

PLANCK2012

Warsaw



Synchrotron radiation vs.
Colliders methods as
constraints on Dark Matter

Bryan Zaldívar (Madrid, IFT-UAM)

arXiv < 1206.XXXX

in collaboration with:

Y. Mambrini, M. Tytgat, G. Zaharijas

30/05/'12



Outline

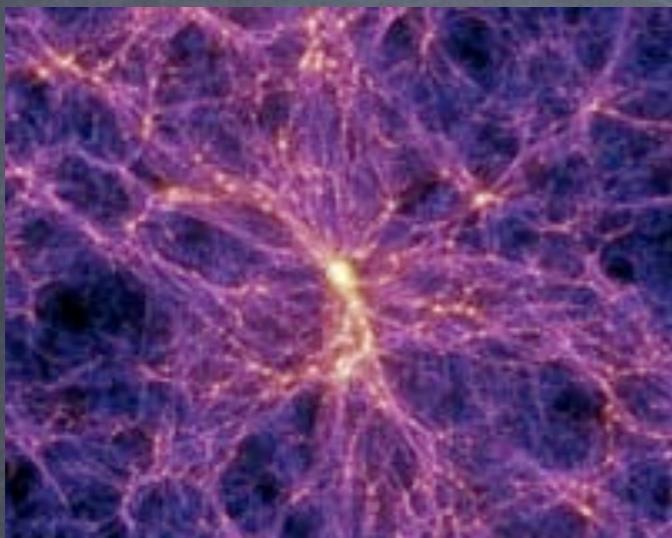
- Introduction
 - Dark Matter, Synchrotron world
 - Collider mono-signals and DM
- Astrophysical set-up(s)
 - DM profile, propagation, B.field
- Results
 - Effective approach (synch, LEP, LHC)
 - Higgs-portal / Z'-portal
- Conclusions

Dark Matter

- Everyone in this room is convinced about the existence of DM, right?

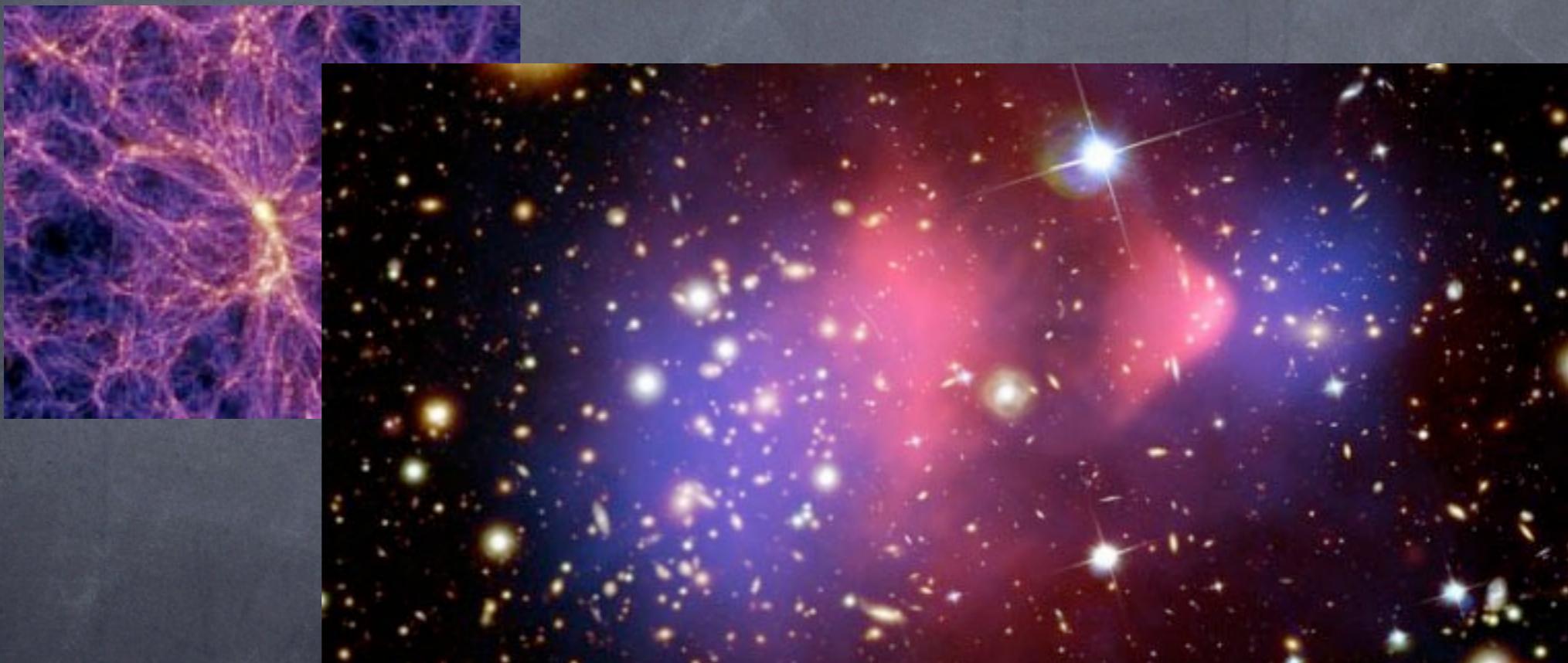
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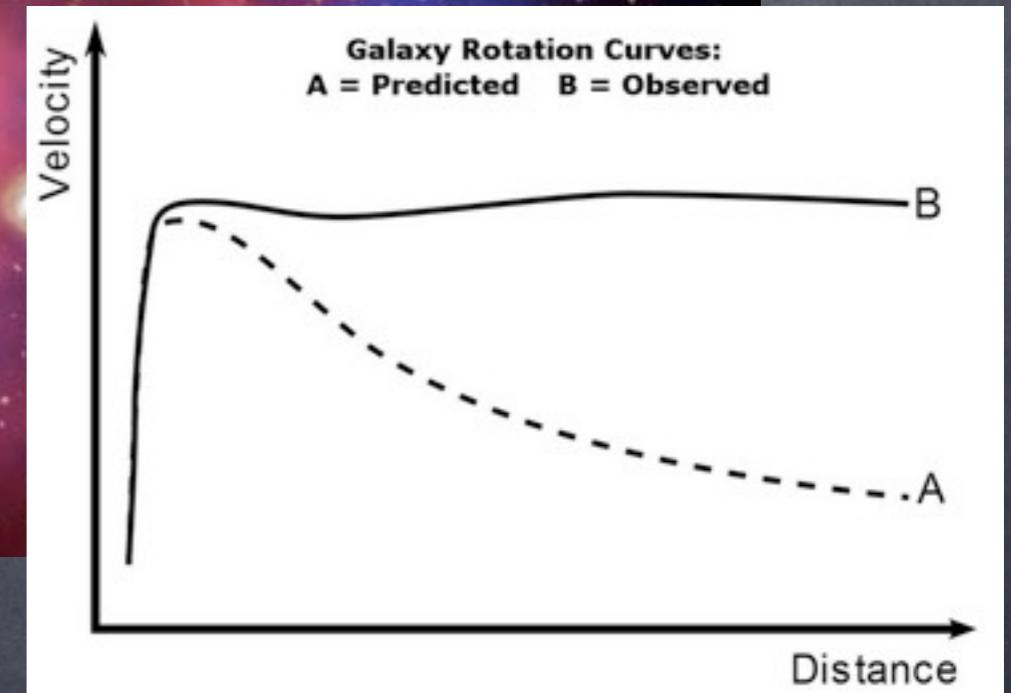
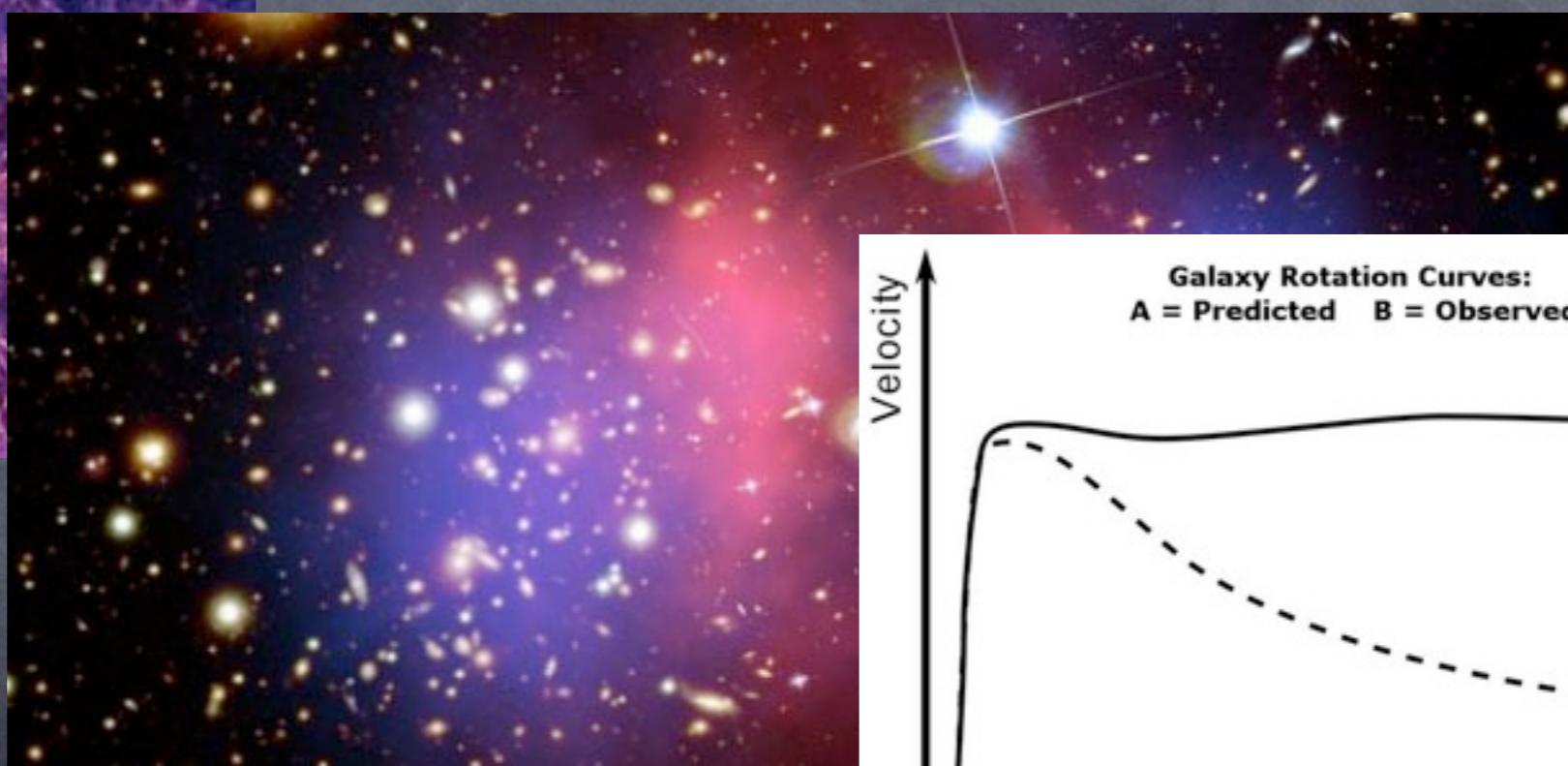
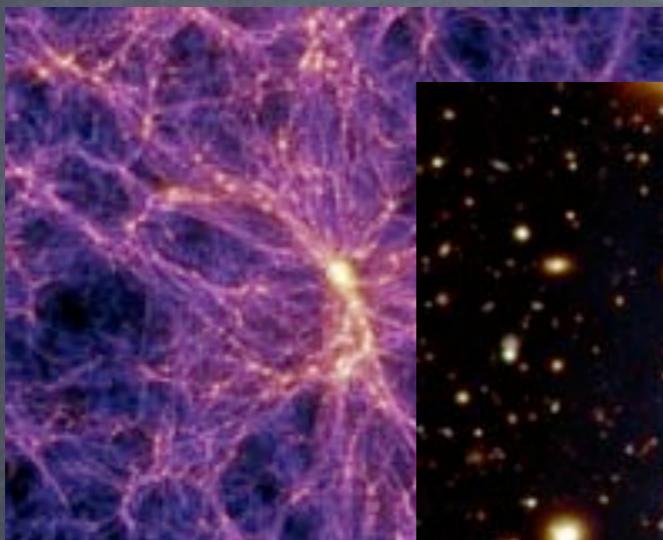
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WIMPs

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• WMAP data: $\Omega_X h^2 = 0.112 \pm 0.006 (1\sigma)$

4.7% baryons, 22% dark matter,
73% dark energy

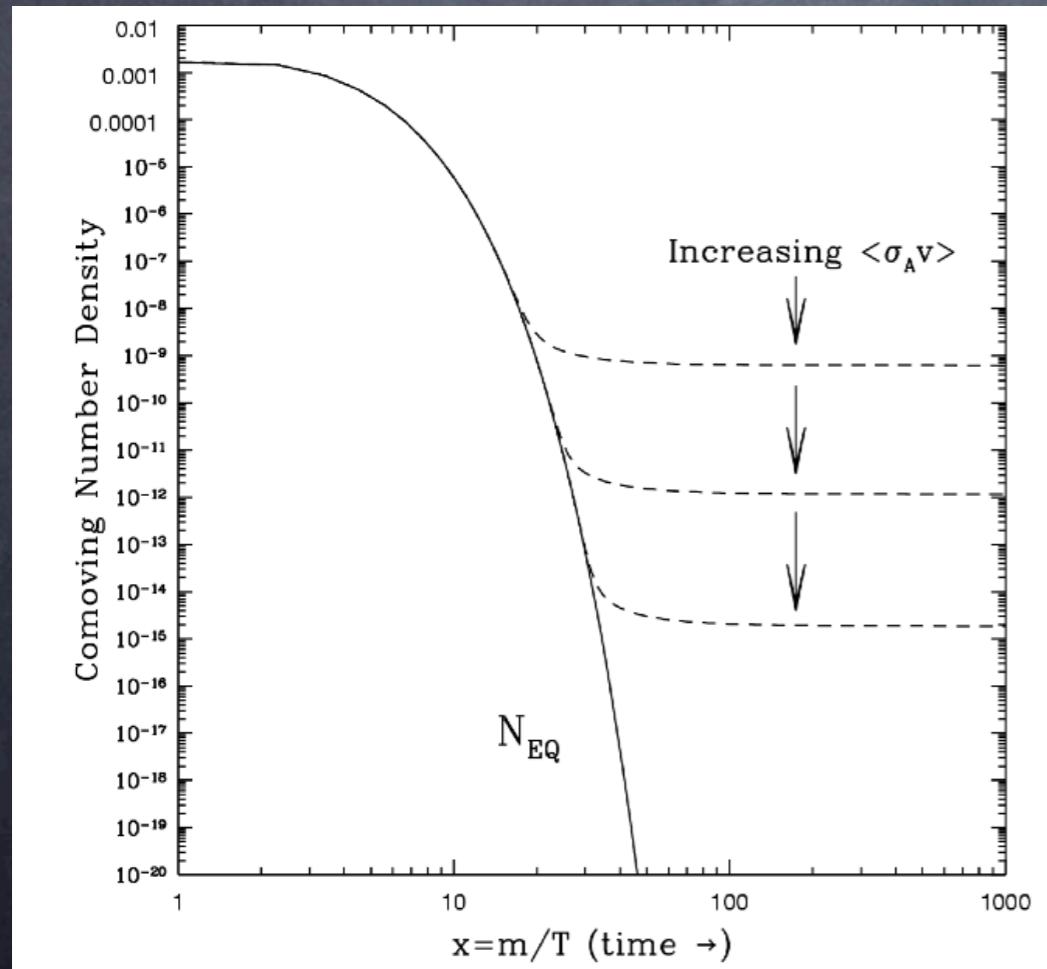
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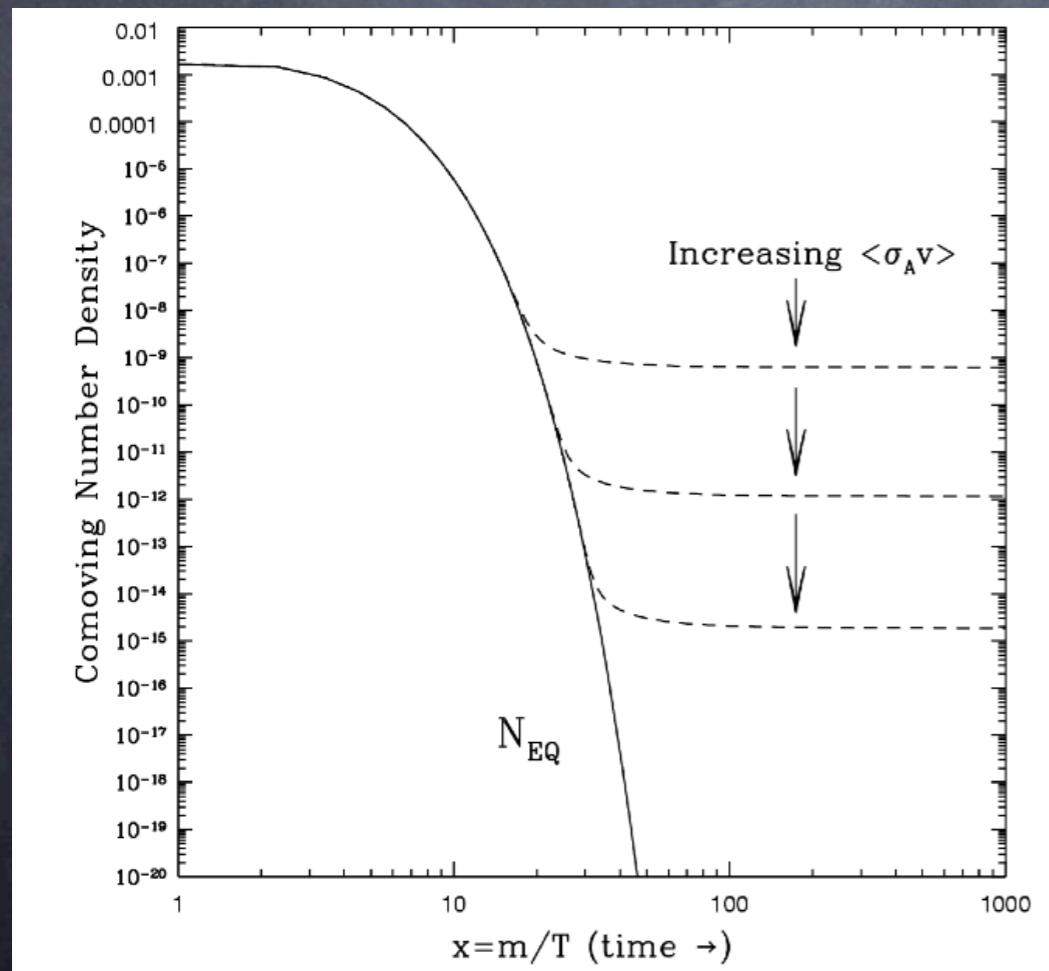


