Search for a Directional Cherenkov Signal from ^{208}Tl Decays in the SNO+ Detector

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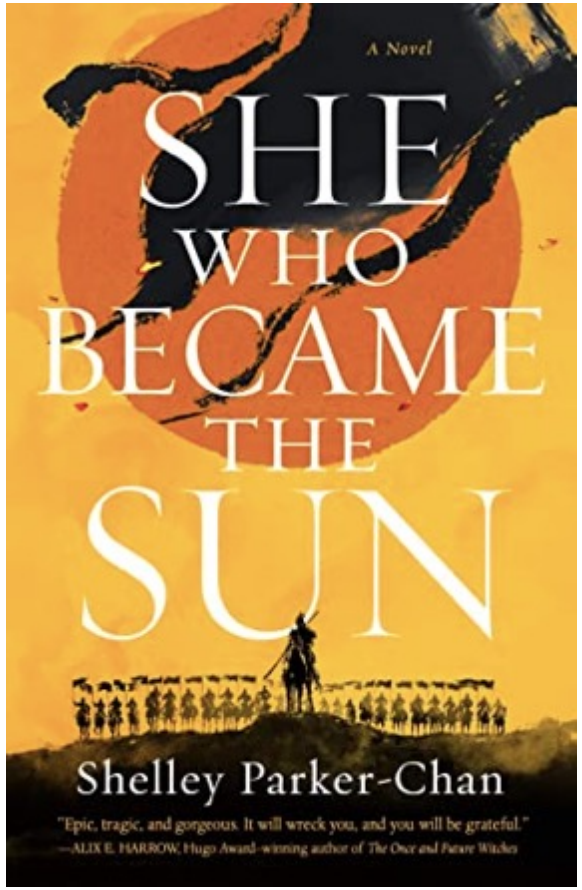
SNO+

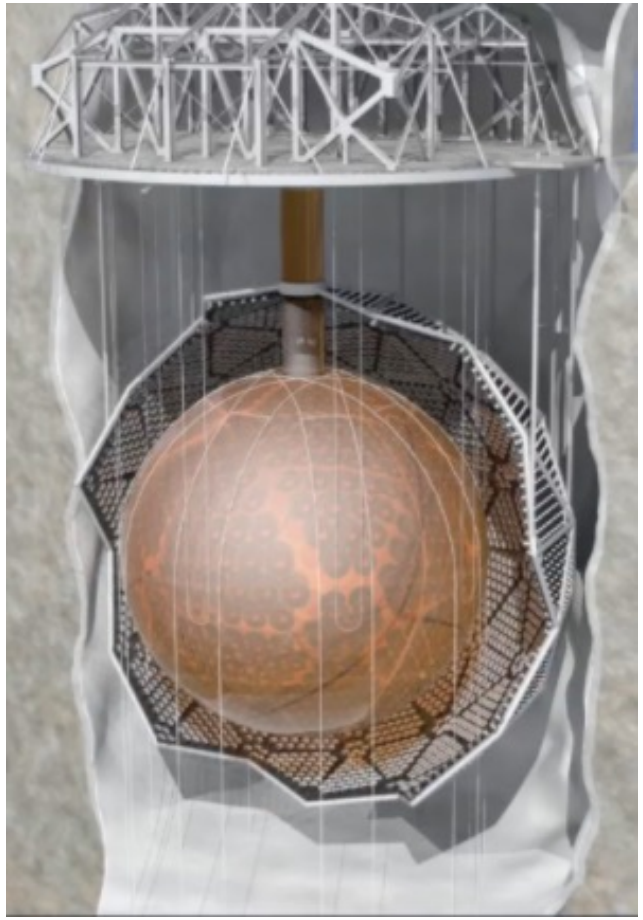
The Canadian Astroparticle Summer Student Talk Competition

About Me


A Novel
SHE WHO BECAME THE SUN
Shelley Parker-Chan
"Epic, tragic, and gorgeous. It will wreck you, and you will be grateful."
—ALIX E. HARROW, Hugo Award–winning author of The Once and Future Witches

