# HIGHLIGHTS FROM PRECOMPOUND AND DE-EXCITATION MODELS

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# Motivations and main activities

- Geant4 pre-compound (PRECO) and de-excitation (DEEX) components are used by majority hadronic models to describe the last step of hadronic interaction
  - *Defines CPU and memory efficiency of hadronic code*
  - *Affect response of hadronic and EM calorimeters*
  - *Responsible for simulation of low-energy neutron and ion fluxes*
- Recent developments were focused on following topics:
  - *Establish set of model parameters for PRECO and DEEX and user interface to these parameters*
  - *Renew internal data structure for nuclear levels adding information on nuclear polarization*
    - New data format was introduced in 10.3
  - *All components of PRECO and DEEX should use this data and not hard-coded numbers*
  - *Provide long-lived isomere production*
    - Added floating level states
  - *Provide correlated gamma emission for radioactive decay*
  - *Make code to be more efficient*
  - *Add c++11 coding style where possible*

# Parameters for pre-compound/de-excitation

- G4DeexPrecoParameters scheme introduced in 10.3 is extended
  - *Printout of all important parameters values at initialisation*
  - *Modification of parameters allowed only at G4State_PreInit*
  - *New boolean parameters is added allowing disable DEEX or PRECO*
- How it can be used?
  - *G4DeexPrecoParameters* param=G4NuclearLevelData::GetInstance()->GetParameters()*
  - *param->StoreAllLevels(true);*
  - *param->SetCorrelatedGamma(true);*
  - *param->SetInternalConversionFlag(true);*
  - *param->SetDeexChannelType(fGEM);*
  - *……*
  - *param->Dump();*
- G4ExcitationHandler has public Set methods
  - *This interface is left in order to allow creation of custom handler*
  - *Normally parameters should be set via G4DeexPrecoParameters class*

# Nuclear level data

- Only one singleton class G4NuclearDataStore left with static data shared between all threads
  - *No thread local data anymore*
  - *Access to*
    - G4DeexPrecoParameters
    - nuclear level data
    - G4PairingCorrections
    - G4ShellCorrections
- The most recent data produced by Laurent
  - *G4PhotonEvaporation5.1*
- Transient data structure may include internal conversion (IC) data
  - *StoreAllLevels() flag enable/disable storing of internal conversion data*
    - If true the full data size 56 M (radioactive decay enebles)
    - If false – 8 M (HEP case)
  - *IC is controlled by InternalConvertionFlag()*
    - If false – only gammas produced
    - If true – electrons produced even if IC data are not stored
    - For some levels no gamma transitions data only IC performed

