# A New Project to Detect GRBs with E > 30 GeV at Mt. Chacaltaya

Shoichi Ogio, Keita Yamada, Fumio Kakimoto and BASJE collaboration*
*Department of Physics, Tokyo Institute of Technology, Meguro, Tokyo, 152-8551, Japan*
**For the full listing, see S. Ogio et al., in these proceedings.*

## Abstract

BATSE revealed out that the gamma ray bursts, GRBs, are of extragalactic origins. Although several models are proposed to explain their production mechanism, we need to obtain more experimental information to get the final conclusion. Up to now GRBs are observed mainly with detectors boarded on spacecrafts and consequently at the limited energy range less than 10 GeV. So we plan to detect GRBs with E > 30 GeV at Mt. Chacaltaya of 5200 m a.s.l.. The result of our Monte Carlo simulations shows that at least one electron reaches at the level of Mt. Chacaltaya for air showers initiated by primary gamma rays with energies of 30 GeV and that the differences in arrival directions of the electrons and of the incident gamma rays are within 8 degrees.

In this project we measure arrival directions of air shower electrons with a scintillation detector array with an angular accuracy of 11 degrees. This array has two planes of 10 m × 10 m area, which are separated vertically by 1 m and each of which consists of 1000 plastic scintillator bars. The sensitivity of this detector for GRBs with E > 30 GeV is $5 \times 10^{-5}$ photons/cm$^2$s at $5\sigma$ significance level.

## 1. Introduction

GRBs are burst like gamma ray flashes from point sources with short durations(typically, $10^{-2}$–$10^{2}$ sec). The recent research of their afterglows revealed out that GRBs are located far from the Earth with cosmological distances[2]. So that the emitted total energies exceed $10^{52}$ ergs and GRB is expected to be one of the most energetic astronomical phenomena[3]. Even though more than 3000 GRBs were detected by BATSE(20keV–2 MeV) at a rate of about one per day, the astrophysical processes which involve GRBs are still unsolved.

The detections of GRBs in GeV–TeV range are most important for our understanding of the processes, and are expected to provide the information of burst parameters such as Lorentz factor, the plasma density and the magnetic field strength[1]. The maximum energy of the gamma rays from GRBs detected by the EGRET experiment is 18 GeV[4]. Among the ground based detectors, atmospheric Čerenkov telescopes have enough flux sensitivities to measure the

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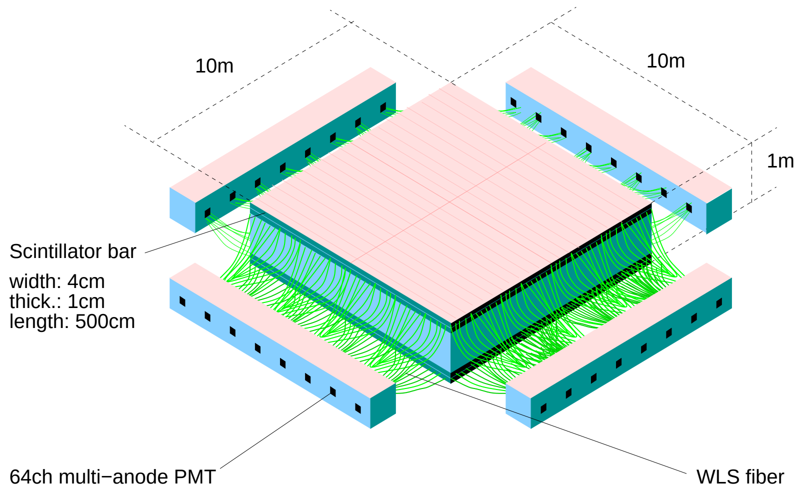


**Fig. 1.** A schematic view of the detector.

GeV–TeV gamma rays from the bursts, but their narrow field of view and short observation time limit the chance to detect GRB events. We proposed a ground based detector for GRBs with a low threshold energy and a wide field of view, and without a limitation of observation time.

## 2. Detector

The proposed detector contains two planes of scintillation counters to measure the tracks of secondary particles induced by primary gamma rays and charged particles. The proposed design of the detector is shown in Fig. 1. Each plane has two layers. Each layer consists of the 500 scintillator bars with wave length shifting fiber readout, and in total the detector has the 2000 readout channels. One scintillator bar has the volume of 4 cm(W) × 1 cm(D) × 5 m(L). Since the direction of the bar alignment in the upper layer is orthogonal to that in the lower one, the location of a hitting electron is measured with an accuracy of 4 cm × 4 cm. The separation of two planes is 1 m. Thus, taking account of the multiple scattering in the detector, the angular determination accuracy is 11° for electrons estimated with the Monte–Carlo simulations with GEANT 4. The outputs of the fiber readouts are fed to multi–anode PMTs. Event triggers are generated with a four–fold coincidence of the four layers, and the estimated coincidence rate for secondary particles is about 50 kHz.

