Upgrade of the Brazilian Southern Space Observatory Multidirectional Muon Detector


dallago@dge.inpe.br

Abstract: A multilateral collaborative effort was carried out to upgrade the Multidirectional Muon Detector (MMD) installed at the Brazilian Southern Space Observatory (SSO/INPE), located at São Martinho da Serra (SMS), (Latitude 29°26′24″S, Longitude 53°48′38″W, 492m above sea level), south of Brazil. An increase detection area was possible with the addition of two layers of 4 m² each. The current configuration of the instrument is 2 layers of 4 × 8 m². The MMD is part of the Global Muon Detector Network (GMDN), which is composed by four detectors: Nagoya, Sao Martinho da Serra, Hobart and Kuwait. The MMD increases the detection area to 28 m².

Key words: muon detector, GMDN, space weather

1 Introduction

Since 1992, an international muon detector network has been established, with detectors in Nagoya (Japan) and Hobart (Australia), with detection areas of 36 m² and 9 m², respectively. In order to fill an observation gap over the Atlantic Ocean and Europe ([1]), a prototype muon detector was installed in São Martinho da Serra (SMS), Brazil, in 2001. The initial configuration of the instrument was 2 layers of 4 m² each ([2]). In 2005, an expansion of the SMS detector took place, increasing the detection area from 4 m² to 28 m².

With the addition of a fourth detector in Kuwait in 2006, the Global Muon Detector Network (GMDN) was established ([3]). A second upgrade in the SMS detector was possible in July 2012. The current configuration of the instrument is 2 layers of 4 × 8 m² (32 m²). The upgrade was sponsored by Shinshu University, Australian Antarctic Division, the Brazilian CNPq funding agency, the National Institute for Space Research (INPE) and its Space Geophysics Graduate Program. We present a status report of the current SMS Multidirectional Muon Detector in operation at the SSO, Brazil. Some preliminary observations after the upgrade are presented.

2 Upgrade

In order to derive the cosmic ray streaming from the GMDN observations, a least-square best-fit calculation is necessary. In the calculation, some parameters are derived, including the amplitude and orientation of the streaming. The SMS detector optimum detection area is the same as its conjugate detector in Nagoya (36 m²), in order to diminish best fitting bias. After the last upgrade, the area of the SMS detector became only ~11% smaller than the area of the Nagoya detector. A final upgrade is planned for the near future, with the inclusion of 2 layers of 4 m².

3 Current status of the SMS detector

The SMS multidirectional muon detector has been upgraded to a configuration of 2 layers of 4 × 8 m² (32 m²) in July 2012. Figure 1 shows a picture of the upper layer of the upgraded instrument.

The detector has 17 directional channels, which combine simultaneous detections on the upper and lower layers. Table 1 presents the hourly count rates and estimated errors for the 17 directional channels before and after the upgrade.
An increase detection area of the Multidirectional Muon Detector (MMD) installed at the Brazilian Southern Space Observatory (SSO/INPE), Brazil, with the addition of two layers of $4 \text{m}^2$ each was done. The current configuration of the instrument is 2 layers of $1 \times 1 \text{m}^2$, $2 \times 1 \text{m}^2$, and $4 \times 1 \text{m}^2$. The purpose of the upgrade is to improve the estimation of the cosmic ray streaming derived from the GMDN observations. Participated in this upgrade the following institutions: Shinshu University, Australian Antarctic Division, Brazilian CNPq funding agency, the National Institute for Space Research (INPE) and its Space Geophysics Graduate Program. Pre-upgraded SMS multidirectional muon detector. These observations from the SMS detector are preliminary (not pressure or temperature corrected). In the figure it is possible to identify an interplanetary shock on November 12th, at 22:08 UT. Behind this shock, an ICME-magnetic cloud is present. This event was a source of relatively intense out-of-the-ecliptic interplanetary magnetic field, and it was responsible for an intense geomagnetic storm, with peak Disturbance Storm time index Dst = -108nT. On November 13th, a decrease in the count rate of the SMS vertical channel is possible related to the passage of this interplanetary event through the earth.

5 Summary

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References

Figure 2: From top to bottom: the interplanetary magnetic field (B), its z component (Bz), proton speed (Vp), proton temperature (T\(p\)), measured by the ACE satellite. Bottom panel: percentage variation of the vertical (V) channel of the upgraded SMS multidirectional muon detector (not pressure or temperature corrected).