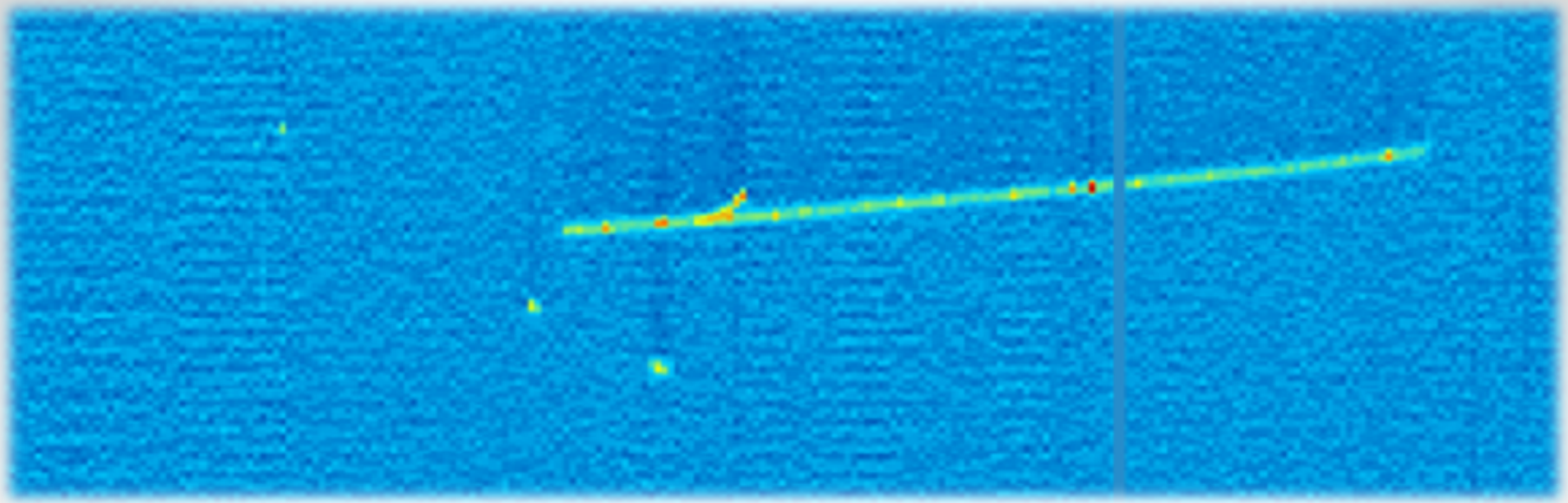


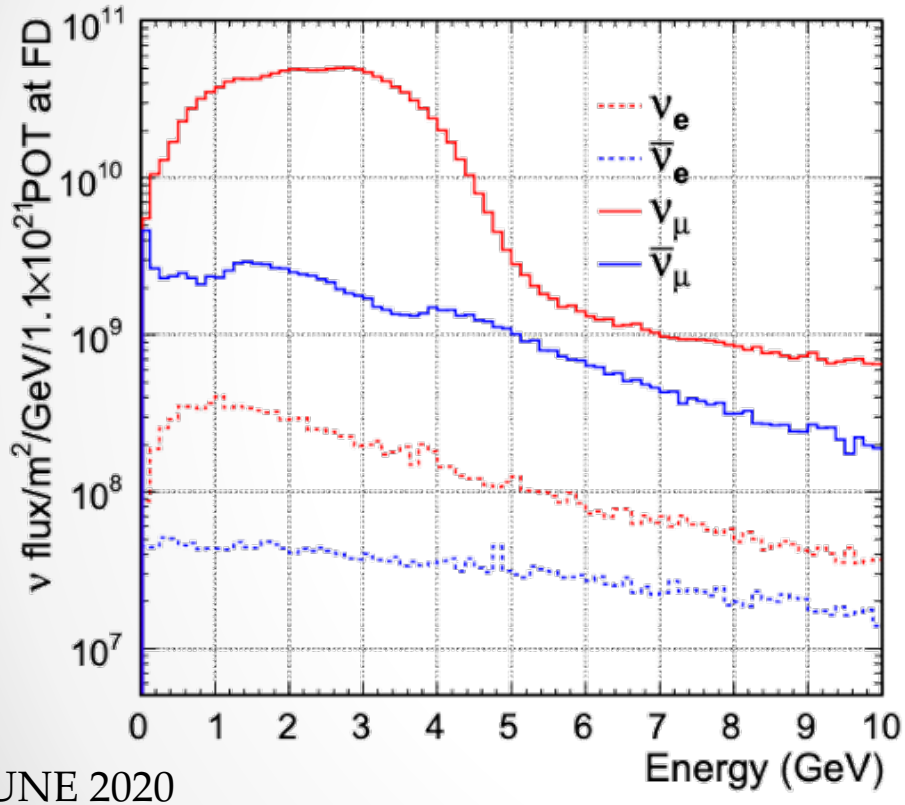
MeV-Scale Signatures in GeV-Scale Events in Liquid Argon

