dark disks and *Fermi*:

the good, the bad, and the ugly...

Greg Dobler *(KITP, UCSB)*

May 11th, 2011 - Fermi symposium

dark halo shapes

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Greg Dobler *(KITP, UCSB)*

Ilias Cholis *(SISSA)*

Neal Weiner *(NYU, IAS)*

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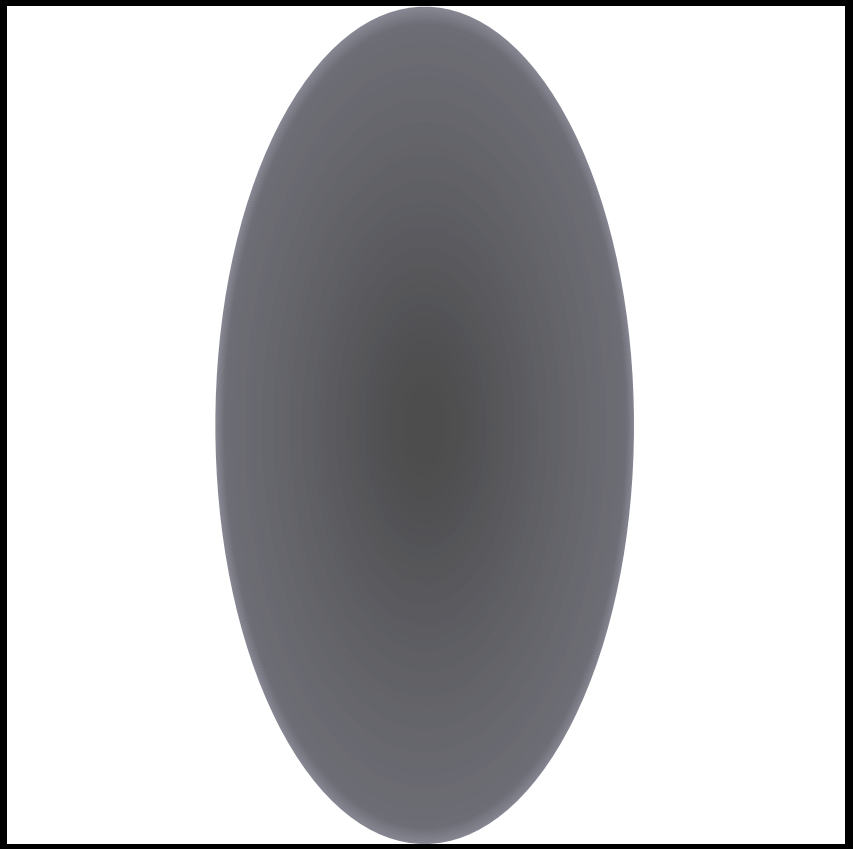
dark disk morphology



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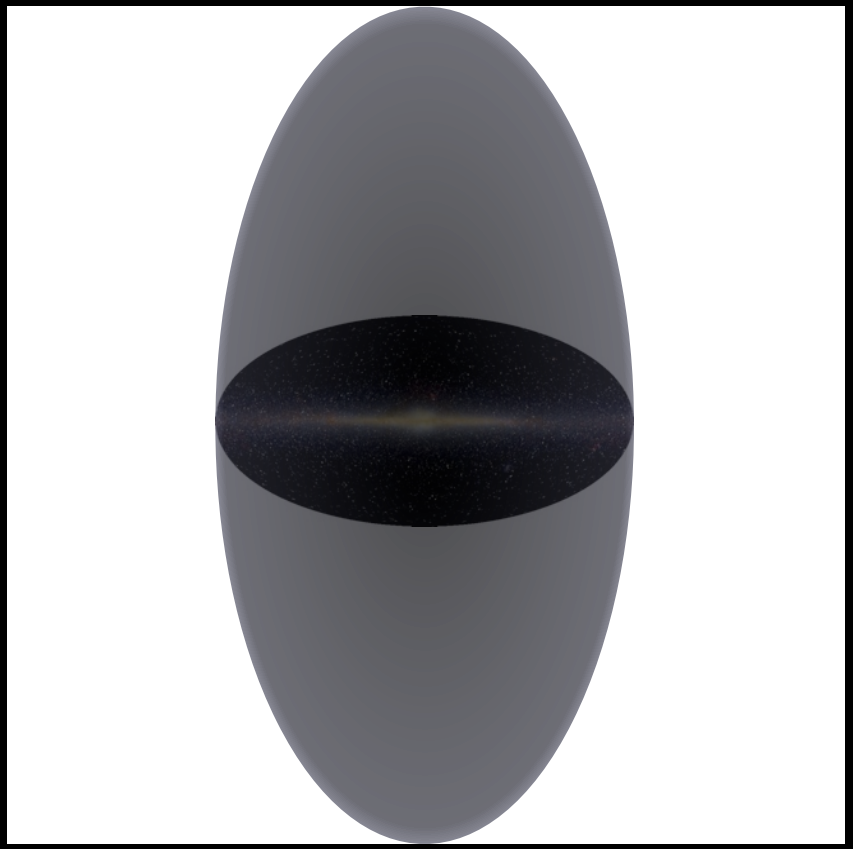

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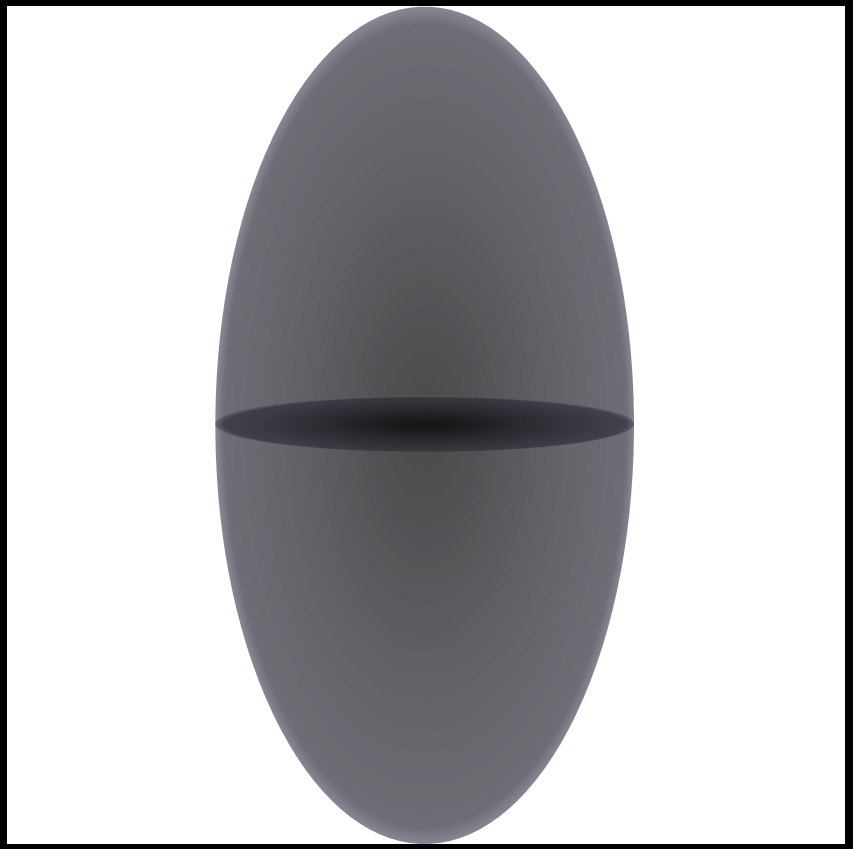

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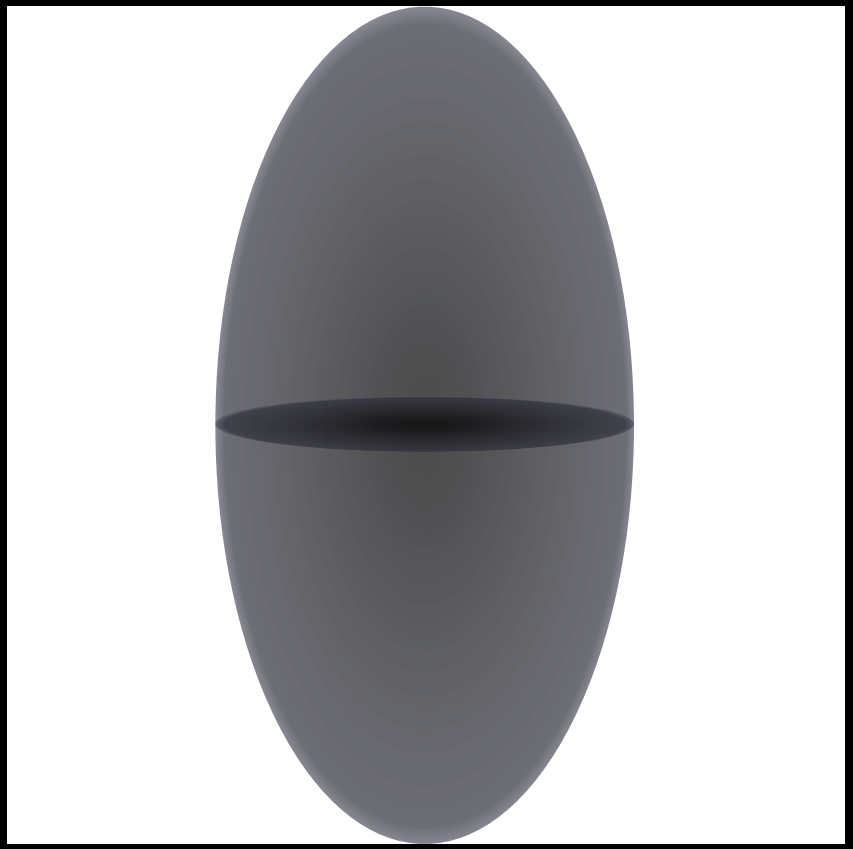


