OG 2.1-2.4: γ-Ray Astronomy

Diffuse Emission, Galactic Sources, Extragalactic Sources + GRBs

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Contents

- General Remarks
  - Contribution Statistics
  - The VHE instruments
  - HE Contributions
- OG 2.1-2.2 Diffuse Emission and Galactic Sources
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- OG 2.3: Extragalactic Sources
- Conclusions

Contribution Statistics

- By Section
  - OG 2.1: 8, OG 2.2: 86, OG 2.3: 58, OG 2.4: 24
- By Author
  - GLAST LAT collaboration: 7
  - From VHE collaborations: 123 –
    - ARGO-YBJ: 1, CANGAROO-III: 6, CASA-MIA: 1, GRAPES-3: 1, HESS: 42, MAGIC: 24, MILAGRO: 10, PACT: 2, SHALON: 4, SPASE-2: 1, STACEE: 4, TACTIC: 1, Tibet ASγ: 4, VERITAS: 15
  - Small groups (mostly theoretical work): 45
- By Topic
  - AGN: 45, Binaries: 11, Diffuse: 9, Galactic Centre: 6, Galaxy Clusters: 4, GRBs: 22, Pulsars: 7, PWN: 17, SNR: 17, Surveys: 9, Unidentified Sources: 11, Misc: 17
- Usual Apology
  - No time to present all 175 papers, highlights only (98!)
  - Bias towards experiment results

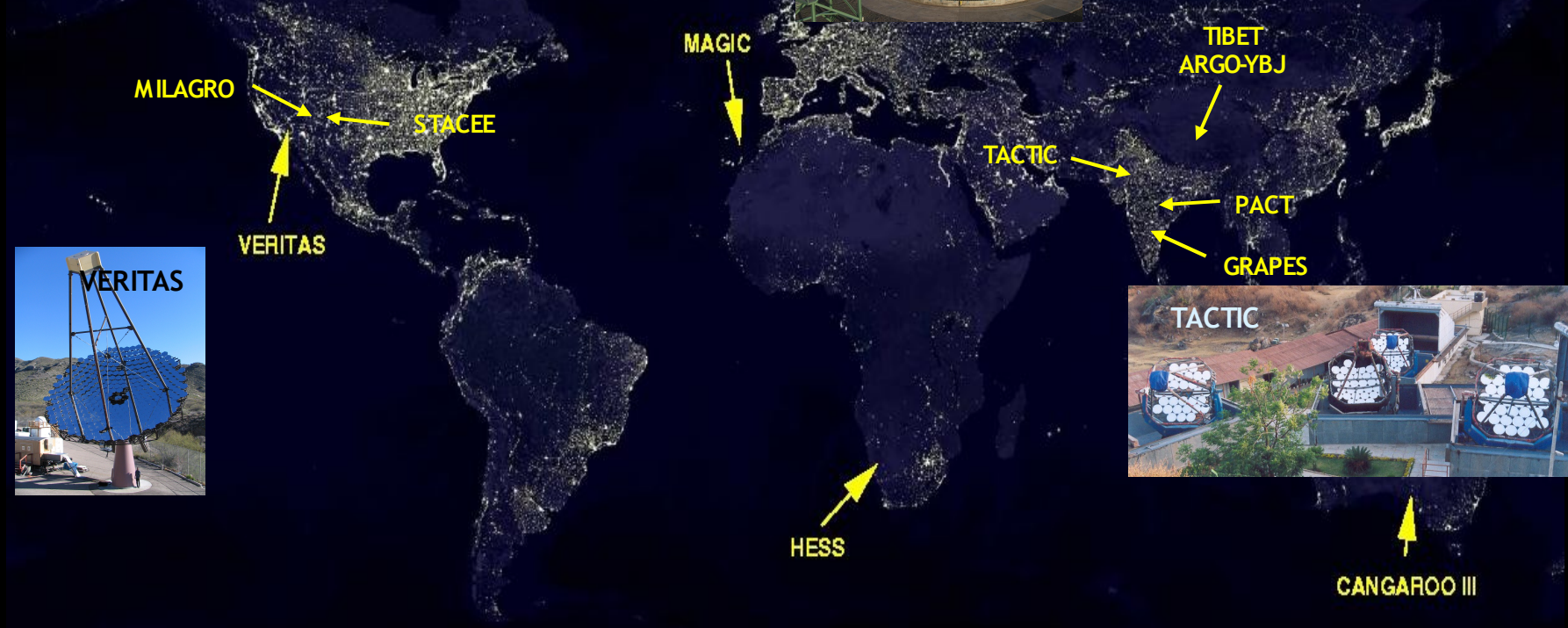
VHE Instruments

MILAGRO

STACEE

MAGIC

TIBET



- Ong 2005

VHE Instruments

MILAGRO

STACEE

MAGIC

TIBET

MILAGRO

STACEE

VERITAS

MAGIC

TIBET
ARGO-YBJ

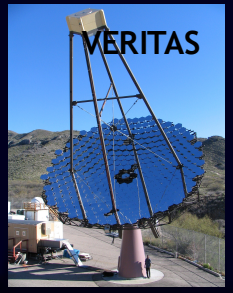
TACTIC

PACT

GRAPES

HESS

CANGAROO III



A truly global effort!

- Ong 2005

A Major New Instrument

- VERITAS is complete!
  - First light (full array) April 2007
  - Sensitivity similar to H.E.S.S.
- Detections presented on
  - IC 443, LS I +61 303, M 87, 1ES 1218+304, Mrk 421, Mrk 501
- Survey of the Cygnus region underway
  - Expect exciting results rather soon!

Southern Hemisphere VHE Sources

- **For the last few years there have been systematic differences between southern hemisphere instruments – these have now been resolved:**

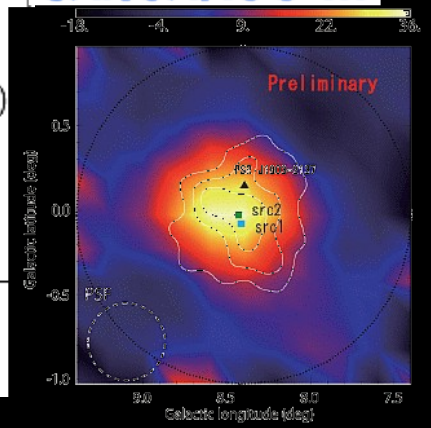
Mori 166

Table 1: Summary of TeV source status claimed by CANGAROO compared with H.E.S.S. results.

Object	C-I	C-II	C-III	H.E.S.S.
Crab	Yes	Yes	Yes [2]	Yes
PSR 1706-44	Yes	†	U.L. [1]	U.L.
Vela pulsar	Yes (0.13° offset)	N/A	U.L. [2]	U.L.
Vela X	N/A	N/A	Yes [2]	Yes
SN1006	Yes	†	U.L. [1]	U.L.
RX J1713.7-3946	Yes	Yes	under analysis	Yes
PSR 1509-58	Yes	N/A	under analysis	Yes (MSH15-52)
Mrk 421	N/A	Yes	N/A	Yes
NGC 253	N/A	Yes	U.L.[4]	U.L.
Galactic center	N/A	Yes	under analysis	Yes
RX J0852.0-4622	N/A	Yes	Yes [3]	Yes

'C-I' means CANGAROO-I, etc. 'Yes': detection, 'U.L.': upper limit, 'N/A': not available. † means the result is not published yet.

CANGAROO III



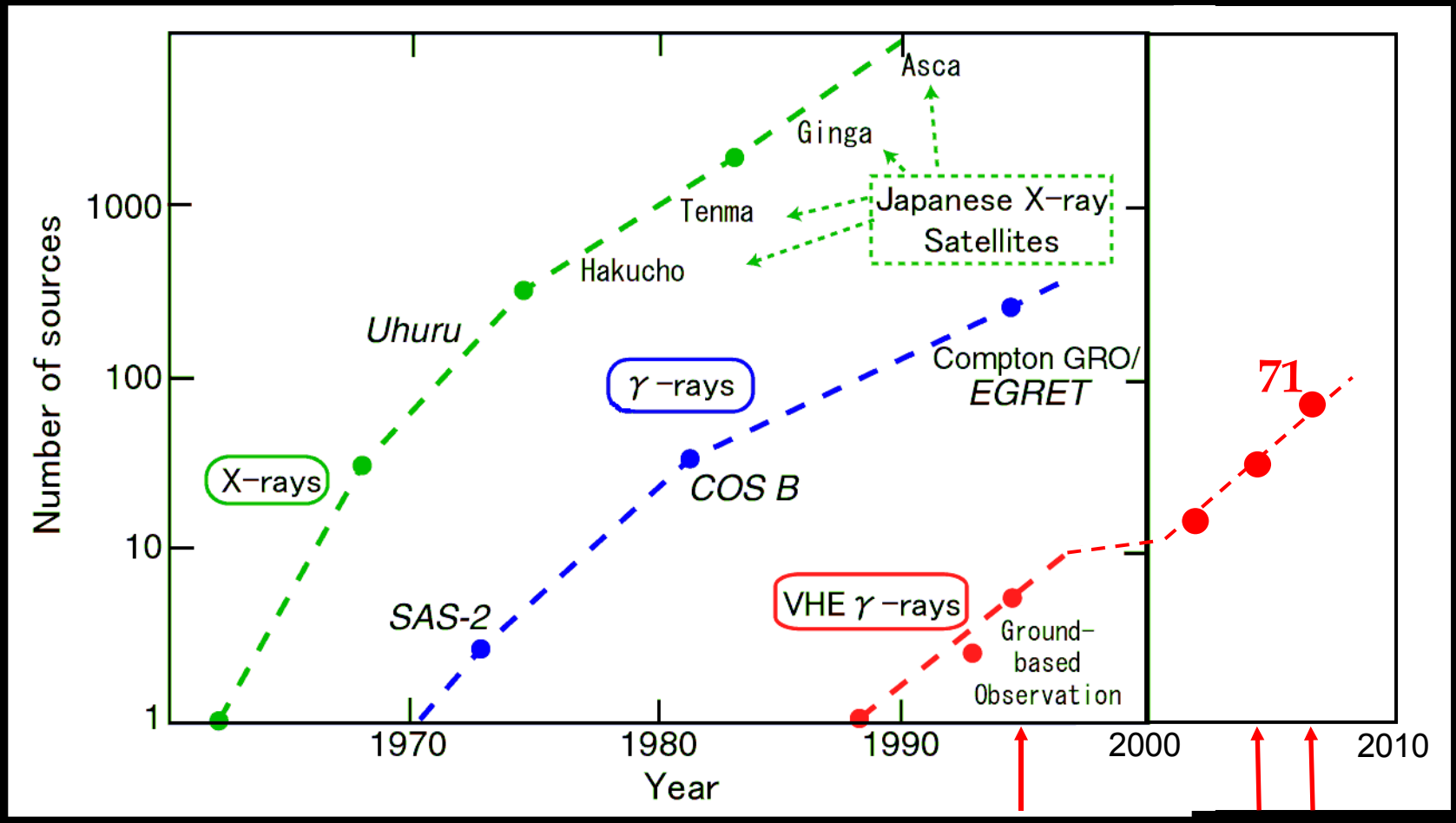
- **Additionally – HESS J1303 and J1804 C-III results presented here – consistent spectra**

Higasi 477 *Kushida* 320

VHE Source Numbers

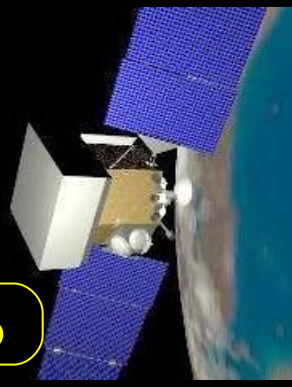
Class	2003	2005	2007
PWN	*1*	*6*	*18*
SNR	*2*	*3*	*7*
Binary	*0*	*2*	*4*
Diffuse	*0*	*2*	*2*
AGN	*7*	*11*	*19*
UnId	*2*	*6*	*21*
Total	12	33	71!

Kifune Plot



Source count versus year
[T. Kifune]

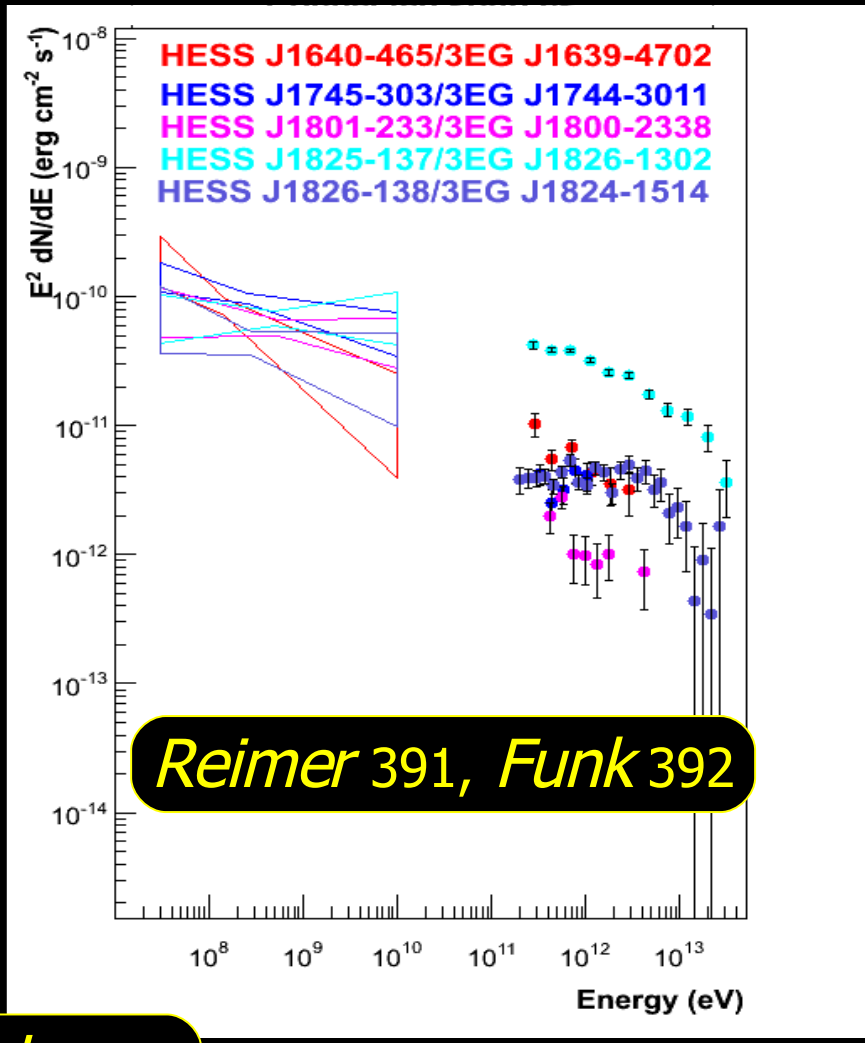
GeV Activity



- **Preparations for GLAST (launch Jan 2008)**
  - Understanding the diffuse background
    - really critical for galactic sources — *Porter* 762, 766
  - Expected science performance
    - Blazars — *Carson* 1211
    - Pulsars (importance of radio ephemerides) — *Guillemot* 1286
    - Also IC halos around massive stars — *Orlando* 606
- **AGILE**
  - Blazar obs. together with TeV instruments — *Persic* 363
- **EGRET reanalysis and interpretation**
  - Catalogue revision (diffuse model change) — *Casandjian* 155
  - Excess from the Coma direction — *Davoudifar* 507
  - Galactic diffuse emission — *Baughman* 1116
- **Studies relating GeV and TeV emission…**

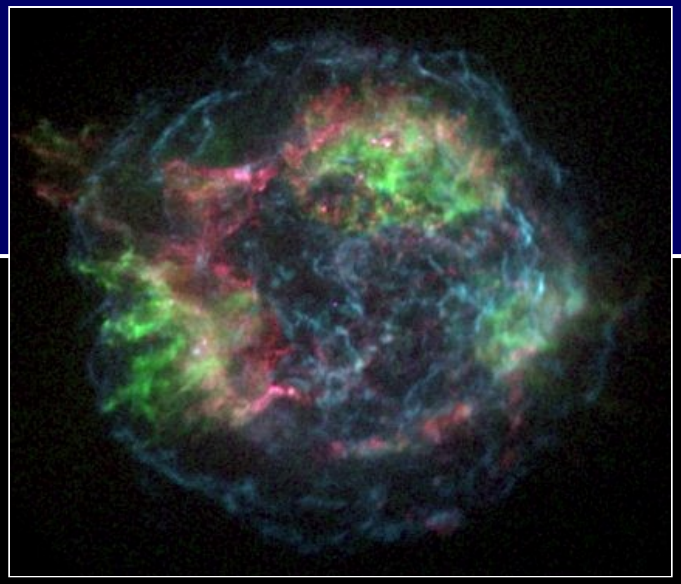
The GeV/TeV Connection

- Do we see the same source populations in the GeV and TeV domains?
  - Sensitivity mismatch of a factor 60 (EGRET lifetime / 5 h HESS survey)
- Not many EGRET/TeV positional coincidences
  - But those that exist have 'matching' spectra
  - This is expected by chance
- Also MILAGRO/EGRET coincidences seem statistically significant
  - Very extended objects?



Abdo 735

OG 2.1-2.2:
Galactic Sources And Diffuse Emission

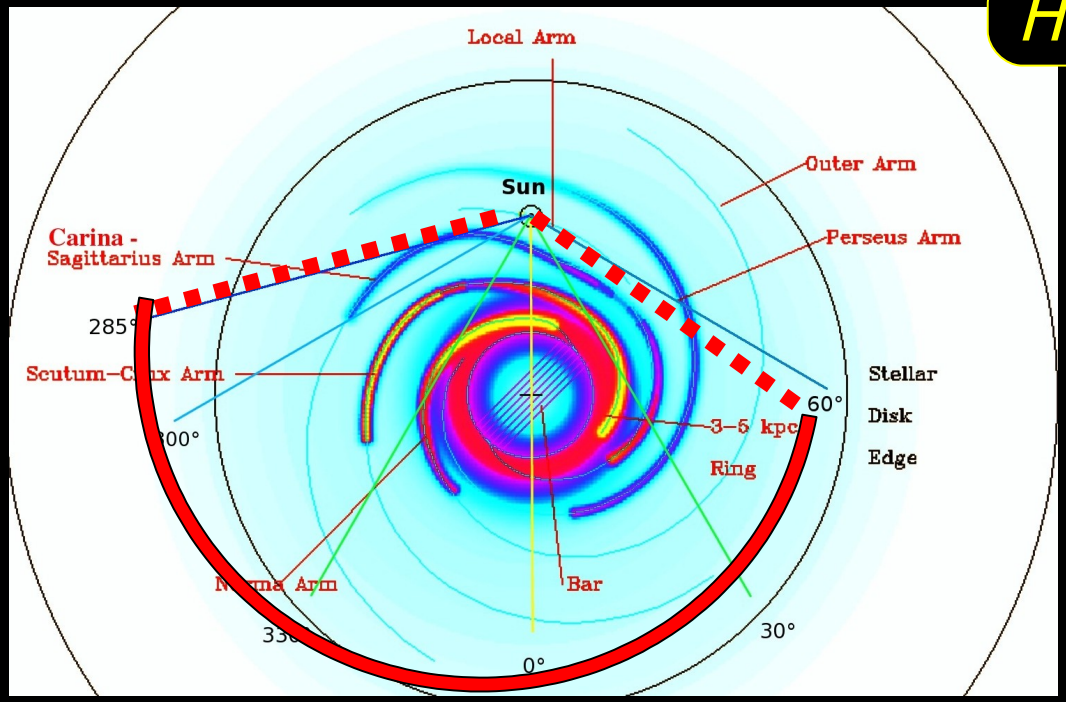


The New Galactic VHE γ-Ray Sources

Name	Discovered	Class	Contributions (detections)
Cyg X-1?	*MAGIC*	*Binary*	*MAGIC*
LS I +61 303	MAGIC	Binary	MAGIC, VERITAS
RCW 86	HESS	SNR	HESS
IC 443	MAGIC	SNR?	MAGIC, VERITAS
W 28	HESS	SNR?	HESS
Kes 75	HESS	PWN/SNR	HESS
G21.5-0.9	HESS	PWN/SNR	HESS
HESS J1023-575	HESS	Stellar Cluster?	HESS
MGRO J2031+41	Milagro	?	Milagro
MGRO J2019+37	Milagro	?	Milagro, Tibet
MGRO J1908+06	Milagro	?	Milagro, HESS
HESS J0632+057	HESS	Binary?	HESS
HESS J1718-385	HESS	PWN?	HESS
HESS J1809-193	HESS	PWN?	HESS
HESS J1912+102	HESS	PWN?	HESS
HESS J1357-645	HESS	PWN?	HESS
+7 UnId sources!	HESS	?	HESS

Since last ICRC

HESS Galactic Plane Survey



Hoppe 269

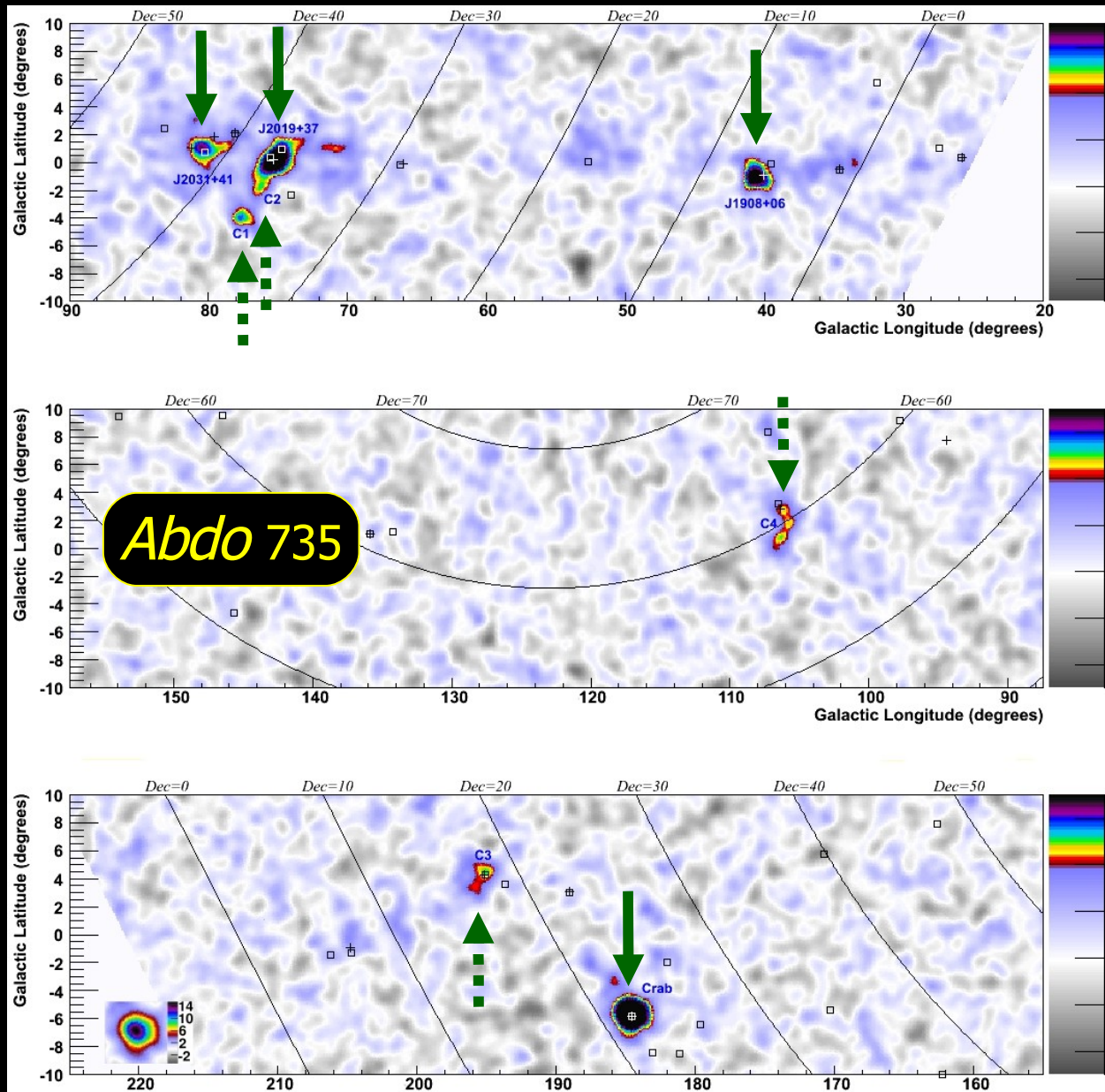
-85° < l < 60°
-2.5° < b < 2.5°

pure scan
400 h

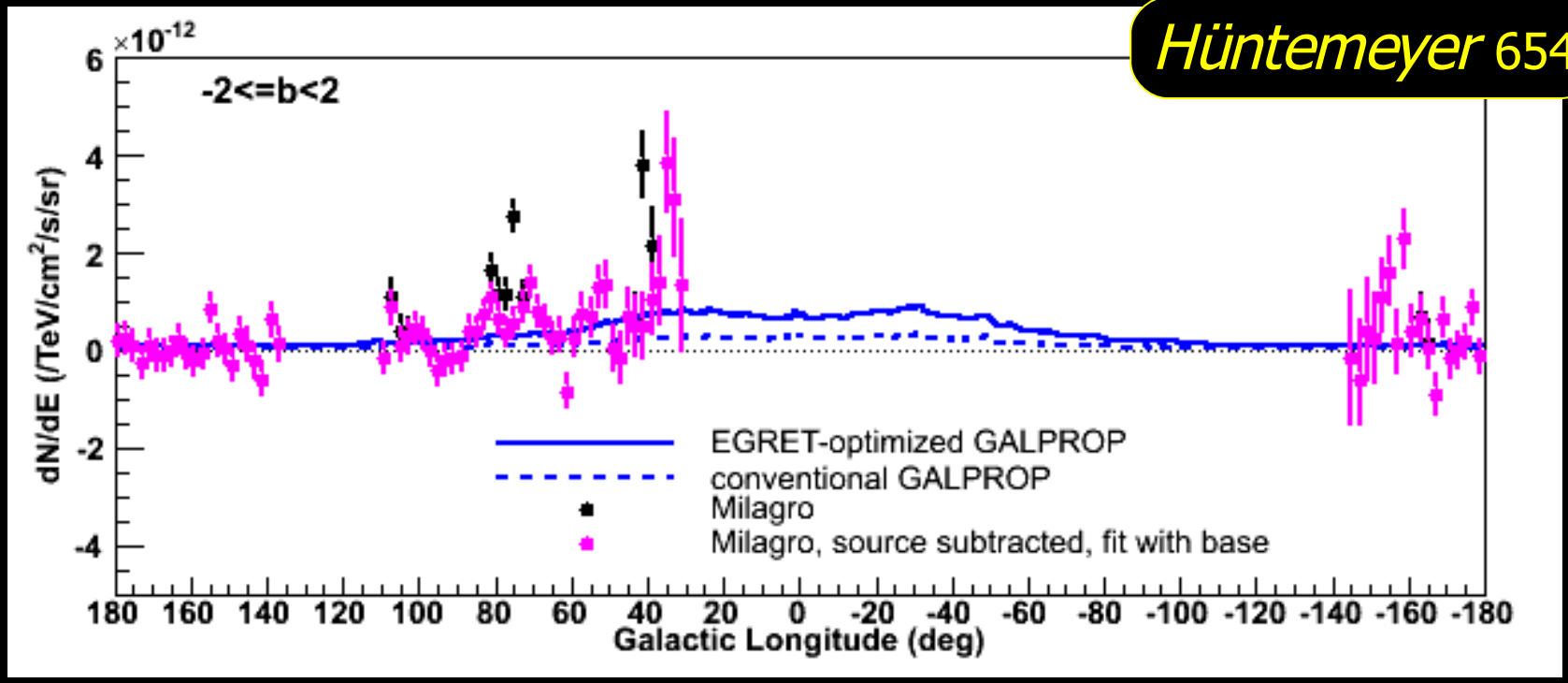
Survey region was extended in the years 2005 – 2007 – many new sources!

