Impact of magnetic field map on reconstructed momentum bias

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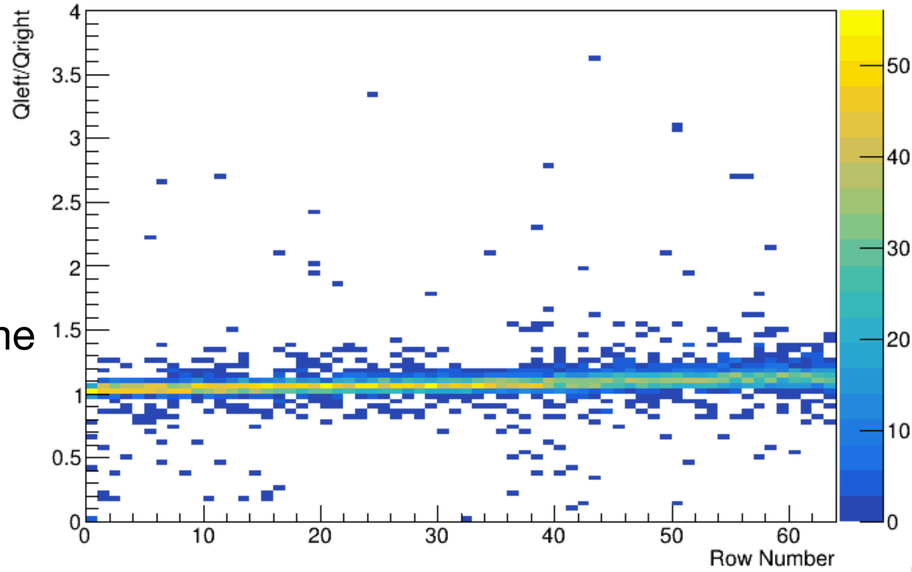
Introduction

- A bias was observed on the reconstructed muon momenta in the hatRecon
- In order to study where this bias is coming from, I looked at the detResponseSim output directly
- I simulated mu+ and mu- vertical (horizontal) 100 GeV tracks and looked at the Qleft/Qright (Qtop/Qbottom) ratio of max of waveforms. Since the tracks are very straight, those ratio should be constant
- I did this using non uniform (~0.2T,~0,~0) and uniform (0.2T,0,0) B field
- The non uniform B field is simulated by a B field map which aims to simulate true ND280 B field: https://git.t2k.org/nd280/base/oaMagnetCalib/-/blob/master/mapdata/MagMap.1kA.ND280.COMSOL.root

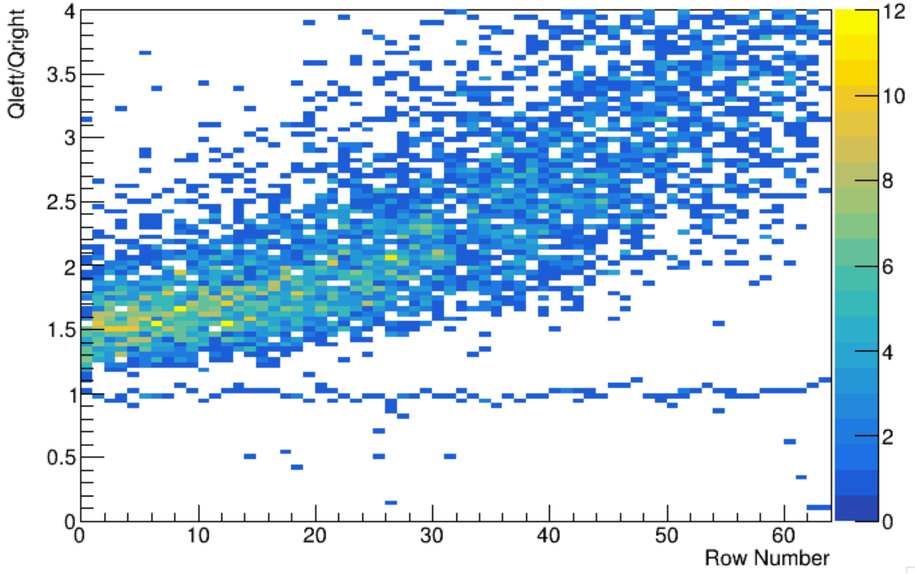
100 GeV vertical mu+ tracks
Using usual B field map

The drift distances are 5cm, 55cm and 95cm, initial position in the Z,Y plane is the same
Tracks supposed to begin at a Z corresponding to middle of the pad
But coordinates are shifted when we go to larger drift distance

