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Fermi Gamma-ray Haze via Dark Matter and Millisecond Pulsars

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arxiv:1002.0587

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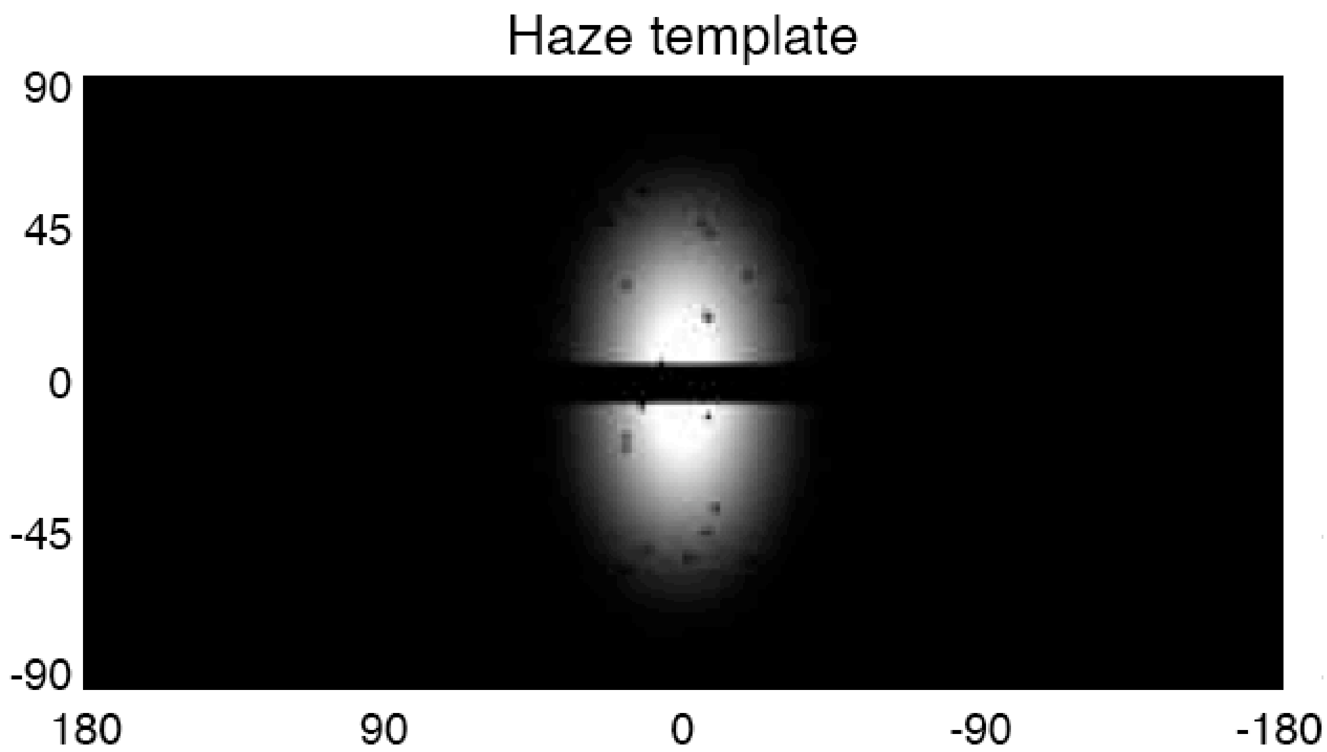
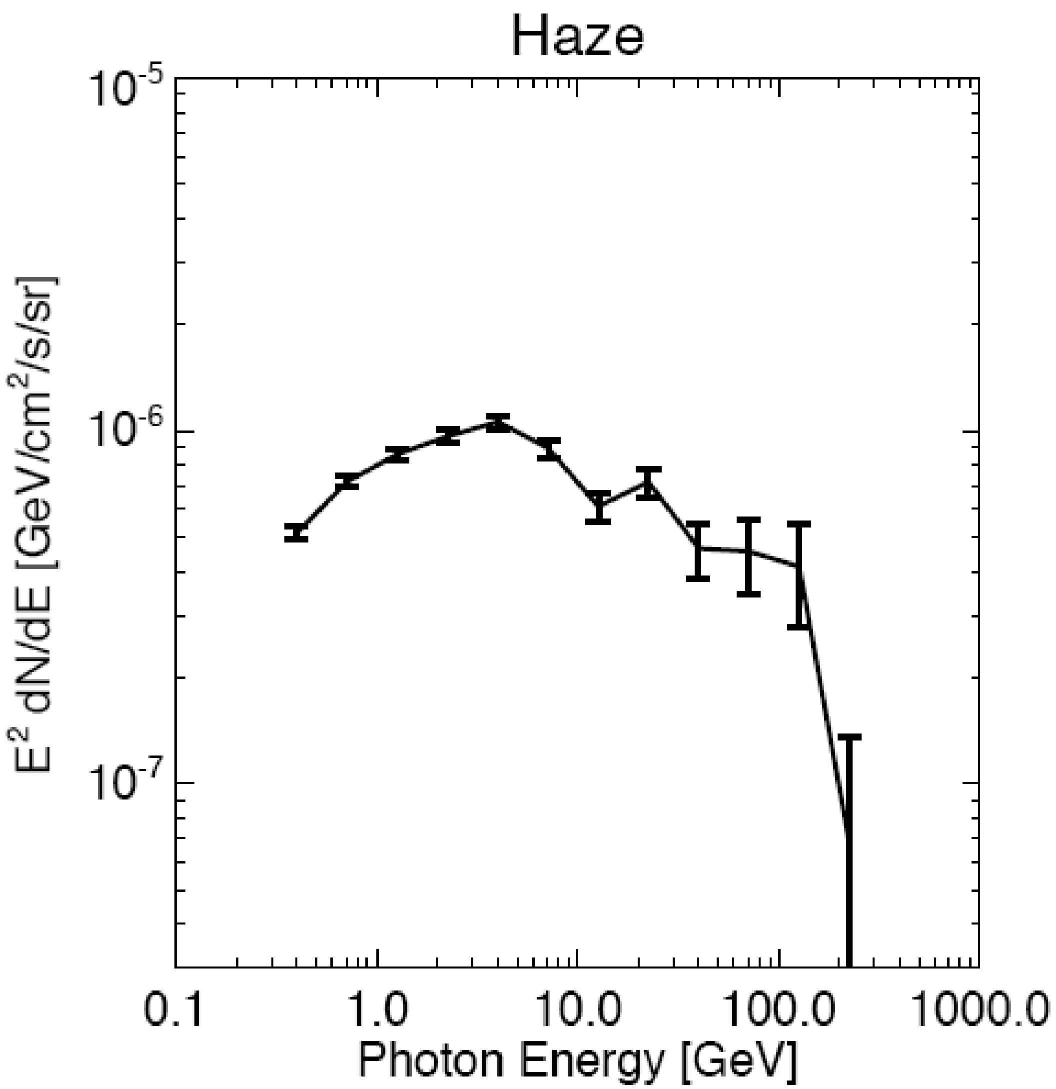
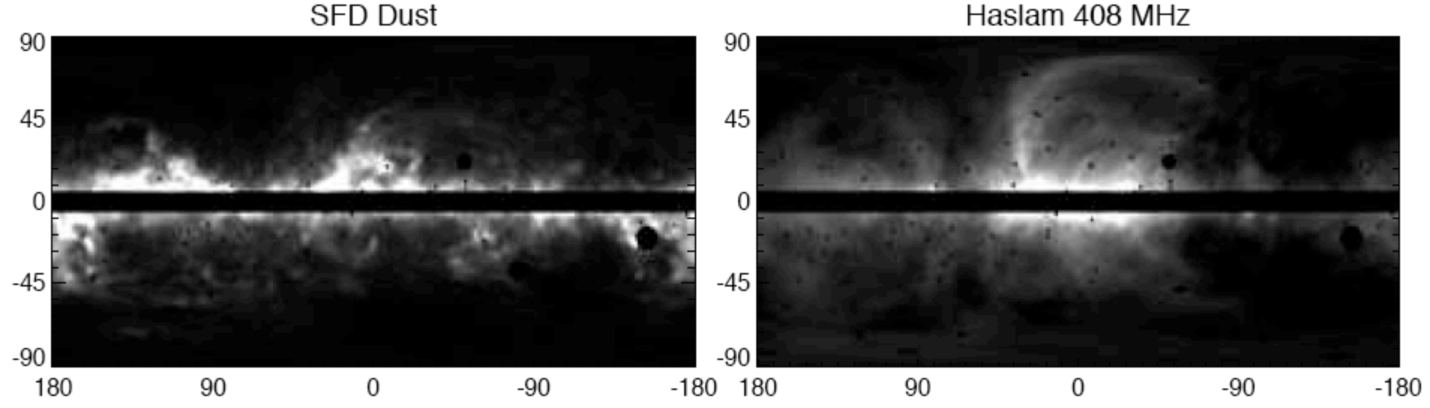
Gamma-ray haze data