Shirley Li

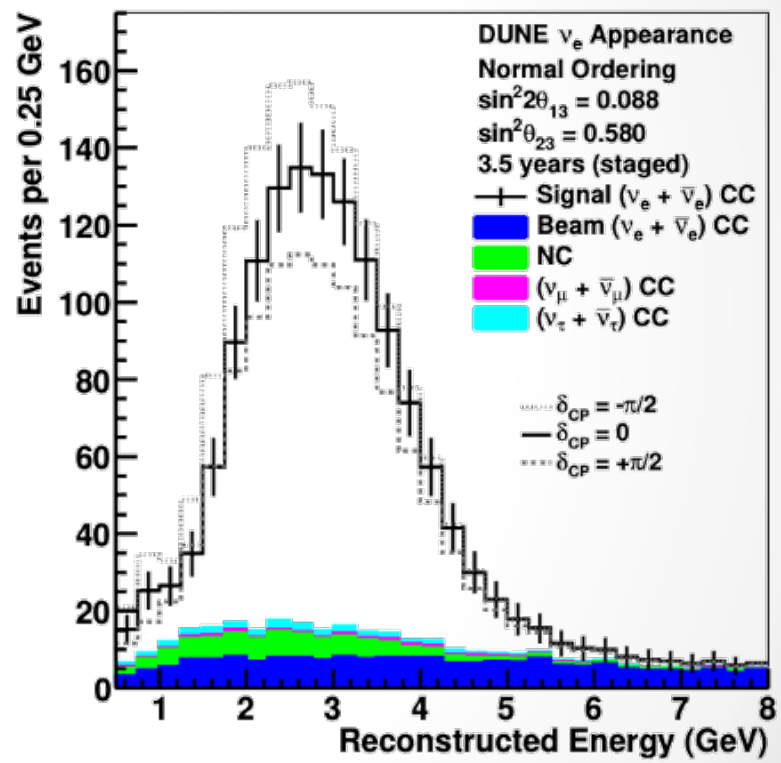
Low-Energy Physics in Liquid Argon, Nov 2020

