High Energy Event Reconstruction

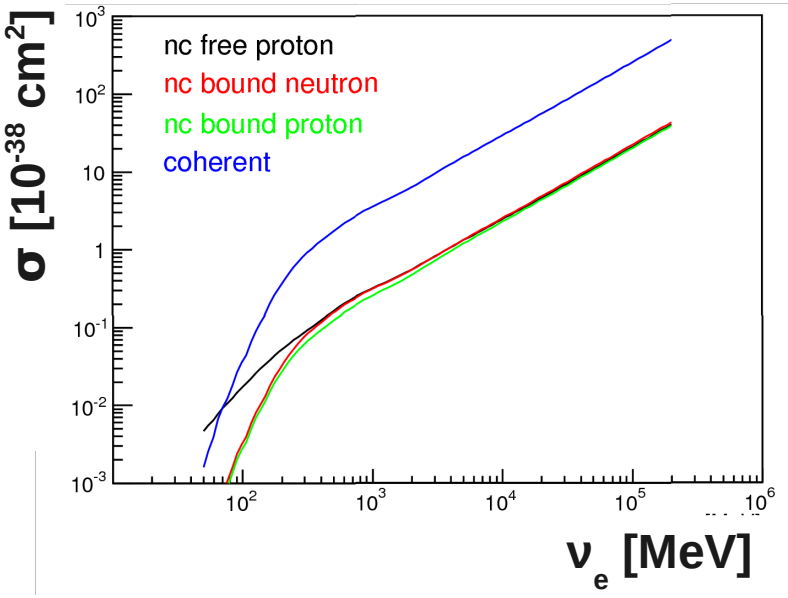
Michinari Sakai

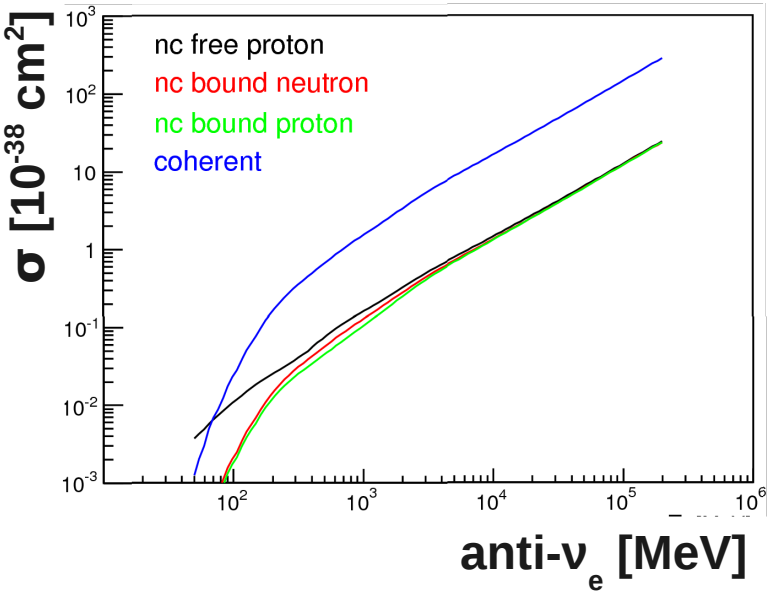
What Tools are Needed to Study High Energy ν Ineractions?

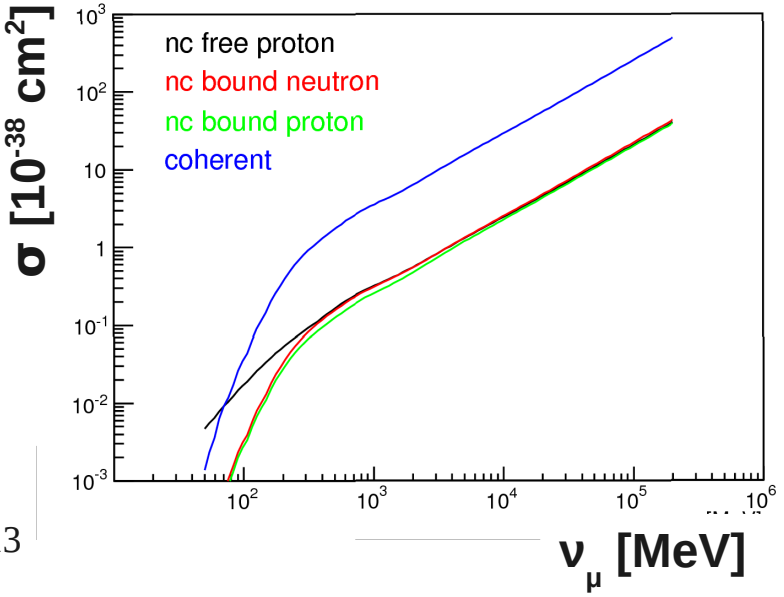
- High energy ν MC
  → Need neutrino event generator for KLG4
- Candidates: Nuance, GENIE
- Need to compare both behaviors.
- Then make choice.

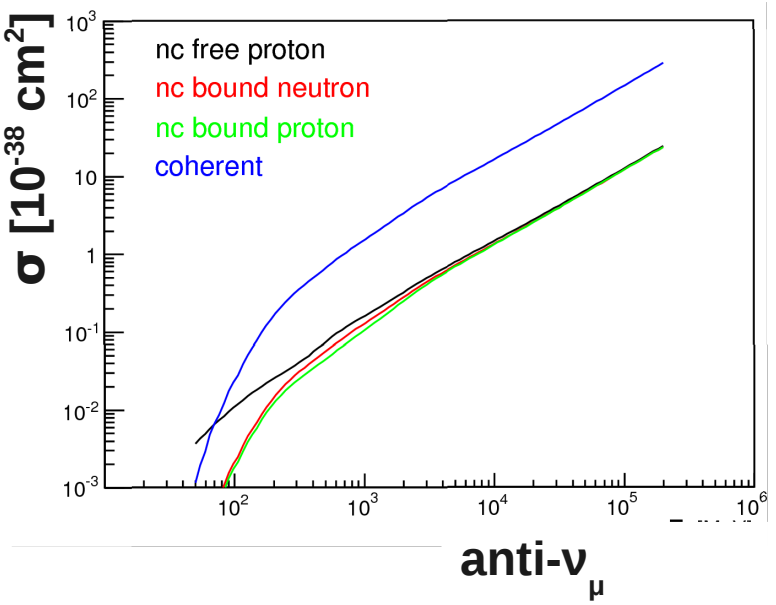
Nuance (NC interactions)

