The NEUT Neutrino Interaction Generator

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NEUT Overview

https://arxiv.org/pdf/2106.15809.pdf

- Originally written in the 1980s to predict atmospheric neutrino backgrounds for Nucleon Decay Experiments at KamiokaNDE.

- Development focussed on 'few GeV' neutrinos for use in T2K and SK long baseline neutrino oscillation measurements.

- Closed source, but code and support are available on request:
  - Plan to make fully open source in the near future.

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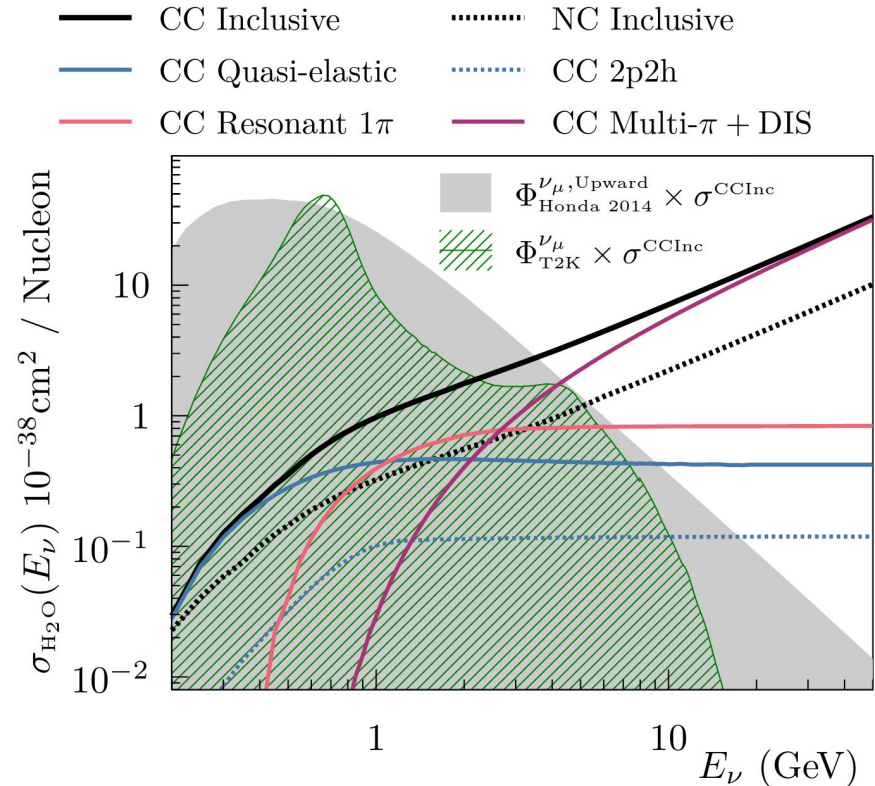
NEUT DIS Model

- Inclusive cross-section from Bodek-Yang-modified GRV98 PDF set

- Fragmentation uses PYTHIA v5.72 included in CERNLIB 2005

- Multiplicity at low energy and W tuned to bubble-chamber data from FNAL and BEBC
  - No explicit tuning for higher W.

