Looking for Supernovae remnants in soft γ-rays

The INTEGRAL view

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Objectives

Observations of non-thermal SNRs in the core program

- **PWN**
  - **G21.5-0.9**
  - **Kes 75, G11.2-0.3**
- **Shell-type SNRs**
  - **G347.3-0.5**
  - **Vela Jr (see M. Renaud's talk)**

Studies in the low energy band

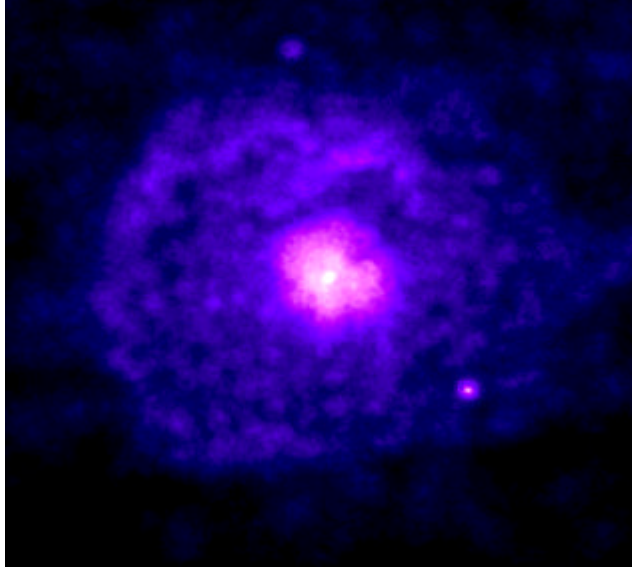
- **Special noisy pixels treatment needed**
- **Need good correction for Low Thresholds (LT)**

Results are still preliminary


SNR, pulsars, SGR, CV

G21.5-0.9

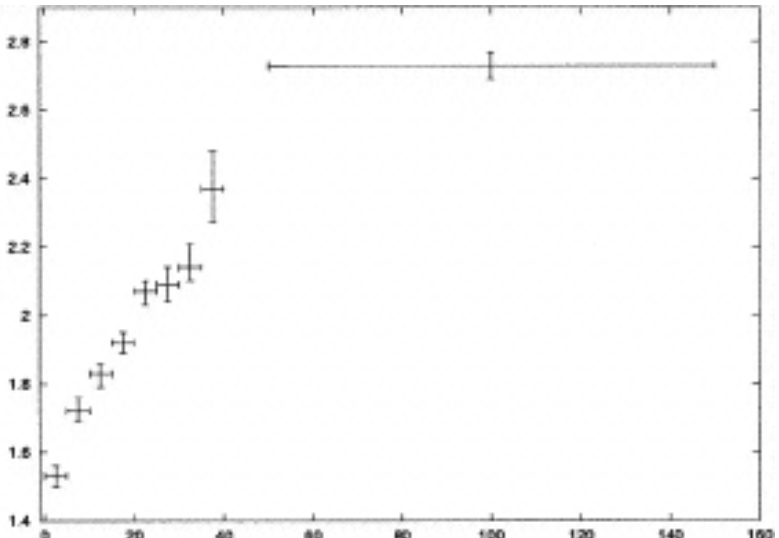
21.5-0.9 is a crab like SNR



xtended non-thermal emission in X-rays
o thermal shell detected
o pulsed emission from CCO

$_X$(0.5-10 keV) is 1.1×10^{-10} ergs cm^{-2} s^{-1}

(Safi-Harb et al. 2001)



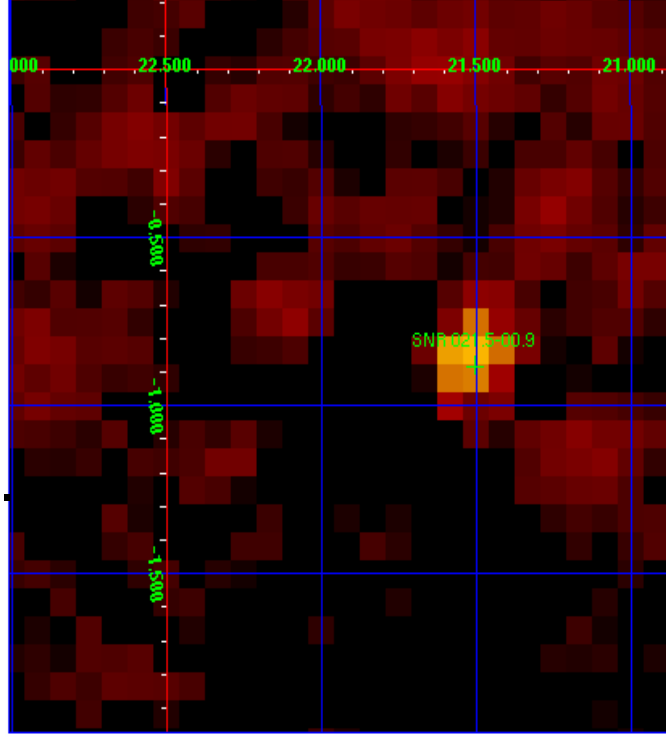
Spectral index depends on distance to the core:
up to 1.5 in the centre
over 2.5 beyond 50"

