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DISCO Experiment

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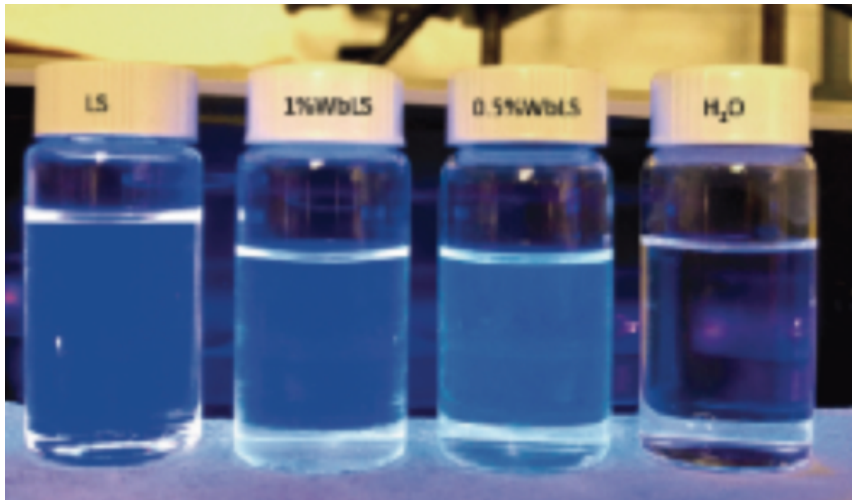
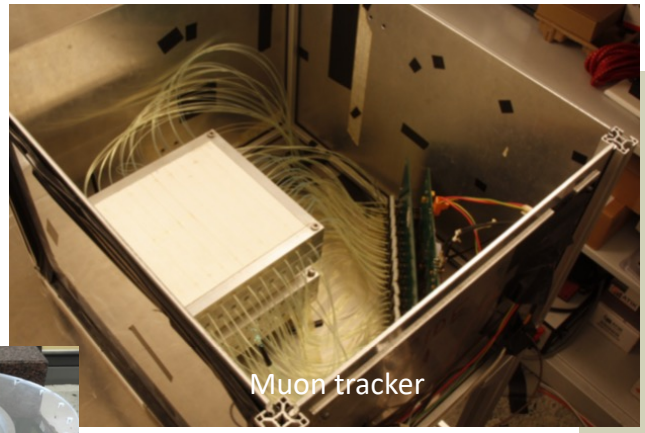
DISCO EXPERIMENT

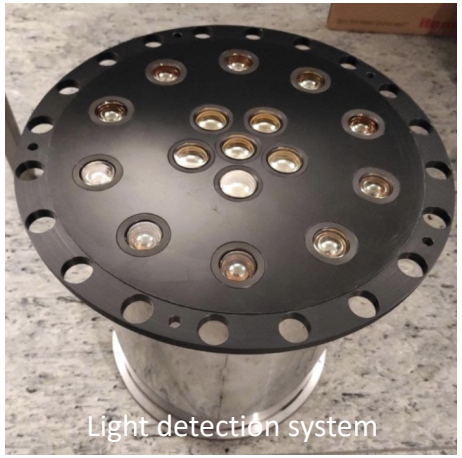
- Directionality In Scintillation Observer (DISCO) detector
  - Demonstrate the sepeartion of Cherenkov and Scintillation light
  - Charecterize Water Based Liquild Scintillators (WbLS)
- WbLS → water + scintillator
- Properties of WbLS
  - Tunable light yield and timing profile
  - Low energy threshold
  - High light yield
  - Directional information
  - Increased attenuation length

