

Galactic γ -ray Continuum

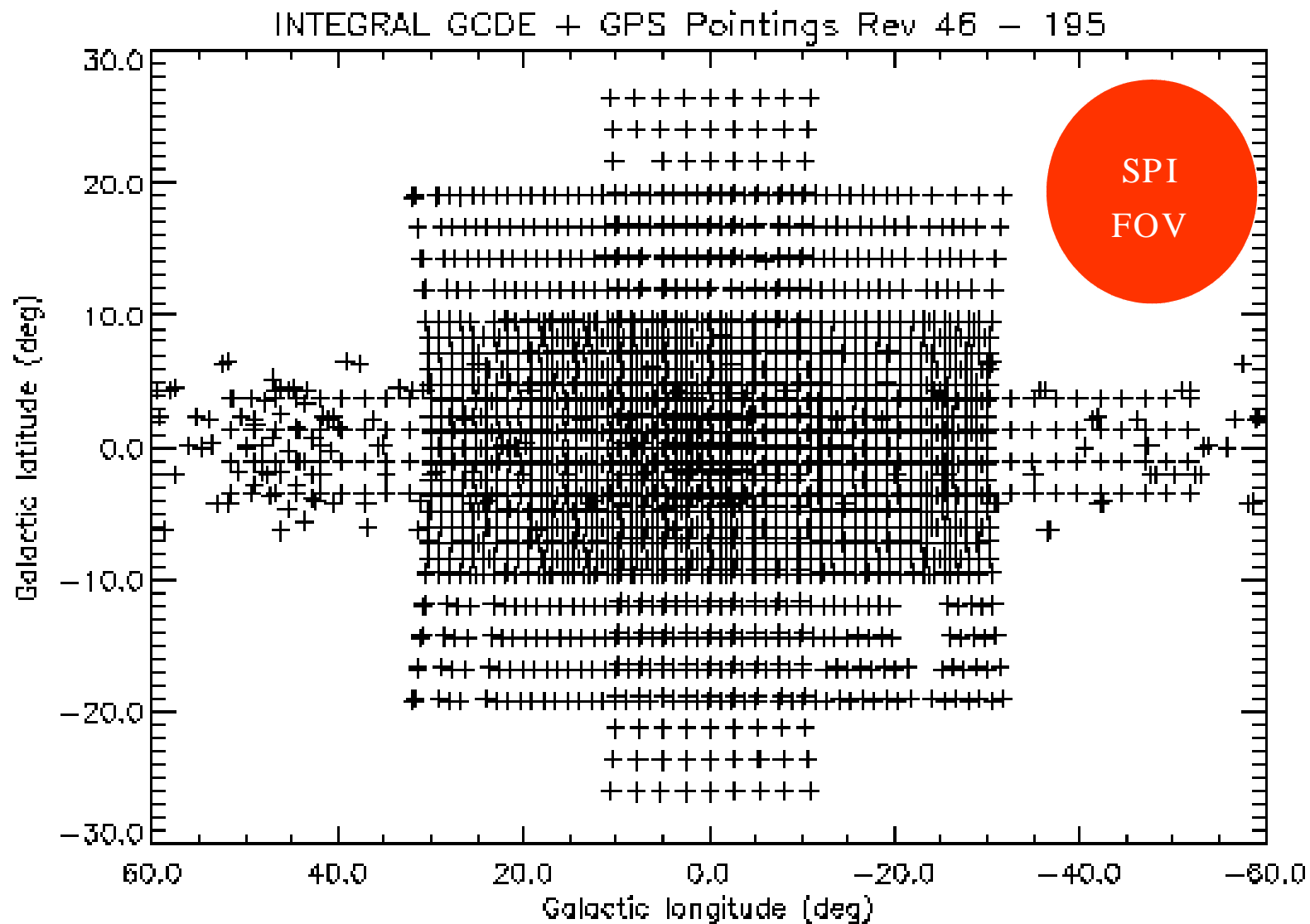
with INTEGRAL/SPI

A. Strong, MPE

INTEGRAL/ESTEC Workshop 2005

Core program: Galactic plane survey

4088 pointings from GCDE 1-2-3. Exposure 6×10^6 sec



Diffuse emission spectral fitting

DATA

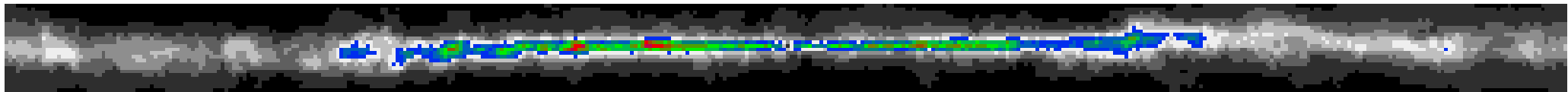
- Data from 65 INTEGRAL revolutions - Core Time
- exposure: $6 \cdot 10^6$ sec
- energy range 18 – 1000 keV

MODEL

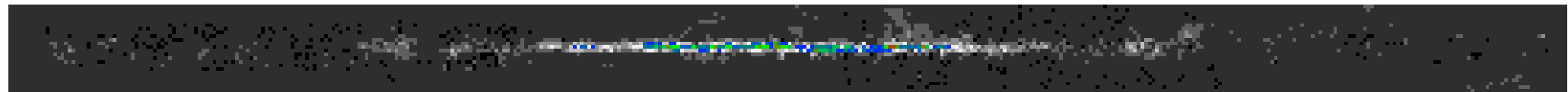
- Fitted components:
 - Background / pointing
 - *Sources : 91 from IBIS* →
 - Disk (HI + CO), bulge



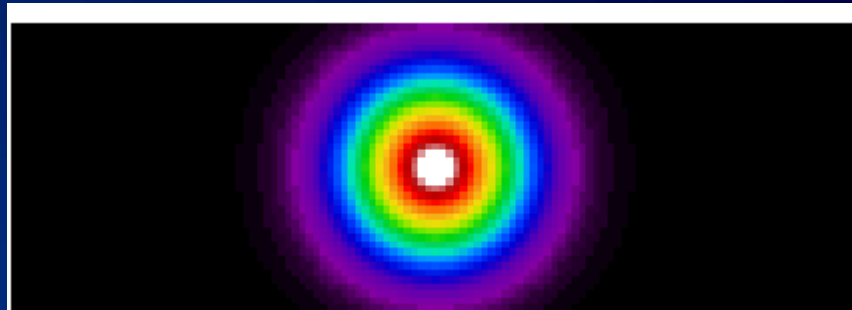
HI



CO



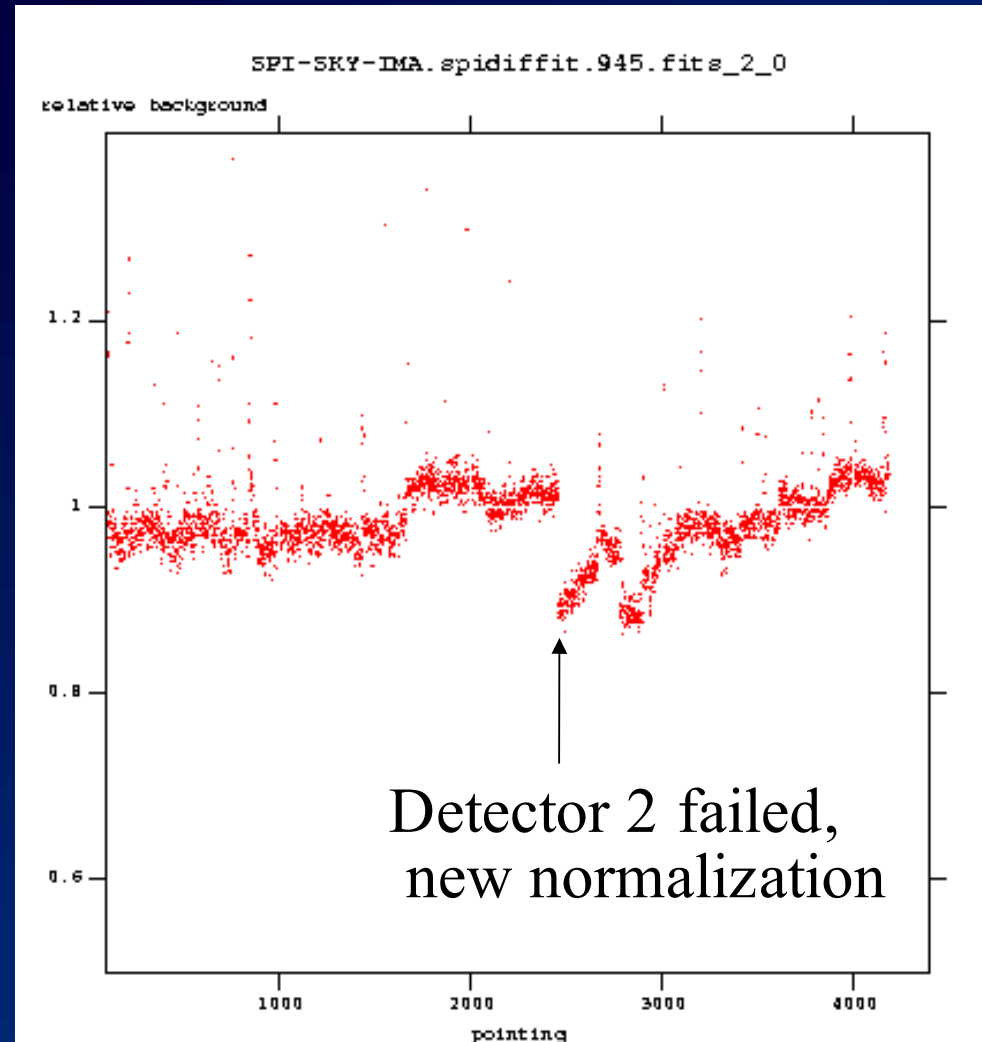
Bulge
 e^+e^- annihilation



IBIS Sources



Example of time-dependence of background
determined by *spidiffit*, $E=108-118\text{ keV}$
Using detector ratios template



Very few sources have hard spectra like Cyg X-1, most cut off.
 Only a few detected > 200 keV.
 So $> \sim 200$ keV, sources are a *minor component*,
 hence including all IBIS sources gives too much freedom.
*Including many sources leads to 'glow' from whole population,
 simulates diffuse emission, indistinguishable from real diffuse.*
 >> At high energies, fit without/with few sources !

