Research plan on nuclear effects and xsec measurement with protoDUNE
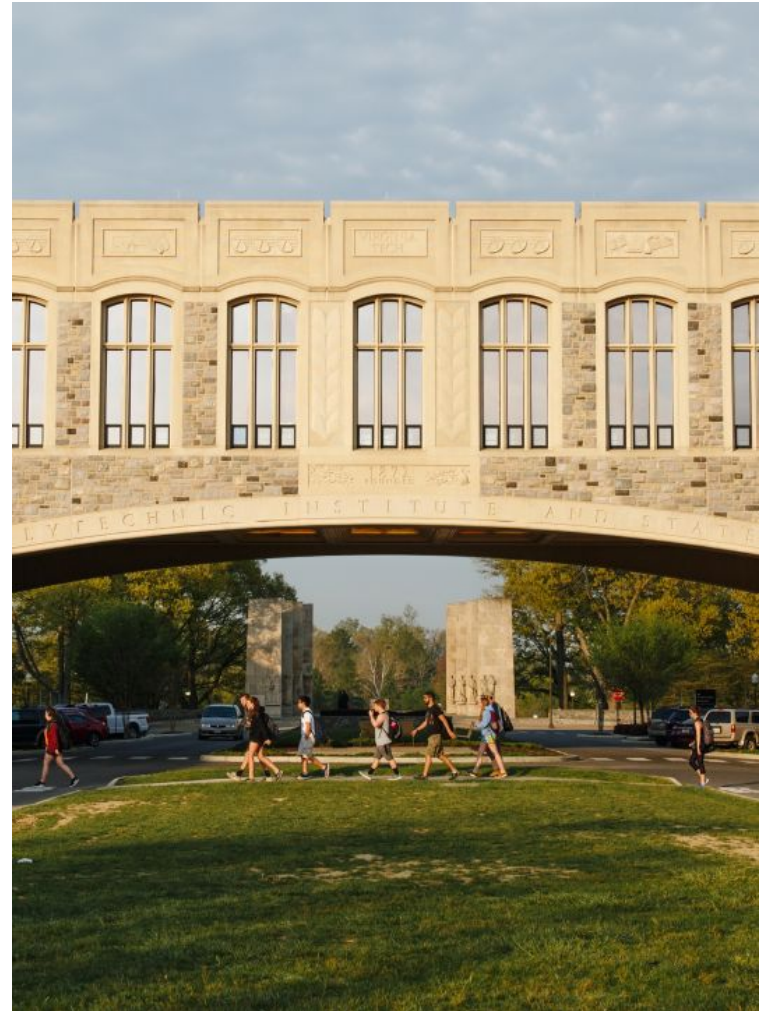
Libo Jiang

Neutrino Group @ VT

Prof. Camillo Mariani

- Electron /neutrino experiment
- protoDUNE CRT

Postdoc: Libo Jiang

- GENIE developer
- MicroBooNE simulation+data analysis
- protoDUNE + FSI
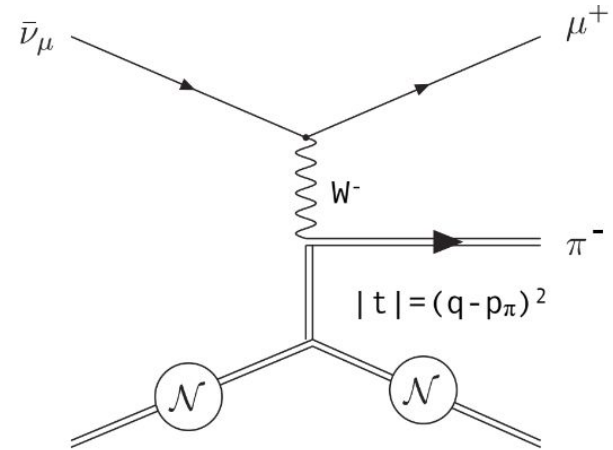
Graduate students: Linjie Gu, Matt Murphy