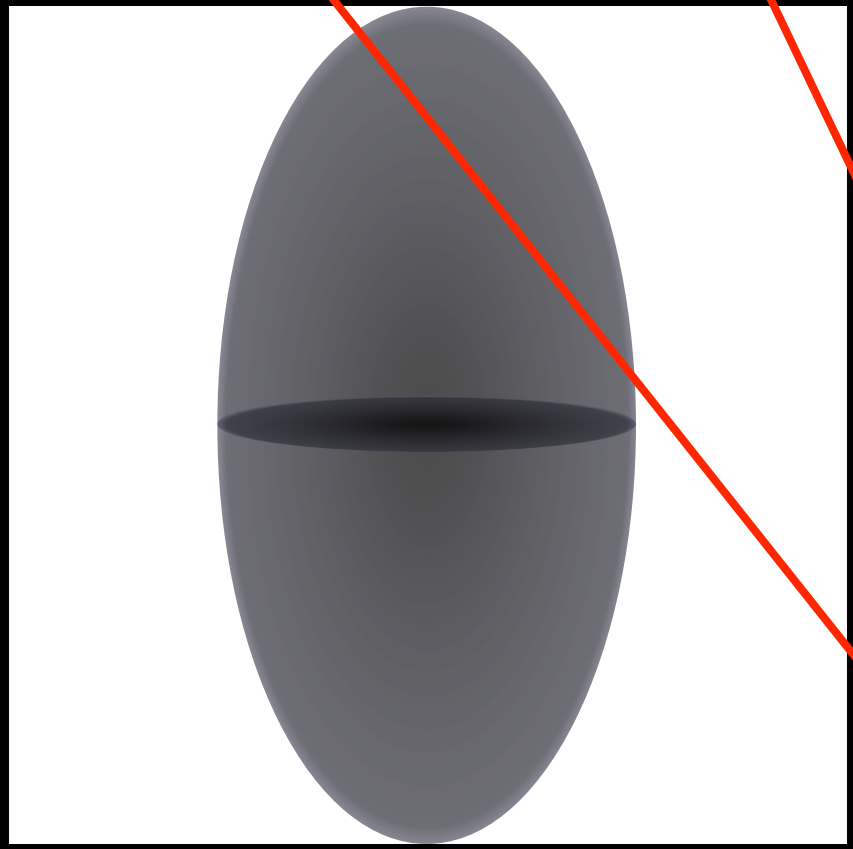
see *Read et al. (2008)*

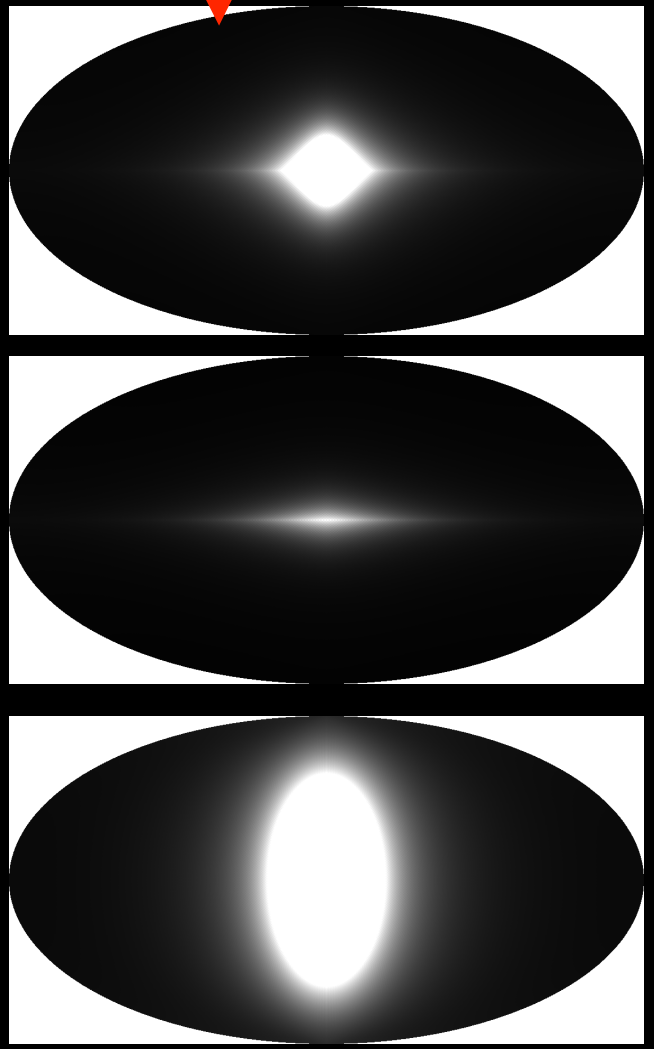
$$\rho(R,z) = \rho_0 \exp\left[\frac{1.68\,(R_\odot - R)}{R_{1/2}}\right] \exp\left[-\frac{0.693\,|z|}{z_{1/2}}\right]$$

dark disk morphology

Cholis & Goodenough (2010)

$$\Gamma_{\rm ann} = \frac{1}{2}\left(\frac{\rho_{\rm SH}}{m_\chi}\right)^2 \langle\sigma_{\rm ann}|v|\rangle_{\rm SH} + \frac{1}{2}\left(\frac{\rho_{\rm DD}}{m_\chi}\right)^2 \langle\sigma_{\rm ann}|v|\rangle_{\rm DD} + \left(\frac{\rho_{\rm SH}\cdot\rho_{\rm DD}}{m_\chi^2}\right)\langle\sigma_{\rm ann}|v|\rangle_{\rm mixed}$$





dark disk morphology (prompt)

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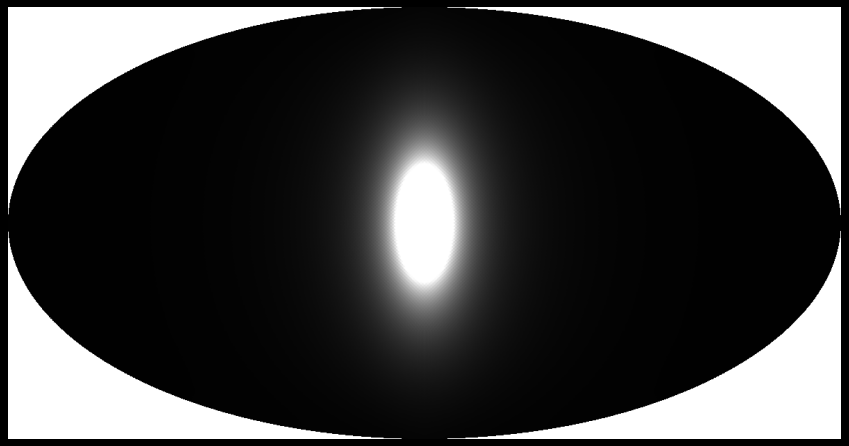
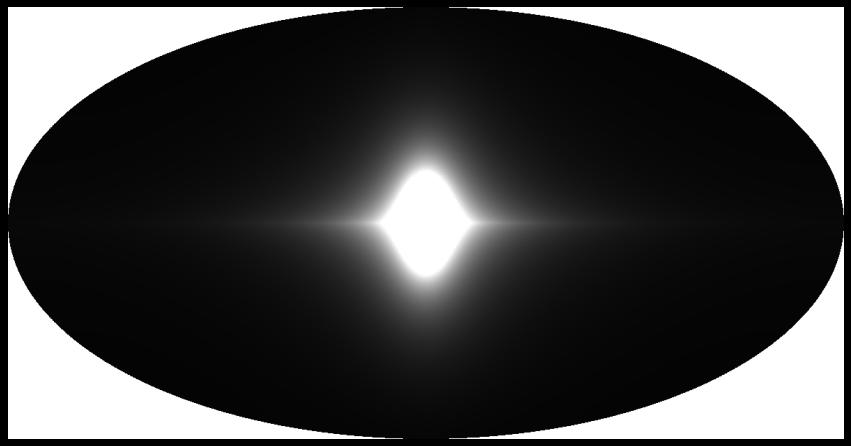


Einasto

(prompt)



Einasto + dark disk (“worst” case)

(prompt)

dark disk morphology (inverse Compton)

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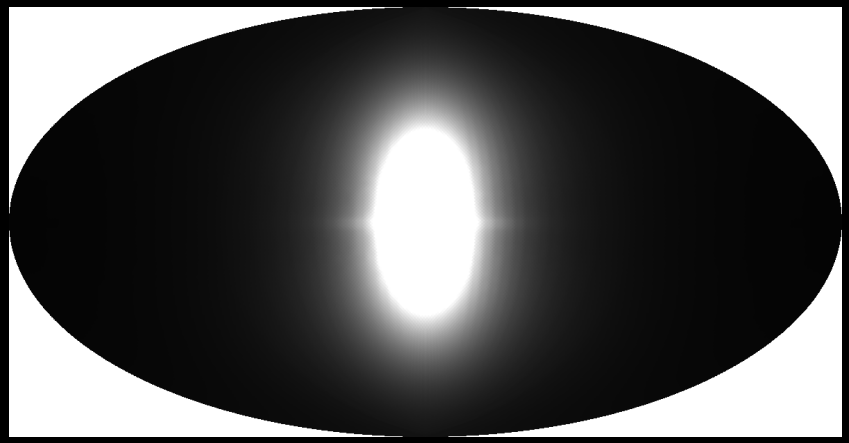
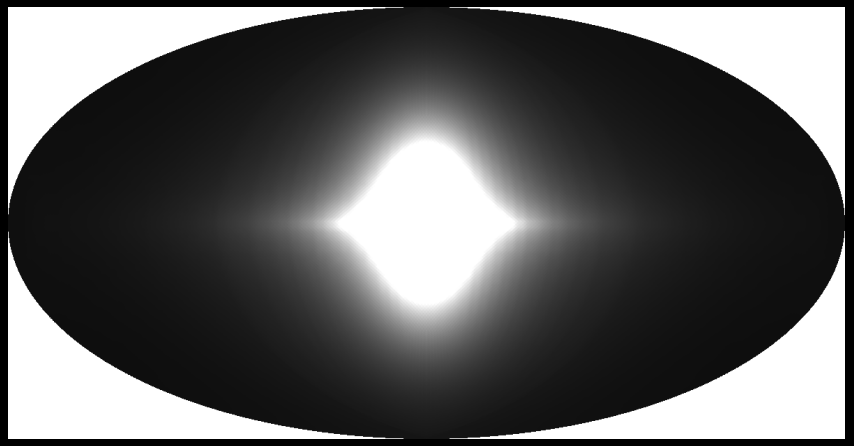


Einasto

(IC, galprop *E*=3 GeV)



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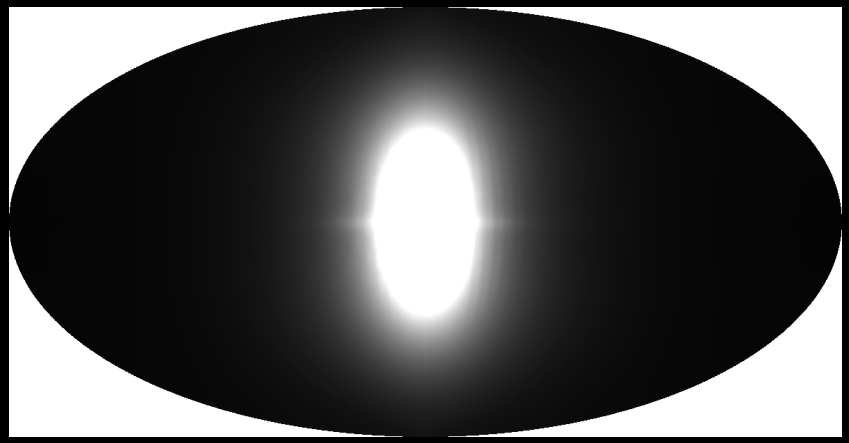

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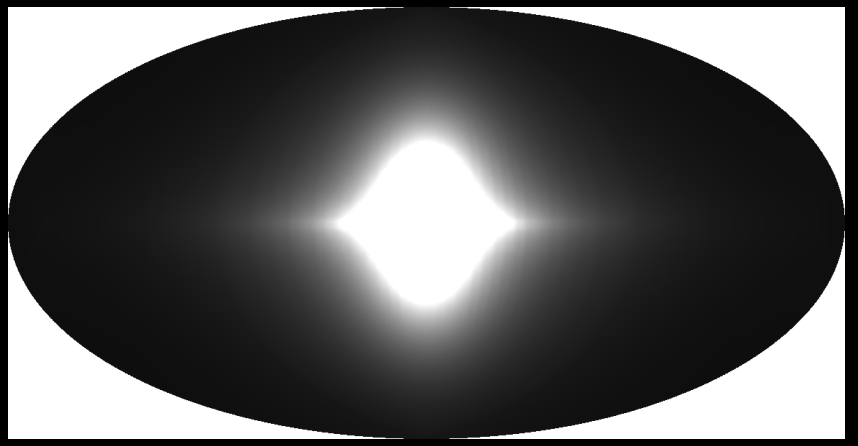
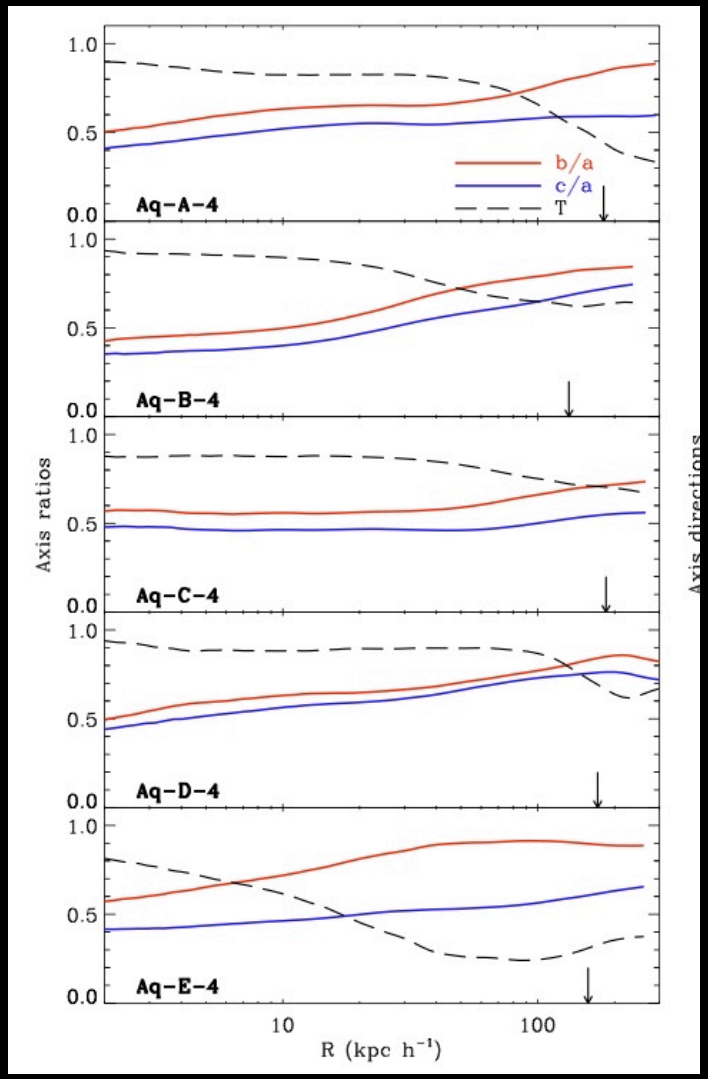


