



# VALIDATION OF GEANT4 10.6 AND PLANS FOR 2020

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# Outline

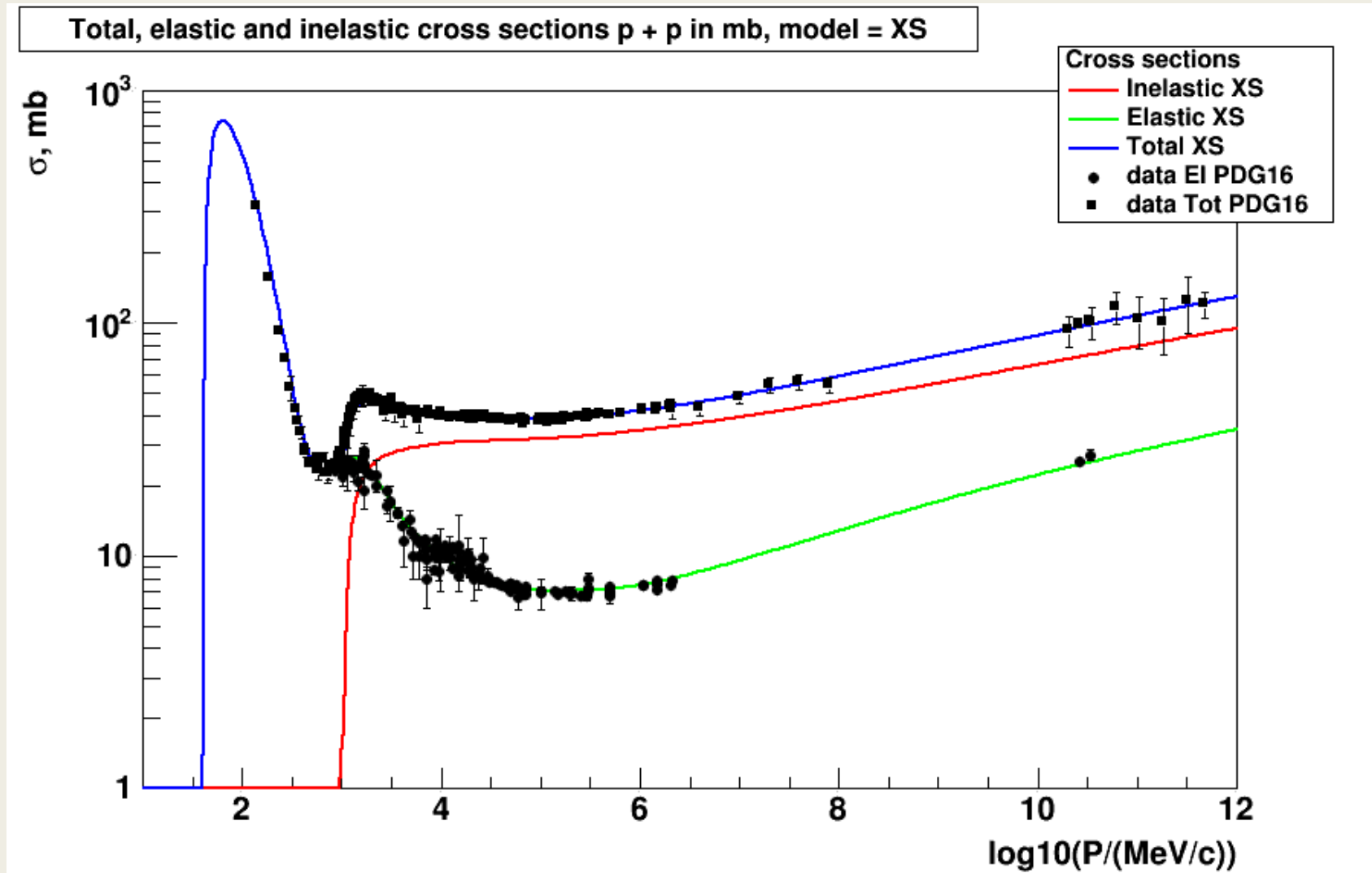
- General infrastructure update
- Hadron cross sections
- Hadron elastic scattering
- De-excitation module
- List of proposed developments for 2020

# General infrastructure update for 10.6

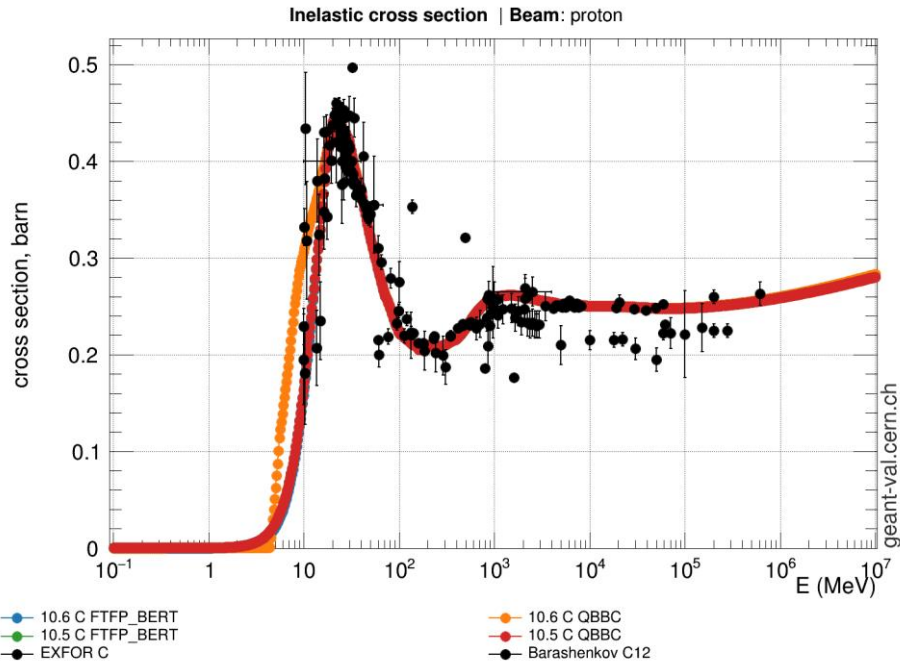
(in collaboration with A.Bagulya and V.Grichine)

