Galactic γ-ray Continuum

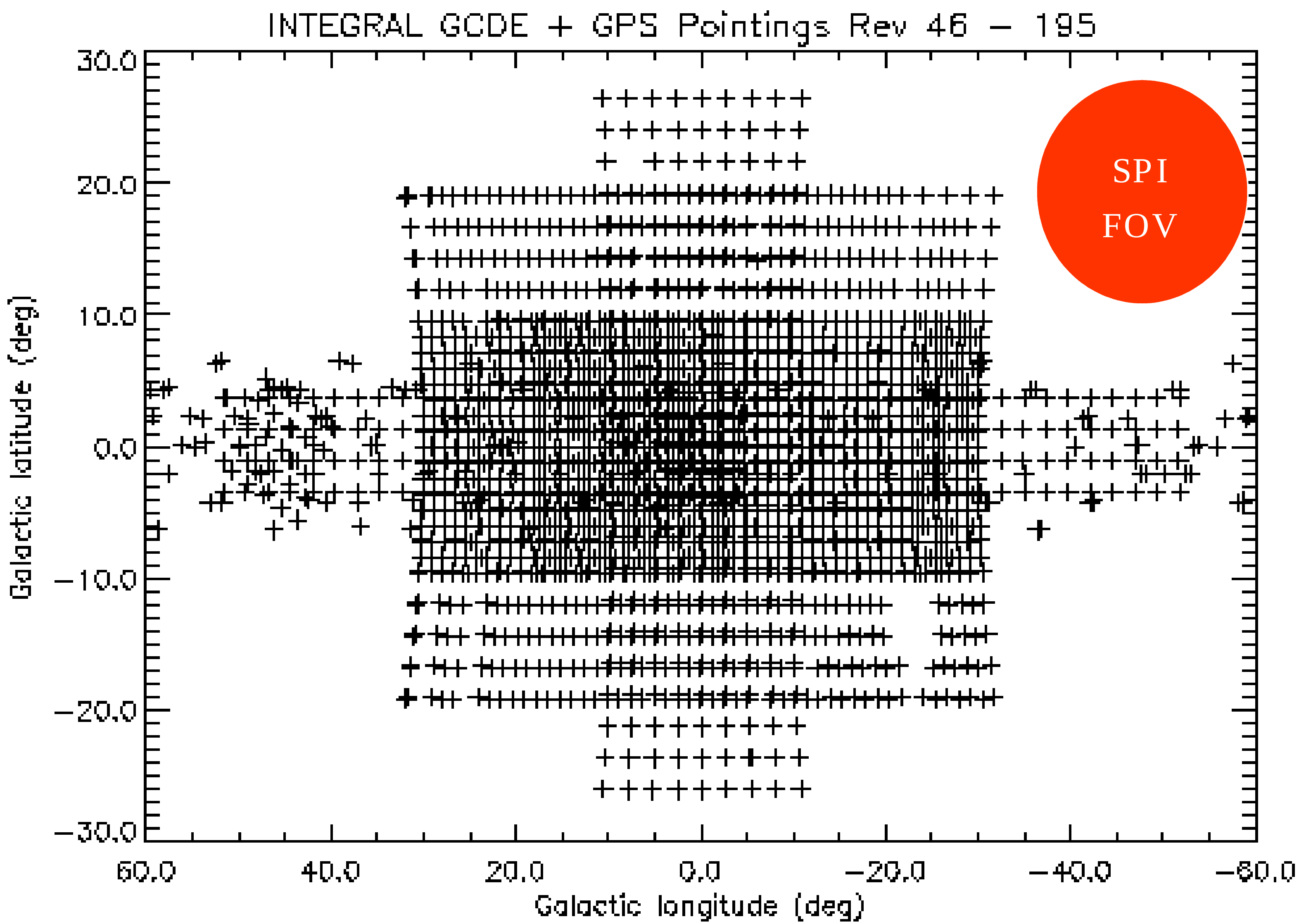
with INTEGRAL/SPI

A. Strong, MPE

INTEGRAL/ESTEC Workshop 2005

Core program: Galactic plane survey

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



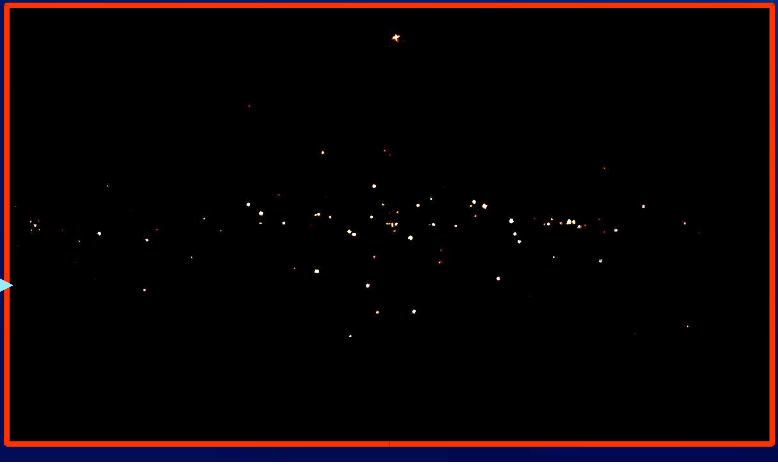
Diffuse emission spectral fitting

DATA

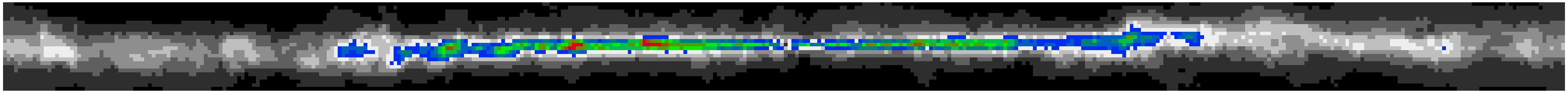
- Data from 65 INTEGRAL revolutions - Core Time
- exposure: $6\ 10^6$ sec
- energy range 18 – 1000 keV

MODEL

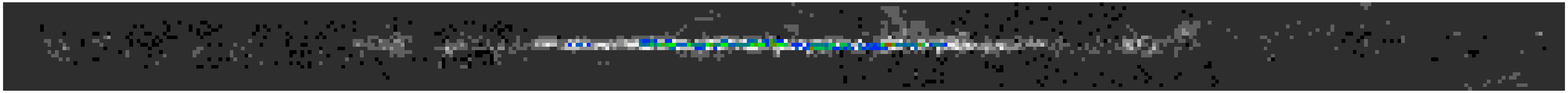
- Fitted components:
- Background / pointing
- *Sources : 91 from IBIS*
- Disk (HI + CO), bulge



