

DESIRE

Dose Estimation by Simulation of the ISS Radiation Environment

<http://www.particle.kth.se/desire/>

Status of the DESIRE project: GEANT4 physics validation studies

2003-01-21 – ESTEC/Noordwijk

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DESIRE / Outline

- Aimed at accurate calculations of radiation flux and doses to astronauts inside the Columbus/ISS.
- Utilizes Geant4 for radiation transport.
- Involved:
 - P. Carlson, T. Ersmark, B. Lund-Jensen, M. Pearce; KTH (Stockholm)
 - C. Fuglesang; EAC/JSC (Cologne/Houston)
 - I. Gudowska; Karolinska Institute (Stockholm)
 - E. Daly, P. Nieminen; ESTEC/TOS-EMA (Noordwijk)
 - N. Sobolevsky; INR (Moscow)

DESIRE / Outline

- Benchmark studies of Geant4. Comparisons to other codes (BRYN-/HZETRN, SHIELD) and experiments.
- Geometry modeling; simpler tests.
- Evaluation of incident radiation fields; full simulations.
- Dose calculations. Phantoms in Geant4?

Test cases

- Longitudinal Energy Deposition Comparisons with SHIELD.
- Radial Energy Deposition Comparisons with SHIELD.
- Proton and Neutron Spectra Comparisons with SHIELD.
- Directional Neutron Spectra Comparisons with Data.
- Proton and Neutron Spectra Comparisons with BRYNTRN.

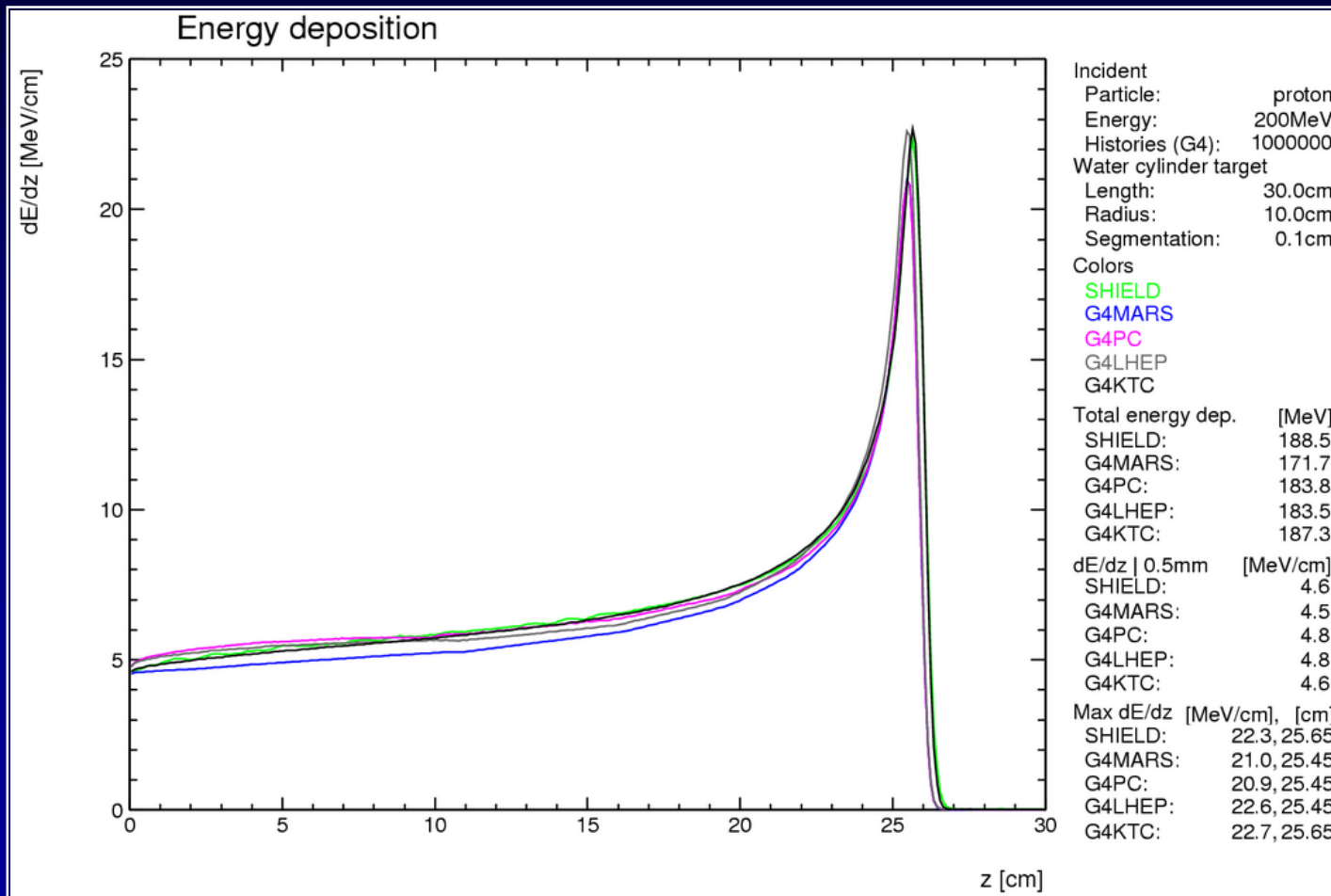
Test details

- Standard electromagnetics.
- Data driven model for neutrons $<20\text{MeV}$.
- Four different physics models for inelastic nucleon scattering. Labels:
 - G4MARS (G4.4.1, G4Mars5GeV, LHEP_LEAD_HP)
 - G4PC (G4.4.1, Precompound, LHEP_PRECO_HP)
 - G4LHEP (G4.4.1, Parametrization, LHEP_HP)
 - G4KTC (G4.5.0, Binary cascade)
- Comparing to SHIELD, BRYNTRN and data.

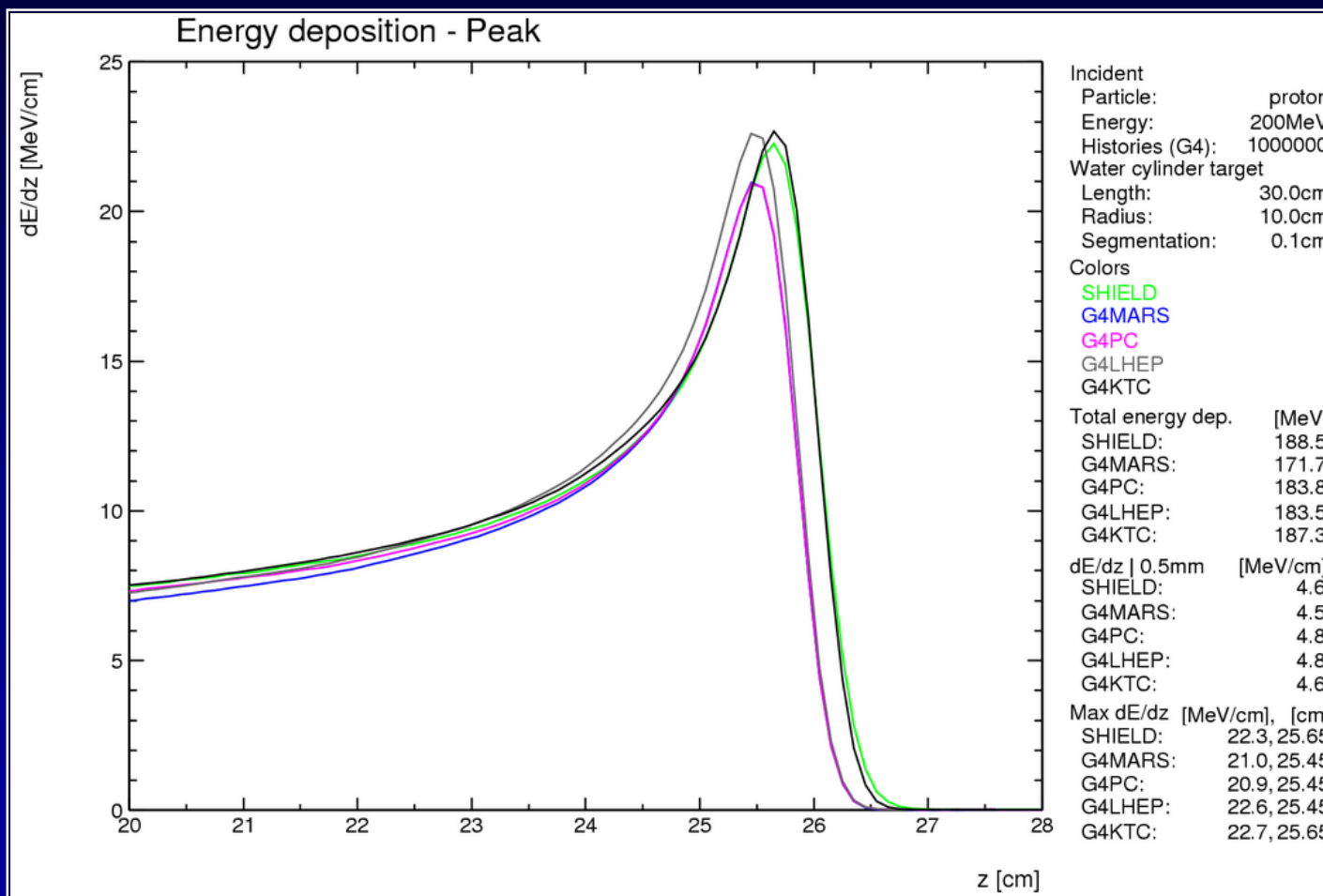
Energy Deposition Comparisons with SHIELD

- Proton (200MeV) pencil beam incident on water cylinder (along axis).
- Cylinder radius 10cm, length 20cm.