- Removed final state rotation both from elastic and inelastic processes
- Removed G4HadronicException and try/catch pattern from cross section sub-library and GetMeanFreePath() method, use only G4Exception
- Removed default GHEISHA cross sections
- Share cross section data between threads for XS and BGG classes
- Created new utility G4NuclearRadii with several parameterizations of nuclear radius
- Updated Starkov parameterizations for p, pi, K, Hyperons, charmed and bottom mesons and baryons
- Added G4PARTICLEXS2.1 dataset
- Properly destruct FTF model end of session

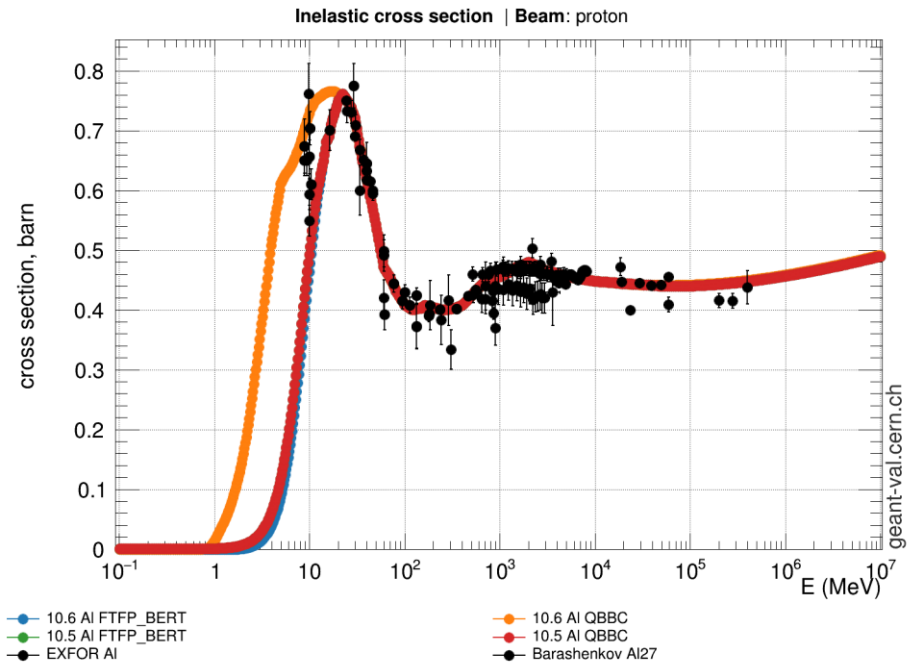
# Elementary cross section



# Geant-Val results for proton projectile

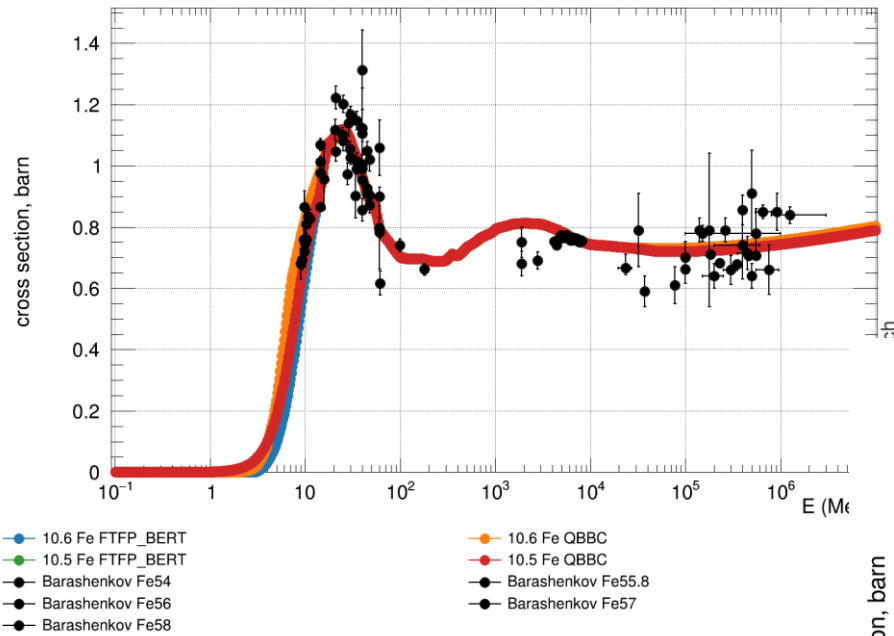


**Low energy inelastic  
requires further work**



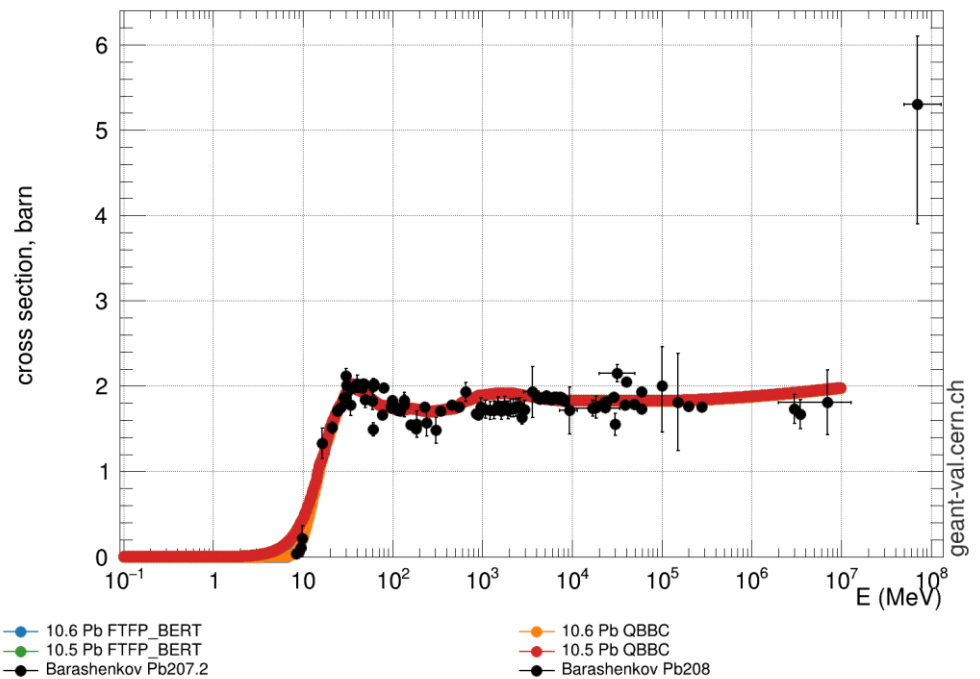
# Geant-Val results for proton projectile

