

CANGAROOの現況

Status of CANGAROO project

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「CANGAROO望遠鏡によるガンマ線天文学の新展開」 Dec.11-12, 2003 京都大学
Workshop "New developments in Gamma-ray Astronomy with the CANGAROO telescope", Dec.11-12, Kyoto U.

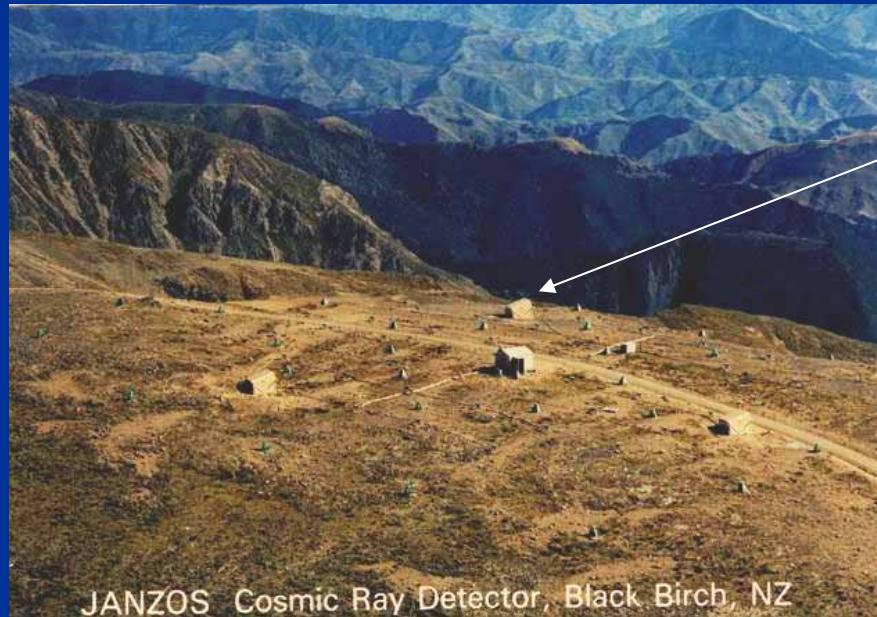
Brief history of CANGAROO

- 1987: SN1987A explosion
- 1990: 3.8m telescope moved
- 1990: ICRR-Adelaide Physics agreement
- 1992: Start obs. of 3.8m tel.
- 1995: PSR 1706-44 result published
- 1998: SNR1006 result published
- 1999: 7m telescope completed
- 2000: Upgrade to 10m telescope
- 2001: U.Tokyo-U.Adelaide agreement
- 2002: Second and third 10m tel.
- 2003: Fourth 10m tel.



JANZOS experiment in New Zealand

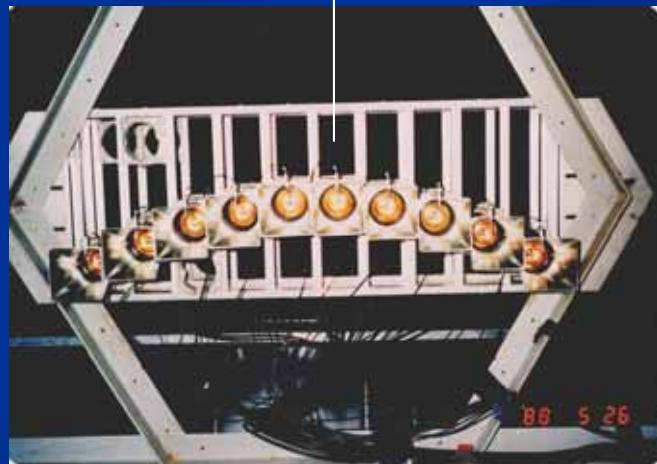
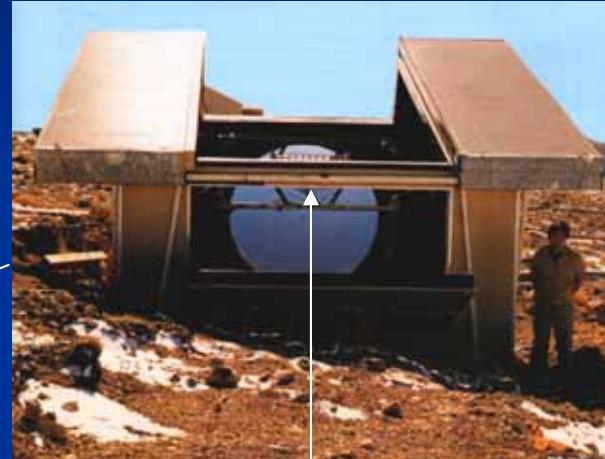
Japan Australia New Zealand
Observation of Supernova 1987A



Air shower detector array

+

3 Fixed 2m ϕ Cherenkov telescopes



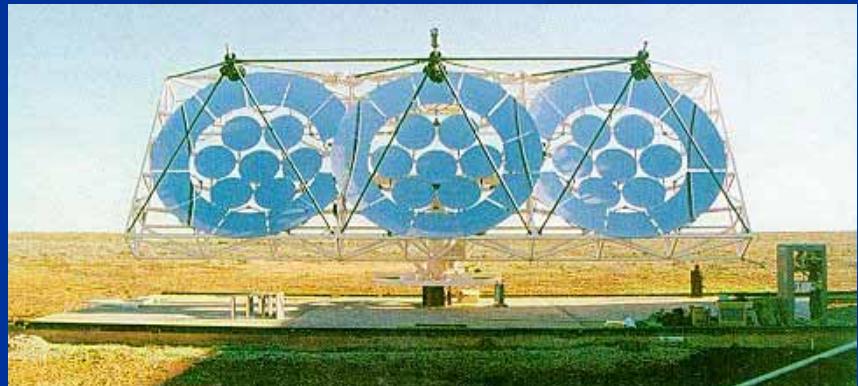
1987-1989, Black Birch, South Island

Why Woomera?

- New Zealand is wet and not many clear nights...
- Woomera:
 - Outskirt of desert
 - Former rocket launch site, prohibited area: existing infrastructure and support center
 - BIGRAT telescope was operated by Adelaide group



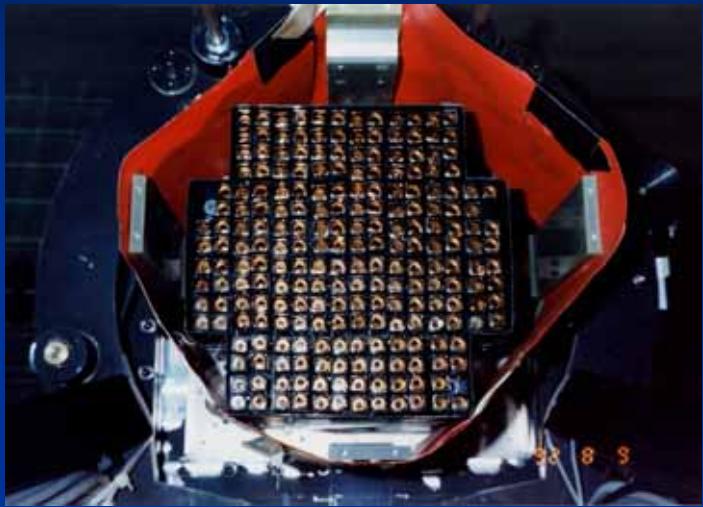
ELDO rocket Launch site in '60s



BIGRAT

(BICentennial Gamma RAy Telescope)

3.8m telescope (ex. Lunar-ranging telescope)



224ch imaging camera at prime focus

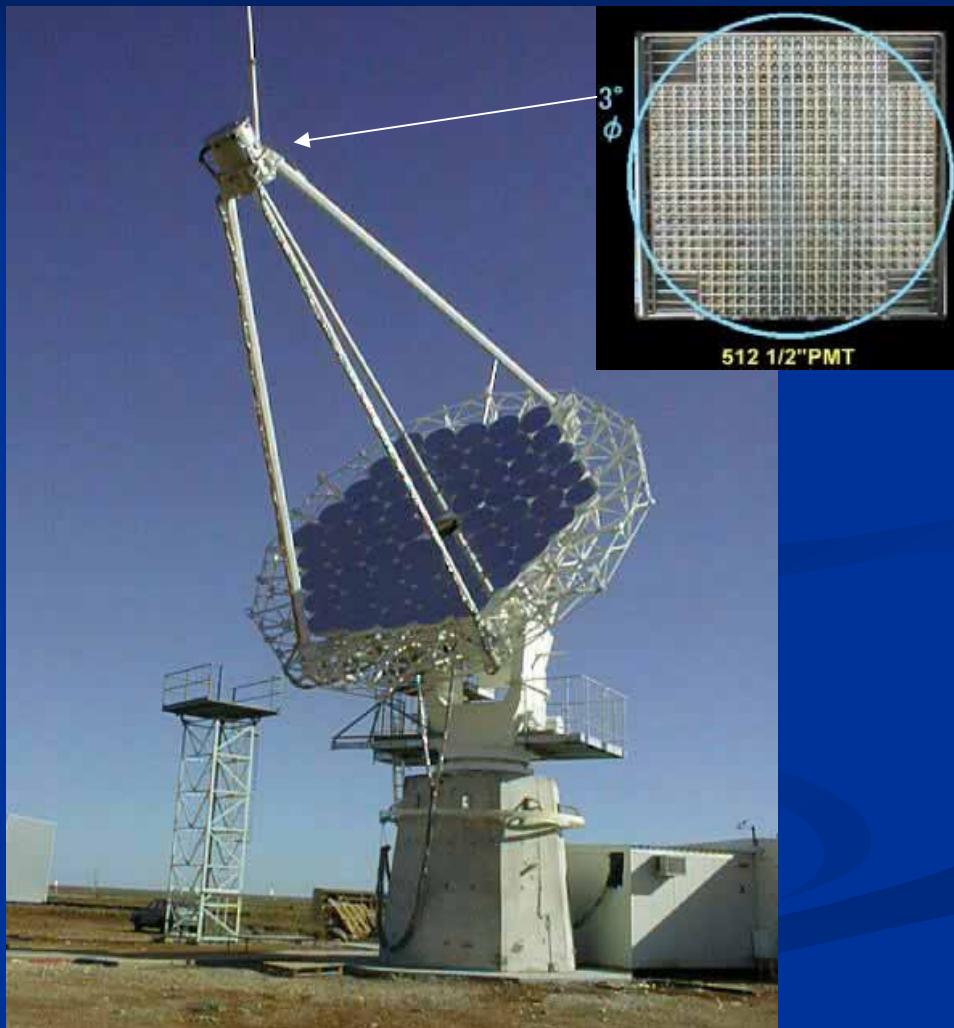


Tadashi Kifune & John Patterson



CANGAROO 7m telescope

- Completed in March 1999
- 60 x 80cm CFRP-based spherical mirror segments (*first plastic-base mirror in the world!*)
- Focal length 8m
- Alt-azimuth mount
- 552ch imaging camera
- Timing and time-over-threshold measurement



(March 1999)

CANGAROO 10m telescope

- Upgraded in March 2000
- 114 x 80cm CFRP-based spherical mirror segments
- 552ch imaging camera
- Charge measurement (ADC) added

≡ "CANGAROO-III T1"



(March 2000)

