

Models of the Galactic Center Excess

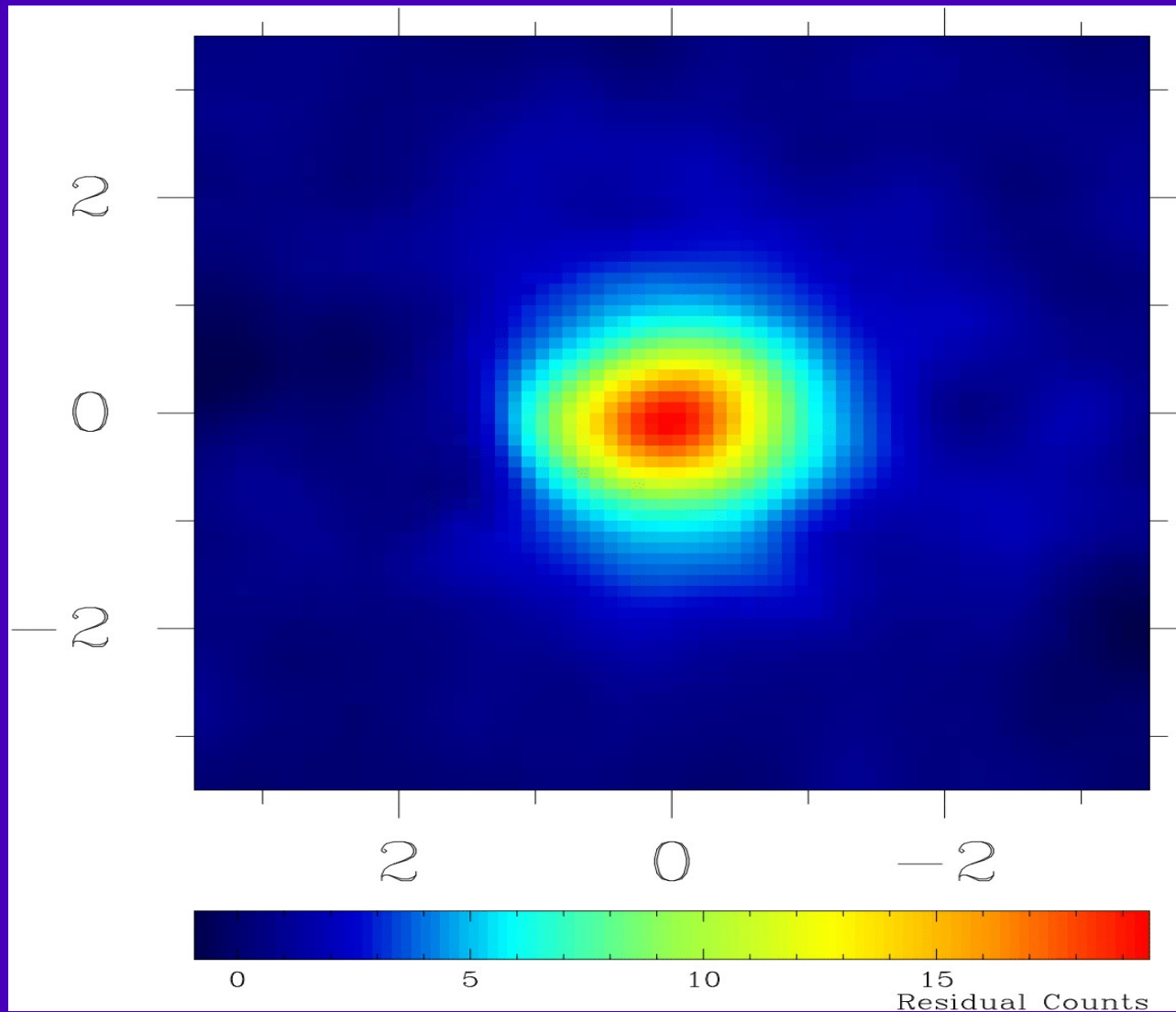
