

Updated antiproton, positron and radio limits on light Dark Matter. Implications for the GeV gamma-ray excess at the Galactic center

Based on:

arXiv: 1406.6027 [astro-ph.HE]

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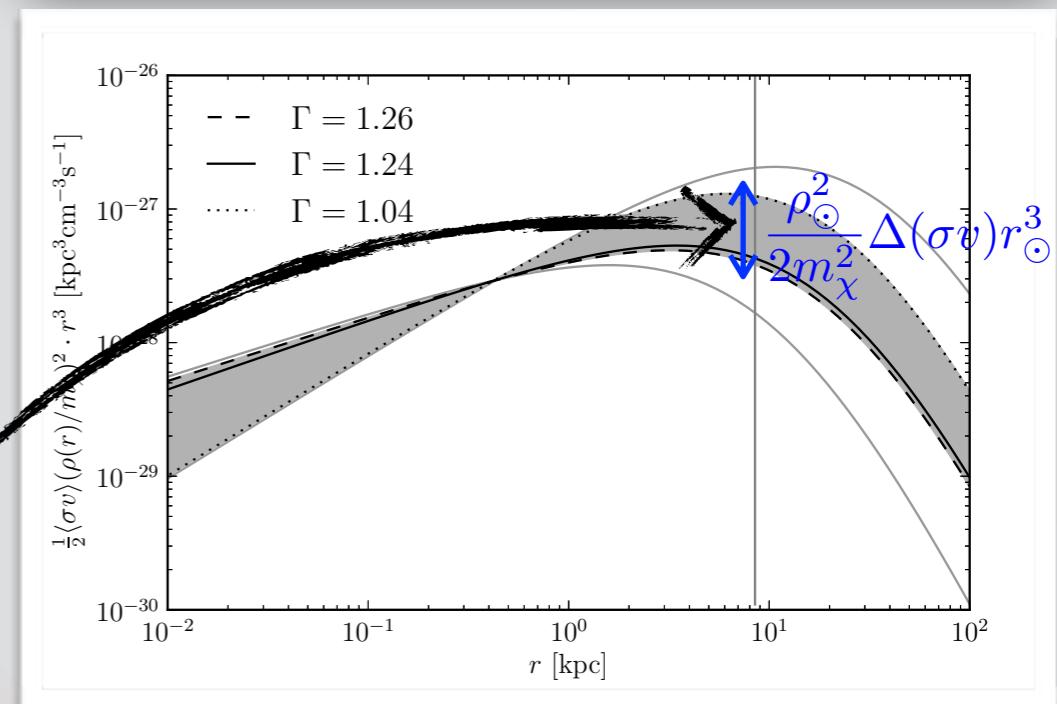
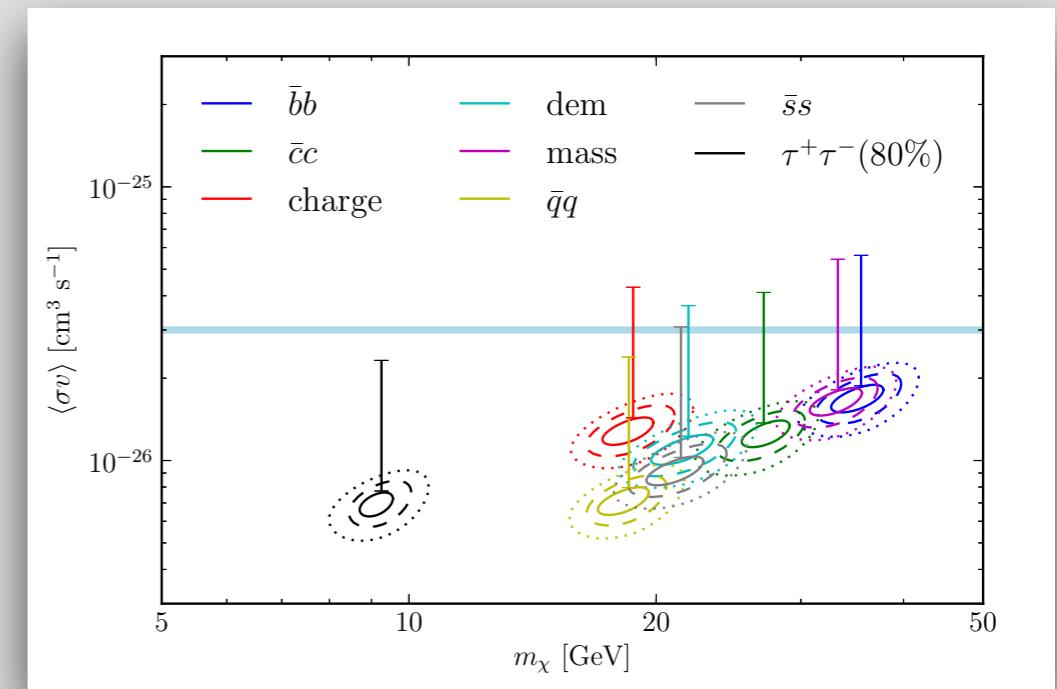


