arXiv:1507±1.xxxx

Global constraints on vector-like effective WIMP interactions

Pedro A N Machado

in collaboration with

M Blennow, P Coloma, E Fernandez-Martinez, B Zaldivar

UNIVERSIDAD AUTONOMA DE MADRID

Universidad Autónoma de Madrid Departamento de Física Teórica

ift

PEOPLE

invisibles neutrinos, dark matter & dark energy physics

pedro.machado@uam.es

WIMP searches: Where do we stand?

What is the global status of WIMP searches?

Different experiments are sensitive to different DM masses, channels, etc

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WIMP searches: Where do we stand?

What is the global status of WIMP searches?

Different experiments are sensitive to different DM masses, channels, etc

How can we be model independent?

We can't.

General ↑ ↓ Useful

pedro.machado@uam.es

WIMP searches: Where do we stand?

Effective field theory

We will examine a part of the WIMP – SM EFT parameter space:

pedro.machado@uam.es

WIMP searches: Where do we stand?

Effective field theory

We will examine a part of the WIMP – SM EFT parameter space:

1) Vector couplings
2) Dirac fermion dark matter
3) DM is a standard model singlet
4) SU(2)xU(1) invariant operators
5) Dimension 6, DM-DM---ψ-ψ operators

$$c_i(\bar{\chi}\gamma^\mu\chi)(\bar{f}_i\gamma_\mu f_i)$$

pedro.machado@uam.es

EFT proxies

"General model"

$c_{e_R}, c_{\mu_R}, c_{\tau_R}$

$c_{\ell e_L}, c_{\ell \mu_L}, c_{\ell \tau_L}$

$c_{u_R}, c_{c_R}, c_{t_R}$

$c_{d_R}, c_{s_R}, c_{b_R}$

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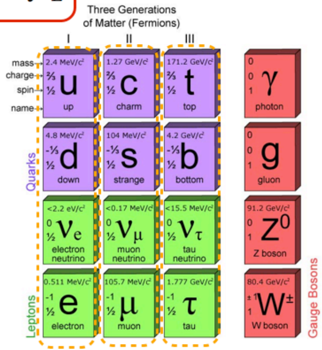

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“Fa

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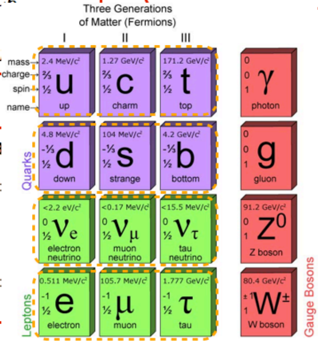

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Ingredients

Constraints

$\Omega_h^2 = 0.1199 \pm 0.0027$

PLANCK '13

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PLANCK '13

CMB constraints

Slatyer Padmanabhan Finkbeiner '09

Lopez-Honorez et al '13

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Dwarf galaxies: Fermi-LAT

Fermi-LAT '15

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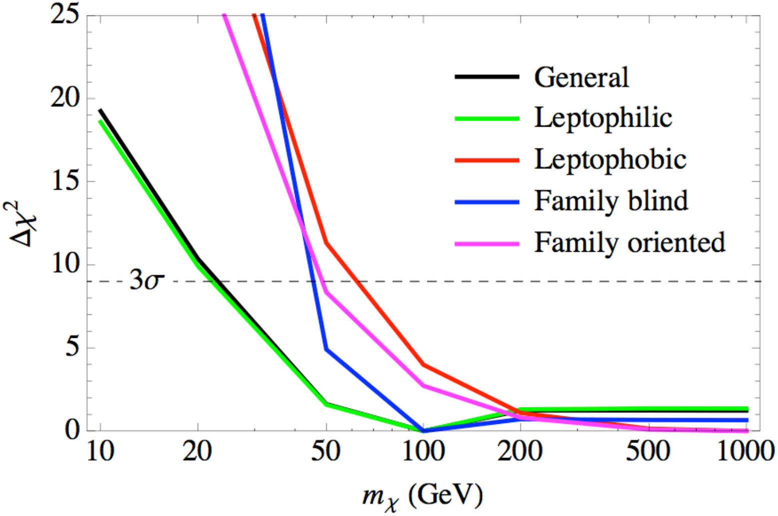
Micromegas + MultiNest + CalcHEP

