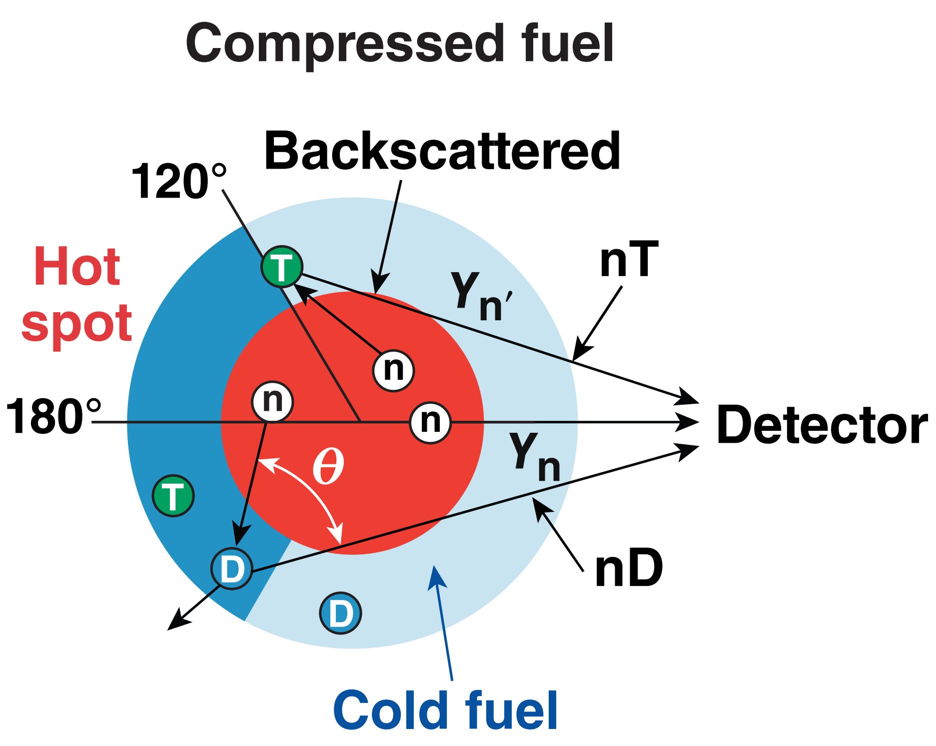
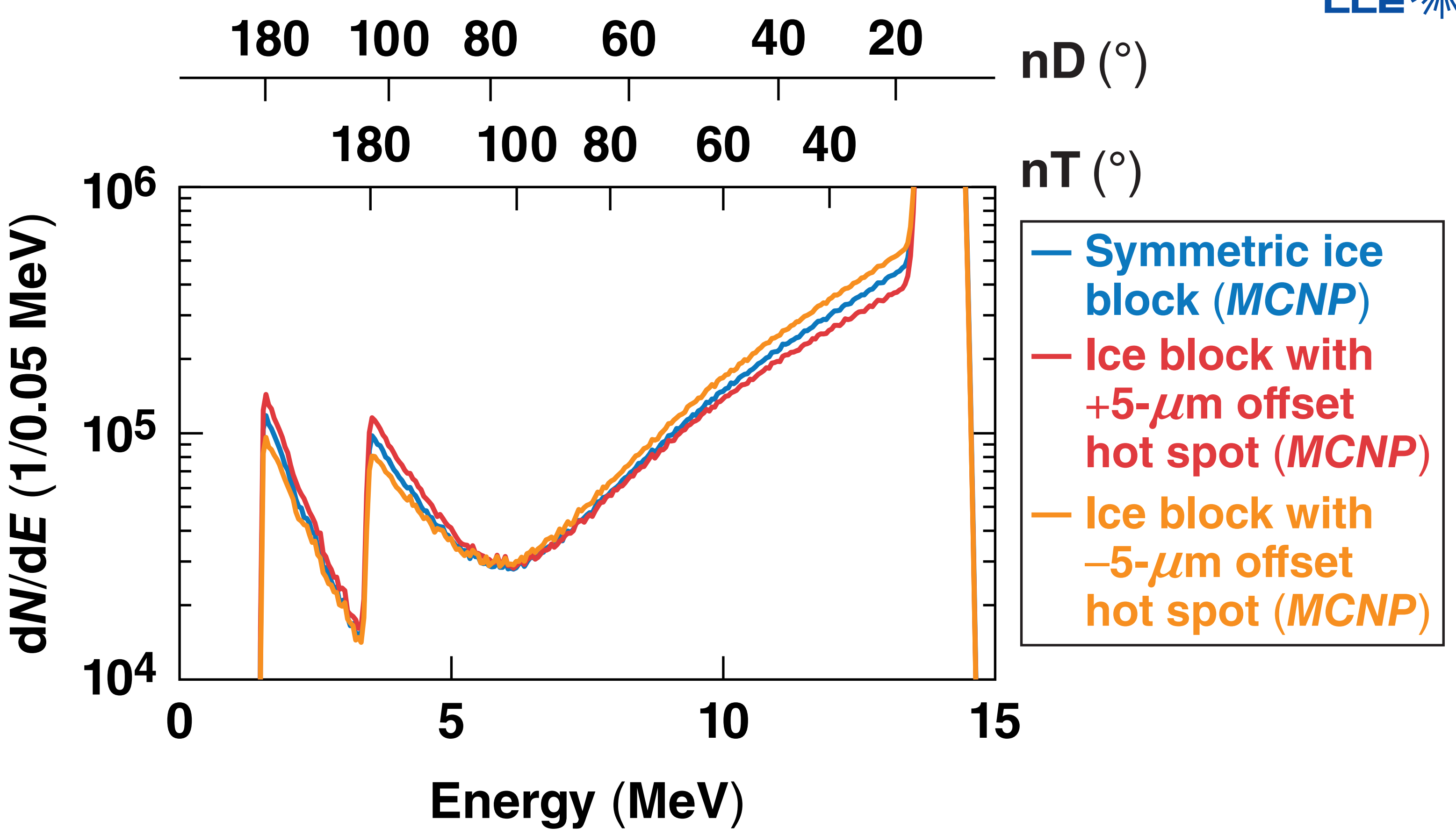
Effects of Hot-Spot Geometry on Backscattering and Down-Scattering Neutron Spectra





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59th Annual Meeting of the
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23–27 October 2017

Spectra from *MCNP* and *IRIS3D* are used to infer spatial ρR variation

UR LLE

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*F. Weilacher, P. B. Radha, and C. J. Forrest, "Three-Dimensional Modeling of Neutron-Based Diagnostics to Infer Plasma Conditions in Cryogenic Inertial Confinement Fusion Implosions," submitted to Nuclear Fusion.

