

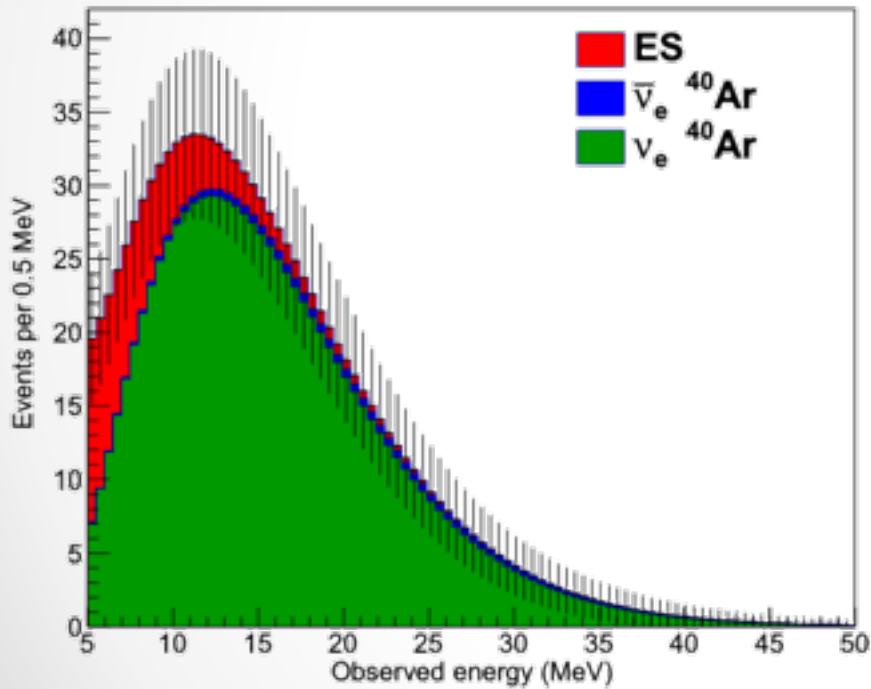
The Role of Neutrons at DUNE: Simulations of GeV Physics

Shirley Li

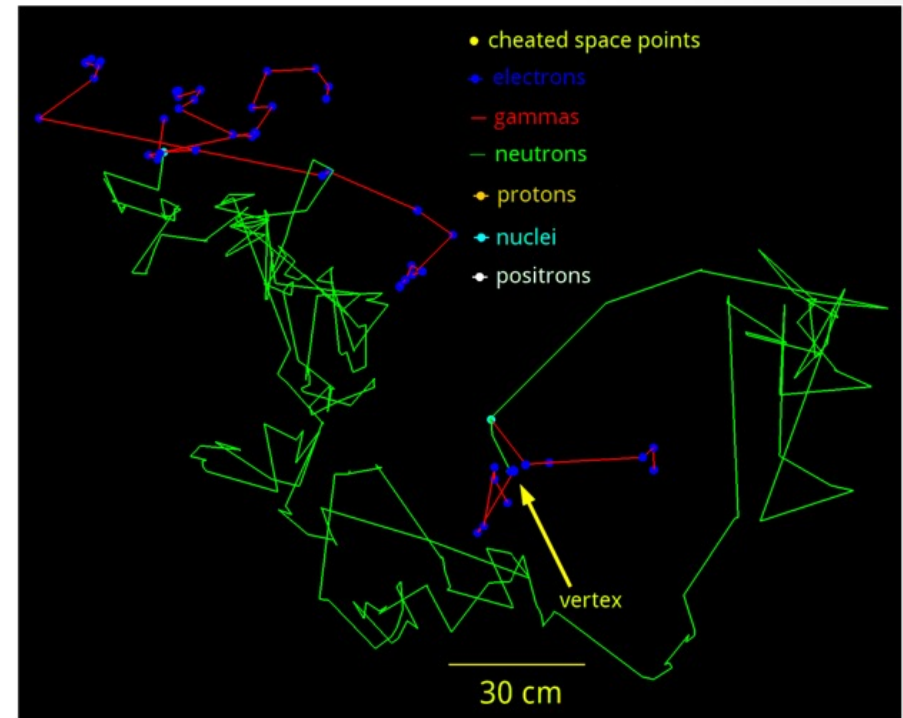
Supernova Neutrinos in DUNE

Neutrons Play A Crucial Role!