Diffuse emission fitted :

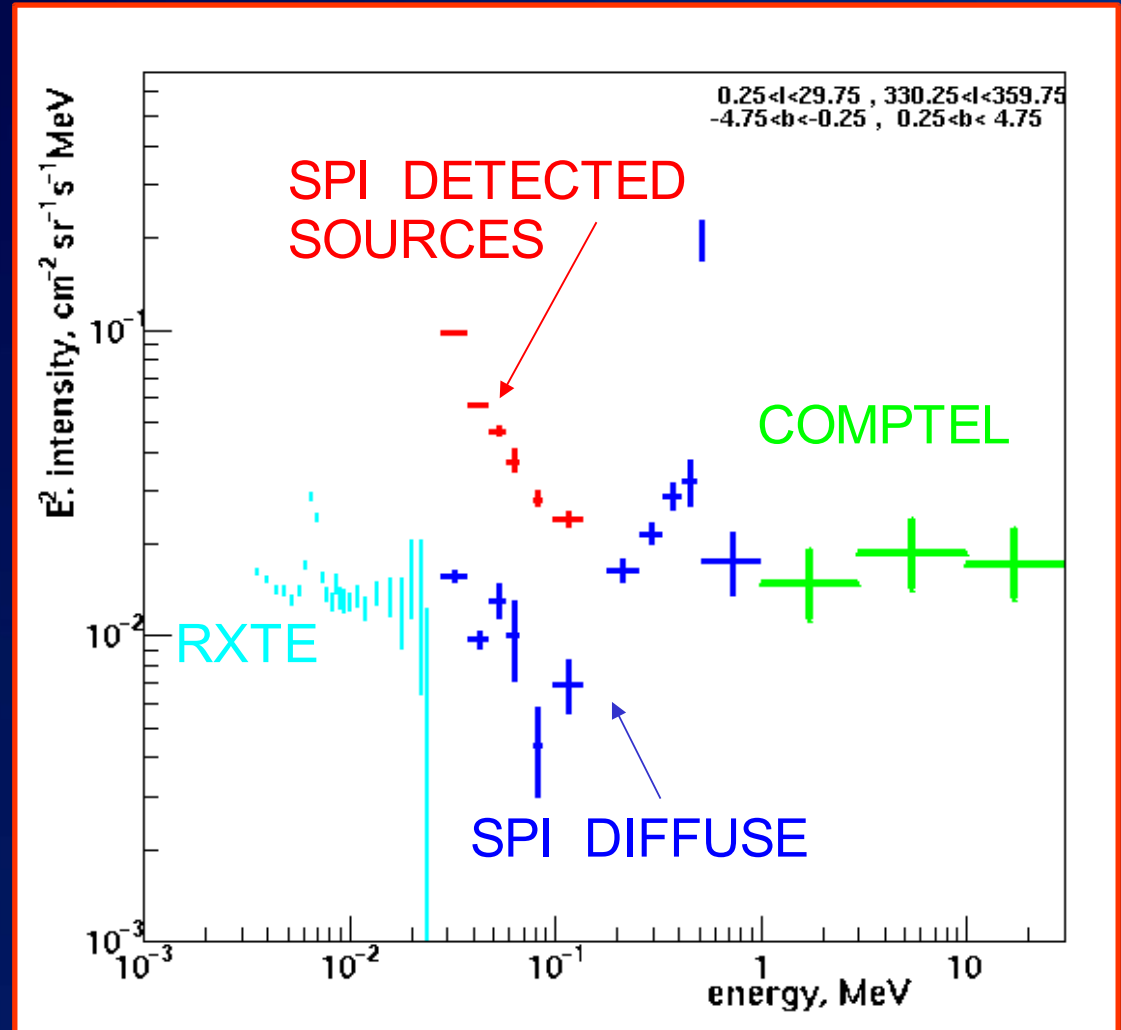
Energy Range	with sources	without sources	with 5 sources	with 14 source
268 - 518 keV	3σ	16σ	13σ	9.3σ
338 - 498 keV	2σ	10σ		
518 - 768 keV	0.4σ	4σ	3.3σ	
768-1018 keV	1.4σ			

Diffuse Emission and Sources in Galactic Ridge

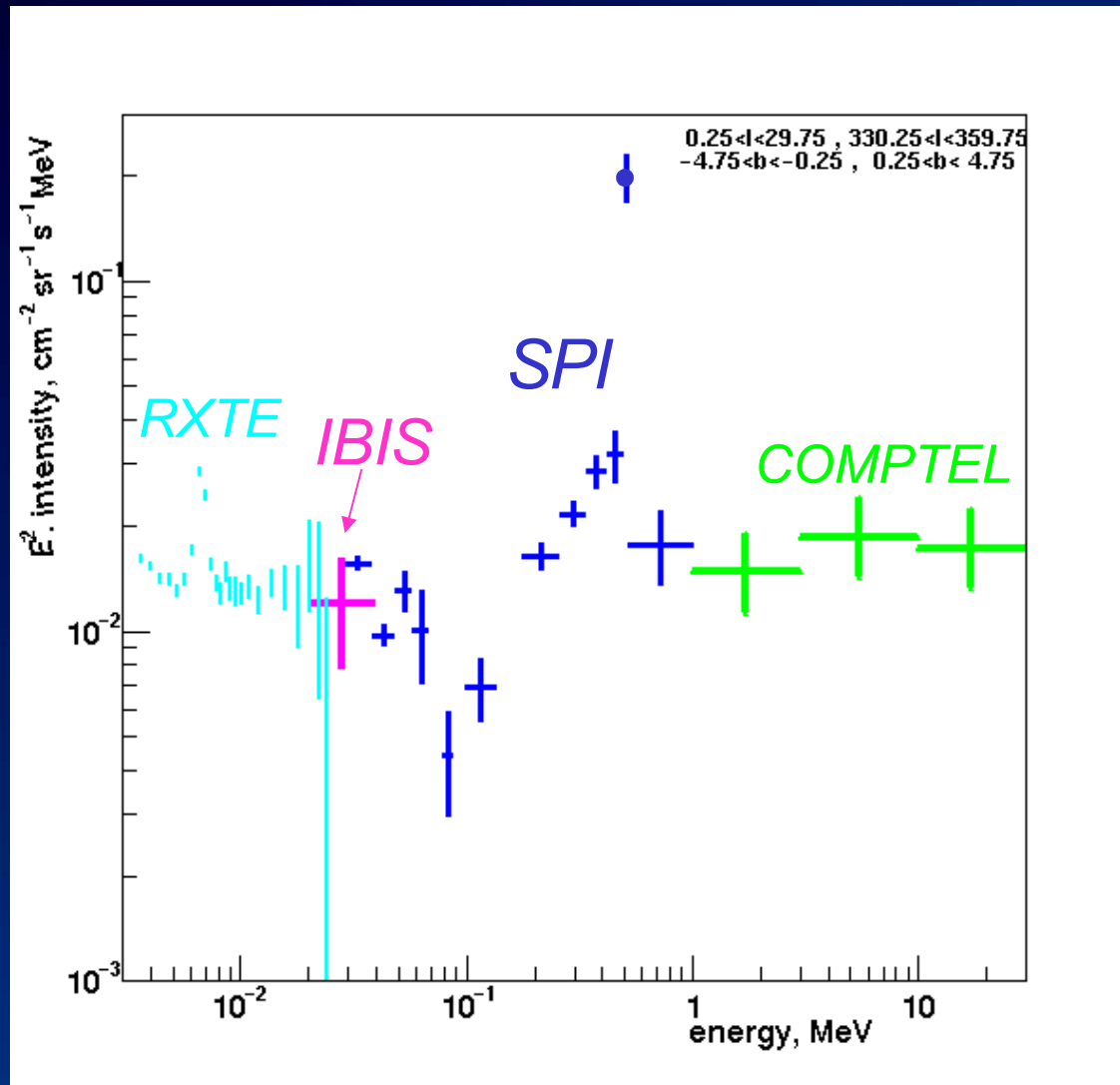
Diffuse emission:
10% to ~100%
of total emission

