Performance Characteristics of the STACEE Gamma-Ray Observatory

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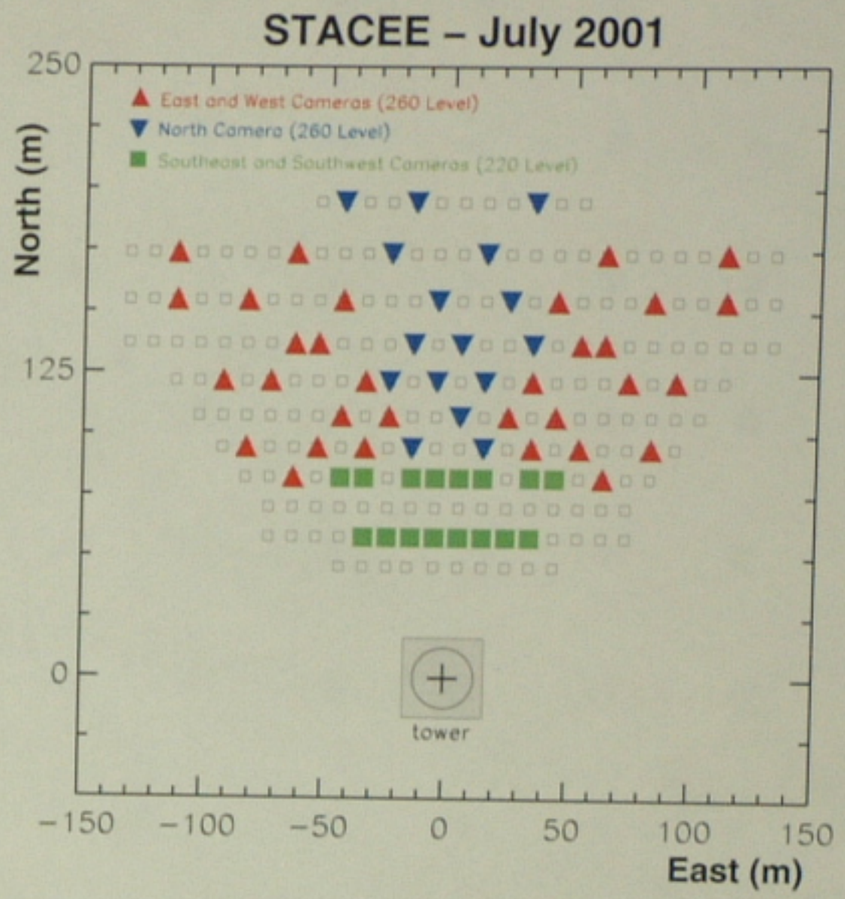
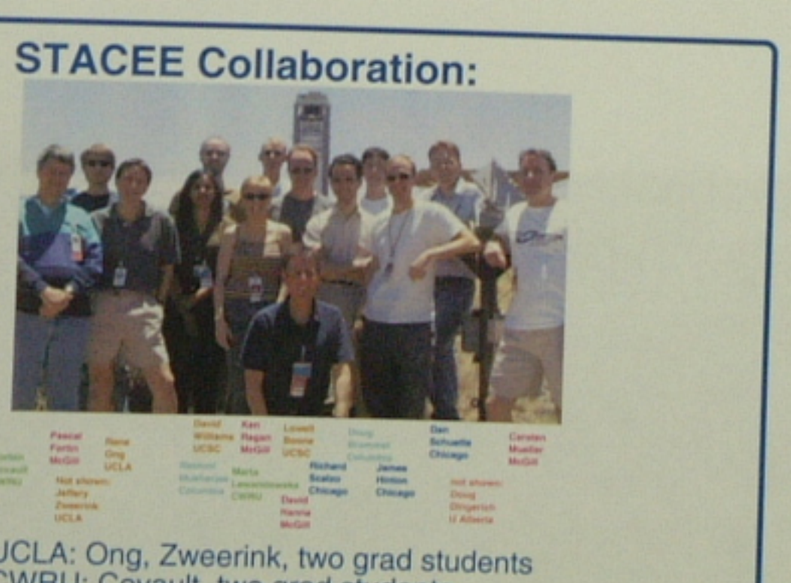
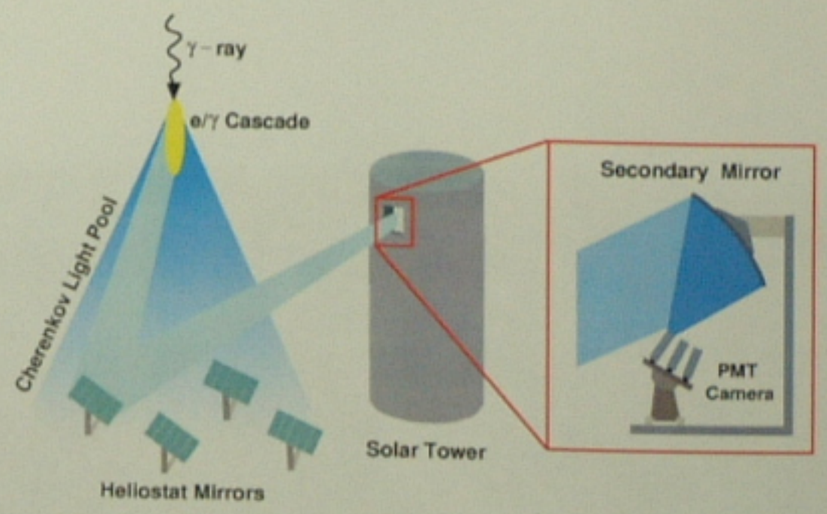
We describe the performance of the Solar Tower Atmospheric Cherenkov Effect Experiment (STACEE). STACEE is located at the National Solar Thermal Test Facility (NSTTF) in Albuquerque, New Mexico, USA. STACEE uses the large heliostat mirrors at the NSTTF to collect Cherenkov light from cosmic ray and gamma-ray air showers. Because of the very large light collecting area provided by the heliostat mirrors, STACEE achieves a particularly low energy threshold in comparison to other ground-based experiments. Construction of the full STACEE experiment using 64 heliostat mirrors has been complete since October, 2001. We have implemented a custom VME-based trigger and delay unit. We have also instrumented all 64 channels with 1 GHz FADC's for optimal event reconstruction. Details on instrument performance characteristics, including sensitivity, position resolution, and event rates are presented. STACEE is currently engaged in a program of regular observations and has already collected data from several candidate source objects.

