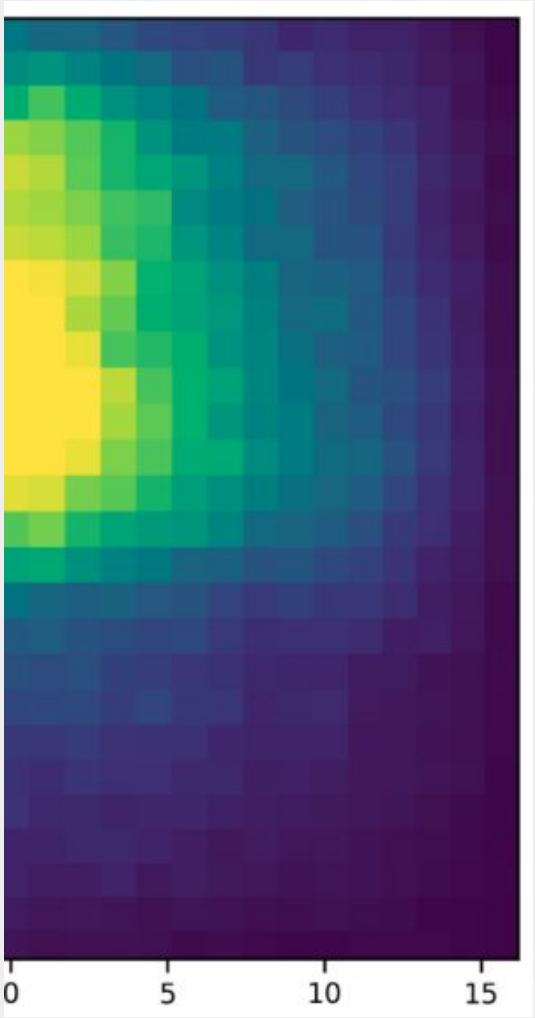


Design, Construction, and Calibration of the MuTe 2.1 Muon Telescope

Christian Sarmiento-Cano

Universidad Autónoma de Bucaramanga
Laboratorio de Investigación en Detección de Radiación y Astropartículas, LIDeRA
Bucaramanga-Colombia

Outline

01

Cerro Machin Volcano

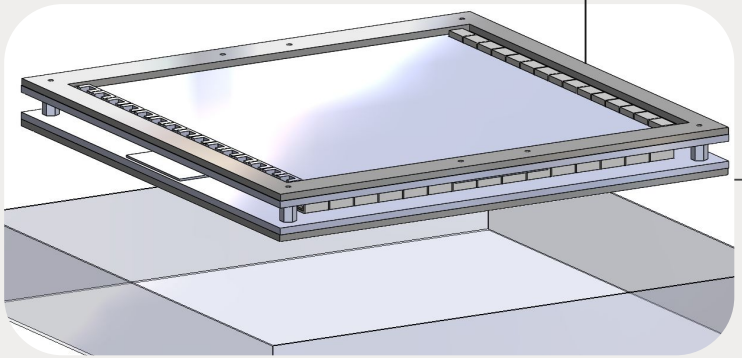

Caribe
Mar
PANAMÁ
VENEZUELA
OCÉANO
PACÍFICO
ECUADOR
PERÚ
BRASIL
Cordillera Occidental
Cordillera Central
Cordillera Oriental
SAN ANDRÉS Y PROVIDENCIA
MAR CARIBE

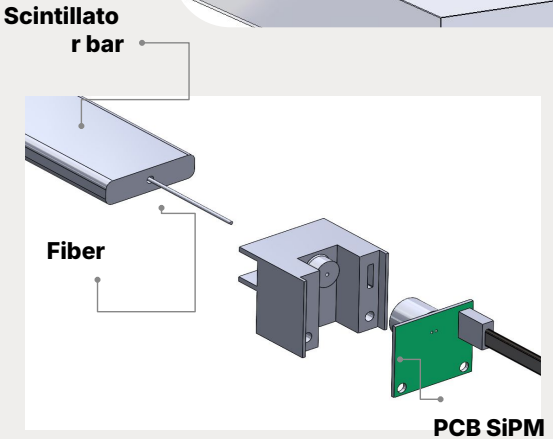

Nevado del Tolima
Volcán Cerro Machín
Toche
El Pando
Cajamarca
Ibagué
http://www.volcanmachin.com

