PRE-COMPOUND AND DE-EXCITATION MODELS AND CROSS SECTIONS

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Outline

- G4NEUTRONXS2.0

- Cross section sub-library improvements

- Physics List components

- Nuclear gamma de-excitation

- Precompound/deexcitation validation results
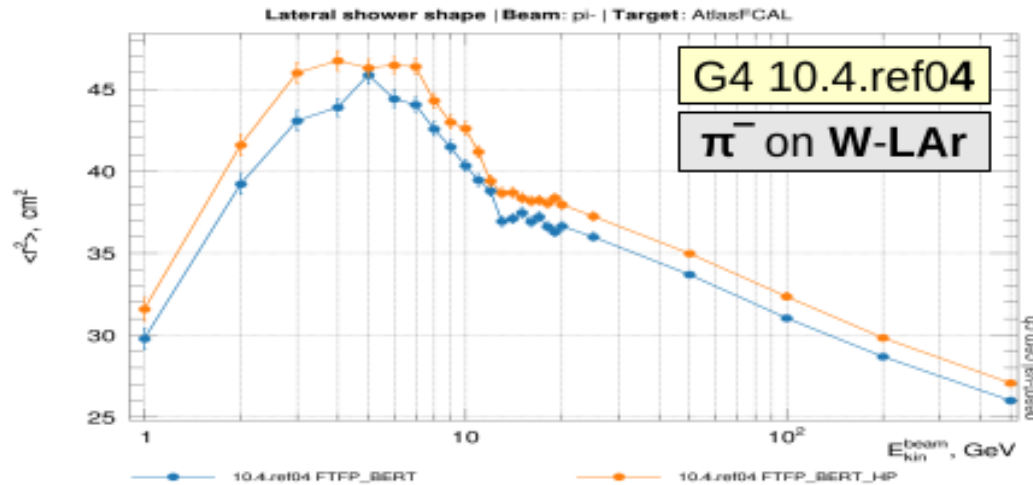
G4NEUTRONXS2.0