DUNE

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



DUNE 2020



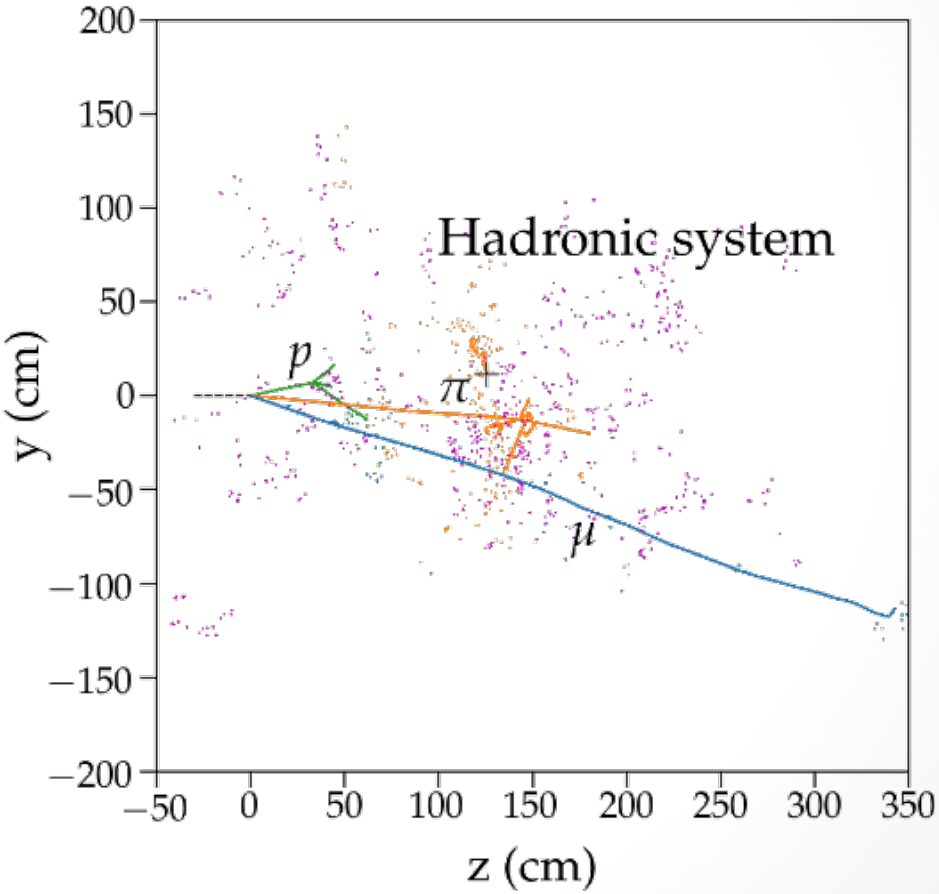
Neutrino Energy: 0.5—5 GeV

A Simulated Neutrino Event

GENIE+FLUKA: 4 GeV ν_μ in Argon

Friedland, Li
2018

170 MeV -> n
at the primary vertex

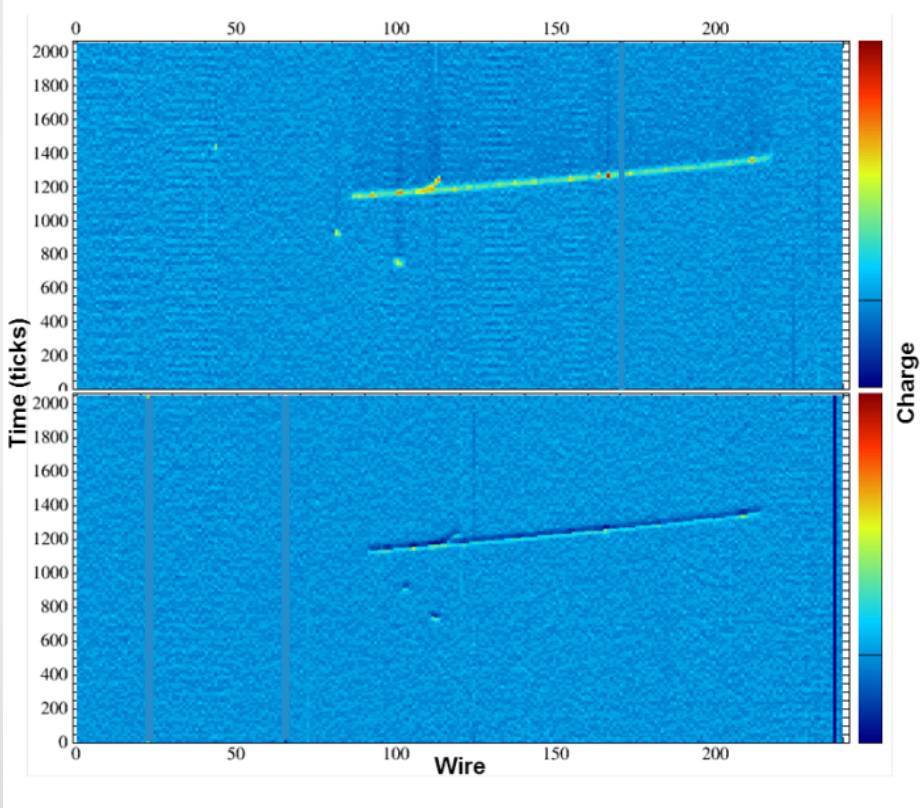


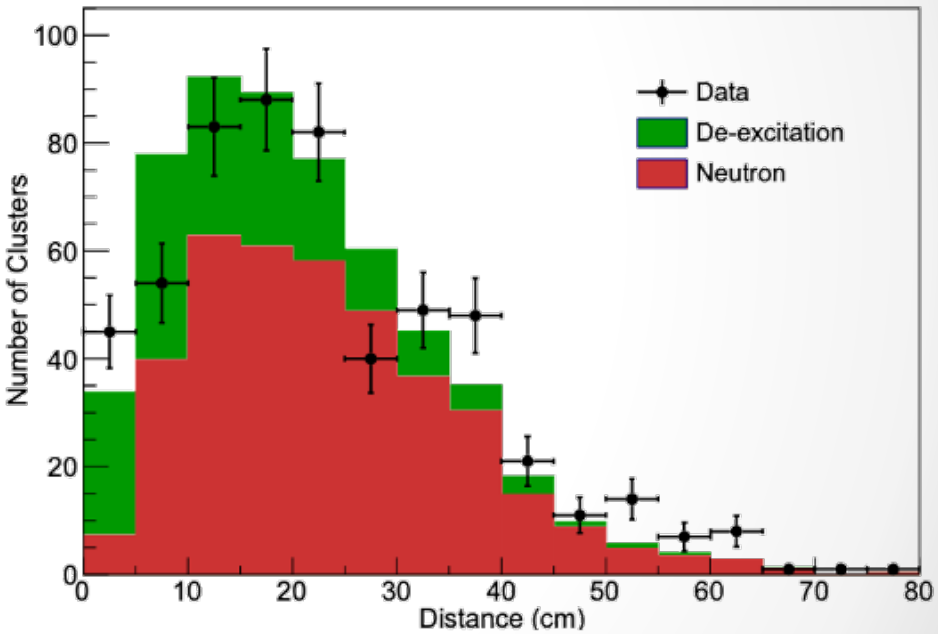
Nucleus Break Up -> MeV Signatures

