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Geant4: Web Application & Validation

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Outline

- Geant4 Web Application:
  http://g4validation.fnal.gov:8080/G4WebAppNG/
  - User editing interface
  - Experimental Data Browser improvements
  - Database schema extension
- Geant4 Simulation:
  - Pion-matter Cross section (Xs) tests
  - Simulation and experimental data comparison

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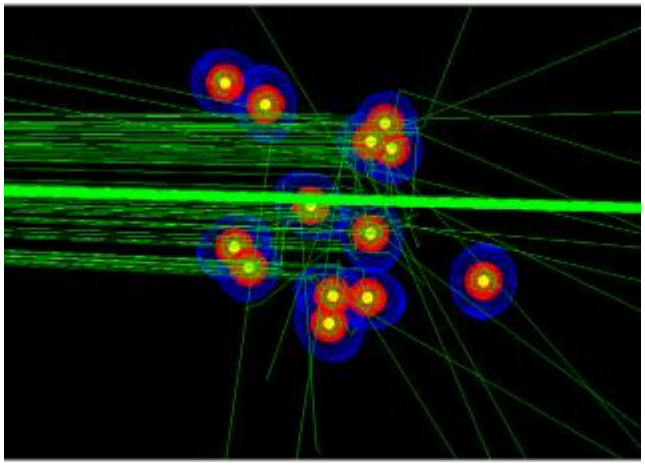
What is Geant4?

- Open-source toolkit for all particle interactions in matter
- Contains physics models for these interactions
  - Energy scale from eV (chemistry) to TeV (high energy physics)
- Important for high energy physics, nuclear and accelerator physics, and studies in medical and space science.
- Constantly checked against experimental data and improved



M Douglass et al.

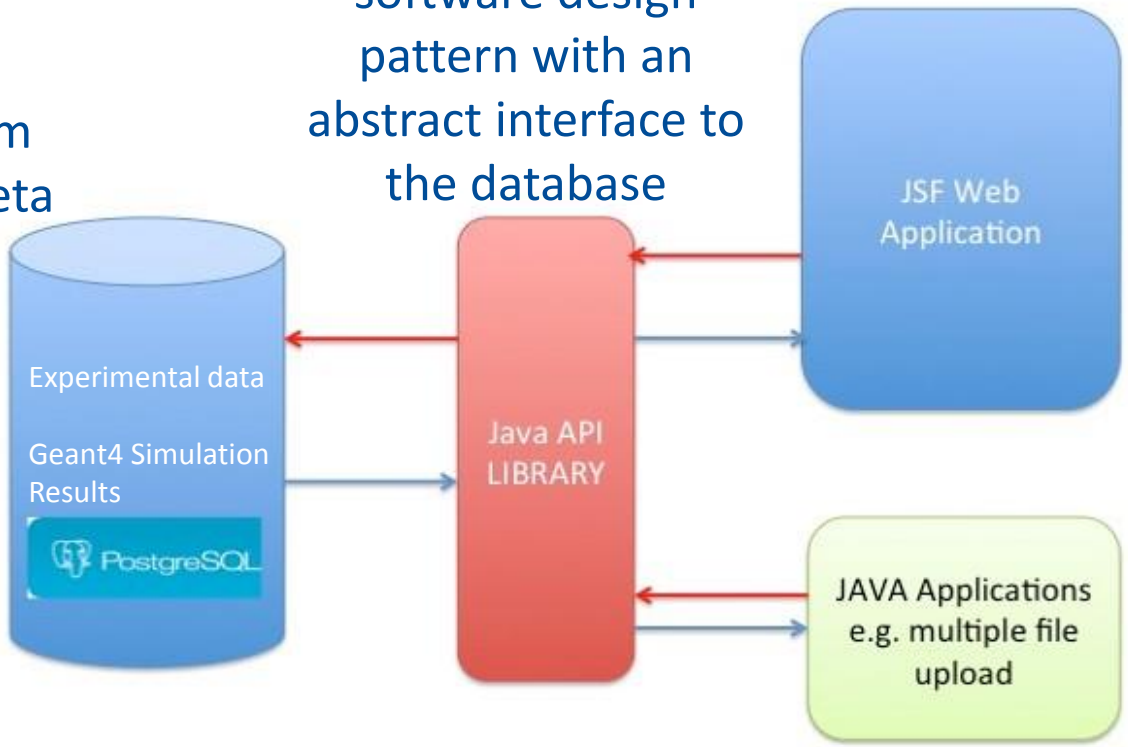
A small group of randomized cells in Geant4 being irradiated by kilovoltage x-rays in the current work at the University of Adelaide in South Australia.

Geant4 Validation Repository Framework

Stores both in form of images with meta data or raw data points.

Data access object software design pattern with an abstract interface to the database

User interface



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Geant 4 validation web ap

Home | Geant 4 Collaborators | Geant 4 Administrator | Release Highlights | GEANT4

Left

- Exp. data browser
- Test result browser
- Display Statistics
- Display test
- Database Statistics
- Display references

Welcome to the GEANT4 validation web application the

Introduction

The Geant4 collaboration regularly performs validation
compared to data obtained by various HEP experiment
have organized the materials in one central repository
select and overlay compatible data, e.g. to compare th
plot.

Please make your selection from the menu on the left.

Reference	Description
J. F. Dicello and G. Igo, Phy. Rev. C Vol.2 Number 2 (1979)	Proton total reaction cross sections in the 10-20MeV/c range: Ca and C

