Dry-Cask Storage Verification using Muon Imaging

MTV Kickoff Meeting

May 20, 2019, 10:05

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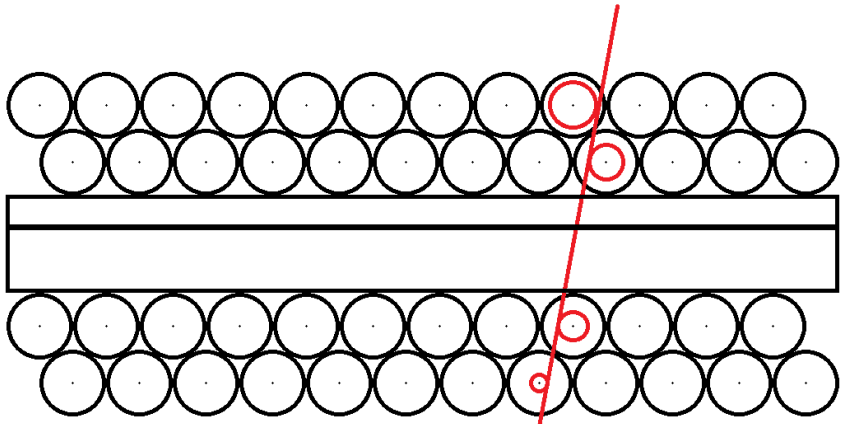
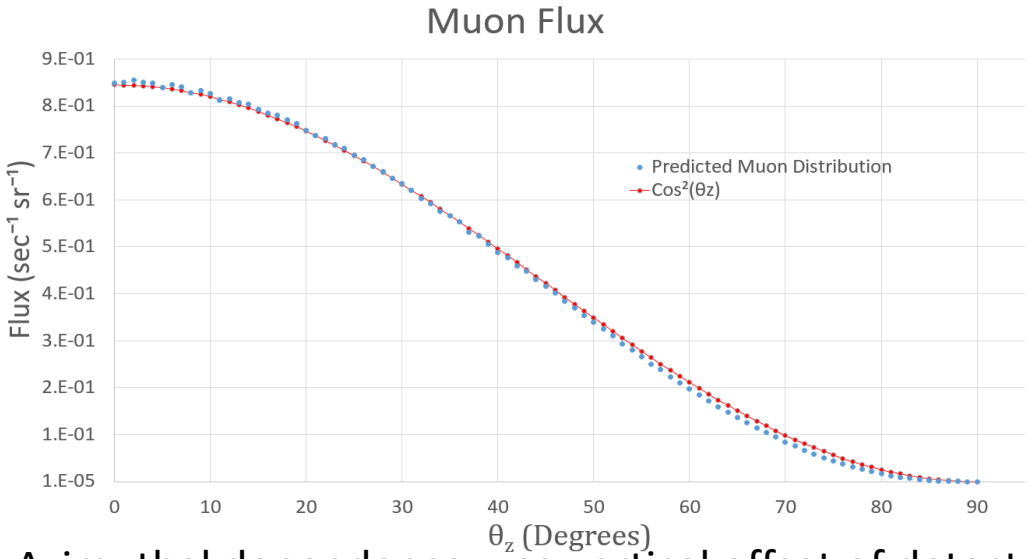
Introduction and Motivation

- The ability to verify the contents of a spent fuel cask in situ is currently unavailable. This poses a gap in the ability of the IAEA to verify nuclear material quantities should the history of the cask content be called into question.
- Currently, cosmic-ray muons are the only radiographic probe that can penetrate the large amount of material in a dry storage cask. Additionally, cosmic-ray muons are background radiation; thus, measurements done are passive and pose zero risk in terms of increased dose.
- Using muons to verify the contents of dry storage casks fills in the gap in the IAEA's ability to track nuclear waste, which reduces proliferation risk from diverted spent fuel and adds additional technical tools to the IAEA safeguard toolbox.

