

Final state interactions in NEUT

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Pion final state interactions in NEUT

Semi-classical cascade simulation

pion interactions

Delta region ($p_\pi < 500 \text{ MeV}/c$)

Mean free path : Salcedo, Oset et al.

Scaled to reproduce π -A exp. data.

(ρ dependences are not changed.)

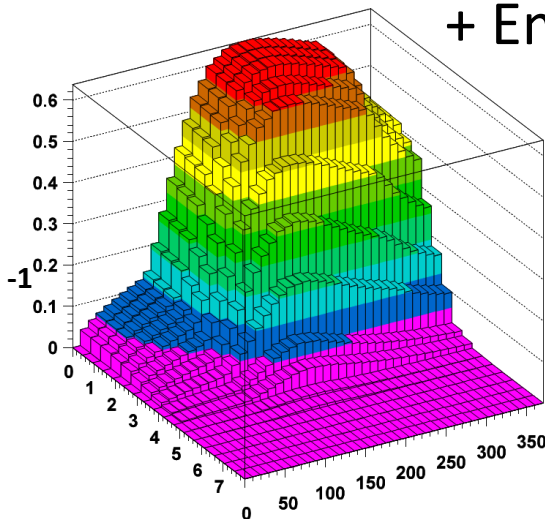
Kinematics : results from phase shift analyses

Local Fermi-gas model is used.

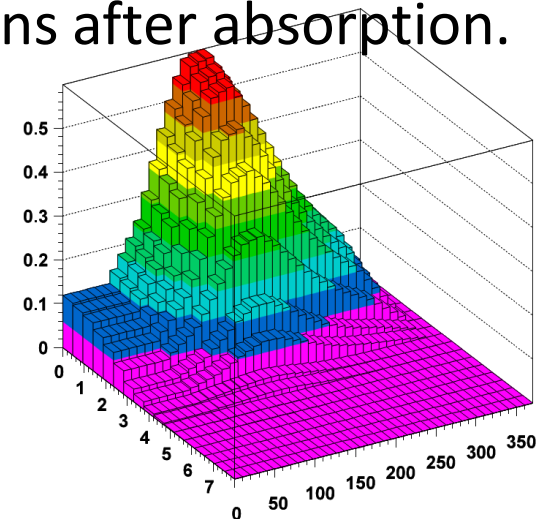
Medium correction by Seki et al.

+ Emission of nucleons after absorption.

Scattering
Mean free path



Absorption
Mean free path



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Semi-classical cascade simulation
pion interactions

Higher energy region ($p_\pi > 500\text{MeV}/c$)

