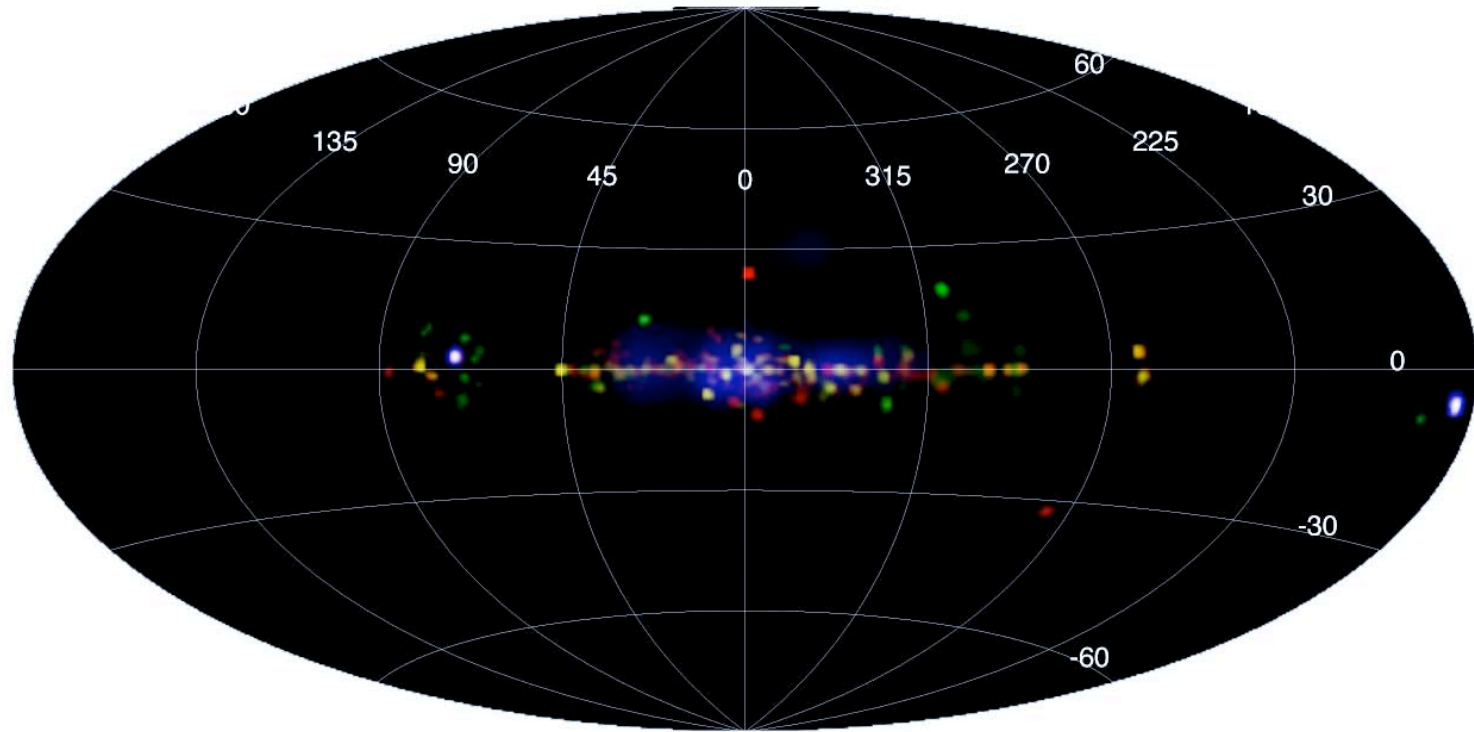


Soft gamma-ray galactic ridge emission as unveiled by SPI aboard INTEGRAL

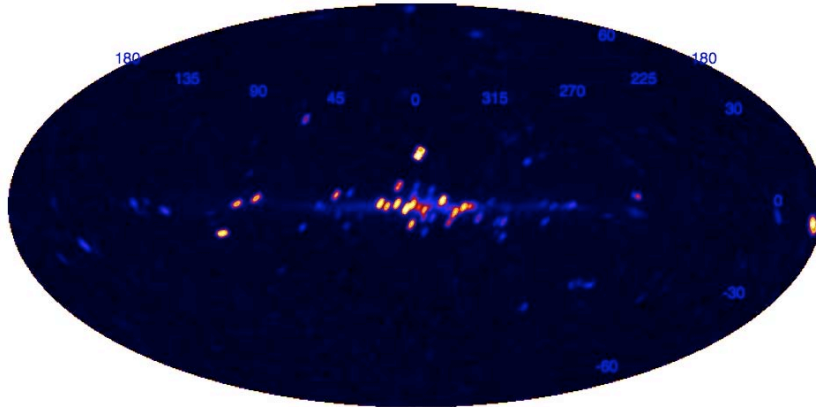


J. Knödlseher*, V. Lonjou, G. Weidenspointner, P. Jean, A. Strong,
R. Diehl, B. Cordier, S. Schanne, C. Winkler

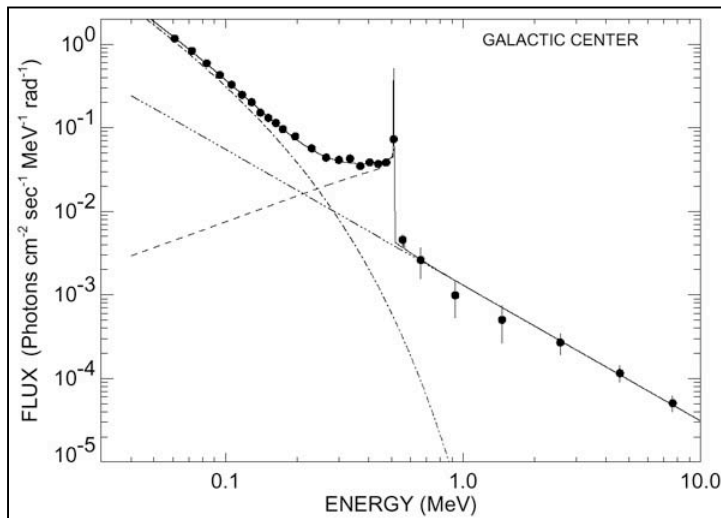
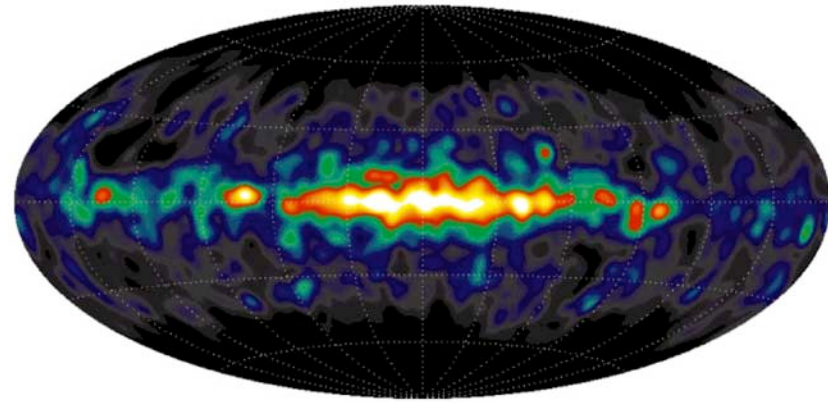
*Centre d'Etude Spatiale des Rayonnements (CNRS/UPS)
Toulouse (France)