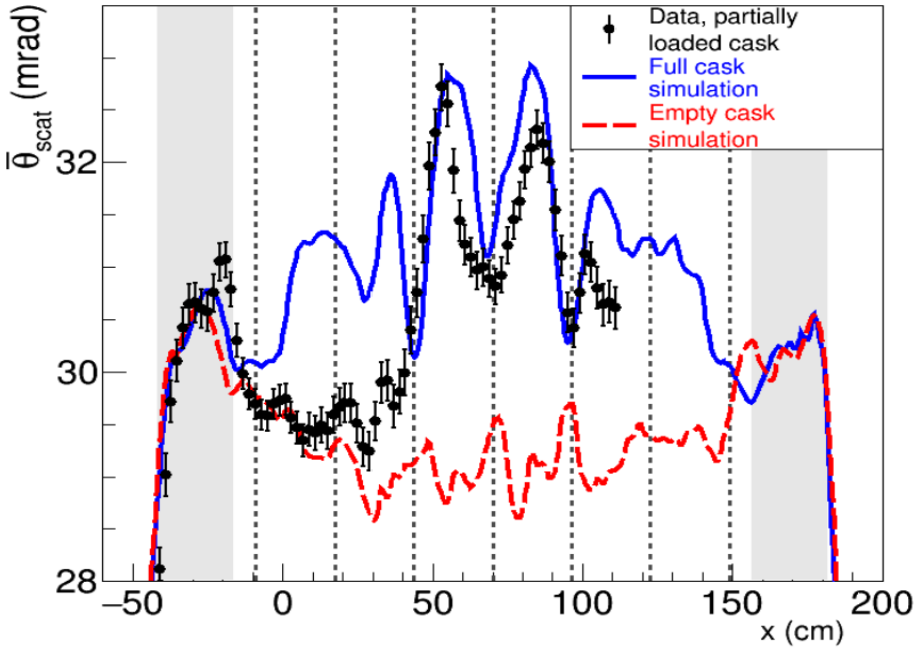


Cosmic ray muons are highly penetrating, Eav = 4 GeV
These can be tracked with drift tubes before and after the object

Single position array test on cask at INL



Azimuthal dependence, use vertical offset of detectors



Data on partially loaded cask, from single angle

Mission Relevance

- This work directly addresses the need to monitor SNM to ensure no diversion

- *NNSA Mission*

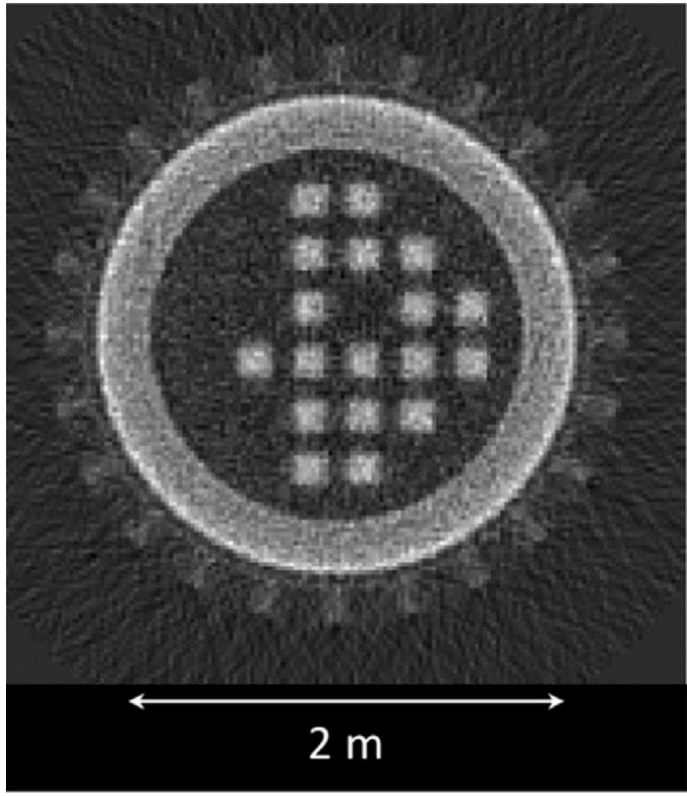
  Preventing nuclear weapons proliferation and reducing the threat of nuclear and radiological terrorism around the world are key U.S national security strategic objectives that require constant vigilance.

  NNSA's Office of Defense Nuclear Nonproliferation works globally to prevent state and non-state actors from developing nuclear weapons or acquiring weapons-usable nuclear or radiological materials, equipment, technology, and expertise.

