A new muon tomography detector for glaciers melting monitoring

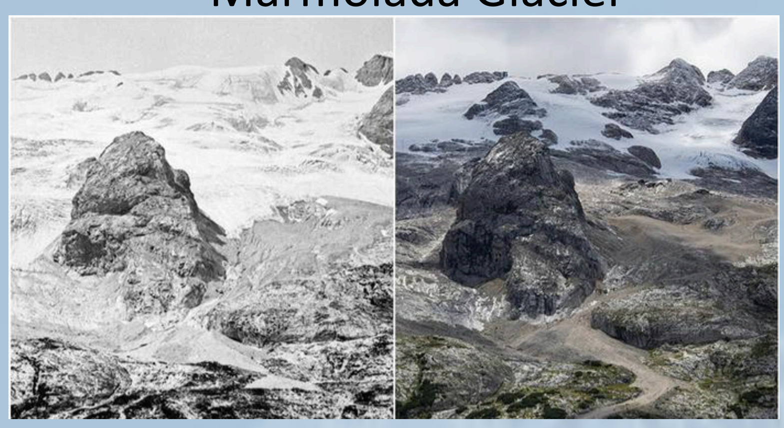
A. Cervelli (INFN-Bologna) , **S. Rabaglia** (University of Bologna) , M. Sioli (University of Bologna)

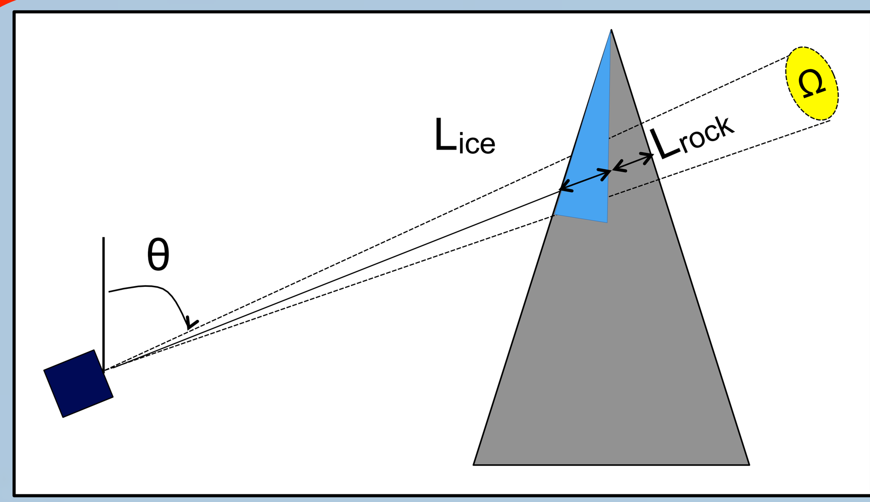
Glacier melting is one of the most visible effects of global warming.

Glacier monitoring has been done using different techniques over the past years, however it relied either on caves under the target glaciers or indirect measurements.

As most glaciers do not offer underground access. → **Open-Sky Detector**

Marmolada Glacier





$\Phi(p,\theta,l) = \Phi_0 \cdot e^{-L/X}$

$L = L_{ice} + L_{rock}$

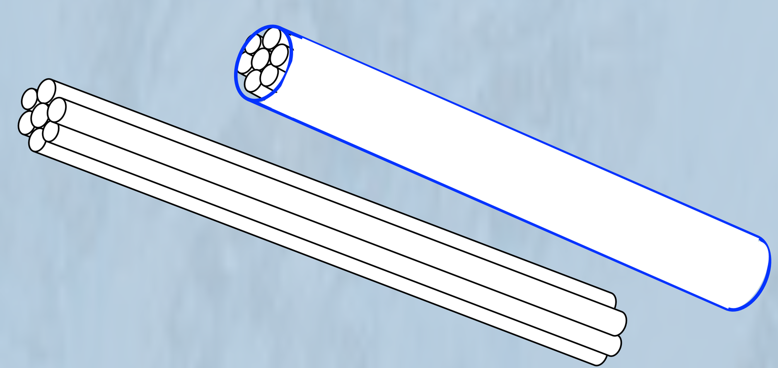
$X(\rho_{ice}, \rho_{rock})$ = by calibration