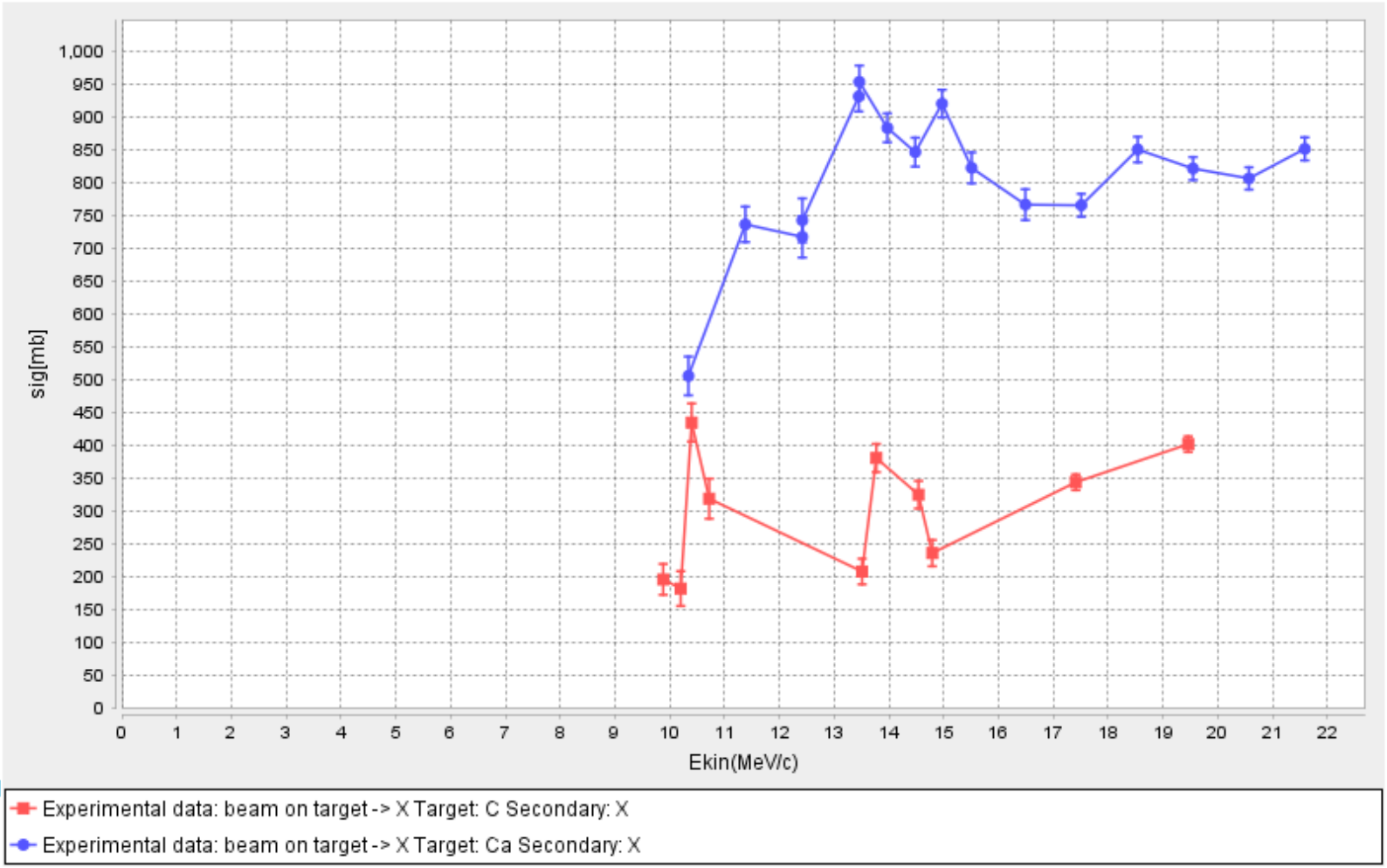
Targets | Reactions | Beam | Beam Energies | Secondaries | sig[mb] vs Ekin(MeV/c)

Display plot: Yes Logarithmic Y-Axis: No Display Errors: Yes

Display data table: Yes Revert to default selections: Default Plot

Make your selections from the menus above and press Submit

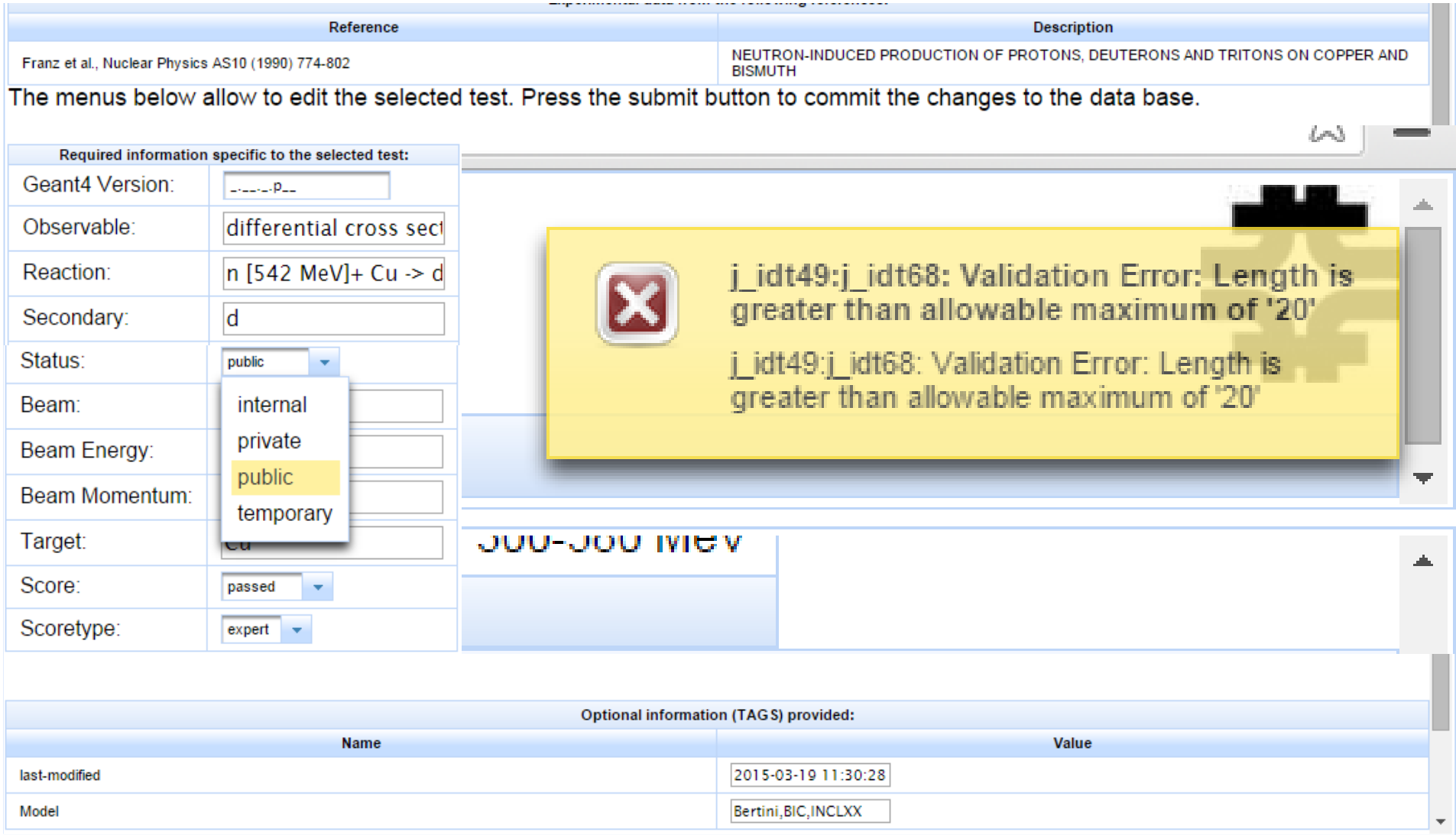
Submit



Web Application Development

- Java development using open-source PrimeFaces library
  - Webpage HTML user interface
- Requested features from my work:
  - Protect against malformed user inputs
  - Staged delete
  - Default display