Exploring the Unexplored

HEAO-1 2-20 keV



COMPTEL 1-30 MeV

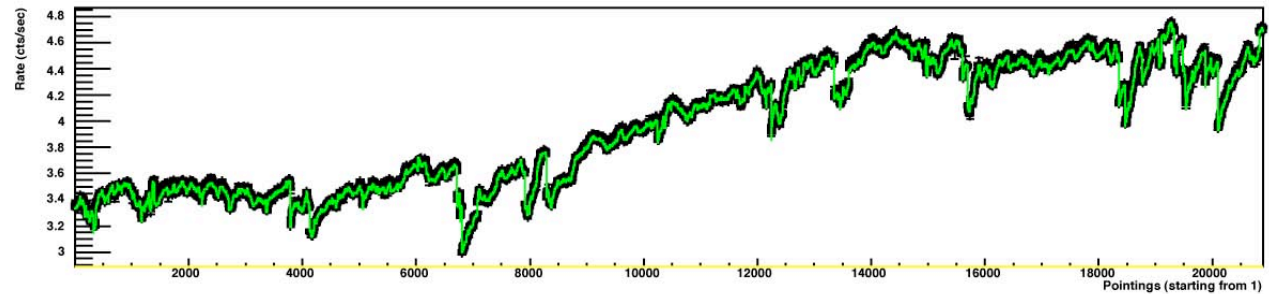


OSSE (Kinzer et al. 1999)

- The hard X-ray to soft γ -ray sky:
- Spectral transition region
 - X-ray sky is point source dominated
 - γ -ray sky is (probably) diffuse

Aim: image the hard X-ray to soft γ -ray transition region with INTEGRAL/SPI

Imaging diffuse emission with a coded mask?



Use SPI also as collimator telescope or light bucket:

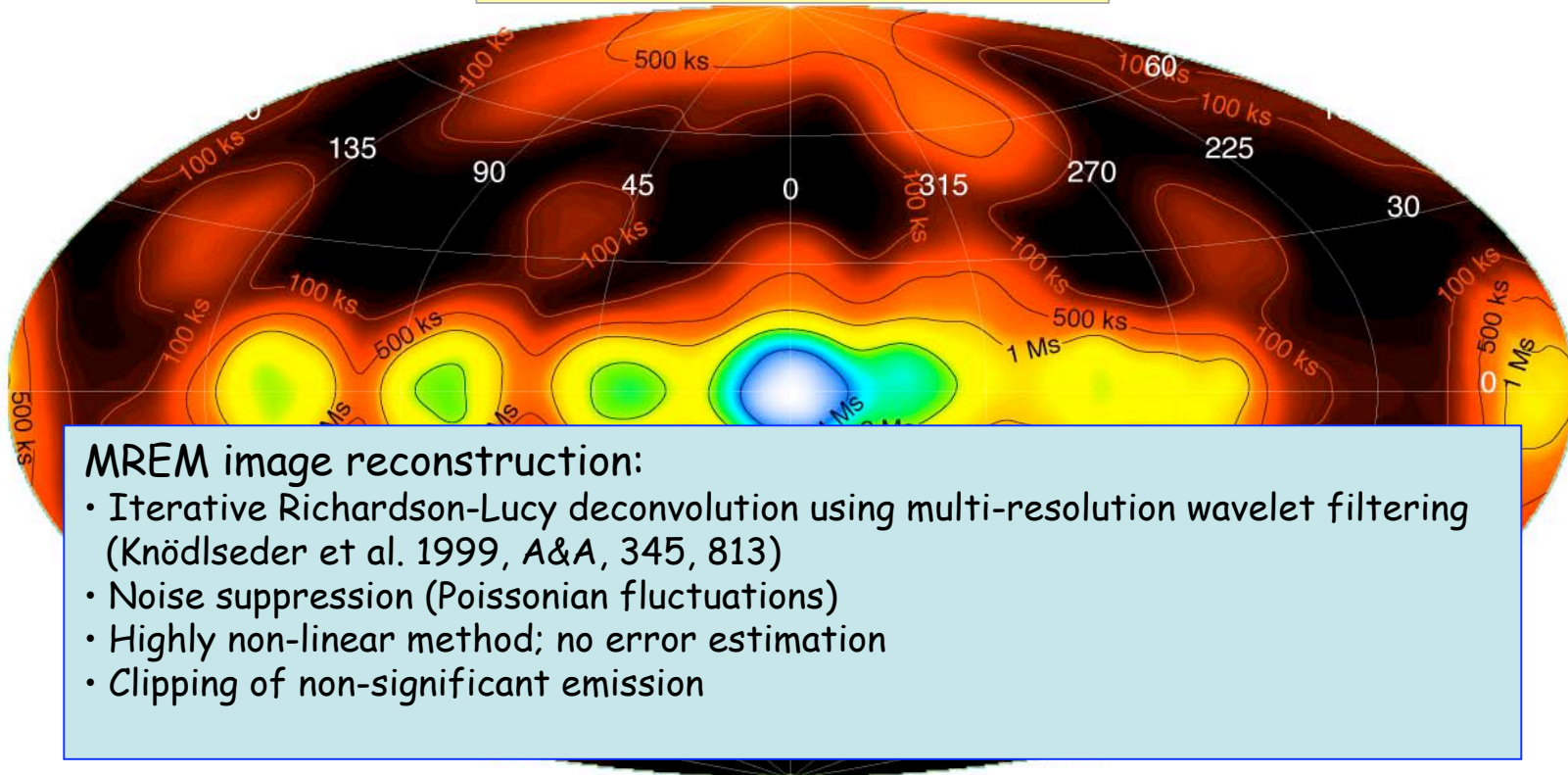
- Telescope pointing sequence encodes emission morphology into time variation of count-rates
- Proper modelling of the (dominant) background variation with cosmic-ray activation tracers allows extracting celestial signal
- Adjustment of activation tracers on reasonably long time scales (per ~ 3 day orbit) reduces systematic uncertainties

Coded mask: a "point-source" telescope

- Simultaneous source & background measurement allows subtracting time variable background
- Emission structures more extended than the mask pattern ($\sim 3^\circ$) are filtered out

Analysed dataset

INTEGRAL/SPI exposure map



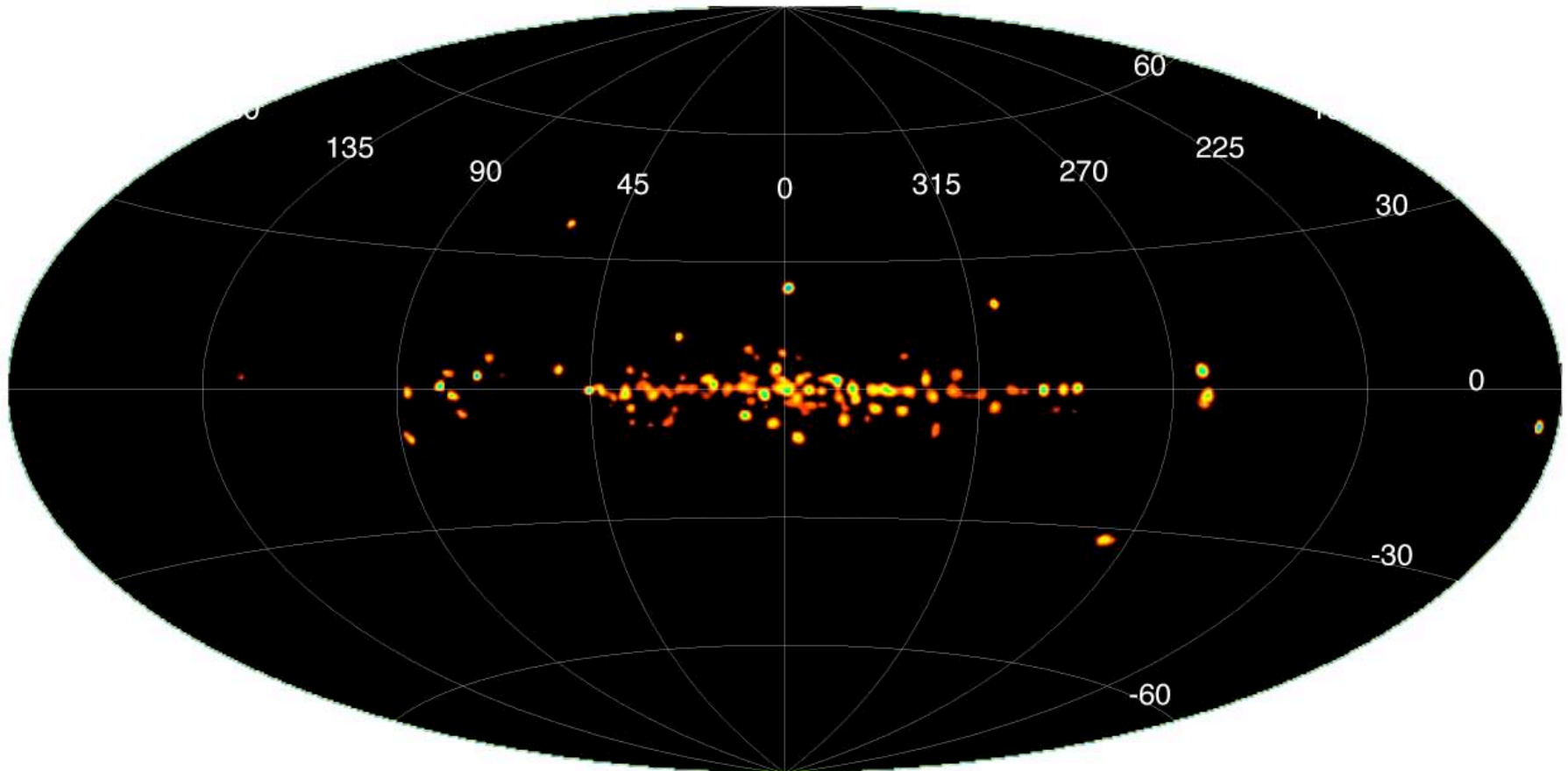
MREM image reconstruction:

