



# Combined Cross Sections and Elastic Scattering

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# Motivation for Combined Elastic

- ▶ It was demonstrated, that G4 elastic is far not perfect especially for pp and np scattering
- ▶ **M.Kosov** put significant efforts to collect data and to create new model
- ▶ **In April 2006 it become clear that we risk postpone the release of updated models**
  - The model of N.Starkov seemed not be ready
  - The model of M.Kosov work only pp, np, and may be for pd, pHe cases

# Design of Combined Process/Model

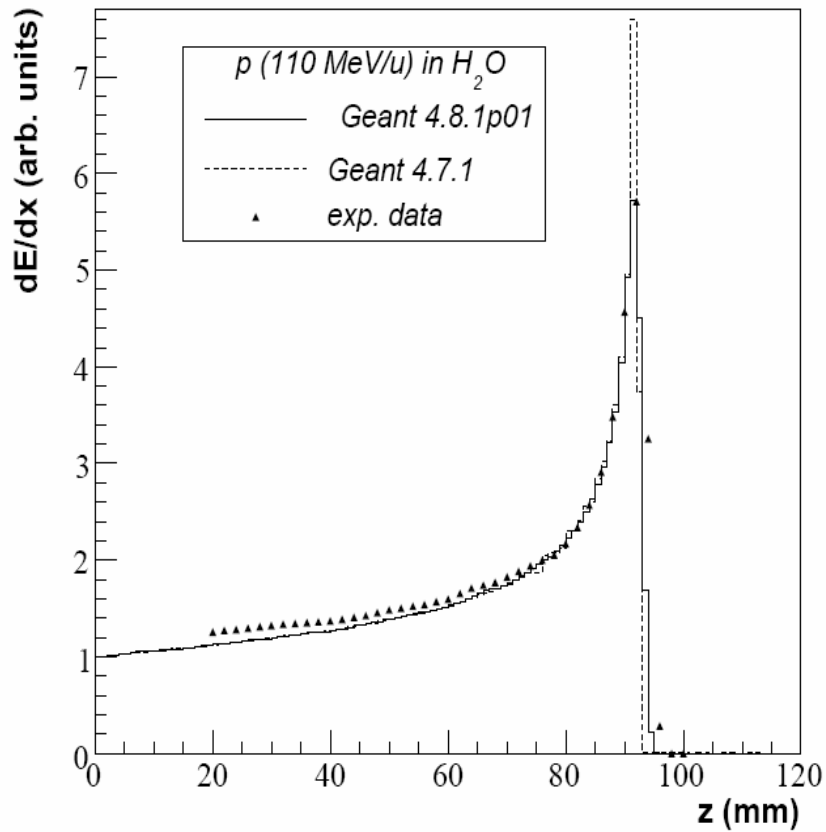
- ▶ New process **G4UHadronElasticProcess**
  - Management on cross section using the best combination of data sets
- ▶ New model **G4HadronElastic**
  - Responsible only for management and kinematics
  - Sampling to momentum transfer by using one the following models
    - ▶ CHIPS for pp and np scattering in 8.1
    - ▶ CHIPS pd and pHe for 8.1ref03
    - ▶ S-wave scattering below some threshold (20 MeV)
    - ▶ G4LElastic for the rest

