

# Effects of Varying Dimensions of ND-GAr on Muon Acceptance

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Phase II Gaseous Argon TPC Group Weekly Meeting  
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University of Colorado  
Boulder



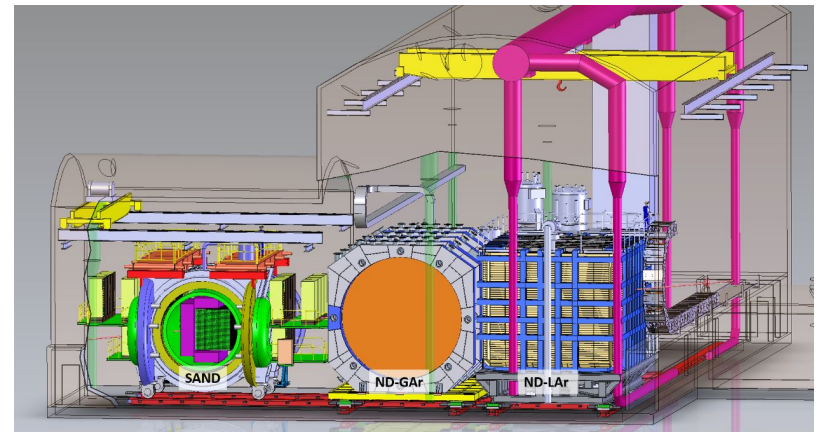
# Outline

- Introduction
- Chris/Mahmood's contributions
- Gluckstern eq and plots
- Show  $\sim 1\text{m}$  required
- Explain improvements chris/mahmood (improved geometry and simulated tracks)
- Show energy/angle, acceptance
- Dip region due to ECAL?
- Varying size
  - Acceptance % vs energy, angle for varying diameter, length (25cm increments)
    - Maybe ratios about 5m?
  - Full matrix of acceptance %, for

# Motivation

- Limited space inside ND hall
- A smaller HPgTPC could reduce costs associated with the size of the hall and the access shaft, as well as with the magnet, ECAL, electronics, etc.
- Previous studies by Chris Marshall and Mahmood Al-Omeri have looked at the effects of varying the dimensions of the HPgTPC on its performance as a muon spectrometer for LAr
- Trying to replicate their results with newer simulations

[2103.13910]

