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A new detector to muon tomography for glaciers melting monitoring

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We present a design project for a muon tomography detector aiming to the monitoring of glacier monitoring. The glacier melting process is not completely understood and is considered an hot topic in lieu of the global warming.
Muon Tomography is a widely used technique, employed to perform imaging of the inner structure of large objects, as volcanoes, container and pyramids. This technique takes advantages of the muon flux that reaches the surface of the Earth (~ 70 m-2 s-1 sr-1), produced by the interaction between the primary Cosmic Rays and the atmosphere. 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 (in equivalent water meter) that the muons cross. In case of glaciers, thanks to the different density of ice and rock, a directional flux measurement provides information on both the glacier thickness and the bedrock -ice interface depth.
The goal of our project is the development of a detector able to measure the glacier thickness with short exposure time, and with a real time data taking and processing, in order to perform studies of the seasonal behavior, and the glacier melting trend through the years.
The detector will be able to reconstruct the trajectory of muons with an angular resolution of order of 5 milliradians to obtain a precision on the target object thickness of the order of few meters. The detector will also be operable in open-sky and be replicable. To fulfill all these requirements, the detector is built of 5 sensitive modules, each of that composed by two layers of bundles of scintillating fibers running along orthogonal directions with respect to each other. Each bundle is coupled with a photodetector, which detects scintillation light produced in the bundle. Thanks to the information of the fired bundles, we can reconstruct the coordinates of the muon hit, and reconstruct each muon trajectory. To work in open sky, the detector readout speed is paramount, in order to reconstruct each muon crossing it individually, including the muons not passing through the target of interest. In order to discriminate the signal (muons coming through the mountains) and the background (the one not passing through the target) the read-out system need to be fast enough to limit to a minimum spurious coincidences, and overlapping events. Given the active surface of the designed detector and the expected muon flux, a sampling of few kHz would be able to cope with the background without limiting the signal efficiency.

In this contribution, we will show the results of a set of simulations aimed to optimize the detector design, and the foreseen performances of the designed detector. The results are obtained through a detector simulation and a track finding algorithm. The angular resolution of the reconstructed muon tracks, will be shown considering different configuration of the triggering system, and the quality of the tracks, together with a study of the dependence of the angular resolution with respect to the direction of the incoming particle.

At present the detector simulations show an expected angular resolution of ~0.7 mrad, by which we can infer the expected resolution on the measurement on the ice-rock interface depth of $\Delta x \sim \Delta\theta L = 14$ m (where L is the distance between the detector and the glacier, that we consider around 2 Km).

We will present also the first full simulation results on the expected resolution on the measured thickness of the target, and the resolution on the depth of the ice-rock interface in a glacier monitoring environment, along with the foreseen exposure time needed for the on-field measurement.

In-person participation

Yes

Primary authors: CERVELLI, Alberto (Istituto Nazionale di Fisica Nucleare); RABAGLIA, Sara (Istituto Nazionale di Fisica Nucleare)

Presenter: RABAGLIA, Sara (Istituto Nazionale di Fisica Nucleare)

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