Poster 28

Cosmic Background Measurements at a Proposed Underground Laboratory in Felsenkeller (Dresden, Germany) by the REGARD Muontomograph

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Physics Motivation

The next generation of **radioactive ion beam experiments** will provide more details about the reactions of stabil nuclei. For the better understanding of these processes, more precise cross-section data are needed at low energies which **require low radiation background** [1]. The muonic component of cosmic ray induced backround is slowly attenuated by the overburden rock thickness. Therefore, the knowledge on the muon flux is a key element to perform experiments on reactions of stabil nuclei. **Our aim is to perform a precise measurement of the cosmic muon background to cover the full 2π** of the upper hemisphere at a proposed laboratory at shallow depth underground in Felsenkeller, Dresden, Germany (*see in Fig. 1*).

A Portable Tracking Detector for Muon Flux Measurements

A portable cosmic particle tracking detector has been developed by the REGARD group (Wigner RCP of HAS and Eötvös Loránd University Collaboration on Gaseous Detector R&D). The **Close Cathode Chamber-based tracking system** [2,3] is optimized for environmental [4] and geophysical [5] applications with its weight of 15 kg, size of 51 × 46 × 32 cm^3 , sensitive area of 0.1 m^2 and angular resolution of 10 mrad (*see in Fig. 2*). Our muon telescope is housed in a plexiglass box, which besides giving mechanical support, provides environmental isolation as well. The Muontomograph **requires continuous gas flow** during data taking, in our case the gas is a non-flammable mixture of Ar and CO_2 in 82:18 proportion. A **PIC32 microcontroller based data acquisition** (DAQ) system is developed, and its small size unit fits well between the middle tracking layers. All functions (high voltage unit, low voltage, trigger system, data handling, environmental control, human machine interface, etc.) are integrated into a common system plan. The measured track coordinates are read out by the chains of Front-End Electronics (FEE) and written to a standard Secure Digital (SD) card. A memory card with with 2 GB capacity enables a full year of run time in 50 meter-rock-equivalent depth. The total power consumption of the complete detector is less than 5 W. **The Muontomograph can operate for a week by a 50 Ah battery!**

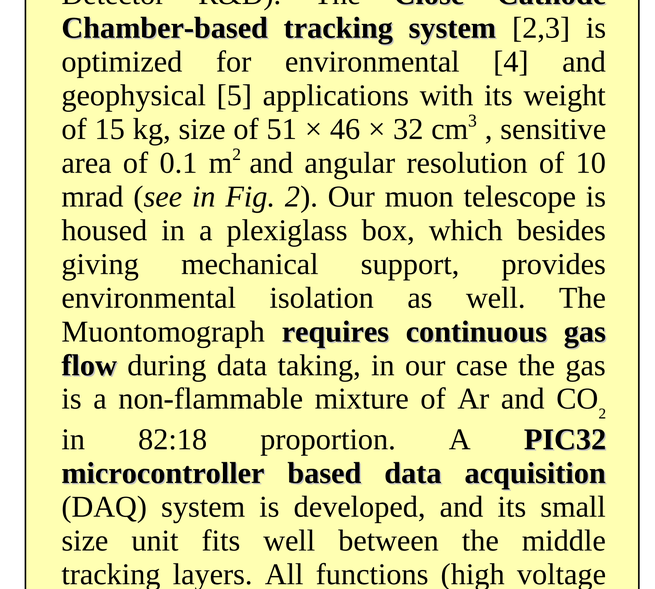

Fig. 1: The structure of our portable muon telescope: four (or five) Close Cathode Chambers (CCC) measure the track of penetrating cosmic particles. An integrated Data Acquisition (DAQ) system controls the detector and manages the data readout by Front-End Electronics (FEE). Furhermore, the detector has a user-friendly Human Machine Interface (HMI) with two buttons.