# Problems

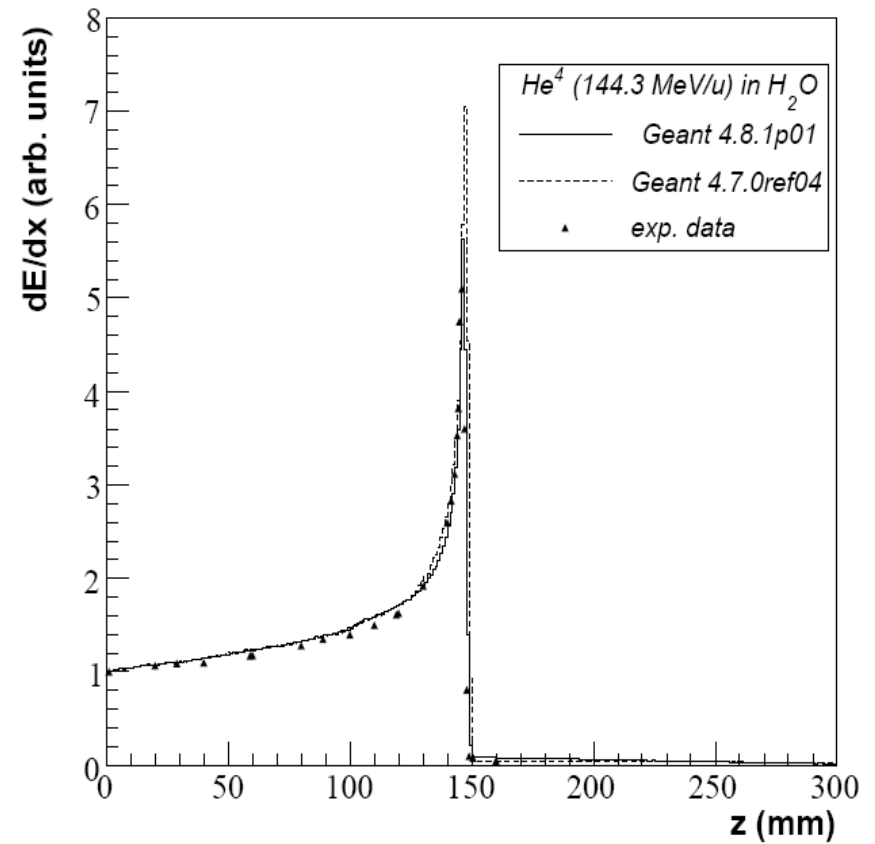
- ▶ Introduction of this combined process was not easy
  - Patch 01 was connect with terrible misunderstanding of GHAD framework
  - In some condition components provided NaN numbers