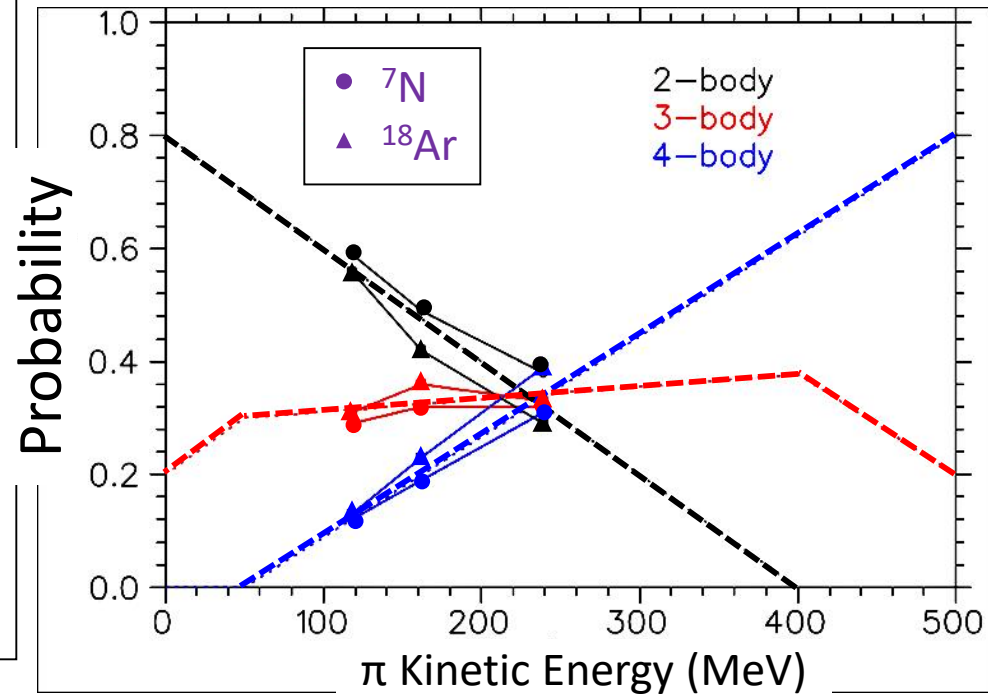
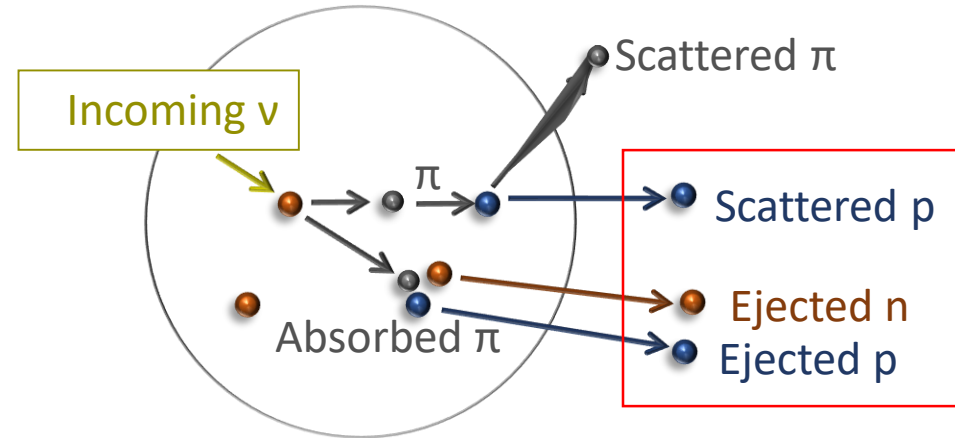
- Use $\pi^\pm N$ and $\pi^\pm d$ scattering data
- Consider elastic scattering & particle production

	$\pi^+ p \mid \pi^- n$	$\pi^+ n \mid \pi^0 N \mid \pi^- p$
$\sigma_{free}^{el} =$	$\sigma_{\pi^+ p}^{el}$	$\sigma_{\pi^- p}^{el}$
$\sigma_{free}^{tot} =$	$\sigma_{\pi^+ p}^{tot}$	$\sigma_{\pi^- p}^{tot}$

- Elastic scattering:
$$\sigma_{el} = \frac{1}{2} \sigma_{\pi^\pm d}^{total} \left(\frac{\sigma_{free}^{el}}{\sigma_{free}^{tot}} \right)$$
- Hadronic Production:
$$\sigma_{inel} = \frac{1}{2} \sigma_{\pi^\pm d}^{total} \left(1 - \frac{\sigma_{free}^{el}}{\sigma_{free}^{tot}} \right)$$

Nucleon ejection after π absorption

- Nucleon ejection after π interactions and Δ absorption were not simulated
- *Roman Tacik* prepared a code to simulate.
- Nucleon multiplicity and charge determined using π - A absorption experimental data¹
- Kinematics determination π d data² (2 body) and phase space (for > 2 body)



