The Charge of Cosmic Rays

Design of the muon-counter

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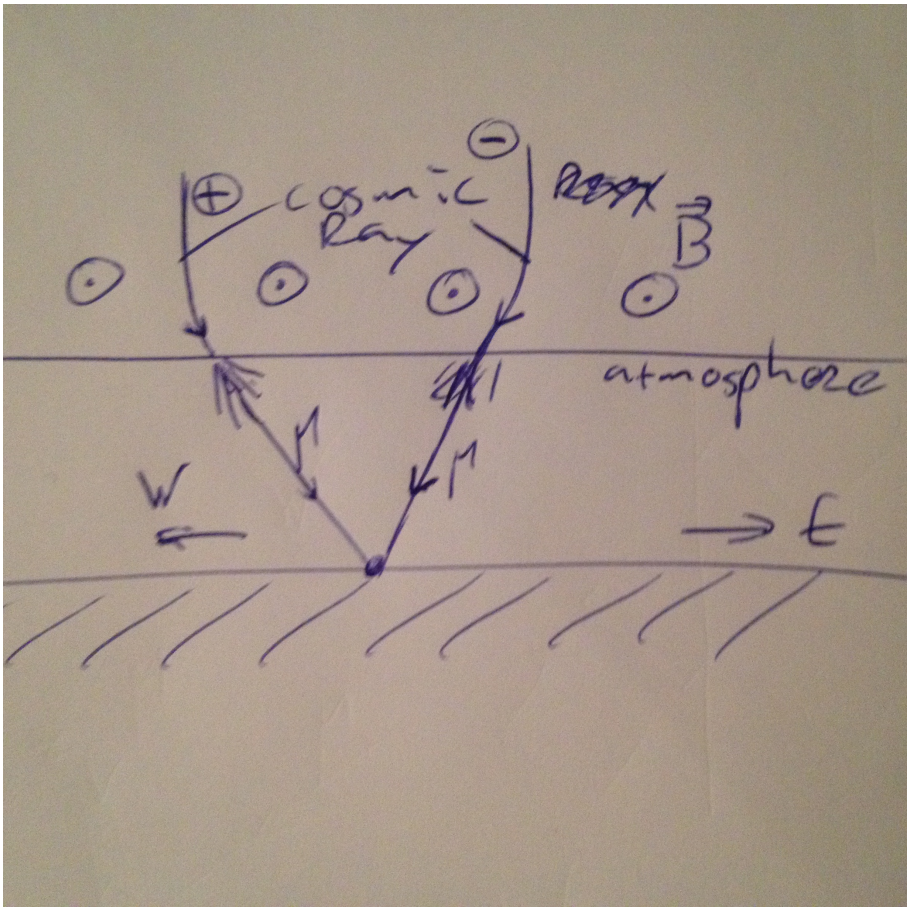
1 Detection priciple

In order to determine the charge of the primary particle (cosmic ray) inducing an air-shower, we will probe the direction of the primary particle in the earth's magnetic field. Due to the magnetic field-lines pointing from the north to the south, charged particels entering the earth's magnetic field from above will be deflected to give an asymetric flux in the east-west direction.

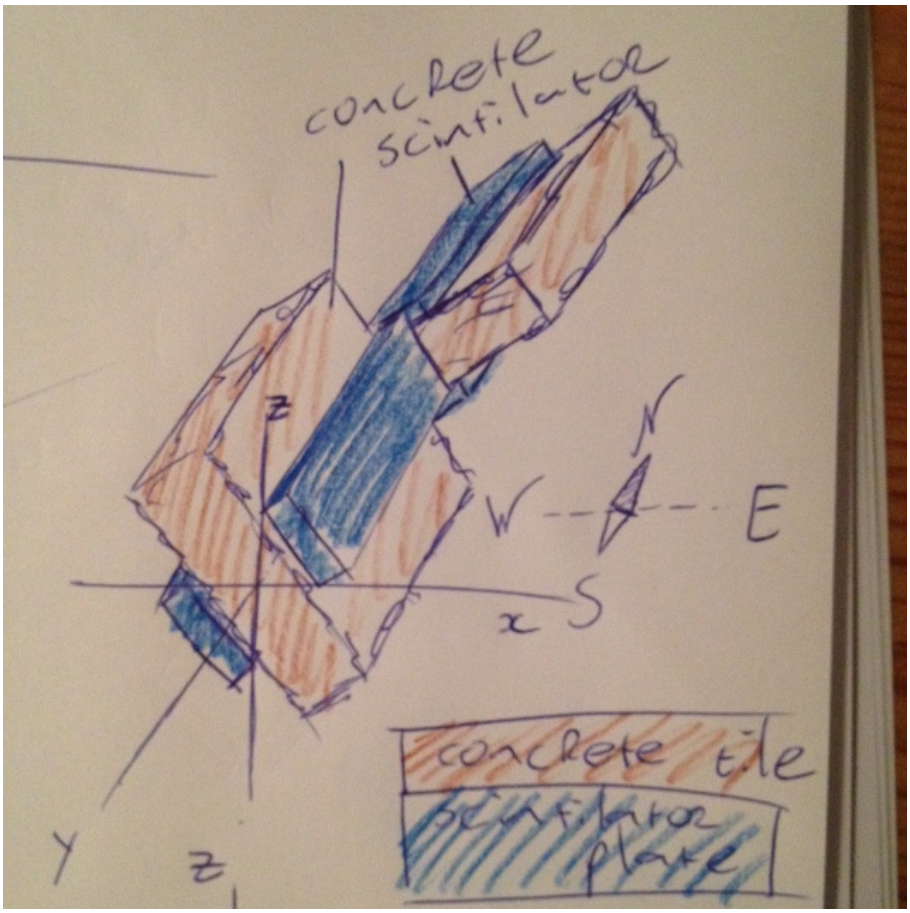
Due to the mentioned Lorentz-force, a majority of the positively charged cosmic rays will cause a higher flux observed from the west than from the east. In the case of a majority negatively charged cosmic rays, the opposite can be expected.

