



Muon Track Reconstruction for the P-ONE Neutrino Telescope

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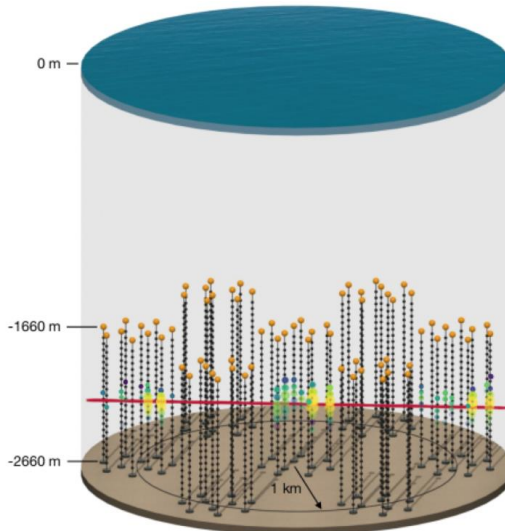
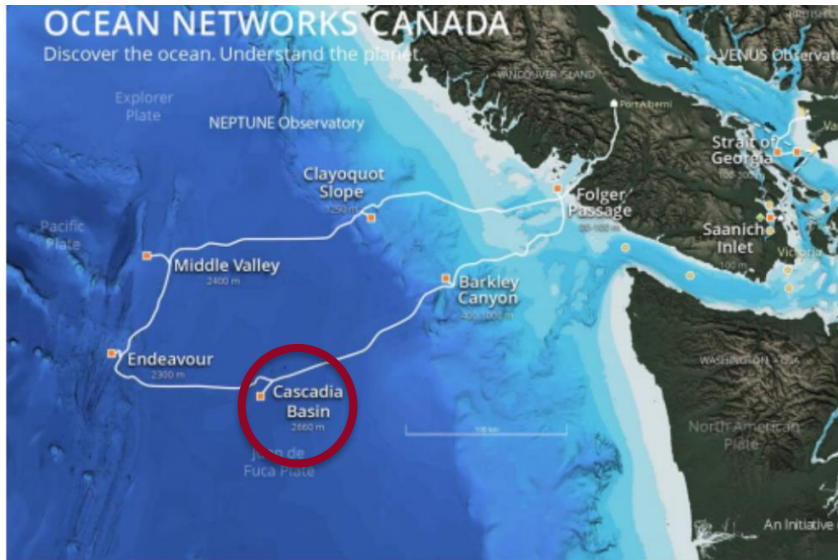


