Dark Matter Signals from GLAST

Doug Finkbeiner
Harvard Center for Astrophysics

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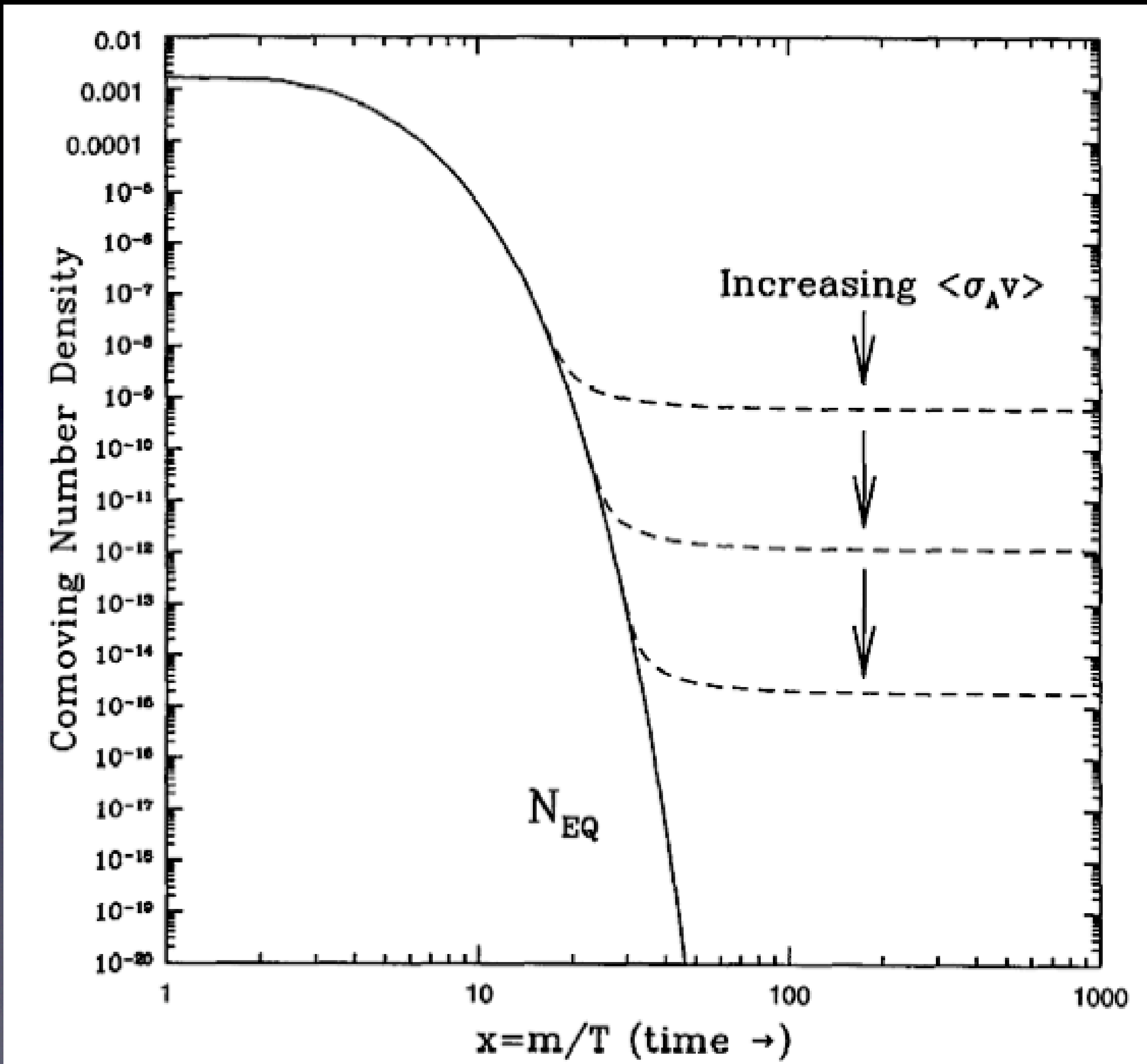
Ways of detecting WIMP dark matter:

(in order of increasing speculation)

- Gravitational force (rot. curves, lensing, CMB)
- Direct detection (e.g. nuclear scattering)
- Annihilation (gamma-rays, particles, microwaves)
- Inelastic scattering (pairs, cluster heating, BHs)

We will focus on the last two.



For a thermal relic of the Big Bang, relic density depends on annihilation cross section at freeze-out.

