VERITAS

Very Energetic Radiation Telescope Array System

Detection of 50 GeV to 50 TeV photons with an array of nine Čerenkov imaging telescopes at the Whipple Observatory in Arizona.

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OX97-1

Smithsonian Astrophysical Observatory

Very Energetic Radiation Imaging Telescope Array System (VERITAS)

HTTP://EGRET.SAO.ARIZONA.EDU

Questions

- Is it possible to detect 100 GeV photons entering the Earth atmosphere from the ground?

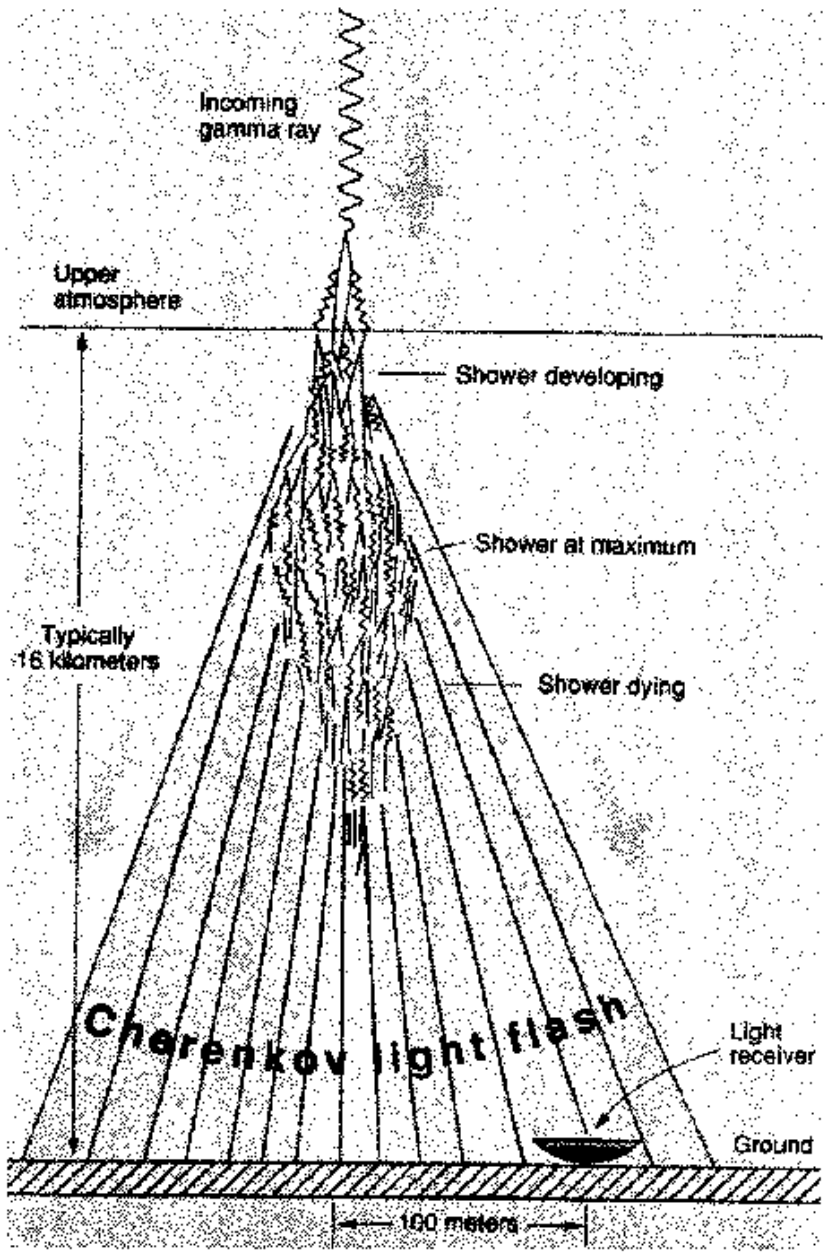
- Are there any natural sources of 100 GeV to 10 TeV photons?

- Do observations at TeV energies answer important questions in astrophysics?

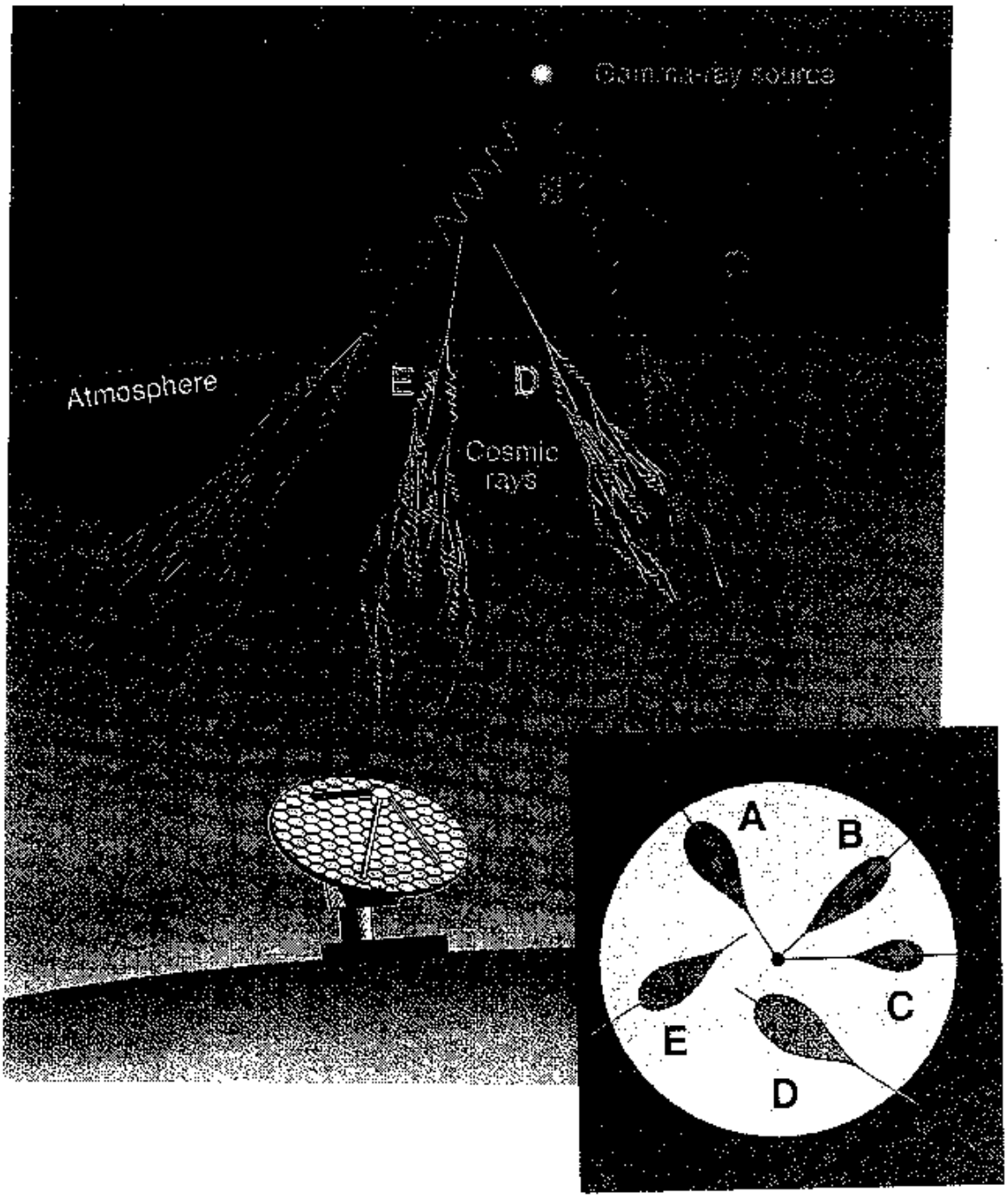
- Can the present experimental techniques be improved?

