



Validation of Geant4 Physics

Fermilab Geant4 Tutorial

27-29 October 2003

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Outline

★ Electromagnetic processes

- plans
- plots

★ Hadronic processes

- plans
- plots

★ Validation of Geant4 in large experiments



Electromagnetic Process Validation and Plans

★ Physics validation

- thin target tests comparing Geant4 with data

★ Statistical tests

- standardized tests (χ^2 , max.likelihood, etc.) of a selected set of physical quantities has been proposed

★ Regression

- planned test of above quantities from release to release
- some tests already being performed

★ User tests

- test setup planned with which user can perform checks of physics, statistics, etc.

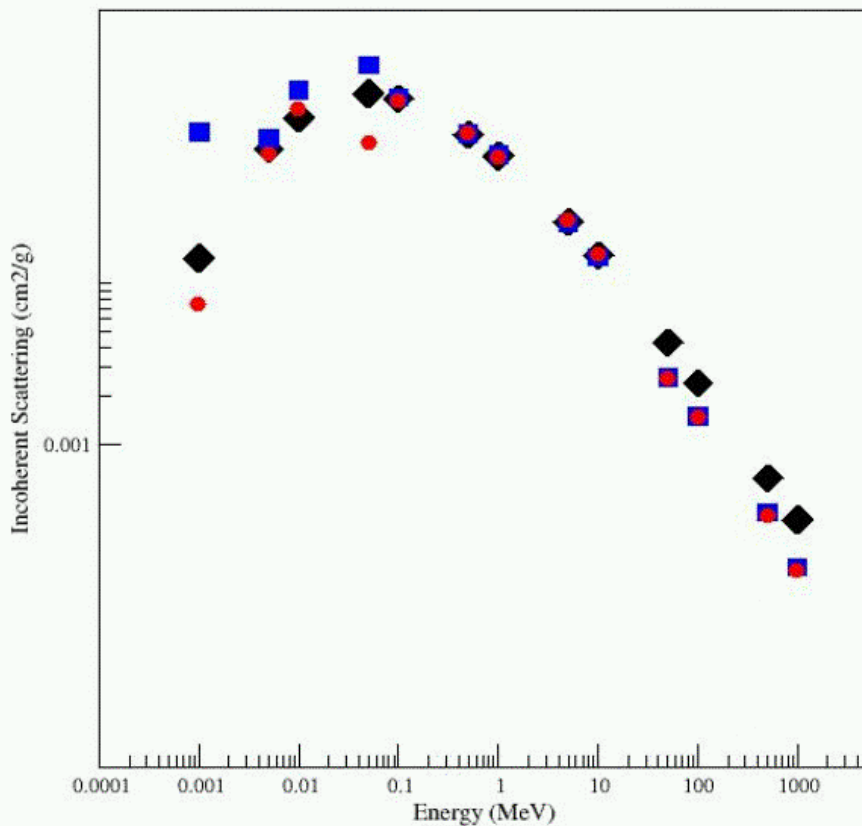


Compton Scattering

Data, *G4 LowE*, *G4 standard*

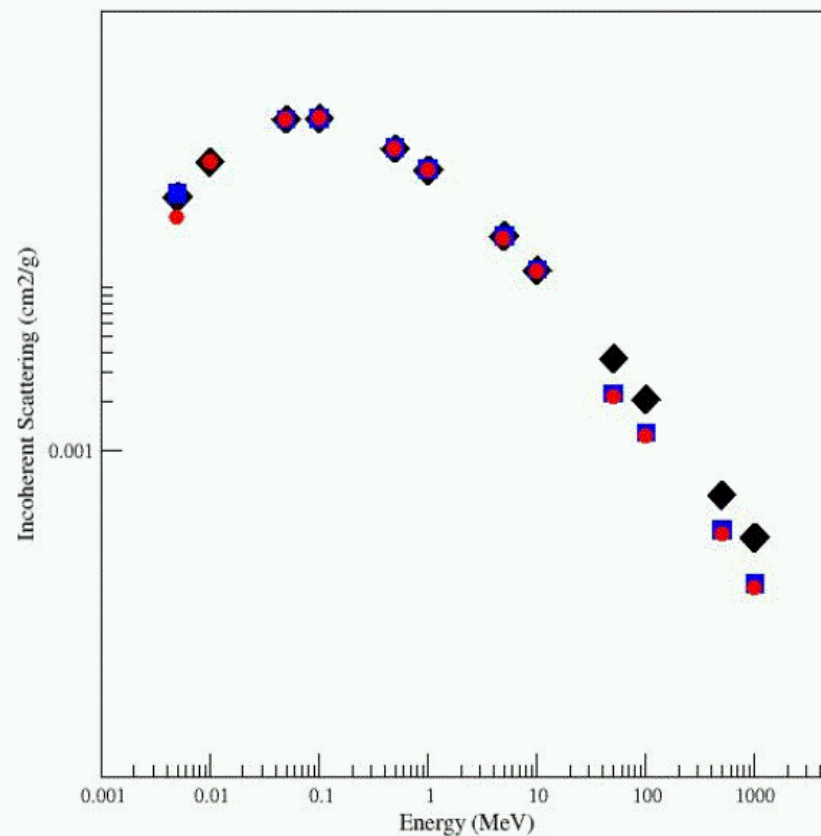
Photons - Incoherent Scattering - Aluminium

(Geant4-05-02)



Photons - Incoherent Scattering - Cesium

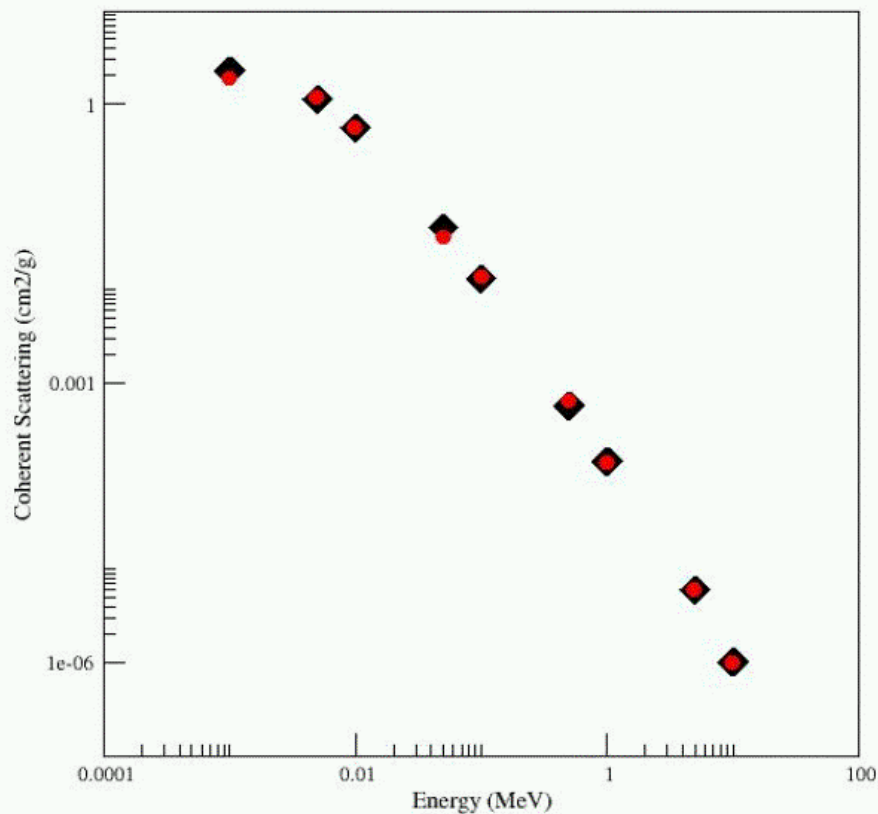
(Geant4-05-02)