Dependence with DM mass



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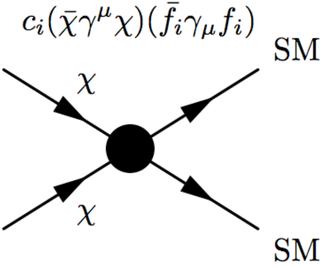
Relic abundance



$$\Omega_h^2|_{\rm exp} = 0.1199 \pm 0.0027$$

PLANCK '13

We assume thermal relic

Larger c_i means more annihilation which leads to less DM

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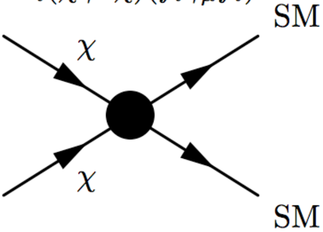
Relic abundance

$$c_i(\bar{\chi}\gamma^\mu\chi)(\bar{f}_i\gamma_\mu f_i)$$



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Larger c_i means more annihilation which leads to less DM

$$(\sigma v_{rel})_i \approx w_i \frac{(c_{i_L} + c_{i_R})^2}{24\pi}(3m_\chi^2 + m_\chi^2 v^2)$$

$$\Sigma_i \equiv \sqrt{\sum_i w_i c_i^2}$$

pedro.machado@uam.es

General model

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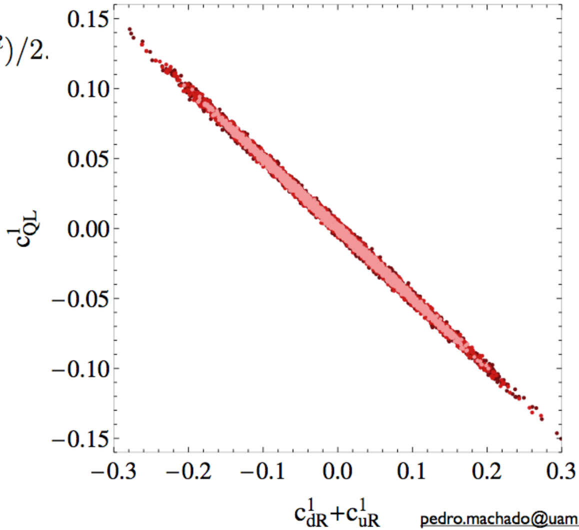
General model

$$g_{\mathrm{Xe}} \propto [(N_u + N_d)g^L_{(u,s)} + N_u g^R_u + N_d g^R_d]$$

$N_u \approx N_d$

$$g^L_{u,d} \approx -(g^R_u + g^R_d)/2.$$



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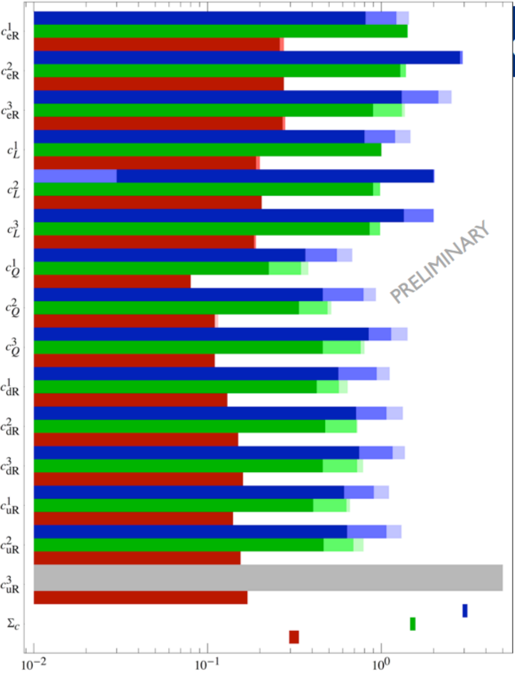
odel



50 GeV

100 GeV

500 GeV

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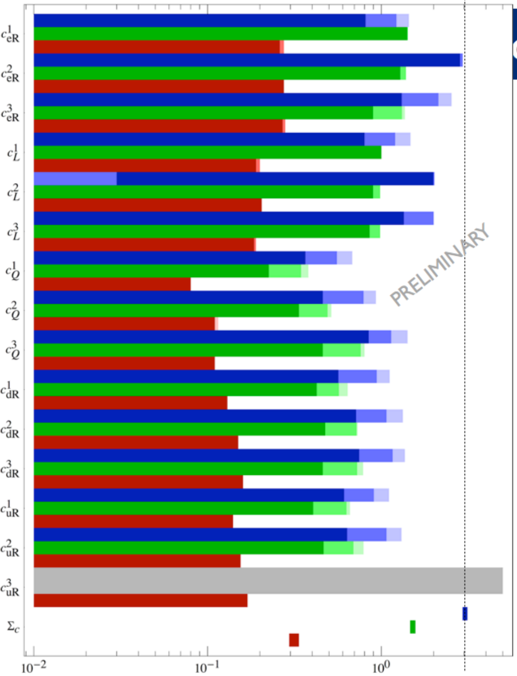
odel