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NEUT FSI Model

Proton-Carbon cross-sections
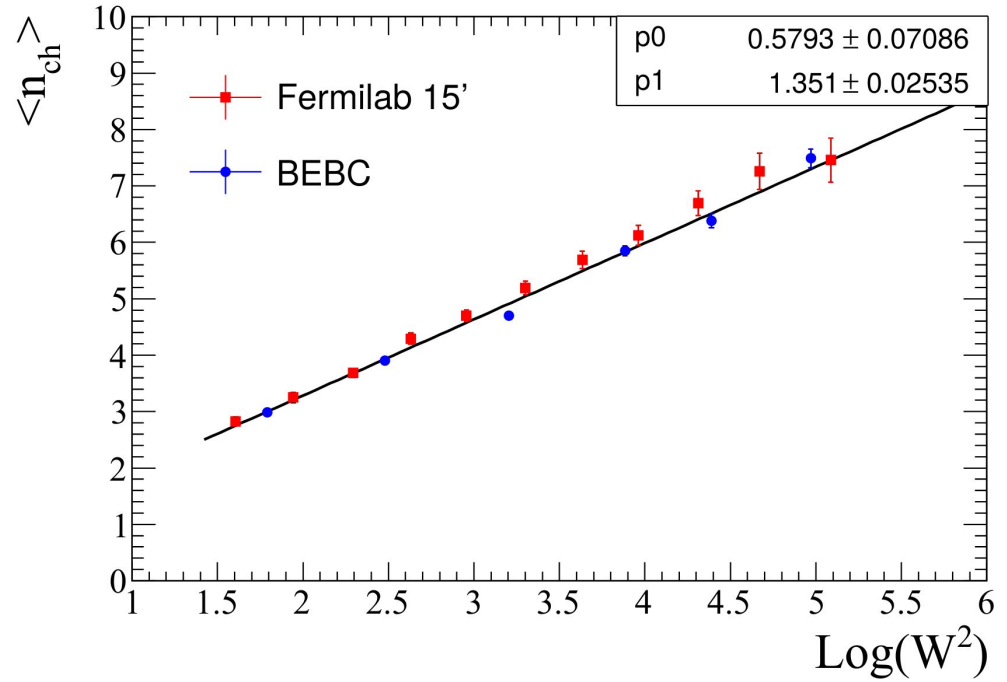
- Semi-classical cascade
  - Hadrons are individually and independently stepped through nuclear volume
  - Interaction probability per 0.2 fm step parameterised by Local Fermi Gas model (charge/nucleon density, nucleon momentum distribution)

- Channels Implemented:
  - Nucleons, pions, kaons, etas, omega
  - Pion model tuned to data: 0.5–2 GeV/c
  - Nucleon cross-sections use Bertini model for E_N < 3 GeV

