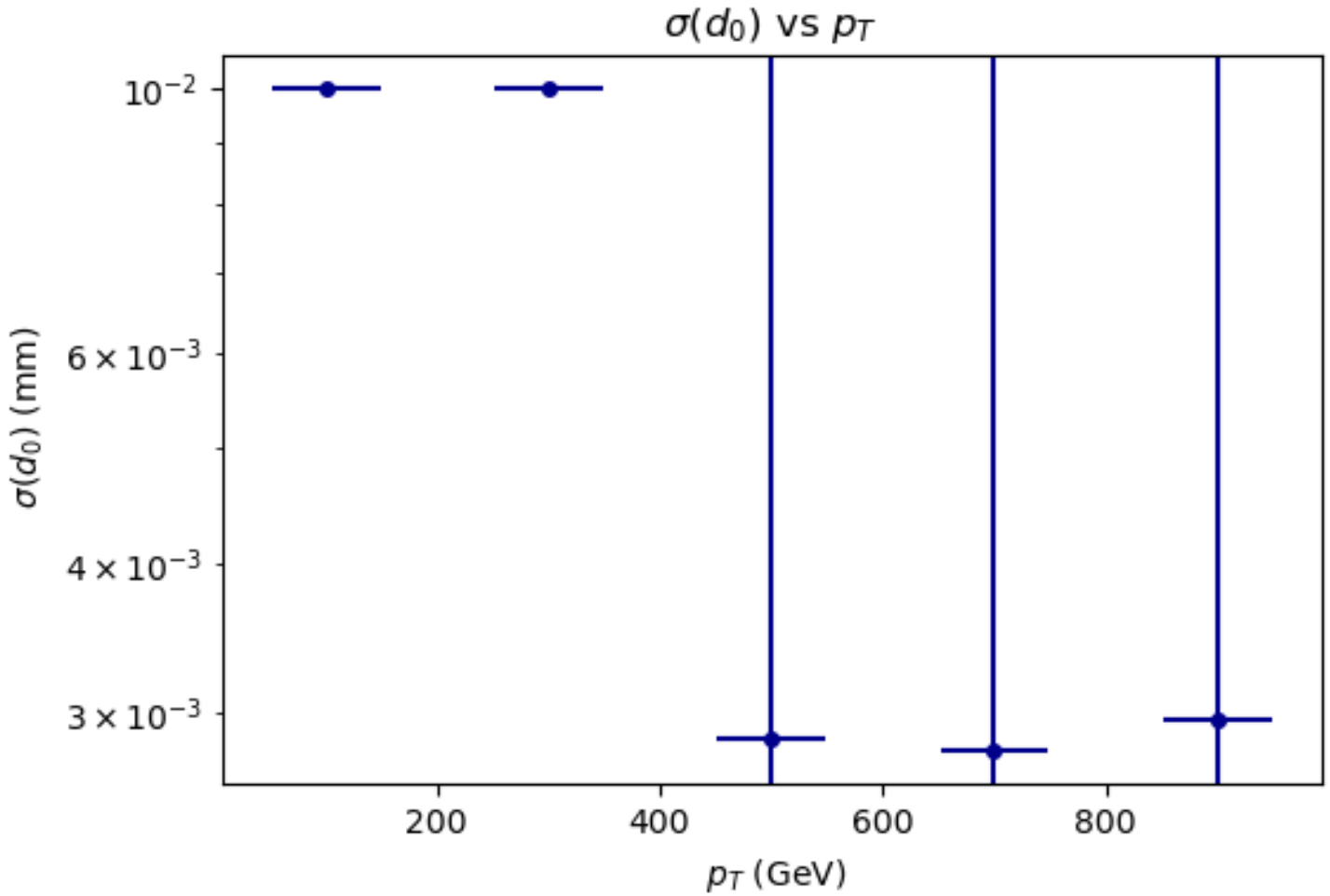
d_0 Resolution

- $\sigma(d_0)$ against matched track p_T
- No selection on d_0
- No selection on θ