Expected Supernova Neutrino Spectrum at DUNE



A Simulated Neutrino Event



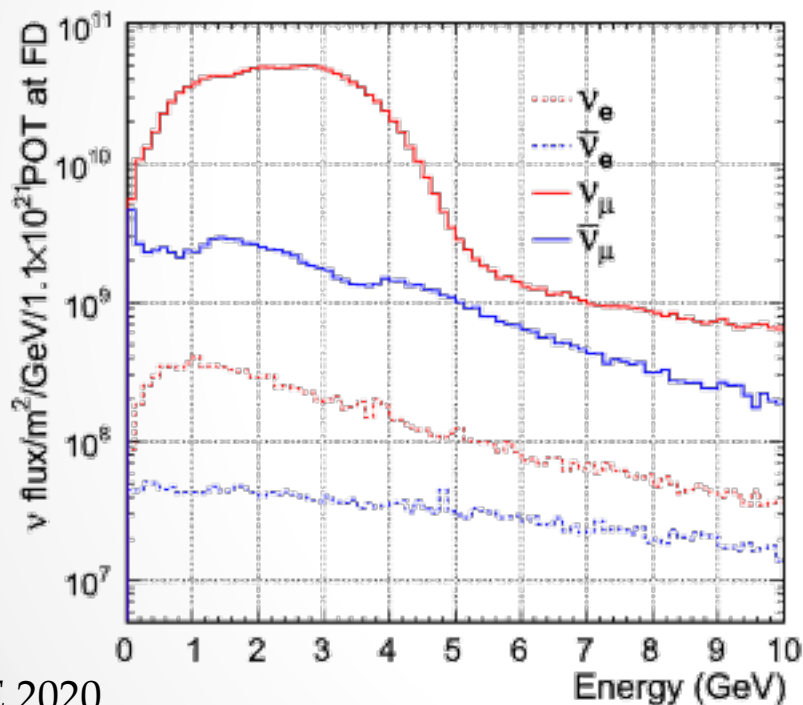
DUNE 2020

See Bob's Talk

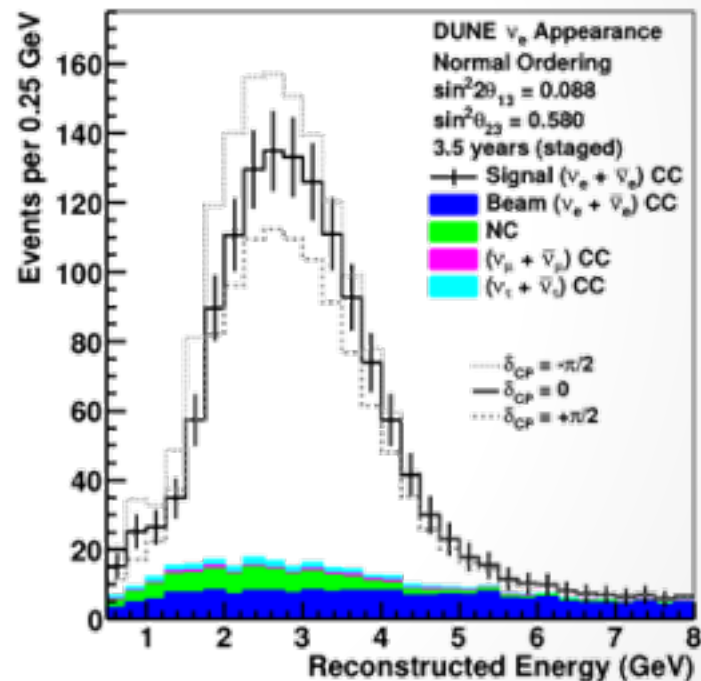
DUNE

Long Baseline Experiment: GeV ν_μ & $\bar{\nu}_\mu$ beam

Accelerator Neutrino Fluxes



Expected Neutrino Spectrum at Far Detector



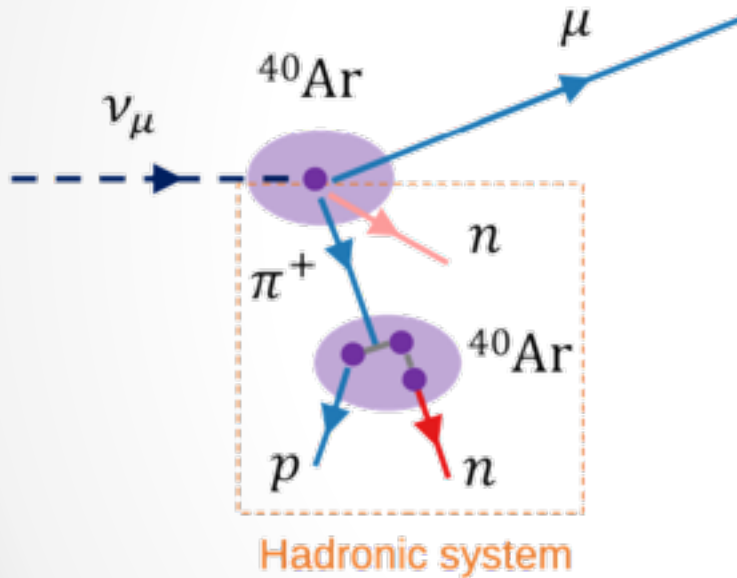
DUNE 2020

Accelerator Neutrino Energy: 0.5–5 GeV

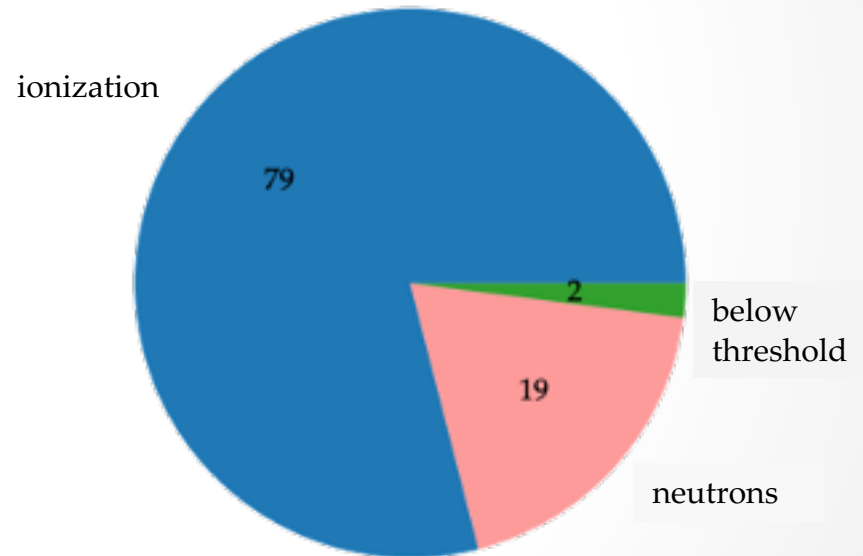