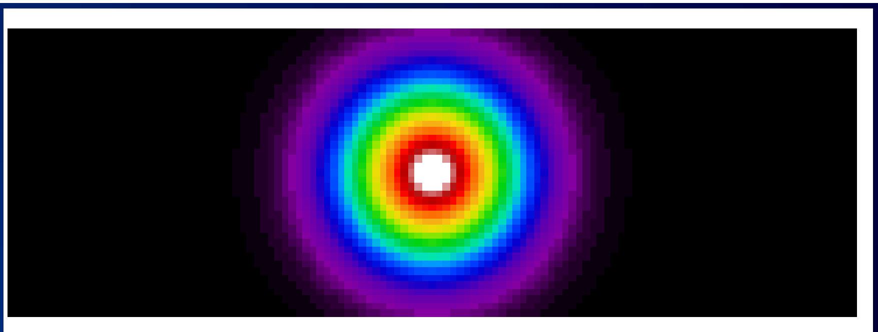
HI



CO



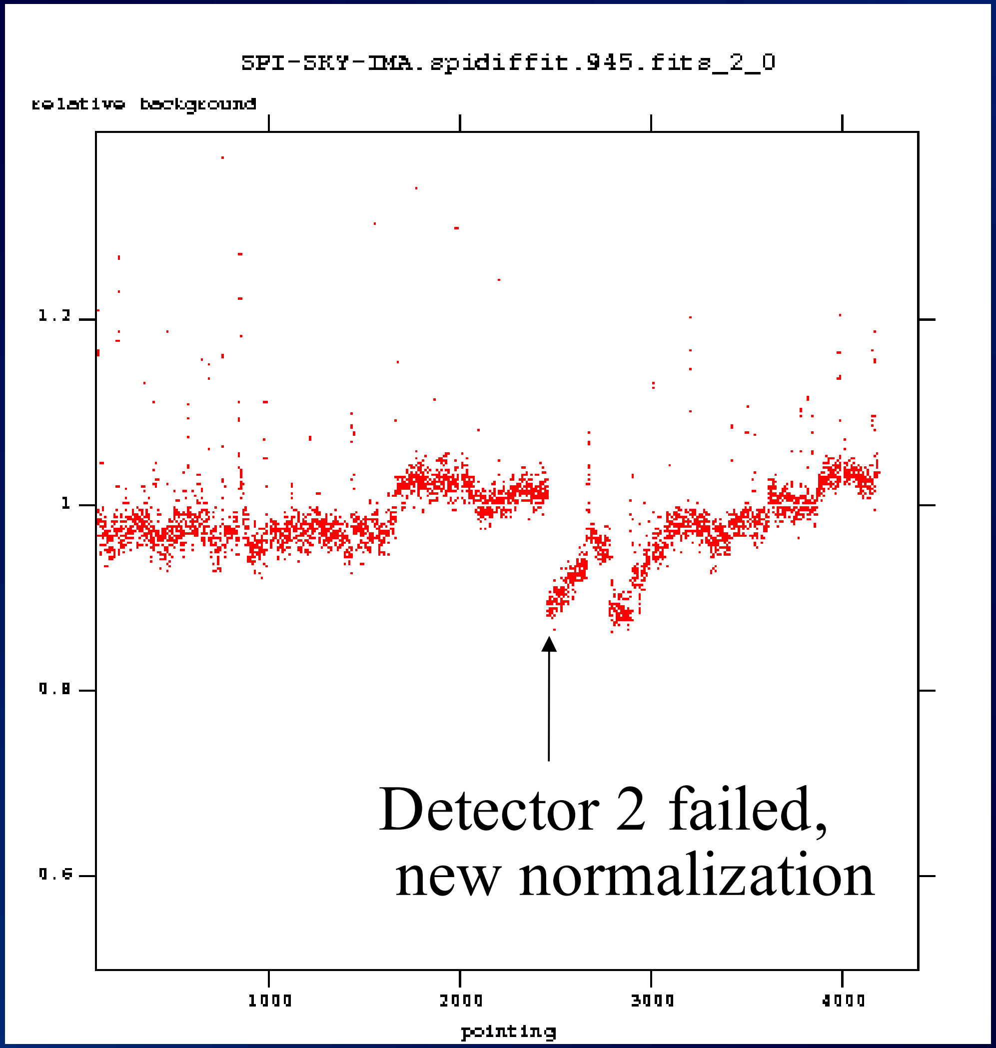
Bulge
e^+e^- annihilation



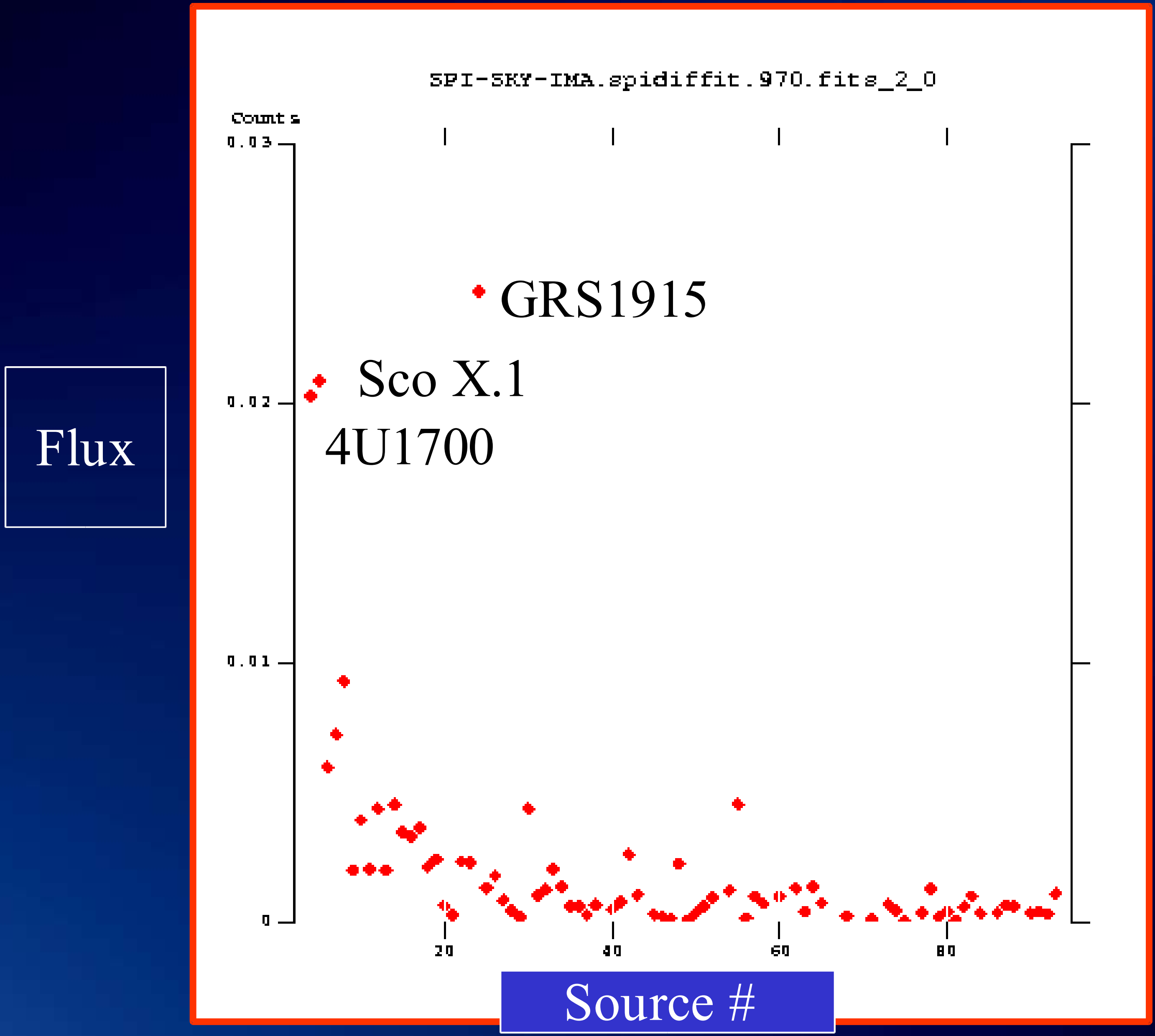
IBIS Sources

Lebrun et al. 2004 Nature 428, 293

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



Source fluxes 28-38 keV



Very few sources have hard spectra like Cyg X-1, most cut off.
Only a few detected > 200 keV.
So > ~ 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 !

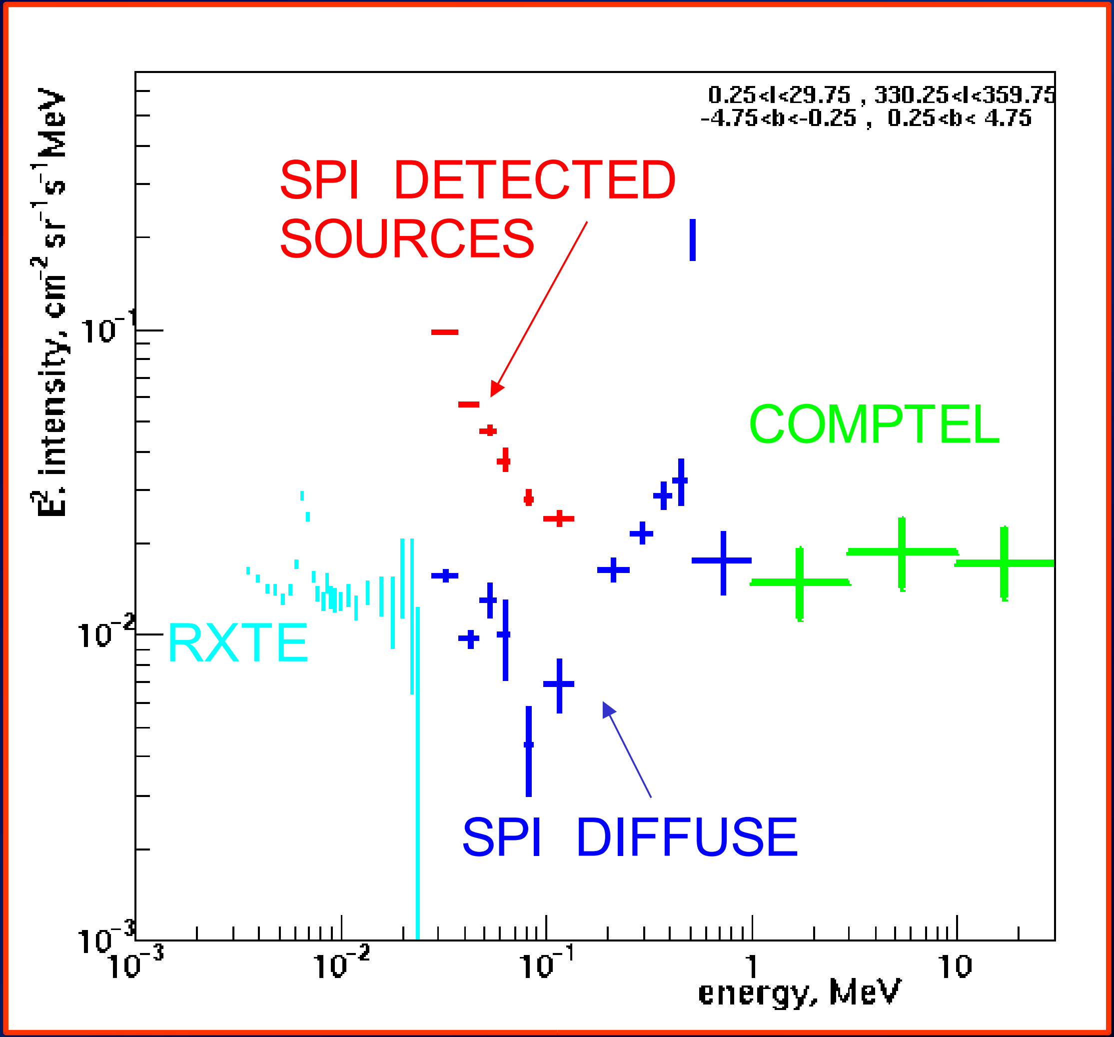
		Diffuse emission fitted :		
Energy Range	with sources	without sources	with 5 sources	with 14 source
268 - 518 keV	3σ	16σ	13σ	9.3σ
338 - 498 keV	2σ	10σ		
518 - 768 keV	0.4σ	4σ	3.3σ	
768-1018 keV	1.4σ			