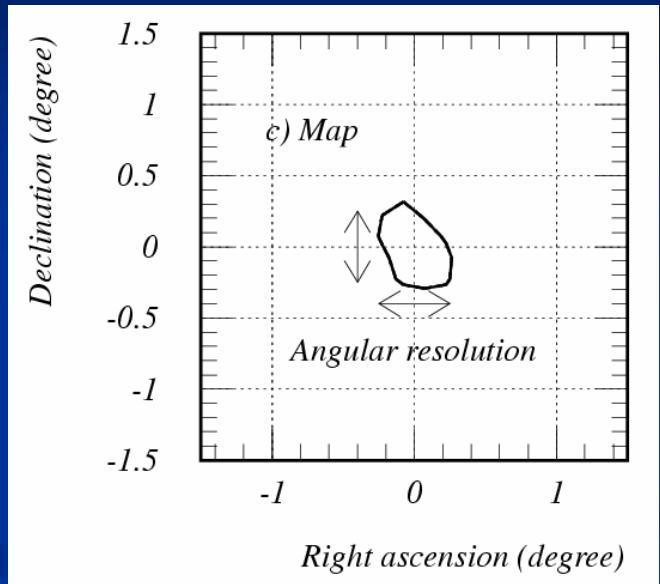
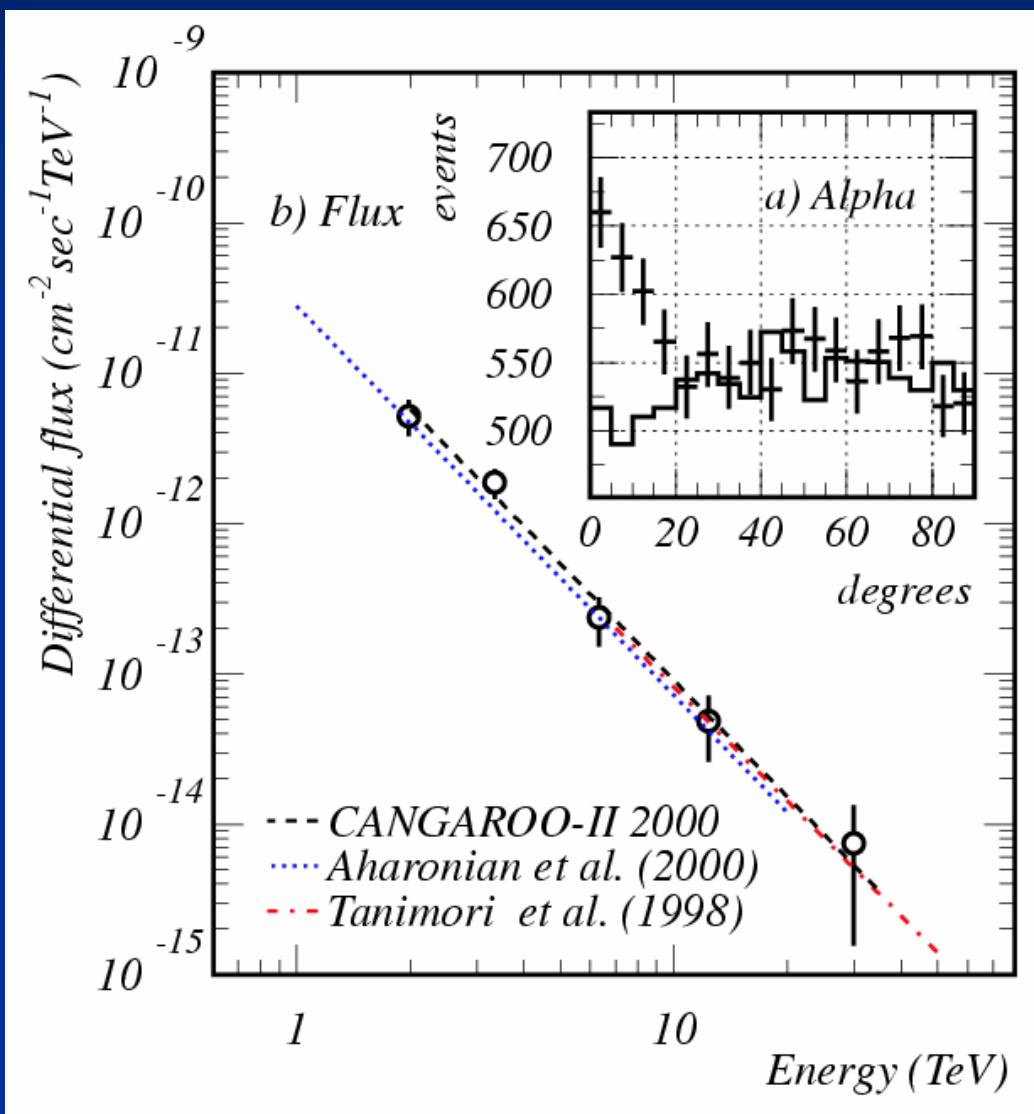
CANGAROO-III T1 target list

	Signal	Publish
■ SNR/Pulsar Crab	○	
■ SNR RX J1713.7-3946	○	○ (Nature2002)
■ AGN Mrk421	○	○ (ApJL2002)
■ Starburst galaxy NGC253	○	○ (AAL02,AA03)
■ SN1987A	↓	○ (ApJL2003)
■ Pulsar PSR 1706-44	○	○ (PhD 2003)
■ SNR SN1006	○	○ (PhD 2002)
■ PSR 1259-63/SS2833	↓	△ (投稿中)
■ AGN PKS2155-304, PKS2005-489	↓	△
■ SNR RX J0852-4622	○	△
■ SNR RCW86	△	
■ Galactic Center/Sgr A*	○	△
■ Galactic jet object SS433	△	
■ EGRET unID 3EG J1234-1318	△	
■ Galaxy Small Magellanic Cloud	△	
■ Vela pulsar	△	

Signal: ○ detected, ↓ upper limit, △ under analysis

Publish: ○ published, △ in preparation

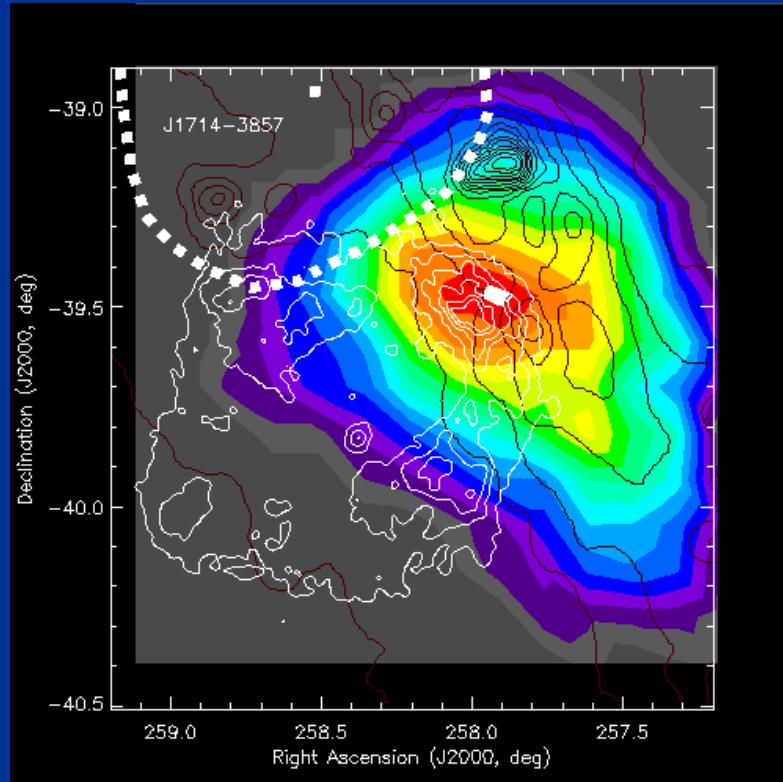
Crab nebula



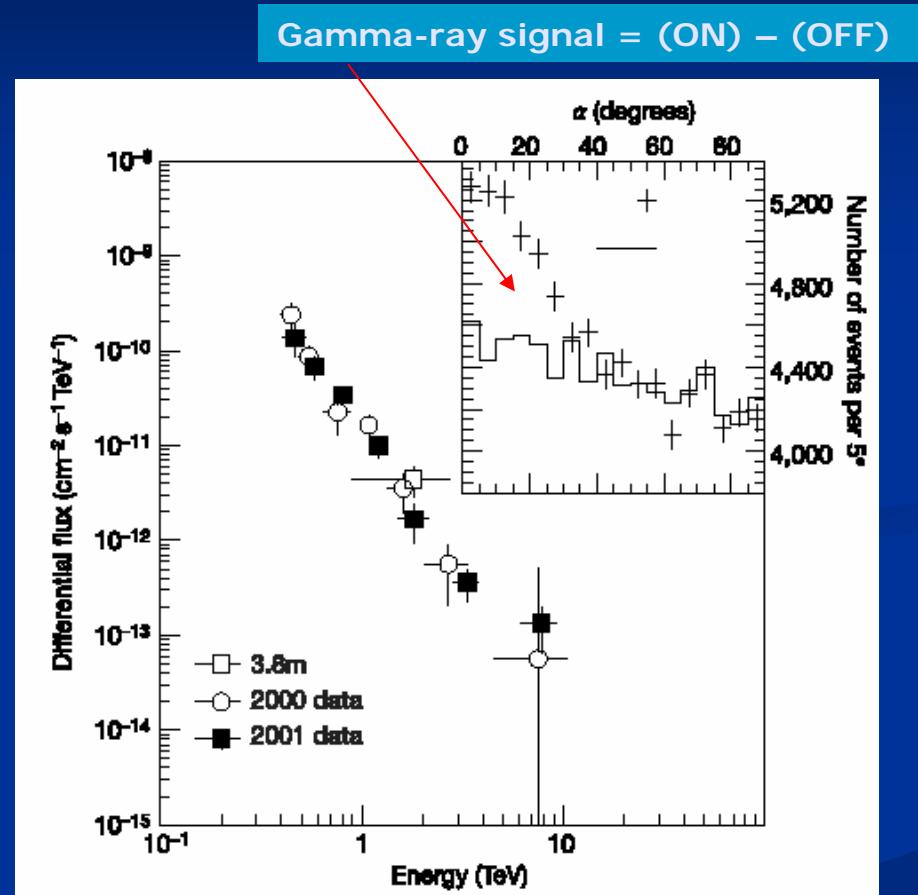
“Standard candle” is observed as it should be
– Our telescope is working properly!

SNR RX J1713.7-3946

- SNR detected by X-ray satellite
- Non-thermal emission

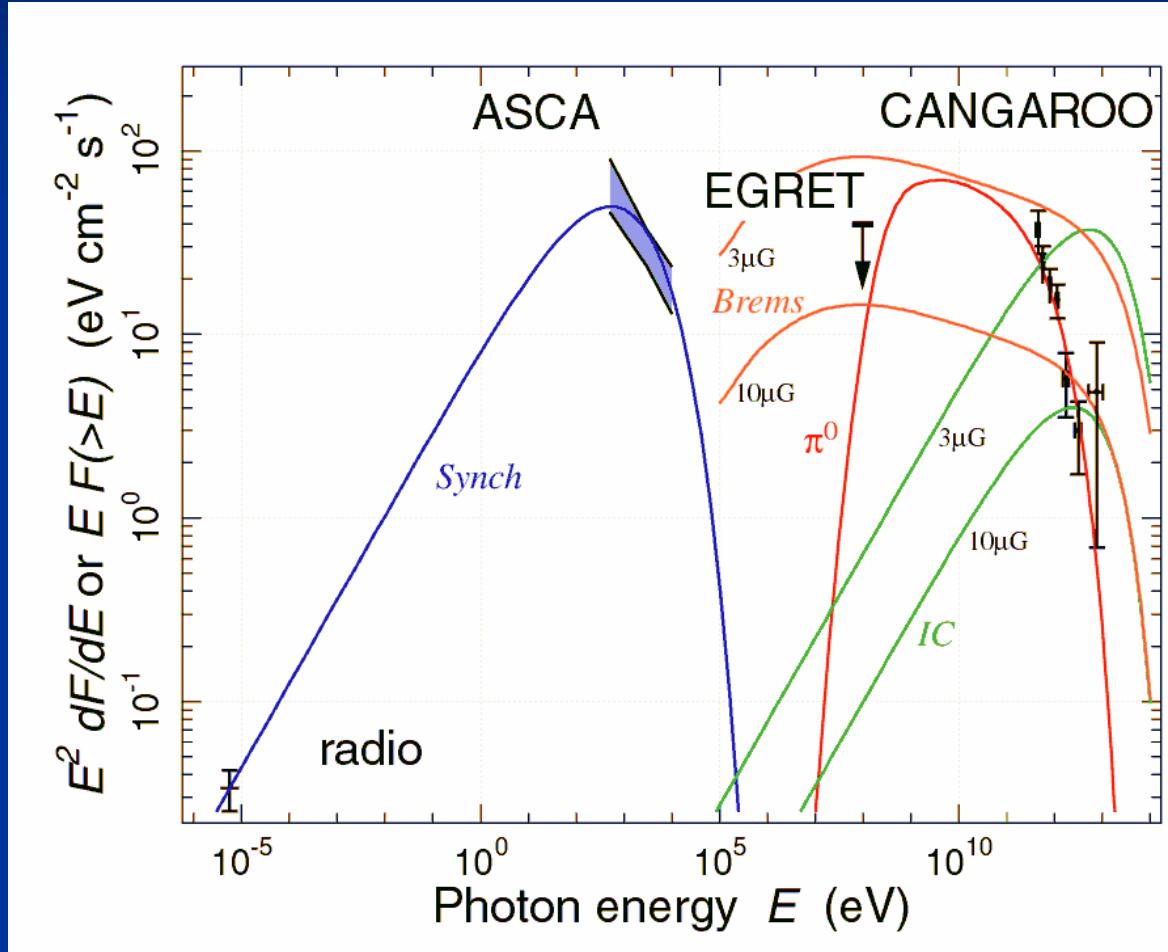


Significance map



Energy spectrum

SNR RX J1713.7-3946: emission from protons?



