

# Validation of hadron elastic models

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# Outline

## Objectives

test30 and elastic scattering models

Experimental data

Multiple electromagnetic scattering

Tuning of G4HadronElastic

- Preliminary results of validation testing

Future plans

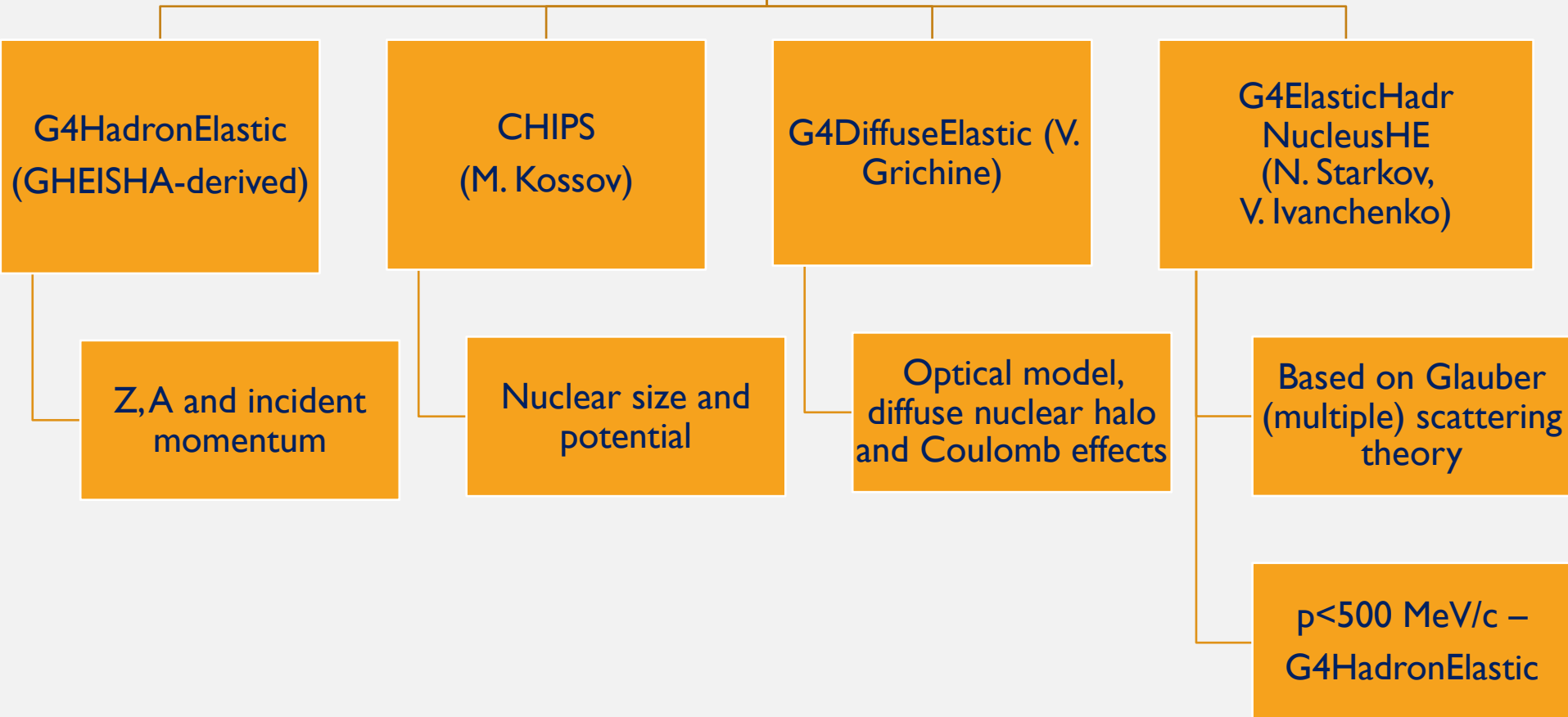
# Objectives

**test30** - Model level test allowing to compare simulation of differential cross-sections vs. experimental data

- Check established models of elastic scattering of pions on nuclei in the resonance energy region  $<1\text{GeV}$  on experimental data
- Make improvements to existing models

