P-ONE

Queen's University

Muon Track Reconstruction: Likelihood Analysis

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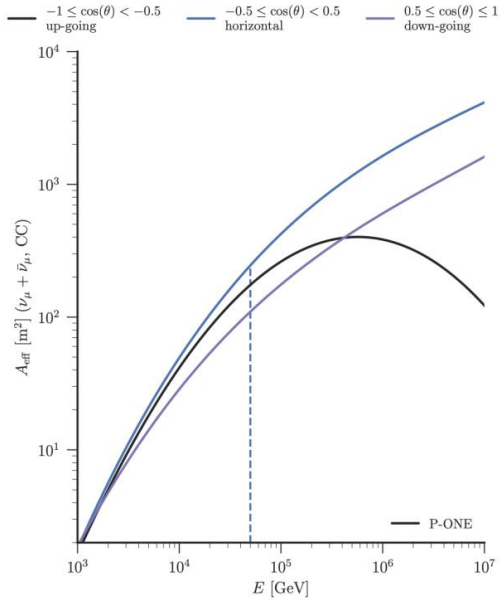
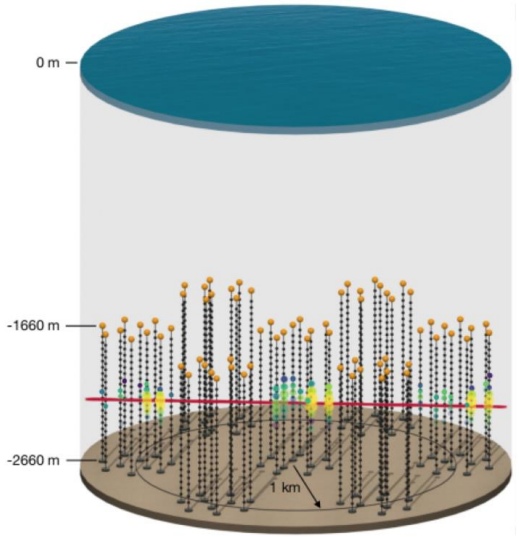
Goal

- Produce Effective Area/Volume Plots of P-ONE.
  - Need a reconstruction method.





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.

- Likelihood Fit
  - Statistical fit on hits of DOMs.

Likelihood Reconstruction

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

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

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

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

Likelihood Reconstruction

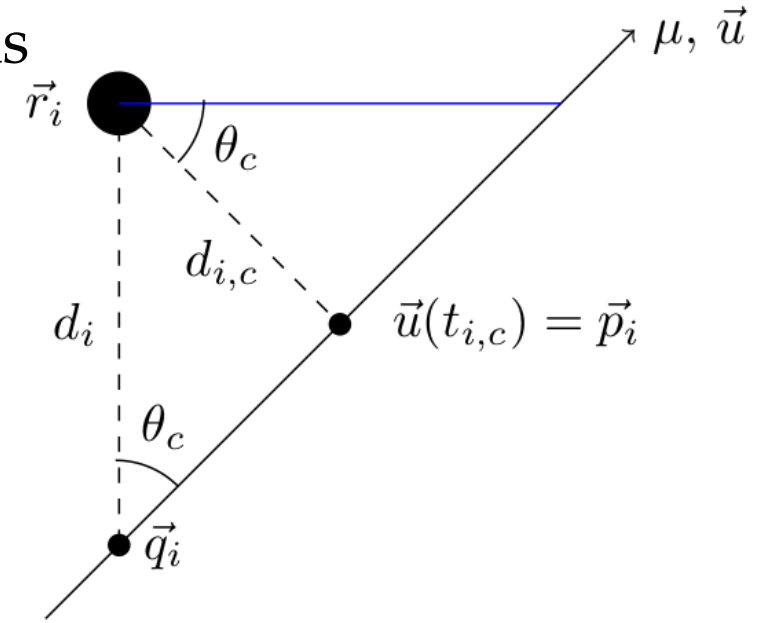
- Will be minimizing to find result.
- Minuit
  - Give initial guess of LineFit
  - Loops over track parameters

