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CZT NANORAIDER VFG FACTSHEET

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Safeguards Technology Factsheet

nanoRAIDER VFG

Summary

Brookhaven National Laboratory (BNL) is working with FLIR System Inc., the manufacturer of the nanoRAIDER, to design a handheld device based on a position-sensitive virtual Frisch-grid (VFG) Cadmium-Zinc-Telluride (CdZnTe or CZT) detector array (with 1% or better energy resolution). The new device called nanoRAIDER VFG will be an improvement to the current nanoRAIDER, which is a compact gamma-ray detection instrument manufactured by FLIR Systems Inc. that employs relatively lower-performing CZT hemispheric detectors (i.e., 3%-FWHM CZT detectors). The nanoRAIDER will significantly improve the accuracy while maintaining similar efficiency, as compared to the nanoRAIDER, for in-field analysis of nuclear materials and detection of undeclared activities during inspections conducted by the International Atomic Energy Agency (IAEA). Since the nanoRAIDER is currently used by the IAEA as part of its Complementary Access toolkit, a relatively quick acceptance of the nanoRAIDER VFG for safeguards is anticipated. The nanoRAIDER VFG will help address several items listed in the IAEA's Long-Term R&D Plan that could enhance the abilities to detect undeclared nuclear material and activities.

Background

The nanoRAIDER is intended to be used by safeguards inspectors during CA missions for the detection, localization, identification and mapping of the gamma and neutron radiation signatures of undeclared nuclear and other radioactive materials and activities, as well as for the verification of the presence and identity of nuclear materials declared pursuant to Article 2 of INFCIRC/540. It is also intended to provide reasonably accurate measurements of the gamma dose rate and the neutron count rate for personal radiation hazard awareness.

The goal of this project is to incorporate a CZT detector array (with 1% or better resolution) into an existing platform (called nanoRAIDER II) to provide better performance than the current nanoRAIDER in safeguards applications, and have the new device commercially available by FLIR. The bench-top demonstration system developed in FY15-16 was based on a 2x2 array of 6x6x20-mm^3 VFG detectors. The significance of this detector technology is that it allows the use of average-grade CZT material with a moderate content of defects, but provides high-energy resolution (1% or less FWHM at 662 keV), large effective area and low-power consumption. The development of the detector technology and new instruments incorporating VFG detectors is motivated by the high cost and low availability of large, > 1 cm^3, CZT crystals suitable for making multi-pixel detectors with acceptable energy resolution and efficiency.

The end product will incorporate the 2x2 detector array into a new platform (called nanoRaider II) as part of FLIR's nanoRAIDER product line. The goal is to have a prototype version completed and ready to test by the end of FY2016. The nanoRAIDER VFG will impact the following items in the IAEA's Long-Term R&D Plan, 2012-2023: 2.2 (elemental and isotopic signatures of fuel cycle processes); 2.3 (detect signatures of undeclared activity and improve analysis); and 2.6 (detect process emanations). The high energy-resolution of the nanoRAIDER VFG also has applicability to 3.2 (fissile content of metal mixtures containing actinides Np, Am, etc.).

(a) (b)

Figure 1. (a) Photo of the nanoRAIDER; and (b) Sketch of the proposed nanoRAIDER II.

Functional Elements

- *Weight/Dimensions:* <1 lb.
- *Portability:* wearable and handheld
- *Operating environment:* indoor and outdoor; -25 °C to 50 °C
- *Data logging:* internal memory for 600,000 spectra
- *Communication:* USB 2.0 (mini-B socket) and Bluetooth
- *Energy Range (Gamma):* 30 keV to 3 MeV
- *Energy Range (Neutron):* thermal
- *Energy Resolution:* 1% FWHM at 662 keV
- *Efficiency:* About 2x compared to the current nanoRAIDER
- *Data analysis and reporting:* embedded software for data analysis, spectrum visualization and isotope identification
- *Power requirements:* 100-240 VAC (USB cable with wall and car adapters); 1800 mAh Li-ion battery
- *Typical measurement time:* Depends on source activity, shielding and standoff distance. Typically 5-60 minutes.
- *Operating Duration:* 8 hours

Figure 2 shows examples of the pulse-height spectra measured with position-sensitive VFG detectors.