H. Ikeda

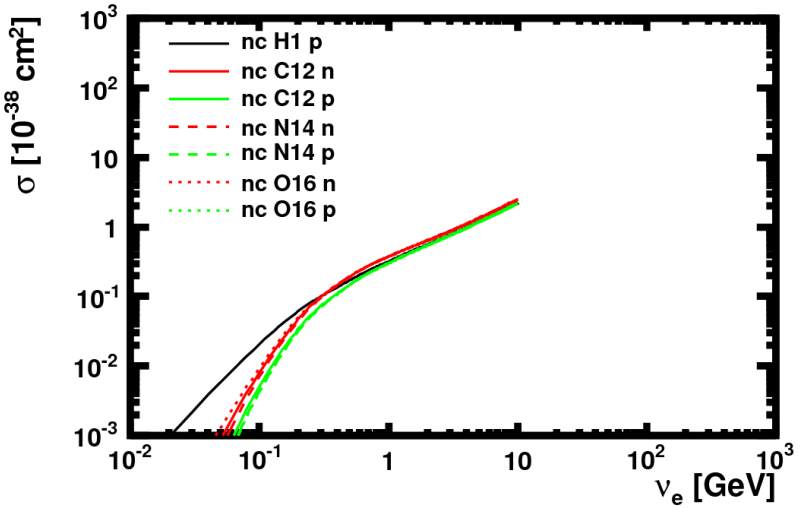


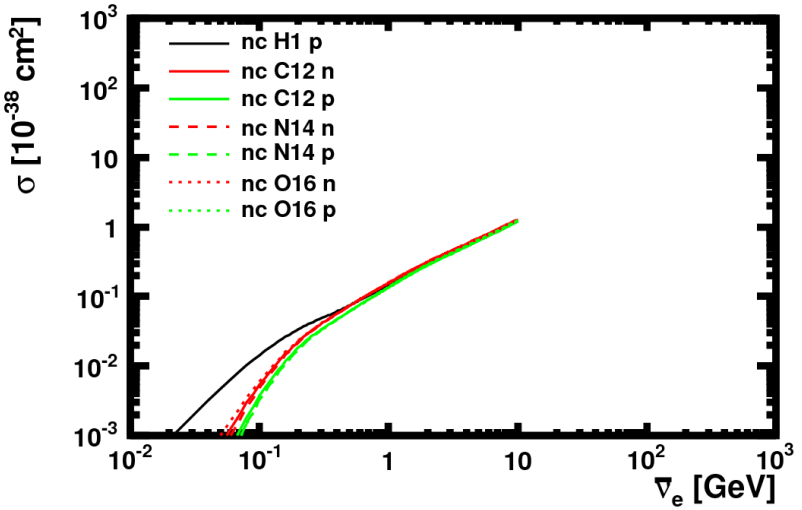


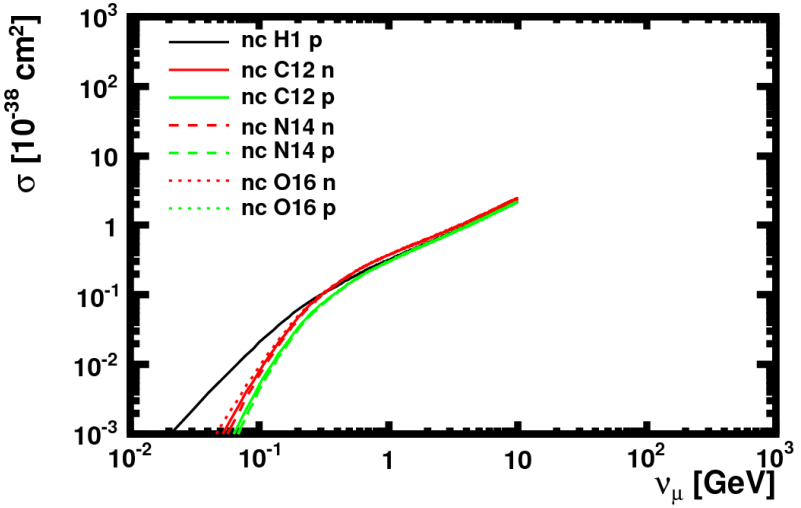


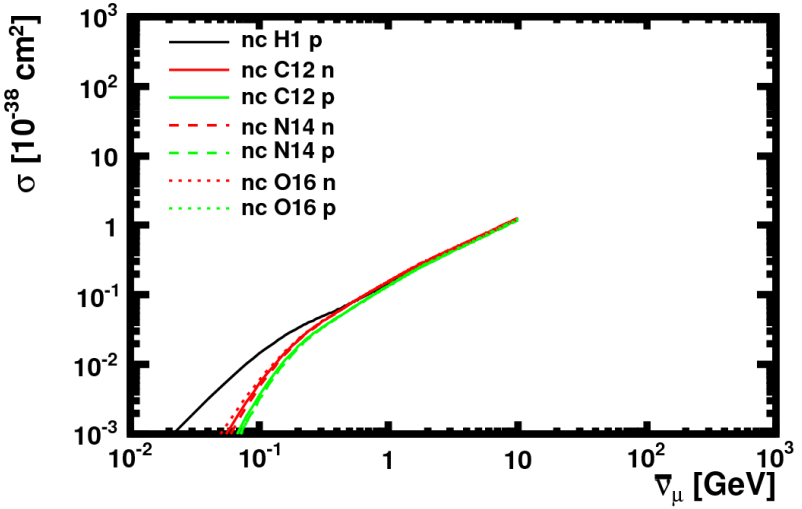


GENIE (NC interactions)



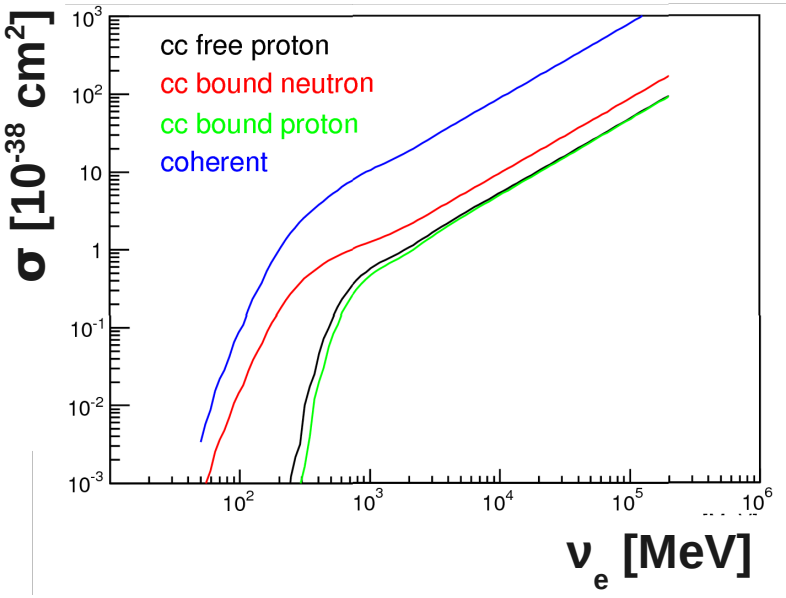


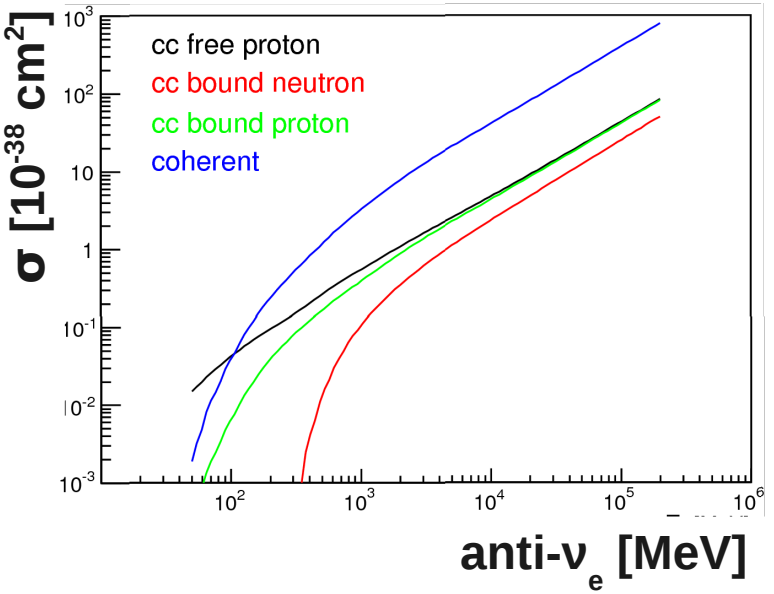


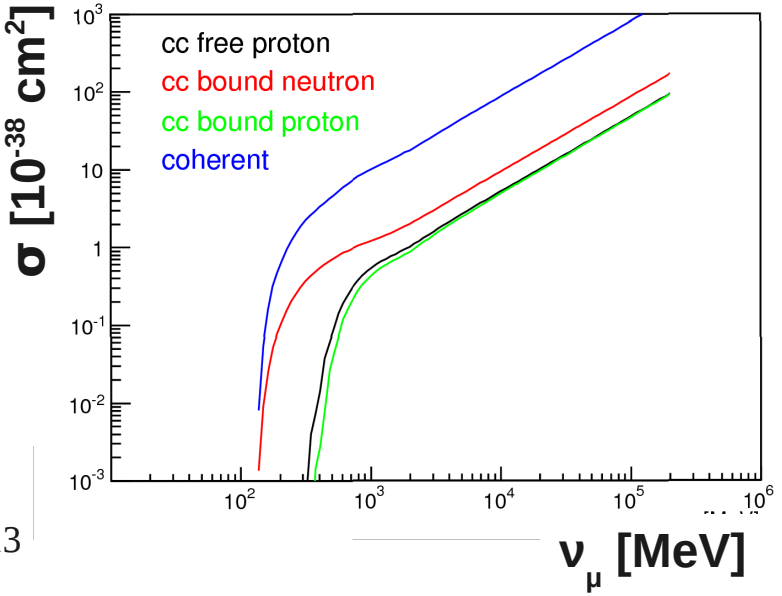


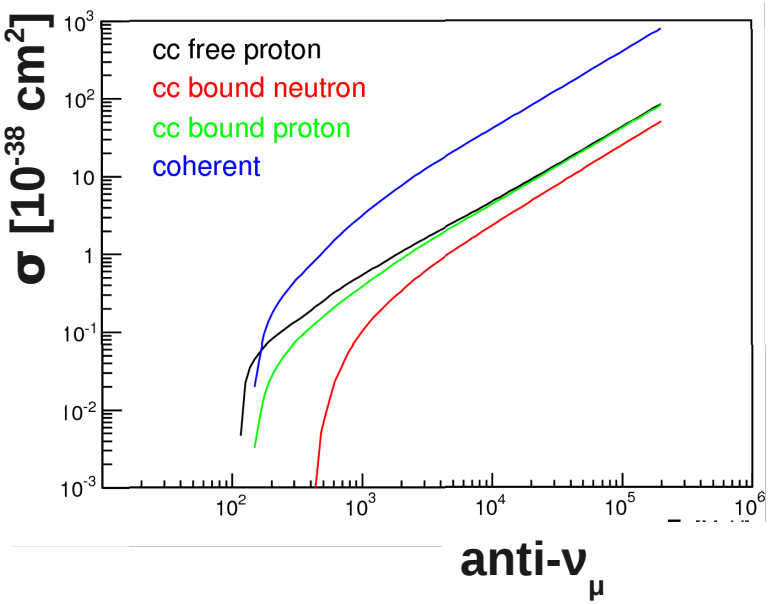
Nuance (CC interactions)