Collaborators

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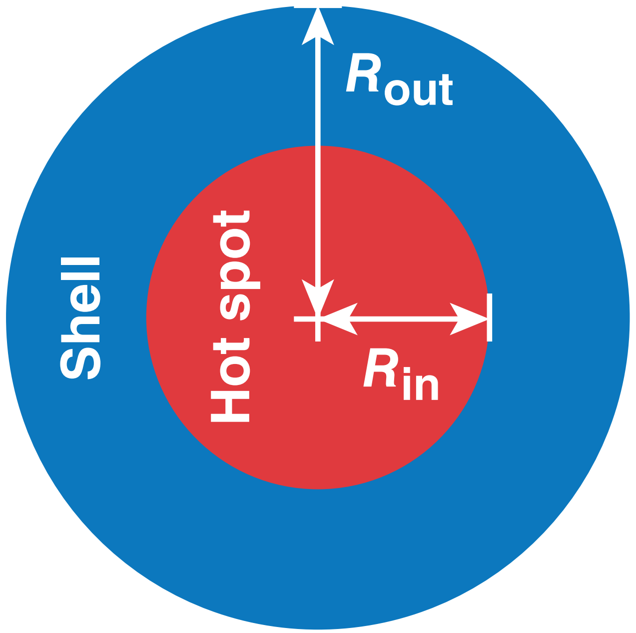
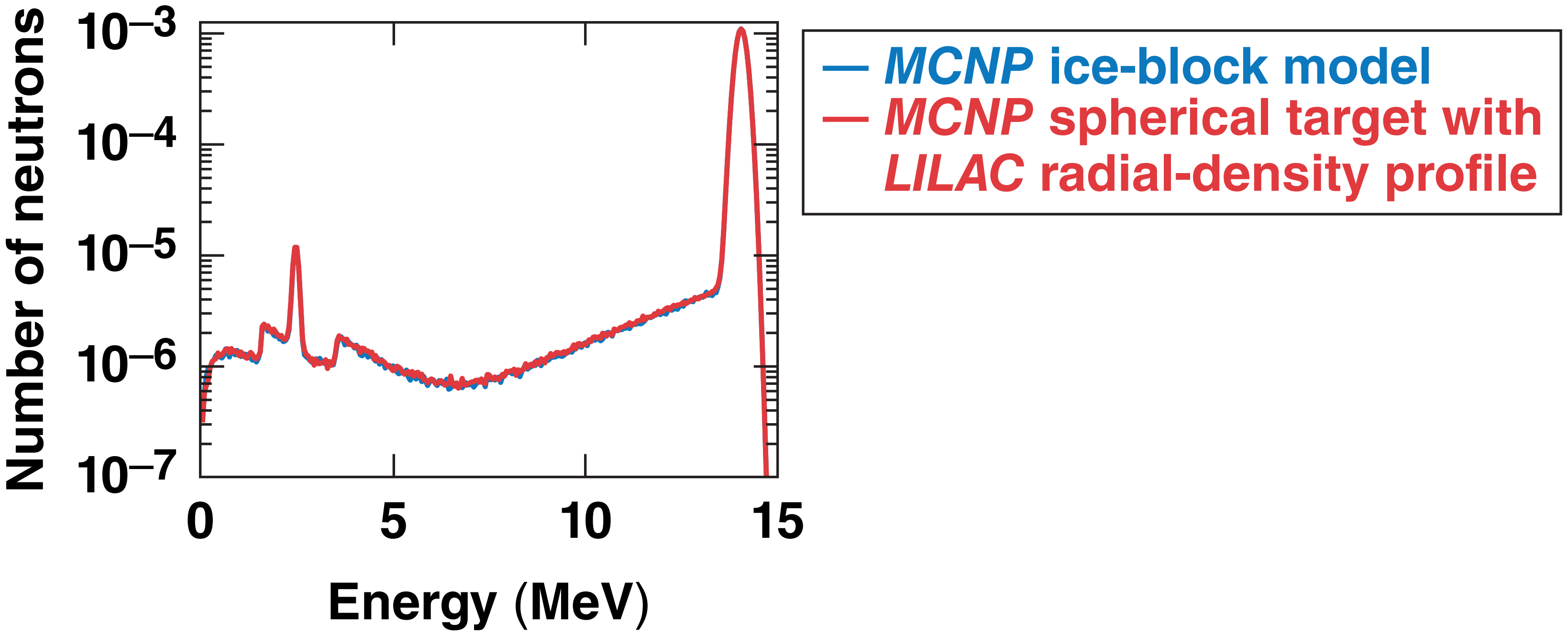
The ice-block model involves uniform densities of DT gas surrounded by DT ice

- Uniform density in the hot spot and shell
  - ρR_{shell} = 0.2 g/cm^2
  - ρ_{shell} = 100 g/cm^3 (20-eV shell), ρ_{hs} = 0.5 g/cm^3 (4-keV hot spot)
  - R_{in} = 25 μm, R_{out} = 45 μm
- Second radial-density profile from 1-D simulation (*LILAC*)