Diffuse Emission and Sources in Galactic Ridge

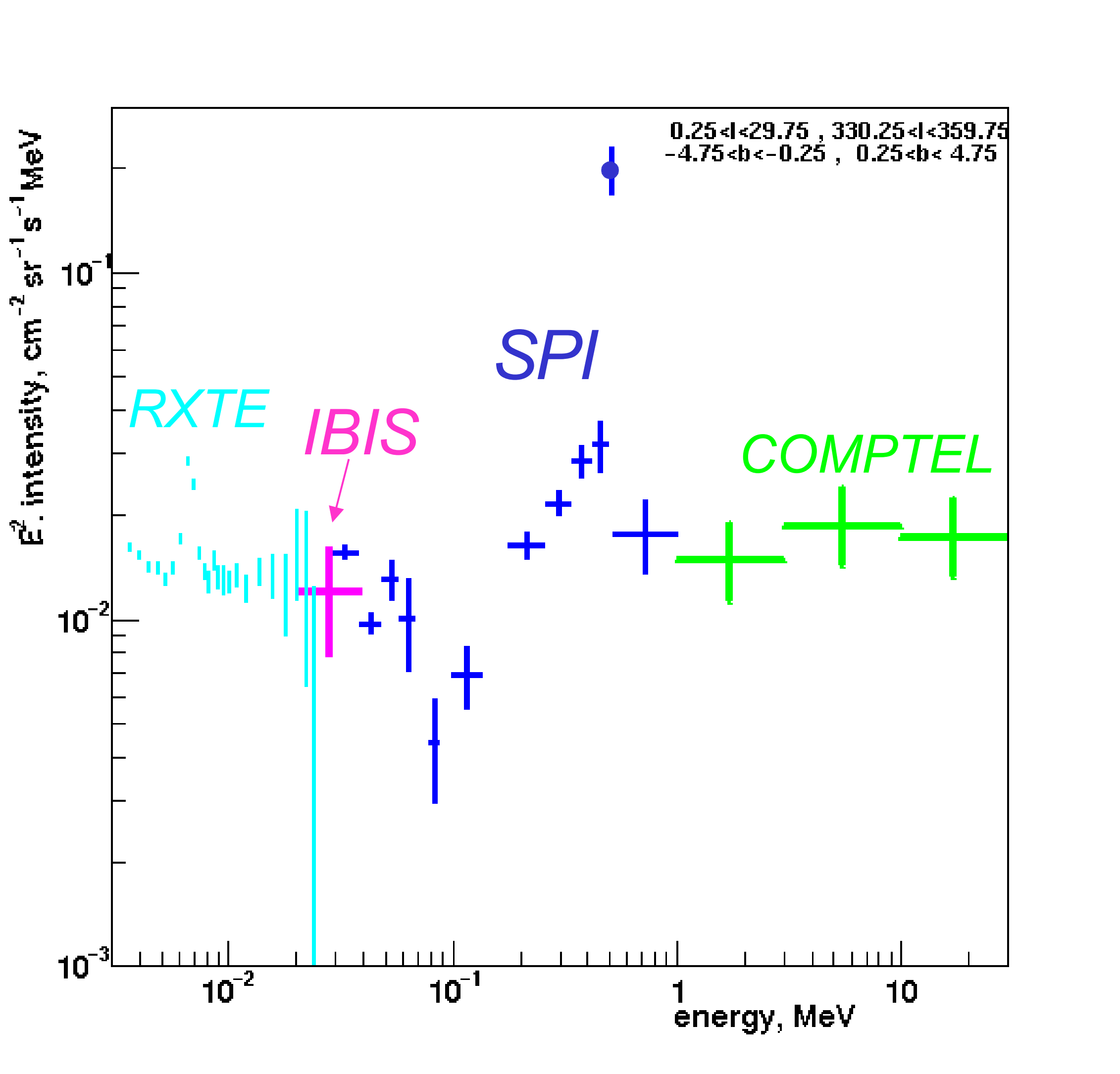
Diffuse emission:
10% to ~100%
of total emission