De-excitation γ & Neutrons

ArgoNeuT Observed MeV γ in ~GeV Events

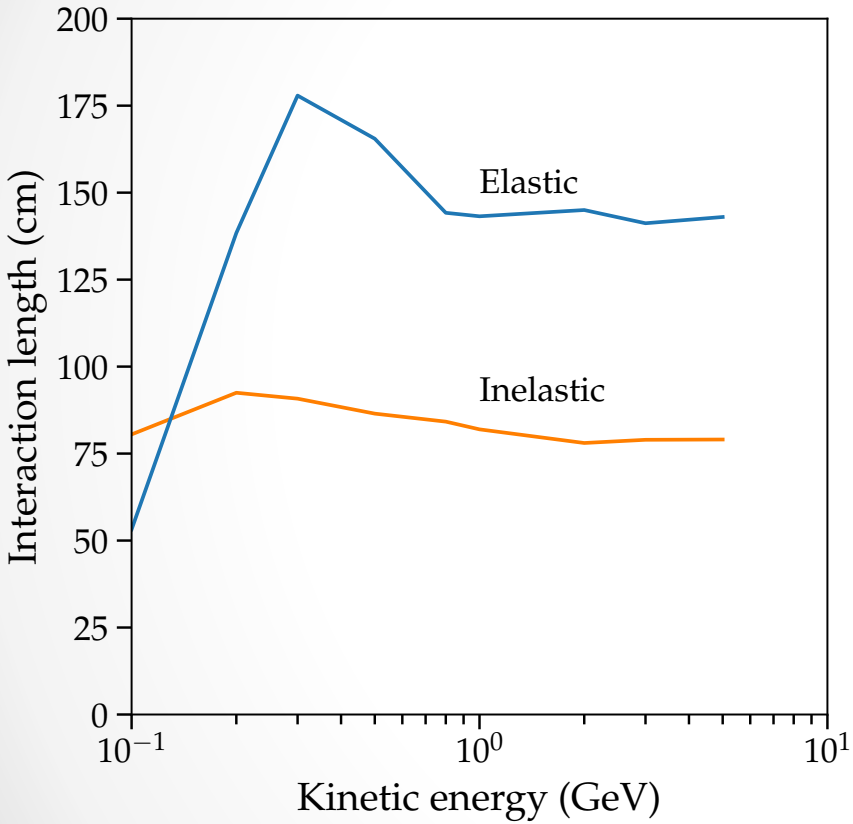
ArgoNeuT 2018



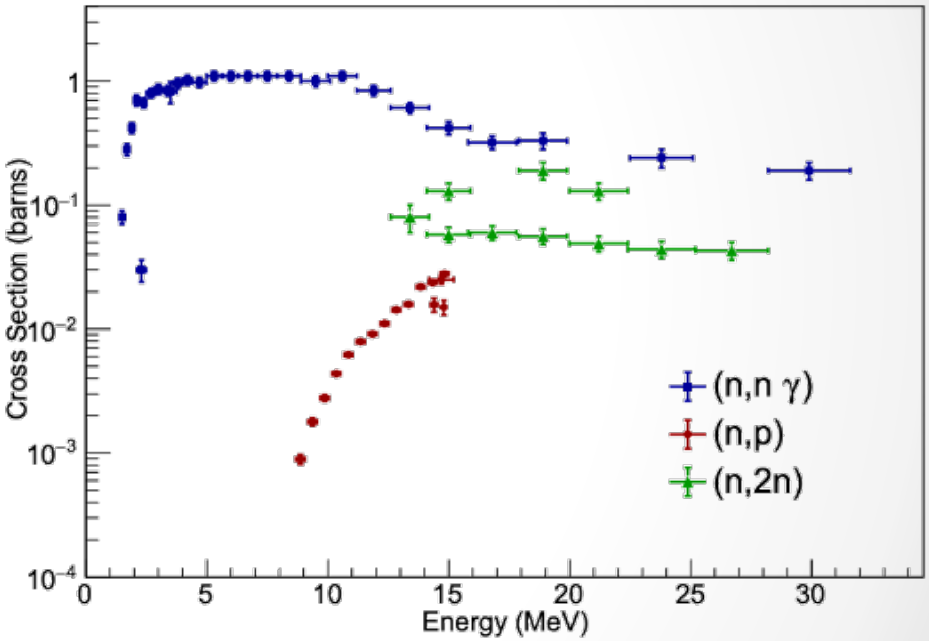


Demonstration of MeV-Scale Physics in Liquid Argon

Neutron Propagation



Castiglioni et al., 2020



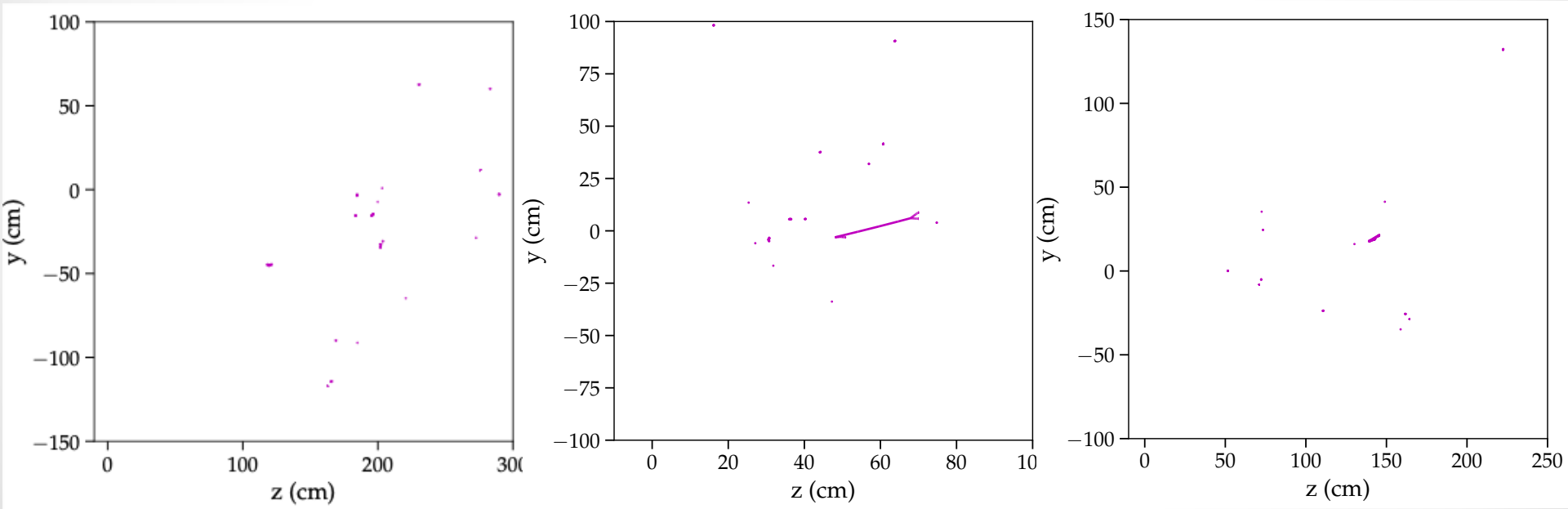
Similar to Protons at High E, Unique at Low E

