The GRAAL experiment

R.Plaga for the GRAAL collaboration

17th ECRS, July 25 2000

allegorical virgin, holding the GRAAL in the form of a PMT

- Gamma Ray Astronomy At aLmeria is an experiment to detect gamma–rays with an energy above 100 GeV
- Concentrate on objects with weak theoretical motivation for high energy gamma–ray emission,like unidentified EGRET sources or GRB afterglows in later stages
- Study of the lateral light–sampling approach to Cerenkov astronomy in the limit of very high (approaching unity) sampling density and time resolution as alternative to imaging method

GRAAL collaboration

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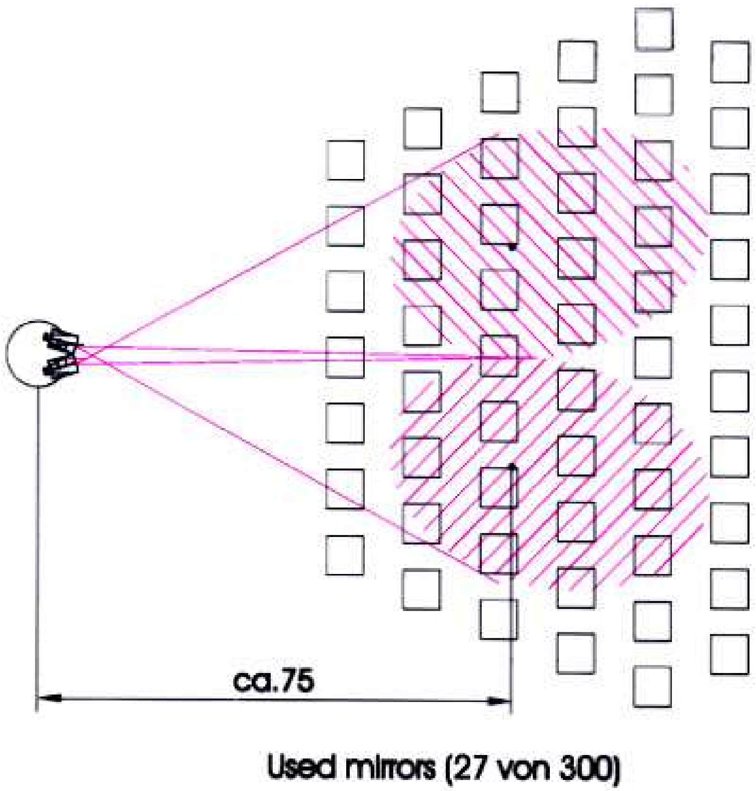
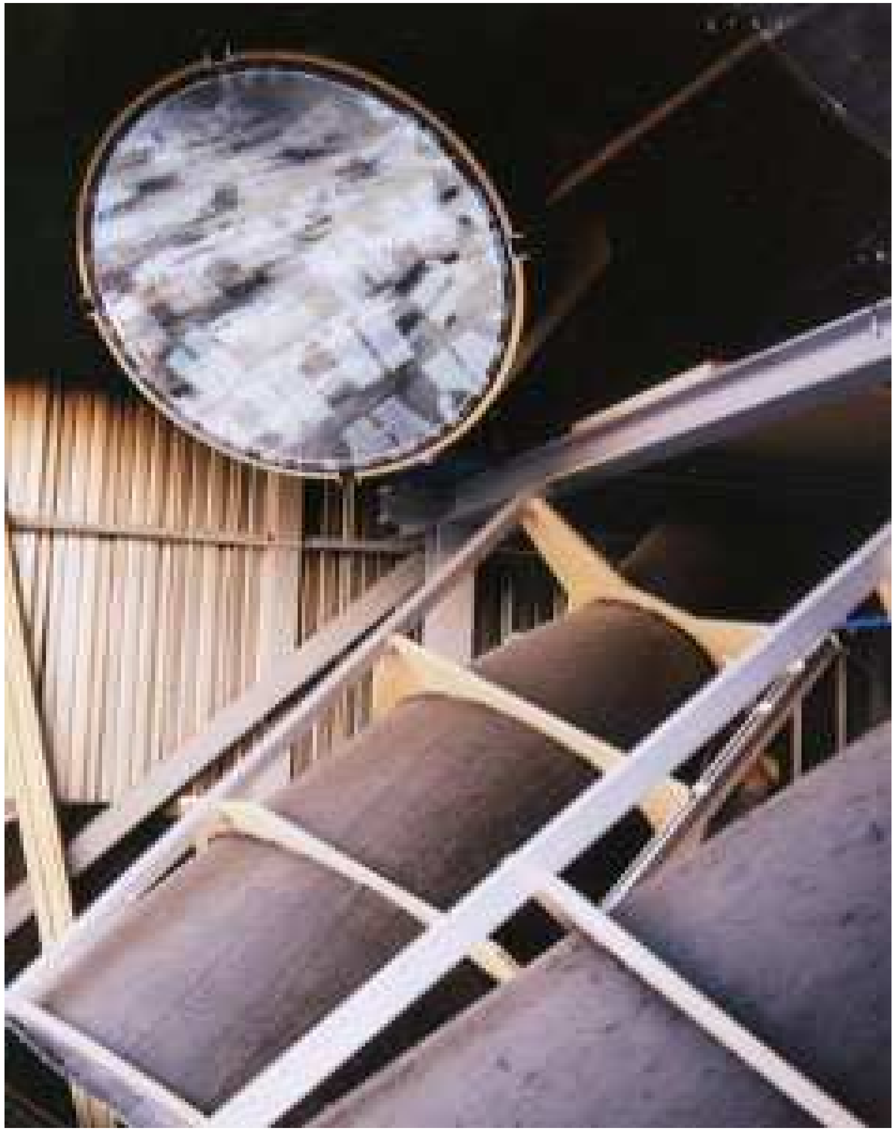
GRAAL general principle of operation (nonimaging optics)



