



H.E.S.S.

High Energy Stereoscopic System

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Durham Univ.
Dublin Inst. for Adv. Studies
Charles Univ., Prag
Yerewan Physics Inst.
Univ. Potchefstroom
Univ. of Namibia, Windhoek**



Physics with H.E.S.S.

Cosmic ray origin and acceleration

- Supernova remnants
- Starburst galaxies
- Unidentified galactic sources/surveys
- Clusters of galaxies

Astrophysics of compact objects

- AGNs
- Micro-Quasars & Stellar-mass black holes
- Pulsars
- Gamma ray bursts

Cosmology

- Diffuse extragalactic radiation fields via cutoff in AGN spectra and AGN halos
- Clusters of galaxies

Astroparticle physics

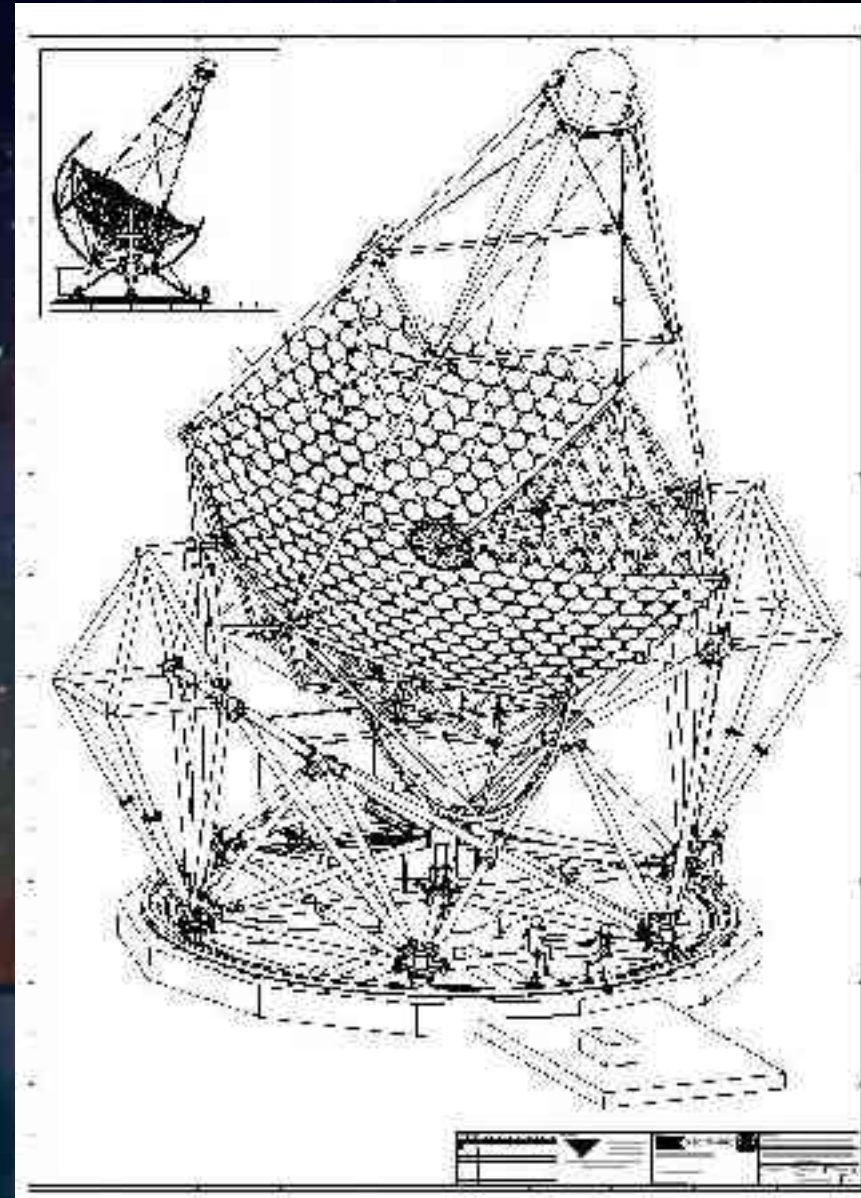
- Neutralino annihilation in DM halos



H.E.S.S. telescope design

- Alt-azimuth mount
- Mirror area $\sim 107 \text{ m}^2$, diameter 13 m, focal length 15 m
- Mirror segmented into 380 individual mirrors of 60 cm diameter
- Steel spaceframe

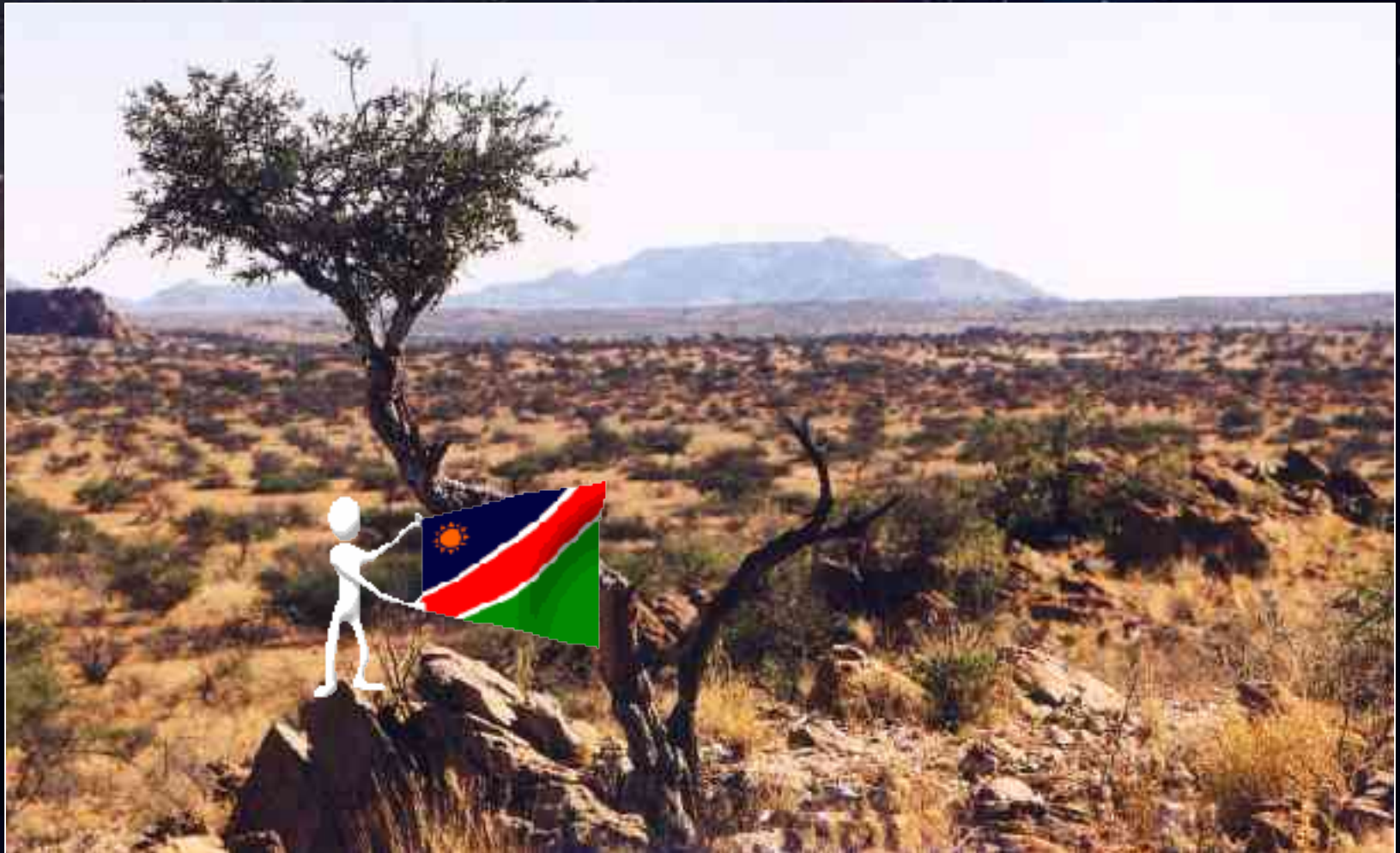
In phase I of the experiment
4 such telescopes,
spaced by 120 m



