

Highlights from VHE Gamma Astronomy:

Where do we stand and where do we go ?

XLIIInd MORIOND, La Thuile 14/March/2007

Manel Martinez



Outline:

0- Introduction

1- Today

2- Tomorrow

3- The near future

Slides from TEXAS Symposium 2006 (W.Hofmann, D.Kranich,...),
GLAST Symposium 2007 (D.Paneque, A.Djanatti-Atai,...),
1st ASPERA Meeting 2006 (G.Hermann)
CTA Meeting in Paris (W.Hofmann, M.Teshima)

0- Introduction

Gamma observation on the ground (experimental status and projects)

EUROPEAN ASTROPARTICLE PHYSICS
Town Meeting
Munich 23-25 Nov 2005

Manel Martinez, IFAE Barcelona

Introduction

- Very special moment in VHE Cosmic gamma-ray observation:
real revolution in consolidation of Cherenkov telescopes as astronomical instruments
=> transition from “HE experiments” to “telescopic installations”
--> exploding interest in the astronomical community... !
 - Big observational step within the last year:
 - quantitative (tripling number of detected sources)
 - qualitative (extremely high quality => unprecedented detailed studies).
- => DOWN OF A GOLDEN AGE FOR CHERENKOV TELESCOPES !**
- > concentrate on Gamma-ray astronomy with Cherenkov telescopes

Now:

witnessing the consolidation and growth of VHE gamma astronomy as one of the most active and exciting pillars of high energy astrophysics.

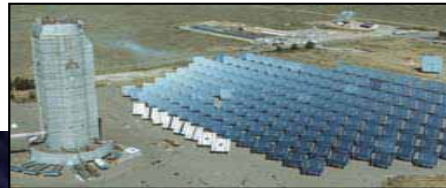
1- Today

VHE Experimental World

MILAGRO



STACEE



MAGIC



TIBET



MILAGRO

STACEE
CACTUS

VERITAS

MAGIC

TIBET ARRAY
ARGO-YBJ

TACTIC

PACT

GRAPES

TACTIC

HESS

HESS

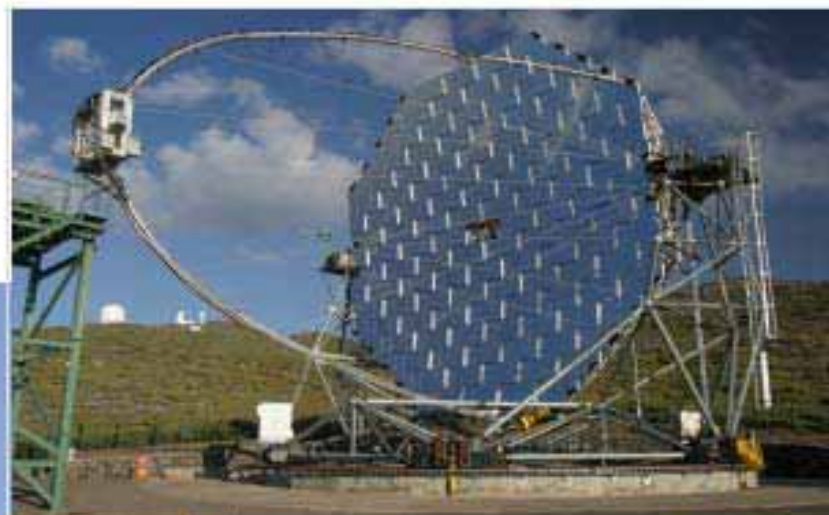


CANGAROO III

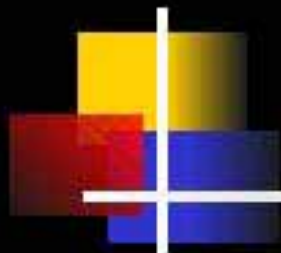
CANGAROO



State of the Art TeV Astrophysics ...

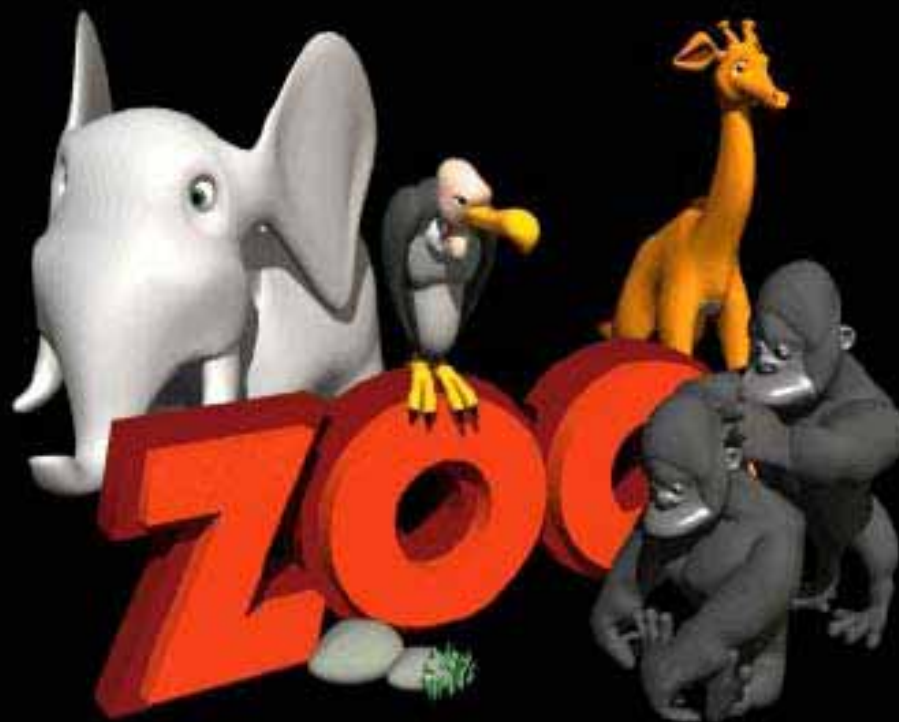


Europe
world-wide
leading in the field !



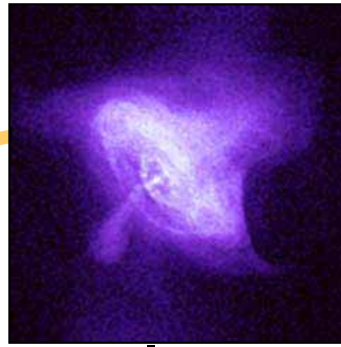
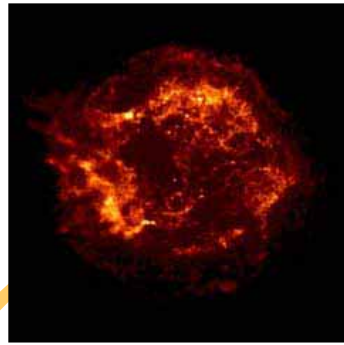
Gamma ray sources & their physics

- Supernova remnants
- Pulsar wind nebulae
- “Dark sources”
- Binaries
- Stellar winds
- Galactic center
- Active galaxies

