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OG2: X-Ray and Gamma Ray Measurements

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Subsessions reported here

- OG 2.1 Diffuse galactic emission
- OG 2.2 Galactic sources
(e.g. supernova remnants, pulsars, binaries)
- OG 2.3 Extra-galactic sources
(e.g. active galactic nuclei, clusters of galaxies)
- OG 2.4 Gamma ray bursts
- OG 2.5 Instrumentation and new projects

Some statistics...

Session	Oral	Poster	Subtotal
2.1	7	4	11
2.2	22	36	58
2.3	20	16	36
2.4	9	10	19
2.5	17	48	65
Total	75	114	189

40min/189=12.7sec!

Before starting this talk...

■ PROVISOS

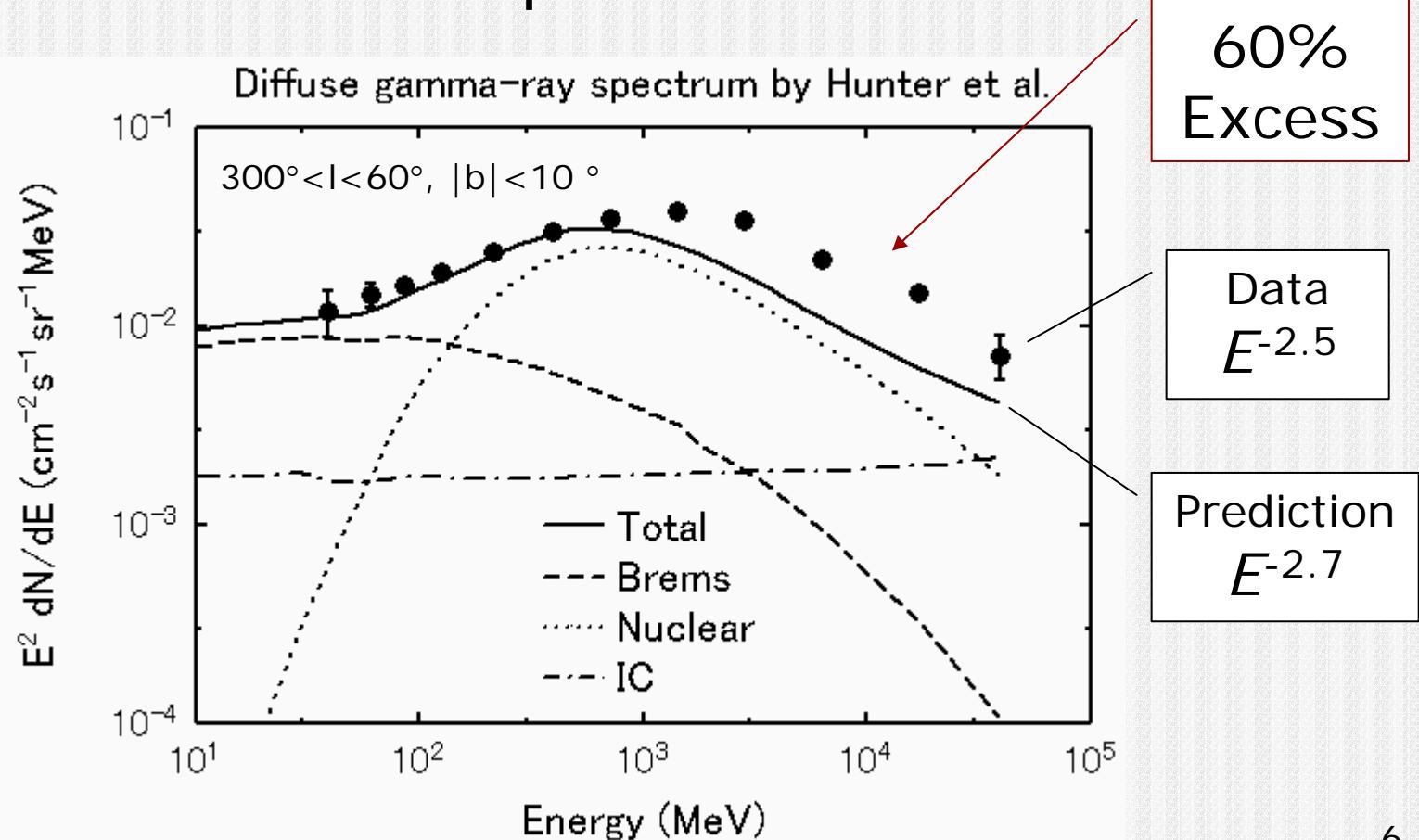
- This talk cannot cover all the papers within my limited time.
- The topics mentioned here are often subject to my prejudice often as an experimentalist (sorry).
- Papers not presented orally nor by poster are not given priority.
- Papers are referred as [First author, page number of proceedings].

X-ray and gamma-ray detectors

- X-rays: inevitably satellite-base
 - ASCA, Chandra, XMM-Newton, (MAXI)
- Gamma-rays: higher energy rays develops cascades in atmosphere
 - Satellite: EGRET, INTEGRAL, HETE-2, (AGILE, GLAST, CALET)
 - Cherenkov telescopes: Whipple, HEGRA CT, CANGAROO, PACT, CELESTE, STACEE, H.E.S.S., MAGIC
 - Airshower detectors: Tibet, Milagro, KASCADE, GRAPES-3, GRAND, ARGO-YBJ

2.1 Diffuse galactic emission

- The problem: EGRET “GeV bump”
 - Hunter et al. ApJ 1997



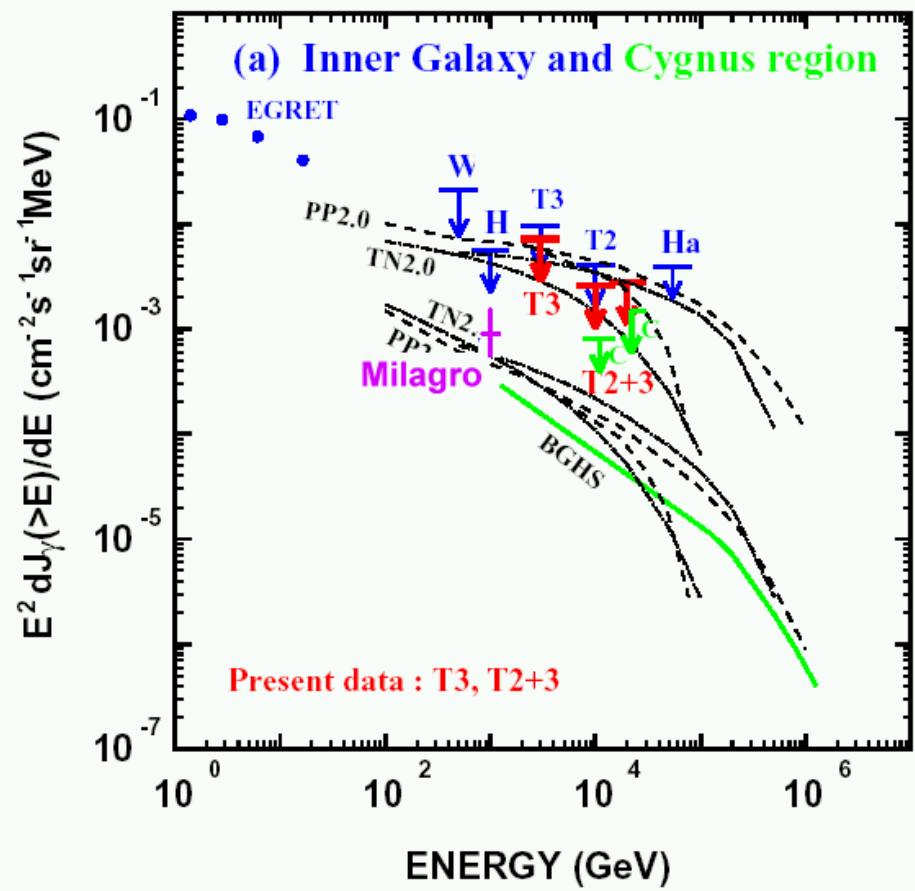
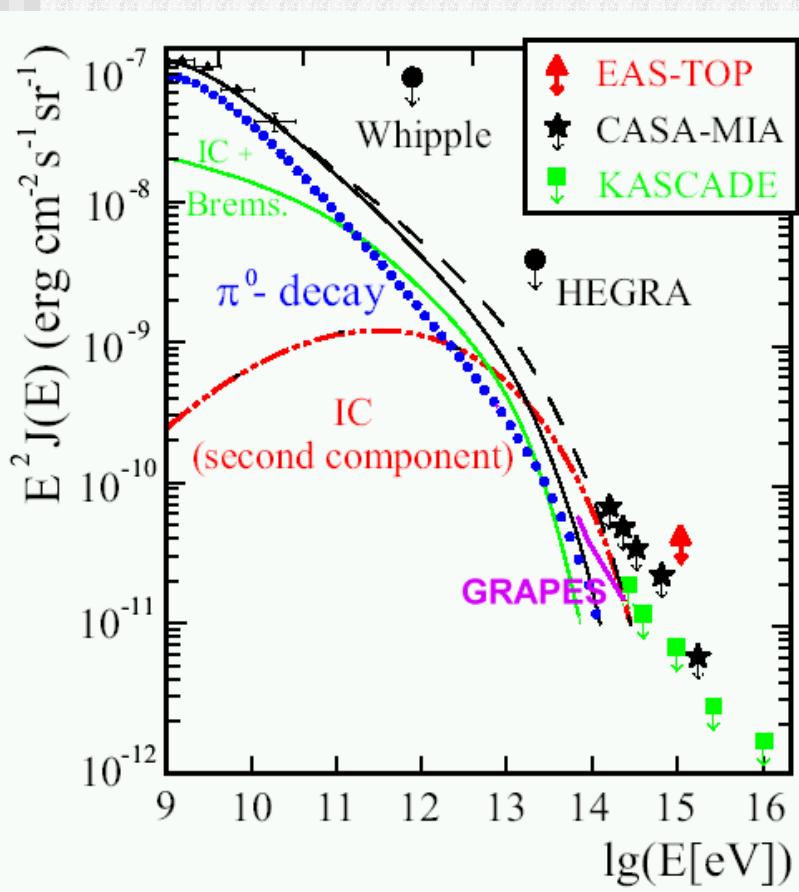
2.1 Diffuse galactic emission

■ New observations

- Milagro [Fleysher 2269]
 - Water Cherenkov air shower detector
 - 2.8σ excess: $20^\circ < l < 100^\circ$, $-7^\circ < b < 7^\circ$
 - $F_\gamma/F_{\text{CR}} = (5.3 \pm 1.9) \times 10^{-5}$ @1TeV
- GRAPES [Hayashi 2273]
 - Air shower array, muon poor events
 - $F_\gamma/F_{\text{CR}} < 3 \times 10^{-5}$ @100-500TeV
- KASCADE [Shatz 2293]
 - Air shower array, muon poor events
 - Upper limit 10^{14} - 10^{16} eV, no point-like source
- Tibet II+III [Amenomori 2305]
 - Air shower array
 - Upper limits for Inner Galaxy, Cyg region
 - $F_\gamma/F_{\text{CR}} < (2-12) \times 10^{-4}$ @3-10TeV

2.1 Diffuse galactic emission

■ Observation: summary



2.1 Diffuse galactic emission

■ New calculations

■ Erlykin and Wolfendale [2281]

- SNR model

■ Tateyama and Nishimura [2285]

- Emission from electrons

■ Shibata et al.[2301]

- π^0 , Spatial and energy distribution

■ Strong and Moskalenko [2309]

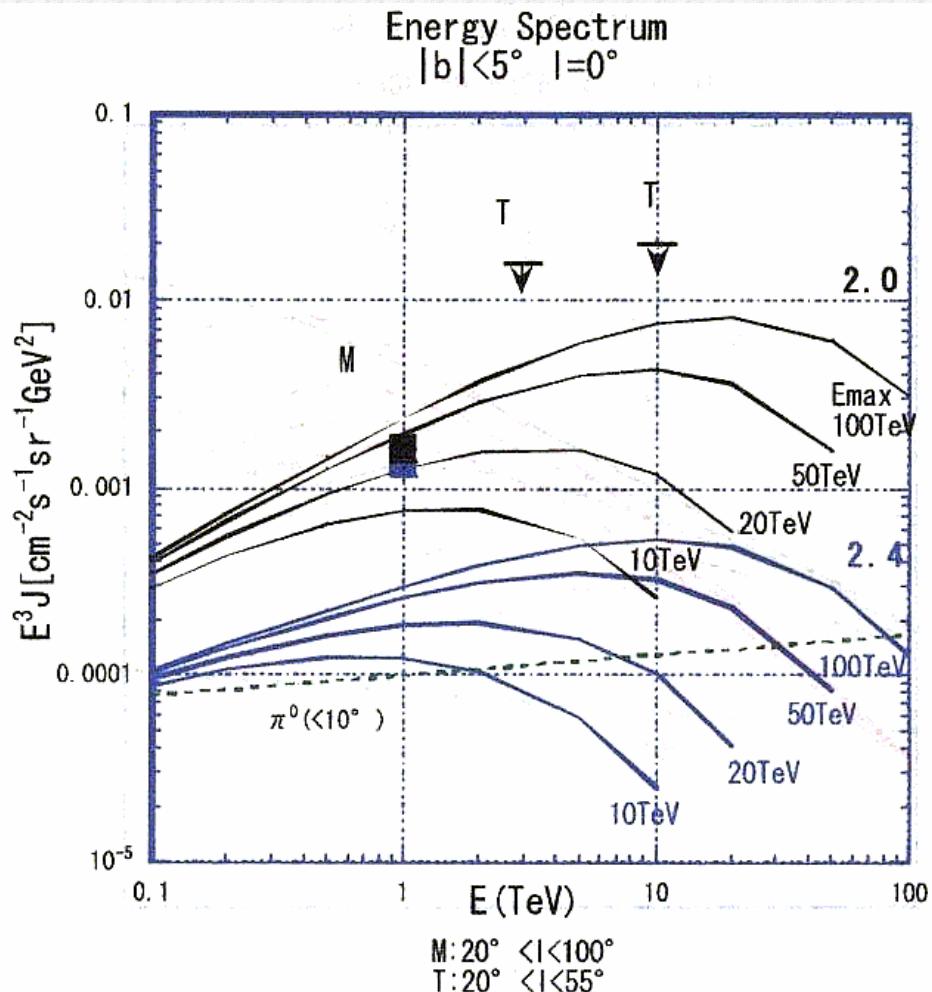
- Hard γ sources + hard electron spectrum

■ C.Y.Huang [2297]

- New π^0 production parametrization

2.1 Diffuse galactic emission

Emission from electrons



M: Milagro
T: Tibet

2.1 Diffuse galactic emission

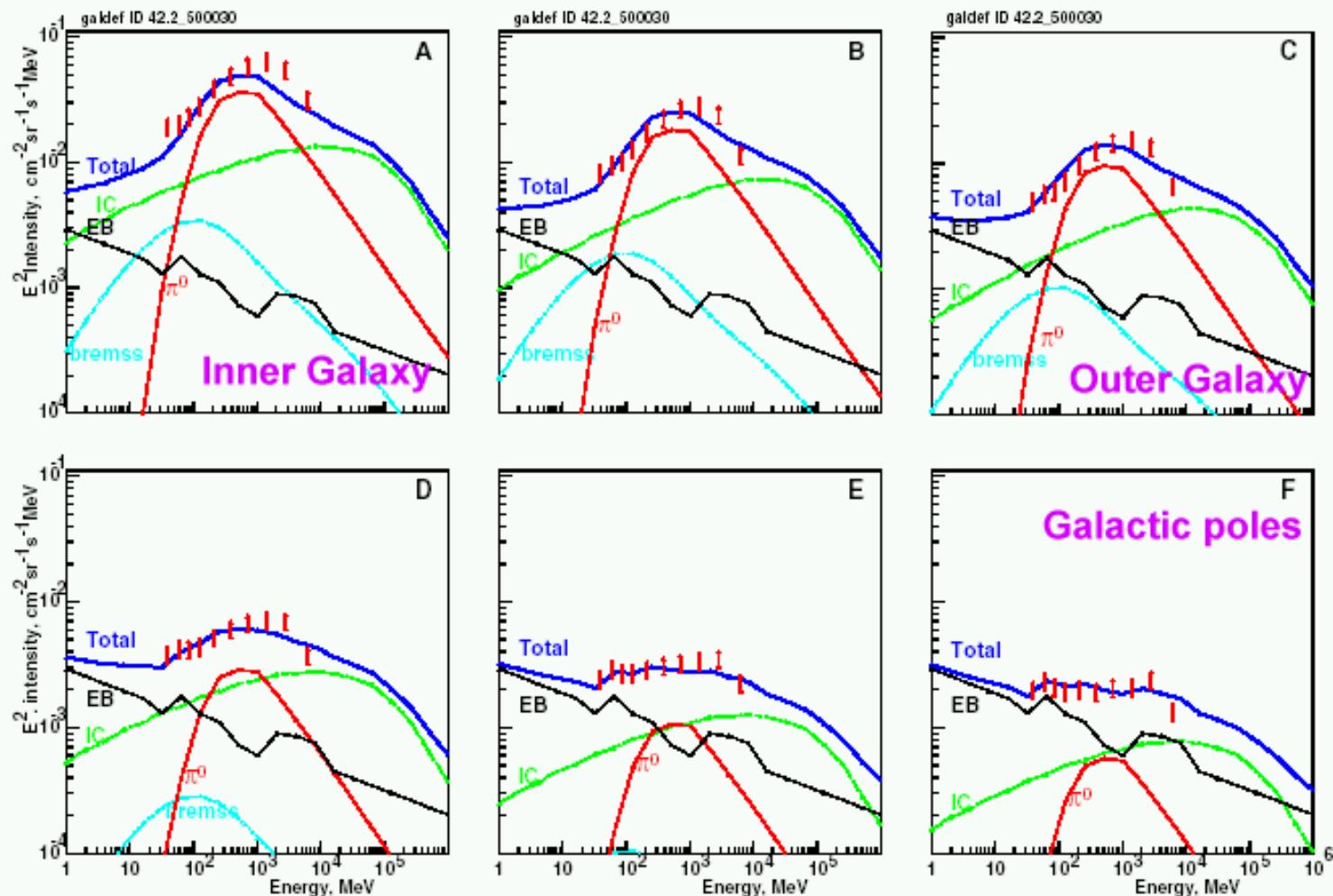
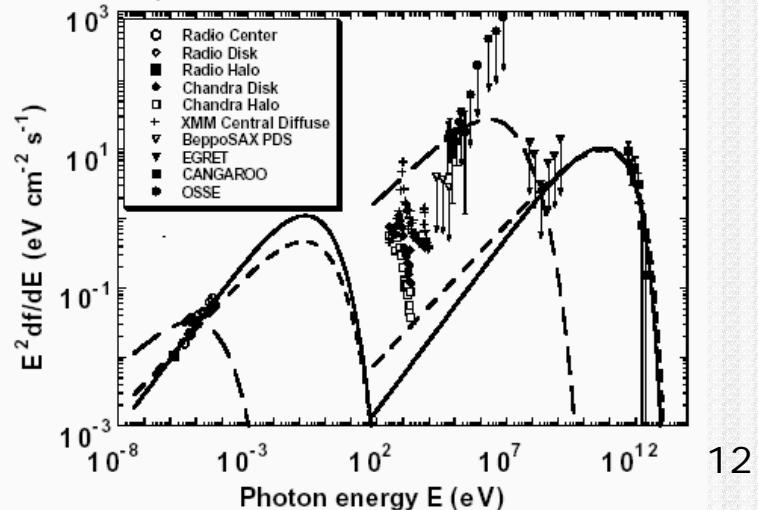
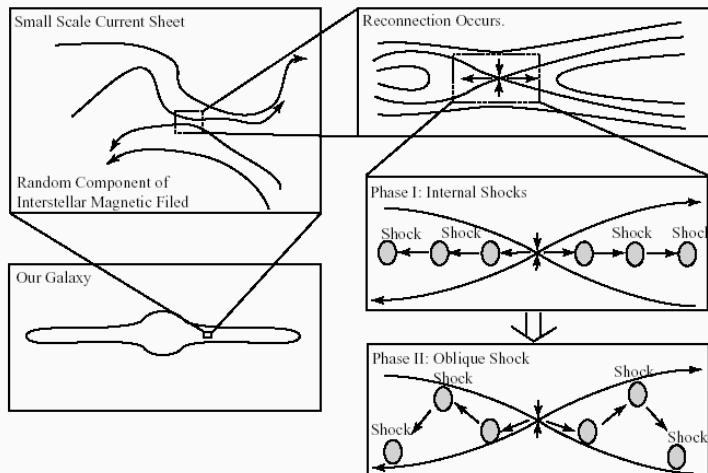


Fig. 2. γ -ray spectra for optimized model. Regions as Fig. 1.