Edit Test – Masked/Dictionary Entries



Reference	Description
Franz et al., Nuclear Physics AS10 (1990) 774-802	NEUTRON-INDUCED PRODUCTION OF PROTONS, DEUTERONS AND TRITONS ON COPPER AND BISMUTH

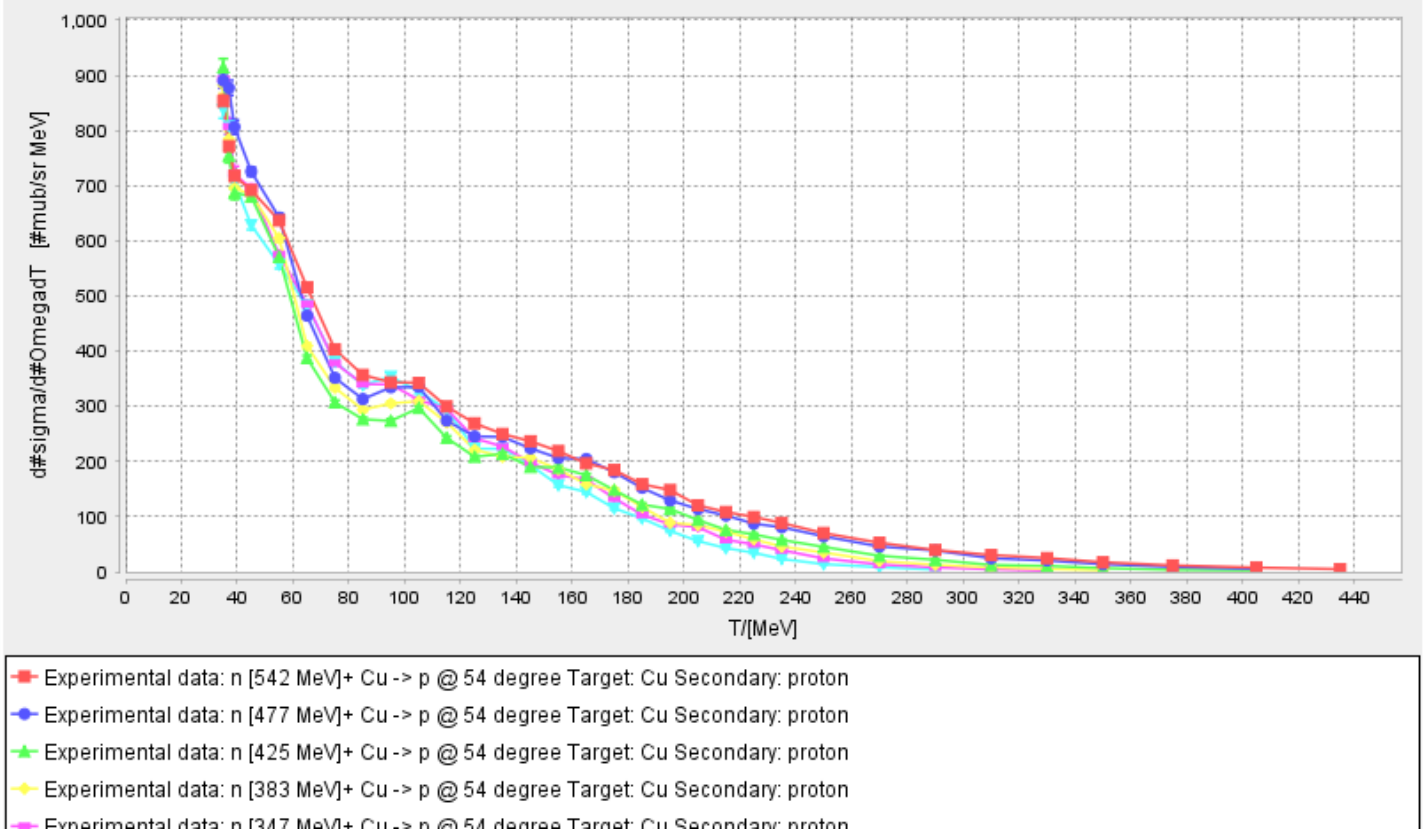
Targets | Reactions | Beam | Beam Energies | Secondaries | d#sigma/d#OmegadT [#mub/sr MeV] vs T/[MeV]

display Plot: Yes **logarithmic Y-Axis:** No **display Errors:** Yes

display data table: No **revert to default selection:** Default Plot

Make your selections from the menus above and press Submit

Submit



Geant4 Simulation Development

- Simulations run will be put into Geant4 database
  - Using Python and ROOT scripts to automate data generation
- User will see data in web application test result browser
- Geant4 simulations compared to experimental data
  - Looked at pion interactions in matter
  - Useful for experiments like LARiAT for detector response and measurement results validation

