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UPGRADE OF THE SOUTHERN SPACE OBSERVATORY'S MULTIDIRECIONAL MUONS DETECTOR TELESCOPE

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ABSTRACT

The utilization of high-energy cosmic rays (muons) detector have been showed to be an useful tool for Space Weather and forecasting of interplanetary structures that can produce geomagnetic storms. Since March 2001, a prototype was installed in Southern Space Observatory (SSO/CRSPE/INPE – MCT), in Sao Martinho da Serra, Brazil like part of an international high-energy cosmic rays detector network, with detectors in Nagoya (Japan) and Hobart (Australia). The objective of the current project is to discus the detector's ampliation and the use of its data, showing preliminary studies of cosmic ray response to geomagnetic storms. Data from plasma and interplanetary magnetic field are also used. With the ampliation of the 2x2 prototype to a 4x9 telescope, it is expected that it may be possible to increase the forecasting accuracy of geomagnetic storms and, in this way, to avoid damages to aerospace the telecommunications equipment. The current work showed itself a very good opportunity for formation of knowledge related to Space Weather, physics of interplanetary medium, cosmic rays and aerospace instrumentation.

INTRODUCTION

It has been showed that ground-based cosmic rays (muons) detectors can be used as a tool for Space Weather forecasting, through the observation of cosmic-ray precursors [Munakata et al., 2000]. As part of an international high-energy cosmic rays detector network, a prototype telescope was installed in Southern Space Observatory (SSO/CRSPE/INPE - MCT), at geomagnetic coordinates (19º 13' 48''S and 16º30'E), in São Martinho da Serra (south of Brazil). It has been operating since March 2001 and during 2005 an updated to a larger telescope has started.

OBJECTIVE

We discuss the upgrade of the multidirecional cosmic rays (muons) detector, showing the differences between the prototype and extended telescope. We also describe and analyze the response of high-energy cosmic rays to interplanetary structures related to great geomagnetic storms in order to compare, in future works, with data from the extended telescope.

THE PROTOTYPE MULTIDIRECIONAL MUONS DETECTOR

The prototype detector was formed by 2 layers, each one with 4 detectors disposed in a square form and aligned with the south-north direction, and between them a lead layer with 5 centimeters that shield particles with less energy than muons. The coincidence of counts between a detector in upper layer and another in lower layer give the count rate of muons in a defined direction. This prototype has nine directional telescopes: V (vertical), 30º S (south), 30º N (north), 30º W (west), 30º E (East), 39º NE, 39º SE, 39º NW and 39º SW.

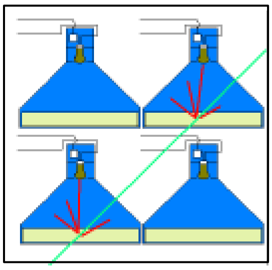

FIGURE 1 – An esquematic vision in vertical flat of the prototype muons detector showing the arrival direction of one muon in scintillation material and its detection by a photomultiplier.

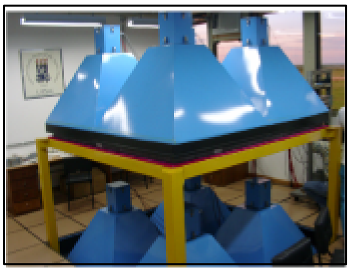

FIGURE 2 - A photography of the prototype muons detector during May 2005 showing the eight detectors in the observation room.

THE EXTENDED MULTIDIRECIONAL MUONS DETECTOR

The extended telescope will have 2 layers of 36 detectors each one, 5 aligned with south-north direction and 8 aligned with west-east direction. Between the layers, there will have a 5 centimeter lead layer. The direction components are: V (vertical), 30º S (south), 30º N (north), 30º W (west), 30º E (East), 39º NE, 39º SE, 39º NW, 39º SW, 49º S (south), 49º N (north), 49º W (west), 49º E (East), 64º S (south), 64º N (north), 64º W (west) and 64º E (East). The coverage will increase to regions like Atlantic Ocean, some Africa's regions.

FIGURE 3 - A photography of part from the extended multidirecional muons detector under construction during November 2005. It shows the upper layer, the lower layer and between them a 5 centimeter lead layer.

DATA ANALYSIS

We used the count rate from the vertical telescope from the SSO's detector in periods with occurence of intense geomagnetic storms To identify geomagnetic storms, we used the Dst index. To identify interplanetary magnetic structures, we use data from the instruments MAG (magnetometer) and SWEPAM (Solar Wind Electron Proton Alpha Monitor) on board the ACE (Advanced Composition Explorer) satellite, orbiting the lagrangean point L1. We show the count rate of muons in a relative rate given by the expression:

$$\text{Count}(\%) = \left(\frac{\text{count(part/h)} - \text{annual average}}{\text{annual average}} \right) \times 100$$

RESULTS

We analyze the prototype telescope's response during two intense geomagnetic storms in the period from November 5th 2004 to November 12th 2004. We found a decrease rate ~2% in first storm with a minimun Dst index of -373 nT and for the second storm a decrease rate of more than 4% with a minimun Dst index of -289 nT.

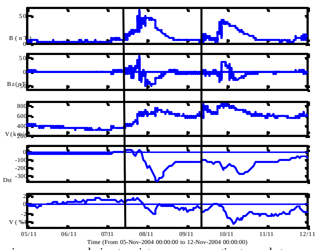

FIGURE 04 – Cosmic ray response during two intense geomagnetic storms between November 5th 2005 and November 12th 2005. The vertical lines show the SSC. There are a gap on cosmic-ray data in first day showed above. The magnetic and plasma parameters show a presence of an interplanetary structure that cause the muons count rate decrease.

CONCLUSION AND COMMENTS

Both decrease rates of muons are caused by interplanetary structures that hit the Earth`s magnetic field causing geomagnetic storms. The ampliation will allow a increase on coverage area and, in this way, a major count rate in each directional telescopes and more accuracy in decrease rates of muons caused in periods with intense geomagnetic storms. The increase in the number of directional telescopes will allow a continuous coverage in sunward IMF direction (best coverage) and reduce "poor coverage" events (PC) like showed by K. Munakata and coworkers [Munakata et. al., 2000].

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