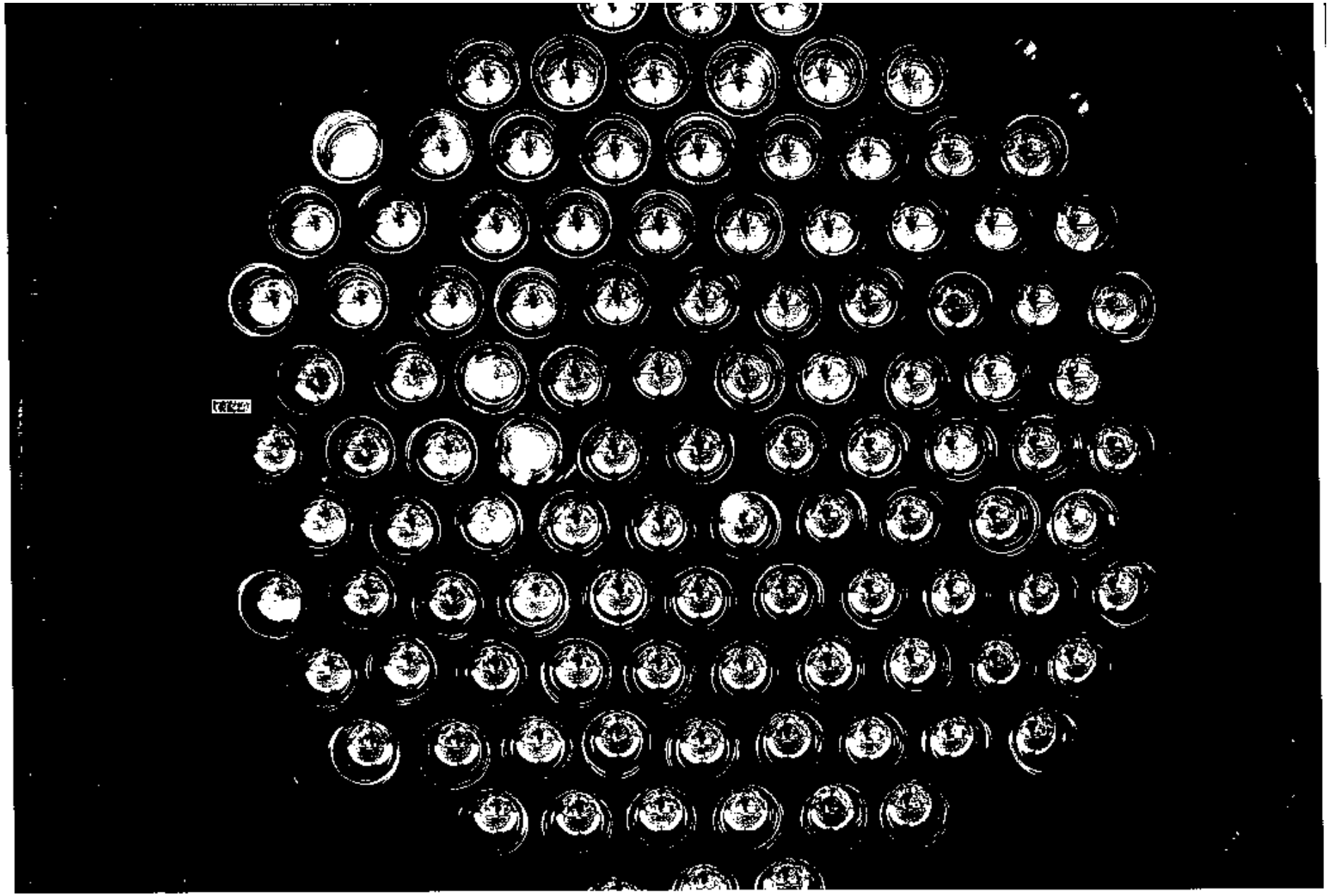
Can particle physics technology be applied in building the next more powerful generation of telescopes?