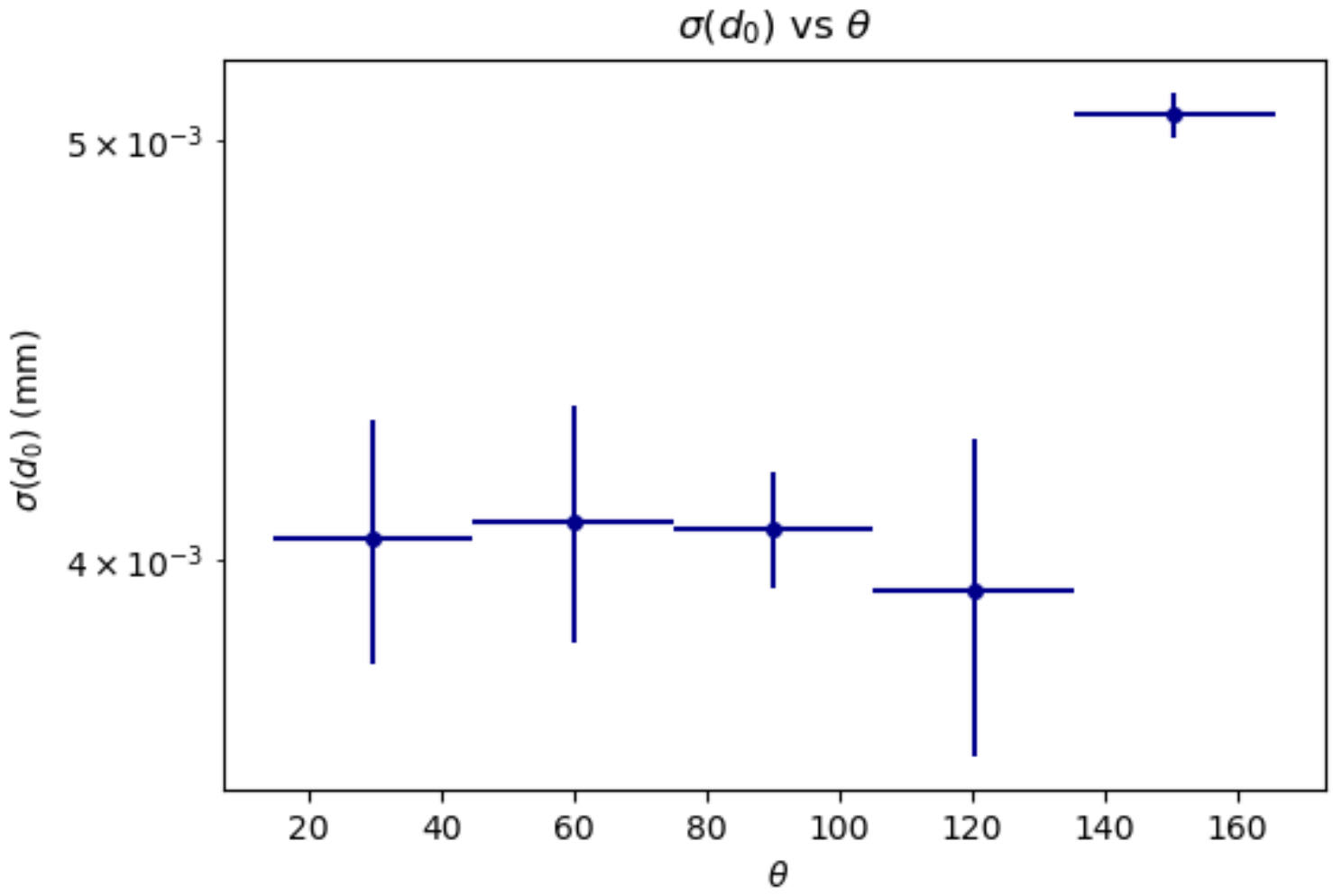
d_0 Resolution

- $\sigma(d_0)$ against matched track p_T
- Using pT_d0_cutoffs = [0.8, 0.7, 0.6, 0.5]
- 70° <= θ < 110°