  - Three threshold energy parameters
- ▶ Current approach – add as much checks on NaN as possible

# Achievements

Energy deposition (MeV/mm/event) in the target



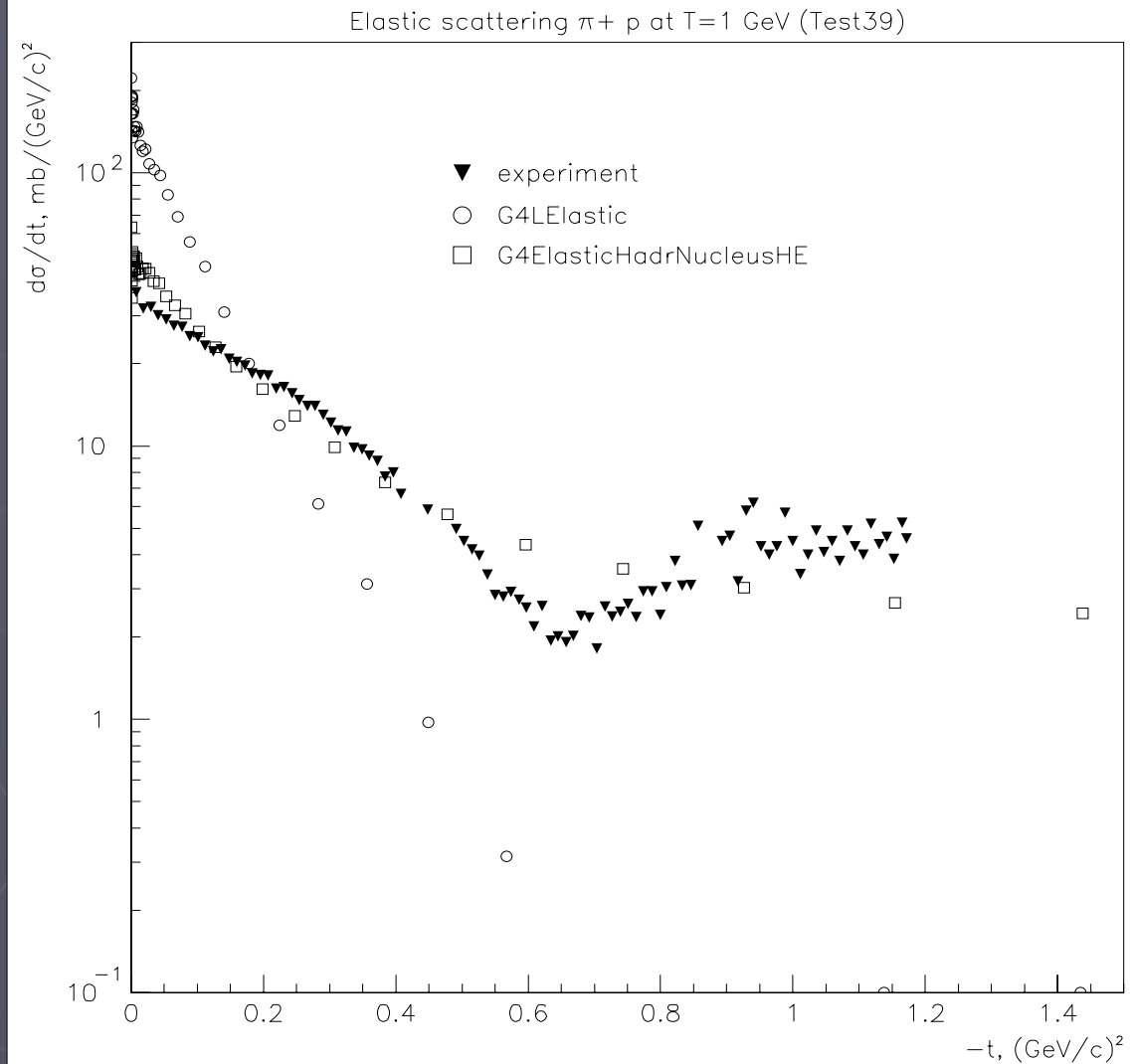
Energy deposition (MeV/mm/event) in the target



