Hadron Physics Verification

Geant4 Hadronic Working Group

22 February 2006

V.Ivanchenko

Outline

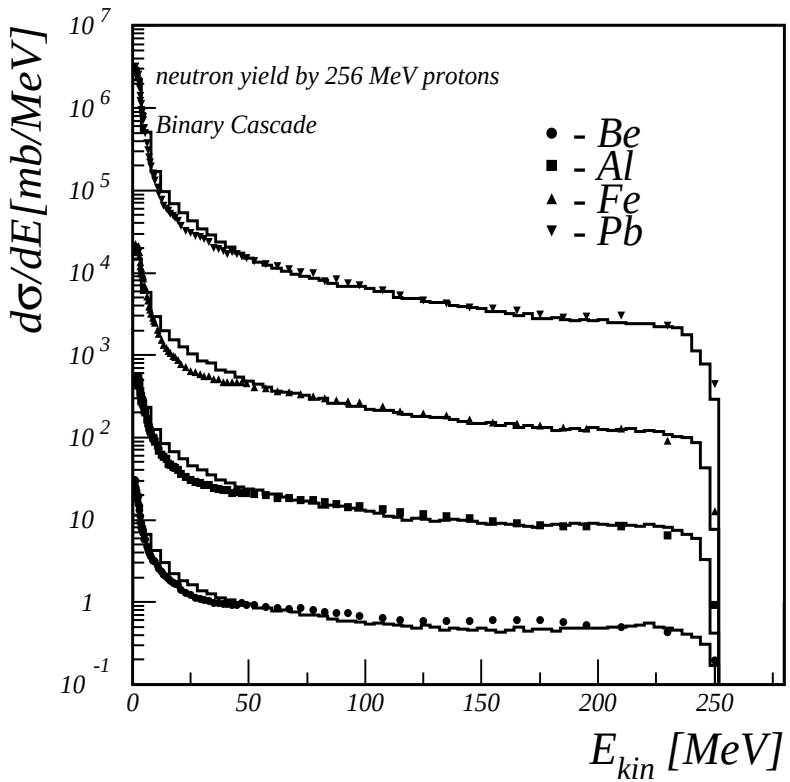
- Status of verification software provided by myself
- Recent comparisons
- Known problems
- Proposed list to do
- What can be done in 2006

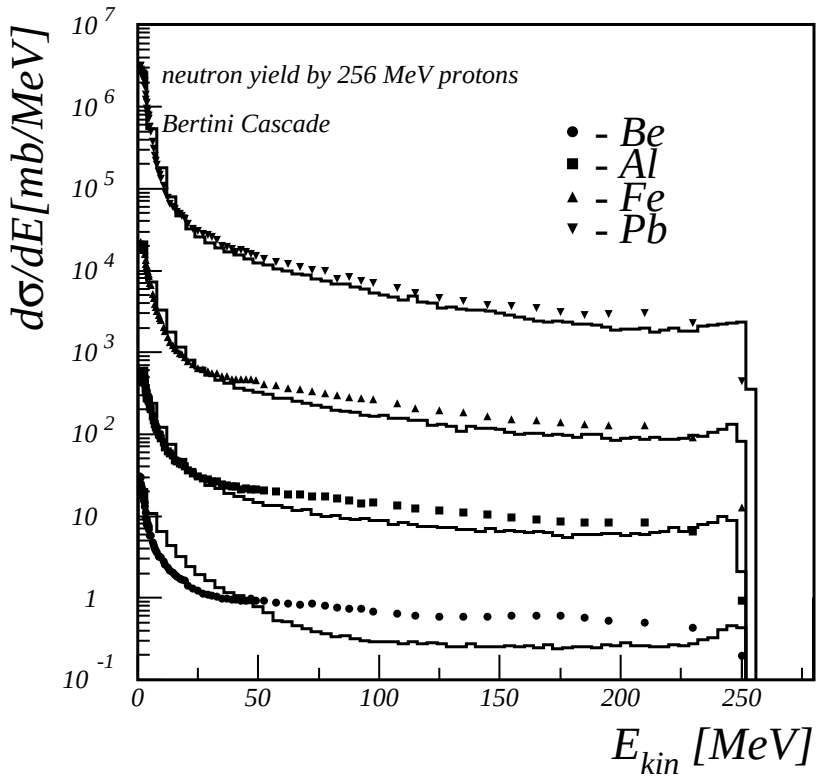
Verification Suite for the Cascade Energy Region