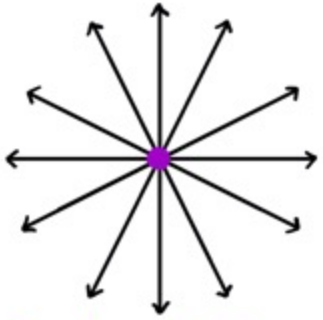
The SNO+ Experiment

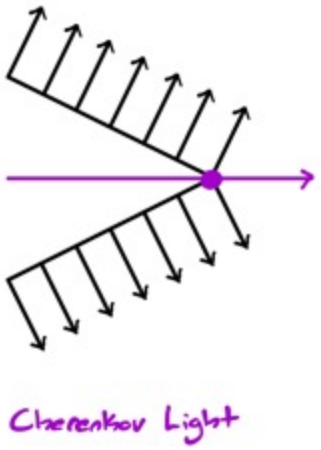
- Liquid scintillator neutrino detector
- Located 2 km underground at SNOLAB
- Target of 800 tonnes of organic liquid scintillator
- Light is detected by ~9400 photomultiplier tubes (PMTs)
- The acrylic vessel, PMTs and PMT support structure are inherited from SNO



Cherenkov Light and Scintillation Light

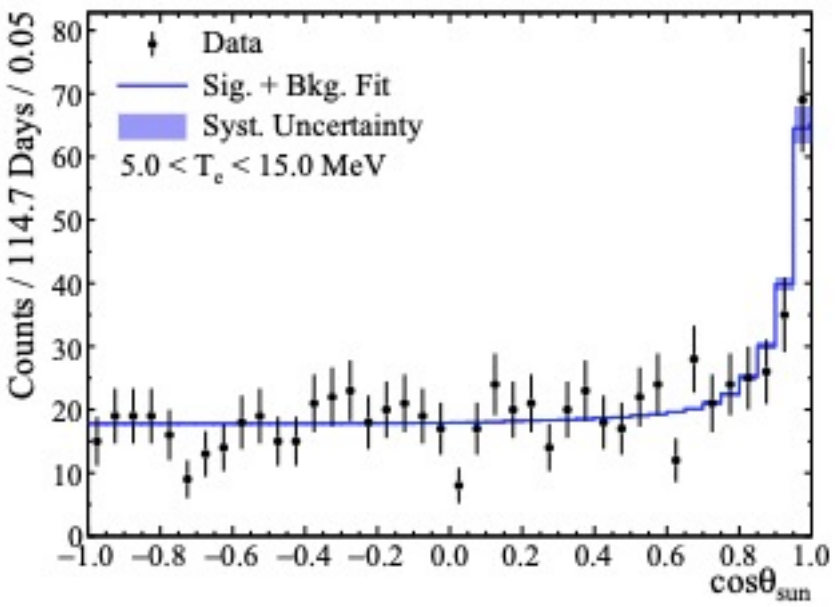
- Cherenkov radiation is generated by charged particles travelling through a medium faster than the speed of light in the medium
- Scintillation light is created by charged particles passing through scintillator
- Cherenkov light contains information about the direction of the charged particle, scintillation light does not
- Cherenkov light is emitted more promptly than scintillation light