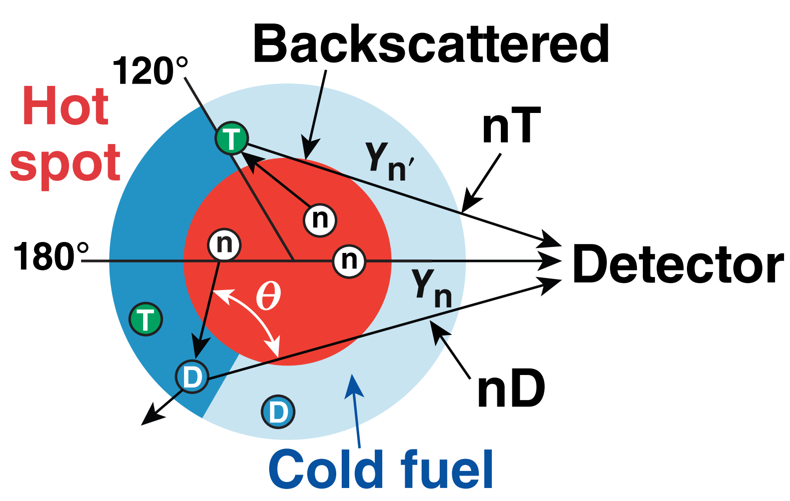




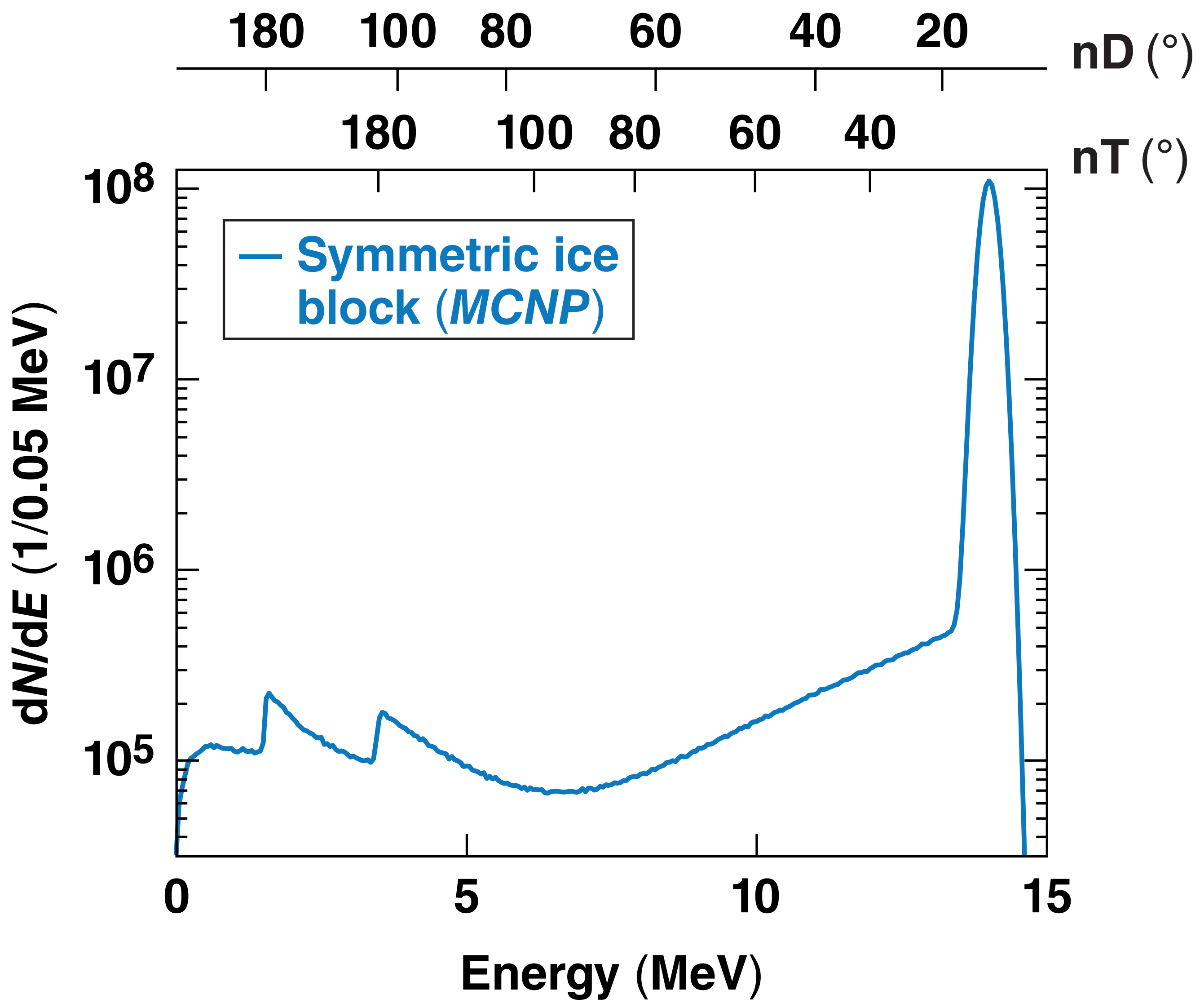
E26792

The neutron spectrum can be used to determine ρR distribution

- $N = Y_0 N_A \Omega \dfrac{\sigma_D f_D + \sigma_T f_T}{m_D f_D + m_T f_T} \rho R$
  - N represents elastic single scatters only
- Energy is related to scattering angle



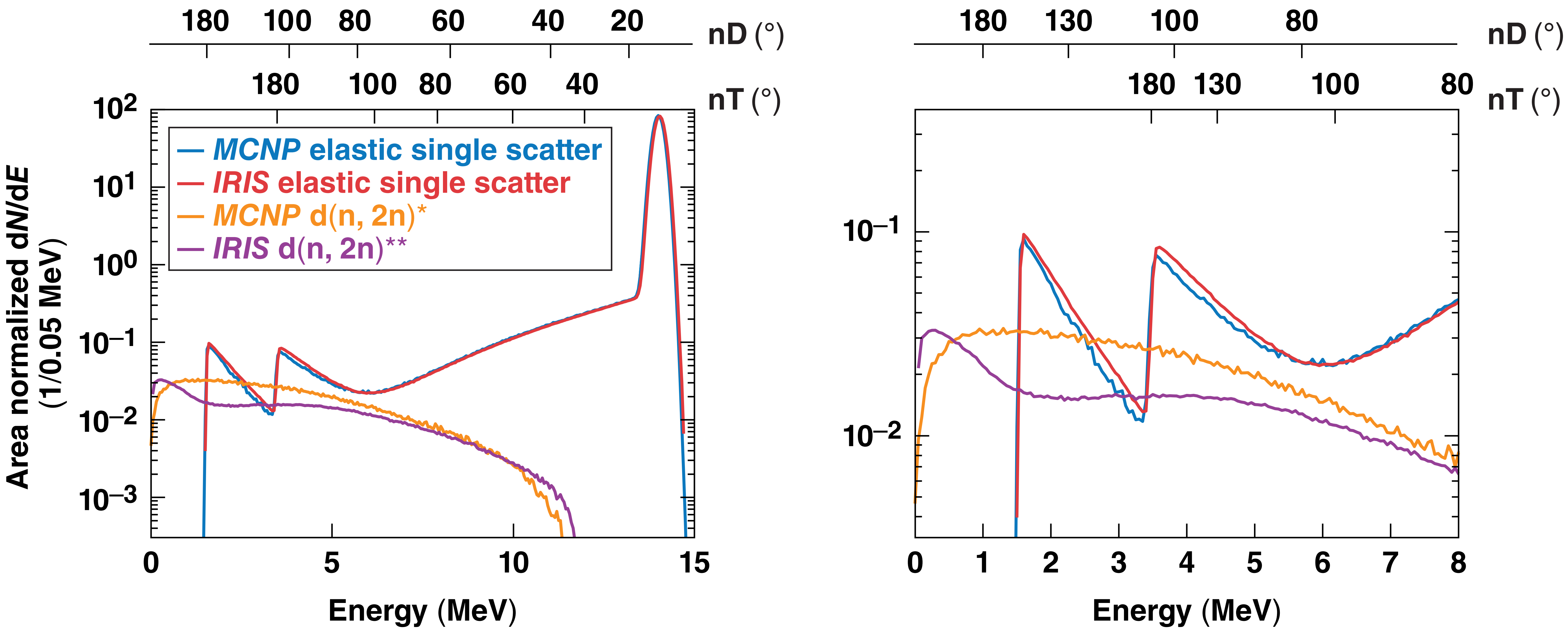
$$\cos\theta = \frac{E_0\left(1+\frac{m}{m_n}\right)+E_0\left(1-\frac{m}{m_n}\right)}{2\sqrt{E_0 E}}$$