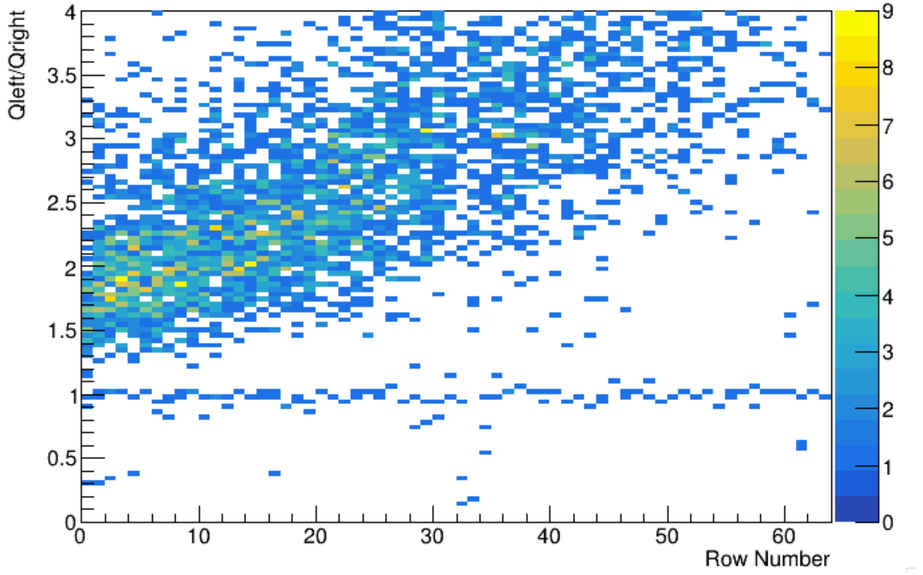
5cm



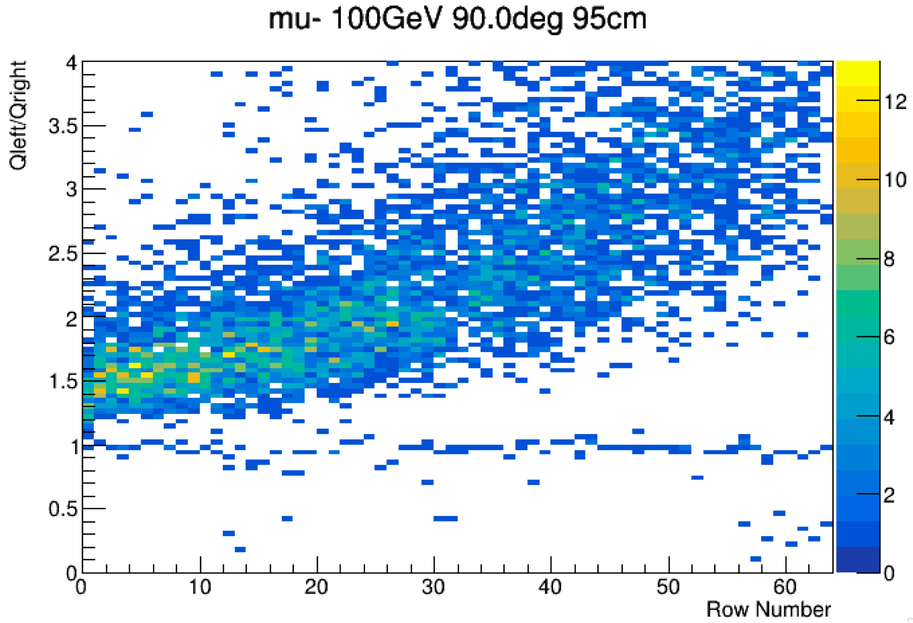
55cm



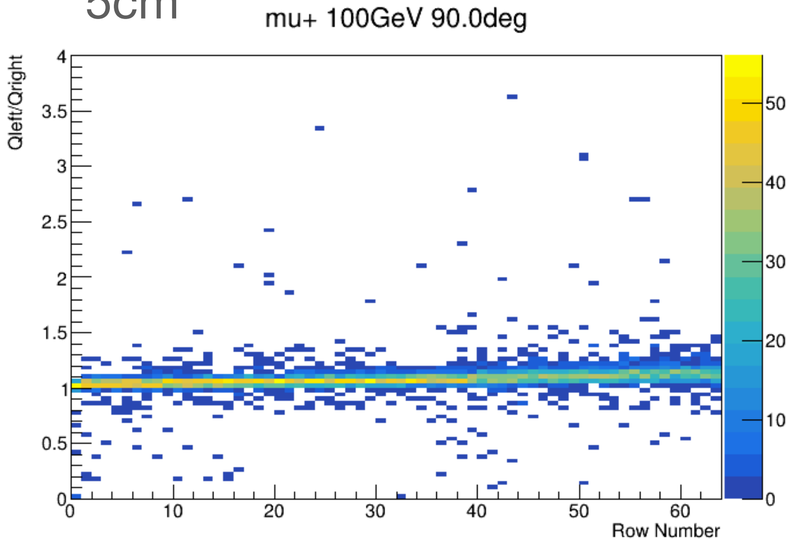
95cm



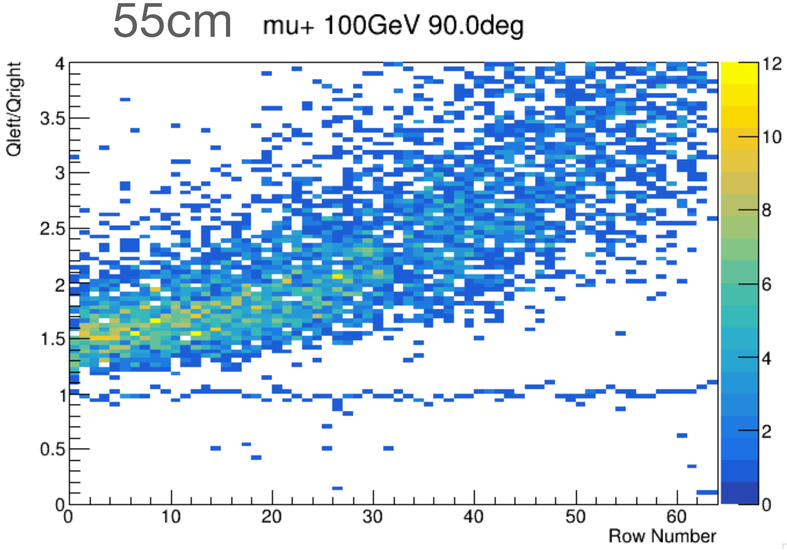
100 GeV vertical mu+ (and mu-) tracks
Using usual B field map