2.1 Diffuse galactic emission

■ New ideas

- Magnetic reconnection as origin of diffuse X and gamma emission [Tanuma 2277]
- Gamma-ray halo around NGC253 – extended electron halo? [Yoshida 2289]



2.2 Galactic sources

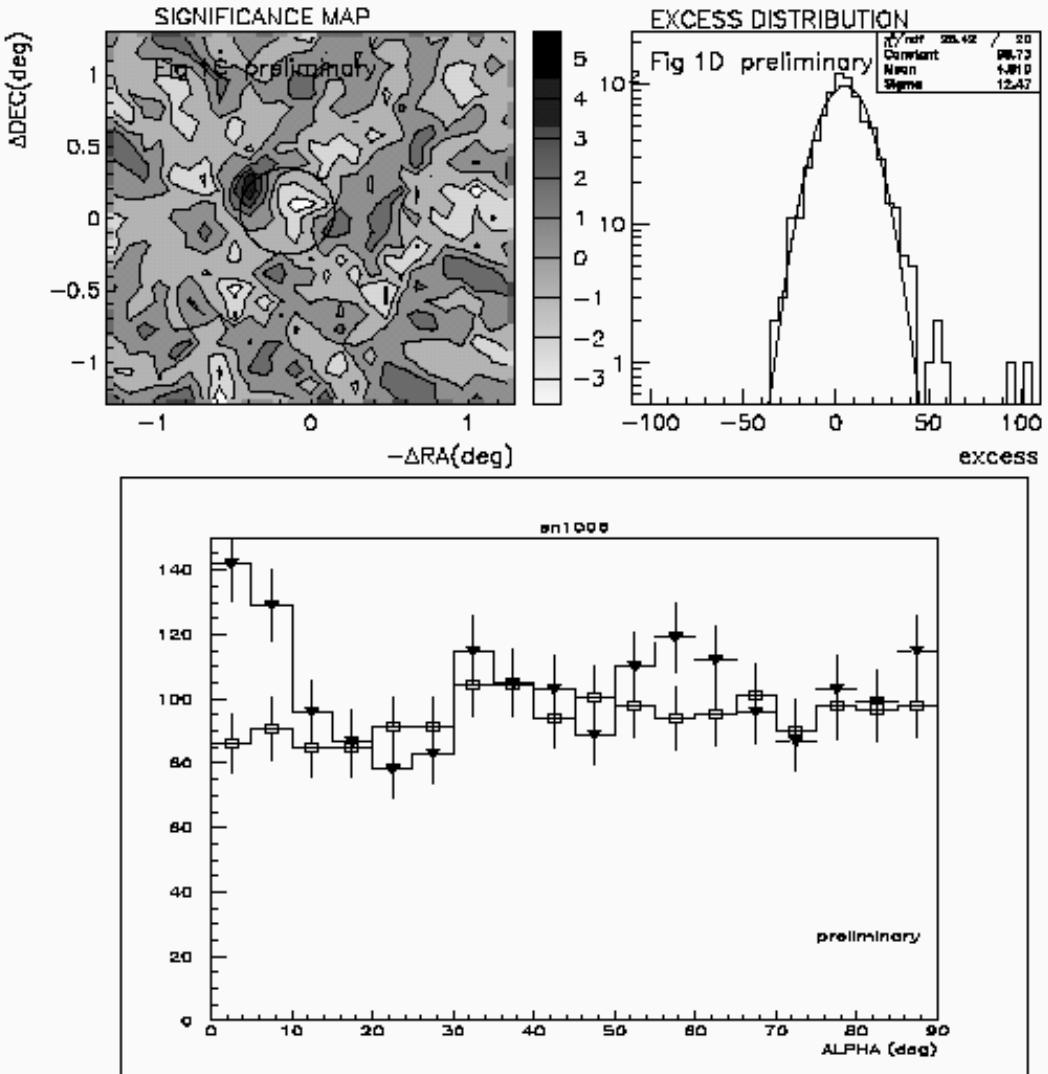
- Supernova remnants = Origin of CR?
 - Energetics – OK
 - Maximum energy – Up to “Knee region”
 - How much of them?
 - Some evidences, which can be ascribed to HE electrons: where are HE protons?
- Pulsar and pulsar wind nebula (plerions)
 - Crab – “The standard candle”
 - Up to a few 10GeV: pulsed+unpulsed
 - Above: unpulsed only
 - - Unpulsed: SSC (Synchrotron-Self-Compton) model
 - - Where is the cutoff?
 - - (Pulsar emission models)
 - Others? Vela, PSR1706-44,...

2.2 Galactic sources

- Supernova remnant SN1006
 - CANGAROO detection [*Tanimori et al. ApJ 1998*]
 - New observations
 - HEGRA CT1 detection [Vitale 2389]
 - H.E.S.S. non-detection [Masterson 2323]
 - Theoretical studies
 - Curved electron spectrum [Allen 2393]
 - Magnetic field configuration [Yamazaki 2417]
 - Efficient proton acceleration [Berezhko 2441]

2.2 Galactic sources

- SN1006
 - HEGRA CT1
 - 219hrs
 - $>18\text{TeV}$
 - 5σ excess
 - Position within 0.1° of CANGAROO hotspot



2.2 Galactic sources

■ H.E.S.S.

CT3 Observations:

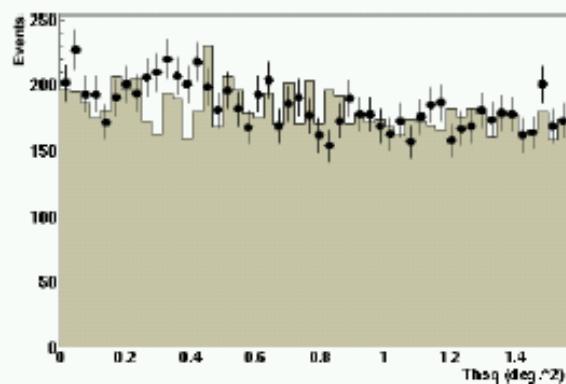
4.5 hrs livetime
14 On/Off pairs
after quality selection

2-D excess:

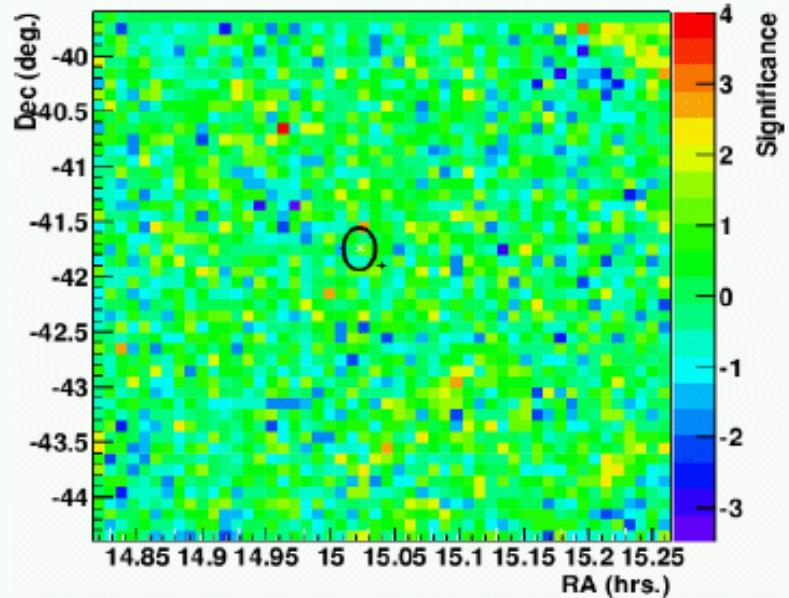
1.0 σ

Background after cuts

0.96 min. $^{-1}$



SN 1006 CT3

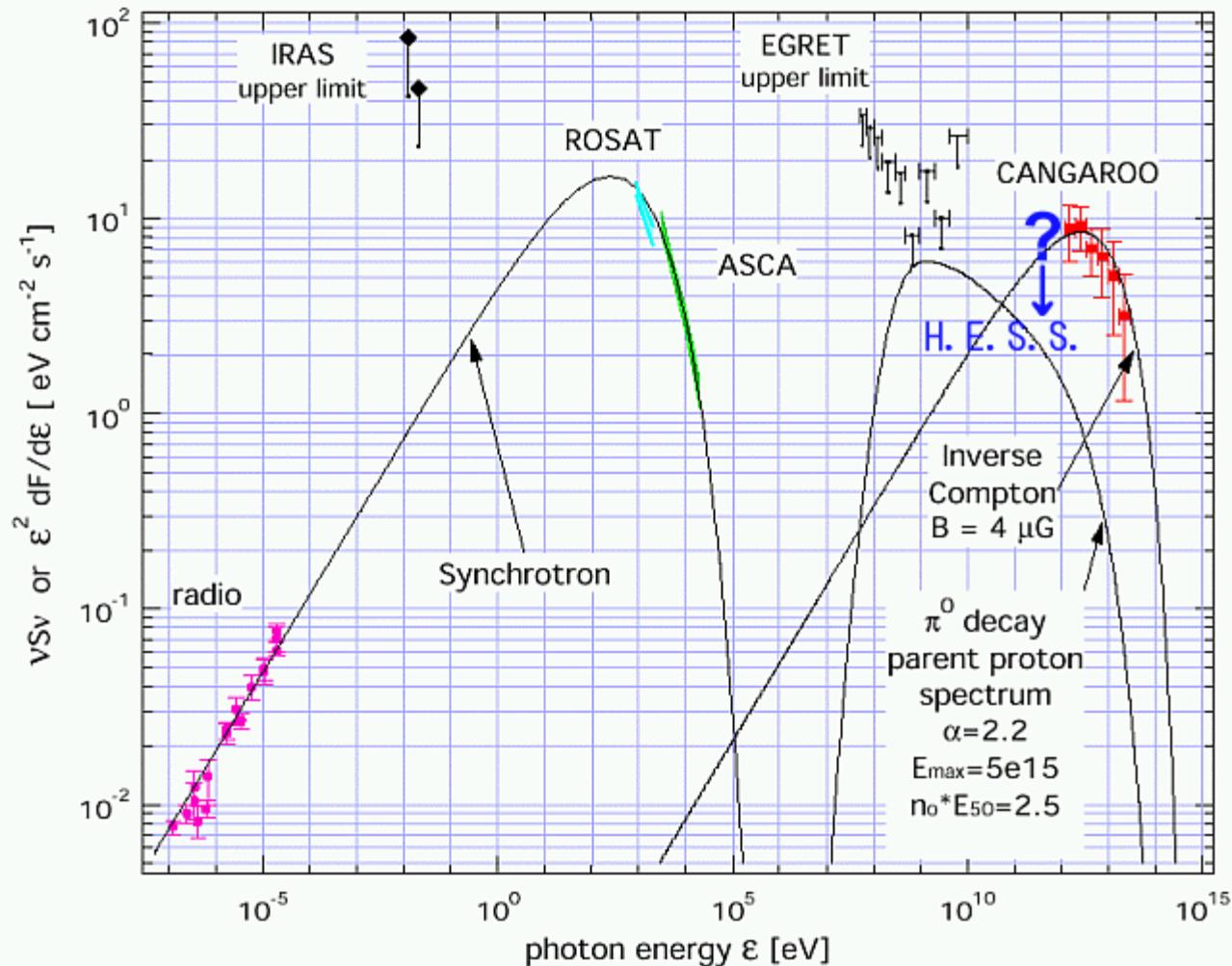


Cangaroo hotspot marked by circle

Excess as function of distance from
Cangaroo hotspot

2.2 Galactic sources

■ SN1006: multiwavelength spectrum



2.2 Galactic sources

■ Crab nebula/pulsar

■ New observations

- Whipple [Kildea 2377] upper limit on pulse
- HEGRA CT system [Horns 2373]
- HEGRA CT1 [Ona-Wilhelmi 2449] optical pulse
- H.E.S.S. [Masterson 2323, Konopelko 2903]
- PACT [Acharya 2381, Acharya 2501] pulsed

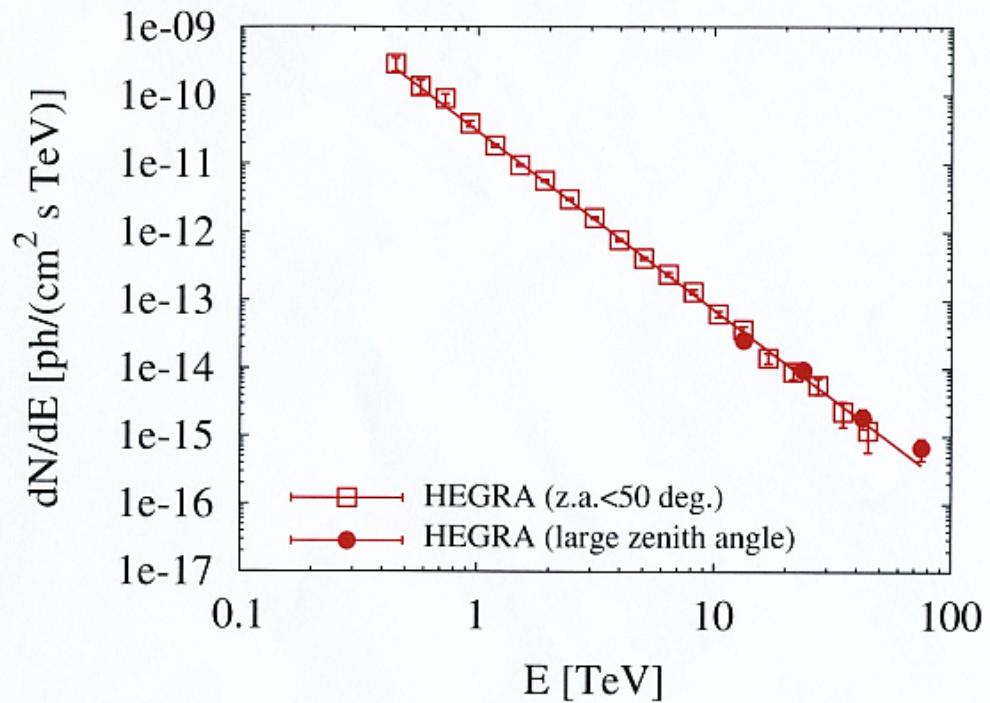
■ Theoretical studies

- Two-component electron [Stephens 2385]

2.2 Galactic sources

■ Crab: HEGRA CT system

Energy Spectrum: 0.4 – 80 TeV

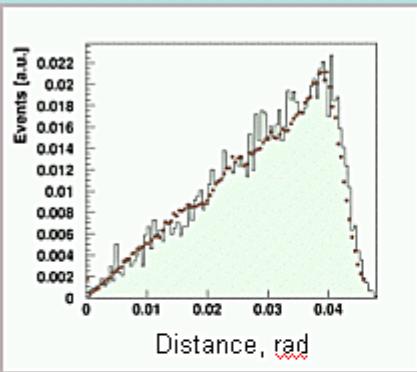


- Measurement over two decades of energy
- Large zenith angle data consistent with small zenith angles (no saturation)
- Pure power-law: $d\Phi/dE \propto E^{-\Gamma}$, $\Gamma = 2.62 \pm 0.02_{stat} \pm 0.05_{sys}$
- No cut-off visible: Signal ($S > 5\sigma$) above 50 TeV

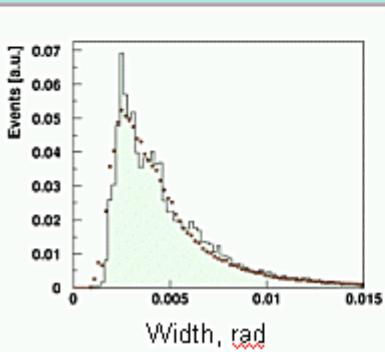
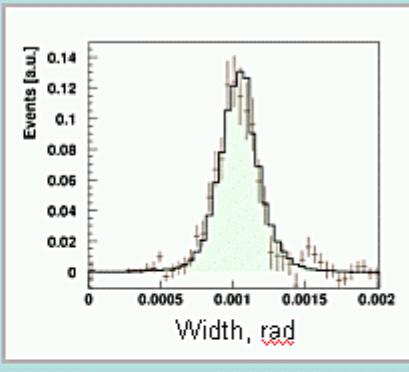
2.2 Galactic sources

■ Crab: H.E.S.S.

