Muon Track Reconstruction in the Scintillator Phase of SNO+

Jasmine Simms
On behalf of the SNO+ collaboration

UNIVERSITY OF OXFORD

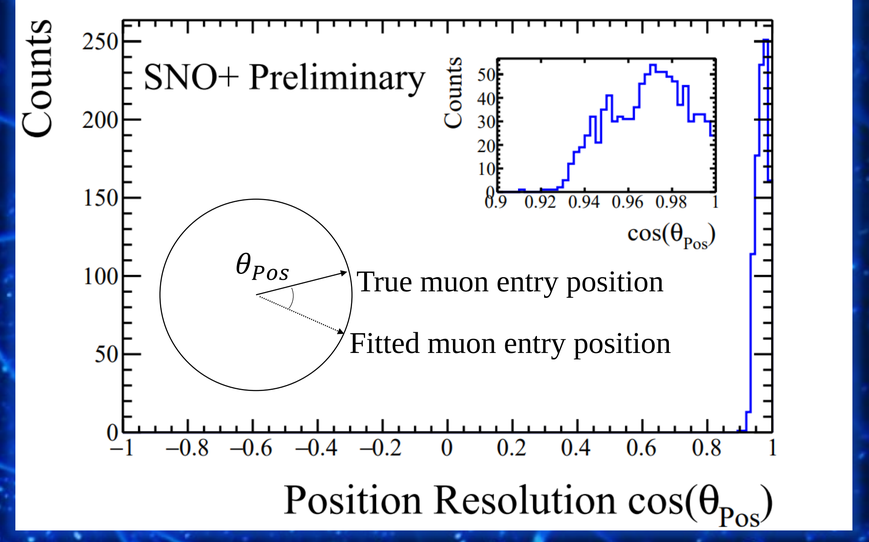
Muons in SNO+

- 3 muons per hour, on average, pass through the SNO+ detector
- High energy muons induce backgrounds which can affect multiple physics analyses
- Reconstructing the muon track would allow for improved rejection of induced backgrounds

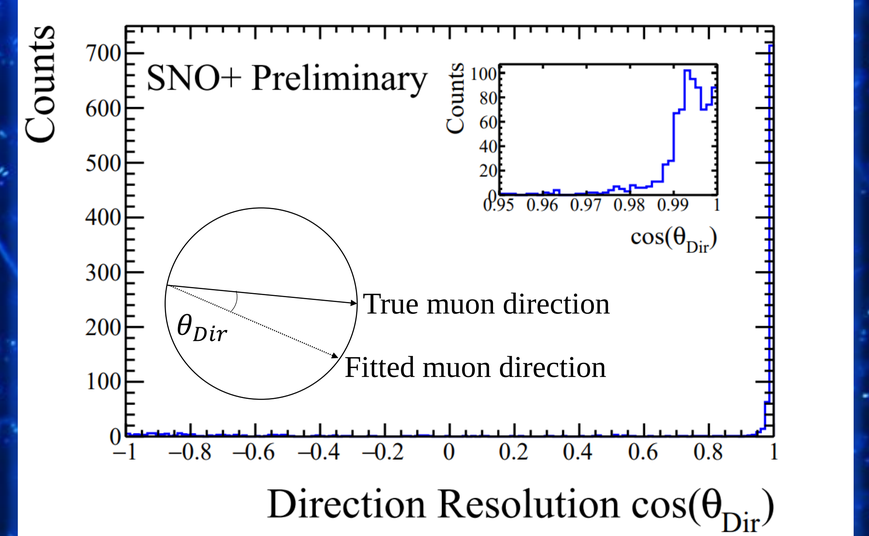
Results

- Angular entry position resolution = 15°
- Angular direction resolution = 7°
- Angular resolution is much better for muons that travel through a larger detector volume
- Muons that graze the edge of the detector have poor reconstruction