H. Ikeda

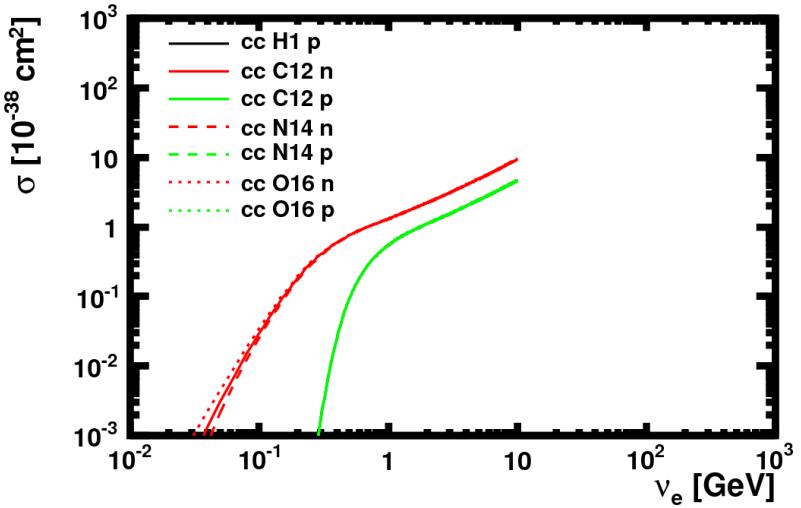


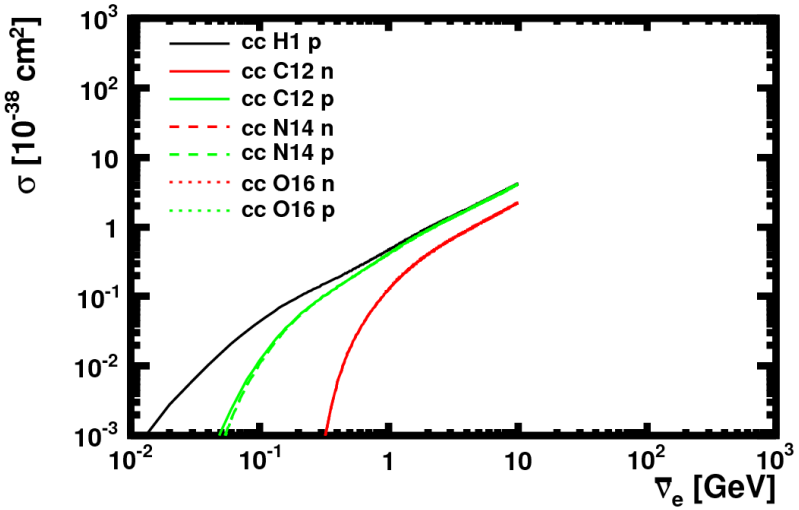


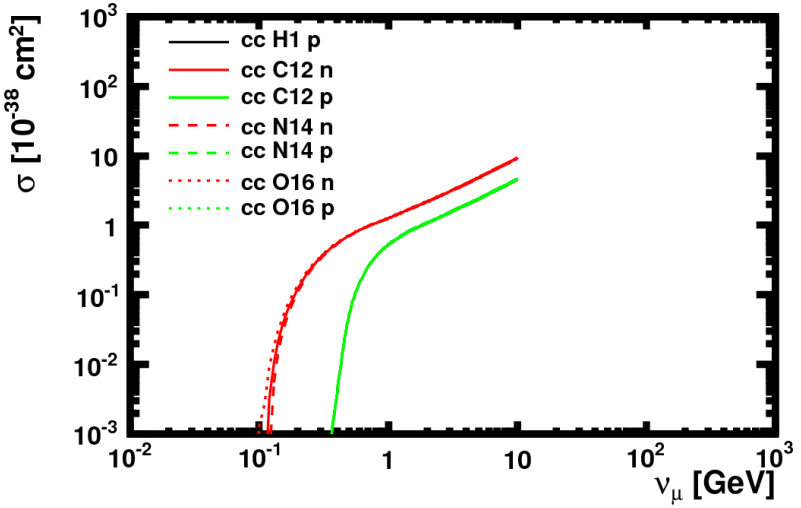


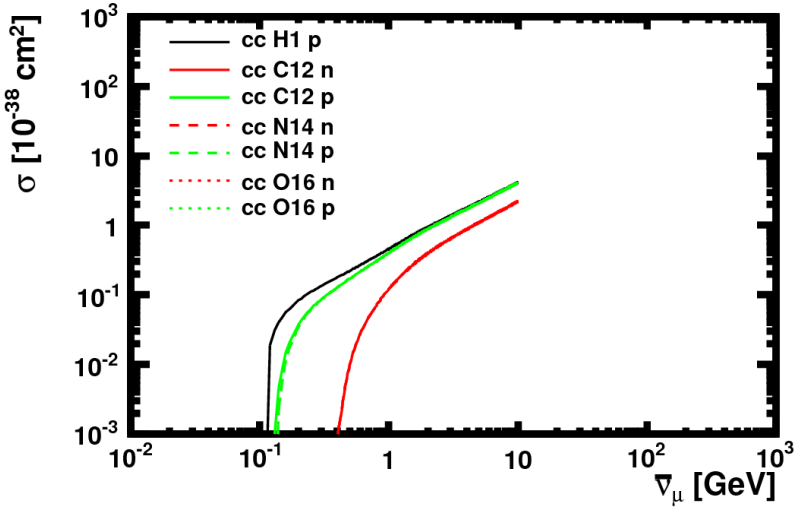


GENIE (CC interactions)







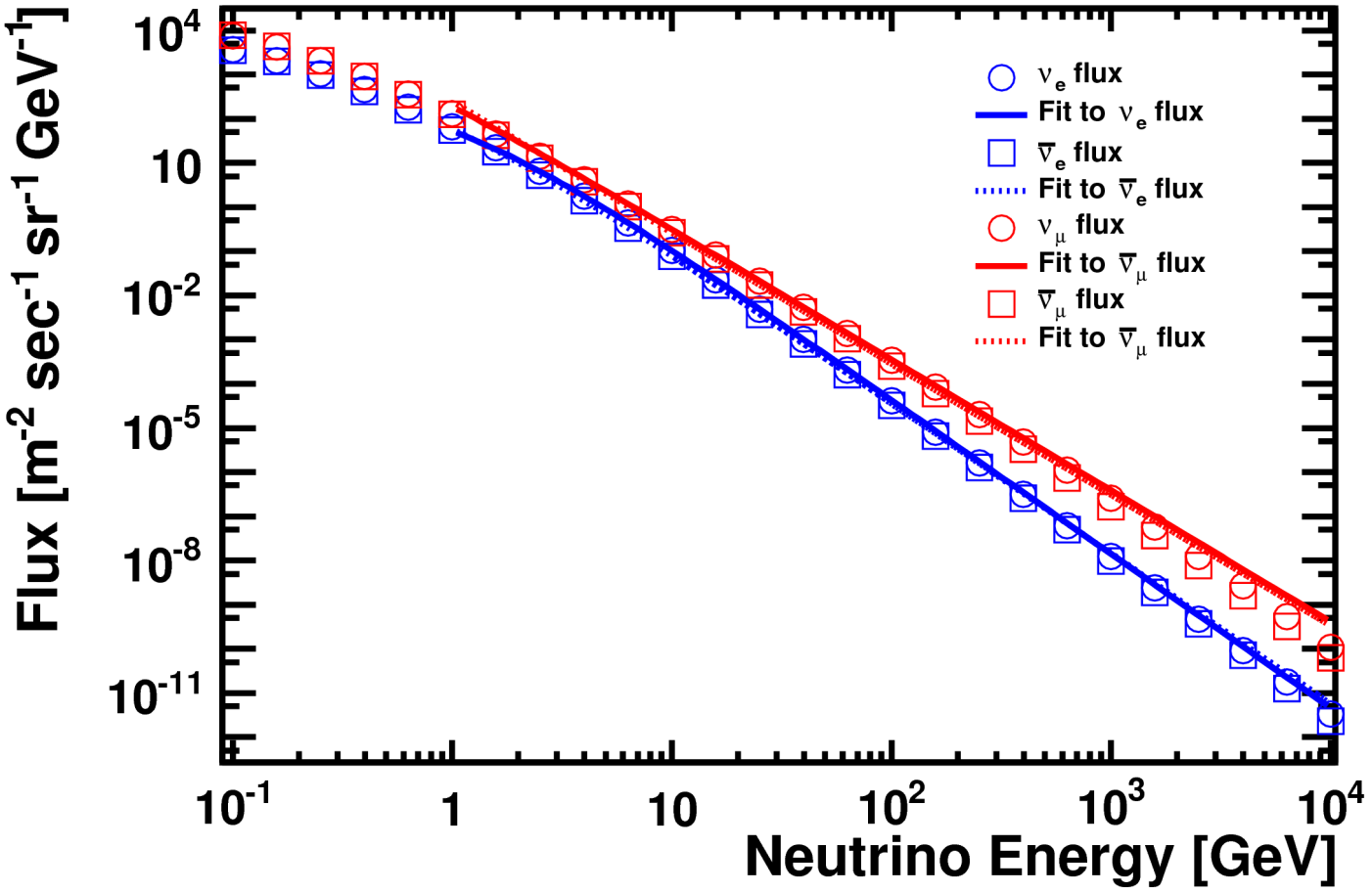


Conclusion for ν Event Generator

- Nuance and GENIE cross-sections seem to be consistent.
- Currently GENIE has better support and is actively developed.
- Choose GENIE.