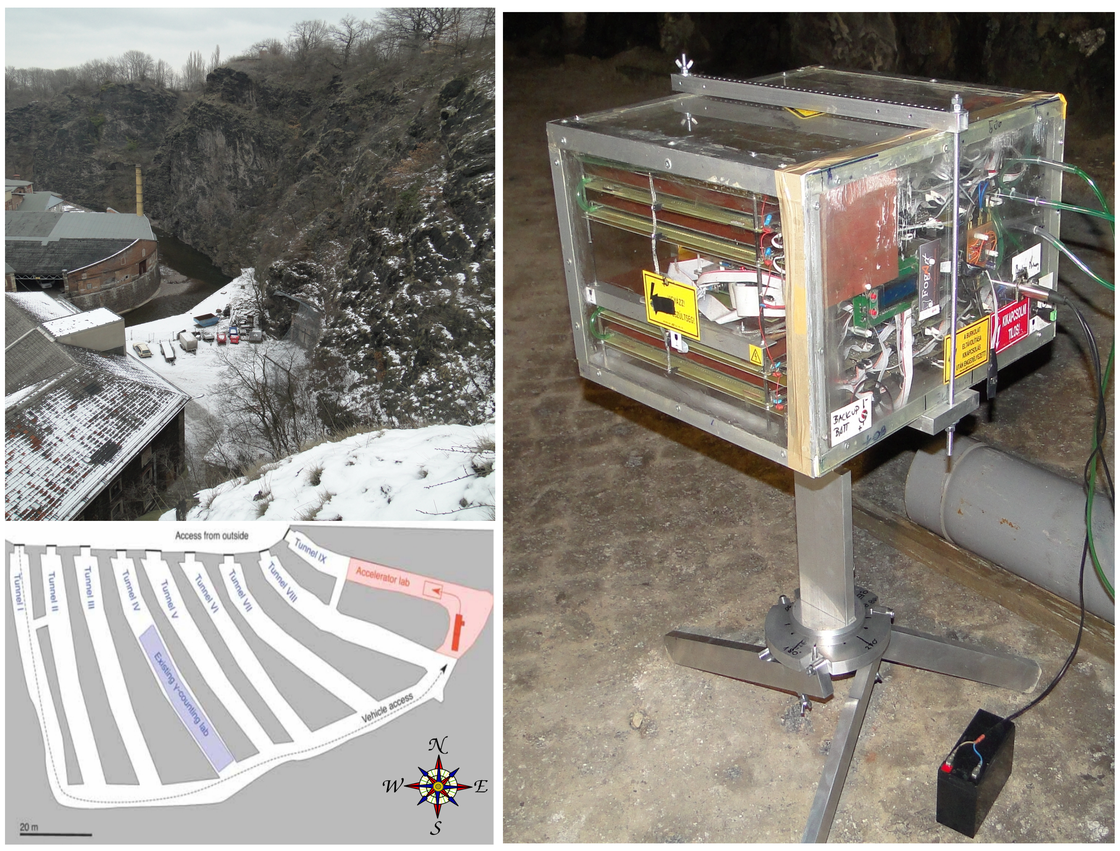

Fig. 1: The Felsenkeller (upper *left*) with the proposed laboratory (*red tunnel in lower left*) where the cosmic background measurements have been performed by the REGARD Muontomograph (*right*).

