

Muon Track Reconstruction: Likelihood Analysis

Dilraj Ghuman

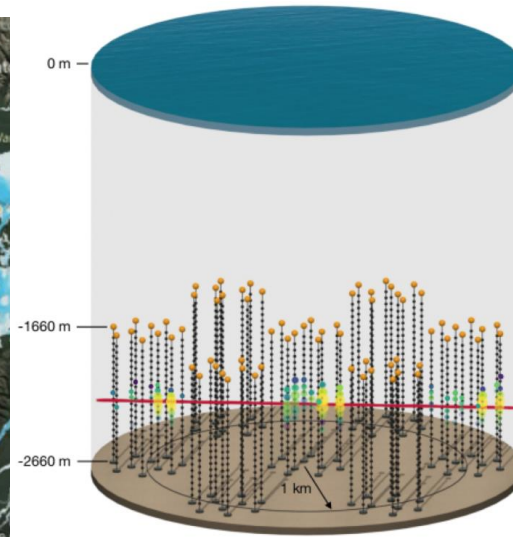
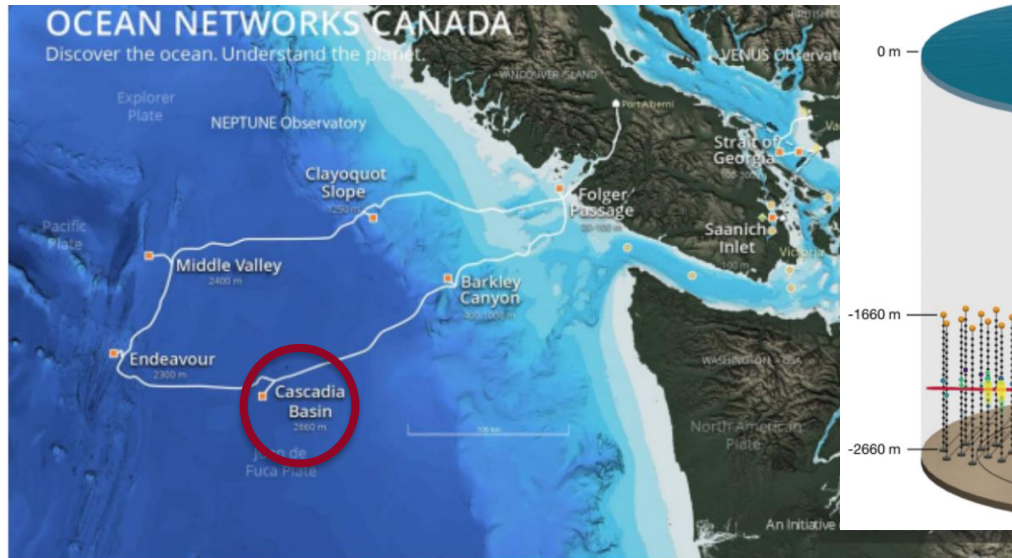