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Motivation and setup

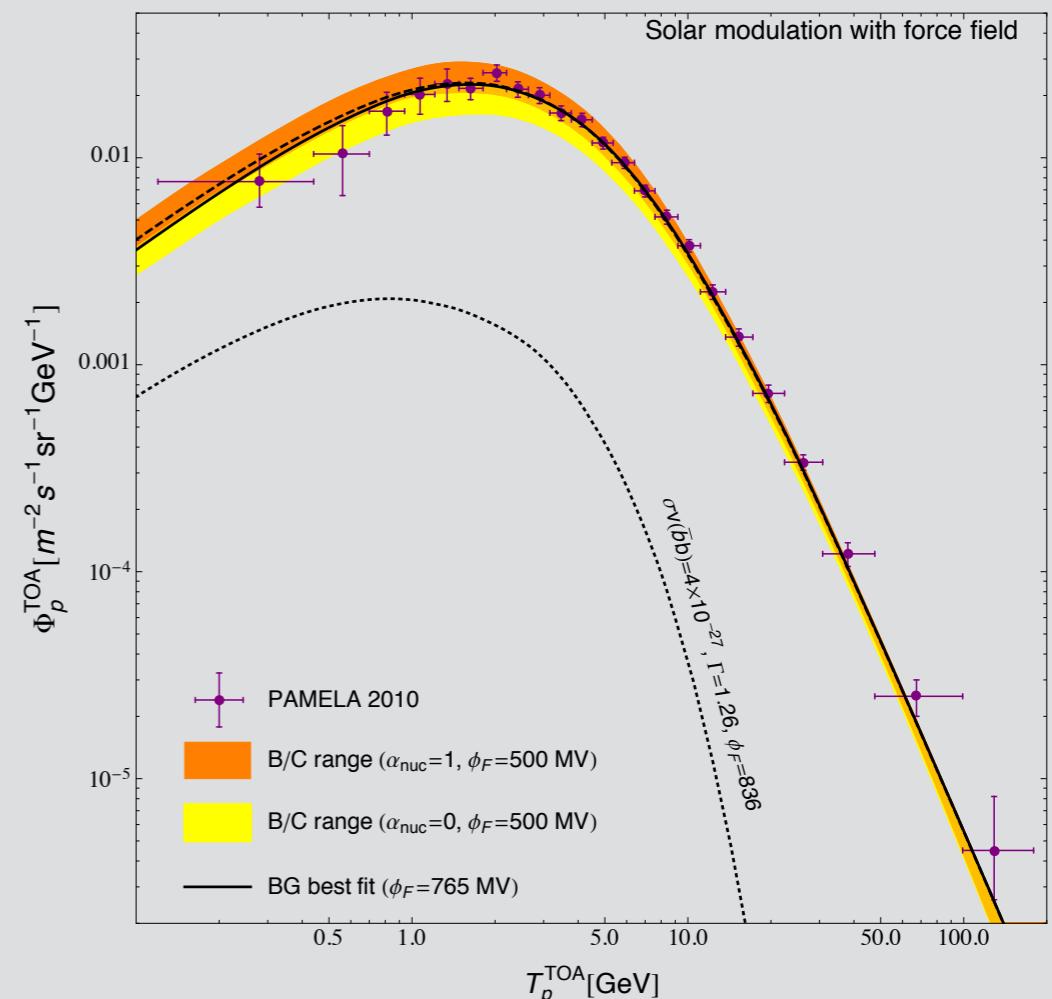
- Would like to further scrutinize the GeV excess in a model-independent way
- Most natural approach: **Indirect** detection strategies!
 - Looking at the same process with different probes: \bar{p} 's, e^+ 's and *radio*
- DM interpretation requires NFW-like profile with inner slope(s) (*Daylan et al [astro-ph/1402.6703]*)
 - $\Gamma = 1.04$ GC analysis
 - $\Gamma = 1.26$ inner galaxy analysis
- Γ uncertainties lead to σv uncertainties



Antiprotons

- Background model (secondaries)
 - Use B/C propagation parameters (*Donato et al [astro-ph/0103150]*)
- 💡 Make a 3-parameter fit
 - account for theoretical uncertainties
 - $\alpha_{\text{nuc}}, \alpha_{\text{prop}} \& \varphi_F$
 - force-field approximation 🤗
- Add the dark matter component
 - ⚠ DM-induced \bar{p} propagation sensitive to degeneracies of the B/C model
 - Reference model ‘KRA’. See Carmelo’s talk and paper [astro-ph.HE/1108.0664]
 - Likelihood ratio test (1 more parameter ➡ σv for each DM mass)

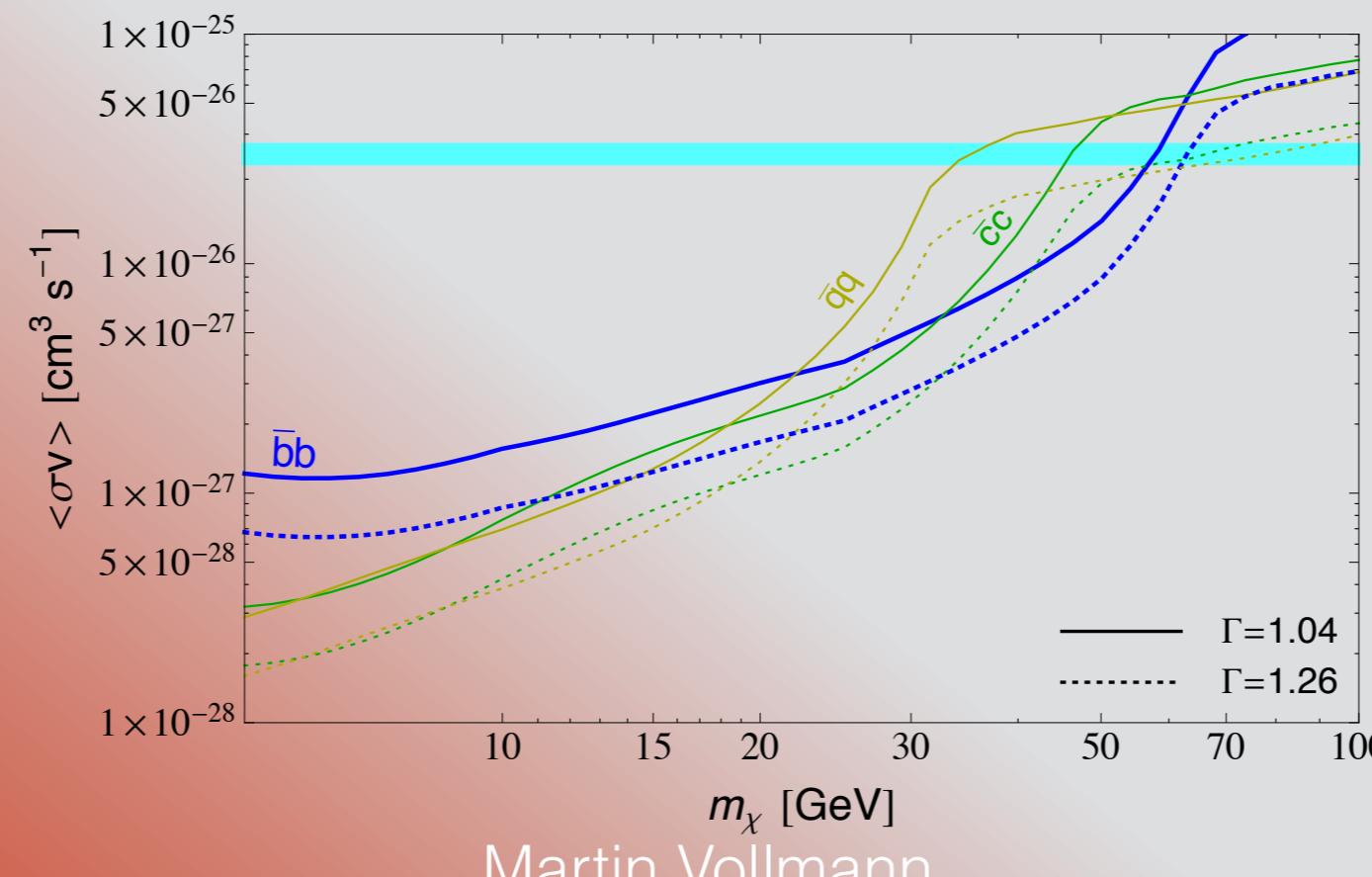
PAMELA data (June 2006- Jan. 2010)
Adriani et al. JETP Lett. 96, 621 (2013)