Cherenkov and Scintillation Light in SNO and SNO+

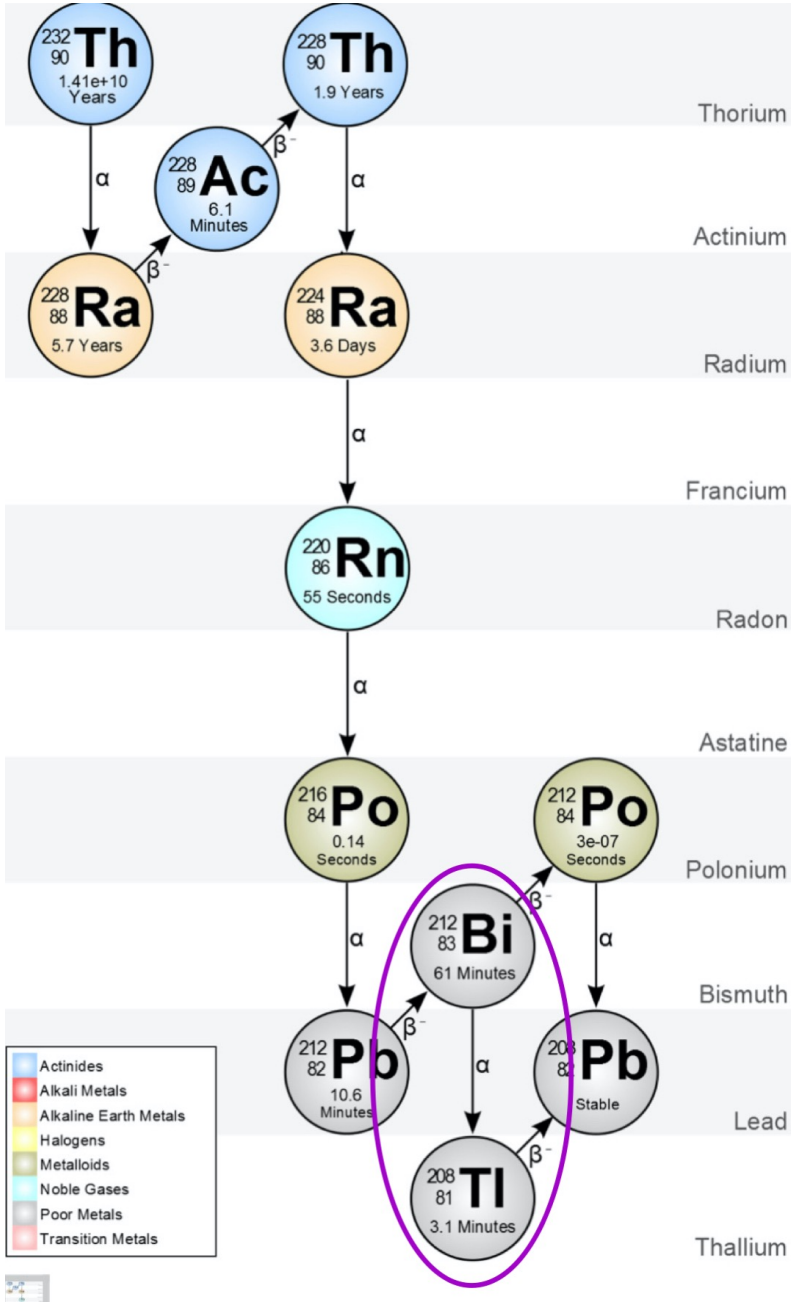
- The signal in the SNO experiment was Cherenkov light
- The signal in the SNO+ experiment consists of both scintillation light and Cherenkov light
- The isotropic scintillation light dominates the signal in SNO+
- Because Cherenkov light is directional it is desirable to separate the Cherenkov and scintillation light
- A signal with a known particle direction is required to identify Cherenkov light



Distribution of event direction with respect to solar direction during the SNO+ water phase. Cherenkov light was used to separate the signal from the backgrounds.

