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Flux window from off axis NuMI

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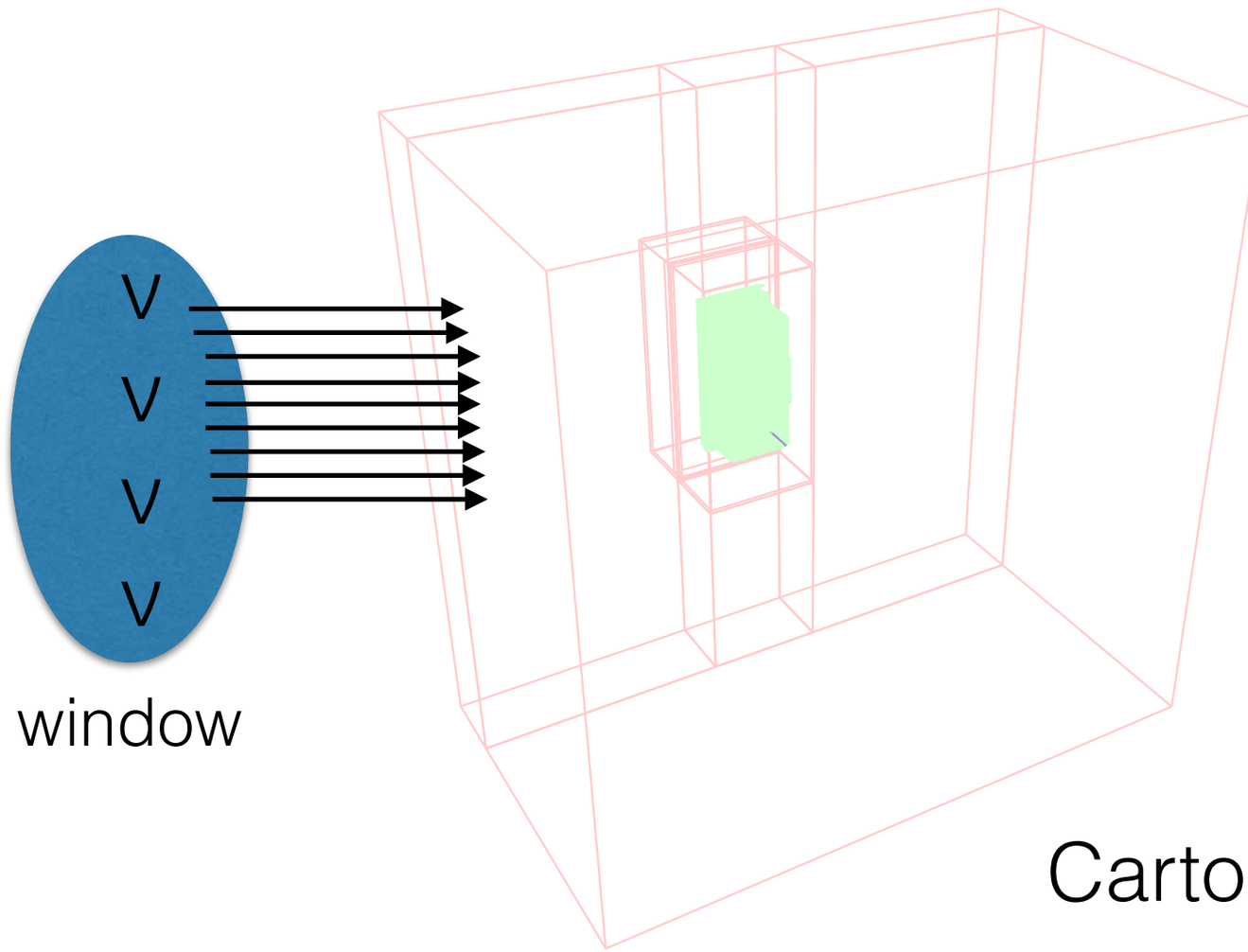
September 20 2018

First Step

- Use the latest MINERvA flux and run GENIE using the detector coordinates
- GENIE needs specific a window to generate the flux

`icarus_geo_5mar2018.gdml`



Cartoon for illustration

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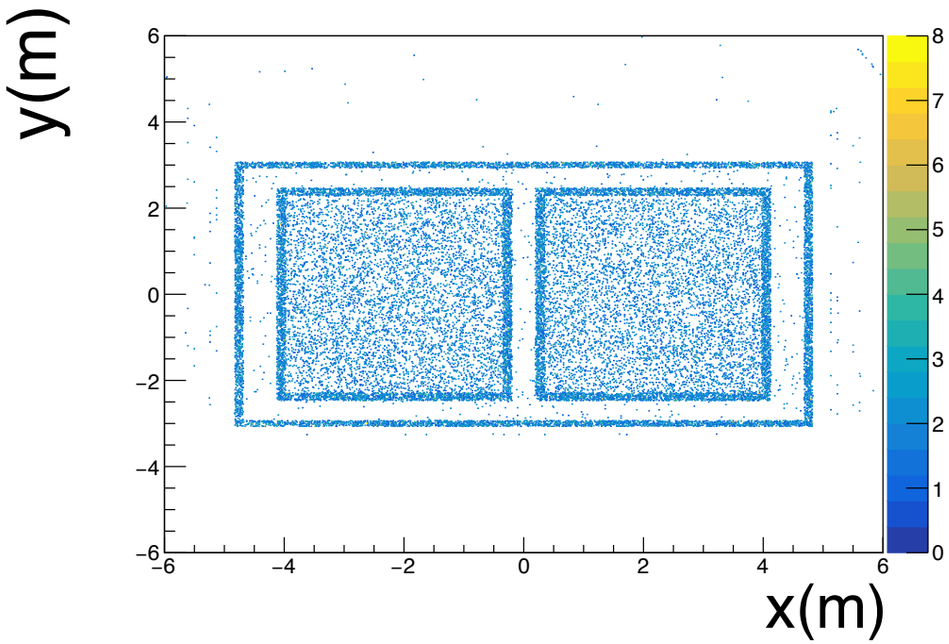
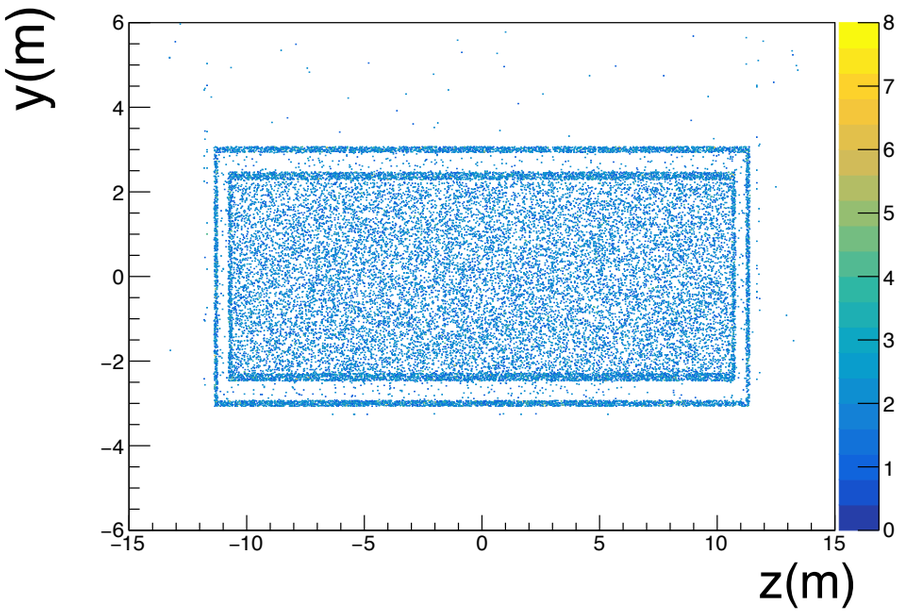
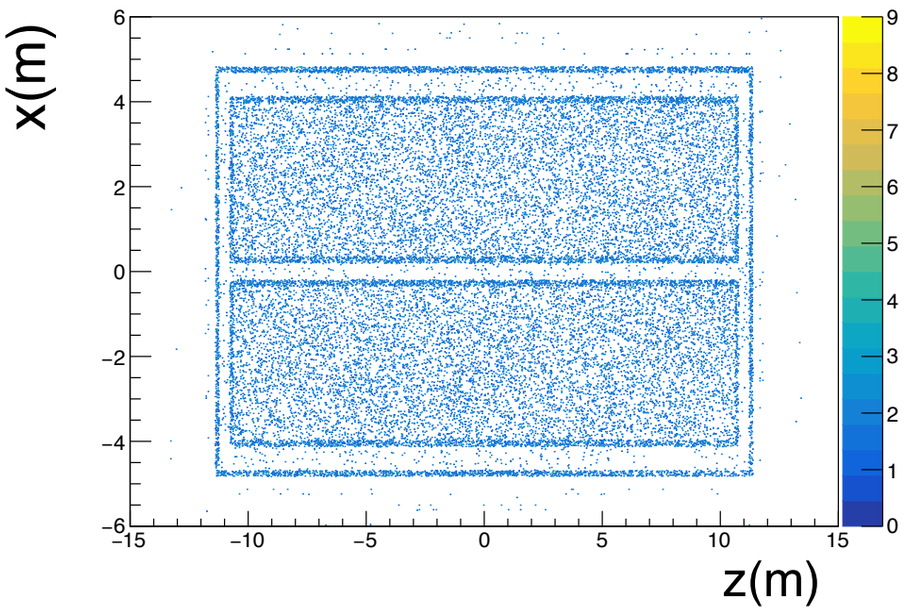
GENIE events at ICARUS from NuMI off axis

