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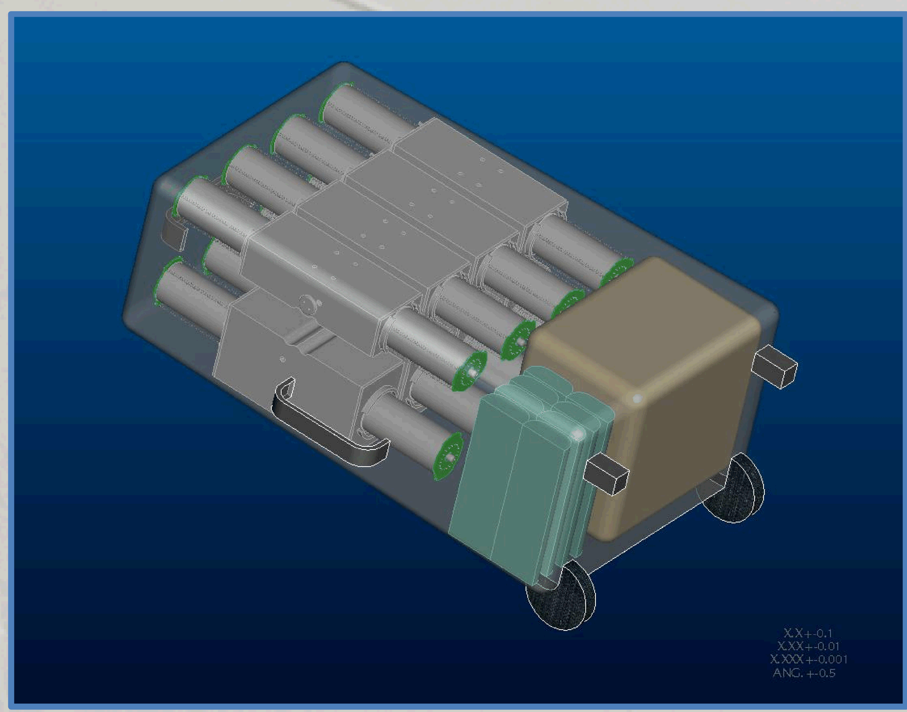

BINGS: A Backpack Imaging Neutron and γ Spectrometer for Emergency Responders

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PROJECT OVERVIEW

- The BINGS system is intended to improve upon capabilities of backpack-mounted neutron detectors. Current systems use moderated ^{3}He tubes to achieve high neutron detection efficiency and γ rejection capabilities. These systems do not provide imaging capability, which can localize sources or exclude position-dependent backgrounds (important for search applications). Moderated ^{3}He tube systems cannot classify neutron sources as industrial (AmBe) or SNM.
- We have proposed a backpack-mounted fast neutron imaging system based upon the successful Neutron Scatter Camera technology. This system uses multiple detection volumes filled with liquid organic scintillator to detect neutrons efficiently. The combination of energy, spatial, and timing information provides neutron imaging and spectroscopy capabilities to locate and classify neutron sources.

A photograph of the PackEye ^{3}He backpack system

PROJECT GOALS

- Develop a backpack-mounted fast neutron imager for emergency responder use
- Provide dual-mode neutron/γ imaging capability for source localization and identification of non-uniform backgrounds
- Investigate system capabilities for advanced diagnostics (spectrometry, neutron multiplicity counting) that enhance source characterization capabilities

PROJECT TECHNICAL APPROACH

- Incorporate Neutron Scatter Camera technology to minimize technology development
  - Pulse shape discrimination (PSD) using liquid scintillator
  - Double scatter neutron imaging technique
  - Neutron spectroscopy
- Customize electronics to minimize data acquisition system size, power consumption
  - Active network PMT bases
  - Digital vs. analog readout
- Compare BINGS prototype to ^{3}He-based backpack systems in the laboratory to quantify performance improvements

DELIVERABLES

- FY11
  - Systems requirements definition (completed)
  - Assemble BINGS detector array and test with rack-mounted electronics (in progress)
  - Comparison of simulated BINGS system to ^{3}He backpack systems (in progress)
- FY12
  - Advanced electronics and software development
  - Completion of advanced diagnostics assessments
  - Comparison of measured BINGS system to ^{3}He backpack systems
- FY13
  - Integrated backpack detector completed and tested

