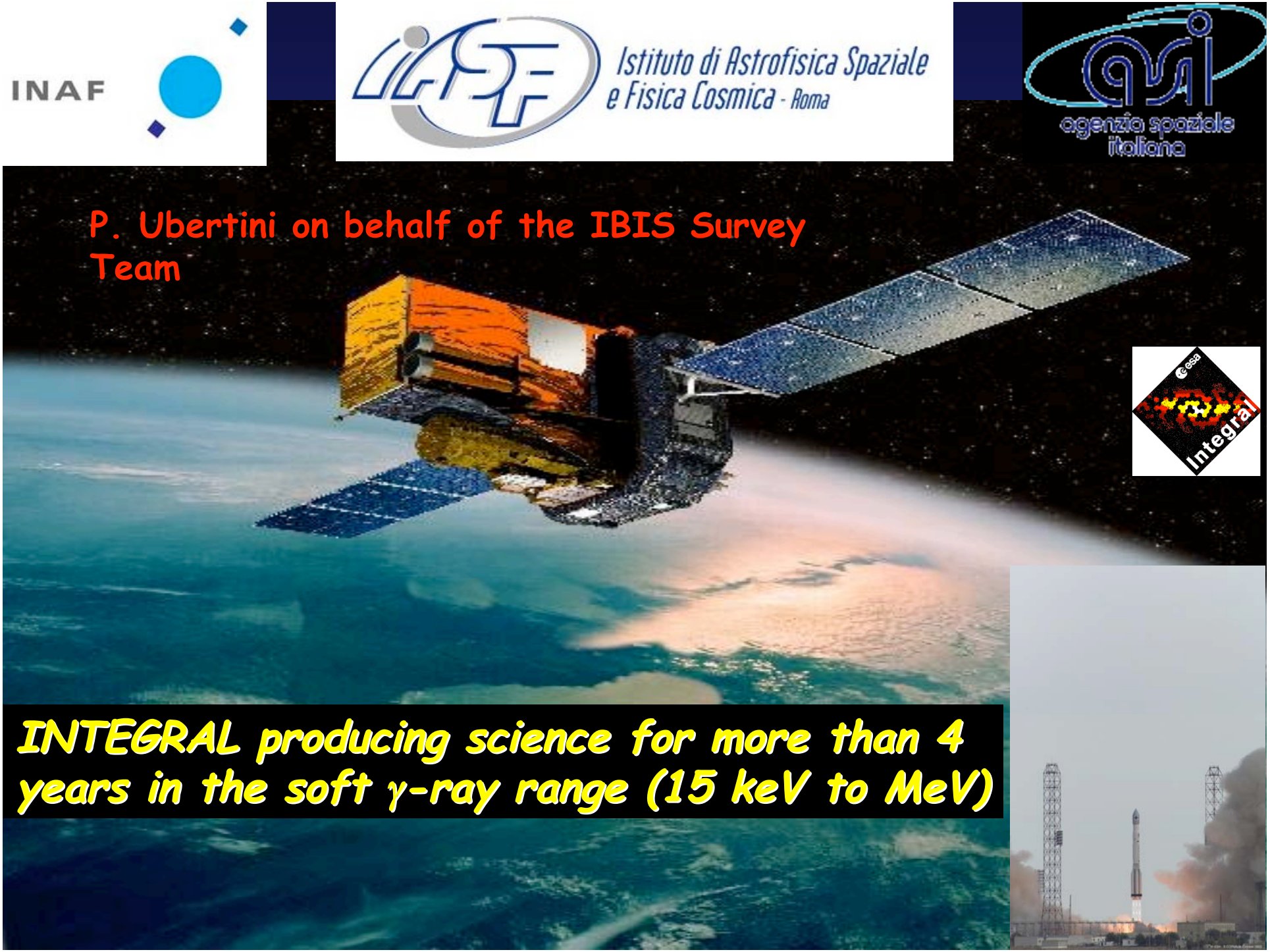
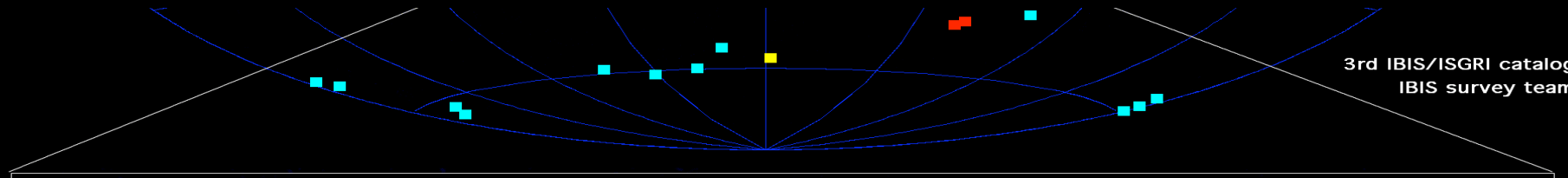

INAF
Istituto di Astrofisica Spaziale e Fisica Cosmica - Roma
agenzia spaziale italiana
P. Ubertini on behalf of the IBIS Survey Team
esa
Integral
INTEGRAL producing science for more than 4 years in the soft γ-ray range (15 keV to MeV)

The INTEGRAL Sky

The lower image shows a false colour image of the central region of our galaxy. This is a composite image based on all-sky IBIS/ISGRI maps in three energy windows between 17 and 100 keV and represents the true 'X-ray colours' of the sources.
Red sources are dominated by emission below 30 keV, while blue sources have harder spectra, emitting strongly above 40 keV.



3rd IBIS/ISGRI catalog
IBIS survey team

Zoom of the Central Radiant of the Galaxy

The upper image shows the distribution on the sky of four of the main populations observed in the third INTEGRAL/IBIS survey catalogue.
Of the known systems, the low-mass X-ray binaries (LMXB) are old systems mainly populating the galactic bulge, the high-mass X-ray binaries (HMXB) are younger systems seen along the galactic plane, and the active galactic nuclei (AGN) are extragalactic sources seen over the whole sky.
Around one in four of the sources seen by INTEGRAL are unidentified, and their distribution is also shown.

