OG 10.3.17

# The Stereoscopic System of Imaging Atmospheric Cherenkov Telescopes of the HEGRA-Collaboration

presented by

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## Overview:

1) Physics Goals
2) Stereoscopic IACT System
3) Description of the HEGRA System
4) Performance of the HEGRA System
5) Observations
6) Conclusions and Outlook

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XXV ICRC,

Durban, South Africa, 1997

# 1) Physics Goals

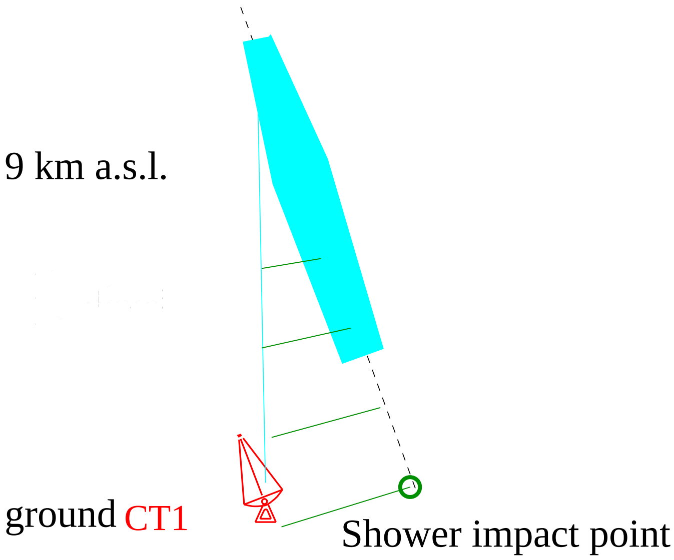
**Investigation of VHE $\gamma$-ray emission as a sensitive probe of acceleration processes**

- Cosmic ray origin ?
- Search for further TeV $\gamma$-ray sources, especially spatial extended like SNRs, $\gamma$-ray halos around AGNs
- Spectroscopic Analysis
- Observational Cosmology by spectral cutoffs due to intergalactic background fields

**required key-features of a detector:**
- high sensitivity
- angular resolution
- energy resolution
- large field of view

