Visualizing Particle Imaging using the HoloLens 2

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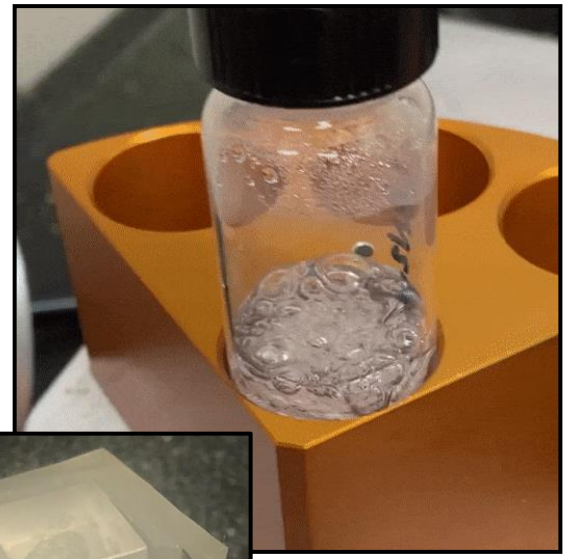
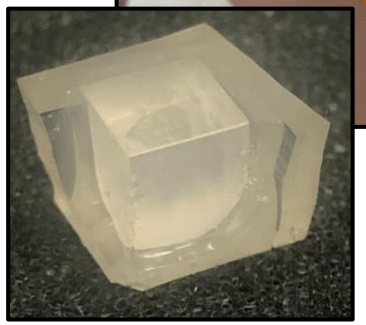
Introduction and Motivation

- Concerns in nuclear verification and nonproliferation fields include accounting for nuclear material
  - Deployable equipment w/ small form factor + user-friendly
- Particle imagers are a powerful tool
  - Neutrons + gamma rays important signatures of U, Pu, etc.
- Organic glass scintillator (OGS) material developed by Sandia National Labs
  - Melt-cast & comparable to other scintillators in performance

- Mixed reality has become more accessible and can convey information in a new medium for users





OGS 6 mm cube cast sample

NNSA Mission Relevance

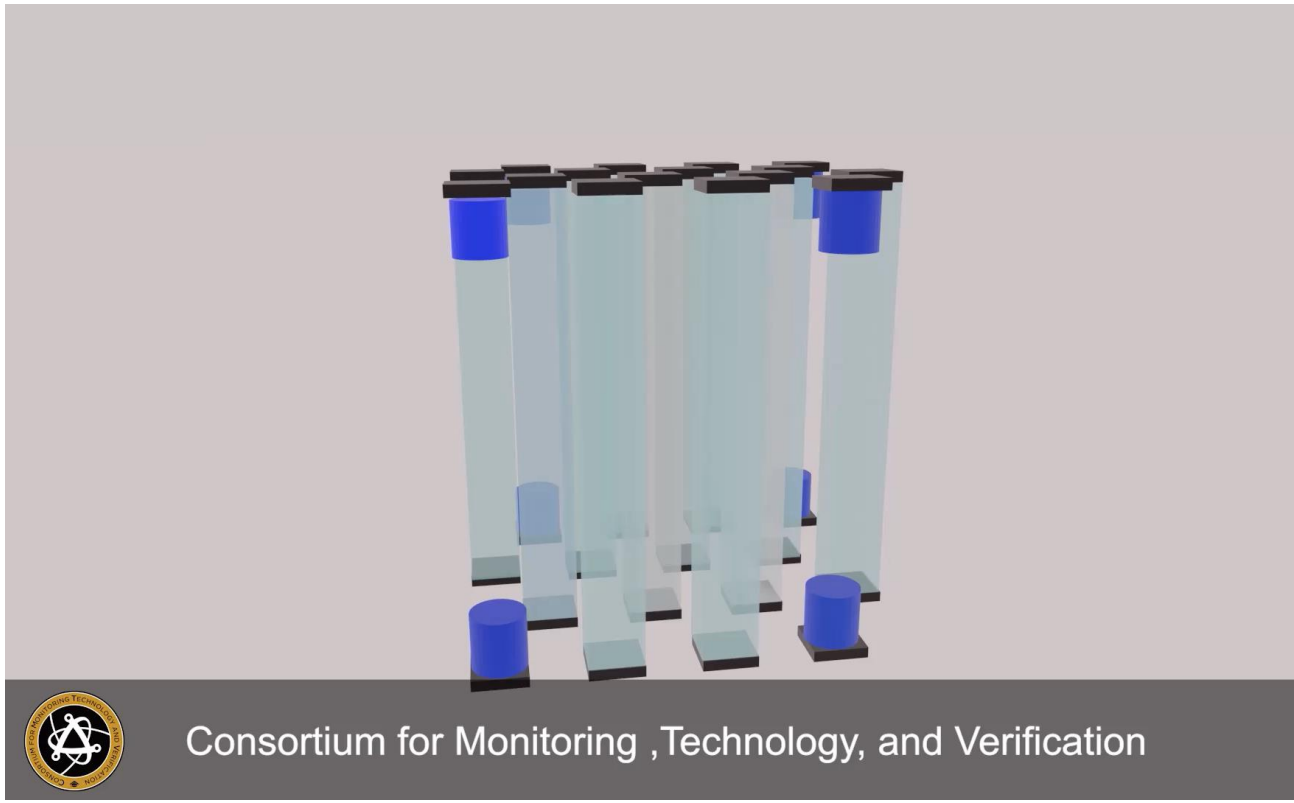
NNSA Office of Defense Nuclear Nonproliferation