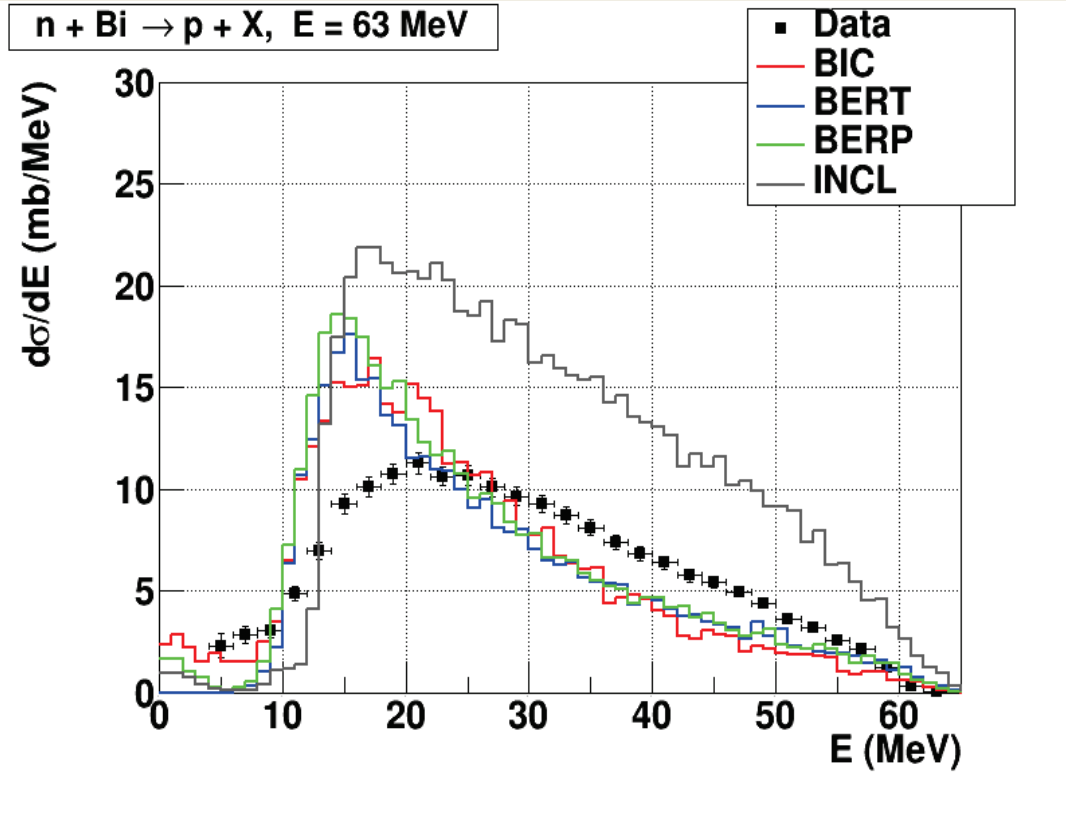
# Isomere production

- Deexcitation of any excited nuclear fragment is stopped if
  - *Excitation energy below 10 eV*
  - *Life time of the stete below time limit*
    - $10^{3}$ s by default
    - $10^{-6}$ s if radioactive decay is enabled
- List of possible excited state ois synhkronized between the deexcitation module and G4NuclideTable
  - *Additionally to simle excited isometers floating level isomeres may be produced*
    - +X,+Y,+Z,+U, +V,+W,+R,+S,+T,+A,+B,+C
