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Tracking cosmic-ray spectral variations during 2007-2018 using neutron monitor time-delay measurements

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Neutron monitors usually measure the flux of cosmic rays above a geomagnetic cutoff rigidity (momentum per charge). Recently, we have developed a new capability to also study the momentum (or energy) distribution of cosmic rays. Here we use time-delay histograms collected at the Princess Sirindhorn Neutron Monitor (PSNM), Thailand, which has the world's highest vertical cutoff rigidity for a fixed station (16.8 GV), and the South Pole neutron monitor with a low geomagnetic cutoff rigidity (near 0 GV). We present measurements of the leader fraction L of neutron monitor counts that did not follow other counts in the same counter tube from the same cosmic ray shower. Variations in the cosmic-ray spectrum can be precisely indicated by changes in L. PSNM started to collect time-delay histograms in Dec 2007 and the South Pole station started in Nov 2013. The electronics have been upgraded during our measurement period, and we have corrected for such changes to develop a long-term leader fraction dataset. In addition, environmental effects from the atmosphere including pressure and water vapor have been corrected. Our procedure extends precise tracking of solar modulation of the galactic cosmic ray flux to higher energies, above 17 GeV. We find that L varied with the sunspot cycle, and a hysteresis between L and the count rate implies a change in the shape of the cosmic ray spectrum due to solar modulation from before to after the solar magnetic polarity reversals of 2012-2014. Up until early 2014, solar modulation extended to energies well above the Doi Inthanon cutoff, but afterwards it extended only shortly above the cutoff. Measurements of L from the South Pole are particularly precise and will allow detailed studies of spectral variation of cosmic rays during Forbush decreases due to solar storms and over 27-day variations due to the Sun's rotation. Partially supported by Grant RTA5980003 from the Thailand Research Fund.

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