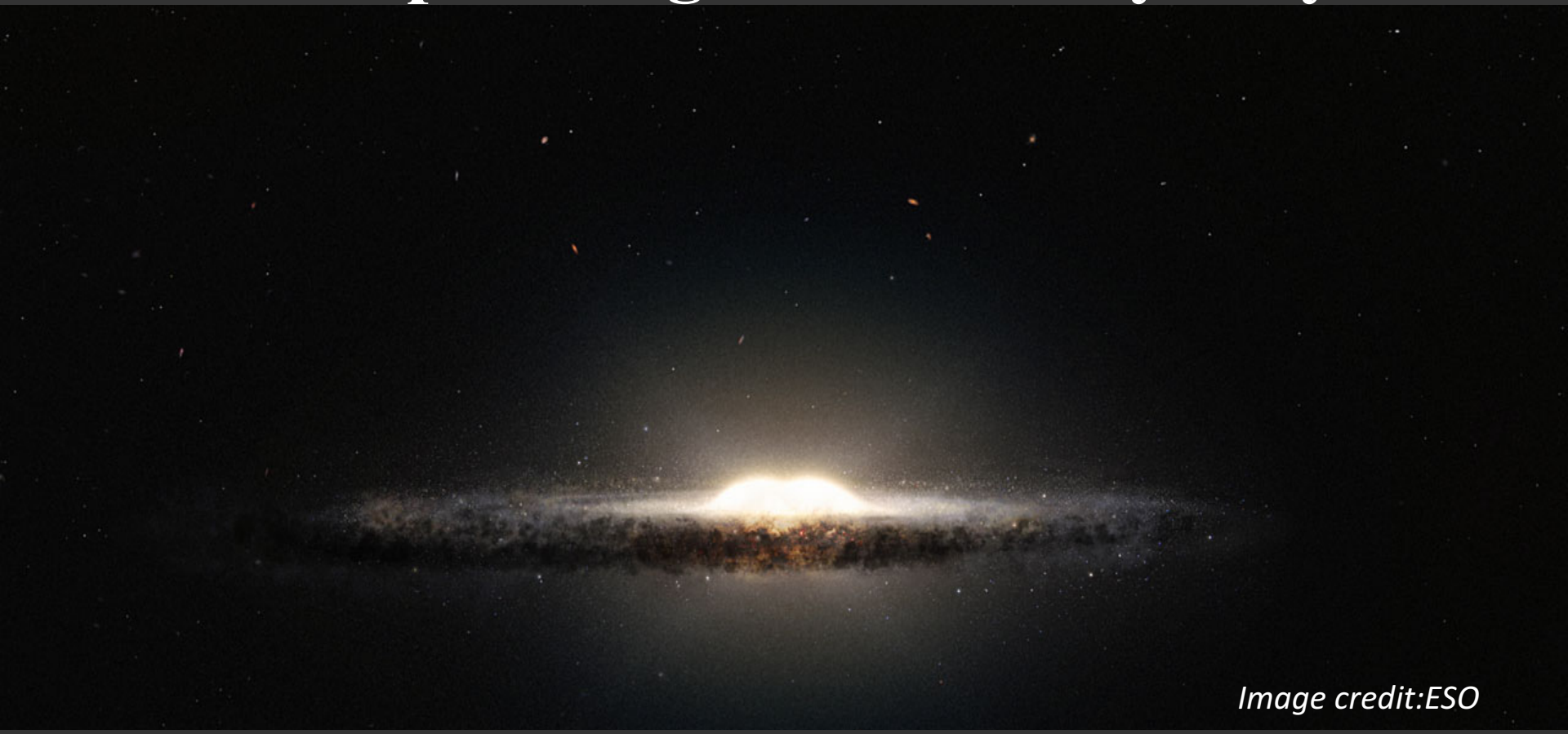
Evidence of Gamma-Ray Emission from the X-Shaped Bulge of the Milky Way

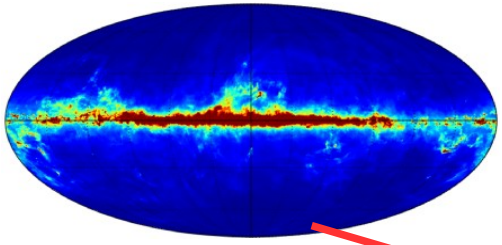


Chris Gordon

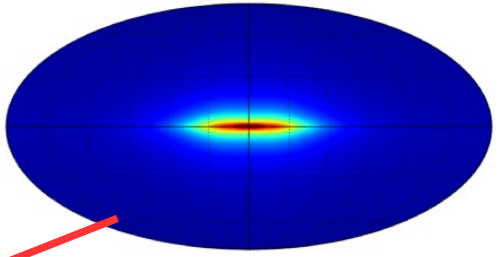
Based on arXiv:1611.06644, Macias, et al.

The Base Model

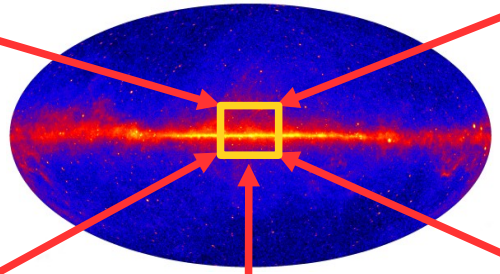
Interstellar gas maps
(Hydrodynamical and Interpolated)



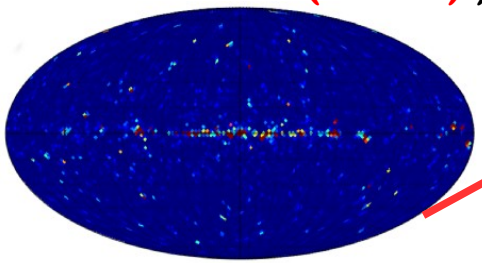
Inverse Compoton
(Predicted by GALPROP)



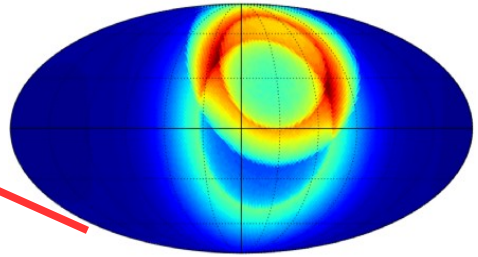
~7 years of Pass8 data
(UltraCleanVeto class)

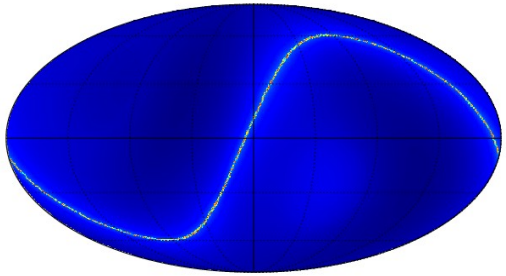


3FGL sources
(Acero et al. (2015))



