The CR-WIMP connection in the Galaxy

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Tokyo | TeVPA 2015 | 29th of October 2015

The challenge!

Andromeda : a MW-like galaxy

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Andromeda : a MW-like galaxy

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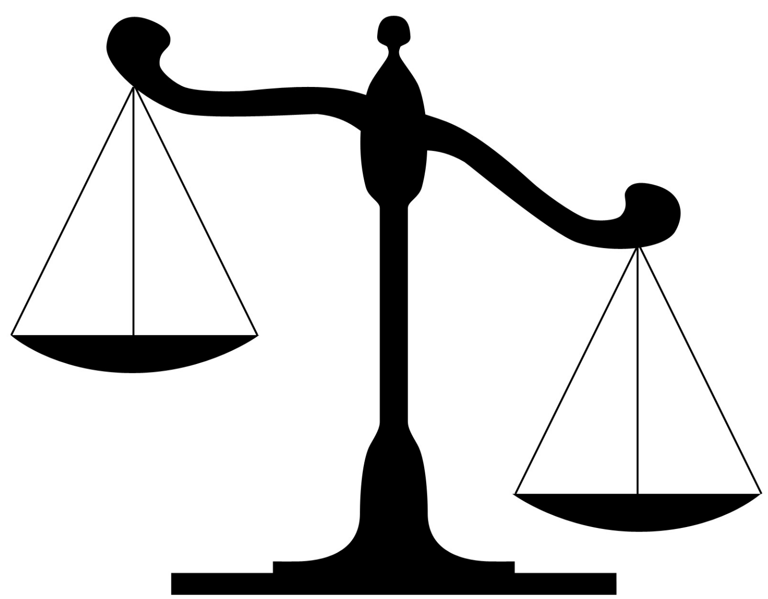

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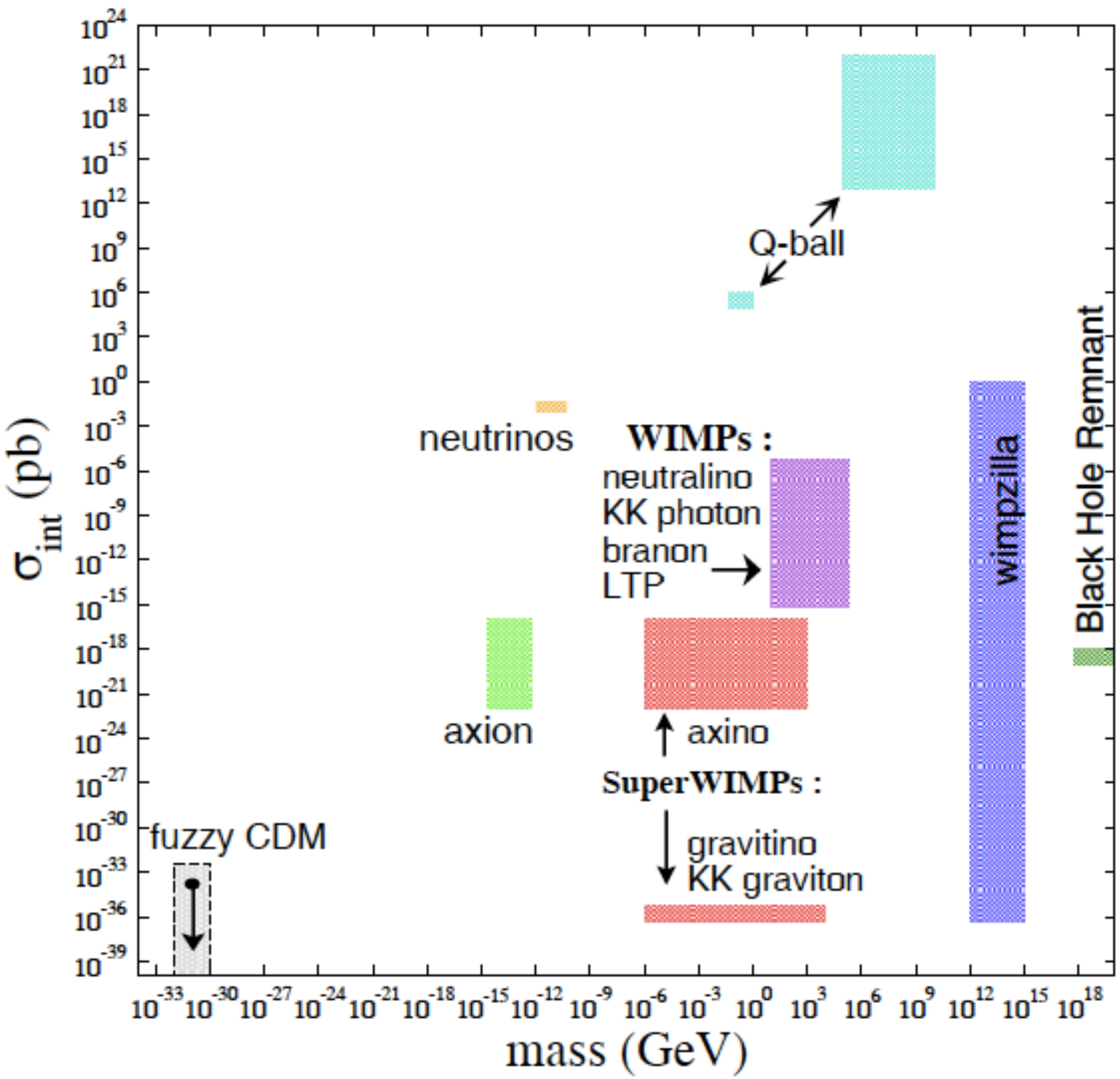
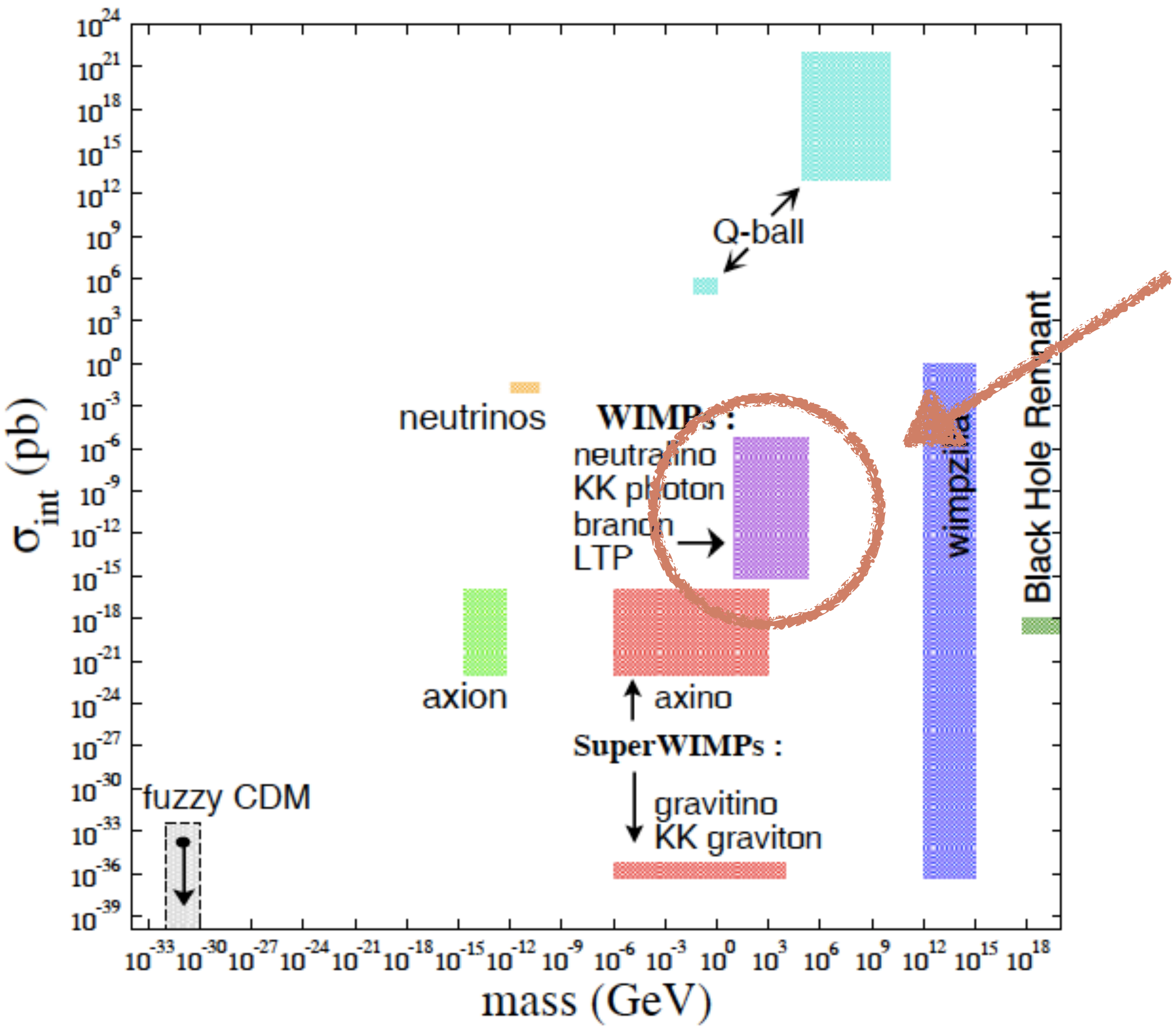
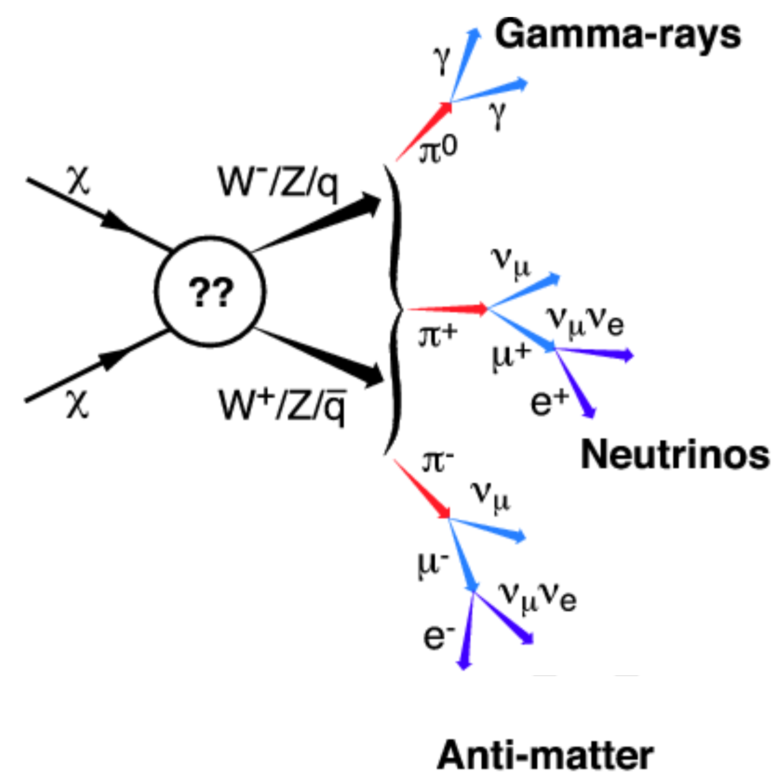
The importance of being WIMP