cf. 2-10 keV (Grimm 2002):
Sources $2 \times 10^{39} \text{ erg s}^{-1}$

Diffuse $10^{38} \text{ erg s}^{-1}$

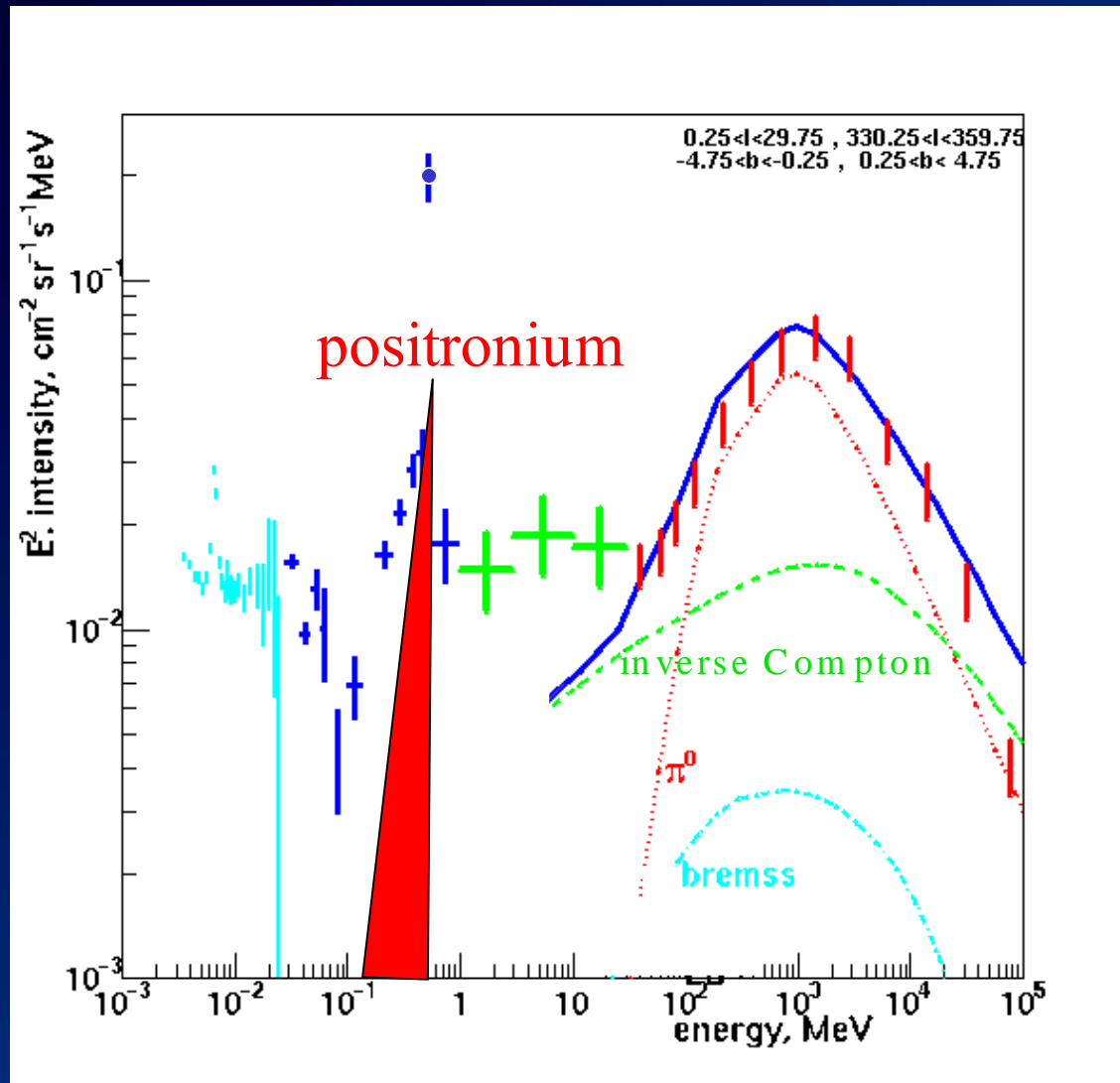


Diffuse Emission from Galactic Ridge

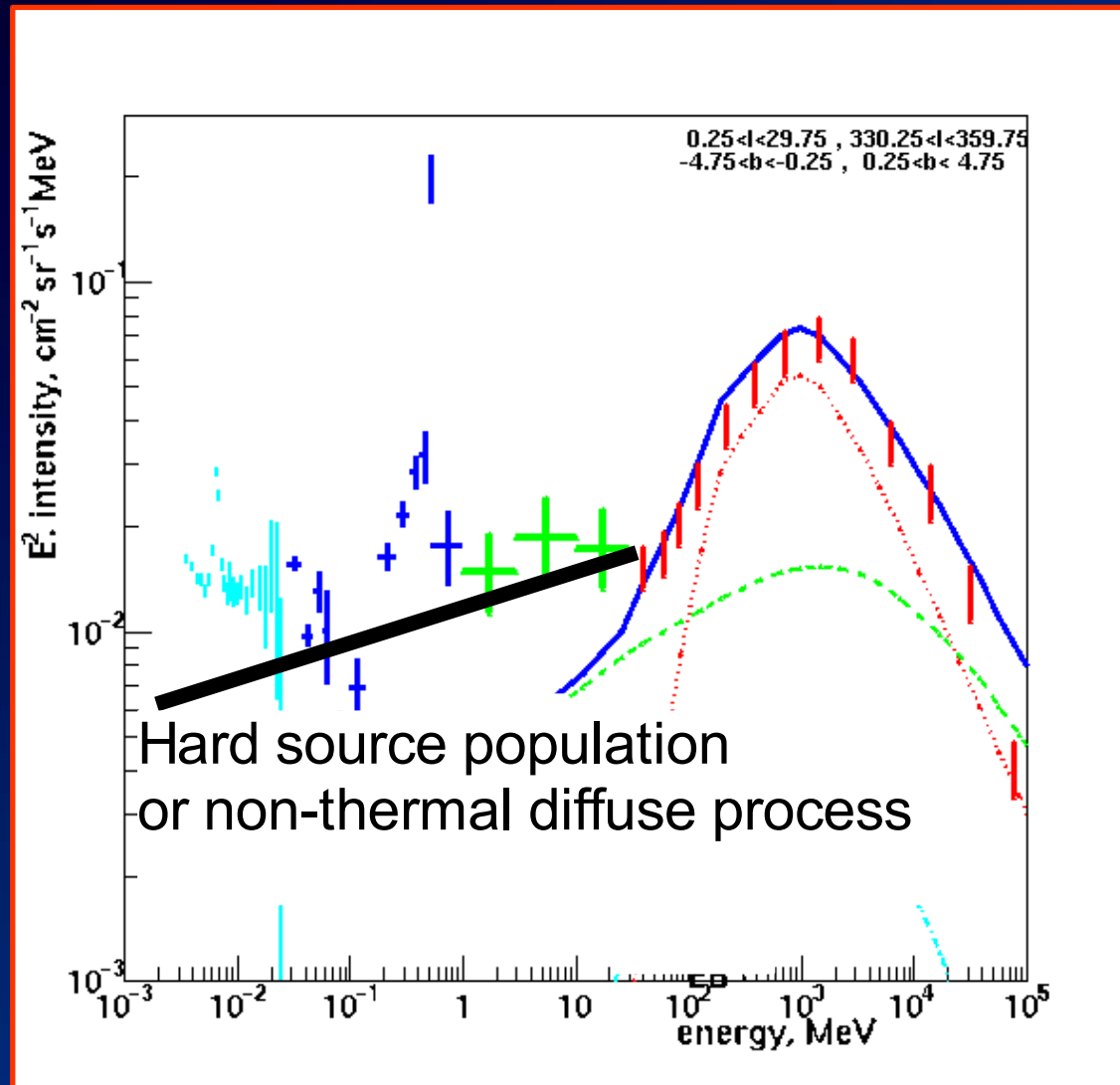