Arthur B. McDonald
Canadian Astroparticle Physics Research Institute

Pacific Ocean Neutrino Explorer



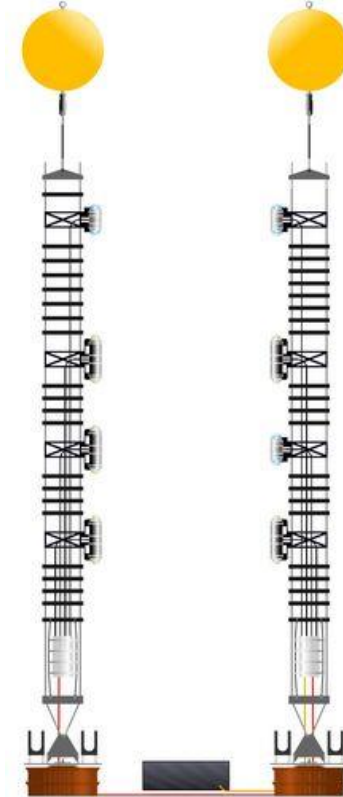
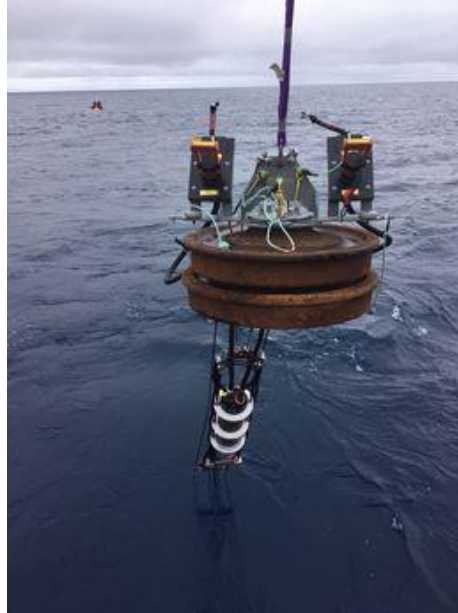
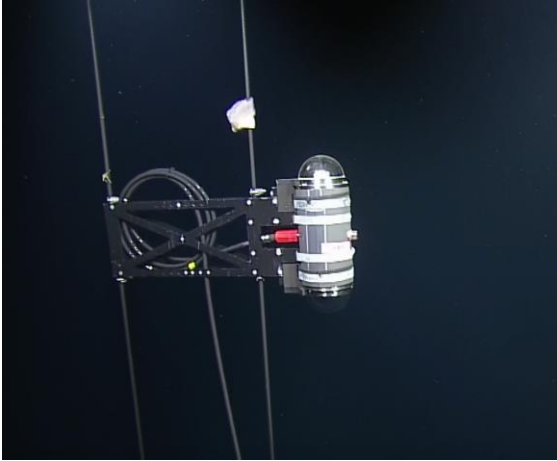
- Neutrino Telescope
- Supported by ONC
- Will be part of Global Neutrino Network (GNN)



