Comparisons to ID for Vector and Axial Vector models

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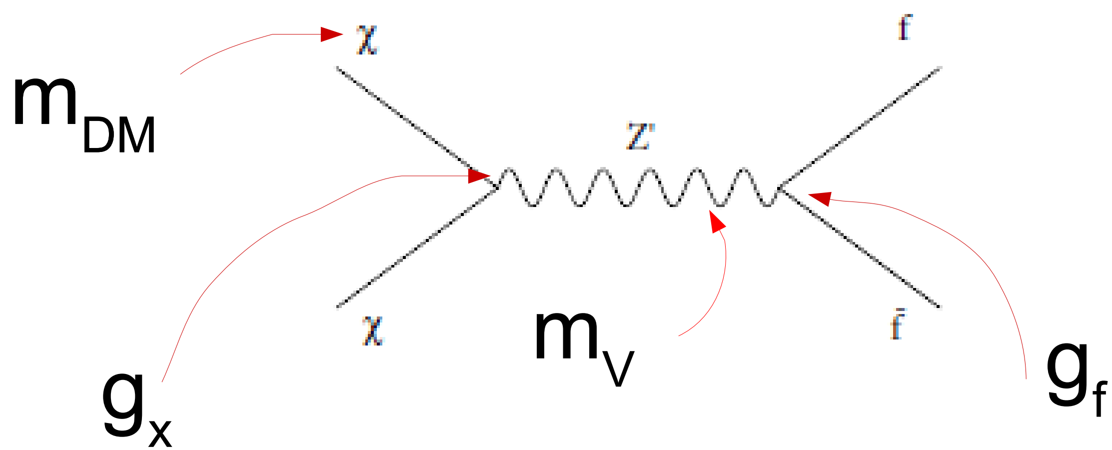
Axial/vector Mediator model

DM coupling to all 6 quarks

gx



4 parameters

5 flavors of available Available quarks if $m_{DM}<m_{top}$ but $>m_b$

Fermi Dwarf Analysis

Dwarf Spheroidal Galaxies large amount of DM

Low Astrophysical Background

photon flux

$$\Phi_\gamma = \frac{1}{4\pi} \sum_f \frac{\langle \sigma v \rangle_f}{2m_\chi^2} \int_{E_{\min}}^{E_{\max}} \left(\frac{dN_\gamma}{dE_\gamma} \right)_f dE_\gamma J.$$