Milagro Sources and Candidates

- 7 year map
- γ/hadron cut raises median energy to 20 TeV
- 3 new sources significant post trials
- 4 'hotspots'
- Interesting regime of hard spectrum/ extended sources



Diffuse Emission with Milagro



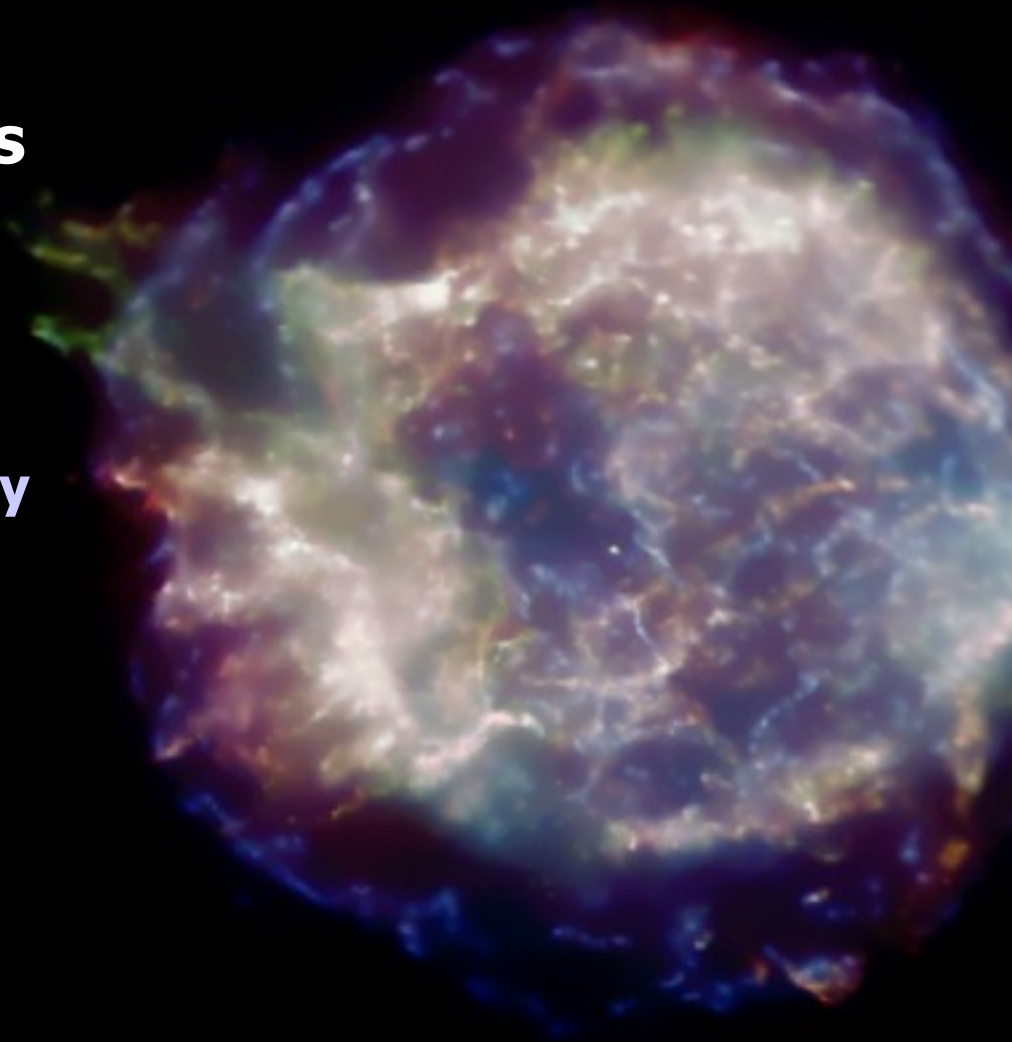
Hüntemeyer 654

- **Galactic plane emission, factor 2 higher than diffuse predictions, seems consistent with ~50% unresolved sources**
- **Large scale (>10 deg) features seen in 'proton-like' events – interesting, but not gamma-ray astronomy – apparently related to the tail-in anisotropy seen by Tibet**

Walker 672

Supernova Remnants

- Long held to be the likely acceleration sites of the (hadronic) galactic cosmic rays
  - Diffusive shock acceleration
  - Require ~10% efficiency of kinetic energy to CR acceleration
- Several young objects well studied in X-ray synchrotron radiation
  - Thin filaments suggest rapid cooling of electrons: $B_{shock} >> B_{ISM}$

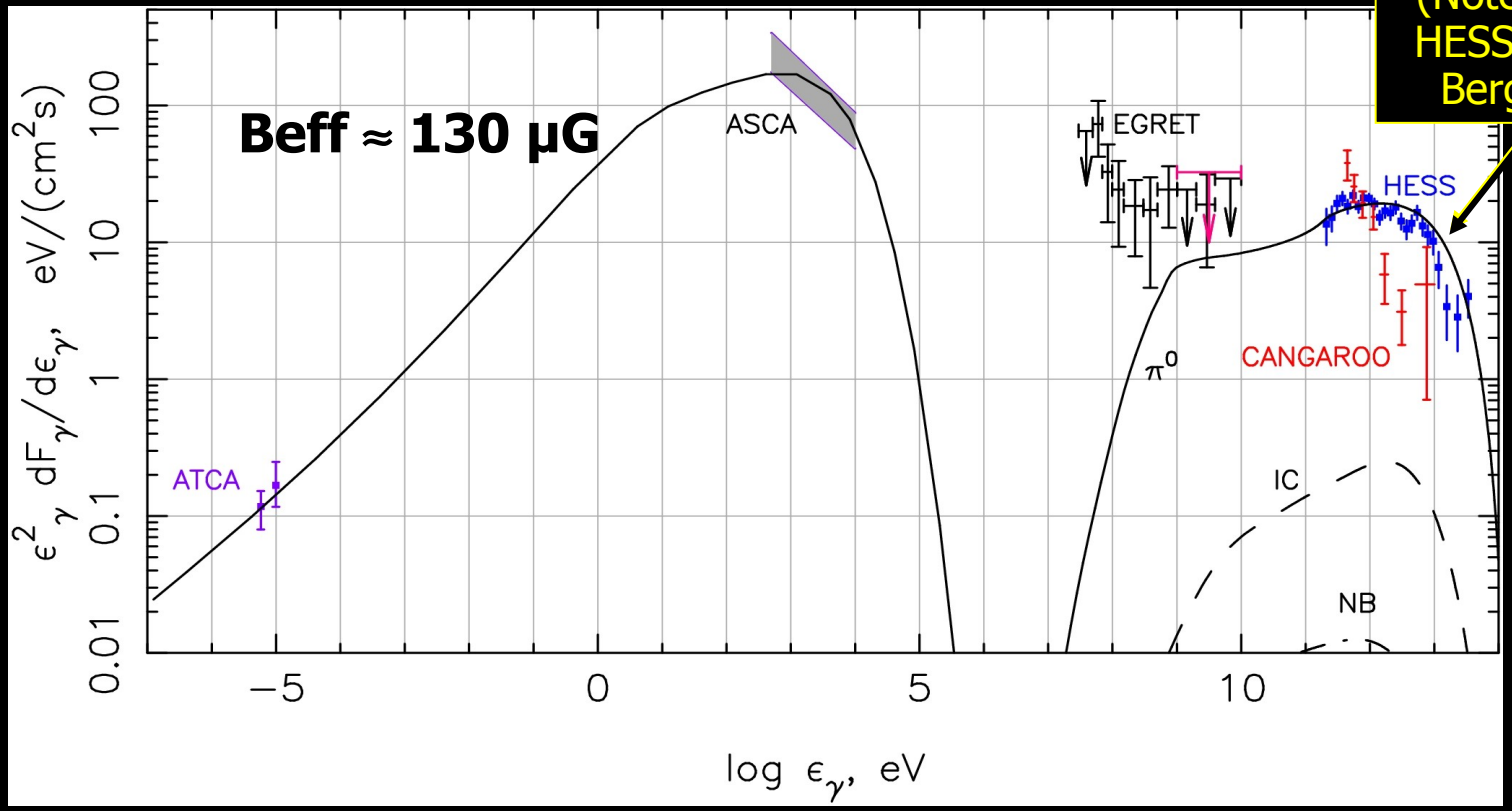


Theoretical Work

- **Models for hadronic γ-rays and radio-X-ray synchrotron emission from**
  - Tycho (Voelk 127), SN 1987A (Berezhko 125), Kepler (Ksenofontov 126) [Also RX J1713 and Vela Jnr in OG1]
- **Effects of small scale random B-fields in SNR shells**
  - Jitter radiation (Yoshida 1268)
- **Separation of non-thermal brems. / synch. in Cas A**
  - (Allen 1175)
- **Investigation of RX J1713.7–3946 with detailed hadronic interaction model**
  - (Huang 681)
- **Evolution of SNRs in non-uniform media**
  - (Ferreira 1175)

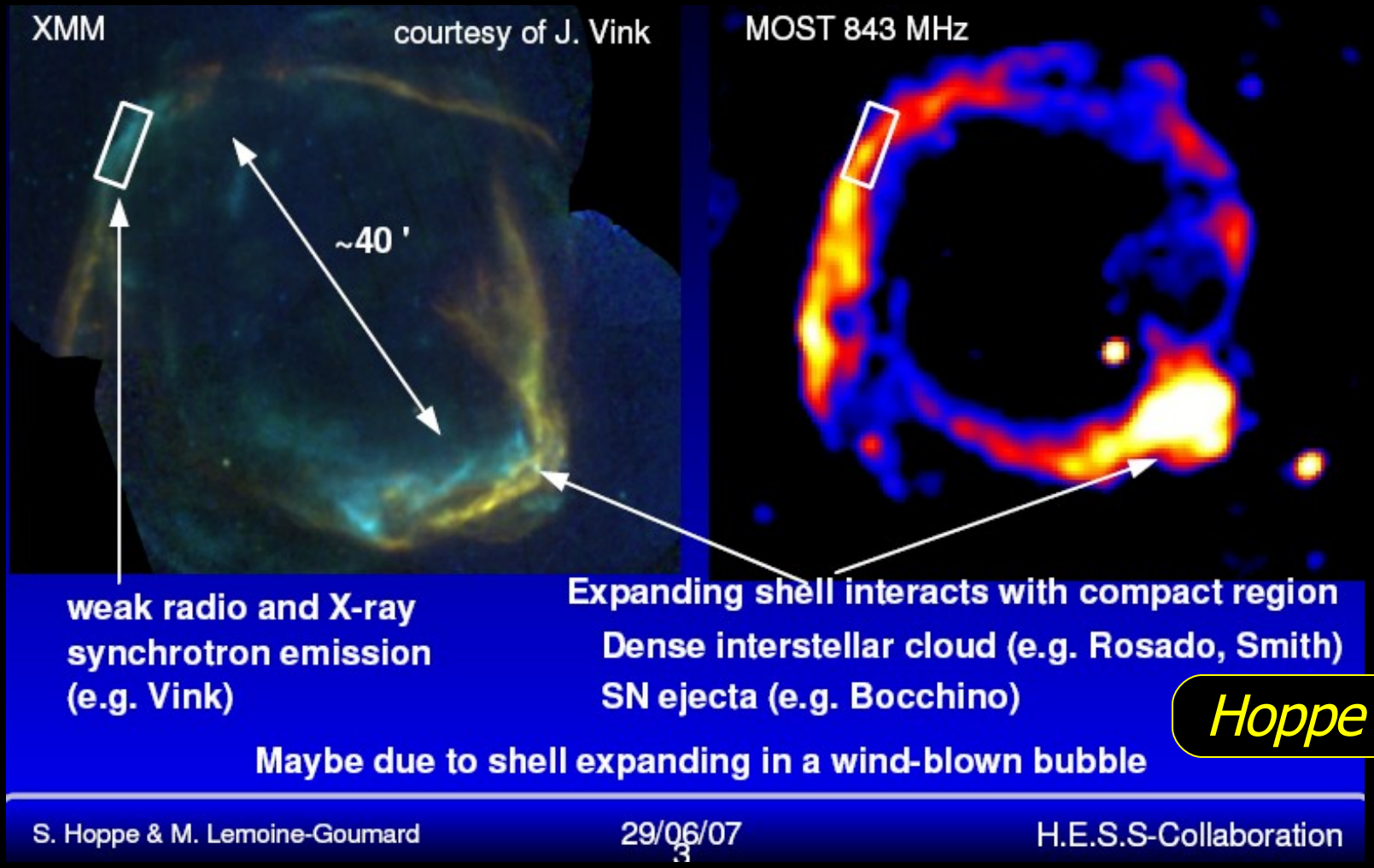
Supernova Remnants

- **Example: Model for RX J1713 from Voelk et al**
  - **Magnetic field amplification assumed to be due to non-linear effects of efficient CR acceleration**
  - **High B-fields suppress IC production**



(Note also new HESS spectrum Berge, 524)

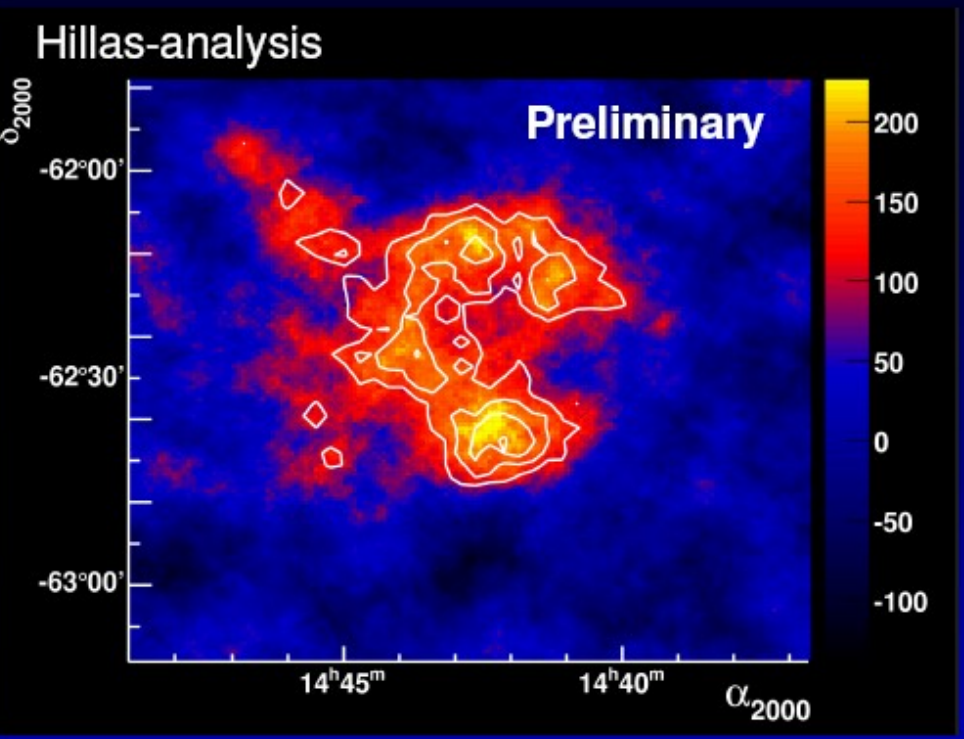
RCW 86

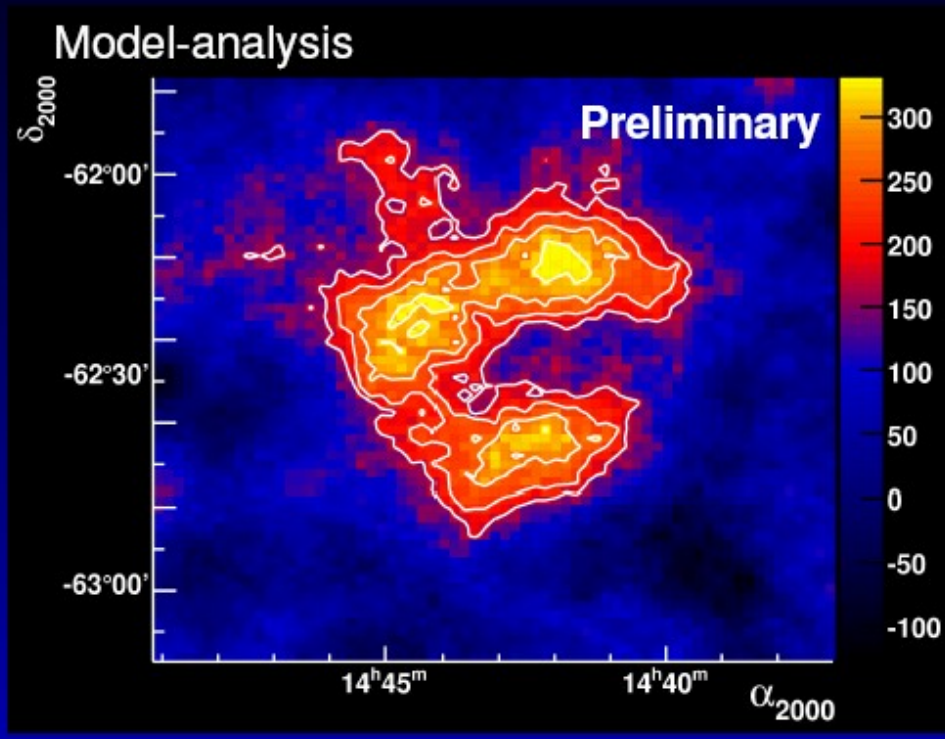


Hoppe 280

- **Well known young (~1 ky) shell type SNR**

RCW 86





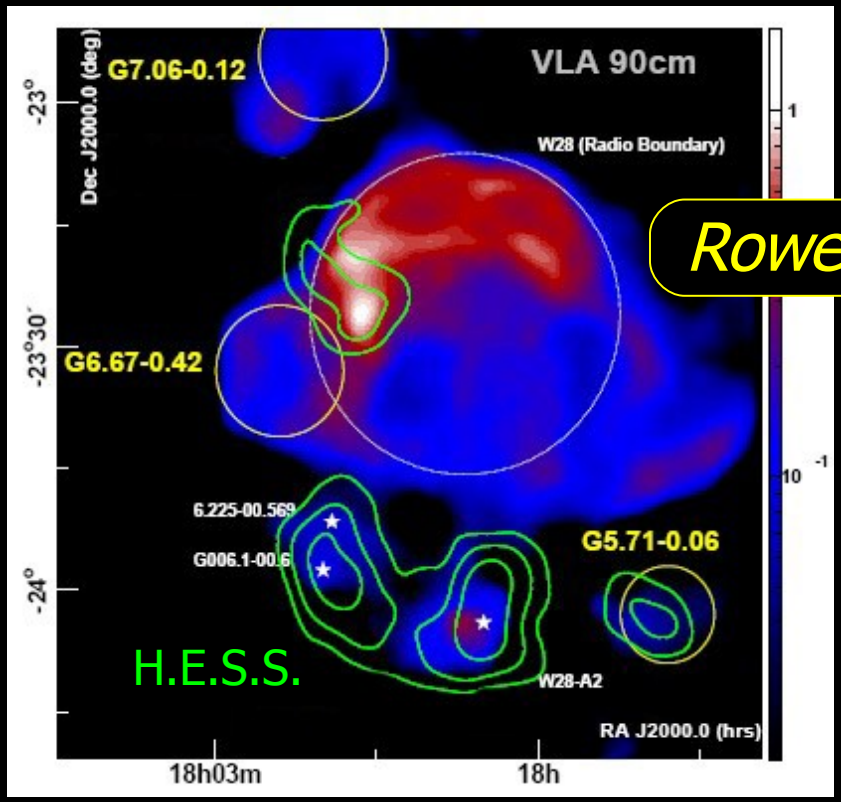
Hoppe 280

Small correlation radius: 0.11°

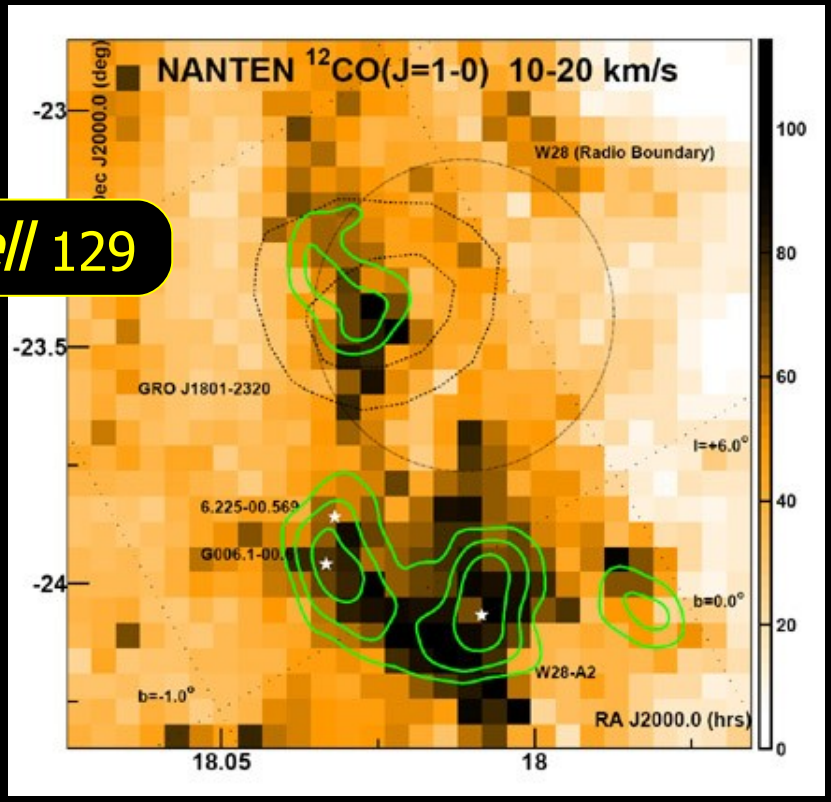
Contours: 3,4,5,6 σ

- 9.4 σ in 30 hours, $E^{-2.5 \pm 0.1}$ spectrum
- Probably the third TeV SNR ***shell***

W 28



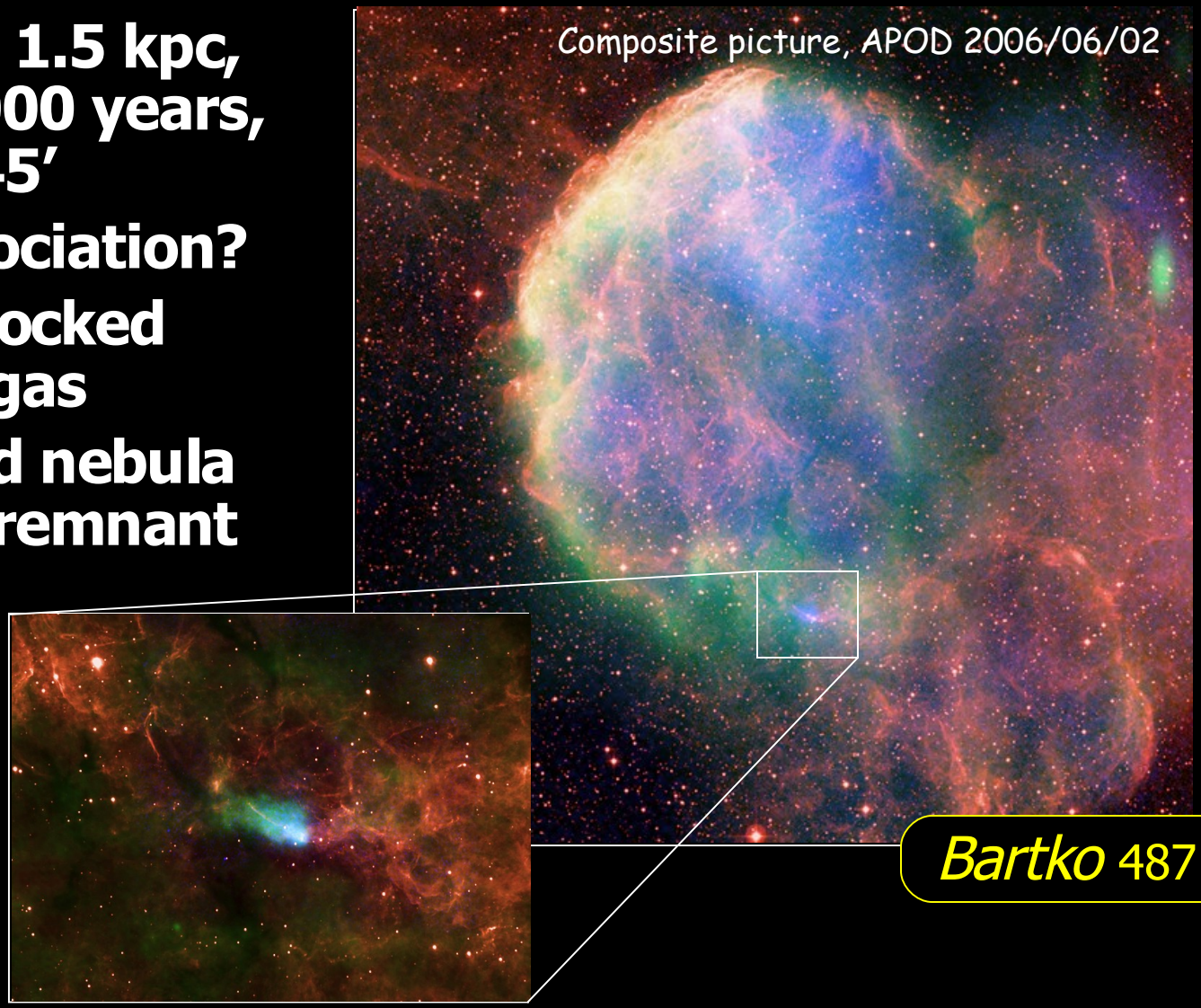
Rowell 129



- TeV emission around old (>10^4 year old) SNR – coincident with molecular clouds
- First evidence for p-p in SNR/Cloud interactions
  - See e.g. Aharonian, Drury & Voelk 1996

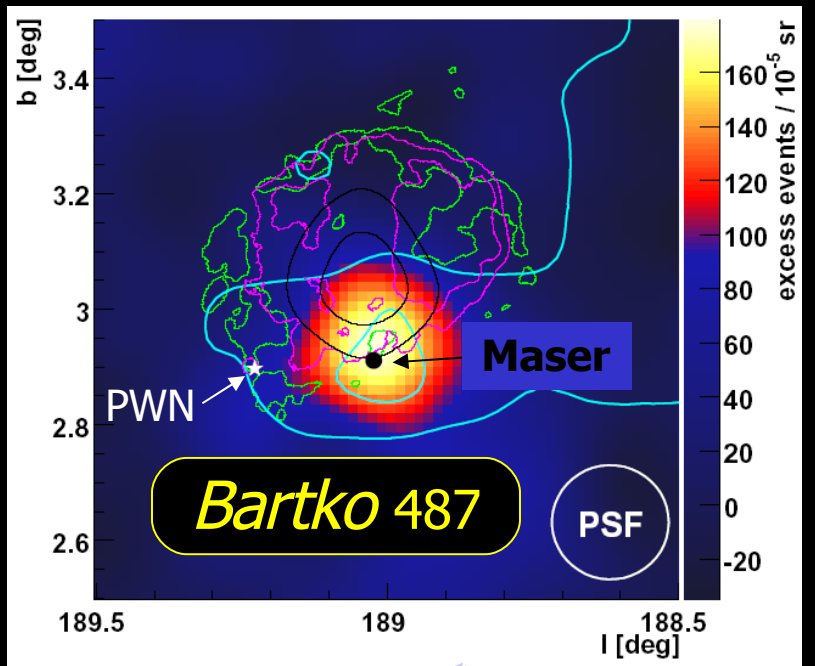
IC 443

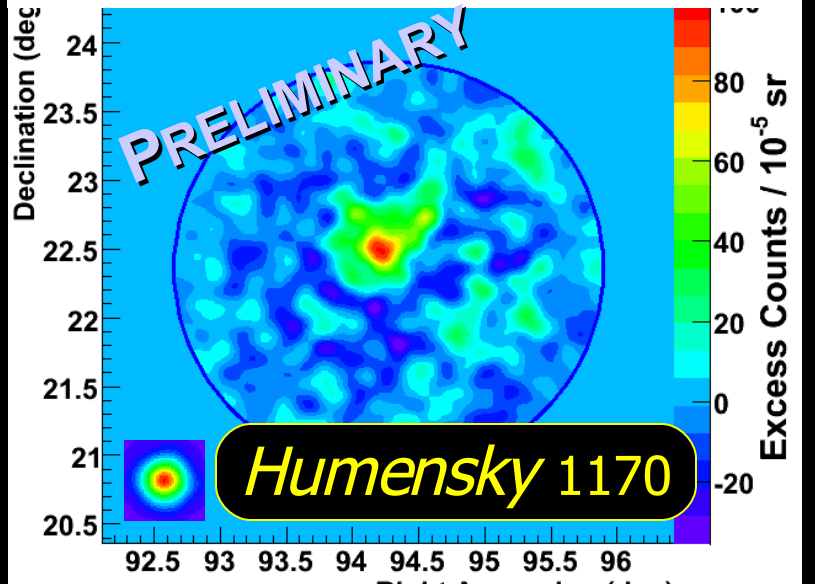
- Distance ~ 1.5 kpc, Age ~ 30,000 years, Diameter 45′
- EGRET association?
- Maser – shocked molecular gas
- Pulsar wind nebula at edge of remnant



