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MARSHALL SPACE FLIGHT CENTER

Geant4 predictions of energy spectra in typical space radiation environment

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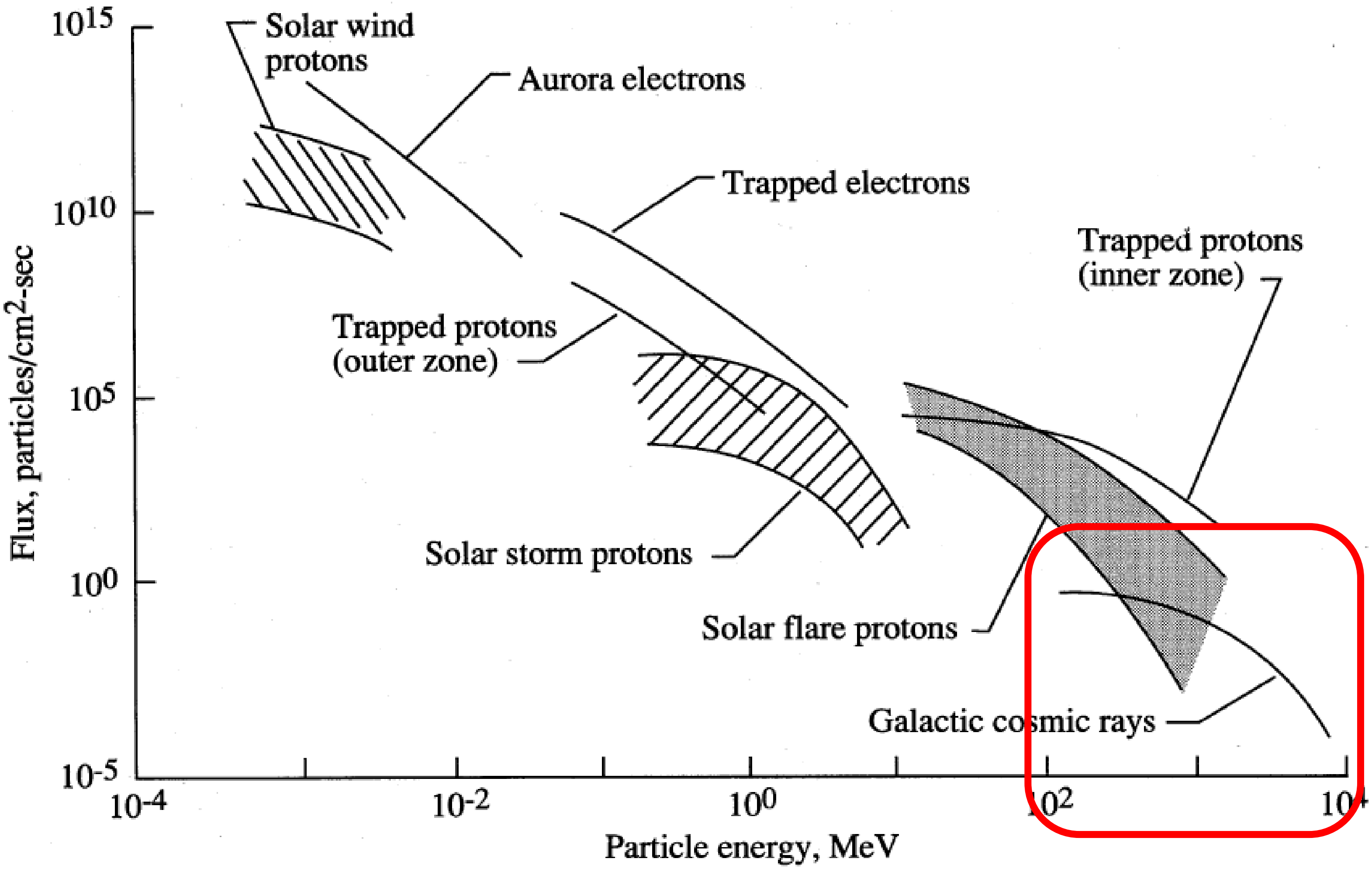
Outline

- Space radiation work at MSFC
- Sample Projects
- Sample Results using Geant4
- Remarks

Space Radiation Environment



- From Wilson *et al.*, NASA Reference Publications 1257 (1991)

Space radiation work at NASA-MSFC

- **Particle Detection**: Marshall designs, builds and tests/flight tests solid-state charged (protons from trapped, solar, and galactic origin) and neutral (neutrons-secondary products) particle detectors over a wide energy range
- **Shielding**: Exposure and characterization of candidate shielding materials to protons and heavy ions at various accelerators (e.g., IUCF and NASA's SRL)

Space radiation work at NASA-MSFC

- **Radiation Hardening**: Marshall with Vanderbilt Univ.'s ISDE developed an advanced, online radiation-effects-on-electronics simulation tool known as Crème (replaced the widely known, NRL developed) Creme96; https://crème.isde.vanderbilt.edu