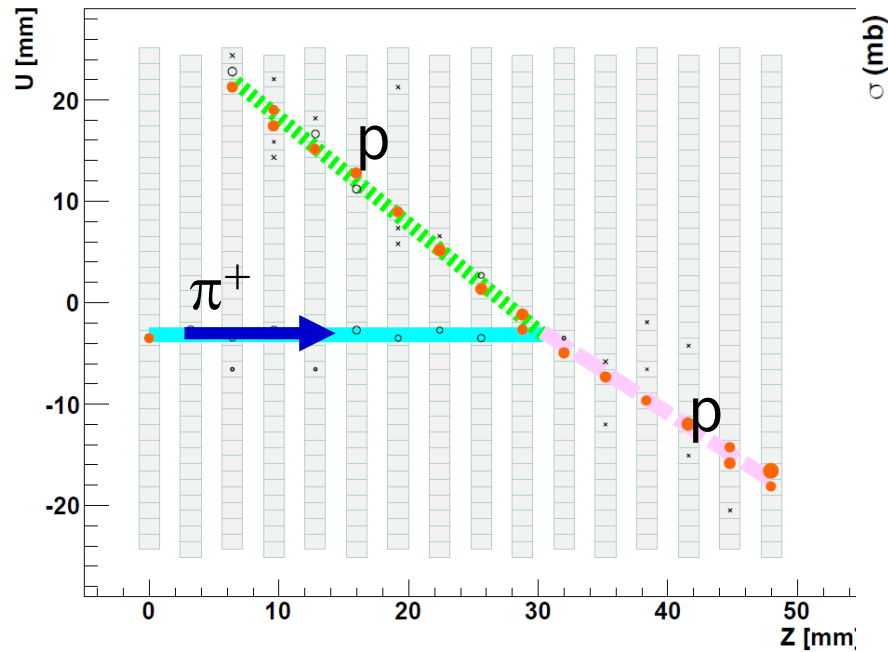
[1] Rowntree *et al.* Phys. Rev. C60 (99) 054610