- Ran 50000 events (nue, nuebar, numu and numubar): 5.8e18 POT
  - NuMI produces about 5.5 e20 POT per year



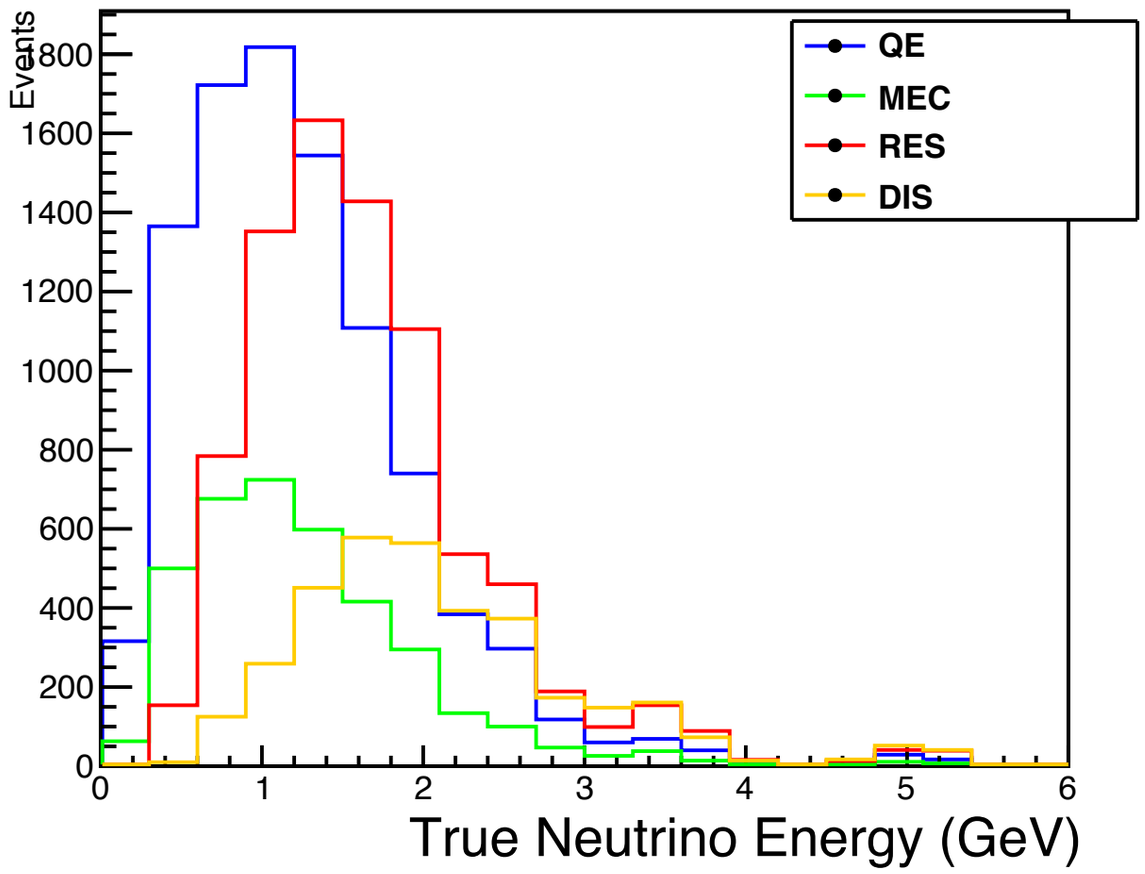




Neutrino Interactions

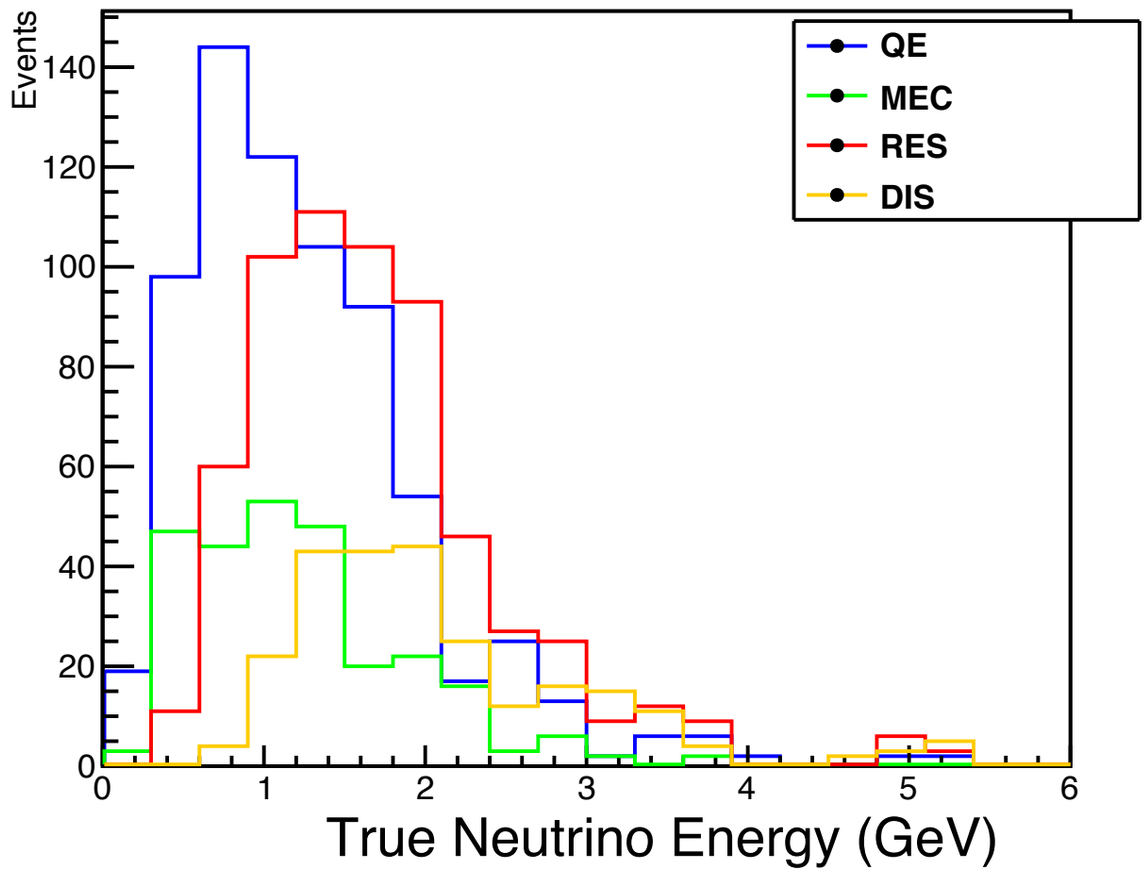
- Ran 50000 events (nue, nuebar, numu and numubar): 5.8e18 POT

vμ+vμ bar