averaged annihilation xsec

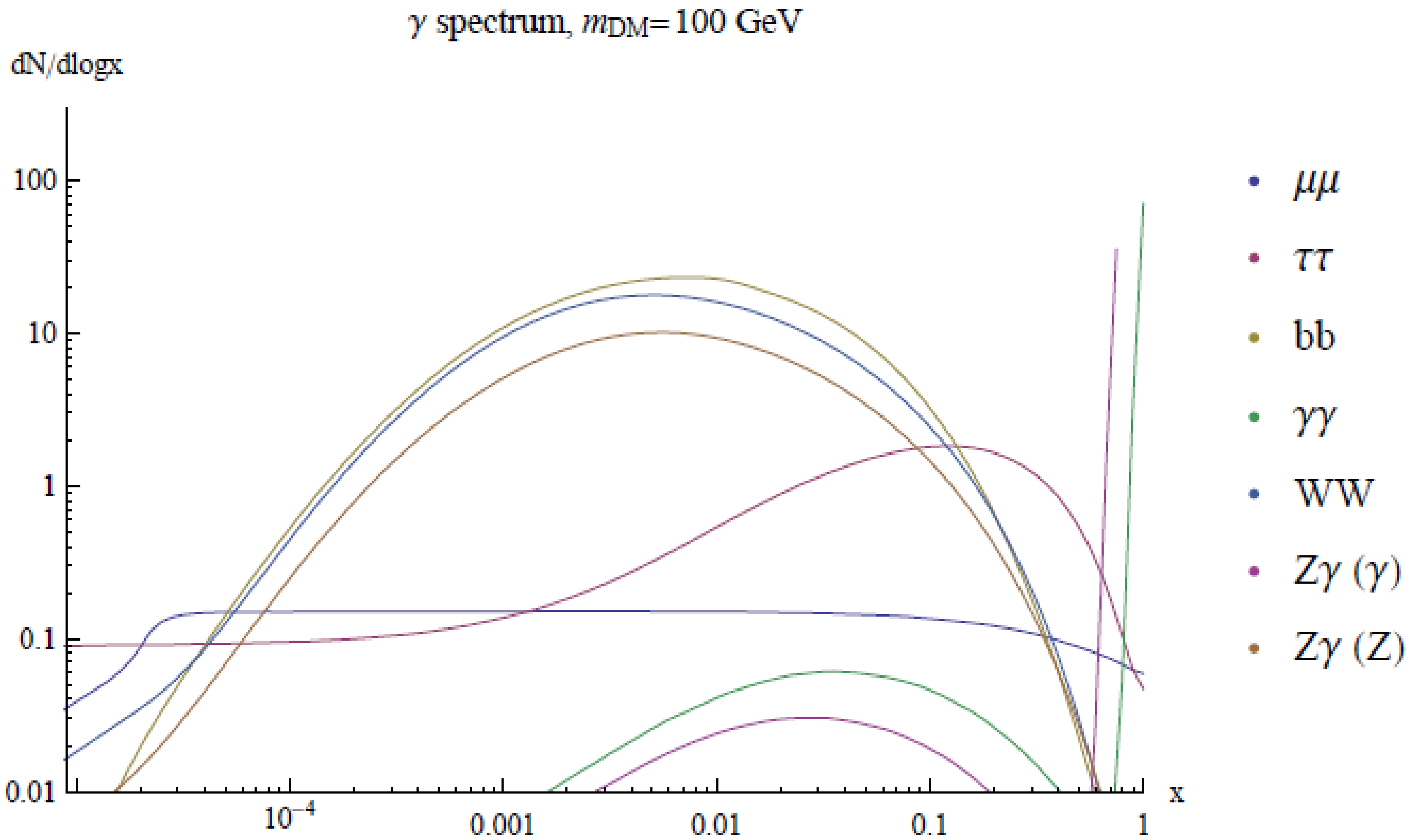
DM mass

Photon energy spectrum

Line of sight integral of DM density

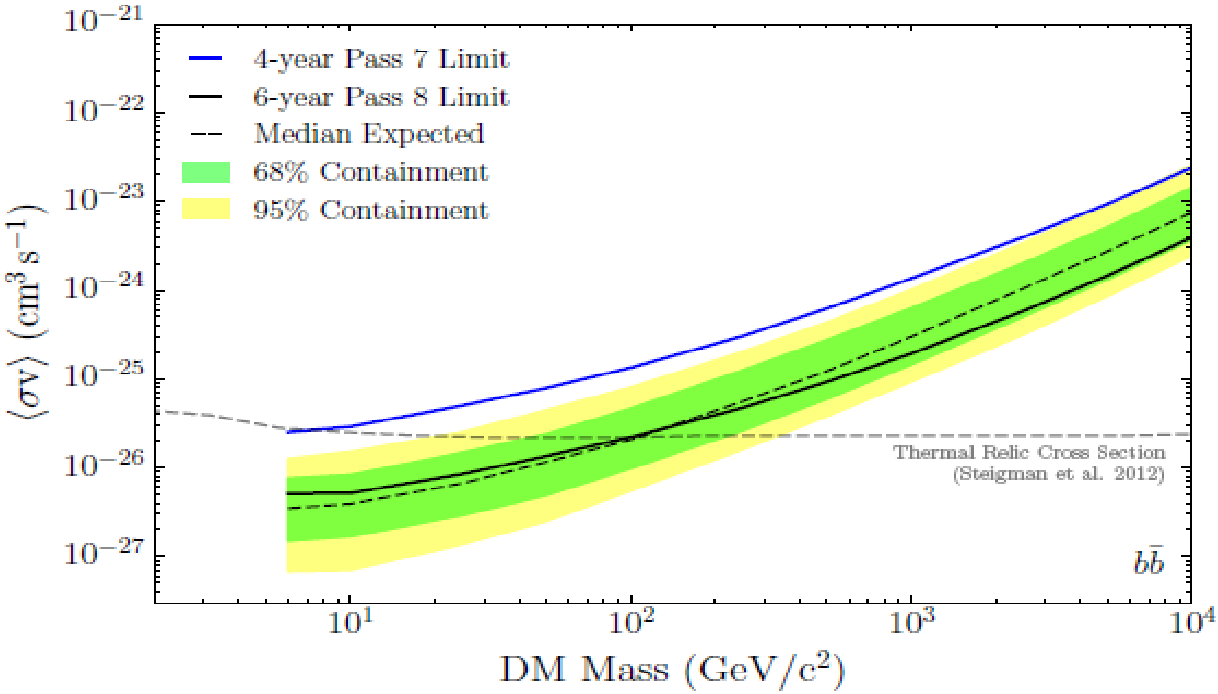
$$J = \int_{\Delta\Omega} \int_{l.o.s} \rho^2(\mathbf{r}) dl d\Omega'.$$

Spectrum



DM annihilates to various SM final states each with a characteristic photon spectrum

Fermi Analysis combine 15 dwarf's with largest J factors, set 95% c.l. upper bound assuming 100% annihilation into a single channel,e.g. b's