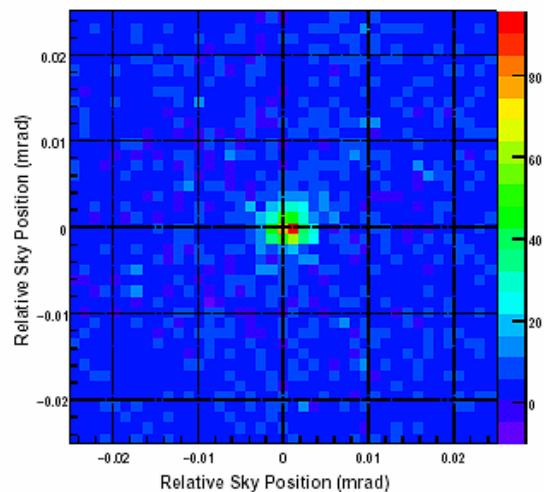
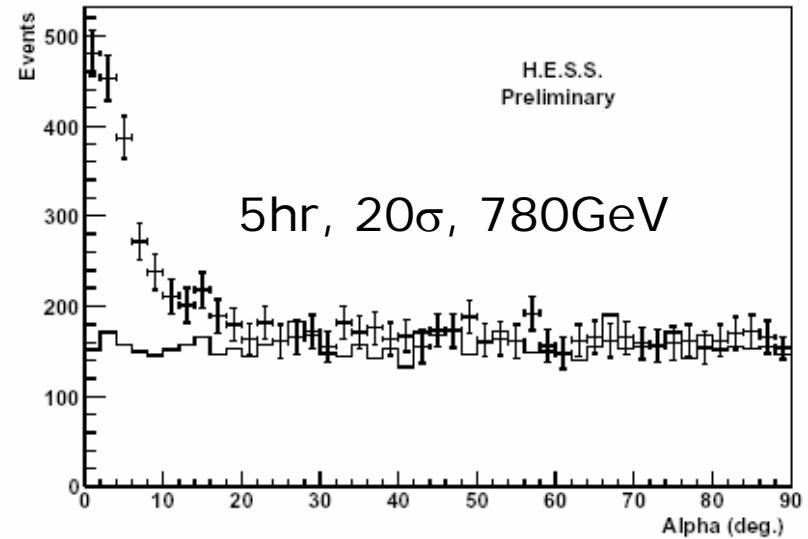
Cosmic Rays



Gamma-rays



Data: filled circles;
MC: histogram.



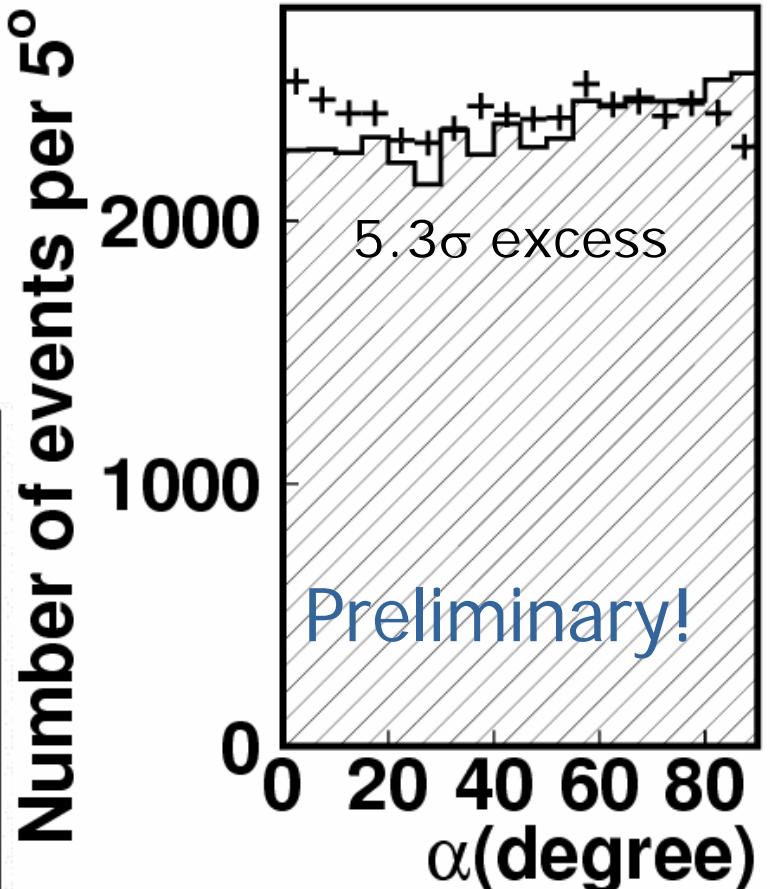
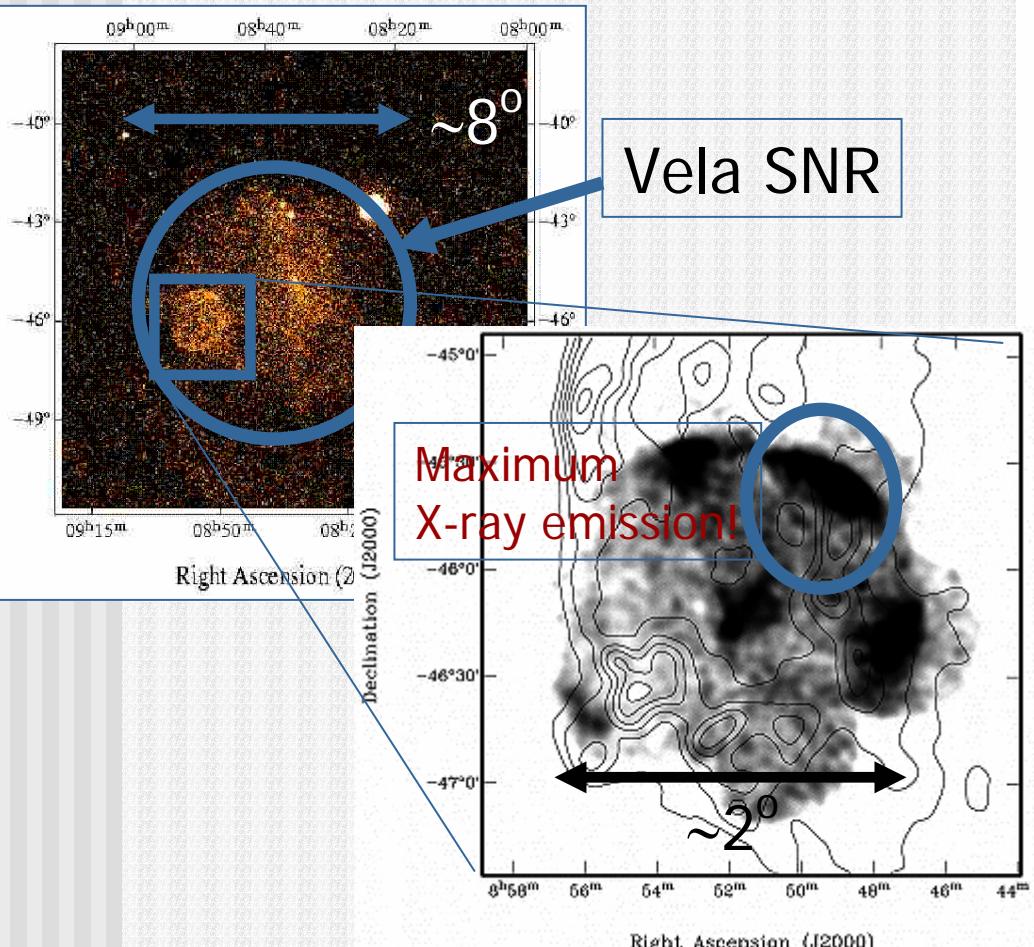
2.2 Galactic sources

- Newly claimed sources
 - SNR RCW86 [Watanabe 2397] 4σ
 - SNR GC40.5-0.5 [Zhang 2405] 4.4σ
 - SNR RX J0852.0-4622 [Katagiri 2409]
 - Galactic center [Tsuchiya 2517]
- Sky survey
 - Tibet-III [Cui 2315]
 - 23 directions $>4\sigma$, 5 possible new associations
 - HEGRA CT system [Puelhofer 2319]
 - TeV J1915.2+11.47

2.2 Galactic sources

- SNR RX J0852.0-4622, CANGAROO 10m

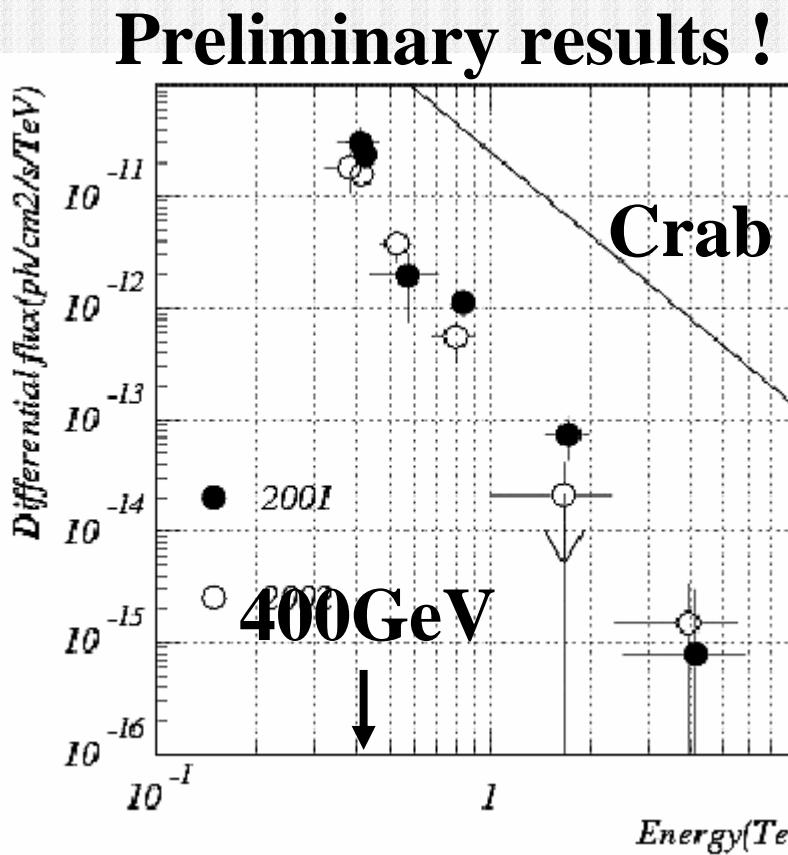
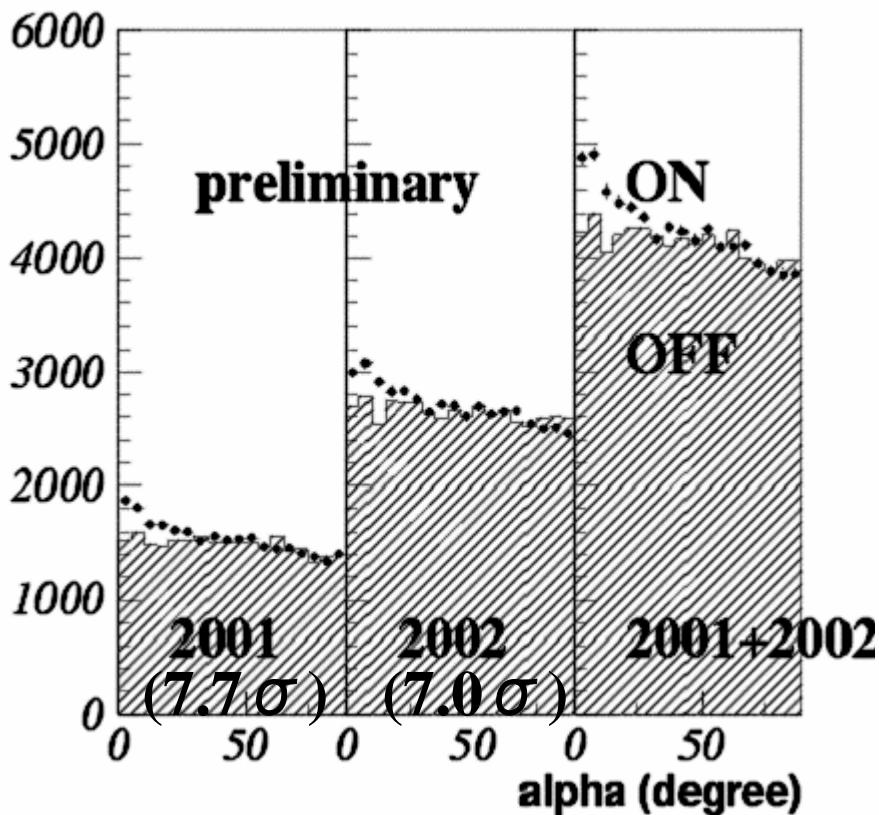
ROSAT X-ray image



[Katagiri 2409]

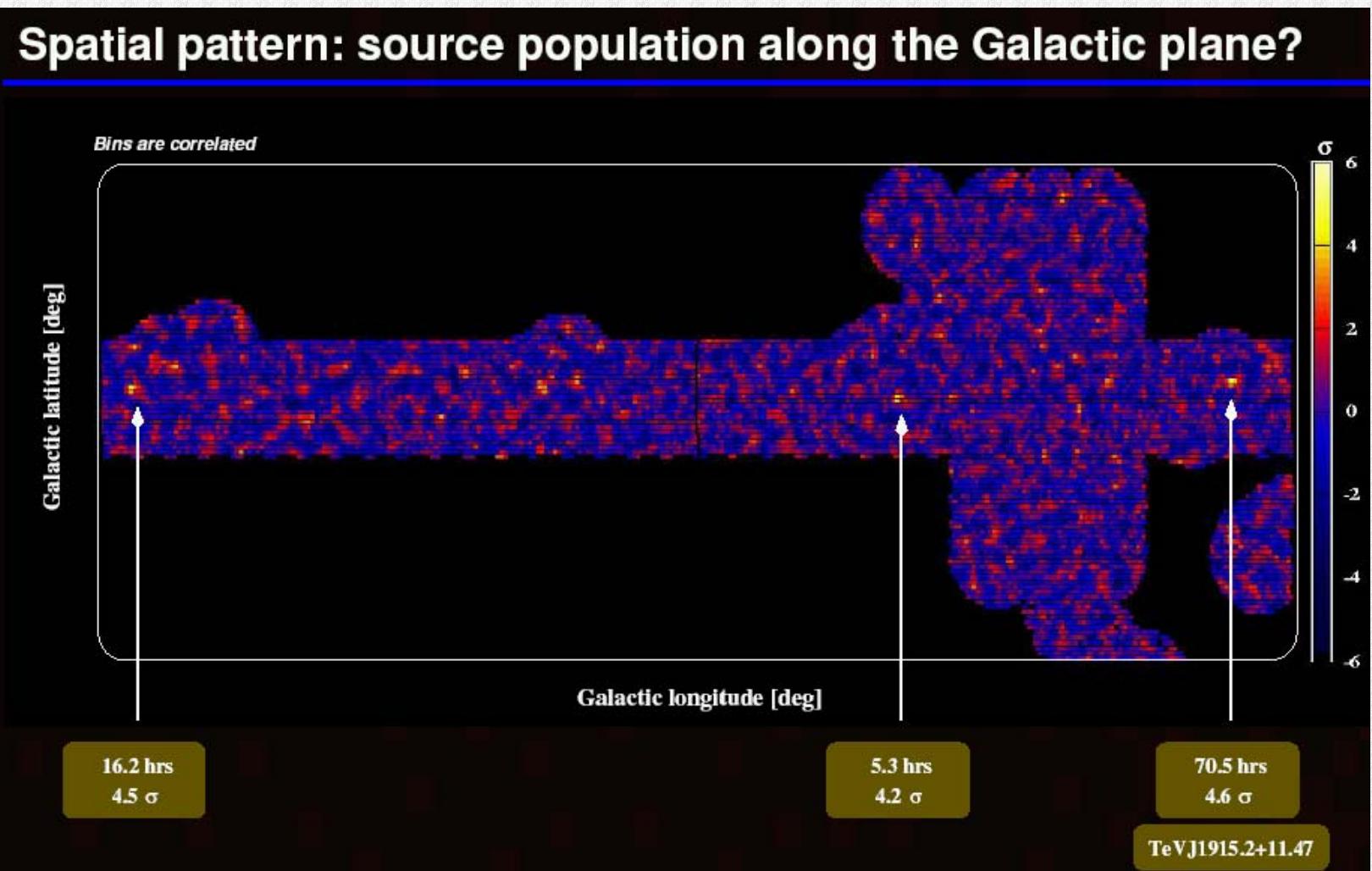
2.2 Galactic sources

- Galactic center, CANGAROO 10m



2.2 Galactic sources

- Scan by HEGRA CT system



2.2 Galactic sources

■ Confirmed sources

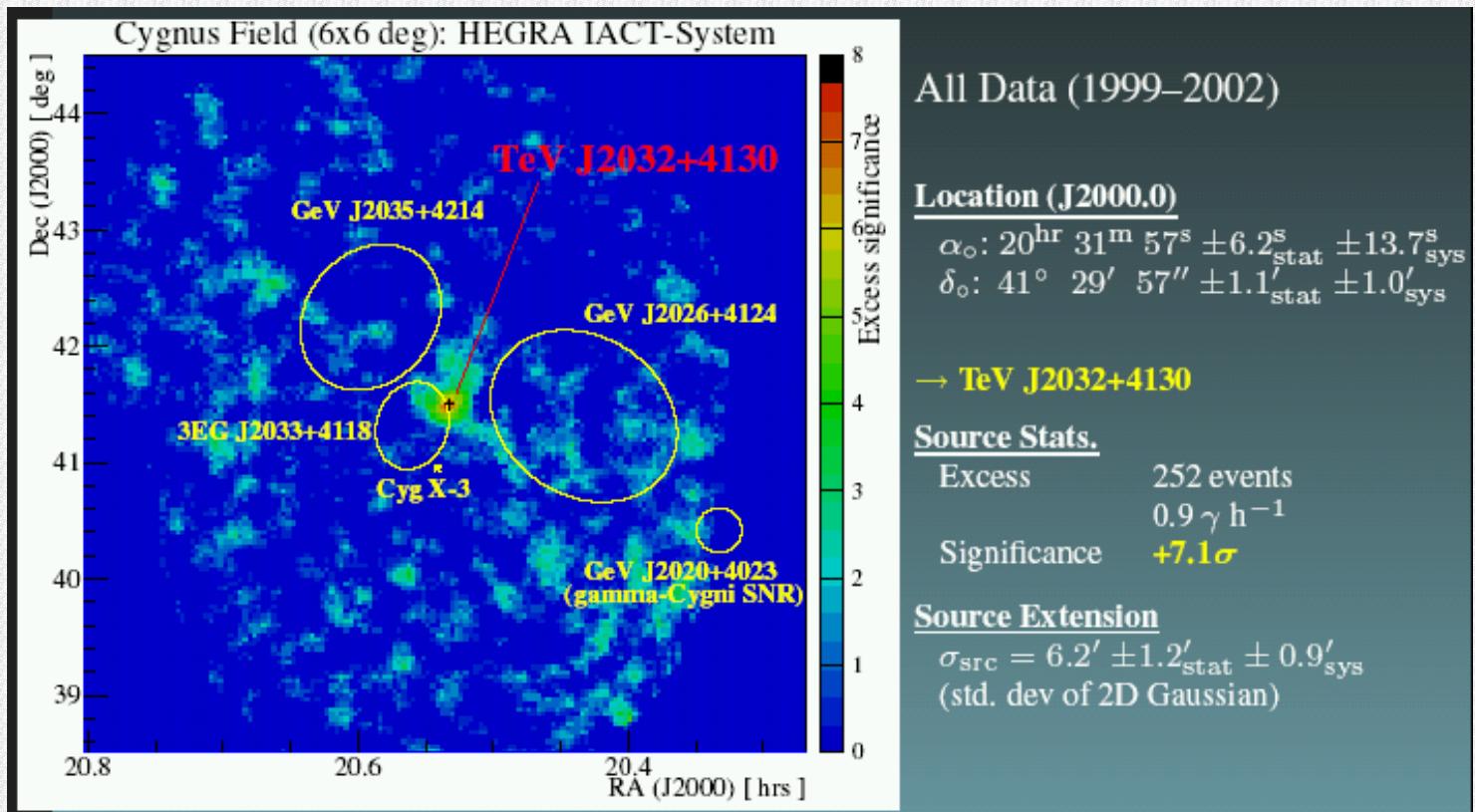
■ TeV J2032+4130

- HEGRA CT system detection [*Aharonian 2002AA*]
- HEGRA CT system revisited [Rowell 2345]
- Emission mechanism [Bednarek 2365]
- Photon absorption [Reimer 2505]
- Relation to Cyg X-3? [Rowell 2345, Sinitzyna 2473]

