The HEGRA Imaging Atmospheric Cherenkov Telescopes: Status and Observations

presented by

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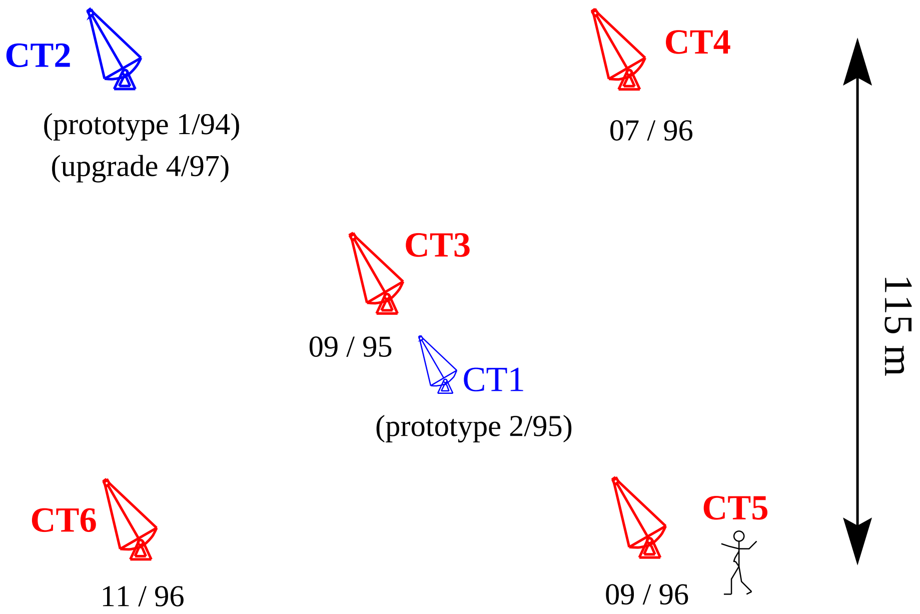
On behalf of the HEGRA–Collaboration

XXXIIeme Rencontres de Moriond

Very High Energy Phenomena in the Universe

Les Arcs, January 18-25, 1997

HEGRA Telescope System



System Telescopes: CT3 – CT6, CT2

Mirror: 8.5 m^2
Camera: 271 Pixels (0.24^o), FoV: 4.6^o
61 Pixels (0.43^o), FoV: 3.6^o (CT2)