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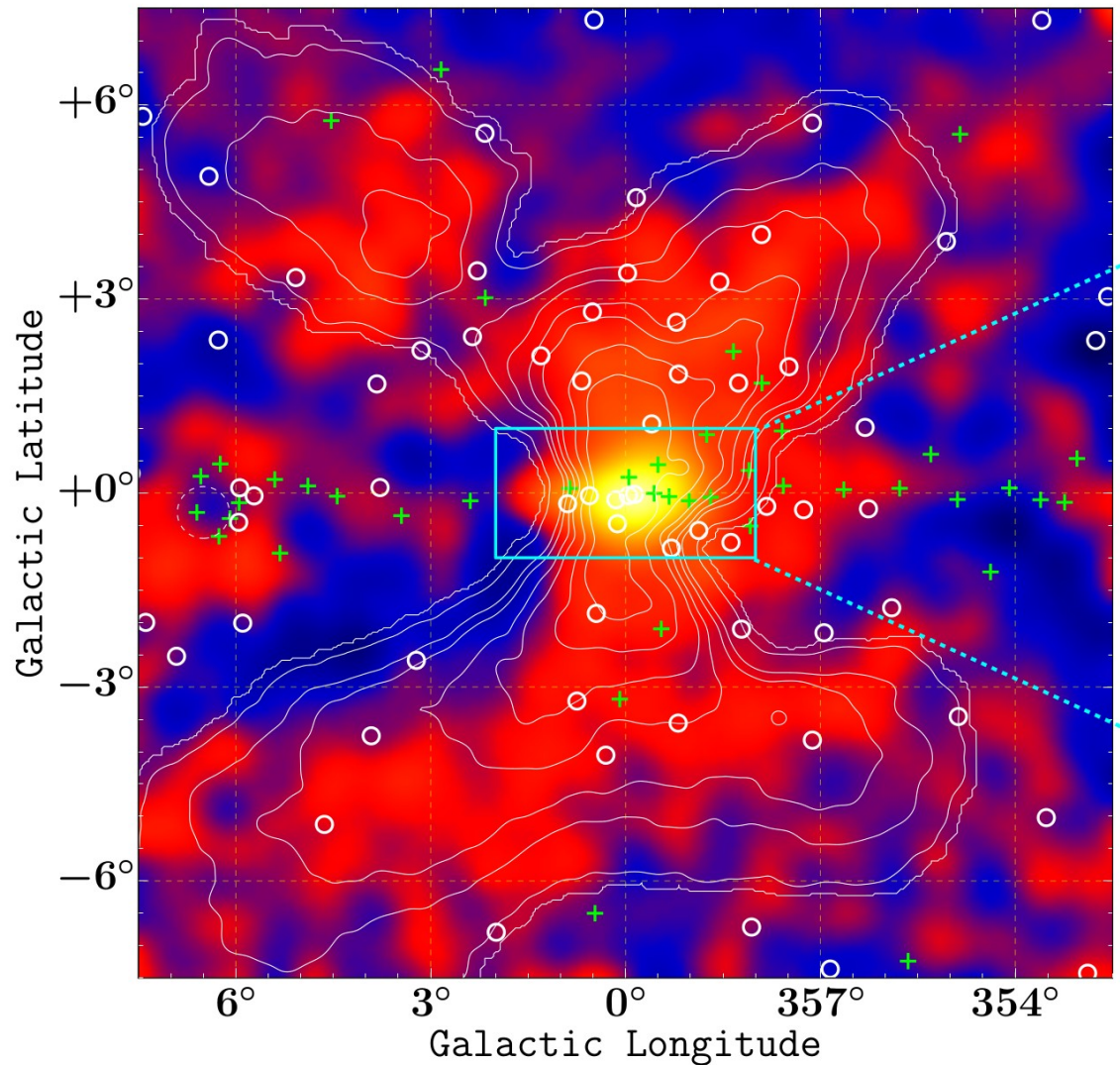