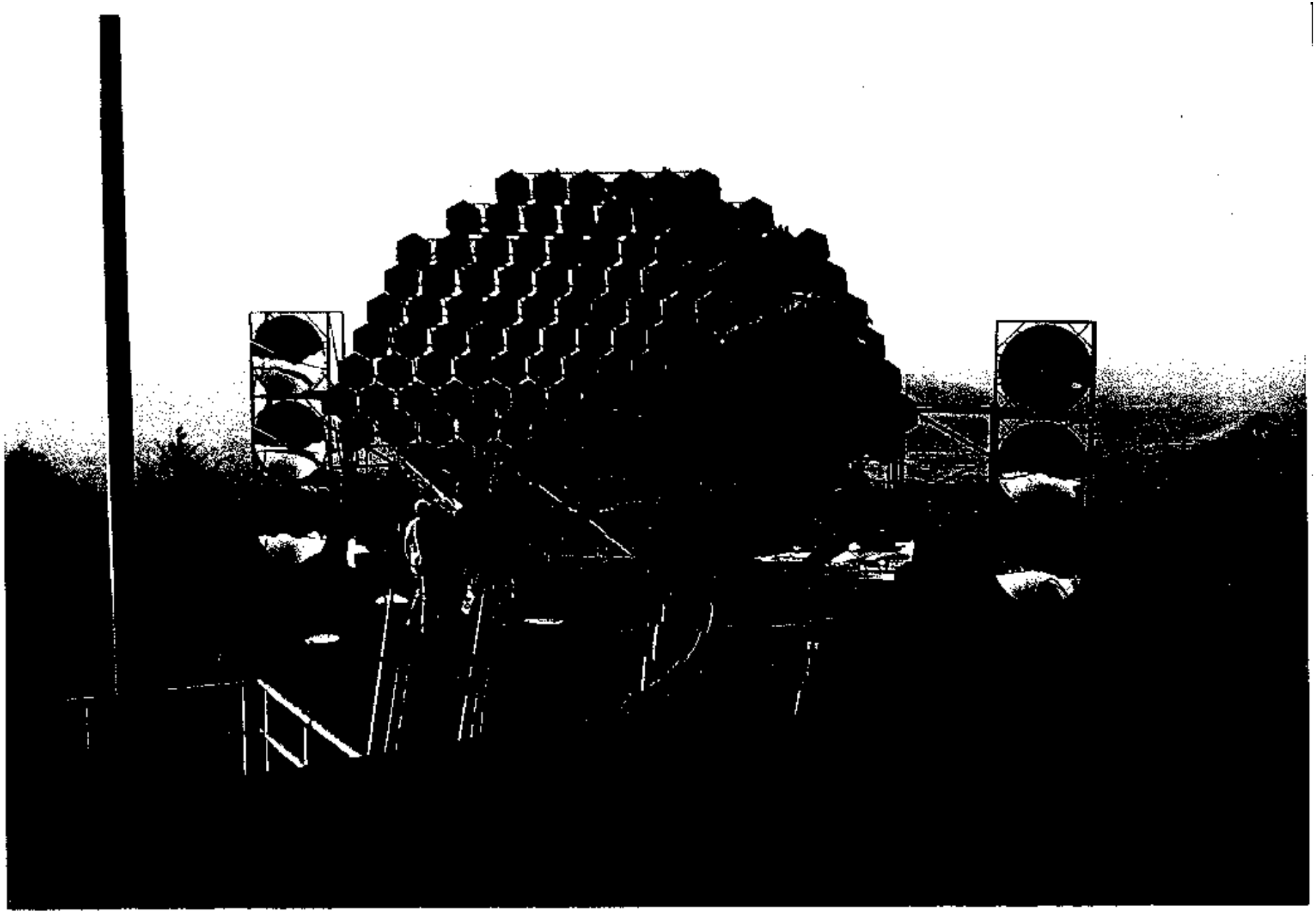
Čerenkov light from $e^- e^+$ showers

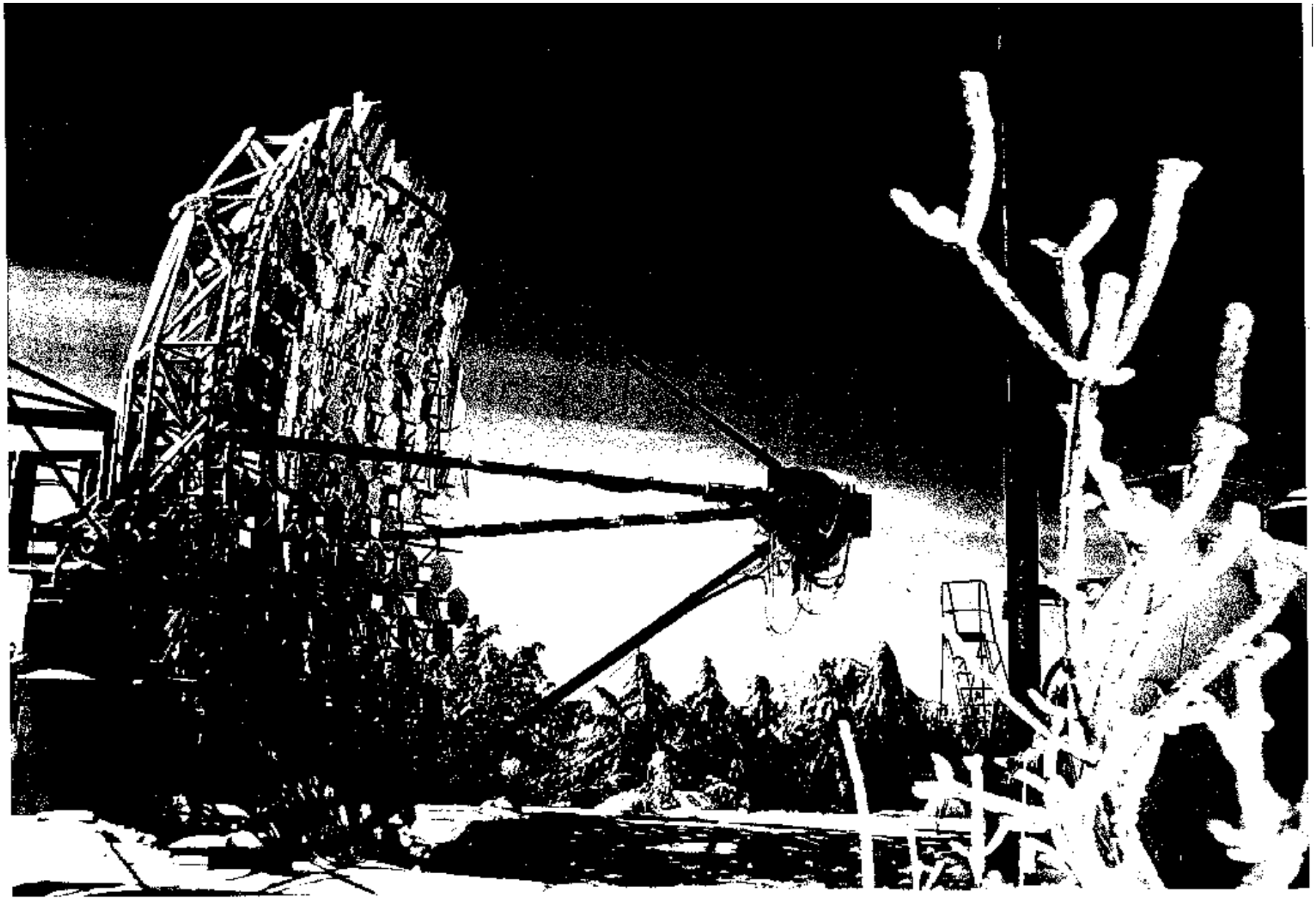


Čerenkov imaging

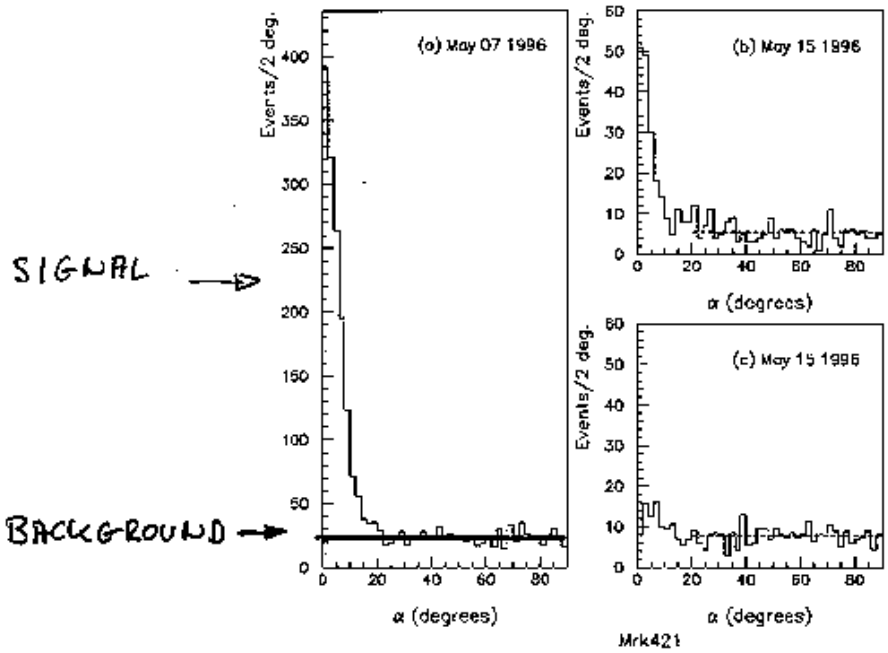




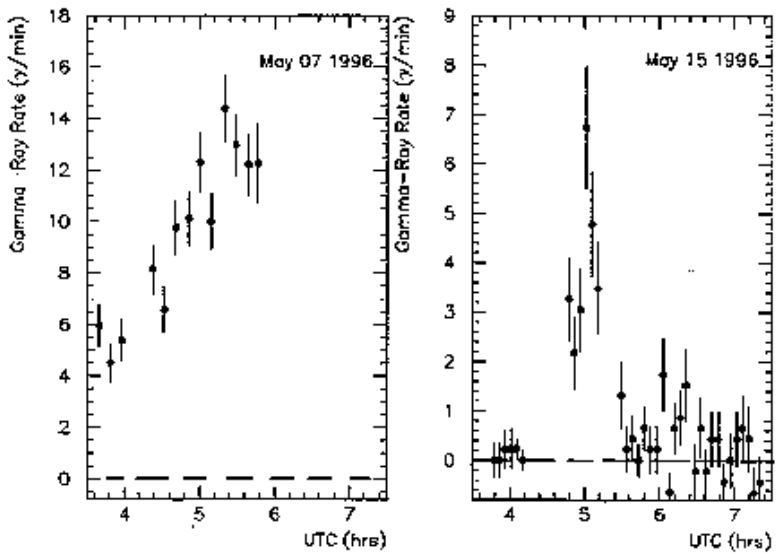




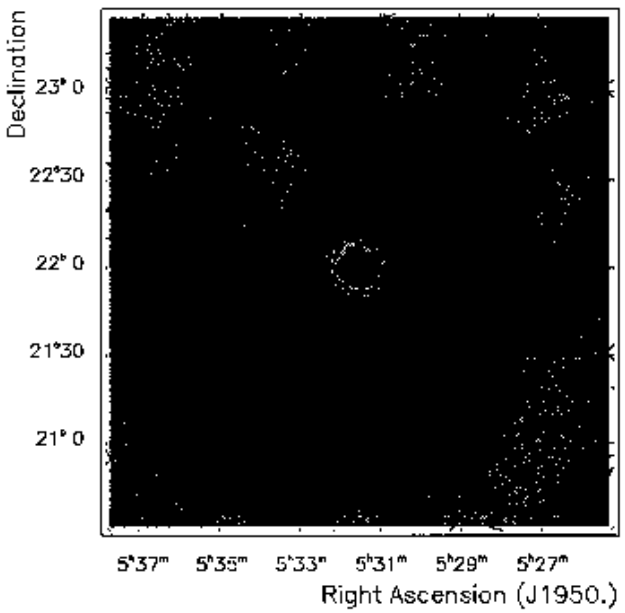
Markarian 421 signal, May 1996



$E_\gamma > 300\,GeV$



