LOS ALAMOS NATIONAL LABORATORY 1992 R&D 100 AWARD WINNER

Thermal Neutron Multiplicity Counter

Inventors: Merlyn S. Krick, Diana G. Langner, Norbert Ensslin, and
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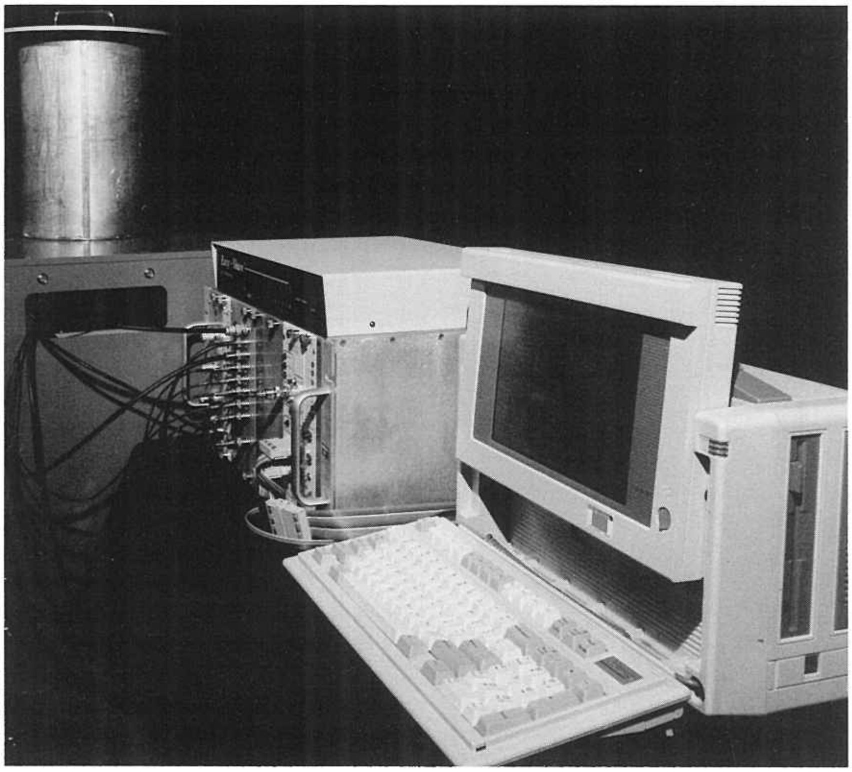

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The Thermal Neutron Multiplicity Counter is used for the rapid, nondestructive assay of plutonium. The multiplicity counter yields accurate assays of the plutonium content of a sample, even in the presence of chemical impurities that affect assays made using conventional neutron coincidence counters. The photograph shows the detector with cables leading to the instrumentation bin. The computer, which interfaces with the instrumentation, controls the instruments and collects and analyzes the data.

Although best known for its use in nuclear weapons, plutonium can also be used as a fuel in nuclear power plants. However, before a reactor can be fueled with plutonium, the material must be processed into a form suitable for fuel and transported from the processing plant to the power plant. During processing, storage, and shipping a serious problem arises—the danger that the nuclear fuel might be stolen and misused. At Los Alamos National Laboratory, we designed the Thermal Neutron Multiplicity Counter to help safeguard nuclear materials.

The multiplicity counter is an instrument for the nondestructive assay of plutonium. Frequently, plutonium is in the form of impure oxides, impure metals, salts, residues, or other forms whose chemical composition is unknown. When the chemical composition is unknown, it is difficult if not impossible to assay the plutonium content of the sample rapidly and accurately. The multiplicity counter's novel features permit the true plutonium content of a sample to be determined, even in the presence of impurities.

Although thermal neutron coincidence counters have been essential for nuclear safeguards measurements for about twenty years, assay errors have been a continuous problem. Assay errors can lead an inspector to overestimate the plutonium content of chemically impure samples, an overestimate that may prevent the inspector from determining that nuclear material is missing. Such overestimates open a window of opportunity for the diversion of nuclear materials for nuclear proliferation or terrorism. The multiplicity counter helps to keep this window closed.

Our Thermal Neutron Multiplicity Counter won a 1992 R&D 100 Award, an honor given annually by Research and Development Magazine to the one hundred most significant technical innovations of the year.

The Invention—Characteristics and Advantages

The multiplicity counter comprises a neutron detector, custom electronic circuitry, and a small computer with analysis software. The neutron detector consists of 126 proportional-counter, neutron-detector tubes filled with helium (^{3}He) gas and embedded in polyethylene. The cylindrical detector is approximately 0.8 meter in diameter and 1 meter high.