[Github.com/rekeeley/GCE_errors](https://github.com/rekeeley/GCE_errors)

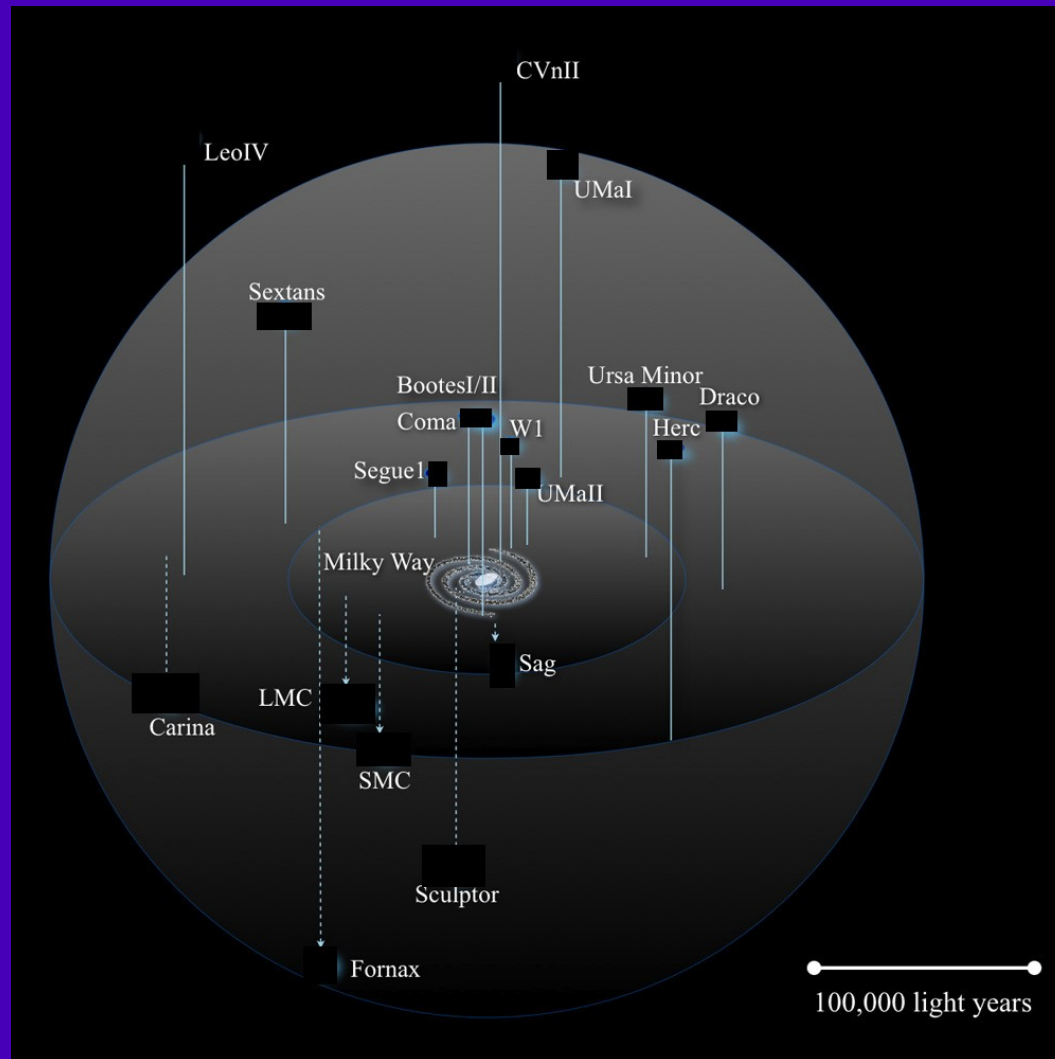
Dark Matter?



X-shape?