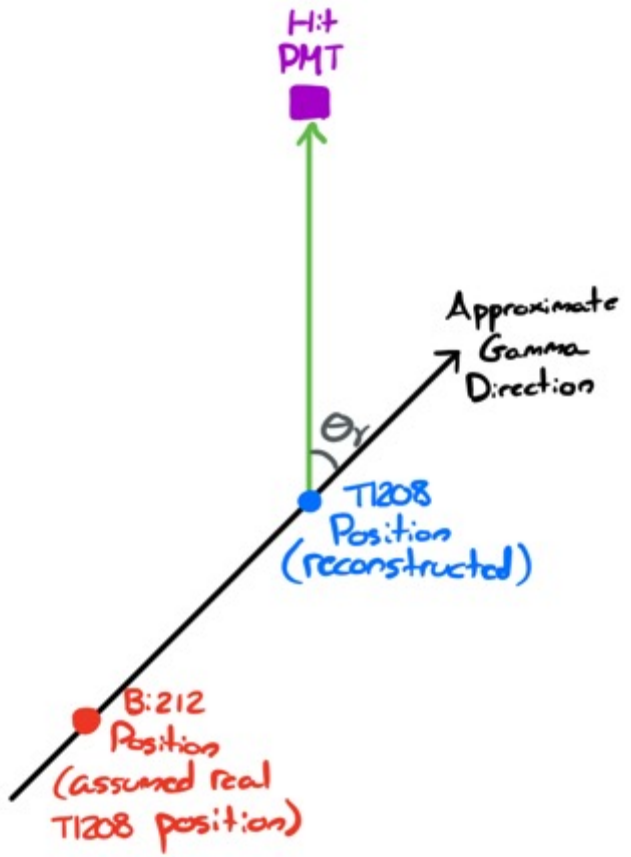
Thallium-208 Decays

- This analysis uses ^{208}Tl decays
- ^{208}Tl is part of the Thorium decay chain
- ^{212}Bi precedes ^{208}Tl in the decay chain
- ^{208}Tl has a half life of 3.1 minutes
- ^{208}Tl is a background in the SNO+ detector
- ^{208}Tl releases a 2.615 MeV gamma during decay