QE 19721 MEC 7325
RES 12317 DIS 7396

ve+ve bar



QE 708 MEC 266
RES 618 DIS 249

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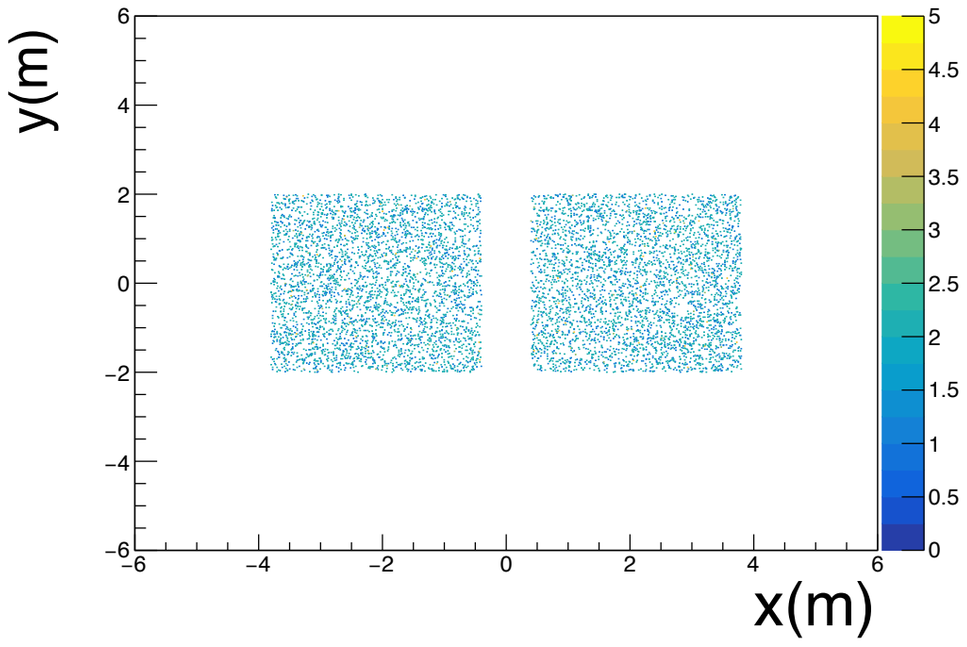
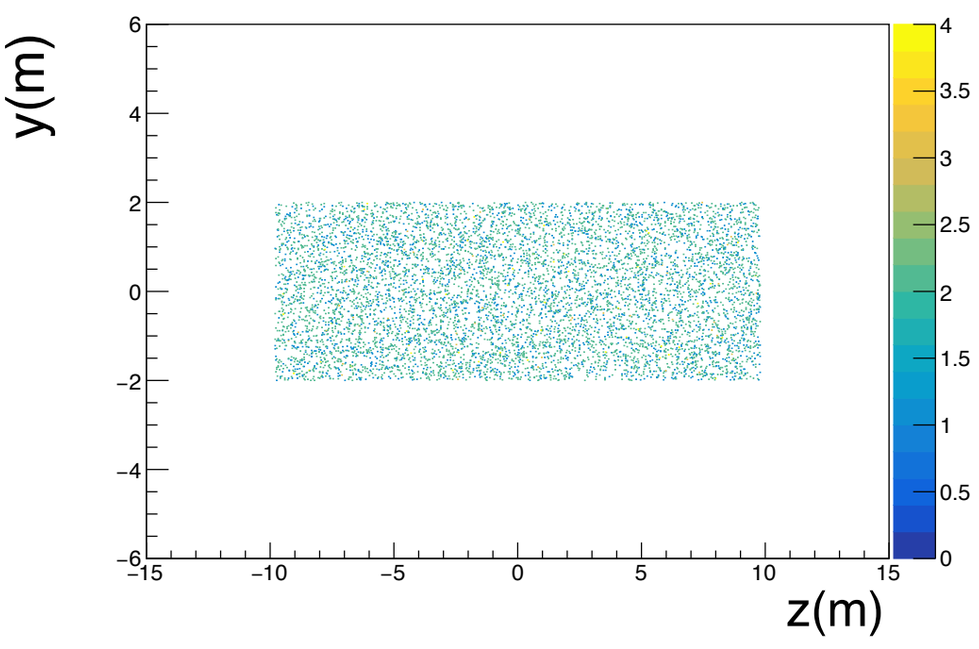
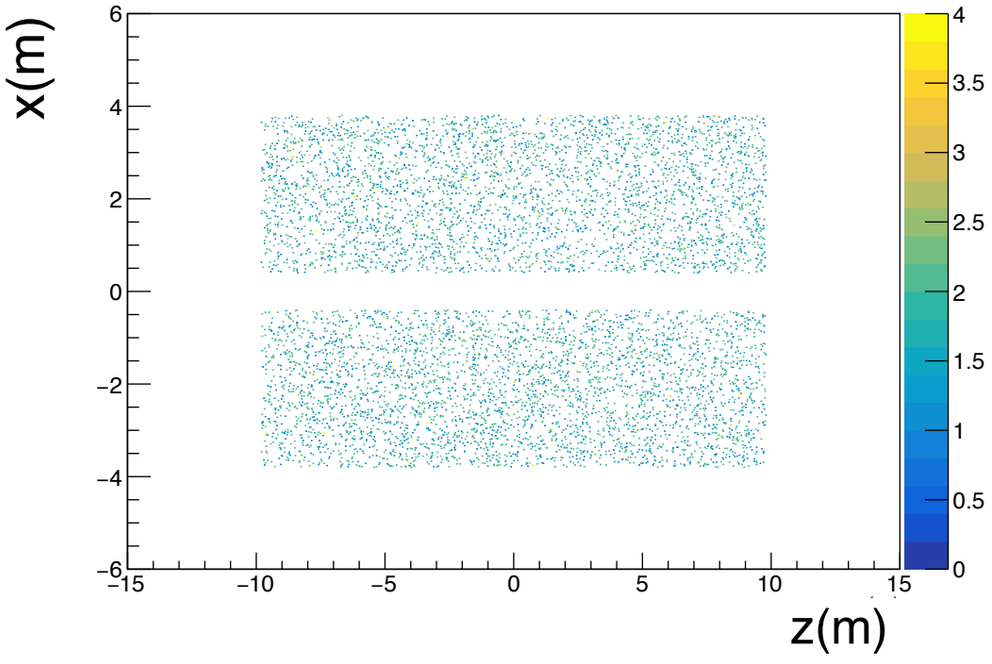
Neutrino Interactions at Fiducial Volumen