Crab Nebula observations at $E > 300$ GeV



Whipple 10 m telescope, Crab Nebula detection:

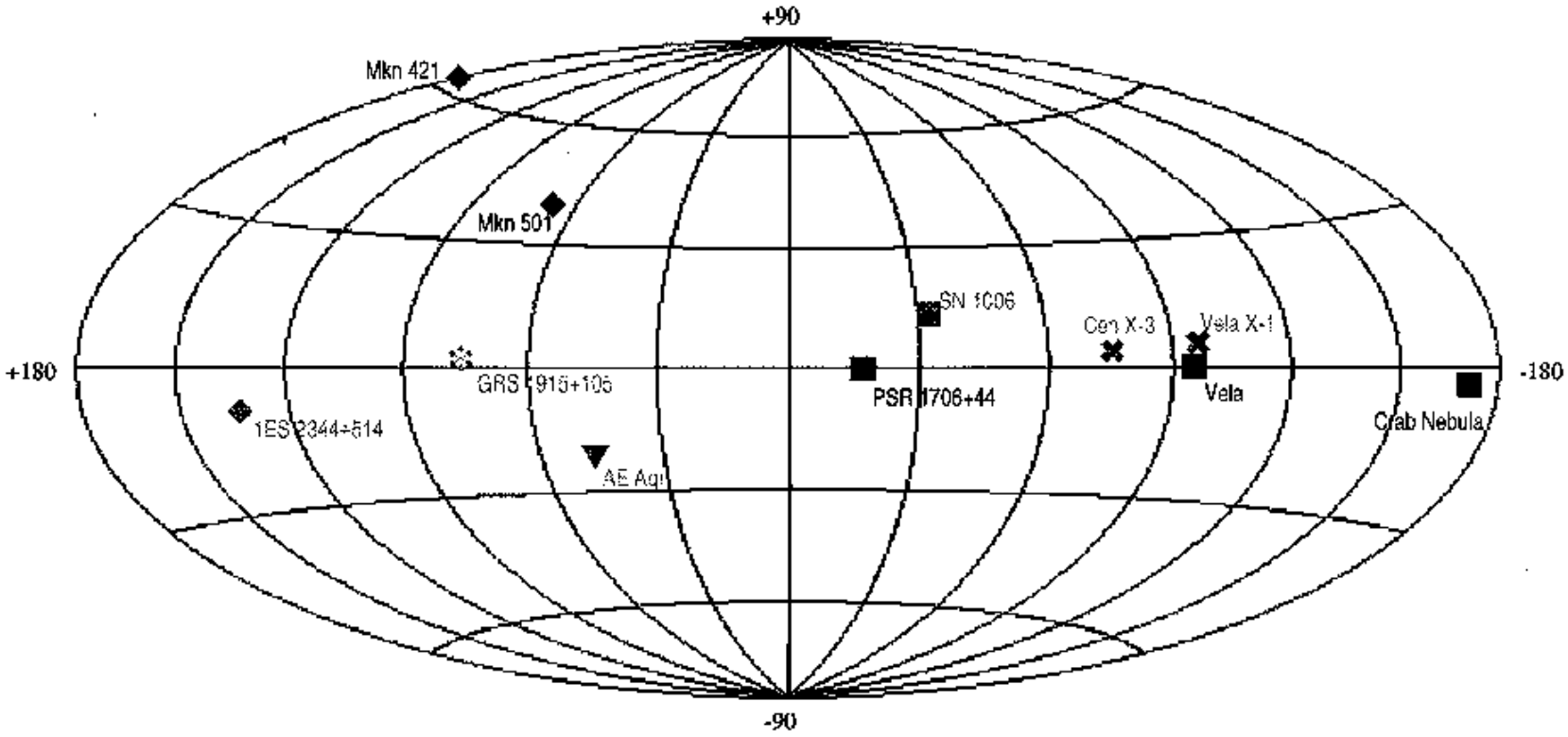
- rate ~ 1 photon per minute, ($4.5\,\sigma$ in 28 minutes)
- flux $\frac{dN}{dE} = (2.5 \pm 0.3) \cdot 10^{-7} \left(\frac{E}{1\,\mathrm{TeV}}\right)^{2.1\pm0.2}$ m^{-1}s^{-1}
- No variability (standard candle, flux = 1 Crab)

