Update on Slicing Methods for Pion Absorption and Charge Exchange Cross Sections

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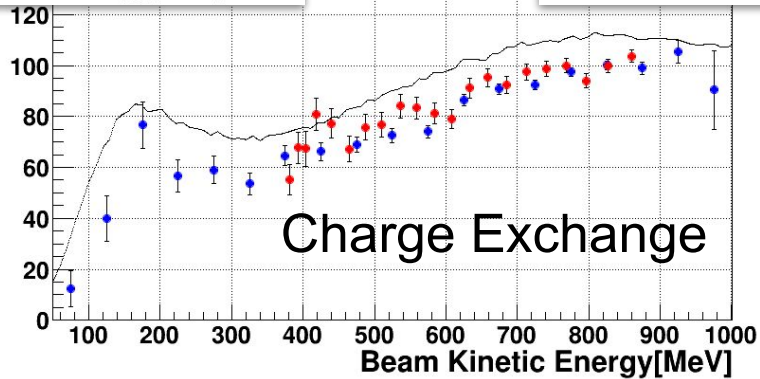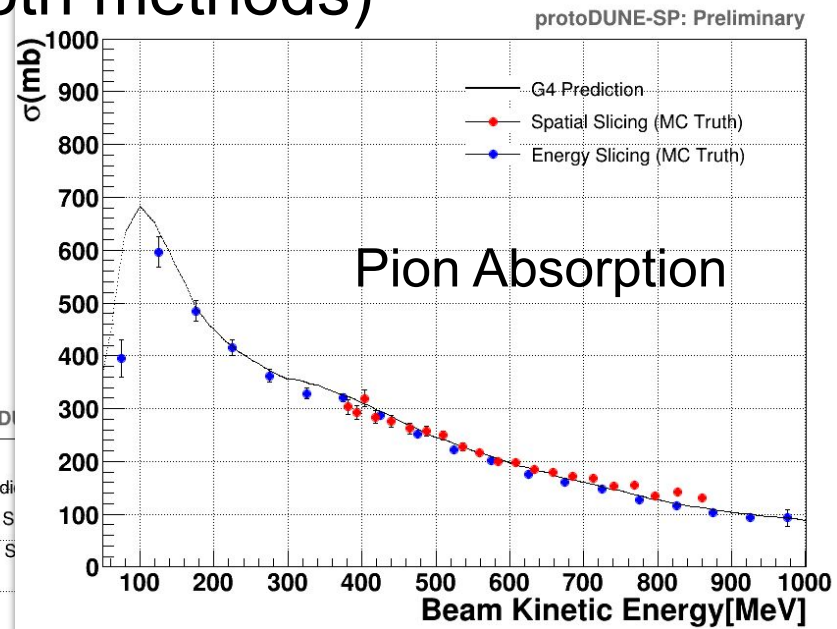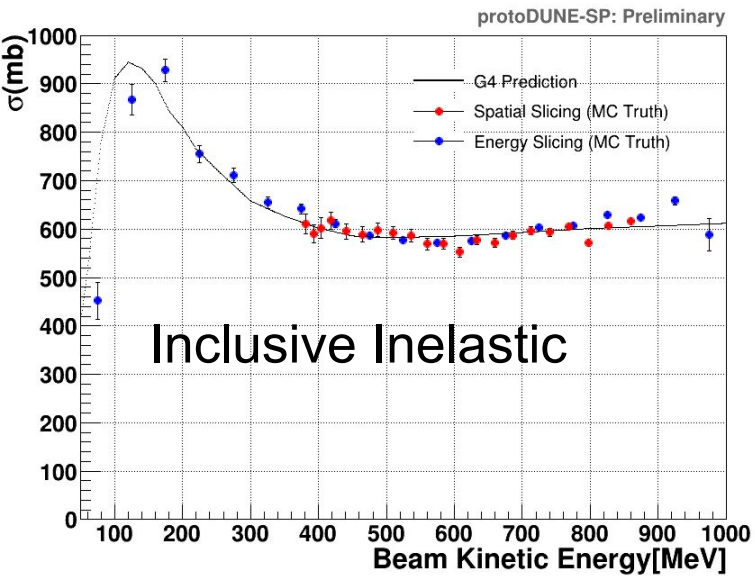
Energy Slicing Method

Separate pions into bins based on energy, and use knowledge of dE/dx from the Bethe-Bloch equation to calculate the cross section.