STRAW: Pathfinder



Strings for Absorption length in Water



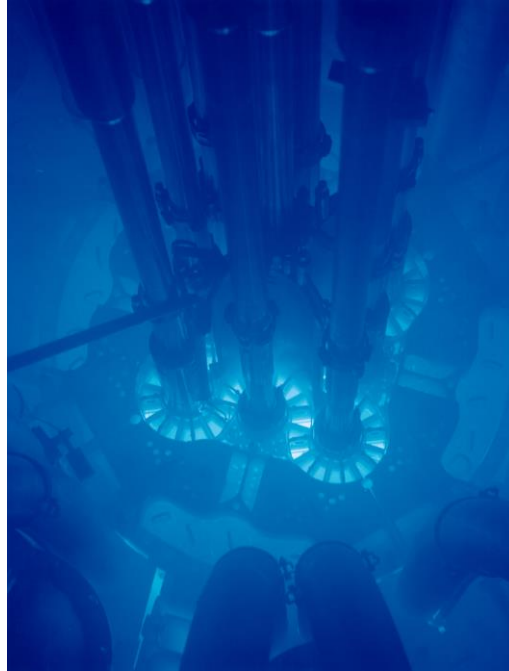
Cherenkov Muon Tracks



$$\nu_{\ell} \rightarrow \ell$$



Courtesy of Wikipedia



Advanced Test Reactor core, Idaho National Laboratory

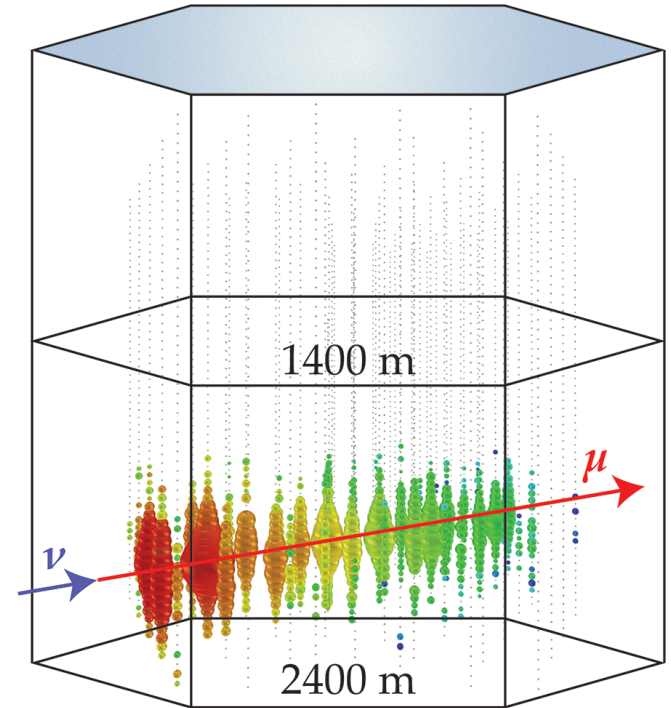


Illustration: APS/Joan Tycko; Neutrino event: IceCube

Simulation



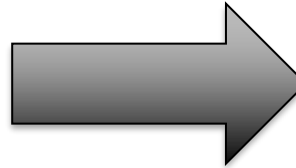
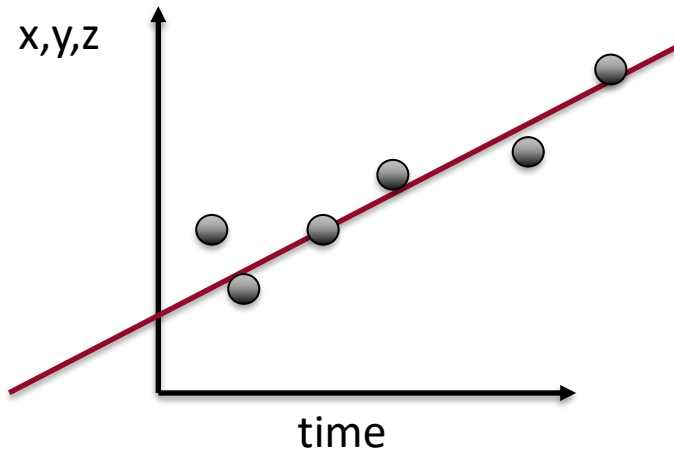
- IceCube Software on Illume
- NuGen
- Clsim
- Pentagon Geometry:
 - 100 meters between strings
 - 40 meters between DOMs
 - 19 DOMs per string
 - 10 strings
- 400,000 events ranging from 100 GeV – 10,000 GeV

Reconstruction



LineFit

- Simple Chi-squared fit of a line to position-time of hits.



3D Track in Time

Reconstruction



Likelihood Fit

- Statistical fit on hits of DOMs.

$$\mathcal{L}(\vec{\theta}; \vec{x}) \rightarrow \text{3D Track in Time}$$

Likelihood Reconstruction

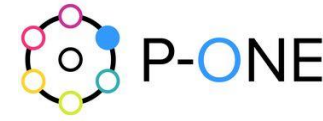


$$p(\vec{x}|\vec{\theta})$$

$$t_{\text{res}} = t_{\text{hit}} - t_{\text{geo}}$$

$$\mathcal{L}(\vec{\theta}) = \prod_i p(\vec{x}_i|\vec{\theta}) \quad \ell(\vec{\theta}) = -\log(\mathcal{L}(\vec{\theta}))$$