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

Diffuse 10^{38} erg s^{-1}

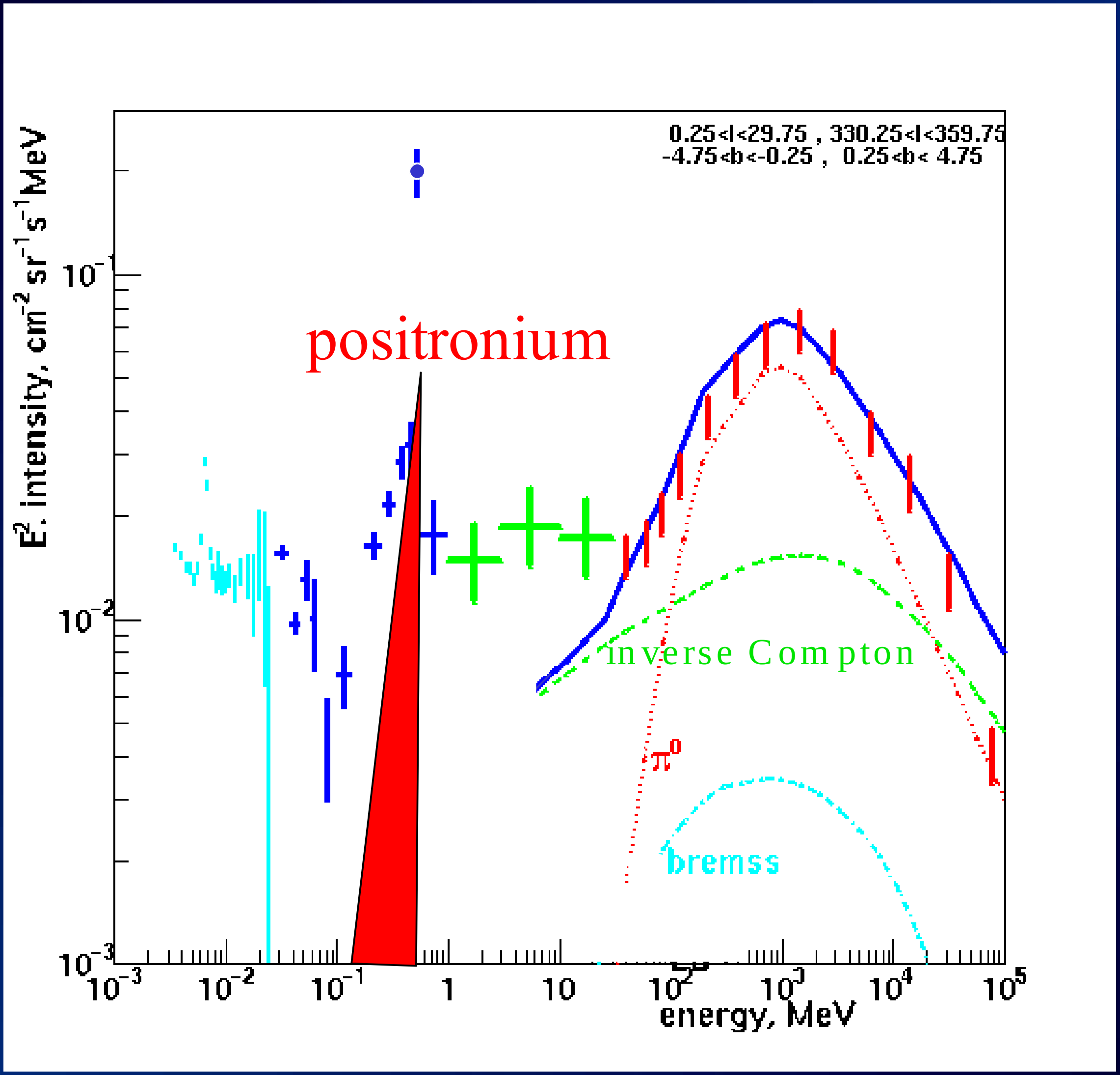


Diffuse Emission from Galactic Ridge

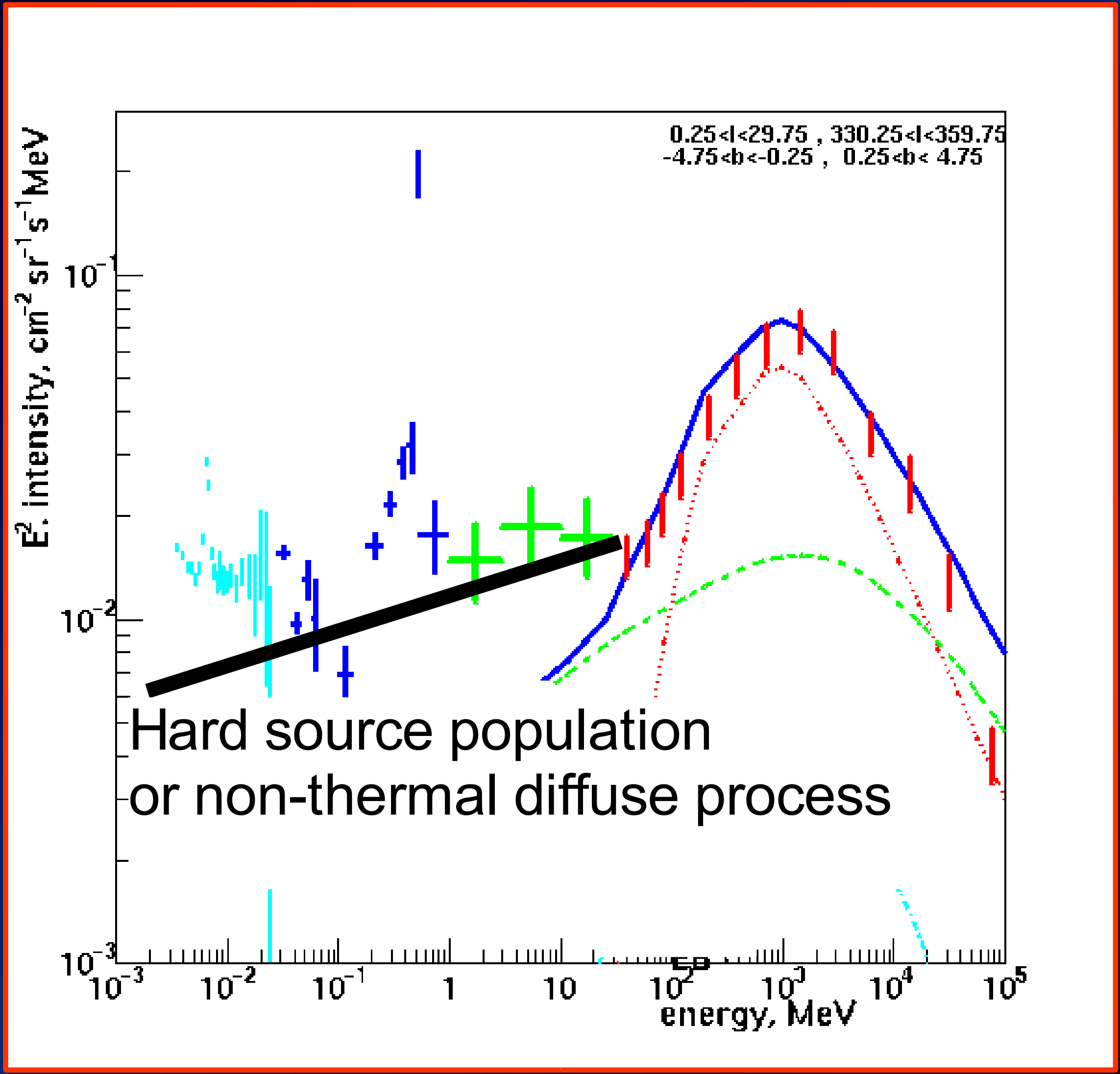


IBIS: Terrier et al. 5th INTEGRAL Workshop

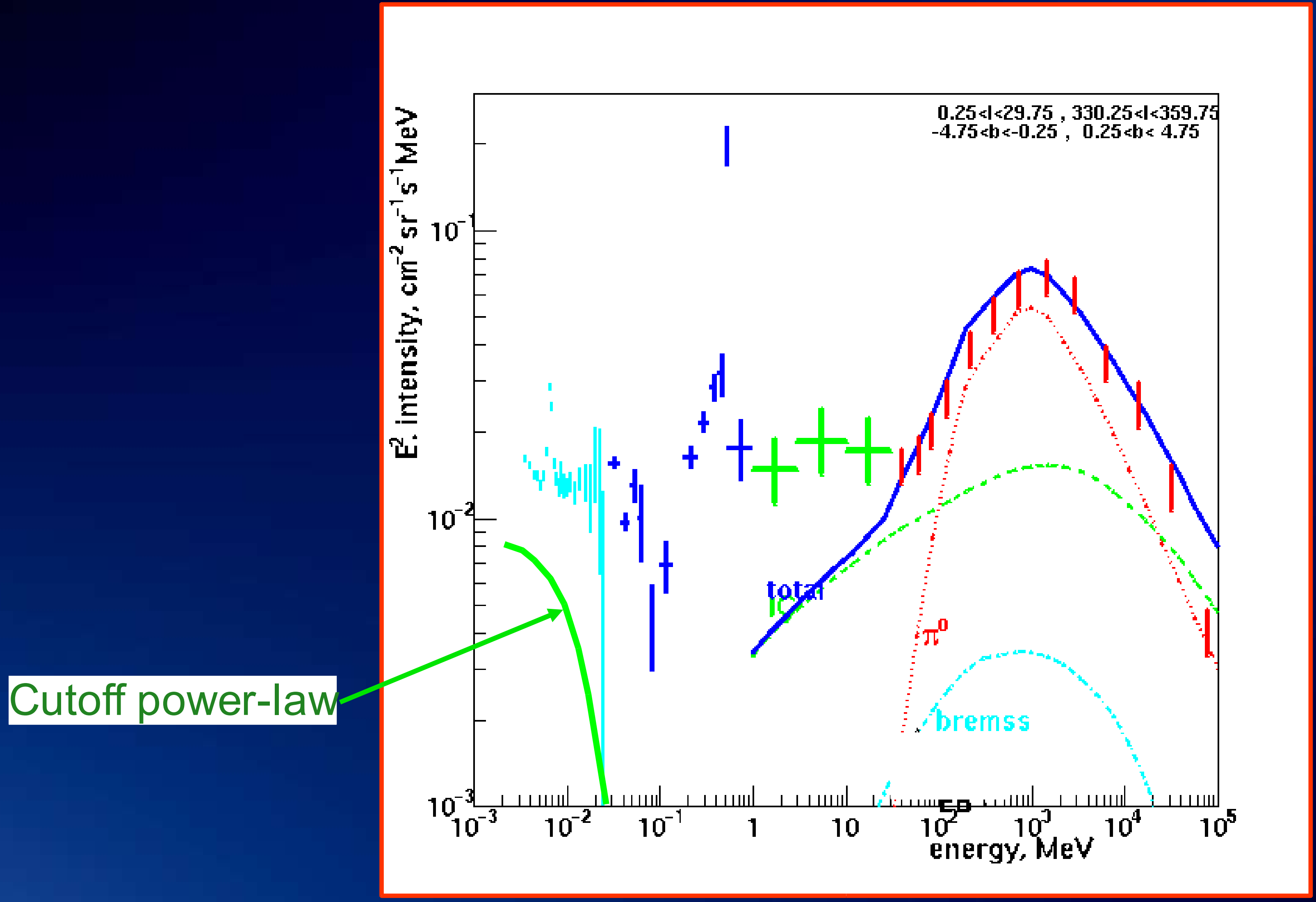
Diffuse Emission from Galactic Ridge



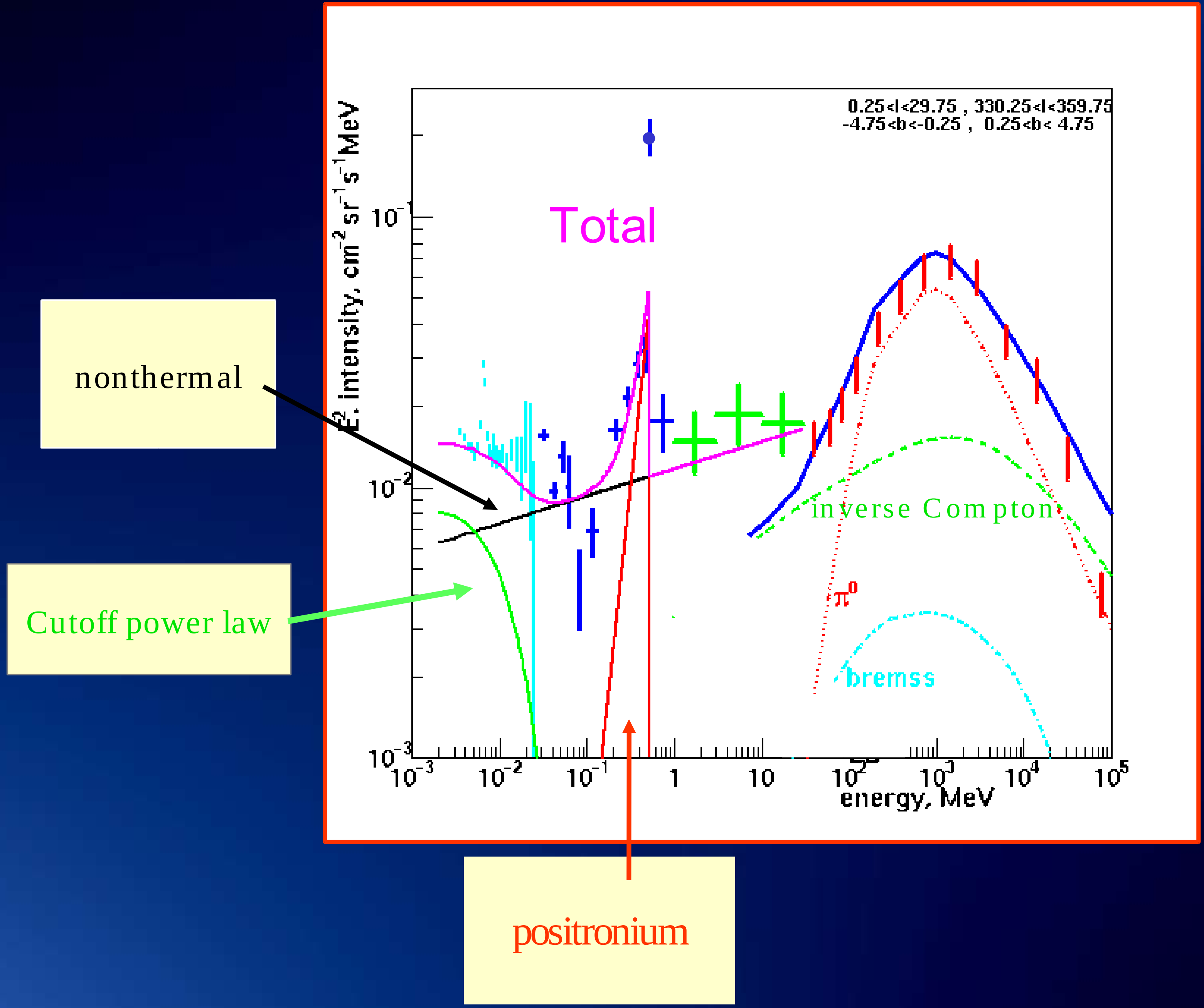
Diffuse Emission from Galactic Ridge

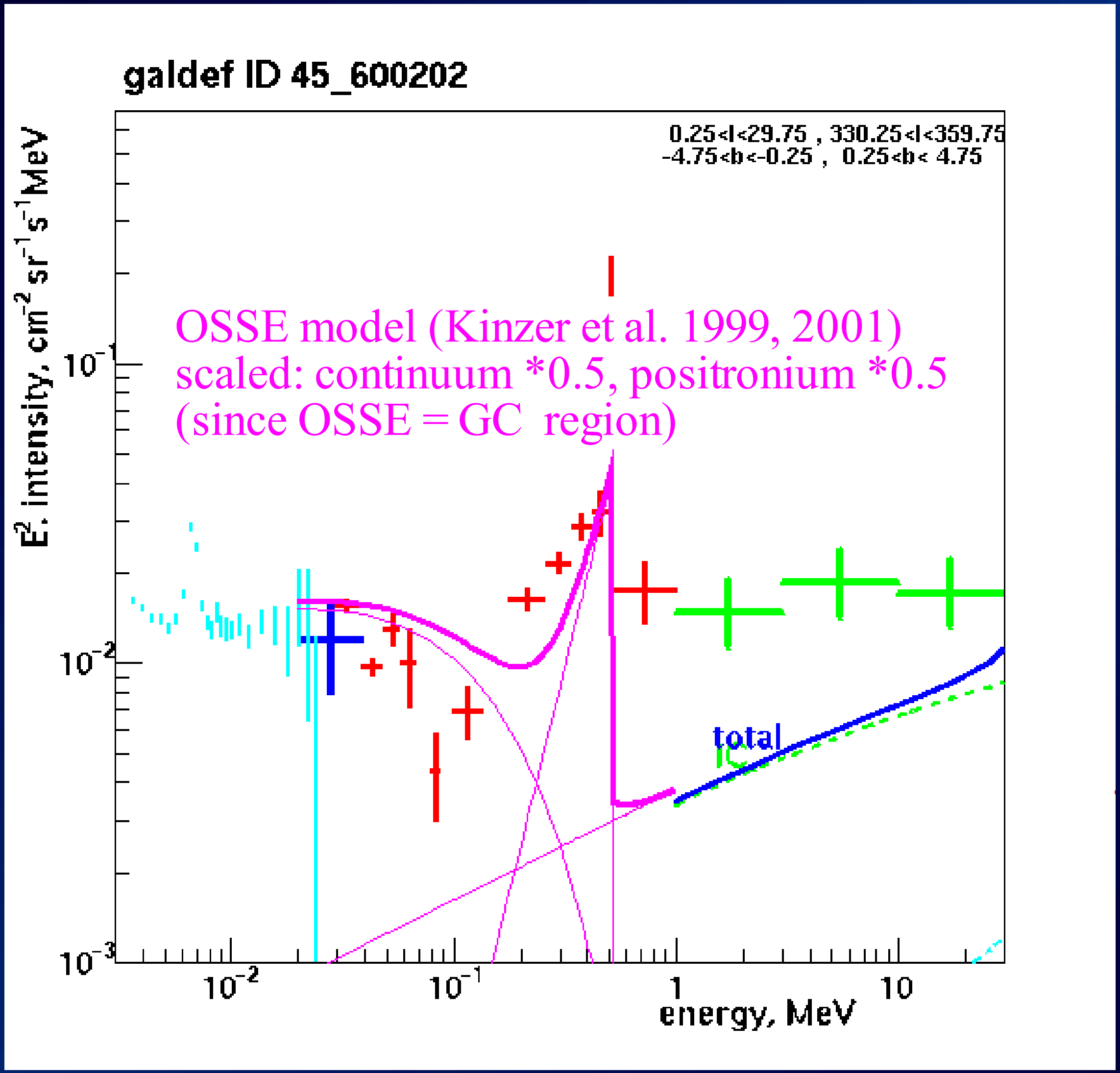