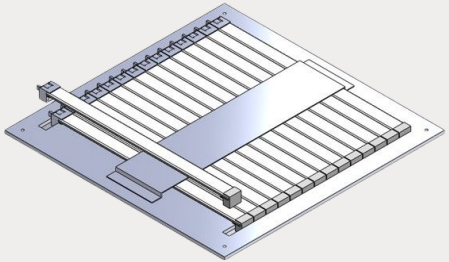
02

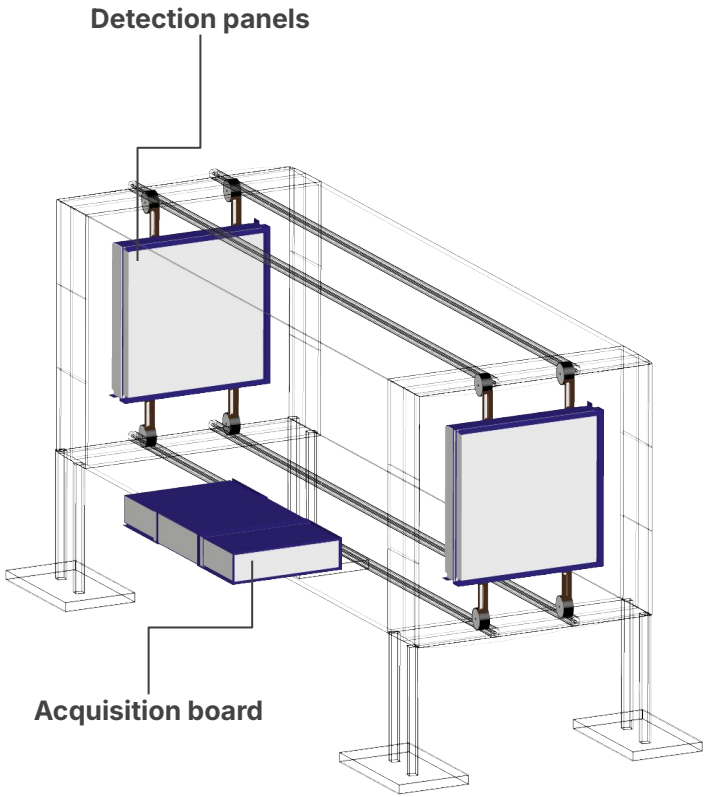
Muon Telescope MuTe 2.1

Muon Telescope, MuTe 2.1







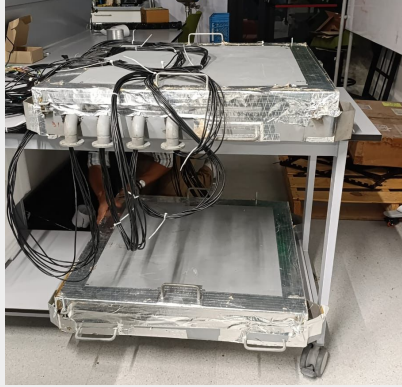


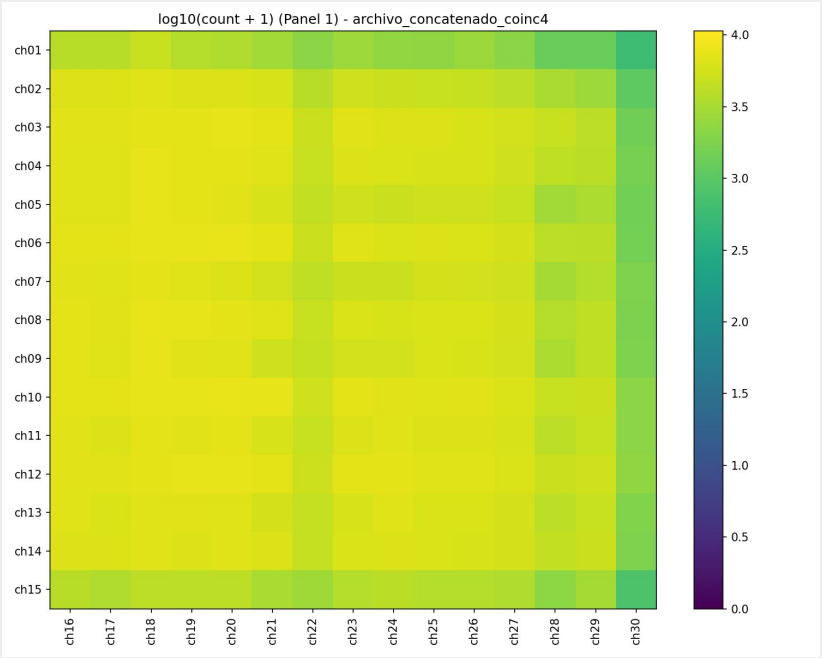
03

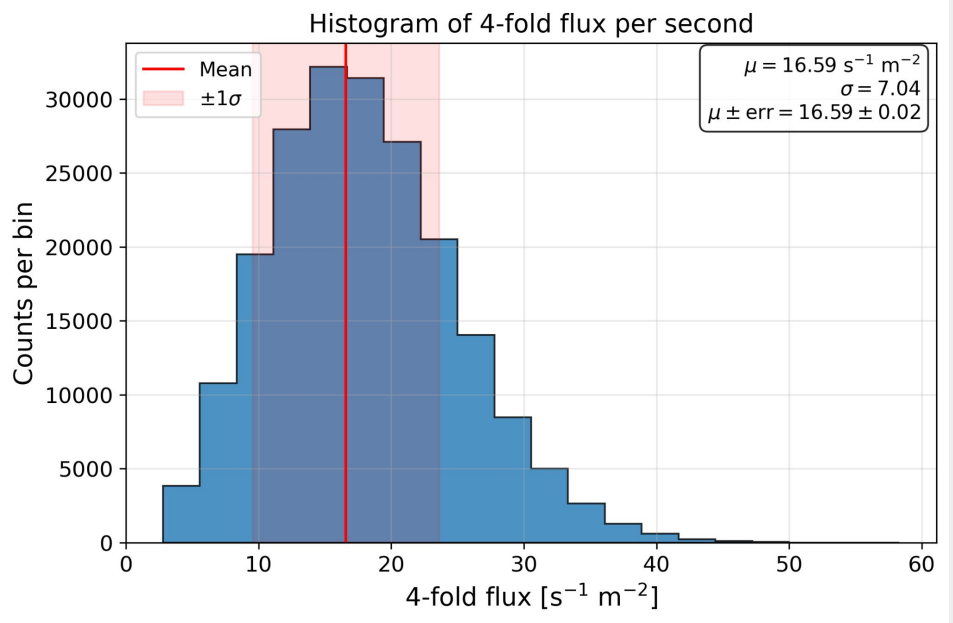
Calibration detector in the lab

Open-sky measurements

The two panels were oriented parallel to each other and facing upward toward the open sky, maximizing the acceptance of vertically incident cosmic ray muons.

