

# GRB Observations around 100 GeV with STACEE

B. Jarvis,<sup>a</sup> D.A. Williams,<sup>b</sup> J. Ball,<sup>a</sup> D. Bramel,<sup>c</sup> J. Carson,<sup>a</sup> C. E. Covault,<sup>d</sup>  
 D.D. Driscoll,<sup>d</sup> P. Fortin,<sup>e</sup> D. M. Gingrich,<sup>f,g</sup> D. Hanna,<sup>e</sup> J. Kildea,<sup>e</sup> T. Lindner,<sup>e</sup>  
 C. Mueller,<sup>e</sup> R. Mukherjee,<sup>c</sup> R. A. Ong,<sup>a</sup> K. Ragan,<sup>e</sup> R. A. Scalzo,<sup>h</sup> J. Zweerink<sup>a</sup>

<sup>a</sup> Department of Physics and Astronomy, University of California, Los Angeles, California, USA, 90025

<sup>b</sup> Santa Cruz Institute for Particle Physics, University of California, Santa Cruz, California, USA, 95064

<sup>c</sup> Department of Physics, Columbia University, New York, New York, USA, 10027

<sup>d</sup> Department of Physics, Case Western Reserve University, Cleveland, Ohio, USA, 44106

<sup>e</sup> Department of Physics, McGill University, Montreal, QC H3A 2T8, Canada

<sup>f</sup> Centre for Subatomic Research, University of Alberta, Edmonton, AB T6G 2N5, Canada

<sup>g</sup> TRIUMF, Vancouver, BC V6T 2A3, Canada

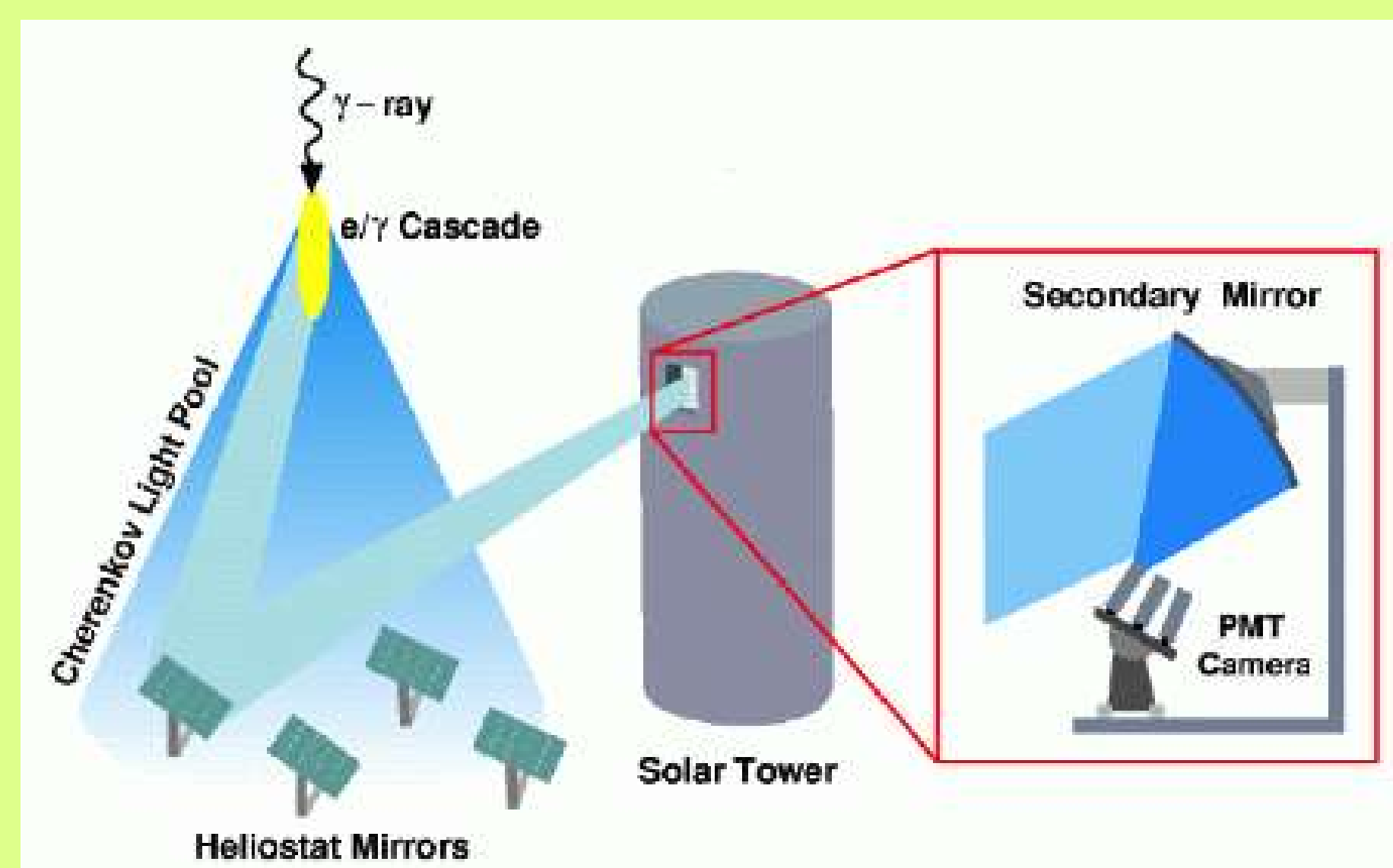
<sup>h</sup> Lawrence Berkeley National Laboratory, Berkeley, California, USA, 94720