Technical Work Plan

- Leveraging the existing arrays, we will work on techniques to define and improve spatial resolution and speeding acquisition times for muon imaging of fuels through thick cask walls
- Work with larger drift tube array
- Run further tests with multiple arrays on casks (at INL).
  - just single test run so far from a single angle
  - Multiple angles = tomographic reconstruction →
- Detector arrays and instrumentation currently exist at LANL
- Expertise exists at LANL
  - my former grad student Dan Poulson, etc
- LANL does not have further funding for this

  - the table is set for us.



Simulated data tomographic reconstruction

Expected Impact

- Tomographic imaging of fuels inside of used fuel storage casks
- Algorithm development for
  - Improved resolution
  - Reduced imaging time
- Z^2/A materials discrimination
  - will even know if U pin replaced with steel, Pb, etc.

MTV Impact

- Impact:
  - Internships and student pipeline with LANL
  - Networking with LANL
- Personnel transitions:
  - Have history of placing students at Los Alamos, Sandia, LLNL, AFRL
- Technology transitions
  - Spin off company examined cargo screening – though slow
  - Appropriate for longer measurement situations such as fuel storage
  - Interest by WIPP, URENCO, NEF etc?
    - (Will they spend the money? If mandated.)

Conclusion

- This work directly addresses the need to monitor SNM to be sure there is no diversion

Extra – shopping for interest:

Laser Induced Breakdown Spectroscopy (LIBS)
with laser filaments for longer range
Isotopic selectivity (resolution < 5 pm) in atmospheric pressure