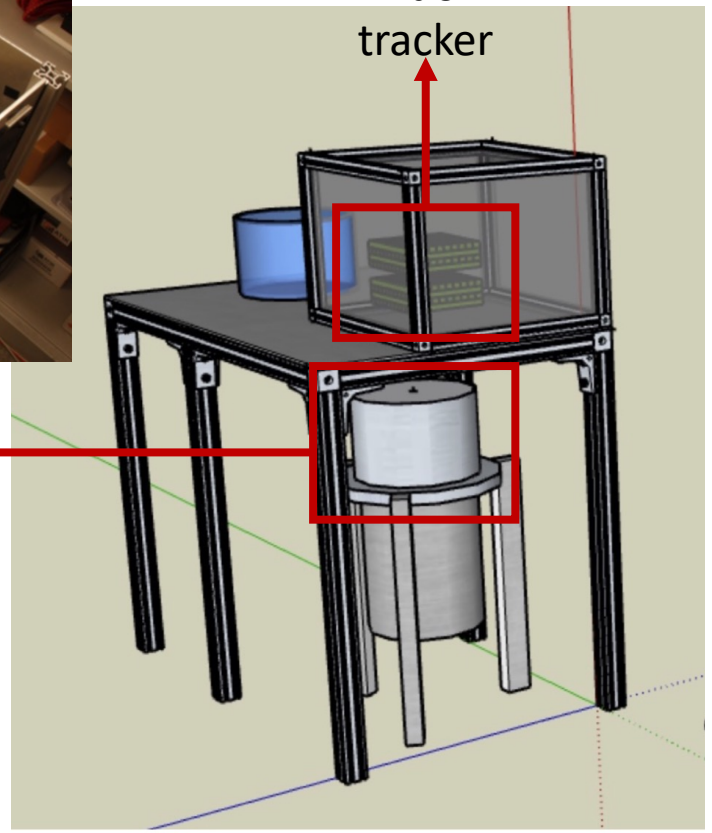


DISCO EXPERIMENT

- 3 main components:
  - Muon tracker
  - Test cell
  - Light detection system
- Test particles – muons







An illustation of the DISCO detector set-up.

DISCO EXPERIMENT: THE THREE COMPONENTS

MUON TRACKER

- Eight planes, each plane consists of eight 19 cm long scintillating rods