- "…build the capacity of the International Atomic Energy Agency (IAEA) and partner countries to implement international safeguards obligations and detect and deter diversion of nuclear material or illicit use of nuclear facilities"

This work is developing equipment capable of source localization while also improving the user experience for personnel.

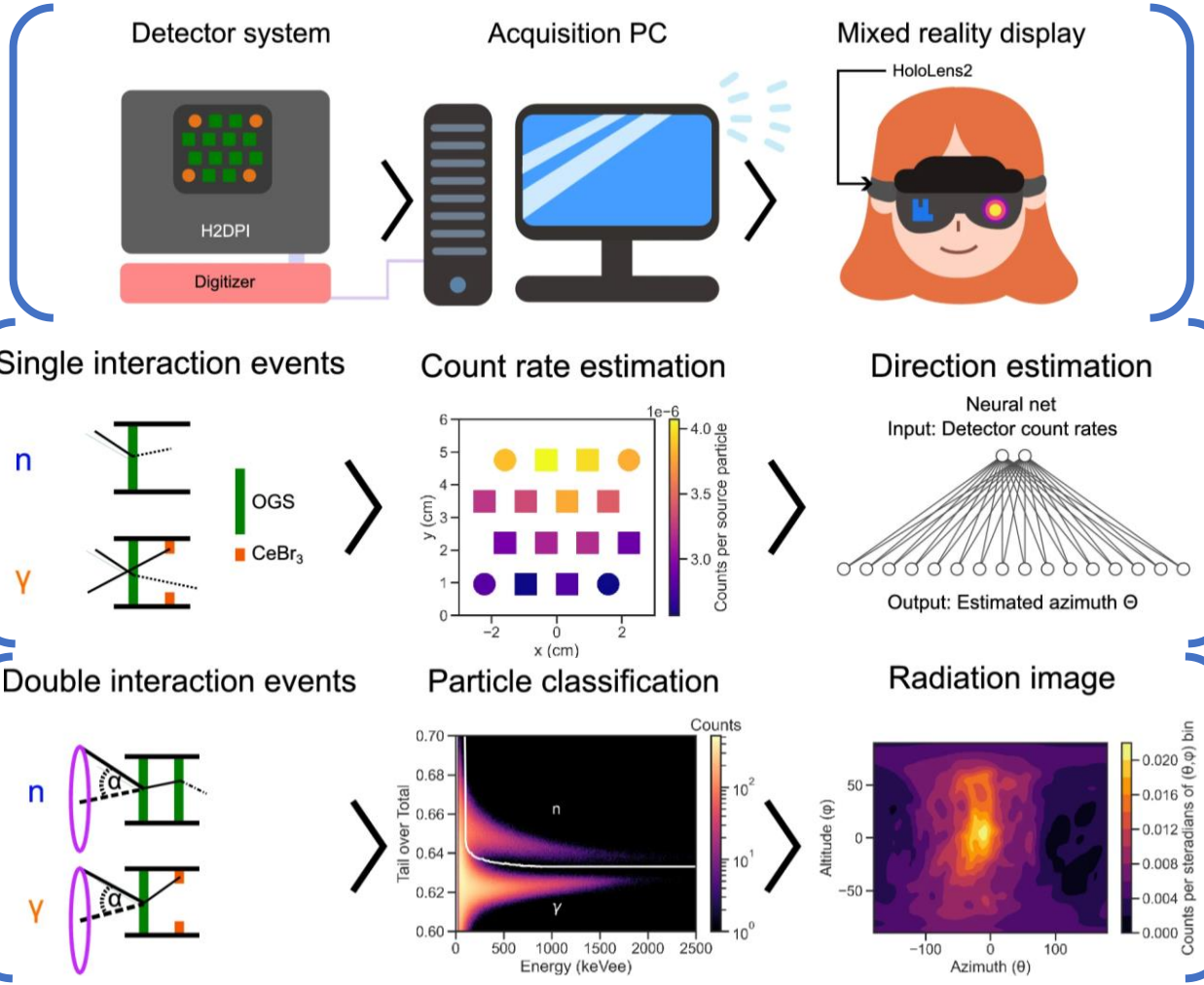
Technical Approach – System Design

- Scatter-based OGS imager design:
  - 12 OGS bars (6x6x50 mm^3) w/ diffuse reflector
  - 8 $CeBr_3$ (6 mm height, 6 mm Ø) cylinders
  - Silicon photomultiplier arrays for output
- OGS composition **can discriminate neutrons and gamma ray events**
- Reconstruct double scatter events using simple back-projection on spherical surface