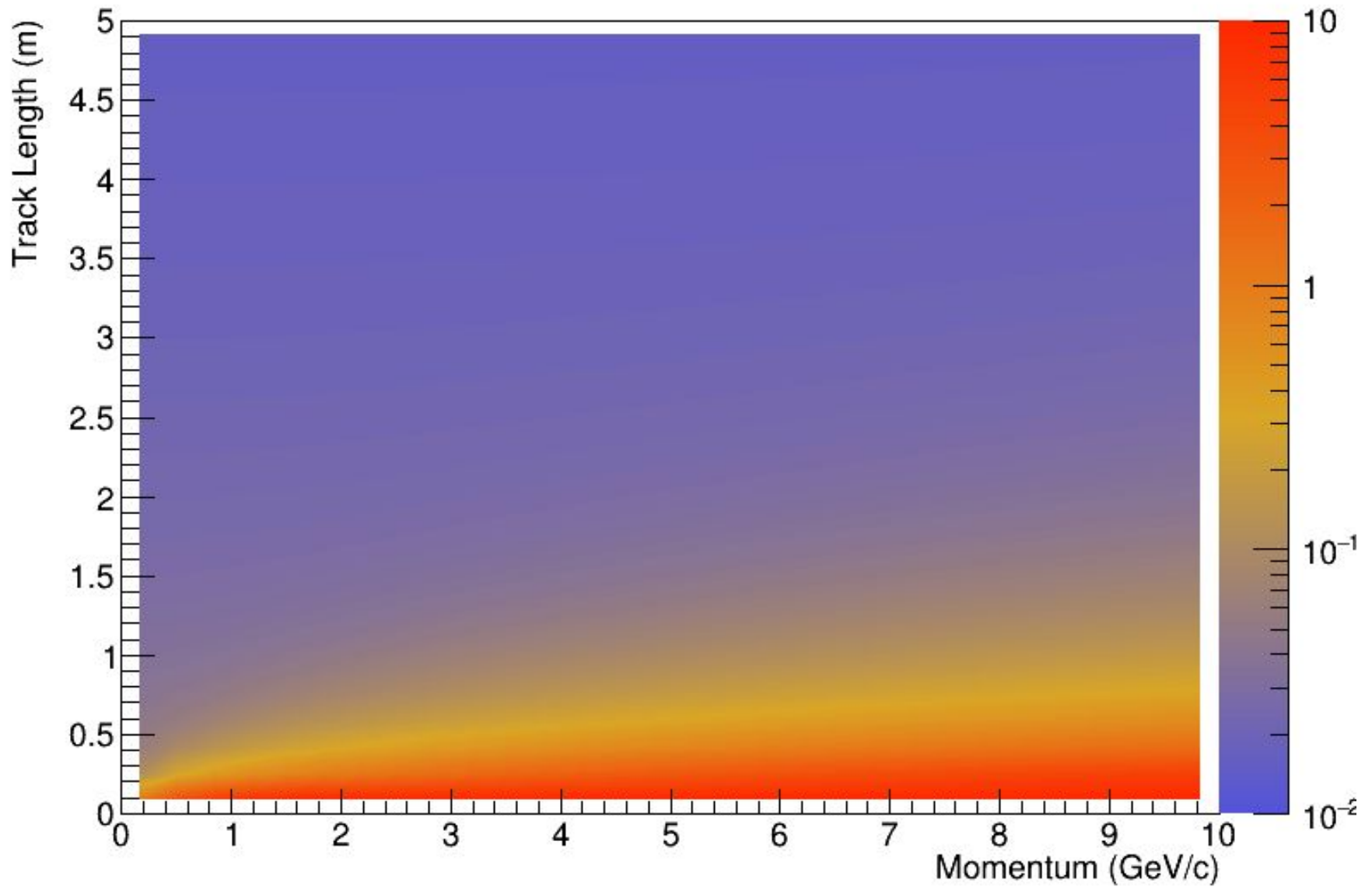


# Momentum Resolution

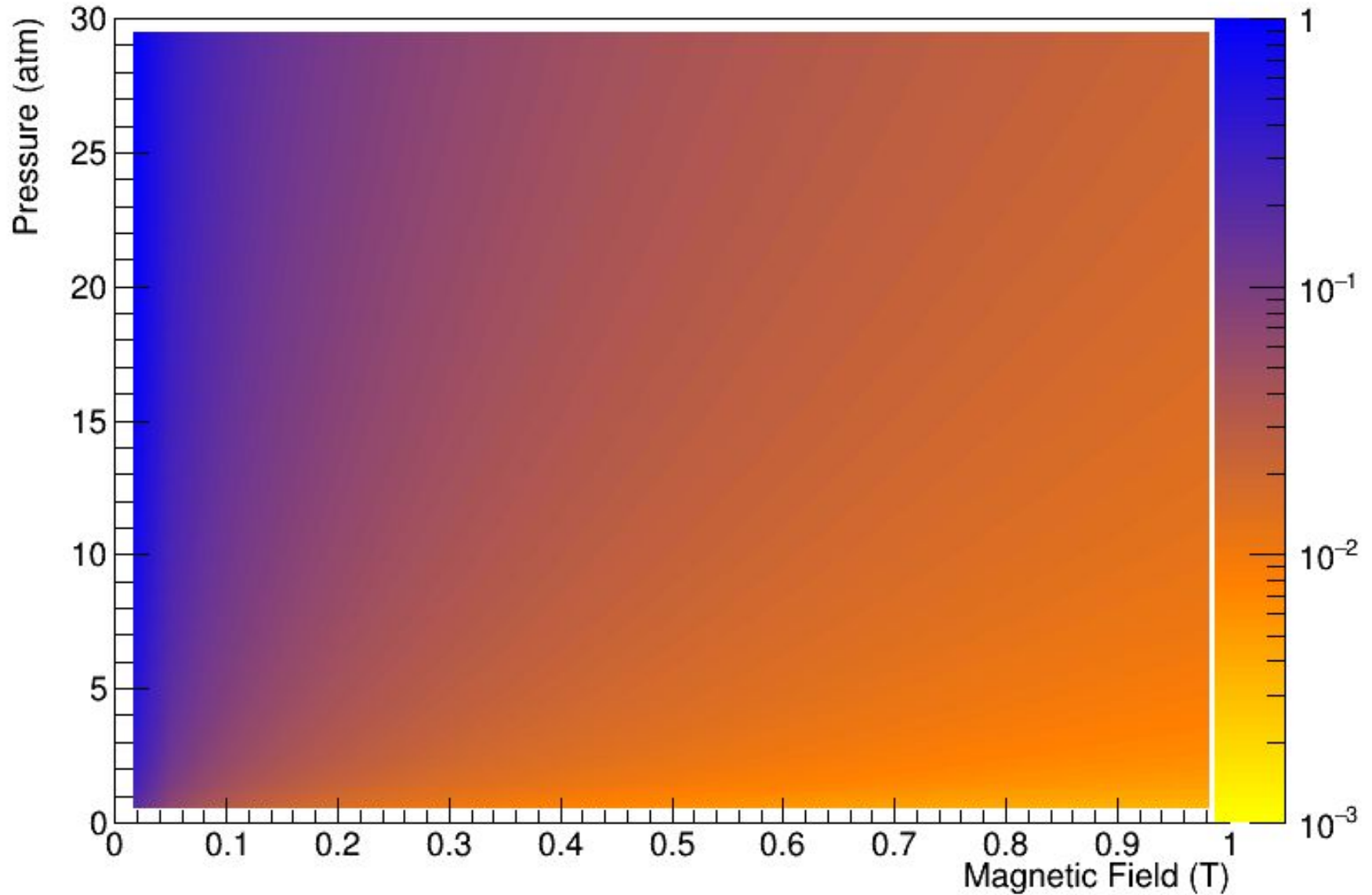
- In a gas detector, the Gluckstern equation relates the momentum resolution to the magnetic field, pressure, track length, number of points, momentum, and position resolution
- Using assumed values of 0.001m resolution and 100 pts/m, make contour plots by fixing all variables but 2
- Pressure at 10 bar, magnetic field at 0.5 Tesla
- Track length of 2m, momentum of 1 GeV

$$\left(\frac{\sigma_p}{p}\right)^2 = \left(\frac{\sigma_x p}{0.3BL^2} \sqrt{\frac{720}{N+4}}\right)^2 + \left(\frac{0.0596}{B\sqrt{LX_0}}\right)^2$$

