Doublet-Triplet Fermionic Dark Matter

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Motivation

- Electroweak scale WIMP.
- No co-annihilations or resonant effects (natural Dark Matter).
- Vanishing WIMP-nucleon interactions (at least at tree level).

The model

Assumptions:

- Vectorial E/M interactions.
- Anomaly free gauge (and gravitational) interactions.
- The new fermions are $SU(3)_C$ singlets.
- Z_2-parity symmetry.

Model details:

- Two doublets with opposite hypercharges and one triplet with zero hypercharge.
- The lightest neutral fermion is an equal admixture of the two doublets.

The Symmetry

$$\mathbf{Y_1} = \mathbf{Y_2} = \mathbf{Y} = \frac{\mathbf{m}}{v}$$

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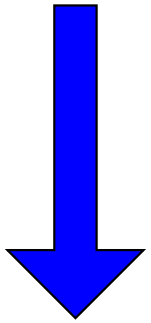
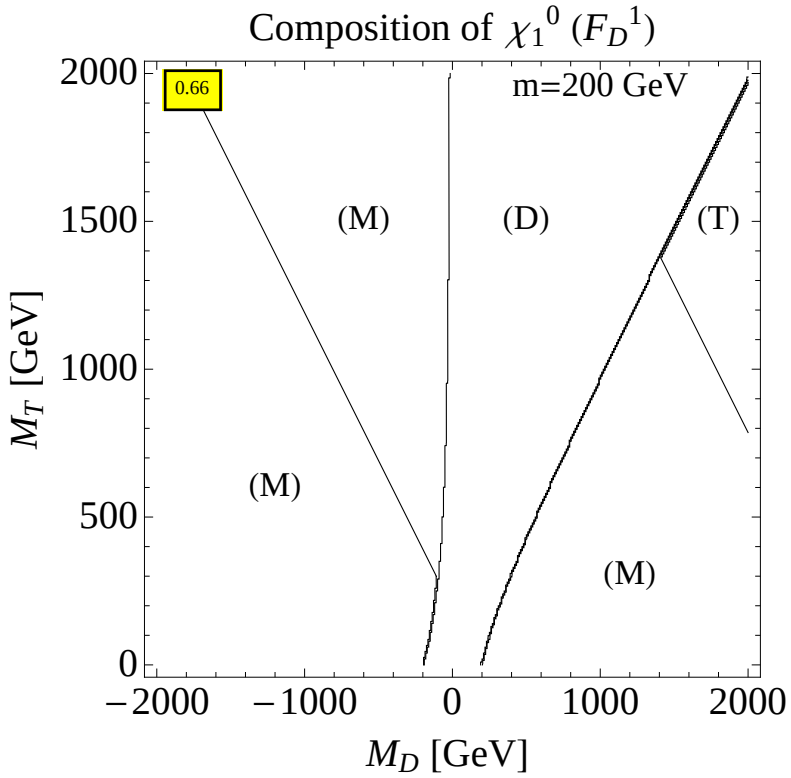


Yukawa sector invariant under rotations of

$$\mathcal{H} = \begin{pmatrix} H \\ H^\dagger \end{pmatrix} \text{ and } \bar{\mathcal{D}} = \begin{pmatrix} \bar{D}_1 \\ \bar{D}_2 \end{pmatrix}.$$

