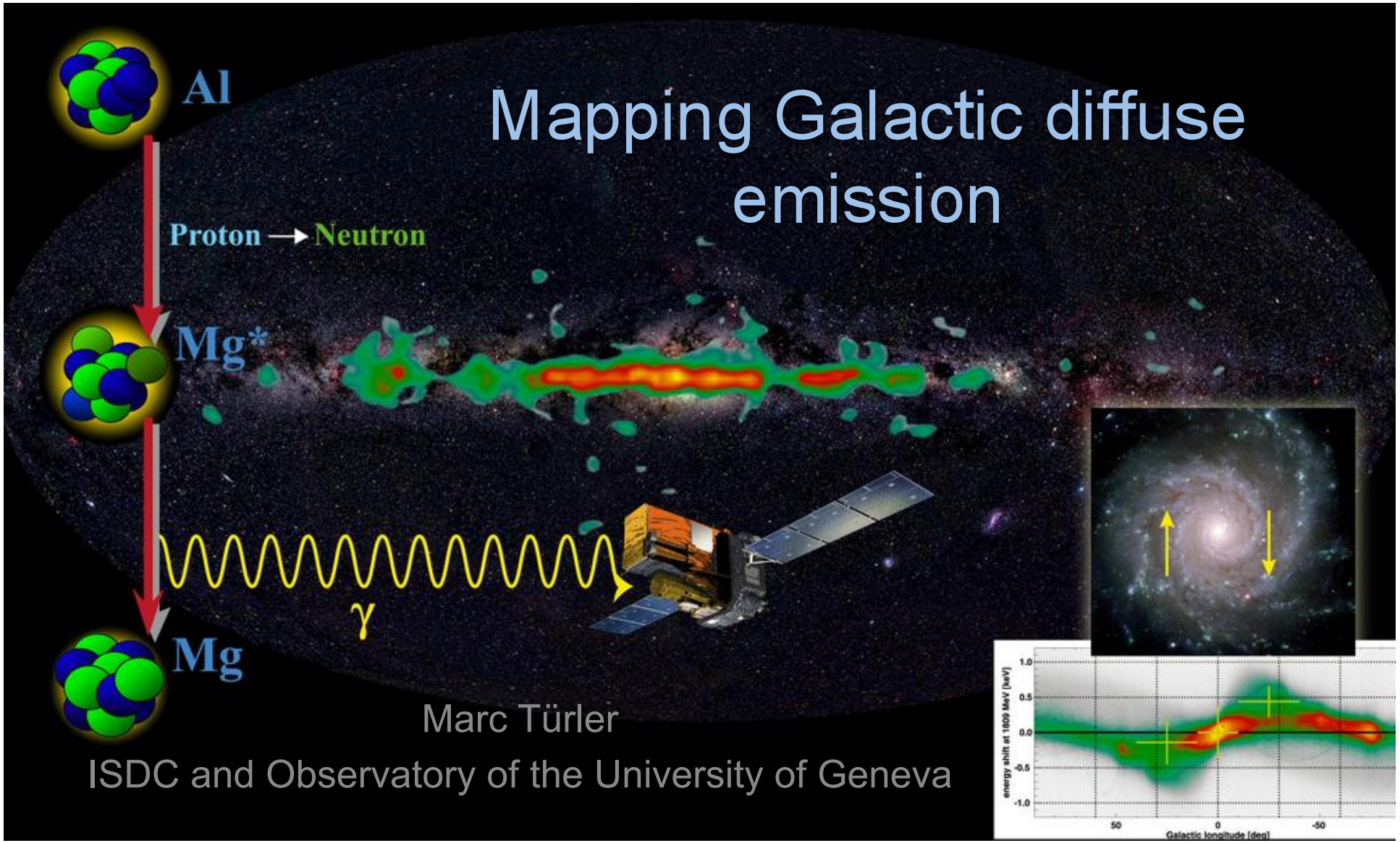
INTEGRAL Tutorial Session

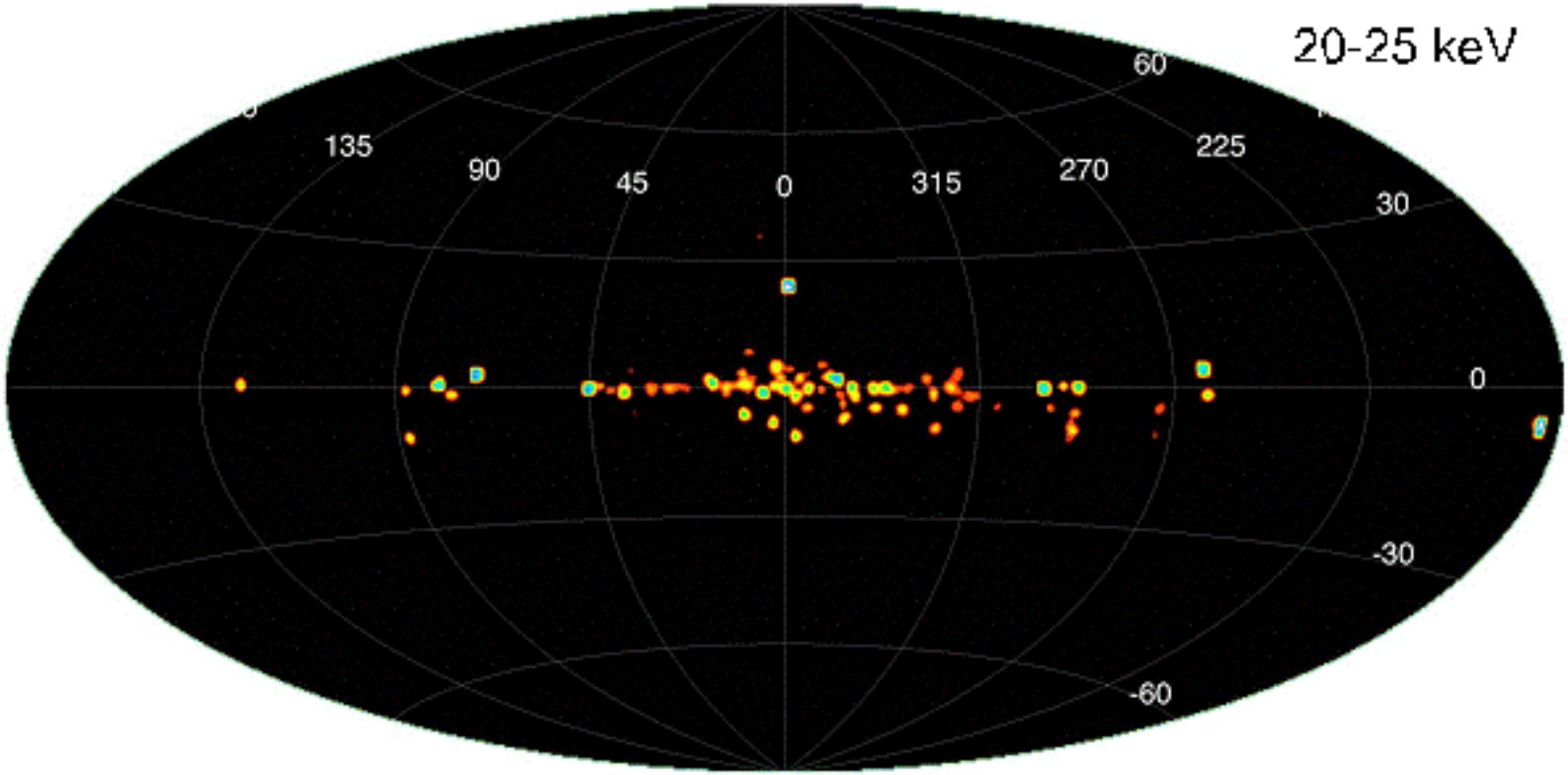


Overview of the Milky Way by SPI

(SPI Team, Knödlseder et al. 2006)