A majority of the secondary particles in an cosmic-ray induced air shower will decay to give low-energetic final particles. The muons however have a large enough lifetime to reach the earth's surface. As a result, an excess in the number of cosmic rays entering the upper atmosphere either from the west or from the east can be probed by counting the number of atmospheric muons hitting the earth's surface from the west resp. east:



2 Detector setup

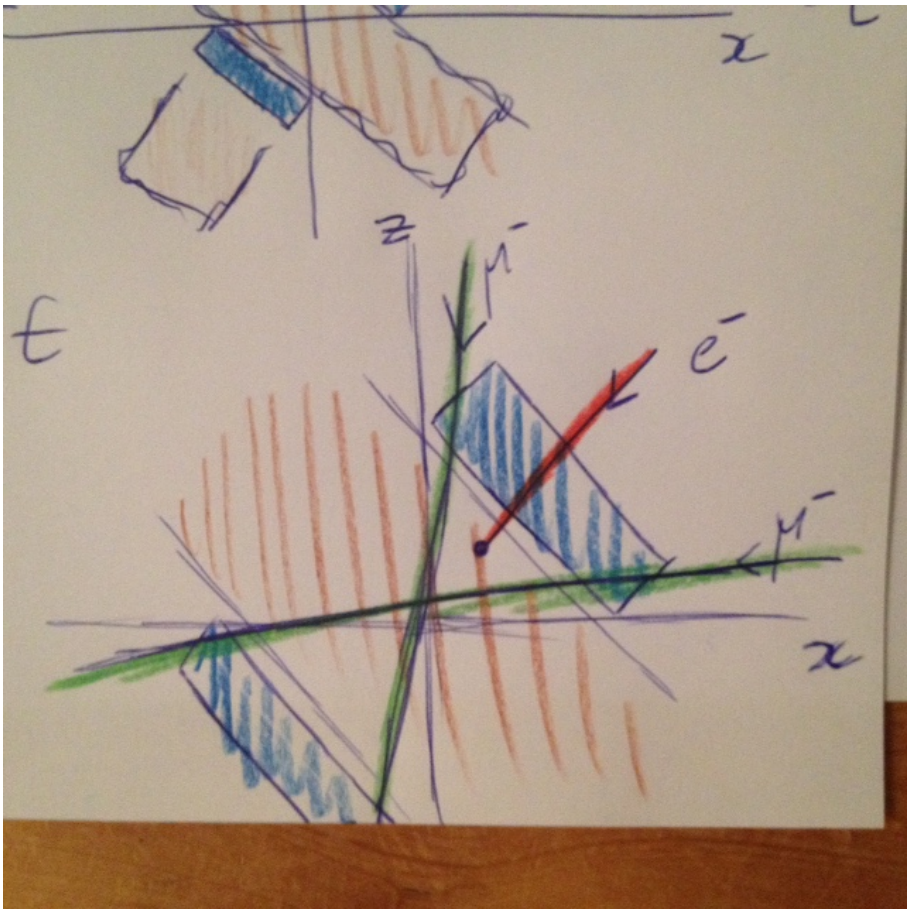
In order to detect the number of muons coming from the west resp. east, the following setup is proposed:



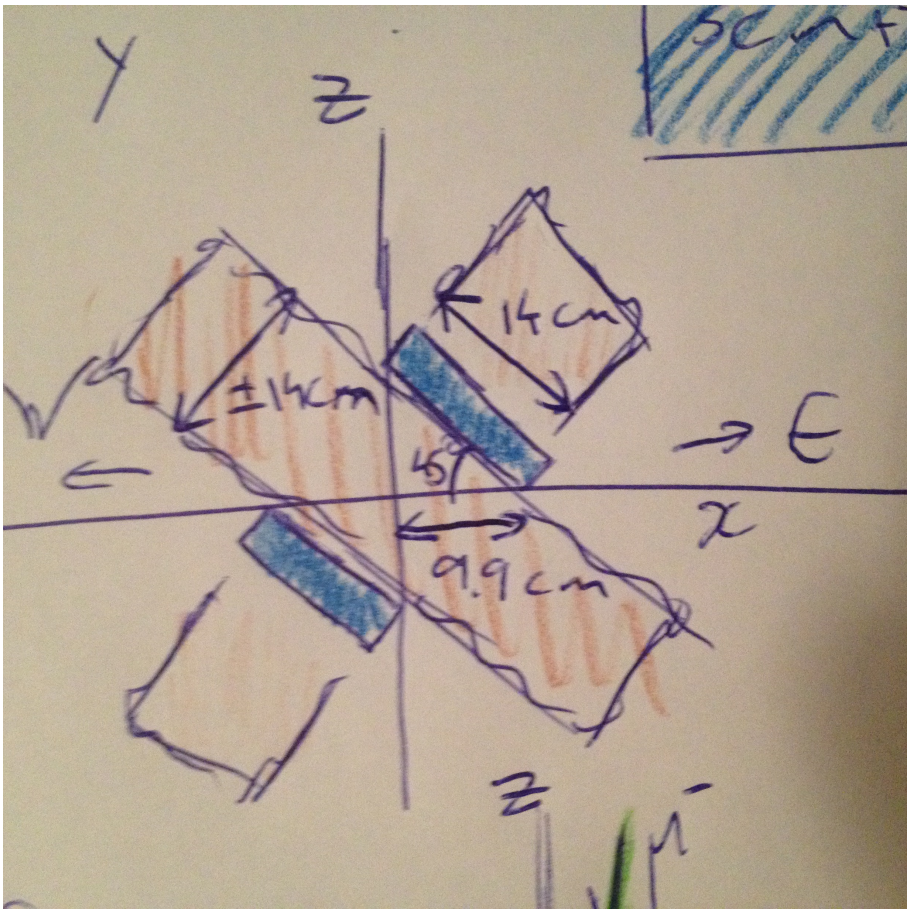
In this figure, the z-axis is oriented vertically, while the x- and y-axis are horizontaly oriented. In this figure, the positive x-axis points towards the East, and the positive y-axis points towards the north. The scintilator plates and concrete tiles are positioned at an angle of 45 degrees with respect to the horizon.

The muons will be detected by four scintillator plates. The four scintilator plates are combined to two pairs, both sandwiching a concrete tile. Wood will be attached to the sides to hold the structure in place. The concrete tile will stop electrons and other (background) particles, while muons will still be able to transverse both scintilator plates.

When a muon transverses a scintilator plate, it will produce light, which will be detected by a PMT attached to the plate. In case of a muon, two coincident signals can be expected from both plates in a scintillator-pair. The number of detected coincidences will give a measure for the number of muons transversing the scintillator-pair.



The asymetry in the flux in the east-west direction will be sampled by comparing the number of coincidences from both scintilator pairs. With placing the edges of the scintilator plates on the vertical (z-) axis and horizontal (x-) axis, the full zenith range of the incident muon is samled, thus providing maximum statistics. The corresponding dimensions are drawn in the following figure (please note that the thickness of the concrete tile is not neccesarily 14 cm, only preferably):



In order to avoid a large influence of neighbouring structures, the complete detector will be covered in plastic garbage-bags (to prevent it from rain), and placed on the roof of the Nikhef building.

By turning the setup (presented above in the E-W orientation) in the azimuth by 90 degrees (N-S orientation) and 180 degrees (the W-E orientation) instrumentational errors can be compensated and systematic errors can be estimated. A preliminary time-schedule of the data-taking is given below:

Orientation	Day+time start	Day+time end
E-W	Tue, 10:00	Tue 19:30
W-E	Tue 19:30	Wed 08:00
E-W	Wed 08:00	Wed 11:00
N-S	Wed 11:00	$\rightarrow$