Scheme of Mini-GRAAL

- 63 heliostats focus onto 4 large area Winston cones in central tower
- each Winston cone detects light of 13−18 heliostats in one PMT
- heliostat are identified via their different arrival times
- use of the CESA−1 heliostat field, 225 heliostat of 39.6 m² each, beam spread 0.25° (1 σ)
- special GRAAL heliostat control

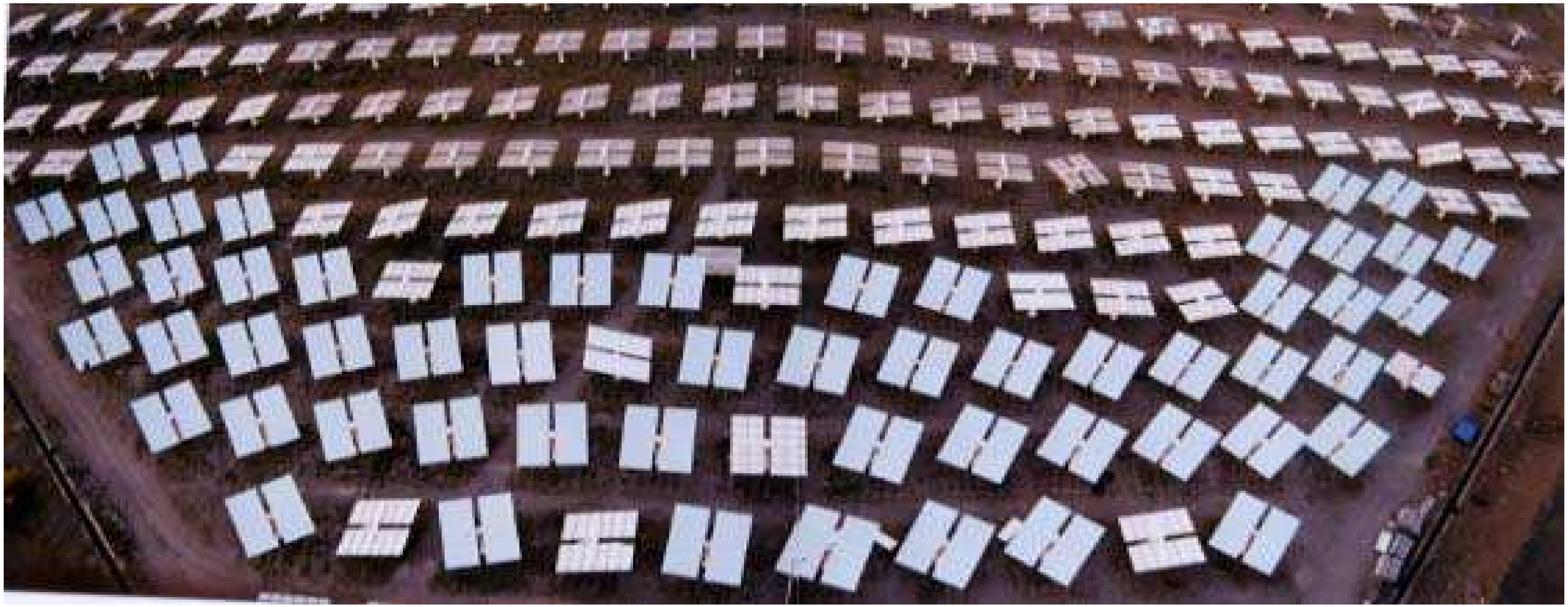
Strengths of GRAAL



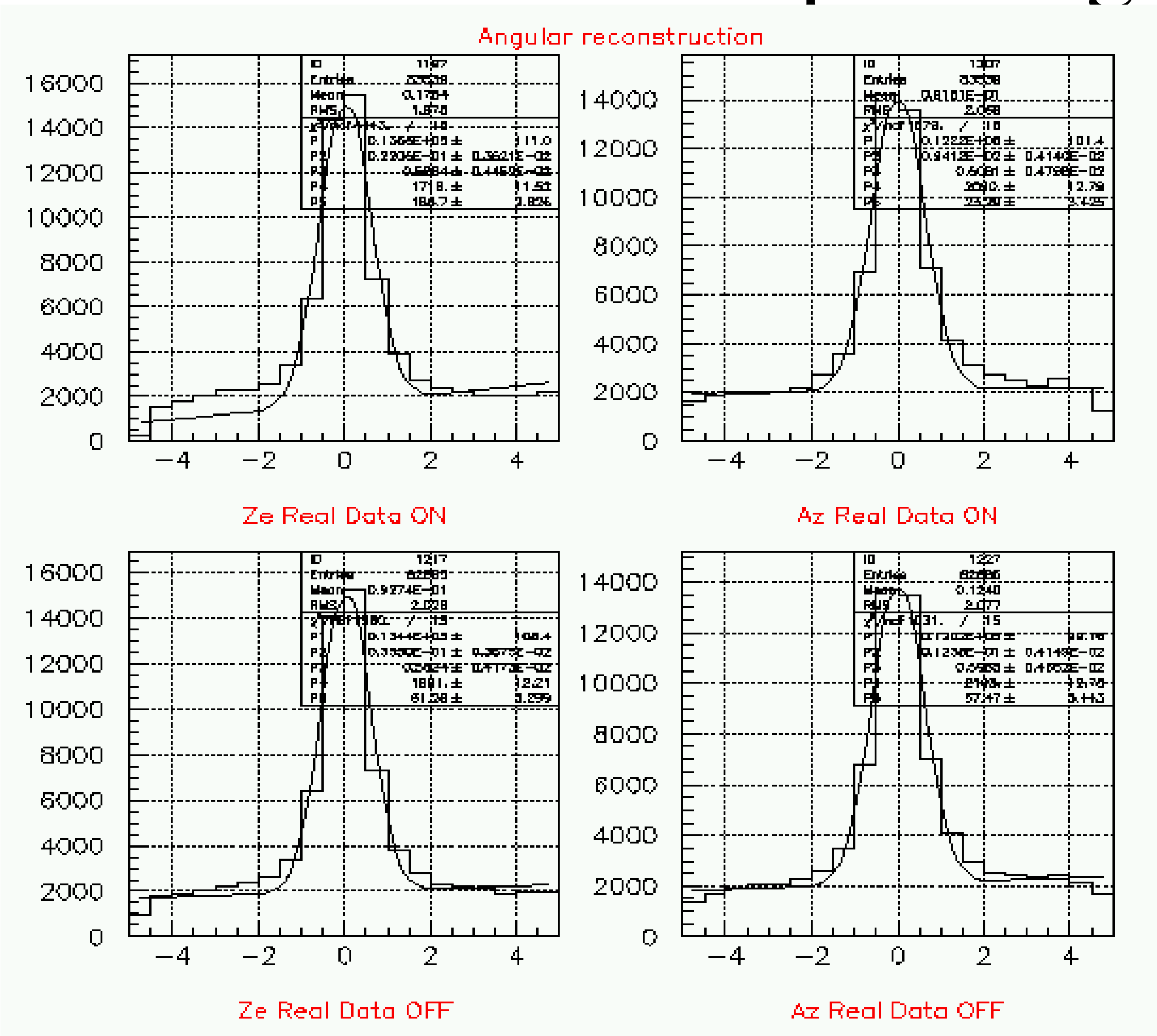
- Highest time resolution Cerenkov experiment: 500 psec/bin with 300 Mhz BW
- Largest total mirror area of any current Cerenkov experiment (2500 m²)
- Central tower detector ca. factor 10 less complex then imaging solar Cerenkov exp.:smaller cost, fewer systematic errors