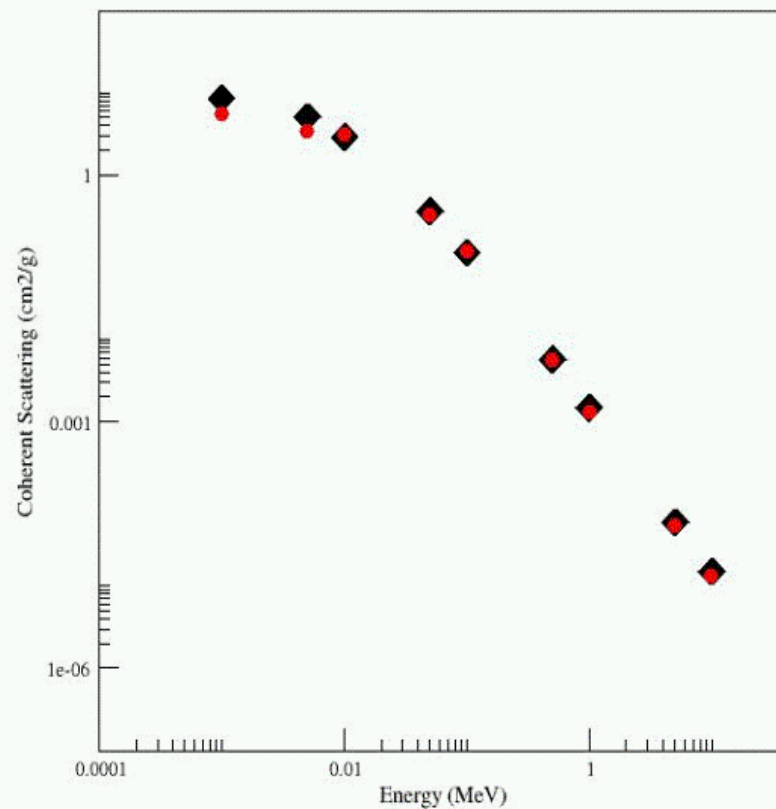


Rayleigh Scattering Data, *G4 LowE*

Photons - Coherent Scattering - Aluminium
(Geant4-05-02)



Photons - Coherent Scattering - Cesium
(Geant4-05-02)



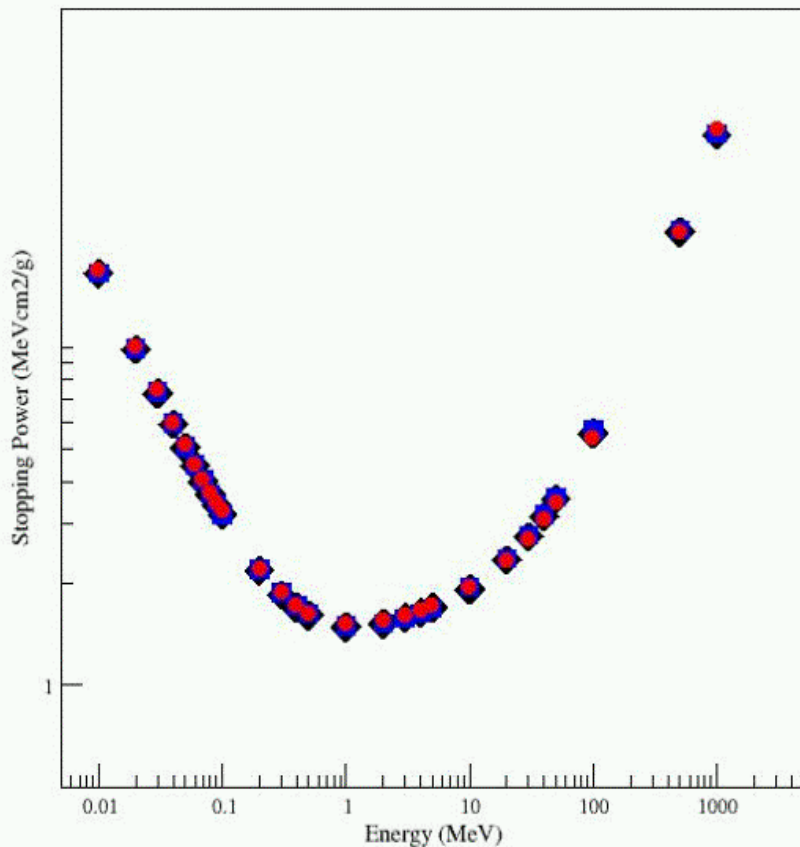


Stopping Power

Data, *G4 LowE*, *G4 Standard*

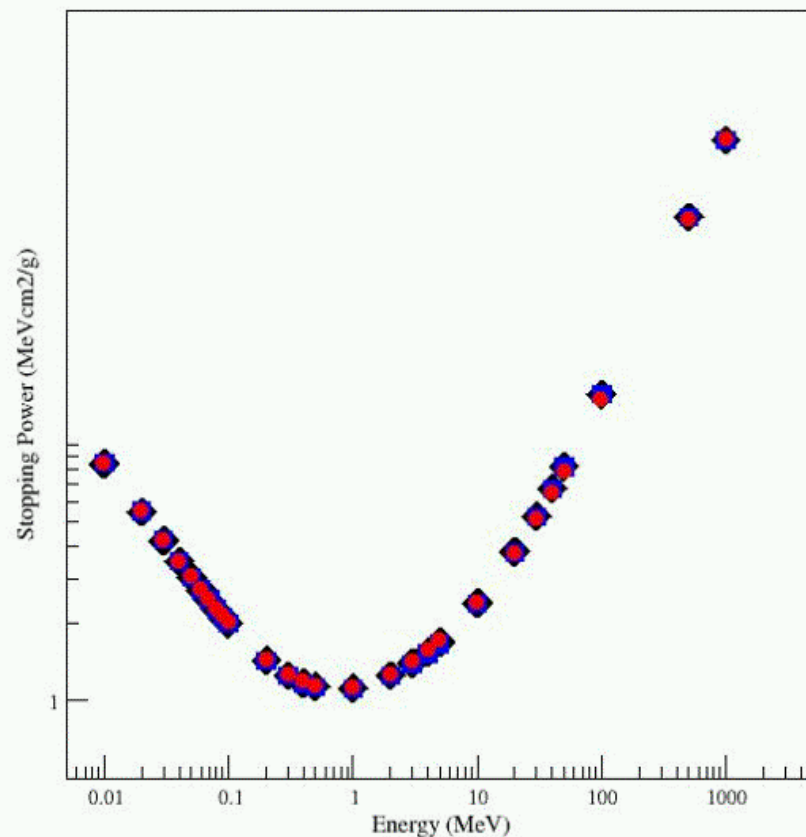
Electrons - Stopping Power - Aluminium

(Geant4-05-02)



