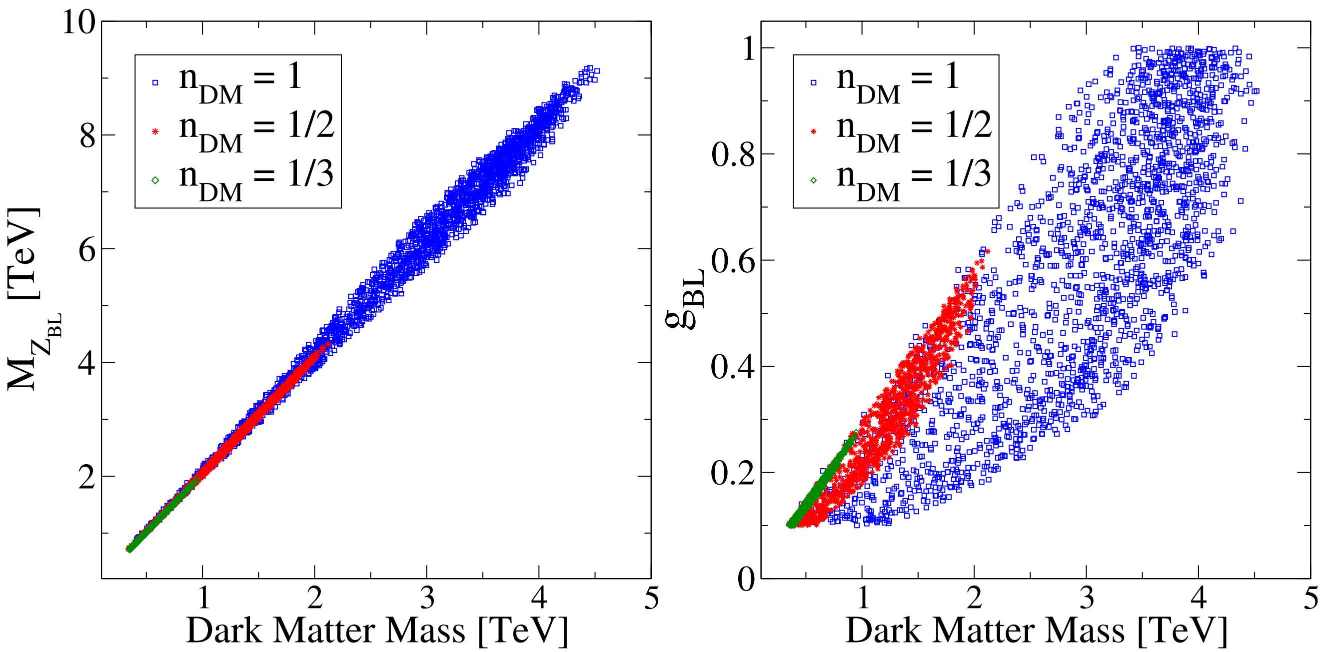
Scalar Dark Matter in the B-L Model



Based on 1509.04036 with
Werner Rodejohann

Carlos E. Yaguna

Max-Planck-Institute for Nuclear Physics
Heidelberg, Germany

2015

$m_\nu = m_L^T - m_D M_R^{-1} m_D$

MANITOP
Massive Neutrinos: Investigating their Theoretical Origin and Phenomenology

Understanding the stability of the dark matter particle is very challenging

Heavy particles tend to decay really fast

$\tau_{top} \sim 10^{-25} s$
$\tau_{DM} \gtrsim 10^{27} s$

Discrete symmetries are typically imposed

Z_2, R-parity, KK-parity

But they are expected to be broken at M_{Planck}

Discrete $\rightarrow$ Gauge

The $U(1)_{B-L}$ extension of the SM is particularly appealing

It is remarkably simple

$$N_R, S_{BL}$$
$$\langle S_{BL}\rangle = v_{BL} \neq 0$$

It realizes the seesaw mechanism

$$M_{N_R} \propto v_{BL}$$

It has interesting collider signatures

$$\frac{M_{Z_{BL}}}{g_{BL}} \gtrsim 7 \text{ TeV}$$

We will add another scalar field charged under $B-L$ to account for the dark matter