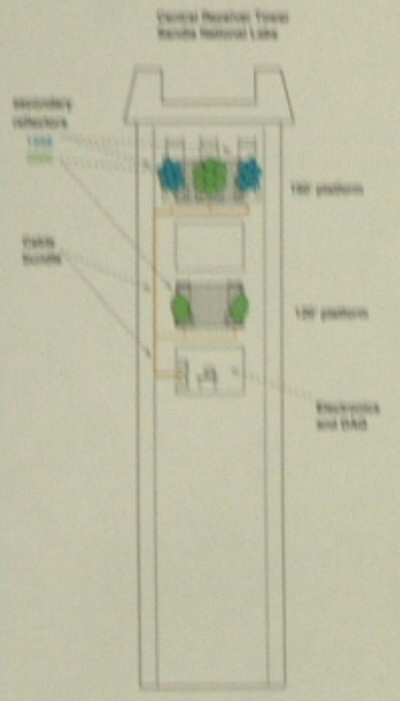


Plan view of the 64 heliostats used at the NSTTF for the STACEE experiment.





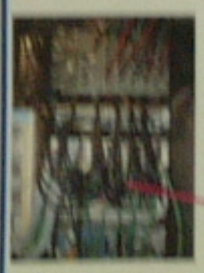
Installation of two new secondary mirrors and PMT camera for 64-channel system:



STACEE mirror and camera box with PMTs

Looking down onto three mirrors and three cameras

STACEE trigger and data acquisition electronics



FADC's used to read out all 64 STACEE channels

Blacktop sealant applied to reduce albedo from scattered light in the field

Details on instrument performance characteristics, including sensitivity, position resolution, and event rates are presented. STACEE is currently engaged in a program of regular observations and has already collected data from several candidate source objects.

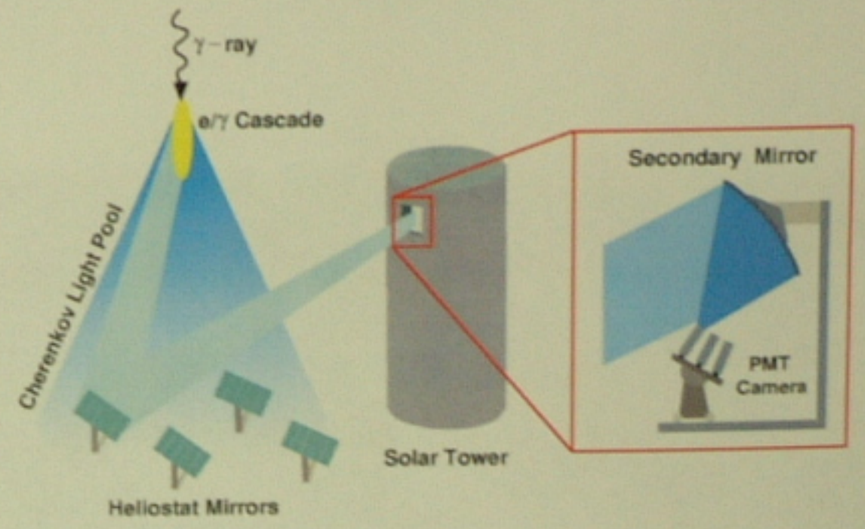
STACEE Collaboration:

UCLA: Ong, Zweerink, two grad students
CWRU: Covault, two grad students
UCSC: Williams, one grad student
Barnard/Columbia: Mukherjee, one grad student
McGill: Hanna, Ragan, three grad students
Alberta: Gingrich

Total Faculty: 7 (4 USA, 3 Canada)
Total Postdocs: 1 (USA)
Total Graduate Students: 9 (6 USA, 3 Canada)

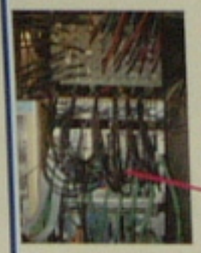
STACEE at the National Thermal Test Facility (NSTTF) site, Sandia Laboratories:

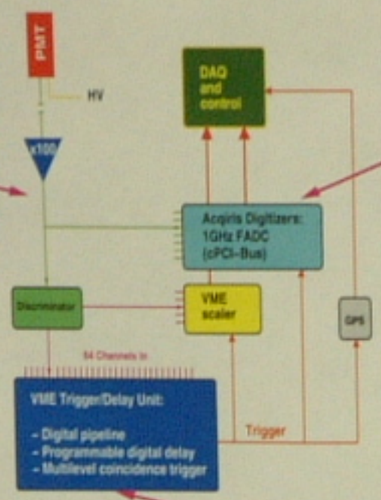
Plan view of the 64 heliostats used at the NSTTF for the STACEE experiment.



The STACEE instrument concept. Cherenkov light is reflected from heliostat mirrors onto one of five secondary mirrors and then onto PMT cameras.

STACEE trigger and data acquisition electronics





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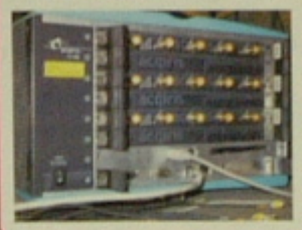
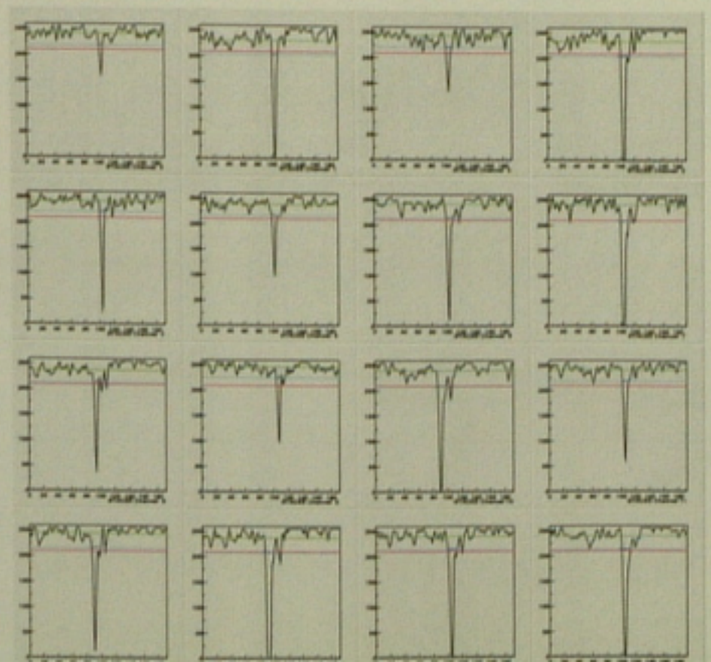


Custom trigger delay boards made by McGill

Blacktop sealant applied to reduce albedo from scattered light in the field

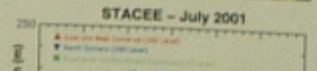
Heliostat optics: aligned, cleaned, and calibrated for optical throughput



STACEE Construction/Installation Activities since January 2001:

1) Commission channels 48–64:
- — Two new secondary mirrors
- — PMT's, cameras, cabling
- — HV, front end electronics
- — Timing, pulse height calibration
- — Incorporation into trigger

2) Commission 1Gs/s digitizers:
- — Linux driver, control software
- — data acquisition



Total Faculty: 7 (4 USA, 3 Canada)
Total Postdocs: 1 (USA)
Total Graduate Students: 9 (6 USA, 3 Canada)