- Exist since 2002 as test30
- Neutron production by p, d, α with E < 1 GeV
  - P + A -> n + X
  - d + A -> n + X
  - α + A -> n + X
  - ^{12}C + A -> n + X
- Pion production
  - P + A -> $\pi^{\pm}$ + X
- 49 thin target experiments with reasonably small systematic
- 1 recent experiment for elastic scattering
- Control on differential spectra
- Model level test

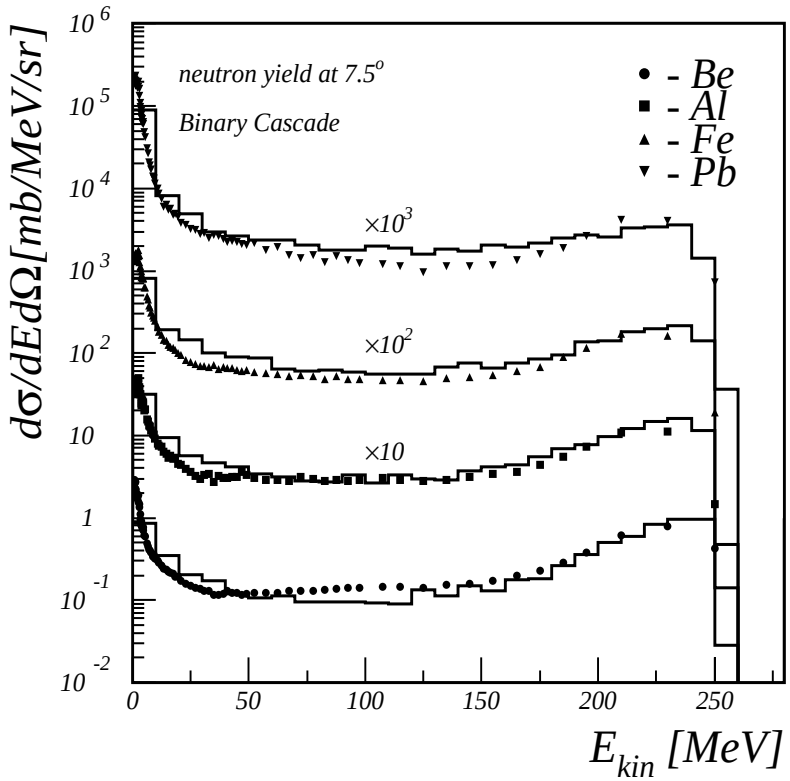
- Models under testing:
  - Binary Cascade
  - Binary Ion cascade
  - Bertini Cascade
  - Wilson-Abrasion model
- Energy range of experiments
  - (22 – 800) MeV
- There is a reasonable automatisation, about 30 hours of pcgeant6 for complete test run with 50000 events per setting

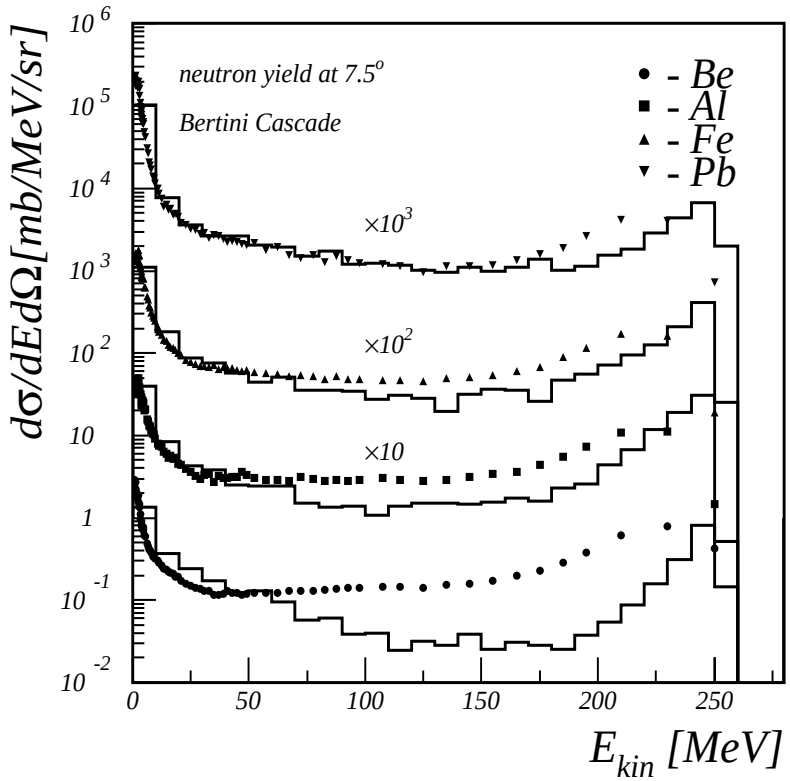
Neutron spectra by 256 MeV protons Binary and Bertini Cascades G4 7.0