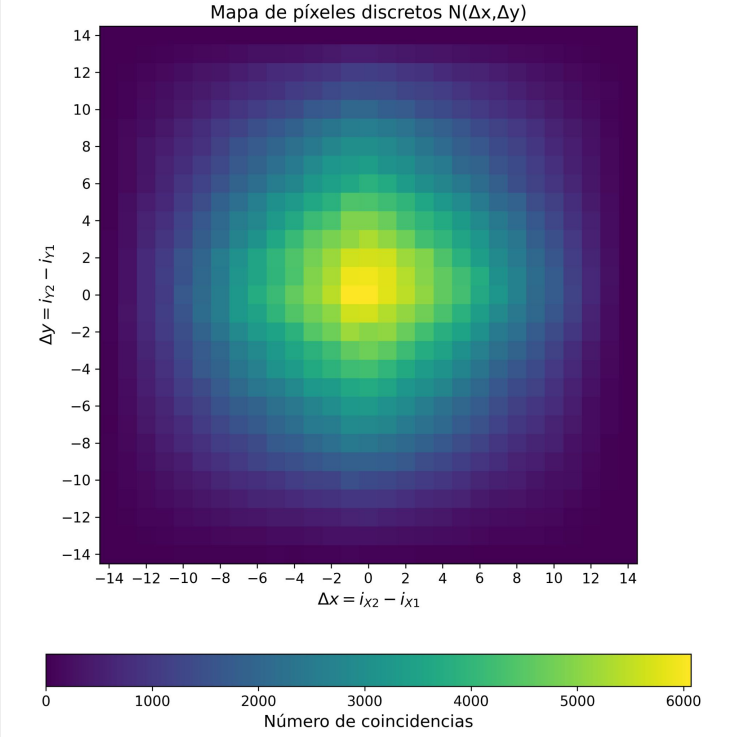


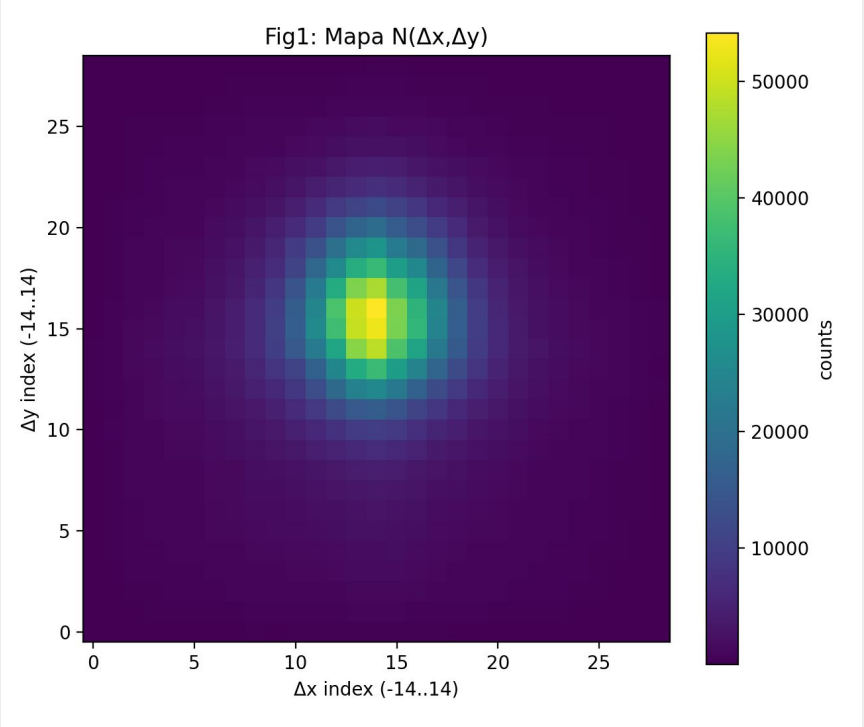




Acceptance: data vs simulation

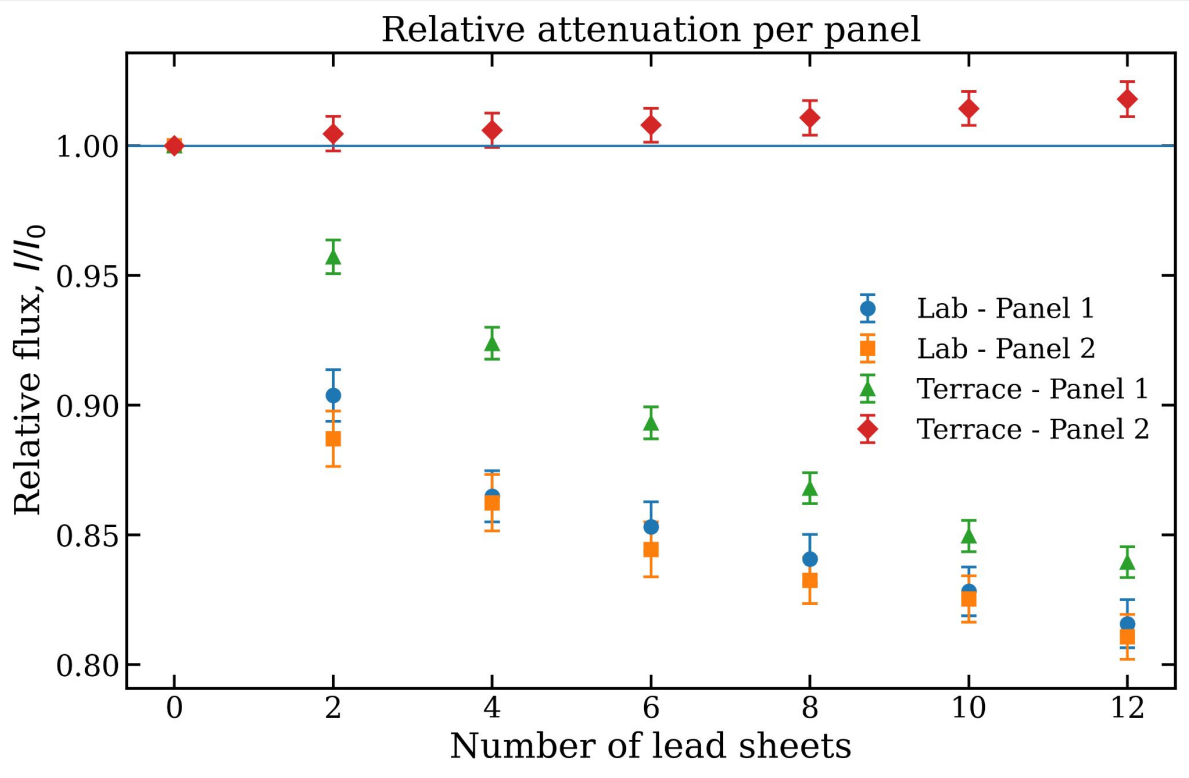
Comparison between observational data and simulations for the detector acceptance in