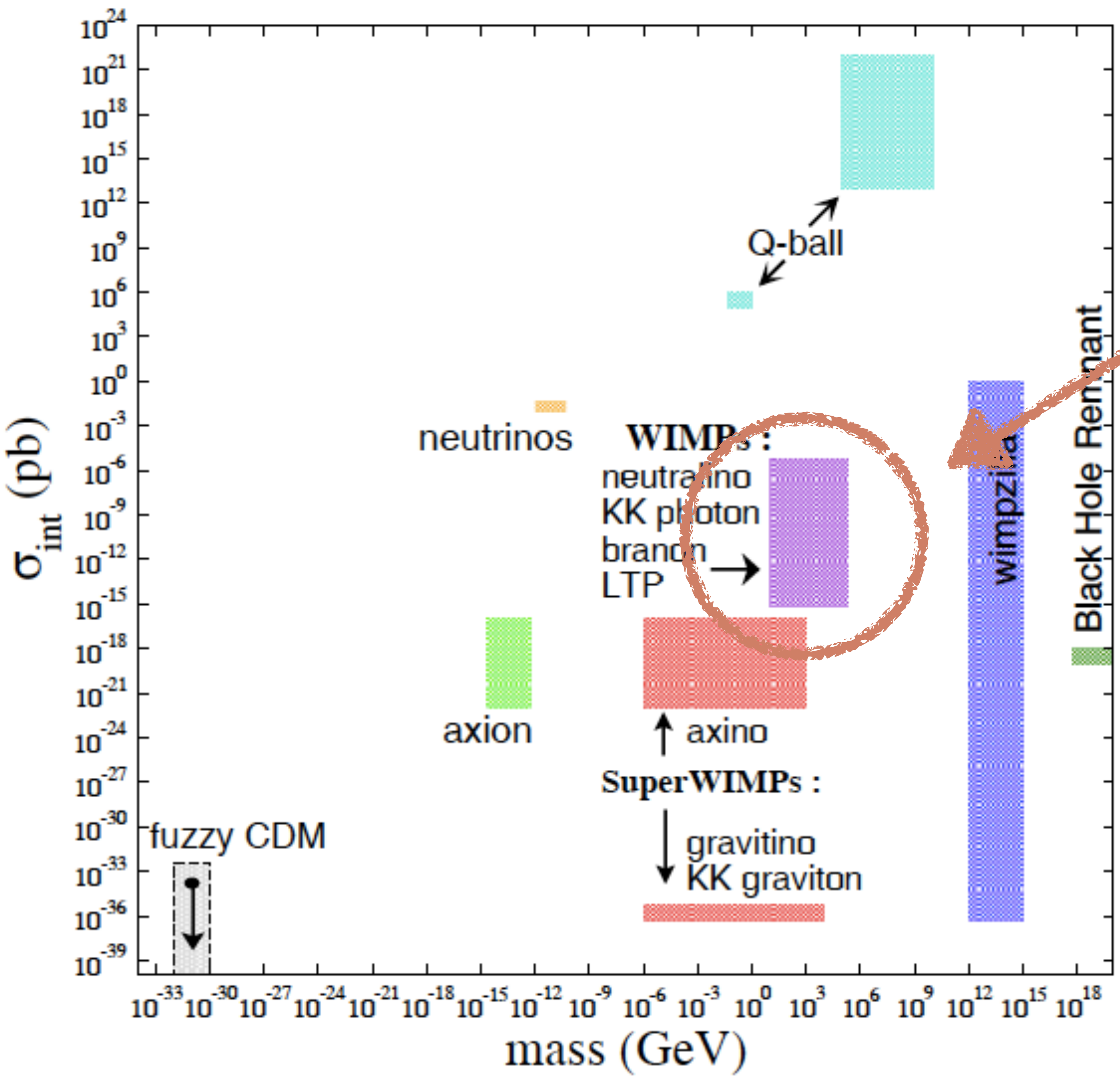


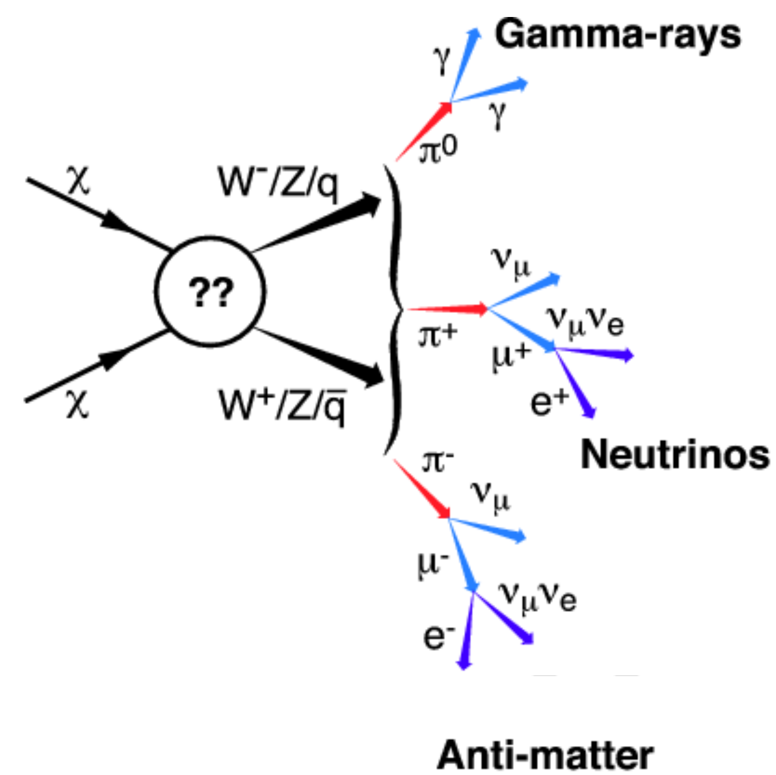
The importance of being WIMP





The importance of being WIMP





$$\epsilon_\chi \sim \frac{\rho_\chi^2}{m_\chi}\langle\sigma v\rangle \sim 5\times10^{-29}\,\mathrm{GeV\,cm^{-3}\,s^{-1}}$$

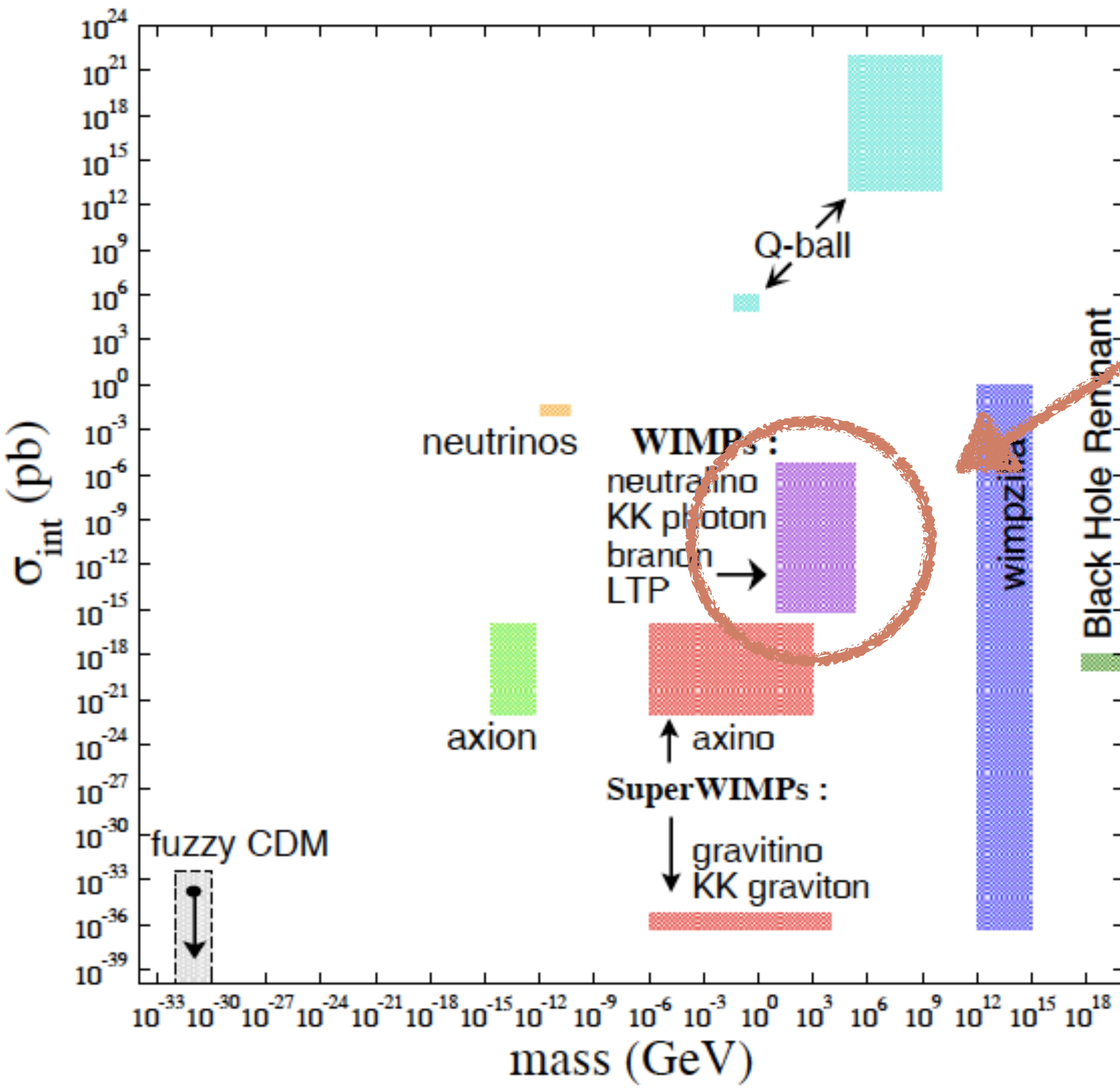
$$\epsilon_{\rm CR} \sim E^2\phi_{\rm CR}\, n_{\rm ISM}\,\sigma_{pp} \sim 5\times10^{-25}\,\mathrm{GeV\,cm^{-3}\,s^{-1}}$$

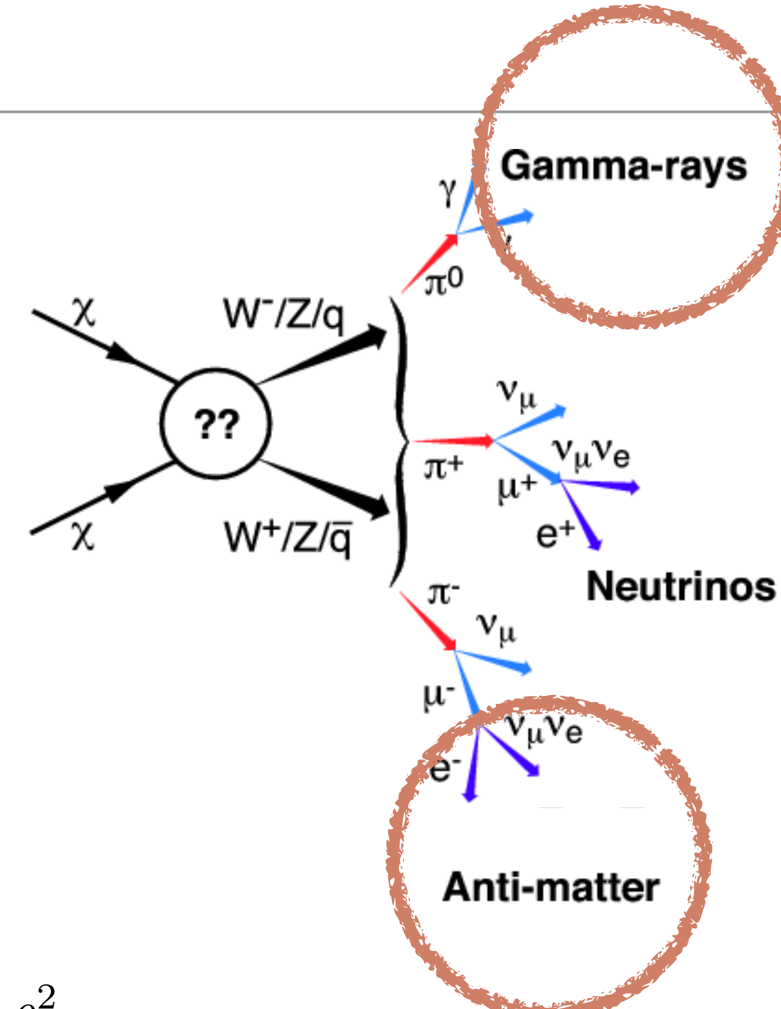
problem!

astrophysical emissivity is much larger than Dark one

This morning by
Keith Bechtol

The importance of being WIMP





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problem!

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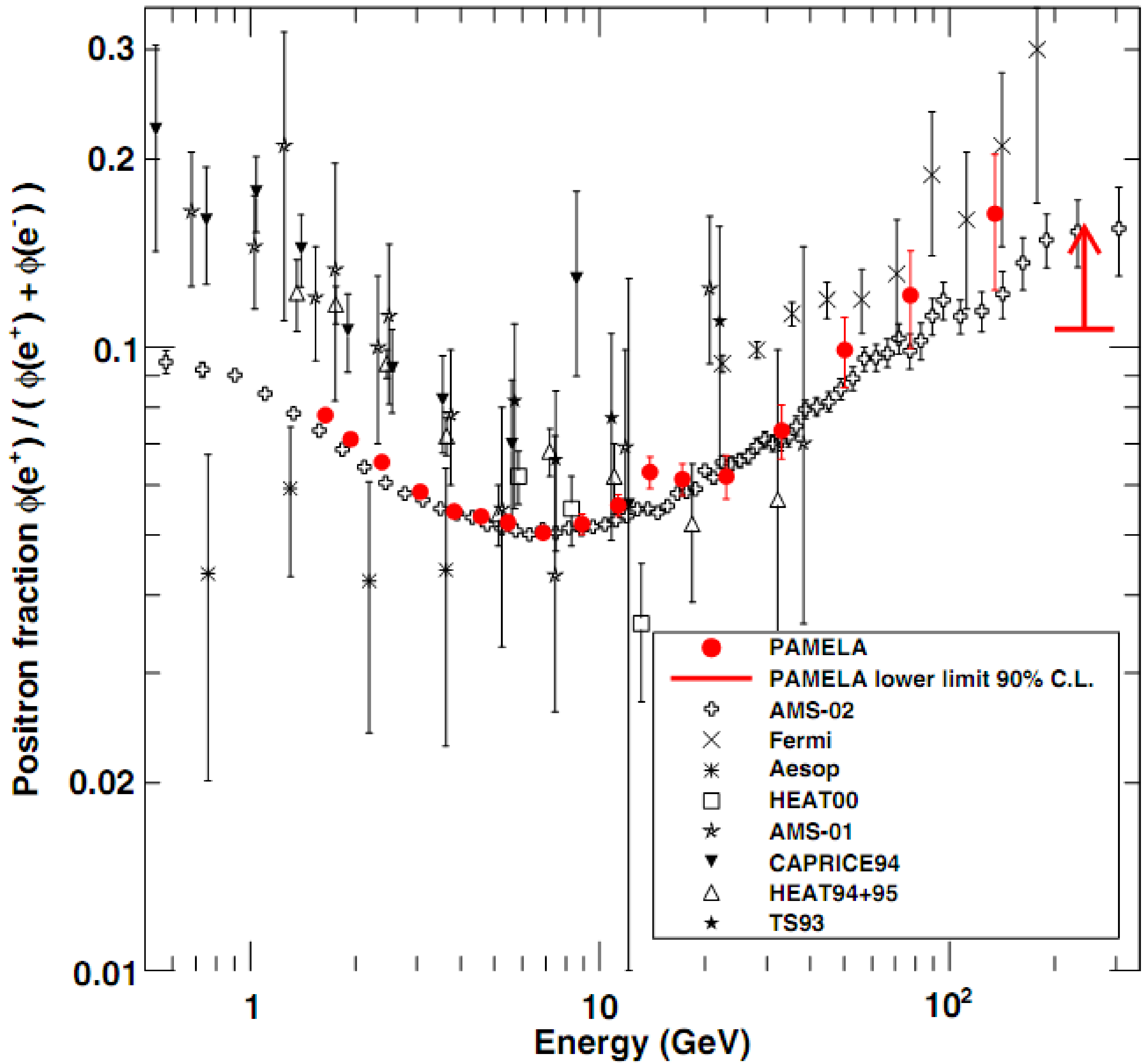
Positrons

