Extracting Cross Section With Slicing Method

(Test with MC Prod4)

Motivations

- Attempted to extract (differential) cross sections with slicing method.
- MC sample: Prod 4
  - Pion Beam Momentum 1GeV
  - /dune/data/users/fstocker/ANALYSIS/prod4_files/pionana_Prod4_mc_1GeV_1_14_21.root
  - Use MC as fake data
- Repository: https://github.com/huajieyu/PionAbsChxAna.git (pionana branch)
  - Script for running: Main/mac/run_maker.py

```
maker.SetSignalTypeAbs(True)
maker.SetSignalTypeChx(False)
```

	Absorption	Charge Exchange
Generated	11135	5902
Selected	7687	----
Efficiency	69%	----

Slicing Method for Cross Section Extraction

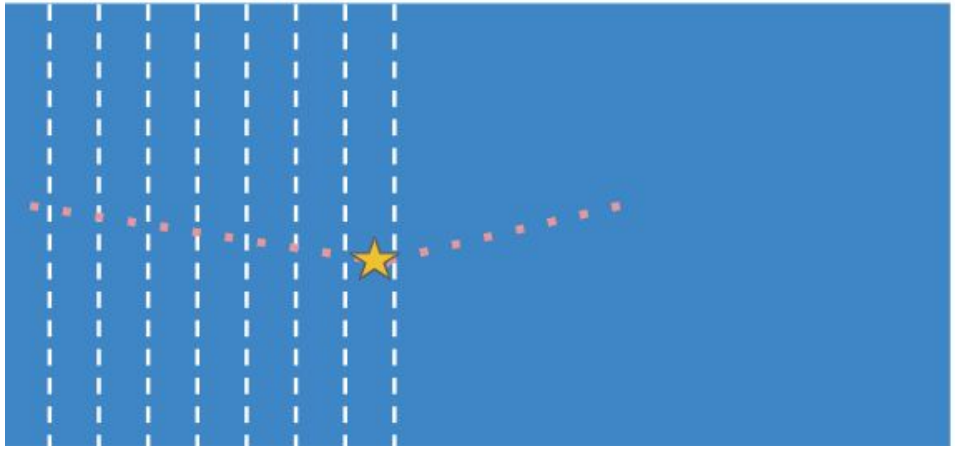
Cross section is proportional to ratio: interacting/incident