E26793

MCNP and *IRIS* ice-block spectra differ in backscattering regions

- The difference in the (total) backscattering region is a result of different deuterium (n, 2n) cross sections

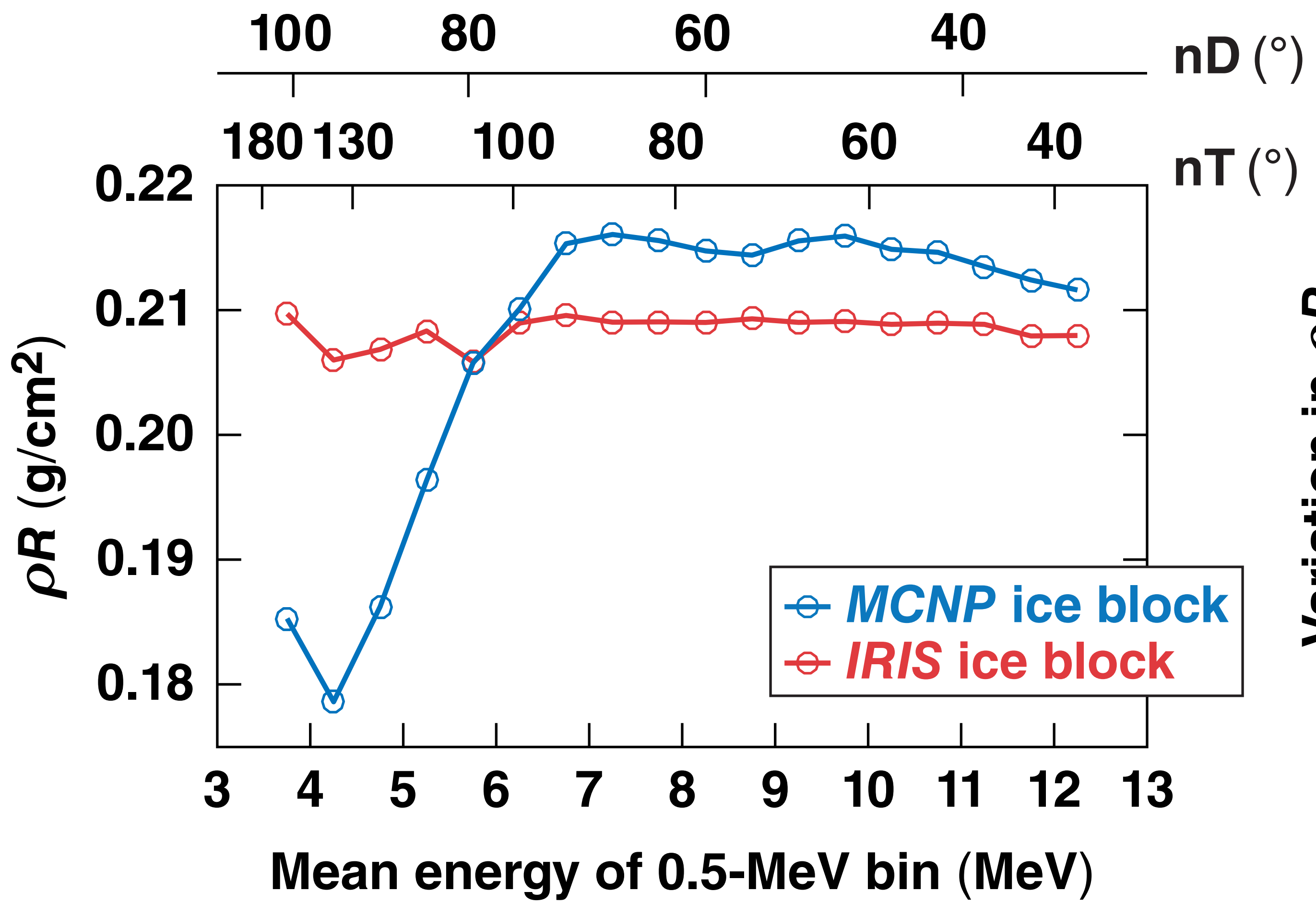


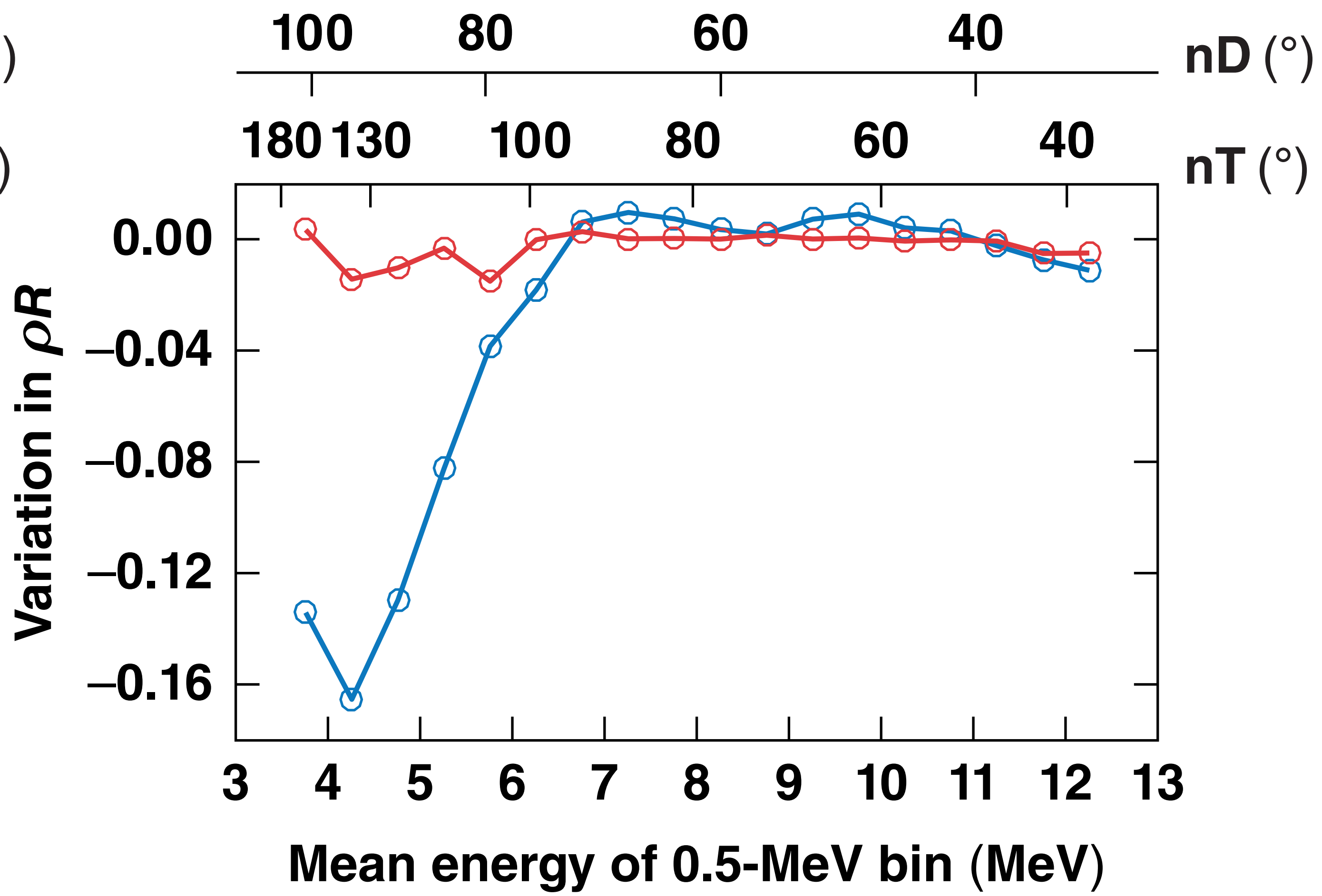
*Generalized three-body scattering **Deltuva *ab initio* calculation