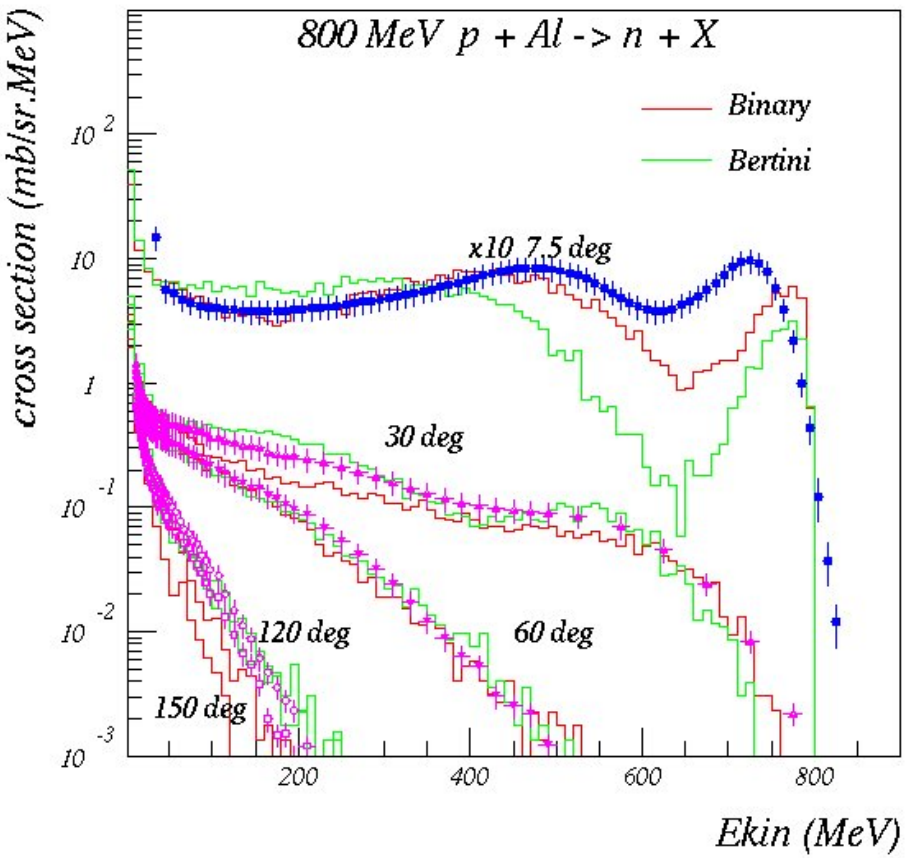
Neutron spectra by 256 MeV protons Binary and Bertini Cascades G4 7.0





Neutron spectra by protons of 800 MeV in Al Binary and Bertini Cascades G4 8.0

- Two sources of data:
  - Reliable data fro LosAlamos for larger angles
  - Problematic data for forward
- Bertini seems to be better at big angles, Binary – at small
- Binary predicts much more forward flux of neutrons



