Open-Sky muon tomography for Glacier Monitoring

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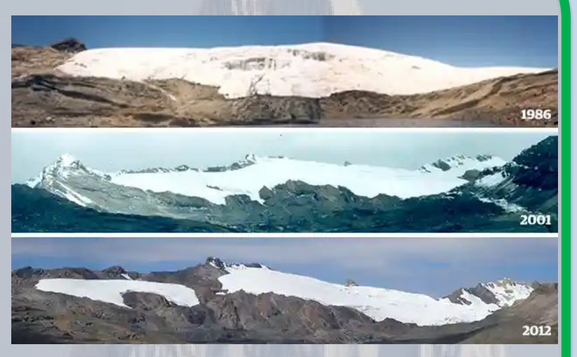
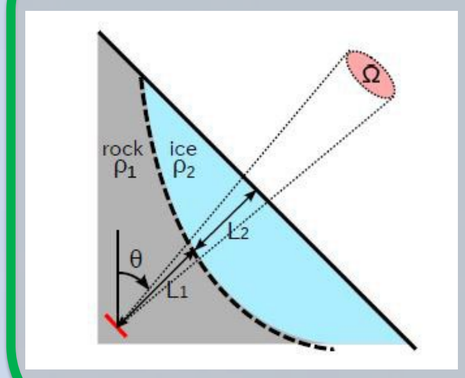
Glacier melting is one of the most visible effects of global warming.
Muon tomography can shed light on glacier thickness and their melting processes.
Only few glaciers have underground access →
open-sky detectors





Measuring muon fluxes with good angular resolution allow for glacier-bedrock interface depth.

Only assumption is made on the overall bedrock+ice thickness T.

$$\Phi(\mathrm{p},\theta,l) = \Phi_0 * e^{\frac{l}{X}}$$

$$X = L_1\rho_1 + L_2\rho_2 \;; \quad T = L_1 + L_2$$

The project goal is to to achieve an ice thickness resolution of O(5m) that corresponds to an angular resolution on the incoming muon tracks of O(7mrad).

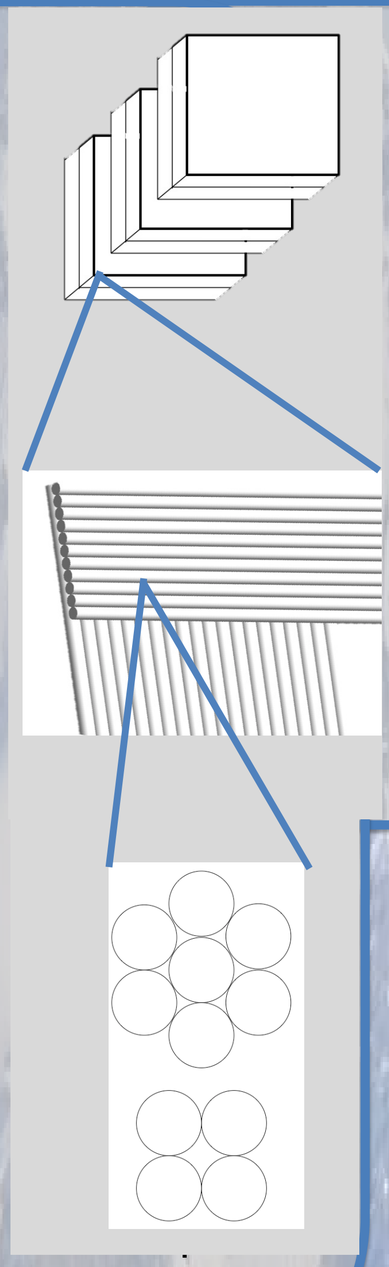
Open-sky operations needs fast detector to reduce to negligible level background tracks not passing through the target.

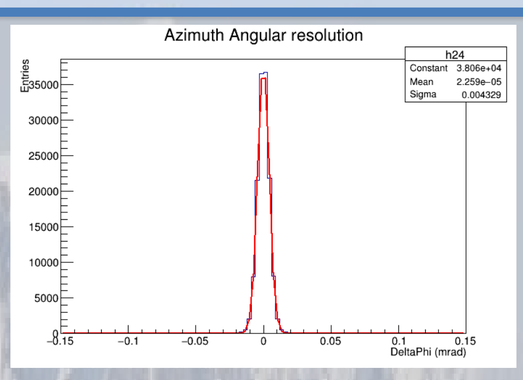
Detector requirements: reduced number of channels, low maintenance needs, able to operate in adverse weather with simple powering scheme.

