A Local Contribution to the Galactic 511 keV Annihilation Radiation?

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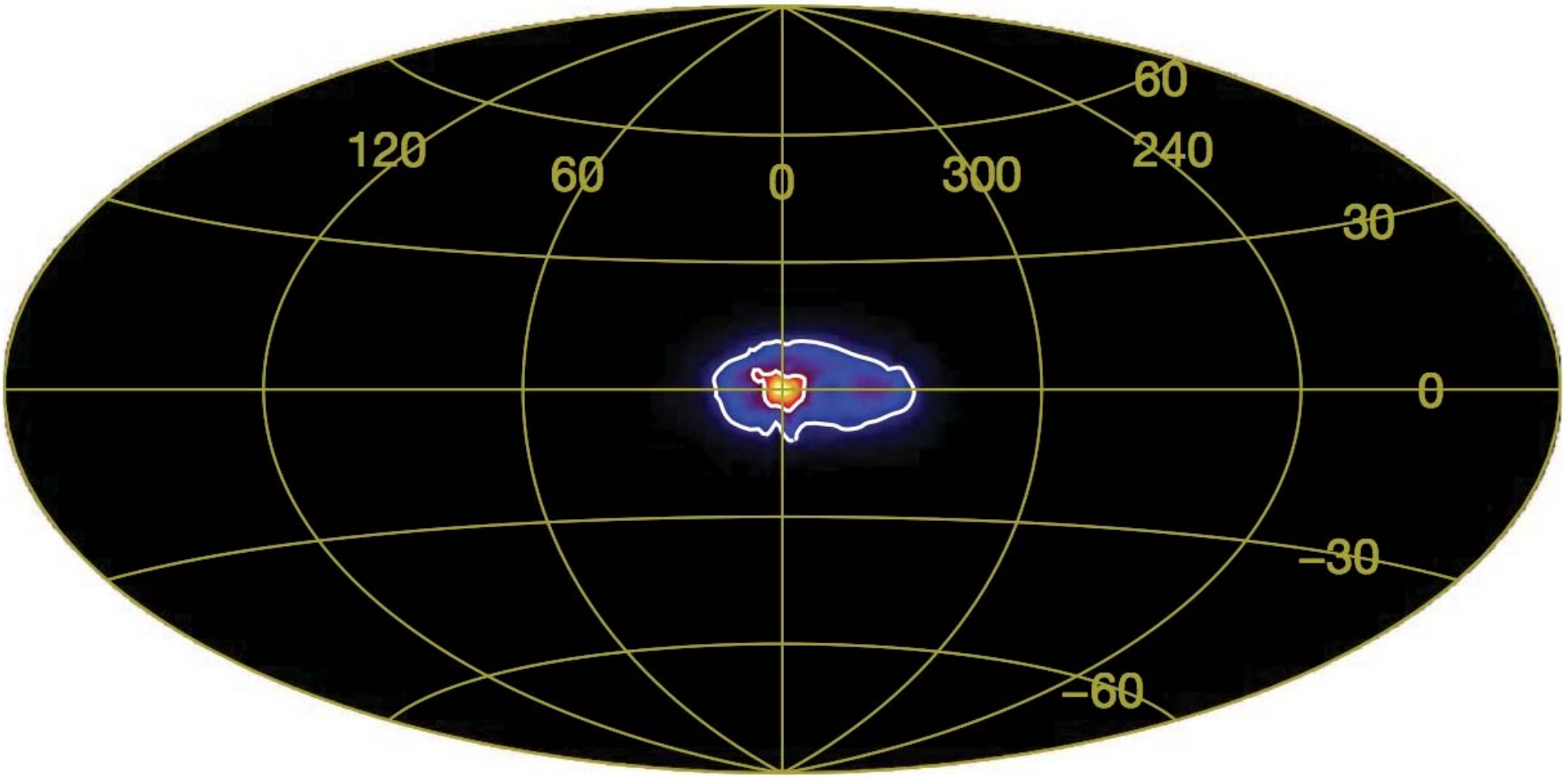