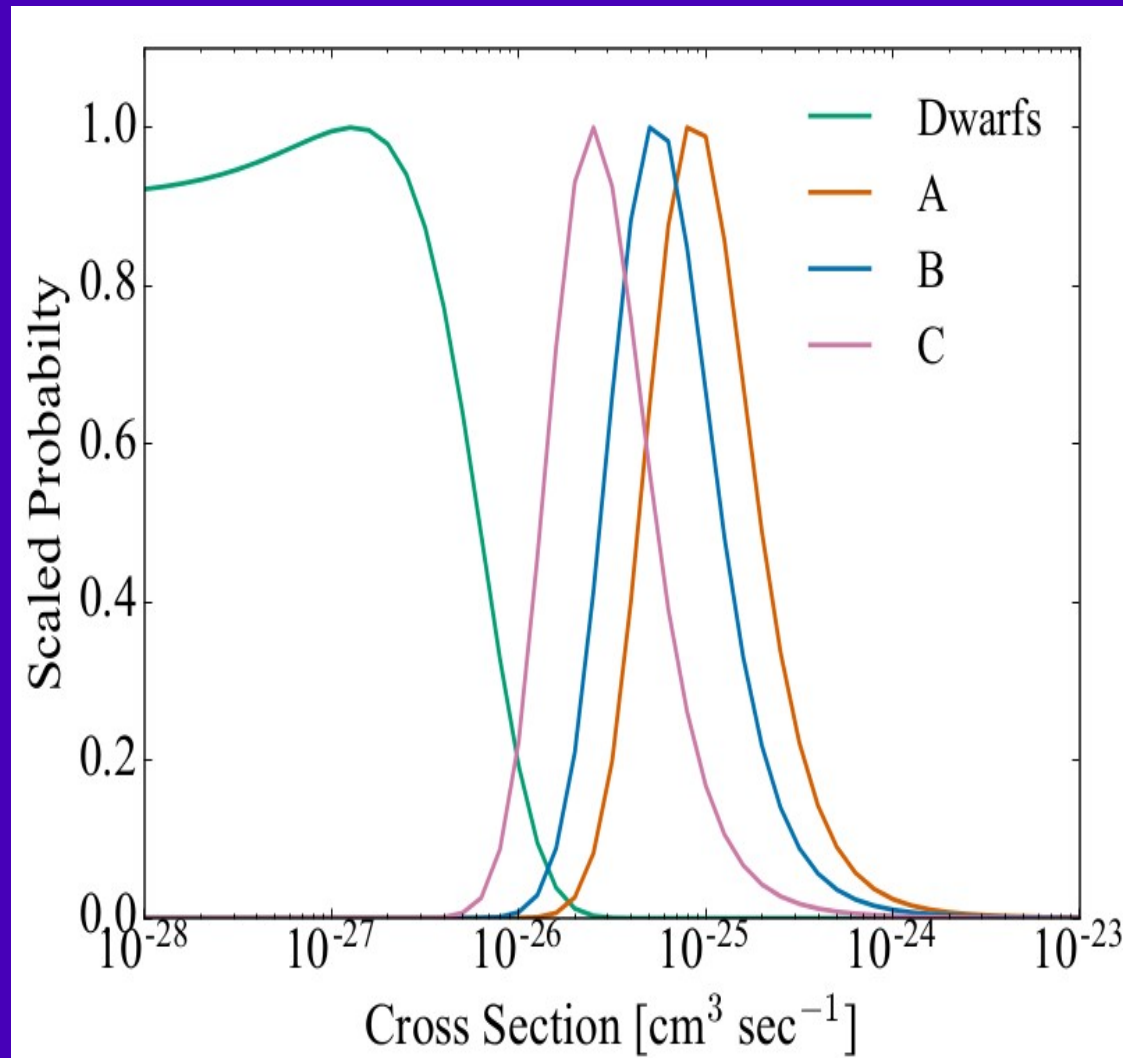
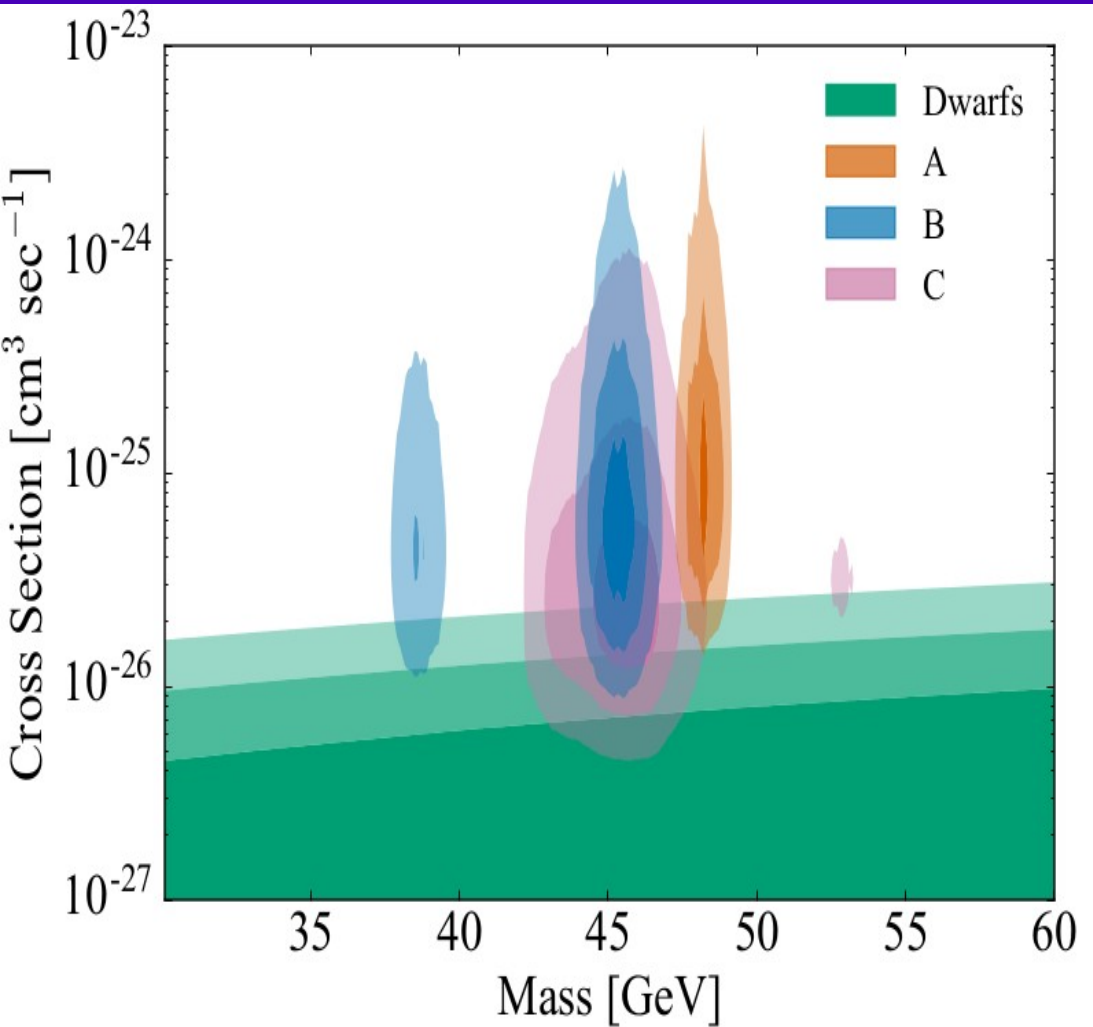


