Accelerator Installation for Active Interrogation Detection Method Development

C.A. Miller[1]*, C.A. Meert[1], A.K. Harvis[1], S.D. Clarke[1], S.A. Pozzi[1]
[1]Department of Nuclear Engineering and Radiological Sciences, University of Michigan, Ann Arbor, MI
*Presenting Author, cmillera@umich.edu
Consortium for Verification Technology (CVT)

Motivation and Introduction

- Highly enriched uranium (HEU) is arguably the most challenging material for nuclear security
  - Gamma rays emitted by HEU are low energy and easily shielded, and it passively emits very few neutrons
- Active interrogation with photons or neutrons is likely necessary to detect shielded HEU
- We are developing organic scintillator based systems to detect photon induced prompt fission neutron detection
- This will enable the application of commercial linacs to reduce the cost and complexity of active interrogation systems

Varian M9 Linear Accelerator

- The linear accelerator is a commercial available Varian model, originally for medical applications
- The electron energy is fixed at 9 MeV, while pulse rate can be adjusted to either 25 or 250 Hz

Varian M9 Linac Parameters	
Beam Endpoint Energy	9 MeV
Pulse Rate	25 or 250 Hz
Average Current	10 or 100 µA
Converter: Copper backed Tungsten, no spectral filtering	

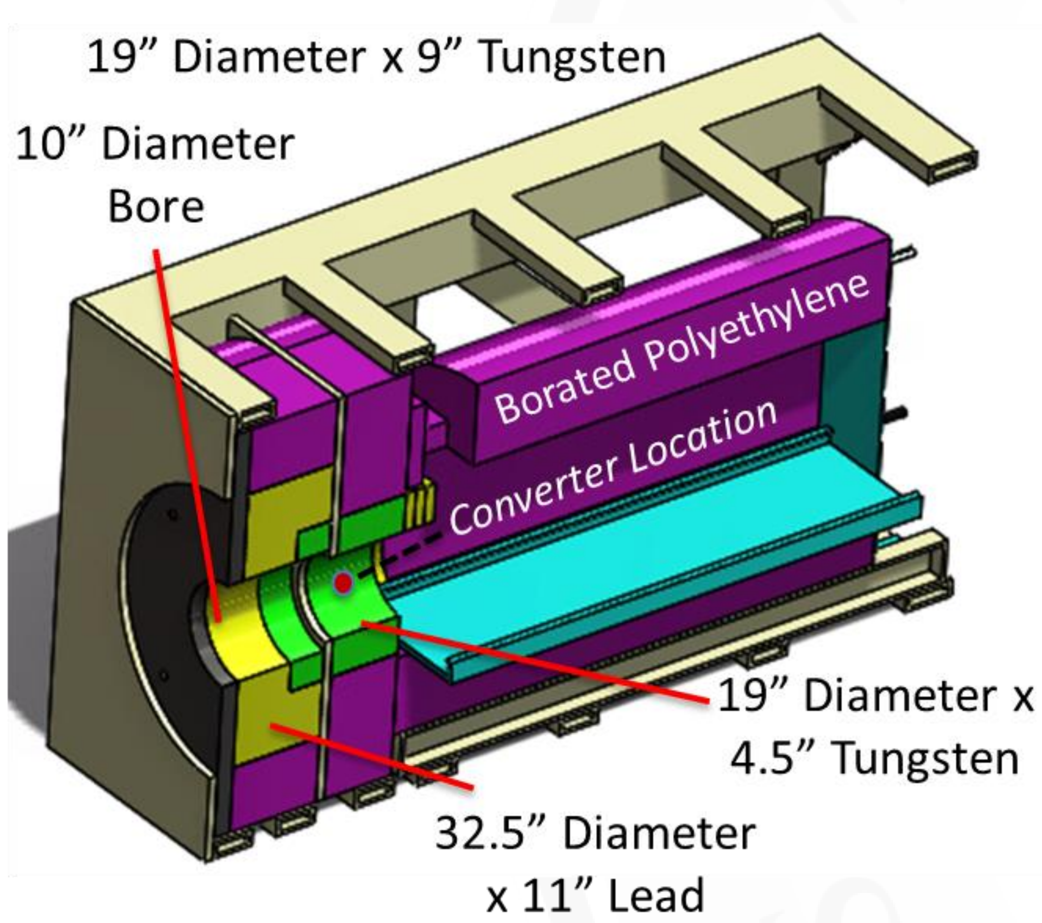

Fig. 1. Shielded Linac Enclosure

- A shielding enclosure was provided by Rapiscan Systems, developed for cargo screening testing
- The accelerator head rolls into the enclosure on an aluminum rack
- A tungsten and lead collimator is centered around the converter
  - Borated polyethylene shields neutrons produced in the high-Z collimator