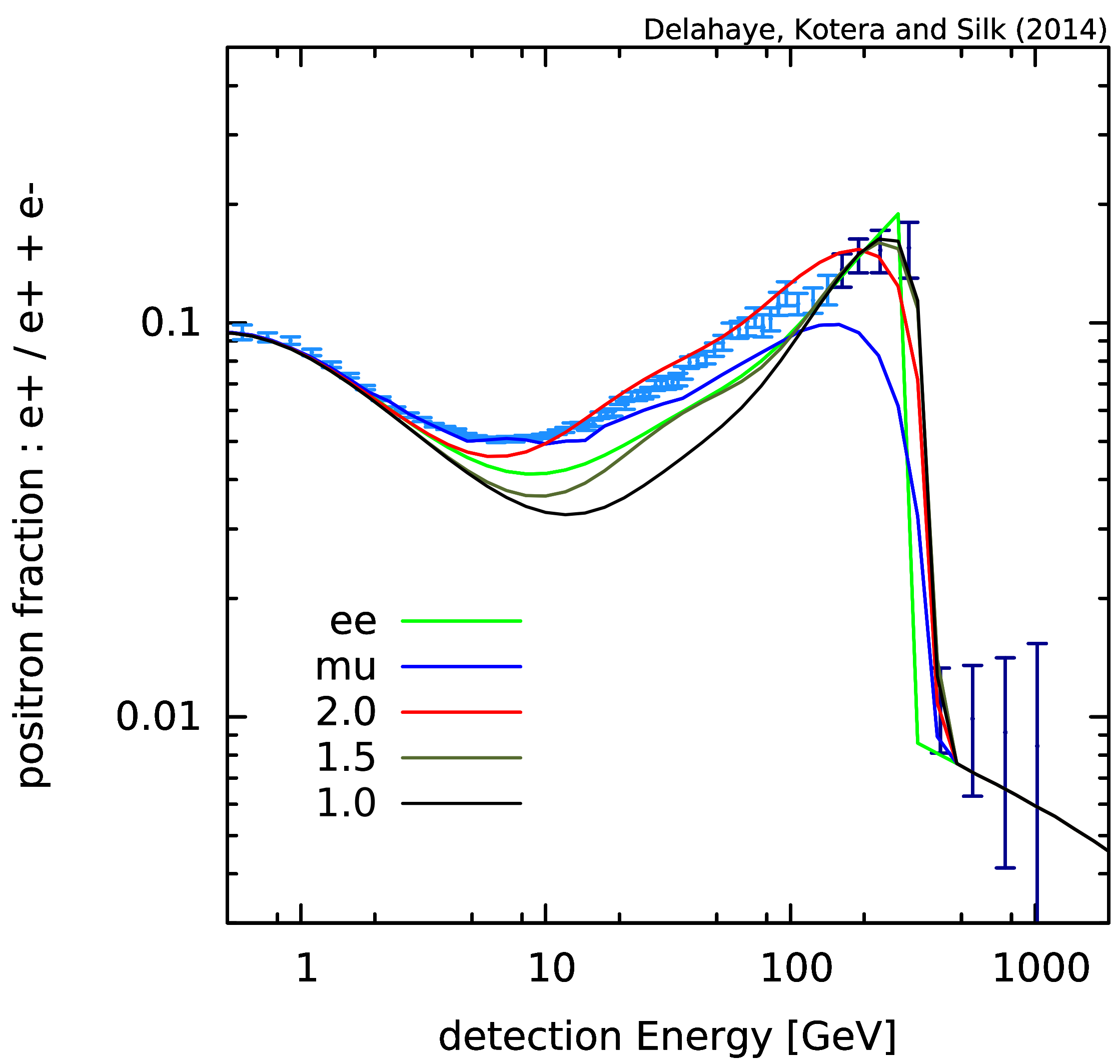
see Marco Casolino's talk here

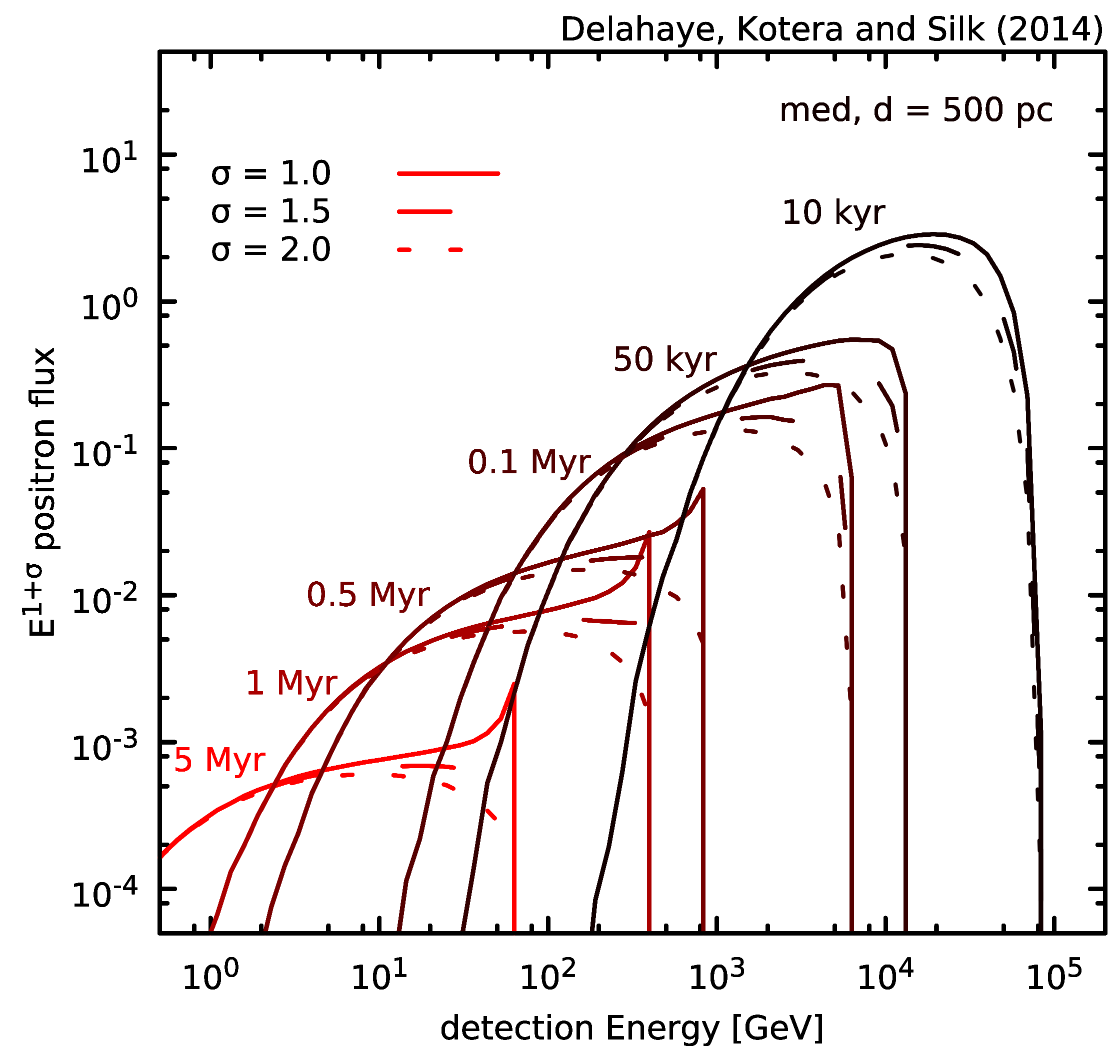


different interpretations
P. Serpico, *1108.4827*

What about a sharply falling positron fraction?