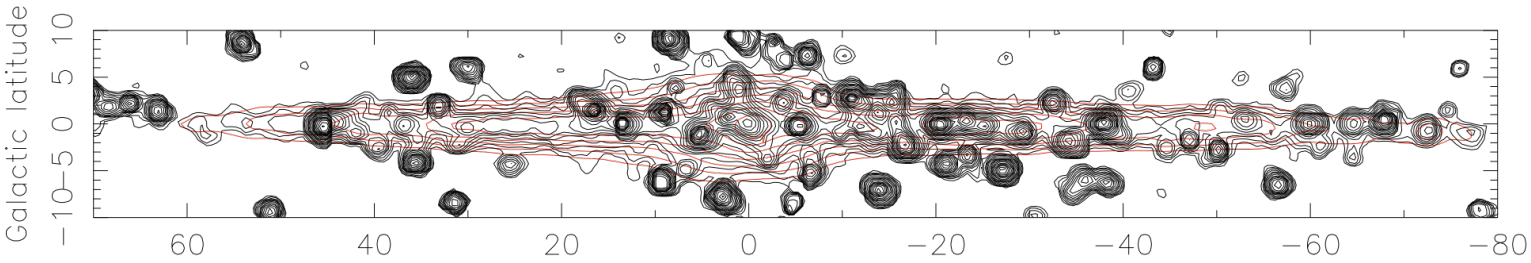
From point source emission at low-energy …

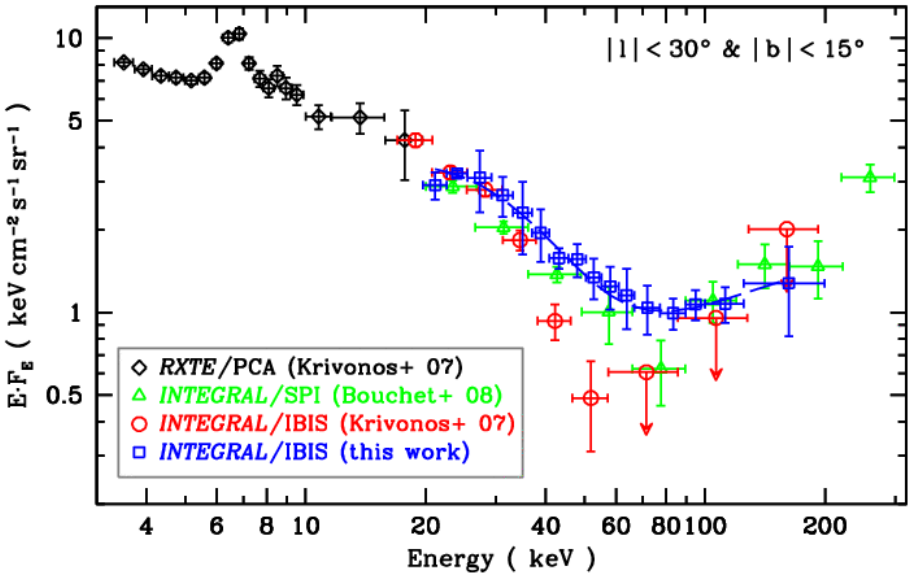
…to diffuse emission at high-energy



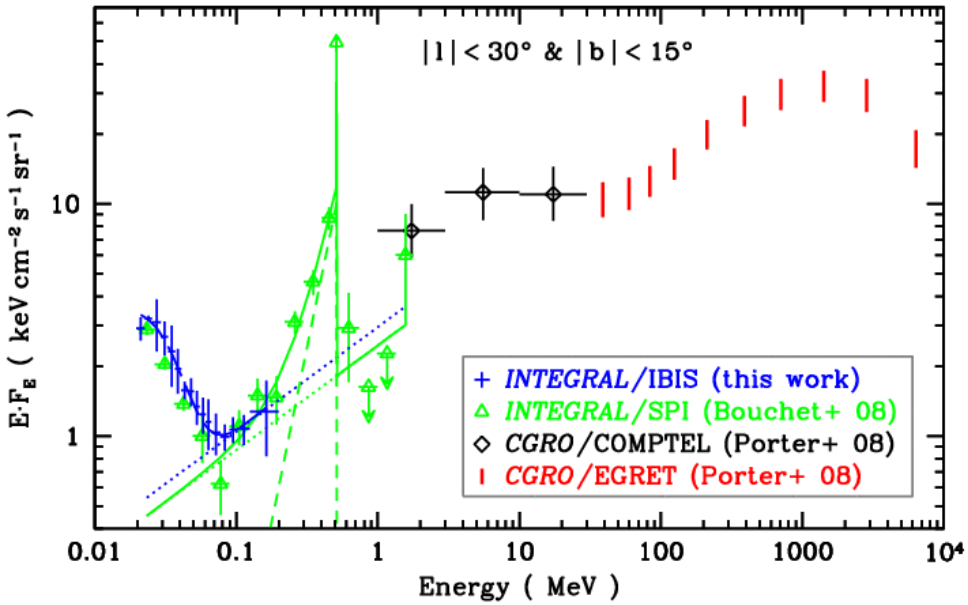
Spectrum of the Galactic ridge

(Krivonos et al. 2007, Bouchet et al. 2008, Türler et al. 2010)





↑ RXTE/PCA (3-20 keV) and COBE/DIRBE mid-IR emission (Revnivtsev et al. 2006)