- Applying fiducial cuts ~ 20 cm cut from the edge of the detector







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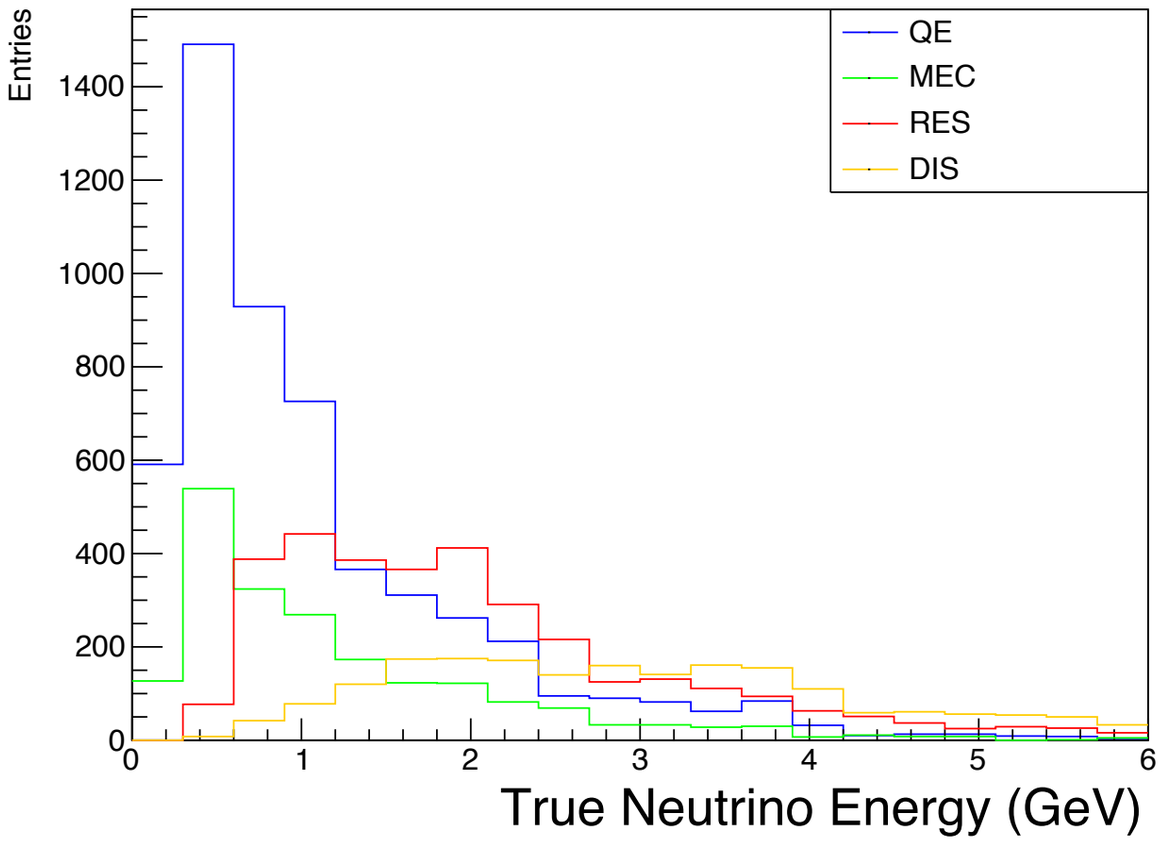
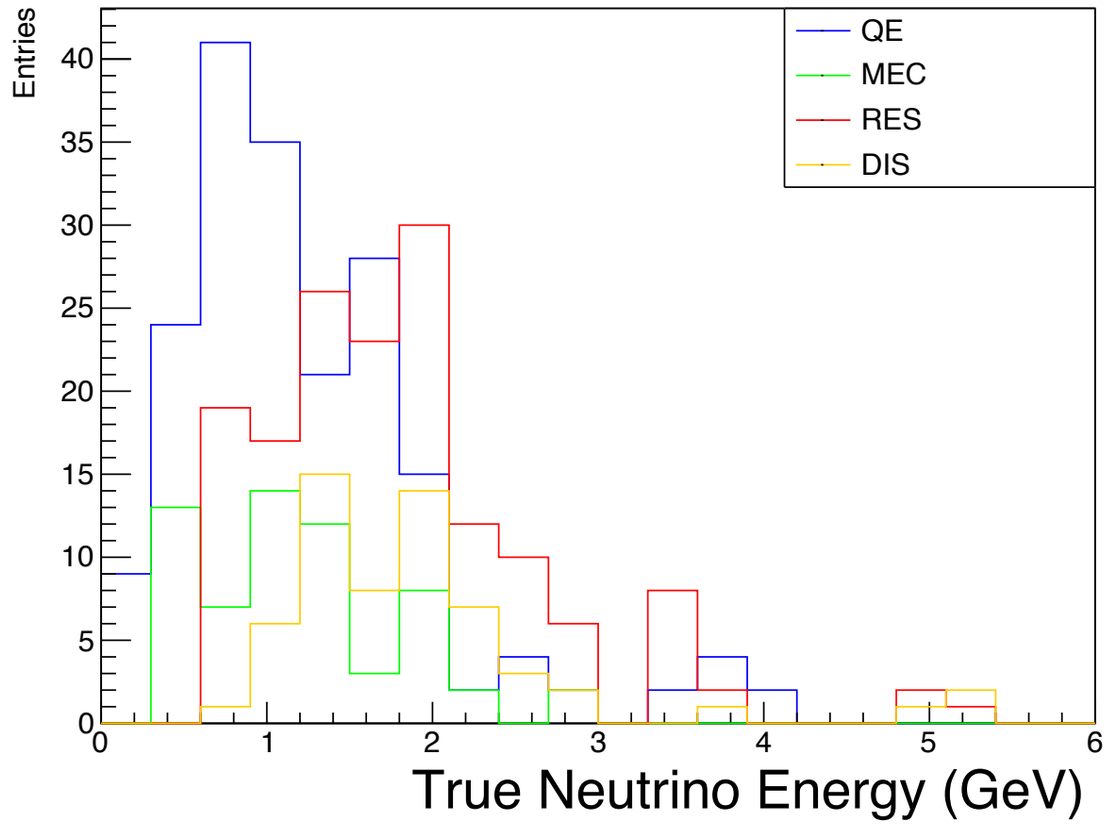


