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Benchmark of multiple geophysics tools to study the voids in the upper levels of a decommissioned iron mine

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Absorption muon imaging is a technique that can measure density variations underground down to a few hundred meters. Then, it can prove to be useful in a mining environment: to help assess the ore bodies volumes and/or to monitor the underground for natural hazards that can happen at the surface because of the mining exploitation. Here we report the result of an experiment designed to test the capabilities and resolution power of a cosmic muon measurement in a mining environment compared to other standard geophysics tools: gravimetry and seismic studies. It consists of three independent measurement of a subset of the decommissioned iron mine of May-sur-Orne (France). The first one was made using a 50x50cm² micromegas based muon telescope installed at the deepest non-submerged level (50m underground) during 3 months. The second one is a gravimetry survey of the surface area inside the muon telescope acceptance cone. And the third one is a study of refracted and reflected seismic waves along a single line above the muon telescope location. The investigation volume was chosen because of the presence of surface risks (neighborhood), the unknown of some uncharted volume and the presence of an ore storage volume of several meter cubed that was used during the mine exploitation and which filling state is unknown.

The data analysis showed that while muon tomography is able to detect the negative density anomaly of the storage volume, the gravimetry measurement is not sensible to it. However, the seismic study was able to detect the volume as well and its location and extension is compatible with the muon measurement.