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# Passive multimodal tomography for dry storage casks imaging using passive neutron and gamma dosimetry and cosmic ray muons

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**ABSTRACT:**

We will develop a method for multimodal tomography of dry storage casks to determine fuel relocation and cladding failures using passive neutrons and gamma emissions in combination with cosmic ray muons. The use of multimodal imaging will allow 3-D reconstructions of the dry storage cask that would be unachievable with any one radiation source. Both neutron and gamma emissions are internally shielded by used fuel assemblies as well as the storage cask itself. They can be used in combination to image the outer region fuel assemblies with good fidelity, but reconstructions are more limited for the inner assemblies. Here, cosmic ray muons, with less attenuation, will boost image resolution for regions deep within the cask. Passive gamma tomography is currently used by the IAEA in its safeguards program, but this capability is missing in the US. By using energy discriminating detectors, passive gamma tomography can be extended to show the presence of $^{137}Cs$ in the cask atmosphere which would indicate cladding failure, Fig. 1. Bayesian data synthesis will be used to combine tomographs made using different imaging paradigms. This type of multimodal imaging with data synthesis is a worldwide first for dry cask inspection and will make US as a world leader in this area. This proposal directly addresses the NEUP FC-4.2 call for *"innovative methods for periodic measurement/inspection of internal conditions within…Monitoring gas composition (to identify if cladding failures occur)… Monitoring dose (mostly as a means for identifying any fuel relocation)".* Critically, this will be done using detectors that are both mobile and external to the cask.

In the proposed work, the project team at the School of Mines, Los Alamos and Idaho National Laboratories will develop and deliver: A recommissioned cosmic ray muon imaging system optimized for dry cask inspection; Optimized algorithms for dry cask inspection tomography using muons, neutrons and gamma rays; Dry cask test pad data for validation of dry cask non-invasive inspection imaging methods to detect fuel movement and the presence of fission gases inside a sealed dry storage cask.