- Iterative Richardson-Lucy deconvolution using multi-resolution wavelet filtering (Knödlseider et al. 1999, *A&A*, 345, 813)
- Noise suppression (Poissonian fluctuations)
- Highly non-linear method; no error estimation
- Clipping of non-significant emission

8-Dec-2006 public database

- Maximum exposure time: 5.6 Ms
- 85% of sky >10 ks exposure 12 / 157 mCrab (20-40 keV / 150-300 keV)
- 52% of sky >100 ks exposure 4 / 50 mCrab (20-40 keV / 150-300 keV)
- 12% of sky >1 Ms exposure 1.2 / 16 mCrab (20-40 keV / 150-300 keV)

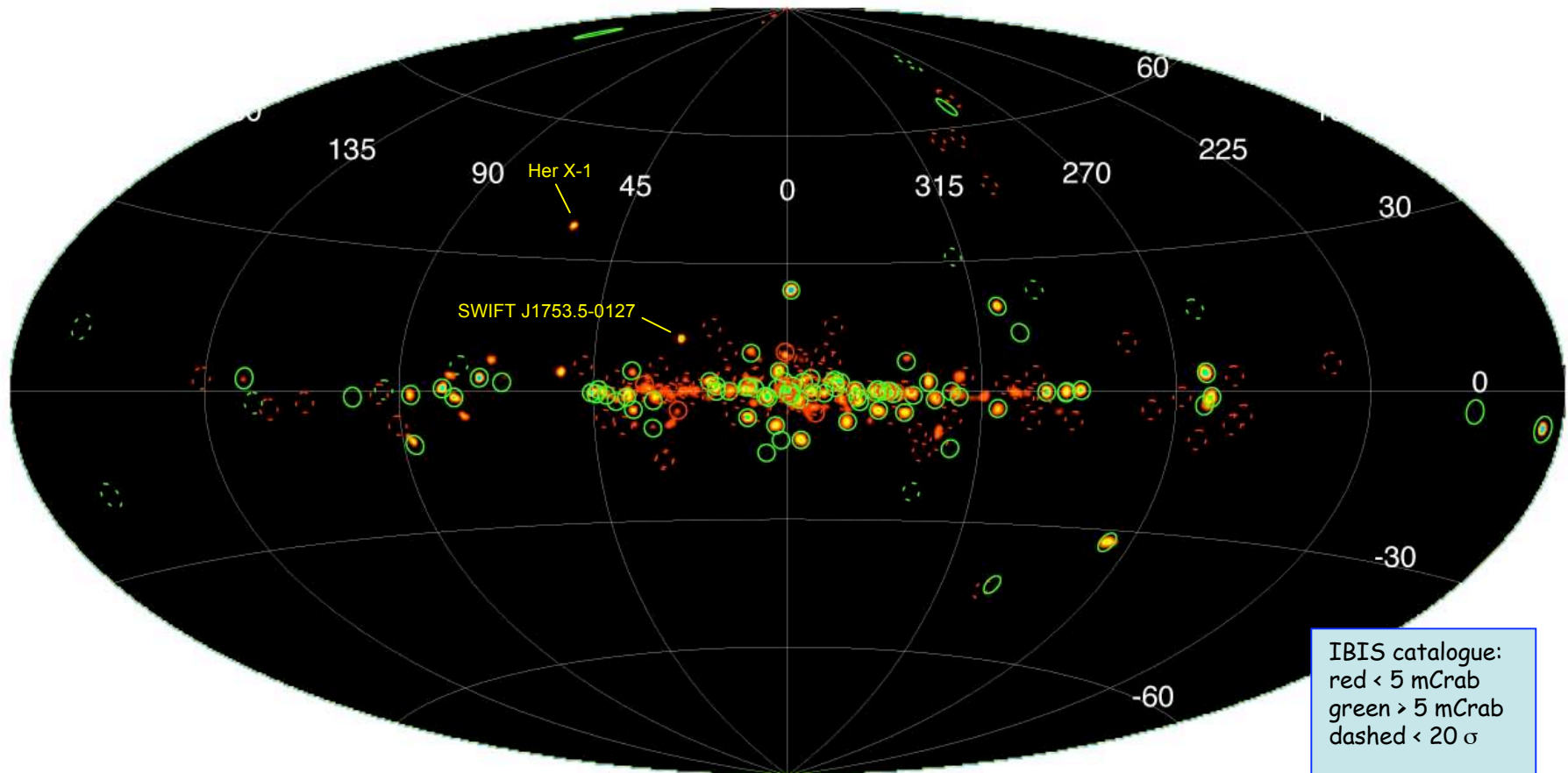
SPI Hard X-ray Sky: 20 - 40 keV



Hard X-ray sky is point-source dominated:

- Galactic sources dominate sky (mainly X-ray binaries, some pulsars, AXPs, PWN, CVs)
- Disk and bulge components (LMXB mainly in bulge, HMXB in narrow disk)
- Extragalactic sources (AGN) relatively weak