- Read-out using SiPMs
- Provide external trigger signal
- Reconstruct muon tracks
- Placed above the test cell

TEST CELL

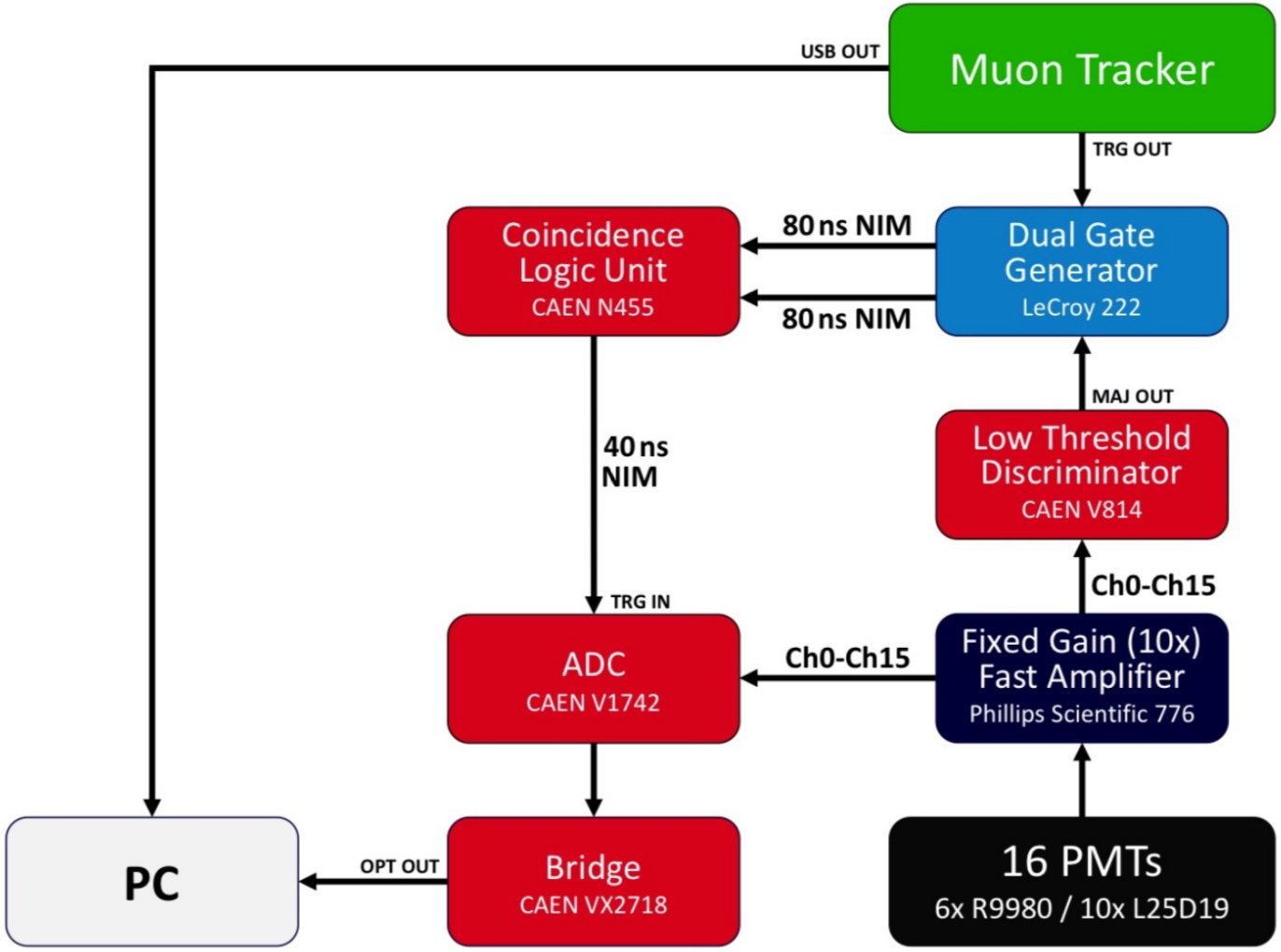
- Cylindrical steel tank enclosed with two plexiglass planes
- Detection volume ~ 14 L
- Height : 20 cm
- Diameter : 30 cm
- Can be filled with water, LS, WbLS
- Currently filled with water

