

SUSY implications from WIMP annihilation into scalars at the Galactic Center

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25th January 2016, RPP Annecy

In collaboration with T.Gherghetta, B.v.Harling, M.A.Schmidt and T.Trott
Phys. Rev. D91 (2015) 105004 [1502.07173]
JHEP 1302 (2013) 032 [1212.5243]

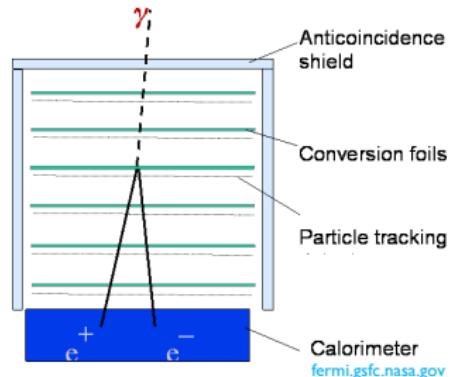


Fermi Satellite Experiment



Fermi-LAT

- Observation of γ -rays
- $E = 30\text{MeV} - 500\text{GeV}$
- High energy resolution: < 15% at energies $> 100 \text{ MeV}$
- large field of view 2.4 sr

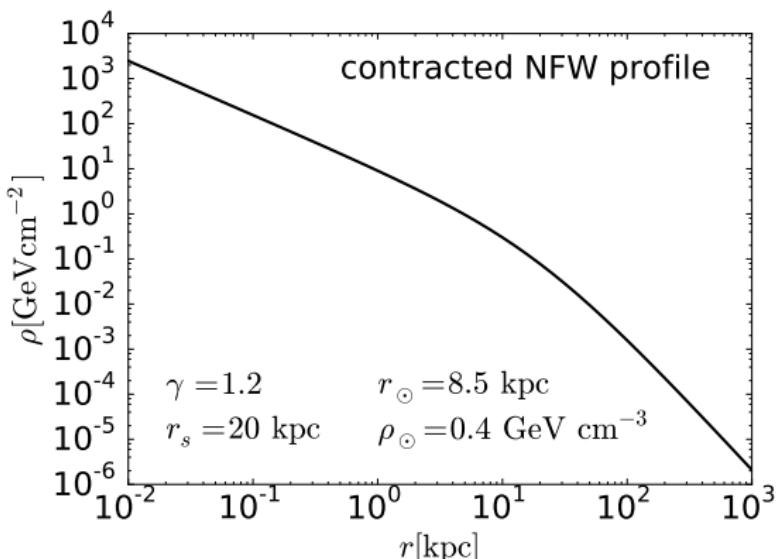


- launched 11 June 2008
- running 5 - 10 years

Dark Matter Interpretation of Fermi GeV Excess

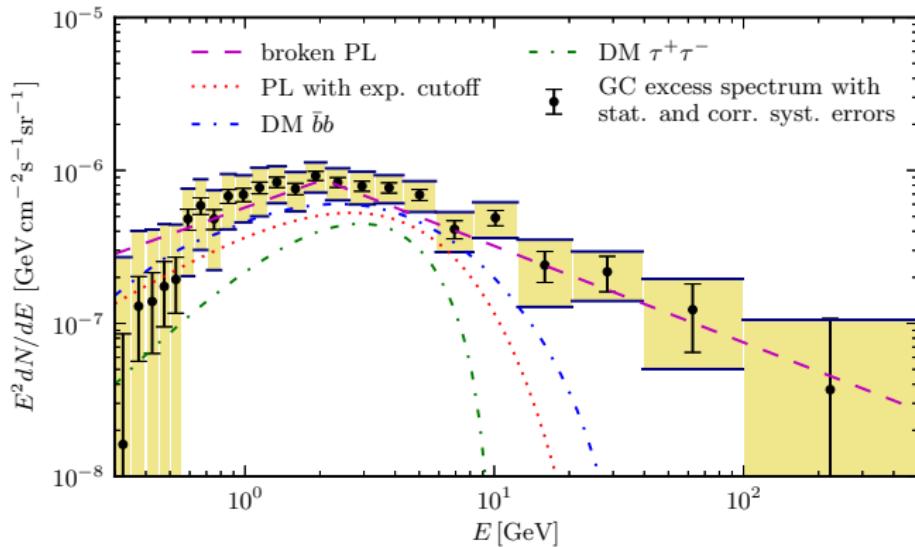
$$\text{DM} \quad \frac{dN}{dE} = \sum_f \frac{\langle \sigma v \rangle_f}{8\pi m_\chi^2} \frac{dN_\gamma^f}{dE} \int_{l.o.s.} ds \rho^2(r(s, \psi))$$

Generalized NFW profile $\rho(r) = \rho_\odot \left(\frac{r}{r_\odot} \right)^{-\gamma} \left(\frac{1 + r_\odot/r_s}{1 + r/r_s} \right)^{3-\gamma}$