Technical Approach – Dual-Particle Imaging

Technical Approach – MR Visualization Pipeline



General Process

Imaging Mode

- Project double event data onto the spatial mesh

Fast Mode

- Feeds single event count rates

For more details see our publication:

O. Pakari, R. Lopez, et al., "Real-time mixed reality display of dual particle radiation detector data", *Sci Rep* 13, 362 (2023). https://doi.org/10.1038/s41598-023-27631-1

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Real-time mixed reality display of dual particle radiation detector data

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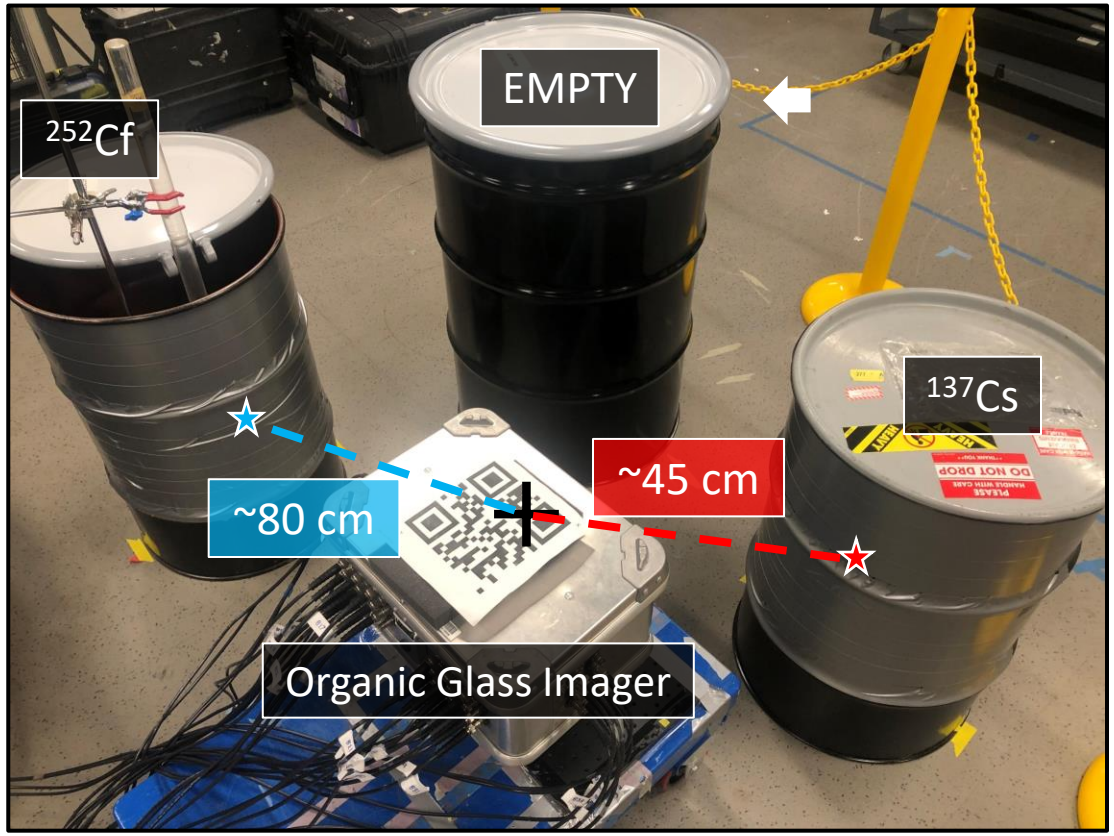
Experimental Setup: Mock Inspection Scenario