**$\rightarrow$ stereoscopic system of IACTs**

# 2) Stereoscopic IACT System



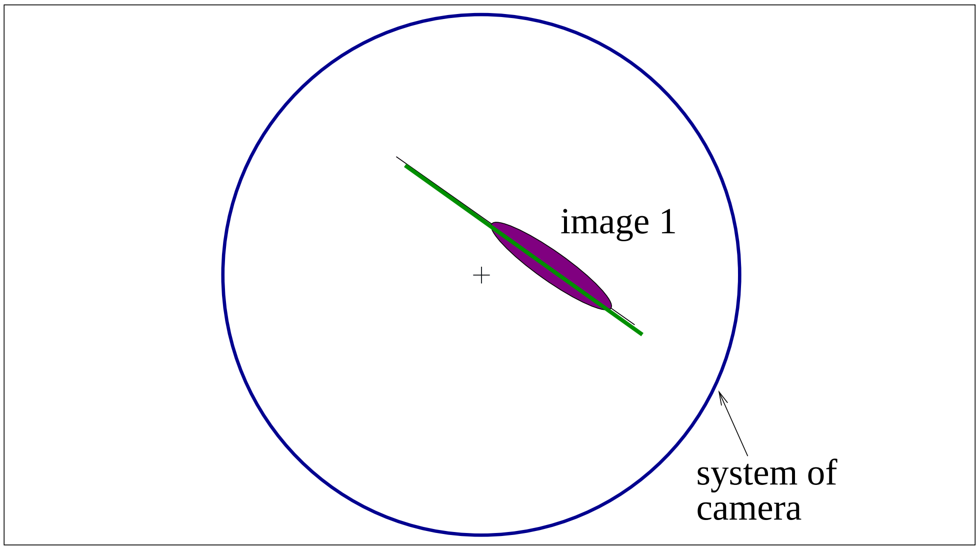
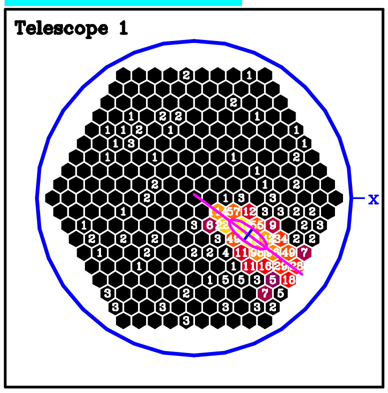
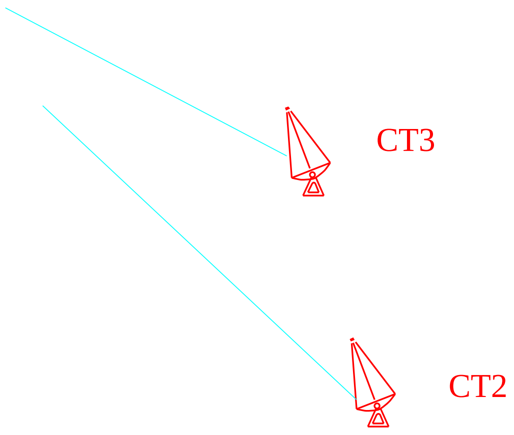
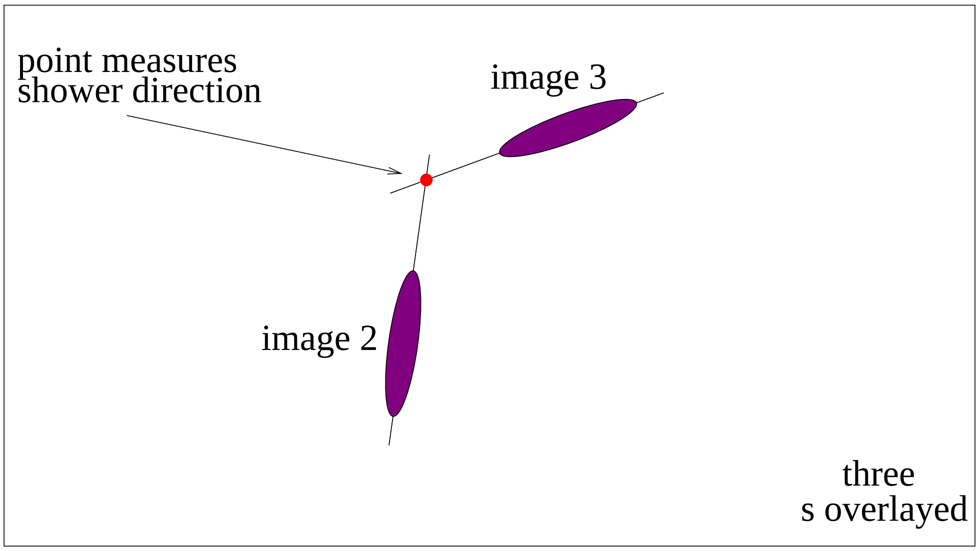



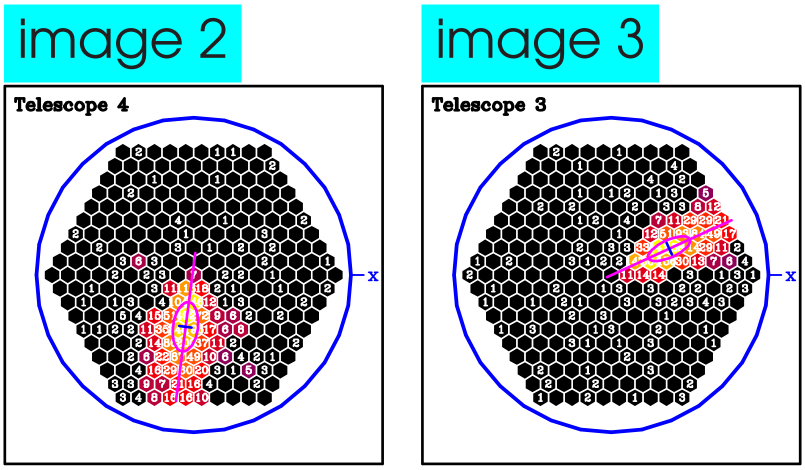

image 1



# 2) Stereoscopic IACT System



# Stereoscopic Observations

# with a IACT System

$\Rightarrow$ 3–dimensional reconstruction of air showers
on an event by event basis and
precise determination of shower parameters

