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Gamma-Ray and Neutron Monitor Observations of the 2017 September 10 Solar Eruptive Event

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In early September 2017, during solar minimum, Active Region 12673 produced 26 M-class and four X-class flares. Gamma-ray emission >100 MeV was observed by the Fermi Large Area Telescope (LAT) for several hours following the X8.2 flare that began at 15:35 UT on September 10 when the active region was at or beyond the solar limb. It was associated with an ~1700 km/s coronal mass ejection (CME) and a high-energy solar energetic particle event observed in space and by neutron monitors. There appear to be three distinct phases of >100 MeV gamma-ray emission, each with energy spectra consistent with the decay of neutral and charged pions produced by protons above a few hundred MeV. The early part of the first >100 MeV phase began at about 15:56 UT, about one minute after the onset of the CME, and followed the time history of the impulsive flare phase as observed in hard X-rays and nuclear de-excitation line gamma rays that lasted until about 16:05 UT.mThe second phase of the >100 MeV gamma-ray emission began at 15:58 UT and peaked two minutes later at the highest solar flux level ever recorded by LAT. This emission was observed until about 16:08UT when the slow onset of the third >100 MeV phase, lasting about 10 hours, became dominant. This is the same time when Type II radio emission, indicating the presence of a shock, was observed. These latter two phases of >100 MeV emission were not detected in hard X-rays and nuclear deexcitation line gamma-rays observed by RHESSI and GBM. We discuss our spectral and temporal analyses of these three phases of >100 MeV gamma-ray emission and their possible origins. We also compare these observations with the Fort Smith neutron monitor measurements early in the Ground Level Event to determine whether protons producing the first two phases of gamma-ray emission (GLE) were also released into interplanetary space. This work was in part supported by Thailand Research Fundgrant RTA5980003.

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