Hard to explain by
emission from
electrons (Brems,
IC)

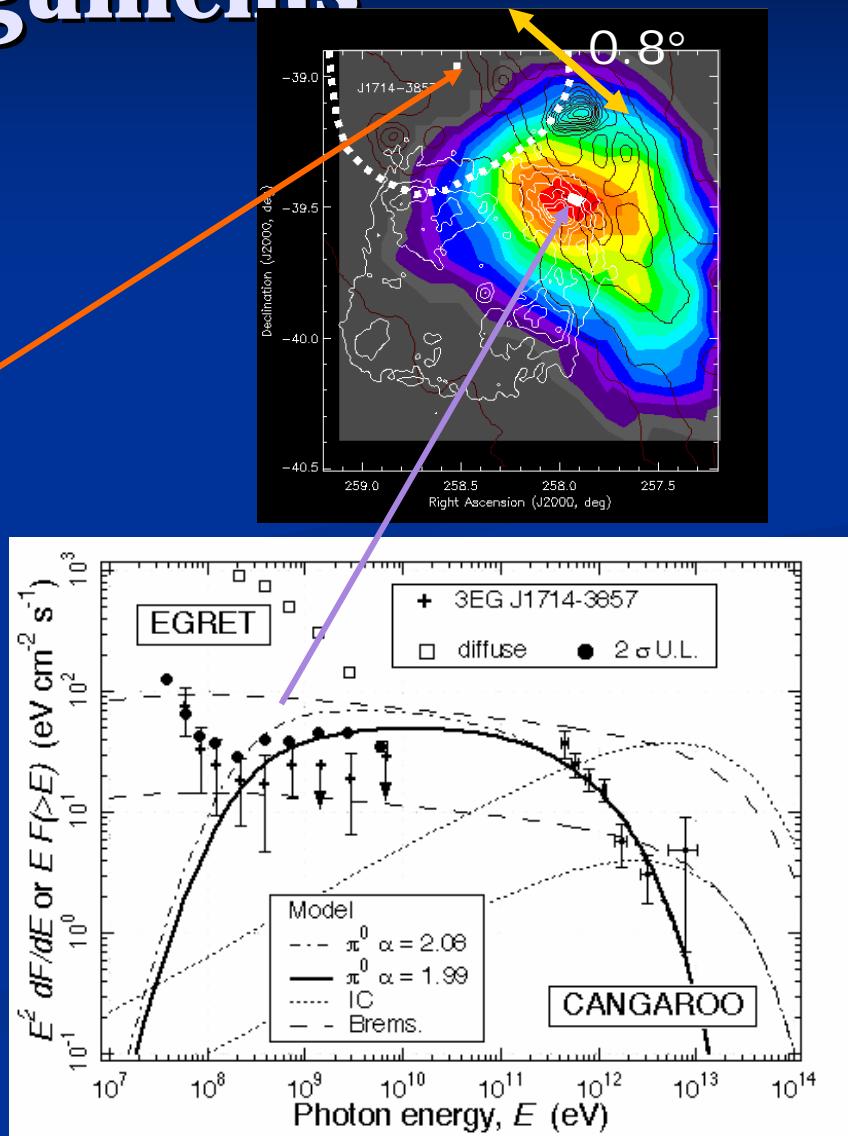
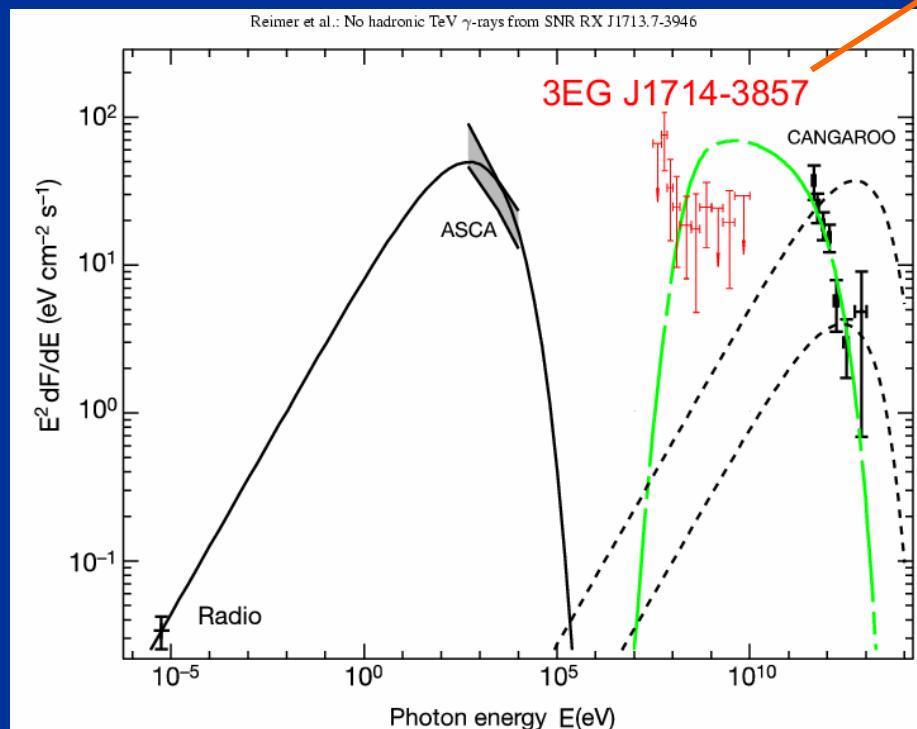
⇒ Emission from
protons (π^0)?

⇒ Cosmic ray
origin?

SNR RX J1713.7-3946: counter arguments

Reimer & Pohl, A&A 390 (2002) L43

Butt et al., Nature 418 (2002) 489

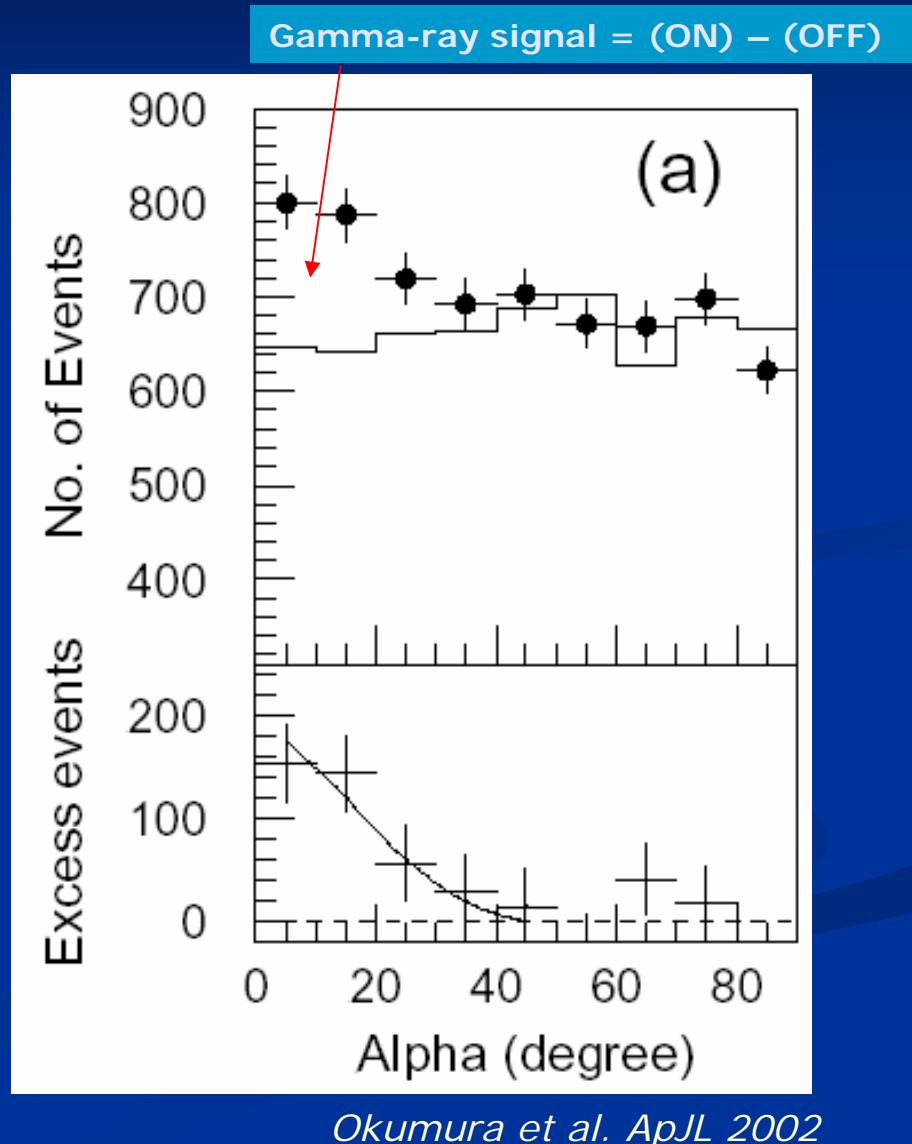


Markarian 421

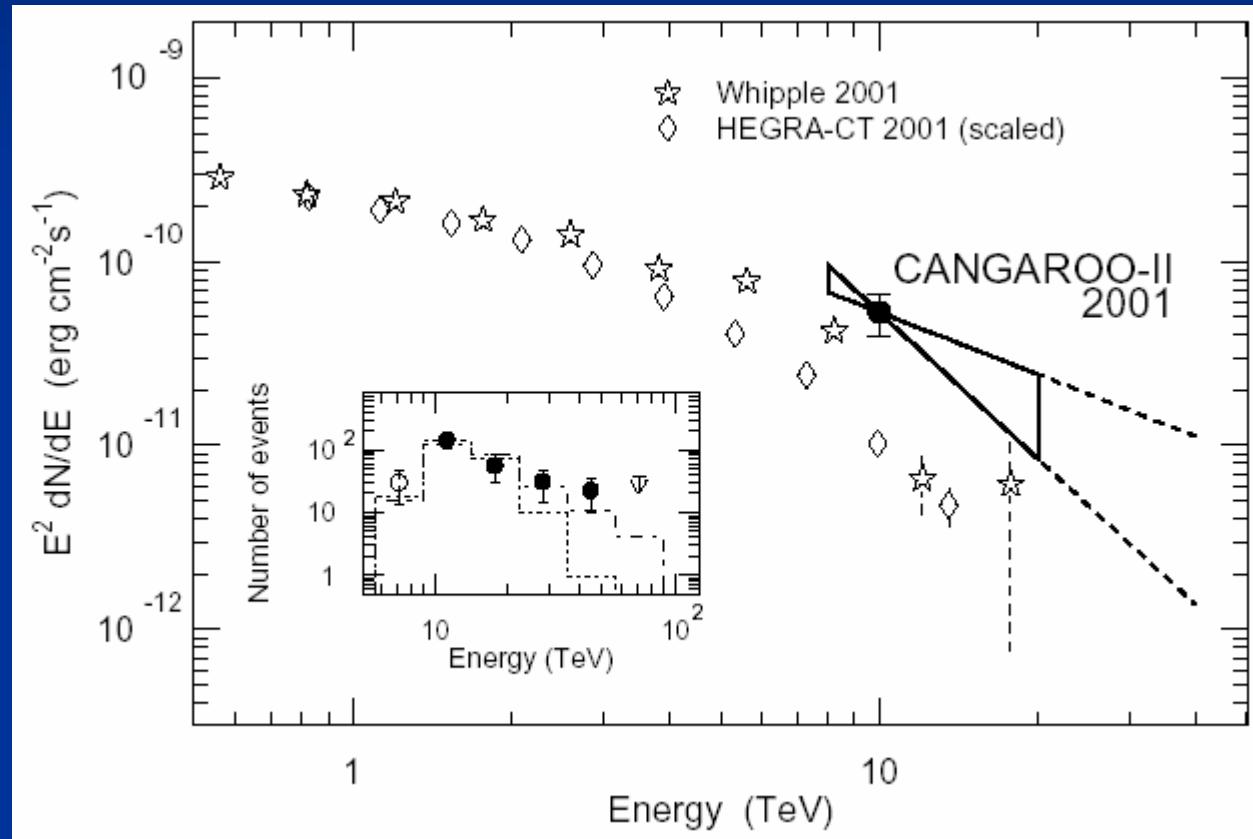
- The first TeV blazar in the northern sky
- $z=0.031$ (~ 130 Mpc)
- Flare in 2001
- Large zenith angle observation from Woomera: higher energy
- Intergalactic absorption by IR:
No 10TeV photons?



Optical image



Mrk 421: hint for cosmology?



Emission above 10 TeV detected
⇒ Fewer IR photons?