Delahaye, Kotera and Silk,1404.7546

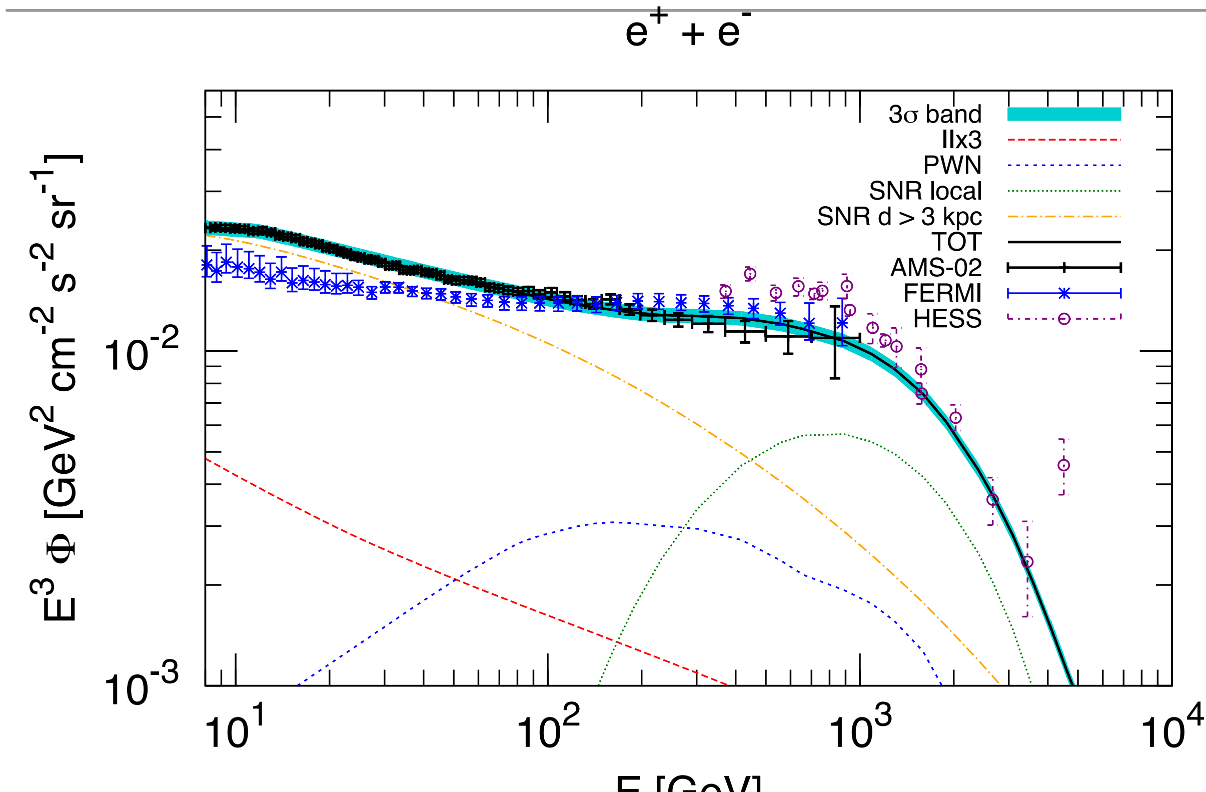


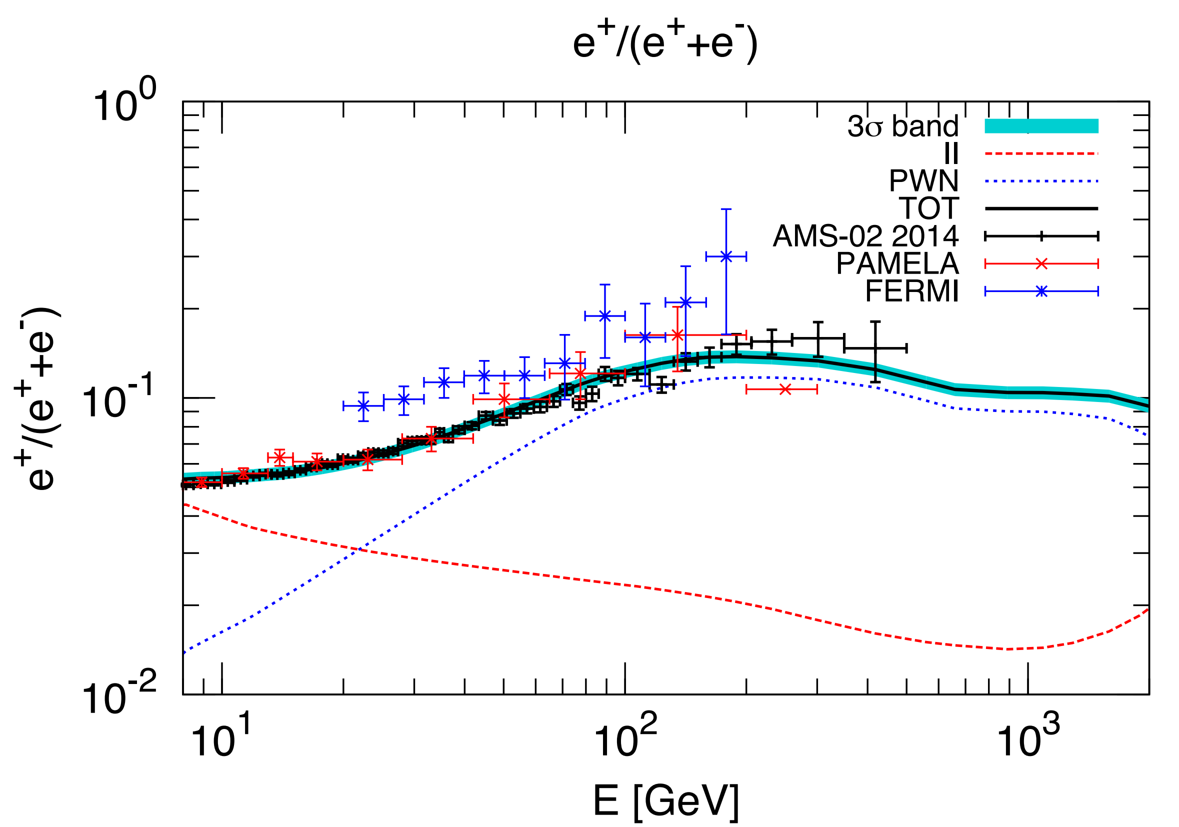


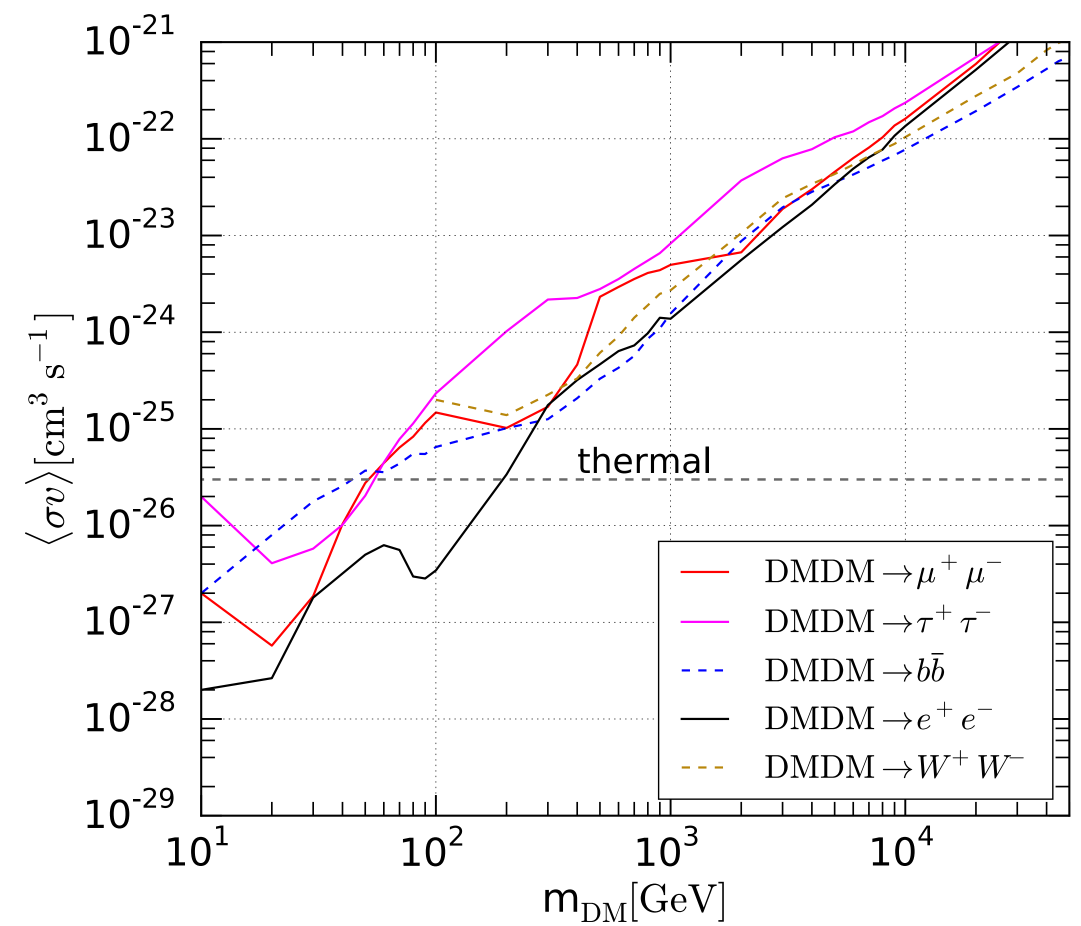
“One should also note that the flux coming from old pulsars drops more sharply, whatever the distance.”

Astrophysical interpretation

Di Mauro et al., 1507.07001



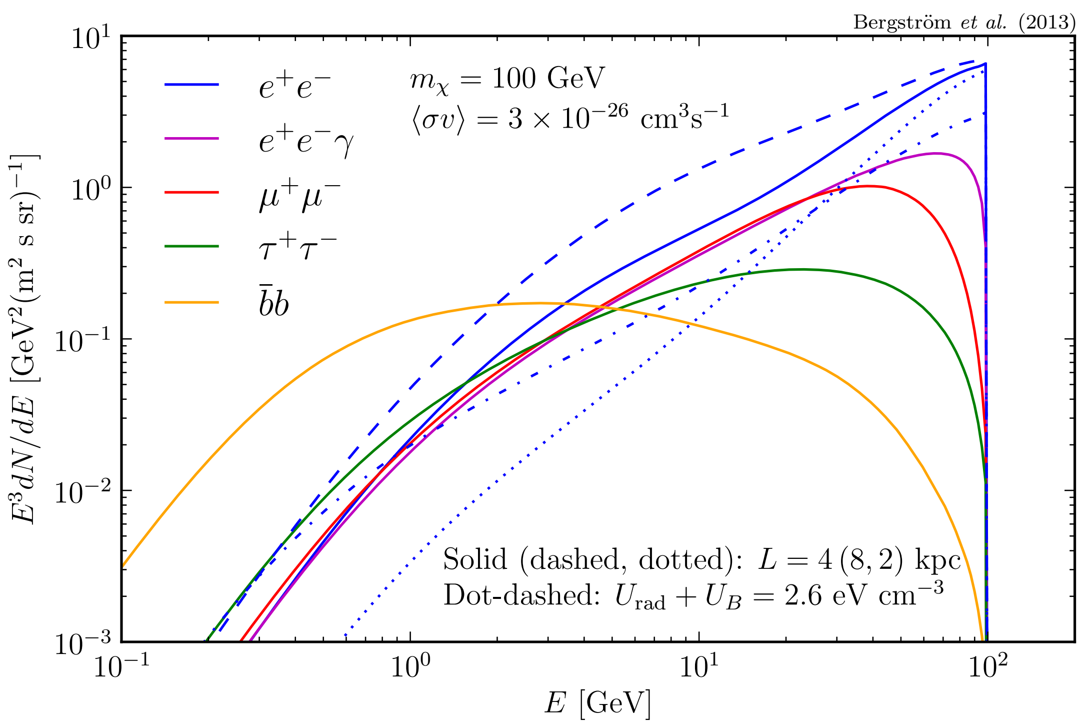




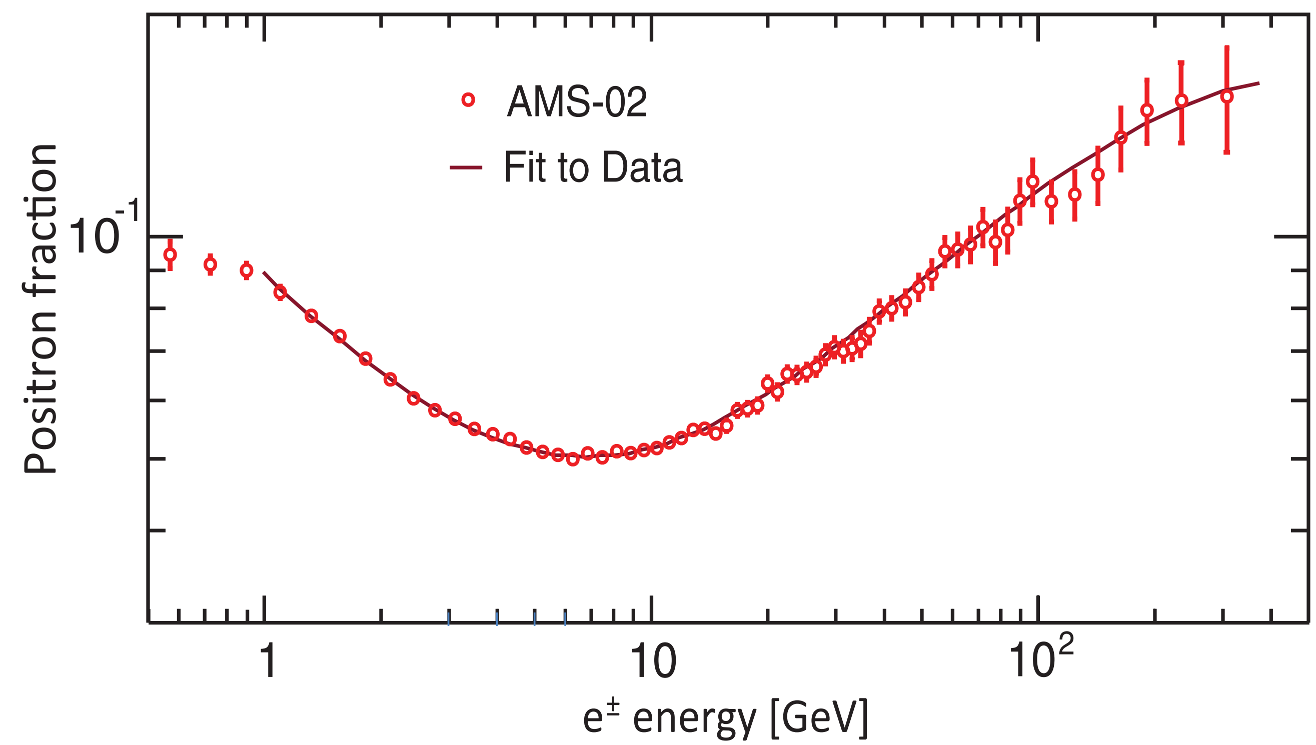
"The main conclusion that one can draw from this first part of our analysis, is: the agreement between the astro model and the AMS-02 measurements is remarkably good and therefore a purely astrophysical interpretation of $e^{\pm}$ data is perfectly viable."

Spectral fit with positrons

Bergstrom et al., 1306.3983



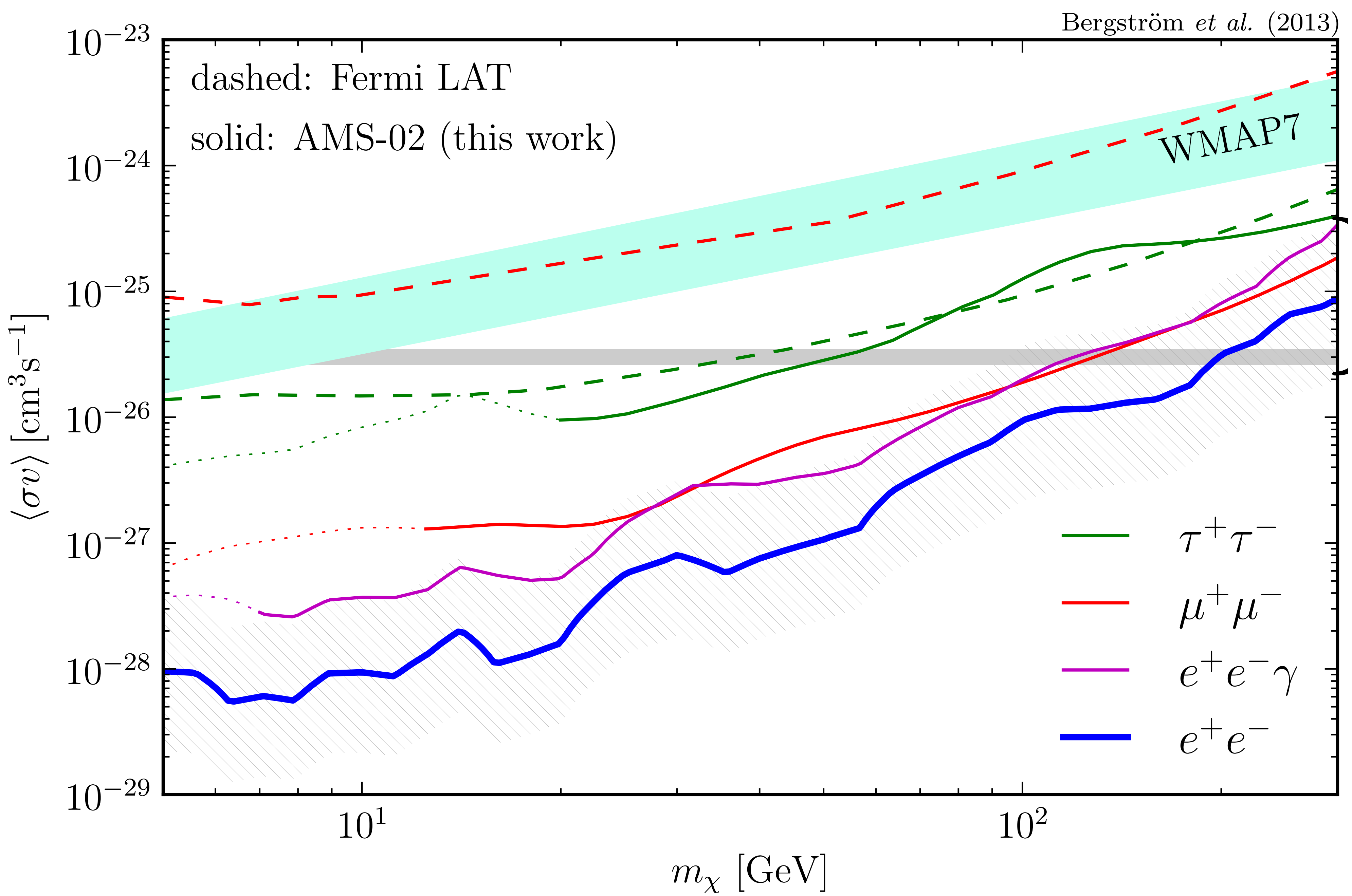
sharp signal
(even *after* propagation)