Dark Matter Interpretation of Fermi GeV Excess

$$\text{DM} \quad \frac{dN}{dE} = \sum_f \frac{\langle \sigma v \rangle_f}{8\pi m_\chi^2} \frac{dN_\gamma^f}{dE} \int_{l.o.s.} ds \rho^2(r(s, \psi))$$



p-values

broken PL

$p = 0.47$

exp cutoff

$p = 0.16$

DM $b\bar{b}$

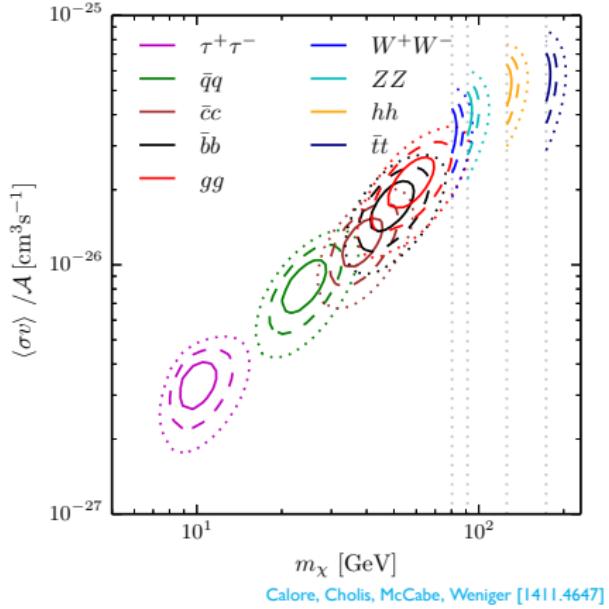
$p = 0.43$

DM $\tau^+\tau^-$

$p = 0.065$

Calore, Cholis, Weniger [1409.0042]

DM Fits: 3σ Regions

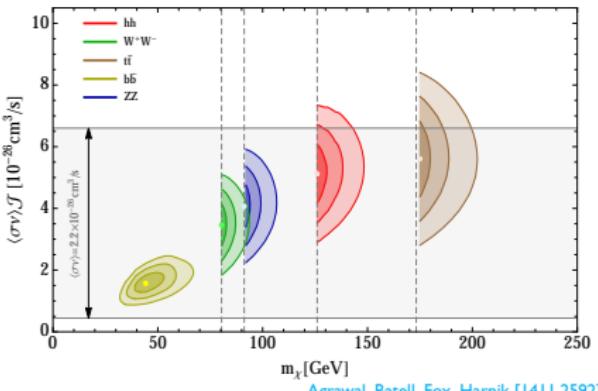


Uncertainties in DM halo

$$\mathcal{A} = [0.17, 5.3] \quad (\mathcal{J} = [0.19, 3])$$

	$\langle \sigma v \rangle$	m_χ	χ^2_{\min}	$p\text{-value}$
$\bar{b}b$	$1.75^{+0.28}_{-0.26}$	$48.7^{+6.4}_{-5.2}$	23.9	0.35
$\bar{t}t$	$5.8^{+0.8}_{-0.8}$	$173.3^{+2.8}_{-0}$	43.9	0.003
hh	$5.33^{+0.68}_{-0.68}$	$125.7^{+3.1}_{-0}$	29.5	0.13
$W^+ W^-$	$3.52^{+0.48}_{-0.48}$	$80.4^{+1.3}_{-0}$	36.7	0.026
ZZ	$4.12^{+0.55}_{-0.55}$	$91.2^{+1.53}_{-0}$	35.3	0.036