Electrons - Stopping Power - Lead

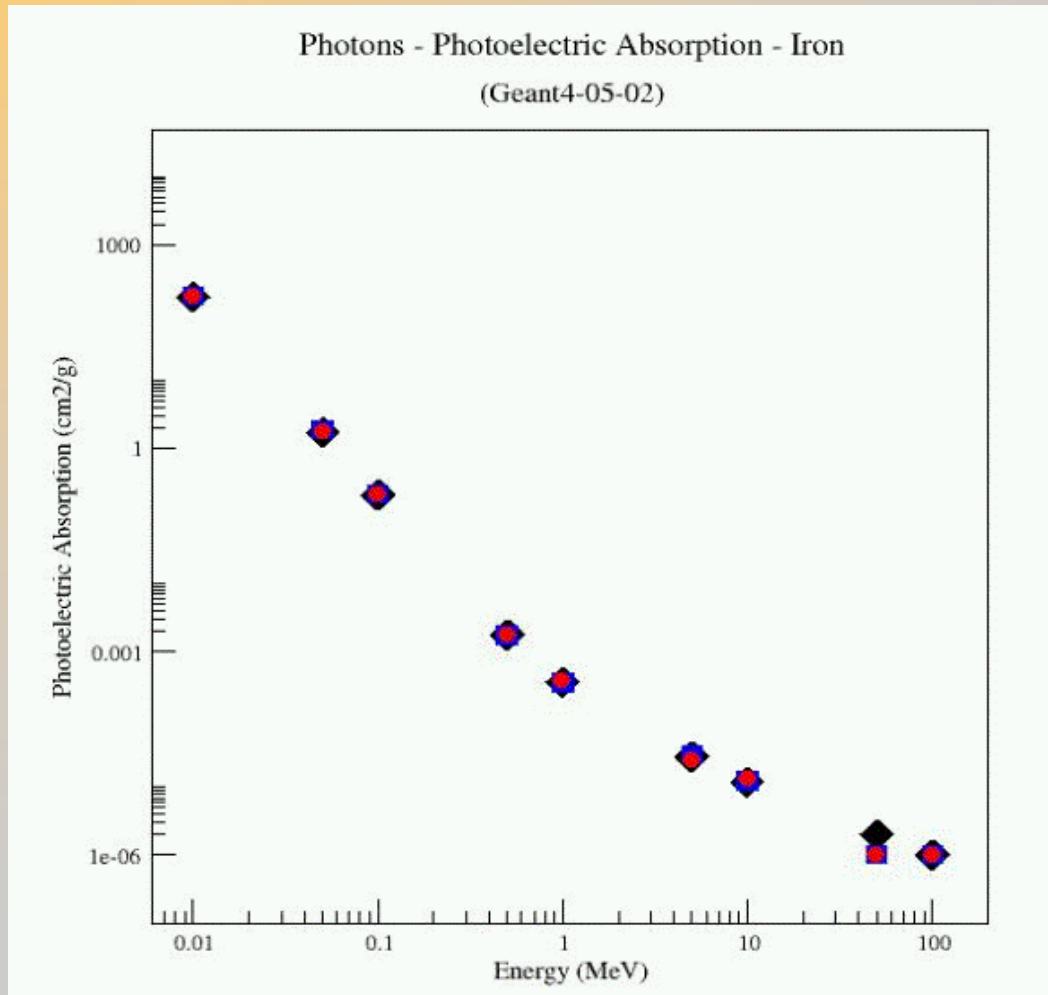
(Geant4-05-02)





