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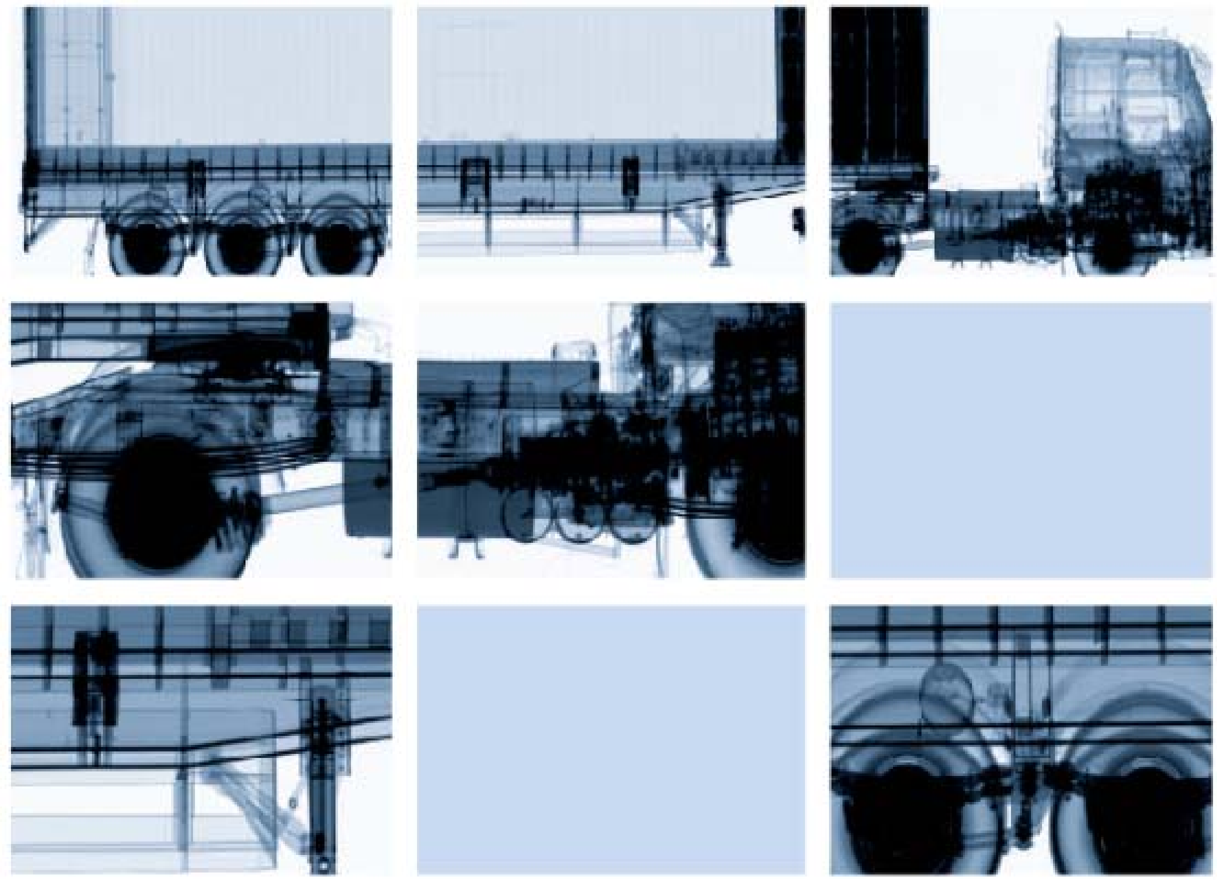
# Neutron Sources and Detectors (for Air Cargo Screening Applications)




**Dan Strellis**

**Rapiscan Laboratories**


**for**

**ADSA11**

**Boston, MA**

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# Motivation

- Screening air cargo is difficult (common theme throughout ADSA10)
- Neutron-based screening techniques offer a measurement of material specificity of the cargo that widely-deployed systems today cannot provide (from ADSA10 Perticone, Cutmore, Gregor)
- To realize these benefits, enabling neutron sources are needed
- COTS systems are available but have limitations
- Initiatives underway to develop new neutron sources and detectors
- Real hurdles exist to field neutron sources due to “perceived risk” and “externalities”