Dobler et al. arxiv:0910.4583

This is the gamma-ray overdensity that remains after subtracting these templates



from the *Fermi* data

Possibilities to consider:

1. Dark Matter annihilation
2. IA supernovae electrons
3. Millisecond pulsars pulsed gamma-rays and e+e-

Compare the luminosities in the Milky Way halo

Gamma-ray haze: $\sim 10^{38}\mathrm{erg/s}$

1. Dark Matter

2. IA supernovae

3. Millisecond pulsars

Compare the luminosities in the Milky Way halo

Gamma-ray haze: $\sim 10^{38}\mathrm{erg/s}$

1. Dark Matter: $\sim 2 \times 10^{37}\mathrm{erg/s}$

freeze out cross section $\langle \sigma v \rangle_0 = 3.0 \times 10^{-26}\mathrm{cm}^3\mathrm{s}^{-1}$
mass 300 GeV
Einasto profile
local DM density $\rho_{\mathrm{DM}} = 0.4\,\mathrm{GeV cm}^{-3}$

We need either large boost factors
or prompt gamma-ray emission

Compare the luminosities in the Milky Way halo

Gamma-ray haze: $\sim 10^{38} \mathrm{erg/s}$

1. Dark Matter: $\sim 2 \times 10^{37} \mathrm{erg/s}$

2. IA supernovae: $< 10^{37} \mathrm{erg/s}$

Based on 1A SNe rate in the halo (Sullivan et al. 2006)

$$5 \times 10^{-14}\,\mathrm{yr}^{-1}\,M_{\odot}^{-1}$$

and average SNe output in electrons necessary to account for high energy cosmic rays (Kobayashi et al. 2004)

