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Improved Analysis of Verification Data Using List Mode Neutron Data Collection

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Neutron timing information in the form of shift register data, which consists of total neutron counts and coincidences, has been utilized for safeguards verification measurements for decades. Mass determination of uranium and plutonium oxide is enabled by measurement of coincident neutron count rates, as this signature of fission can be used to determine fissile mass. While the shift register provides valuable information about neutron behavior in an item, that information is extremely limited. In typical systems, all detectors must be fed into the shift register as a combined signal, and the time domain of analysis must be pre-selected. Additionally, only multiplicity analysis and coincidence counting can be applied to shift register data.
Advances in data collection and storage technology enable a transition from shift register to list mode neutron data collection for verification measurements. List mode neutron data is a record of the time of arrival of every neutron in every detector channel. While this is a data intensive shift, the possibilities for application of advanced data analytics methods are vast, as will be demonstrated. Rather than considering all channels together, each detector can be treated independently allowing for cross correlation analysis of fission neutrons and creation of coincidence matrices, providing useful geometric information. In addition, signatures from several different neutron timing distributions (i.e. multiplicity, Rossi-alpha, time interval, etc.) can be combined and analyzed for better characterization of challenging items (spent/fresh fuel, unknown geometries, loss of continuity of knowledge, etc.) where shift register analysis has proven ineffective in the past. Importantly for continuity and comparison to previous methods, obtaining list mode data still allows for all of the same analysis as shift register data; therefore, in transitioning from shift register to list mode, no information or analysis capabilities are lost. This paper will show advantages of using list mode data for verification measurements using fresh and spent fuel neutron list mode datasets.

Which ”Key Question” does your Abstract address?

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Topics

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Primary author: Dr TRAHAN, Alexis (Los Alamos National Laboratory)

Co-author: Dr MENDOZA, Paul (Los Alamos National Laboratory)

Presenter: Dr TRAHAN, Alexis (Los Alamos National Laboratory)

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