$$\sigma(E_i) = \frac{M_{Ar}}{\rho \Delta E N_A} \frac{dE}{dx}(E_i) \, ln\left(\frac{N_{inc}(E_i)}{N_{inc}(E_i) - N_{int}(E_i)}\right)$$

Additionally, building the incident histogram is more difficult than in the spatial slicing method as, for example, a pion with 800 MeV initial energy will not be among the incident sample for higher-energy bins

$$N_{incident}(i) = \sum_{j=0}^{i-1} N_{KE\ initial}(j) - \sum_{j=0}^{i-1} N_{KE\ interacting}(j)$$

Previous results (MC Truth with both methods)

protoDUNE-SP: Preliminary

Inclusive Inelastic

protoDUNE-SP: Preliminary

Pion Absorption

Charge Exchange

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Unfolding with RooUnfold

To examine the cross sections for the MC reconstruction and the data one must use an unfolding procedure.

The RooUnfold package allows one to build a response matrix between true and reconstructed information and use this to unfold the data and compare to the true cross section

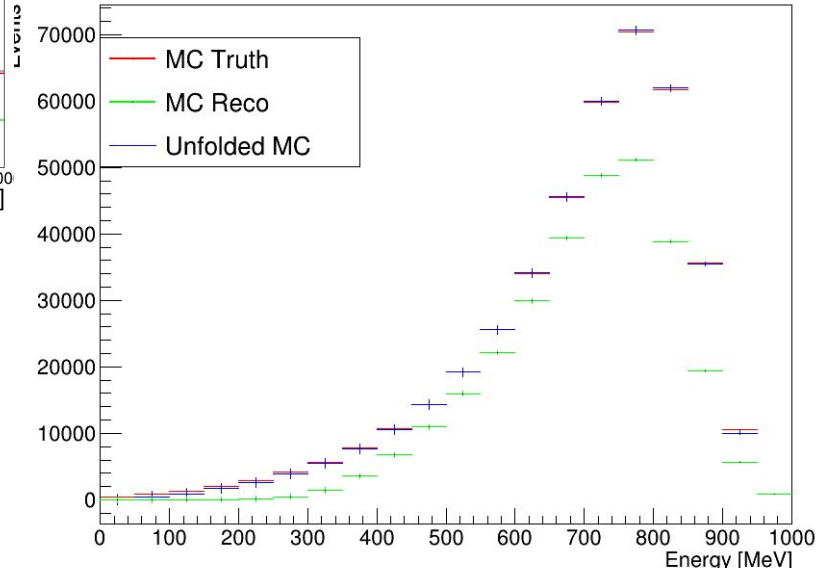Here I perform a Bayesian unfolding with 4-8 iterations.

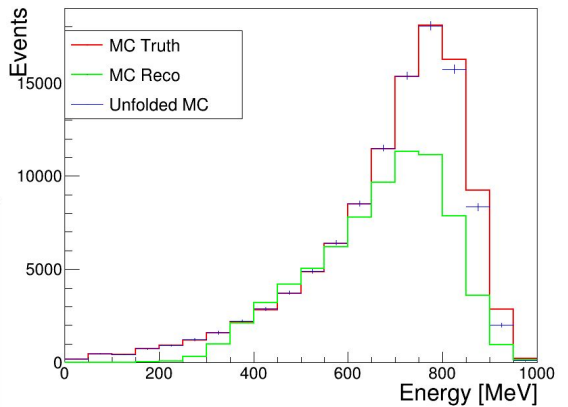# ESlice method - initial and interacting histograms
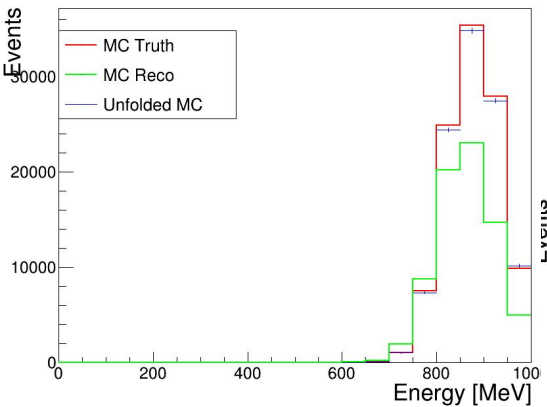
$$N_{incident}(i) = \sum_{j=0}^{i-1} N_{KE\ initial}(j) - \sum_{j=0}^{i-1} N_{KE\ interacting}(j)$$

Initial Energy (MC)