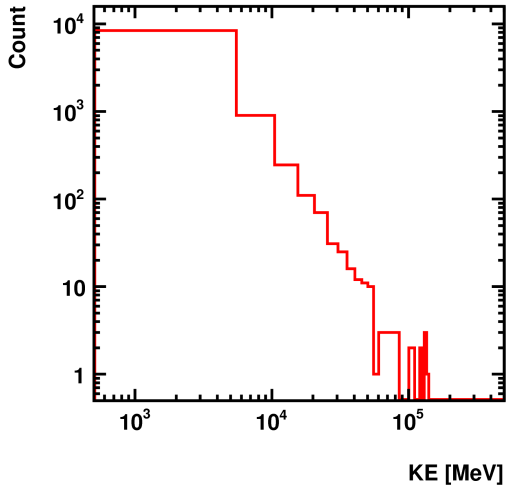
Calculated Atmospheric Neutrino Spectrum and Fit for Kamioka Mine

Honda et al. Improvement of low energy atmospheric neutrino flux calculation using the JAM nuclear interaction model Phys. Rev. D 83, 123001 (2011) [34 pages]

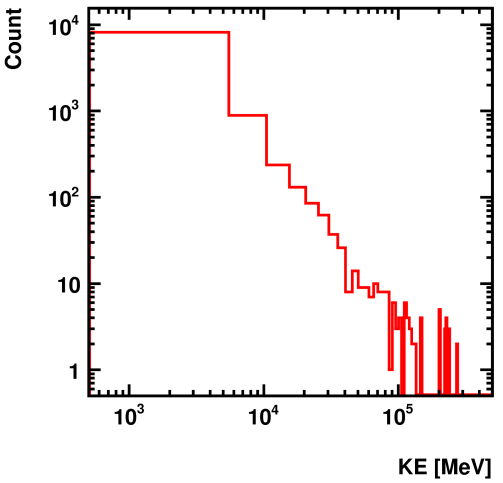


GENIE Neutrino Spectrum using Fit

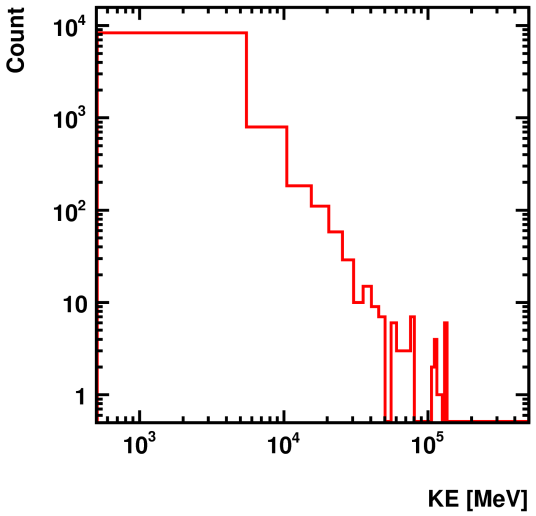
Nu_e



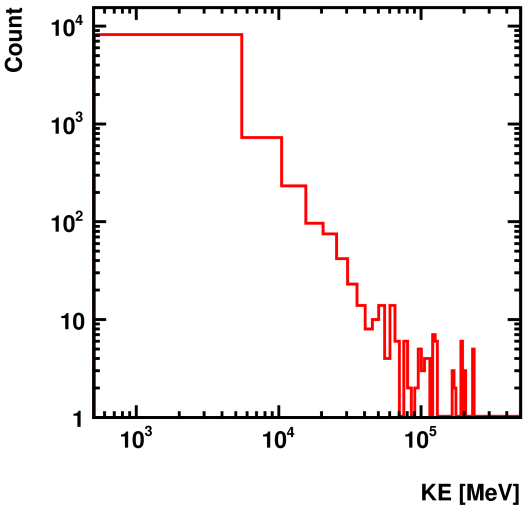
Nu_mu



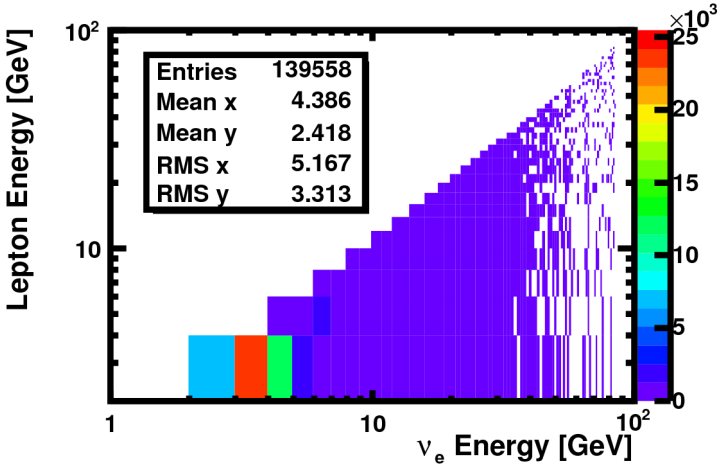
Antinu_e

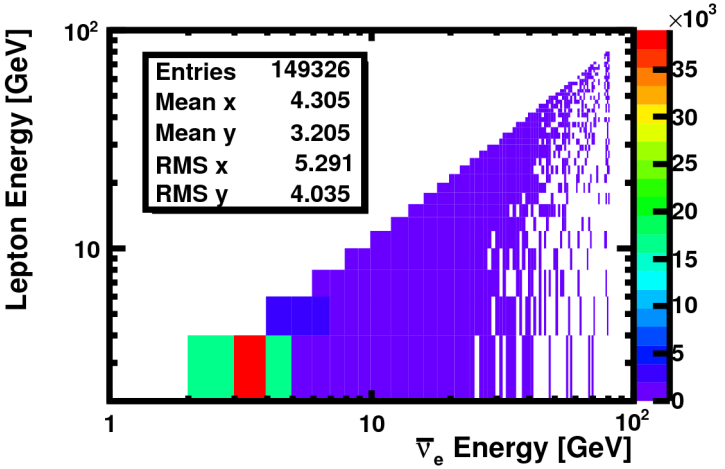