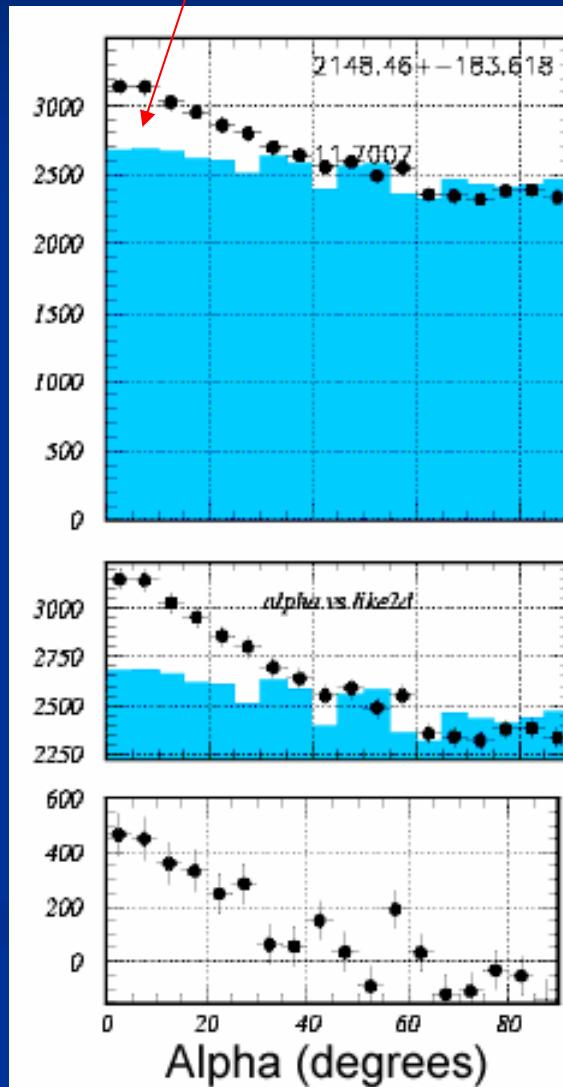
Starburst galaxy NGC253

- Nearby spiral galaxy (2.4Mpc)
- Starburst activity
 \Leftrightarrow frequent SNe



Optical
image

Gamma-ray signal = (ON) – (OFF)

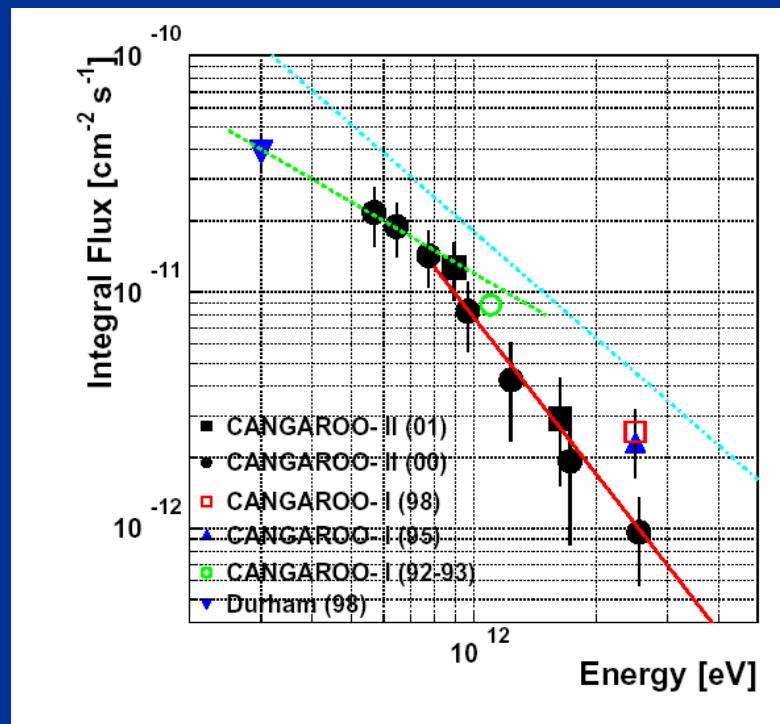


Itoh et al.
A&AL 2002

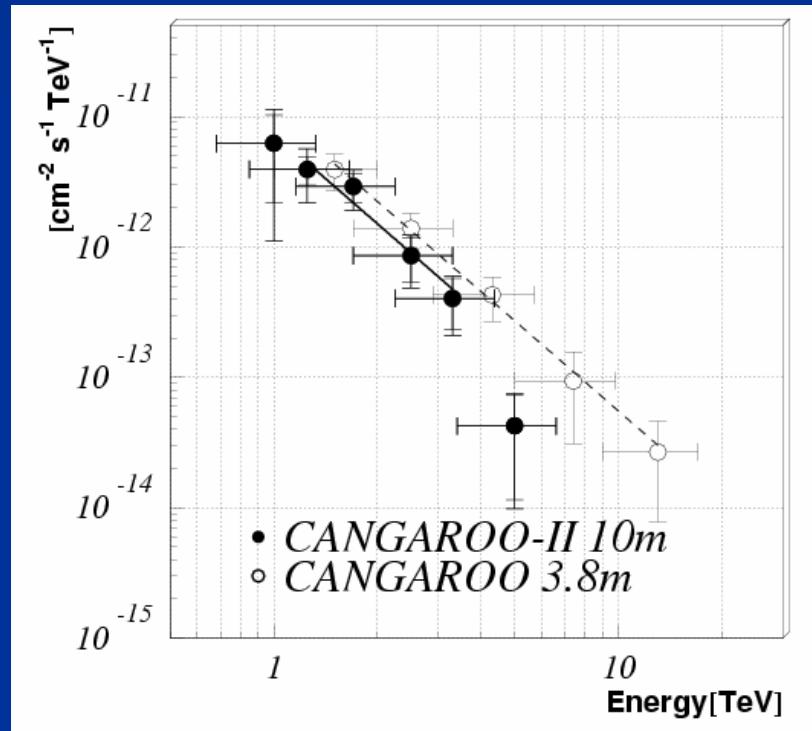
CANGAROO-I sources revisited

■ PSR 1706-44

■ SN1006 NE rim

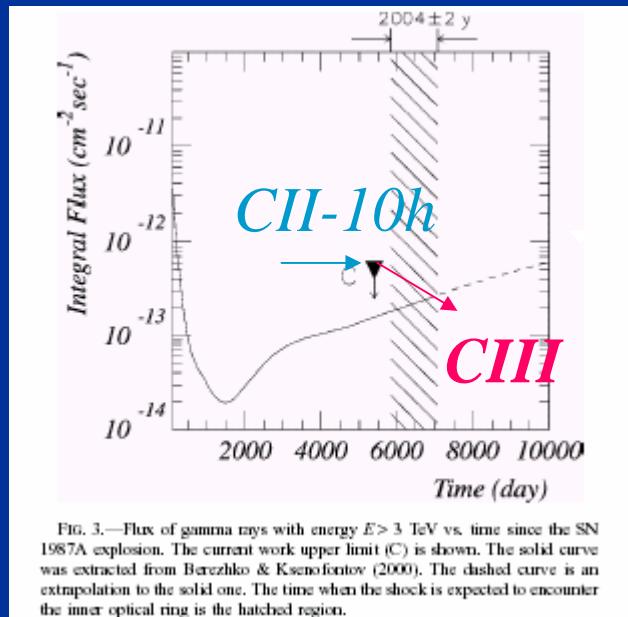
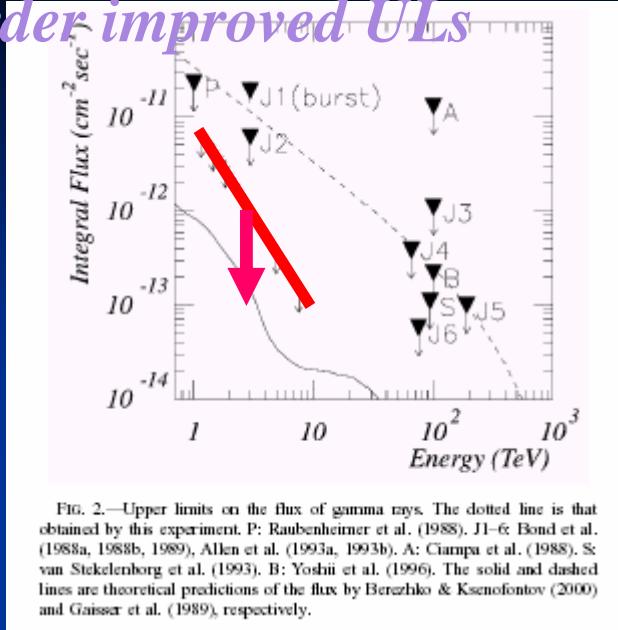


J. Kushida, Ph.D. thesis 2003



S. Hara, Ph.D. thesis 2002

Order improved ULs



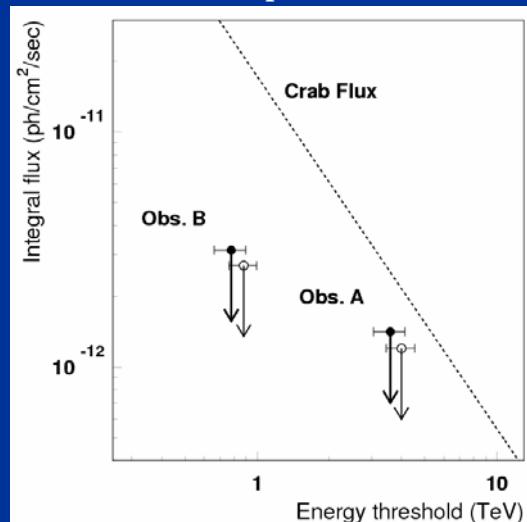
SN1987A

Enomoto, Ksenofontov, Katagiri, Tsuchiya et al., ApJ, 591(2003)L25-28

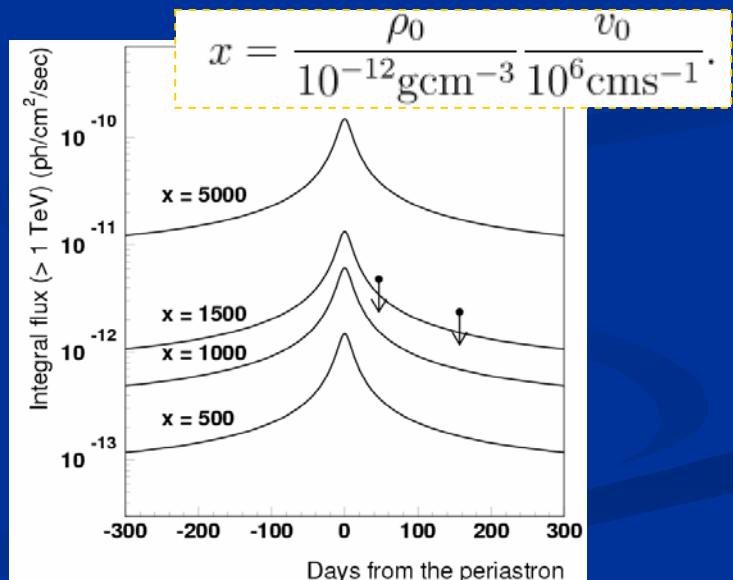
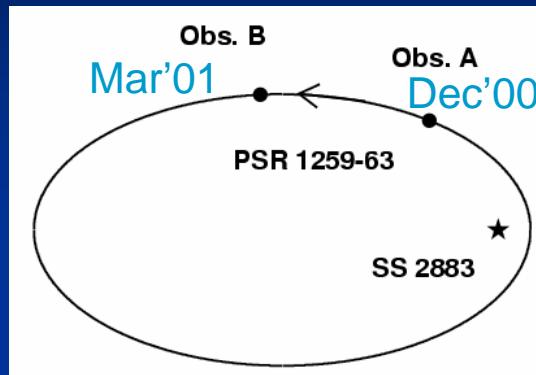


PSR1259-63/SS2883

- 48ms pulsar/Be star binary
- Eccentricity 0.87, $T_{\text{orb}}=1236.72\text{days}$
- X-ray emission around periastron
→ Synchrotron emission from nonthermal electrons
- TeV inverse Compton emission?