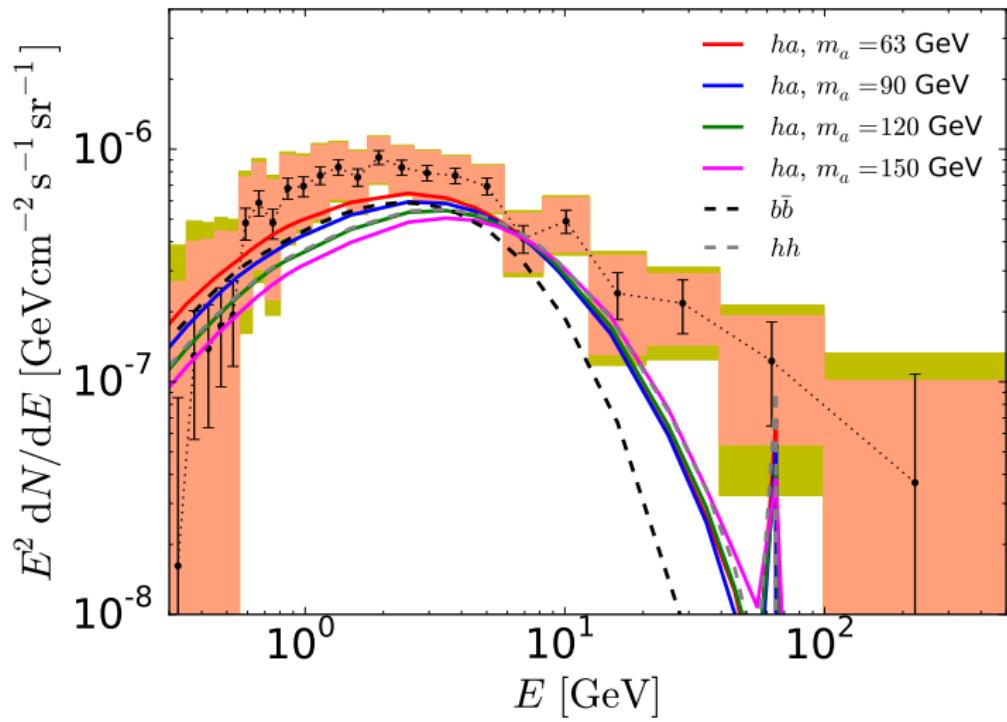
Calore, Cholis, McCabe, Weniger [1411.4647]



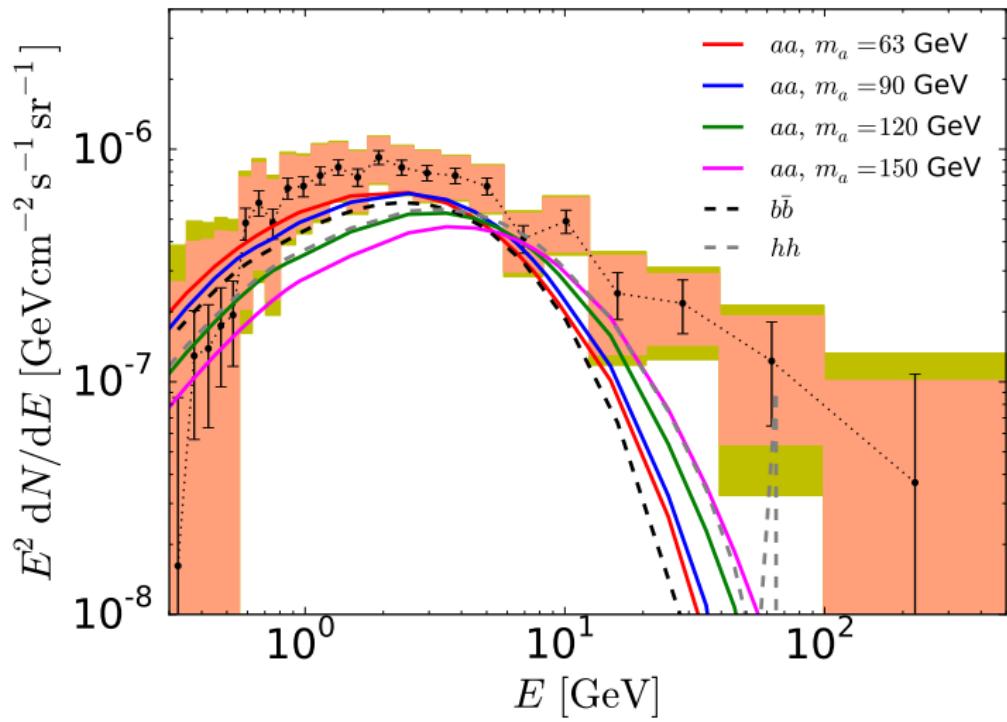
Annihilation into ha and aa in type II 2HDM

- Independent of additional scalar singlets (**includes the NMSSM**).
- Fits with a Higgs at 125 GeV with SM couplings and setting $\tan \beta = 3$.
- Consider the **dominant decay** channels $b\bar{b}$, $\tau^+\tau^-$, $c\bar{c}$, $\gamma\gamma$ and gg and simulate the prompt photon spectra using PYTHIA 8.201.
- For intermediate $\tan \beta \Rightarrow$
 $\text{Br}(a \rightarrow \gamma\gamma)/\text{Br}(h_{\text{SM}} \rightarrow \gamma\gamma) \sim 1/(10 \times \tan^4 \beta)$.
- Spectral line from $a \rightarrow \gamma\gamma$ **barely distinguishable** from the continuum for $m_a \sim 150$ GeV and $\tan \beta \sim 1$ using Fermi-LAT resolution.
- 2-peak structure in ha **may be detectable** in future experiments.

