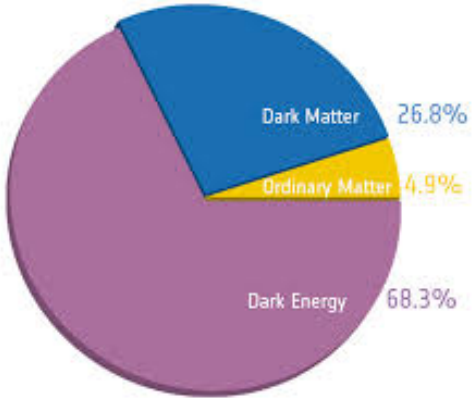
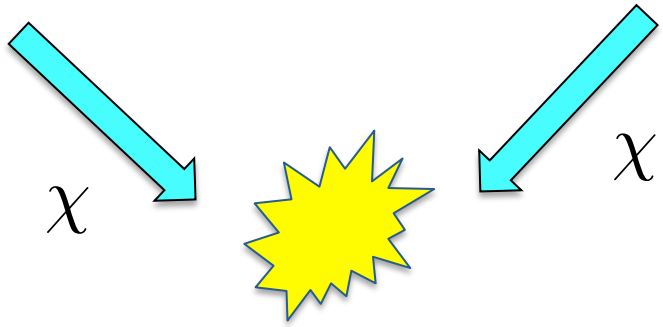
What is the particle nature of Dark Matter?



Some questions:

- How do forecasts on Dark Matter annihilation change when including a realistic model of foregrounds?
- How much can we tighten the constraints on DM annihilation by adding prior information on the scalar amplitude?
- What other dark matter scenarios can we learn about from the CMB? (baryon/dark matter interactions, a complex dark sector, dark matter scattering with neutrinos, other models?)
- What are the degeneracies with other non-standard cosmological parameters (i.e., N_{eff})?

WIMP Dark Matter Annihilation



$$W^{\pm}, Z, b\bar{b}, h$$

FINAL PRODUCTS

$$p\bar{p}, \nu\bar{\nu}, e^{\pm}, \gamma$$

Energy Injection in the CMB

FINAL PRODUCTS

$$p\bar{p}, \nu\bar{\nu}, e^{\pm}, \gamma$$

- **Heat the plasma**
- **Ionize neutral hydrogen**
- **Excite H atoms**

Shull and van Steenberg, ApJ (1985)
Chen and Kamionkowski, PRD (2004)

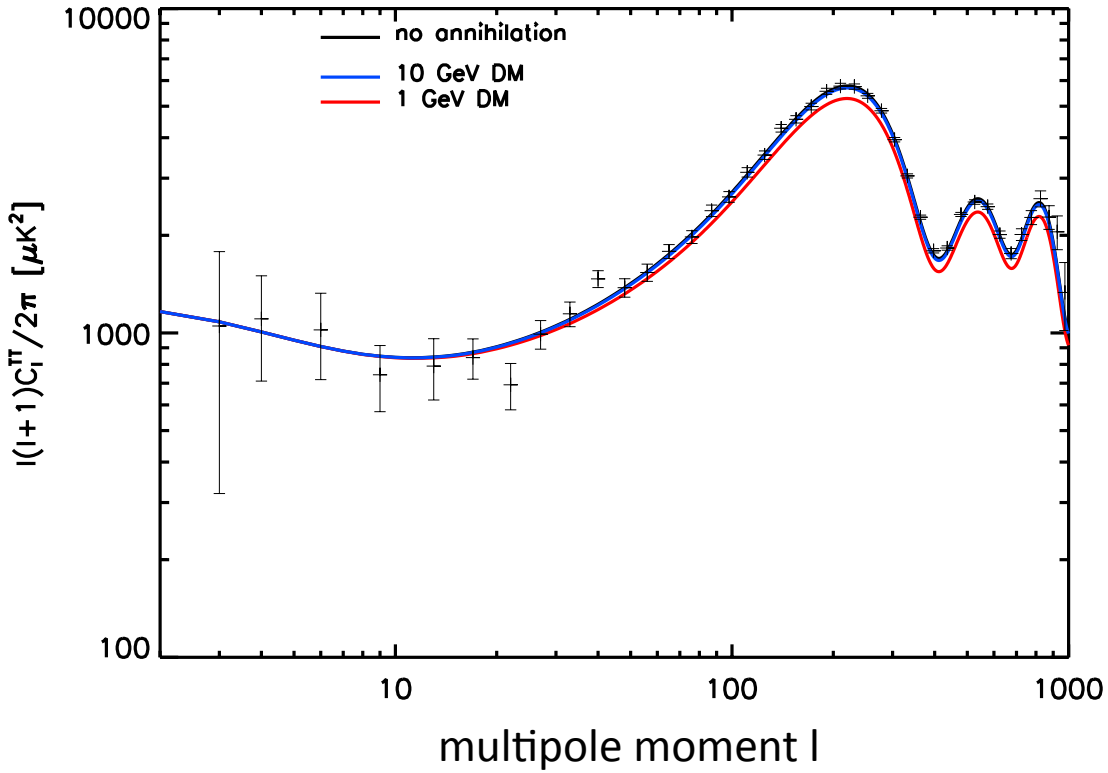
Energy injected into the plasma per unit volume, per unit time:

$$\frac{dE}{dtdV} = \rho_{\chi}^{2} \left[\frac{f(z)\langle \sigma v \rangle}{m_{\chi}} \right]$$

(Majorana particle)

Effect of Dark Matter Annihilation on the CMB Temperature

A higher ionization suppresses the CMB temperature fluctuations.



Degeneracy:

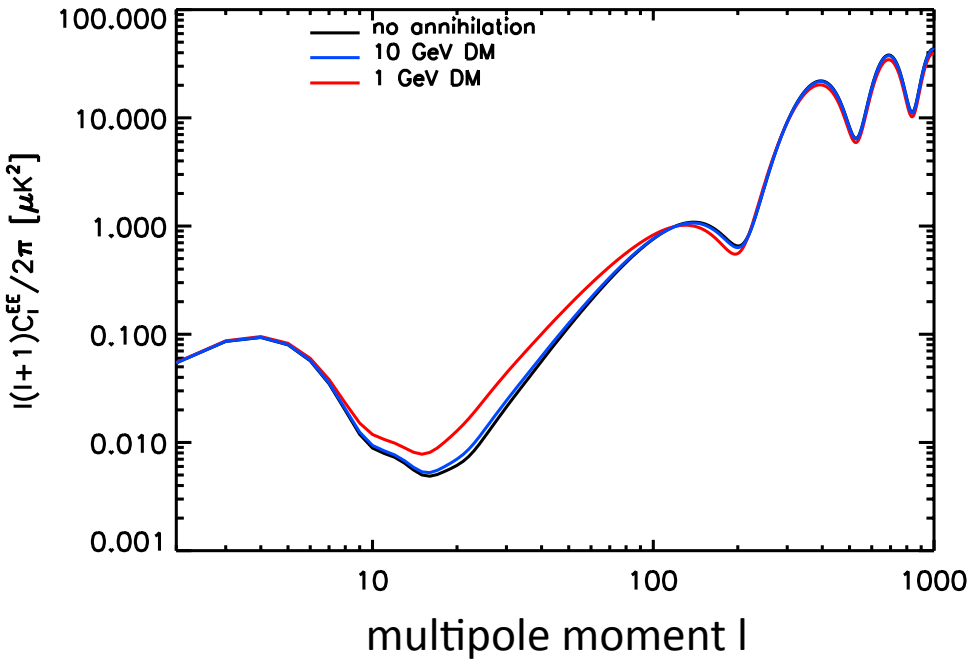
$$C_\ell \to e^{-2\Delta\tau} C_\ell$$

$$A_s \to e^{2\Delta\tau} A_s$$

Padmanabhan and Finkbeiner (2005)

