Pion elastic scattering

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Overview

- T2K Neutrino oscillation experiment uses selections of neutrino interactions based on the number of detected pions (CC0π, CC1π, CC>1π).
- Detailed understanding of final state interactions and secondary of pions in the T2K Near Detector ND280 (mainly carbon and water) and the Far Detector Super-K (water) crucial!
- DUET experiment at TRIUMF performed in order to improve measurements of pion interactions on carbon and water.

Pion elastic scattering

Fig. from DUET paper

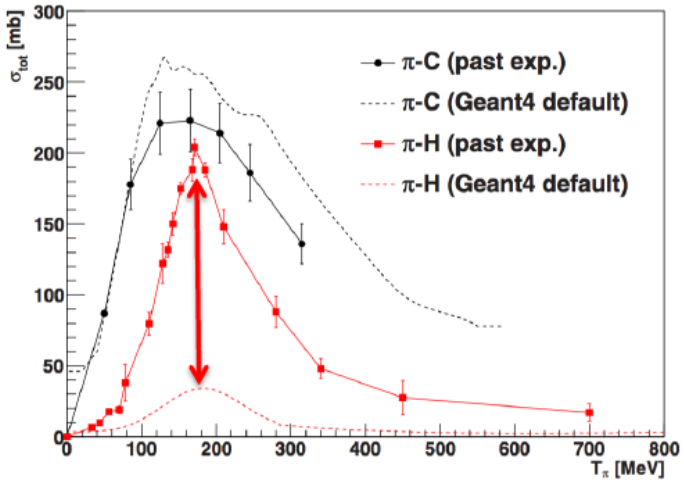

FIG. 16. (Color online) Comparison of elastic inclusive cross section between the previous experiments (summarized in Table IV) and the default GEANT4. The cross sections are plotted as a function of pion kinetic energy.

- During DUET analysis serious discrepancies found in Geant4.9.4 in thin target particle gun simulation of pion elastic scattering on Carbon and Hydrogen (Phys Rev C 92, 035205 (2015))
- Elastic scattering uses model "hElasticLHEP" based on a simple parametrization of the cross section.
- DUET reparametrized using existing experiments.

Pion elastic scattering

TABLE IV. List of data sets used for cross-section tuning in simulation.

Measurement	Kinetic energy (MeV)	Reference
π-C inclusive (elastic, inelastic, ABS, and CX)	85, 125, 165, 205, 245, 315	D. Ashery *et al.* [8]
π-C elastic inclusive	49.9	M. A. Moinester *et al.* [32]
π-H elastic inclusive	33, 44, 56, 70	S. L. Leonard *et al.* [33]
	78, 110, 135	H. L. Anderson *et al.* [34]
	165	H. L. Anderson *et al.* [35]
	128, 142, 152, 171, 185	J. Ashkin *et al.* [36]
	210, 280, 340, 450, 700	Lindenbaum *et al.* [37]
π-C elastic differential	40	M. Blecher *et al.* [38]
	50	R. R. Johnson *et al.* [39]
	67.5	J. F. Amann *et al.* [40]
	80	M. Blecher *et al.* [41]
	100	L. E. Antonuk *et al.* [42]
	142	A. T. Oyer *et al.* [43]
	162	M. J. Devereux *et al.* [44]
	180, 200, 230, 260, 280	F. Binon *et al.* [45]
π-H elastic differential	29.4, 49.5, 69	J. S. Frank *et al.* [46]
	69	Ch. Joram *et al.* [47]
	87, 98, 117, 126, 139	J. T. Brack *et al.* [48]
	87, 98, 117, 126, 139	J. T. Brack *et al.* [49]
	166.0, 194.3, 214.6, 236.3, 263.7, 291.4	P. J. Bussey *et al.* [50]