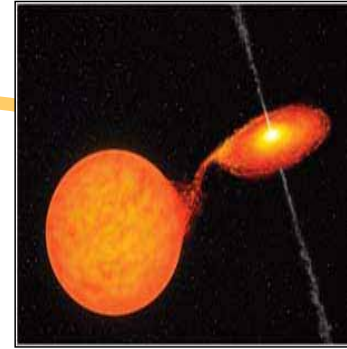


The VHE γ -ray Physics Program

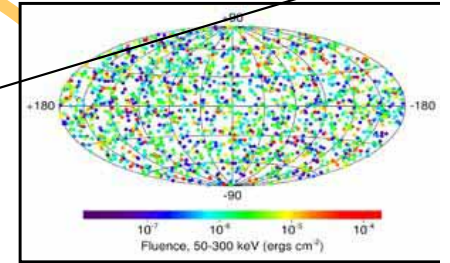
SNRs
Origin of
Cosmic Rays



Pulsars



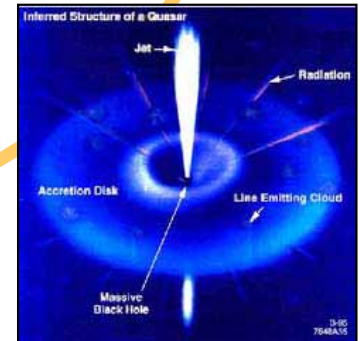
Binary systems



Galactic

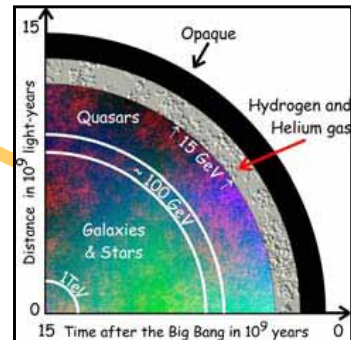
Extragalactic

GRBs

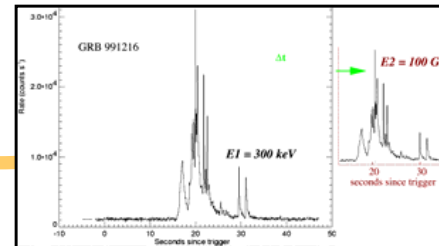


AGNs

Cold Dark
Matter



Cosmological
 γ -Ray Horizon



Test of the speed
of light
invariance

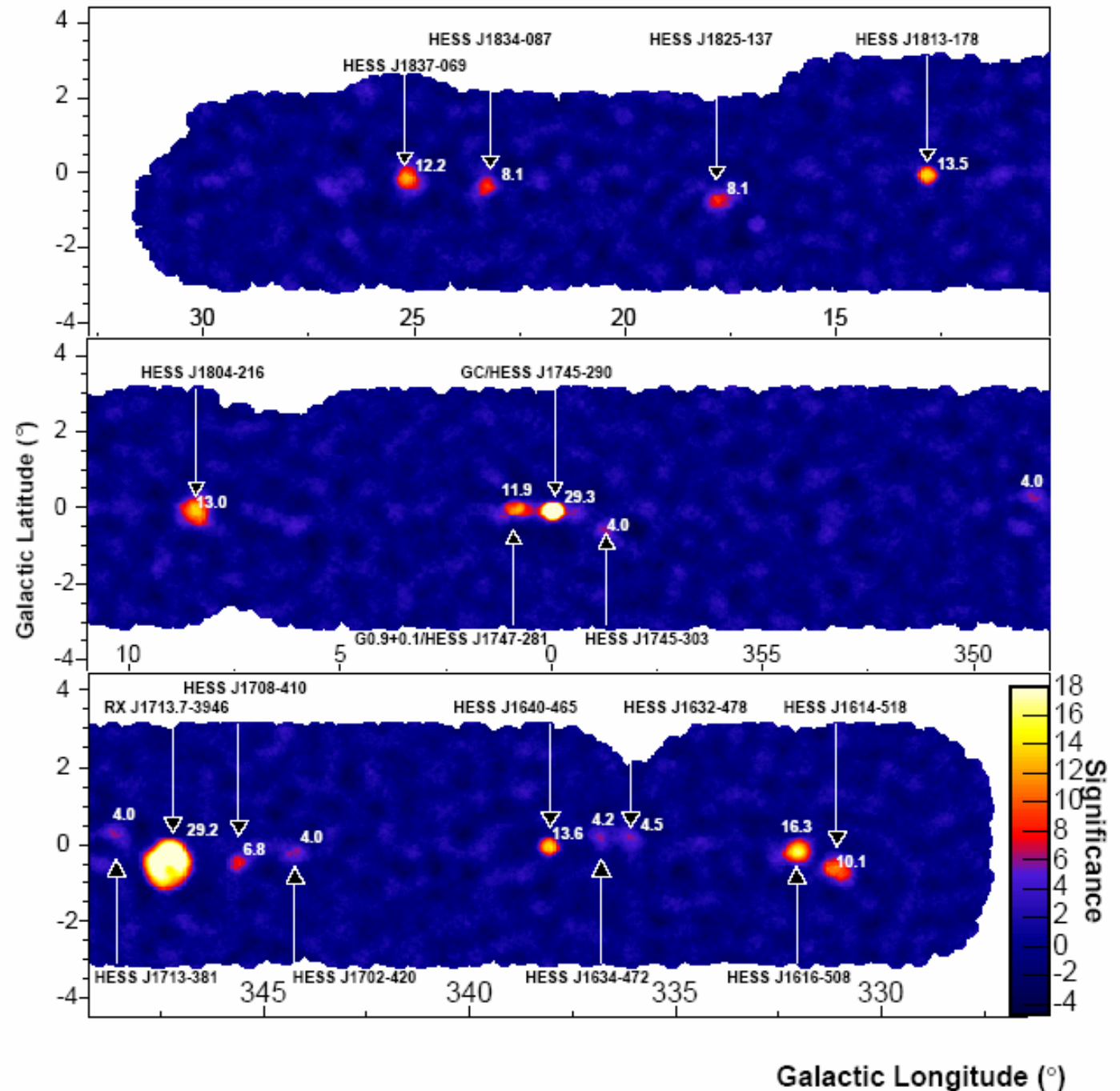
HESS Galactic Plane Survey

Sources > 6 sigma:
9 new, 11 total

Sources > 4 sigma:
7 new

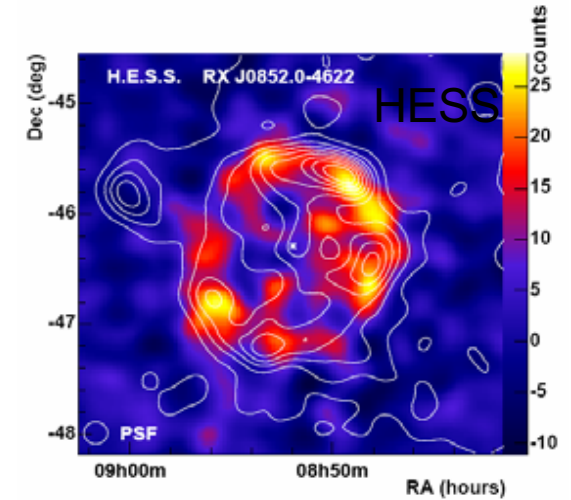
Most sources:

- Shell-type SNR
- Pulsar-Wind-Nebulae
- Unidentified
- New objects



SNRs (9)

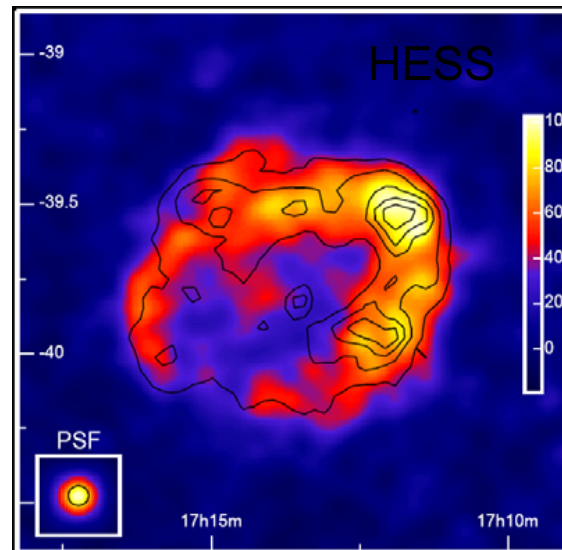
Category	Name	Discovery	Observ.
SNR	Cas-A	HEGRA	
SNR	Vela Junior, RX J0852.0-4622	CANGAROO	HESS
SNR/Un-ID	HESS J1640-465 (G338.3-0.0; 3EG J1639-4702)	HESS	
SNR	HESS 1713-381, G348.7+0.3 ?	HESS	
SNR	RX J1713.7-3946, G347.3-0.5	CANGAROO	HESS
SNR/PWN	HESS J1804-216 (G8.7-0.1 / W30; PSR J1803)	HESS	
SNR	HESS J1813-178 (G12.8-0.02; AX J1813-178)	HESS	MAGIC
SNR	HESS J1834-087 (G23.3-0.3 / W41)	HESS	MAGIC
SNR/PWN/Un-ID	HESS J1837-069 (G25.5+0.0; AX J1838.0-0655)	HESS	