Location of GRAAL

- Plataforma Solar de Almeria, Sierra Nevada, southern spain, 505 m a.s.l.
- Spanish CIEMAT research centre for solar energy
- dark desert site, main problem is frequent high humidity



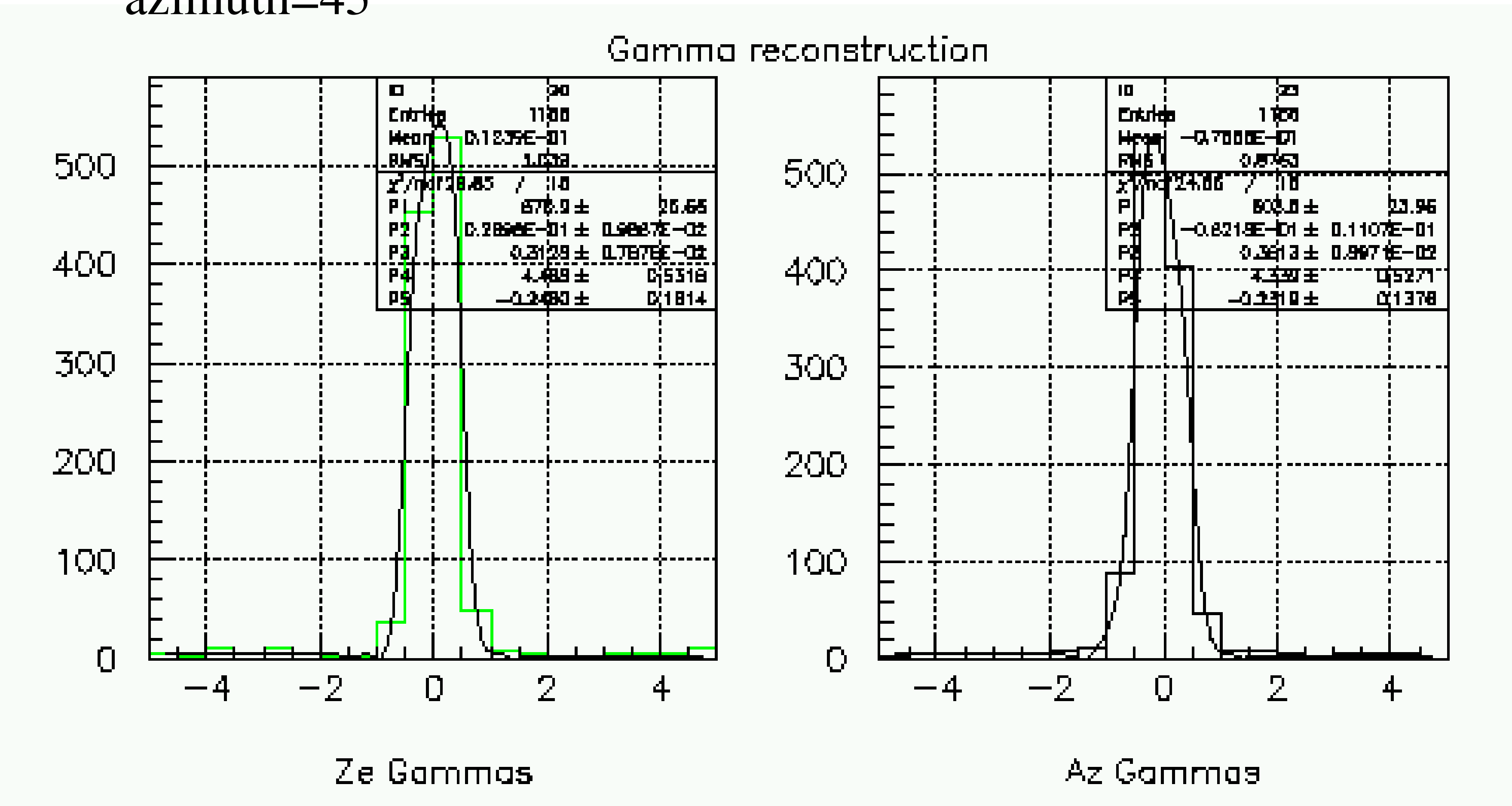
Performance 1:Precision of absolute pointing