Incident Energy (MC)

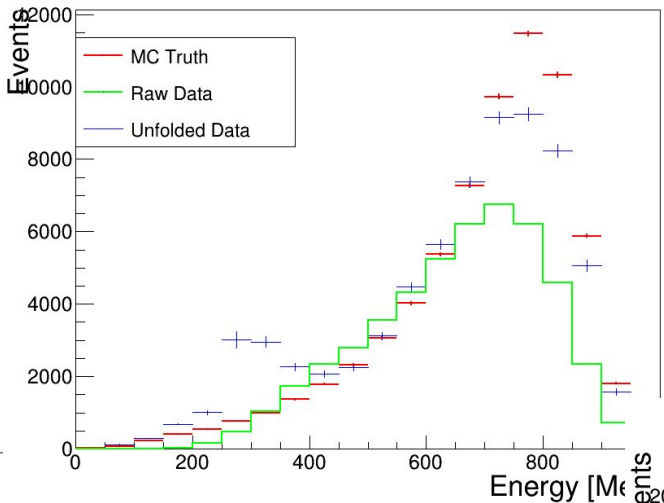Interacting Energy (MC)

Unfolding trained with full MC - to verify, planning to train with ⅔ and test on ⅓ of events
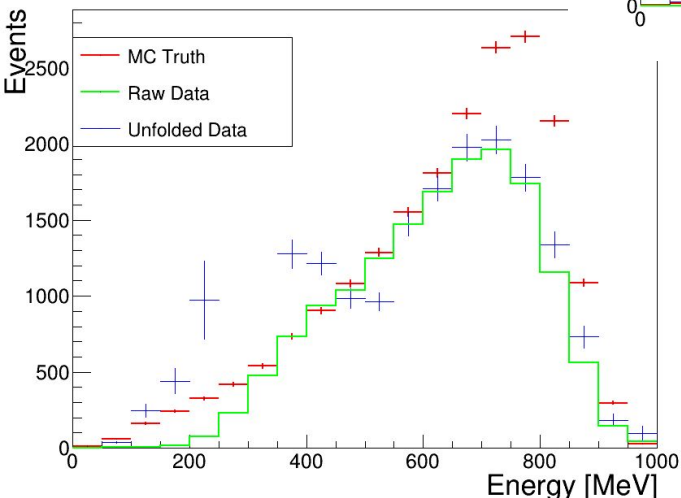
5

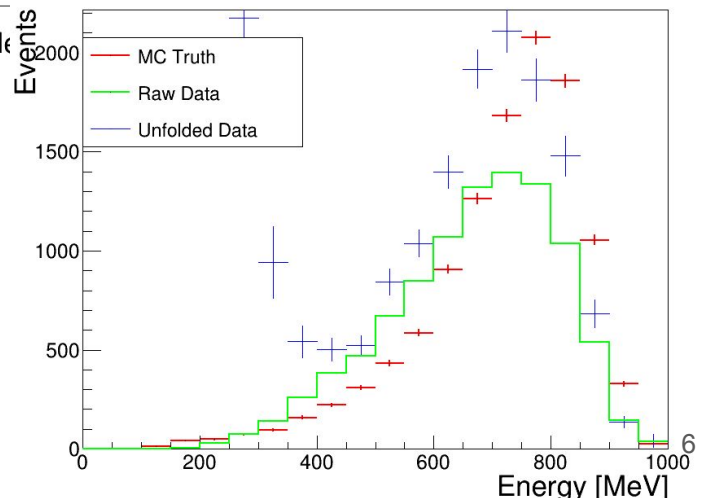# ESlice method - Data interactions

Inelastic Inter. Energy (Data)

Here we notice an excess around 300-400 MeV - possibly muon content that needs to be removed.