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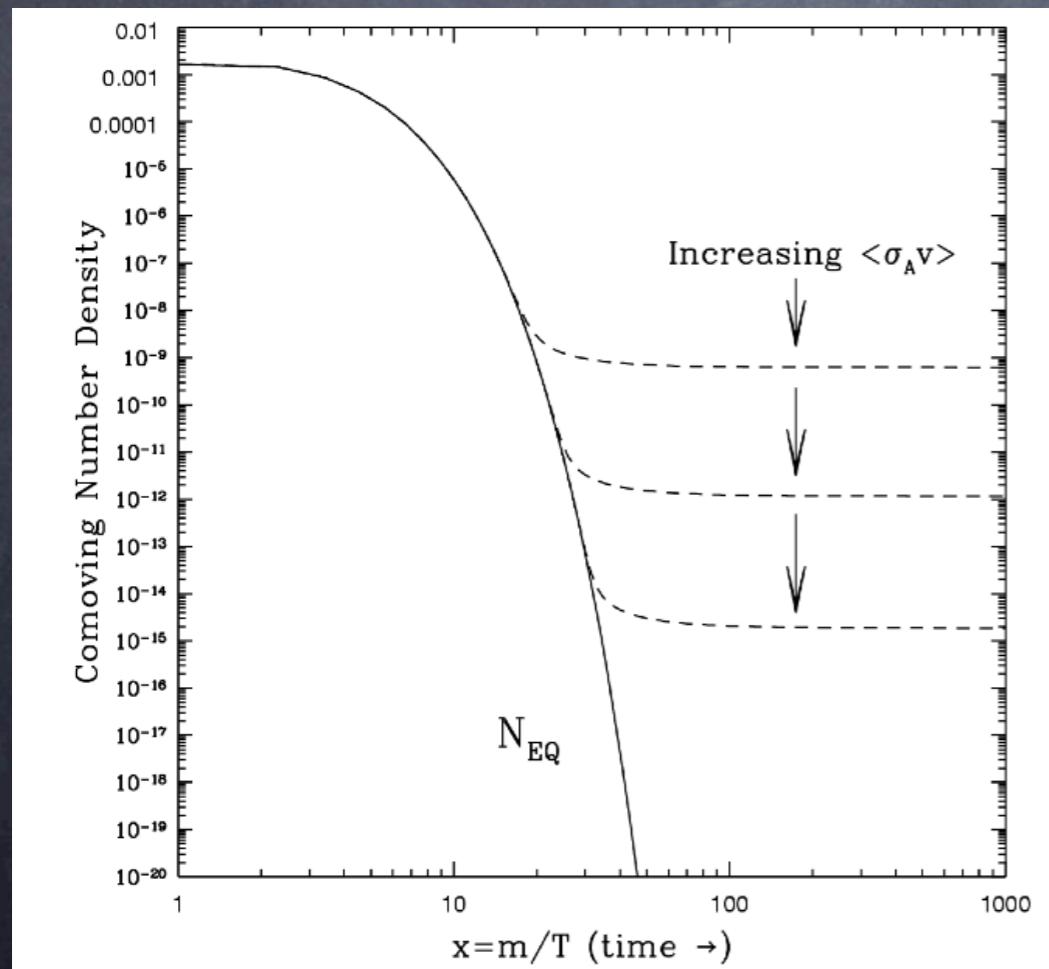
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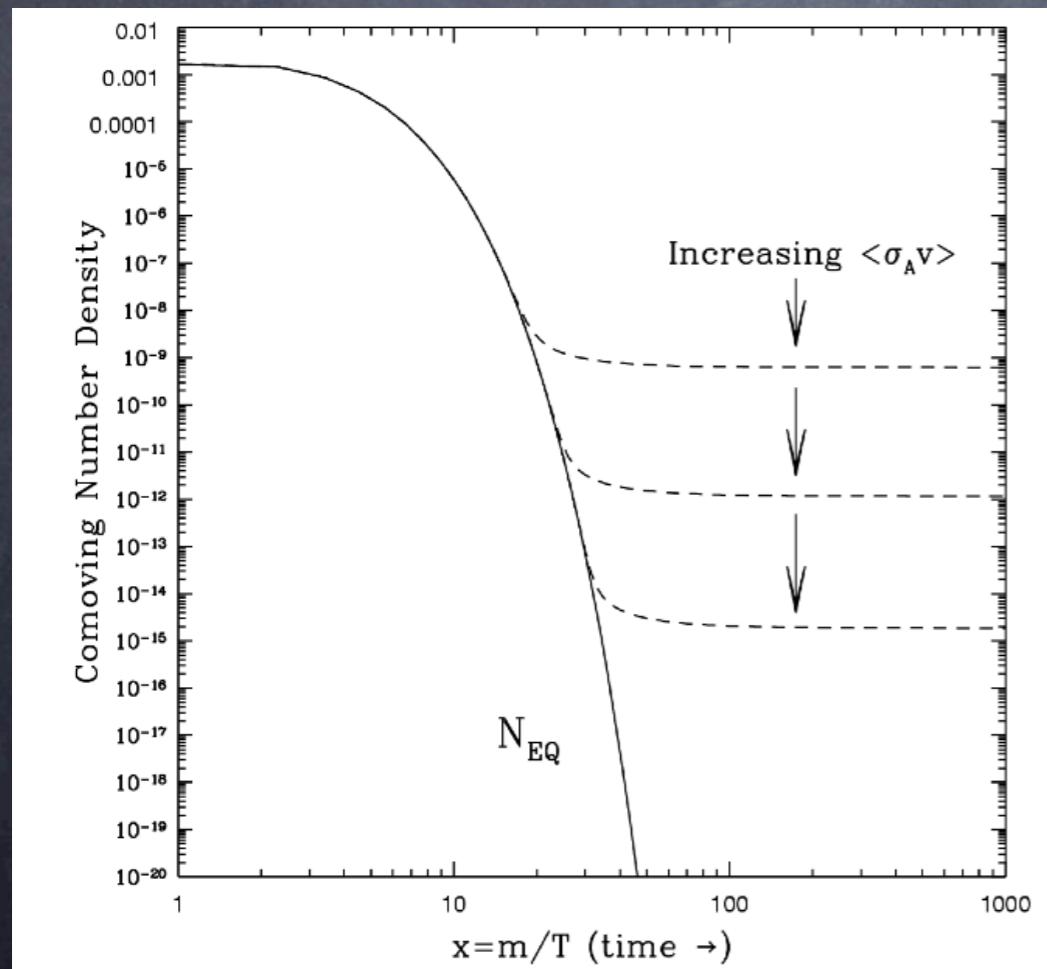
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 $m \approx 100 \text{ GeV} \Rightarrow g_{\text{weak}}$
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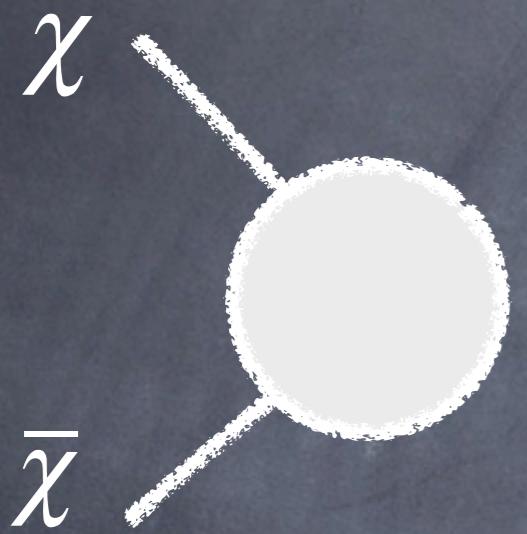
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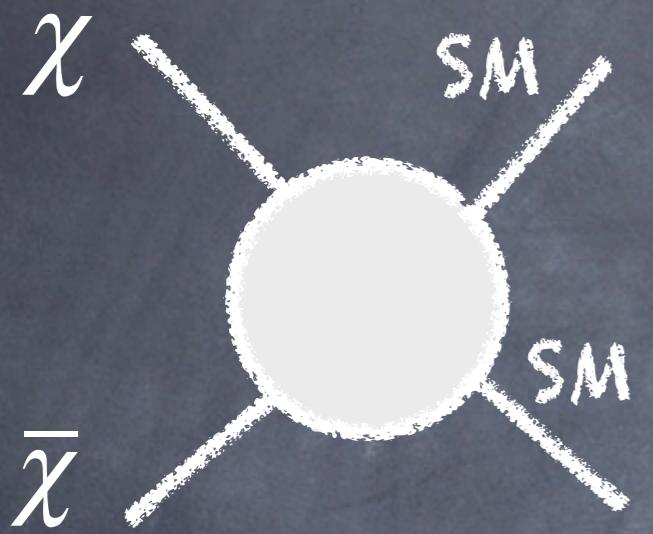
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 weakly interacting,
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 neutral

Synch. radiation

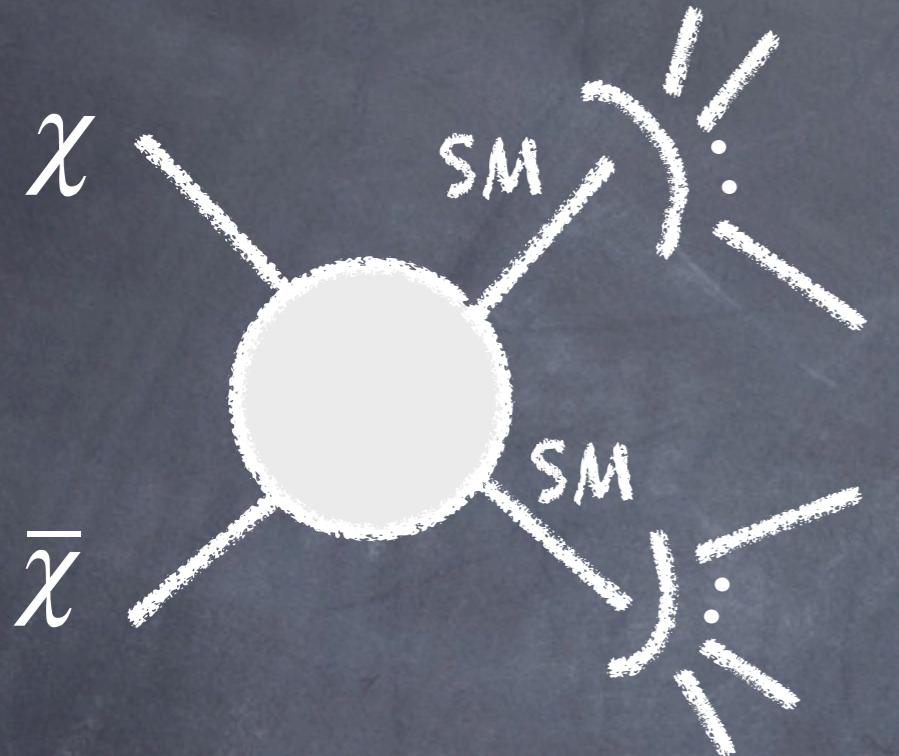
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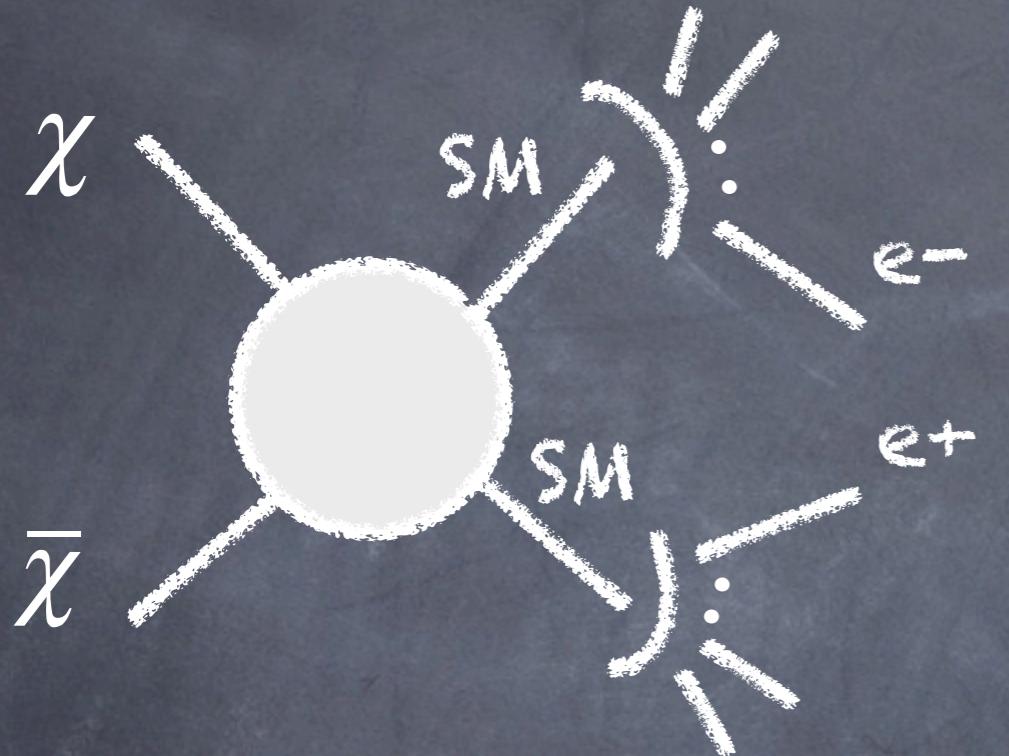
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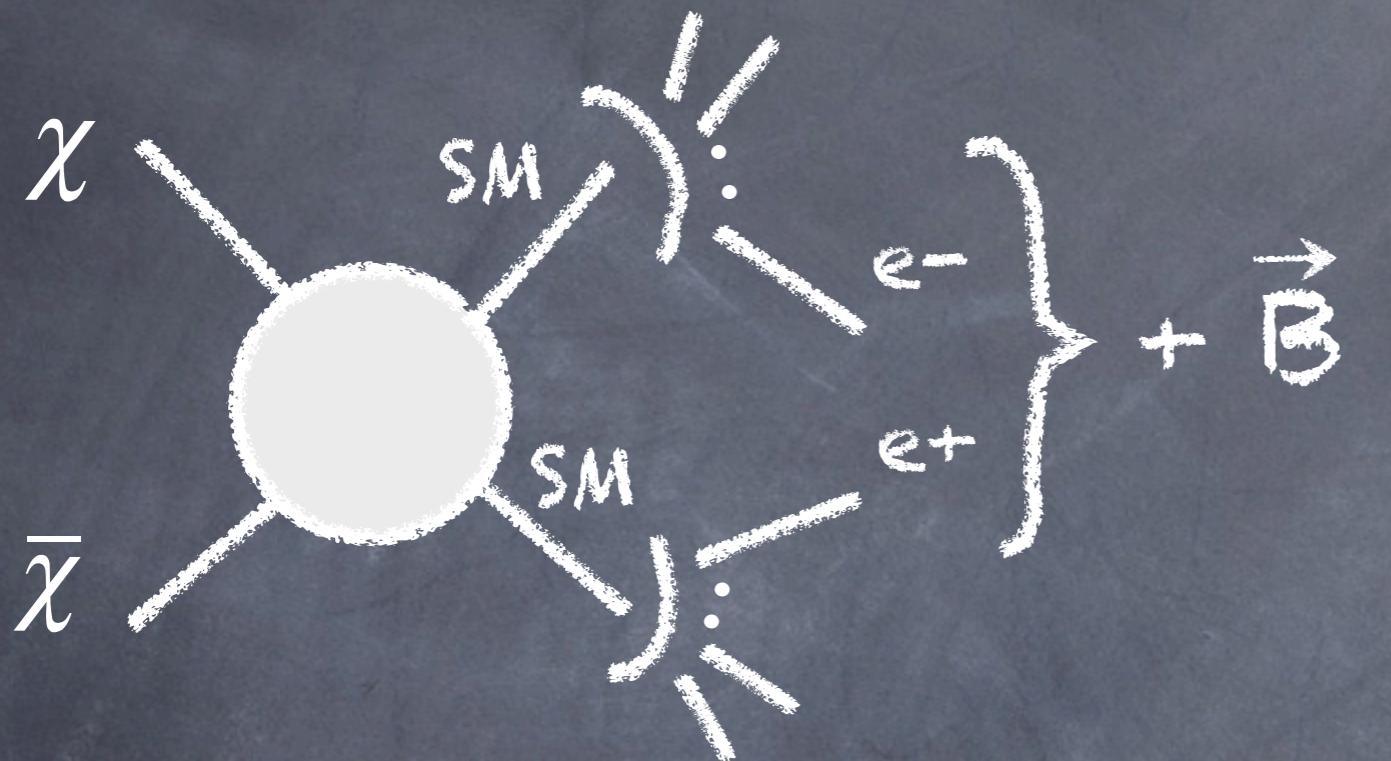
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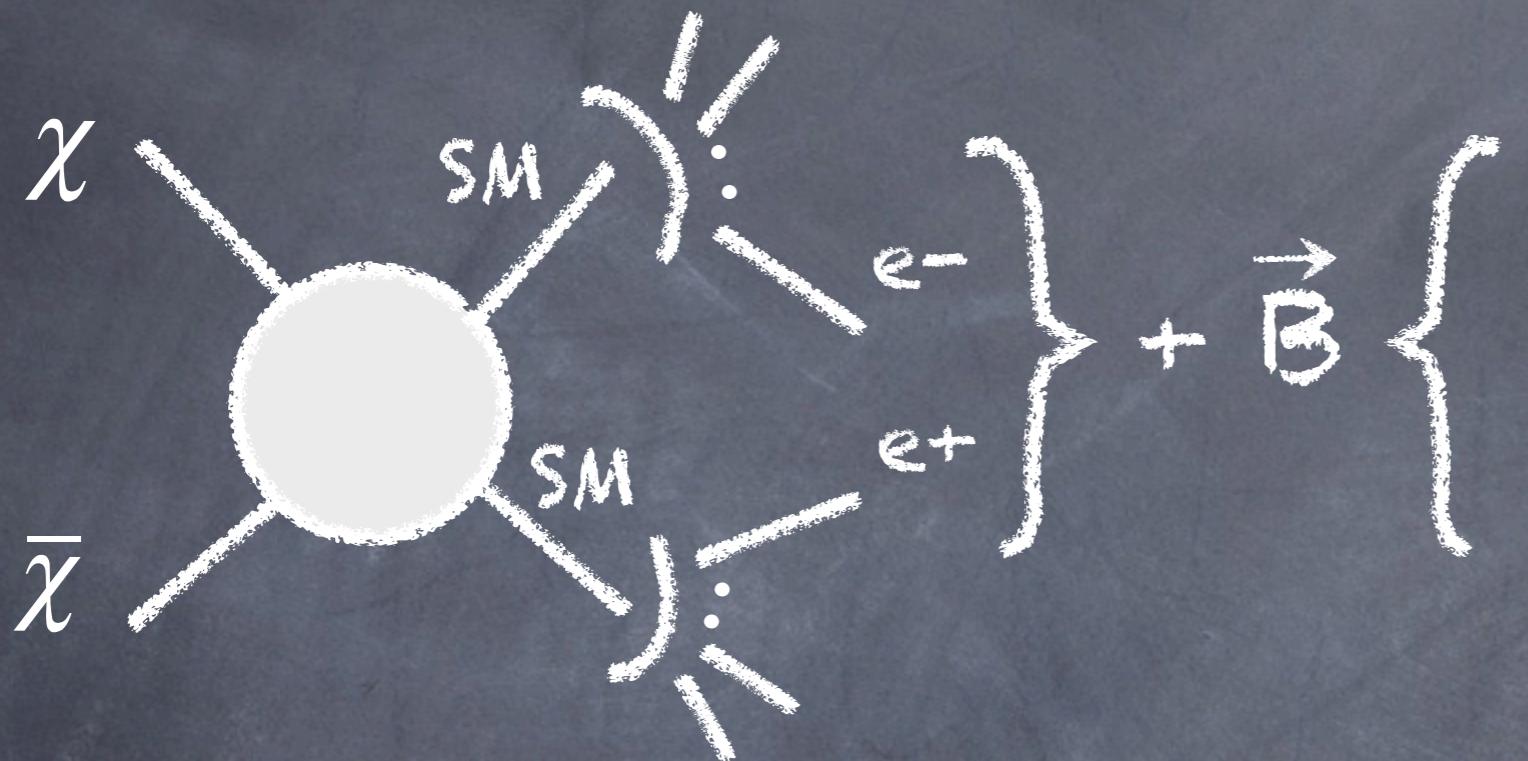
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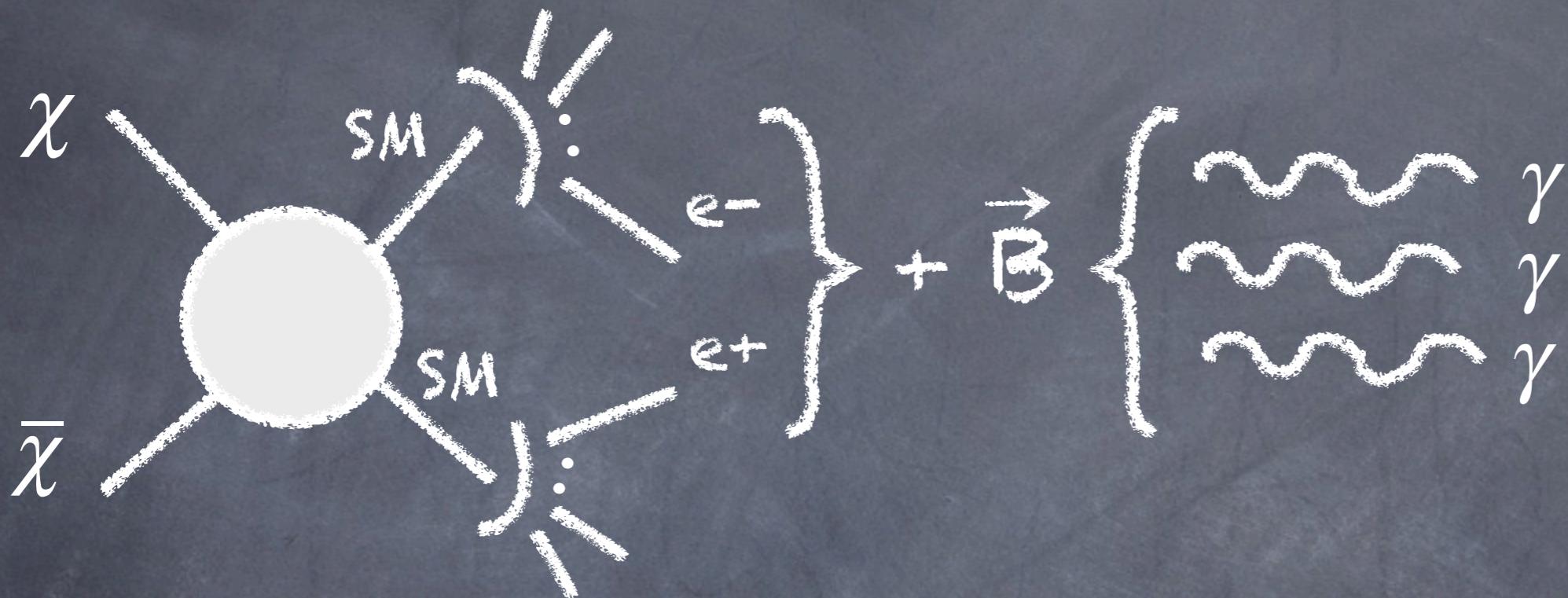
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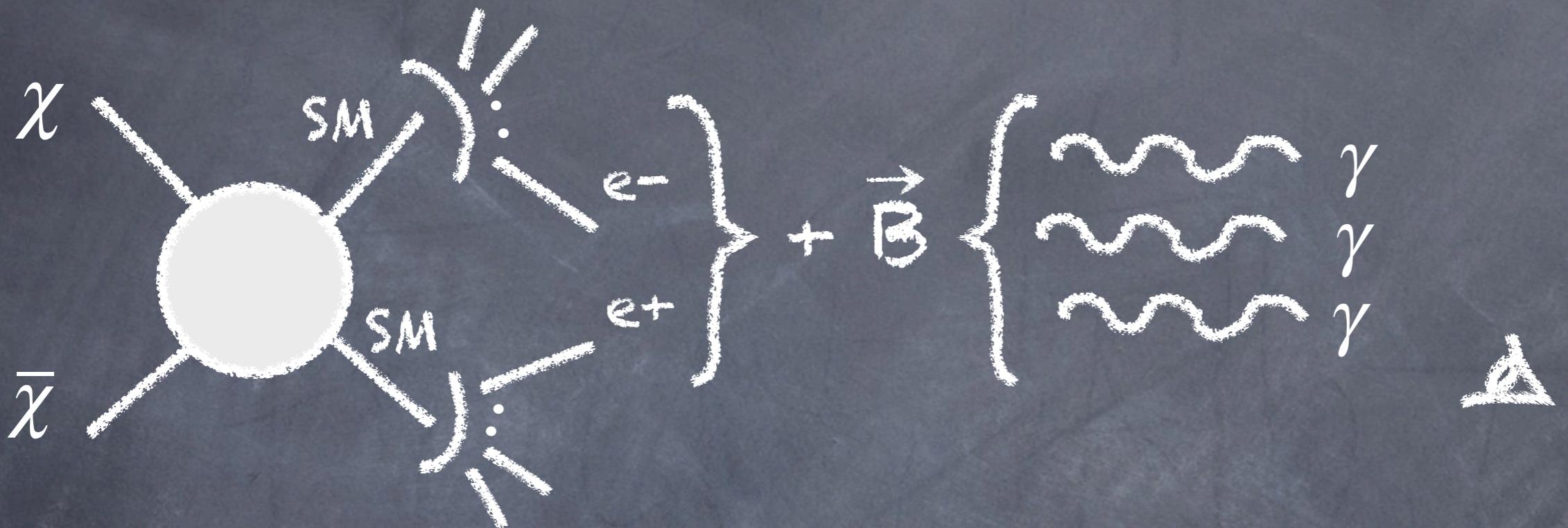
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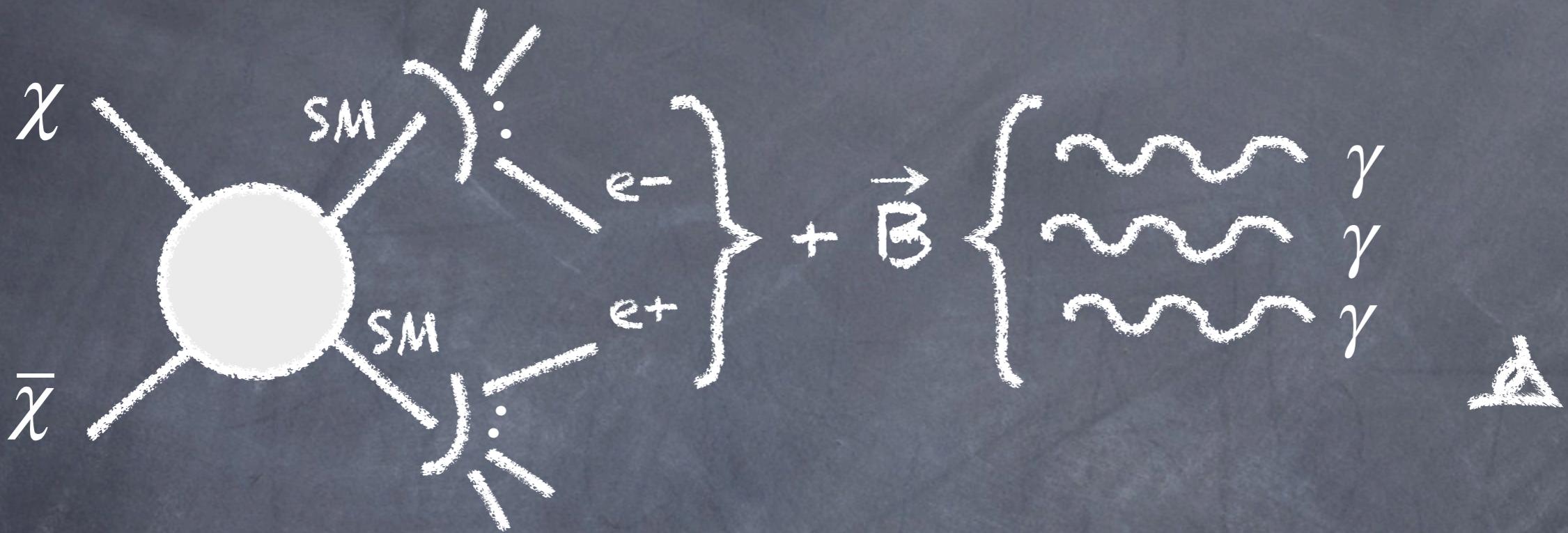
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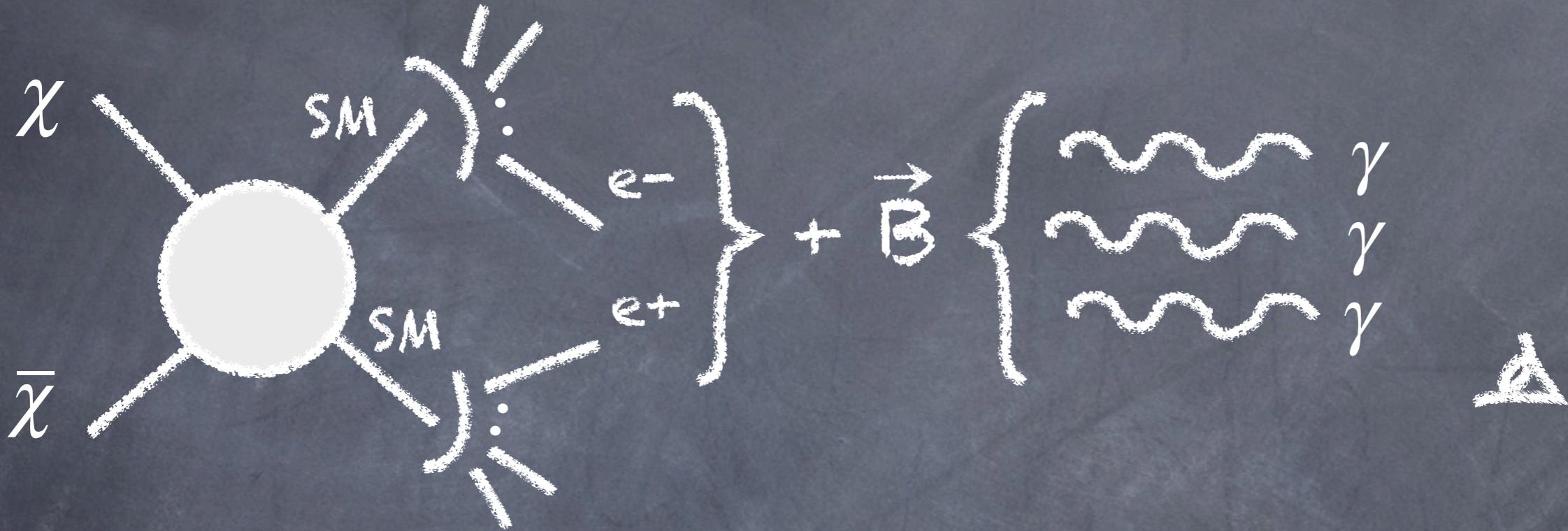