Position Resolution



Direction Resolution

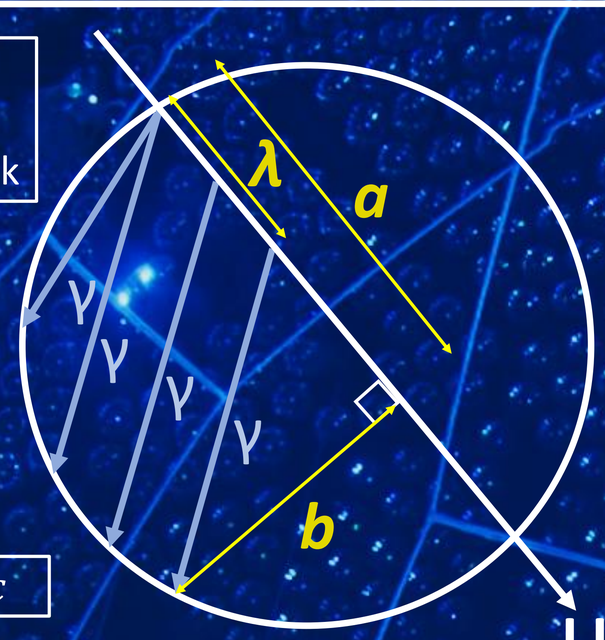


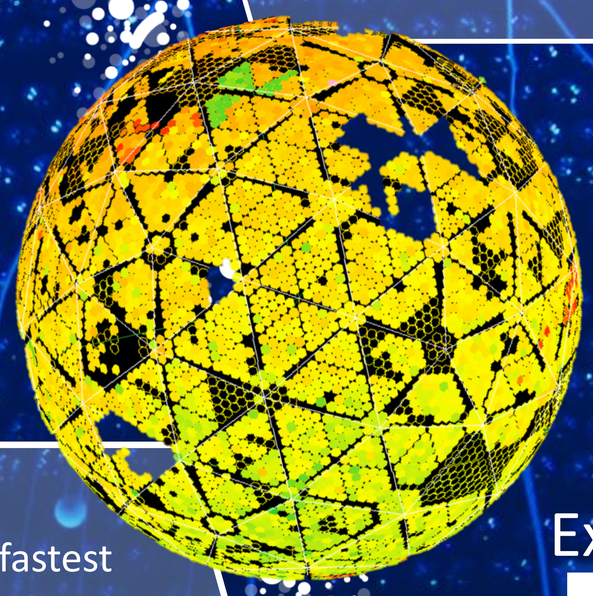
Scintillator photons created along muon track

Fastest paths for a photon to hit each PMT shown in blue

Muon speed $\approx c$

Scintillator photon speed $= c/n$





Reconstruction Method

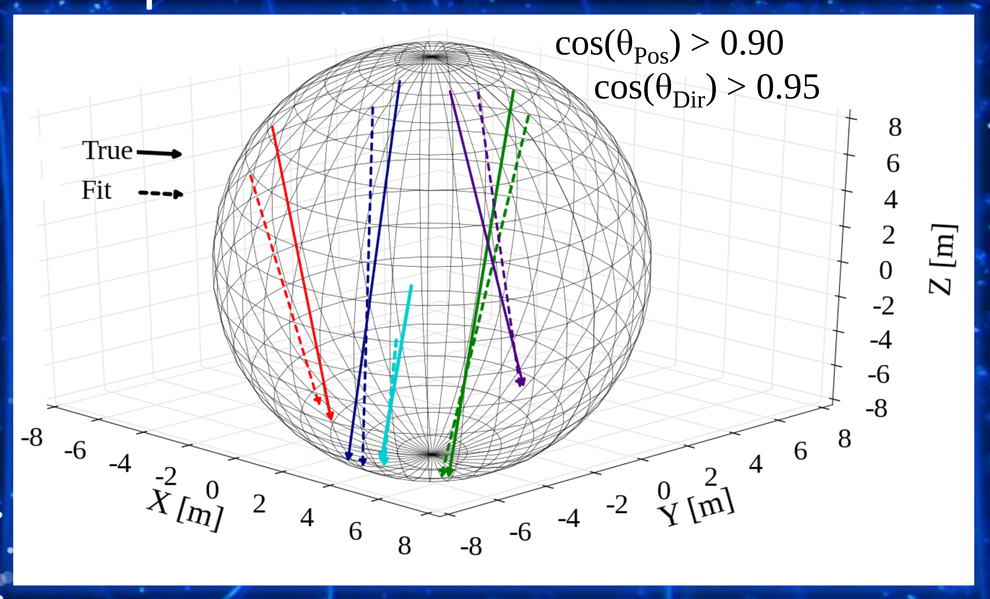
- Assume each PMT is hit by a photon that took the fastest possible path through the detector
- The time residual for each PMT is calculated using a guess of the muon entry position and direction

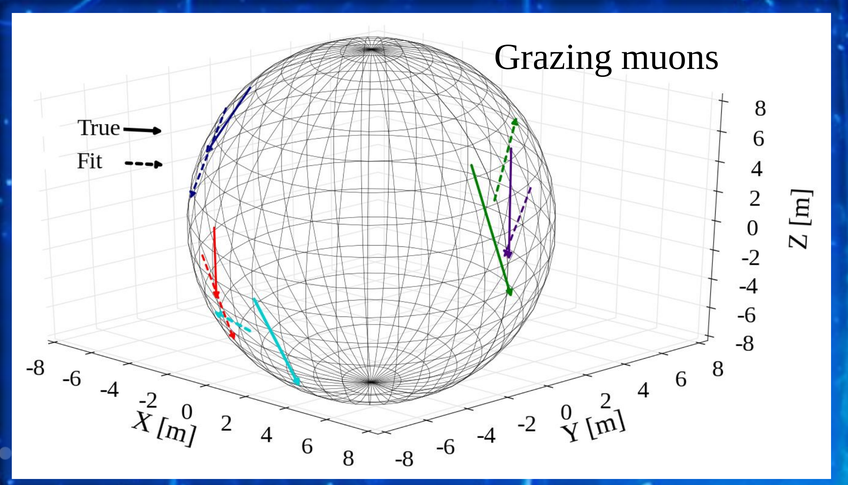
$$T_{residual} = t_{hit} - \frac{n}{c}\sqrt{b^2 + (a-\lambda)^2}$$