The site

Farm Goellschau, Khomas Highland, Namibia

Coordinates 23°16' S, 16°30' E, 1800 m asl
100 km from Windhoek





Installation

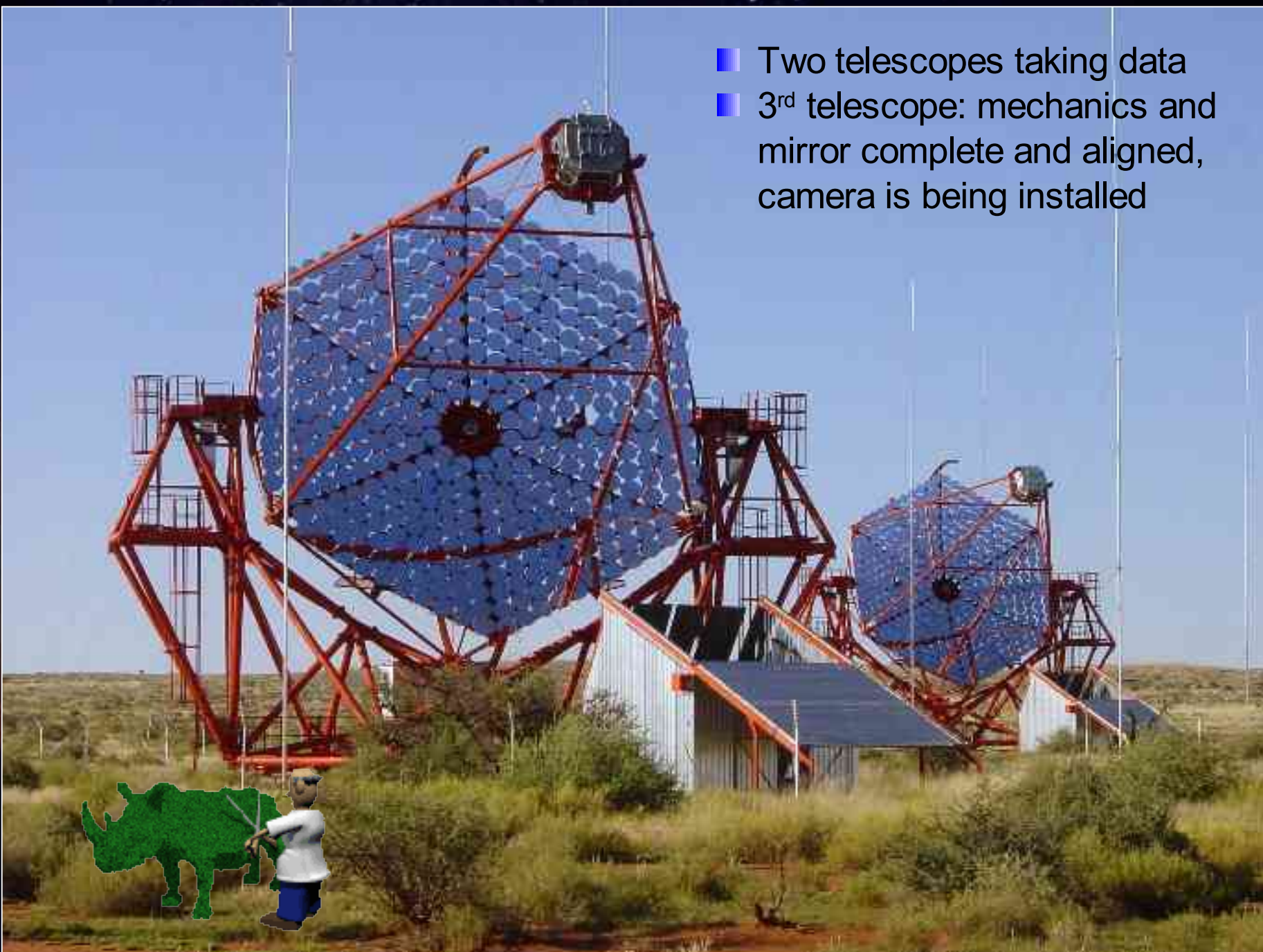




Infrastructure

- Control building
- “Residence”
- Generators, Microwave link, ...

- Two telescopes taking data
- 3rd telescope: mechanics and mirror complete and aligned, camera is being installed

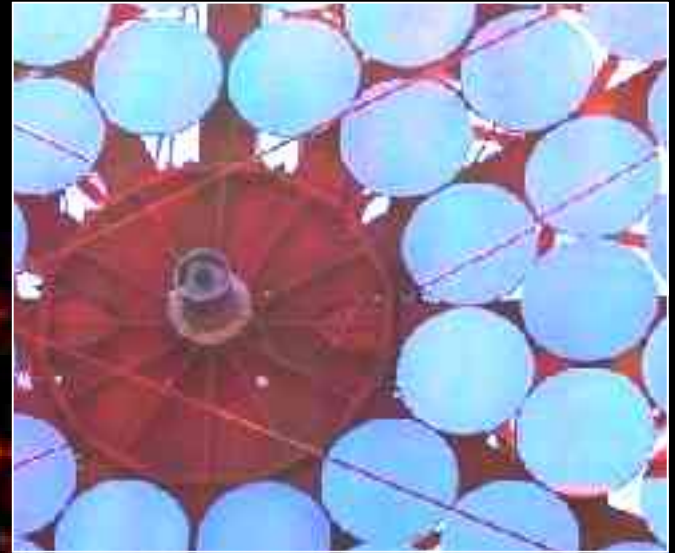


August 30

■ 4th telescope: mirrors are installed, camera follows in December



Optics



before alignment

- Spot well within one pixel
- Spot size changes very little with telescope pointing
- Psf well understood, reproduced by simulations
- All telescopes identical
- Psf stable over > 1 y, no re-alignment required
- Absolute pointing good to $\sim 10''$, $2-3''$ with guide telescope



after alignment

Camera

960 Pixels of 0.16°

5° Field of view (1.4 m)

Readout integrated in camera body

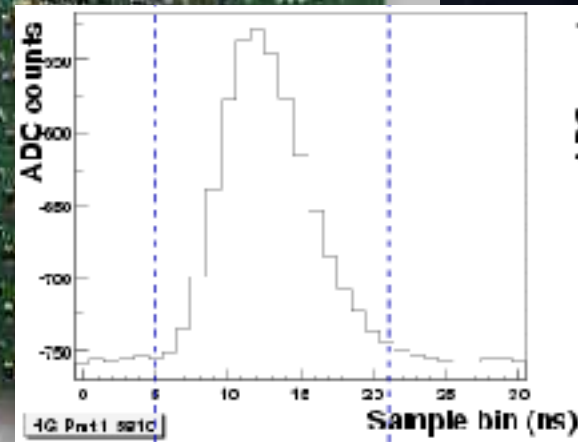
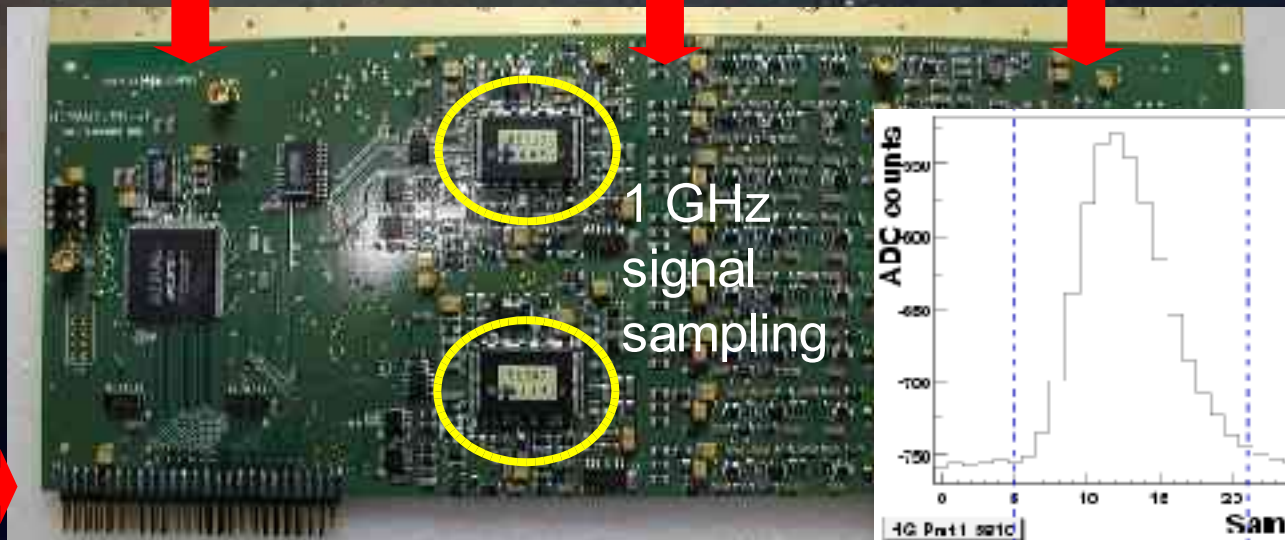




