# 論文の内容の要旨

# Study of the Emission of Gamma-ray Bursts above 10 GeV with the Standard and Newly Recovered Data of the Fermi-LAT
# （フェルミガンマ線宇宙望遠鏡の標準データと新たに回復したデータによるガンマ線バーストからの１０ＧｅＶ以上の放射に関する研究）

高橋　光成

Gamma-ray bursts (GRBs) are the most energetic explosions in the Universe. They are cosmologically distant, and each of them releases a huge amount of energy in keV - MeV gamma-rays within a short period. Such "prompt" emission is followed by gradually decaying broadband "afterglow". The GRB emission is radiated by relativistic jets. Their progenitors, engines, mechanisms of jet acceleration and electromagnetic wave radiations are being debated. The afterglow emission is basically well explained by synchrotron radiation from fluid shocked by collisions between the jets and external medium. However, the Energetic Gamma Ray Experiment Telescope detected a 18 GeV photon, and the *Fermi* Large Area Telescope has detected many afterglow photons with energy from tens of GeV up to 95 GeV in these ten years. Such energy is challenging for a popular combination of the fireball jet acceleration and synchrotron radiation from the external shocks and may require another component such as inverse-Compton scattering. Identifying the responsible emission process in this energy range is important for revealing the central engine and energy dissipation process which causes the bursts.

In the energy range above $\sim 10$ GeV, the sensitivity of the telescope is limited by the signal statistics. I developed novel photon classes of the *Fermi* Large Area Telescope in order to recover untapped events with energy above 20 GeV. Multivariate analysis for rejecting cosmic-ray backgrounds was optimized, and an increase of about 70% in the signal acceptance around the peak energy, $\sim 100$ GeV, was achieved according to Monte Carlo simulation. In these classes, four candidates of photons correlated to gamma-ray bursts were found. The observed energy of an event correlated to GRB 090926A at $\sim 4.2 \times 10^2$ s after the trigger is 50 GeV. The redshift-corrected energy is 157 GeV. The observed energy of an event correlated to GRB 150902A at $\sim 2.1$ ks after the trigger is 84 GeV, and the redshift is unknown. Two

new events correlate to GRB 160509A at $\sim 2.1$ ks and at $\sim 5.8$ ks after the trigger. The observed and redshift-corrected energy is 116 GeV and 252 GeV, respectively, for the first event and 63 GeV and 137 GeV, respectively, for the second event. These events arrived much later than the end of the prompt phase, which is $\sim 16$ s and $\sim 3.8 \times 10^2$ s after the trigger for GRB 090926A and for GRB 160509A, respectively. Here, the prompt and afterglow mean the periods before and after the time at which 95% of the total fluence has been detected in 10 keV − 1 MeV. Regarding the redshift-corrected energy, the highest energy event ever detected was a 144-GeV event from GRB 080916C in the prompt phase and a 127-GeV event from GRB 130427A in the afterglow phase. The GRB-frame energy of all the three redshift-known events is higher than that of GRB afterglow photons ever detected by any instruments although the background probabilities are not negligible, from 0.02% to 7%. These values exceed the synchrotron energy limit; otherwise, the energy injection to the external shocks might continue much longer than the observed prompt emission.

I also performed likelihood analysis focusing on the afterglows of the two GRBs. Reproducing their temporal and spectral features with synchrotron emission alone requires the loss of the energy of the shocked fluid dominated by radiation and a strong magnetic field. The simplest description for these afterglows is the synchrotron self-Compton emission from the external shocks although potential contributions of prompt components, late-time energy injection and flares cannot be excluded. If this synchrotron self-Compton interpretation is correct, detection of GRBs by Cherenkov Telescope Array in the near future is quite promising. Detailed light curves with little statistical uncertainty will enable us to differentiate effects of the long-term activities of the central engines and the external shock afterglows.