http://heasarc.gsfc.nasa.gov/docs/objects/heapow/heapow.html

3rd IBIS/ISGRI soft gamma-ray source catalogue

The 3rd IBIS catalogue (Bird et al., 2007, ApJ Supplement in press),

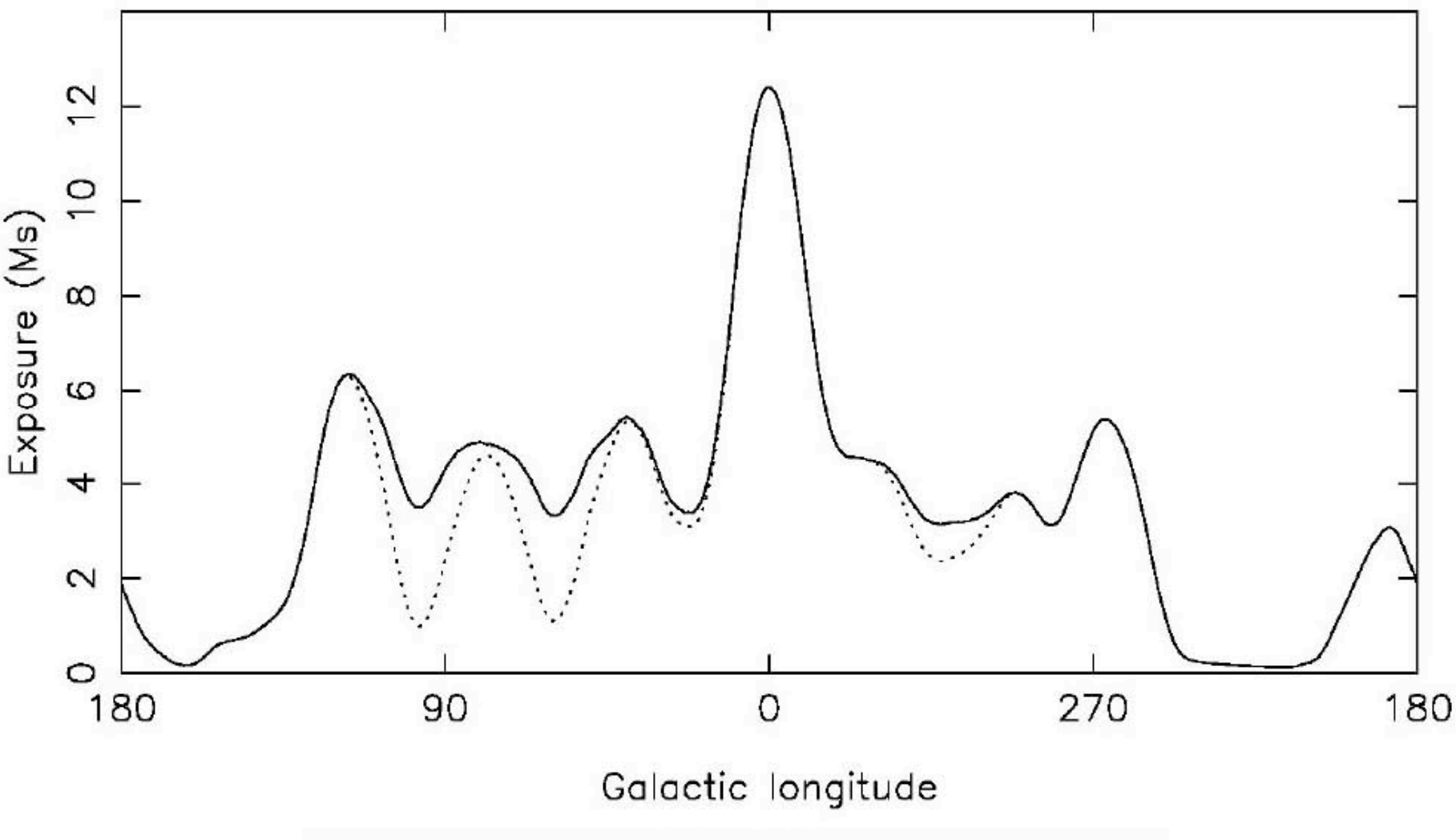


Fig. 1.— Exposure maps for the third IBIS/ISGRI catalog observations

3rd IBIS/ISGRI soft gamma-ray source catalogue

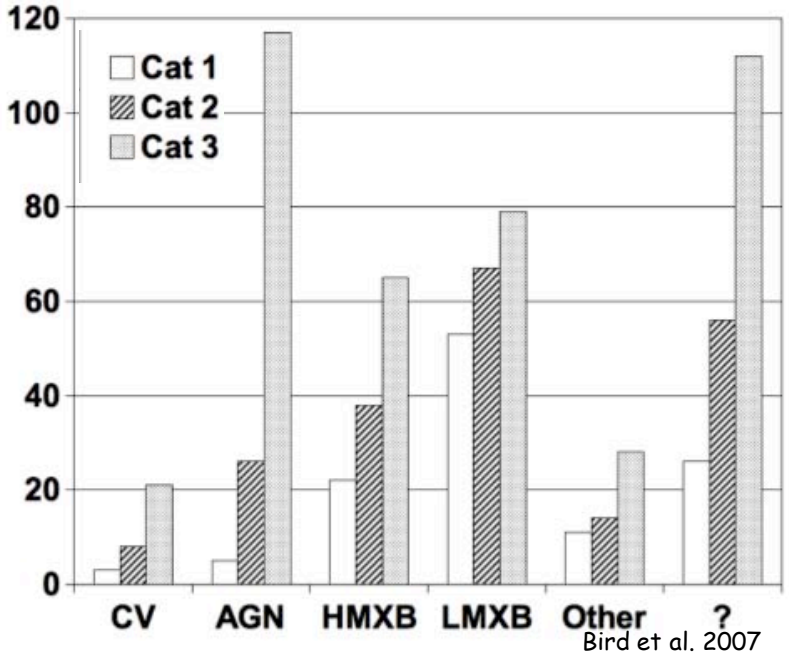
The catalogue includes 421 sources detected in the energy range 17–100 keV :

41% galactic accreting system

29% extragalactic objects

8% other types

26% not classified i.e. unknown origin



Bird et al. 2007

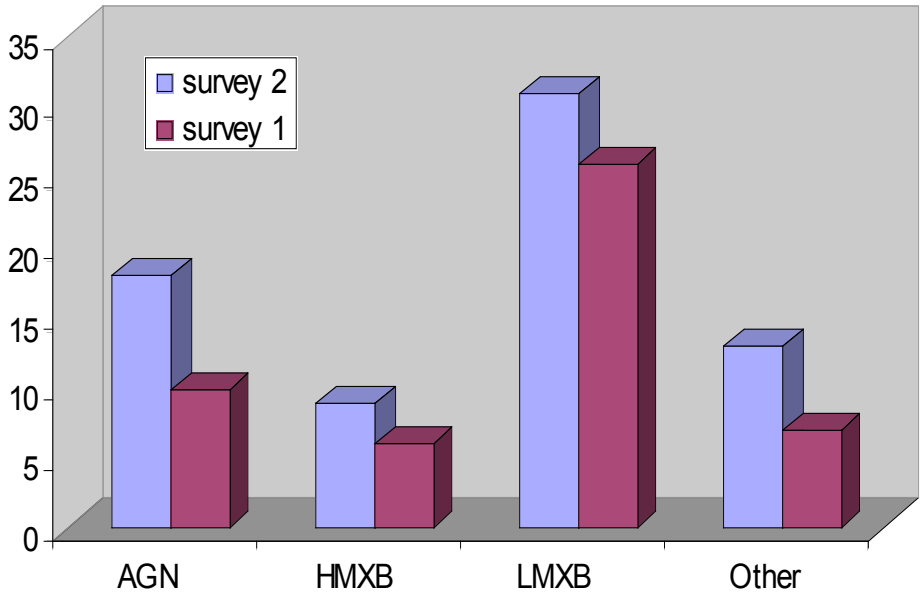
Comparison to previous IBIS/ISGRI surveys:

- Increase in AGN number due to a increased exposure away from the GP
- Increase of the rate of discovery of HMXB
- The percentage of sources without an identification has remained constant

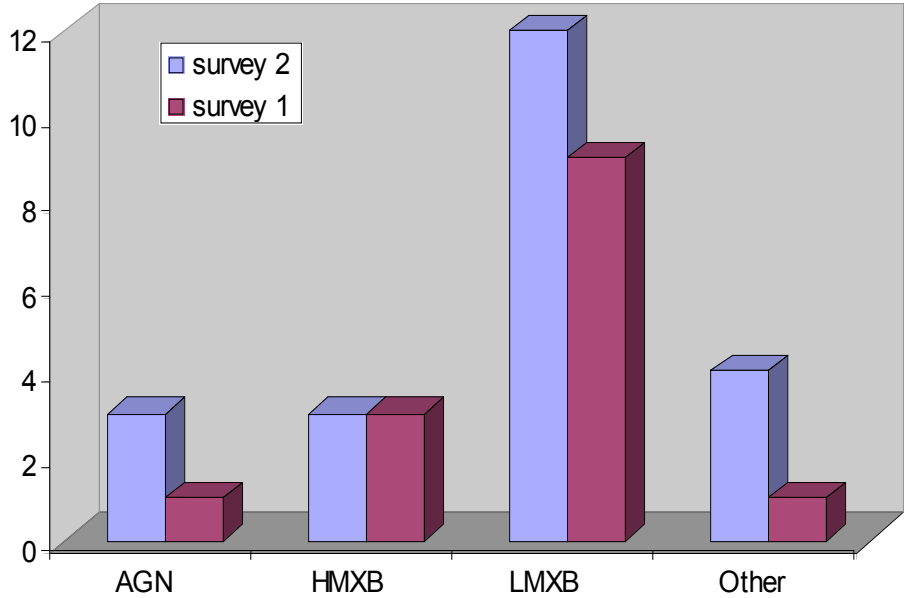
2nd HARD IBIS/ISGRI gamma-ray source catalogue

The 2nd IBIS "high energy" catalogue, in the range 100-150 keV and 150-300 keV, is based on public and Core Program observations performed in between end March 2003 to the end of April 2006 including special "staring" observations and does not including observations performed before the first Crab calibration in February 2003.
An absolute initial threshold of 4.5σ has been applied to combine initial list that has been then checked for appropriate PSF shape and systematic map artefacts.

100-150 keV



150-300 keV



New unknown sources at high energy

- INTEGRAL unknown sources: hints o fa population of a new class of high energy emitters.
- There is a sustained number of 25% in the running catalogues (so far 110 for release 3 (Bird et al, ApJS, in press), in the range 17-100 keV
- A smaller number of them is present in the highest INTEGRAL band (Bazzano et al., ApJL, 2006):
  Above 100 keV (Bazzano et al., 2007) there are 11 INTEGRAL new IGRs sources:
  4 are BHC o NS in LMXB
  1 AXP
  2 unidentified, but resembling BHC behavior
  3 AGN and 1 possibly AGN.
- Lack of "unknown" at higher energy (systematic effect due to sensitivity or coverage?).
- We expect a similar discovery area with GLAST (unprecedented sensitivity with a arcmin PSLA as for IBIS)➔how to solve the problem?
- Common observations/analysis between INTEGRAL and GLAST could unveil the nature of this class of unknown high energy sources.
- INTEGRAL could plan a "key programme" in common to GLAST.

IBIS/ISGRI hard gamma-ray source catalog

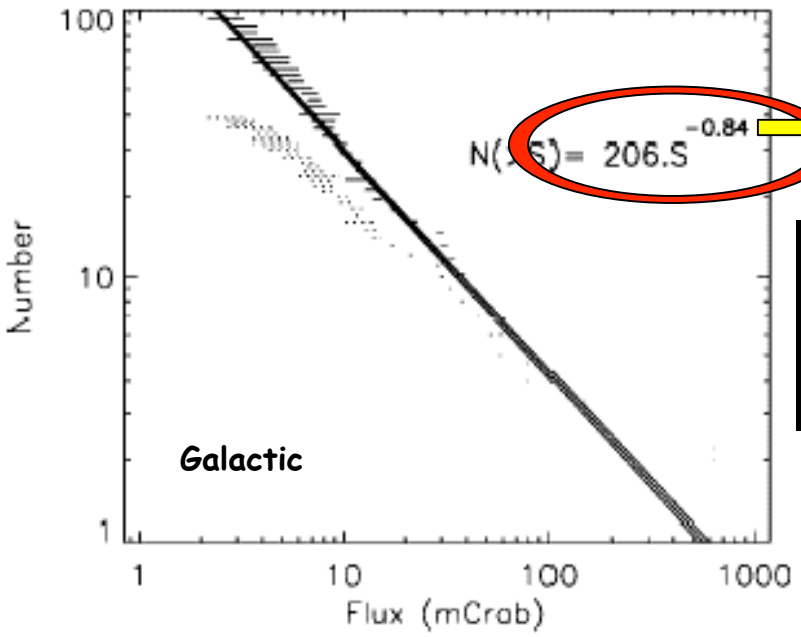


Fig. 5.—Same as Fig. 4, but for the 39 galactic sources in the sample.