$$10^{48} \mathrm{erg}$$

Compare the luminosities in the Milky Way halo

Gamma-ray haze: $\sim 10^{38} \mathrm{erg/s}$

1. Dark Matter: $\sim 2 \times 10^{37} \mathrm{erg/s}$

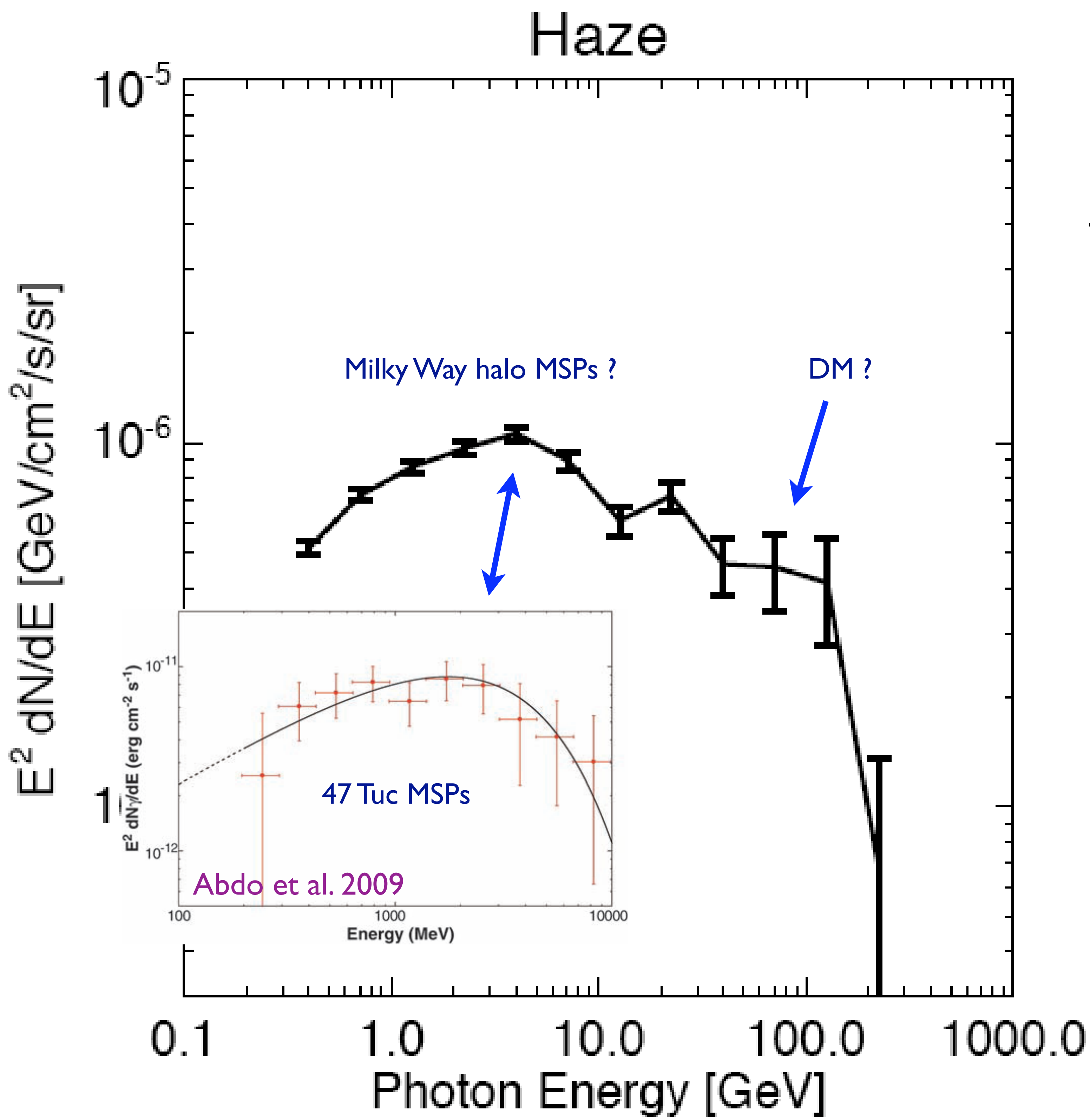
2. IA supernovae: $< 10^{37} \mathrm{erg/s}$

3. Millisecond pulsars: $< 10^{39} \mathrm{erg/s}$

For a population of 50 000 pulsars in the Milky Way halo
with average spin-down luminosity for 8 MSPs observed by *Fermi*
(Abdo et al. 2009)