Antiprotons

- DM-induced \bar{p} 's propagated by DarkSUSY
- Factor of 2-5 improvement respect to previous reports!

1. Used updated PAMELA datasets
2. Theoretical uncertainties taken into account
3. Improved statistical analysis

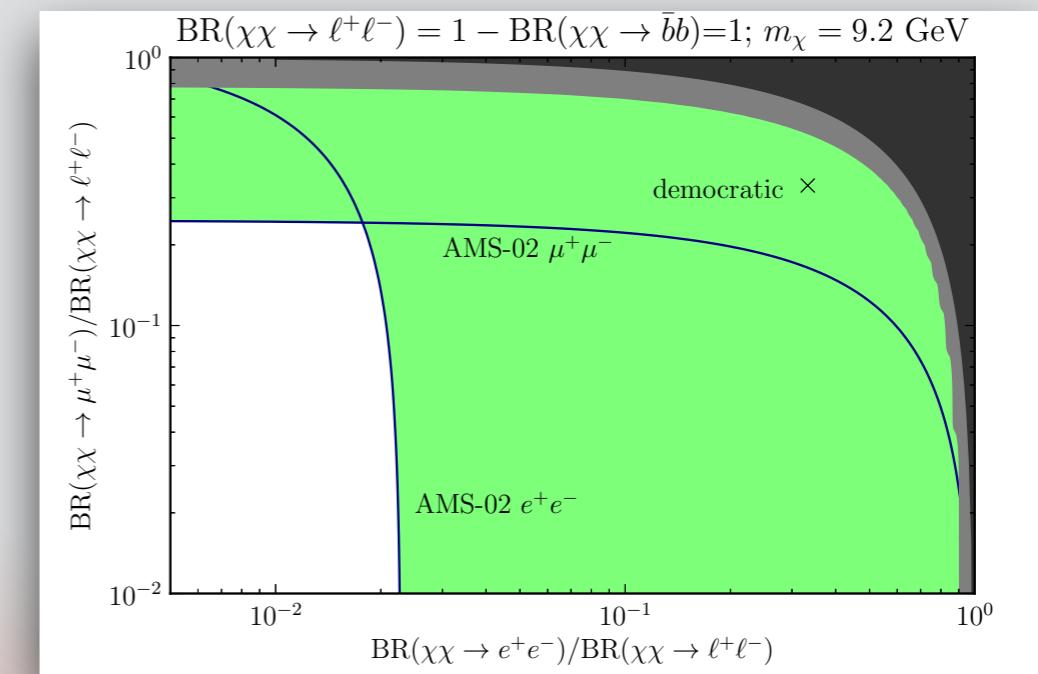
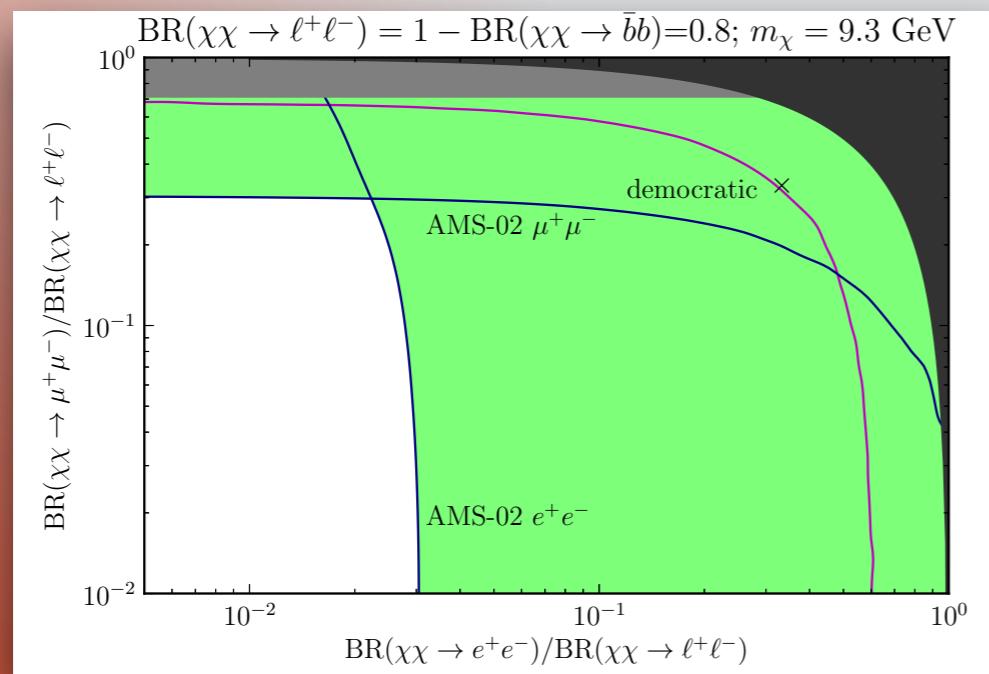