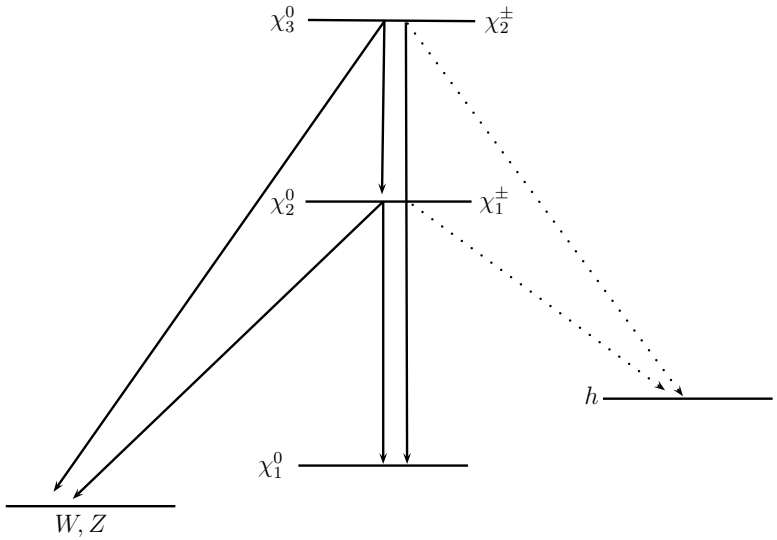
WIMP composition

$$\left|\chi_1^0\right\rangle = A\left|T^3\right\rangle + B\left|\bar{D}_1^1\right\rangle + C\left|\bar{D}_2^2\right\rangle$$



$A = 0$ means that the WIMP is an equal admixture of $\bar{D}_1^1$ and $\bar{D}_2^2$.
Vanishing tree level interaction with Z and Higgs boson.

Spectrum



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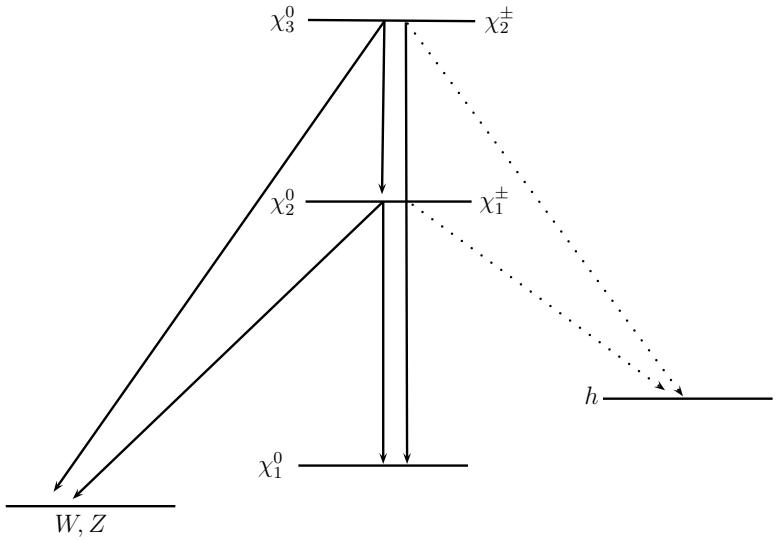
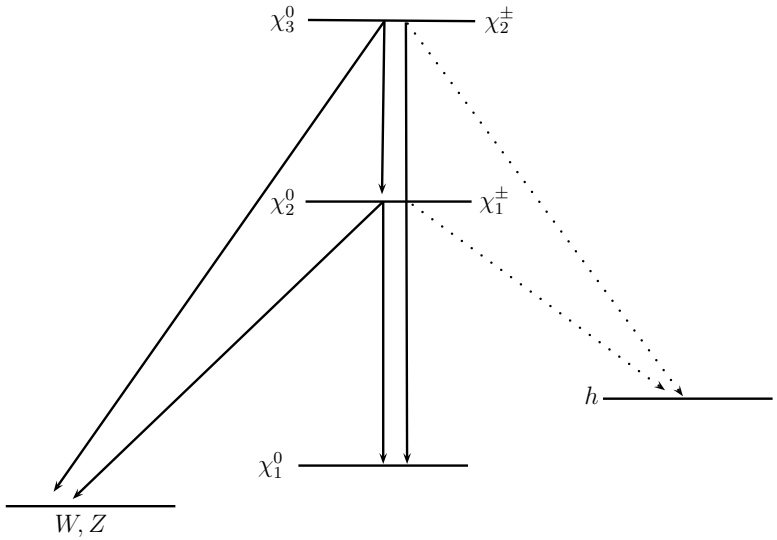


$\chi^{\pm}_{1,2}$ and $\chi^{0}_{2,3}$ are born to die!