Jungmann, Kamionkowski, & Greist (1996)

After freeze out, annihilation is negligible until galaxies form and densities are relatively high again.

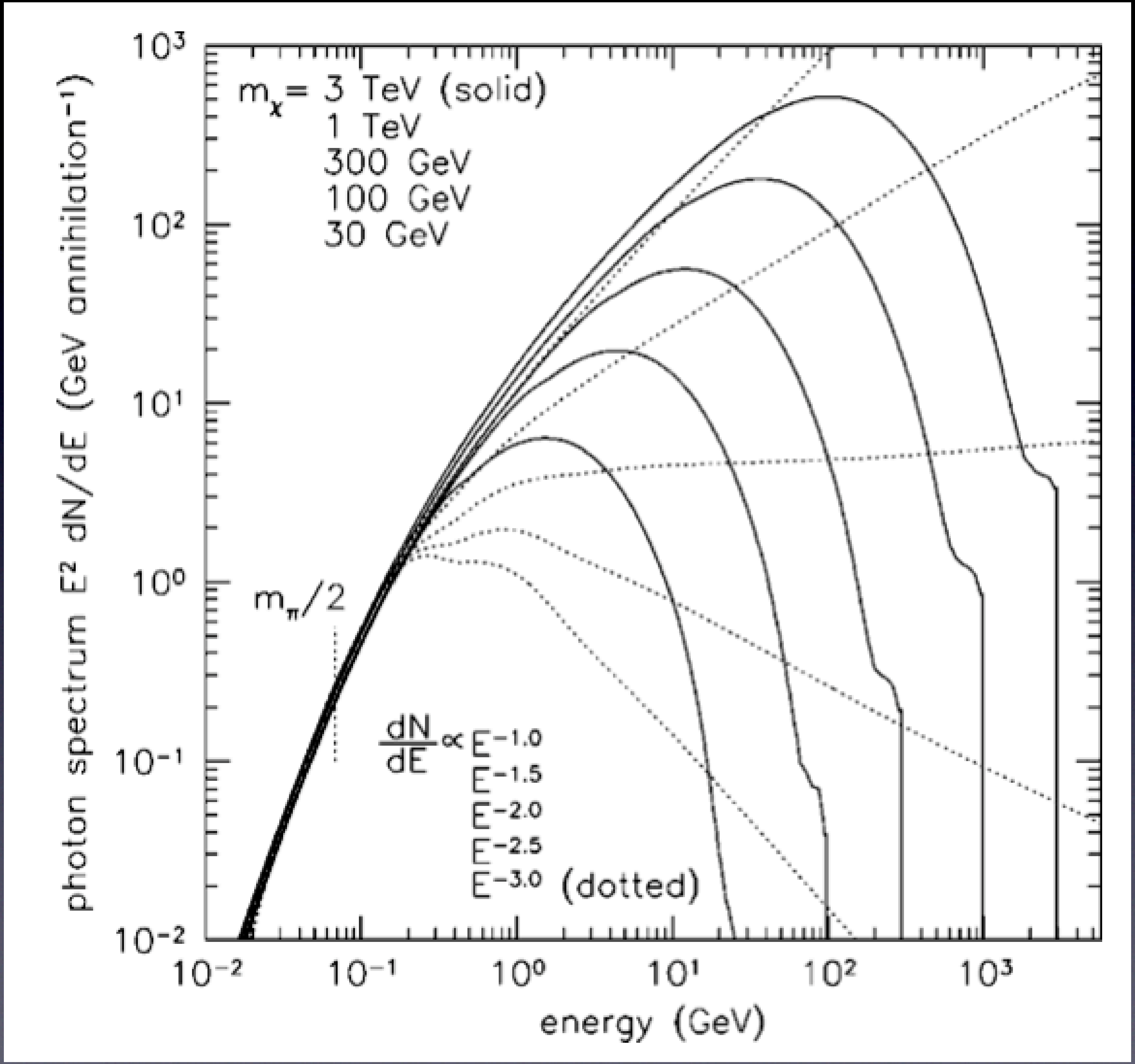
In the inner Milky Way, annihilation rates are high enough that the gamma-rays and synchrotron emission from annihilation products may be visible.

Substructure could also enhance annihilation by a factor of few - several.

Subhalos themselves may be detectable.