LoopI template
(Wolleben (2007))

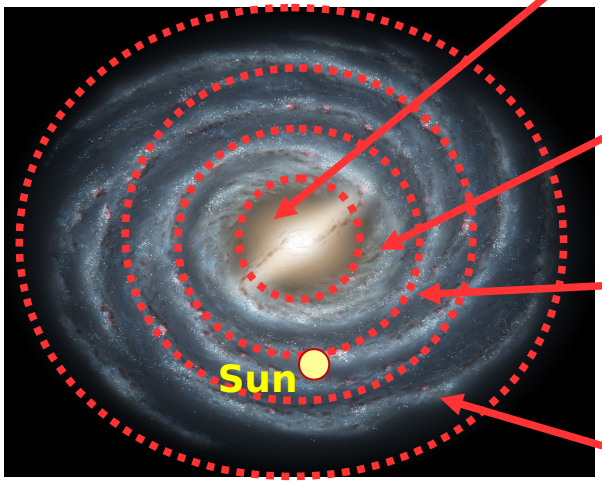




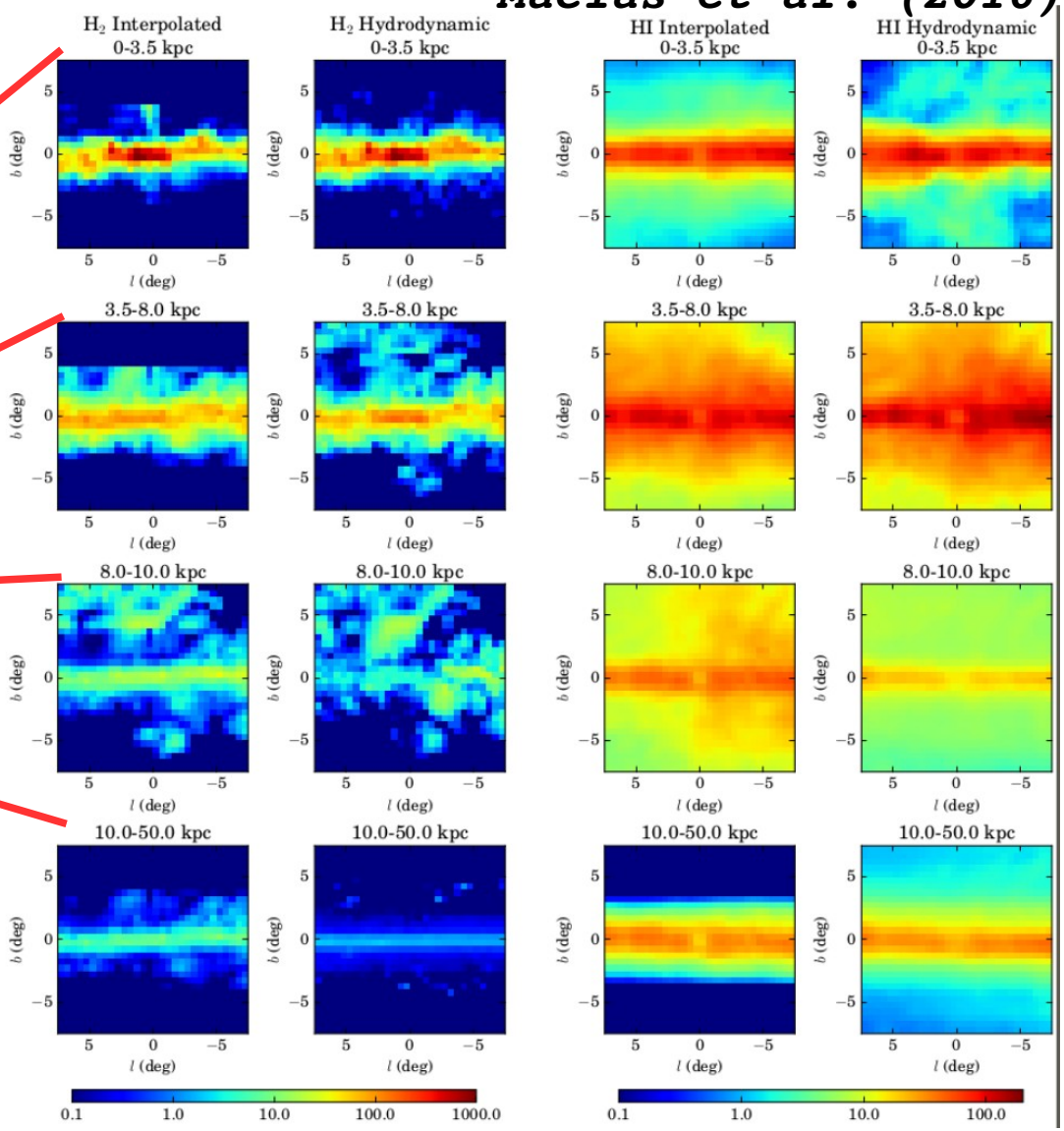
Sun & Moon templates
(Generated with the *gtsuntemp* tool – *FermiTools*)

Interpolated vs Hydrodynamical method

Used Pohl et al. (2008)
3D hydrodynamic model.