Arthur B. McDonald
Canadian Astroparticle Physics Research Institute

Pacific Ocean Neutrino Explorer



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



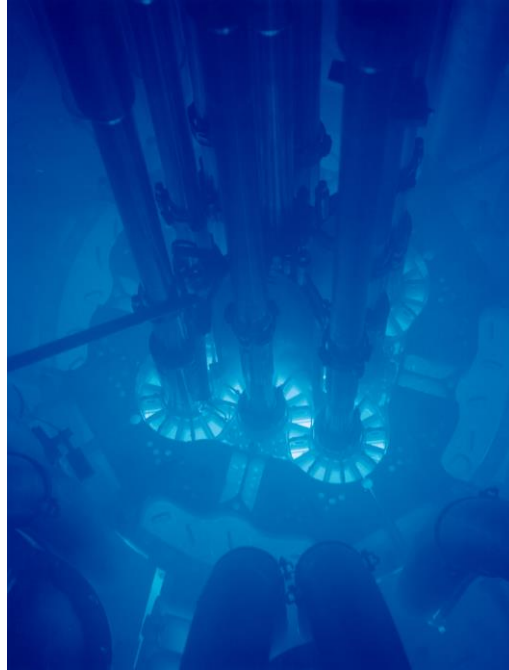
Cherenkov Muon Tracks



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



Courtesy of Wikipedia



Advanced Test Reactor core, Idaho National Laboratory

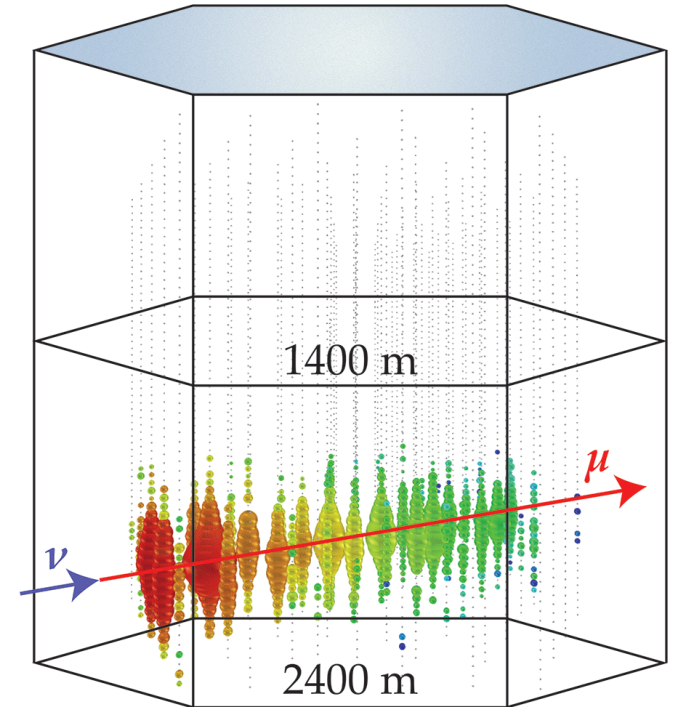
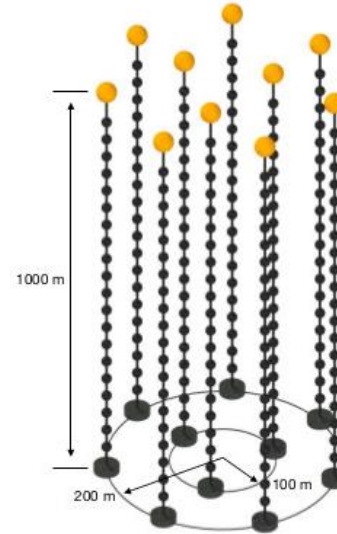


Illustration: APS/Joan Tycko; Neutrino event: IceCube

Simulation



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

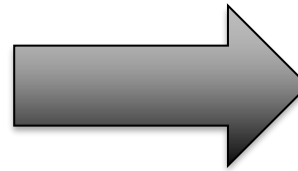
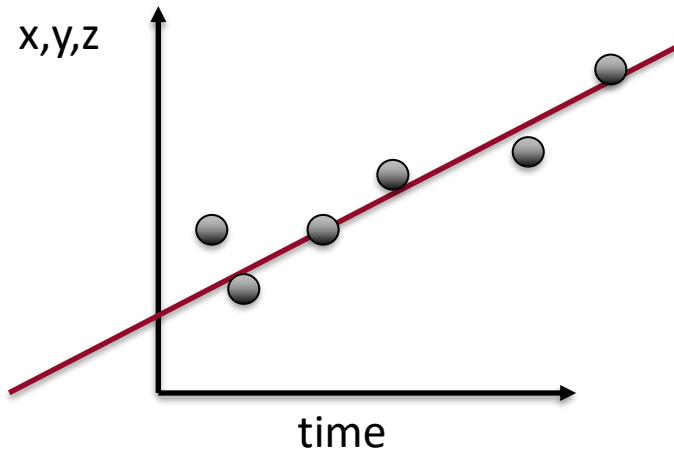


Reconstruction



LineFit

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



3D Track in Time

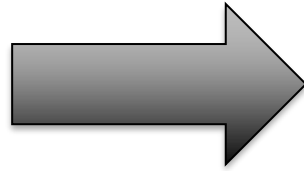
Reconstruction



Likelihood Fit

- Statistical fit on hits of DOMs.