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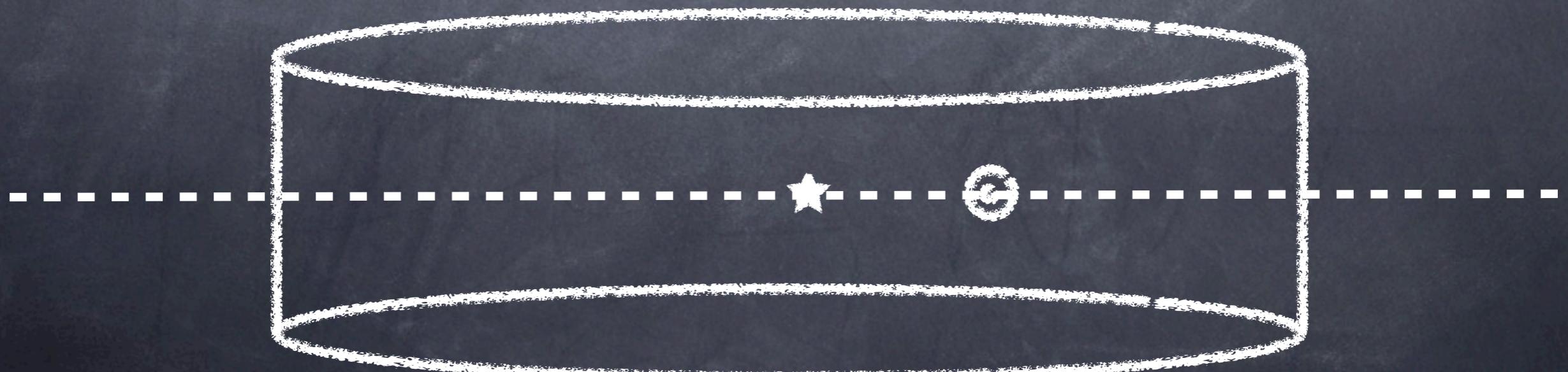


Diffusion region:

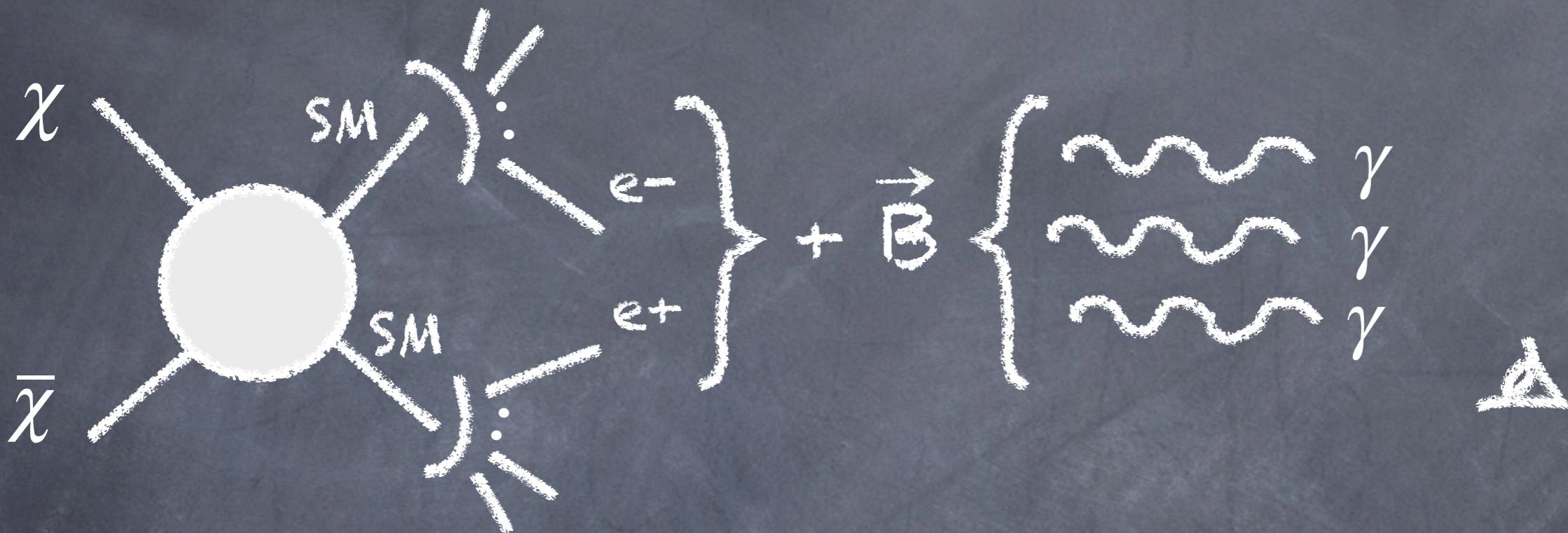
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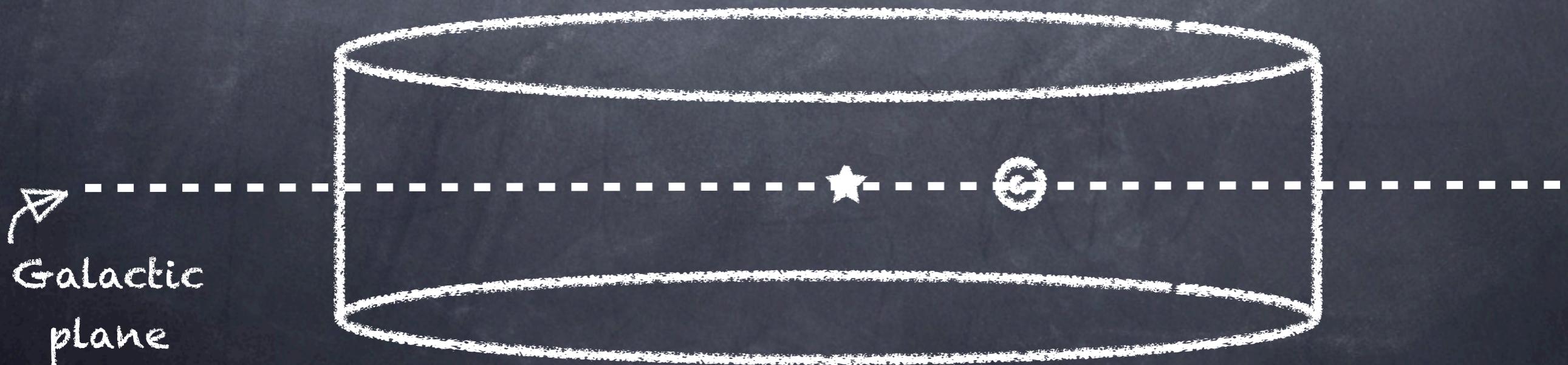
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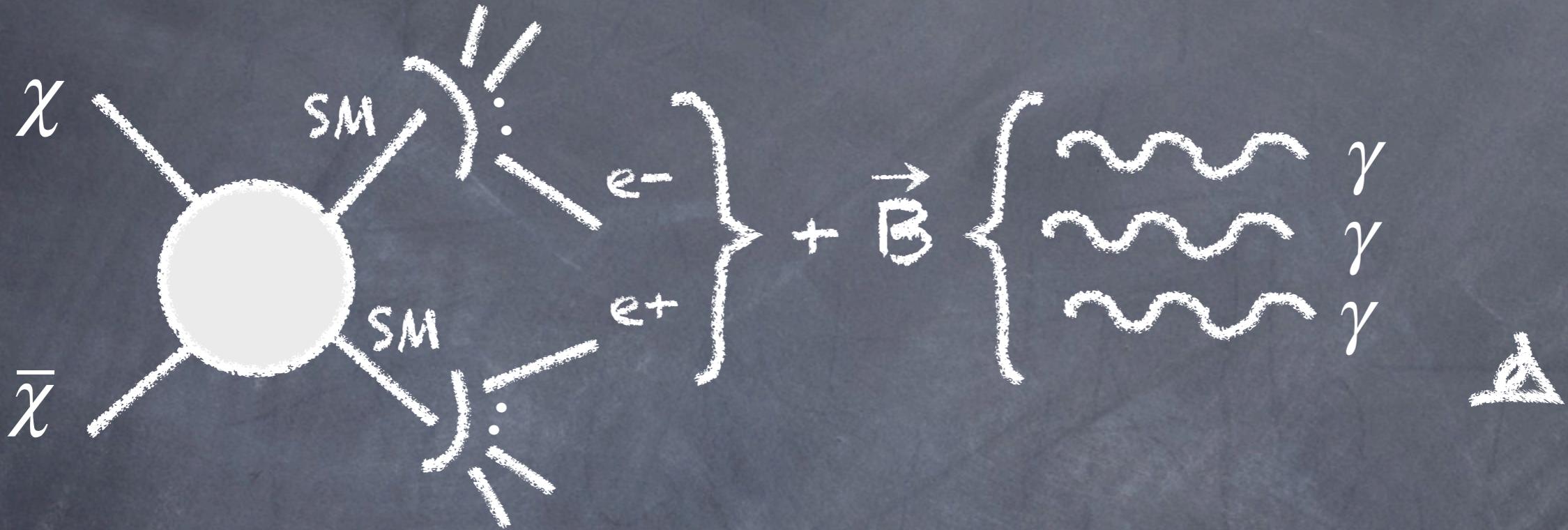
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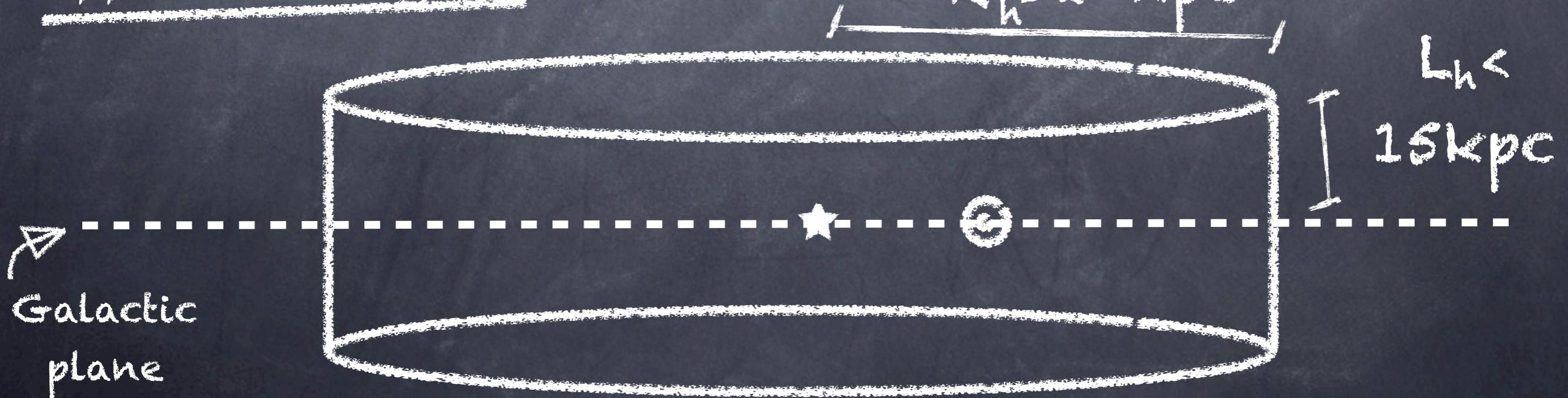
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Transport Eq.

$$\frac{\partial n(x,E)}{\partial t} - \nabla \cdot (K(E) \nabla n(x,E)) - \frac{\partial}{\partial E} (b(x,E) n(x,E)) = q(x,E)$$

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$$n(x, E) = \frac{1}{b(E)} \int dE_S \int_{DZ} d^3x_S G(x, E \leftarrow x_S, E_S) q(x_S, E_S)$$

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$$F_\nu = 1.21 \times 10^8 \frac{\text{Jy}}{\text{Hz} \cdot \text{sr}} \left\{ \frac{\eta}{2} \left(\frac{\langle \sigma v \rangle}{3 \times 10^{-26} \text{cm}^3 / \text{s}} \right) \left(\frac{1 \text{GeV}}{m_x} \right)^2 \left(\frac{\rho_0}{1 \text{GeV/cm}^3} \right)^2 \times \right. \\ \left. \sqrt{\frac{1 \mu\text{G}}{\text{B}}} \frac{1 \text{GHz}}{\nu} \frac{P(E_c)}{b(E_c)} \frac{1}{4\pi} \int_{\text{los}} \frac{dl}{\text{kpc}} \int_{E_c}^{m_x} dE_s \frac{dN(E_s)}{dE} I(E, E_s) \right\}$$

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Synch-loss:

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$$r_{\text{IC/syn}} = 6 \left(\frac{U_{\text{rad}}}{8 \text{eV/cm}^3} \right) \left(\frac{B}{6 \mu\text{G}} \right)^2$$

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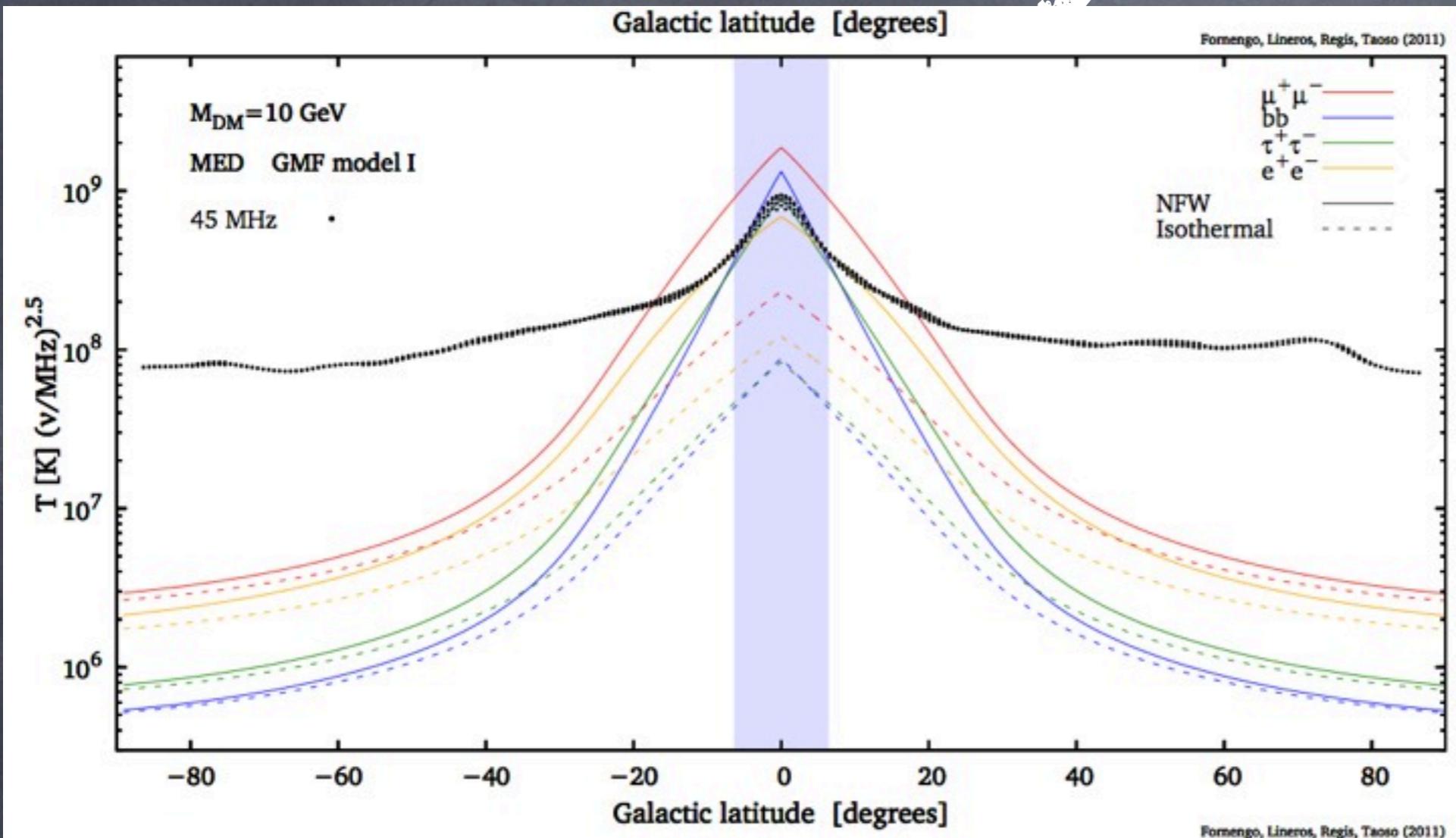
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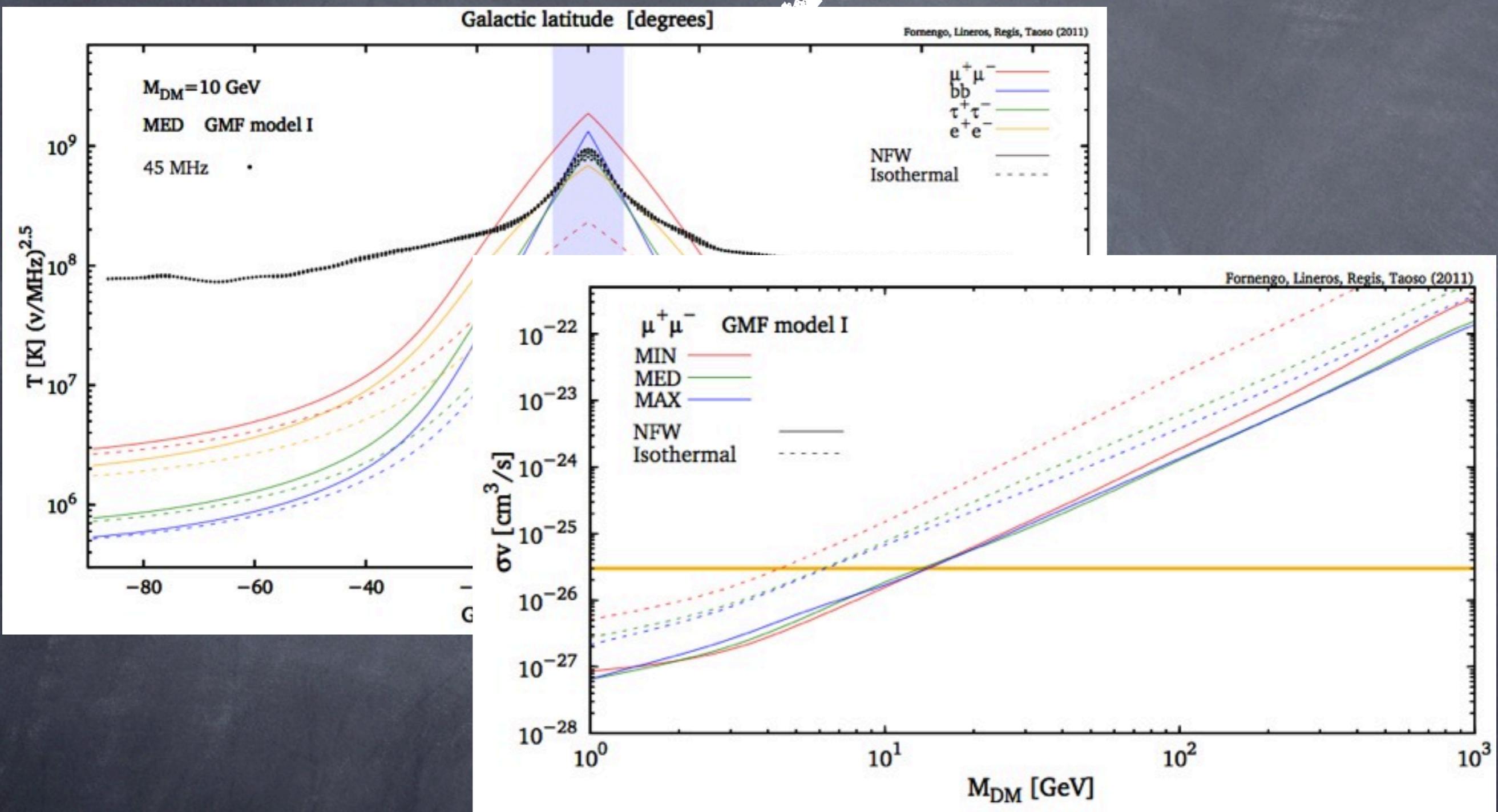
$\langle\sigma v\rangle$ from synchrotron