$\sigma = (M_{Ar}/\rho t N_A) * (N_{Int}/N_{Inc})$

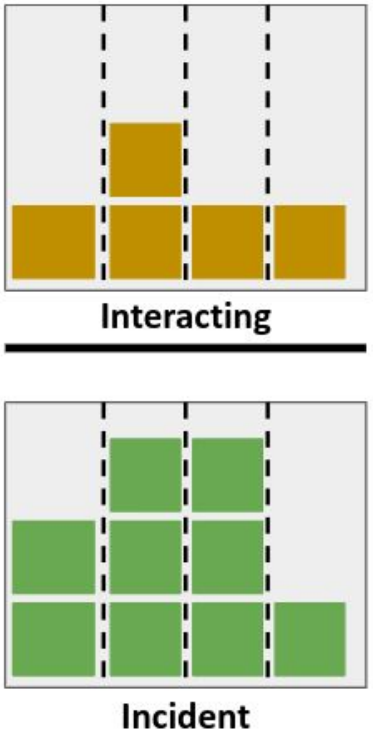
M_{Ar} -- Mass of Ar

t -- Thickness of slice

ρ -- Density of Ar

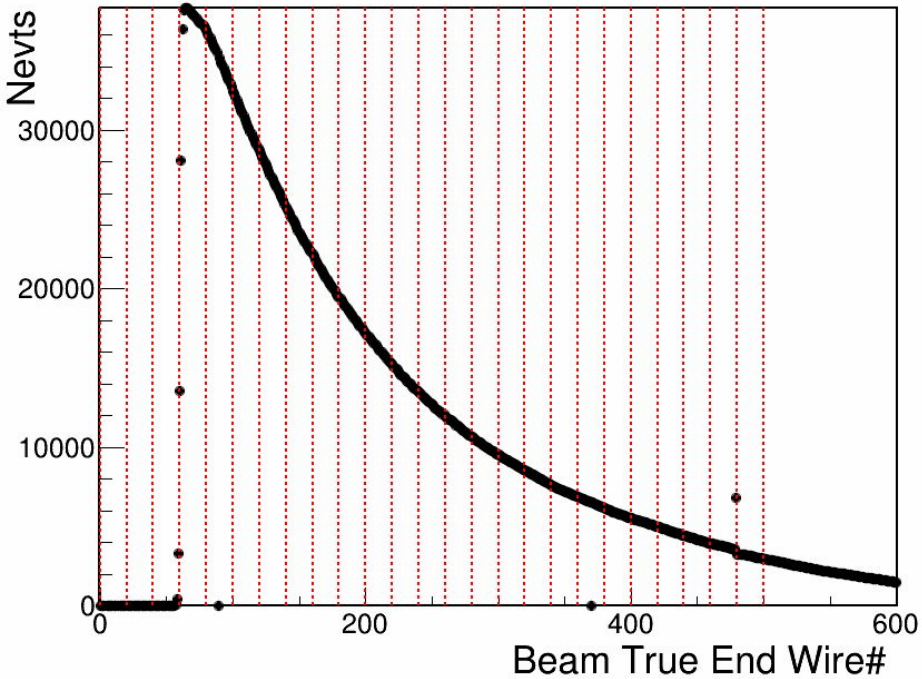


$\sigma \sim$



Credit: Jake Calcutt

Slicing Based on Wires

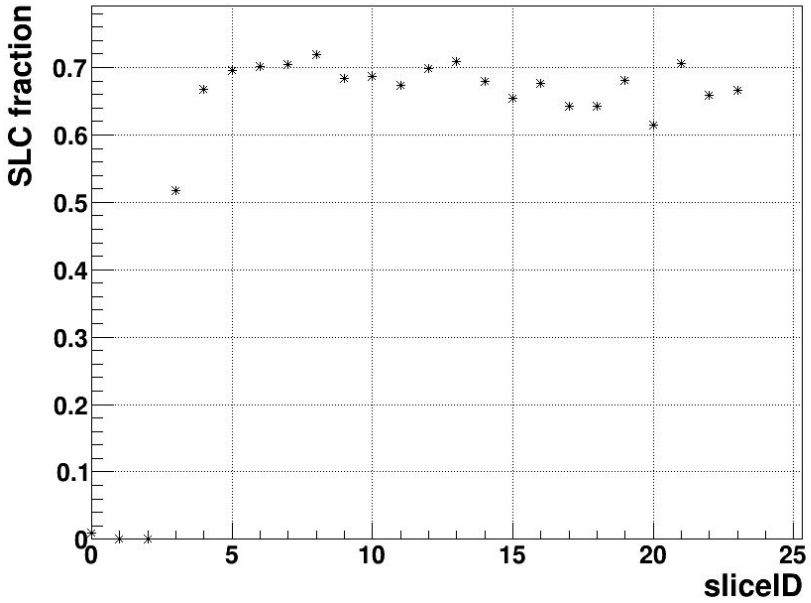


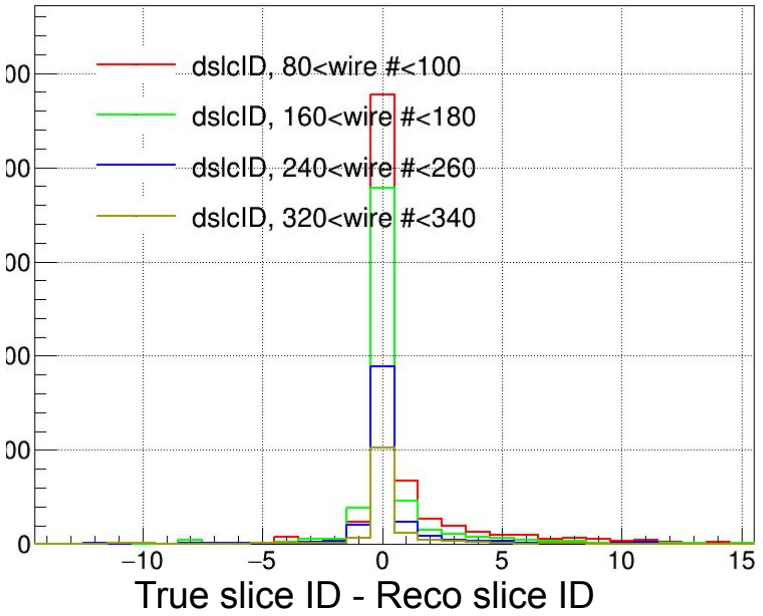
- 1 Slice = 20 Wires ; 24 slices in total from wire #0 to wire 480
- Slicing ID is determined by true beam end point z with SCE correction
  - “True beam end Z” -> “SCE correction” -> “new True end Z->Wire ID&true_slice ID”
  - Number of **interactions** and number of **incidents** are calculated in each true slice ID

$$\sigma = (M_{Ar}/\rho t N_A) * (N_{Int}/N_{Inc})$$

  - Why not reco?