[2] Ritchie, Phys. Rev. C 44, 533

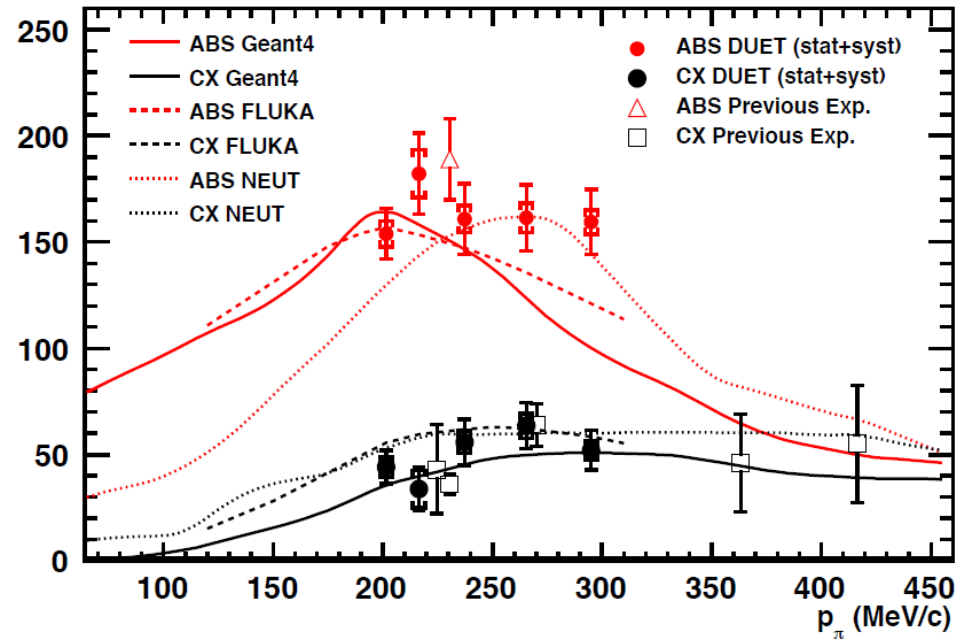
π interaction simulation in NEUT

~ comparisons with π -C scattering

Absorption candidate event



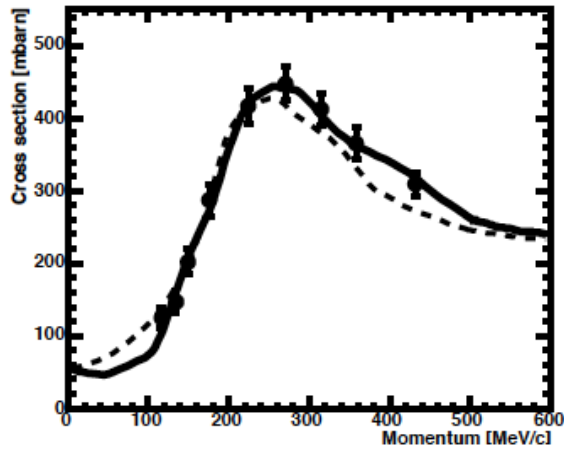
Phys.Rev. C95 (2017) 045203



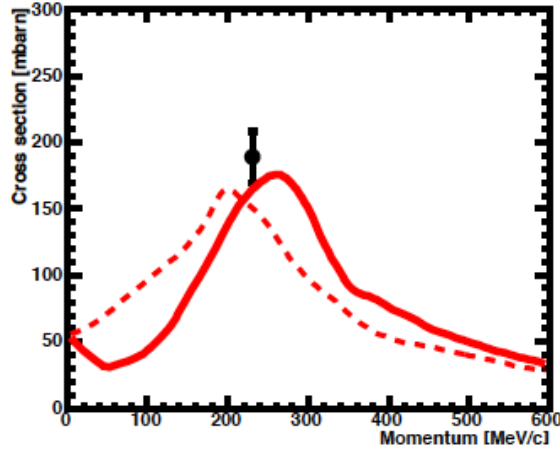
π interaction simulation in NEUT

~ comparisons with π -C scattering