Einasto + dark disk ("worst" case)

(IC, galprop *E*=3 GeV)

dark disk can slightly impact the *morphological classification* of the DM signal, but not (significantly) the amplitude

halo shapes (oblate, prolate, spherical, triaxial....)



Vera-Ciro et al. (2011)

. DM only simulations generically yield prolate halos *(e.g., Diemand et al 2008, Kuhlen et al 2008, Springel et al 2008, Vera-Ciro et al 2011)*

for indirect detection with *Fermi*, the MW halo is likely prolate

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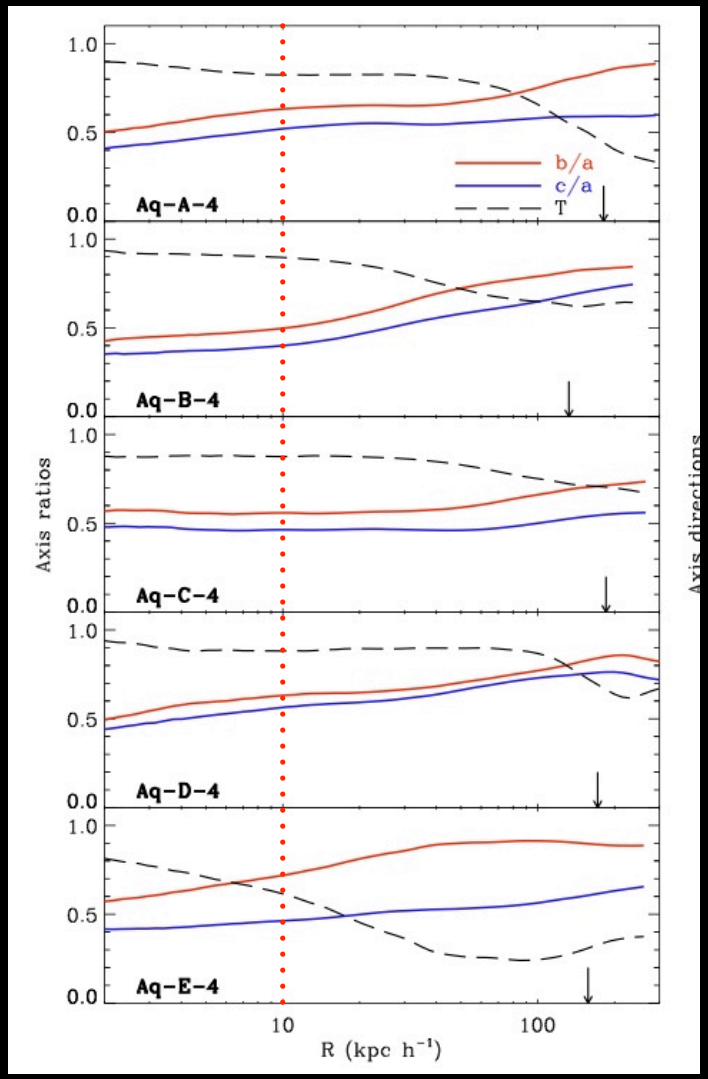

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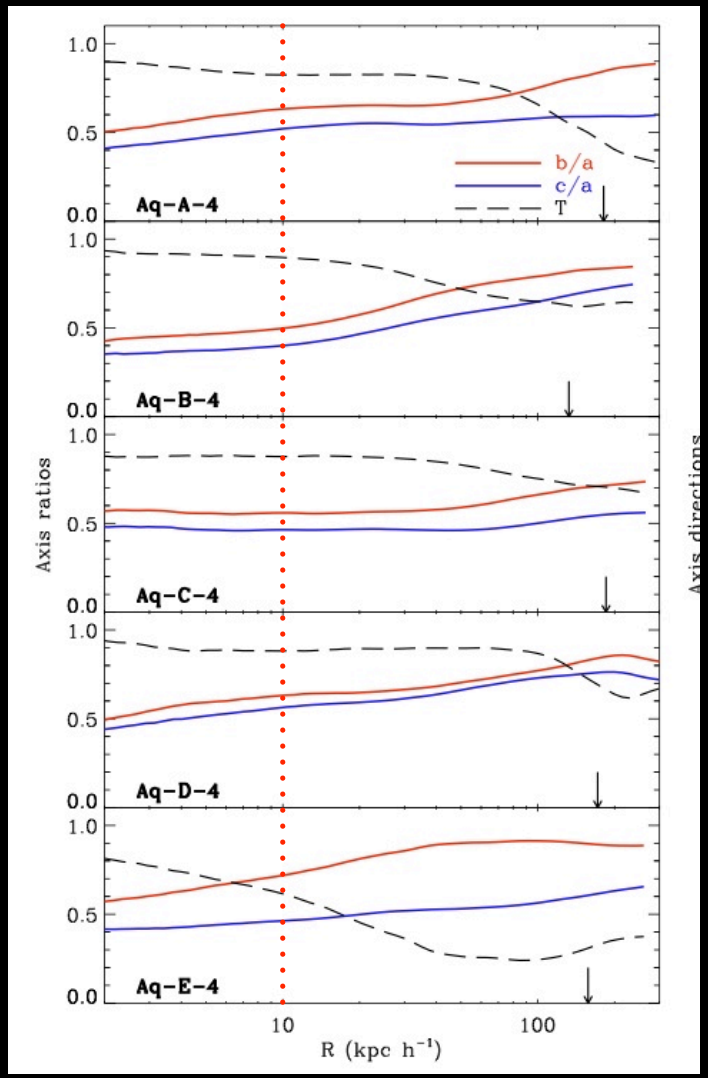

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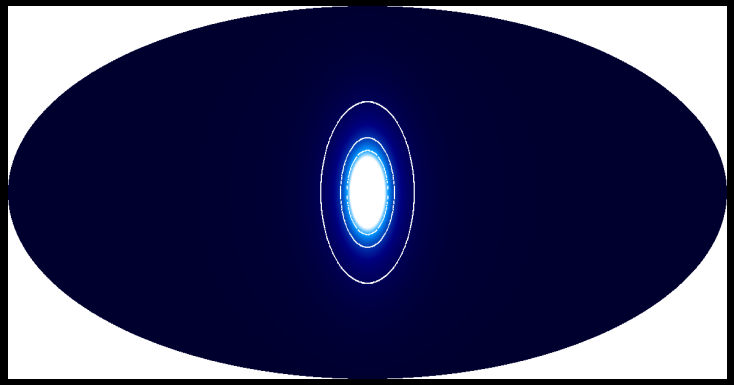
. recent findings of triaxial (and/or oblate) shapes are mostly for the **outer** parts of the halo *(Vera-Ciro et al 2011)*

for indirect detection with *Fermi*, the MW halo is likely prolate

halo orientation (???)

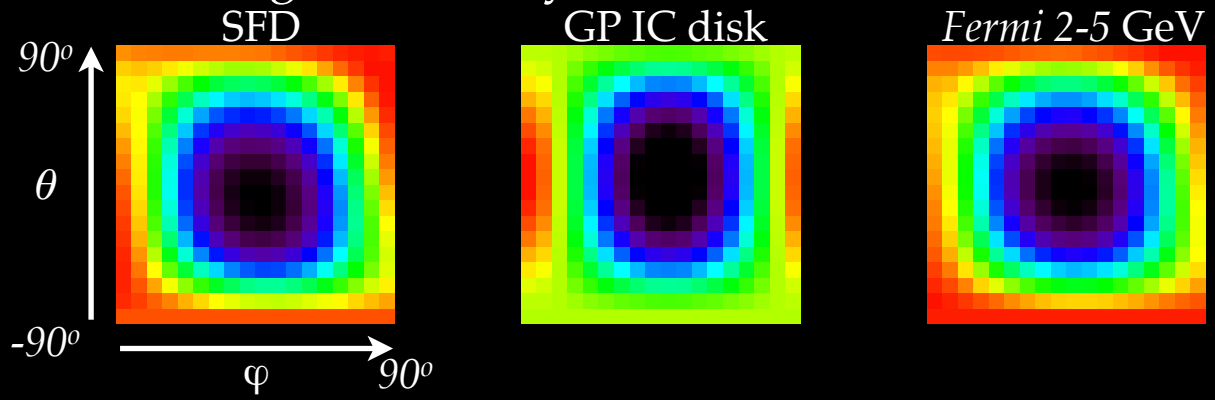
. some evidence for perpendicular alignment with Galactic disk from distribution of Galactic satellites (eg., *Zenter et al 2005*)

. alternative alignments (prompt only):



. correlation with known foregrounds vary at the *30%* level

$$\frac{\langle T_i T_j \rangle}{\sqrt{\langle T_i^2 \rangle \langle T_j^2 \rangle}}$$



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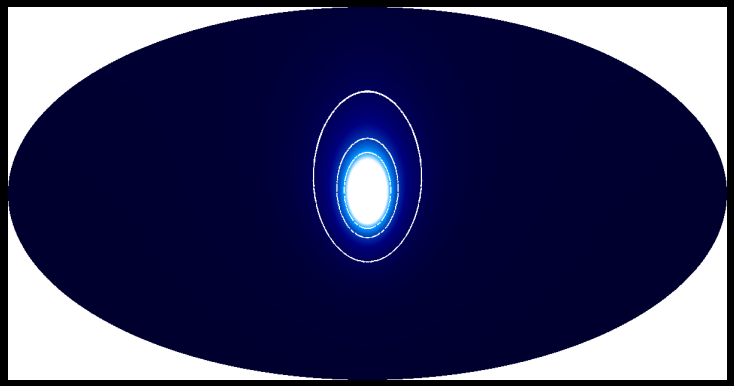