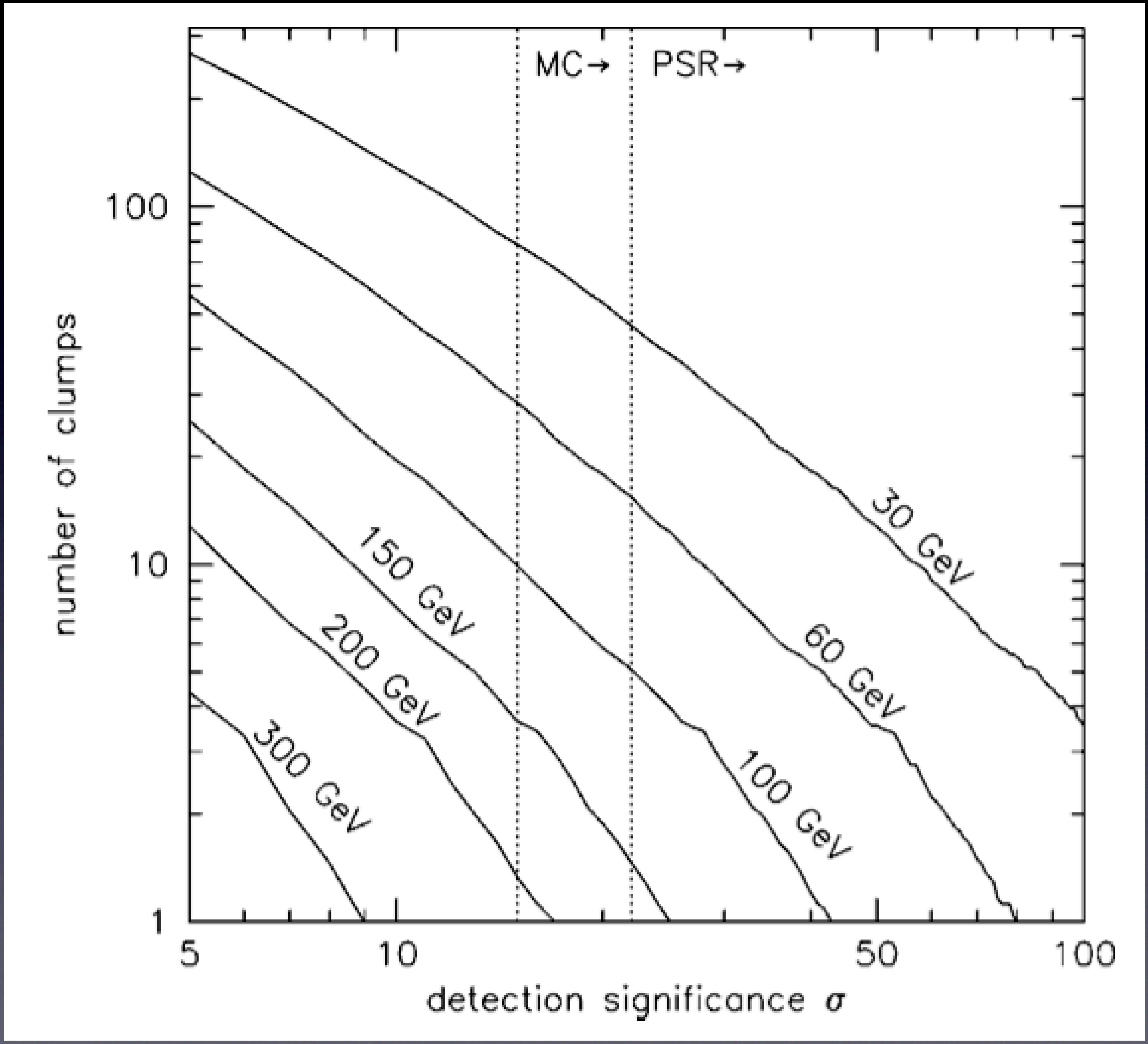
What is the gamma-ray spectrum of DM annihilation?

Assume we go through b quarks. (Z,W bosons give similar results).



Baltz, Taylor, & Wai (2007)

How many of these will GLAST detect?