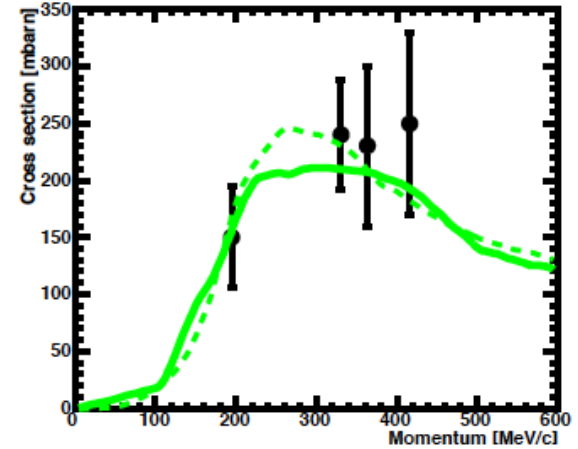
Reactive



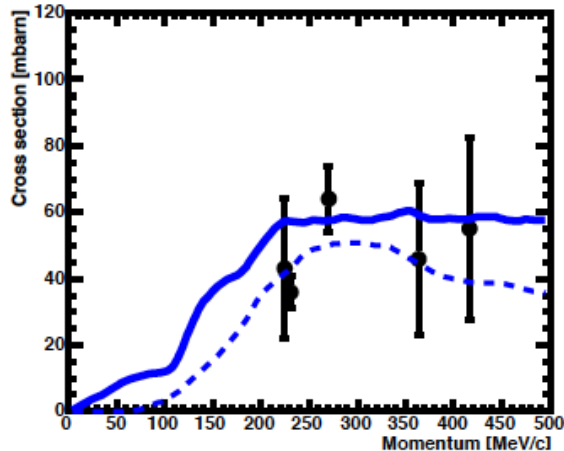
Absorption



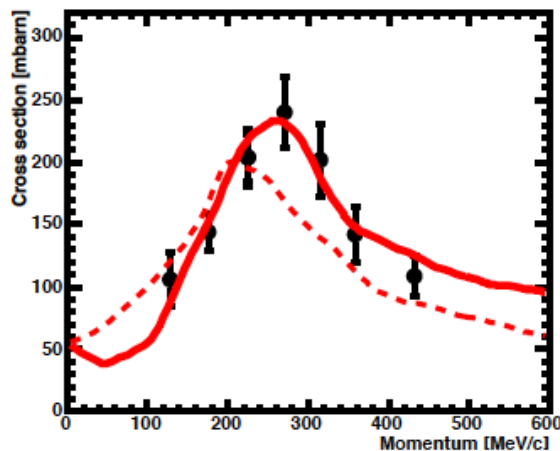
Inelastic



Charge exchange



Abs+CX



π^+ -C Cross Sections

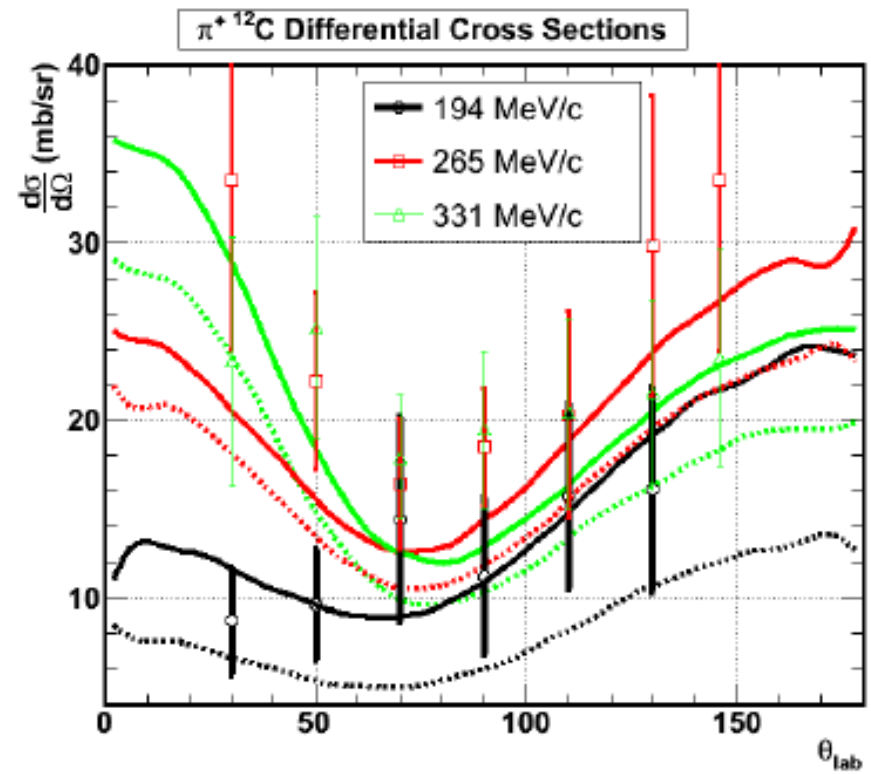
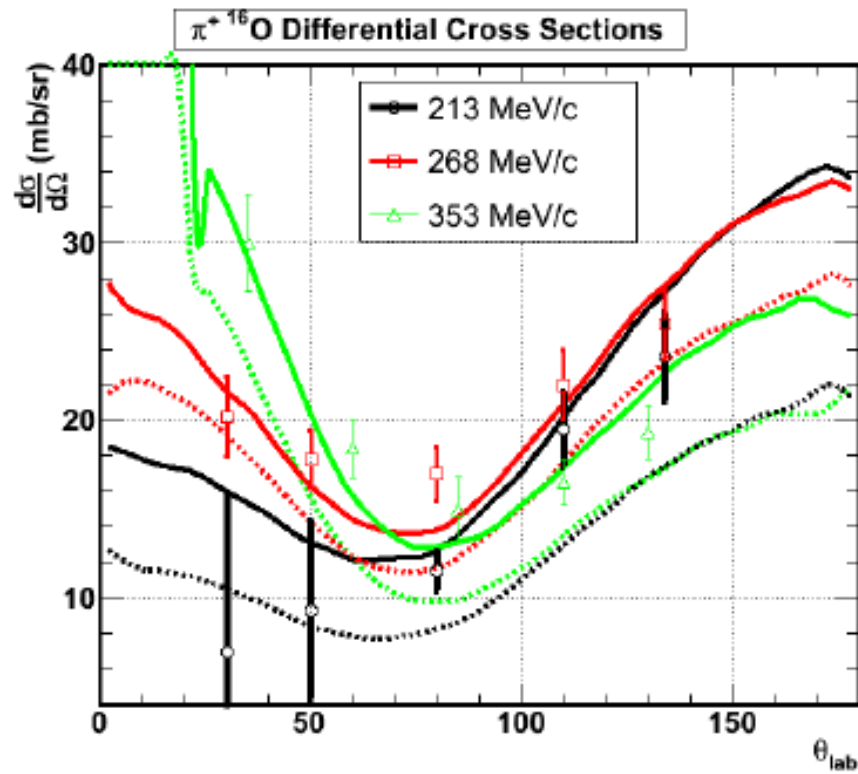
Solid lines: NEUT
Dashed lines: Bertini