this configuration. Simulations were performed using CORSIKA and Geant4.





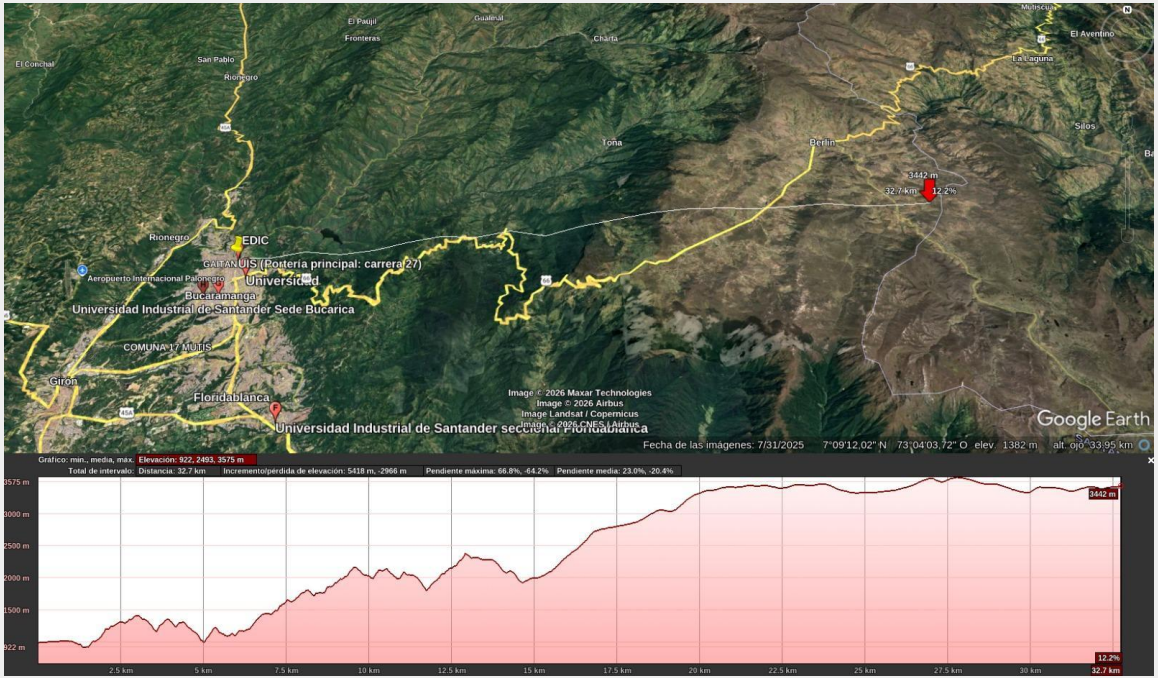
Attenuation using lead shielding

Lead thickness was increased in 0.5,cm steps, with one-hour measurements taken at each step.