Energy Deposition Comparisons with SHIELD (full)



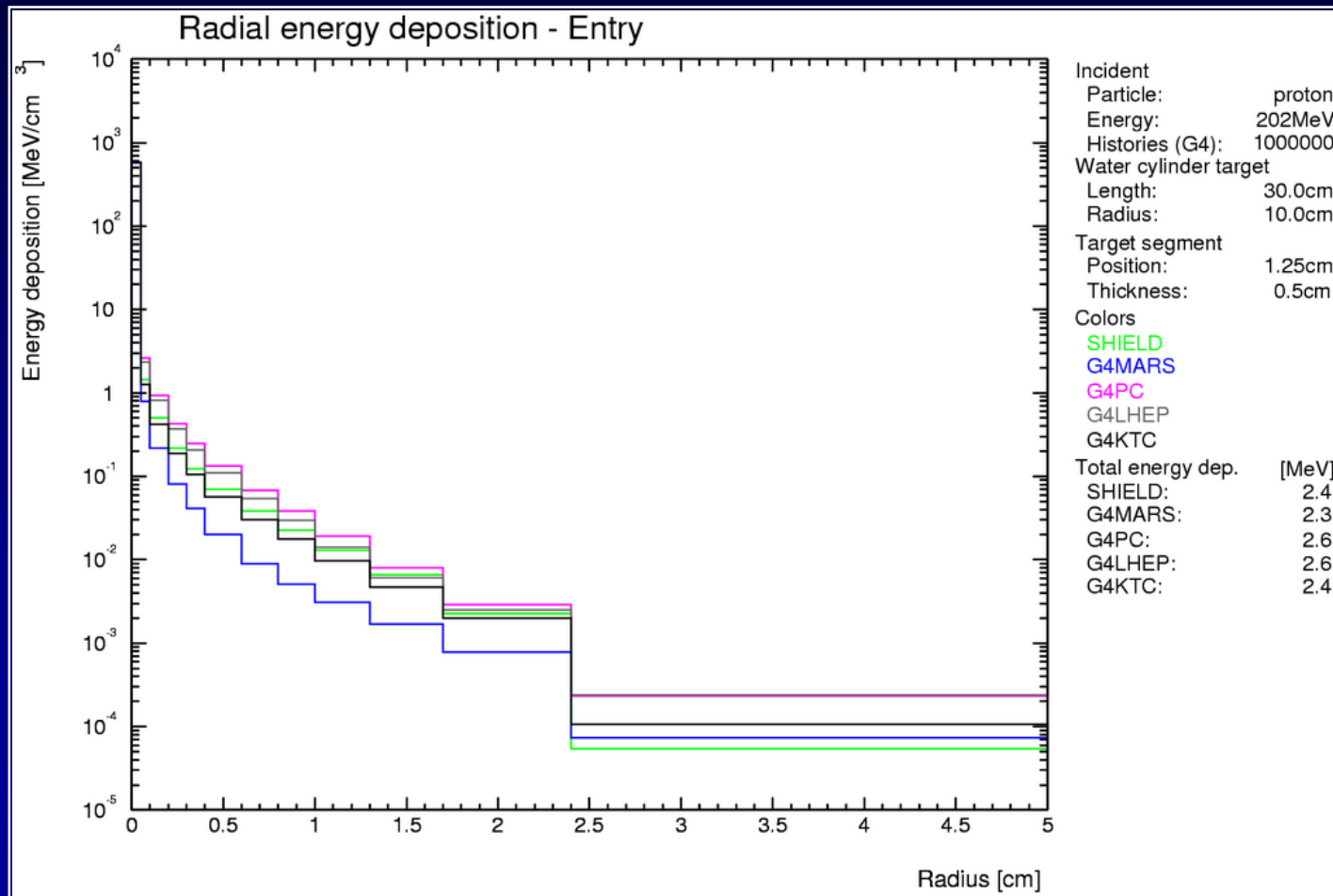
Energy Deposition Comparisons with SHIELD (peak)



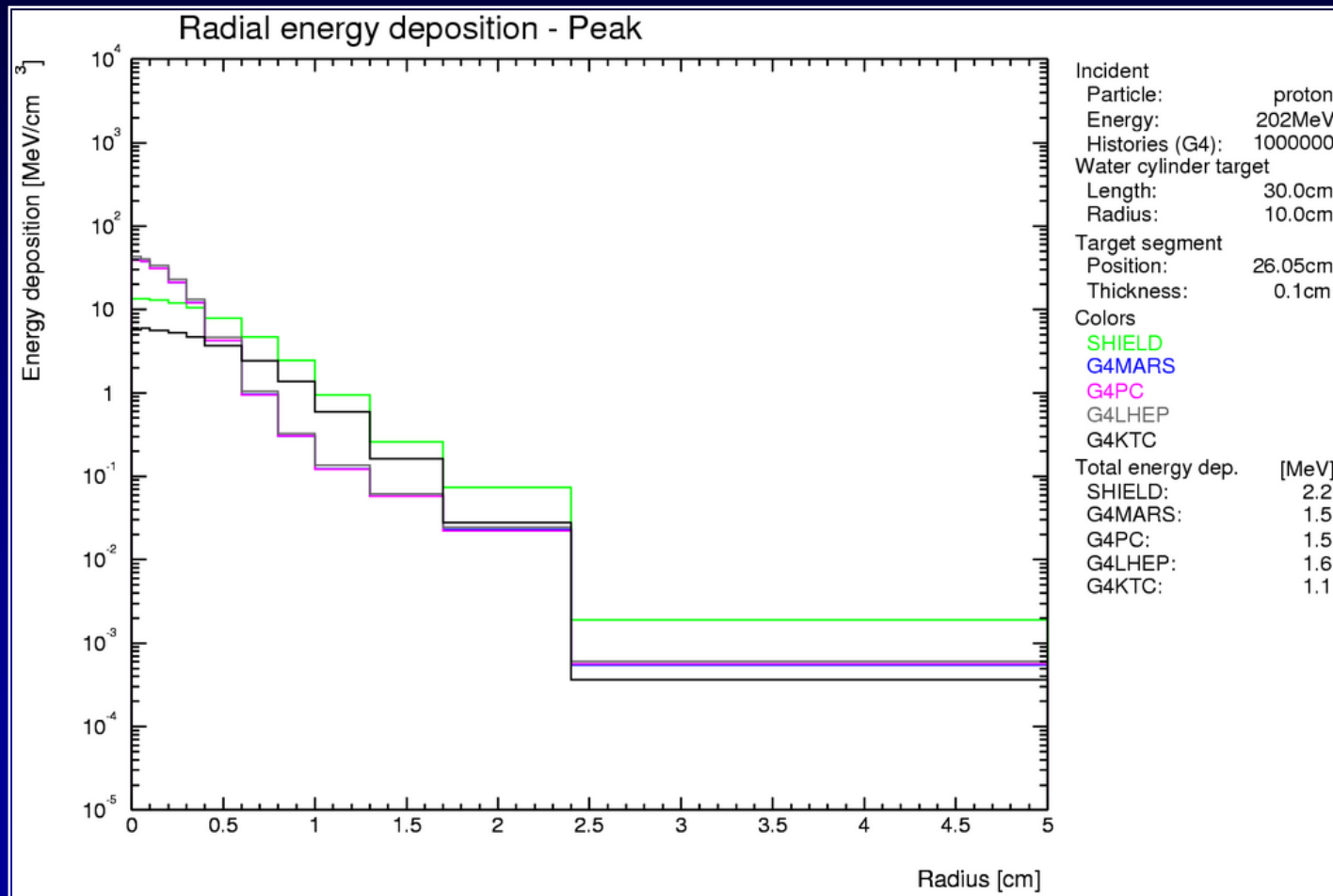
Radial Energy Deposition Comparisons with SHIELD

- Same geometry as previously.
- Proton (202MeV) pencil beam incident on water cylinder.
- Looking at one segment centered at 1.25cm depth, and at a second segment at 26.05cm.
- Segment lengths are 5mm and 1mm respectively.
- 12 radial segments.