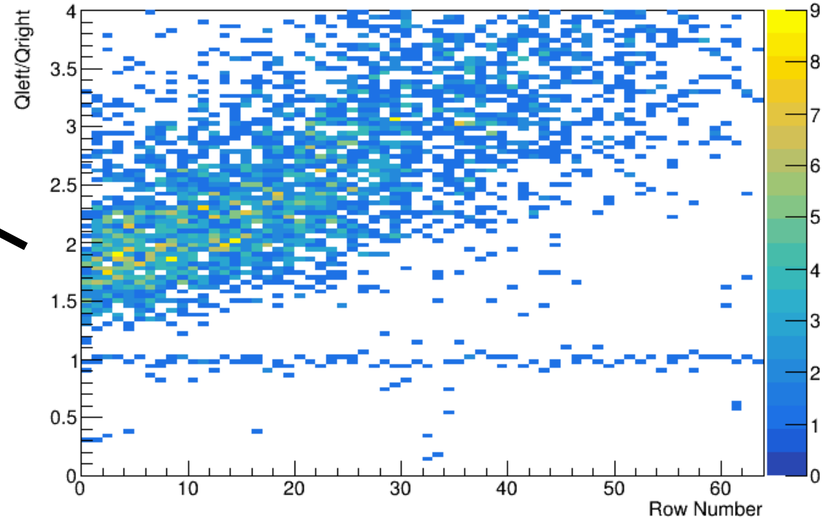
5cm



55cm



95cm

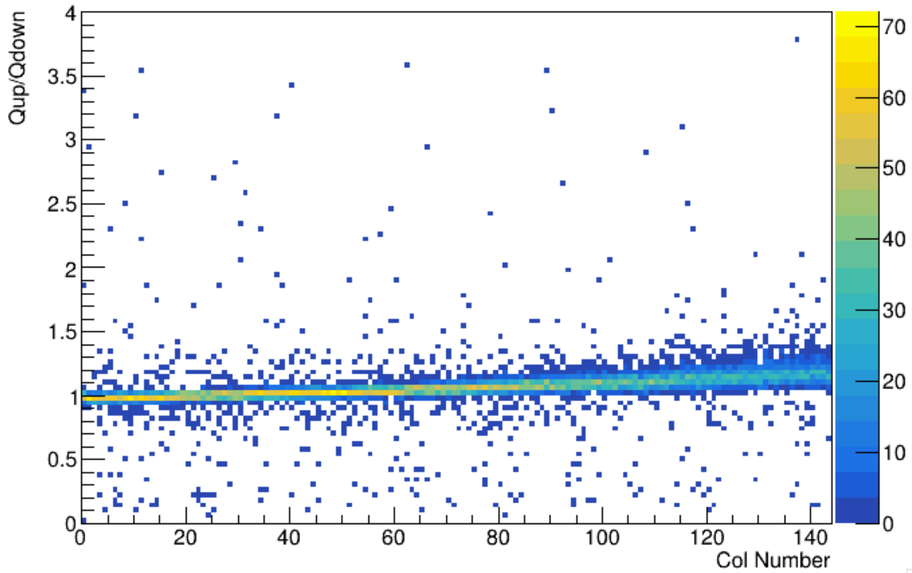


mu- tracks position shifted in the same direction,
so problem can't come from magnetic field!

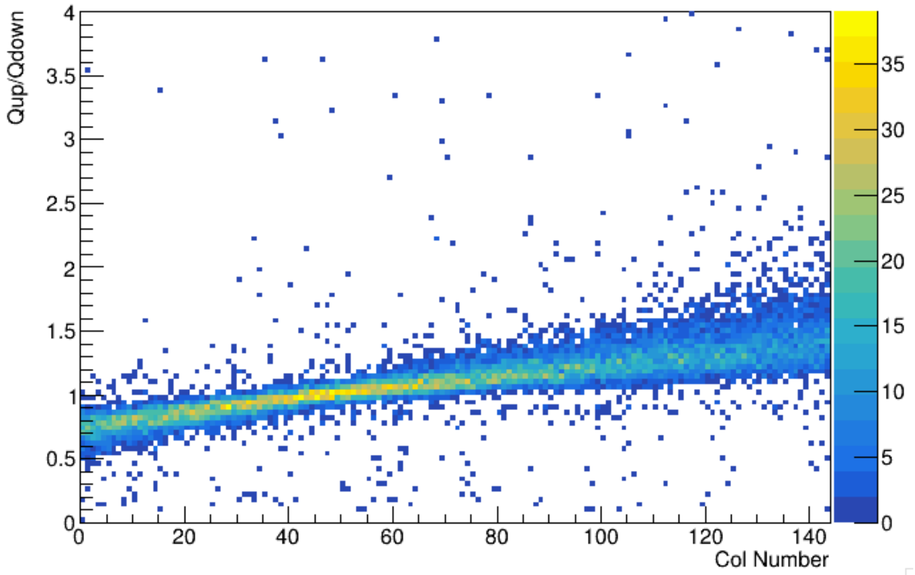
100 GeV horizontal mu+ tracks
Using usual B field map

The drift distances are 5cm, 55cm and 95cm, initial position in the Z,Y plane is the same
Tracks supposed to begin at a Y corresponding to middle of the pad
But coordinates are shifted when we go to larger drift distance, effect opposite and smaller than for vertical tracks