Muon Track

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

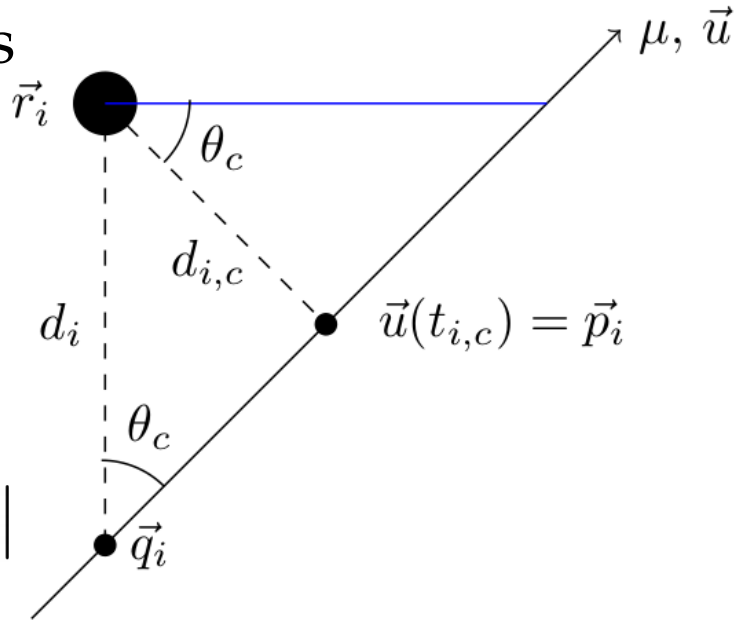
$$d_i = \frac{d_{i,c}}{\sin\theta_c}$$

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



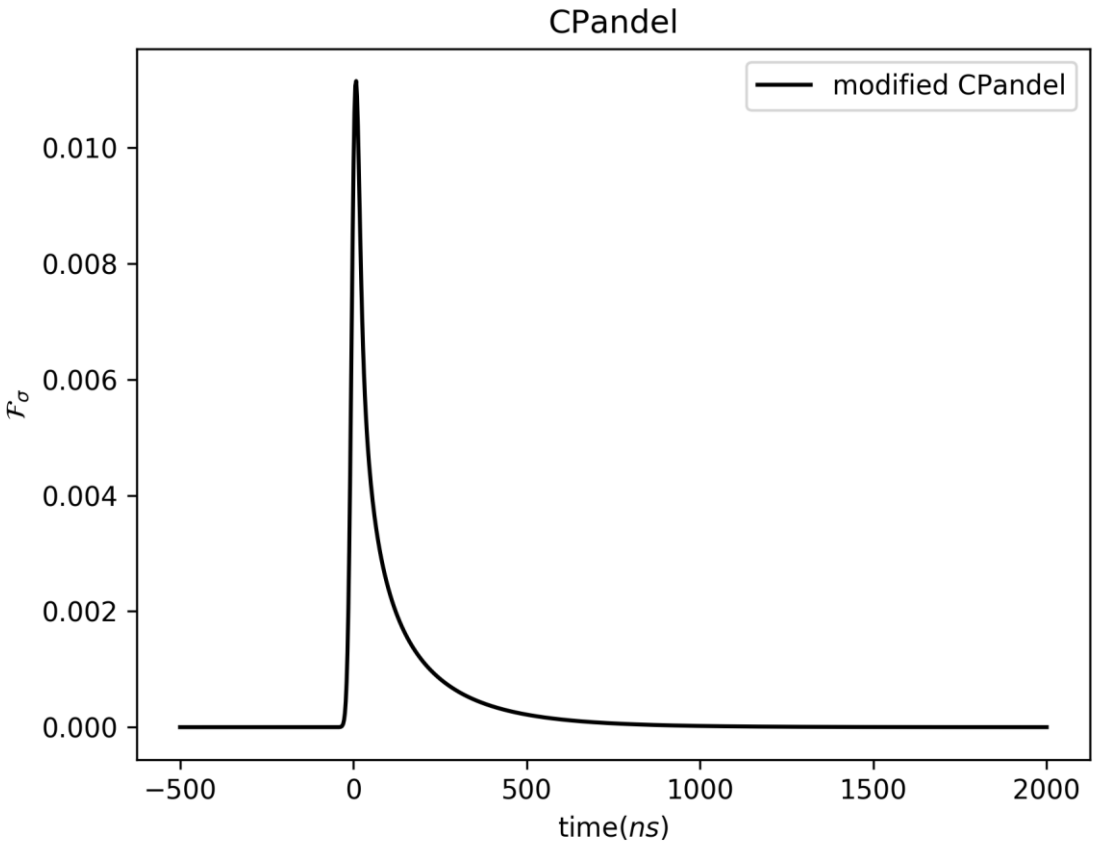
Muon Track

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

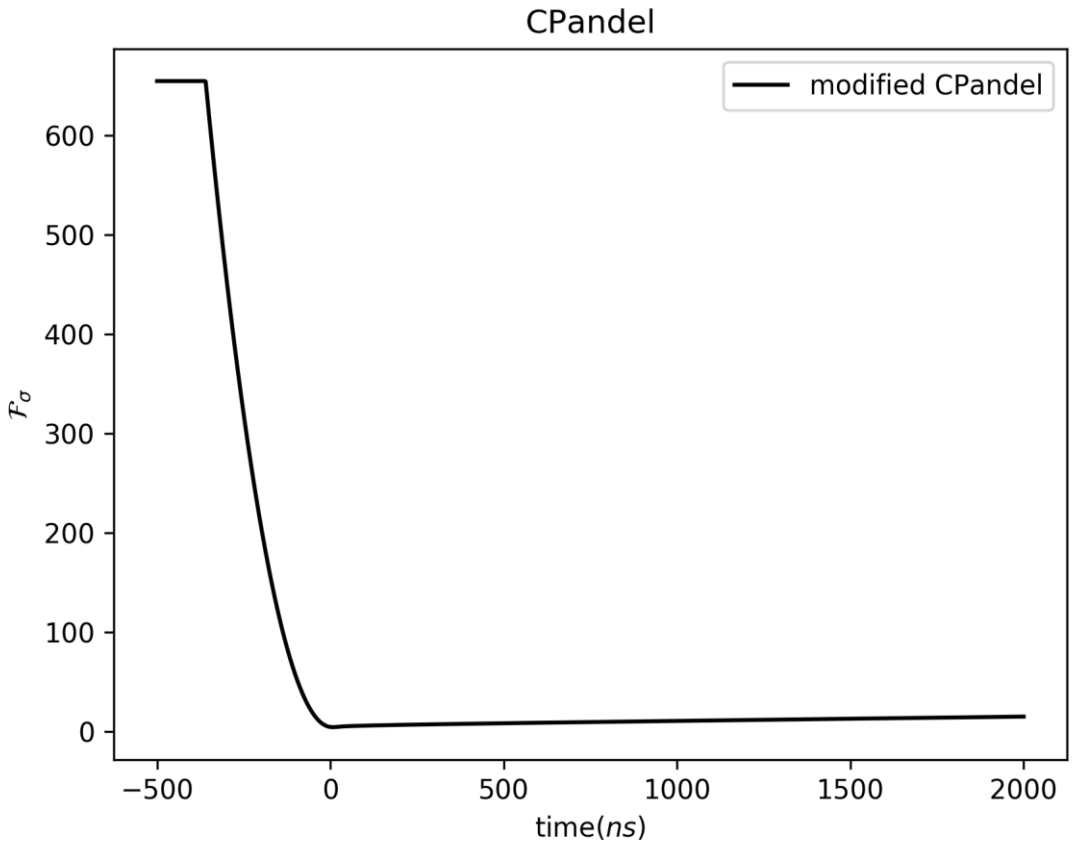