smooth background

Spectral fit with positrons

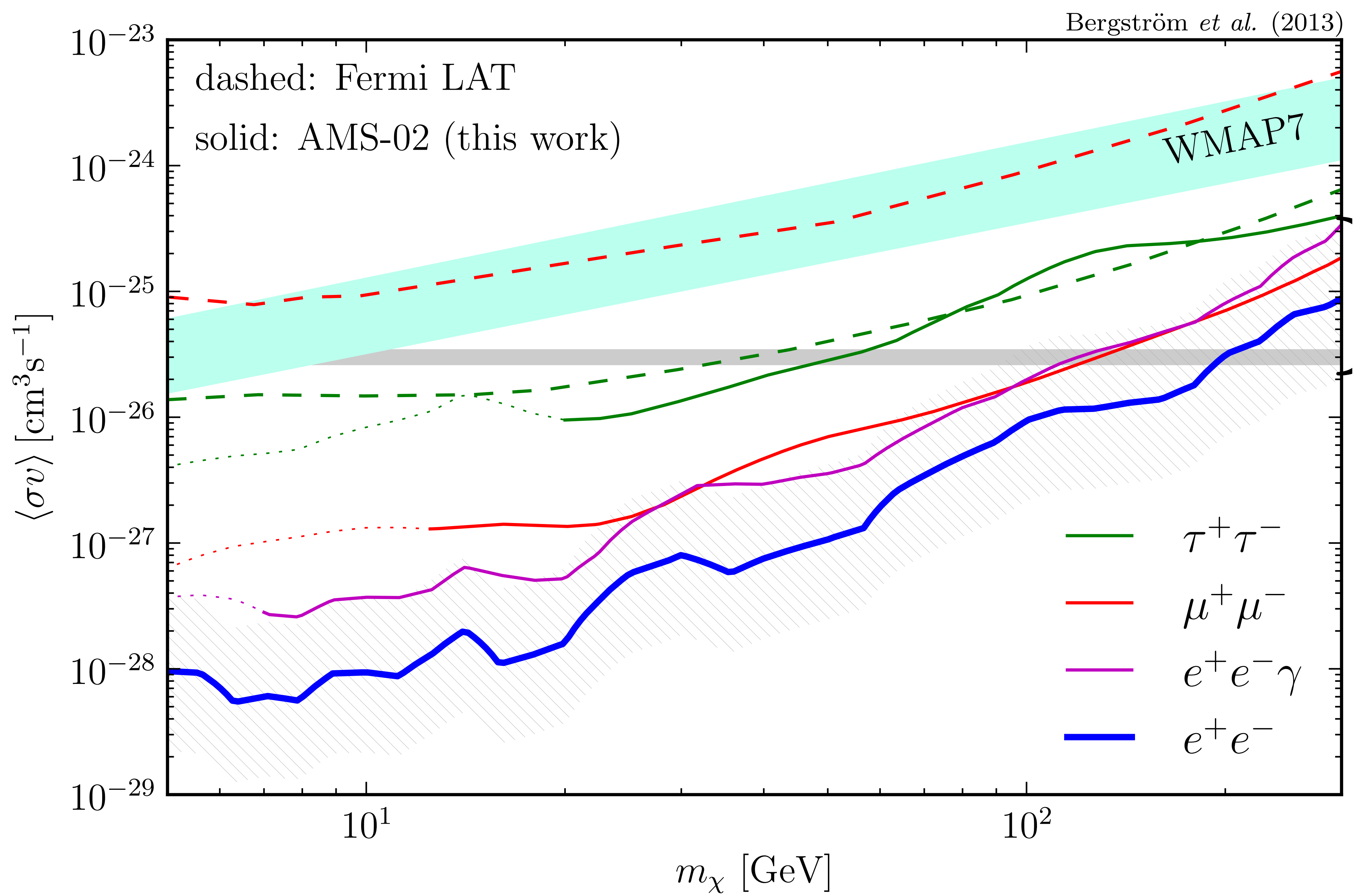
Bergstrom et al., 1306.3983



see also Ibarra, Lamperstorfer and Silk, 1309.2570

Spectral fit with positrons

Bergstrom et al., 1306.3983

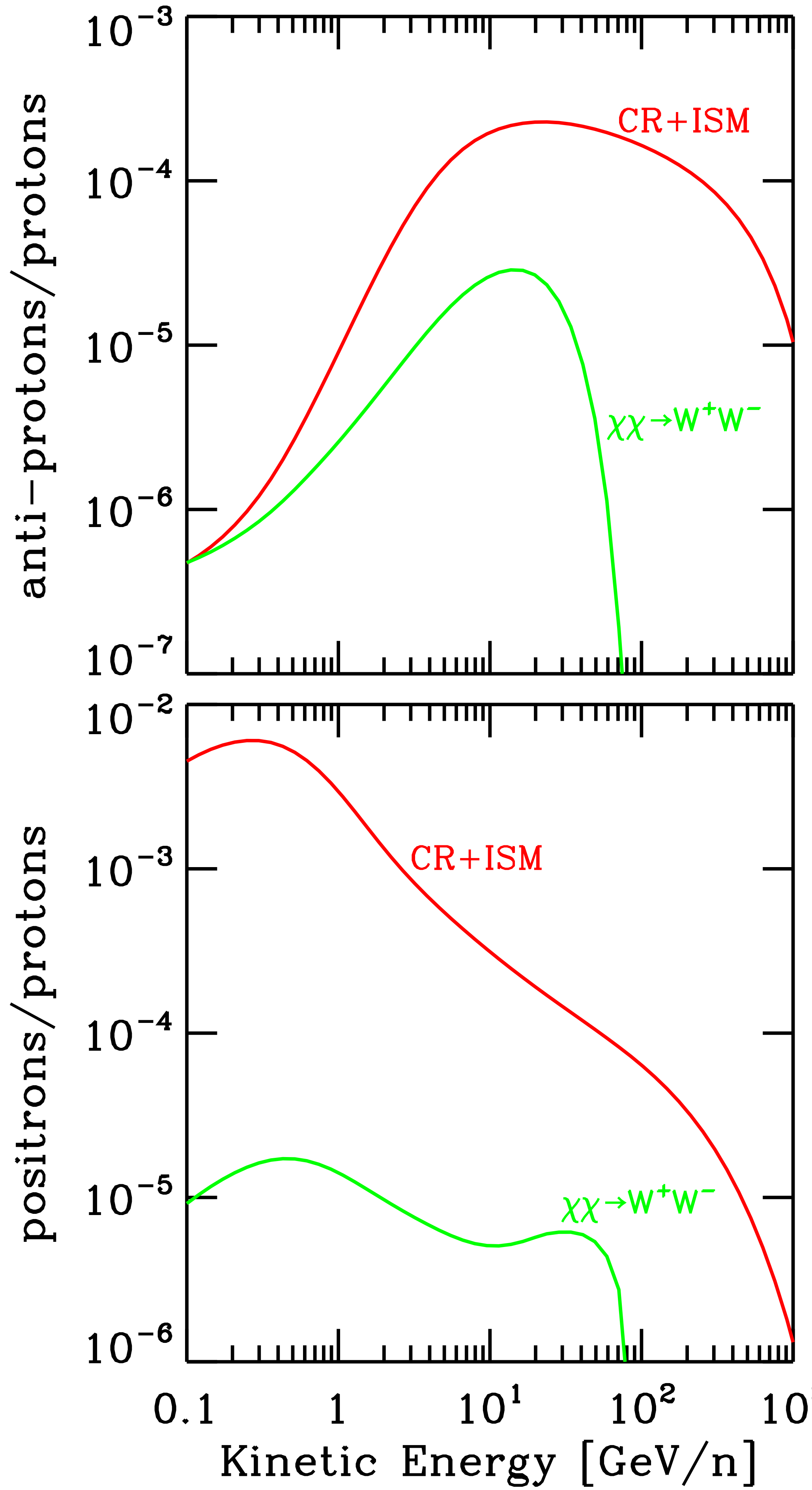


independent on bkg interpretation!

see also Ibarra, Lamperstorfer and Silk, 1309.2570

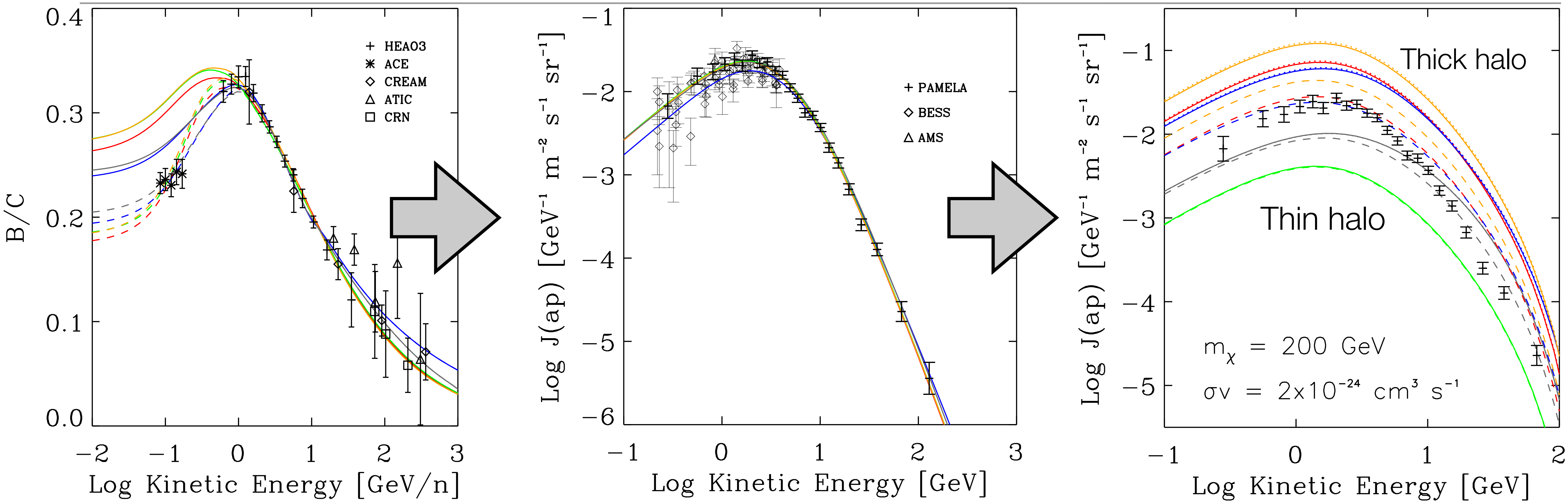
Why antiprotons?

- we know the **background** with good accuracy
- in a **democratic** WIMP model the ratio between DM signal and background from standard astrophysical sources is usually much larger in the **antiproton** channel with respect to all other indirect detection methods.



Playing with anti-protons from DM

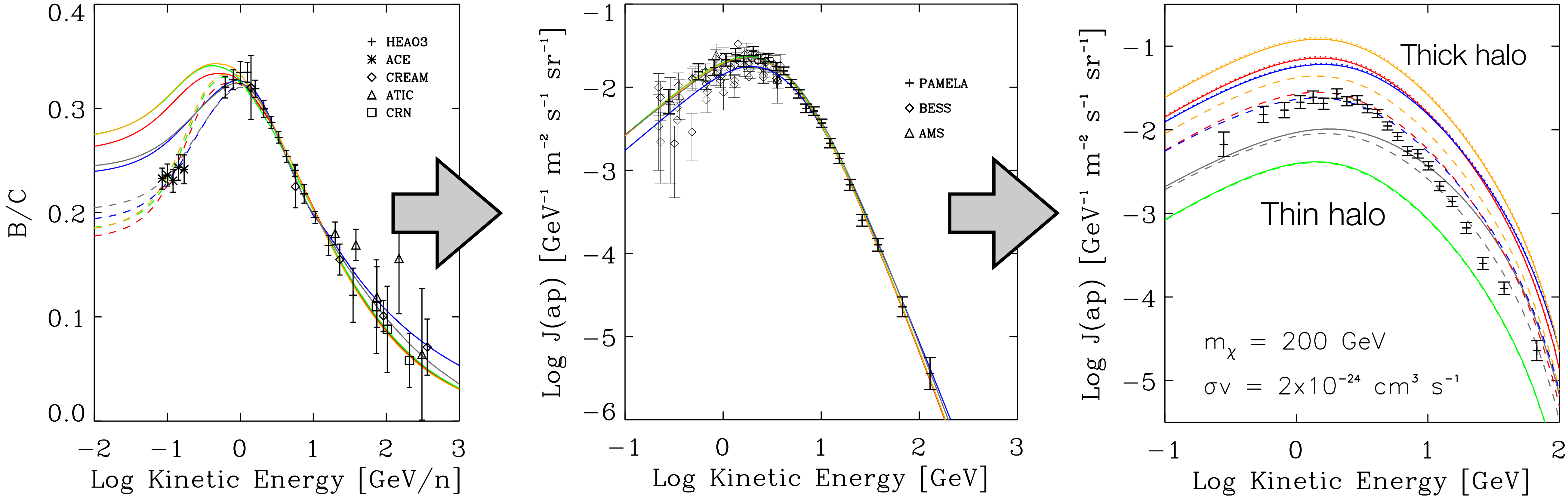
CE, I.Cholis, D.Grasso, L.Maccione & P.Ullio, PRD, 2012, 1108.0664