Accelerator Laboratory Space

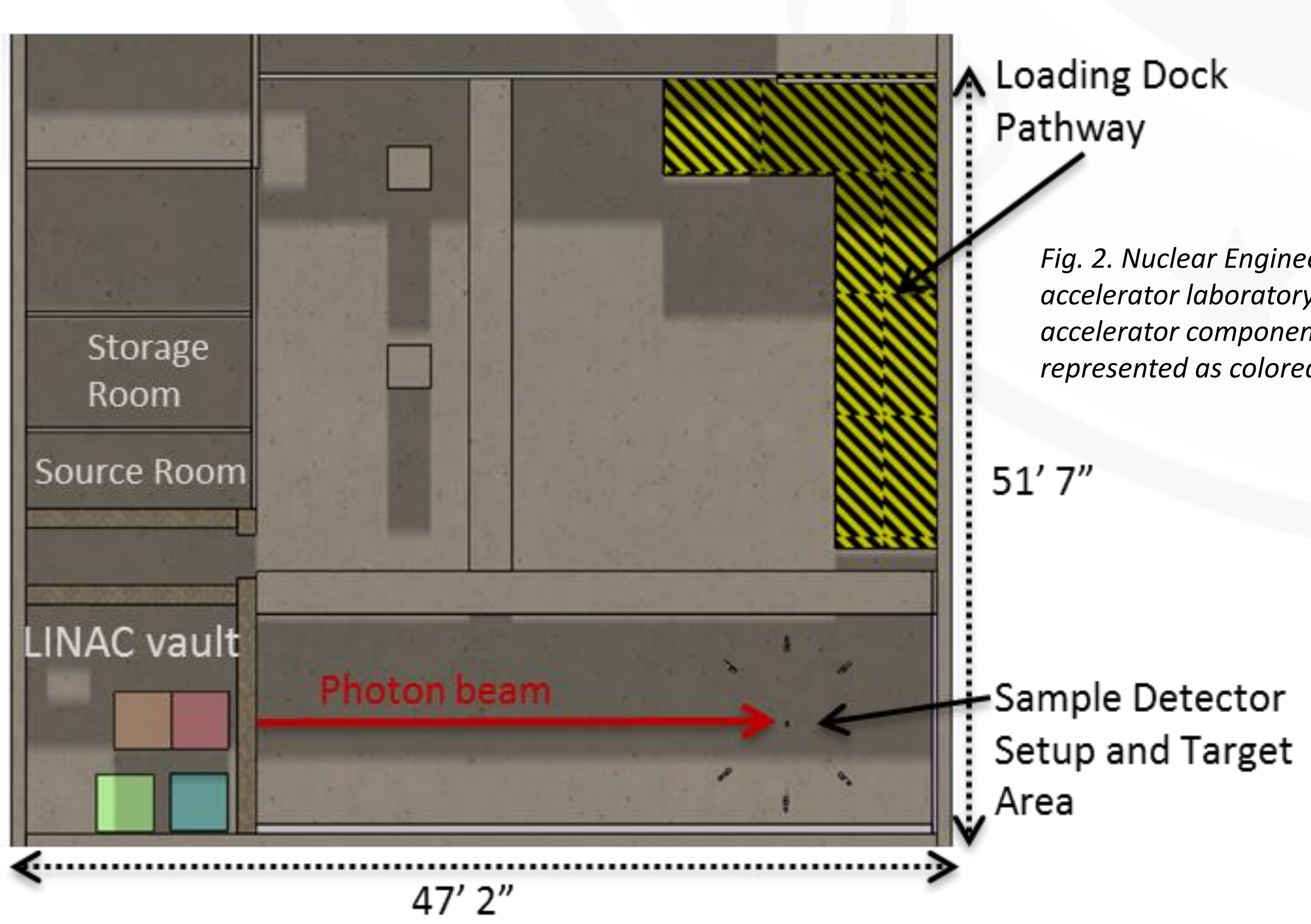

Fig. 2. Nuclear Engineering Lab accelerator laboratory, accelerator components represented as colored boxes