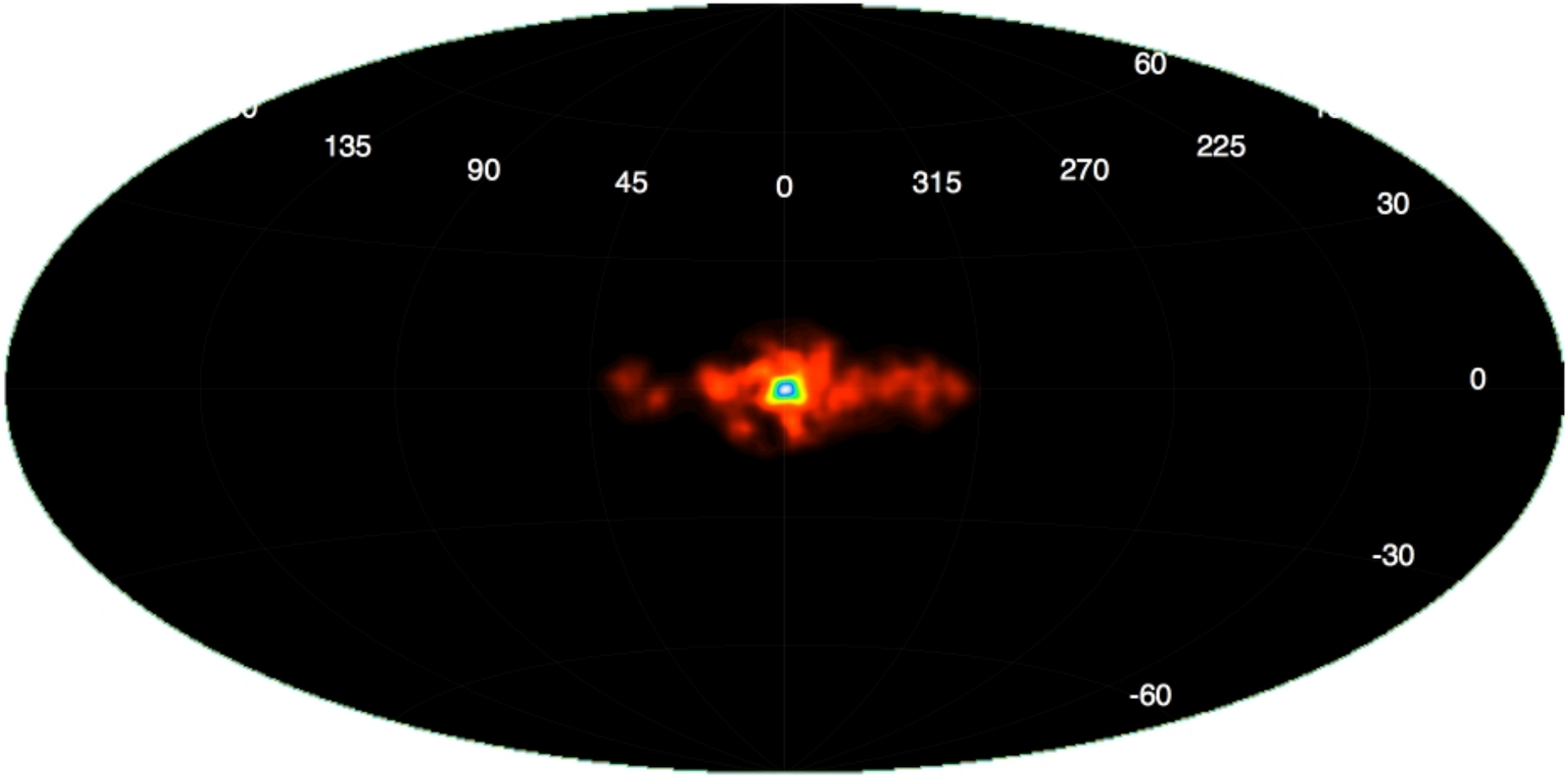
Weidenspointner et al. (2008)

Rationale

- **Is the current galactic annihilation map and its 3 components (inner bulge, outer bulge, disk – Weidenspointner et al. 2008 and other teams) a robust paradigm?**

  Any different mapping?

  Any local contribution?


60
135
225
90
45
0
315
270
30
0
-30
-60

Any local contribution?