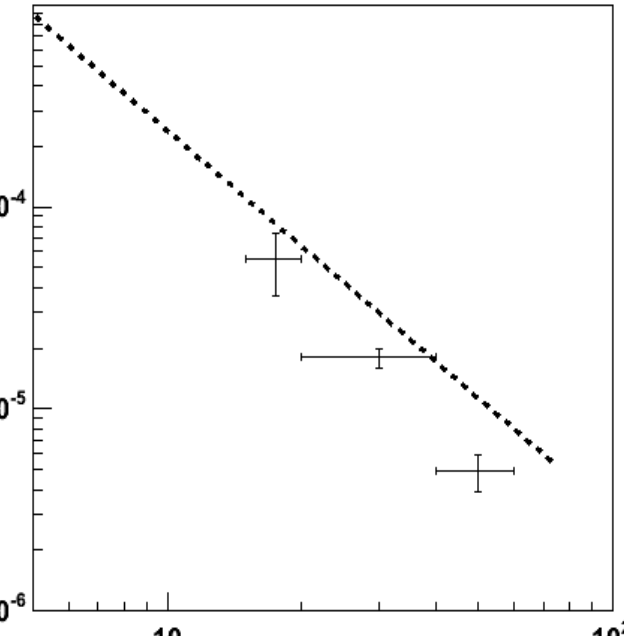
G21.5-0.9

G21.5-0.9 is detected at >10 σ in the 20-40 keV band.

The total flux obtained

F_γ(15-60keV) is 3.6×10^{-11} ergs cm^{-2} s^{-1}.





Spectrum steeper than X-ray data

photon index Γ~2.4

Flux compatible with PDS observations

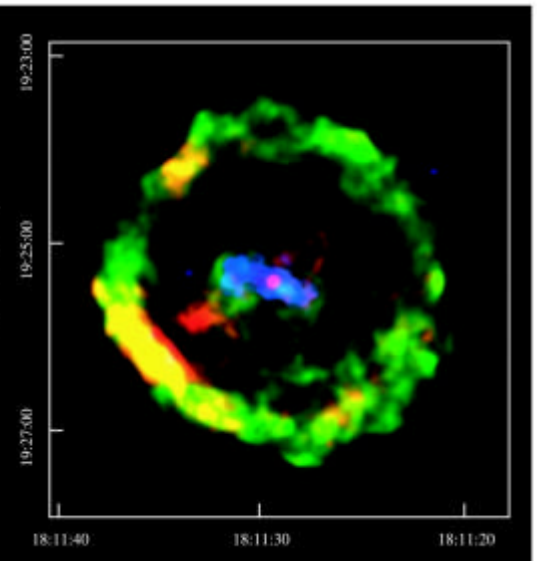
(*Malizia et al. 2004*)

0.3

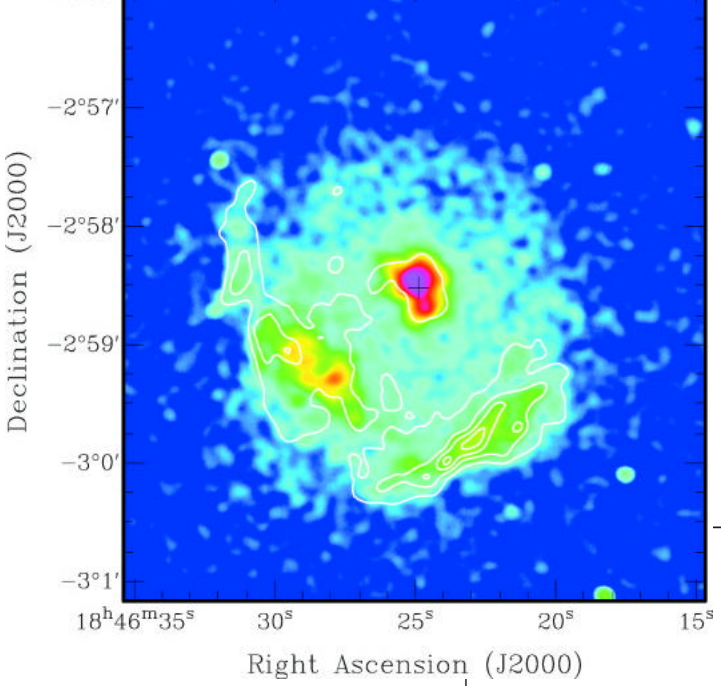
- young PWN & thermal shells
- X-ray detected PSR
- Very hard PSR spectrum (Γ~1)

