TRACK MULTIPLICITY ANALYSIS UPDATE

ZELIMIR, ALEENA, DAVID, AFRODITI, BILAL ET AL.

The 2x2 Analysis Meeting

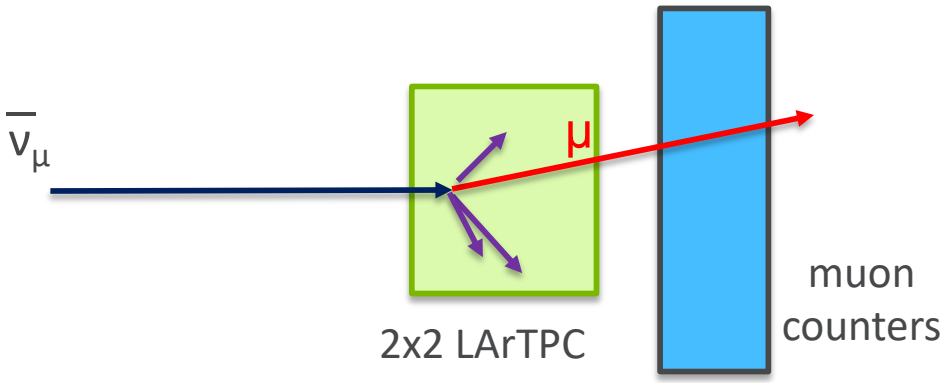
08/18/2023

Overview

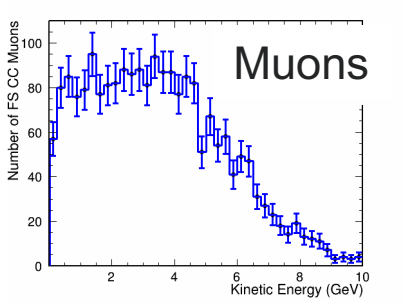
- We continued truth-based studies of track multiplicity within analysis acceptance using the official flow files
- We performed initial studies to investigate alternative FSI models
- We continued validating the preliminary reconstruction file from Pandora team
- We are also performing the neutrino energy estimation analysis

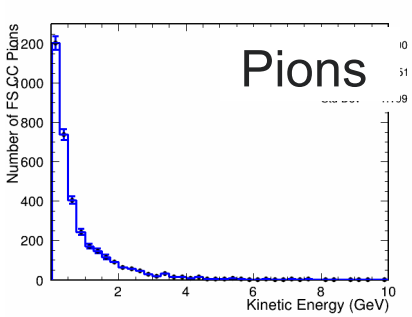
True Multiplicity Studies

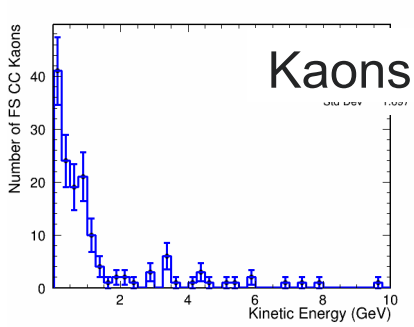
Bilal, Zelimir, Aleena et al.

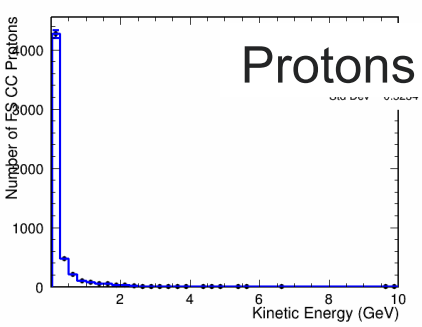


- Final state charge particles' kinetic energy (FHC mode)









True Multiplicity Studies (cont.)

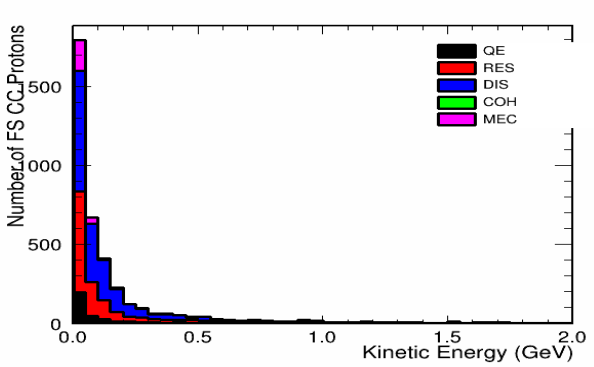
- Effect of the minimum kinetic energy cut