Diffuse Emission from Galactic Ridge



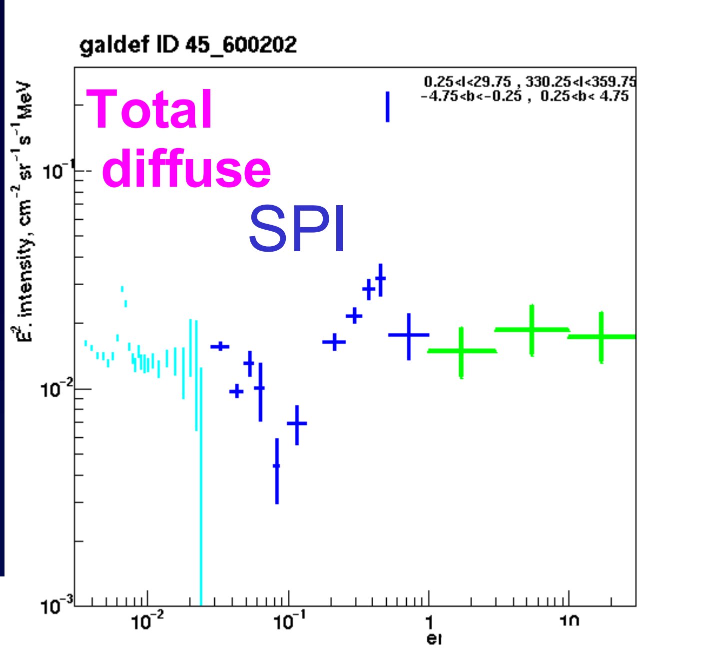
Diffuse Emission from Galactic Ridge

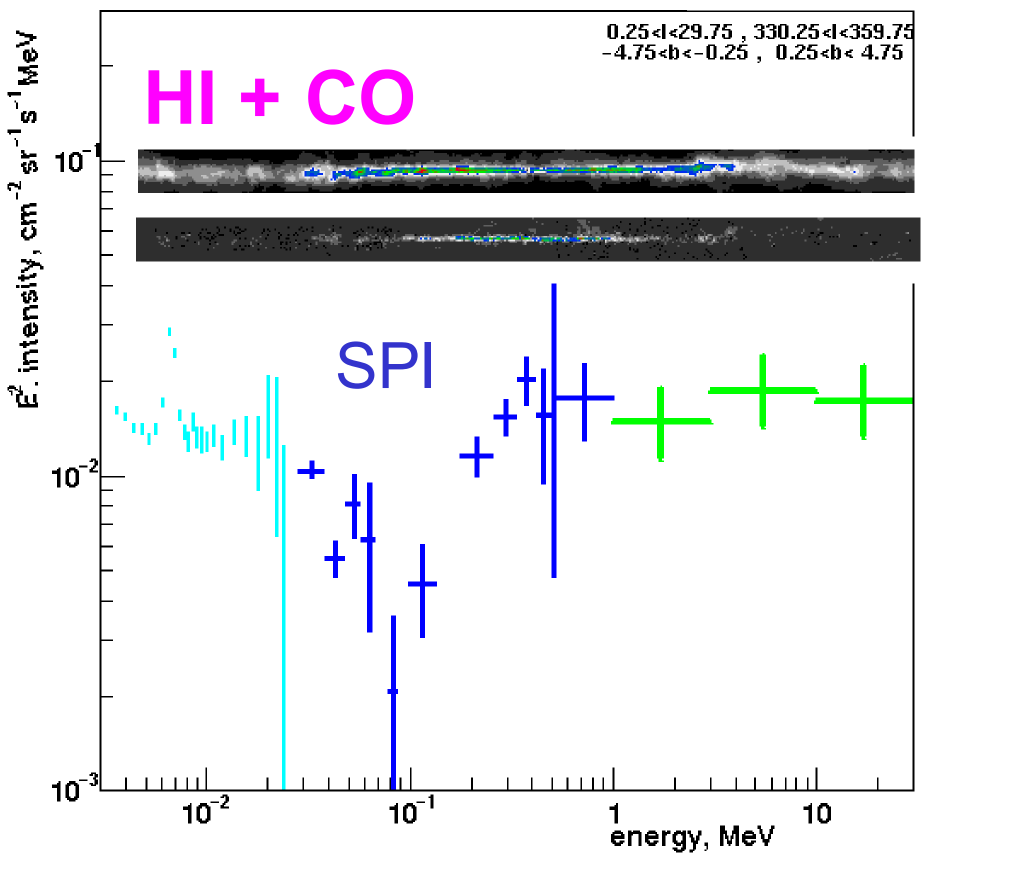


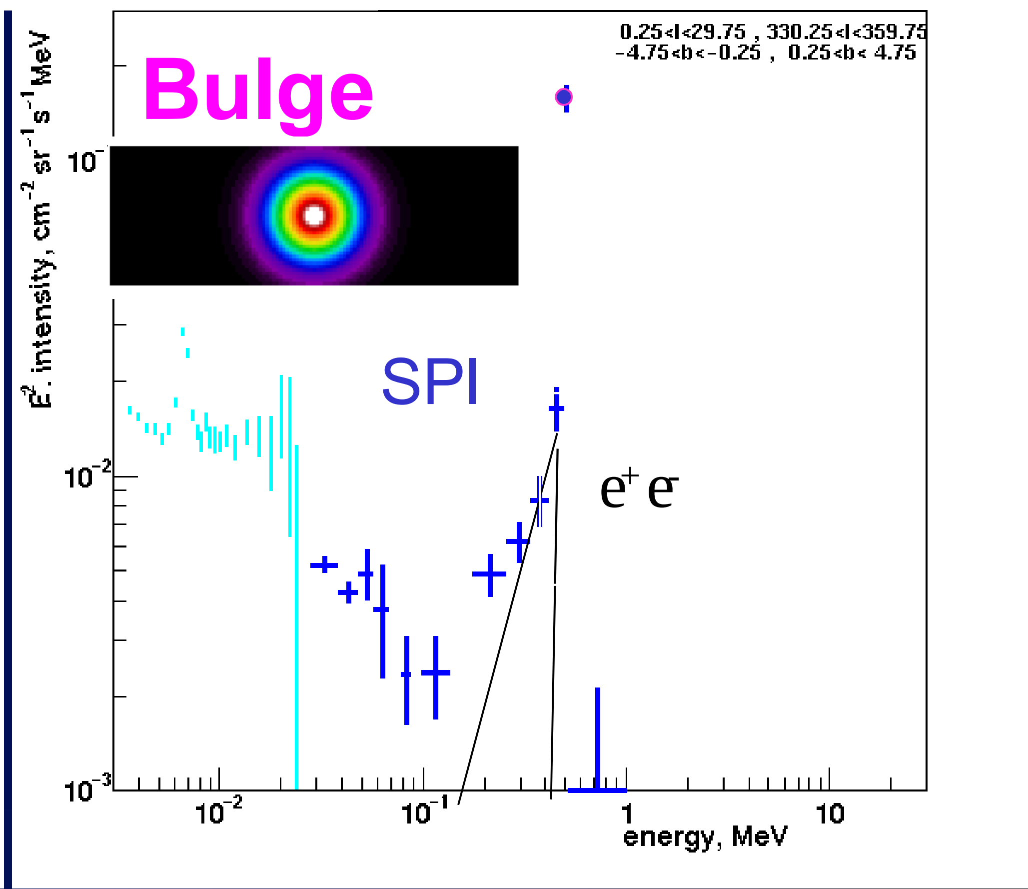


galdef ID 45_600202
0.25<l<29.75 , 330.25<l<359.75
-4.75<b<-0.25 , 0.25<b< 4.75
OSSE model (Kinzer et al. 1999, 2001)
scaled: continuum *0.5, positronium *0.5
(since OSSE = GC region)
total
IC
E². intensity, cm⁻² sr⁻¹ s⁻¹ MeV
energy, MeV