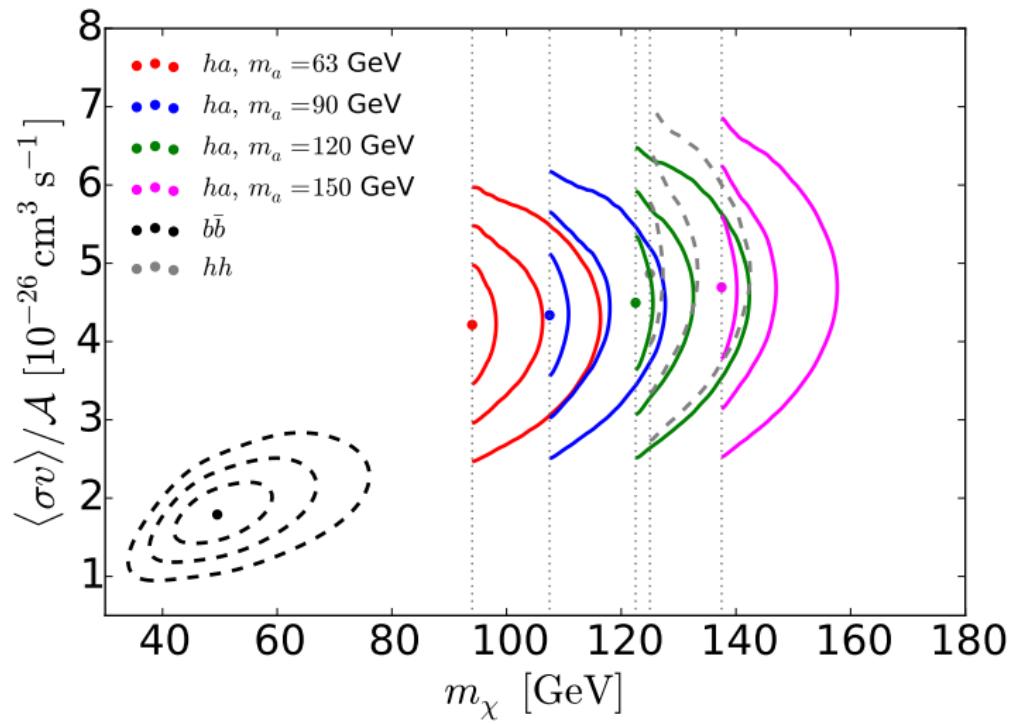
Spectral Fit for ha



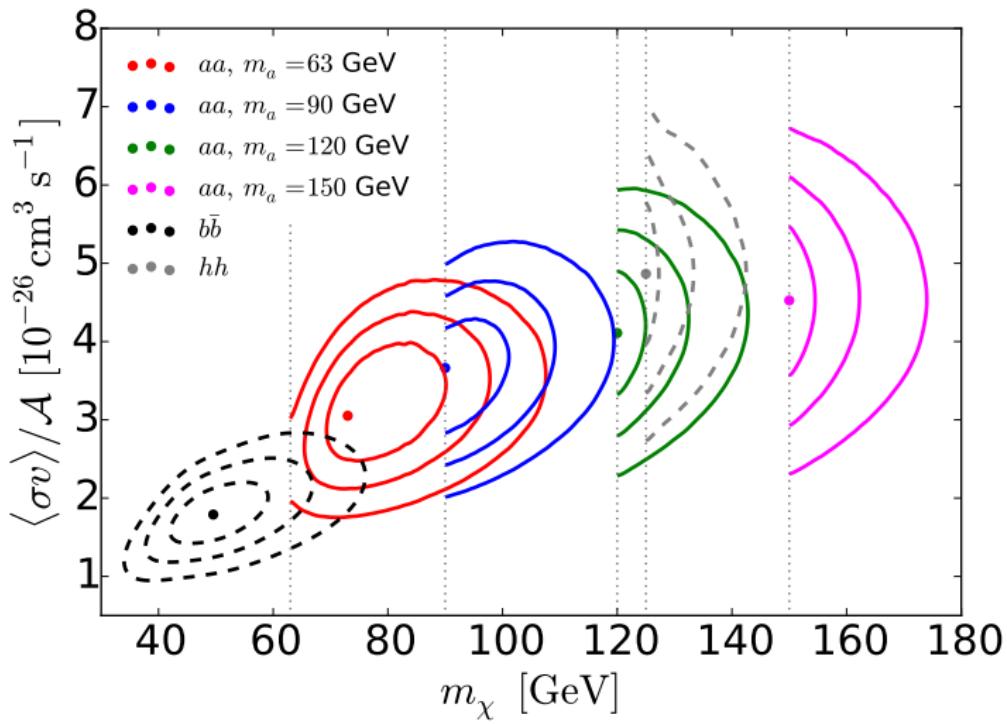
Spectral Fit for aa



Best fit regions for ha



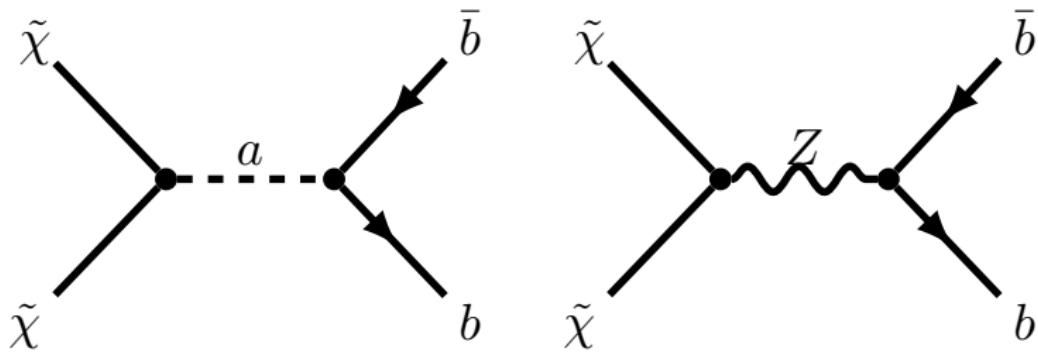
Best fit regions for aa



channel	m_a [GeV]	m_{DM} [GeV]	$\langle \sigma v \rangle_0$ [$10^{-26} \text{cm}^3/\text{s}$]	χ^2_{min}	p -value
$b\bar{b}$		$49.5^{+8.1}_{-6.3}$	$1.8^{+0.3}_{-0.3}$	24.5	0.32
hh		$125.0^{+2.3}_{-0.0}$	$4.9^{+1.0}_{-0.9}$	30.0	0.12
ha	63	$94.0^{+4.2}_{-0.0}$	$4.2^{+0.8}_{-0.8}$	22.4	0.43
	90	$107.5^{+3.4}_{-0.0}$	$4.3^{+0.8}_{-0.8}$	25.3	0.28
	120	$122.5^{+3.0}_{-0.0}$	$4.5^{+0.9}_{-0.9}$	30.3	0.11
	150	$137.5^{+2.7}_{-0.0}$	$4.7^{+1.0}_{-1.0}$	36.0	0.03
aa	63	$73.0^{+15.4}_{-10.0}$	$3.1^{+0.6}_{-0.6}$	24.3	0.33
	90	$90.0^{+10.9}_{-0.0}$	$3.7^{+0.5}_{-0.8}$	24.4	0.33
	120	$120.0^{+4.9}_{-0.0}$	$4.1^{+0.8}_{-0.8}$	31.0	0.10
	150	$150.0^{+4.4}_{-0.0}$	$4.5^{+1.0}_{-1.0}$	41.4	0.01