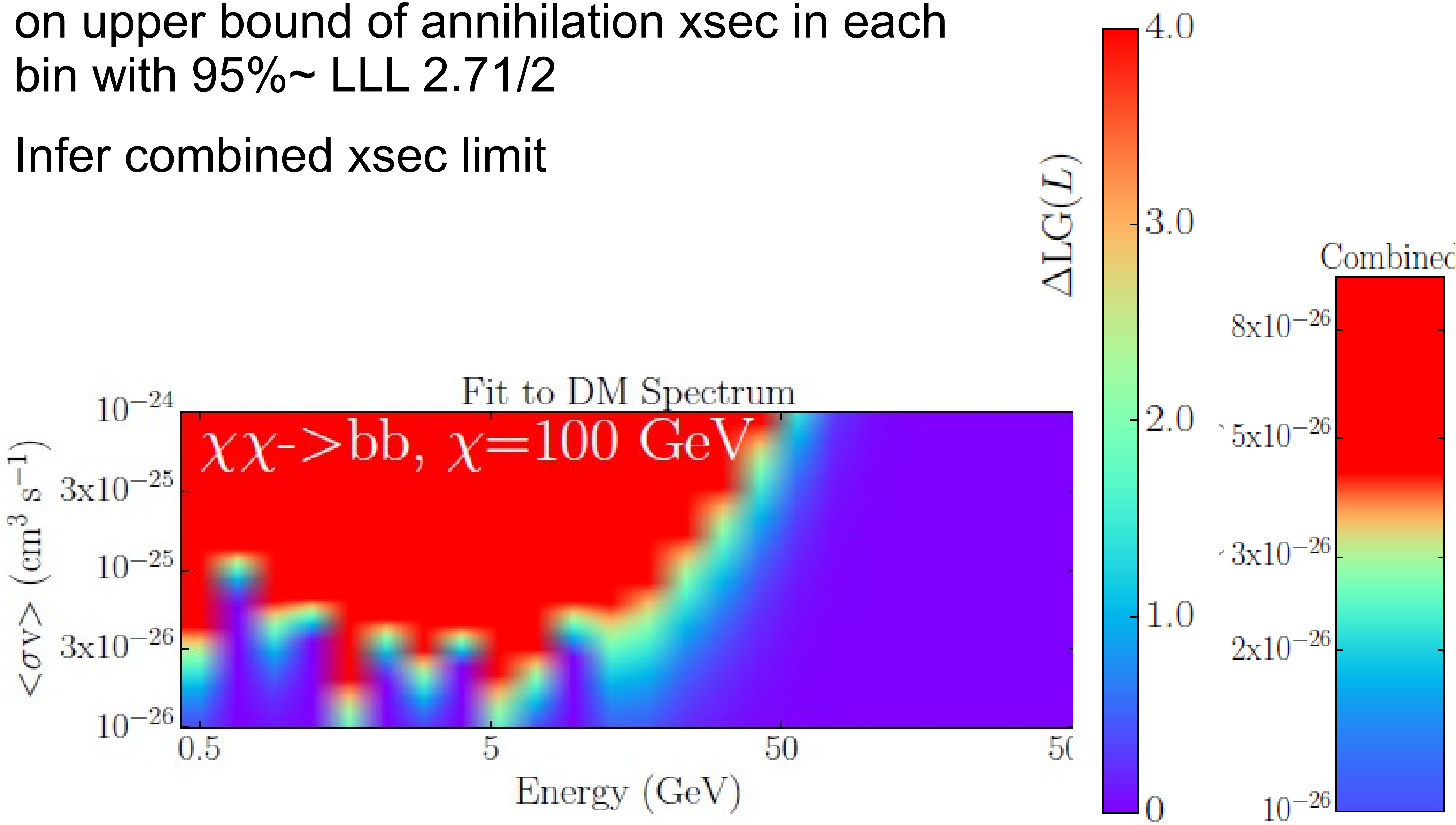
ArXiv:1503.02641

Choose DM mass and annihilation channel

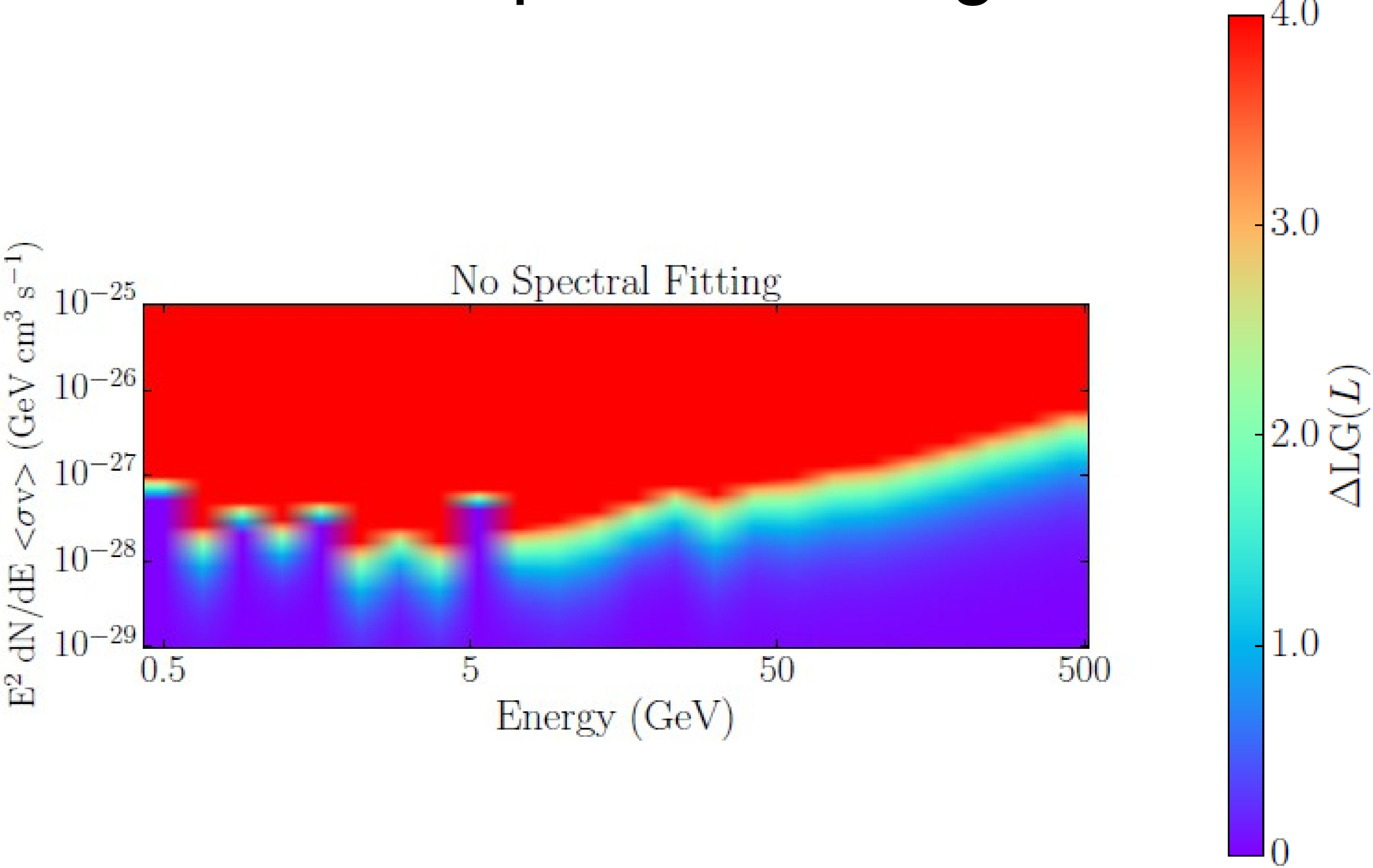
Allow J factor to float with Least Log Likelihood cost $\Delta\mathrm{LG}(\mathcal{L}) = (\mathrm{J}_{bf} - \mathrm{J}_{meas})^2 \,/\, (2\sigma_J^2)$

Compare to null hypothesis no DM to set limit on upper bound of annihilation xsec in each bin with 95%~ LLL 2.71/2

Infer combined xsec limit



No spectral Fitting



Dark Matter Lagrangian
For Axial/VectorCv

$$\mathcal{L} = V_\mu \bar{\chi}\gamma^\mu (g_\chi^V - g_\chi^A \gamma^5)\chi + \sum_f V_\mu \bar{f}\gamma^\mu (g_f^V - g_f^A \gamma^5) f,$$

With x-sec

$$\langle \sigma v \rangle (\chi\bar{\chi} \to V \to f\bar{f}) = \frac{N_c^f m_\chi^2}{2\pi[(M_V^2 - 4m_\chi^2)^2 + \Gamma_V^2 M_V^2]} \left(1 - \frac{m_f^2}{m_\chi^2}\right)^{1/2}$$
$$\times \left\{ |g_\chi^V|^2 \left[|g_f^V|^2 \left(2 + \frac{m_f^2}{m_\chi^2}\right) + 2|g_f^A|^2 \left(1 - \frac{m_f^2}{m_\chi^2}\right)\right] + |g_\chi^A|^2 |g_f^A|^2 \frac{m_f^2}{m_\chi^2} \left(1 - \frac{4m_\chi^2}{M_V^2}\right)^2 \right\},$$

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Large suppression for axial vector
Light quark flavors. And for top quark
Channel For heavy DM