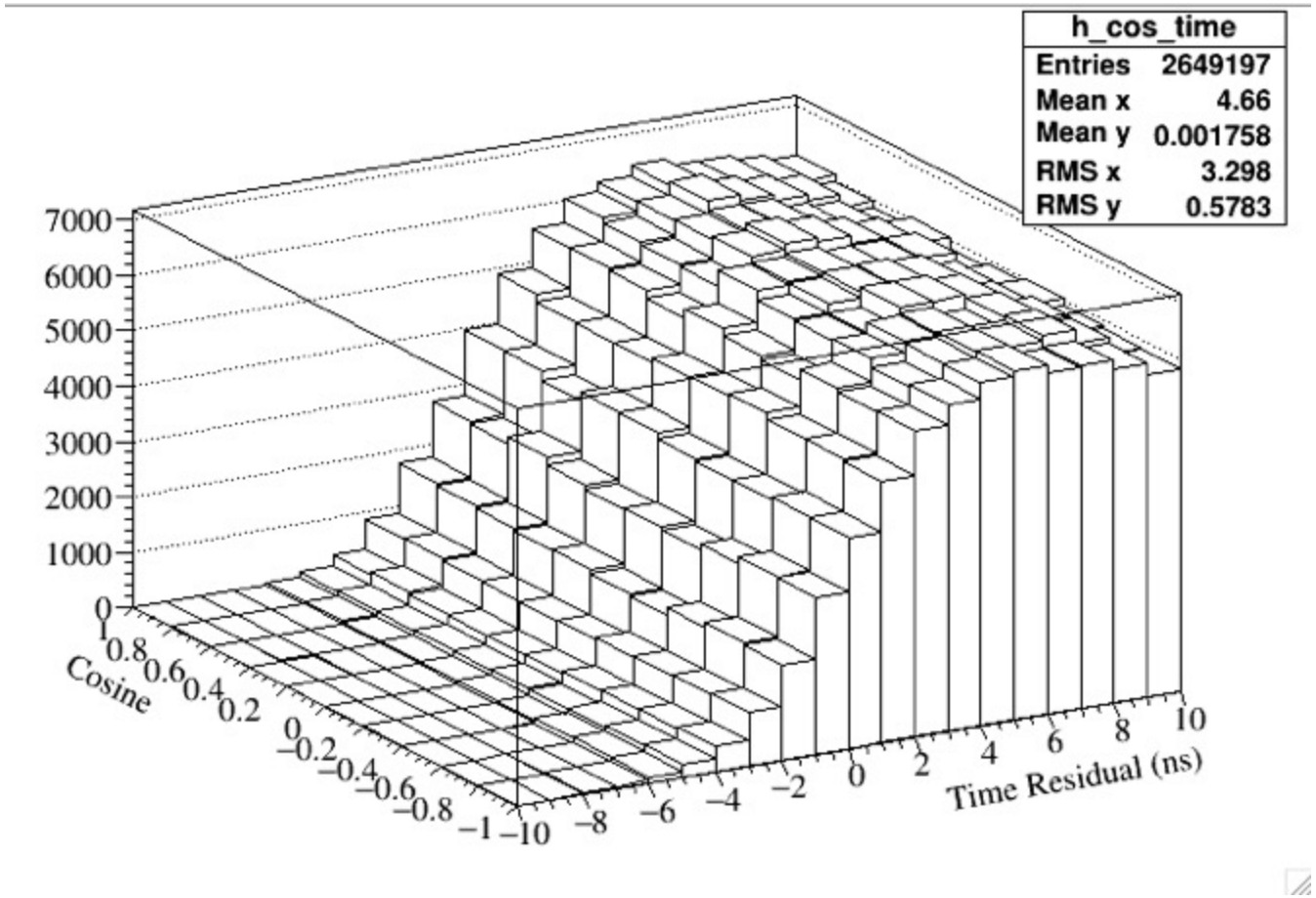


Method

- My analysis looks at the cosine of θ_γ
- The vector from the true to reconstructed ^{208}Tl position approximates the direction of the high energy gamma
- The ^{212}Bi position approximates the true ^{208}Tl position
- The vector from ^{208}Tl decay to the PMT is approximately the photon direction

