Bonifacio September 12-15, 2005

FOCUSSING TELESCOPES IN NUCLEAR ASTROPHYSICS

P. Ubertini, IASF/INAF - Roma

INTEGRAL-HESS

Gamma

WAVE

The keV-TeV connection

The IBIS survey sources

- After first catalogue (Bird et al., ApJL, 2004)
  - **123 sources**, including:
  - 14 new unidentified sources
  - 14 other sources of unknown nature

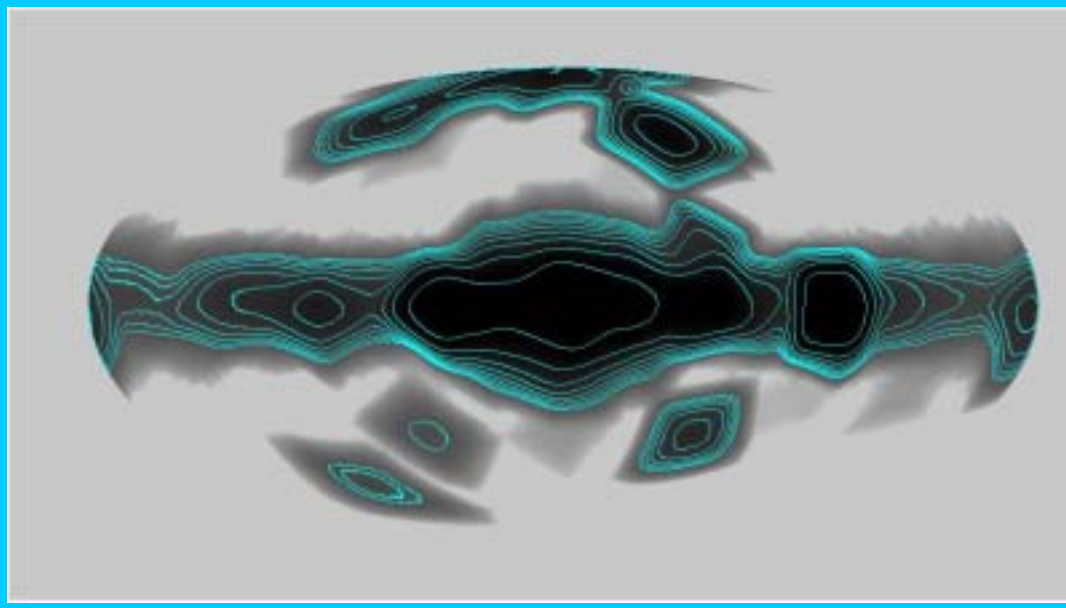
- ***The second catalogue*** (Bird et al., ApJ, 2005, in press)
  - **209 sources**, including:
  - 21 new unidentified sources>>decreasing
  - 22 other sources of unknown nature

- More than 30% of the sources detected by INTEGRAL/IBIS were not previously known

2st IBIS survey results

209 hard X-ray sources detected, of which:

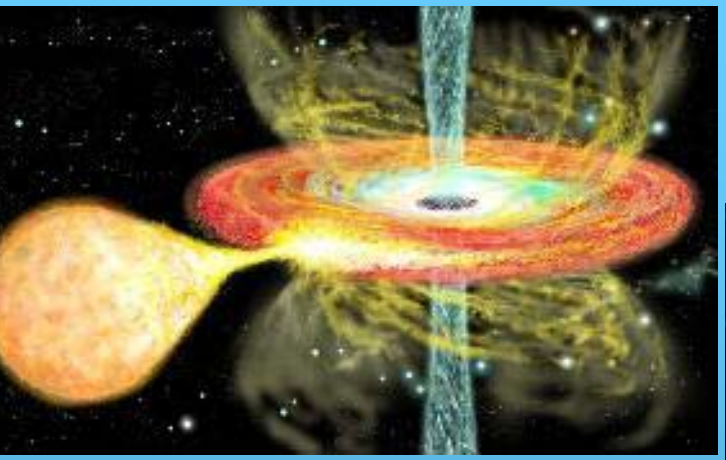
- **115 accreting objects**
  - 67 Low Mass X-ray Binaries
  - 38 Massive X-ray Binaries
  - 4 Supernova remnants
  - 4 Isol. PSRs & SGR
  - 2 Molecular Clouds
- **33 Extragalactic sources**
  - 2 Galaxy cluster
  - 22 Seyfert Galaxy
  - 3 Blazars
  - 6 unconfirmed AGN
- **57 unknown sources i.e.~25% of the sample**



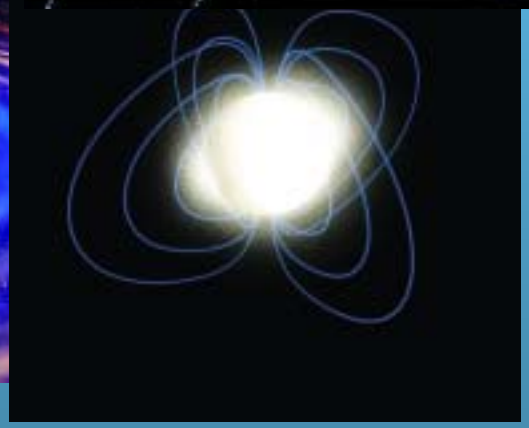
GC radian >2-5 Ms exposure

Bird et al. (2004)

What we expect these sources are…



Compact objects of all kinds.. and possibly hints of extended ones:



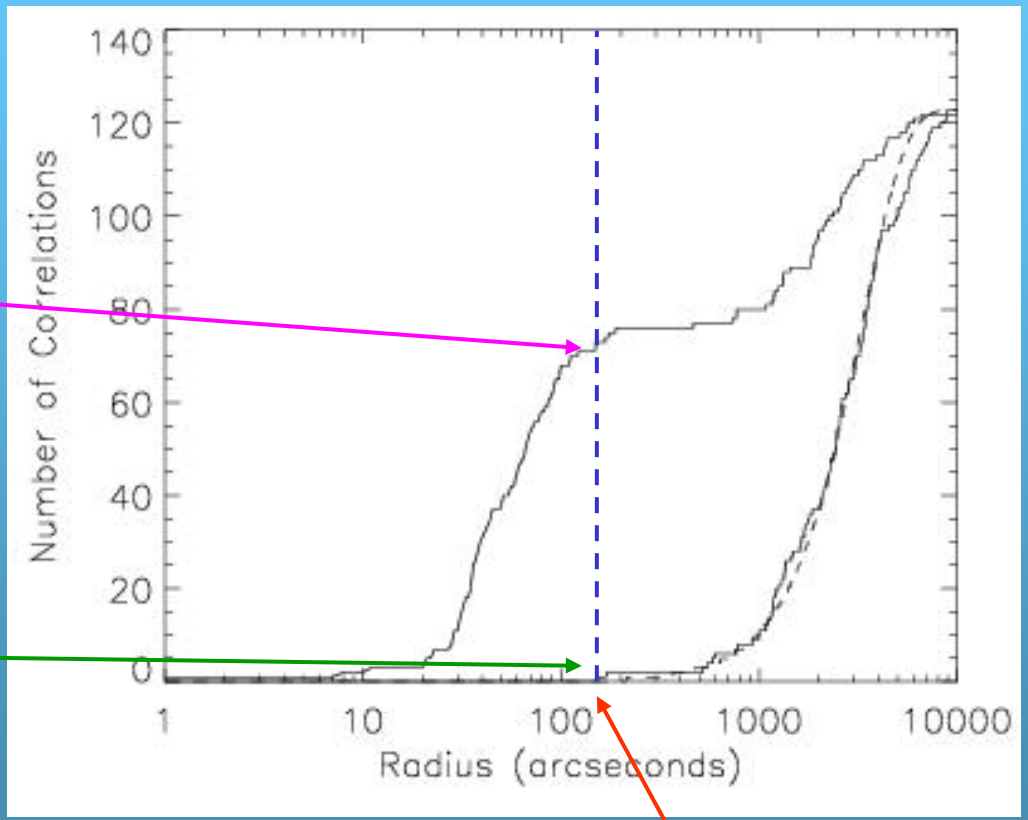
accreting stellar mass Binary BHs, galactic μQSO, X-ray pulsars, NSs (strongly and weakly, isolated, magnetars, accreting, etc…), SNRs, AGNs, QSOs, Clusters of Galaxies and hopefully more exotic objects, i.e. TeV emitters etc.

...or a systematic search we had to improve the source error box and positioning to perform a reliable optical identification…

Correlation with ROSAT catalogues

Assuming a (conservative) 3′ radius for all INTEGRAL error boxes, there are **75** IGR/ROSAT associations.