Digital signal processing

Analog signal processing

Trigger circuitry

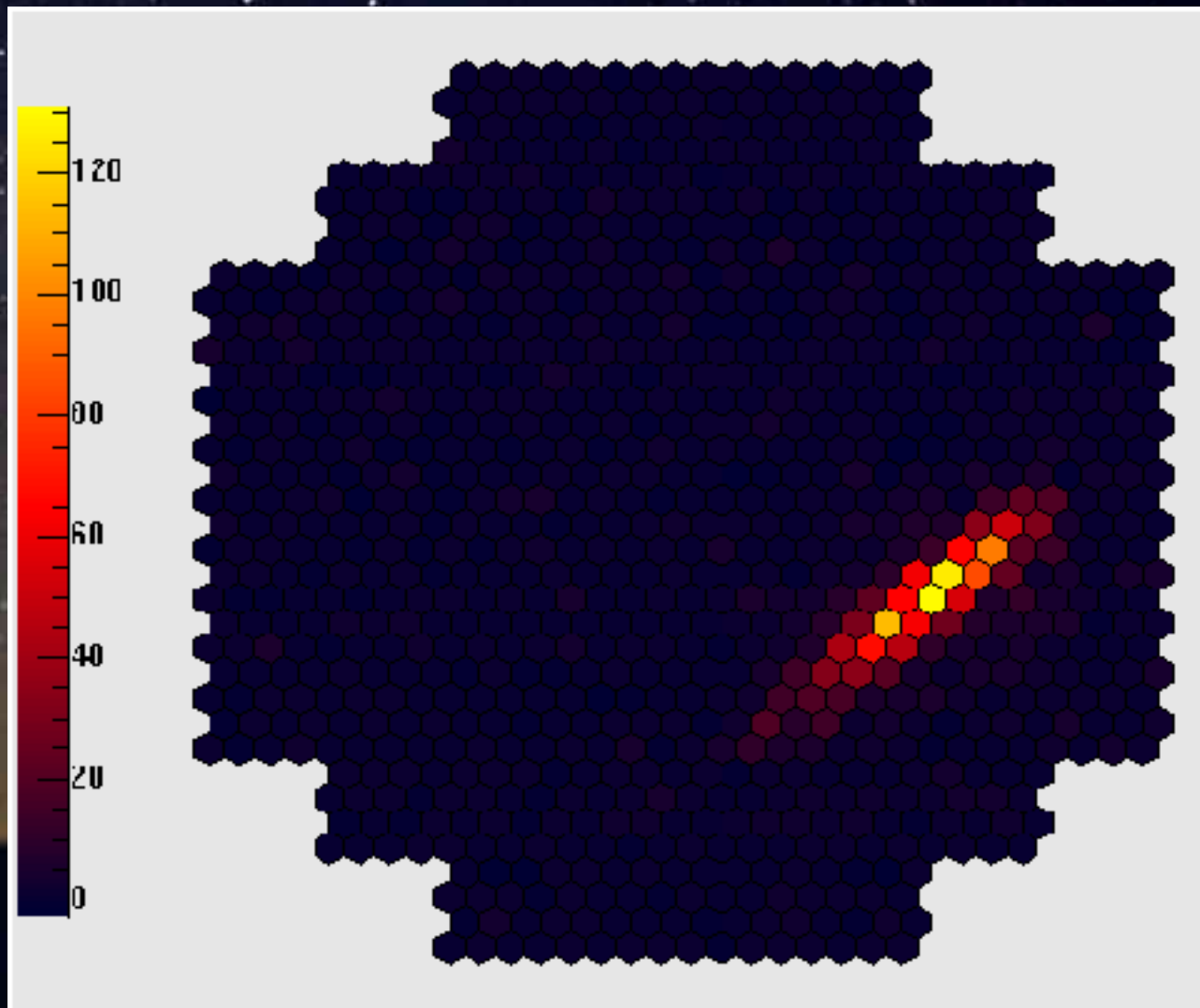




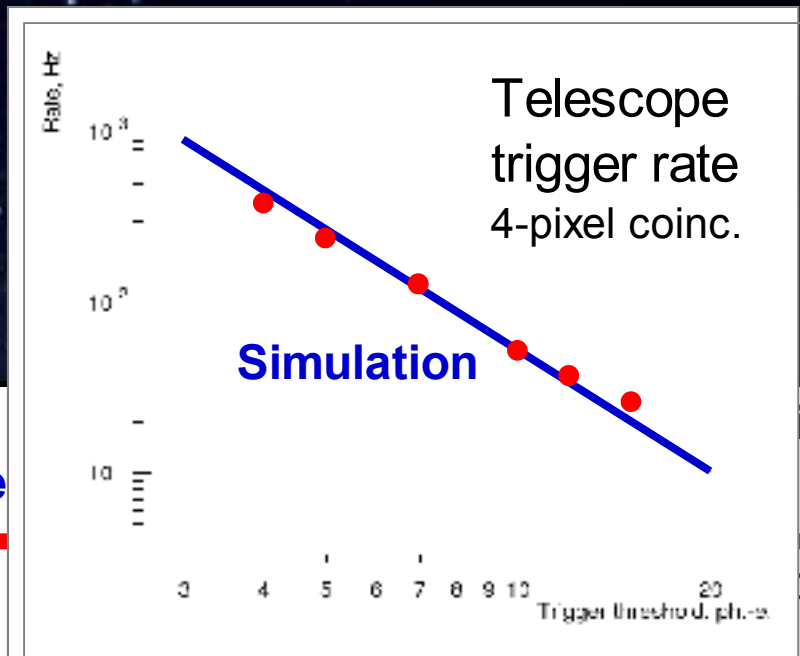
Operation



First events (June 11, 2002)