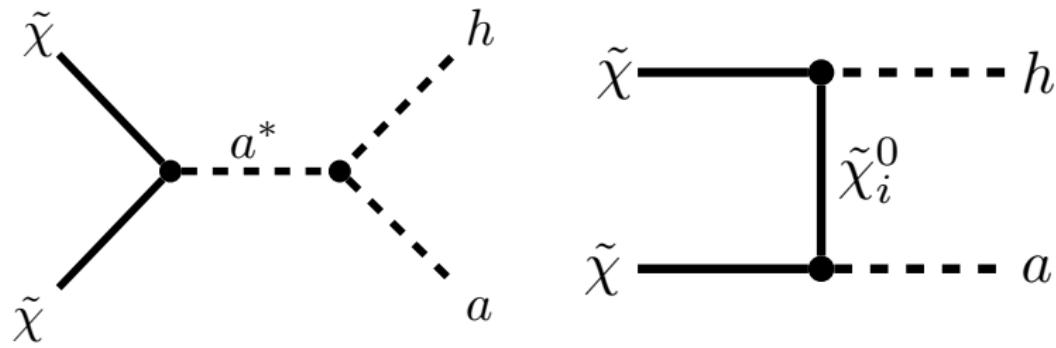
Dark Matter Annihilation in the NMSSM

- $\tilde{\chi}\tilde{\chi} \rightarrow b\bar{b}$ Annihilation

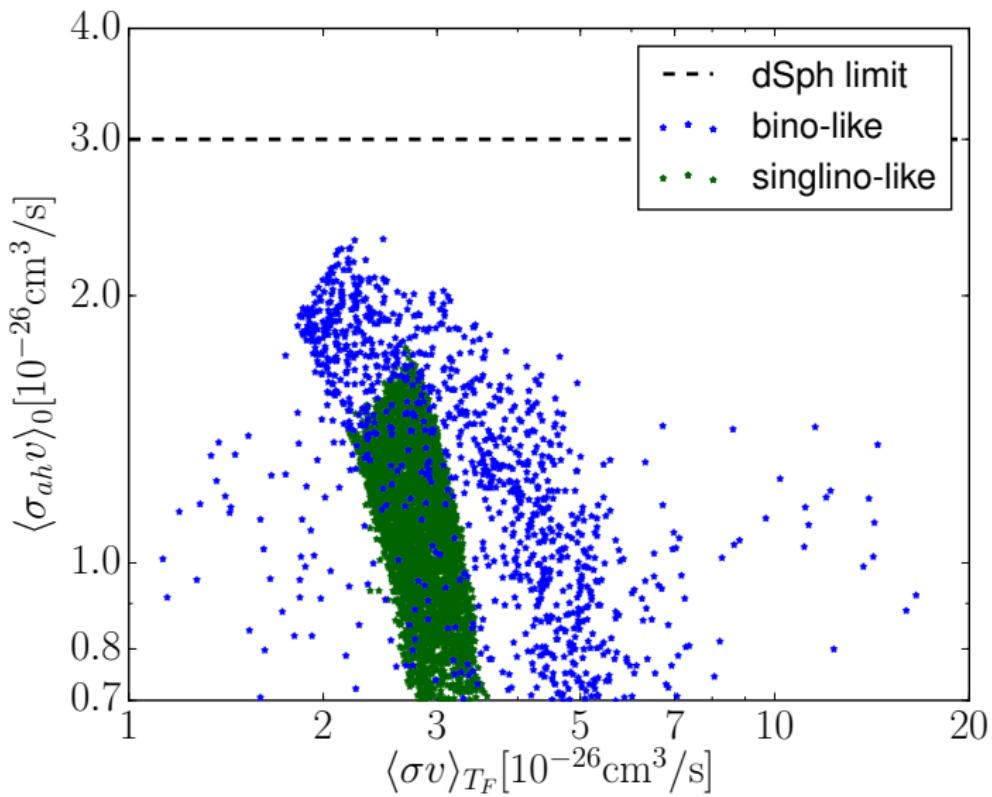


Dark Matter Annihilation in the NMSSM

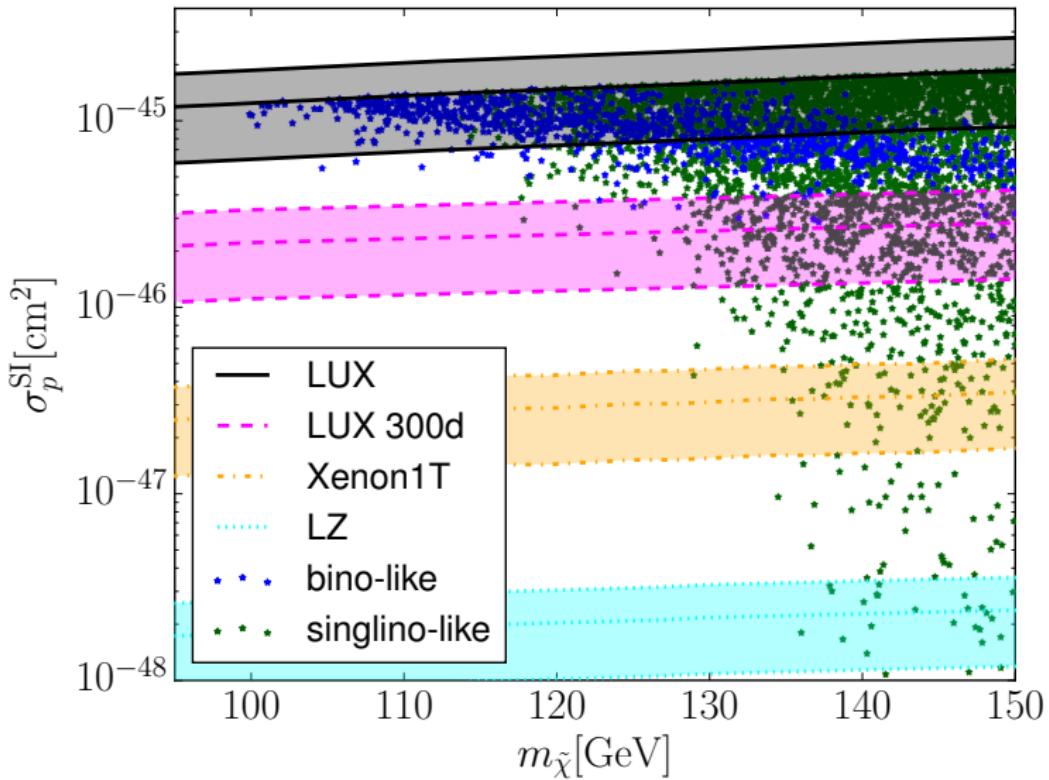
- $\tilde{\chi}\tilde{\chi} \rightarrow a_1 h$ Annihilation