Positrons

- Cosmic-ray positrons \Rightarrow adequate messengers to investigate
 $DM \ DM \rightarrow \ell^+ \ \ell^-$
- Good enough precision and statistics of AMS-02 data (Aguilar et al [PRL 110, 141102]) to perform spectral fits including a DM component
(Bergstrom et al [astro-ph.HE/1306.3983], Ibarra et al [hep-ph/1309.2570], also previous talk)



Constrain the model-building



Radio

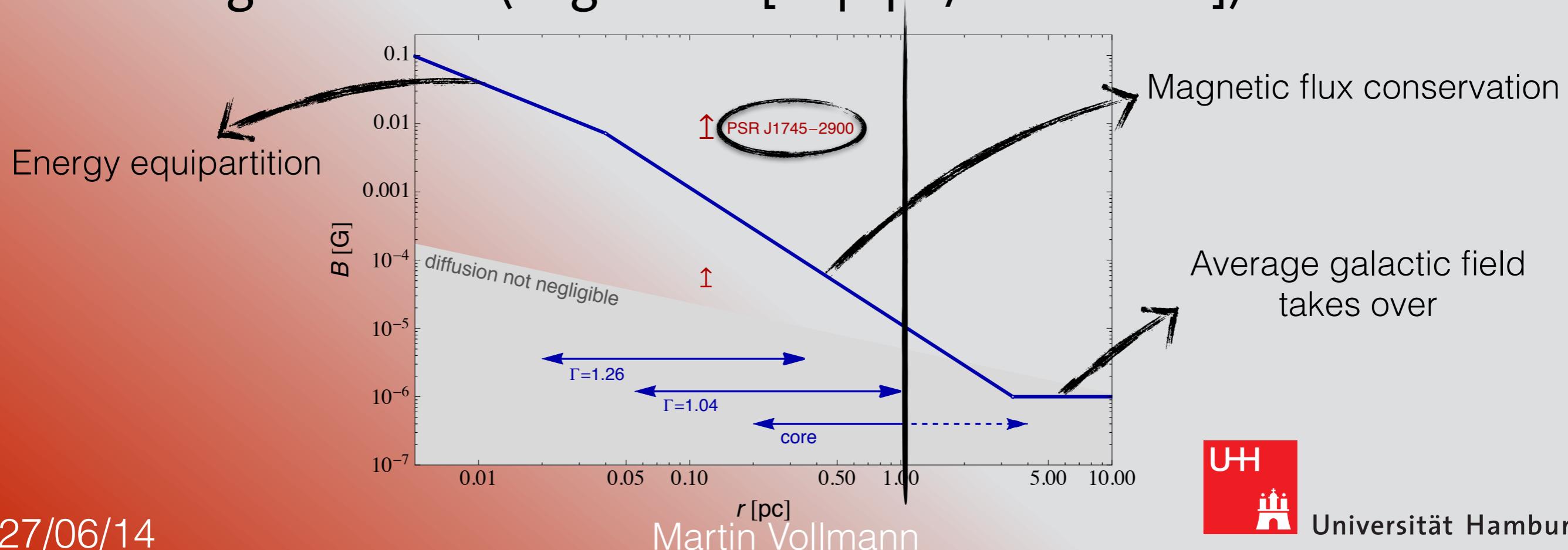
- Under certain assumptions can predict differential radio flux analytically (Bertone et al [astro-ph/0101134]):

$$F_\nu \simeq \frac{\langle \sigma v \rangle}{8\pi\nu R_\odot^2 m_\chi^2} \int E \rho_\chi^2(r) N_e(E) dV$$

(energy of e^\pm emitting
radio frequency ν)

$$E = 0.46 \left(\frac{\nu}{\text{GHz}}\right)^{\frac{1}{2}} \left(\frac{B}{\text{mG}}\right)^{-\frac{1}{2}} \text{GeV}$$

- Magnetic field (Regis et al [hep-ph/0802.0234])