- Includes 'formation zone' effects where primary hadrons are stepped away from production point before experiencing cascade.
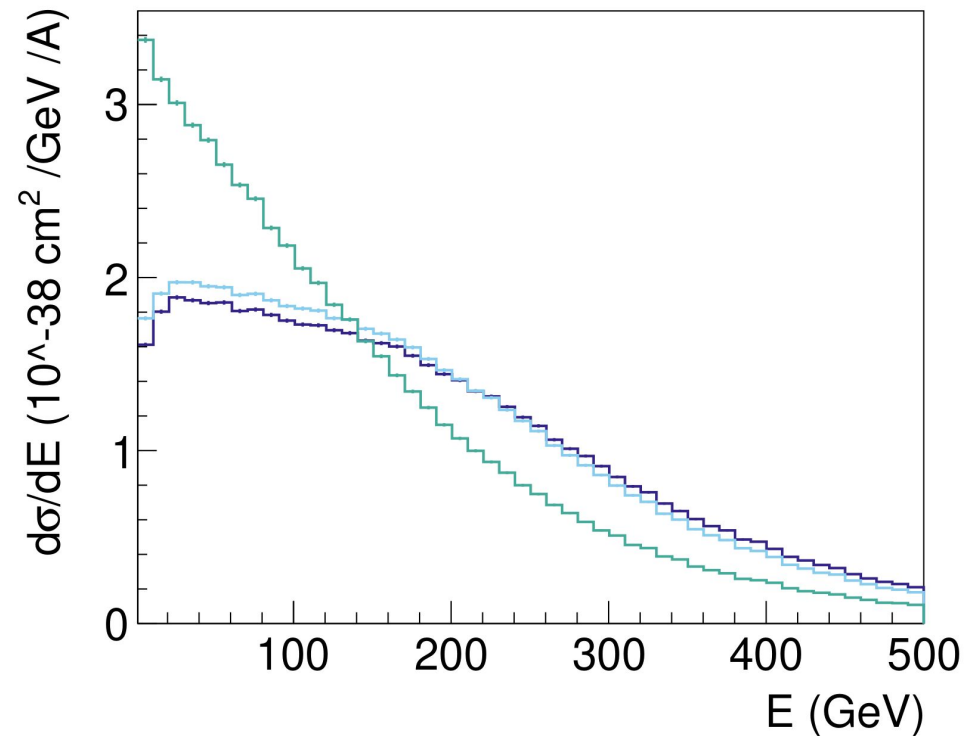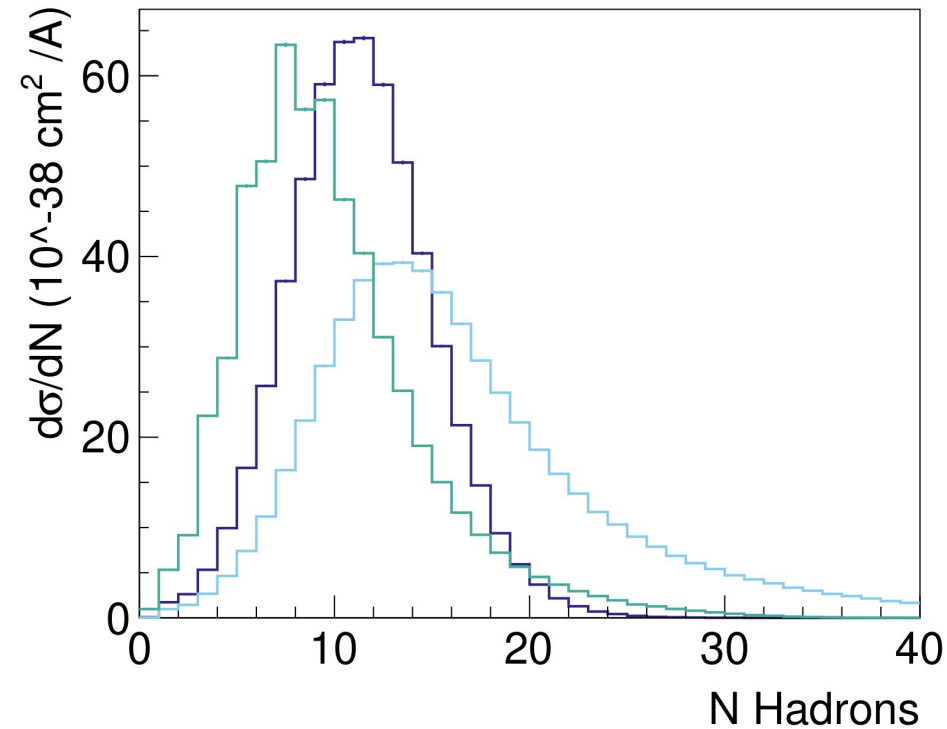
$$L_{FZ} = p/\mu^2,$$