Reco Slice ID - True Slice ID

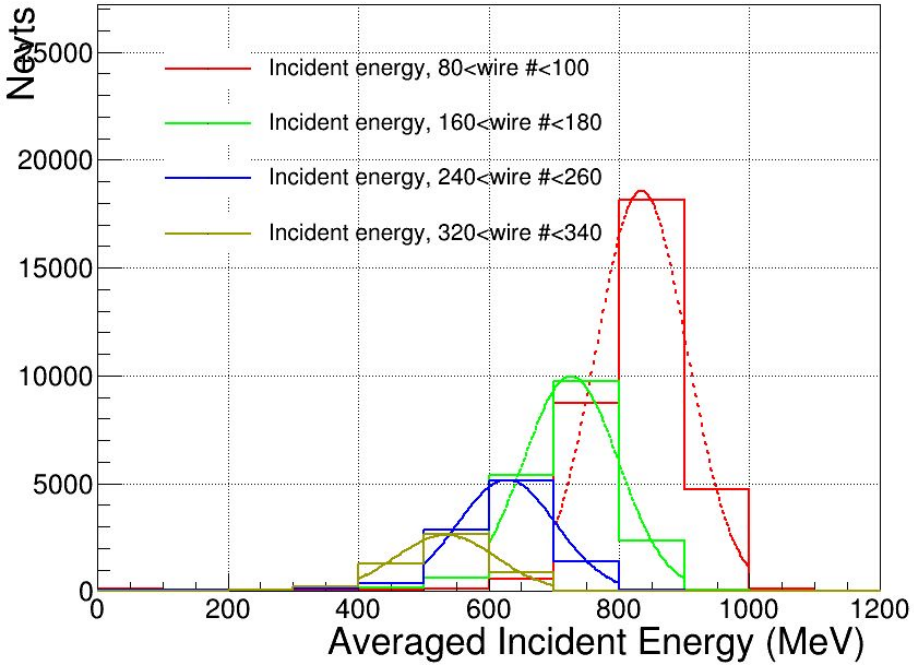


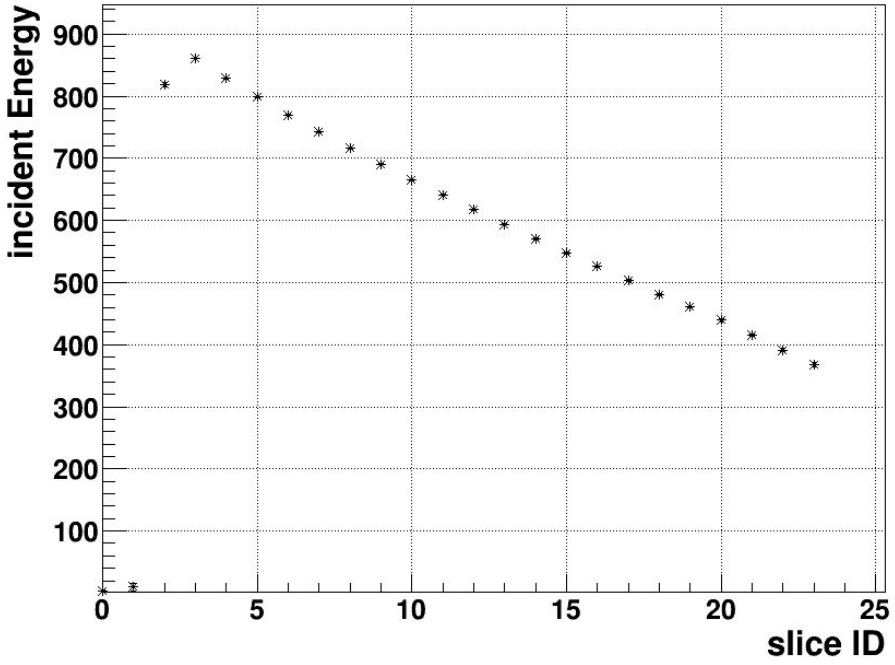


- Around 70% of the pion processes reconstructed in the correct slices
- A lot of them were shifted to the next few slices
- Xsec in the slice determined by reconstructed wires will be lower than the xsec calculated in the slice determined by true wires with sce correction

Averaged Incident Energies (reco_beam_incidentEnergies)

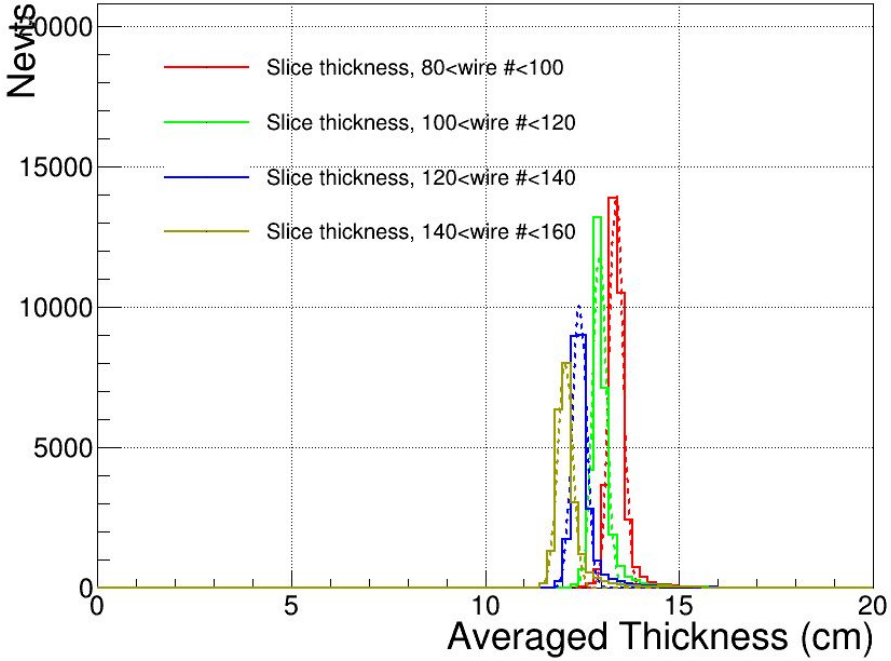
- (Averaged) Incident Energies in each slice are calculated in order to convert the cross sections as a function of slice ID into a function of averaged incident energy.
- Averaged incident energy decreases with the increasing of slice ID (wire number) - 4 sample curves shown in the figure on the left side -> Roughly gaussian distribution.
- Figure on the left shows the incident energy distribution as a function of slice ID