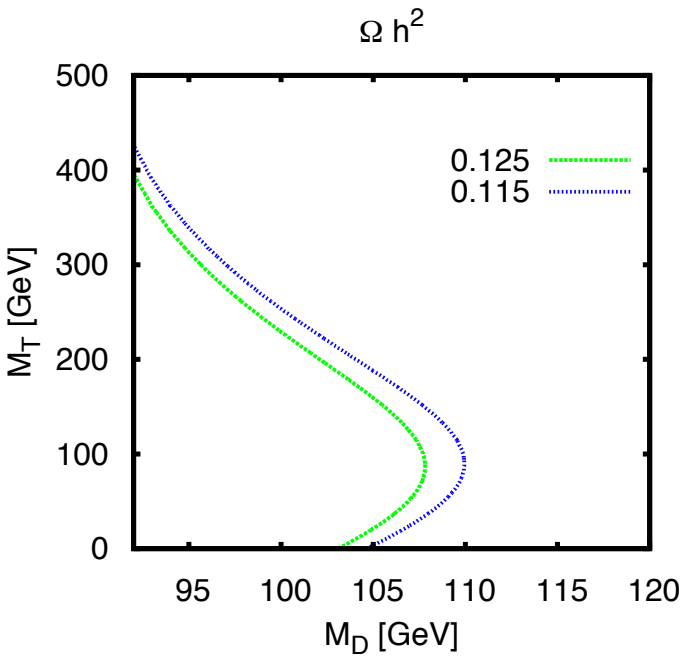
Spectrum

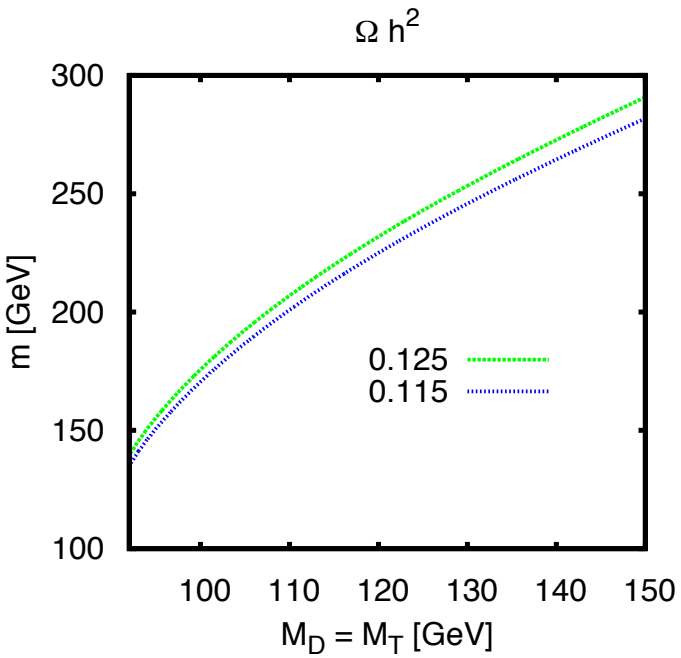


$\chi_{1,2}^{\pm}$ and $\chi_{2,3}^{0}$ are born to die!

χ_1^0 is here to stay!