Its B-L charge ensures dark matter stability

$$n_{DM} \neq 2n, n \in \mathbb{Z}, n \leq 4$$

Multi-component dm is allowed

v_{BL} cannot be much above the TeV scale

$$M^2_{\phi_{DM}} = \lambda_{DM} v^2_{BL} + \ldots$$

ϕ_{DM} has gauge and scalar interactions

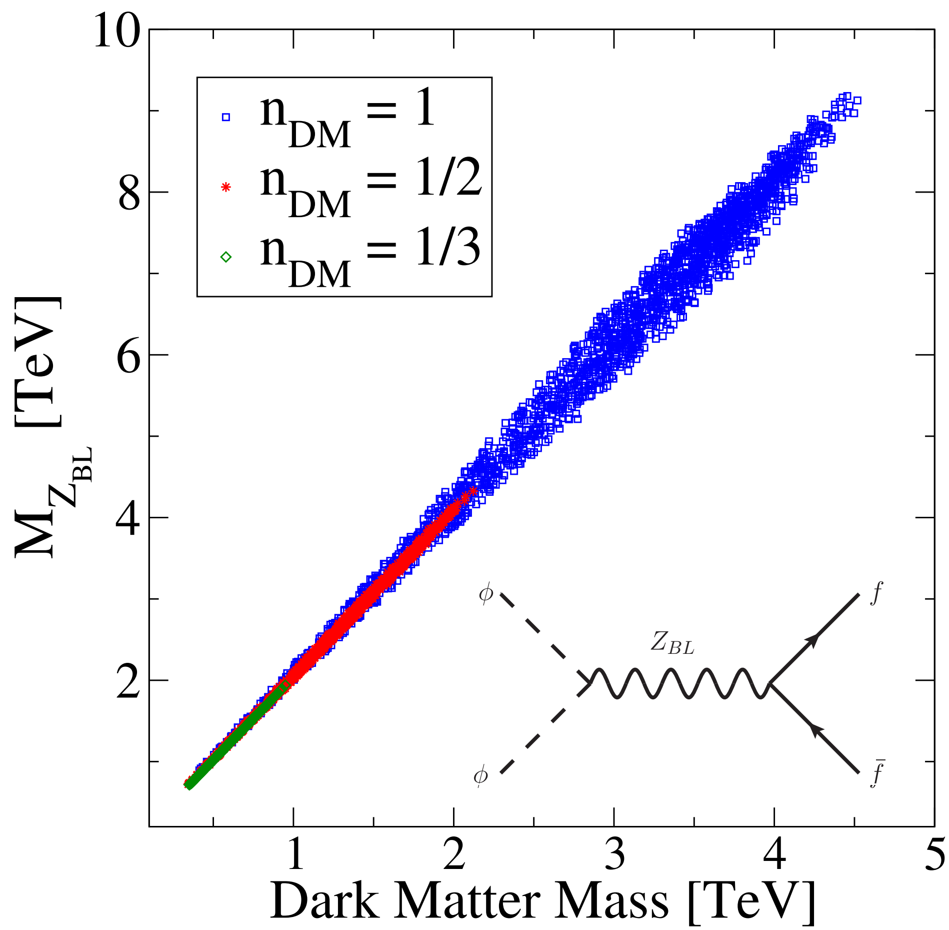
$$V = \lambda_H (\phi^\dagger_{DM} \phi_{DM})(H^\dagger H)$$
$$+ \lambda_{DM} (\phi^\dagger_{DM} \phi_{DM})(S^\dagger_{BL} S_{BL}) + \ldots$$

The B-L gauge interaction can account for the relic density only close to the resonance