First muogram with MuTe 2.1

A test muography was performed on the mountain range located in front of the university, allowing a first validation of the detector performance under real field conditions.



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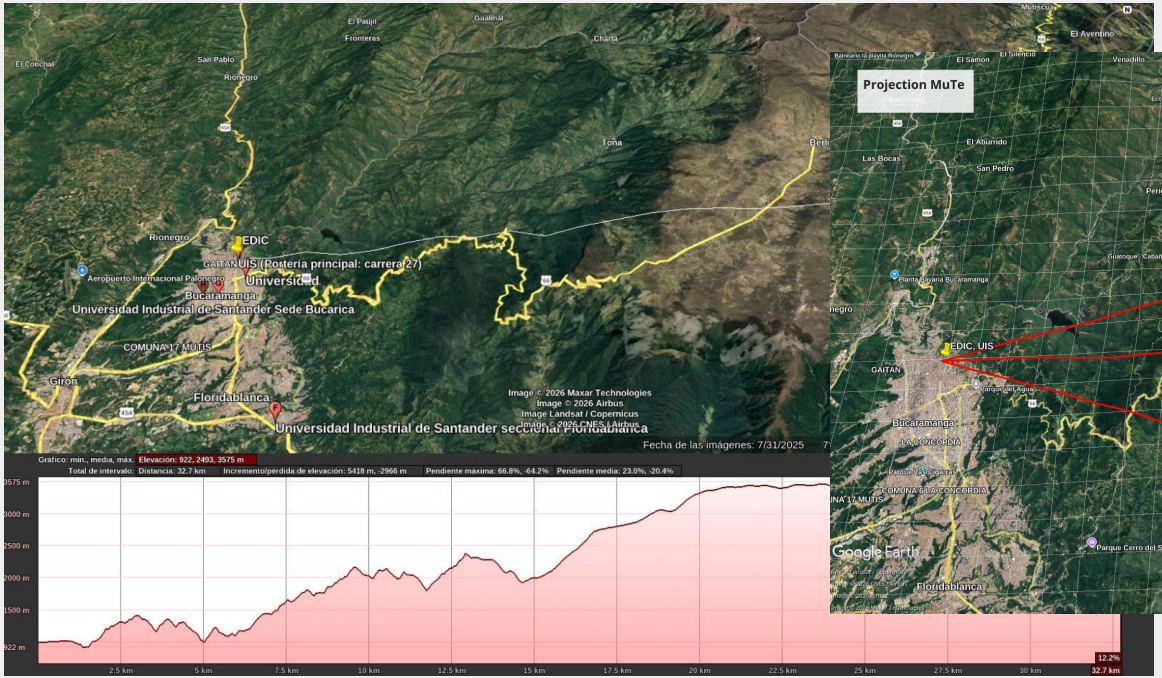
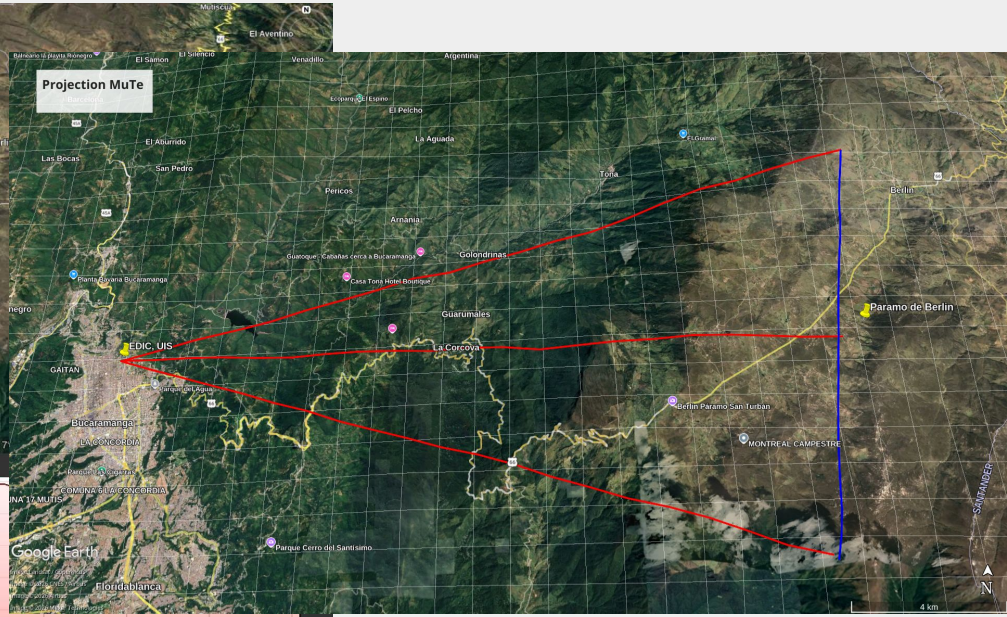
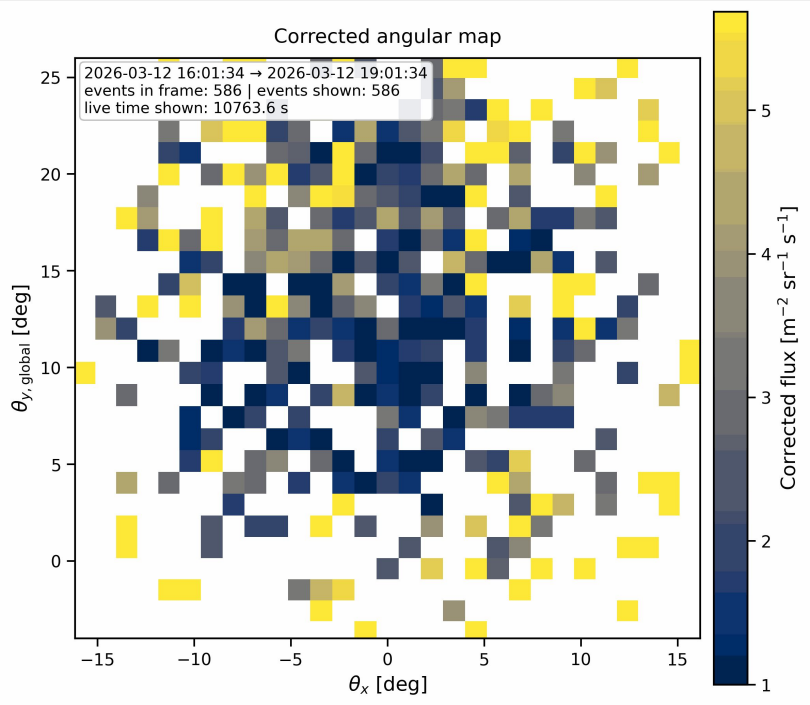