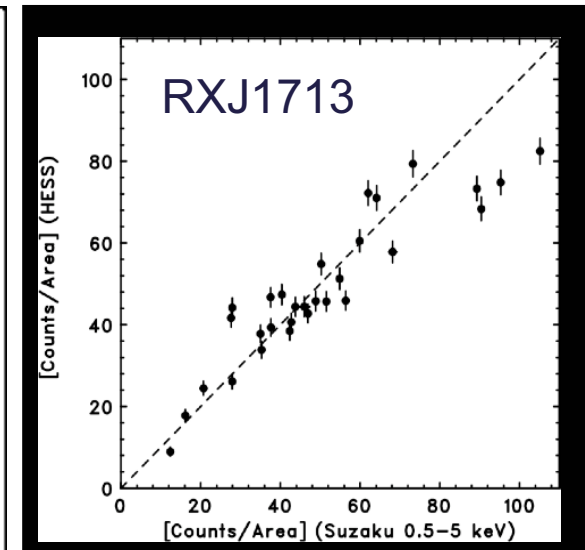
Vela Junior



Cas-A

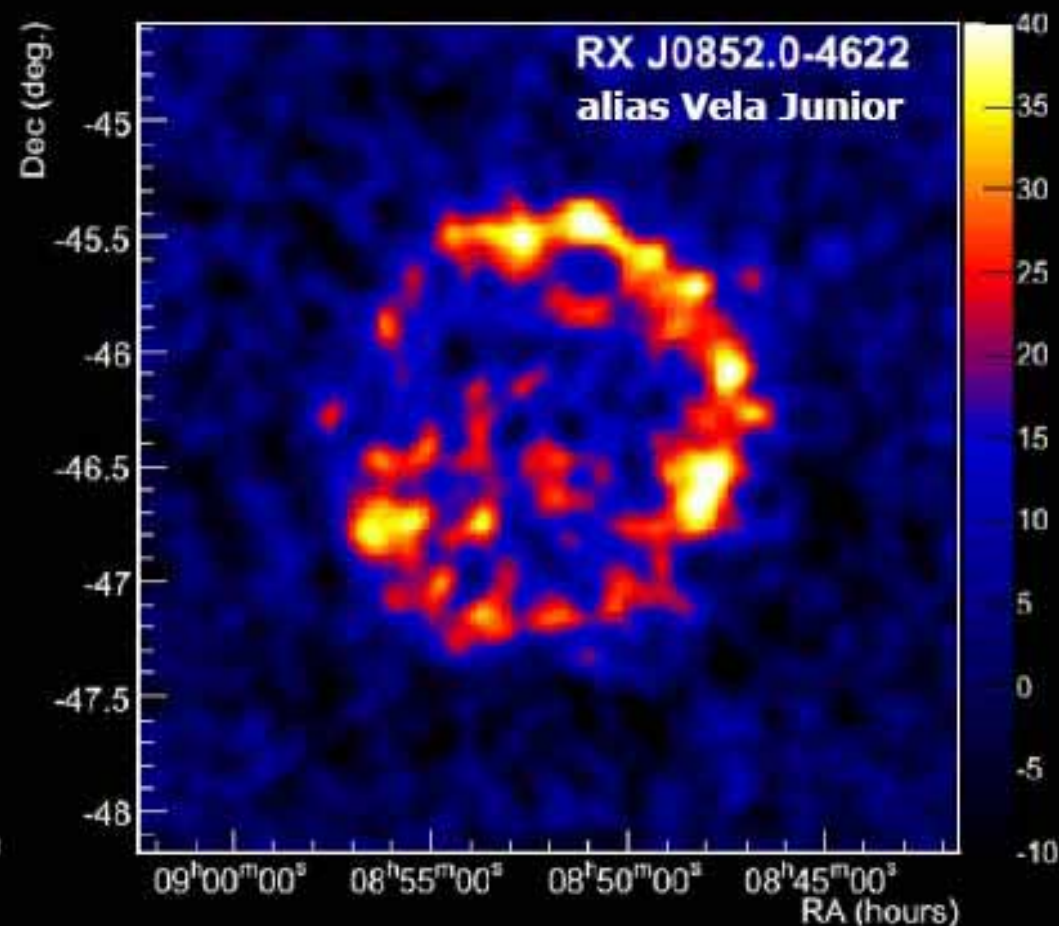
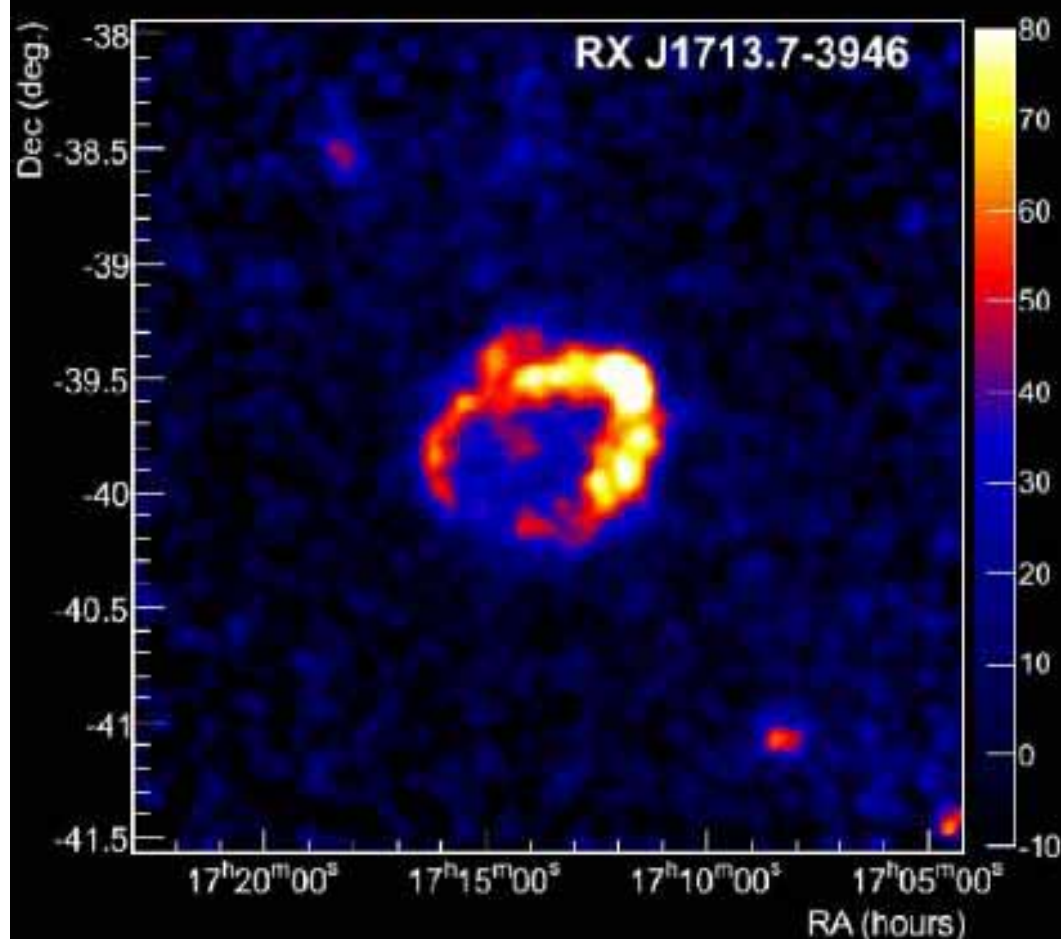


RX J1713



Supernova remnant shells

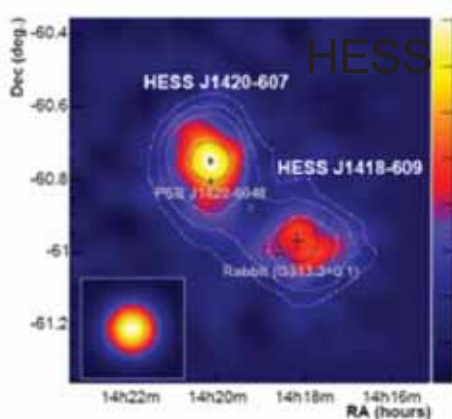
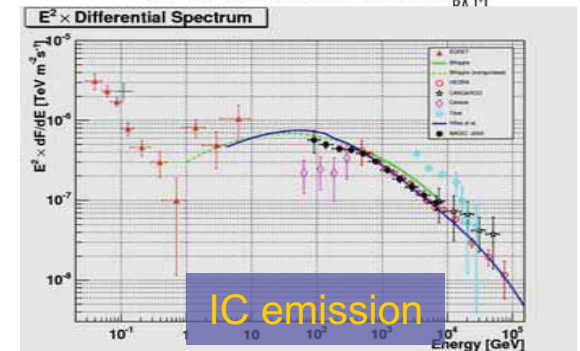
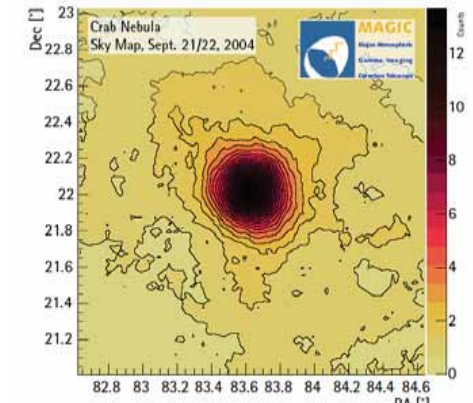
γ -ray morphology \cong morphology in non-thermal X-rays



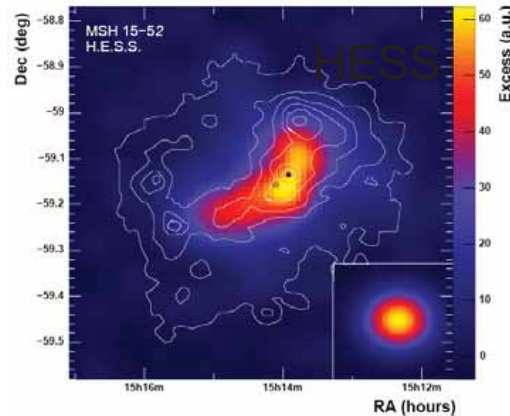
PWN (8)

Category	Source	Discovery	Observation
PWN	Crab Nebula	Whipple	many
PWN	Vela X	CANGAROO	HESS
PWN	HESS J1418-609 (G313.3+0.1, Rabbit)	HESS	
PWN	HESS J1420-607 (PSR J1420-6048, Kookaburra)	HESS	
PWN	MSH 15-52, PSRB1509-58	CANGAROO	HESS
PWN	HESS J1616-508 (PSR J1617-5055)	HESS	
PWN	HESS J1747-281 (G0.9+0.1)	HESS	
PWN	HESS J1825-137 (PSR J1826-1334)	HESS	

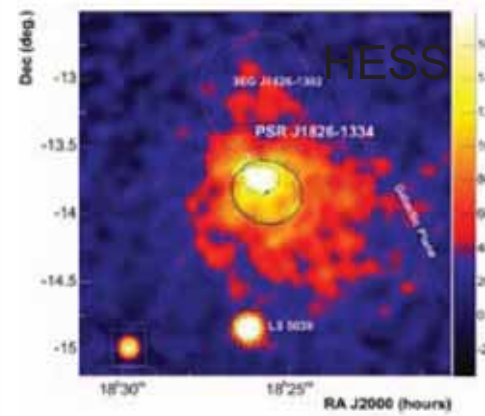
MAGIC Crab Nebula



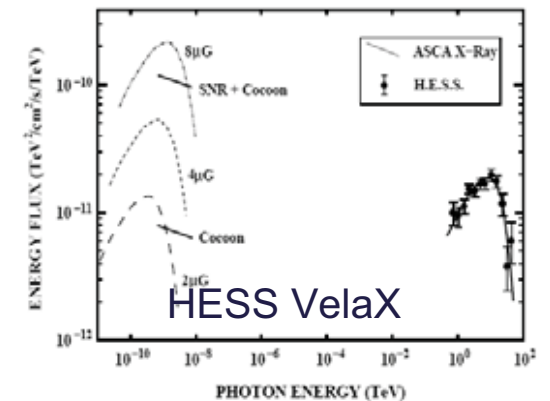
Kookaburra



MSH 15-52



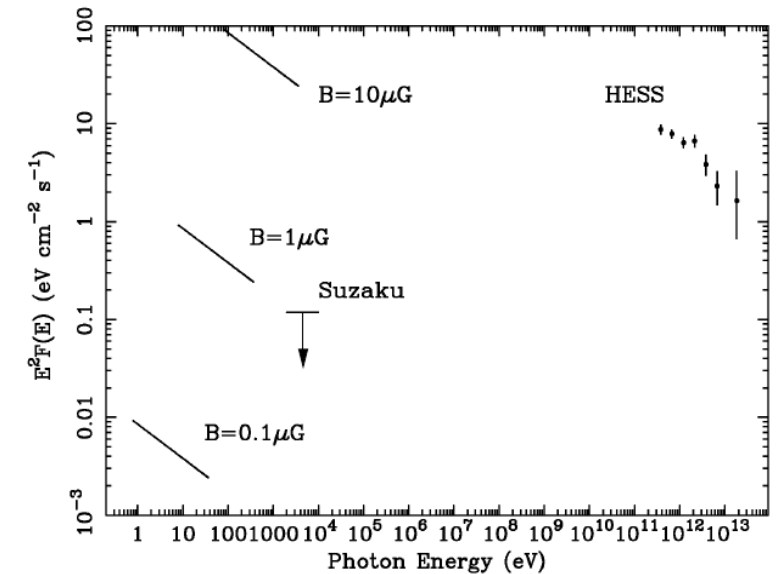
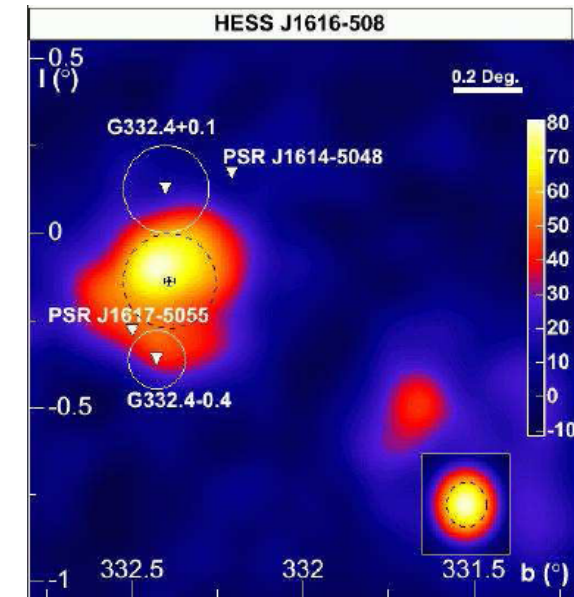
HESS J1825