That is, for $2M_{\phi_{DM}} \sim M_{Z_{BL}}$

The viable range of $M_{\phi_{DM}}$ increases with n_{DM}

We find $M_{\phi_{DM}} \lesssim 4.5$ TeV for $n_{DM} < 1$

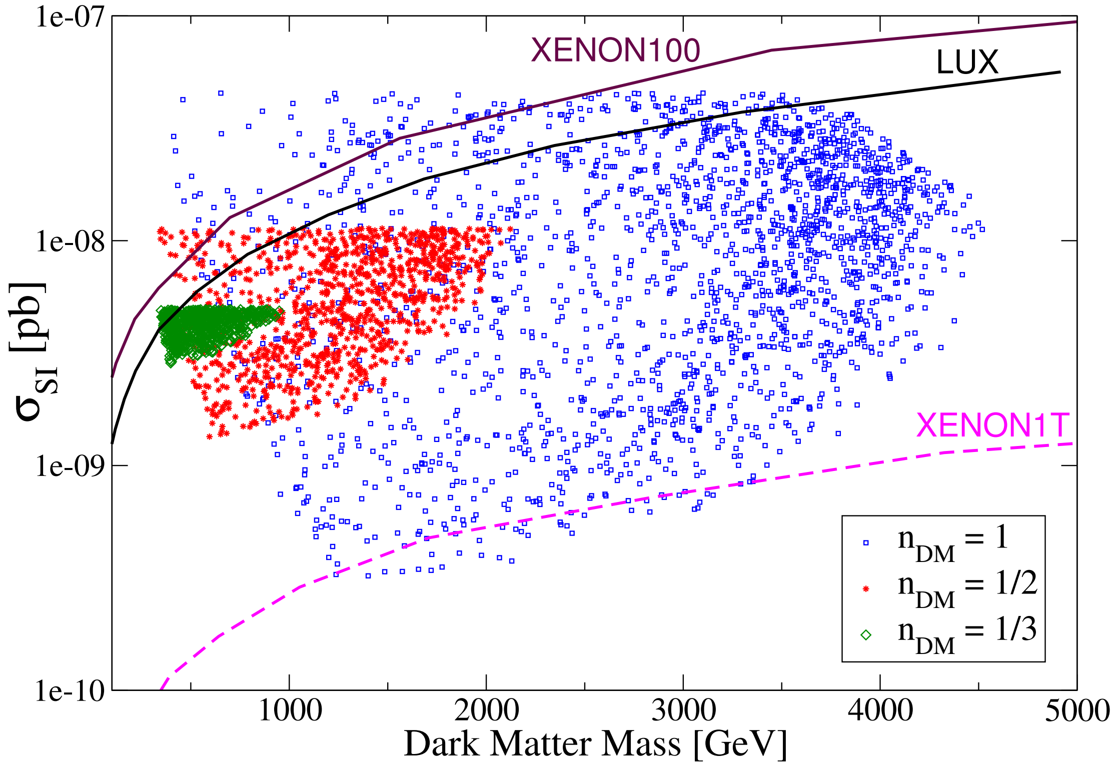


This possibility will be probed by direct detection experiments in the near future

Some points are already excluded

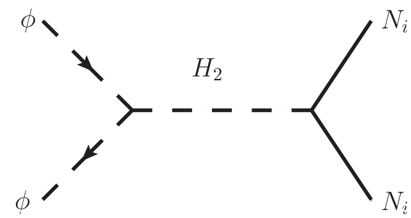
XENON1T will probe the region $n_{DM} < 1/2$

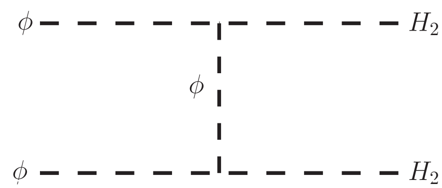
And most of the points with $n_{DM} < 1$