2.2 Galactic sources

■ UnID TeV source TeV J2032+4130

- Very hard spectrum $E^{-1.9}$
- No counterpart in radio or X-rays



2.2 Galactic sources

■ Upper limits

- GRAPES-3 [Mohanty 2327] Crab & IC443
- HEGRA CT system [Rowell 2329]
 - CTB1, LS I+63°303, GeV J2026+4124, GeV J2035+4214
- SYS [Aoki 2333]
 - Hadronless, no excess but X1822-377 period?
- Tibet [Wang 2357]
 - 10 SNRs
- CANGAROO
 - PSR J1420-6048, SS433 [Nishida 2489, Hayashi 2533]
- Whipple
 - PSR B1823-13, Galactic center, Globular cluster M15 [Hall 2497, Kosack 2513, LeBohec 2521]

2.2 Galactic sources

■ Source studies

- SNR origin/shock acceleration [Erlykin 2353, Berezhko 2425, Voelk 2429, Berezhko 2433, Berezhko 2437, Shimada 2421]
- EGRET unID = pulsars? [Erlykin 2337]
- PSR1706-44 [Kushida 2493] small X-ray nebula
- SNR W28 [Ueno 2401] non-thermal X-rays

■ Emission models

- Pulsar wind nebulae, Galactic center, LSI+61°303, Cyg X-3 [Bednarek 2471, Bednarek 2509, Sierpowska 2465, Sierpowska 2477, Bartosik 2485]

■ Proposed targets

- Single source SNR: Monogem? [Erlykin 2349]
- Microquasars [Reimer 2341, Latham 2525, Merck 2529]

2.3 Extragalactic sources

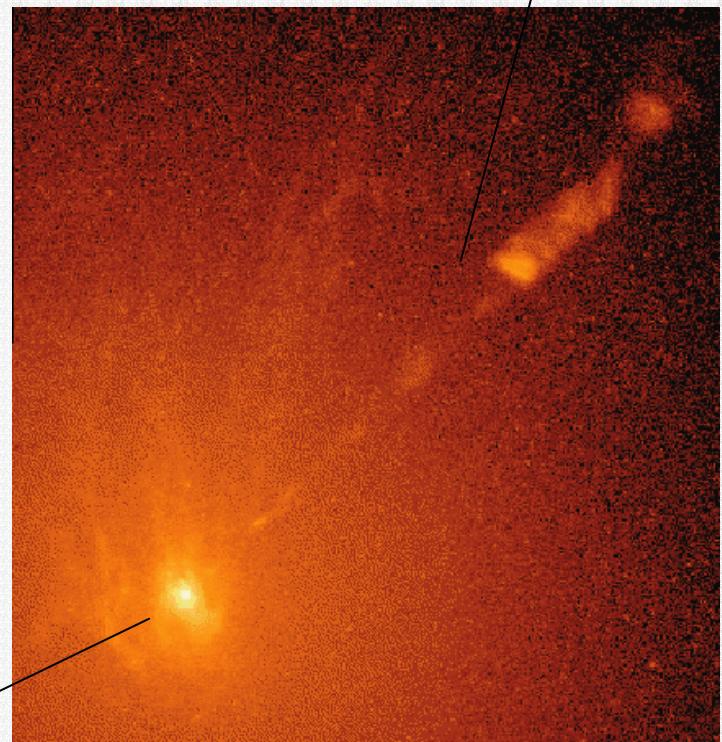
- Active galactic nuclei
 - Blazars
 - Wide-band spectrum – nonthermal
 - Quasars – LBL (RBL) – HBL (XBL) sequence
 - Leptonic models
 - SSC or EC (External Compton)
 - Hadronic models
 - Proton-initiated cascades
 - Radio galaxy,...
- Gamma-ray absorption by EBL (Extragalactic Background Radiation)
 - Infrared photon field: uncertain
- Center of galaxies
 - Accumulation of dark matter??
- Extragalactic background radiation

2.3 Extragalactic sources

■ Newly claimed sources

- M87 (Vir A, Giant radio galaxy, $z=0.00436$ or 16Mpc)
 - HEGRA CT system detection [Goetting 2623]
 - Whipple upper limit [LeBohec 2627]
 - Theoretical study [Reimer 2631, Donea 2671]
 - Proton blazar model, emission from torus?

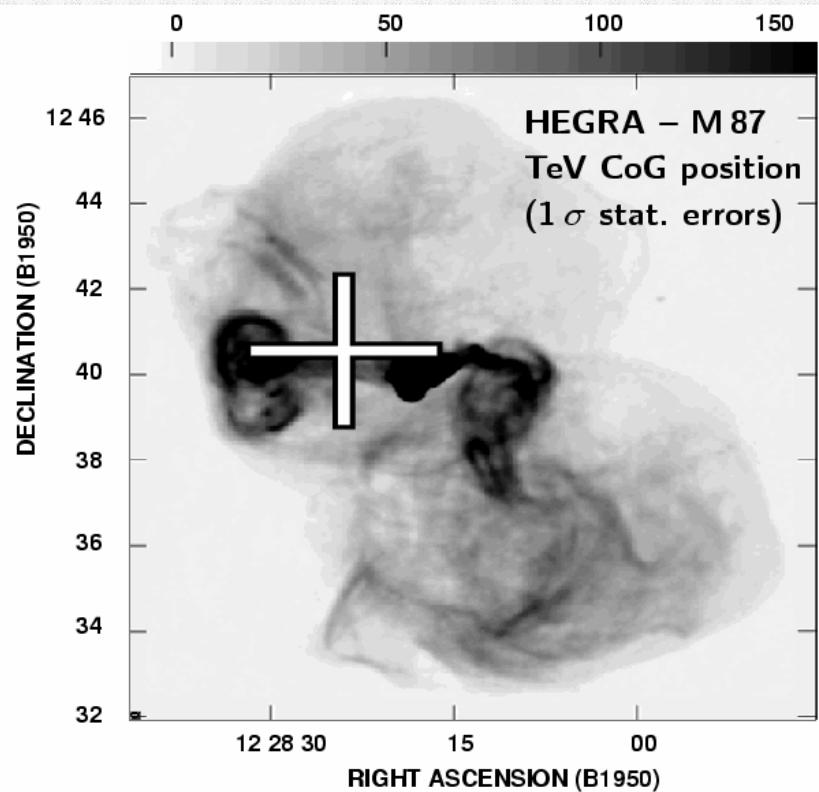
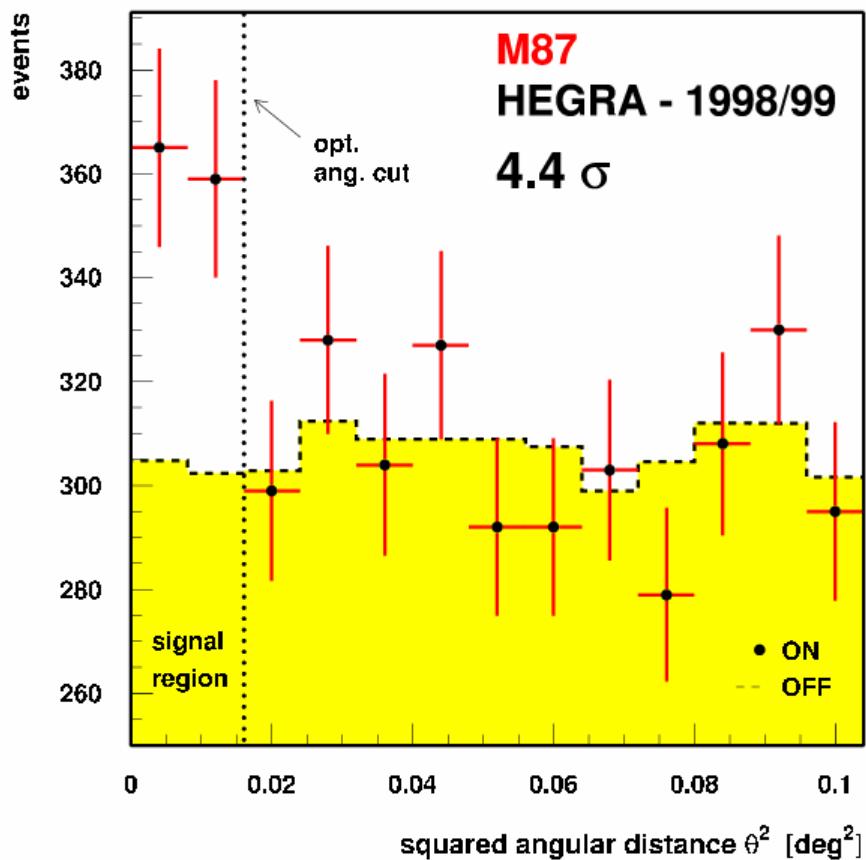
AGN
 $\sim 10^9 M_\odot$ B.H.



Jet

2.3 Extragalactic sources

- M87: HEGRA CT system 1998-1999 4.4σ



2.3 Extragalactic sources

- M87: Whipple 2000-2001 2.4σ , 2002-2003 no excess

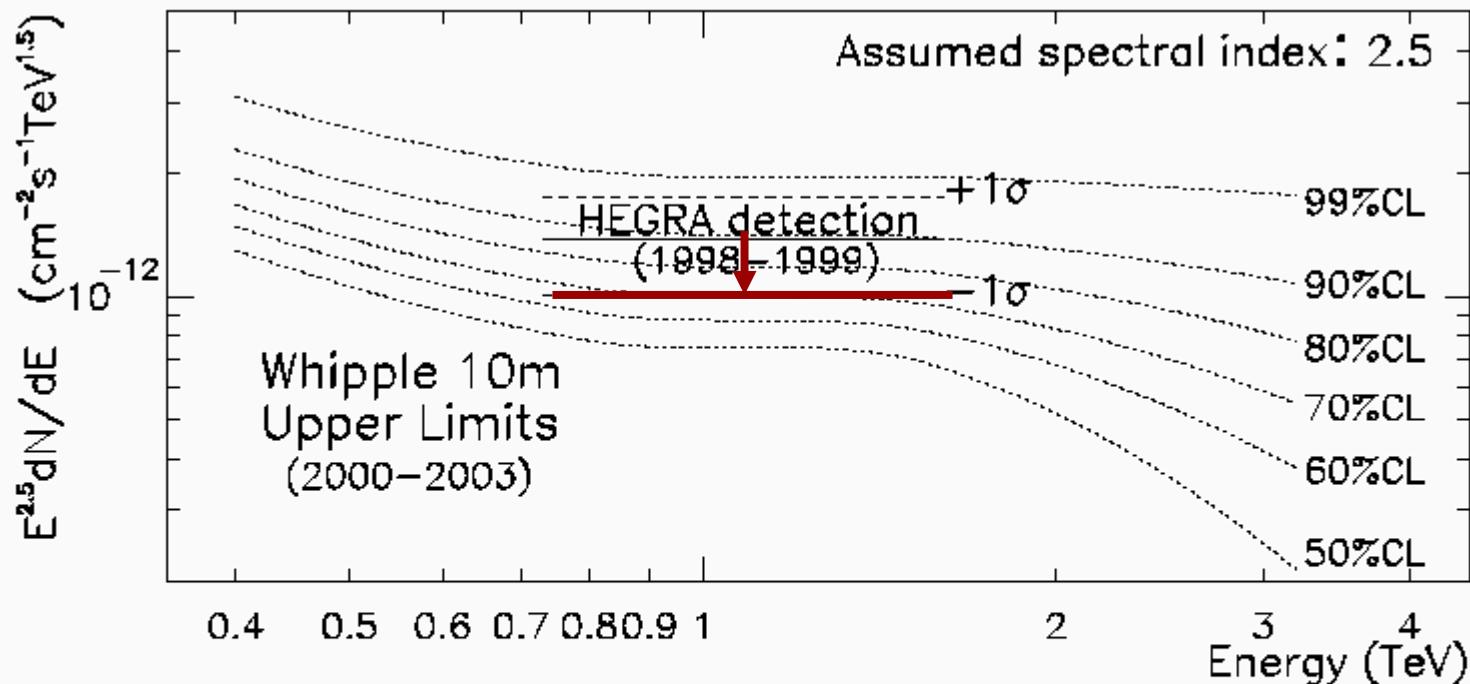
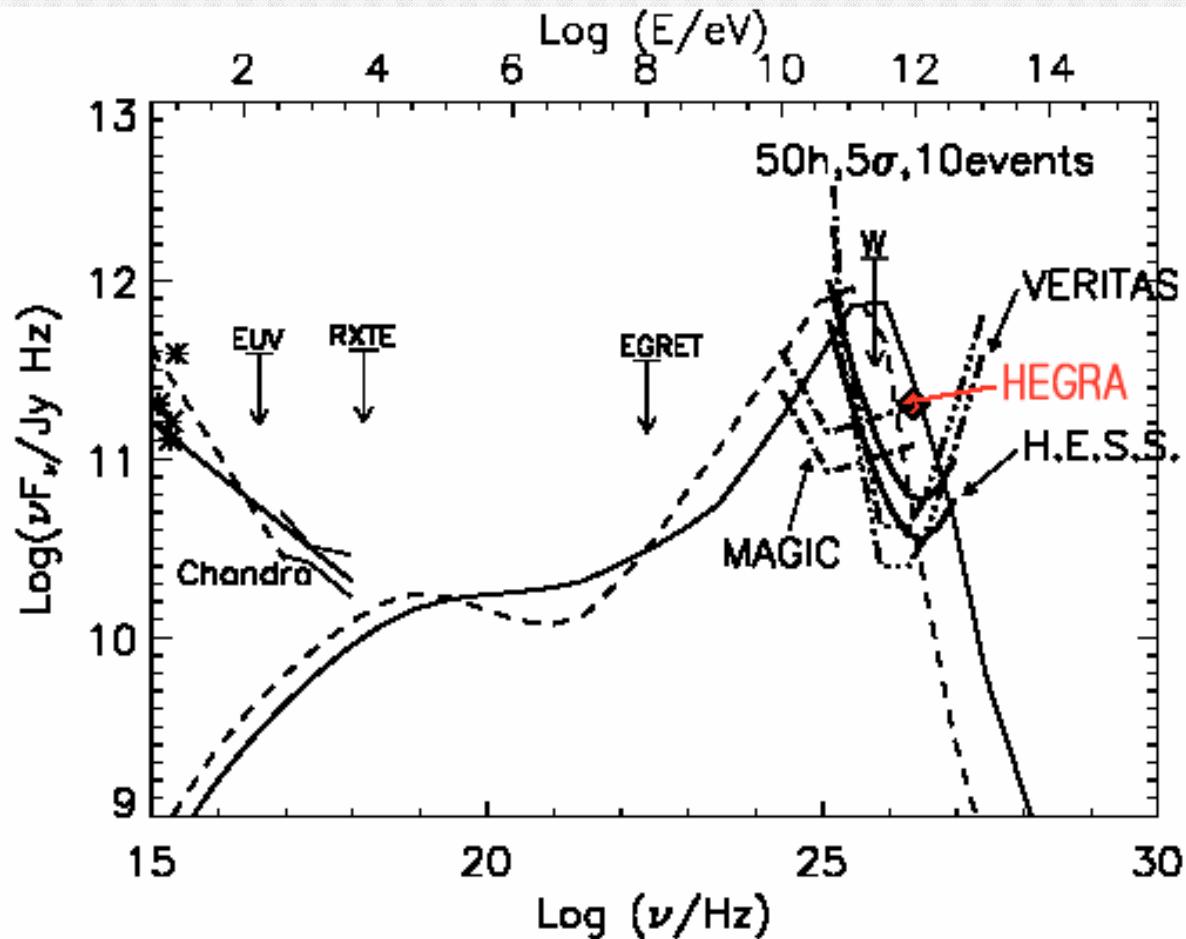


Fig. 1. The Whipple 10-m upper limit on the differential flux from M87 compared to the detection by HEGRA under the assumption that the spectrum can be described by a power law of index 2.5.

