Improvements to DCHAIN-SP and its data libraries

*Hunter Ratliff[1], Chikara Konno[1], Norihiro Matsuda[1] and Tatsuhiko Sato[1]
[1]Japan Atomic Energy Agency

DCHAIN-SP, the radionuclide build-up and decay code distributed alongside the PHITS particle transport code, is being updated with modern data libraries and calculation features, the most important being propagation of statistical uncertainties in its input data to the reported nuclide inventories, activities, decay heat, and gamma-ray spectra. These data library and feature updates will be detailed in this presentation.

Keywords: PHITS, activation calculation, uncertainty, nuclear data

1. Introduction

PHITS, the Particle and Heavy Ion Transport code System, is a general purpose Monte Carlo particle transport code capable of a wide variety of calculations, including nuclide production through spallation, neutron capture, and other common reactions. However, PHITS only considers short time spans designed for observing nuclear reactions, meaning it cannot simulate radionuclide build-up and decay; DCHAIN-SP was built explicitly for these build-up and decay calculations though. The two codes can be used together to simulate the production, build-up, and decay of nuclides.

2. DCHAIN-SP data library improvements and uncertainty implementation

The current version of DCHAIN-SP distributed with PHITS utilizes somewhat dated data libraries—the decay data largely consisting of 1980s and 1990s evaluations and the neutron reaction cross section library being from a 2005 evaluation. This work has modernized both libraries in DCHAIN-SP to evaluations from the past five years (including JENDL/DDF-2015, JENDL/AD-2017, and ENDF/B-VIII.0), updating the decay data for all previously supported nuclides and expanding the total number of supported nuclides from 3144 to 4013, primarily adding many exotic, short-lived nuclides. Shown in the example calculation in Fig. 1, notable differences exist in the data for some nuclides. These updates and more differences between data libraries will be further detailed in the presentation.

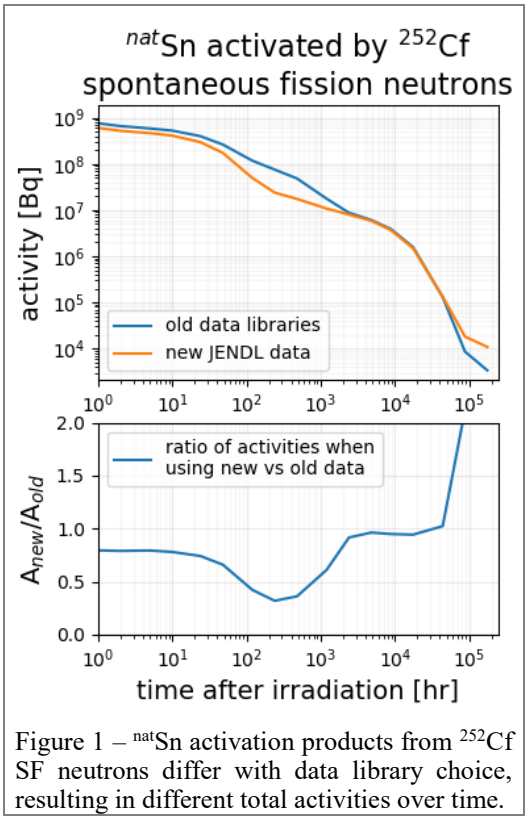

Figure 1 – ^{nat}Sn activation products from ^{252}Cf SF neutrons differ with data library choice, resulting in different total activities over time.

The nuclide yields and neutron fluxes produced by PHITS, then used in DCHAIN-SP, contain statistical uncertainties which DCHAIN-SP currently does not propagate through its build-up and decay calculations, allowing users to, sometimes mistakenly, interpret its results as being of high statistical clarity. This research adds this uncertainty propagation functionality, resolving that concern. Other improvements include an updated empirical model for predicting positron emission probabilities for competing β+ and electron capture decays where that data was absent from the decay data libraries and the ability for users to select between a variety of data libraries to use in their calculations.

3. Conclusion

These updates to DCHAIN-SP modernize its data libraries and allow for easier and faster assessment of the statistical validity of reported results. They will be released alongside a future version of PHITS.