Muon Tomography Optimization for Dry Cask Spent Nuclear Fuel Storage Imaging

Jesus Valencia\textsuperscript{1*}, Adam Hecht\textsuperscript{1}, Chris Morris\textsuperscript{2}, Elena Guardincerri\textsuperscript{2}, Dan Poulson\textsuperscript{2}, Jeff Bacon\textsuperscript{2}, Matt Durham\textsuperscript{2}

University of New Mexico\textsuperscript{1}, Los Alamos National Laboratory\textsuperscript{2}

jvalencia127@unm.edu\textsuperscript{*}

Background

- Dry-cask storage containers are the only form of commercial long-term spent fuel storage in the U.S.
- The amount of shielding required to reduce dose rates causes difficulties for x-ray and neutron imaging techniques.
- Cosmic-ray muons are naturally created, highly energetic, and highly penetrating particles.

Cask Measurements

- Muon positions and trajectories are recorded in supermodules, before and after interacting with cask.
- Overall deflection is used to distinguish high atomic number material regions from low atomic number regions. Fuel vs vacant regions. Deflection is an integral effect along the path.

Lab Data

- Using a 10-gallon steel drum filled with concrete, muon tracks were collected at LANL.
- Brass, lead and tungsten wedges were placed in different position in the barrel.
- The drum was rotated in 15-degree intervals between measurements to give 24 views around the barrel.

Multiple plenoptic tomography and traditional backprojection tomography methods were compared

- Plenoptic depth of field reconstruction method created better images, using less detector views and less muons per view.

Goals

- Utilize lessons learned from prior cask and lab measurements to optimize future spent fuel cask measurements.
- Minimize the amount of muon data needed to generate informative reconstruction images.

This work was funded in part by the Consortium for Monitoring, Technology, and Verification under US-DOE NNSA award number DE-NA0003920, and uses data from LANL.

Schematic of fuel bundle fill in the measured MC-10 cask. Orange regions are locations where fuel is loaded.

One-dimensional scatter intensity projection image of MC-10 Fuel Cask. Approximately 30-days of measurement data.