2.3 Extragalactic sources

- M87: misaligned ‘synchrotron proton blazar’ model



2.3 Extragalactic sources

■ Confirmed sources

- 1ES1959+650 (Blazar, $z=0.048$)
 - Utah 7TA detection [*Nishiyama 1999ICRC*] 3.9σ
 - Large Flare in 2002
 - HEGRA CT system [*Aharonian 2003A&A*]
 - HEGRA CT1 [Tonello 2615]
 - Whipple [Holder 2619]
- 1ES2344+514 (Blazar, $z=0.??$)
 - Whipple detection [*Catanese 1998ApJ*]
 - HEGRA CT system [Tluczykont 2547] 4.4σ
- PKS2155-304 (Blazar, $z=0.116$)
 - Durham Mark6 detection [*Chadwick 1999ApJ*]
 - CANGAROO [Nakase] upper limit, 2000-2001
 - H.E.S.S. [Djannati-Atai 2575] detection, 2002

2.3 Extragalactic sources

■ 1ES1959+650: HEGRA CT1

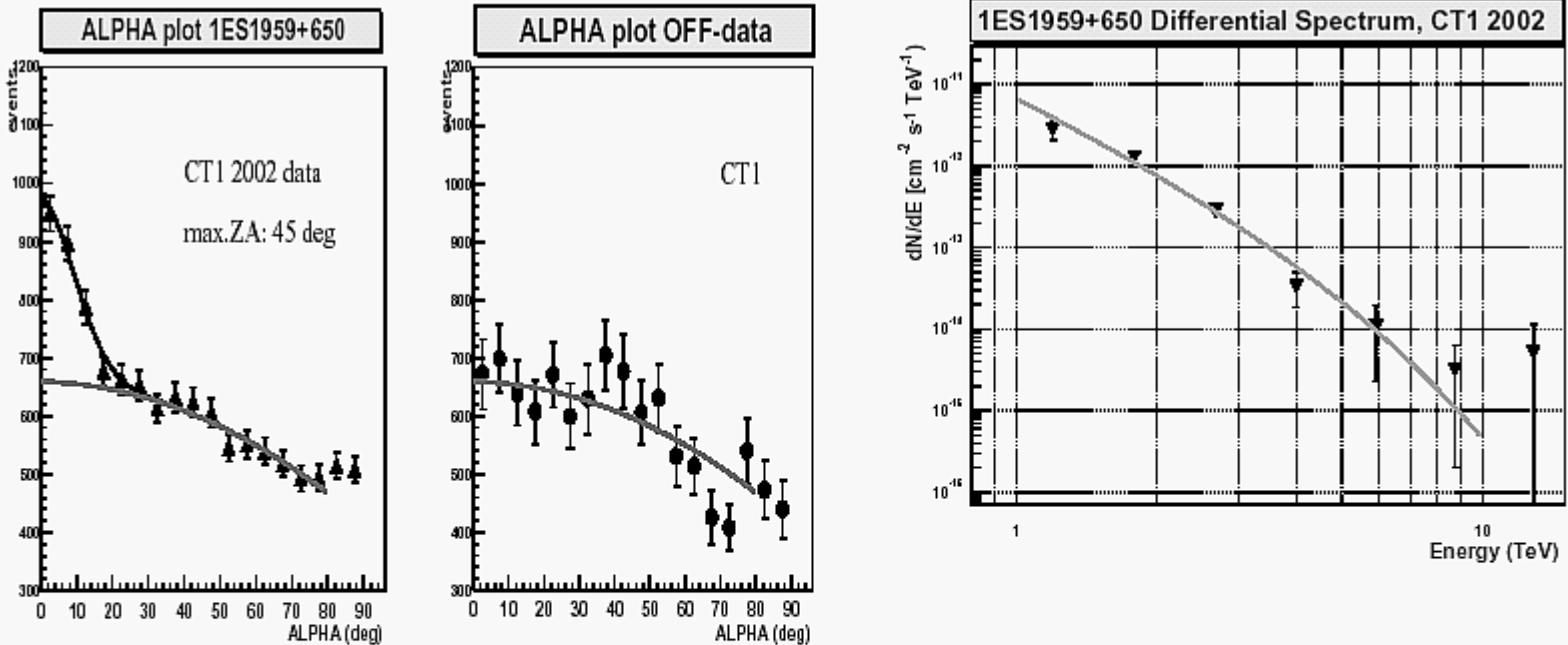


Fig. 1. Left: Distribution of the image parameter ALPHA for the 2002 data; maximum zenith angle: 45° . Right: ALPHA distribution of a normalized sample of off-data, plotted here for comparison.

Fig. 2. Differential spectrum of the AGN 1ES1959+650 (HEGRA CT1 2002 data set, no moonlight, max.ZA 45°). The line that fits the data is a power law with a fixed cut-off energy of 2.4 TeV.

2.3 Extragalactic sources

■ 1ES1959+650: Whipple May-July 2002

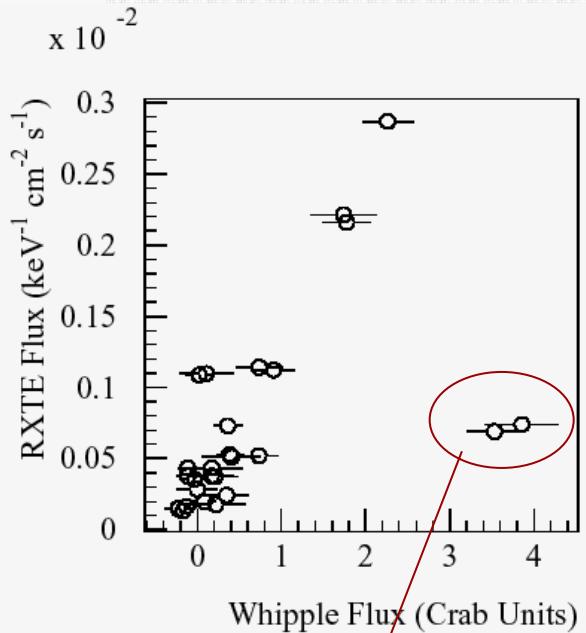
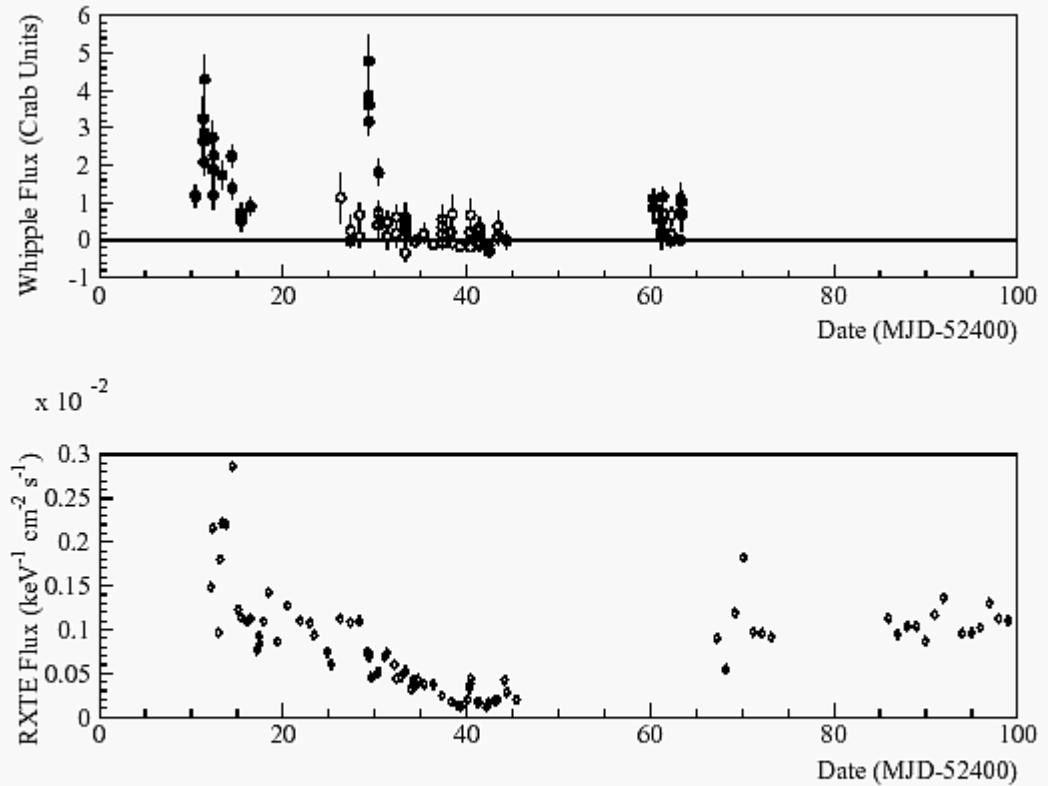


Fig. 1. The Whipple (top) and RXTE (bottom) light curves for 1ES1959+650 in May-July 2002. The filled Whipple points correspond to $> 3\sigma$ detections. The RXTE data are from [6].

"Orphan"
gamma-ray flare

2.3 Extragalactic sources

■ 1ES2344+514: HEGRA CT system

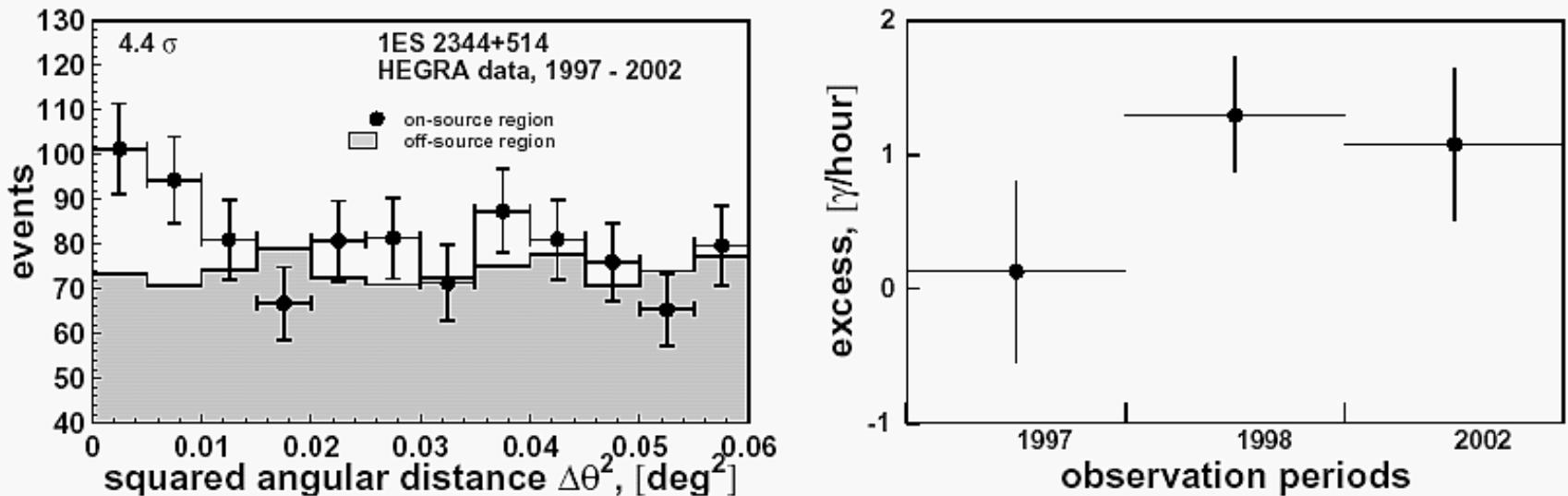


Fig. 2. Left: Distribution of reconstructed squared angular distances of the 1ES 2344+514 data. The distribution of the on-source events is represented by the data points. The background is shown as a shaded histogram. Right: The excess rate in γ/hour for the three observation campaigns on 1ES 2344+514. The excess is accumulated almost exclusively in 1998 and 2002.

2.3 Extragalactic sources

■ PKS2155-304: H.E.S.S.

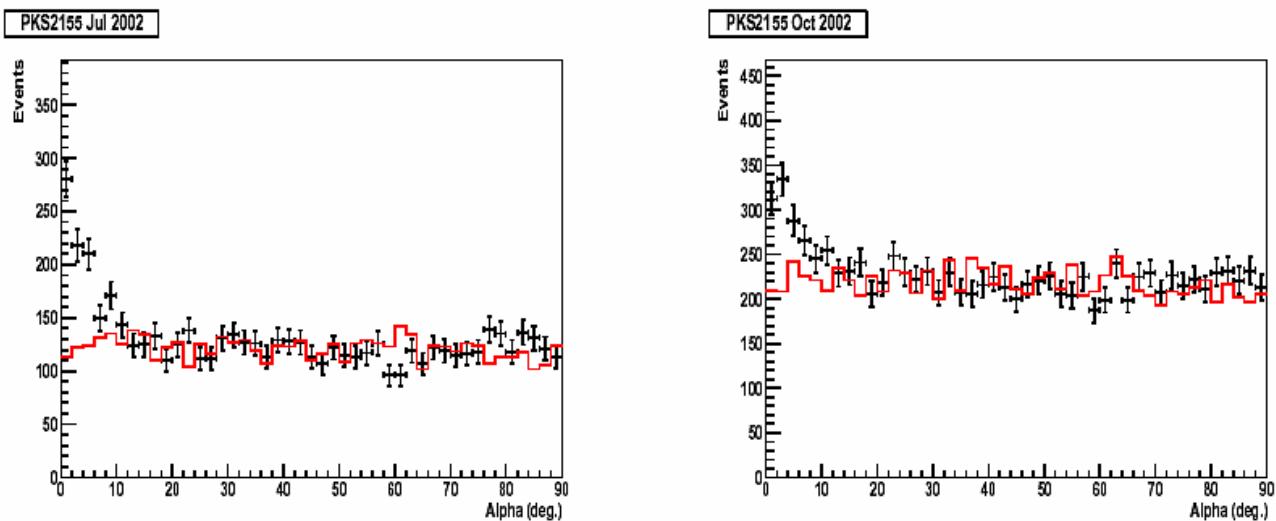


Fig. 1. The pointing angle α -plot of PKS 2155-304 observations for July (left panel) and October (right panel) 2002. The OFF-source distributions have been normalised to the control region between 30° and 90° .

PKS2155	T_{live} (h)	Non	Noff	Excess	γ/min	Significance
Jul 2002	2.2 h	1029	625	404	3.1	9.9 σ
Oct 2002	4.7	1444	1107	337	1.2	6.6 σ

2.3 Extragalactic sources

- Detailed study of established sources
 - Mrk421 (Blazar, $z=0.031$)
 - STACEE [Covault 2551]
 - CELESTE [Piron 2607]
 - Milagro [Sinnis 2583] 4.4σ
 - Tibet [Amenomori 2595] 5.5σ
 - Whipple [Rebillot 2599] Flare Dec02-Jan03
 - Whipple [Krennrich 2603] hourly variability
 - 1H1426+428 (Blazar, $z=0.129$)
 - Whipple [Horan]
 - HEGRA CT system [Horns]

2.3 Extragalactic sources

■ Crab/Mrk421: CELESTE

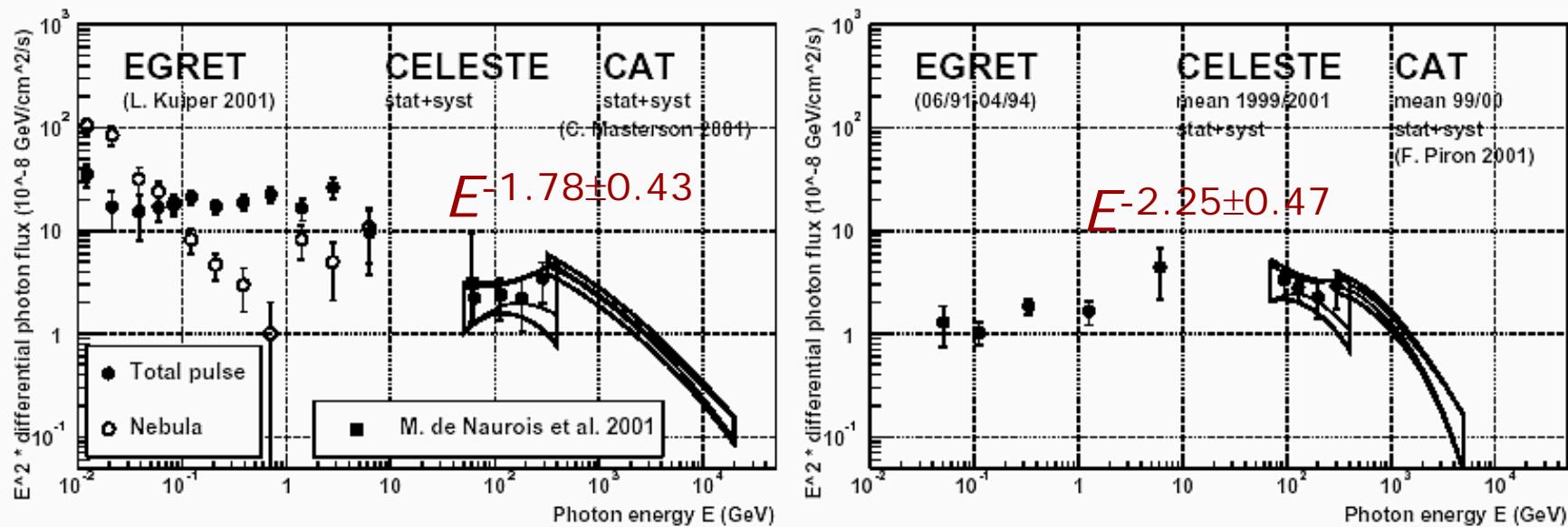
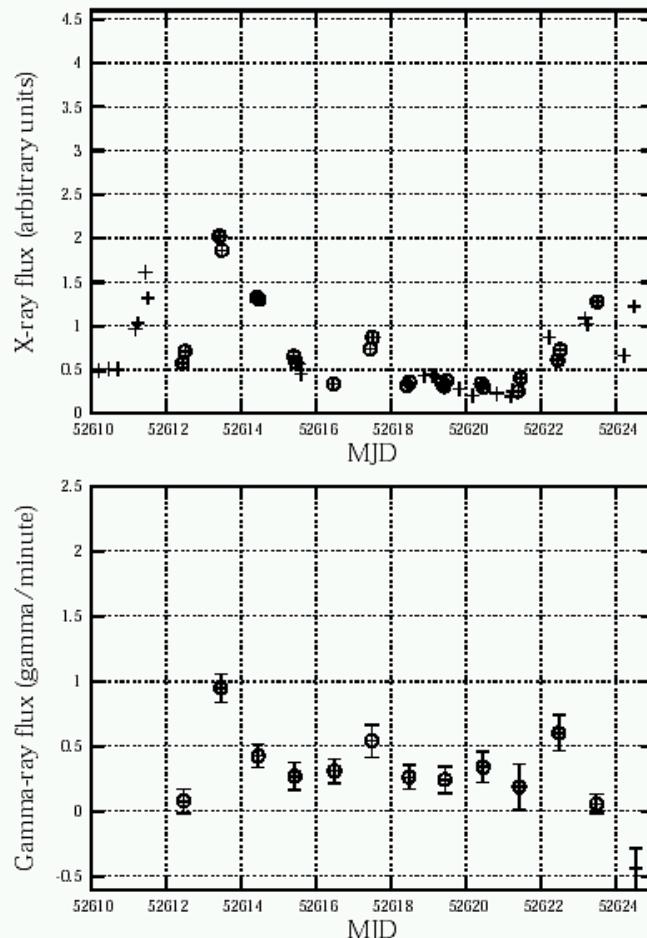


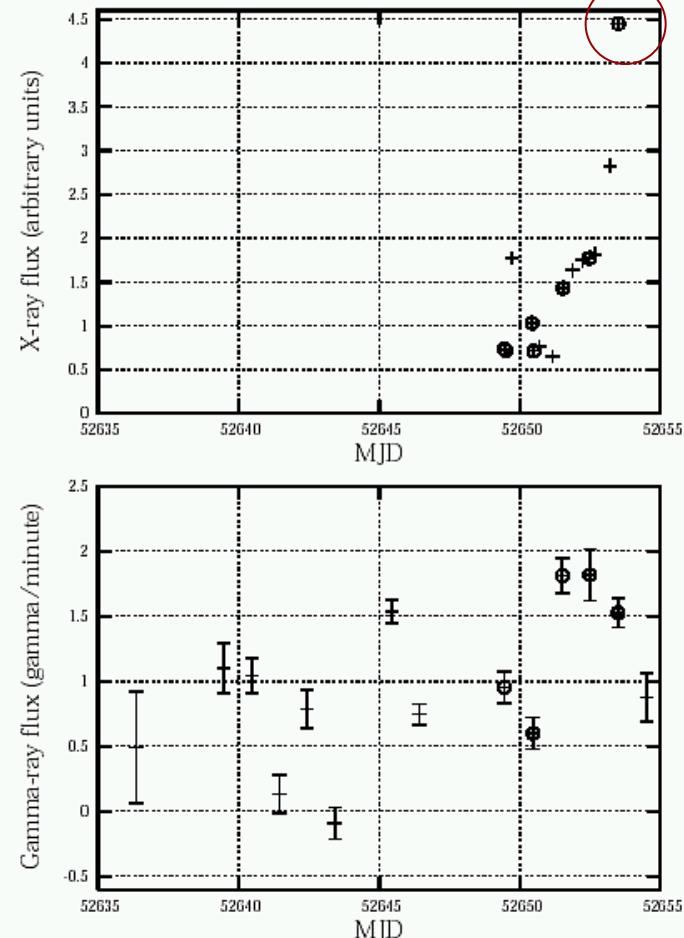
Fig. 3. The Crab nebula (left) and Mkn 421 (right) broad-band SEDs as measured by CGRO/EGRET, CELESTE ([2] and this work) and CAT. For ground-based experiments, the inner thin contours stand for statistical errors only, while the outer thick contours combine statistical and systematic errors.