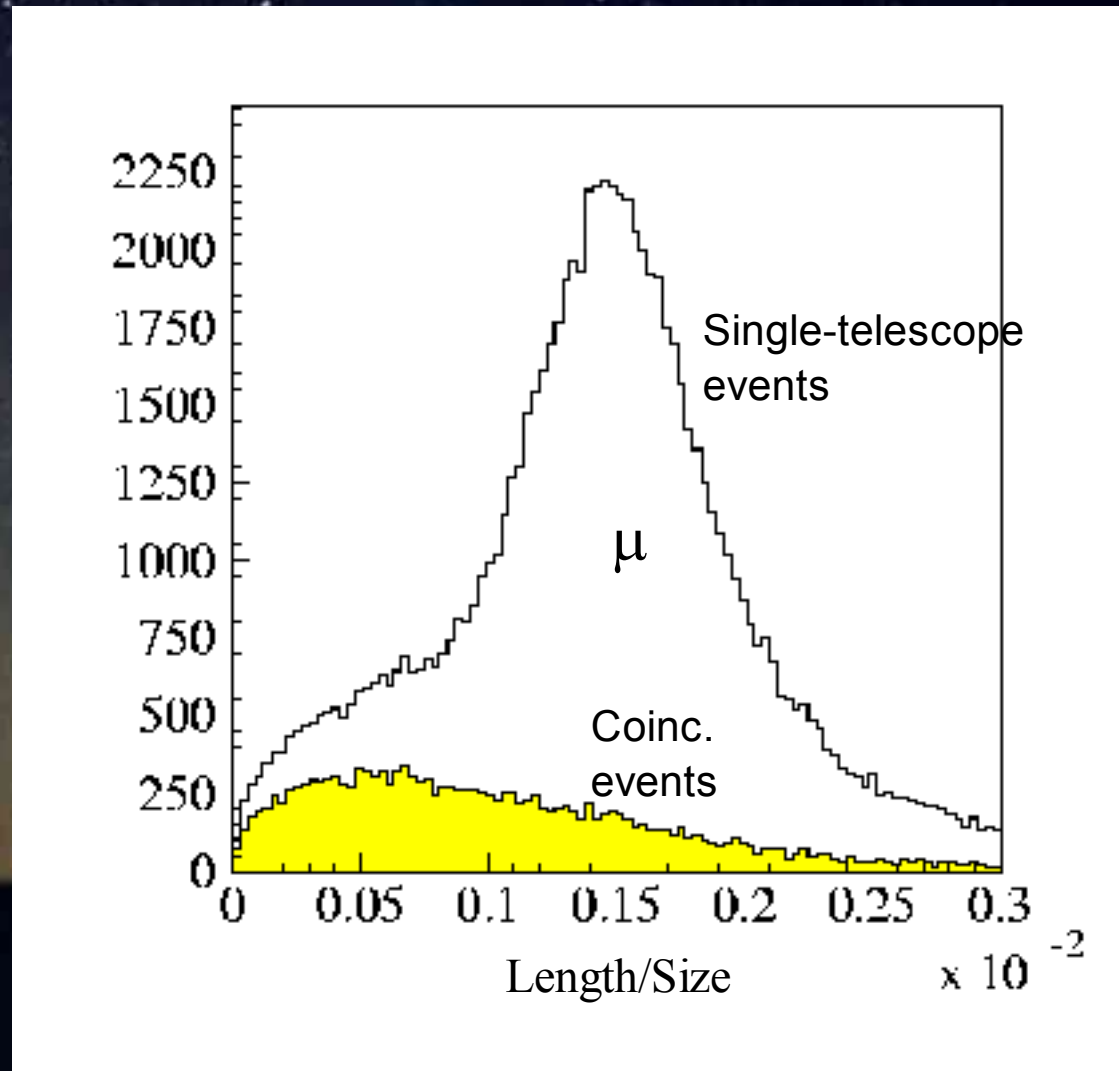


Trigger and DAQ

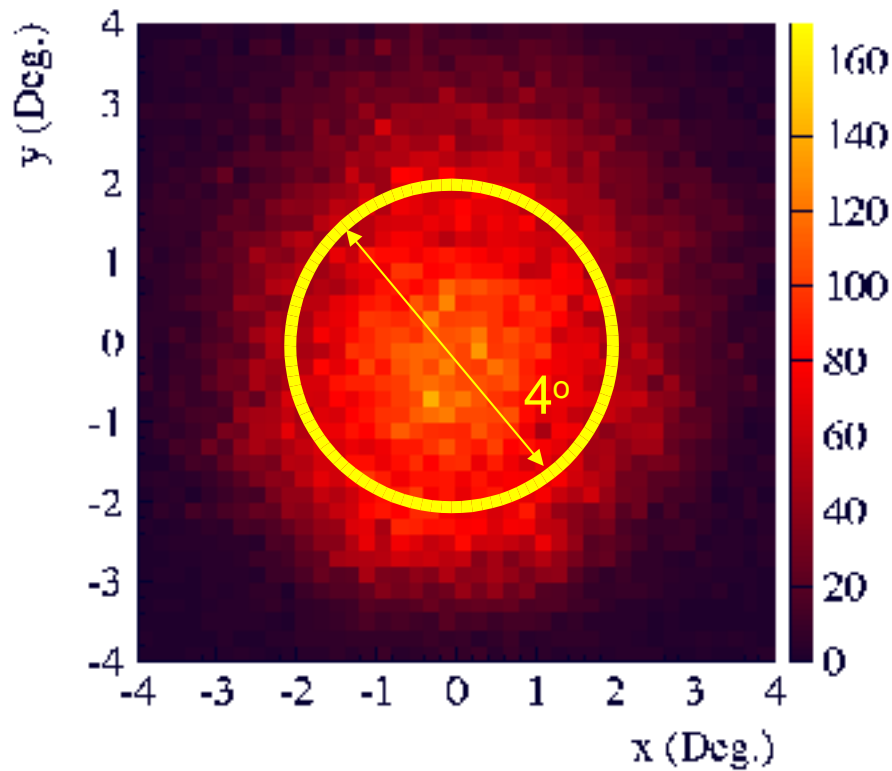


	Trigger cond.	Telescope trigger rate			
July 2002 – Feb. 2003 CT3	4 Pixels > 5 pe	~ 250 Hz			
March – July 2003 CT2, CT3	4 Pixels > 5 pe two independent telescopes	~ 250 Hz	~ 30 Hz	~ 150 Hz x 2	~ 500 Hz x 2
since August 2003 CT2, CT3	3 Pixels > 4 pe hardware telesc. coincidence	~ 2 kHz	~ 110 Hz	~ 100 Hz	~ 1.6 kHz x 2
2004 CT1 – CT4	hardware telesc. coincidence	< 10 kHz	O(500) Hz	O(500) Hz	~ 2.3 kHz x 4

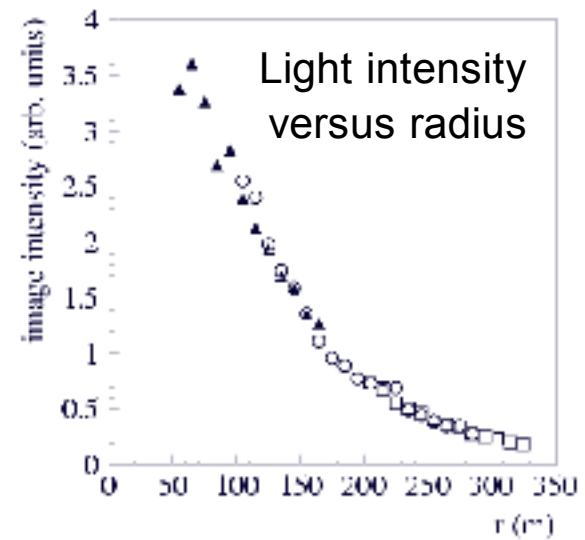
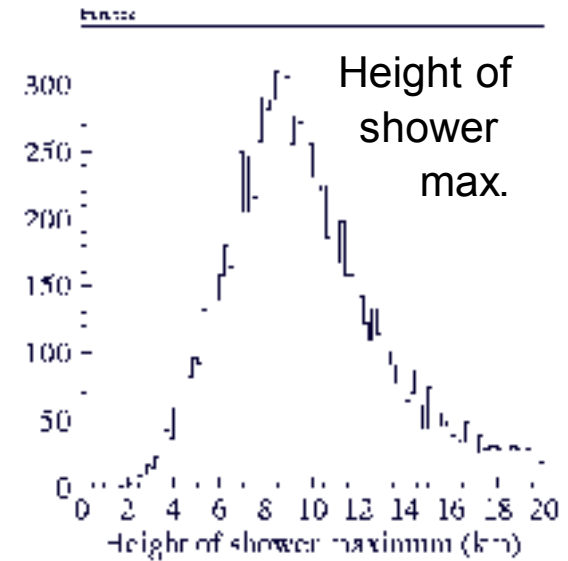
2-Telescope coincidence rejects muons

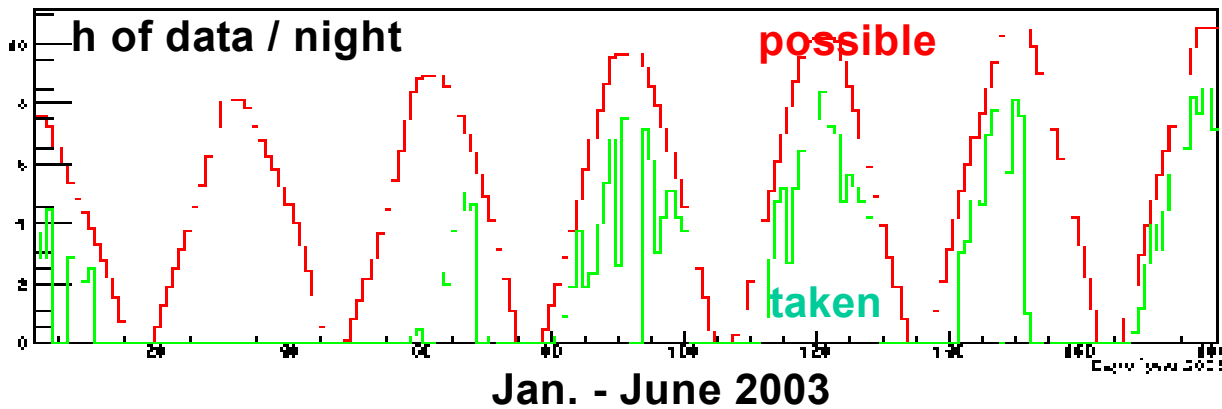


Stereo analysis ... technical plots (uncorr. raw data)



Reconstructed shower directions
relative to telescope axis





own sources
 stinging ones in detail
 get objects

ected by

Cangaroo, Durham

VELA	26 h	Pulsar	Cangaroo
SN 1006	107 h	SNR	Cangaroo
RXJ 1713	50 h	SNR	Cangaroo
Sgr A	34 h	Gal. center	Cangaroo, VERITAS
Cen X3	32 h	X-Ray Binary	Durham
PKS 2155	92 h	AGN	Durham
PKS 2005	52 h	AGN	
M87	32 h	AGN	HEGRA
NGC 253	34 h	Starburst-Gal.	Cangaroo