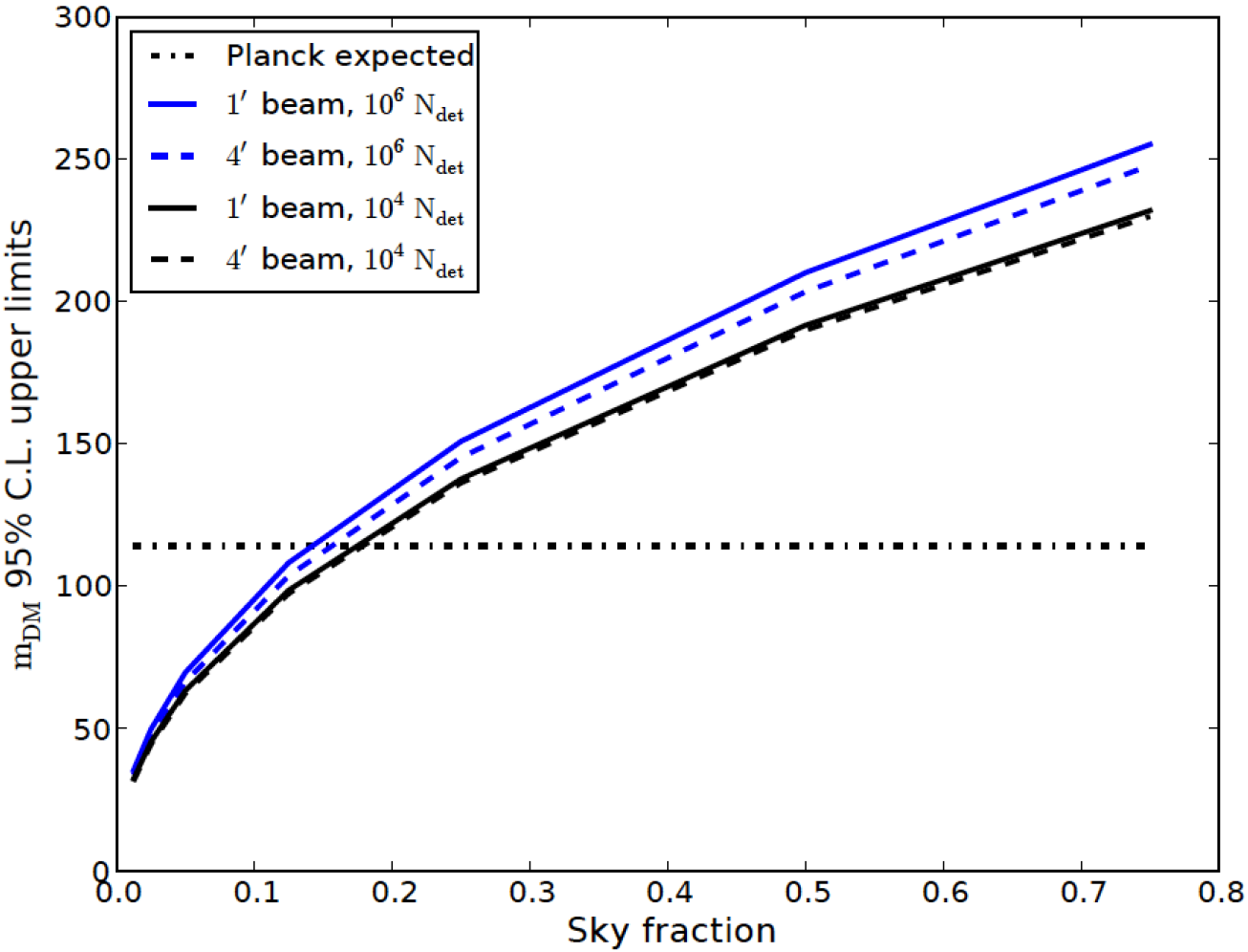
Effect of Dark Matter Annihilation on the CMB Polarization

A higher ionization enhances the polarization fluctuations at large scales.