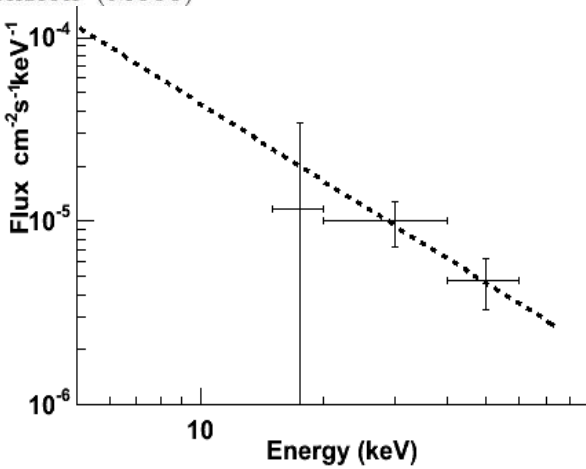
oth are detected in the 20-60 keV band

SR is expected to dominate
ove a few tens of keV



Kes 75





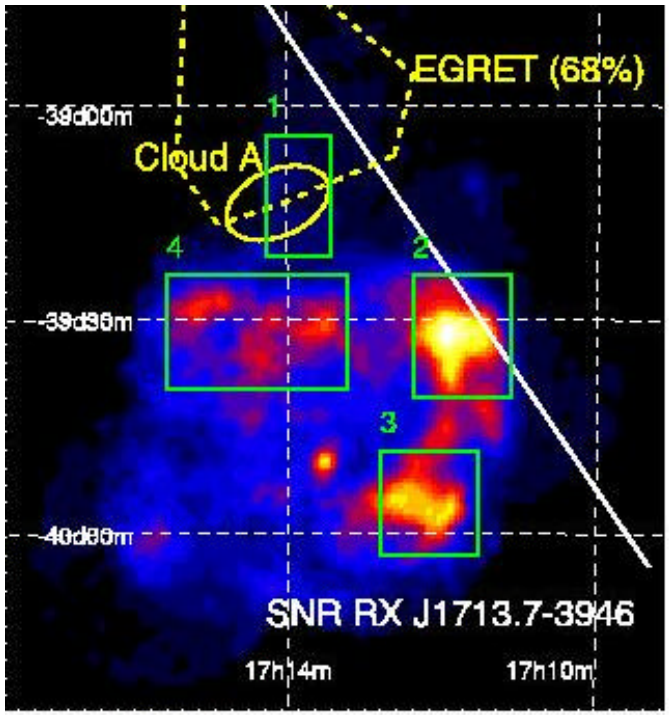
G347.3-0.5

arge (>40') non-thermal shell first detected by ROSAT
right structures on the West and North

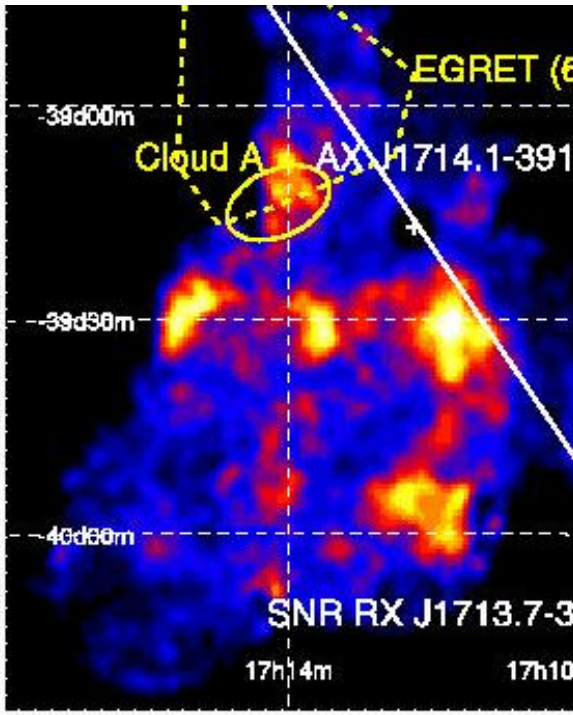
W:
4 10^{-11} erg.cm^{-2}s^{-1}
=2.3

W:
. 10^{-11} erg.cm^{-2}s^{-1}
=2.3

5 10^{-11} erg.cm^{-2}s^{-1}
=2.3



(a) ASCA GIS 1-3 keV



(b) ASCA GIS 5-10 keV

X J1714.1-3912: *(Uchiyama et al. 2002)*

absorbed (N_H~1.5 10^{22} cm^{-2}) hard extended emission: Γ~1

non-thermal Bremstrahlung of CR in interaction with molecular cloud A

G347.3-0.5

SNR in interaction with a molecular cloud in the West region:

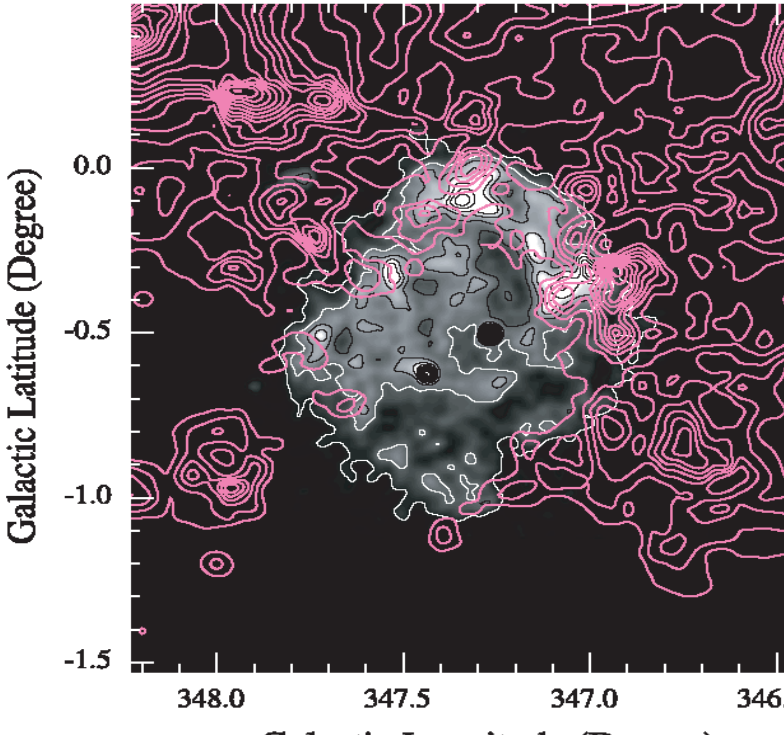
-ray flux positively correlated with column density
negatively correlated with spectral index

(Cassam-Chenaï et al 200

D map in the -12km/s<v<-8 km/s
ukui et al. 2003)

istance of SNR: ~1kpc
ge : ~ 1.6 kyr
mnant of AD386?

ecent detection at TeV energies
HESS (*Aharonian et al. 2004*)