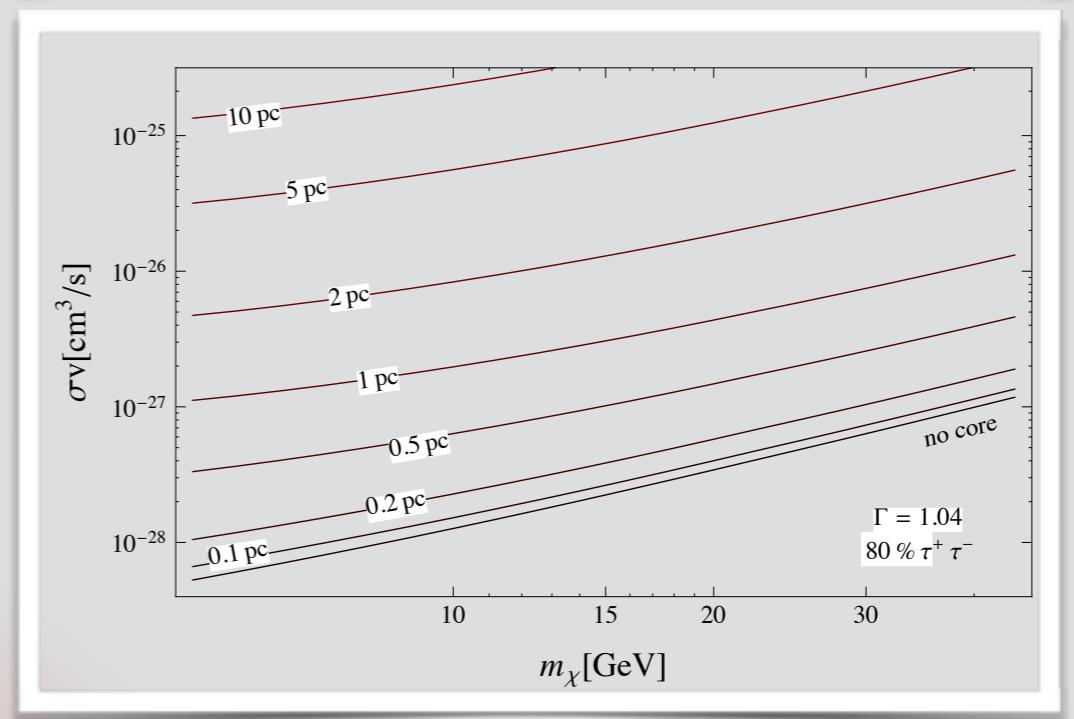
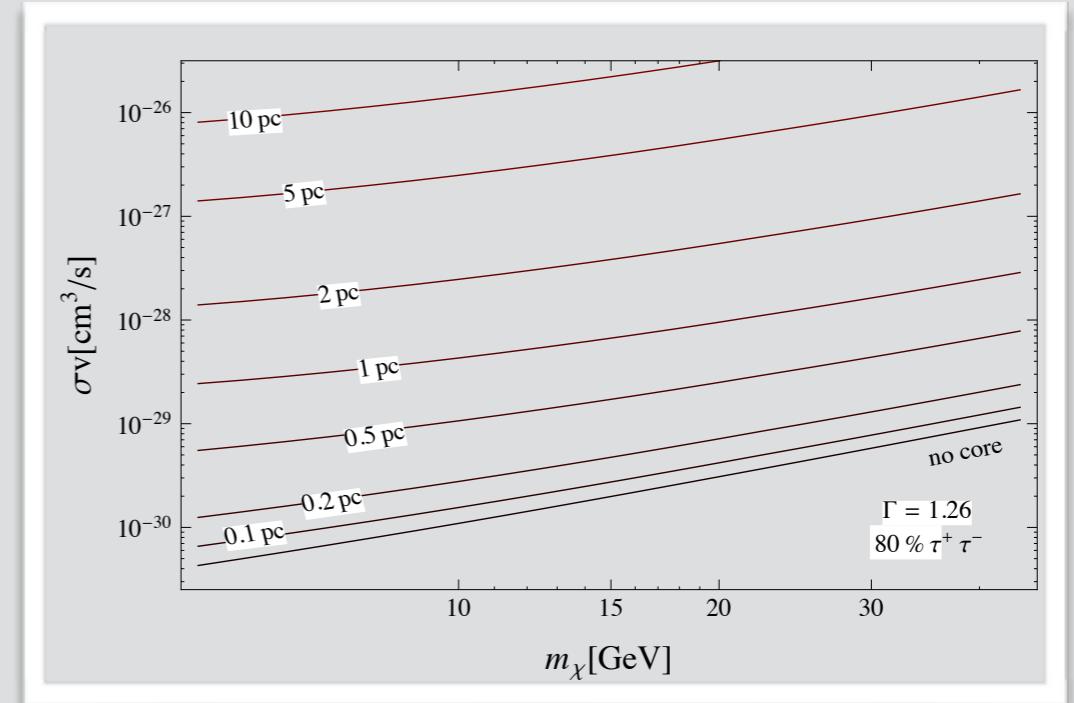


