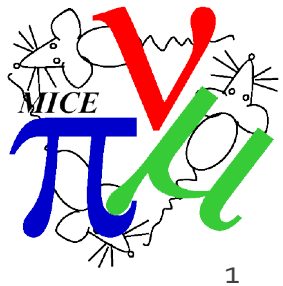
Introduction

- Aim to answer whether we can tell the difference between forward polarized and backward polarized muons via their decay electrons energy spectrum (EMR)
- Looking at:
  - Depolarization of beam - Muon spin changes as it traverses the cooling channel due to presence of electric and magnetic fields and scattering effects
  - Effects of polarization of muon beam on the number of decay electrons seen
- The muon spin vector in the rest frame evolves in electric and magnetic fields according to the Thomas-BMT equation in GEANT 4 : G4EqEMFieldWithSpin :

$$\frac{d\vec{s}}{dz} = -\frac{e}{p_z}\,\vec{\Omega}\times\vec{s}$$

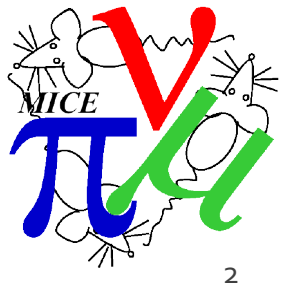
- Where:

$$\vec{\Omega} = (a\gamma + 1)\,\vec{B} - a(\gamma - 1)(\hat{v}\cdot\vec{B})\,\hat{v} + \gamma\left(a + \frac{1}{\gamma + 1}\right)\vec{E}\times\beta$$



Spin Tracking in MAUS

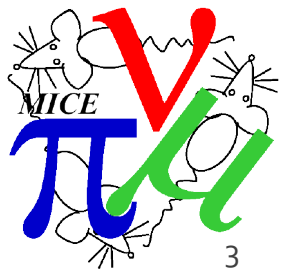
- Each muon in beam needs a normalized spin three vector (sx, sy, sz) in the muon rest frame – these have been added to the primary and virtual hit definitions
- Spin evolution calculated using GEANT4
- Option added in detector construction to allow spin tracking to be turned on in datacards by adding line "StepperType =SpinTrack"
- Integration tests carried out to ensure that spin is correct i.e that there is some difference between initial and final spin in presence of B field
- Changed the MAUS physics list to use G4DecayWithSpin- added option in datacard to turn polarized muon decays on/off



Simulating in MICE

- Ran MC of beam of muons through SpecialVirtual SensitiveDetector and a simple block of plastic for three cases:
  - "unpolarised beam"
  - "forward polarised beam" (sx, sy, sz) ~ (0, 0, +1)
  - "backward polarised beam" (sx, sy, sz) ~ (0, 0, -1)

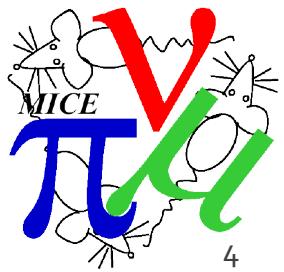
- Look at angular distribution of decay electrons in each case- can we tell the difference between those from foreward/backward polarized muon beams ?



Checks:

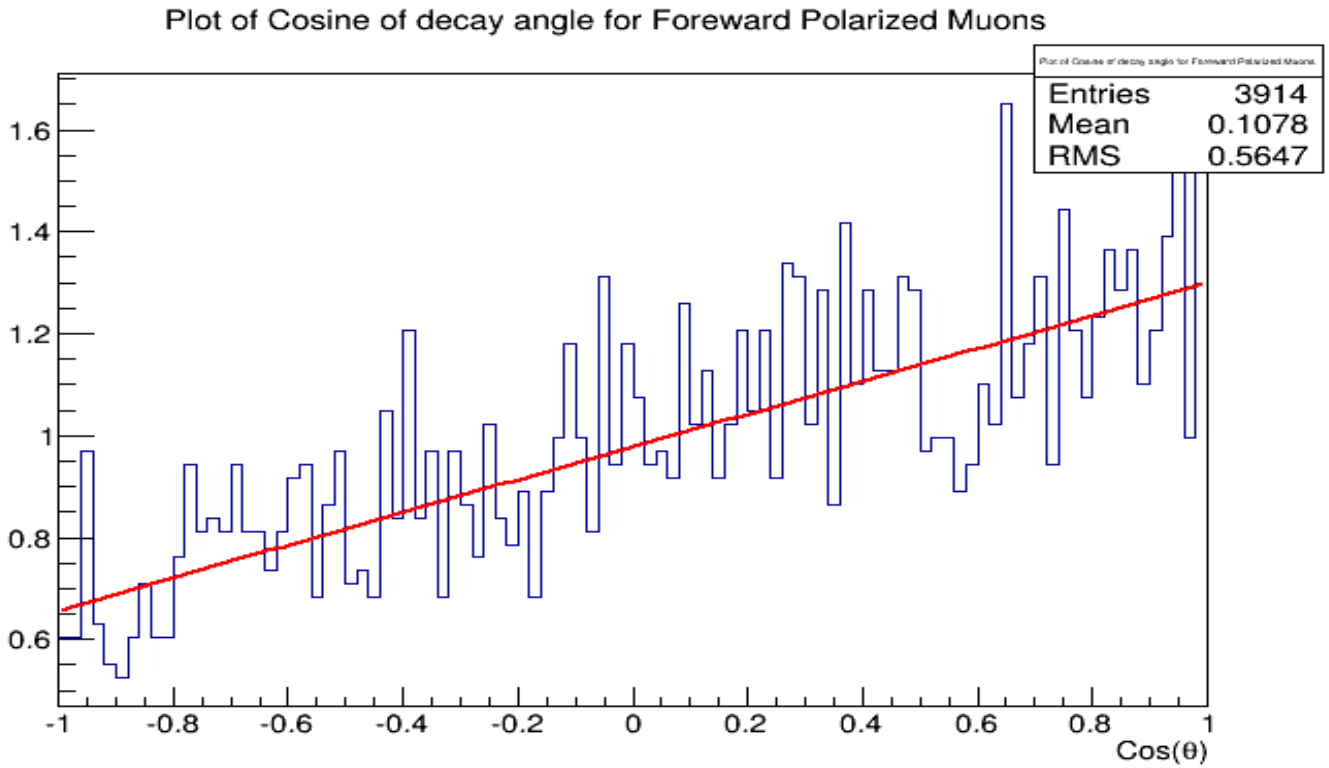
- Is this in the muon rest frame?
  - If the decay occurred in the muon rest frame the decay angle in all three beam types would be the same

- Does it have the right decay shape?
  - For muon : $$\frac{d\Gamma}{d\cos\theta} \sim 1 + \frac{1}{3} P_\mu \cos\theta.$$
  - Where the angle between the muon spin and the momentum vector of electron/positron is θ, and the muon polarization is Pμ, minus (positive) sign for negative (positive) muons
  - P = +1 (foreward), 0 (flat), -1 (backward)



