

Space weather forecasting - a multi directional telescope for detection of high energy cosmic rays - muons - Southern Space Observatory - Brazil

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ABSTRACT

A multi-directional telescope for detection of high-energy galactic cosmic rays (GCRs) - muons was installed in 2001, through an international cooperation between Brazil, Japan and USA, and operated since then at the Southern Space Observatory - SSO/CRS/INPE - MCT, (29S, 53W), Sao Martinho da Serra, RS, in the south of Brazil. The telescope capability and sensitivity were upgraded in 2005. The observations conducted by this telescope are used for forecasting the arrival of the geomagnetic storm and their interplanetary coronal mass ejection (ICME) drivers in the near-earth geospace. The telescope measures high-energy GCRs by detecting secondary muons produced from the hadronic interactions of primary GCRs (mostly protons) with atmospheric nuclei. Since muons have a relatively long life-time (about 2.2 microseconds for muons at rest) and can reach the detector at ground level preserving the incident direction of primary particles, the telescope can measure the GCRs intensity in various directions with a multidirectional detector at a single location, such as in Brazil. ICMEs accompanied by a strong shock often forms a GCR depleted region behind the shock - this abrupt decrease of the GCR density (i.e. the isotropic intensity), is known as a Forbush decrease, which is a region of suppressed cosmic ray density located downstream of an ICME shock. The ICME arrival also causes a systematic variation in the GCR streaming (i.e. the directional anisotropy of intensity). The magnitude of the streaming is small (about 1 % or less), but its variation is relevant. Some particles from this suppressed density region traveling with about the speed of light leak into the upstream region, much faster than the approaching shock, creating the possibility of being observed, at earth's surface, by a network of ground based multi-directional telescopes, as a precursory loss-cone anisotropy ahead of the upstream region. Loss-cones

are typically visible 4-10 hours ahead of shock arrival for shocks associated with major geomagnetic storms. The Brazilian muon telescope, at SSO, is part of a global network on an international collaboration, consisting of 10 institutions from 7 countries. ICMEs traveling in interplanetary space and reaching the Earth - cause reduction in cosmic ray counts at the earths surface by one to ten percent, and can be detected sometimes as much as ten hours before their arrival at Earth - with the global network of muon detectors developed at Shinshu University, Japan, thus permitting accurate and reliable Space Weather forecasting.

Keywords: cosmic rays, Muon telescope, solar-terrestrial interactions, space weather, geomagnetic storms.

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