Galactic LogN/LogS much flatter than Extragalactic (we see the closeby universe at Z<0.1)

Bazzano et al. 2006

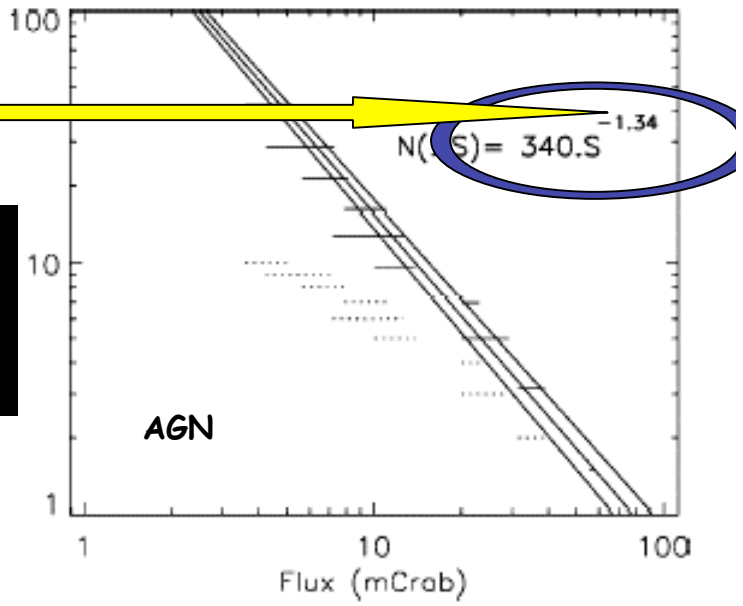


Fig. 4.—The 100–150 keV full-sky number-flux relationship for the 10 AGNs in our sample. Data points for both before (*dotted lines*) and after correction for exposure are shown as the best-fit power law with 1 σ limits.

The logN-logS curves for galactic and extragalactic objects:

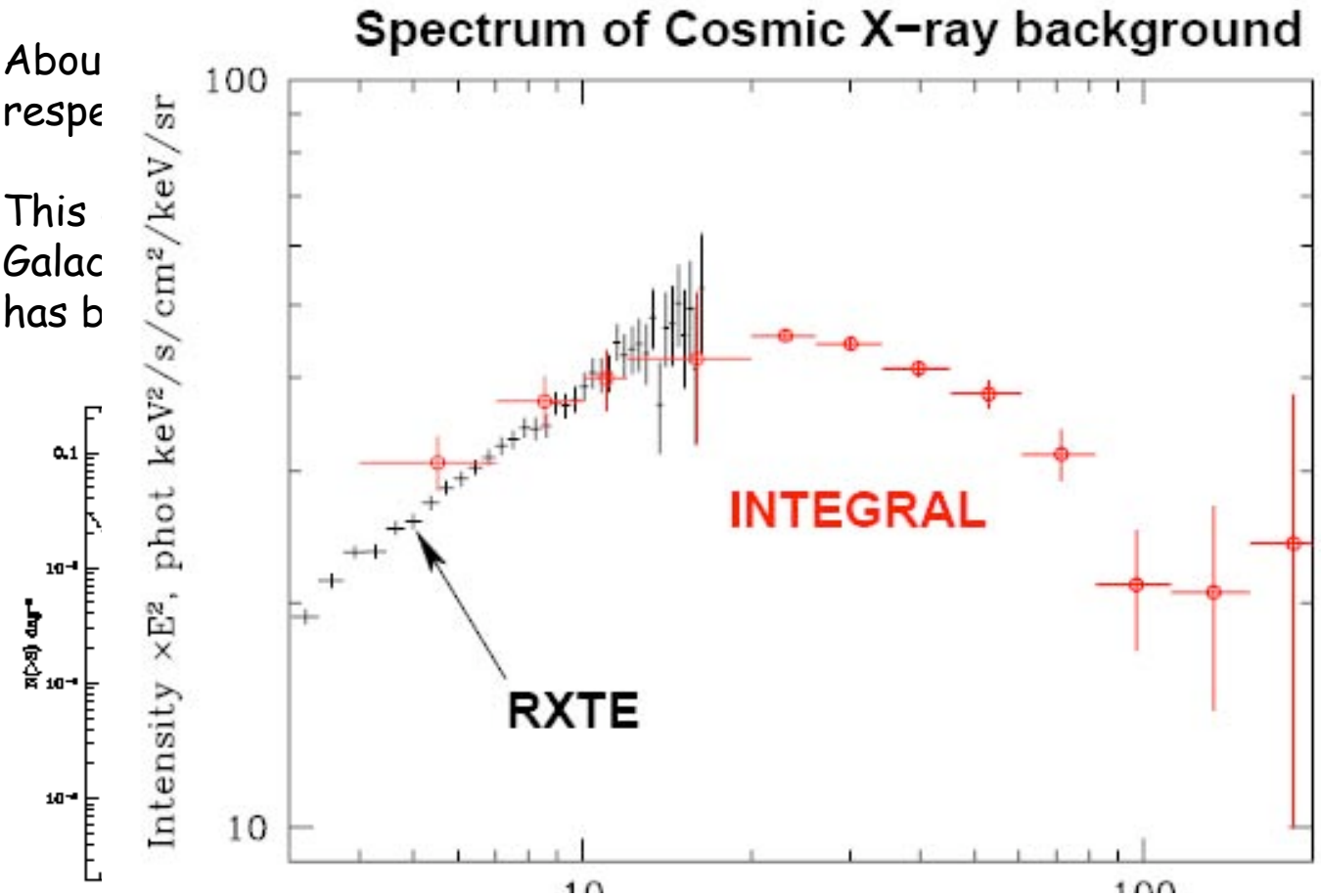
- above a 1 mcrab sensitivity limit we expect that around 200 galactic sources and almost 350 active galaxies populate the sky above 100 keV.
- The contribution of individual point sources to the total Galactic emission has been estimated to be 70%-80% between 100 and 300 keV.
- The active galaxies detected above 1 mcrab account for only about 3% of the cosmic hard X-ray background in the 100-150 keV band.

Other recent Survey (17-60 keV)

Krivonos R. et al. (astro-ph/0701836) presented an all-sky survey based on 33 Msec of INTEGRAL/IBIS data.

Abou … f 1 & 5 mCrab
respe

This … f which 213 are
Galac … galactic source
has b



… at |b| < 5° is
…agalactic at |b|
…ty function of
…pulation (as per

…itude |b| >5° the
…er law with α of
5.7±0.5 × 10^{-3}

Are AGN comptonised or power law?

Fig. 11 Cumulative $\log N - \log S$ distribution in the energy band 17–60 keV of all sources in the Galactic plane region ($|b| < 5°$, dashed histogram) in comparison with that of AGNs at high latitudes ($|b| > 5°$, solid histogram). The dashed line represents the best-fitting power law to the number-flux relation of AGNs.

… flux (0.8 mCrab)
over the 17-60 keV band, make up ~ 1% of the Cosmic X-ray Background.

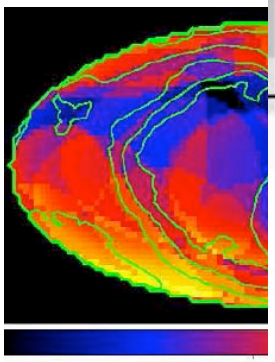


Fig. 7 2D-map of the AG
Universe. This map was
nates using the sample o
$D < 70$ Mpc. Shown for
malization of the AGN lu
ical cone with a half-open
rection. The density is giv
luminosities higher than 1
is the average local density
Green contours show the s
ies detected during the I
$D < 70$ Mpc.

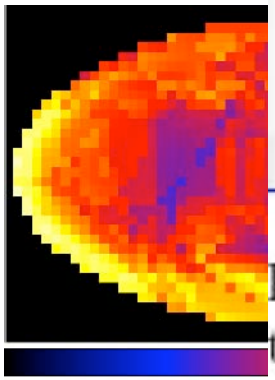


Fig. 8 2D-map of the nu
$D > 70$ Mpc. See Fig.
based on 40 obejcts.