The number of expected chance associations instead is **0.35.**

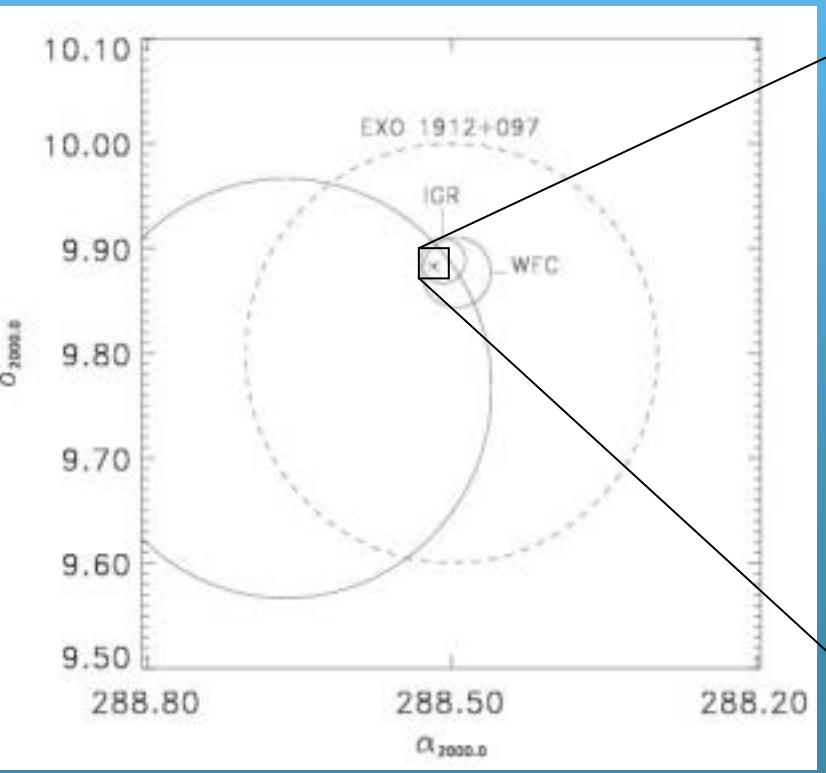


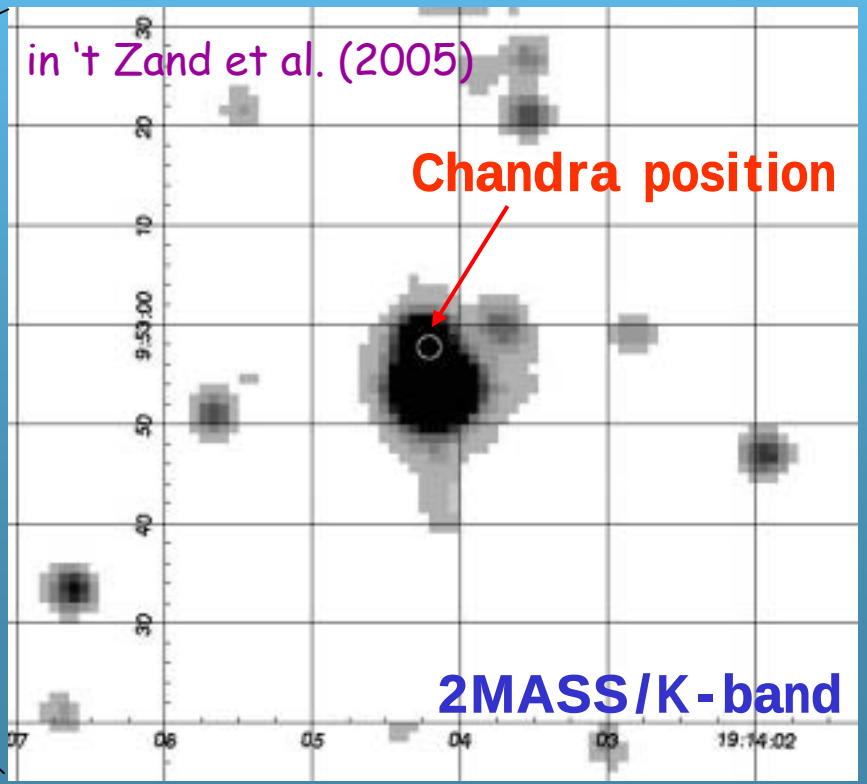
Stephen et al. (2005)

IGR J19140+0951 *galactic mess ….*

- X-ray persistent emitter (Rodriguez et al. 2005)
- MXRB with NS from X-ray data (Hannikainen et al. 2004)
- P_{orb} = 13.5 days (Corbet et al. 2004)
- subarcsec X-ray position with Chandra (in 't Zand et al. 2005)
- optical spectrum of an early-type star (in 't Zand et al. 2005)

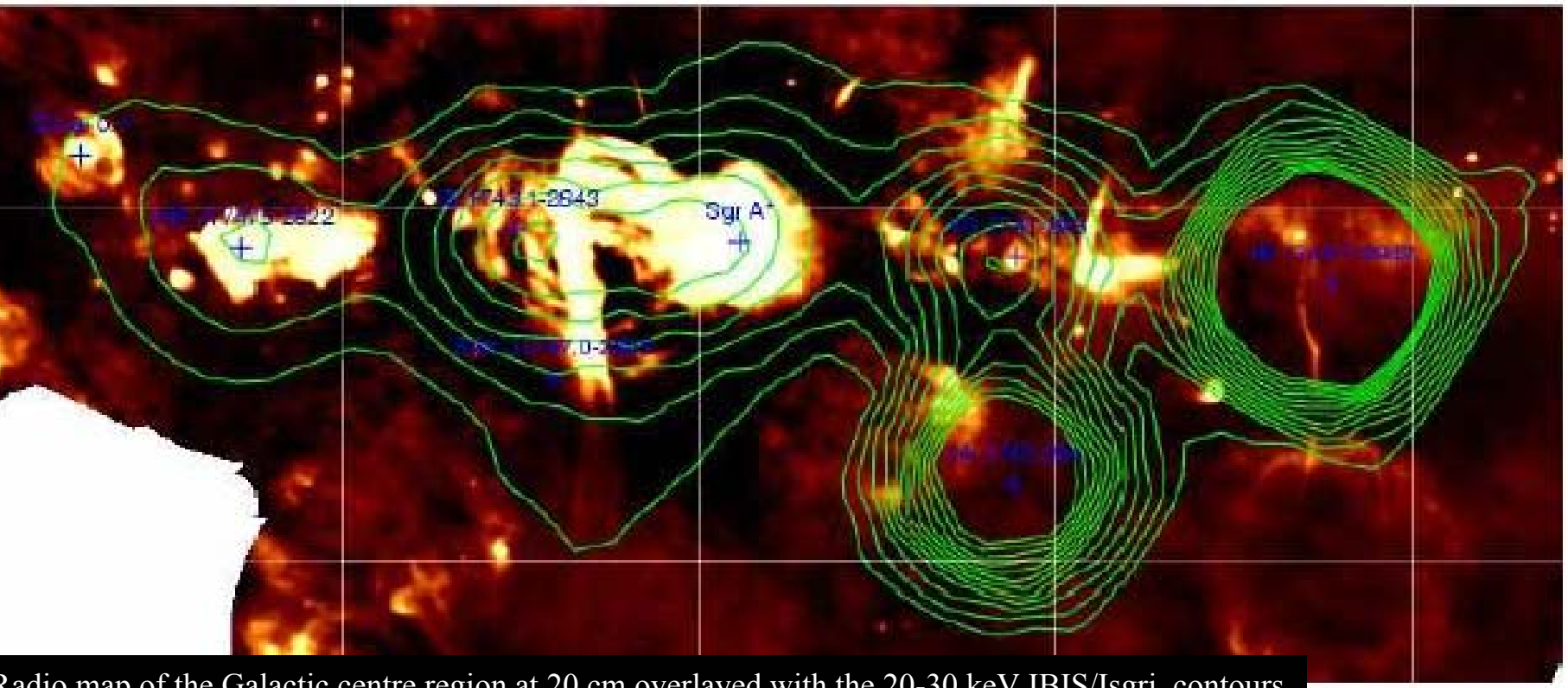
MXRB with supergiant





*The Centre of our Galaxy Sgr A**

- *Deep study of the Sgr A* region*
- *4.7 Ms with Integral + 0.6 Ms with XMM*
- *Soft γ-ray emission centered within 1'; "faint persistent" IGR J17456-2901 (power law α=3)*
- *Hint of compact diffuse emission region i.e. not hot thermal plasma in the SGR complex nor integrated flux of transients near the SMBH neither the SgrA* flaring extrapolation*