IC 443

- MAGIC 5.7σ in 29 h
  - Steep spectrum $E^{-3.1\pm0.3}$
- VERITAS 7.1σ in 16 h
  - Consistent position
- Position compatible with dense gas, not PWN, not shell
  - Interaction of hadrons accelerated in SNR?
  - Morphology may be key to interpretation

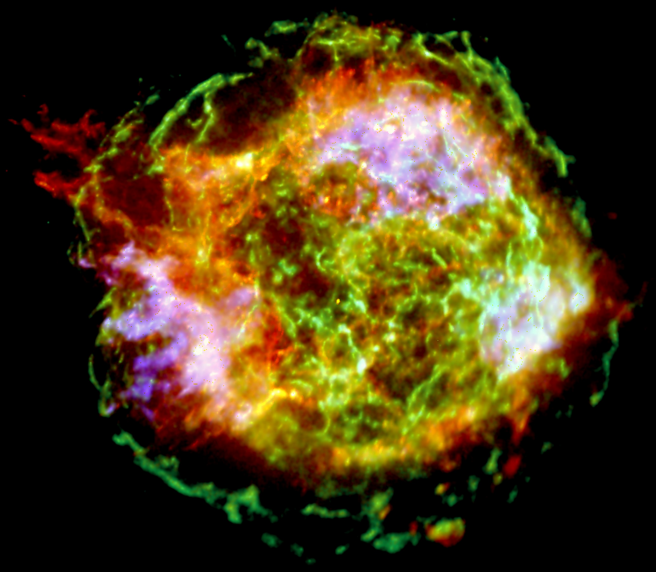


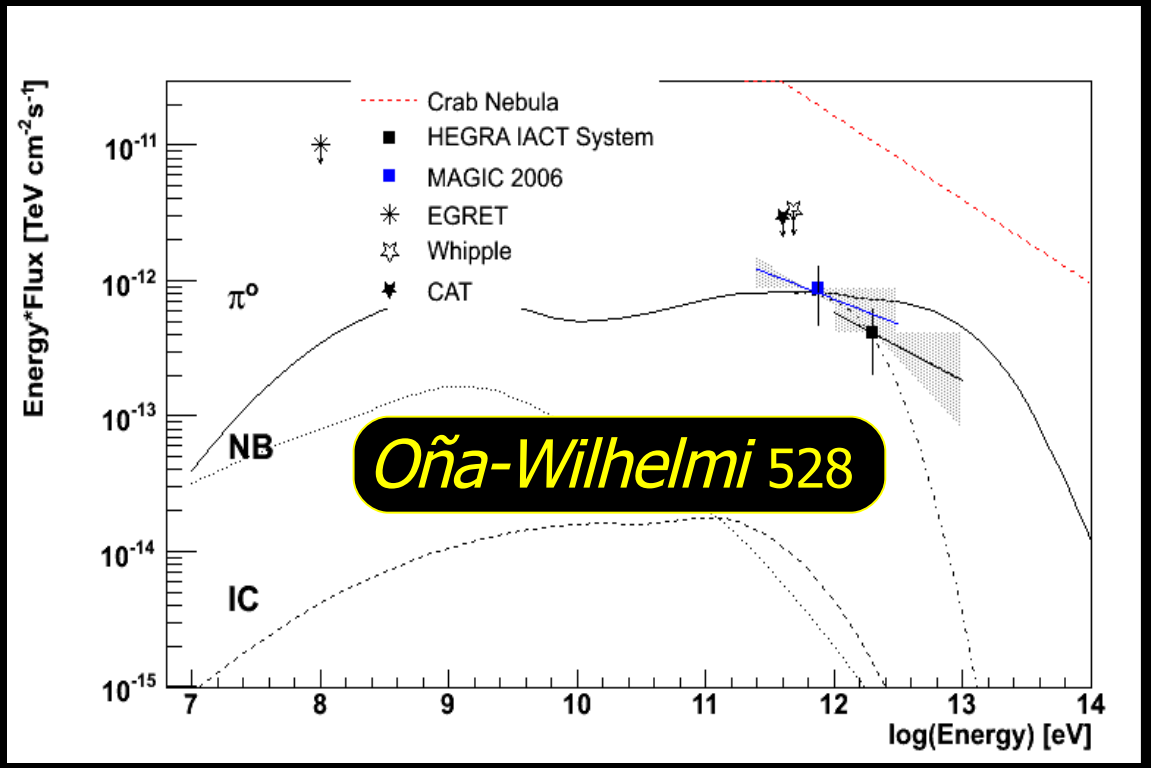


Cassiopeia A

- **Young and very bright radio/X-ray SNR shell**
- **MAGIC detection (5.2 σ) in 47 h**
- **Consistent with HEGRA measurement, $\Gamma = 2.4 \pm 0.2$**

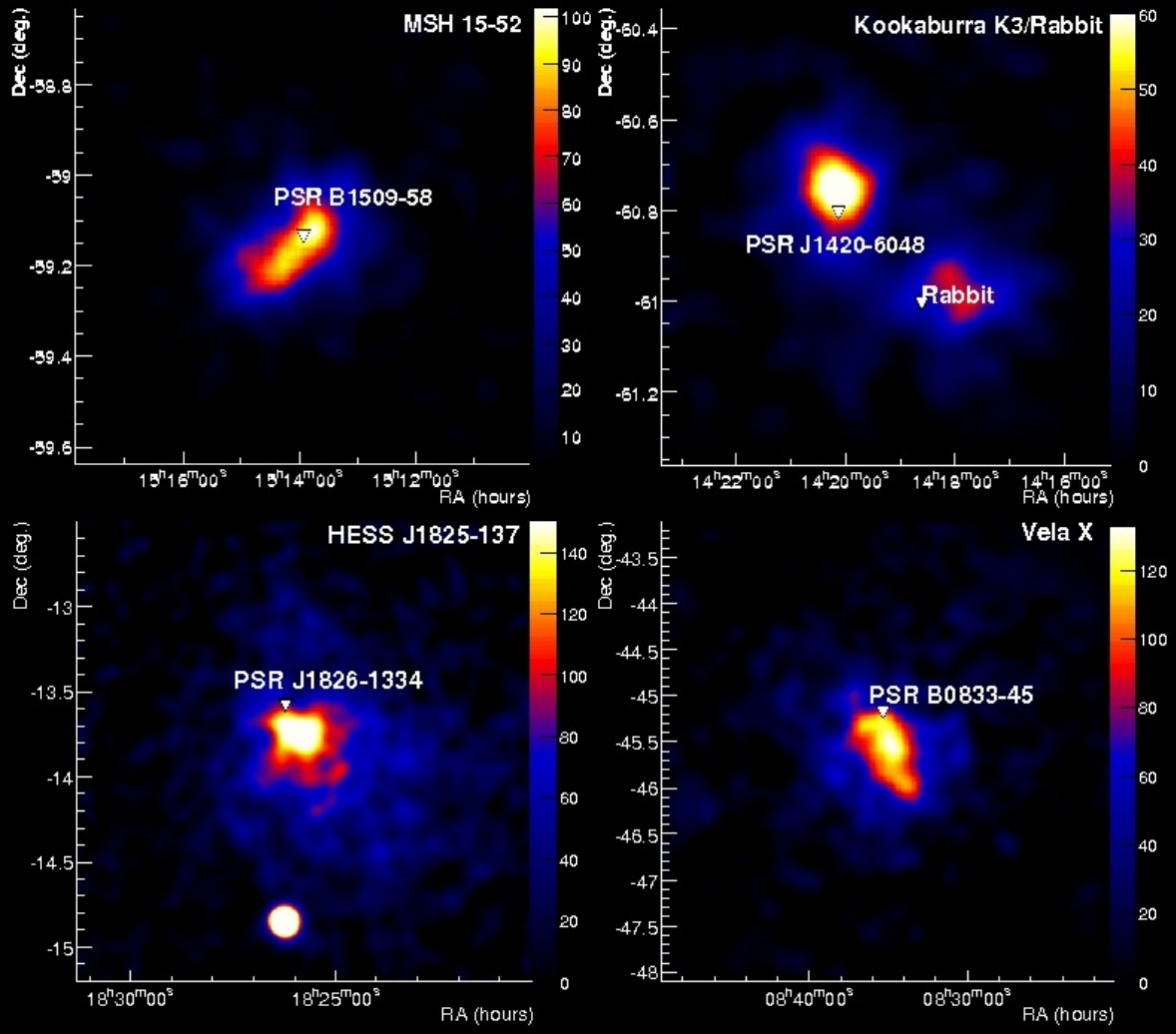
Chandra, 1 Ms





Pulsar Wind Nebulae

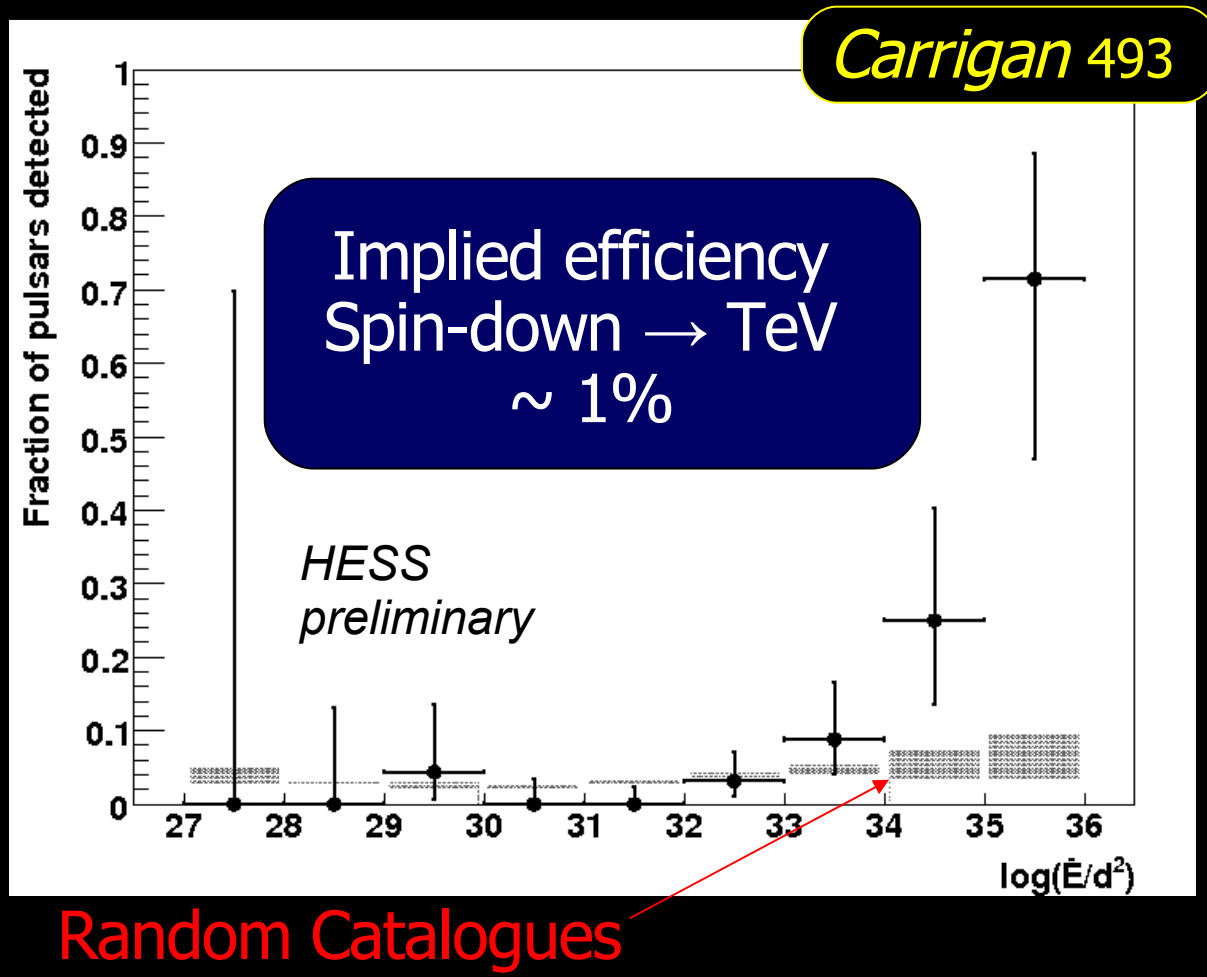
- Major galactic TeV source population
  - Associated with relatively young ($<10^5$ year old) and energetic pulsars
- Generally believed that we see inverse Compton emission of 1-100 TeV electrons



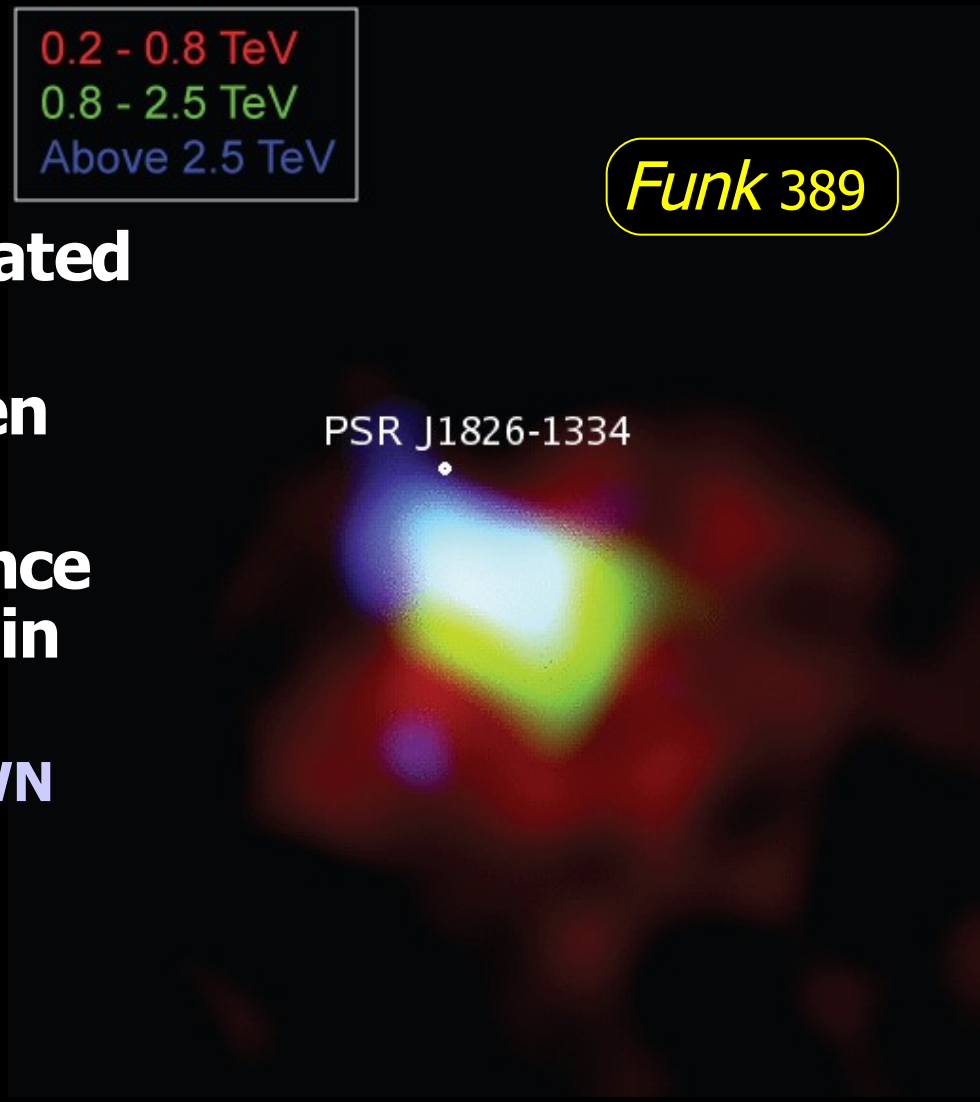
Funk 2006

Systematic Search For PWN

- γ-ray PWN can be large, asymmetric and offset from the pulsar
- Need to assess chance coincidence
- HESS scan analysis shows that 70% of $Edot/d^2 > 10^{35}$ erg/s/kpc² are TeV sources



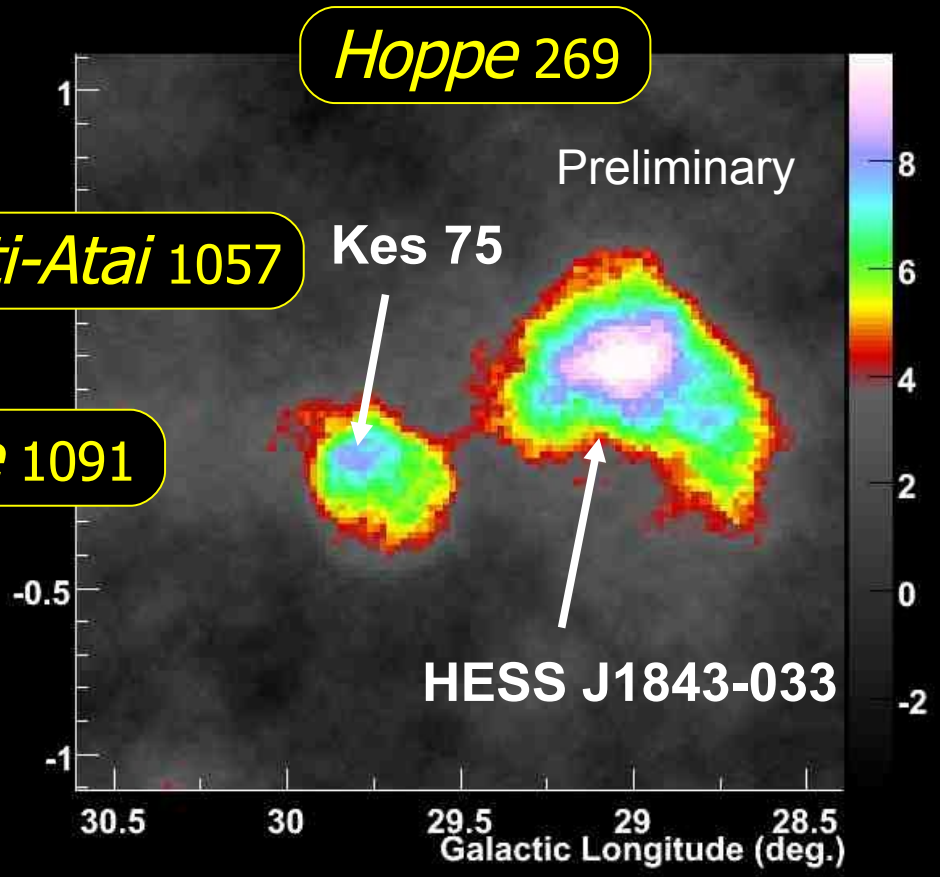
Energy Dependant Morphology



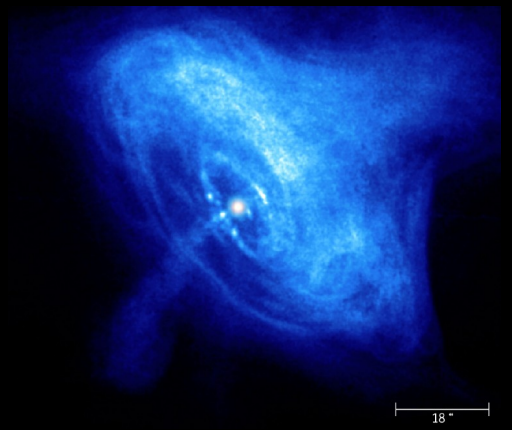
- **HESS J1825-137 associated with energetic pulsar**
- **Spectral steepening seen away from the pulsar**
- **Very likely this is evidence for cooling of electrons in the Nebula**
  - **Seen in several *X-ray* PWN**
- **A first in gamma-ray astronomy!**

New PWN Candidates

- PSR J1846-0258 in Kes 75
  - Youngest pulsar in our galaxy
- G21.5-0.9
  - Also v. young
- HESS J1357-645, HESS J1718-385, HESS J1809-193, HESS J1912+102
  - PWNe of middle aged pulsars
- Geminga??
  - C3 'hotspot' from Milagro – 5.1 → 2.8 σ
  - 3 degrees across – almost impossible for IACTs…



The Crab Nebula

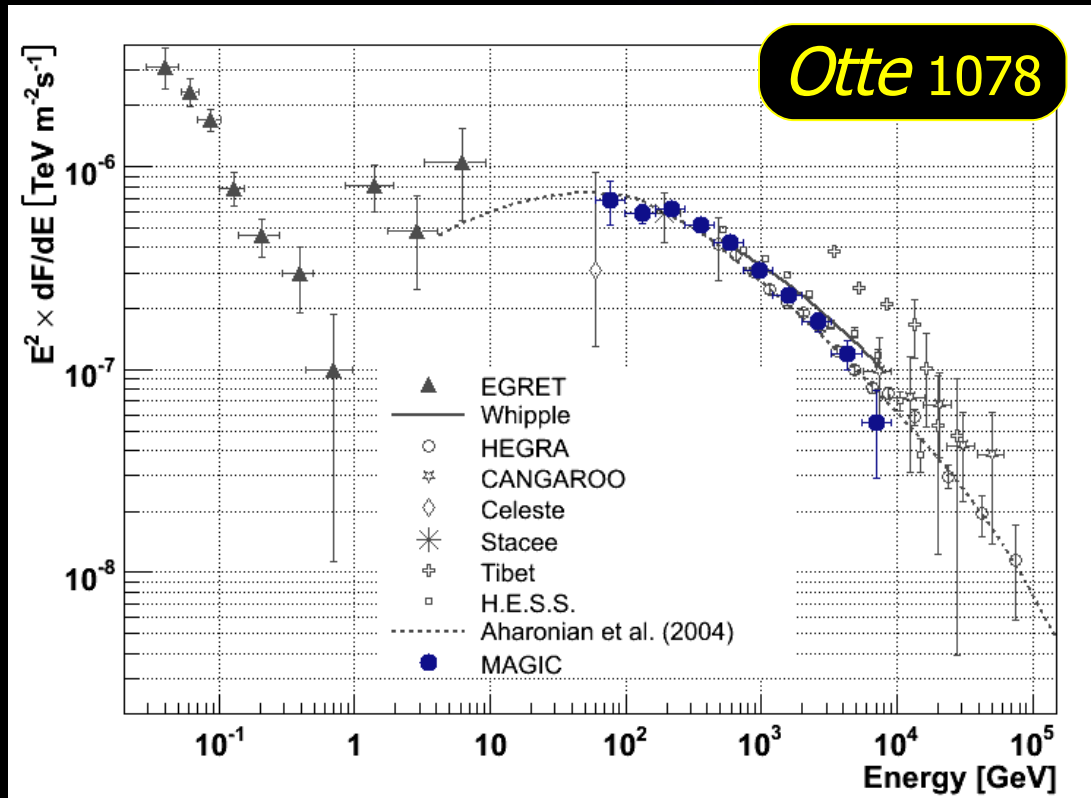


- **Many results reported**
  - **VERITAS**
    - **31 σ/√ h with 3 tels**
  - **Whipple** *Grube* 543
  - **MAGIC**
    - **19 σ/√ h**
    - **Curvature seen**
    - **Peak:** 77±47 GeV
  - **HESS**
    - **Up to 80 TeV**
  - **Milagro** *Khelifi* 986
    - **First spectrum** *Yodh* 710
  - **ARGO YBJ**
    - **5 σ in 50 days (~2 σ in 50 days for Milagro)**

Celik 1290

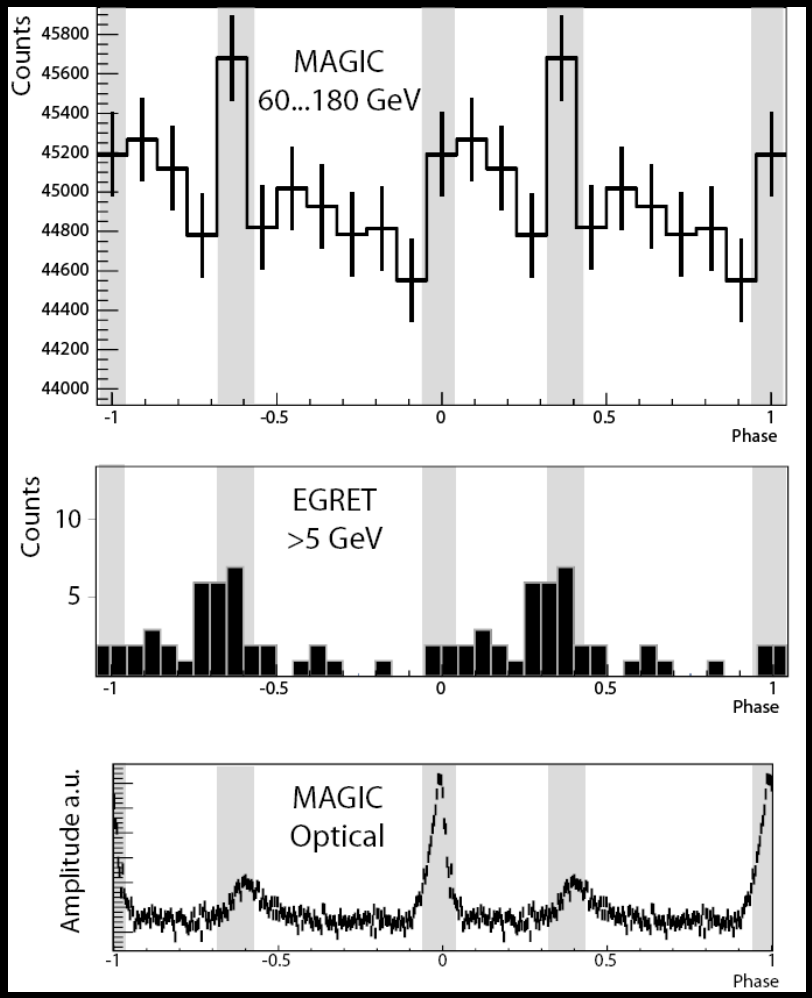
Martello OG2.7

Otte 1078



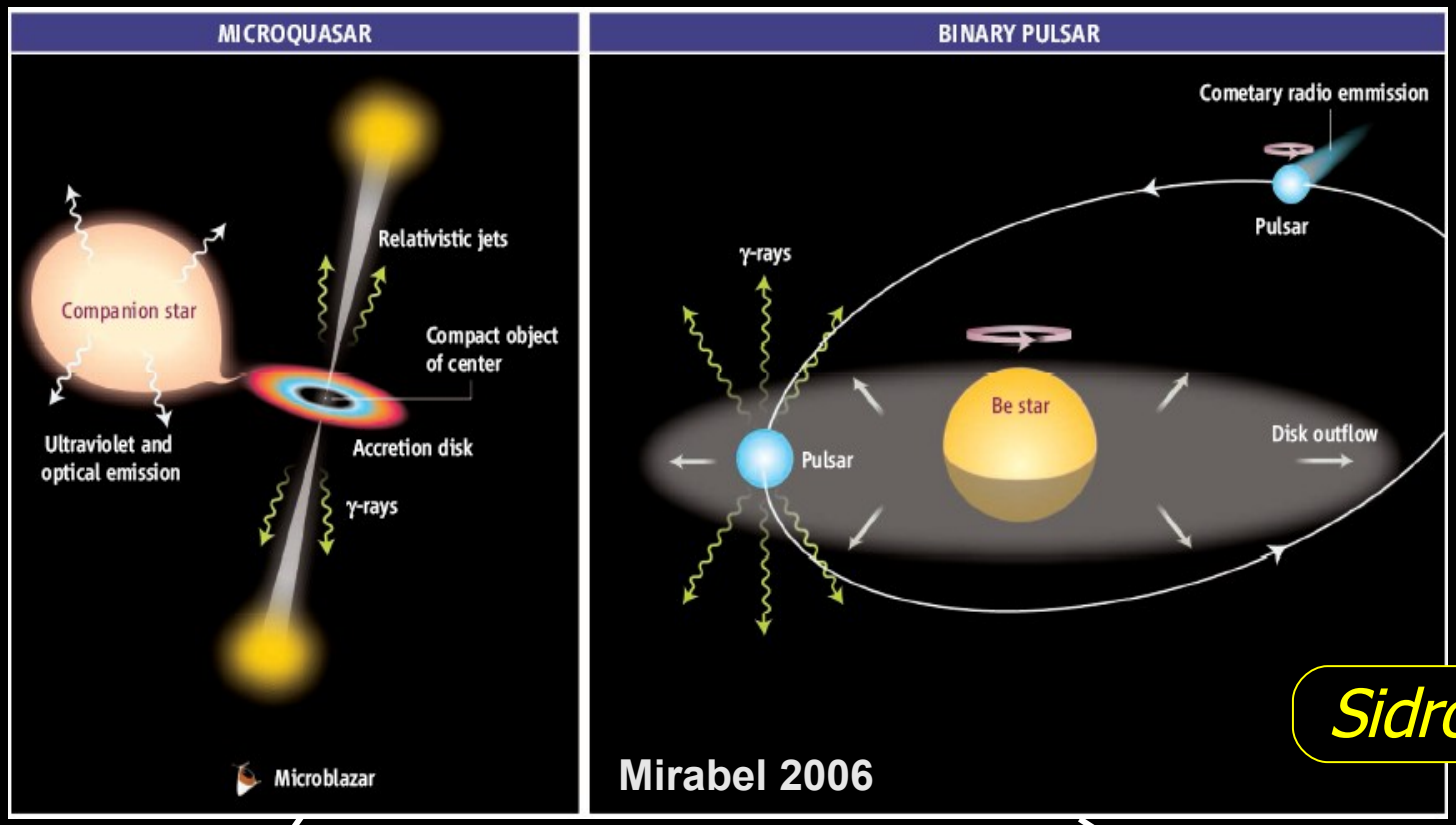
Pulsed Emission

- **Upper limits on pulsed emission from many groups**
  - PACT — *Acharya* 517
  - Tibet — *Amenomori* 844
  - HESS — *Füssling* 572
  - STACEE — *Kildea* 830
- **Hints for pulsed emission from the Crab pulsar at 60-180 GeV from MAGIC!**
  - 2.9 σ in 16 hours of data
  - Should/could be confirmed very soon…