# Resolution at 10 bar, 0.5 T

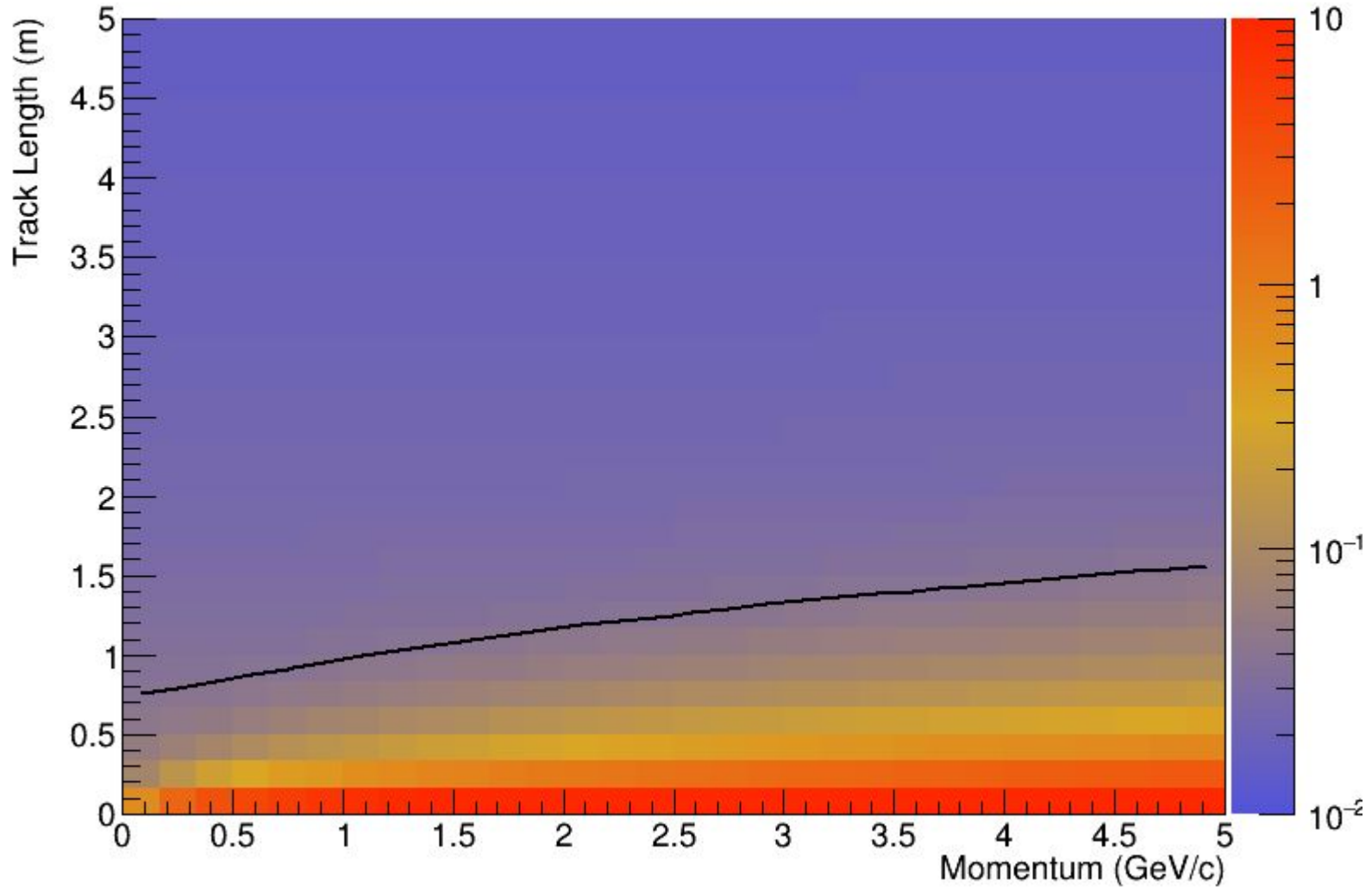


# Resolution at $L = 2$ m, $p = 1$ GeV/c

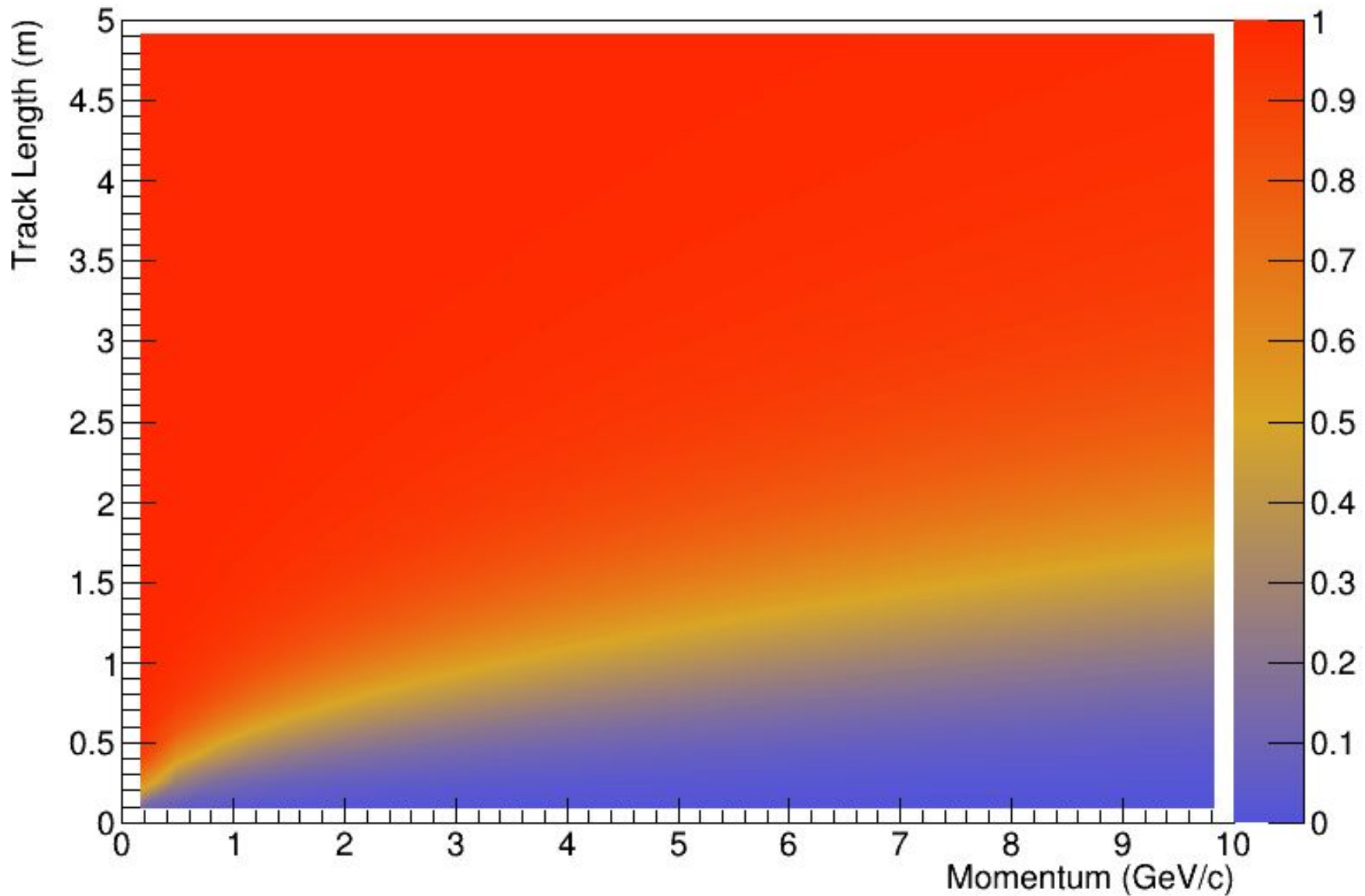


Line showing fixed 4% momentum resolution

Resolution at 10 bar, 0.5 T



# Fraction due to Multiple Scattering at 10 bar, 0.5 T

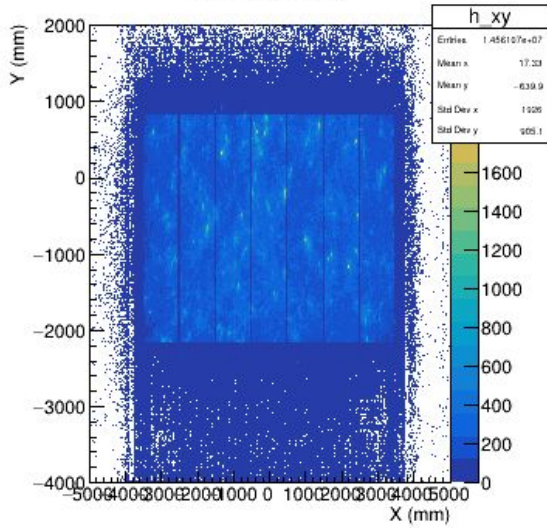




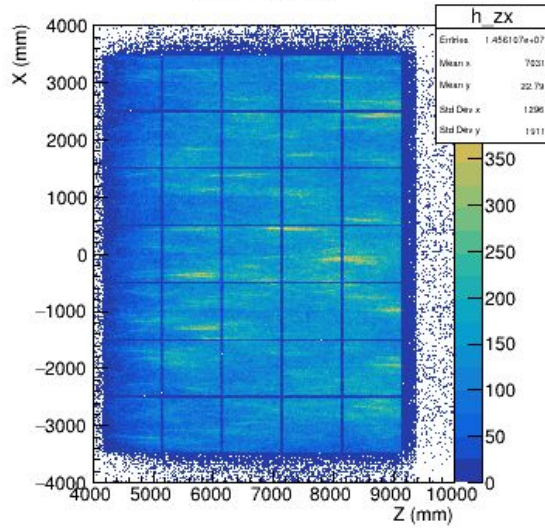
# Details

- 10,000 Events, starting anywhere in detector hall
  - Chris Marshall's had evenly distributed events starting in GAR
  - Mahmood Al-Omeri's data was same as mine, except for material between detectors (ECAL and magnet) and magnetic field simulation (tracks curve)
- Used a right hand coordinate system with y being vertical, and +z pointing roughly with the beam ( $-5.4^\circ$  angle)
- LAr active volume:
  - $-3500\text{mm} < x < 3500\text{mm}$ ,  $-2200\text{mm} < y < 800\text{mm}$ ,  $4100\text{mm} < z < 9100\text{mm}$
  - Fiducial volume found by excluding 500mm from all sides, with 1500mm excluded from the downstream z side
- GAR active volume:
  - Cylinder centered at  $x=0\text{mm}$ ,  $y=-1500\text{mm}$ ,  $z=14850\text{mm}$ , Diameter of 5m in yz and extending  $\pm 3500\text{mm}$  in x