Relic abundance

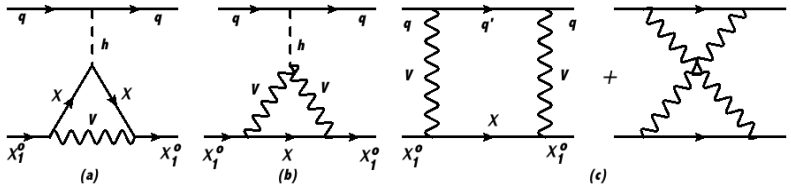


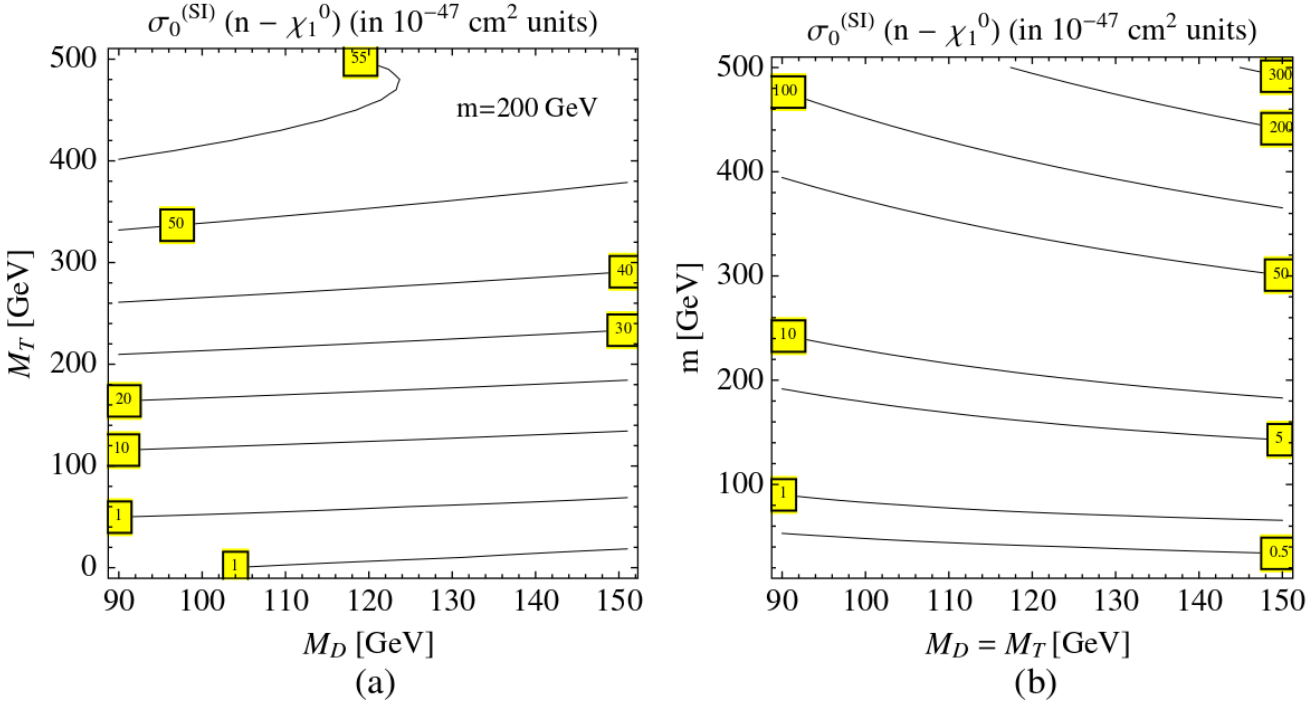


$92 \lesssim M_D \lesssim 110$ *GeV* and $M_T \lesssim 420$ *GeV* for $m \sim 200$ *GeV*.
There exists low mass WIMP for large Yukawa coupling.

Direct detection

Spin independent cross section:

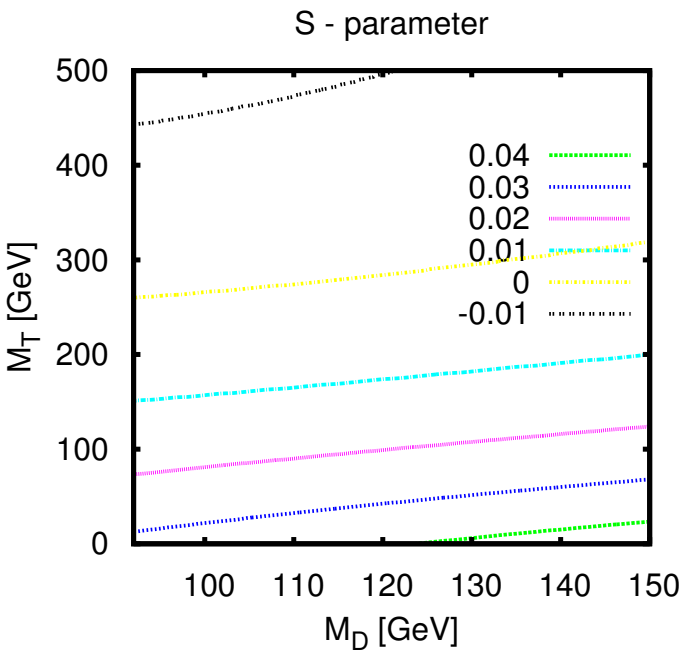


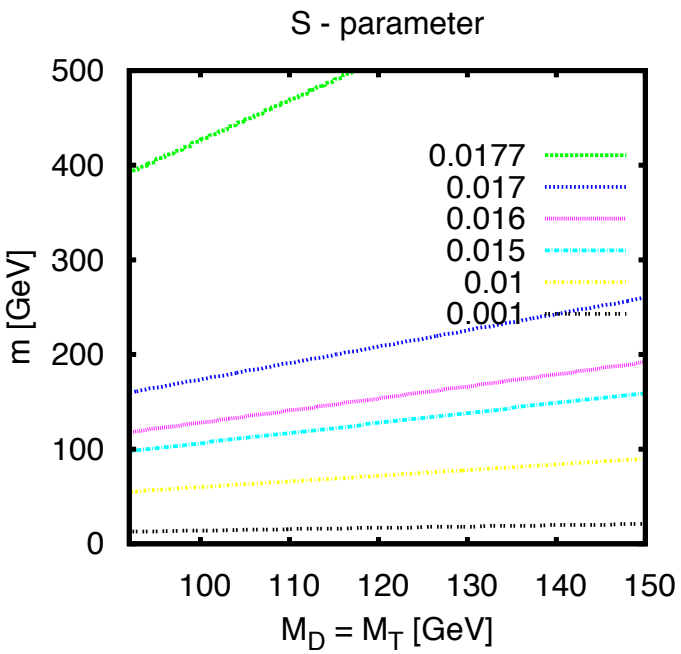


Latest experiments show that $\sigma_0^{(SI)} \lesssim 2 \times 10^{-45}$ *cm*^{2} *for a WIMP at* 100 *GeV*.

Electroweak corrections

From experimental fits we know that $S = 0.04 \pm 0.09$ and $T = 0.07 \pm 0.08$

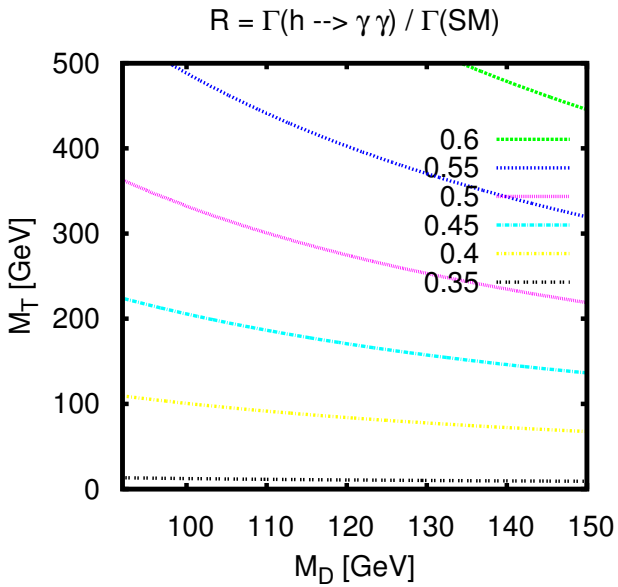


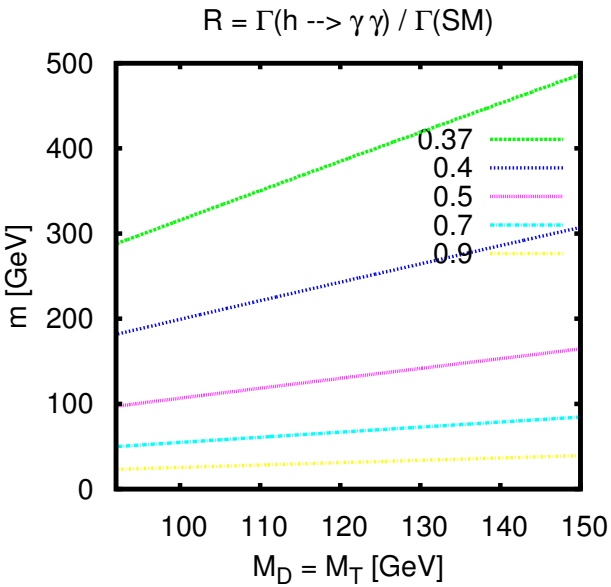


T and U are suppressed, because $Y_1 = Y_2$.