Upper limits from obs. By 10m telescope

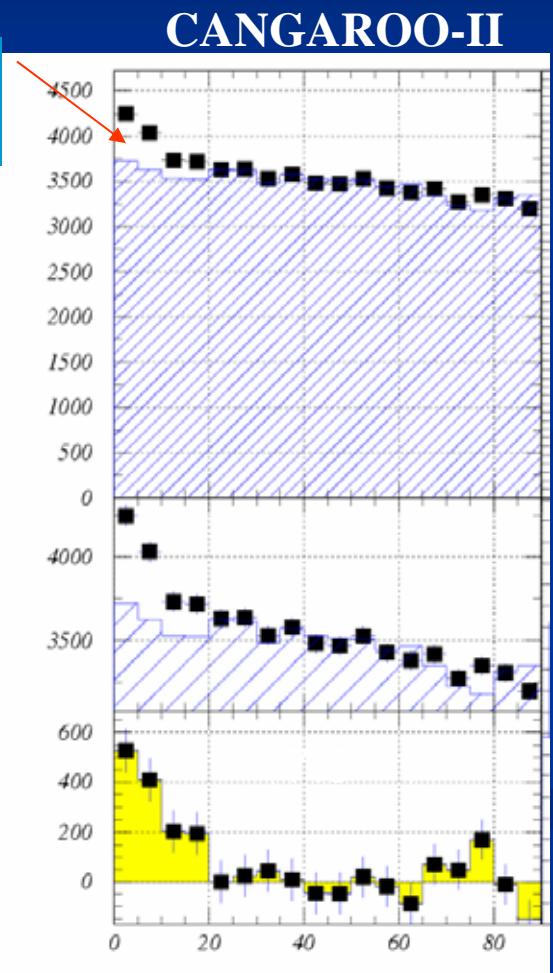
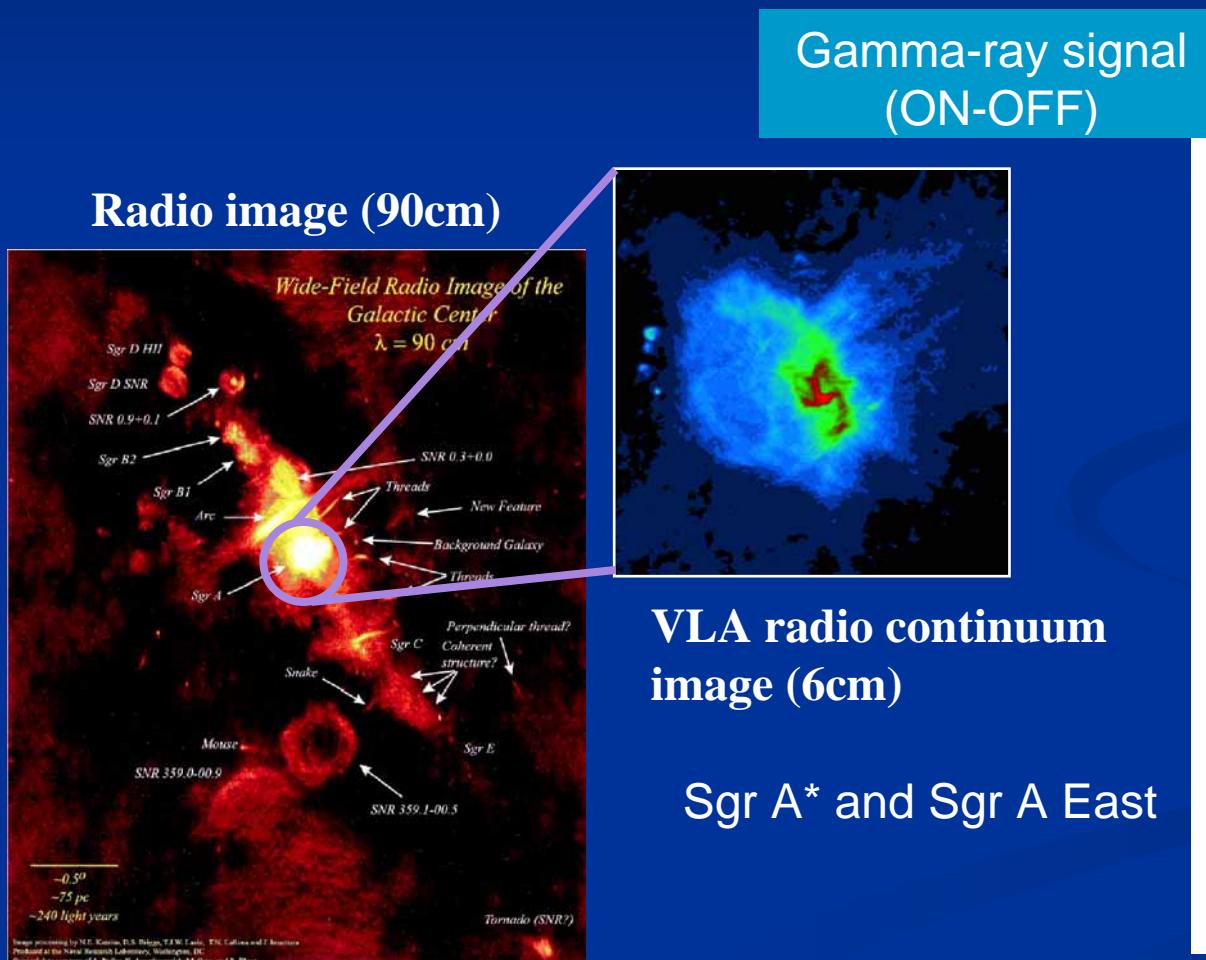


Limits on a model parameter

Kawachi et al., submitted

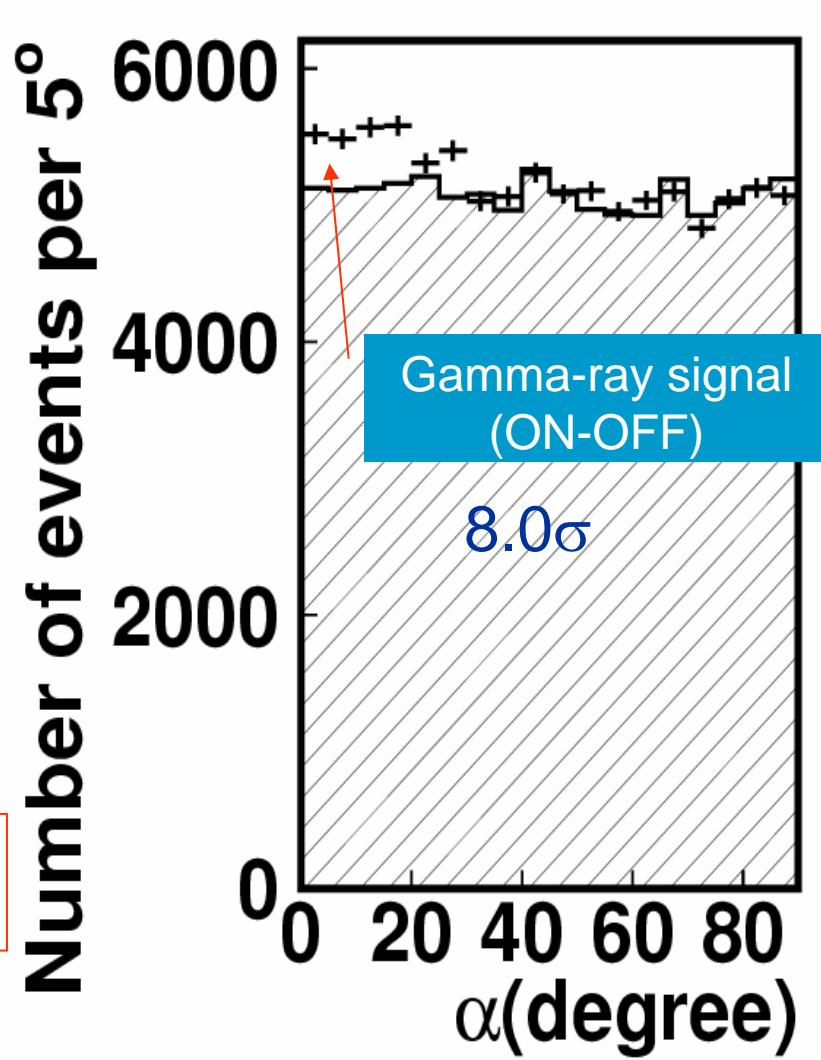
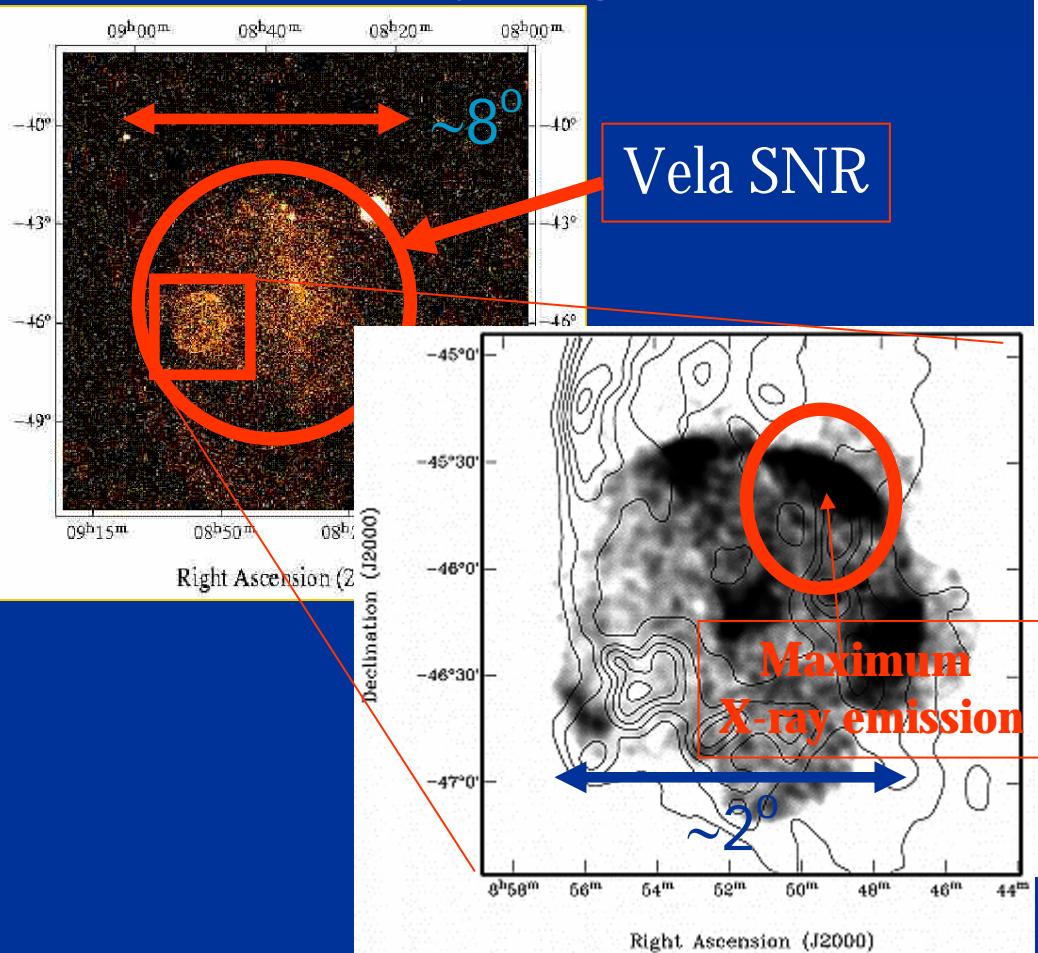
Galactic Center