Inelastic cross section | Beam: proton



**Stable results for heavy targets**

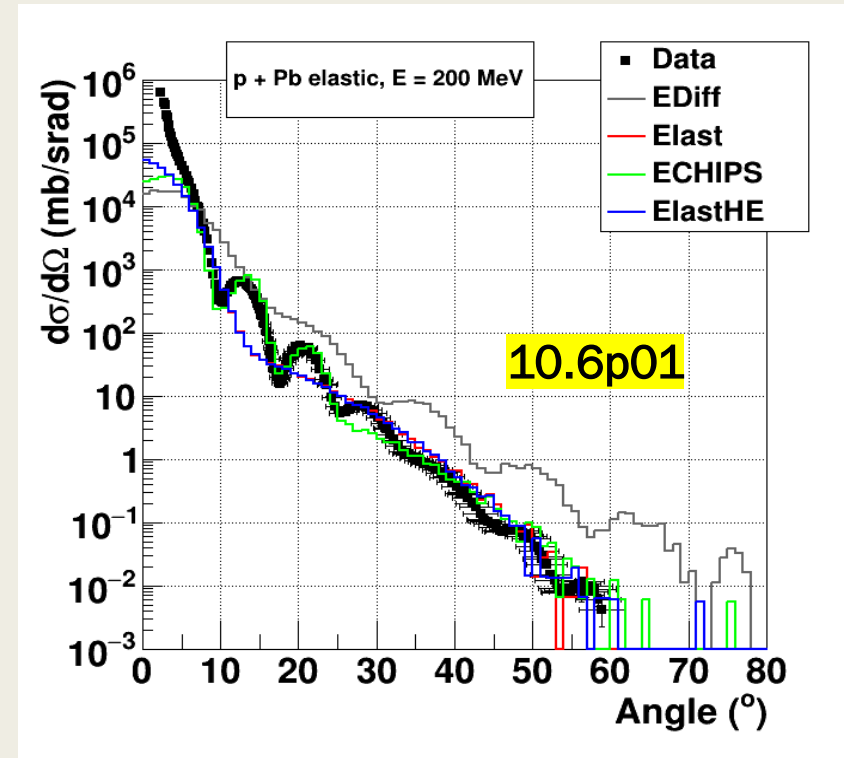
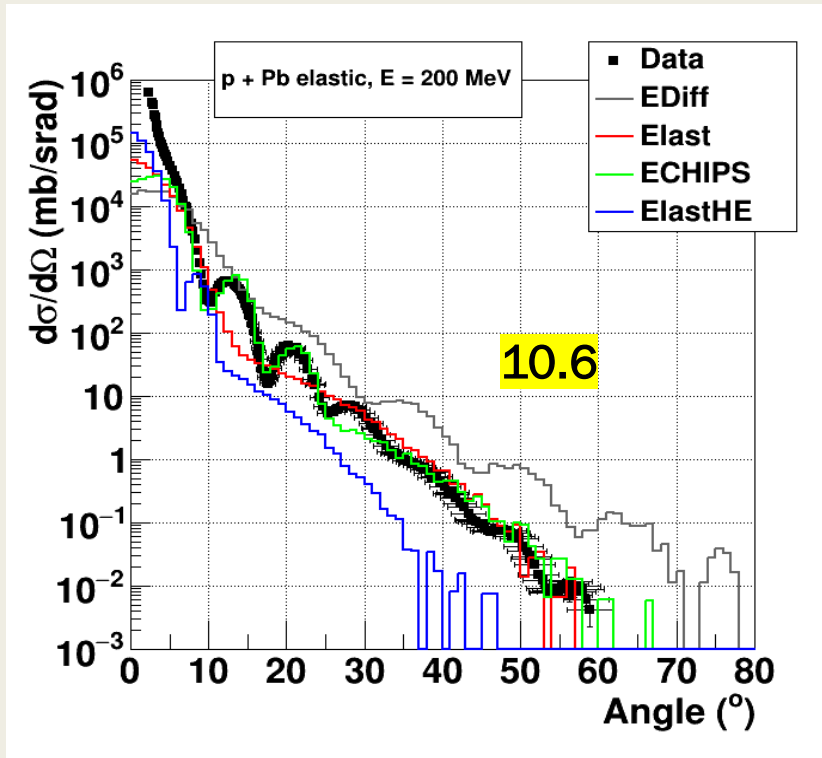
Inelastic cross section | Beam: proton



# Hadron elastic models

- There is summer student contribution
  - *Alikhan Yeltokov was working for 8 weeks*
  - *The main goal is to study performance of elastic scattering for pions and protons with energy up to 1 GeV*
- G4HadronElastic – based class for hadron elastic models
  - *By default implements a'la GHEISHA scattering function*
  - *Now tuned both for pion and proton data*
- G4ElasticHadrNucleusHE – based on Glauber approach, original author N. Starkov
  - *There were technical problem and ineffective memory usage and initialization*
  - *Now data are shared between threads and no lazy initialization for pions (initialized before event loop)*
  - *Added parameterization for large angle scattering (was sharp cut)*
- Diffuse elastic model (V.Grachine) and CHIPS models are also validated