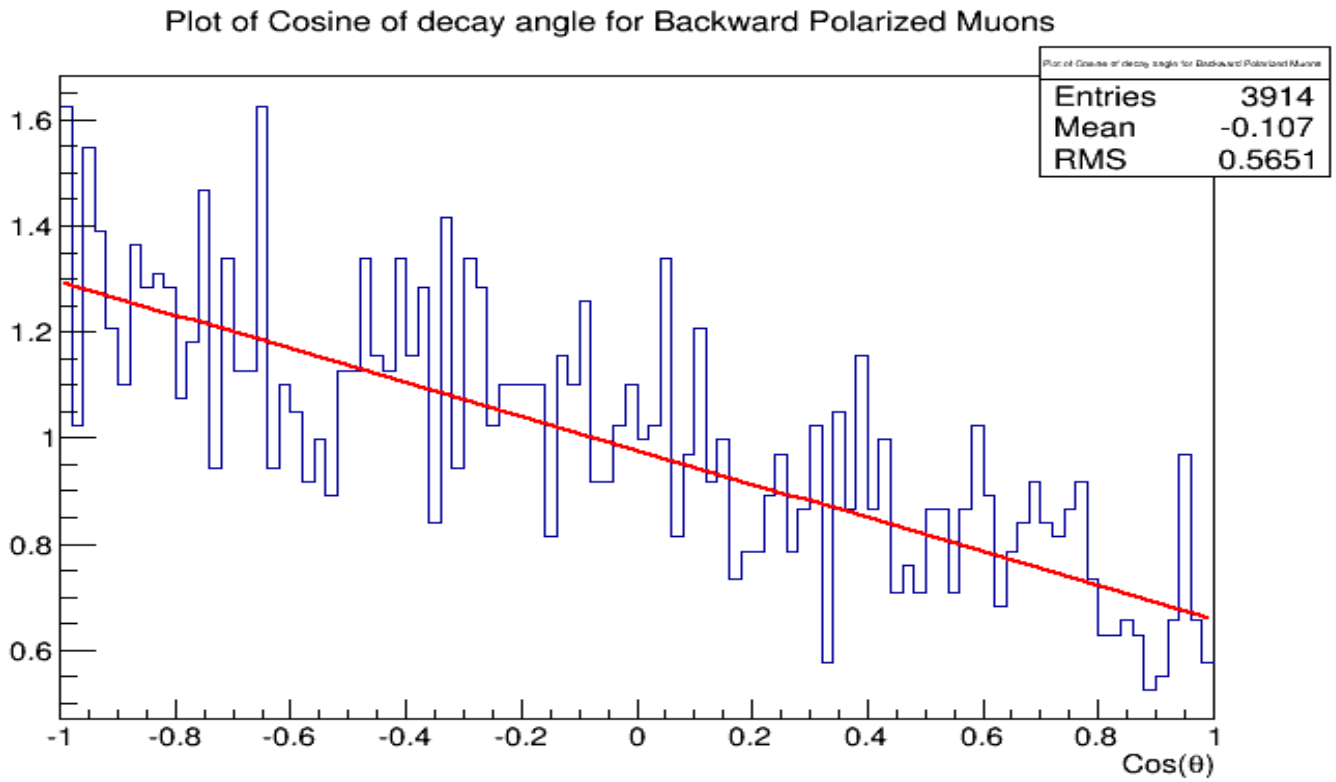
Cos Theta: Foreward

- Gradient = 0.976±0.098

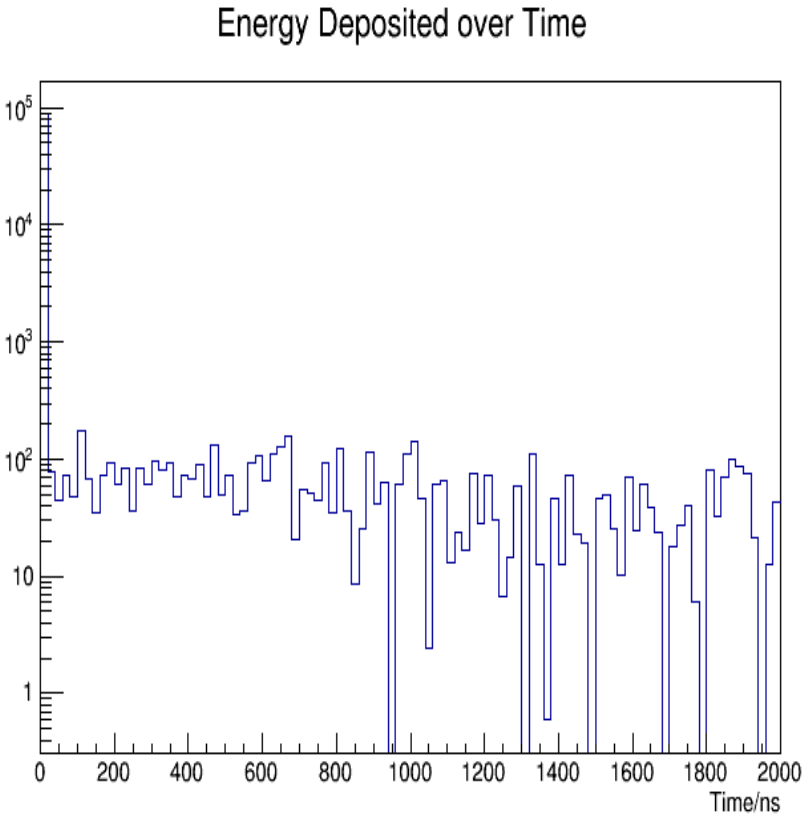


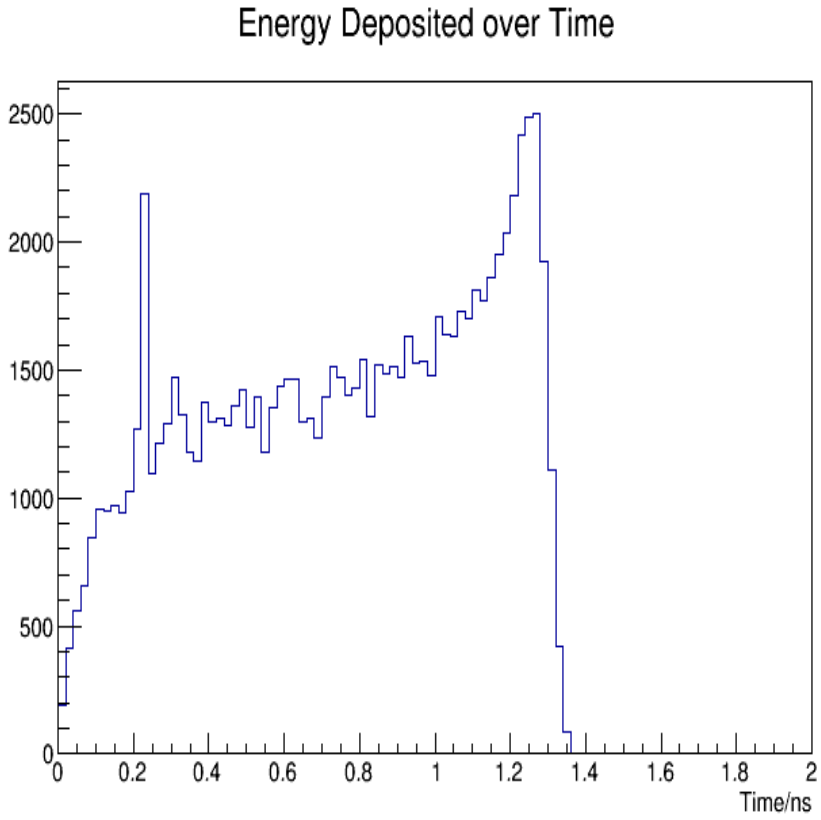
Cos Theta: Backward

- Gradient = -0.976 ± 0.098



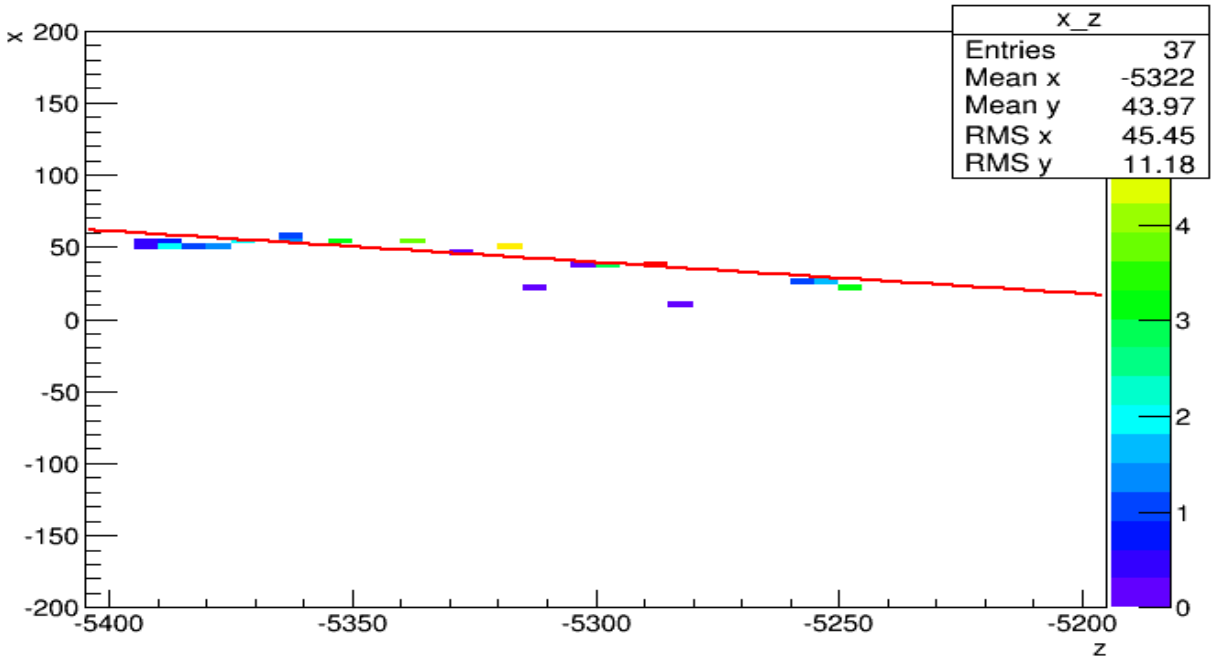
Energy Deposited





Energy Dep in x and z

- Can look at individual positron tracks which have originated from decaying muon
- Can find angle between these tracks and beam optical axis (taken as z-axis)
- Done by fitting straight line to single track (gradient = tan(angle))



Conclusions

- Sources of Error:
  - What if muon falls off the edge of detector?
  - What if decay electron does same?
  - Mis-identification ?

- What's Next?- Recon, data?