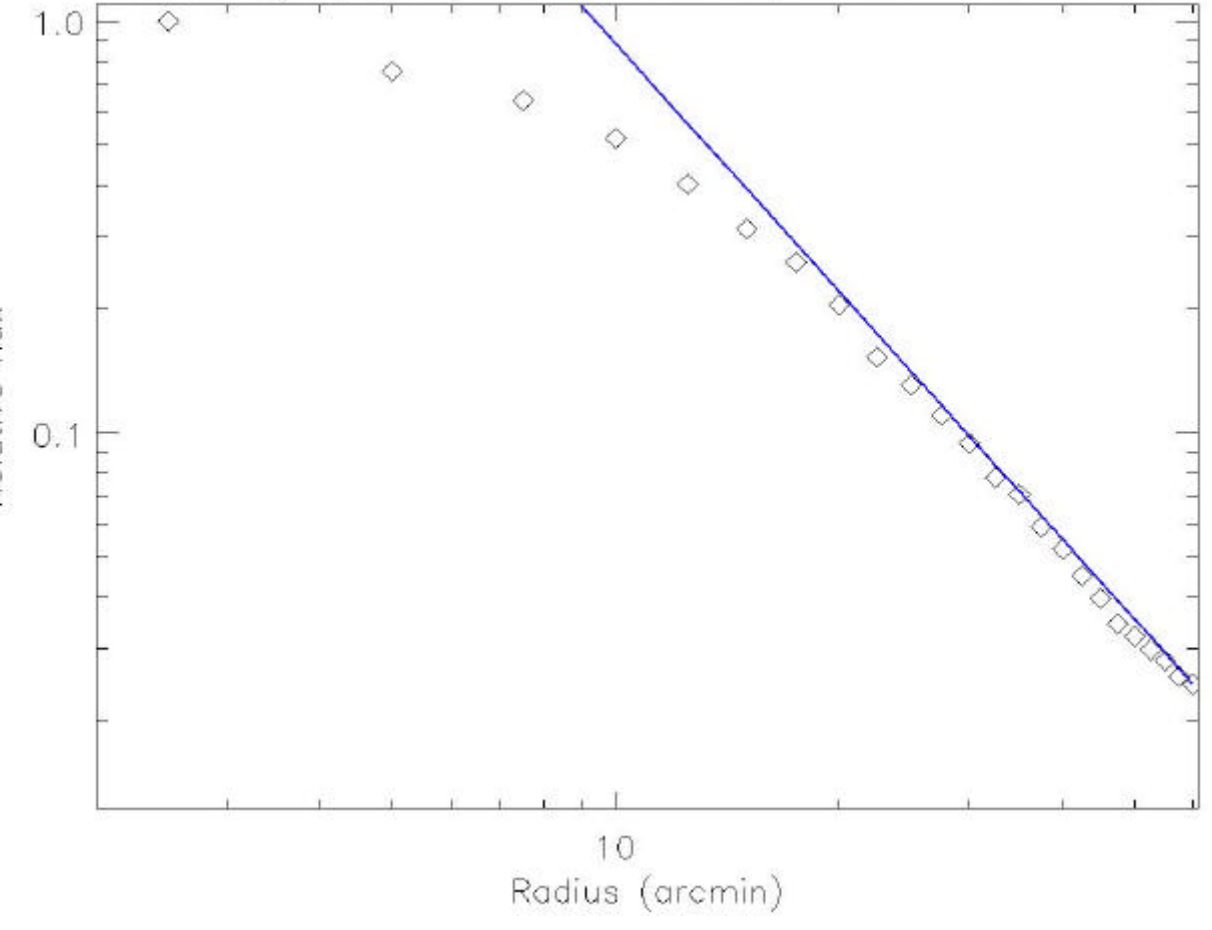


Deconvolved flux

Extended sources reconstructed flux lower

Depends on the number of mask elements larger than the source extension

2D top-hat function



5' radius : ~20% loss

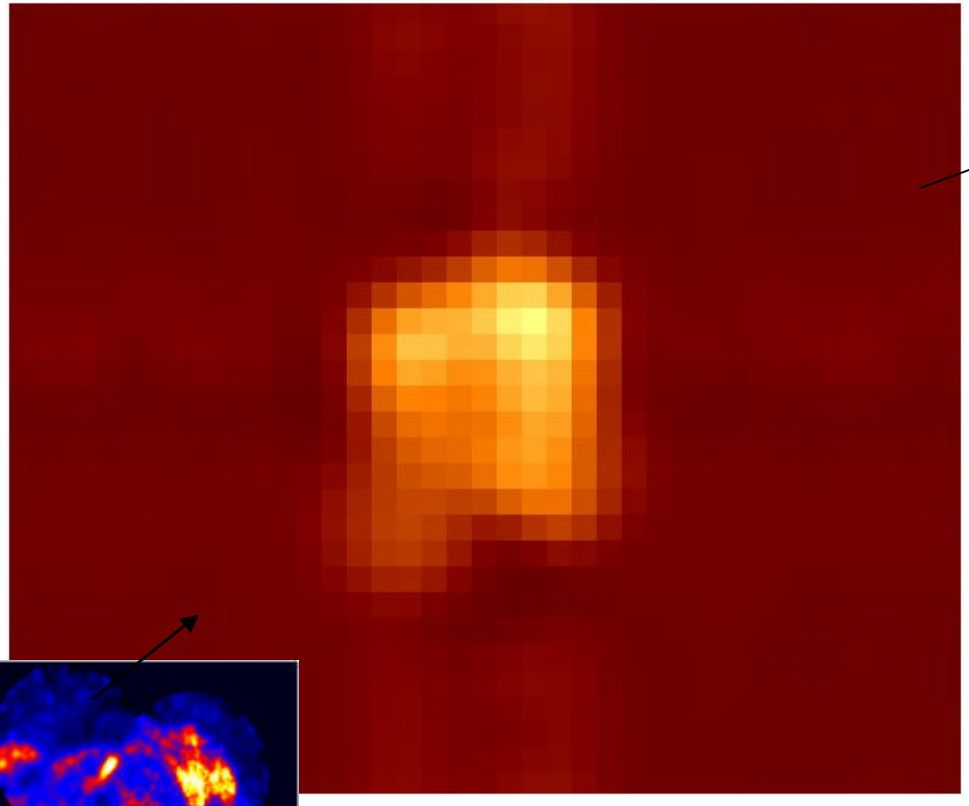
10' radius: ~40% loss

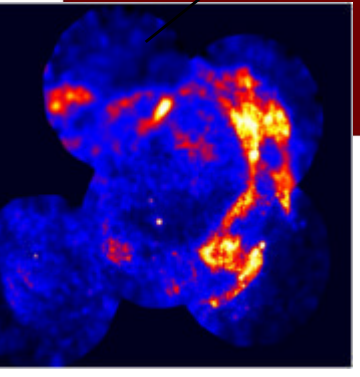
30' radius: ~90% loss

From M. Renaud

lux : the case of G347.3-0.5

From XMM 1-10 keV map (*Cassam-Chenaï, 2004*), compute shadowgram and estimate loss through ii_skyimage





Reconstructed flux:
12% efficiency

Total expected flux (extrapolation fr
X-ray data):