ESlice method - Inclusive Cross Section
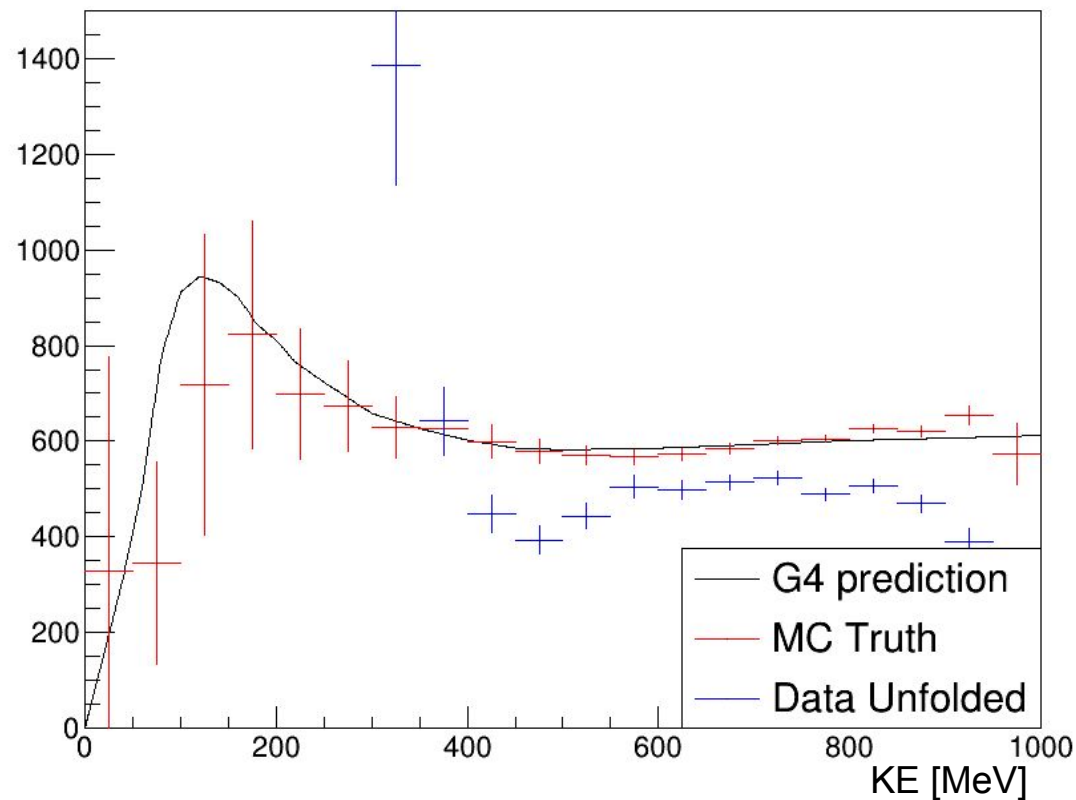

Inclusive XS

G4 prediction
MC Truth
Data Unfolded
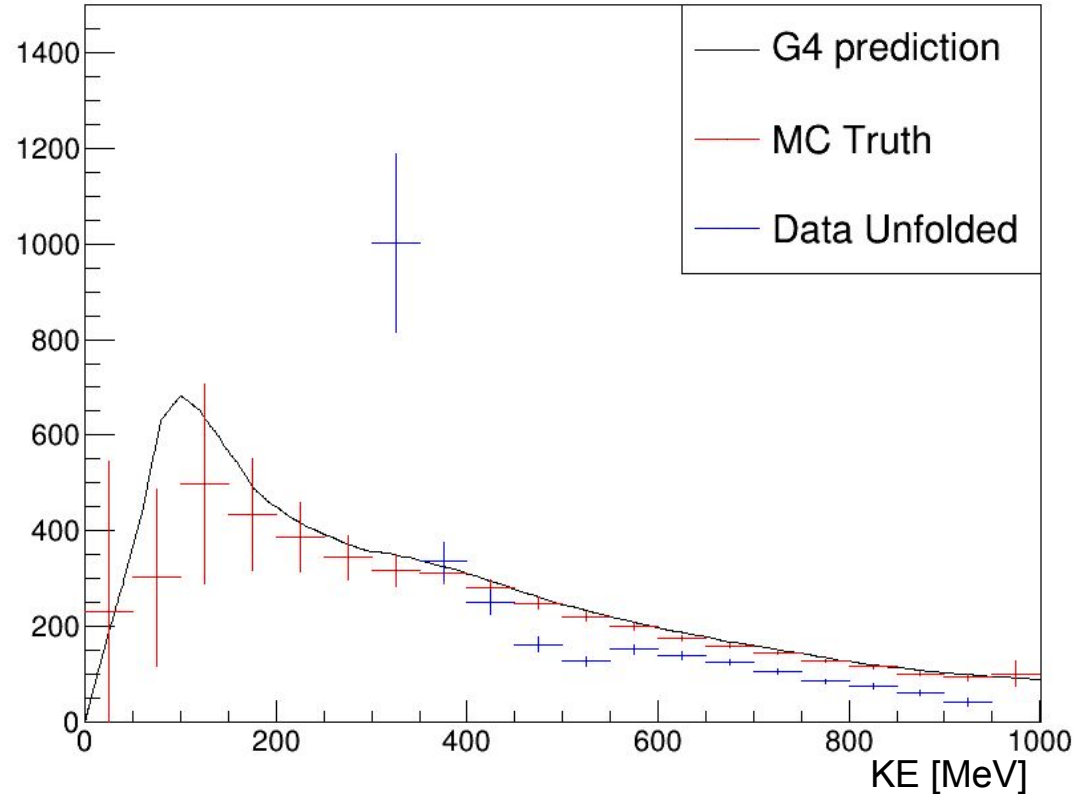
MC true has only stat. error
Unfolded data has stat. + unfolding
error