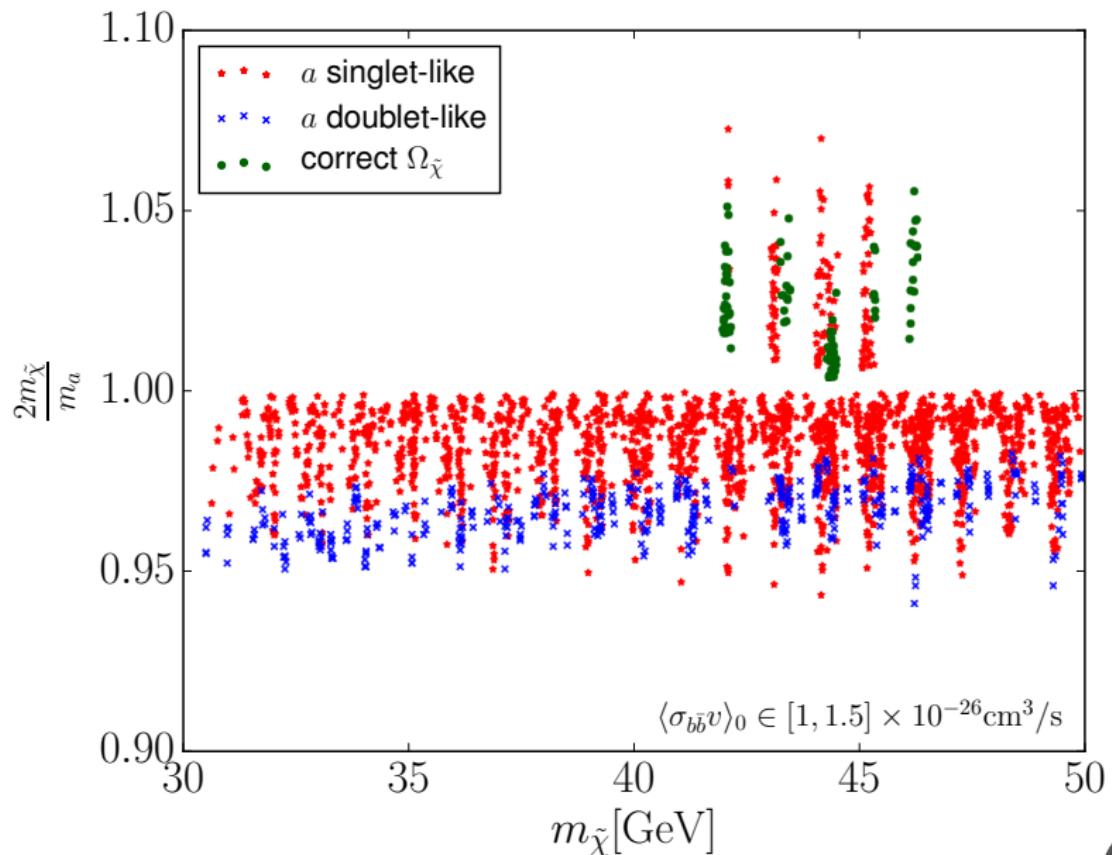
Early and late time cross sections for ha case