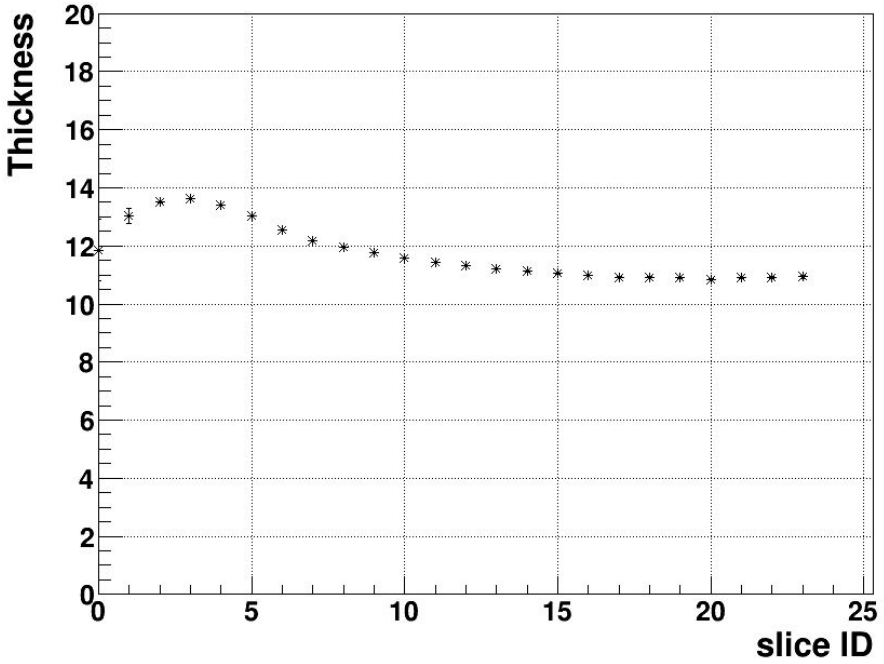




Averaged Thickness of each slices (reco trk pitch)

- Averaged Thickness decrease with the increasing of slice ID(wire number) - lower averaged energy
- Low standard deviation in the estimation of thickness