Photoelectric Effect

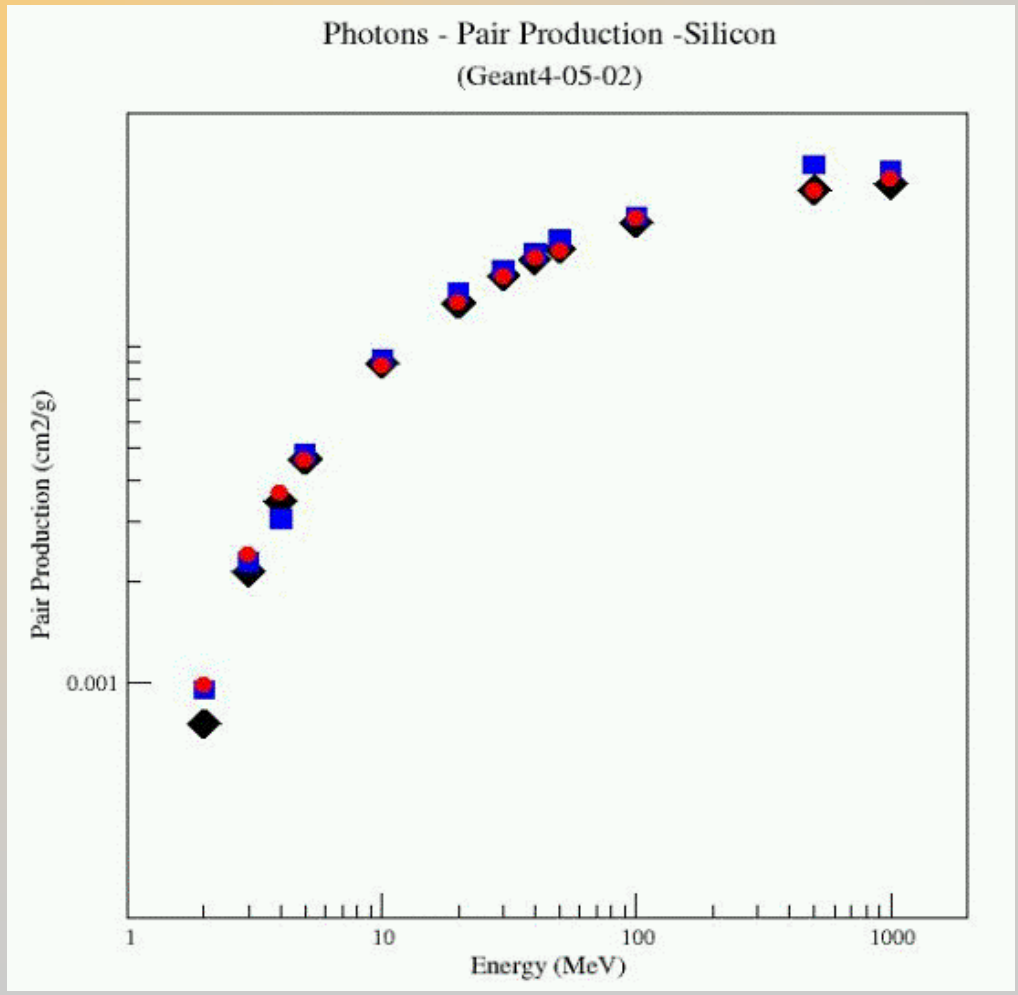
Data, G4 LowE, G4 Standard





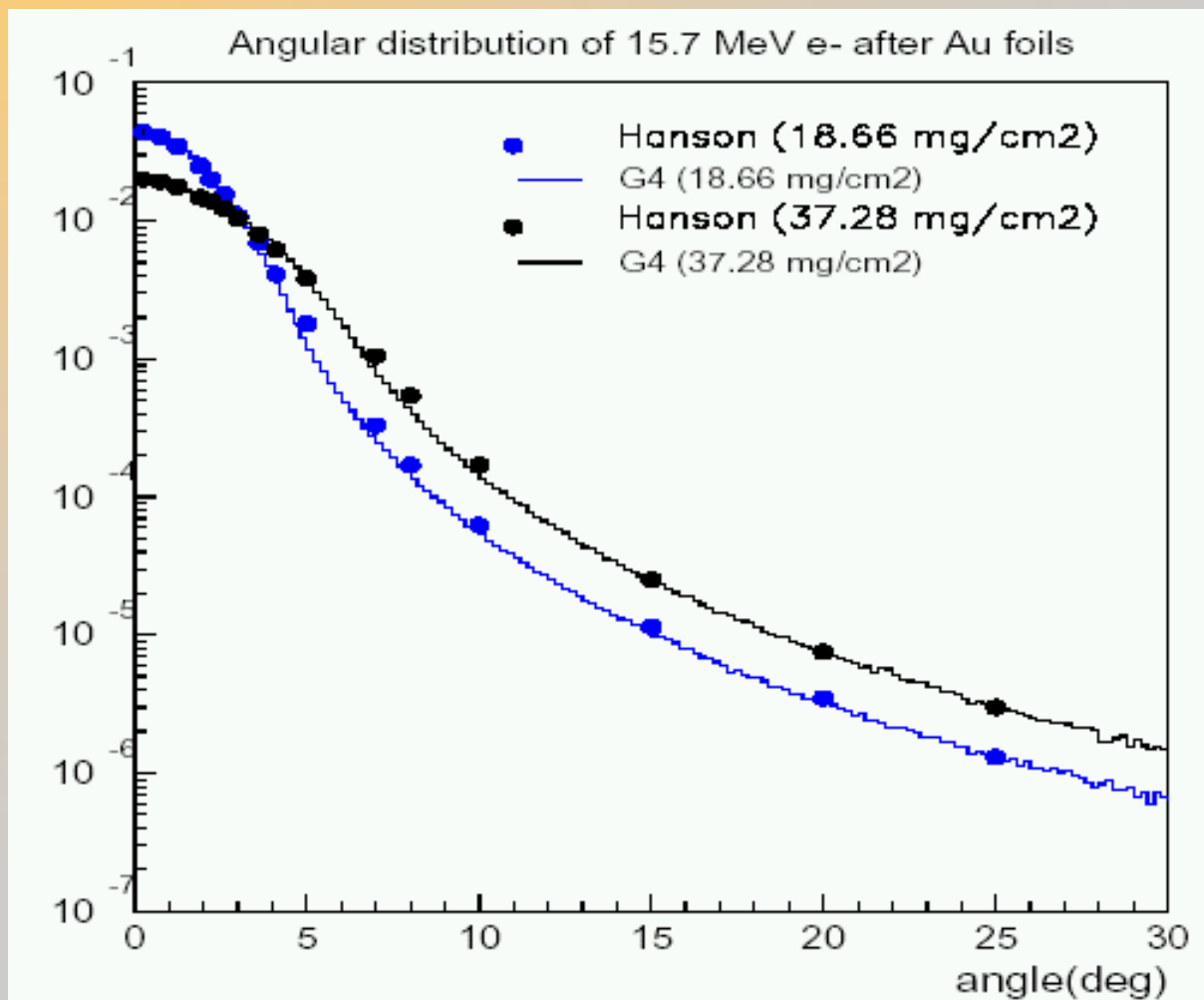
Pair Production

Data, *G4 LowE*, *G4 Standard*





Multiple Scattering (1)





Multiple Scattering (2)

Proton energy	Target	Data θ_0 (mr)	Geant4 θ_0 (mr)
1.984 MeV	3.42 mg/cm ² Al	35.6(1.9)	35.4
158.6 MeV	1.82 g/cm ² Pb	24.00(.24)	23.88
158.6 MeV	1.82 g/cm ² Be	6.39(.18)	6.46
174 GeV	0.58 g/cm ² Pb	0.0213(.0029)	0.0213



Hadronic Process Validation and Plans

★ Physics testing

- thin target tests (comparing single Geant4 process with data)
- full setup tests (full physics and full geometry)

★ Statistical testing

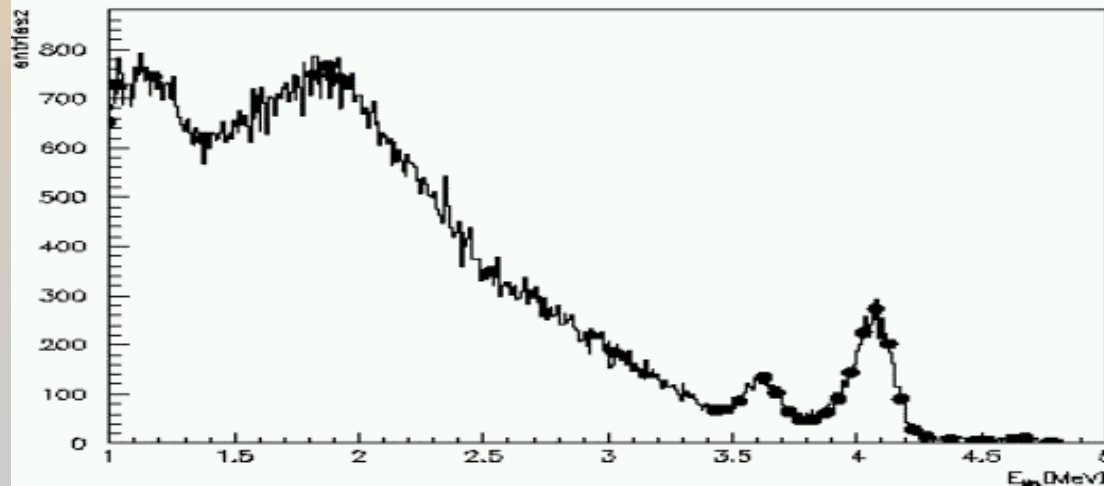
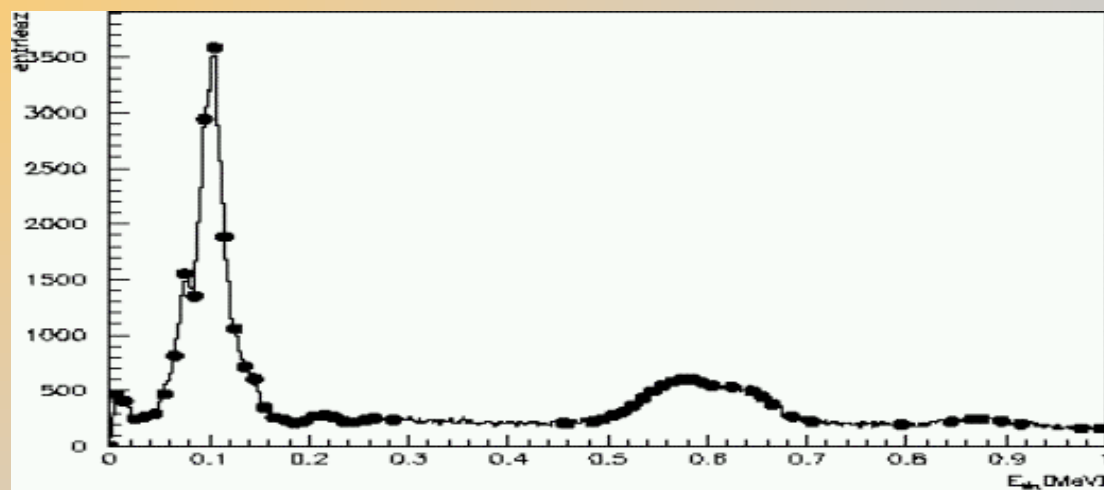
- Too early, many models still under development