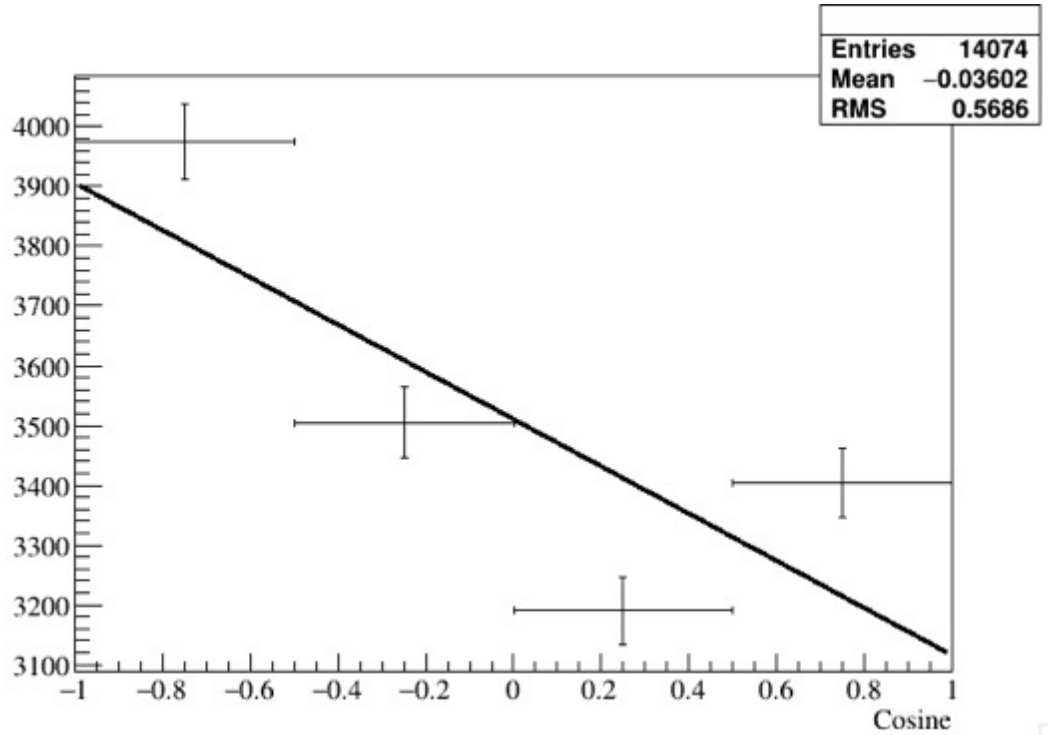


Angular Distribution of PMT hits

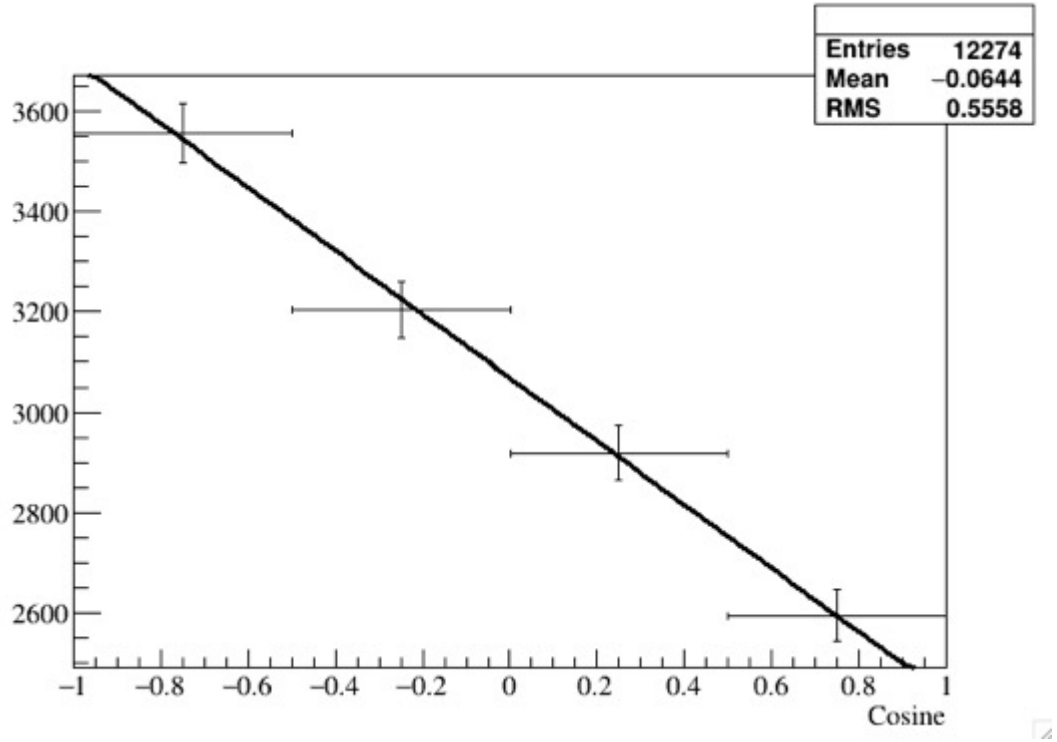


Angular distribution of hits as a function of time residual for 10000 simulated ^{212}Bi-^{208}Tl pairs.

Effect of Cherenkov Light on the Early Hit Time Angular Distribution in Monte Carlo Simulations