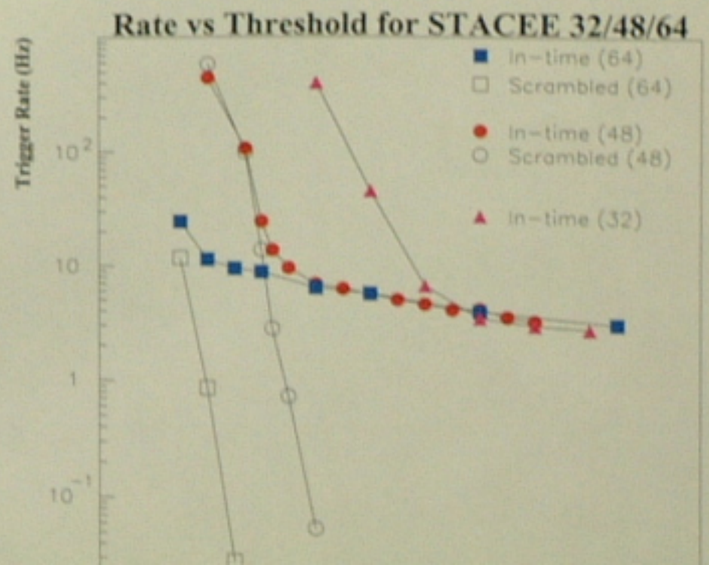
STACEE at the National Thermal Test Facility (NSTTF) site, Sandia Laboratories:

- Site in operation for >20 years in solar power and high–intensity light research
- Site owned and operated by DOE, most activities supported by DOE solar energy.
- Site personnel provide excellent infra–structure to support STACEE research.

PMT cameras.

64-channel trigger rate	~8 Hz
Discriminator threshold	4 p.e. = ~ 50 GeV
Crab detected at 10σ	25 hours
Crab 10σ w/ hadron rejection	4 hours

	100 GeV	250 GeV
Angular Resolution	0.18°	0.15°



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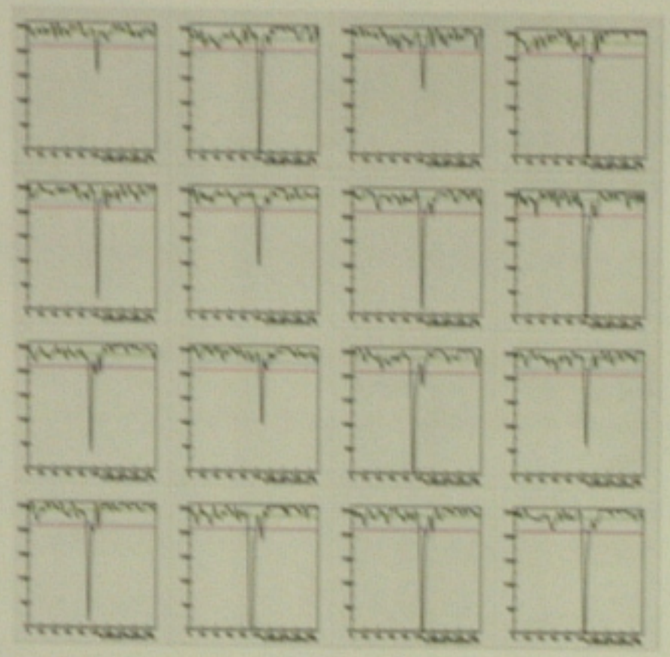
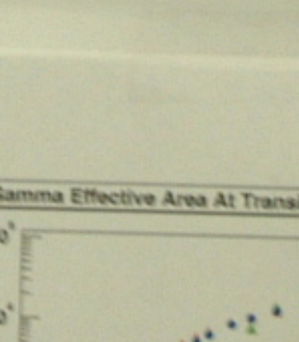


A representative subset of 16 out of 64 channels of Cherenkov data from the Acqiris DC270 FADC's (1 ns bin width) which allow STACEE to accurately reconstruct both arrival direction and energy of individual air shower events.



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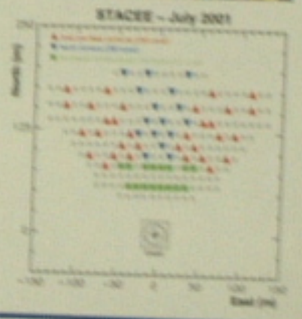
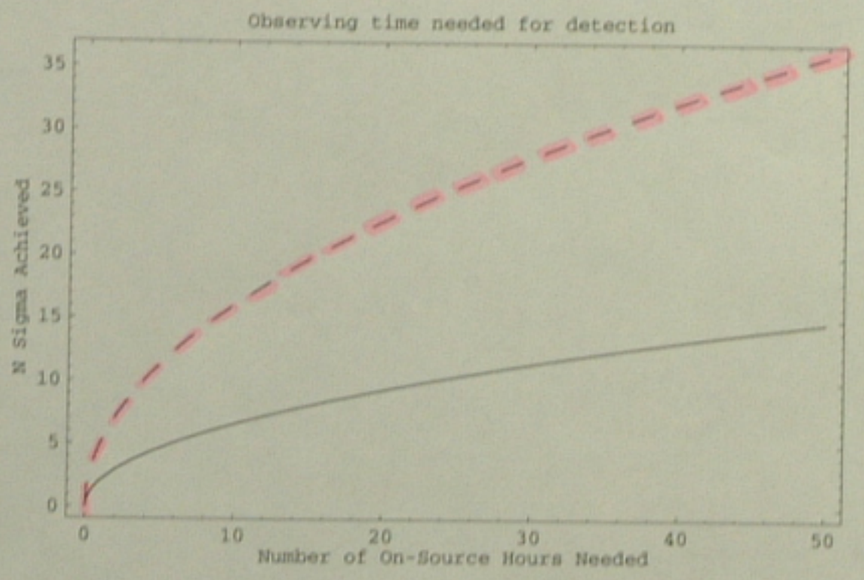