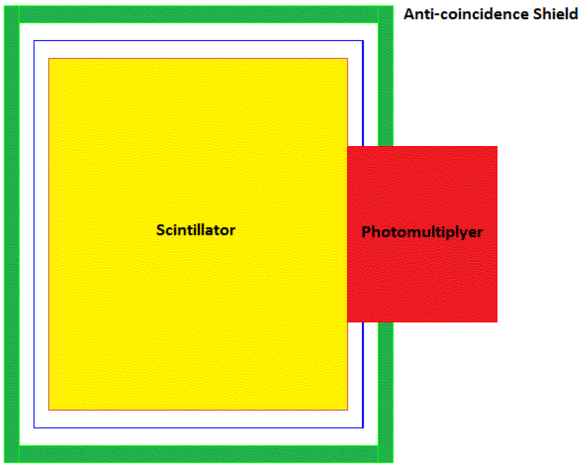
Space radiation work at NASA-MSFC

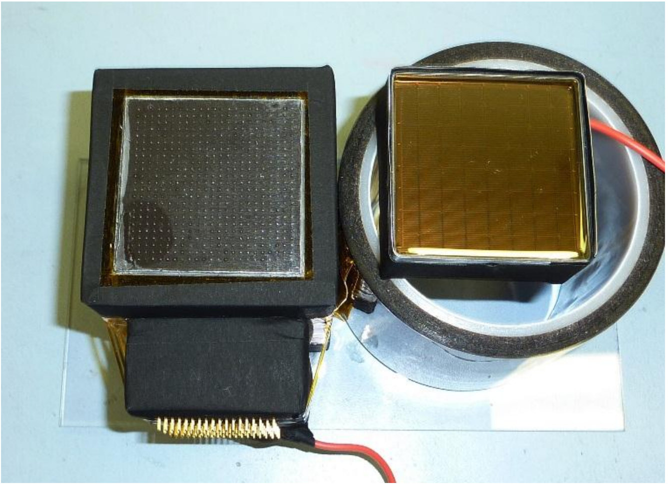
- **Prediction**: Marshall with UAH developed a state-of-the-art, near real time, an "all-clear" forecasting tool for solar flares, coronal mass ejections (CMEs) and solar particle events (SPEs), known as 'Mag4': http://www.uah.edu/cspar/research/mag4-page
- **Analysis & Simulation:** radiation environment modeling; detector response; radiation-transport; dose and shielding analysis

Sample Projects

Advanced Neutron Spectrometer (ANS)

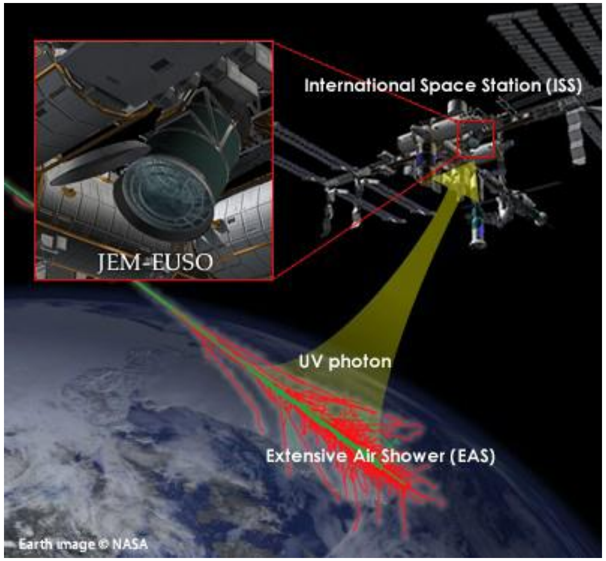
- ANS is an advanced radiation detection instrument that meet the requirements for future human exploration missions. Its objective is accurately measure the neutron spectrum on manned mission beyond the Low Earth Orbit (LEO)





JEM-EUSO

➢ The Japanese Experimental Module-Extreme Universe Space Observatory (JEM-EUSO) is an observatory that uses the earth's atmosphere as a detector to detect the extreme energy cosmic rays ~ 10^{20} eV.