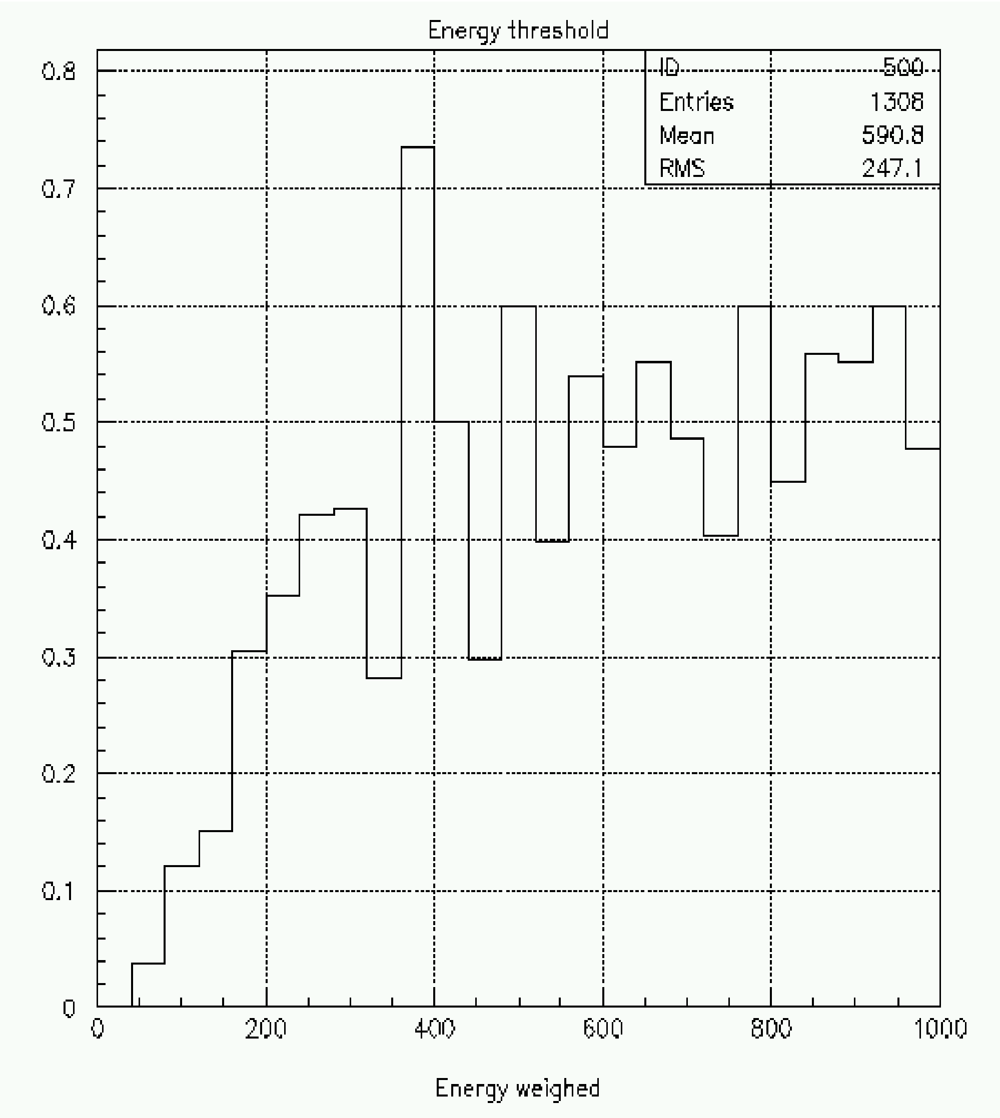
- All Crab data from February, March 2000 (also unfavourable weather conditions) 32 h on, same time off
- projections in zenith and azimuth angle for on and off runs
- critical test (reconst. is independent of heliostat pointing)
- deviations always smaller than 0.05°