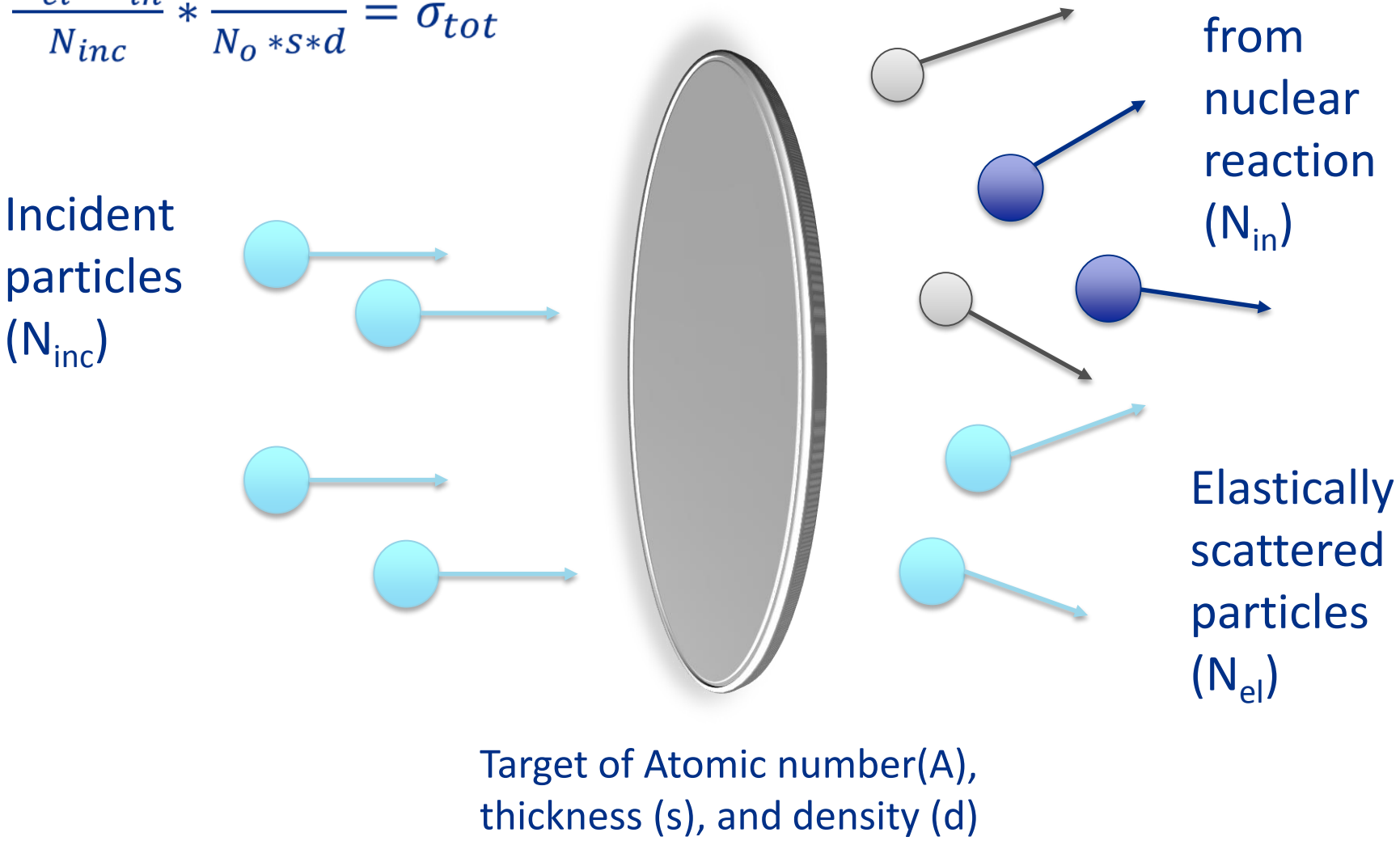
Experimental Data Browser

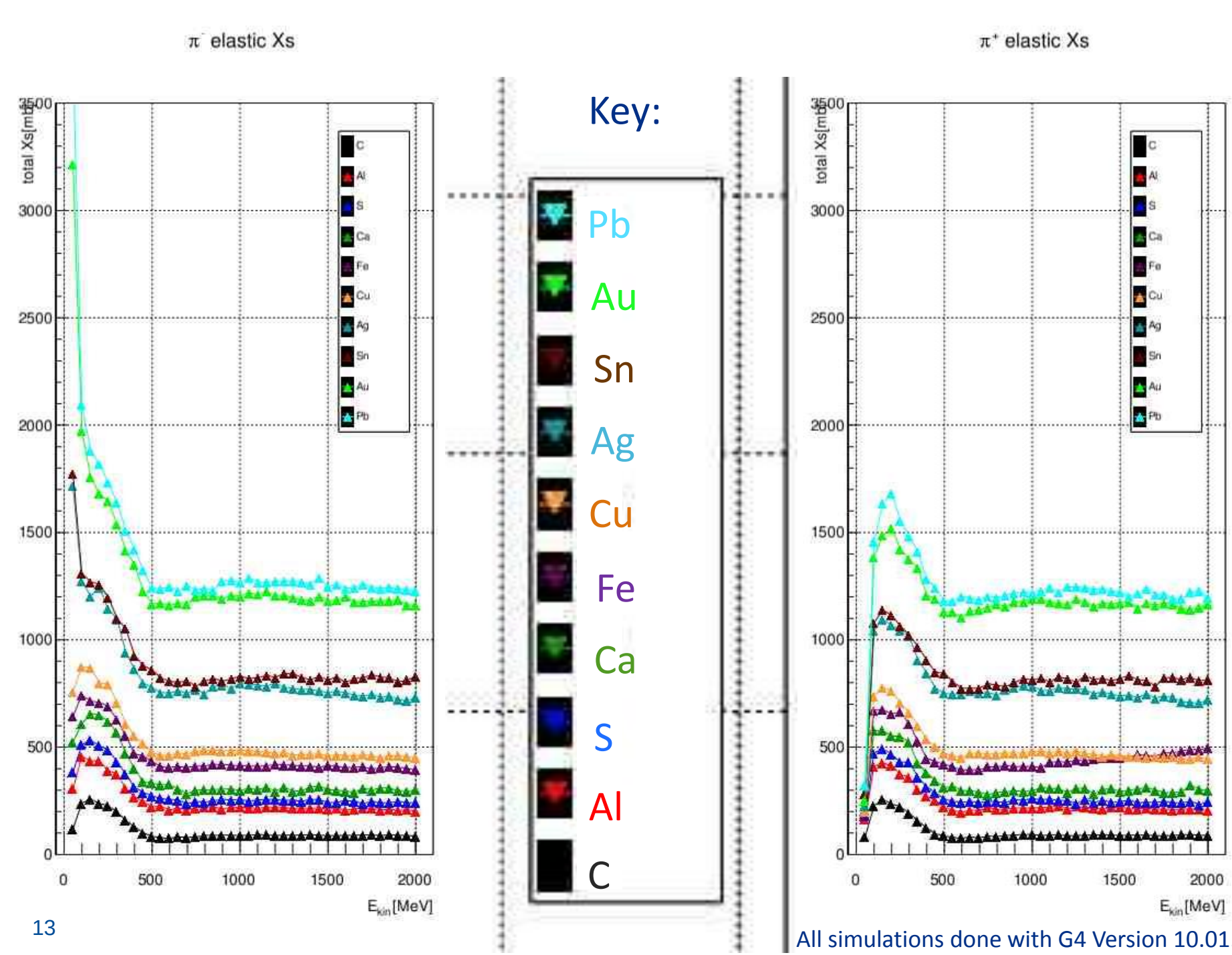
Click on the name in the left column to select the Experiment:

Name	References	
Madey et al.	R. Madey et al., Phys. Rev. C 25, 3050–3067 (1982)	Neutrons from nuclear capture of negative pions
Allardyce et al.	B. Allerdyce et al., Nuclear Physics A209(1973) 1-51	Pion Reaction Cross Sections and Nuclear Sizes
Friedman et al.	E. Friedman et al., Phys. Rev. C 55, 1304 (1997)	K+ nucleus reaction and total cross sections: New analysis of transmission experiments
Schumacher et al.	R.Schumacher et al., Phys.Rev. C25, 2269 (1982)	Cu(γ,p)X reaction at Eγ=150 and 300 MeV
Baba et al.	K. Baba et al., Nucl.Phys. A306, 292 (1978)	Quasi-free pion photoproduction from carbon above 300 MeV
NA61	N.Abgrall et al., Phys.Rev. C84, 034604 (2011) (NA61 Exp.)	Measurements of Cross Sections and Charged Pion Spectra in Proton-Carbon Interactions at 31 GeV/c
P.Singer	P.Singer, Springer Tracts in Modern Physics, 71, 39 (1974)	Emission of particles following muon capture in intermediate and heavy nuclei
NA49	see further details	Analysis of soft hadronic interactions at the SPS by the NA49 pp&pA group is presented.
Saunders	Saunders et al., Phys. Rev. C Vol.53 Number 4 (1996)	Reaction and total cross sections for low energy pi+ and pi- on isospin zero nuclei
McGill	McGil et al., Phys. Rev. C Vol.10 Number 6 (1974)	Measurements of the proton total reaction cross section for light nuclei between 20 and 48MeV/c
Gelderloos	Gelderloos et al, Phys Rev C 62, 024612 (2000)	Reaction and total cross sections for 400 – 500 MeV pi minus on nuclei
Auce	A. Auce, Phys. Rev C71, 064606 (2005)	Reaction cross sections for protons on C, Ca, Zr, and Pb at energies between 80-180 MeV/c
Shibata et al	Shibata et al., Nuclear Physics A408 (1983) 525-558	Particle prodcution in the target-rapidity region from hadron-nucleus reactions at several GeV
Franz et al.	Franz et al., Nuclear Physics AS10 (1990) 774-802	NEUTRON-INDUCED PRODUCTION OF PROTONS, DEUTERONS AND TRITONS ON COPPER AND BISMUTH
Enyo et al.	H. Enyo, Phys. Lett 159B, 1 (1985)	ANALYSES OF PARTICLE PRODUCTION IN HADRON-NUCLEUS REACTIONS AT SEVERAL GeV WITH A TWO-MOVING-SOURCE MODEL
Dicello	J. F. Dicello and G. Igo, Phy. Rev. C Vol.2 Number 2 (1979)	Proton total reaction cross sections in the 10-20MeV/c range: Ca and C
Clough et al.	A. S. Clough et al., Nuclear Physics B76 (1974)	Pion-nucleus total cross sections from 88 to 860 MeV
Sundelin et al.	R.M.Sundelin et. Al., Phys.Rev.Lett., Vol.20, Number 21, 11	Spectrum of Neutrons from Muon Capture in Silicon, Sulfur, and Calcium