$$d_{i,c} = |(\vec{r} - \vec{x}) - ((\vec{r} - \vec{x}) \cdot \hat{v})\hat{v}|$$

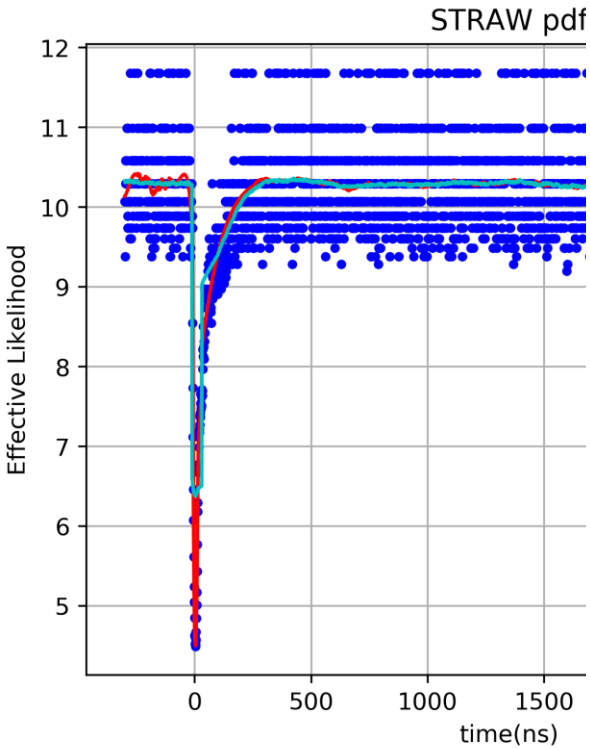
Likelihood Distribution

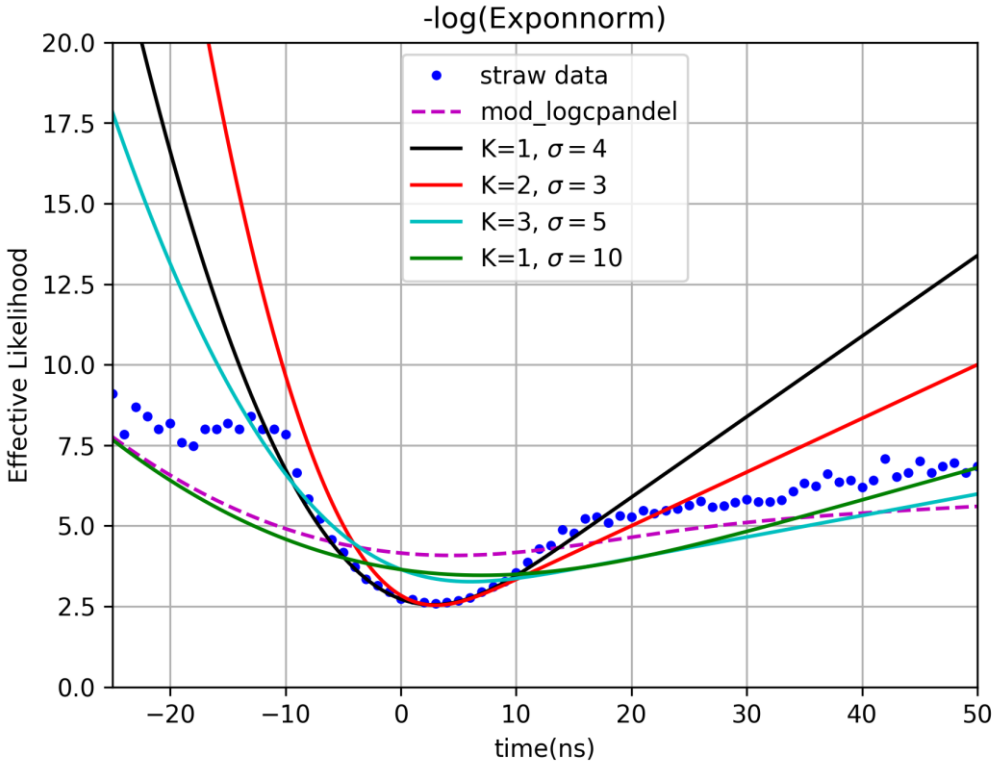


Likelihood Distribution

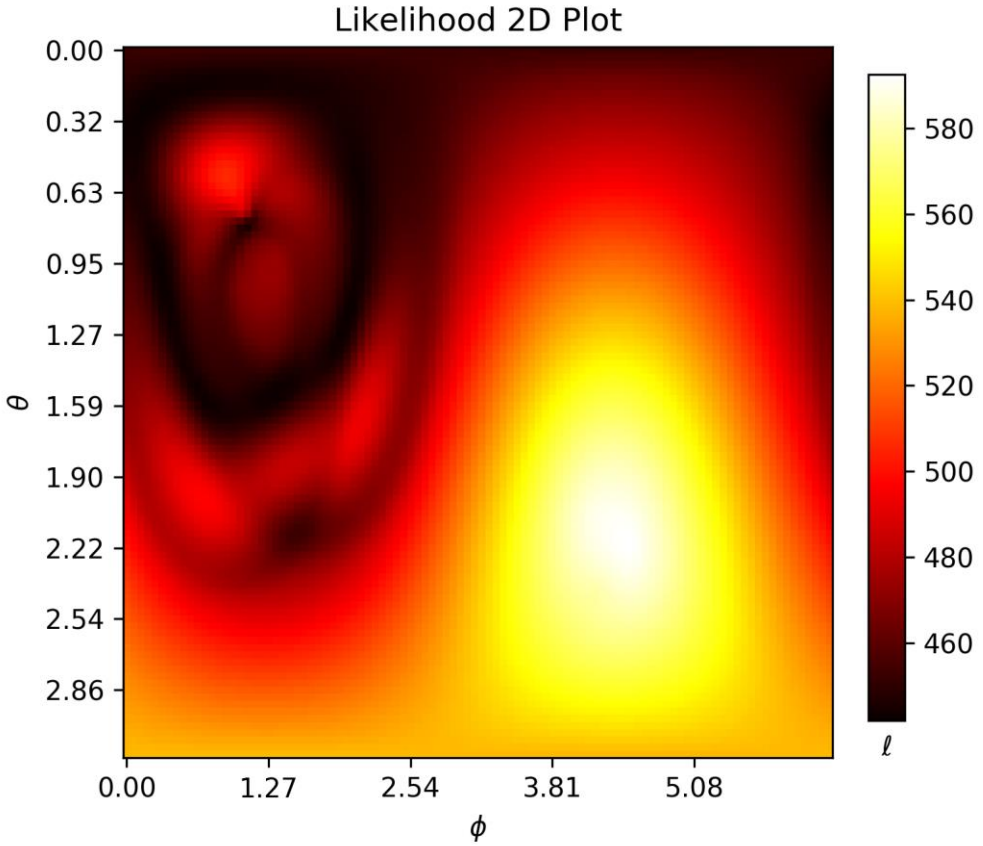


Likelihood Distribution





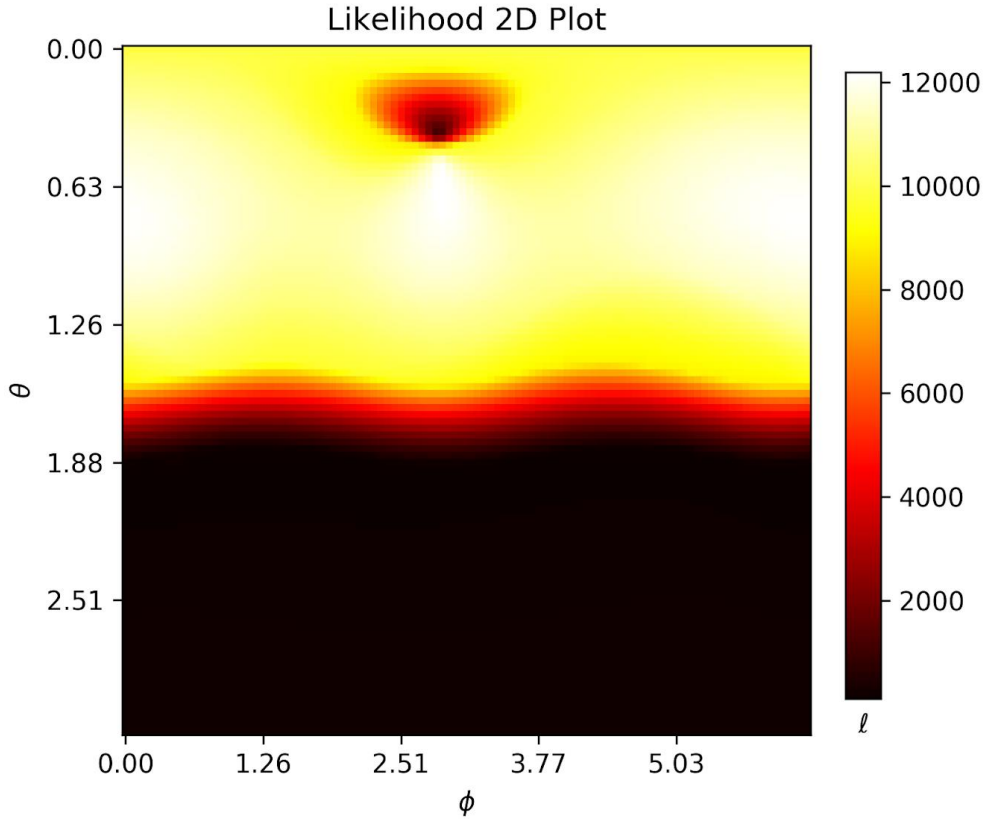
Testing Likelihood



- ~60 hit DOMs
- Fixed at True Vertex
- True direction

(phi, theta) = (1.10, 0.81)

Testing Likelihood



- <10 hit DOMs
- Fixed at True Vertex
- True direction

(phi, theta) = (2.84, 0.31)

Testing Likelihood

- Minuit Misbehaves
  - Gets pulled by other minima
- Likelihood Distribution needs some fine-tuning
- Finnicky, but looks hopeful!

Future Goals

- Account for charge of hits
  - Thomas McElroy has written some code for this
  - Uses charge and acceptance angle
  - Should help with lower hit counts
- Fine tune Likelihood Distribution
  - Need to account for emission point distance
  - Something more accurate for water (fit to POCAM data)