| | | |
|---|---|---|
| $\rightarrow$ | Angular Resolution | $0.1^o$ |
| | Impact Position | 15 m |
| | Energy | 20 % |
| | Shower Maximum | 1 $X_0$ |

$\Rightarrow$ "Background free" detection of TeV $\gamma$-rays:

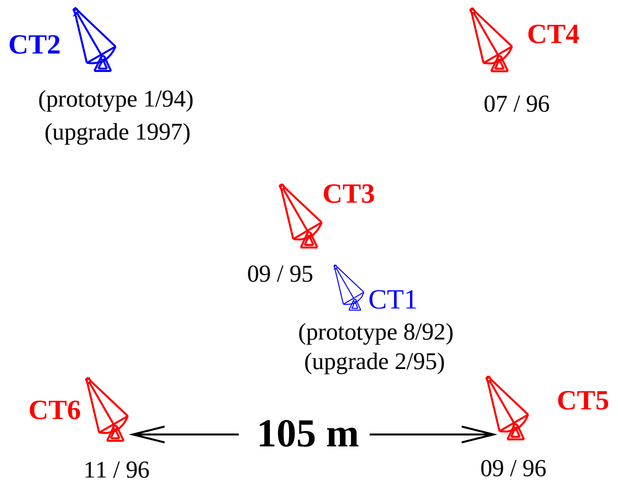
- no local muons or NSB (system trigger)
- strong hadron suppression based on image shape cuts depending on shower parameters

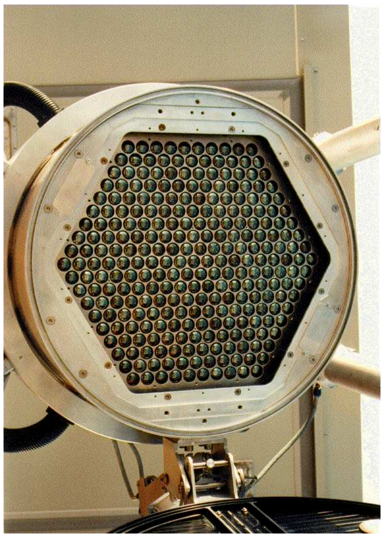
$\Rightarrow$ Investigate systematics based on redundant Information

