# The 511 keV sky as seen by INTEGRAL/SPI, CGRO-OSSE, SMM/GRS and WIND/TGRS combined

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Historically, different instruments led to different estimates of the 511 keV flux and hence to fallacious conclusions of variability.

In fact they were sampling different subsets of a diffuse emission.

Integral SPI has produced the most detailed information so far. But SPI alone samples preferentially on a 3°-16° scale and misses information, particularly on larger scales.

Here we take advantage of the very effect that led to the wrong conclusions early on - different instruments, different fields of view.

Plus confirmations and cross-checks.

### INTEGRAL / SPI : 2002 - ....



#### performance at 511 keV :

effective area : 75 cm<sup>2</sup> (with mask !) field of view : 16° (FWHM) angular resolution : 3° energy resolution : 2 keV (0.4%)

19 Ge (500 cm<sup>2</sup>) imaging : tungsten mask and large anticoincidence shield





#### SMM / GRS 1980 - 1989



7 Nal (315 cm<sup>2</sup>) imaging : Csl anticoincidence



performance at 511 keV :
effective area : 150 cm<sup>2</sup>
field of view : 130° (FWHM)
angular resolution : energy resolution : 41 keV (8%)



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#### CGRO / OSSE : 1991-1999



4 Nal-CsI phoswich A 13700 cm<sup>2</sup>, h 102+76 mm imaging : slat collimators



performance at 511 keV effective area : 2000 cm<sup>2</sup> field of view : 3.8 x 11.4° (FWHM] angular resolution : energy resolution : 46 keV (9%)



main results : first sky maps Bulge, disk & "fountain" no variability

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#### WIND/TGRS : 1994-1996

Single Germanium detector  $35 \text{ cm}^2$ Monitored ecliptic plane continuously Modulated field of view  $90^\circ \times 6^\circ$  (FWHM)





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Some terminology

One of the surprises was that the 'bulge' emission from around the centre of the galaxy is surprisingly strong



simple model fit to Integral/SPI data

What do the data tell us of the form of the disk emission ?

- Surrogates for the distribution of the 1809 keV <sup>26</sup>Al emission do not fit the SPI data
- Thin disks modelling young star distributions do not fit either the SPI data or the combined OSSE/SMM/TGRS data
- The best fit found so far, for both SPI and for OSSE/SMM/TGRS is a thickened disk e.g. Robin disk with R<sub>+</sub> = 5 kpc, R<sub>-</sub> = 2.5 kpc, aspect ratio ε=0.3

$$\exp\left[-\frac{1}{R_{+}^{2}}\left(x^{2}+y^{2}+\frac{z^{2}}{\epsilon^{2}}\right)\right] - \exp\left[-\frac{1}{R_{-}^{2}}\left(x^{2}+y^{2}+\frac{z^{2}}{\epsilon^{2}}\right)\right]$$
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$$-50^{\circ} \qquad 0^{\circ} \qquad +50^{\circ}$$

#### Is there emission from a halo far from the disk?

Effect of adding a spheroid to SPI bulge + disk model



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#### • Is the emission symmetric about the galactic centre ?

#### Background

Weidenspointner et al (Nature, 2008) reported an asymmetry in the 511 keV emission from the galactic disk

Other analyses (Churazov et al. MNRAS 2011) did not see the effect or reported a possible offset in the central bulge (Bouchet et al., ApJ 2010)







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#### Alternative descriptions of the asymmetry

Offset of the outer bulge component by about 1.4° towards negative galactic longitude

Asymmetry of the disk component as modeled by Weidenspointner et al sharp change in level at longtitude 0 is needed

Addition of a further emission component best fit would be a source extended by about  $2^{\circ}$  at  $-2^{\circ}$ luminosity of about  $3 \times 10^{42}$  e<sup>+</sup> s<sup>-1</sup> not a point source







### The luminosities of the different components

1) Cross-checking luminosity estimates

SPI and OSSE/SMM/TGRS estimates of fluxes from the model components are typically with 10-15% of each other

## The luminosities of the different components

2) Results

Inner bulge 
$$0.9$$
  
Outer bulge  $5.1$  ×  $10^{42}$  e<sup>+</sup> s<sup>-1</sup>  
Disk  $8.0$ 

Inner bulge
$$0.9$$
Outer bulge $4.2$ Disk $5.9$ Halo14

#### SUMMARY

Combining SPI data with data from the archives of other instruments confirms results from SPI and constrains the range of possible models for the 511 keV emission.

An extended halo seems to be required and contains a large fraction of the flux.

Although some possibilities for the form of the disk emission can be eliminated, multiple possibilities remain.

There is an asymmetry in the 511 keV emission from the general region of the centre of the galaxy. The form of the asymmetry remains unclear - it could be an inner disk asymmetry, an offset of the outer bulge, or an additional somewhat extended component.

