

Weakly Interacting Massive Particles

Assumptions:

- 1 no $X - \bar{X}$ asymmetry
- 2 @ $T < M_X$ in thermal equilibrium with plasma

$$n_X = n_{\bar{X}}$$

$$n_X = n_{\bar{X}} = g_X \left(\frac{M_X T}{2\pi} \right)^{3/2} e^{-M_X/T}$$

$X\bar{X} \rightarrow$ light particles

freeze-out temperature T_f

$$\frac{1}{n_X} \frac{1}{\langle \sigma_{\text{ann}} v \rangle} = H^{-1}(T_f) \rightarrow T_f = \frac{M_X}{\ln \left(\frac{g_X M_X M_{\text{pl}}^* \sigma_0}{(2\pi)^{3/2}} \right)}.$$

Bethe formulae:

s-wave: $\sigma_{\text{ann}} = \frac{\sigma_0}{v}$

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density after freeze-out:

$$n_X(T_f) = \frac{T_f^2}{M_{\text{Pl}}^* \sigma_0}$$

today's density:

$$n_X(T_0) = \left(\frac{a(T_f)}{a(T_0)}\right)^3 n_X(T_f) = \left(\frac{s_0}{s(T_f)}\right) n_X(T_f)$$

$X + \bar{X}$ contribution to critical density:

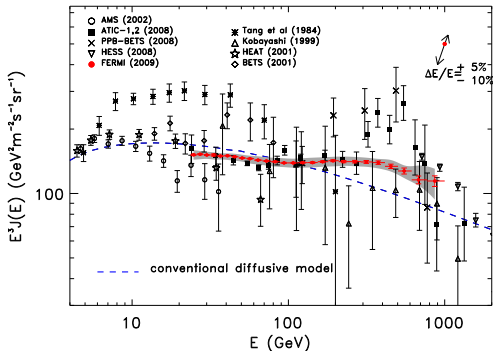
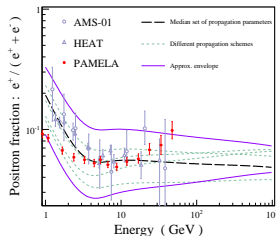
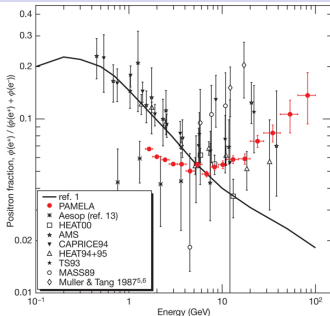
$$\begin{aligned} \Omega_X &= 2 \frac{M_X n_X(T_0)}{\rho_c} = 7.6 \frac{s_0 \ln\left(\frac{g_X M_{\text{Pl}}^* M_X \sigma_0}{(2\pi)^{3/2}}\right)}{\rho_c \sigma_0 M_{\text{Pl}} \sqrt{g_*(T_f)}} \\ &= 0.1 \cdot \left(\frac{(10 \text{ TeV})^{-2}}{\sigma_0}\right) \frac{0.3}{\sqrt{g_*(T_f)}} \ln\left(\frac{g_X M_{\text{Pl}}^* M_X \sigma_0}{(2\pi)^{3/2}}\right) \cdot \frac{1}{2h^2} \end{aligned}$$

naturally "light"

naturally dark matter

$$\sigma_0 \lesssim \frac{4\pi}{M_X^2} \longrightarrow M_X \lesssim 100 \text{ TeV}$$

Dark Matter signals in cosmic rays

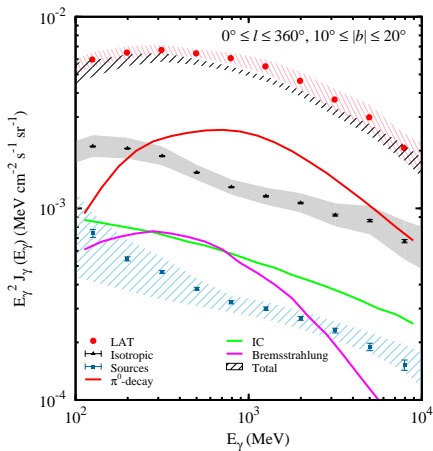
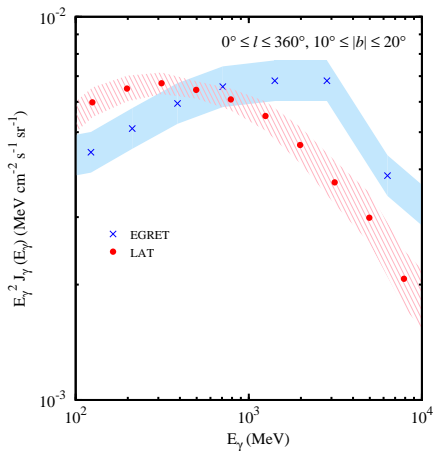


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- too strong signal
(boost factor: clumps or new light mediators)
- no antiproton excess
(leptophobic)
- “isotropic” γ -diffusion

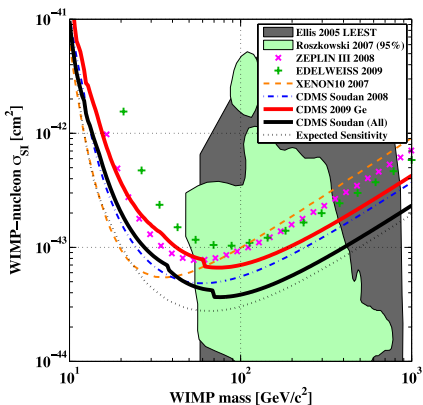
0909.1182, 0911.4779

Fermi LAT vs EGRET

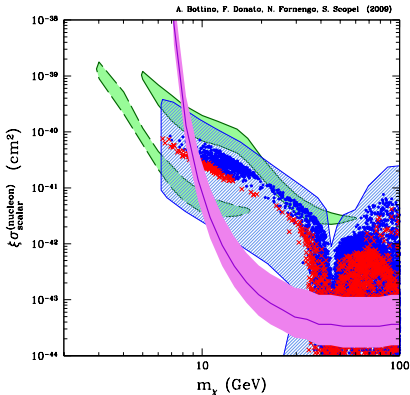


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Recent results of direct searches



see 2 events in [0912.3592](#)



[0912.4025](#), see however, [0912.4264](#)