Prototype Telescope: CT1

Mirror: 5.0 m^2
Camera: 127 Pixels (0.24^o), FoV: 3.2^o

$\longrightarrow$ **First stereoscopic observations**

$\longrightarrow$ **Results from single–CT observations**

Single CT–Observations

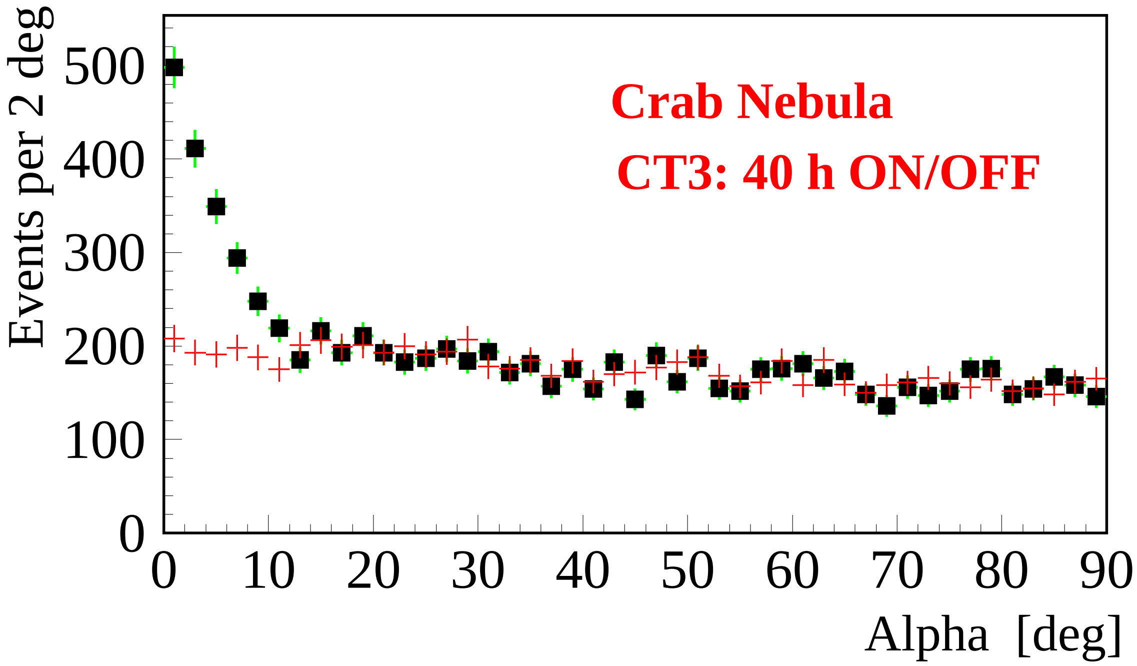
Telescope Parameters

→ Crab as *Calibration Source*

CT	Active	E_{thr}(TeV)	Γ_γ(h^{-1})	$\sigma/\sqrt{h}$	Φ_{min}($cm^{-2}s^{-1}$)
#1	> 02/95	1.5	8	1.5	$6 \cdot 10^{-12}$
#2	> 01/94	1.0	14	1.1	$8 \cdot 10^{-12}$
#3	> 09/95	<0.8	28	2.3	$4 \cdot 10^{-12}$

$\left.\begin{array}{l}\gamma\text{–Rate}\\ \sigma/\sqrt{h}\end{array}\right\}$ for Crab Observation (after Cuts)

$\Phi_{min} = \Phi_{min}(E > 1\text{TeV}, 50\text{ h}, 5\sigma)$



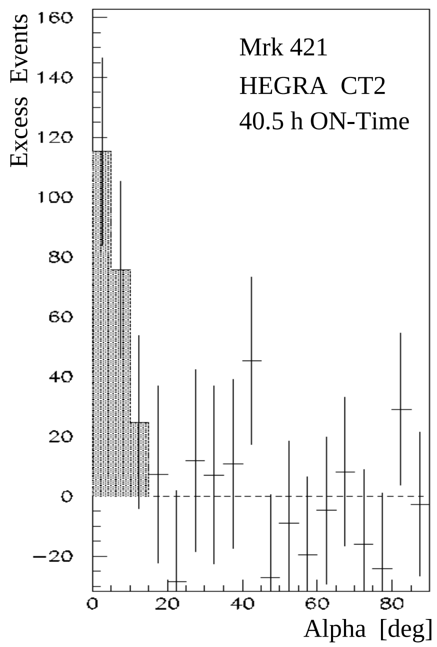
→ Mrk421, Mrk501, GRS1915

Markarian 421

Petry et al.: A&A **311**, L13-L16 (1996)

First Detection: Whipple, Punch et al.: Nature **358**, 477 (1992)

Observing Telescopes: CT1 and CT2 (independently)
Periode: Dec. 1994 – May 1995
Mode: ON/OFF
Analysis: Standard 2^{nd}–Moment Analysis



$\Theta < 25^o$

		CT1	CT2
T(h)	:	26	41
Excess	:	111	218
Rate (h^{-1})	:	4.0±1	5.4±1.3
σ	:	4.0	4.2

→ 5.8σ combined significance
First independent confirmation

Flux $\Phi(E > 1\text{TeV}) = 8(\pm 2)_{stat} \left({+6 \atop -3}\right)_{sys} \cdot 10^{-12}\ \text{cm}^{-2}\ \text{s}^{-1}$

Spectrum $\alpha_{diff} = 3.6 \pm 1.0$

No Flares observed (→ marginal statistics)