# 3) Description of the HEGRA CT System

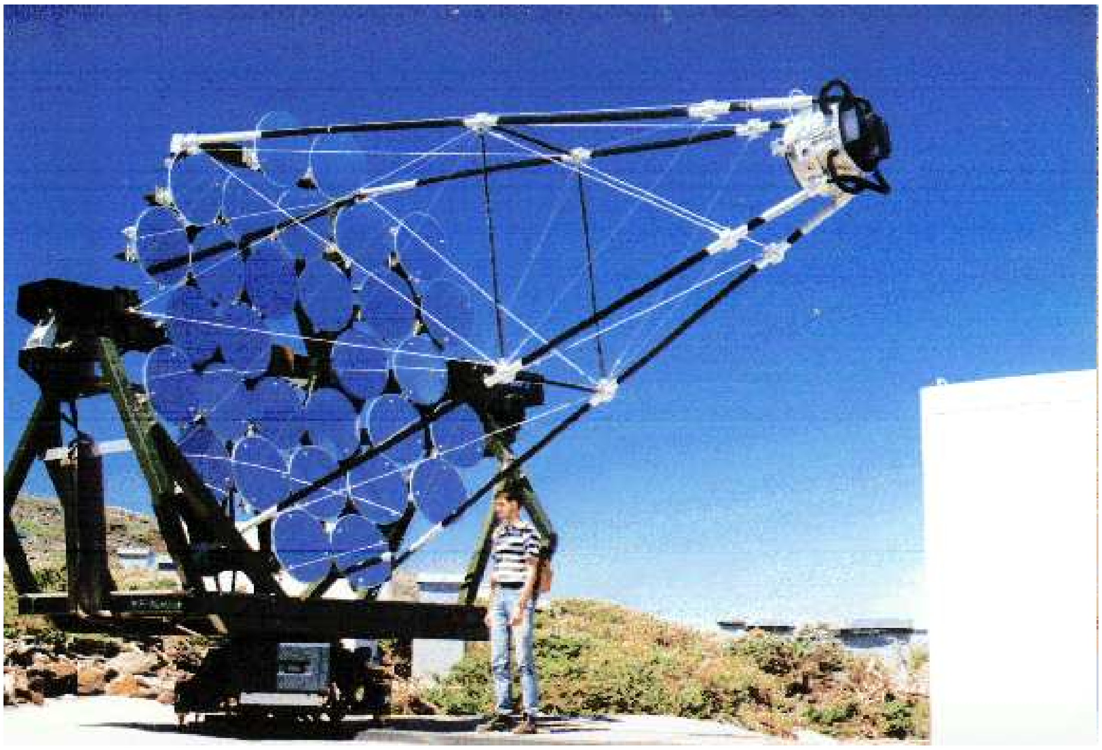
## 5 identical telescopes CT2-6;

1 central trigger station; 1 main computer for control and online event building.



PMT Camera



central telescope CT3

- **Location:** Canary Island of La Palma
  28.75$^o$N , 17.89$^o$W , 2200m a.s.l.

- **Telescopes:**

  **Reflector:** 8.5 m$^2$ mirror area;
  focal length ≈5 m; $\sigma \approx$ 3 arcmin

  **Mount:** alt-azimuth; position control 1.2 arcmin;
  stepping motors 1.2 arcsec per step.

  **Camera:** closed packed cluster of 271 PMTs;
  faced with hollow hexagonal light guides;
  pixel size = 0.25$^o$, FoV ≈ 4.3$^o$

  **Electronics:** placed nearby in a hut;
  VME standard; 120 MHz 8-bit FADC
  with 34$\mu$sec ring buffer in hardware;

  **Trigger:** 2/271 (>10mV≈ 8 p.e.)
  2/271 neighboured pixels (>8mV≈7p.e.) since July '97

- **Central Trigger Station:**

  **System Trigger:** 2/4 telescopes (70ns coincidence gate);
  cumputer controlled delays of telescope triggers;
  distribute system trigger and event number tag;