E26824

MCNP and *IRIS* neutron spectra lead to a similar ρR for an ice-block model

- Noticeable differences in the nT scattering region (~3.5 to 6.0 MeV)
- Similar values of inferred ρR at $\geq$6 MeV
  - *IRIS* ~ 0.209 g/cm^2 (1.05 ρR_0) versus *MCNP* ~ 0.214 g/cm^2 (1.07 ρR_0)

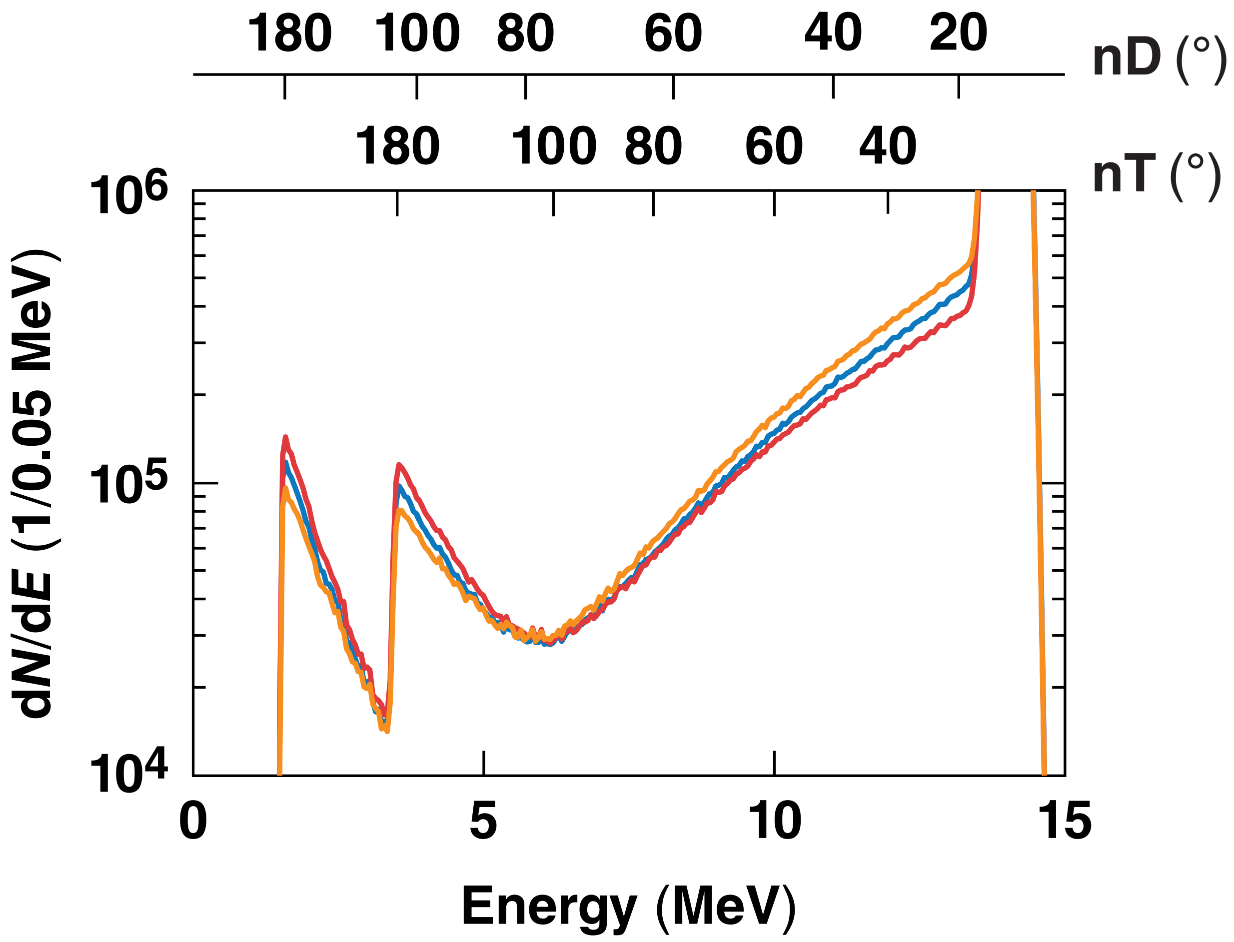


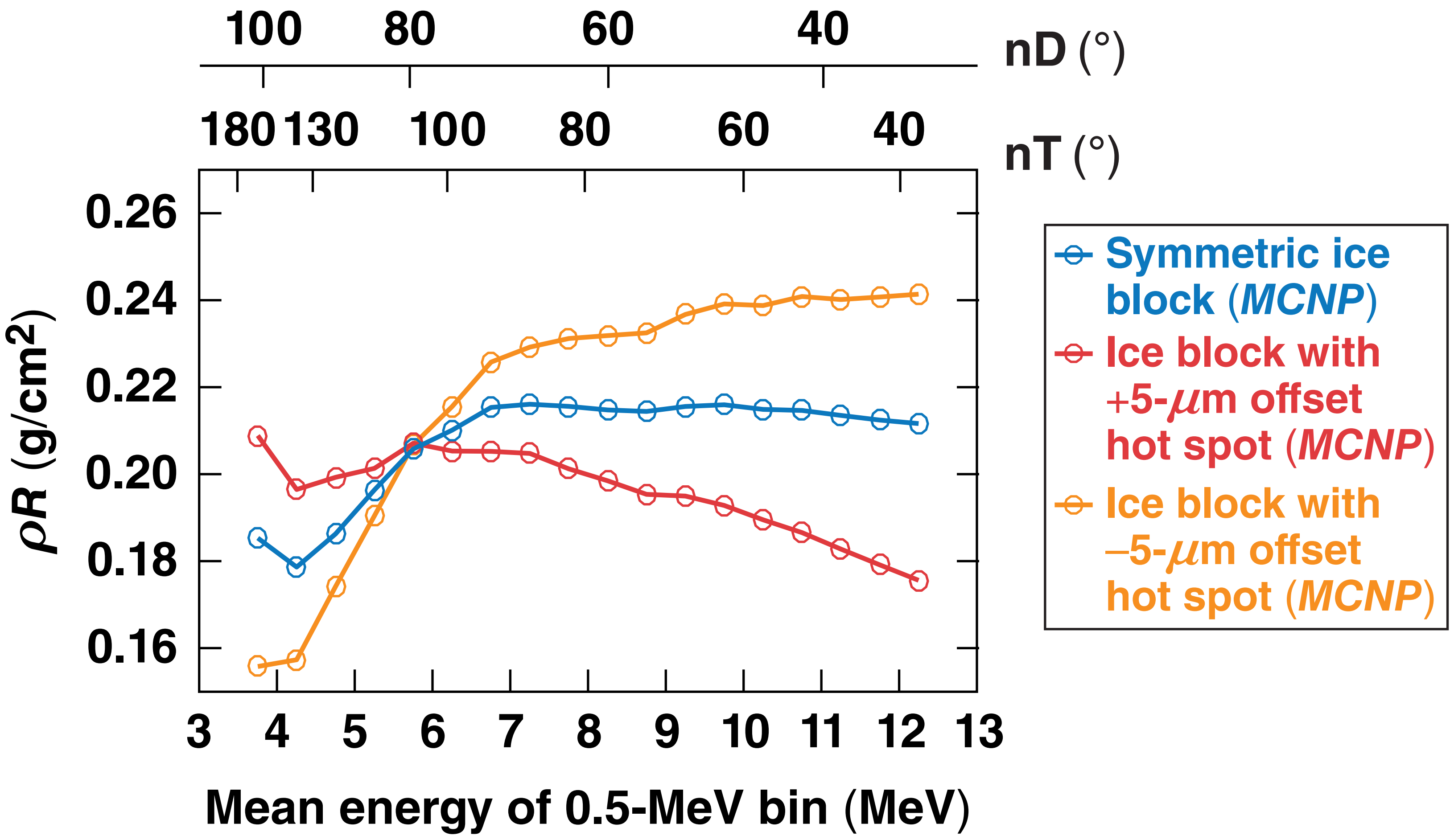


E26795

Offset hot-spot/asymmetrical ice thickness causes changes to elastic scattering and forward scattering

