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Abstract. STACEE is an atmospheric Cherenkov telescope using the large mirror area of a solar research facility to obtain a low energy threshold. The telescope has a peak in the detected signal of a power-law gamma-ray spectrum near 100 GeV. The low energy threshold of STACEE allows detection of gamma rays from higher redshifts than most other ground-based experiments. The STACEE instrument can be re-targeted to the position of a GRB within a few minutes of an alert to search for emission above 50 GeV. So far, data have been acquired within a few hours of the burst for five GRB. We discuss the STACEE sensitivity to high energy gamma-ray emission from GRB and preliminary results of the observations.

THE STACEE TELESCOPE

STACEE uses the National Solar Thermal Test Facility (NSTTF) at Sandia National Laboratories outside Albuquerque, New Mexico, USA. The NSTTF is located at 34.96° N, 106.51° W and is 1700 m above sea level. The facility has 220 heliostat mirrors designed to track the sun across the sky, each with 37 m^2 area. STACEE uses 64 of these heliostats to collect Cherenkov light produced by cascades in the atmosphere.

STACEE employs five secondary mirrors on the solar tower to focus the Cherenkov light onto photomultiplier tube (PMT) cameras, as shown in Figure 1. The light from each heliostat is detected by a separate PMT and the waveform of the PMT signal is recorded by a flash ADC. A programmable digital delay and trigger system[1] selects showers for acquisition while eliminating most random coincidences of night sky background photons. Details about the STACEE instrument can be found in D. M Gingrich *et al*. [2], with additional information about an earlier phase of the device in D. S. Hanna *et al*. [3].

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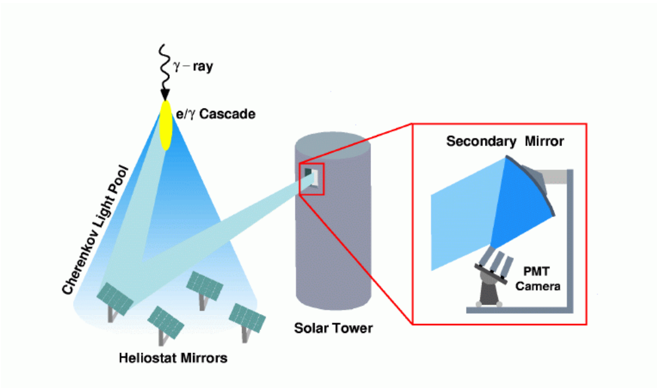

FIGURE 1. The STACEE technique. Cherenkov light produced in the atmosphere is reflected by the heliostat mirrors, which track the candidate source, to stationary secondary mirrors on the solar tower. The secondary mirrors focus the light from each heliostat onto a distinct PMT in the PMT camera.

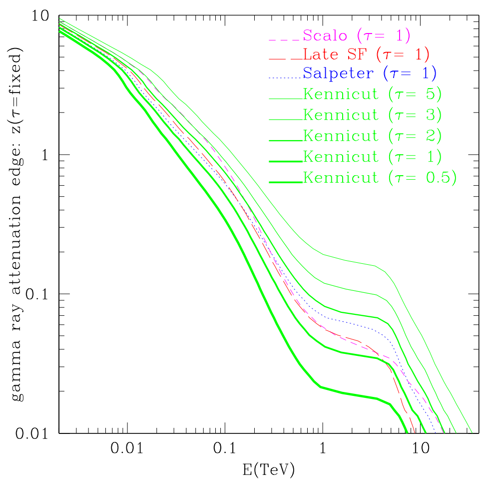

FIGURE 2. Expected gamma-ray horizon *vs*. energy, from [4] (see [5] for updated results). The curves show the redshift corresponding to a given level of extinction τ, as a function of energy. The different line styles correspond to different assumptions in the model. The family of solid lines all correspond to the same model, but different levels of extinction. As source distance increases, lower gamma-ray energies are required to evade absorption by the extragalactic background light (EBL).

STACEE PERFORMANCE

The large mirror area used by STACEE leads to an energy threshold – defined as the peak of a detected power law spectrum – around 100 GeV, with significant effective area as low as 50 GeV. This threshold is lower than most other current ground-based detectors. The low energy threshold opens up the possibility of detecting more distant sources, as shown in Figure 2. Collisions of high energy gamma rays with starlight photons to create electron-positron pairs attenuate the gamma-ray flux from more distant sources. The extinction becomes more severe with increasing energy, producing an energy-dependent horizon for gamma-ray observations.[1] STACEE has sensitivity in the energy range from 50 to 500 GeV. Energies above $\sim$20 GeV have been inaccessible to satellite measurements, because the gamma-ray flux of sources is too small, and until very recently other ground-based instruments have had thresholds of 300 GeV or higher.