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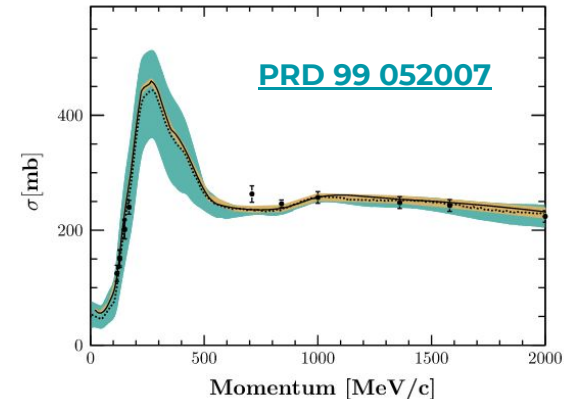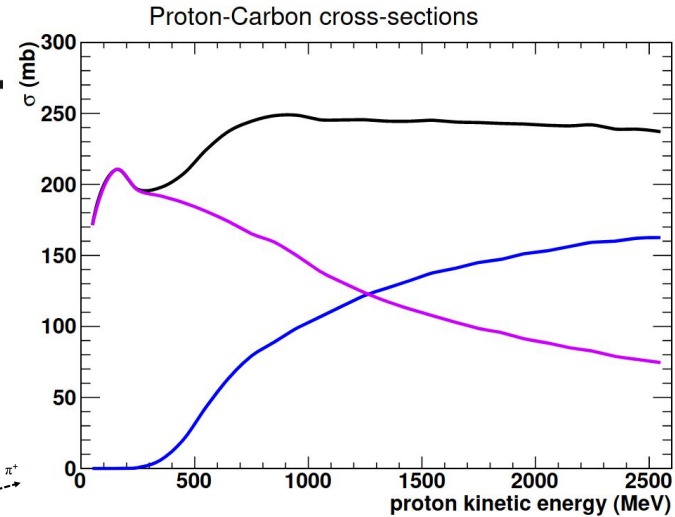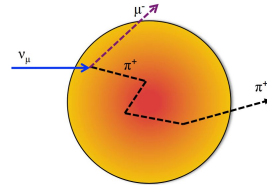
(a) Reactive

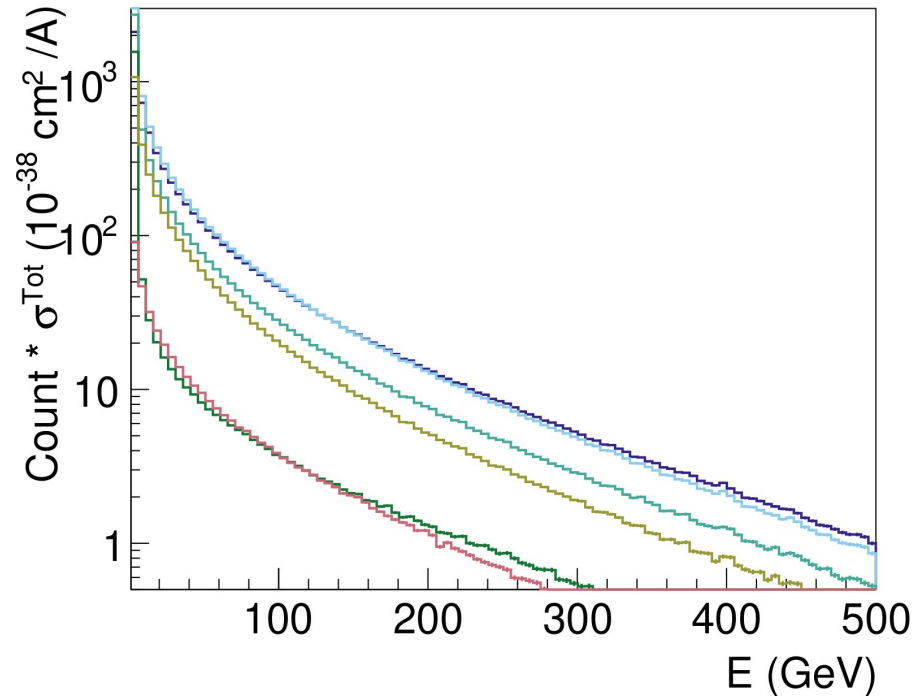# Multiplicity and Leading Hadron Energy

Primary Hadrons

Final-state Hadrons

Final-state Charged Hadrons

Bonus: Hadron Energy

Legend:
- Primary Hadrons
- Final-state Hadrons
- Final-state Charged Hadrons
- Final-state Protons
- Final-state Charged Pions
- Final-state Charged Kaons

Y-axis: Count * σ^{Tot} (10^{-38} cm^2 /A)

X-axis: E (GeV)

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Summary: NEUT

- NEUT was not developed or tuned with TeV neutrinos in mind.
    - Most development at the GeV scales

- We would be excited to produce predictions and work on improving those predictions with CERN physicists.

- Open to incorporating new, more appropriate models for high energy Neutrinos.

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Thanks for listening