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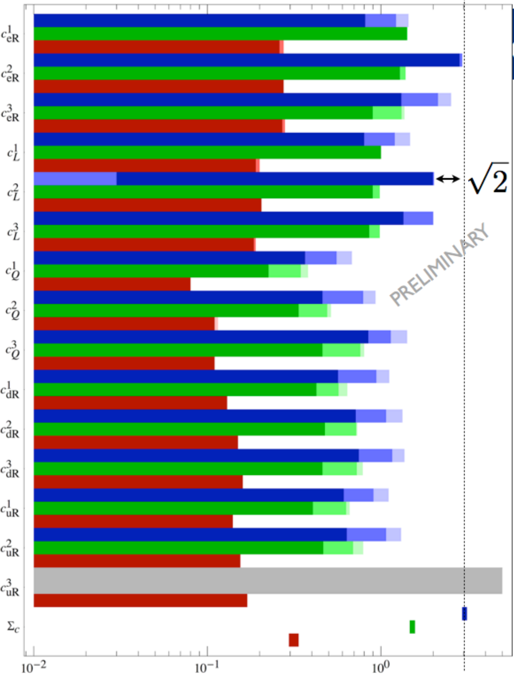

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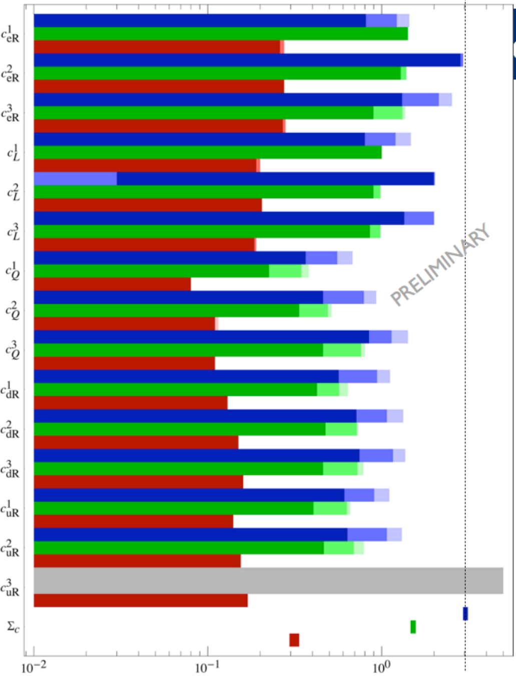

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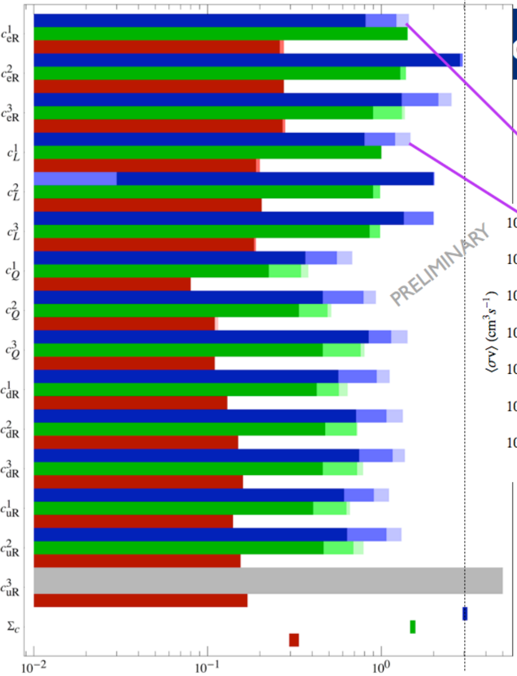