→ CT3–Data (March 1996–Mai 1996), analysis in progress

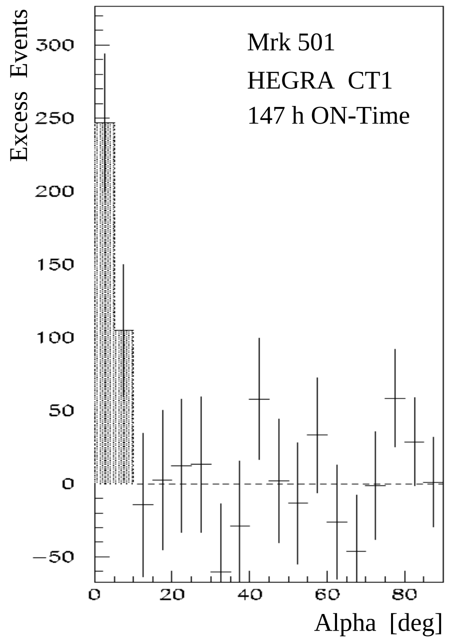
→ Stereoscopic Observation in 1997

Markarian 501

Bradbury et al.: submitted to A&A

First Detection: Whipple, Quinn et al.: ApJ. **456**, L83-L86 (1996)

Observing Telescopes: CT1
Periode: March 1996 – August 1996
Mode: Tracking
Analysis: Standard 2^{nd}–Moment Analysis



$\Theta < 25^o$

		CT1
T_{on}(h)	:	147
T_{off}(h)	:	86
Excess	:	351
Rate (h^{-1})	:	2.4±1
σ	:	5.2

First independent confirmation

Flux $\Phi(E > 1.5\mathrm{TeV}) = 2.3(\pm 0.4)_{stat} \left({}^{+1.5}_{-0.6}\right)_{sys} \cdot 10^{-12}\ \mathrm{cm}^{-2}\ \mathrm{s}^{-1}$

Spectrum $\alpha_{diff} = 2.6 \pm 0.5$

No Flares observed (→ marginal statistics)

GRS 1915+105

Observing Telescopes:	CT2, CT3
Periode:	March 1996 – August 1996
Mode:	Tracking and ON/OFF
Analysis:	Standard 2^{nd}–Moment Analysis

CT2–analysis:	ON–source:	70.8 h
	OFF–sample:	11.5 h GRS–OFF
		15.7 h Others

$\rightarrow$ 4.7 σ evidence
$\rightarrow$ needs confirmation

CT3–analysis:	ON–source:	74.8 h
	OFF–sample:	12.6 h GRS–OFF

$\rightarrow$ Perpignan Symposium: positive evidence

BUT: problems with some pixels
$\rightarrow$ may fake γ–rays
analysis in progress

No definitive statement possible at present !

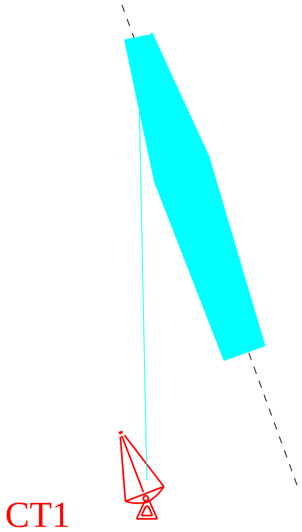
Stereoscopic Observations

⇒ 3–dimensional reconstruction of air showers on event by event basis and accurate determination of the shower parameters.

→ Direction	0.1^o
Core Position	15 m
Energy	20 %
Shower Maximum	$1\ X_0$

What does it mean ?

- Enhanced sensitivity for pointlike sources
- Resolution of extended soures
- Possibility to detect sources off-axis
- 'Accurate' measurement of spectra
- Improved background suppression:
  - → No night sky triggers
  - → No local muons
  - → Improved hadron rejection, due to energy/distance dependent cuts.