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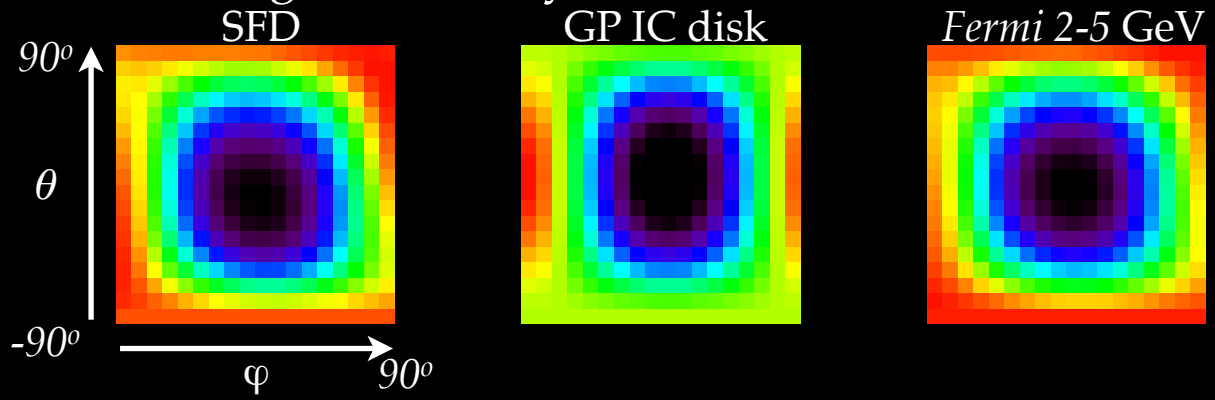

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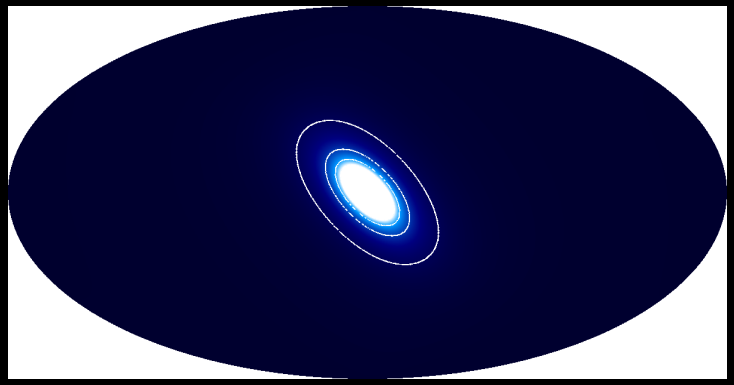

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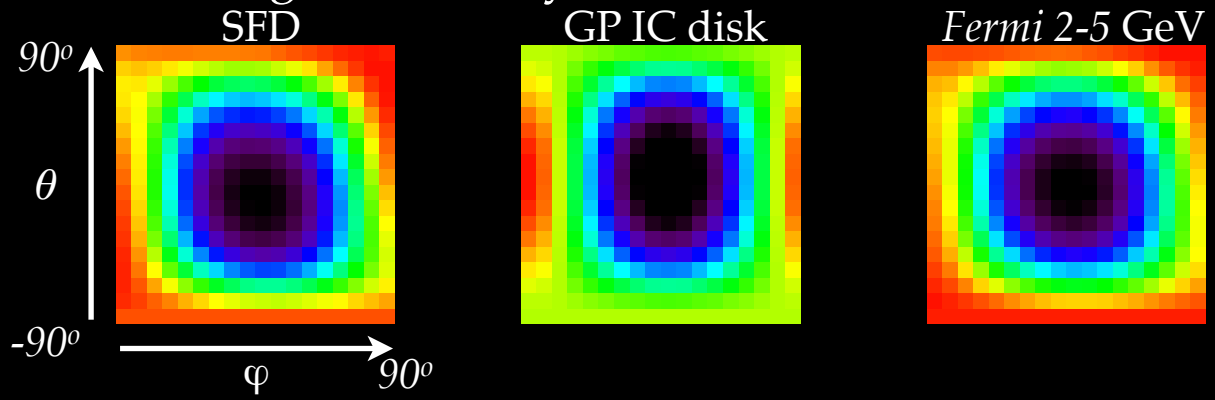

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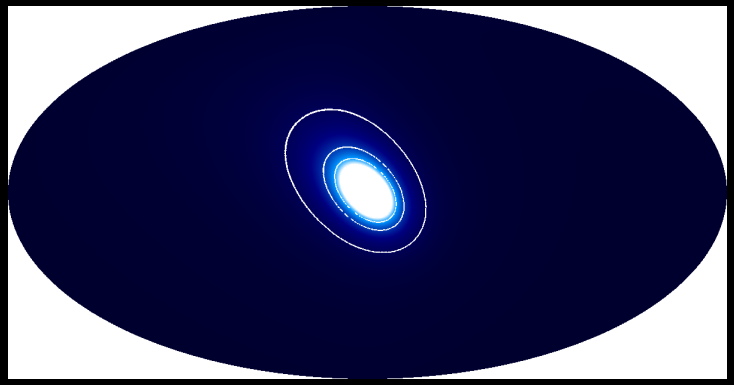

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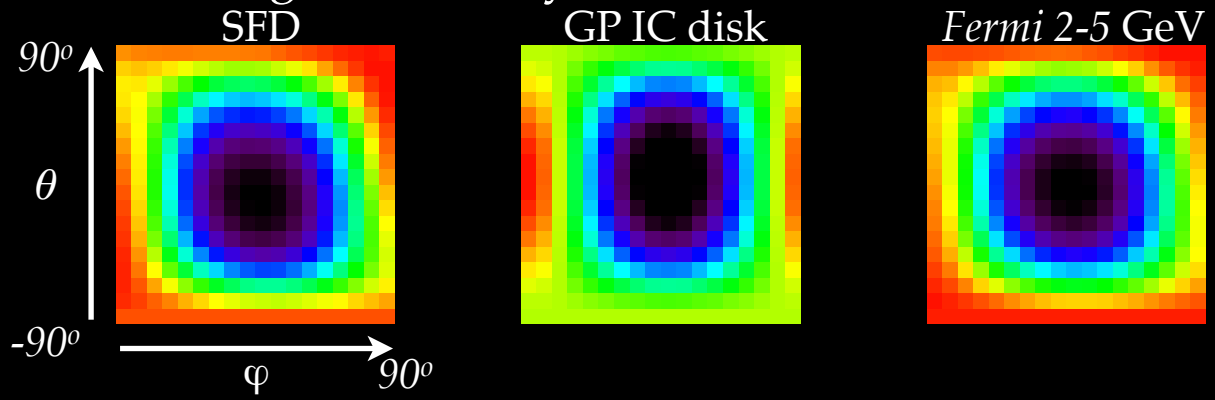

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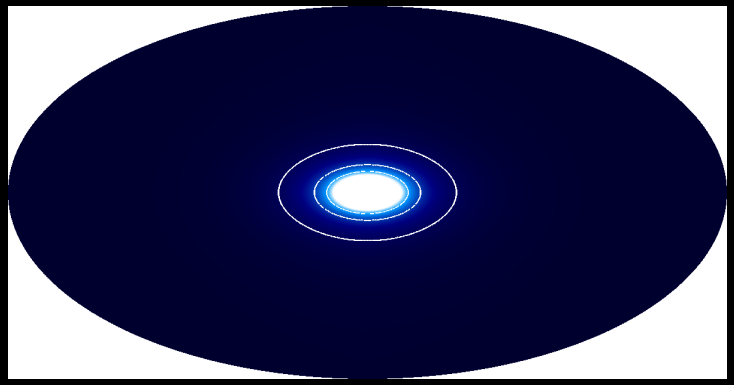

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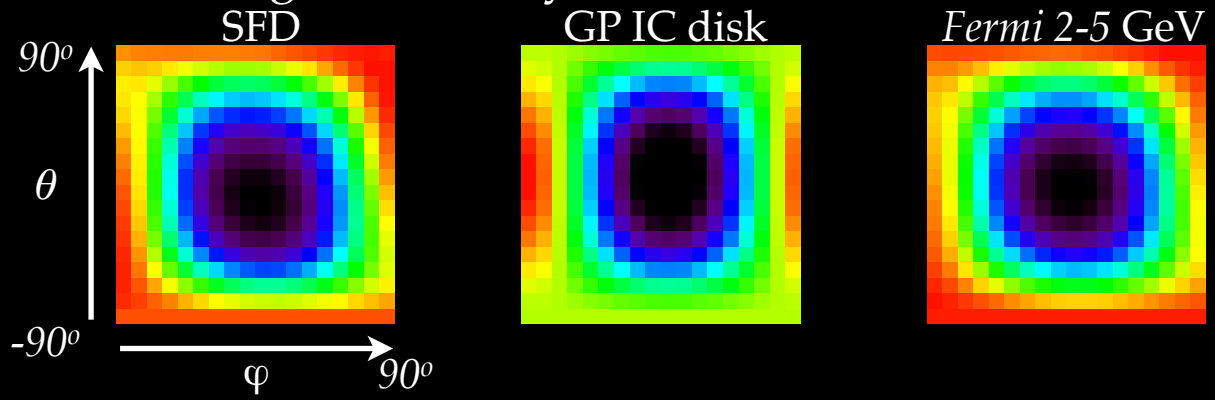

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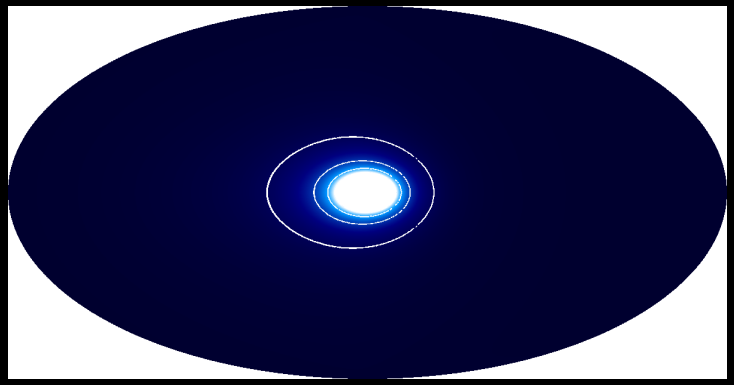

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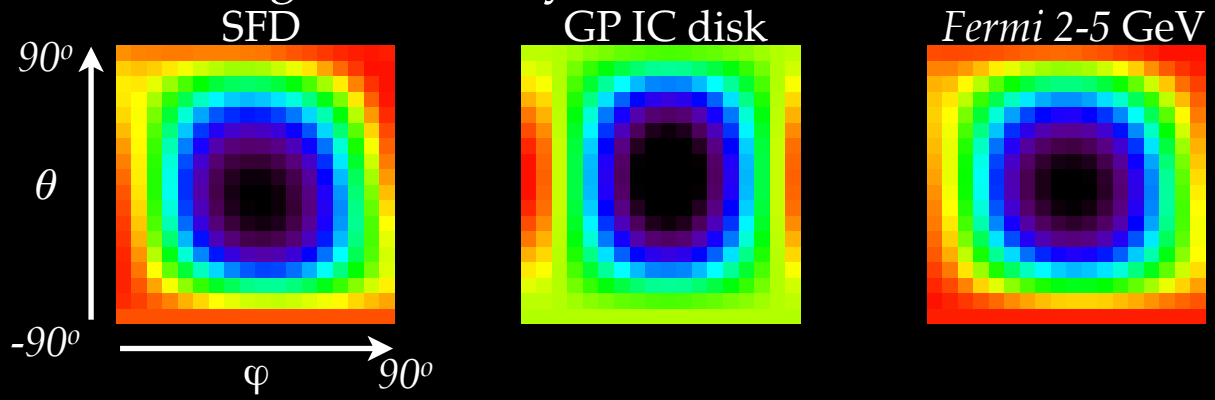