- Structure of the data set is change because of particle HP
  - *Separate directories for n, p, d, t, he3, he4 cross sections*
  - *Element x-sections from threshold to max hadronic energy (100 TeV)*
    - Physics data tables shared between threads extracted from ParticleHP
    - Glauber Gribov cross section above 20 GeV
- Added extra isotope data for 11 more elements (was 17 before)
  - *Ne, Mg, S, Cl, K, Sc, Ti, Ga, Pd, In, Pt*
  - *Limit on isotope abundance is reduced to 0.001 (was 0.01)*
- Fixed discontinues in last bins
  - *Isotope data only for E < 20 MeV*
- Fixed G4CrossSectionDataStore code
  - *Isotope selection*
  - *Integral approach*
  - *Added possibility to remove unused data sets*
    - Problem #2057
- New proton and light ion inelastic x-section is tested in QBBC Physics List
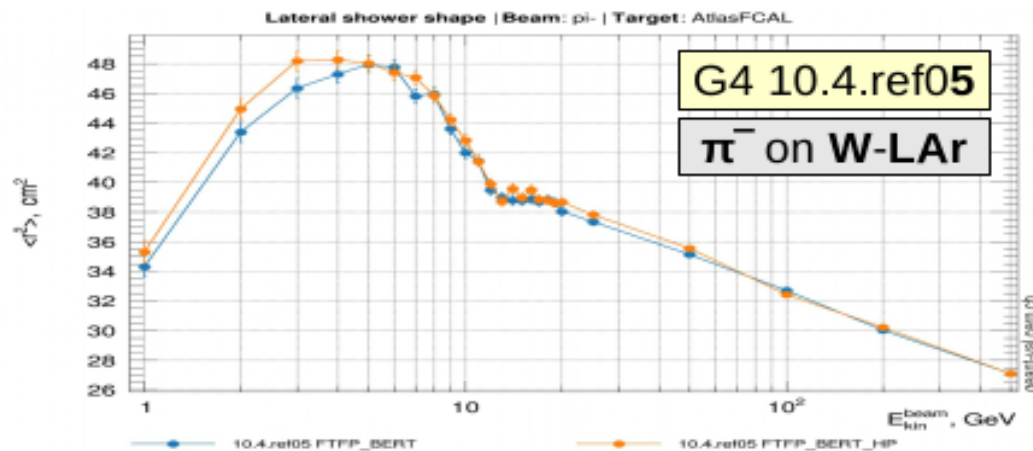
Neutron x-sections in Aluminum
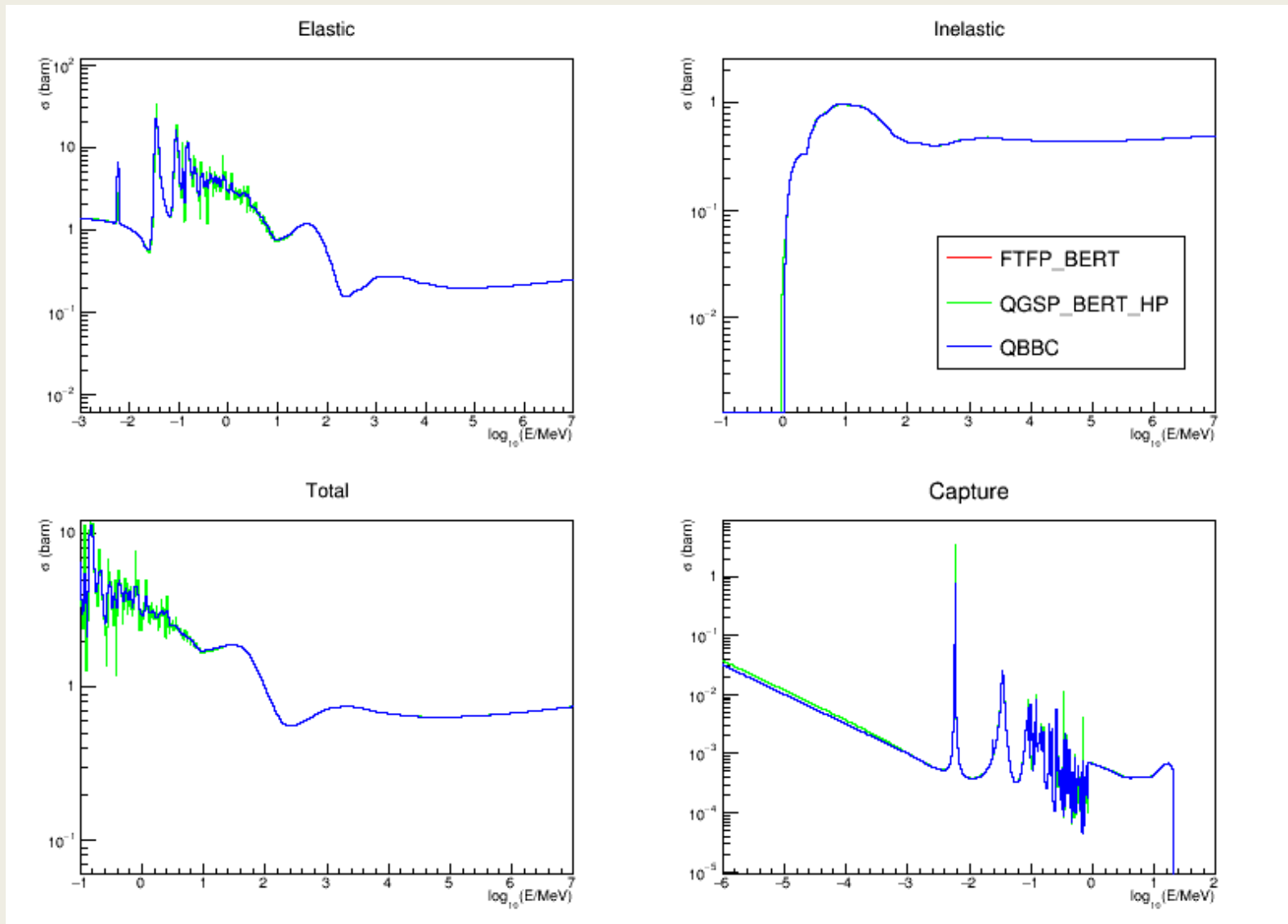
G4NEUTRONXS2.0 for hadronic shower