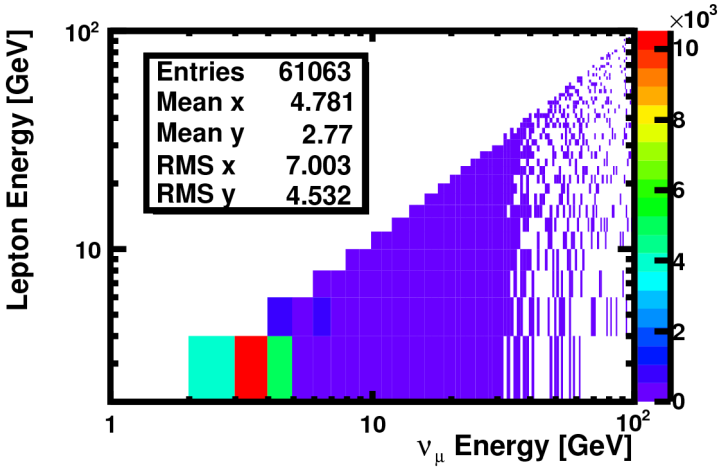
Antinu_mu

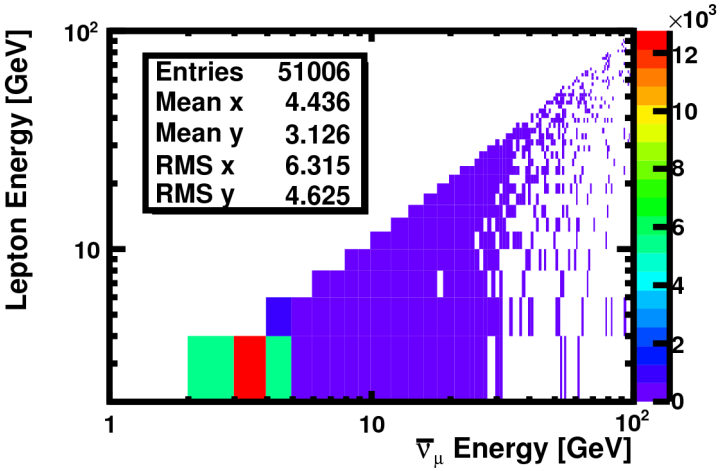


GENIE: Lepton VS Neutrino Energy

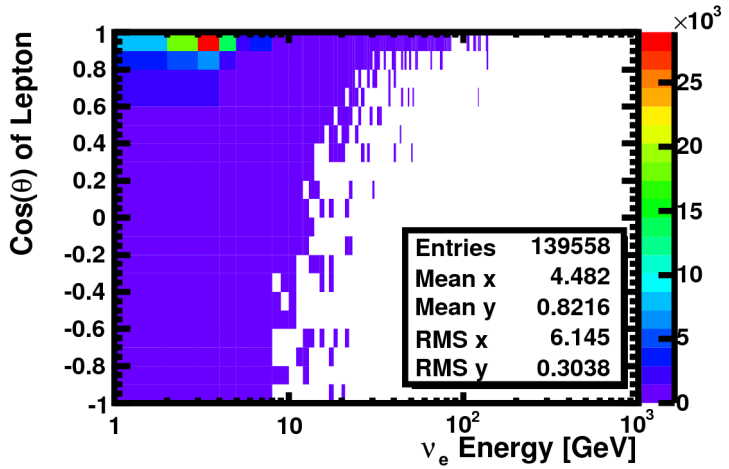


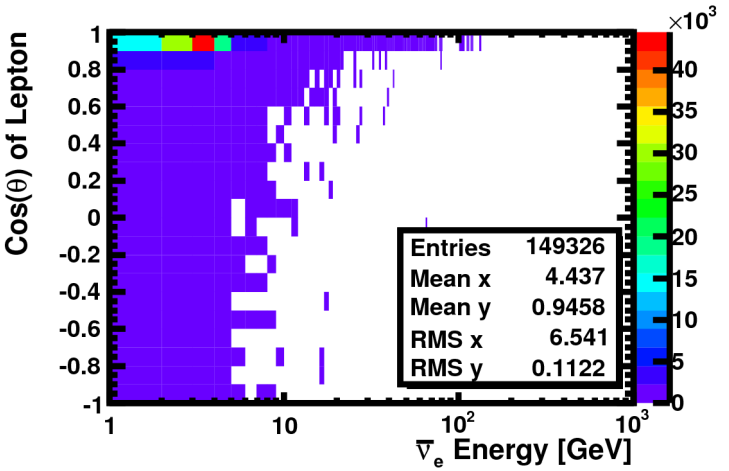


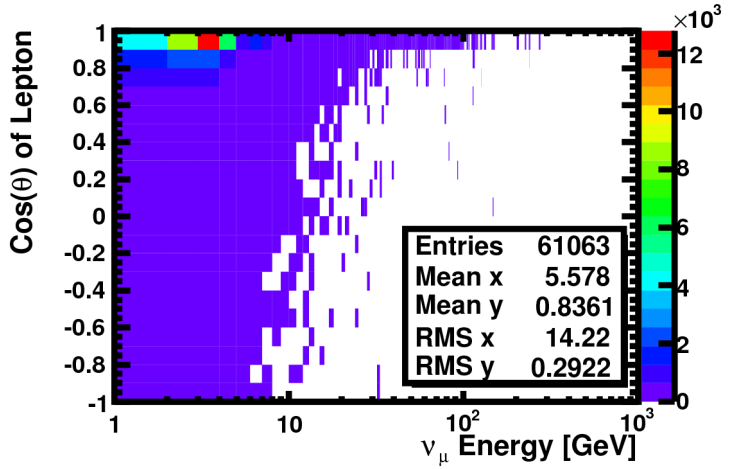


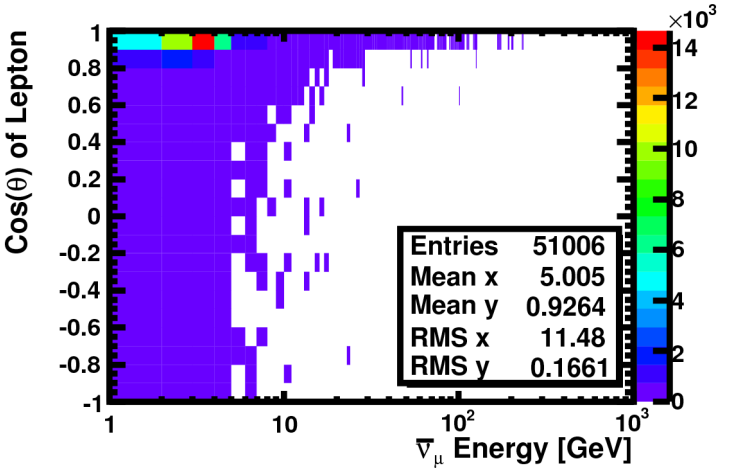


GENIE: Lepton Angle VS Neutrino Energy

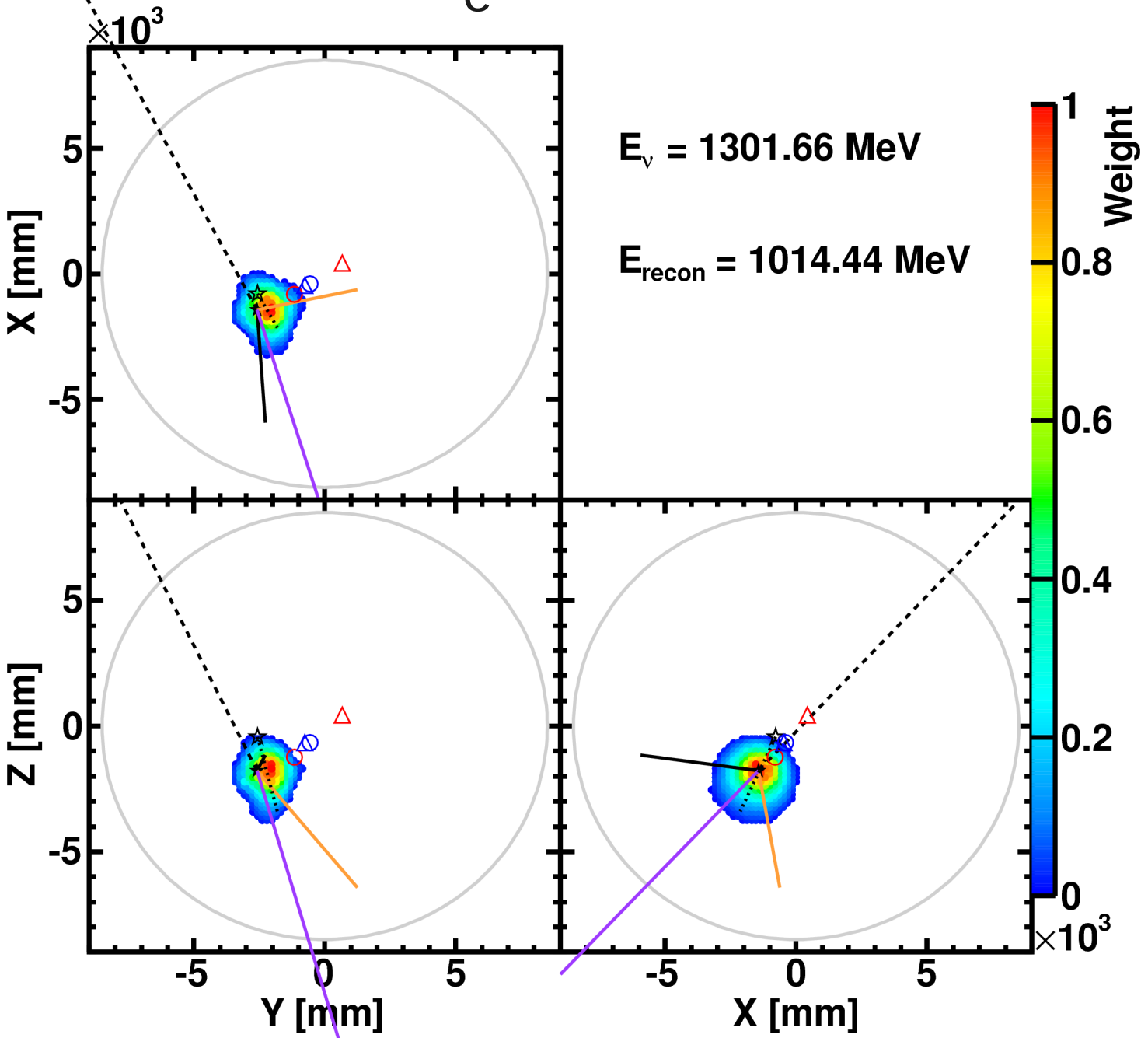








Sample ν_e Event (KLG4)



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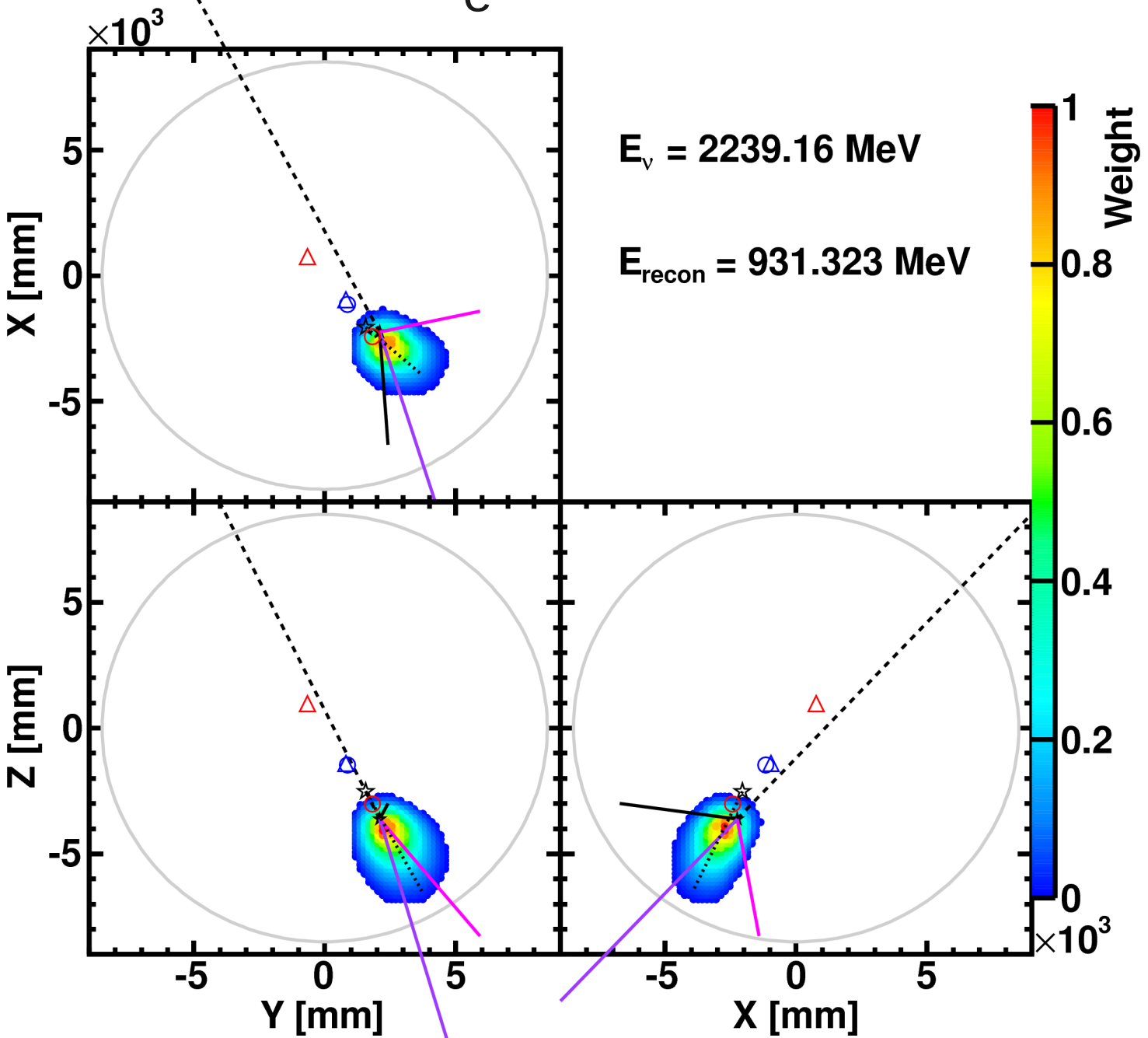
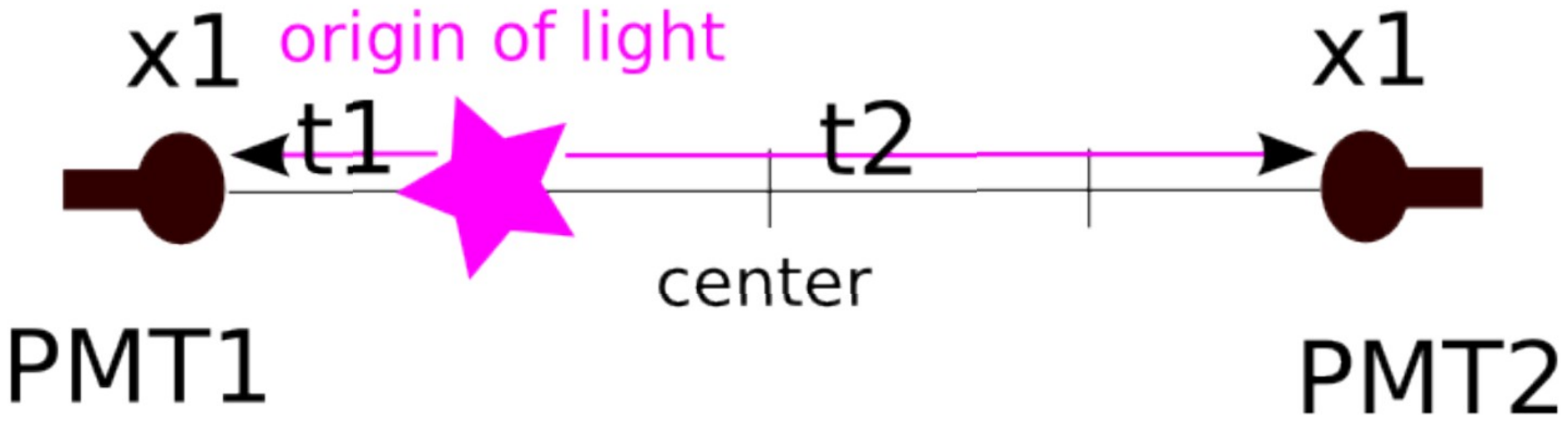