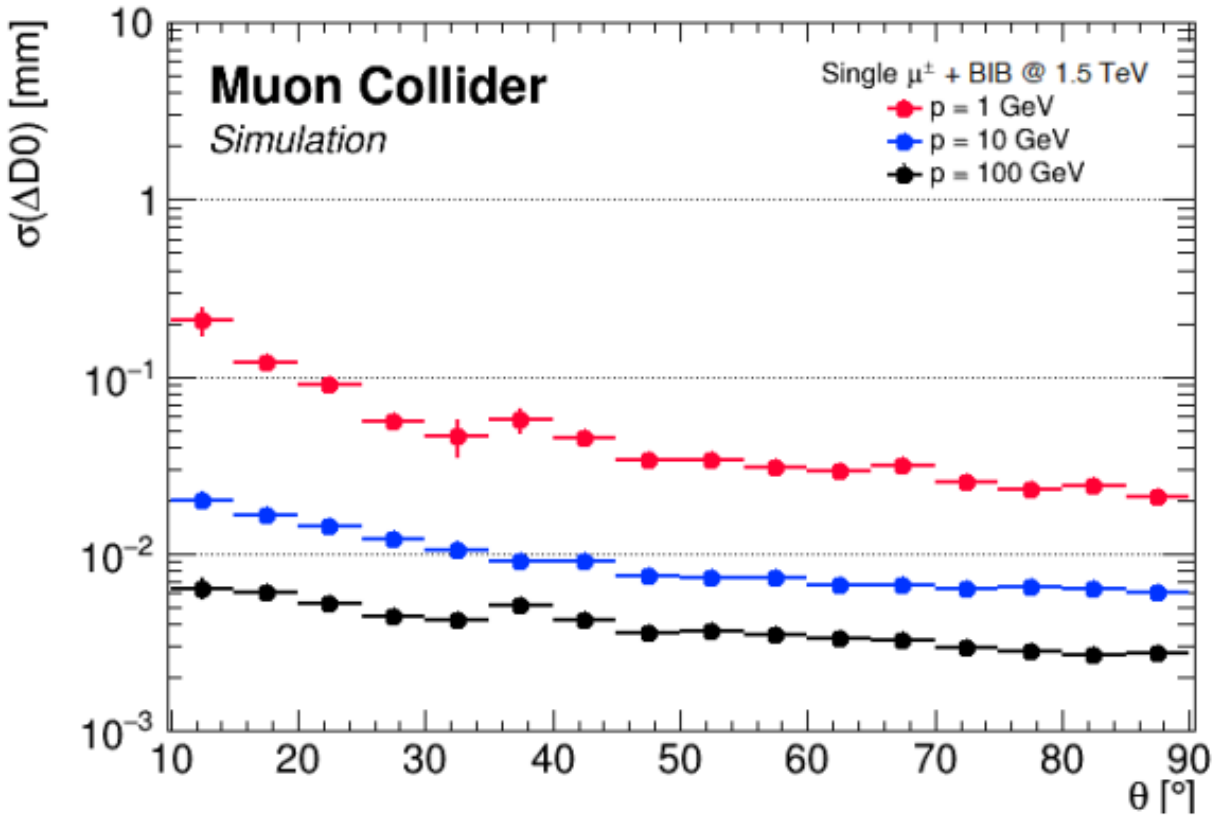
d_0 Resolution

- $\sigma(d_0)$ against matched track θ
- No selection on d_0
- No selection on θ