Un-IDs (Dark Source)

Category	Source	Discovery	Observation
Un-ID	TeV J2032+4130	HEGRA	
Un-ID	HESS J1303-631	HESS	
Un-ID	HESS J1614-518	HESS	
Un-ID	HESS J1702-420	HESS	
Un-ID	HESS J1708-410	HESS	
Un-ID	3EG J1744-3011 ?	HESS J1745-303	

Name	Possible counterpart	Type ^a	Γ_{TeV}^b	f_{TeV}^c	N_{H}^d	Γ_{X}^e	f_{X}^f	$f_{\text{TeV}}/f_{\text{X}}$	Reference ^g
HESS J0852-463	RX J0852-4622	SNR	2.1	6.9	4	2.6	~ 10	~ 0.7	1, 2, 3
HESS J1303-631	—	?	2.4	1.0	20	2.0	< 0.64	> 1.6	4, 5
HESS J1514-591	PSR B1509-58	PWN	2.3	1.6	8.6	2.0	3.2	0.5	6, 7
HESS J1632-478	AX J1631.9-4752	HMXB?	2.1	1.7	210	1.6	1.7	1.0	8, 9
HESS J1640-465	G338.3-0.0	SNR	2.4	0.71	96	3.0	0.30	2.4	8, 10
HESS J1713-397	RX J1713.7-3946	SNR	2.2	3.5	8	2.4	54	0.065	11, 12
HESS J1804-216	Suzaku J1804-2142	?	2.7	0.48	2	-0.3	0.025	19	8, 13
HESS J1804-216	Suzaku J1804-2140	?	2.7	0.48	110	1.7	0.043	11	8, 13
HESS J1813-178	AX J1813-178	?	2.1	0.89	110	1.8	0.70	1.3	8, 14
HESS J1837-069	AX J1838.0-0655	?	2.3	1.4	40	0.8	1.3	1.1	8, 15
TeV J2032+4130	—	?	1.9	0.20	?	?	< 0.20	> 1.0	16
HESS J1616-508	—	?	2.4	1.7	4.1	2.0	< 0.031	> 55	This work

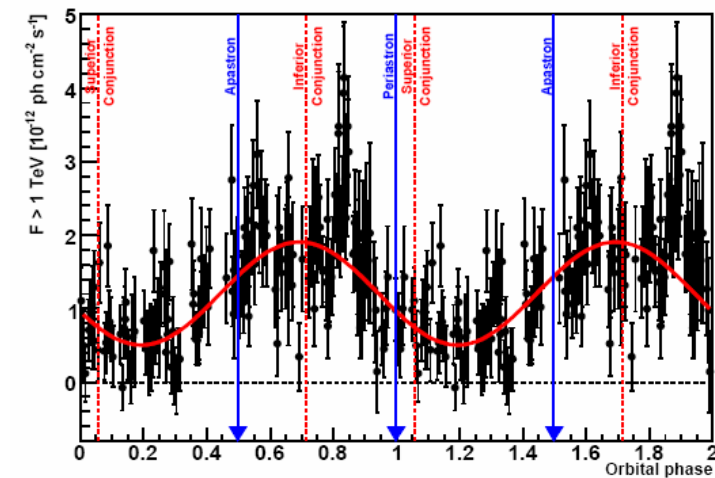
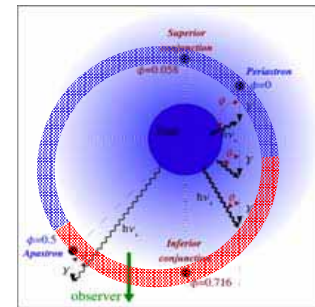


Suzaku (Matsumoto et al. 1996)

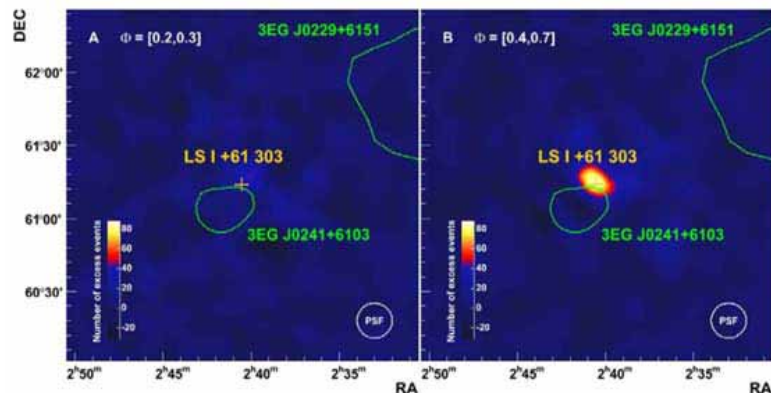
Binary Systems (5)

Category	Source	Discovery	Observation
Binary	PSR B1259-63 / SS 2883	HESS	
XRB	IGR J16320-4751	HESS J1632-478	
XRB/SNR	IGR J16358-4726 ?; G337.2+0.1 ?	HESS J1634-472	
XRB	LS 5039	HESS	
XRB	LSI+61303	MAGIC	VERITAS

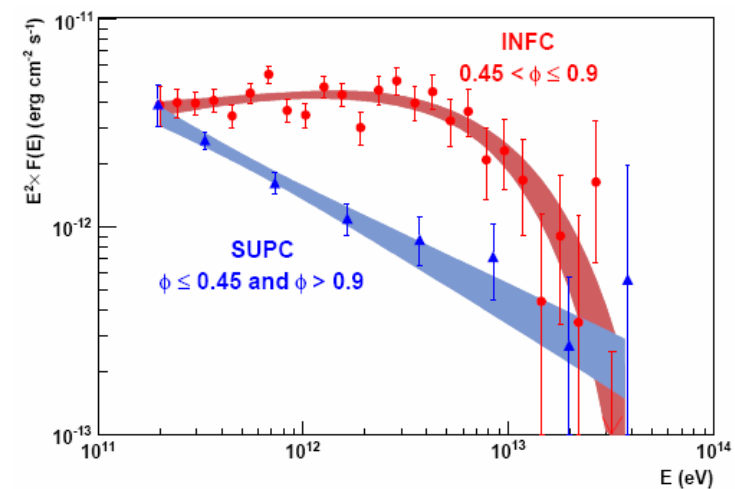
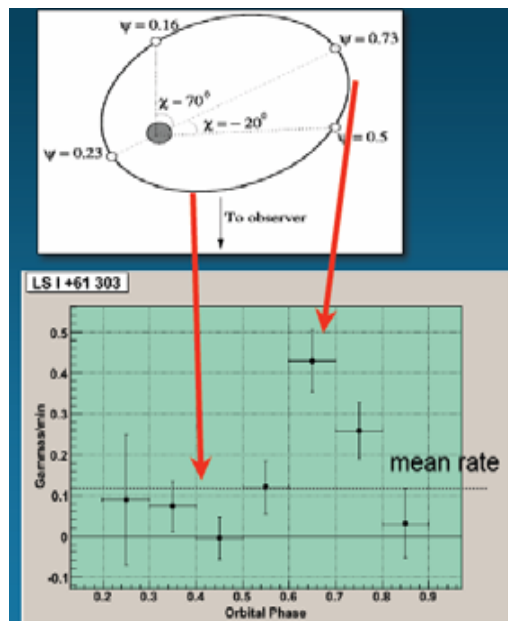
LS 5039
HESS