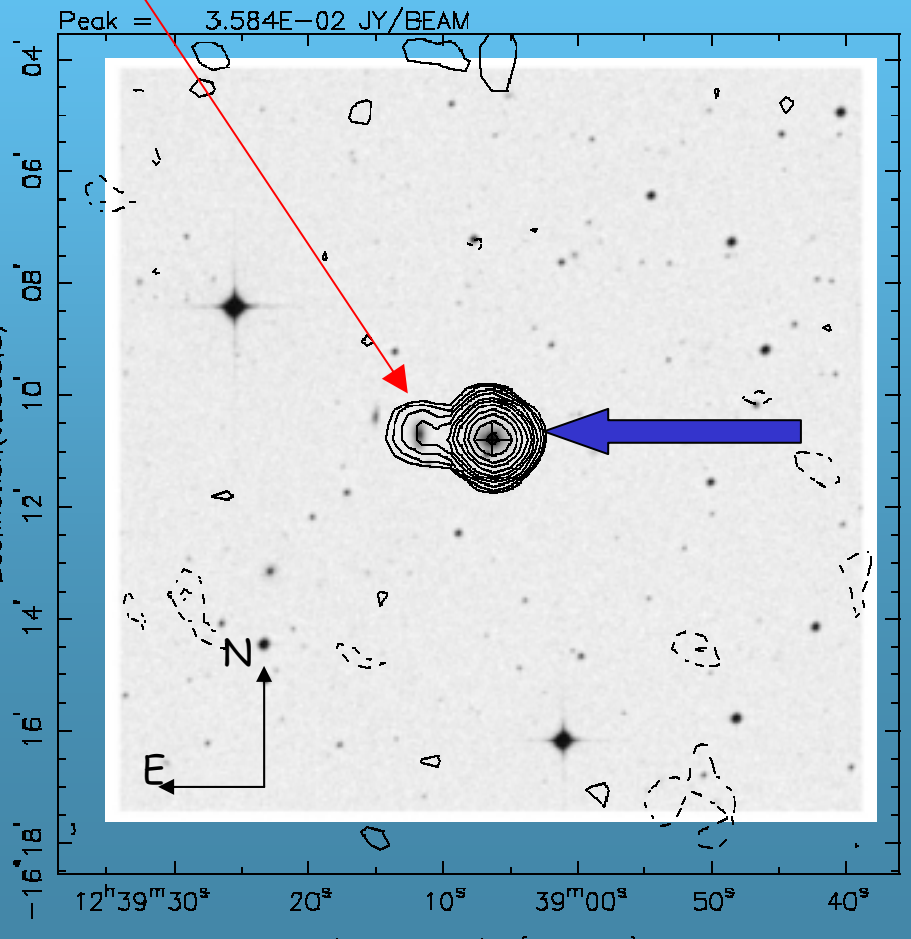


Radio map of the Galactic centre region at 20 cm overlayed with the 20-30 keV IBIS/Isgri contours

...and extracgalactic confusion! IGR J12391-1610 = LEDA 17019

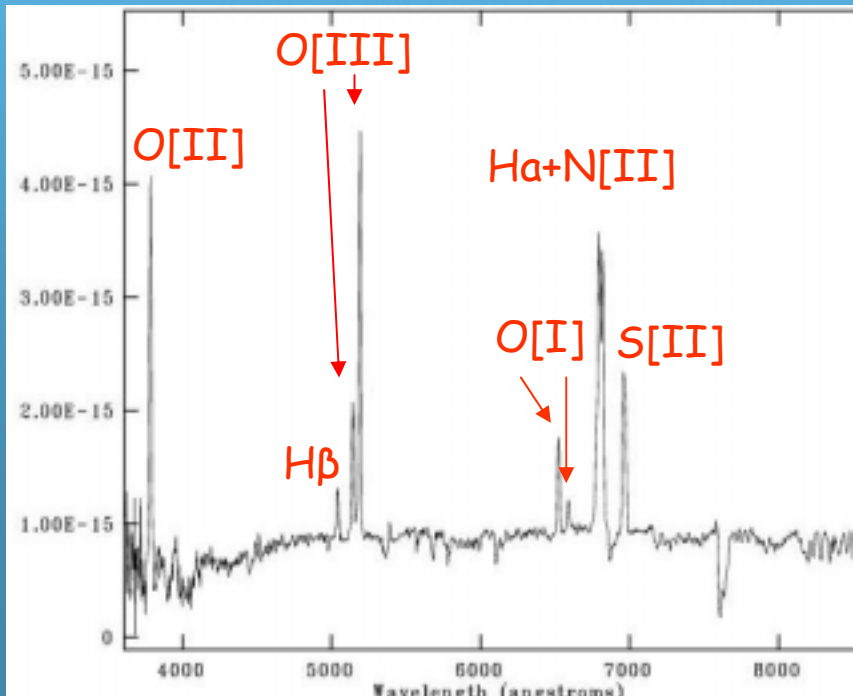
- galaxy at $z = 0.037$ (da Costa et al. 1998
- d = 176 Mpc; unknown spectral type
- radio emitter: $F_{1.4\ GHz} = 39.4 \pm 1.6$ mJy
- $F_{20\text{-}40\ keV} = (2.0 \pm 0.4) \cdot 10^{-11}$ erg/cm^2 s
- $F_{40\text{-}100\ keV} = (5.2 \pm 0.8) \cdot 10^{-11}$ "

Ha-emission line galaxy at $z = 0.071$
adio emitter: $F_{1.4\ GHz} = 3.8 \pm 0.5$ mJy
co-responsible of X-rays?



Type 2 Seyfert galaxy

- $L_{20\text{-}40\ keV} \sim 7.3 \cdot 10^{43}$ erg s^{-1}
- $L_{40\text{-}100\ keV} \sim 1.9 \cdot 10^{44}$ erg s^{-1}

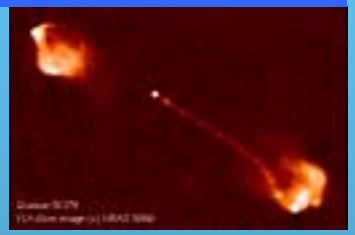


(Selected) science themes

Cosmic accelerators
The most dynamic and powerful sites in the Universe

- **Accretion on compact objects**

Binaries
μ-blazars
AGN



- **Rotation of neutron stars**

Pulsars
Magnetars

- **Explosions and shocks**

GRB
SNR
Stellar winds

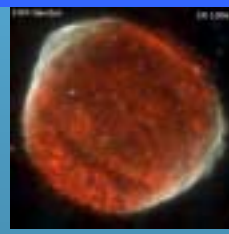
Cosmic explosions
The most violent events in the Universe

- **Gravitational collapse**

Core-collapse SN
GRB

- **Thermonuclear explosions**

Type Ia SN



- **Thermonuclear runaways**

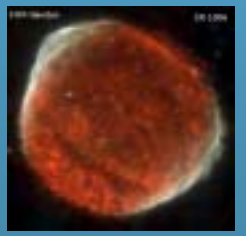
Novae
X-ray bursts

Selecting in particular

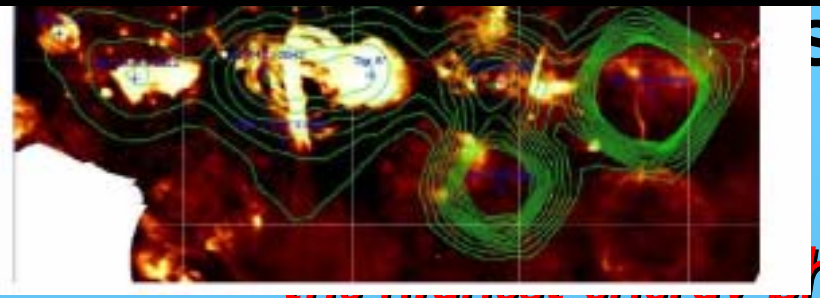
Cosmic accelerators
The most dynamic and powerful sites in the Universe