- The hot-spot offset is 5 μm toward or away from the detector
- Results for detection on line of sight of offset agree with *MCNP* simulations*



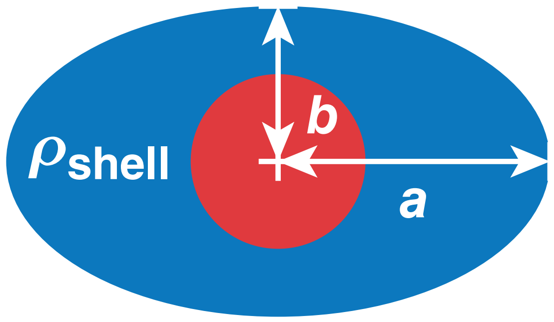


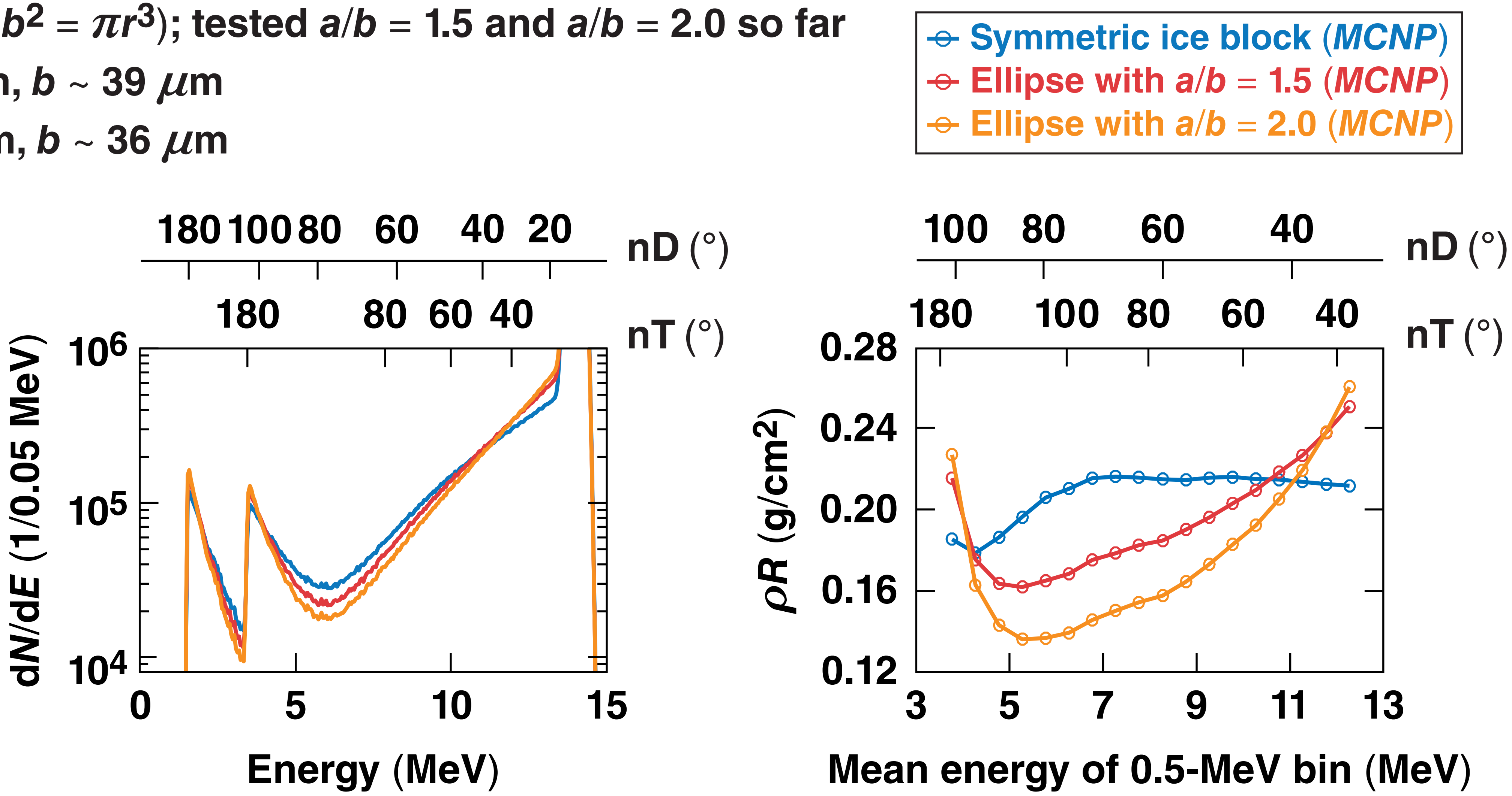
*C. J. Forrest *et al.*, JO4.00005, presented at the 56th Annual Meeting of the APS Division of Plasma Physics, New Orleans, LA, 27–31 October 2014.