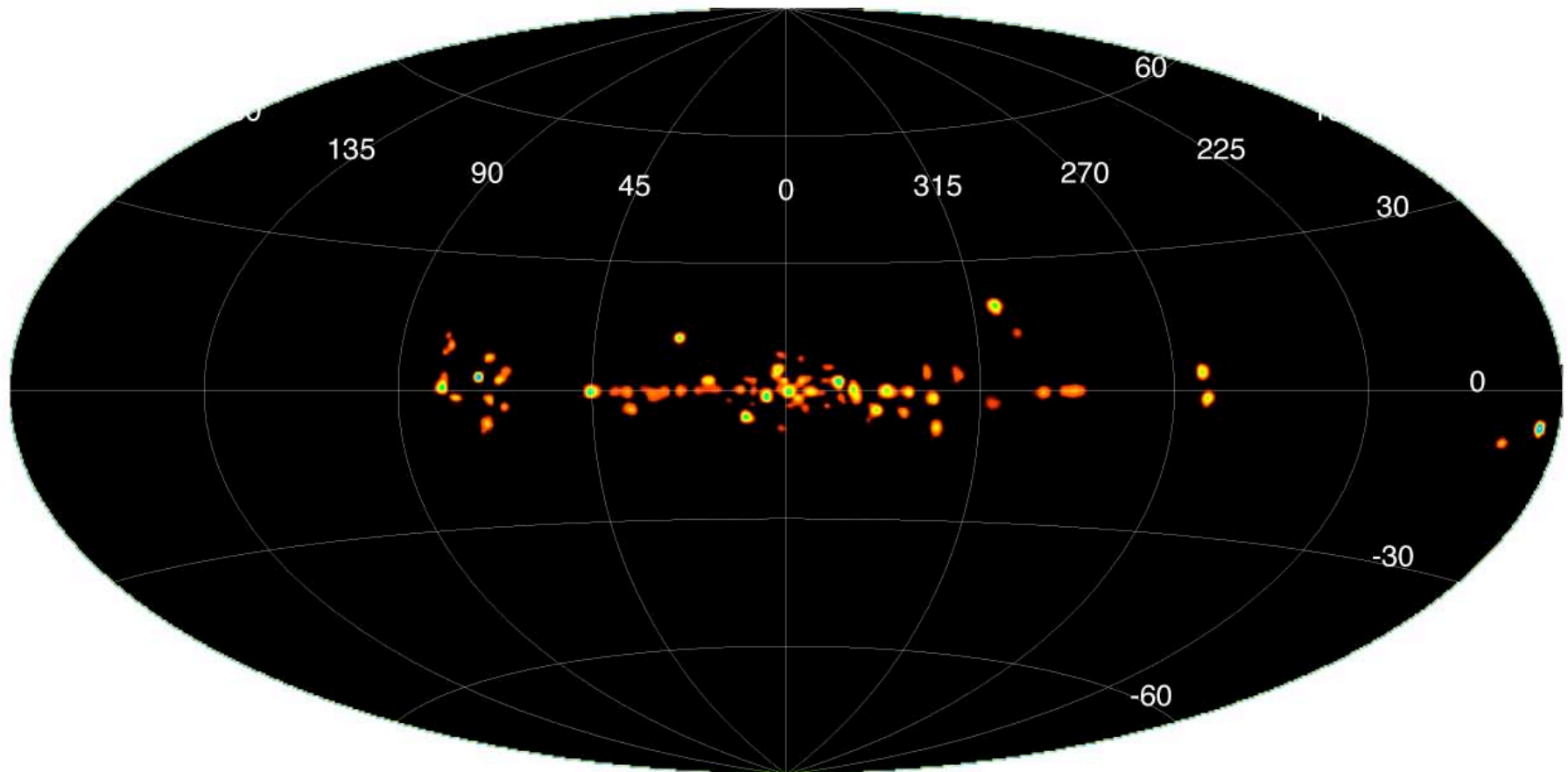
SPI Hard X-ray Sky: 20 - 40 keV



Hard X-ray sky is point-source dominated:

- 2nd IBIS point-source catalogue overlaid
- Source variability explains IBIS - SPI differences
- Absence of bright sources in longitude interval 20°-30° (window for diffuse emission studies)

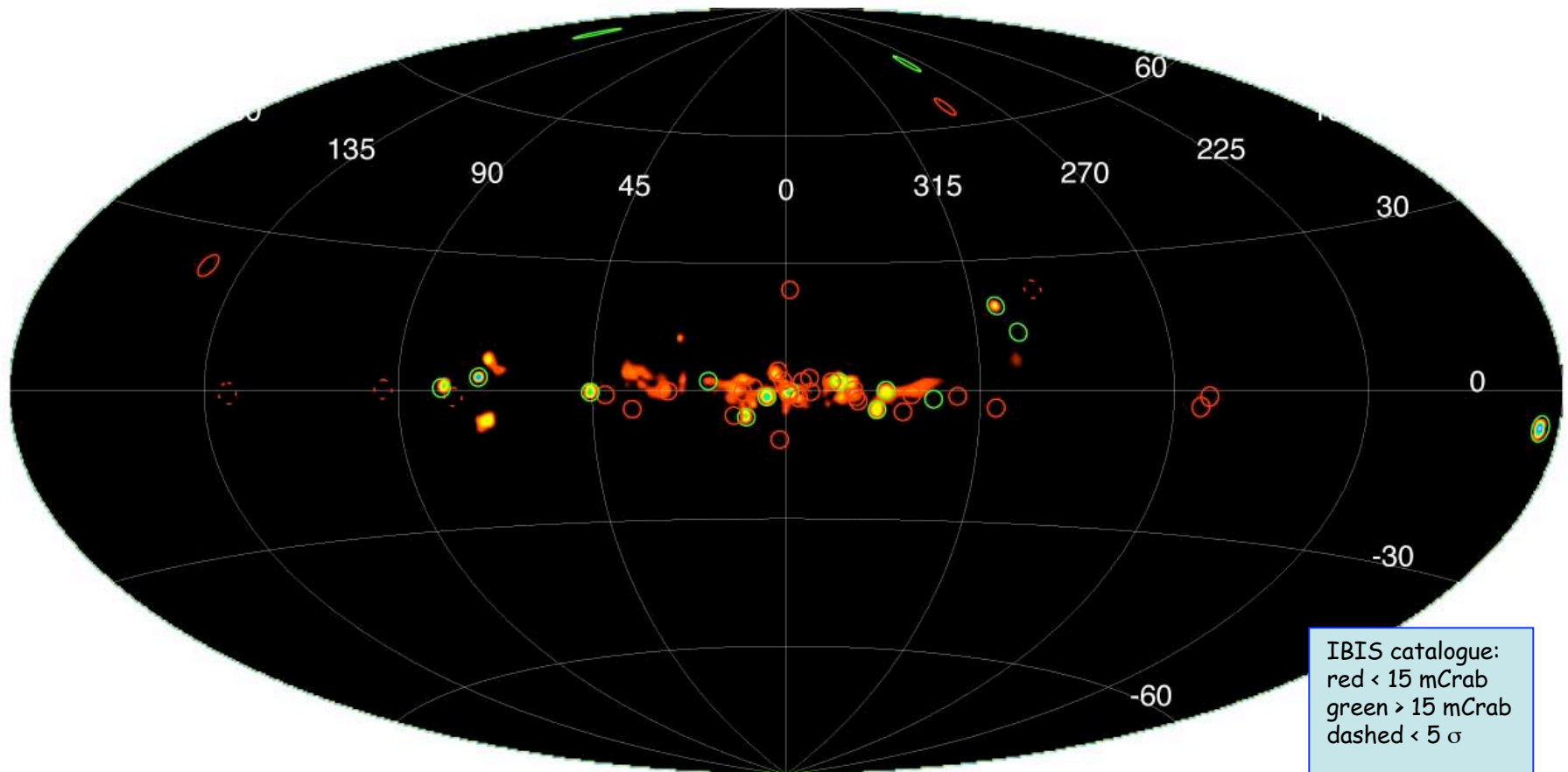
SPI Hard X-ray Sky: 40 - 100 keV



Hard X-ray sky is point-source dominated:

- Little change w/r 20 - 40 keV band
- Softer and/or weaker sources fade away (e.g. Sco X-1, LMC X-1)