Energy Budget of GeV ν

GENIE: 4 GeV ν_μ in Argon

Friedland, Li
2018



Energy Budget for Hadronic System



Understanding Neutrons Is Important for
Neutrino Energy Reconstruction

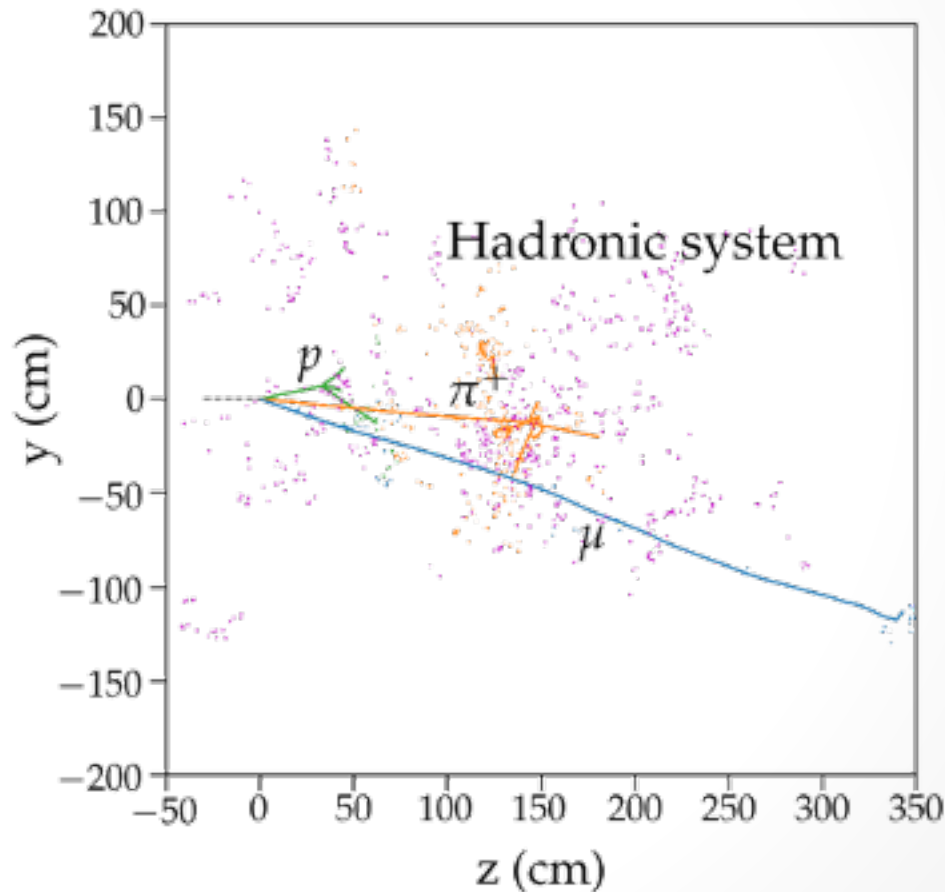
A Simulated Neutrino Event

GENIE+FLUKA: 4 GeV ν_μ in Argon

Friedland, Li
2018

170 MeV \rightarrow n
at the primary vertex

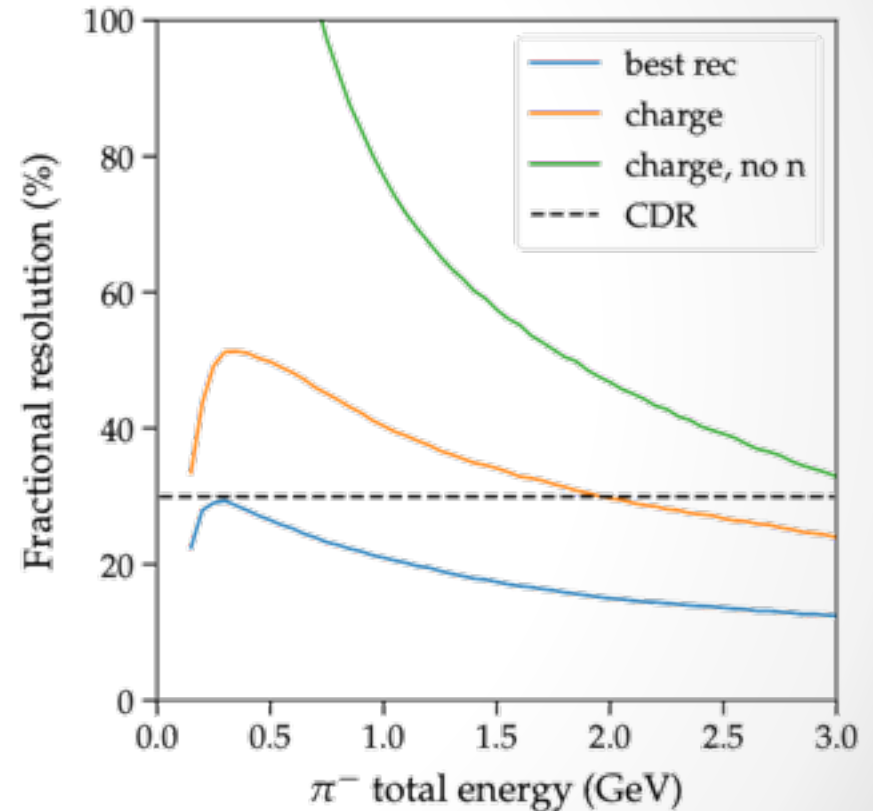
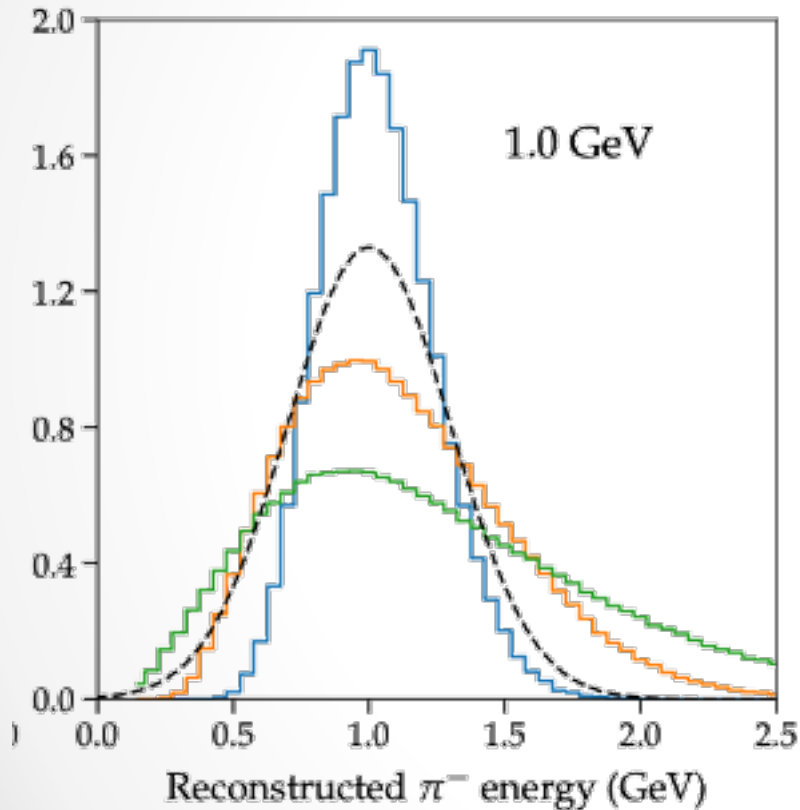
230 MeV \rightarrow n
at secondary vertices



