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System Construction of the Stilbene Compact Neutron Scatter Camera

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This report documents the construction of a stilbene-crystal-based compact neutron scatter camera. This system is essentially identical to the MINER (Mobile Imager of Neutrons for Emergency Responders) system previously built and deployed under DNN R&D funding,[1] but with the liquid scintillator in the detection cells replaced by stilbene crystals. The availability of these two systems for side-by-side performance comparisons will enable us to unambiguously identify the performance enhancements provided by the stilbene crystals, which have only recently become commercially available in the large size required (3" diameter, 3" deep).

Stilbene crystals come from the manufacturer wrapped in Teflon tape on the sides and bottom of the crystal. This Teflon coating acts as a diffuse reflector. Before putting the crystal in lower cell housing, foam tape is used to pad the crystal from impacts and vibration. 3 strips of 1/16" thick closed cell adhesive backed foam are placed on the sides of the crystal. These strips are clocked at ~120 degrees around the circumference. Additional small strips are placed on the bottom of the crystal. Once the foam is installed, the outer surface is lightly coated with silicone optical grease to allow smooth installation into the cell housing. Using a soft cotton pad, light pressure is used to push the crystal into the cell holder. Once the crystal is fully seated in the cell holder, a light coating of silicone optical coupling grease is built up in the center of the crystal face. The PMT is then placed on the crystal face and gently twisted to spread the grease around the face of the crystal/PMT interface. An annulus of open cell neoprene foam pipe insulation ~0.75" in height is slipped over the end of the PMT and slid down to the back of the 3" diameter body. The cell/PMT coupler is then placed over the back of the PMT and threaded onto the cell holder. The cell/PMT coupler is threaded until it stops to achieve proper preload. The PMT base is then installed, followed by the MUMetal shield, and the electronic feed through cap. Screws are used to fasten the MuMetal shield to the cell/PMT coupler. 1 large O-ring is used under the electronics feed through cap to seal for light leaks. Additional smaller O-rings are used under the screws that retain the electronics cap. Finally, black vinyl tape is used to seal the MuMetal and threaded interfaces. A CAD drawing of the components of the cell is shown in Figure 1 (the crystal, shown in blue, is not entirely wrapped by the foam indicated in grey, but rather using three strips as described above). The green circuit board at the top of the photomultiplier tube represents the same custom-built high-voltage circuit that has been used with MINER. A partially assembled cell is also shown in Figure 1.