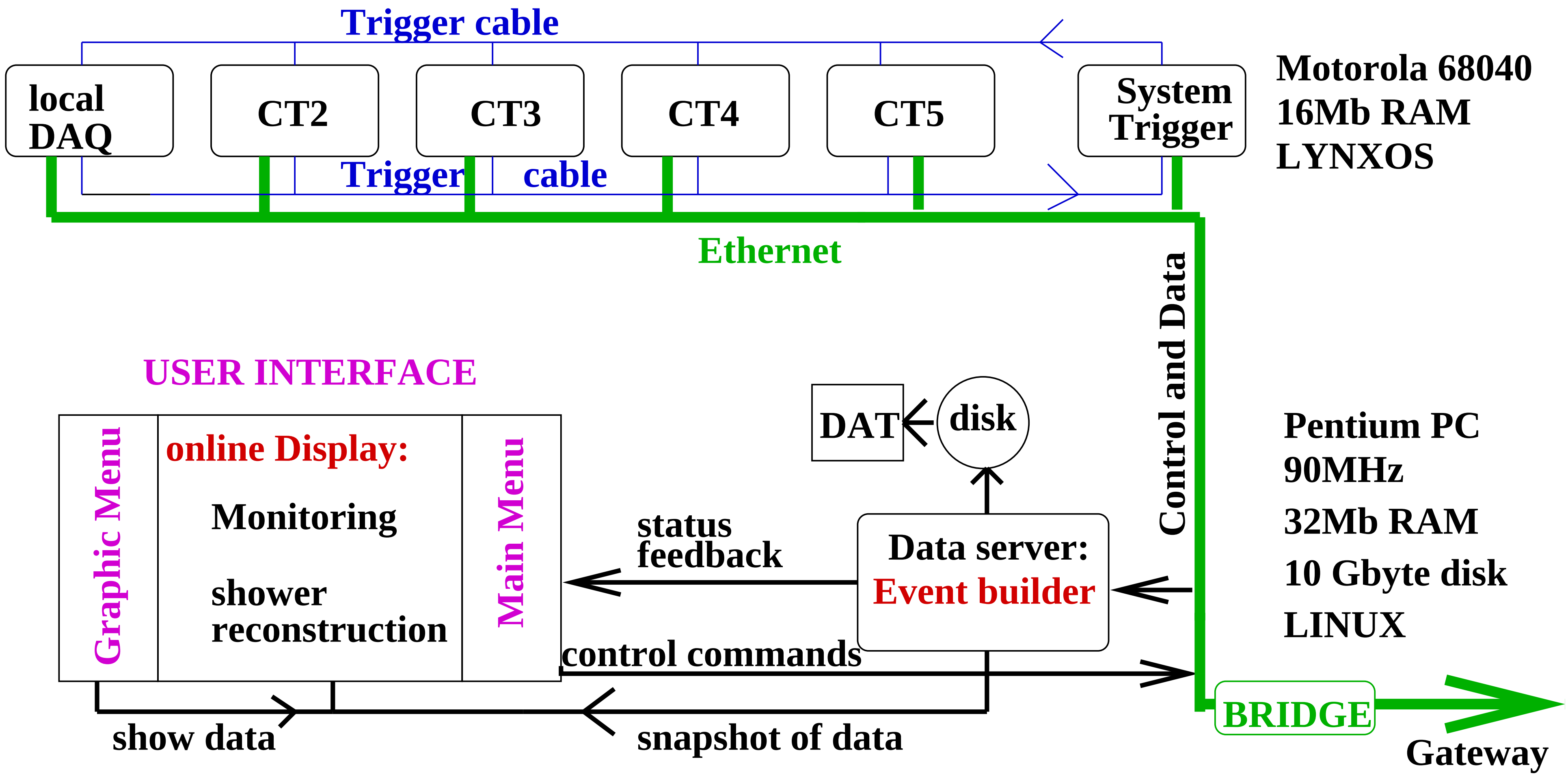
- **Control:**

  **Front End:** Motorola 86040 CPUs placed inside VME electronics; LynxOS real time system, interrupt handling, multi threading;

  **Main computer:** 90 Pentium PC; Linux System;
  online event building; graphical user interface;

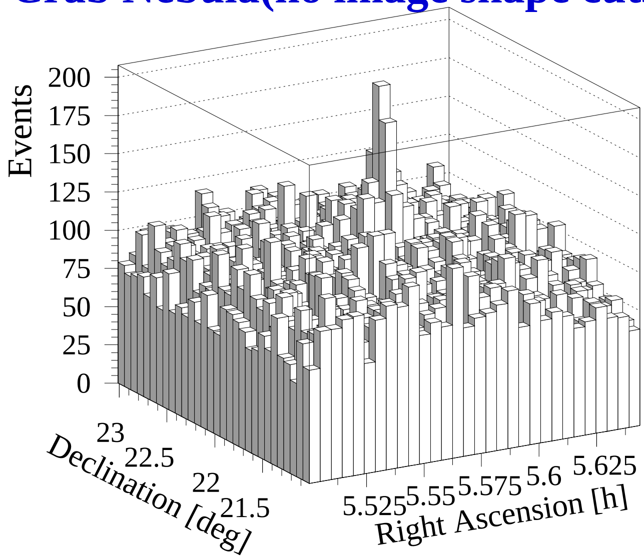
  **Software:** C source code; Tk/Tcl based mouse menus;
  VOGL based graphical display; shell scripts for control;