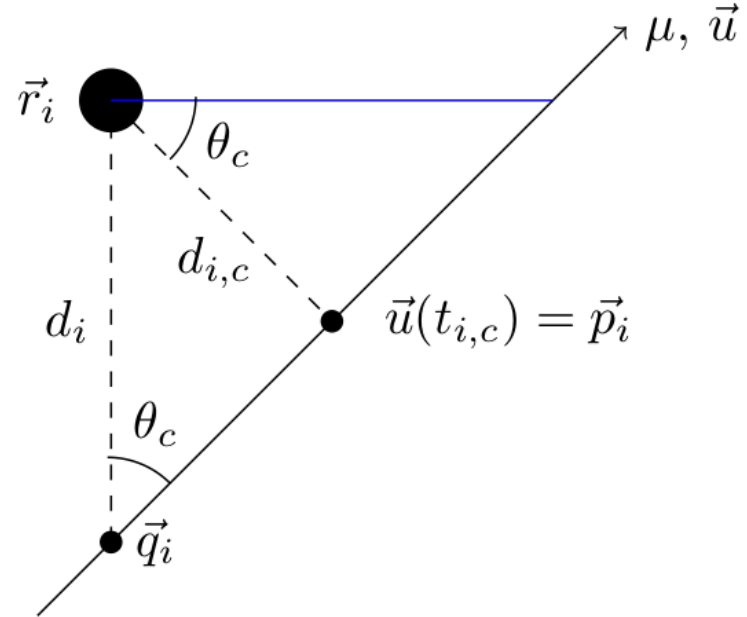
Muon Track



- Simple geometric derivations
- Rests on finding distance of closest approach

$$d_i = \frac{d_{i,c}}{\sin \theta_c}$$

$$t_{i,\text{geo}} = \frac{d_{i,c}}{\sin \theta_x \cdot c_n} + \frac{|\vec{q}_i - \vec{q}_0|}{c}$$