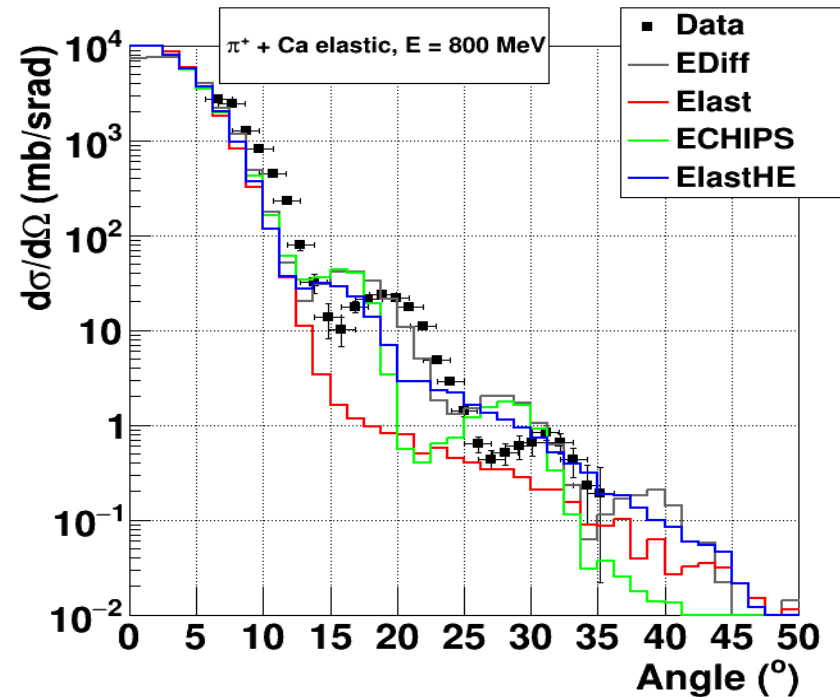
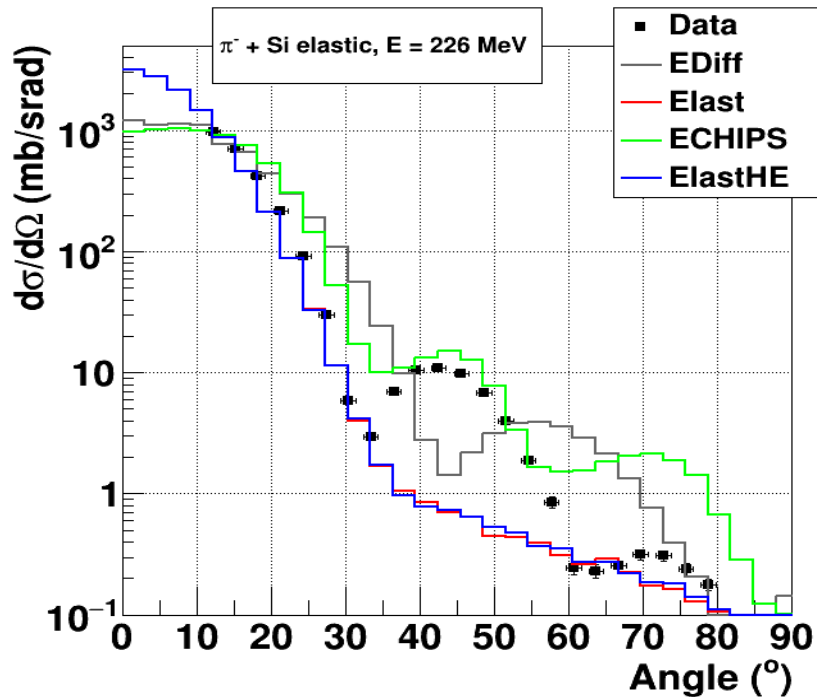
# Proton scattering for 10.6



- Switch from HE model to parameterized should be done via kinetic energy, not momentum threshold
- The basic parameterisation is competitive to CHIPS
- Diffuse elastic requires much more work