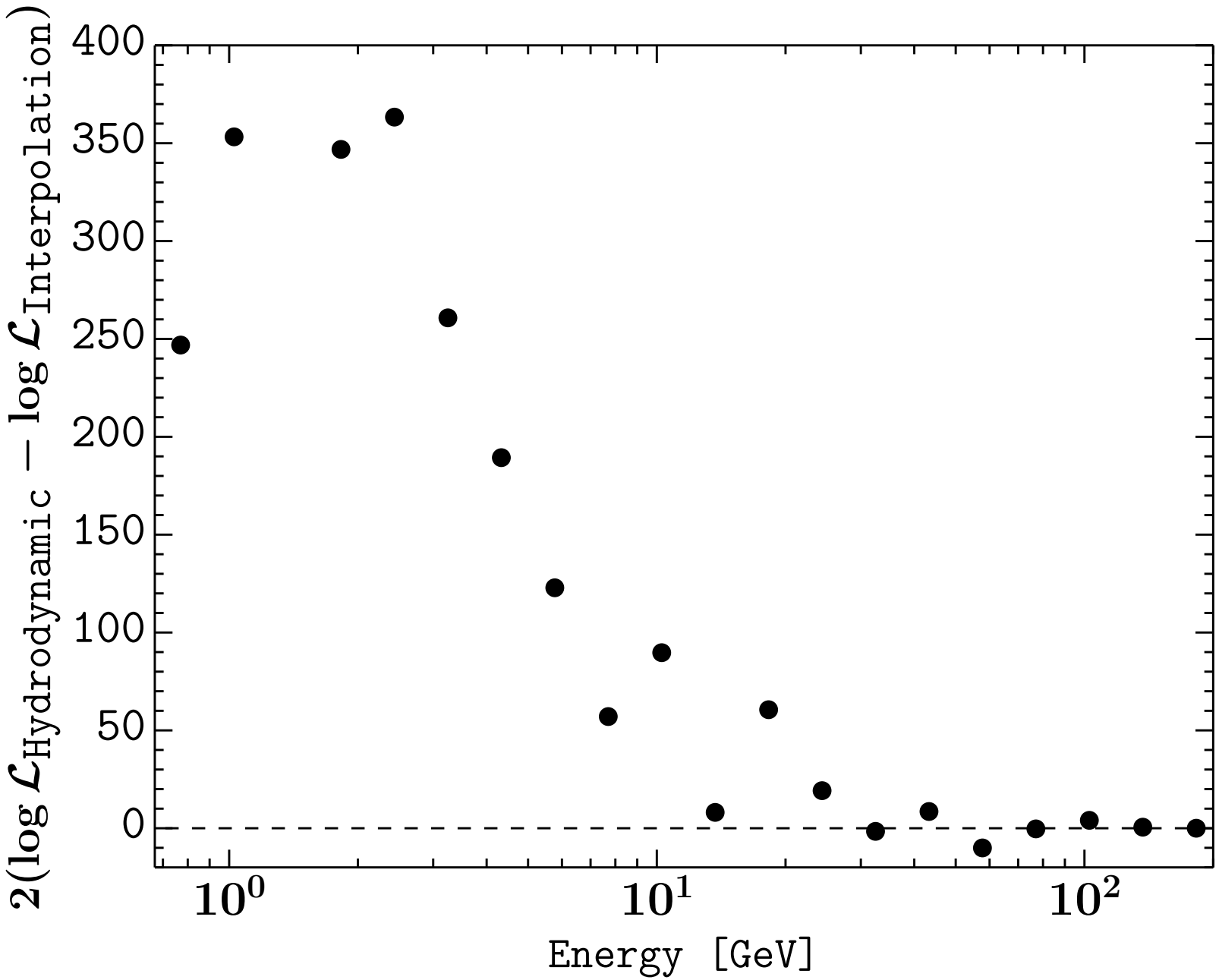


Macias et al. (2016)

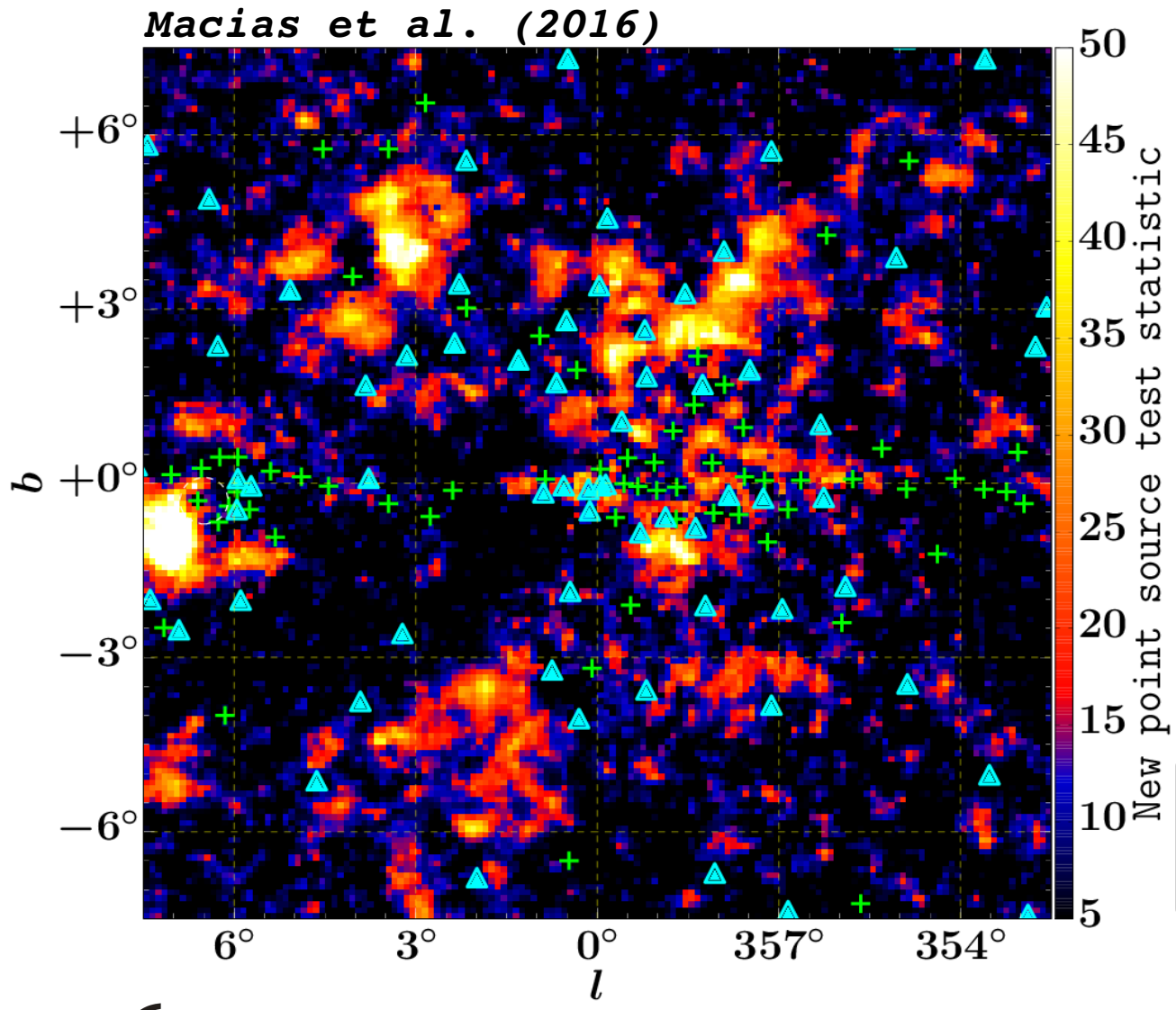


There are noticeable morphological differences between the two methods.