Otte 1078

Gamma-ray Binaries



Sidro 574

Microquasar: particles (electrons or hadrons) are accelerated in a jet

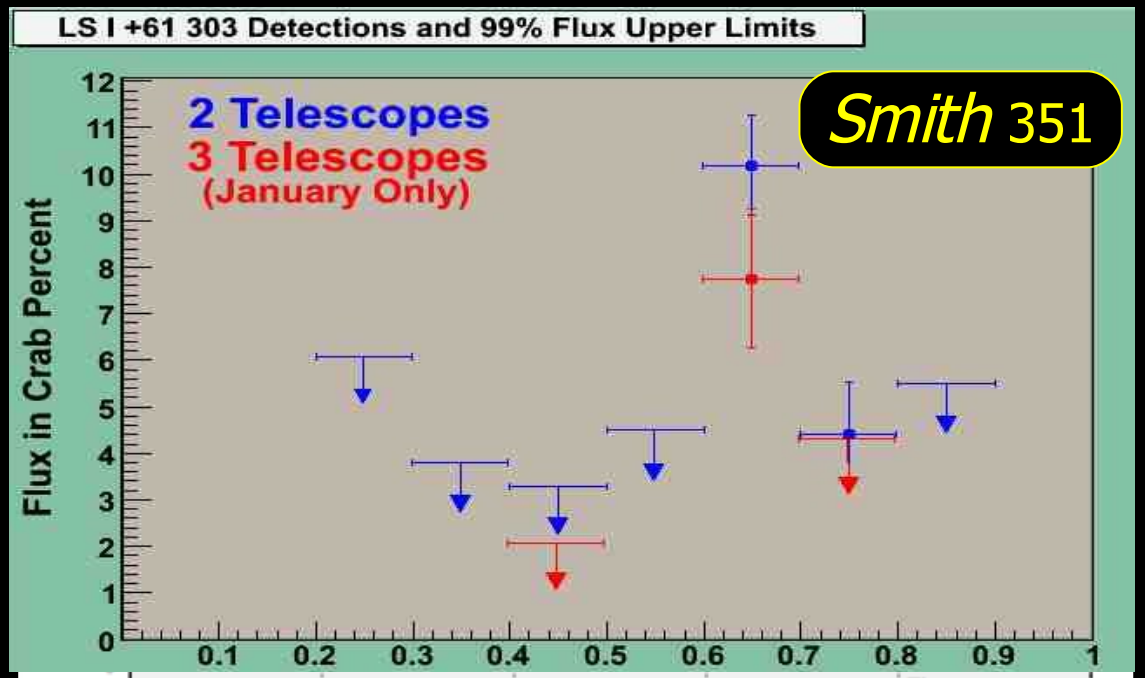
Bosch-Ramon et al. (2006), Romero et al. (2007)

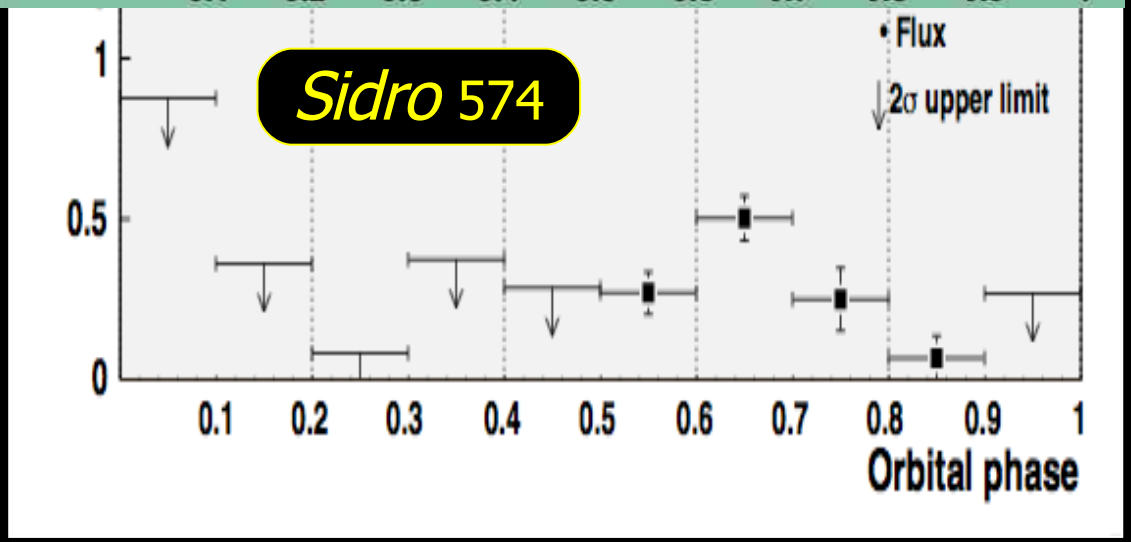
γ-rays produced in the shock where the wind of the young pulsar and the wind of the Be star collide

Dubus (2006), Dhawan et al. (2006)

LS I +61 303: VERITAS+MAGIC

- Variable (flaring) mostly at phase 0.5-0.85 – but not really periodic?
- Overall correlation with X-ray – but many differences
- A real challenge to modellers!

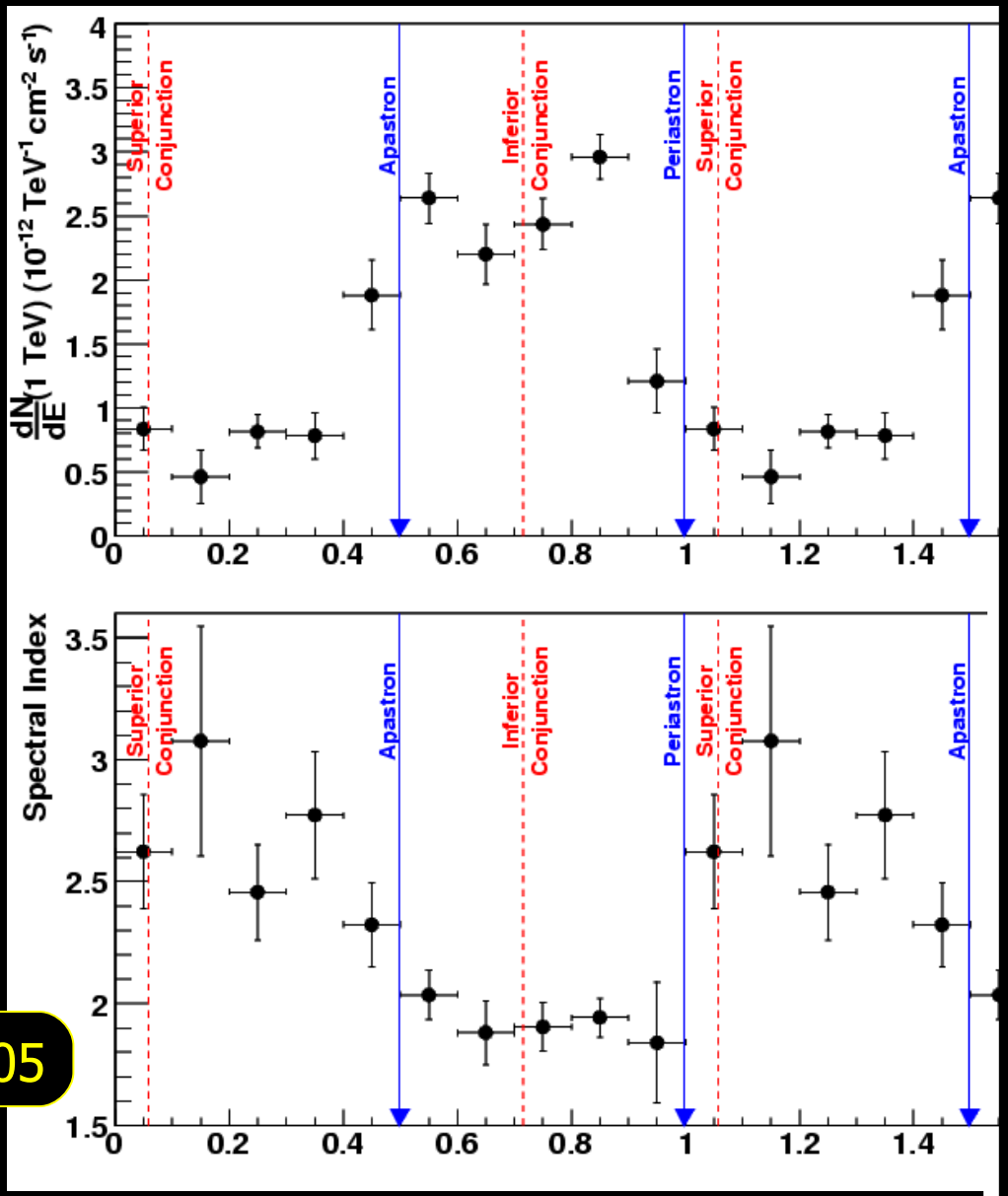




LS 5039 WITH HESS

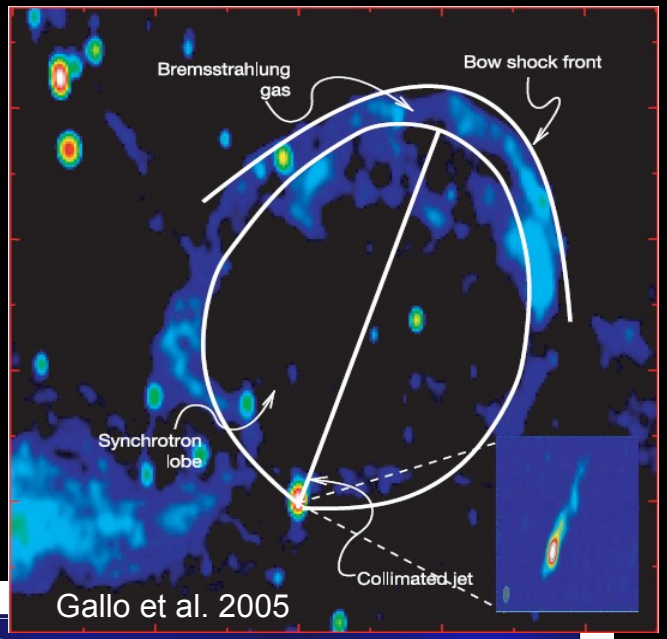
- Strong modulation of flux and spectrum with orbital phase
  - Beautifully measured!
- Maximum is when star lies in front of compact object along the line of slight
- Absoption/ cascading effects?

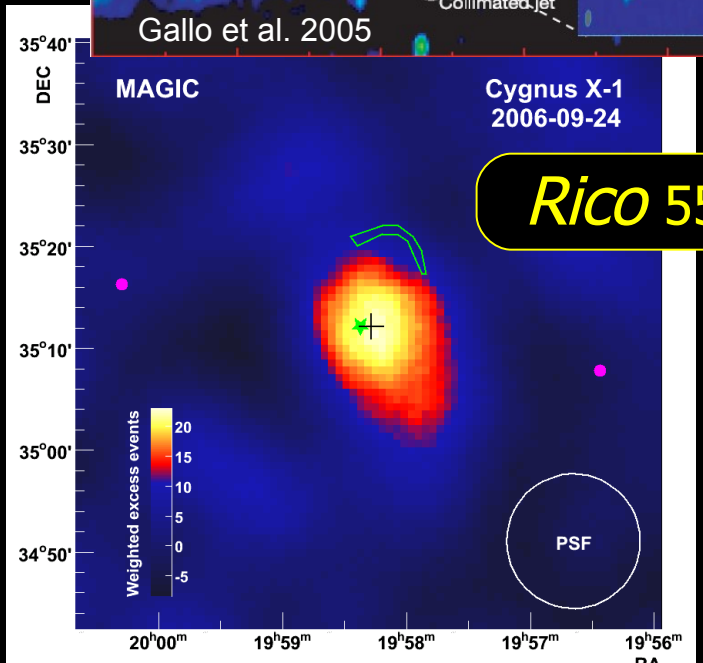
De Naurois 1305



Cygnus X-1: A VHE Emitter?

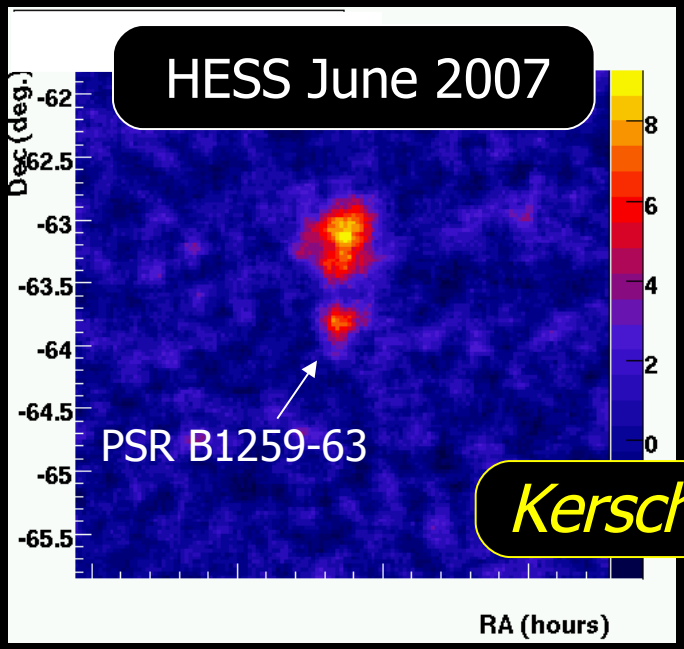
- **Black hole binary**
  $M_{BH} > 13 M_{\odot}$, $M_{star} \sim 30\ M_{\odot}$
- **Relativistic jet v > 0.6 c**
- **40 hours of MAGIC observations**
- **4.9 σ signal seen in one 79 minute time slice**
- **Estimated significance 4.1 σ after correction for statistical trials**
- **Very exciting but not yet firmly established as a VHE source**

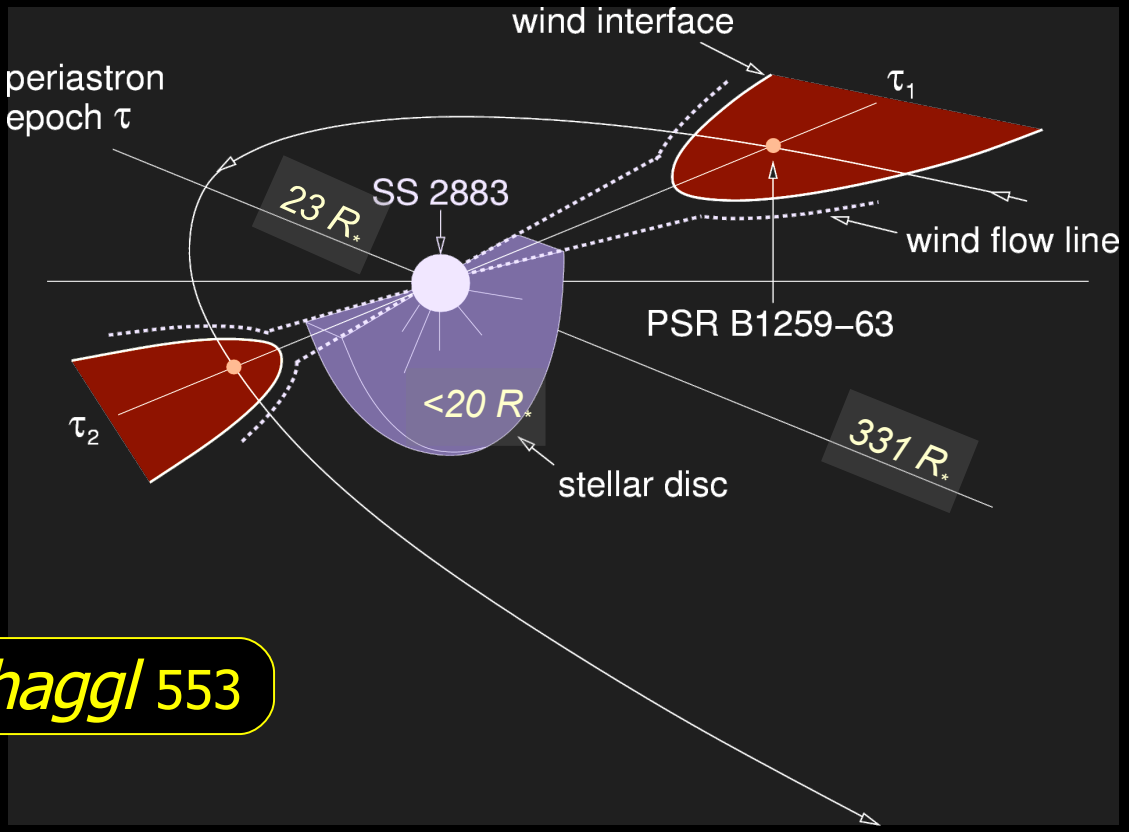




PSR B1259-63 Periastron

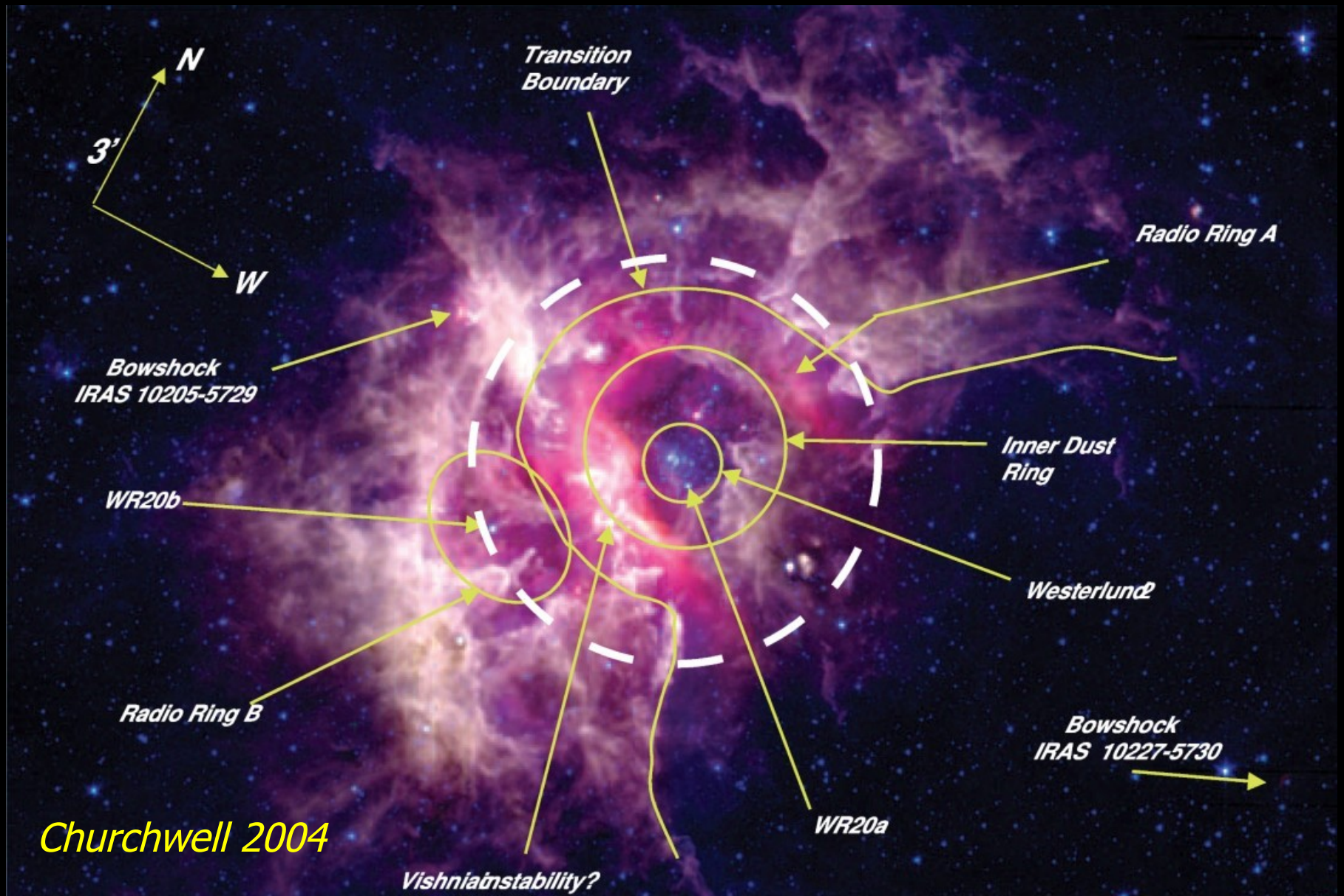
- Periastron passage in 16 days! (3.4 year period)
- Extensive MWL campaign
  - HESS – April-August
  - Suzaku - July
  - Chandra - August





Kerschhaggl 553

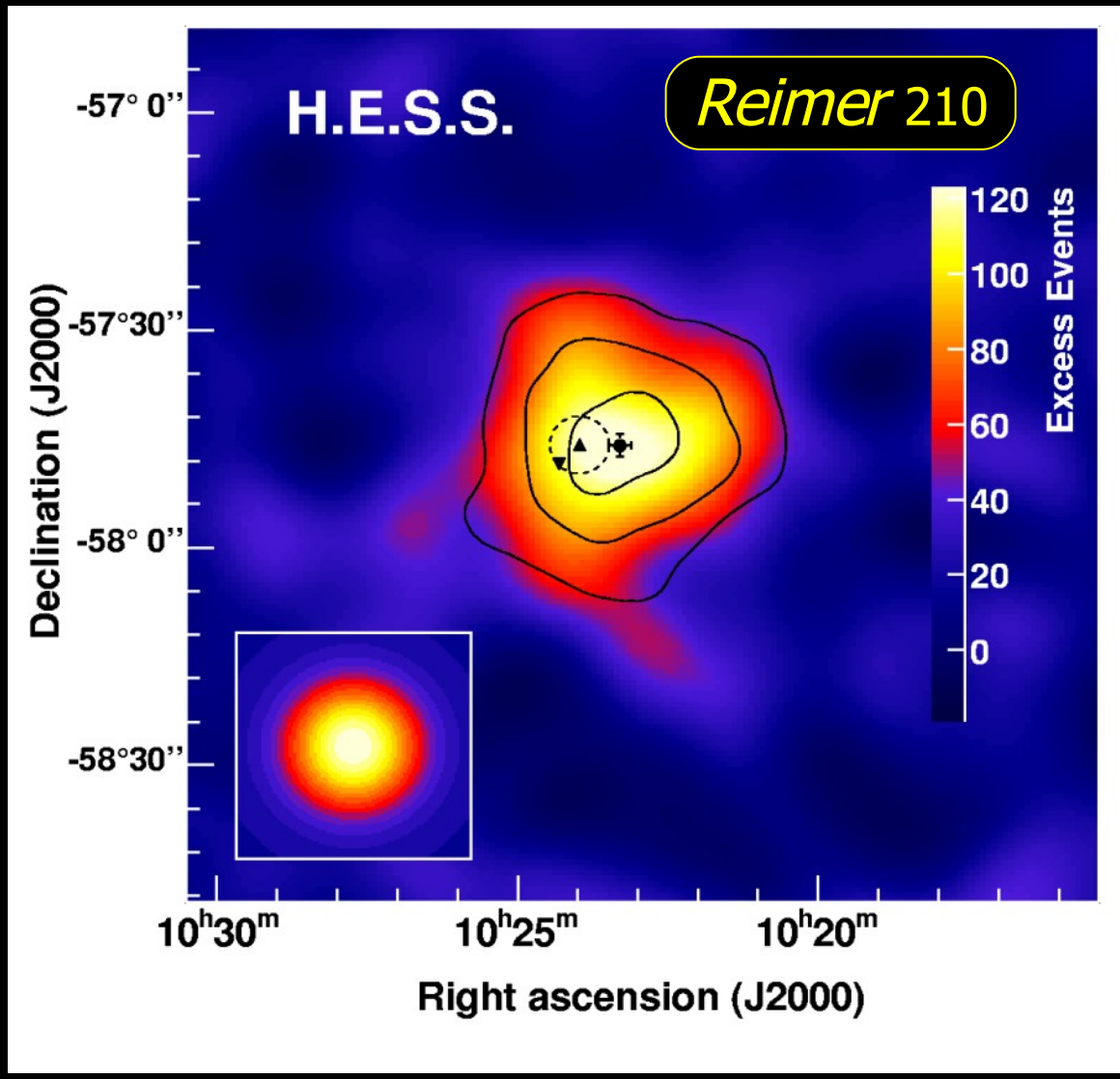
Westerlund 2



HESS J1023-575

- Extended gamma-ray emission covering (but offset from) Westerlund 2
- Due to collective effects of stellar winds in the cluster?
- A new source class?
- See also model of