Model	z_t (kpc)	δ	$D_0(10^{28}$ cm^2/s)	η	v_A (km/s)	γ	dv_c/dz (km/s/kpc)	$\chi^2_{B/C}$	χ^2_p	Φ (GV)	$\chi^2_{\bar{p}}$	Color in Figs.
KRA	4	0.50	2.64	−0.39	14.2	2.35	0	0.6	0.47	0.67	0.59	Red
KOL	4	0.33	4.46	1.	36.	1.78/2.45	0	0.4	0.3	0.36	1.84	Blue
THN	0.5	0.50	0.31	−0.27	11.6	2.35	0	0.7	0.46	0.70	0.73	Green
THK	10	0.50	4.75	−0.15	14.1	2.35	0	0.7	0.55	0.69	0.62	Orange
CON	4	0.6	0.97	1.	38.1	1.62/2.35	50	0.4	0.53	0.21	1.32	Gray

Playing with anti-protons from DM

CE, I.Cholis, D.Grasso, L.Maccione & P.Ullio, PRD, 2012, 1108.0664



30%

~1 oom

Model	z_t (kpc)	δ	$D_0(10^{28}$ cm^2/s)	η	v_A (km/s)	γ	dv_c/dz (km/s/kpc)	$\chi^2_{B/C}$	χ^2_p	Φ (GV)	$\chi^2_{\bar{p}}$	Color in Figs.
KRA	4	0.50	2.64	−0.39	14.2	2.35	0	0.6	0.47	0.67	0.59	Red
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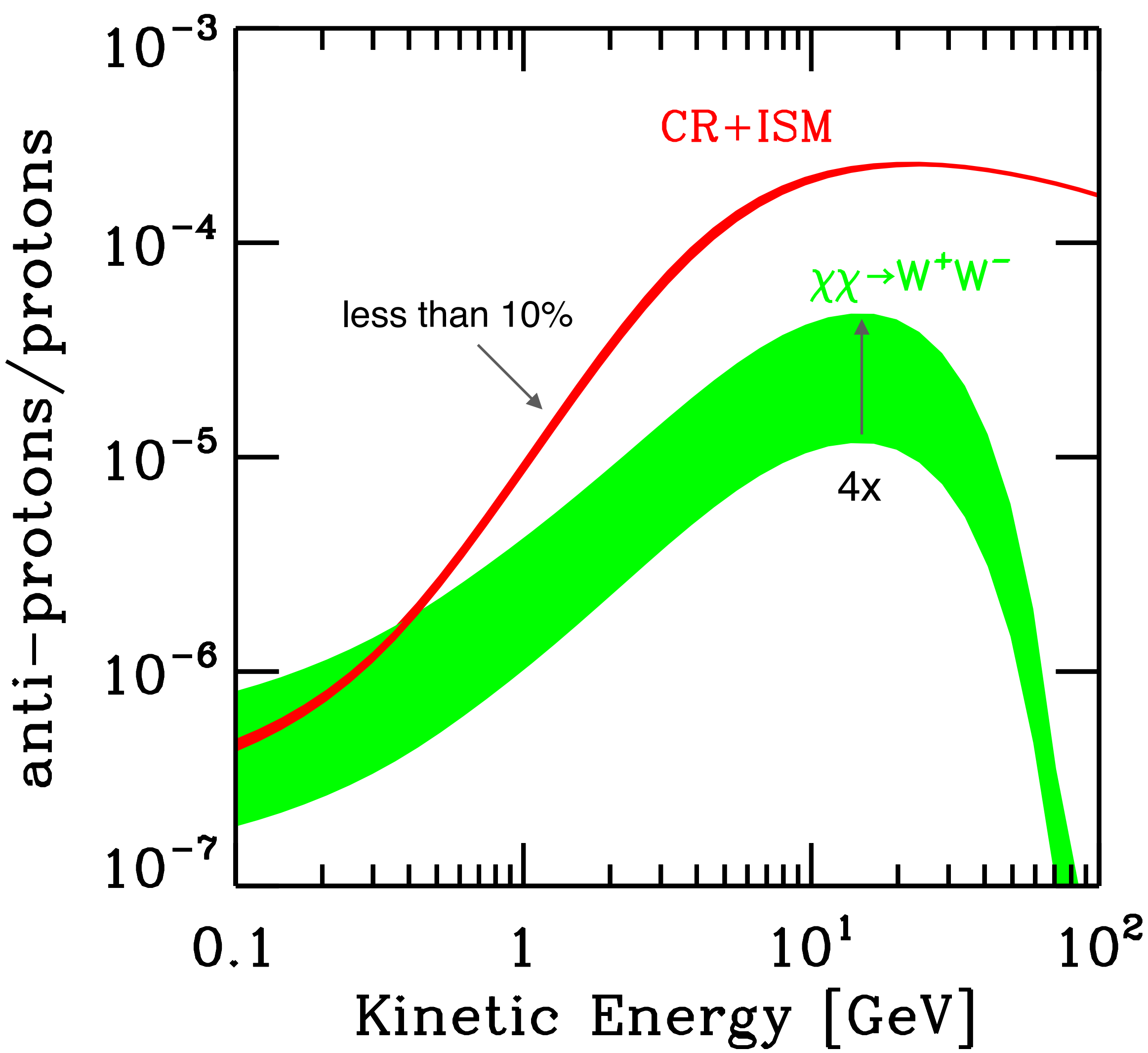
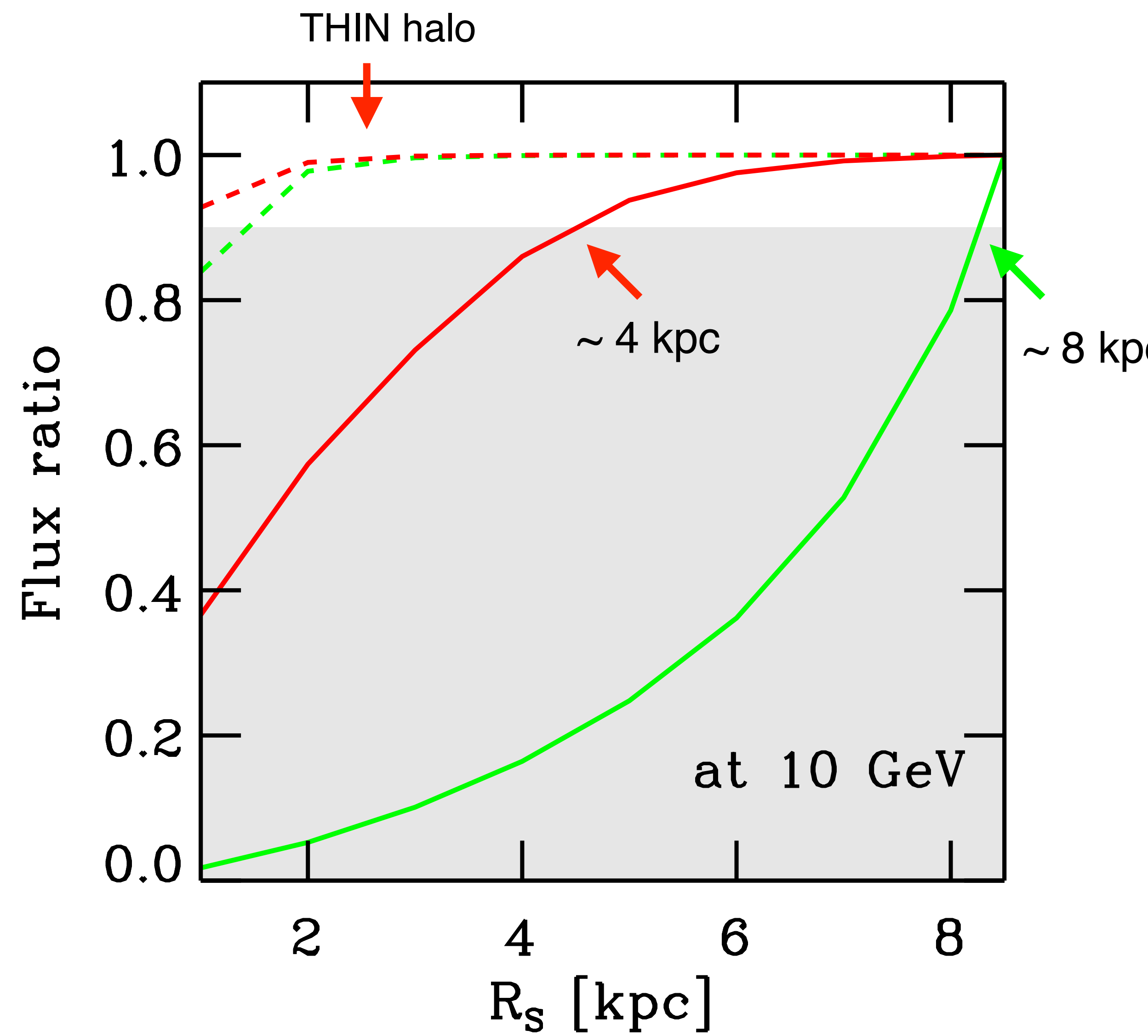
CON	4	0.6	0.97	1.	38.1	1.62/2.35	50	0.4	0.53	0.21	1.32	Gray