3) Full system integration:
- — Determination of optimal trigger
- — Routine nightly laser calibration

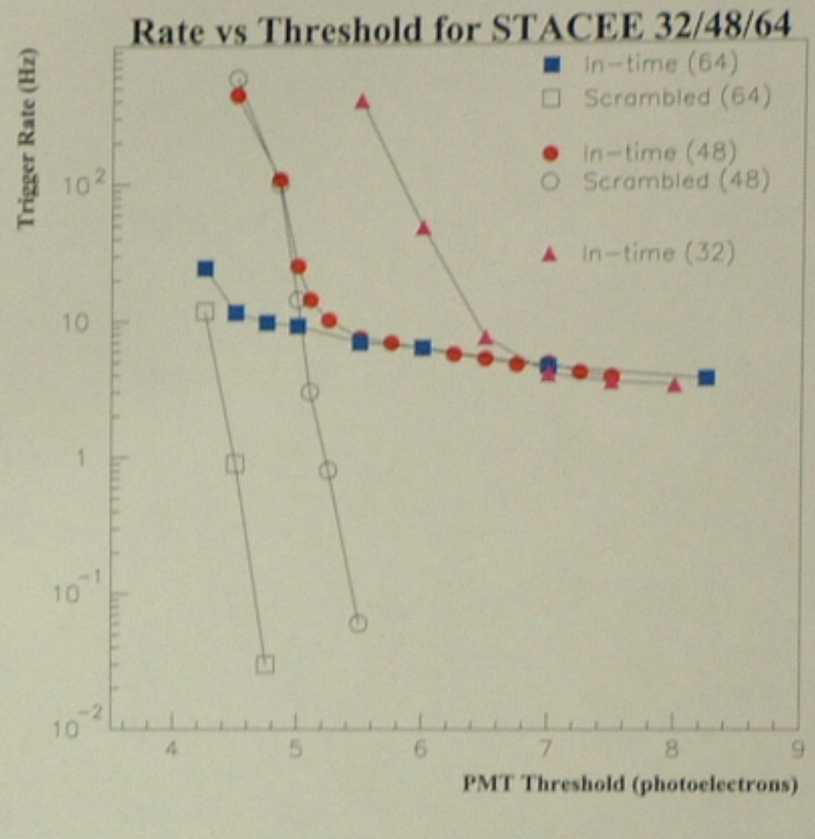
October 2001: STACEE construction is complete!

64-channel trigger rate	~8 Hz
Discriminator threshold	4 p.e. = ~ 50 GeV
Crab detected at 10σ	25 hours
Crab 10σ w/ hadron rejection	4 hours

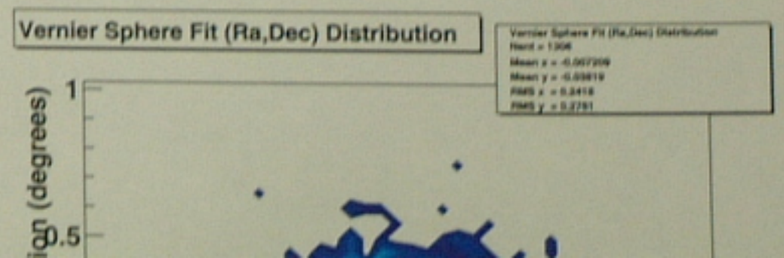
	100 GeV	250 GeV
Angular Resolution	0.18°	0.15°
Energy Resolution	30%	25 %
Effective Area	4,000 m^2	15,000 m^2