★ Regression

- Some tests done currently, more are planned

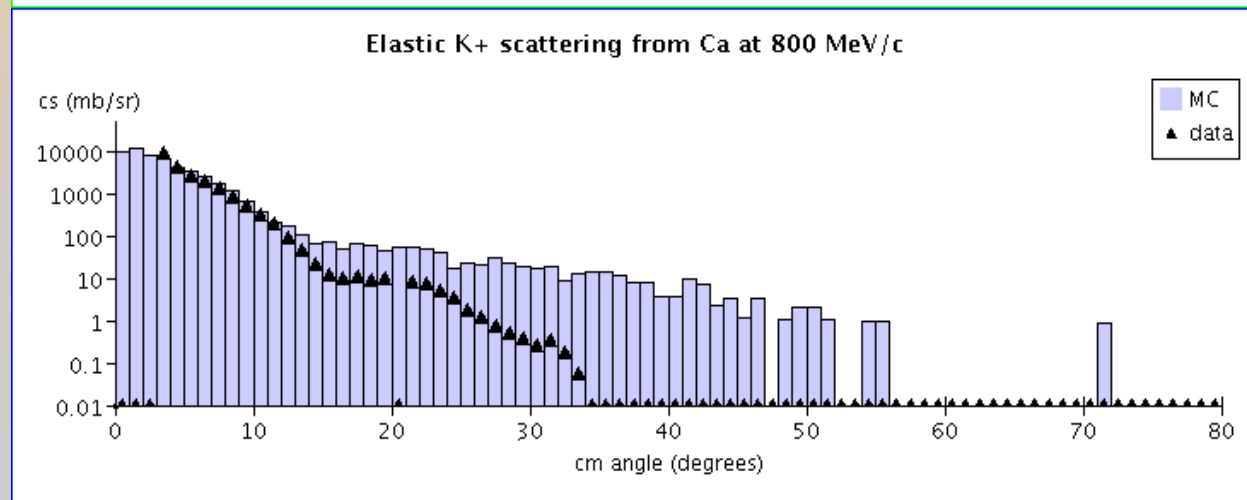
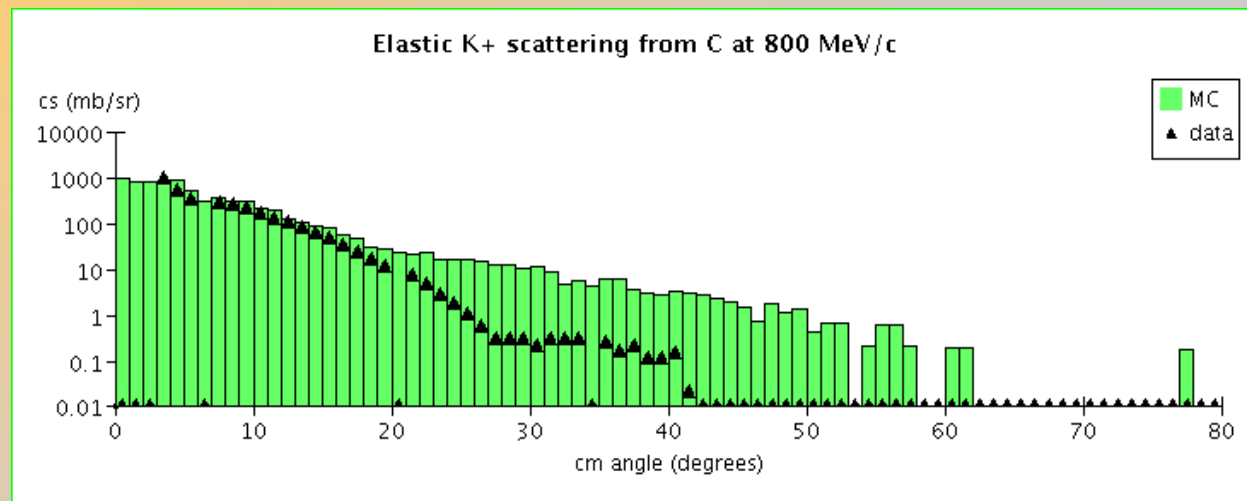


Gamma from 14 MeV Neutron Capture on U (Data driven model)



