

Observations of high-energy gamma rays from winter thunderclouds on the Sea of Japan (2)

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Recently, gamma-ray detections have been reported from natural lightning and lightning triggering experiments. These results suggest that electrons are accelerated to relativistic velocities in the electric fields of thunder clouds and/or lightning discharges, and then emit bremsstrahlung gamma-rays. Some of these events have been observed by the monitoring posts in nuclear power plants along the coast of Japan. Ionization chambers and NaI scintillators

of these posts recorded short (shorter than 30 sec) intense bursts, and dose increases for a minute or two, both associated with winter thunder clouds. However, little is known about the types of radiations, detailed time variations, and energy spectra of these phenomena.

In order to investigate these phenomena in more detail, we designed and manufactured two complementary types of detectors. One has coarse directional sensitivity toward the zenith direction, and the other in contrast has an isotropic sensitivity. We set up these detectors in the Kashiwasaki-kariwa nuclear power plant in 2007 December, and started the observation (GROWTH Collaboration, or Gamma-Ray Observation

of Winter Thunderclouds Collaboration). In our operation through two winters, we have detected at least two radiation enhancement events,

which can be both explained as the arrival of energetic gamma-rays. Here we report the detailed analysis of these gamma-ray events from winter thunderclouds.

The first event was observed on 2007 January 7 (JST), when two big low-pressure systems combined into huge one above the Sea of Japan. The gamma-ray event lasted for ~40 second, and the burst spectrum extends up to 10 MeV. The gamma-rays have been interpreted as bremsstrahlung photons from energetic electrons, which are accelerated in thunderclouds (Japan Geographical Union, T.Enoto et al., 2007).

The second event was detected with our two independent instruments on 2007 December 14 (JST), when the wintry atmospheric pressure system appeared above the Sea of Japan line in the first event. This event lasted for ~70 second, and the spectrum extended up to ~10 MeV line in the first one. These ground-based observations provides the clear evidence that electrons are accelerated to the relativistic energies in the strong electric fields of thunderclouds.