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MUCH: a compact Imaging Atmospheric Cherenkov Telescope for volcano muography

Significant progress has been made in the last years in the field of volcanic muography. This technique takes advantage of the large penetrating power of atmospheric muons and allows us to infer information about the internal structure of volcanoes observing the differential absorption of muons passing through the target.

This, in conjunction with other monitoring techniques, can help to determine the state of activity of a volcano and to reduce the risk related to paroxysmal events. The main challenge in the application of this technique is given by the background noise, due to protons, electrons and scattered low-energy muons, that affects detectors. In order to improve the signal-to-noise ratio it is necessary to use several detection layers and shielding plates that make the detector expensive and difficult to transport. In order to overcome these issues, the use of Imaging Atmospheric Cherenkov Telescopes (IACTs) devoted to muography has been recently proposed and its feasibility demonstrated by our team using Geant4 simulations.

IACTs are telescopes dedicated to the gamma-ray astronomy consisting of an optical system that focuses the Cherenkov light into a high-sensitive and fast read-out camera. When a muon with energy above 5 GeV passes near the telescope aperture, Cherenkov photons induced along the trajectory form on the telescope camera an easily recognizable arc-shaped signal from which it is possible to determine the muon arrival direction. Although Cherenkov telescopes are not able to operate in the daytime, they are not disturbed by the previously mentioned sources of background and a Cherenkov telescope devoted exclusively to muography can be designed with a lightweight support structure that could be easily transported.

Here we present MUCH, a compact IACT specifically designed for volcano muography. The telescope design is characterized by a Schmidt-like optical system and a Silicon Photo-Multipliers (SiPMs) camera working at wavelengths between 280 nm and 900 nm, equipped with a fast read-out electronics capable to operate SiPMs contemporarily in charge integration and photon counting mode. The optical system has an entrance pupil of 2.5 m diameter and is composed of an aspherical mirror and a PMMA Fresnel lens corrector. This results in a field of view (FoV) of about 12° and an angular resolution better than 0.2° throughout the entire FoV which allows us to determine the direction of muons, passing through the whole telescope aperture, with a reconstruction precision better than a few tenths of degree.

Author: MOLLICA, Davide (INAF)

Co-authors: CAPALBI, Milvia (INAF); CATALANO, Osvaldo (INAF); CONTINO, Giovanni (INAF); CONCONI, Paolo (INAF); CUSUMANO, Giancarlo (INAF); D'ANCA, Fabio (INAF); DEL SANTO, Melania (National Institute for Astrophysics - INAF); GARGANO, Carmelo (INAF); LA PAROLA, Valentina (INAF); LA ROSA, Giovanni (INAF); MACCARONE, Maria Concetta (INAF - Istituto Nazionale di Astrofisica (Italy)); MINEO, Teresa (INAF-IASF Palermo); PARESCHI, Giovanni (INAF); SOTTILE, Giuseppe (INAF)

Presenter: MOLLICA, Davide (INAF)

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