Current Problems

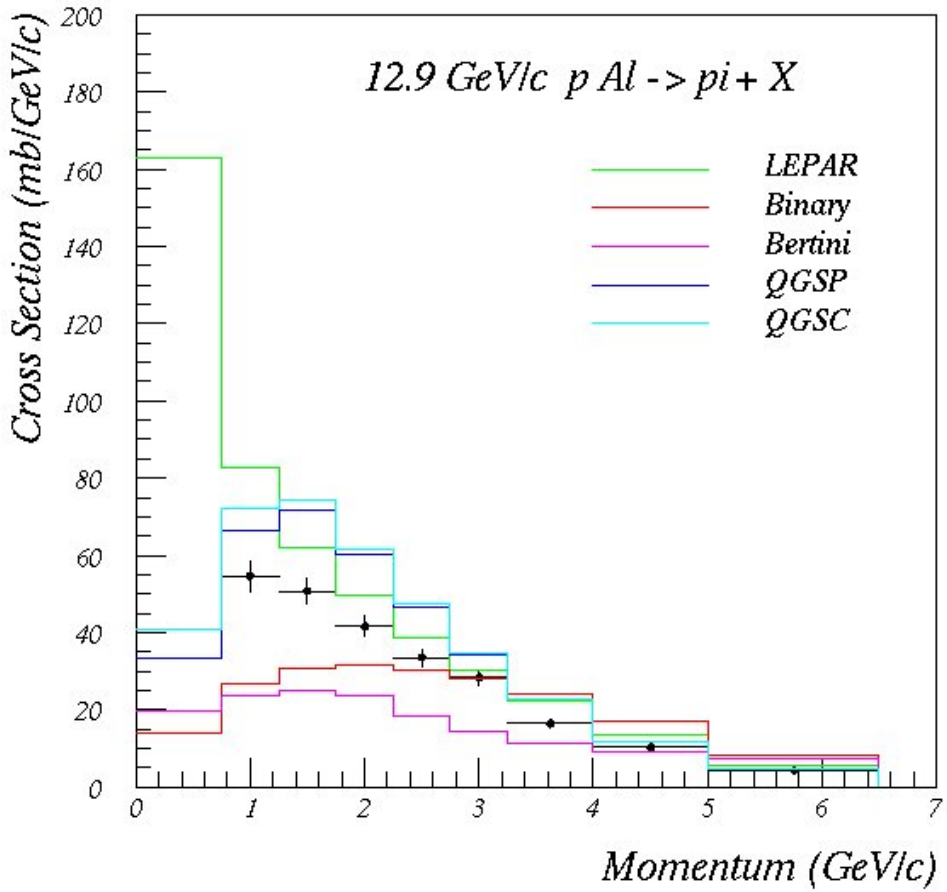
- Some part of analysis software have been lost during my migration to the new office
- We need to have a clear system where develop test and analysis software and where to store results per reference tag/release
    - Currently there are tests/ and hadronic/models/verification
    - Would be nice to move everything significant to tests
- Analysis part need to use more advance software – less manual operations for each release/reference tag
- We need to extend the suite by setting with forward production at about 1 GeV for clear recommendations of Physics Lists for radiation studies