Dim Dwarf Galaxies



- J. Bullock, M. Geha, R. Powell

Tension



Evidence Ratios

$$\begin{aligned} ER &= \frac{E(D_1)E(D_2)}{E(D_1, D_2)} \\ &= \frac{\int d\theta_1 P(D_1|\theta_1)P(\theta_1) \int d\theta_2 P(D_2|\theta_2)P(\theta_2)}{\int d\theta P(D_1, D_2|\theta)P(\theta)} \end{aligned}$$

- ✓ For A,B,C cases, WIMP annihilation to $b\bar{b}$ yields $ER = 2200, 260, 20$ (Definitive to Moderate)

Tension Points to New Models: Astrophysics

$$\frac{d\Phi}{dE} = \frac{\dot{N}}{4\pi R^2} \frac{M_*}{M_\odot} \frac{dN}{dE}$$

✓ Evidence ratio ~ 1

$$GCE \rightarrow 3 \times 10^{32} \text{ s}^{-1} M_*^{-1}$$

Consistent with known MSPs

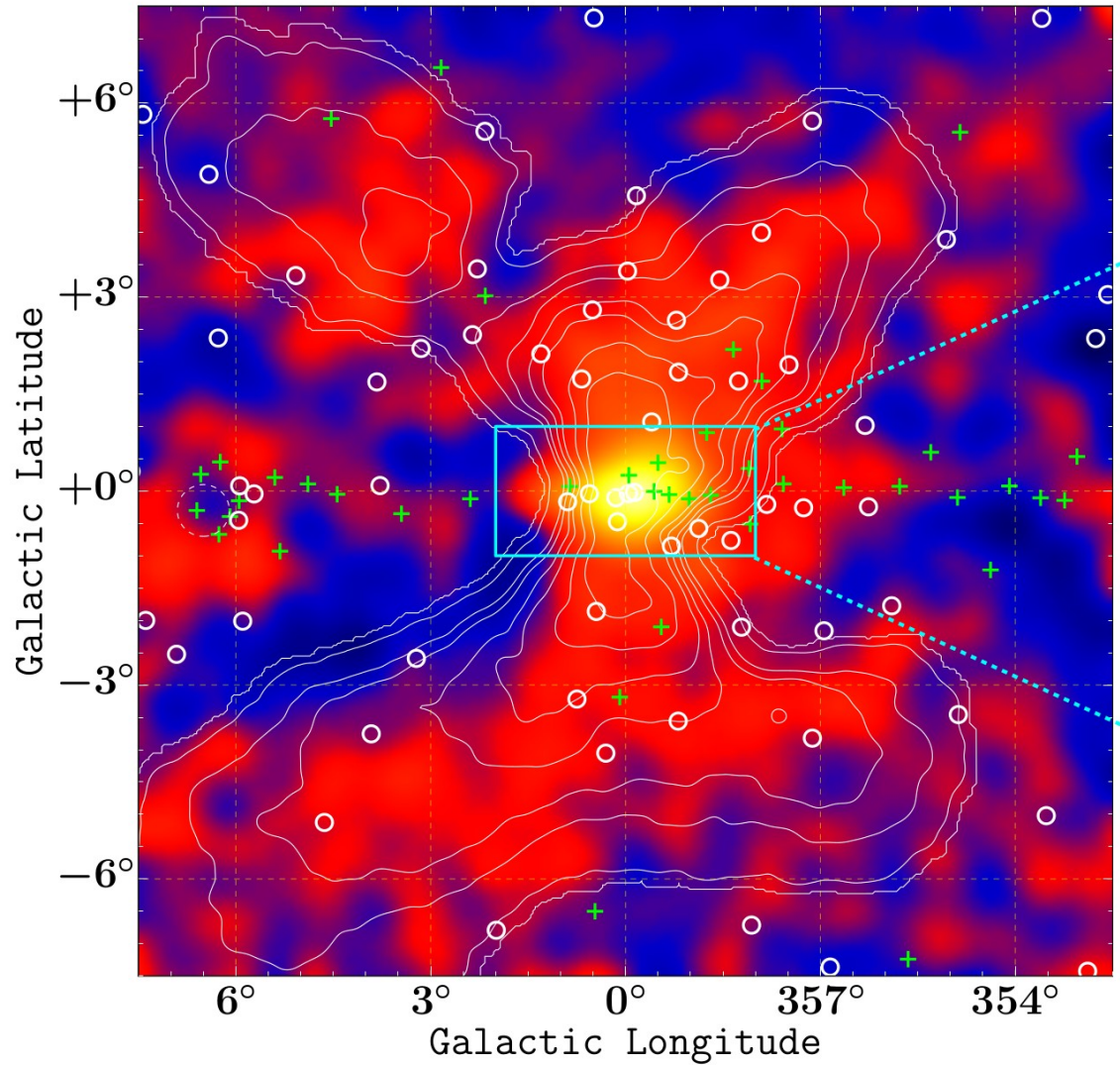
Tension Points to New Models: SIDM & IC

- ✓ Dark matter annihilates to a light mediator particle