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Fornengo et al (astro-ph/1110.4337)

<OV> from synchrotron



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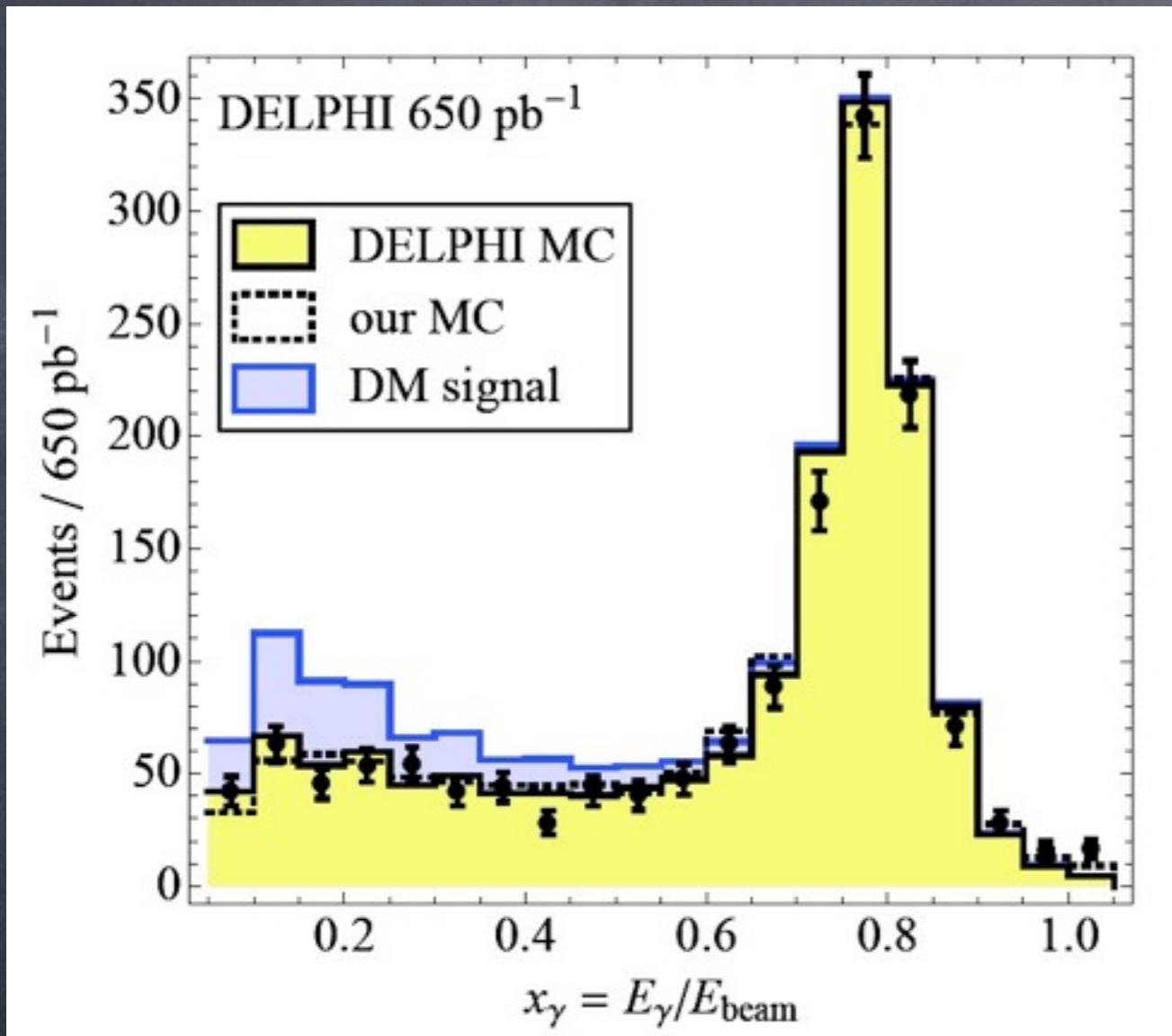
SM bckgr. e.g.:

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J. Abdallah et al (hep-ex/0901.4486)

Fox et al (hep-ph/1103.0240)



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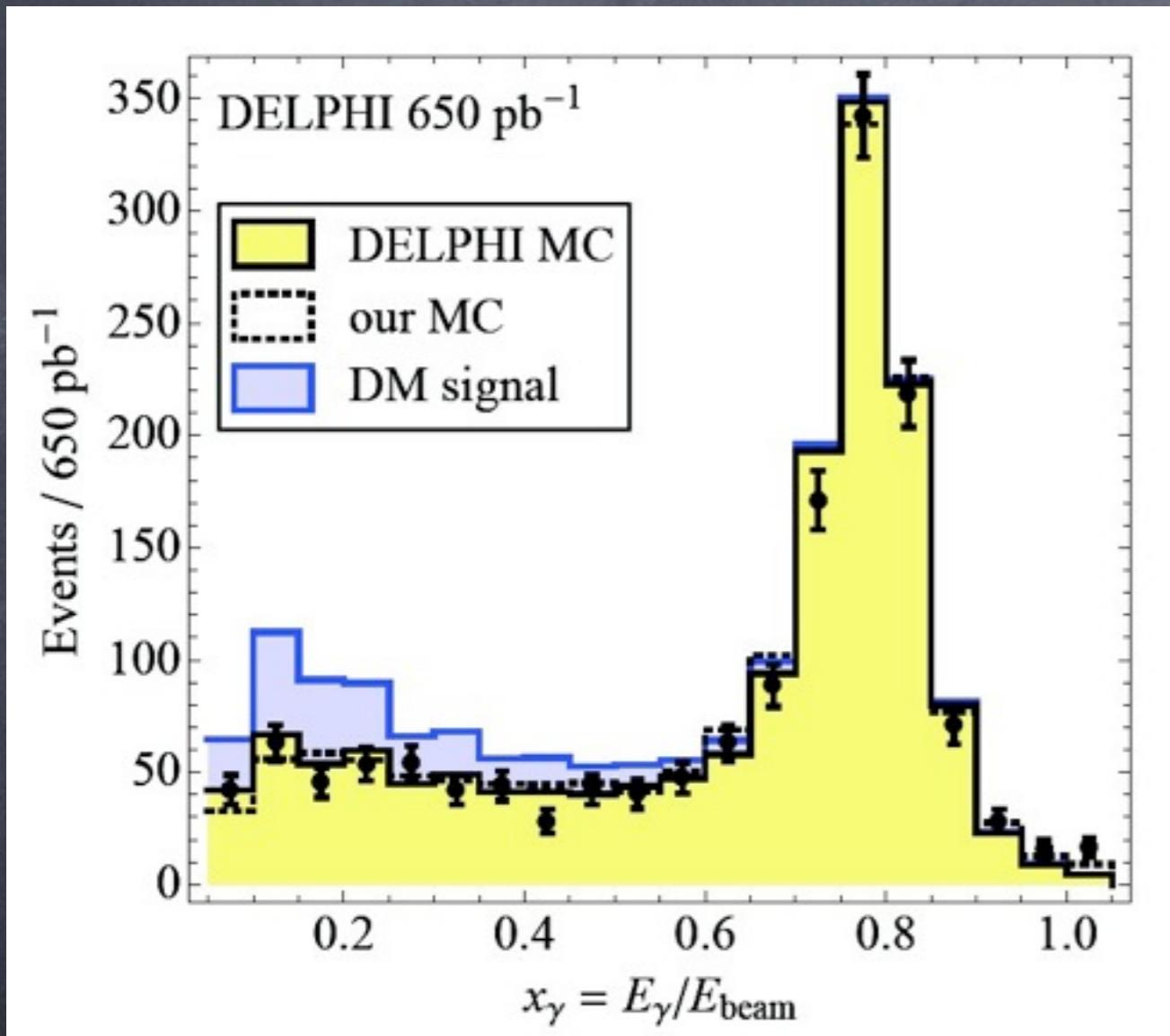
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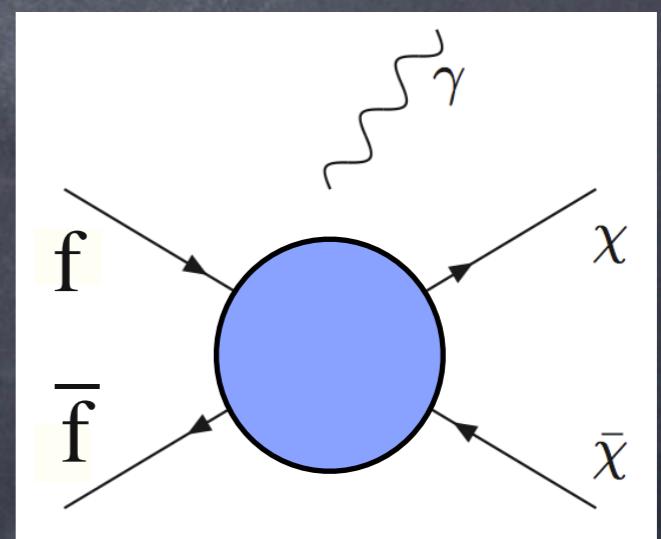


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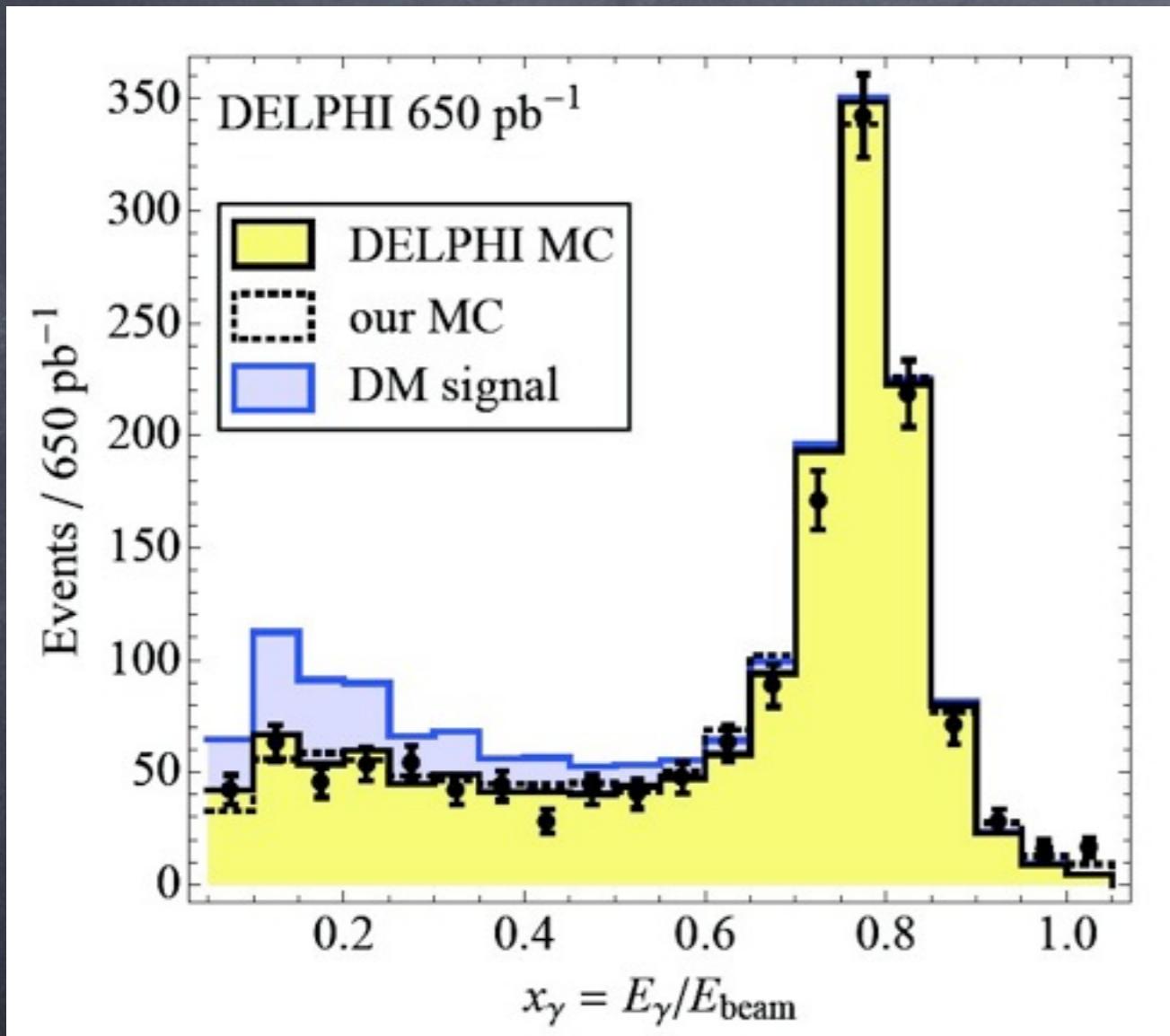
DM would-be signal:



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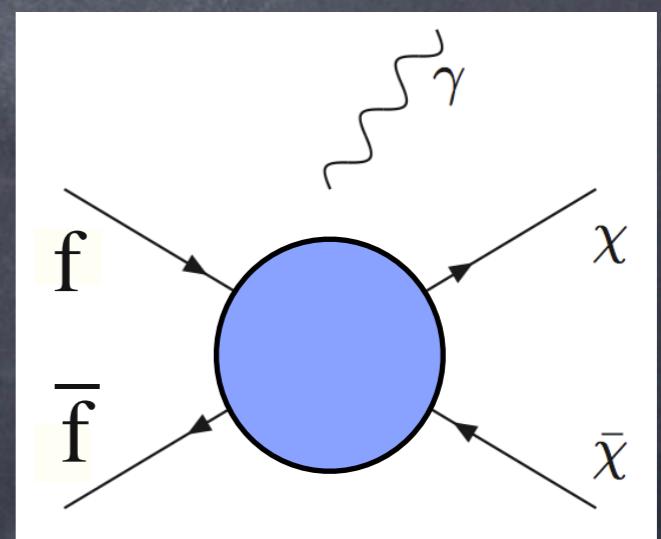
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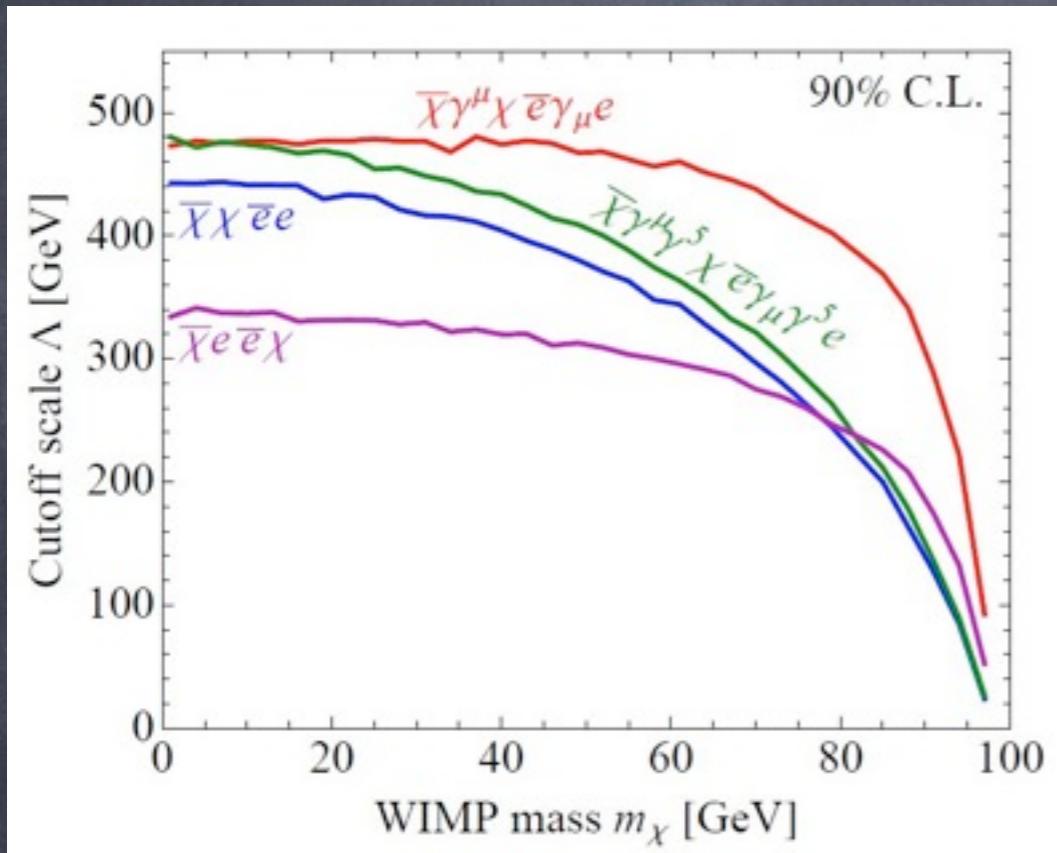
$$O_V = \frac{(f\gamma^\mu\bar{f})(\chi\gamma_\mu\bar{\chi})}{\Lambda^2}$$



$\langle\sigma v\rangle$ from colliders

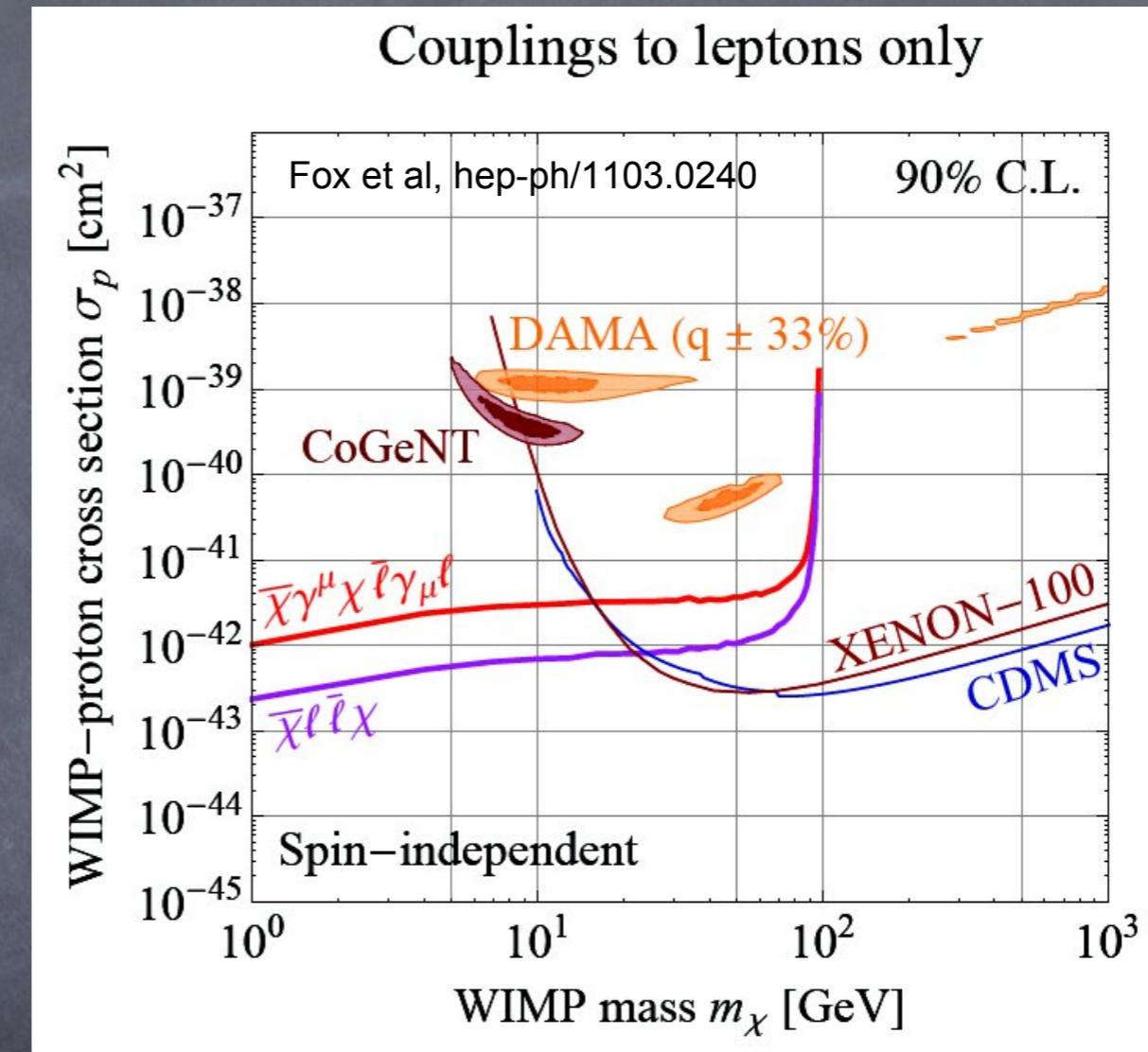
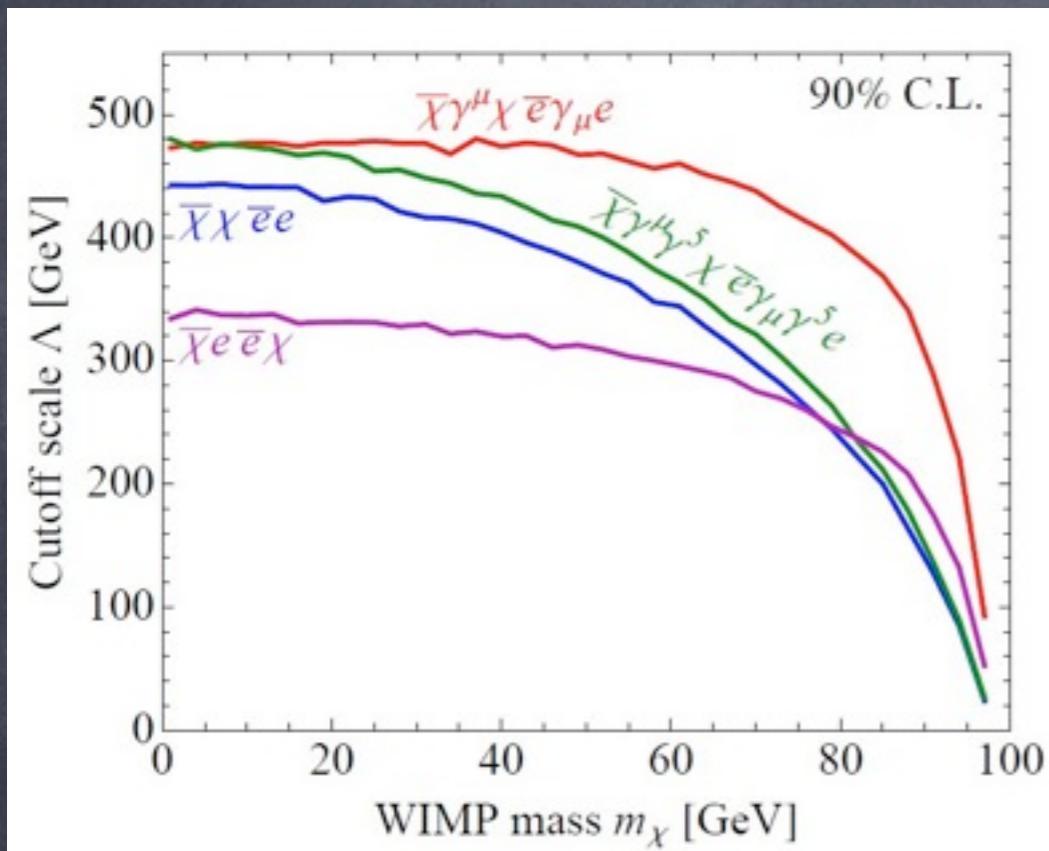
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Fox et al., 1103.0240



