Space weather diagnosis using cosmic rays: observation with a global network of cosmic ray muon detectors

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The galactic cosmic ray (GCR) intensity often shows a dramatic variation responding to the arrival of the interplanetary disturbances at the Earth. For instance, the Interplanetary Coronal Mass Ejections (ICME) accompanied by strong shock often forms a GCR depleted region behind the shock. The abrupt decrease of GCR density (i.e. the isotropic intensity), known as Forbush Decrease (FD), is recorded by ground-based detectors when the Earth enters the depleted region. In addition to the variation of GCR density, 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 (of the order of 1 % or less in most cases), but the variation is significant. Since the variation reflects the spatial gradient of the GCR density in the interplanetary magnetic field (IMF), the systematic variation of the streaming gives us important information on both the structures of the depleted region and the IMF.

Muon detectors measure high-energy GCRs by detecting secondary muons produced from the hadronic interactions of primary GCRs (mostly protons) with the atmospheric nuclei. Since muons have relatively long life-time (about 2.2 microsecond) and can reach the detector at the ground level preserving the incident direction of primary particles, we can measure the GCR intensity in various directions with a multidirectional detector at a single location. In March 2001, we constructed a prototype network of multidirectional detectors by installing a small detector in Brazil in addition to other two in Japan and Australia. By March 2006, the prototype network was upgraded by expanding the Brazilian detector in its size and also by putting an additional detector in operation at Kuwait City in Kuwait. This new global network, currently consisting of four detectors at Nagoya (Japan), Hobart (Australia), Sao Martinho (Brazil) and Kuwait City (Kuwait), can continuously monitor the GCR intensity in total 60 directional channels covering almost entire sky and can precisely measure the variation of the GCR streaming separately from the variation of the GCR density. In this paper, we summarize results derived from the observation using a prototype network and also report the initial performances of the new global network.