# Pion scattering for 10.6

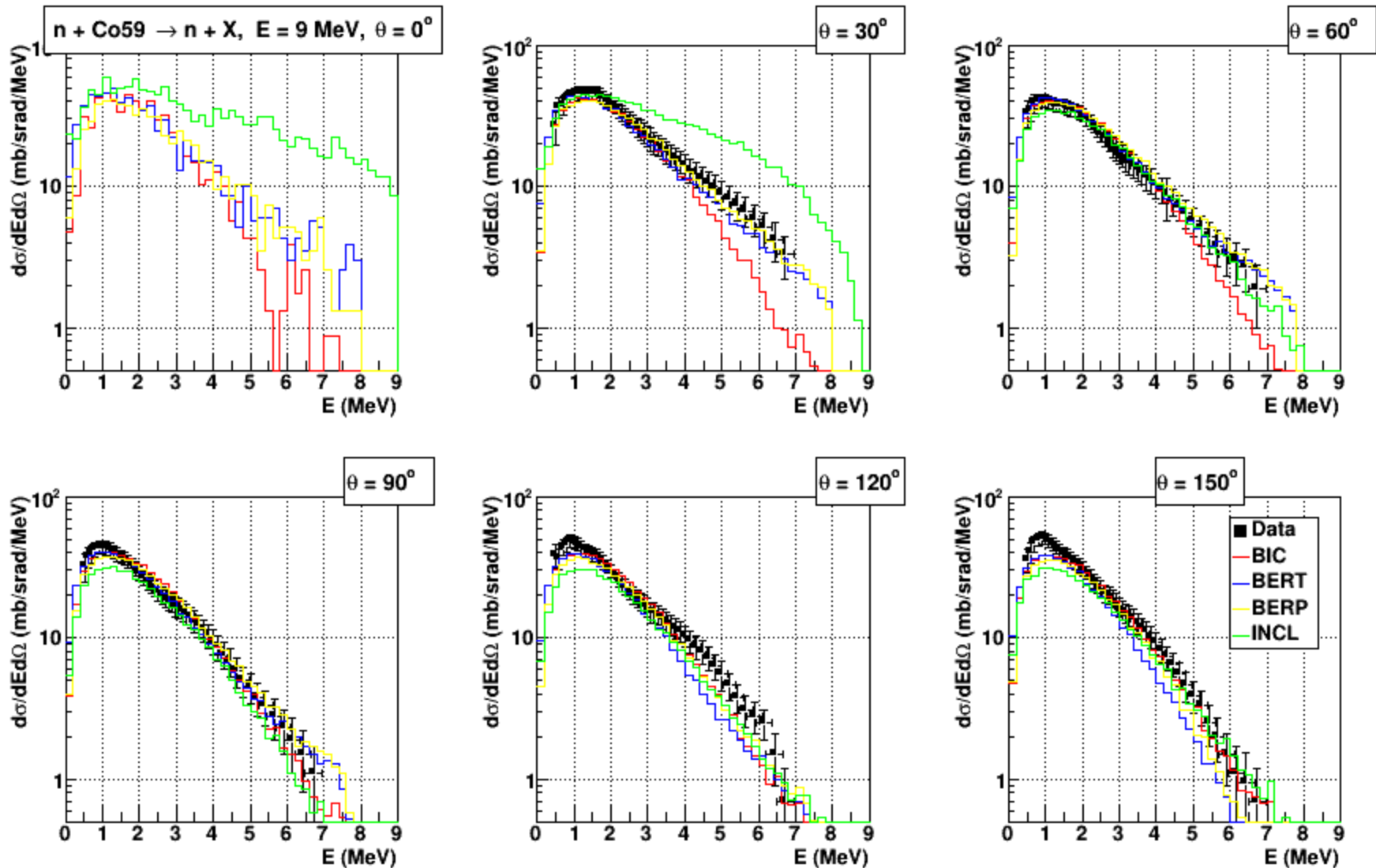


- HE model applicable for  $E > 400$  MeV better described data
- Parameterisation is fine for the main diffraction peak but does not well describe 1<sup>st</sup> maximum
- Diffuse and CHIPS models have qualitatively correct shapes but not fit the data

# De-excitation module in 10.6

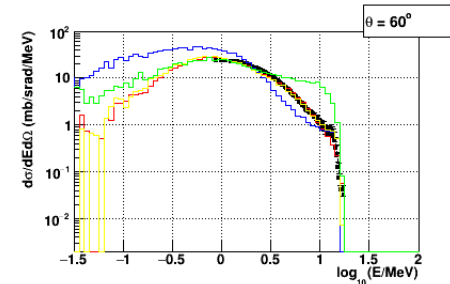
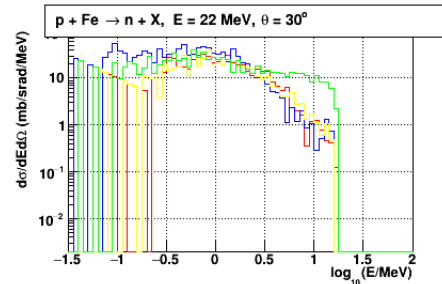
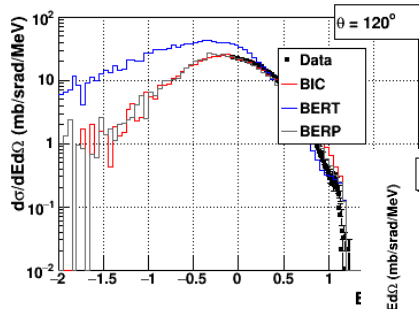
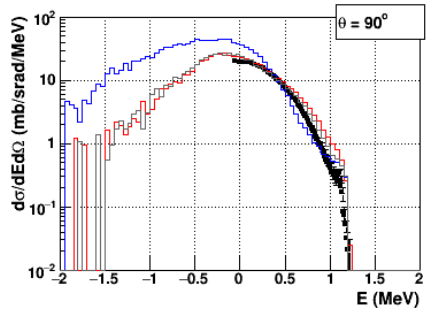
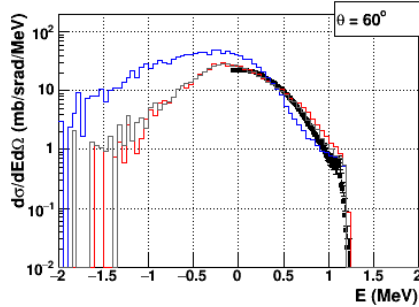
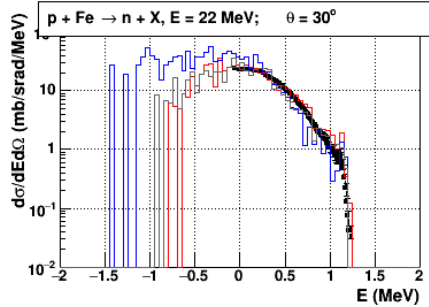
- Taking care for decay of unphysical fragments
  - *Very high excitations*
  - *Abnormal Z/A combination*
- G4FermiBreakUpVI
  - *Fixed Coulomb Barrier correction – may affect medical tests*
  - *Allowed to have gamma transition from excited levels*
  - *Remove treatment exotic states to G4Evaporation*
- G4PhotonEvaporation
  - *Fixed #2124 – limit value for IC probability*
  - *Fixed #2123 – if no data for a given level make transition to the closest one*
- G4Evaporation
  - *Simplified method of integration of differential inverse cross section and sampling of final state*
  - *Added treatment of unphysical fragments*
  - *Recognize secondary t and He3 as stable fragments*
- Introduced a possibility (optional), forcing final state after each evaporation to correspond to one of level for given isotope
  - *There is a problem, which not allows making this option the default*
  - *This issue needs further study, may be activated together with Radioactive decay*
- Migrated test30 to ROOT6