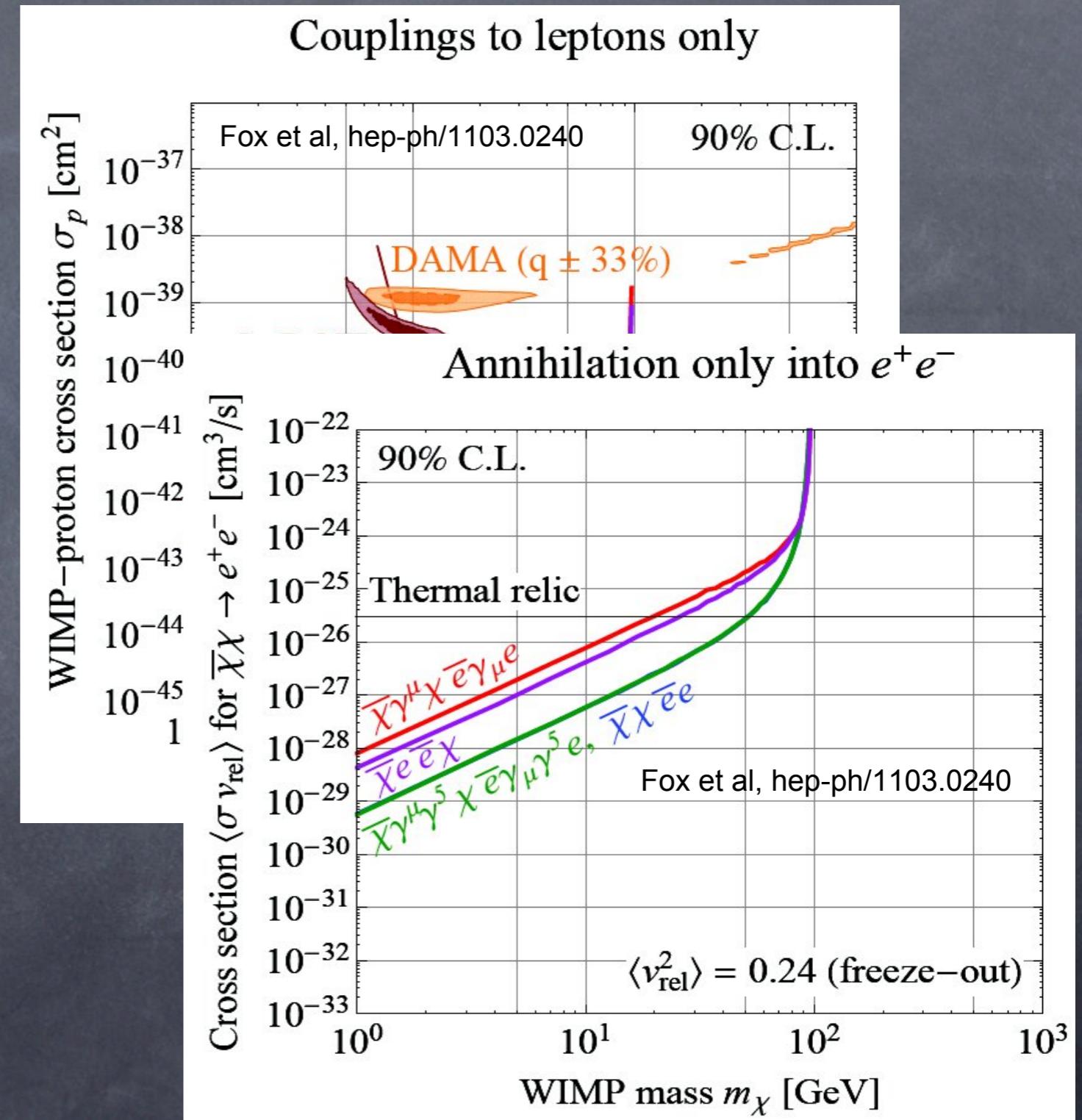
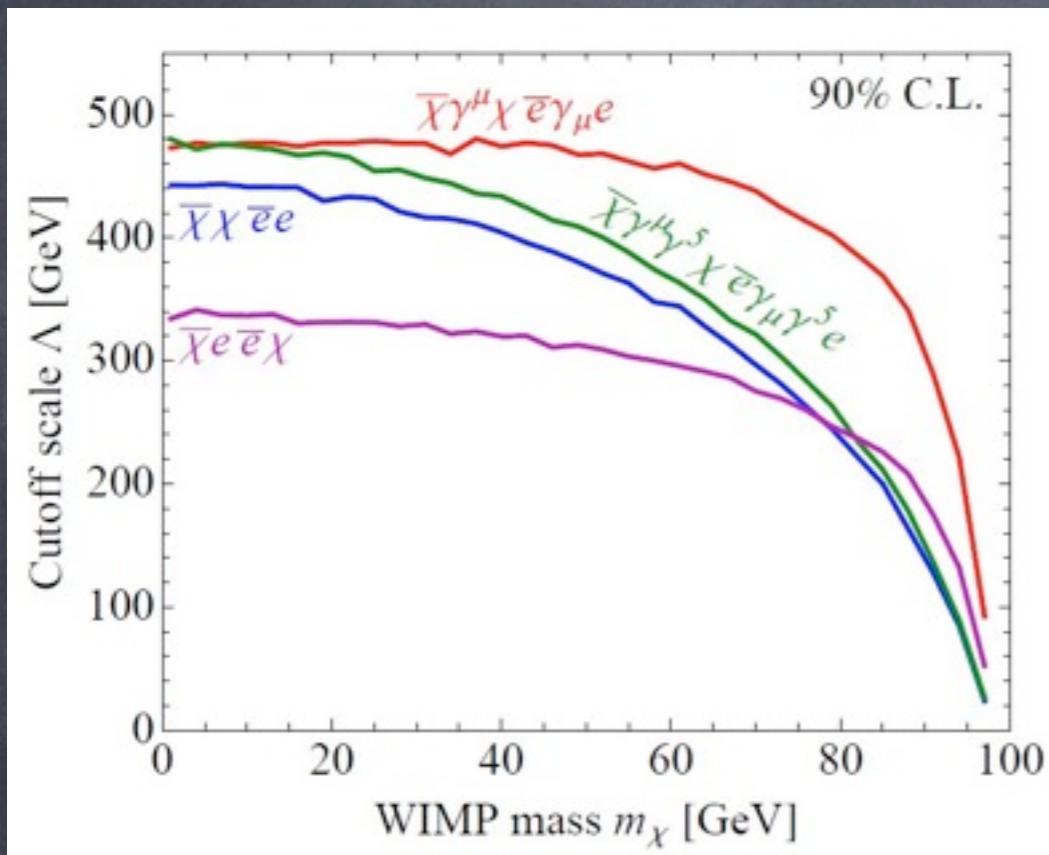
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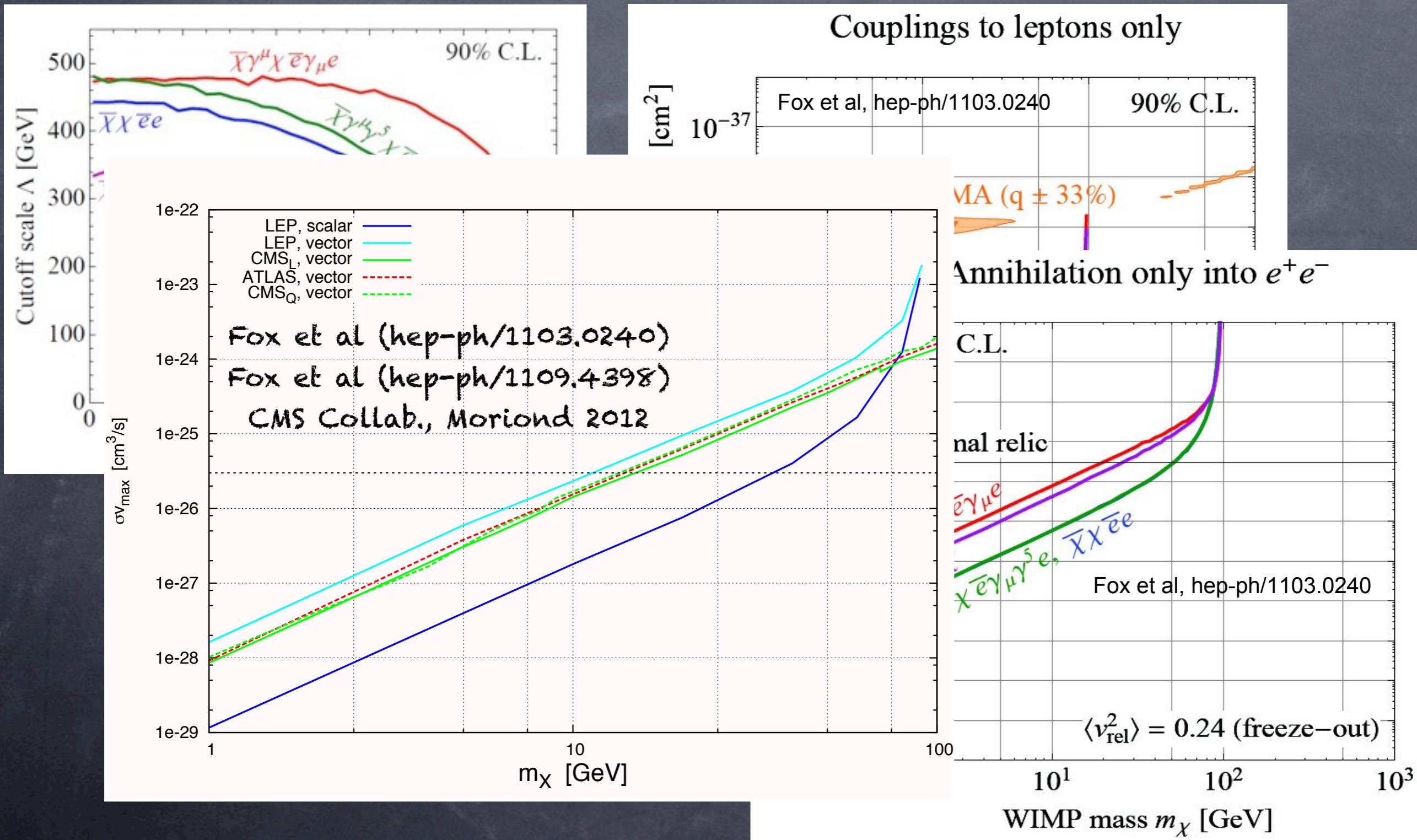
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OUR ANALYSIS

Uncertainties (I)

• DM profile

$$\rho_{\text{NFW}}(r) = \rho_s \frac{r_s}{r \left(1 + \frac{r}{r_s}\right)^2}$$

$$\rho_{\text{ISO}}(r) = \rho_s \frac{r_s^2}{r^2 + r_s^2}$$

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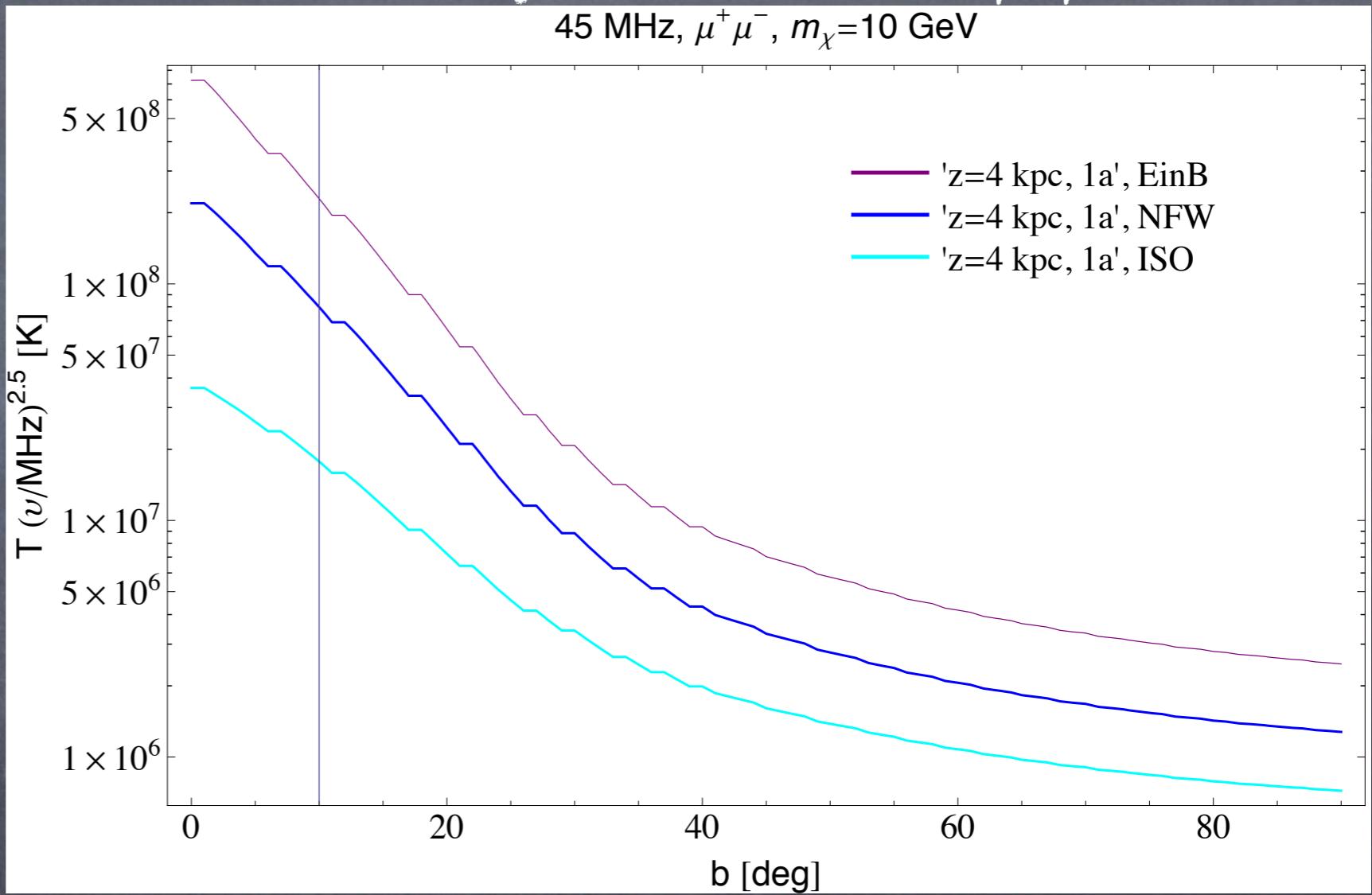
Navarro et al (astro-ph/9508025)

Begeman et al, 1991.

Graham et al (astro-ph/0509417)

Mambrini,Tygał,Zaharijas,BZ (in preparation)

45 MHz, $\mu^+ \mu^-$, $m_\chi = 10$ GeV



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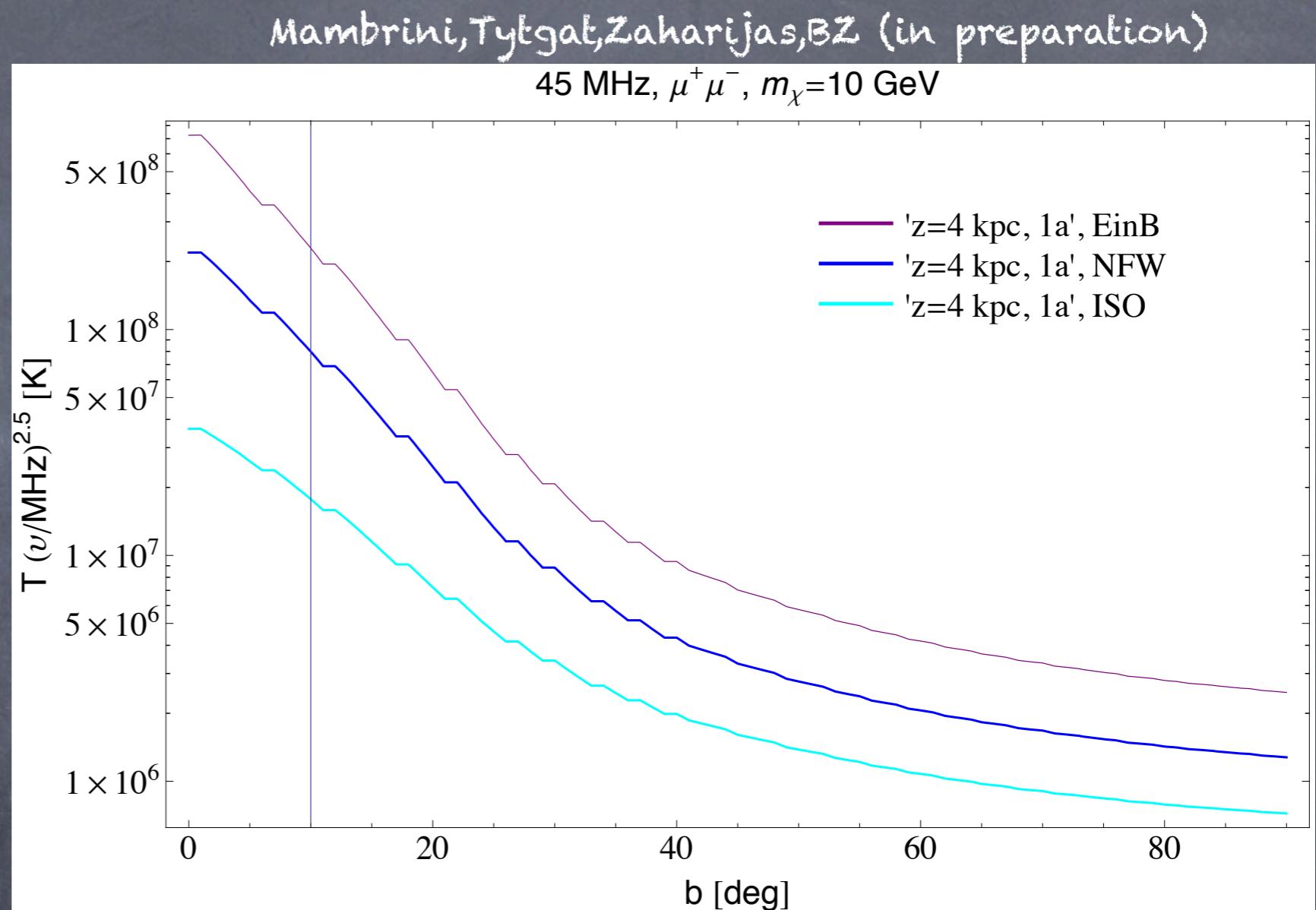
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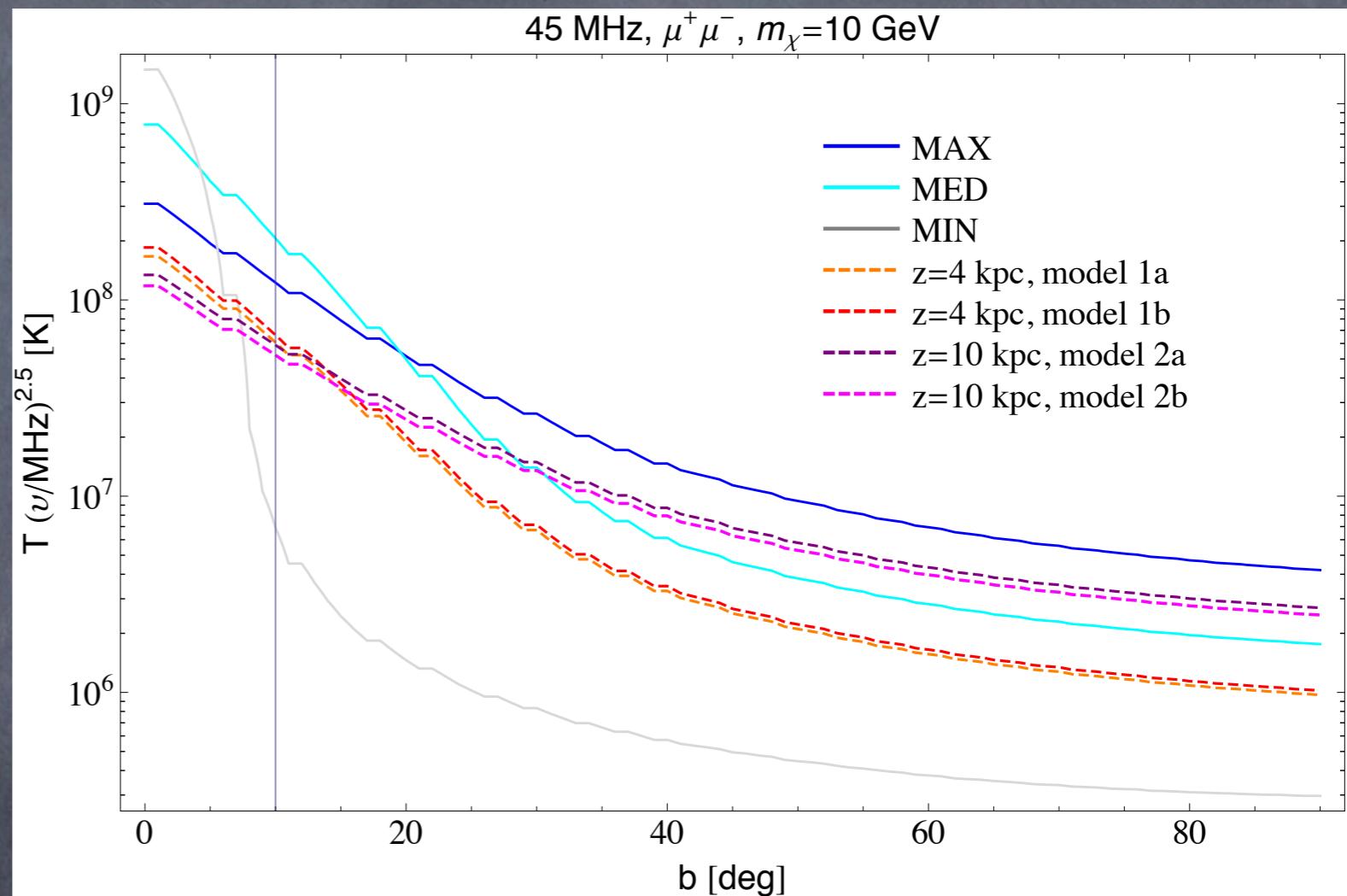
Uncertainties (II)

