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A new technique for probing the internal structure of volcanoes using cosmic-ray muons

Among the considerable number of studies that can be carried out using muons,
we pay specific attention to the radiography of volcanoes based on the same principle
of the X-ray radiography of human body. Thanks to their high penetration capability, cosmic-ray muons can be used to reconstruct the density distribution of the interior of huge structures by measuring the attenuation induced by the material on the muon flux.
In particular, the quantitative understanding of the inner structure of volcanoes is a key-point to forecast the dangerous stages of activity and mitigate volcanic hazards.
The instrumental approach is currently based on the detection of muons crossing hodoscopes made up of scintillator planes. Unfortunately, these detectors are affected by a strong background comprised by accidental coincidence of vertical shower particles, horizontal high-energy electrons and upward going particles.
We propose an alternative technique based on the detection of the Cherenkov light produced by muons. This can be achieved with a fast optical system (F# = 0.5) composed of high reflectivity mirror that focus the Cherenkov light onto a multi-pixel focal camera with fast read-out electronics. The Cherenkov light emitted by a muon is imaged on the focal plane camera as an annular pattern which contains information to reconstruct direction and energy of the incident muon. We have estimated that using the Cherenkov imaging technique for muon radiography of volcanoes gives the advantage of a negligible background and improved spatial resolution compared to the usual particle detectors.
We present results of simulations based on a telescope with a positioning resolution of 13.5 m which corresponds to an acceptance of 9 cm^2 sr. The optical system is located 1500 m far from a toy-model volcano, namely, a cone with a base diameter of 500 m and a height of 240 m. We test the feasibility of the proposed method by estimating the minimum number of observation nights needed to resolve inner empty conduits of different diameter.

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