- Target and detectors can be placed ~15 m from the accelerator , with the beam 3 ft off the floor
- The beam has a 22 cm radius at 15 m

Shielding Design

- The accelerator laboratory is in the basement of the University of Michigan Nuclear Engineering Laboratory, so is shielded well in most directions
  - However, the beamline is directed towards a storage room in an adjacent building
  - A beamstop is simulated as 8” thick lead with a 1” BPE coating

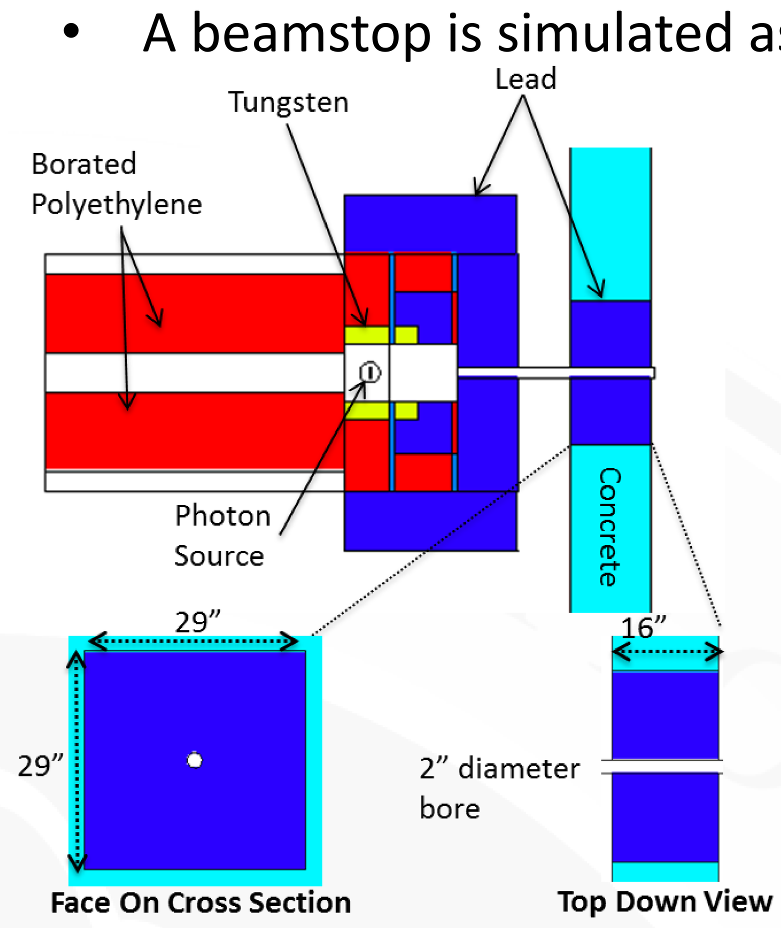

Fig. 3. Top-down view of accelerator shielding, secondary collimator placed in concrete vault wall