Diffusion models

Model	L_h [kpc]	K_0 [$\text{cm}^2 \text{s}^{-1}$]	δ	v_a [km s^{-1}]
MIN	1	$4.8 \cdot 10^{26}$	0.85	0
MED	4	$3.4 \cdot 10^{27}$	0.70	0
MAX	15	$2.3 \cdot 10^{28}$	0.46	0
1a	4	$6.6 \cdot 10^{28}$	0.26	34.2
1b	4	$6.6 \cdot 10^{28}$	0.35	42.7
2a	10	$1.2 \cdot 10^{29}$	0.3	39.2
2b	10	$1.05 \cdot 10^{29}$	0.3	39.2

Donato et al (astro-ph/0306207)
 Trotta et al (astro-ph/1011.0037)

Mambrini,Tytgat,Zaharijas,BZ (in preparation)



Uncertainties (II)

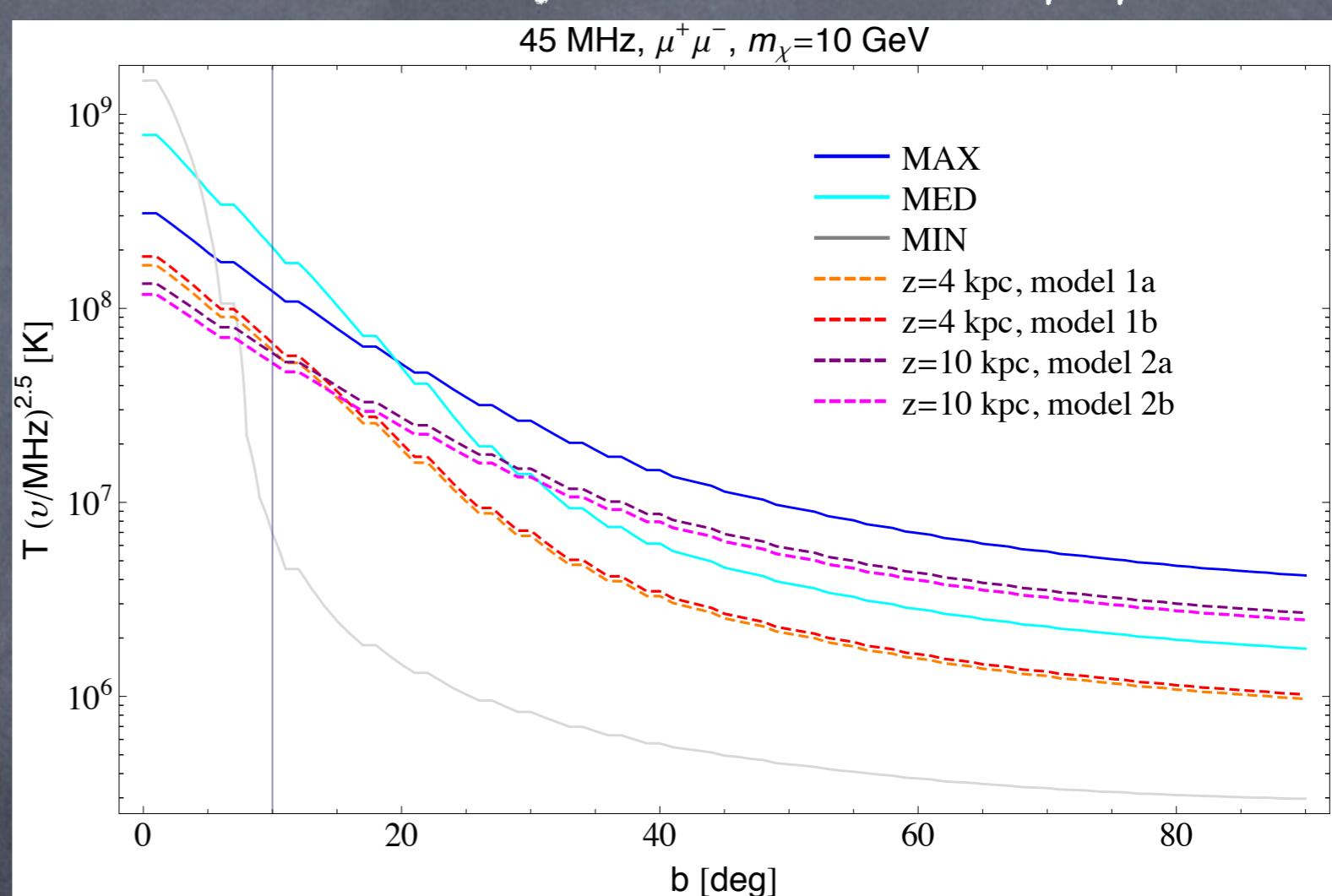
Diffusion models

Model	L_h [kpc]	K_0 [$\text{cm}^2 \text{s}^{-1}$]	δ	v_a [km s^{-1}]
MIN	1	$4.8 \cdot 10^{26}$	0.85	0
MED	4	$3.4 \cdot 10^{27}$	0.70	0
MAX	15	$2.3 \cdot 10^{28}$	0.46	0
1a	4	$6.6 \cdot 10^{28}$	0.26	34.2
1b	4	$6.6 \cdot 10^{28}$	0.35	42.7
2a	10	$1.2 \cdot 10^{29}$	0.3	39.2
2b	10	$1.05 \cdot 10^{29}$	0.3	39.2

Donato et al (astro-ph/0306207)
 Trotta et al (astro-ph/1011.0037)

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45 MHz, $\mu^+ \mu^-$, $m_\chi = 10$ GeV



Uncertainties (III)

• Magnetic field

Mambrini, Tytgat, Zaharijas, BZ (in preparation)

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• Magnetic field

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Fornengo et al (astro-ph/1110.4337)

$$B(\rho, z) = B_0 \exp\left(-\frac{r - r_\odot}{\delta \cdot R_h} - \frac{|z|}{\delta \cdot L_h}\right)$$

$$B_0 = B_\odot [1 + K \cdot \Theta(r - R_{IG})]$$

Uncertainties (III)

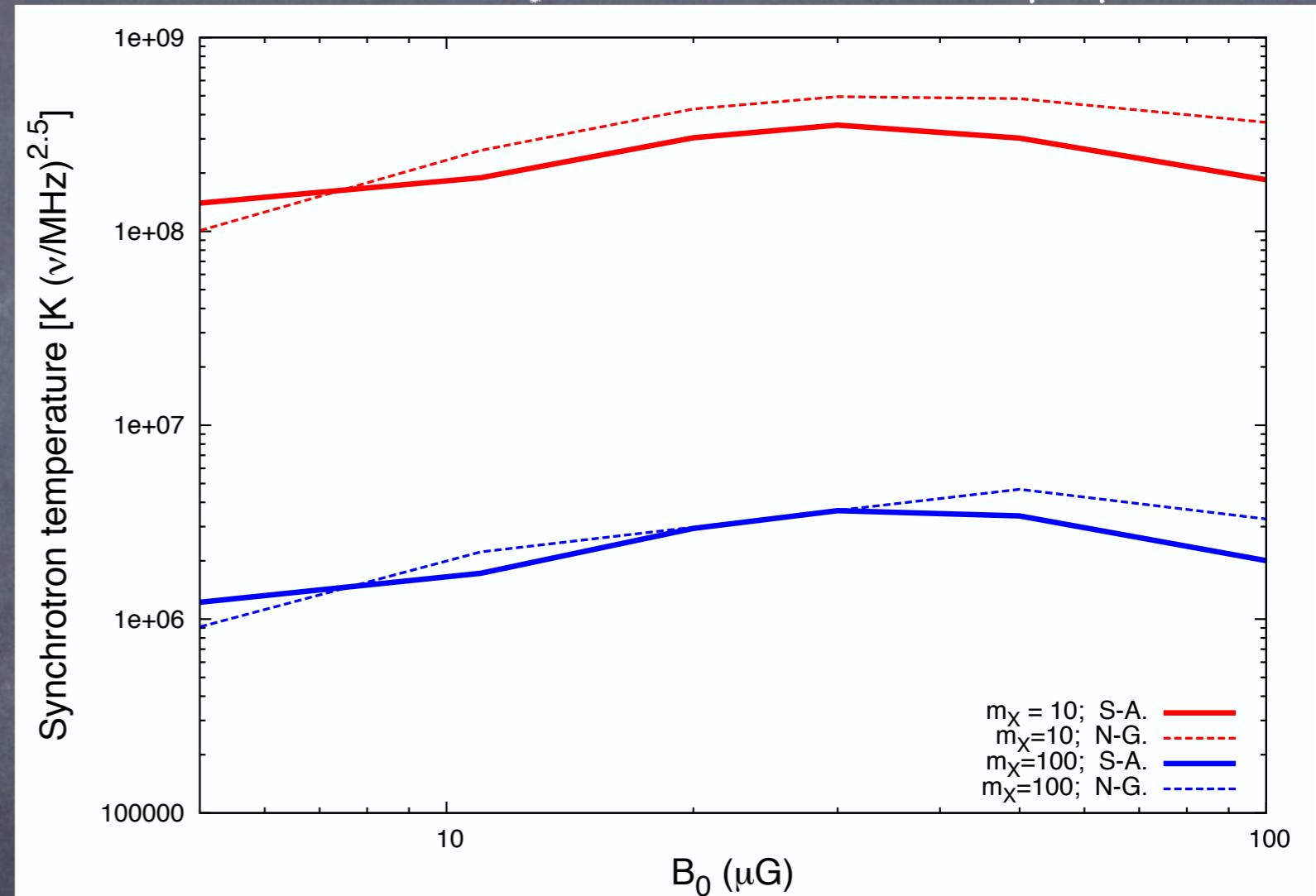
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Mambrini, Tytgat, Zaharijas, BZ (in preparation)



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Fornengo et al (astro-ph/1110.4337)

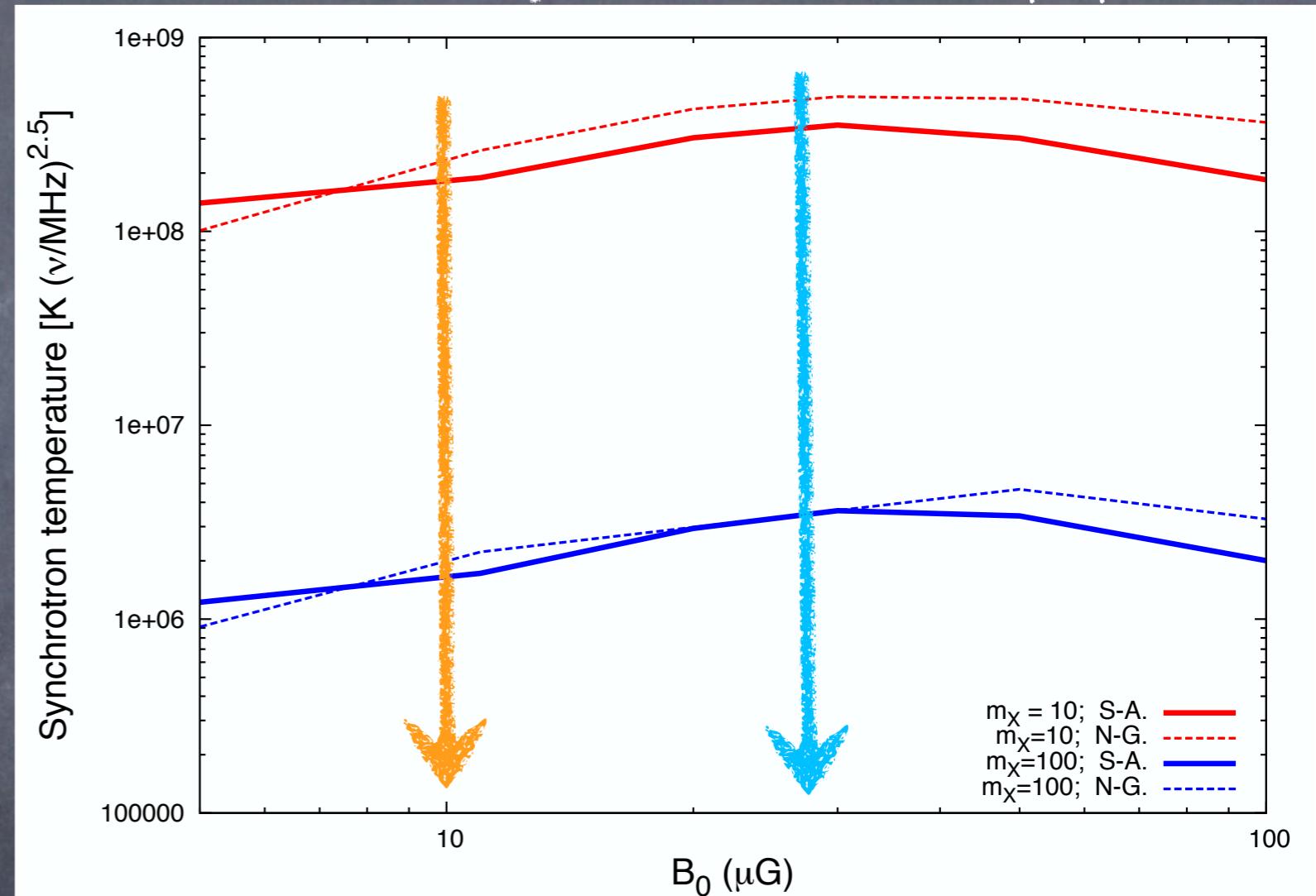
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$$B_{GC} = 10 \mu G$$

$$B_{GC} = 26 \mu G$$

Mambrini, Tytgat, Zaharijas, BZ (in preparation)



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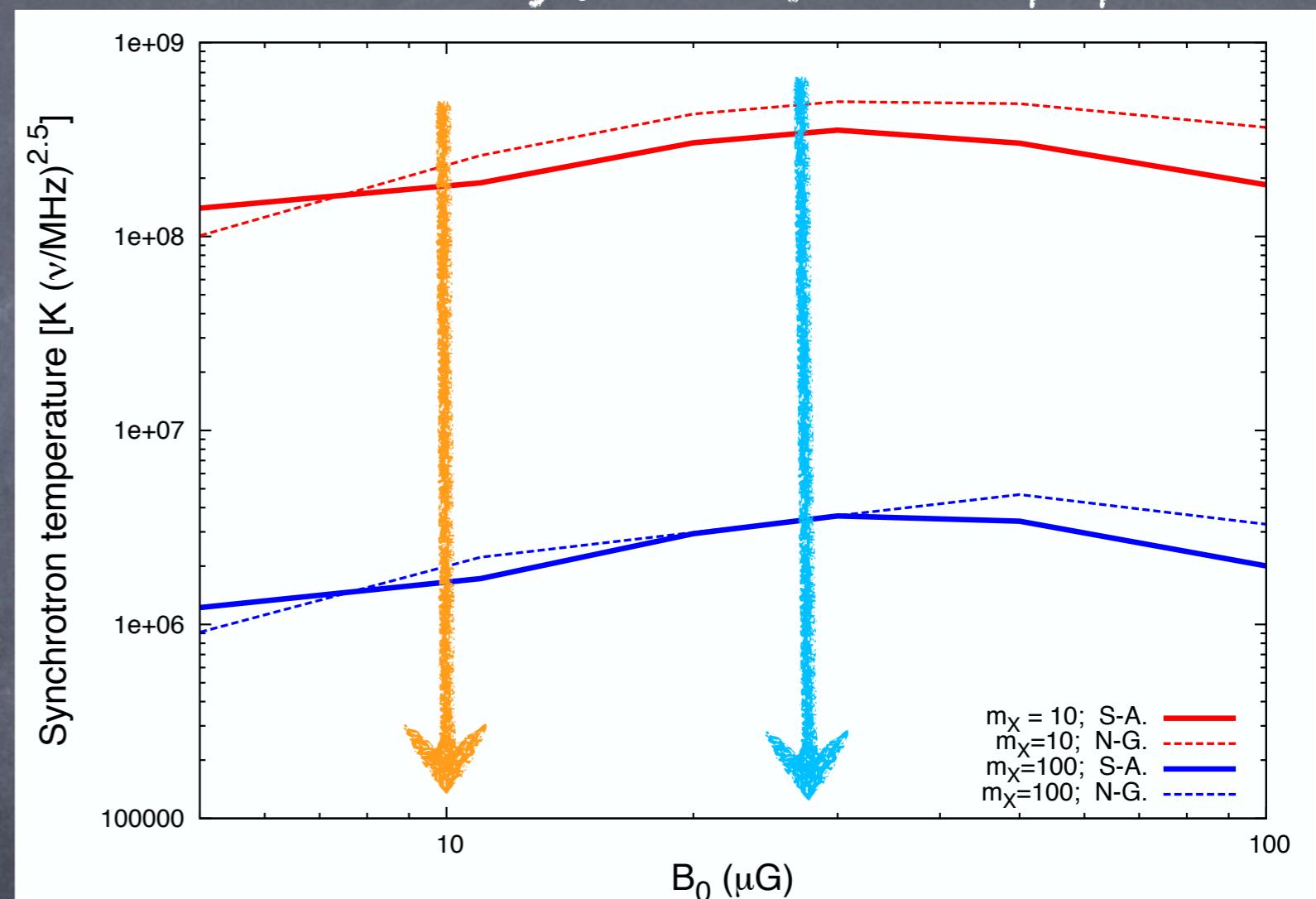
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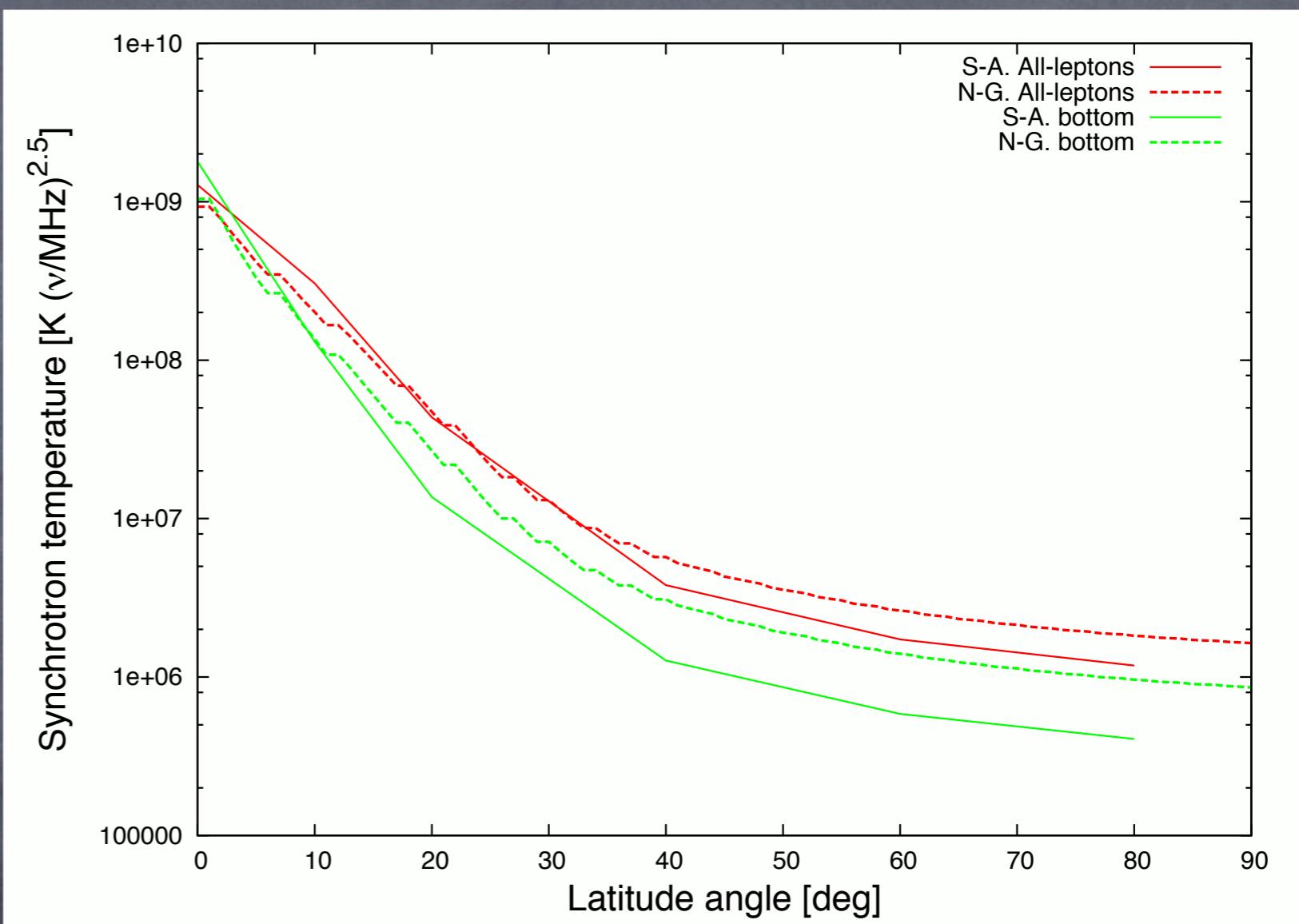
$$B_{GC} = 26 \mu G$$

can be obtained
analytically!