CAPABILITY IMPROVEMENT FOR NONPROLIFERATION MISSION

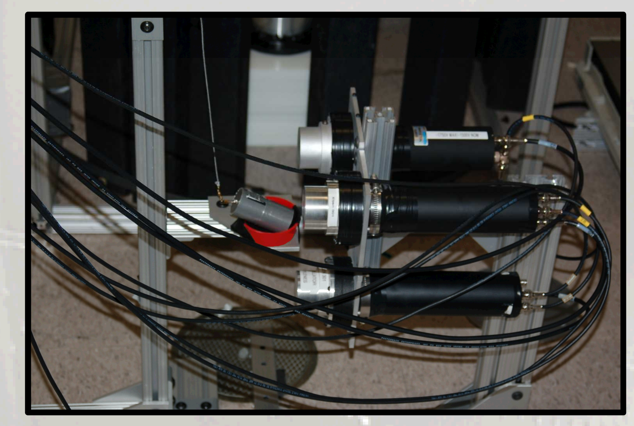
- Increased neutron sensitivity for detecting weak or shielded sources
- Reduction in time spent on false alarms arising from non-uniform backgrounds (neutron imaging)
- Sources can be localized without human action, in locations where access may be difficult
- Neutron spectroscopy, multiplicity counting can be performed with the same instrument and used to classify sources (example: AmBe vs. SNM)

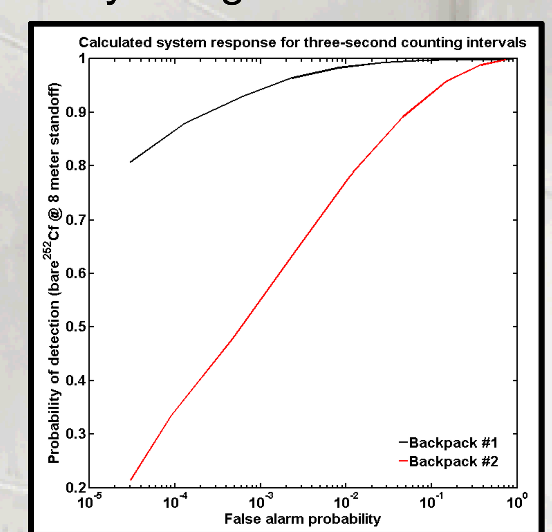
EXPECTED TECHNICAL CHALLENGES

- System mass vs. neutron sensitivity
  - Users desire a backpack system with a total mass near 20 lbs
  - Liquid scintillator mass in current design: about 18 lbs
- Maintaining neutron imaging resolution and spectroscopy capabilities with compact system
  - Close-packed design improves double-scatter efficiency, but increases relative uncertainty in scatter distance

TECHNICAL PROGRESS: ^{3}He BACKPACK TESTING

- Tested three systems in the laboratory using a ^{252}Cf source
  - Small BINGS prototype
  - Two ^{3}He backpack systems

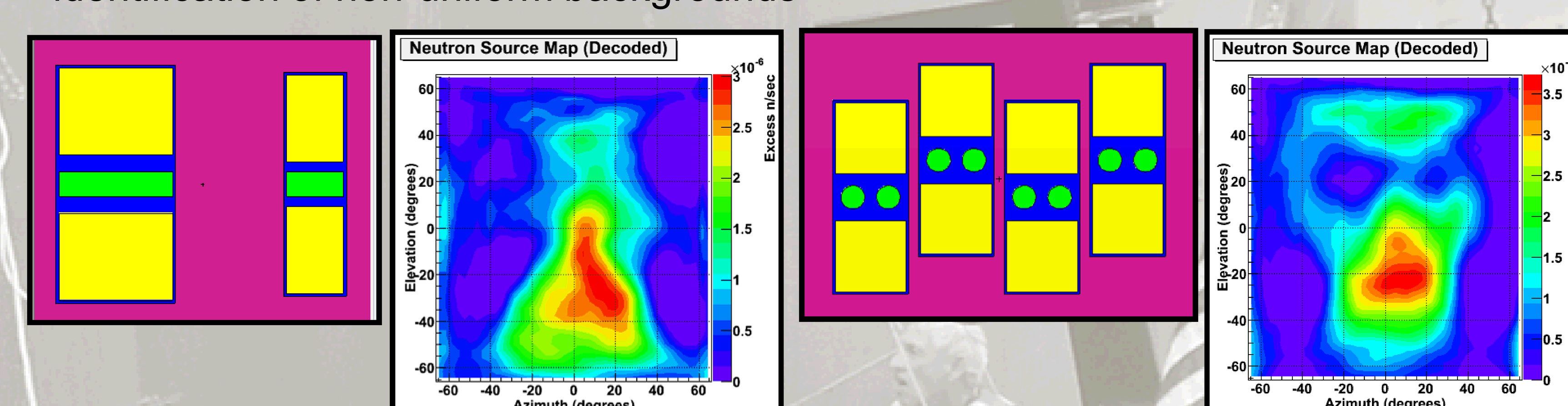




LEFT: Photograph of BINGS prototype cells; RIGHT: a ROC curve generated from measured backpack performance