LIGHT DETECTION SYSTEM

- Cherenkov photons detected using sixteen 1” PMTs placed below the test cell.
- PMTs arranged in two concentric circles of radii 40 mm and 110 mm.

DAQ

- PMT signal is amplified by a factor of 10
- External trigger:
  - Muon tracker + PMT signal
- Offline analysis → Extract hit time and charge

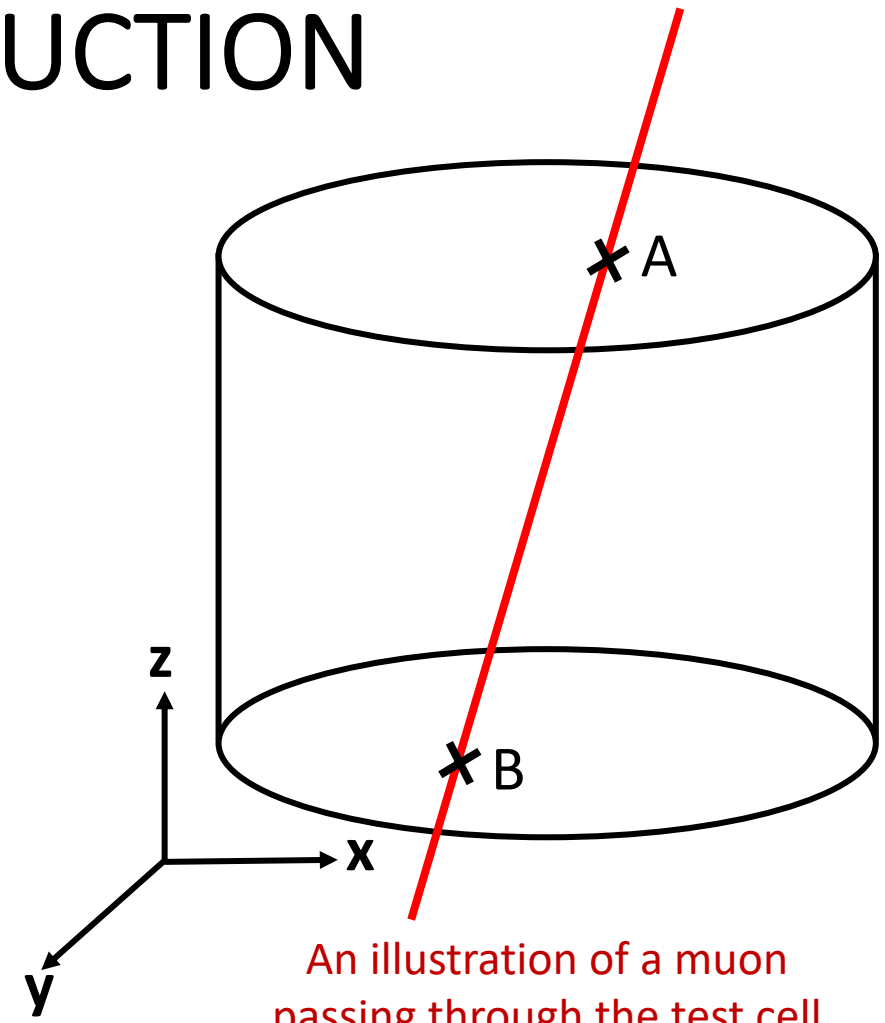


A schematic of the DAQ

TRACK RECONSTRUCTION

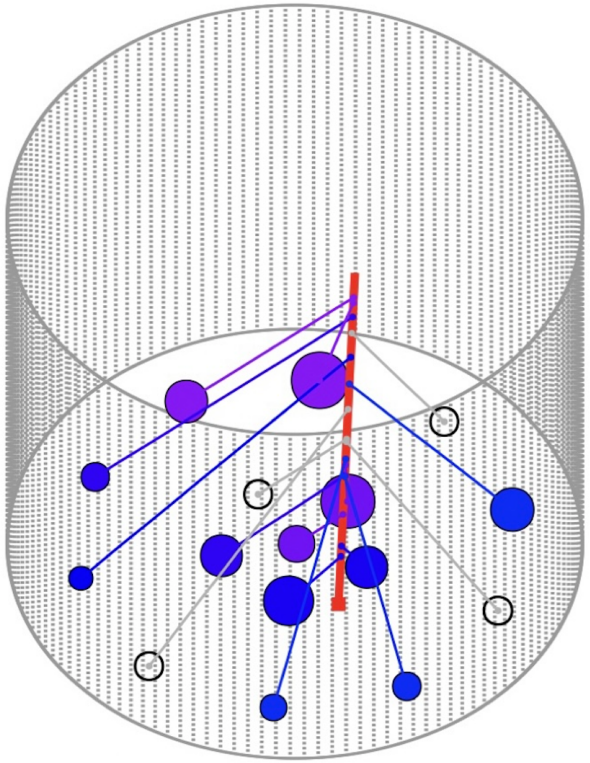
- Triggering on muons passing through the cell
- The track is described by the point at which muon enters and exits the DISCO test cell:
  - Entry point (A) – (x_1, y_1, z_1)
  - Exit point (B) – (x_2, y_2, z_2)
- Known parameters – z_1, z_2
- Unknown parameters – x_1, y_1, x_2, y_2
- Track parameters are obtained by minimizing the sum of time based chi-square and log likelihood (for charge) function:

