

# Neutrino Directionality

Test with KLG4

Michinari Sakai

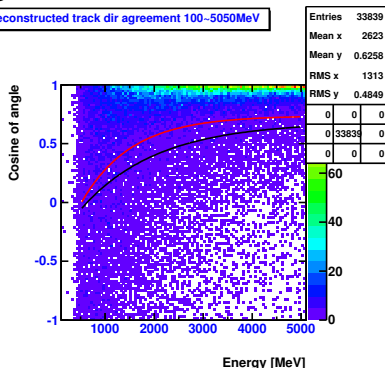
April 18, 2014

# Agreement between true/reconstructed $\nu$ angle

no fiducial volume cut

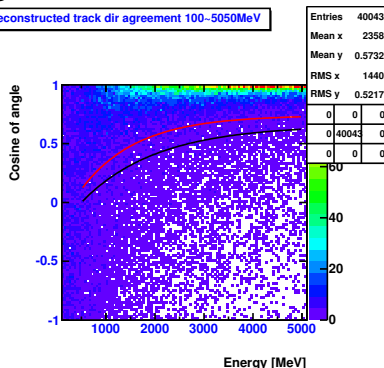
$$\nu_e + {}^1\text{H} \longrightarrow e^- + ?$$

reconstructed track dir agreement 100~5050MeV



$$\nu_e + {}^{12}\text{C} \longrightarrow e^- + ?$$

reconstructed track dir agreement 100~5050MeV

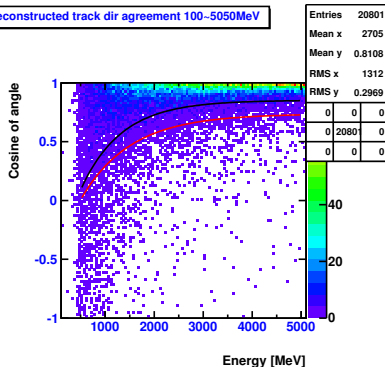


# Agreement between true/reconstructed $\nu$ angle

vertex  $R < 600$  cm

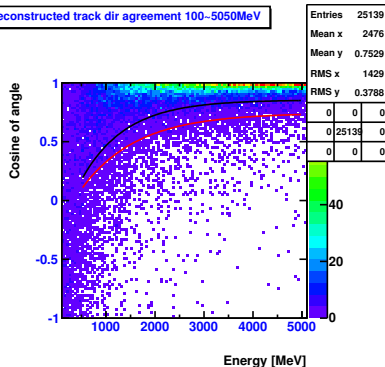
$$\nu_e + {}^1\text{H} \longrightarrow e^- + ?$$

reconstructed track dir agreement 100-5050MeV



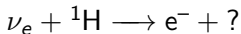
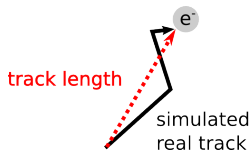
$$\nu_e + {}^{12}\text{C} \longrightarrow e^- + ?$$

reconstructed track dir agreement 100-5050MeV

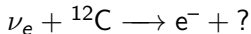
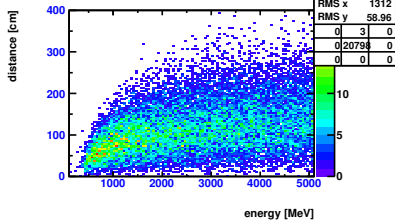


- ▶ Direction reconstruction is improved by fiducial volume cut on reconstructed vertex.
- ▶ What does the vertex mean for an finite size track shape event?

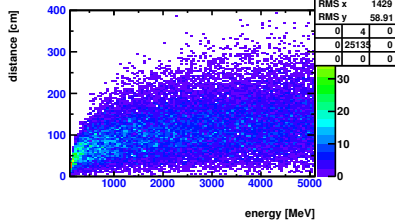
# $e^-$ track length



hist\_distBetweenPrimaryStartEndPoints

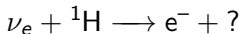
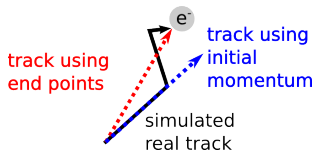


hist\_distBetweenPrimaryStartEndPoints

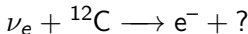
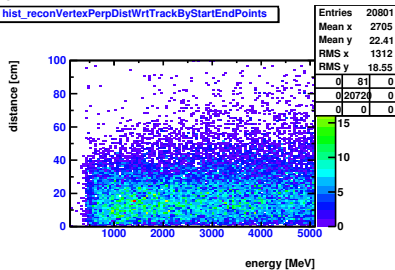