$h \to \gamma\gamma$

Recently has been observed a Higgs-like particle at the LHC with mass around 125 GeV and $h \to \gamma\gamma$ R-ratio
CMS: $R = 1.14^{+0.26}_{-0.23}$
ATLAS: $R = 1.29 \pm 0.30$

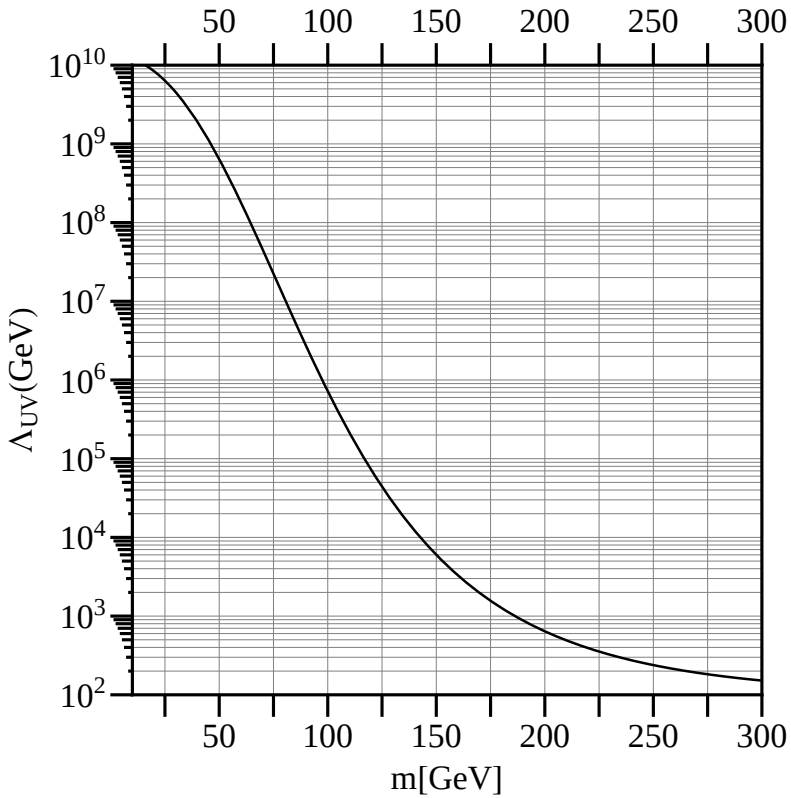




$0.35 \lesssim R \lesssim 0.55.$

Vacuum stability

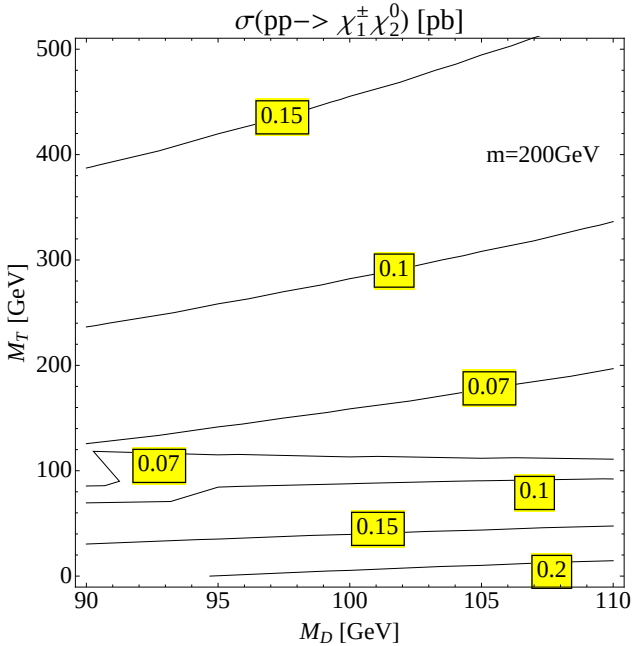
We need to find the energy scale (Λ_{UV}) where this model needs completion, by demanding that the SM vacuum has survived until today.