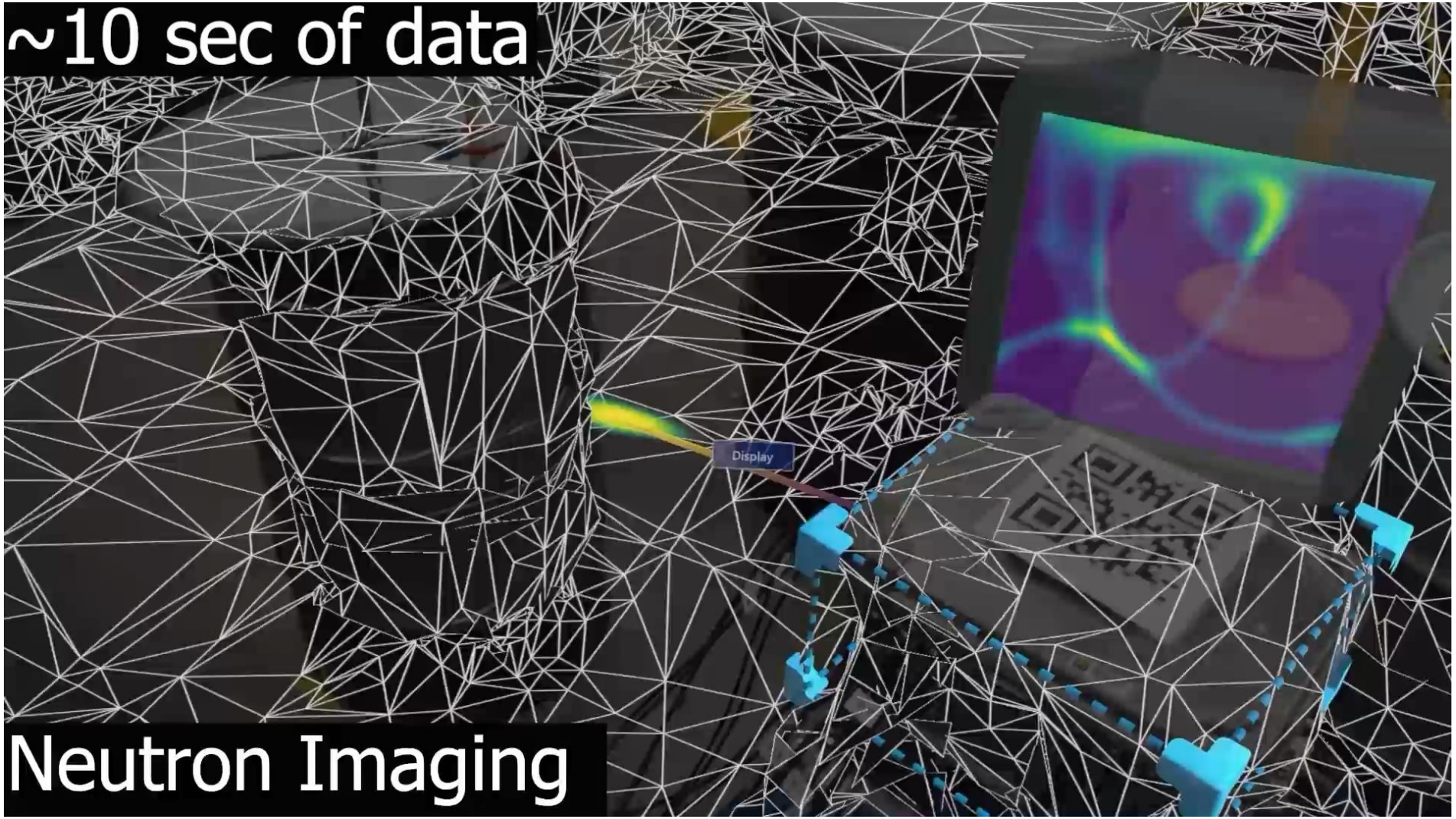
Mock scenario with multiple sources in FOV inside storage barrels