Motivations

- Provide pion-xsec for the hadronic part of neutrino Argon interaction

E.g: Rein-Sehgal model assumes the pion-nuclear interaction is elastic in coherent process,
  - *no Argon data*
  - *extrapolated from lighter nuclears*
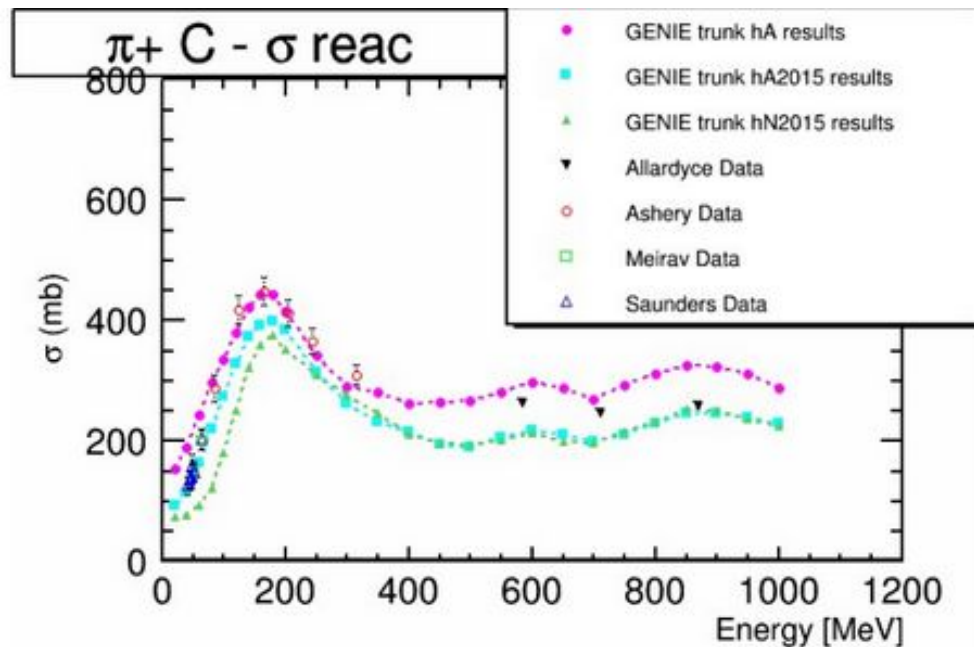
$$|t| = (q - p_\pi)^2$$

Motivations

- Provide xsec for the data-driven FSI model in GENIE

E.g: GENIE data-driven FSI model takes xsec of hadron-nuclear interaction (pion, proton, kaon) as input
- *Under estimated data*
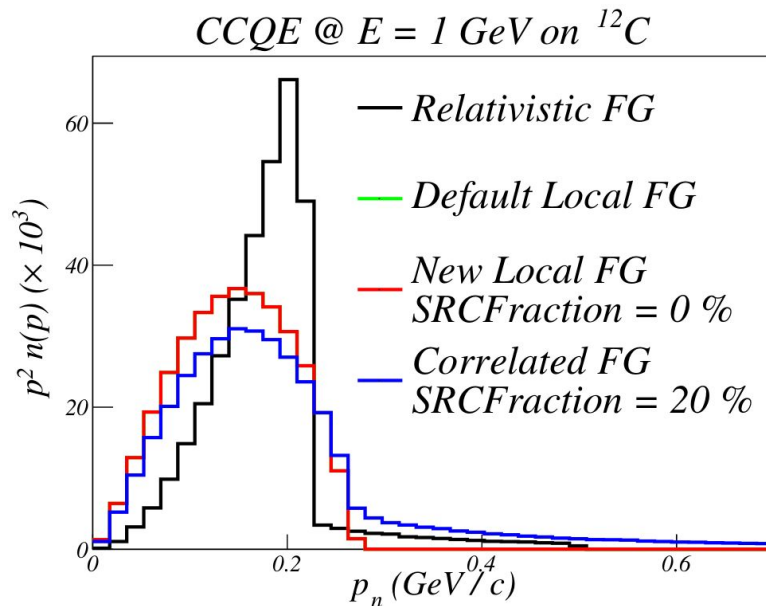- *extrapolated from lighter nuclears to Argon*

Motivations

- ## Nuclear effect measurement
  - ### FSI
  - ### Short-Range Correlations

  E.g: Short Range Correlations
  - *Can be studied through the final state nucleons*