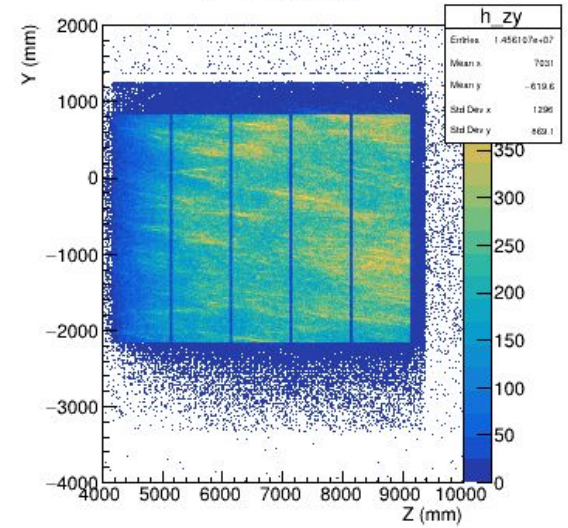
XY Plane First



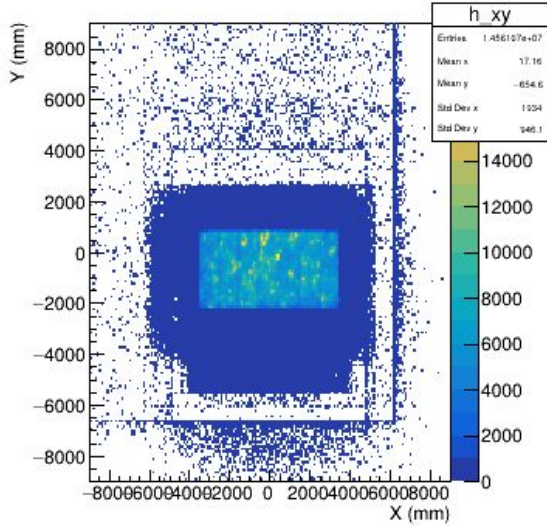
ZX Plane First



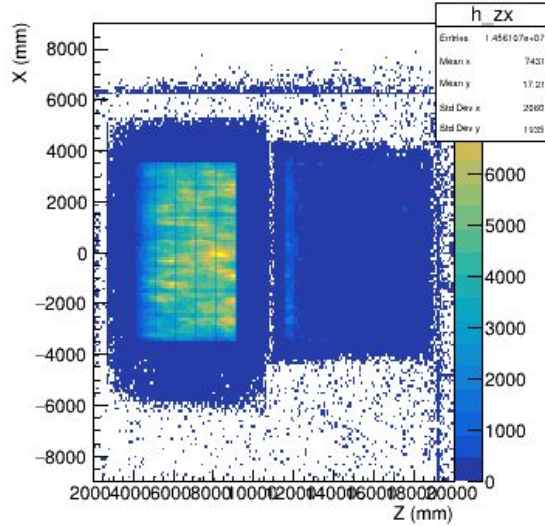
ZY Plane First



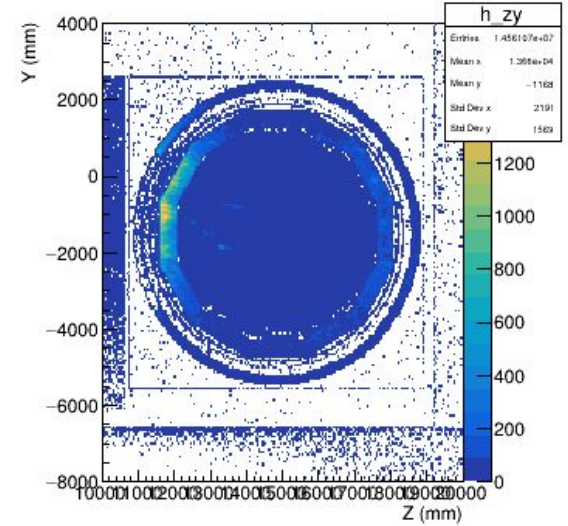
XY Plane Final



ZX Plane Final



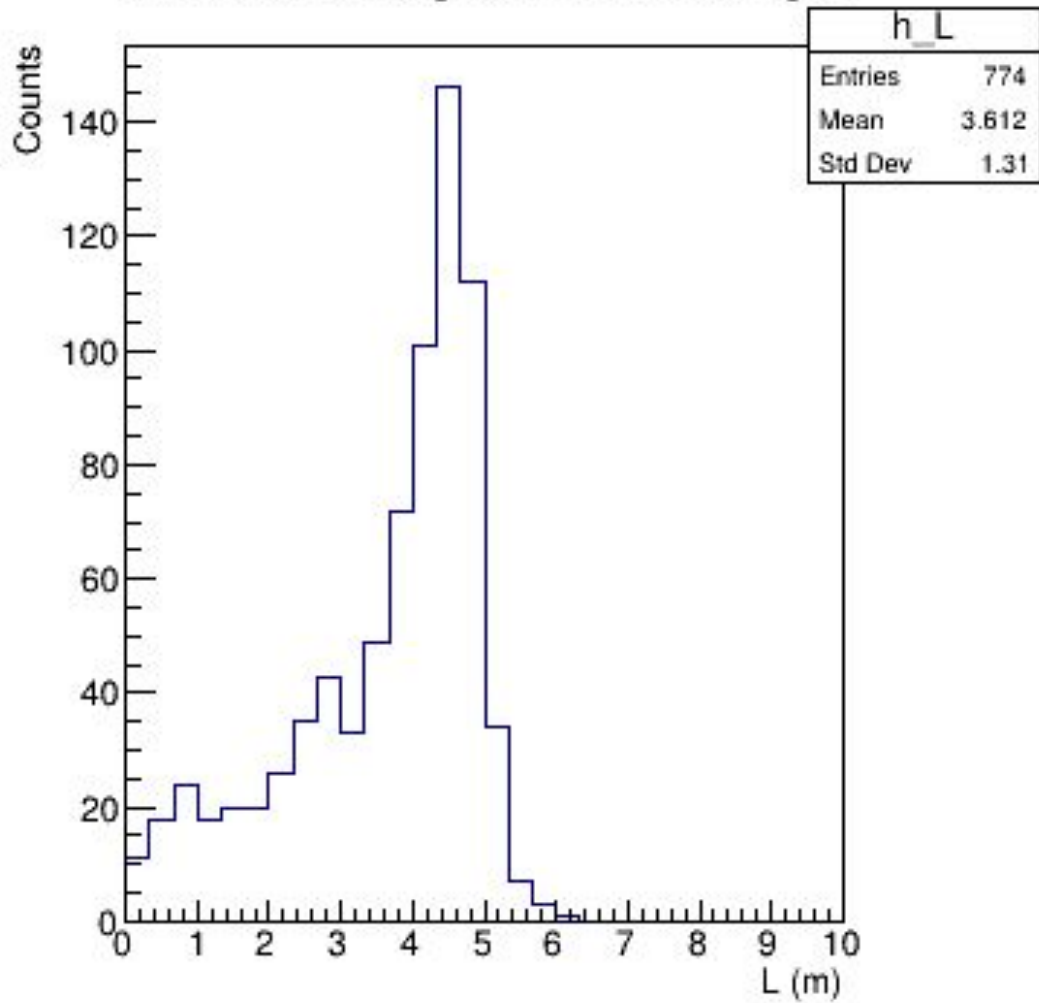
ZY Plane Final



# Study Definitions

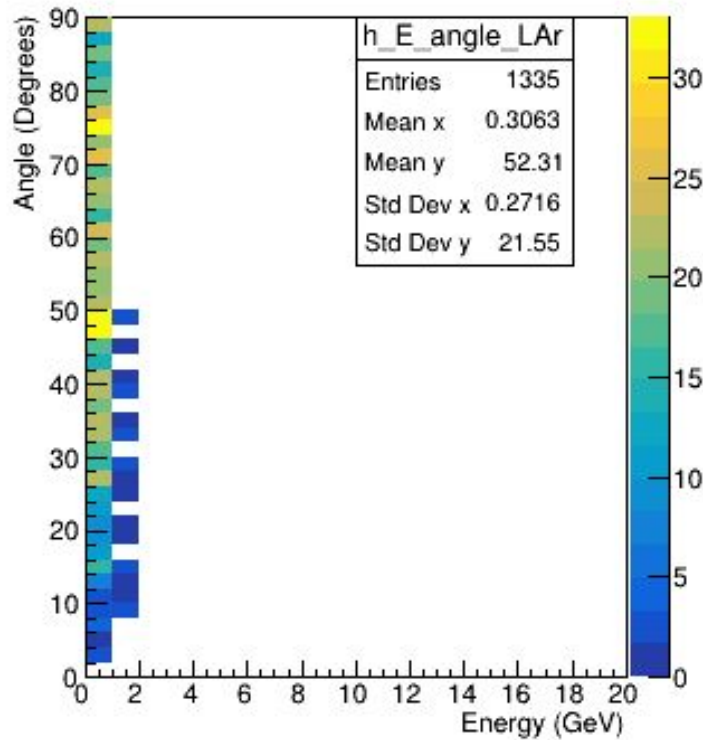
- Considered primary muons starting in fiducial volume of LAr
- Marked as accepted if ends in active volume of LAr, or have a track length  $>1\text{m}$  in GAr
- For muons entering GAr, also separated if the muon was contained in GAr or “punched out”
- Instead of extrapolating straight line between start and endpoints, loop over points in trajectory and calculated distance between points inside of GAr