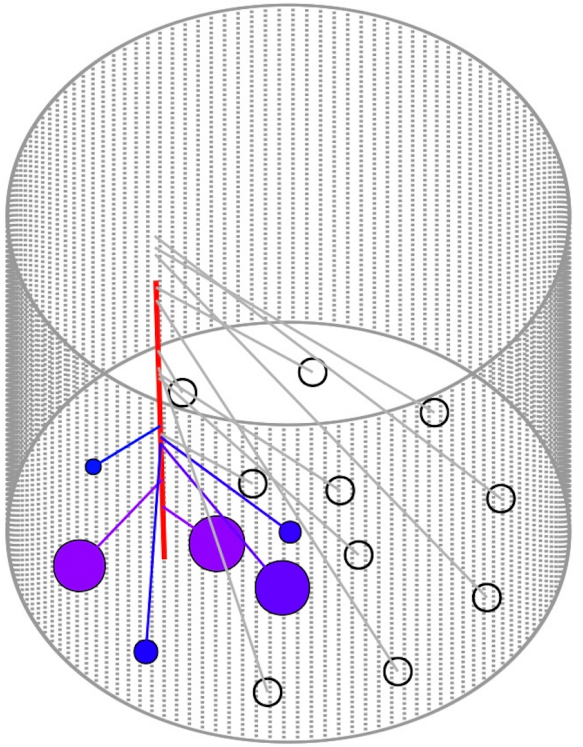
$$F = \chi_t^2 + L$$

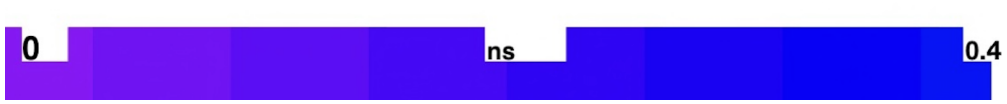


An illustration of a muon passing through the test cell

EVENT DISPLAY



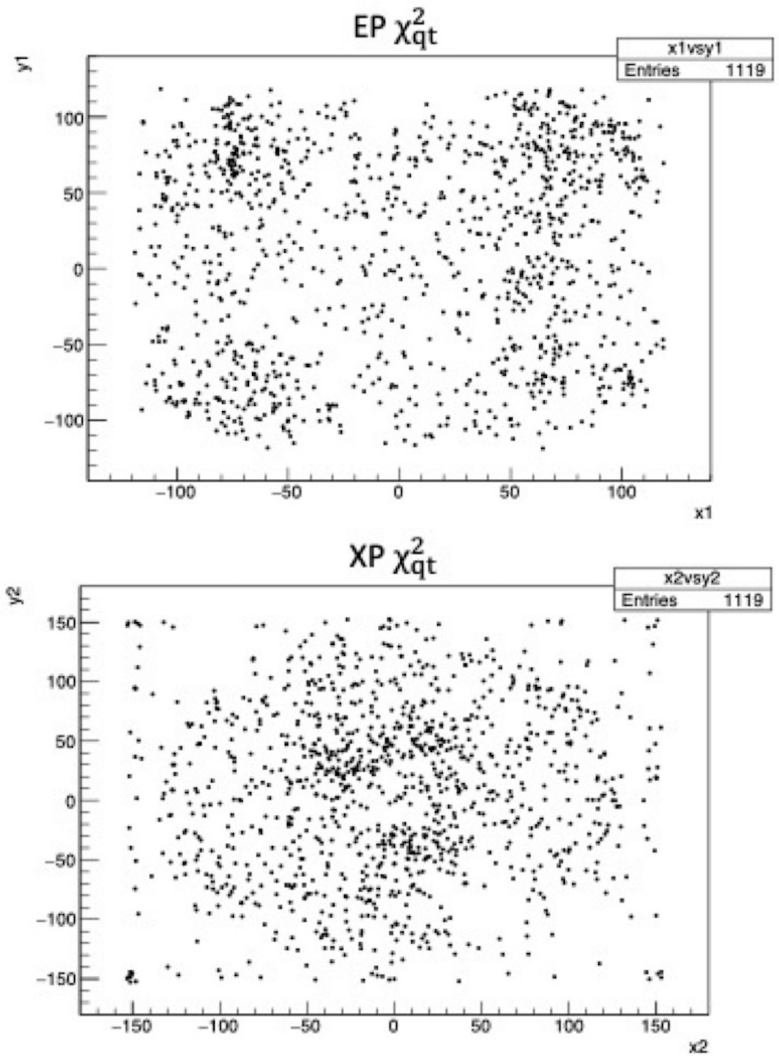




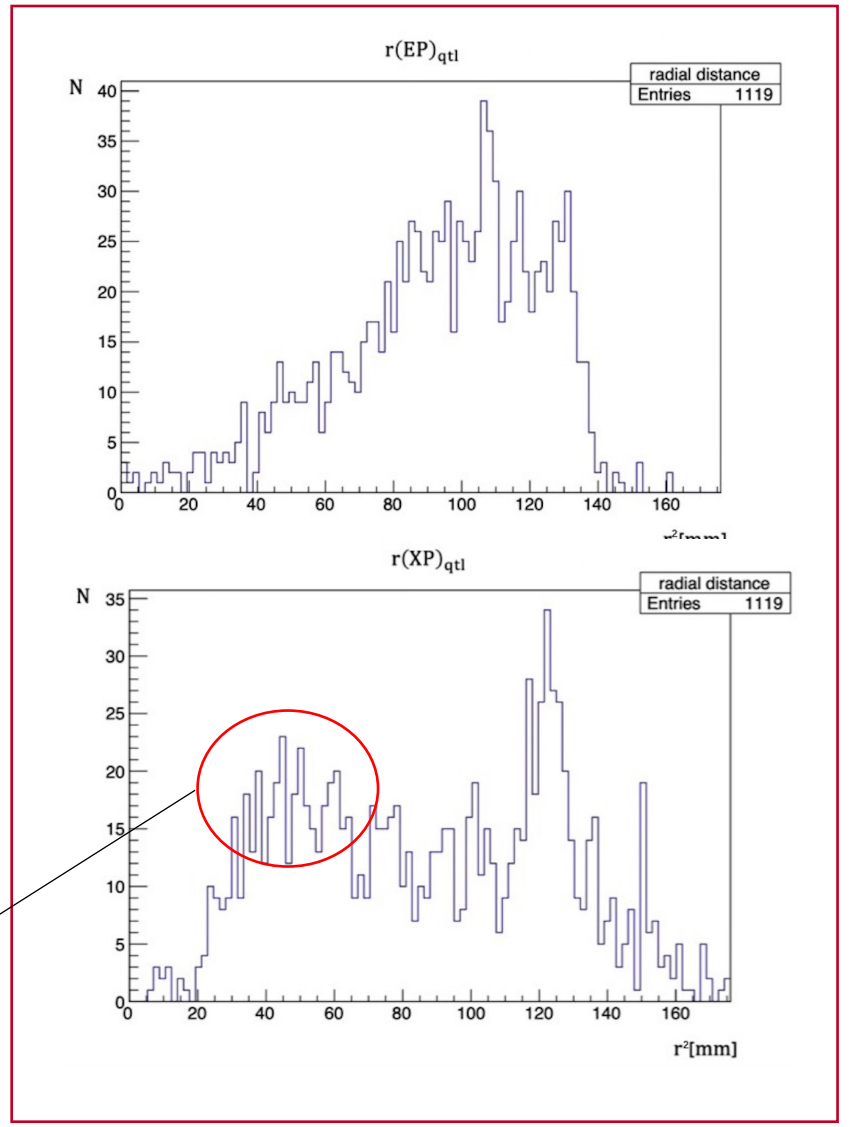
MEASURES OF GOODNESS OF RECONSTRUCTION PROCEDURE

- Quantitative assessment: Compare reconstructed tracks with tracks obtained from muon tracker
- Perform qualitative assesment of track reconstruction algorithm using the distributions:
  - Entry Points
  - Exit Points
  - Radial distances of entry and exit points
  - Angular distributions – Zenith and Azimuthal angle