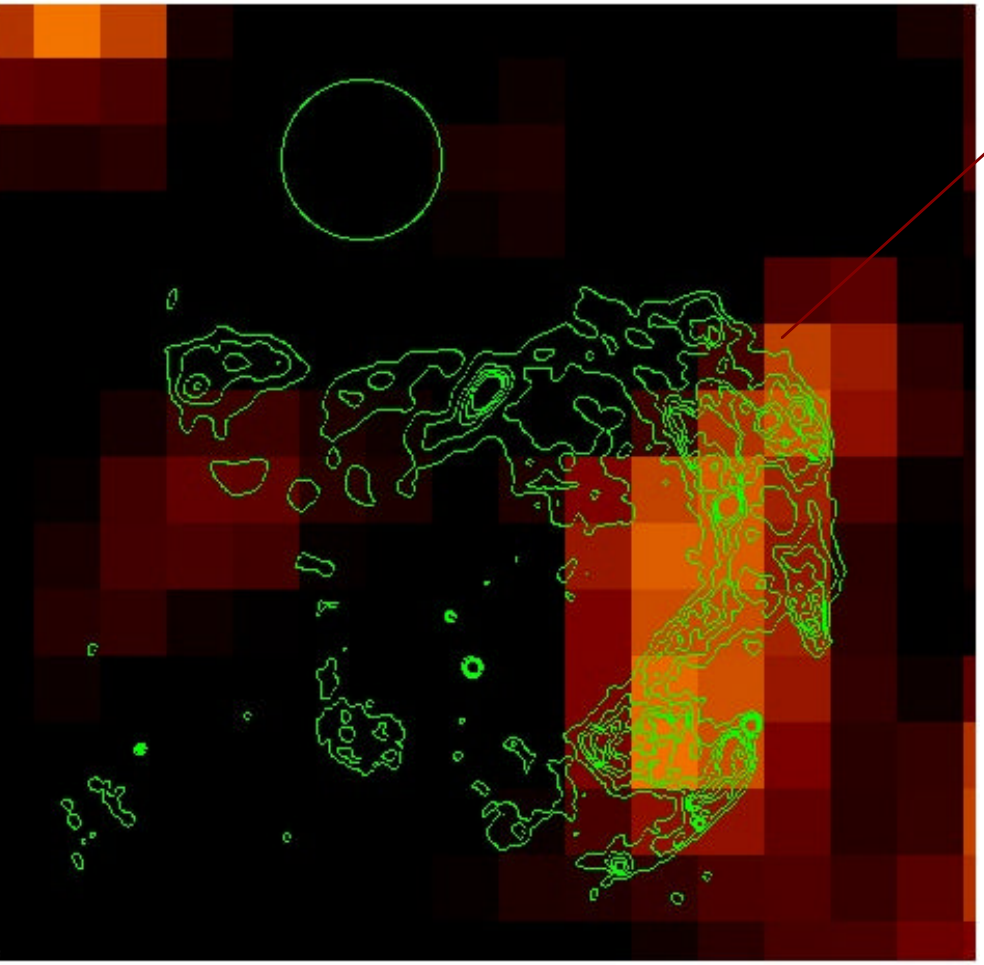
~1.1 count/s in 15-30 keV band

After imaging:
~0.13 counts/sec (peak value)

esults

15-30 keV map

Special treatment of noisy pixels – need correction of LT



Low significance (comparable to the systematics)

Flux: ~0.11 count/s

No significant emission from AX J1714.1-3912

- Extrapolation: 1.05 c/s
- Extension: 10' => 60% efficiency
- Expected flux: 0.6 c/s

3σ upper limit:

$3\ 10^{-4}\ cm^{-2}.s^{-1}$ (15-30 keV)

Strong spectral steepening needed

Non-thermal bremstrahlung hypothesis unlik

SNR in Galactic Central radian

4 detected PWNe (G21.5-0.9, Kes 75, G11.2-0.3, PSR B1509)

1 AXP in a shell-type SNR

Still no clear signal from shell-type SNRs

Evidence of emission from Western rim of G347.3-0.5

ux and upper limits (to be updated):

	Exposure ks	Flux 15-20 keV 10^{-4}cm^{-2}s^{-1}	Flux 20-40 keV 10^{-4}cm^{-2}s^{-1}	Flux 40-60 keV 10^{-4}cm^{-2}s^{-1}
G21.5-0.9	1153	2.74 +- 0.95	3.74 +- 0.42	0.99 +- 0.21
Kes 75	598	0.58 +- 1.16	2.10 +- 0.56	0.96 +- 0.30
Kes 73	770	1.2 +- 0.97	2.68 +- 0.52	1.02 +- 0.25
G11.2-0.3	1438	2.82 +- 0.95	01.5 +- 0.43	0.54 +- 0.21
SN 1006	270	<4.76	<2.46	<1.35
Kepler	1279	<3.59	<1.44	<0.68
W44	254	<5.70	<2.54	<1.40
RCW86	10	<28.0	<16.5	<7.78

Conclusions

G21.5-0.9 is one the brightest visible SNR in the Galactic central regions

- Clear spectrum steepening compared to X-ray data

Several PWNe are detected: Kes 75, G11.2-0.3, MSH 15-52

No clear signal from shell-type SNRs

- Nothing on Kepler, RCW 86
- Indications of emission from Western rim of G347.3-0.5
  - No emission from AX J1714.1-3912
  - Extension has to be corrected for
- Emission from clumps in γ-Cygni (Bykov et al., 2004)
  - Interaction of SNR with molecular cloud