- ✓ The light mediator kinetically mixes to standard model leptons
- ✓ The electrons from this annihilation up-scatter starlight to produce the GCE
- ✓ No starlight in the dwarfs means no IC photons
- ✓ Final state radiation, even suppressed by fine structure constant, dominates

Tension Points to New Models: SIDM & IC

- ✓ To avoid AMS bounds, the electrons have to come from the decay of a light mediator which naturally leads to the rich phenomenology of SIDM
- ✓ Potential constraints from BBN, CMB, Reionization...
- ✓ These constraints are dependent on assumptions about the thermal history of the visible and dark sectors and about the strength of the kinetic mixing

X-shape

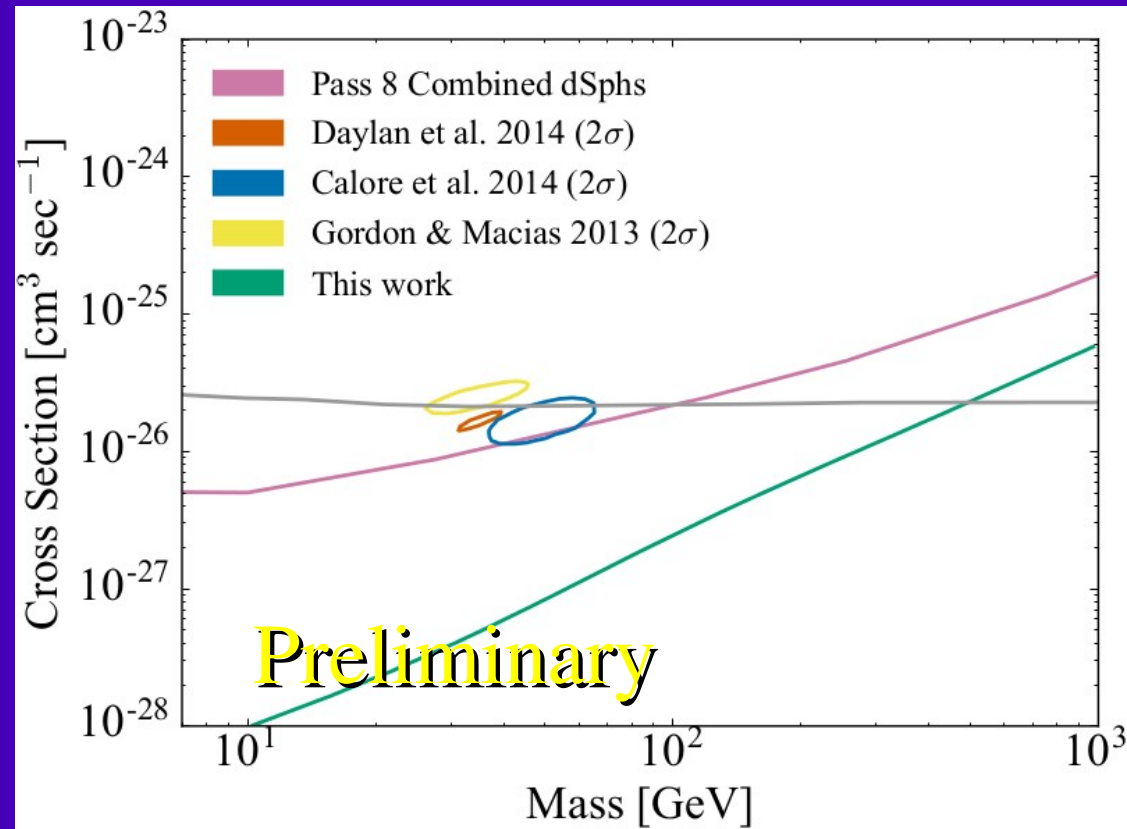
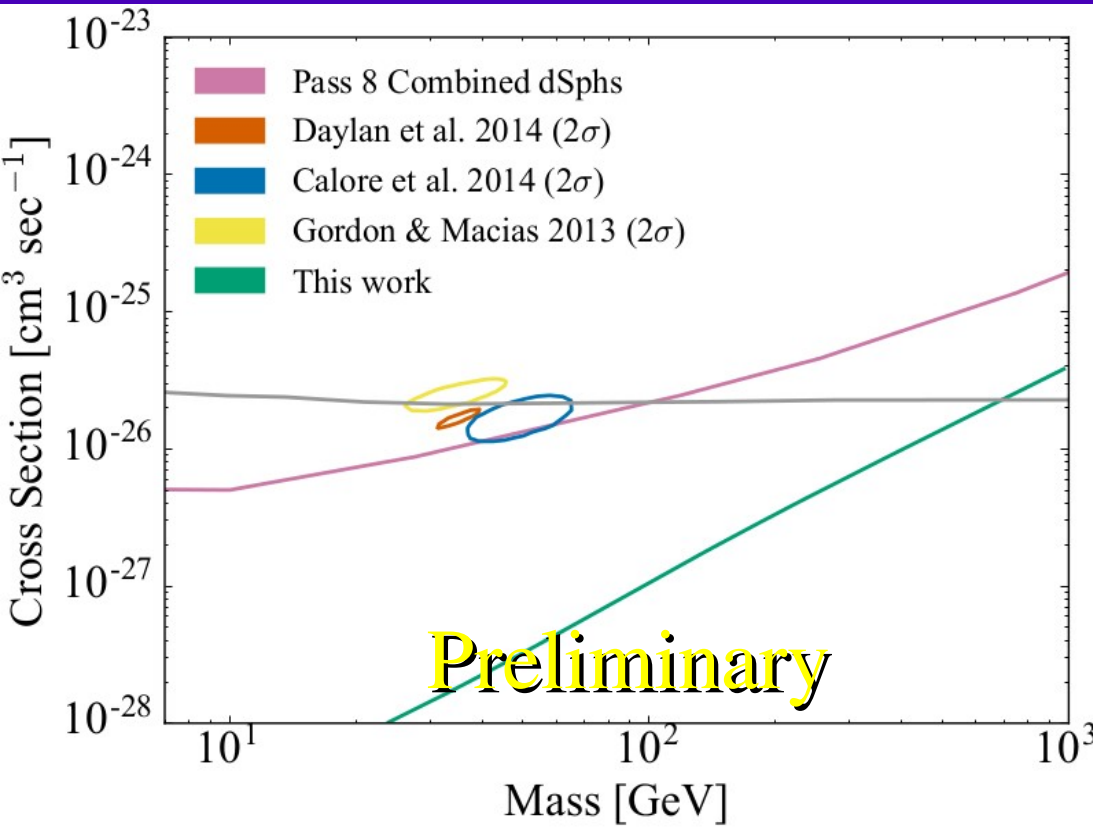


