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Muography for the Colombian Volcanoes

R. de León-Barrios,[a] **J. Peña-Rodríguez,**[a] **J.D. Sanabria-Gómez,**[a] **A. Vásquez-Ramírez,**[a] **R. Calderón-Ardila,**[b,c] **C. Sarmiento-Cano,**[b,c] **A. Vesga-Ramírez,**[d] **D. Sierra-Porta,**[e] **M. Suárez-Durán,**[f] **H. Asorey**[b,c] **and Luis A. Núñez**[a,g,*]

[a] *Escuela de Física, Universidad Industrial de Santander, Bucaramanga, Colombia*
[b] *Instituto en Tecnologías de Detección y Astropartículas, Buenos Aires, Argentina.*
[c] *Consejo Nacional de Investigaciones Científicas y Técnicas, Buenos Aires, Argentina.*
[d] *International Center for Earth Sciences, Comisión Nacional de Energía Atómica, Argentina.*
[e] *Departamento de Física, Universidad de Los Andes, Bogotá, Colombia.*
[f] *Université Libre de Bruxelles, Brussels, Belgium.*
[g] *Departamento de Física, Universidad de Los Andes, Mérida, Venezuela.*

We describe the Muography Program to study the Colombian volcanoes:

- We discuss the criteria adopted for designing, building, and commissioning *MuTe*: a hybrid Muon Telescope. *MuTe* implements a composite detection technique combining a hodoscope for particle tracking and a water Cherenkov detector for enhancing the muon-to-background-signal separation of extended air showers.
- The impinging muon flux calculation and its corresponding signals in the detector consider four factors with different spatial and time scales: the geomagnetic effects, the development of extensive air showers in the atmosphere, the propagation through the scanned structure and the detector response at a particular geographic point.
- We discuss the detailed *MuTe* digital twin employed to estimate the instrument's response to the muon flux and its impact on its design and performance. We examine the structural – mechanical and thermal– behaviour of *MuTe*, its first calibration measurements and identify the possible volcano candidate with the best observation points.
- *MuTe* incorporates particle-identification techniques for reducing the background noise sources and discrimination of fake events by a picosecond Time-of-Flight system and implementing an offline machine learning framework.
- We found that the frontal flux adds up 78% of the recorded events. From this total, 36% corresponds to electromagnetic component, 33% single-muon events, and 30% multiple particle detection.
- We discuss an optimization algorithm to improve our instrument's estimation of the volcano's internal density distribution based on the Simulated Annealing method

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*Presenter