\* Data from original publications and EXFOR is given for  $\Theta$  in center-of-mass system

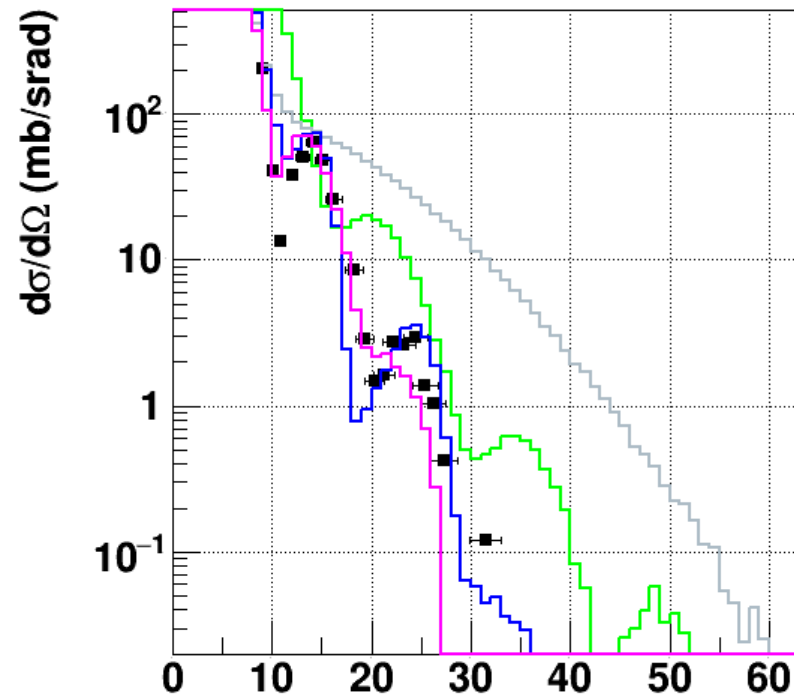
# Test30 for hadron elastic



# Proton Elastic Scattering Geant4 10.5

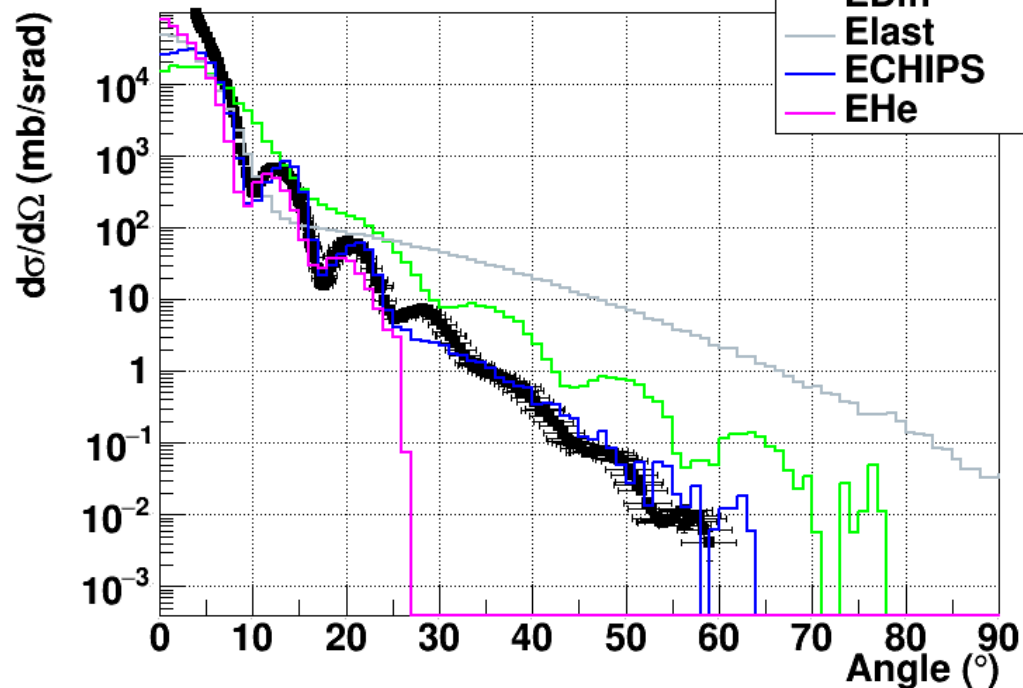
$p + \text{Fe} \rightarrow p + X, E = 400 \text{ MeV}$