Neutron Event Display

Three 500-MeV Neutrons in Argon

Friedland, Li 2018

Simulated with FLUKA

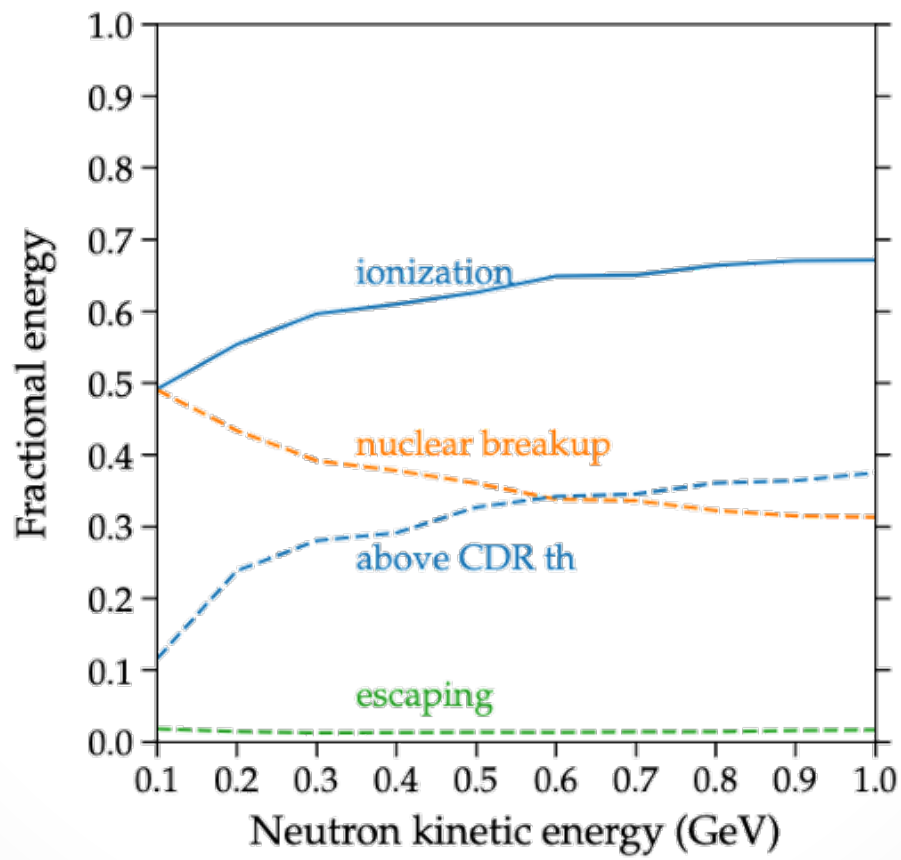


Large Variation; Proton Tracks + Blips

Neutron Detectability

Energy Budget

Friedland, Li 2018

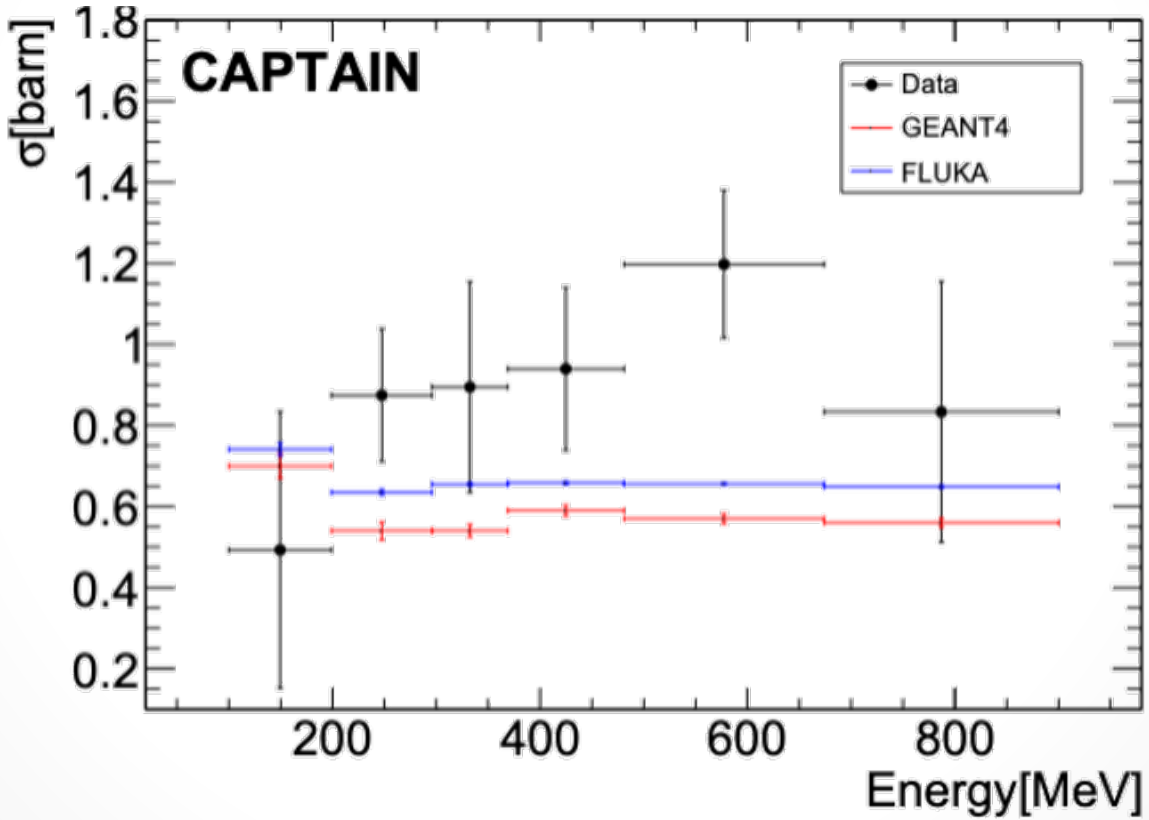


A Large Fraction of the Energy Could be Detectable

