Benchmarking of Heavy Ion Transport Codes

Remec, I.
Oak Ridge National Laboratory[1]
Oak Ridge, TN 37831-6172, USA

Ronningen, R. M.
Michigan State University
National Superconducting Cyclotron Laboratory
East Lansing, MI 48824-1321, USA

SUMMARY

The next generation of rare isotope beam (RIB) facilities is anticipated to use primary beam powers up to 2 orders of magnitude greater that those being handled at currently operating RIB facilities. A Facility for Rare Isotope Beams (FRIB) at Michigan State University, expected to be completed by 2020 at the cost of $550 million, will be based on a driver linear accelerator capable of accelerating light and heavy ions with beam powers up to 400 kW and a specific energy of 200 MeV/nucleon for uranium ions.

Interactions of energetic heavy ion beams with a target, beam dumps, catchers, and other structures produce intense fields of neutrons, gamma rays, and other secondary reaction products. Accurate prediction of radiation fields, activation, helium production, radiation damage, and heat deposition in facility components and structures is essential for design and operation of the facility.

Simulations of heavy ion interactions and resulting radiation fields can be performed with codes such as PHITS, MCNPX, FLUKA, HETC-HEDS, MARS, and GEANT4. Despite significant recent progress in computer resources and in Monte Carlo codes, such simulations are computationally intense and challenging and the need for further intercomparisons and benchmarking is often emphasized [*1*].

This paper will discuss recent benchmarking efforts, performed in preparation for FRIB R&D and design work. One of the processes of primary interest is neutron production from heavy ion interactions, because it usually drives shielding requirements and activation. An example of the comparison of calculated and measured double-differential neutron spectra from 600 MeV/nucleon Si ions interacting in a Cu target is shown in Fig. 1. The experimental data are from [*2*], and the simulation was performed with the MCNPX code [3]. Similar comparison of the simulation results obtained using the PHITS code with the measurements for the 600 MeV/nucleon Si ions interacting in a C target is shown in Fig. 2 [*4*]. Intercomparison and benchmarking of other quantities relevant for the FRIB R&D and design work will be discussed.

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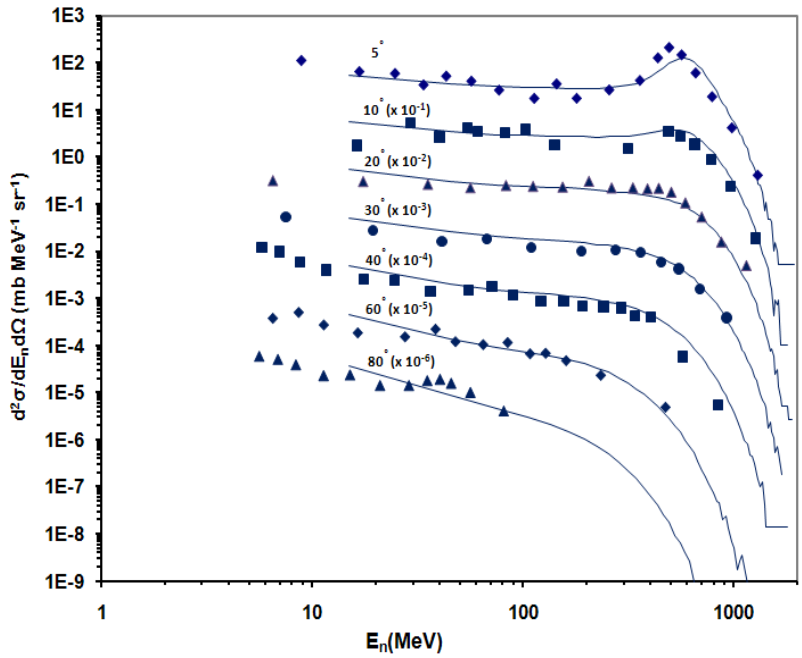

Figure 1. Double-differential neutron spectra from 600 MeV/nucleon Si ions interacting in a Cu target. The spectra at each laboratory angle are offset by the indicated factors of 10. Results from MCNPX simulation denoted by lines are compared with measurements shown as symbols.

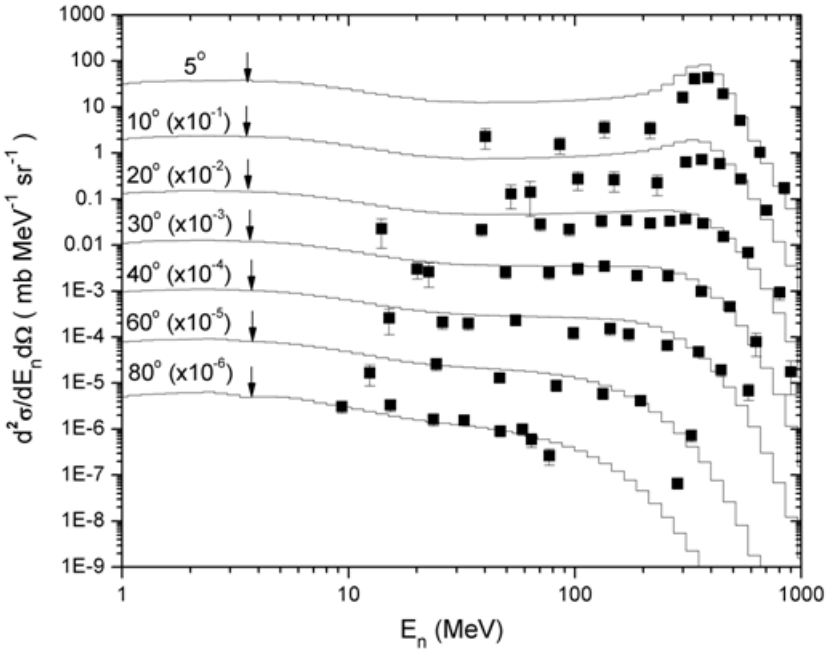

Figure 2. Double-differential neutron spectra from 600 MeV/nucleon Si ion interacting in a C target. The spectra at each laboratory angle are offset by the indicated factors of 10. Results from PHITS simulation denoted by lines are compared with measurements shown as symbols.