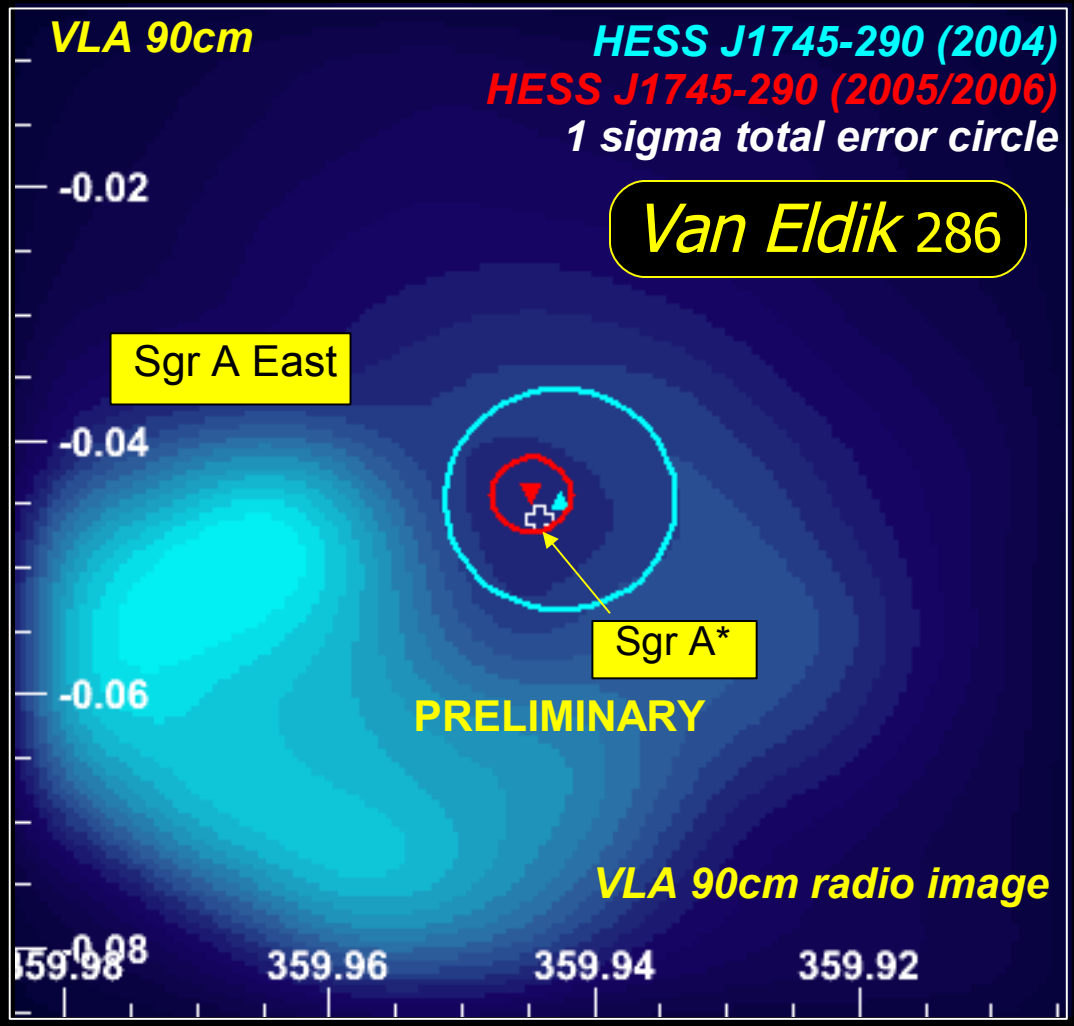
Anchordoqui 407



The Galactic Centre

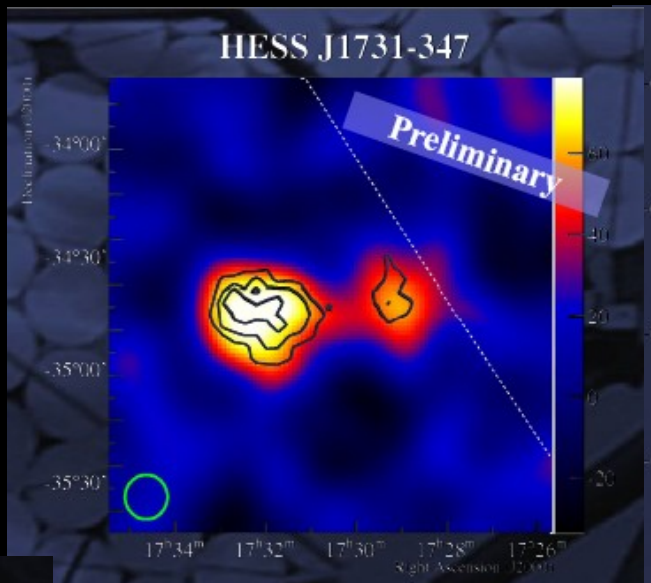
- Very high precision (6" stat, 6" sys) measurement of GC TeV source location by HESS
  - Sgr A East excluded as the source
- Sgr A*?
  - No increase during X-ray flare
  - No variability or QPO found…

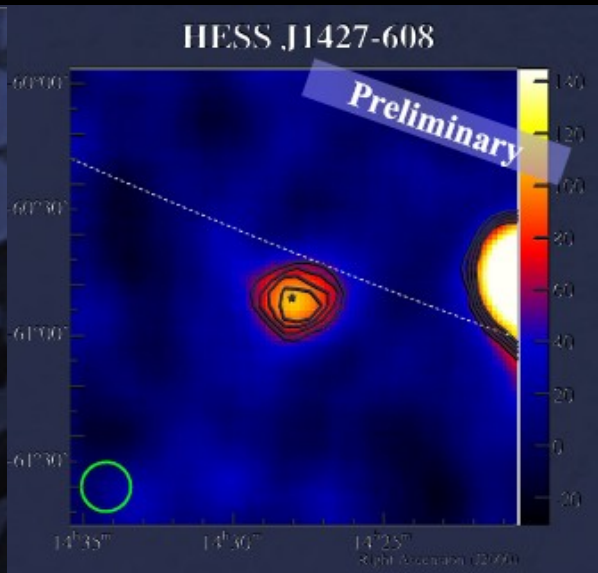
Hinton 463, *Vivier* 1023

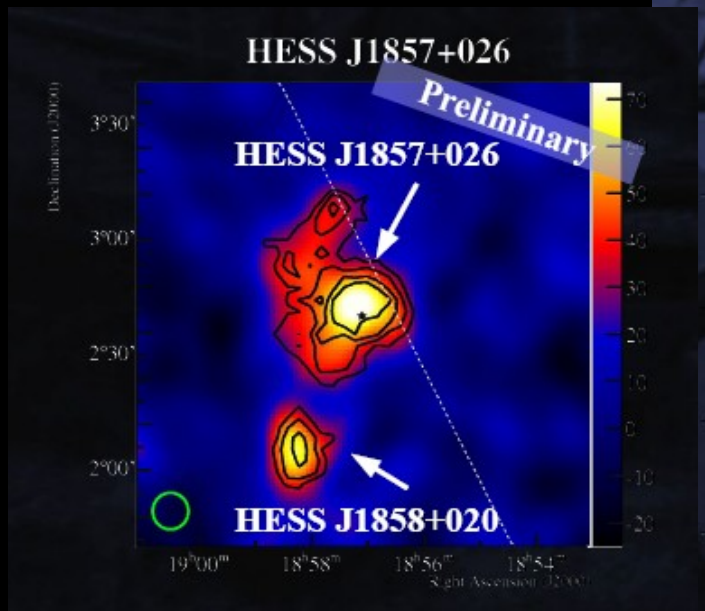


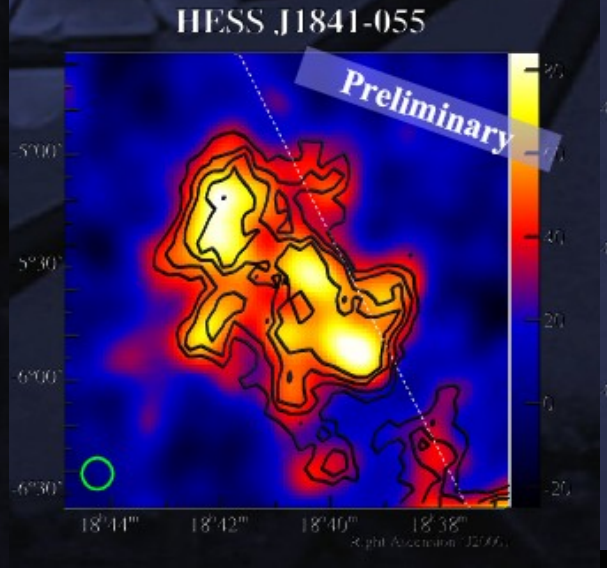
New HESS Sources Without Counterpart

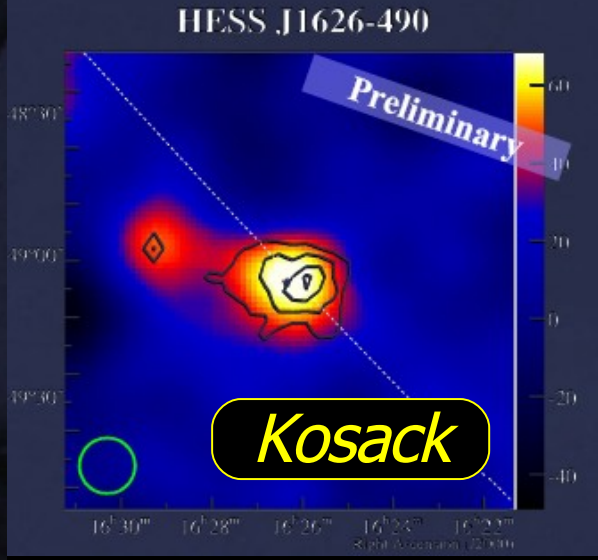
- 6 new TeV gamma-ray sources
  - none with compelling conterpart
- Relegated to a poster!





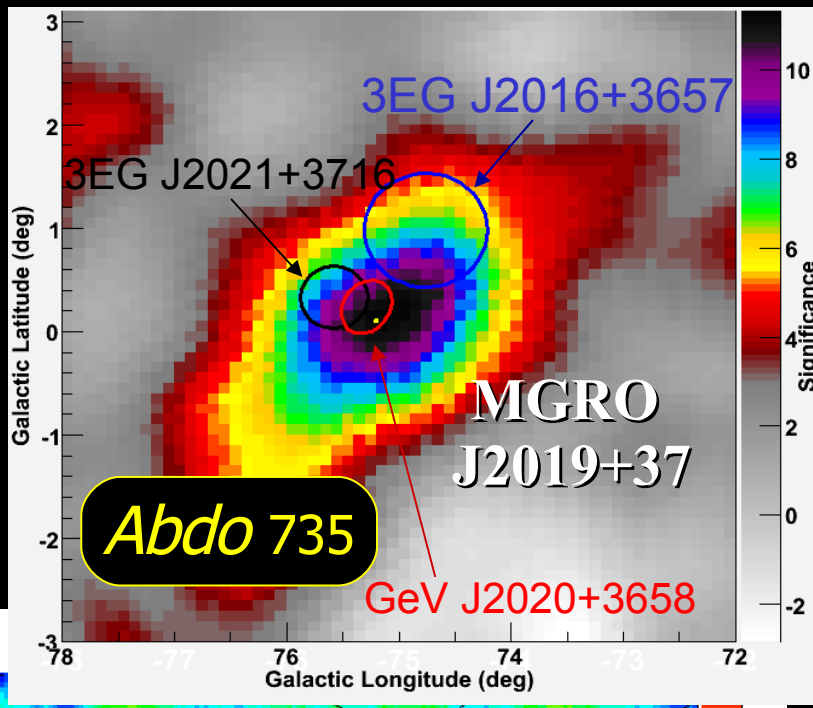


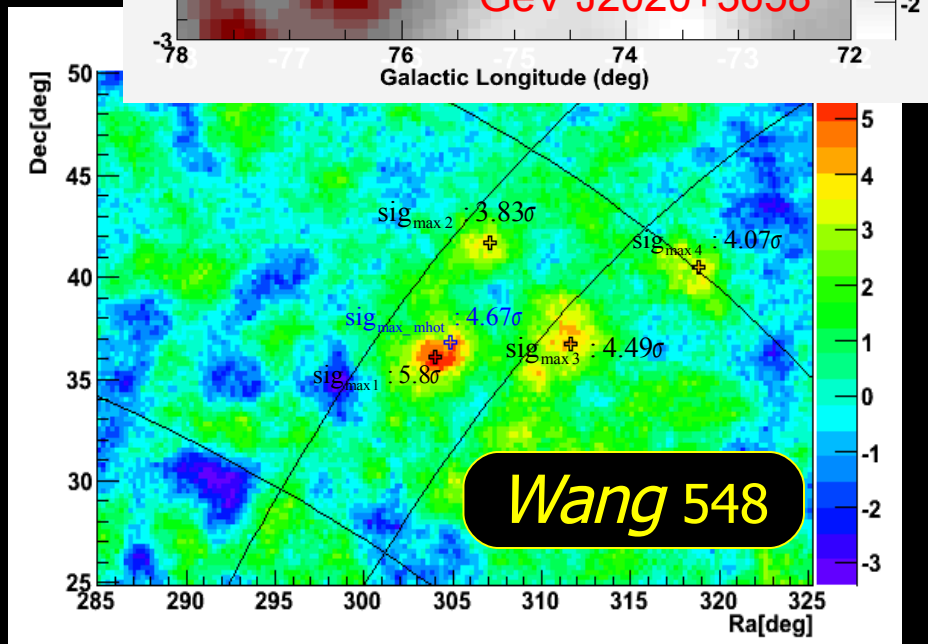




MGRO J2019+37

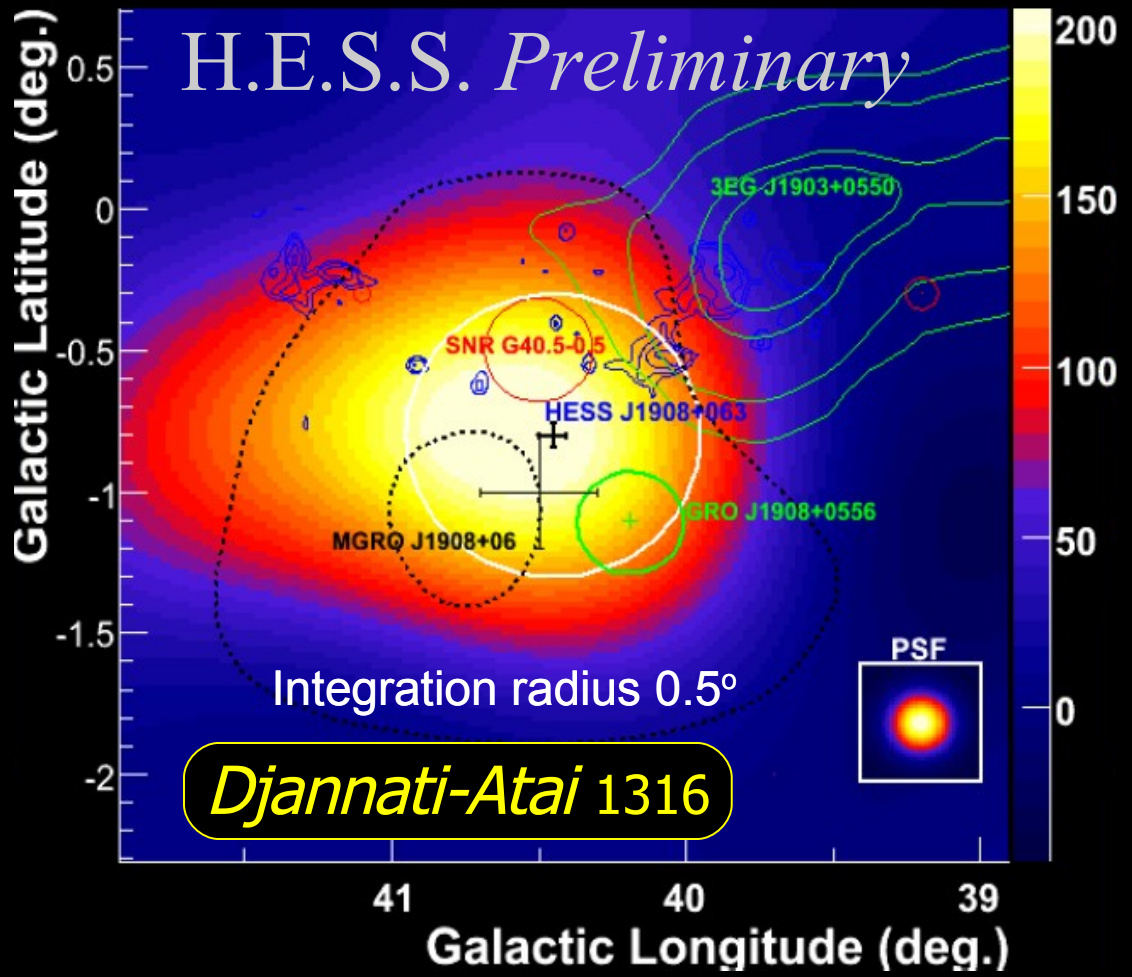
- **MILAGRO**
  - Bright extended source coincident with GeV source
  - 10.4 σ → 9.3 σ post-trials
- **Tibet ASγ**
  - 5.8 σ excess close to MILAGRO position
- **Point-source limits from MAGIC + VERITAS**
  - No contradiction to MILAGRO flux for hard spec. extended sources



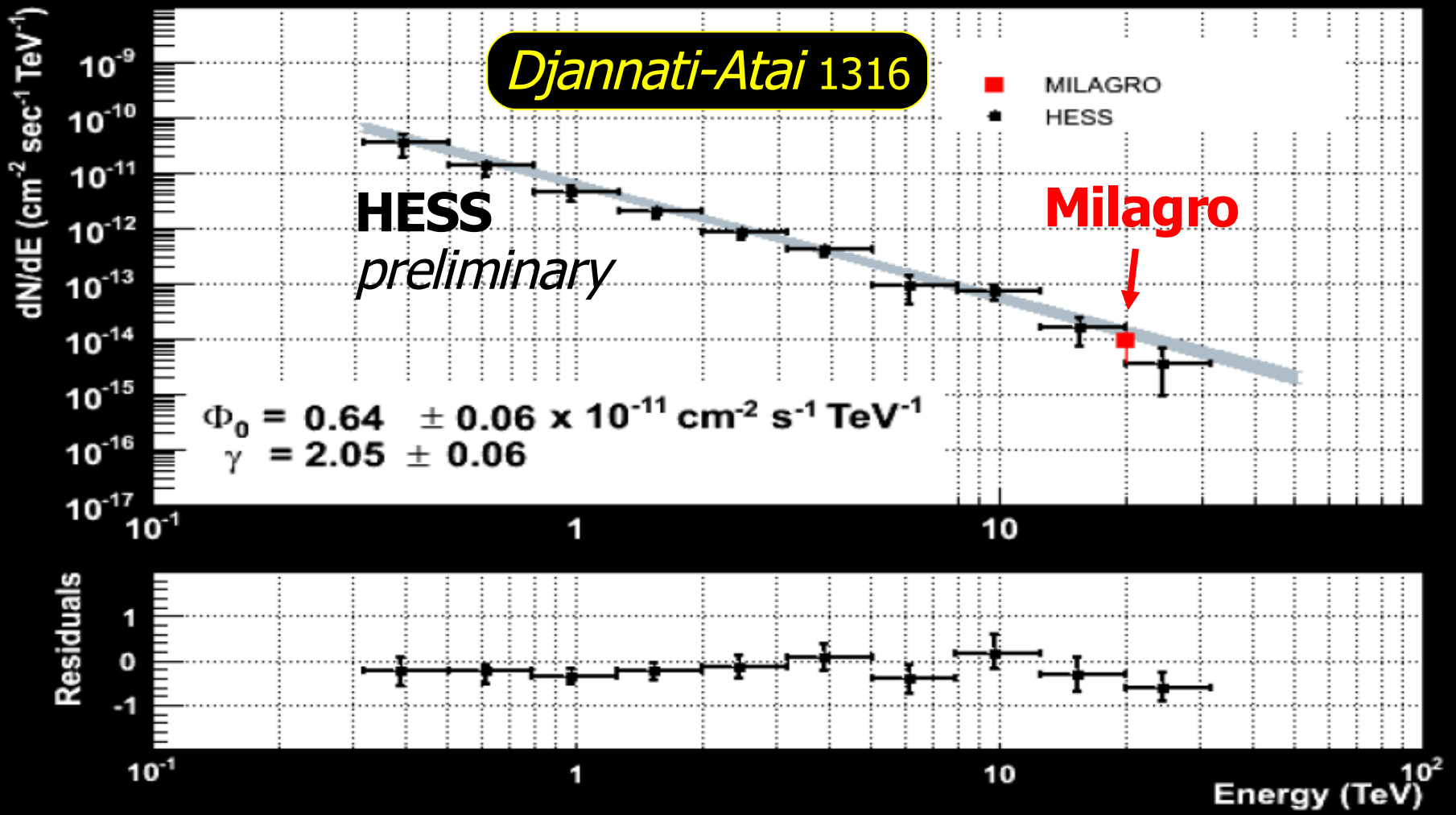


MGRO J1908+06

- Confirmation of Milagro source by HESS
  - First confirmed TeV source not detected by an IACT
- 9.4 σ
- 30% Crab flux > 1 TeV
- $E^{-2.05}$ spectrum
- $\sigma_{src} = 0.21°$



MGRO J1908+06

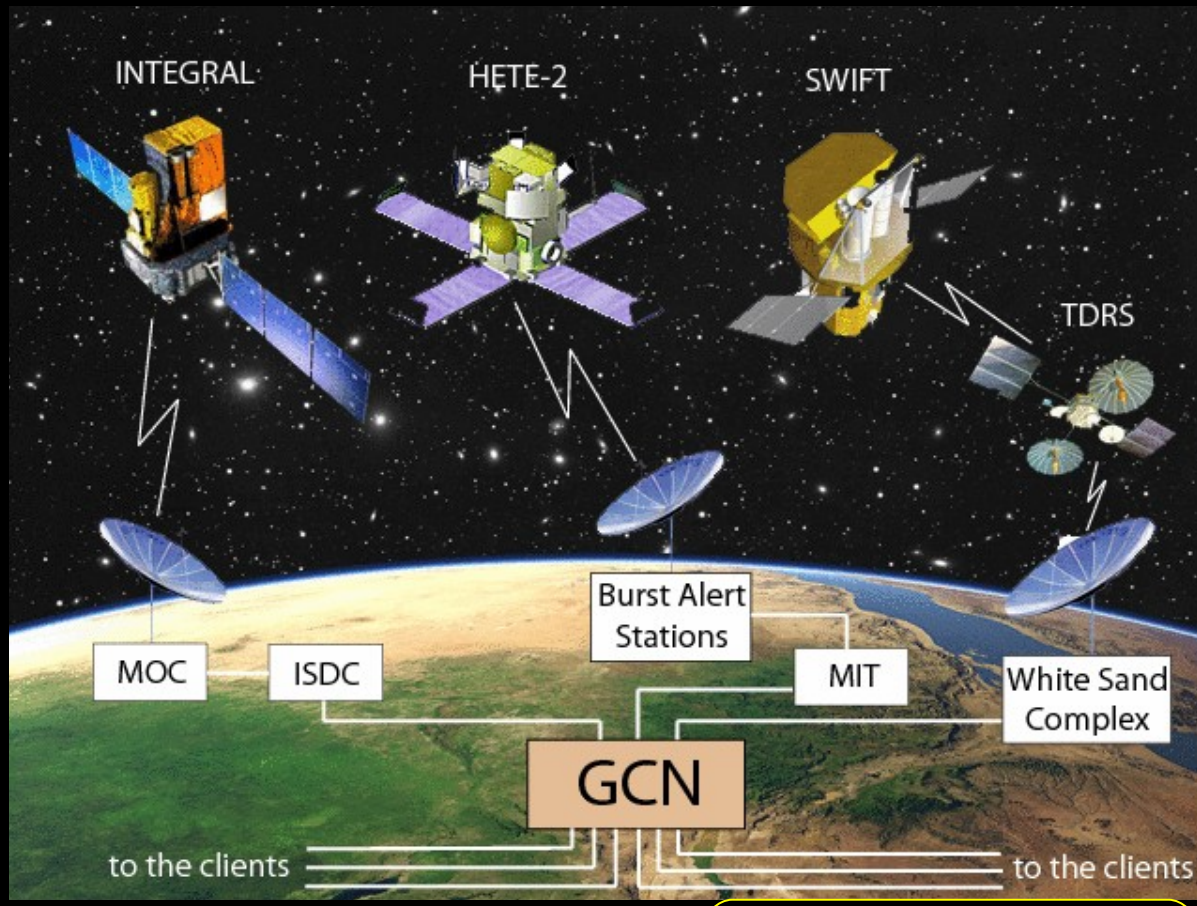


- Consistent with MILAGRO flux

OG 2.4:
Gamma-Ray Bursts

Burst Alerts

- **Frequent – mostly SWIFT burst alerts provided via GCN**
- **All major IACTs slew rapidly on receiving alerts**



Garczarczyk 566

Experimental Work

- Several challenges for VHE GRB observations
  - Redshift reach limited by EBL absorption to << 1
    - Roughly one third of GRBs
    - Relatively small fraction have measured redshift – without which limits are not meaningful
  - IACTS
    - Limited duty cycle, small FoV, response time
  - Non-Imaging
    - Sensitivity (angular resolution, eff. area, threshold)
- Many instruments routinely follow GRB triggers
  - Whipple, VERITAS, MAGIC, HESS, STACEE,…
  - Wide field of view instruments such as Milagro get more bursts with zero delay – but worse sensitivity
  - Several years of follow-up observations…

Experimental Work: Upper Limits

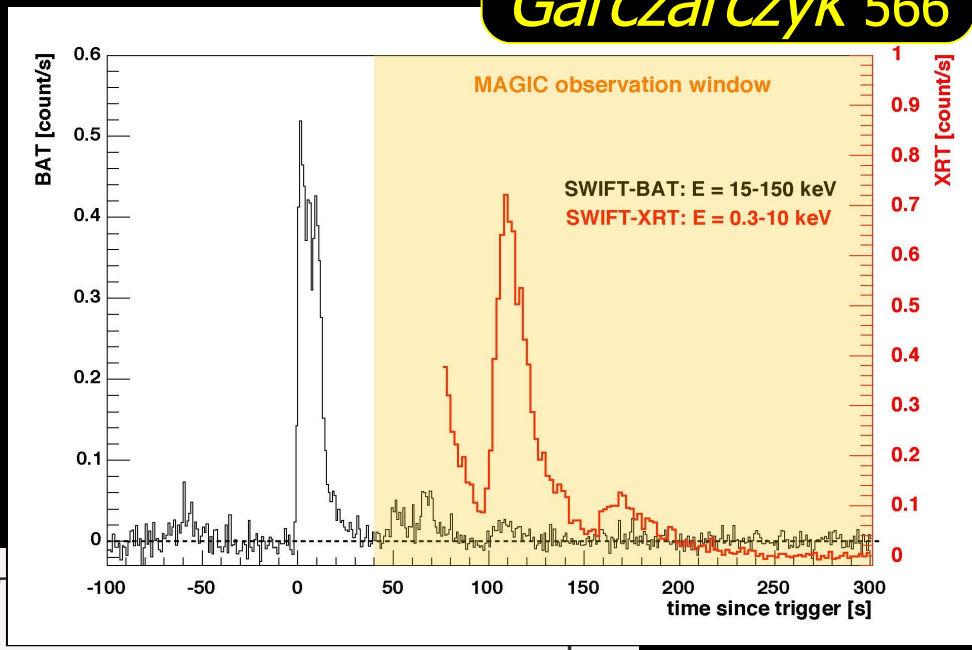
- **MAGIC**
  - **42 second mean repositioning time** — *Garczarczyk* 566
  - **23 follow-ups of GRBs (8.3% duty cycle)**
  - **GRB050713a, 40 second response, but no z known**
- **VERITAS + Whipple** — *Horan* 406
  - **Ongoing program. 3 GRBs obs. with VERITAS so far**
- **HESS**
  - **17 follow-ups** — *Tam* 466
  - **1 prompt GRB obs:** GRB060602b ! — *Tam* 464
- **STACEE** — *Jarvis* 409
- **MILAGRO**
  - **VHE band and 1-100 GeV** — *Vasileiou* 674, *Aune* 689
- **ARGO YBJ** — *Girolamo* 1034
- **Auger + LAGO + IceCube**

Bertou 1042,175 — *Kappes* 1132

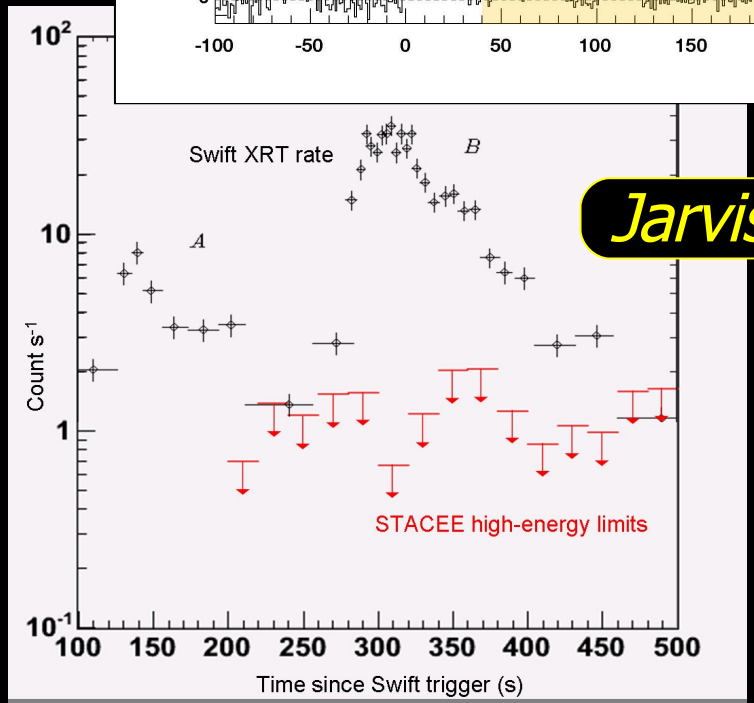
GRB Follow-up Limits

- Observations have taken place during periods of strong X-ray activity, e.g.
  - MAGIC
    - GRB 050713a
  - STACEE
    - GRB 050607
- But not yet for bursts with known redshift…