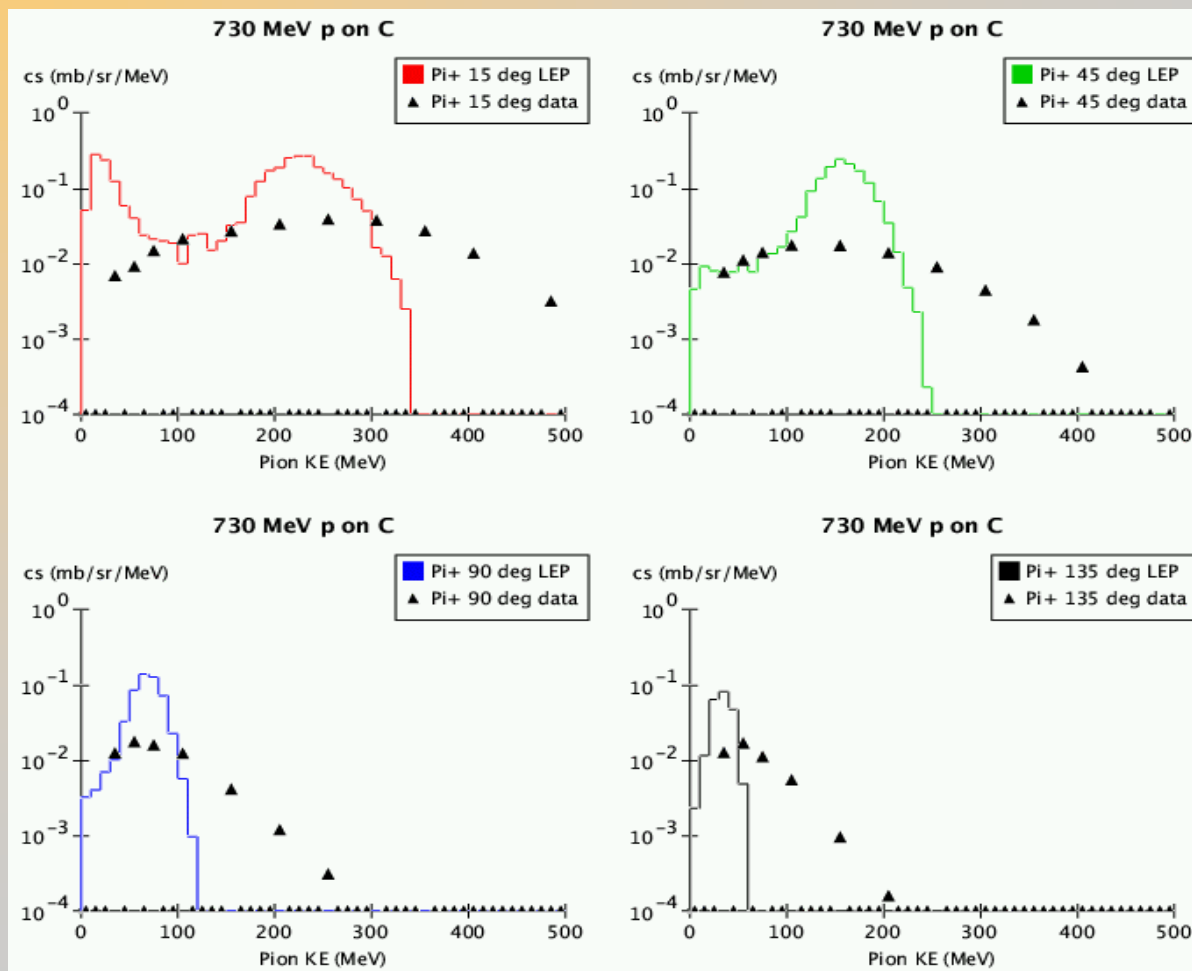


Elastic Kaon Scattering at 800 MeV/c



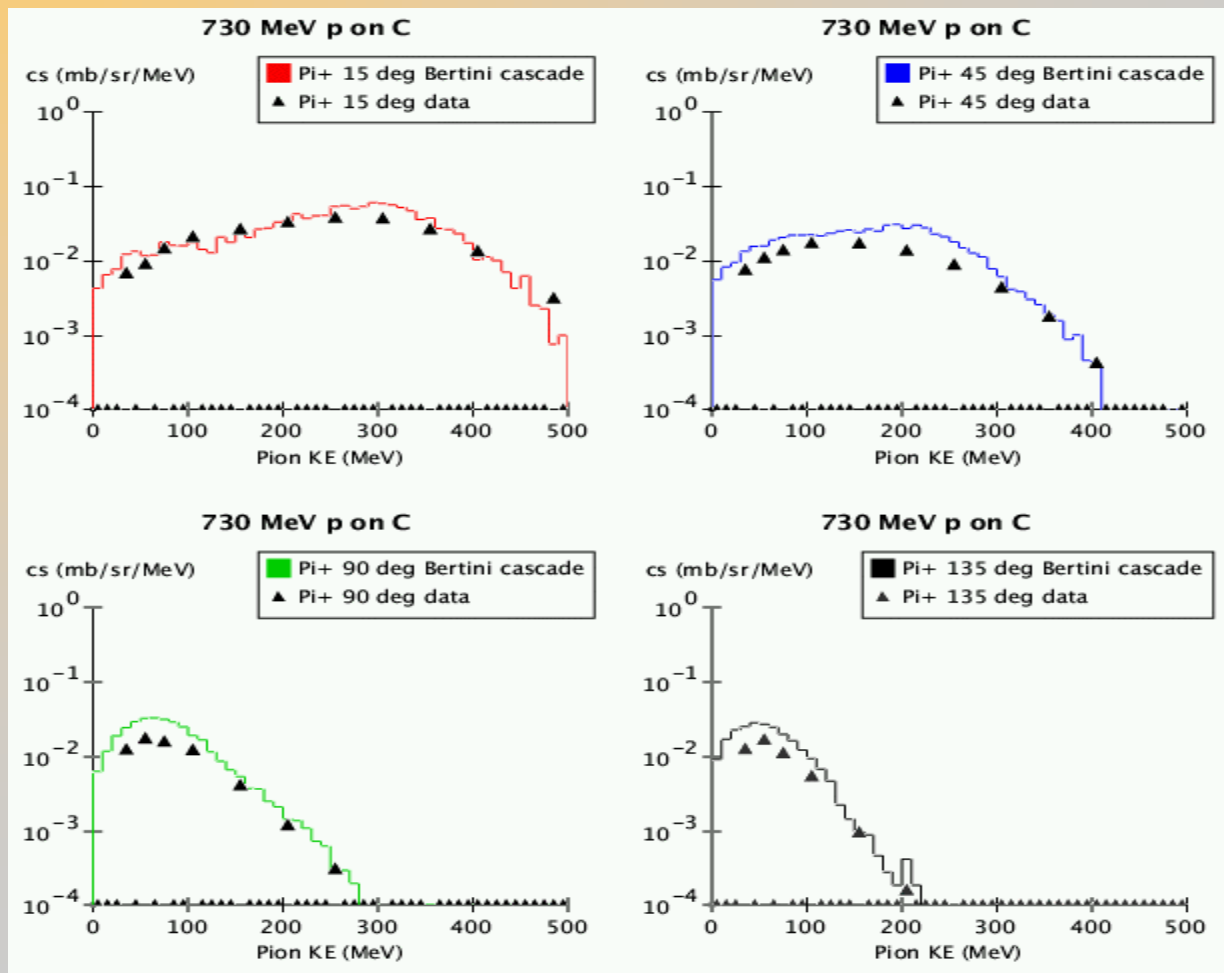


π Production from 730 MeV p (LEP Model)



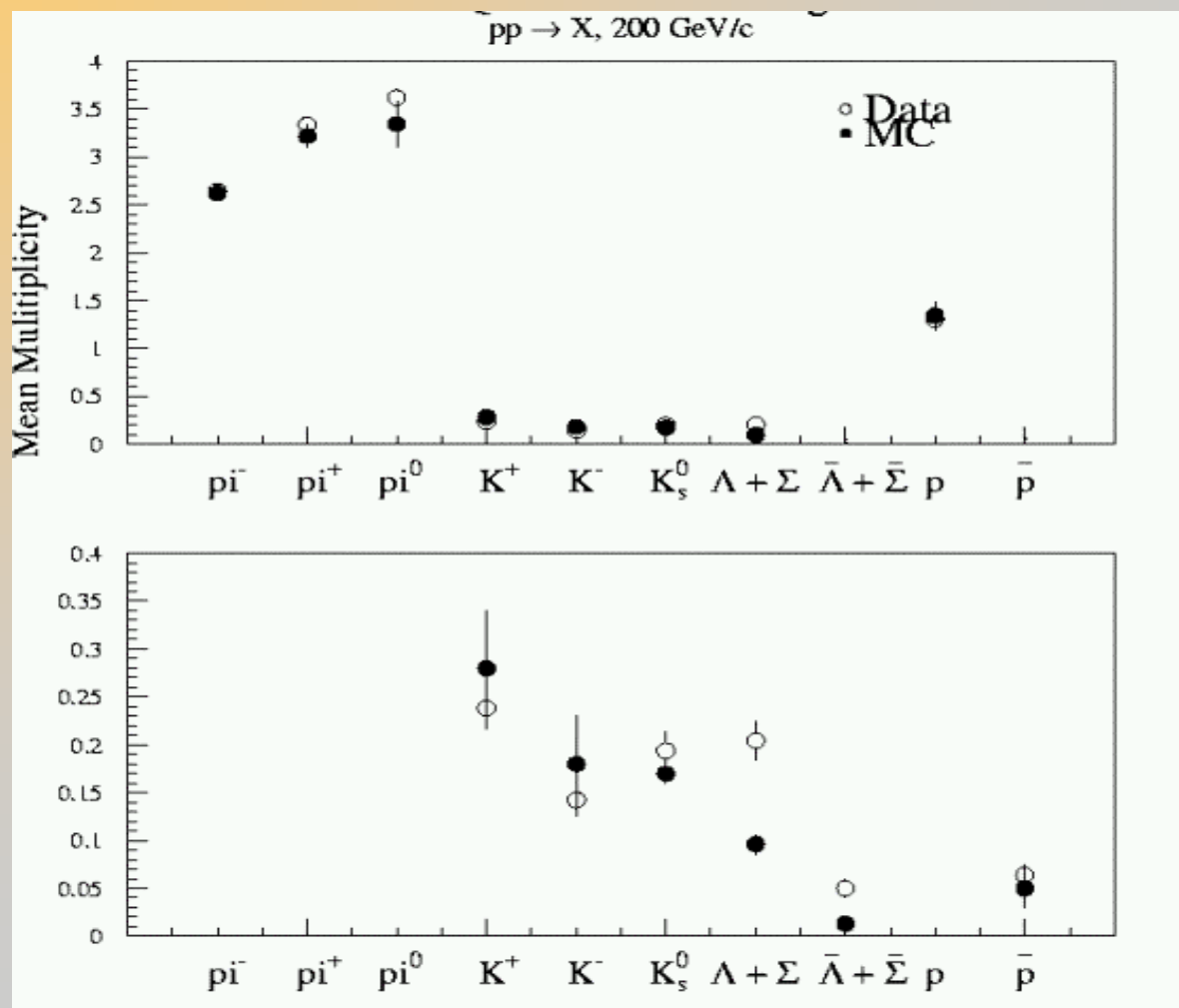


p Production from 730 MeV *p* (Bertini Model)