TECHNICAL PROGRESS: MONTE CARLO SIMULATIONS

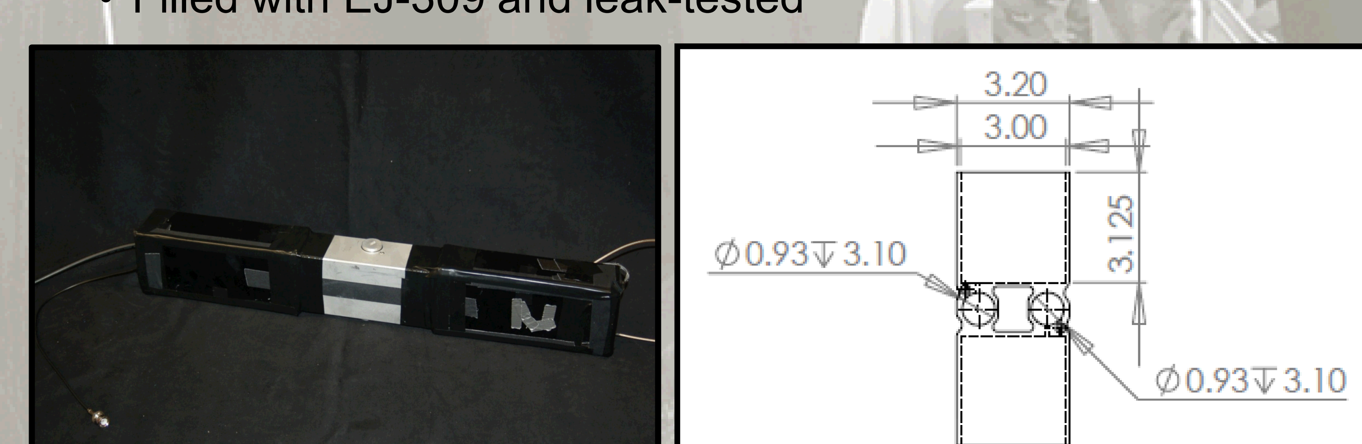
- Neutron Scatter Camera simulation framework to model detector response/imaging
- Consider geometry variations with a fixed liquid scintillator mass
  - Cell spacing: double scatter rates vs. scatter length uncertainty, compact form factor
  - Staggered cells: ideal double-scatter energy sharing
  - Cell sizes: cubes vs. thick/thin planes—best imaging resolution vs. uniform response, higher double-scatter rates
- Provide dual-mode neutron/γ imaging capability for source localization and identification of non-uniform backgrounds



LEFT: Cell geometry and back projection image for a neutron source at (10°, -10°). RIGHT: Using staggered cells, the back projection image is improved.

TECHNICAL PROGRESS: MECHANICAL DESIGN

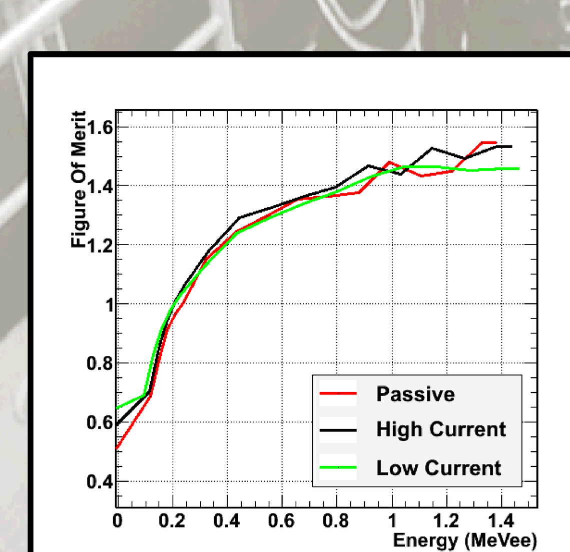
- Have designed and constructed a prototype liquid scintillator cell
  - A piston allows complete liquid fill (no air gap for thermal expansion)
  - Filled with EJ-309 and leak-tested



A photograph and drawing of the double-cell design

TECHNICAL PROGRESS: CUSTOM ELECTRONICS

- Designed active (transistorized) biasing circuit
  - Low power: ~80% reduction in power draw compared to a COTS passive base
  - Tested vs. passive biasing circuit: no measured performance (PSD) degradation
- Neutron Scatter Camera uses analog electronics; need to investigate digital
  - Reduced volume, mass
  - Increased data processing capability
- Investigating sampling frequency options
  - Higher frequency=higher fidelity measurement
  - Lower frequency=lower power consumption
- Starting custom readout using a development board (analog/digital converter, FPGA)



Comparing the PSD figure-of-merit (FWHM/band separation) for three active base designs: 0.047, 0.140, 0.334 μA

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