Presenter: C.E. Covault (covault@case.edu), usa-covault-C-absi-og24-poster



## 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<sup>2</sup> area. STACEE uses 64 of these heliostats.



STACEE employs five secondary mirrors on the solar tower to focus the Cherenkov light produced by cascades in the atmosphere onto photomultiplier tube (PMT) cameras. The light from each heliostat is detected by a separate PMT and the waveform of the PMT signal is recorded by a Flash ADC[1].

## GRB Observations

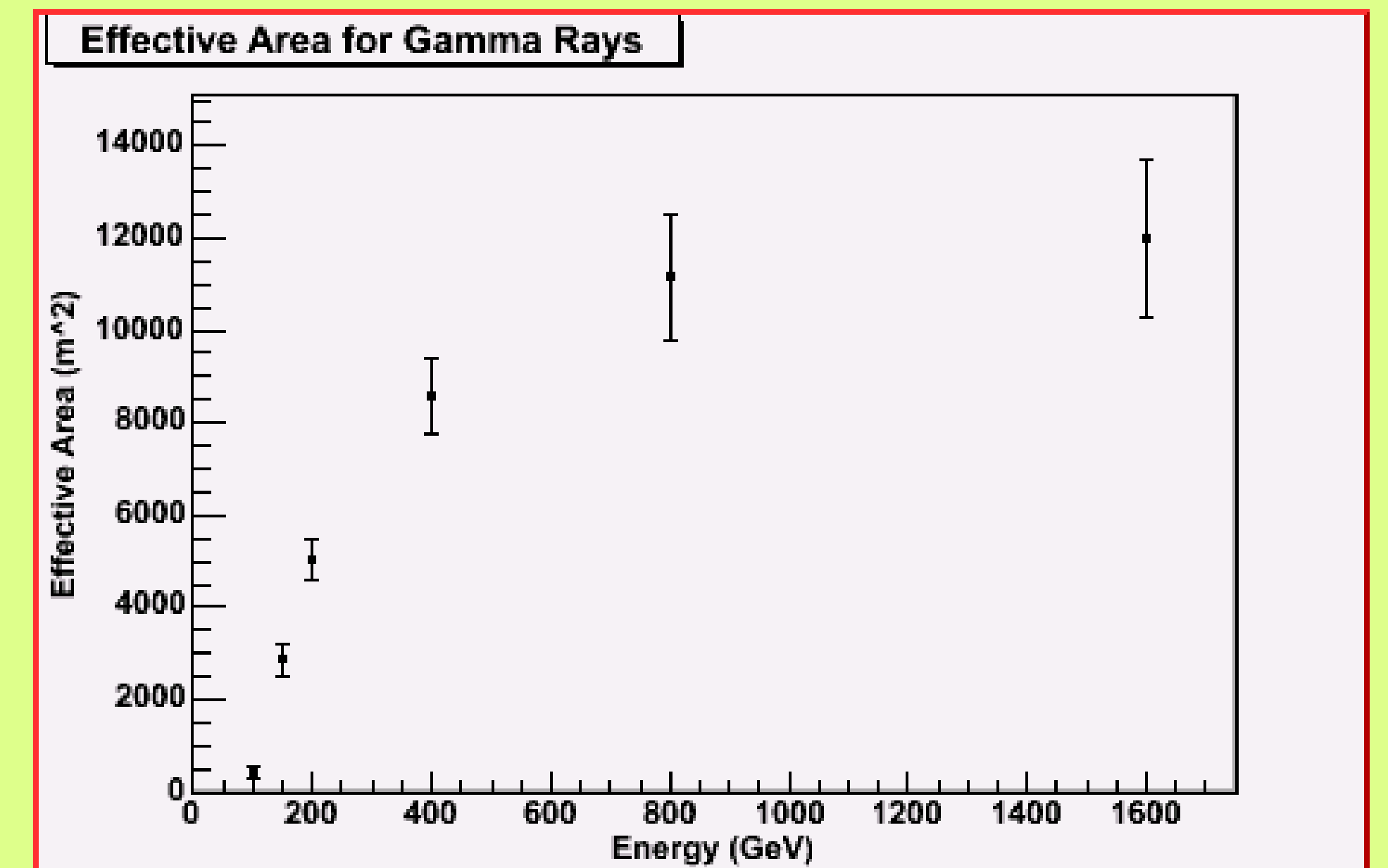
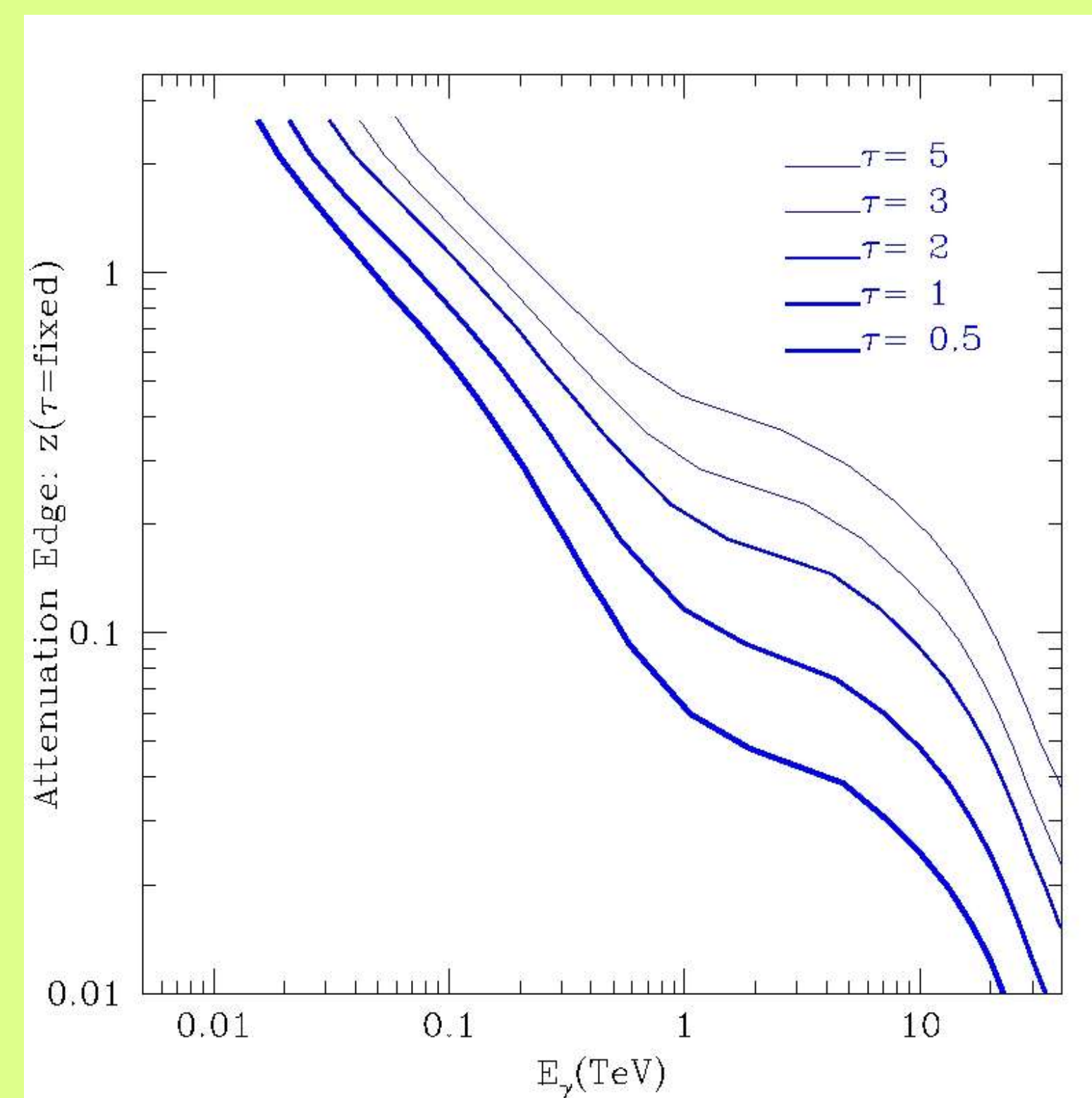
Since the fall of 2002, STACEE has made follow-up observations of 14 bursts. Half of those were made in 2005 alone, once the Swift GRB Observatory[3] had become fully operational. Swift provides fast, accurate localizations, which have allowed STACEE to make observations within minutes of some bursts.