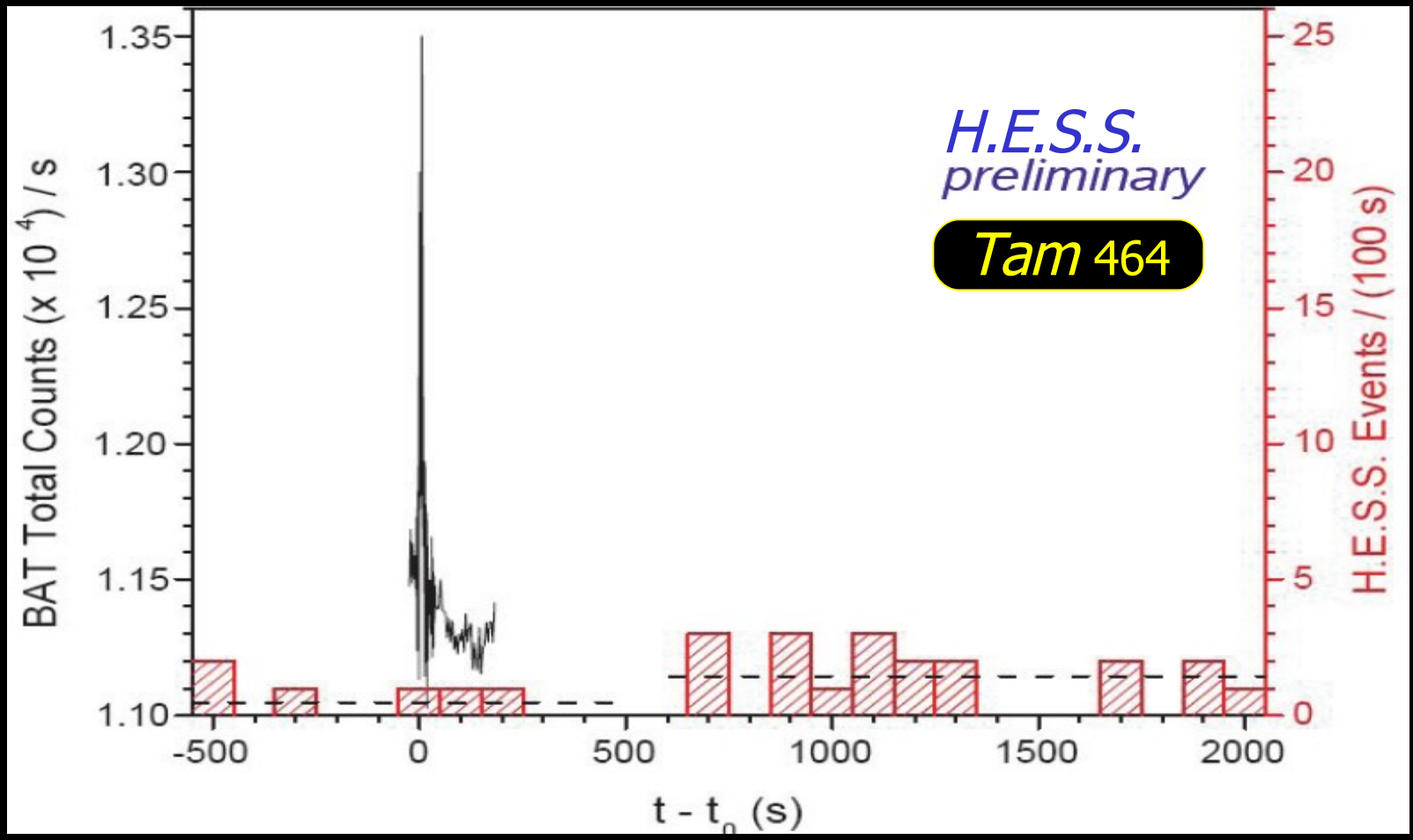
Garczarczyk 566



Jarvis 409

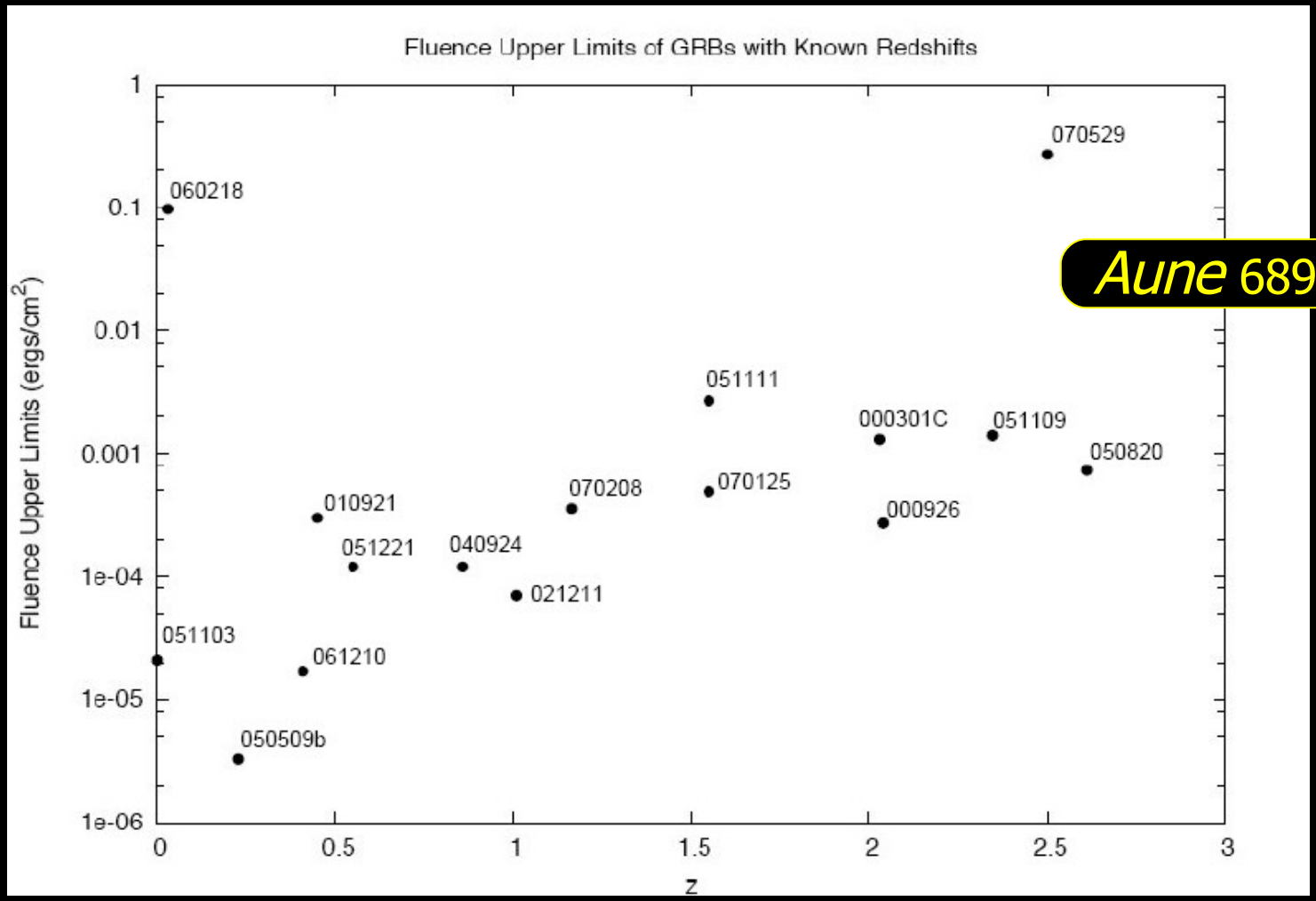


Simultaneous GRB Observation



- GRB 060602b – simultaneous observation with HESS by chance (2.5°)!
- But no redshift found – and may have been a galactic X-ray burster

Milagro 'Scaler' Limits



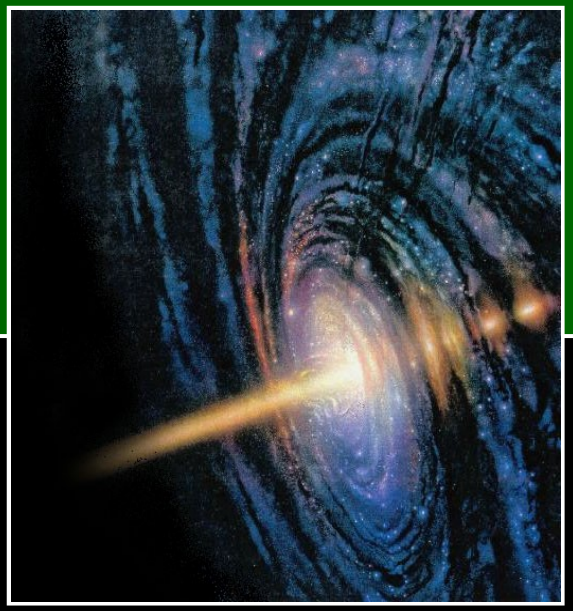
Aune 689

- **Looks as if bright 1-100 GeV emission is not common in GRBs**

Other GRB Contributions

- **Theoretical Work**
  - Compton dragged supercritical piles — *Mastichiadis* 1134
  - Synchrotron emission modelling — *Guiriec* 1079
  - Radiation from Internal Shocks in Magnetized Flows — *Sapountzis* 1141
  - Opacity build-up — *Cohen-Tanugi* 1168
- **Suzaku WAM Observations** — *Yamaoka* 1010
- **Expectations for GLAST GMB/LAT** — *Piron* 1020
  - GMB 220 bursts/year
  - LAT 40 alerts/year – but only 1/year with sufficient accuracy for IACTs

OG 2.3:
Extragalactic Sources

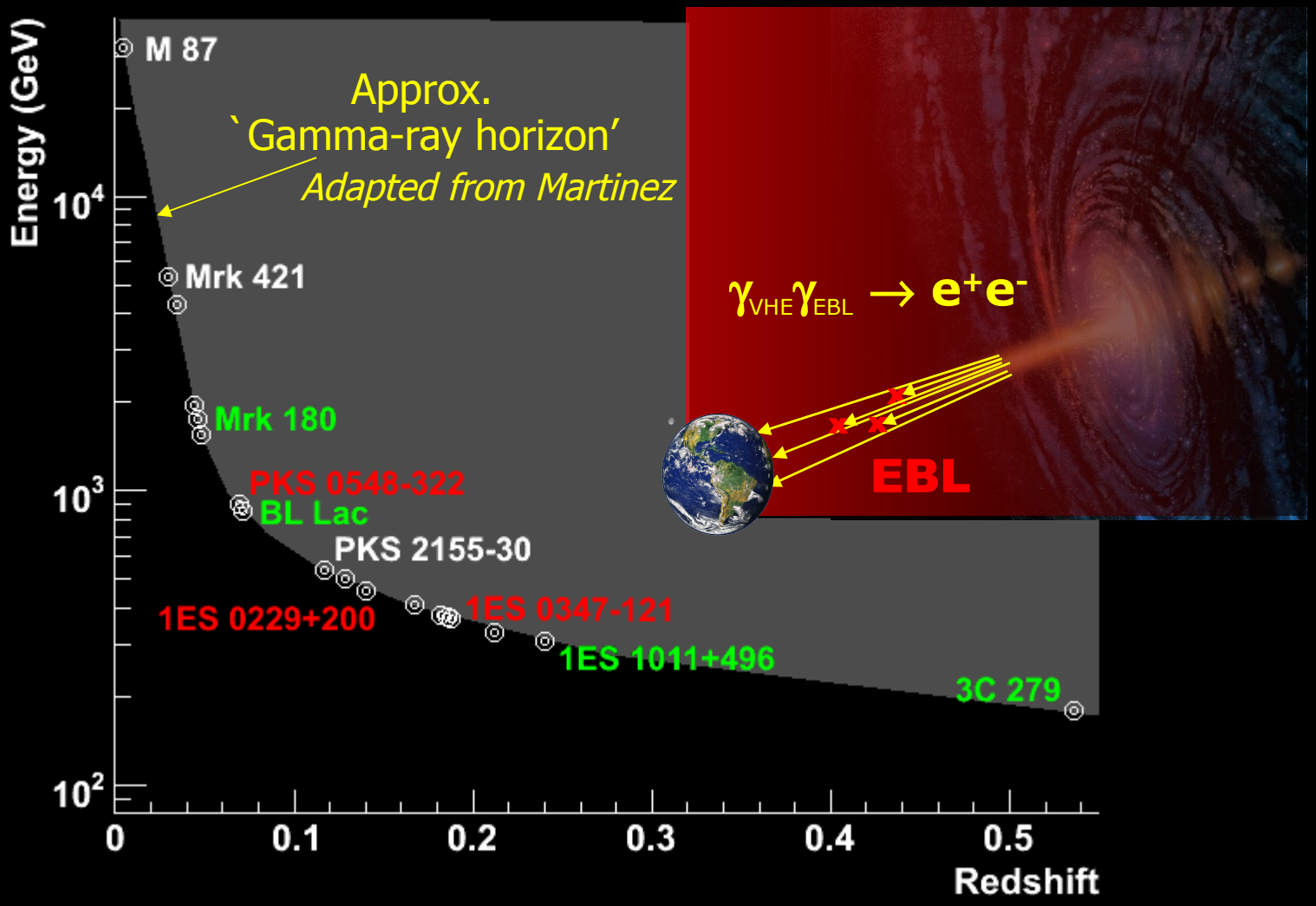


Extragalactic VHE Gamma-Ray Sources

	Name	Discovered	Year	z	Contributions
	M 87	HEGRA	2003	0.004	VERITAS-Colin, HESS-Beilicke, MAGIC-
	Mrk 421	Whipple	1992	0.031	MILAGRO-Smith, VERITAS-Fegan, +
	Mrk 501	Whipple	1996	0.034	TACTIC-Godambe, MAGIC-Paneque, +
	1ES 2344+514	Whipple	1998	0.044	MAGIC-Wagner
→	Mrk 180	MAGIC	2006	0.046	MAGIC-Mazin
	1ES 1959+650	TA	2002	0.047	MAGIC-Hayashida
→	BL Lac	MAGIC	2006	0.069	MAGIC-Hayashida
→	PKS 0548-322	HESS	2006	0.069	HESS-Superina
	PKS 2005-489	HESS	2005	0.071	HESS-Costamante
	PKS 2155-304	Durham	1999	0.116	HESS-Punch, CANGAROO-Sakamoto, +
	H 1426+428	Whipple	2002	0.129	VERITAS-Krawczynski
→	1ES 0229+200	HESS	2007	0.140	HESS-Raue
	H 2356-309	HESS	2005	0.165	HESS-Costamante
	1ES 1218+304	MAGIC	2005	0.182	MAGIC-Hayashida
	1ES 1101-232	HESS	2005	0.186	HESS-Puelhofer
→	1ES 0347-121	HESS	2007	0.188	HESS-Raue
→	1ES 1011+496	MAGIC	2007	0.212	MAGIC-Mazin
→	PG 1553+113	HESS/MAGIC	2005	?	MAGIC-Wagner, HESS-Benbow
→	3C 279	MAGIC	2007	0.536	MAGIC-Teshima

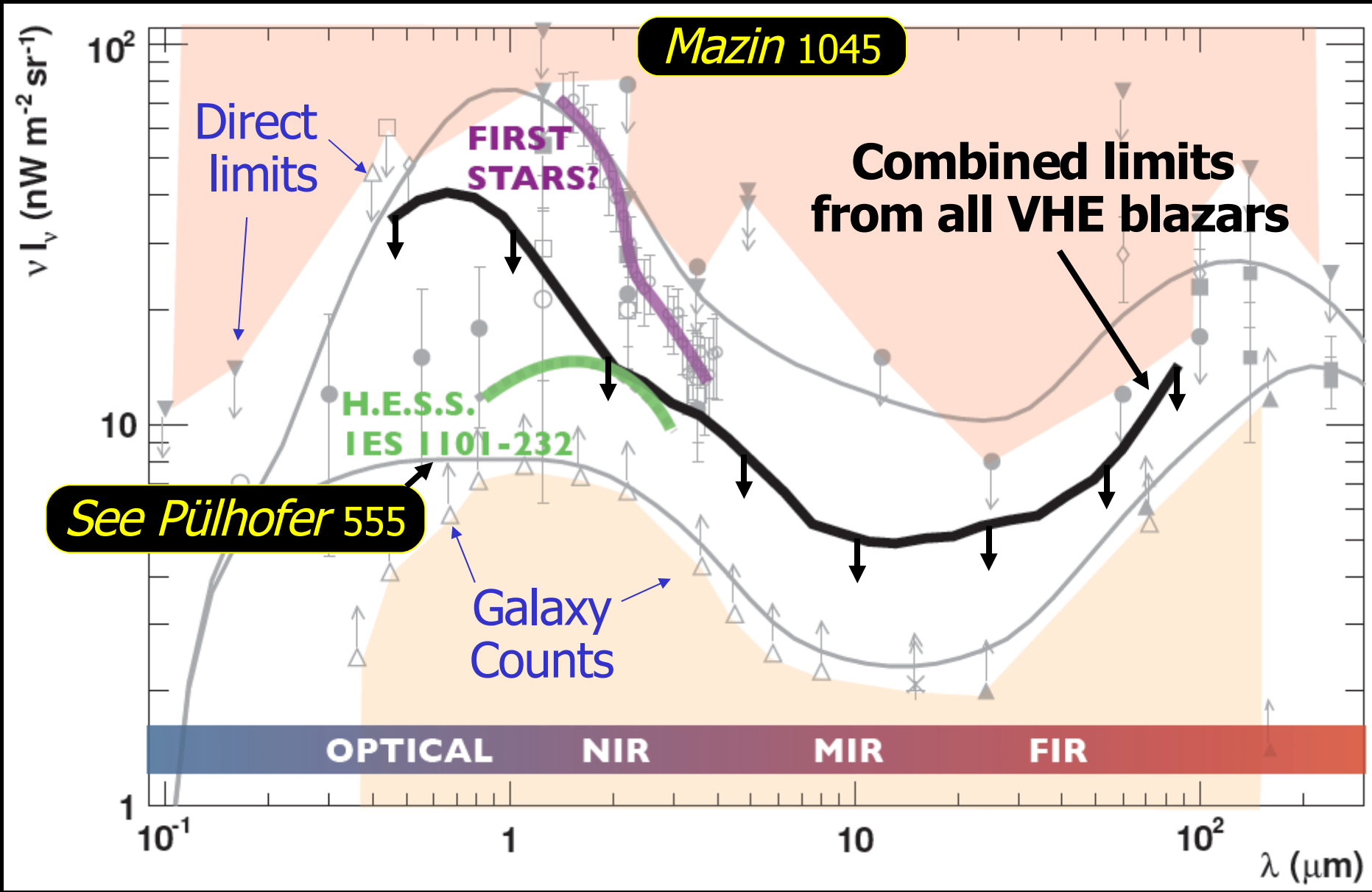
8 new AGN

Extragalactic Background Absorption

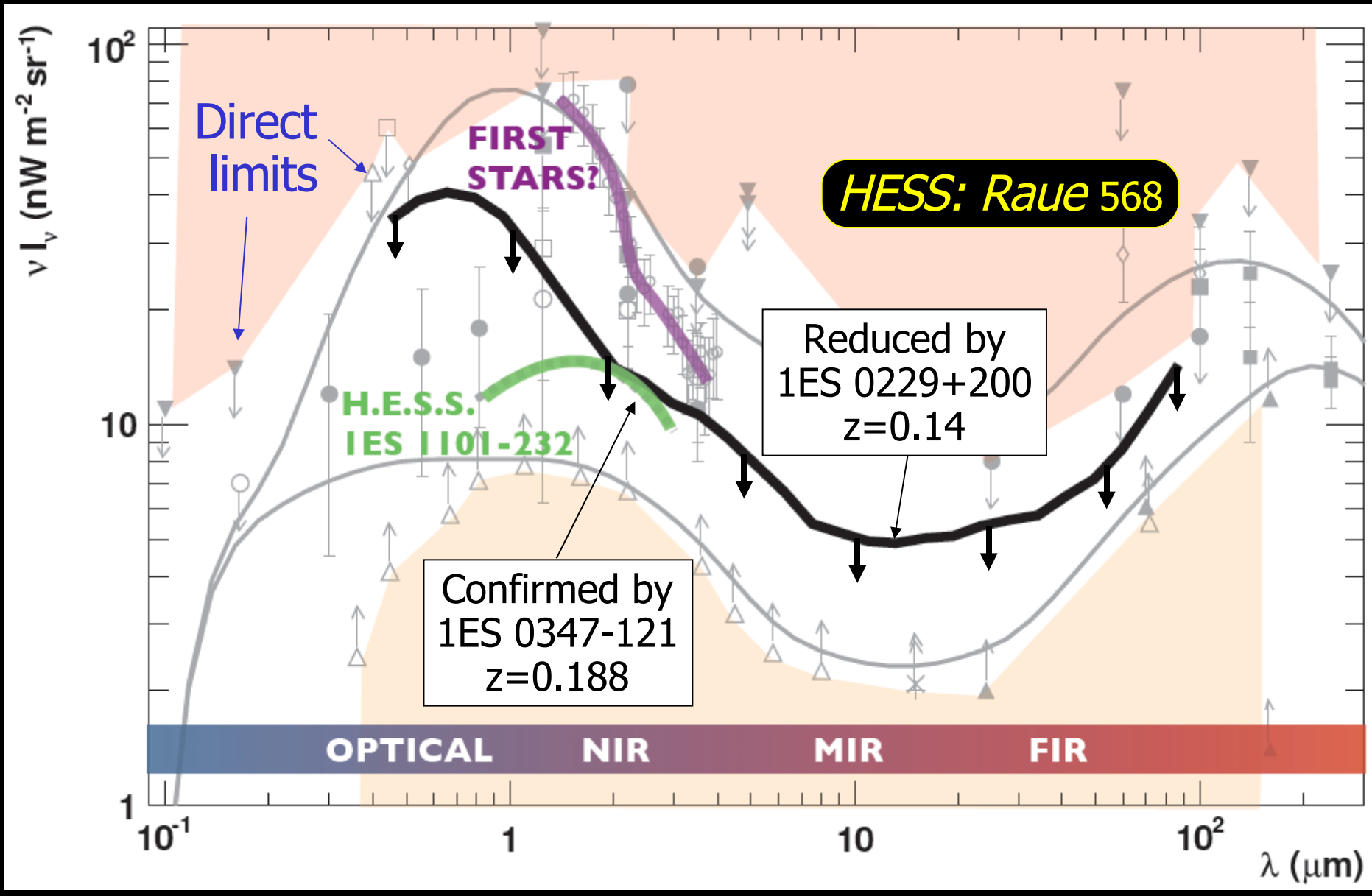


- **100 GeV threshold implies z < 1 (but need very luminous sources!)**

EBL Limits from VHE Spectra



EBL Limits from VHE Spectra



Theoretical work

- **Blazars**
  - time variability
  - Effects of expansion
- **EBL**
  - A unique absorption signature?
  - Combined limits
- **Galaxy Clusters**
  - Giant AGN outbursts
- **Globular clusters**

Milovanovic 304

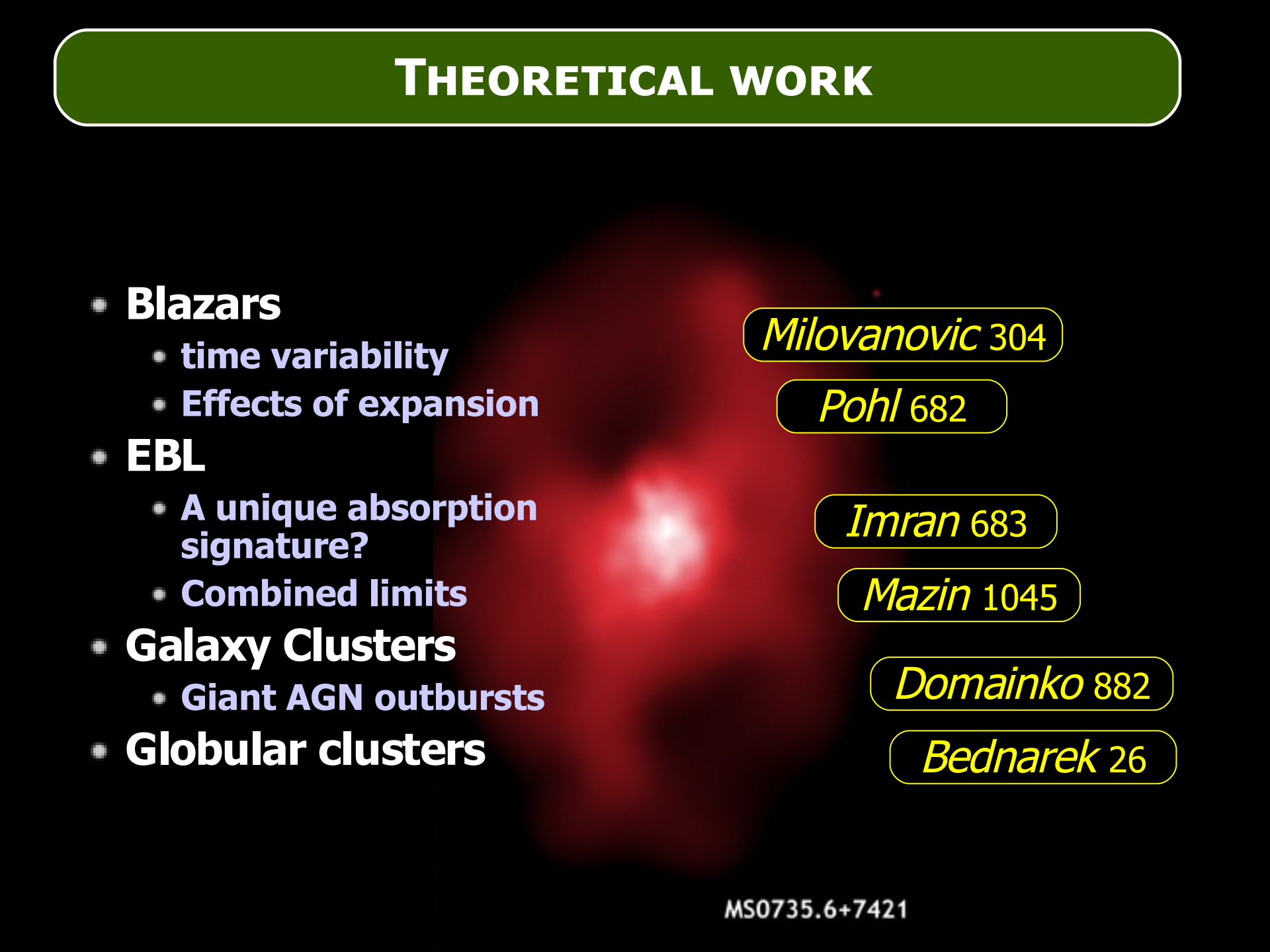
Pohl 682

Imran 683

Mazin 1045

Domainko 882

Bednarek 26

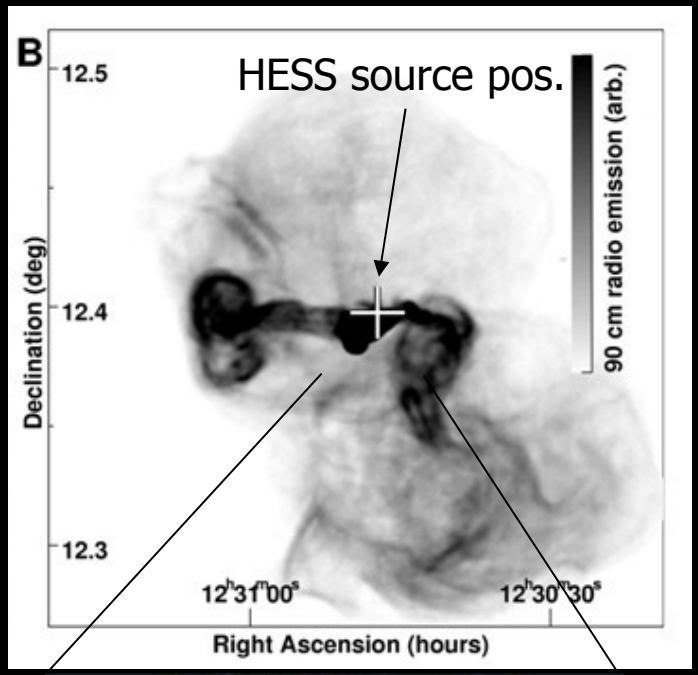


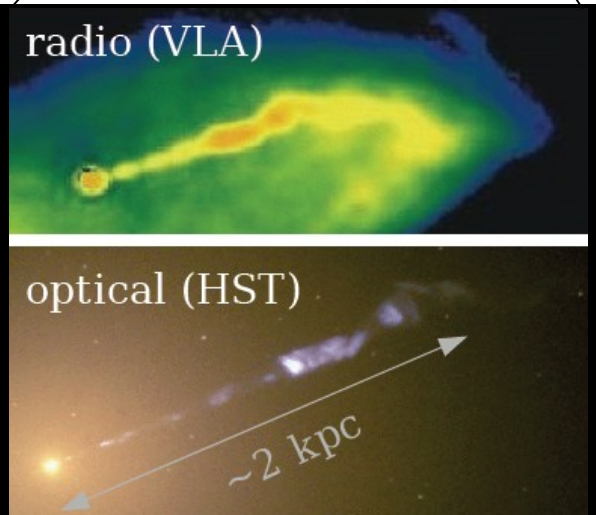
Experimental Results: M 87

- Famous nearby radio galaxy
  - 16 Mpc, Jet angle ~30°
- HESS 2 day variability
  - Emission region $< 5\ \delta\ R_s$
- VERITAS 5.1 σ
  - Observations in 2007
- Emission site?
  - Knot HST1?
  - Very close to SMBH?
- Mechanism?
  - Hard spectrum $\Gamma = 2.2$ is a challenge for 'standard' models