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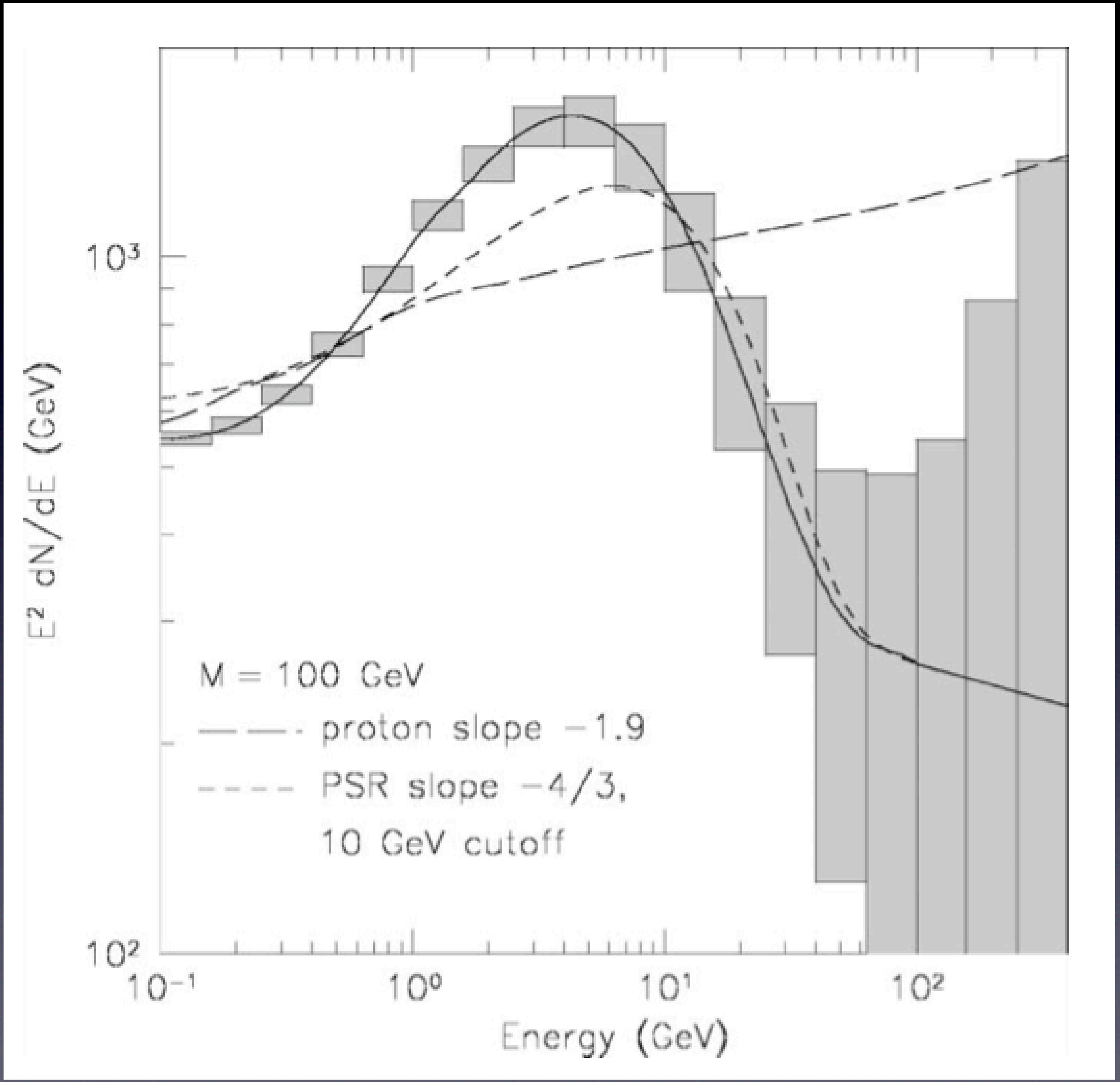


Baltz, Taylor, & Wai (2007)

These estimates are fairly generic, assuming plain vanilla MSSM WIMPs annihilating through quarks. This is the best guess.