Dark Matter Lagrangian
For Axial/Vector couplings

$$\mathcal{L} = V_\mu \bar{\chi}\gamma^\mu (g_\chi^V - g_\chi^A \gamma^5)\chi + \sum_f V_\mu \bar{f}\gamma^\mu (g_f^V - g_f^A \gamma^5) f,$$

With x-sec

$$\langle \sigma v \rangle (\chi\bar{\chi} \to V \to f\bar{f}) = \frac{N_c^f m_\chi^2}{2\pi[(M_V^2 - 4m_\chi^2)^2 + \Gamma_V^2 M_V^2]} \left(1 - \frac{m_f^2}{m_\chi^2}\right)^{1/2}$$
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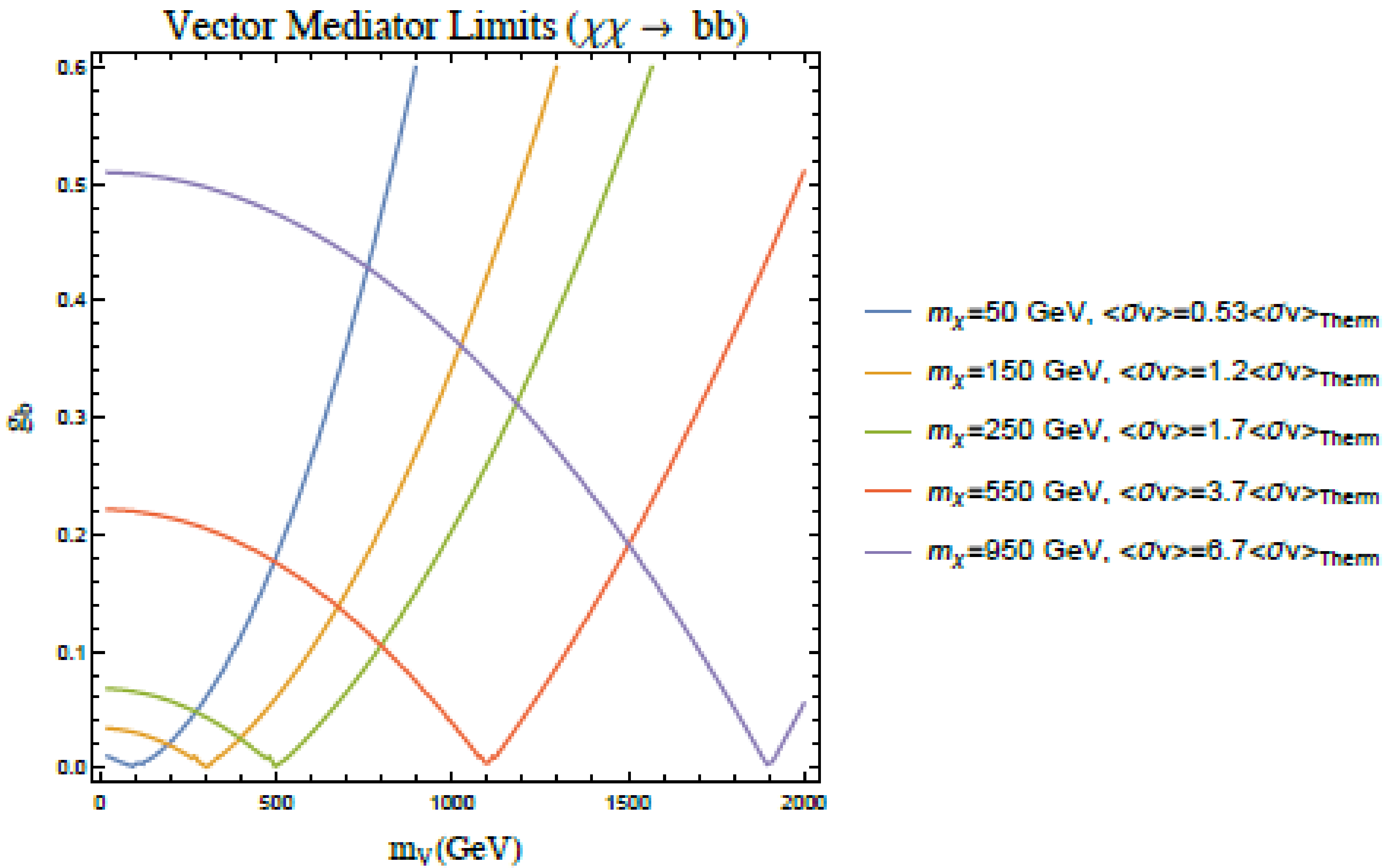
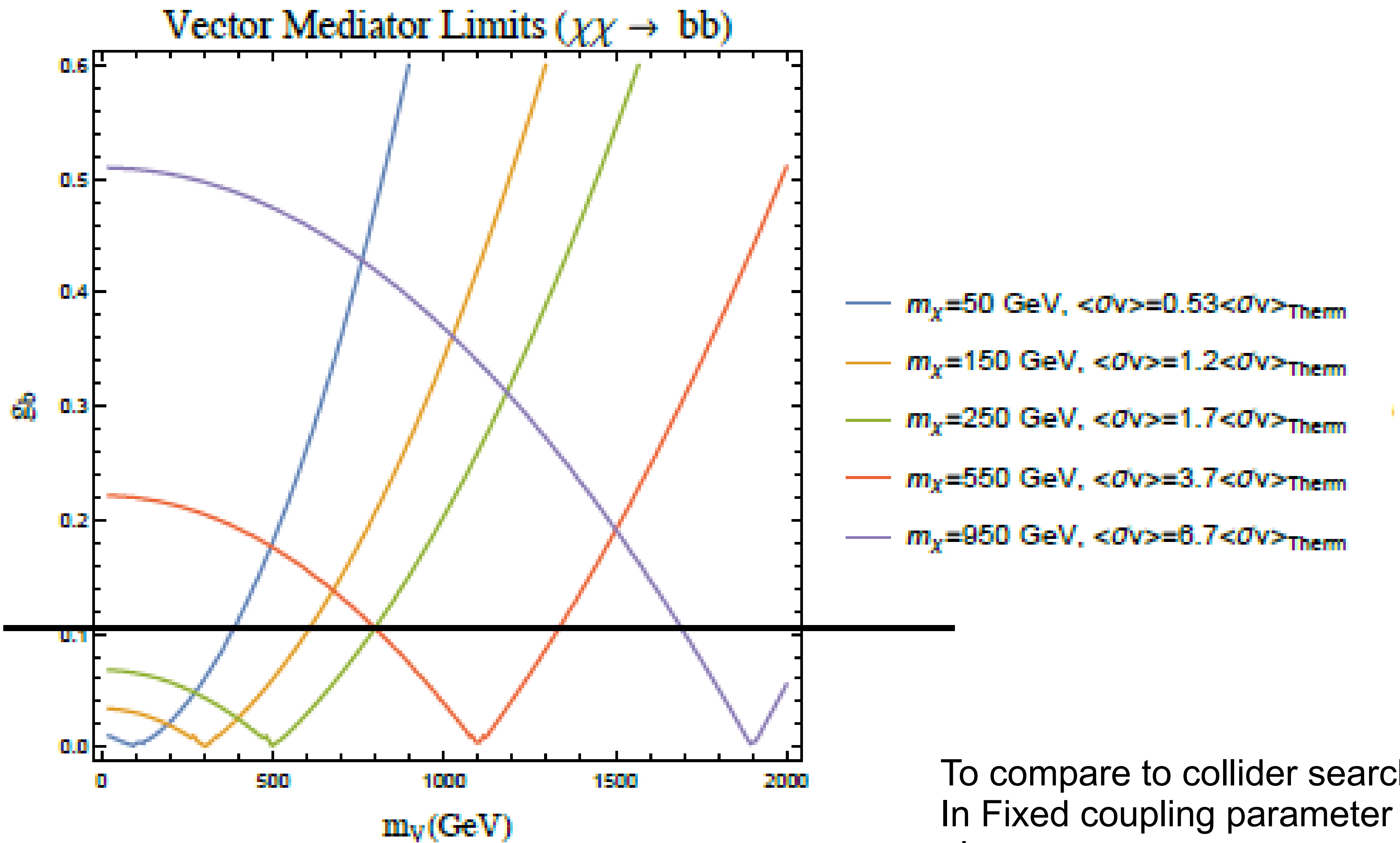
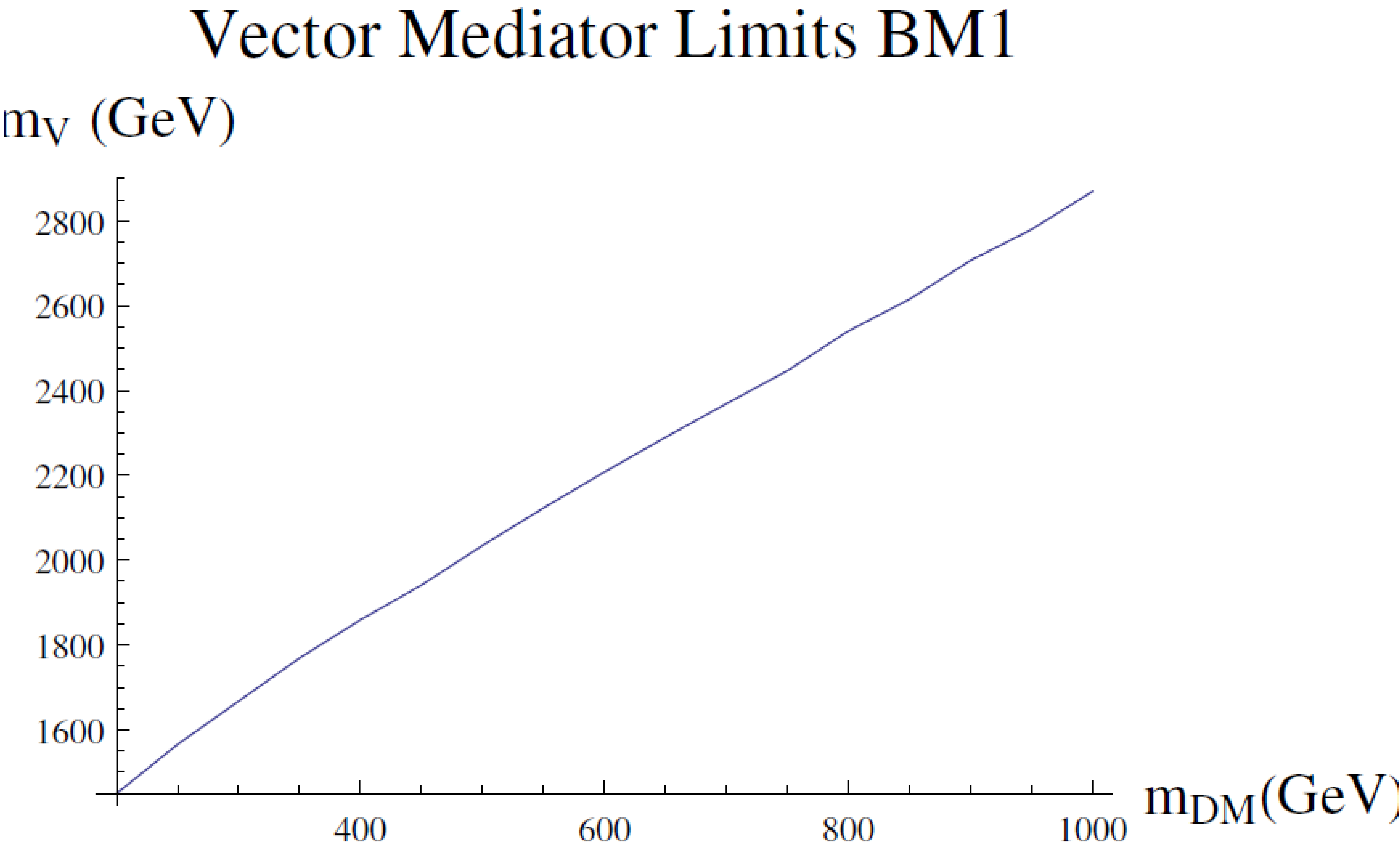
Resonance behavior in annihilation x-sec cut off by decay width