## Counts vs Length of Tracks in gAr

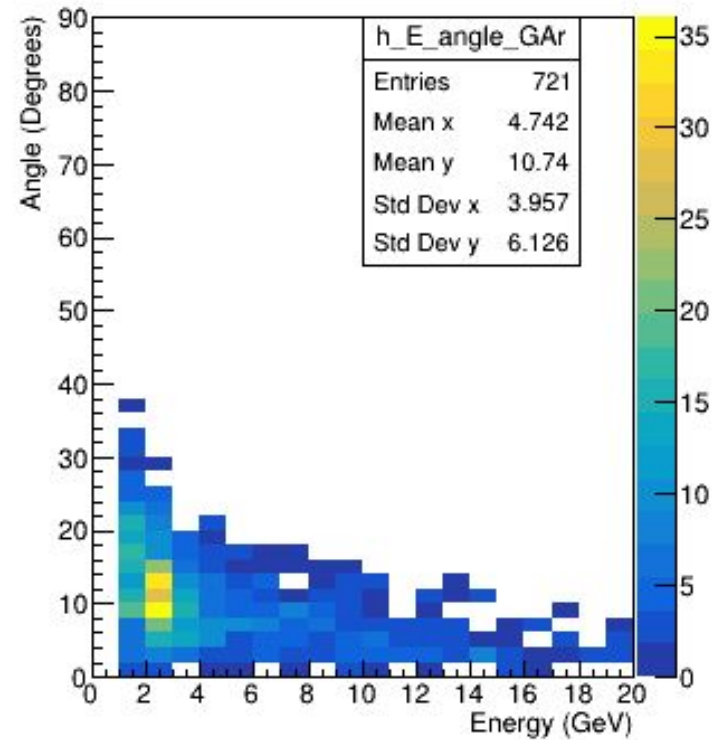


# Accepted Events, Split by LAr and GAr

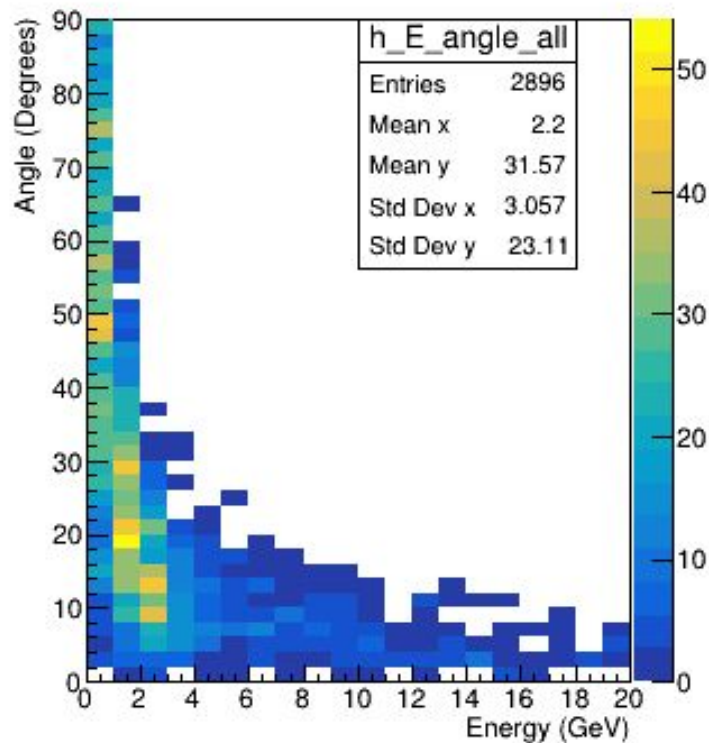
## LAr Muons



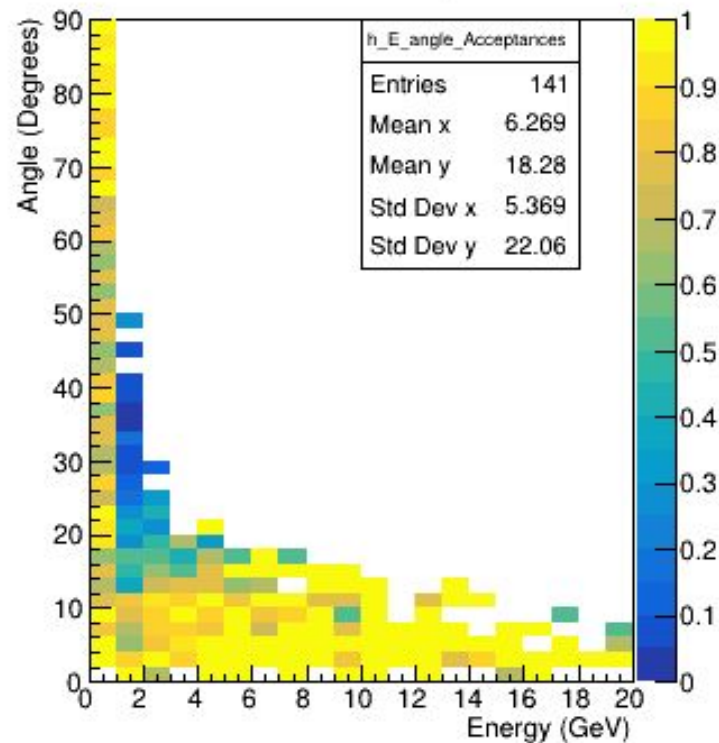
## GAr Muons



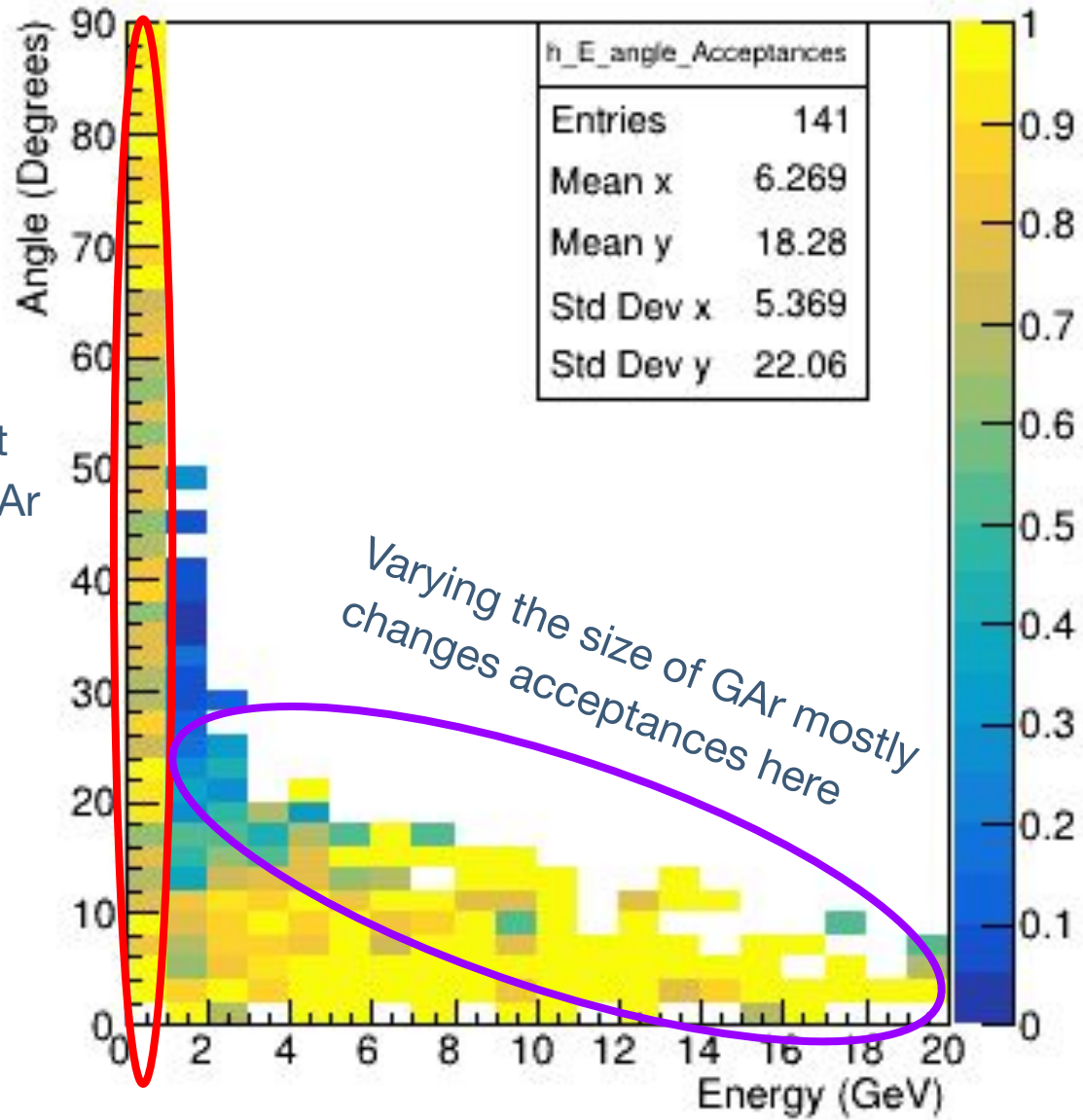