Radial Energy Deposition Comparisons with SHIELD (entry)



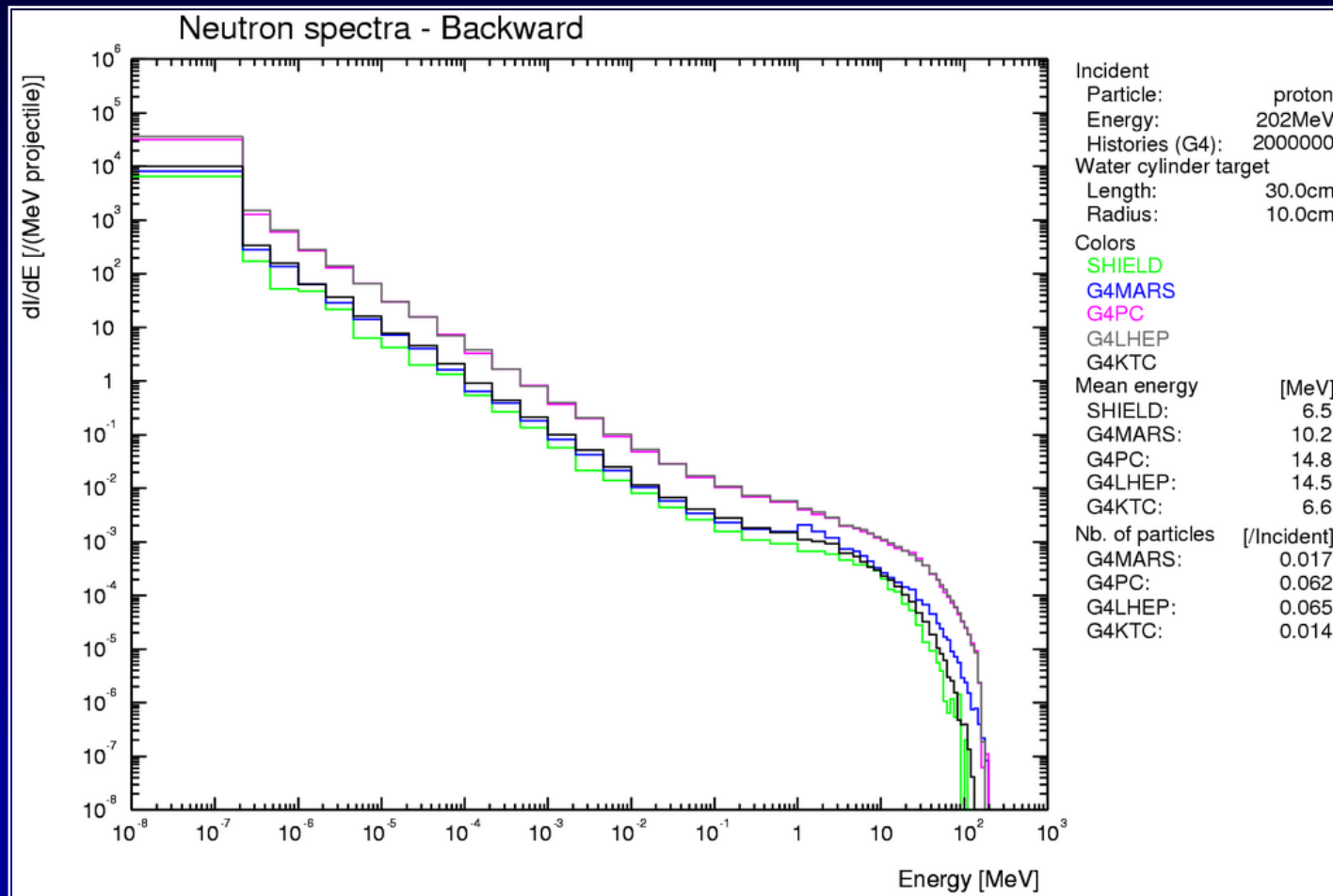
Radial Energy Deposition Comparisons with SHIELD (peak)



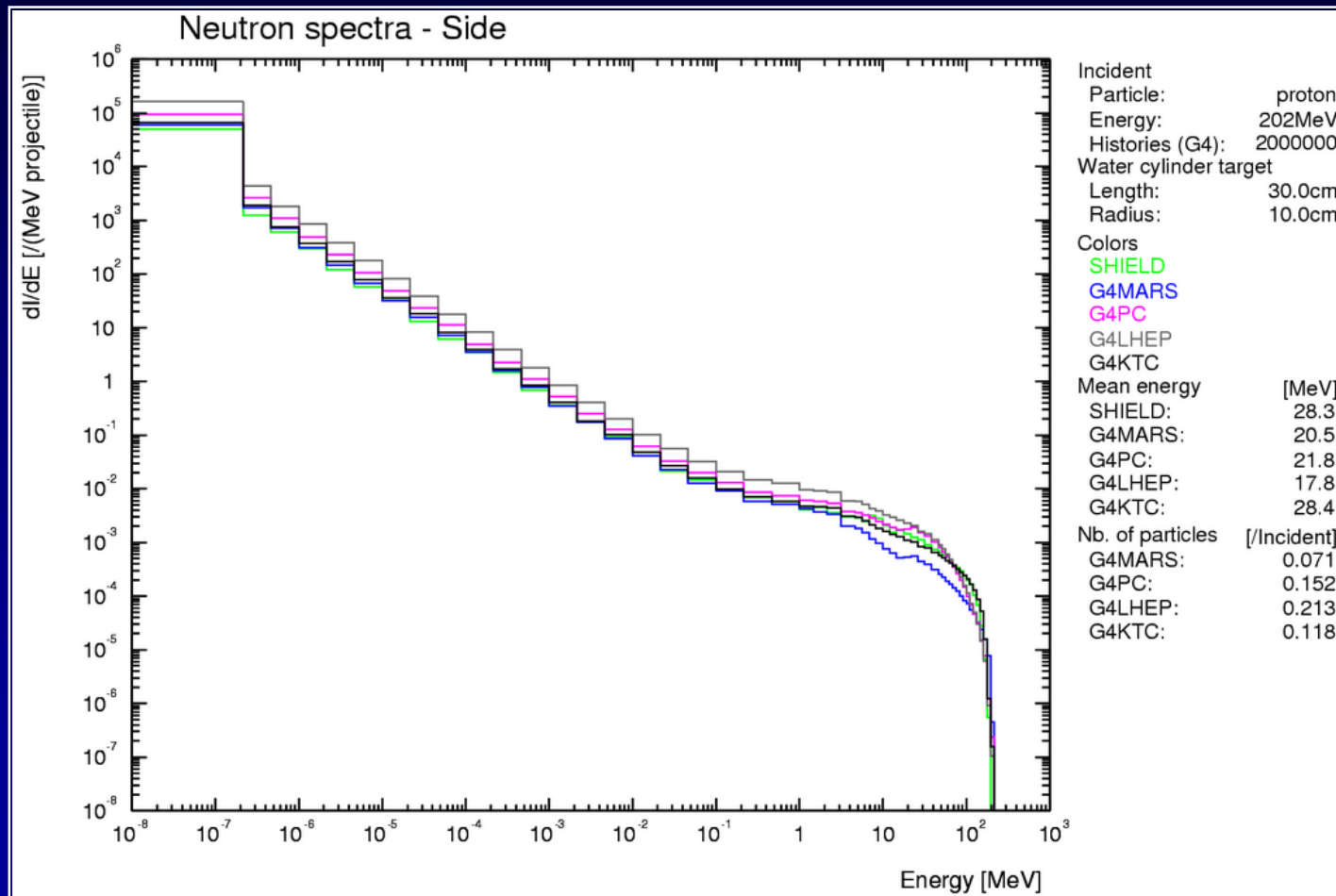
Proton and Neutron Spectra Comparisons with SHIELD

- Same global geometry as previously.
- Same proton beam as previously.
- Looking at spectra of protons and neutrons leaving the target, per geometrical boundary surface.