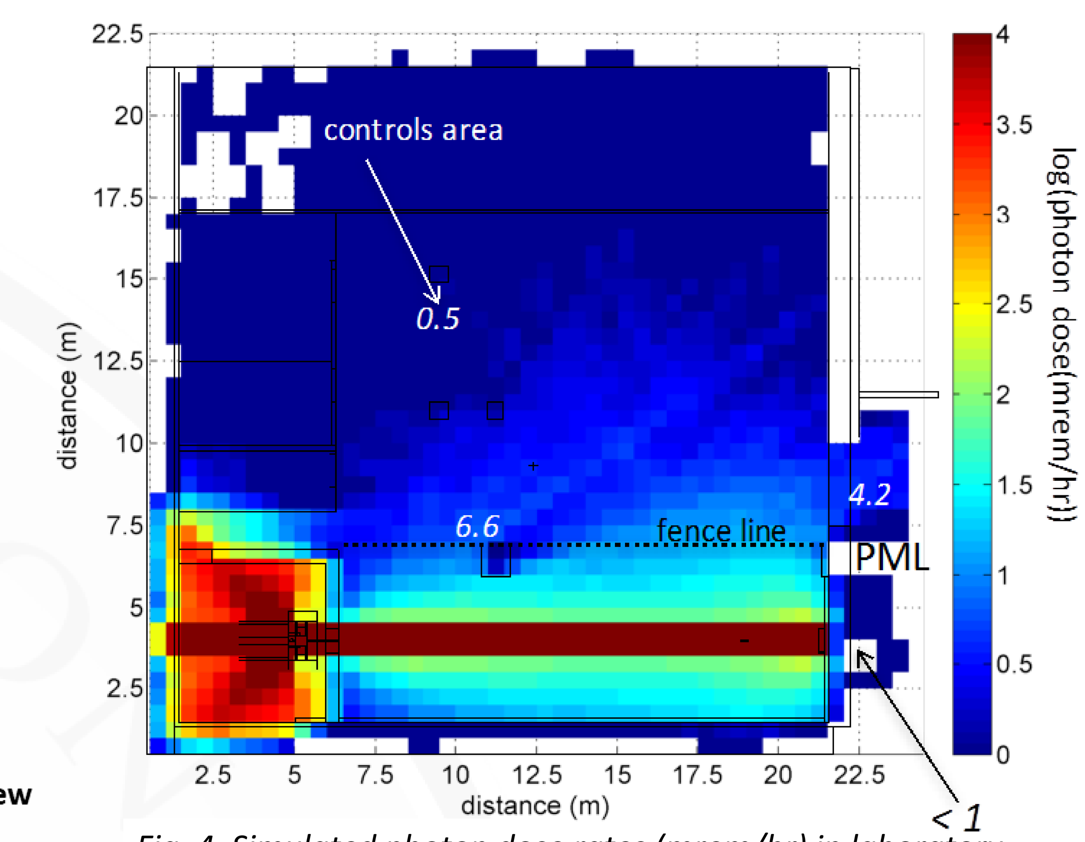

Fig. 4. Simulated photon dose rates (mrem/hr) in laboratory. Neutron Dose rates insignificant outside linac vault