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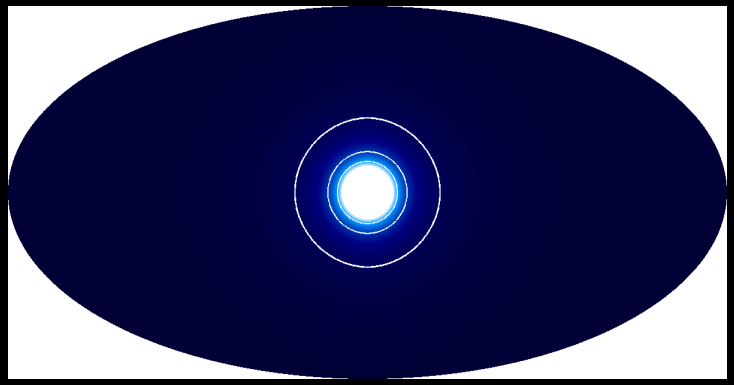

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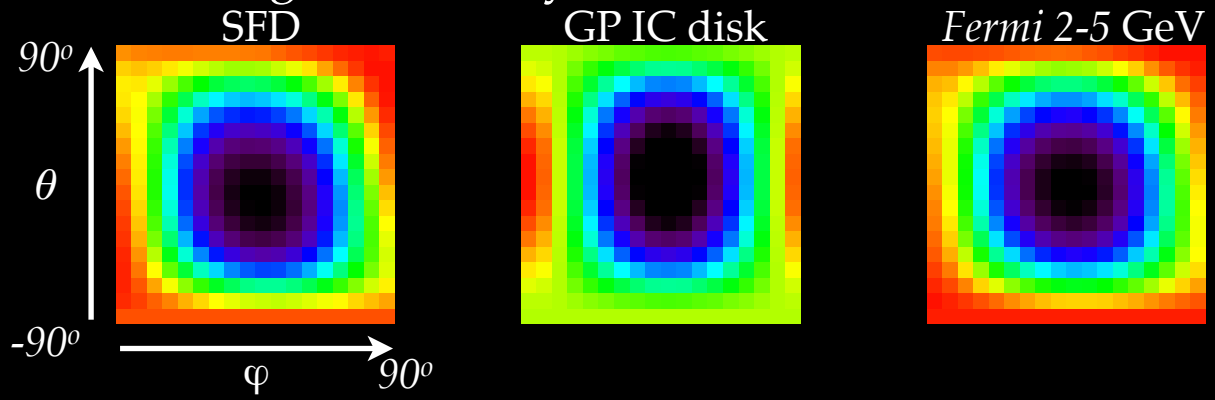
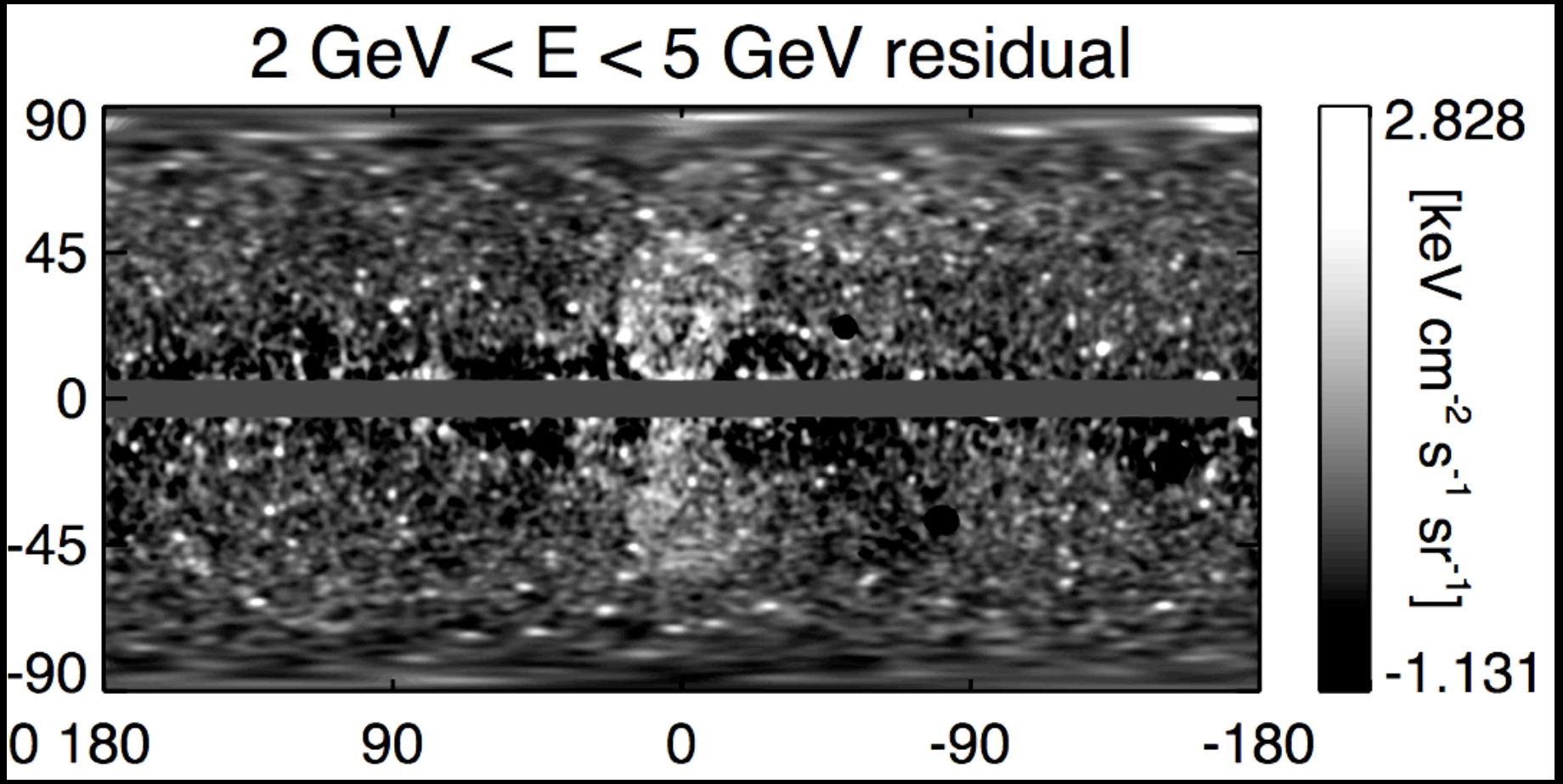


the Fermi haze/bubbles

e.g., *Dobler et al. (2010); Su, Finkbeiner, & Slatyer (2010); Dobler, Cholis, & Weiner (2011)*



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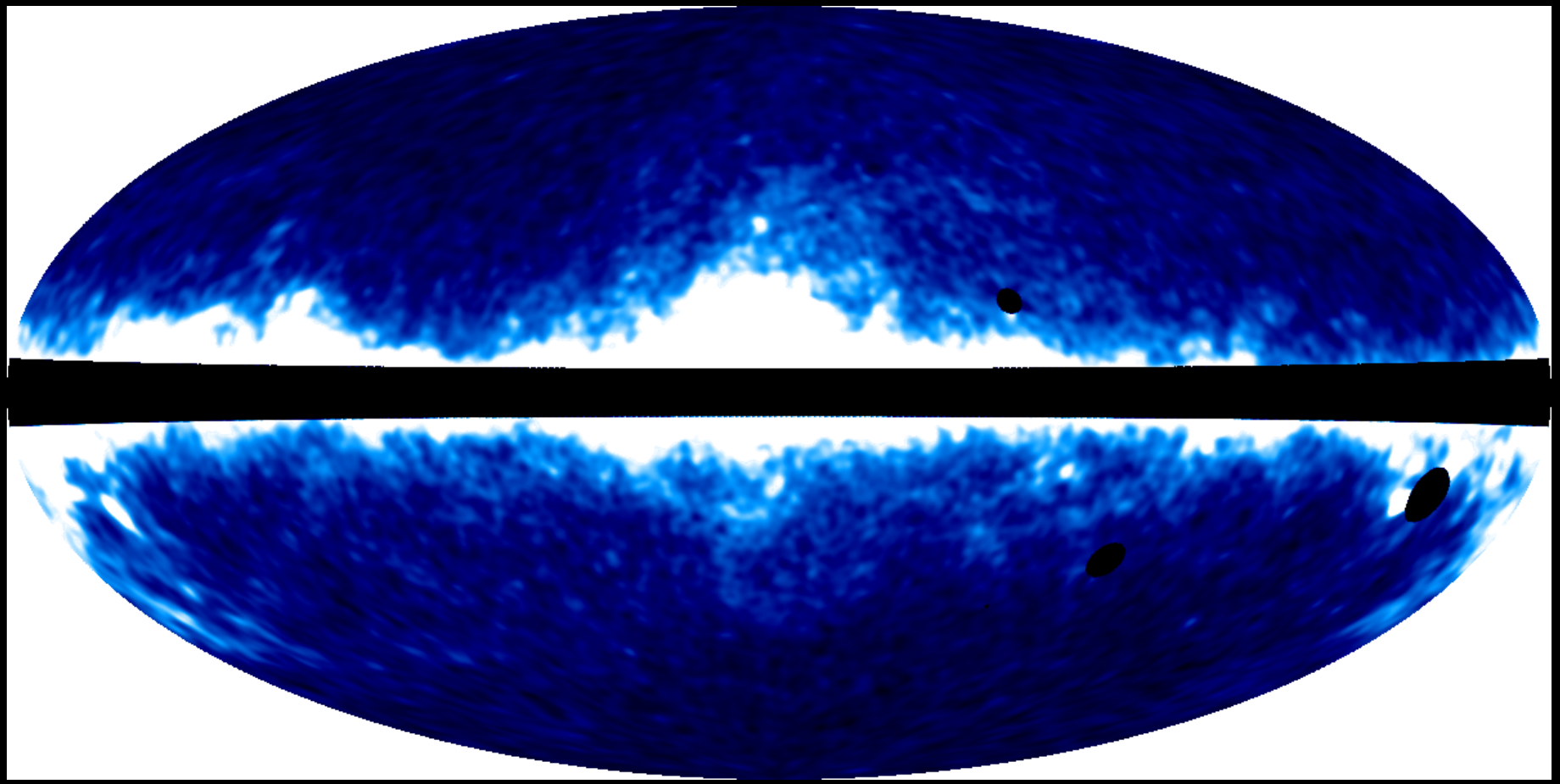