- After each de-excitation reaction the time is defined
  - *For radioactive decay no extra sampling*
  - *For other cases sample decay time according to the life time of the level*
- Information on time and creator model is propagated to G4HadronicProcess
  - *Allowing proper checks of charge and energy conservation*
    - Emision of Auger electrons breaks old checks

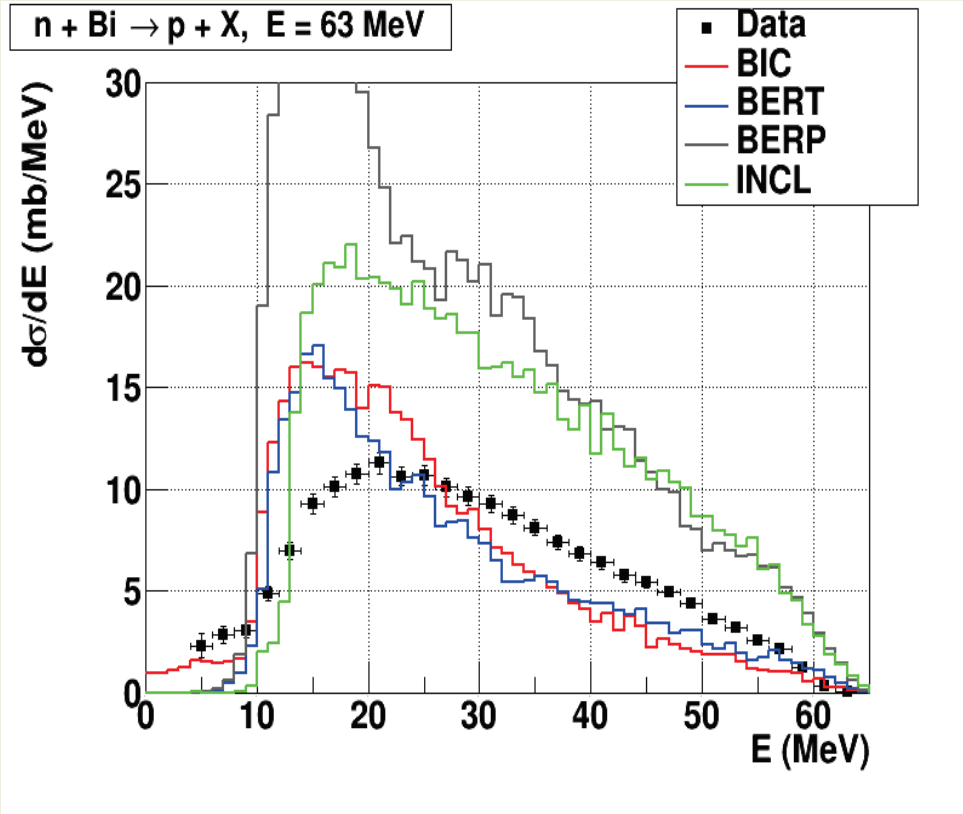
# Problem in BERP – Bertini model with interface to PRECO