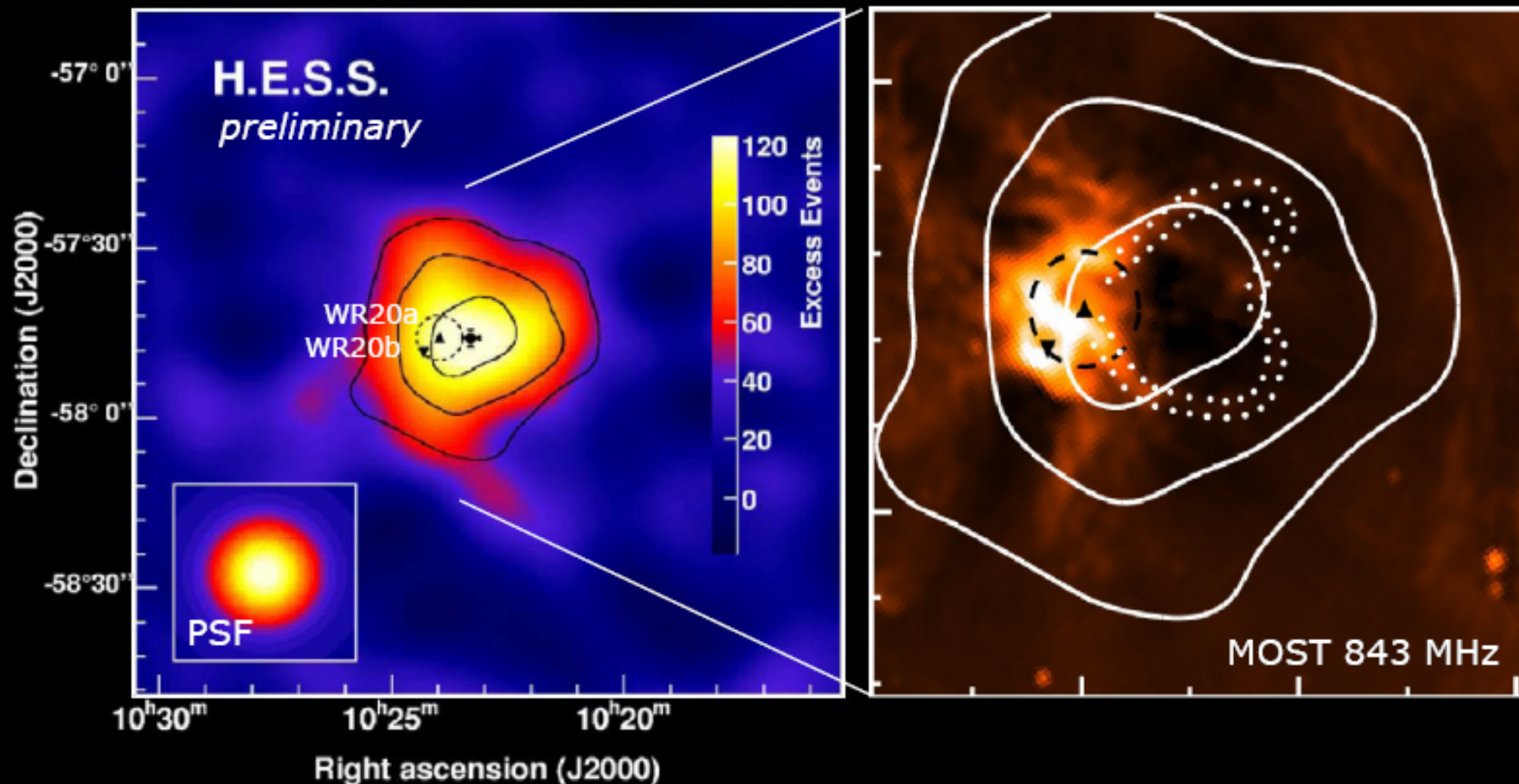
LS I +61 303 VERITAS



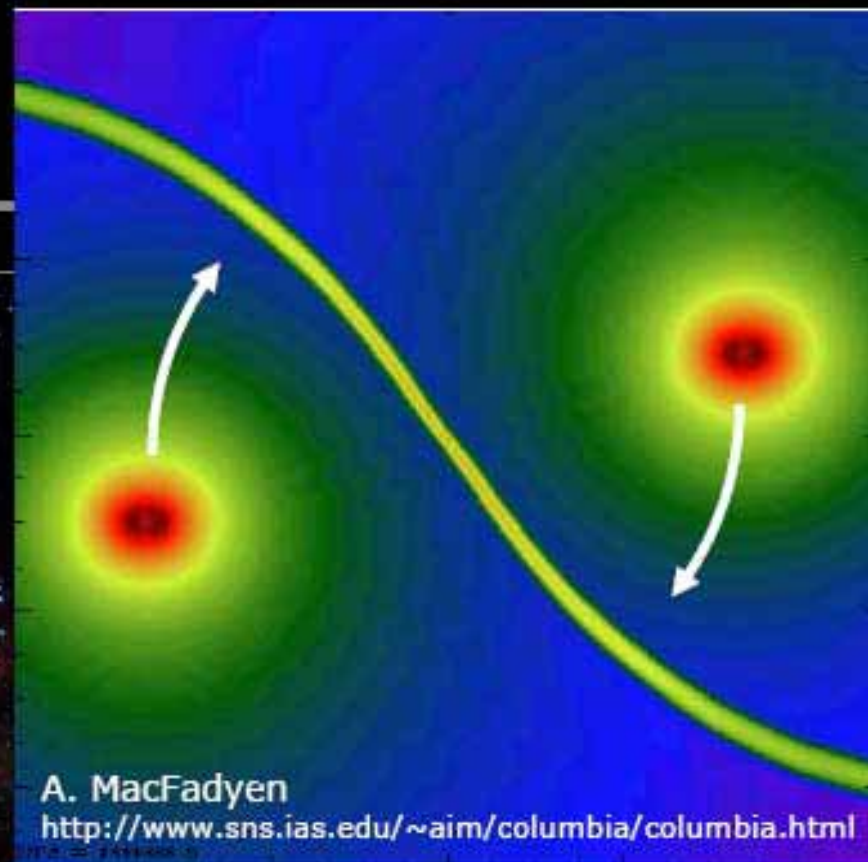
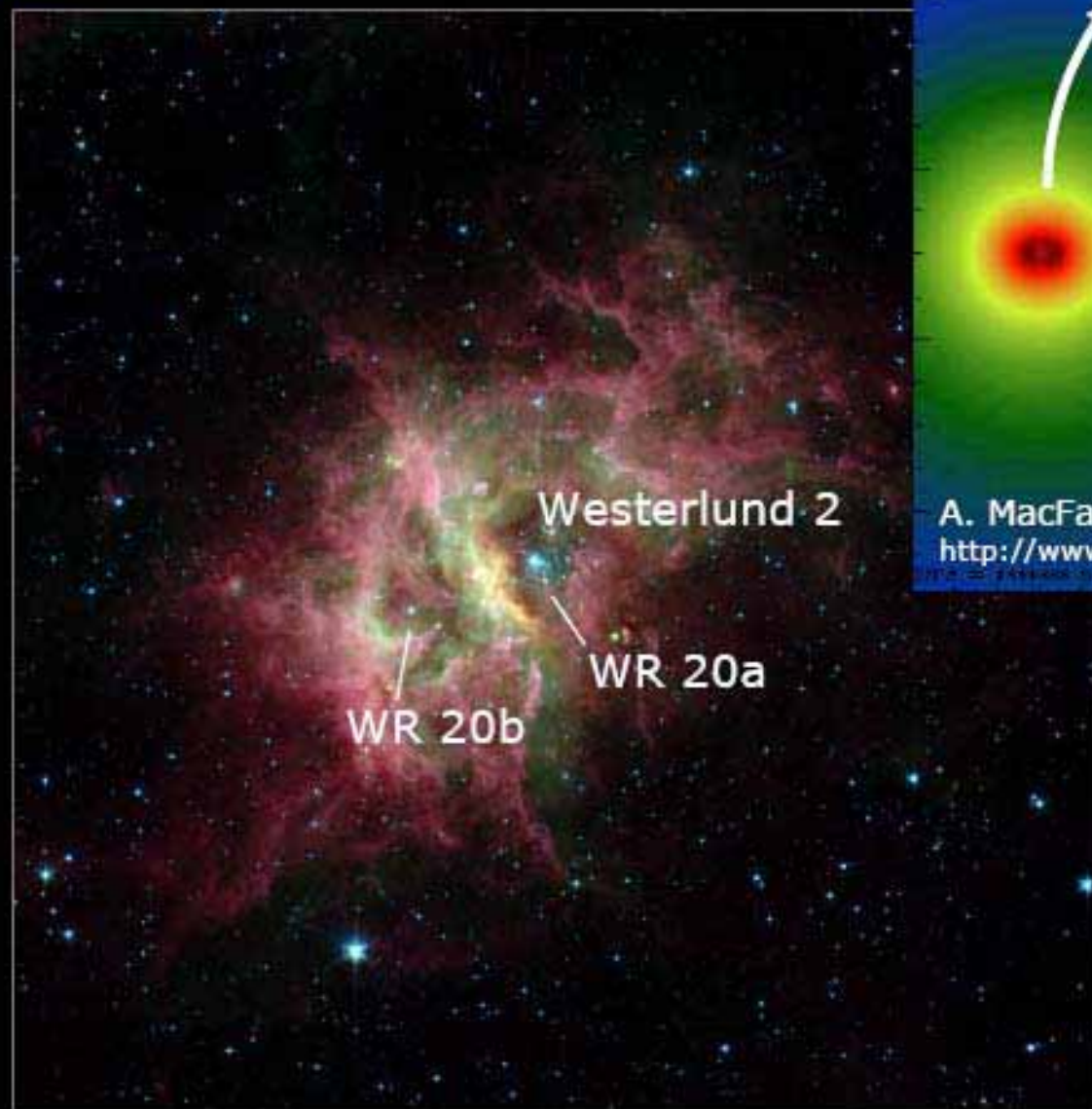
MAGIC LSI +61303



HESS J1023-575: gamma rays from stellar winds ?