Detected supernova remnants:

- Crab Nebula, Whipple 1989, confirmed
- PSR 1706-44, Cangaroo 1995, (confirmed?) ✓
- Vela Pulsar, Cangaroo 1996, preprint
- SN 1006

VHE Gamma Sources (E > 300 GeV)

(Status September 1997)



Galactic Coordinates

D.Petry, 9-1997

■= Pulsar/Plerion ◆= AGN (BL Lac) ✖ = XRB ▼ = CV ✻ = Microquasar

VHE Gamma Sources (E > 300 GeV)

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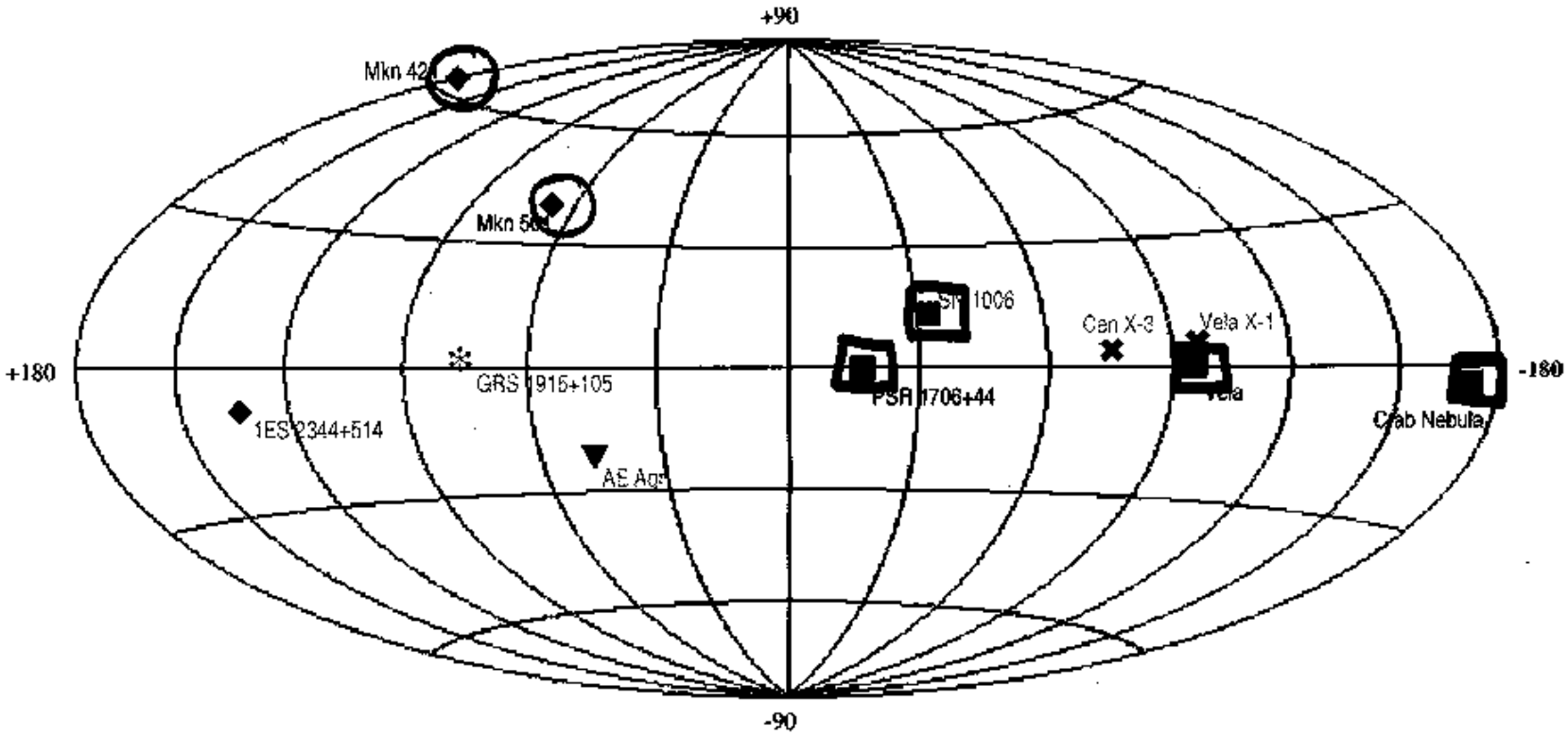