Neutrons Could Be Produced at Every Step

Effect on Energy Resolution

Friedland, Li
2020

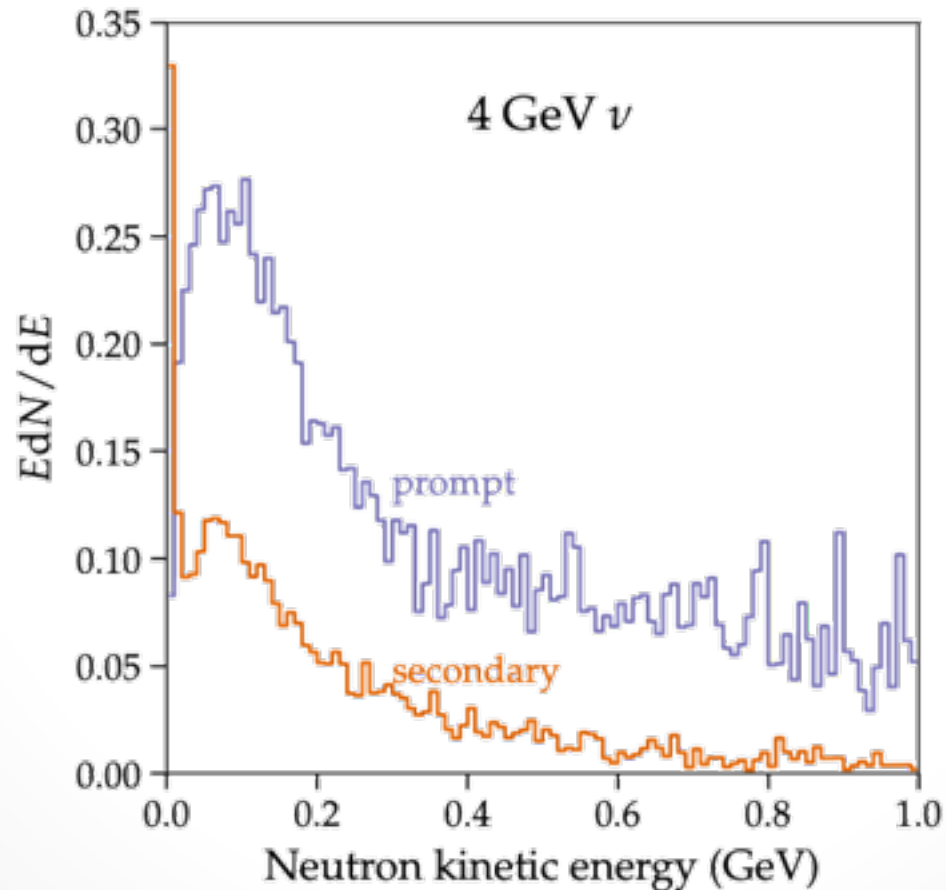


Significantly Worse Resolution Without Neutrons

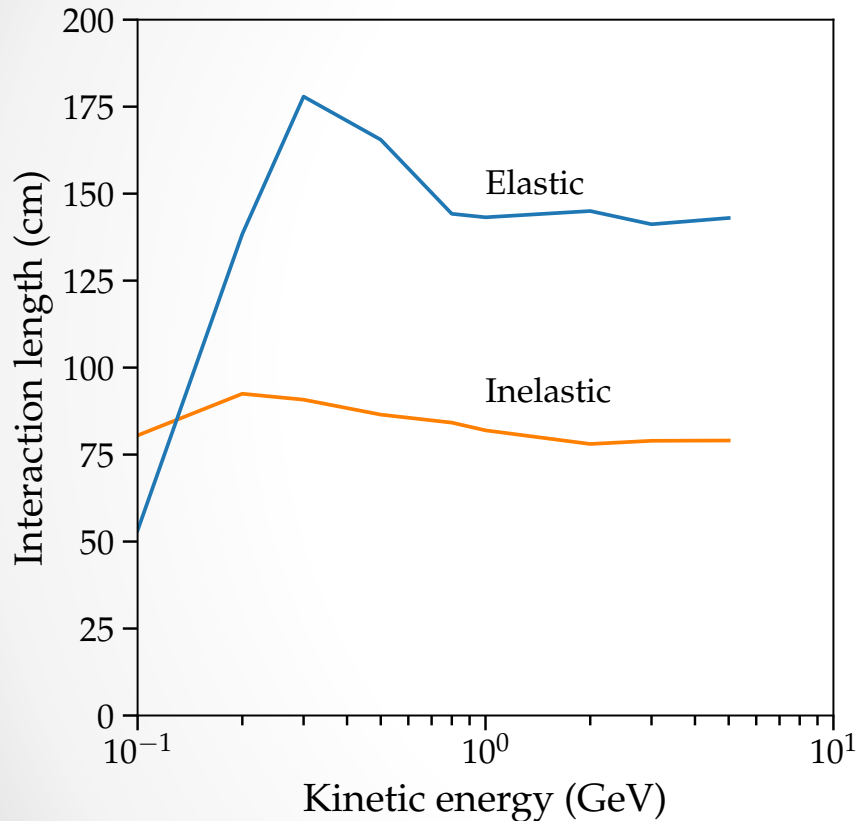