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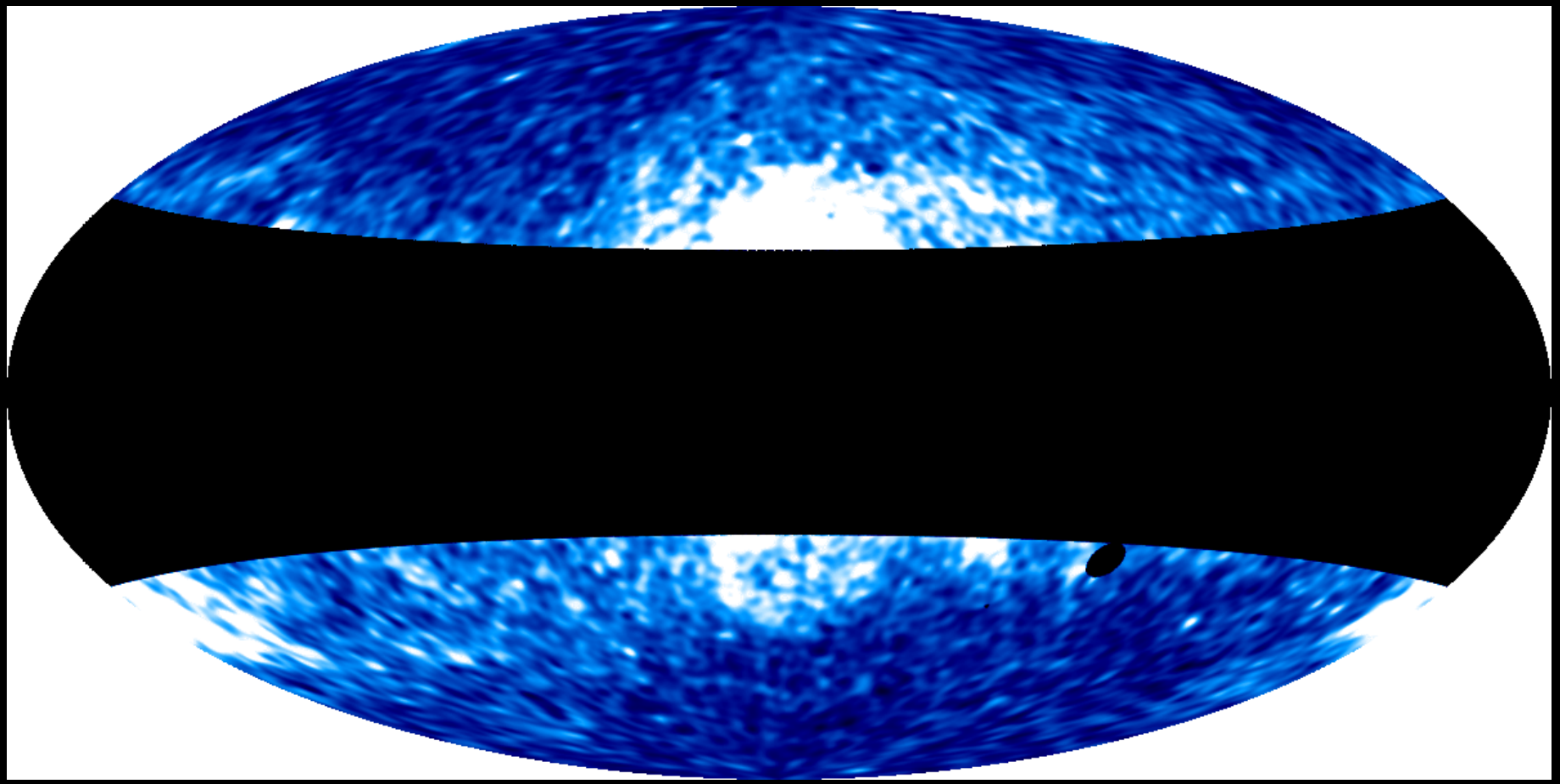

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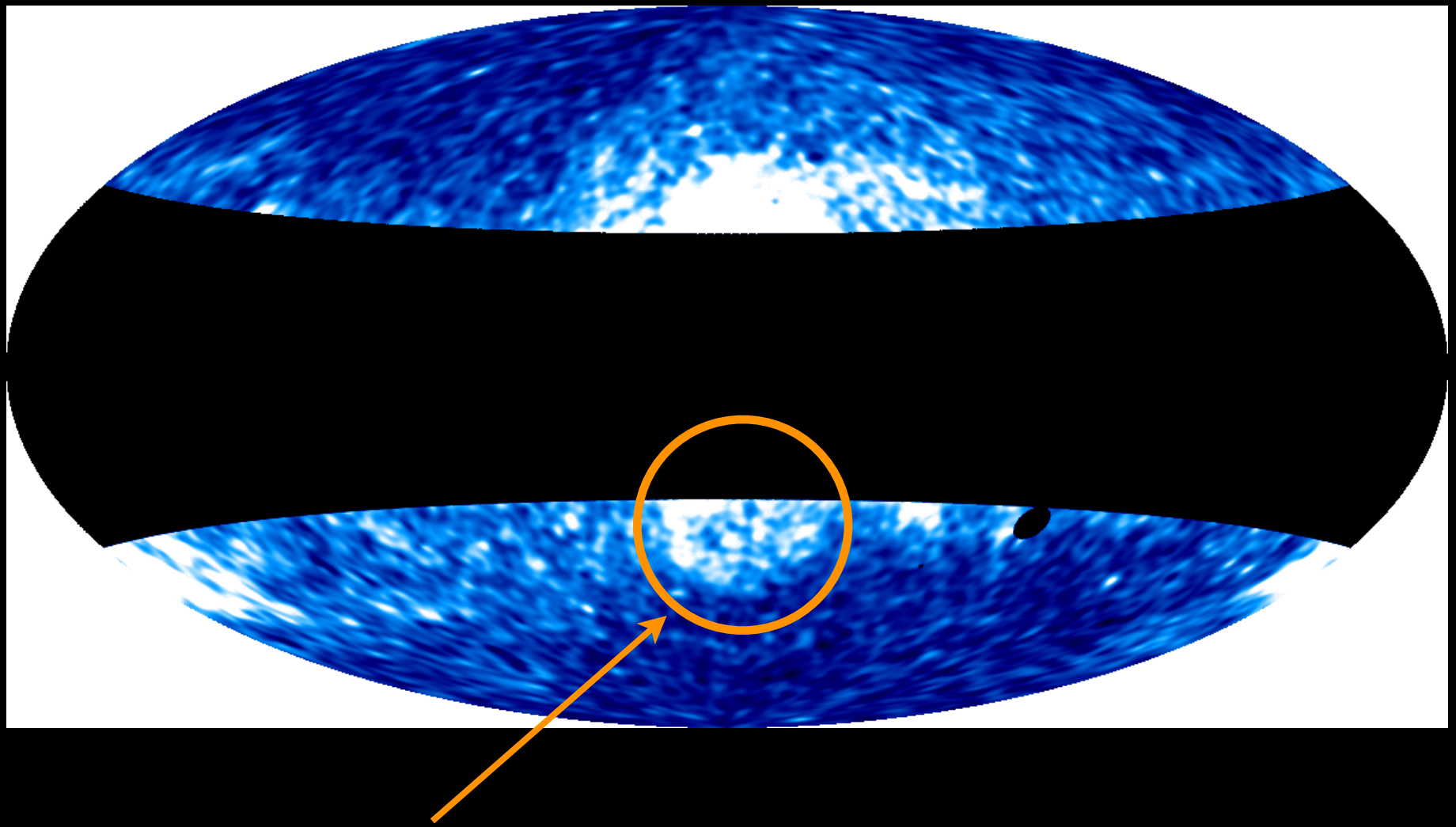

visible ***even*** with ***no*** templates, ***no*** fitting, ***no*** subtraction, etc...

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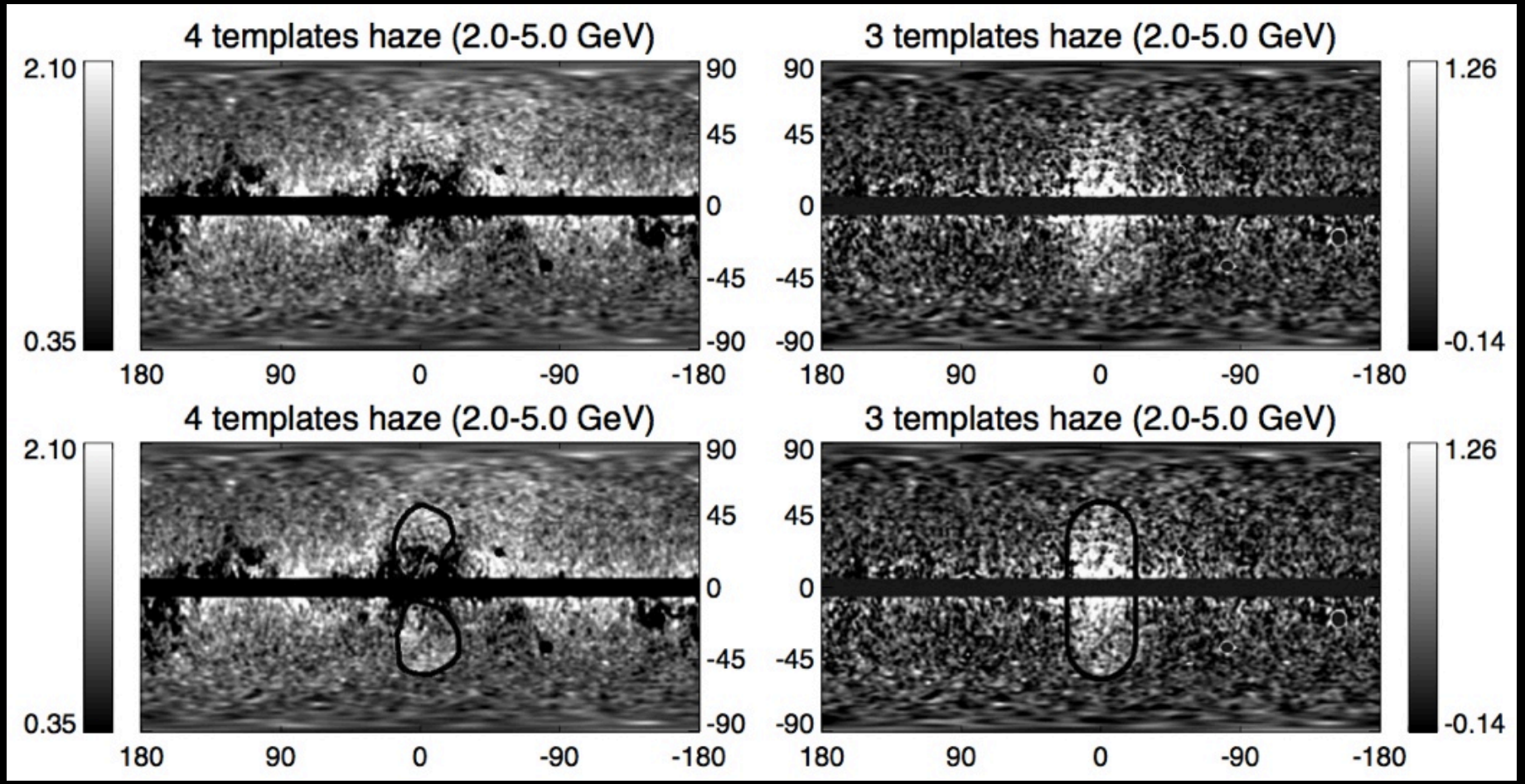
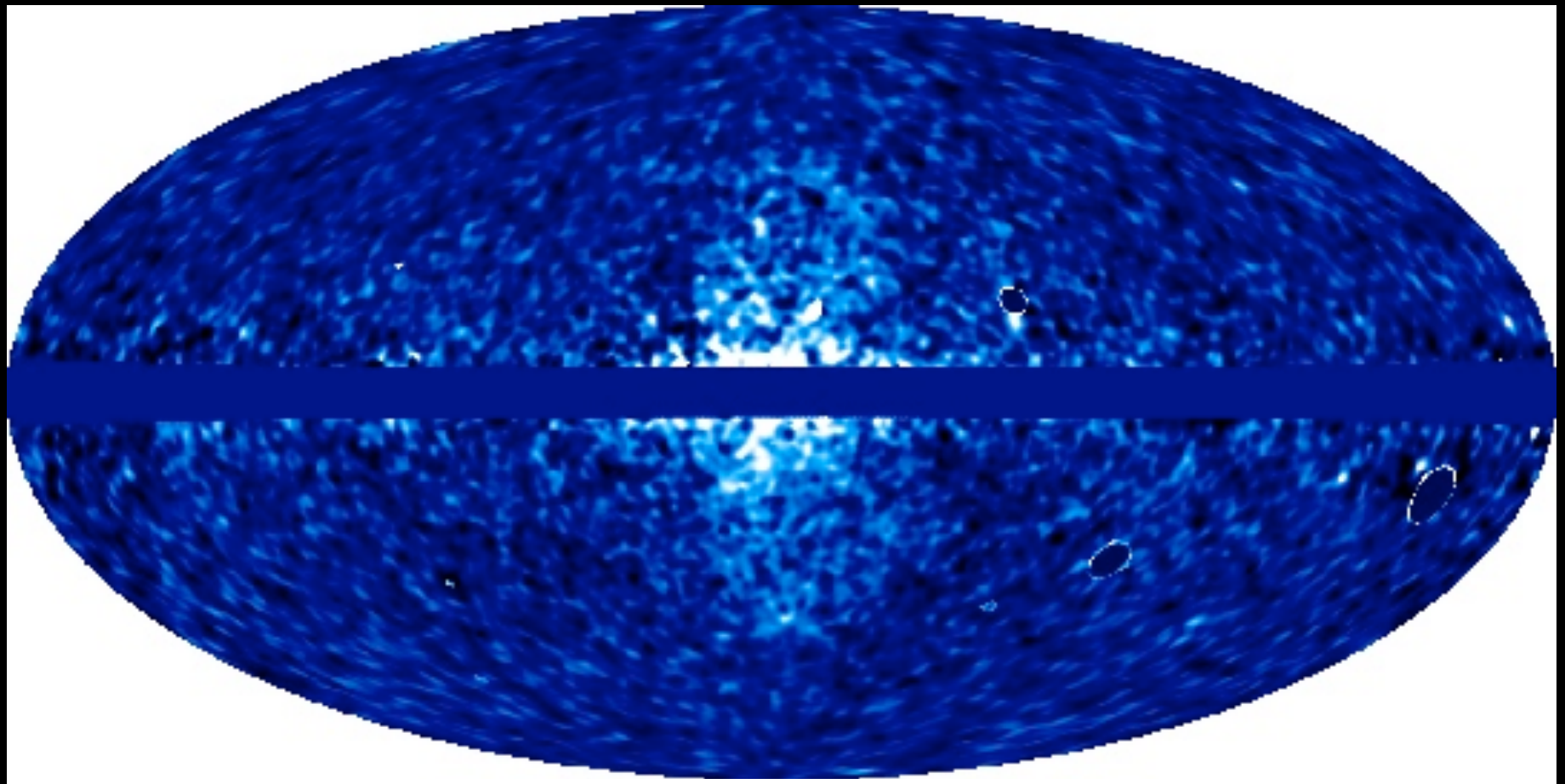