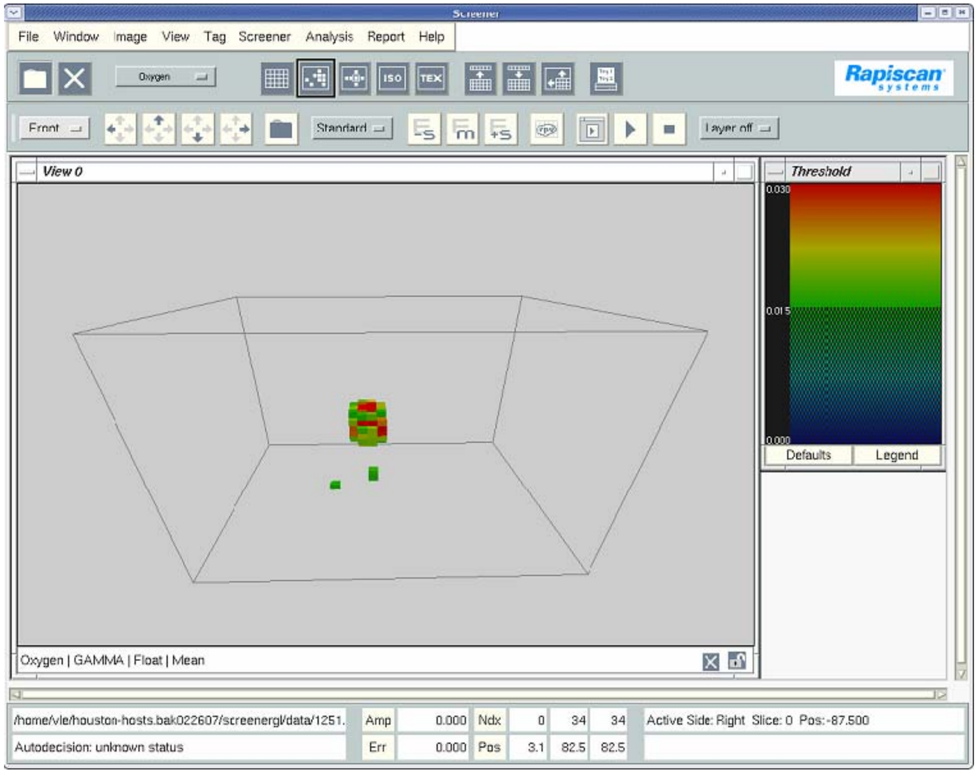
# Applications

**Fast Neutron Radiography (n in, n through)**

- One part of CSIRO / NucTech's Dual Species scanning system (gamma

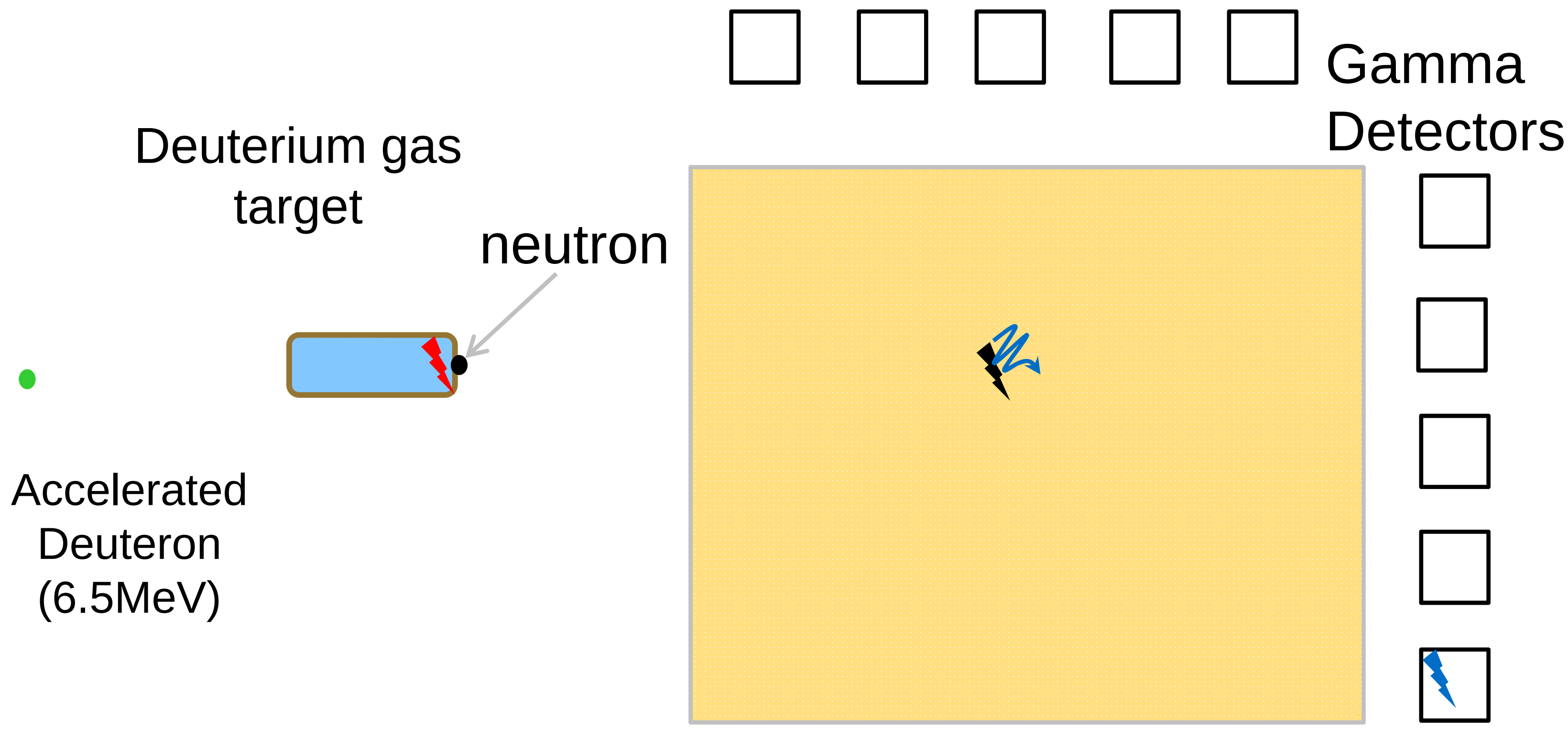
**Neutron interrogation, measure secondary emissions (n in, $\gamma$ out)**