CT1

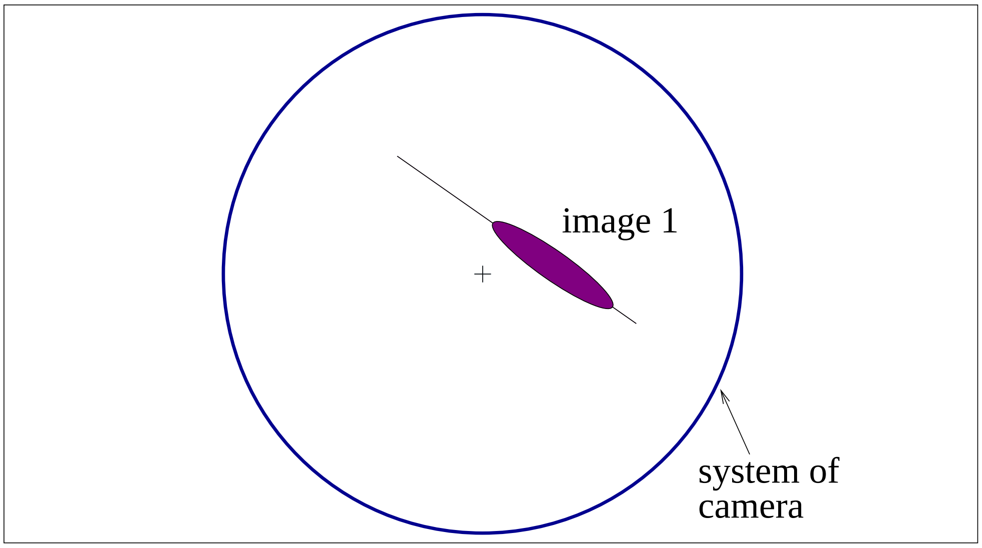


image 1
system of
camera

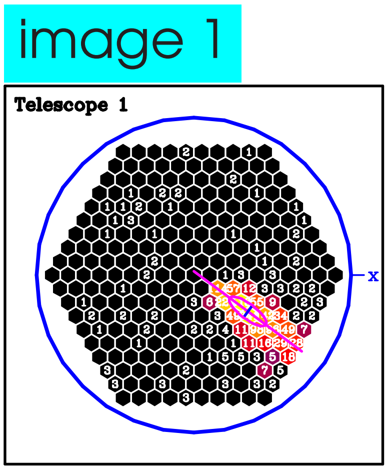
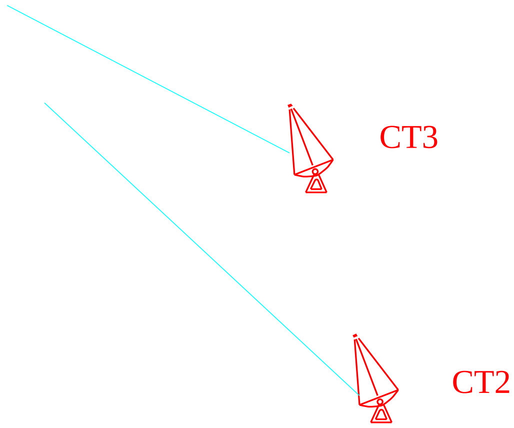
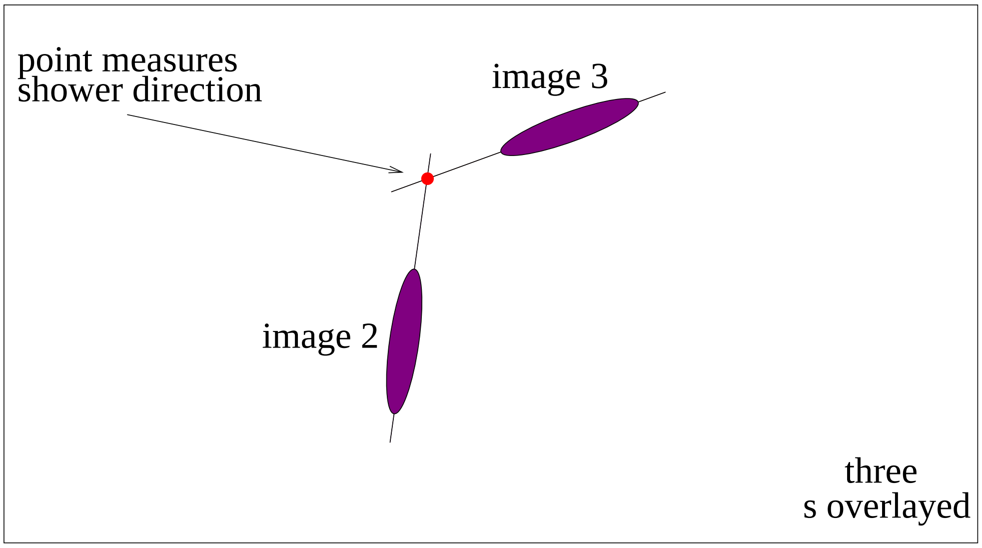