Neutrons in Neutrino Events

Neutron Spectra

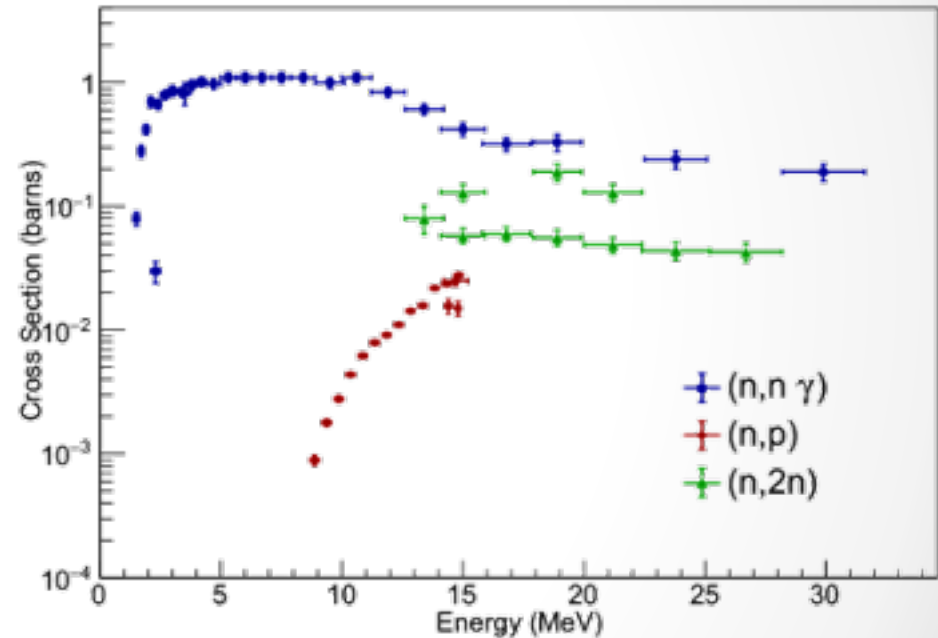
Friedland, Li
2018



Neutron Propagation



Castiglioni et al., 2020



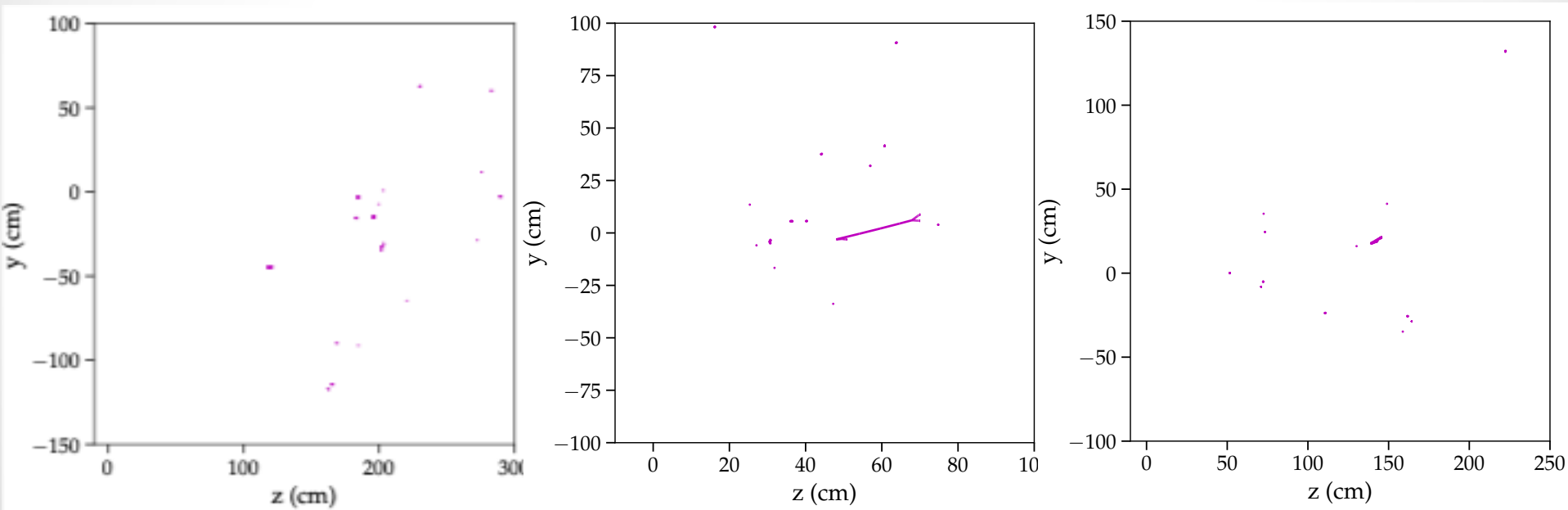
Similar to Protons at High E, Unique at Low E