Neutron Interactions

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

CAPTAIN 2018

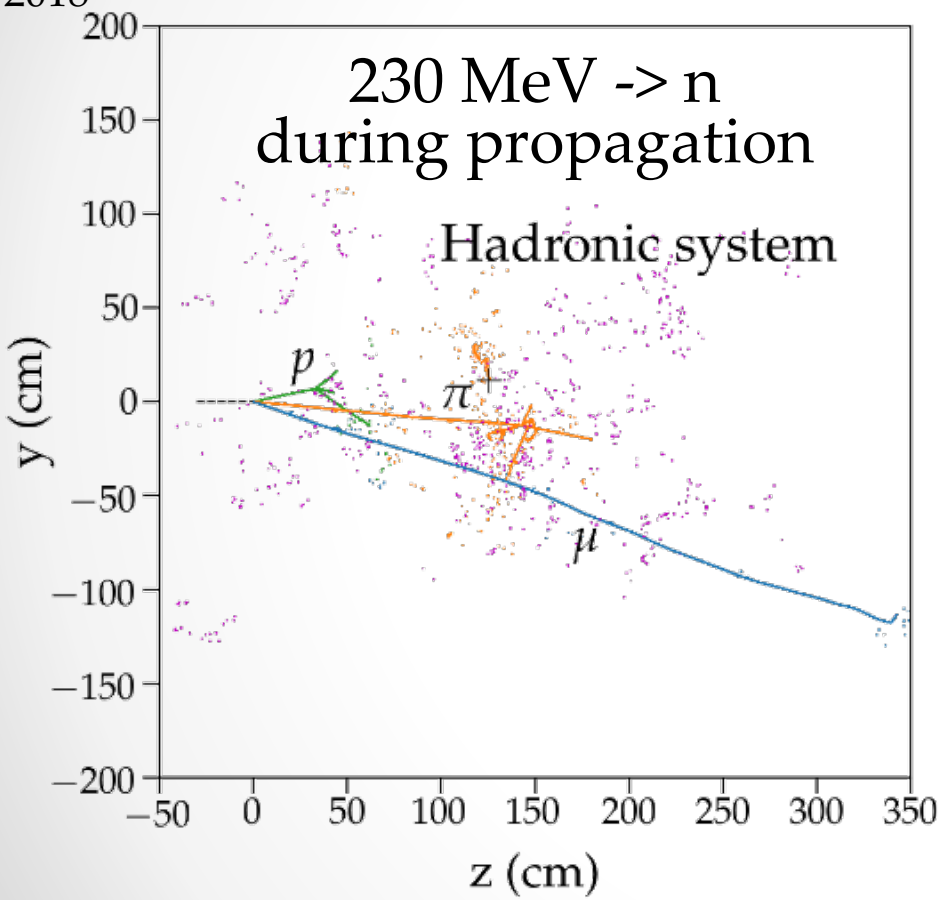


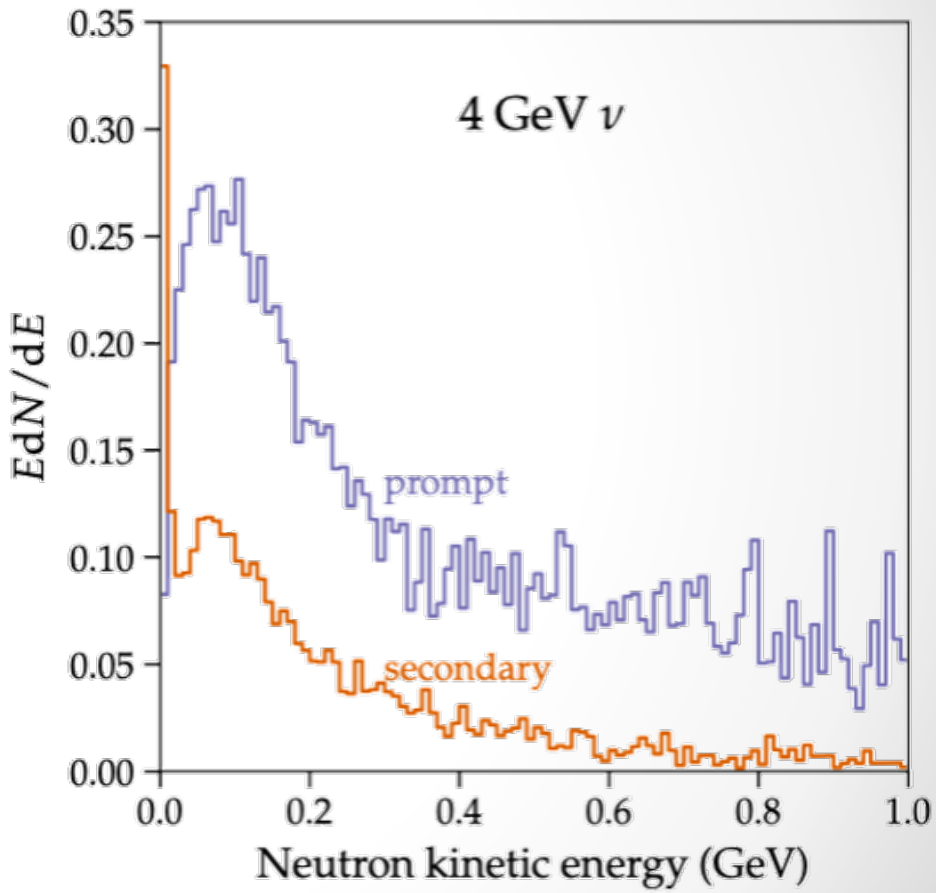
Uncertain! Need More Measurements

Secondary Nuclear Breakup

Friedland, Li 2018

Pions/Protons Interact Further in Argon