$$2 \times 10^{34} \mathrm{erg/s}$$

Gamma-ray haze via DM and MSPs



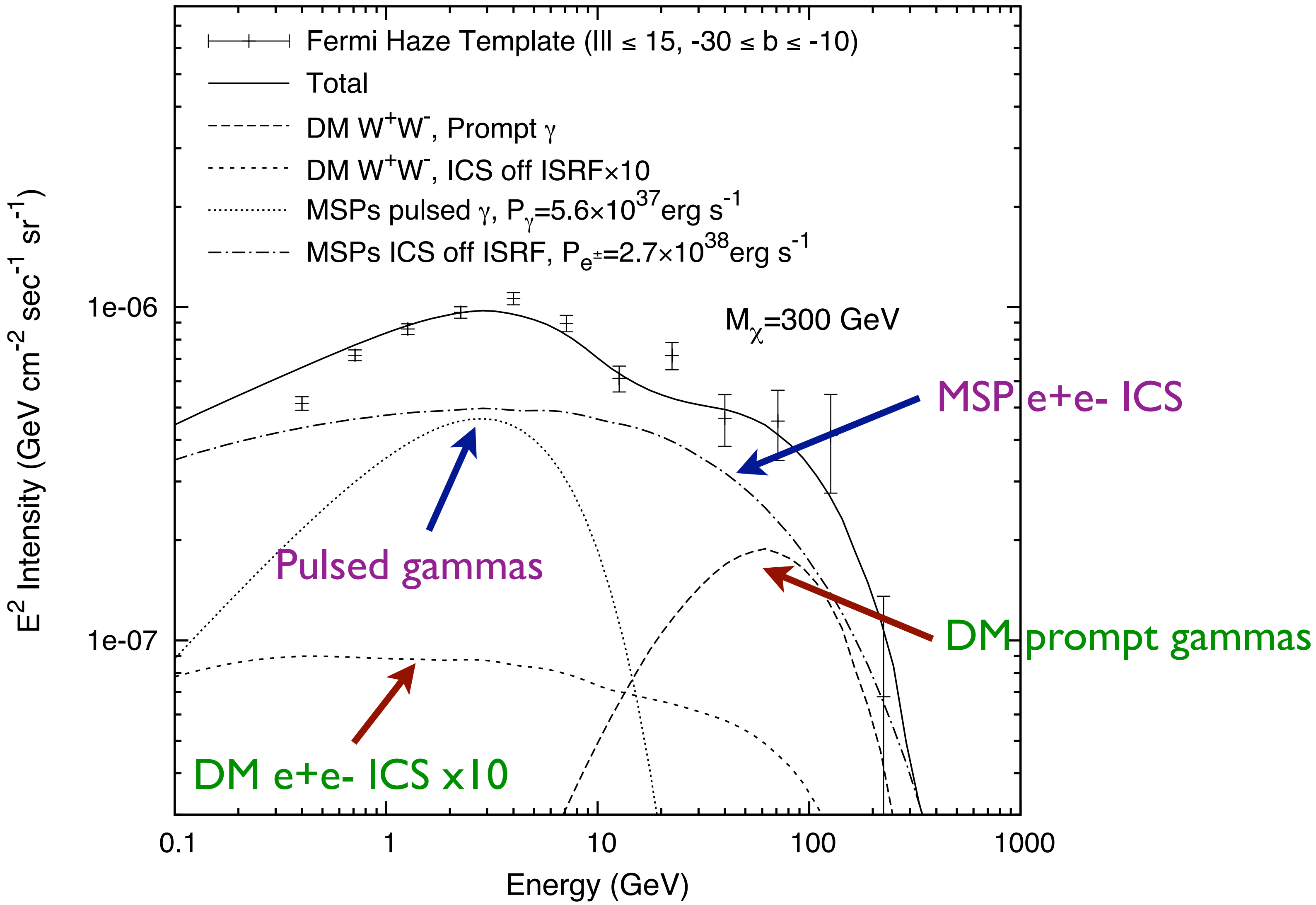
Dobler et al. 2009

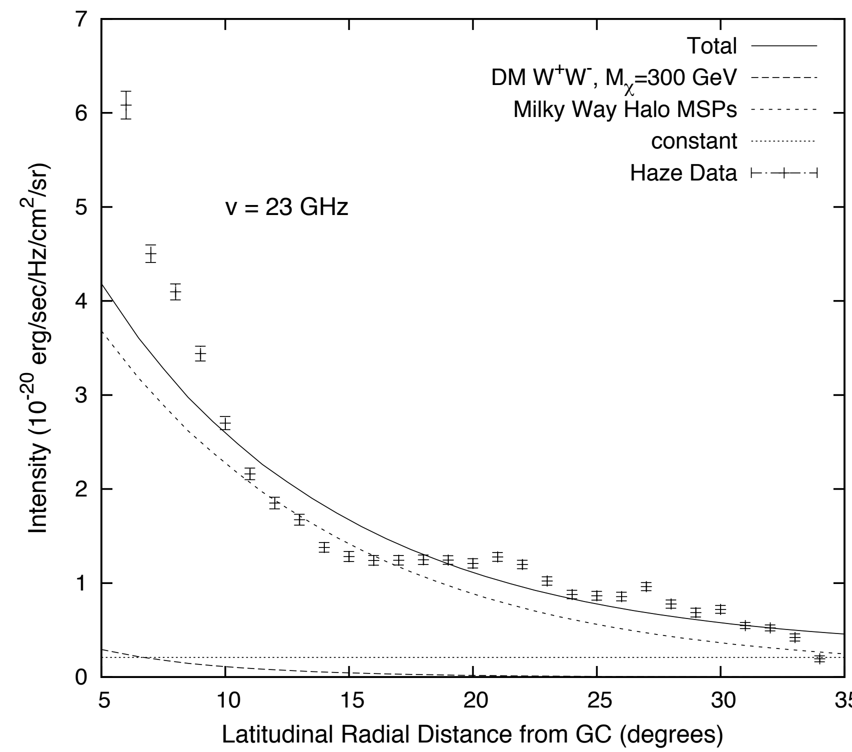
Pulsed gamma-rays from 47 Tuc MSPs are similar to low energy part in the gamma-ray haze spectrum.

