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Development and validation of muon imaging techniques to investigate the internal structure of volcanoes by integrating geophysical and muon tomography methods

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Muon imagery techniques, that use cosmic-ray muons generated in the upper atmosphere, are currently intensively being developed by several international groups to probe the internal structures of volcanic edifices to depths up to several kilometers. The method is based on the measurement, with a muon telescope, of the attenuation of the flux of these high energy atmospheric particles due to their interaction with the constitutive rocks of the volcanic edifice. Muon tomography can thereby be used to construct precise 3D models of rock density distribution, and, even more, its variation with time, within volcanoes.

The development and validation of this innovative imaging method are currently being pursued by the multidisciplinary TOMUVOL collaboration that involves both particle and astroparticle physicists, volcanologists and geophysicists. Indeed, a main critical and acknowledged issue among the community is to validate the results of the muon imagery using other geophysical techniques. In particular, the robust reconstruction methodology would require the combined integration of topographic, geological and geophysical information with muon flux interpretation, in order to obtain a reliable internal structure of volcanoes.

To achieve this goal, the TOMUVOL project is carrying out this cross-validation approach on an experimental site, the Puy de Dôme volcano. It is a 11000-years old trachytic lava-dome located in the near vicinity of Clermont-Ferrand. A complete interpretation of the internal structure of the dome will be obtained using in situ measurements that started in 2011 and will continue until mid-2012. The field experiment dataset includes two muon radiography surveys acquired from different points of view, two 2km long perpendicular resistivity profiles and a high resolution gravity survey. In addition, a high resolution topographic model has been calculated from a dedicated airborne LIDAR survey, in order to improve the accuracy of geometric reconstructions and to better constrain inversion models.

When validated on the Puy de Dôme experimental site, the structure study which integrates muon and traditional geophysical techniques will be used for the study and monitoring of active volcanoes.