plus ~ 10 sources with less exposure

Since Sept. 03: data fully calibrated & analyzed a few h after being taken

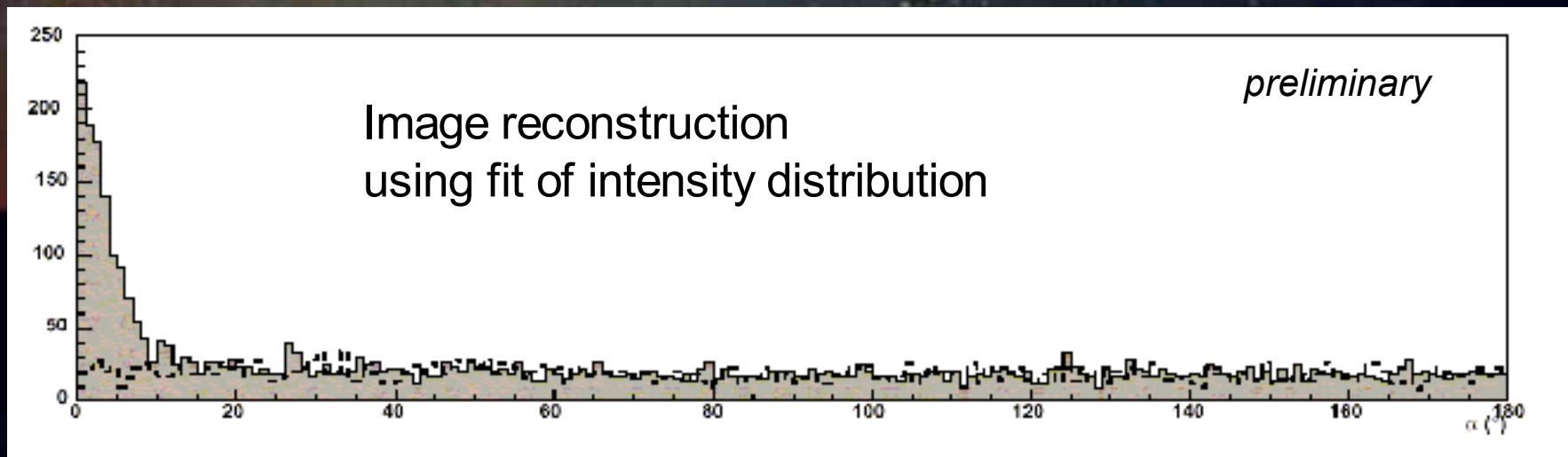
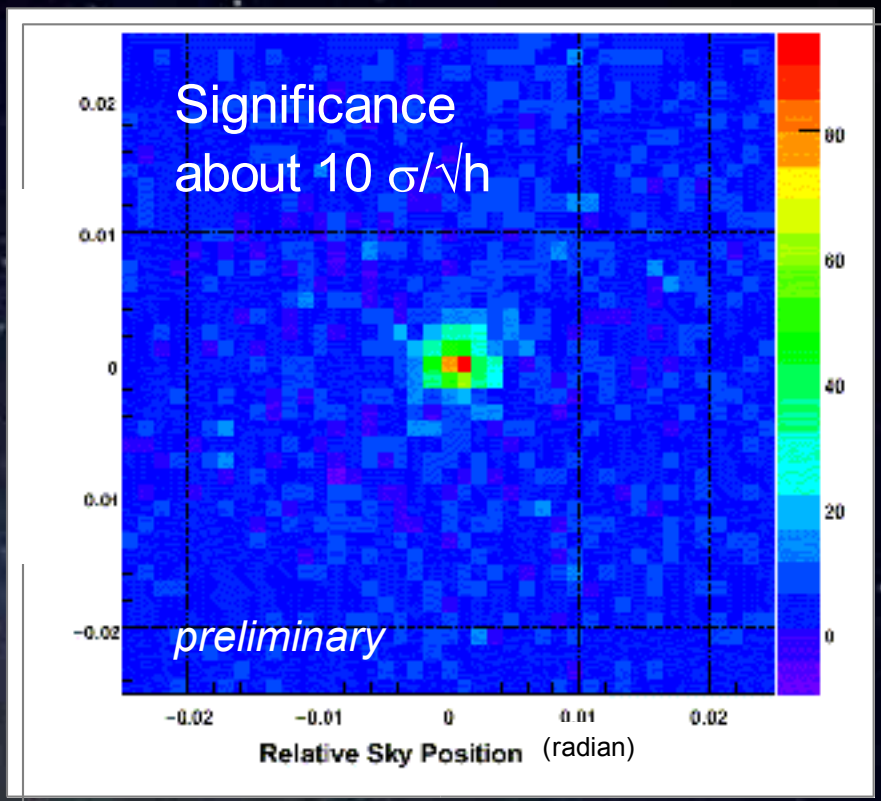
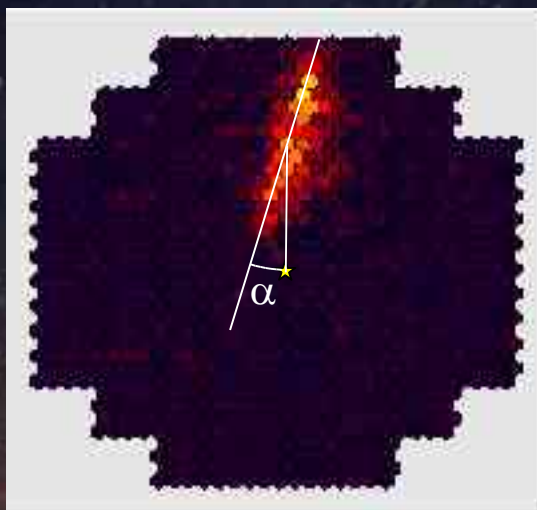


First results

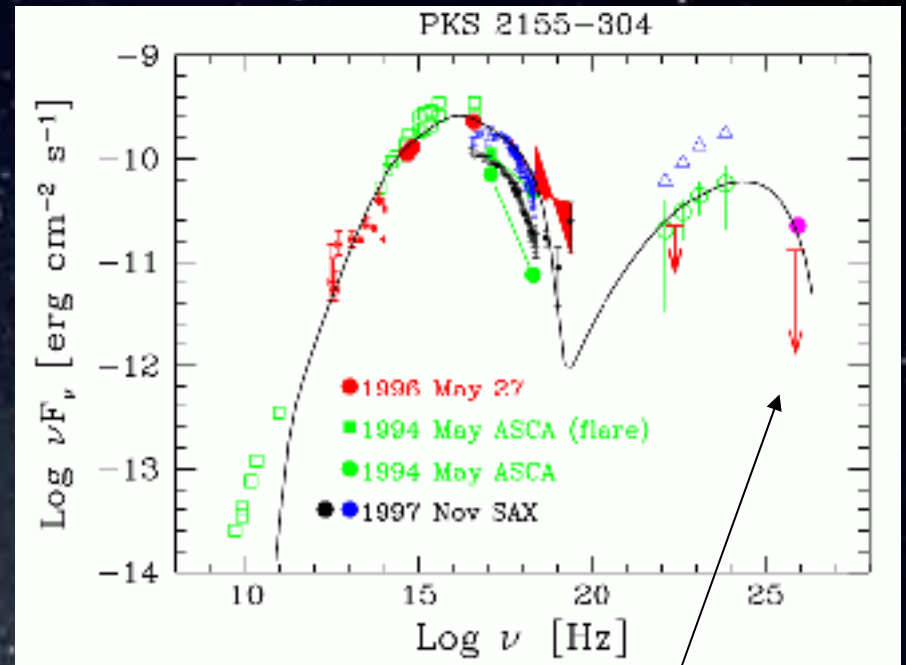
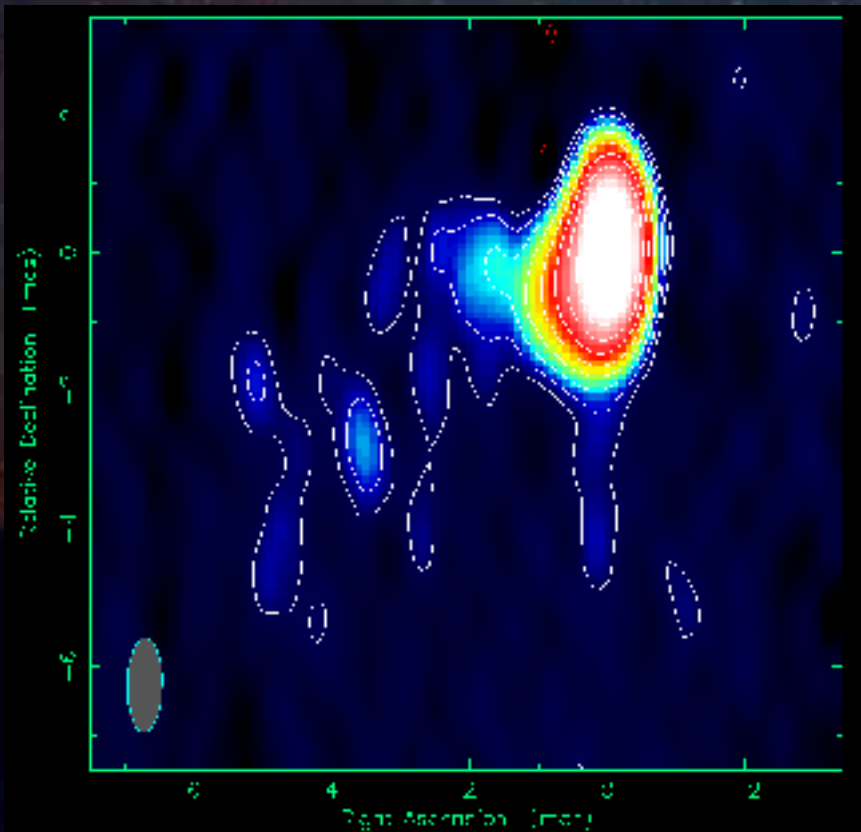
(ICRC 2003 status)



Crab Nebula (CT3)

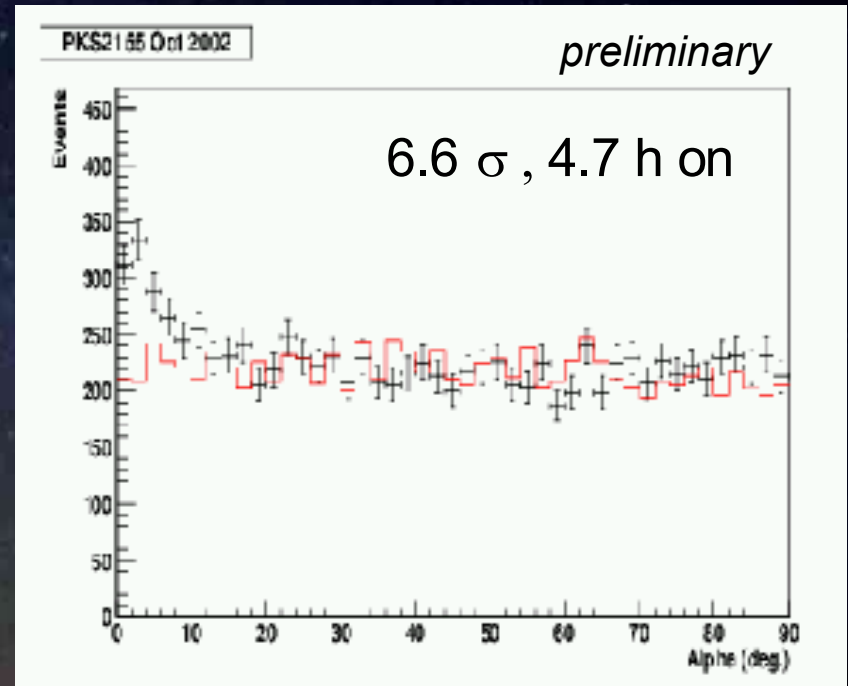
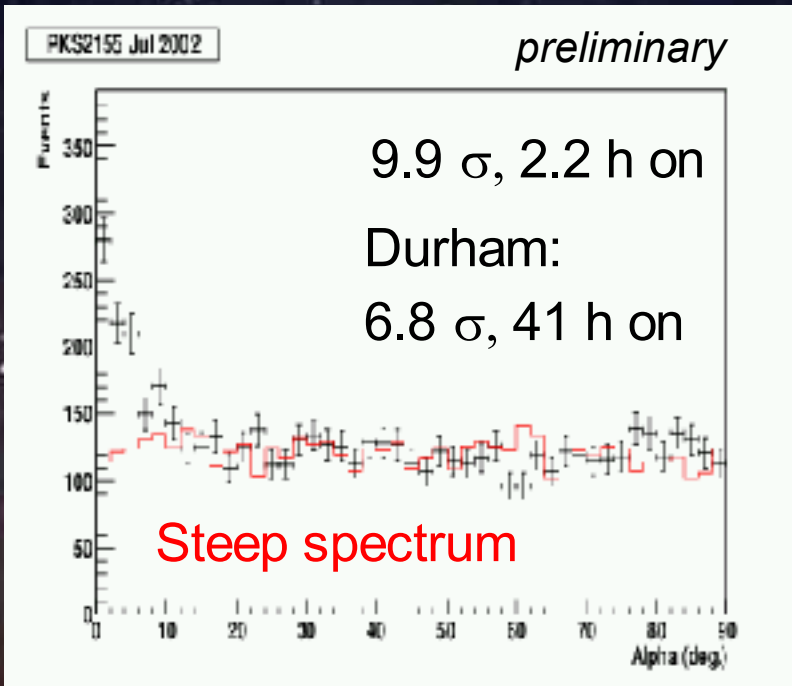