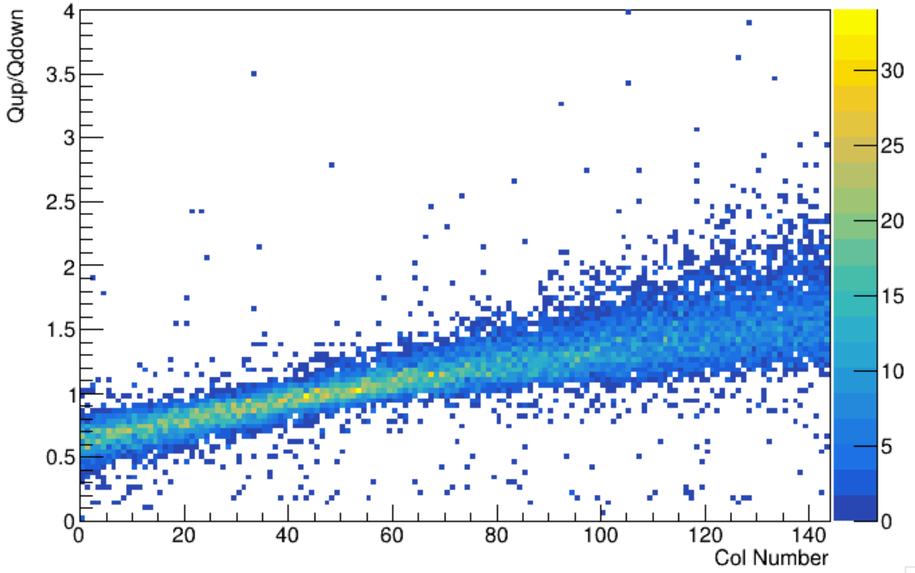
5cm mu+ 100GeV 0.0deg



55cm mu+ 100GeV 0.0deg



95cm mu+ 100GeV 0.0deg

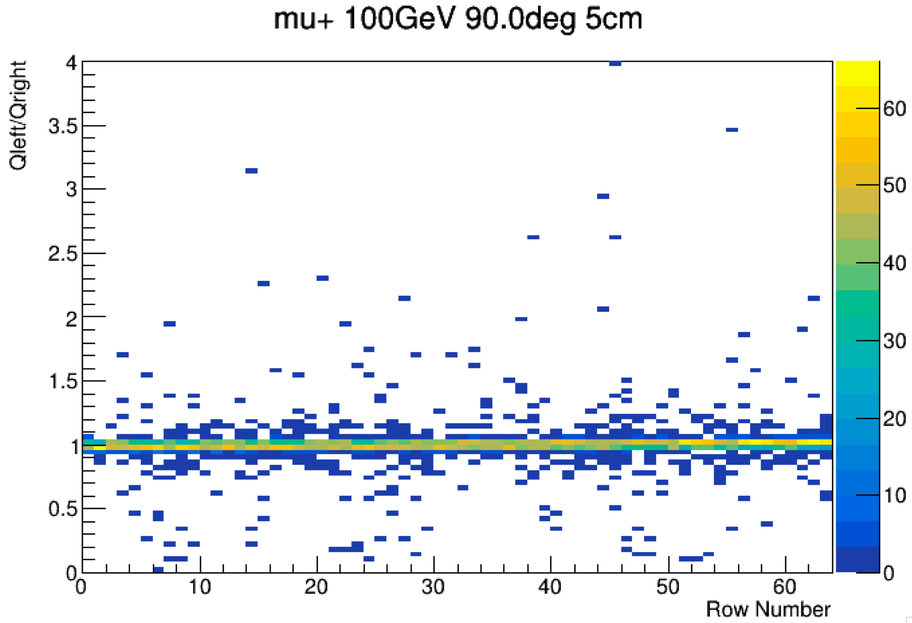


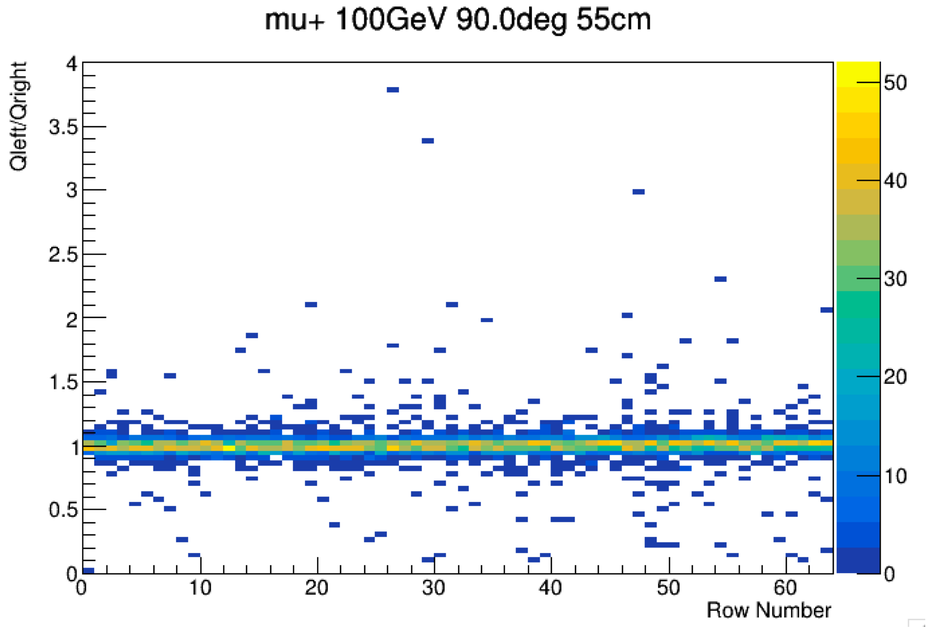
100 GeV vertical mu+ tracks
Using uniform B field