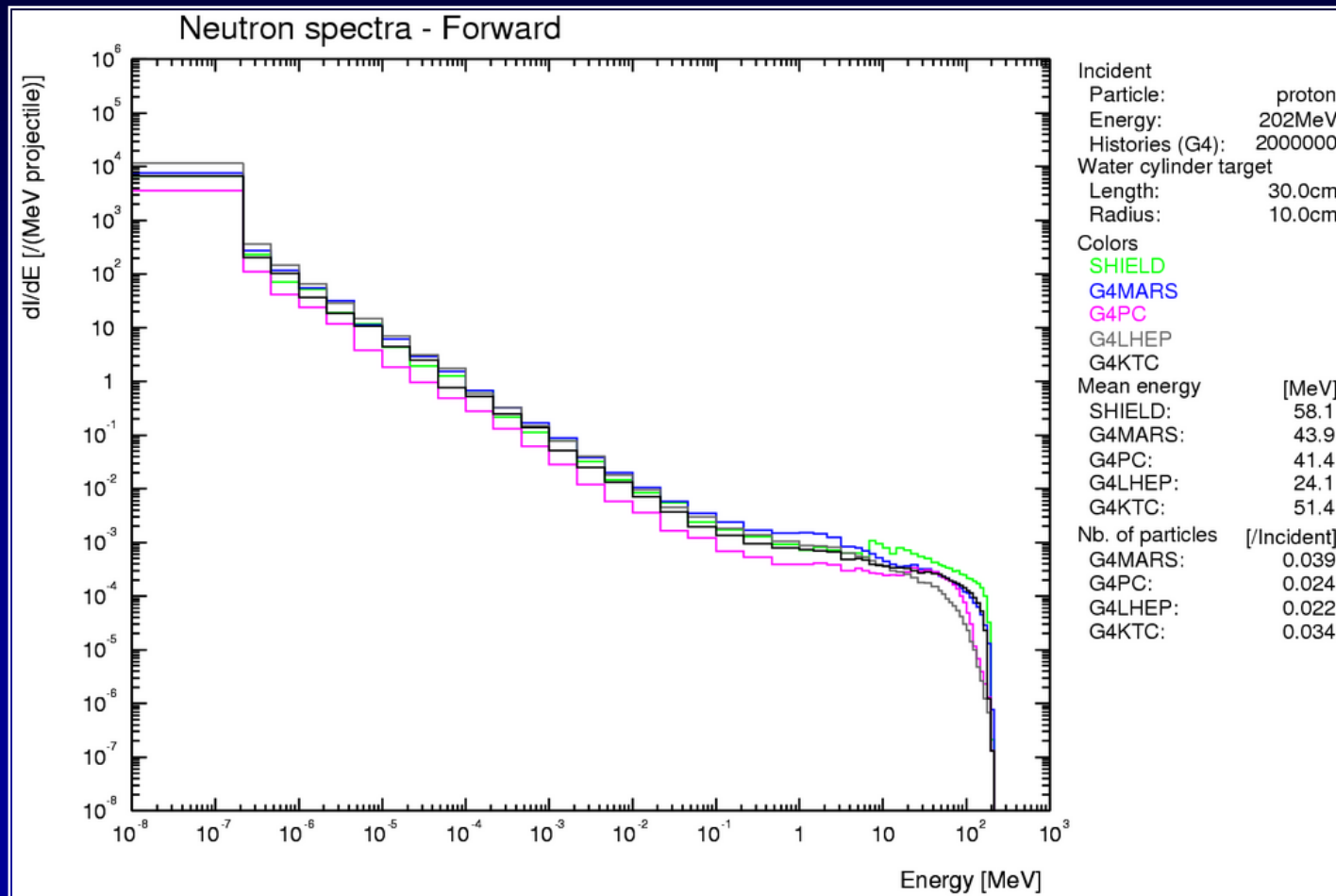
Proton and Neutron Spectra Comparisons with SHIELD (n, bwd)



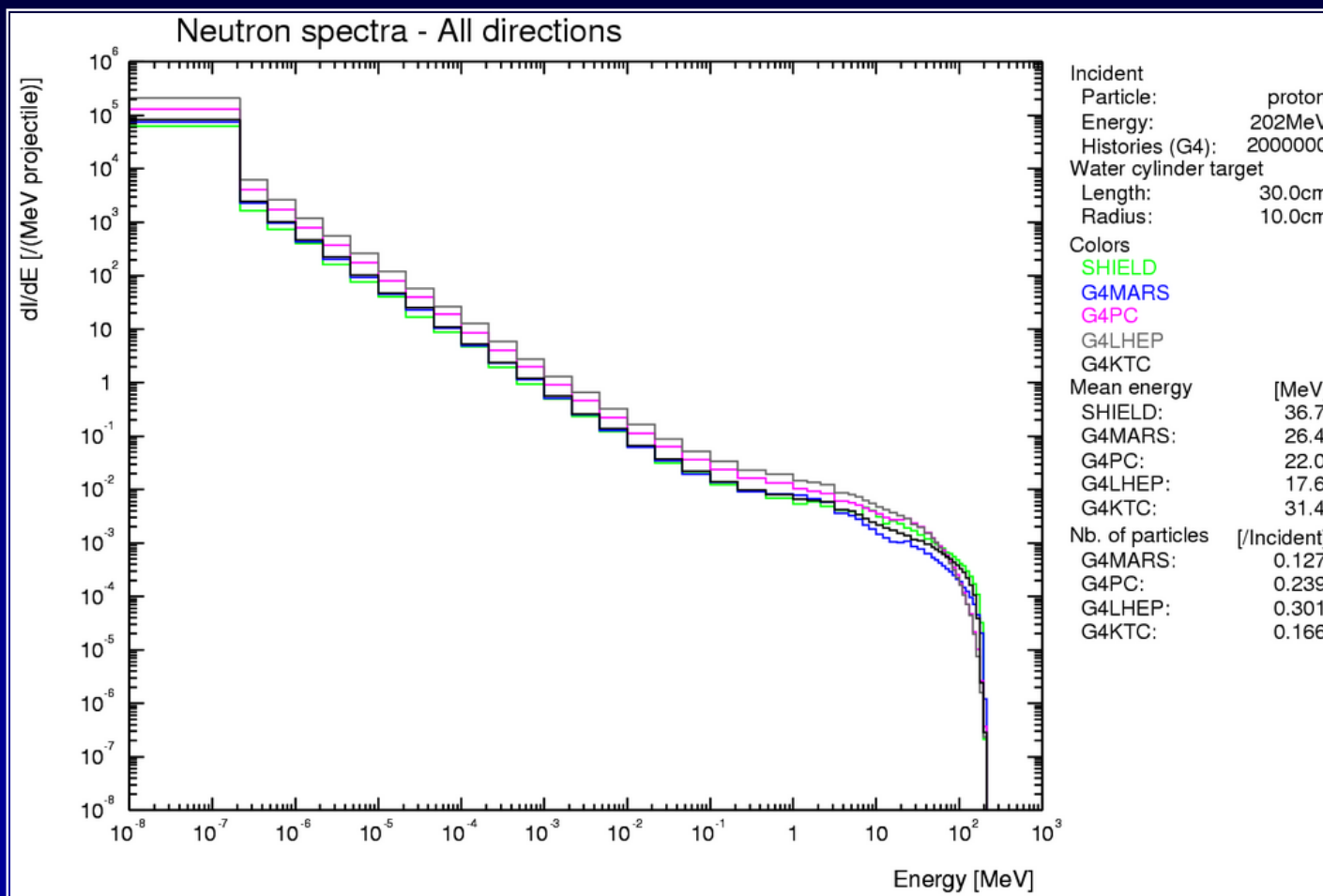
Proton and Neutron Spectra Comparisons with SHIELD (n, side)



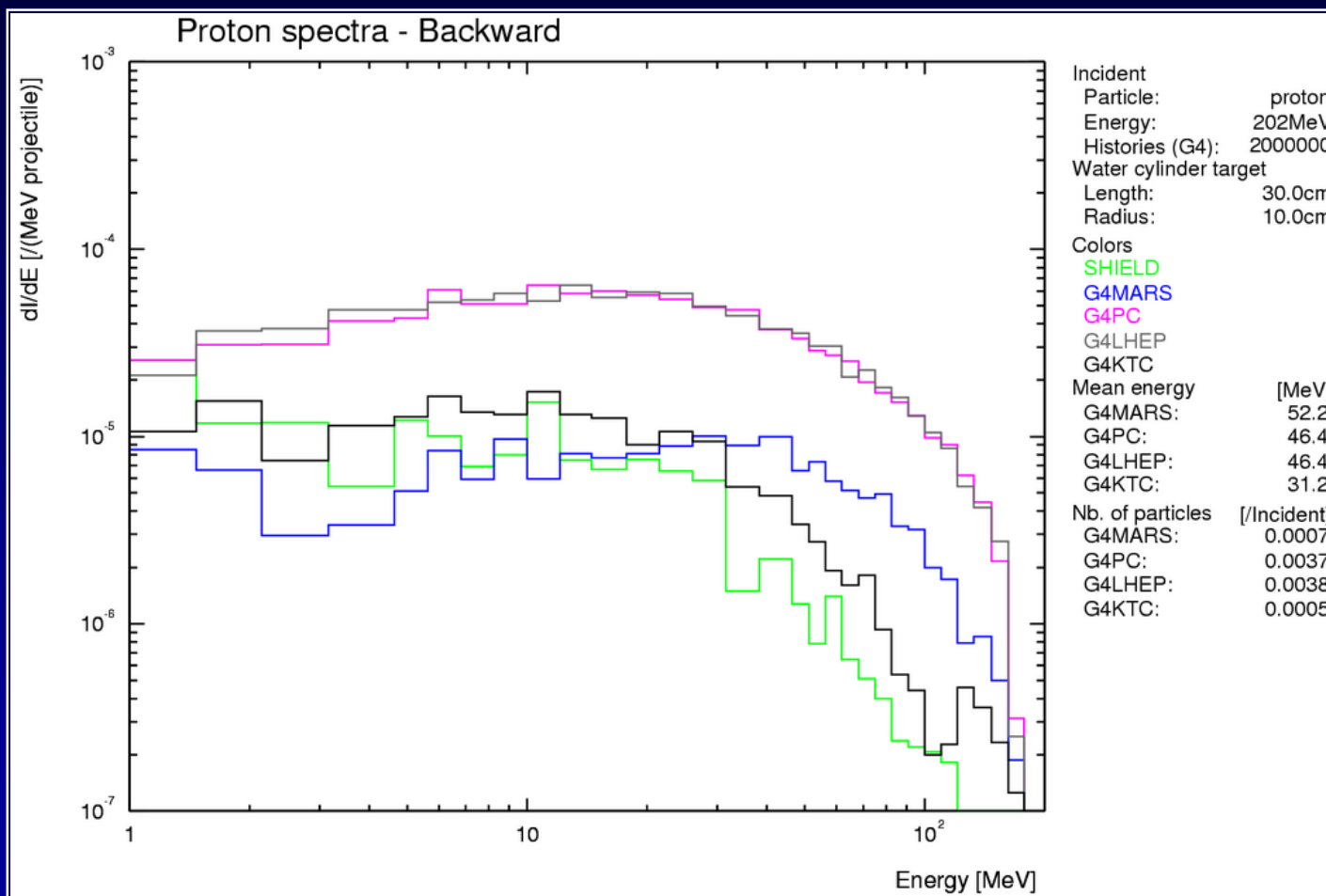
Proton and Neutron Spectra Comparisons with SHIELD (n, fwd)



