Muon Tomography for Waste Imaging and Material Identification

Research area: Waste and Fuel Management

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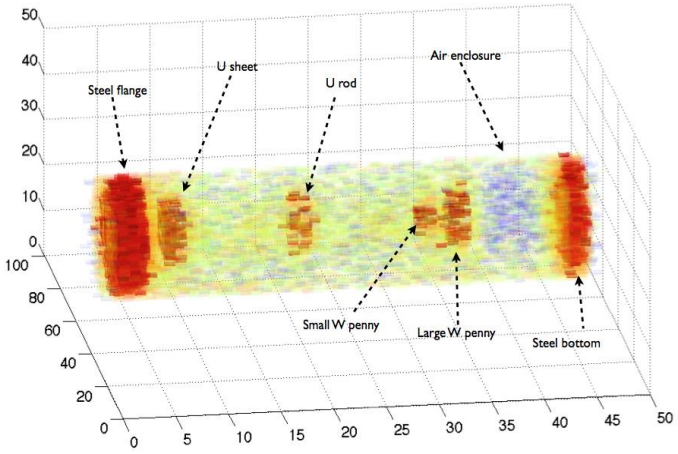
The Challenge

A lot of nuclear waste has been stored in drums and filled with concrete. Measuring the contents of small waste drums and of large volume nuclear waste packages, such as large spent fuel casks and large concrete waste packages with heterogeneous waste, is essential to manage risk and find the appropriate disposal solution.

Figure 1



Reconstructed objects encased in a concrete waste drum.

The Solution

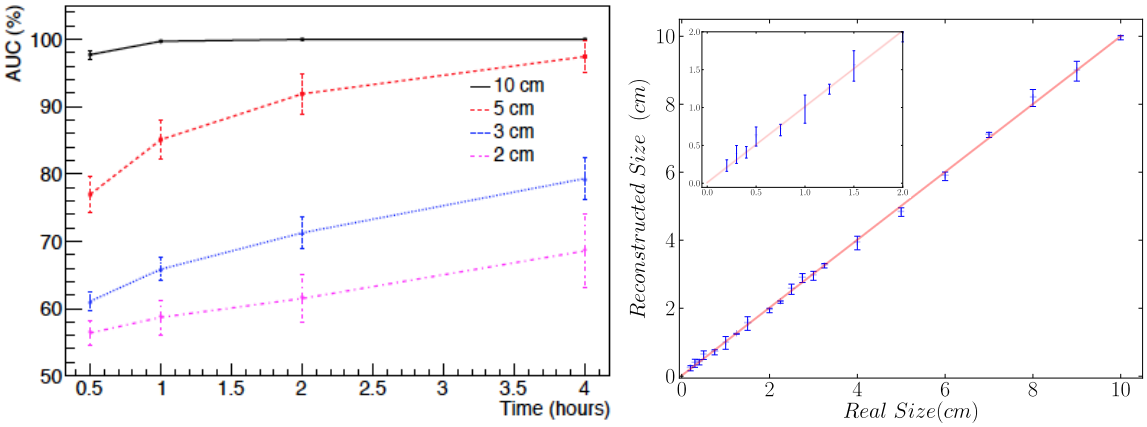
Muons are naturally occurring particles with a flux at ground level of around 1 $cm^{-2}min^{-1}$; they are capable of passing through several hundred metres of rock. When they interact with matter, they scatter depending on the atomic number, Z, of the material. Hence, if muon trajectories are measured before and after traversing a volume, an image of the different materials in that volume can be produced.

This mature and well-established technique is known as ‘muon tomography’ (MT). MT is fully passive and works for heavily-shielded volumes. The technique is particularly useful to detect heavy elements like lanthanides and actinides.

This technique has been developed to distinguish small lumps of material and measure their sizes while encased in concrete in the waste drum. We use a statistical technique for material discrimination and produce ROC curves to evaluate the discrimination power.

Figure 2 (*left*) shows the area under the ROC curve for various sizes of lumps that are either U or W encased in concrete as a function of measurement time. Similarly, we measure the size of small lumps inside the concrete. Figure 2 (*right*) shows the reconstructed length as a function of the actual length for a block of U encased in concrete. The method works down to 2 mm pieces with a resolution of 0.7mm.

Figure 2



The Impact

Muon tomography allows improvements to the safety of the radioactive waste management process throughout the full storage cycle.

It has become possible to characterize large volume nuclear waste with a non-destructive technique which was not previously possible since the volumes are inappropriately large or too heterogeneous for gamma or neutron scanning and imaging.