Interpolated vs Hydrodynamical method



New point source candidates in the ROI



3FGL

New point source candidates

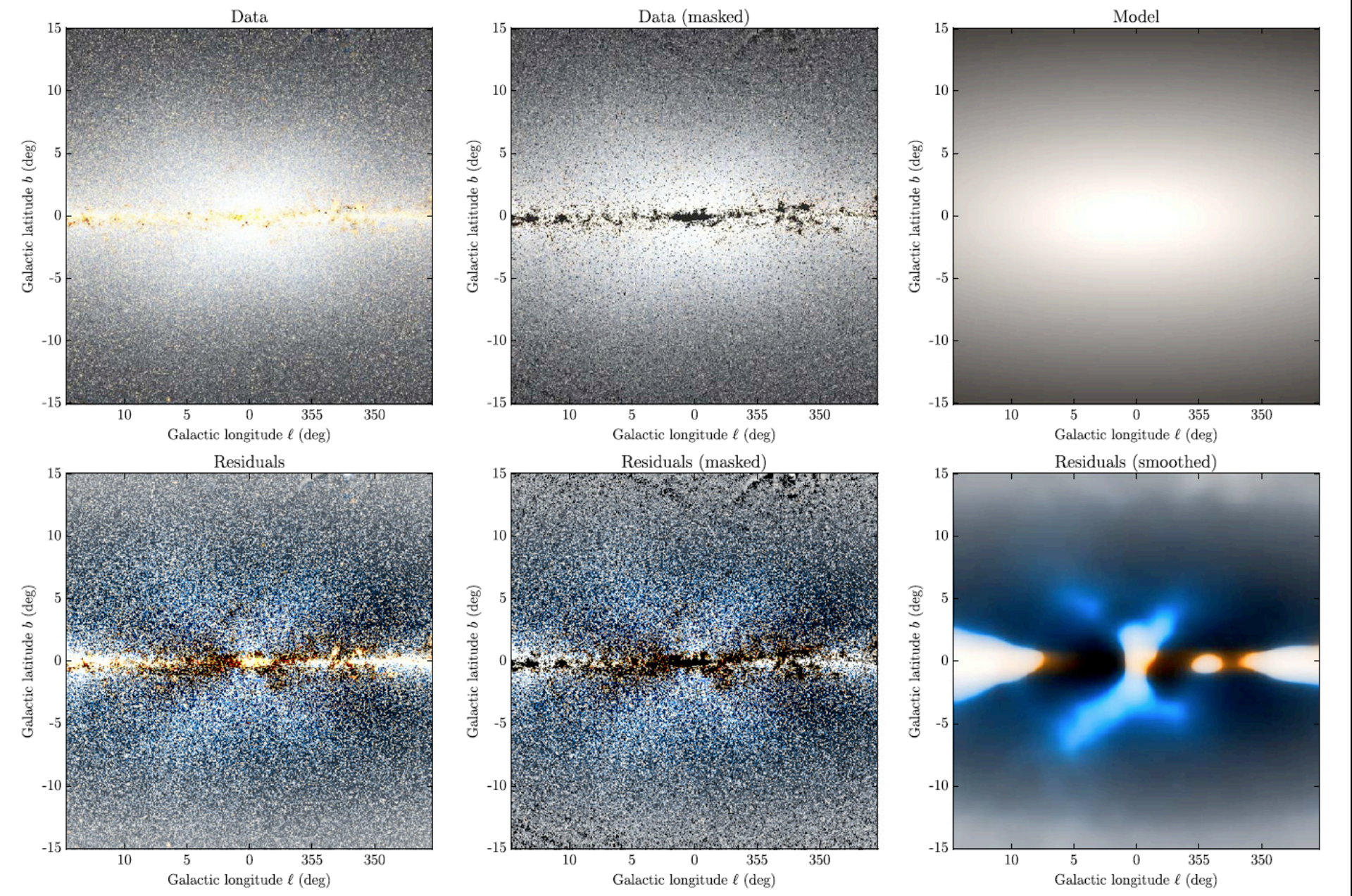
$$TS = 2\,[\log(\mathcal{L}_{new+old}) - \log(\mathcal{L}_{old})]$$

Detection threshold:

TS > 41.8

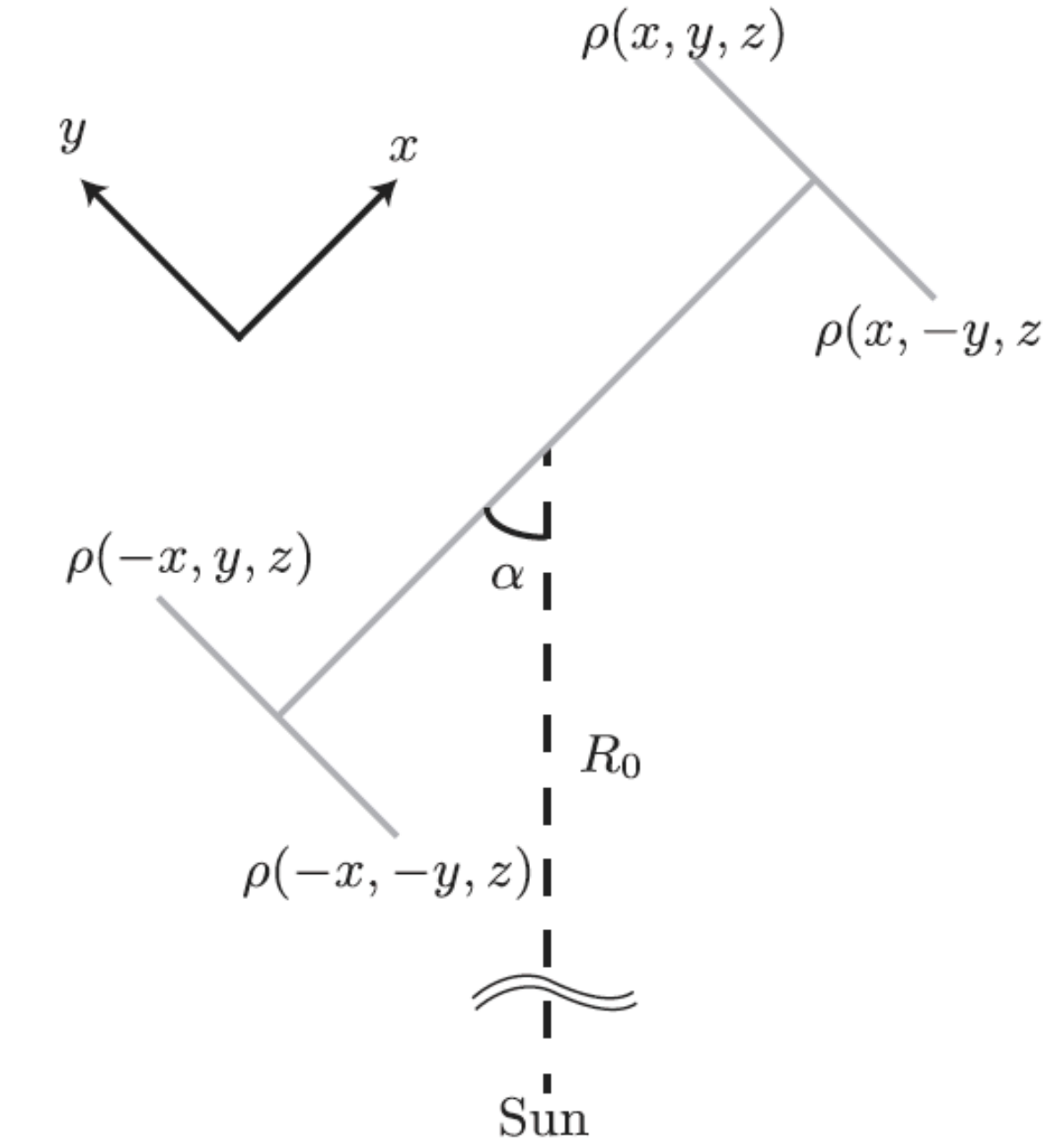
(for 19 d.o.f.)