Varying the halo size in the range 2 - 10 kpc

CE, I.Cholis, D.Grasso, L.Maccione & P.Ullio, PRD, 2012, 1108.0664



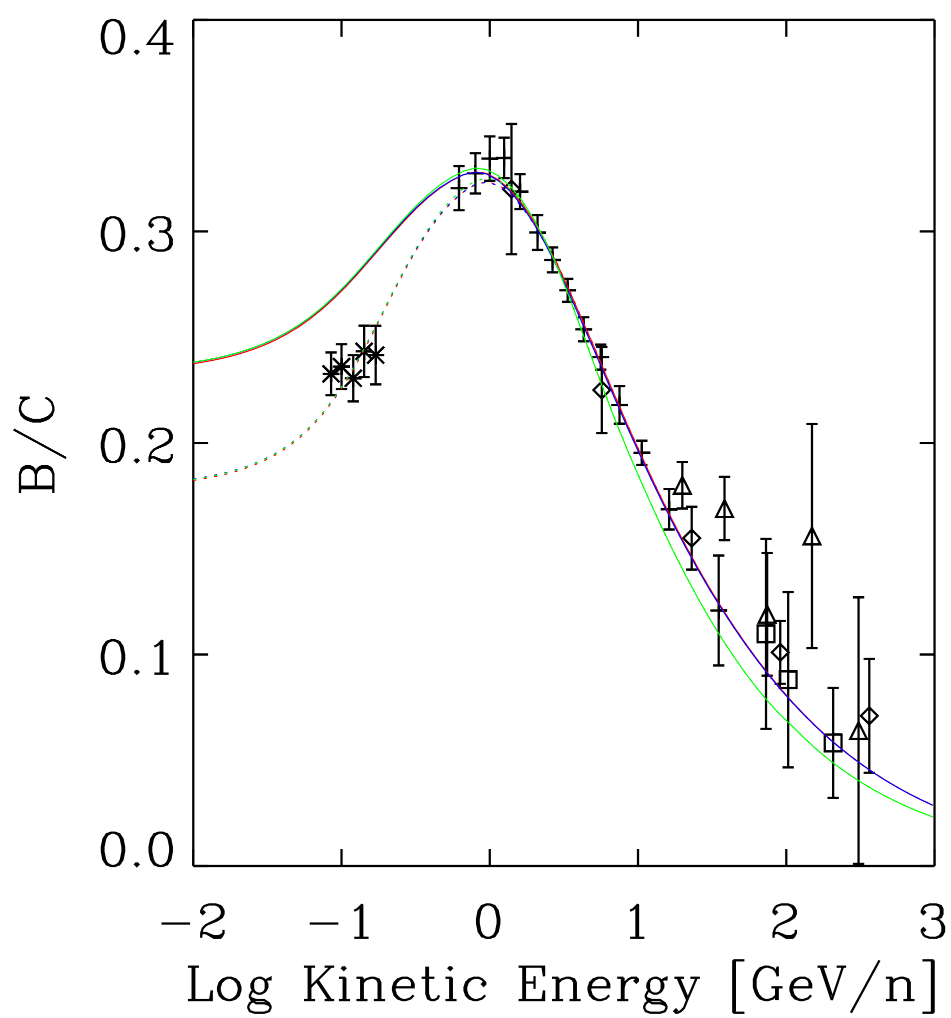


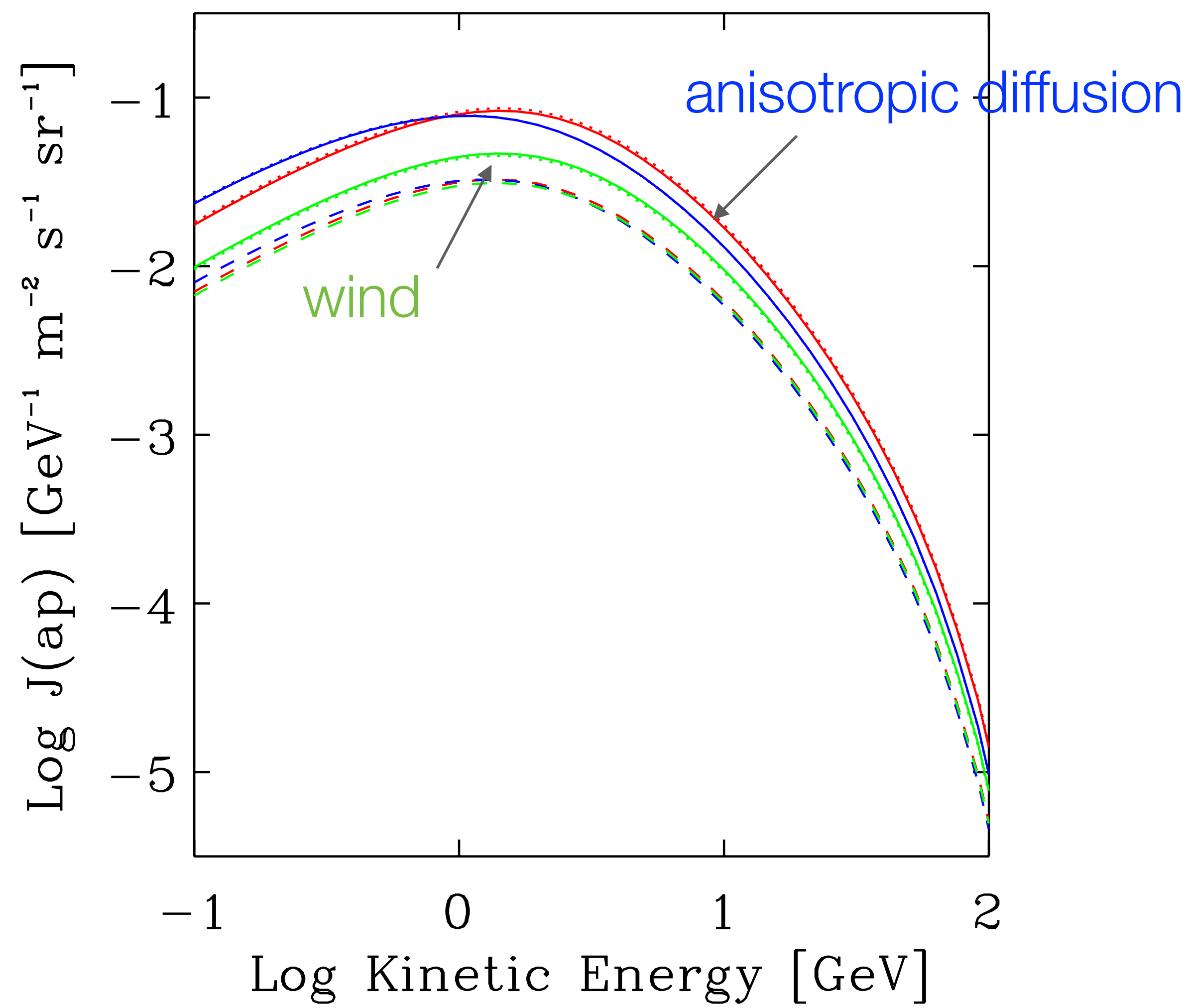
Much larger uncertainty in the DM fluxes!

The ratio of the local flux obtained considering sources with distance smaller than R_S to that obtained with $R_S = \infty$
(see also R. Taillet & D. Maurin, A&A, 2003)

Unavoidable uncertainties?

CE, I.Cholis, D.Grasso, L.Maccione & P.Ullio, PRD, 2012, 1108.0664

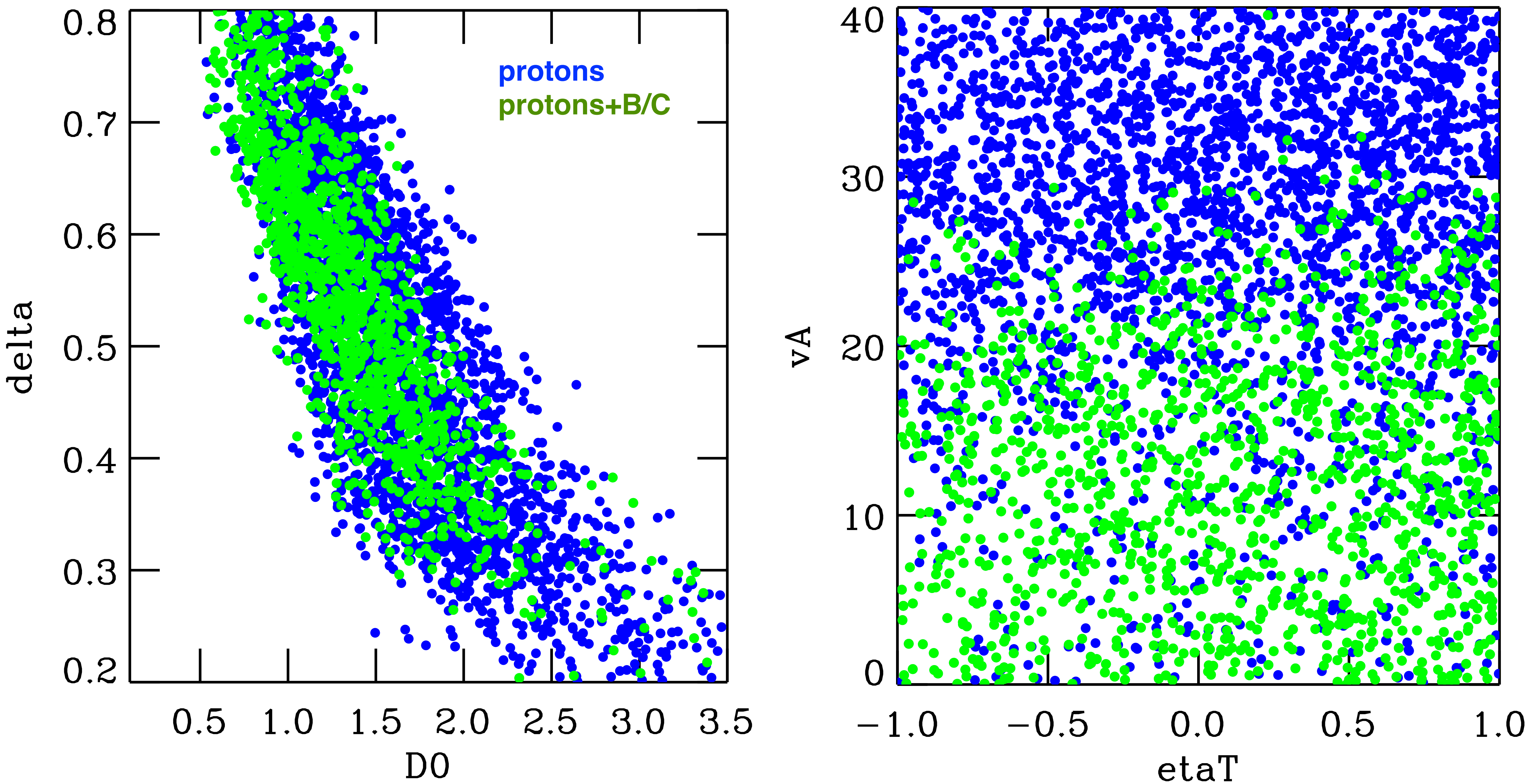




Changing diffusion conditions in the inner Galaxy gives significant effect on the DM contribution without affecting the local observables

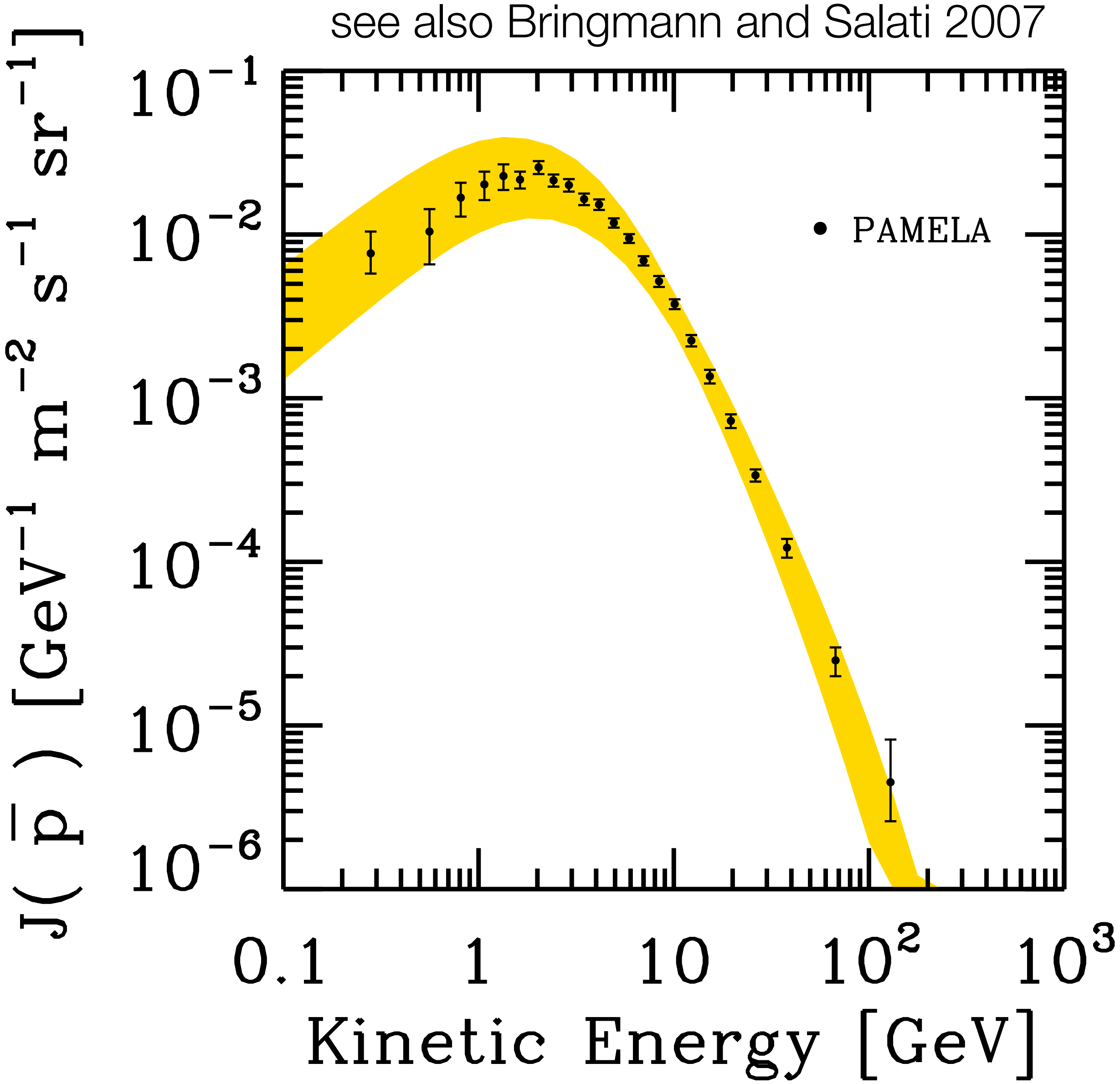
Only a comprehensive study including local and non-local observables may succeed in reducing safely the propagation uncertainties.