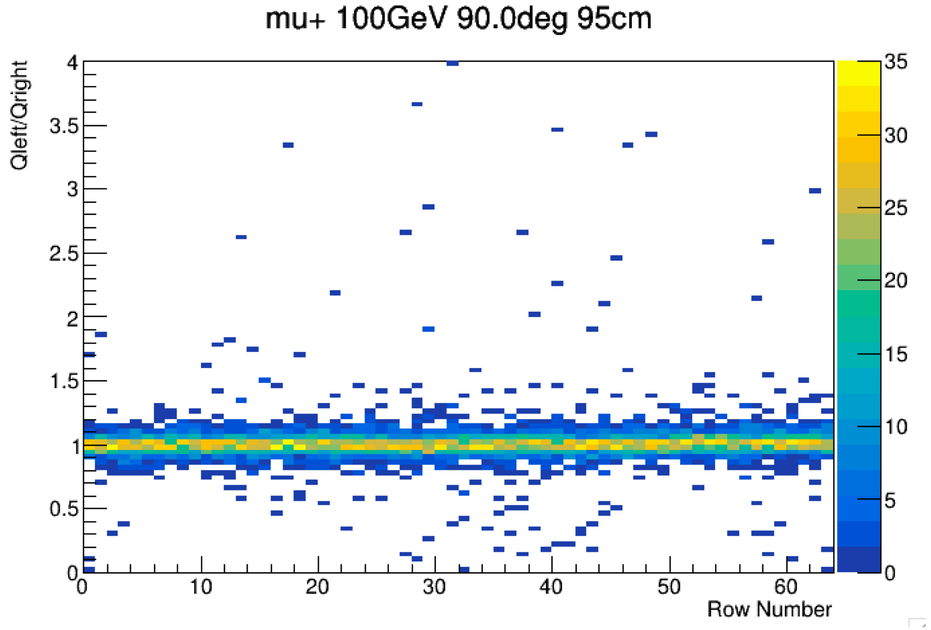
The drift distances are 5cm, 55cm and 95cm, initial position in the Z,Y plane is the same

Tracks supposed to begin at a Z corresponding to middle of the pad

Coordinates not shifted at all !







Observations

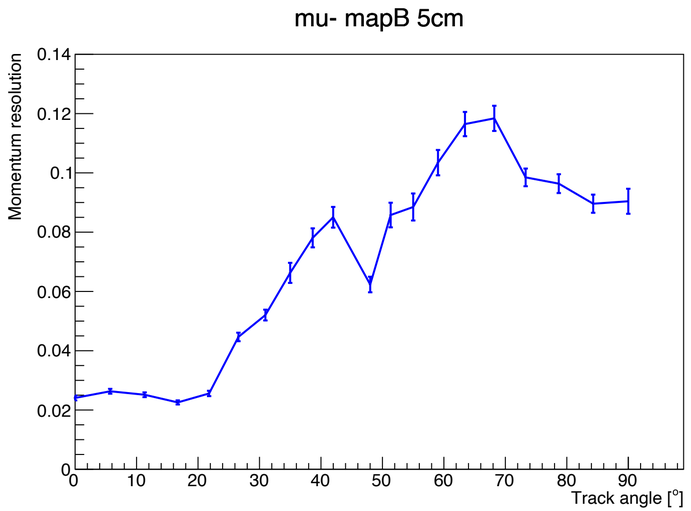
- Magnetic field map shifts the track positions, and make them look as if they were curved (they are in reality almost not curved since they are 100GeV).
- This effect impacts more vertical tracks than horizontal tracks and the effects are opposite, (which is exactly the same as the momentum bias…)

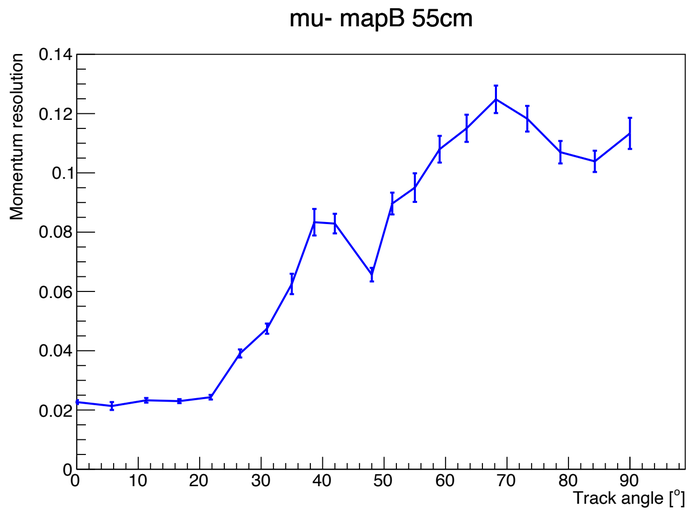
- Since this effect is increased when the drift distance is larger, I tried to study the momentum bias at different angles and drift distances, with and without B field map (i.e. with non-uniform or uniform B field)
- For this, I take 700 MeV (~800MeV/c) mu- tracks

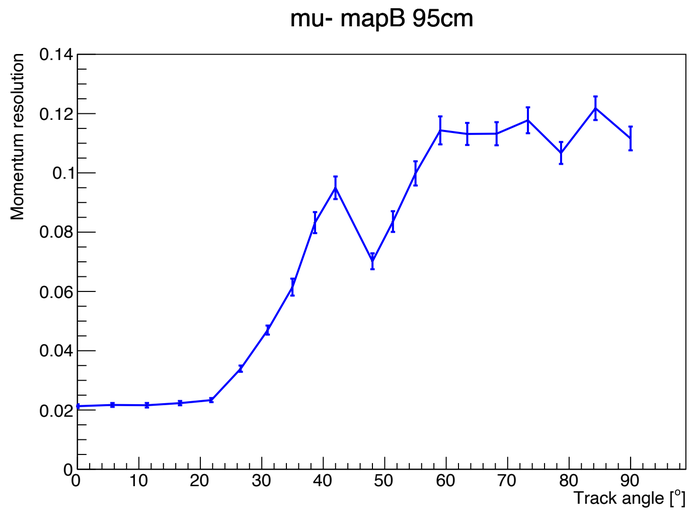
Momentum resolution Non-uniform B field, at 5cm, 55cm and 95cm of drift