Found 64 gamma-ray point source candidates in the inner 15x15 deg RoI of the Galactic Center

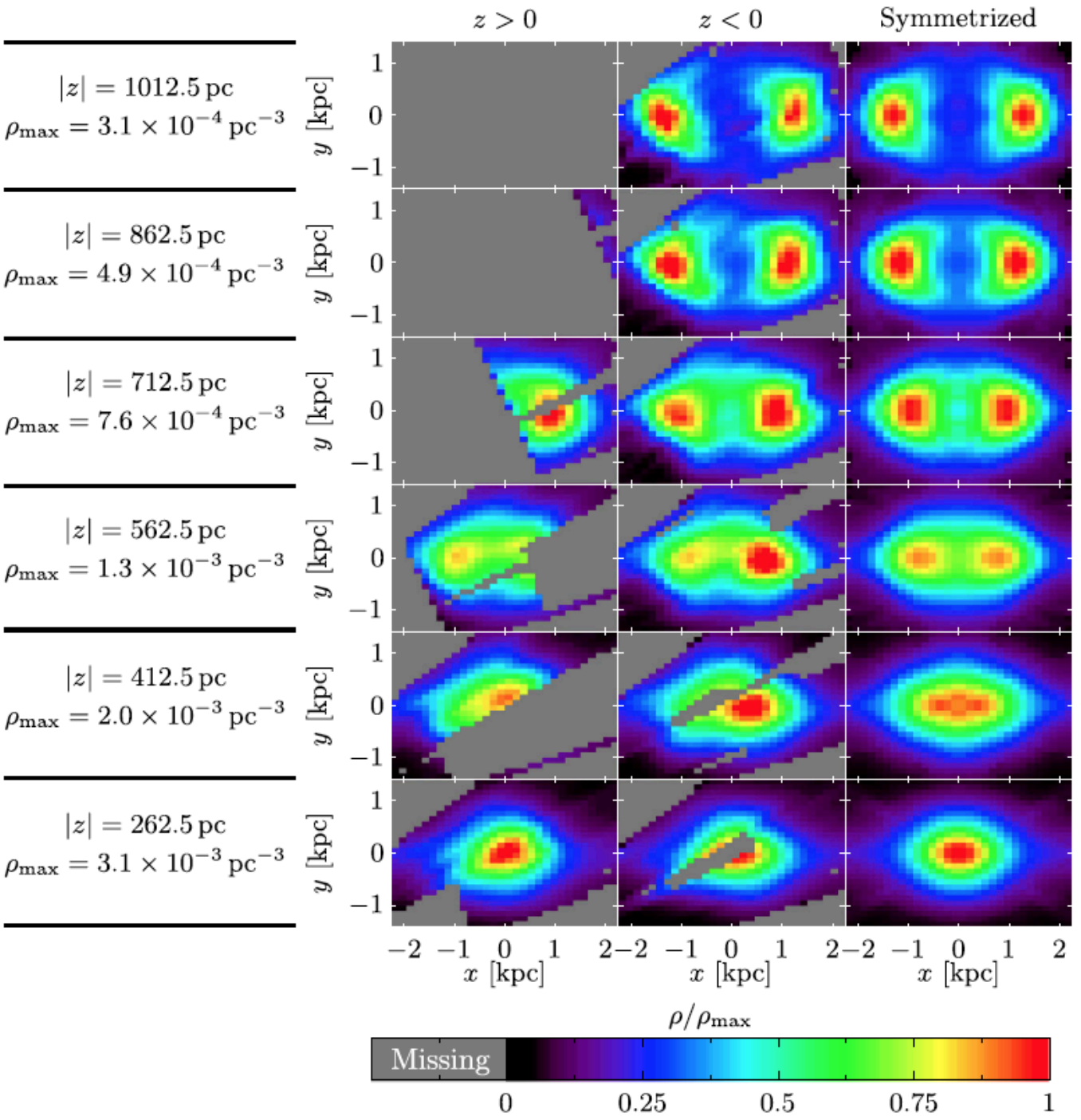


X-bulge seen in WISE infrared data by Ness and Lang (2016).