# Neutron 9 MeV scattering of Co59

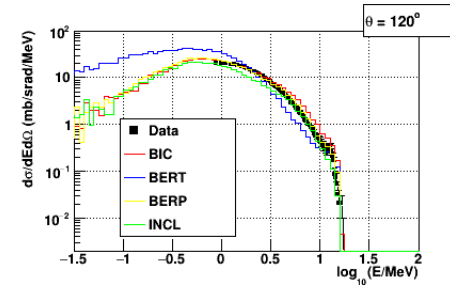
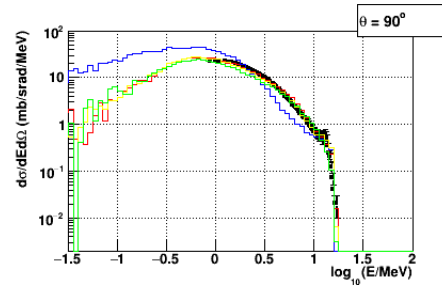


# Proton 22 MeV scattering of Fe

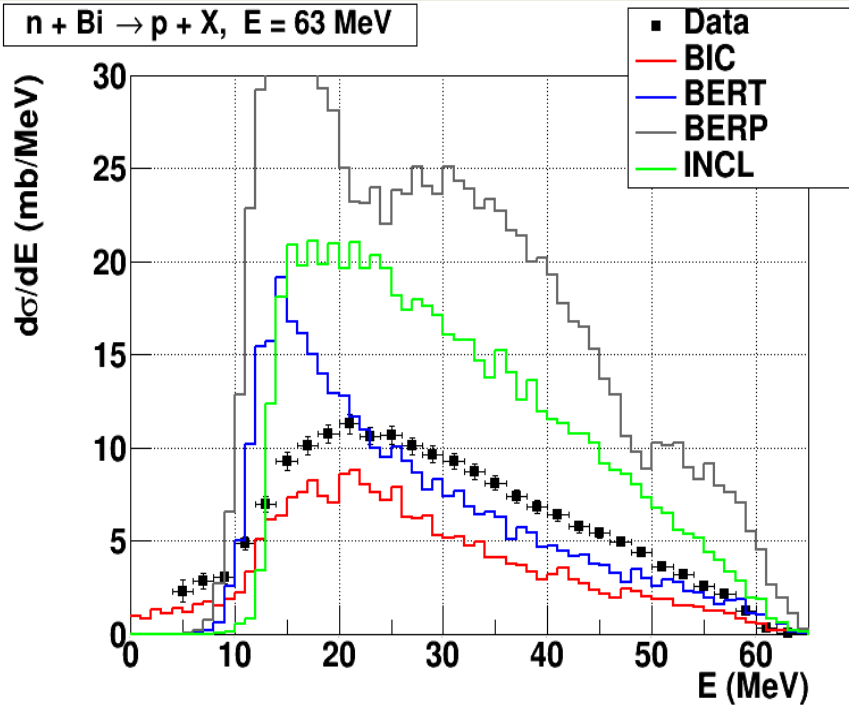
10.5



10.6



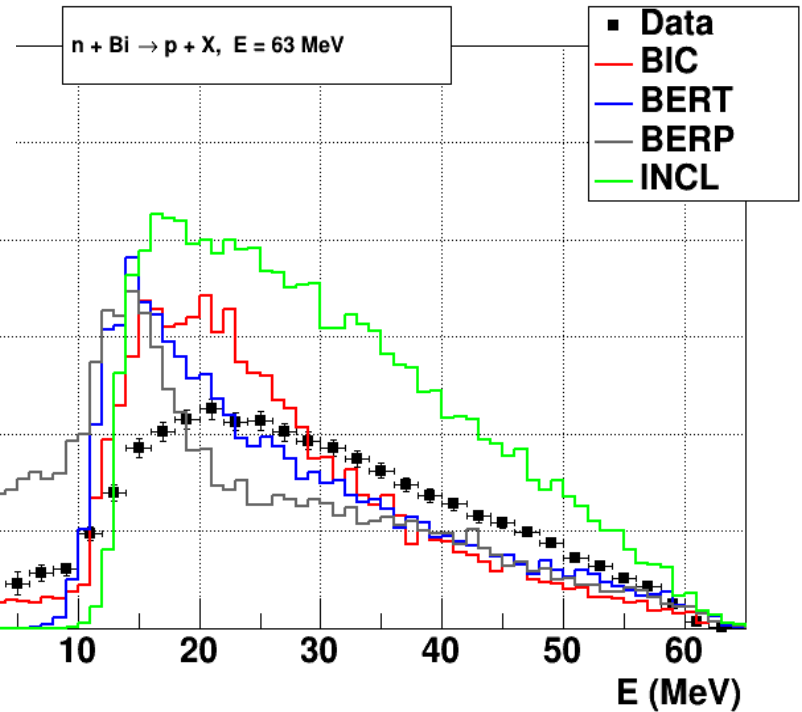
$n + \text{Bi} \rightarrow p + X, E = 63 \text{ MeV}$