# Architecture of the DAQ of a 5 CT System

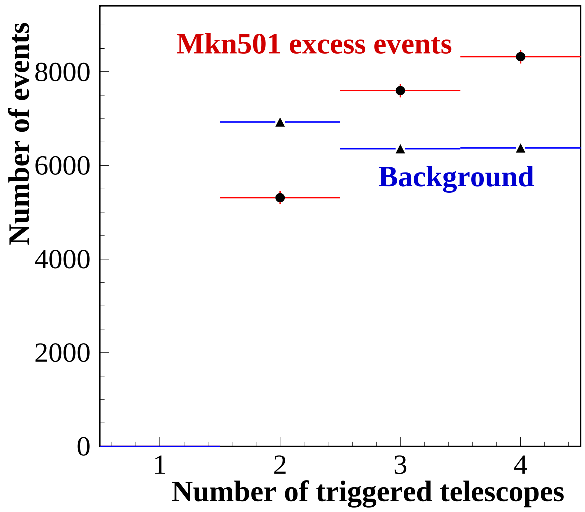


# 4) Performance of the HEGRA IACT System

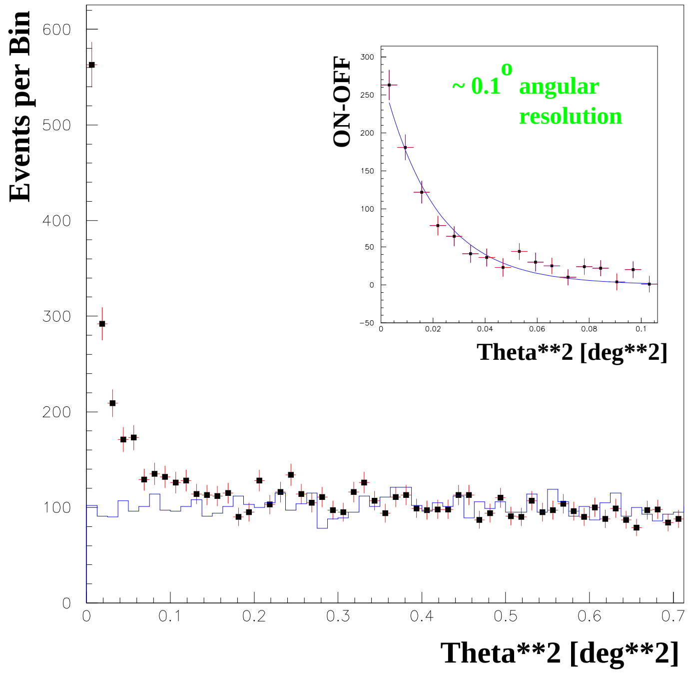
Crab Nebula(no image shape cuts)