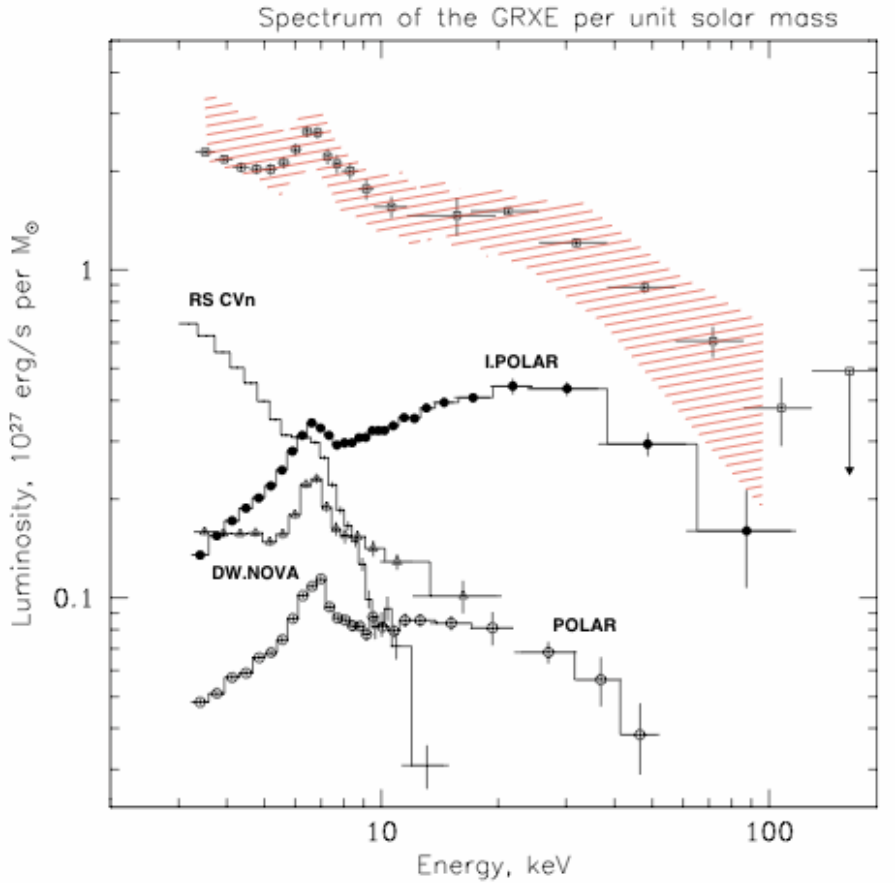


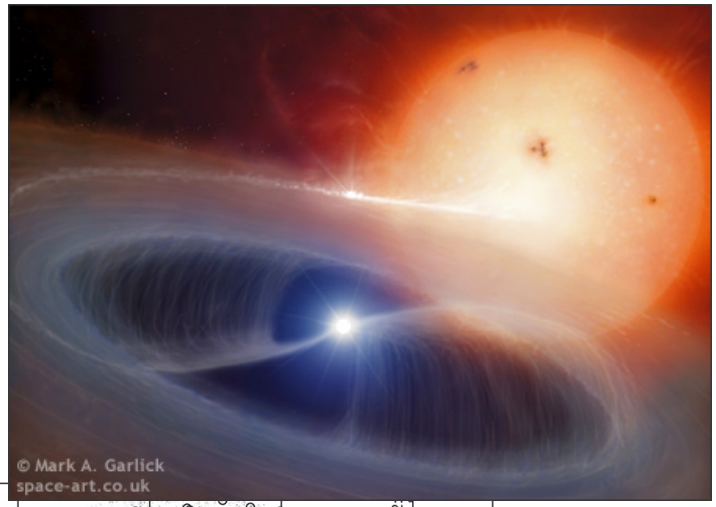
INTEGRAL detects a high-energy tail consistent with high-E measurements and GALPROP models of IC emission (Porter et al. 2008)

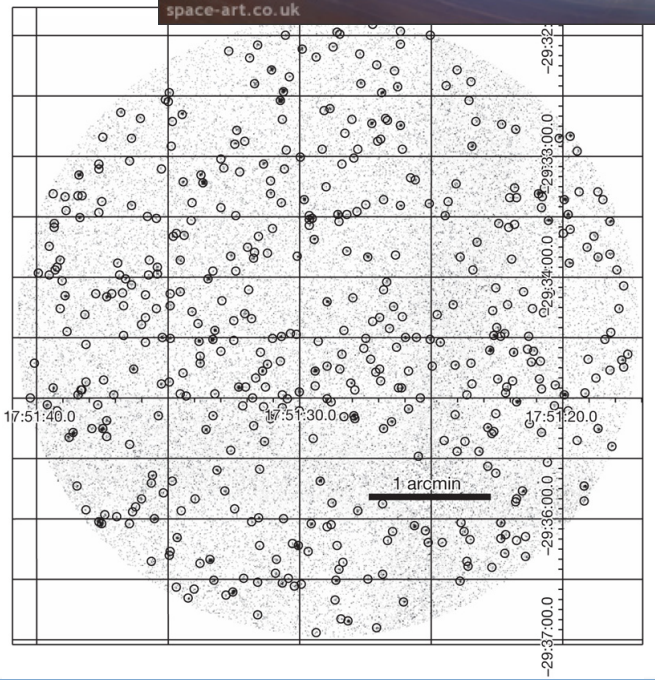
Cataclysmic variables at low-energy

(Revnivtsev et al. 2006, 2008)

- Low-energy (<80 keV) emission from CVs (intermediate polars) resolved up to 80% by Chandra at 6-7 keV
- A few are even seen by INTEGRAL