(DUET data not included in this plots)

π interaction simulation in NEUT

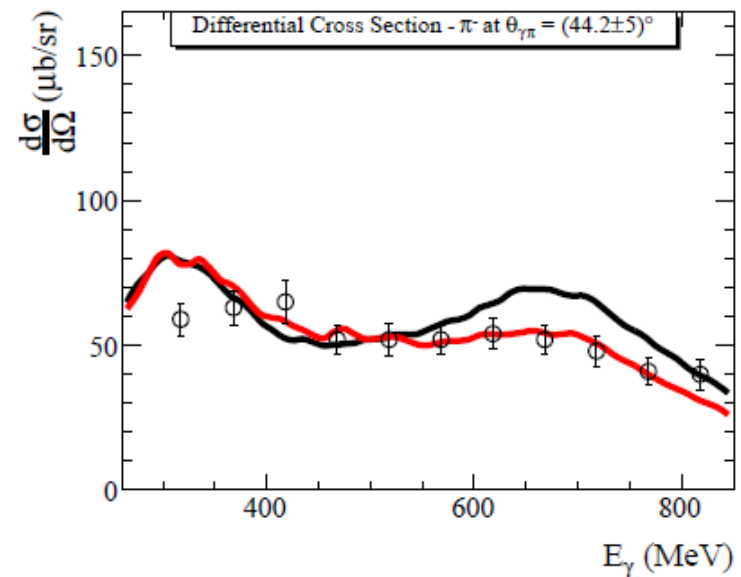
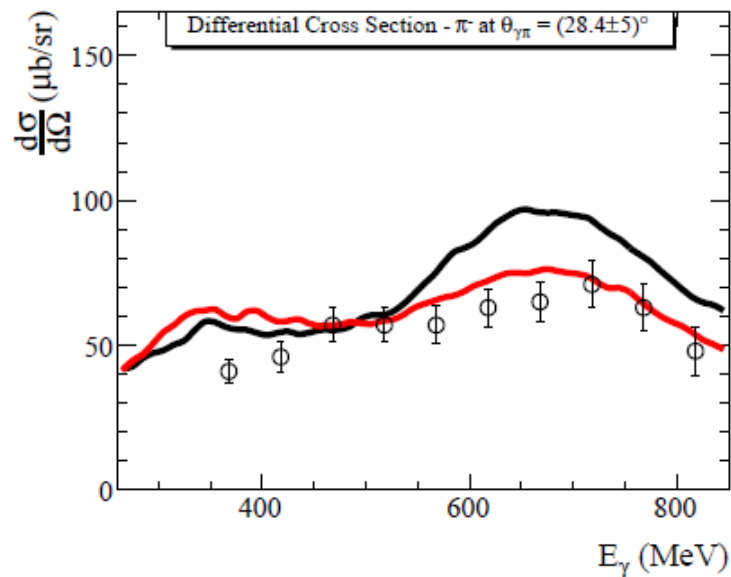
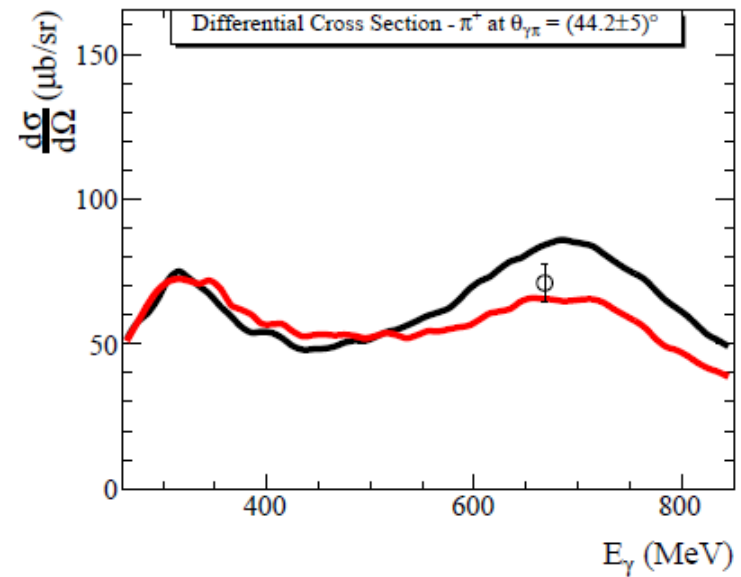
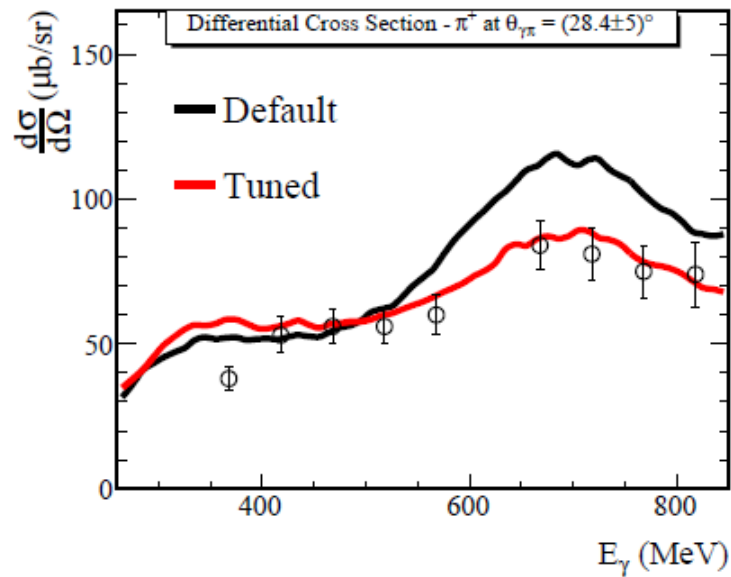
~ comparisons with π^- -Al scattering