- For this, I take sets of 1000 tracks of 700 MeV (~800MeV/c) mu-

Same behavior, almost no degradation with the drift distance



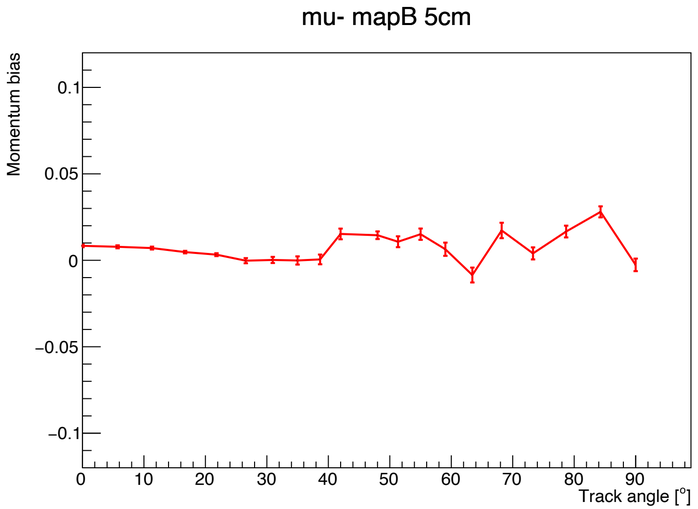


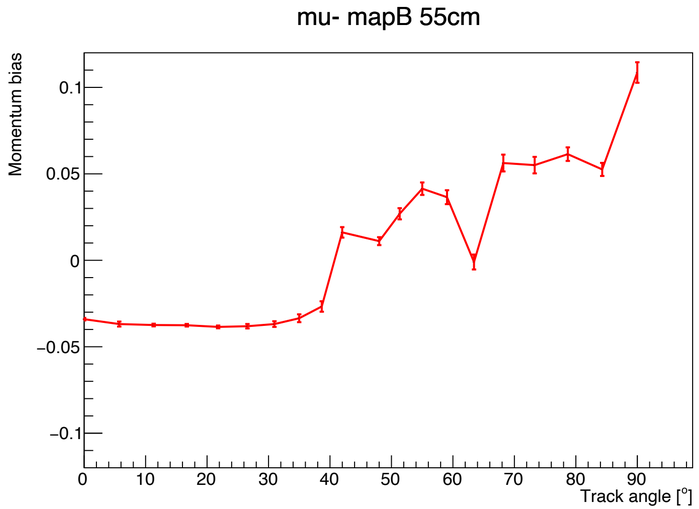


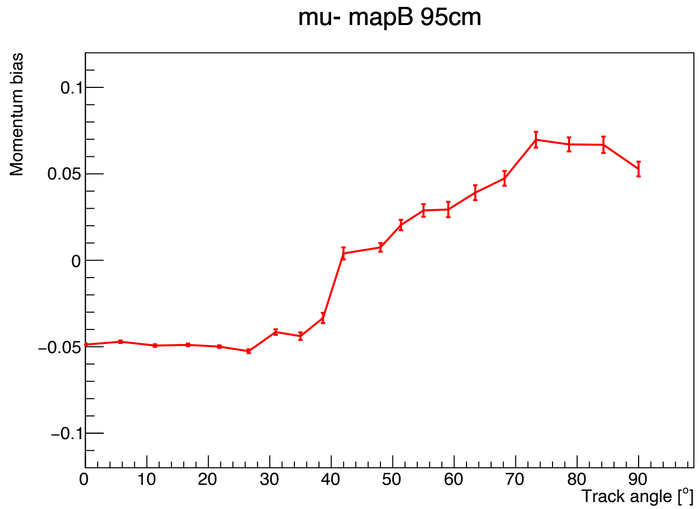
Momentum bias Non-uniform B field, at 5cm, 55cm and 95cm of drift

- For this, I take sets of 1000 tracks of 700 MeV (~800MeV/c) mu-

Almost no bias for low drift but bias appears when going to larger drift distance