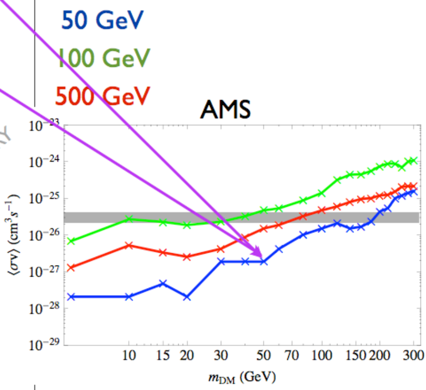

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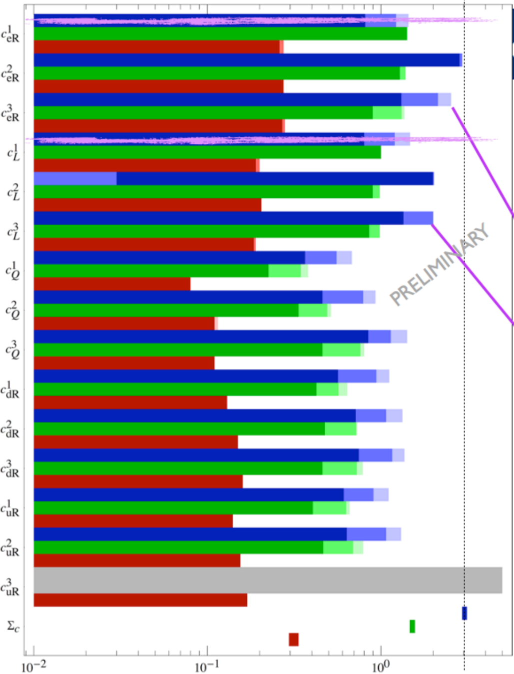

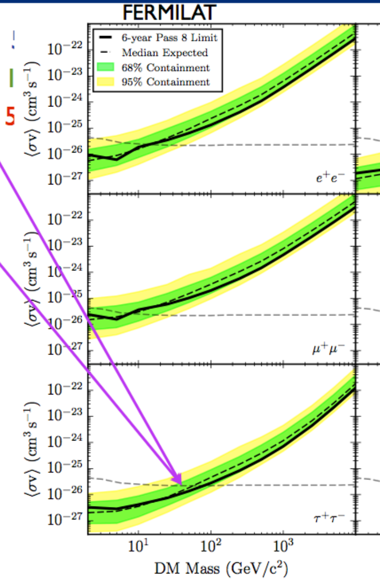

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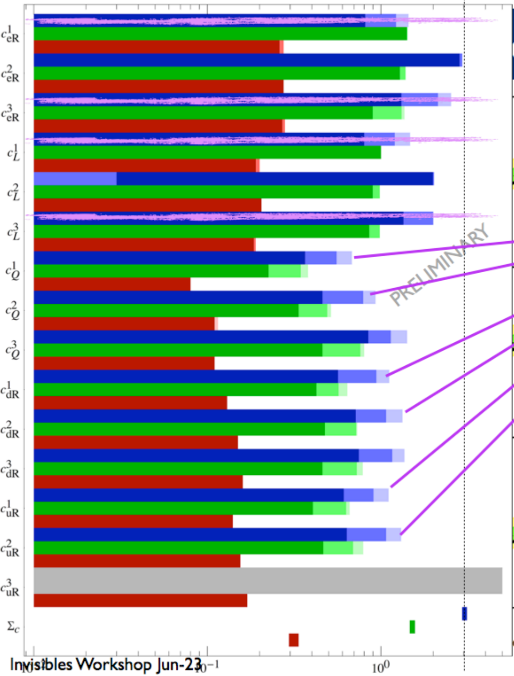

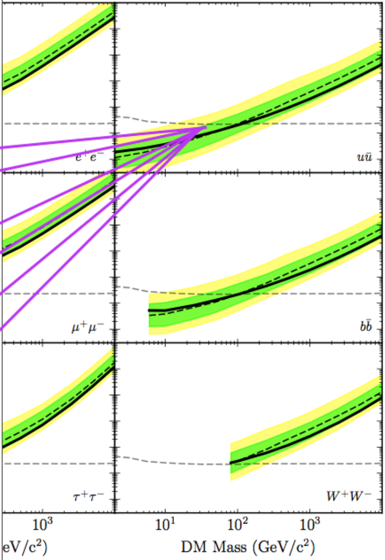

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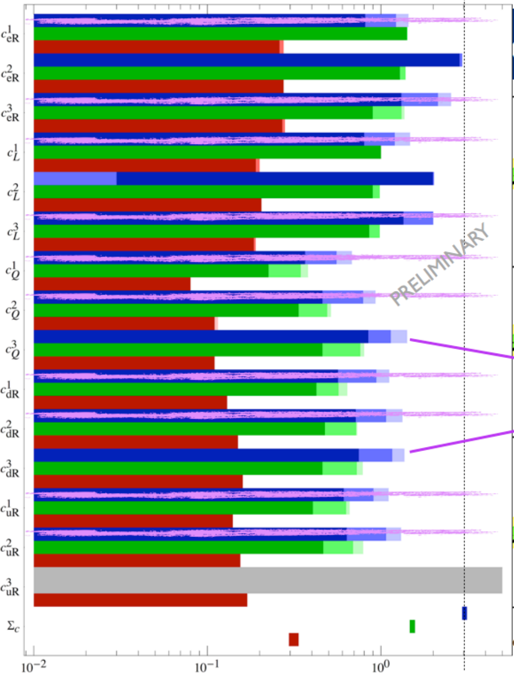