Experiment Planning

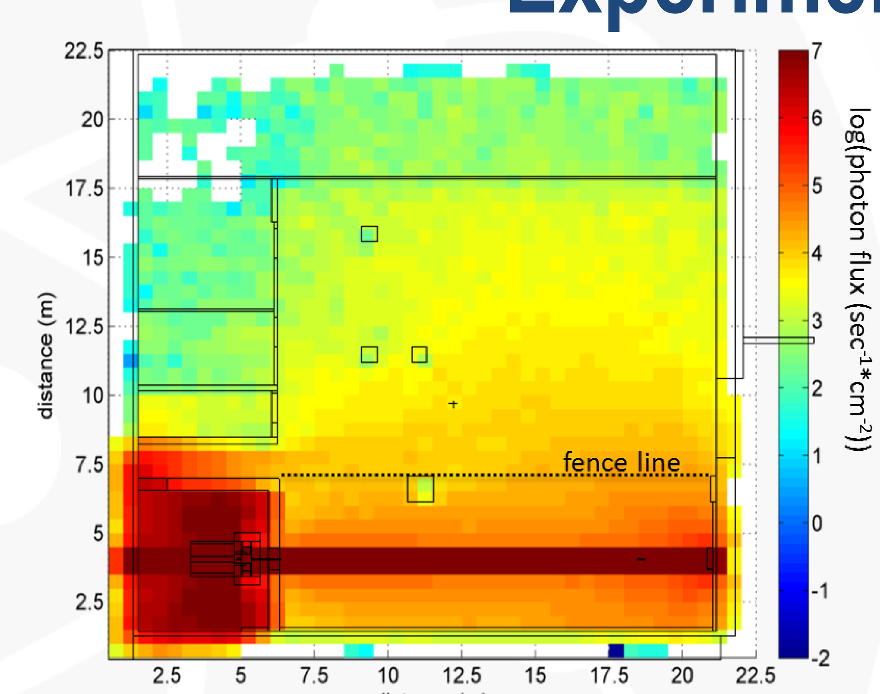

Fig. 5. Photon flux in 50 cm cubed voxels, run at 25 Hz

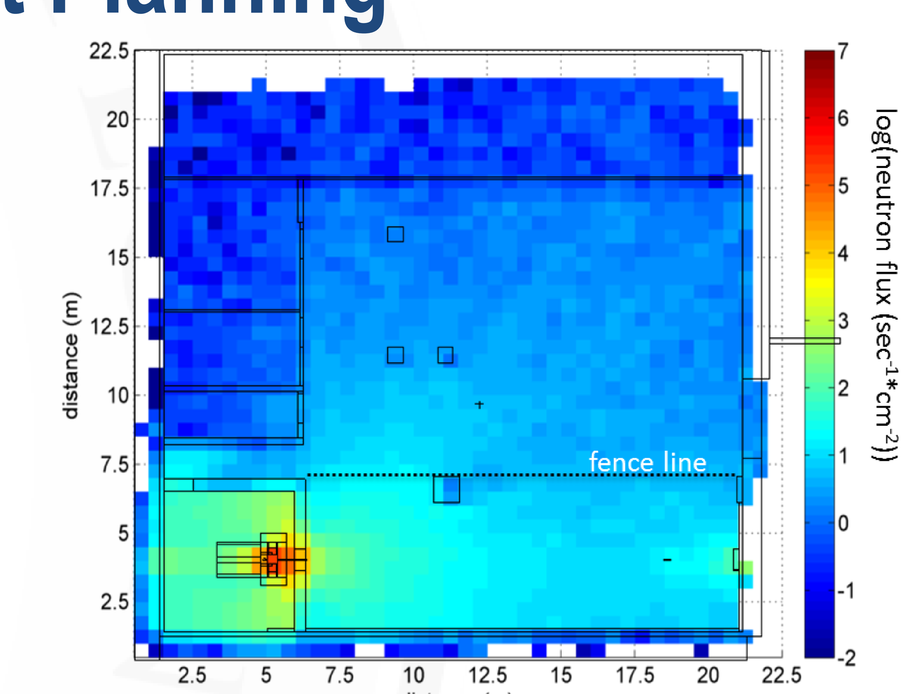

Fig. 6. Neutron flux in 50 cm cubed voxels, run at 25 Hz

- As neutron detection is the main objective for determining SNM or a proxy, photons are treated as a nuisance
- Different target sizes and materials have been tested, with particle flux calculated towards detector array

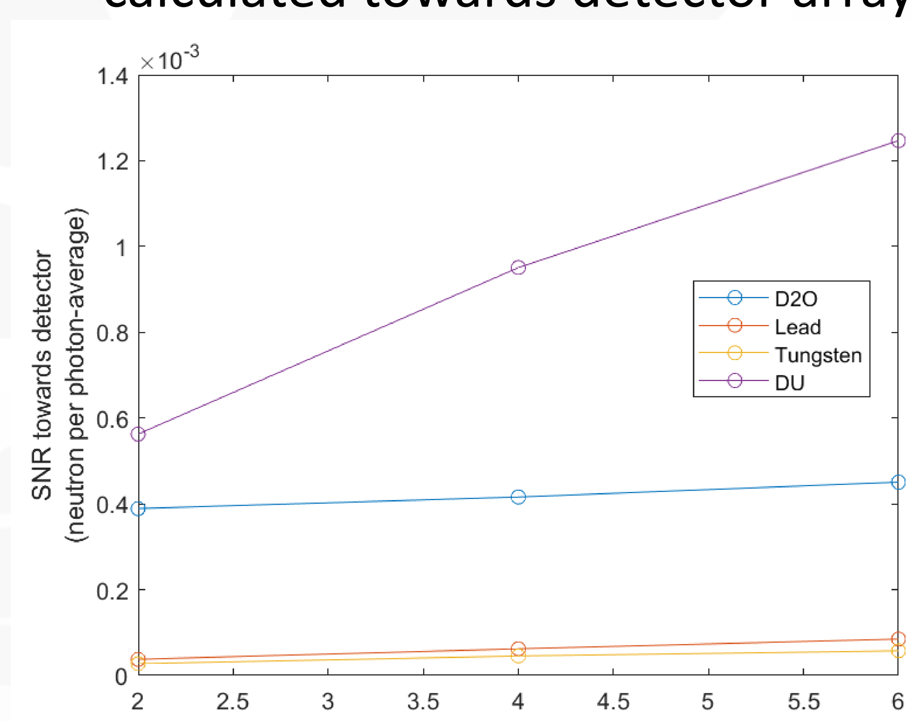

Fig. 7. Signal to noise (neutron to photon ratio) for different size targets of different materials

Fig. 8. Current construction of linac laboratory

Conclusions

- Interrogation of targets with a 9 MV linac will allow for investigation into scintillator based active detection methods
- These methods will enable the use of commercially available accelerators and detectors in nuclear security applications
- The construction of this facility is progressing well, and will be open for collaboration on experiments when complete

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