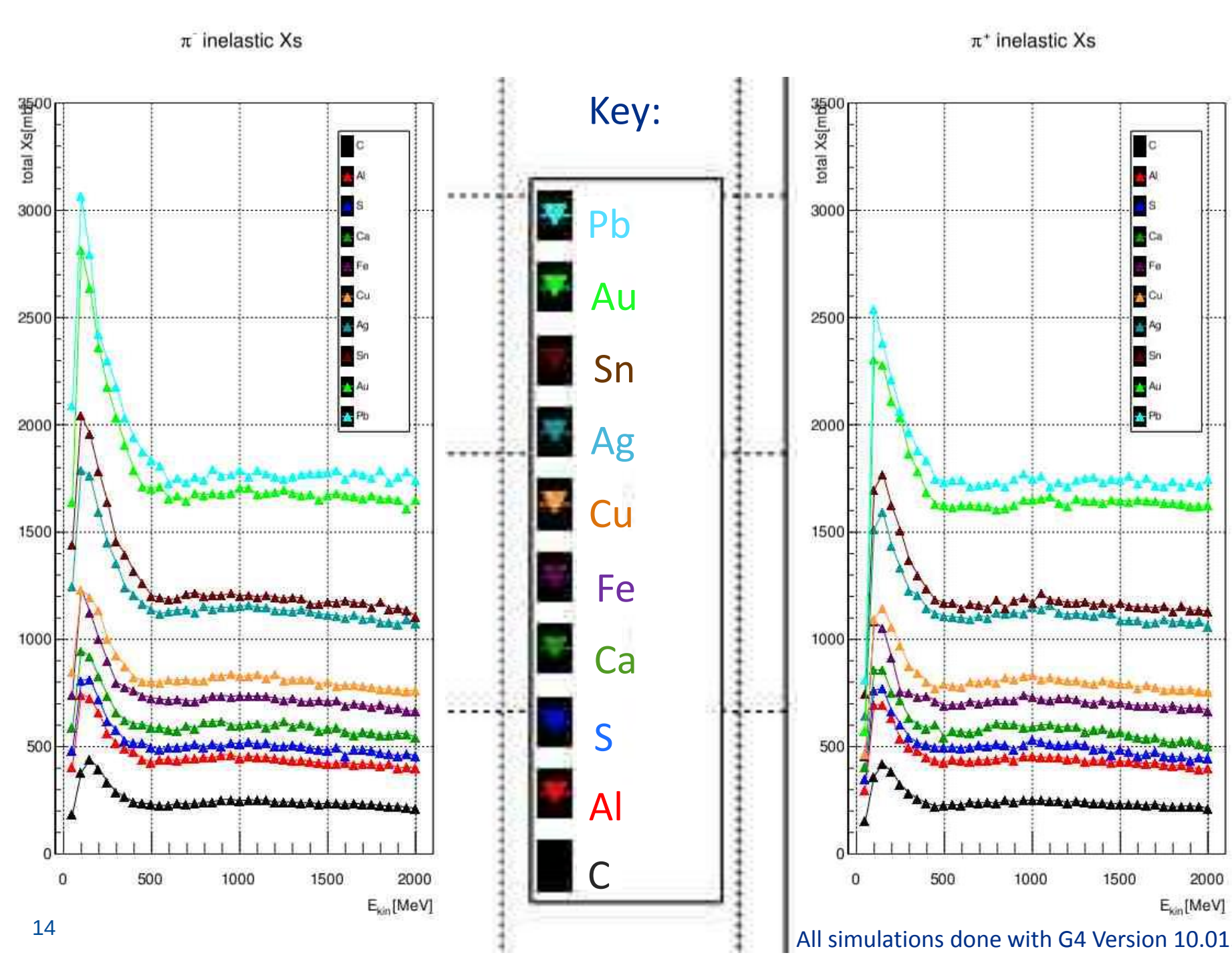
Geant4 Event Simulation

$$\frac{N_{el}+N_{in}}{N_{inc}} * \frac{A}{N_o * s * d} = \sigma_{tot}$$

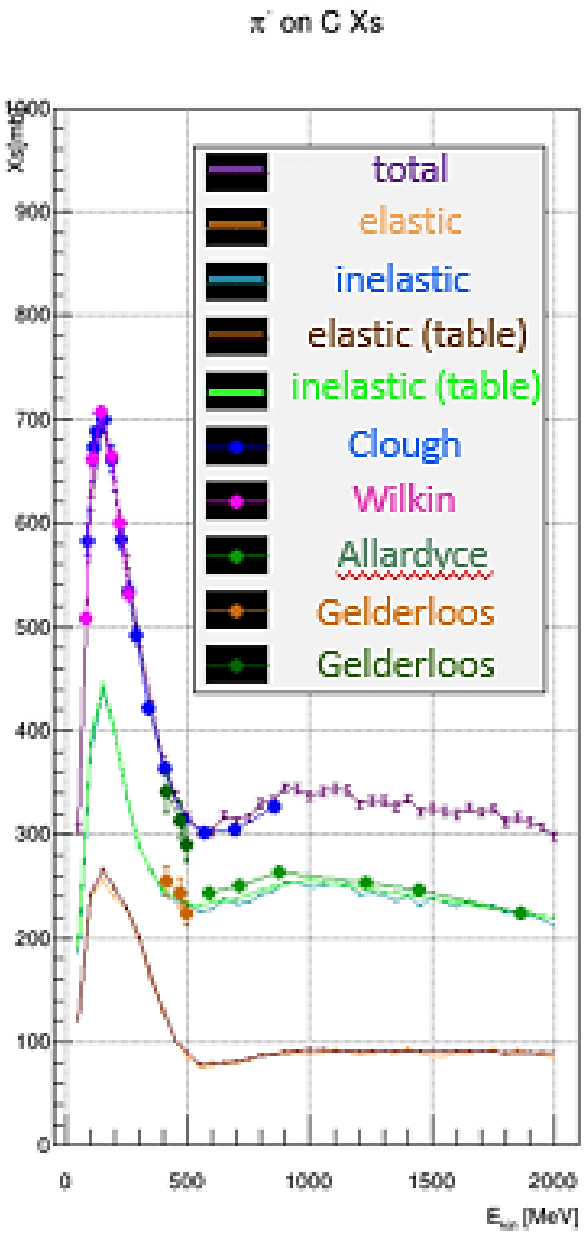


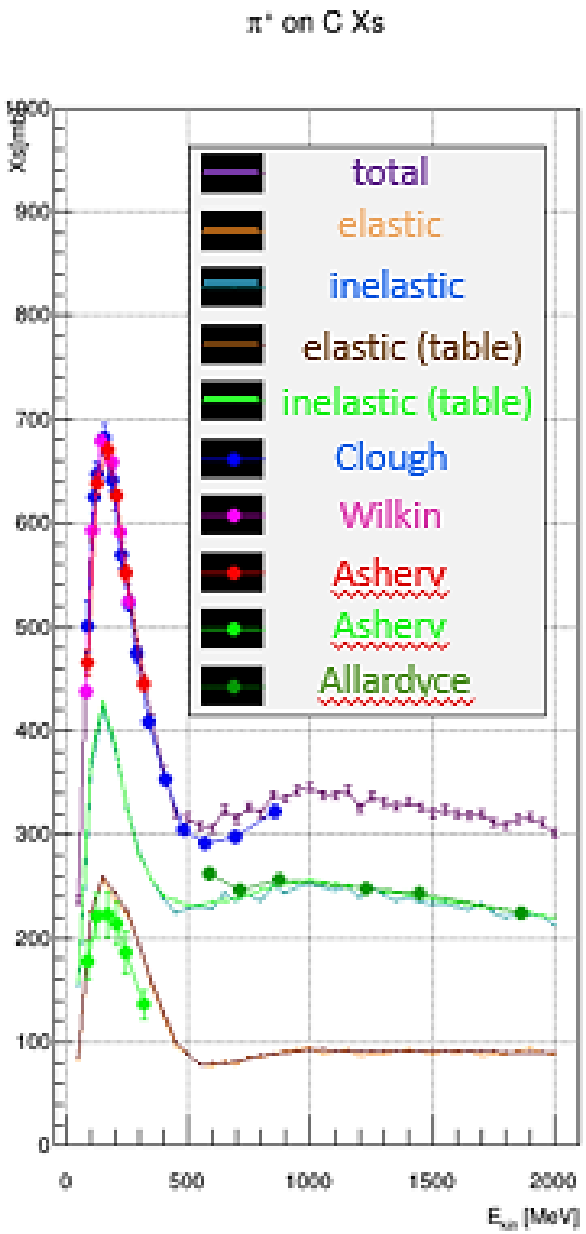


All simulations done with G4 Version 10.01.p02



All simulations done with G4 Version 10.01.p02





Geant4 Simulation (lines) agree nicely with experimental data (dots)