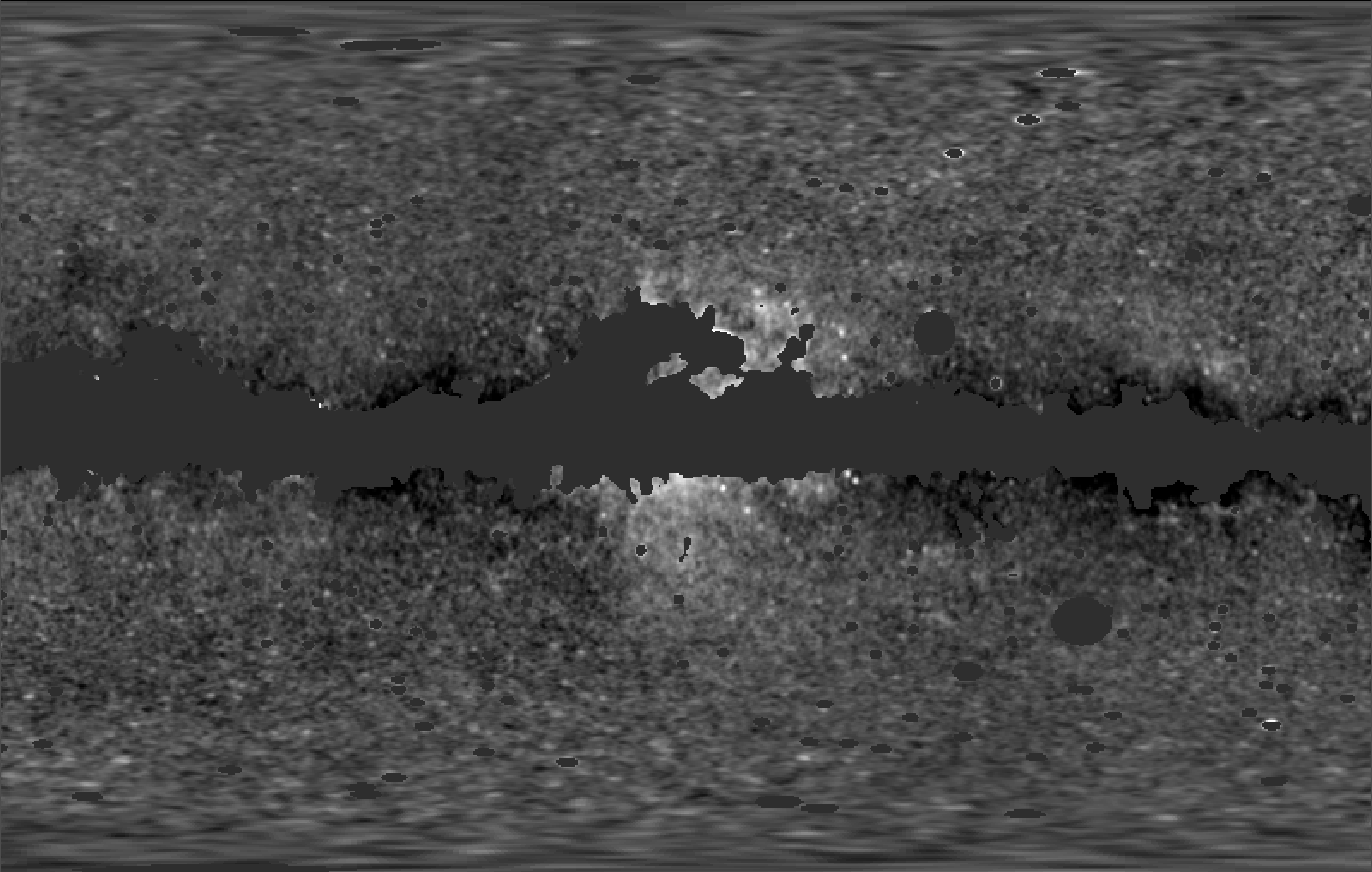
What if the WIMPs annihilate some other way (e.g. through an intermediate scalar boson) ?

Then what signals would we look for?

Signals have already been observed that are consistent with WIMP annihilation, though there may be (exotic) astrophysical explanations as well.

EGRET excess (few GeV gammas, Galactic center)
HEAT excess (10-50 GeV positrons near Earth)
WMAP excess (microwaves from Galactic center)
OSSE excess (511 keV gammas from GC)

Do these have anything to do with each other?