## checks wrongly energy balance when e- are produced by DEEX

10.2p02




10.3ref08

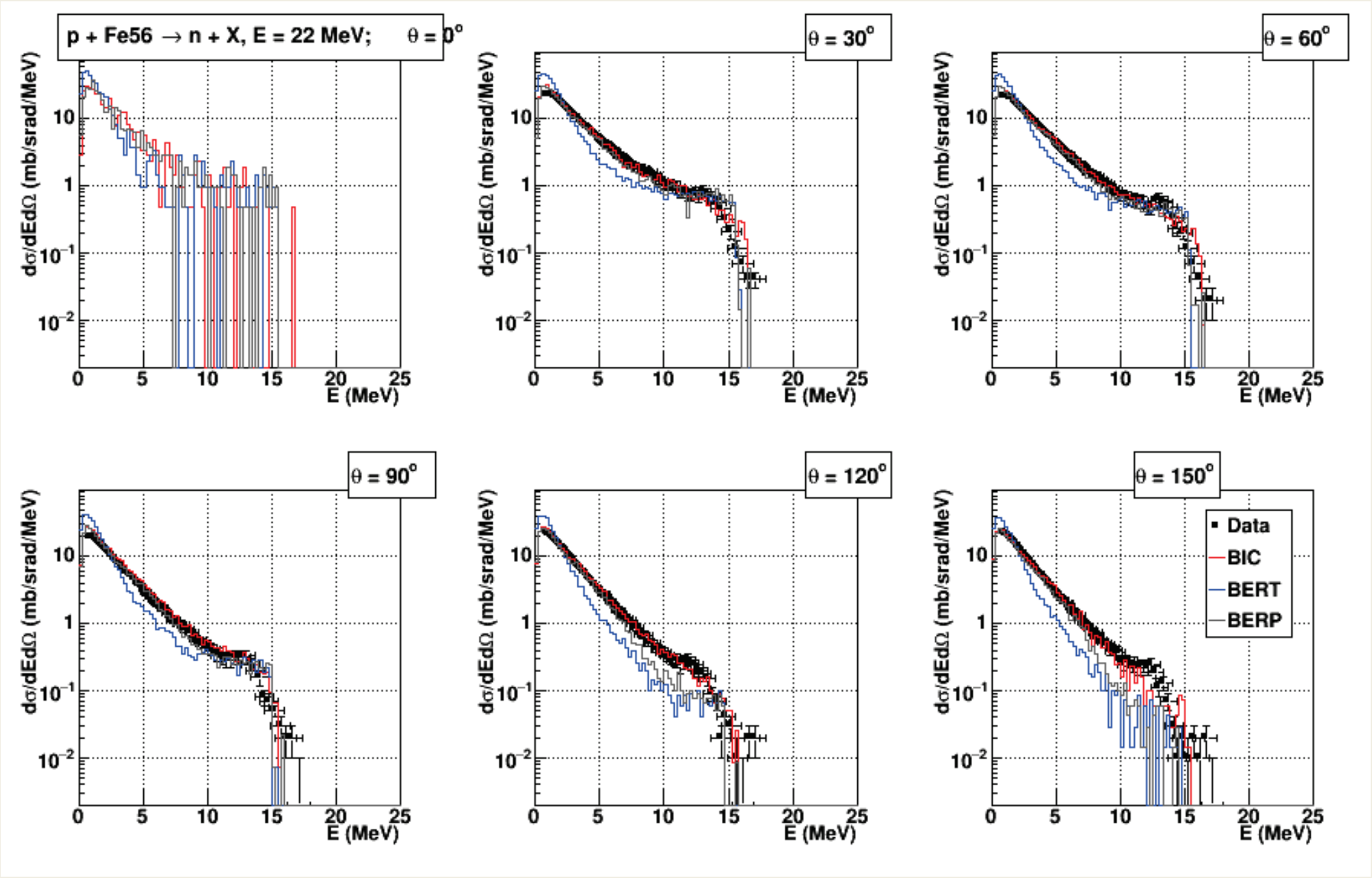


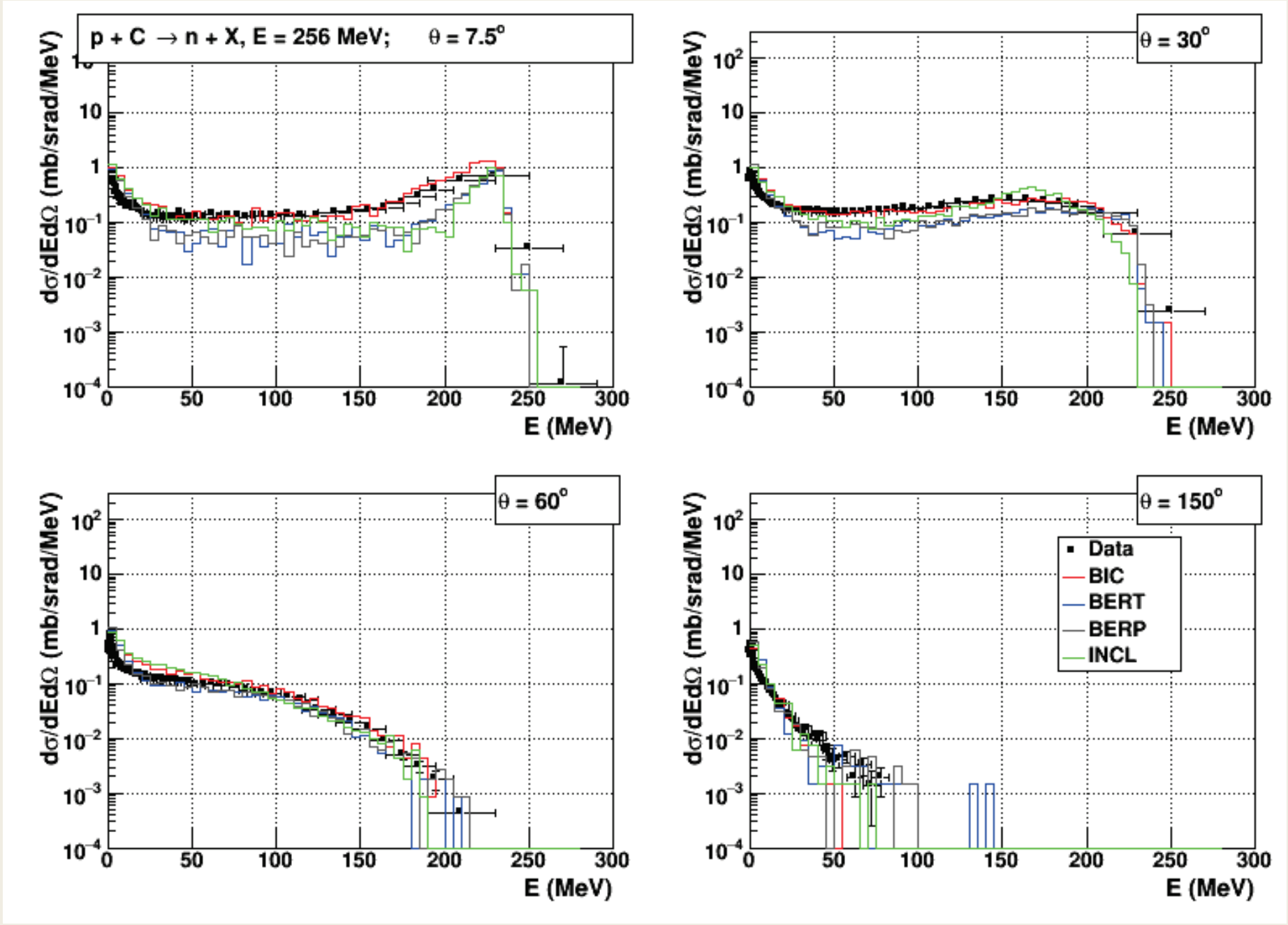
# Correlated gamma decay

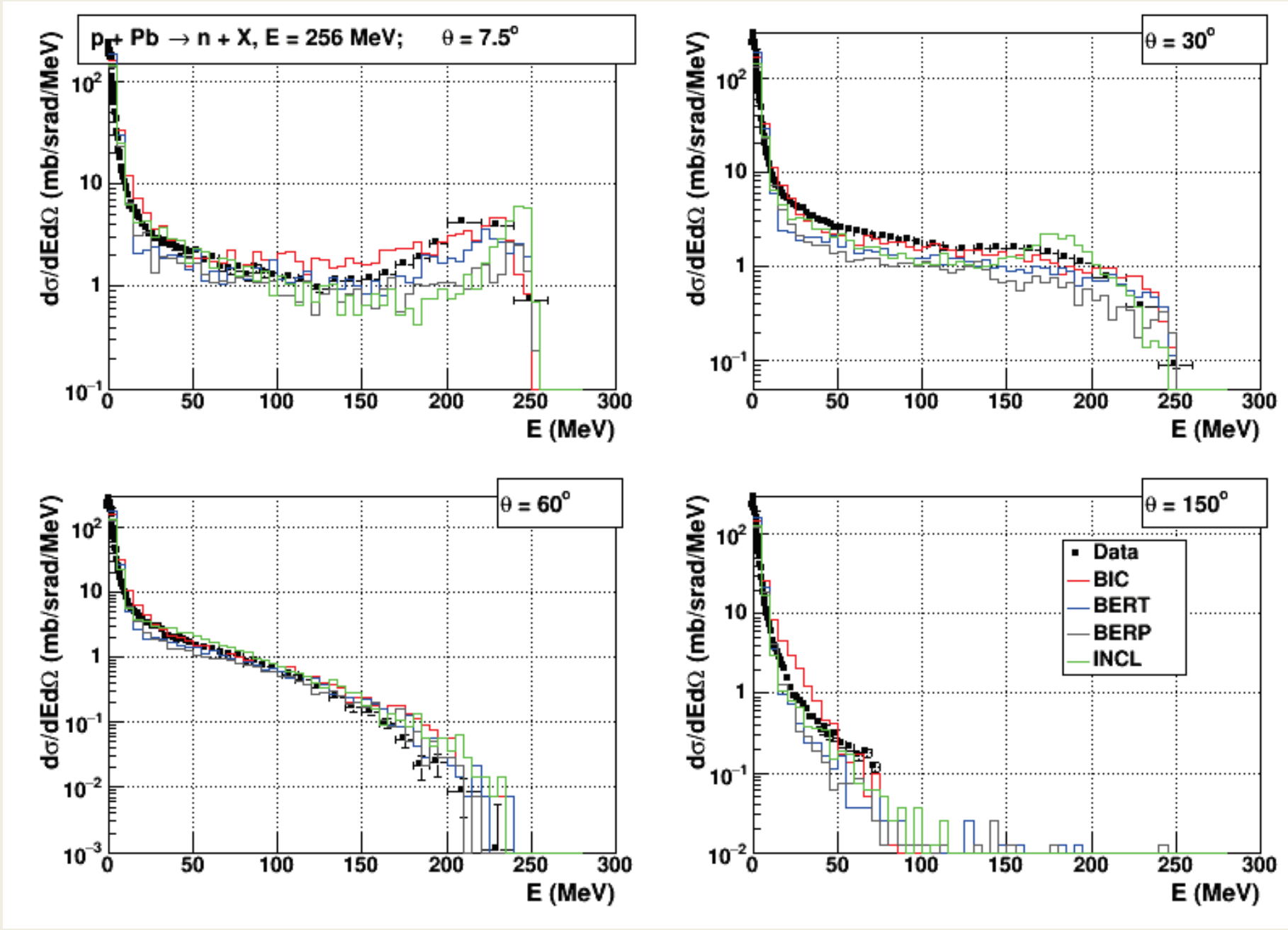
- Correlated gamma decay chain (Jason Detwiler, University of Washington)
  - *G4NuclearPolarization class keeps polarization state*
  - *Each new instance is created at the beginning of a new chain*
  - *It is assumed that excited isomere is created with polarization and may be tracked*
- Current state
  - *Work for several important isotopes (Co60)*
    - Provides very long loops if applied in general
    - Triggers non-reproducibility and slow down radioactive decay chain sampling
  - *Enabled by request or by G4RadiactiveDecayPhysics*
    - May be disabled  by default also for radioactive decay if problems will not be fixed before 10.4

