Feasibility study of detection of high-Z material in nuclear waste storage facilities with atmospheric muons

N. Mori1,2, F. Ambrosino2,4, L. Bonechi2, L. Cimmino2,4, R. D’Alessandro1,2, D. Ireland5, R. Kaiser5, D. F. Mahon5, P. Noli5, G. Saracino2,4, C. Shearer6, L. Viliani2,3, G. Yang6

1) Department of Physics and Astronomy, University of Florence 2) INFN sezione di Firenze 3) Department of Physics, University of Naples “Federico II” 4) INFN sezione di Napoli 5) School of Physics and Astronomy, University of Glasgow 6) National Nuclear Laboratory, Central Laboratory

Muon radiography

Muon radiography is a well-established technique for investigating the internal density structure of a target body. Atmospheric muons crossing the target undergo multiple scattering and ionization energy loss processes; these result either in a deviation of the original trajectory or in a muon loss because of absorption inside the target. By investigating these two observables the internal density structure of the target can be probed.

Monte Carlo simulations

A cylindrical storage silo with diameter 3.5 m and height 4 m has been simulated with Geant4. The silo is filled with concrete and contains cubic uranium samples with size 2, 5, 10 and 20 cm in different positions. The detector is made of two 2x2 m2 tracking layers separated by 50 cm, with a position resolution of 0.3 cm. The input muon spectrum is modeled after ground measurements taken with a magnetic spectrometer.

Results

Data have been analyzed with different methodologies for multiple scattering and for absorption studies. Both analyses rely on the known positions of the uranium samples, since the main goal is to assess the entity of an eventual signal.

Legacy nuclear waste storage

Legacy containers for nuclear waste from the half of last century now pose significant challenges in terms of ensuring a safe disposal route as well as protection of the environment. In the past there perhaps wasn’t the same safety culture and detailed record-keeping procedures as there are now, which of course means that for these legacy waste containers there is a strong need to better characterise the contents of these containers. Muon radiography is a very promising technique for safe, non-invasive interrogation of legacy containers.

References

- F. Ambrosino et al., Assessing the feasibility of interrogating nuclear waste storage silos using cosmic-ray muons, JINST 10 (2015) T06006
- L. Bonechi et al., A projective reconstruction method of underground or hidden structures using atmospheric muon absorption data, JINST 10 (2015) P02003