- Cf-252 (555 µCi) placed ~ 80 cm from imager
  - Shielded with 14 mm of lead
- Cs-137 (150 µCi) placed ~45 cm from imager
- Third barrel kept empty

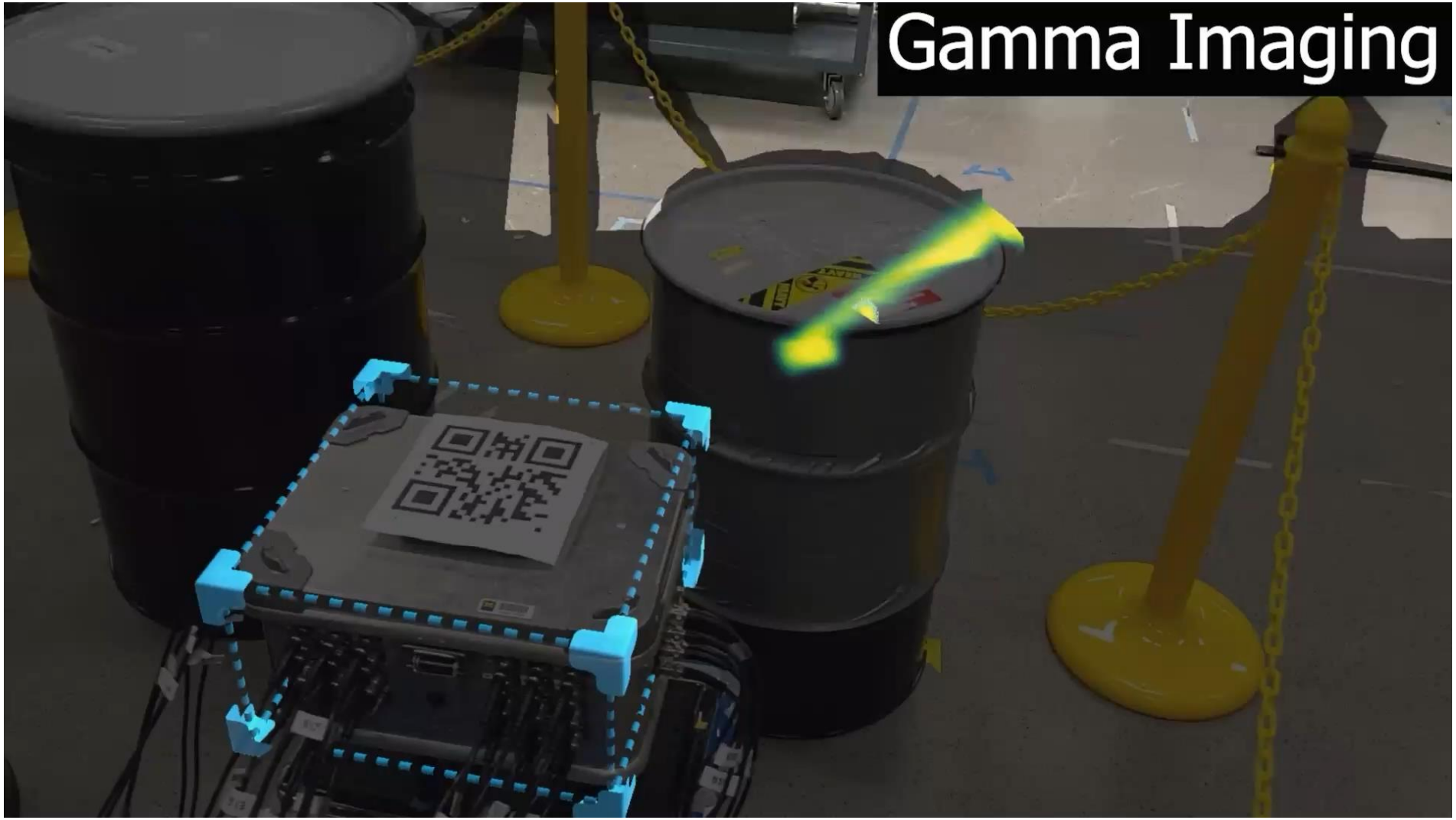
Demonstrate both real-time acquisition and visualization from 1.5 hours of data.