Completion is needed at $\sim 600\ GeV$!

Production

LHC studies for $pp \to W^* \to \chi_1^{\pm}\chi_2^0$ have shown $\sigma \sim 0.1 - 1\ pb$.

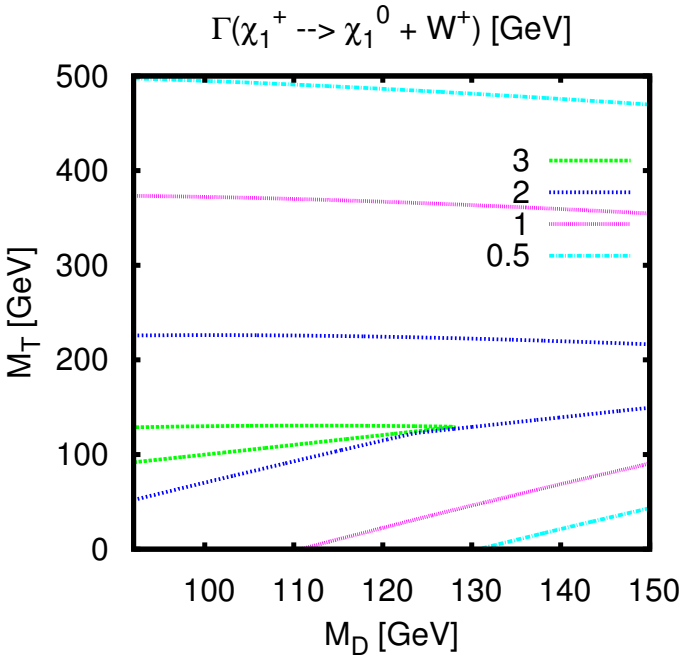


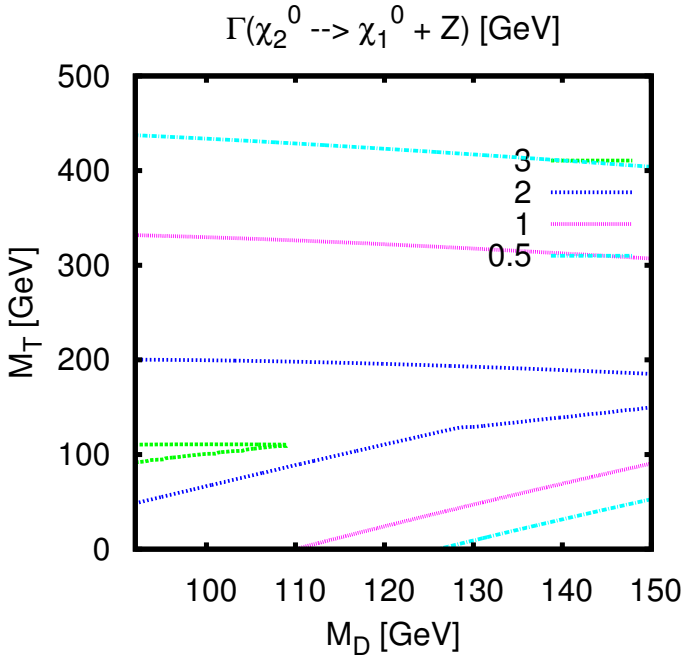
At 20 fb^{-1} **1400-4000 events!**

Decays

For pure doublet WIMP the only available channels are:

$$\chi_2^0 \to \chi_1^0 \, Z$$
$$\chi_1^+ \to \chi_1^0 \, W^+$$





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SM vacuum instability.

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QUESTIONS?

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