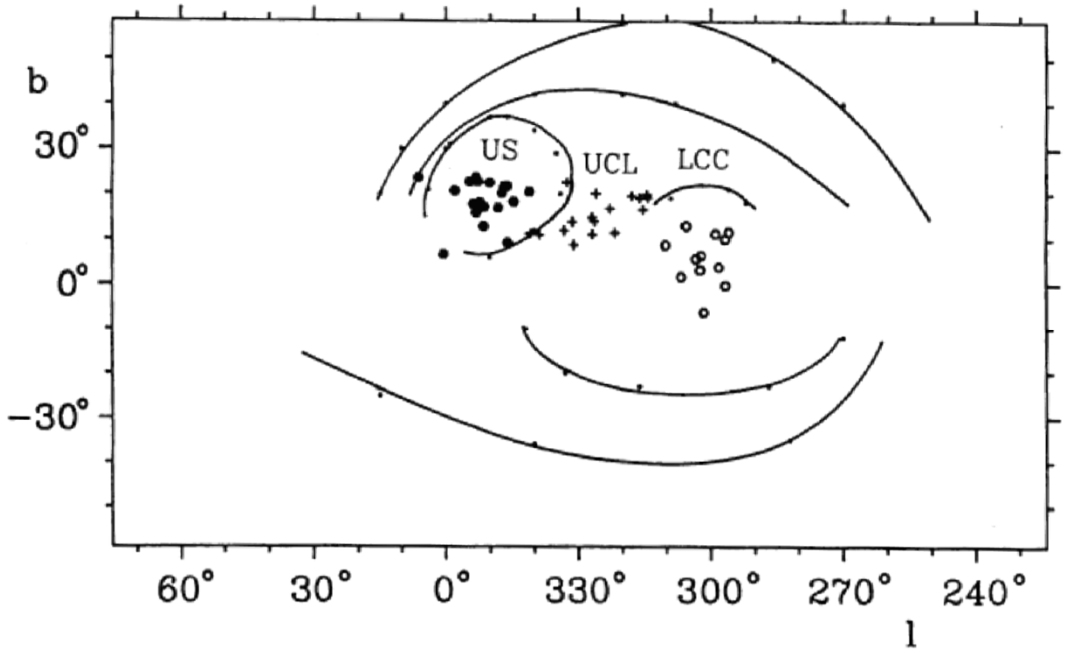
- **If the Sco-Cen association presents non-negligible ^{26}Al (Martin et al. 2009, Diehl et al. 2010), does it contribute noticeably to positron annihilation observations and the map?**

The Sco-Cen Complex

of massive stars nearby (~ 130 pc)

and young (5-15 Myr)

+ possible recent (~ 1Myr) SN



de Geus (1992)

Two approaches in this work

1. **Does the Sco-Cen group contribute much?** Attempt to estimate and model.

2. **Redo the annihilation data analysis**, keeping assumptions as loose as possible **and look for "local" effects,** particularly around the Sco-Cen region.

Sco-Cen and its possible contributions

1. **Simple Modelization of Sco-Cen:** 3 spheres at the following locations (Ohlendorf 2009) but with varying sizes and contributions:

	Centroid Location
US (Upper Sco)	**-16 deg, 21 deg**
UCL (Upper Cen-Lup)	**-37 deg, 17 deg**
LCC (Lower Cen-Lup)	**-60 deg, 4 deg**

• We leave aside, in the first trial, the fact that the 3 sub-groups have different ages (US about 5-6 Myr, UCL and LCC both about 10-12 Myr), and numbers of stars (US about 4 times less than UCL and LCC).

Sco-Cen and its possible contributions

2. How many positrons?

- Observation of the ^{26}Al line from Sco-Cen implies a recent (Myr old) SN or massive-star production, i.e. ^{26}Al and possibly ^{56}Ni and ^{44}Ti.
- Additional assumptions (escape of ^{56}Ni and positrons) are required in estimating the rates of positrons coming out of the region and annihilating in denser regions (possibly the Ophiuchus GMC).
- Rates ranging from 10^{37} to ~ 3 x 10^{39} e^{+}/s can be inferred.
- But this is not important here, as we have not yet physically modeled the region…

Sco-Cen and its possible contributions

3. **Effect on the map data analysis** (orbits up to 958, energy band 508.5 to 513.5 keV, standard background noise model):
   a) Adding Sco-Cen to an inner bulge and a disk (no outer bulge), one finds a bad MLR (~2420-2460 instead of 2692), even when varying the sizes of the Sco-Cen spheres or keeping their relative contributions as free parameters → **cannot replace the outer bulge.**