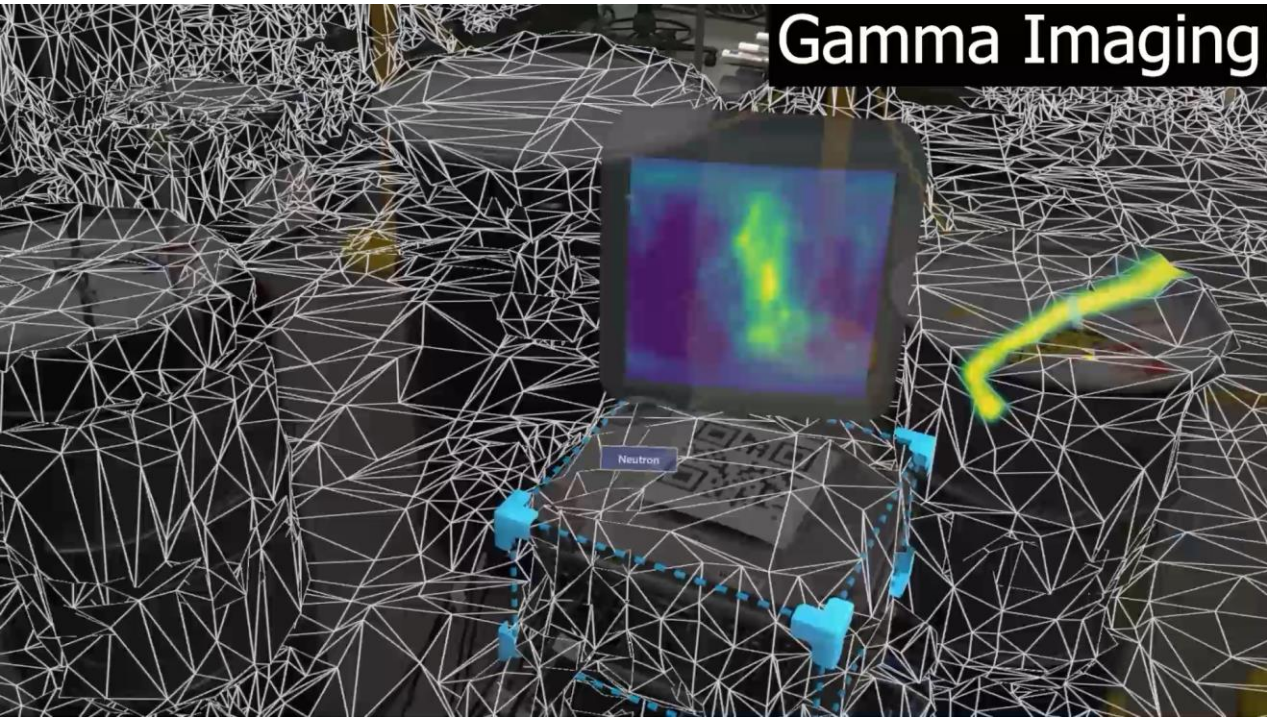
Real-Time Data Acquisition



Final Imaging and Spectroscopy Results

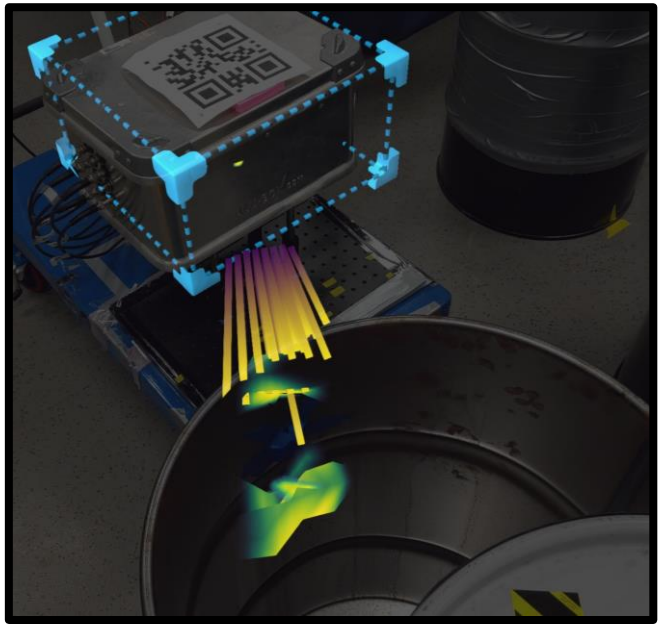


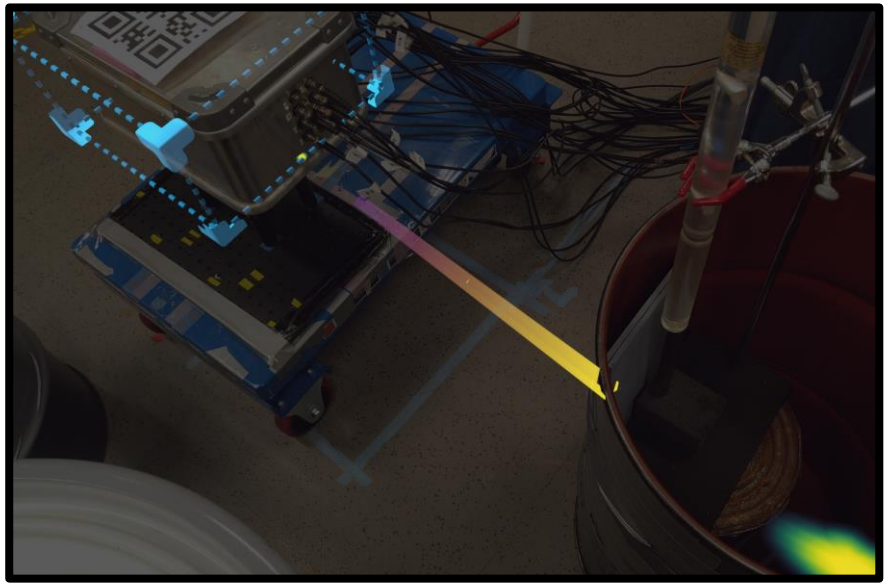
Source Localization Results



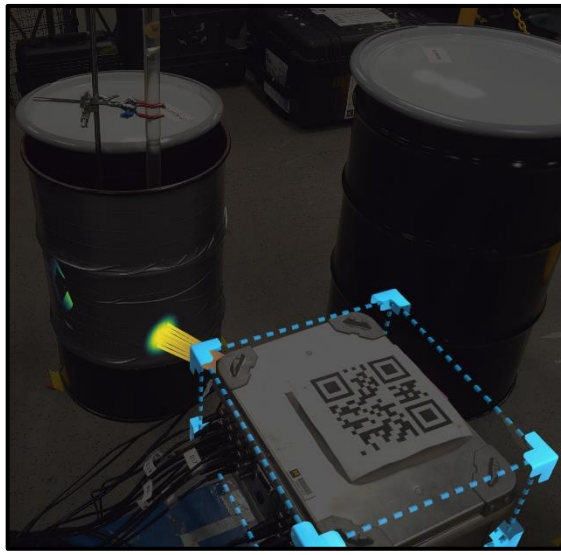
Expected Impact of Work

- Successful MR visualization implementation results in:
  - Expanding repertoire of tools available to personnel in safeguards
