Current status of MuSTAnG at the Christian-Albrechts-University Kiel

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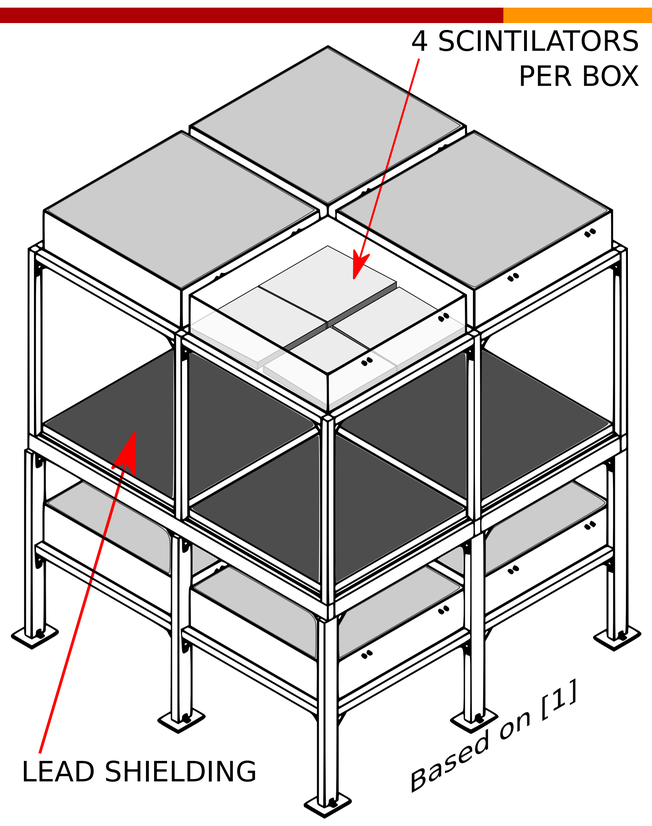


Fig 1: A schematic of MuSTAnG

Muon Spaceweather Telescope for Anisotropies Greifswald

MuSTAnG is a particle experiment measuring the secondary muon flux at Earth's surface. It is configured as a 2 layer 4x4 scintilator array (fig.1). It measures penetrating muons which deposit at least 4MeV in one detector of each layer. This array-like configuration makes it possible to consider detector combinations. Each of these combinations forms a virtual telescope. Therefor there are 49 distinct viewing directions (fig.2). The telescope has been originally built in Greifswald, Germany. Its goal is to be integrated in to the global muon network. Its goal is to serve as an alarm system for the arrival of Coronal Mass Ejections [CME]. This is to be achieved by monitoring the temporal anisotropy of the muon flux which is modulated by the CME between Earth and the Sun (fig 3).

In 2014 MuSTAnG was transfered to Kiel, Germany and has been reassembled by April 2015. Since May 11th 2015, MuSTAnG is operating nominaly at its new location (54.34702°N 10.11188°E). However its orientation is tilted by 35° relative to the north south direction. Work has been started to reintegrate MuSTAnG in to the global muon network. Until now, we have investigated the geometrical response of the instrument and the corresponding asymptotic directions.

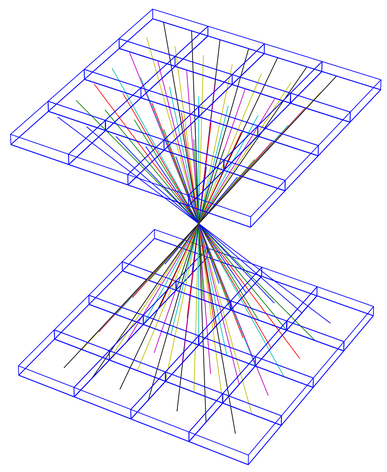


Fig 2: 49 distinct viewing directions

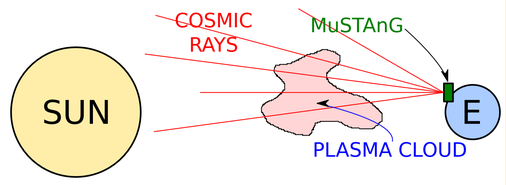


Fig 3: Modulation of the galactic cosmic ray flux by a plasma cloud moving toward Earth.

THE DATA PRODUCT

The raw data includes rates for each of the 49 viewing directions (60s intervals). The directions span a 7x7 matrix in which the central element represents muons penetrating parallel detectors.

117	564	1433	2405	1446	574	148
509	2568	8733	15614	8836	2733	546
1245	8796	36945	74242	37743	8688	1341
2158	15556	73833	156047	74418	15553	2189
1286	8315	35272	71891	36273	8580	1315
486	2541	8476	15863	8630	2719	528
142	521	1296	2248	1356	597	130

The data is provided in ascii format and in near real-time on:
www.mustang.physik.uni-kiel.de

INSTRUMENT RESPONSE FUNCTION

- Mean viewing directions, weighting factors and sensitivity matrices for each viewing direction have been calculated based on [5] [lower left panel]
- More detailed simulation using GEANT4[4] is in progress.