Telescope Coincidences

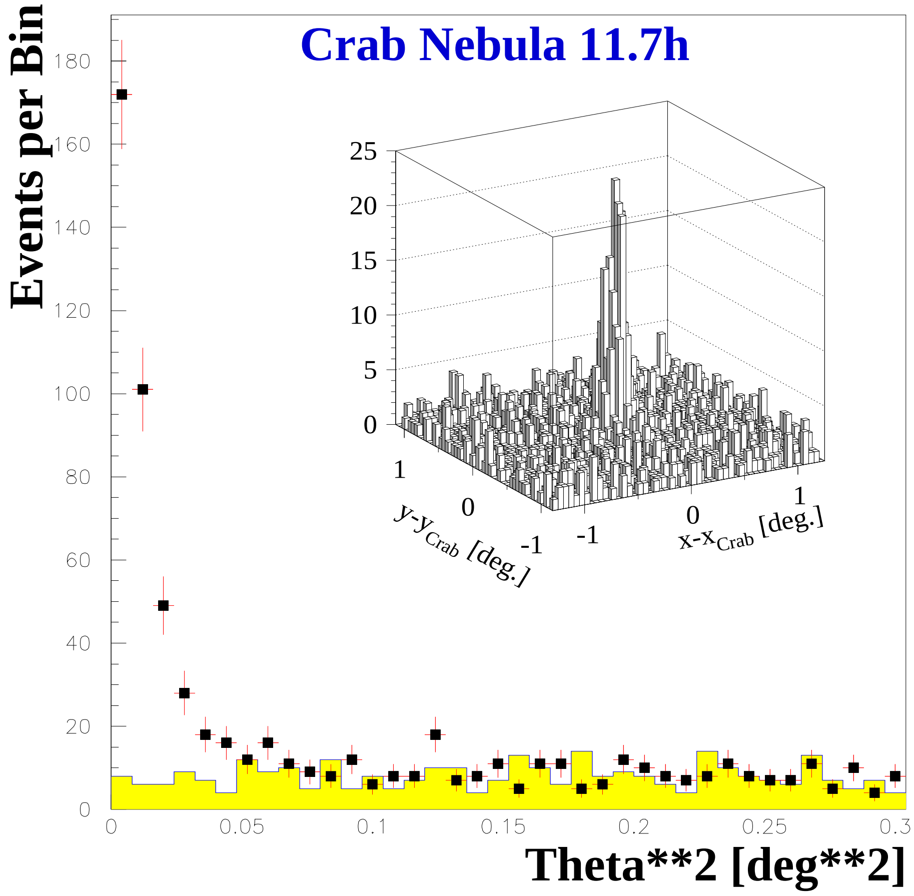



Crab Nebula ( 11.7 hours ON)




- $\approx 6\sigma/\sqrt{h}$ for a Crab Flux level;
- $\leq 0.1^o$ angular resolution of single $\gamma$;
- $0.01^o$ resolution of point source location;

# Background "free" TeV $\gamma$-ray detection




width and lenght=f(core location,amplitude,altitude)

$\Theta < 0.13^o$

$\rightarrow$ 23 excess events per hour

1.2 background events per hour

$\rightarrow$ **Flux Sensitivity of the 4 IACT System:**

Target Mode ($5\sigma$ detection in 100h):

$J_{min}$=0.03 Crab

Extended Source ($1^o$ diameter, $5\sigma$ in 100h):