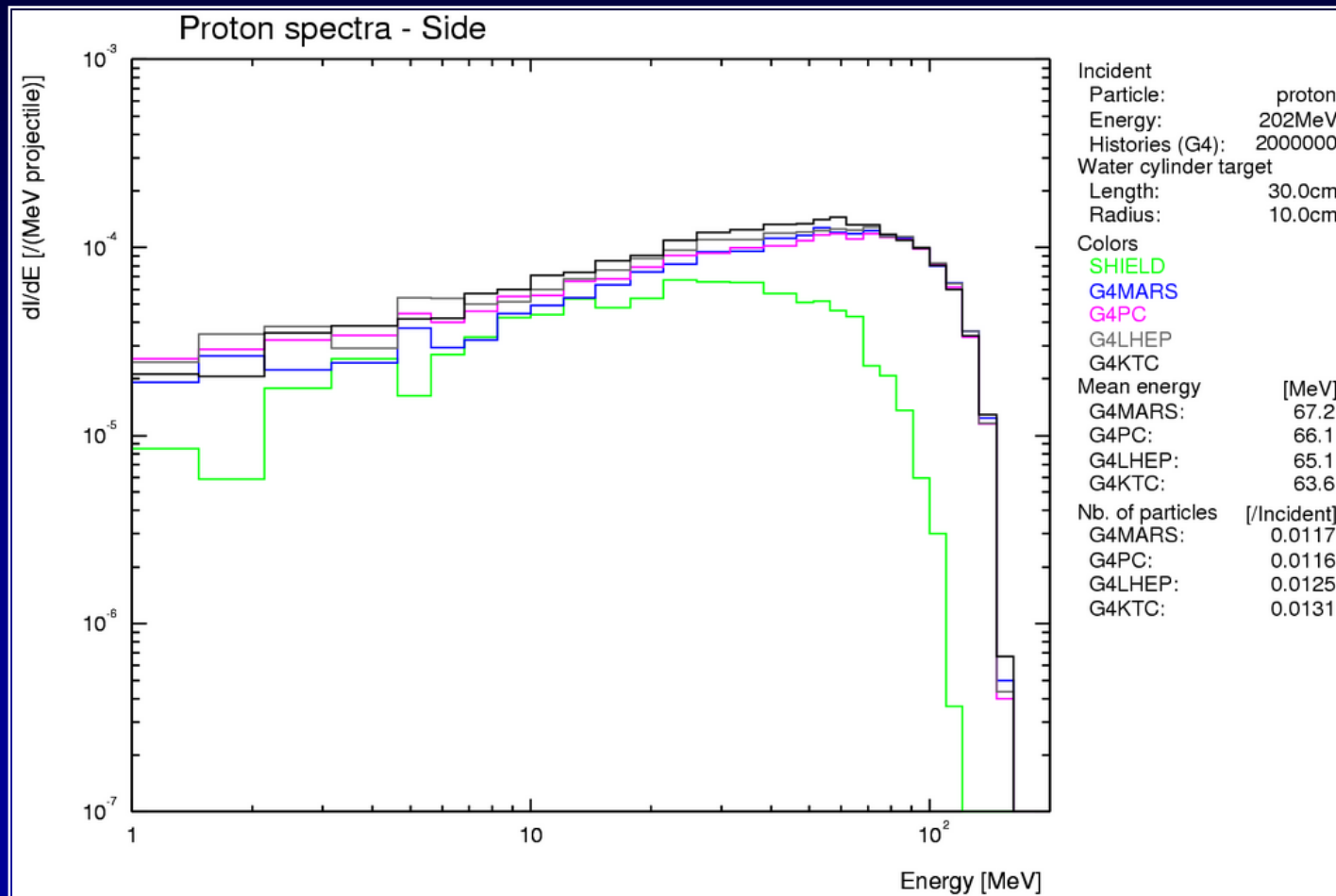
Proton and Neutron Spectra Comparisons with SHIELD (n, all)



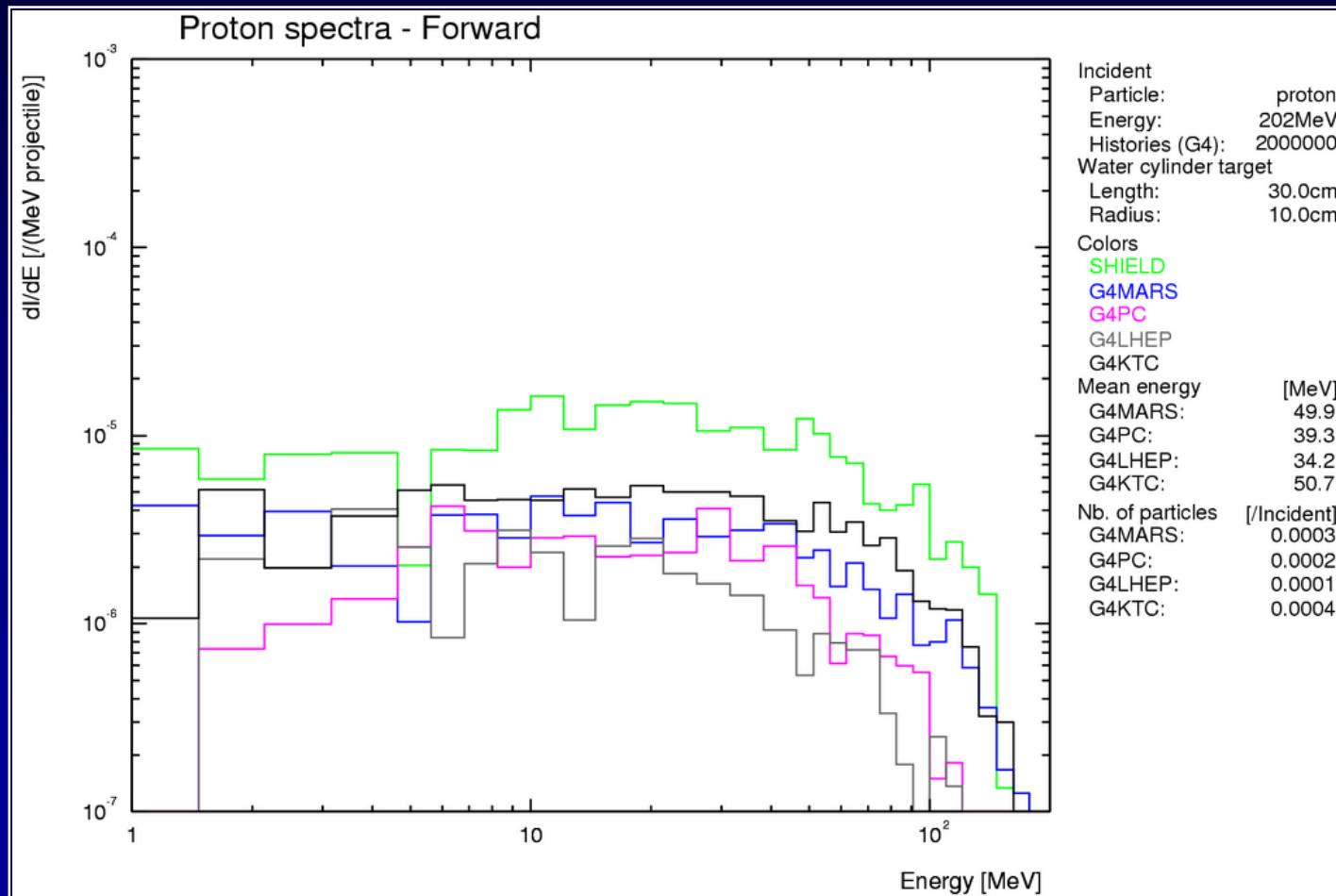
Proton and Neutron Spectra Comparisons with SHIELD (p, bwd)