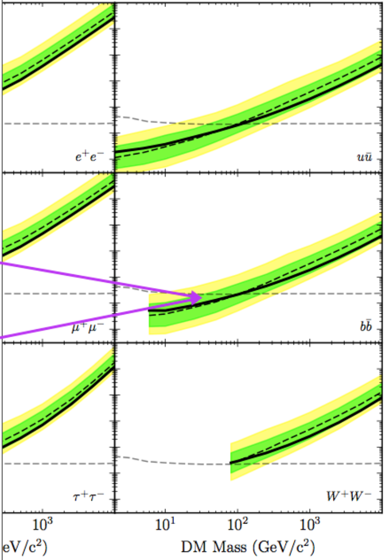

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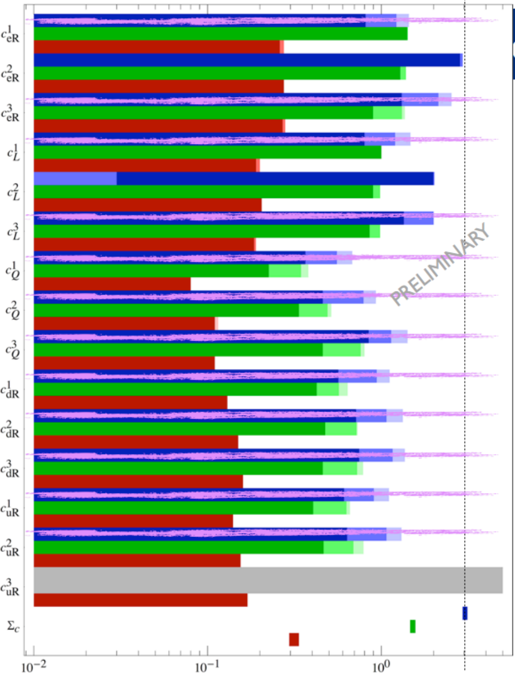

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In this scenario, for a 50 GeV DM, the right abundance is obtained by the coupling to muons and muon neutrinos!

pedro.machado@uam.es

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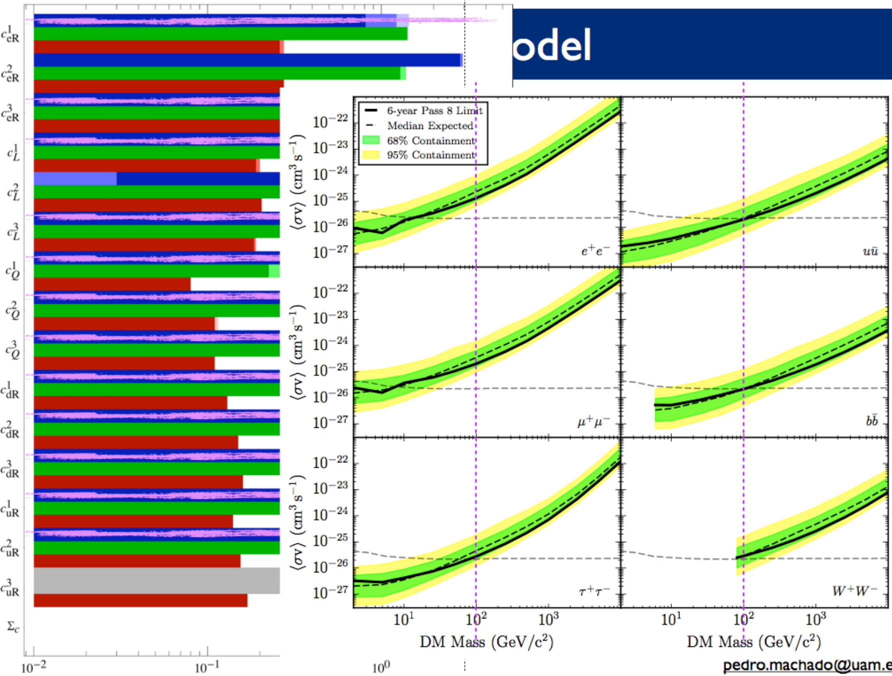

