MURAY : volcano radiography with cosmic ray muons

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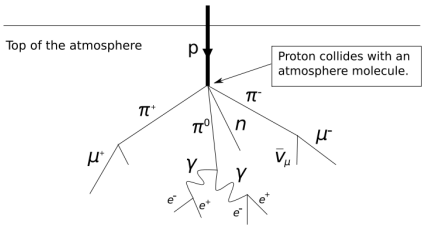
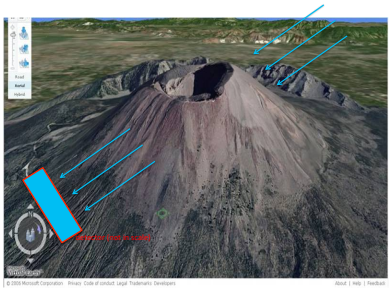
Measurement principle

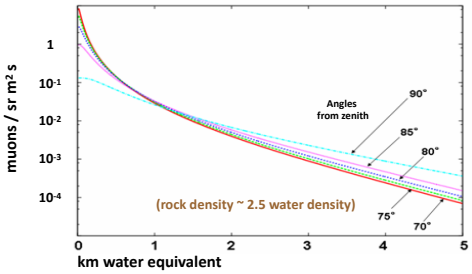
Cosmic ray interactions in the atmosphere produce high energy muons



A "muon telescope" detects muons having traversed the volcano



The average rock density is derived from muon absorption as function of direction



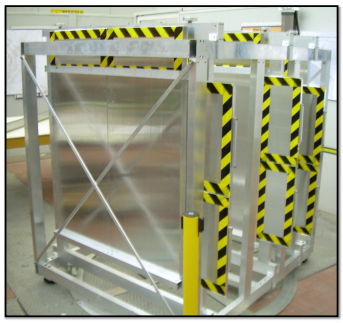
Muon telescope prototype

REQUIREMENTS

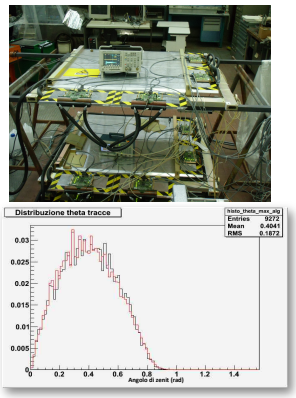
- High background rejection
- Redundant tracking
- Time resolution < 1 ns → TOF
- Angular resolution ~ 10 mrad
- Low power budget
- Real time data acquisition
- Modular structure
- Low noise
- Large area
- Low cost

TECHNIQUE

- Extruded plastic scintillator strips
- 3.3 cm wide, 1 m long strips
- 32 strips modules
- Fast-decay WLS fibers ϕ =1mm
- Silicon Photon Multipliers
- SPIROC-Easiroc f.e. electronics
- Custom readout electronics
- Three X-Y planes 1 m² area

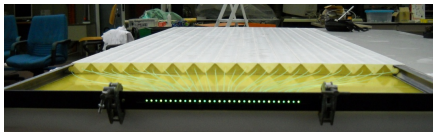


COSMICS .vs. ZENITH ANGLE



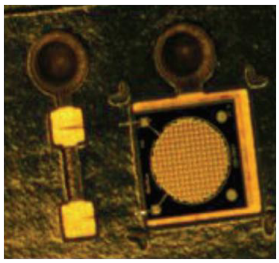
Muon telescope components

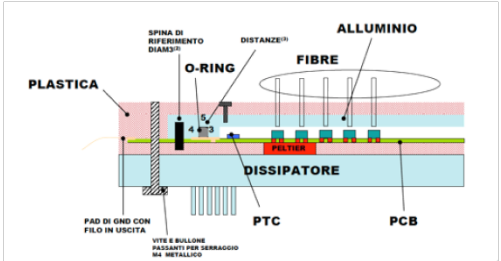
Scintillator modules

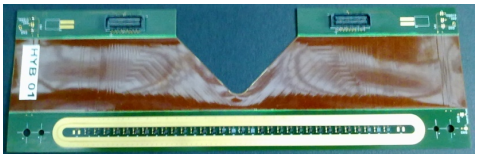


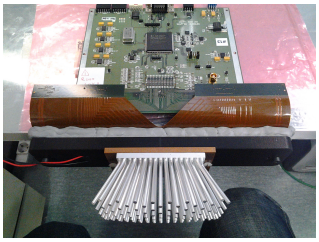
The scintillator bars are produced at FERMILAB by extrusion. The strips have a co-extruded TiO_2 coating (0.25 mm thick) for reflectivity. They have triangular transverse shape with a ≈3mm diameter hole in the center. Scintillation light is collected by fast WLS fibers (BICRON BCF92) glued in the hole with optical glue. The weighted average of the signal amplitude of two adjacent strips gives ≈3mm of spatial resolution.

SiPMs on Printed Circuit Board









Electronics

The SPIROC (SiPM Read-Out Chip) ASIC has been developed by OMEGA group at IN2P3/LAL at the Orsay laboratory specifically for SiPM read-out. Realized with 350 nm Si-GE technology, it is an auto-triggered, bi-gain, 36 channel chip which allow to measure the charge from one photoelectron to 2000 and the time with 100 ps accuracy. It can provide to each SiPM a fine supply voltage. The power consumption is very low: 20 µW per channel.

The analog output from the SPIROC is digitized from a dedicated board that also provide data communication, transmission and trigger logic

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