■ Data  
— EDiff  
— Elast  
— ECHIPS  
— EHe



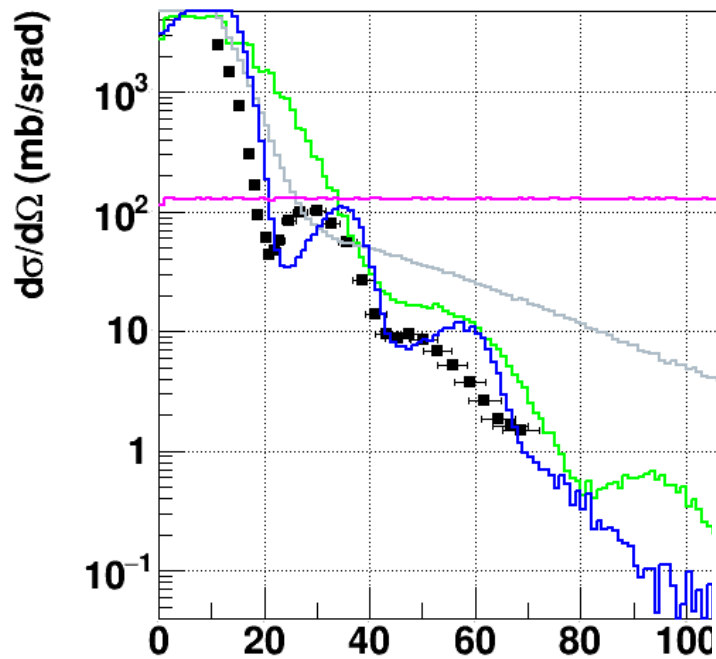
$p + \text{Pb} \rightarrow p + X, E = 200 \text{ MeV}$