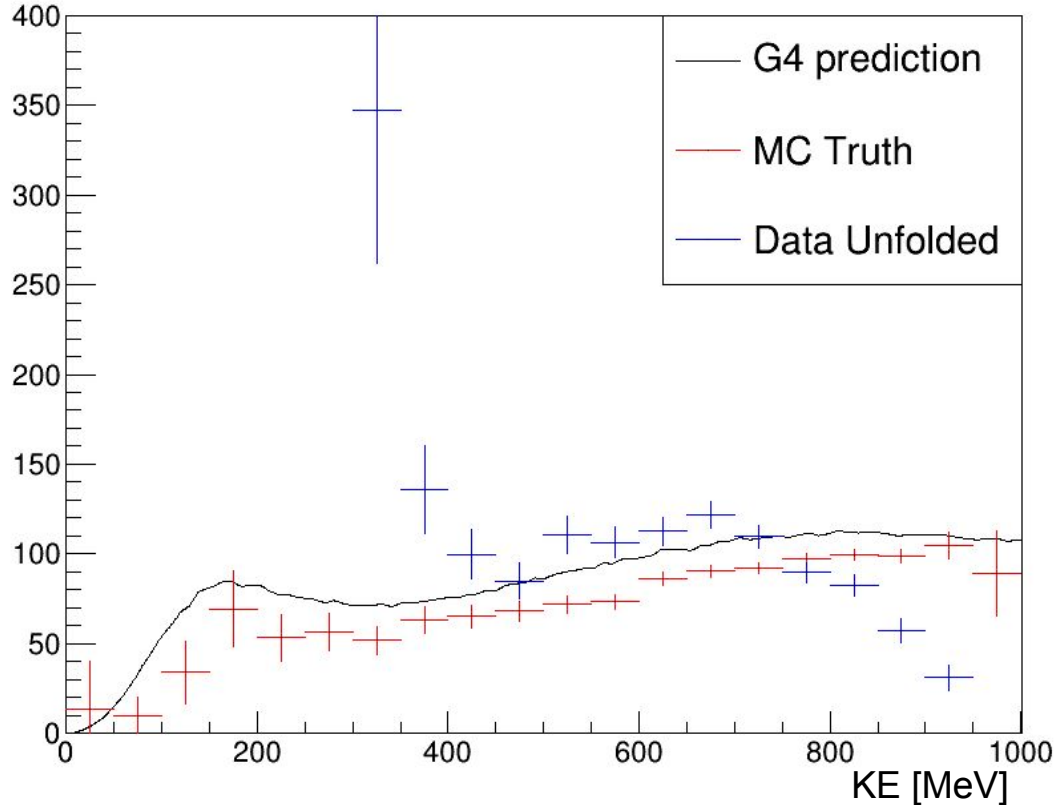# ESlice method - Absorption Cross Section

Absorption XS

ESlice method - Charge Exchange Cross Section

Charge Exchange XS

To-Do

Add correction to initial energy determined previously by Yinrui
Investigate data event selection at low energies
Establish charge exchange signal definitions

Spatial slicing method

Analysis is almost at the same point - need to account for the unfolding error and can present direct comparisons next week

Backup

Data and MC files used

MC:
/pnfs/dune/tape_backed/dunepro/protodune-sp/root-tuple/2022/mc/physics/PDSPProd4a/18/80/01/67/PDSPProd4a_MC_1GeV_reco1_sce_datadriven_v1_ntuple_v09_41_00_03.root (Jan 18)

Data:
/pnfs/dune/tape_backed/dunepro/protodune-sp/root-tuple/2022/detector/physics/PDSPProd4/00/00/52/19/PDSPProd4_data_1GeV_reco2_ntuple_v09_41_00_04.root (Jan 18)