QE 5201 MEC 1931
RES 3130 DIS 1888

ve+ve bar



QE 189 MEC 61
RES 156 DIS 60

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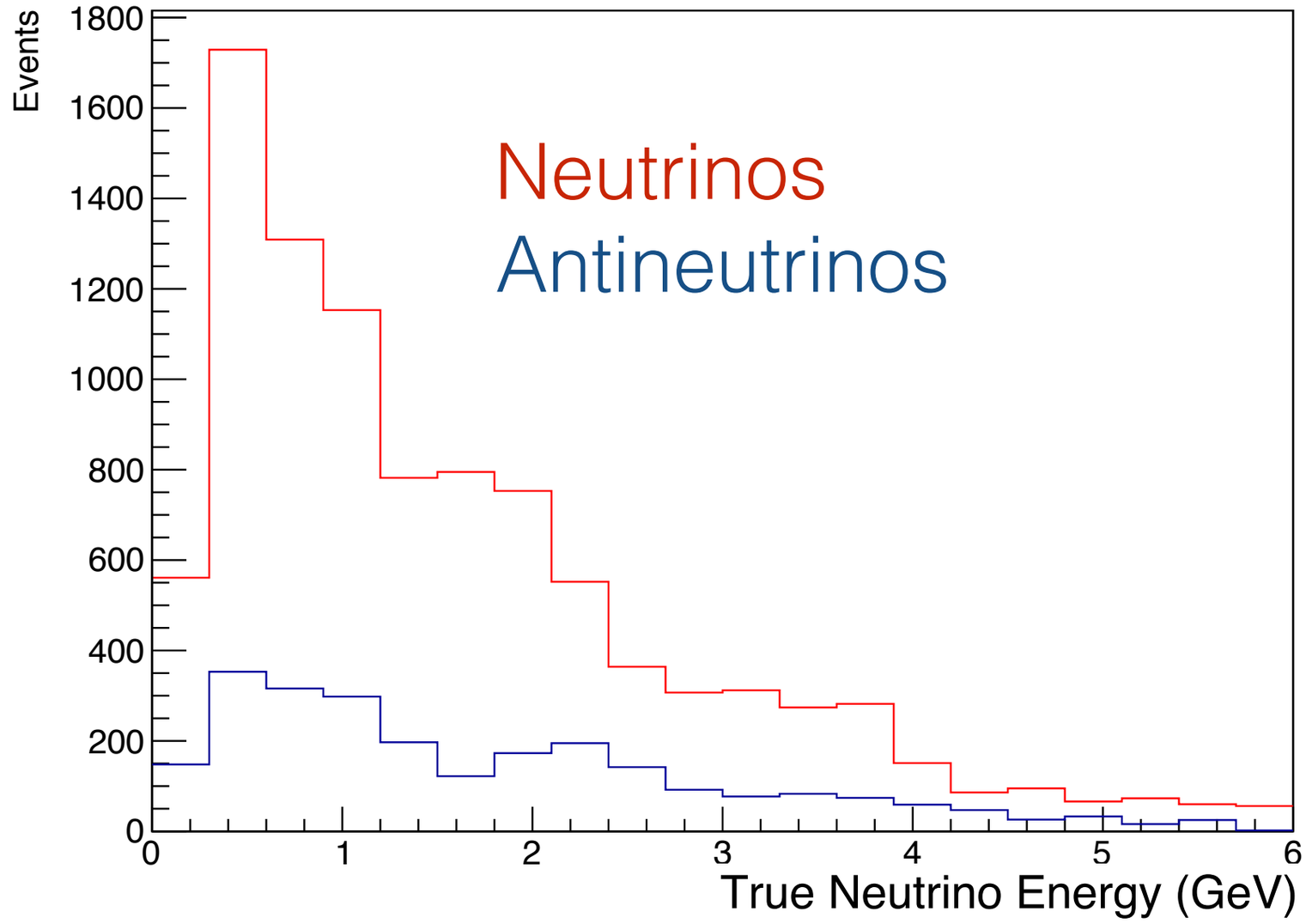
Neutrinos and Antineutrinos