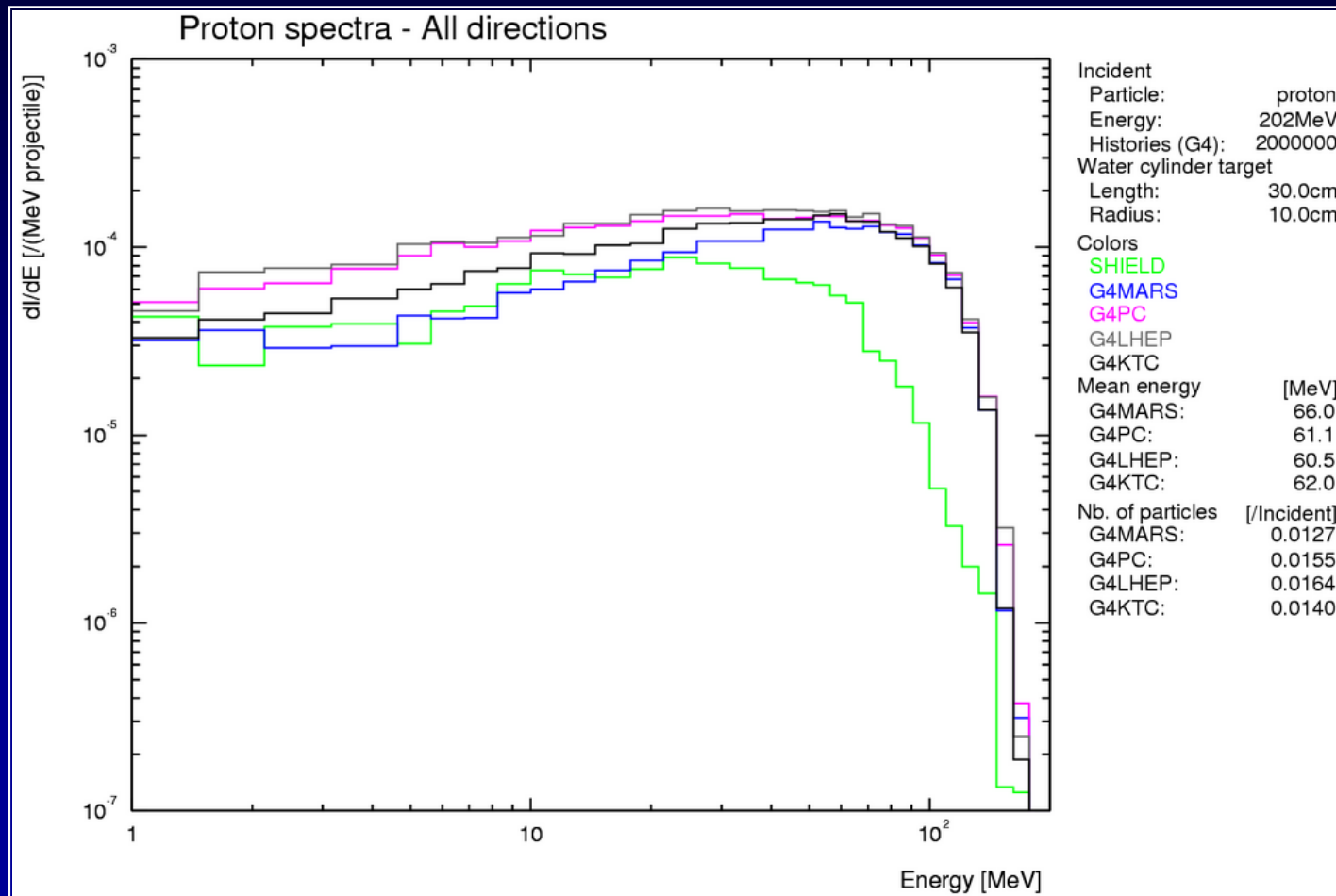
Proton and Neutron Spectra Comparisons with SHIELD (p, side)



Proton and Neutron Spectra Comparisons with SHIELD (p, fwd)



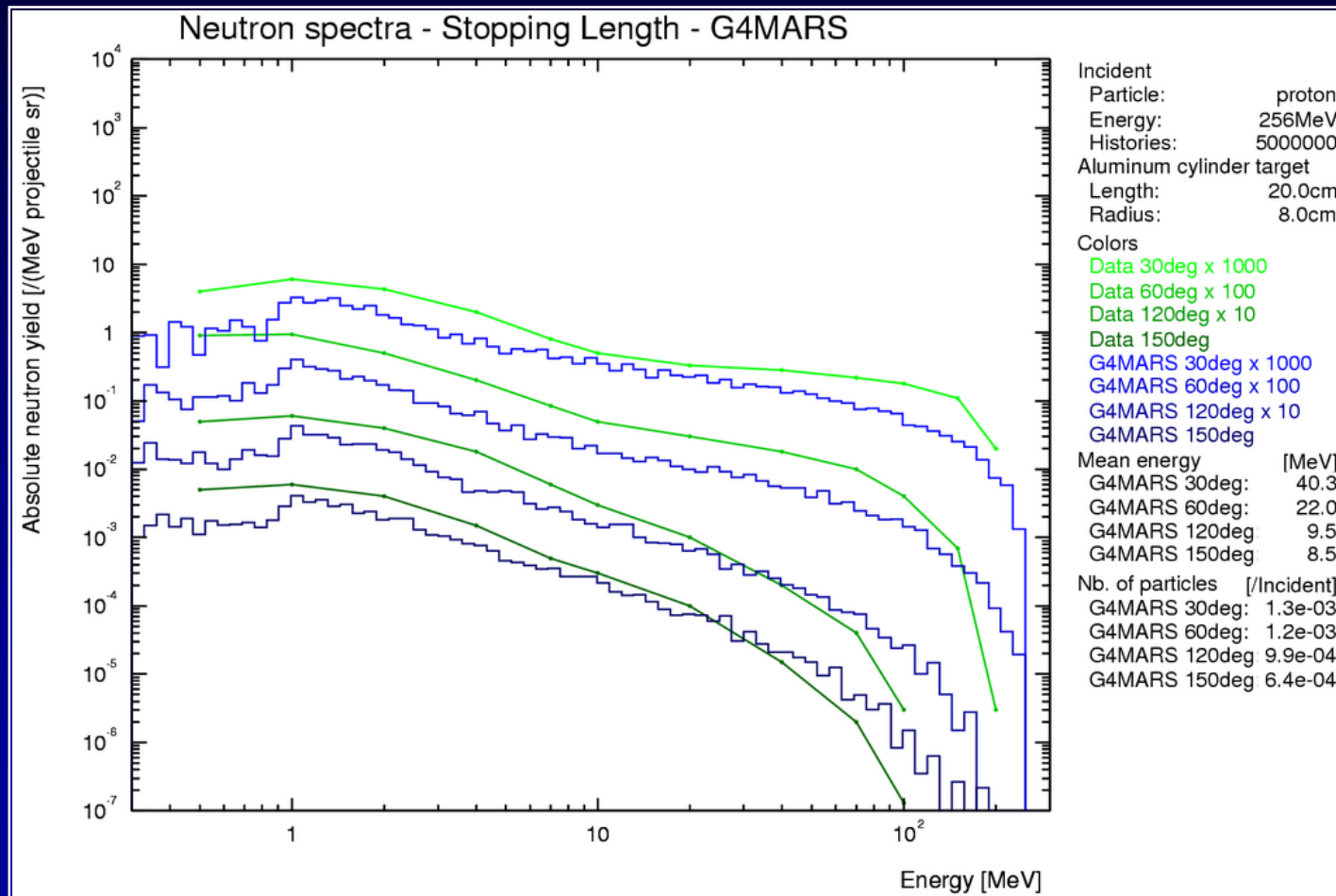
Proton and Neutron Spectra Comparisons with SHIELD (p, all)



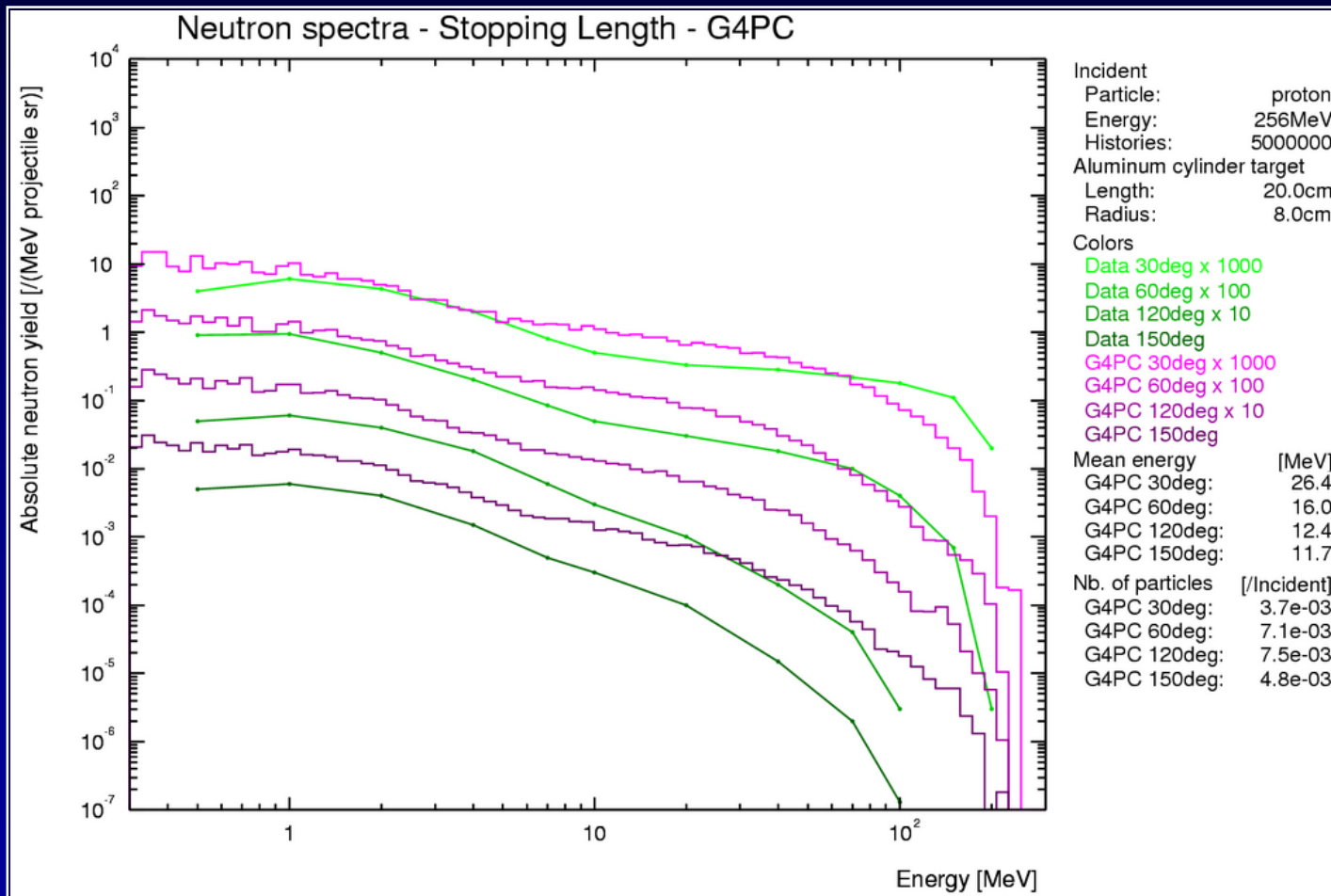
Directional Neutron Spectra Comparisons with Data