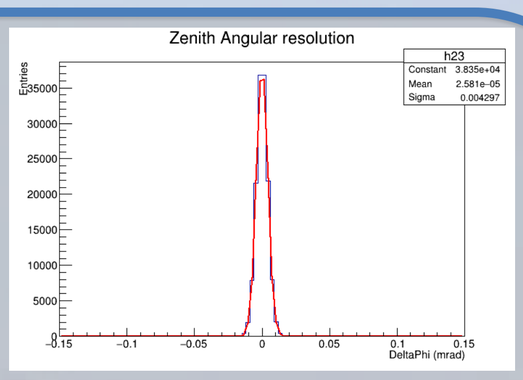
Detector Design:

- 5 pairs of plastic planes with embedded scintillating fibers bundles, running on orthogonal axes
- Plane dimensions 1mx1m
- Fiber bundle diameter 6cm
- One phodotedector per bundle: number of channels O(2000)

Optimization was done with different configurations in terms of detector length and plane spacings.



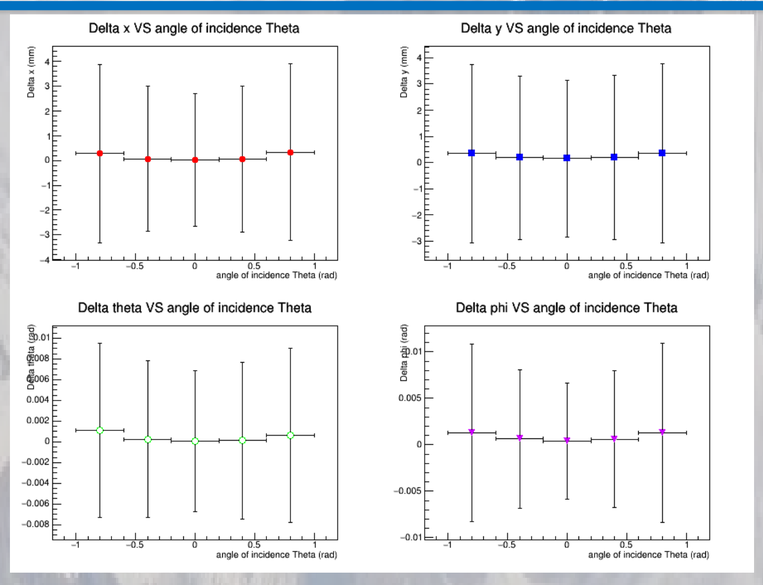




Feasibility study done using a full GEANT4 simulation for the full detector under different special configurations.

Simulation results show an angular resolution for muon directions of 5mrad on both polar and azimuthal angle.

These allow for measurement of glacier thickness with few meter resolution, and allow to study glacier internal structure and seasonal variation



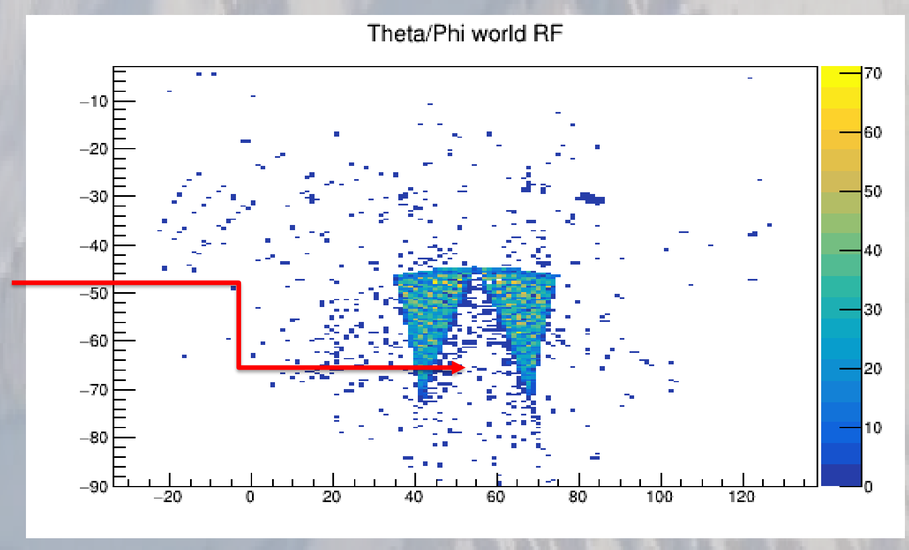
Main Challenges:

- Multiple scattering in atmosphere and target: mitigated by uniform response of the detector at the edges of the geometrical acceptance
- Combinatorial background from muons not passing through target: reduced to negligible level thanks to fast response of scintillating fibers, with expected O(10^{-4}Hz) reconstructed tracks not coming from target

Outlook

Simulation studies confirmed that this detector can operate in open-sky achieving resolutions on par, or better, than current tomography detector used for glacier monitoring or volcanology.

A first simulation with reduced statistics showed first results for a direct measurement of bedrock-glacier interface, and a higher statistics simulation is in preparation to understands the exposure time needs for the detector



References:

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