E26796

Perturbations in shell shape can be simulated by modeling the ice as an ellipse

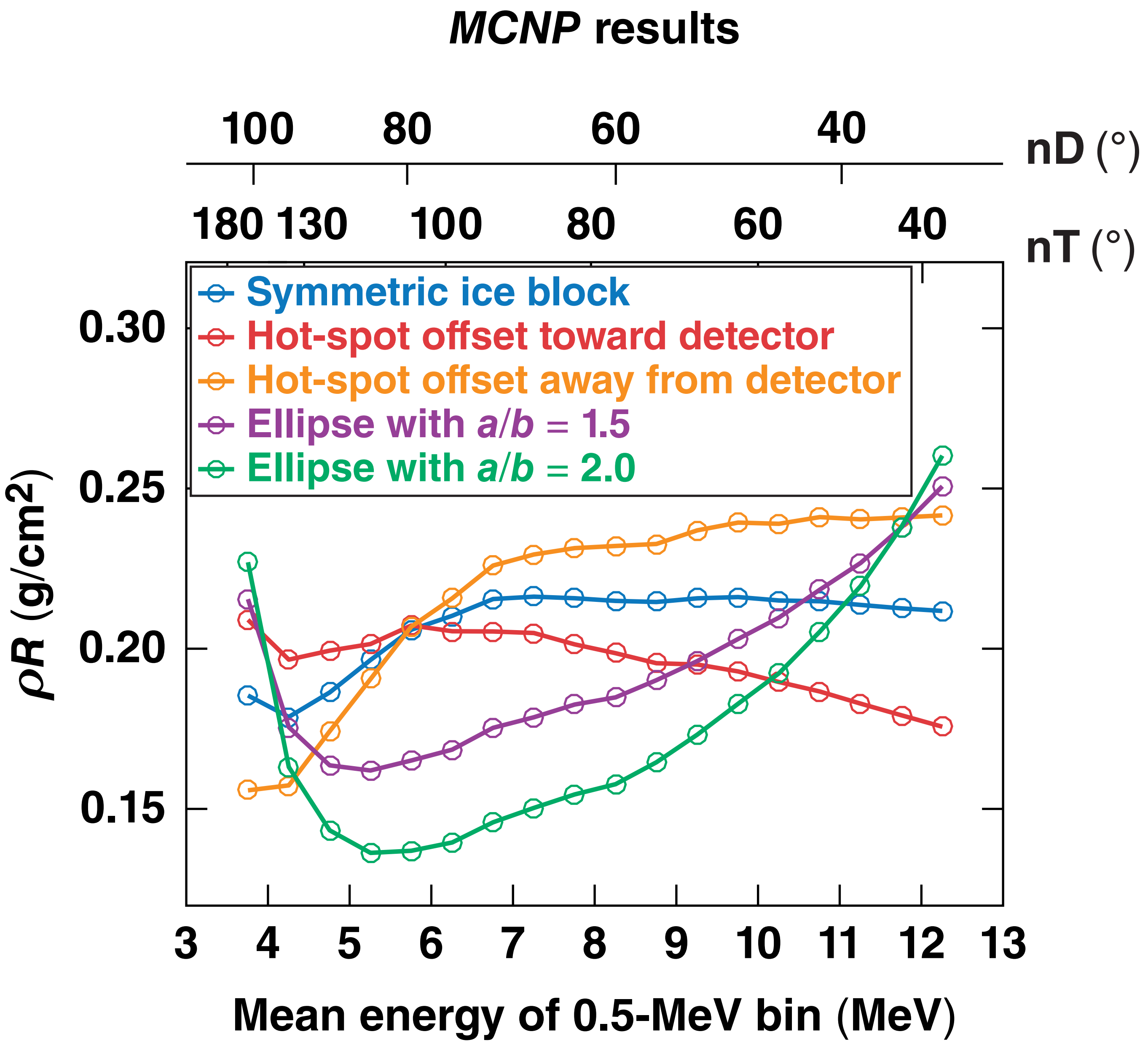
- The spherical hot spot is surrounded with elliptical ice
- Volume conserved ($\pi ab^2 = \pi r^3$); tested a/b = 1.5 and a/b = 2.0 so far
  - a/b = 1.5: a ~ 59 μm, b ~ 39 μm
  - a/b = 2.0: a ~ 71 μm, b ~ 36 μm