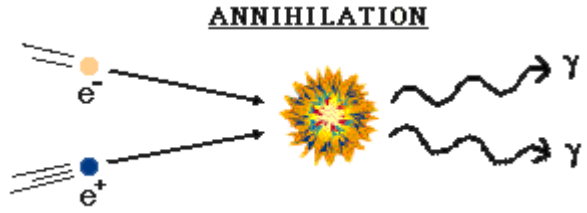


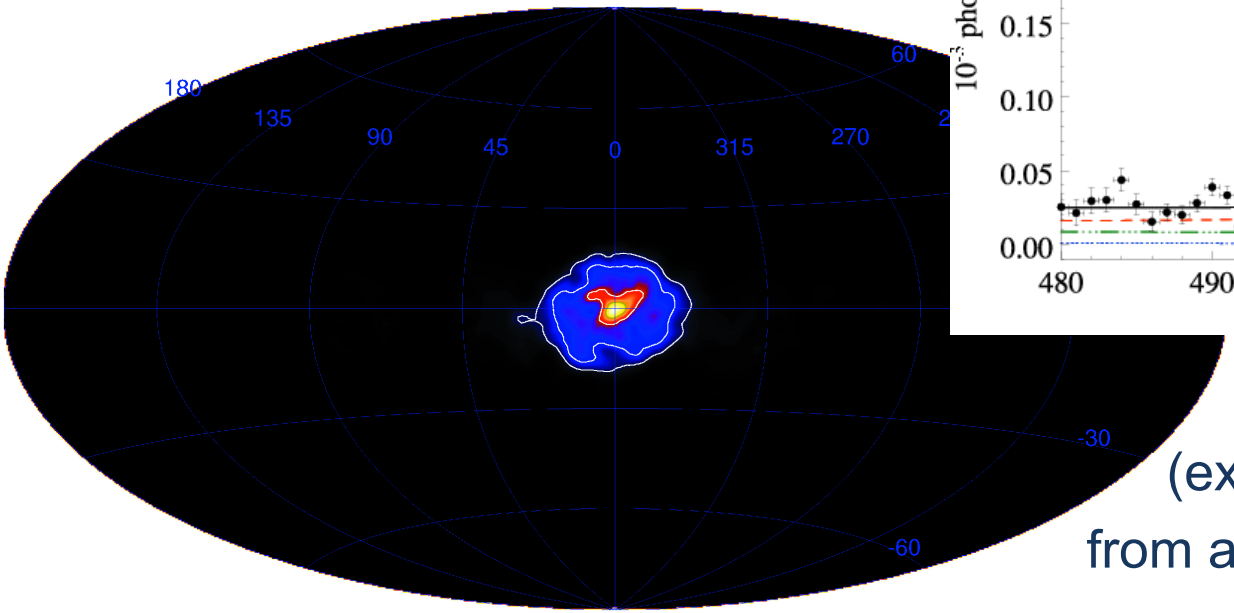


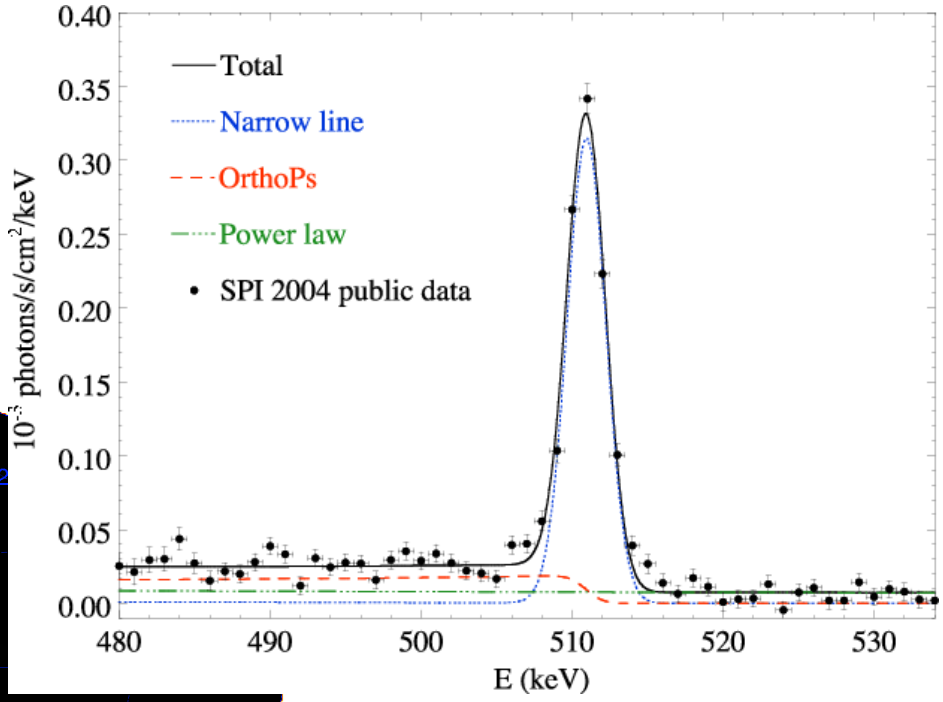
Positron annihilation line at 511 keV

(Churazov et al. 2005, Knödlseder et al. 2005, Jean et al. 2006)

- Annihilation of 10 billion tons of antimatter per second in the central bulge of the Galaxy





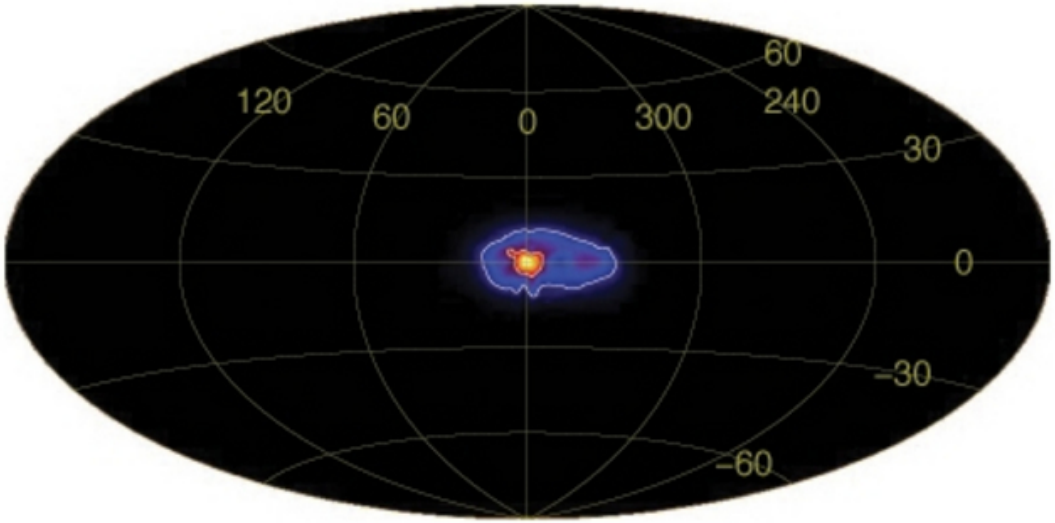


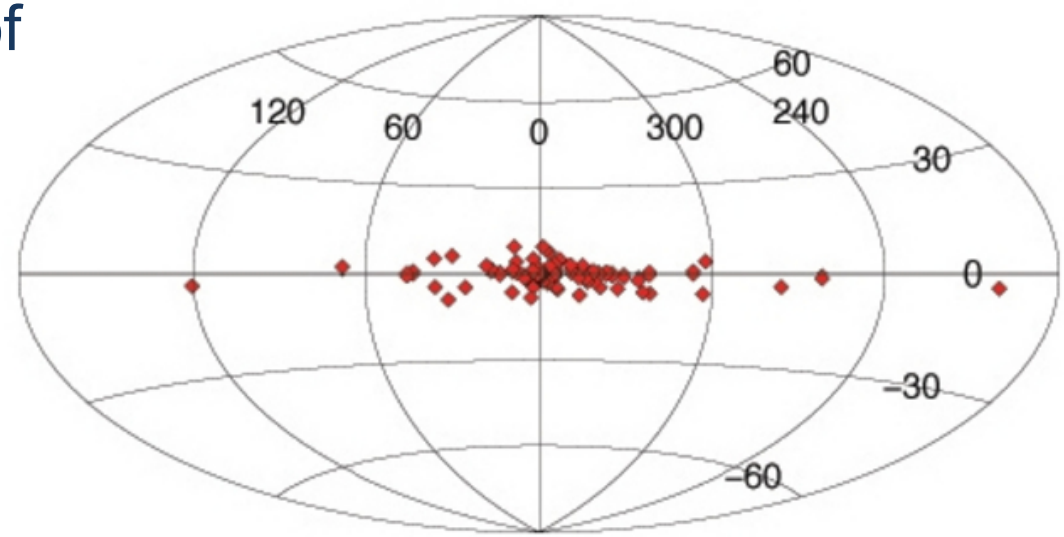
> 100 papers propose (exotic) origins of the positrons from astrophysical sources to light dark matter, axions, etc.

Asymmetry in the 511 keV emission

(Weidenspointner et al. 2008)