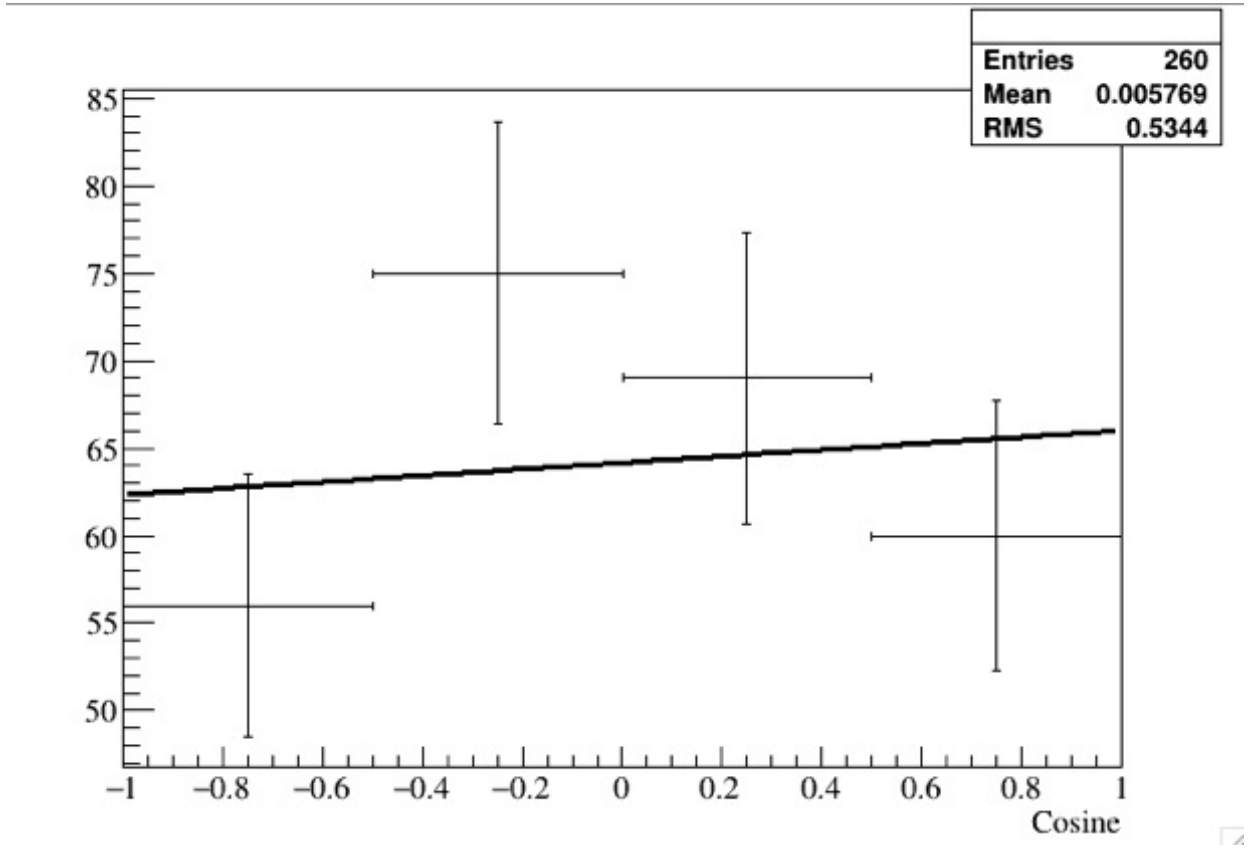


Angular distribution of hits with time residuals between -5 ns and -2 ns and Cherenkov light included. The angular distribution is trough shaped. Cherenkov shape factor is -1.52 +/- 0.58.



Angular distribution of hits with time residuals between -5 ns and -2 ns and Cherenkov light excluded. The angular distribution is linear. Cherenkov shape factor is 2.63 +/- 0.61.

A First Look at Data



Angular distribution of hits with time residuals between -5 ns and -2 ns of 21 ^{212}Bi-^{208}Tl pairs from the data. Unfortunately, the statistics are too low to extract a significant signal.

Conclusions and Continuing Work

- In Monte Carlo Simulations there is a significant Cherenkov signal at early hit times
- There are currently too few tagged ^{212}Bi-^{208}Tl pairs in the data to extract a statistically significant signal
- Many more ^{212}Bi-^{208}Tl pairs exist in the data
- Work is ongoing to extract a pure high statistics data set
- I'd like to thank Dr. Serena Ricetto and Dr. Alex Wright