Radio limits

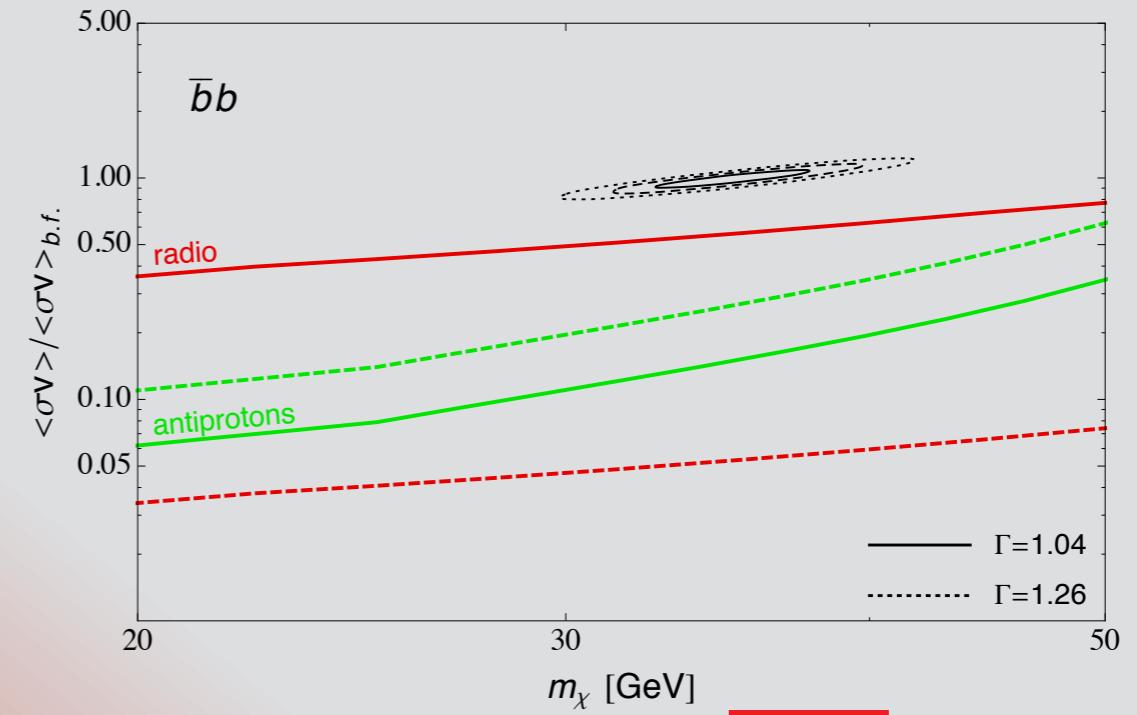
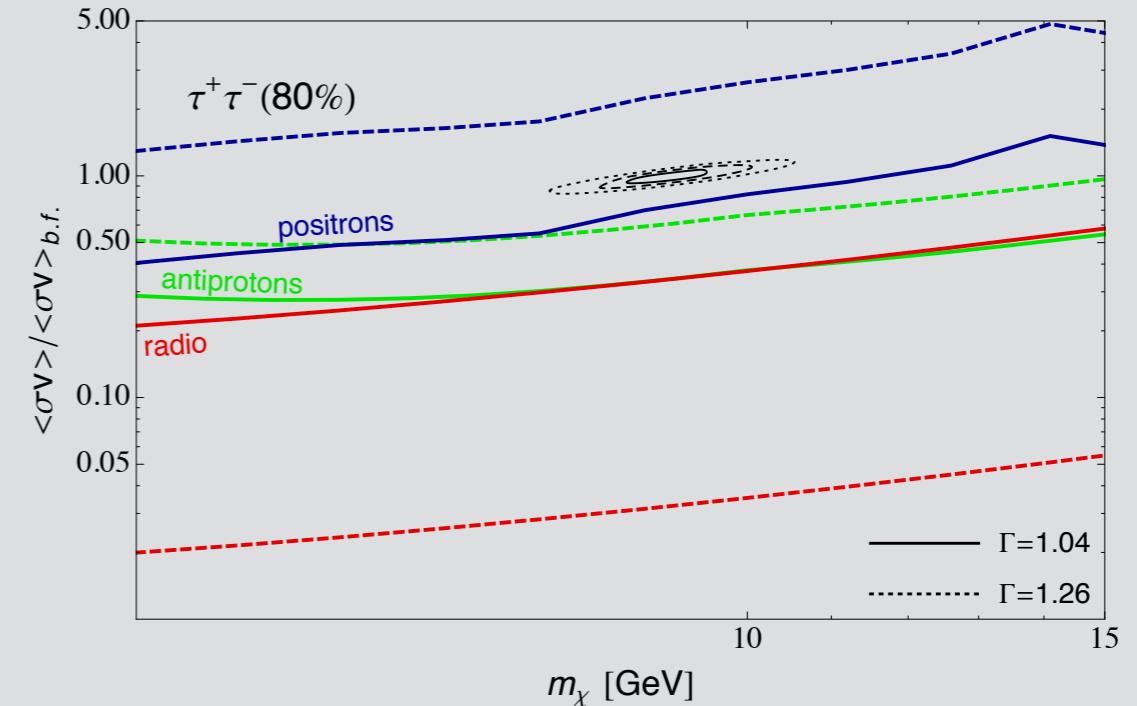
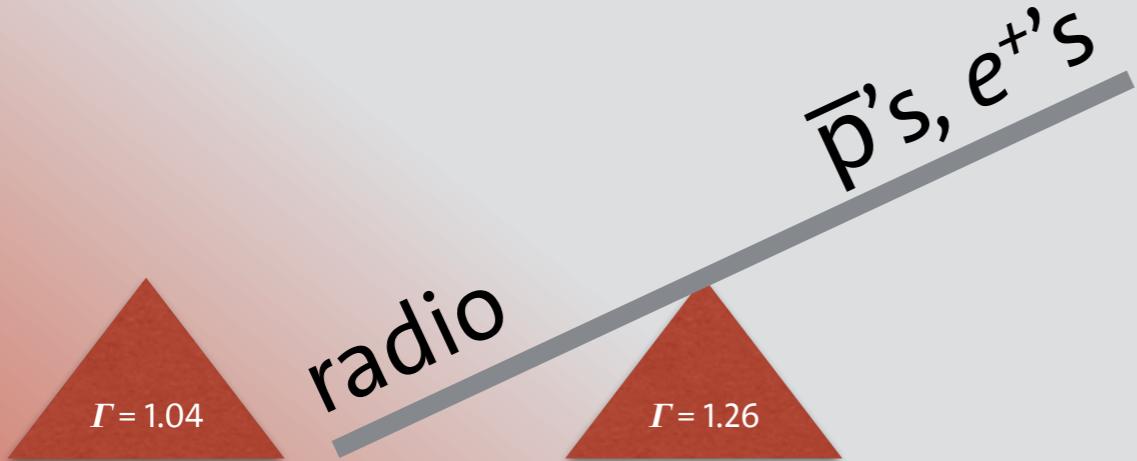
- Jodrell Bank **408MHz** measurement (Davies et al, MNRAS 177, 319-333) → upper limit of 50mJy
 - If signal is only DM (no BG) → rather strong constraints for σv

★ These are highly (mildly) sensitive to ρ (B)