  -Example: protons with E_{kin} > 50 MeV cut

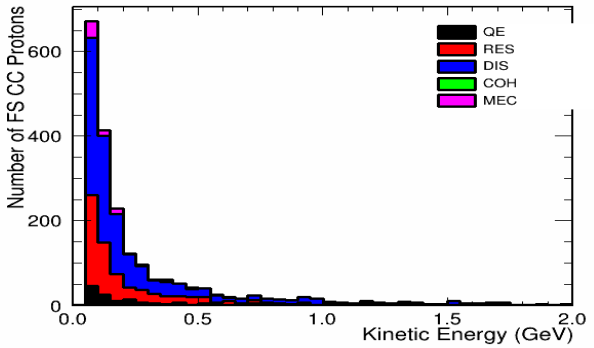
Number of Final State of CC Protons (RHC Mode)		
Type	**No Cut**	**Cut**
QE	332	135
RES	1260	618
DIS	2028	1267
COH	0	0
MEC	287	91
Total	**3907**	**2111**

-Here E_{kin} > 50 MeV is a proxy for more sophisticated cuts (see next slides).

➢ No Cuts



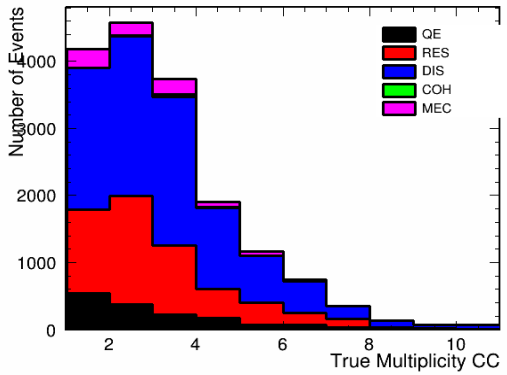
➢ E_{kin} > 50 MeV Cut



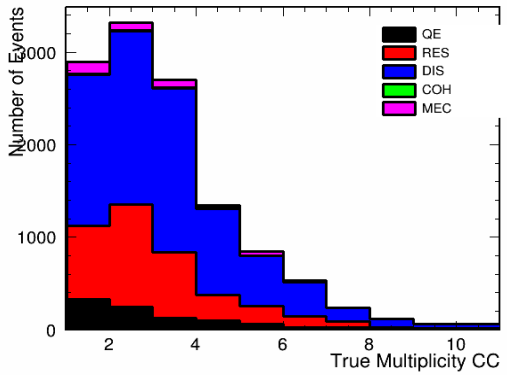
True Multiplicity Studies (cont.)

- Multiplicity Distribution (RHC mode)
  -Effect of the minimum kinetic energy cut

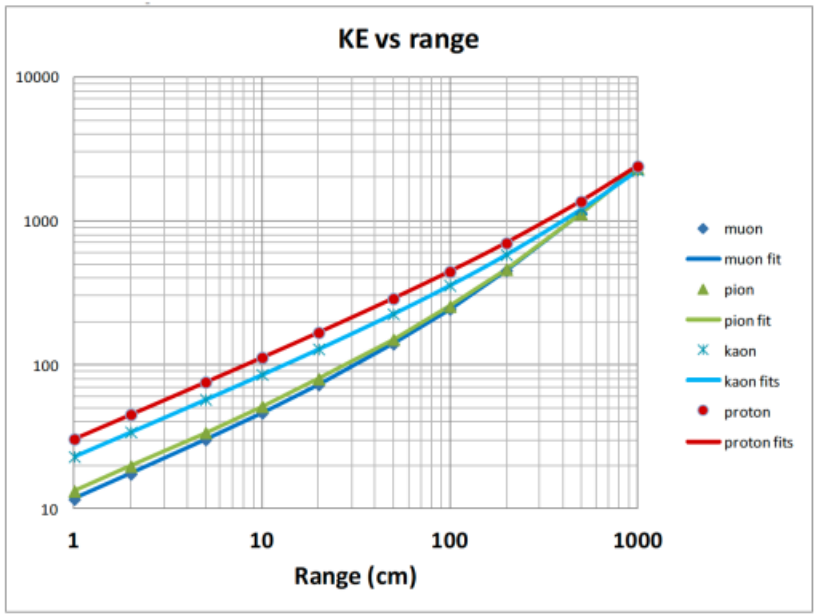
➢ No Cuts



➢ E_{kin} > 50 MeV



➢ First analysis will be based on track length cuts based on kinetic energy calculation (see uB docdb-6572)