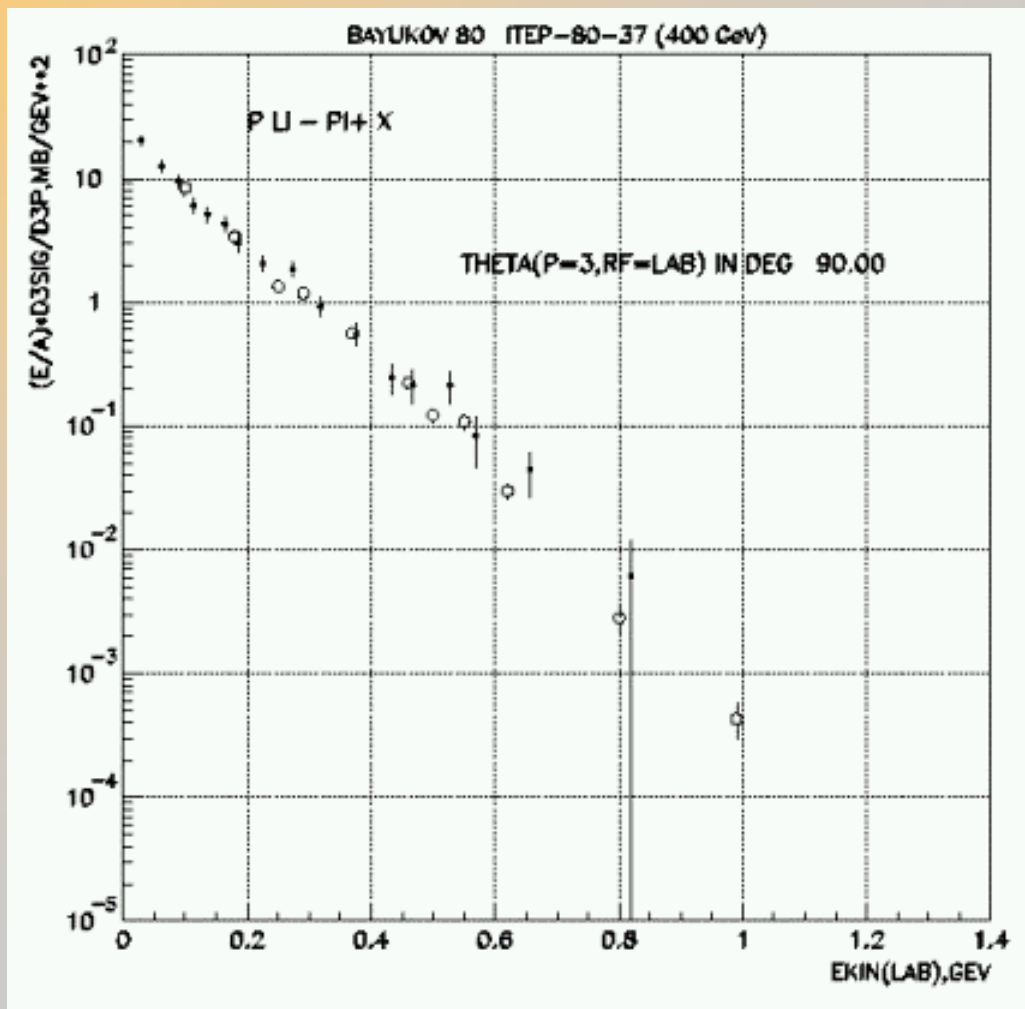


Multiplicity in $pp \rightarrow X$ at 200 GeV/c (QGS Model)





Cross section for $p Li \rightarrow p + X$ at 400 GeV (QGS Model)





Validation at Large Experiments

★ ATLAS

- Test beam studies

★ BaBar

- Running experiment
- Geant4 in production for two years

★ CMS

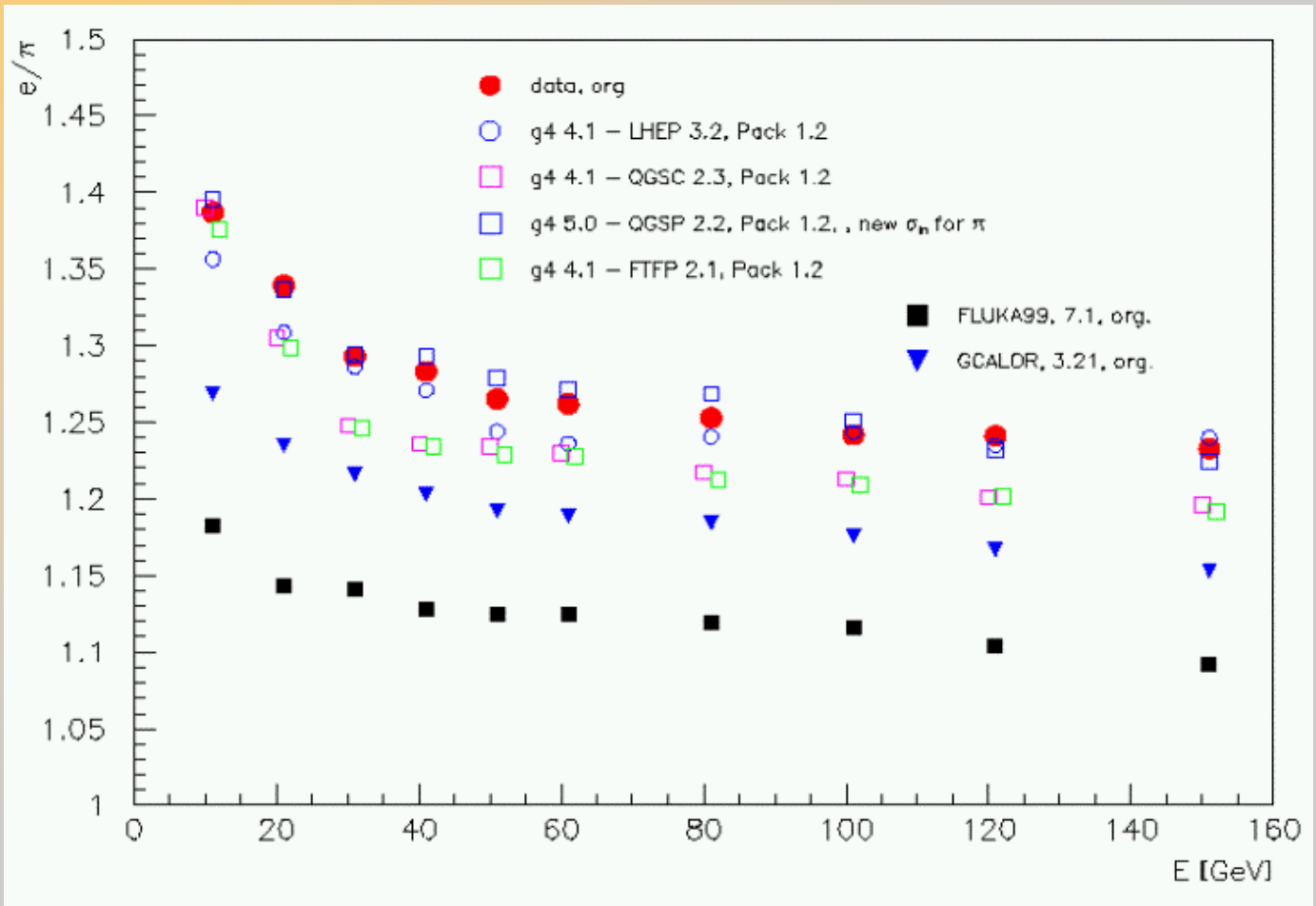
- Test beam studies

★ HARP

- Running test beam experiment
- Results to be used to validate Geant4 thin target studies