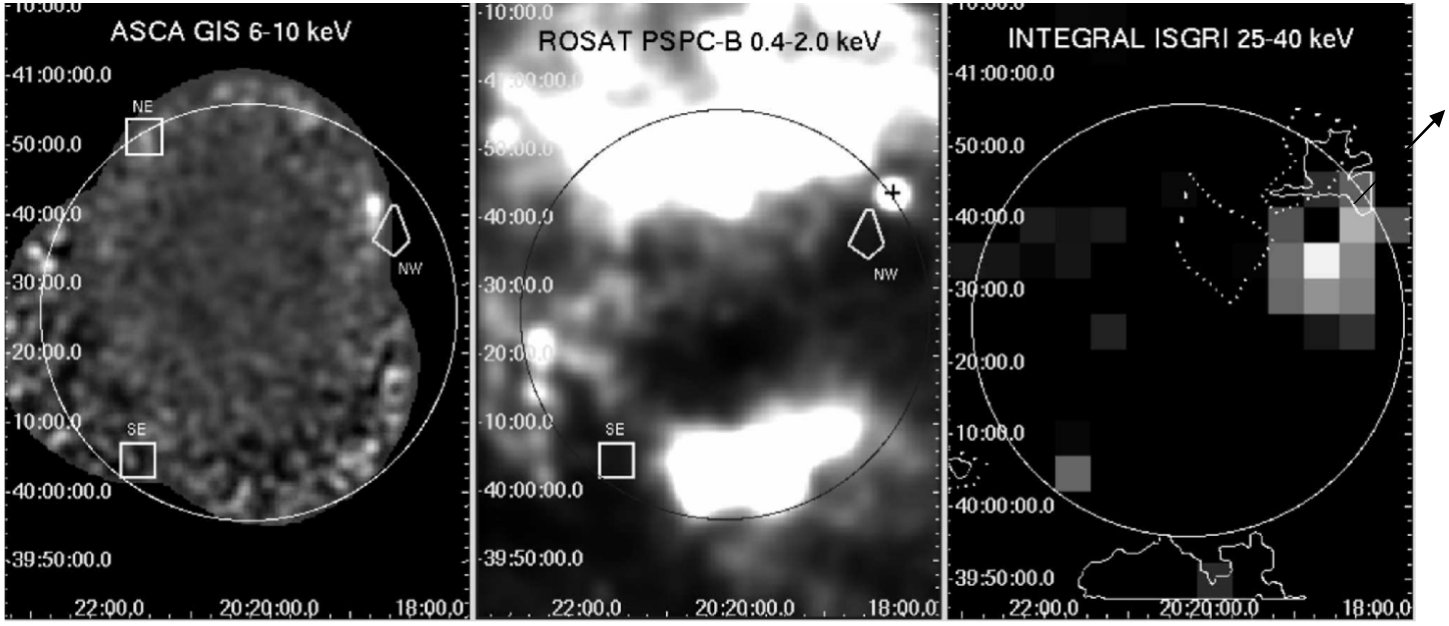
Future improvements:

- **Extended sources analysis**
- **LT correction should enhance sensitivity at low energy**

γ Cygni

Observations of cygnus X1 & Cygnus X3 during PV phase

(Bykov et al. 2004)



Significance above 5s

2 ISGRI clumps in the NW & SE regions in highly absorbed regions ($N_H > 5.10^{21}$ cm^{-2})

Presence of Ha+N[II], S[II] and O[III] line emission

Interaction of the SNR radiative shock with a nearby cloud?

γ Cygni

Multiwavelength spectrum

XTE & ASCA (3-15 keV) fitted by a broken PL

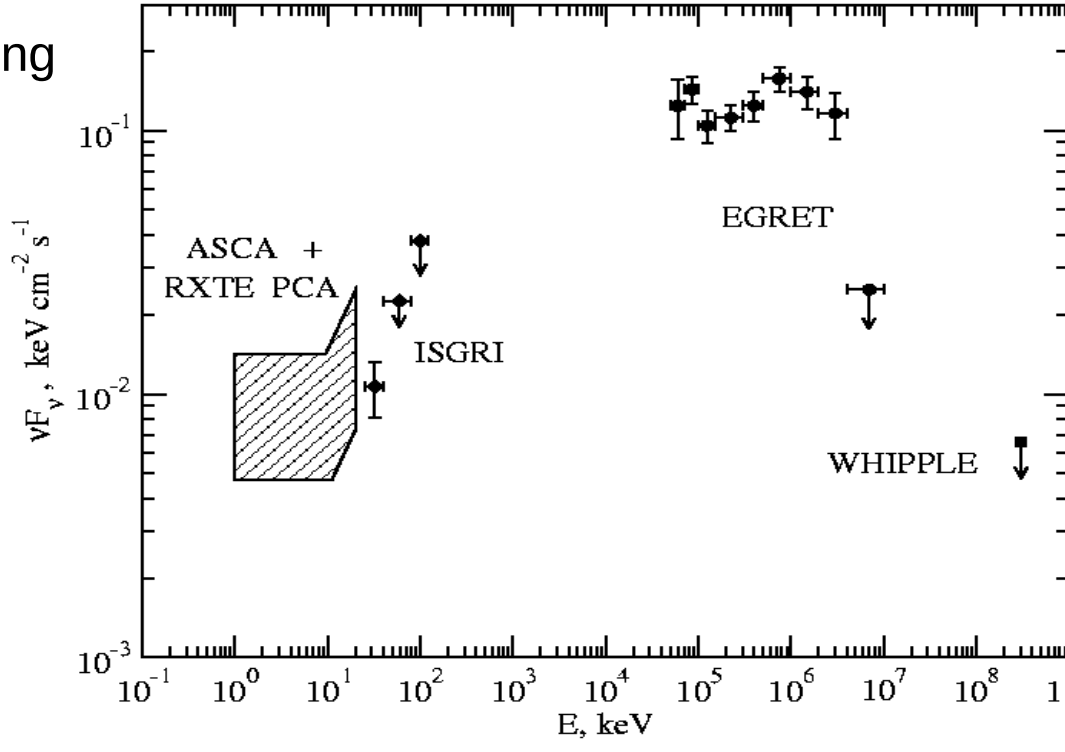
- $\alpha = 2.0 \pm 0.4$ $E<E_b = 11.1 \pm 1.2$ keV
- $\alpha = 1.1 \pm 0.4$ $E>E_b$

Extrapolation in rough agreement with ISGRI data

Origin: non-thermal bremsstrahlung emission?