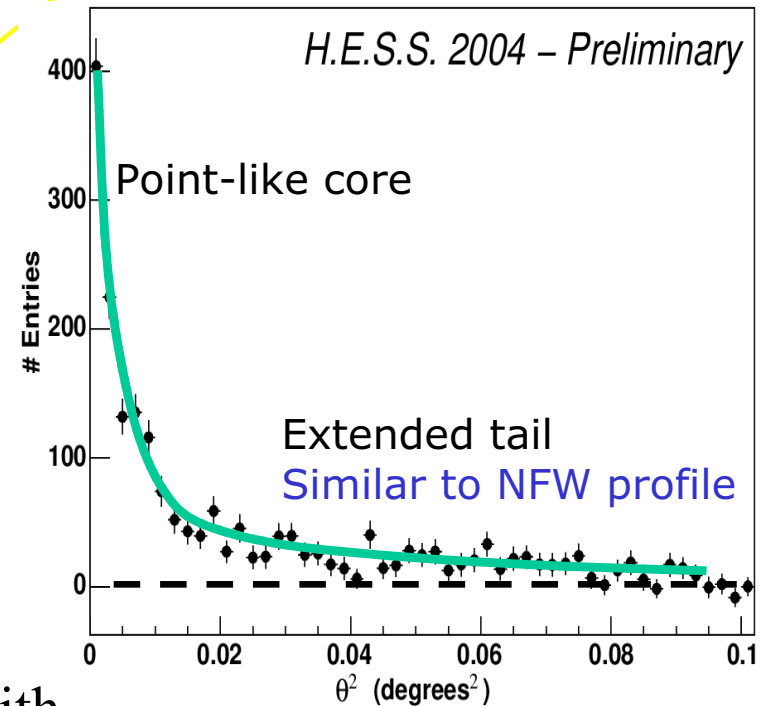
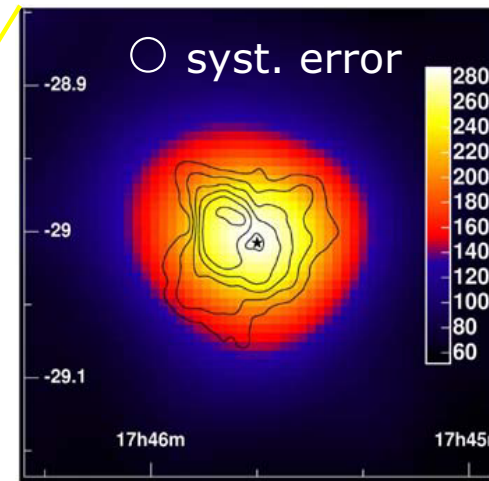
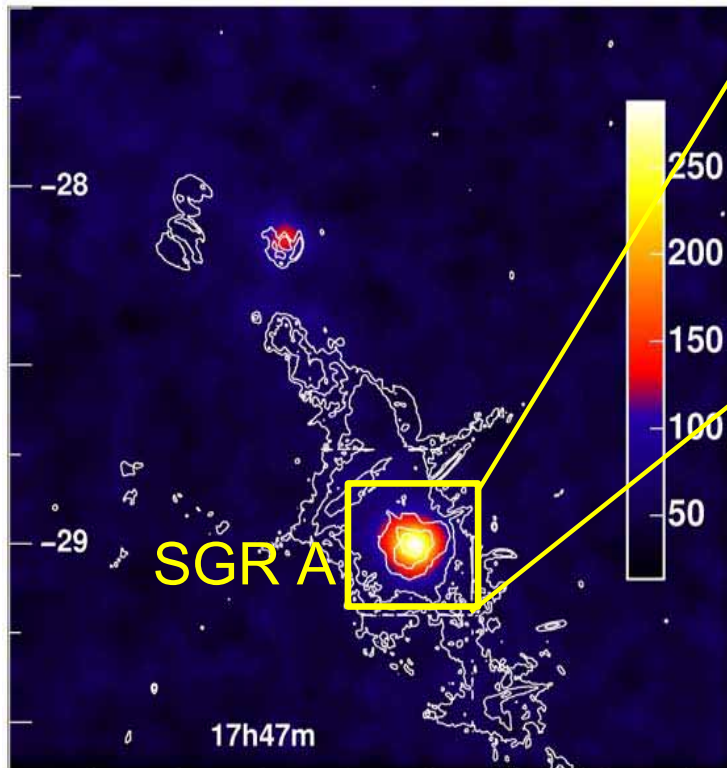


RCW 49



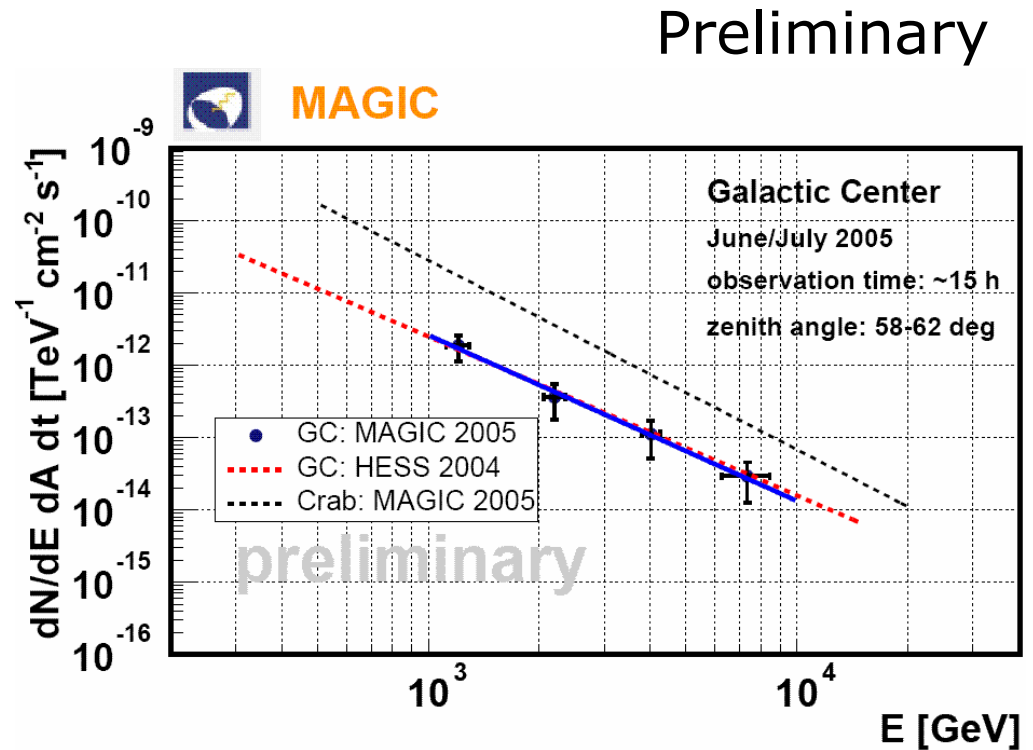
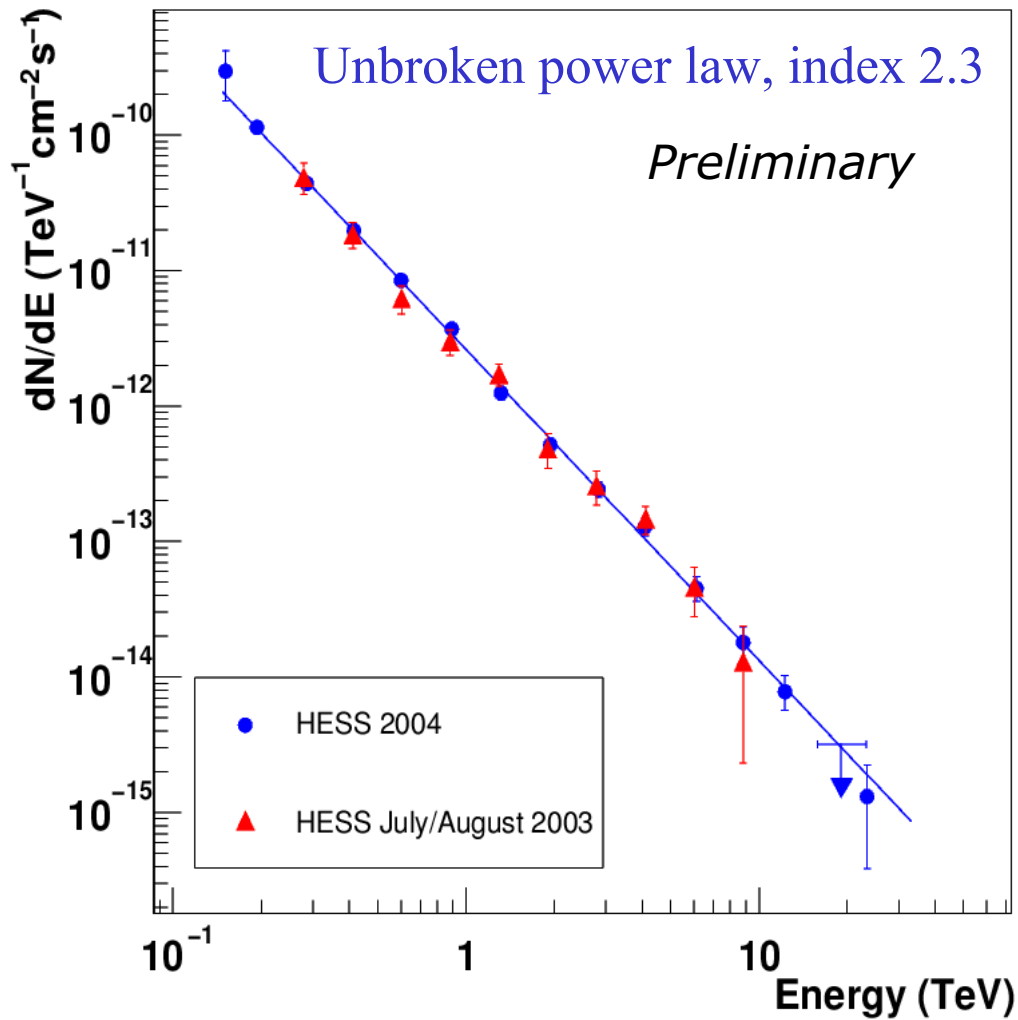
WR20a:
Two $\sim 70 M_{\odot}$ WR stars
in 3.7 d orbit

Galactic Center



- > Consistent with SGR A* to 6'' and slightly extended.
- > No significant variability from year to minute scales (in ~40 h obs. time distributed over 2 years)

Gamma ray spectrum



Good agreement between HESS and MAGIC (large zenith angle observation).