Galactic Coordinates

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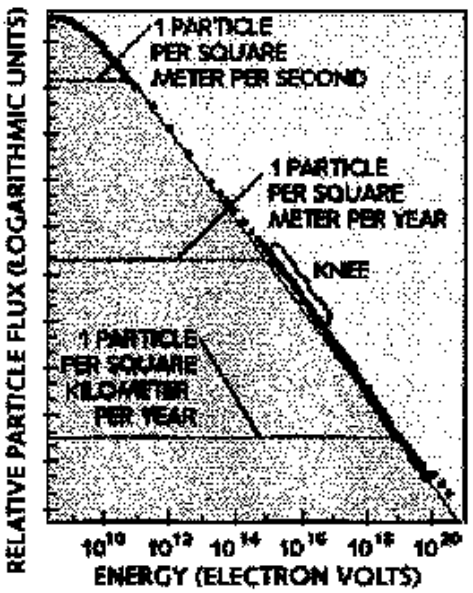
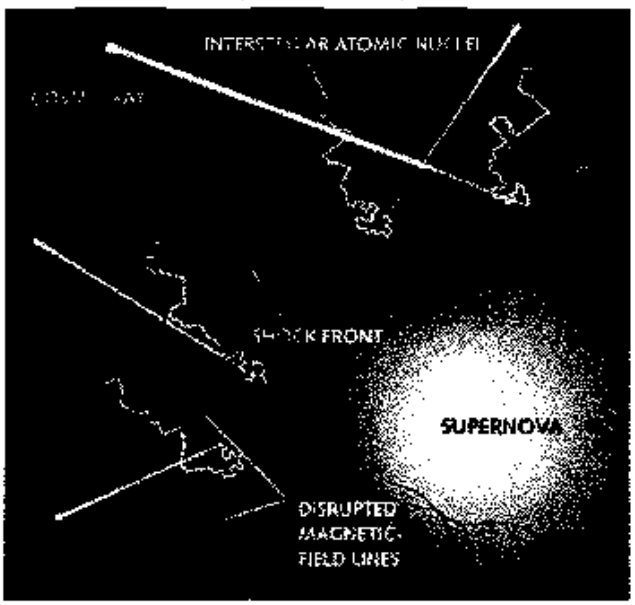
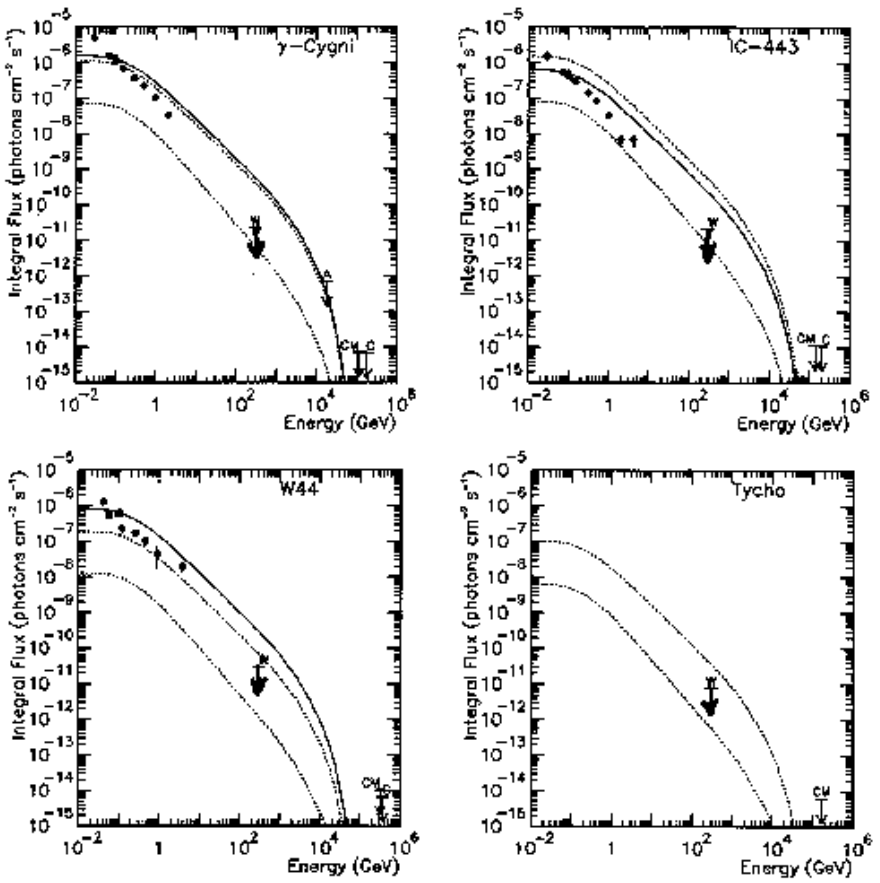
Cosmic ray problem



COSMIC RAY
ENERGY SPECTRUM



Shell type SNR limits

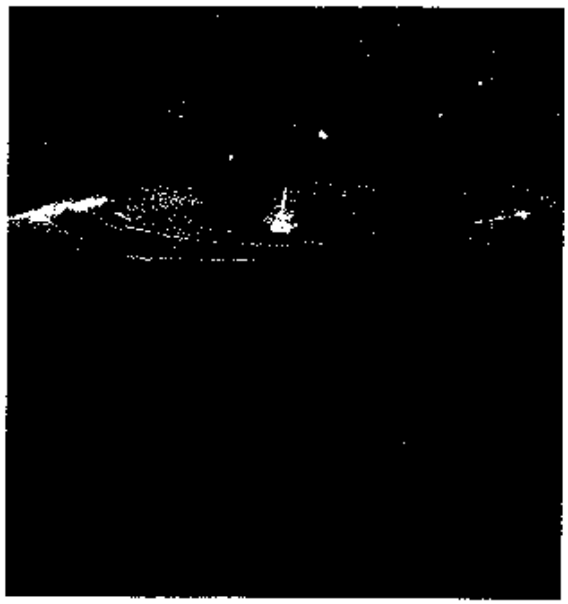


Buckley et al. (Whipple Collaboration), 1997

Why are there no high energy photons from collisions of high energy protons with interstellar matter?

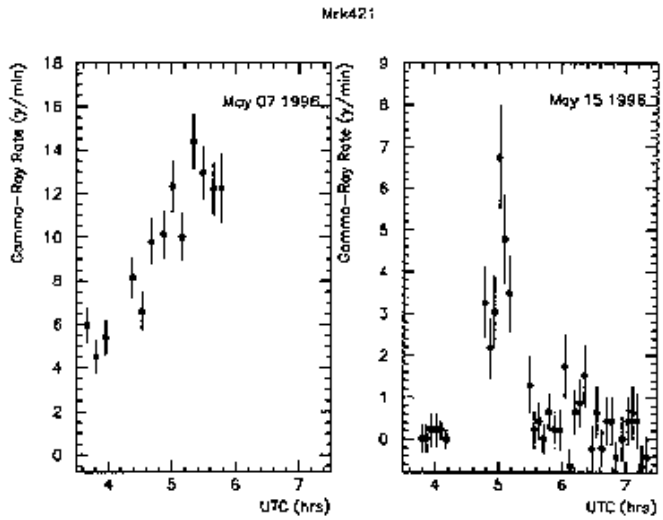
Is there something wrong with the model of cosmic ray origin in shell type supernova remnants?