■ Data  
— EDiff  
— Elast  
— ECHIPS  
— EHe



$p + \text{Fe} \rightarrow p + X, E = 65 \text{ MeV}$

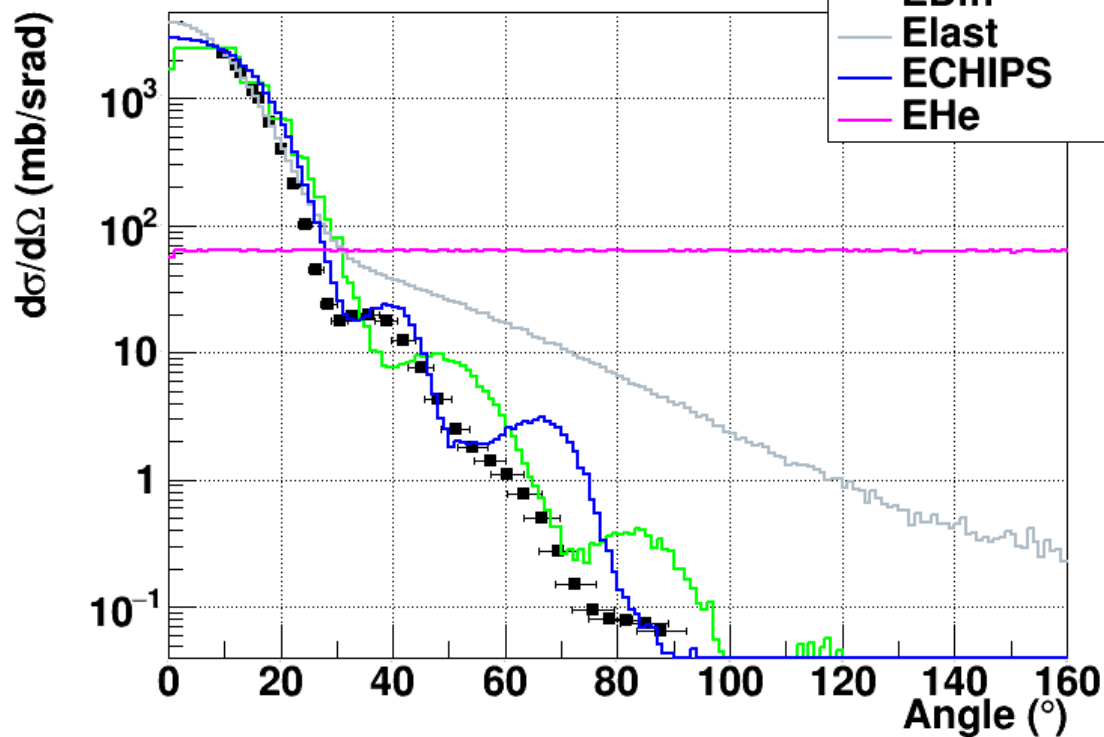
■ Data  
— EDiff  
— Elast  
— ECHIPS  
— EHe



Geant4 10.5

$p + \text{Si} \rightarrow p + X, E = 80 \text{ MeV}$

■ Data  
— EDiff  
— Elast  
— ECHIPS  
— EHe





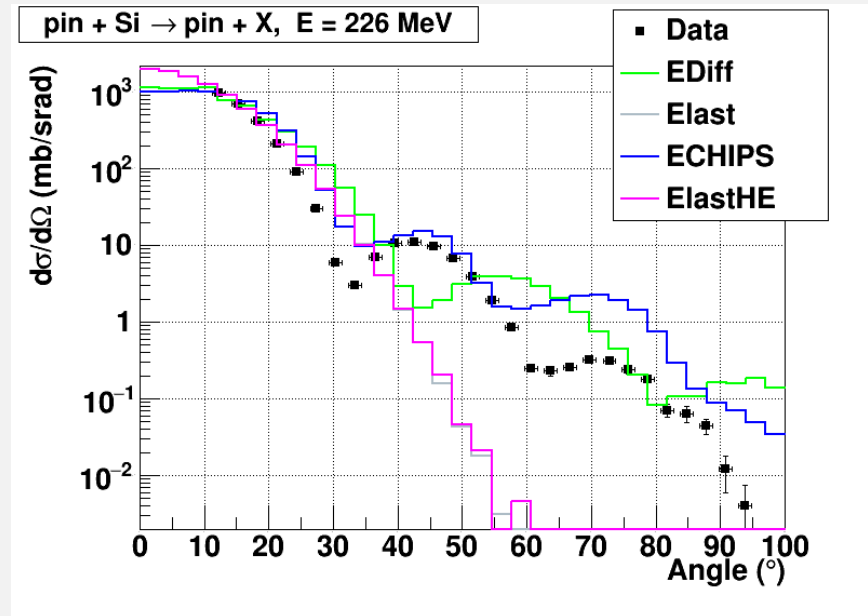
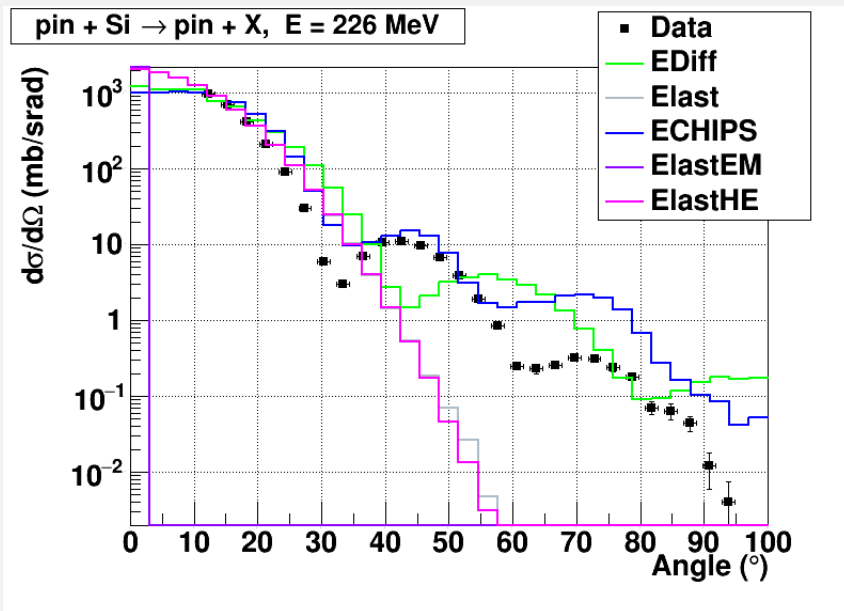
## New experimental data