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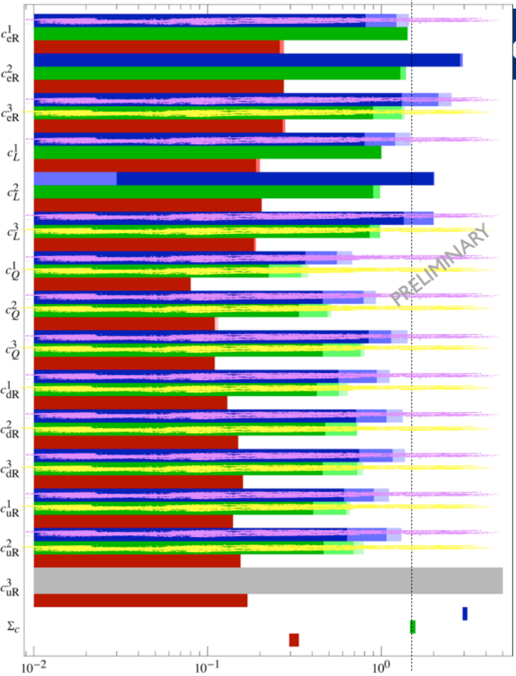

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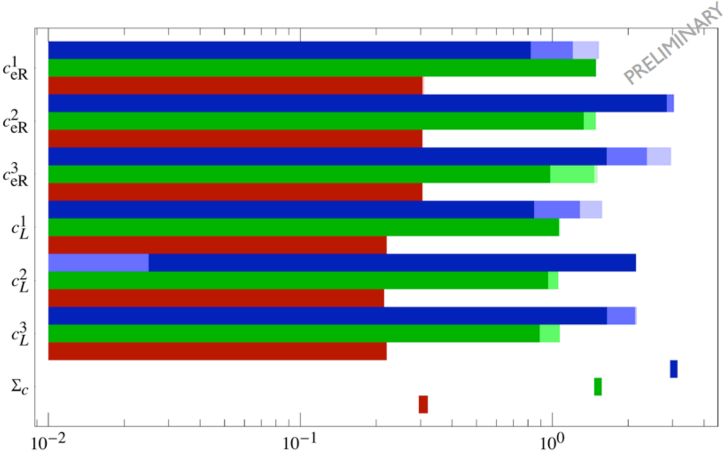
Leptophilic



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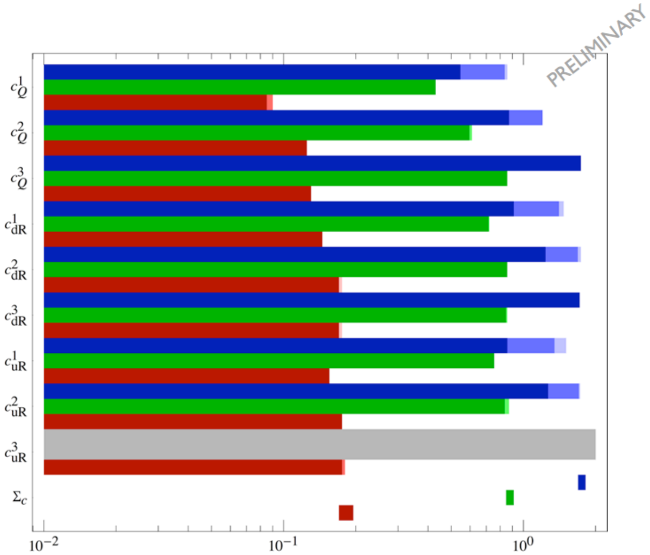

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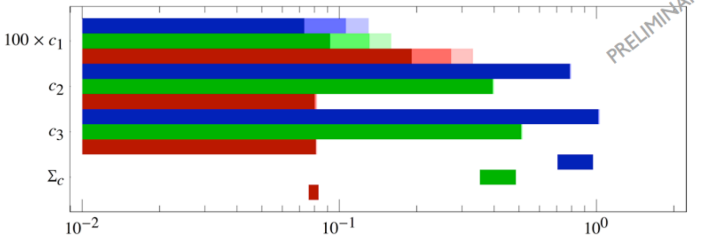
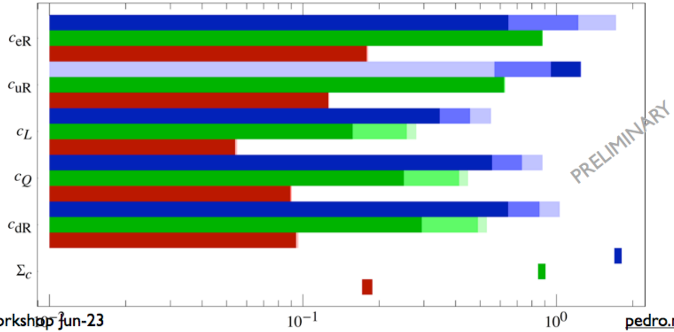
Other models