- Muon neutrino and muon antineutrino



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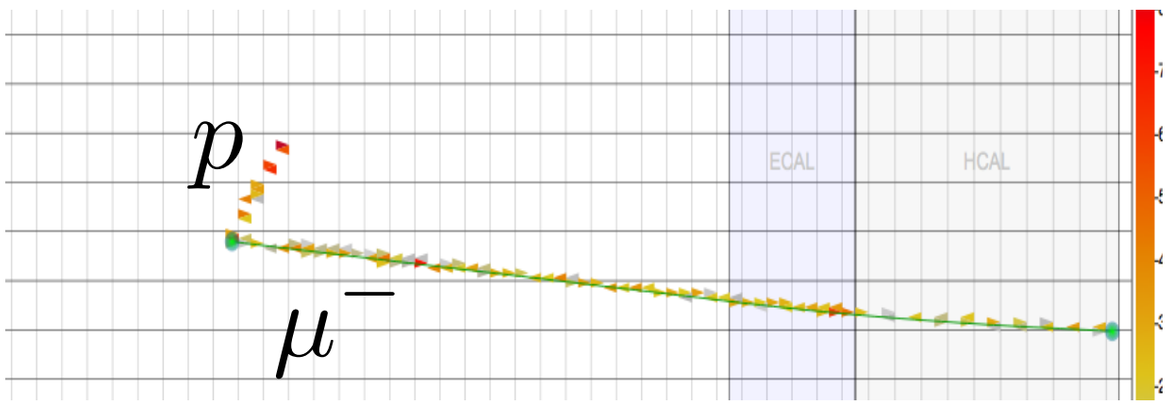
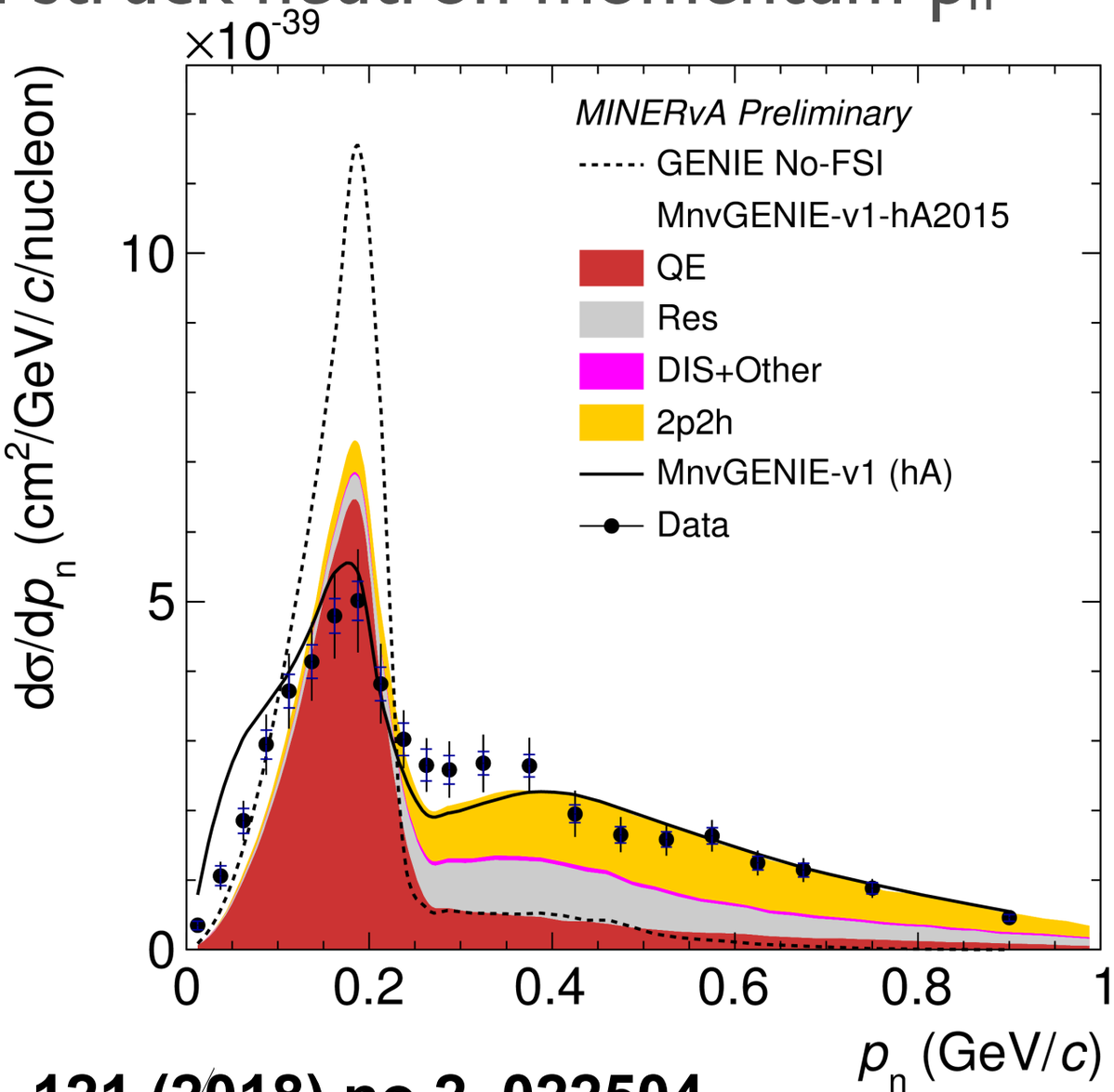
Quasi Elastic Scattering Measurements

- MINERvA experiment measured quasi-elastic interactions with 2 tracks
- Differential cross section in initial struck neutron momentum p_n

- One muon, no pions and at least one proton with momentum > 450 MeV/c





Phys.Rev.Lett. 121 (2018) no.2, 022504

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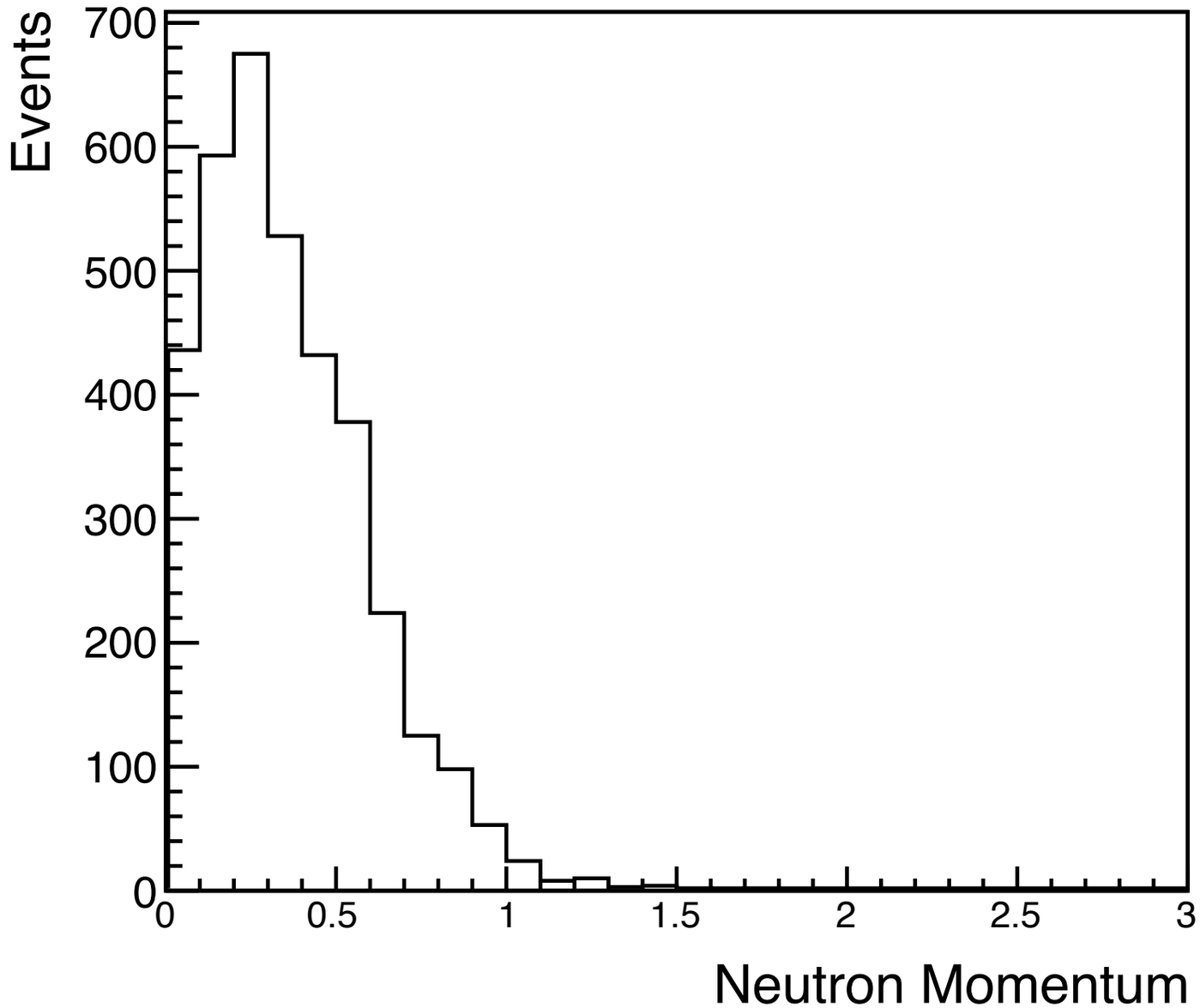
Prediction for ICARUS

