Open-Sky muon tomography on Glacier: first prototype results

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

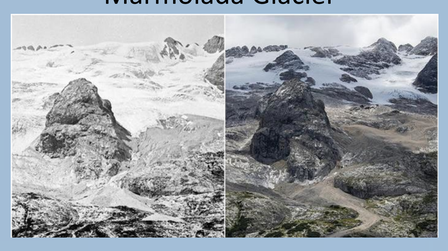
INFN BOLOGNA
Istituto Nazionale di Fisica Nucleare
Sezione di Bologna

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA A.D. 1088

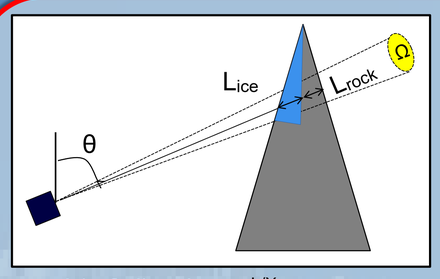
Glacier melting is one of the most visible effects of global warming.

Different techniques were used during the past years. Among them muon tomography,, however it relied either on caves under the target glaciers or indirect measurements.
As most glaciers do not offer underground access.

Marmolada Glacier



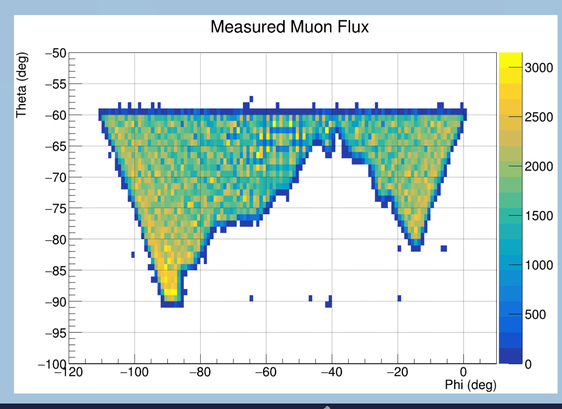
Open-Sky Detector

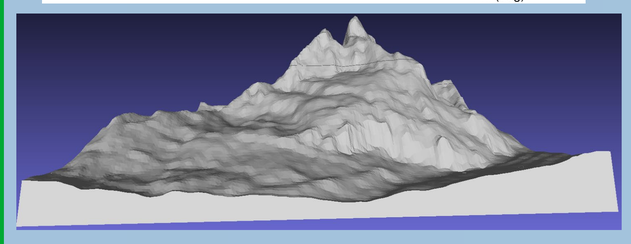


$\Phi(p,\theta, l) = \Phi_0 \cdot e^{-L/X}$
$L = L_{ice} + L_{rock}$
$X(\rho_{ice}, \rho_{rock})$ = by calibration

The goal is to perform an absorption measurement of the muons: 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

Simulation Results





The first detector simulations and performance results were reported here

- 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

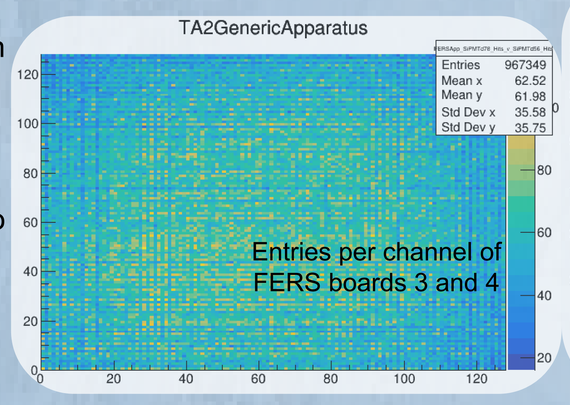
The mountain profile is well reconstructed in the simulation

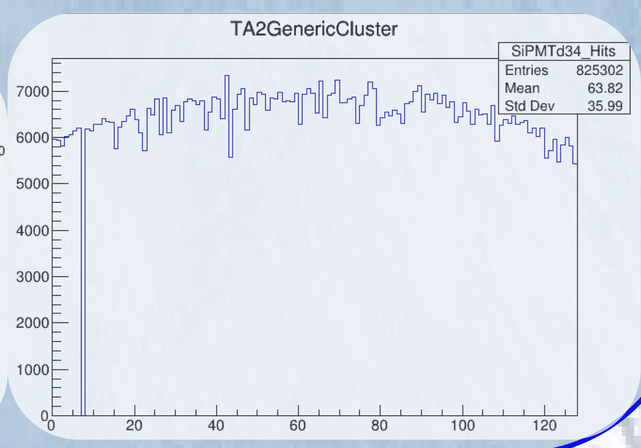
Detector Prototype

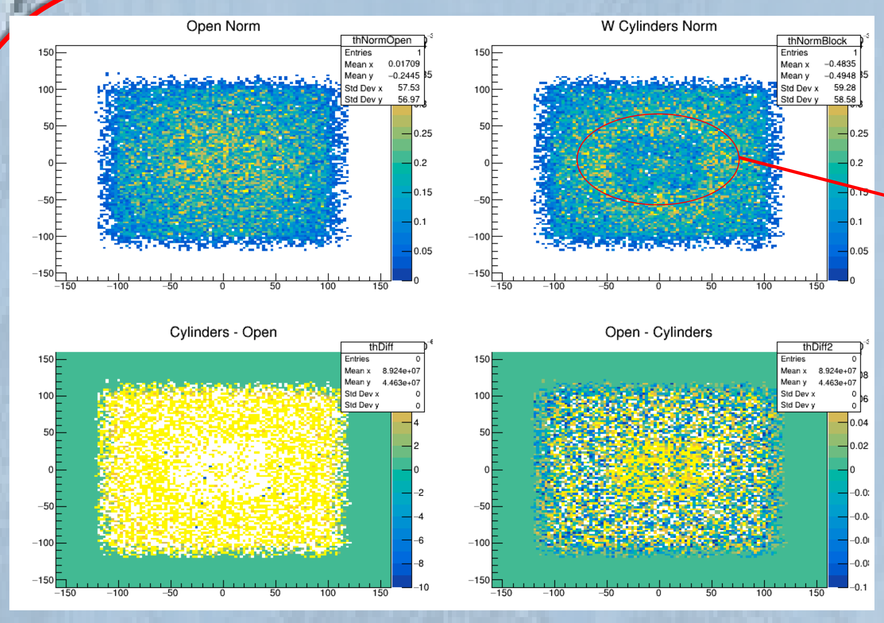
The detector is based on scintillating fiber planes stacked in modules each formed by two scintillating fiber planes with orthogonal fibers (x and y coordinates), with respect to the final detector the module dimension are reduced and only 4 modules are assembled instead of 6