2.3 Extragalactic sources

■ Mrk421: Whipple



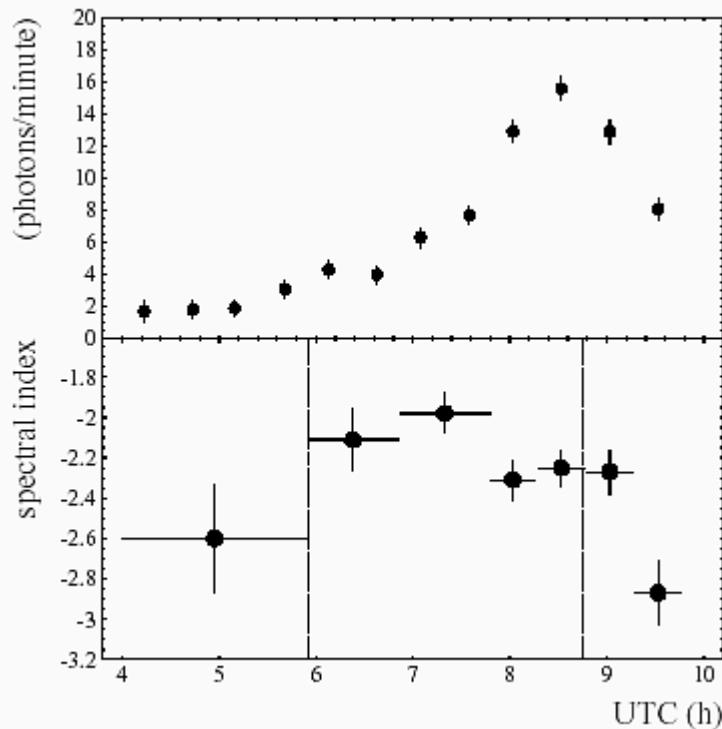
“Orphan” X-ray flare
Flare Dec02-Jan03



2.3 Extragalactic sources

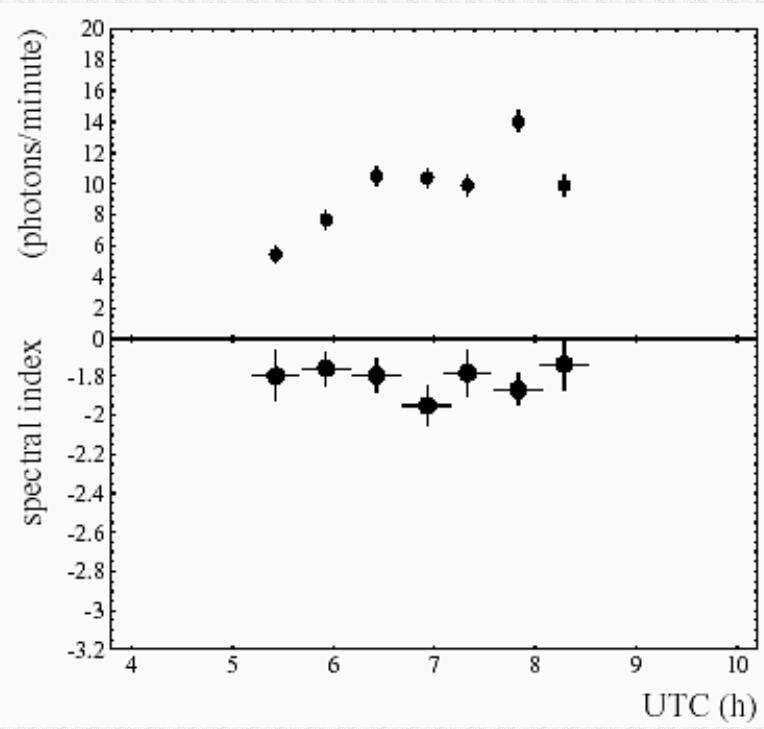
■ Mrk421: Whipple Hourly variability

Mar 19, 2001



Harder for stronger

Mar 25, 2001

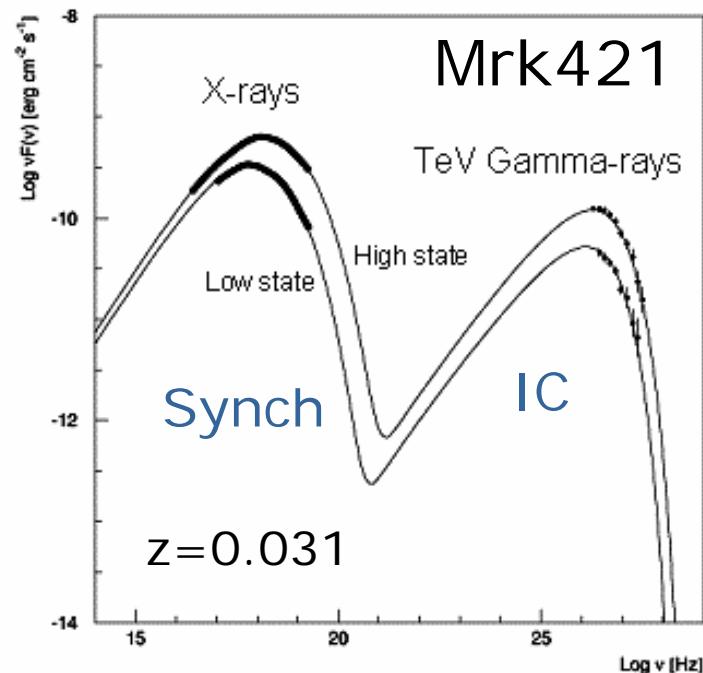


↔ Constant slope

[Krennrich 2603]

2.3 Extragalactic sources

- TeV gamma-ray absorption on EBL
 - Mrk421, Mrk 501 [Konopelko 2611]
 - H1426+428 [Horns 2651]
- Model parameters: too many? [Lipari 2683]



Fit parameters:

Doppler factor: $\delta = 55$

$R = 4.8 \times 10^{15} \text{ cm}$

High state: $\gamma_{\max} = 5 \times 10^5$, $B = 0.10 \text{ G}$

Low state: $\gamma_{\max} = 3 \times 10^5$, $B = 0.10 \text{ G}$

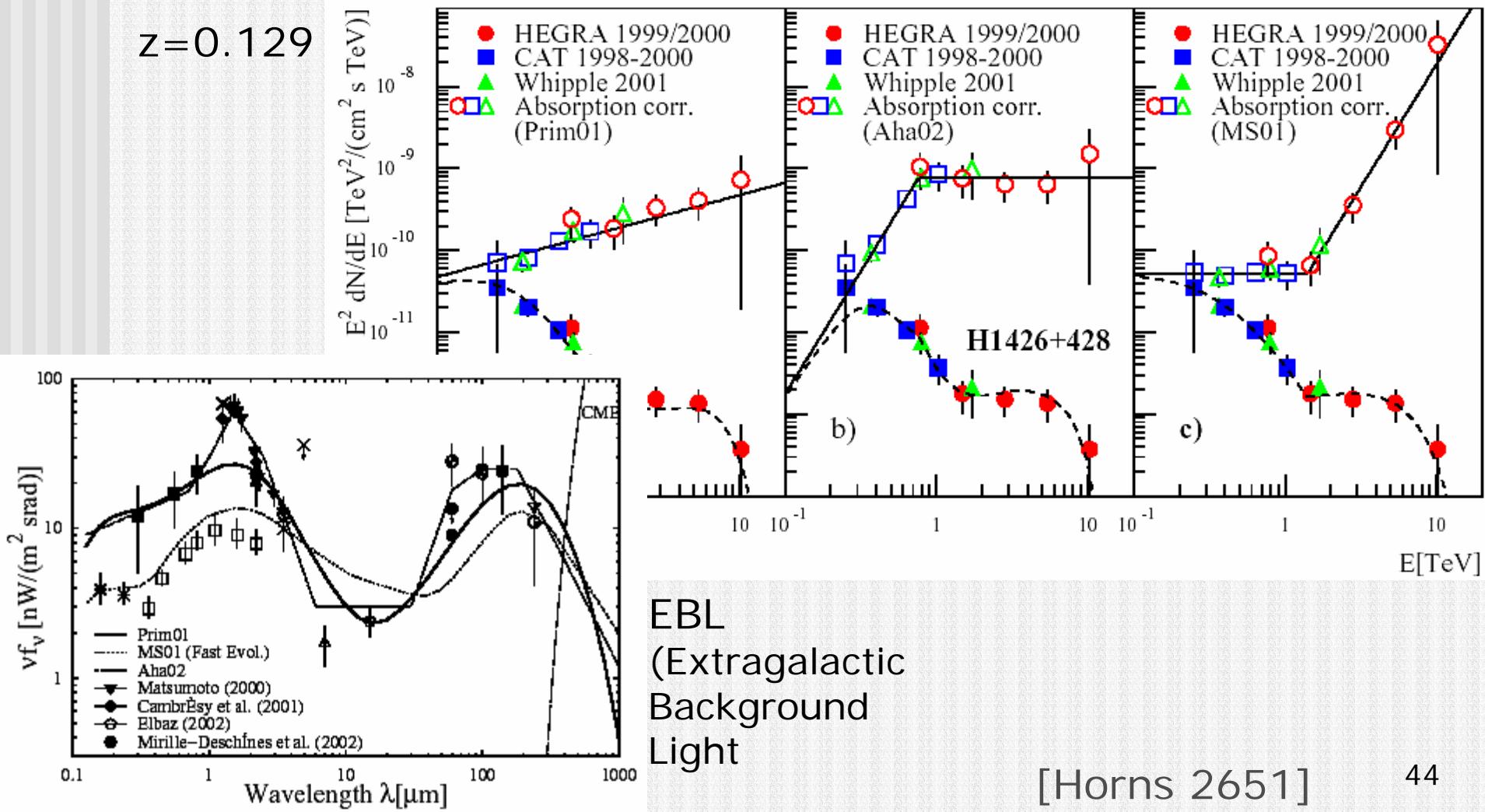
$\chi^2 / \text{dof} = 0.53(\text{high state}), 0.61(\text{low state})$

[Konopelko 2611]

2.3 Extragalactic sources

■ H1426+428: HEGRA CT system

$z=0.129$



2.3 Extragalactic sources

■ Upper limits

■ Blazars

- HEGRA CT system [Tluczykont 2547] 54 AGNs
- STACEE [Covault 2551] W Comae, H1426+428
- Whipple [Horan 2567] 29 BL Lacs
- CANGAROO [Nakase 2587] PKS2005-489
- H.E.S.S. [Djannati-Atai 2575] PKS2005-489, PKS0548-322

■ Starburst galaxies

- Whipple [Nagai 2635] M82, M81, IC342, NGC3079

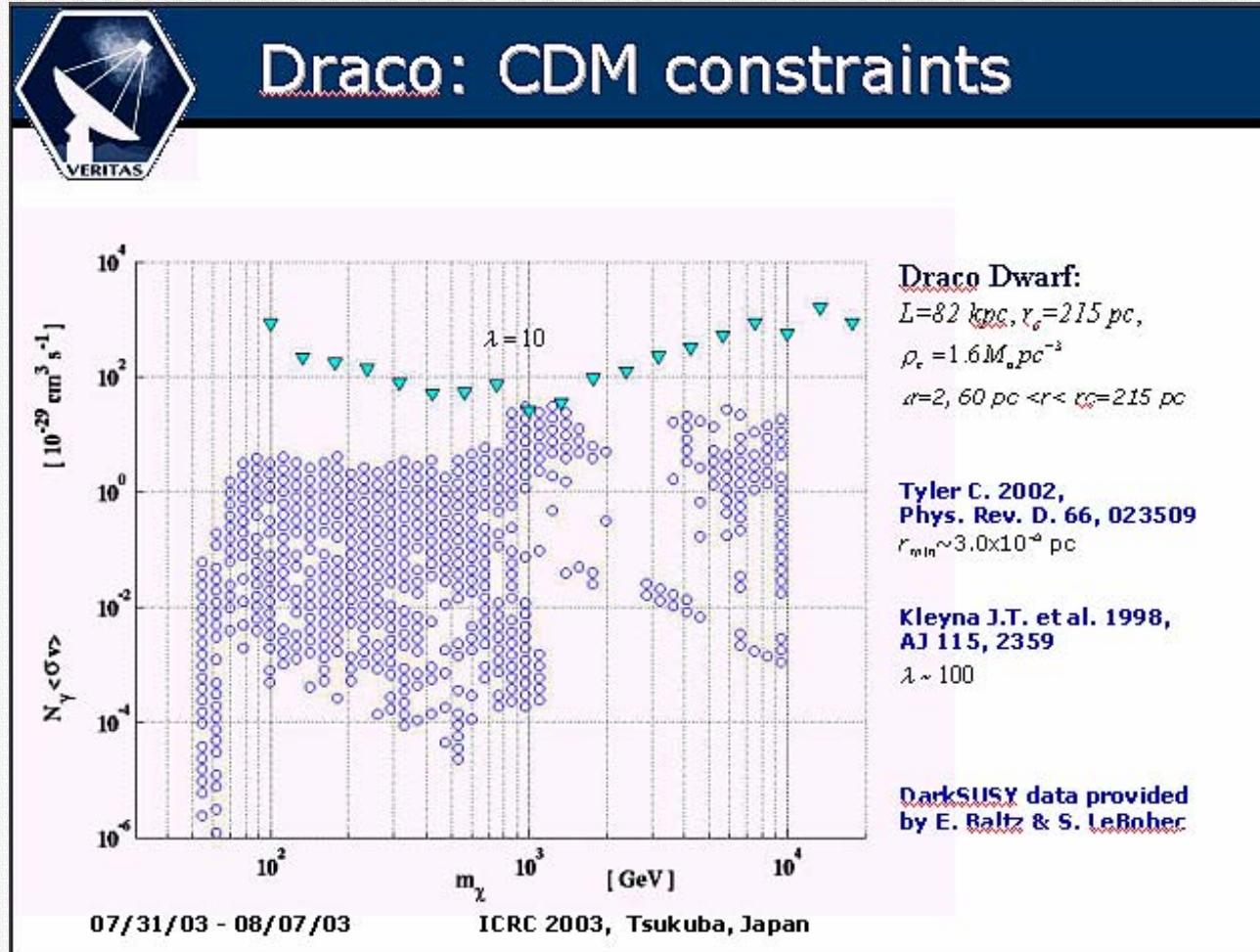
■ Nearby galaxies: neutralino search

- Whipple [Vassiliev 2679] Dra/UMi dwarf, M33

■ Tibet hotspot by Whipple [Walker 2679] 5 spots

2.3 Extragalactic sources

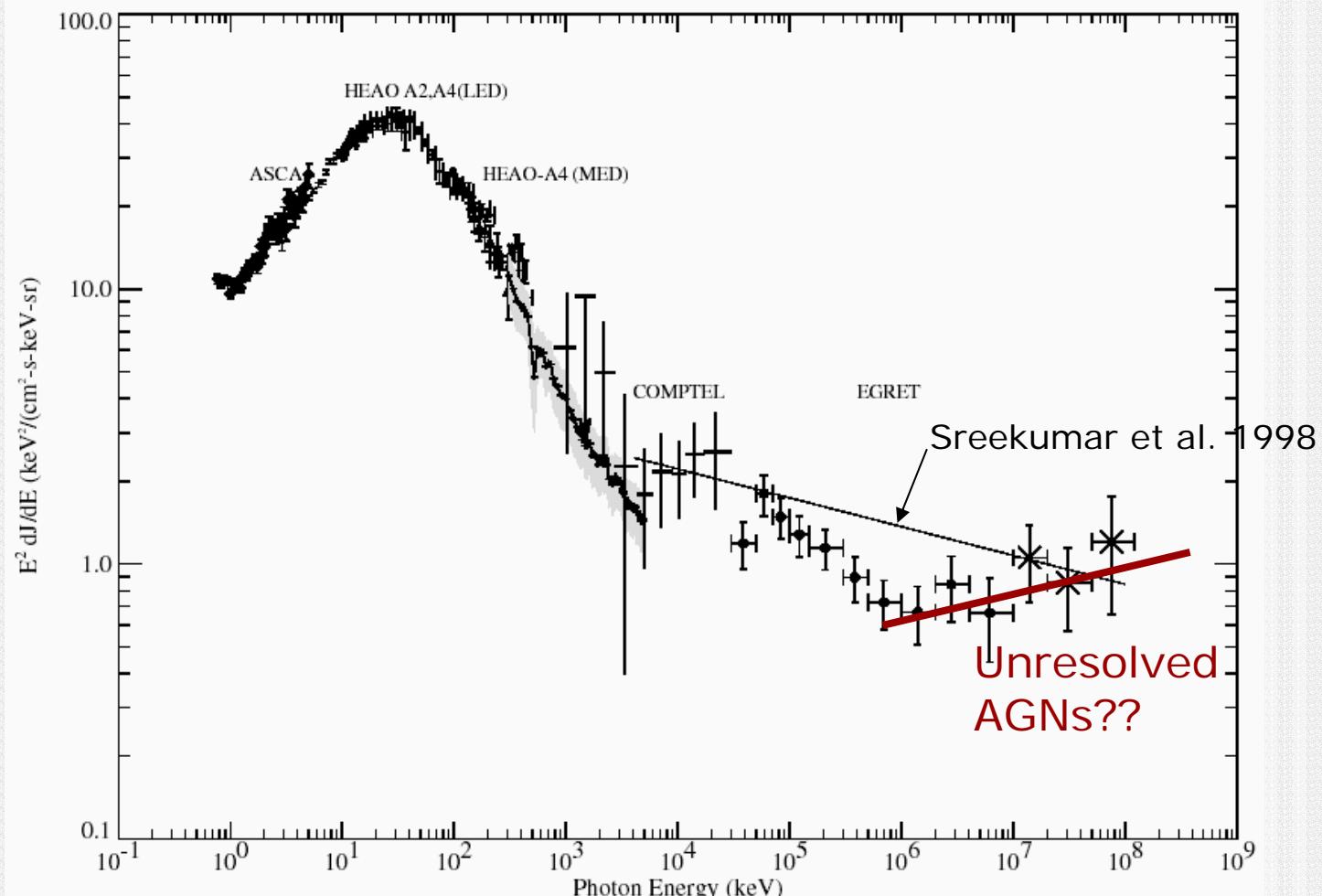
■ Neutralino dark matter search by Whipple



Suffers large
theoretical
uncertainties
!