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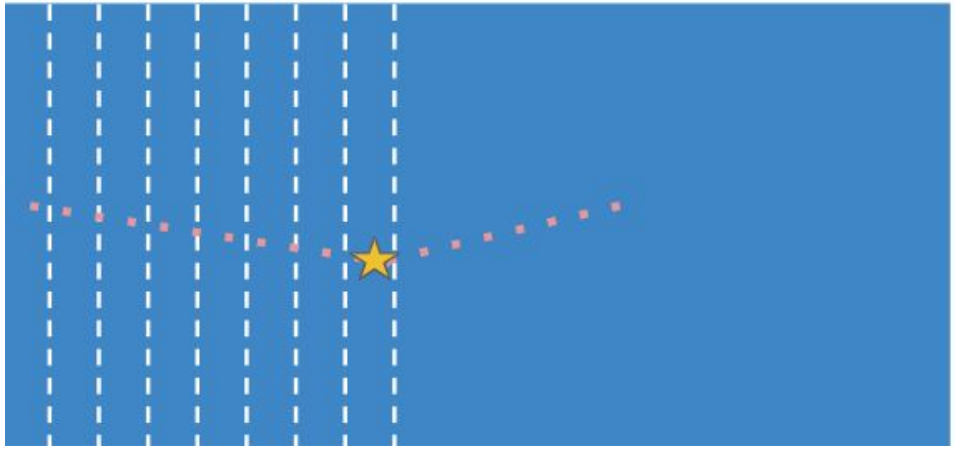
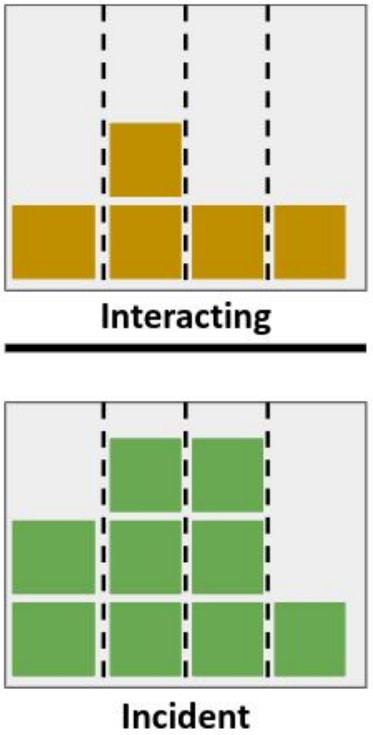
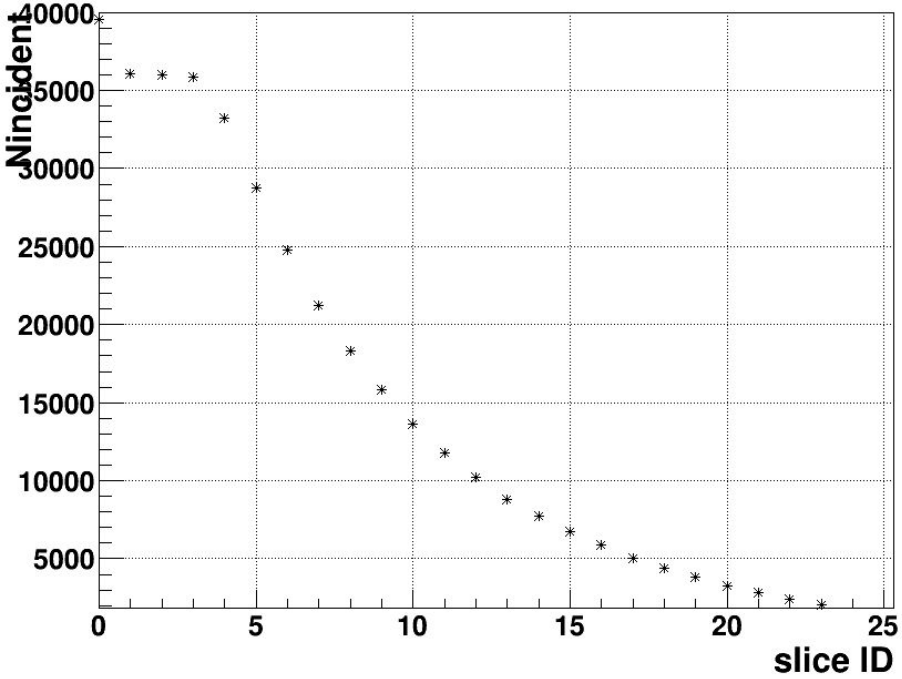
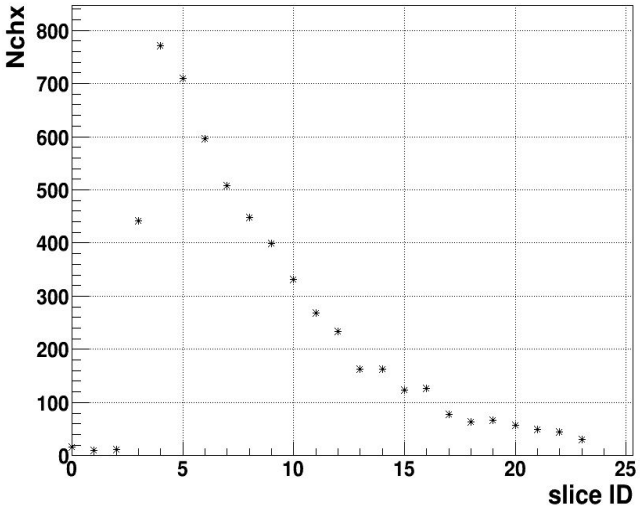