■ CANGAROO 10m result

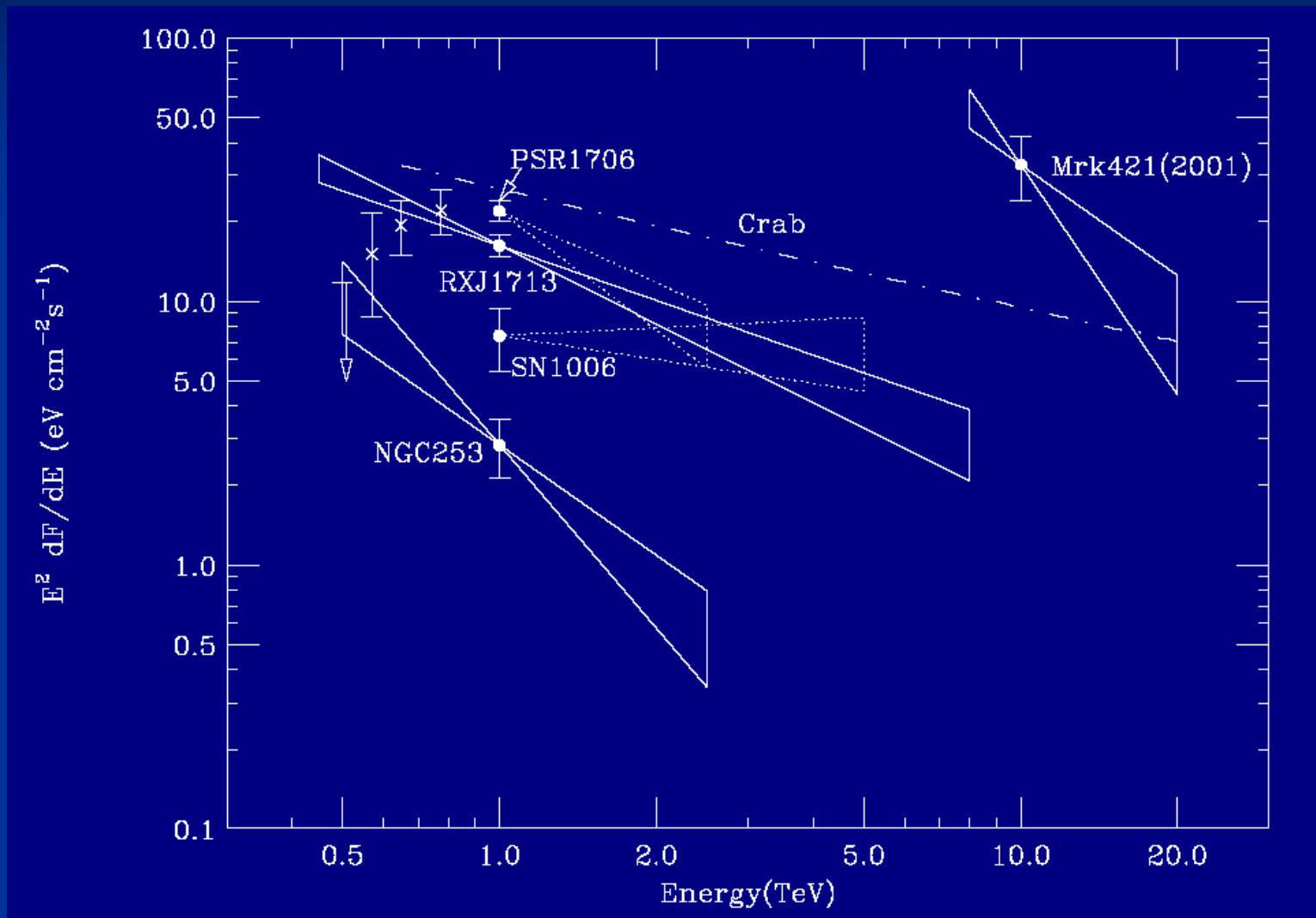


RX J0852.0-4622

ROSAT X-ray image

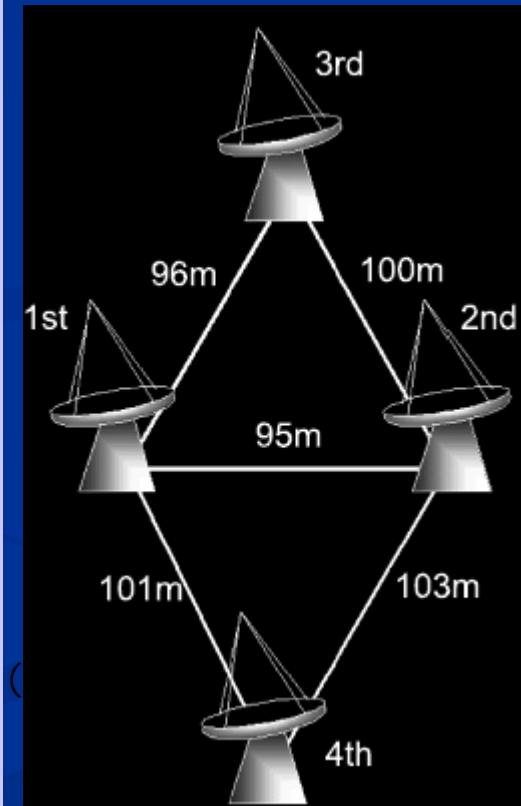
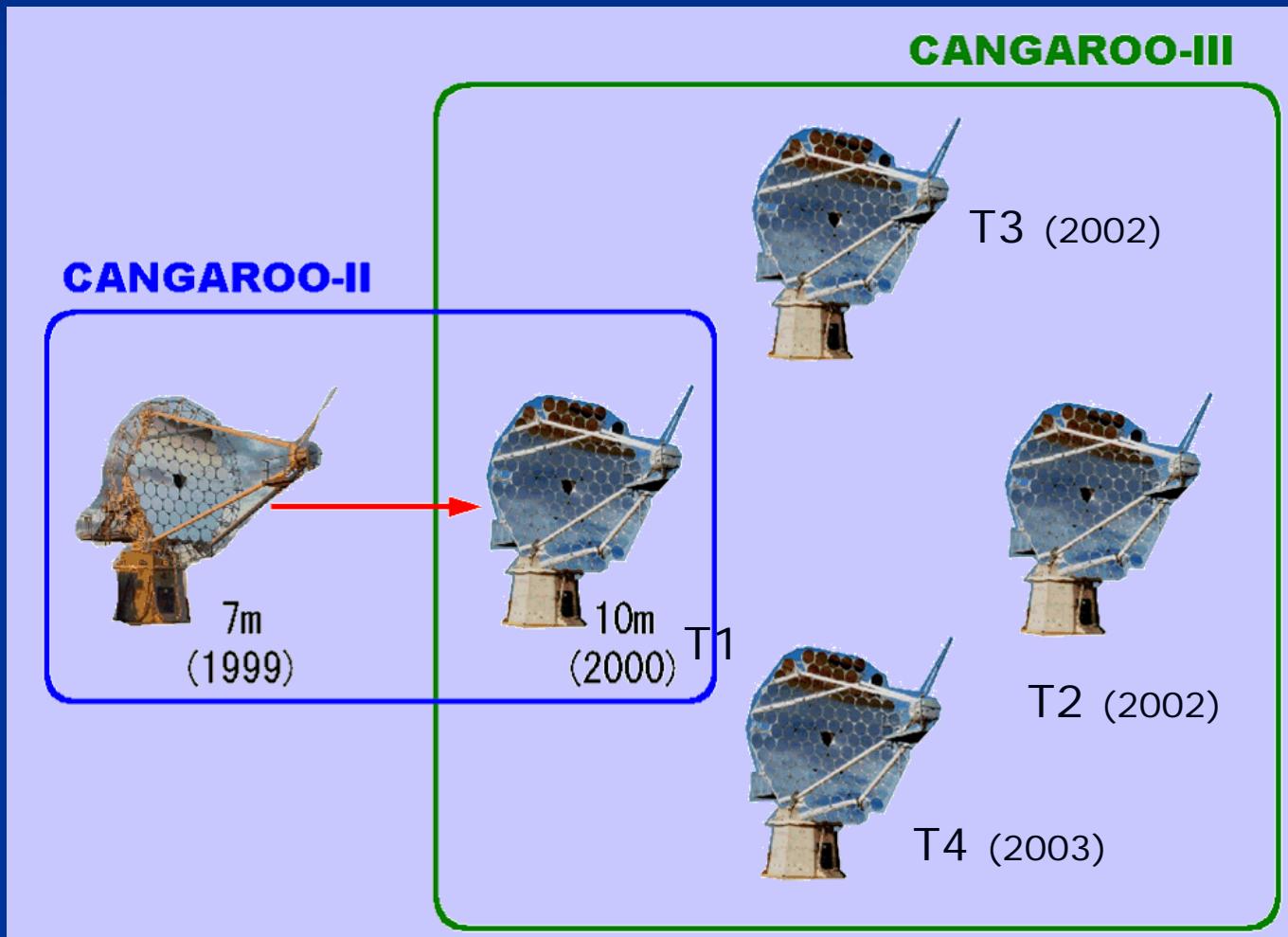


CANGAROO sensitivity



CANGAROO-III project

- An array of four 10m telescopes



Second 10m telescope

- Completed in 2002, operating since Dec. 2002
- Refined FRP-based mirror segments
- 427ch imaging camera
- Fast ADCs and TDCs

≡ “CANGAROO-III T2”

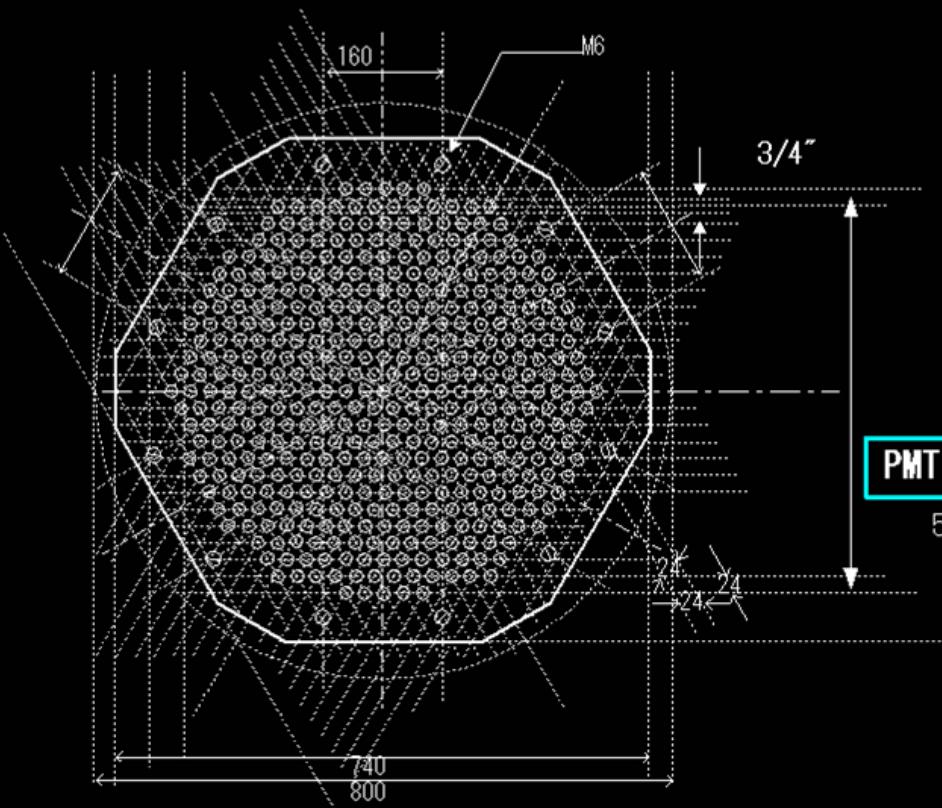


T2 imaging camera

CANGAROO III

PMT plane

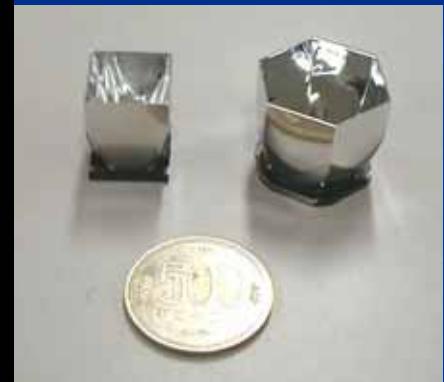
- Field of view of 4 degree
- 427-pixel PMT
- hexagonal miniure arrangement



Chie Ito (Ibaraki Univ.)

(HAMAMATU R3479)

- 3/4" diameter
- Risetime 1.3ns
- TTS 0.36ns
- UV Window



Light guide



R3479+Preamp

T2 electronics

- All VME-based
- 16bit q-ADC
- VME frontend
- TDC
- Pattern trigger
- Linux OS

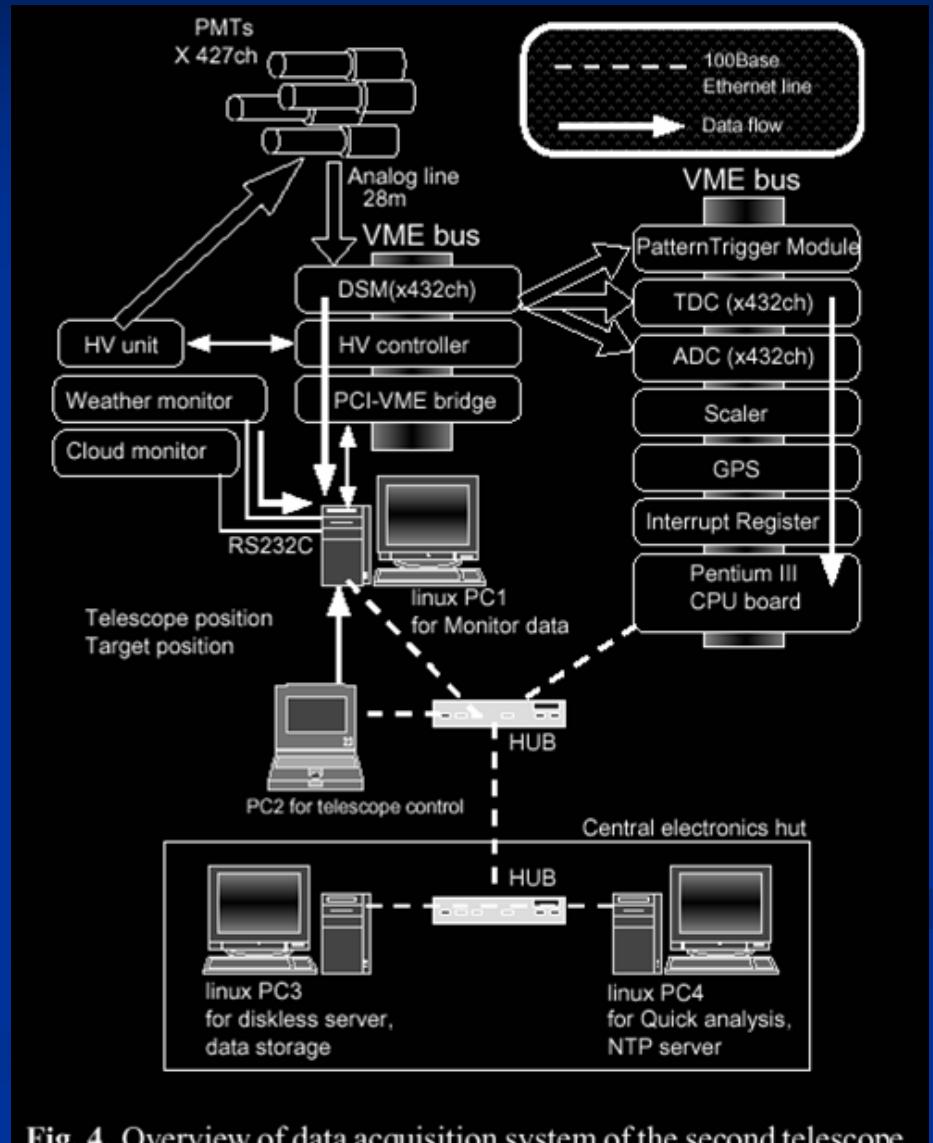
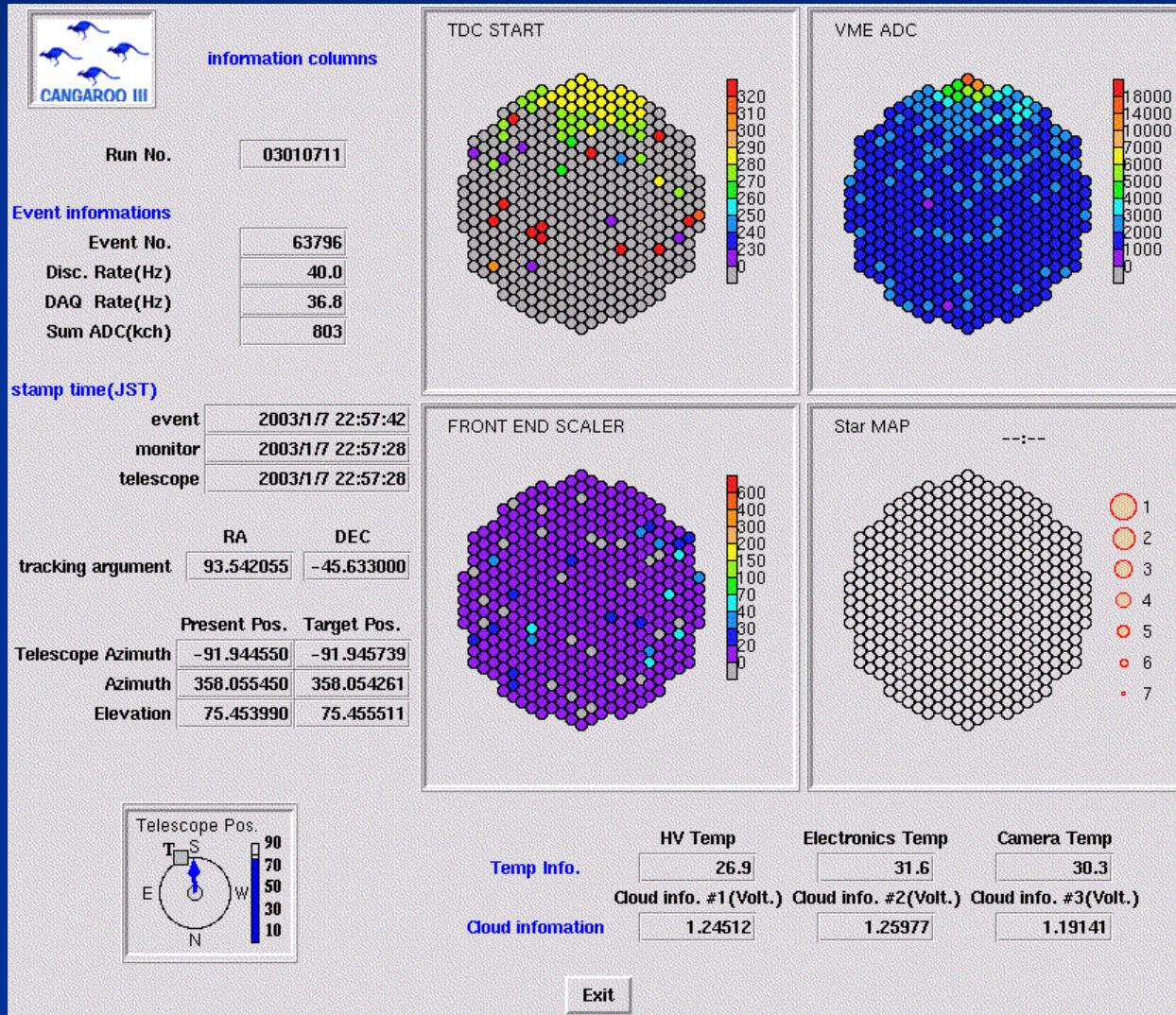