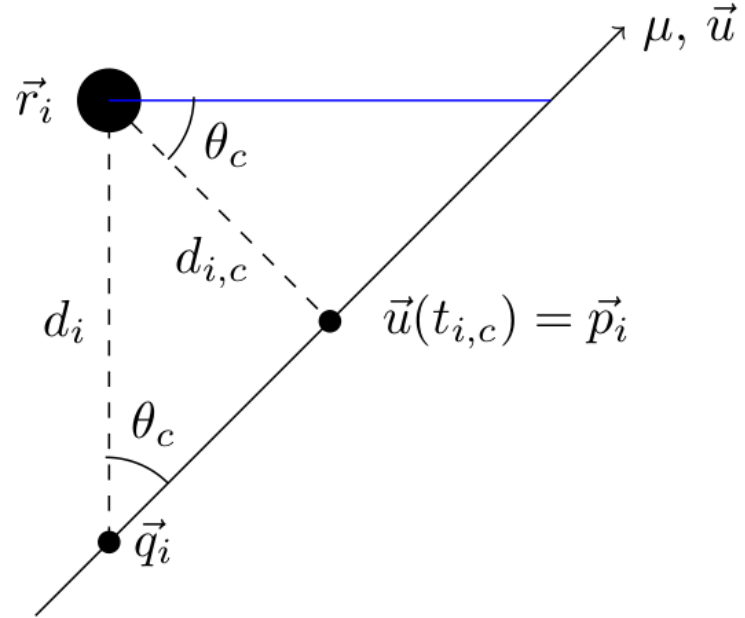


Muon Track

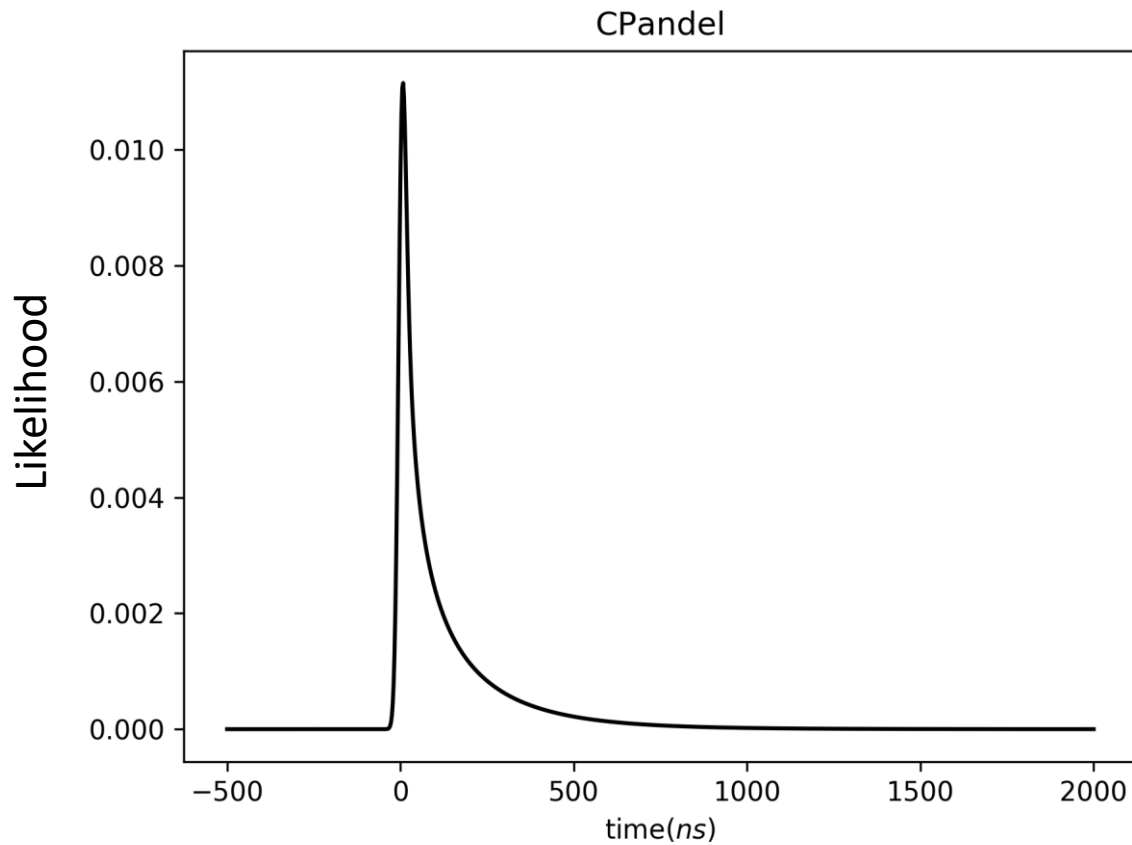


- Simple geometric derivations
- Rests on finding distance of closest approach

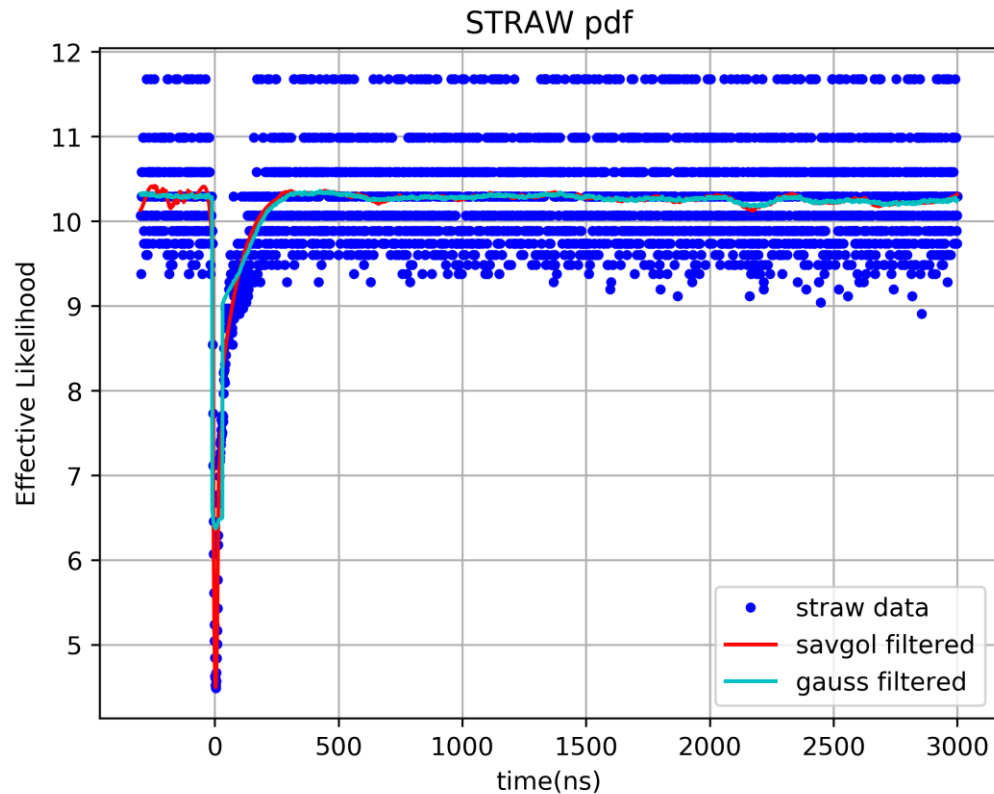
$$d_{i,c} = |(\vec{r} - \vec{x}) - ((\vec{r} - \vec{x}) \cdot \hat{v})\hat{v}|$$