$$\mathcal{L}(\vec{\theta}; \vec{x})$$



3D Track in Time

Likelihood Reconstruction



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

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

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

$$\ell(\vec{\theta}) = -\log(\mathcal{L}(\vec{\theta}))$$

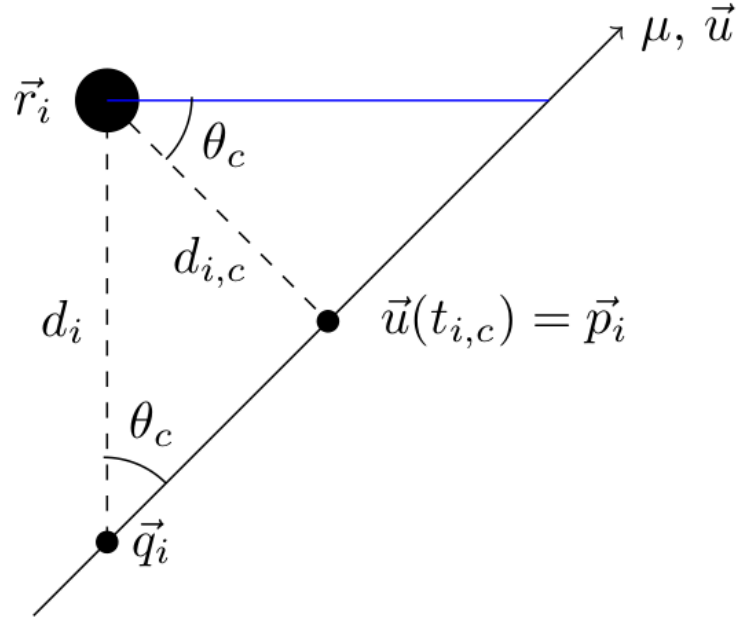