image 1
Telescope 1
x


CT3
CT2


point measures
shower direction
image 3
image 2
three
s overlayed

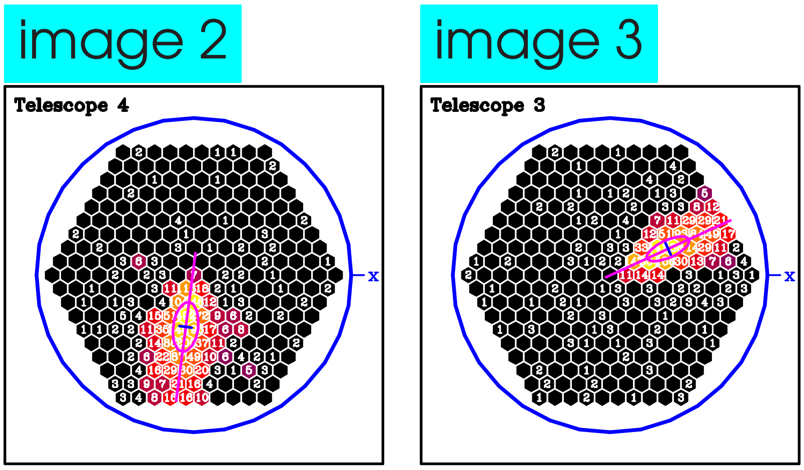


image 2
image 3
Telescope 4
Telescope 3
x
x

First Stereoscopic Observations of the Crab Nebula

$\Rightarrow$ Preliminary performance test

2 Datasets:

1) Sept./Oct. 1996: 3 Telescopes
   8.7 h ON/OFF–Time;
   Electronics in intermediate stage

2) December 1996: 4 Telescopes
   2 h ON/OFF–Time;
   3 CTs with final electronics; 1 CT intermediate

Trigger: Coincidence 2/N CTs

Single CT: 2 Pixels $>$ 8 p.e. (10 mV)

