Precursors of the forbush decrease on December 14, 2006 observed with the Global Muon Detector Network (GMDN)

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We analyze the precursory anisotropy of a Forbush decrease observed with the multidirectional muon detector at Sao Martinho in Brazil on December 14, 2006. By subtracting contribution from the diurnal anisotropy precisely determined by the Global Muon Detector Network (GMDN), we succeed in extracting clear signatures of the precursor. The precursor first appeared ten hours prior to the onset of the Storm Sudden Commencement (SSC) as an increase of muon rate at the pitch angle of ˜60 degree around the IMF. This increase is consistent with the measurement of galactic cosmic rays reflected and accelerated by an interplanetary shock approaching toward the Earth with a radial speed of ˜1160 km/sec. This intensity increase is observed for four hours and then followed by an intensity deficit known as a loss cone (LC) around ˜0 degree pitch angle during the next four hours before the SSC onset. Weak signature of LC is also observed with Sao Martinho one day earlier on December 13, at the similar local time as December 14. This suggests that the LC appeared only 6.6 hours after the CME eruption on the sun, when the interplanetary shock was expected to be located 0.2 AU from the sun.