- One muon, no pions and at least on proton with momentum>300 MeV/c



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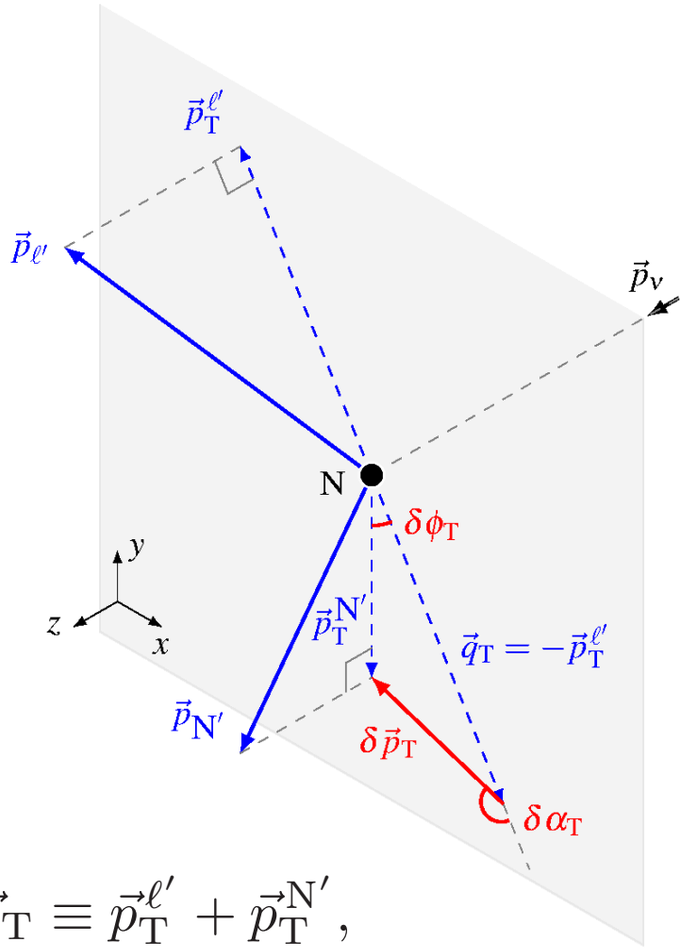
Next

- We need to generate a good sample of neutrino interactions and reconstruct the events to start some analysis
- Include the flux constraints from the MINERvA experiment, MINERvA had used external data to constraint the NuMI flux

Back Slides

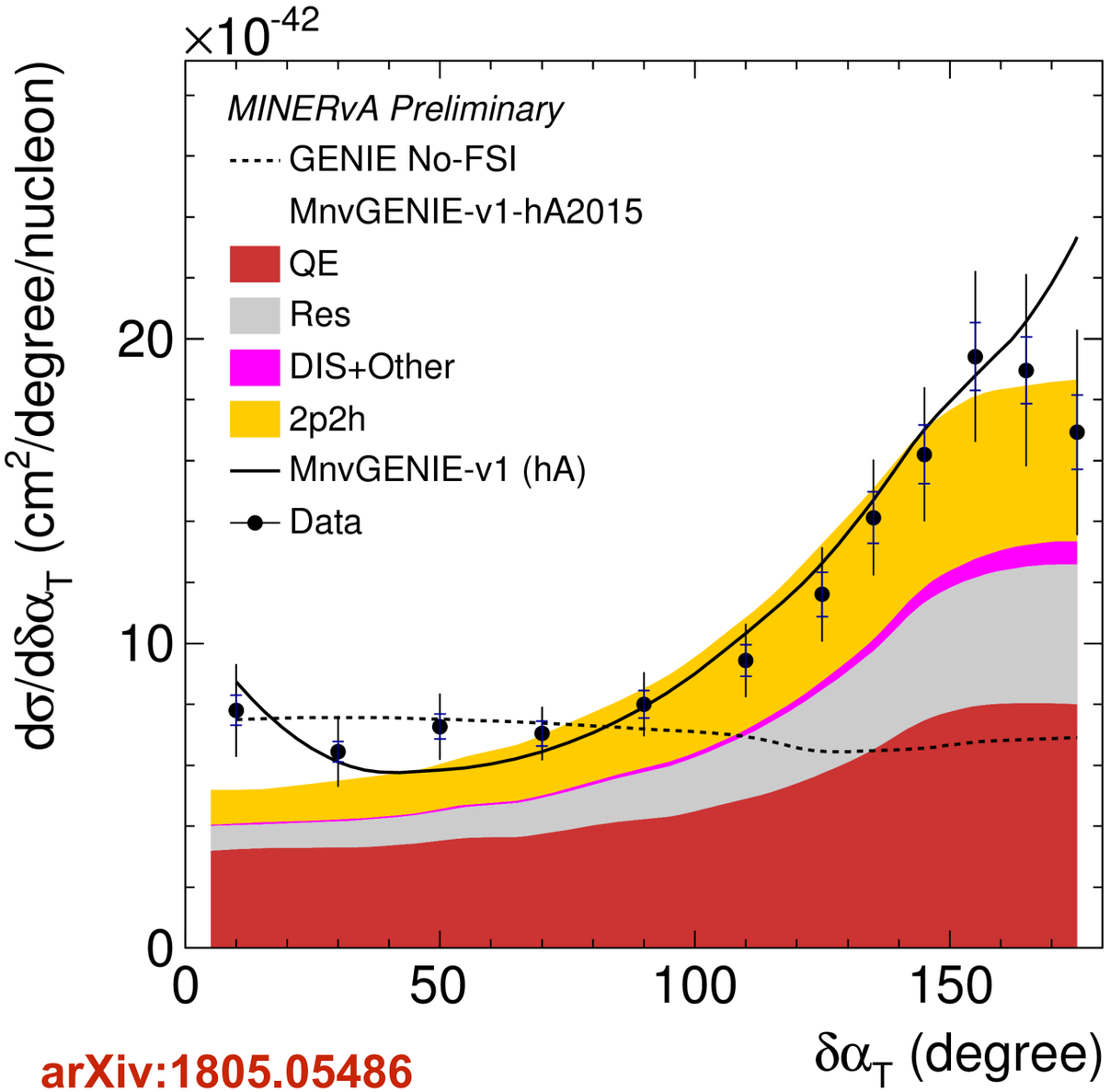
Transverse Kinematic Imbalances (CCQE-like sample)