- NSE: 104, 339-363; 1990.
- Proton (256MeV) pencil beam incident on aluminum cylinder (along axis). Cylinder radius 8cm, length 20cm.
- Looking at neutron spectra in 30° , 60° , 120° and 150° off axis.
- Distances between target and detectors are 30-60m.
- Angular coverage for the experiment $<0.05^\circ$; for simulation 1° .
- Collimation issues; errors.

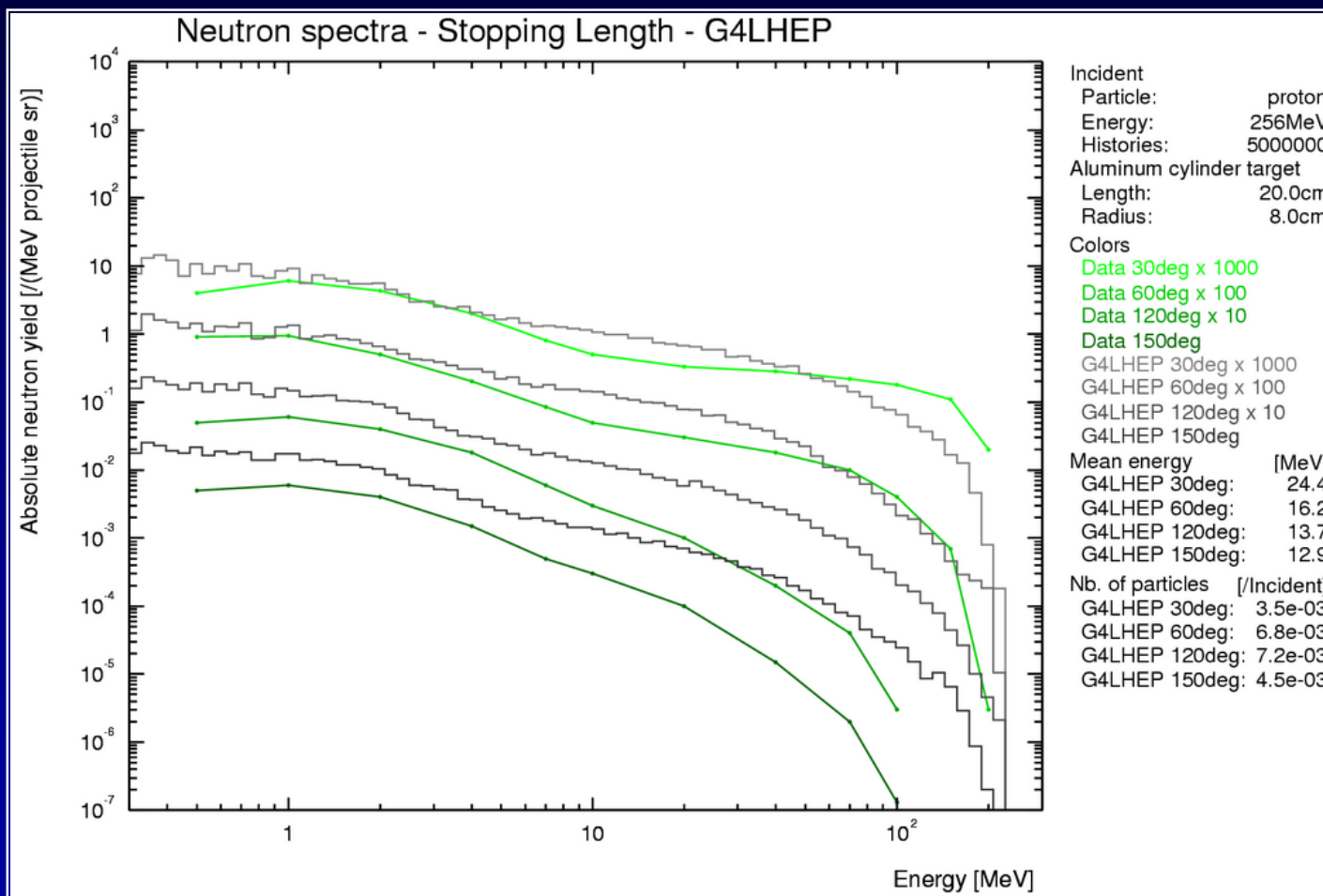
Directional Neutron Spectra Comparisons with Data (sl, G4MARS)



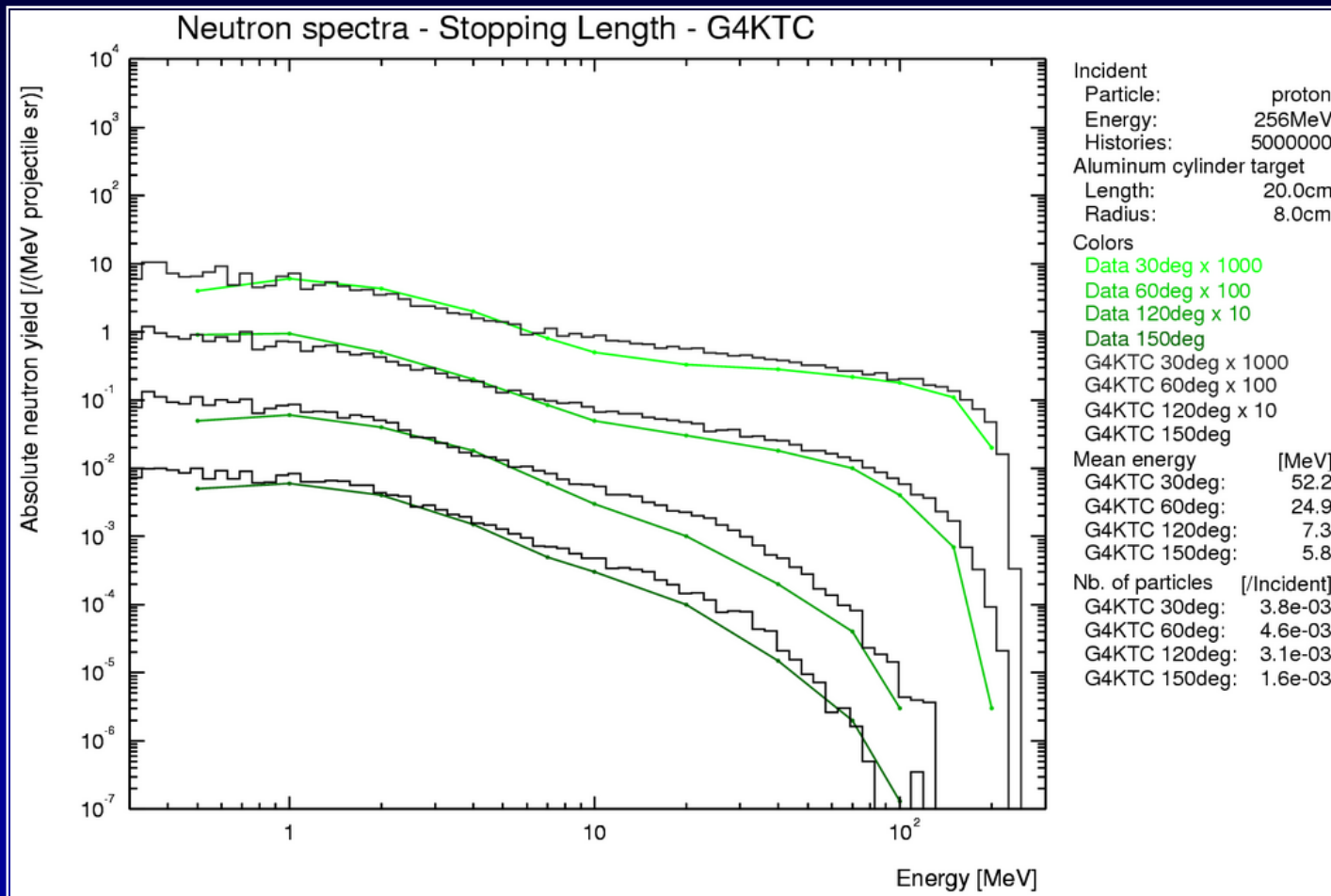
Directional Neutron Spectra Comparisons with Data (sl, G4PC)