Shock in the interclump medium or fast moving ejecta fragment

(Bykov 2000)



G0.9+0.1

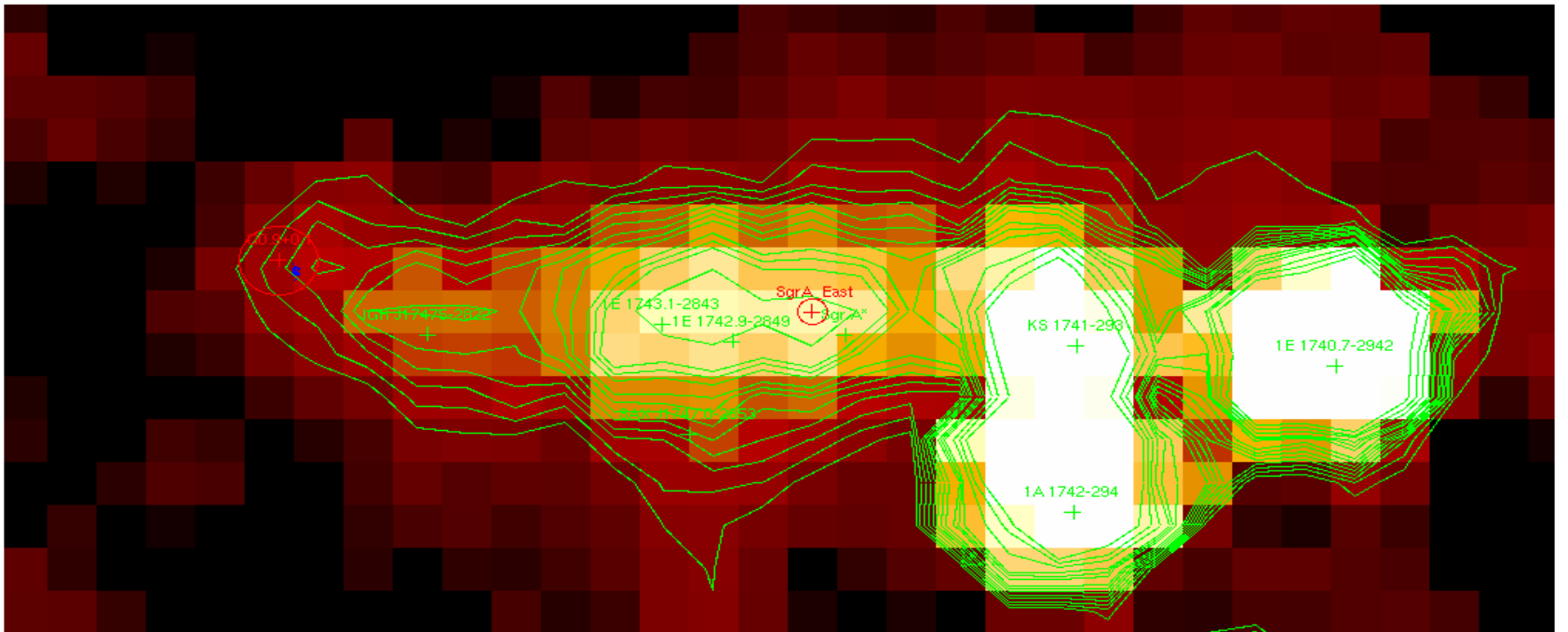
Extrapolation of PWN is consistent with the observed flux (20-40 keV)

Presence of an LMXB close-by

– Detected by XMM (Sidoli et al. 2004)

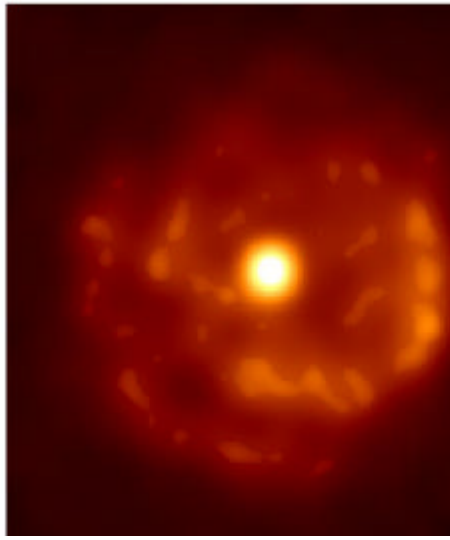
Position consitent with G0.9+0.1 but closer to the binary

Comparison of GCDE 1 and GCDE 2 data suggests flux variability



Kes 73

es 73 is a young shell-type SNR (<2000 yr) at 6 kpc



E 1841-045, anomalous X-ray pulsar (AXP):
- period is 11.8s
- spectral index is 2±0.3

he thermal shell is very faint
o nebula around the pulsar.

es 73 is detected at 5σ in the 20-40 keV
he integrated flux obtained is
(15-60keV) = 2.2×10^{-11} ergs cm^{-2} s^{-1}.

pectrum harder than in X-rays