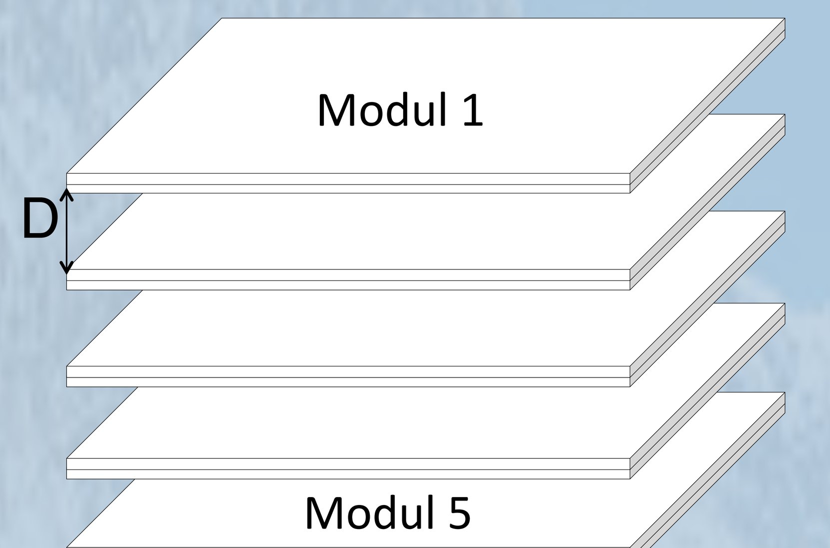
The difference between the measured muon flux, with and without a certain object in the field of view, allows to infer the thickness of material traversed by the muons.

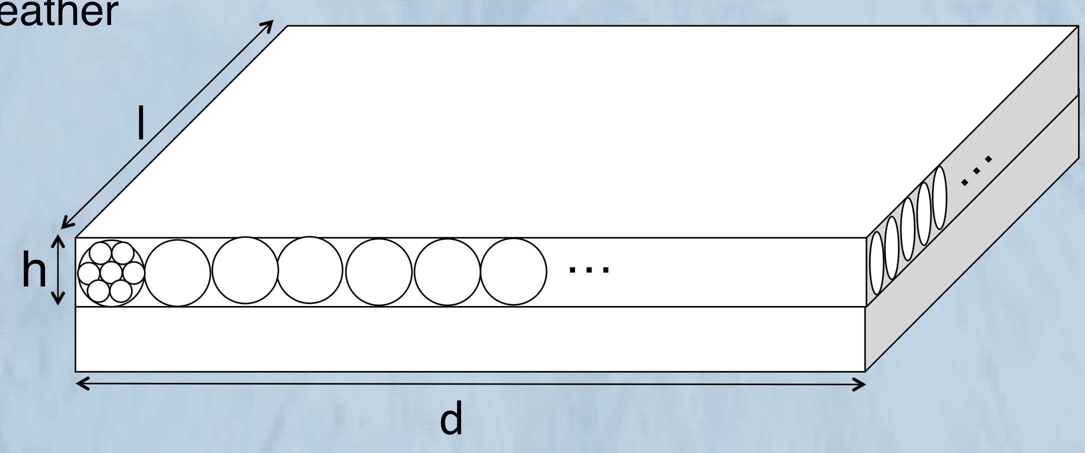
In case of glaciers, this muon tomography can be exploited thanks to the significant difference between ice and rock density

Detector Requirements & Challenges:

- Exposure time of few mounths to measure ice thickness
- Real-time data taking
- Operable in open-sky
- Movable and easy scalable
- Trigger and response > 1 kHz to reject background from muon not traversing the target and secondaries
- Resolution on ice thickness of ~5 m
- Low power consumption and able to operate in adverse weather