Dobler, Cholis, & Weiner (2011)

different templates yield somewhat different morphologies:
hourglass vs. oval

the Fermi haze/bubbles from DM annihilation

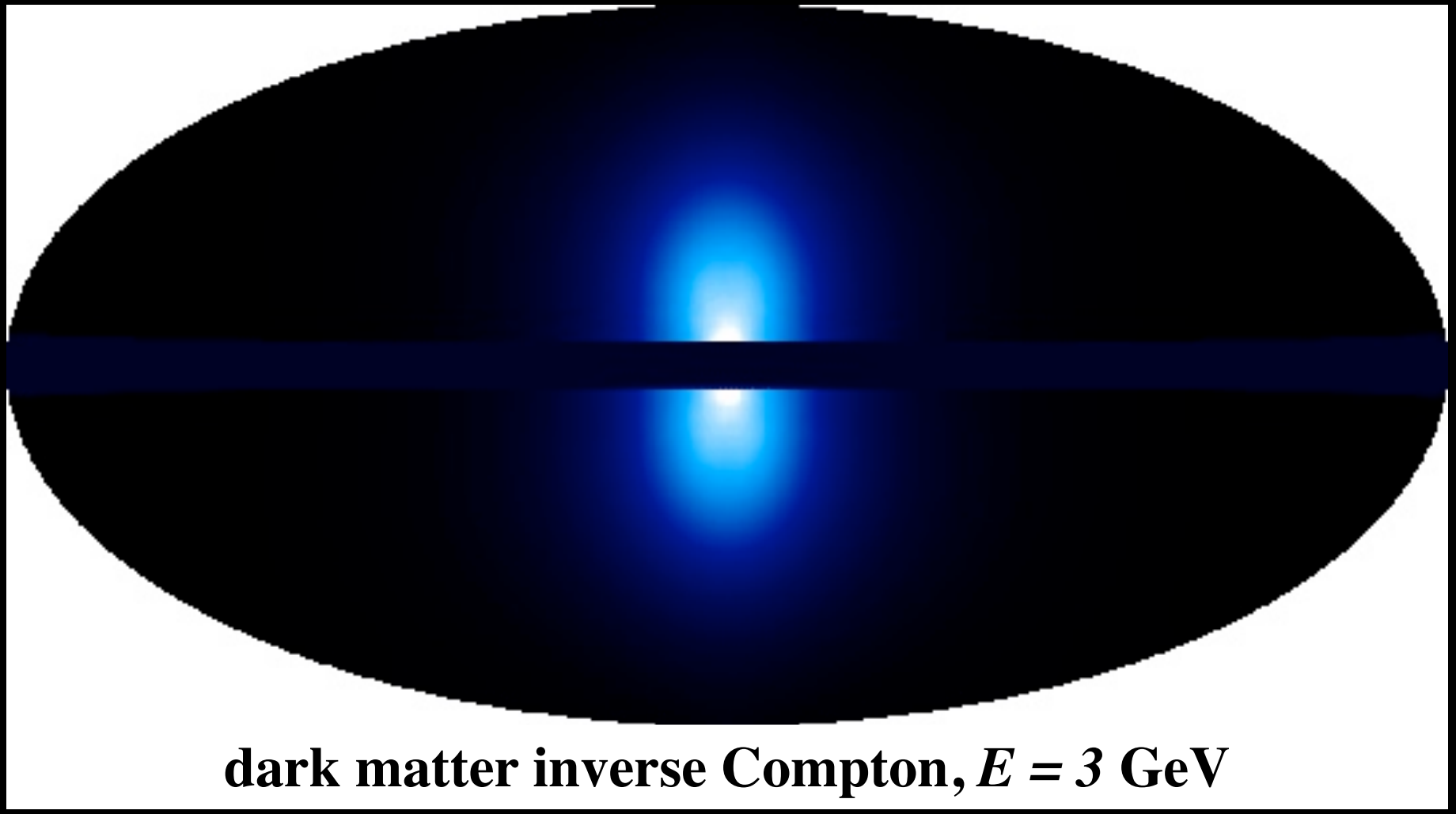


***Fermi* haze, $2 < E < 50$ GeV**

Dobler, Cholis, & Weiner (2011)

the Fermi haze/bubbles from DM annihilation

assuming: prolate halo $r=2$, anisotropic diffusion



dark matter inverse Compton, $E = 3$ GeV

Dobler, Cholis, & Weiner (2011)

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see poster by Ilias Cholis

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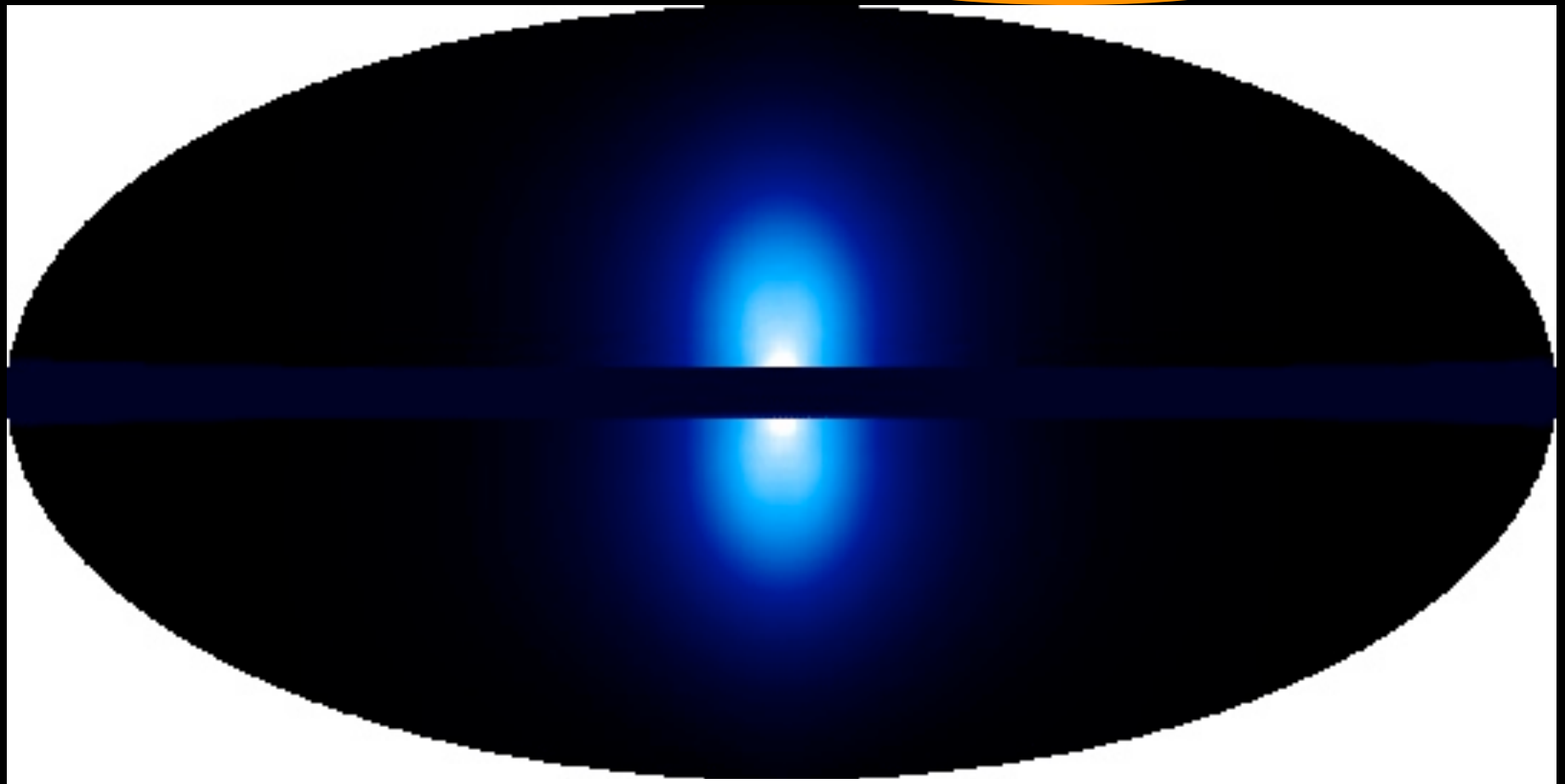