Muon Track



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

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

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

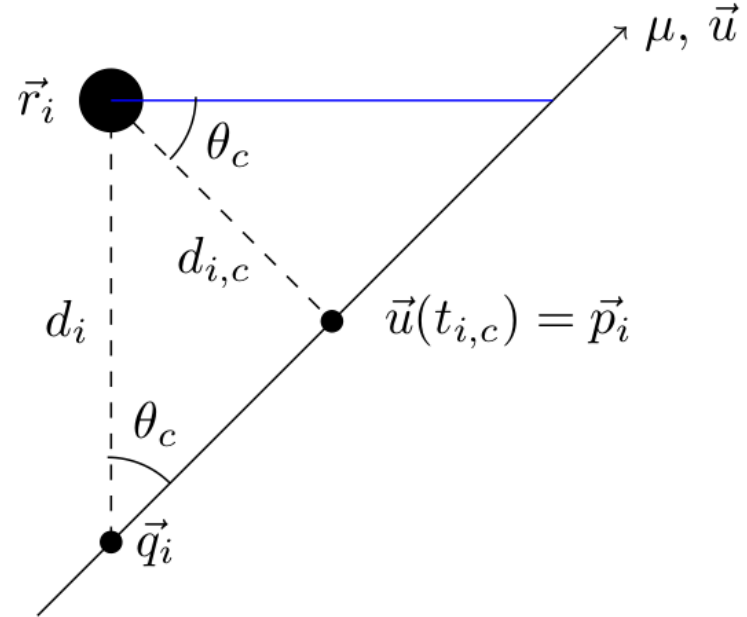


Muon Track

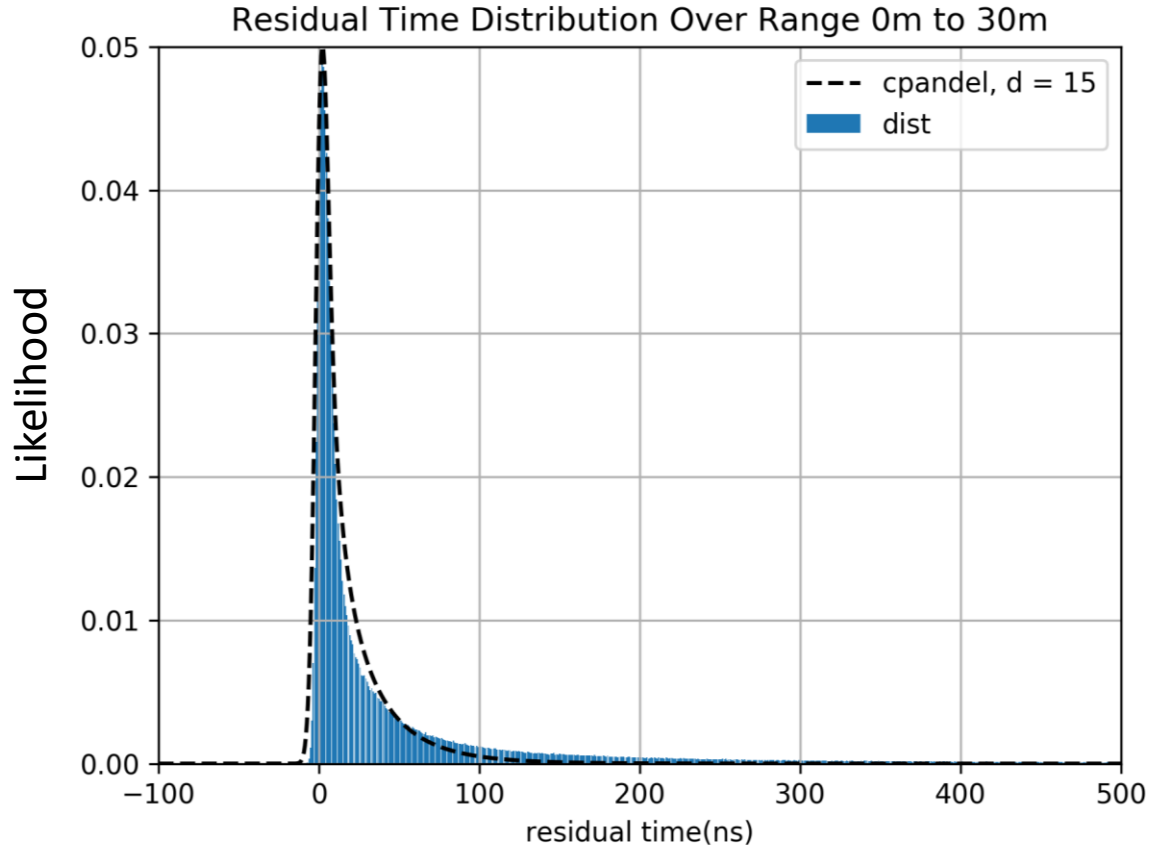


- Simple geometric derivations
- Rests on finding distance of closest approach