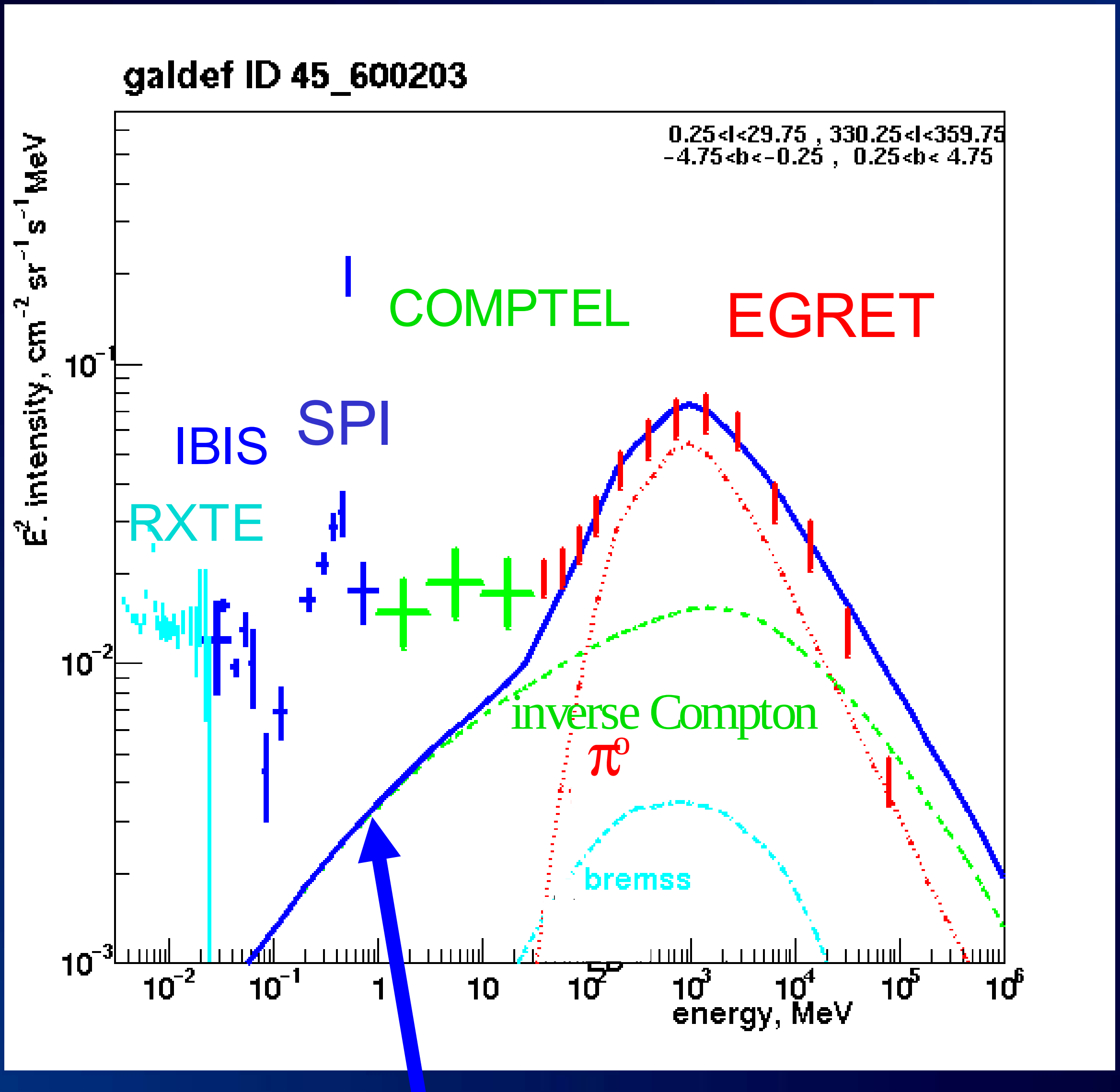
Morphological decomposition





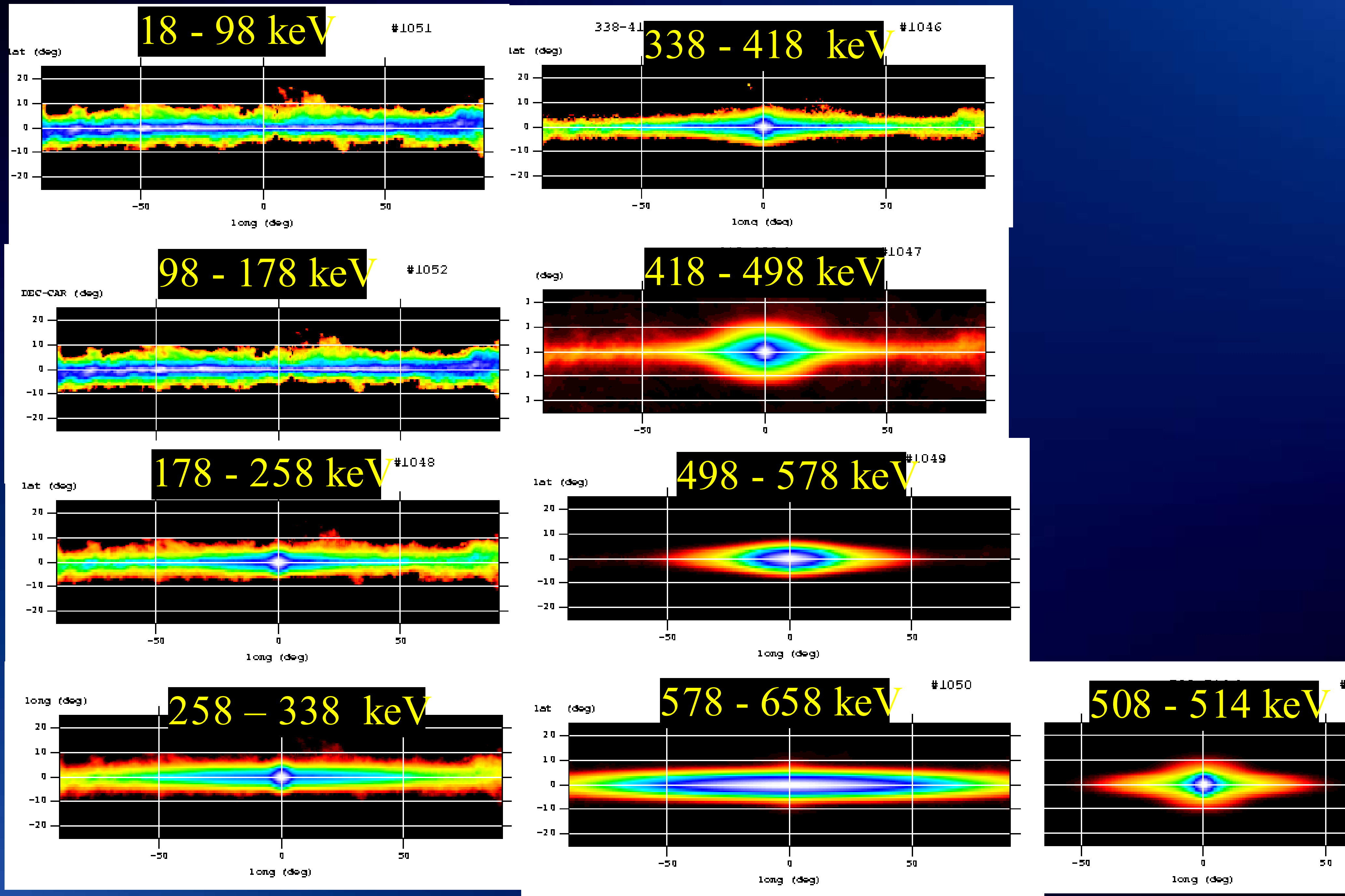


Hard X-rays from inverse Compton ?



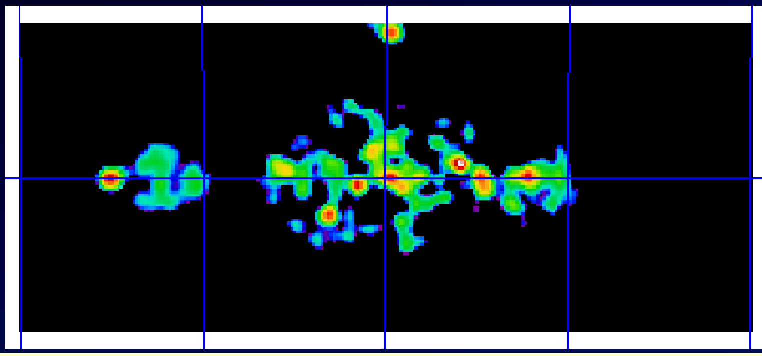
Inverse Compton can explain 10 - 30% in SPI range....but electron spectrum could be steeper, then could produce more…..