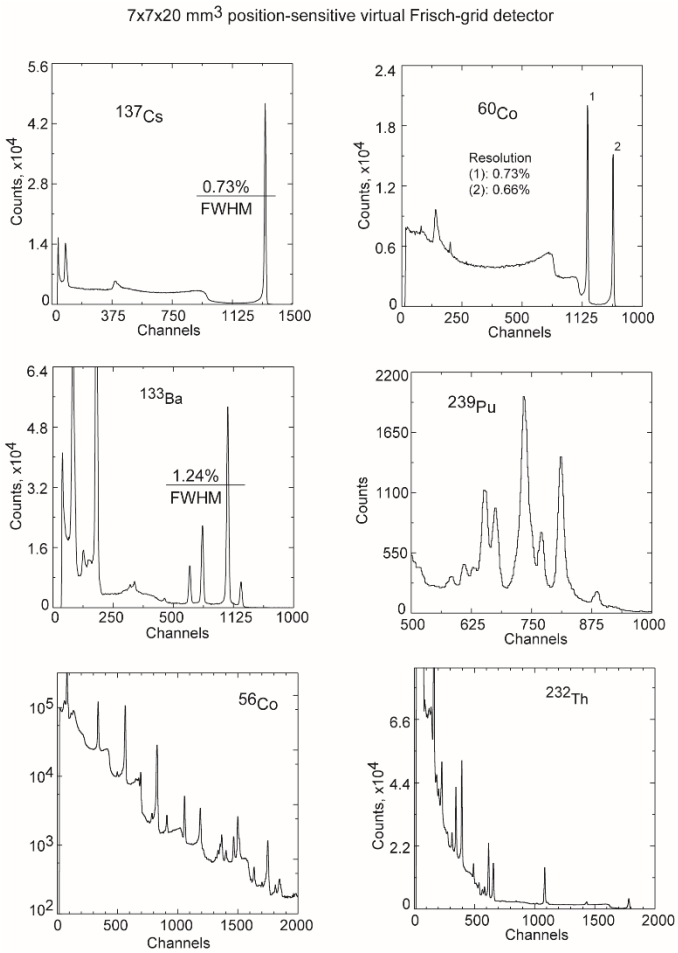

Figure 2. Pulse-height spectra measured from Cs-137, Co-60, Ba-133, Pu-139, Co-56, and Th-232 with a 7x7x20 mm^3 position-sensitive VFG detector.

Operational Description

The nanoRAIDER VFG device will work as a wearable or handheld device in the field. It can operate as a stand-alone device with self-contained software for spectral analysis and isotope identification and a LCD screen for data visualization and information display. In addition, it can communicate with a computer via USB or Bluetooth, so data can be downloaded to computer and further maintained in a user database. Given the high energy resolution of VFG detectors, the nanoRAIDER VFG will be the highest performing Spectroscopic Personal Radiation Detector (SPRD).

To reduce the training burden on first responders and security personnel, the nanoRAIDER VFG will use the same firmware as in the nanoRAIDER and nanoRAIDER II for its user interface. With a few button controls, operators can pick up the device and begin using it simply and quickly.

FY16 Status

After demonstrating the high energy-resolution spectroscopic capability of VFG detectors in FY15, this project focuses on the following tasks:

1. Fabricate VFG detector arrays for the new nanoRAIDER VFG devices;

2. Develop an interface between VFG detector array plus its readout electronics and the data acquisition platform at FLIR;
3. Assemble and test the new device in laboratory environment and in the field.

Tasks 1 and 2 are on-going now. Two detector modules have been fabricated. The adaptor printed circuit board is being designed and will be finished by mid FY16. An engineering prototype will be built and tested in laboratory by the end of FY16. The prototype will also be available for field tests by end users and for demonstration purposes.