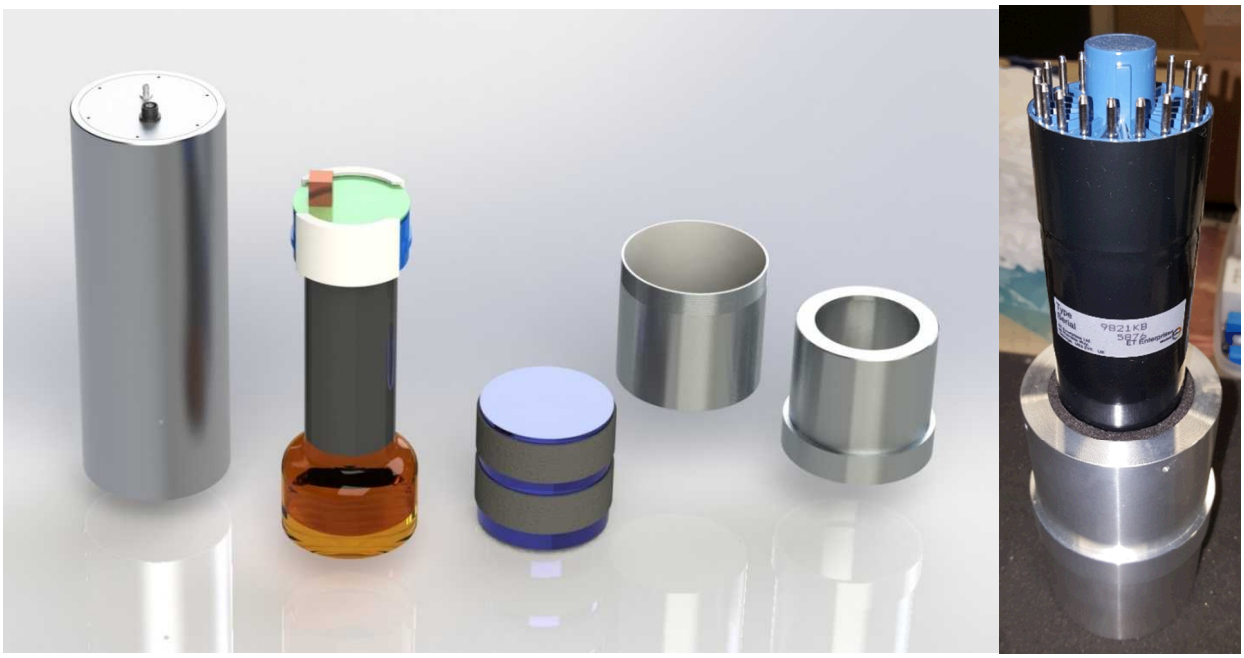

Figure 1. Left: CAD diagram of cell components. Right: partially assembled cell.

The design and construction of the framework and wiring of the stilbene system is identical to the liquid-scintillator system. Photographs of the two systems are shown in Figure 2. The only obvious difference is the presence of small thermal-expansion volumes on the end of the liquid-scintillator cells, and their absence on the stilbene cells.

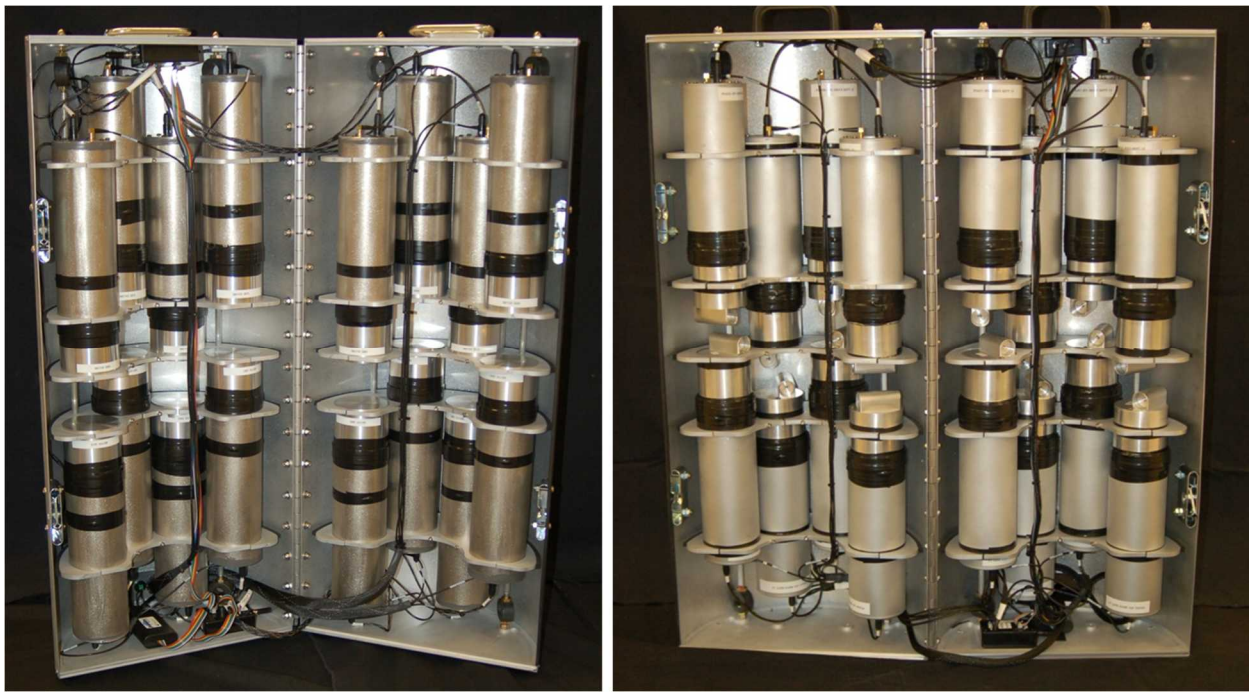

Figure 2. Stilbene (left) and liquid scintillator (right) compact neutron scatter camera systems.

Reference

1. John E. M. Goldsmith, Mark D. Gerling, and James S. Brennan, "A Compact Neutron Scatter Camera for Field Deployment," Review of Scientific Instruments **87**, 083307 (2016); doi: 10.1063/1.4961111