- Explosions and shocks

GRB
SNR **And PWN**
Stellar winds

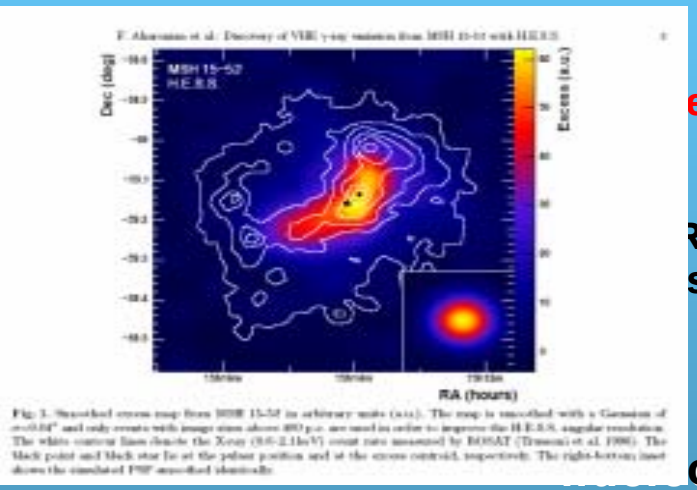


A NEW COSMIC HIGH ENERGY ACCELERATOR FROM KEV TO TEV



S sources
emitting

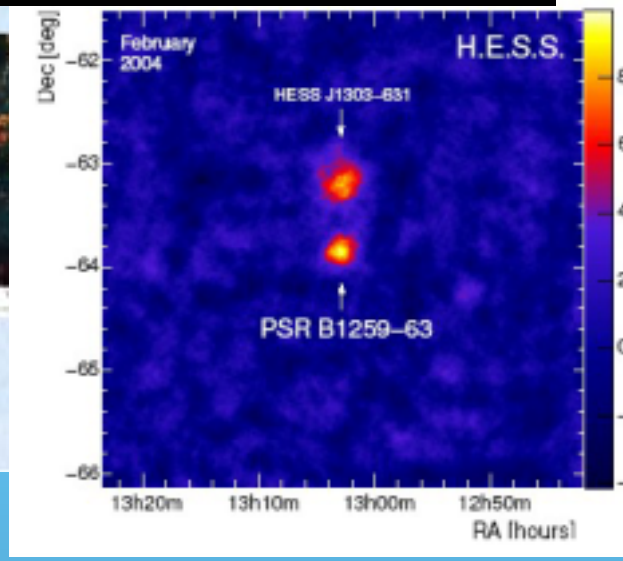
photons from

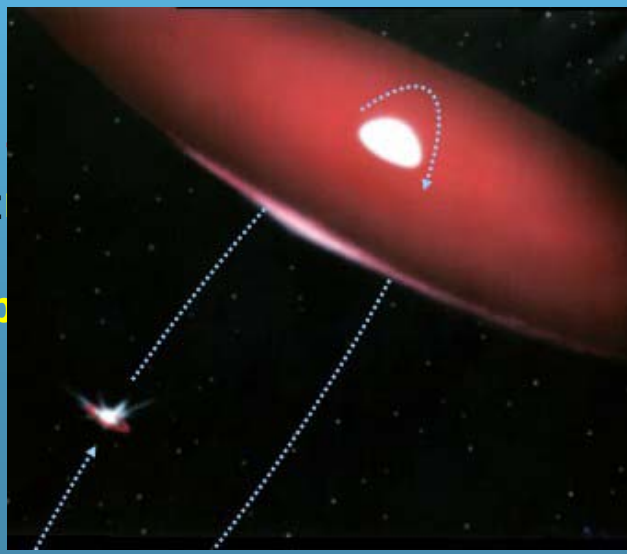


e Accelerators

Regions
s (pulsar / microQSO)

counterparts can be
ons rather than elect





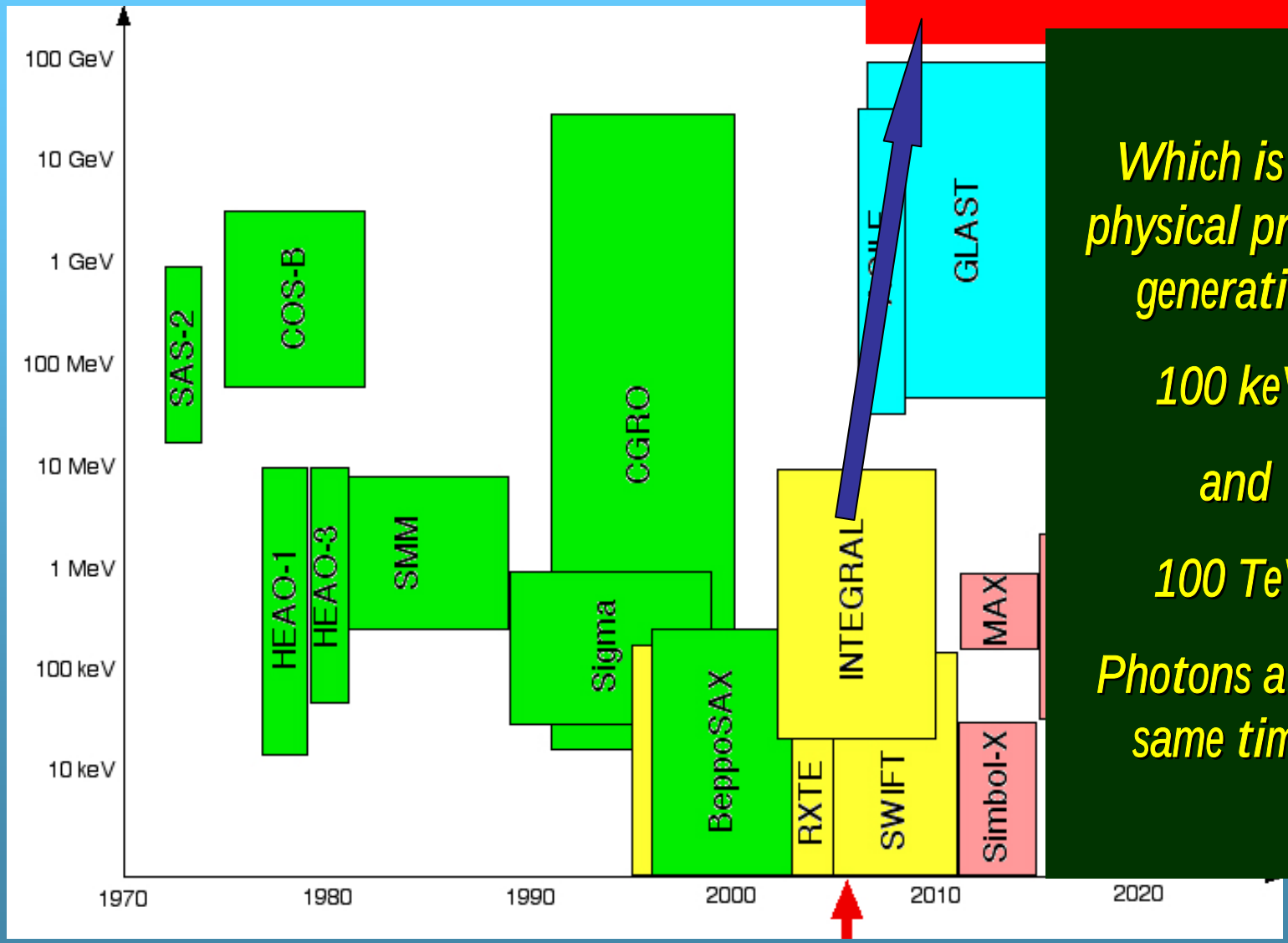
HESS sources with IBIS / ISGRI counterp

Crab Nebula	PWN
MSH15-52	PWN
Galactic Center	??
PSR B1259-63	HMXRB

New ones to come……

Observing the Gamm

HESS



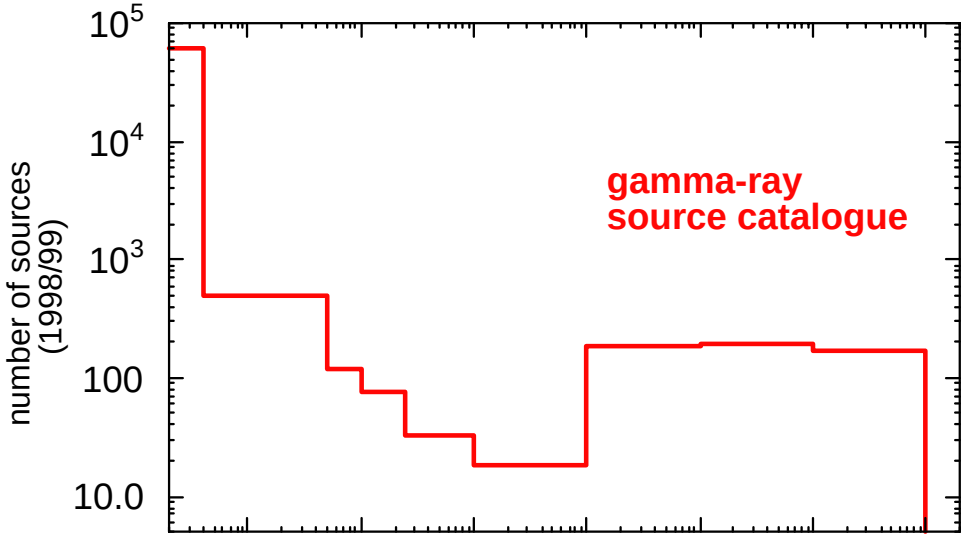
Which is the physical process generating

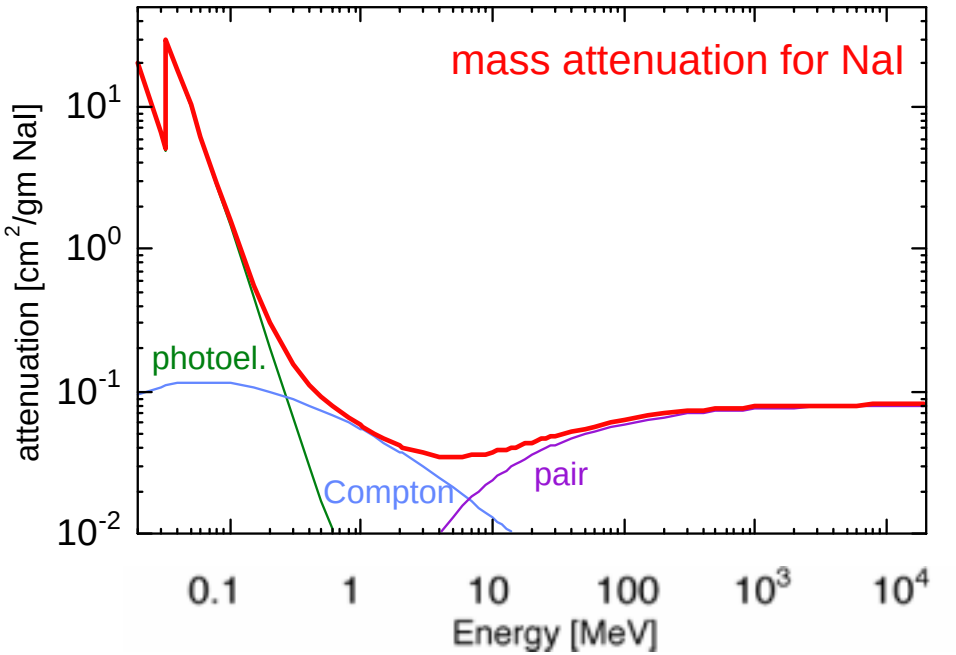
100 keV

and

100 TeV

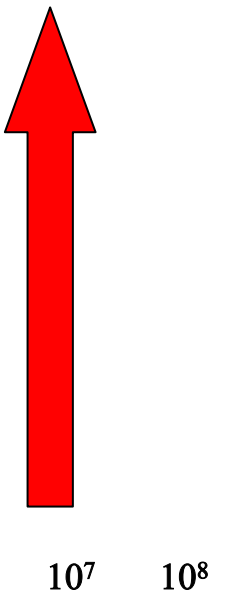
Photons at the same time?