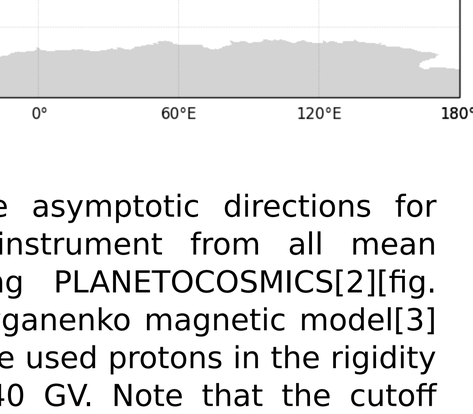
MODELING OF THE MUON FLUX

- Determination of the asymptotic direction for all viewing directions using PLANETOCOSMICS [2] has been performed [lower right panel]
- Correction for temperature effects
- Investigation of muon production, propagation and decay using CORSIKA [6]

DATA ANALYSIS AND VISUALIZATION

- Investigation of the flux variations on different time scales
- Investigation of the response to Forbush effects caused by CMEs
- Development of an online data browser including an interactive plot

SEP WARNING SYSTEM



*Preliminary example, no physical significance

Simulation of the Instrument's geometric response

For the purpose of investigating how sensitive the instrument is to muons ariving from various directions, we investigated its response to an isotropic flux (fig.4). This is similar to the method described in [5],[8].

Since there are 16 detectors in each layer, there are in total 256 combinations of one detector from each layer. Each of these combinations forms a virtual telescope. Many of these virtual telescopes have the same viewing direction, i.e. there are 16 combinations of parallel detectors. There are in total 49 distinct viewing directions. Fig.5 shows the contribution of each viewing direction to the total response. Fig.6 differs from fig.5 in that it corresponds to an isotropic flux, that is, it is properly weighted. The instrument is most efficient in measuring particles whose inclination is about 25°.

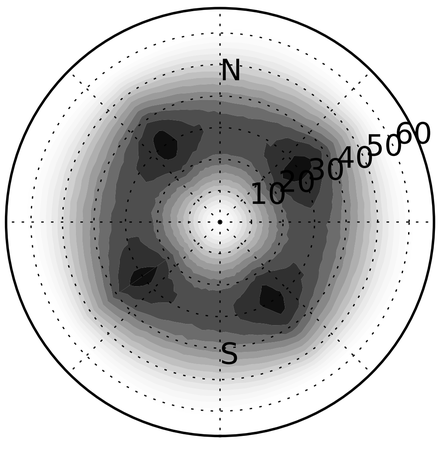


Fig.4: total geometrical response of the telescope. Also indicated is the orientation relative to Earth's poles

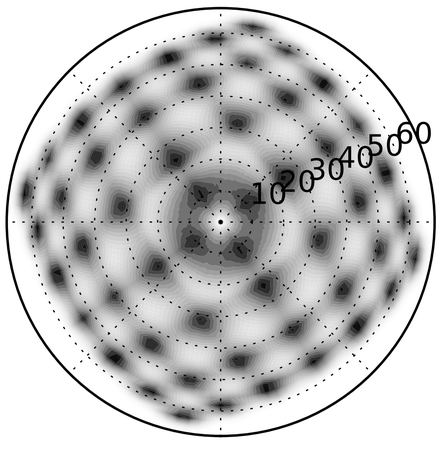


Fig.5: geometrical response of the 49 viewing directions. The ring in the center represents parallel detectors

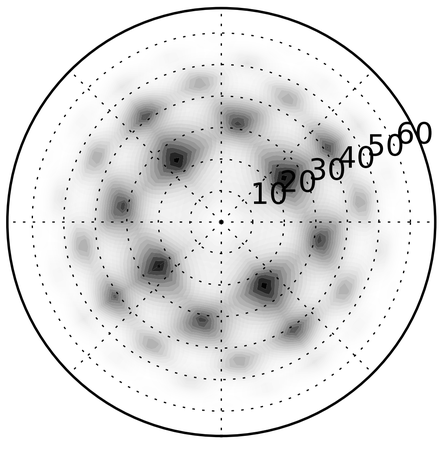
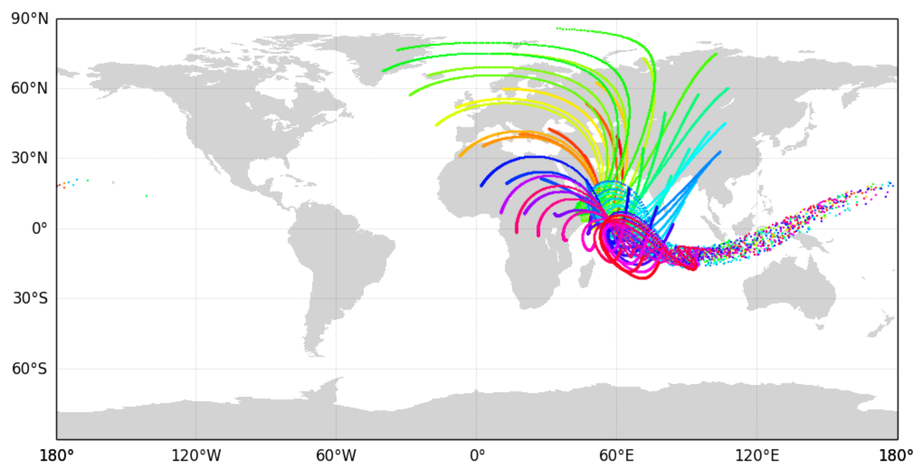


Fig.5: Same as Fig.4, just properly weighted. The corner directions have relatively low efficiency.

Determination of asymptotic directions



We have simulated the asymptotic directions for protons reaching the instrument from all mean viewing directions using PLANETOCOSMICS[2][fig. above]. We used the Tsyganenko magnetic model[3] with a Kp-Index of ~2. We used protons in the rigidity range between 3 and 40 GV. Note that the cutoff rigidity varies between 2.4GV and 3.1GV, depending on the viewing direction. This is also valid for the secondary muons, assuming that their path does not deviate from the one of the protons. It is striking that almost all particles below ~10GV seem to originate from a region over the western part of the indian Ocean. It remains to determine the muon distribution reaching the instrument by more sophisticated simulations.

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