First muogram with MuTe 2.1

Daily pixel occupancy map. The progressive filling of the detector matrix over time reflects the stability of the acquisition system and the uniformity of the detector response across all channels.

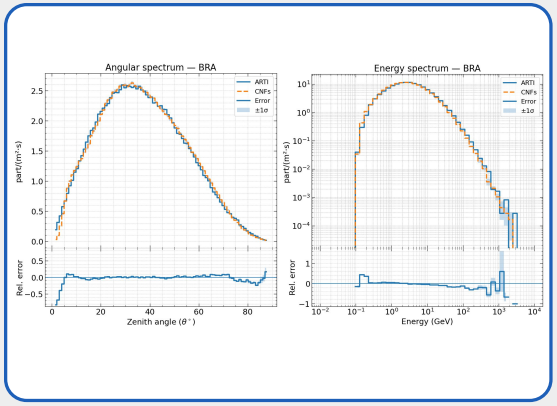


04

End to end simulation with CABRIALES framework

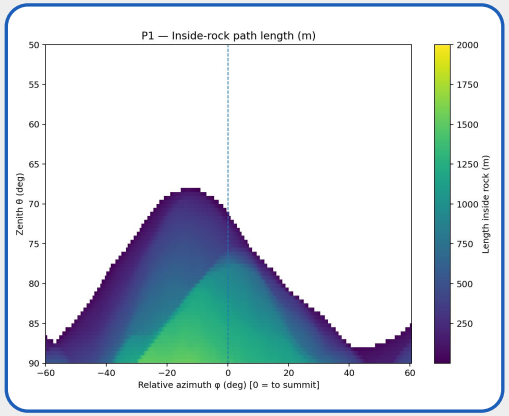
CABRIALES framework: muography simulation