# N.Starkov

## Recent plot

- ▶ Differential cross section in LElastic model is far from the data
- ▶ Starkov's HE model describe the data much better but not ideally



# Combined Cross Section Data Set

## ► Motivation:

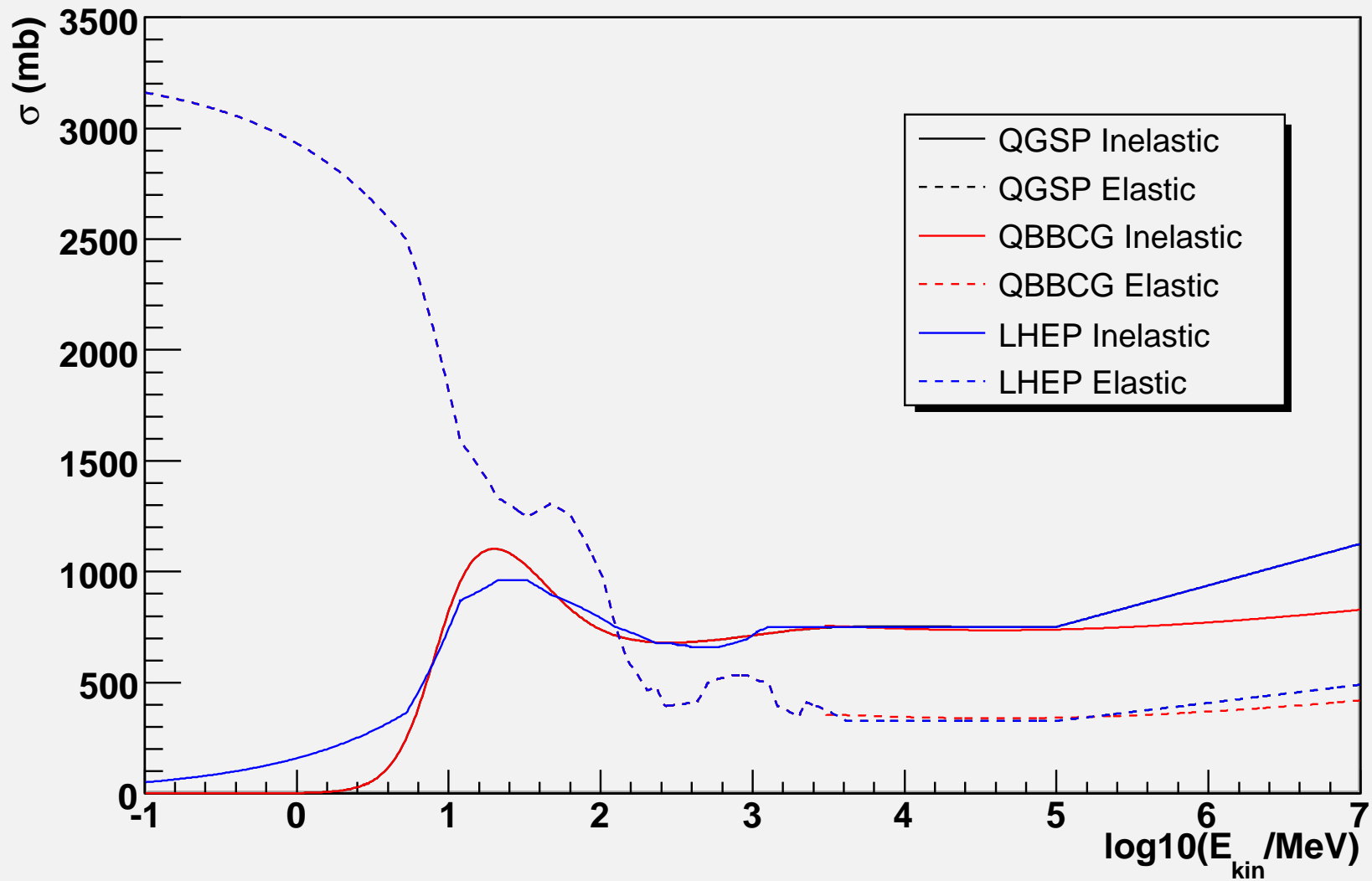
- The number of data sets have total cross section and elastic cross section, thus wrapper classes are already used in G4
  - LHEP
  - Pion Barashenkov's data (elastic is not used)
- New Glauber-Gribov model developing by V.Grichine have to be tested