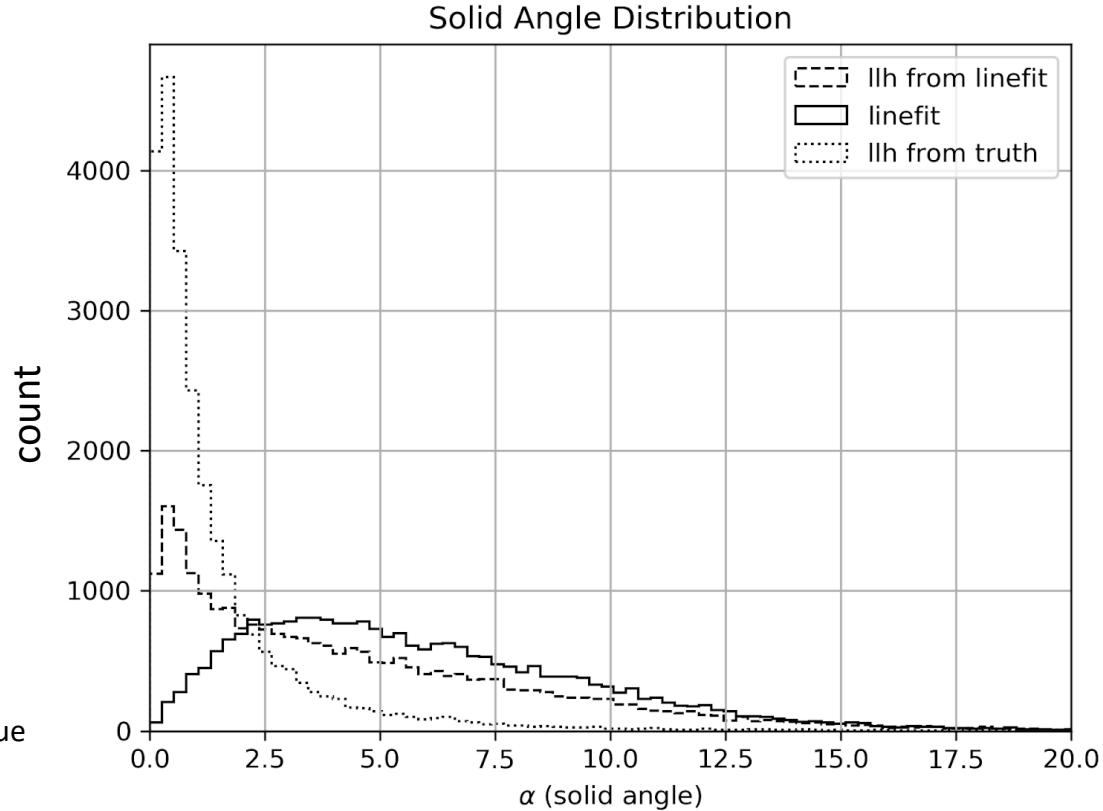
$$d_{i,c} = |(\vec{r} - \vec{x}) - ((\vec{r} - \vec{x}) \cdot \hat{v})\hat{v}|$$



Likelihood Distribution



Reconstruction



Solid angle is between
reconstructed track and true
track directions

Take Away

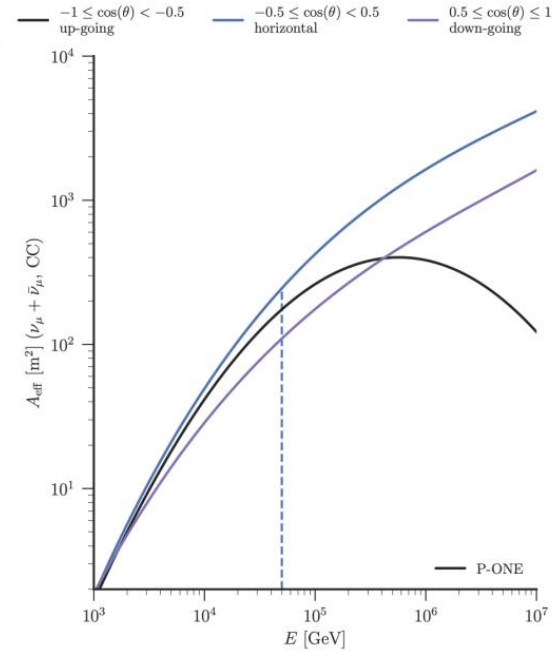
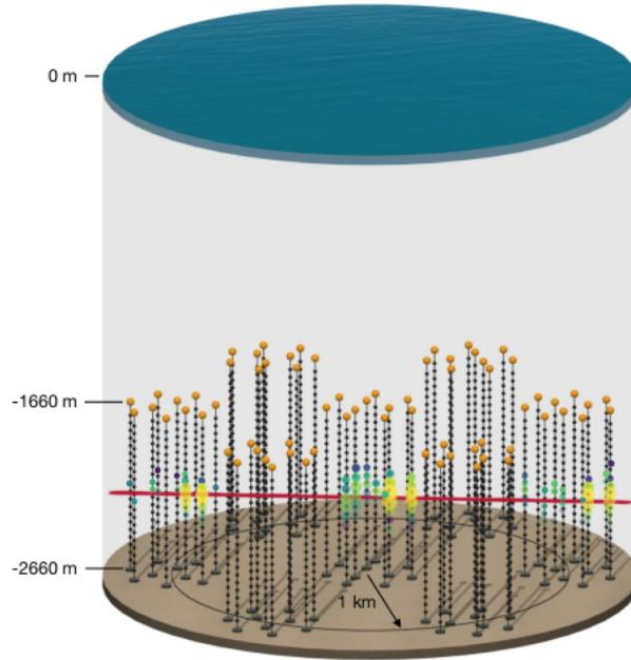