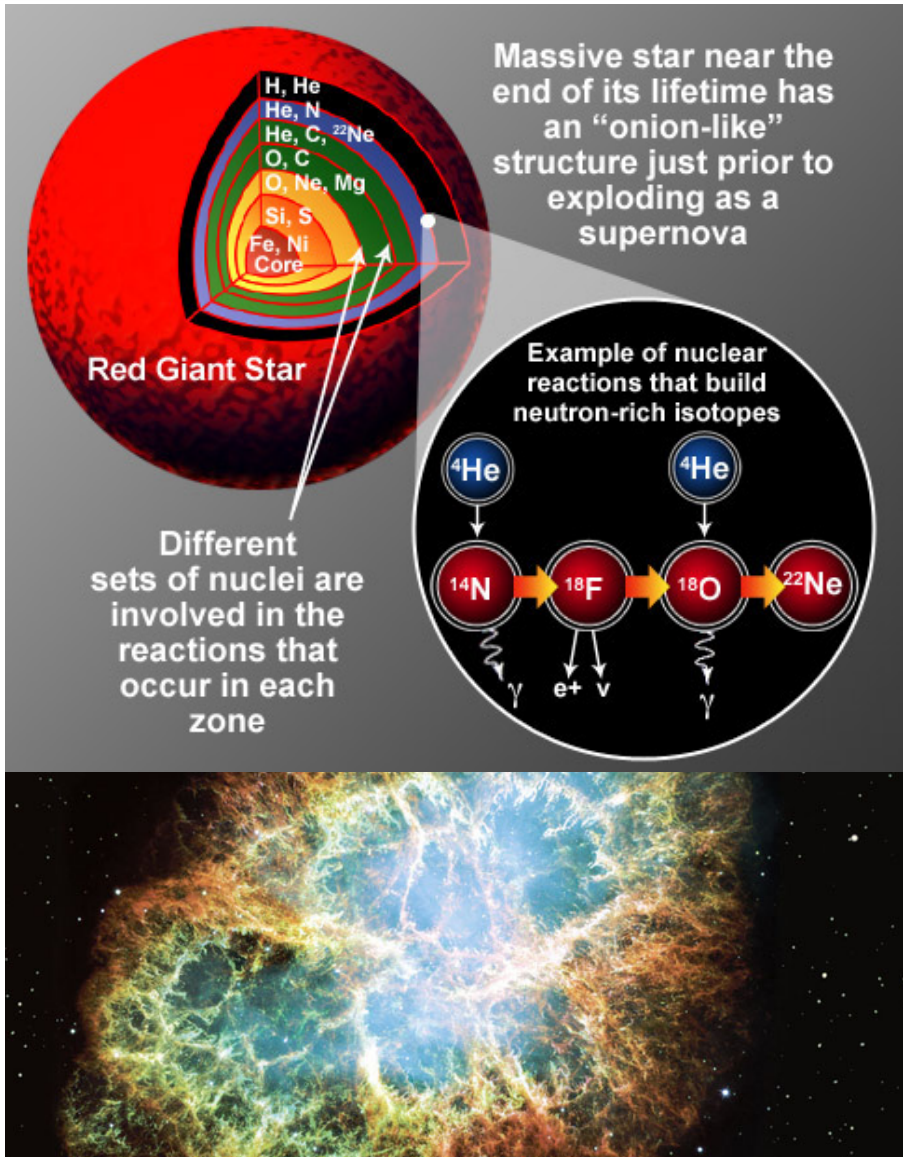
- Asymmetry in the disk component of the annihilation emission
- Only sources having a similar asymmetry are low-mass X-ray binaries
- Suggests that positrons come from leptonic jets of microquasars
- Alternatively, the effect could come from the distribution of molecular clouds where positrons annihilate predominantly





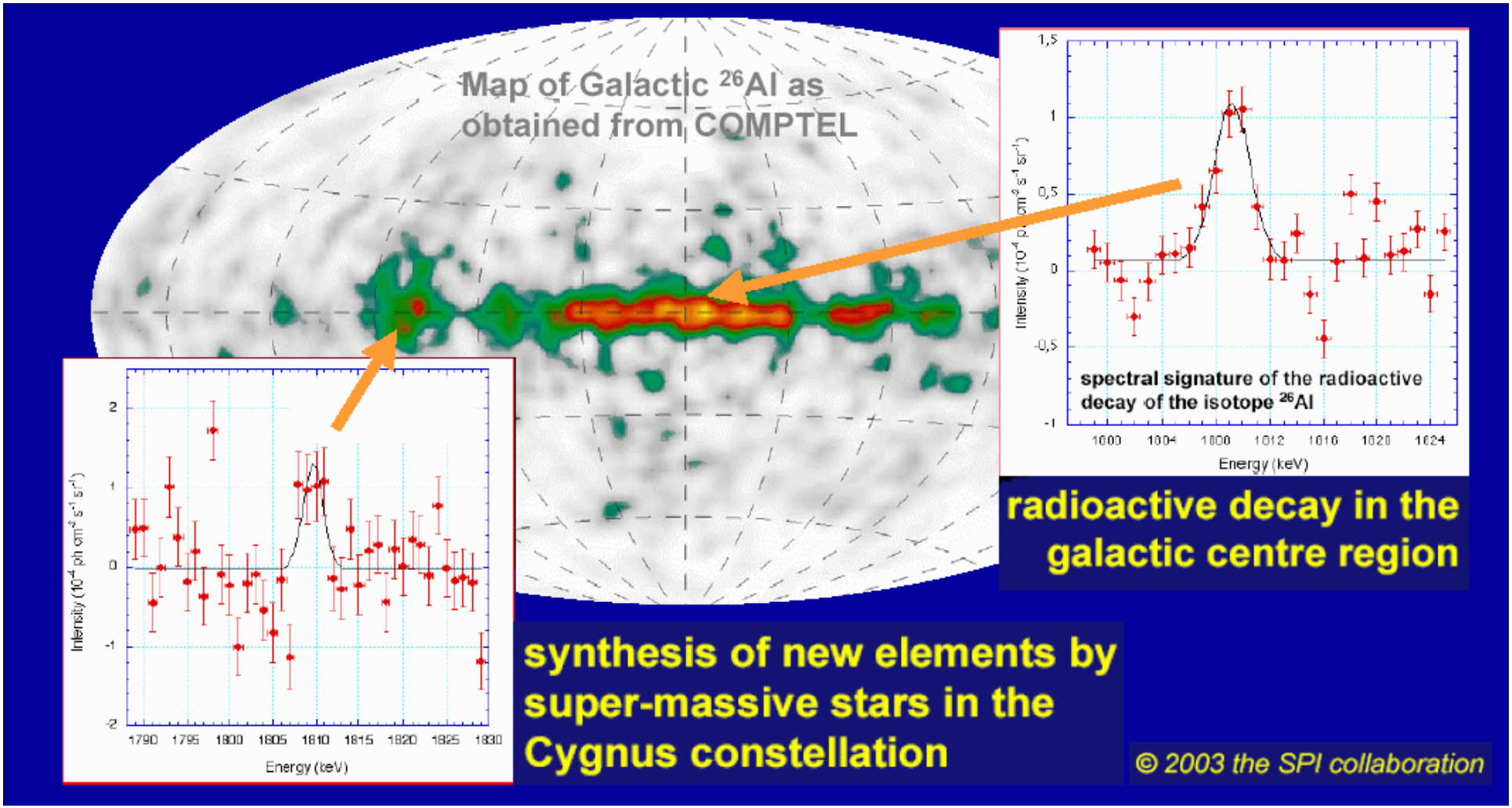
Nucleosynthesis & radioactive nuclei

- Big-Bang nucleosynthesis produces ~25% of He, but no C, N, O, Fe, etc.
- These heavy elements are all produced inside massive stars and ejected by supernova explosions
- Some radioactive nuclei are produced by the explosion itself. For ex. Aluminum 26
- ^{26}Al has a lifetime of ~1 million years and emits a gamma-ray line at 1.8 MeV