With the Monte–Carlo simulations of the gamma ray induced air showers, we found that, on average, at least one electron( or positron ) with energies greater than 20 MeV reaches the ground at 5200 m a.s.l. for 30 GeV primary gamma rays. The threshold energy of 30 GeV gives the upper bound to the detectable GRB redshift $z$ because of the absorption of GRB emission by pair production

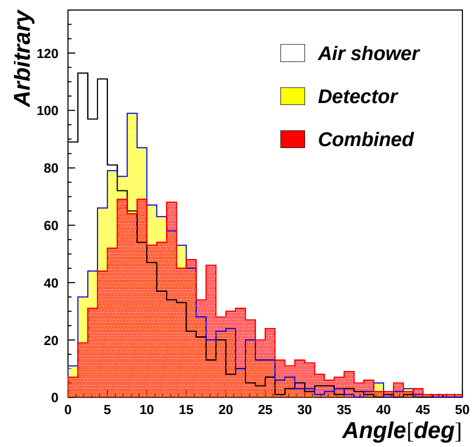


**Fig. 2.** The histograms show the simulated results of the secondary electron's angular distribution in air showers induced by primary gamma rays, the angular determination accuracy of the detector, and their combination.

with external infra–red background photons. We expect that the detector is possible to see GRBs up to $z = 2$. At this altitude, the standard deviation of secondary electron's angular distribution against the incident direction of primary gamma rays is 8°. Taking accounts of the angular determination accuracy of the detector, the secondary electrons are detected within the 15° opening angle around the direction of a GRB(Fig. 2). Thus, by our detector a GRB event will be recognized as an excess of particle counts above the background with a short duration coincidentally with both the time and the direction determined by satellite observations.

## 3. Expected Performance

The background particle rate at the altitude of 5200 m a.s.l. is about 500 Hz/m$^2$. When we assume the duration time of the bursts is a typical value, 50 sec, the lower limit of the observable GRB flux with 5 $\sigma$ excess is $5 \times 10^{-5}$ photons/cm$^2$s. In Fig. 3(left), this flux sensitivity is shown with the gamma ray flux in MeV–GeV region of GRBs observed by EGRET. It is shown that Some of the EGRET events have large enough fluxes to be observed with our instruments.

The field of view of our detector, which is limited by the number of secondary electrons and their energy distribution , increases with energy. Therefore, the effective acceptance of the detector increases with the energy as shown in Fig. 3(right). If we assume the observed MeV–GeV spectra are extended up to 100 GeV without any cutoff, the expected GRB events observed by our detector are one per year above 30 GeV, and four per year above 100 GeV.

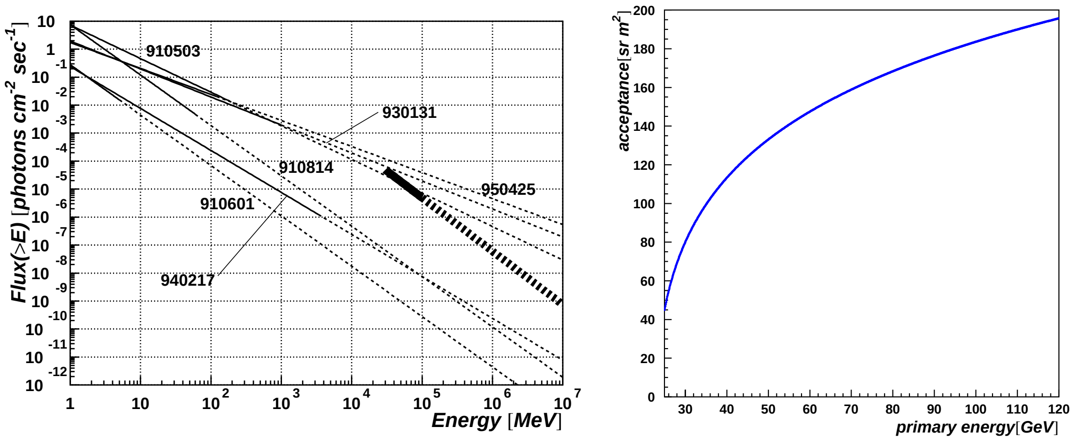


**Fig. 3.** *(left)*The bold solid line shows the sensitivity of the detector. The solid lines are the observed spectra by EGRET, and dashed line shows their extrapolations. *(right)*The calculated acceptance of the detector.

In this experiment, it is difficult to determine the primary energies of GRB photons since the number of secondary particles reached at the ground are not enough to determine the associated air shower sizes. However, we can distinguish their primary energies of 30–100 GeV range or more than 100 GeV, using the particle multiplicity in an air shower.

## 4. Summary and Conclusion

We are developing an ground–based detector for the GRB measurement. The detector will be installed at 5200 m a.s.l., so that we will archive the threshold energy of 30 GeV equivalent to the maximum detectable distance of $z = 2$. The detections of the GeV gamma rays from GRBs are important for our understandings of GRB phenomena, and give opportunities for testing theories of frequency dependent propagation of high energy photons, as predicted for quantum gravity.

## References

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