School of Electrical, Computer and Energy Engineering

PhD Final Oral Defense
Nuclear Fission Weapon Yield, Type, and Neutron Spectrum Determination
Using Thin Li-ion Batteries

by
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Abstract
With the status of nuclear proliferation around the world becoming more and more complex, nuclear forensics methods are needed to restrain the unlawful usage of nuclear devices. Lithium-ion batteries are present ubiquitously in consumer electronic devices nowadays. More importantly, the materials inside the batteries have the potential to be used as neutron detectors, just like the activation foils used in reactor experiments. Therefore, in a nuclear weapon detonation incident, these lithium-ion batteries can serve as sensors that are spatially distributed.

In order to validate the feasibility of such an approach, MCNP models are built for various lithium-ion batteries, as well as neutron transport from different fission nuclear weapons. To obtain the precise battery compositions for the MCNP models, a destructive inductively coupled plasma mass spectrometry (ICP-MS) analysis is utilized. The same battery types are irradiated in a series of reactor experiments to validate the MCNP models and the methodology. The MCNP nuclear weapon radiation transport simulations are used to mimic the nuclear detonation incident to study the correlation
between the nuclear reactions inside the batteries and the neutron spectra. Subsequently, the irradiated battery activities are used in the SNL-SAND-IV code to reconstruct the neutron spectrum for both the reactor experiments and the weapon detonation simulations.

Based on this study, empirical data show that the lithium-ion batteries have the potential to serve as widely distributed neutron detectors in this simulated environment to (1) calculate the nuclear device yield, (2) differentiate between gun and implosion fission weapons, and (3) reconstruct the neutron spectrum of the device.