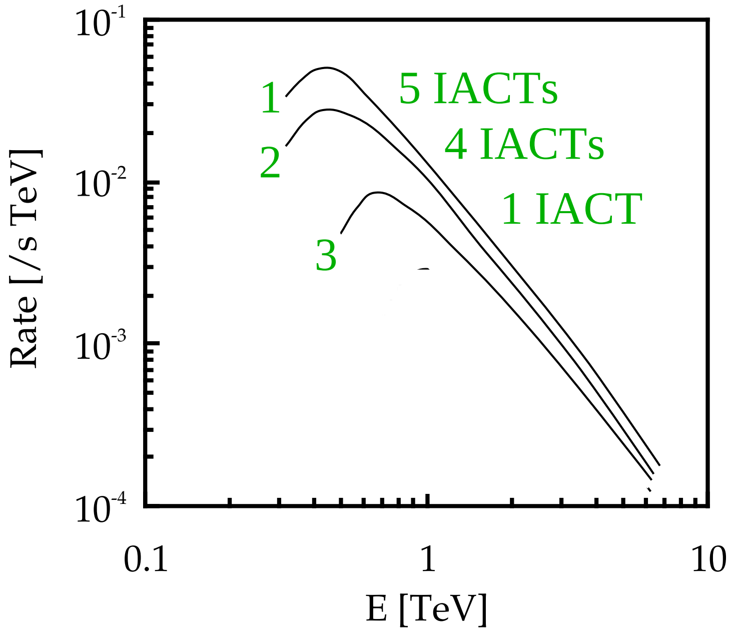
$J_{min}$=0.15 Crab

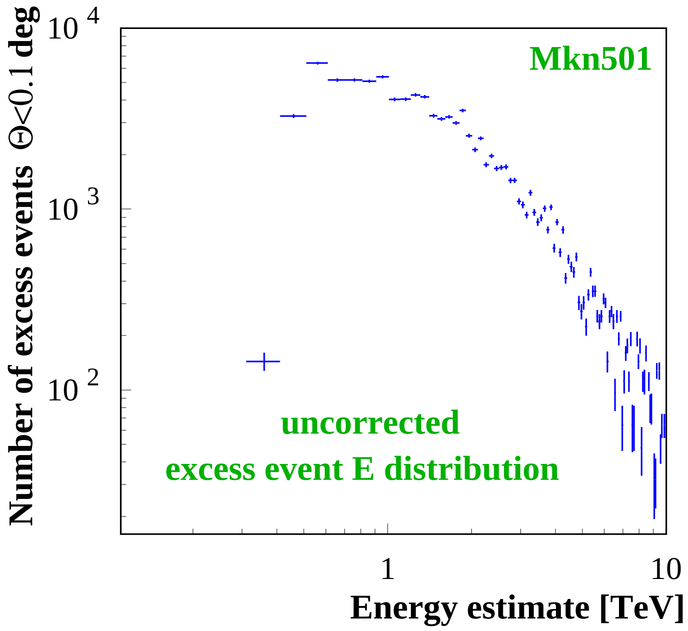
Survey Mode ($10\gamma$'s "background free" in 1 h):

$J_{min}$<0.5 Crab, (effective FoV=$2^o$x$2^o$)

# Energy Threshold

**Simulated differential detection rates**




$\rightarrow \gamma$-Energy Threshold $\approx$ 500 GeV

# 6) Observations

**TeV $\gamma$ detections:**

| | |
|---|---|
| Crab Nebula | Talk OG 10.3.19 |
| Mkn 501 | Talk OG 10.3.19 |
| Mkn 421 | |

**preliminary upper limits :**

| | |
|---|---|
| BL Lac 2202+42 | $<$ 0.21 Crab (July '97) |
| 1ES2344+514 | $<$ 0.15 Crab (Oct/Nov '96) |
| GRS1915+105 | $<$ 0.07 Crab (April-July '97) |
| G78.2+2.1 | Talk OG 4.2.5 |
| IC443 | Talk OG 4.2.5 |

Galactic Survey$(-2^o < l < 55^o, -1^o < b < 1^o)$
no outstanding point source found so far

# 7) Conclusions and Outlook

## Stereoscopic Observation Works !

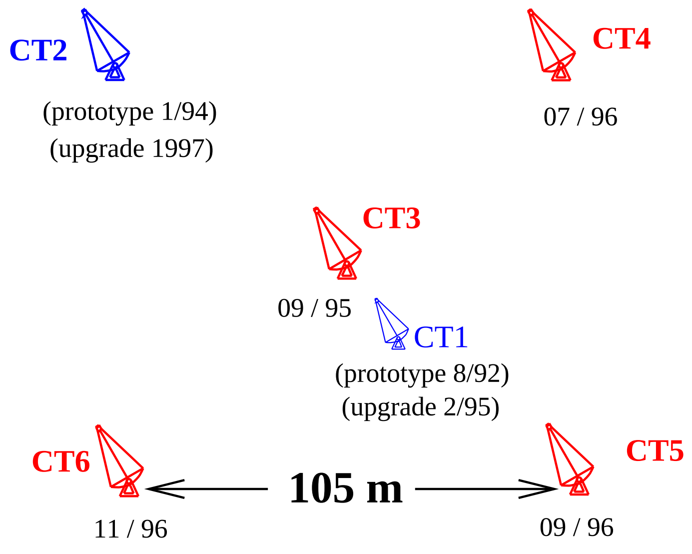
**Angular Resolution**

| | |
|---|---|
| Single $\gamma$ | $< 0.1^o$ |
| Source Location | $\approx 0.01^o$ |
| **Energy Threshold** | $\approx$ 500 GeV |
| **Energy Resolution** | $\approx$ 20% single $\gamma$ |

**Sensitivity**

| | | |
|---|---|---|
| Point Source | 3% Crab | (100 h) |
| Extended Source | 15% Crab | (100 h) |
| Survey Mode | 50% Crab | (1 h) |

Extension to a 5 IACTs System




**Ongoing investigation of systematics**
**$\Rightarrow$ "Bias free" determination of source parameters based on unambigous and redundant information of a TeV event**