Active Galactic Nuclei



- massive blackhole at center of galaxy
- rotating accretion disk
- wound up, turbulent magnetic field lines, frozen into ionized accretion disk
- twisted magnetic field lines recombine
- gravitational energy is turned into relativistic particle jet

TeV AGN variability observations



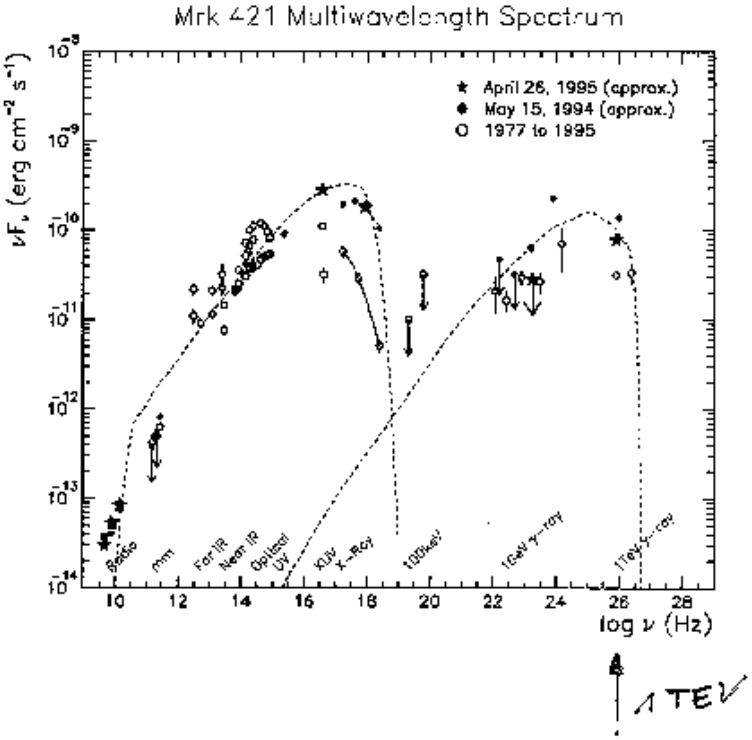
Interpretation

- Fermi process shock acceleration
- Inverse Compton scattering $e^{\pm}\gamma \rightarrow e^{-}\gamma$
  or pion decay $p + \gamma \rightarrow \Delta^{+} \rightarrow \pi^{0} + p$

Results

- emission region smaller than solar system
- electron models favoured (faster cooling)
- indirect measure of jet velocity
- study injection mechanism at the base of the jet

Multi-wavelength AGN observations

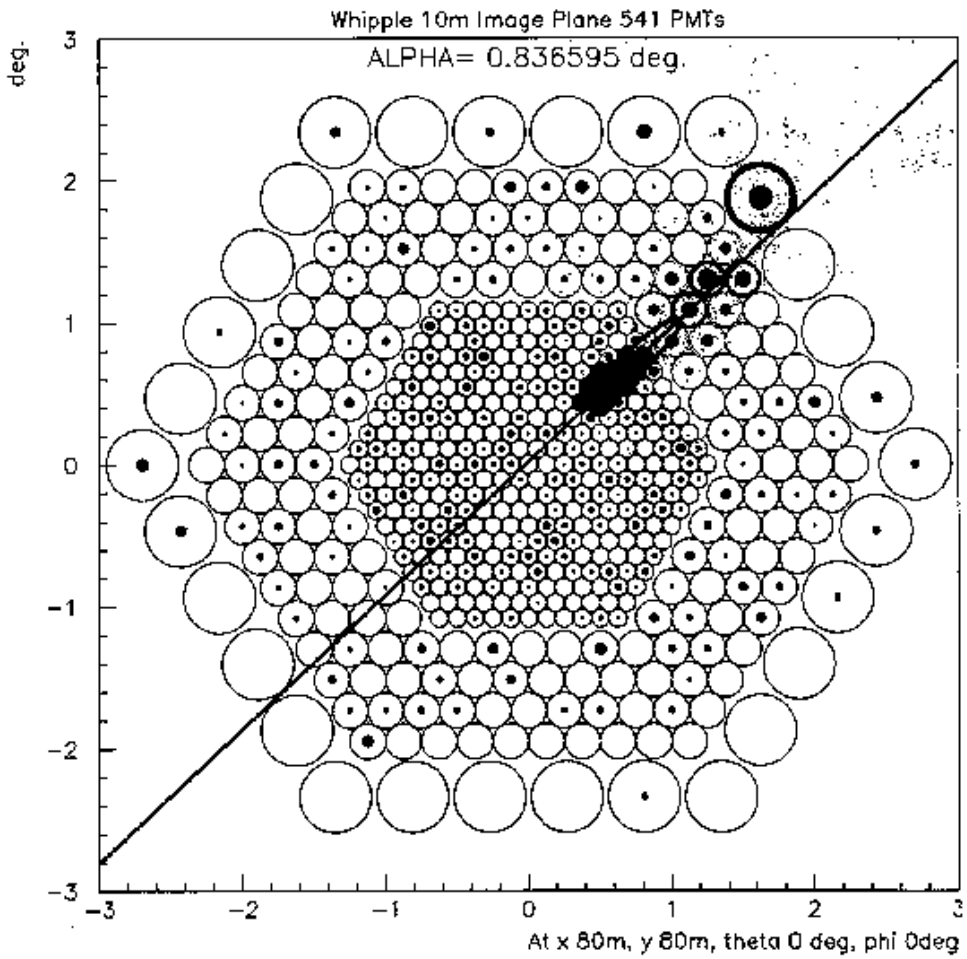


- Electron inverse Compton scattering?
- target photons are IR, UV, synchrotron?
- source of target photons external?
- proton beam and pion production?