Performance 2: Angular resolution

- Angular resolution from MC for gammas $\sigma(63)=0.35°$
- Projection in zenith and azimuth for MC from zenith=10°, azimuth=45°



Performance 3:Analysis energy threshold, detection area



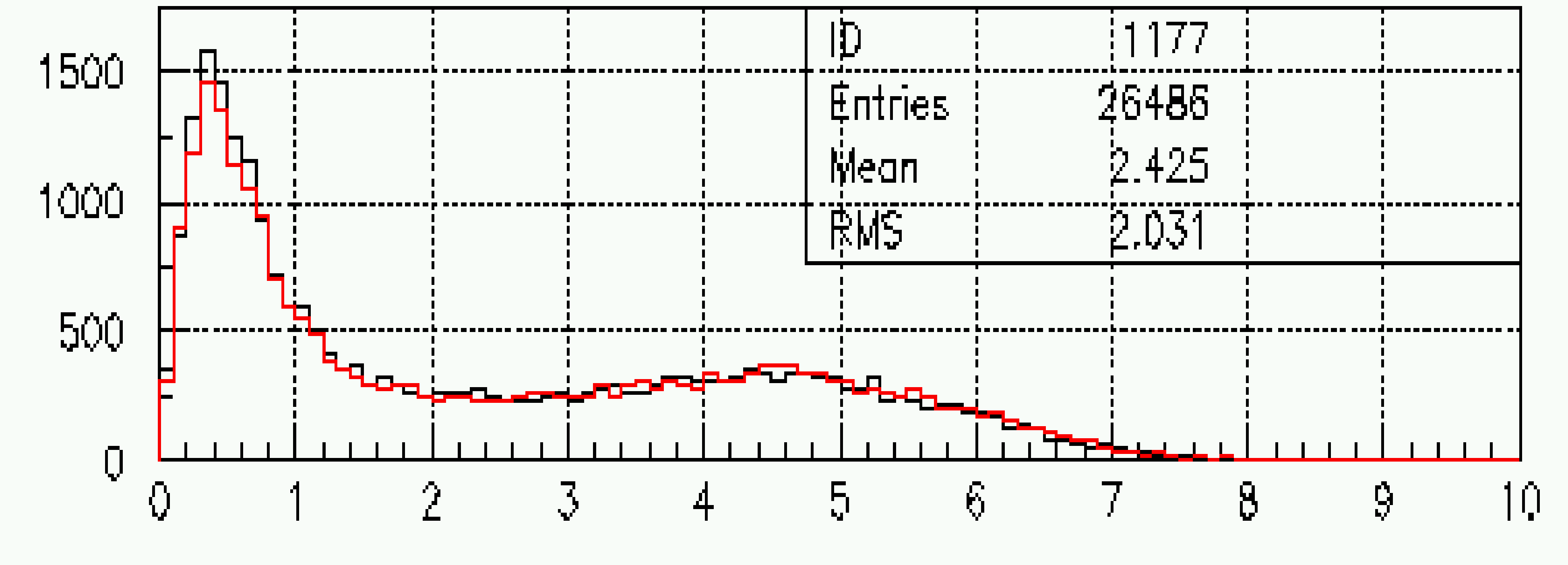
- MC result for gammas, fraction of MC showers passing analysis threshold >5 peak>s at >5 sigma above night–sky background as function of energy in GeV
- asymptotic detection area at > 400 GeV: 15000 m²
- Rate: 2–4 Hz, Singles ca. 1 Mhz