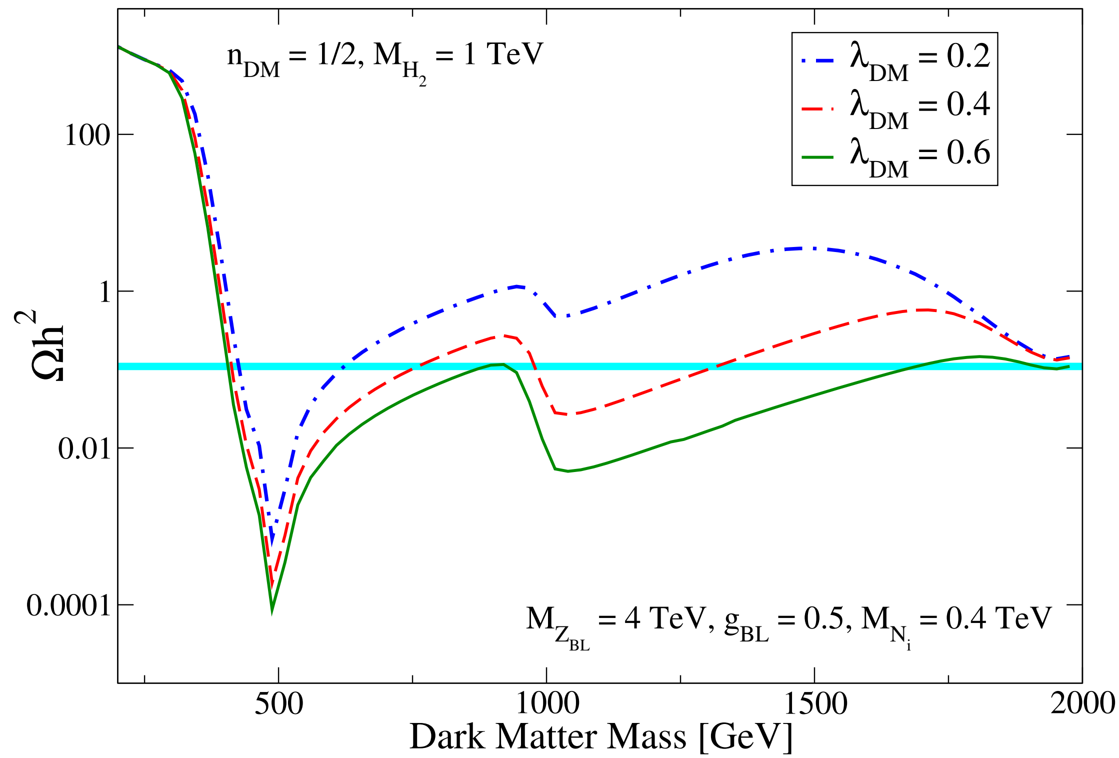
Scalar interactions can give rise to dark matter annihilations into $N_R N_R$ and $S_{BL} S_{BL}$