The construction of the STACEE experiment is complete. However, analysis methods, including background rejection techniques, are under continued development. STACEE operates with a trigger rate of about 8 Hz and a trigger threshold around 4 photoelectrons per heliostat, enabling detection of some showers with energy as low as 50 GeV. Including the anticipated contributions from analysis methods under development, the STACEE performance can be summarized as follows:

- Angular resolution: 0.15°–0.18°
- Energy resolution: 25%–30%
- Effective area:
  - 4,000 m^2 at 100 GeV
  - 15,000 m^2 at 250 GeV
- Crab sensitivity (time for a 10σ detection):
  - Without background rejection, 25 hours
  - With background rejection, 4 hours

A summary of recent STACEE gamma-ray observations is given in J. Kildea *et al.* [6].

The STACEE sensitivity (5σ in a 30 minute observation) to a GRB will be about 2×10^{-9} cm^{-2} s^{-1} above 70 GeV. STACEE would easily detect the flux estimated by power-law extrapolations of the EGRET data. For example, the flux from GRB940217 [7] extrapolated to STACEE energies is $\sim$50 times higher than this sensitivity.

GRB OBSERVATIONS

Observing gamma-ray bursts is a high priority for STACEE. Since October 2001 the GCN burst alerts have been monitored with a computer program that alerts the STACEE operators if one is visible from the STACEE site. The STACEE instrument can be retargeted to the position of a GRB within a few minutes to search for emission above 50 GeV. We also search for afterglow emission from bursts that have occurred within the previous 12 hours. The computer network link to the STACEE site has occasional outages, which do not otherwise interfere with STACEE operations. To insure that burst alerts are not missed as a result of such an outage, we have also equipped the STACEE operators with a pager, which receives alerts directly from the GCN.

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[1] Primack presented improved calculations of the extinction at this meeting [5], which incorporate the latest data and give somewhat less extinction–and hence more distant horizons–than earlier work [4]. The results are still qualitatively similar to those shown in Figure 2.

TABLE 1. Summary of STACEE gamma-ray burst observations. The time between when the burst occurred and when the burst was within the STACEE field of view and the sky was dark (no Sun or Moon) is indicated by the STACEE delay. σ denotes the preliminary signficance in standard deviations of the excess events from the direction of the burst.

GRB	UTC Time	Satellite Providing Alert	Notice Delay (min)	STACEE Delay (min)	STACEE Observations	σ
021112	03:28:16	HETE	81	189	Starting 219 min after burst; 112 min on burst position	-0.6
030324	03:12:43	HETE	0.4	117	Starting 123 min after burst; 56 min on burst position	$+1.0$
030501A	03:10:19	INTEGRAL	0.3	276	Starting 369 min after burst; 28 min on burst position	-0.4
031220	03:29:57	HETE	228*	0	Starting 359 minutes after burst; 28 minutes on burst position	$+0.2$
040422	06:58:02	INTEGRAL	0.2	71	Starting 95 minutes after burst; 55 minutes on burst position	-1.9

* Earlier notices gave a location that was different by 0.5° or more

The ability of STACEE to observe the GRB source position within minutes of the first emission is very significant. EGRET detected GeV emission, including an 18 GeV photon, from GRB940217 up to ninety minutes after the start of the burst [7].

Since September 1, 2002, we have received notices containing a burst localization within 12 hours of the burst onset for about fifty GRBs. Of these, five were observable with STACEE and are summarized in Table 1. STACEE can only observe bursts within about 60° of zenith and when both the Sun and the Moon are below the horizon. The time after the burst until these three astronomical conditions were met is given in the table. Weather at the STACEE site may additionally hinder observing and accounts for additional delay to the start of observing burst 040422. The shortest delay from the burst onset for any of the obsesrvations is 95 minutes for GRB 040422. In a preliminary analysis of the data taken for these bursts, no evidence for delayed high-energy gamma-ray emission from any of the bursts is found. The significance of the excess at the burst position for each burst is given in the table.

STACEE IN THE SWIFT ERA

STACEE will continue to operate until the summer of 2006, at least. We expect to have rapid observations for about 2% of the bursts localized by the Swift satellite[8], or about 3 per year. Afterglow observations within the first 24 hours should be possible for an additional 10% of the bursts, about 15 per year. These numbers assume that the bursts are found isotropically on the sky. The number of Swift bursts visible to STACEE could increase by as much as a factor of two to the extent that the Swift field of view is aligned in the antisolar direction.

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