Neutrino Directionality: Center of Inverse Time

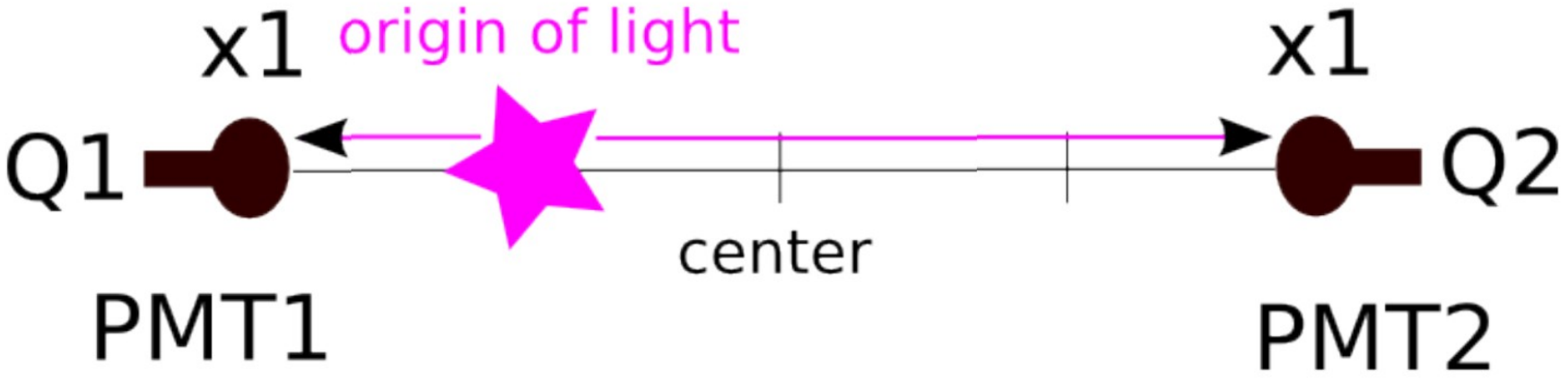
Algorithm



- Center of $\frac{1}{time}$ to fit initial guess of beginning of track.
- Center of $\frac{1}{time} = \frac{\frac{1}{t_1}x_1 + \frac{1}{t_2}x_2}{\frac{1}{t_1} + \frac{1}{t_2}} = \frac{1}{2}x_1$ gives correct vertex.

Neutrino Directionality: Center of Sqrt of Charge

Algorithm

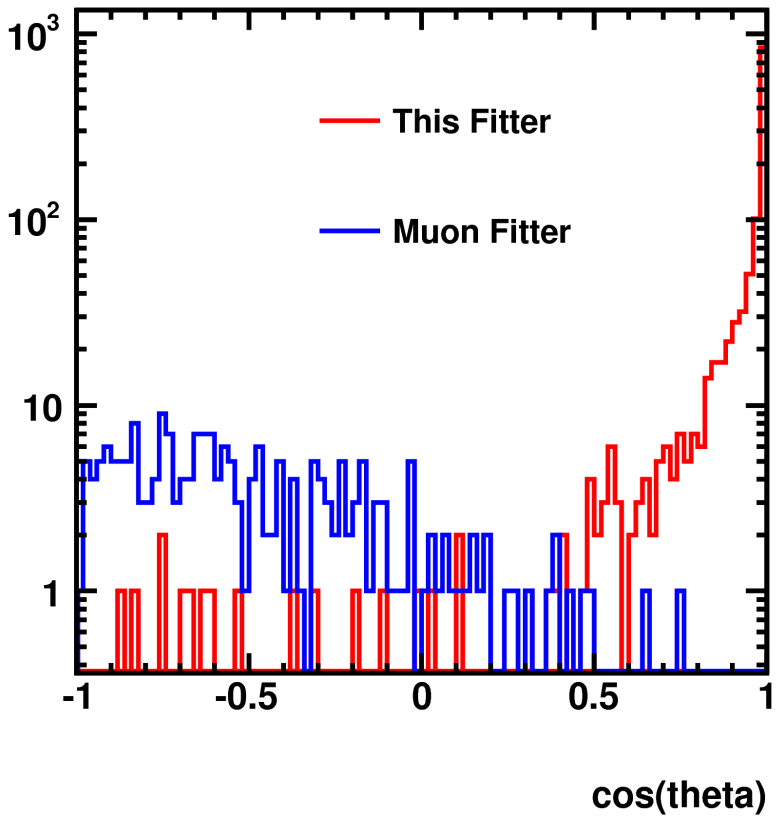


- Center of $\sqrt{charge}$ to fit initial guess of middle of track.
- Center of $\sqrt{charge} = \frac{\sqrt{q_1}x_1 + \sqrt{q_2}x_2}{\sqrt{q_1} + \sqrt{q_2}} = \frac{1}{2}x_1$ gives correct vertex.

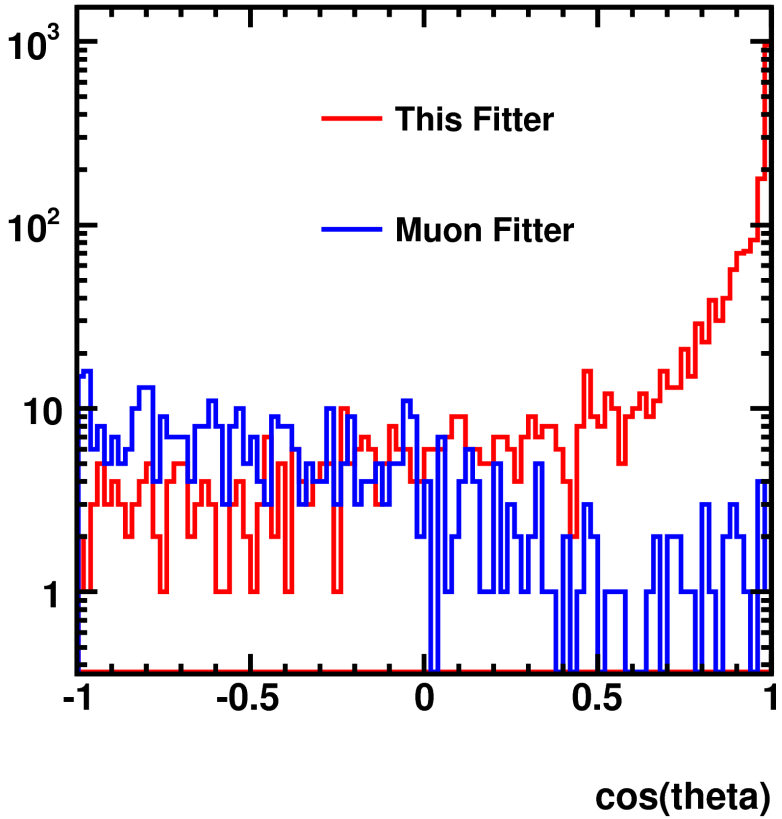
Vector from “center of 1/time” to “center of sqrt(charge)” is a good and quick estimate of particle direction.