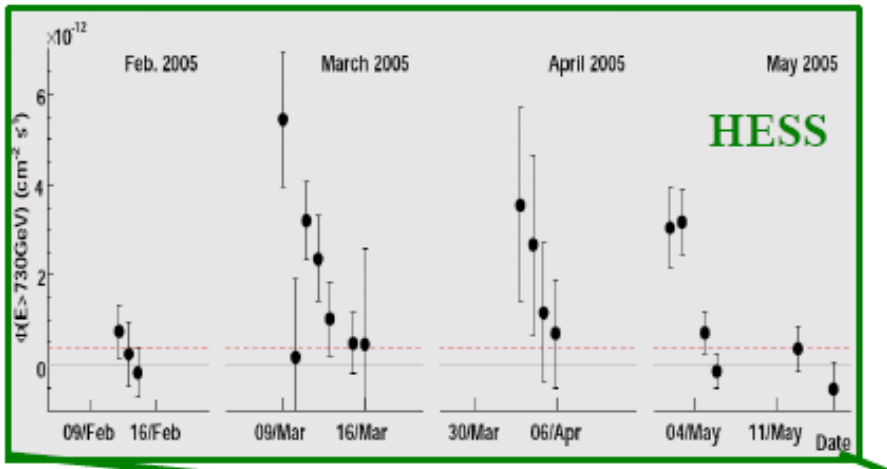
Beilicke 499

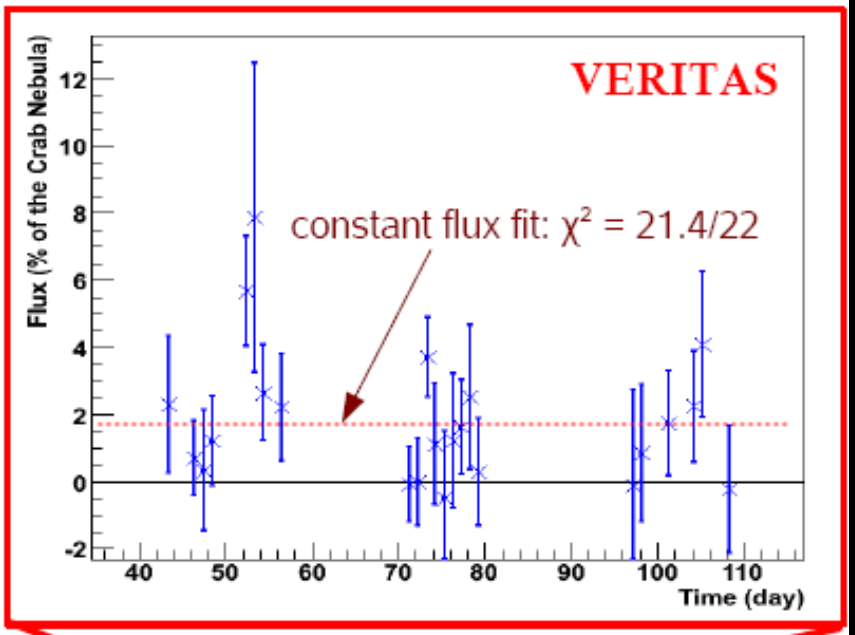
Colin 756

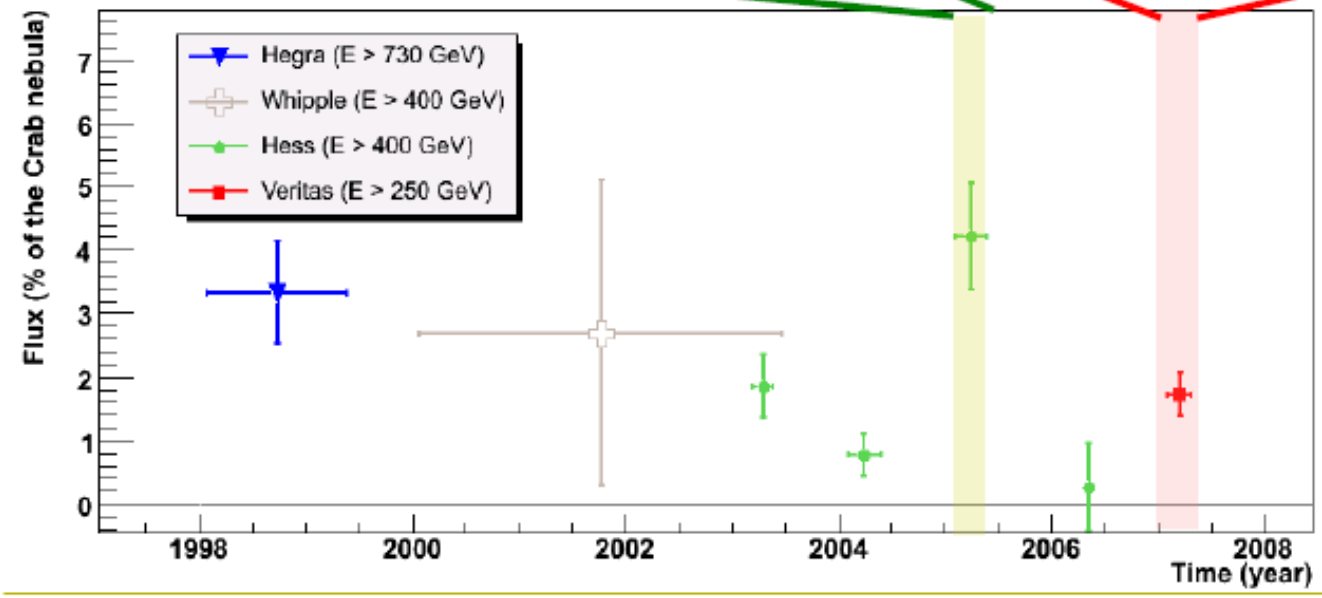




TeV Variability of M87





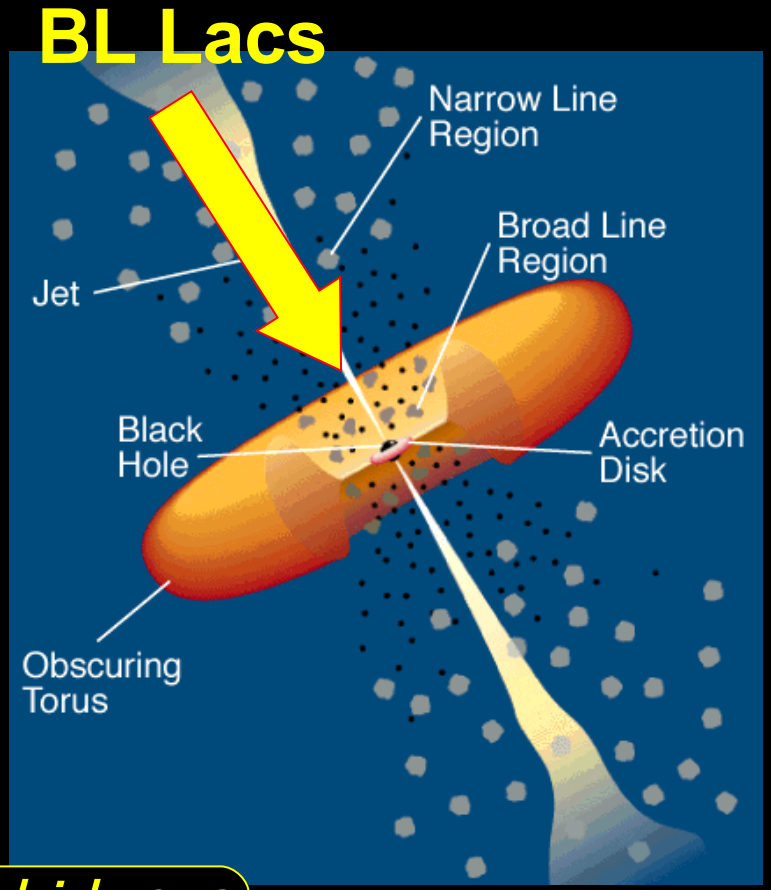


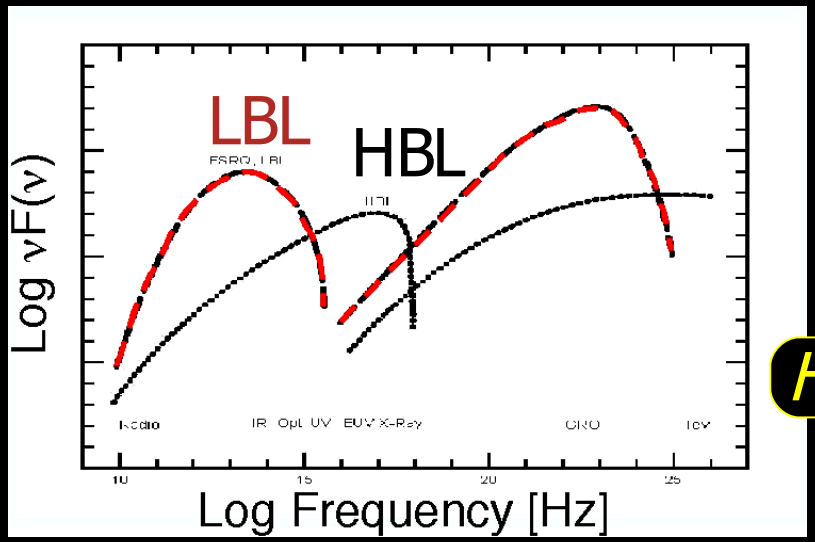
Colin 756

Prime candidate for coordinated VERITAS/HESS/ MAGIC + MWL observations in the future

BL Lacs

- Jets aligned very close to line of sight
  - Beaming allows us to see very distant objects with modest sensitivity
- Characteristic double peaked spectrum

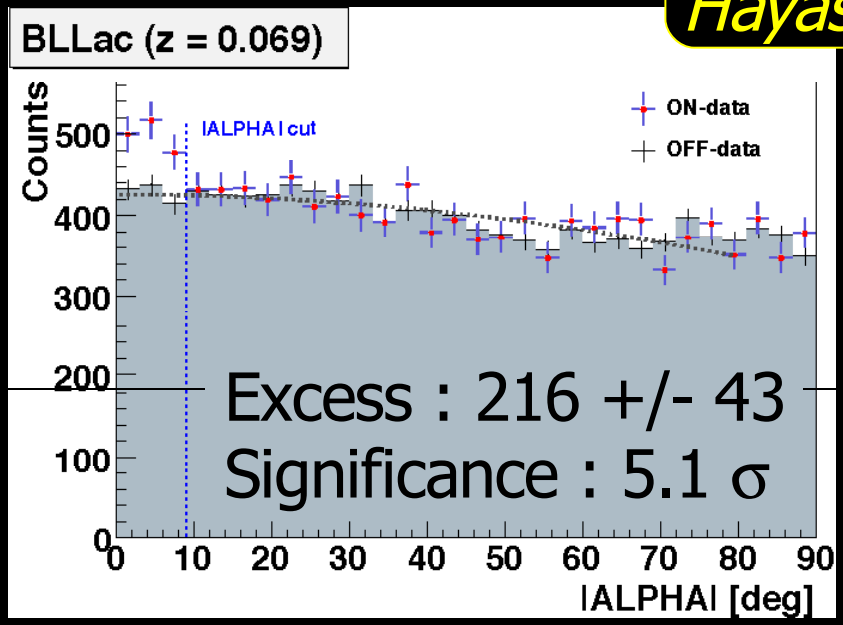


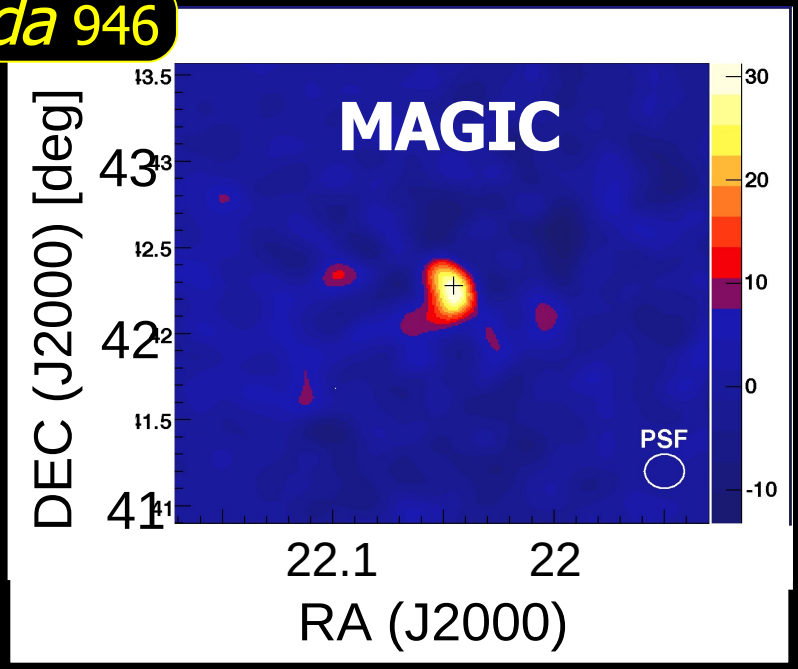


Hayashida 946

BL Lac

Hayashida 946

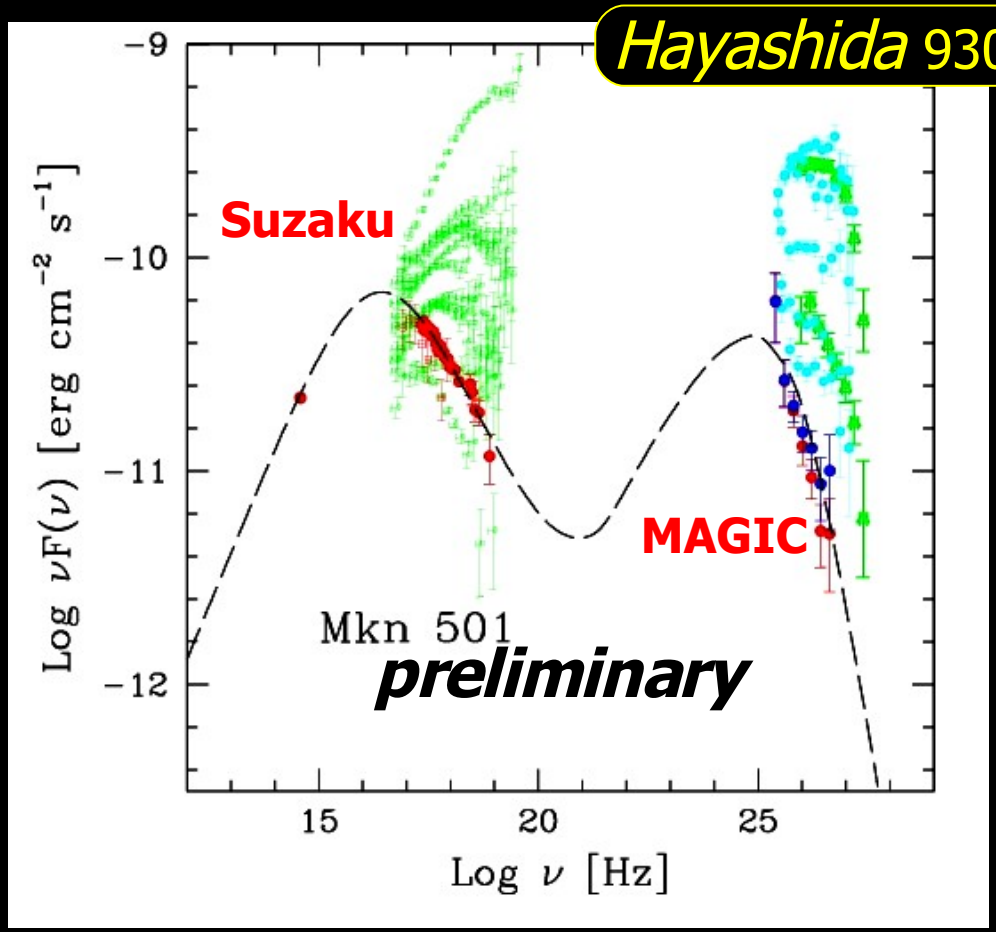




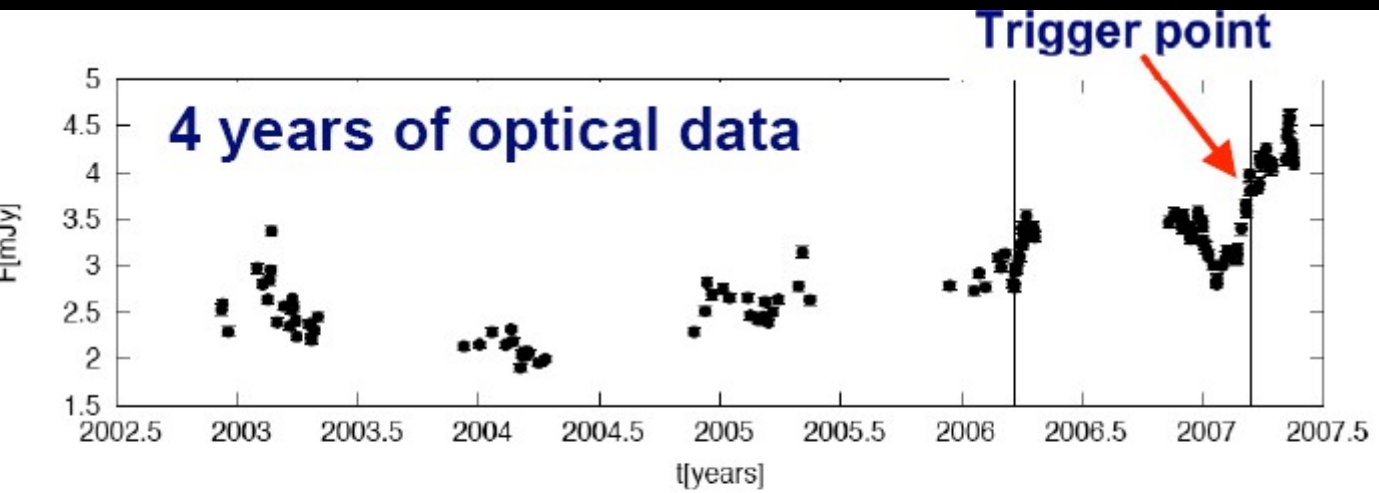
- **First Low energy peaked BL Lac observed at VHE energies**
  - **Steep (Γ = -3.6±0.5) , not due to absorption – intrinsic low energy peaked source**
  - **There will be many more if we reach lower sensitivity!**

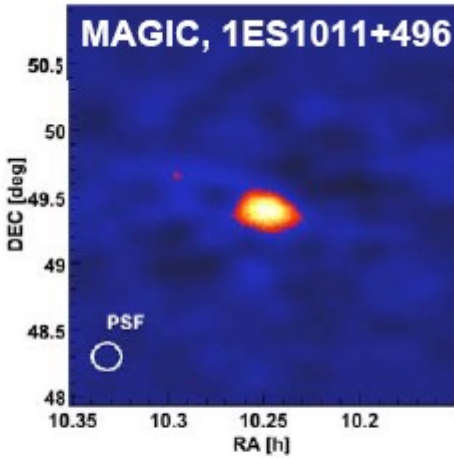
Multiwavelength Activity

- Several campaigns with optical, keV & TeV on were presented
- A wealth of detail for modelers
- Synchrotron self compton models still seem able to explain most HBL observations



Optical Triggers → New Blazars



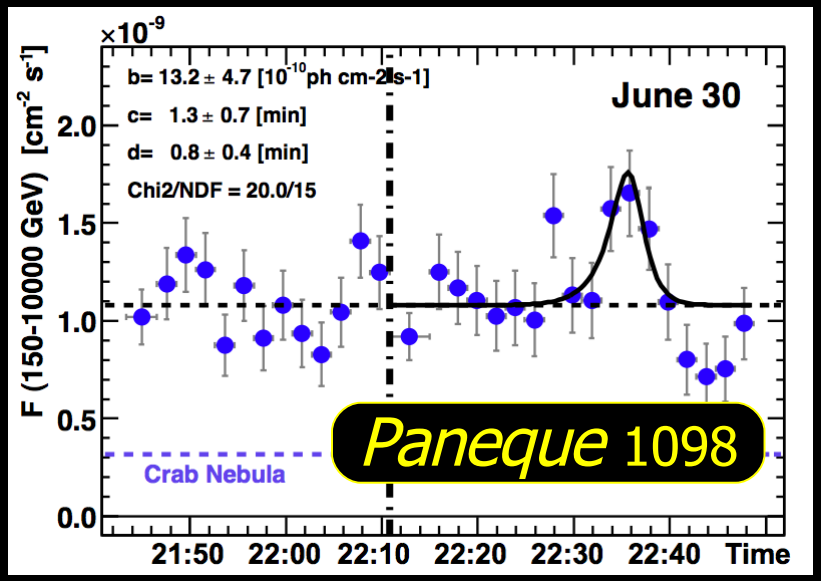


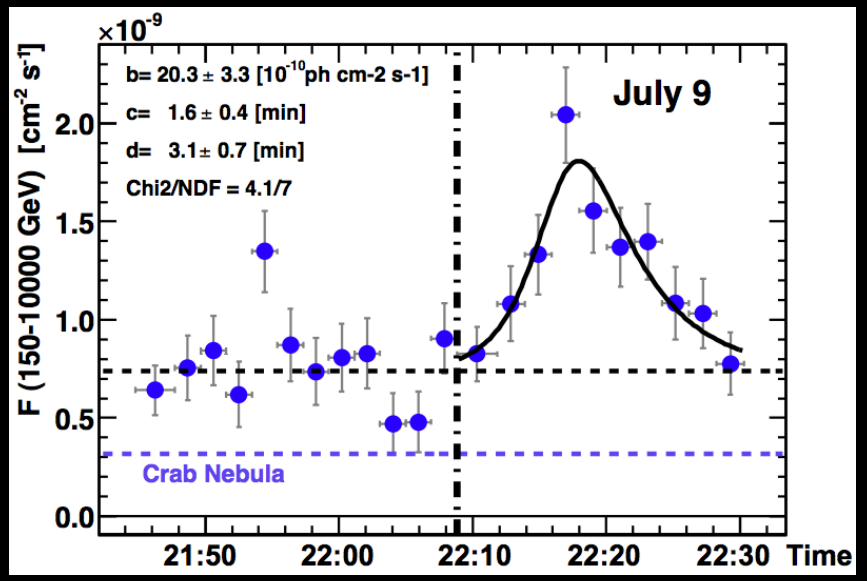
Optical trigger: MAGIC observations in March-May 2007, 18.7h of data, clear signal (6.2 σ): discovery ! ApJL submitted, arXiv:0706.4435

Mazin 936

- **Mrk 180 and 1ES1011+496 (z=0.212!) discovered at VHE energies by MAGIC following optical triggers**
- **Optical monitoring of AGN much easier than X-ray, if a connection exists (even on ~month timescales) then the efficiency of TeV blazar observations can be considerably improved**

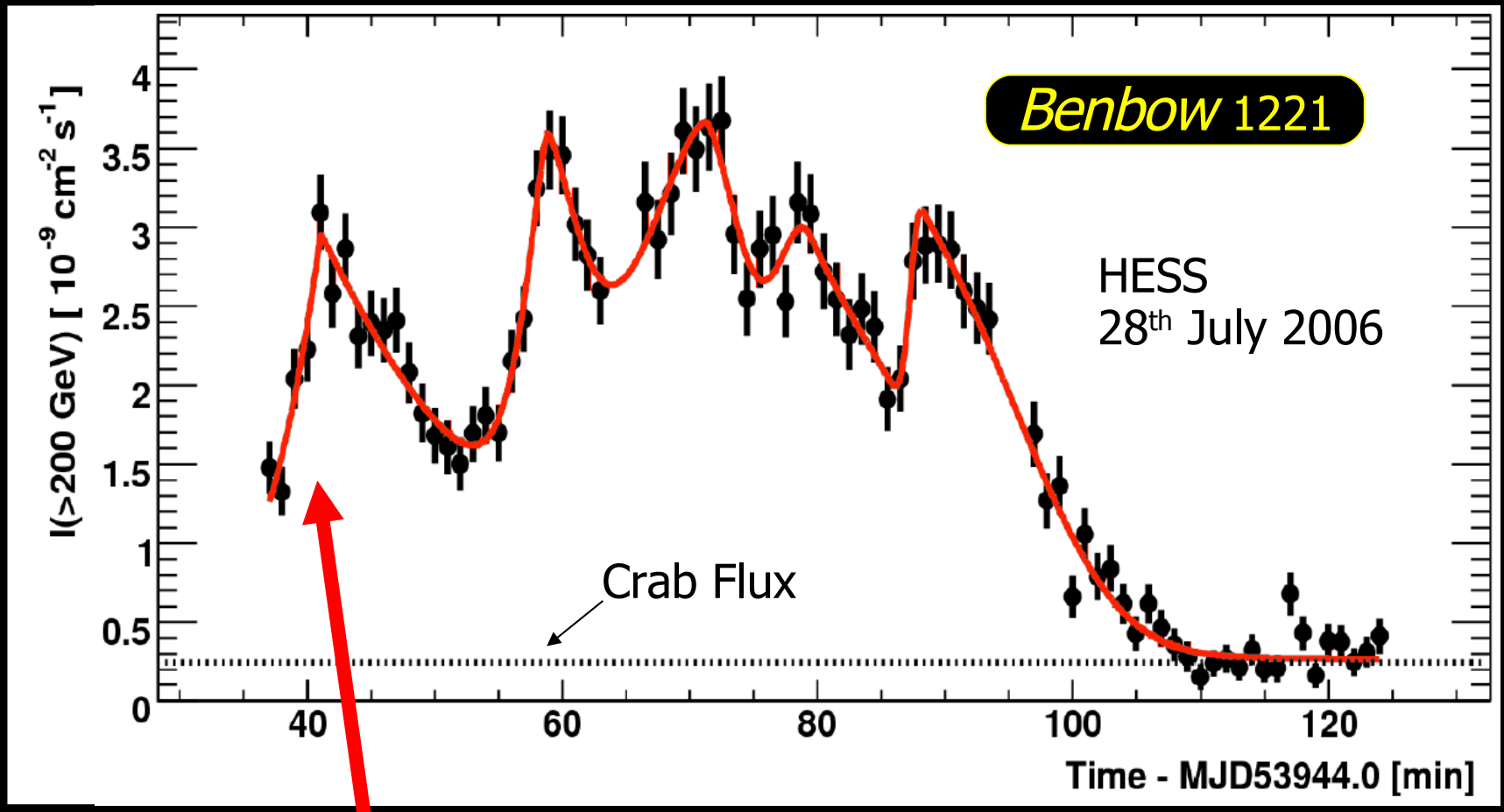
Mrk 501 Flares





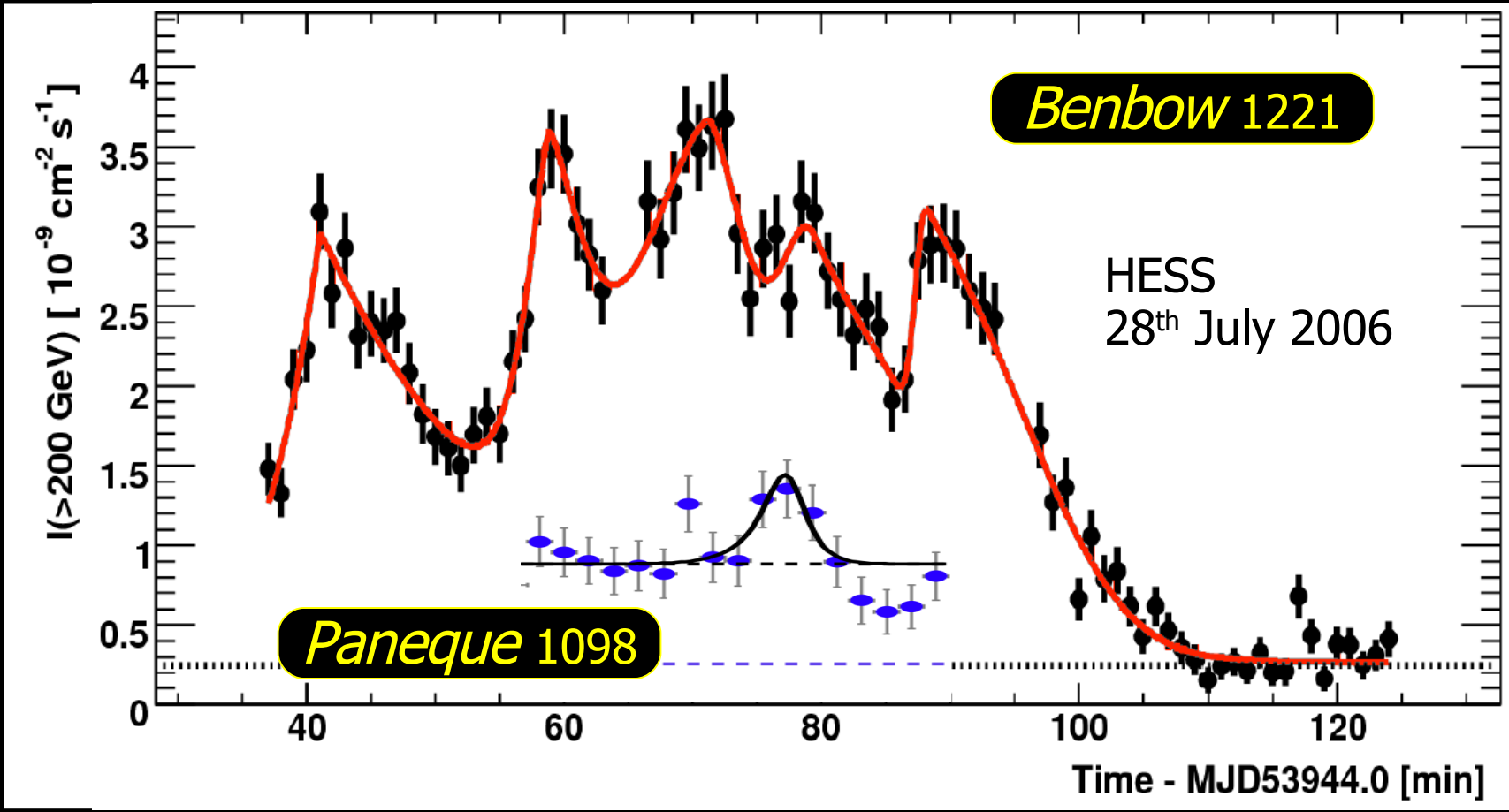
- June 30th flare has *~3 minute* variability (but is not so strong statistically), July 9th better measured but slower
- First big flare seen by a third generation Cherenkov instrument
- ***But…***