Limits

- ✓ Same template based likelihood techniques
- ✓ “X-shape” template detected – points to astrophysics
- ✓ Accounts for entirety of GCE. Fit prefers essentially no amount of NFW template
- ✓ Allows us to put robust constraints on dark matter interpretation.

Limits

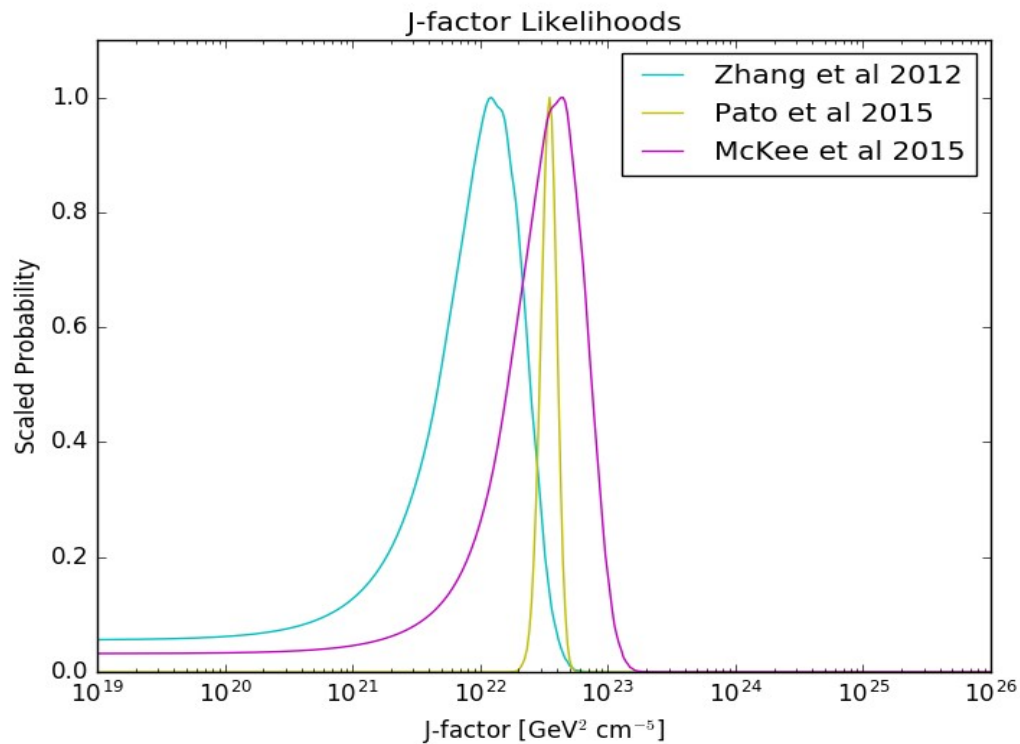
- ✓ 10-100 times stronger in cross section
- ✓ 5-7 times stronger in mass along thermal relic line