*π^+ Oxygen scattering differential cross-sections
(bit old parameters are used for this figure)*



π interaction simulation in NEUT

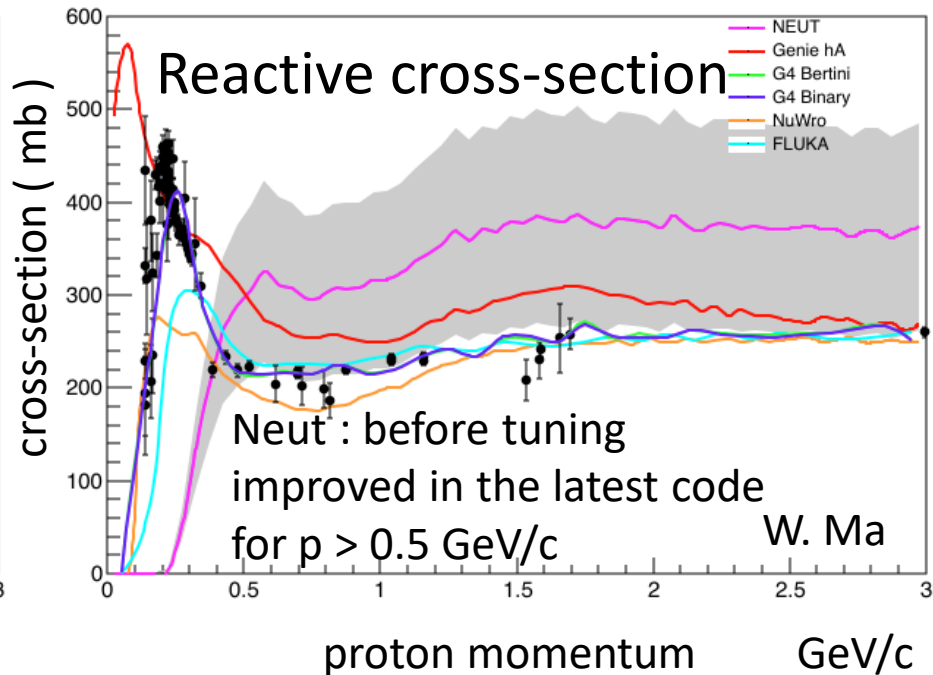
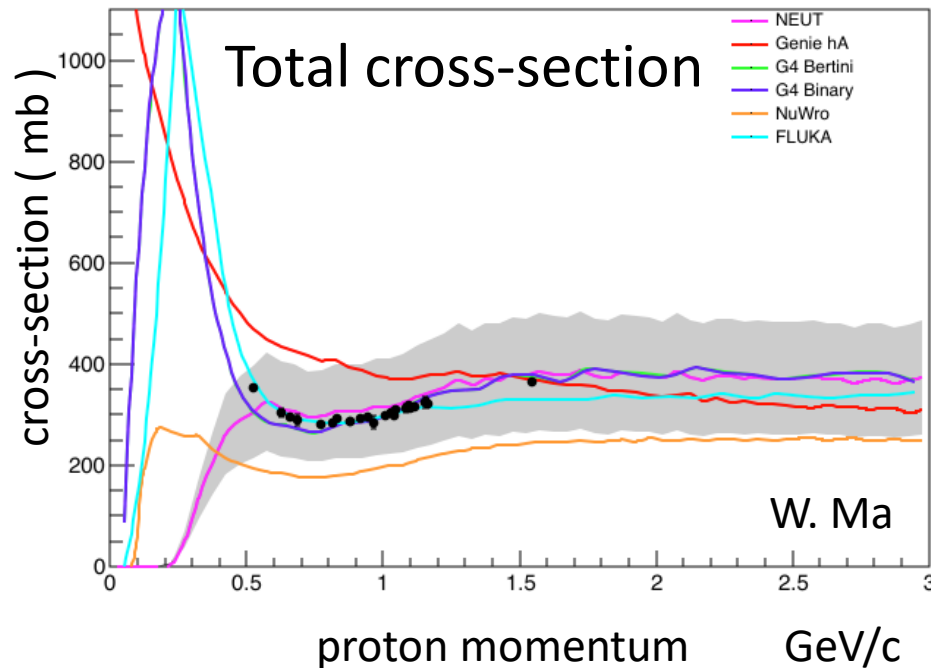
~ comparisons with π -C scattering