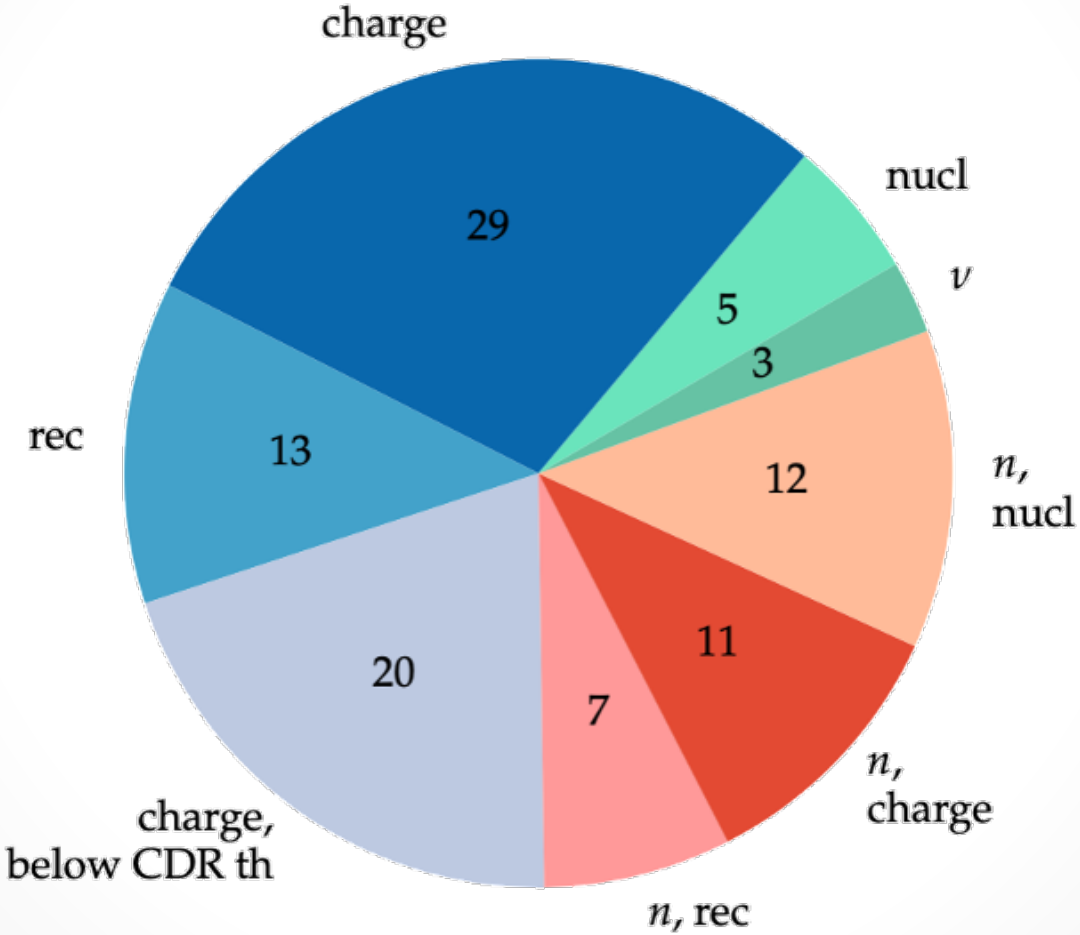


More De-excitation γ & Neutrons

Final Energy Budget

Friedland, Li 2018

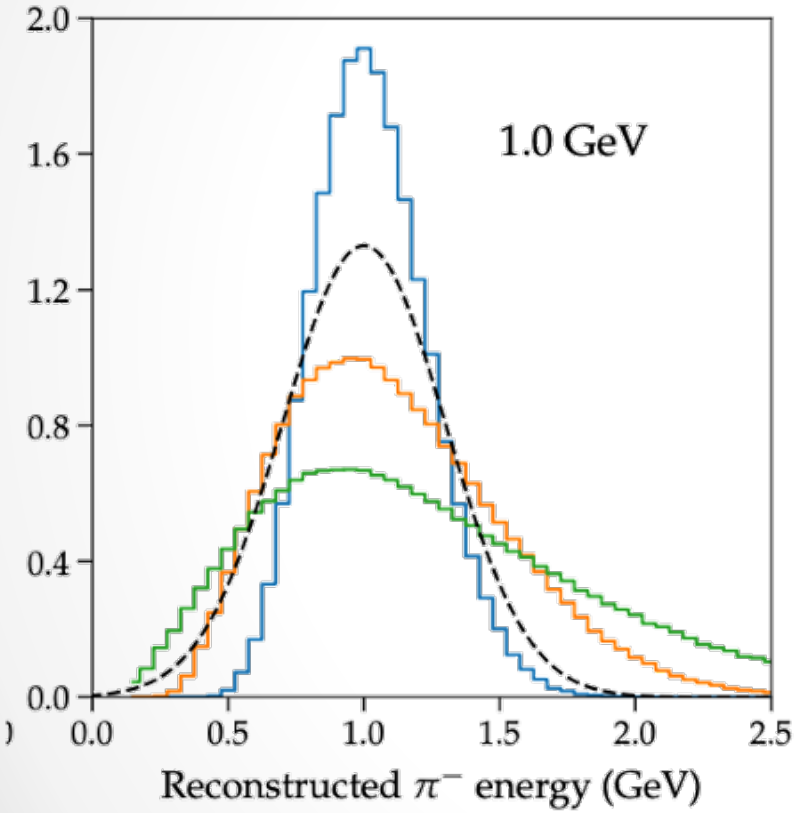
4 GeV Neutrino Hadronic System

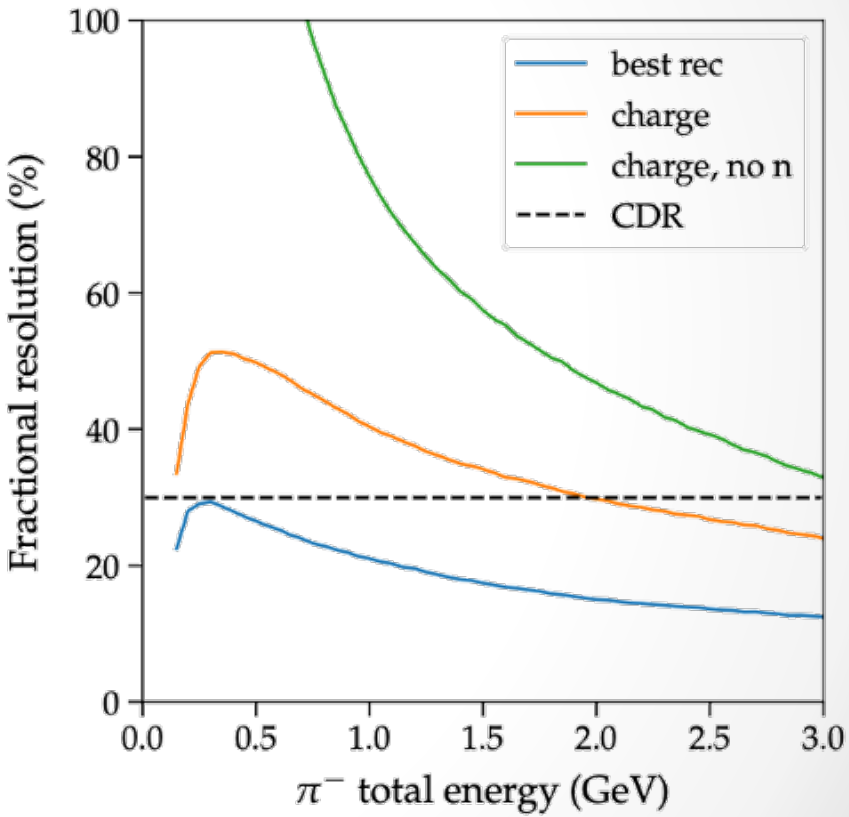


18% Energy Can Be Recovered; 12% Invisible

Effect on Energy Resolution

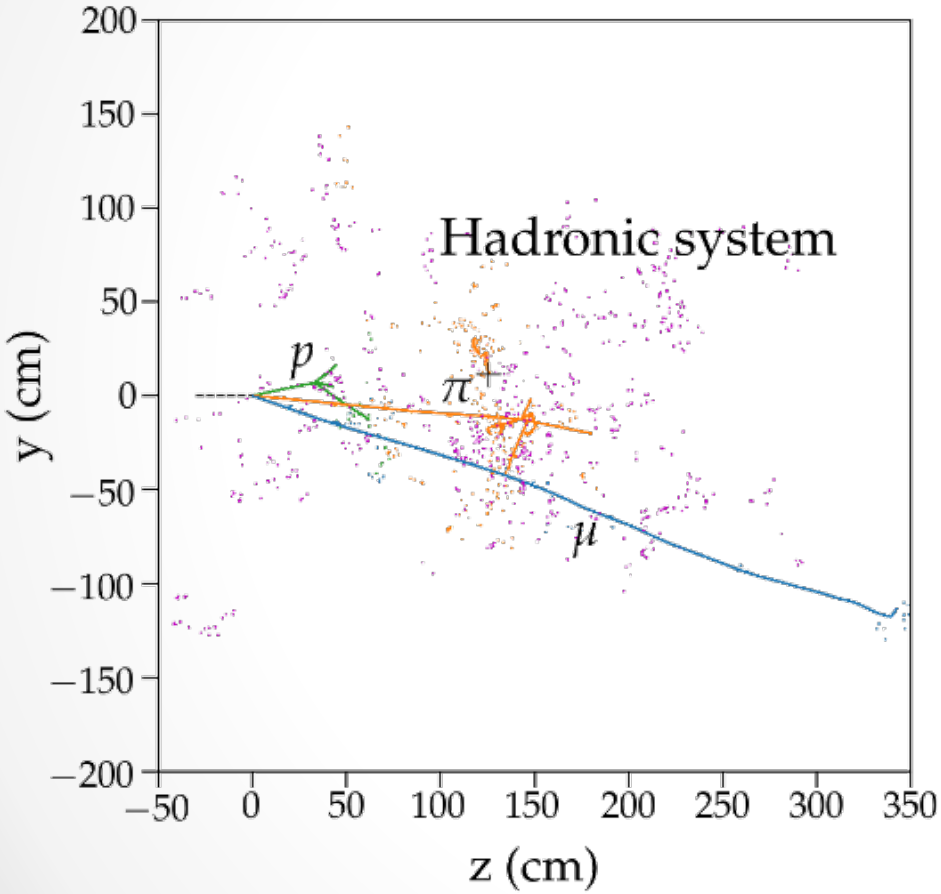
Friedland, Li
2020





Significantly Worse Resolution Without Neutrons

Conclusions



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

DUNE CDR Threshold

DUNE 2015

Particle type	Detection Threshold (KE)
$\mu^{\pm}$	30 MeV
$\pi^{\pm}$	100 MeV
$e^{\pm}/\gamma$	30 MeV
p	50 MeV
n	50 MeV
other	50 MeV