LANL Demonstrates Airport Liquid Explosive Detection by Low-field NMR/MRI

December 29, 2008 (HP15). Los Alamos National Laboratory (LANL) SQUID Team successfully demonstrated real-time explosive detection system *MagViz*, which employs ultralow-field MRI using magnetic pre-polarization and SQUID detectors. The two-week long trials conducted at the Albuquerque International Airport, the Sunport, in December 2008 were so successful that the sponsor, the Department of Homeland Security, qualified these as a "home run"!

The MagViz is designed to measure relaxation parameters of liquids with volumes ranging from ~ .001 – 3 liters. MRI is used for simultaneous detection of multiple samples, in random configurations. The instrument consists of a sample handling conveyor system (inlet, assay, outlet), a magnetically shielded enclosure (~ 2m x 2m x 2m), magnetic field generation coils generating a ~ 50 mT pre-polarization field, and about 100 μT measurement field and three gradients along three axes. For signal detection, several SQUIDs are configured as an array of second-order axial gradiometers for signal detection. Figure 1 shows the external view of the final design, including the integration of the entire system into the shielded enclosure.

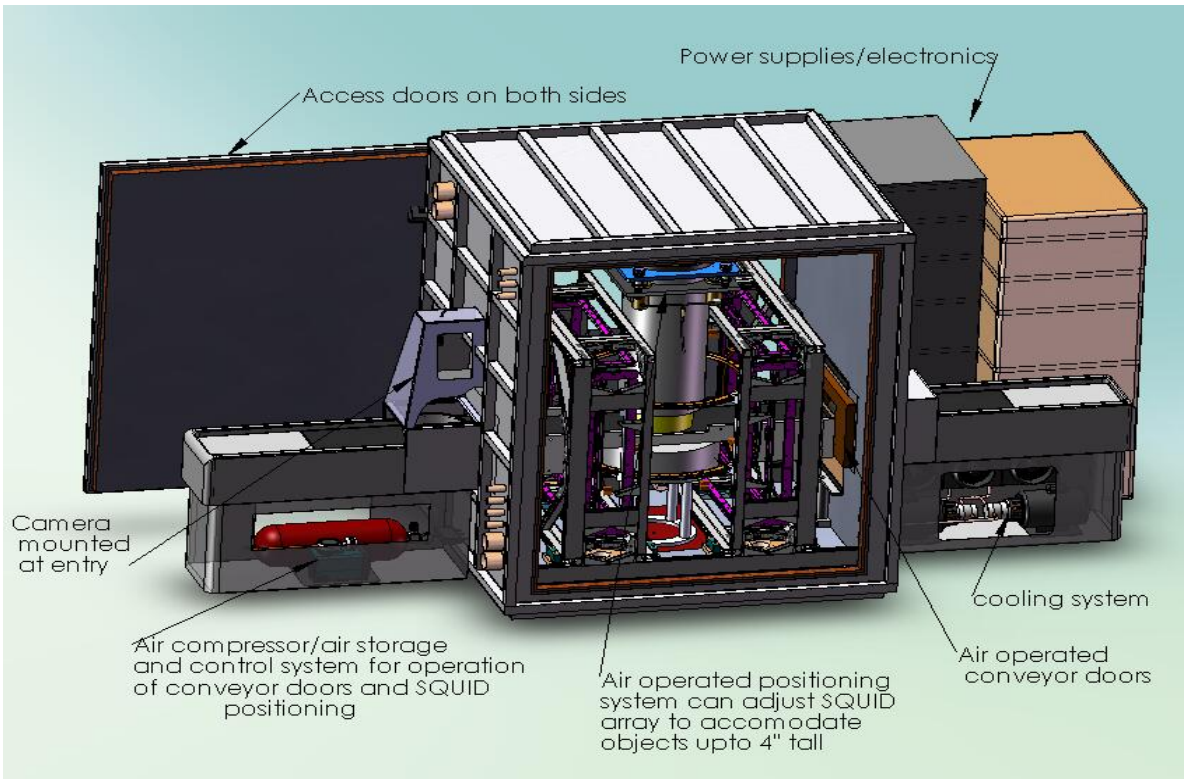

Fig. 1. Artist's rendition of external view of *MagViz* final design.

Liquid explosives and precursors for their fabrication ("threats") can be identified by gated two-parameter NMR measurement with MRI providing two- and three-dimensional (2D and 3D) imaging of tested objects placed in a bin. The 2D imaging provides information about where a threat material is in the bin. The 3D imaging provides further detail and detects threats even in crowded scenes or when a threat

is located beneath other items. Information is presented as “slices” through the bin. Figure 2 shows examples of 2D and 3D detection. Relaxation properties are used to differentiate between materials. Objects classified as threat liquids are circled with a red line. A yellow circled line is used for questionable liquids. A false color MRI, reflecting relaxation properties, is also generated to provide an additional visual cue to the operator. The color map was designed such that benign objects typically appear blue and threats are of different color (orange/red, green, *etc*.). Photographic images are also acquired and can be viewed separately or with MR Images superimposed. This allows the operator to determine which bottle contains the threat.

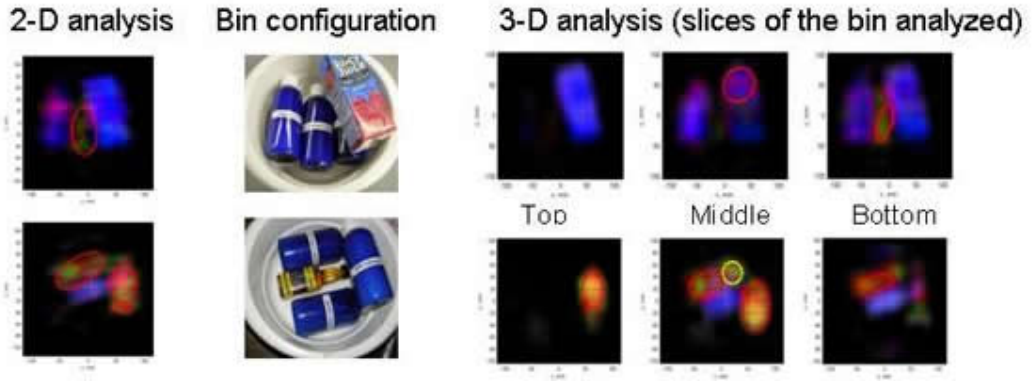

Fig. 2. Left: 2D images of samples, with threat identification. Center: sample photographs. Right: Three slices through the samples (3D image) with threat identification.

The MagViz system offers several advantages over competing high-field NMR and other threat identification methods. It does not require any superconducting or permanent magnet, reduces magnetic susceptibility artifacts, is suitable for liquids in wide range of volumes, and, last but not least, can be relatively inexpensive. It also can recognize threat liquids inside aluminum foil or can or inside a bottle hidden inside a bigger bottle with benign liquid. While the model tested at the Sunport provides SQUID cooling by liquid helium, a commercial prototype may also use a mechanical cryocooler “invisible” to the user.