IBIS: Terrier et al. 5th INTEGRAL Workshop

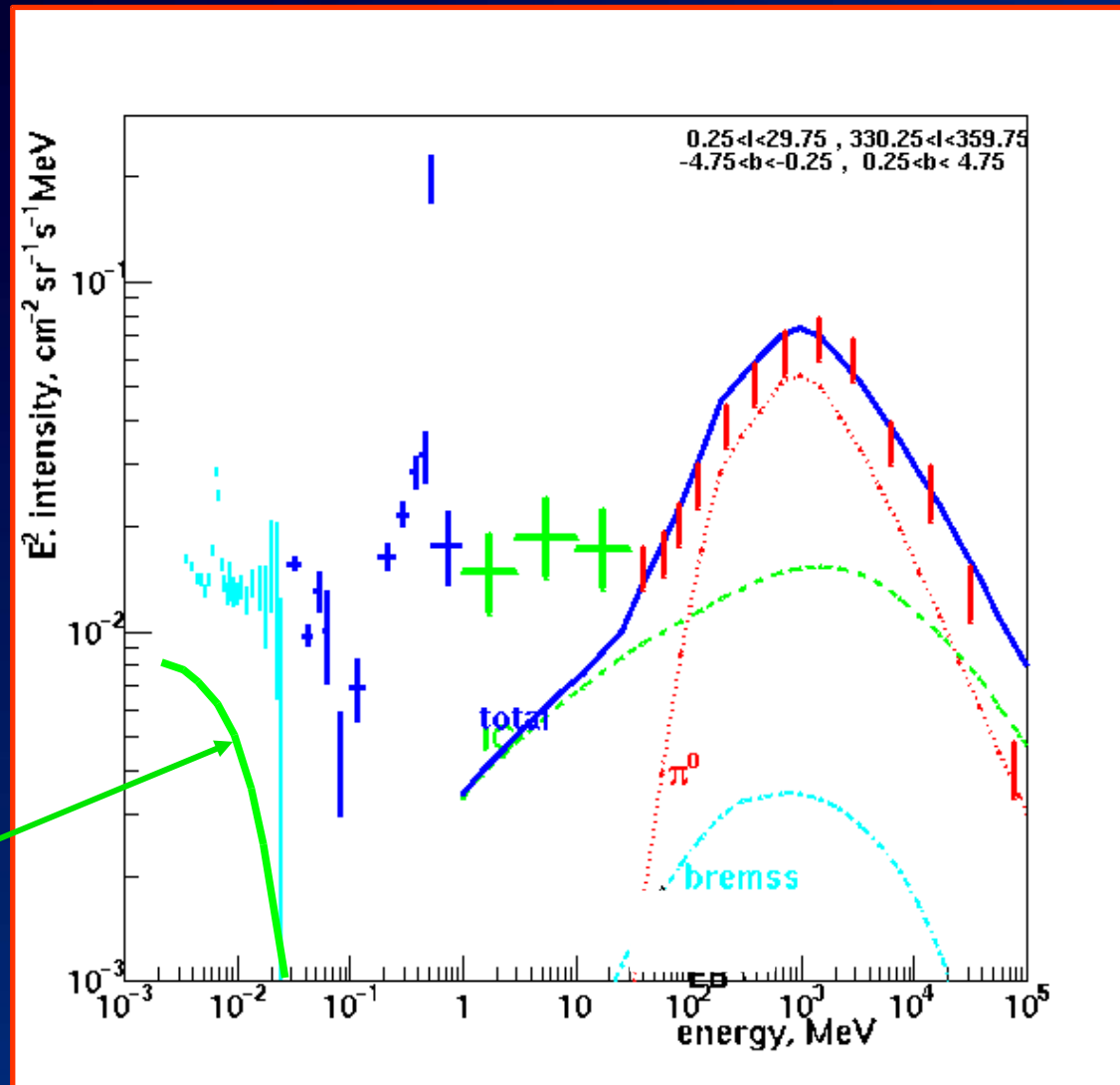
Diffuse Emission from Galactic Ridge



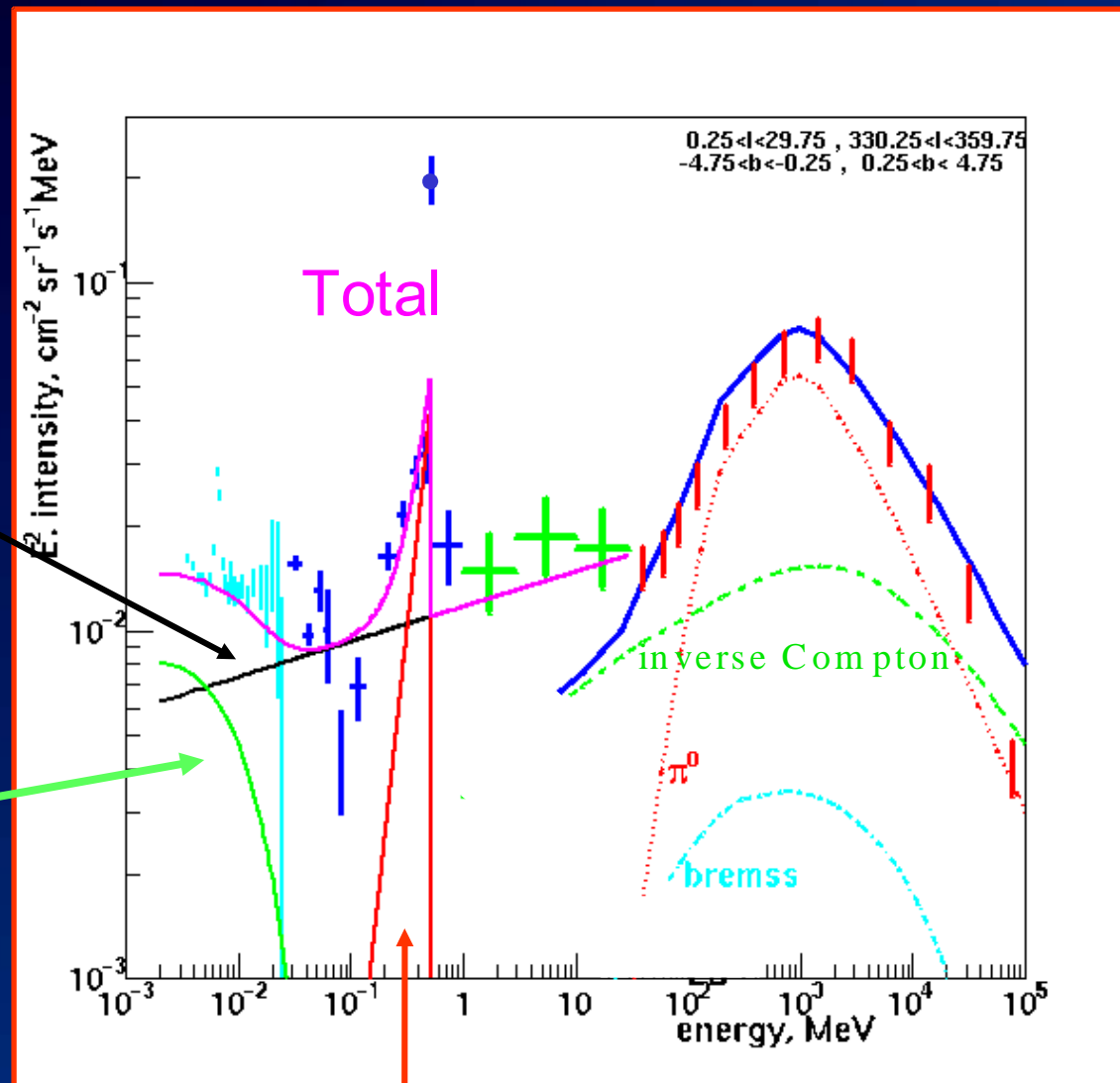
Diffuse Emission from Galactic Ridge



Diffuse Emission from Galactic Ridge