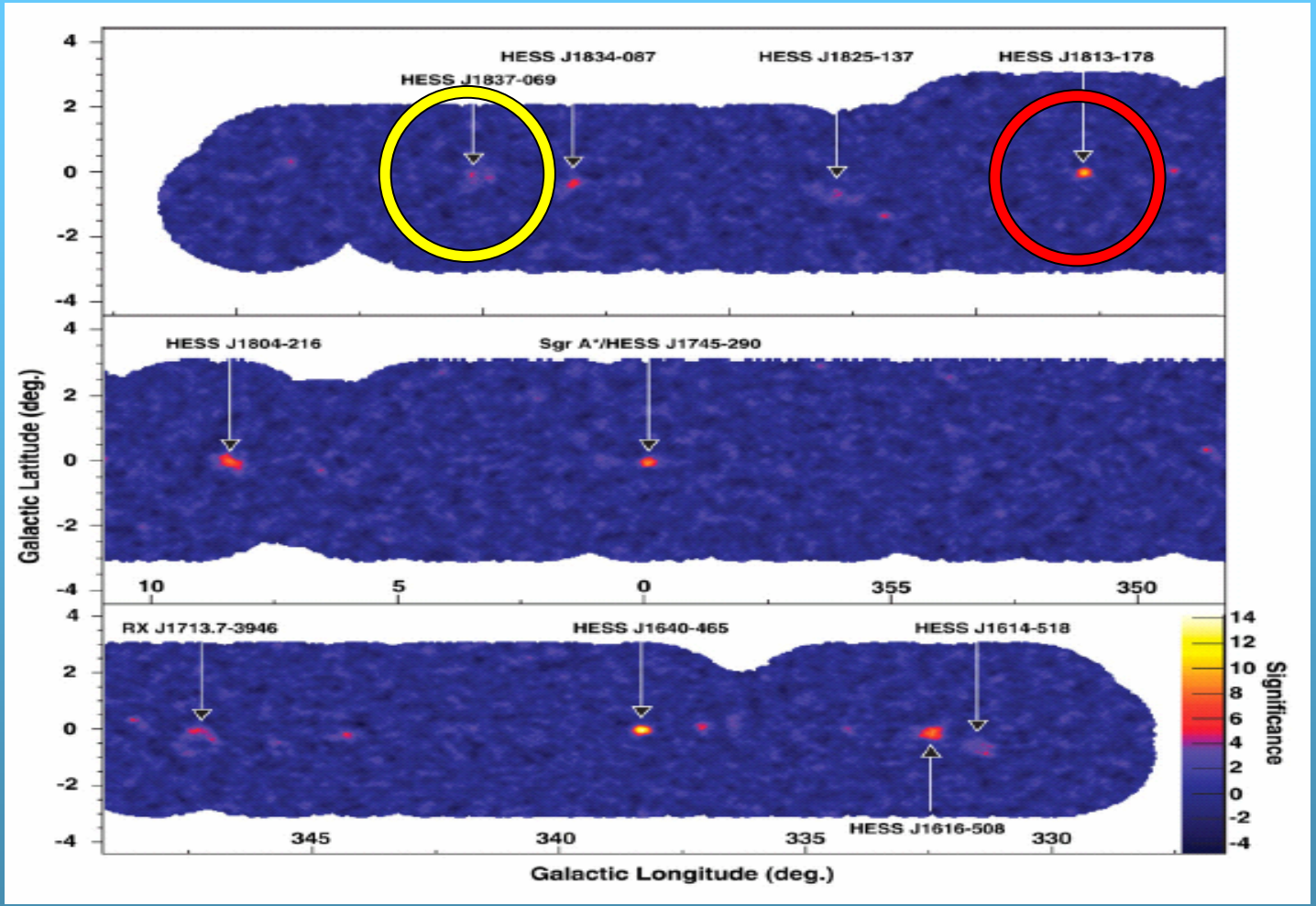
A new class of high energy sources

HESS



10^5 10^6 10^7 10^8

Unidentified H.E.S.S. Sources



HESS significance map of the Galactic Plane Scan (Aharonian et al., 2005)

Unidentified HESS Sources

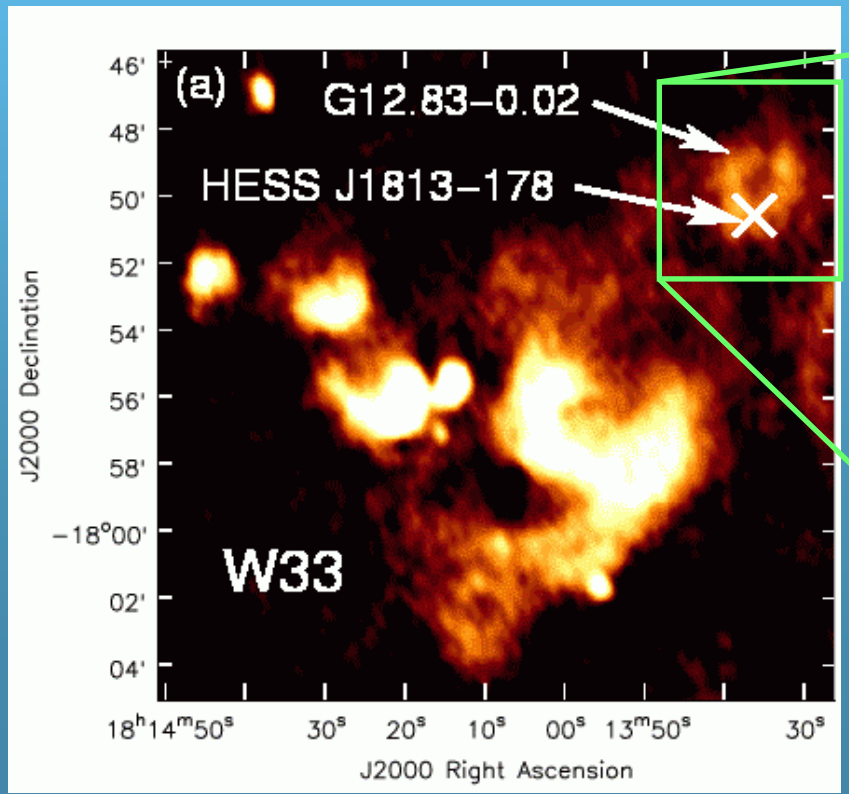
Name	Position		Size σ	Significance					Flux
	l	b	(arcmin.)	S_1	S_2	S_3	S_4	S_5	
HESS J1614-518†	331.54°	−0.59°	12	5.2	4.3	6.7	4.7	6.8	9
HESS J1616-508	332.40°	−0.15°	11	7.4	8.9	11.6	10.5	12.8	17
HESS J1640-465	338.32°	−0.02°	2	11.7	8.3	14.3	13.4	11.5	19
HESS J1804-216	8.44°	−0.05°	13	8.2	5.9	10.1	8.8	9.6	16
HESS J1813-178	12.81°	−0.03°	3	10.2	8.3	13.2	12.2	8.9	12
HESS J1825-137†	17.78°	−0.72°	10	4.4	3.7	5.8	3.7	6.5	9
HESS J1834-087	23.28°	−0.34°	12	6.7	5.6	8.7	7.2	7.8	13
HESS J1837-069	25.21°	−0.12°	4	6.0	6.0	8.4	6.9	6.4	9