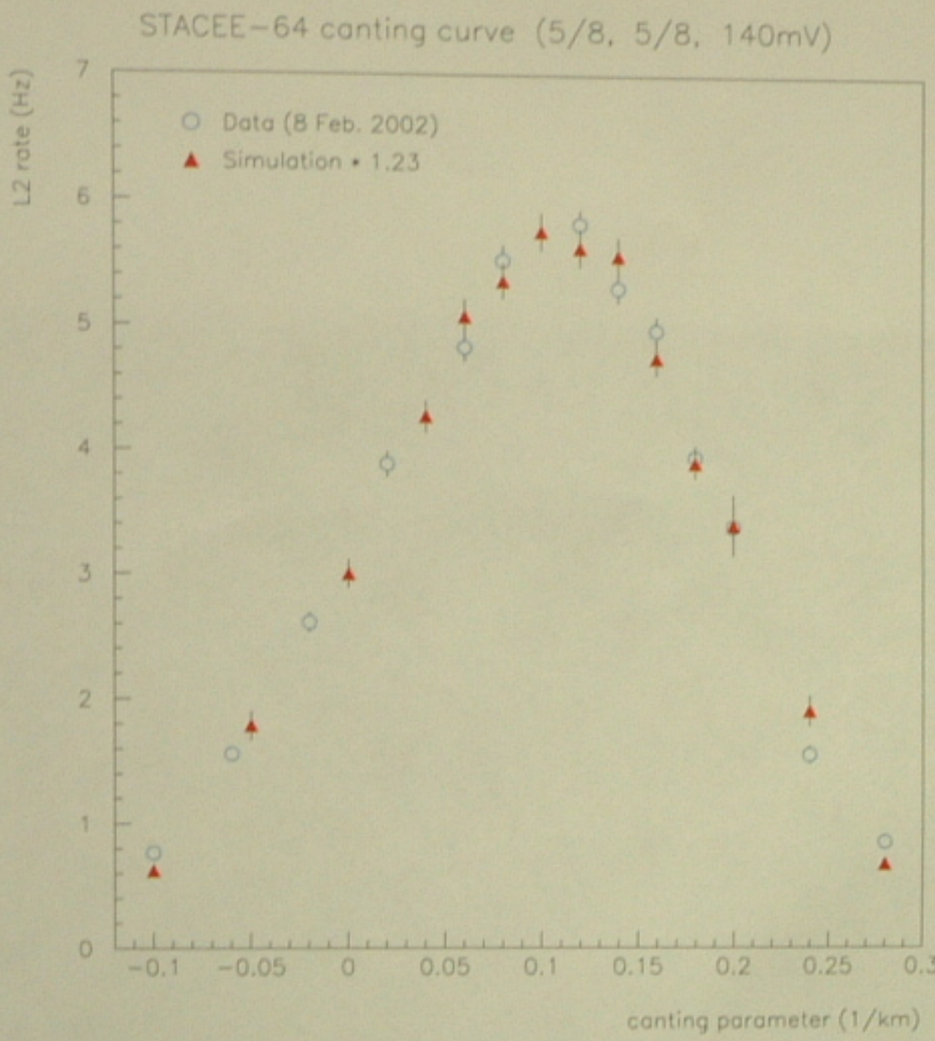


Sensitivity (in terms of achieved significance) vs. observation period for the Crab Nebula. The solid line is sensitivity achieved using

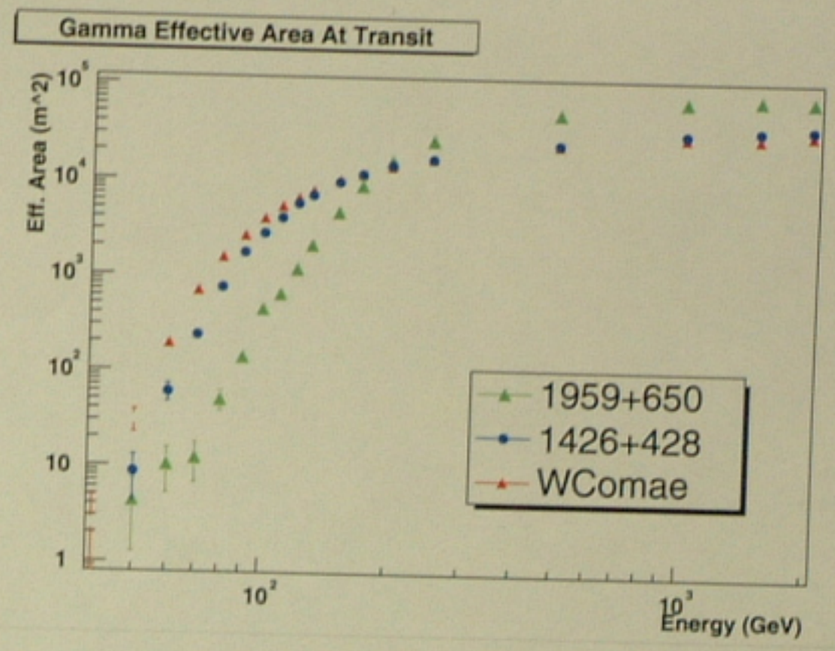


STACEE measured trigger rate vs. discriminator threshold in photoelectrons (p.e's) for three different construction stages. An upgrade to our DAQ trigger system along with the addition of many more heliostats for STACEE-64 allows us to operate at a lower threshold corresponding to about four p.e.'s or about 50 to 75 GeV.