2.3 Extragalactic sources

- New estimate of extragalactic diffuse emission

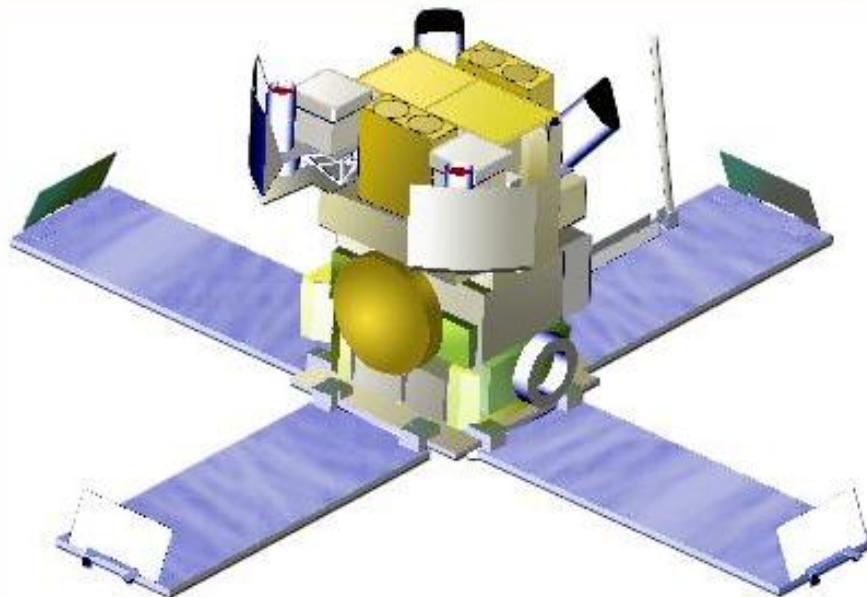
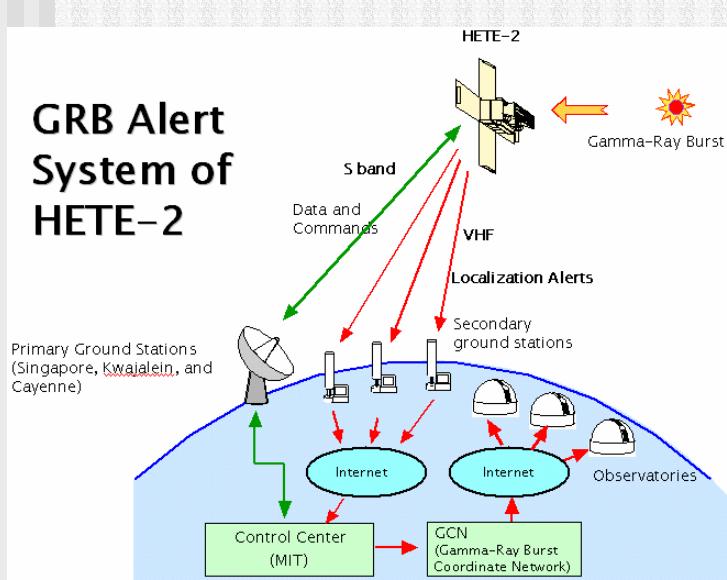


2.4 Gamma ray bursts

- HETE-2 [Kawai 2737, Yoshida 2693, Shirasaki 2745]
 - Launched on Oct. 9, 2000
 - 39 bursts till Apr. '03, 16 w/afterglows
 - Burst alert system (fastest: 22sec)
[Tamagawa 2741]

Now
44

GRB Alert System of HETE-2



2.4 Gamma ray bursts

■ HETE-2 observations

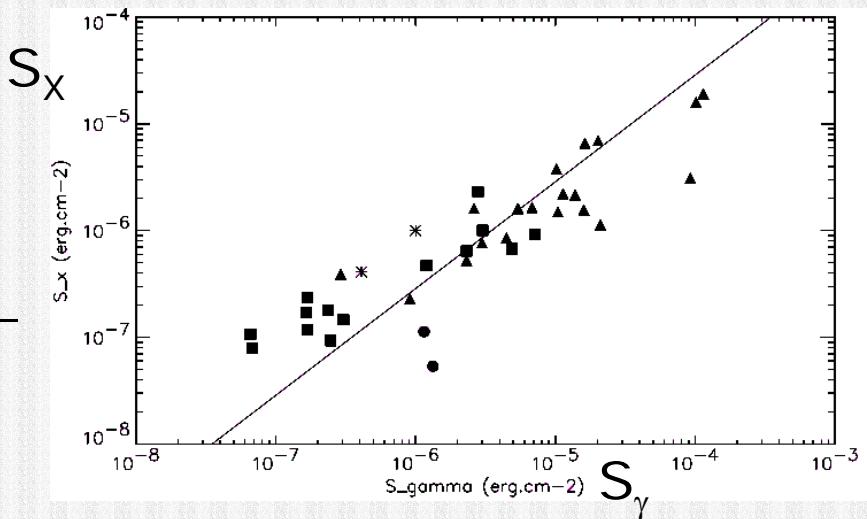
■ Monster GRB030329 [Kawai 2737]

- Duration in the 30-400 keV band was > 25 s
- The fluence of the burst $\sim 1 \times 10^{-4}$ ergs cm $^{-2}$
- peak flux over 1.2 s was $> 7 \times 10^{-6}$ ergs cm $^{-2}$ s $^{-1}$
(i.e., $> 100 \times$ Crab flux in the same energy band)
- X-ray afterglow: 7 mCrab (RXTE, +5 hr)
- Connection to SN

■ Timing properties

[Suzuki 2697]

- Classical GRBs, X-ray rich GRBs, X-ray flash – a single phenomenon!



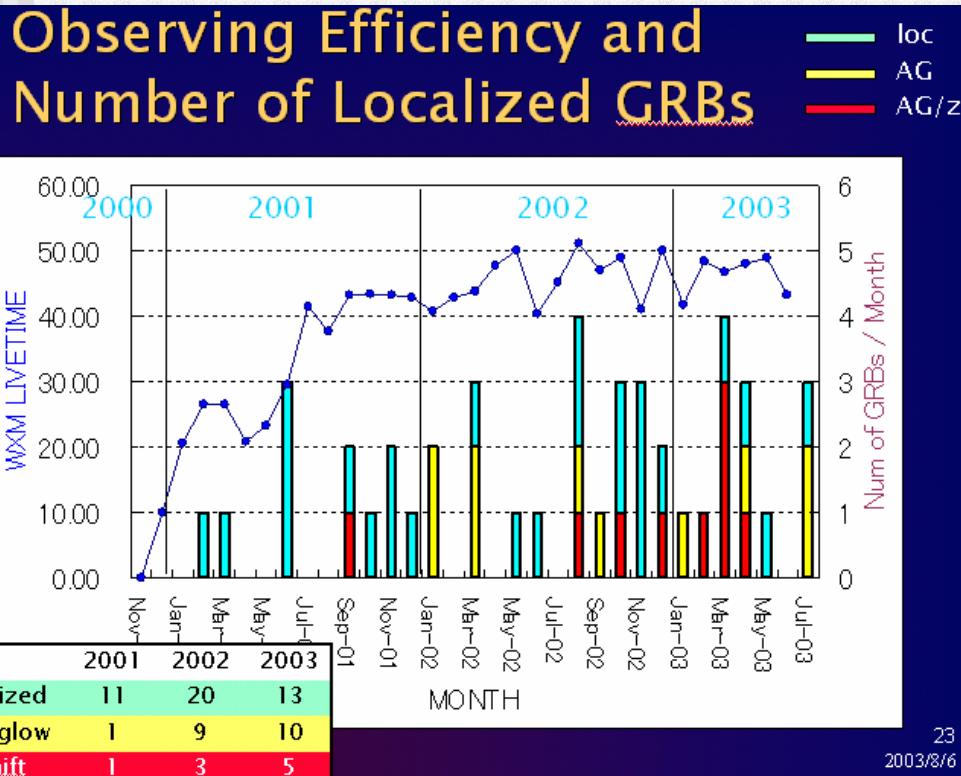
2.4 Gamma ray bursts

- INTEGRAL observations [Produit 2701]
 - Launched Oct.2002
 - 4 cameras (JEMX, IBIS, SPI, OMC)
 - 6 GRBs detected, but unluckily no GRB detected by all instruments.
- SZ2/XD observations [Ma 2765]
 - 30 candidates, 10 confirmed GRBs in 6 months since Jan.'01

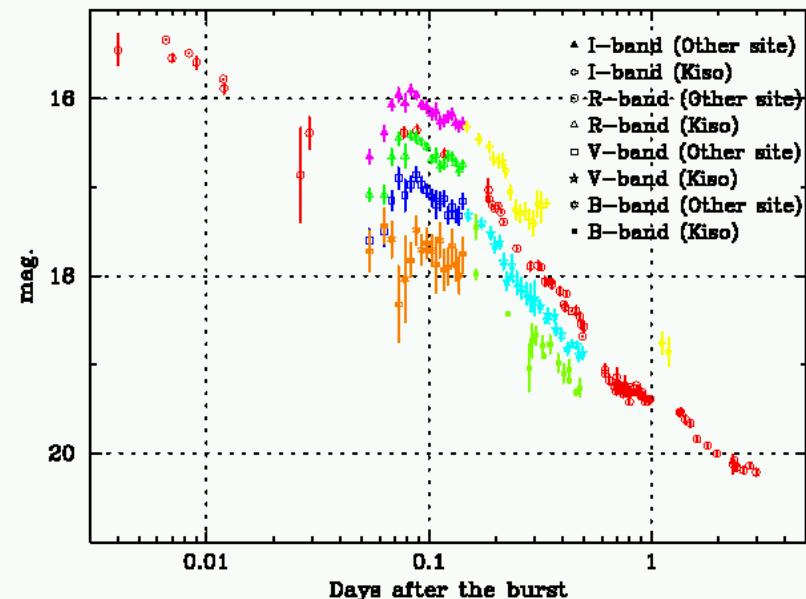
2.4 Gamma ray bursts

■ Afterglows

- Found for half of HETE-2 GRBs [Kawai 2737]



- Kiso observatory (optical) [Urata 2749]



2.4 Gamma ray bursts

- Ground-based experiments
 - Air shower rate
 - Tibet-III [Zhou 2757] upper limit
 - Single particle rate
 - GRAND [Poirier 2709] w/BATSE, upper limit
 - ARGO-YBJ [Vallania 2761]
 - Tibet-III [Amenomori 2705]
 - TeV gamma-rays
 - MAGIC [Galante 2753] a few per year expected
 - Neutrinos
 - Super-Kamiokande [Turcan 2713] w/BATSE, upper limit on fluence
 - AMANDA [Hardke 2717] w/BATSE, upper limit

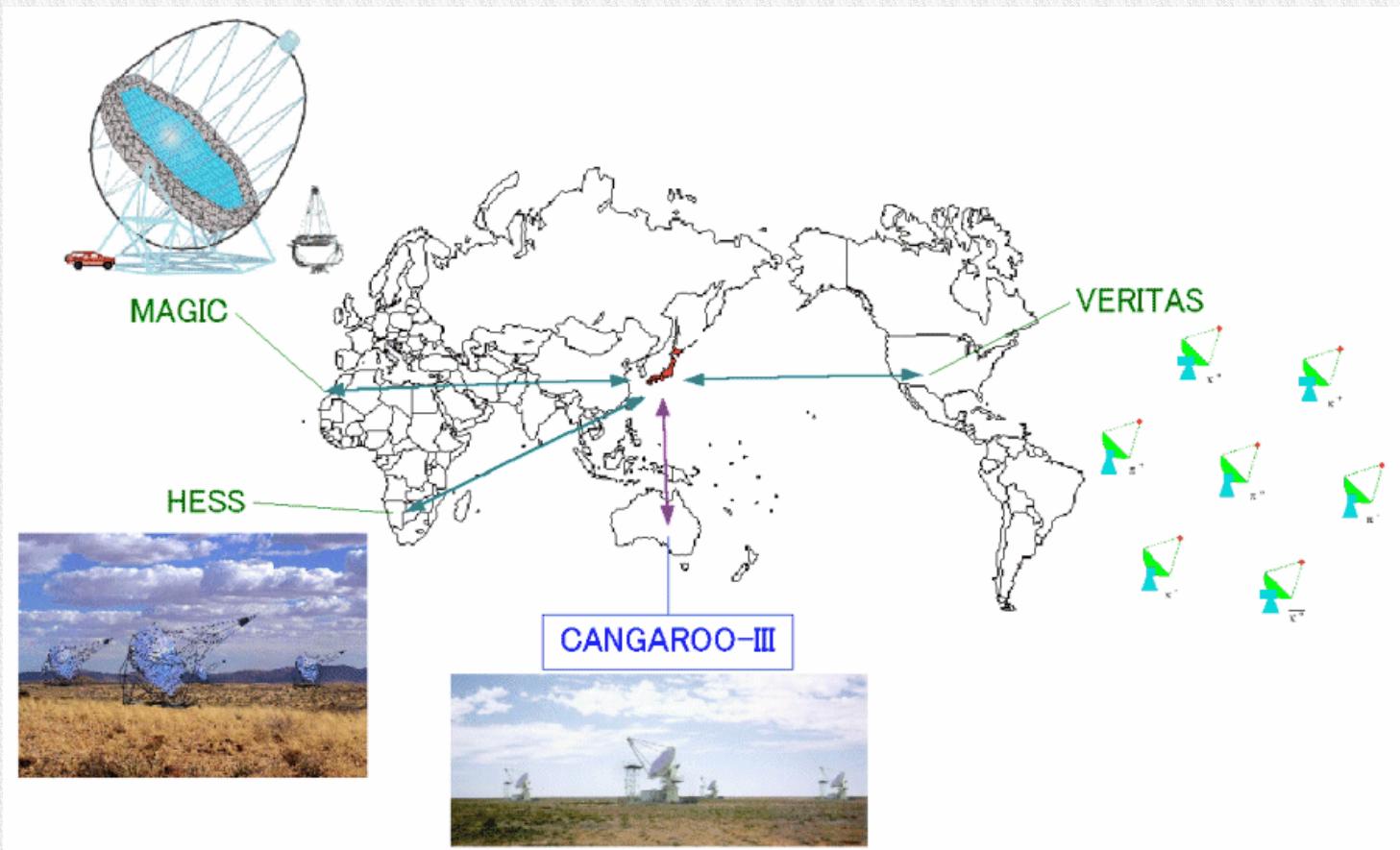
2.4 Gamma ray bursts

■ Theories/Models

- CME (Coronal Mass Ejection) model [Aoki et al. 2729]
 - Log-normal distribution can be produced
- Compton trail [Parizot&Allard 2721]
 - Accumulation of past GRBs can be detectable in our Galaxy < a few 1000yr
- Gravitational collapse of rotating magnetized stars
[Kryvdyk 2725, Mizuno et al. 2733]

2.5 Instrumentation and new projects

■ Cherenkov telescopes ■ The “Big Four”



2.5 Instrumentation and new projects

- CANGAROO-III: completion in 2003



[Enomoto 2807, Ohishi 2855, Kabuki 2859, Kubo 2863,
Hayashi 2867]

2.5 Instrumentation and new projects

- H.E.S.S.: completion in 2004



[Hofmann 2811, Cornils 2875, Le Gallou 2879, Chadwick 2883, Vincent 2887, Schlenker 2891, Leroy 2895, Masterson 2899, Konopelko 2903, de Naurois 2907, Masterson 2987] 56

2.5 Instrumentation and new projects

- MAGIC: completion in 2003



[Martinez 2815, Bastieri 2919, Cortina 2923, Paneque 2927, Cortina 2931, Mirzoyan 2935, Goebel 2939, Wagner 2943, Wagner 2947, Mase 2951, Mase 2955, Stamerra 2959, Mirzoyan 2963, Noutsos 2975]

2.5 Instrumentation and new projects

■ VERITAS: VERITAS-4 by 2006, then -7



New site: Horseshoe
canyon, Kitt Peak

Prototype



[Wakely 2803, Gibbs 2823,
Rebillot 2827, Kieda 2831,
Kieda 2835, Wakely 2839,
Gibbs 2843, Fegan 2847,
Vassiliev 2851]

2.5 Instrumentation and new projects

■ New ground-based projects

- ARGO-YBJ [Vernetto 3007, Martello 3011, DiSciascio 3015]
 - Full coverage air shower detector in Tibet
- HAGAR [Acharya 2999]
 - Hanle (Himalaya), 4517m a.s.l.
 - 7×7 2m ϕ telescope array, installation 2004
- ASHRA [Sugiyama 2991]
 - Hawaii, $50^\circ \times 50^\circ$ Field-of-view, 1 + 1/3 by 2006
 - Also air fluorescence [EHE CR and Neutrino]
- ECO-1000 [Merck 2911]
 - 35m ϕ (1000m^2) telescope, 5 GeV threshold
 - Rigidity cutoff: no charged particle below $\sim 10\text{GeV}$

2.5 Instrumentation and new projects

■ New technologies

■ Cherenkov telescopes

- STACEE GHz FADC [Zweerink 2795]
- “Paracanting” for solar tower ACT [Scalzo 2799]
- Vacuum-forming Aluminium mirrors [Latham 2915]
- Image Intensifier [Tada 2983]
- All sky monitor [Osone 2979]
- Shower direction by single telescope [Kranich 3023]