PKS 2155 ($z = 0.116$)



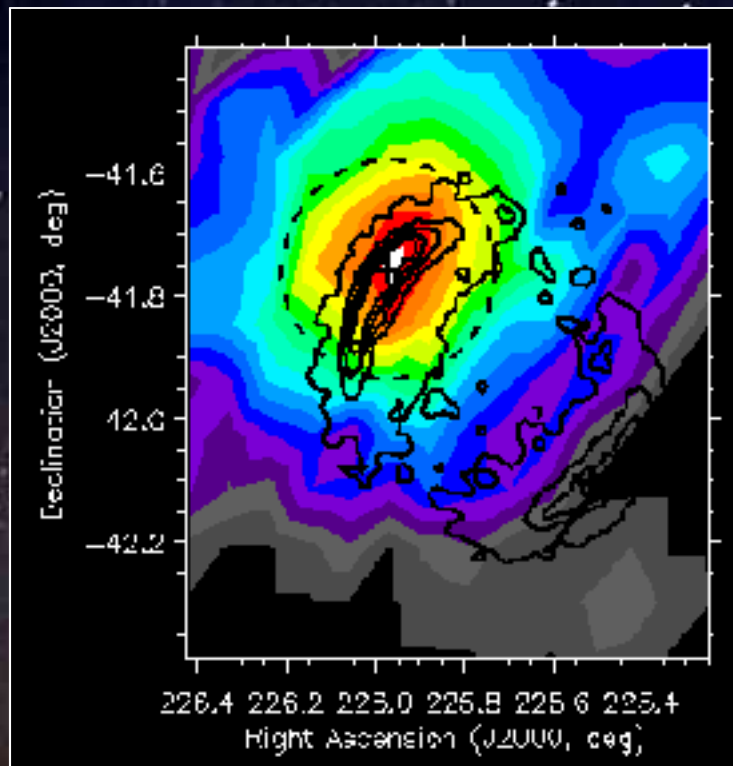
Chadwick et al.,
APJ 513, 161 (1999)

L. Costamante,
G. Ghisellini,
astro-ph/0112201



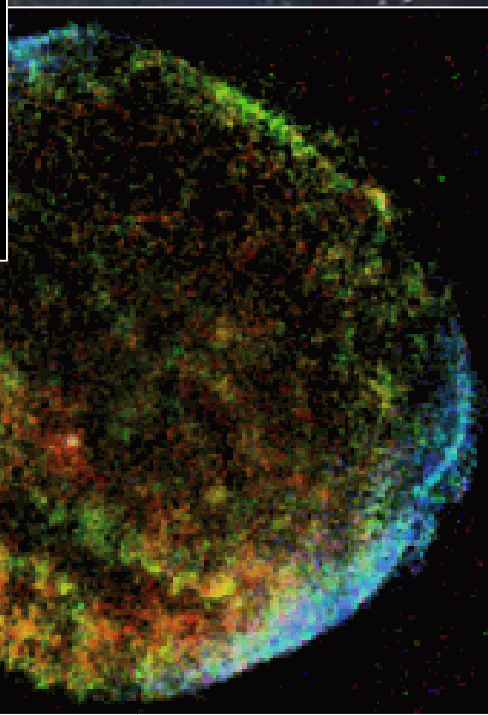
Weekes classification: so far “B”, now “A”

Supernova 1006



CANGAROO

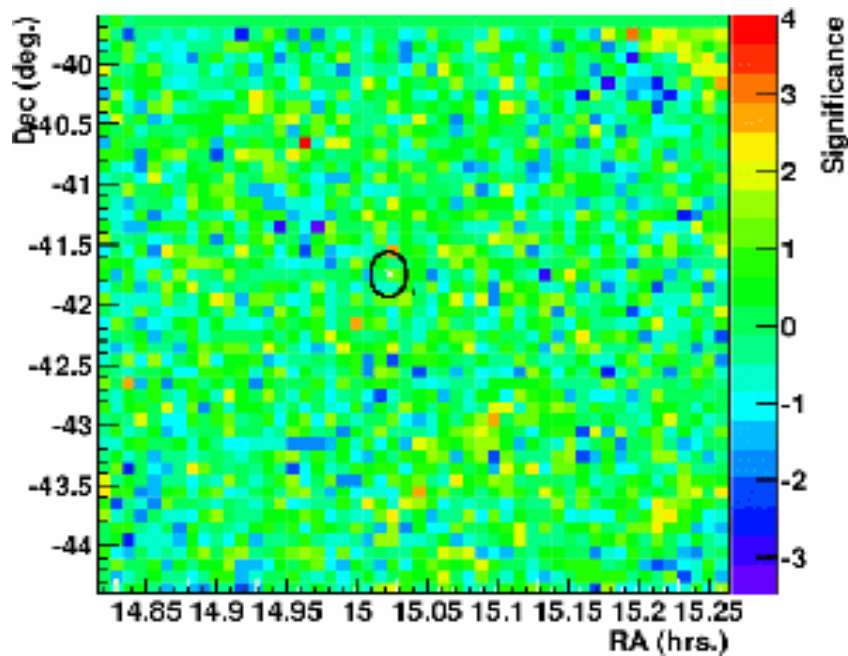
100 light years
5° diameter



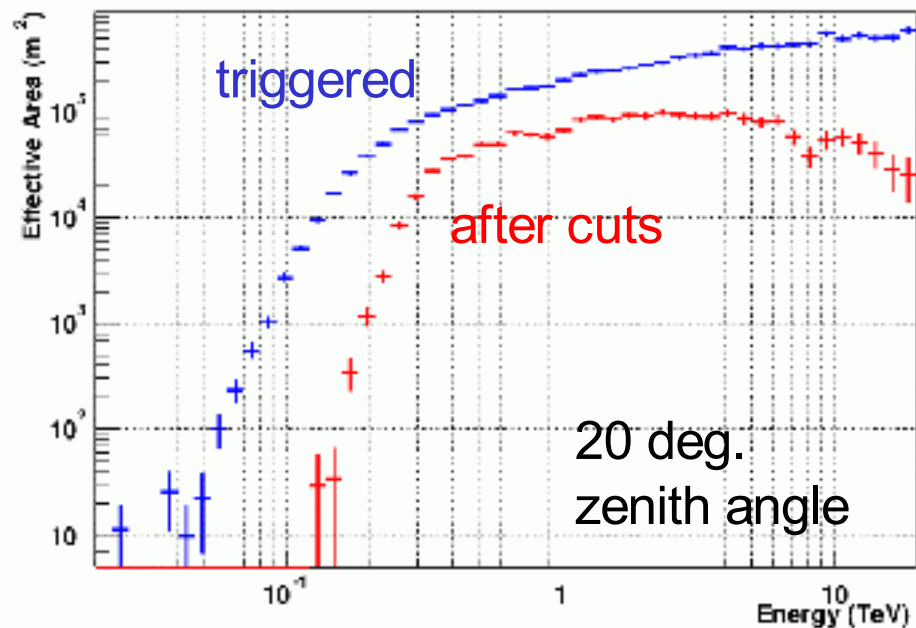
以後七月以前、客星入羽林中
 一條院寛弘三年四月二
 日、突西、夜以降騎官中有大客星、如熒惑、光明如燄
 連夜正見南方、或云、騎陣將軍星變未體增光獻054後
 泉院天喜二年四月中旬以後丑時、客星出嶺參辰、見東
 方、字天關星、大如熒星、二條院永萬二年四月廿二日、