Modifications for cross section sub-library

- Where triggered by G4NEUTRONXS2.0 developments

- Some problems in design and implementation of cross sections were identified

G4CrossSectionDataStore

- This class keep cross sections for a given particle and at each step provides computations for the G4HadronicProcess

- Added extra method:
  - *ComputeCrossSection(const G4DynamicParticle*, const G4Material*)*
  - *This method includes direct computation of a cross section avoiding several extra "if" statements introduced with "fast track" approach, which was never fully tested*
  - *Is used now by G4HadronicProcess*
  - *"Fast track" approach is on hold but exist*

G4CrossSectionDataSetRegistry

- Keeps pointers for G4CrossSectionDataSet per thread allowing sharing of cross section classes between particles and models

- Added list of pointers to G4VComponentCrossSection
  - *Now developer should not care about deletion of a "component" object, if there is a deletion of a component it is recommended do not delete it or to use a method:*
    - G4CrossSectionDataSetRegistry::DeleteComponent(…)
  - *Components may be shared between particles and models*

- No need in explicit deletion of cross section classes or its components in physics_list constructors or builders anymore

G4VCrossSectionDataSet

■ Main interface to cross section

■ Added methods:

– *G4bool ForAllAtomsAndEnergies()*

– *void SetForAllAtomsAndEnergies(G4bool f)*

– *This flag tells, that this data applicable for any target, so any cross section data set assigned to G4CrossSectionDataStore will not be used and can be removed*

   ■ Fix of problem report #2057

– *This saves CPU at initialization (not in run time) and reduce user confusions*

G4CrossSectionElastic and G4CrossSectionInelastic

■ These are generic classes, which provides cross section using whatever G4VComponentCrossSection class

■ Modifications:

– *Safe deletion of a component class*

– *Component object may be shared between particles and processes*

G4HadronNucleonXsc

- Main class to compute hadron-nucleon cross section, which is used for Glauber cross sections computations
  - *Was developed by N.Starkov and V.Grichine*

- Modifications:
  - *Introduced a new interface with projectile defined via G4ParticleDefinition* and kinetic energy*
    - This allows avoiding new/delete of extra G4DynamicParticle object
  - *Old interfaces via G4DynamicParticle* are inlined*
  - *Clean the code removing duplications*
  - *Use G4Pow, G4Log, G4Exp*
  - *Fixed KS and KL cross section computations*
  - *Introduced PDG 2016/2017 high energy parameterizations of cross sections instead of PDG 2008*

G4ComponentGGHadronNucleousXcs

■ **Main class implementing Glauber-Gribov approach for hadron-nucleus cross sections**

  – *Developed by V.Grichine*

■ **Modifications:**

  – *General clean-up*

  – *Use interfaces with G4ParticleDefinition* and kinetic energy to avoid new/delete of fake G4DynamicParticle*

  – *Implemented cache*

  – *Old obsolete methods are not removed*

G4ParticleInelasticXS and G4IonPhysicsXS

- New class for p, d, t, He3, He4 cross sections and new ion physics component, which uses these cross sections

  - *Below 20 MeV isotope x-sections are available for selected elements (the same set as for neutrons)*

  - *Above 20 MeV only element cross sections are available*

- G4IonPhysicsXS is used in QBBC

Hadron physics constructors

- They are located inside physics_lists/constructors/hadron_inelastic and hadron_elastic sub-libraries

- Modifications:

    – *Simplified instantiation of Capture and Fission processes, number of lines of code substantially reduced*

    – *Removed deletion of cross section objects*

Pre-compound/de-excitation models development and validation

- Cross section developments slow down other activity on pre-compound/de-excitation

- Main fixes were introduced in the handling of photon evaporation
  - *If (Ic > 0) - intensity of internal conversion non zero*
    - Sample internal conversion even if shell probabilities are not known
    - Problem #2076