Bracketing the propagation uncertainties with PAMELA

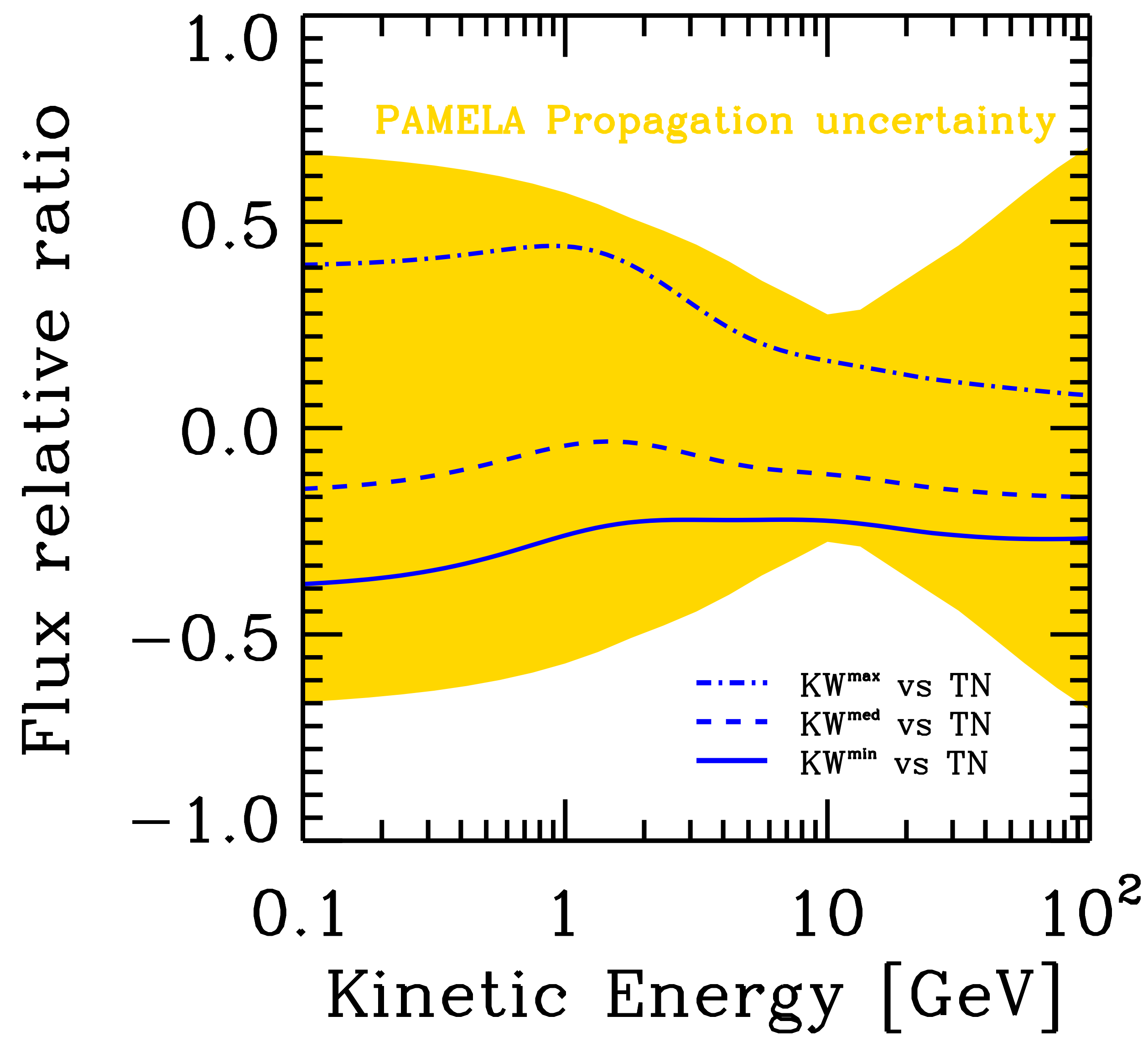


Bracketing the propagation uncertainties with PAMELA

see also Bringmann and Salati 2007

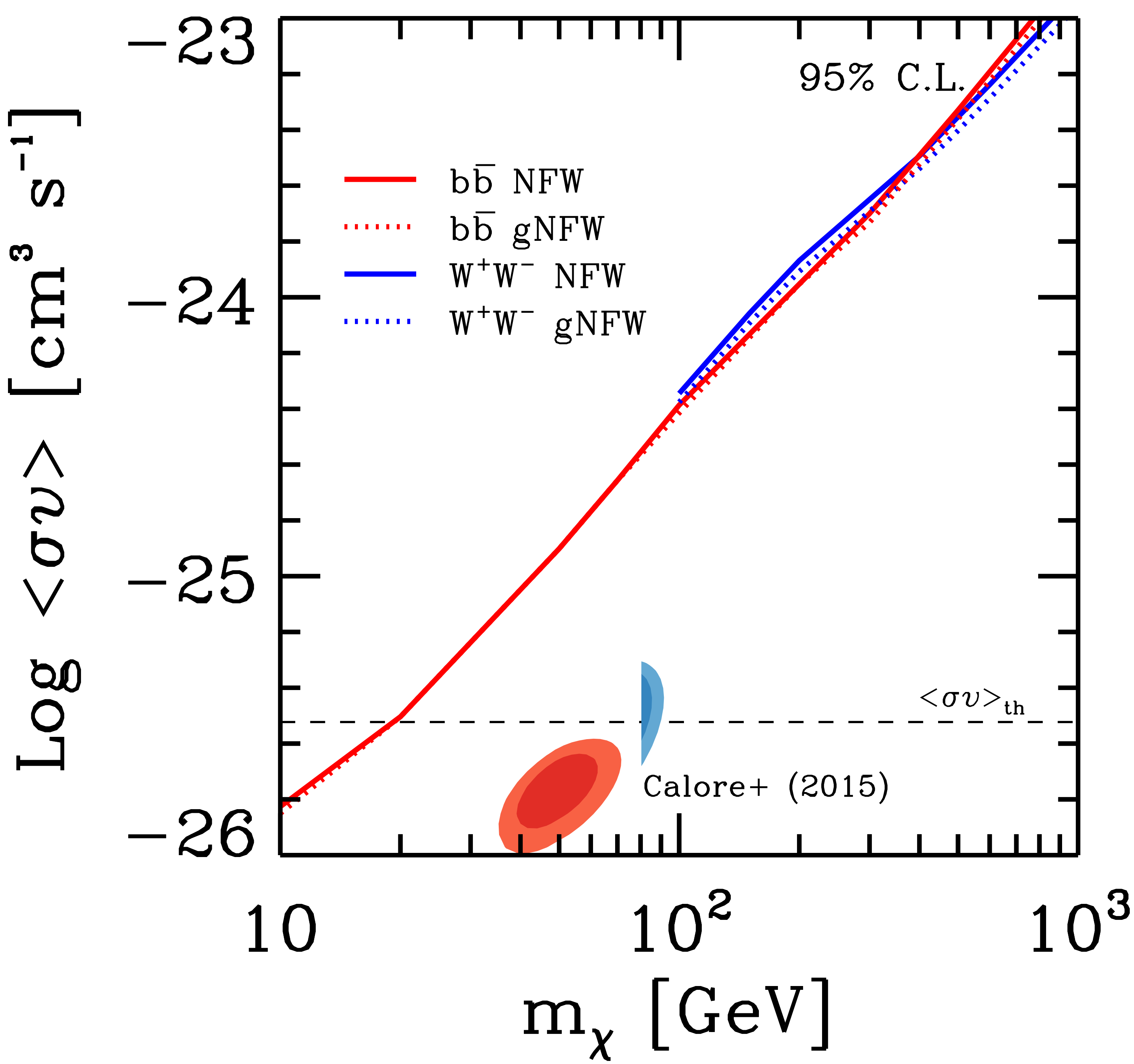


see also Di Mauro *et al.*, 2014



DM bounds after PAMELA data

CE, D.Gaggero & D.Grasso, 1504.05175

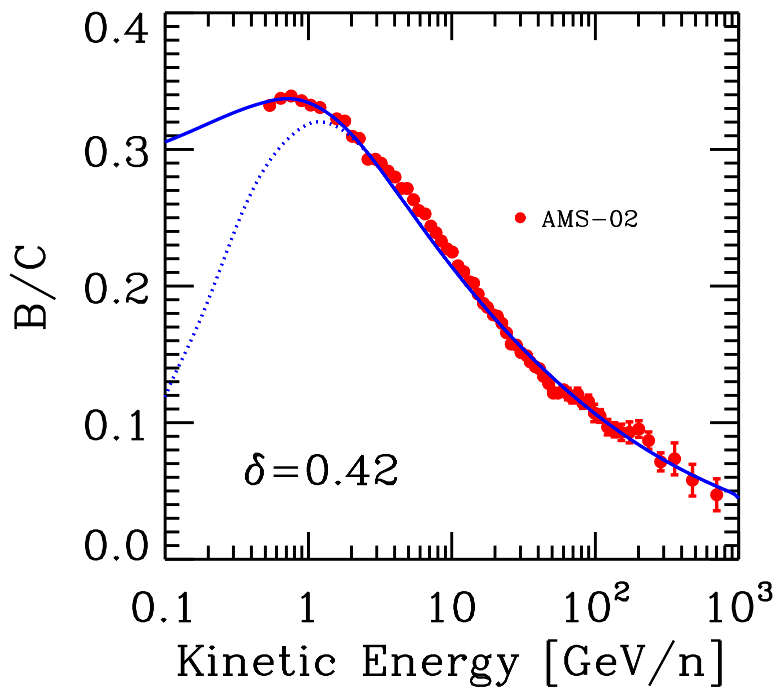


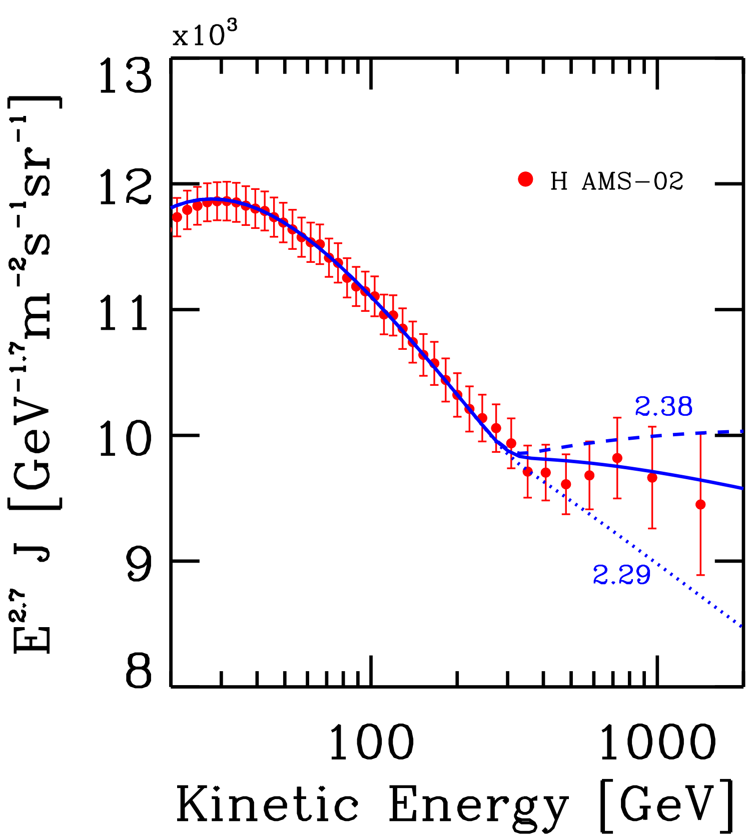
"The main difference in our approach is to make use of a broader analysis of the propagation and nuclear uncertainties in order to determine the background."

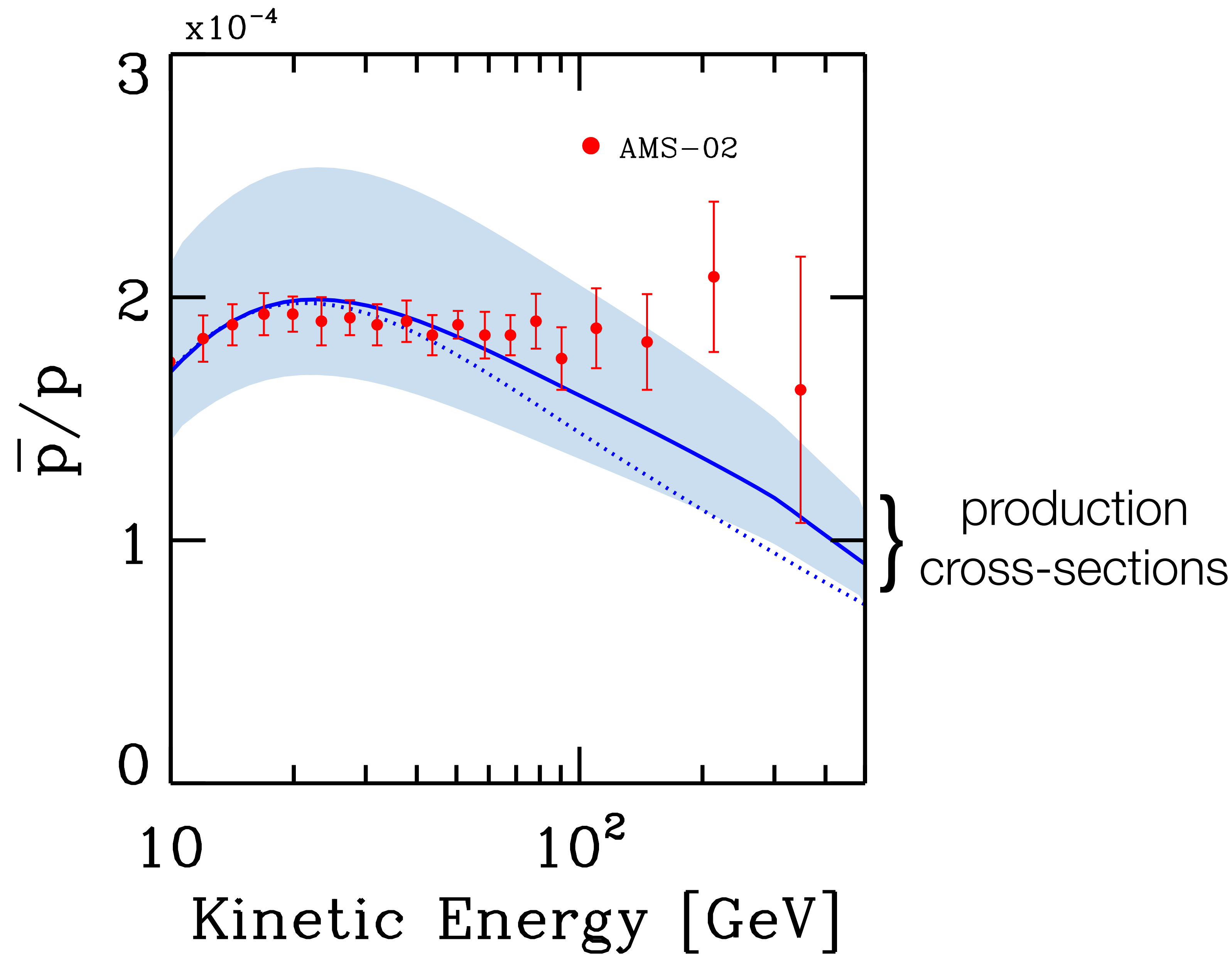
Testing the AMS-02 high-energy data

CE, D.Gaggero & D.Grasso, 1504.05175

see also Giesen *et al.*, 1504.04276
Kappl, Reinert and Winkler, 1506.04145







Conclusions

- Whether or not **dark matter** contributes to the observed CR fluxes is one of the most important open problem in Cosmology.
- Indirect searches with charged CR have become competitive in terms of excluding candidates
- Astrophysical and nuclear uncertainties on the background predictions are comparable limiting factors at the moment
- Multi-Wavelength and multi-messenger studies in combination with more precise measurements are going to shrink the astrophysical uncertainties significantly (what about nuclear ones?)