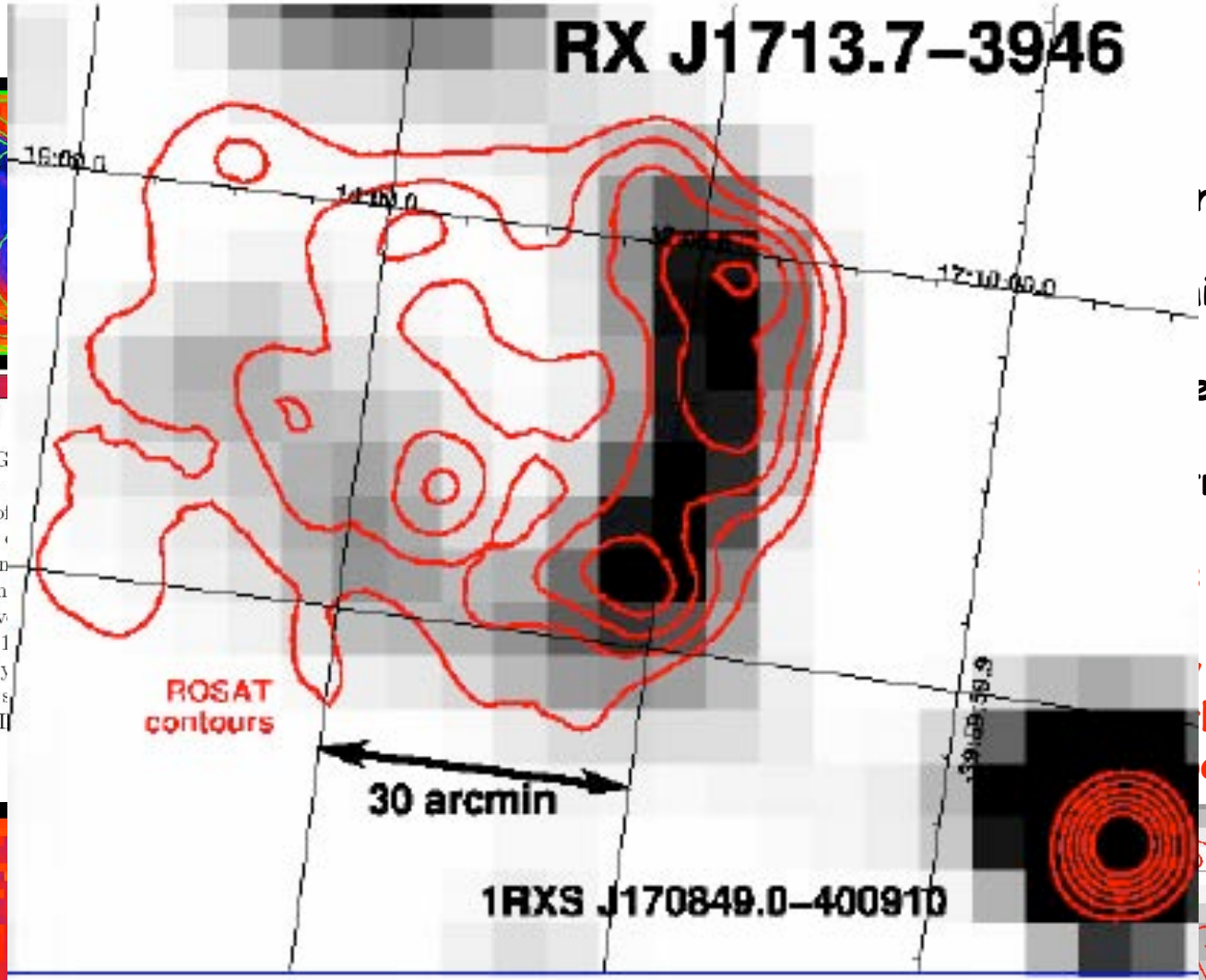


Fig. 4 INTEGRAL/IBIS hard X-ray (17–60 keV) image of the supernova remnant RX J1713.7−3946. The gray scale on the map is proportional to hard X-ray flux. The map obtained by ROSAT in the soft X-ray (0.5–2.5 keV) band is shown by contours.

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J1713.7-3946
ructure.
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h the X-ray
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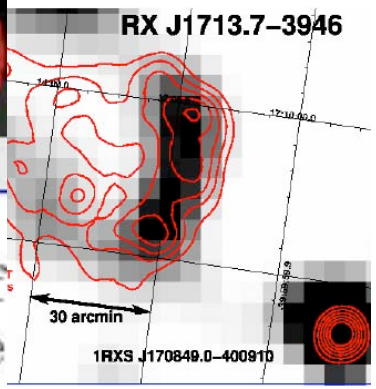


GRAL/IBIS hard X-ray (17–60 keV) image of
va remnant RX J1713.7−3946. The gray scale
is proportional to hard X-ray flux. The map
ROSAT in the soft X-ray (0.5–2.5 keV) band
contours.

sity

HESS sources: a new exciting class emitting gamma-rays at E>10^{12} eV. Search for counterparts at other wavebands

Step 1: Find positional agreement

Possible source nature:

1. SNRs
2. Pulsars and PWN
3. Microquasars and binaries
4. Background AGN
5. New class?

Most important wavebands:

1. Radio
2. X-rays (>few keV) ==> INTEGRAL

Then

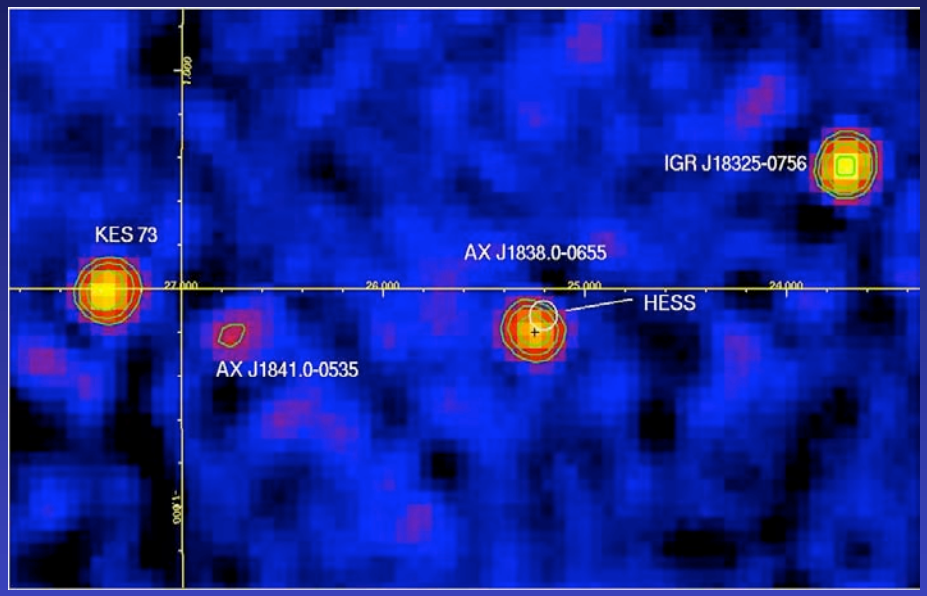
Step 2: Find a viable gamma-ray emission mechanism of the positional counterpart

Step 3: Provide a consistent multi-wavelength picture

Additionally: if source extended – Study morphological match → time variability

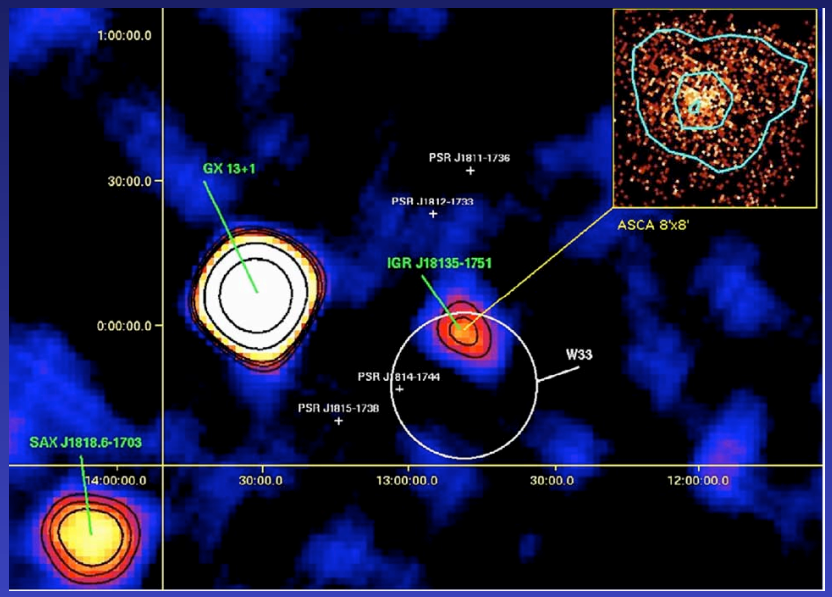
INTEGRAL Uncovered Two HESS Unidentified TeV Sources:

HESS J1837-069 = AXJ1838.0-0655



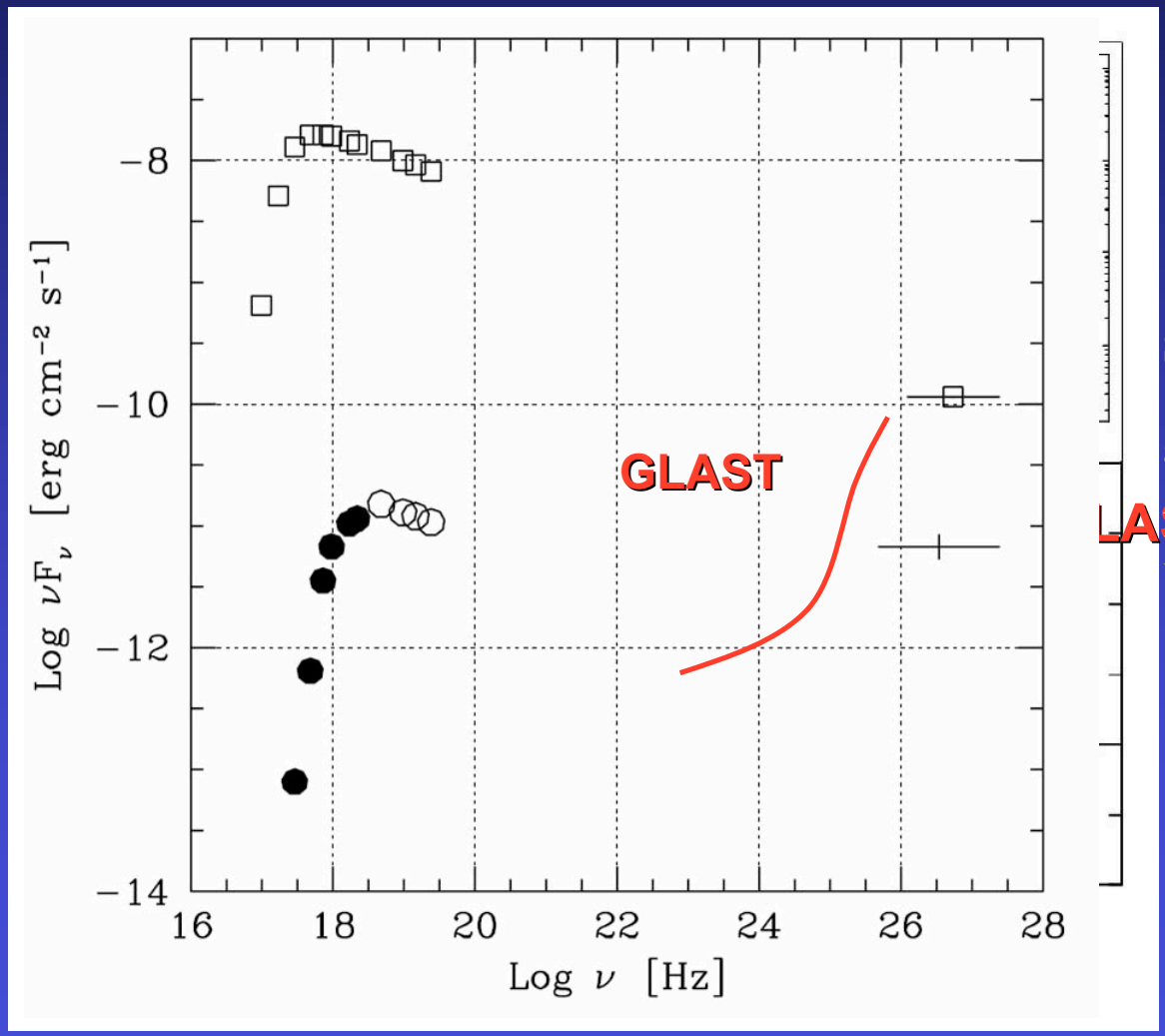
IBIS/ISGRI 20-300 keV significance map showing the location of AX J1838.0-0655 - HESS J1837-069 (white circle) and the Einstein position (black cross). (Malizia et al., ApJL 630. 2005).

HESS1813-178 = IGR J18135-1751



The IBIS/ISGRI 20-40 keV significance map showing the location of IGR J18135-1751. The extension of HESS J1813-178 and AGPS273.4-17.8 are both contained within the internal IBIS/ISGRI contour. The ASCA-SIS image is shown as an insert on the top right side of the figure. (Ubertini et al. 2005, ApJL, 629, 109)

INTEGRAL Uncovered Two HESS Unidentified TeV Sources: Spectral Energy Distribution



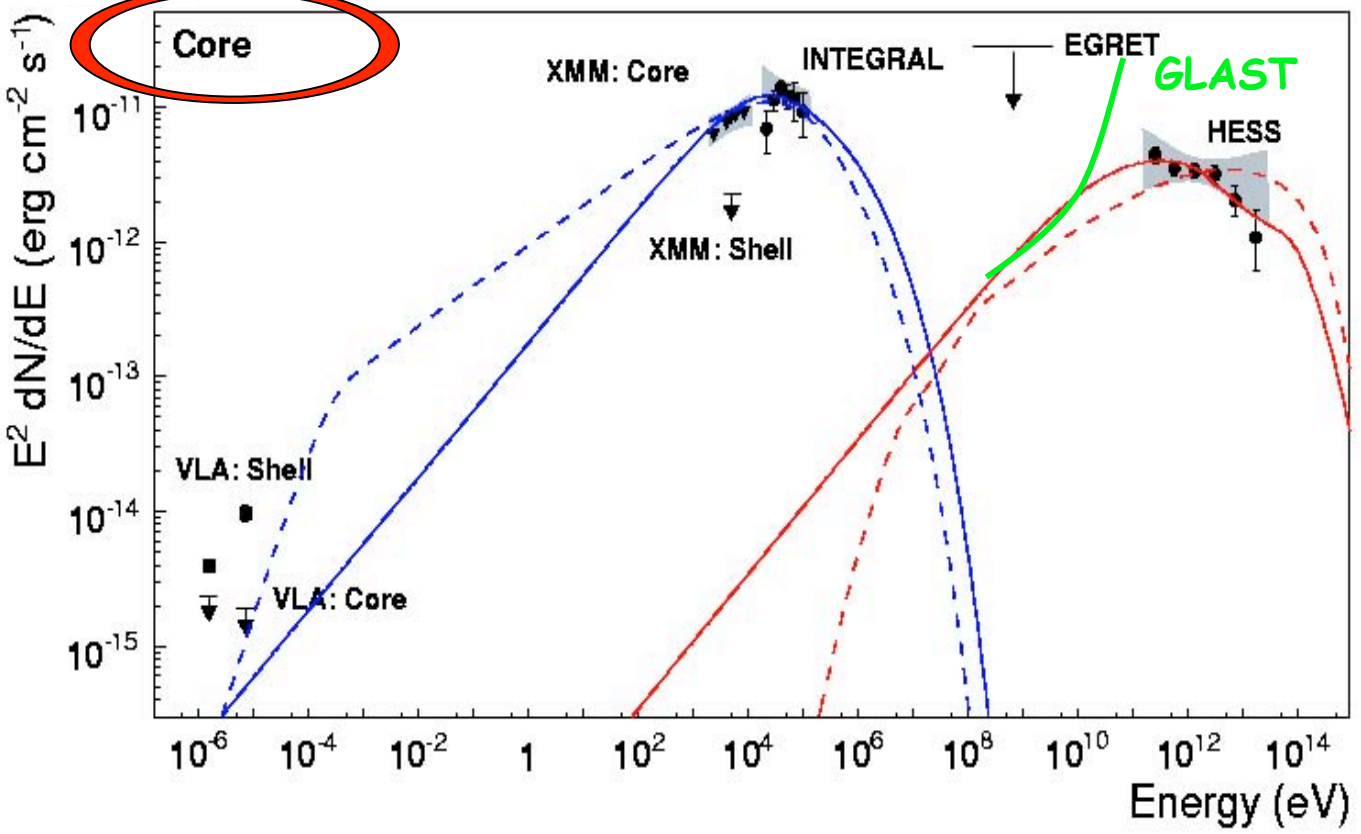
Spectral Energy Distribution (SED) of AX J1838.0-0655 (top) and IGR J18135-1751 (bottom). The Crab Nebula (grey) ASCA X-ray data are 2-10 keV, IBIS soft g-ray 20 to 100 keV and HESS from 0.2 to 10 TeV.

Spectral Energy Distribution (SED) from radio to TeV of IGR J18135-1751 (bottom) and the Crab Nebula (top). Rays including EGRET upper limit and GLAST sensitivuty curve for 1 year observation with LAT. The insert is the blow-up of the combined ASCA and ISGRI spectrum.