- Differential cross section in transverse boosting angle $\delta\alpha_T$
  - The transverse boosting angle $\delta\alpha_T$ represents the direction of the transverse momentum imbalance



$$\delta\vec{p}_{\mathrm{T}} \equiv \vec{p}_{\mathrm{T}}^{\,\ell'} + \vec{p}_{\mathrm{T}}^{\,\mathrm{N}'},$$

$$\delta\alpha_{\mathrm{T}} \equiv \arccos\frac{-\vec{p}_{\mathrm{T}}^{\,\ell'} \cdot \delta\vec{p}_{\mathrm{T}}}{p_{\mathrm{T}}^{\ell'}\delta p_{\mathrm{T}}},$$



arXiv:1805.05486

CCQE-like: One muon, no pions and at least one proton with momentum > 450 MeV/c

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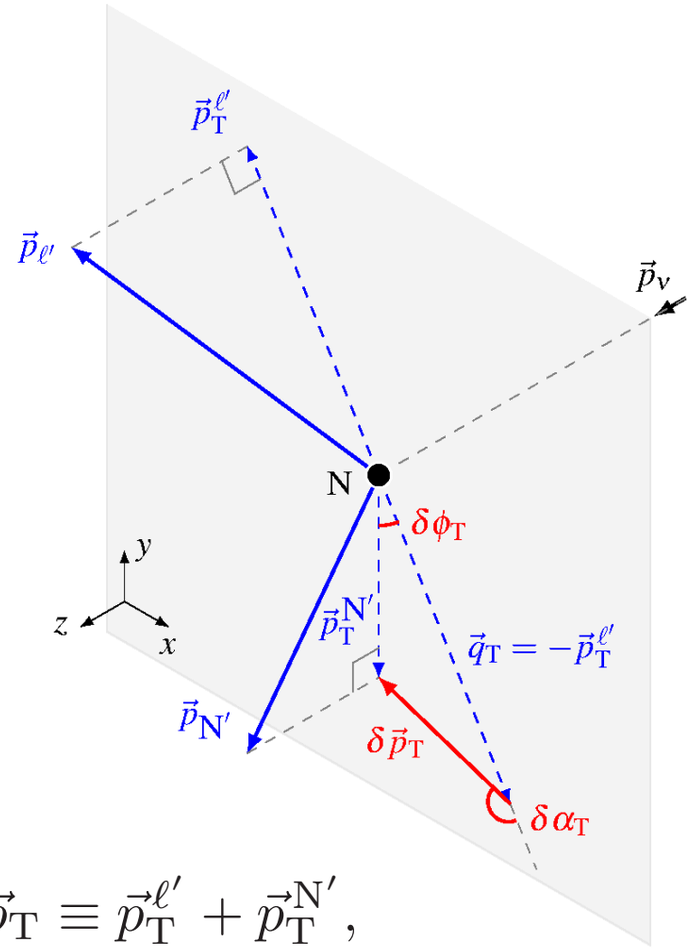

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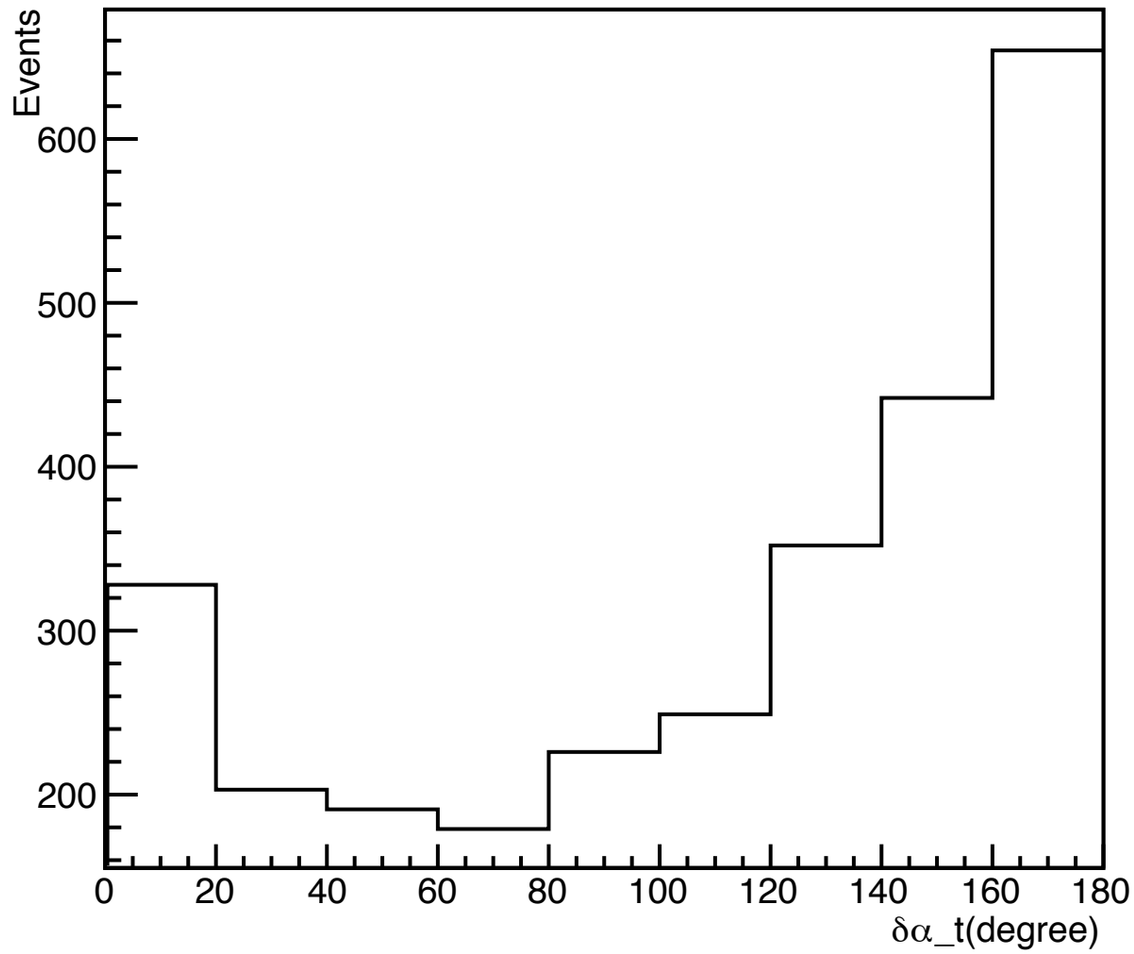

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