GRAAL project development

- 2.99 collaboration agreement with PSA about GRAAL
- 6.99 construction of new test platform finished
- 8.99 routine data acquisition begins
- 11.99 additional final 4 Cone integral trigger in operation
- 2.00 anti–dew spray system in operation
- 5.00 remote operation of experiment begins
- 8.00 remote auto alarm operational (mobile telephone)

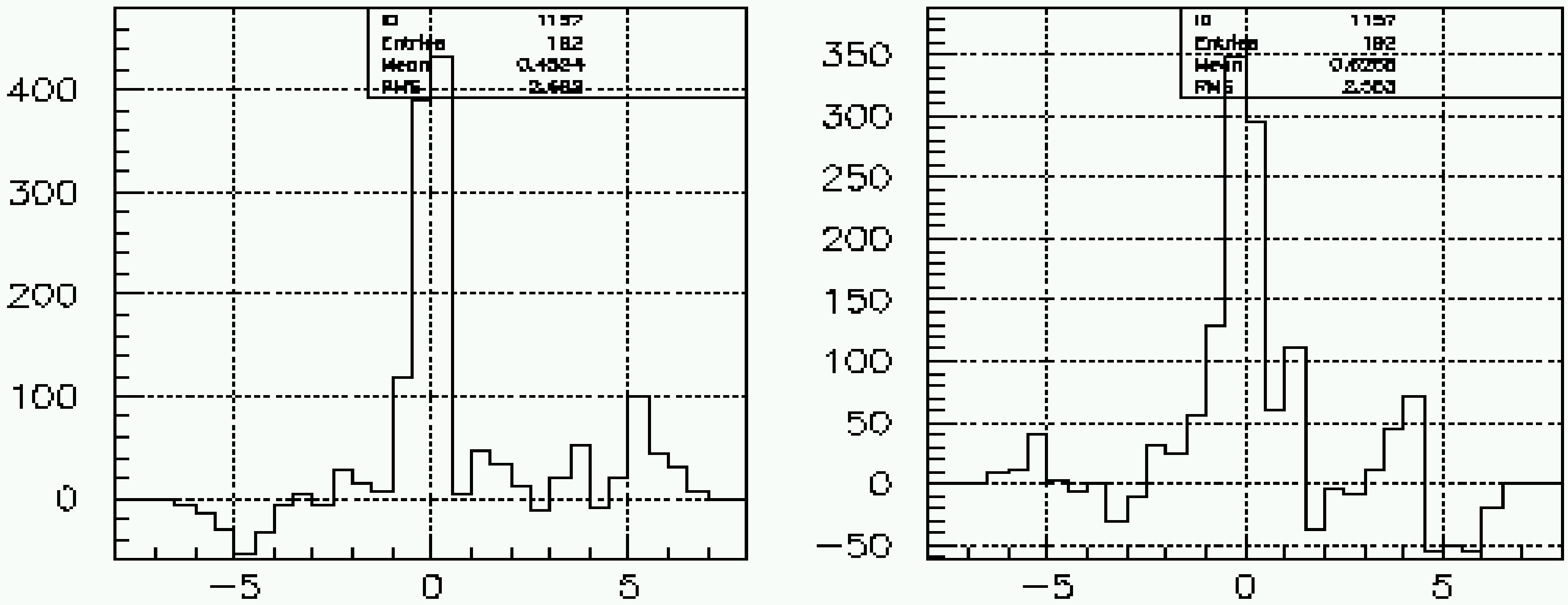
Observation of Crab pulsar 1

- After anti−dew system operational, 32 h Crab on, same off, 165k reconstructed events
- after cuts for good weather (fraction of well reconstructed events,on/off ratio in outer angular region,effective rates within certain limits) 5h50min on, same off
- 2.87 Hz on vs 3.03 Hz off. Red: off, black on events as f(degrees) from source position



