Neutron scatter camera provides a new-and-improved way to look at radiation

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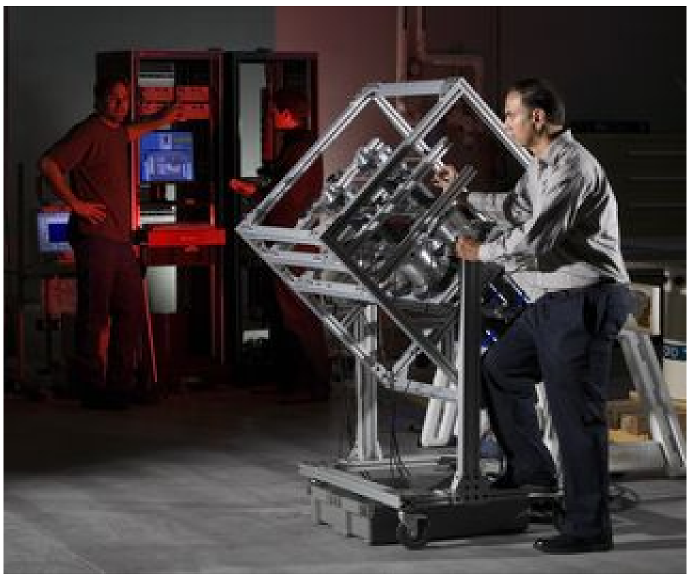

Nick Mascarenhas, physicist and principal investigator, prepares the detector for a test. The neutron scatter camera detects radiation at significant standoff distances and through shielding, and pinpoints radiation sources. (Photo by Randy Wong)

In an effort to find an answer to the problem of identifying smuggled special nuclear material (SNM), researchers at Sandia National Laboratories in California say a neutron scatter camera they are developing may be able to detect radiation from much greater distances and through more shielding than current detection instruments.

The neutron scatter camera, says Sandia physicist Nick Mascarenhas, has the capability to count neutrons from a source of SNM and localize it — meaning it doesn't only indicate there is radiation present, but also where it is emanating from and, under some circumstances, how much.

"This instrument can pinpoint a hot spot in another room through walls, something not typically possible with gamma-ray detectors," says Mascarenhas. "Performance-wise, it's beating the older technologies, but we want to continue to push the limits of sensitivity and detection distance."

Distance, says Mascarenhas, is a significant benchmark because it means the neutron scatter camera has the potential to detect through various types of shielding, a concern at any border crossing or point of entry.

Results of neutron scatter camera testing have been encouraging. "It's more penetrating and can detect unambiguously at a greater distance and through more shielding," says Jim Lund, who manages the Rad/Nuc Detection Systems group at Sandia/California.

Since 9/11, radiation detection has taken on a new immediacy as a means of preventing a nuclear weapon attack within the United States. Gamma-ray and neutron detectors are being deployed at border crossings and ports, with the goal of enabling interdiction of a nuclear weapon or material before it enters the country.

Role in in-transit radiation characterization

The neutron scatter camera project is currently supported by the Office of Nonproliferation R&D in the National Nuclear Security Administration (NNSA). After successful initial development, the technology is being transitioned to both the Defense Threat Reduction Agency (DTRA) and Domestic Nuclear Detection Office (DNDO) to support specific application studies.

Recently, representatives from DNDO sat in on a presentation by Mascarenhas to NNSA. They were sufficiently impressed to inquire how quickly he could modify the camera for shipping to and from Hawaii as part of Sandia's in-transit radiation characterization project, which has been examining the viability of radiation detection onboard a ship.

The neutron scatter camera will make three round-trips to Hawaii; the first departed from the Port of Oakland in early September. Sandia physicist George Lasche, who leads the project known as Experimental Limits for In-Transit Detection of Radiological Materials, says the camera has the potential to reduce false alarm rates — a critical issue for in-transit radiation detection.

"Our other instruments have told us a lot about the nature of nuclear radiation at sea, but not where it is coming from," says Lasche. "The neutron scatter camera can tell us where the radiation is coming from and whether it is coming from a small object or not. This information is very helpful in deciding if we have a serious threat on our hands, and can lead to fewer false alarms and a better chance of not missing the real thing," he said.

DTRA is funding a separate project to use the neutron scatter camera to measure and characterize background neutrons at Sandia/California, Sandia/New Mexico, and in Alameda, Calif.

"There are neutrons all over the place from cosmic radiation, even when you are sitting indoors," explains Mascarenhas. "Our instrument can measure the energies, rates and angular variation. This is important in understanding standard operating conditions. You can't really detect anomalies until you understand what's normal. This data can also be used to improve instruments to better suppress the standard operation conditions."

The neutron scatter camera has an advantage over traditional neutron detection because it can differentiate low energy neutrons from high energy neutrons.

"It doesn't have to worry about the low-energy nuisance neutrons that are always all around us because it can only see high energy neutrons, and the high-energy neutrons carry almost all of the imaging information," says Lasche.

Another advantage is shielding. While some gamma rays can be blocked from detectors, neutrons are much more difficult to conceal. In a lab test, the camera easily detected and imaged a source placed across the hallway, through several walls and cabinets.

Size and feedback time limitations

Lund notes that the neutron scatter camera does have limitations, particular in terms of size and time. "Ideally, we'd use both the neutron scatter camera and a gamma-ray detector," he says. "The neutron scatter camera is not practical as a handheld detector with immediate feedback."

The neutron scatter camera consists of elements containing proton-rich liquid scintillators in two planes. As neutrons travel through the scintillator, they bounce off protons like billiard balls. This is where "scatter" comes into play — with interactions in each plane of detector elements, the instrument can determine the direction of the radioactive source from which the neutron came.

The neutron eventually flies off, but not before energizing the protons with which it has interacted. The proton will lose its energy in the scintillator. As that energy is lost, it is converted into light. Photomultiplier tubes coupled to the scintillator detect the light.

Computers record data from the neutron scatter camera, and using kinematics, determine the energy of the incoming neutron and its direction. Pulse shape discrimination is employed to distinguish between neutrons and gamma rays.

The biggest obstacle to the camera becoming widely adopted is the liquid scintillator, which is flammable, hazardous, and requires special handling. According to Mascarenhas, materials exist that could be used as a solid scintillator, but they need to be mass produced and made readily available in the U.S. for this purpose. Solid scintillator material, he says, is not in the scope of the current project but is a logical next step.

The current version of the neutron scatter camera has four elements on one side and seven on the other. To improve sensitivity and direction, all that is required is to add more elements.

Mascarenhas describes scaling up as an engineering challenge rather than a scientific limit. Bigger means more places where things can break down, but this isn't a physics issue, he says.

"We are not concerned with size at this point — our mission is to understand everything about the performance of this instrument and make it the best it can be," he says. "Making it portable or compact might be the next steps, but that's something I'm confident that Sandia, as an engineering laboratory, can solve."

Source: Sandia National Laboratories