Deep learning muon flux



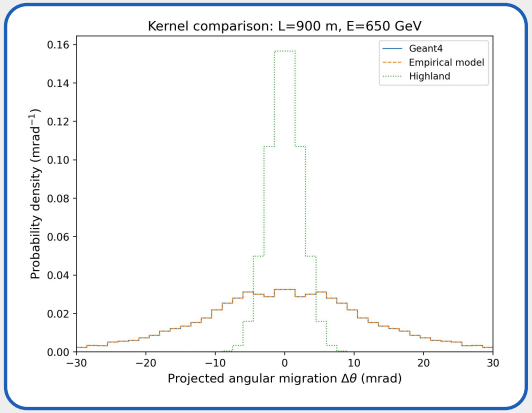
+

Backpropagation



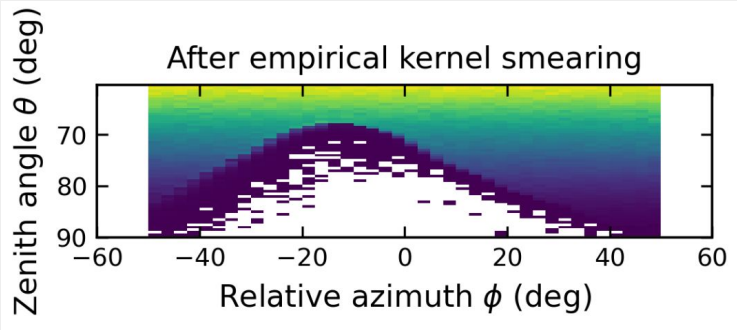
+

Angular Scattering



=

Poster: Muon spectrum generation with generative AI



muogram

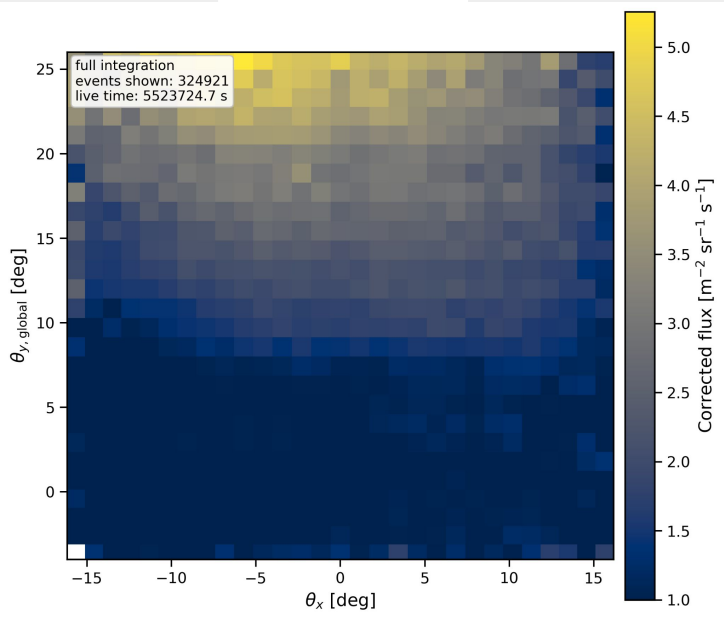
Tuesday, 14:15
Rafael Martinez talk

05

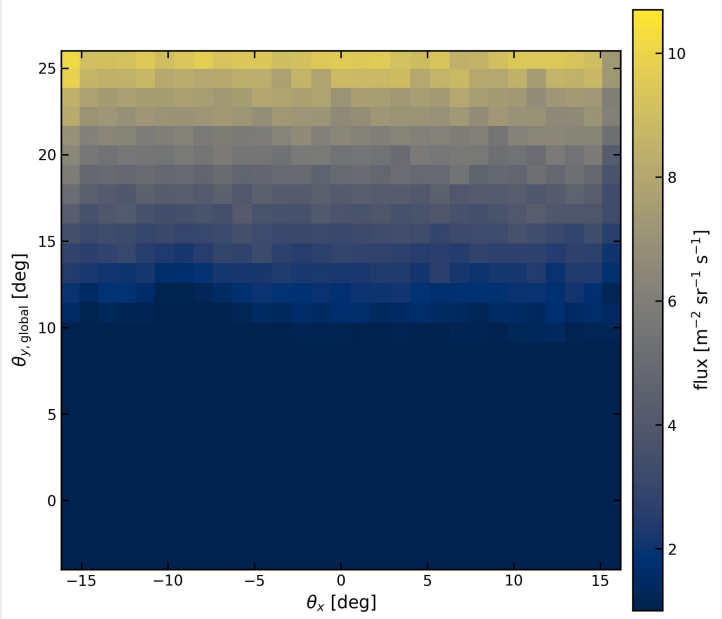
Simulated and experimental muogram

Simulated and experimental muogram

Comparison between simulated and observational muogram. The agreement between both distributions validates the detector response model and confirms the reliability of the reconstruction chain under real field conditions.



Measurements



SImulation

06

Final remarks

- MuTe 2.1 shows reliable performance under controlled conditions, with good agreement between data and simulations across all calibration stages.
- The CABRIALES simulation and analysis chain has been validated end-to-end, providing a fast density imaging.
- We expect to deploy MuTe 2.1 at Cerro Machín volcano in Tolima, Colombia later this year.

¡Gracias!