Thus we can expect that the low energy part can be explained by a population of MSPs in the Milky Way halo.

The high energy part of the gamma-haze spectrum is more difficult to explain.

Gamma-ray haze via DM and MSPs



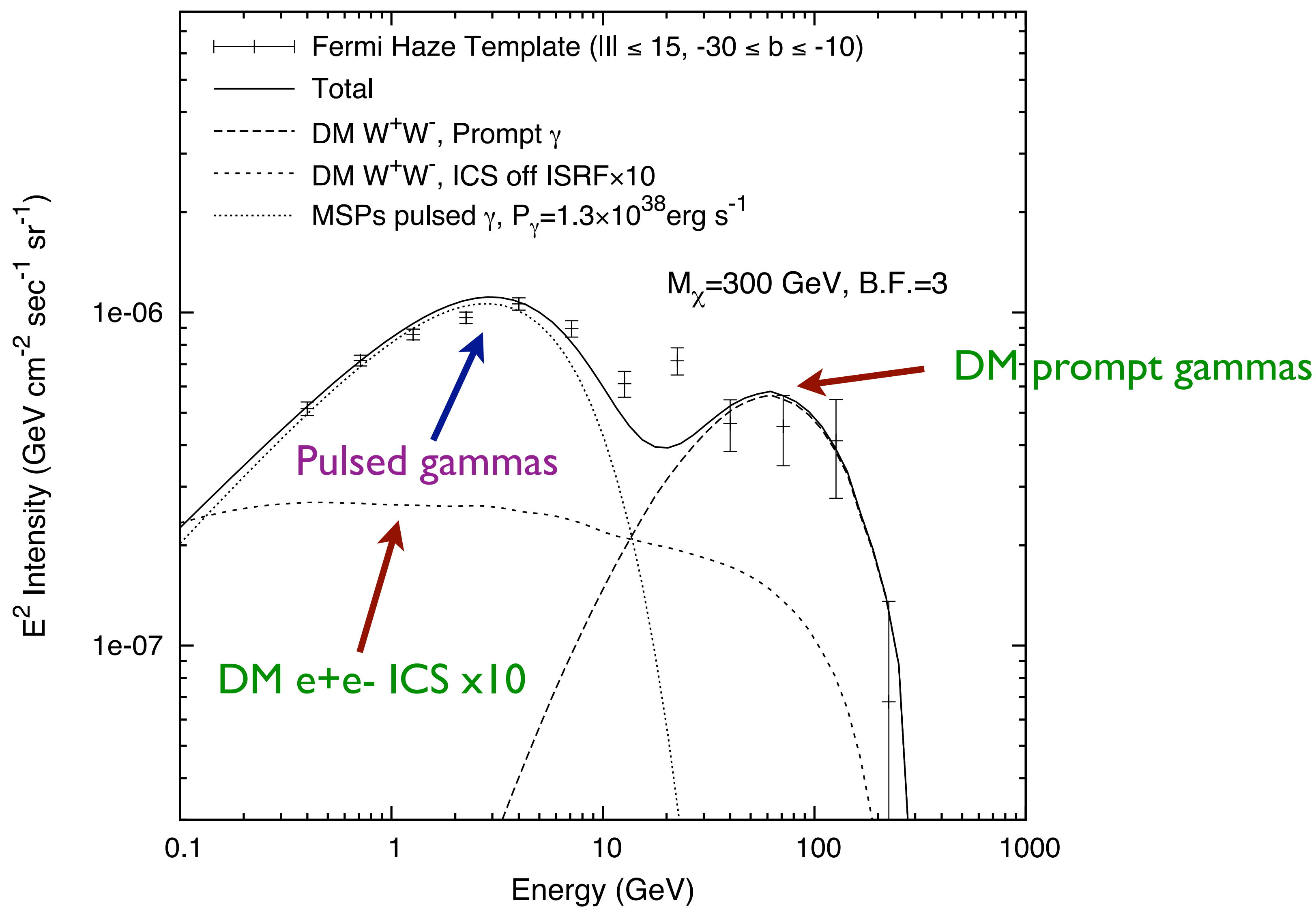


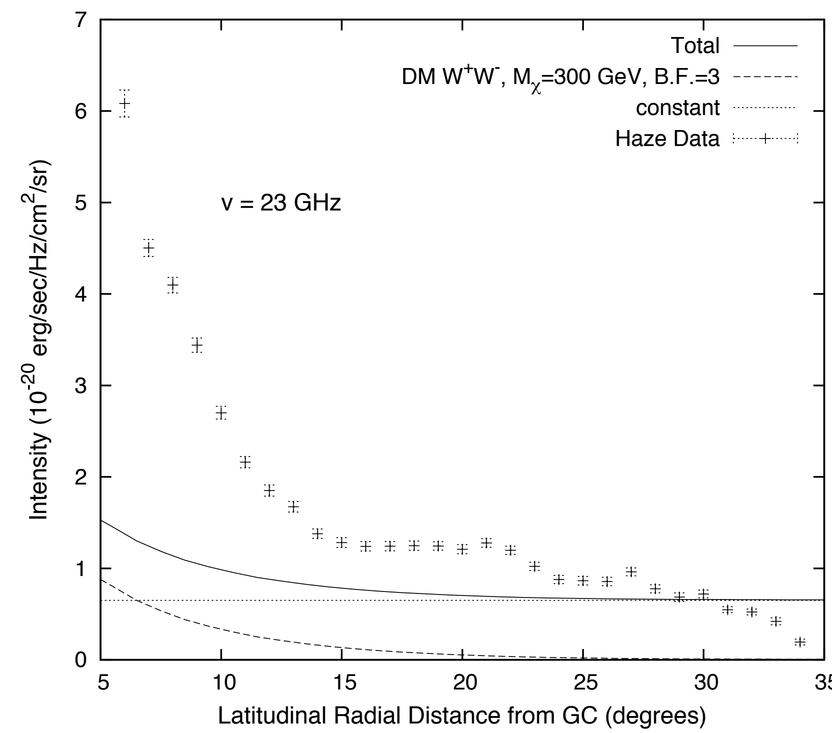
Both gamma-ray haze and WMAP haze are OK

In this model we need 30 000 MSPs in Milky Way halo with average spin-down energy conversion efficiencies