$N_R N_R$ is relevant close to the S_{BL} resonance



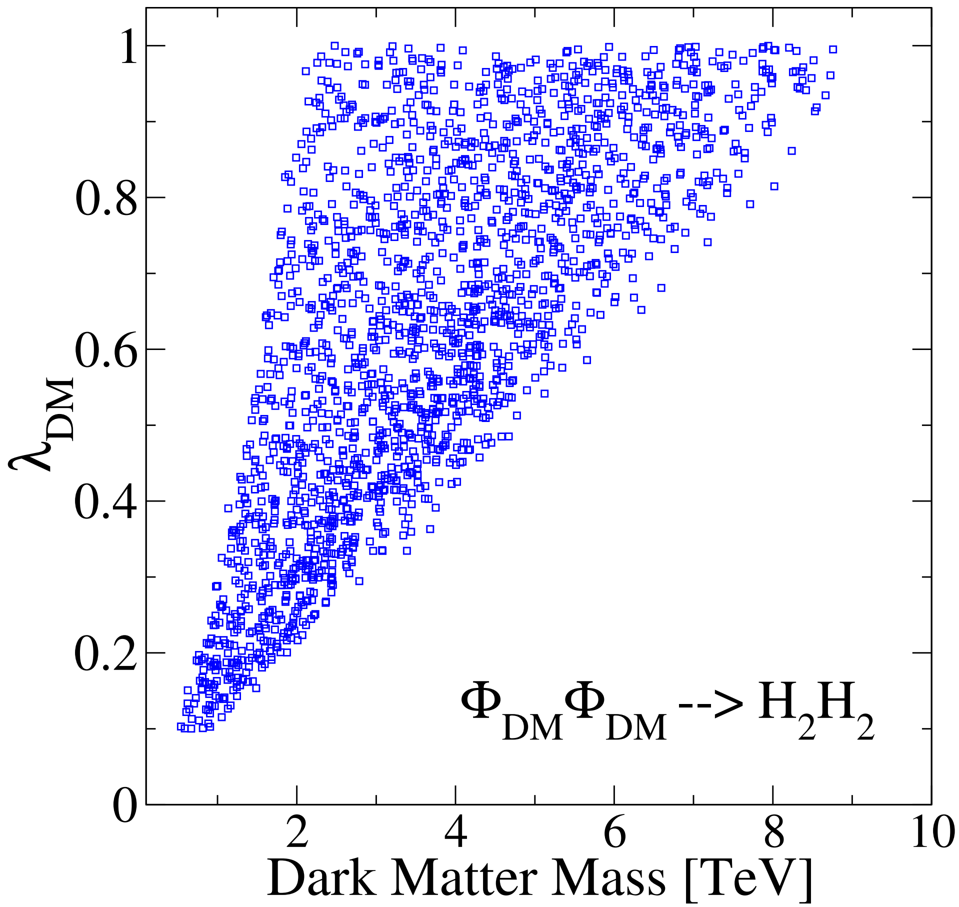


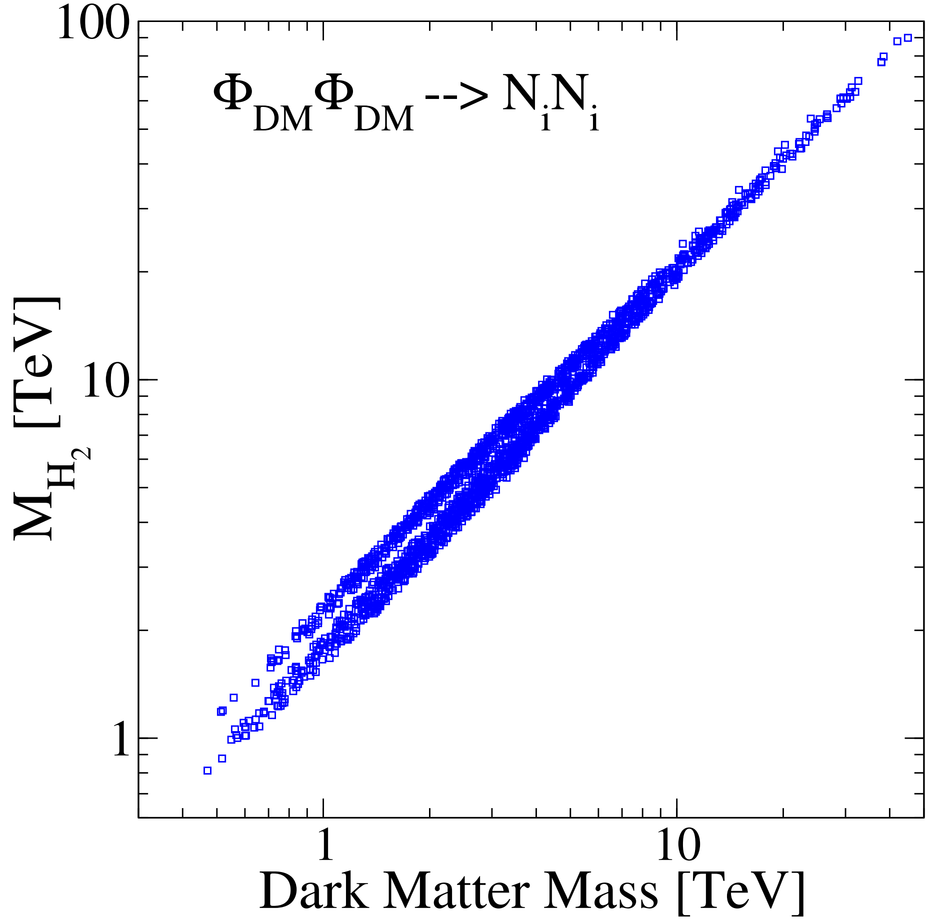
$\phi_{DM} \phi^{\dagger}_{DM} \to S_{BL} S_{BL}$ is instead non-resonant



They do not induce DM-N scattering

Scalar interactions allow for heavier dark matter particles





The B-L model provides a compelling scenario to explain ν masses and dark matter

It is simple and well motivated

DM is automatically stable

It has a rich dm phenomenology