In a framework of this project we extend test30 by addition of extra data for  $\pi^\pm$  elastic scattering from EXFOR database and original publications:

1. [Takahashi et al., 1995](#) (*Physical Review C*, 51(5)):
  - ${}^6\text{C}^{12}$  -610, 790, 895 MeV/c
  - ${}^{82}\text{Pb}^{208}$  - 790 MeV/c
2. [Aoki et al., 2007](#) (*Physical Review C*, 76(2)):
  - ${}^6\text{C}^{12}$  - 995 MeV/c
3. [Preedom et al., 1979](#) (*Nuclear Physics A*, 326(2-3)):
  - ${}^{14}\text{Si}^{28}$  - 130, 180, 226 MeV/c

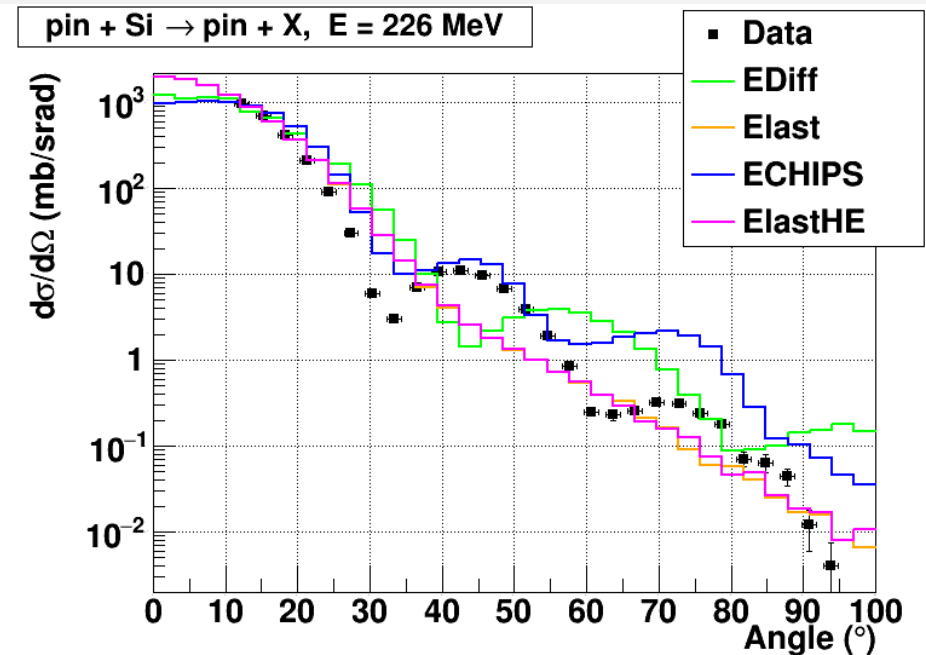
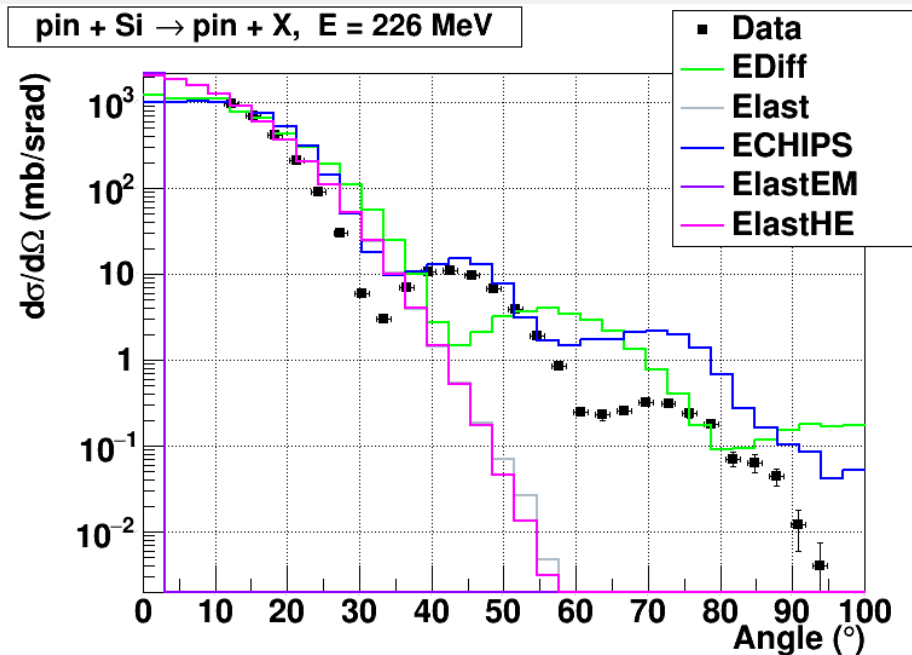
# Contribution of multiple electromagnetic scattering