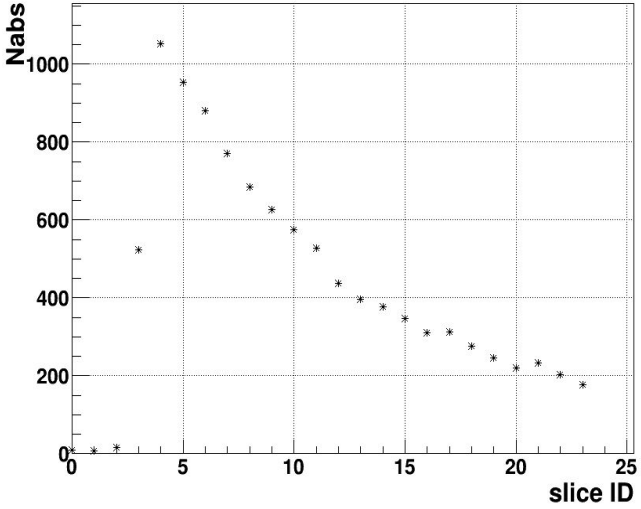
$\sigma \sim$



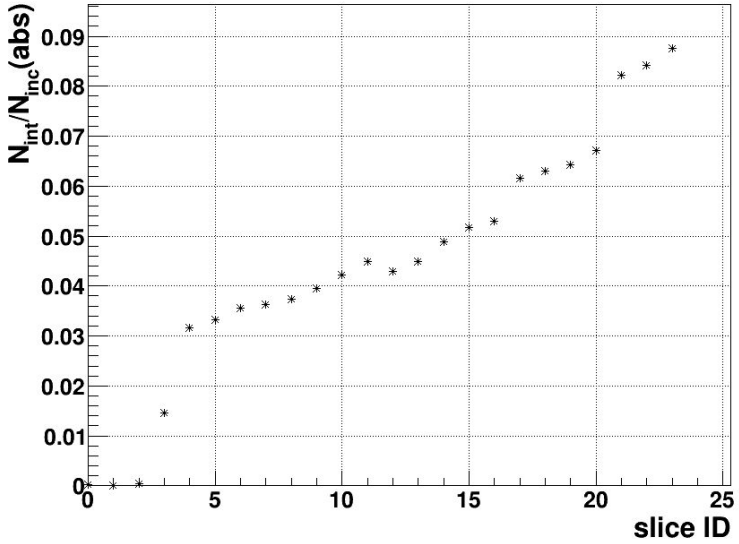
Incident Vs Interactions

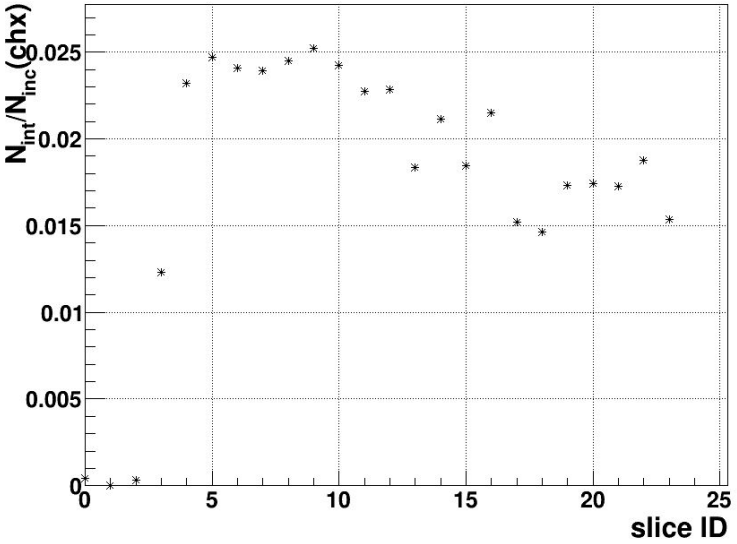






Fraction of Absorption and Charge Exchange

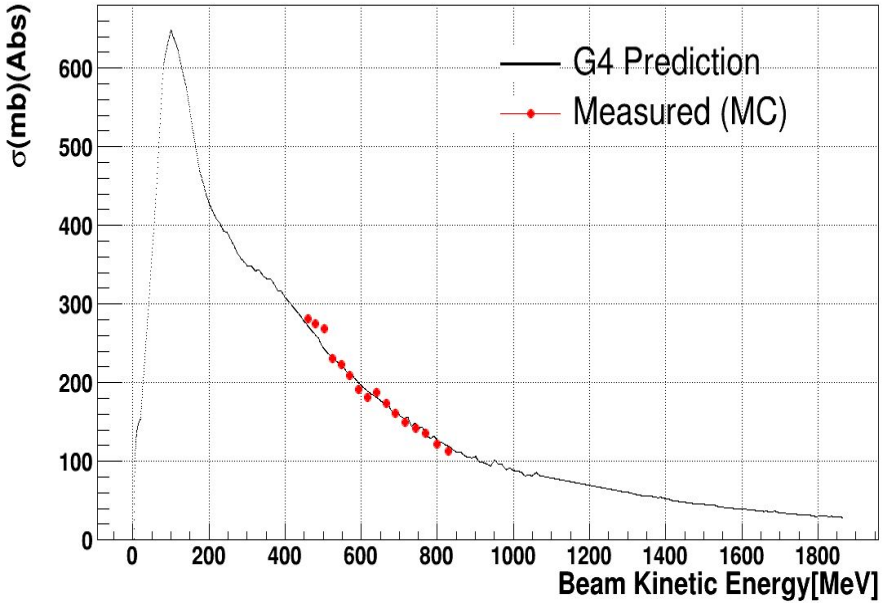


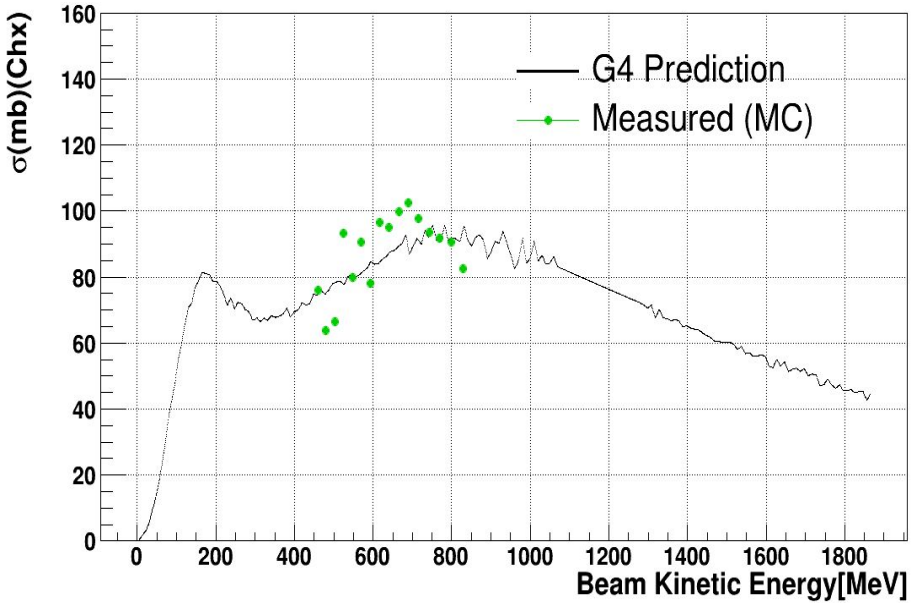


- Fraction of absorption / charge exchange of all the incident particles
- Large scattering in pion charge exchange processes
