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# MINER – A Mobile Imager of Neutrons for Emergency Responders

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We are developing a mobile fast neutron imaging platform to enhance the capabilities of emergency responders in the localization and characterization of special nuclear material. This mobile imager of neutrons for emergency responders (MINER) is a compact neutron scatter camera that is designed to provide omnidirectional ($4\pi$) imaging with only a ~twofold decrease in sensitivity compared to our much larger neutron scatter cameras. The system was designed to optimize its performance for neutron imaging and spectroscopy, but it does also function as a Compton camera for gamma imaging.

Figure 1. Left: detector head opened up.
Right: system with side-mounted electronics

The detector head is housed in a 36” high, 15” diameter cylinder. A power conditioning module (top) and sixteen-channel digitizer (bottom) can be mounted on the side of MINER (Fig. 1) to aid in portability, with power supplied from a wallplug outlet or a battery. The only other component of the system is a laptop computer. The entire system (including detection electronics and the laptop computer) is transported in a 43”x27”x20” Pelican case and can be set up in a few minutes.

During a field campaign at the Idaho National Laboratory (INL), we conducted measurements on three plutonium-containing objects (a metal sphere and two cans that contain plutonium oxide) in a variety of configurations, and with and without various combinations of poly moderator and stainless steel shielding around the objects. Fig. 2 presents representative neutron and gamma images of the shielded plutonium sphere. Roughly half an hour was needed to generate a good gamma image, but the neutron signature of the object was sufficiently strong that its direction relative to the detector could be determined within the first minute.

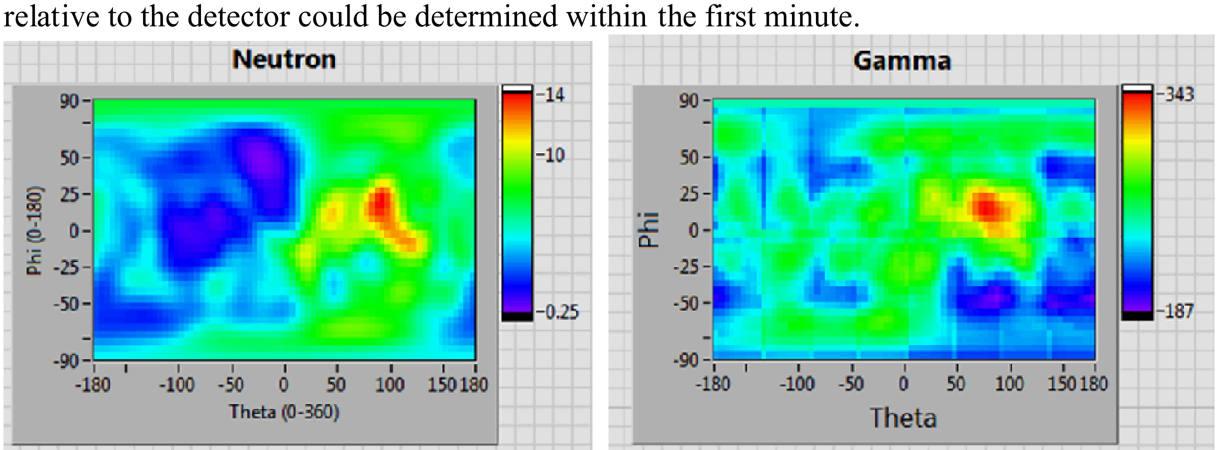


Figure 2. One-minute measurement (neutron) and thirty-minute measurement (gamma) of the plutonium sphere surrounded by 3.5” of poly and 2” of stainless steel, located 2 m from the detector at a relative angle (theta) of 90°

For neutron double-scatter events, MINER measures energy spectra as the sum of the energy deposited in the first liquid scintillator cell and the kinetic energy of the scattered neutron, the latter determined by its velocity as measured by the time of flight between the two cells. The instrument does introduce some distortions in the spectra (especially at low energies), but these effects do not vary from measurement to measurement. We therefore have good confidence in our ability to detect changes in spectra from sources measured under the same conditions. Fig. 3 displays spectra recorded at INL for the three plutonium sources, plus the Cf source, a Cf source at Sandia, an AmBe source at Sandia, and a background measurement at Sandia.

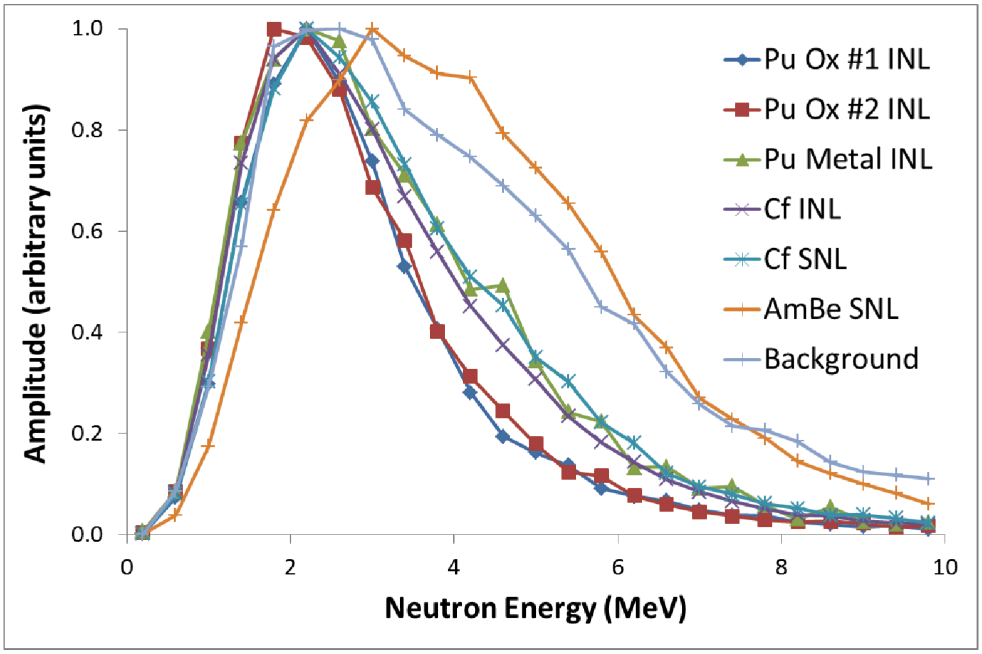

Figure 3. Peak-normalized neutron energy spectra for the indicated sources.

As expected, the AmBe spectrum has significantly more high-neutron-energy content than the fission sources. Also as expected, the spectrum measured from the bare Pu sphere is very similar to the Cf spectrum (a second Cf spectrum measured at Sandia is displayed to indicate the spectral reproducibility; other Cf spectra measured at INL and Sandia show similar agreement). The spectra from the two plutonium oxide objects are very similar to each other, but, somewhat unexpectedly, are significantly different than the Pu sphere or Cf spectra. Measurements made at Sandia of a bare Cf source and the same source surrounded by various thicknesses of poly show much less variation in spectral shape. We are therefore left with the intriguing possibility that neutron spectra can not only distinguish between fission and AmBe sources, but also possibly between metallic and plutonium oxide.

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