System Rate: N = 3 $\Rightarrow$ 9 Hz

N = 4 $\Rightarrow$ 12 Hz

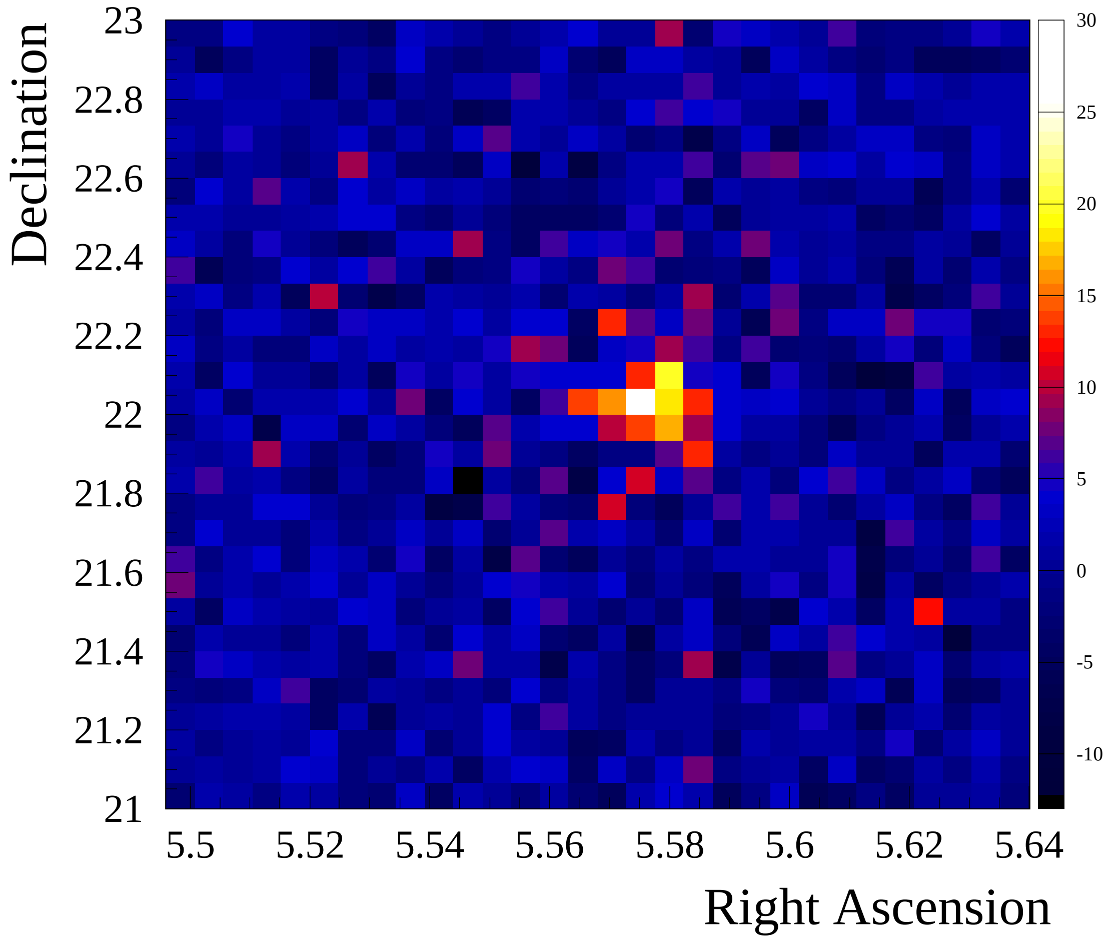
Analysis: First glance

$\rightarrow$ Starting from CT3–experience

Second Moment + geometrical reconstruction

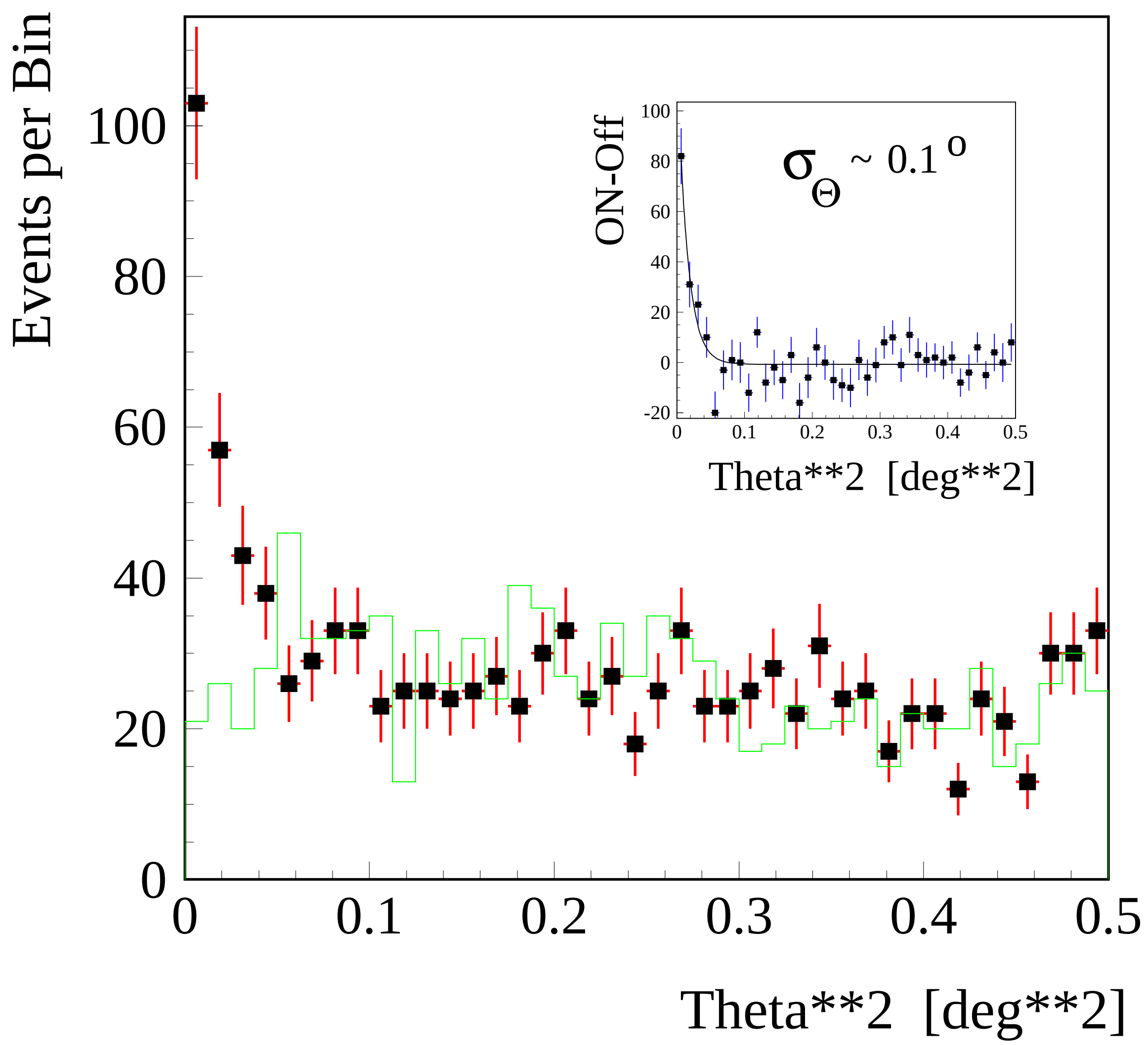
Full reconstruction of the direction of individual showers

ON–OFF excess events $\rightarrow$ Crab Nebula



Angular Resolution of the System

Dataset 2: 4 CTs; 2 h ON/OFF Time



$\rightarrow$ 136 $\pm$16 Excess Events
68 Events/hour