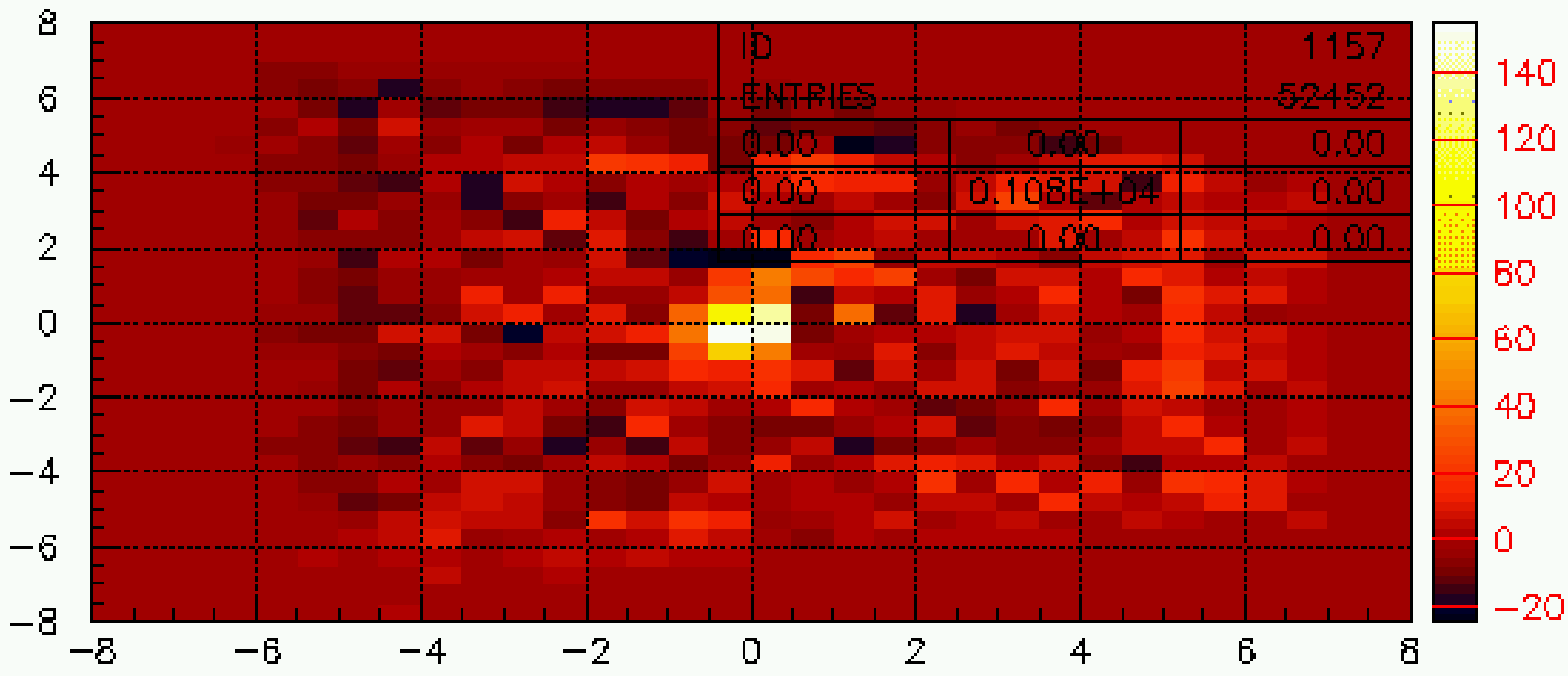
Observation of Crab pulsar 2

- After reconstruction 520 ± 230 excess (25966 on)
- in central region < 0.6° 590 ± 124 (8004 on)
- excess of 4.8 σ, 1.7/min, 0.03 Hz
- projection of ON – OFF events onto zenith (left panel) and azimuth (right panel) as function of angular difference to source position in degrees:



Observation of Crab pulsar 3

- rate is expected from the flux as measured by the Whipple collaboration if their flux is simply extrapolated to 200 GeV
- angular distribution of background hadrons is significantly broader as the one of the excess, as expected for gammas
- 2d display, x=zenith, y=azimuth, excess at source postion 0,0 is clearly visible



Summary

- GRAAL takes data since August 1999, the only major technical problem was dew formation on heliostat mirrors
- The experiment performs as planned, and has lower systematic errors than expected
- The very restricted field of view destroys the difference between gamma and hadron showers, and worsens the angular resolution
- GRAAL presently also searches for gamma radiation at energies above 100 GeV from "theoretically risky" sources like e.g. unidentified EGRET sources at high Galactic latitudes