Sco-Cen and its possible contributions

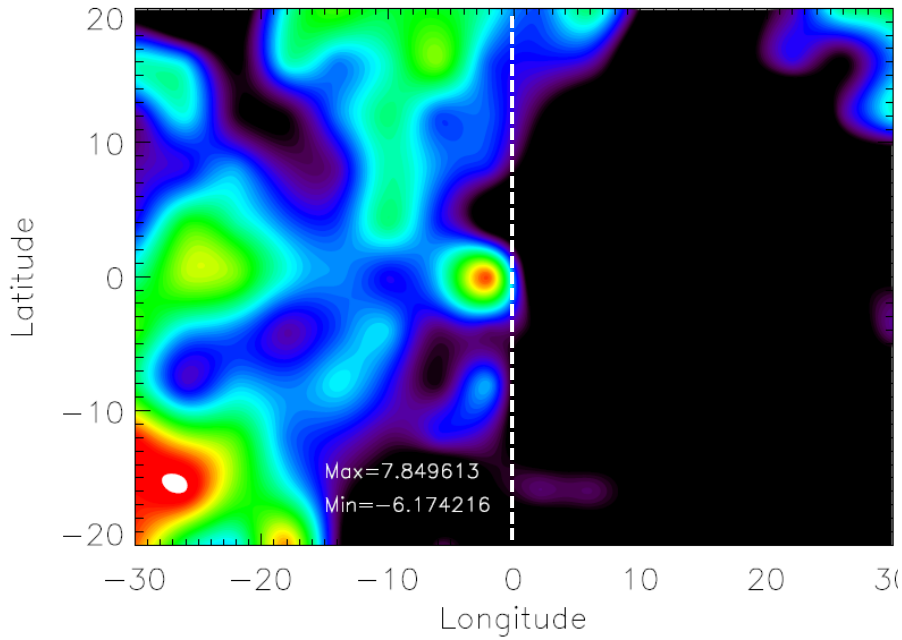
b) **Adding Sco-Cen to the three "standard" components** (inner bulge, outer bulge, and a disk), one finds a slight improvement in the MLR: 2698 instead of 2692, totally insignificant for 4 dof, with very unusual relative normalizations of the subgroups.

Conclusion: the SPI data is not precise and fine-grained enough to see any such possible contribution (by Sco-Cen).

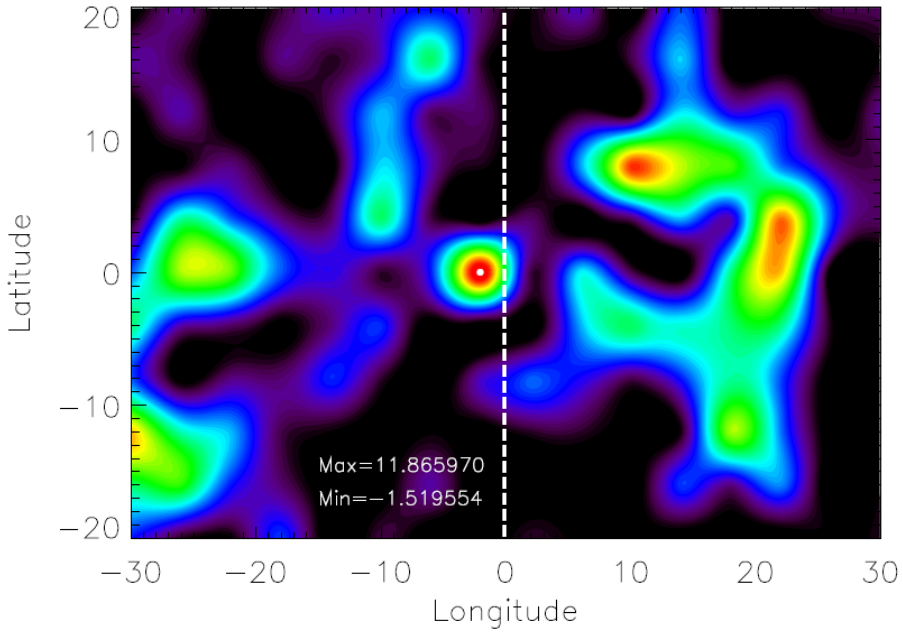
Open Analysis (not tied to Sco-Cen)

- **Method:** Perform a scan, using for probe a sphere/spot (of size 4, 8, or 12 deg in diameter) to the "standard model", i.e. explore the morphology of the deficit/excess between data and the standard model:

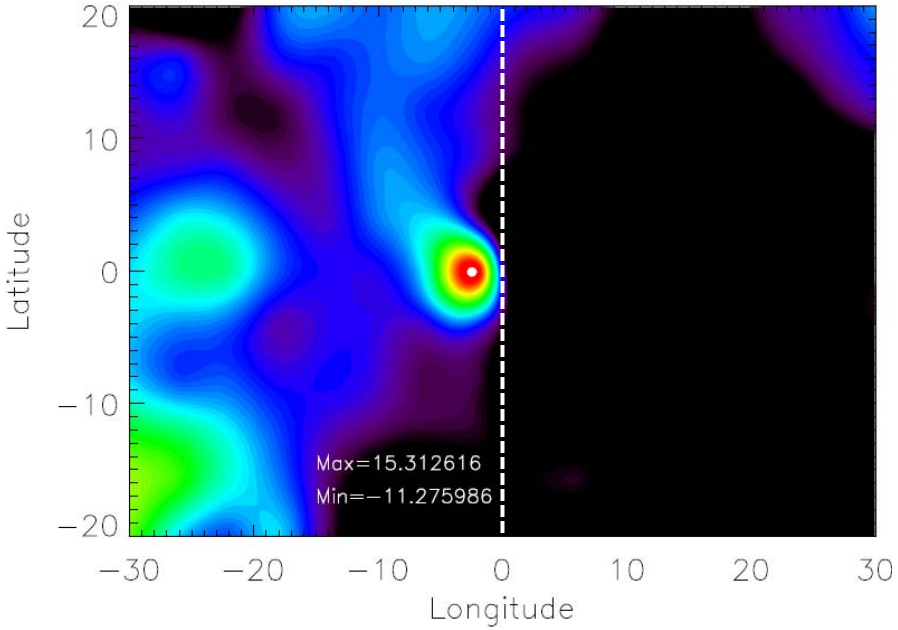
- **Results:**
  - Overall, an improvement of 12-13 in MLR (for 3 dof), i.e. about 3 sigmas.
  - See maps of Flux and MLR…