6 σ/h

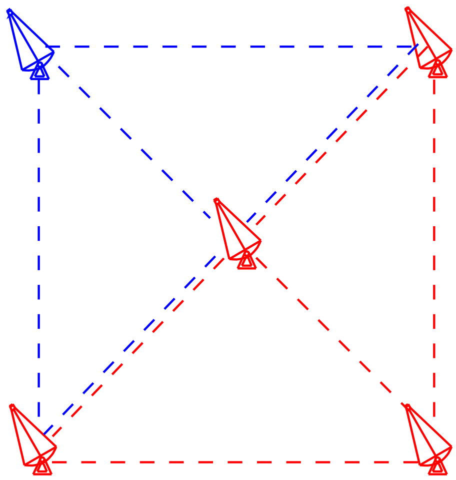
Summary and Outlook

Stereoscopic Observation works !

Angular resolution $\approx 0.1^o$
Enhanced sensitivity 6 $\sigma/\sqrt{h}$; $\approx$ 70 γ/h^{-1} (Crab)
Energy threshold $\approx$ 500 GeV

$\rightarrow$ **Expected for 5 CT–System :**

Angular resolution $< 0.1^o$
Sensitivity $\approx$ 8–10 $\sigma/\sqrt{h}$
Φ_{min} (E>1 TeV)$\approx$
10^{-12} cm^{-2}s^{-1}



Single CT–Observation

Successfull detection of :
Markarian 421 and
Markarian 501