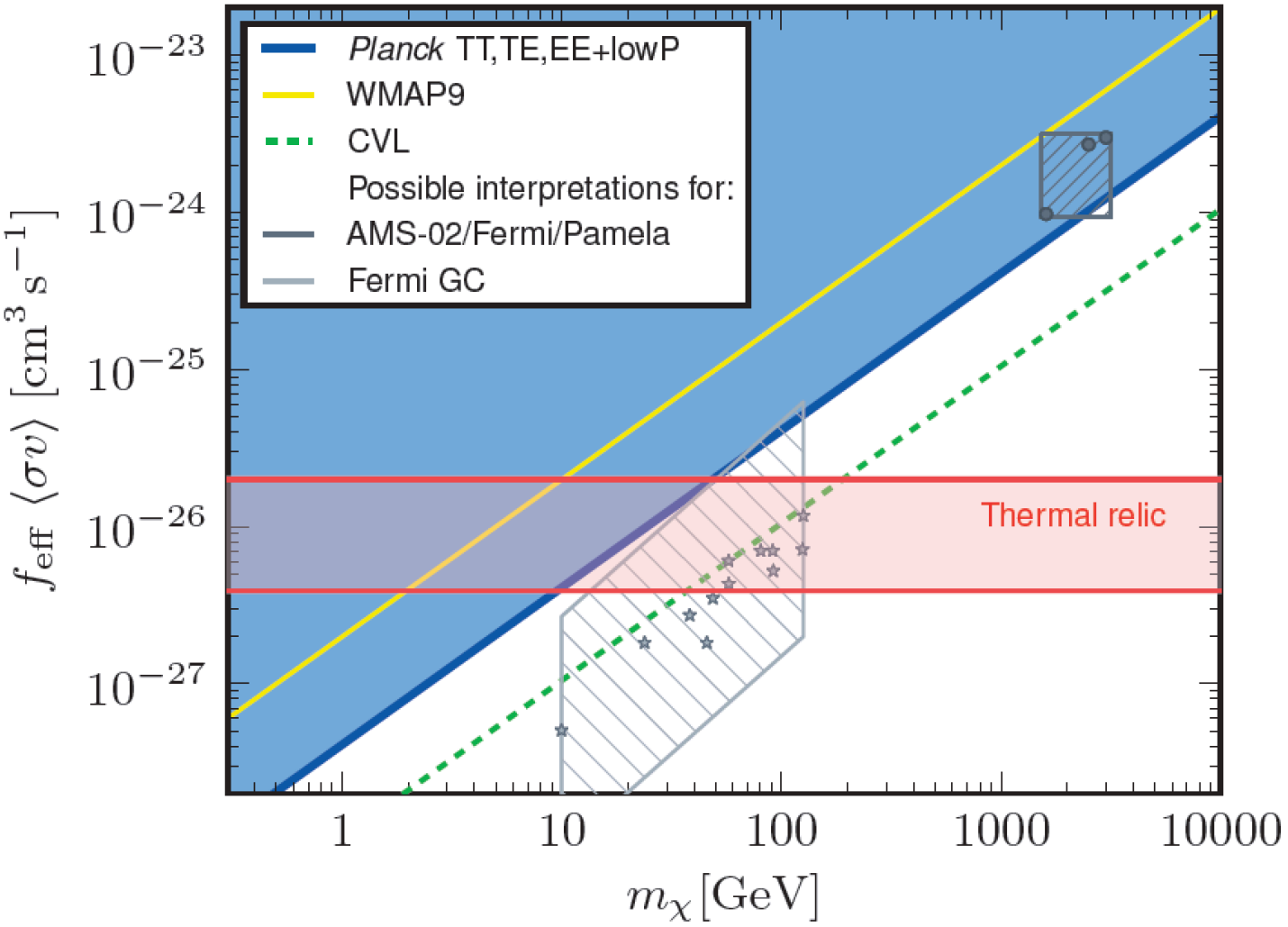
- Screening of the observed spectrum at l>100.
- Re-scattering of photon generates extra polarization at large scales.

WIMP Dark Matter Annihilation



W. Wu, J. Errard, C. Dvorkin, C. L. Kuo, A. Lee, et al., ApJ (2014)

WIMP Dark Matter Annihilation



Planck, paper XIII (2015)

An example of a non-standard model: Dark Matter-Baryon Interactions