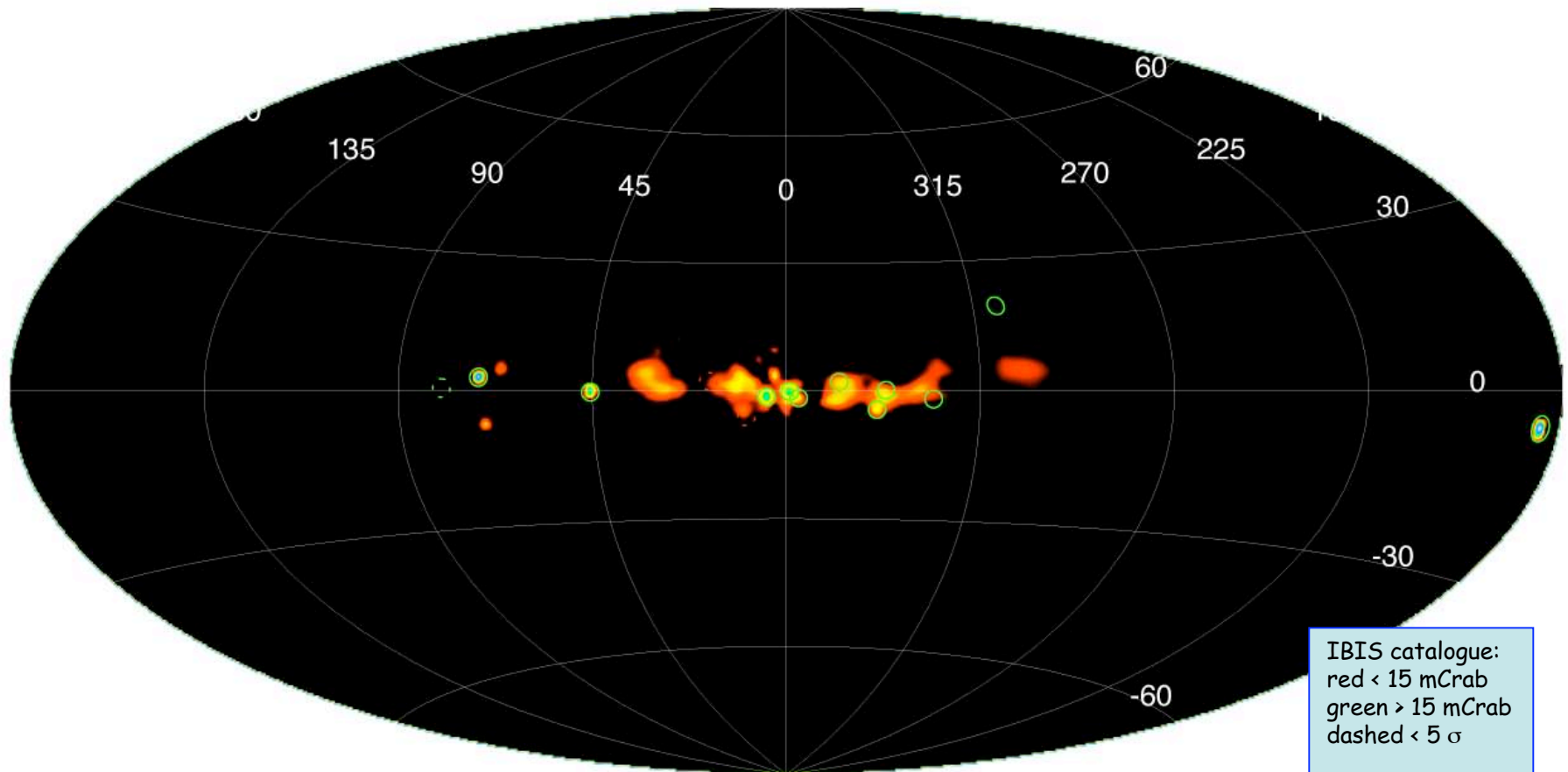
SPI Hard X-ray Sky: 100 - 150 keV



Evidence for diffuse hard X-ray emission:

- 2nd IBIS point-source catalogue overlaid (49 sources)
- Clear indication for diffuse emission in the galactic plane for $|l| < 40^\circ$
- Intrinsically diffuse or weak point sources? (Inner Galaxy IBIS limit ~ 2 mCrab)

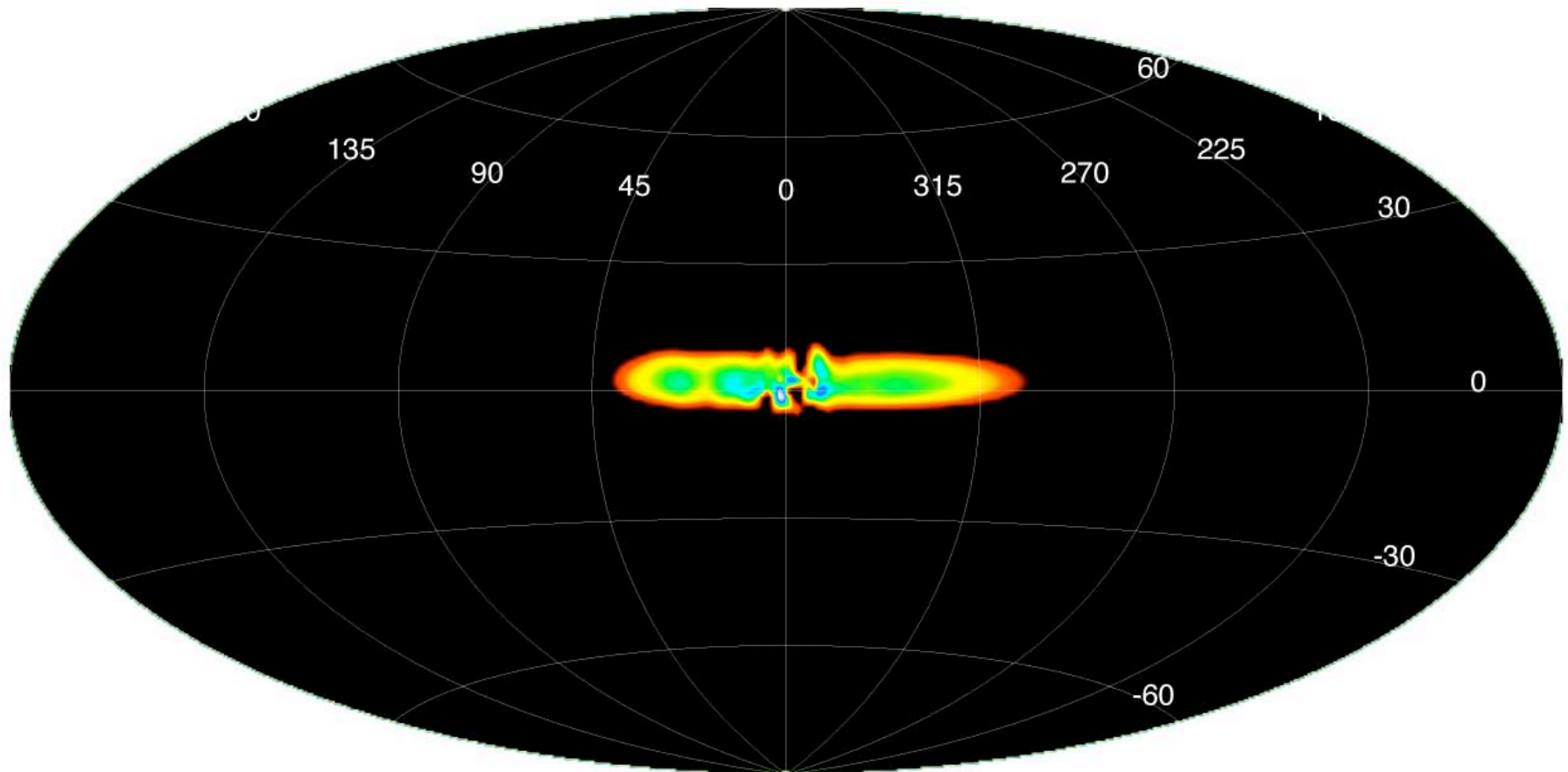
SPI Hard X-ray Sky: 150 - 300 keV



Clear evidence for diffuse hard X-ray emission:

- 2nd IBIS point-source catalogue overlaid (14 sources; inner galaxy IBIS limit ~ 6 mCrab)
- Diffuse emission concentrated towards inner *Galaxy*
- No indications (so far) for diffuse emission in *Cygnus* region