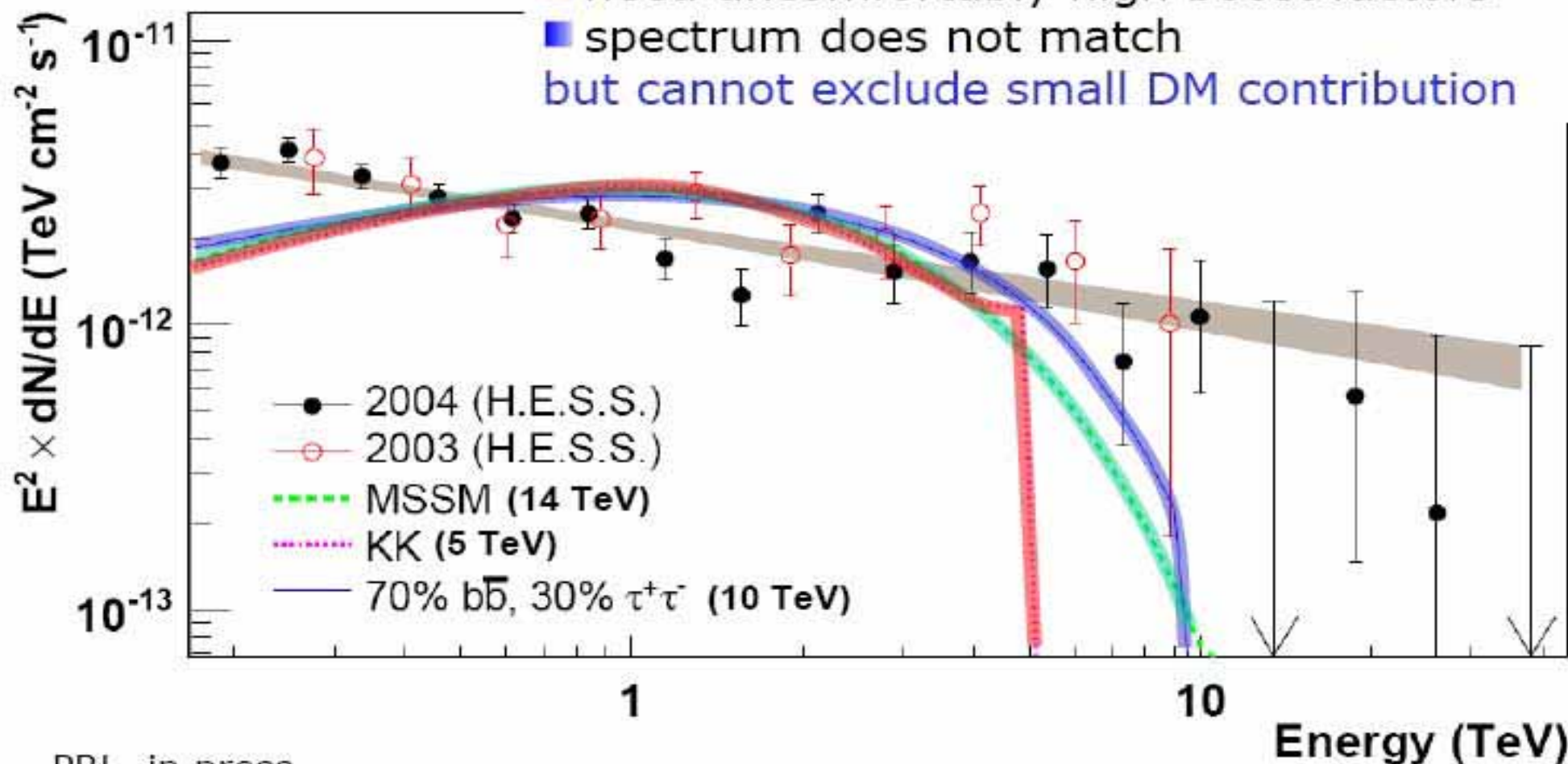
⇒ Very unlikely to be dark matter.

⇒ Presence of a strong gamma-ray source outshines any possible DM signal



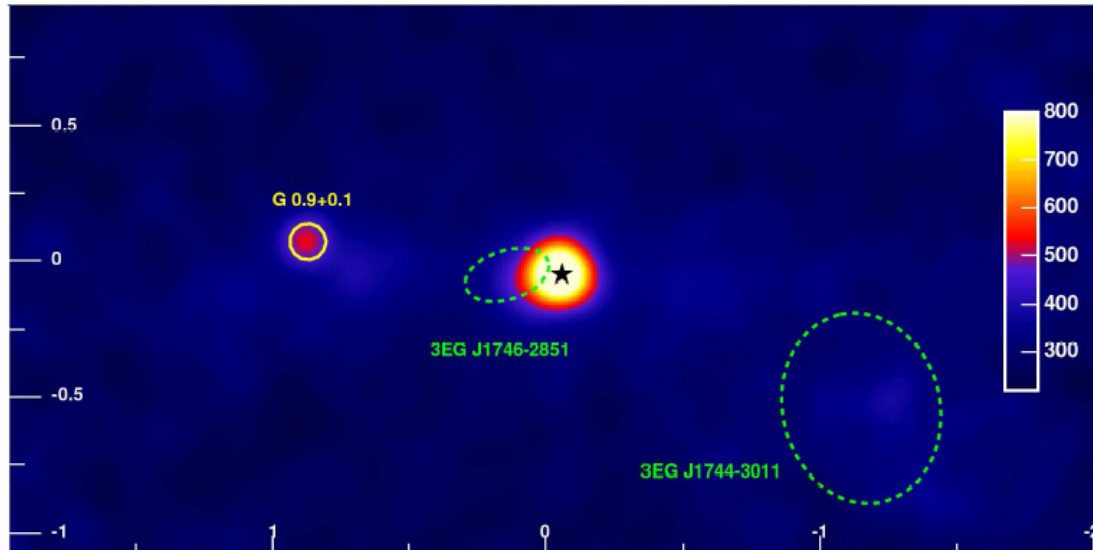
Is it DM? ► Spectrum

- need uncomfortably high neutralino masses
- need uncomfortably high boost factors
- spectrum does not match
but cannot exclude small DM contribution