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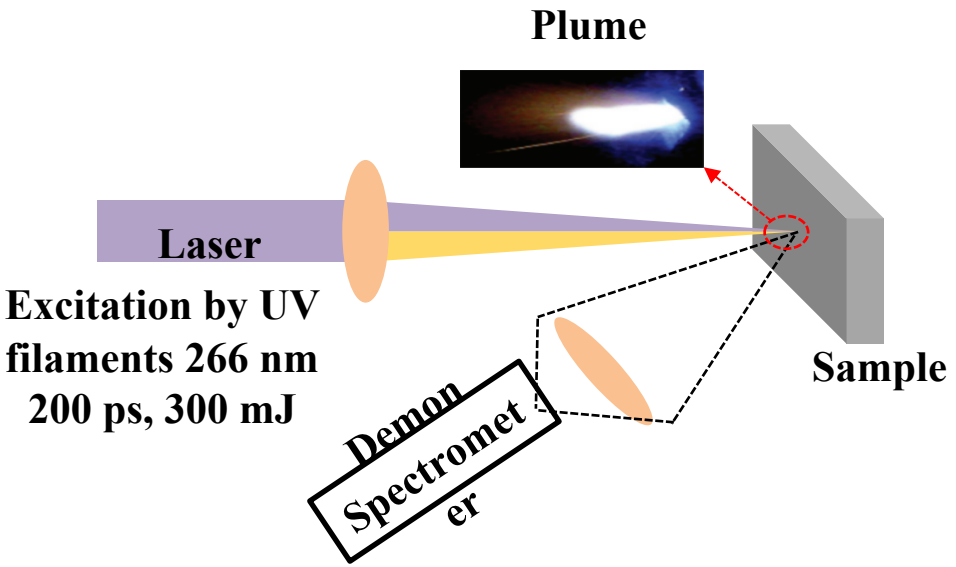
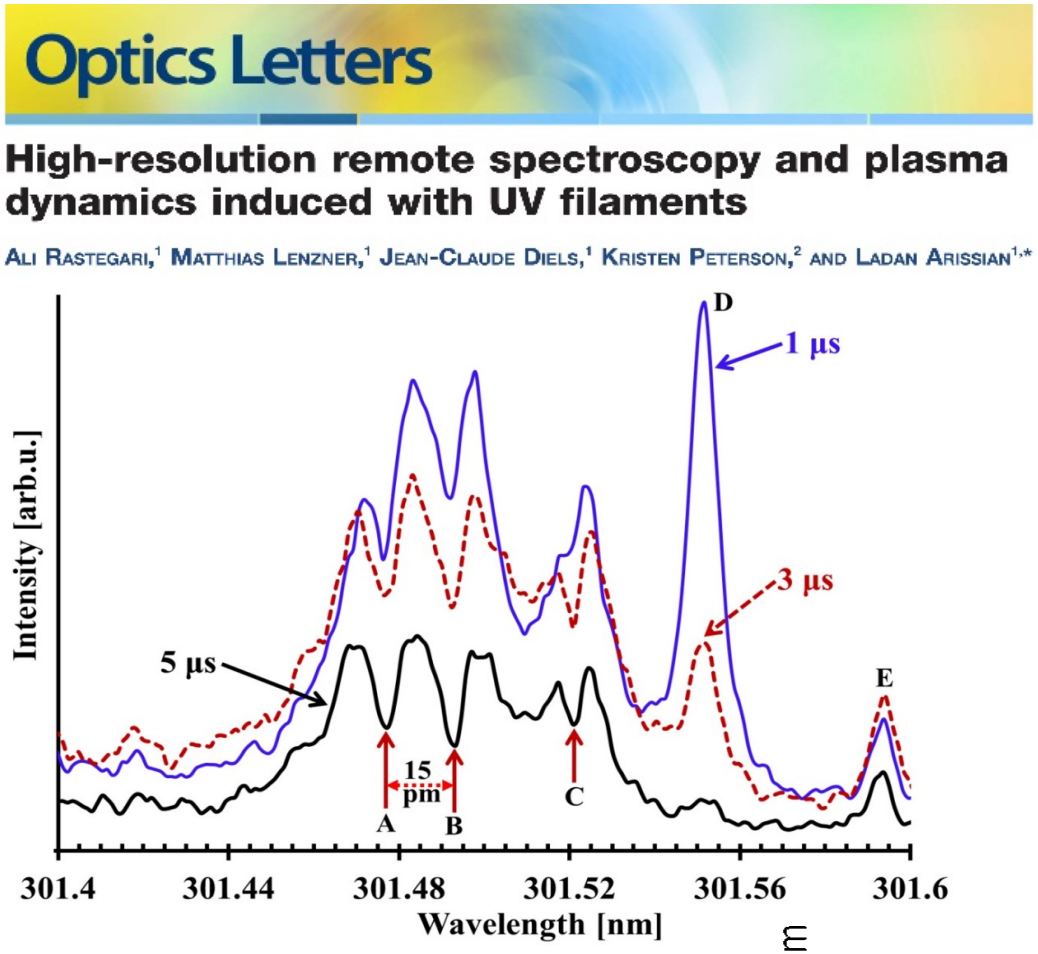
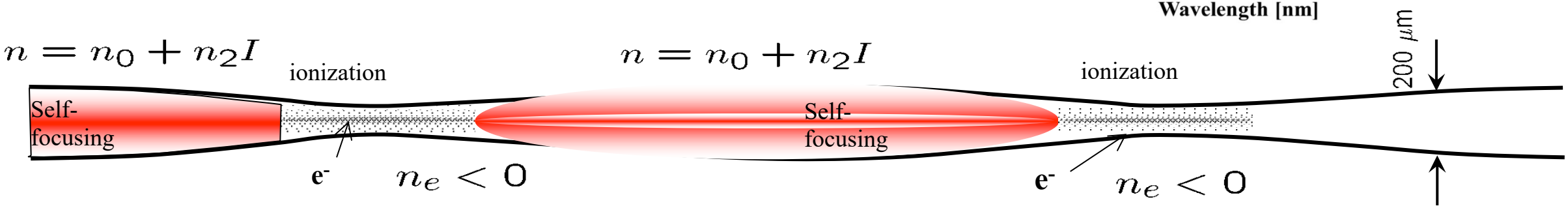




Our finding: The resolution in isotope detection can be restricted in the plasma generation process rather than the measurement.
We had shown that in plasma generation with long UV pulses resolution in picometer detection is possible. As the hot high pressure broad emission is absorbed with lower pressure cooler plasma.



Acknowledgements

The Consortium for Monitoring, Technology, and Verification would like to thank the NNSA and DOE for the continued support of these research activities.

This work was funded by the Consortium for Monitoring, Technology, and Verification under Department of Energy National Nuclear Security Administration award number DE-FOA-0001875