Vector Mediator Limits (χχ → bb)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
500
1000
1500
2000
m_V(GeV)
m_χ=50 GeV, <σv>=0.53<σv>$_{Therm}$
m_χ=150 GeV, <σv>=1.2<σv>$_{Therm}$
m_χ=250 GeV, <σv>=1.7<σv>$_{Therm}$
m_χ=550 GeV, <σv>=3.7<σv>$_{Therm}$
m_χ=950 GeV, <σv>=6.7<σv>$_{Therm}$



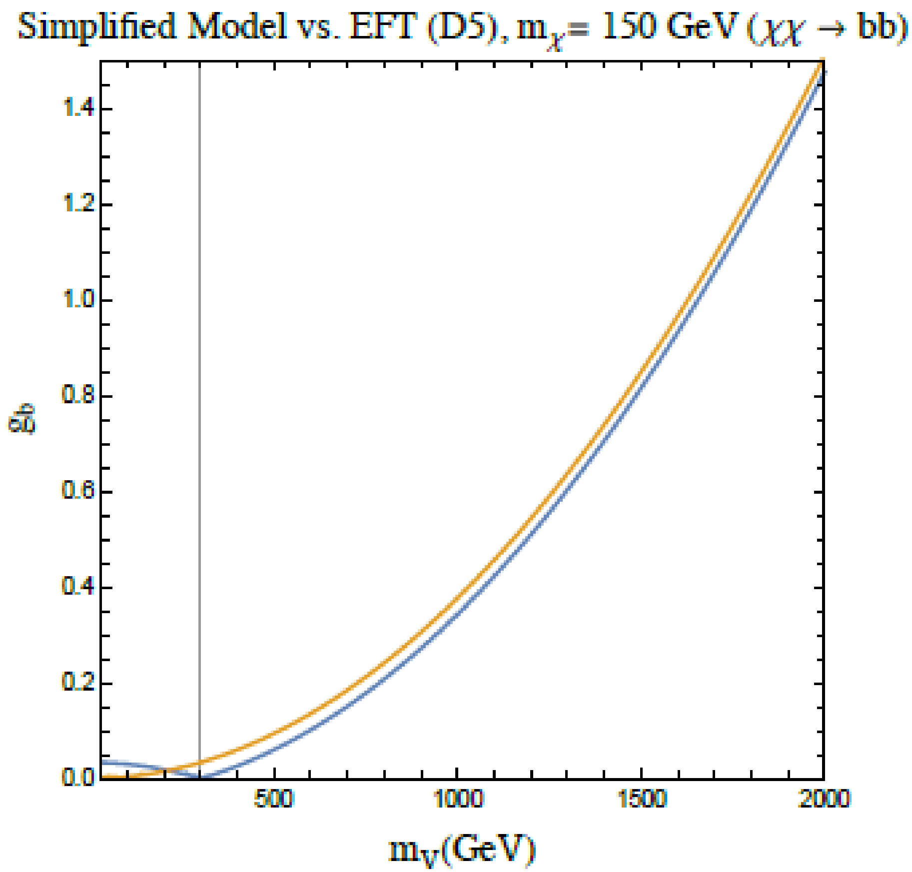
To compare to collider searches
In Fixed coupling parameter
plane