All simulations done with G4 Version 10.01.p02

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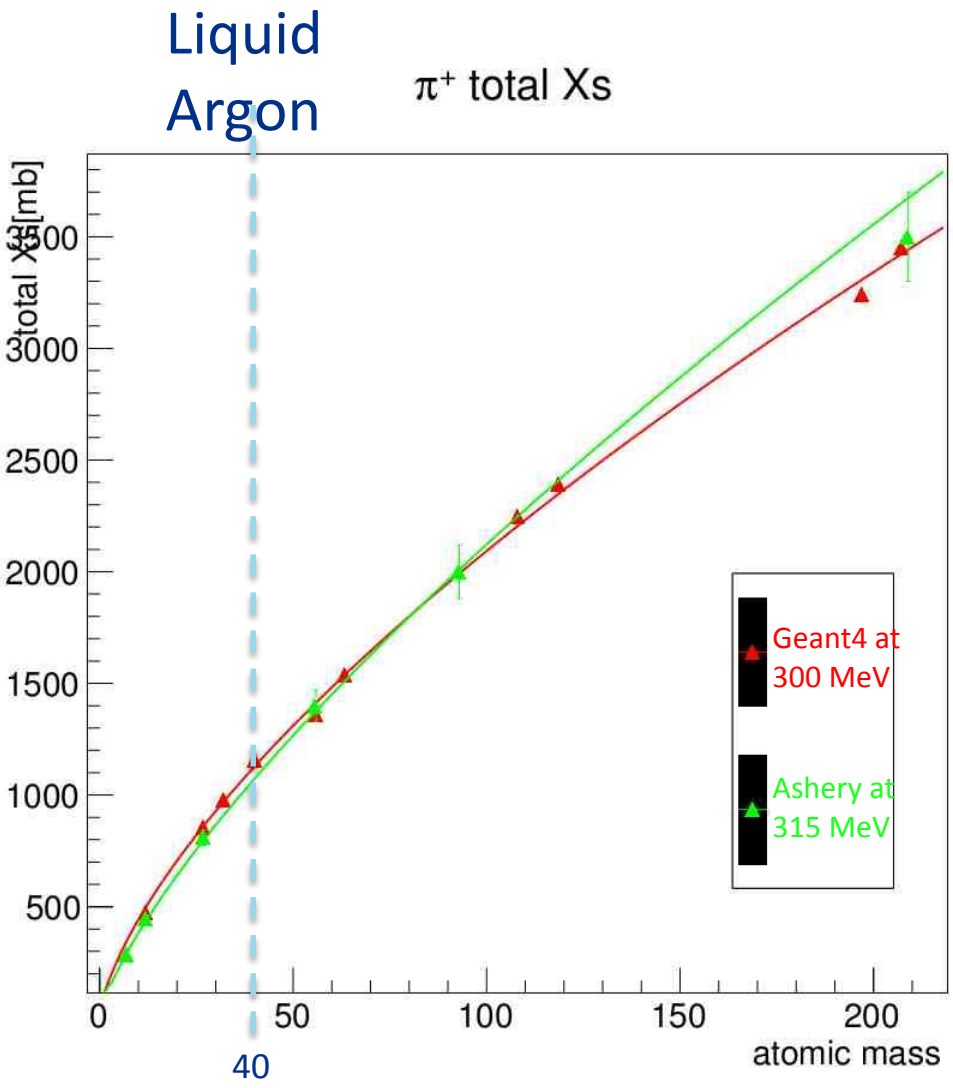
Geant4 total cross section simulation vs. data (Ashery)



C1*(atomic mass)^C2

total cross section fit results

Geant4
C2 = 0.67 +/- .01

Experimental data
C2 = 0.70+/- .008

Close to expected C2 = 0.66

Conclusion

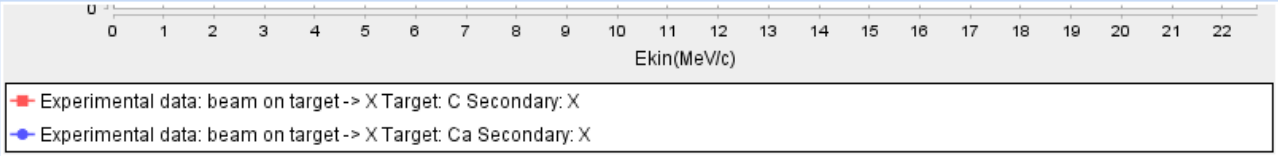
- PostgreSQL database development
- Programming with Java and HTML and modern web application framework
- Simulation automation with Python and Root
- Cross-section experimental procedure
- Experimental physics versus simulation

Acknowledgements

- Hans Wenzel for project supervision and advice
- Geant4 PDS group at Fermilab for welcoming atmosphere
- Geant4 Collaboration for feedback
- The SIST committee for the opportunity to intern at Fermilab

BACKUP SLIDES

- Geant4 Dicello et al. Display table
- Database schema implementation
- Total cross section plot



Decription	Data Table

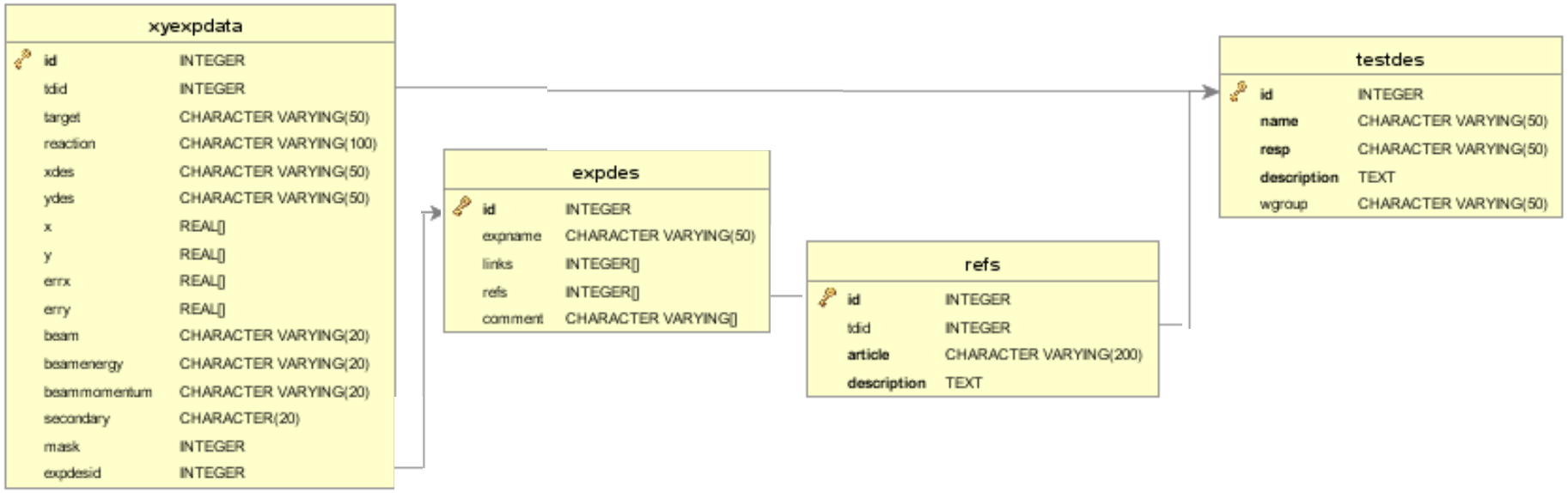
Reaction: beam on target -> X
Target: C
Beam: p
Beam Energy: 10-20 [MeV/c]
Secondary: X