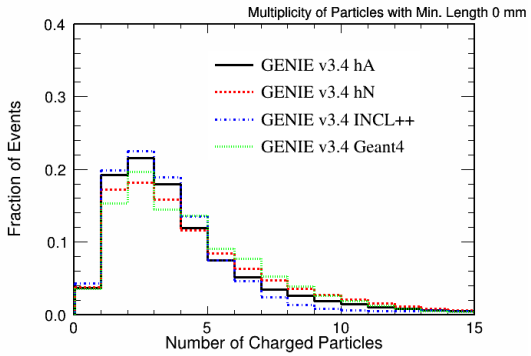


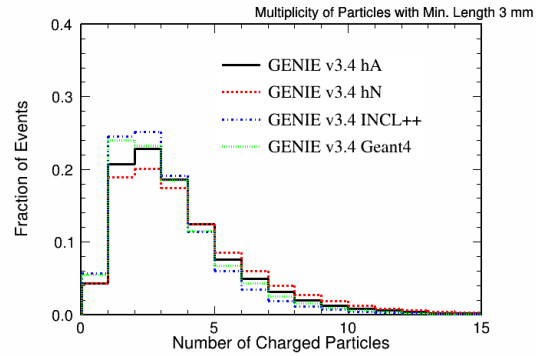
Alternative FSI models

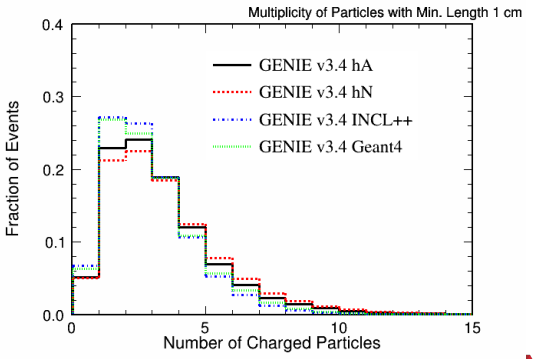
Afroditi, Jan, Richie, Georgii et al.

- Generated the four final state interaction (FSI) models (hA, hN, INCL, Geant4) of DUNE base model (AR23_20i).
  - -Alternative simulations for how particles from the neutrino interaction escape the target nucleus.
  - -GST files exist here: /pnfs/dune/persistent/users/rdiurba/2x2_RHC_gst/
  - -Generation files here: /dune/app/users/rdiurba/genieTunes (Thanks to Afroditi for the format and Jan for configuring)
  - -Preliminary comparisons presented at NUIWG meeting.
- Integrated track length cuts based on kinetic energy vs range calculations from uB docdb6572

  - Multiplicity of final state charged tracks using FSI models of GENIE AR23_20 tune as function of minimum track length (0 mm, 3 mm, 1 cm):