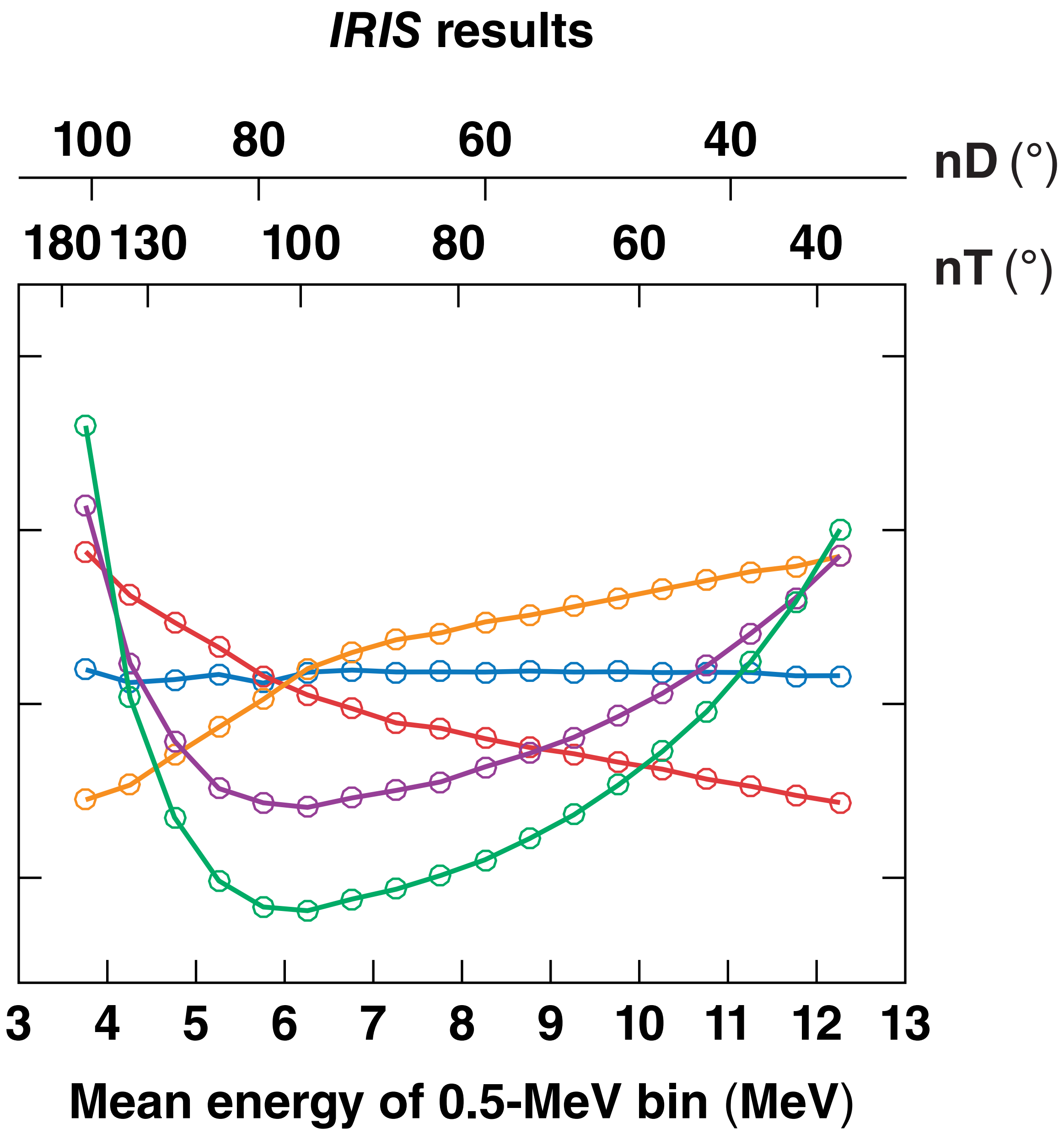




E26797

Both *MCNP* and *IRIS* results show the expected trends for the relevant cases

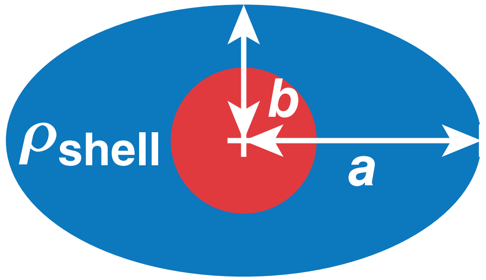




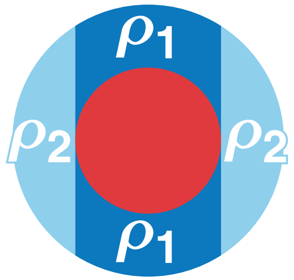
E26799

The perturbation in the ice shape can be distinguished from variations in the density of a spherical target

- Can we distinguish between elliptical ice and "elliptical" density in spherical ice?

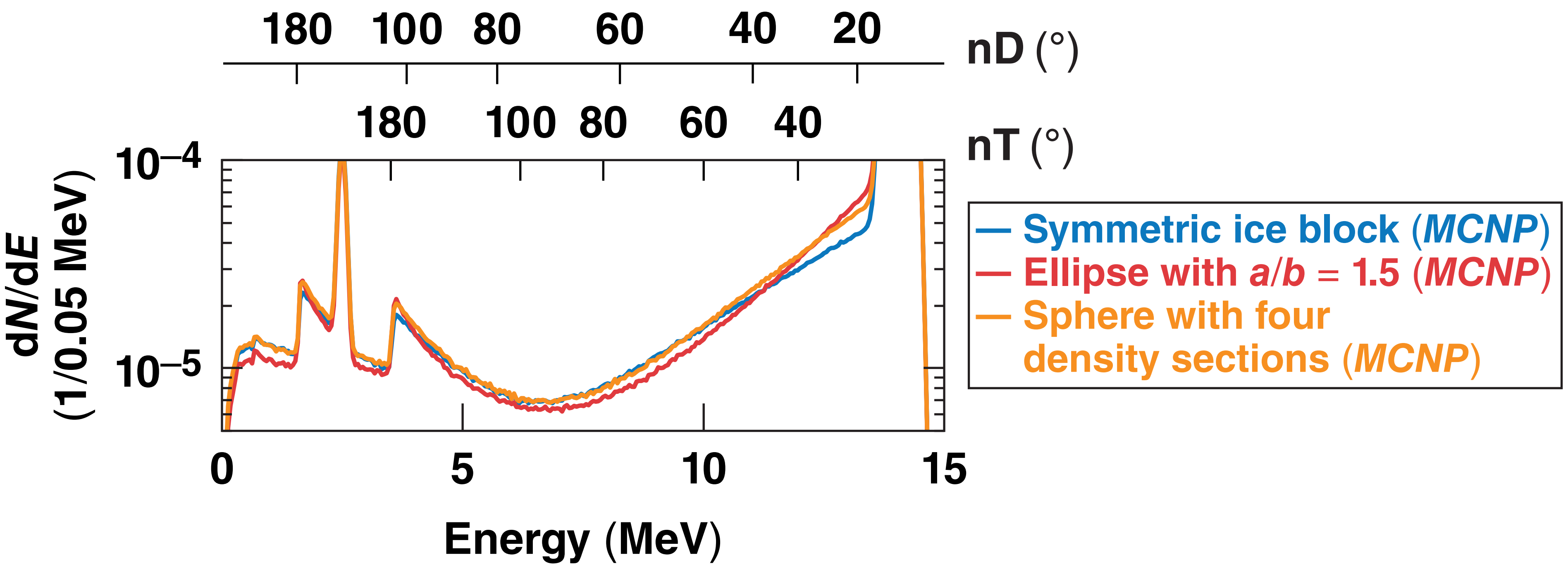


Versus



$$\frac{\rho_1}{\rho_0} = \frac{b}{r}, \frac{\rho_2}{\rho_0} = \frac{a}{r}$$

- Spherical ice with variable density is very similar to a regular ice-block model up to 10 MeV



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