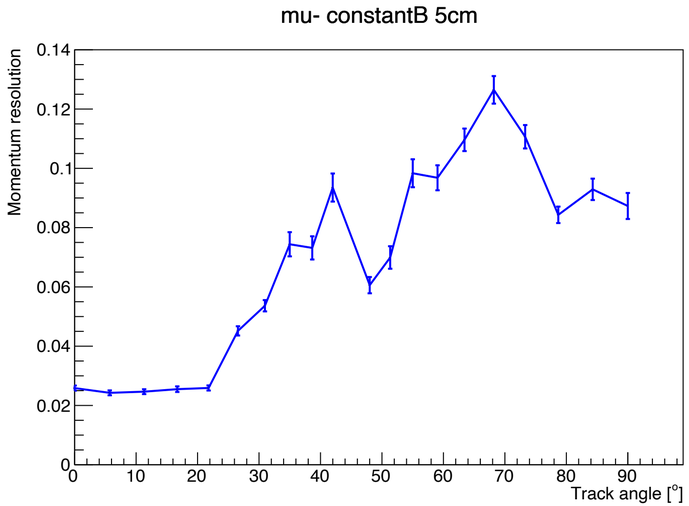


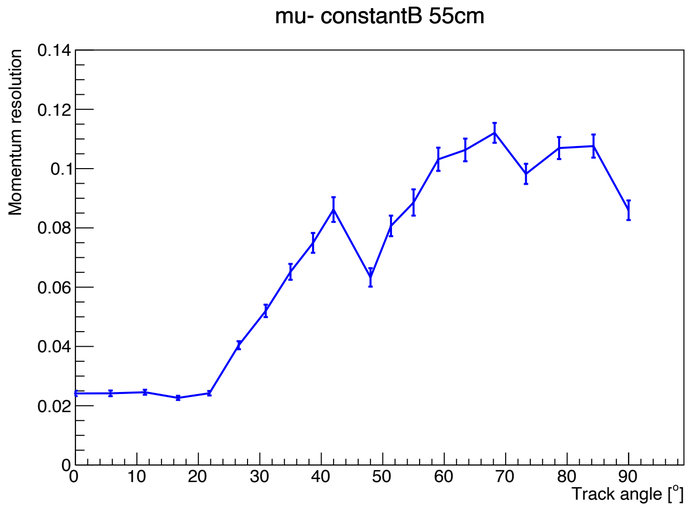


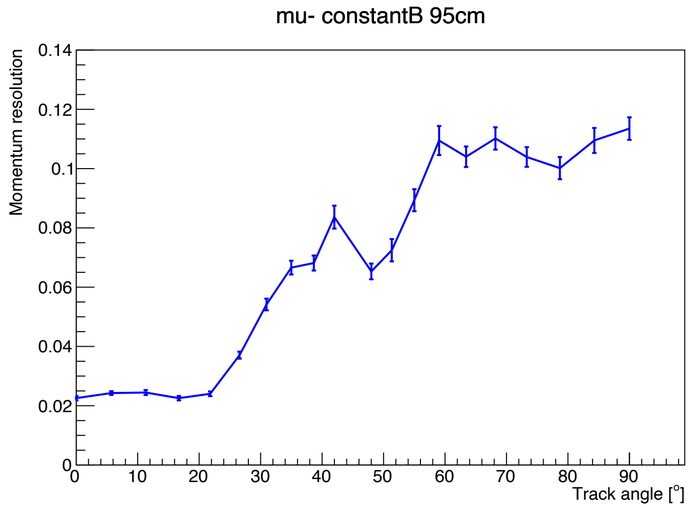
Momentum resolution Uniform B field, at 5cm, 55cm and 95cm of drift

- For this, I take sets of 1000 tracks of 700 MeV (~800MeV/c) mu-

Same behavior, almost no degradation with the drift distance



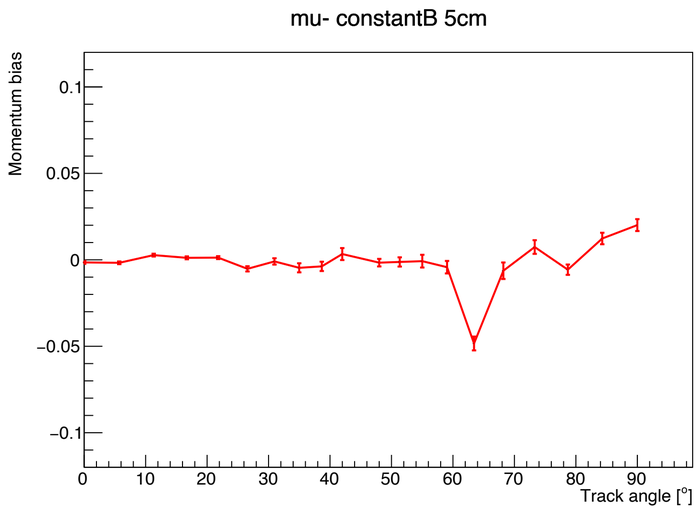


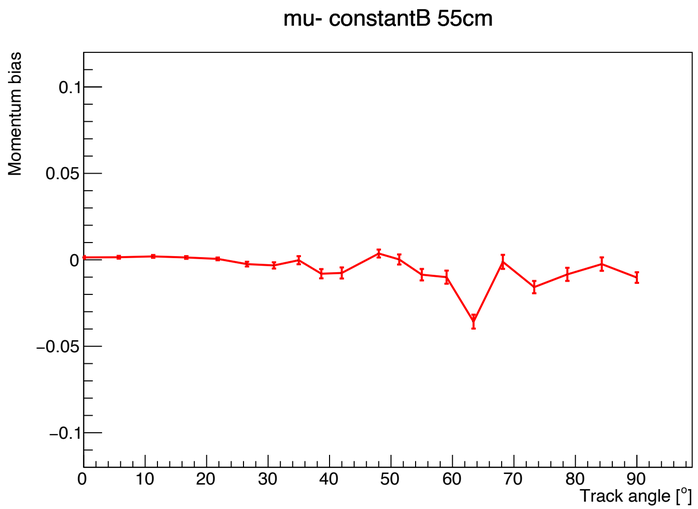


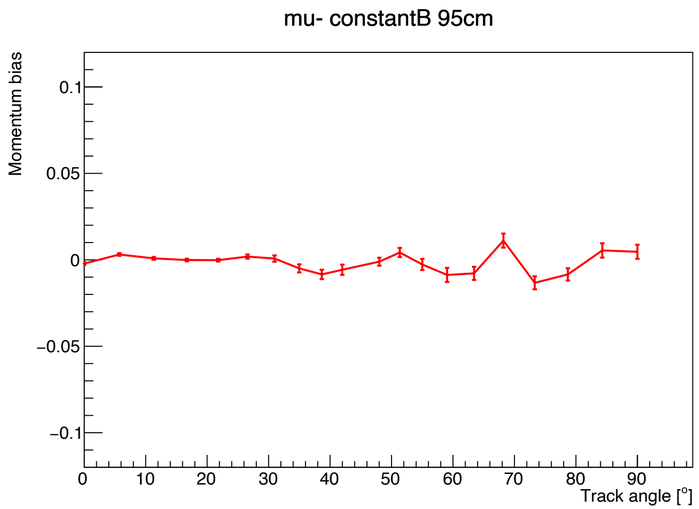
Momentum bias Uniform B field, at 5cm, 55cm and 95cm of drift

- For this, I take sets of 1000 tracks of 700 MeV (~800MeV/c) mu-

Bias cancelled, even when going to larger drift distance!

