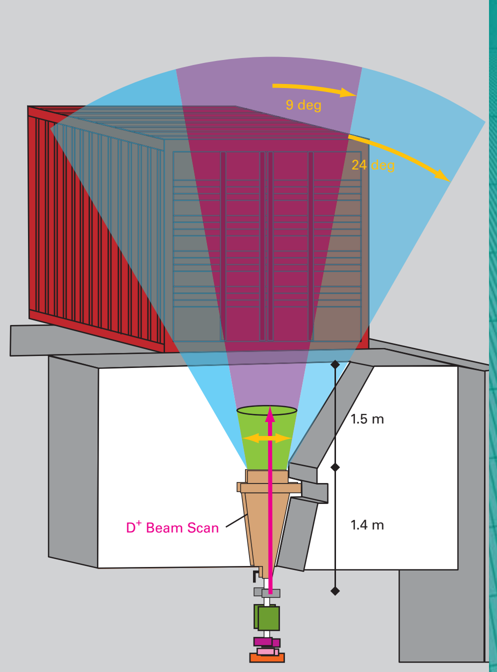


Screening for Special Nuclear Materials

Applied Accelerator and Detector Technology Lead To Efficient Security

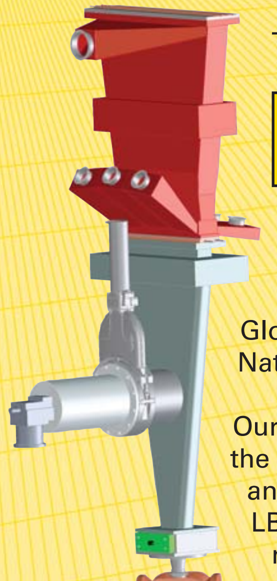
- 6 MeV, 1.2 mA (time-averaged) D^+ beam.
- $D(d,n)_3He$ in a D_2 gas target.
- Forward-directed neutron beam with energies up to 8.5 MeV.
- Bursts of short (several hundred μs) pulses of arbitrary length; 5% duty cycle during each burst.