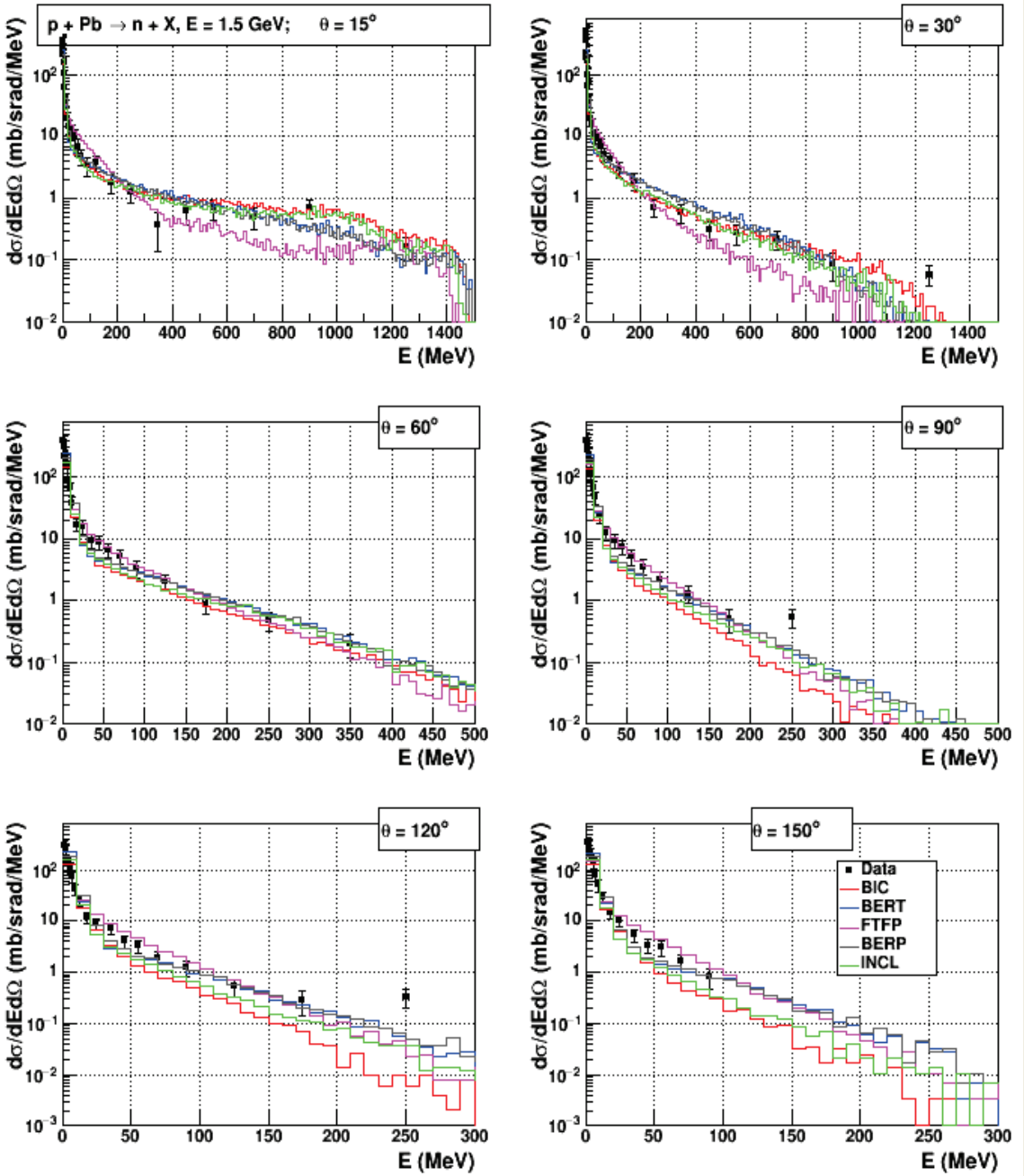
# Summary and plans

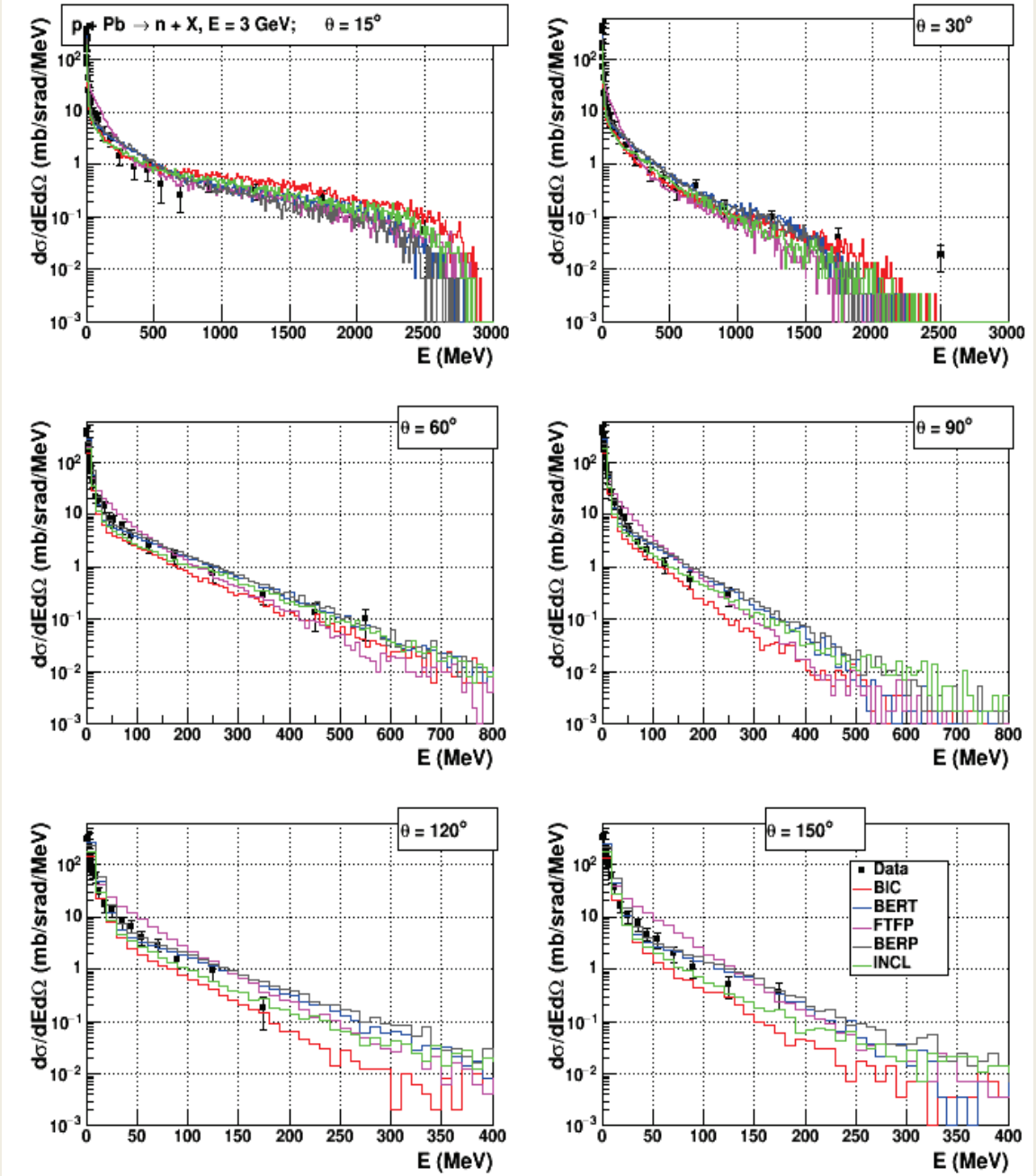
- Transition to the new data structure is completed
- Photon evaporation is fully migrated to the new data structure
  - *Isomer production*
  - *Floating levels*
  - *Correlated gamma decays*
    - Still there are problems
- FermiBreakUp and Evaporation are based on the new data structure
- GEM model is not yet migrated
- Some recent plots are shown in the next slides


p + Fe56 → n + X, E = 22 MeV; θ = 0°
θ = 30°
θ = 60°
θ = 90°
θ = 120°
θ = 150°
dσ/dEdΩ (mb/srad/MeV)
E (MeV)
Data
BIC
BERT
BERP


p + C → n + X, E = 256 MeV; θ = 7.5°
θ = 30°
θ = 60°
θ = 150°
dσ/dEdΩ (mb/srad/MeV)
E (MeV)
Data
BIC
BERT
BERP
INCL


p + Pb → n + X, E = 256 MeV; θ = 7.5°
θ = 30°
θ = 60°
θ = 150°
dσ/dEdΩ (mb/srad/MeV)
E (MeV)
Data
BIC
BERT
BERP
INCL


p + Pb → n + X, E = 1.5 GeV; θ = 15°
θ = 30°
θ = 60°
θ = 90°
θ = 120°
θ = 150°
Data
BIC
BERT
FTFP
BERP
INCL
dσ/dEdΩ (mb/srad/MeV)
E (MeV)


p + Pb → n + X, E = 3 GeV; θ = 15°
θ = 30°
θ = 60°
θ = 90°
θ = 120°
θ = 150°
Data
BIC
BERT
FTFP
BERP
INCL
dσ/dEdΩ (mb/srad/MeV)
E (MeV)