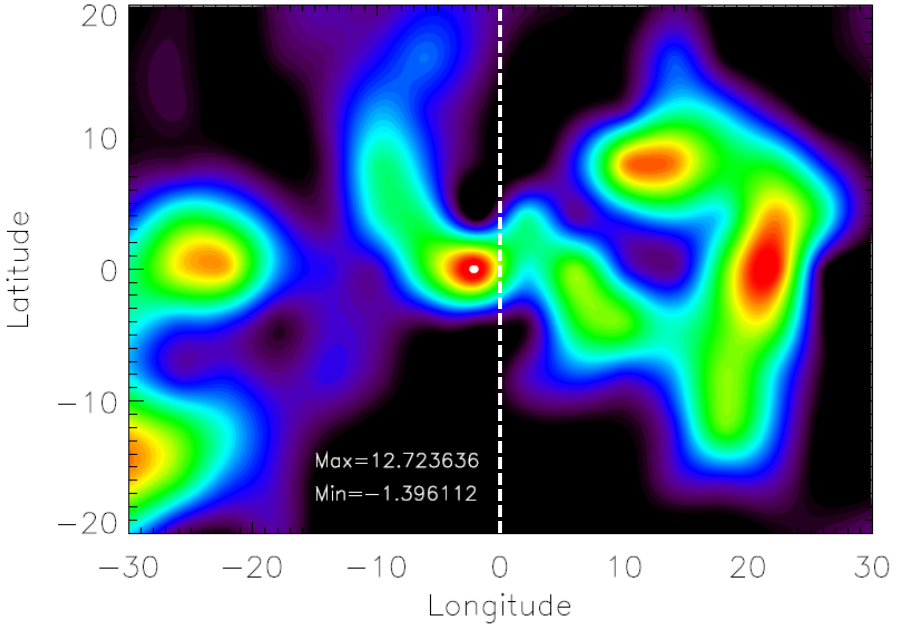
FLUX map, scanned with spot of 4 deg



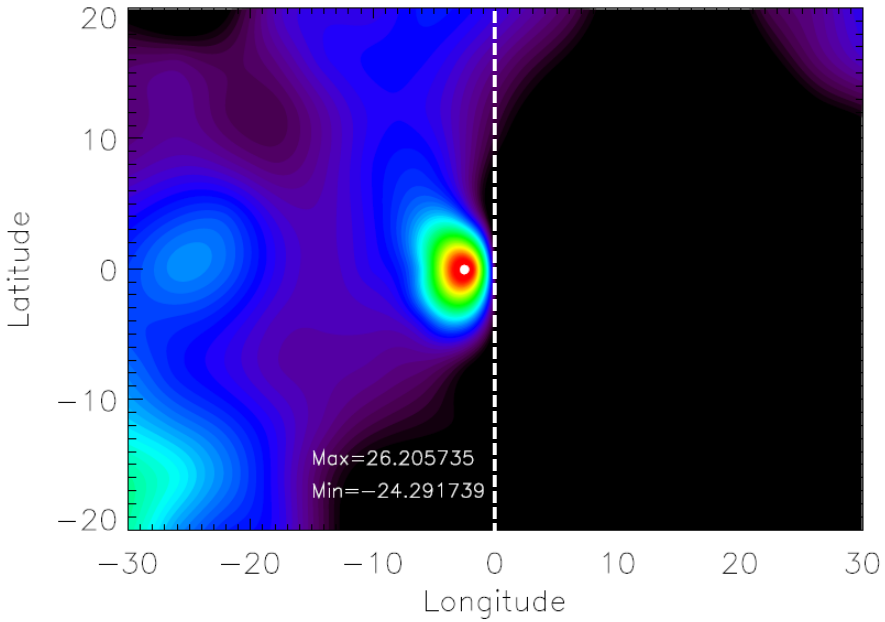
MLR map, for spot of 4 deg



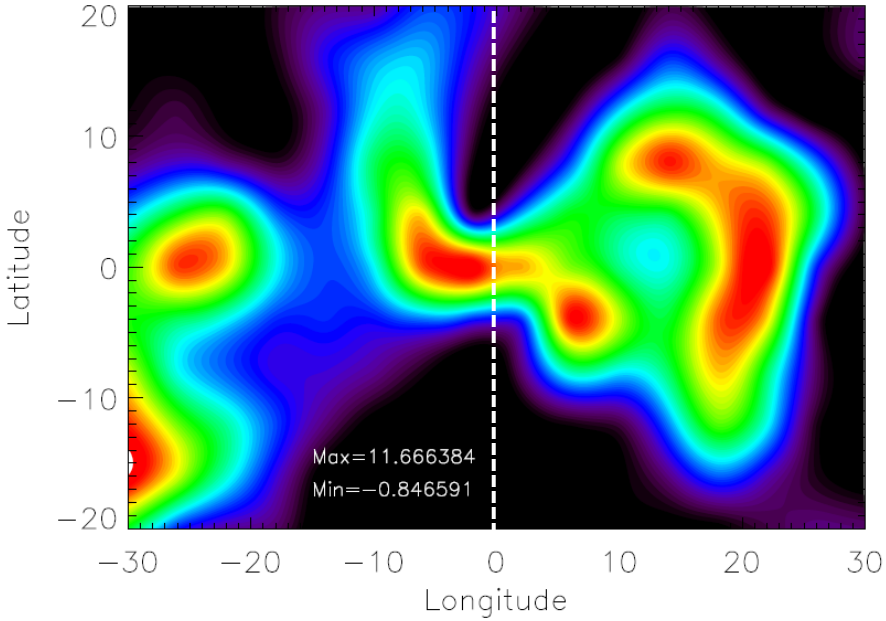
FLUX map, scanned with spot of 8 deg



MLR map, for spot of 8 deg



FLUX map, scanned with spot of 12 deg



MLR map, for spot of 12 deg

- **The Pos-Neg Longitude Effect:**
  - Positive Longitudes = flux deficit
  - Negative Longitudes = flux excess
  - ❖ Both relatively confirmed by MLR.