# Perpendicular distance from reconstructed vertex to track

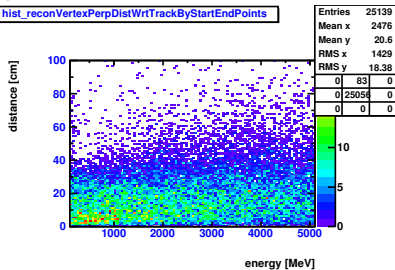
track using simulated track end points



hist\_reconVertexPerpDistWrtTrackByStartEndPoints

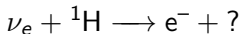
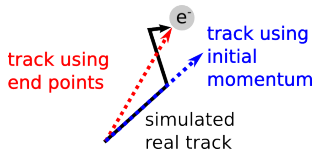


hist\_reconVertexPerpDistWrtTrackByStartEndPoints

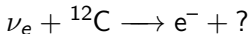
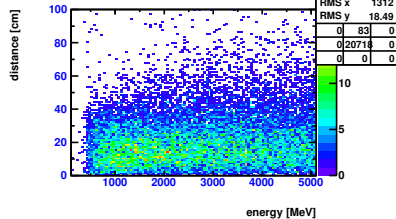


# Perpendicular distance from reconstructed vertex to track

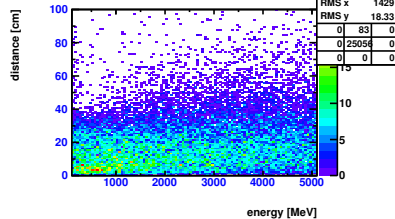
track using simulated initial momentum



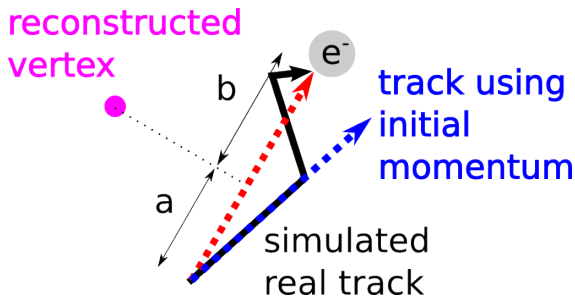
hist\_reconVertexPerpDistWrtTrackByMomentum