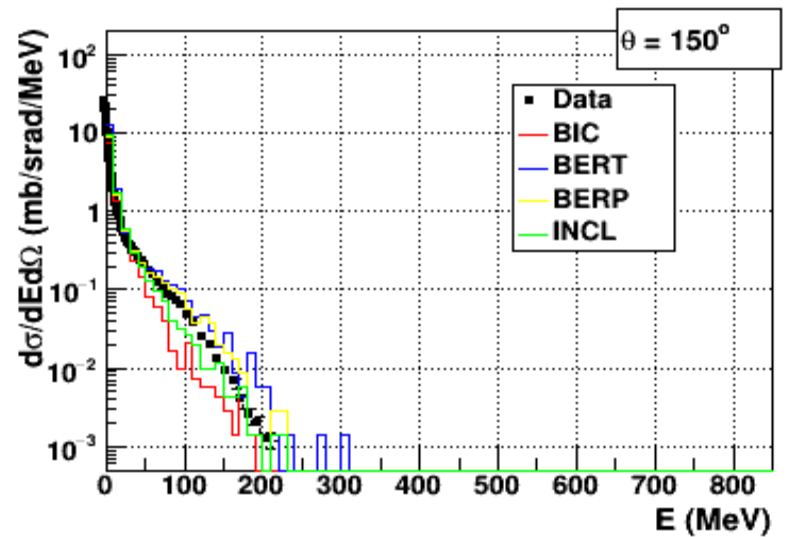
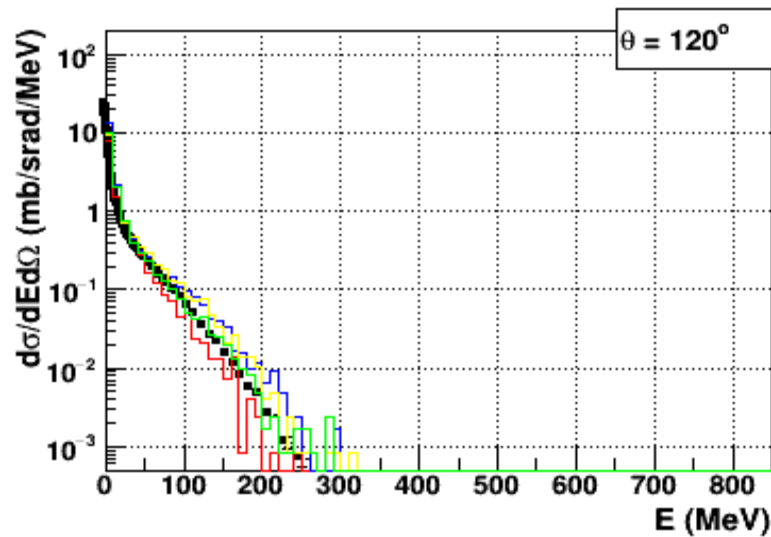
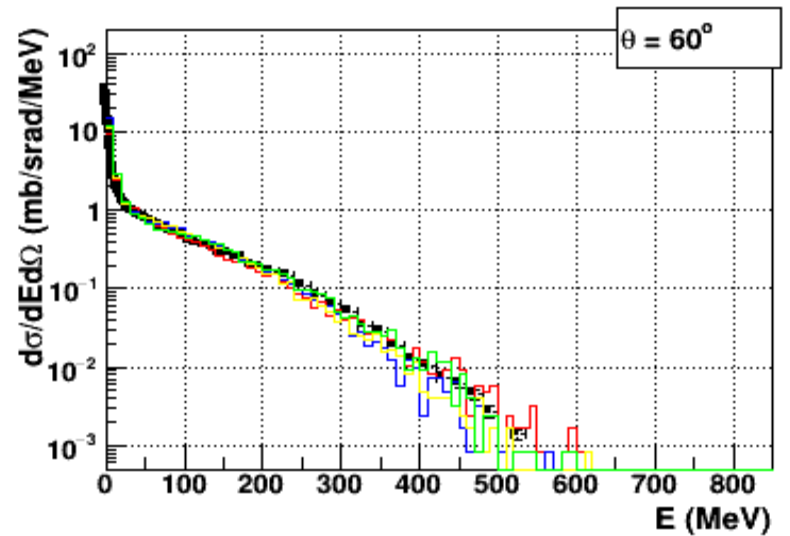
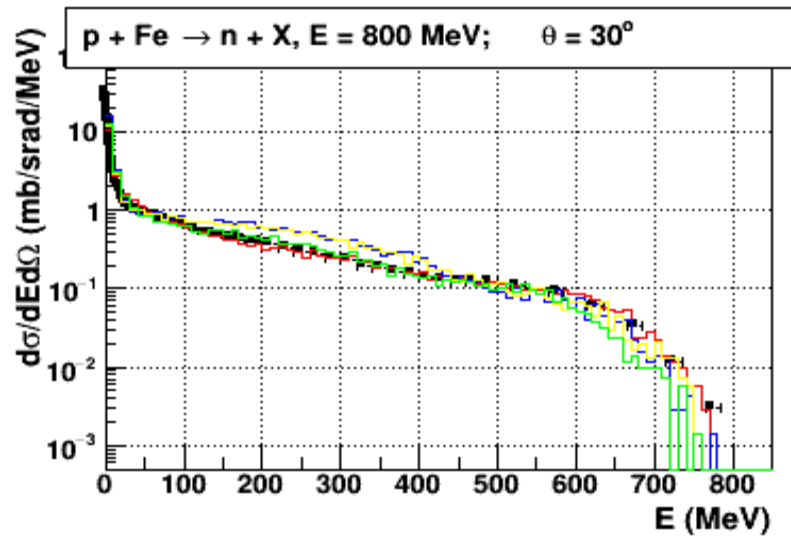
10.6beta – due to IC e-  
BERP become biased  
and as slow as BIC

with MR !733 10.6 BERP start  
to work faster in ~4 times but  
Coulomb barrier is wrong