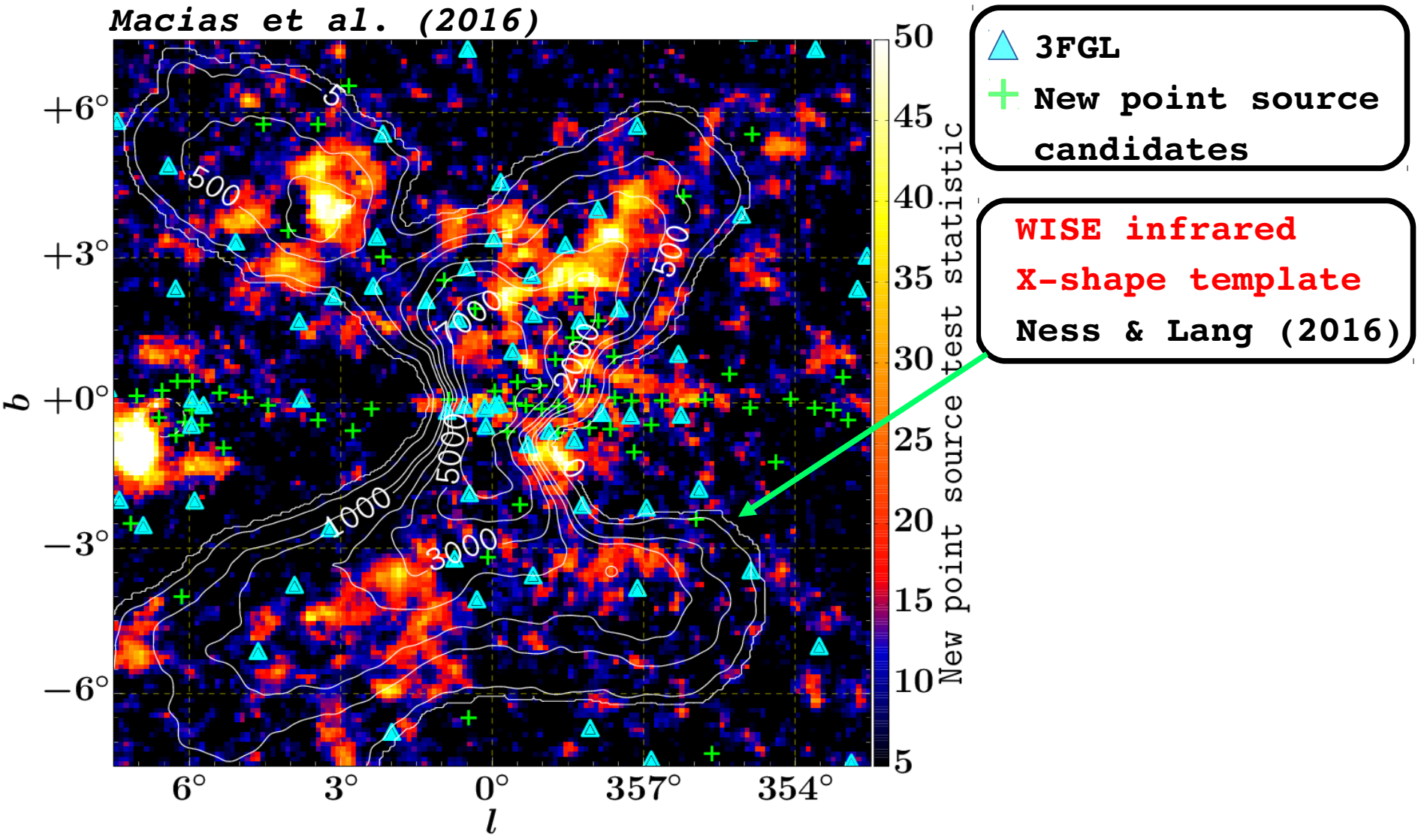
Wegg & Gerhard (2013) measured the three-dimensional density of red clump stars in the bulge, earlier revealed to show two peaks along theline of sight (McWilliam & Zoccali 2010 ; Nataf et al. 2010).



- Credit: Wegg & Gerhard (2013) .