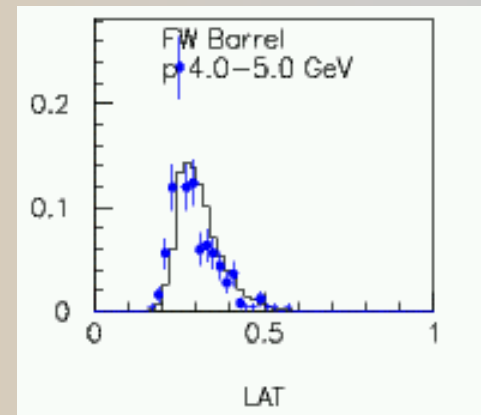
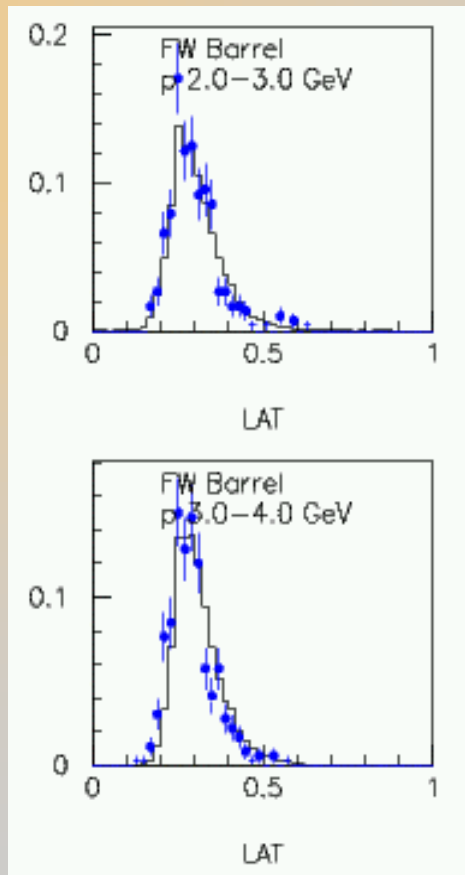
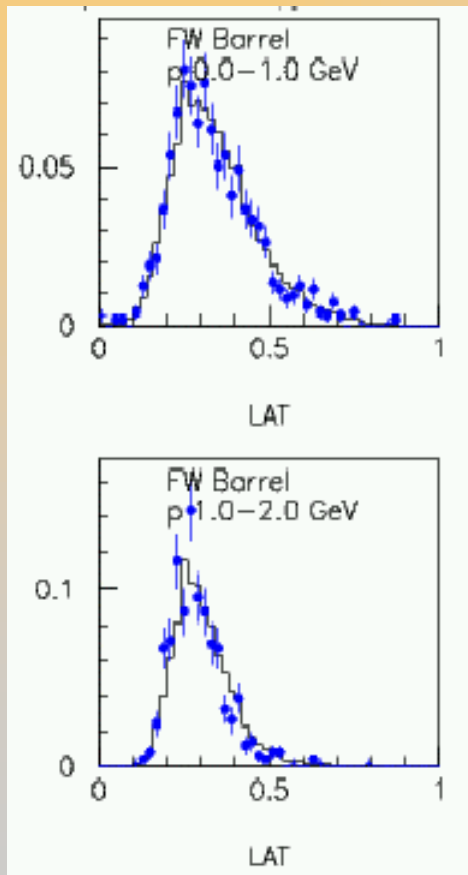


Atlas HEC (e/p ratio)





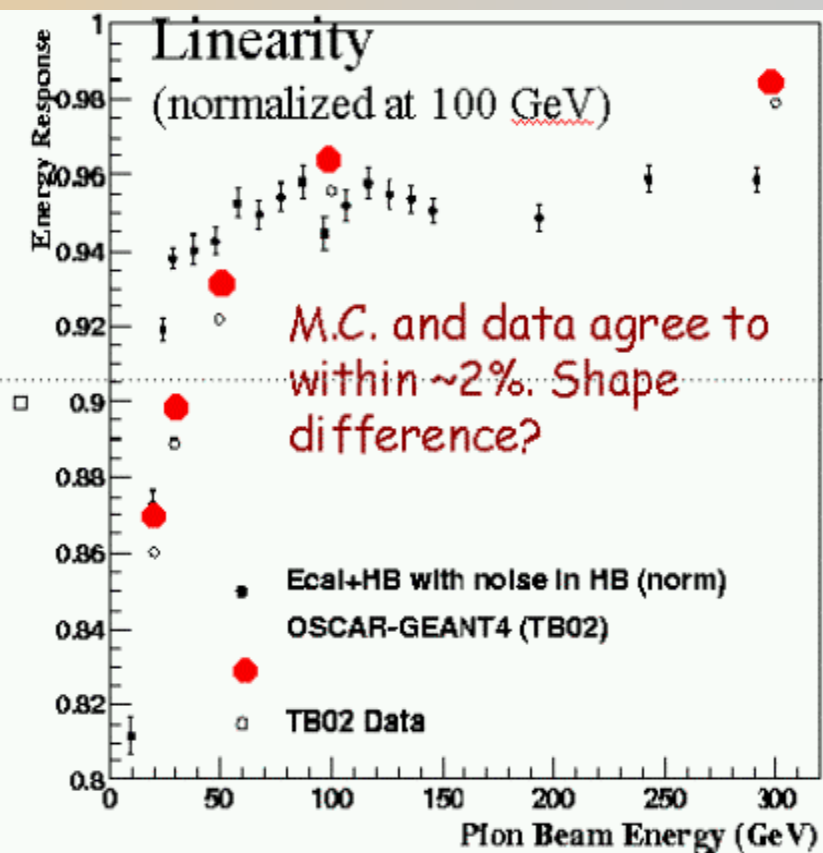
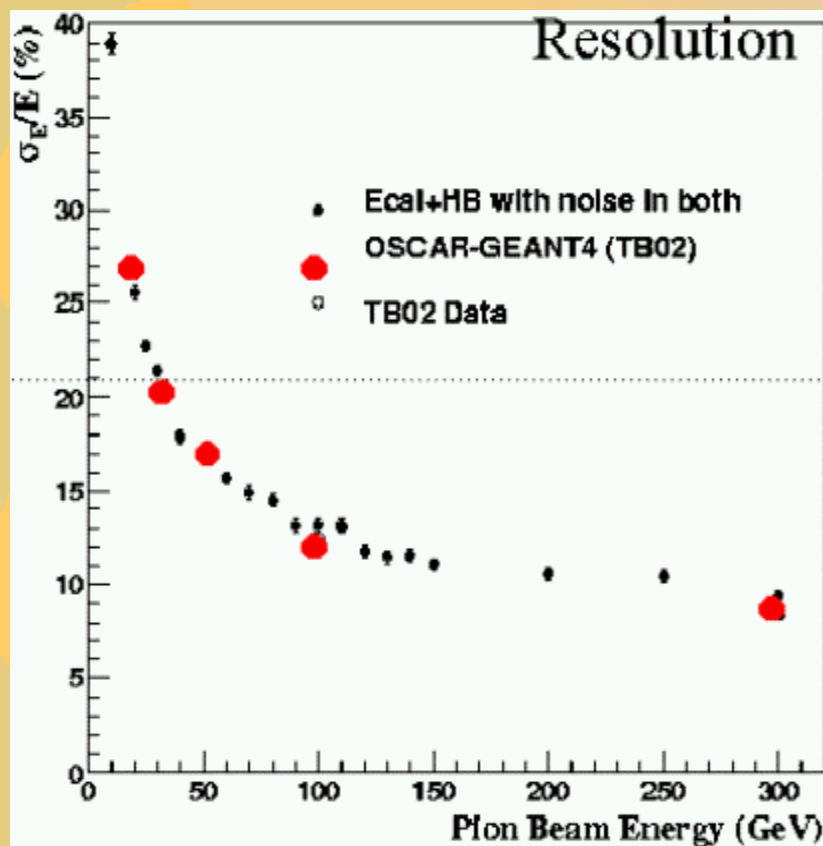
BaBar EM Calorimeter (EM shower shapes)



- Bhabha scattering data
- Geant4



CMS Test Beam (p resolution)





HARP Experiment and Goals

- ★ p and π beams between 1.5 and 15 GeV/c on solid targets (Be through Pb) and liquid targets (H_2 , D_2 , N_2 , H_2O)
- ★ Provide a systematic study of hadron production cross sections
- ★ Will provide much-needed data for Geant4 hadronic model validation and tuning
- ★ Data taking complete, analysis underway



Summary

- ★ Geant4 is pursuing 3 types of validation:
 - physics
 - statistical
 - regression
- ★ Much of the validation is done by users:
 - experiments
 - individuals
- ★ Expanded validation suites are planned
 - prototypes exist for EM, hadronic physics
 - validation suite for users planned