- Introducing (*ad-hoc*) a core in the DM distribution makes them less stringent



Summary

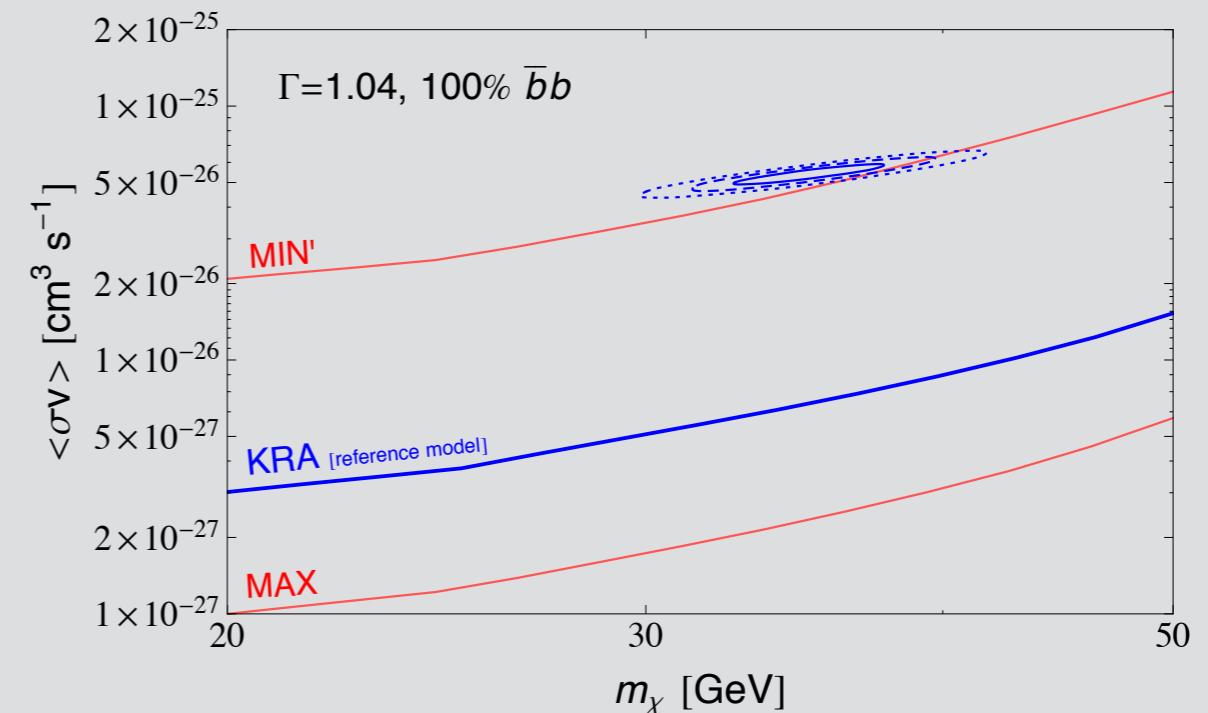


Conclusions

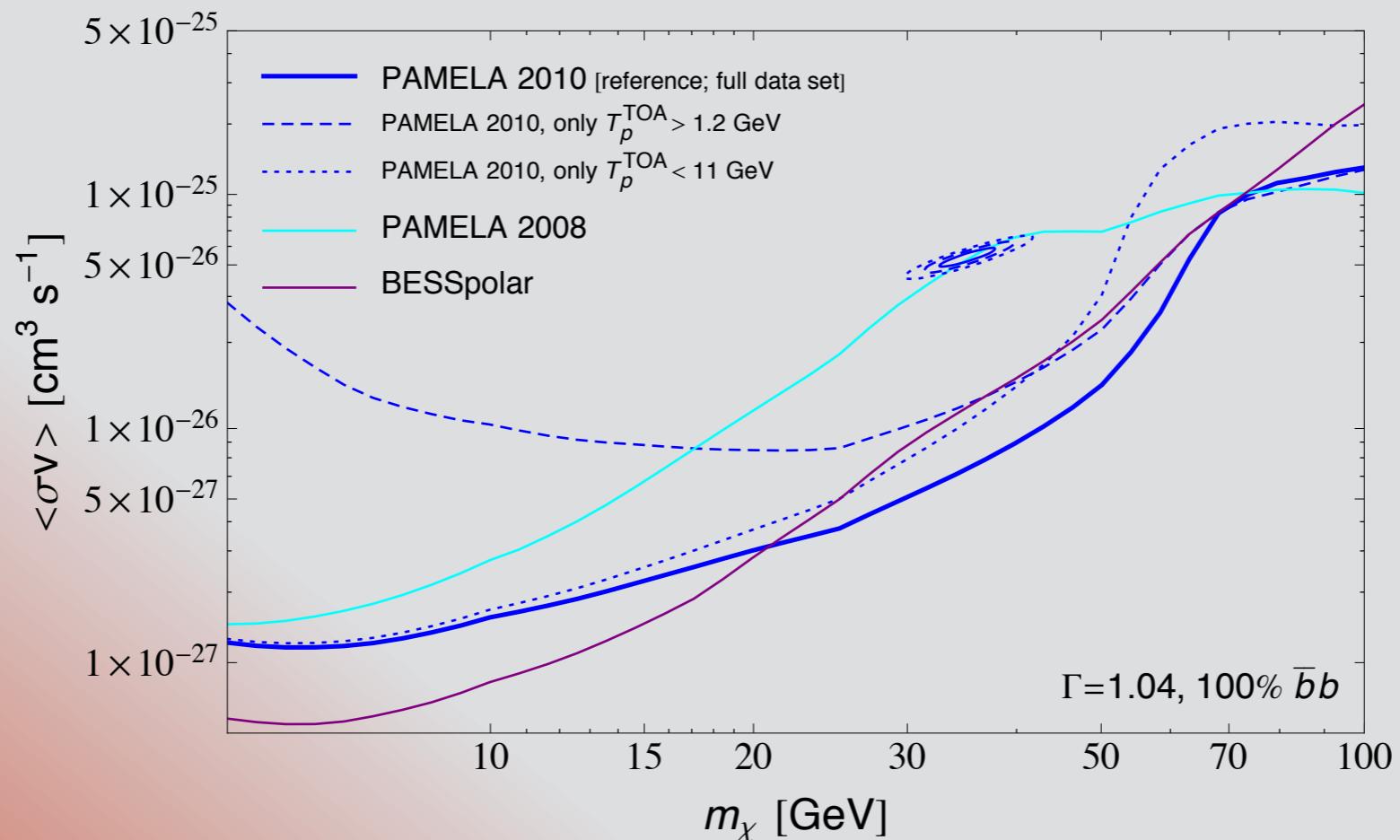
- ✓ Improved antiproton limits
- ✓ AMS-02 spectral fit offers interesting bounds on DM $DM \rightarrow$ charged leptons
- ✓ Revisited derivation of radio fluxes
- ✓ DM interpretation GeV excess is either
 - excluded by other indirect detection channels, or
 - very likely to be soon confirmed in those channels
- Look forward to AMS-02 antiproton data!!

Antiproton backup 1

- Also considered extreme cases within allowed parameter space by B/C
- 💡 MIN' model features $L=2\text{kpc}$
 - $L \lesssim 1\text{kpc}$ ruled out by radio data (Bringmann et al [astro-ph.GA/1106.4821], Di Bernardo et al [astro-ph.HE/1210.4546])
 - Moreover, radiative isotope analysis favours $L \sim 10\text{kpc}$ (Putze et al [astro-ph.HE/1001.0551])
 - Similar results when adding γ -rays and e's to the analysis (Delahaye et al [astro-ph.HE/1102.0744], Fermi-Lat coll. [astro-ph.HE/1202.4039]; Delahaye et al [astro-ph/0809.5268],