hist\_reconVertexPerpDistWrtTrackByMomentum

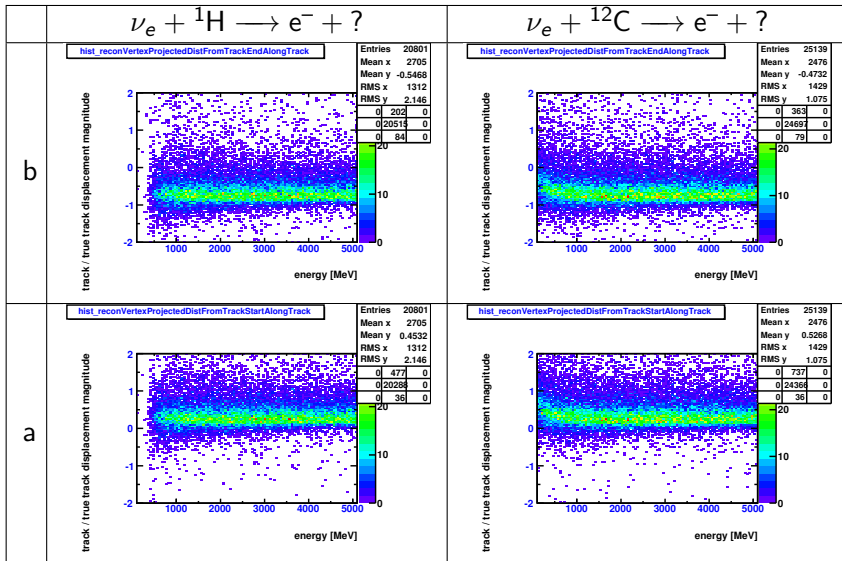


# Distance of reconstructed vertex from track end points projected along tracks





# Distance of reconstructed vertex from track end points projected along tracks



# Conclusion for reconstruction vertex

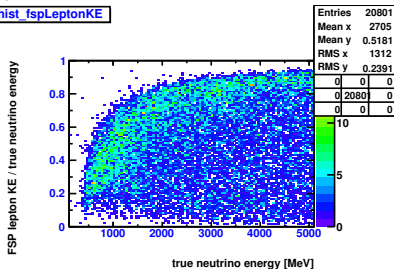
For  $\nu$  energies 100 MeV to 5000 MeV:

- ▶ Vertex is within 40cm from track
- ▶ Vertex is on average at middle of track
- ▶ peak of vertex distribution is biased toward track beginning.

# Lepton energy vs true $\nu$ energy

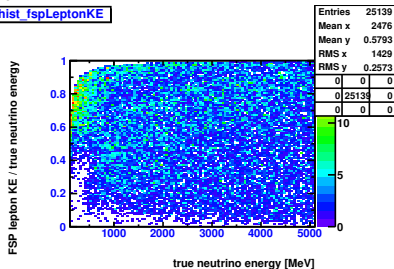
$$\nu_e + {}^1\text{H} \longrightarrow e^- + ?$$

hist\_fspLeptonKE



$$\nu_e + {}^{12}\text{C} \longrightarrow e^- + ?$$

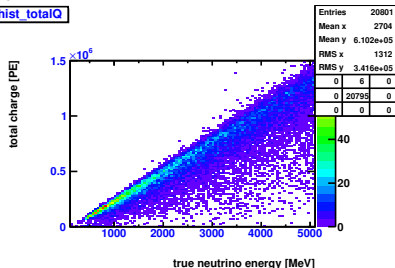
hist\_fspLeptonKE



# Total charge vs true $\nu$ energy

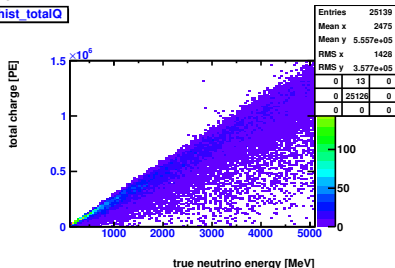
$$\nu_e + {}^1\text{H} \rightarrow \text{e}^- + ?$$

hist\_totalQ

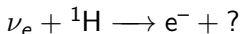


$$\nu_e + {}^{12}\text{C} \rightarrow \text{e}^- + ?$$

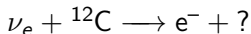
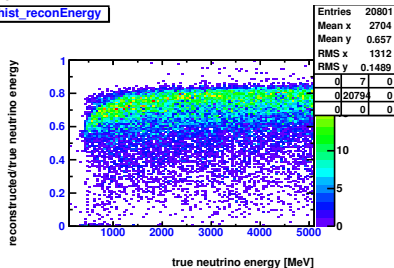
hist\_totalQ



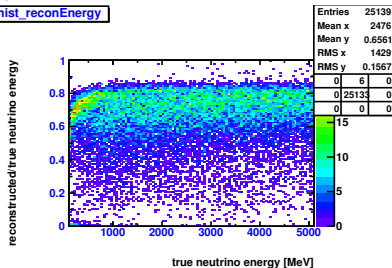
# Reconstructed vs true $\nu$ energy



hist\_reconEnergy



hist\_reconEnergy



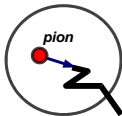
Consistently 80% of energy is reconstructed for extremely large energy range.

# Pion energy loss in nucleus?



## Intranuclear rescattering

nucleus



Very important effect at low energies !!

$$E(\text{visible}) \neq E(\text{neutrino})$$

- Large fraction of the pion energy can be lost within the nucleus
- Hadronic energy scale calibration has MC-dependence

Outline

Introduction

Softw. highlights

Physics

$\nu N$  at  $\sim \text{GeV}$

Basics

QEL

RES

DIS

Summing-up

RES  $\rightarrow$  DIS

Hadronization

**Intranuke**

RFG

Etc

Uncertainties

Development path

Summary