from Meigetsuki

HESS Observations of SN 1006 *preliminary*



Effective Area



CT3
4.5 h live on source
1.0 σ excess

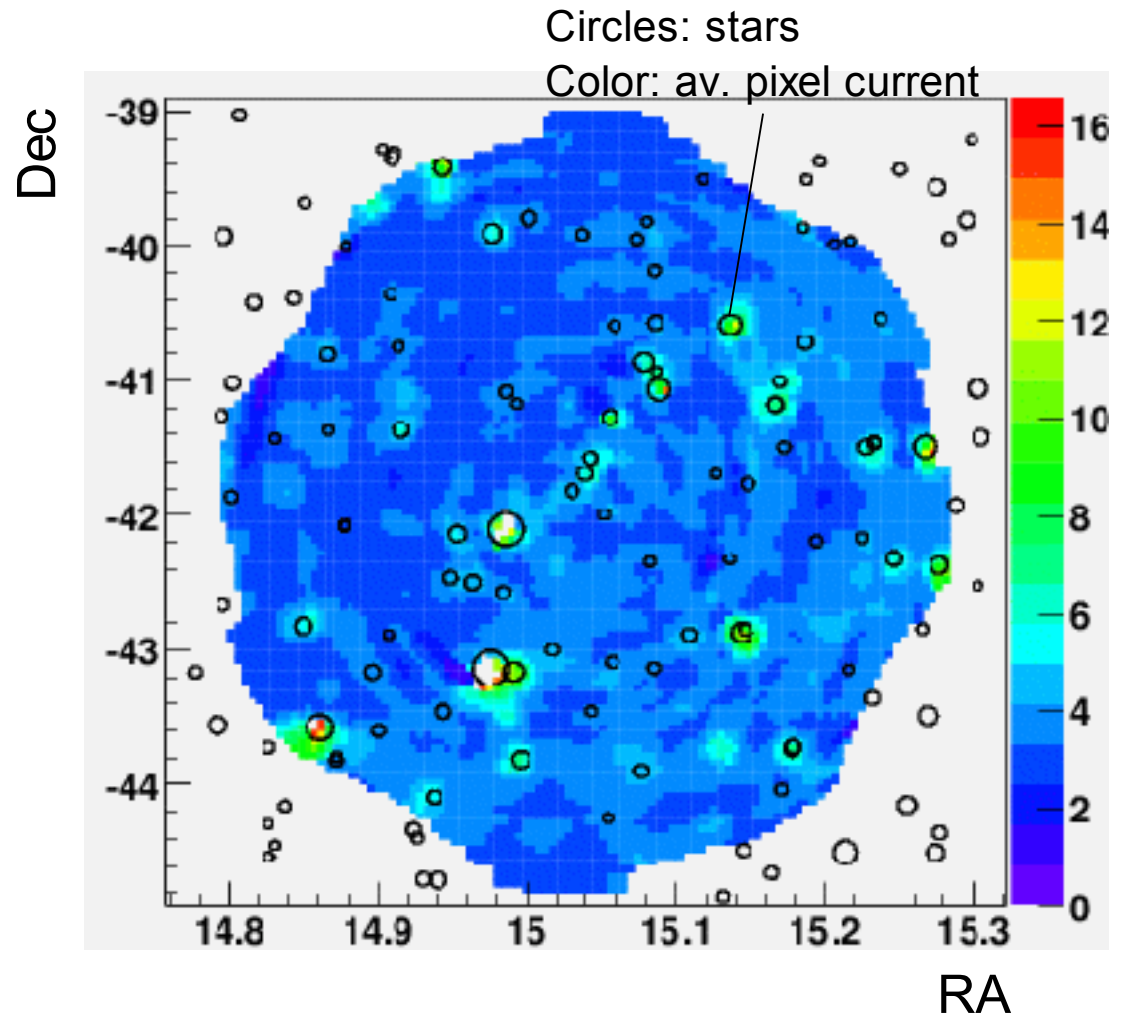
CT2
2.5 h live on source
-1.3 σ excess

Should easily see source assuming CANGAROO flux ...

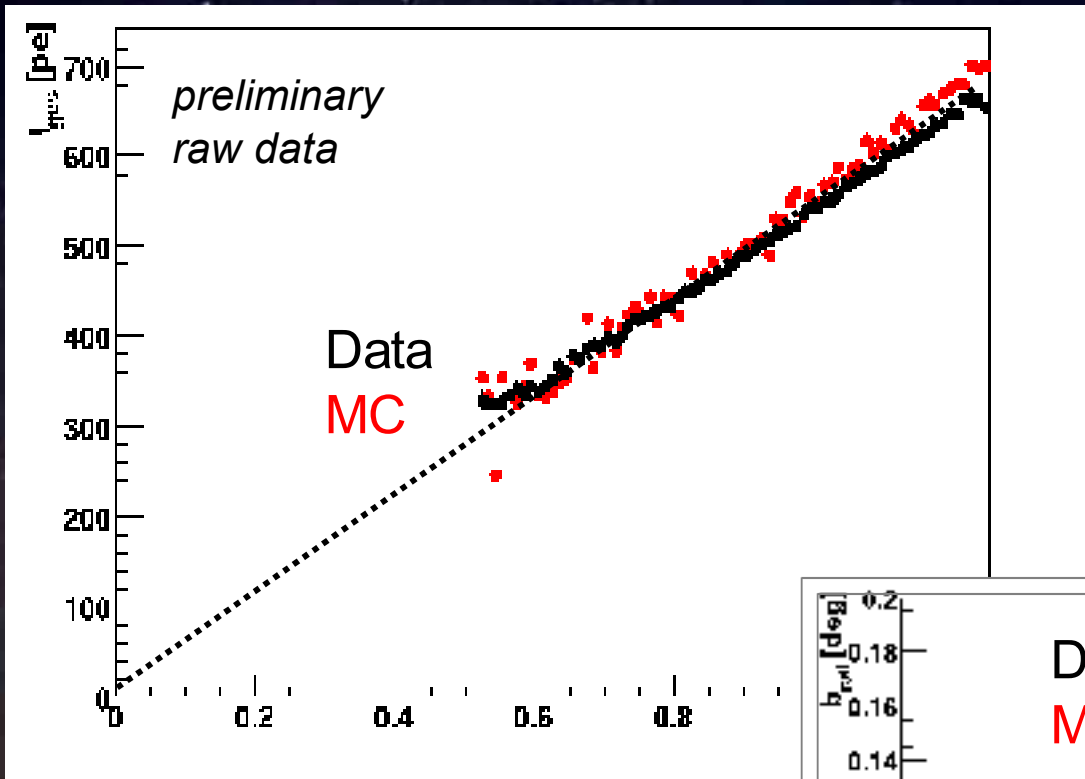
Pointing ok ?

Calibrated with stars, should be good to $\sim 10''$

Nevertheless:
Checked with pixel currents for all runs

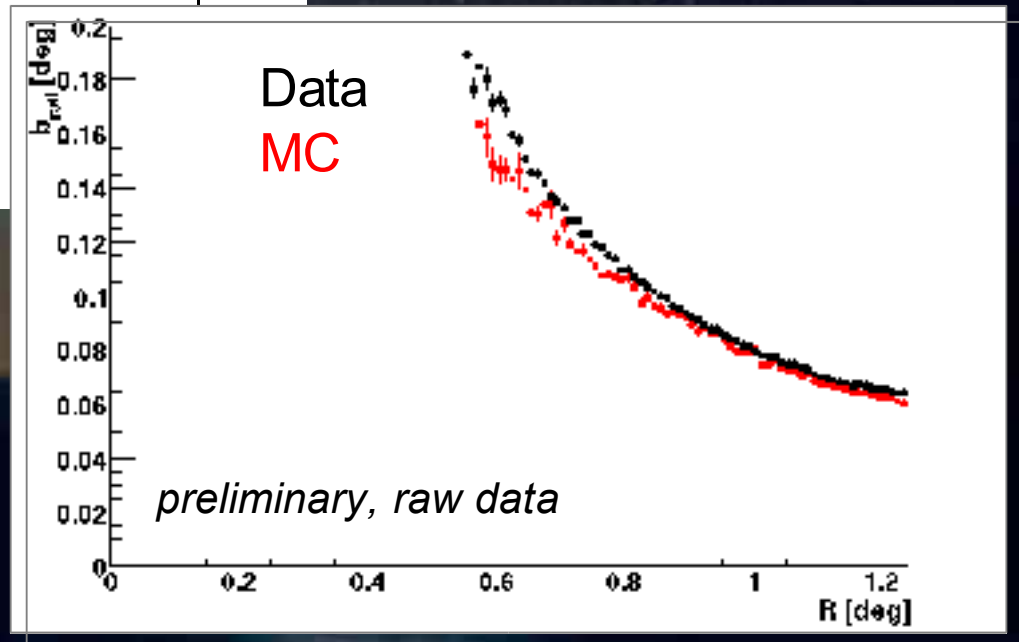
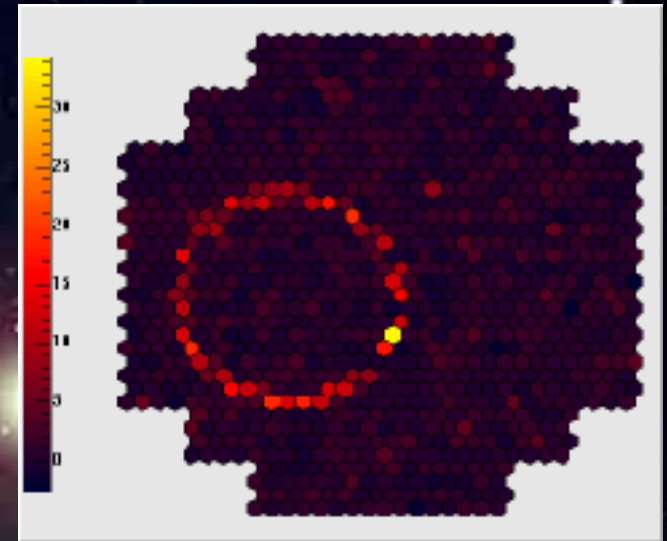


Do we understand the imaging ?