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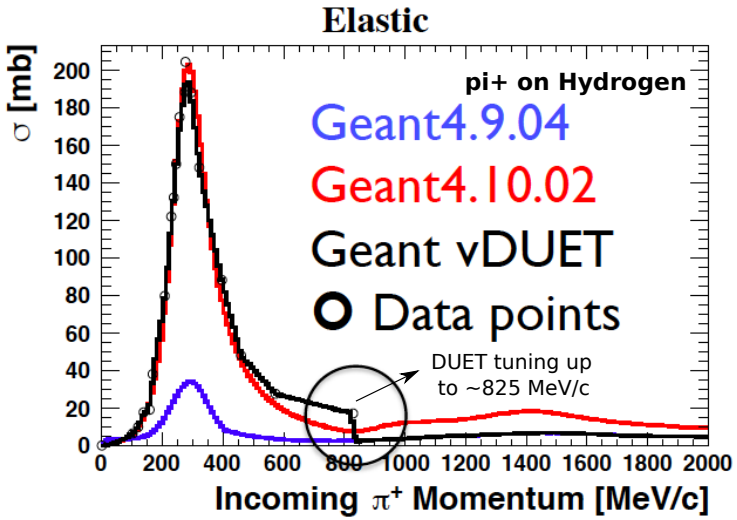
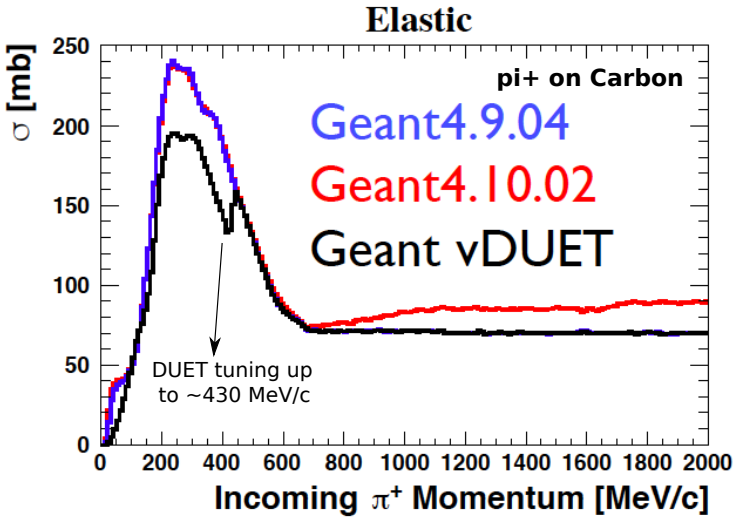
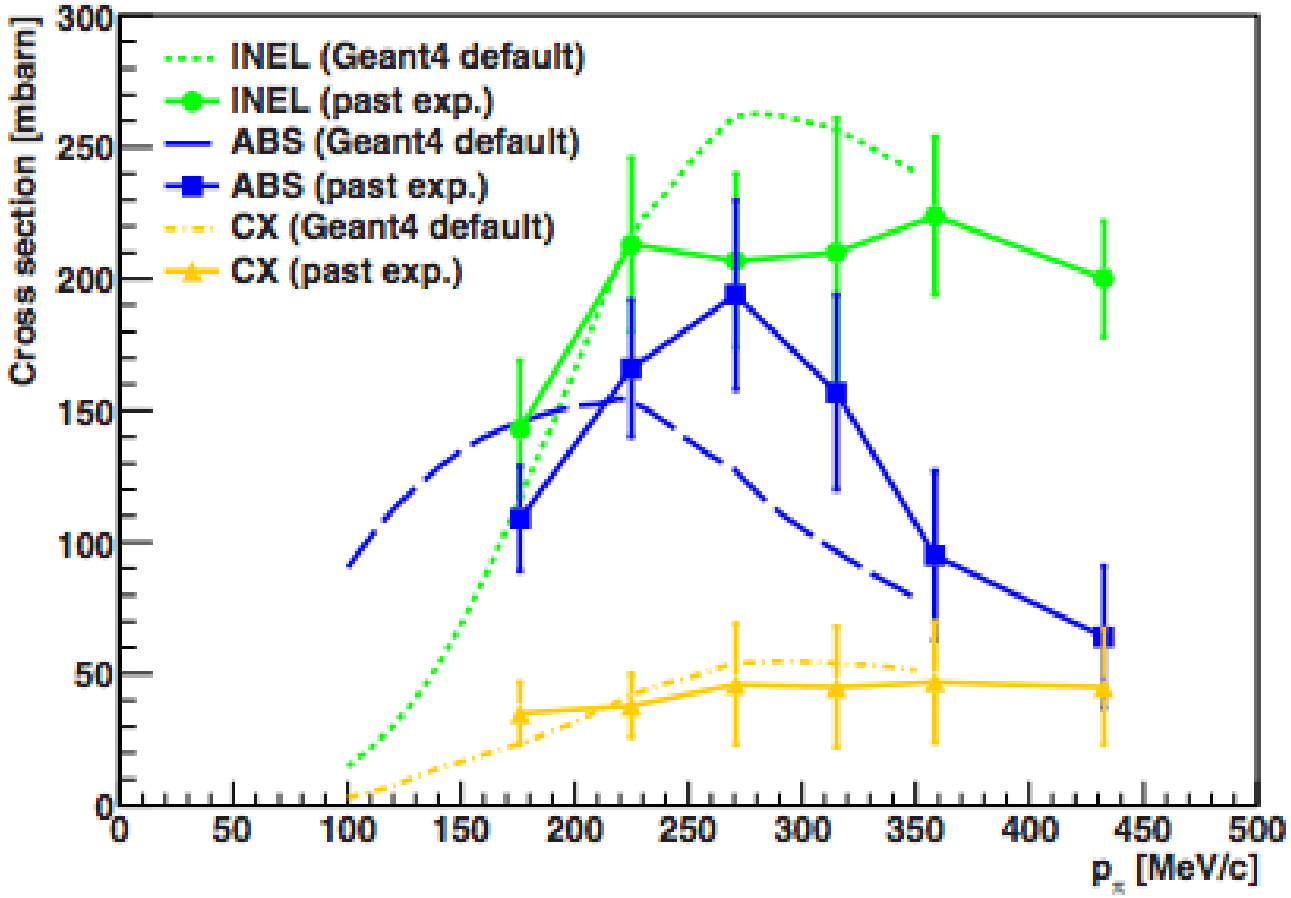




- Discrepancy seemed to be solved since Geant4.10.01-patch-02 (19-June-2015), but only for Hydrogen and does not fit highest energy data point.
- How was this retuned? Can DUET tuning help Geant4?

Pion inelastic scattering



- Bertini Cascade model could use retuning as well.
- Detailed tuning of NEUT cascade model ongoing in T2K.

Summary

- Correctly tuned pion elastic model in Geant4 crucial for neutrino oscillation experiments!
- Could DUET/T2K provide feedback to Geant4's elastic (and inelastic) models?
- Other generators only have implementation of quasi-elastic processes. How does Geant4 treat quasi-elastic and elastic processes in pion/nucleon - nucleus scattering?