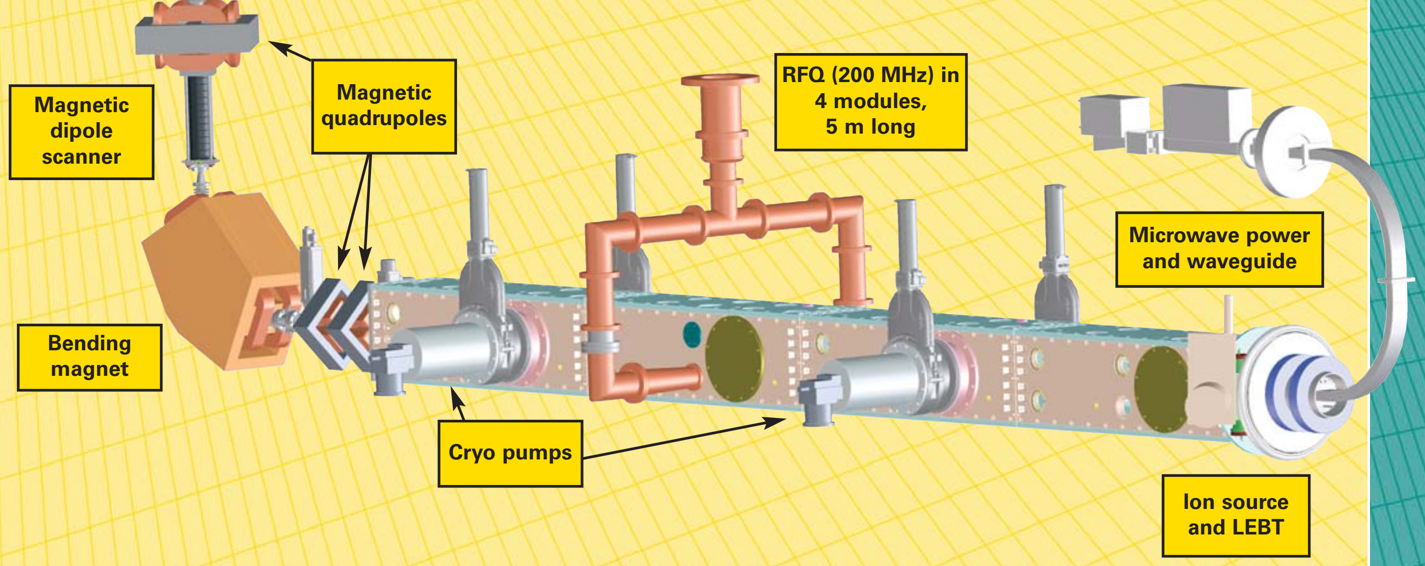
Accelerator-Driven Neutron Source

Screening land-sea cargo containers for SNM is a difficult technical challenge because it must be efficient (some 10 million containers arrive at US ports each year) yet also reliable (even if the materials are shielded).

This approach scans the container with a beam of fast neutrons, followed by counting of beta-delayed photons and neutrons for up to tens of seconds (so that emissions from capture reactions can die off). With the support of the Domestic Nuclear Detection Office of the Department of Homeland Security, we have been working in concert with General Electric's Global Research Center and Lawrence Livermore National Laboratory.

Our contribution (shown here as a computer-aided engineering model) comprises the ion source, low-energy beam transport line, radiofrequency quadrupole linac, and a gas target, all areas of particular scientific and engineering expertise at LBNL. Construction of a high current Accelerator-Driven Neutron Source is the next major goal of the collaboration.





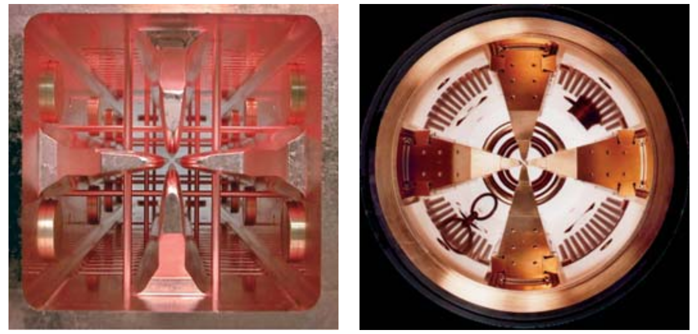
The achievements and capabilities described here are centered in the Accelerator and Fusion Research Division (AFRD) of Lawrence Berkeley National Laboratory. AFRD carries forward key aspects of the Laboratory's central heritage, including expertise in ion sources, beam dynamics and small, efficient proton and ion accelerators. Many of the capabilities most relevant to security are grouped together in AFRD's Ion Beam Technology Program (IBT).

The IBT Program's approach is to creatively and innovatively leverage scientific excellence as a foundation for strongly applied, goal-focused practical R&D. We work closely with the Laboratory's Engineering Division, with researchers in other fields developing complementary parts of a system, with industry and with end users.

AFRD programs have won a total of 15 R&D 100 awards, including one in 2006 for the High-Output Coaxial-Target Neutron Generator. The award serves as an indicator not only of innovation but also of technology transfer.

To explore these capabilities and learn about licensing, Cooperative R&D Agreements, and other ways for the public and private sectors to put this expertise to work, visit http://www-ibt.lbl.gov and http://www.lbl.gov/ttd/

Contacts:
Robert K. Johnson, head of the LBNL Homeland Security Department, (510) 486-4020, or
Richard A. Gough, head of the AFRD Ion Beam Technology Program, (510) 486-4573.



The compact and efficient radiofrequency quadrupole linear accelerator, or RFQ, is one of the keys to the ADNS project. Designing and building RFQs is a special strength of AFRD and Engineering.

Ion Beam Technology Program
Accelerator and Fusion Research Division

LBNL is a multiprogram laboratory managed by the University of California and supported principally by the U.S. Department of Energy under Contract No. DE-AC02-05CH11231. Work described here was additionally supported by, or performed in collaboration with, the organizations mentioned in each section.