Ekin(MeV/c)	Error	sig[mb]	Error
9.88	0.0	195.0	47.0
10.2	0.0	181.0	53.0
10.4	0.0	434.0	58.0
10.72	0.0	318.0	61.0
13.51	0.0	207.0	39.0
13.77	0.0	380.0	43.0
14.54	0.0	324.0	42.0
14.79	0.0	235.0	40.0
17.41	0.0	343.0	24.0
19.46	0.0	401.0	24.0

Reaction: beam on target -> X
Target: Ca
Beam: p
Beam Energy: 10-20 [MeV/c]
Secondary: X

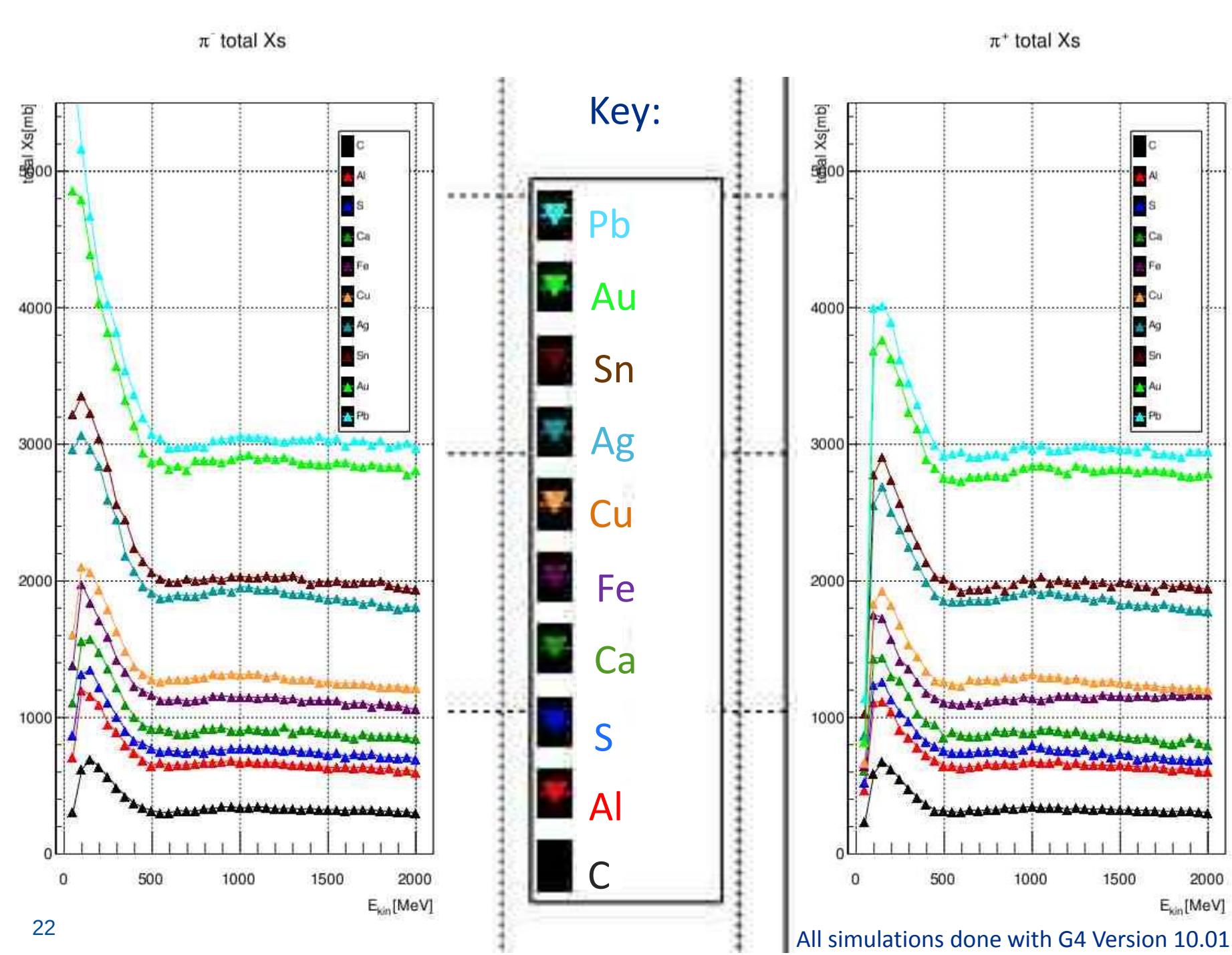
Ekin(MeV/c)	Error	sig[mb]	Error
10.34	0.0	505.0	59.0
11.38	0.0	736.0	54.0
12.42	0.0	717.0	63.0
12.42	0.0	742.0	67.0
13.45	0.0	931.0	46.0
13.46	0.0	953.0	50.0
13.97	0.0	883.0	44.0
14.48	0.0	846.0	44.0
14.97	0.0	920.0	42.0
15.51	0.0	822.0	47.0
16.49	0.0	766.0	47.0
17.51	0.0	765.0	35.0
18.54	0.0	850.0	39.0
19.55	0.0	821.0	35.0
20.57	0.0	806.0	34.0
21.59	0.0	851.0	35.0

Default Display – Extension of Database Schema



Replace xyexpdata elements (i.e. nameofexperiment) with reference to unique experiment description table (expdes)

Experimental data relates to simulated data (testdes) so that they both can be overlaid



All simulations done with G4 Version 10.01.p02