$CCQE @ E = 1 \, GeV \, on \, ^{12}C$

Legend:
— Relativistic FG
— Default Local FG
— New Local FG SRCFraction = 0 %
— Correlated FG SRCFraction = 20 %

y-axis: $p^2 n(p) \, (\times 10^3)$
x-axis: $p_n \, (GeV/c)$

Motivations

- **Universal Study on Pion Production**
  - A big mount of e->e,π production in electron-Argon experiment

  - Better understanding of pion production with the combination of electron-Argon experiment at JLab, neutrino-Argon scattering from MicroBooNE and pion argon scattering protoDUNE

Electron-Argon Experiment at Jefferson Lab
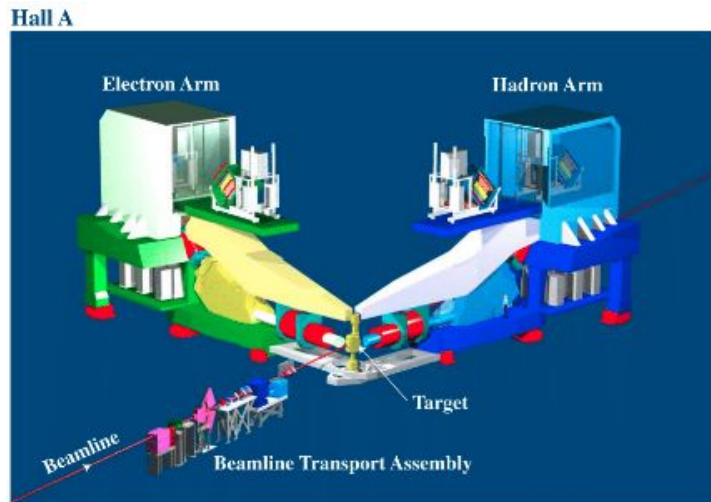
Particle Identification in MicroBooNE

Particle identification base on the pattern of dEdx vs track residual range
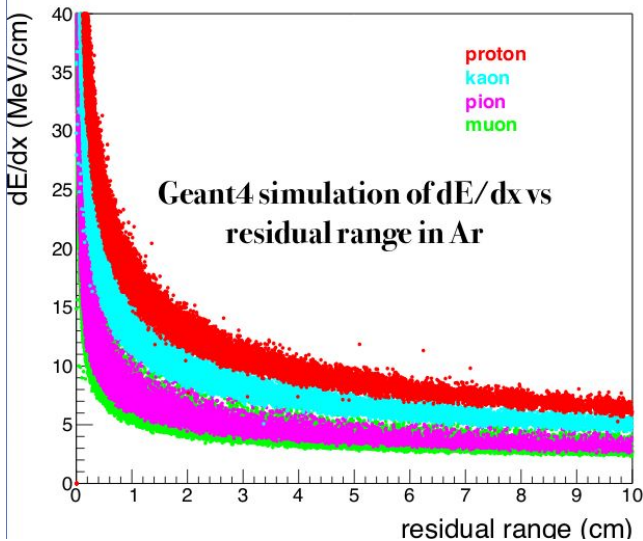
$$PID = \chi^2_{proton}/ndof = \sum_{hit}(\frac{(dE/dx_{measured} - dE/dx_{theory})}{\sigma_{dE/dx}})^2/ndof$$

ndof: number of hits on collection plane.
- First and last hits of each track excluded to avoid any mis-identified residual range

Geant4 simulation of dE/dx vs residual range in Ar

proton
kaon
pion
muon

Proton enhanced sample	Before PID requirement	After PID	relative efficiency after PID requirement
true μ	18.7%	2.0%	
true proton	64.5%	92.6%	85.2%
other	16.8%	5.4%	

- All the proton candidates are required to have at least 5 hits on collection plane