- Pulsed Fast Neutron Analysis



# Pulsed Fast Neutron Analysis

- PFNA
- D + D → n (~8.5 MeV) + $^{3}He$



# Requirements

- For cargo scanning, neutron source is too large, too expensive but output is right – $10^{12-13}$ n/s

*Pelletron Source $M, size of the Egan Research Center front lobby*

- For portable systems, neutron source is too large, flux not high enough

# COTS

- Radioisotope – $^{252}Cf$ spontaneous fission neutron source
  - Steady state
  - $10^7$-$10^8$ neutrons/s fission neutron E spectrum
- Electronic Neutron Generators
  - 1-3 $x10^8$ ($x10^6$) neutrons/s dT (dD)
  - 10-cm diameter, 91-cm long, 25 lbs
  - Vendors
    - Thermo Scientific (www.thermoscientific.com)
    - EADS Sodern (www.sodern.com)
  - 100x higher flux generators also offered for each vendor but much larger



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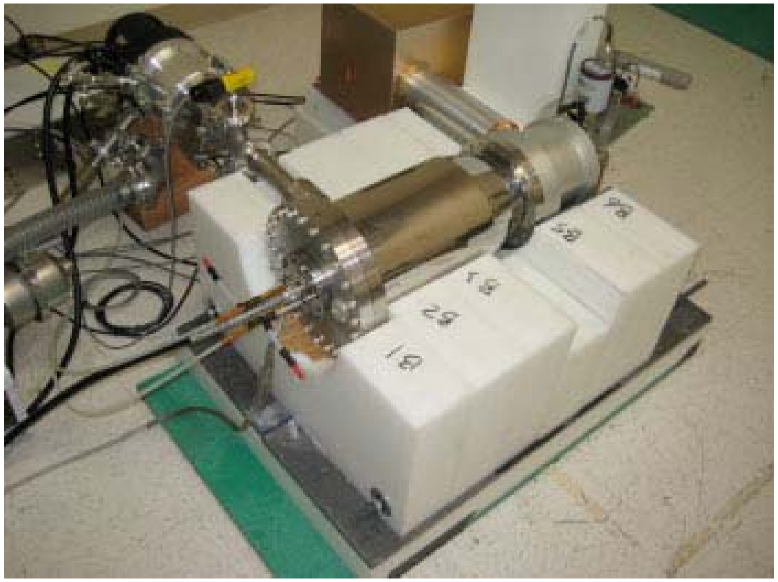
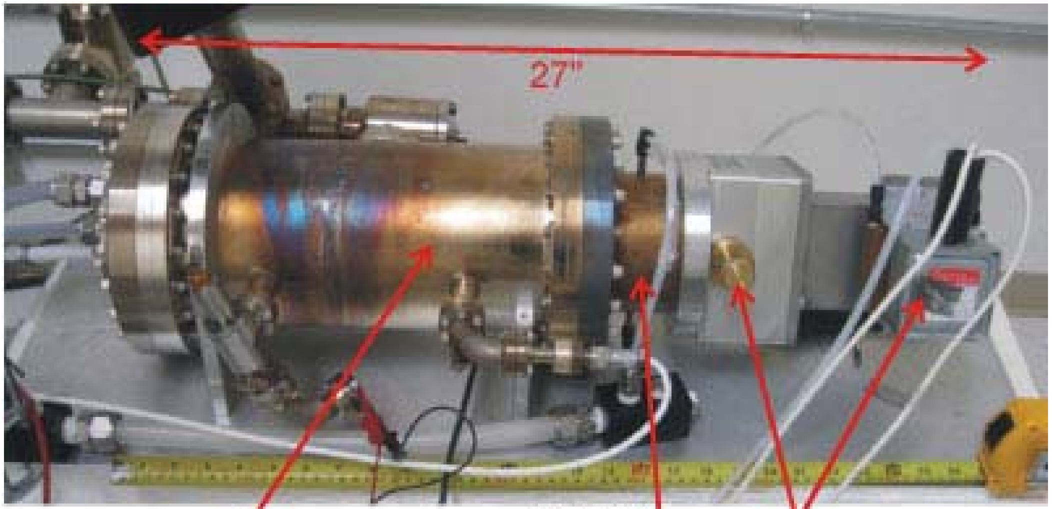
# COTS