HESS J1813-178=IGR J18135-1751:

SED & emission models

No distinction is possible between a scenario in wich Gamma rays are emitted from the shell of the SNR or from the PWN. No



Models:

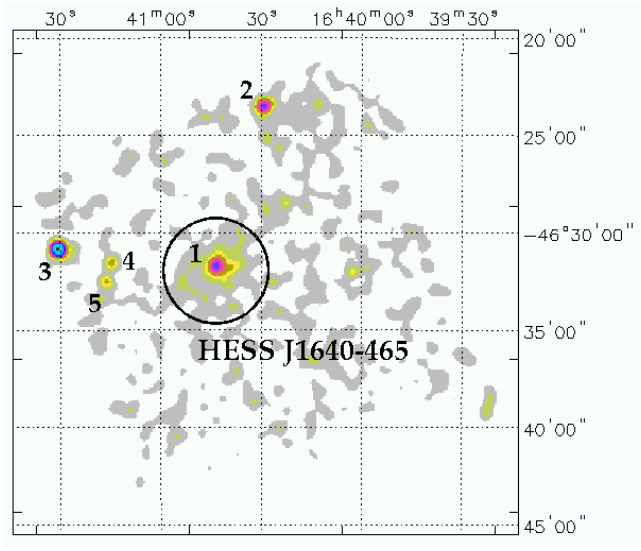
Dashed line
E_{min}=25 GeV
E_{max}=1.5 PeV
Γ=2.4
B=4.2 μG
leptonic model with electrons accelerated in the SNR shell

Solid line
E_{min}=1 MeV
E_{max}=1.5 PeV
Γ=2
B=7.5μG

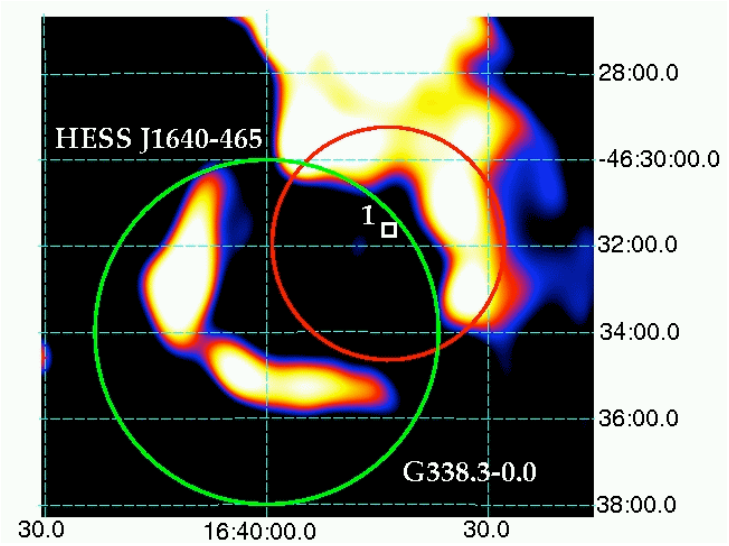
Dashed line:
hadronic model

HESS J1640-465: search for radio and X-ray counterparts

0.3-10 keV Swift/XRT



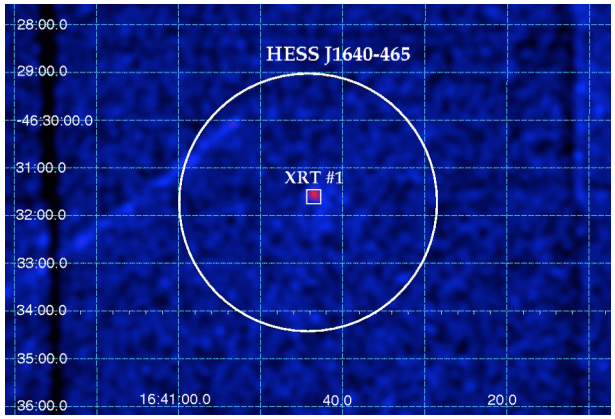
MOST 843 Mhz



Associated to the broken shell SNR 338.3-0.0 detected by ASCA AX J1640-4632=#1 in SWIFT/XRT no optical/IR counterpart SWIFT/XRT spectrum and flux compatible with ASCA one (Γ= 2.6, $NH \sim 10^{23} cm^{-2}$, $F_{2-10keV}=7.2 \times 10^{-13}$cgs, C.P.=0.01)

SNR?

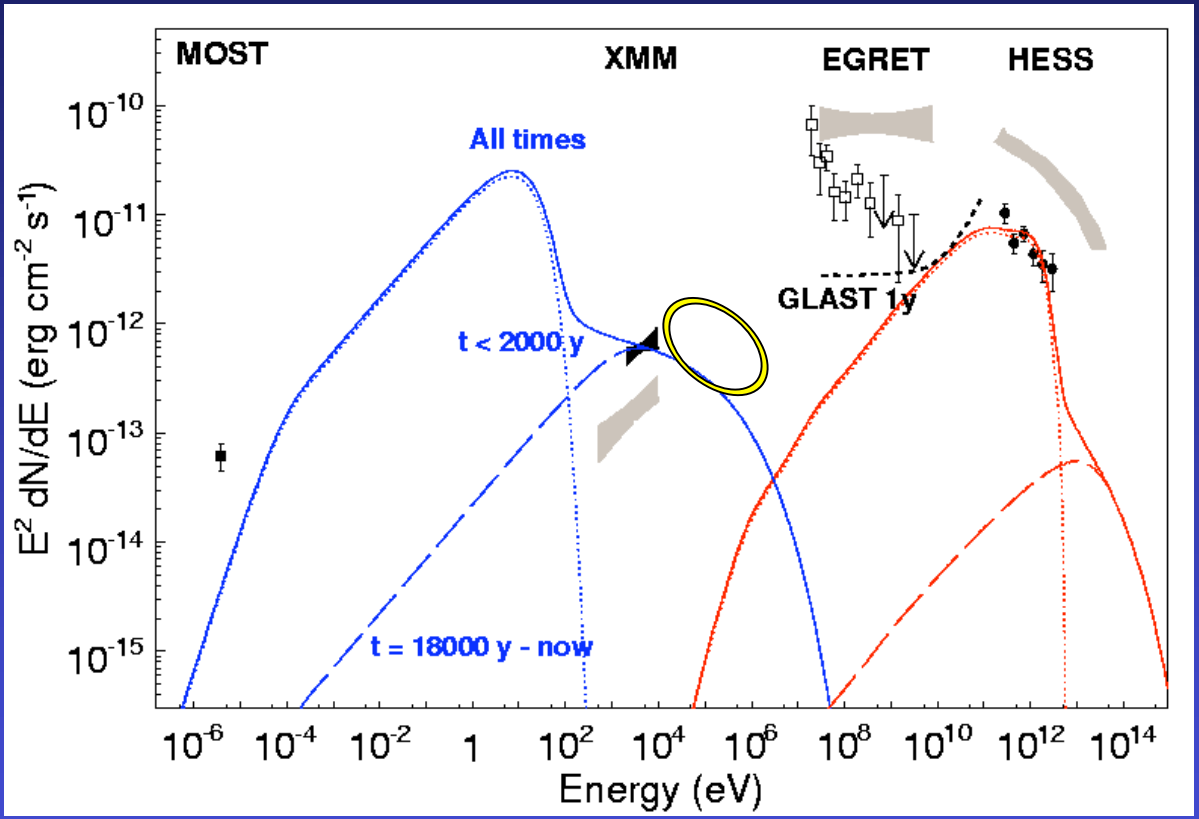
Although lack of evident diffuse emission and central location in SNR cannot exclude a PWN



XMM/MOS 2-10 keV

HESS J1640-465: multi-wavelength picture

Funk et al. 2007



Time dependent rate of injections of relativistic electrons:

young electrons => X-ray emission (dashed line)

old lectrons => Gamma ray emission (dotted line)

No INTEGRAL data yet

Weak hard X-ray emission: need deeper exposure with INTEGRAL to look for γ-ray counterpart

How can we distinguish the PWN vs SNR scenario?

PWN: detect the pulsar

a) pulsation

b) cooling of electrons through softening of the X-ray spectrum

==>deep hard X-ray observations with CHANDRA, XMM and INTEGRAL

Chandra and INTEGRAL for high and good angular-resolution soft X-rays ad soft-gamma observations

New light in the MeV-GeV region with the superior GLAST angular resolution and sensitivity.

BLAZARS: a large fraction of the EGRET Sky but
➔ limited population, not very strong in soft-γ

- EGRET 97% radio loud,
- INTEGRAL transiction range 3% only + unknown?

- Flat spectrum radio QSOs (high L) and BLac (low L) looking at jet direction (see Paolo Padovani and Annalisa Celotti talks)
- Compat, core dominated radio sources
- Brigth at any frequency
- The optical counterpart dominates the host galaxy
- Strongly variable at any energy band
- Strong and variable polarisation in optical (>3%) and radio (>1-2%) flux

BLAZARS

Leptonic Model: EC vs SSC; the relativistic electrons emitting synchrotron radiation (responsible of the radio-UV-X emission) produce gamma-ray emission via Inverse Compton with soft photons

➔ which the origin of the soft photons?, the hypothesis are:

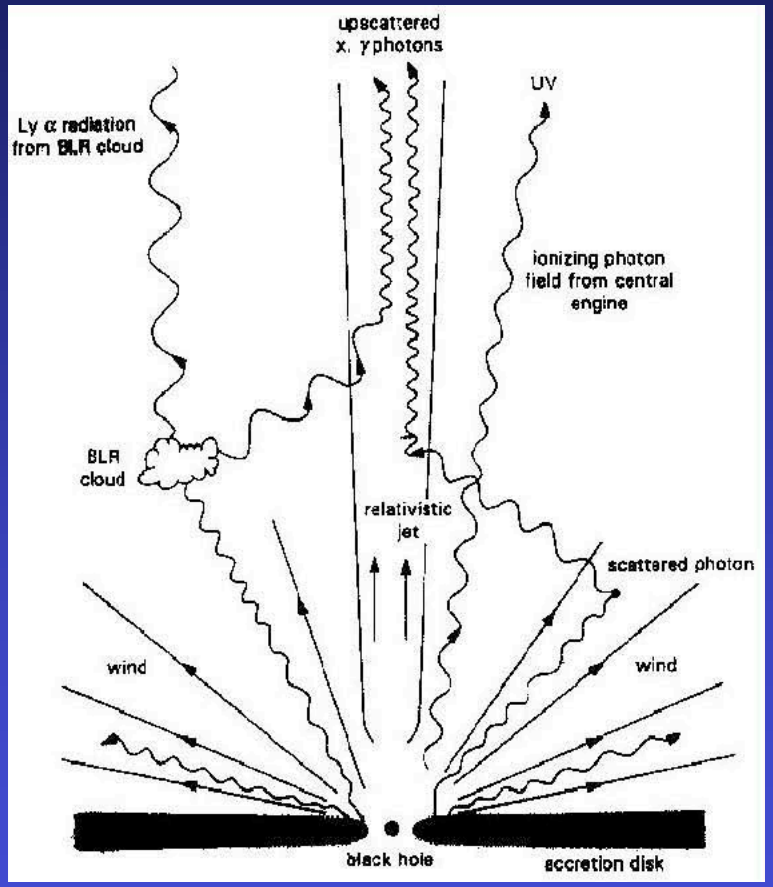
Synchtrotron photons (SSC: Marscher & Gear 1985, Maraschi et al. 1992, Bloom & Marscer 1996)

External photons: accretion disc, broad line region (ECR: Dermer et al. 1992, Sikora et al. 1994, Ghisellini and Madau 1996, Dermer et al. 1997)

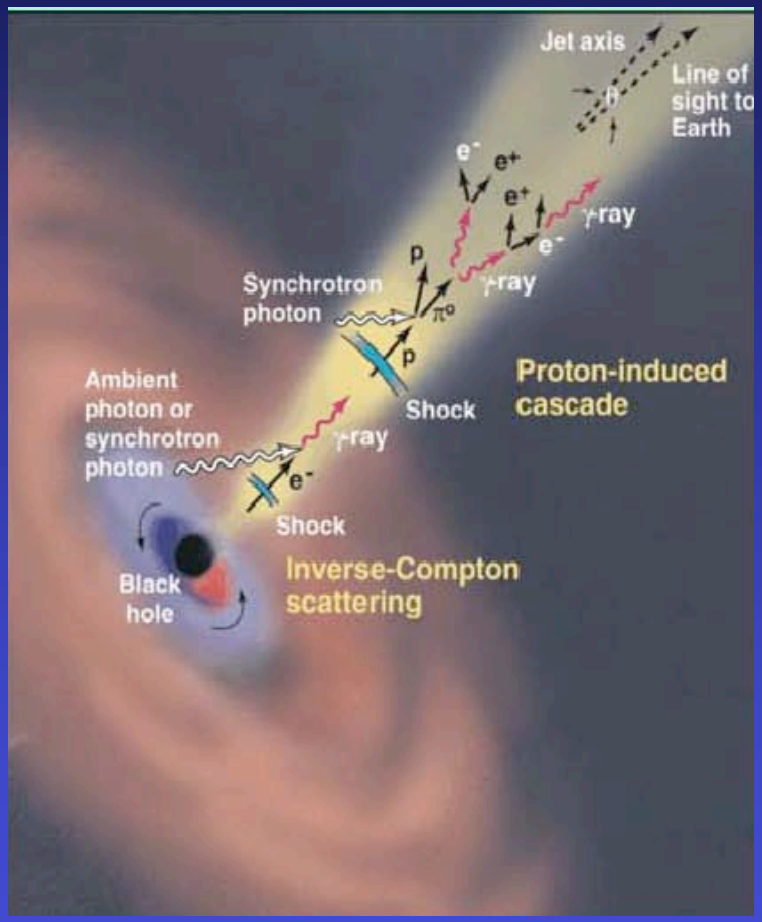
Hadronic Model: Gamma ray originates from accelerated protons (and to a lower extension hadrons) that interact with ambient particles or photons releasing their energy.

A simple cartoon

Leptonic model



Hadronic model



INTEGRAL detects BLAZARS and constrain their Spectral Energy Distribution

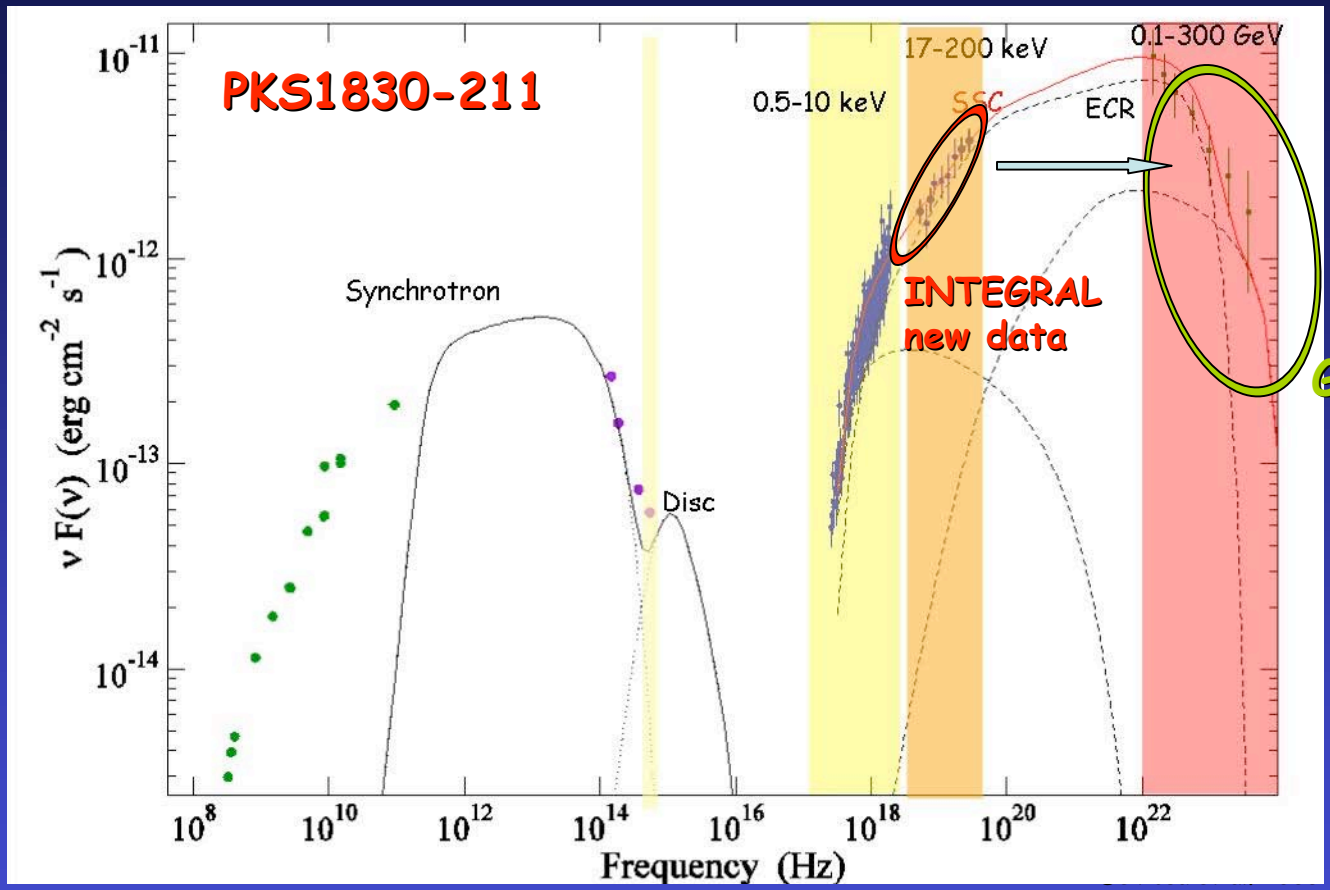
- Simultaneous INTEGRAL, GLAST and lower energy multifrequency observations will provide a powerful tool to fully understand the Blazar physics.

- It will be of particular value to monitor (via TOO or planned "Key projects") flux variation episodes with those two powerful Observatories, in particular GLAST monitoring capability for fast varations to be observed with INTEGRAL TOOs to have a full coverage from keV to GeV vs time.