Fig. 4. Overview of data acquisition system of the second telescope.

Event samples of T2

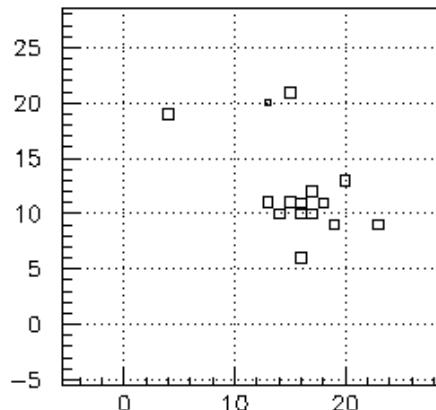


TDC ADC

Scaler Star

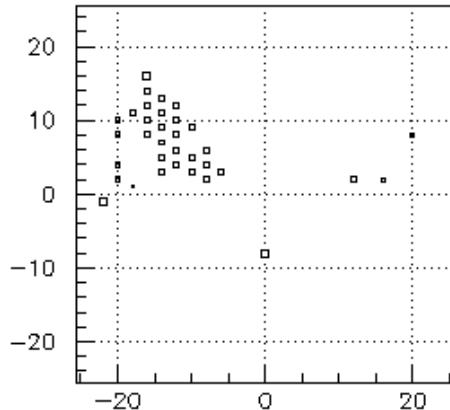
Samples of stereo events

T1 TDC



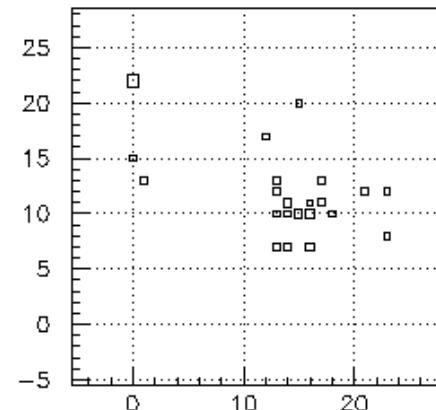
TMP Hit pattern TDC T1

T2 TDC



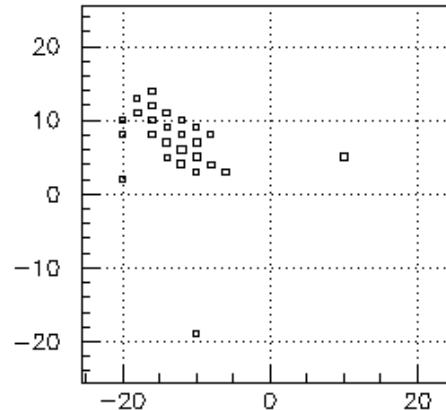
TMP Hit pattern TDC T2

T1 ADC

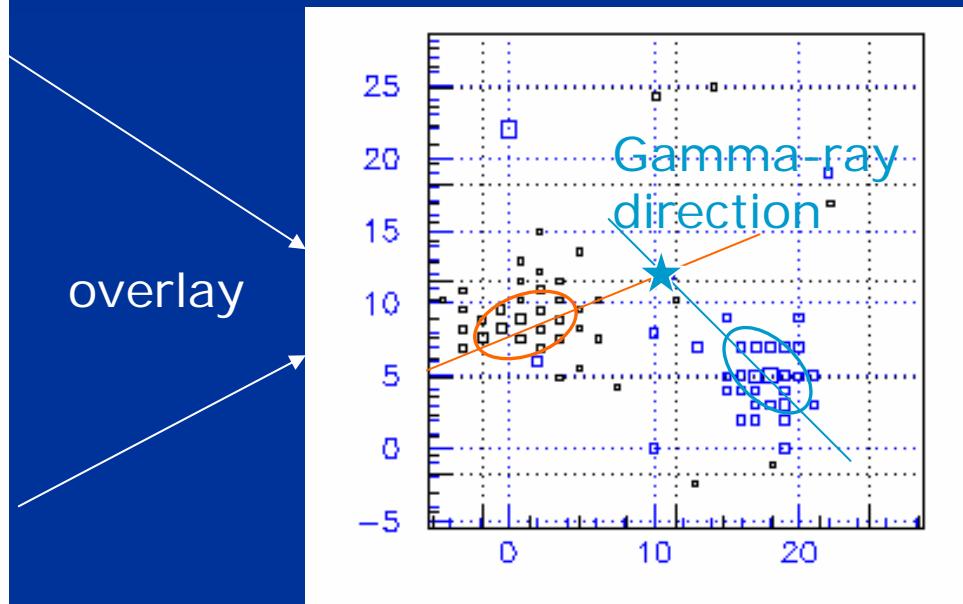
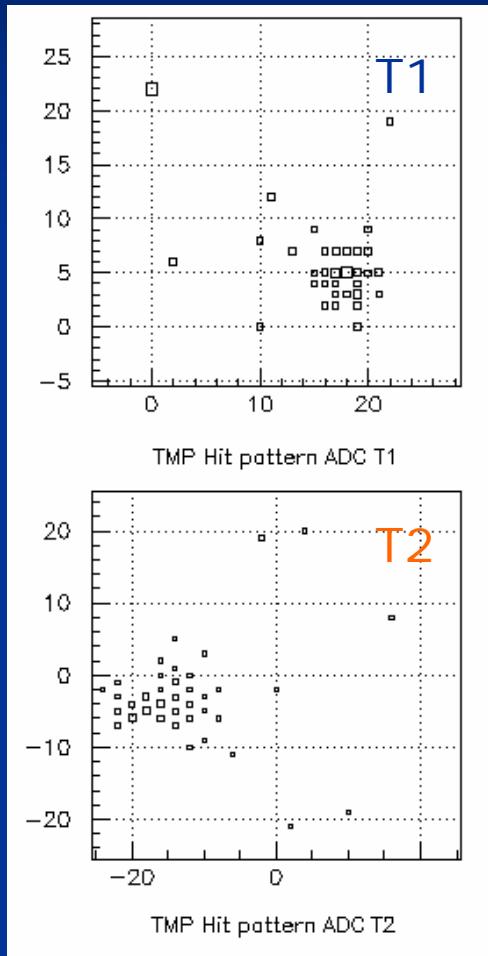


TMP Hit pattern ADC T1

T2 ADC



Stereo reconstruction



(This is just an illustrative example.)



Present status



T3

Jul. 2003 started

T2

Dec. 2002 started

T1

Since 2000

T4

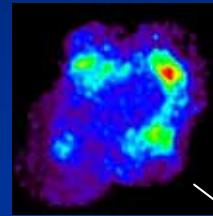
Jul. 2003
completed



427ch Imaging camera
for T2, T3, T4

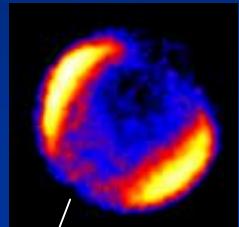
Systematic survey of SNRs

RX J1713.7-3946 (CANGAROO)



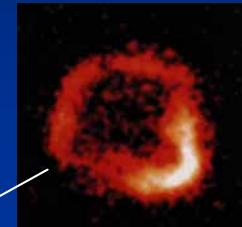
ASCA

SN1006 (CANGAROO)



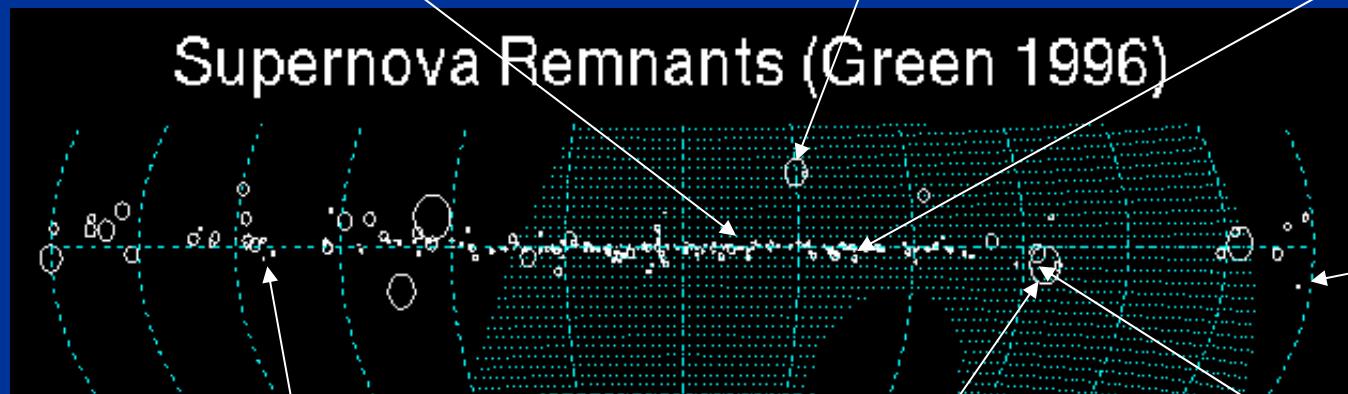
ASCA

RCW86 (CANGAROO under analysis)

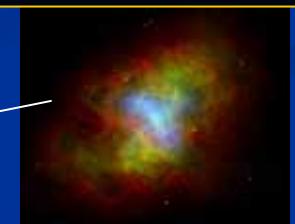


ROSAT

Supernova Remnants (Green 1996)



Crab nebula
("Standard candle")



Chandra
· optical

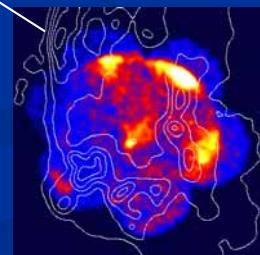
Chandra



Cas A (HEGRA)