Ref: MicroBooNE talk at NuINT 2018

CC1uNP XSec Measurement in MicroBOONE
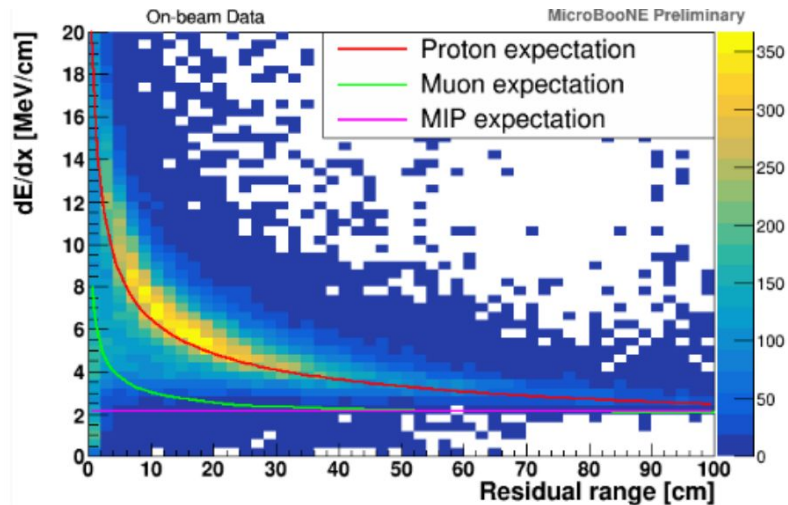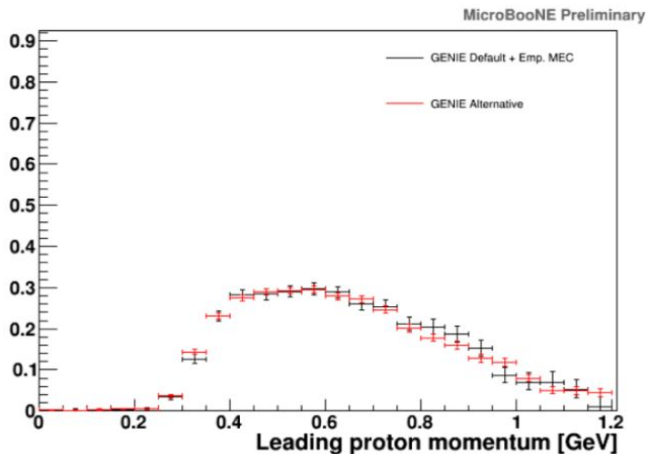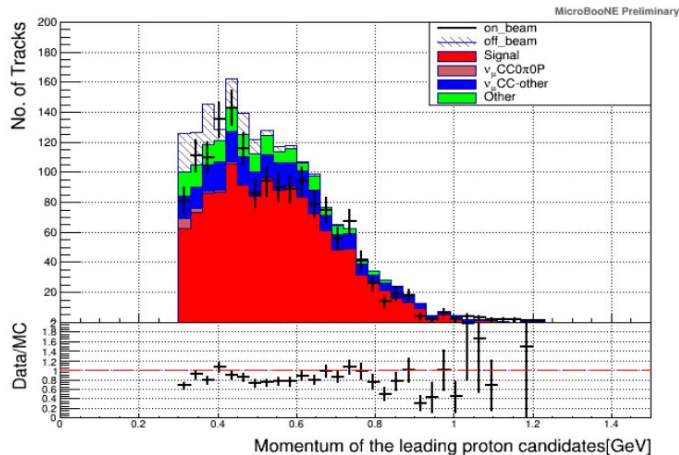
- Plots come from NuFact 2018, a paper with xsec measurements is in preparation aiming for PRD
- Proton's low momentum threshold down to 300 MeV (kinetic energy~47MeV)
- Systematic uncertainties is dominated by the detector systematics
- Systematic from proton re-interaction is much bigger than the pion re-interaction

Possible topic for research

A couple possible topics in mind after talking with Tingjun Yang

- Pion Absorption/ pion->n proton 0 pion
    - No measurement with energy above 400 MeV
    - No π^+ Measurement with Argon
- Proton Argon interaction
    - Low momentum behavior
    - Nuclear effects
- Happy to collaborate with others

Research Plan with ProtoDUNE

P, kaon, π⁺ → Ar → X

0.1 GeV

0.3 GeV
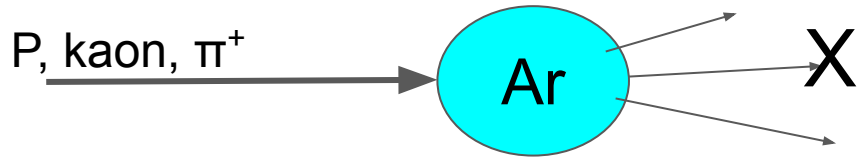
- Start from particle identification, pion, proton discrimination (similar low momentum threshold as microboone)

- Develop a good algorithm for event selection

- Measure cross section of beam particle and Argon interaction

- Nuclear effect study