Technology

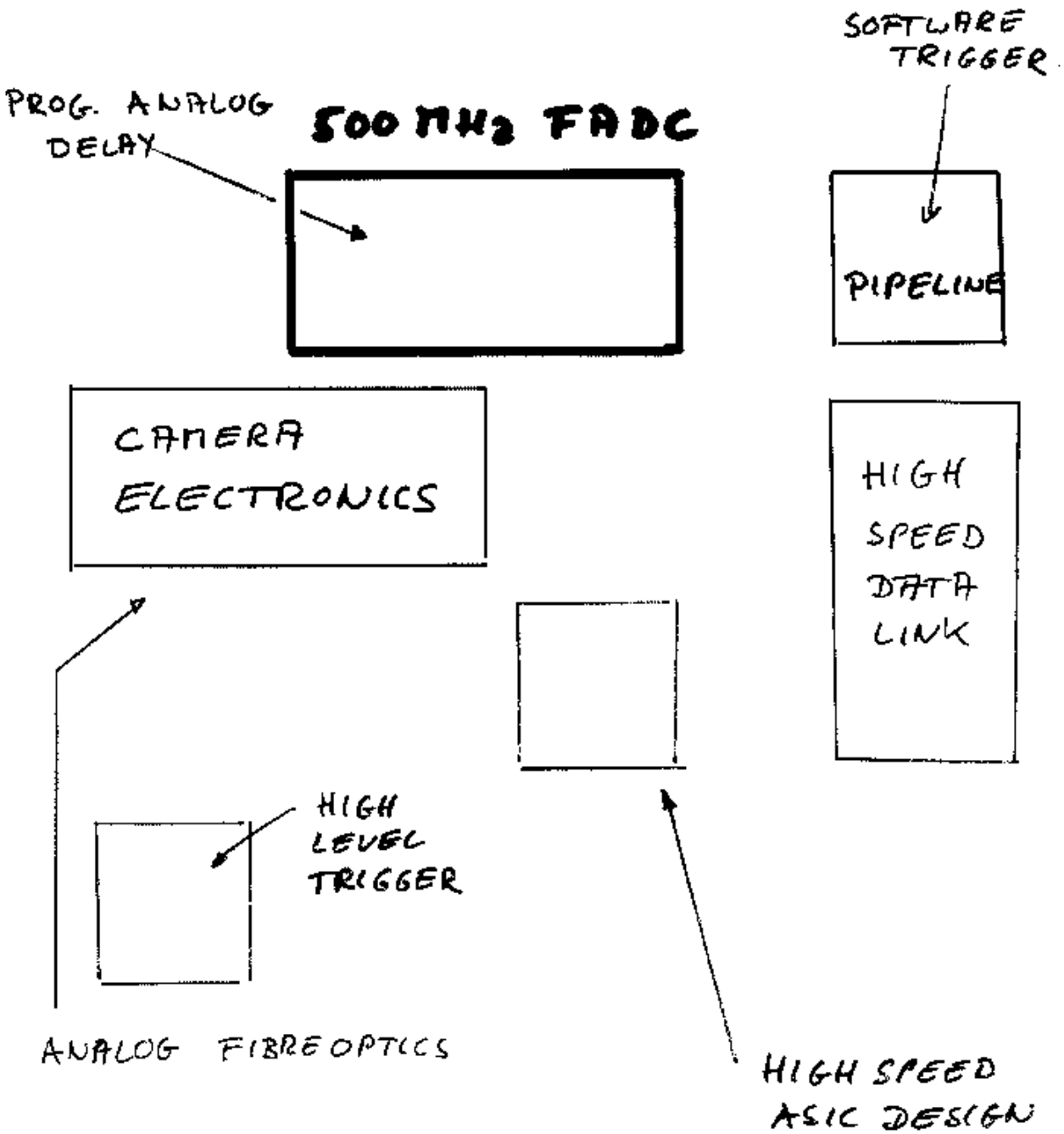
- smaller size PMTs, large channel numbers
- advanced multi-level trigger
- high quantum efficiency, fast HPMT or APD
- high bandwidth analog fibre optics
- low cost, machined aluminium mirror facets
- 500 MHz, 10 bit FADC systems
- programmable analog delays
- real time data analysis
- fast data acquisition via LANs
- adaptive optics, auto alignment
- optimised, fast Monte Carlos
- GPS precision timing
- ...

High resolution camera

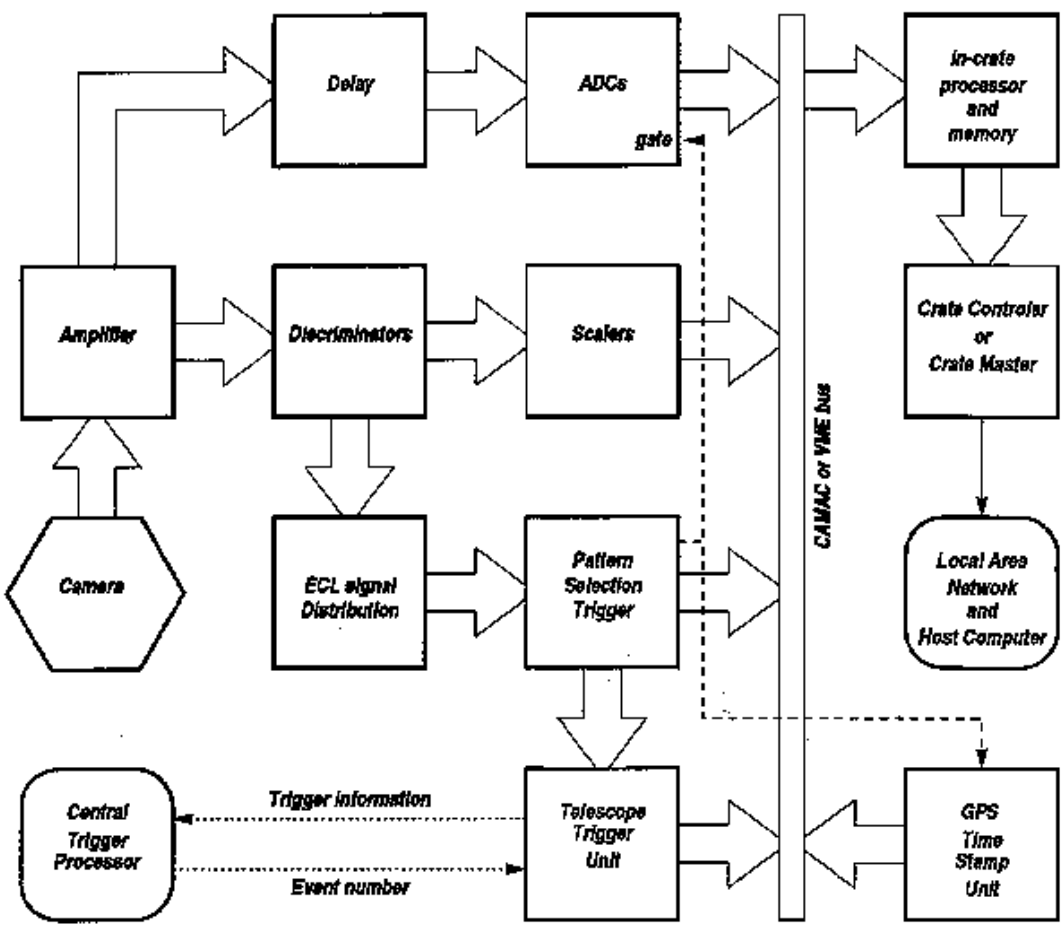


Higher quantum efficiency, fast light detectors:
hybrid phototubes or avalanche photodiodes

Low cost per electronics channel:
custom build electronics


SOFTWARE TRIGGER
PROG. ANALOG DELAY
500 MHz FADC
PIPELINE
CAMERA ELECTRONICS
HIGH SPEED DATA LINK
HIGH LEVEL TRIGGER
ANALOG FIBREOPTICS
HIGH SPEED ASIC DESIGN

Data acquisition system



Status of VERITAS

1989-1996	Imaging concept demonstrated with Whipple 10 m camera.
Mar 1996	Whipple collaboration approved for upgrade of Whipple telescope to 541 pixel camera.
Sep 1996	VERITAS proposal submitted to the Smithsonian Astrophysical Observatory.
Nov 1996	VERITAS short-listed by internal Smithsonian review committee.
Jan 1997	External review by 16 referees, highly ranked, VERITAS workshop held.
Jul 1997	VERITAS approved for support by Smithsonian
Oct 1997	Organisational meeting of VERITAS collaboration at University of Chicago (24/25 Oct), design studies, working groups
Oct 1998	Workshop on TeV Astrophysics
Oct 1999	construction starts
Sep 2003	VERITAS operational prior to GLAST launch.

Guest investigator program

New collaborators