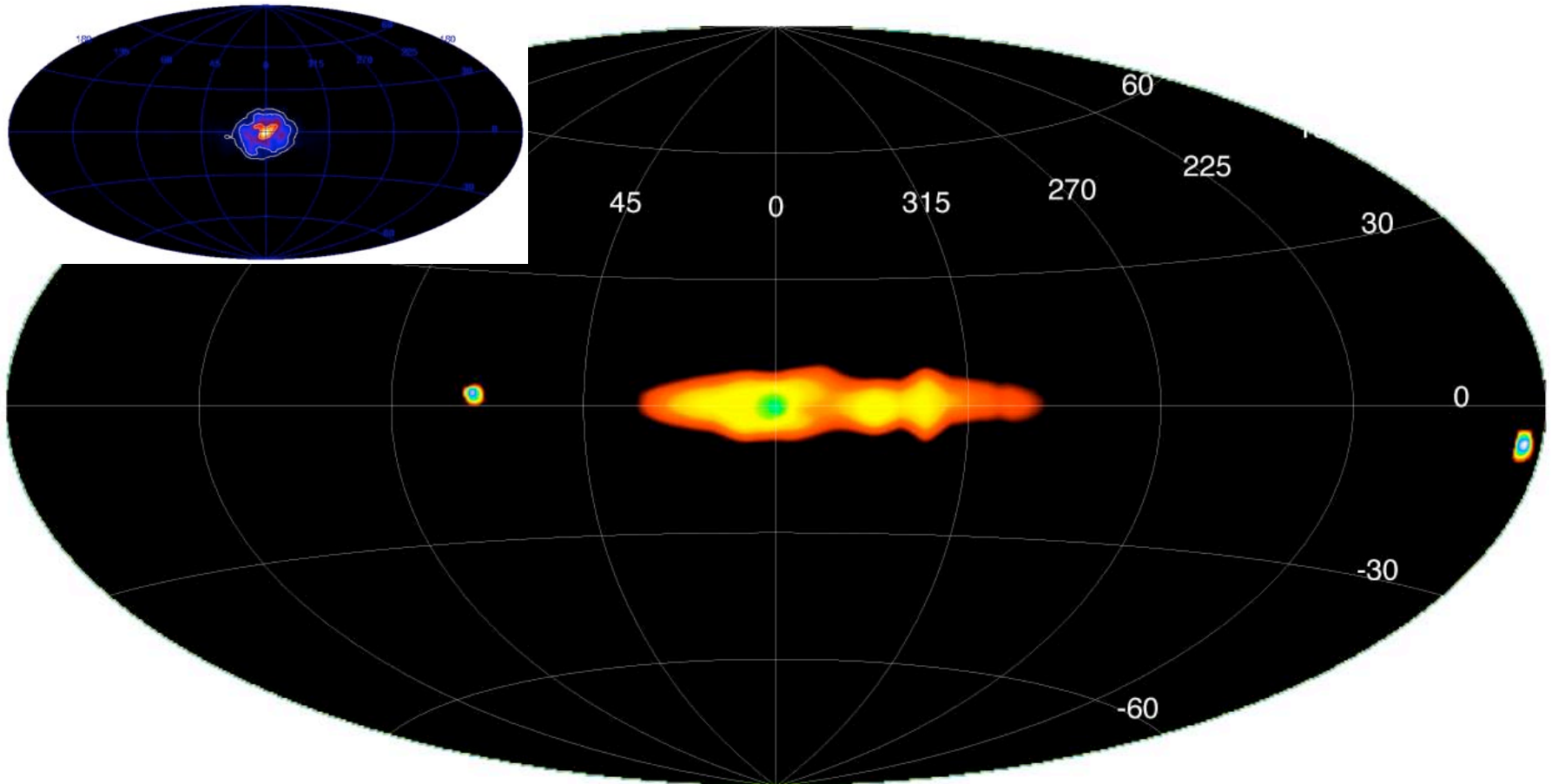
SPI Hard X-ray Sky: 150 - 300 keV



Extracting the diffuse hard X-ray emission:

- Imaging of residual count-rates after subtraction of 2nd IBIS catalogue point-sources
- Flux of all point-sources is fitted independently and simultaneously with image deconvolution
- Residual structure of strong point sources apparent in image
- Emission appears slightly asymmetric w/r to galactic centre

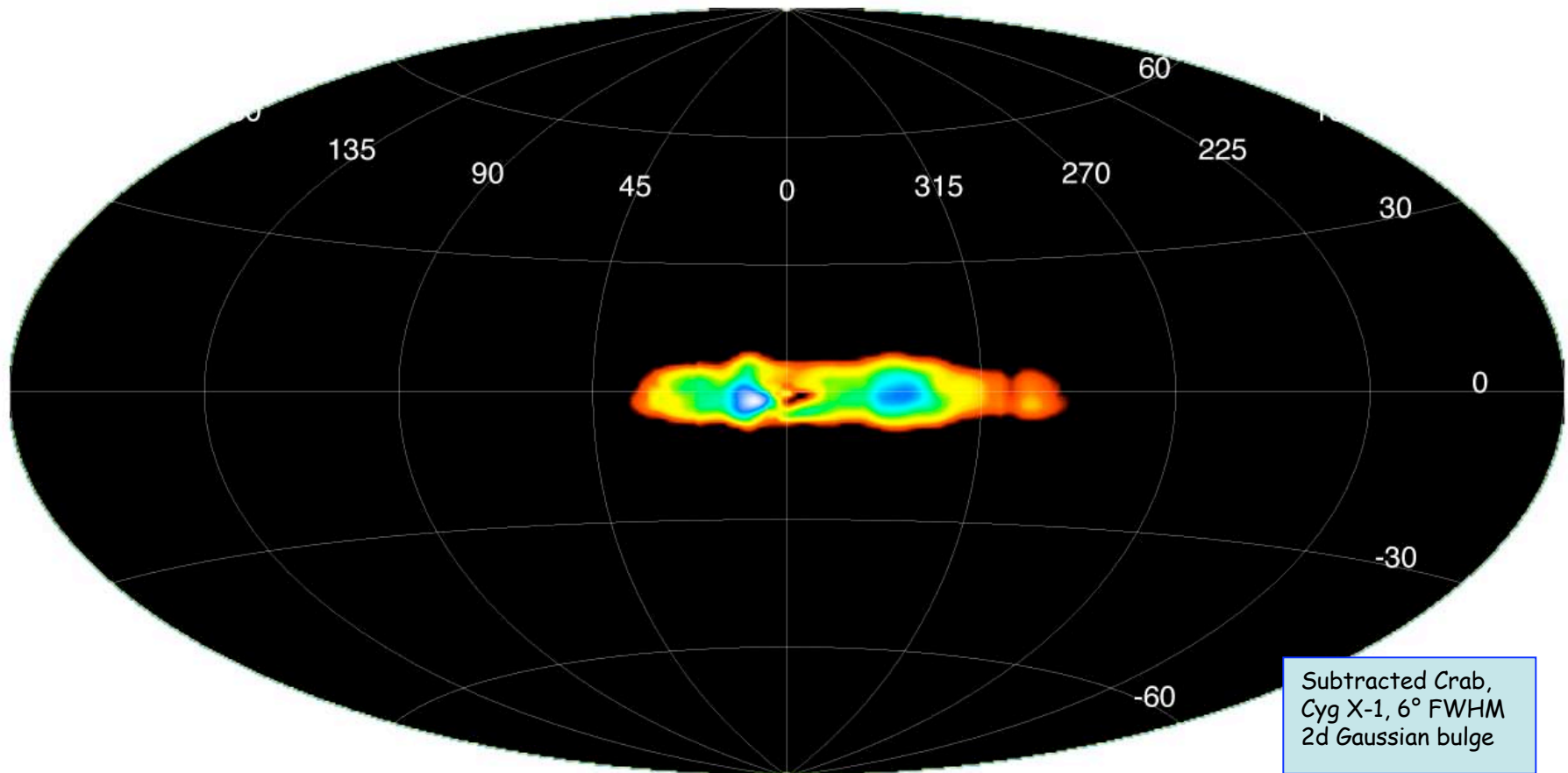
SPI Soft Gamma-ray Sky: 300 - 500 keV



Positron and diffuse continuum emission:

- Only 2 point sources (Crab, Cyg X-1)
- Strong positronium continuum bulge component (morphology known from 511 keV line analysis)
- Diffuse continuum morphology similar to lower energies

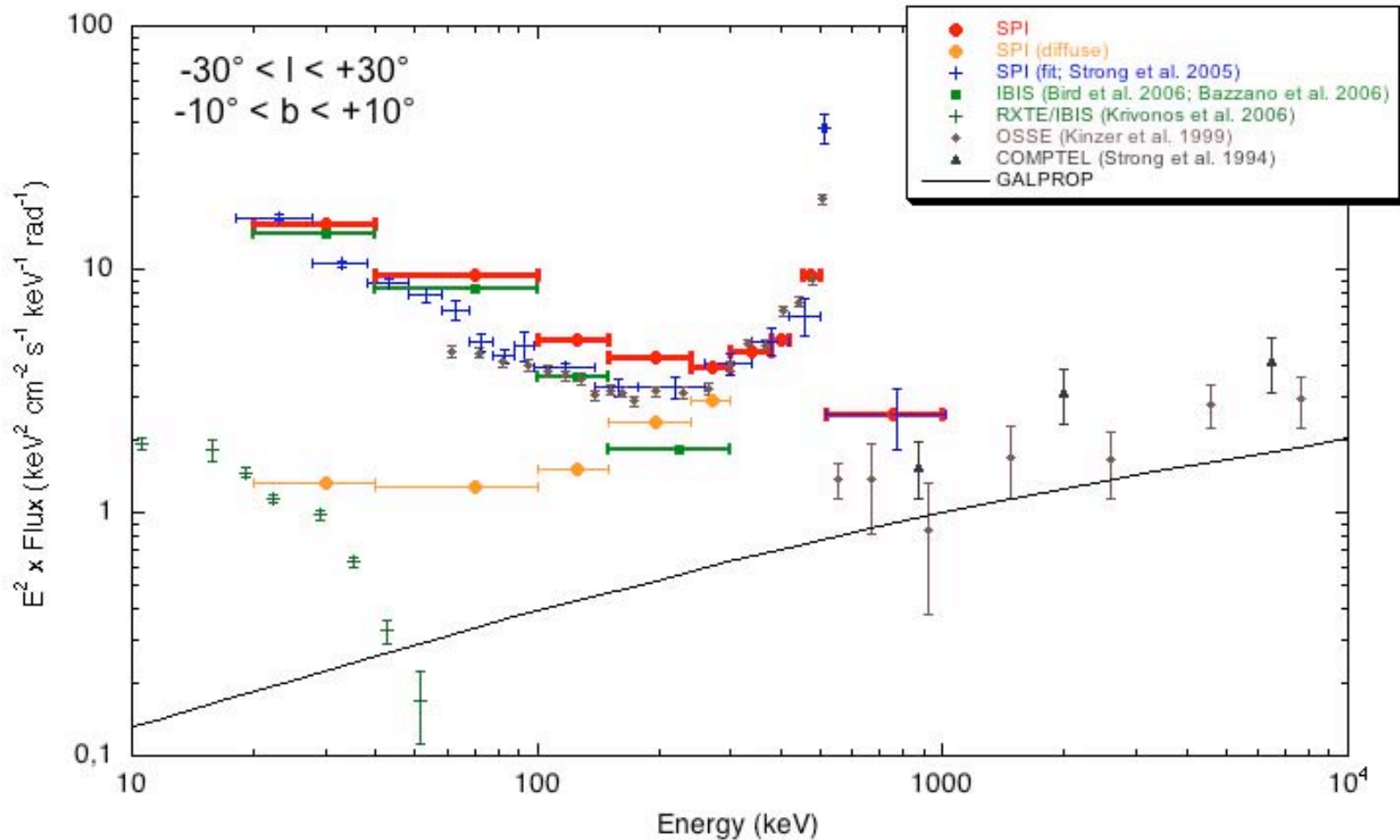
SPI Soft Gamma-ray Sky: 300 - 500 keV



Positron and diffuse continuum emission:

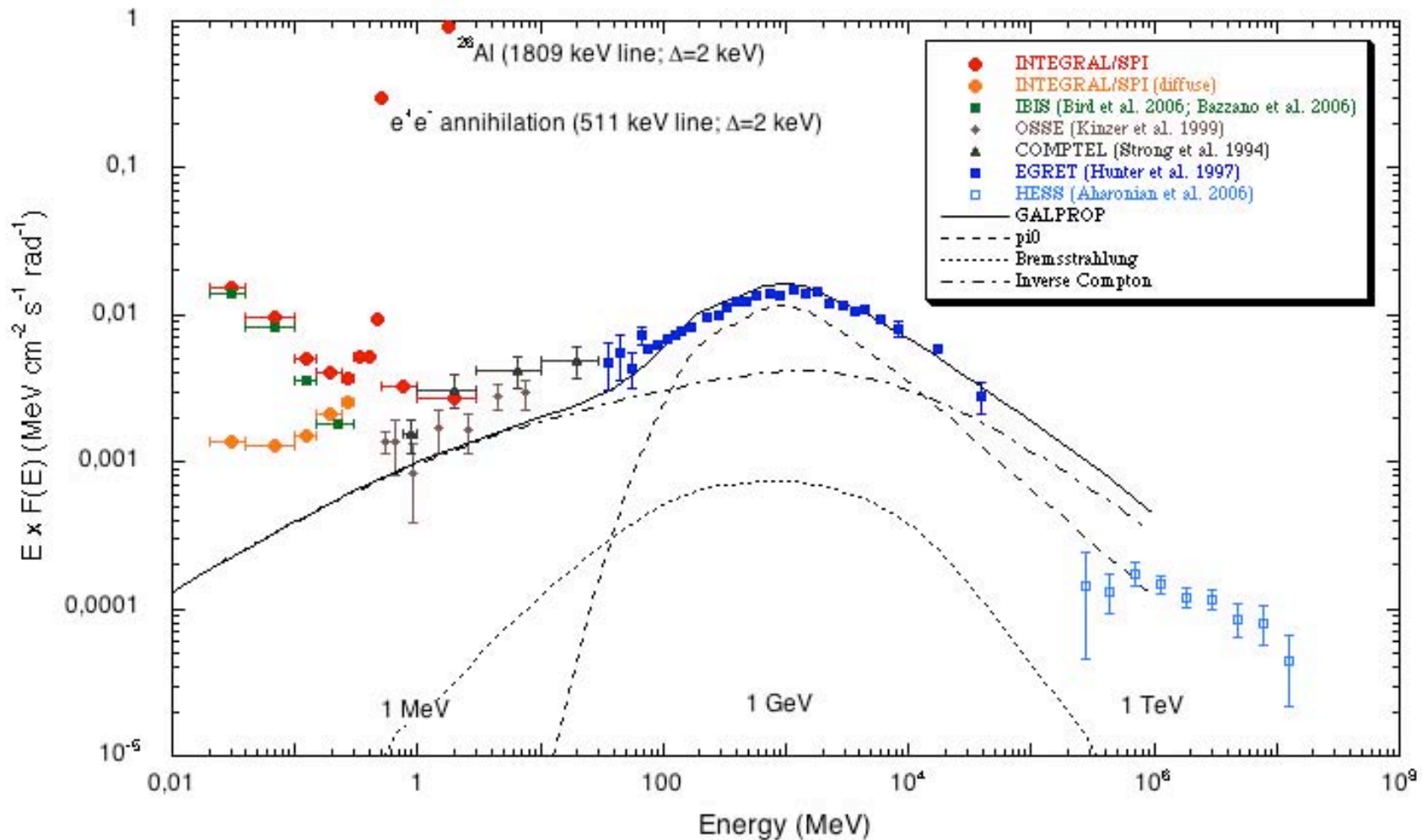
- Only 2 point sources (Crab, Cyg X-1)
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Inner Galaxy Spectrum