- P-ONE is an exciting new avenue of Neutrino Research!
- Reconstruction is still being improved, but looks good!



EXTRA SLIDES

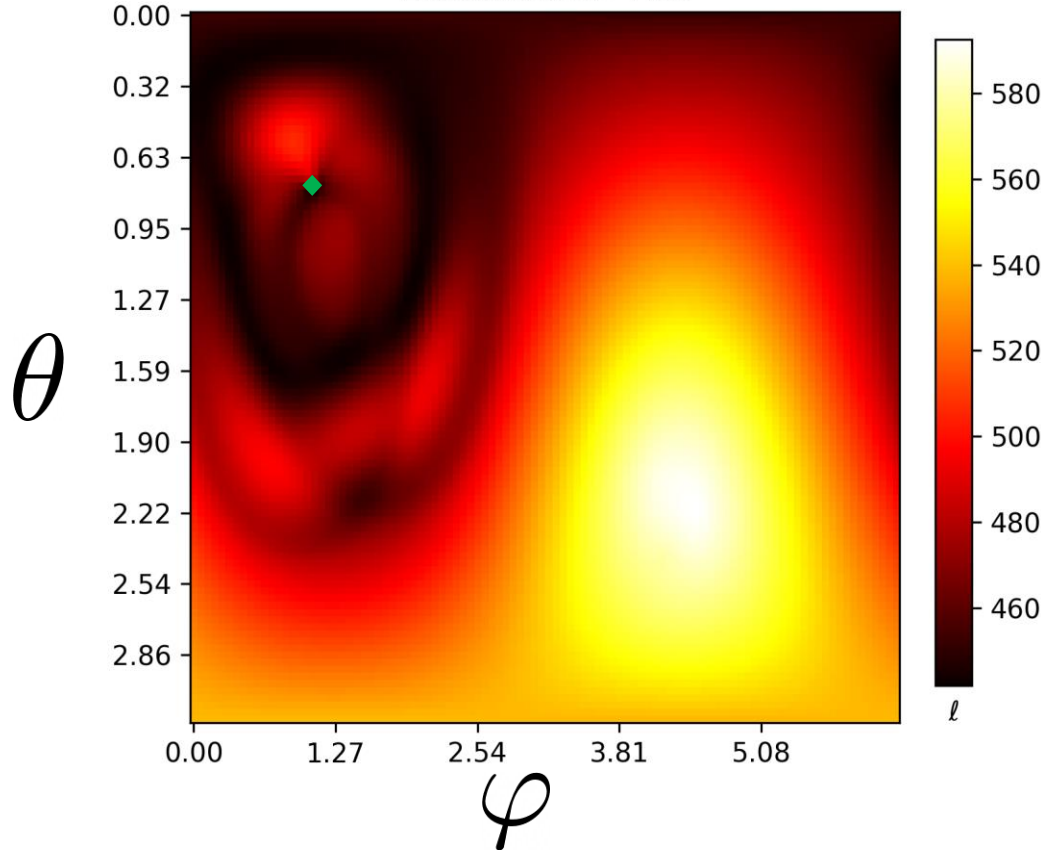
Effective Area



Testing Likelihood



Likelihood 2D Plot



- ~60 hit DOMs
- Fixed at True Vertex
- True direction
(φ, θ) = (1.10, 0.81)



Global Coverage