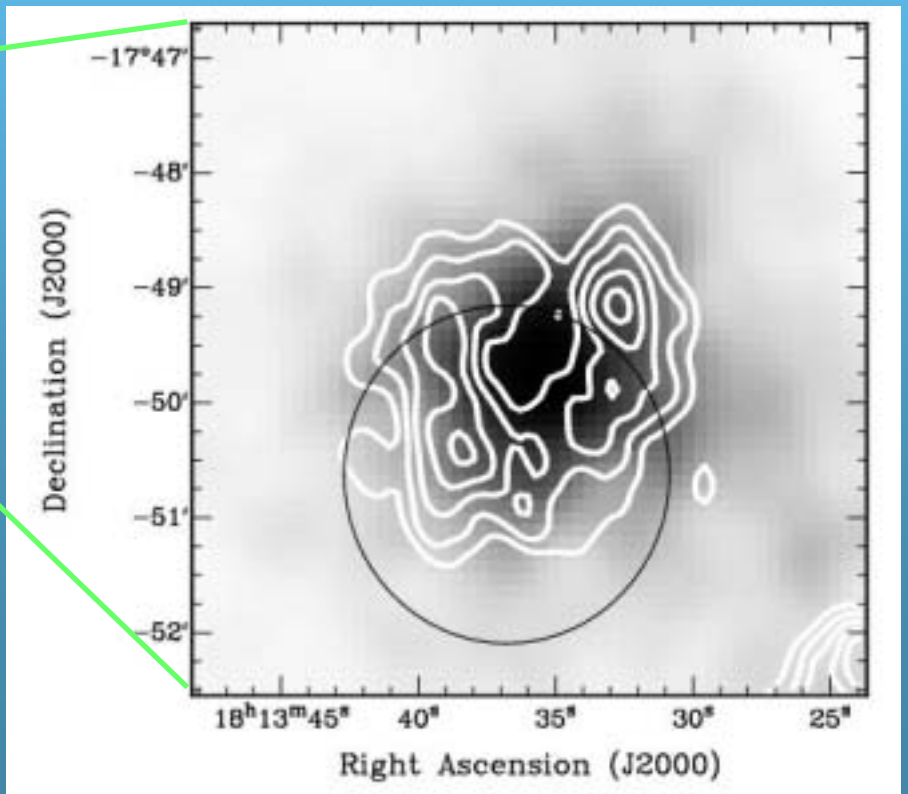
Table 1: Characteristics of the new γ-ray sources. Position: Galactic Longitude (l) and Latitude (b) with a statistical error in the range of 1-2 arcmin. Size: estimated source extension σ for a brightness distribution of the form $\rho \propto exp(-r^2/2\,\sigma^2)$ with a statistical error in the range of 10-30%. S_1: Significance for a point source cut of $\theta^2 = (0.14^\circ)^2$, using scan data only, without correction for the number of trials. S_2: As for S_1 but only including follow-up observations of this source (no correction needed). S_3: Significance of combined scan and follow-up observations (as shown in Fig. 1). S_4: As S_3 but including a correction for the number of trials ($n = 250000$). S_5: As for S_4 but with an extended cut of $\theta^2 = (0.22^\circ)^2$. Flux: Estimated flux above 200 GeV ($\times 10^{-12}$cm^{-2}s^{-1}) with a statistical error between 10-35%. †: These sources were re-observed within the field of view of dedicated observations of another target.

IGR J18135-1751 has now an X and soft γ-ray counterpart

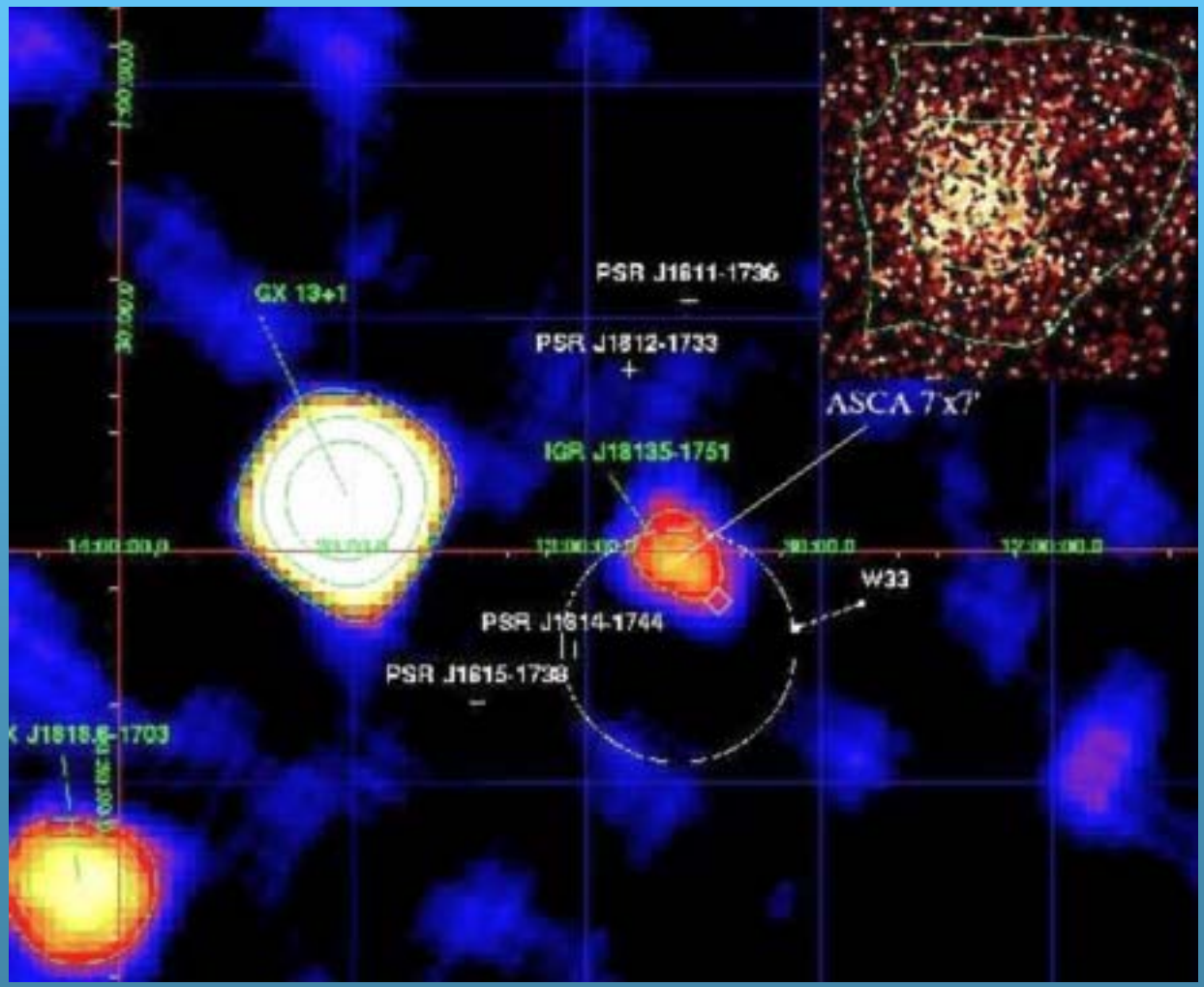
- HESS TeV source (Aharonian et al. 2005)
- radio counterpart (Brogan et al. 2005)
- IGR/ASCA X-ray source (Ubertini et al. 2005)

→ **SNR (a 'dark particle accelerator' ?)**



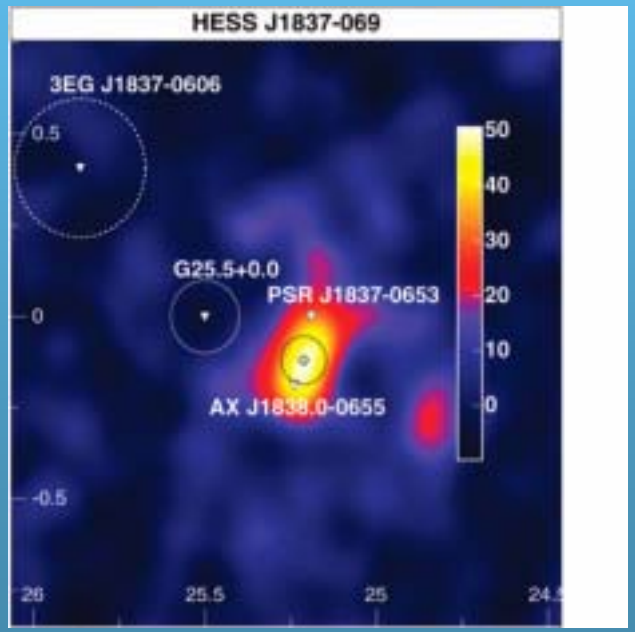


IGR J18135-1751=HESS J1813-178:
A NEW COSMIC HIGH ENERGY ACCELERATOR FROM KEV TO TEV

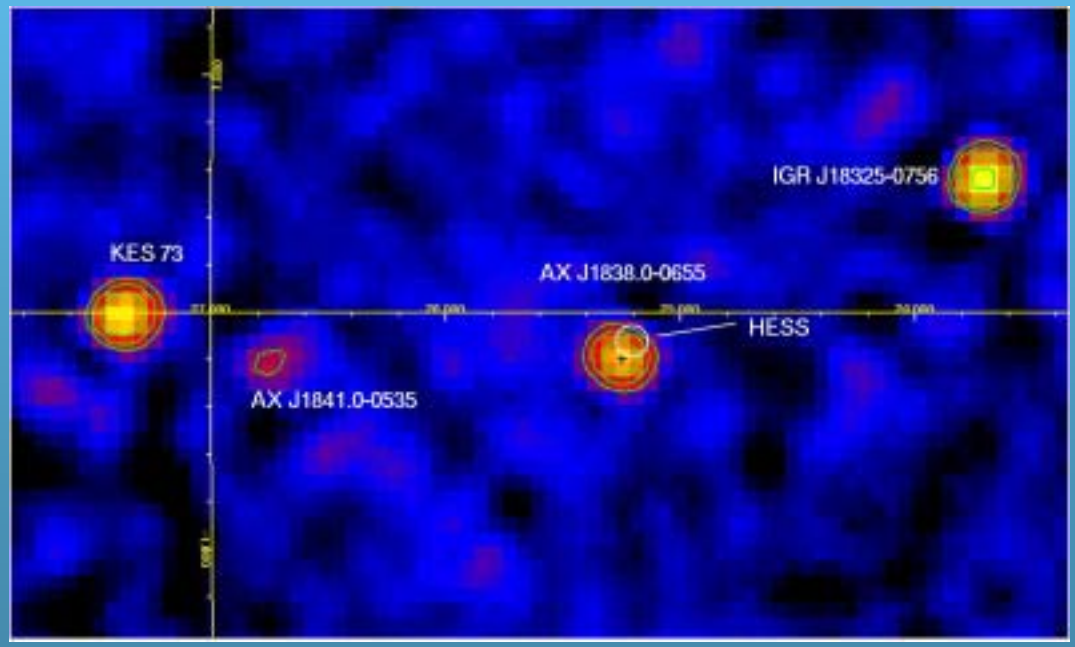


AX J1838.0-0655=HESS J1837-069
a nice surprise…from a muddy ASCA object!