- In this case, the sub arcmin PSL of INTEGRAL may have a key role to prove the mechanism generating the soft gamma (keV to MeV) and high energy (GeV to TeV) is the same

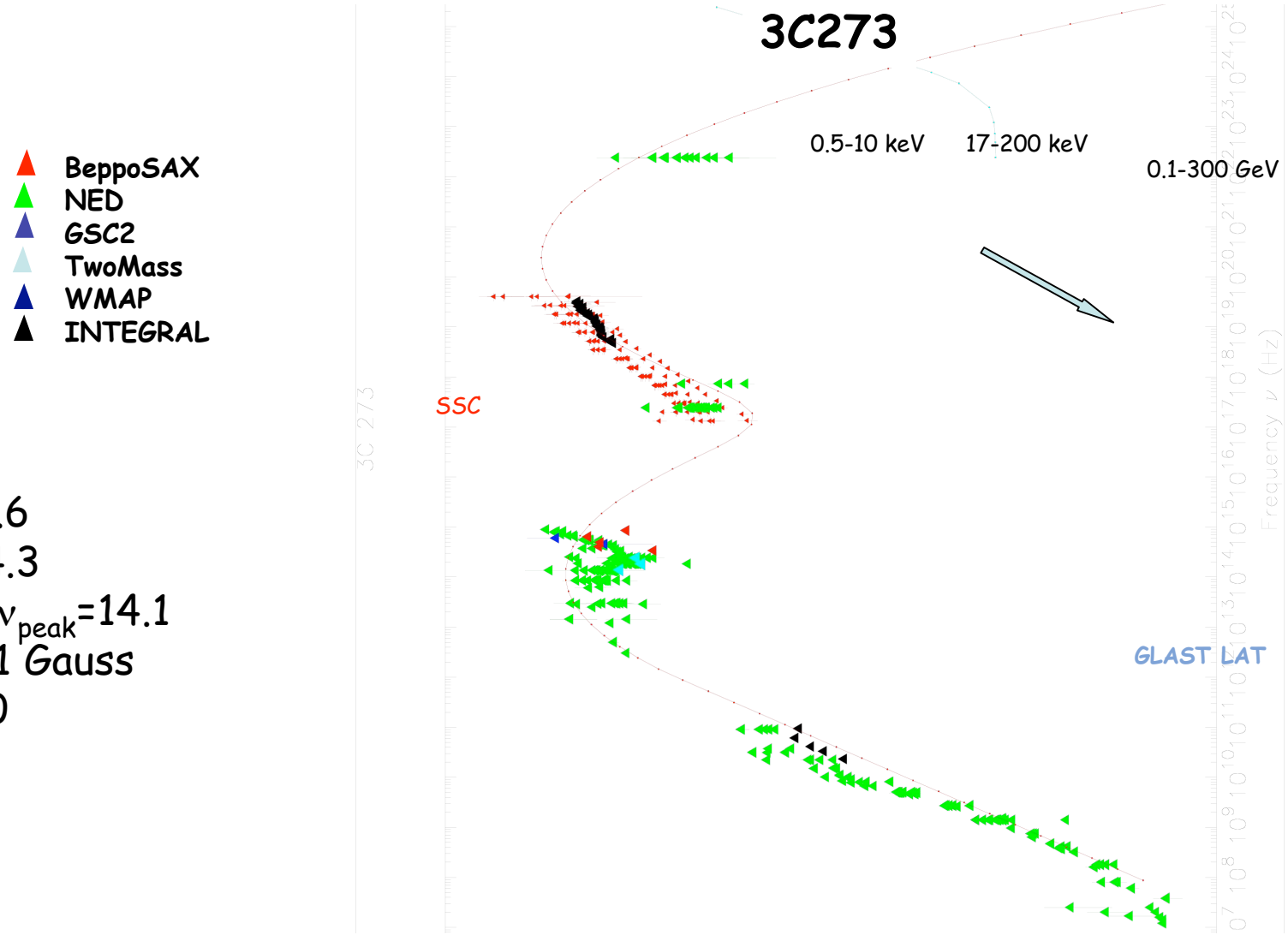
- This is particularly important in view of the fact that the few detected INTEGRAL Blazars always shows a rising spectrum (in energy) in the SSC part of the models, while the EGRET data have usually a negative slope ➔

A few examples of BLAZARS Spectral Energy Distribution



The Spectral Energy Distributions of PKS1830-211 in the observers' frame derived from INTEGRAL and CHANDRA and other published data. Radio measurements are from Pramesh Rao & Subrahmanyan (1988), IR and optical data from Courbin et al. (2002) and gamma-ray data from the EGRET public data archive.

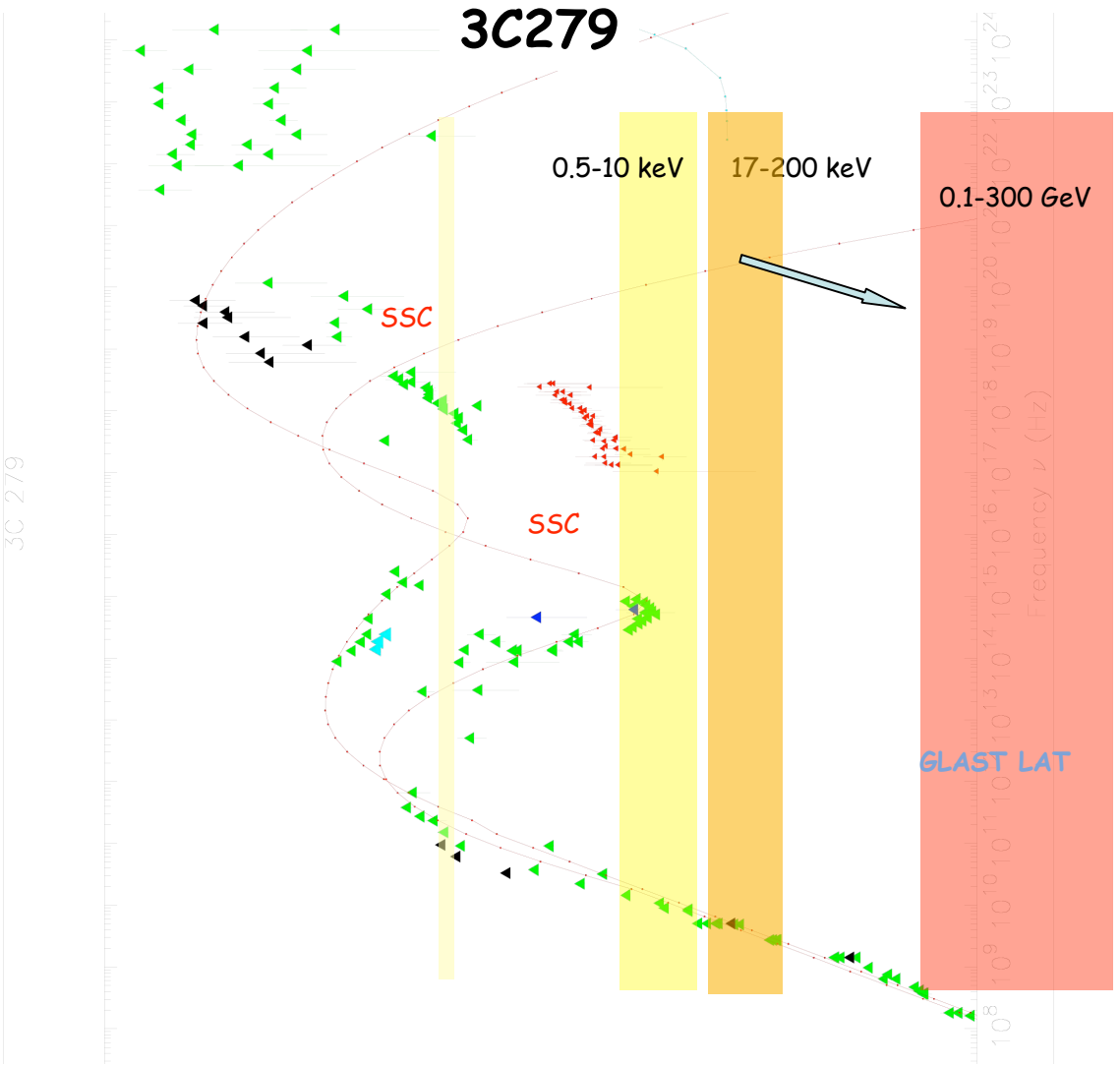
BLAZARS Spectral Energy Distribution



Γ_1=1.6
Γ_2=4.3
Log ν_{peak}=14.1
B=1.1 *Gauss*
δ=20

BLAZARS Spectral Energy Distribution

- BeppoSAX
- NED
- GSC2
- TwoMass
- WMAP
- INTEGRAL



1° SSC

Γ_1=1.3
Γ_2=4.6
Log ν_{peak}=12.6
B=0.5 Gauss
δ=20

2° SSC

Γ_1=1.3
Γ_2=4.2
Log ν_{peak}=13.4
B=0.5 Gauss
δ=20

What could GLAST and INTEGRAL do taking advantage of common Observations?

- Both are sensitive in the peak energy emission of HESS high energy sources and BLAZARS:

- Test the different sources of compton seed photons:
  Synchrotron Self Compton (SSC)
  External Radiation Compton (ERC)

- Disc-Jet coupling, geometry of the emitting region, physical acceleration/deceleration processes, variability mechanisms

- INTEGRAL source location < 1 arcmin will be crucial to prove topological/morphological coincidence not to be chance association

- INTEGRAL is the turn over from thermal to non thermal regime: the new populated soft γ-ray sky is completely different from the EINSTEIN one and populated by misterious sources

- AGILE finally planned to fly next 31st of March from India ➔

Be ready……lot's of fun to come!!

PKS1830-211

Problems with the GHz radio emission component:

Nella SED di PKS1830-211 non c'e' modo di riprodurre i dati al GHz perche' la frequenza si self-absorption di SSC e' circa 3 10^{11} Hz (per il B di 0.8 g assunto). lo steso problema si ha in altri blazar (3c279 per esempio) e si potrebbe risolvere ipotizzando un modello multicomponent dove l'emissione di SSC venga anche dalle regioni piu' esterne, dove il campo magnetico e' piu' basso. da solo questo campo basso pero' non basterebbe a fare X-ray e Gamma ray osservati, quindi serve la multicomponent.