FC Lepton Direction Fit (KLG4)

1GeV mu-

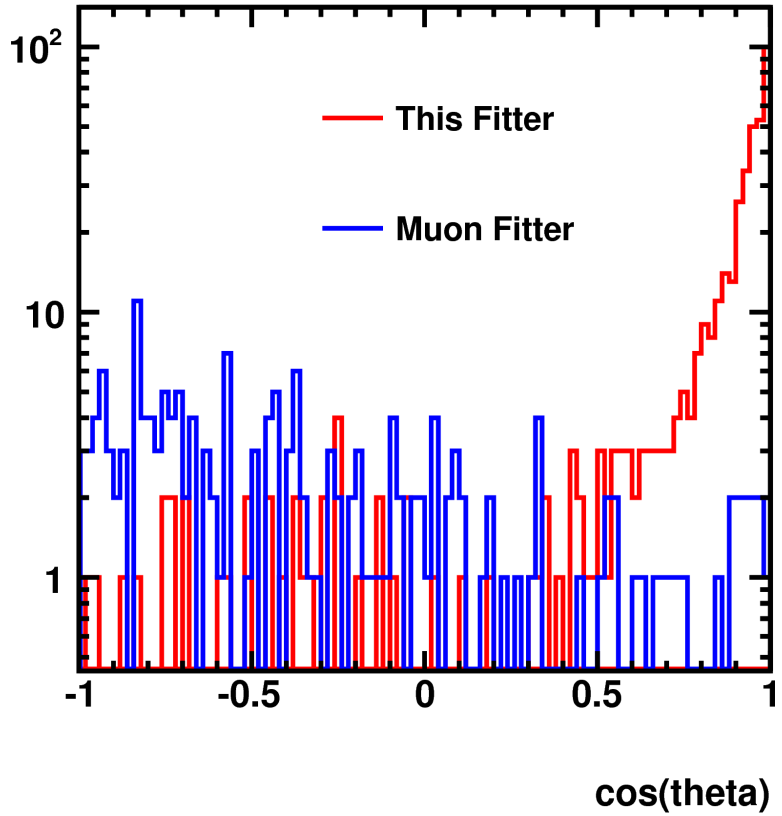


1GeV e+

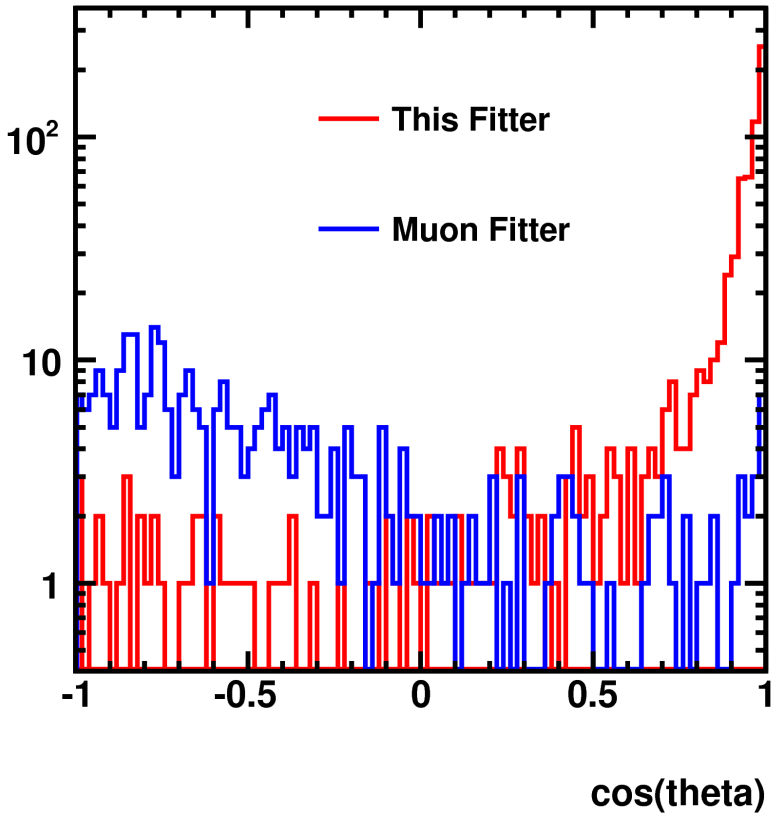


FC Nu_e Direction Fit (KLG4)

> 1GeV atmospheric nu_e

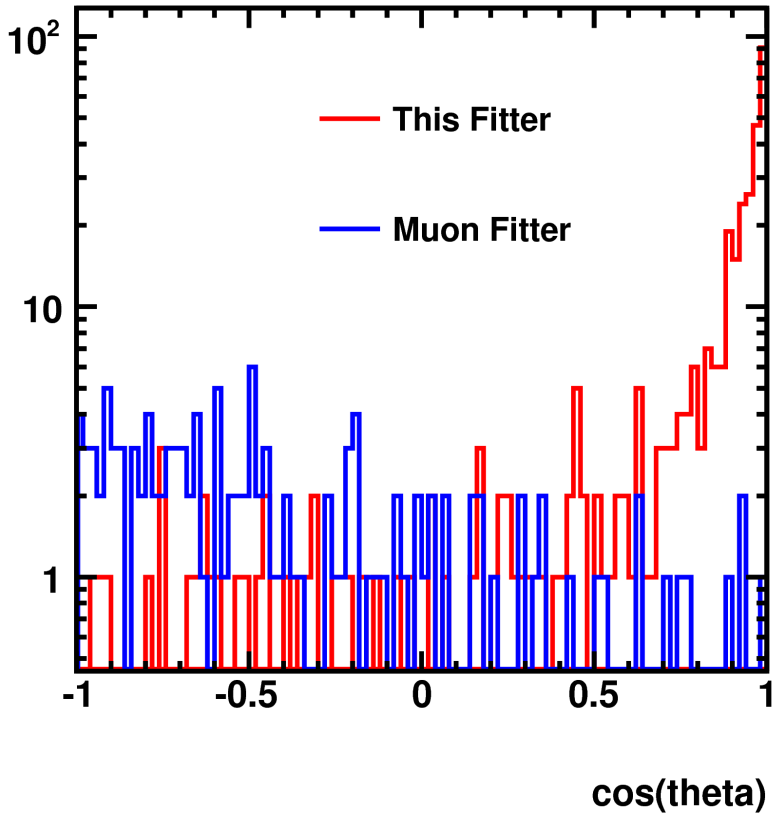


> 1GeV atmospheric nu_e_bar

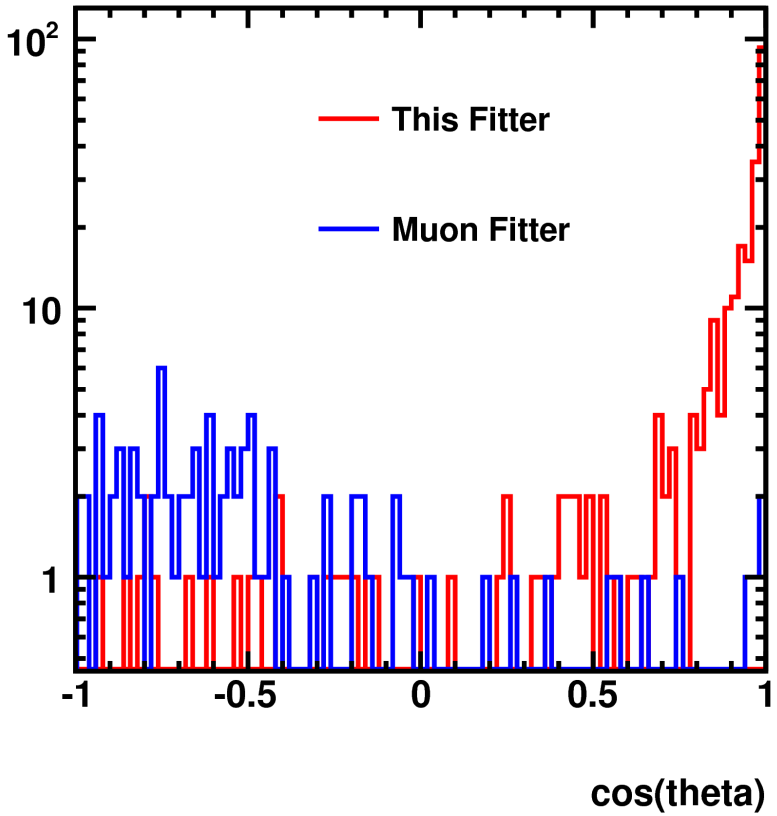


FC Nu_mu Direction Fit (KLG4)