GeV to TeV map….. and



…soft gamma ray map

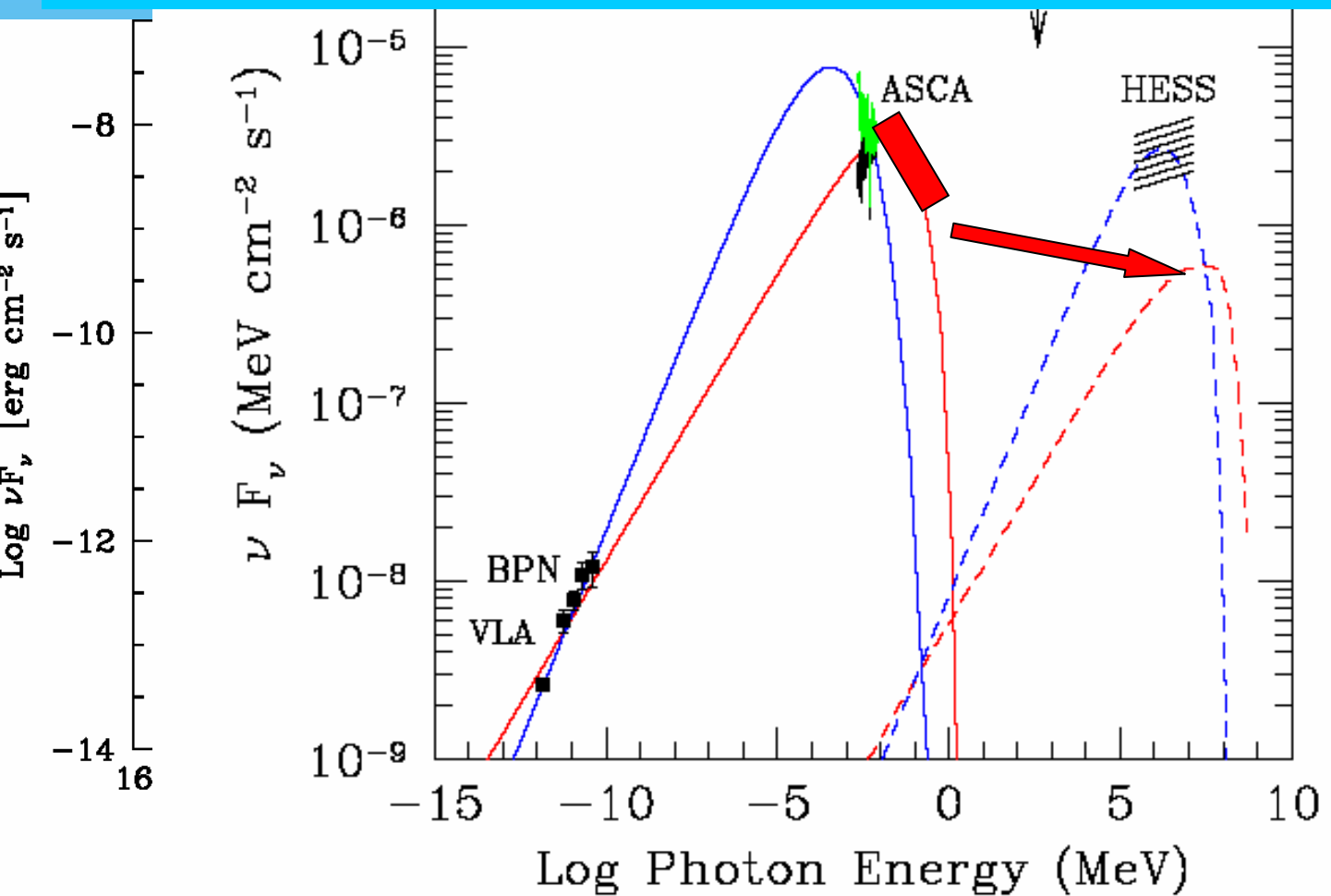


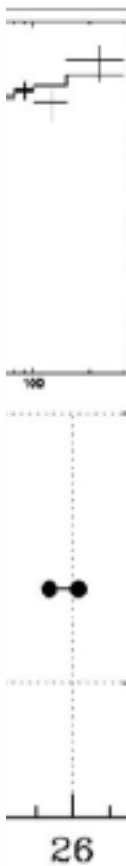
Electron or proton generate soft and TeV γ – rays?

*Serching for more **IBIS/HESS** counterpart ….*

…The syncrhotron – Inverse Compton models do not work well >>

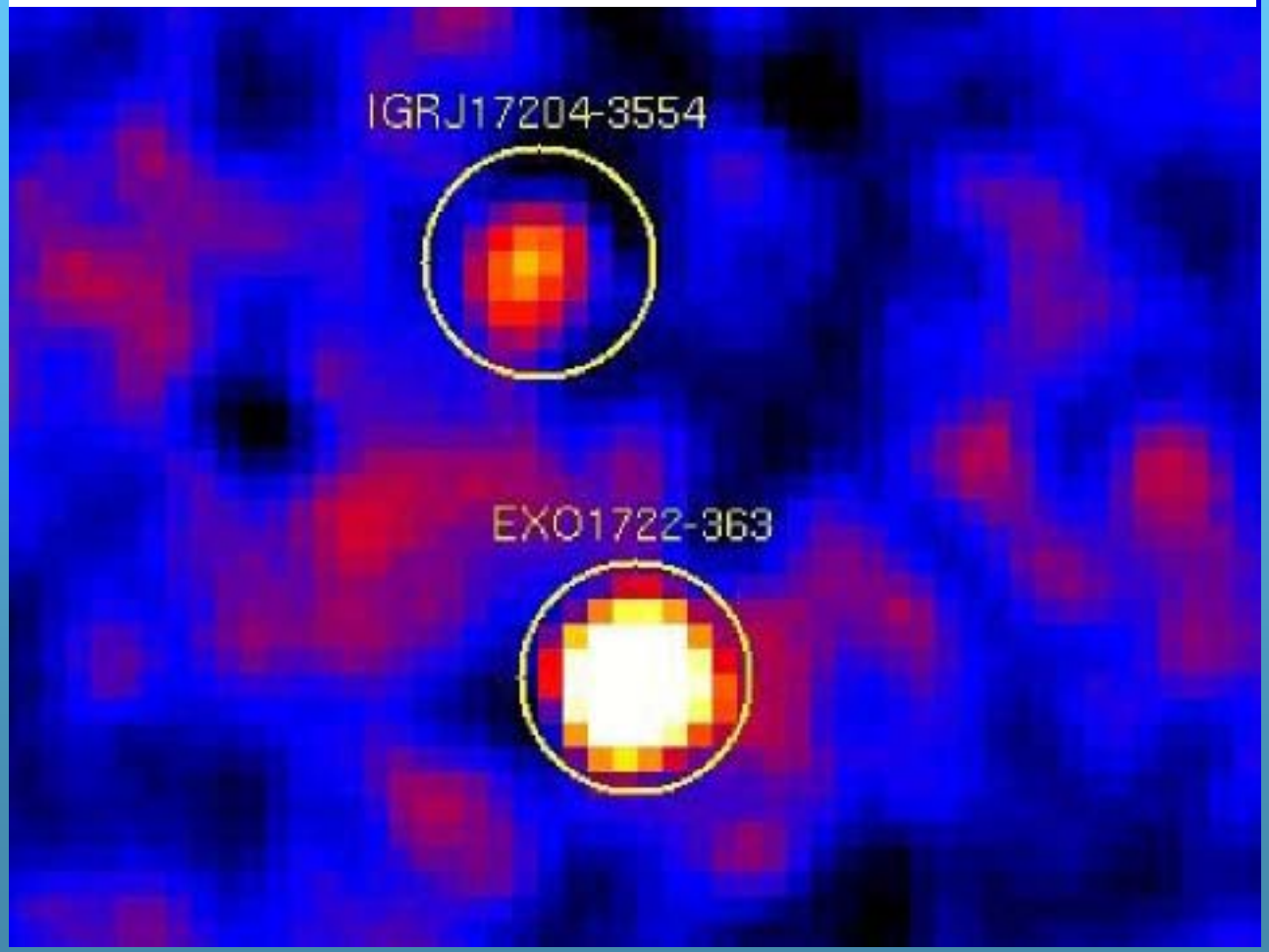
Not enough photons and electron life time too short…