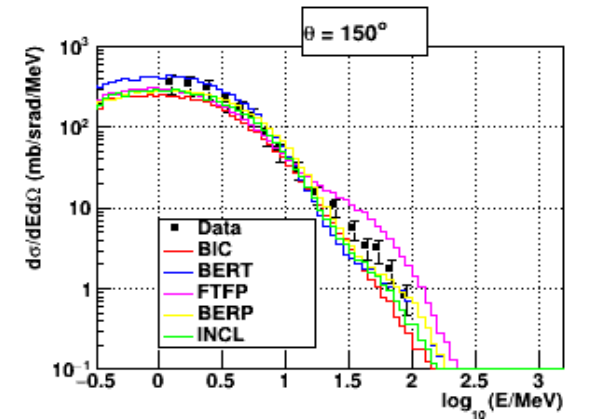
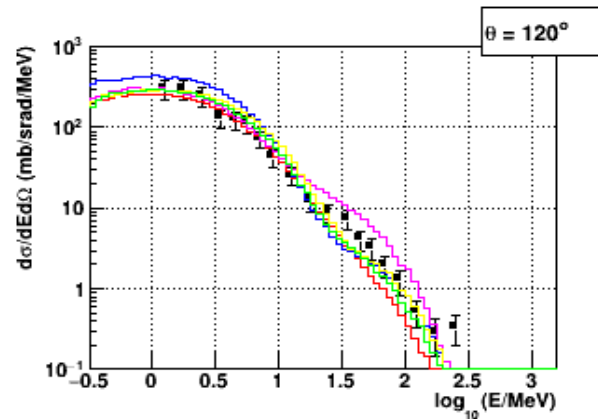
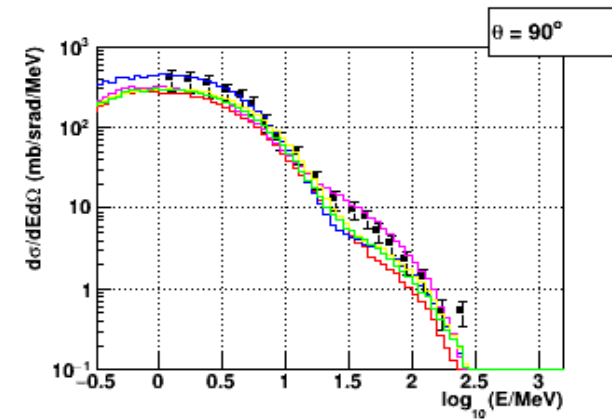
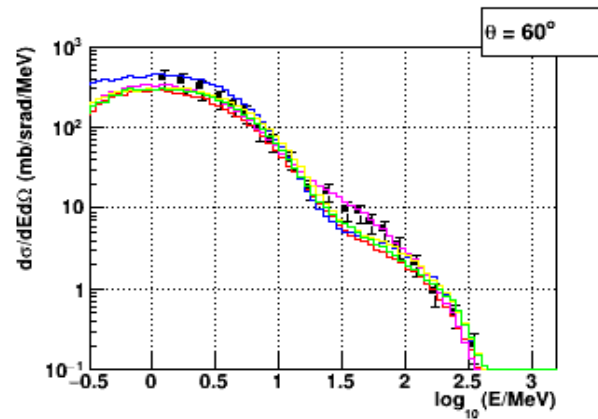
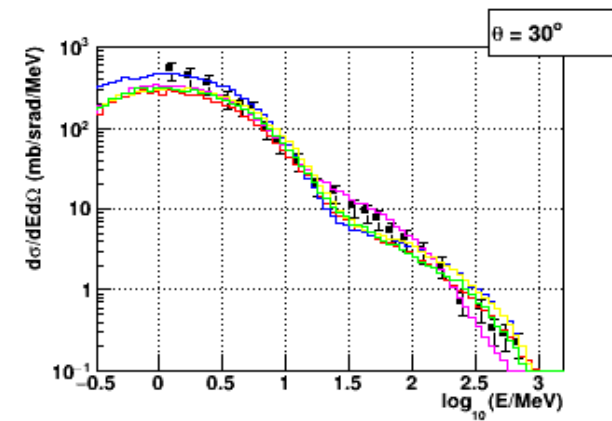
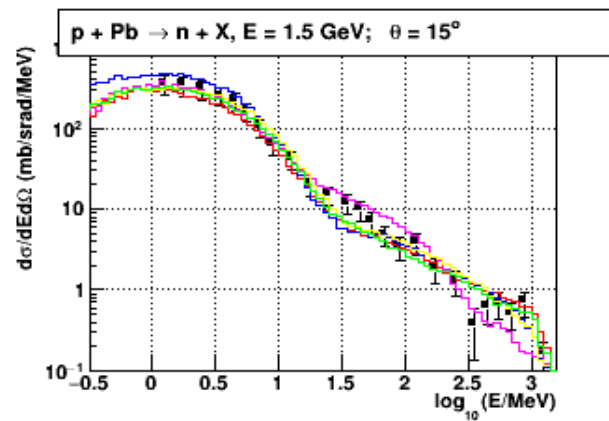
Extra fix should follow



# New 10.6 results



# 10.6 Results



# List of proposed developments for 2020

- Having in mind me, A.Bagulya, V.Grichine, and may be students
  - *Geant-val may be further extended by D.Konstantinov and the team*
- Anybody else welcome to discuss and contribute



# Hadronic cross sections

## ■ Elementary cross sections

- *Make class with parameterisations fully static without instantiation of it in each thread many times*
- *Extend elementary cross section test to pbar and gamma*

## ■ Verify and extend G4PARTICLEXS dataset

- *Evaluate data for light targets*
- *Provide data for n, d, t, He3, He4 on p, d, t, He3, He4 needed for fission*
- *Added data for elastic scattering for p and light ions*
- *Added gamma cross sections*

## ■ Develop a new interfaces and UI commands allowing switch cross sections on top of any Physics Lists

- *Identify the list of reliable alternatives to default cross sections*
  - *Should not include GHEISHA and other obsolete x-sections ?*
- *Provide an interface for user defined cross section per element or per material*

## ■ Make a publication on GG cross sections

# Hadron elastic models

- Include hadron elastic for charmed and bottom mesons and baryons into physics list
  - *Would be useful to define explicit list of particles for hadronic interactions*
- Consider interface to easy switch of elastic models on top of any physics list
  - *May be coupled or not with cross sections ?*
- Extend validation for pbar and light anti-ions

# Pre.compound/De-excitation

- Complete new GEM model
  - *All components are in place technically*
  - *Probabilities of transitions should be verified*
  - *Model should be tested with ROOT6*
- Tuning of evaporation probabilities
  - *Migration of test30 to CONDOR and EOS*
  - *Special attention to He4 production in light fragment decay*
- Added test on gamma production

# Infrastructure update

- Complete destruction of hadronics end of session
  - *Simplified instantiation of FTF and QGS model*
    - Builders should not instantiate Lund fragmentation and Participants
      - *This can be done without interface change*
  - *Provide correct destruction of HP and AllHP models and cross sections*
  - *Finally provide correct destruction of all physics*
- Modernization of hadronic builders in physics\_list libraries
  - *Cross section and model instantiation should be done separately*
  - *We should not use G4THREAD\_LOCAL data members*
    - a builder should be a simple class which is used only locally to save number of lines of code