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Recent Developments in the Application of Cosmic-Ray Muons to Nuclear Security and Safeguards at Canadian Nuclear Laboratories

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Throughout the past decade, Canadian Nuclear Laboratories (CNL) has gained considerable expertise in the development of muon tomography techniques and algorithms for applications in nuclear waste management and safeguards verification. Two prototype muon detectors have been constructed at CNL's Chalk River site: the Cosmic Ray Inspection and Passive Tomography (CRIPT) detector, a unique muon tomography prototype with the ability to measure muon momenta; and the Muon Portable Imager for Counter-terrorism (MuPIC), a compact portable muon tomography system for field use that is still undergoing preliminary testing and development. Algorithm development has included imaging algorithms for muon scattering tomography (MST) and attenuation-based muon computed tomography (muCT), as well as a non-parametric dense object detection (NPDOD) algorithm. These techniques have applications in imaging fuel storage containers, characterizing legacy waste or lost-knowledge casks, dense-object detection in support of nuclear disarmament, and imaging large nuclear infrastructure (such as a reactor core or fuel repository).

A brief review of CNL detector and algorithm capabilities will be presented, as well as preliminary results from recent experimental studies with MuPIC. Field tests using the portable detector have been used to assess MuPIC's capabilities in conjunction with CNL's MST imaging and NPDOD algorithms, and can be compared with CRIPT capabilities. In addition, muon flux measurements taken in CNL's ZED-2 reactor facility have been used to provide a first stage of experimental validation for CNL's muCT imaging algorithm.

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