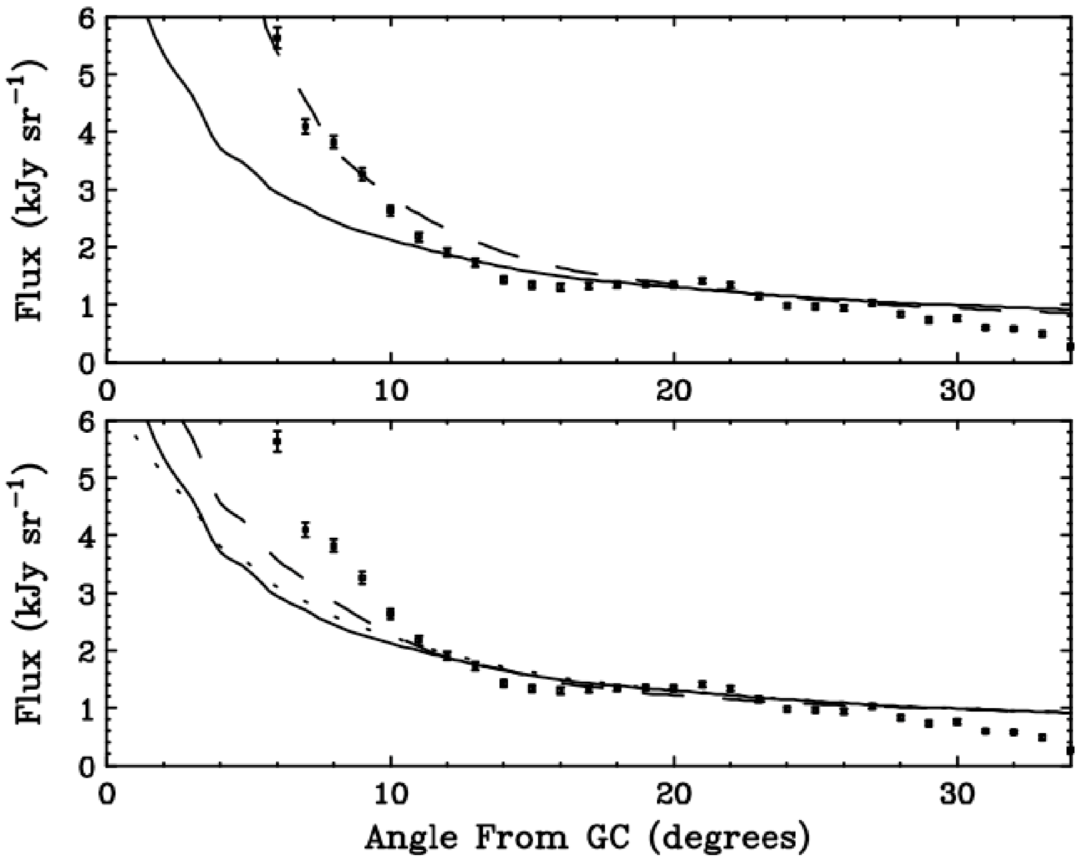
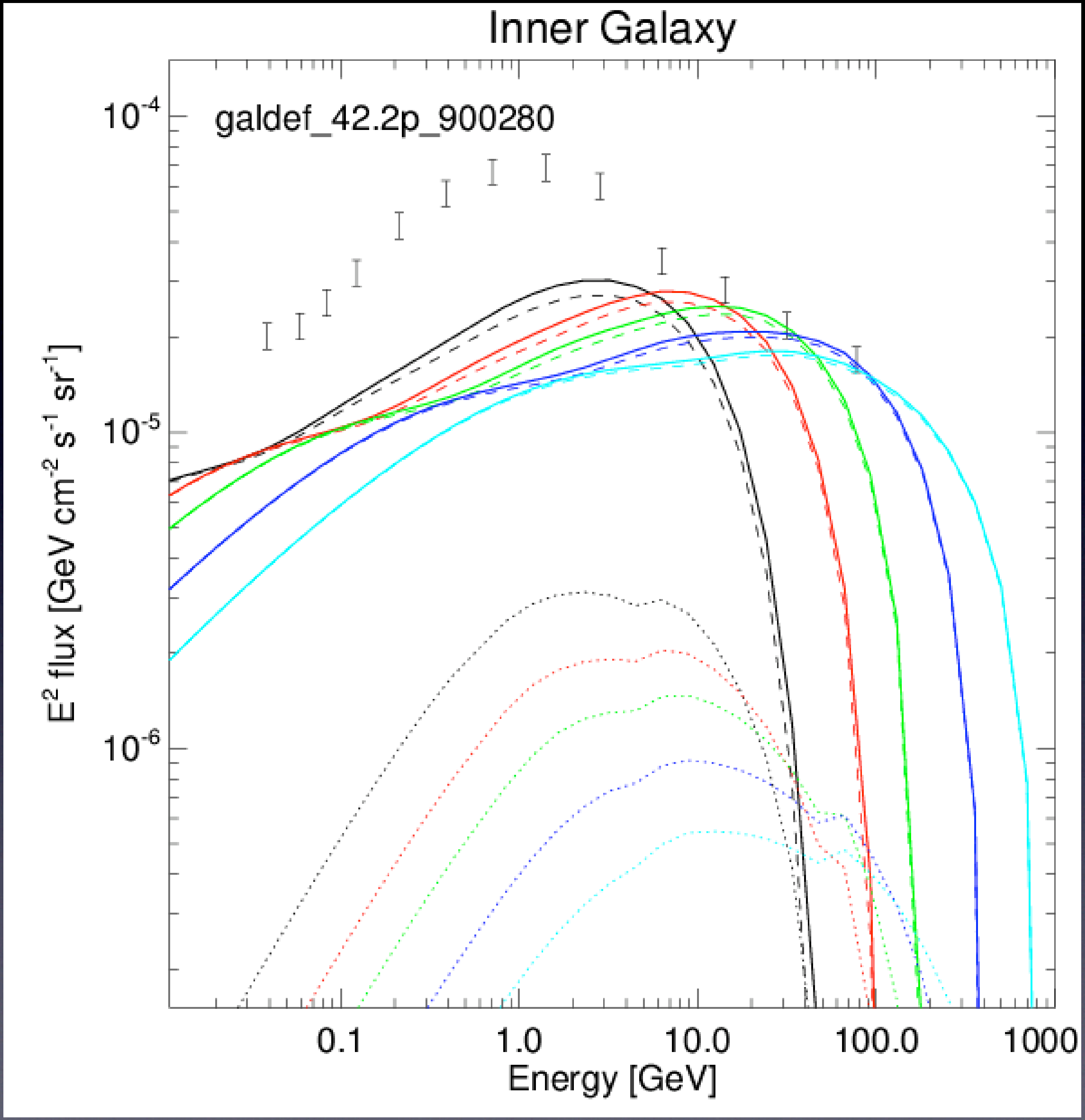