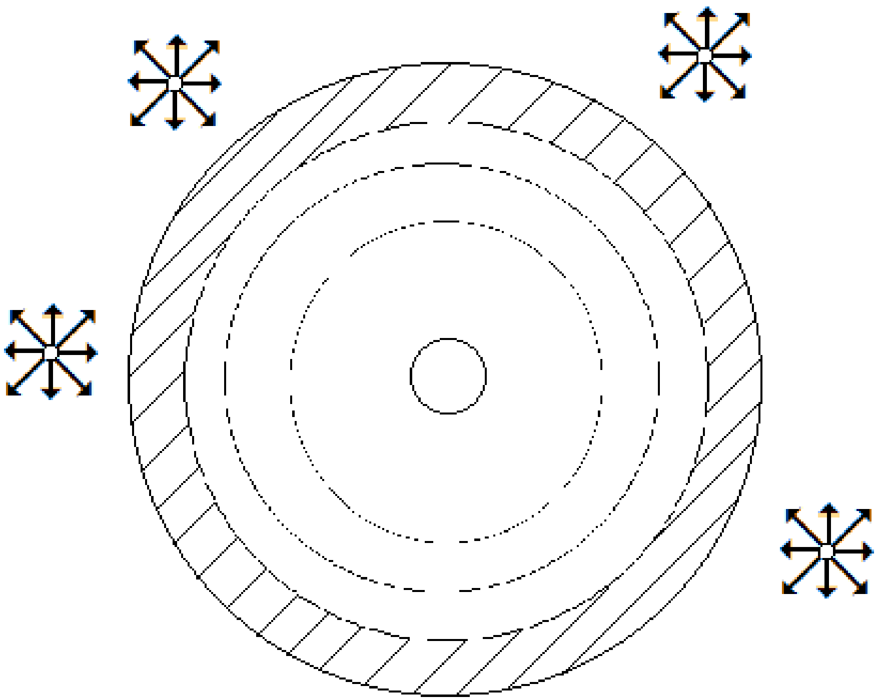
Sample Simulation Results using Geant4

Simulation Setup

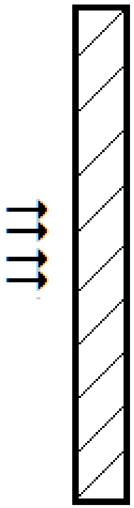
- Geant4 application is developed to simulate the interaction of different beams on different targets,
- For both configurations (Spherical-shell & Slab):
  - Incident beam: Proton and Iron,
  - Incident energy range: 0.2, 0.4, 0.6, 1.0 GeV/u,
  - Target: Al, Water,
  - Target thickness = 15 g/cm^2,
- Simulated energy spectra: e^+/e^-, γ, n, p, d, t, ^3He, α

Geometry configuration

(a) Isotropic radiation on spherical-shell shield



(b) Normal incident radiation on slab shield

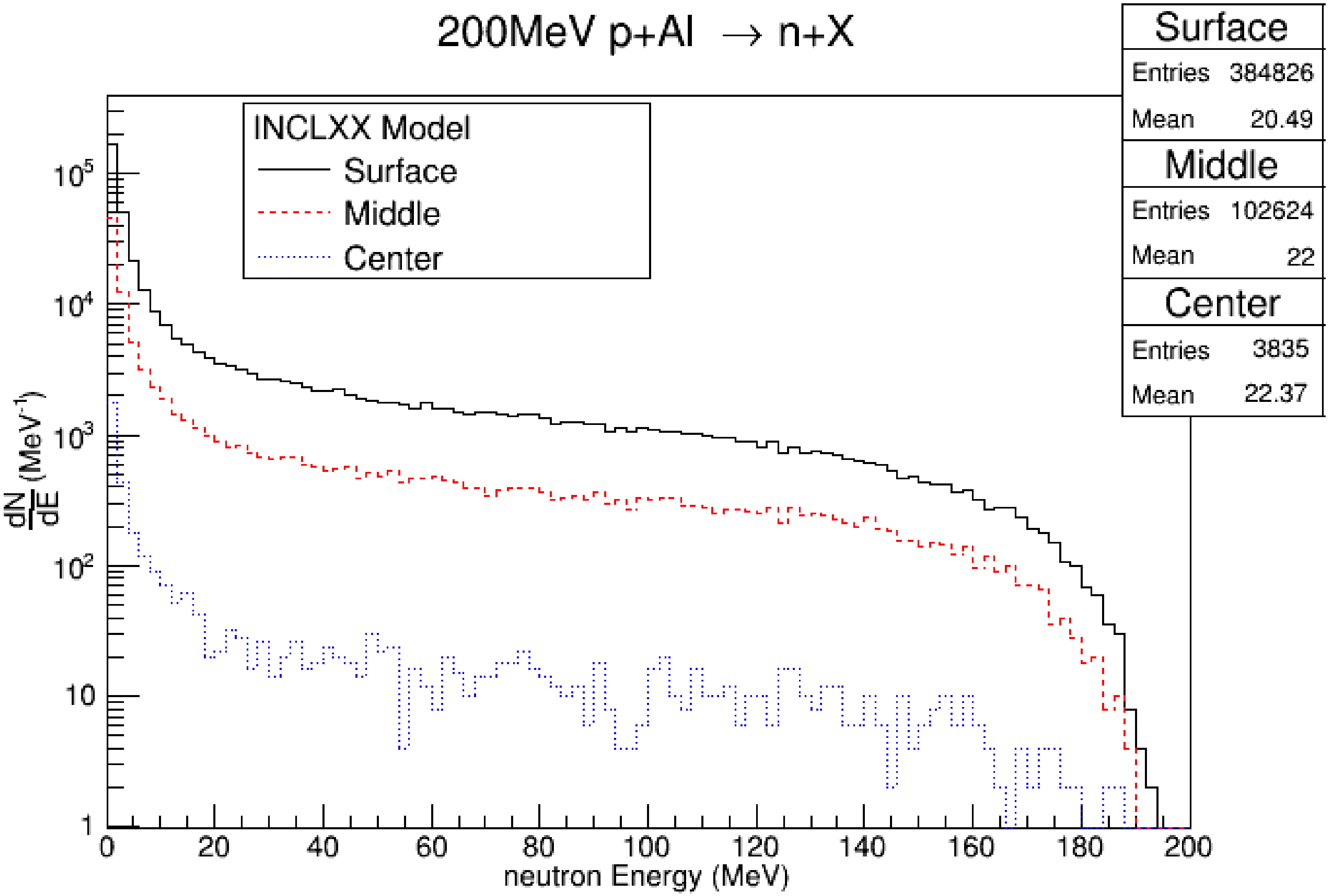


G4 Nuclear Physics Models

- The following nuclear physics models are tested:
  - a) G4-INCLXX: Updated version of the intranuclear cascade model (INCL++) that can handle heavy-ion collisions,
  - b) G4-Shielding: Based on Bertini model, and Quantum-Molecular-Dynamics (QMD) model,
  - c) Binary Cascade Model (BIC),