DISTRIBUTION OF ENTRY AND EXIT POINTS

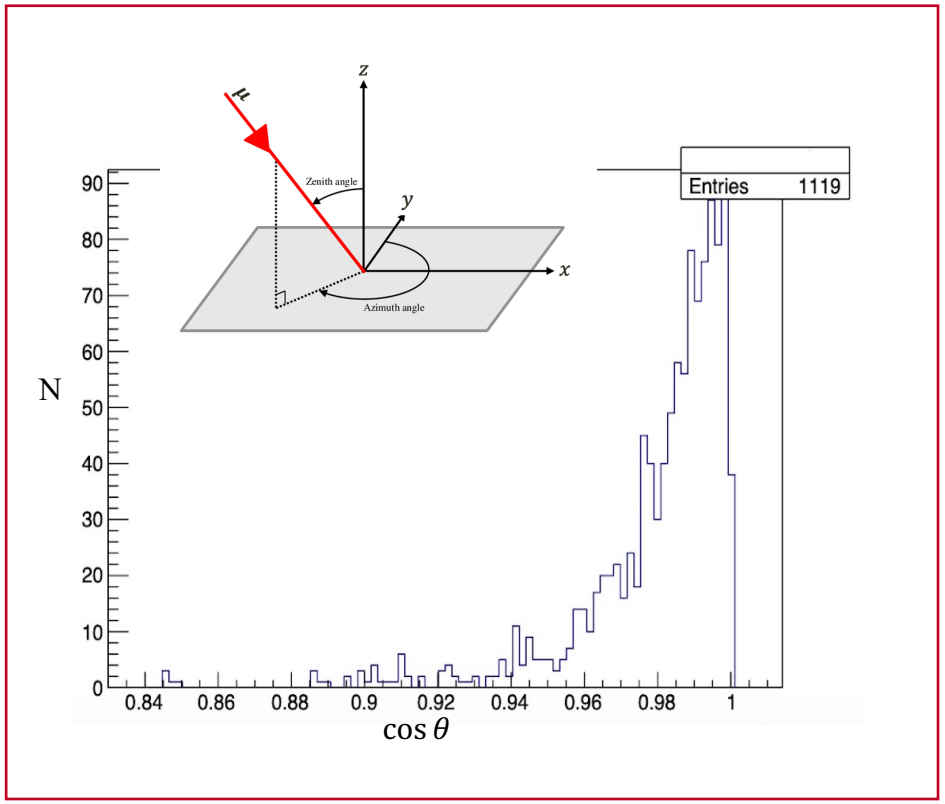


- Number of muons detected on a surface of radius r $\propto \pi r^2$
- Mostly uniform distribution
- Slight clustering of events towards the inner PMTs



Clustering near inner PMTS

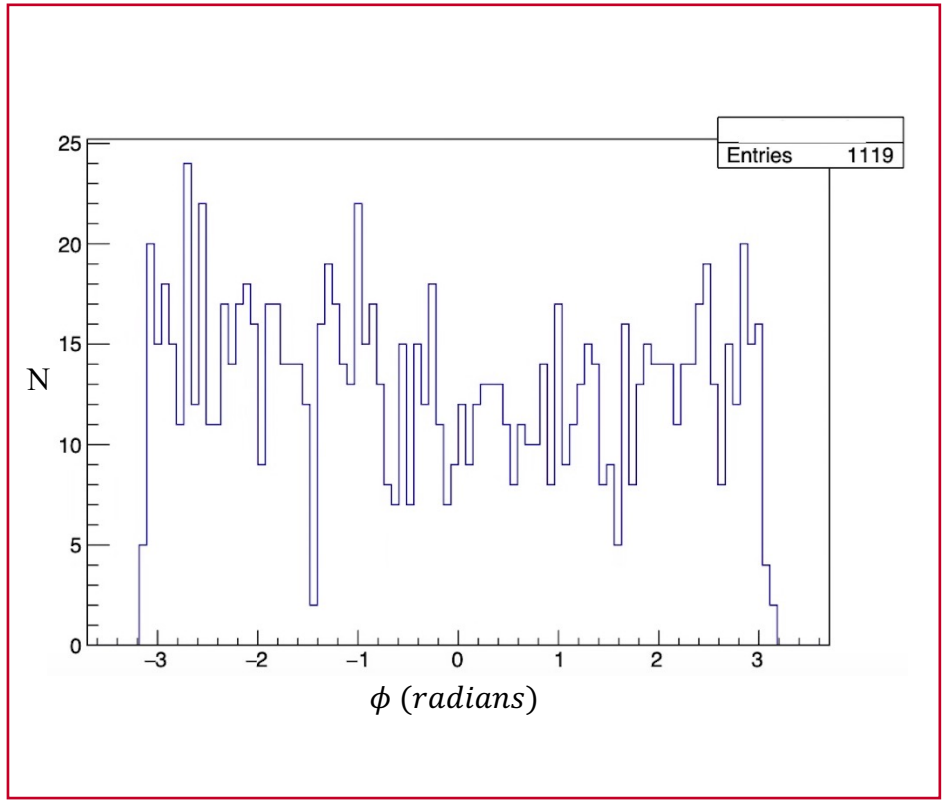
ANGULAR DISTRIBUTIONS



- Zenith angle is defined as:

$$\theta = \frac{\pi}{2} - \tan^{-1}\frac{\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}}{(z_2 - z_1)}$$

- Distribution of muons is described by $\cos^2\theta$.



- Azimuth angle is defined as:

$$\phi = \tan^{-1}\frac{(y_2 - y_1)}{(x_2 - x_1)}$$

- Azimuth angle distribution of muons is uniform.

SUMMARY AND NEXT STEPS

- DISCO: lab scale experiment to charecterize WbLS
- Muon tracks were reconstructed by combining the PMT hit-time (χ_t^2) and charge information (log likelihood)
- Next Steps:
  - Replace water with WbLS in test cell and take data
  - Replace PMTs at the bottom with LAPPD → enables precise track reconstruction. Check out Noah's talk for more on LAPPDs