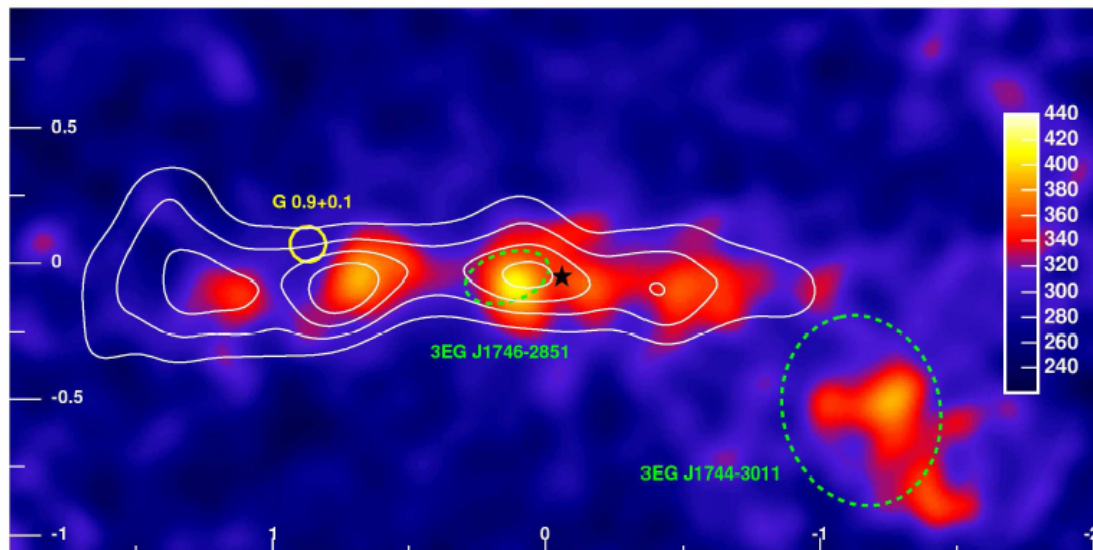


The Galactic Centre Ridge

HESS

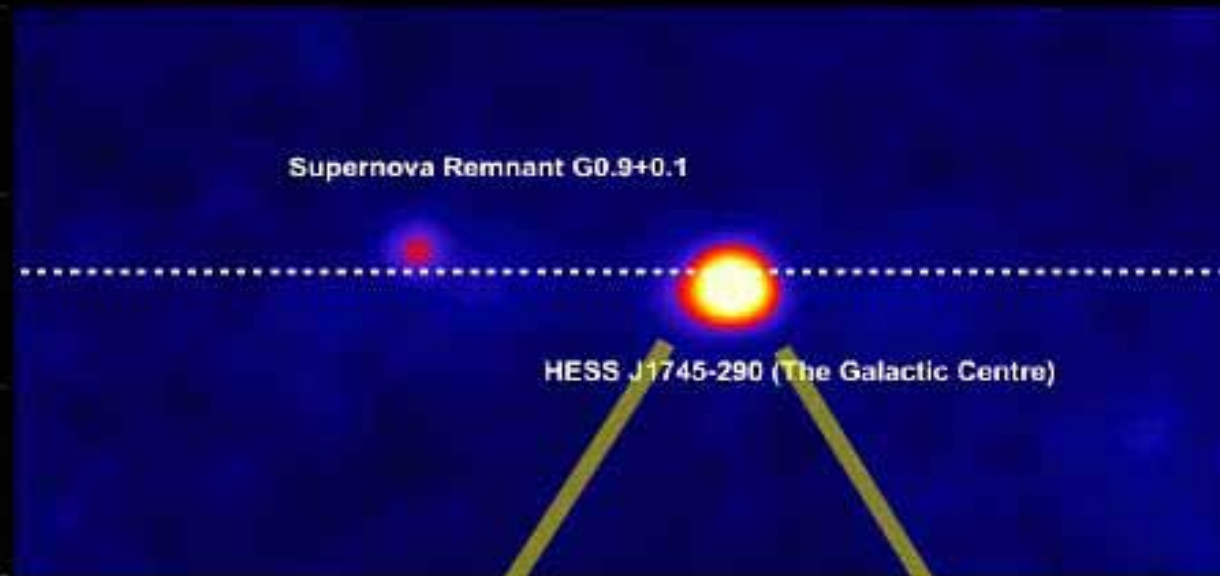


Galactic Centre gamma-ray
count map



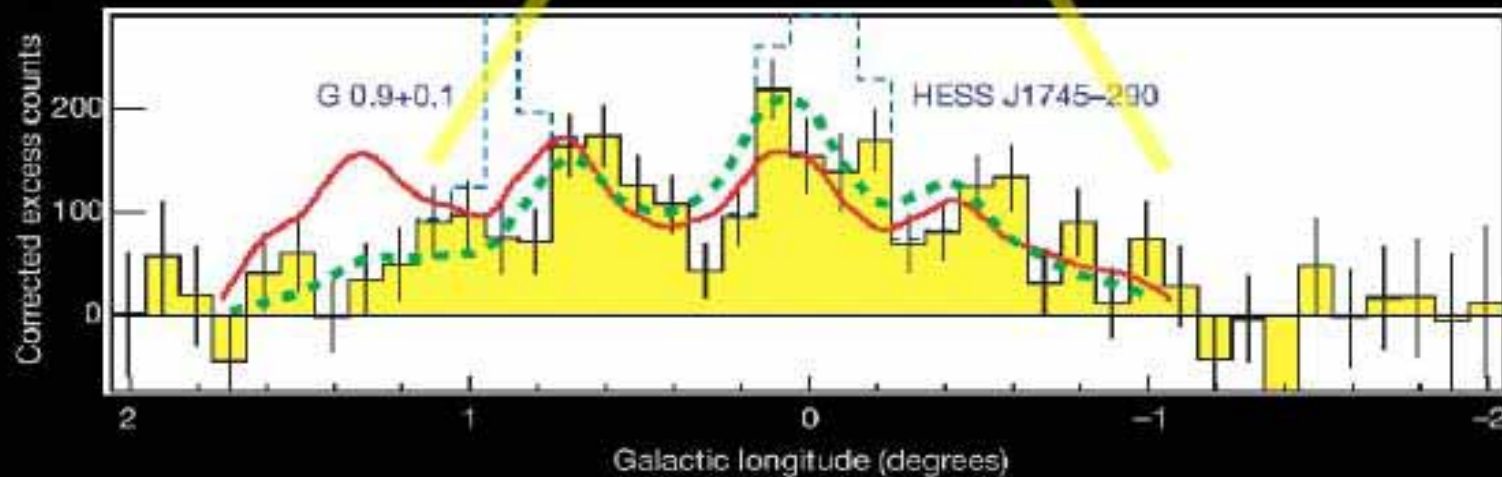
Same map after subtraction of
two dominant point sources =>
Clear correlation with molecular
gas traced by its CS emission

The center of our Galaxy

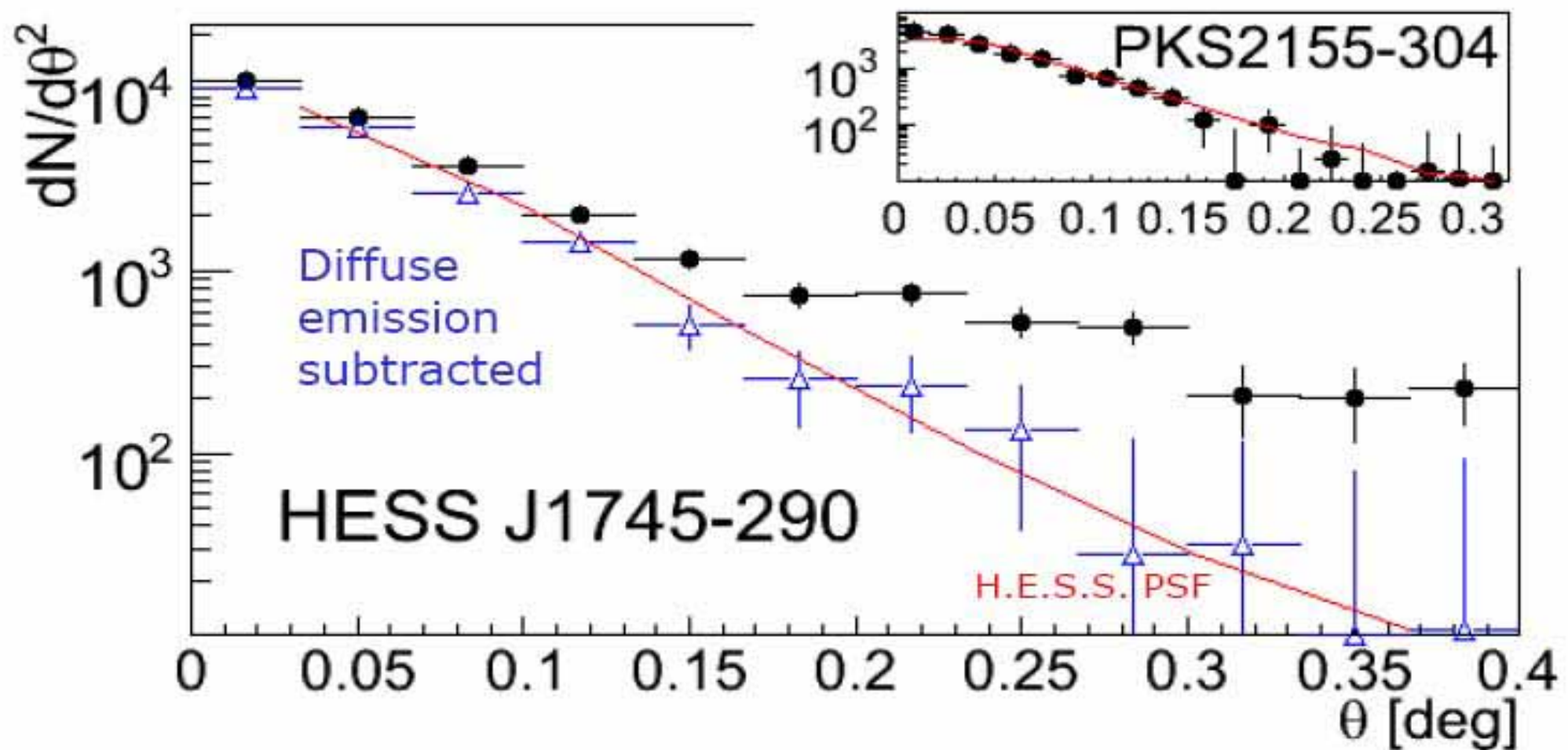


Nature
Feb. 2006

Galactic plane



Is it DM? ► Angular distribution



VHE AGN: Where do we stand as of Feb 2007

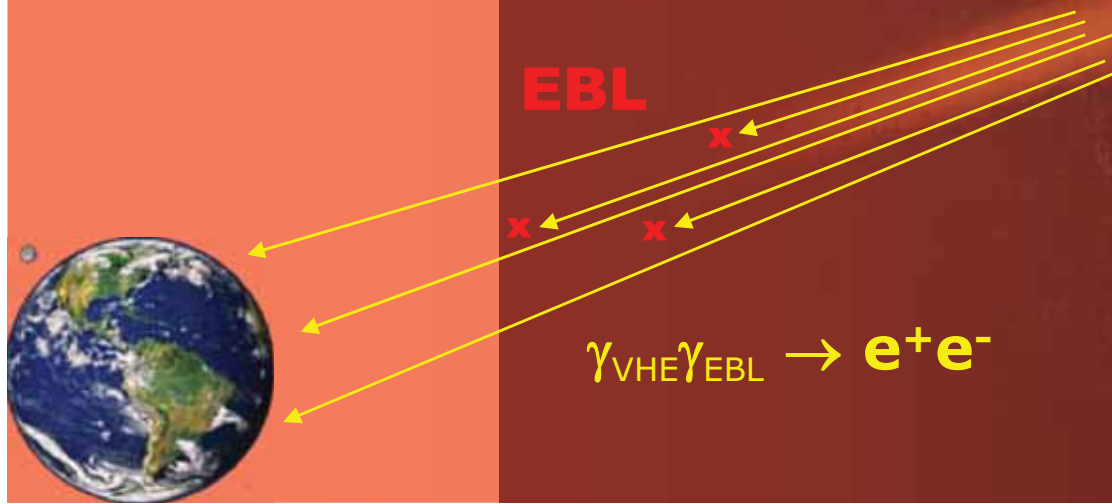
	Object	Redshift	Type	1 st Detection	
	M 87	0.004	FR I	HEGRA	
	Mkn 421	0.030	HBL	Whipple*	
	Mkn 501	0.034	HBL	Whipple*	-> Very large flare (MAGIC)
	1ES 2344+514	0.044	HBL	Whipple*	
	Mkn 180	0.046	HBL	MAGIC	
	1ES 1959+650	0.047	HBL	7-Tel. Array*	
→	PKS 0548-322	0.069	HBL	H.E.S.S.	~0.01 CRAB –very preliminary-
	PKS 2005-489	0.071	HBL	H.E.S.S.	
	PG 1553+113	>0.09	HBL	H.E.S.S. (+ MAGIC)	
	PKS 2155-304	0.116	HBL	Mark VI	-> Very large flare (H.E.S.S.)
	H 1426+428	0.129	HBL	Whipple*	
→	1ES 0229+200	0.139	HBL	H.E.S.S.	~0.02 CRAB –preliminary-
	H 2356-309	0.165	HBL	H.E.S.S.	} -> EBL constraint
	1ES 1218+304	0.182	HBL	MAGIC	
	1ES 1101-232	0.186	HBL	H.E.S.S.	
→	1ES 0347-121	0.188	HBL	H.E.S.S.	~0.03 CRAB –preliminary-

16 AGNs detected already + more coming soon...

Cosmological measurements from VHE Gamma Ray absorption

Extragalactic TeV astronomy

- Space is filled with diffuse extragalactic background light: sum of starlight emitted by galaxies through history of universe
- Gamma Rays absorbed by interaction with Background radiation fields



1ES 1101-232 ($z = 0.186$)