■ Others

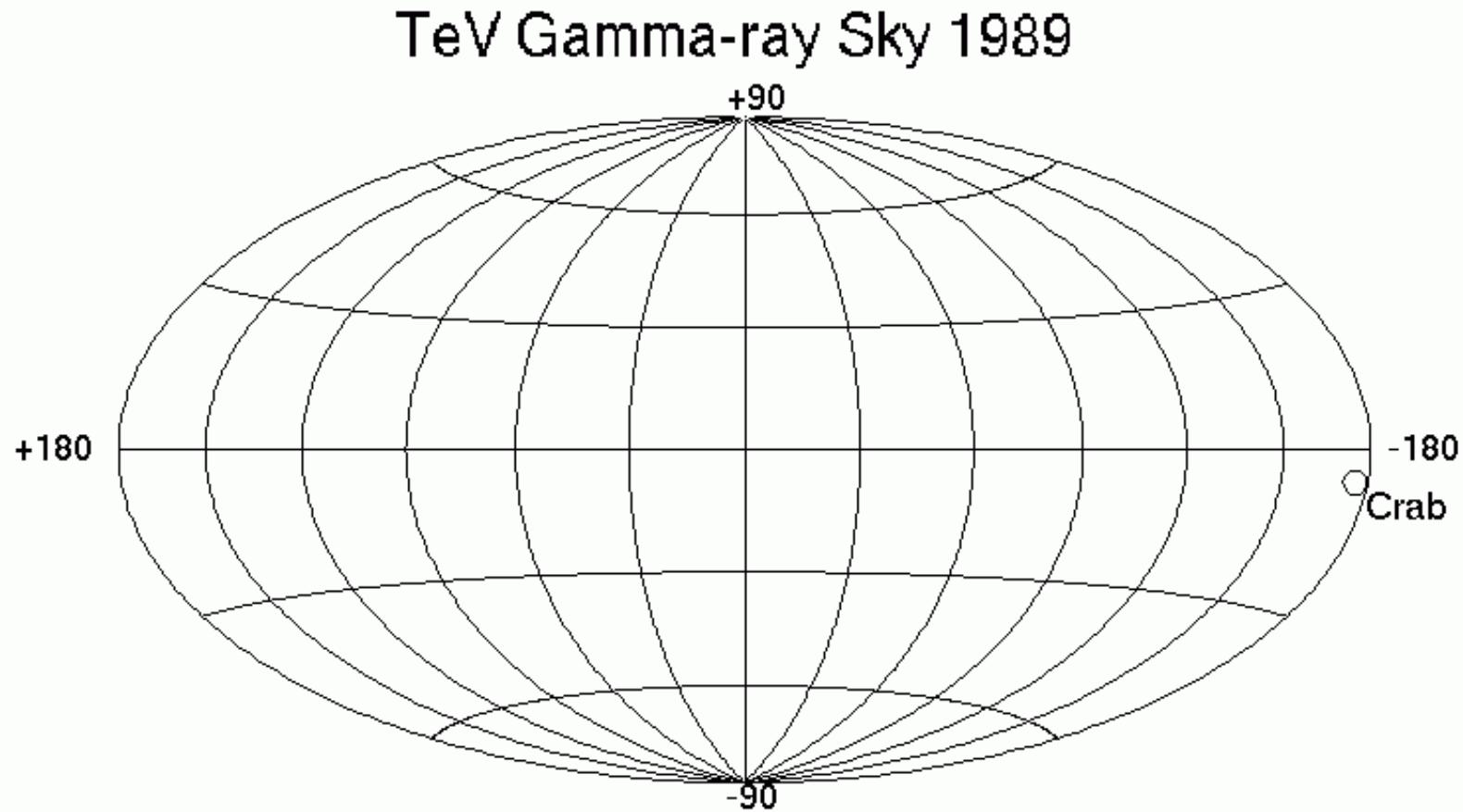
- X-ray polarimeter [Gunji 2779]
- Diamond Compton recoil telescope [Hibino 2995]
- GRB detector at Mt.Chacaltaya [Ogio 3003]
- Photoelectron number calibration [Kajino 2871]
- Signal search using Likelihood ration [Hu 3027]

2.5 Instrumentation and new projects

■ Space observatories

- MAXI [Kohama 2771]
 - All-sky X-ray imager on ISS in 2008
- GLAST [Carlson 2787]
 - Radiation hardness tests of CsI(Tl)
- CALET [Yoshida 2791]
 - Electron/gamma-ray, performance study
- HXMT [Li 2775]
 - Hard X-ray modulation, prototype

TeV Gamma-ray sky



TeV source catalog

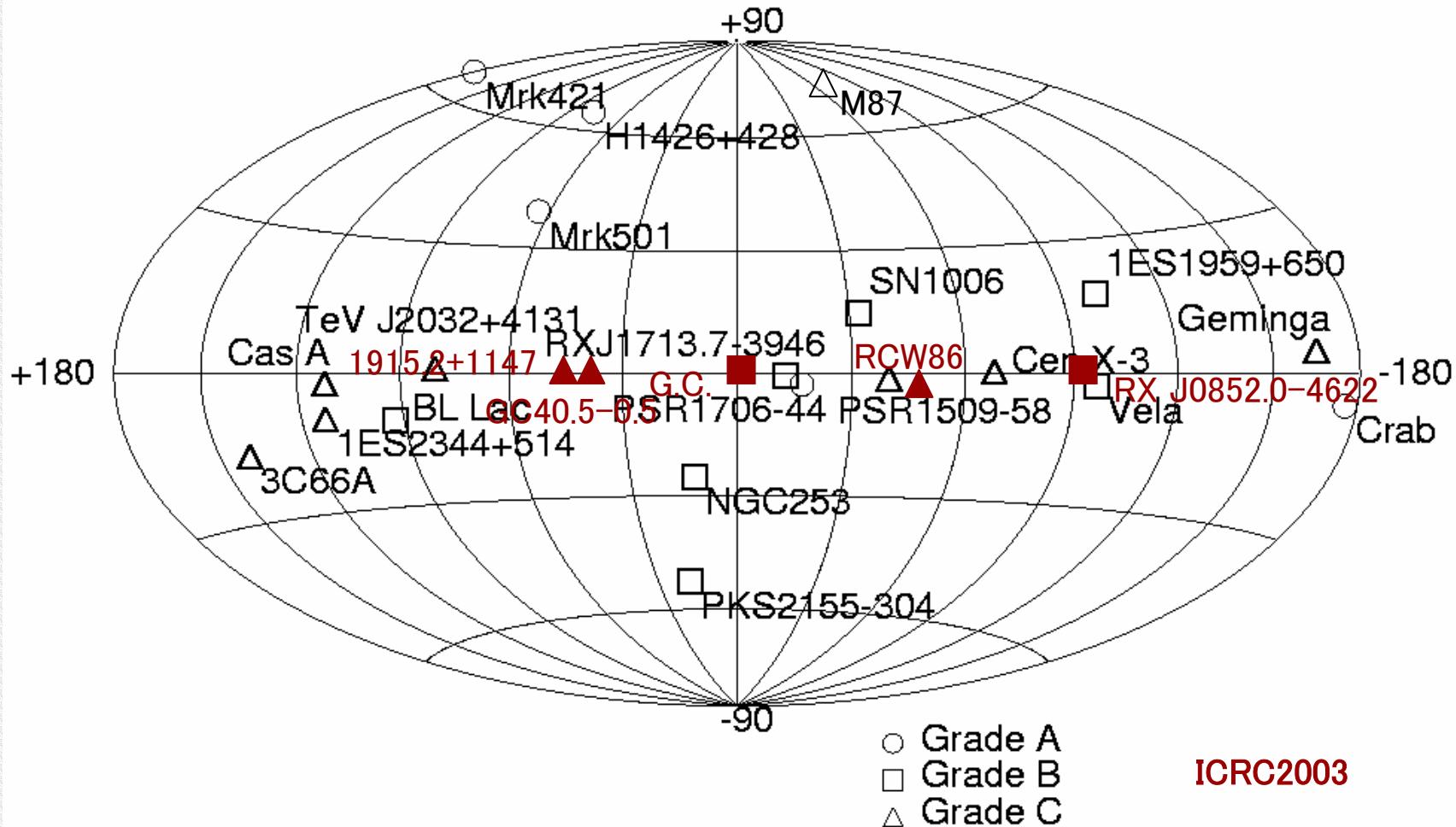
[Weekes
Highlight talk
“Before ICRC”]

Catalog Name	Source	Type	Date/Group	EGRET	Grade
TeV 0047-2518	NGC 253	Starburst	2003/CANG.	no	B
TeV 0219+4248	3C66A	Blazar	1998/Crimea	yes	C-
TeV 0535+2200	Crab Nebula	SNR	1989/Whipple	yes	A
TeV 0834-4500	Vela	SNR	1997/Whipple	yes	C
TeV 1121-6037	Cen X-3	Binary	1997/Durham	yes	C
TeV 1104+3813	Mrk 421	Blazar	1992/Whipple	yes	A
TeV 1231+1224	M87	Radio	2003/HEGRA	no	C
TeV 1429+4240	H1426+428		2002/Whipple	no	A
TeV 1503-4157	SN1006	SNR	1997/CANG.	no	B
TeV 1654+3946	Mrk 501	Blazar	1995/Whipple	no	A
TeV 1710-2229	Fornax 5-44	SNR	1995/CANG.	no	A
TeV 1712-3932	RXJ1713-39	SNR	1999/CANG.	no	B+
TeV 2000+6509	1ES1959+650	Blazar	1999/TA	no	A
TeV 2032+4131	CygOB2?	OB Assoc.	2002/HEGRA	yes?	C
TeV 2159-3014	PKS2155-304	Blazar	1999/Durham	yes	A
TeV 2203+4217	BL Lacertae	Blazar	2001/Crimea	yes	C
TeV 2323+5849	Cas A	SNR	1999/HEGRA	no	B
TeV 2347+5142	1ES2344+514	Blazar	1997/Whipple	no	C

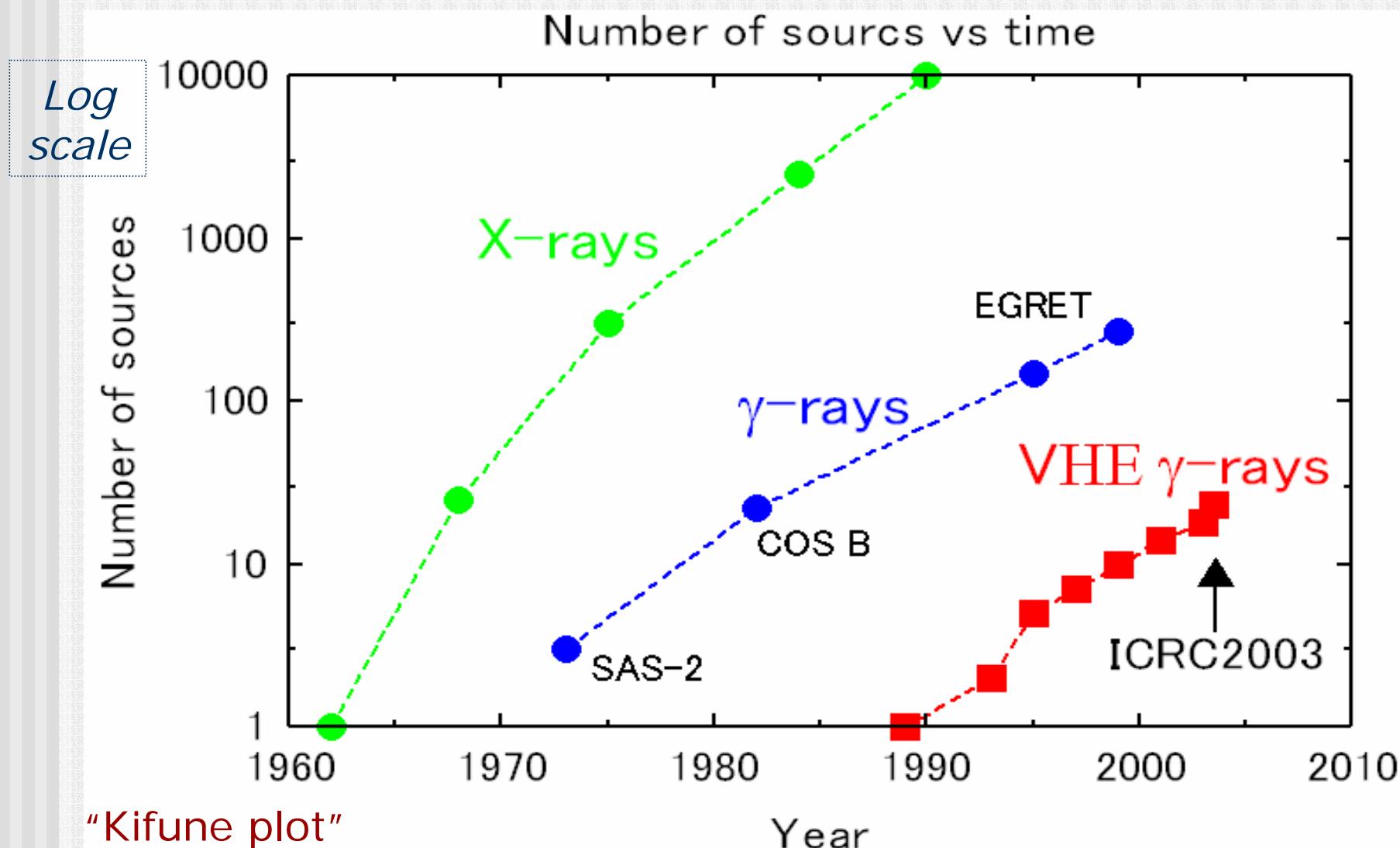
≈ Second COS B catalog!

TeV Gamma-ray sky 2003

TeV Gamma-ray Sources



High-energy sources

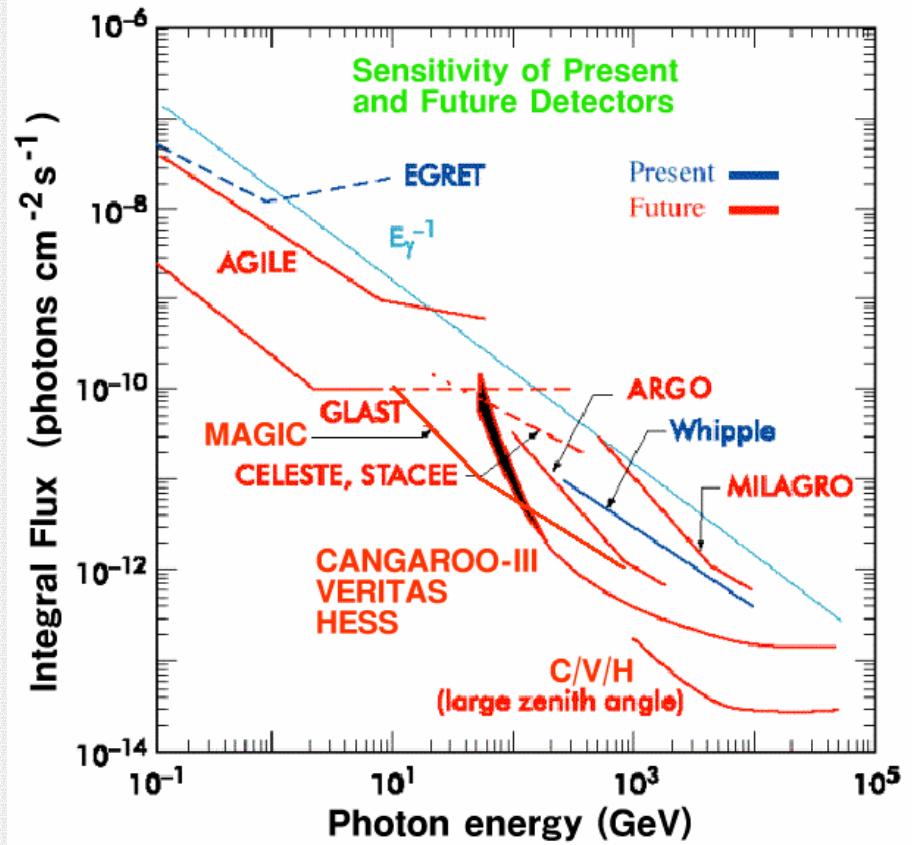
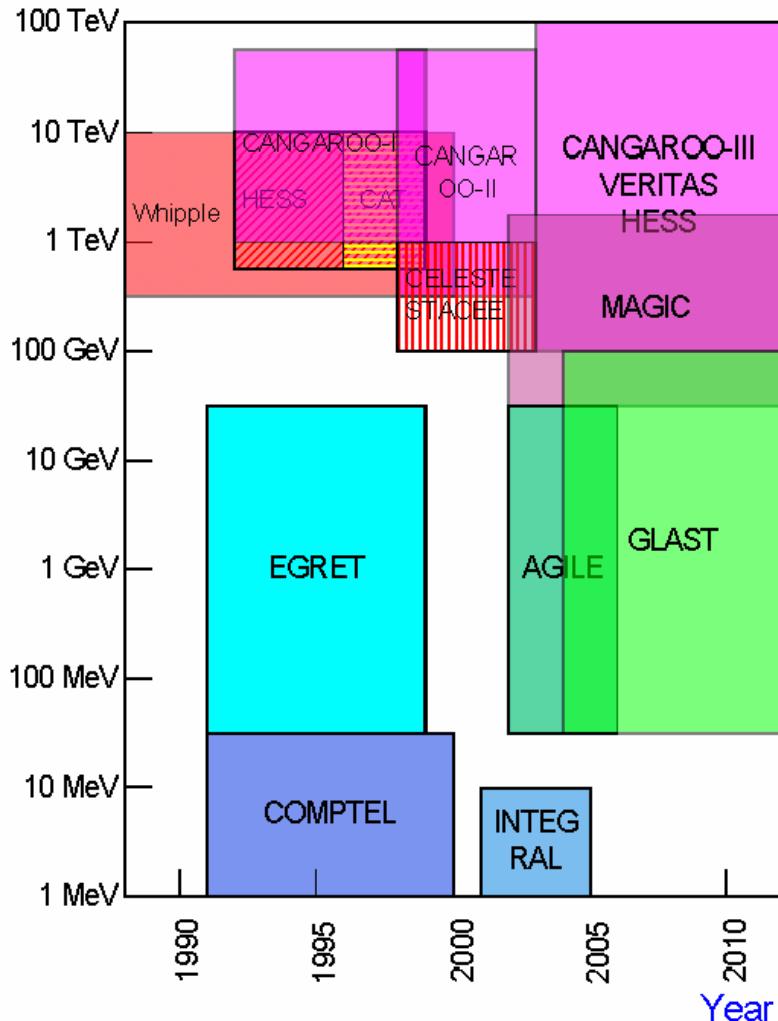


Summary

- X-ray / gamma-ray astrophysics is a rapidly growing field. [*See the number of contribution papers in OG2!*]
- Technology innovation is a key of this fast development.
- Many advances in understanding the underlying high-energy phenomena – still lacking firm evidence on cosmic ray origin. More data necessary.
- More TeV sources are being found with the “third generation” Cherenkov telescopes distributed in the northern and southern hemisphere: results will be reported in ICRC2005!
- Next generation of space instruments follows!

Near future

Energy



Thank you so much for your
contribution and cooperation!

Masaki Mori

皆様の貢献と協力に感謝します。

森 正樹

This presentation will be posted at:
<http://www.icrr.u-tokyo.ac.jp/~morim/>