Neutron Event Display

Three 500-MeV Neutrons in Argon

Friedland, Li 2018

Simulated with FLUKA

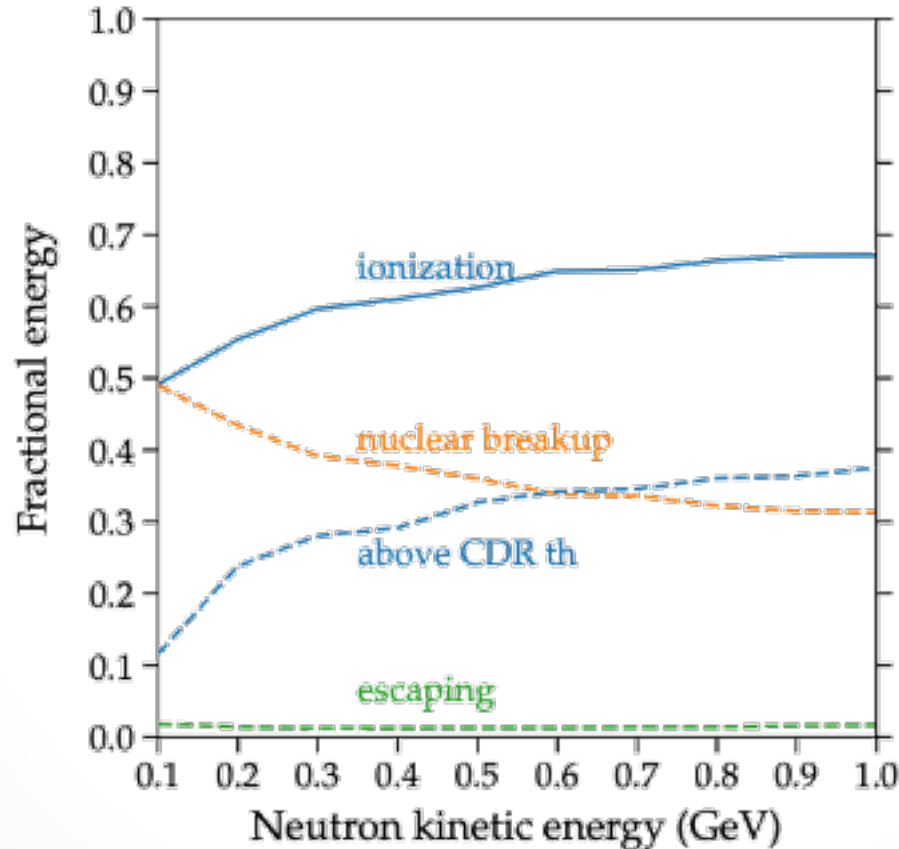


Large Variation; Proton Tracks + Blips

Neutron Detectability

Energy Budget

Friedland, Li 2018

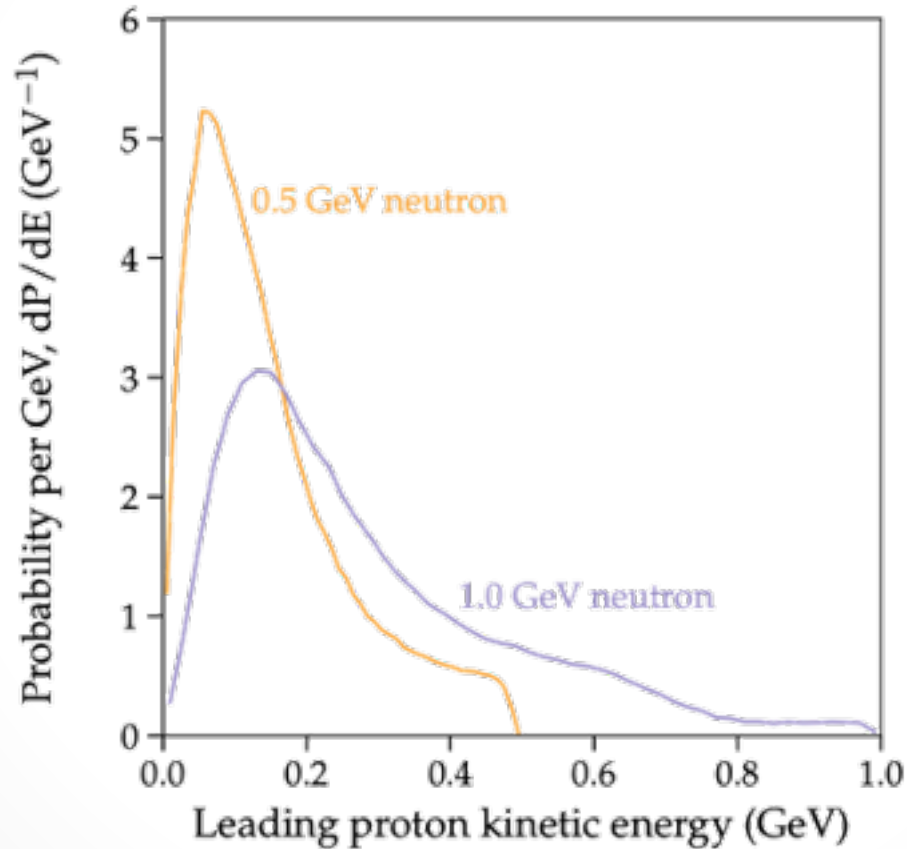