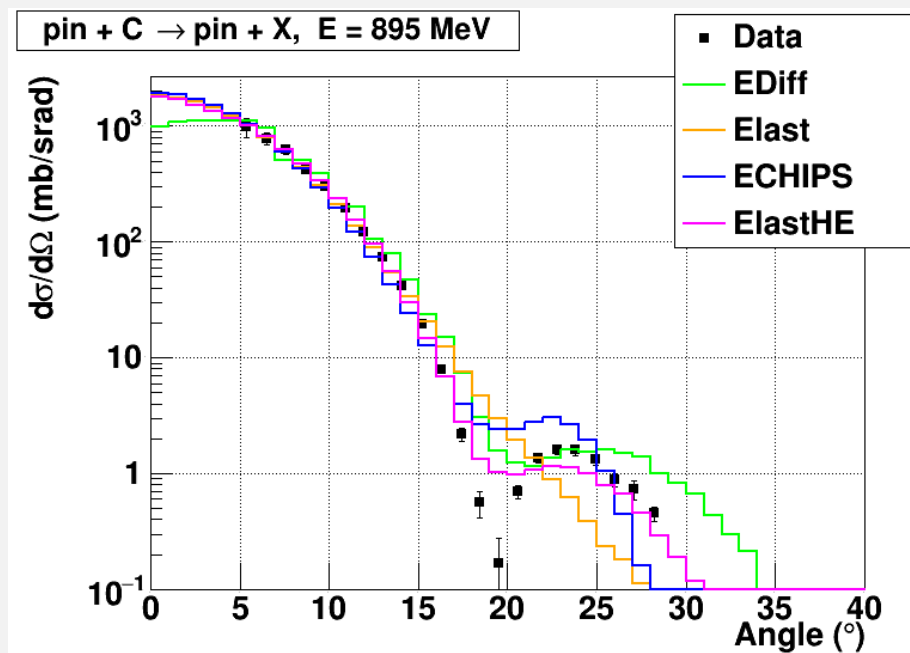
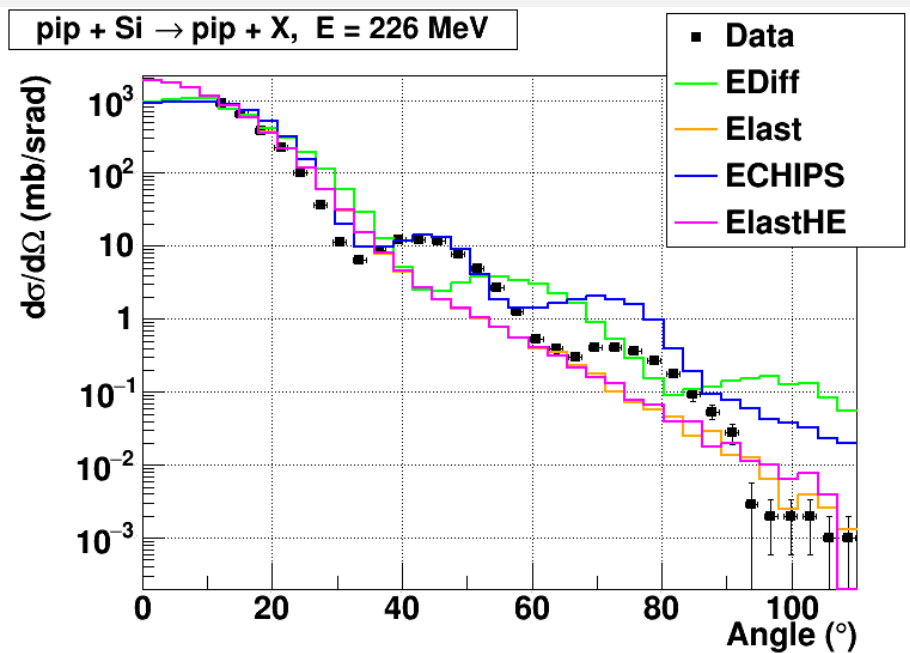
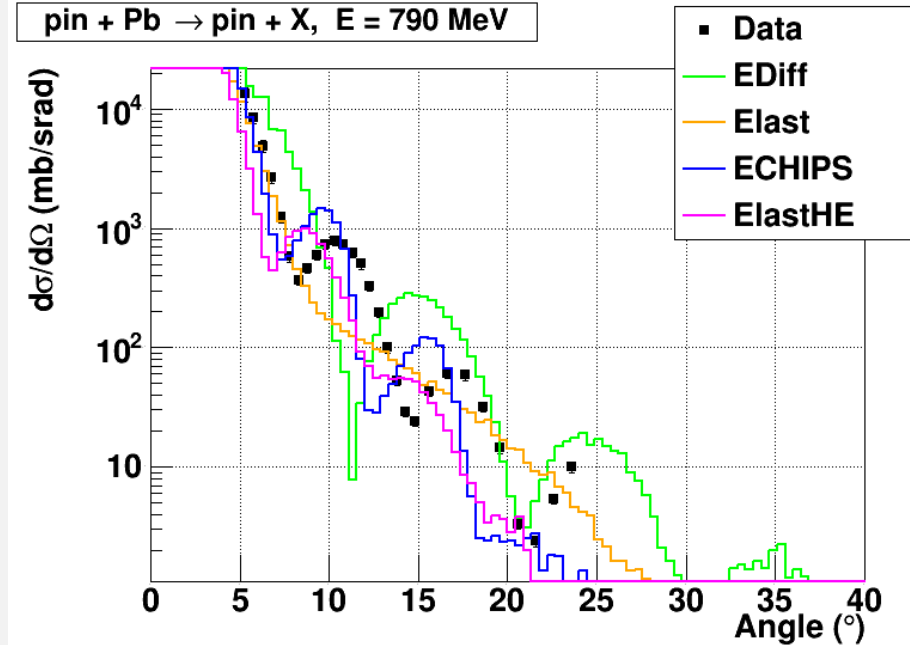
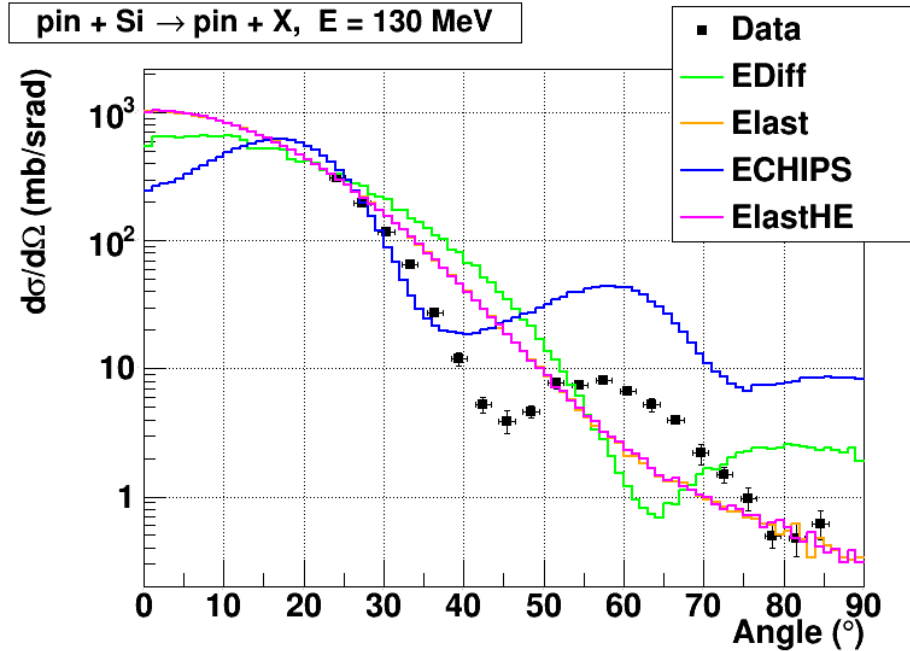
- Inside the target particles undergo multiple Rutherford scattering
- It is concluded that in the experiments authors of articles choose parameters of the target so as to minimize this EM contribution
- Rutherford scattering is very peaked at 0
- EM multiple scattering wasn't included before, now G4WentzelVI model is used to sample scattering off target which is added to any hadron scattering (though has a small effect)