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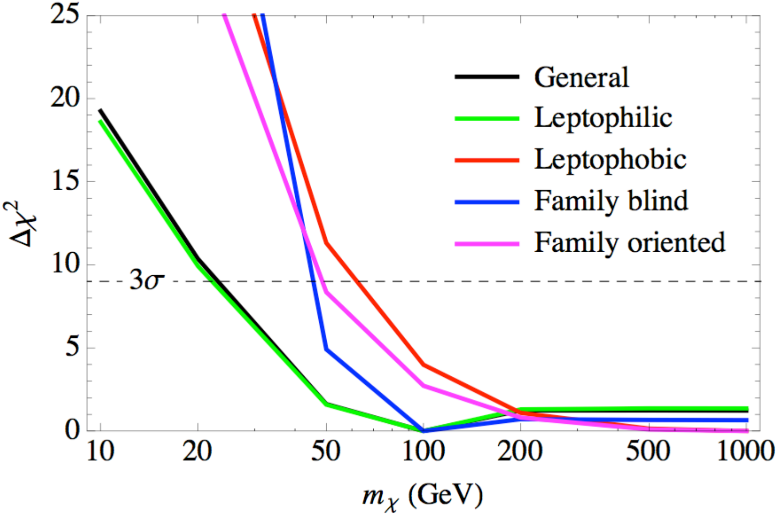
Dependence with DM mass



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Conclusions

We have analyzed the status of thermal WIMP dark matter in the context of effective field theory

In some cases, specific couplings are required to obtain the abundance

For the leptophilic and general models, masses below 20 GeV are disfavored

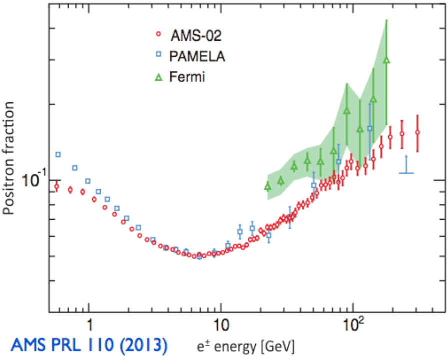
For the other proxies, masses below 50~60 GeV are disfavored

pedro.machado@uam.es

Backup

pedro.machado@uam.es

AMS



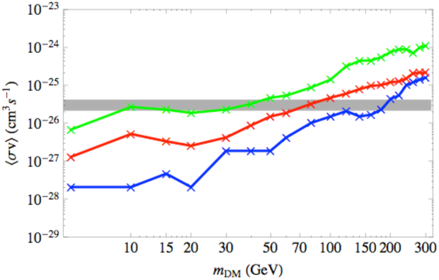
AMS PRL 110 (2013)

Backgrounds:

$$\Phi_{e^+} = C_{e^+} E^{-\gamma_{e^+}} + C_s E^{-\gamma_s} e^{-E/E_s};$$

$$\Phi_{e^-} = C_{e^-} E^{-\gamma_{e^-}} + C_s E^{-\gamma_s} e^{-E/E_s}$$

We marginalized the positron background, fixed the electron background, and fitted the DM signal.



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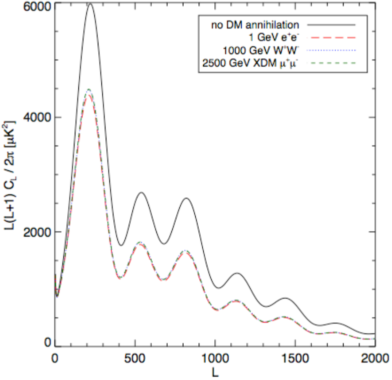
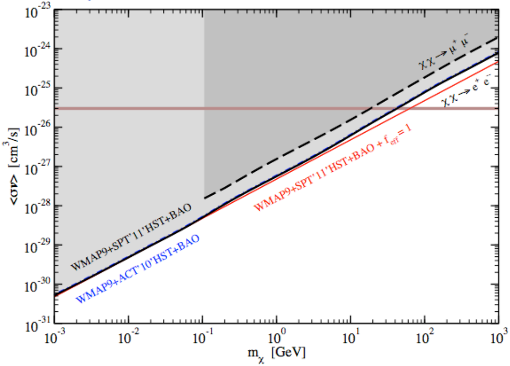
CMB

Dark matter annihilations can heat up and ionize the photon-baryon plasma, changing the CMB temperature and polarization angular power spectra

