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Absorption-based muography for ore bodies prospecting: a case study from Temperino Mine (Italy)

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In the last twenty years several applications of muography (or muon radiography) technique have been carried out for geological purposes. Among them, particular attention was given to underground ore bodies prospections. For thousands of years humans have been searching new methods to understand where to find underground ore bodies and how to localize it in the three-dimensional space. Often, economically useful minerals are bounded to other minerals, forming rocks of high density values that are hosted, usually, in rocks with lower density values. In literature gravimetry and magnetometry represent the most employed geophysical methods for imaging and detection of mineral-rich ore bodies. To verify the feasibility of muography as a non-invasive geophysical prospecting technique, our research group, composed by subnuclear physicists and geologists, carried out some underground measurement campaigns at the Temperino Mine (Campiglia Marittima, Italy). Here it is located a pliocenic metasomatic ore deposit, a Cu-Pb-Zn-Fe skarn complex composed by johannsenite, quartz, hedenbergite, ilvaite and accessory primary sulphides (chalcopyrite, galena, sphalerite, pyrite). These metalliferous bodies of skarn have tabular geometries with sub-vertical orientations. Currently, the first level of Temperino Mine has been equipped as a touristic path and belong to the Archeological Mining Park of San Silvestro. Along this gallery, carved both into the metamorphic and non-metamorphic rocks, it's been installed the MIMA muon tracker (Muon Imaging for Mining and Archaeology), a small and rugged prototype (0.5 x 0.5. x 0.5 m^3) developed by the physicists of the National Institute of Nuclear Physics (INFN), unit of Florence, and the Department of Physics and Astronomy of Florence. MIMA detector is able to measure the underground muon flux inside the mine gallery. Matching the simulated muon transmission rate with the experimentally measured one it's

possible to obtain a two dimensional average density angular map of the observed target. Also, using algorithms based on triangulation and back-projection techniques is possible to obtain a reconstruction of the 3D volume of high-density areas (and also low-density areas) inside the studied volume. The latter is the volume that falls within the detector's acceptance. The aim of this research is to obtain a georeferenced 3D model of the Cu-Pb-Zn ore bodies hosted in the rocks between the top of the mine gallery and the surface of the Temperino Mine area. We want to confirm that muography technique could become a suitable and reliable tool for the mining prospections field.