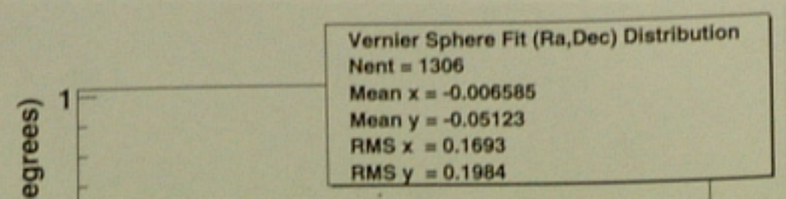




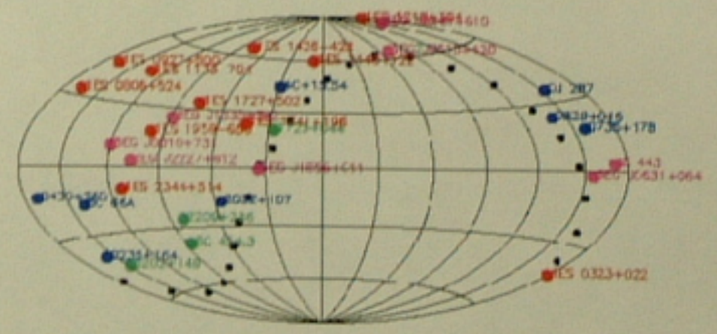
STACEE simlated vs. real canting curve. Here the canting parameter is the inverse of the distance from the ground to the interaction point htat is tracked by the heliostats. A parameter of zero corresponds to heliostats tracking the source at infinity. A negative parameter means that the heliostats are canting divergently.



Effective area vs. energy for three example AGN sources as inferred from full detector simulations of the STACEE experiment.



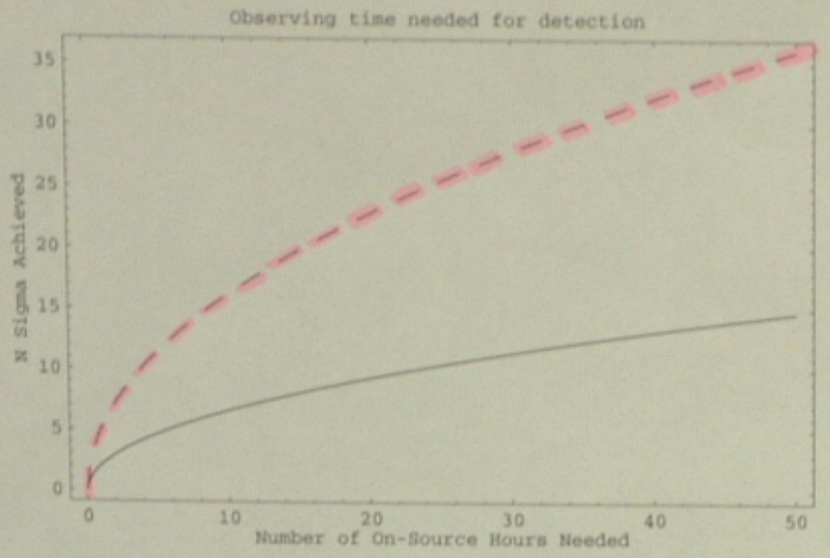
STACEE Three–year Observing Plan:



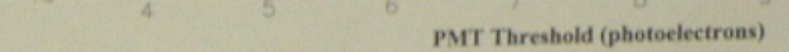
• EGRET FSRQs, • EGRET BL Lacs, • Other TeV candidates,
• EGRET Unidentified Sources.

- > AGN
- > Pulsars, SNR, Unidentified EGRET
- > Super nova remnants

Effective Area	4,000 m^2	15,000 m^2



Sensitivity (in terms of achieved significance) vs. observation period for the Crab Nebula. The solid line is sensitivity achieved using straight on-off method. The dashed line includes advanced reconstruction for improved hadron rejection.