➔Asymmetric disk and/or slightly ex-centric outer bulge

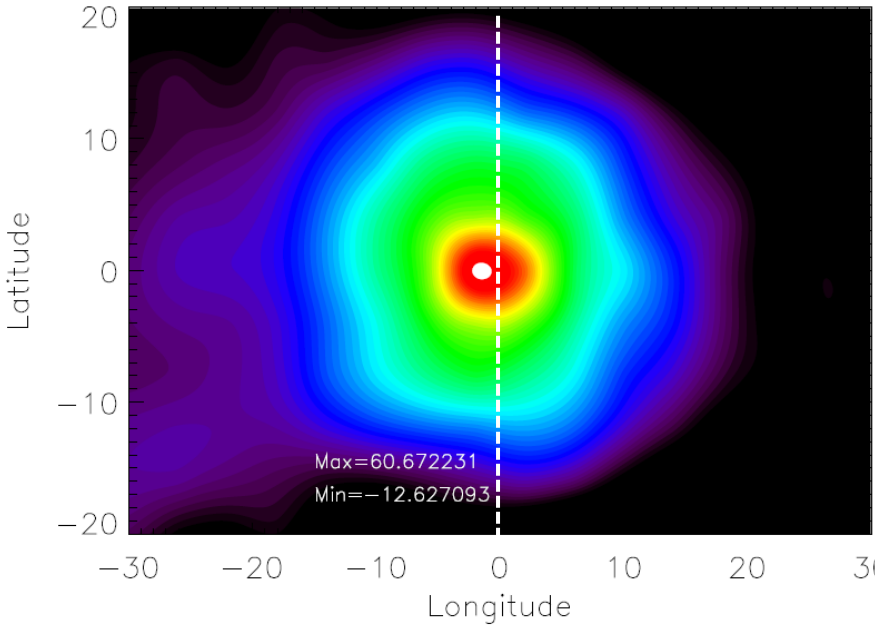
- **There <u>seems to be an excess</u> at:**

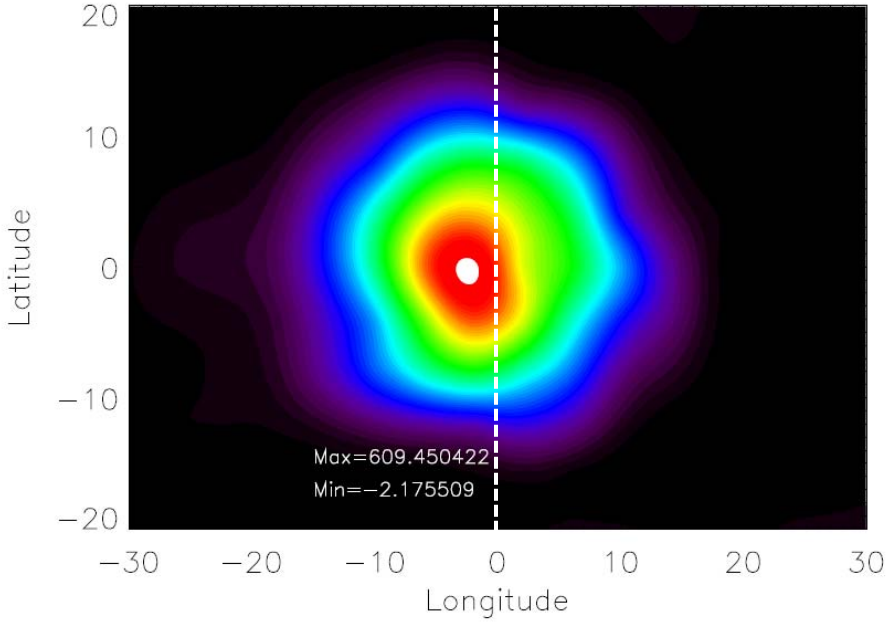
(l, b) = (-2 deg, 0 deg)

and possibly at

(l, b) = (-25 deg, 0 deg)

Now we use only the inner bulge and add a free 8-deg sphere:





FLUX map, scanned with spot of 8 deg

MLR map, for spot of 8 deg

- **We find that:**
  - **The data seem to imply the existence of an additional component, which is shifted by 1-2 degrees toward the negative longitudes, but of a symmetric shape** (similar to Bouchet et al. 2010 and Skinner et al. 2010).
  - **There seems to be some additional effect between -15 and -25 deg,** with a thickness of a few degrees, but this does not quite seem to resemble Sco-Cen.
  - Perhaps an irradiation of nearby ("local") molecular clouds by Sco-Cen's positrons?...

Summary and Conclusion

- **A simple modeling of Sco-Cen**, either replacing the outer bulge or even added to it, **is not supported by the SPI data**, which is not rich and detailed enough to allow for such specific probe.
- A loose "model-free" analysis of the data shows that aside from the central spot, **there seems to be a shifted but symmetric bulge and apparently some excess at l ~ -20 deg.**
- Additional modeling and interpretation is needed.