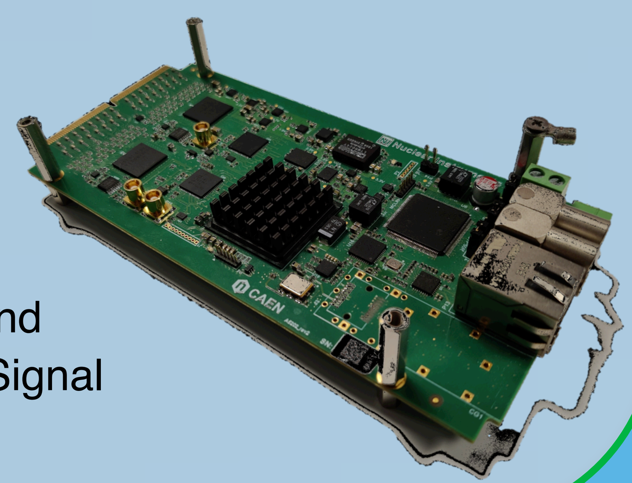


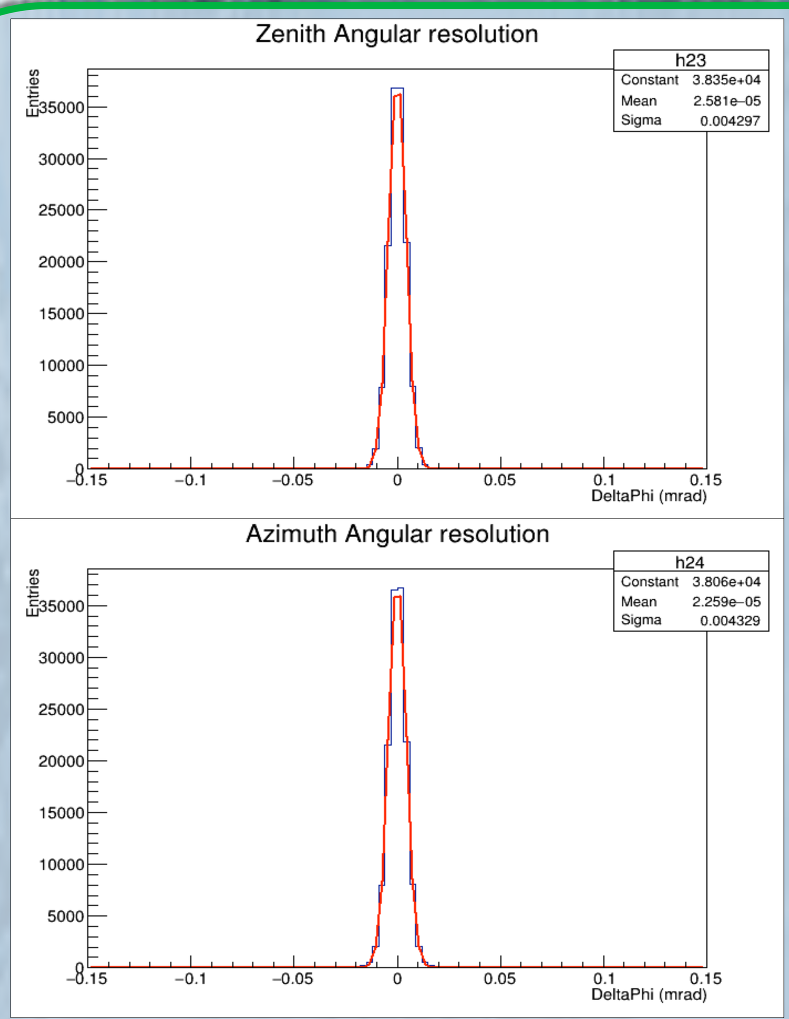


Detector Design:

The base element is composed of **5 modules** each made of **2 layers** of **scintillating fiber bundles** embedded in a plastic cladding to provide mechanical stability and running along orthogonal directions with respect to each other, to provide the **three coordinates** of each hit

Scintillation light is read by SiPMs driven by FERS boards (A5202), developed by CAEN s.p.a. The board provides power supply for SiPMs, manages the trigger and performs measurements of time (Time over Threshold and Time of Arrival) and of Signal Amplitude (PHA)





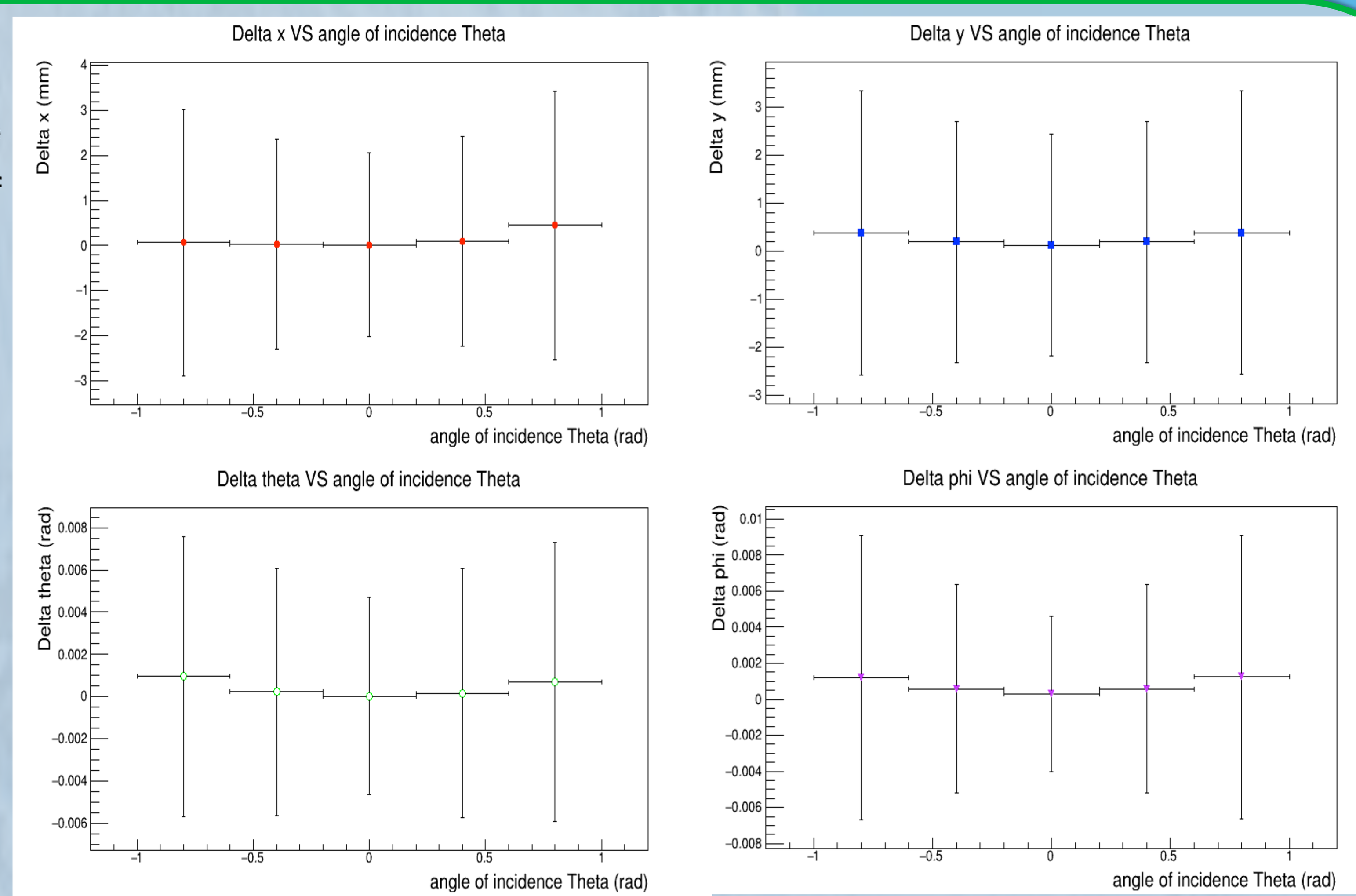
Detector Simulation & Optimization:

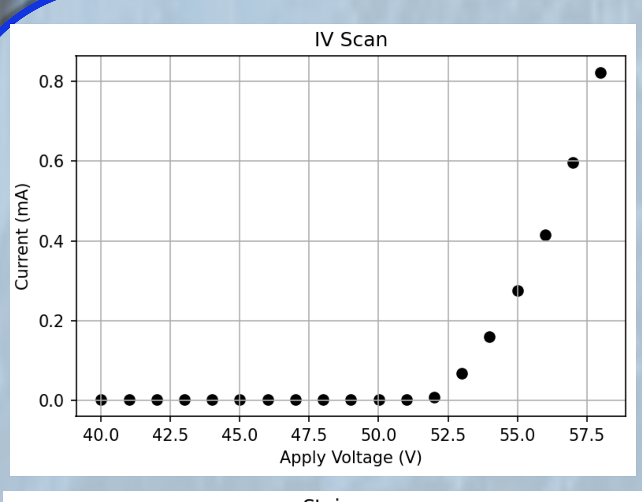
GEANT4 simulations were used to evaluate **performances** and to **optimize** the design of the detector.

Angular resolution and resolution stability over field of view are studied

↓

Angular resolution range from 10 mrad (basic) to 5 mrad (long), and worsen for high impinging angles for less than 3%

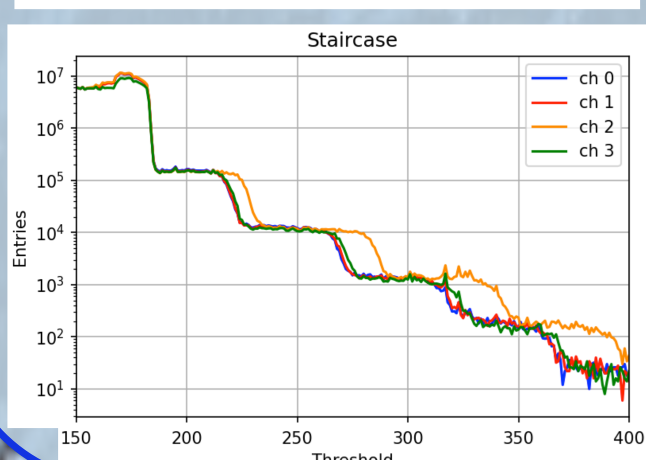


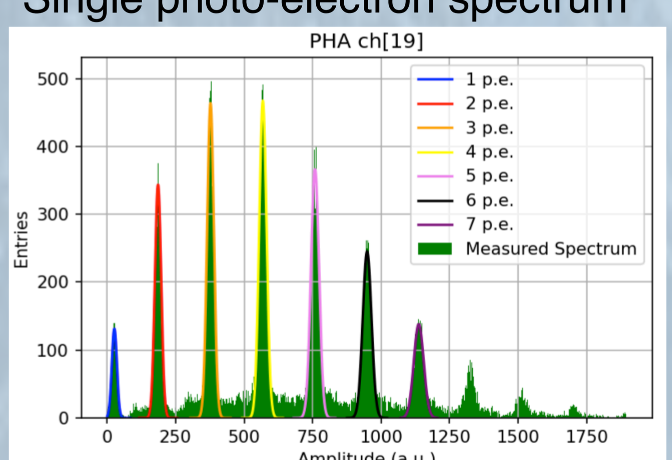


Characterization of a SiPM matrix to study the **read-out system** (FERS A5202) **performances**.