Vector Mediator Limits BM1
mV (GeV)
2800
2600
2400
2200
2000
1800
1600
400
600
800
1000
mDM(GeV)

Conclusions

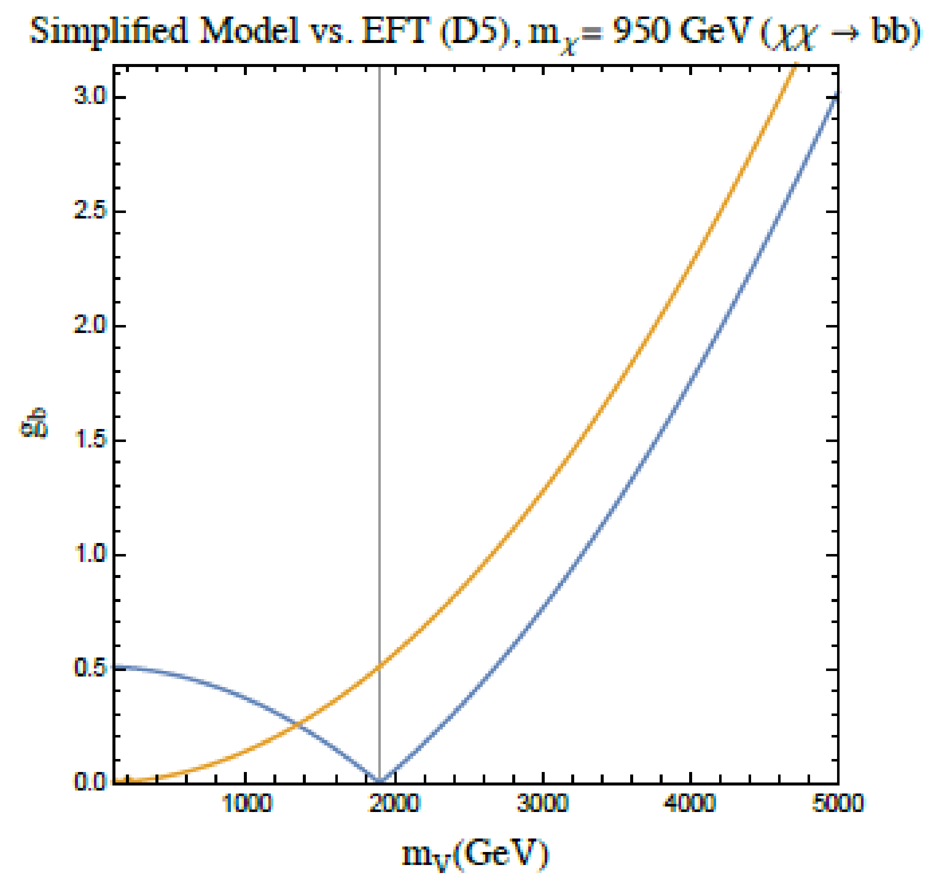
- Indirect detection provdes interesting limits for anxial/vector DM models.
- There are both Top mass threshold and resonance effects
- Axial strongly favor favor heavy flavor annihilation while Vector is democratic
- Have completed structure of benchmark collider points and Now working on isolating top threshold effects



$$\Lambda \sim m_V / \sqrt{g_\chi g_f}$$

Simplified Model

EFT



Upper bounds on DM-mediator coupling as a
Function of mediator mass for vector model with g=1
Compared to EFT D5 $(\bar{\chi}\gamma^\mu\chi f\gamma_\mu f)$