- Main pending problem – new GEM model, which is not completed

- Validation with test30 and IAEA is ongoing
  - *Results are stable for recent releases*
  - *Current tests cover n, p, d, t, He3, He4, and general isotope productions*
  - *No tests for light fragments inside testing suite*
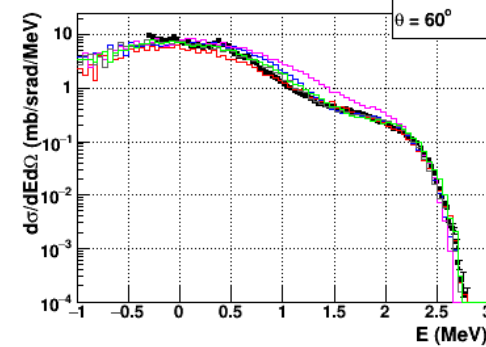
Proton production 63 MeV
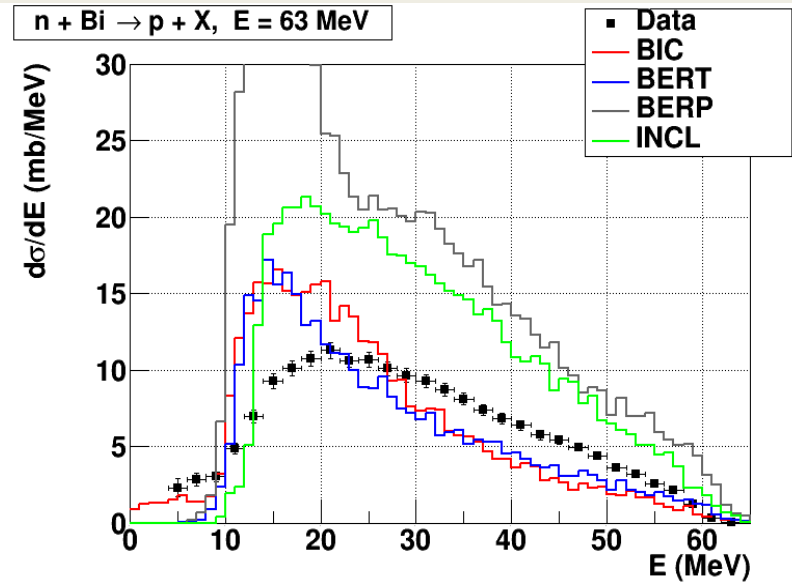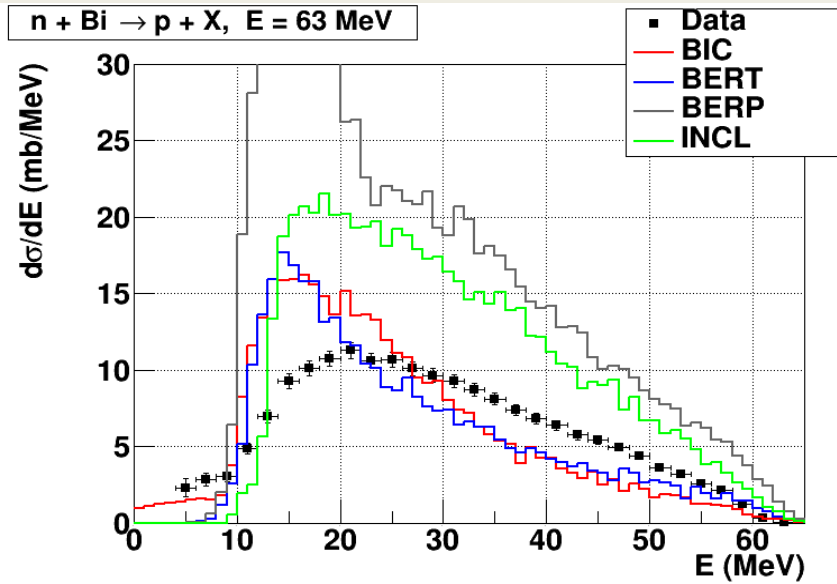
Bertini problem remains: BERP does not work properly