  - Slicing is based on the track beam end z positions with SCE correction
  - Can explain the fluctuation in the xsec of pion charge exchange

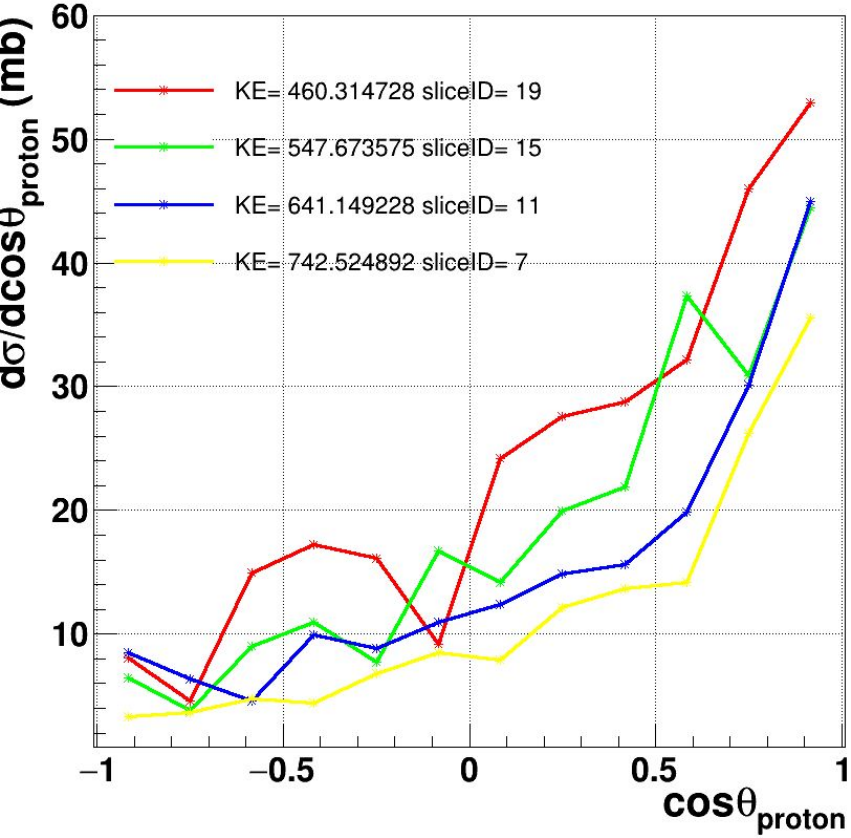
Cross Sections of Absorption and Charge Exchange

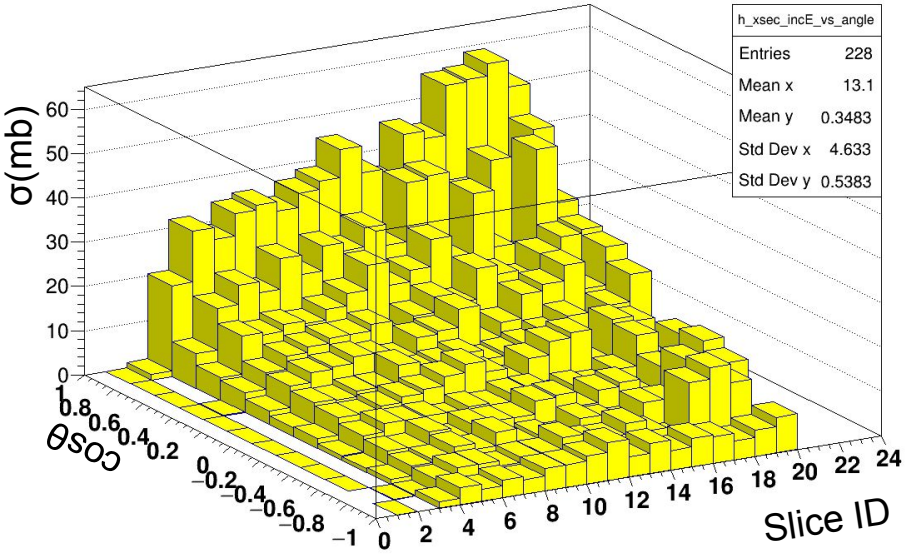
- Slicing Method with MC truth successfully reproduced the cross section of pion absorptions and charge exchange
- Only Slice 4 to slice 20 are plotted due to the statistics





