Observations of high-energy gamma rays from winter thuderclouds on the Sea of Japan (1)

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Intense electric fields associated with thunderclouds and lightning are considered to accelerate charged particles to relativistic energies, which in turn will produce Bremsstrahlung photons. Thus, detailed investigation of such photons is expected to provide a valuable key to the particle acceleration process in strong electric fields.

Actually, near Earth satellites have detected terrestrial gamma-ray flashes from Earth's upper atmosphere, which have been interpreted as arising from high-altitude electrical discharges above thunderstorms. In addition, ground-based observatories have also detected similar energetic-photon bursts from natural and rocket-triggered lightning, revealing that the bursts are mostly associated with lightning discharge processes, especially so-called stepped leader stages. These bursts including the terrestrial gamma-ray flashes are found to have typical duration of millisecond or less and the photon spectra occasionally extend to 10 - 20 MeV.

In addition to those short-duration bursts, more prolonged radiation from thunder activity, lasting for a few tens seconds to minutes, have been observed by other ground-based detectors. In particular, radiation-monitoring posts, arranged in nuclear power plants in the coastal area of Sea of Japan, have frequently detected such prolonged events on the occasion of winter thunderstorms. However, compared with the short-duration events, the longer-duration ones have remained much less understood, because of inadequate information on, e.g., the particle species, their arrival direction and energy spectrum.

To investigate the particle acceleration mechanism in strong electric fileds, an automated radiation detector system, newly developed by our GROWTH collaboration, has been installed and successfully operated since 2006 Dec in Kashiwazaki-Kariwa power plant along the Sea of Japan, where thunder activity is very high in winter. Using the system, we actually detected an intense burst of gamma rays from thunderclouds at early morning of 2007 Jan 7 (JST). The emission, lasting for aorund 40 seconds, preceded lightning discharges. The burst spectrum clearly extends up to 10 MeV. These results reveal that electrons were continuously accelerated in thundercloud-electric fileds, prior to lightning discharges, to energies beyond 10 MeV.

Showing our scientific motivation and instruments used in Kashiwazaki-Kariwa power plant, we will make a brief report on two-years observations including new ones.Then, a brief discussion on how long-duration bursts are produced in thunderclouds is given in this talk. More detailed analyses and discussion are given in another talk.