Simulation Results

Shell Configuration



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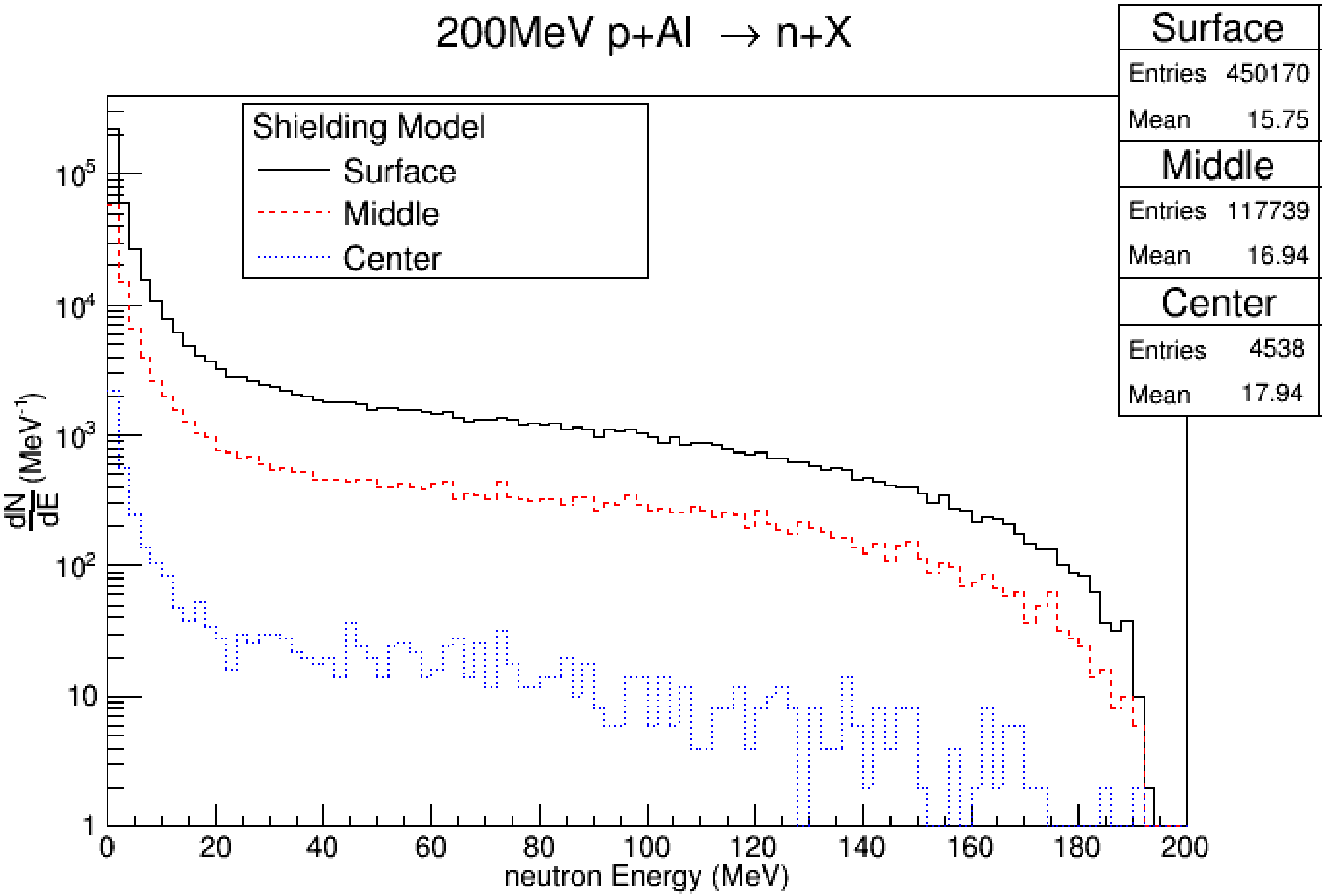