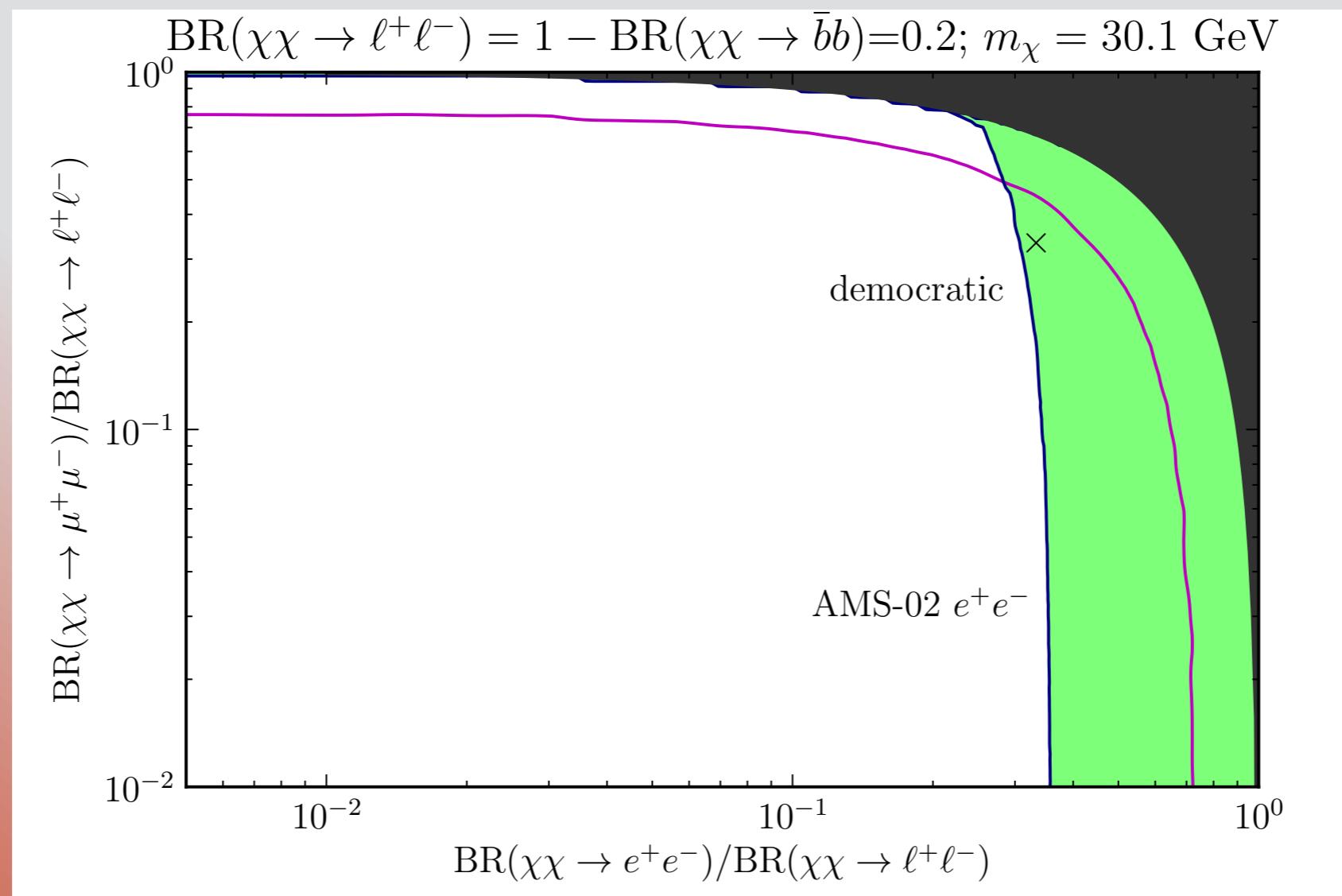


Antiproton backup 2



Positrons backup

- Only lepton annihilations



Radio Backup 1

- Expect energy losses to dominate $\rightarrow e^\pm$ lose all of their energy *in situ* provided that (Bohm diffusion assumed):

$$B(r) \gtrsim 4 \Gamma^{2/3} \left(\frac{pc}{r} \right)^{2/3} \mu G$$

- Rotation measurements give a handle on the minimum strength recently discovered Magnetar (Beck et al DOI 10.1007/978-94-007-5612-0 13)



50 μ G conservative, 8 mG realistic

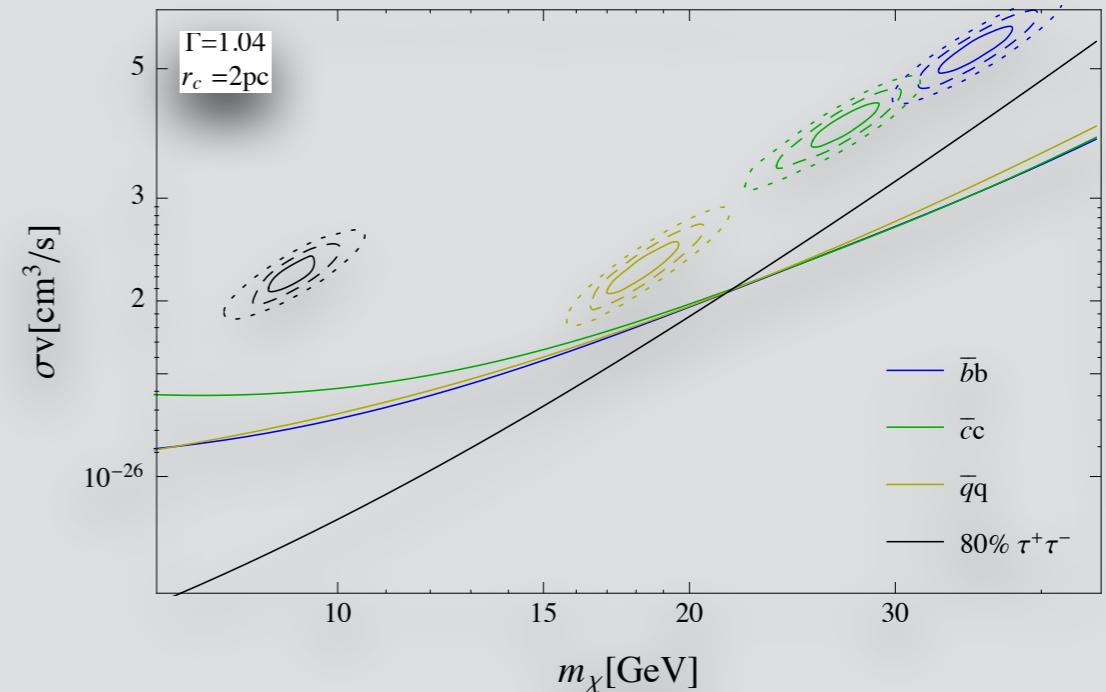


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Radio backup 2

- Taking a core radius $r_c=2\text{pc}$ and B as in slide above



- If we take constant $B \Rightarrow$