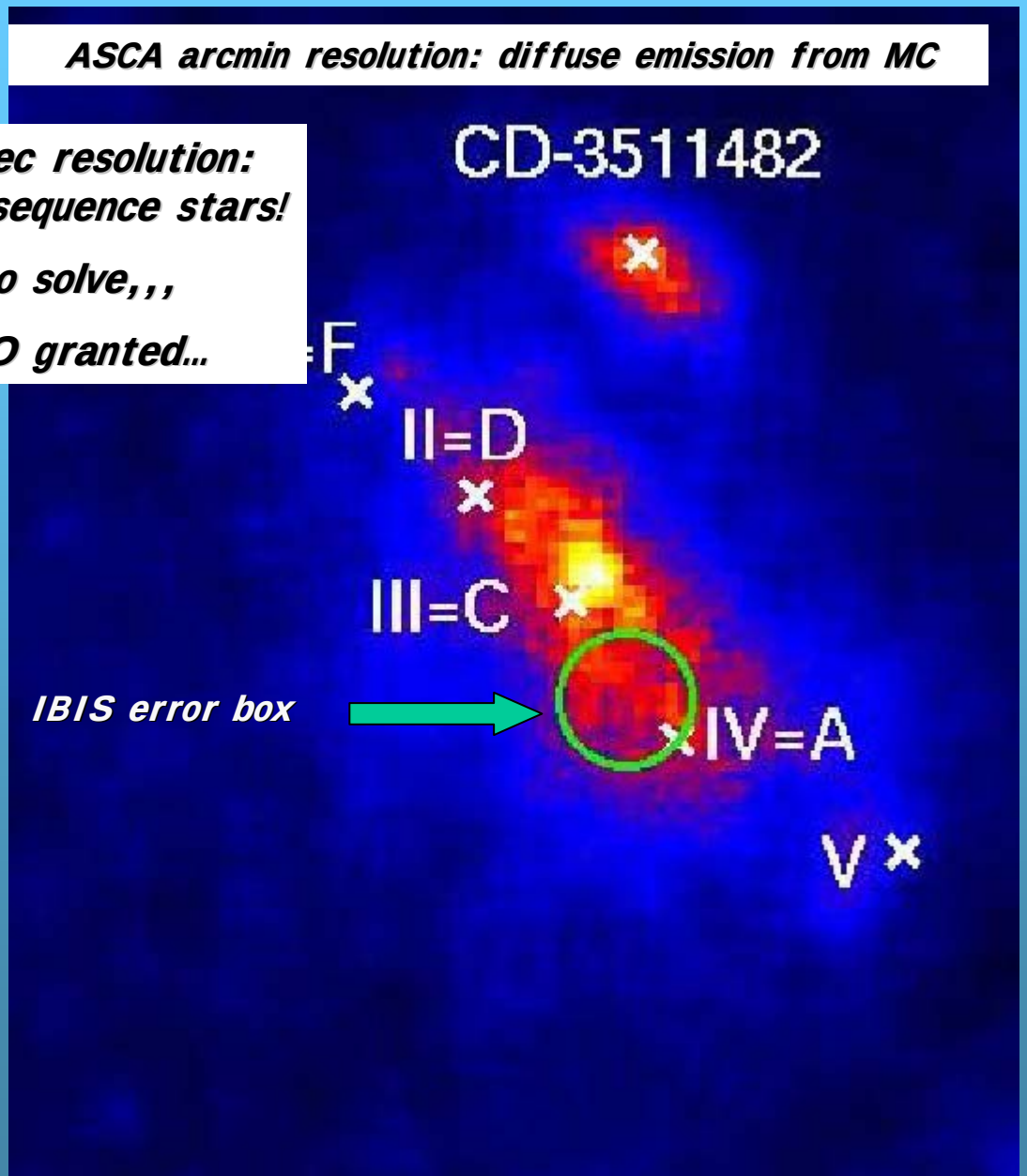


Mol Cloud NGC 6334: one more of the same kind?

IBIS arcmin resolution: emission from MC? A SNR HESS type emission? Search for a SNR in the region… we found one!



Mol Cloud NGC 6334: one more of the same kind?

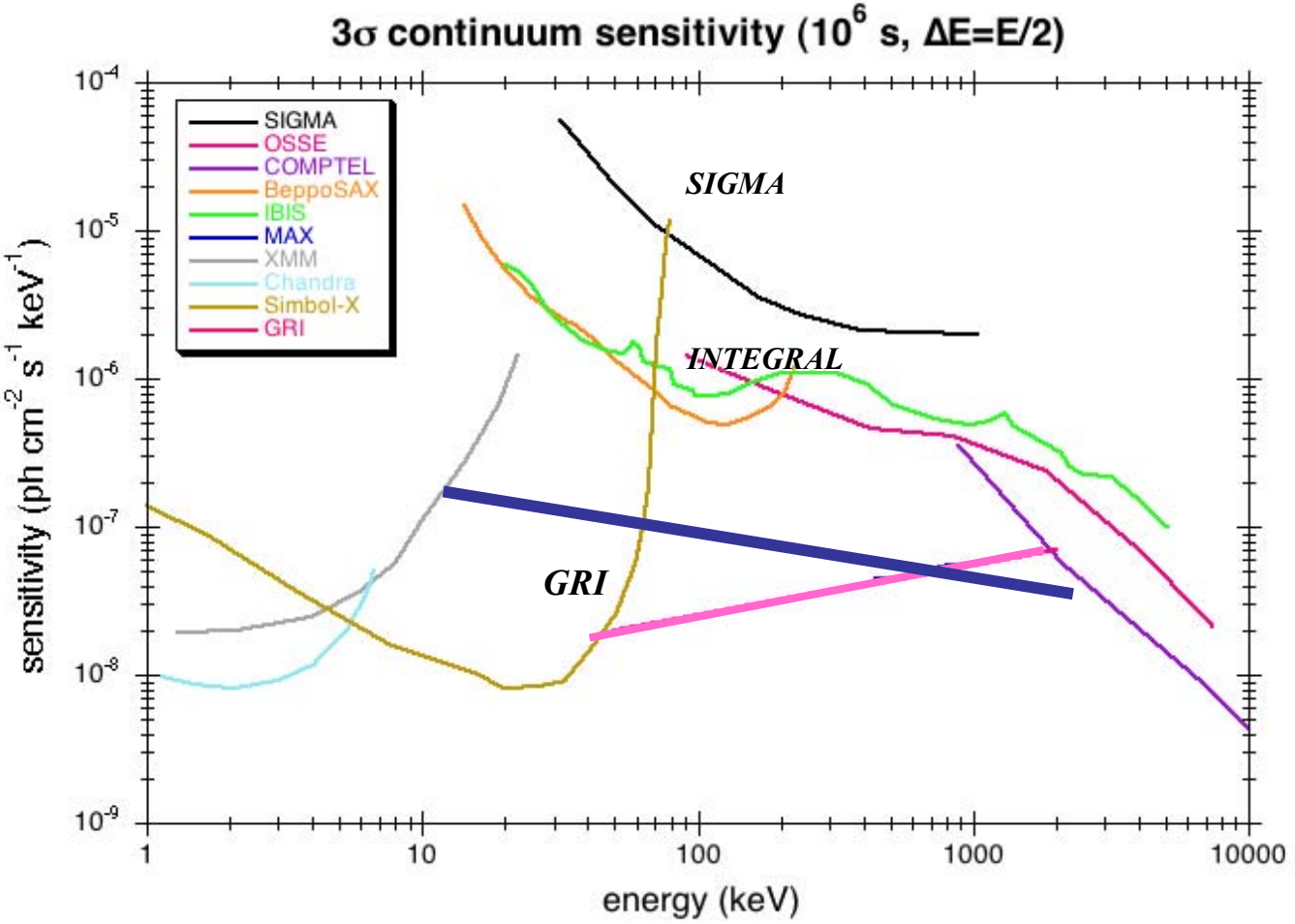


CHANDRA arcsec resolution:
ots os pre main sequence stars!

A mistery to solve,,,

a SWIFT ToO granted…

The Gamma-Ray sensitivity leap



The Gamma-Ray sensitivity leap:
basic scientific requirements

- *Sensitivity is mandatory in the gamma ray domain*
- *Angular resulution is also essential to avoid source confusion*
- *Photons are necessary to do physics : i.e timing, spectra, polarisation studies*

- *The Integral arcmin era is over >> arcsec is needed for future experiments with as ensitivity breakthrough*
- *Over a degree or so FoV, desired zooming capability?*
- *< 10 μCrab sensitivity in the 10 – 600 keV range is possible, better not easy within the mandatory scientific requirements*

adding a low energy coded mask (>1m²) to the clean lens concept?