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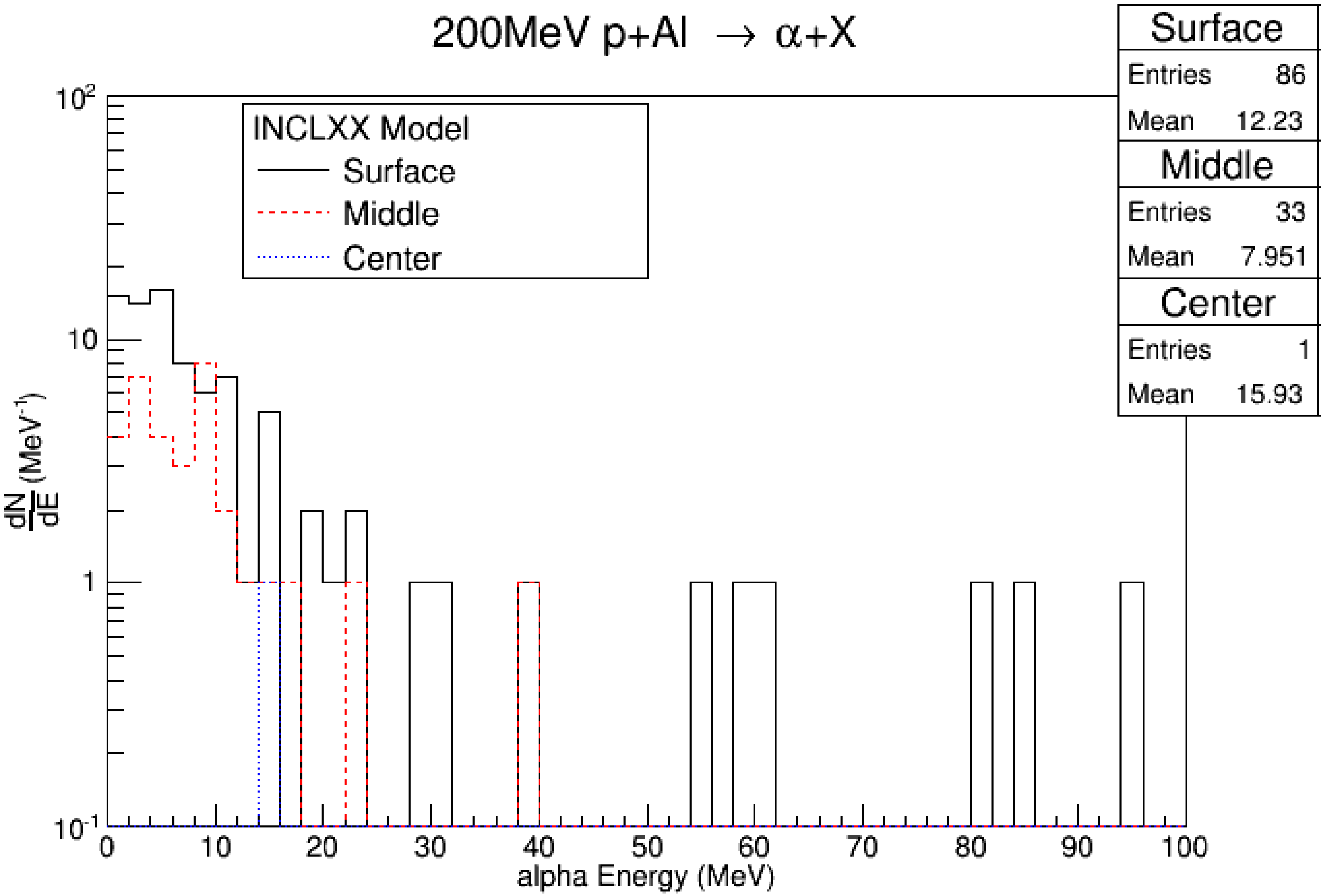

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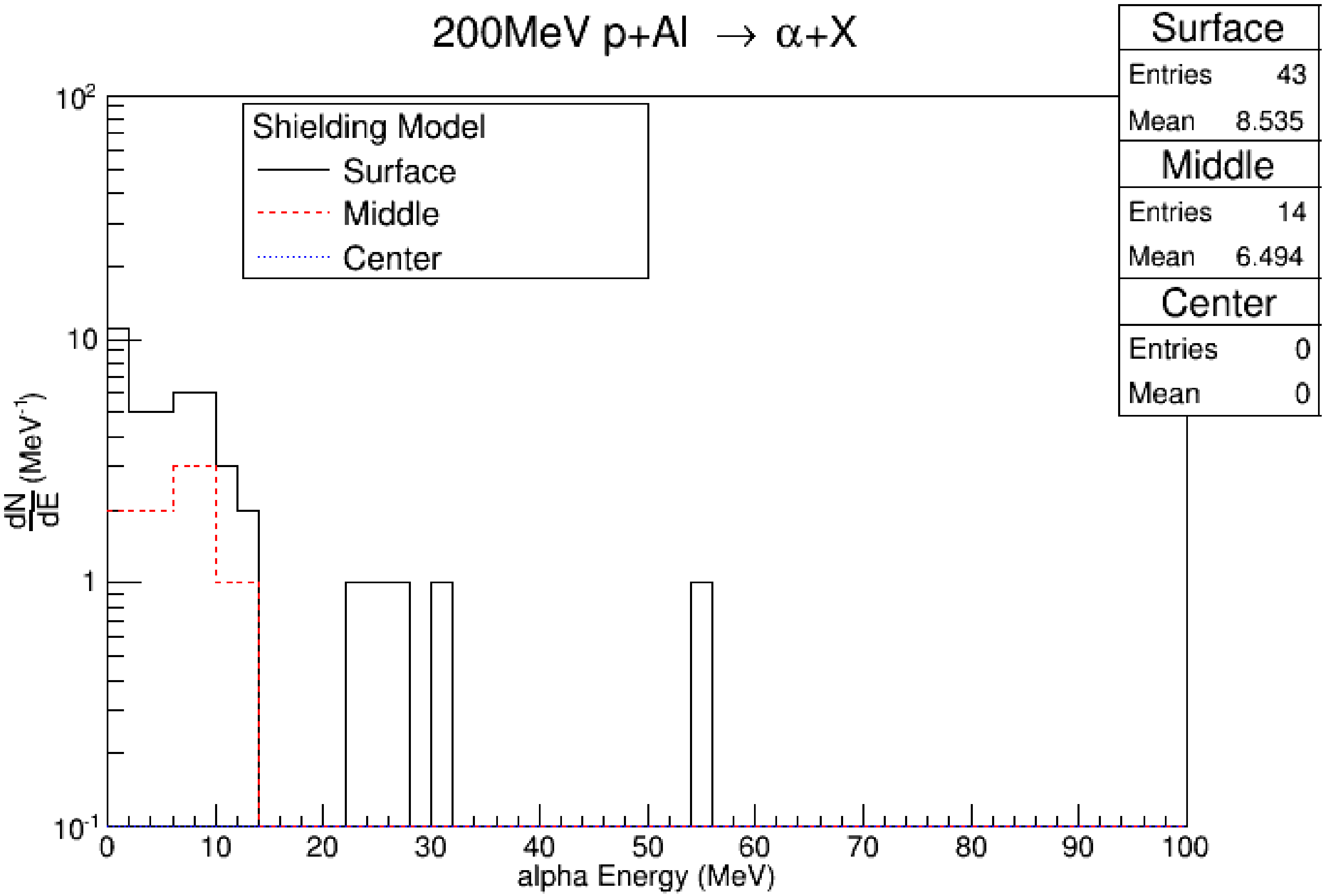

