Liquid explosive or soda?

MagViz BLS measures the chemical fingerprint for liquids–even inside metal containers. Chemical identification of liquids inside closed containers, especially those that are opaque or metal, is a difficult problem. To protect the public from the hazard of explosive liquids that might not be detectable by traditional x-ray methods, restrictions on the amounts of liquids that can be carried aboard airplanes are enforced. However, a new technology has been developed that enables nuclear magnetic resonance (NMR) to be performed in ultra-low magnetic fields comparable to those of the Earth. NMR is an ideal technique for understanding the chemical composition of liquids and can also provide images based on this information, known as MRI. But either approach traditionally relies on high magnetic fields that are incompatible with standard packaging and a public setting. Ultra-low-field NMR enables scanning even inside metal cans and at weak magnetic fields safe for use in airports. The instrument, known as MagViz BLS (bottled liquid scanner), is soon to be tested at the Albuquerque International Sunport, in New Mexico.

MagViz applications

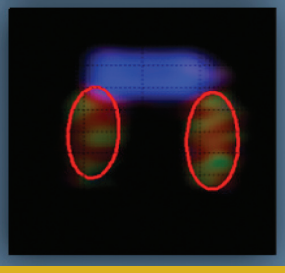
- Airport screening of carry-on liquids.
- Portal screening at government buildings, courthouses, and other potential target facilities.
- Differentiating spoiled from unspoiled foods, including substances in metal cans.
- Providing low-cost, portable MRI instrumentation for field applications, medical clinics, and hospitals in resource-poor settings.

MagViz capabilities

- Prevents the transportation of hazardous and/or toxic materials or materials that may be used as components of an explosive device. Applicable for public transporation as well as access to public buildings.
- Works with existing x-ray screening technology and other imaging methods.
- Evaluates liquids from their chemical fingerprints. By linking with a computer database, different threats can be added as they emerge.
- Provides rapid secondary screening for 3-1-1 exemptions.

◀▲ MagVIZ BLS tabletop unit unassembled.

The sealed bottles at right all look the same. Without time-consuming or potentially dangerous chemical tests, MagViz can tell the harmless from the harmful, and circles the harmful materials in red, below.



2009 R&D 100 Award Winner

The MagViz team

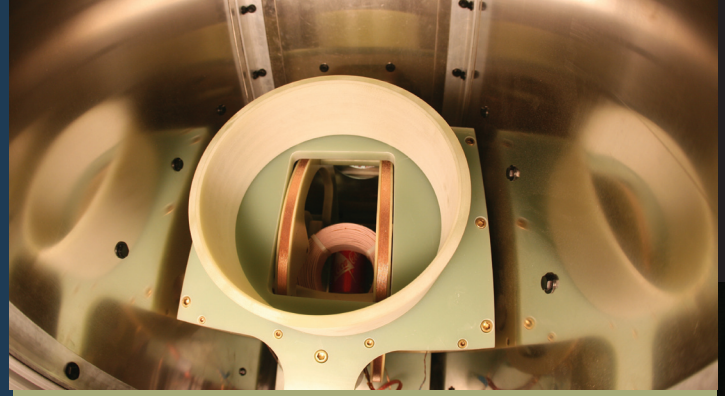
The team in Los Alamos National Laboratory's Physics Division has a decades-long history of science applications requiring detection of ultra-low magnetic fields. The focus was initially on using ultra-sensitive detectors know as SQUIDs, or superconducting quantum interference devices.

These devices have traditionally been used for detecting the ultra-weak magnetic fields emanating from the brain for passive measurements of neuronal activity, a technique known as magnetoencephalography.

The SQUID is also used in an application known as ultra-low-field (ULF) magnetic resonance, which relies on the same physics behind the traditional hospital MRI–with one big exception. Instead of big magnetic fields, the fields in ULF magnetic resonance are no stronger than the magnetic field of the Earth. This method retains the primary strength of traditional MRI–the abililty to probe chemical environments as well as provide images. The same physics that gives rise to tissue contrast in an anatomical MRI of the body also allows MagViz to determine differences in the chemical environment of liquids.

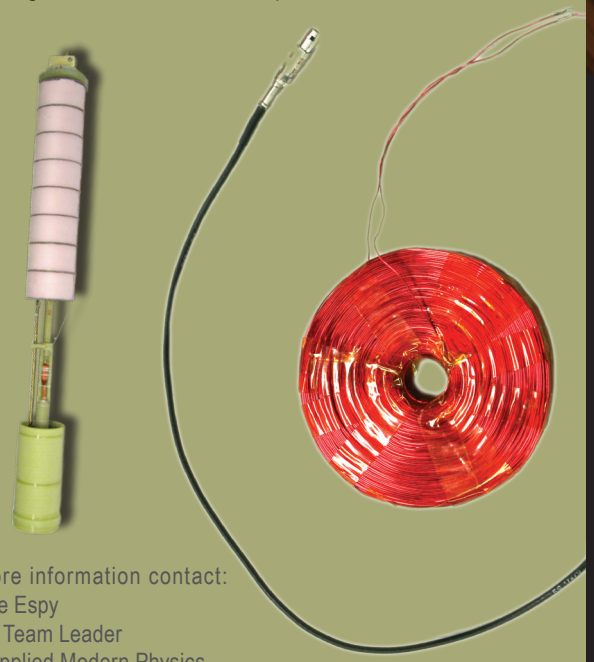
While x-ray methods sample density and nuclear properties, MagViz can directly probe chemical environments, providing complementary information. The team has recently focused on smaller-scale nuclear magnetic resonance applications, which retain the power to discern chemical properties, but are much faster and simpler because imaging is not required. A major breakthrough has been the recent demonstration of coil-based detection for these applications (see next panel), which translates to a smaller and less expensive device that does not require cryogenic cooling.

The Department of Homeland Security sponsors work on MagViz.



Cryogen-free operation

Although the SQUID (below, left) remains the world's most sensitive magnetic field detector, it requires cryogenic cooling. Recent breakthroughs in both electronics and signal processing have allowed for the creation of MagViz BLS, which operates with a more conventional room-temperature sensor, while retaining detection capability. The key to this advance is simple wire coils (below, right) performing with unprecedented sensitivity in the ultra-low-field magnetic resonance regime, translating to a smaller and less expensive device.



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MagViz
Bottled Liquid Scanner

Low Field MRI

Los Alamos
NATIONAL LABORATORY