Huge Flare From PKS 2155-304



- **Best measured risetime: 173 ± 28 s**
- **Two orders of magnitude brighter then typical state**

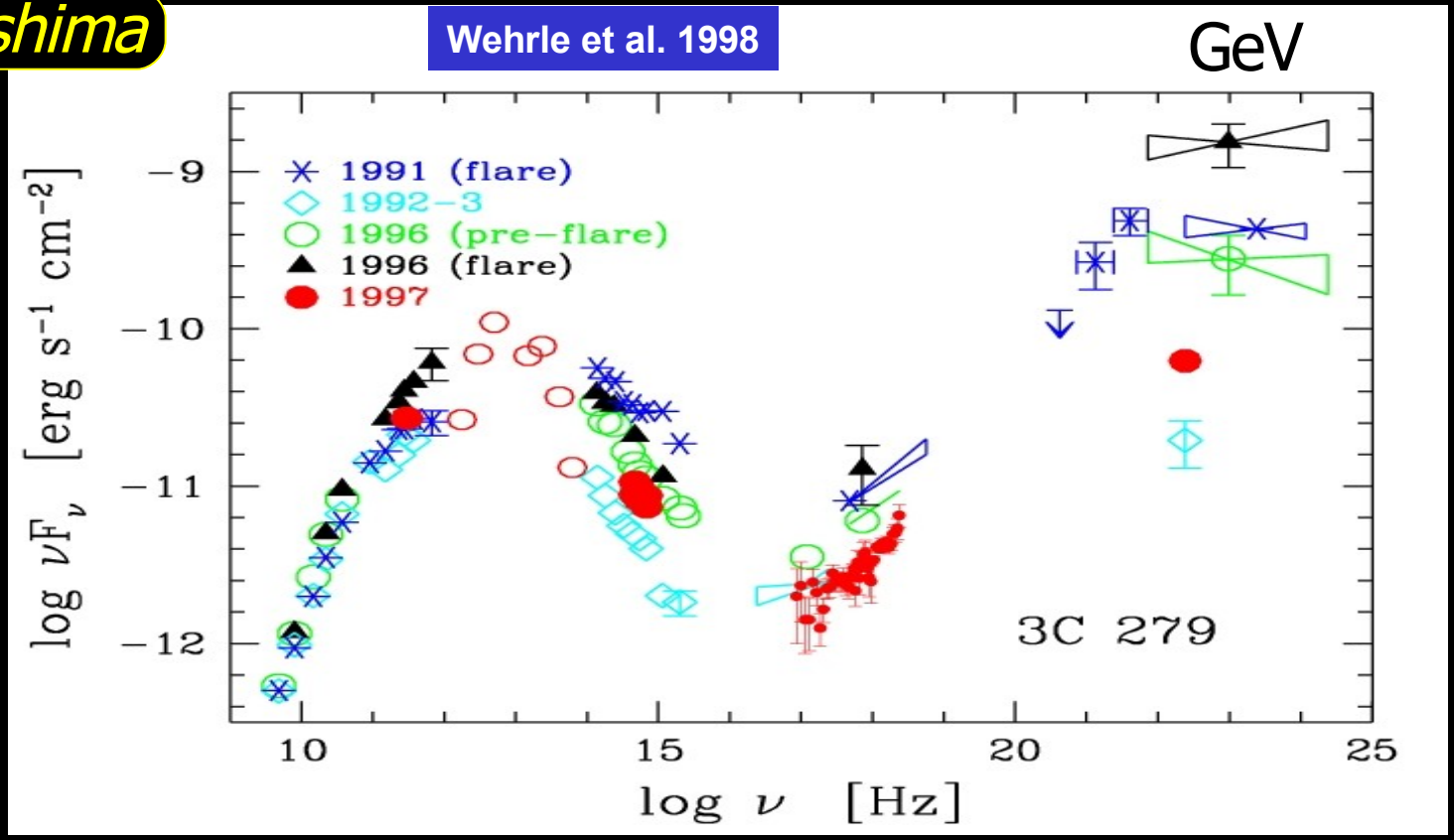
Huge Flare From PKS 2155-304



- Comparison of Mrk 501 (MAGIC) and PKS 2155-304 (HESS) flares

3C 279

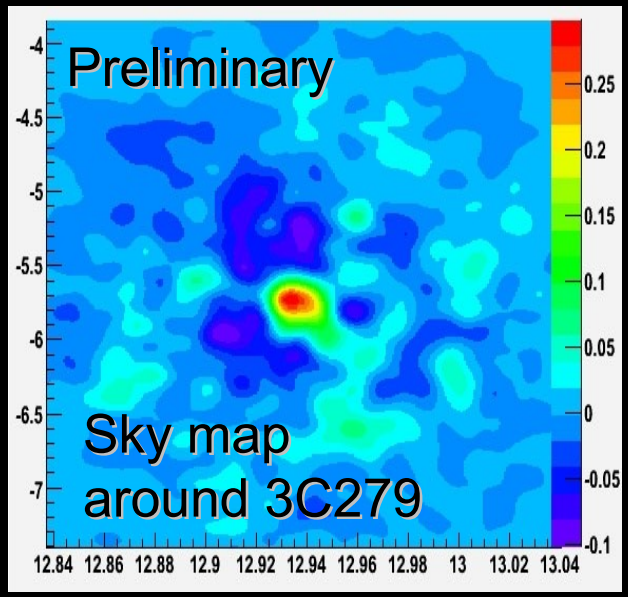
Teshima

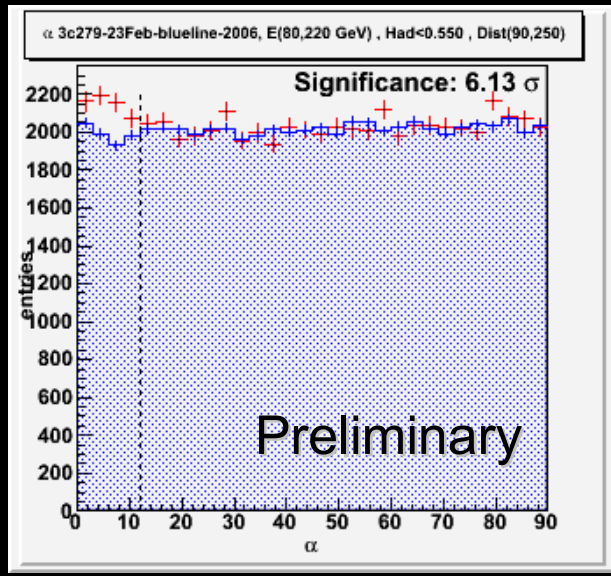


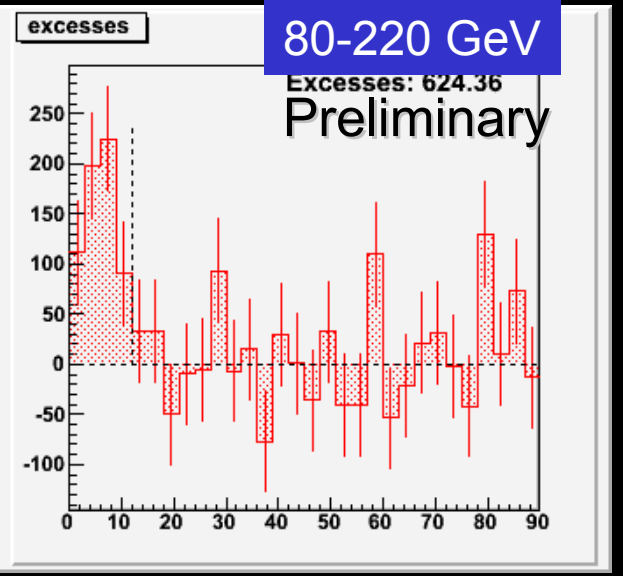
- **Brightest EGRET AGN, Flat Spectrum Radio Quasar**
- **Redshift of 0.538**

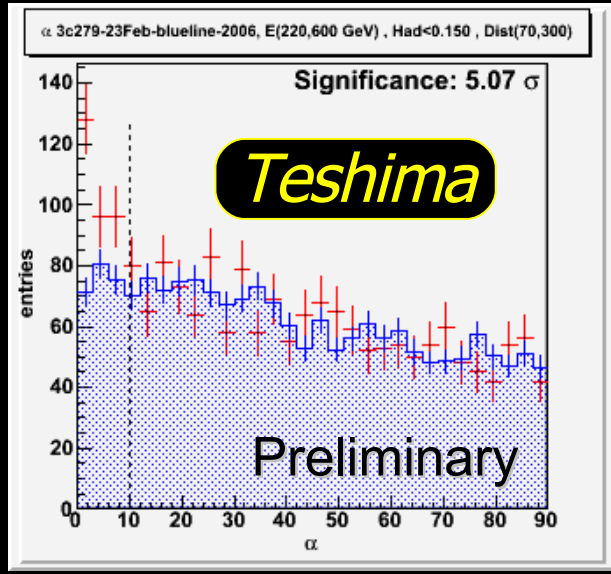
3C 279: One night, 23rd Feb 2006

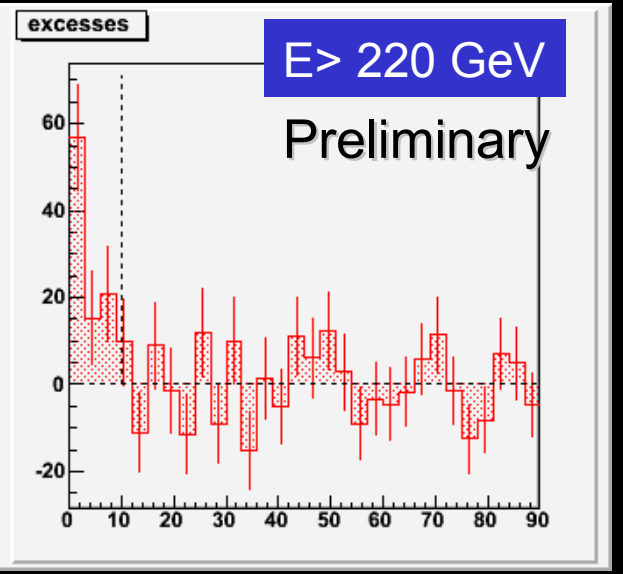
- 6.1 σ in low Energy band
  - Post-trails?
- 5.1 σ >220 GeV
  - Surprising!





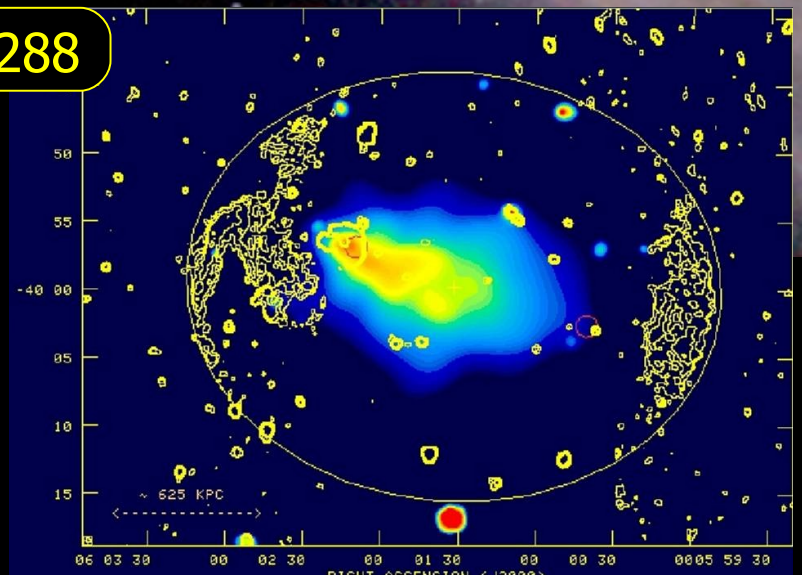






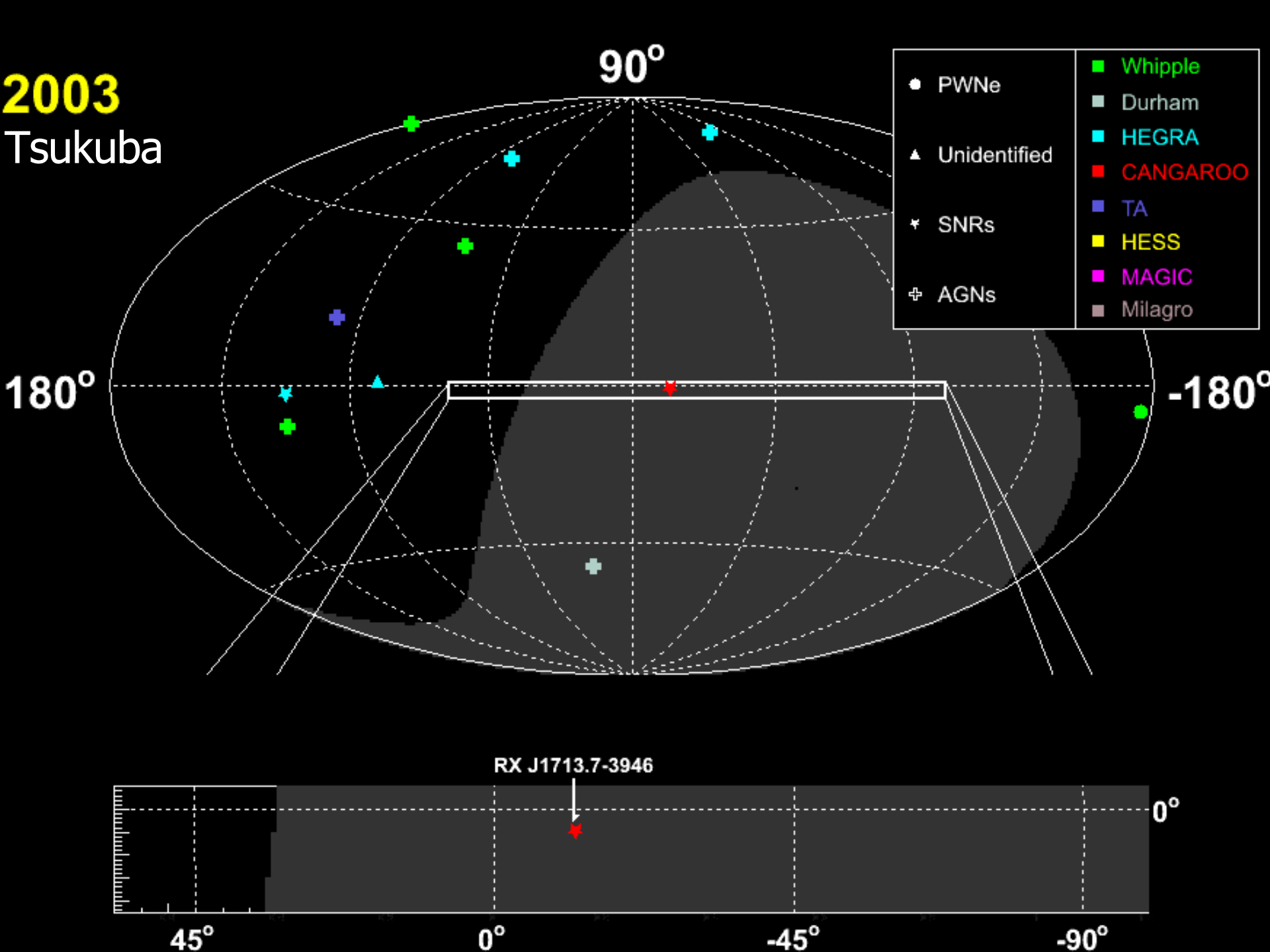
Upper Limits On Other Object Classes

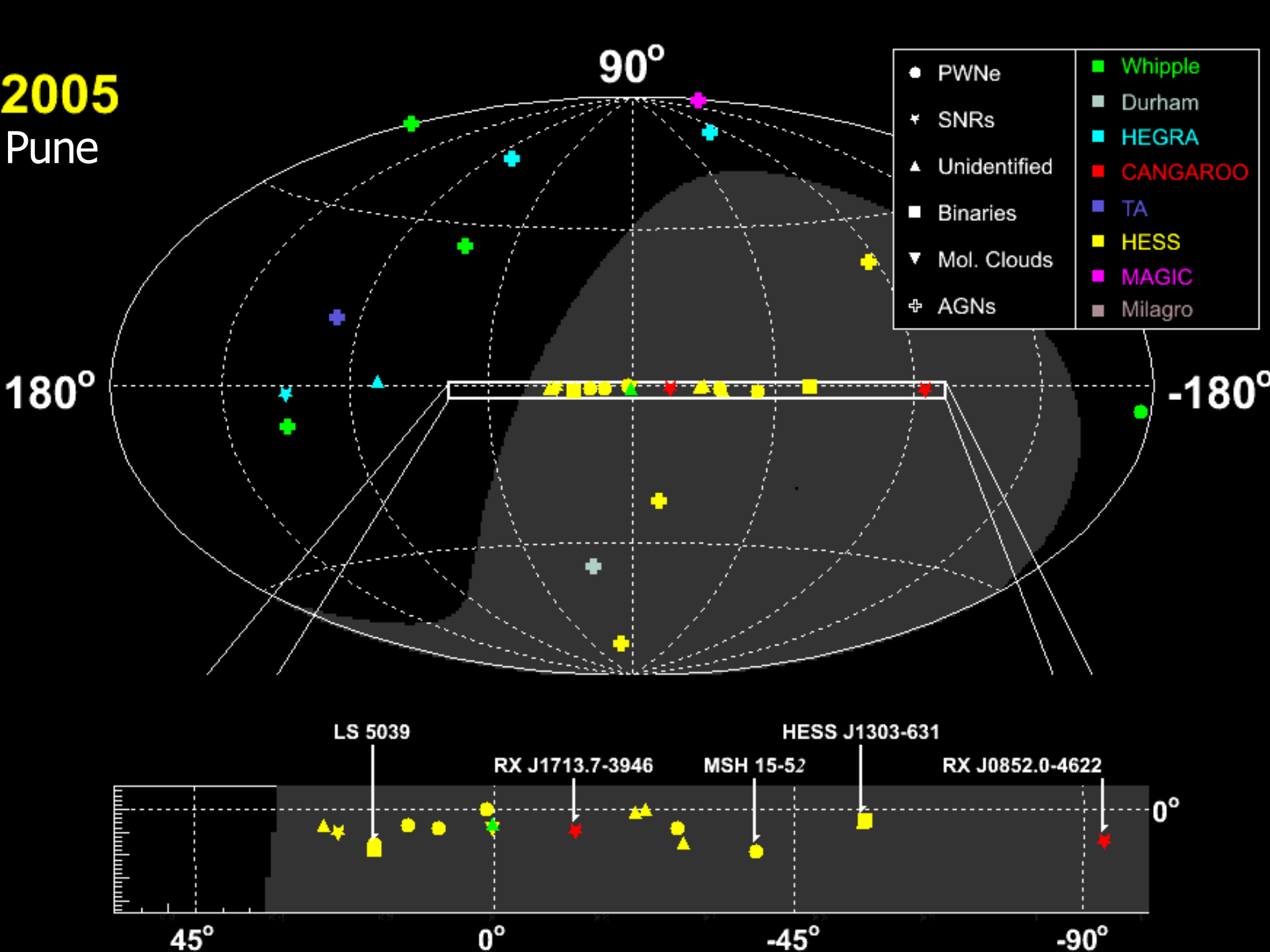
- **Starburst galaxies**
  - **HESS: NGC 253 & M 83** *Nedbal* 468
- **Galaxy clusters**
  - **CANGAROO-III**
    Abell 3667 & Abell 4038 *Kiuchi* 428
  - **HESS**
    Abell 496 & Coma *Domainko* 535
- **Ultra luminous IR galaxies**
  - **MAGIC Arp 220** *Vitale* 1288
- ***Non-beamed extragalactic objects may be too dim for current TeV instruments***
  - **GLAST may help with target selection**



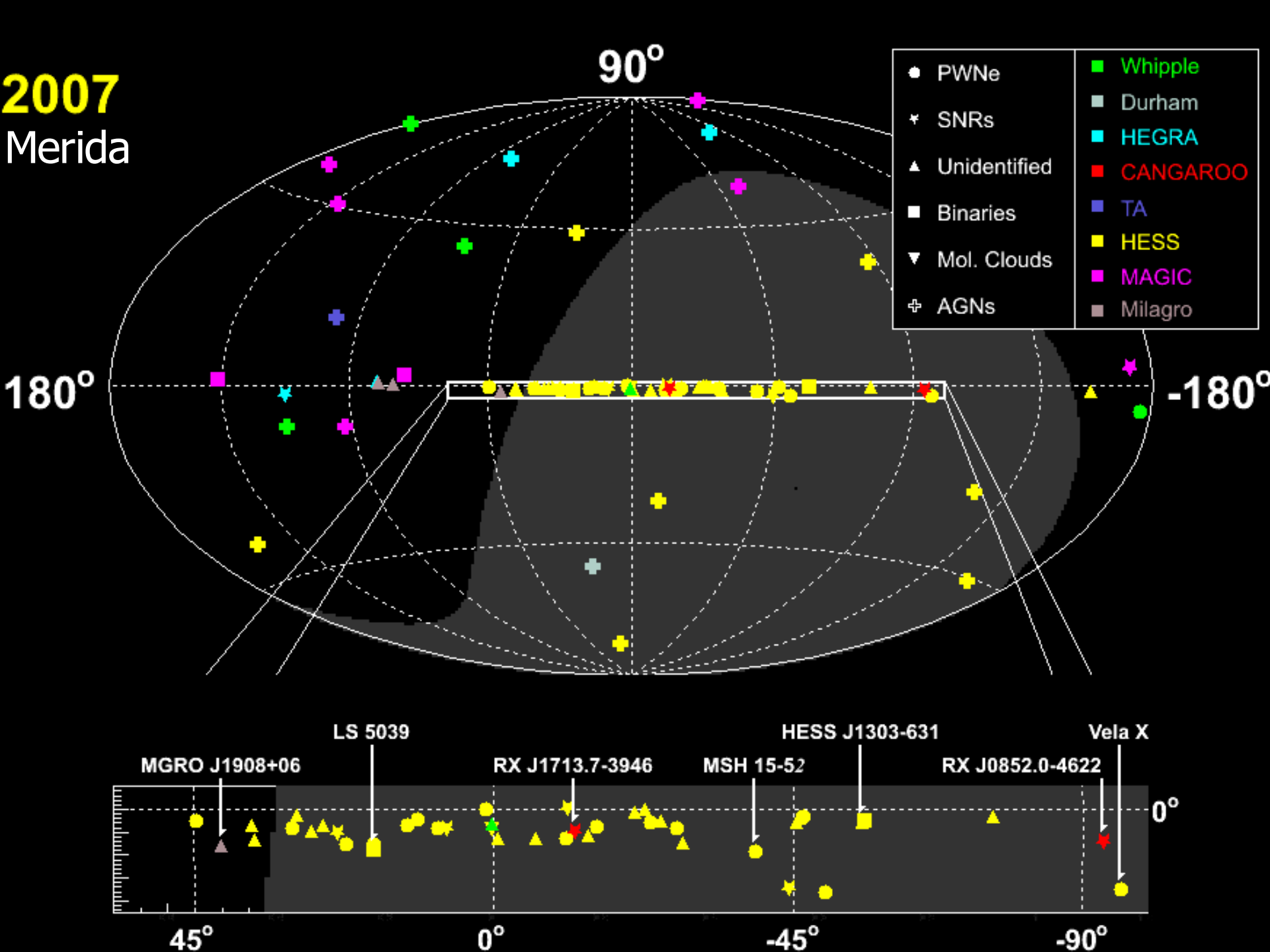
Serious Conclusions

- VHE γ-rays is currently a *very* active field
- Number of sources is rising rapidly but also the precision with which the bright sources can be measured
  - E.g. Energy dependant morphology in HESS J1825-137, 6" location acc. at the Galactic Centre with H.E.S.S.
- The redshift range has been more than doubled!
  - MAGIC detection of 3C 279
- Expect >100 VHE sources at the next ICRC
  - VERITAS is now fully operational
  - First MAGIC-II sources?
- and >1000 GeV sources from GLAST!


2003
Tsukuba
90°
180°
-180°
PWNe
Unidentified
SNRs
AGNs
Whipple
Durham
HEGRA
CANGAROO
TA
HESS
MAGIC
Milagro
RX J1713.7-3946
0°
45°
0°
-45°
-90°


2005
Pune
90°
180°
-180°
PWNe
SNRs
Unidentified
Binaries
Mol. Clouds
AGNs
Whipple
Durham
HEGRA
CANGAROO
TA
HESS
MAGIC
Milagro
LS 5039
RX J1713.7-3946
MSH 15-52
HESS J1303-631
RX J0852.0-4622
0°
45°
0°
-45°
-90°

2007
Merida


90°
180°
-180°
PWNe
SNRs
Unidentified
Binaries
Mol. Clouds
AGNs
Whipple
Durham
HEGRA
CANGAROO
TA
HESS
MAGIC
Milagro
MGRO J1908+06
LS 5039
RX J1713.7-3946
MSH 15-52
HESS J1303-631
RX J0852.0-4622
Vela X
0°
45°
0°
-45°
-90°

Less Serious Conclusion

- Basically we are all very happy