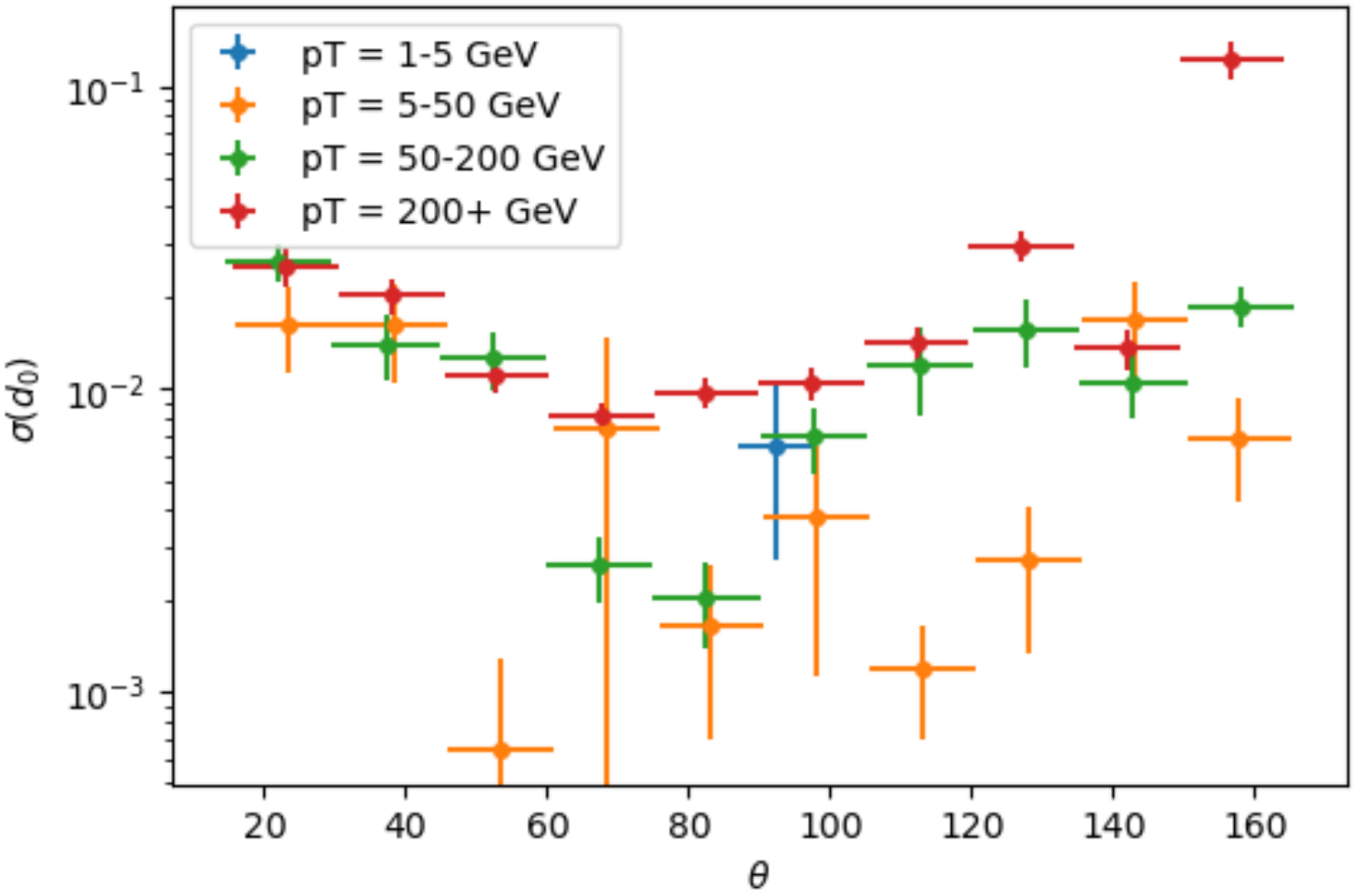
Tracking Performance

- This is what I want to reproduce from ‘Towards a Muon Collider’ pg. 58
- Here it uses 1.5 TeV geometry, with BIB
- It’s worth noting the 1.5 TeV momenta are apparently produced discretely, at 1 GeV, 10 GeV, and 100 GeV, whereas the momenta I’m using is continuous