Diffuse Emission from Galactic Ridge

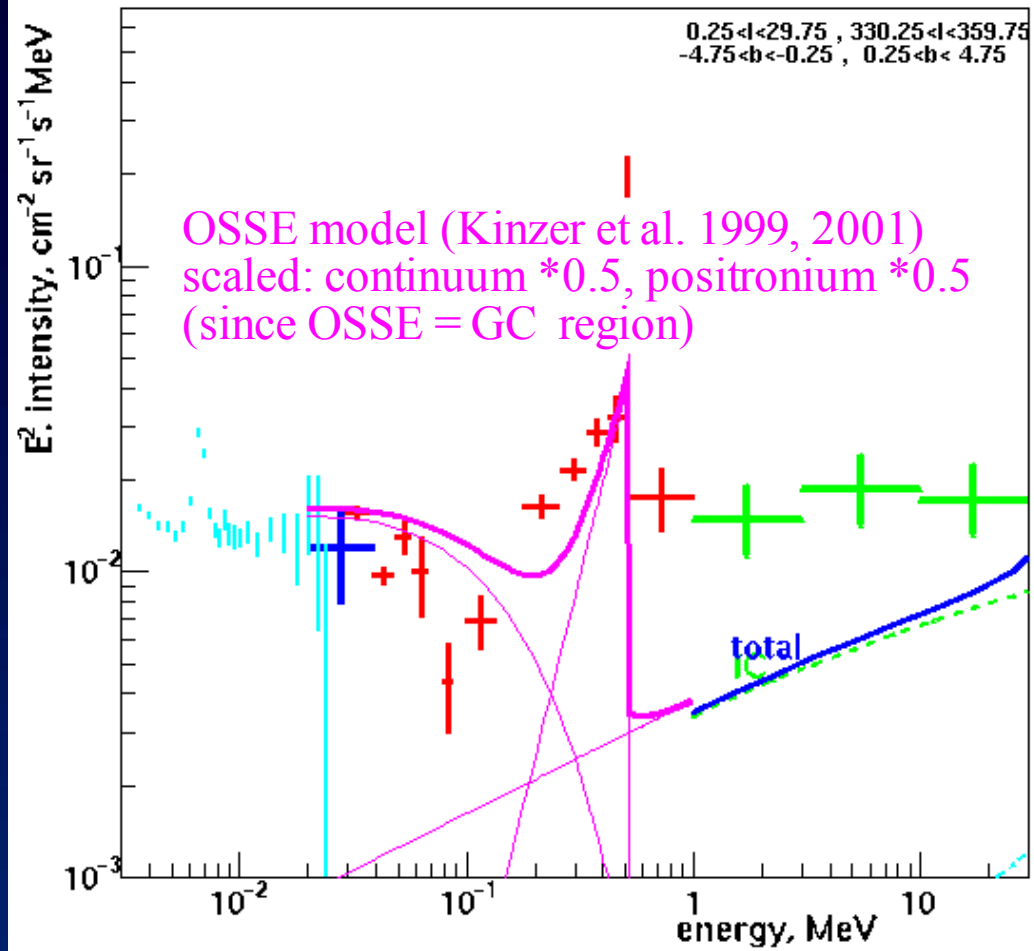


nonthermal

Cutoff power law

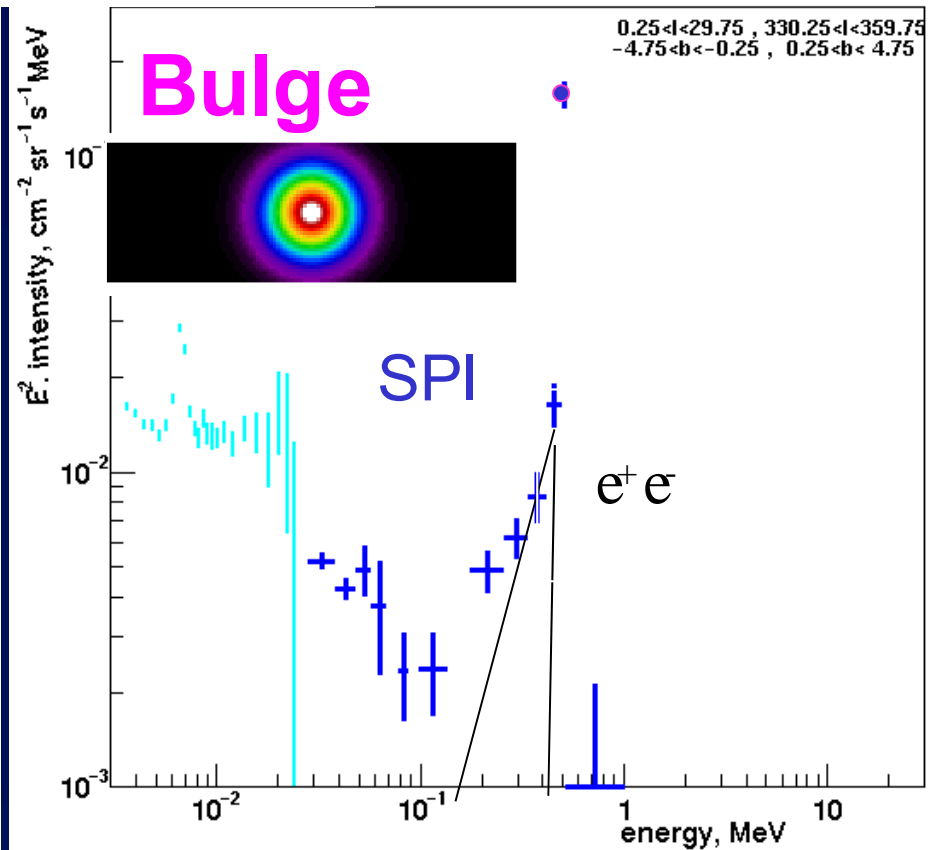
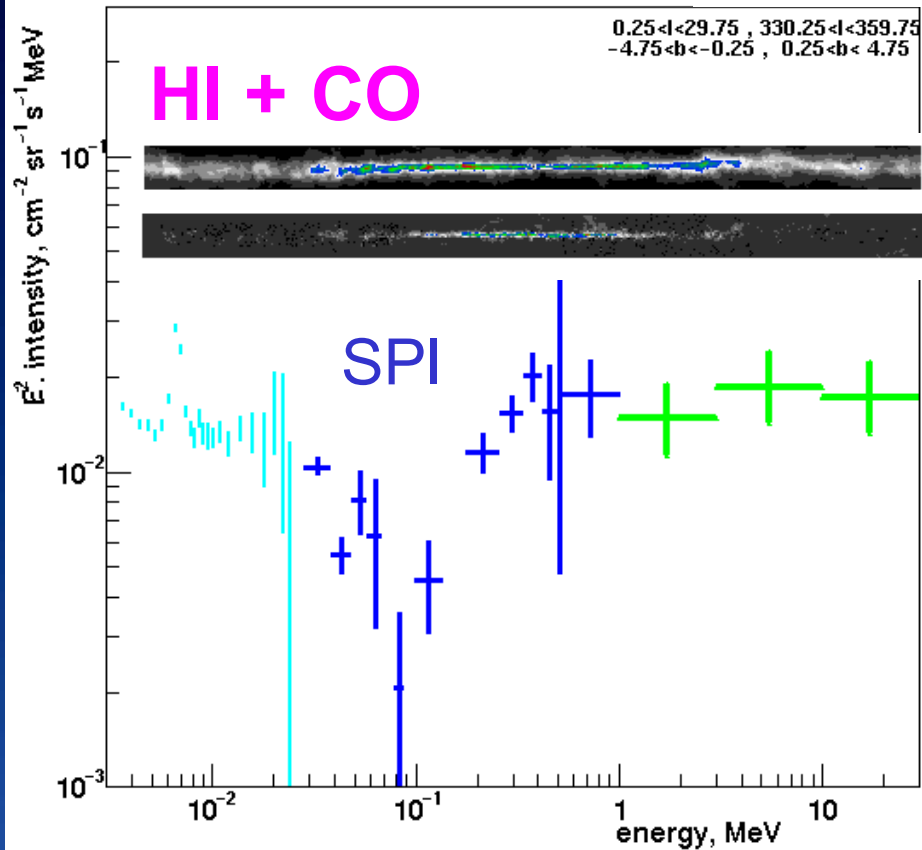
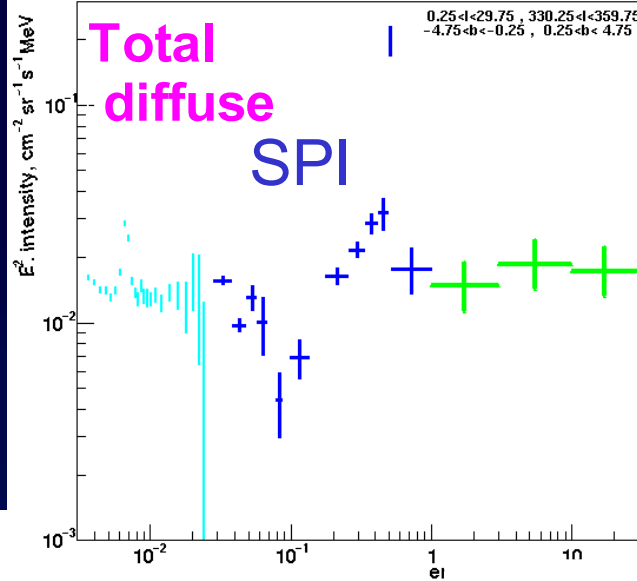
positronium