FIG. 2: The specific intensity of microwave emission in the 22 GHz WMAP channel as a function of the angle from the Galactic Center, compared to the synchotron emission from the annihilation products of a 100 GeV WIMP annihilating to e^+e^-. In the upper frame, our default diffusion parameters have been used. The solid line denotes the choice of an NFW halo profile, while the dashed line is the result from a profile with a somewhat steeper inner slope, with $\rho(r) \propto r^{-1.2}$. In the lower frame, we have used an NFW profile with our default propagation parameters (solid), and with a smaller diffusion zone with $L = 2$ kpc (dashes), and a longer energy loss time of $\tau(1\,\text{GeV}) = 4 \times 10^{15}$ s (dotted).

Hooper, Finkbeiner, & Dobler (2007)



GALPROP runs with electrons ONLY.

Inverse Compton dominates.

Cutoff determined by KN limit.

Padmanabhan & Finkbeiner in prep.

The same electrons required to produce the WMAP "haze" excess would produce the EGRET ~10 GeV excess.

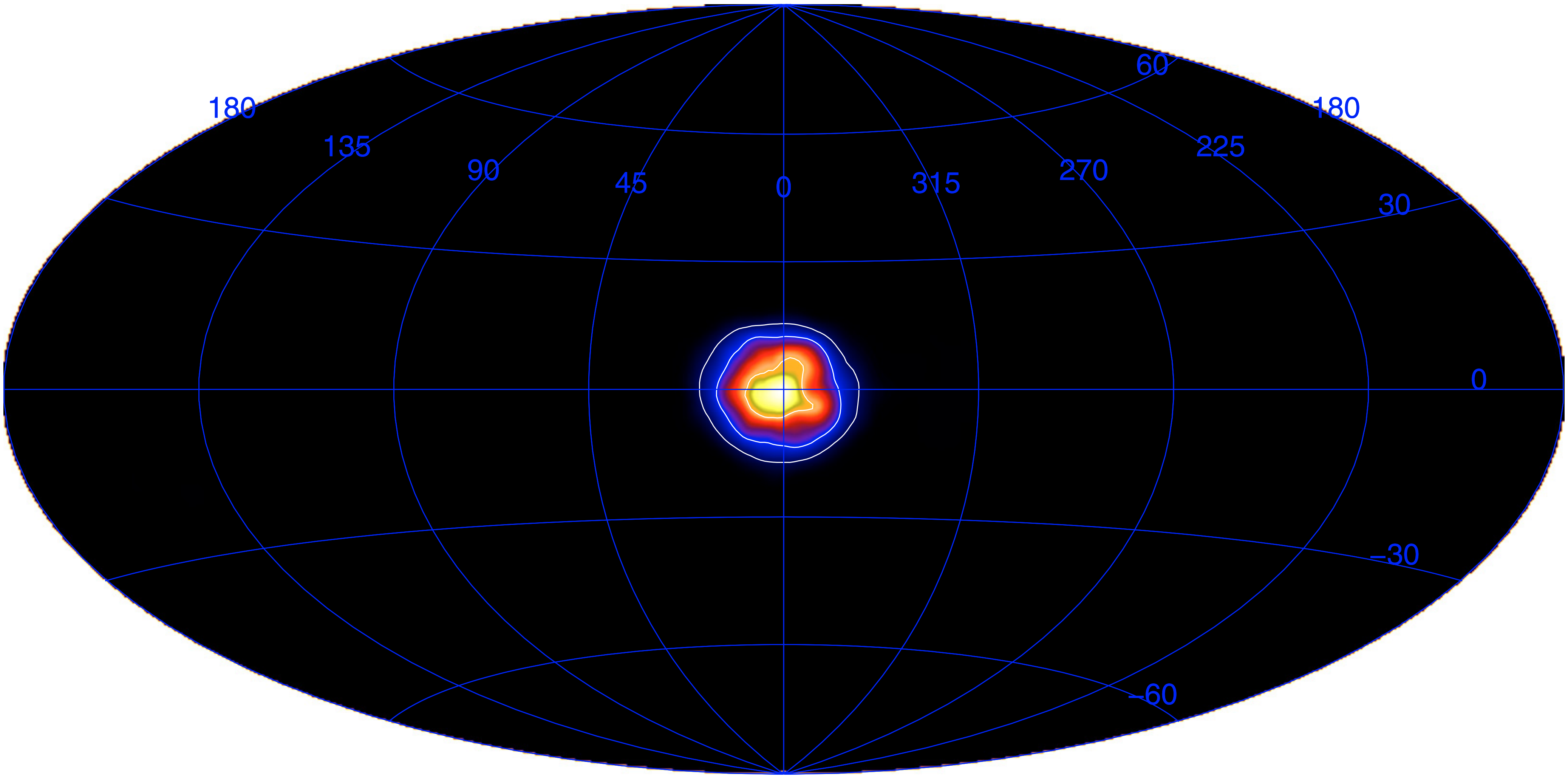
Confirmation of the EGRET spectrum of the inner Galaxy by GLAST would be very strong evidence of a peculiar (hard) electron spectrum in the inner Milky Way.

What has this to do with DM annihilation?

The Exciting Dark Matter (XDM) model (Finkbeiner & Weiner 2007) was engineered to explain the 511 keV positronium excess in the center of the Milky Way with *inelastic* DM scattering.

(2006)

G. Weidenspointner et al.: The sky distribution of positronium continuum emission



XDM WIMPs annihilate through a light chargeless boson, and so annihilate almost purely to e+ e- with very few direct gammas.

May not interact with SM particles at all.

It's possible that WIMPs would only be detected through their contribution to e+ e- spectrum.