LBNL/PUB-965

CSO JO12379

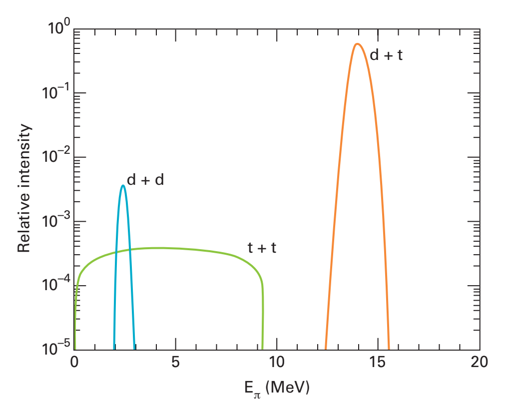
Beam Technology for National Security

Active-Interrogation Tools for Detecting Explosives and Special Nuclear Materials

Lawrence Berkeley National Laboratory, Accelerator and Fusion Research Division

Neutron Generators

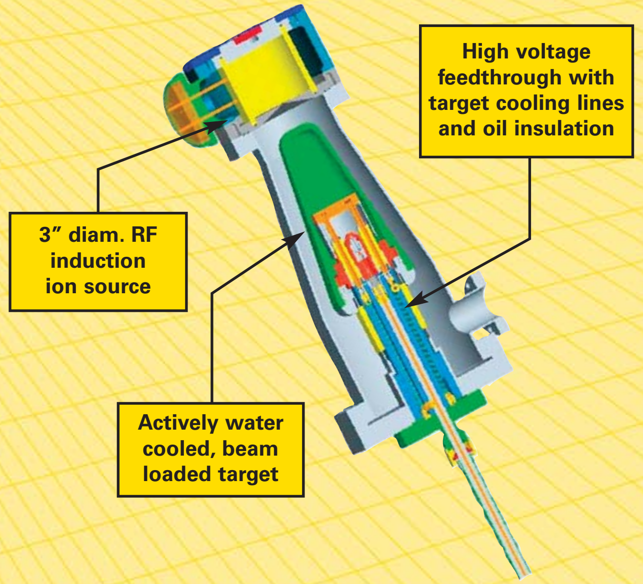
A Versatile Family of Tools Moves From Lab to Application With Unprecedented Performance



Deuterium-deuterium, deuterium-tritium, and tritium-tritium fusion reactions produce neutron energy spectra useful for different active-interrogation techniques.

Many properties of materials—including aspects of elemental composition that can reveal either chemical explosives or special nuclear materials—can be probed with neutrons. LBNL developed a new generation of simple, efficient neutron generators, using technology that began in magnetic fusion energy and accelerator-based high-energy and nuclear physics. Progress over the last several years has increased their output by five orders of magnitude; now they far eclipse the performance of existing commercial sources of comparable size.

The High Output Coaxial Target Neutron Generator won a 2006 R&D 100 award. It is a high yield, continuous-beam deuterium-deuterium neutron generator that gives 1000x higher neutron yield than direct competitors. Several applications in homeland security, industry, research, and the medical field are in use or under development. This 10^{11} n/s version was delivered to the hospital/university consortium EUROSIA in Turin.



This fast-pulsing neutron source features shielded high-voltage components. Its small size and user-friendly operating characteristics appeal to university and laboratory researchers. The output is up to 10^8 neutrons per second from the deuterium-deuterium reaction.

Future Neutron-Generator Prospects

This family of technologies can be applied to many scenarios besides continuous-duty, deuterium-deuterium operation. These are some examples that are especially interesting from a security and counterterrorism standpoint.