# Implementation

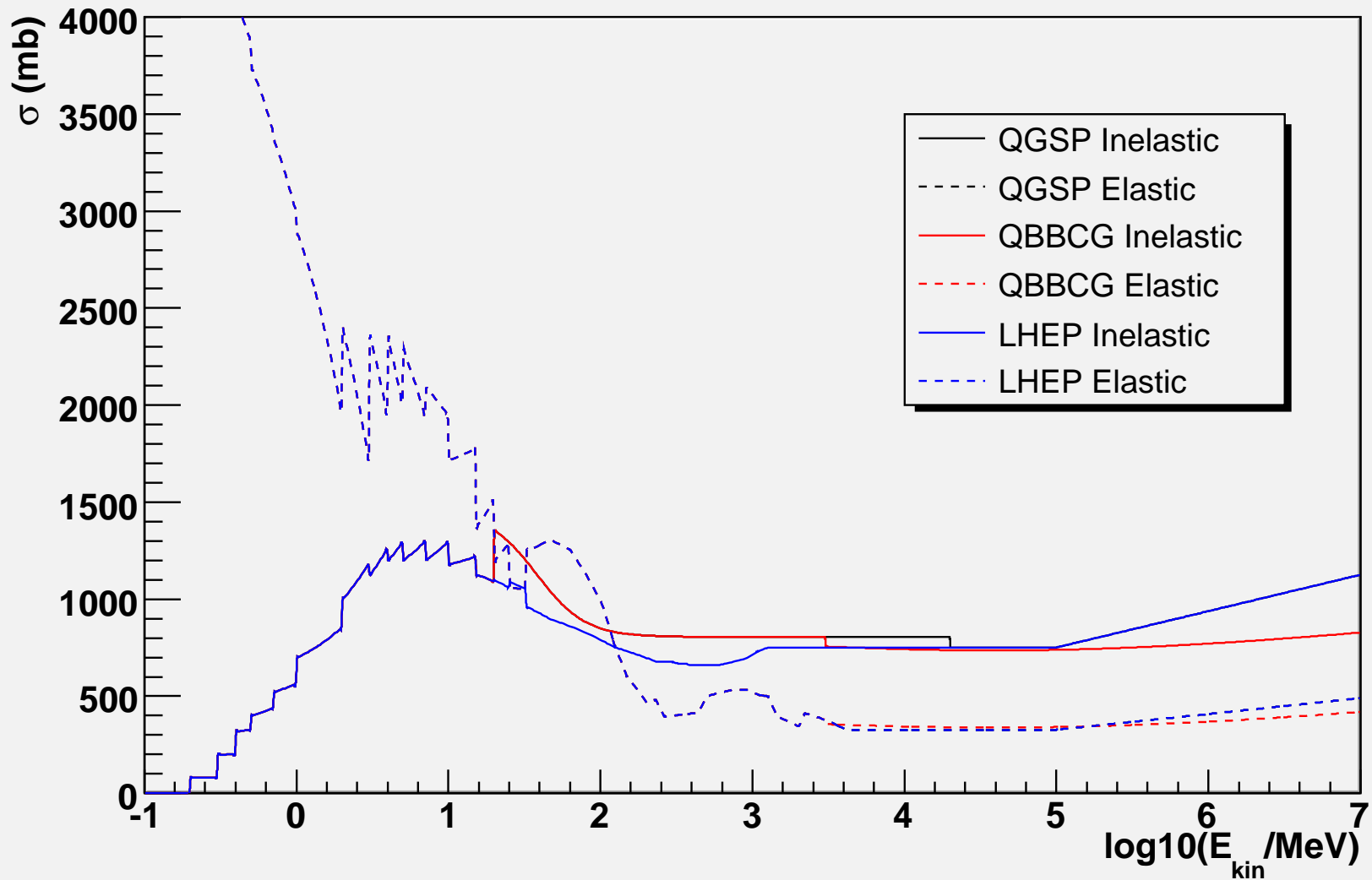
- ▶ New pion data set using Barashenkov's data
  - G4PhysicsTable for data interpolation
  - Both elastic and inelastic cross sections
  - Log/log interpolation
- ▶ Wrapper for hadron inelastic cross section
  - LHEP data
  - Proton data
  - Neutron data
  - New pion data
  - New Gribov-Glauber cross section
- ▶ Wrapper for hadron elastic cross section
  - LHEP data
  - New pion data
  - New Gribov-Glauber cross section
- ▶ **Benchmark using Hadr01 and QBBC PhysicsList**