Neutron production 800 MeV

10.4p01
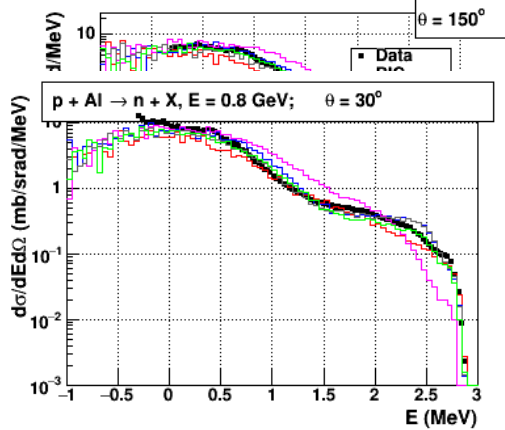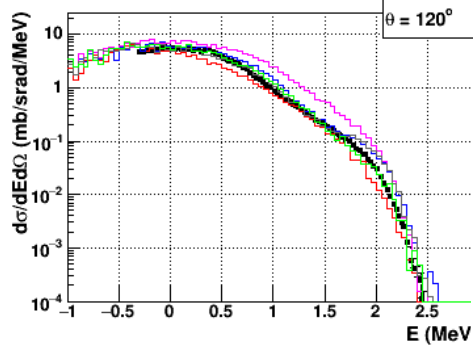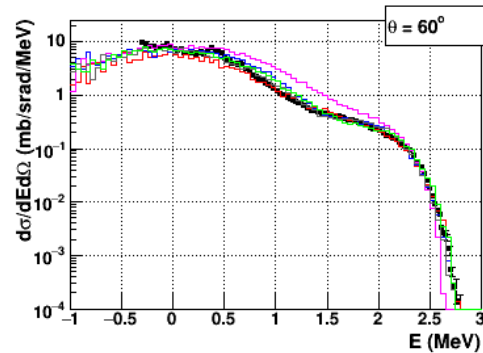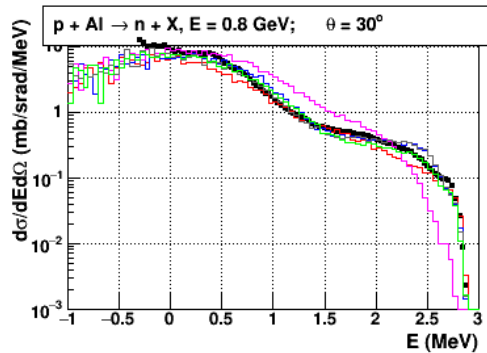
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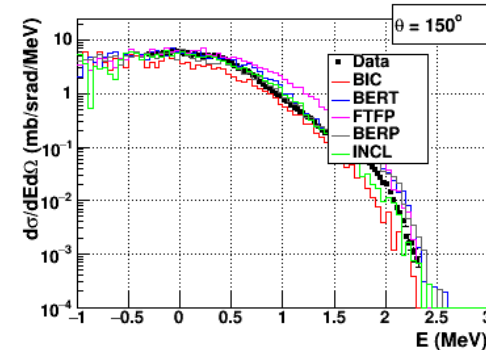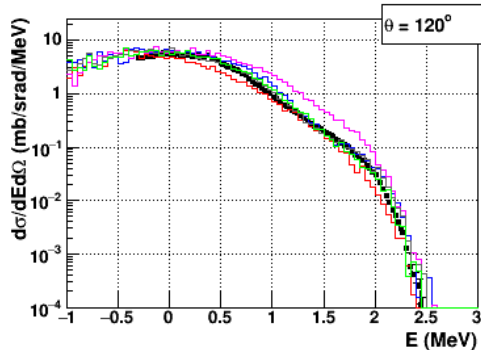
Neutron production at 1.6 GeV