### All Muons



### Ratio of Accepted

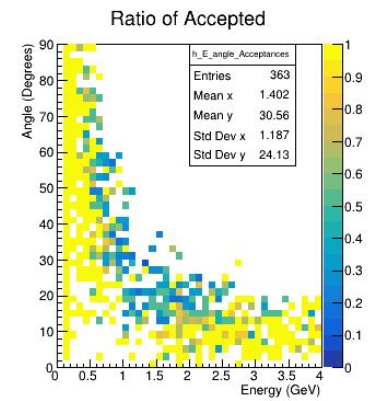
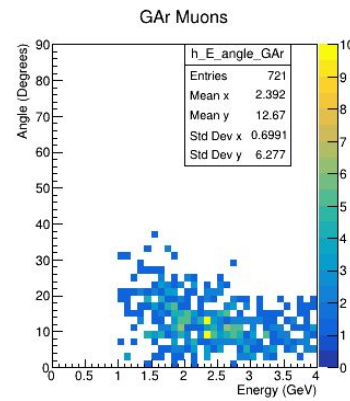
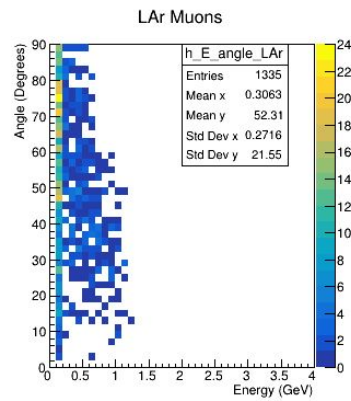
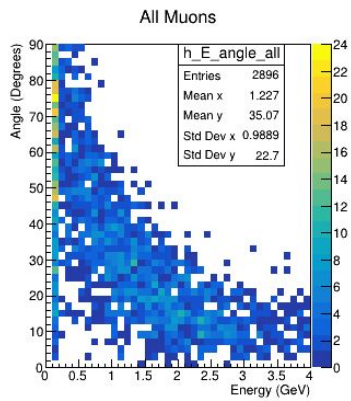
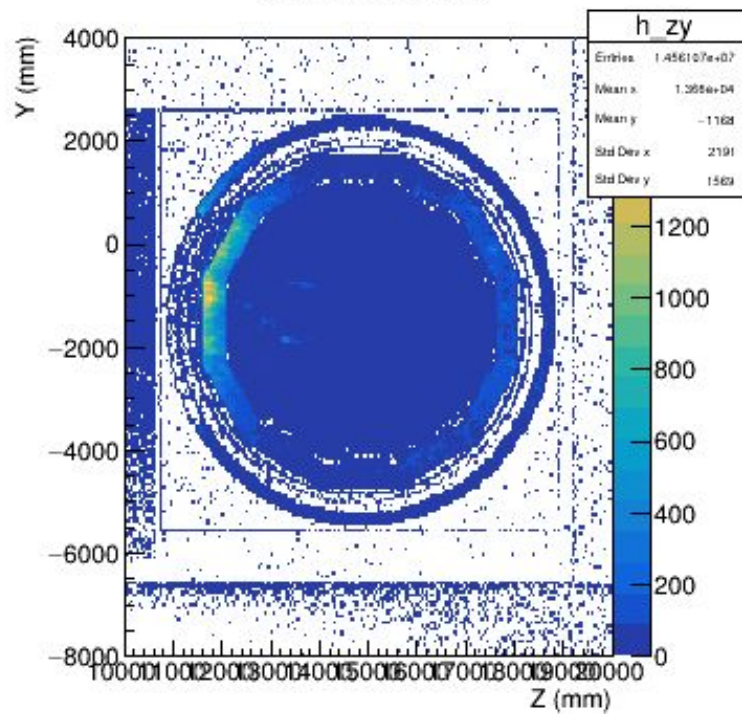


