High precision spectroscopic observation of gamma rays from thundercloud

T.Kanda, S.Ogasawara, K.Yamamoto, J.Kataoka (Waseda University), M.Tsurumi, T.Enoto (Kyoto University)

Thunderclouds are known to emit minute-long gamma-ray bursts, commonly referred to as gamma-ray glows. These emissions are believed to originate from bremsstrahlung produced by high-energy electrons accelerated within the clouds. We conducted winter lightning observations in a mountainous area of Niigata, Japan, where thunderclouds are easily observable. Our detection system comprises various scintillation detectors, including BGO, CsI(Tl), SrI_2 (Eu), and a high-purity germanium (HPGe) detector, to search for line gamma-ray emissions such as nuclear gamma rays and pair annihilation lines (511 keV). On December 24, 2024, we observed a gamma-ray glow event lasting approximately three minutes. Radar data indicated the presence of rain clouds over the observation site during this period. Each detector recorded an increase in gamma-ray count rates. In addition to the enhancement of continuum emissions, we detected tentative line emissions between 200 and 600 keV. Although the event was relatively weak as a gamma-ray glow, the presence of line-like features suggests that future, more intense events may reveal clearer spectral structures.

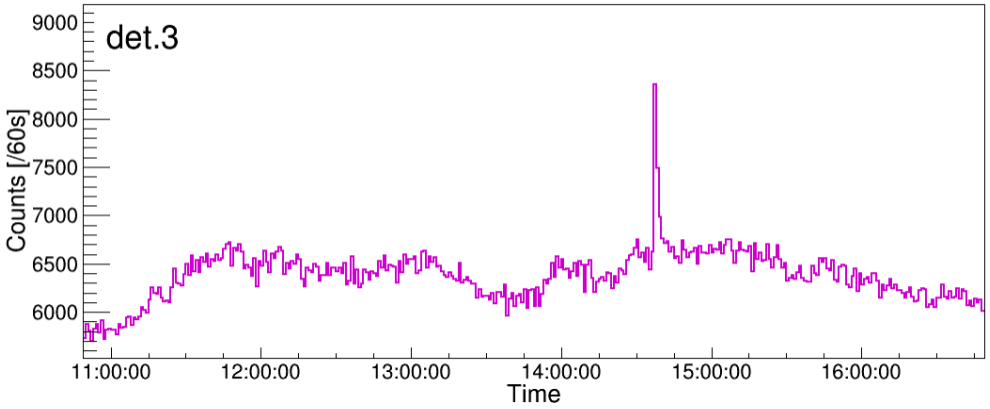

fig 1. Count rate recorded by the HPGe detector. The vertical axis shows the number of counts per 60 seconds, and the horizontal axis indicates time in JST.

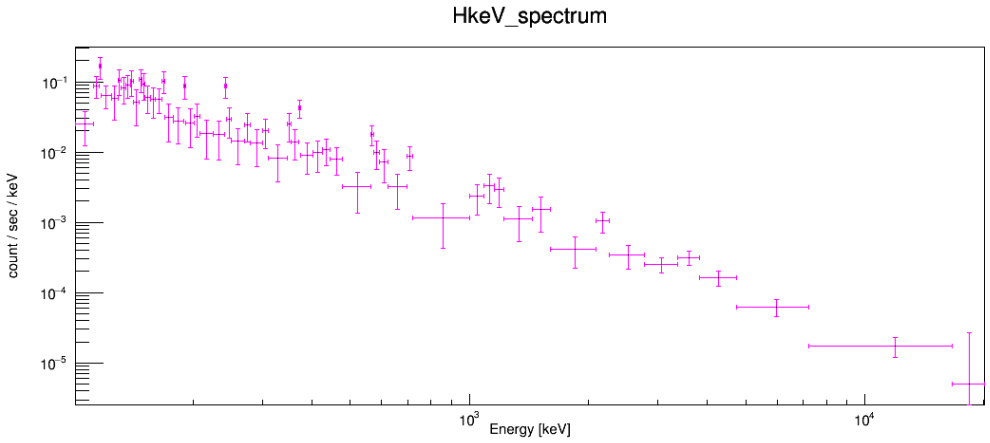

fig 2. Energy spectrum detected by the HPGe detector during the peak interval (14:36:00-14:39:00). The background has been subtracted, and binning was applied to ensure sufficient counts per bin.

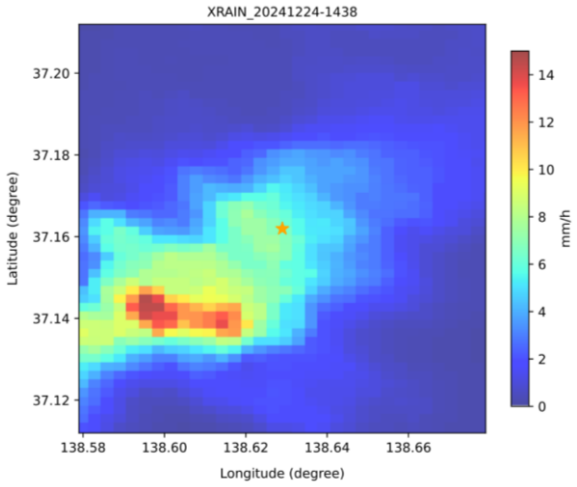

fig 3. Radar image of the rain cloud at 14:38 JST. The star at the center marks the observation site.