Slatyer Padmanabhan Finkbeiner '09



Lopez-Honorez et al '13



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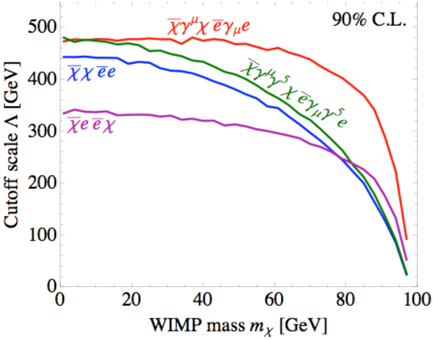
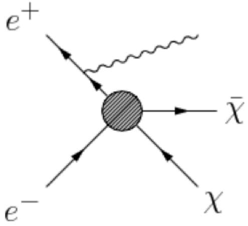
LEP

Fox Harnik Kopp Tsai PRD84 (2011)





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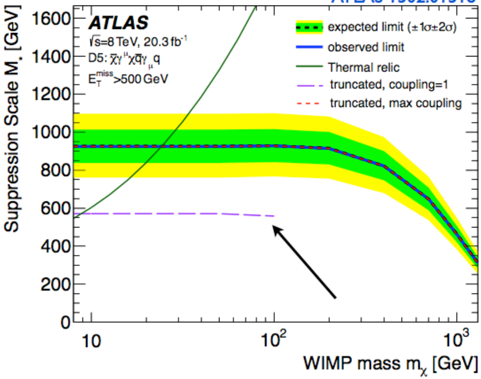
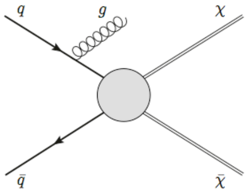
LHC

ATLAS 1502.01518

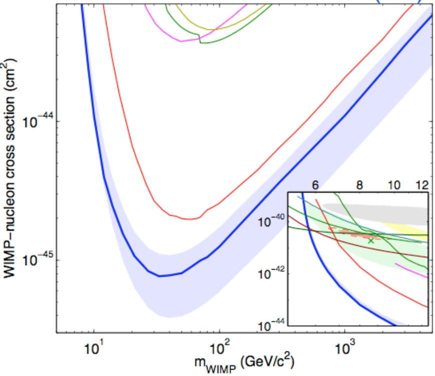




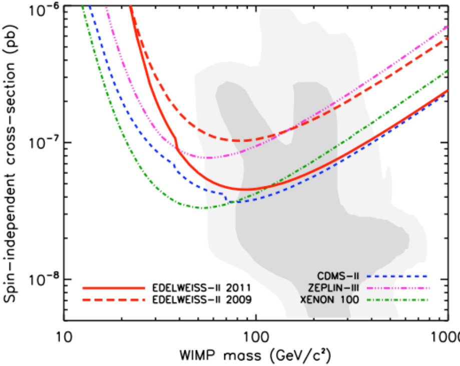
pedro.machado@uam.es

Direct detection

LUX PRL 112 (2014)



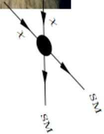
EDELWEISS II PLB702 (2011)

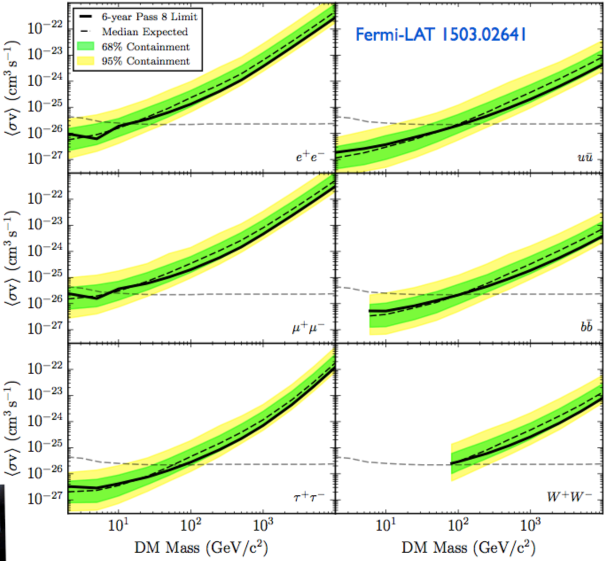


pedro.machado@uam.es

FermiLAT

$$\phi_s(\Delta\Omega) = \underbrace{\frac{1}{4\pi}\frac{\langle\sigma v\rangle}{2m_{\rm DM}^2}\int_{E_{\rm min}}^{E_{\rm max}}\frac{{\rm d}N_\gamma}{{\rm d}E_\gamma}{\rm d}E_\gamma}_{\text{particle physics}} \times \underbrace{\int_{\Delta\Omega}\int_{\rm l.o.s.}\rho_{\rm DM}^2(\boldsymbol{r}){\rm d}l{\rm d}\Omega'}_{\text{J-factor}} .$$





pedro.machado@uam.es