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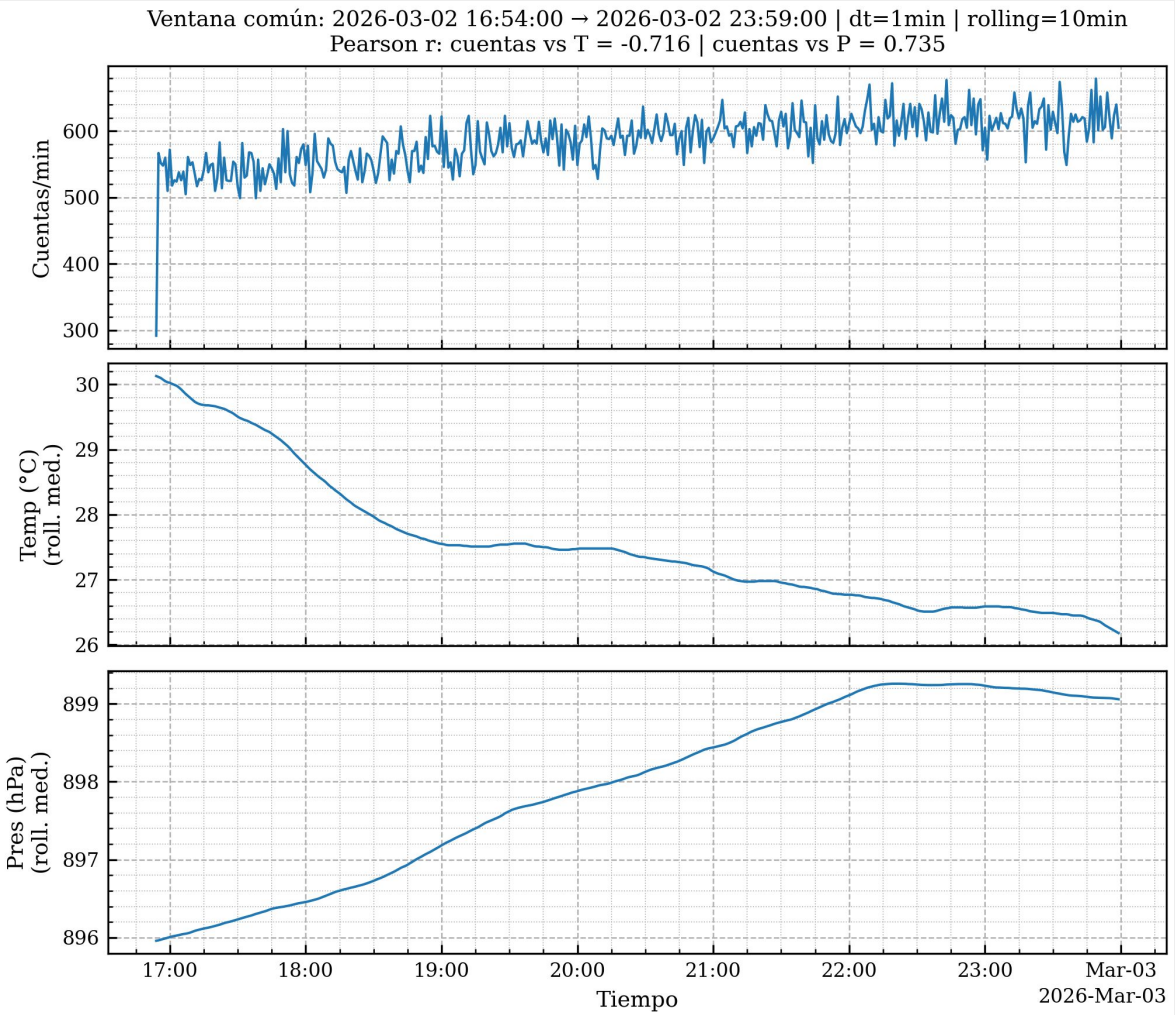
csarmiento32@unab.edu.co

Acknowledgements

Proyecto " Integración de muongrafía con métodos geofísicos estándar para la construcción de un modelo 3D de densidad: aplicación al Volcán Cerro Machín" , financiado con recursos de Minciencias por medio de la convocatoria 890 de 2020 y administrados por el ICETEX mediante contrato No. 2022-0718.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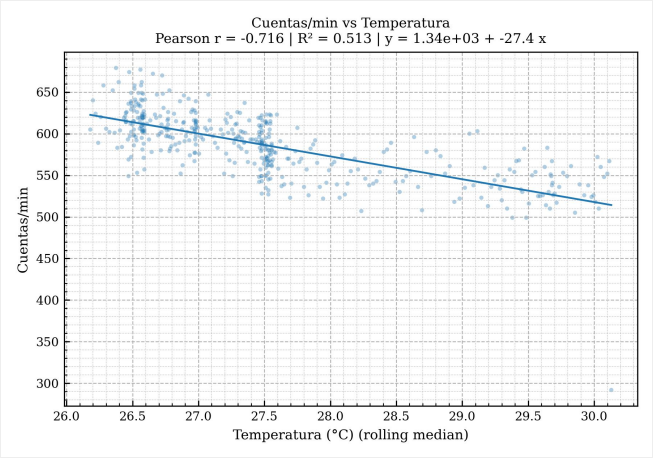
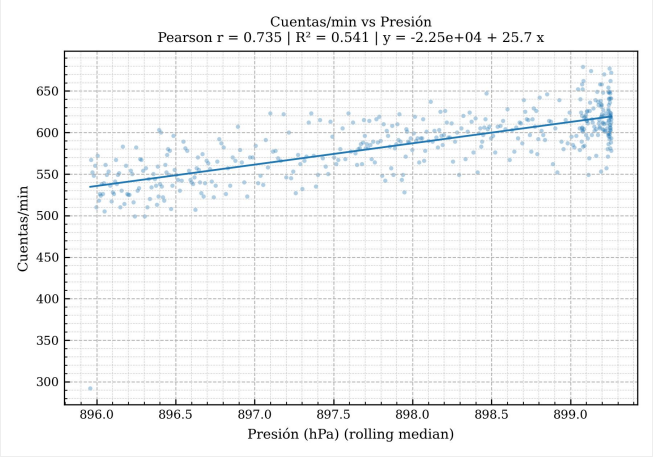
Pearson r: cuentas vs T = -0.716 | cuentas vs P = 0.735
Cuentas/min
Temp (°C) (roll. med.)
Pres (hPa) (roll. med.)
17:00
18:00
19:00
20:00
21:00
22:00
23:00
Mar-03
2026-Mar-03
Tiempo


Cuentas/min vs Temperatura
Pearson r = -0.716 | R² = 0.513 | y = 1.34e+03 + -27.4 x
Cuentas/min
Temperatura (°C) (rolling median)


Cuentas/min vs Presión
Pearson r = 0.735 | R² = 0.541 | y = -2.25e+04 + 25.7 x
Cuentas/min
Presión (hPa) (rolling median)