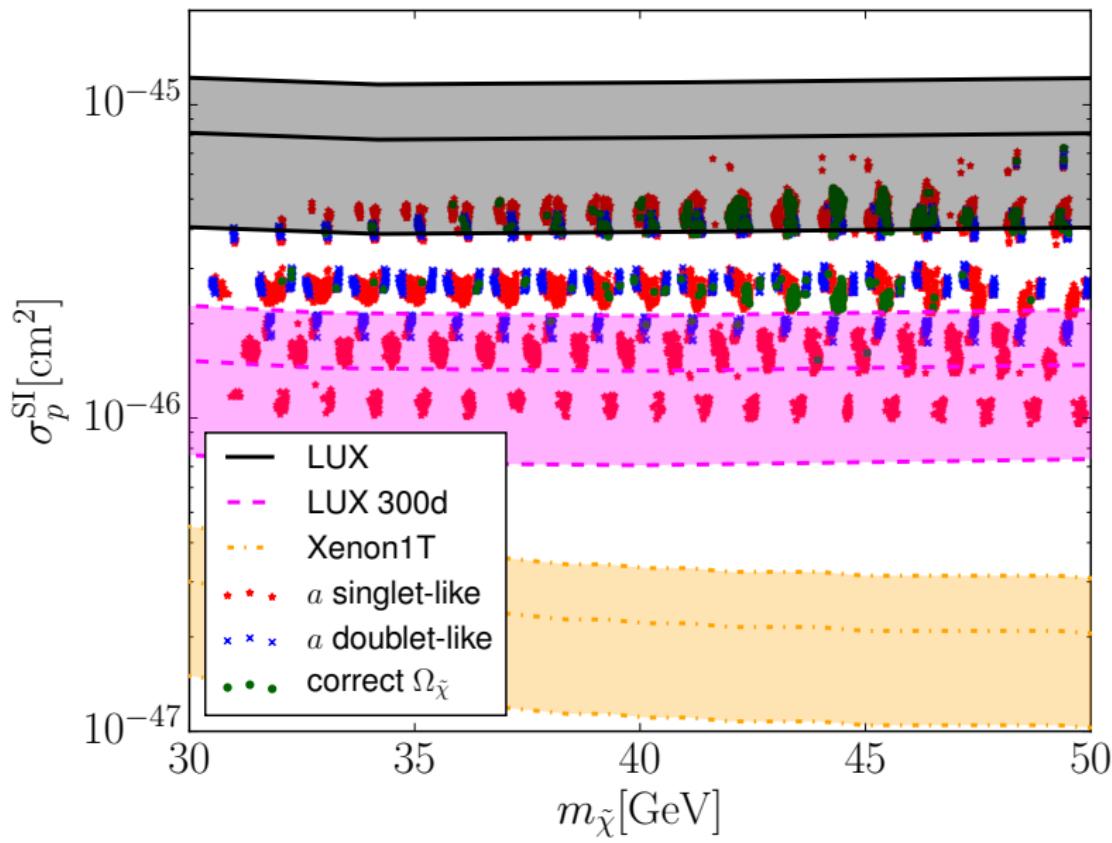
Direct Detection for ha case



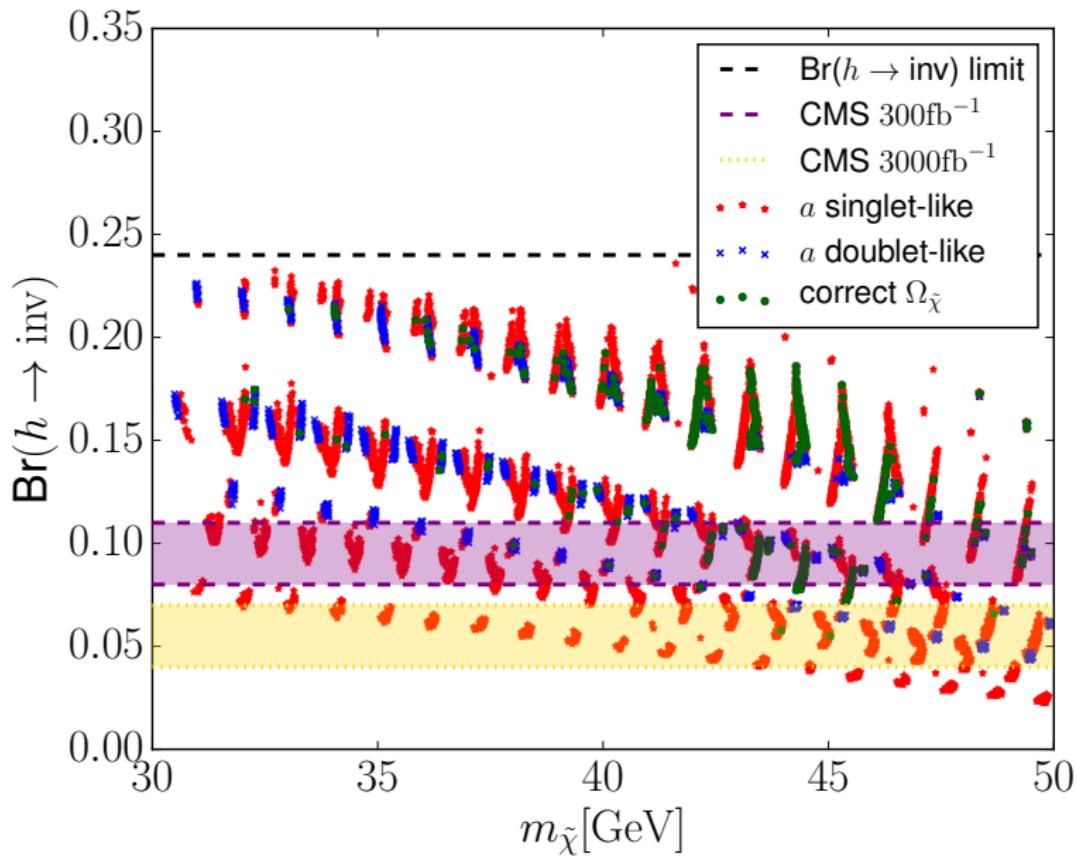
Resonance Condition for $b\bar{b}$ case with DSph bounds



Direct Detection and Invisible decay for $b\bar{b}$ case



Direct Detection and Invisible decay for $b\bar{b}$ case



Conclusions

- Fermi GeV Excess stands all tests
- Dark matter annihilations to $b\bar{b}$ as well as hh close to threshold provide a good fit
- We showed that annihilations to ha also provide a good fit and are naturally present in NMSSM