HARP test

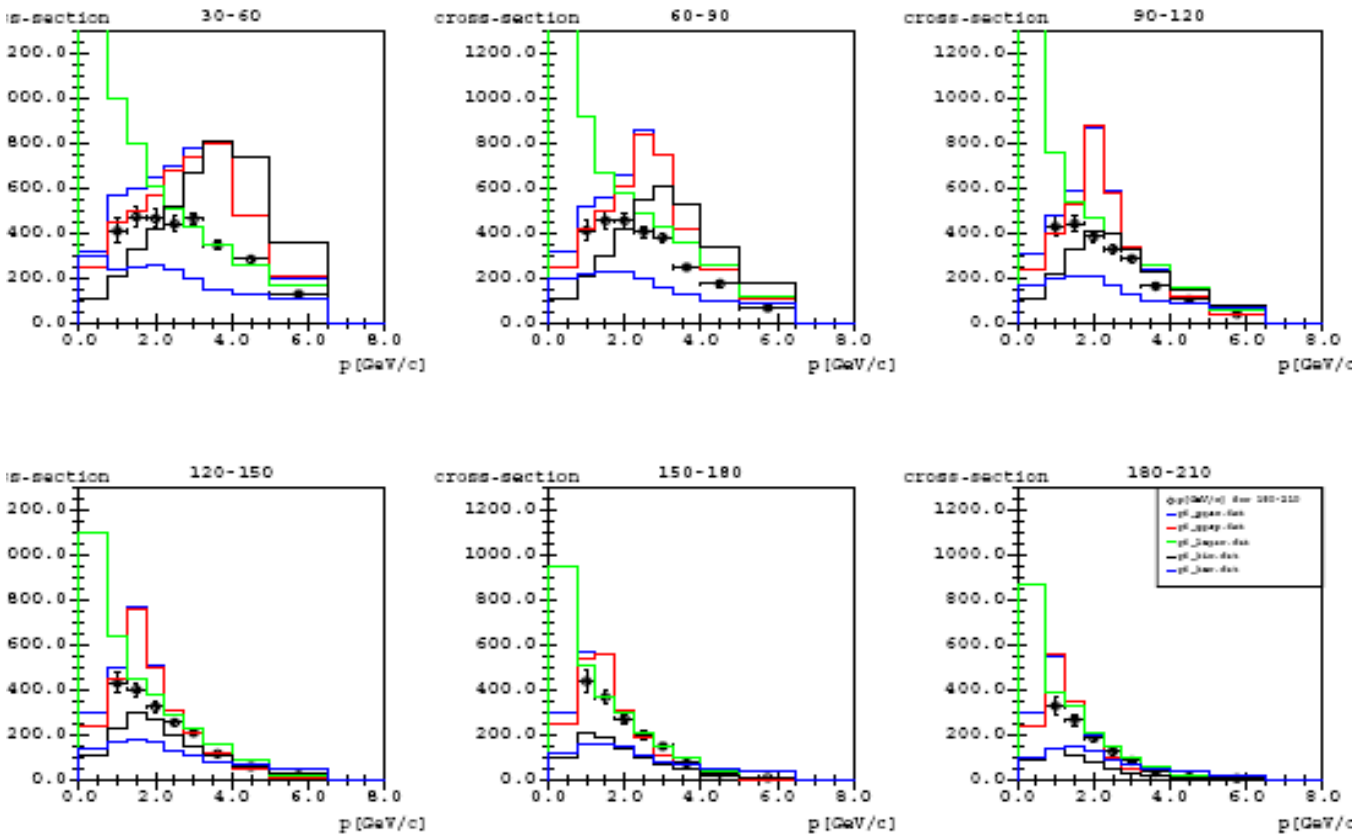
- HARP starting produce papers
- Focus on charged pion production in proton and pion beams with momentum (1.5 – 15)GeV/c
- 2 setting have been used for recent releases
  - 8.9 GeV/c p + Be (MiniBooNE setup)
  - 12.9 GeV/c p + Al (K2K setup)
- Models under study:
  - Binary, Bertini, LHEP, QGSP, QGSC
- Important for tuning of high energy hadronic shower shapes

Forward π^+ Production in Al by 12.9 GeV/c Proton Beam

- $0.03 < \theta < 0.21$ rad
- LHEP has obvious problem producing too many low energy pions
- QGS model seems to predict pion yield the most closed to the data
- Both cascade models underestimate low energy pion production



Double Differential Cross Section of π^+ Production by 12.9 GeV/c Protons in Al



Summary

- Routine procedure for verification of hadron generators in the energy range 20 MeV – 15 GeV is established
- It is being used by developers and is performed in the release time
- The improvements in organization of storage of the results are required
- For the energy about 1 GeV we need to find out more trustable data

Concerns to Geant4 Hadronics

- 4-momentum balance
- Isotopes
- Total cross sections
- Model management
- Use case coverage
- User support

What must be done in 2006

- Identify duplicate or conflicting data in isotope tables: particles, materials, CHIPS
- Revision of total and elastic cross sections
  - Providing testing facility
- Optimization of structure of directories for verification, organization of storage of results accessible for G4 members
- Extend existing validation to comparison with data important for main G4 applications

What can be done in 2006?

- Converge efforts on elastic process improvements and testing – currently 5 models
  - We need one or at least two but very good
- Isotope composition to be used in cross section calculation and in isotope sampling
- Tuning of models using HARP data
- Better understanding of hadronic showers
  - e/p ratio
  - Longitudinal and transverse size
- Providing hadronic extended examples

Problem and proposals

- Current hadronic package has a number of simplifications and biases, which at the end may compensate each other providing reasonable results
- Eliminating each single problem may provide less accurate agreement with the data
- There may be two strategy:
  - Moving forward with small increments and very strong verification of each step
  - Bypath current design and implementation creating alternative approach and freezing GHAD