Differential Cross Section (Leading Proton)





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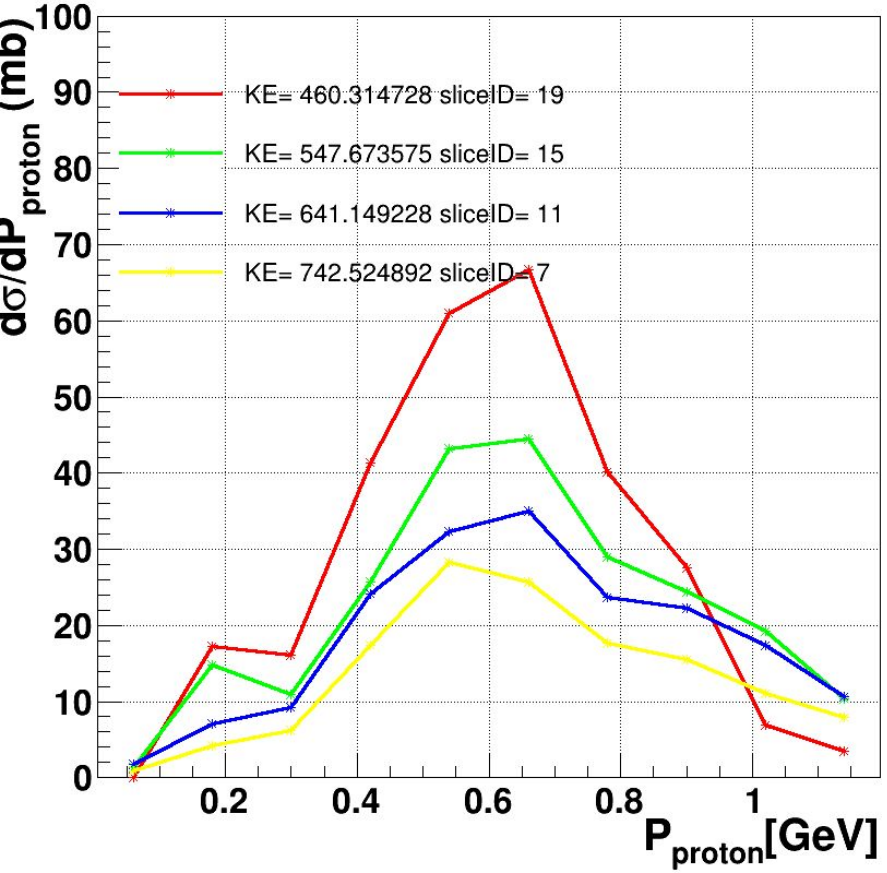

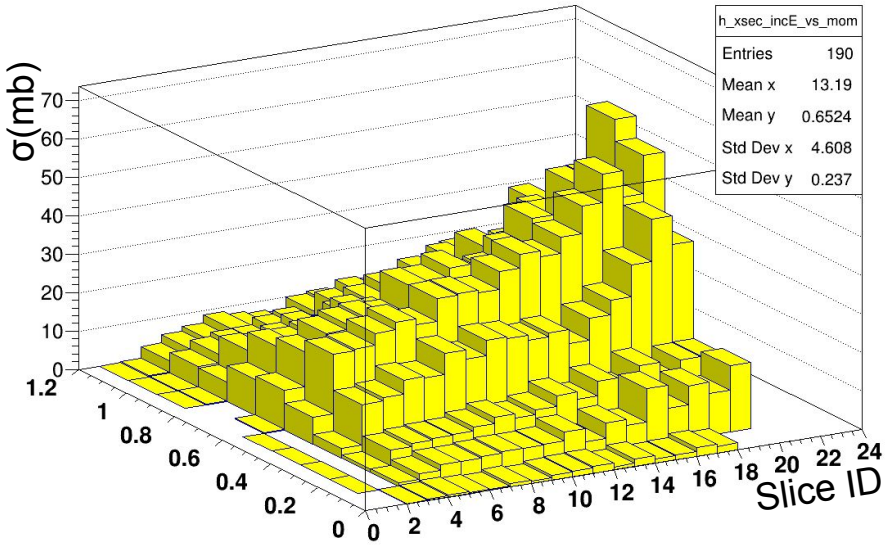

Summary

- First Test of the cross section extraction with slicing method and MC prod4
- Successfully reproduced the cross section of absorption and charge exchange processes in Geant 4
- Next Step:
  - Background constraint
  - Further investigate to the difference between slicing determined by reco slice ID and true slice ID
  - Test slicing method with data
  - Evaluate systematic from Geant 4