**Table (right)** shows the list of GRB follow-up observations made by STACEE. Our most rapid follow-up to date, was an observation of GRB050607. Data acquisition began 3 minutes and 11 seconds after the initial detection of the burst by Swift. This burst also occurred at a relatively high elevation of 62°. We can place an upper limit on the afterglow flux above 100 GeV of  $4.4 \times 10^{-9} \text{ cm}^{-2} \text{ s}^{-1}$ , assuming a source with a differential power-law spectral index of -2.8. For spectral indexes of -2.6 and -3.0, the limits on the flux above 100 GeV would be  $4.1 \times 10^{-9} \text{ cm}^{-2} \text{ s}^{-1}$  and  $4.8 \times 10^{-9} \text{ cm}^{-2} \text{ s}^{-1}$ , respectively. Although this is our fastest follow-up so far, there is plenty of room for improvement. For example, in the case of GRB050607, approximately 90 seconds could have been gained if the response of the detector to the alert was automated, though there are unresolved difficulties with implementing such a response. An additional improvement of about 30 seconds can be made by switching from the email alert system to a socket connection with the GCN.

## STACEE Performance

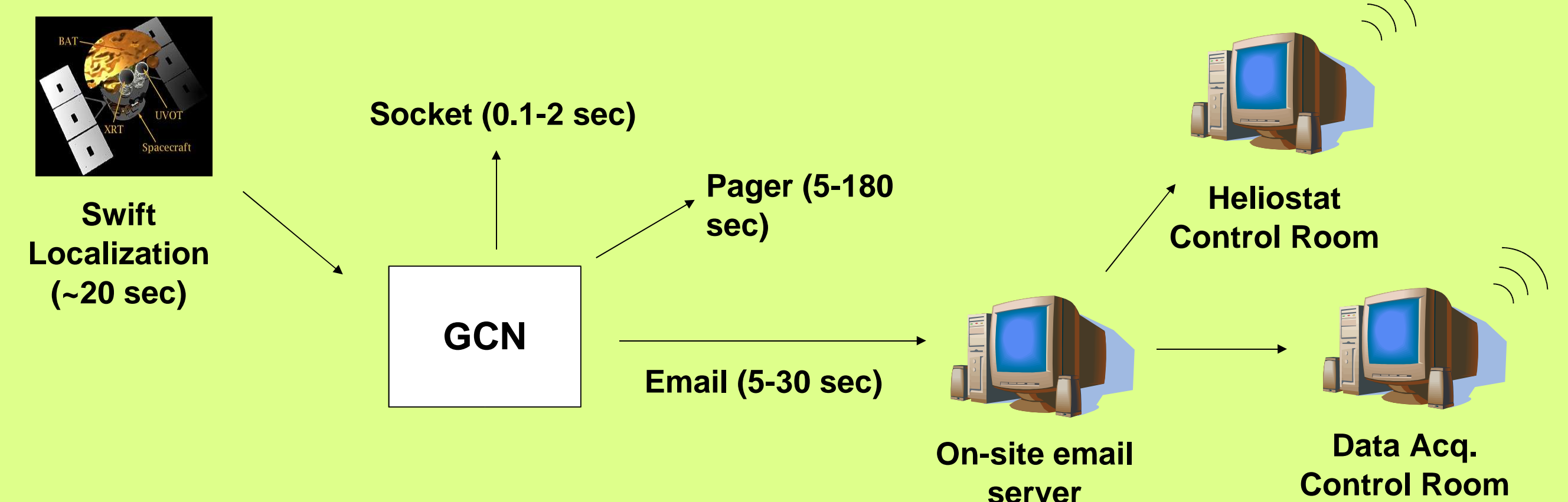
As with all atmospheric Cherenkov telescopes, the probability that a gamma ray will be detected by STACEE increases with the energy of the gamma ray. One advantage that STACEE has is its large mirror area, which allows for the detection of gamma rays as low in energy as 50 GeV, depending on the direction of the source. **Figure (right)** shows a rough effective area curve for STACEE as determined by simulations of gamma rays at an elevation of 63°. The effective area is defined as the fraction of simulated showers which trigger the detector multiplied by the area over which those showers were scattered.