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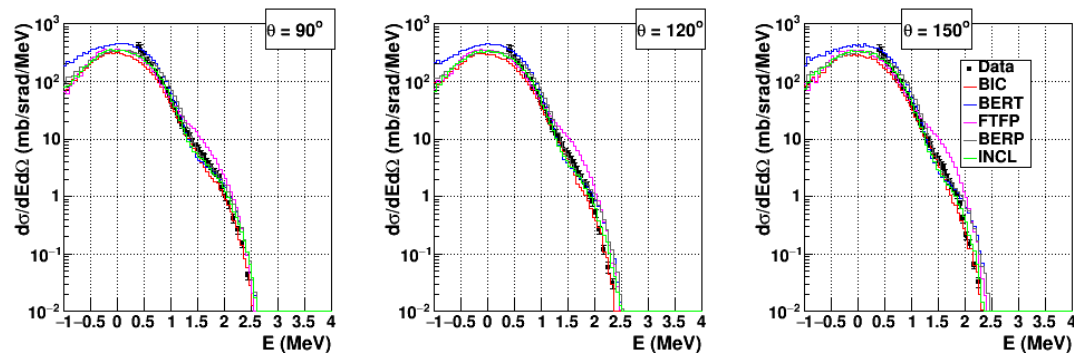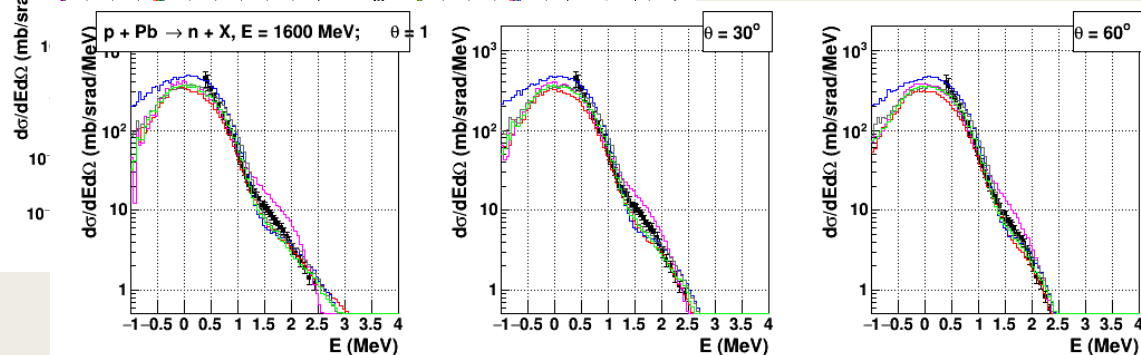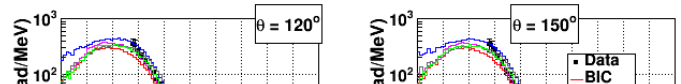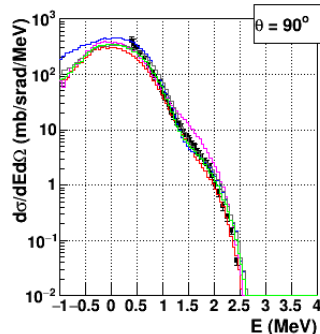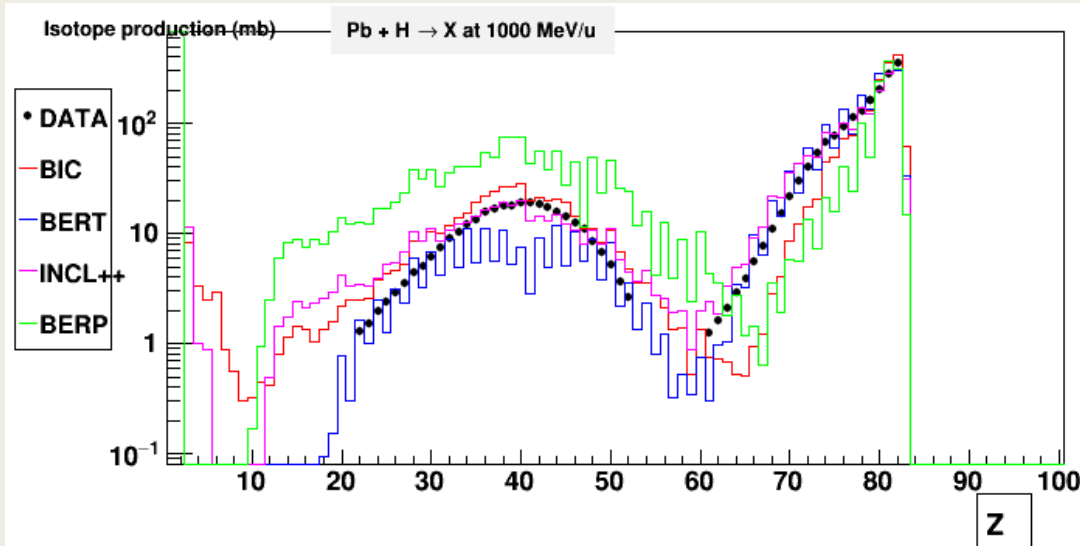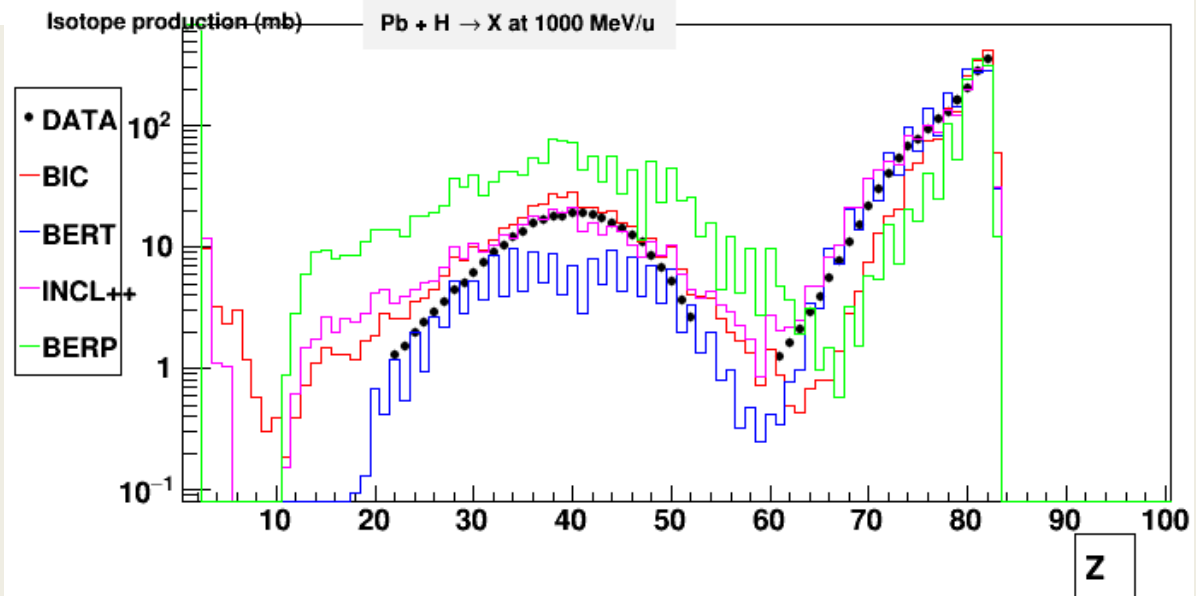
10.4ref07