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



SPI maximum entropy skymaps

18-143 keV

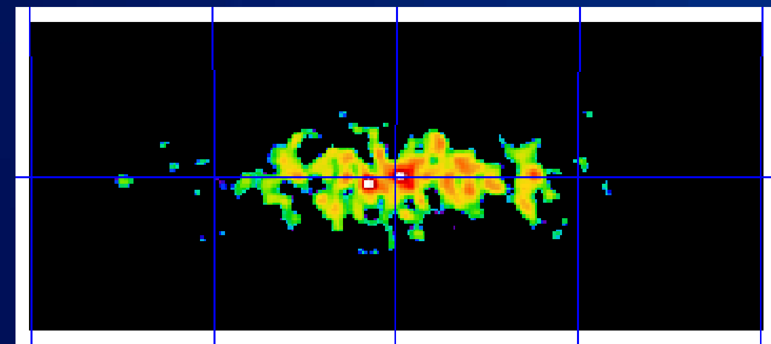


+25

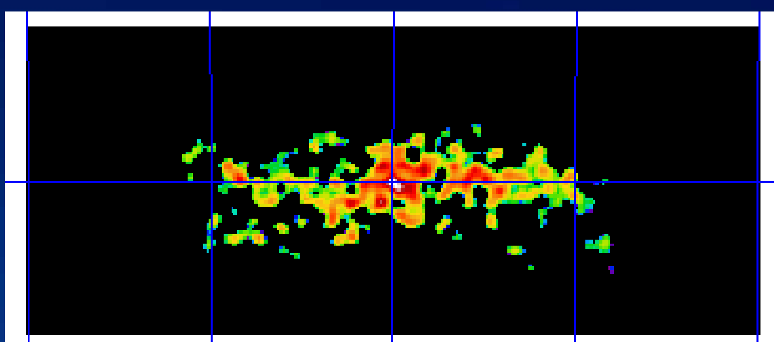
-25

60 0 300

143-268 keV

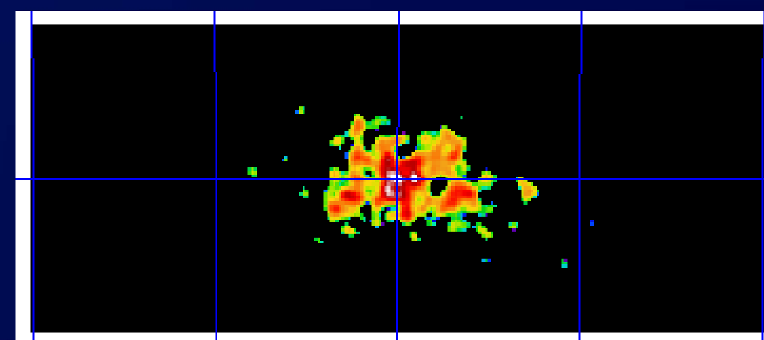


268-393 keV

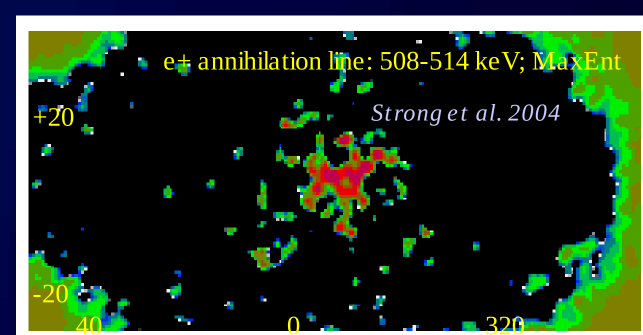


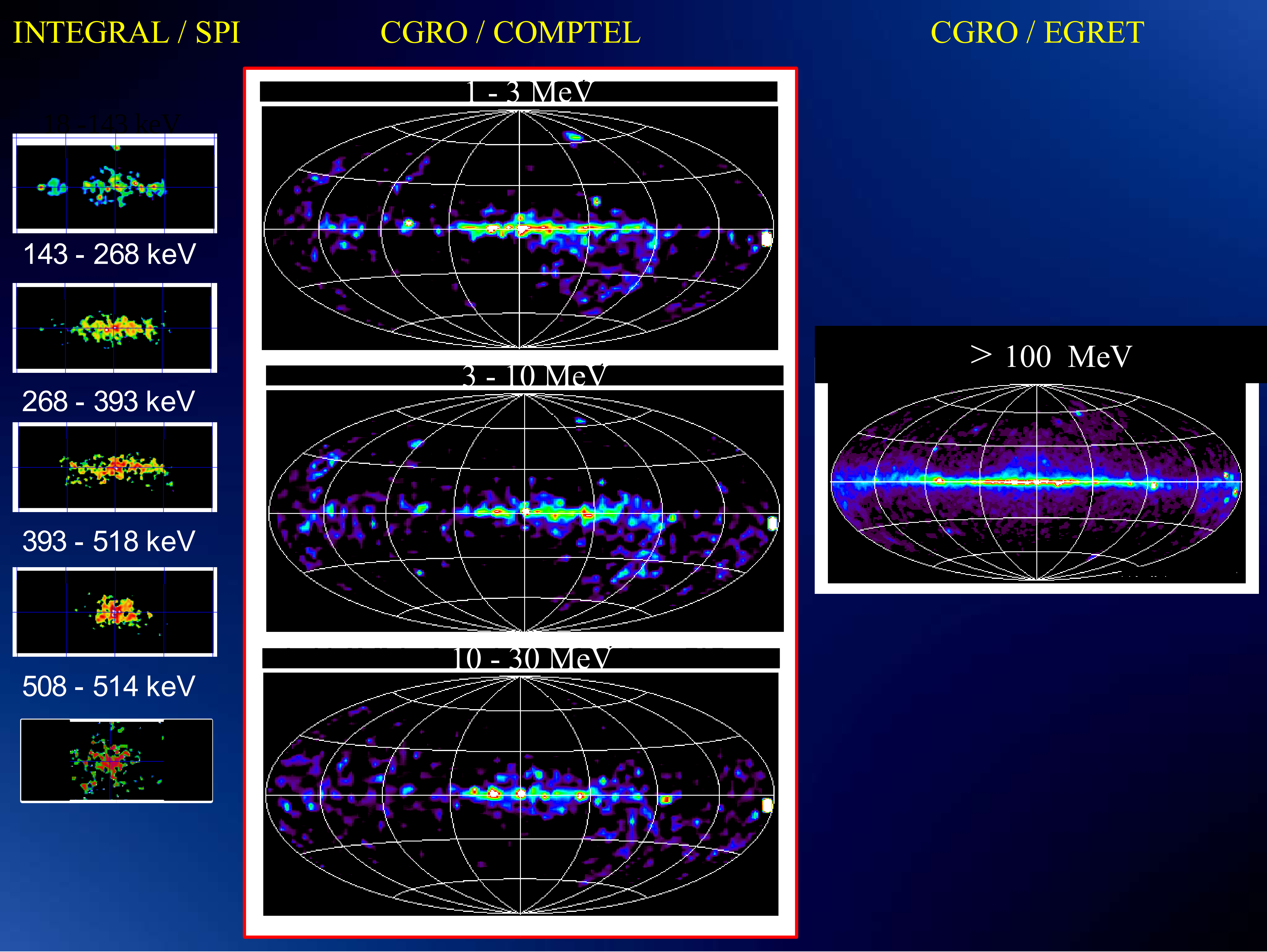
393-518 keV

positronium



508-514 keV

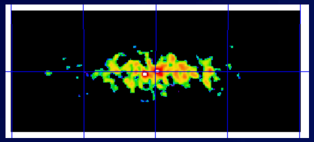



INTEGRAL / SPI
CGRO / COMPTEL
CGRO / EGRET
143 - 268 keV
268 - 393 keV
393 - 518 keV
508 - 514 keV
1 - 3 MeV
3 - 10 MeV
10 - 30 MeV
> 100 MeV