**Figure below:** The curves show the redshift, as a function of gamma-ray energy, at which the flux will be attenuated by the factor  $e^{-\tau}$  due to pair-production with starlight photons[2]. A low energy threshold allows sensitive observations of many more gamma-ray bursts, which, evidence suggests, are distributed fairly uniformly throughout the cosmos to high redshift.



## GRB Observing Strategy

Observing gamma-ray bursts is a high priority for STACEE. The GCN burst alerts are monitored with a computer program which alerts STACEE operators if a burst is visible from the STACEE site by updating a web page and initiating an audio alert.



In the summer of 2004, the slewing speeds of the STACEE heliostats were more than doubled through motor upgrades. The heliostats can now re-target from zenith to any direction above 45° elevation about a minute or less. In addition to doing immediate GRB follow-ups, STACEE makes afterglow observations for bursts less than 12 hours old.

GRB	Time to Target (min)	Initial Elevation	Approx. Live-time On Source (min)	Preliminary Significance	Comments
021112	217	73°	66	0.2	
030324	123	31°	0	na	Analysis complicated by bright star at edge of FOV
030501	369	47°	0	na	Unstable rates due to instrumental problem
031220	310	59°	0	na	Unstable rates due to weather
040422	95	35°	20	-0.7	
040916	104	46°	na	na	Partial data corruption has delayed analysis
041016	142	51°	16	-1.8	
050209	146	56°	22	1.1	
050402	3.8	49°	0	na	Partial heliostat malfunction has delayed analysis
050408	640	43°	20	-1.0	
050412	5.7	54°	na	na	Partial data corruption has delayed analysis
050509B	20	83°	25	0.45	
050509A	480	53°	15	0.1	
050607	3.2	62°	19	-0.9	

## References

- [1] D.M. Gingrich et al., Presented at the 2004 IEEE Nuclear Science Symposium; astro-ph/0506613.  
 [2] J.R. Primack et al., Proc. AIP Conf. 745, 23 (2005); astro-ph/0502177.  
 [3] N. Gehrels et al., ApJ 611, 1005 (2004).