galdef ID 45_600202

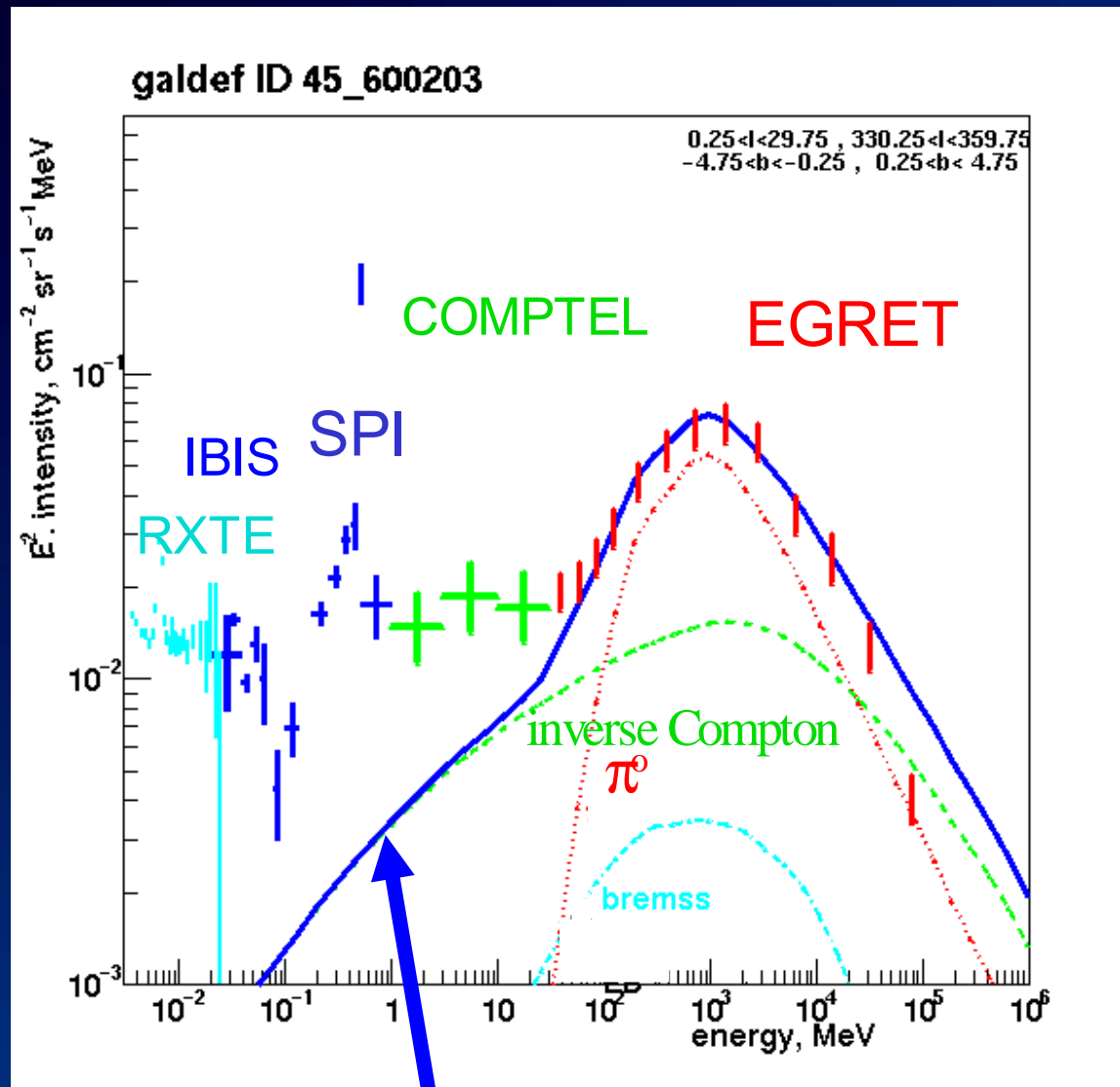


Morphological decomposition

galdef ID 45_600202

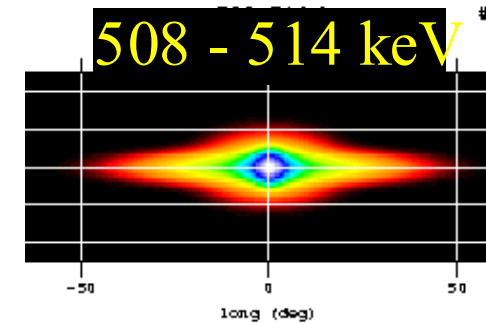
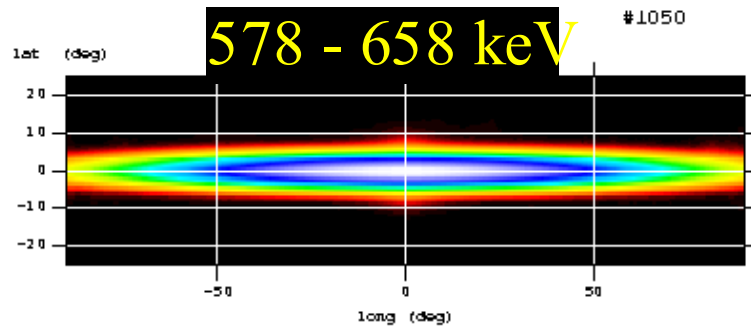
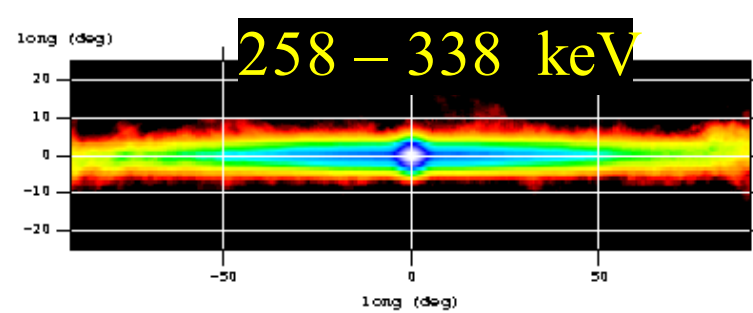
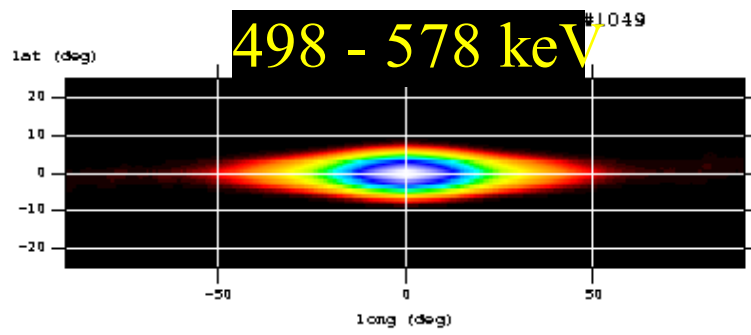
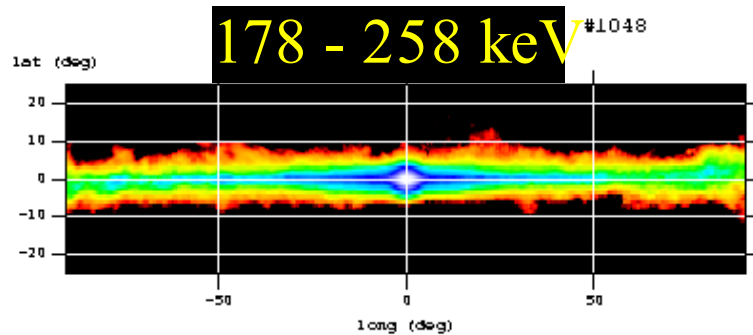
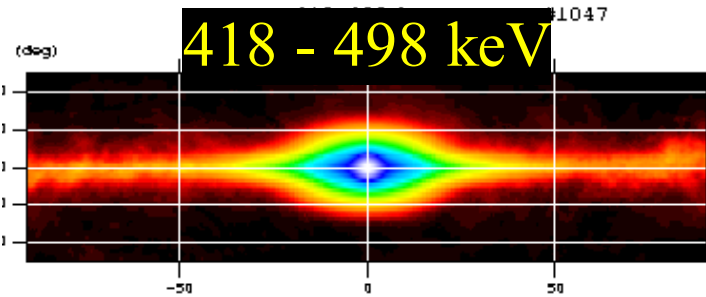
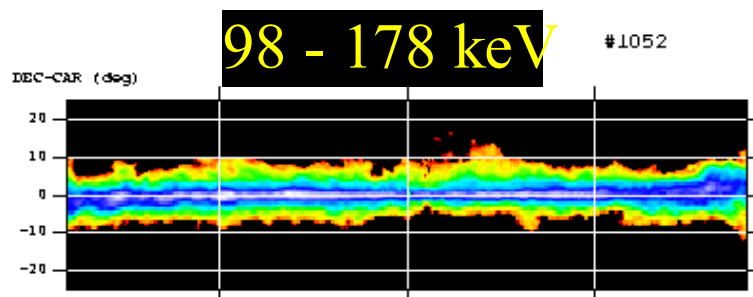
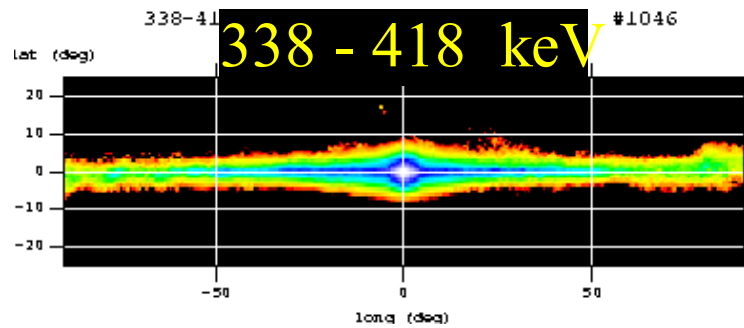
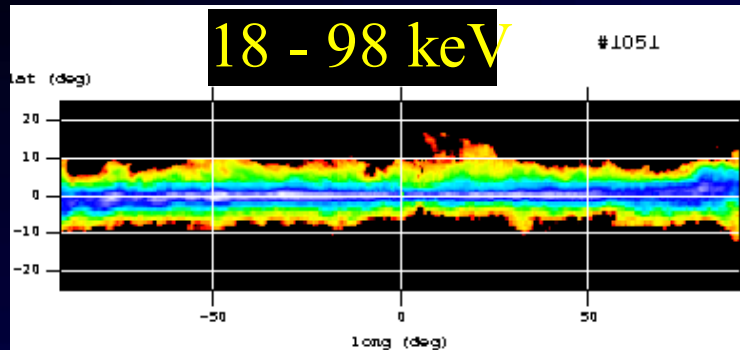


Hard X-rays from inverse Compton ?



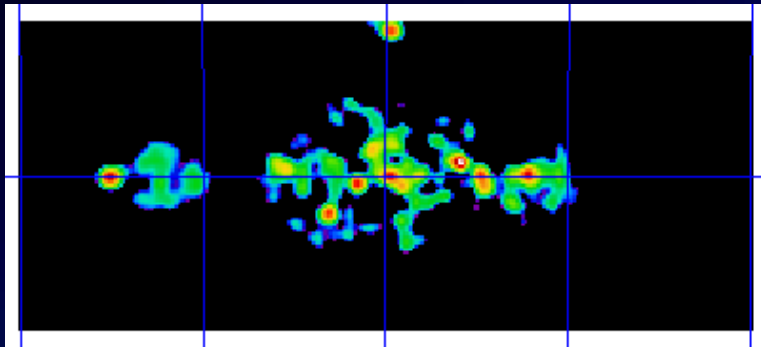
Inverse Compton can explain 10 - 30% in SPI range....but electron spectrum could be steeper, then could produce more.....

Multicomponent („pixon“) images 10 components : HI + CO + 8 Gaussians (5°-80° FWHM)