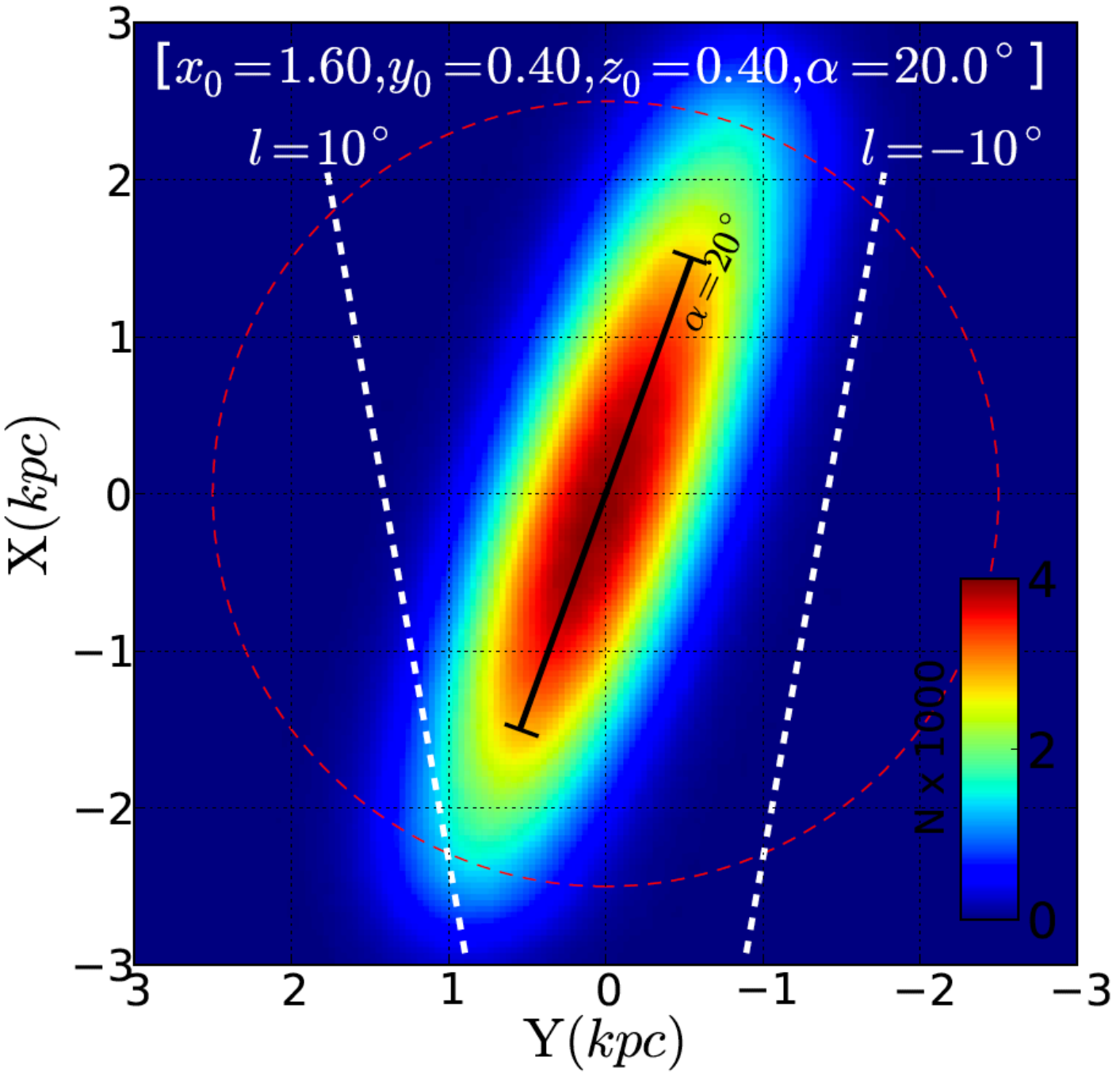


Residual extended gamma-rays

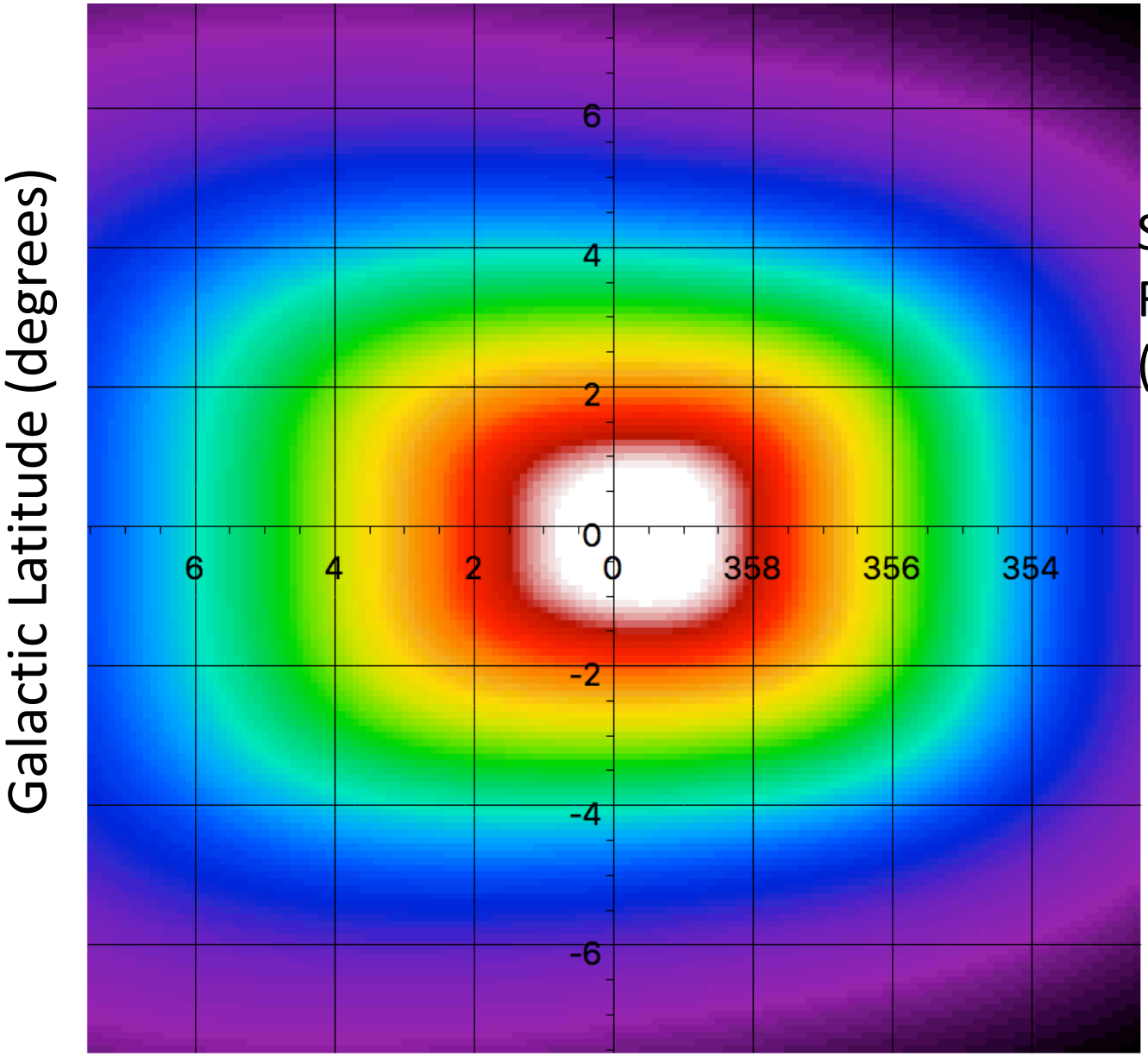


There is residual extended emission which looks very similar to the X-shaped infrared bulge.

- Image Credit: Simion et al. (2017).
- Bar angle implies asymmetry in line of sight integrated image.