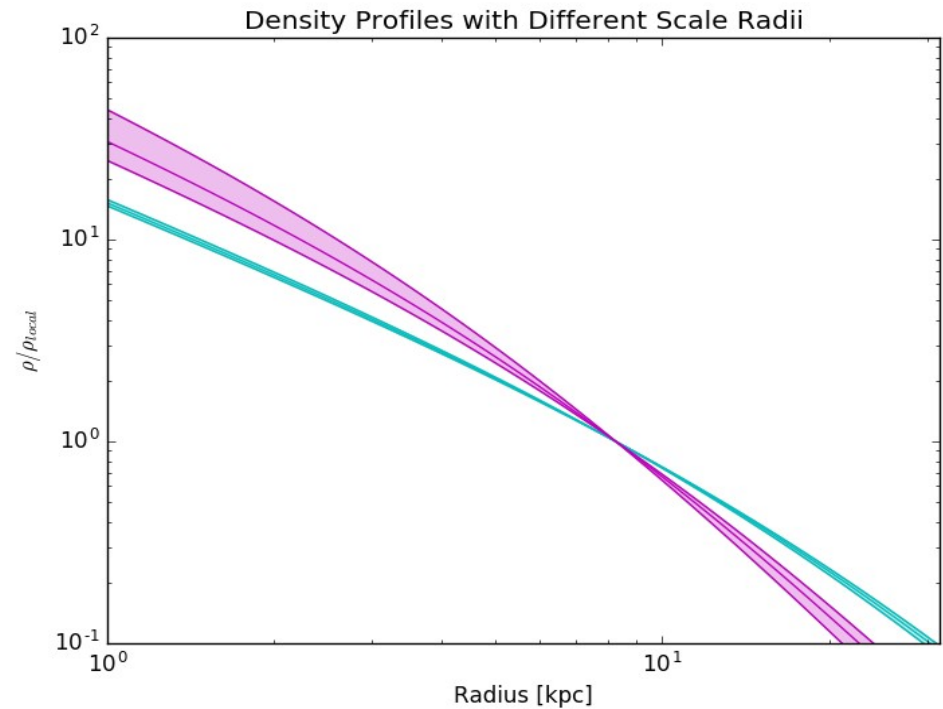
Summary

- ✓ An 11-30 sigma excess of photons towards the Galactic Center
- ✓ Tension with a lack of signal in the dwarfs
- ✓ “X-shape” template preferred over NFW template
- ✓ Both of these point to an astrophysical interpretation of the GCE.

Relieving the Tension: J-factor



✓ New Gaia results may push the local density even higher



✓ J-factor must change by >1 order of magnitude

Relieving the Tension: J-factors

- ✓ J-factors for the dwarfs are also unknown
- ✓ Systematics / assumptions can change the inferred values by an order of magnitude or more
- ✓ More correct analysis tend to push up the values of the J-factors, which pushes down the inferred best fit cross section, making the tension with the GCE worse

Relieving the Tension: Models

- ✓ At the energies where the GCE dominates, the uncertainties in the astrophysical backgrounds are small and can be ignored. Systematics tend to shift the best fit mass, but do not alter the best fit cross section significantly
- ✓ This tension cannot be resolved just from novel dN/dE
- ✓ If attempting to relieve the tension through different dark matter physics, it has to go beyond $\chi\chi \rightarrow \gamma\gamma$

List of Dwarfs

Dwarf J-factor priors