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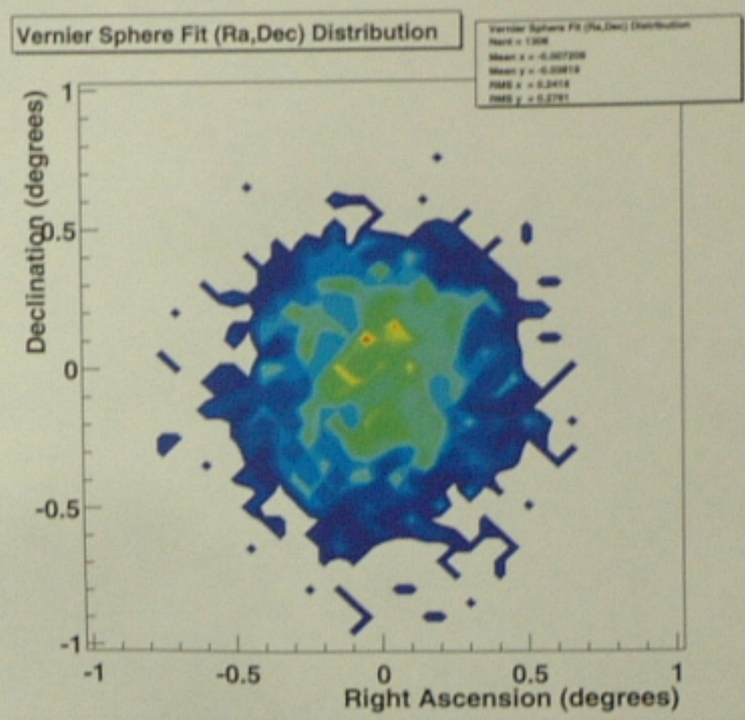
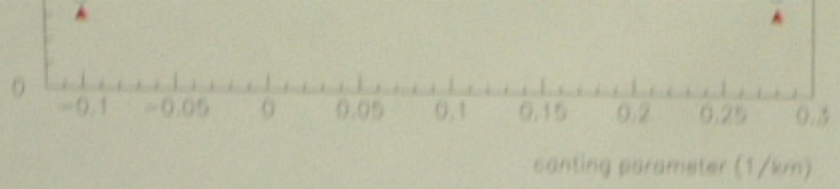


The reconstructed arrival directions for simulated STACEE vertical gamma-rays. In this example the core location is not determined in the fit.



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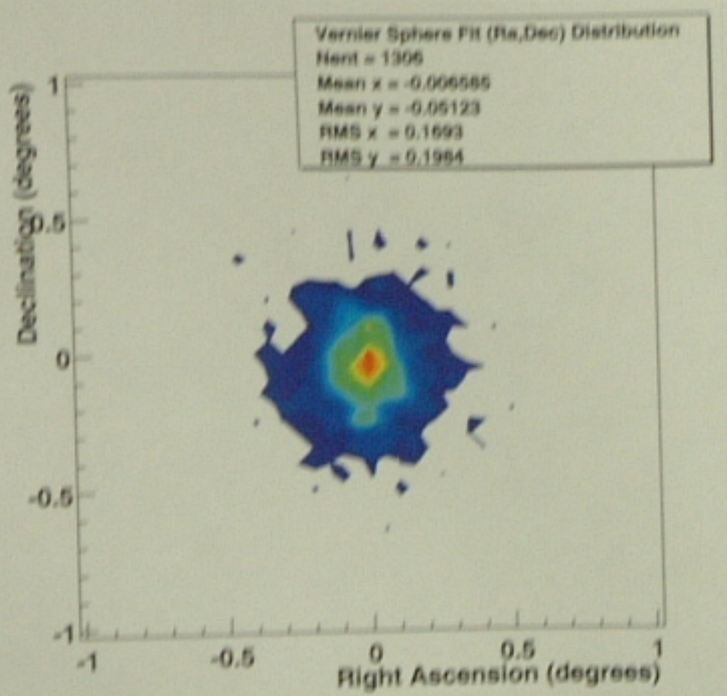
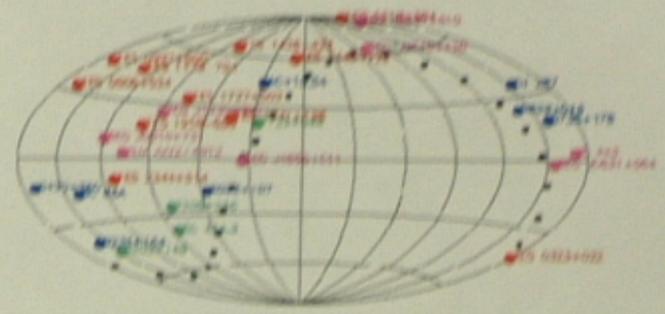


This plot is the same the previous figure, except that the new technique of maximum likelihood fitting is used to constrain the core position of the shower to achieve a dramatic improvement in the angular resolution on reconstructed arrival directions.

from full detector simulations of the STACEE experiment.

STACEE Three-year Observing Plan:



• EGRET FSRQs, • EGRET BL Lacs, • Other TeV candidates,
• EGRET Unidentified Sources.

- AGN
- Pulsars, SNR, Unidentified EGRET
- Super nova remnants
- Gamma-ray bursts
- Possibly WIMPs, other exotics

STACEE will have an essentially unique ability to observe any of these sources at energies below 250 GeV for the next 3 years.

17