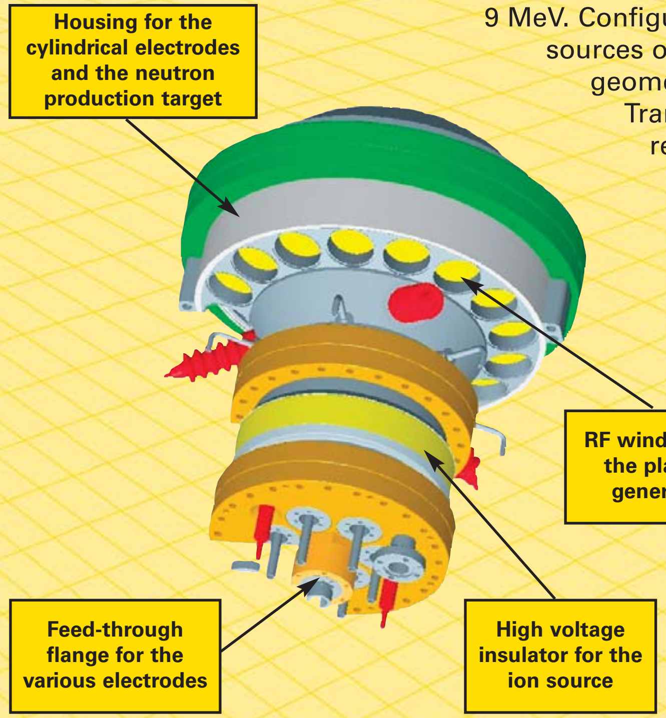
- 90% atomic-species purity (7x better than Penning-type sources.
- Output ≥ 10^{11} neutrons per second in sustained, continuous deuterium-deuterium operation.
- Deuterium-tritium operation provides higher energy, more penetrating neutrons with 100x higher yield.
- Pulsed versions can be engineered (e.g., for neutron die-away analysis in special nuclear materials detection).

Fast-Pulsed Source for Differential Die-away Detection

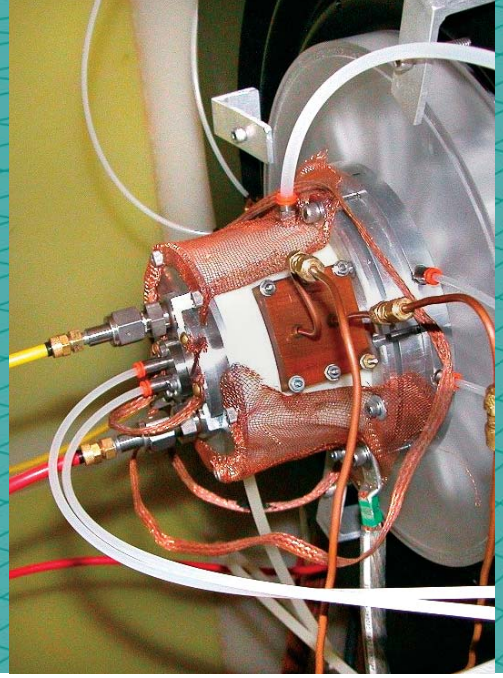
Screening for special nuclear material is a subtle challenge because the SNM need not be smuggled as weapons shapes nor in large amounts in one shipment. A high-output neutron source with fast, clean pulse falloff would be a valuable tool for efficiently searching incoming vehicles and cargo. Repeatable and stable pulse structures in the sub-microsecond regime are achieveable.

T-T Line and Point Sources for FNTS and PFNTS

The T-T reaction gives off neutrons across an exceptionally broad energy distribution: from 1 to 9 MeV. Configured as line sources or point sources rather than a cylindrically radiating geometry, these could be used for Fast Neutron Transmission Spectroscopy (FNTS) or Pulsed FNTS, respectively: techniques that can be used for explosives screening.



Left: A federal agency supports work on a tritium-tritium source that uses Pulsed Fast Neutron Transmission Spectroscopy (PFNTS) to detect explosives and other contraband concealed in aircraft cargo containers. We are subcontracted by a private-sector collaborator to provide the neutron generator. The device is 80 cm tall (secondary containment not shown).



Gamma Generator for Special Nuclear Materials Detection

Extending Neutron-Generator Technology to Additional Active-Interrogation Methods

The gamma generator exemplifies how the basic technology of the neutron generators can be extended to use low-energy nuclear reactions to solve additional problems in active interrogation.

Together with Sandia National Laboratories, we have been developing a high-energy gamma-ray generation device based on the reaction $^{11}B(p,\gamma)^{12}C$. It can be used in another, exploratory approach to screening cargo containers for special nuclear materials, as well as for other homeland security applications.

Shown above left (on one of our test stands) and below is a pre-prototype, experimental device. It produces high-energy gamma rays (11.7 MeV) to cause photofission in SNM, giving off a distinct signature that can be detected.

Testing is now underway to evaluate this new interrogation tool. Since it is compact and simple, it is expected to be a useful addition to the array of active-interrogation capabilities for nonproliferation and SNM detection.