# Ratio of Accepted



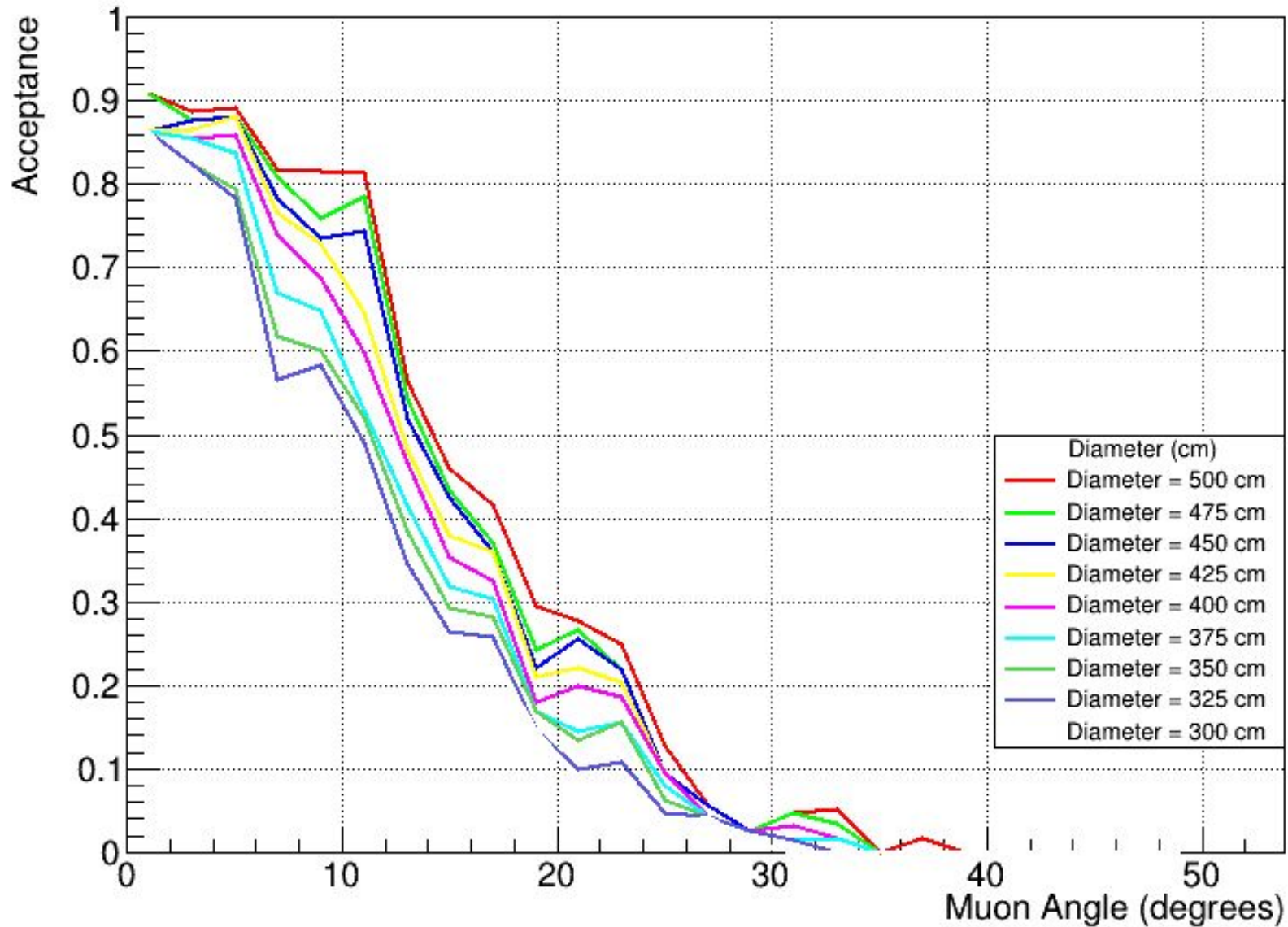
Contained in LAr, not affected by size of GAR

# ZY Plane Final

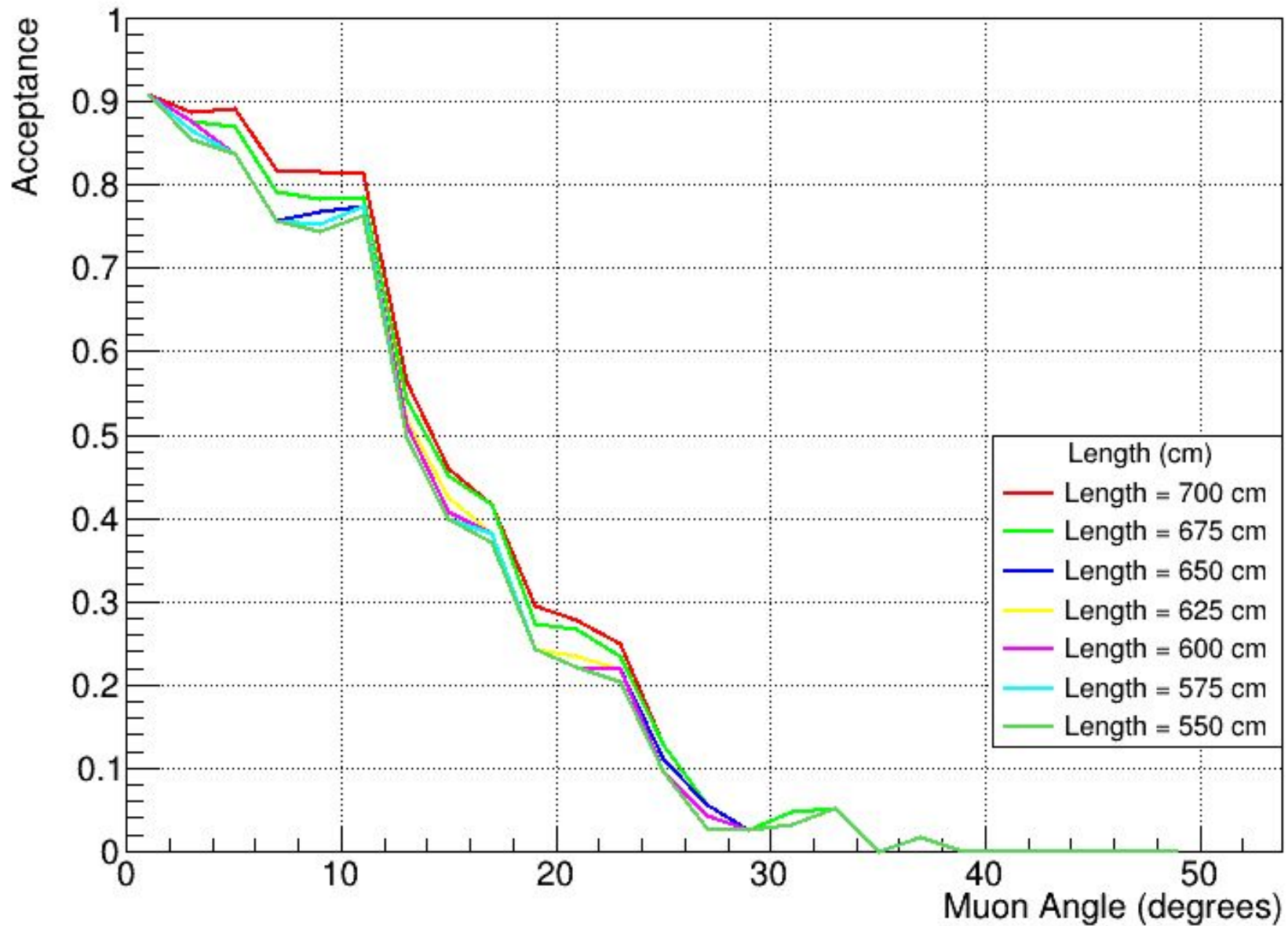




# GAr Muon Acceptance vs Muon Angle



# GAr Muon Acceptance vs Muon Angle



# Conclusions and Next Steps

- Diameters as low as 4m are viable and do not affect the acceptances too drastically
- Varying the width of the detector has less effect on acceptances than varying the diameter
- Space is more of an issue in the beam direction and it is likely easier to increase the width than the diameter.
- Better statistics would help in smoothing out acceptance vs angle curves
- Explore full range of diameter and length, plot acceptance vs energy
- Can replicate diameter and length vs mass of detector plots, set bounds on minimum size

Thank You!