> 1GeV atmospheric nu_mu

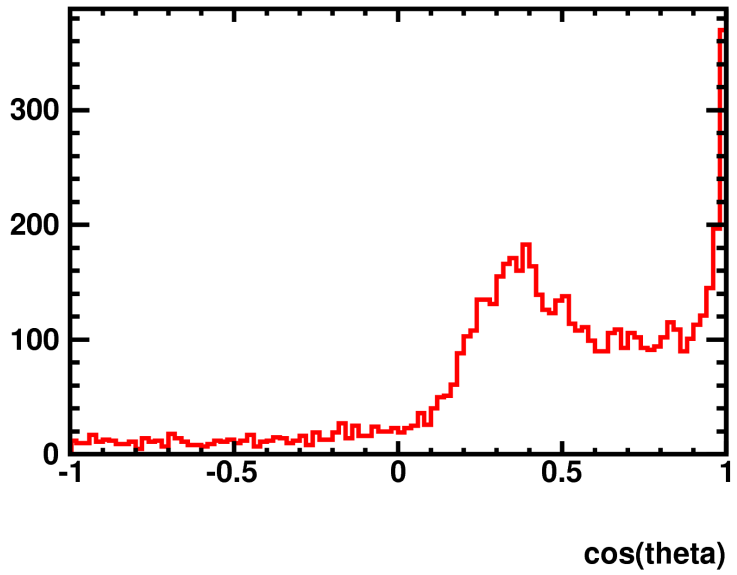


> 1GeV atmospheric nu_mu_bar

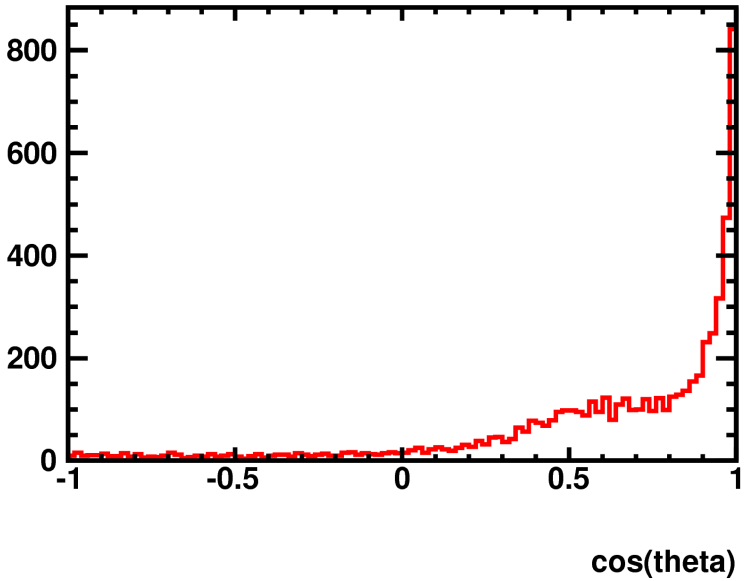


Disagreement of This Fitter from KAT Muon Fitter (muon from RTQ run 5000~5099)

No PE cut on PMTs



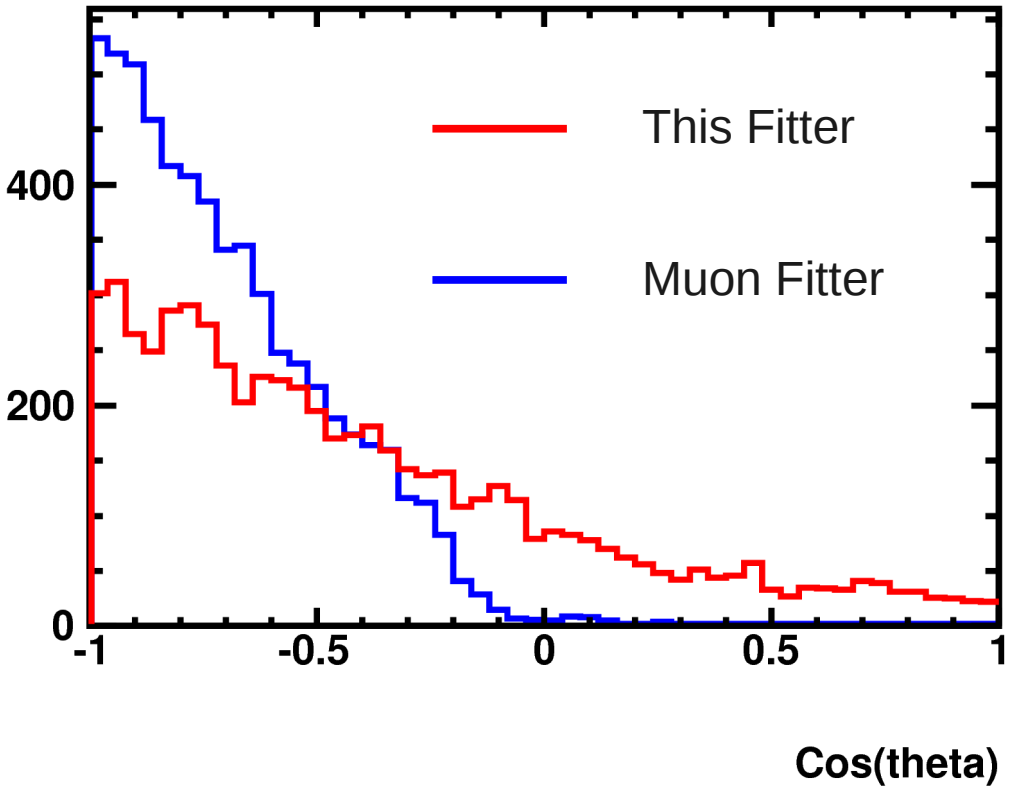
< 600 PE cut on PMTs



- Average OD Nsum ~45.
- Mostly through going muons.
- Prepulsing of PMTs near entry/exit points giving strange first hit times when calculating “center of 1/time”?

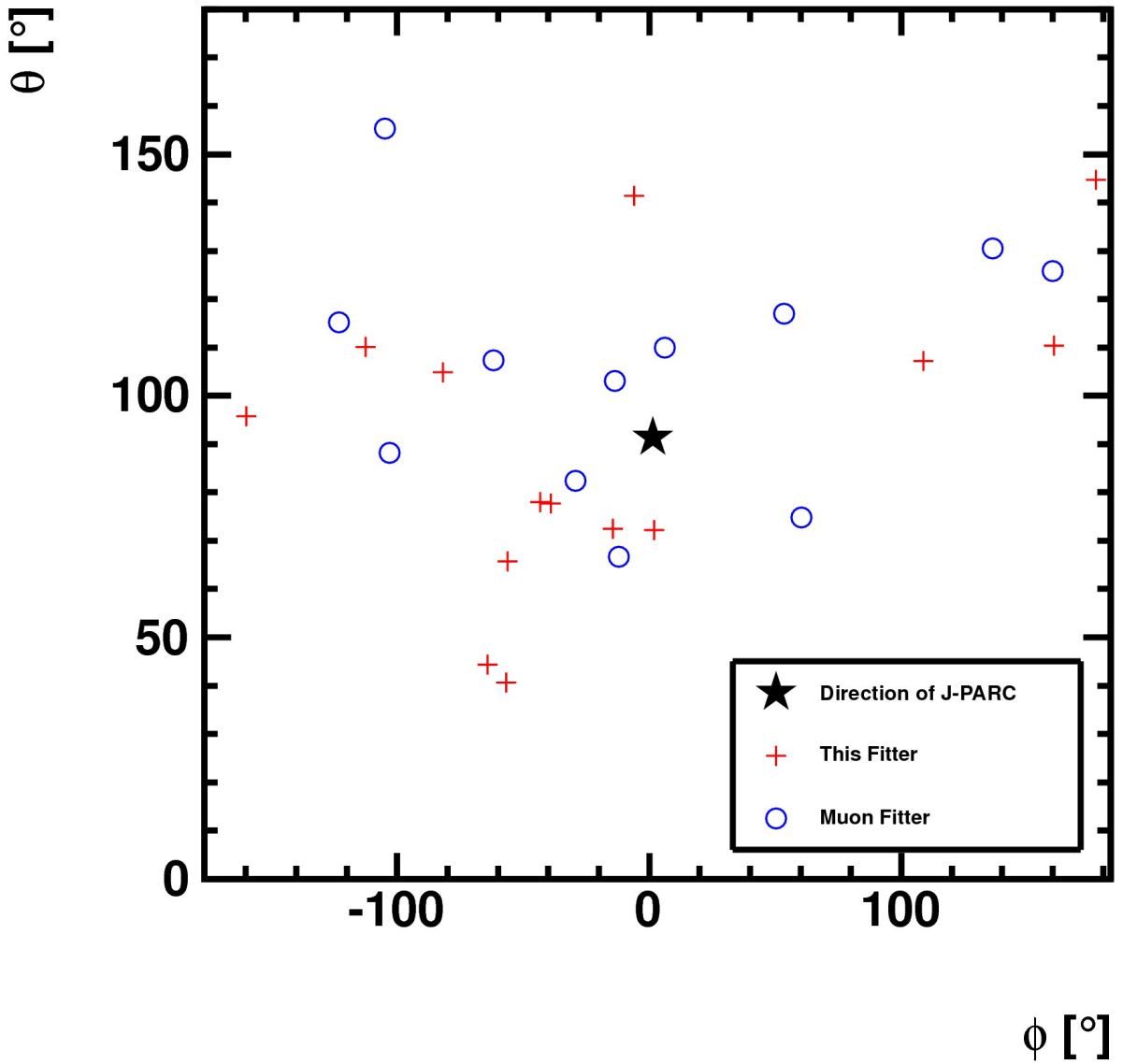
- Fitter agreement Improved by placing cut on PMTs with high first hit PE when calculating “center of 1/time”.

Zenith Angle of Both Fitters (muons from RTQ run 5000~5099)



- Muon Fitter is fitting through-going muons well.
- New fitter is less accurate for through going muons..

Reconstructed T2K Event Direction



Summary

- ν event generators were compared, and GENIE was selected.
- Fully contained atmospheric neutrino directionality achieved in KLG4Sim.
- T2K ν direction reconstruction tried with Muon fitter and new fitter.

To Do

- Use GENIE neutrino spectrum with finer bins.
- Combine advantages of both fitters to achieve good directionality in FC, PC, through-going events.
- Test algorithm on atmospheric neutrinos.