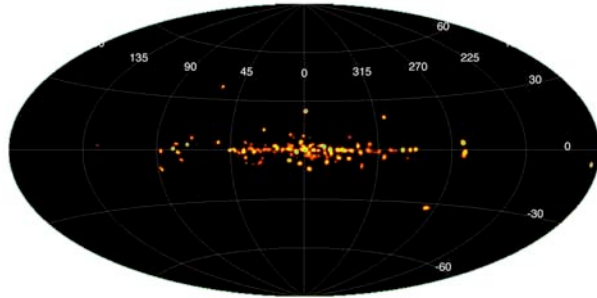
- Below 150 keV: galactic emission dominated by point-sources; above: unresolved/diffuse
- Unresolved component below 60 keV (Krivonos et al. 2006); probably CVs
- Unresolved/diffuse component above ~100 keV follows Inverse Compton shape; factor ~3 missing

Galactic diffuse emission spectrum

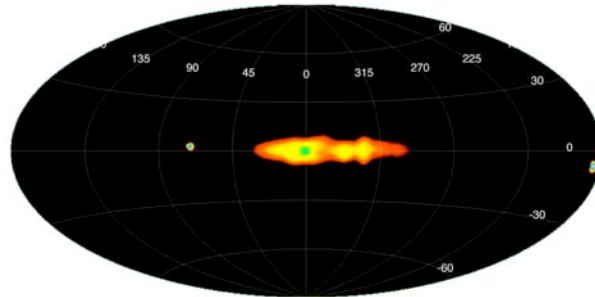


- Extra diffuse emission component? (inflight e^+ annihilation)
- Unresolved point-sources? (e.g. pulsars, AXP)
- see also poster P17.13 by Andy Strong

Thank you!

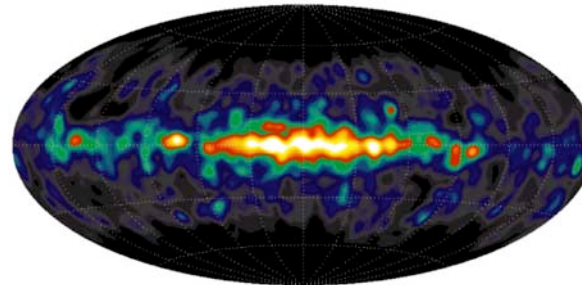


Hard X-rays
20-40 keV

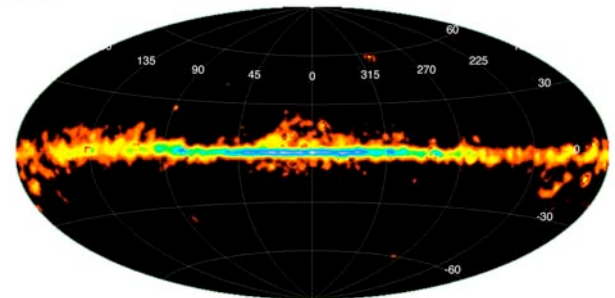


Soft γ -rays
300-500 keV

Medium-energy γ -rays
1-30 MeV

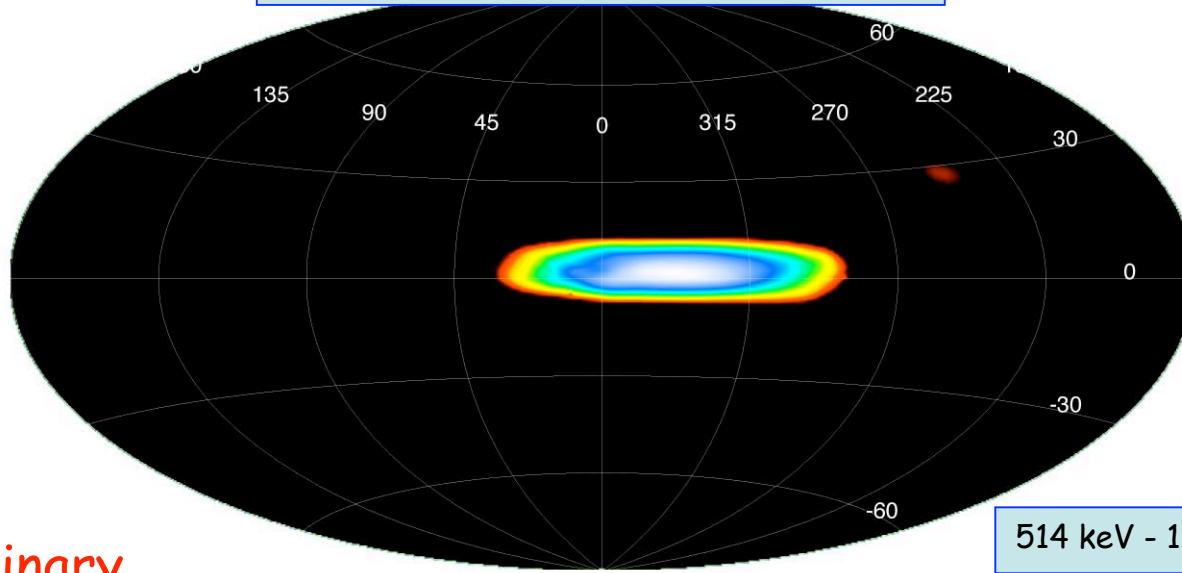


High-energy γ -rays
>100 MeV



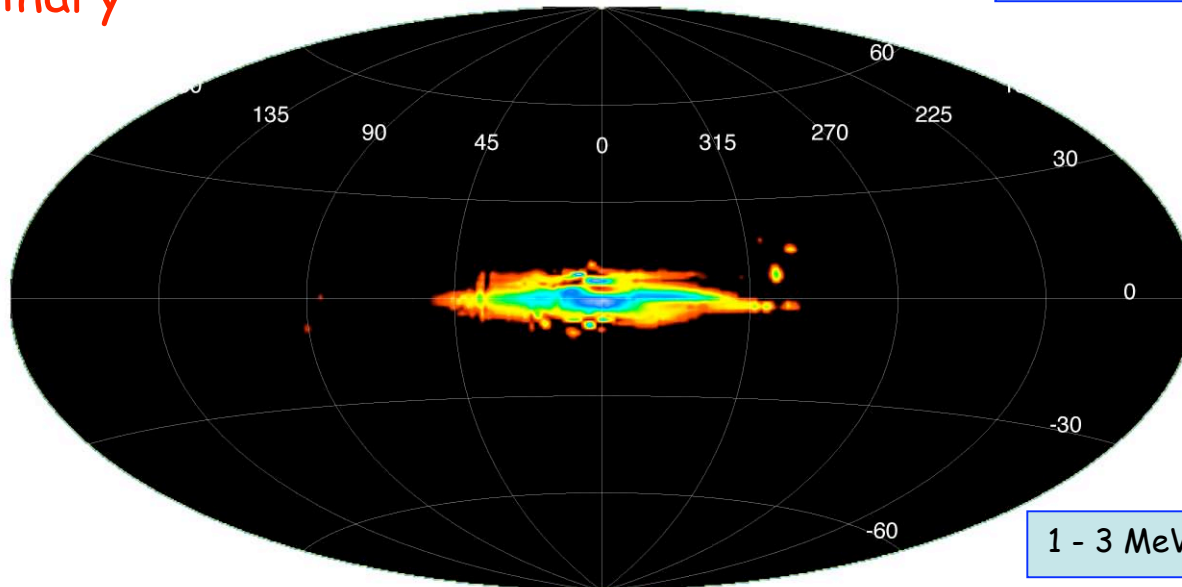
SPI Soft Gamma-ray Sky > 500 keV

Crab (and Cyg X-1) subtracted maps



514 keV - 1 MeV

preliminary



1 - 3 MeV