Ring intensity

Ring width



Explanations

Instrument

- Problem in our hardware or software: unlikely, continue checks
- Problem in flux normalization: unlikely, see Crab

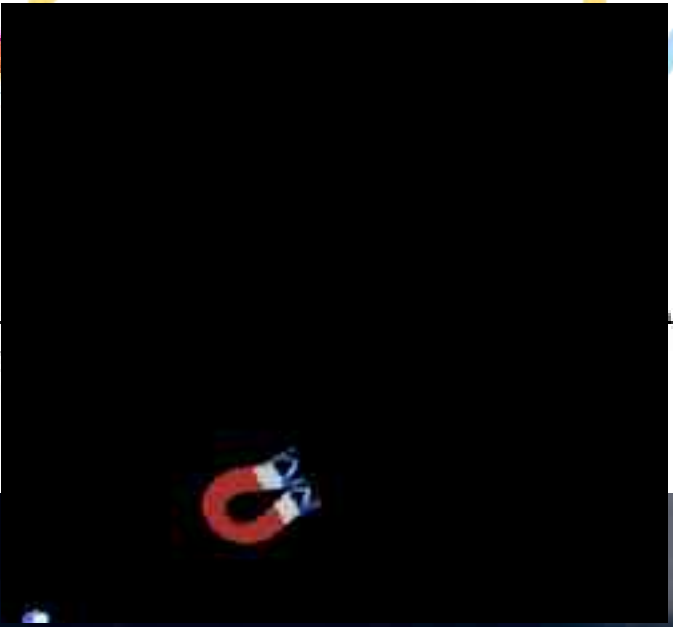
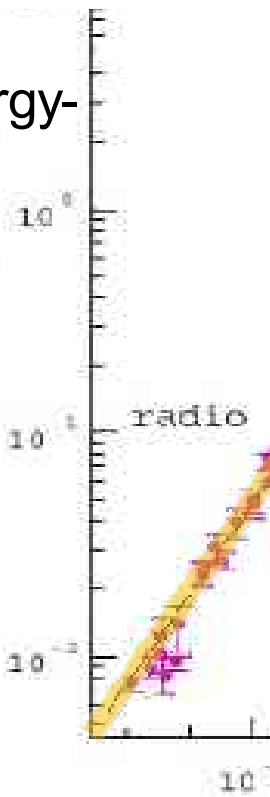
Physics

- Spectrum drops below CANGAROO threshold (1.7 to 3 TeV)
 - H.E.S.S. upper limits for 1.7, 3 TeV below CANGAROO flux
- Time dependence of flux
 - Seems unlikely for source of 50 LY size ... but actual X-ray features are smaller ...
 - Electron source: cooling time of one year or less requires very high B fields O(mG)
 - Hadron source: requires extremely dense target

SN 1006: Interpretation

1) Electron accelerator

Energy-flux



Synchrotron radiation
by electrons

$B \approx 4 \mu\text{G}$

ROSAT

ASCA

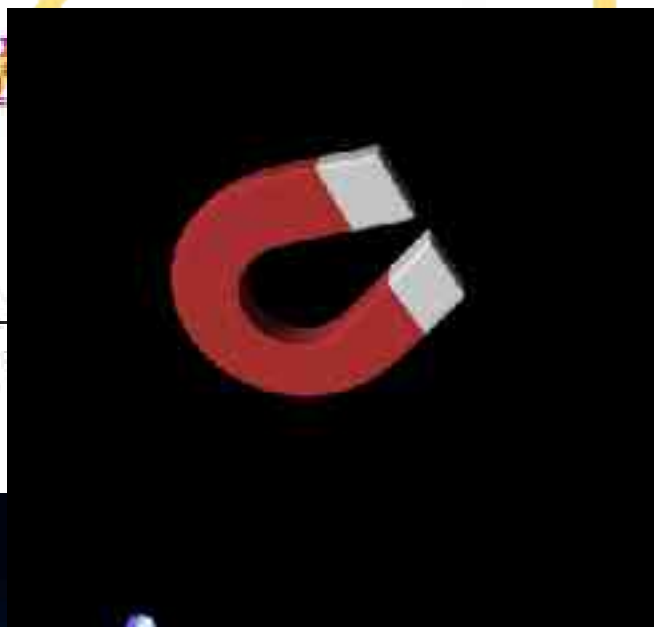
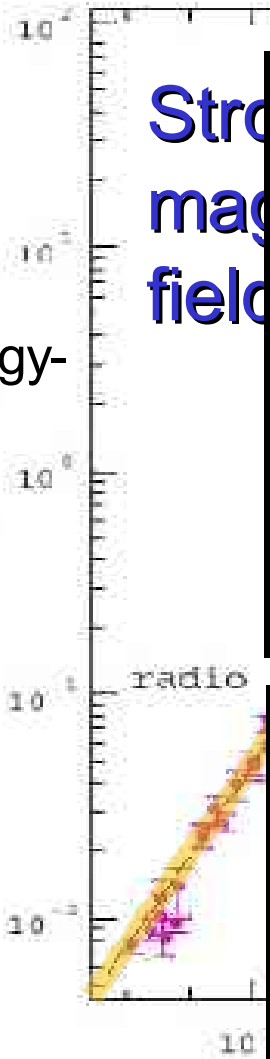
CANGAROO

Scattering of light
off electrons

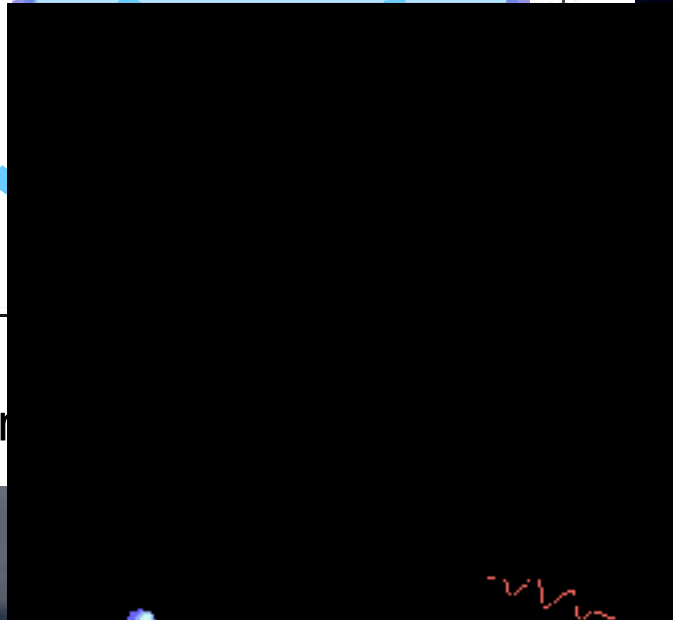
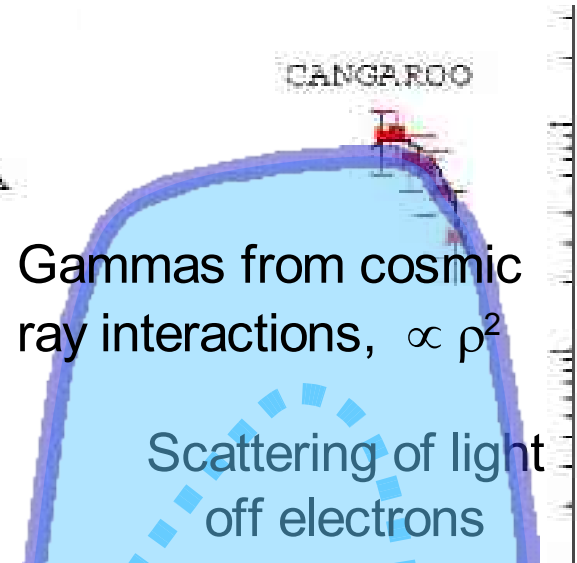


Strong
magnetic
field

Energy-
flux



II) Proton accelerator



Handwritten scribble



bmb+f - Förderschwerpunkt

Astro-Teilchenphysik

Großgeräte der physikalischen
Grundlagenforschung

- **H.E.S.S. is on its way; telescopes well understood**
- **Single-telescope data since Fall 2002, only small part of data fully calibrated and presented here**
- **... no new sources, a bit puzzled about SN 1006 ...**
- **Now taking data with 2 telescopes and stereo trigger**
- **Full 4-telescope array by early 2004**
- **Phase II designs under preparation**