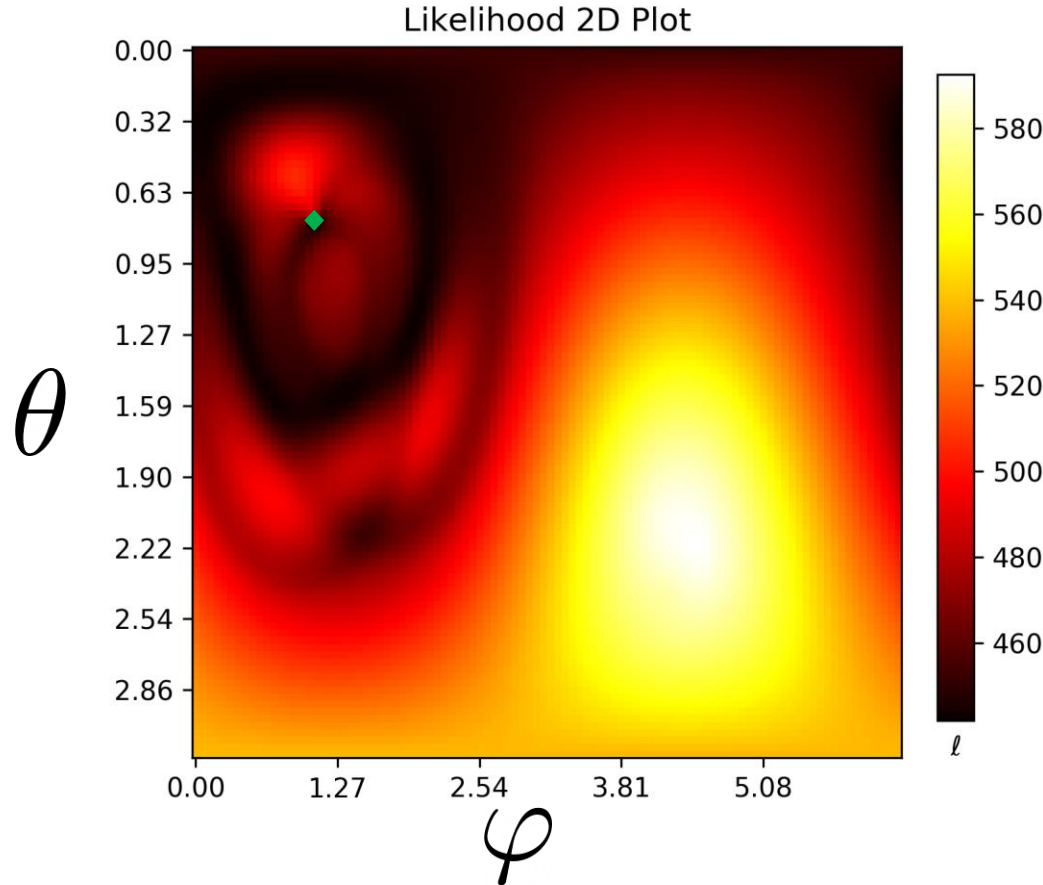
Likelihood Distribution



Likelihood Distribution



Testing Likelihood



- ~60 hit DOMs
- Fixed at True Vertex
- True direction
 $(\phi, \theta) = (1.10, 0.81)$



Take Away



- P-ONE is an exciting new avenue of Neutrino Research!
- Analysis Software is being developed.
 - Track Reconstruction
 - Tau analysis
 - K decay