Mambrini, Tytgat, Zaharijas, BZ (in preparation)



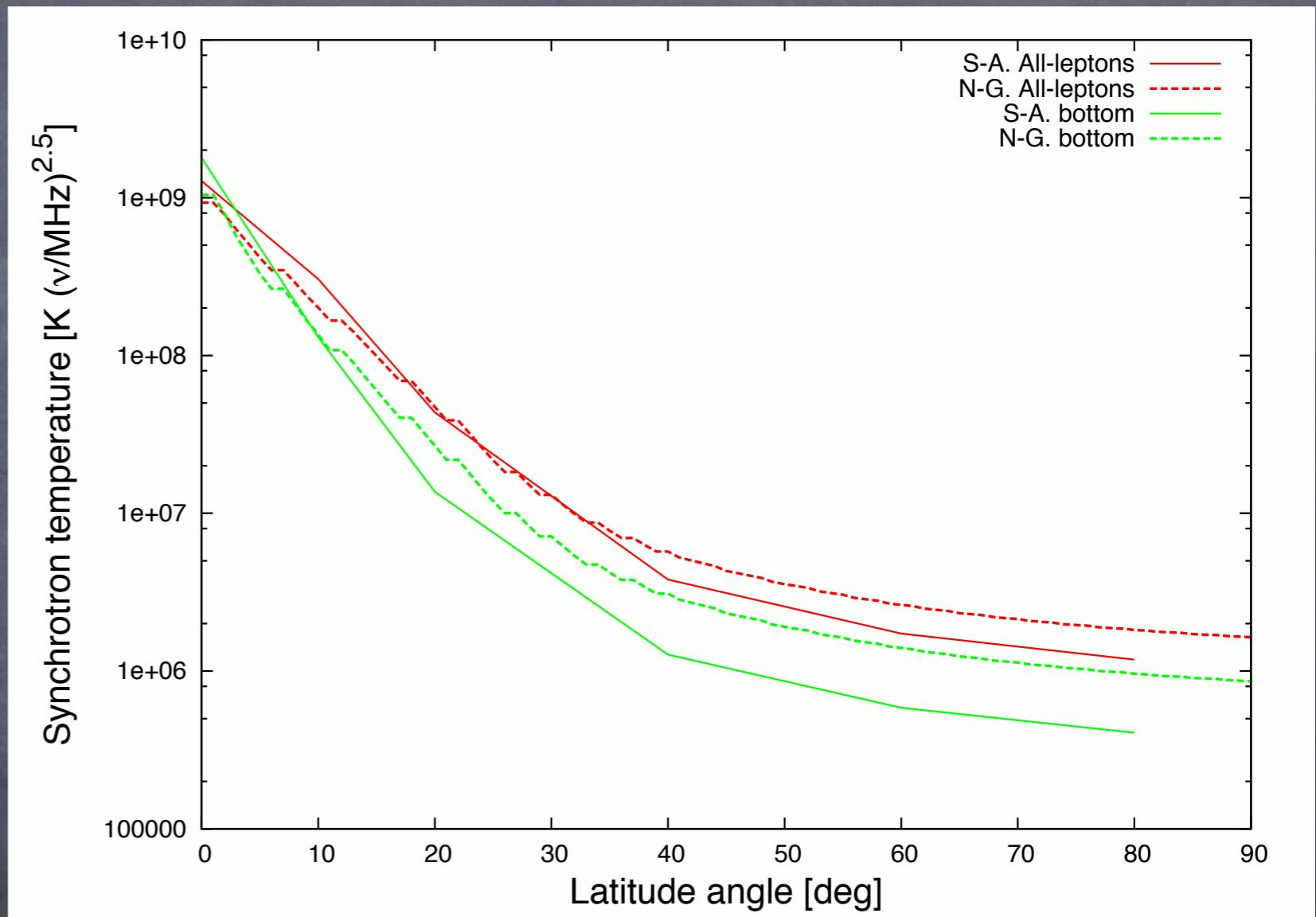
Data,direction, SA/N cross-check



Mambrini,Tytgat,Zaharijas,BZ (in preparation)

Data,direction, SA/N cross-check

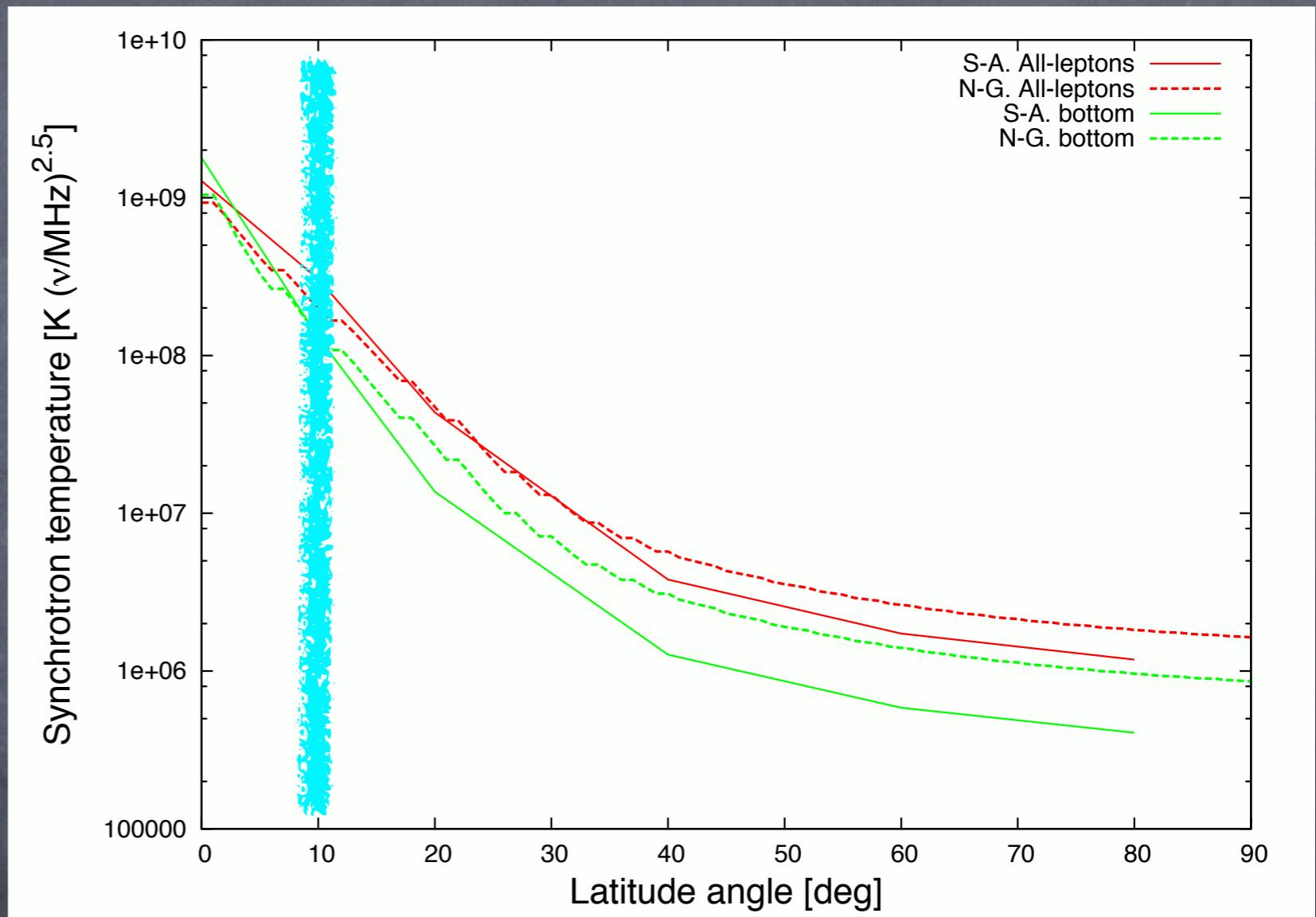
Data: HASLAM
408 MHz \rightarrow 45 MHz
Haslam et al, 1982.
Fornengo et al (astro-ph/1110.4337)



Mambrini,Tytgat,Zaharijas,BZ (in preparation)

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Direction(deg):
 $b=10\pm1$, $|l|<3$

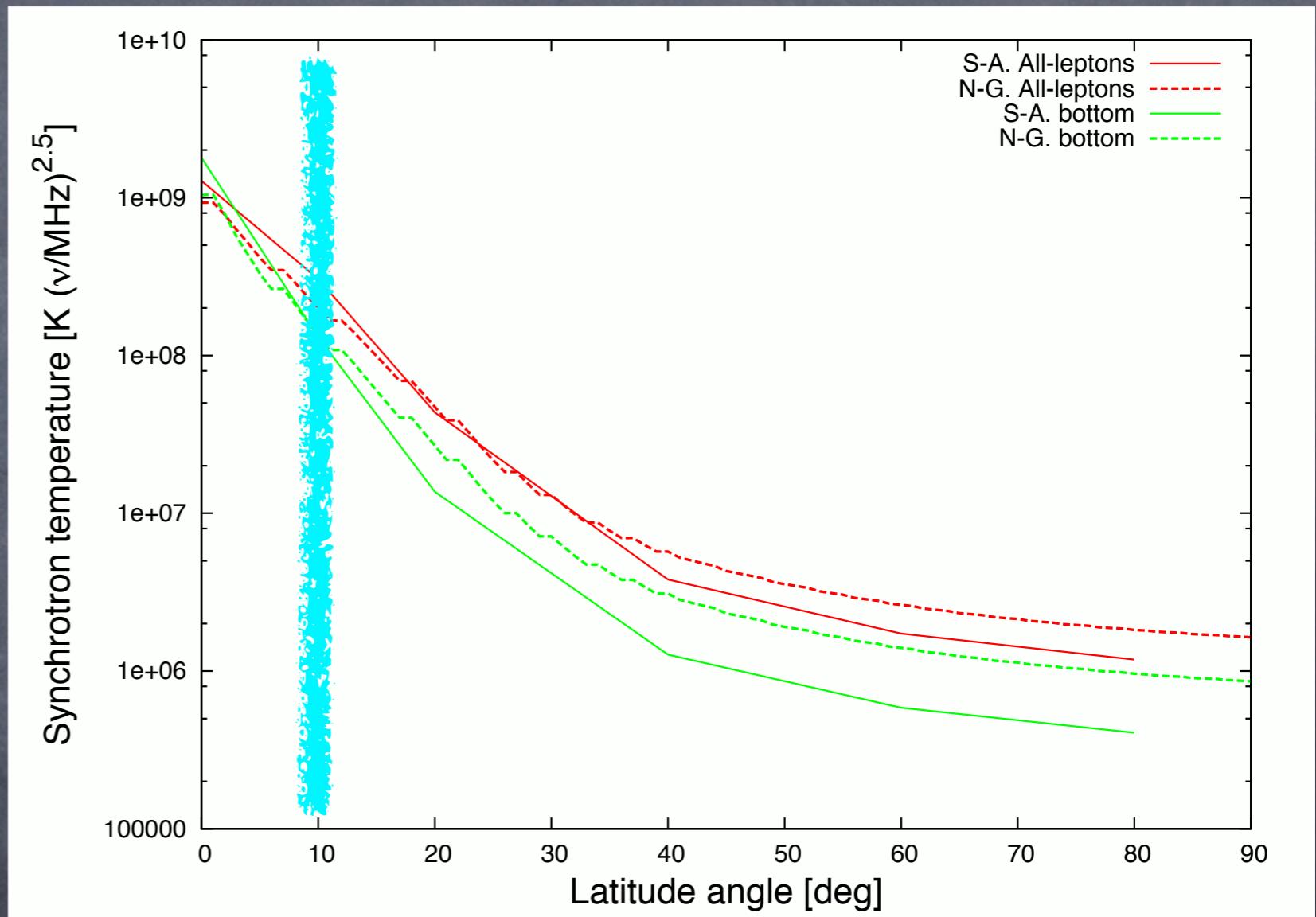


Mambrini,Tytgat,Zaharijas,BZ (in preparation)

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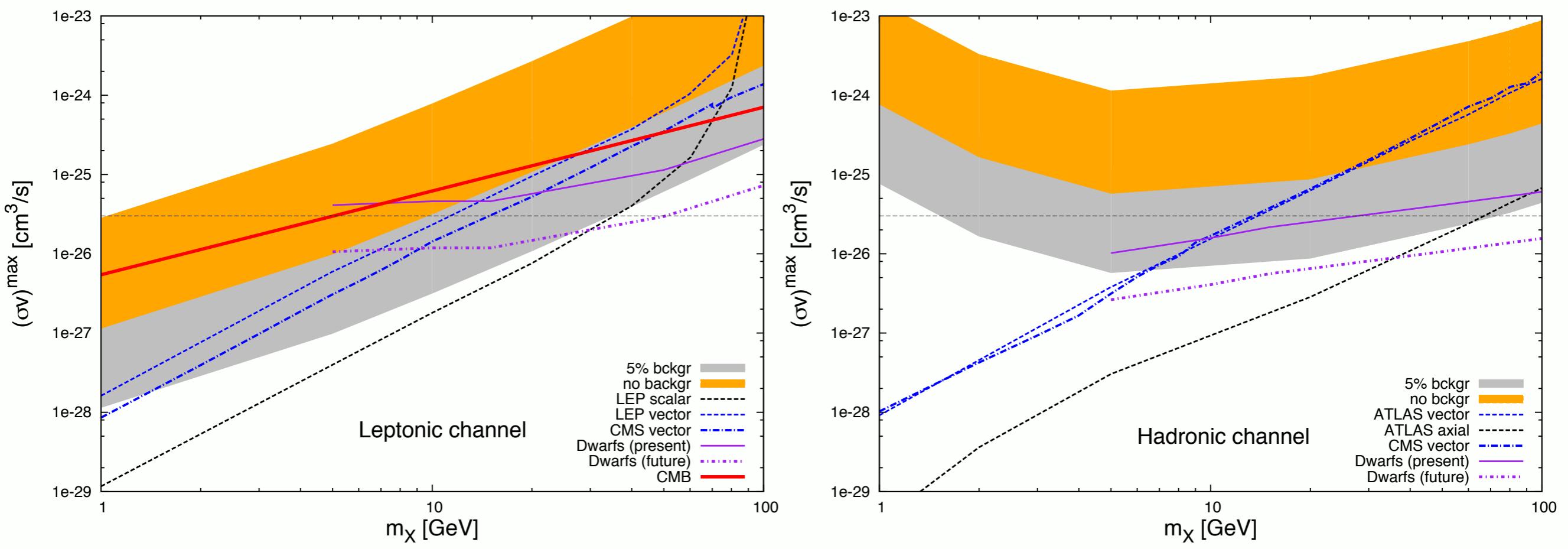
Cross-check:
 $U_{\text{rad}}=8 \text{ eV/cm}^3$



Mambrini,Tytgat,Zaharijas,BZ (in preparation)

Synch vs. Colliders (effective approach)

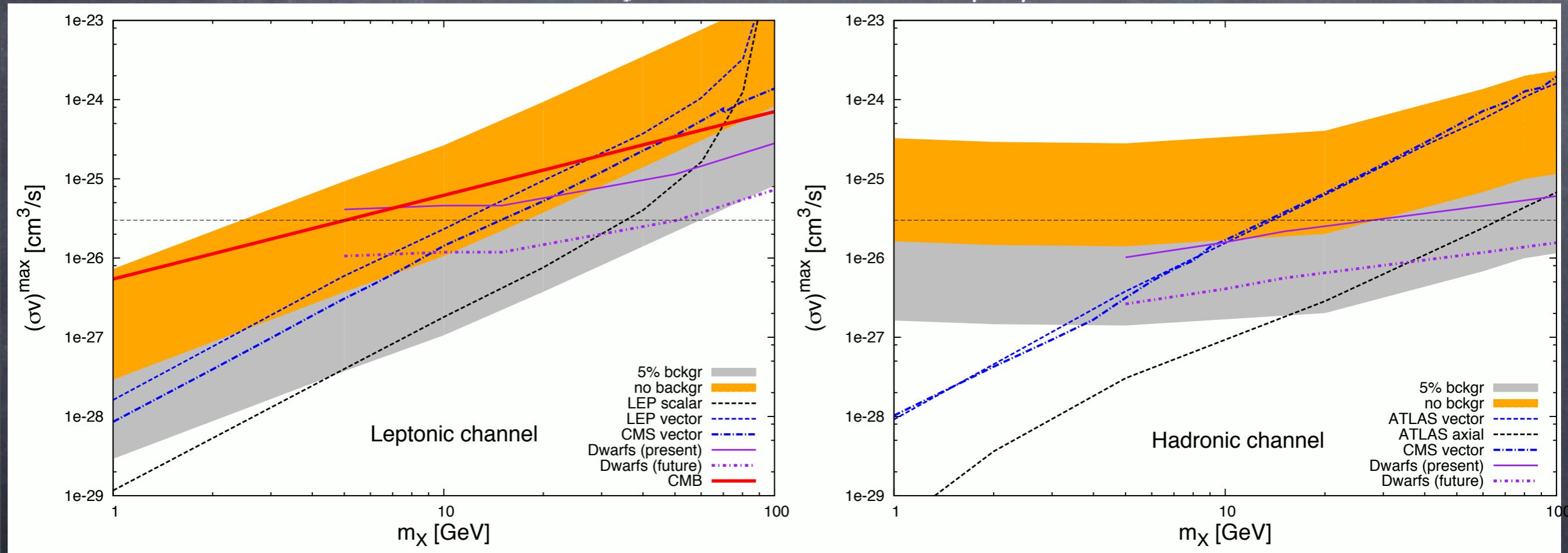
Mambrini,Tytgat,Zaharijas,BZ (in preparation)



$$B_{GC} = 10 \mu G$$

Synch vs. Colliders (effective approach)

Mambrini,Tytgat,Zaharijas,BZ (in preparation)