# Tuning of G4HadronElastic

- Differential cross-section is a combination of two exponents
  - First describes **first diffraction maximum**
  - Second describes **satellite maxima**
- We were trying to improve parametrization of exponent parameters





# PLANS

- We will commit new data for test30 to Geant4 repository
- **G4HadronElastic** - attempt to find a better way to parametrize
- **G4ElasticHadrNucleusHE** – attempt to improve internal data handling and extend sampling for full momentum transfer range

# REFERENCES

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2. Aoki, K., Sakaguchi, H., Nose-Togawa, N., Takahashi, T., Hasegawa, T., Hashimoto, O., Nagae, T., Sekimoto, M., Ohkusu, A., Bhang, H., Yu, H. and Gavrilov, Y. (2007). Elastic and inelastic scattering of  $\pi^+$  and  $\pi^-$  on  $^{12}\text{C}$  at 995 MeV/c. *Physical Review C*, 76(2).
3. Freedom, B., Corfu, R., Egger, J., Gretillat, P., Lunke, C., Piffaretti, J., Schwarz, E., Jansen, J. and Perrin, C. (1979). A systematic study of  $\pi^+$  AND  $\pi^-$  inelastic scattering from  $^{28}\text{Si}$  in the region of the  $\pi\text{N}(3,3)$  resonance. *Nuclear Physics A*, 326(2-3), pp.385-400.
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