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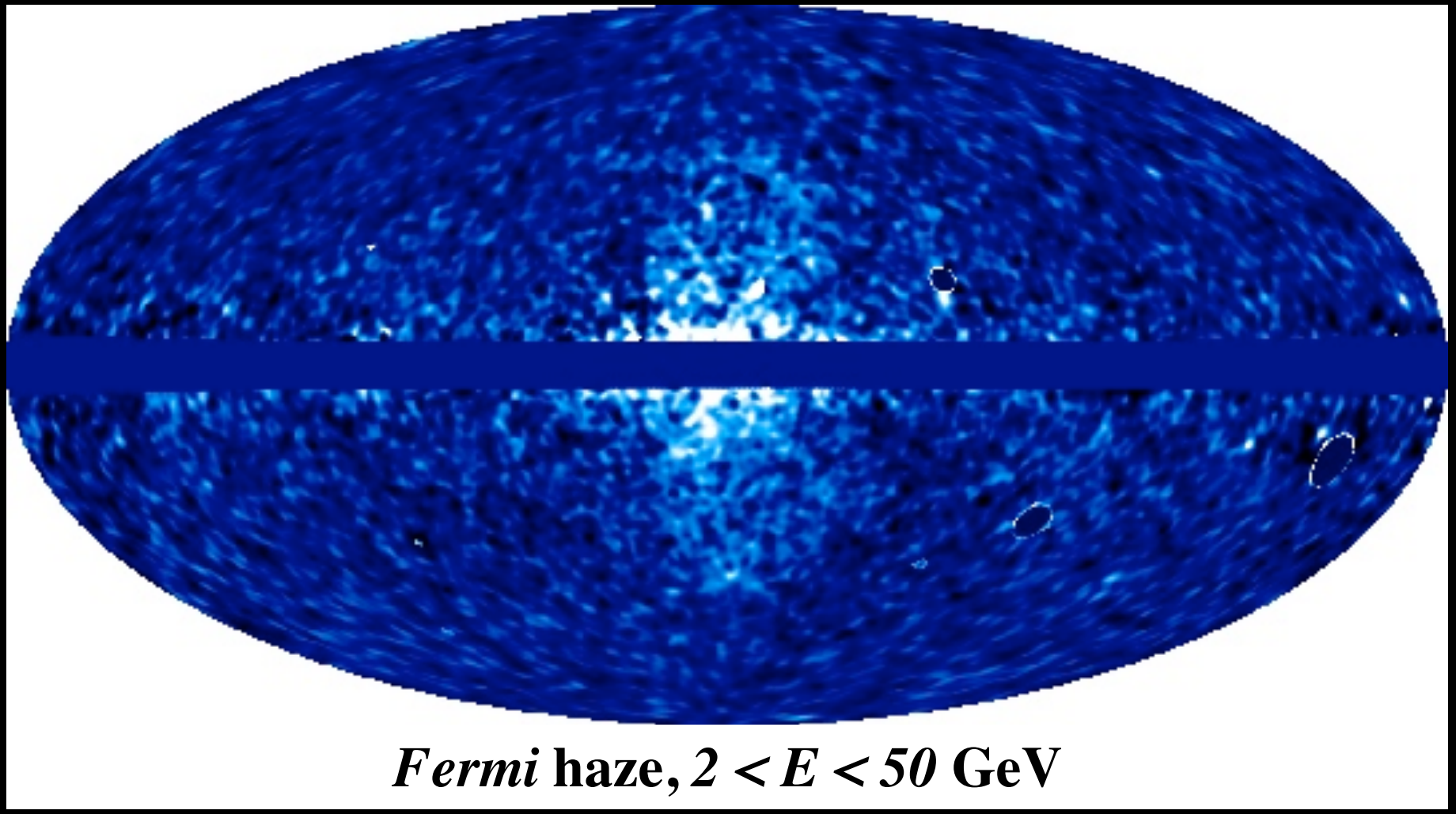

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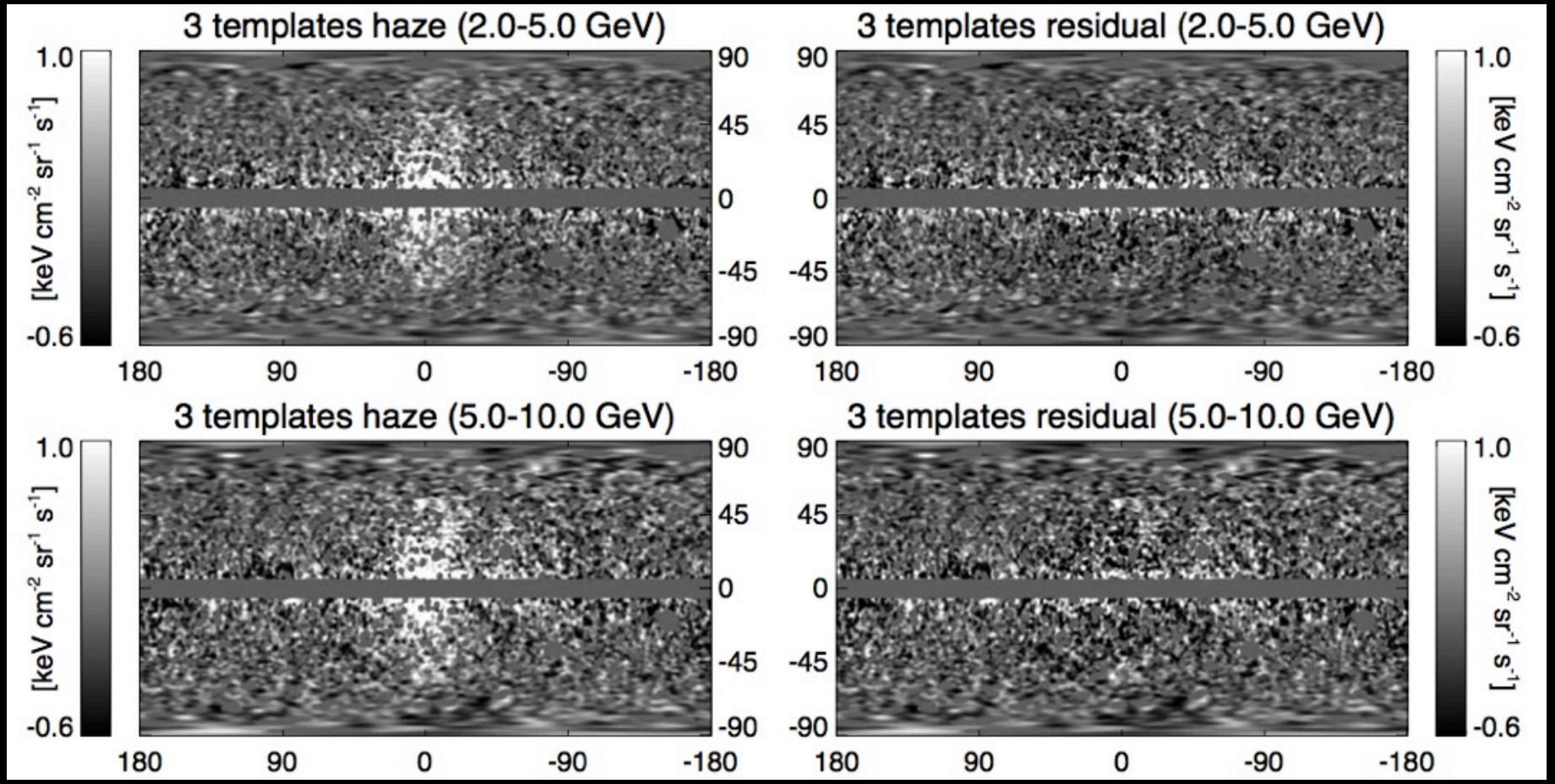
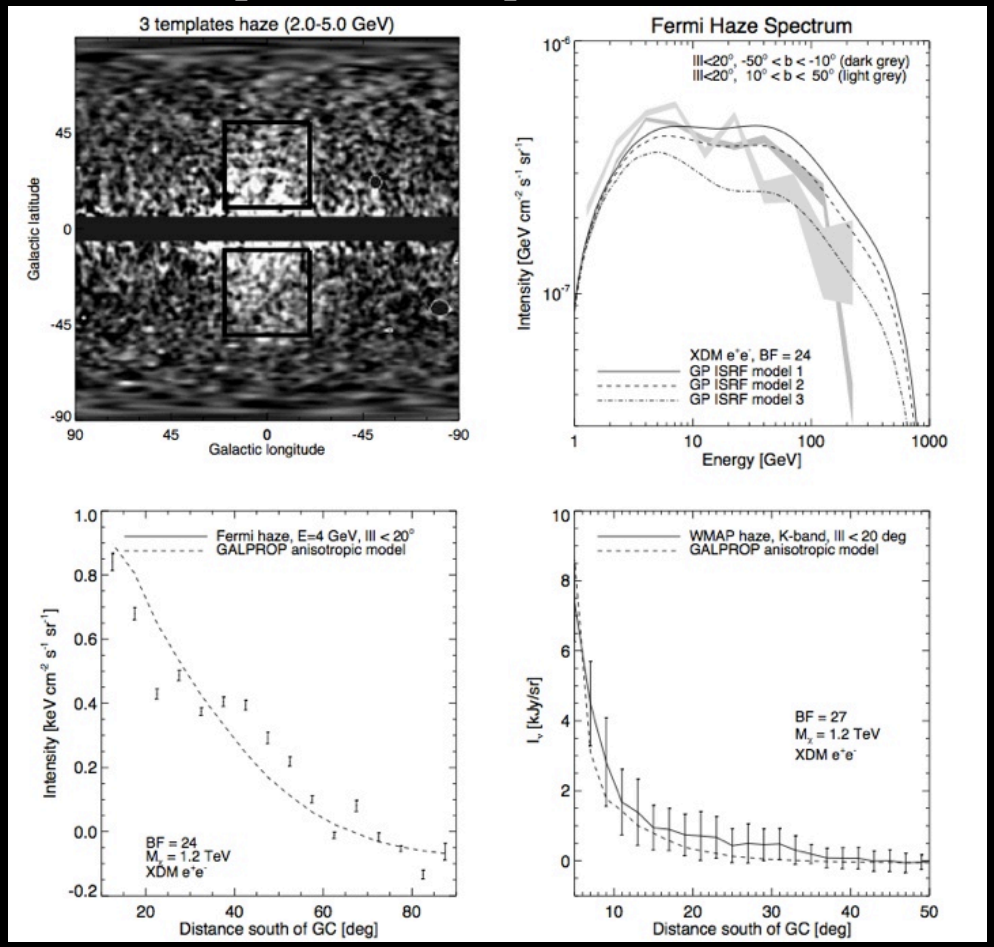


Dobler, Cholis, & Weiner (2011)

the Fermi haze/bubbles from DM annihilation

. assuming: prolate halo r=2, anisotropic diffusion

. matches spectrum, amplitude (BF=30), and morphology of the haze/bubbles



outstanding issues: low latitude shape? edges? flat profile?

summary

. dark disks will **not** particularly impact **morphological** searches for DM annihilation

. the MW dark halo is likely **prolate** in the regions of interest

. the orientation of the halo is not well known

- some evidence for perpendicular orientation
- other orientations affect observable signal
- some orientations can be confused with known non-DM signals

. the *Fermi* haze/bubbles can be reasonably fit with a prolate halo

- BF = 30, hard spectrum, elongated morphology
- anisotropic diffusion effects

summary (haze/bubbles)

this structure is ***very odd!***

1.) sharp edges plus flat profile

2.) lower energy "cutoff"

1.) seems to imply a very contrived electron distribution since constant volume emissivity gives limb-darkened profiles and shell emissivity gives limb brightened profiles.

2.) seems to imply injection of electrons at ~TeV with a ***very*** hard spectrum

the contenders:

- wind (e.g., *Crocker & Aharonian 2011*)
- starburst
- AGN (e.g., *Guo & Matthews 2011*)
- *2nd* order Fermi acc. (e.g., *Mertsch & Sarkar 2011*)
- DM annihilation (e.g., *Dobler, Cholis, & Weiner 2011*)

summary (haze/bubbles)

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1.) seems to imply a very contrived electron distribution since constant volume emissivity gives limb-darkened profiles and shell emissivity gives limb brightened profiles.

2.) seems to imply injection of electrons at ~TeV with a ***very*** hard spectrum

the contenders:

- wind (e.g., *Crocker & Aharonian 2011*): time scales too long, no Hα, violates 1.)
- starburst: no Hα, likely violates 1.) and 2.)
- AGN (e.g., *Guo & Matthews 2011*): violates 1.), instabilities at the edge?, radio?
- *2nd* order Fermi acc. (e.g., *Mertsch & Sarkar 2011*): violates 1.), synchrotron?
- DM annihilation (e.g., *Dobler, Cholis, & Weiner 2011*): violates 1.)

summary (haze/bubbles)

this structure is ***very*** ***odd!***

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2.) lower energy "cutoff"

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2.) seems to imply injection of electrons at ~TeV with a *very* hard spectrum

IF THE EDGES ARE REAL,
DOES THIS SUGGEST A HYBRID SCENARIO???