- 4 modules
- 2 layers per module (x and y coordinates)
- 128 fibers per layer

SiPM are connected to the fibers and the readout is performed by 2 CAEN FERS board per layer.The 4 FERS boards of each module are connected in daisy-chain to 1 link of the Concentrator, and Data is transferred to a PC through Ethernet connection.
Trigger produced by the AND of hits in two layers of different modules. Trigger is distributed to the 16 board through Wired-OR connection



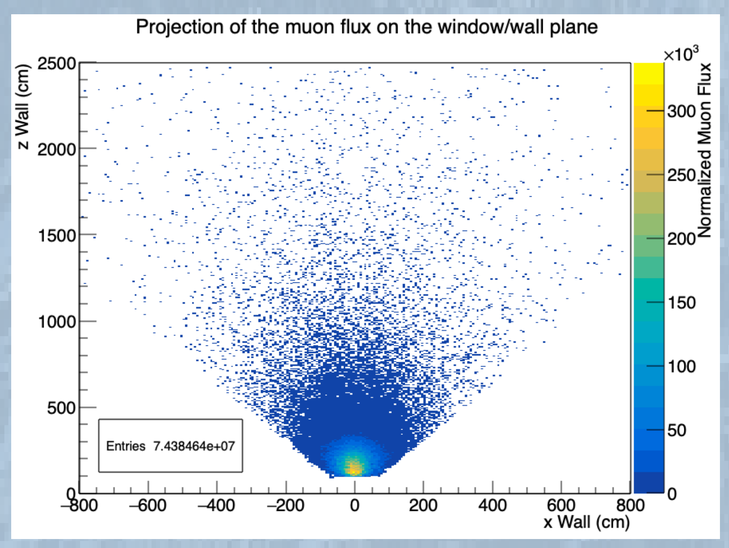


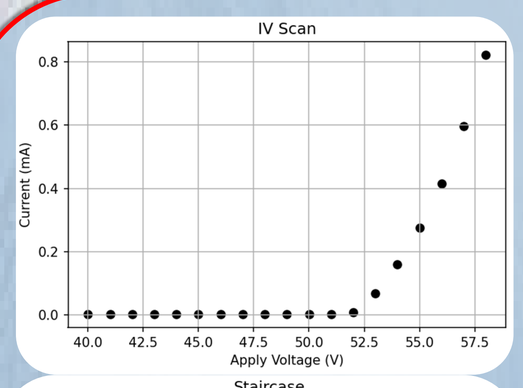


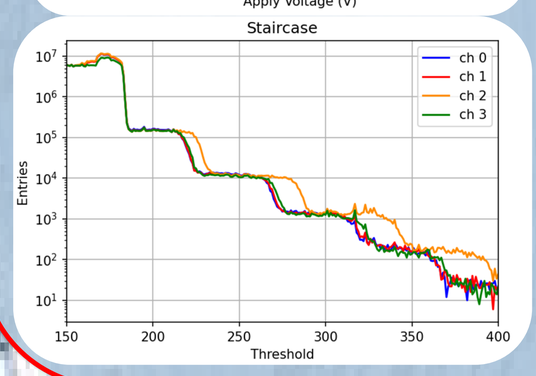
First results obtained by running the complete prototype system with readout and reconstruction two test were made separately:

Reconstruction of Tungsten targets placed on the last module of the detector with exposition time of few hours, using muons coming vertically

Reconstruction of a small window on the laboratory wall, exposition time of few days due to the lower muon flux, the position and dimension of the window are well measured by the detector.



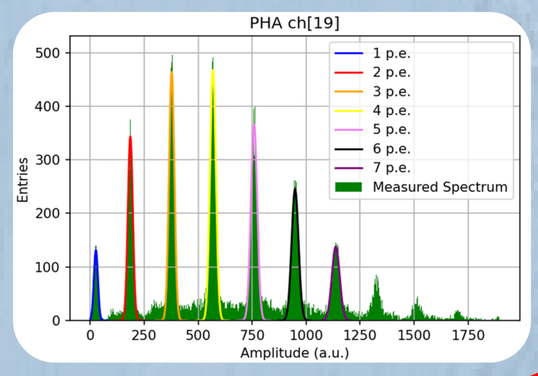




Characterization of a SiPM matrix to study the **read-out system** (FERS A5202) **performances**.

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



Outlook

- A first prototype for an open-sky muon tomographer has been produced and tested in all its components.
- The detector prototype was assembled in collaboration with the University of Glasgow.
- The first results on test-targets and structures has been performed and the prototype shows that the detector can fulfil the goals for glacier muon tomography.
- A first test-run using buildings as targets has been performed last month and the data are currently being analysed
- During the next year a test run is expected for measuring the water level of an hydroelectric dam basin, to evaluate the performance on ice

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]