The inspector places a sample into the central cavity of the multiplicity counter. Neutrons emitted by the sample encounter the layer of polyethylene, lose energy, and are slowed so that they are captured by the ^{3}He detector tubes. Each captured neutron evokes an electronic pulse from the tubes. The electronic circuitry and analysis software sort these pulses by their multiplicity; that is, groups of pulses are sorted as single events, double events, triple events, and so on.

The neutrons are produced by several sources including spontaneous fissions, neutron-induced fissions, and nuclear reactions induced by alpha particles. Only the spontaneous-fission neutrons accurately reflect the amount of plutonium in the sample.

Conventional thermal neutron coincidence counters cannot distinguish between spontaneous-fission neutrons and coincident neutrons from other sources; they count all coincident neutrons. When the plutonium sample is impure, alpha particles reacting with the impurities produce neutrons that increase the detector response by an unknown amount.

However, because the multiplicity distributions of these sources are known, the multiplicity counter can determine the contribution from spontaneous fissions and assay the true plutonium content in the sample. Our experiments show that assay errors can exceed 1,000 percent when conventional coincidence counting is used, whereas with multiplicity counting, the assay error is typically only a few percent.

For more information about the Thermal Neutron Multiplicity Counter, please contact Kay Adams, Industrial Partnership Center, Los Alamos National Laboratory, P.O. Box 1663, Mail Stop K763, Los Alamos, NM 87545, Telephone (505) 665-9090, Fax (505) 665-3164.

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Application

The principal application of the Thermal Neutron Multiplicity Counter is the assay of plutonium-bearing material. Specific examples of safeguards applications include the following:

- Plutonium-processing plants can use the device for materials accounting and process control.
- Plutonium shippers and receivers can use the device to confirm that a shipment has not been tampered with in transit. The device can play a similar role in materials accounting when a plutonium container is placed in or removed from storage.
- The International Atomic Energy Agency can use the device to verify declared plutonium inventories under nonproliferation treaty agreements.
- Inspectors can use the device to verify inventories of dismantled nuclear weapons components in domestic or international storage facilities.
- The nuclear waste recovery industry can use the device to assay the plutonium content of waste that is being prepared for disposal.

Because of its unique features, the Thermal Neutron Multiplicity Counter can assay a much wider variety of materials than can conventional coincidence counters. In addition, many conventional coincidence counters now in use can be retrofitted with the multiplicity counting circuits and analysis software. Our multiplicity counter will provide a higher level of safeguards confidence during the shipping, storage, and processing of plutonium and other nuclear materials.

The developers of the Thermal Neutron Multiplicity Counter are staff members in the Safeguards Assay Group of the Nuclear Technology and Engineering Division.

Merlyn Krick's research interest is in neutron measurements for nuclear safeguards. After earning a Ph.D. in physics from the University of Pennsylvania, he came to the Laboratory in 1968 as a postdoctoral staff member. He left to teach nuclear engineering at Kansas State University and returned as a regular staff member in 1975. In 1977 he conducted the first experiments that led to the multiplicity counter. He spent two years working at the International Atomic Energy Agency in the early 1980s.

Diana Langner's research interests are in the theory and computational modeling of neutron detection. She has a B.S. in mathematics and physics from Wheaton College, and she has done graduate work at Johns Hopkins University and the University of New Mexico. In 1977 she came to the Laboratory as a contractor with EG&G, where she worked on image processing and the analysis of high atmospheric physics. In 1976 she became a regular staff member in the Safeguards Assay Group. She began working on the multiplicity counter in 1988.

Norbert Ensslin's research interests are in neutron coincidence and multiplicity counting for plutonium assay. After earning a Ph.D. in nuclear physics from the Massachusetts Institute of Technology, he joined the Laboratory in 1973 as a postdoctoral staff member at the Meson Physics Facility. In 1975 he became a member of the Safeguards Assay Group. He began working on the multiplicity counter in the early 1980s.


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Merlyn Krick (left), Diana Langner, and James Halbig are three inventors of the Thermal Neutron Multiplicity Counter. The fourth inventor is Norbert Ensslin.

James Halbig's research interests are international nuclear safeguards and instrumentation for the domestic nuclear industry. After earning his Ph.D. in physics at Iowa State University, he came to the Laboratory in 1973 as a staff member in the Accelerator and Beam-Line Development Group at the Meson Physics Facility. He joined the Safeguards Assay Group in 1978. He began working on the multiplicity counter electronics in 1989. This work was a spin-off from his ongoing interest in the development of instrumentation for nuclear safeguards.

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