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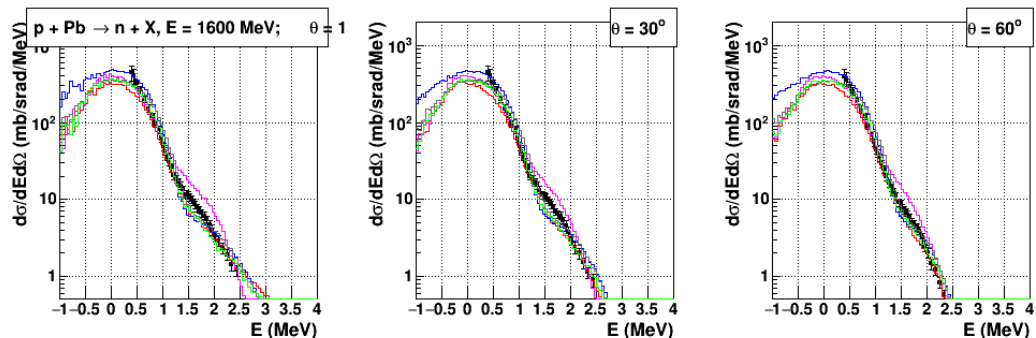
Isotope production at 1 GeV

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Summary

- A substantial clean-up of hadronic cross sections classes was introduced
    - *Expected reduction of memory and CPU*
- Usage of PDG 2016/2017 parameterizations of hadron cross sections may affect results for calorimeters
- What is not done:
    - *Check remaining cross section classes*
    - *Nucleus-nuclei GlauberGribov*
    - *Elastic cross sections*
    - *Review of gamma transition DB – there are user complains*
    - *Updated GEM model*
    - *We have shortage in tests for ions*
        - Both primary and secondary
- Further validation of hadron-nucleon and hadron-nucleus cross sections is needed
    - *May be G4NEUTRONXS2.1 will be needed*