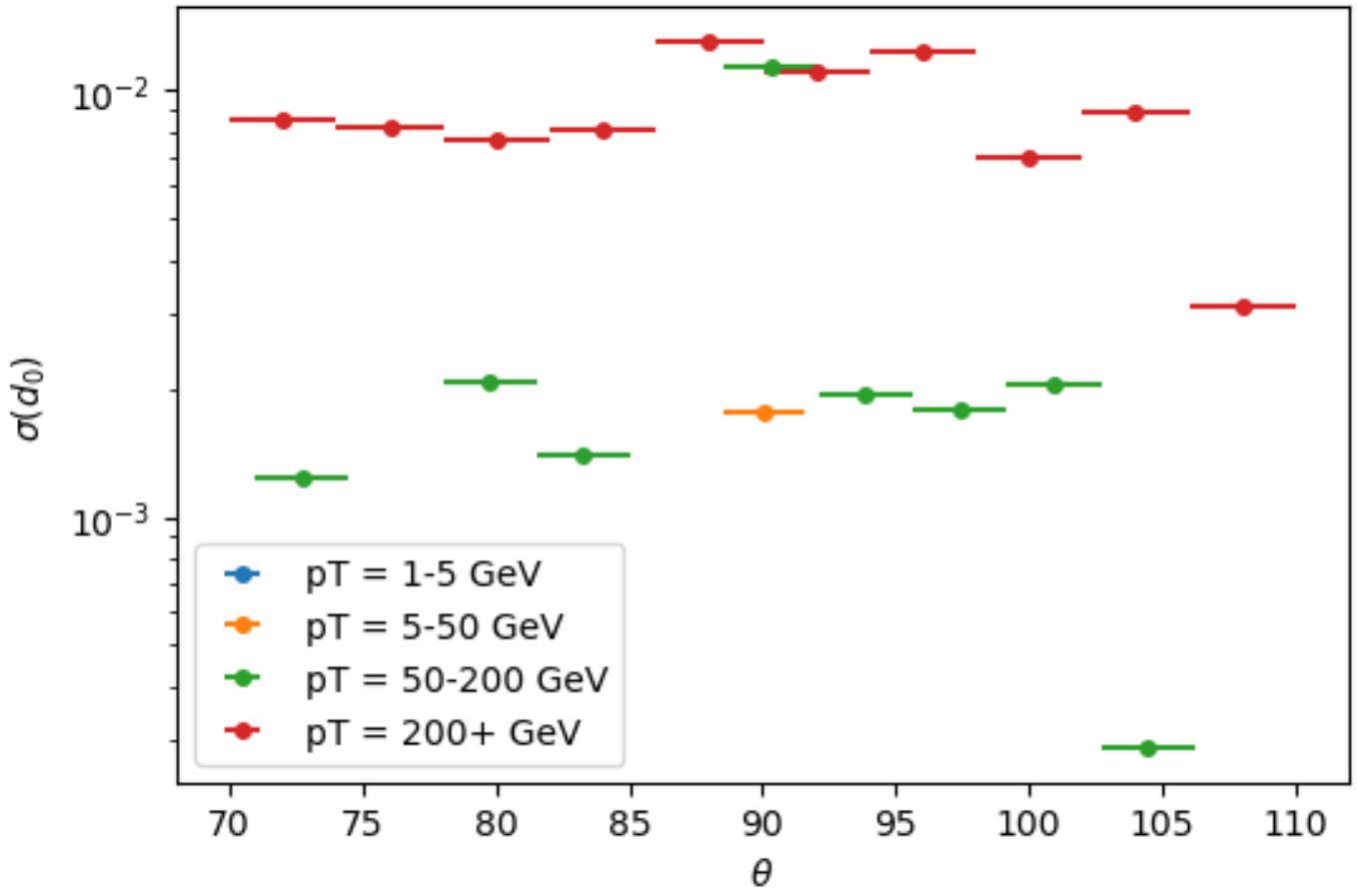
d_0 Resolution

- $\sigma(d_0)$ against Matched track θ
- Using pT_d0_cutoffs = [0.8, 0.7, 0.6, 0.5]
- Using pT_ranges = [1, 5, 50, 200, np.inf]
- No selection in θ
- # of points in pT range 1 - 5 = 6
- # of points in pT range 5 - 50 = 61
- # of points in pT range 50 - 200 = 226
- # of points in pT range 200 - inf = 615



d_0 Resolution

- $\sigma(d_0)$ against Matched track θ
- Using pT_d0_cutoffs = [0.8, 0.7, 0.6, 0.5]
- Using pT_ranges = [1, 5, 50, 200, np.inf]
- 70° <= θ < 110°
- # of points in pT range 1 - 5 = 4
- # of points in pT range 5 - 50 = 9
- # of points in pT range 50 - 200 = 36
- # of points in pT range 200 - inf = 191



Conclusion

- I performed an analysis on tracking performance in muon gun samples without BIB
- Trends for p_T and d_0 resolution look as expected with available statistics
- However, I don't have enough statistics for low p_T range to see how the d_0 resolution is affected by p_T across different θ
- **Next steps**
  - Understand what's happening in the tails
  - Repeat analysis after overlaying BIB and/or with new data