- Electron Cyclotron Resonance (ECR)
  - Adelphi Technologies (www.adelphitech.com)
  - DD – $10^9$-$10^{10}$ neutrons/s
  - 25-cm diameter, 80-cm long, 500 lbs,





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# Newer Neutron Source Developments

- Starfire Industries – www.starfireindustries.com
  - $10^7$ neutrons/s DD, 8-cm diameter, 60-cm length, 43 lbs


- Phoenix Nuclear Lab – www.phoenixnuclearlabs.com
  - $3 \times 10^{11}$ neutrons/s DD, $5 \times 10^{13}$ DT
  - 8 cubic meter volume
  - 4500 lbs
  - Also working on compact generators

# Ongoing Neutron Source R&D

**DARPA Intense Compact Neutron Source (ICONS) Program (DARPA BAA 14-46)**

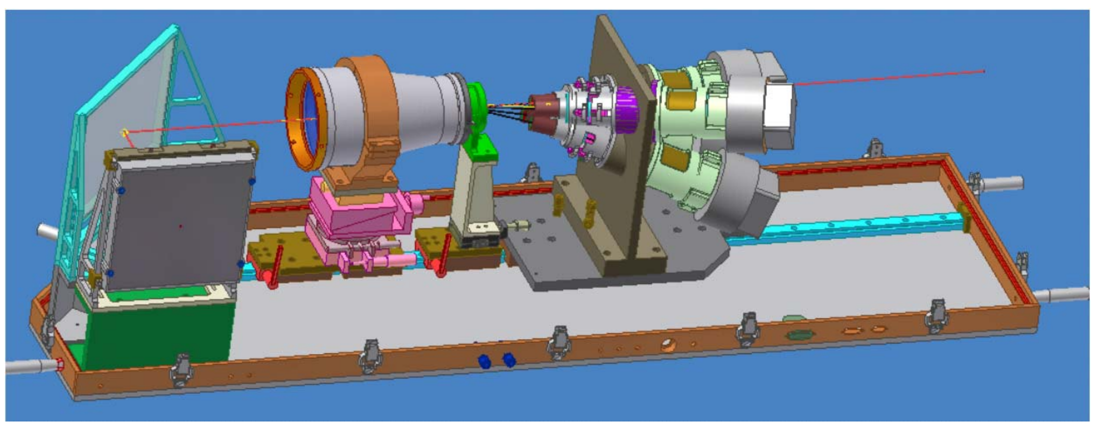
- TA1: Development tool box sized intense neutron source for radiography
- TA2: Development of a human portable directional neutron source

- Orders of magnitude improvement on SWaP
- Looking for innovative designs and construction methods to shrink a neutron accelerator from 10 meters or longer down to 1 meter or less, similar to the size of portable X-ray tubes today.
- Creating a high-yield, directional neutron source in a very compact package is a significant challenge
- Provide an imaging able to deliver very detailed, accurate internal imaging of objects in any setting

- Two 18-month phases

# Neutron Detectors

- Application for air cargo limited to neutron radiography (n in, n through)
- Transmission Radiography
  - Thermal neutrons (limited by penetration depth needed for cargo), thus thermal neutron detector not relevant for this application
  - Fast neutrons (plastic scintillators – Cutmore)
- Fast Neutron Resonance Radiography (FNRR)
  - Vartsky (Soreq, Israel), Dangendorf (PTB, Germany)





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# Summary on Neutron Techniques

- Neutron-based technologies are sensitive to elemental composition of the inspected objects, which allow in many cases to identify the materials of interest. True for fast neutron radiography, fast neutron resonance radiography, and fast neutron analysis (FNA) techniques
- These techniques have been employed with some success but advancements in neutron source technology are required to meet SWaP requirements
- COTS systems exist, development programs underway
- Nonetheless, hurdles still exist for wide spread utilization of neutron sources:
  1) changes to regulations (like AT for checkpoint),
  2) public acceptance (like AIT)