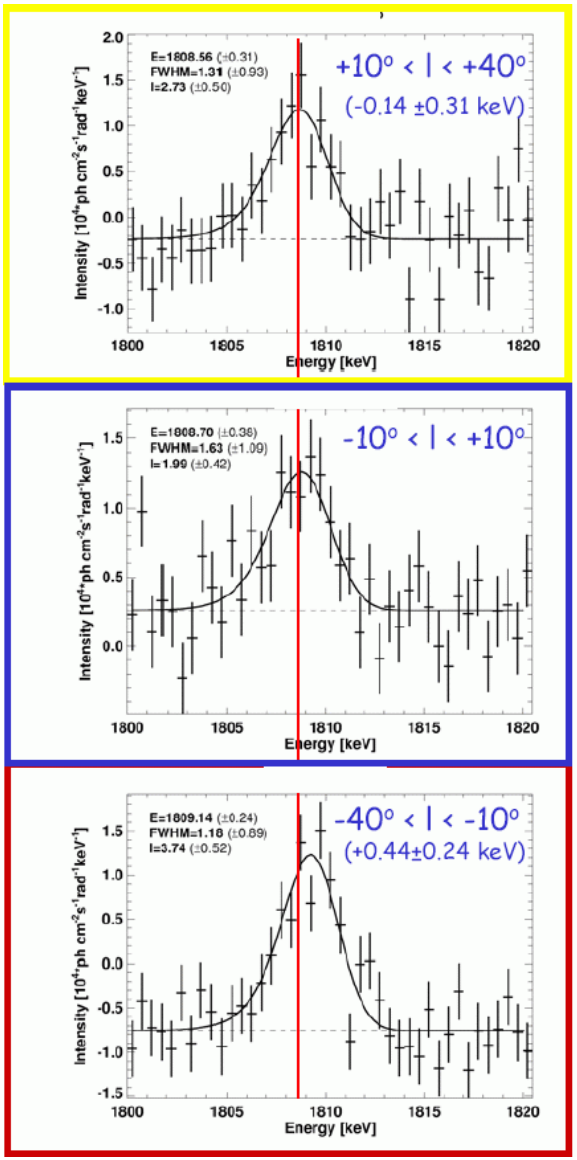
Radioactive ^{26}Aluminum in the Galaxy

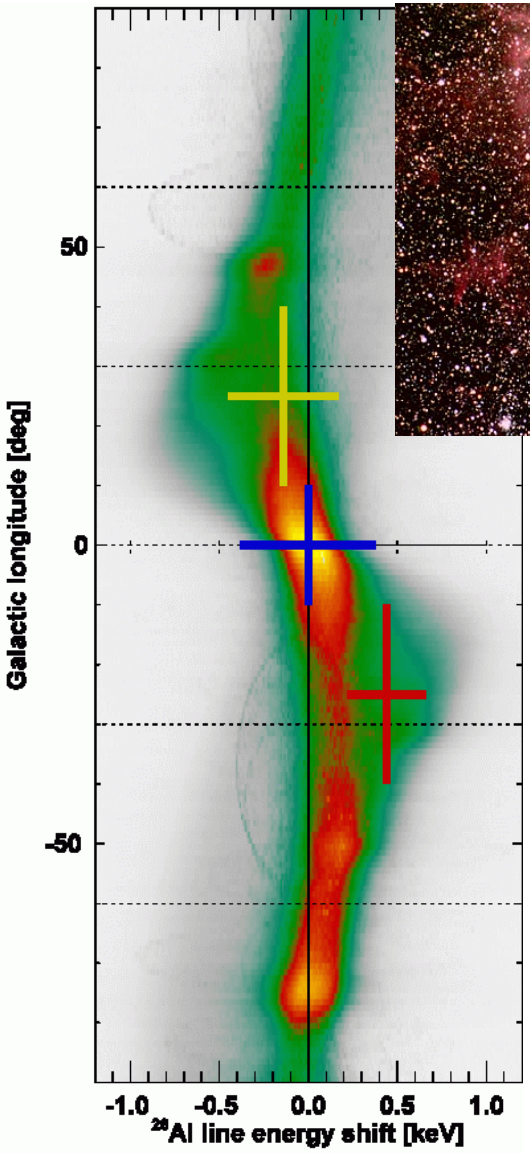
(SPI Team since 2003, Wang et al. 2009, Martin et al. 2009)



Aluminum 26 is in Galactic rotation

(Diehl et al. 2006)