Directional Neutron Spectra Comparisons with Data (sl, G4LHEP)



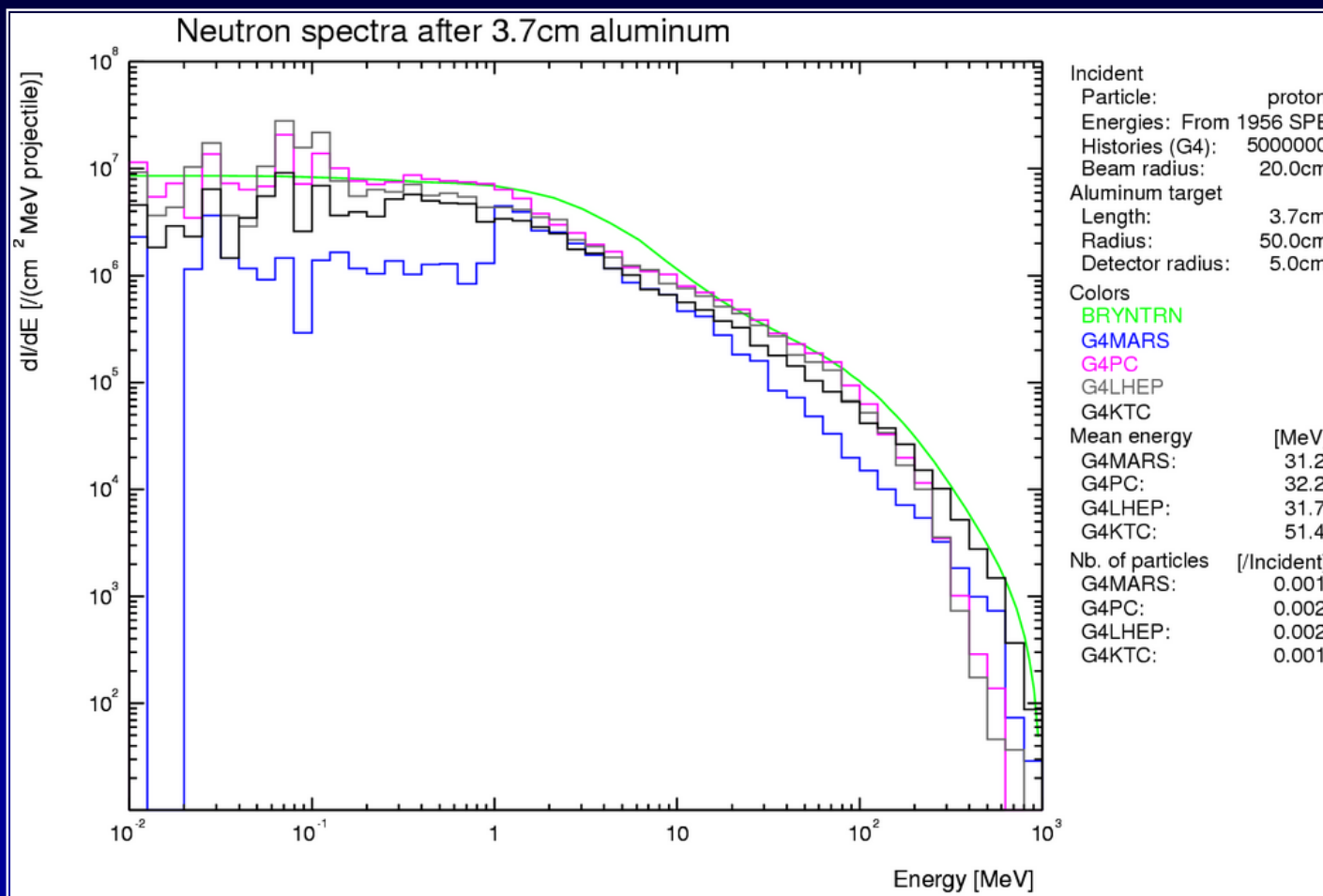
Directional Neutron Spectra Comparisons with Data (sl, G4KTC)



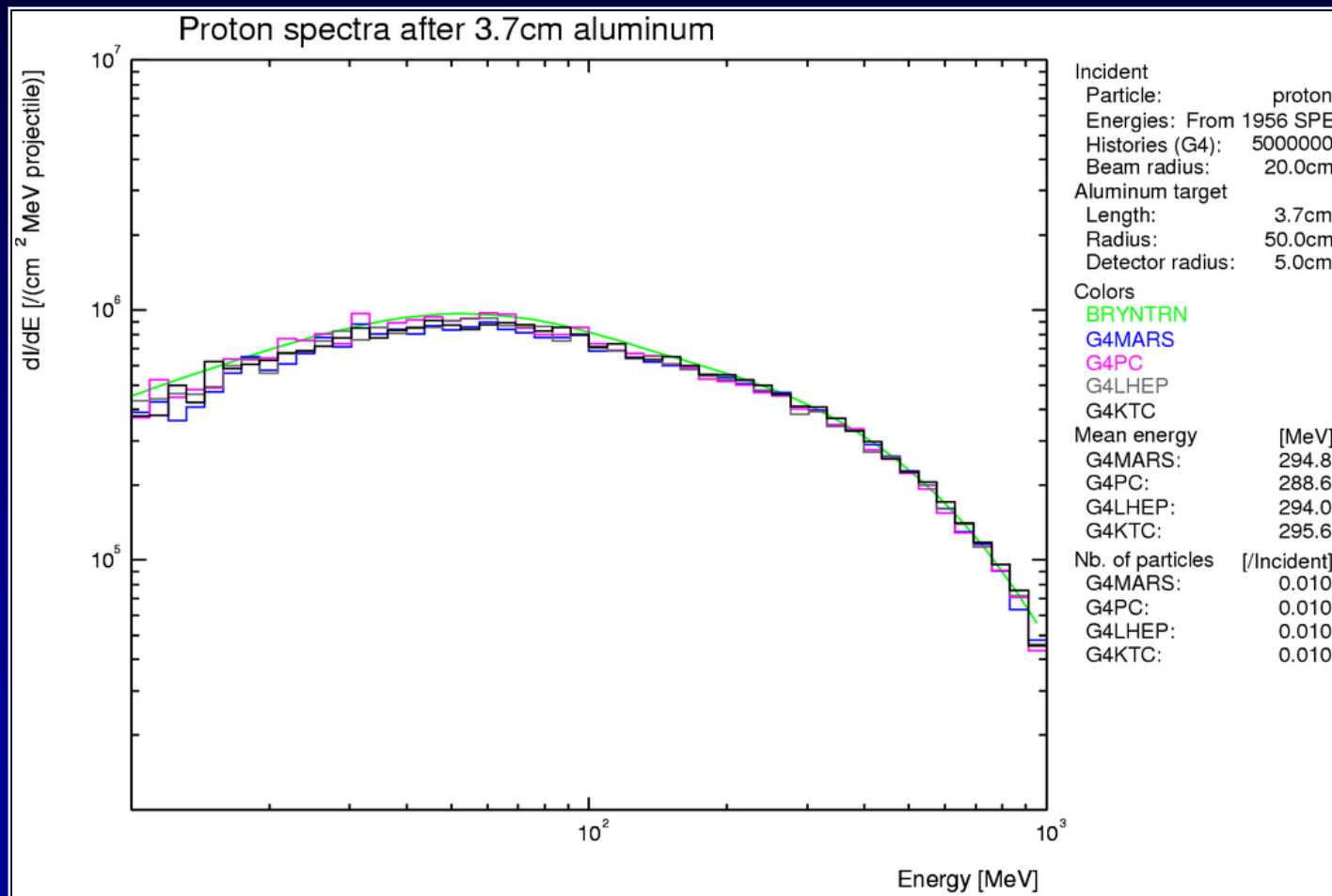
Proton and Neutron Spectra Comparisons with BRYNTRN

- Geometry for BRYNTRN is a semi-infinite slab of aluminum.
- For Geant4 we have a cylindrical slab with diameter 1m. Beam width 40cm and detector diameter 10cm.
- Incident proton spectra as in the 1956 SPE.
- Looking at particles leaving the slab in the forward direction, per unit area.

Proton and Neutron Spectra Comparisons with BRYNTRN (n, Al, 10g/cm²)



Proton and Neutron Spectra Comparisons with BRYNTRN (p, Al, 10g/cm²)



Acknowledgements

- J.P. Wellisch; Physics lists.
- I. Gudowska, N. Sobolevsky; SHIELD data.
- F. Cucinotta; BRYNTRN data.