A Large Fraction of the Energy Could be Detectable

Neutron Detectability

Leading Secondary Proton

Friedland, Li 2020

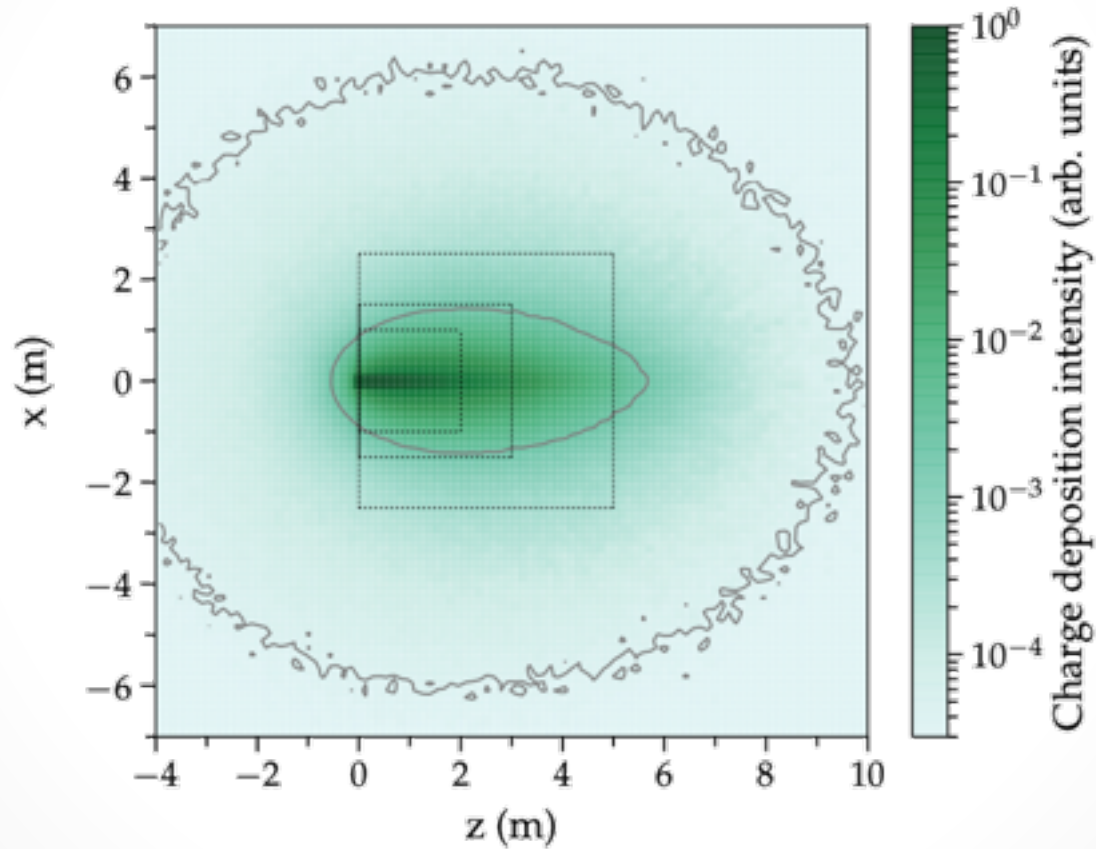


Requires Low Thresholds

Neutron Detectability

Geometry

Friedland, Li 2020

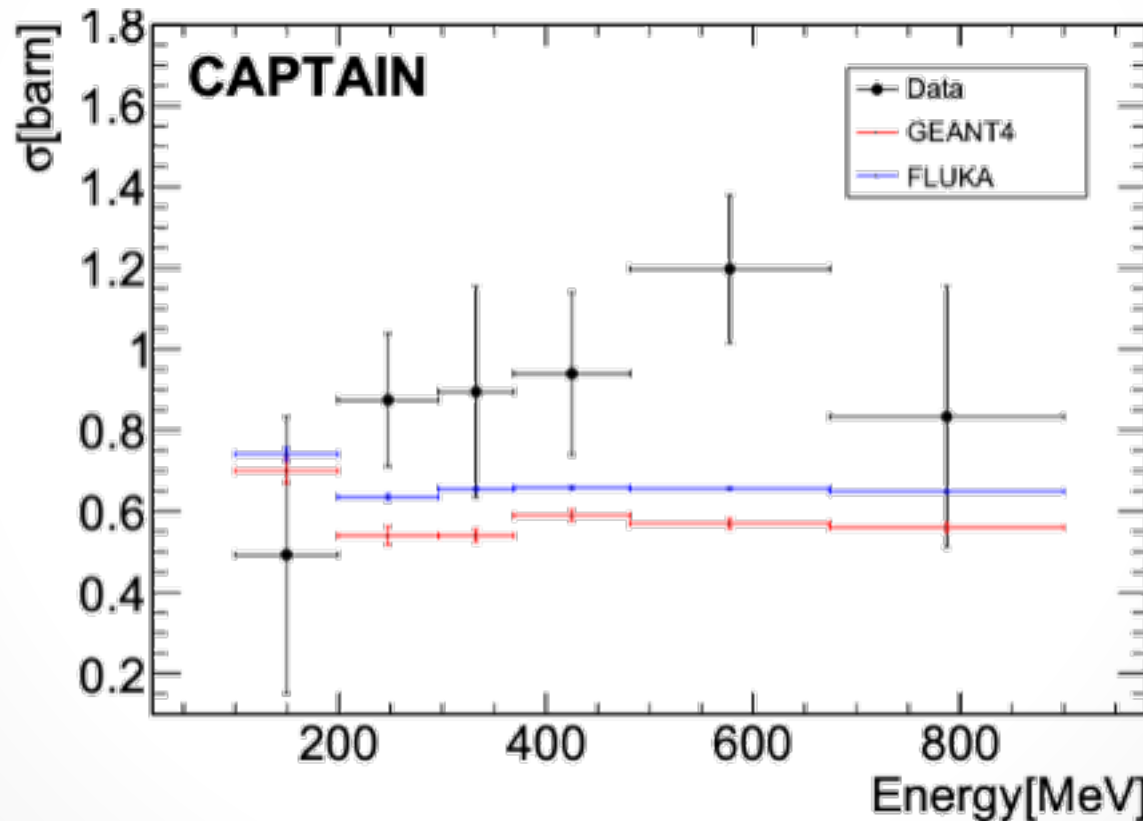


Neutrons Travel Far...