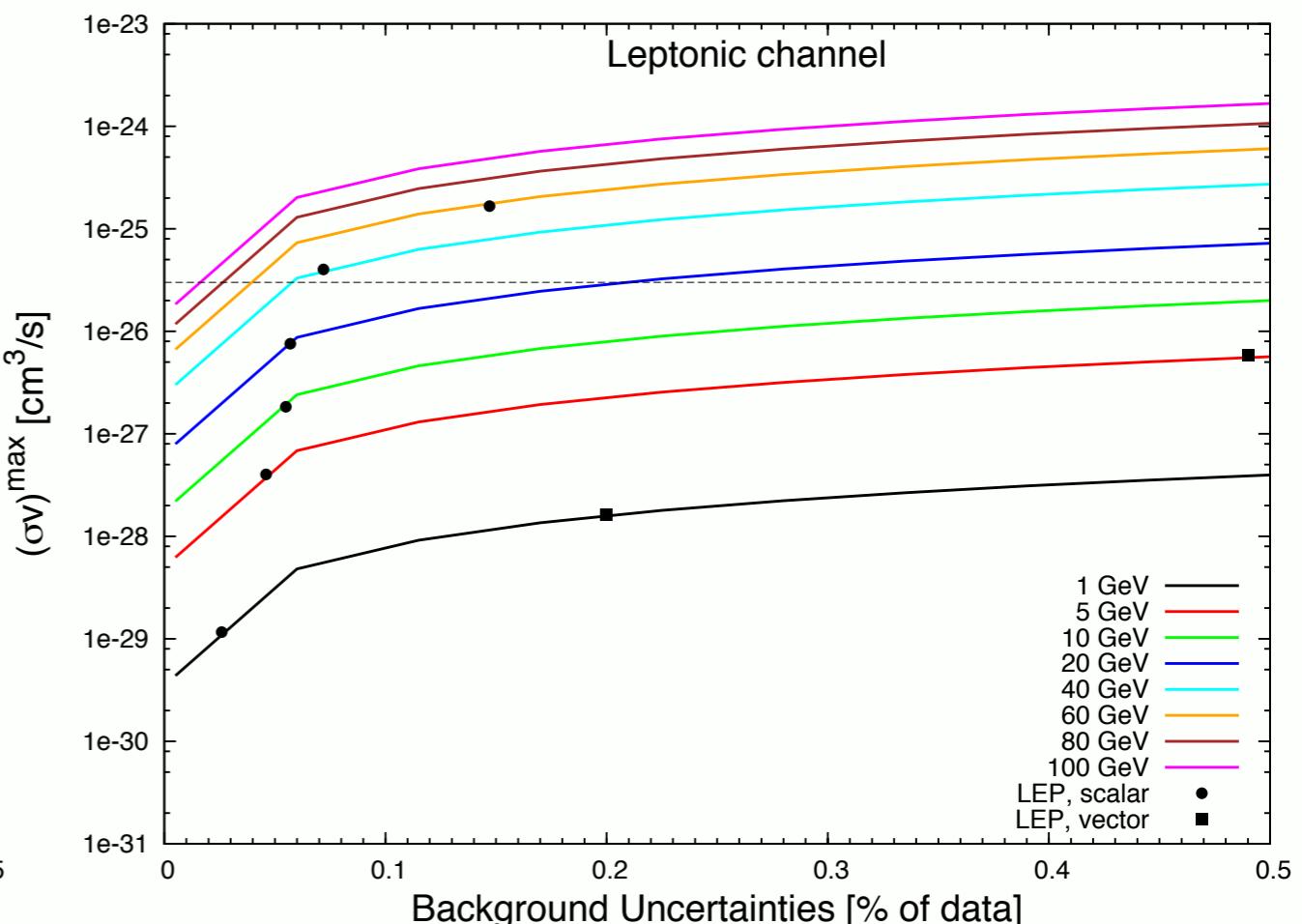
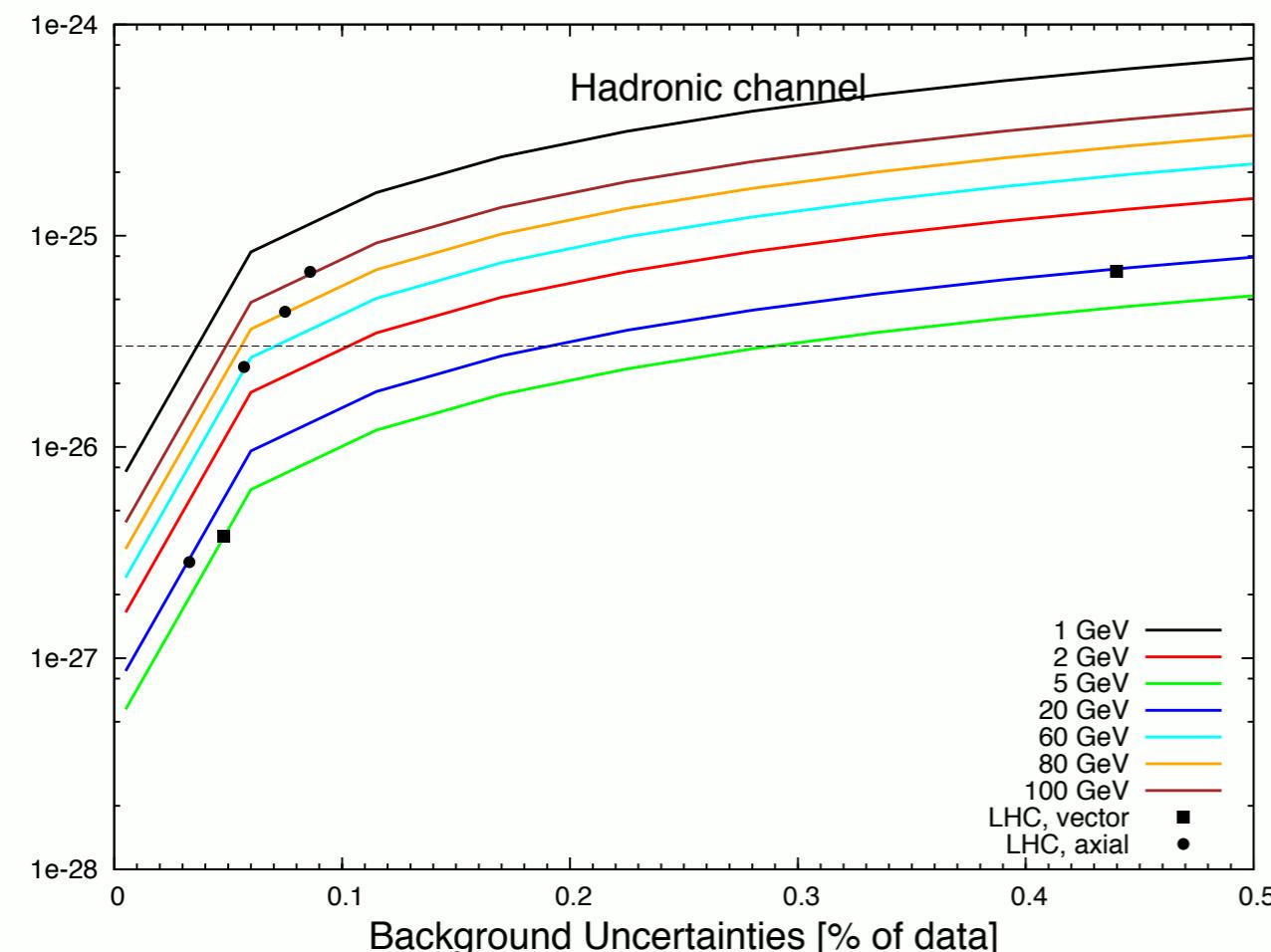


$$B_{GC} = 26 \mu G$$

Bckg. uncertainties

NFW+MED set-up

Mambrini,Tytgat,Zaharijas,BZ (in preparation)

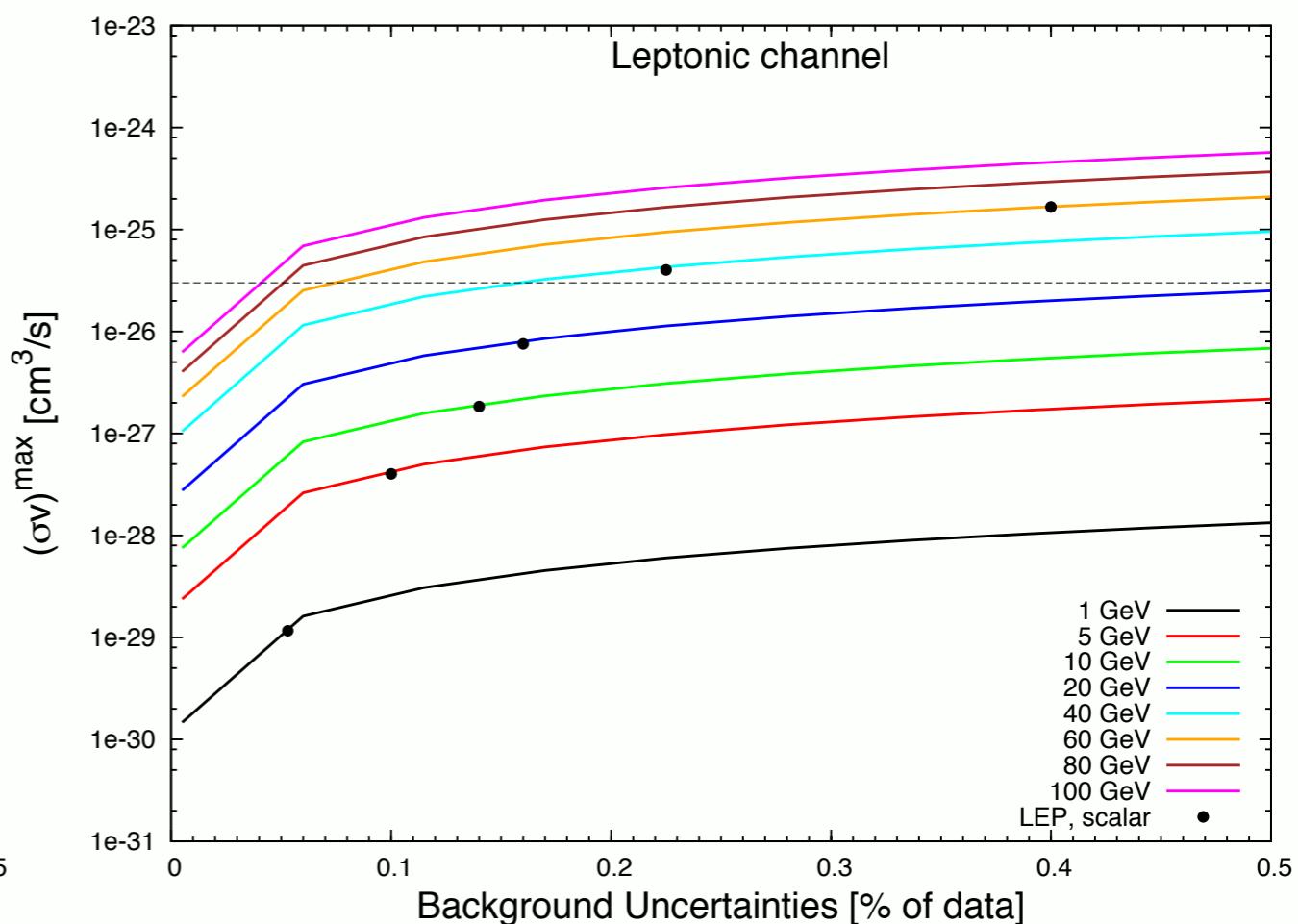
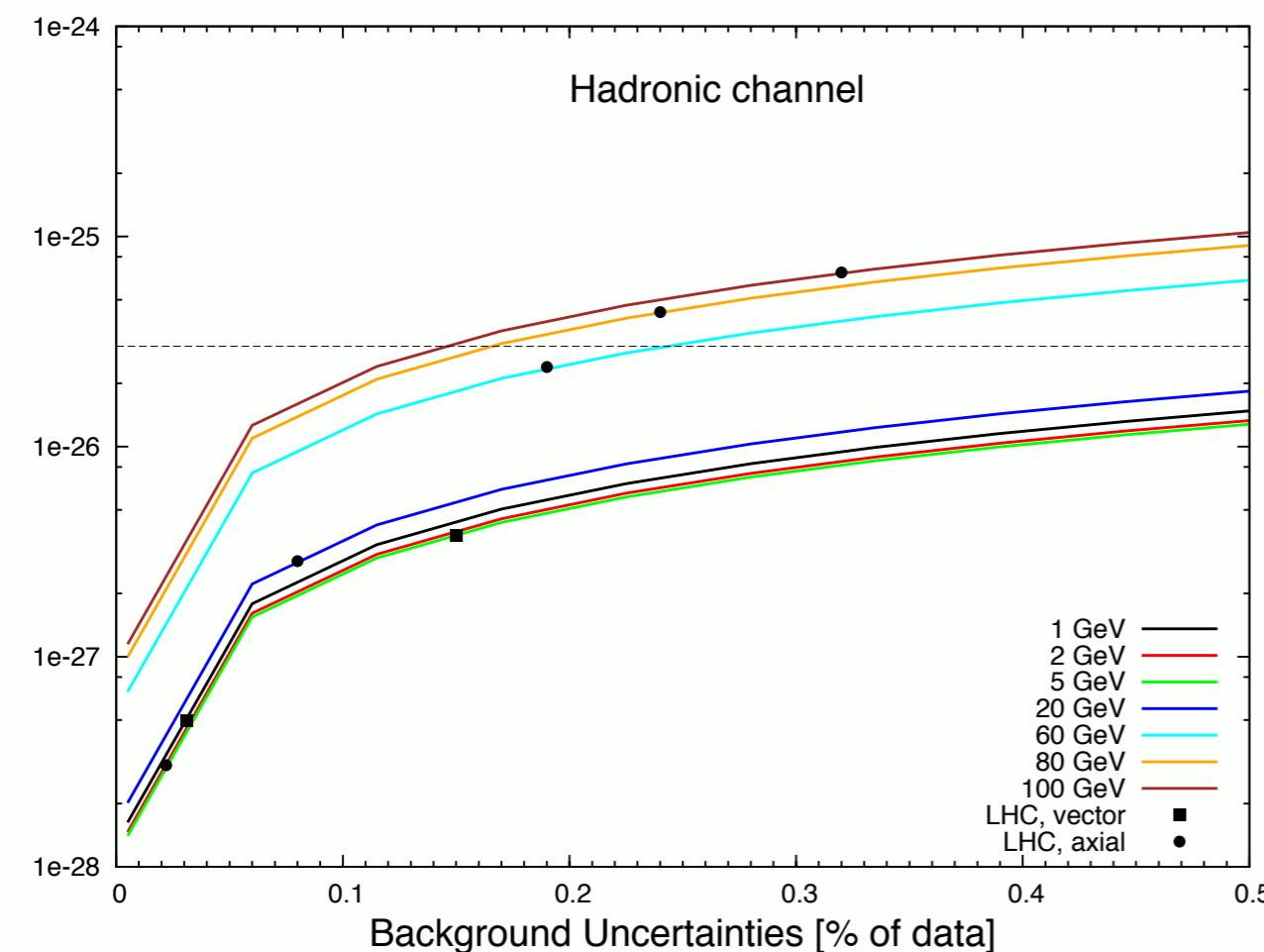


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Bckg. uncertainties

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Mambrini,Tytgat,Zaharijas,BZ (in preparation)

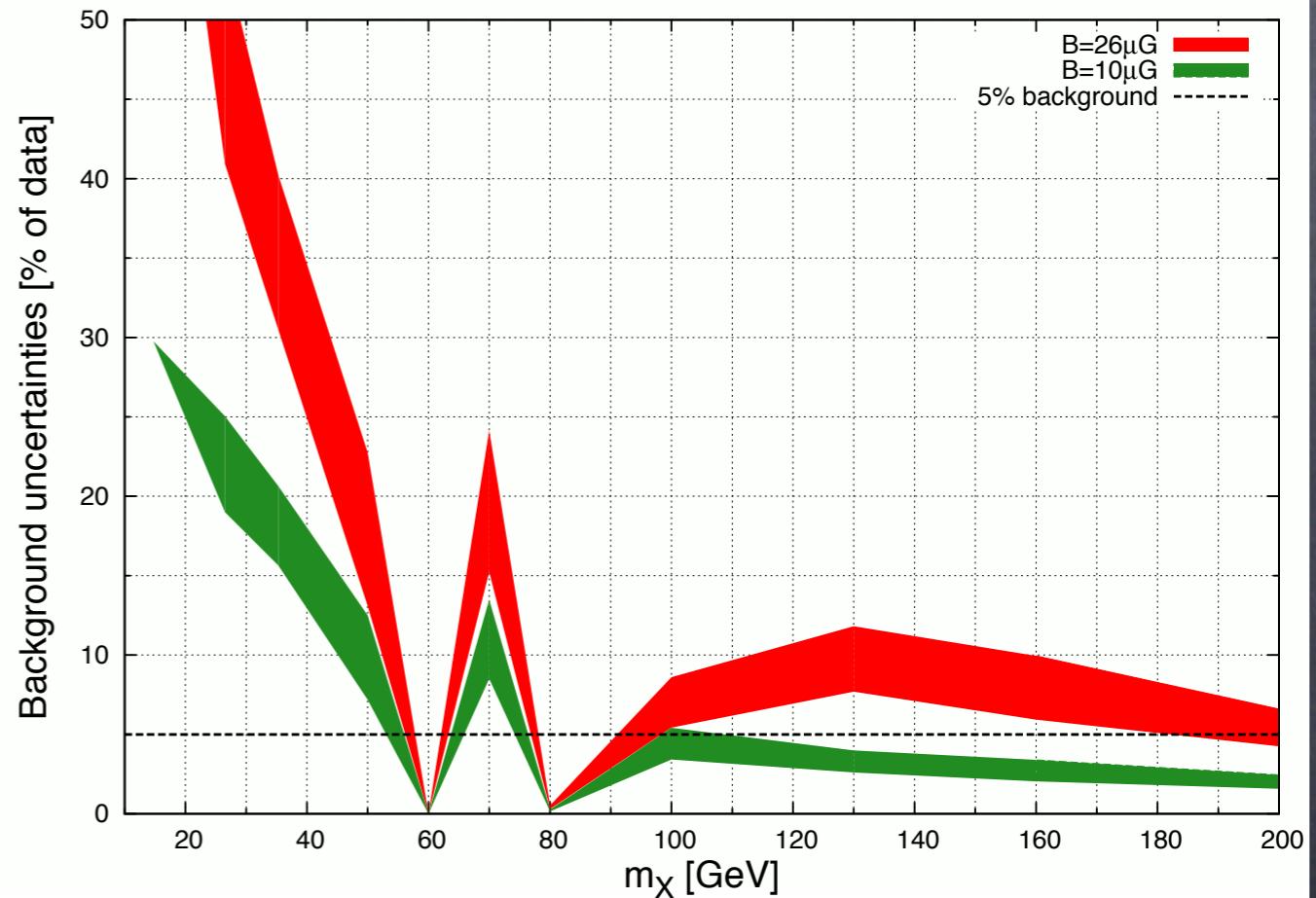
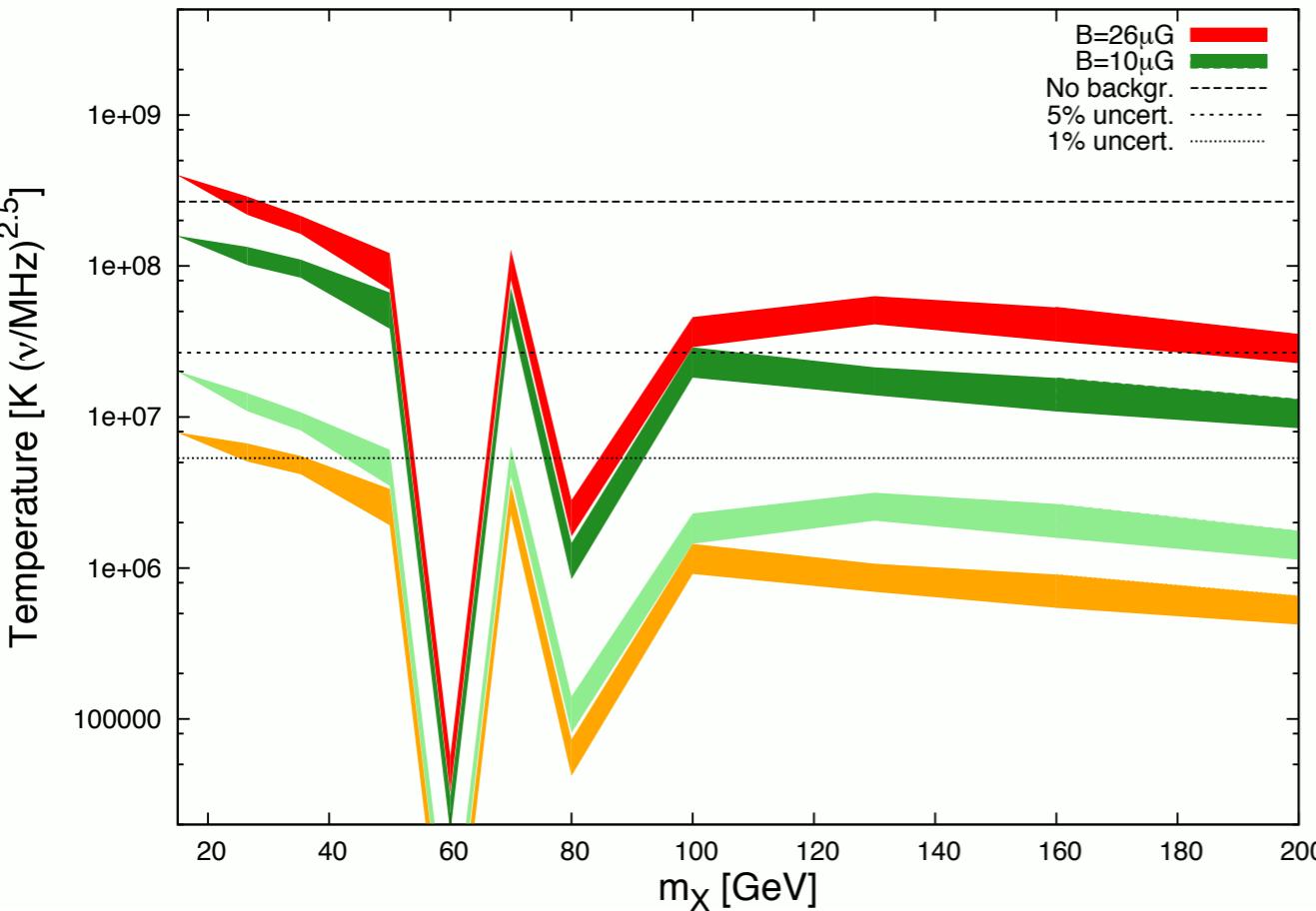


$$B_{GC} = 26 \mu G$$

UV: Higgs-portal

see e.g. Barger et al, 0706.4311

NFW+MED / ISO+1a set-ups

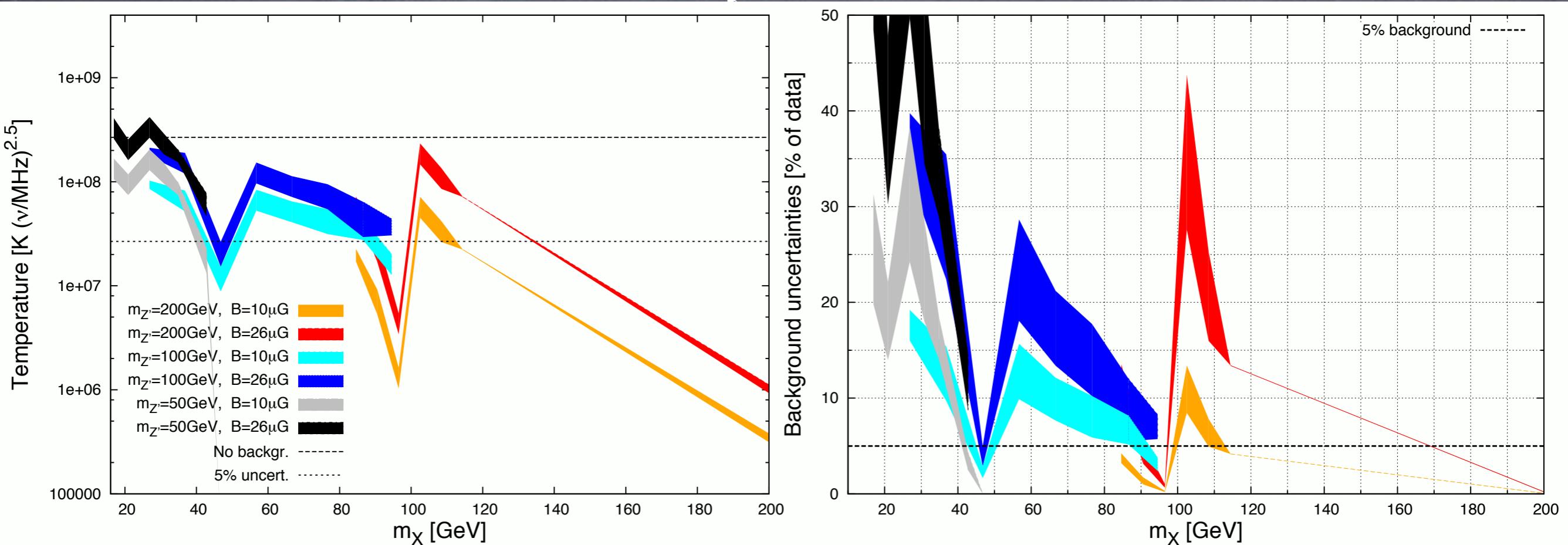


Mambrini,Tytgat,Zaharijas,BZ (in preparation)

UV: Z' -portal

see e.g. Langacker, 0801.1345/hep-ph

NFW+MED set-up



Mambrini,Tytgat,Zaharijas,BZ (in preparation)

Summary

- Study of DM models from synchrotron perspective
 - Effective Approach / 2 Minimal SM Extensions
- Considered all possible sources of uncertainties
 - DM profile / Propagation / Magnetic field
- Direct comparison with present bounds from colliders

• Reasonable set-ups can produce synchrotron bounds better/comparable to collider's

- Study of impact of bckgr uncertainties
- Strong bounds on Higgs-portal / Z'-portal models

THANKS!!