  - Less background necessary for data interpretation from the user
  - Intuitive method of visualizing source localization and spectroscopy





Conclusion

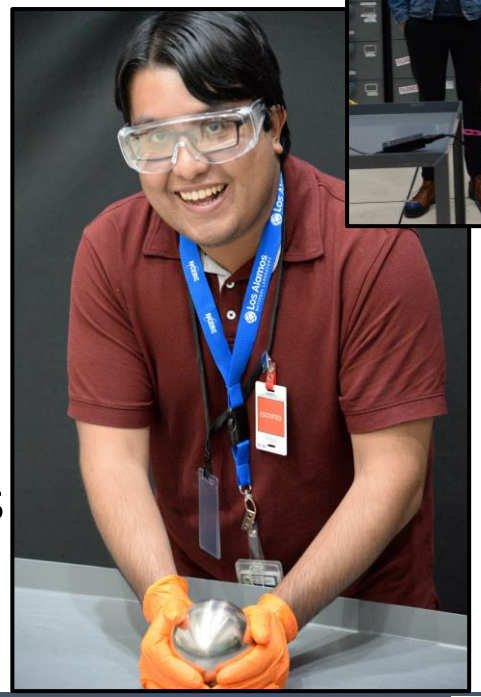


- Results demonstrate the capability of a mixed reality approach to the visualization of imaging data
  - **Neutron mode successfully localized Cf-252 source in barrel**
  - **Gamma mode successfully localized Cs-137 source in barrel**