Studied features:

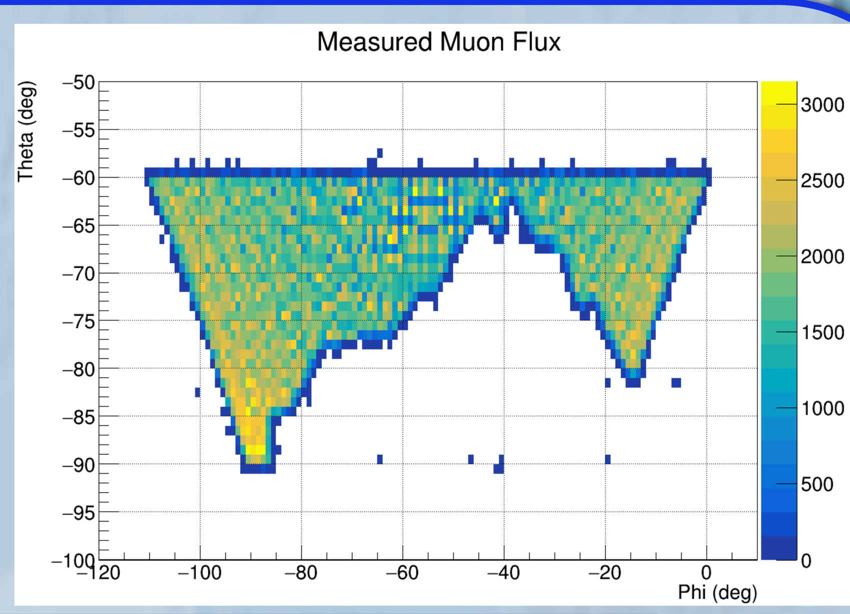
- IV to set the over voltage tension
- Staircase (scan of threshold) to set the threshold to reject the background
- Single photo-electron spectrum





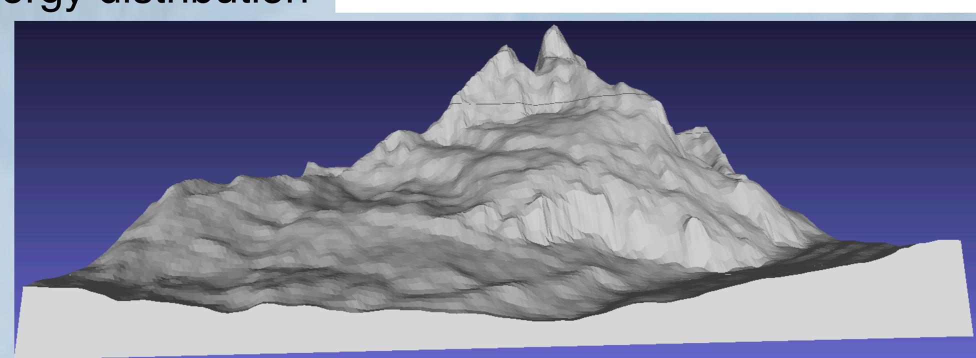
Preliminary Simulation

- Simulation of a real data acquisition situation.
- To simulate the mountain profile, a CAD step is introduced inside the simulation
- 6M of muon generated inside the range of θ[60°, 90°] and ϕ[0°, 110°] with an exponential energy distribution



↓

The mountain profile is well defined



Outlook

- The detector design fullfil all the requirements to operate in open-sky, and the simulation confirms that the resolution is ~5 m as required to measure the ice thickness
- A prototype of the detector will be tested in collaboration with the University of Glasgow
- Simulation will be compared with real data.

References:

A. Lachmann et al., Earth-Science Review, Volume 222, 2021

T. Avgitas, S. Elles, C. Goy, Y. Karyotakis, J. Marteau, arXiv:2203.00946v2 [physics.geo-ph]