Conclusions:

It is likely that GLAST will yield information about WIMPs.

It may not do it in the ways we are thinking about.

Either way, GLAST makes a critical contribution to the search for WIMP annihilation.

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Exciting Dark Matter and the INTEGRAL/SPI 511 keV signal

Douglas P. Finkbeiner (CfA), Neal Weiner (CCPP, NYU)

(Submitted on 21 Feb 2007 (v1), last revised 10 May 2007 (this version, v3))

We propose a WIMP candidate with an ``excited state'' 1-2 MeV above the ground state, which may be collisionally excited and de-excites by e+e- pair emission. By converting its kinetic energy into pairs, such a particle could produce a substantial fraction of the 511 keV line observed by INTEGRAL/SPI in the inner Milky Way. Only a small fraction of the WIMPs have sufficient energy to excite, and that fraction drops sharply with galactocentric radius, naturally yielding a radial cutoff, as observed. Even if the scattering probability in the inner kpc is << 1% per Hubble time, enough power is available to produce the ~3x10^42 pairs per second observed in the Galactic bulge. We specify the parameters of a pseudo-Dirac fermion designed to explain the positron signal, and find that it annihilates chiefly to e+e- and freezes out with the correct relic density. We discuss possible observational consequences of this model.

Comments: 11 pages; v2 references added; v3 updated model to allow for single excitations and calculation of single excitation cross section; updated halo profiles; references added; conclusions unchanged
Subjects: Astrophysics (astro-ph); High Energy Physics - Phenomenology (hep-ph)
Cite as: arXiv:astro-ph/0702587v3

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