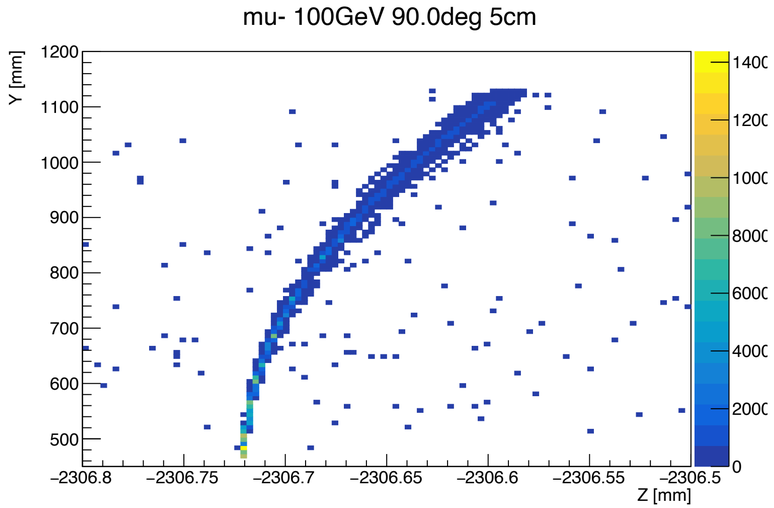


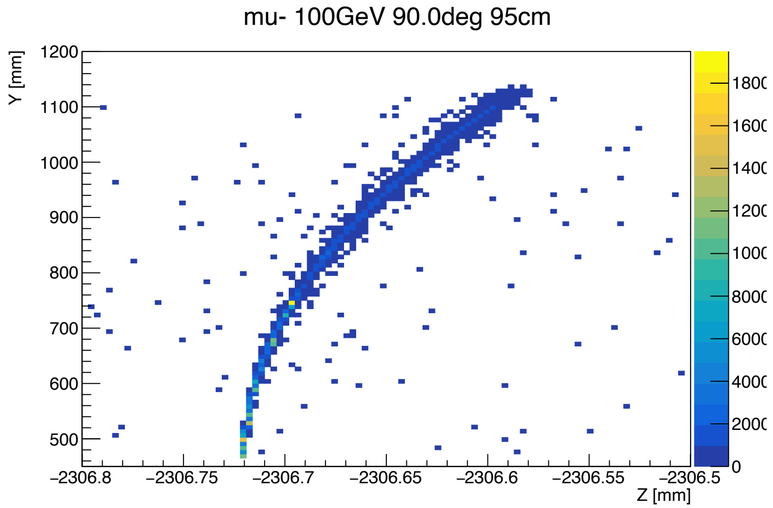




Additional test: TG4HitSegment

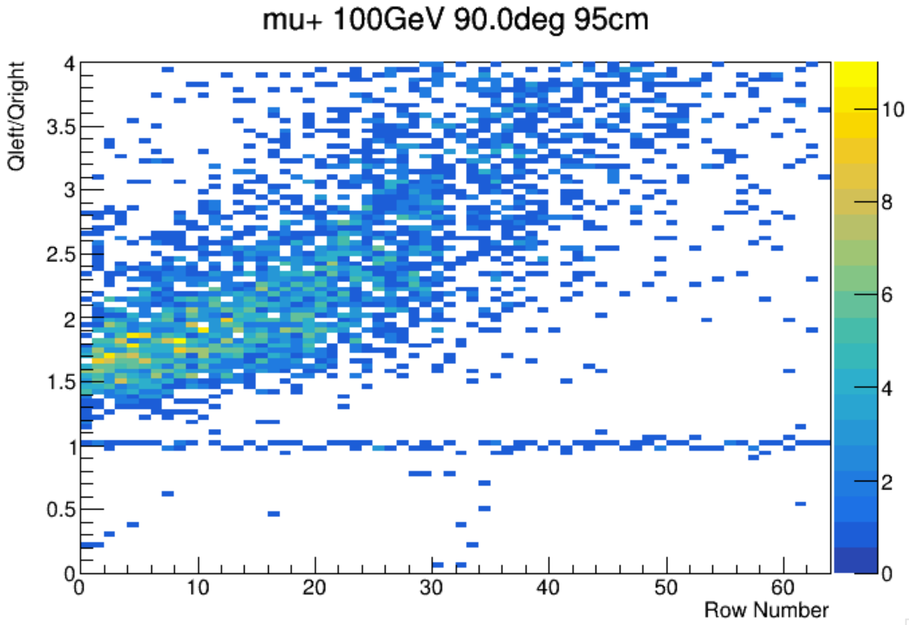
Sets of 100 GeV vertical (90°) mu- tracks, at different drift distances
We look at the position given by the TG4HitSegment, to see if the problem is coming from the Geant4 simulation itself
No shift observed, even at 95cm drift distance, so problem is coming later…





Additional test: removing diffusion

- One additional test I’ve done is to suppress the diffusion (by putting LongDiff and TranDiff to 0), and check again the Qleft/Qright ratio.
- As shown here, this was not succesful. But this is coherent since we don’t observe shift when not taking B field map



Conclusion, next steps

- Momentum bias seems to be clearly due to the magnetic field map non-uniformities
- For short drift distances, the effect is small and we observe a small bias
- We observe opposite effects for vertical and horizontal tracks and we observe opposite momentum bias for those 2 topologies of tracks
- The good news is that there’s almost no bias when taking uniform magnetic field so the problem doesn’t come from the fit but really when applying the magnetic field map!
- Non-uniformities in the B field are to small to explain the position shifts we observe, and Pierre Billoir didn’t observe those shifts when using Runge-Kutta method to simulate the tracks
- Next step is to show those results to the people involved in detResponseSim software in order to try to see where this problem could come from