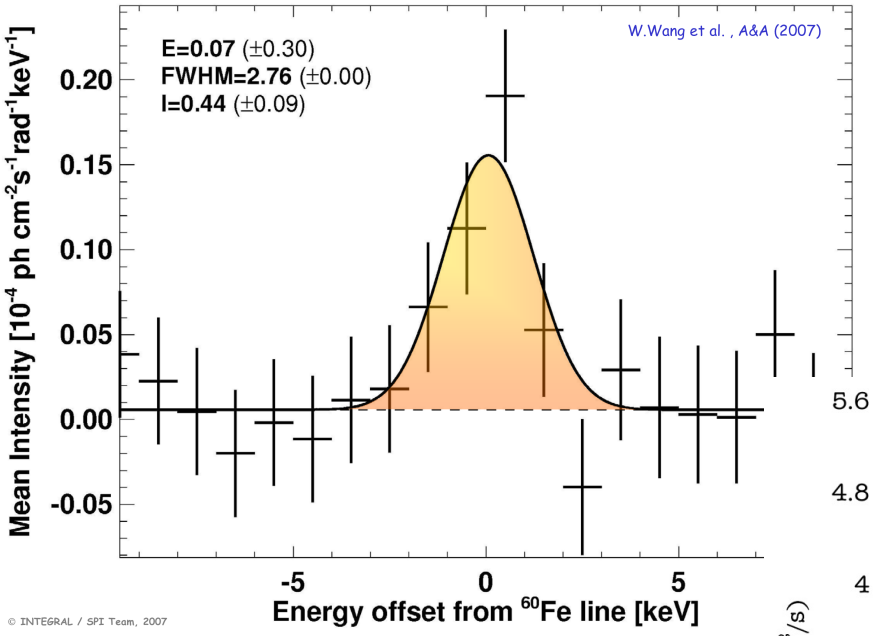
Detection of Galactic rotation with SPI

➔ emission comes from the whole Galaxy

➔ ~2 Supernovæ per century needed to account for the ^{26}Al emission

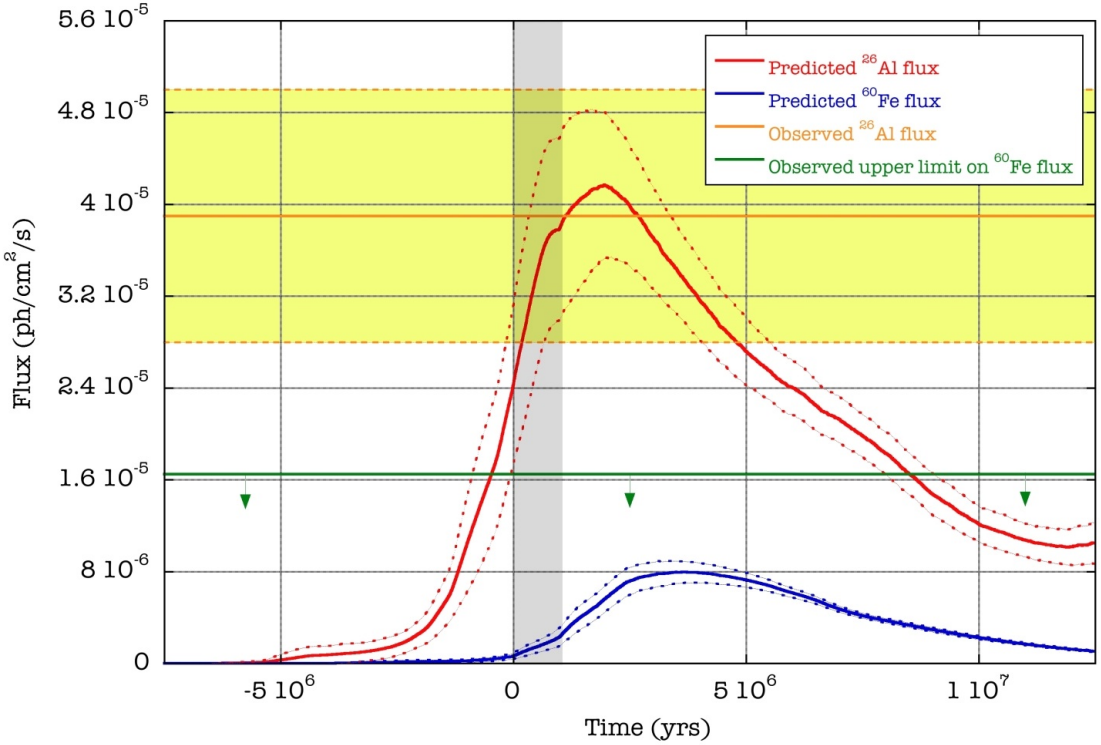
Iron 60 emission detected with SPI

(Wang et al. 2007, Martin et al. 2009)



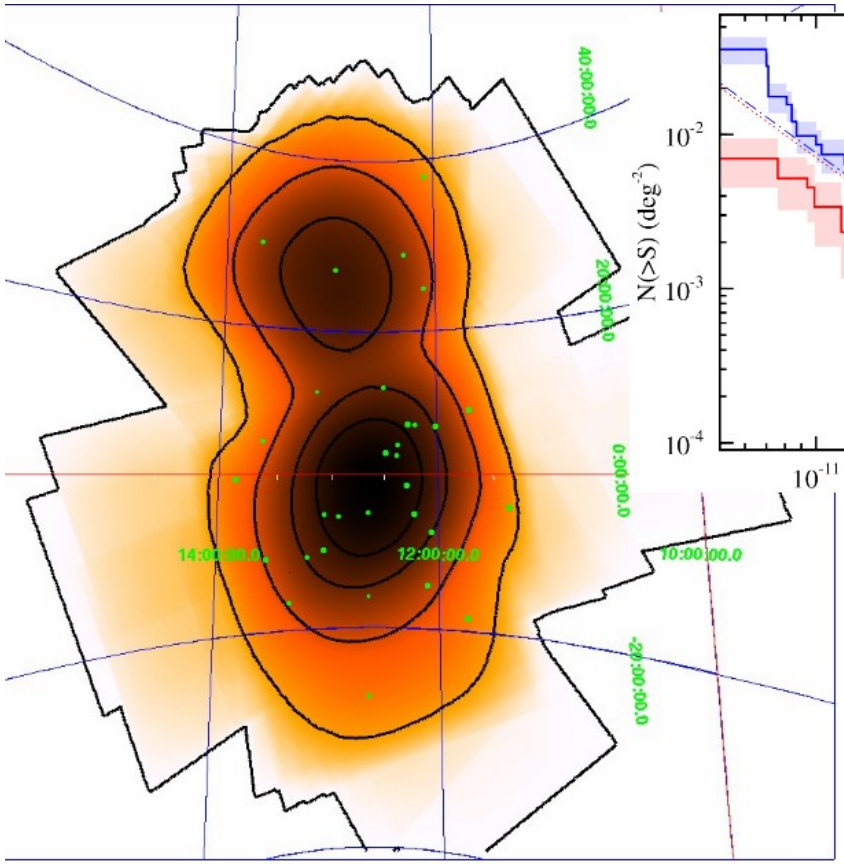
← Detection of ^{60}Fe integrated in the Galactic disk

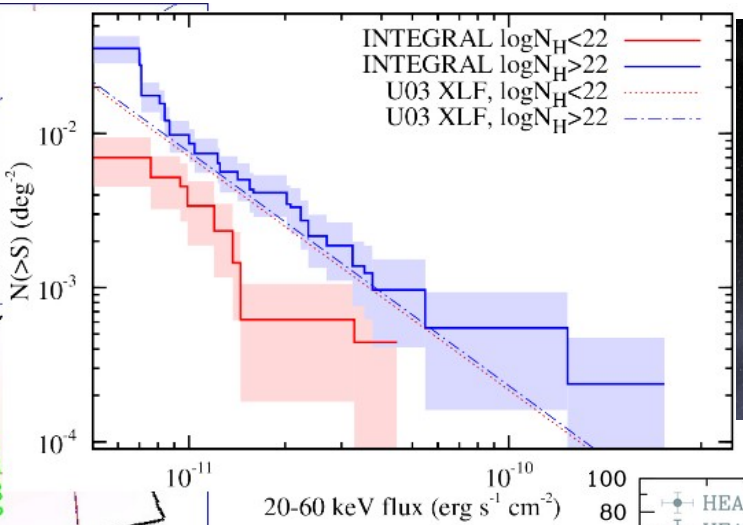
Upper limit of ^{60}Fe in → the Cygnus region above predicted level

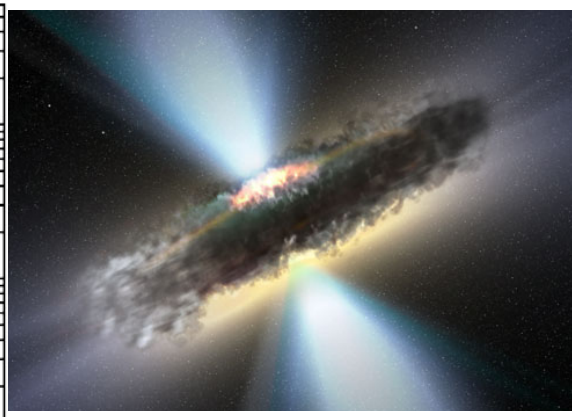


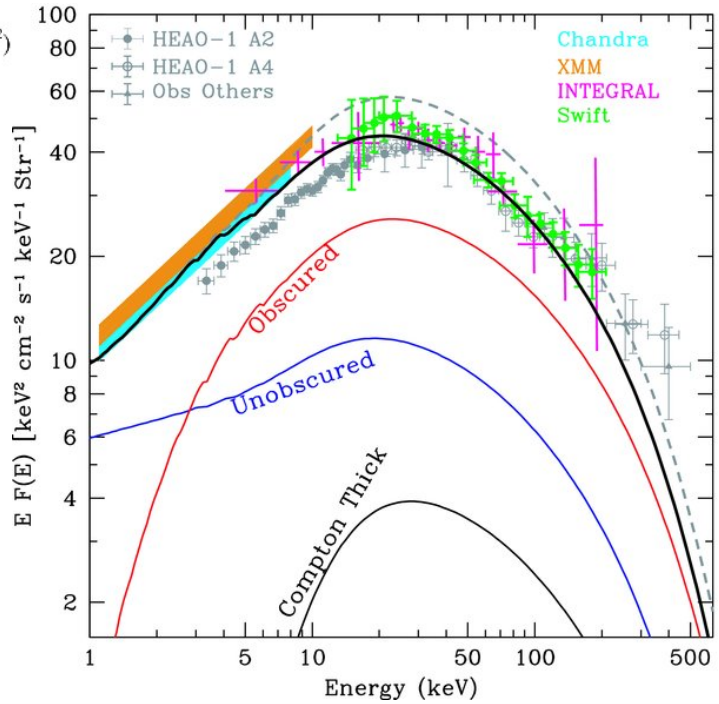
Obscured AGN & the X-ray background

(Paltani et al. 2008, Treister et al. 2009)