SPI maximum entropy skymaps

18-143 keV

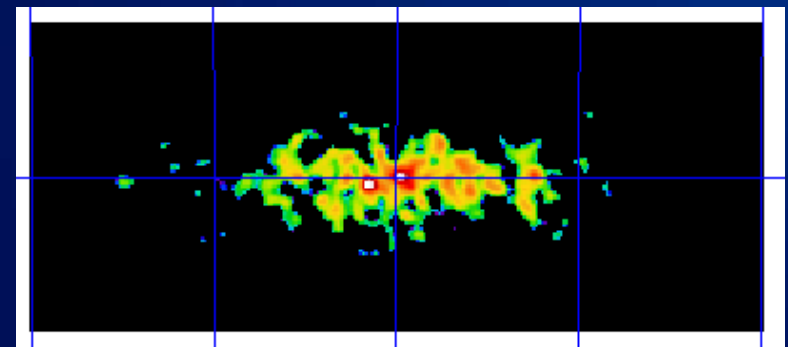


+25

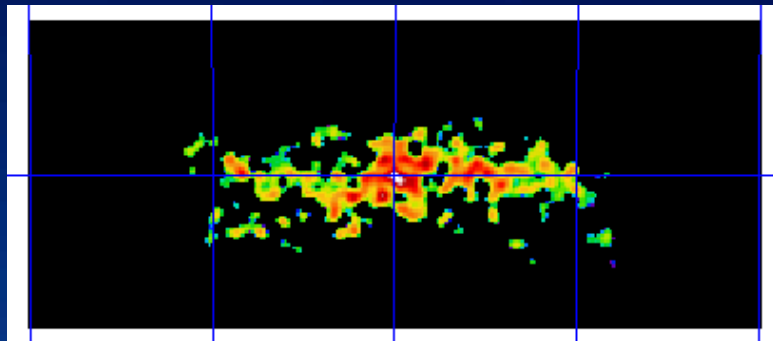
-25

60 0 300

143-268 keV



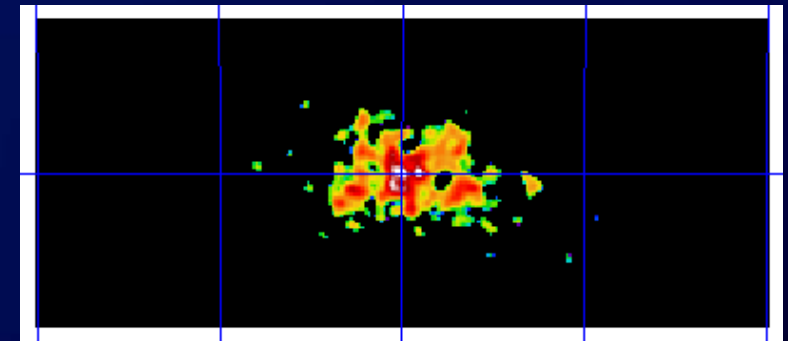
268-393 keV



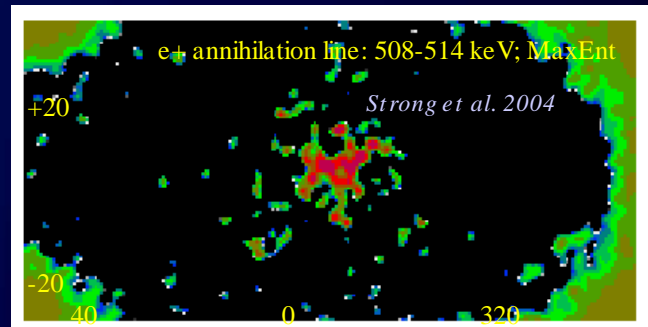
positronium



393-518 keV



508-514 keV

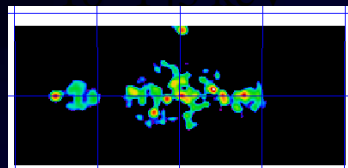


INTEGRAL / SPI

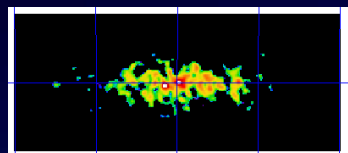
CGRO / COMPTEL

CGRO / EGRET

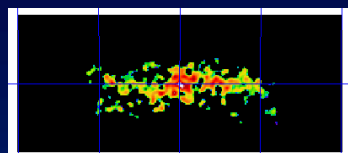
18 - 143 keV



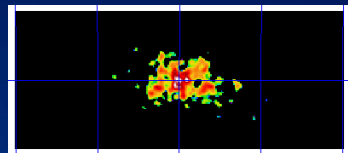
143 - 268 keV



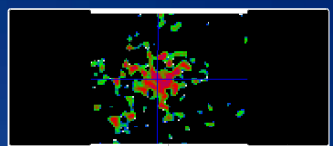
268 - 393 keV



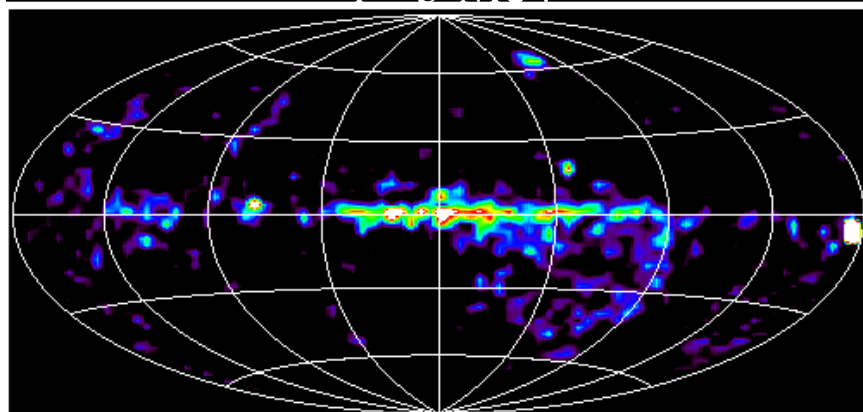
393 - 518 keV



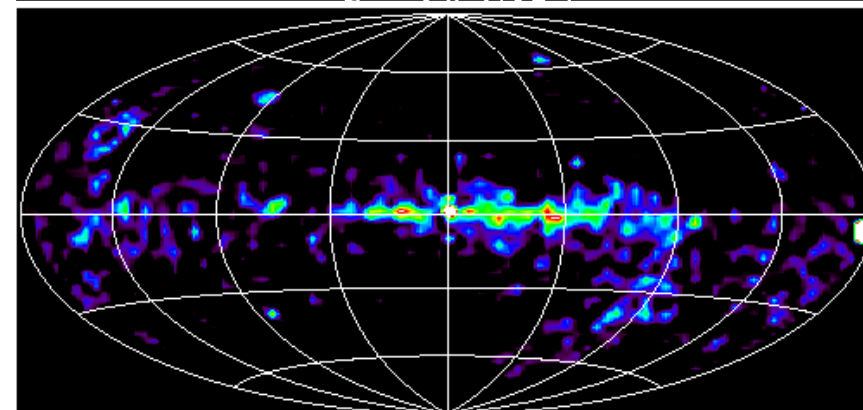
508 - 514 keV



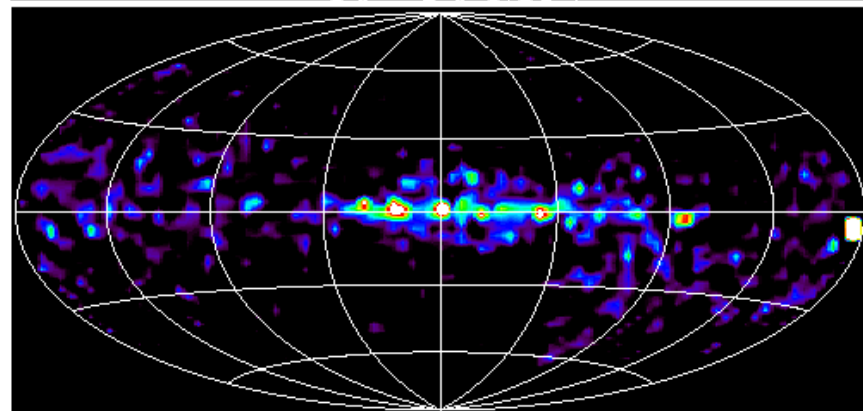
1 - 3 MeV



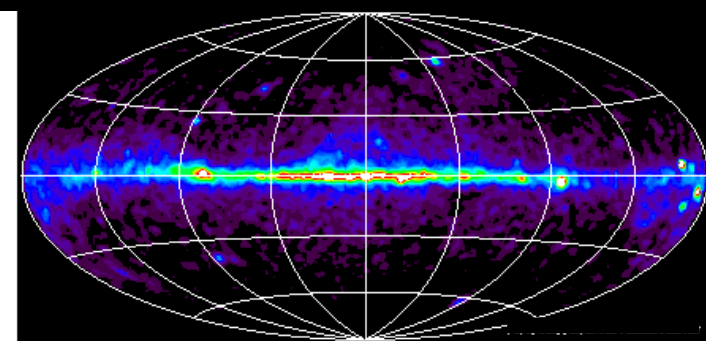
3 - 10 MeV



10 - 30 MeV



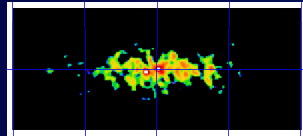
> 100 MeV



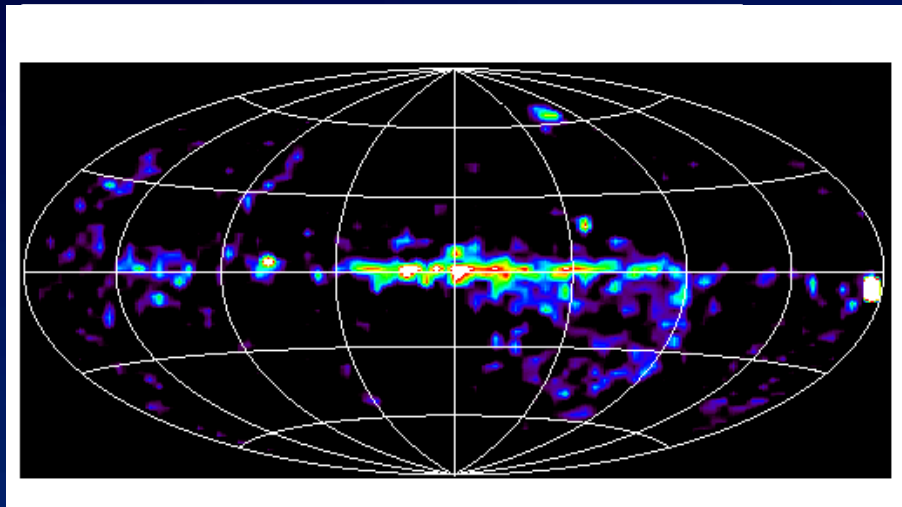
Comparison of SPI and COMPTEL skymaps

INTEGRAL/SPI

143 - 268 keV



COMPTEL
1 - 3 MeV



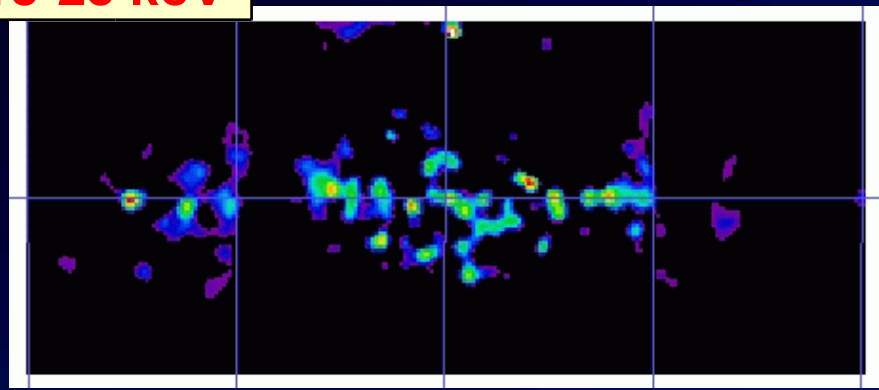
Hard X-ray emission
more concentrated
to inner Galaxy
than for MeV ?

Reflects different origin ?

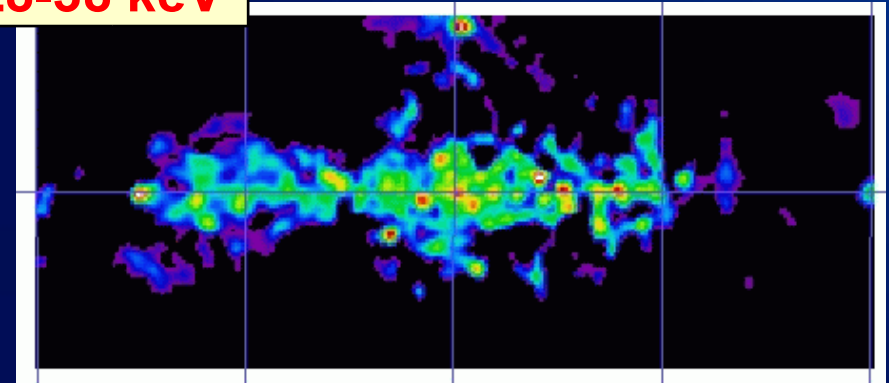
Hard X-rays:
Source population like LMXB