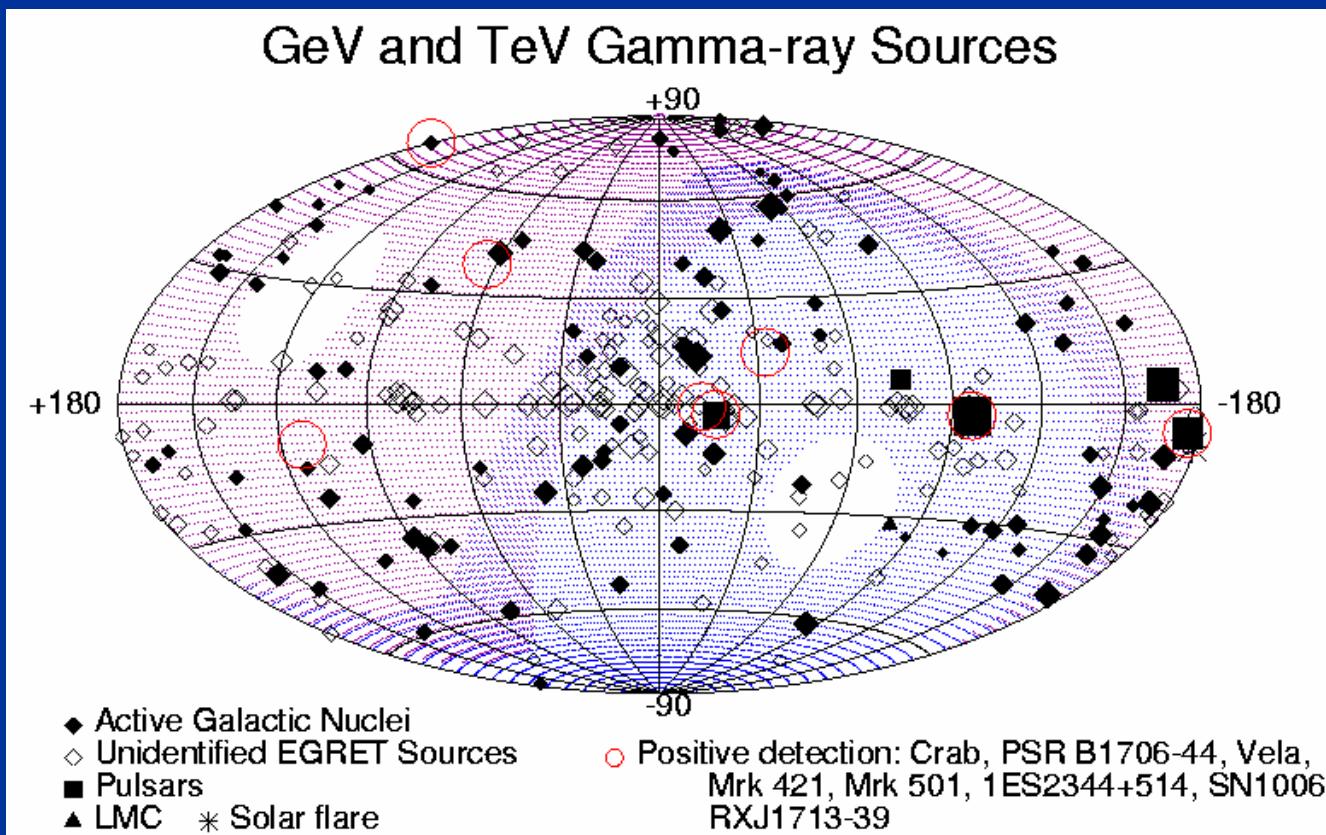
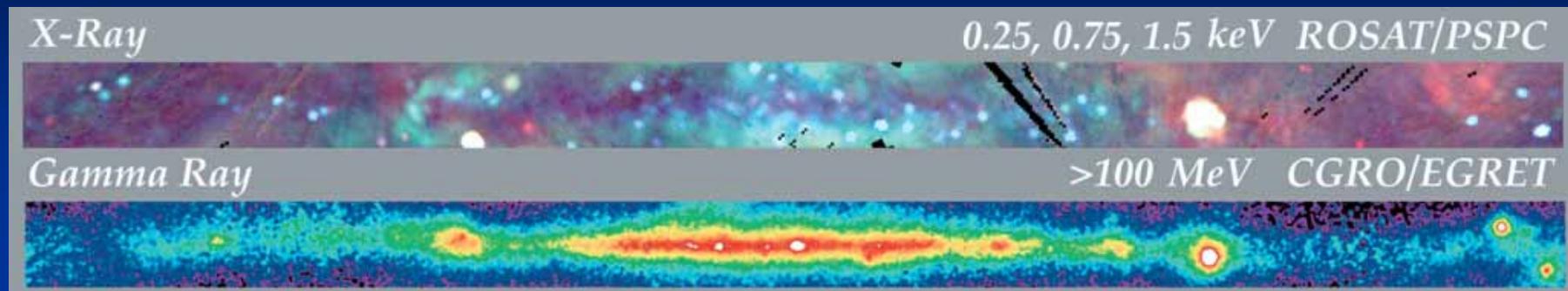
Vela (CANGAROO)



ROSAT

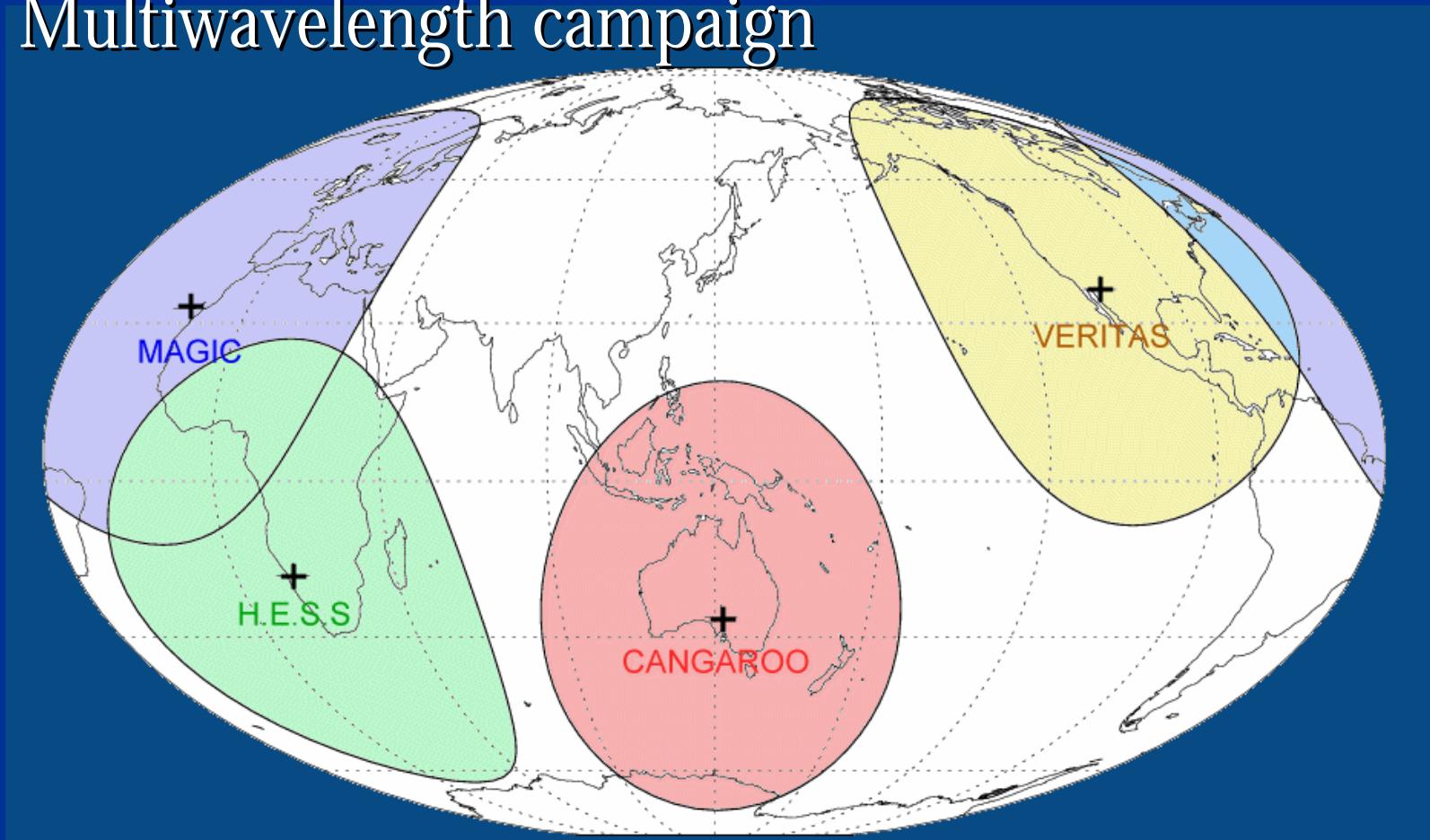
RX J0852-46 (CANGAROO under analysis)

Galactic plane survey

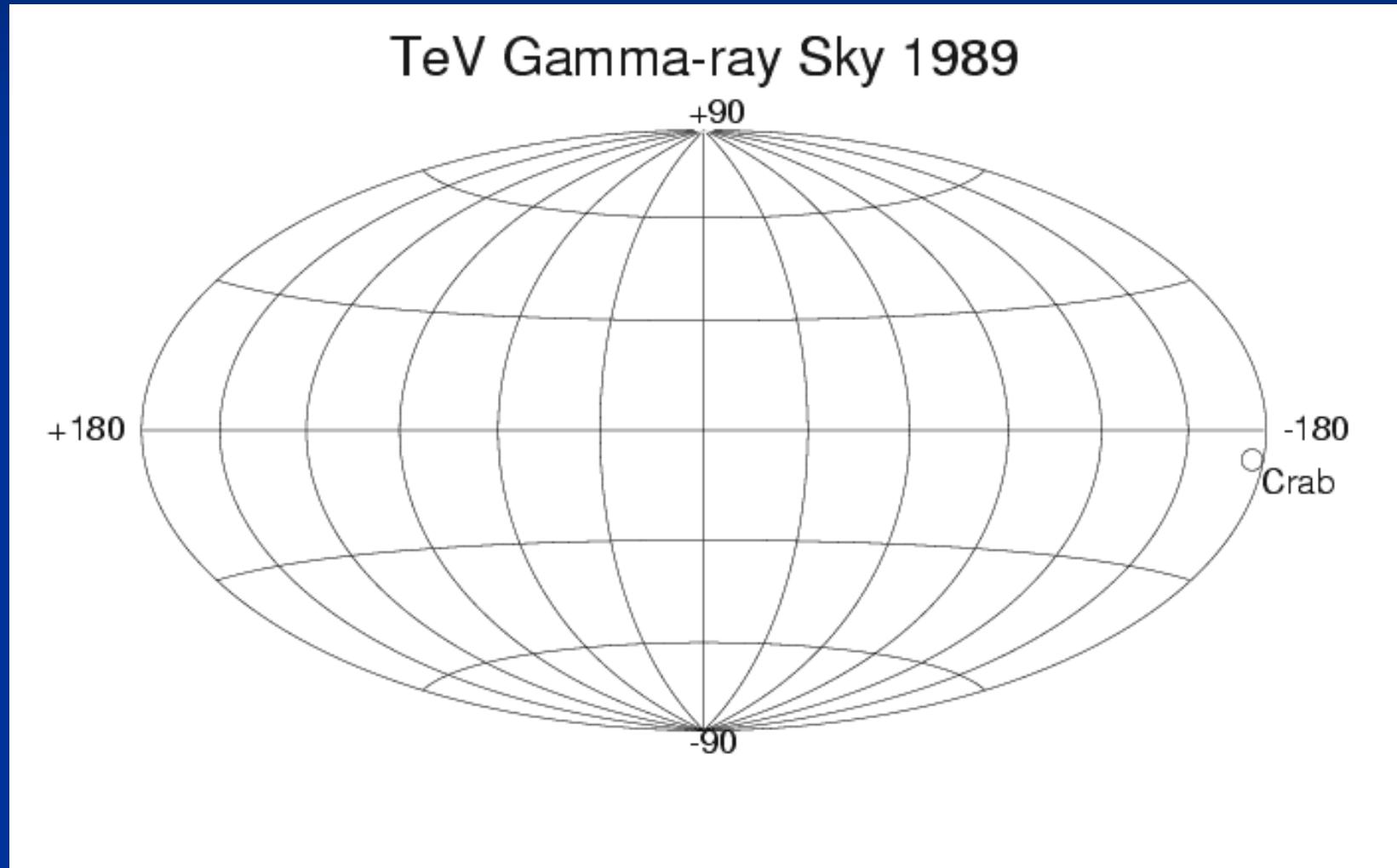


International coordination

- Continuous observation of time variable objects (ex. Blazars)
- Multiwavelength campaign



“Evolution” of the TeV gamma-ray sky



“Evolution” in number of objects