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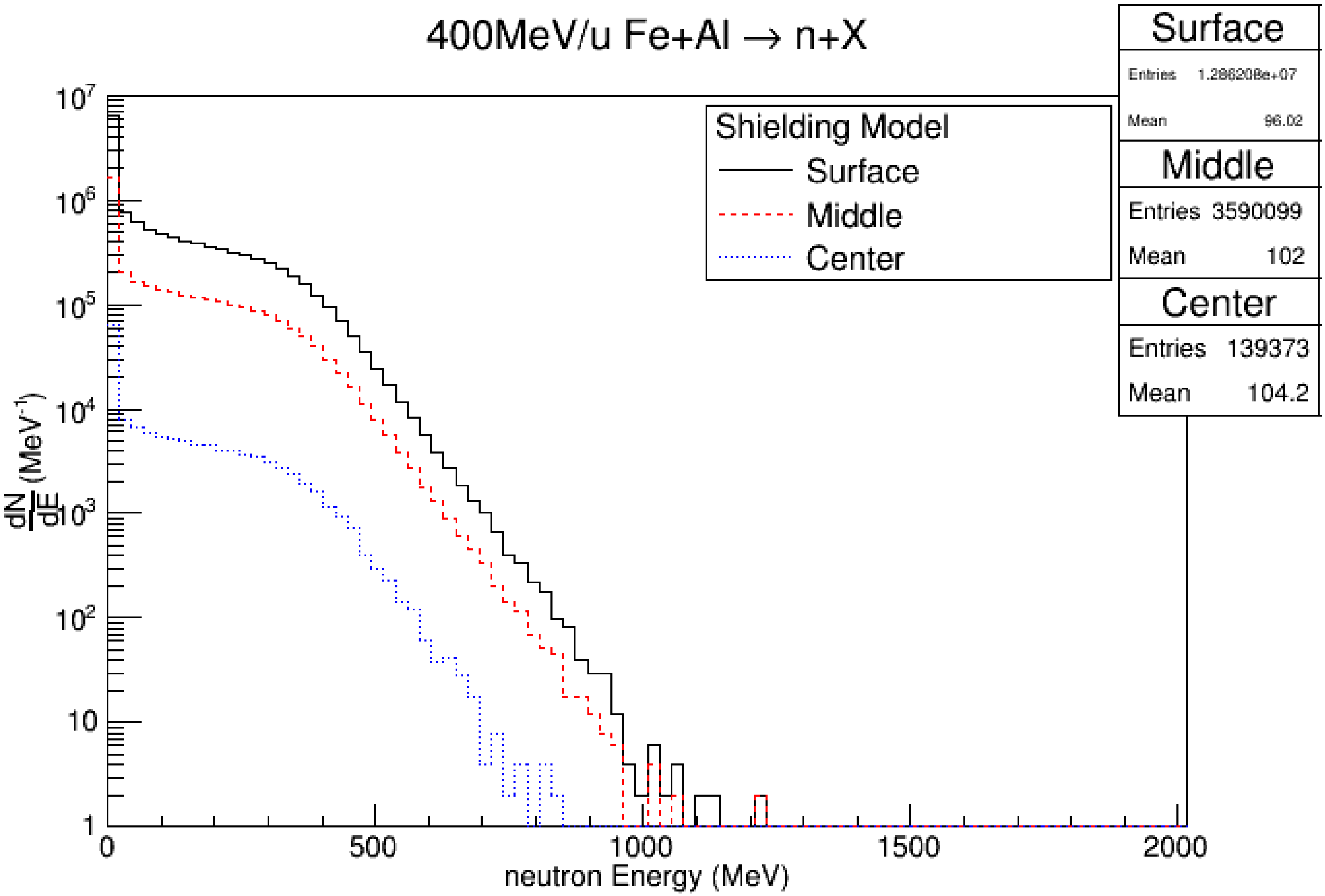