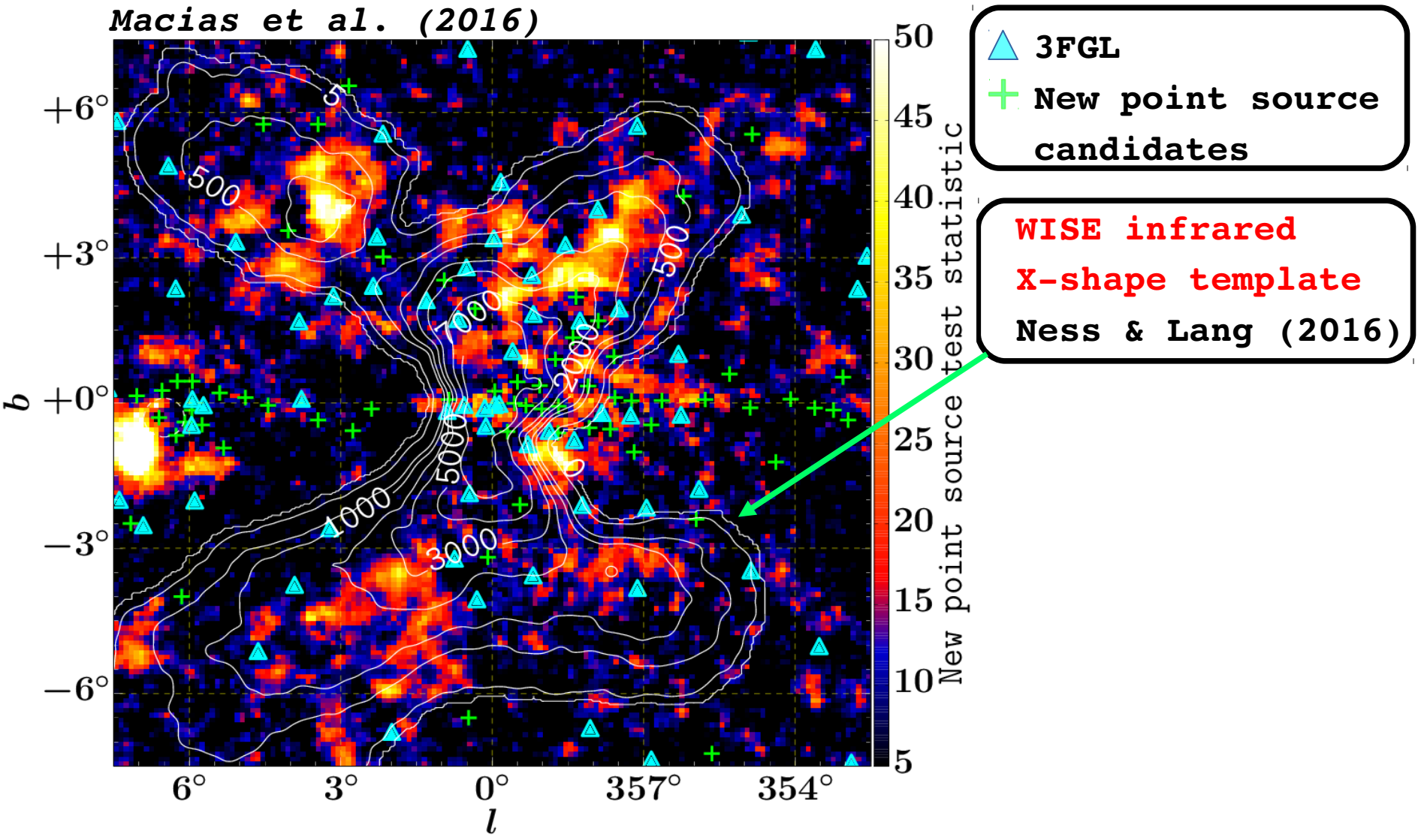


Boxy bulge model fit for COBE DIRBE infrared data



See Freudenreich (1998)

Residual extended gamma-rays



There is residual extended emission which looks very similar to the X-shaped infrared bulge.

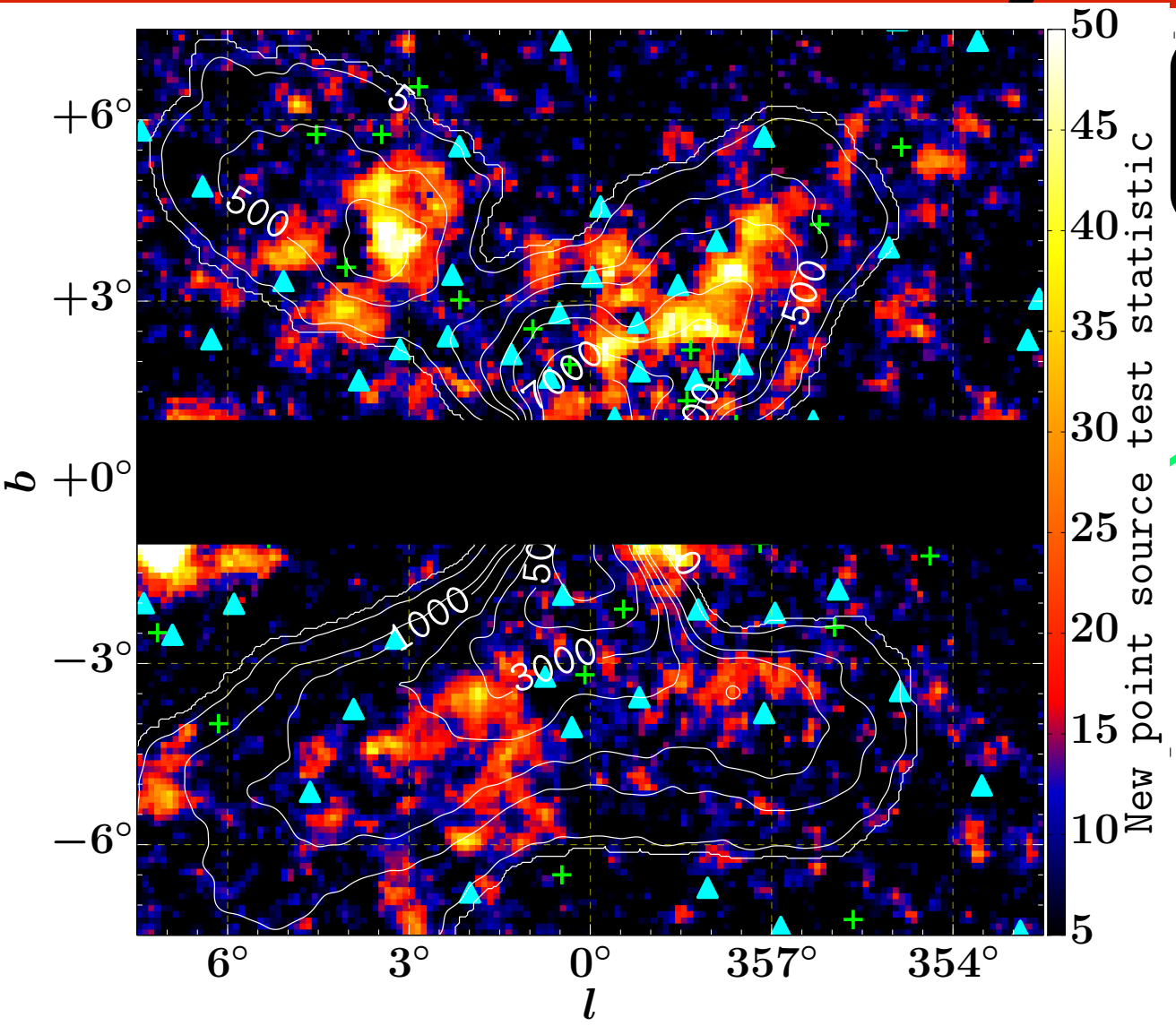
Spectrum

The X-bulge is well fit by an exponential cutoff spectrum:

$$\frac{dN}{dE} \propto E^{-\Gamma} \exp(-E/E_{\rm cut})$$

where $\Gamma = 2 \pm 0.2$ and $E_{\rm cut} = 13 \pm 5$ which is consistent with resolved MSPs.

Residual extended gamma-rays



3FGL

New point source candidates

WISE infrared X-shape template Ness & Lang (2016)

There is residual extended emission which looks very similar to the X-shaped infrared bulge.

Statistical Significance

Base	Source	TS_{Source}	σ	Number of source parameters
baseline	NFW	134	9.8	19
baseline	X-bulge	200	12.5	19
baseline	NP	631	12.9	22×19
baseline+NP	NFW	98	8.0	19
baseline+NP	Boxy-bulge	280	15.2	19
baseline+NP	X-bulge	322	16.5	19
baseline+NP+X-bulge	NFW	19	2	19

- $|b| \geqq 1^o$.
- NP = new point source.
- Baseline=interstellar gas maps, IC, 3FGL, sun/moon, and loop1.

Conclusions

- Analyzed Fermi-LAT Galactic center excess emission taking into account degeneracy with point sources and systematics in diffuse Galactic background.
- Interstellar gas maps constructed with the help of hydrodynamical simulations are a better description of the data than the ones constructed with the interpolation approach used in most previous works.
- WISE based X-bulge template better fit to the excess than a boxy bulge or NFW[2].
- May be further evidence that Galactic Center Excess is associated with stellar activity such as an unresolved population of MSPs.