$$\eta_\gamma = 0.1$$
$$\eta_{e^\pm} = 0.5$$

MSPs pulsed gammas and DM to W+W- prompt gammas



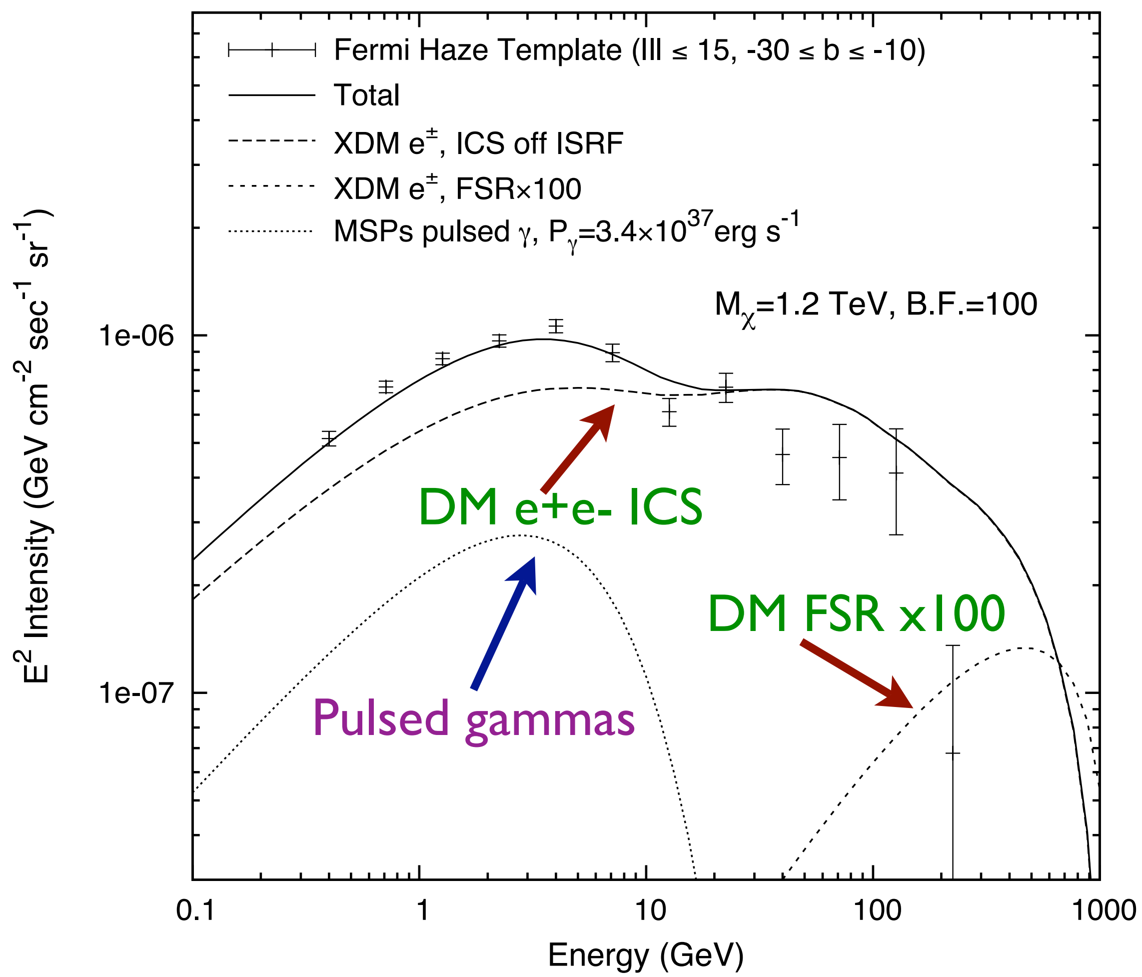


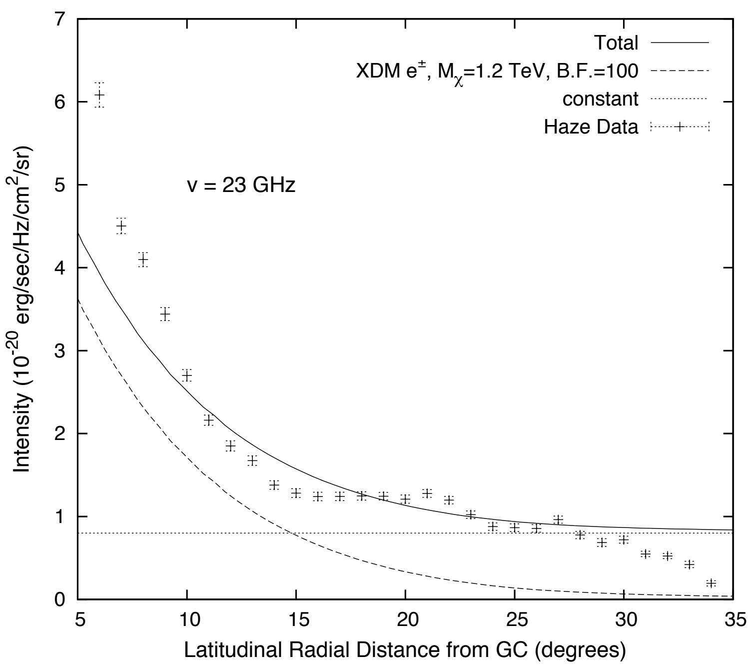
WMAP haze: No

Gamma-ray haze: OK with DM BF = 3

Here we need 60 000 MSPs in Milky Way halo with $\eta_\gamma = 0.1$

MSPs pulsed gammas and DM e+e- annihilation





WMAP haze: OK

Gamma-ray haze: OK with DM BF = 100

In this case we need 20 000 MSPs in Milky Way halo with $\eta_\gamma = 0.1$

Conclusions

1. In DM models with one type of DM particles we need an astrophysical source of gamma-rays in the Milky Way halo

2. Millisecond pulsars is the most plausible such source

3. We need about 20 000 - 60 000 MSPs in the Milky Way stellar halo.

4. To fit the WMAP haze we need either
   - leptonically annihilating DM with BF ~ 100 or
   - significant e+e- emission from MSPs (about 50% of spin-down)