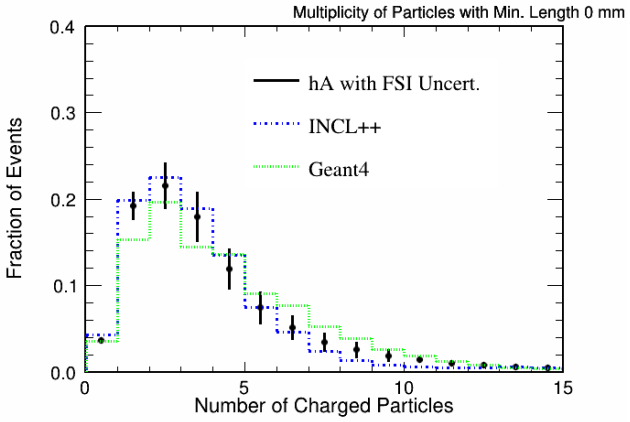


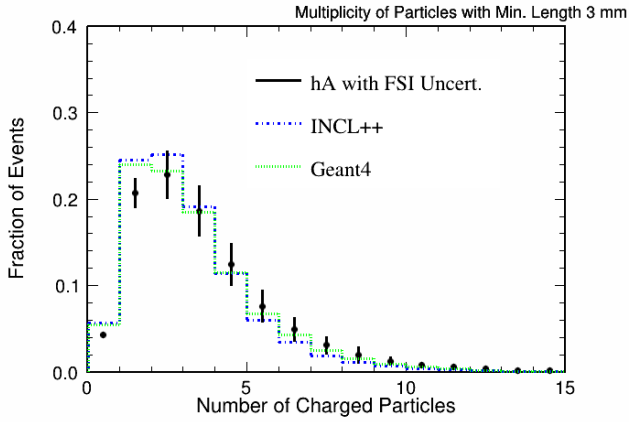


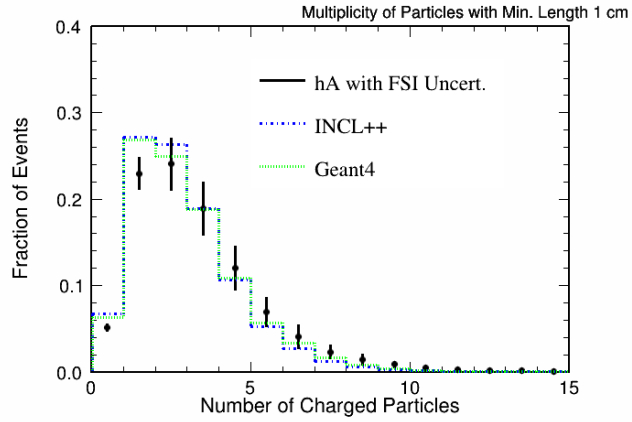


Alternative FSI models (cont.)

- Evaluating Comparisons with FSI Uncertainties
- Used nusystematics to generate 100 throws of all FSI dials that exist in GENIE v3.4 for hA
  -Reweights pion and nucleon total and exclusive cross sections for intermediate state particles
  -Comparisons of GENIE v3.4 AR23_20i with FSI uncertainties to GENIE AR23_20 with INCL++ and Geant4 FSI models.







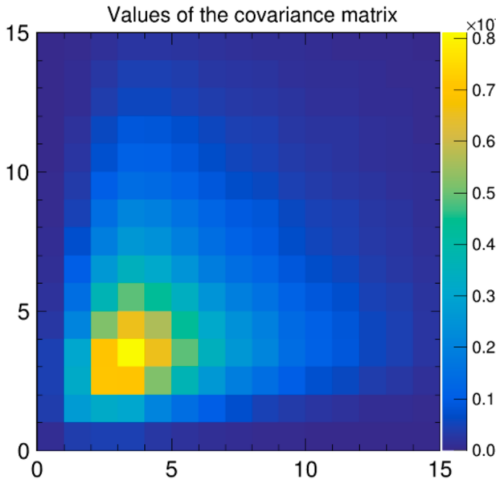
- Uncertainties cover roughly the difference between the base model and the two alternative models.

Alternative FSI models (cont.)

- Evaluating Comparisons with FSI Uncertainties

  -Characterization of model uncertainties

  -Example: hA model where differences within 100 universes have been characterized with are covariance matrix and chi-square statistics.



Covariance matrix for 0 cm threshold

$chi2 = \Delta^T * C^{-1} * \Delta$,

Δ – vector of differences between histograms,

C^{-1} – inverse covariance matrix.

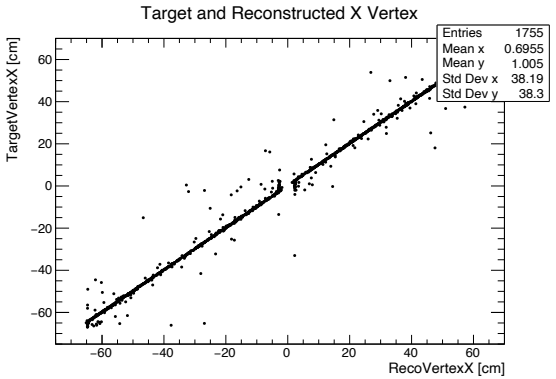
Table with calculated chi-square values:

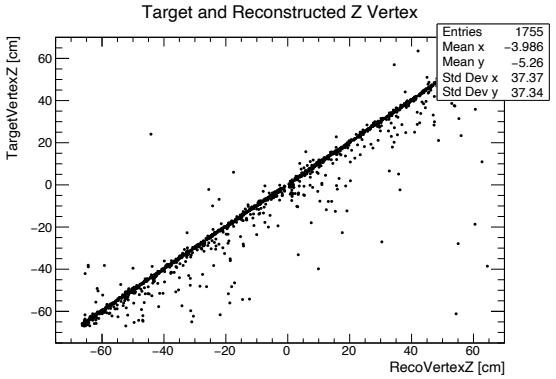
Minimum track length / treatment of bins	All bins are used	Bins with index greater than 8 are discarded	Bins with index greater than 8 are merged together
0 mm	629	337	430
3 mm	97.5	37.7	47.2
5 mm	97.4	40.7	40.7
1 cm	109	42.2	63.1
3 cm	73.3	28.7	28.7
5 cm	102	26.0	26.0
N_{bins}:	**15**	**9.**	**10**