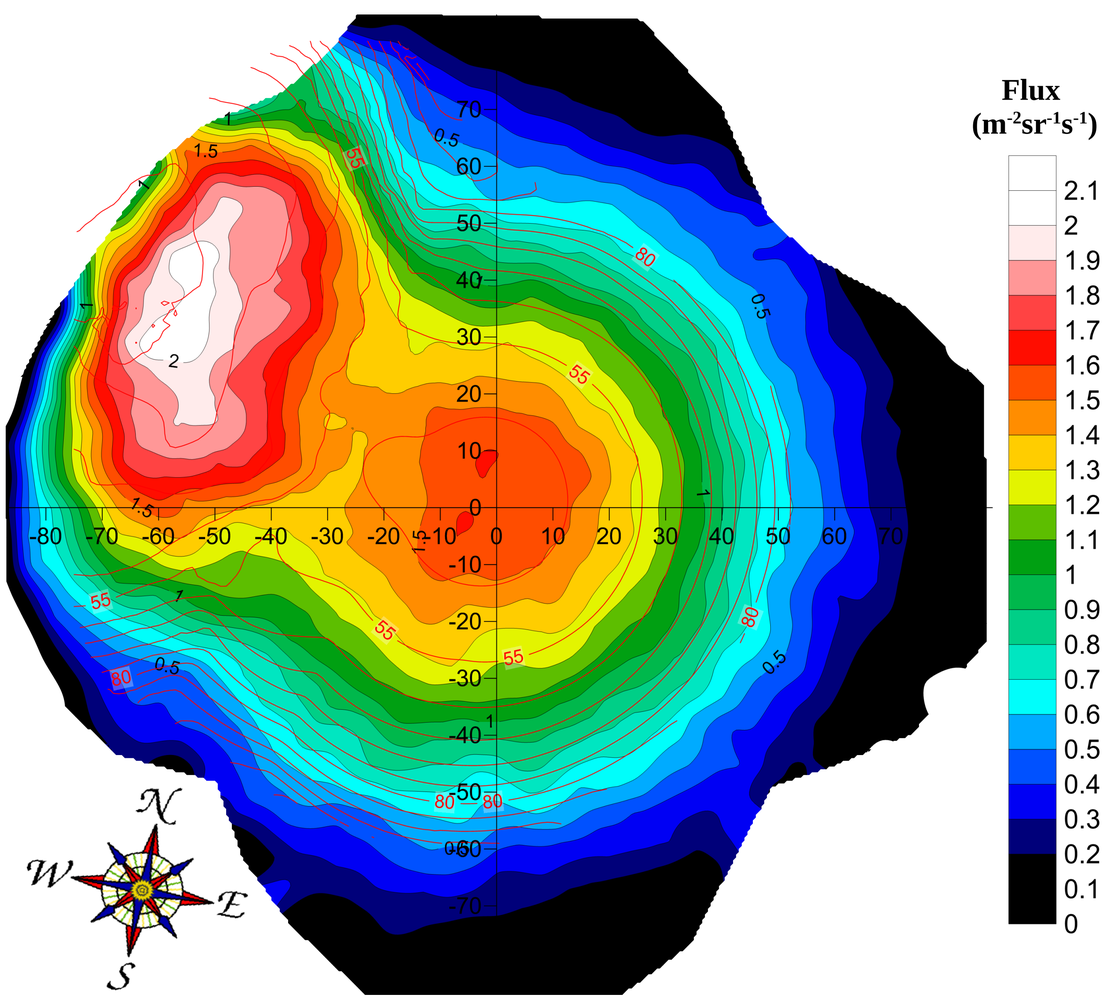

Fig. 3: The cosmic background measurements have been performed during 40 days to cover the full 2π solid angle by the REGARD Muontomograph in Felsenkeller Dresden, Germany. The measured muon flux is plotted here in $m^{-2}sr^{-1}s^{-1}$ units. The detector (placed at the *origo*) was oriented at 350° to the magnetic North. The measurement error is typically 3-10% statistical and 5% systematic.

Cosmic Background Measurements at a Proposed Laboratory in Felsenkeller, Dresden, Germany

Cosmic muon flux measurements have been performed during 40 days to cover the full 2π solid angle of the upper hemisphere. During the measurements, our detector was in a fix position. In the vertical setting (highest statistics) it was oriented at 350° to the magnetic North. *Table 1* shows the main parameters of the runs with various angular settings: detector position in spherical coordinates (the azimuth angle to the magnetic North and the zenith angle in degrees), the duration of measurements in days and the number of detected cosmic muon tracks. **Standard high energy physics tracking procedures have been applied during the offline data analysis.**

The determined muon flux have been corrected for all systematic effects such as detector acceptance, time of measurement, trigger efficiency and angular dependent tracking efficiency.

Azimuth (deg)	Zenith (deg)	Time (day)	Tracks (×10³)
350	0	17.5	215
350	45	7.5	60
80	45	4.5	110
170	45	3.5	26
260	45	4.5	45
305	45	1.5	21

Tab. 1: The main parameters (detector position, duration, detected tracks) of the cosmic background measurements in Felsenkeller, Dresden, Germany.

Results

The muon telescope reliably operated during the 40 days of measurements, there were no degradation in detector performance. The map of the measured cosmic muon background is shown in *Figure 3:* the flux of cosmic muons appears with *color-scale contours* in $m^{-2}sr^{-1}s^{-1}$ units. The *red contour lines* show the overburden rock thickness above the detector in meter-rock-equivalent, which has been measured by a laser scanning total station. As expected, the measured muon flux correlates well with the overburden rock thickness. **The top muon flux is found to be below 3 $m^{-2}sr^{-1}s^{-1}$. The results provide a well defined baseline for the design of the proposed accelerator-based experiments in the Felsenkeller site**.

Summary and Conclusions

The cosmic background originating from cosmic muons have been measured in the full 2π solid angle of the upper hemisphere by the newly developed portable tracking detector at an underground laboratory in Felsenkeller, Dresden, Germany. The maximum muon flux value is found to be below 3 $m^{-2}sr^{-1}s^{-1}$. The results quantify the shielding of Felsenkeller tunnel system for the proposed radioactive ion beam experiments. The portability, reliable tracking peformance, low power consumption and the good angular resolution makes the presented Muontomograph to be a useful tool to perform reference measurements of cosmic background.

References:

[1] EPJ A48 (2012) 8
[2] NIM A648 (2011) 163–167
[3] NIM A698 (2013) 11–18
[4] NIM A689 (2012) 60-69
[5] Adv. in HEP (2013) 560192 7

The **REGARD** is the collaboration of Wigner RCP **R**MI of HAS and **E**ötvös Loránd University on **GA**esous Detetector **R**esearch and **D**evelopment. We are working on project oriented development of particle and applied gaseous detectors with multiwire and microstructure technologies. The REGARD group participates the upgrade of a CERN LHC ALICE and CERN NA61 experiments, and has ongoing projects on muon tomography radon detection.

Our Supporters:

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