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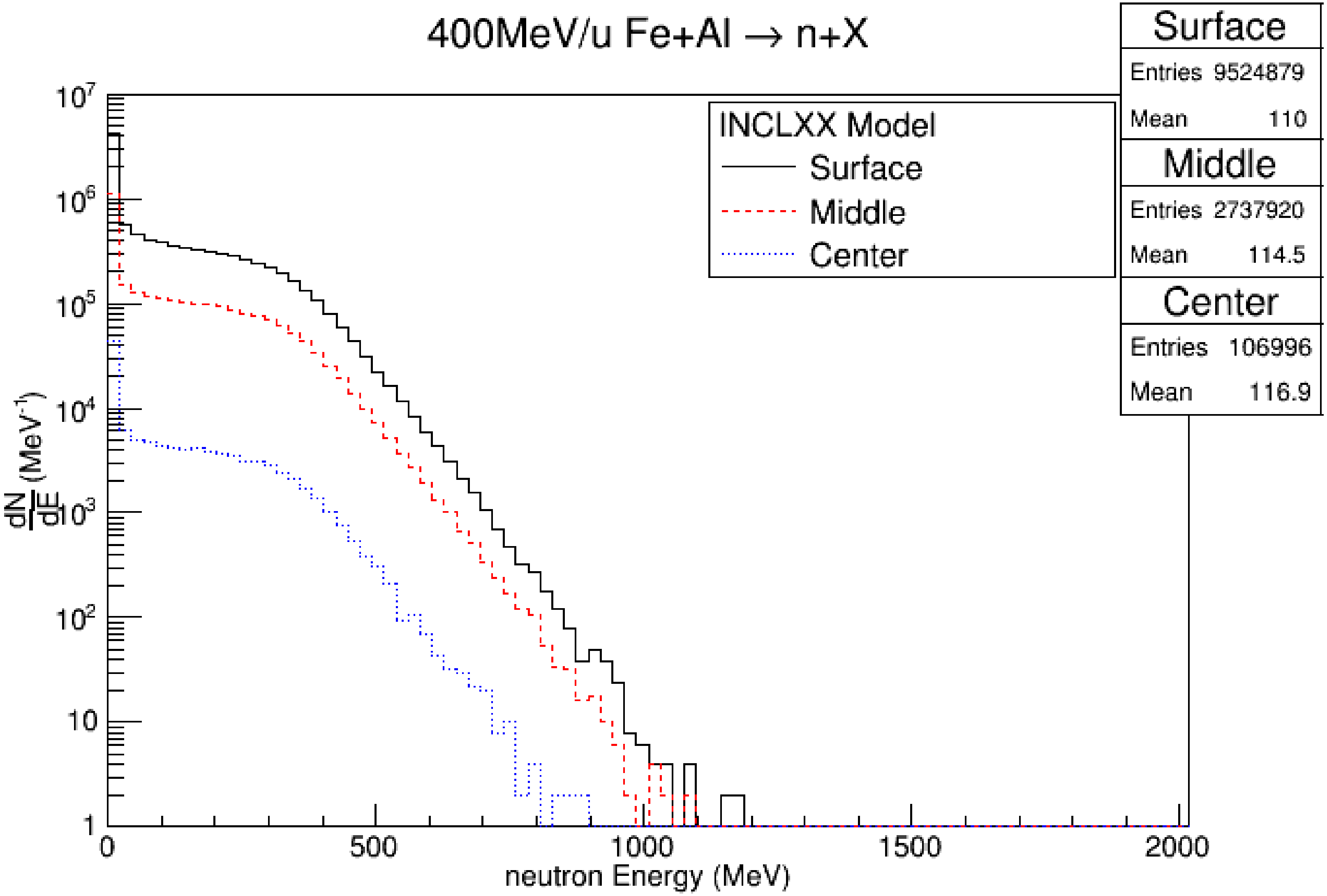
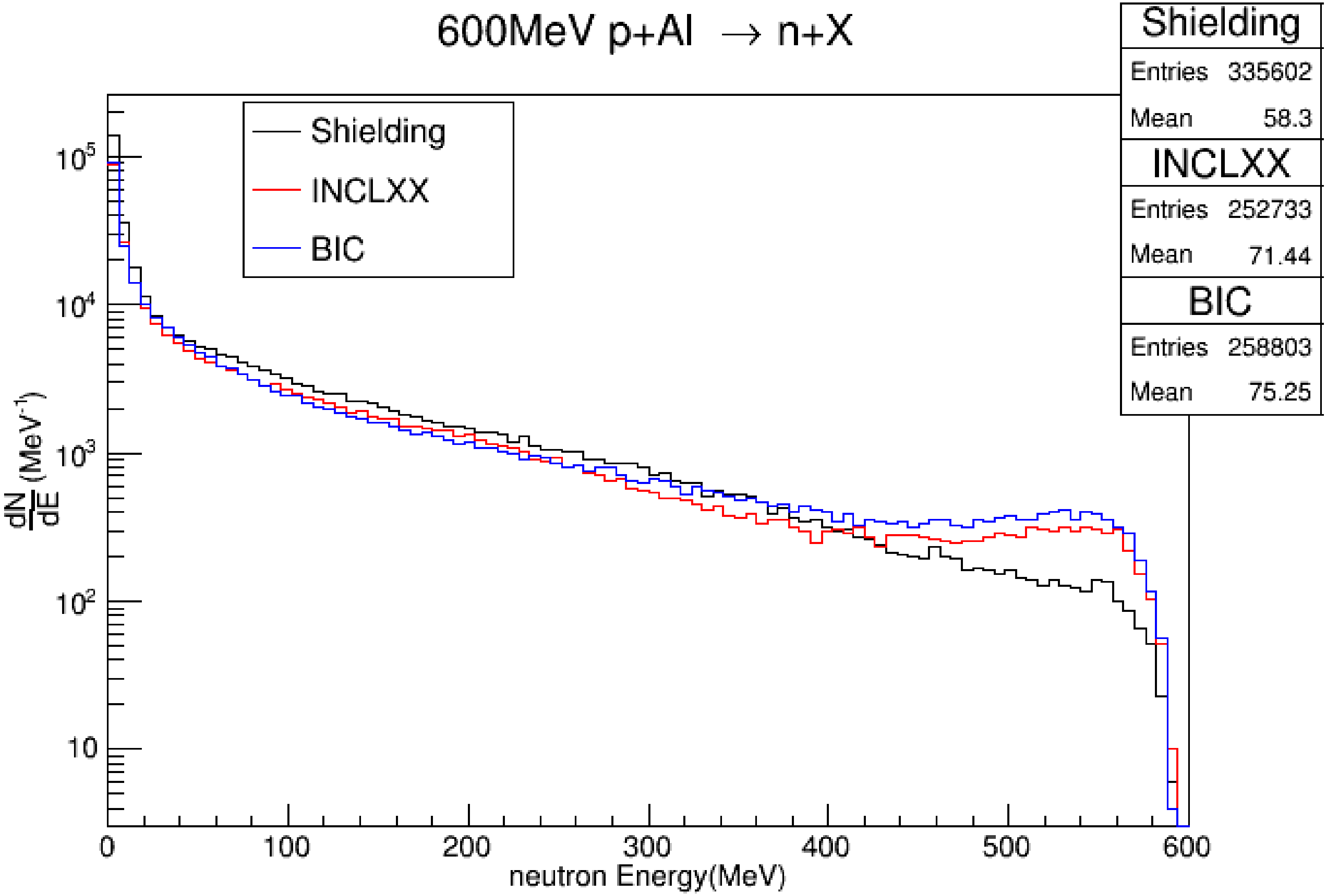
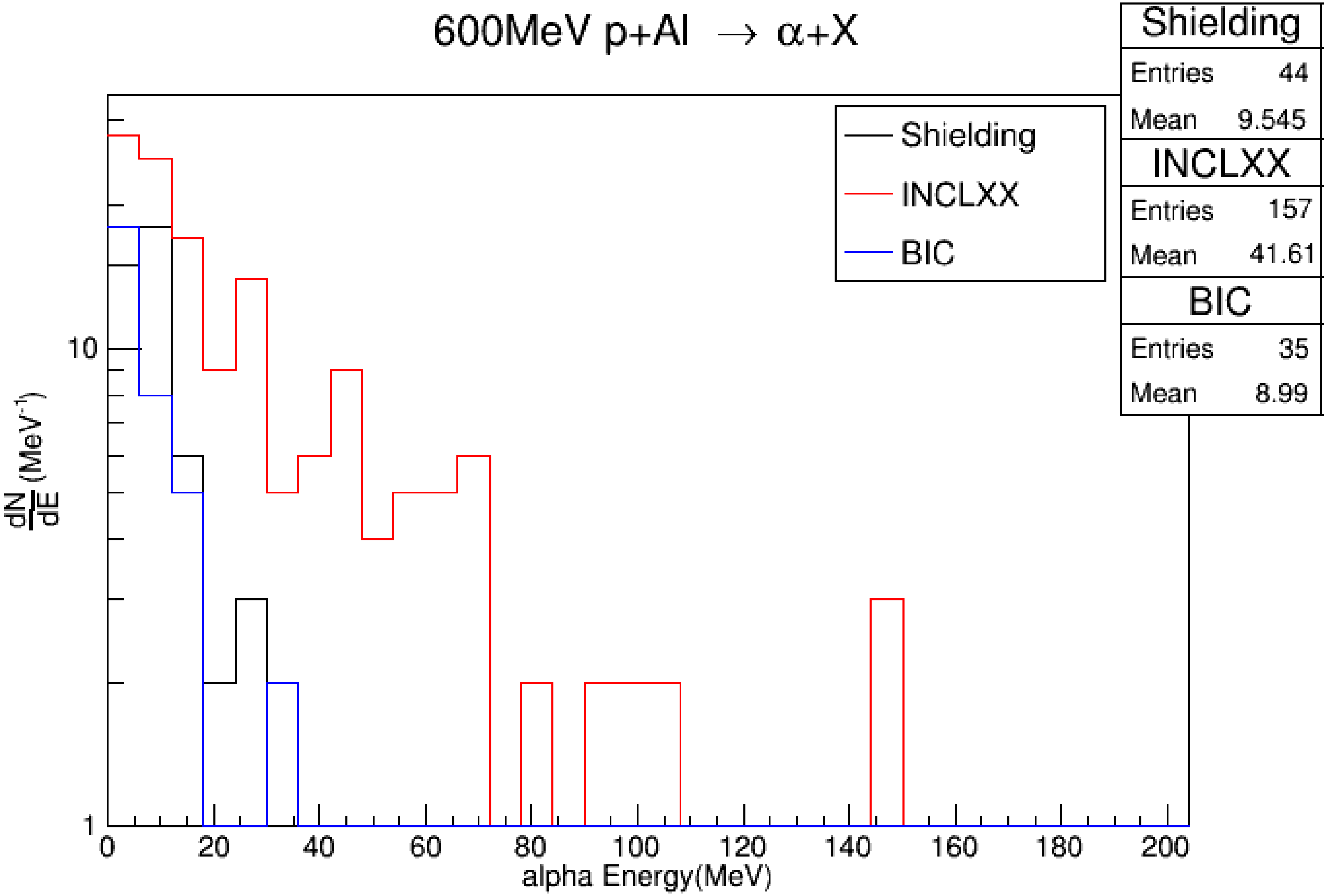


Slab Configuration



Slab Configuration



Remarks

- Prediction of neutron energies in p+Al reaction using Geant4 Models Shielding, INCLXX and BIC are in good agreement
- For alpha energy spectra, INCLXX shows better prediction than Shielding Model
- For Fe+Al reaction, both INCLXX and Shielding agree in predicting neutrons protons.
- MSFC will be hosting the 10^{th} Geant4 Space User Workshop, May 27-29,2014

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Thank You!

Questions ?