n = Scintillator refractive index t_{hit} = Time the PMT was hit

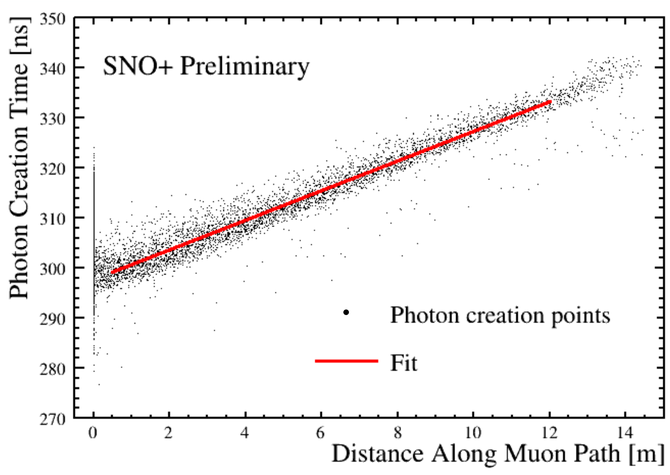
- λ is the distance along the muon path the photon is created
- $T_{residual}$ is the time the photon was created
- Plotting $T_{residual}$ as a function of λ gives the distance time graph of the muon as shown below

Example Muon Track Reconstruction



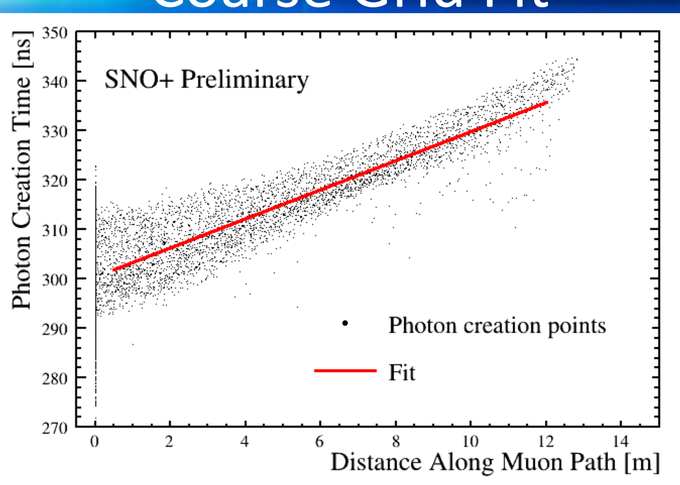


True

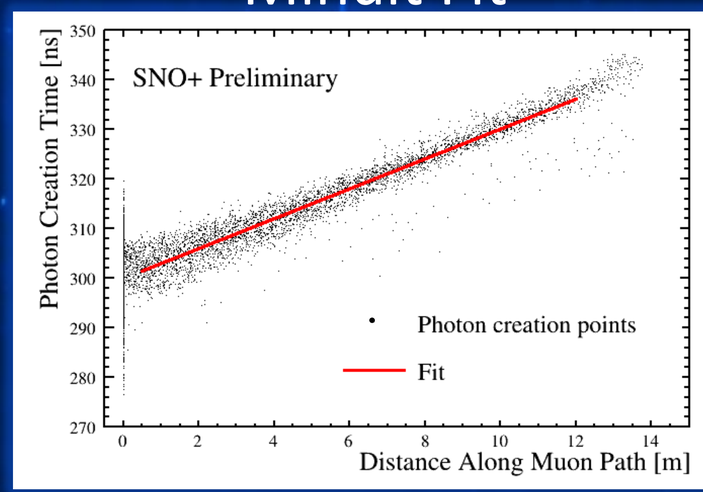


- Entry position and direction are found by minimising the variance of this graph
- Entry positions and directions are trialled using a grid search followed by Minuit optimiser
- The graphs show the true, grid fit and Minuit fit results for muon entry position and direction

Coarse Grid Fit



Minuit Fit



Further Work

- The water phase of SNO+ has an angular resolution of 2° for entry position and direction
- Further work is needed to improve the minimisation of the variance which will improve the angular resolution of the scintillator phase