Nucleon final state interactions

Nucleon re-interaction is also treated similar ways for pion FSI.

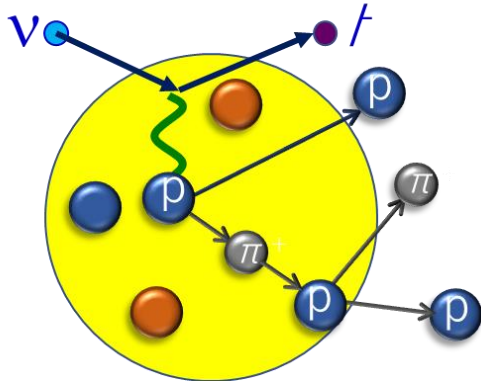
Neut Cascade model



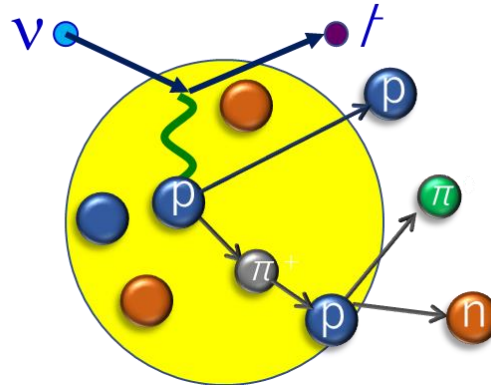
Recent neutrino data requires further studies on this interaction.
Not so many available data sets for the tuning.

Final state interactions in NEUT

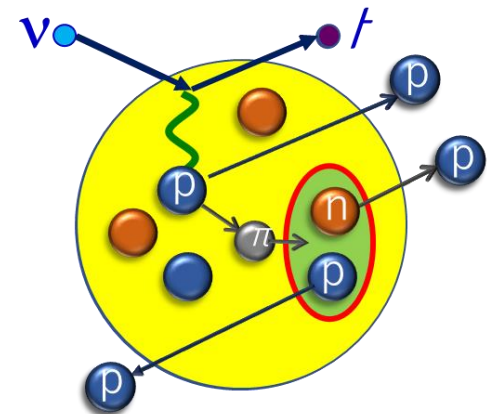
Inelastic scattering



Charge Exchange



Absorption



Interaction probability of π^0 produced in Oxygen. (NEUT)