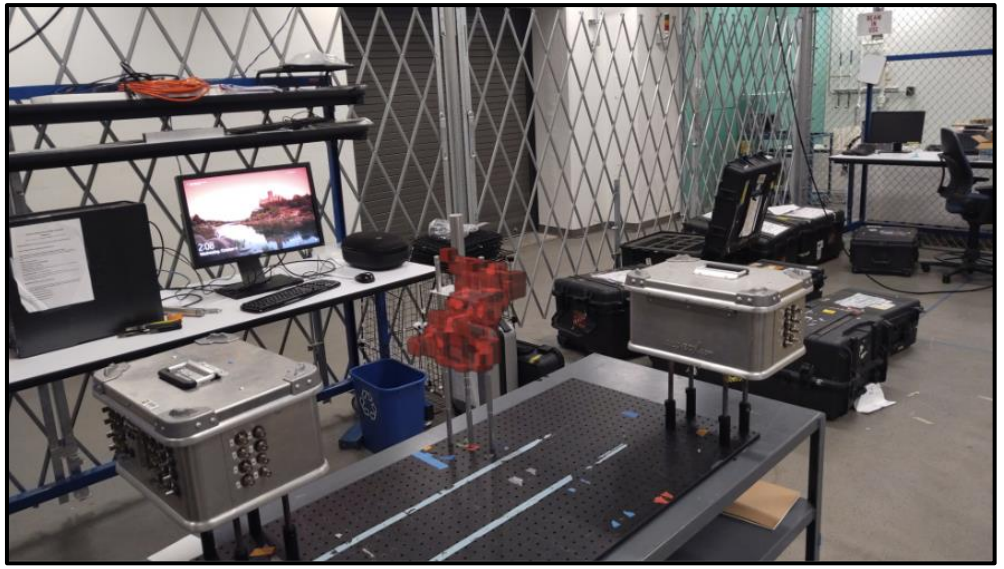
- Positively impacts the NNSA mission by developing:
  - Equipment that localize sources for on-site monitoring/ verification activities/search, etc.
  - Software that eases burden of data interpretation

MTV Impact

- I thank MTV for providing the following unique opportunities over the course of the project:
  - Campaign at the Nevada National Security Site (3x)
  - Campaign at Savannah River National Laboratory
  - Campaign at Lawrence Livermore National Laboratory
- We plan on continuing our collaborative relationship with Sandia + NCERC
  - Open for more national lab collaboration opportunities

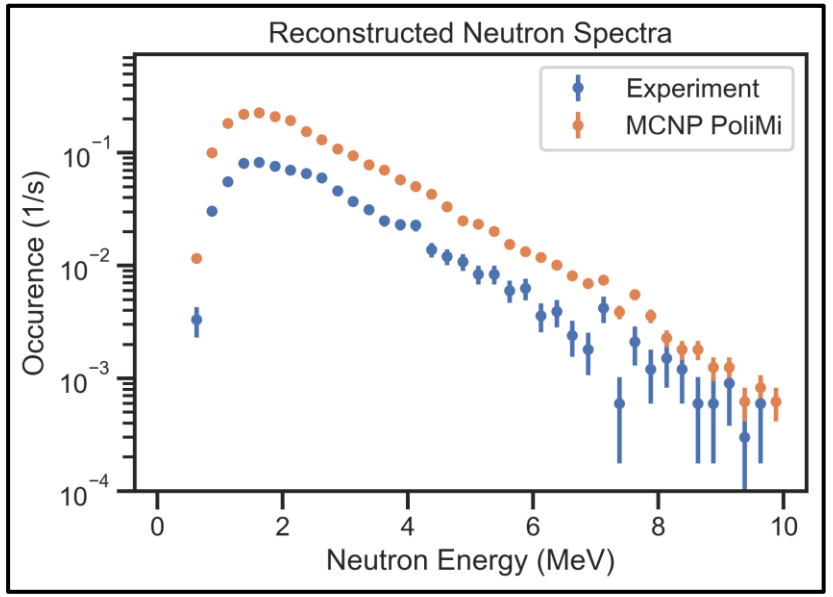


Next Steps and Future Work



- Ongoing work includes:
  - 3D imaging algorithm for MR visualization
  - Further characterization of the OGS imager
  - Improving HoloLens application software programs

- Future work with imager includes measurement campaigns in collaboration with:
  - NCERC at the Device Assembly Facility
  - Lawrence Livermore National Laboratory



Acknowledgements

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