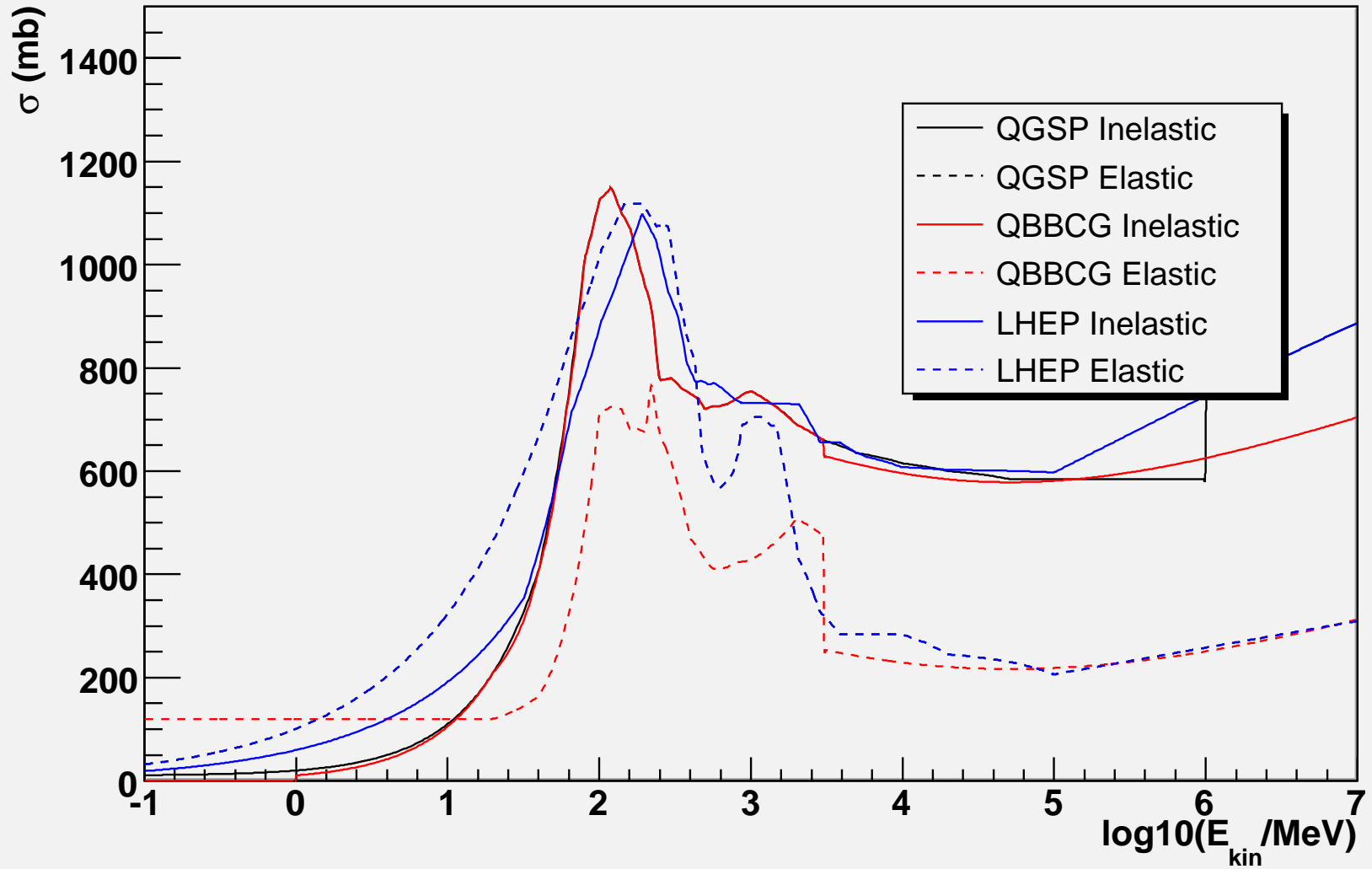
## Proton in Iron



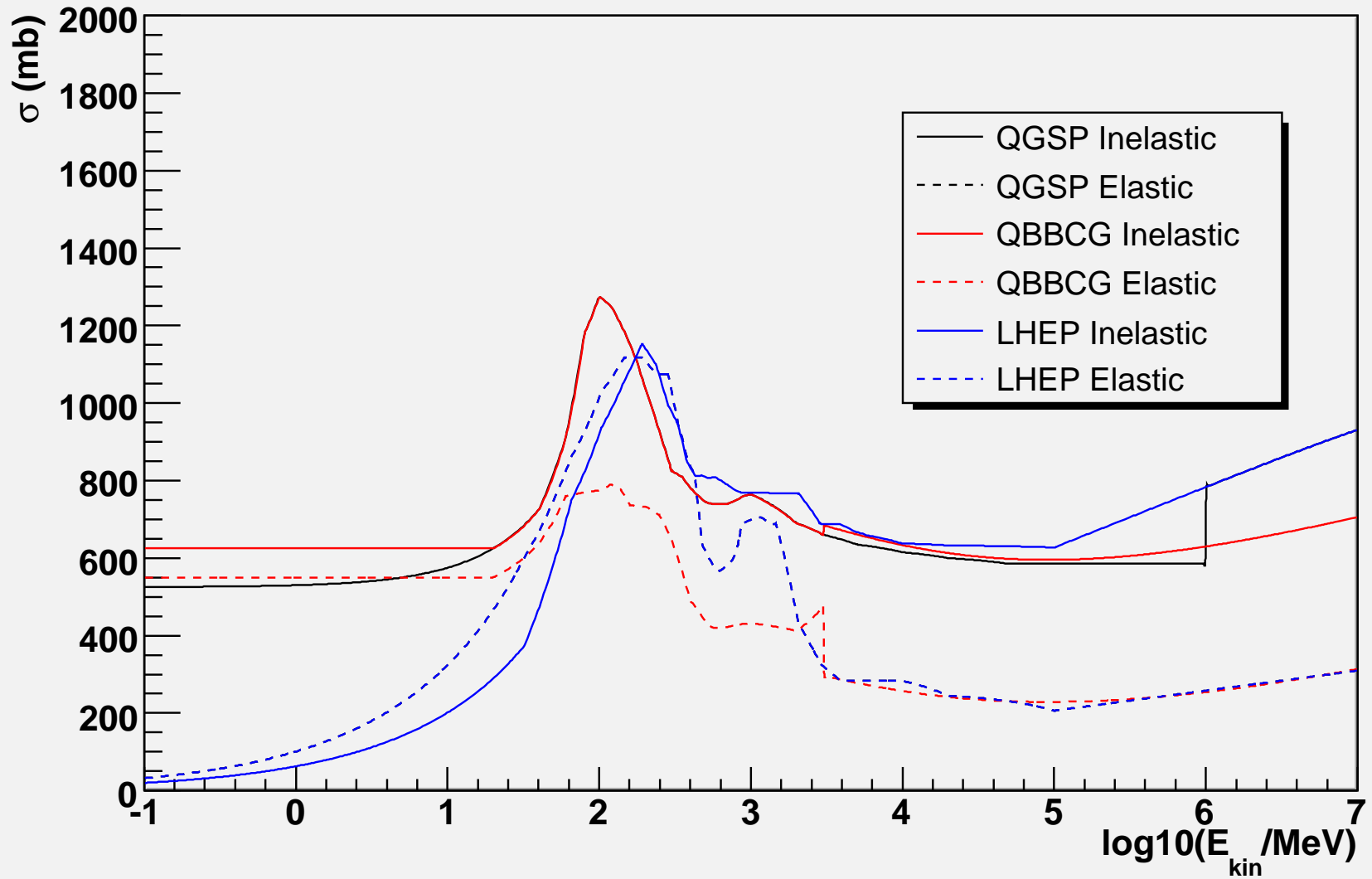
# Neutron in Iron



# $\pi^+$ in Iron



# $\pi^-$ in Iron



# Comments

- ▶ Proton cross sections look reasonable
- ▶ Neutron cross section has problem in interpolation
- ▶ Pion cross sections show problems
  - Threshold shape for  $\pi^+$  LHEP
  - Low energy cross section of  $\pi^-$
  - Elastic pion data contradict to each other
- ▶ Glauber-Gribov cross section promising a good accuracy above 10 GeV
  - Threshold is not clear (3 GeV?)
- ▶ **We need to review cross sections below 10 GeV**

# General Comments

- ▶ Combined approach has number of advantages:
  - Allows to study and to deliver new models/data sets partially developed
  - Provides the best possible results
  - Allows complicate combination of models
    - Energy range
    - Particle type
    - Material/elements
  - Clear controlled combination of data and models
  - Clear personal responsibility
- ▶ Need more control on output of models
  - extra checks required

# Conclusions

- ▶ Combined elastic process was released with 8.1
- ▶ It is possible to improve elastic scattering
  - N.Starkov is working now to provide HE model
  - M.Kosov will release improved model
  - Total elastic cross section may be improved
- ▶ Combined inelastic and elastic data sets are available with g4 8.1ref03
  - QBBC PhysicsList
  - Hadr01 example
  - Hadr00 example may be created (?)