Finer energy resolution

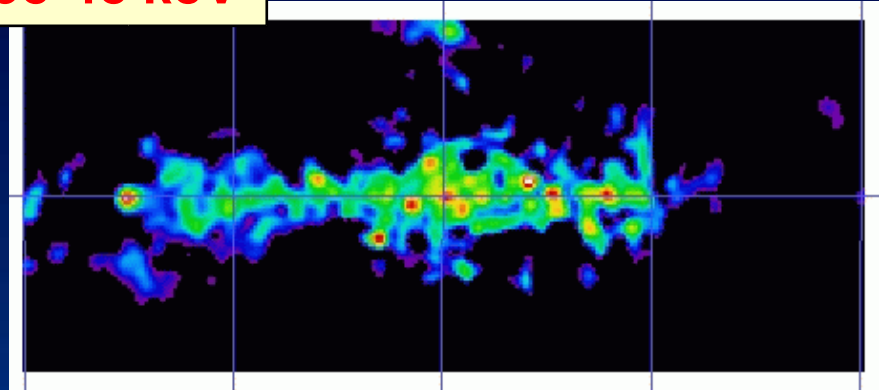
18-28 keV



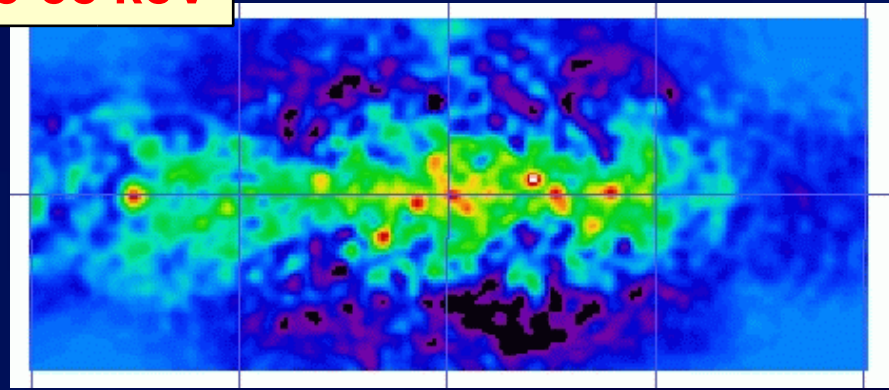
28-38 keV



38-48 keV



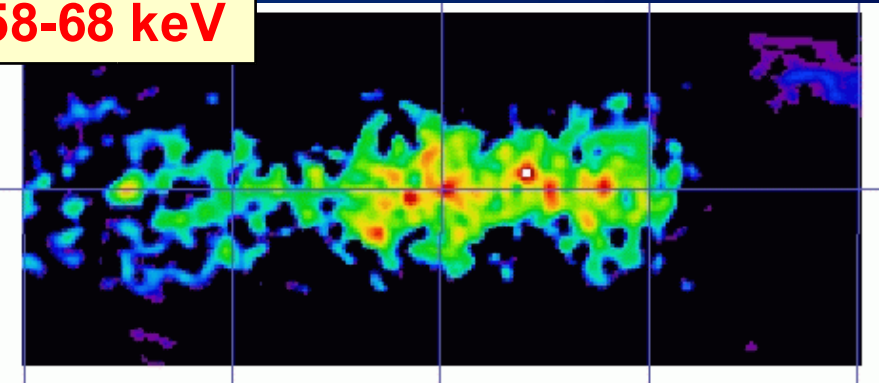
48-58 keV



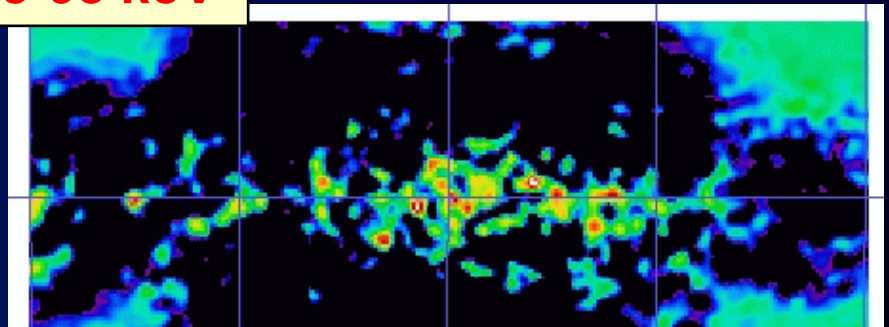
+25

-25

58-68 keV

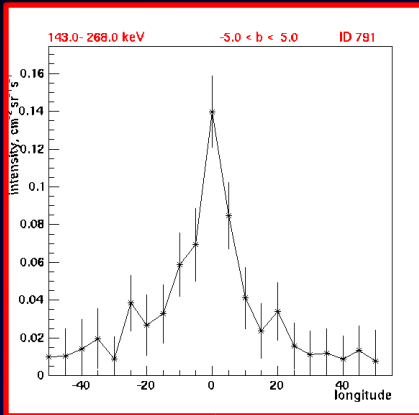


88-98 keV

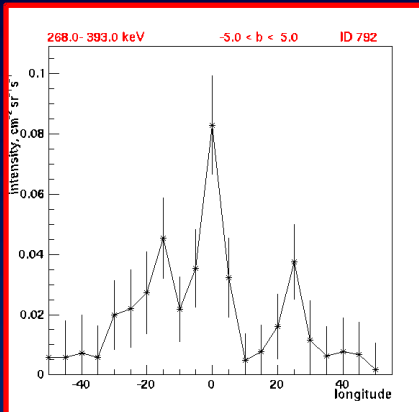
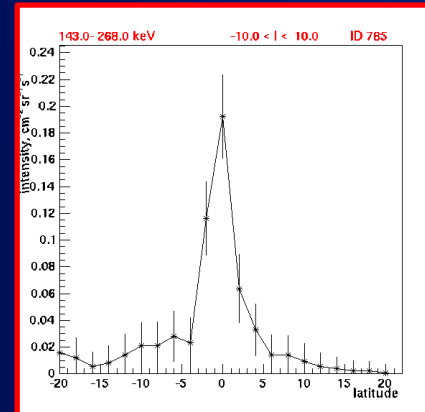


60 0 300

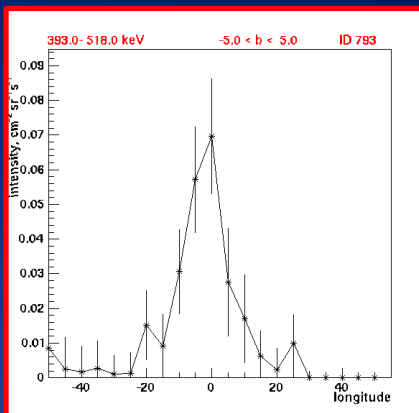
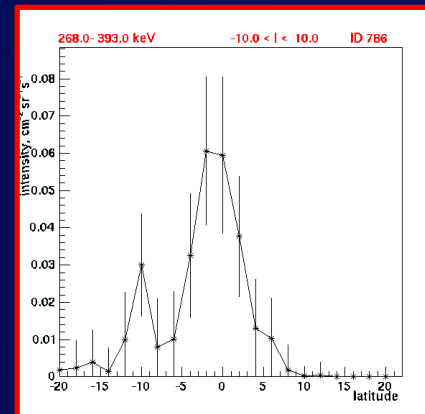
Longitude/latitude profiles from maximum entropy method



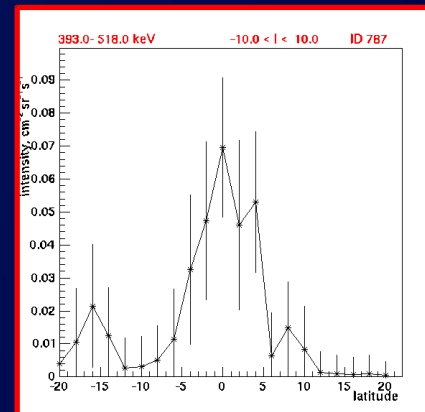
143-268 keV



268-393 keV



393-518 keV



Origins of interstellar emission

Thermal: 10 keV exceeds escape energy for gravitational containment
& implies large power to replenish hot gas.

Non-thermal: electron bremsstrahlung
very inefficient due to ionization losses
X-ray luminosity 10^{38} erg s⁻¹ needs 10^{42} erg s⁻¹ particle input,
> total SN, cosmic-ray power !

Possible mechanisms

In-situ acceleration of suprathermal electrons from thermal pool (Dogiel)

In-situ acceleration of secondary electrons by interstellar turbulence (Schlickeiser)

Continuous acceleration in SNR (Yamasaki)

Or

Unresolved (& unknown) point-source populations

Is 'diffuse emission' from unresolved sources ?

Can estimate based on 2 - 10 keV luminosity function from

RXTE: Grimm et al (2002): A&A 391, 923

700 LMXB+HMXB in Galaxy $> 10^{34}$ erg s $^{-1}$

(217 detected, 190 $> 2 \cdot 10^{35}$ erg s $^{-1}$)

Total luminosity 2-3 10^{39} erg s $^{-1}$ 'dominated by 5 - 10 brightest sources'

$$\int L(LMXB) = 10 \int L(HMXB)$$

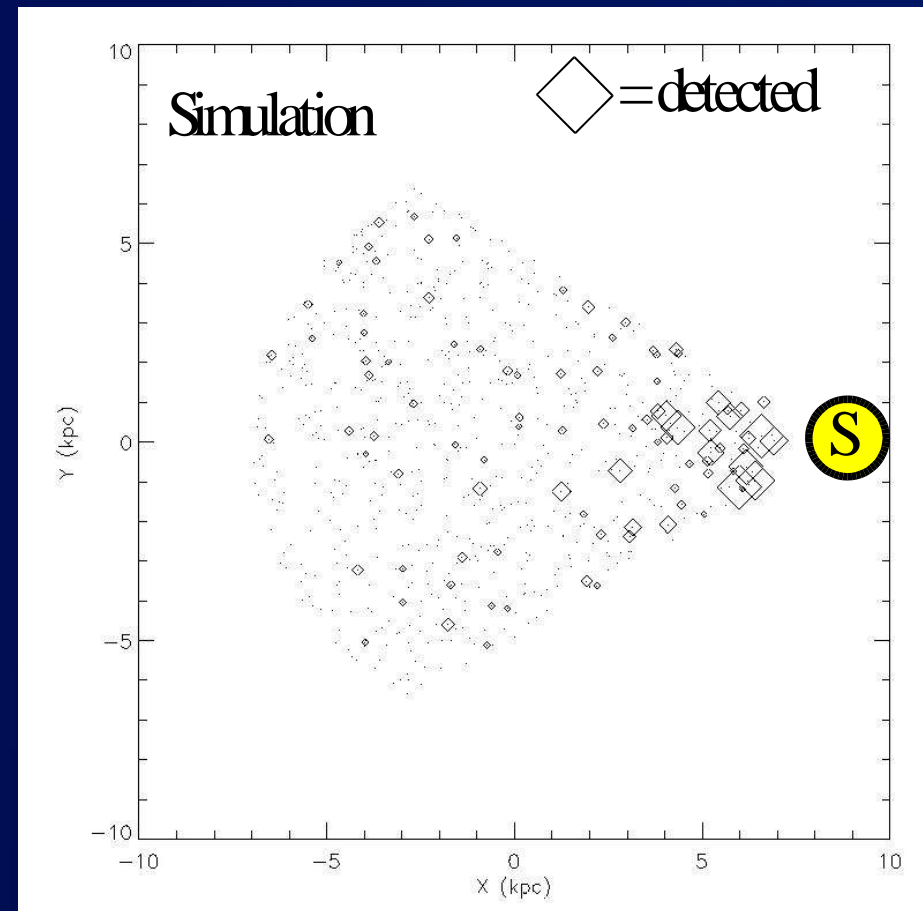
$$\text{LMXB: } N(L) \sim L^{-1.26}$$

$$\text{HMXB: } N(L) \sim L^{-1.64}$$

$$L = 10^{34} - 2.7 \cdot 10^{38} \text{ erg s}^{-1}$$

simulation: 700 sources:
choose limit so 90 (cf. IBIS) detected.
~1% of flux is in undetected sources.

\ll SPI 'diffuse' / detected sources
below 50 keV
but rather sensitive to model



Next steps:

Use all public + Core Time data

Update source catalogue

Analysis with with more diffuse components

Prepare publication

END