Comparison of SPI and COMPTEL skymaps

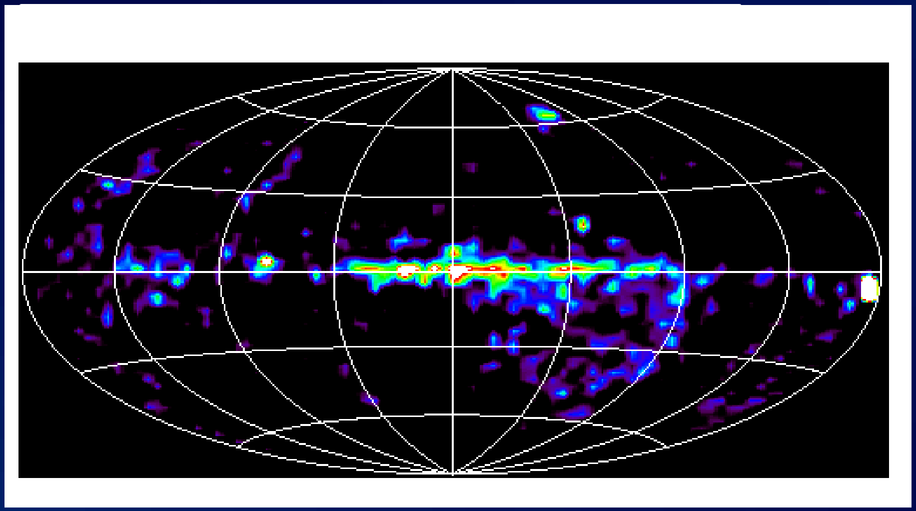
INTEGRAL/SPI

143 - 268 keV



COMPTEL

1 – 3 MeV

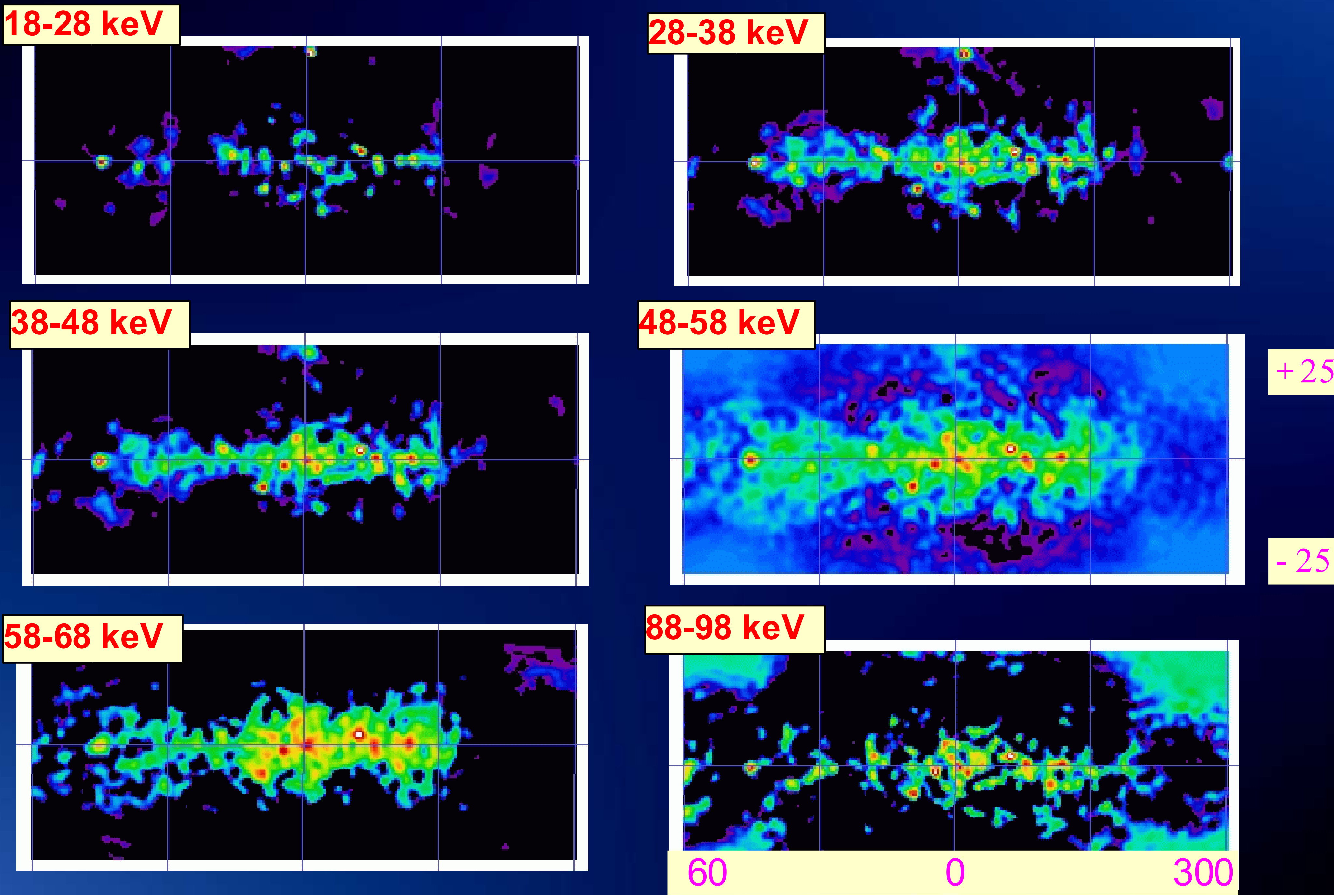


Hard X-ray emission
more concentrated
to inner Galaxy
than for MeV ?

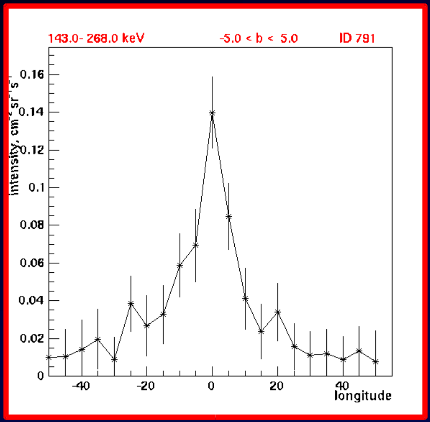
Reflects different origin ?

Hard X-rays:
Source population like LMXB

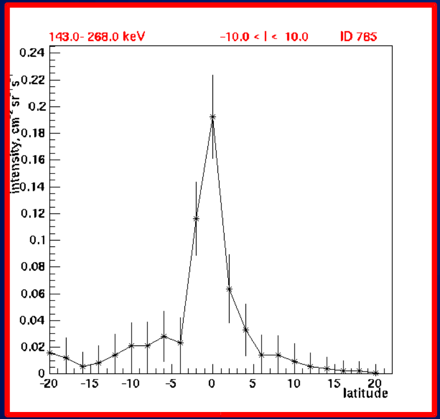
Finer energy resolution

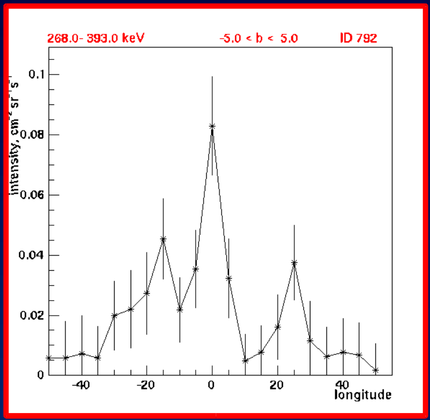


Longitude/latitude profiles from maximum entropy method

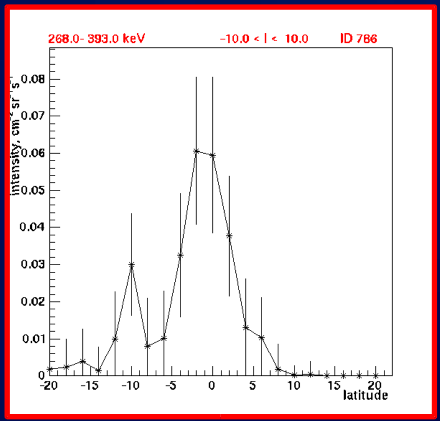


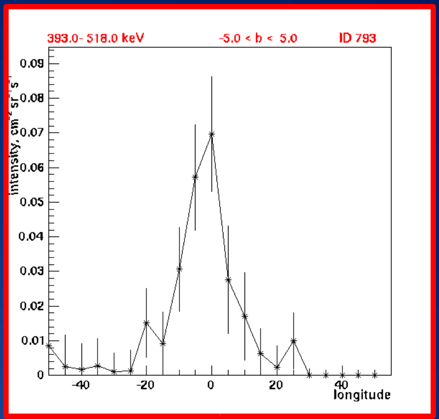
143-268 keV



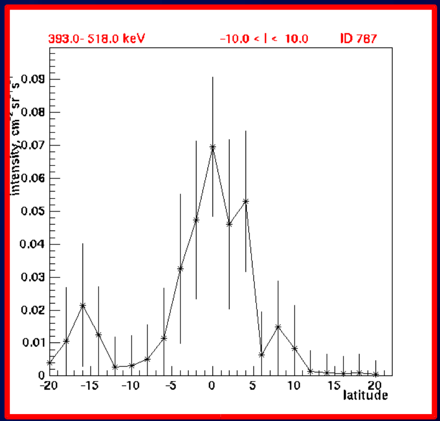


268-393 keV





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 ?

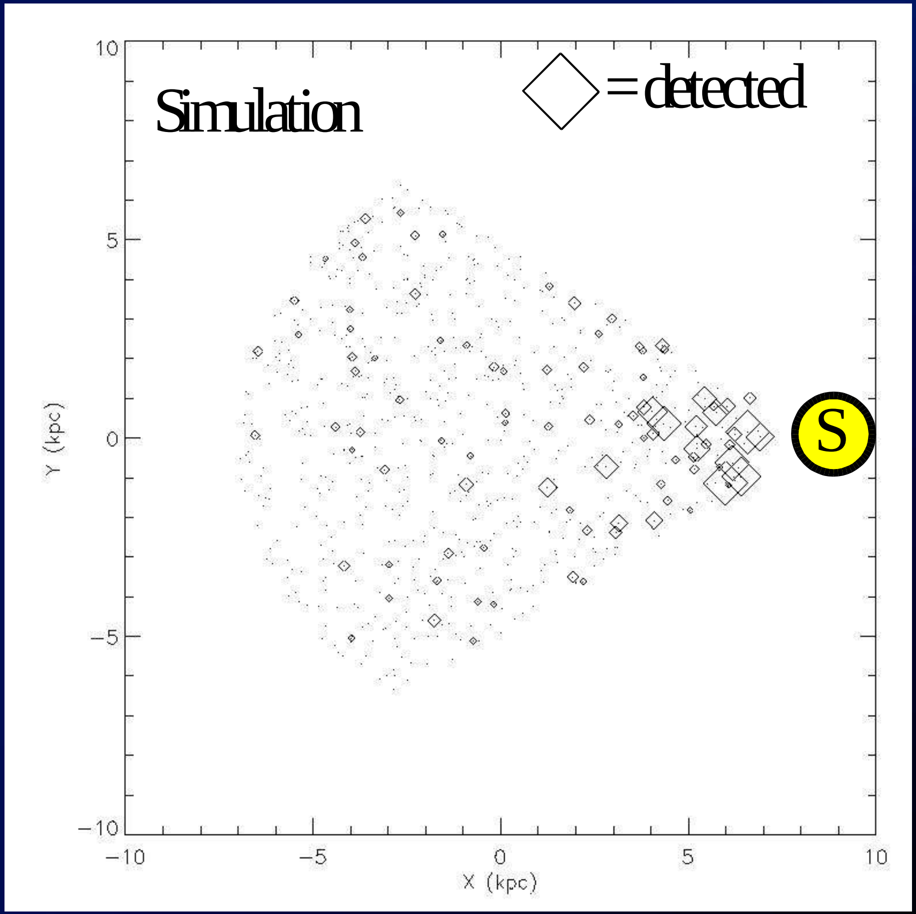
Can estimate based on 2 - 10 keV luminosity function from
RXTE: Grimm et al (2002): A&A 391, 923
700 LMXB+HMXB in Galaxy > 10^{34} erg s^{-1}
(217 detected, 190 > 2.10 ^{35} erg s^{-1})
Total luminosity 2-3 10^{39} erg s^{-1} 'dominated by 5 - 10 brightest sources'
. L(LMXB=10 . L(HMXB)

LMXB: $N(L) \sim L^{-1.26}$
HMXB: $N(L) \sim L^{-1.64}$

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

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

<< 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