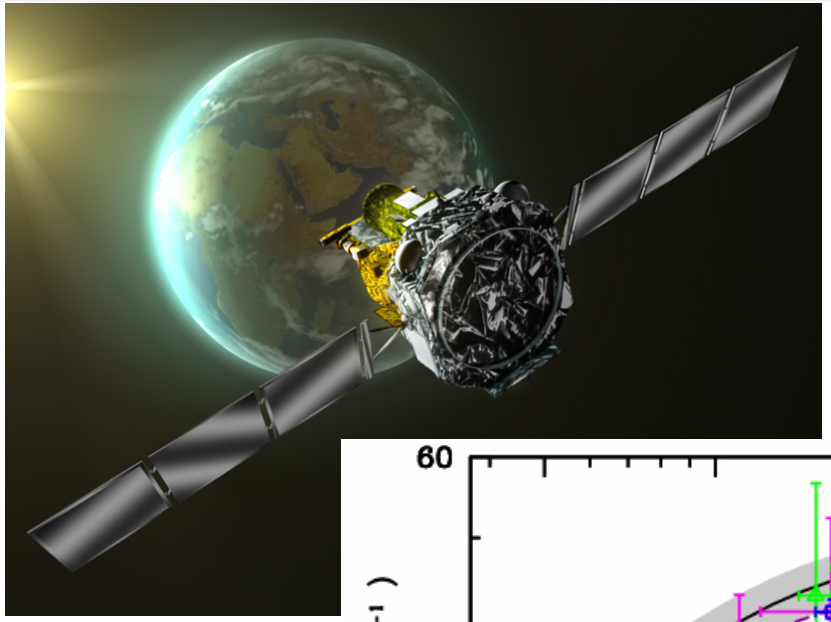


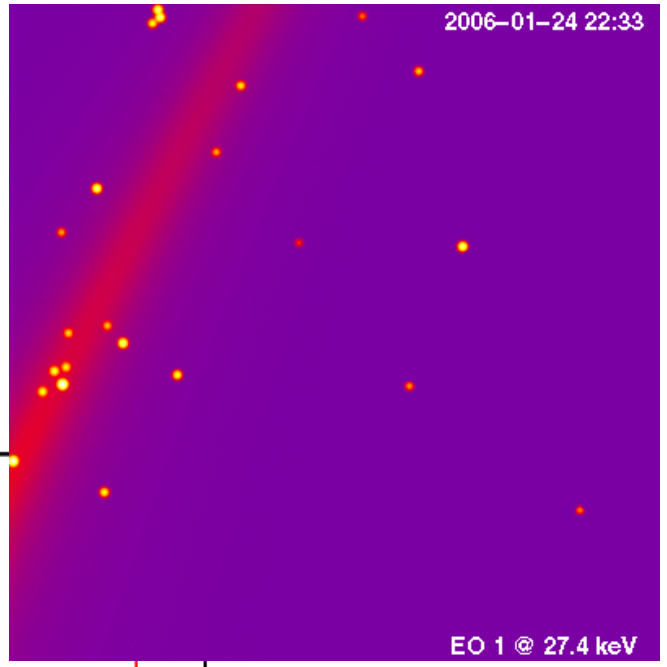


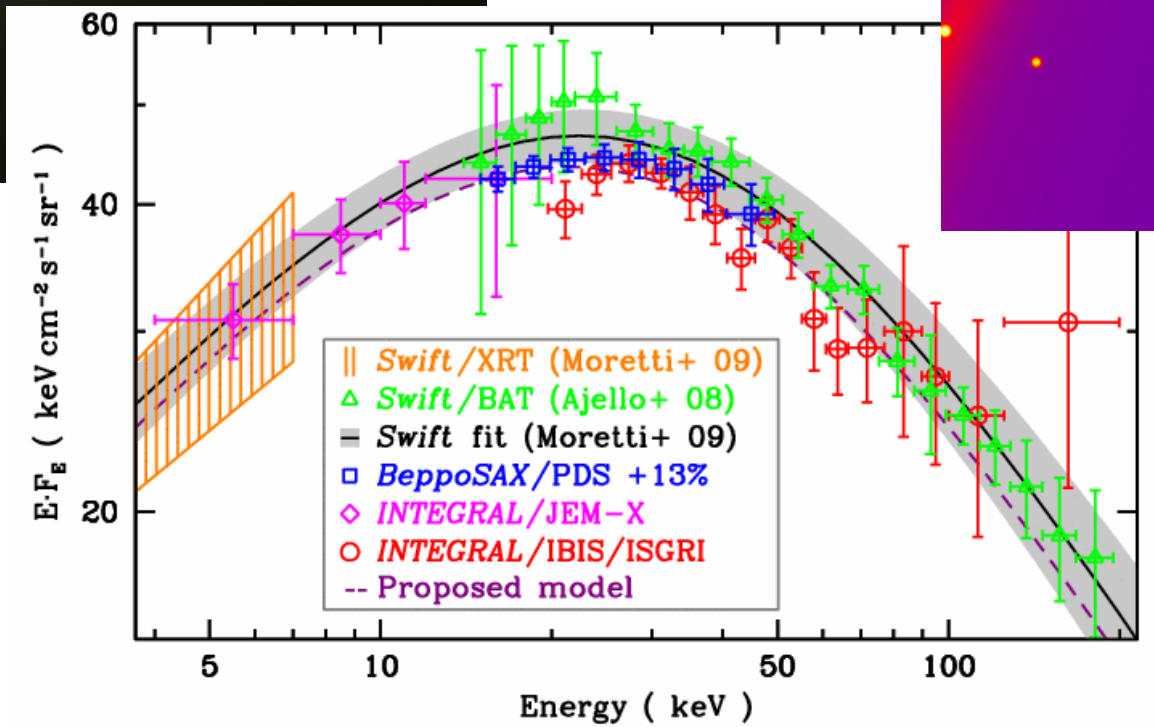
- Only 34 AGNs detected in the deepest INTEGRAL extra-galactic field (12% of the sky). ¾ of them are absorbed AGN
- High-fract. of obscured AGN implied by CXB

CXB via occultation by the Earth

(INTEGRAL Obs. in 2006, Churazov et al. 2007, Türler et al. 2010)







Conclusion

- INTEGRAL is a great tool to observe diffuse emission with its wide field of view and especially thanks to its unique spectrometer SPI for studying line emission of positron annihilation and of radioactive nuclei – in particular ^{26}Al – all along the Galaxy.
- It does also provide the deepest extragalactic view of the hard X-ray sky and a good measure of the CXB

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