Neutron Interactions

First Measurement of the Total Neutron Cross Section on Argon between 100 and 800 MeV

CAPTAIN 2018

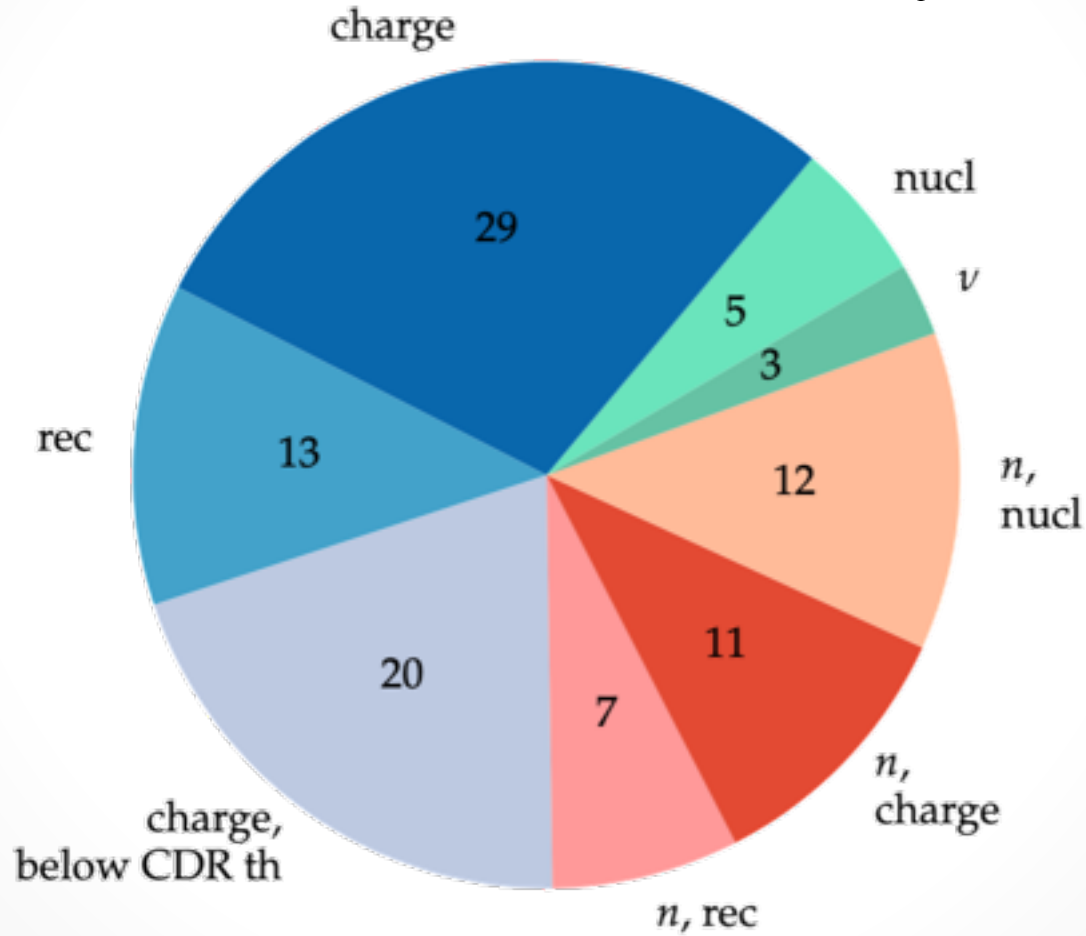


Uncertain! Need More Measurements

Final Energy Budget

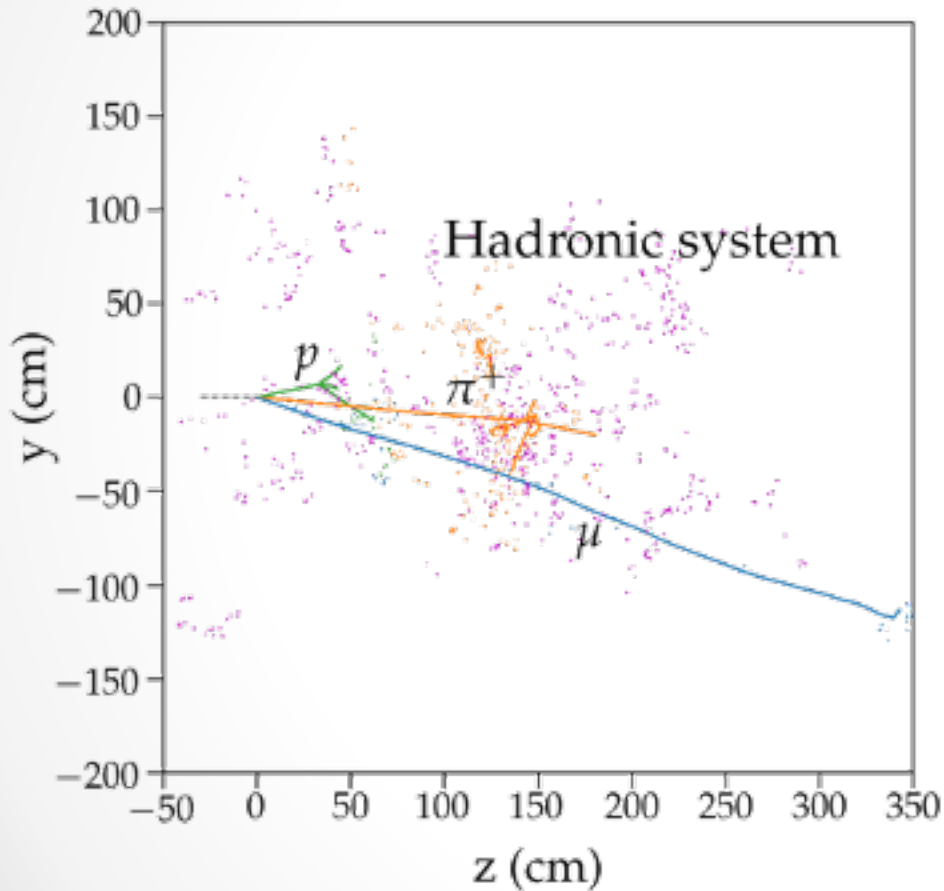
Friedland, Li
2018

4 GeV Neutrino Hadronic System



18% Energy Can Be Recovered; 12% Invisible

Conclusions



- ✓ Important
- ✓ Challenging
- ✓ Uncertain
- ✓ Need More Studies!