Multiplicity Events Reconstruction Status

Pandora:

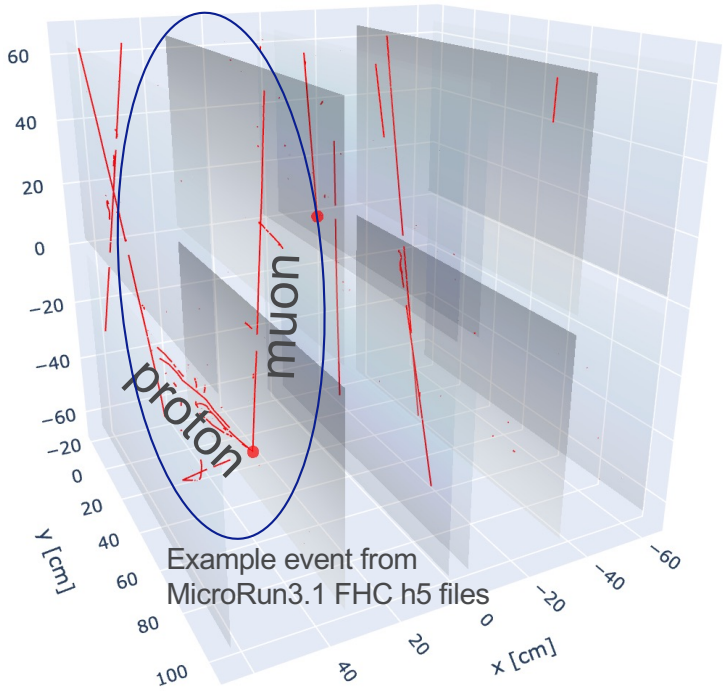
- Performing preliminary reco files validations
- File locations:
  - /pnfs/dune/persistent/users/rdiurba/Validation_both_RHC_withSkips_RHC_0-3011.root
  - /dune/data/users/lwhite86/ndValidation
- Waiting for the CAFs from the Pandora team



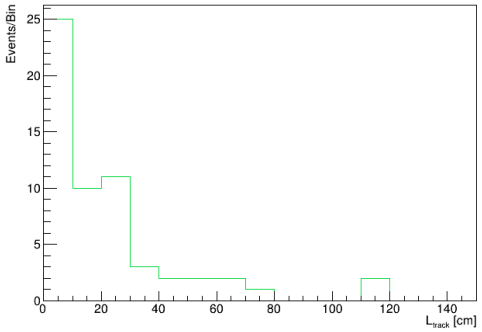


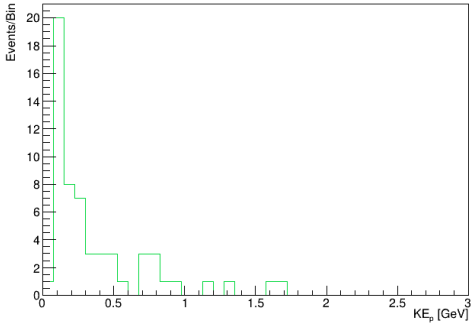
NEUTRINO ENERGY ESTIMATION STUDIES

- Based on assumption that proton momentum and muon angle are reconstructed
  (see our presentation from two weeks ago: https://indico.fnal.gov/event/60434/)
  -Continue validation studies: require contained proton.

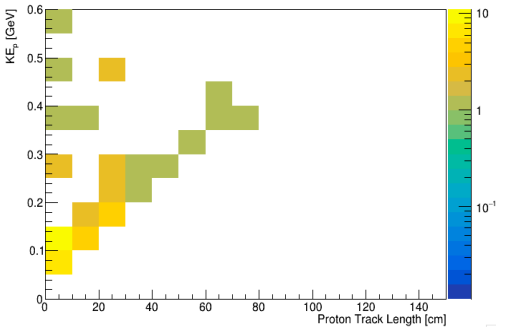


Example event from
MicroRun3.1 FHC h5 files





➢ Examples:
proton track length
and kinetic energy.



-Note this is FHC Microrun3.1: still using a low statistics.

Summary

- Our multiplicity group is performing studies on various sub-topics
  - Truth-based analysis studies
  - Reconstruction validation studies
  - Neutrino and final state interaction systematic studies
  - Neutrino energy estimation.
- Will perform reconstructed event selection once the CAF files are ready.