The Protophobic Light Vector Boson as a Mediator to the Dark Sector

25 Oct. 2016 @ KIAS workshop

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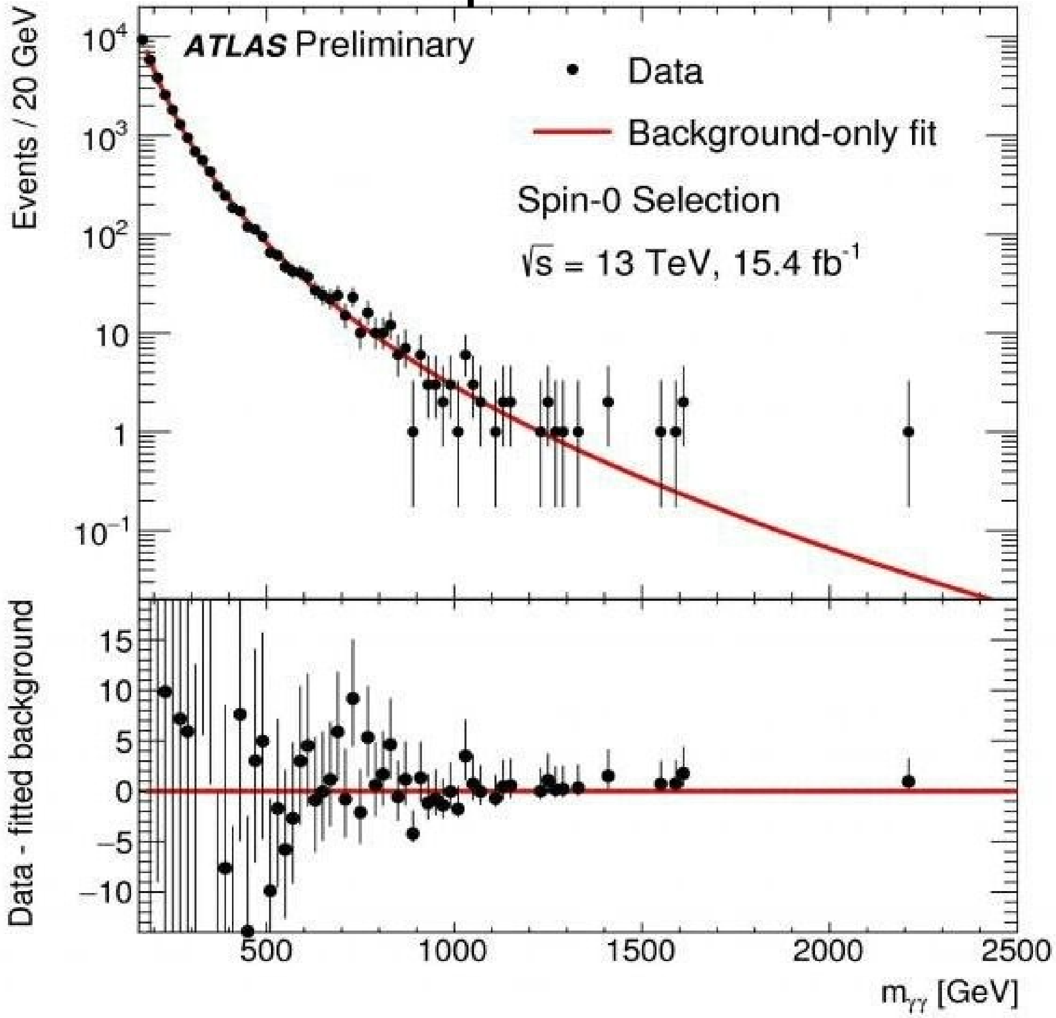
Based on arXiv:1609.01605
in collaboration with T. Kitahara (Karhlsruhe Inst. Tech.)

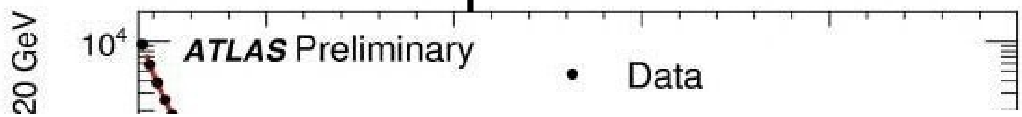
Gone with the anomalies

750GeV diphoton

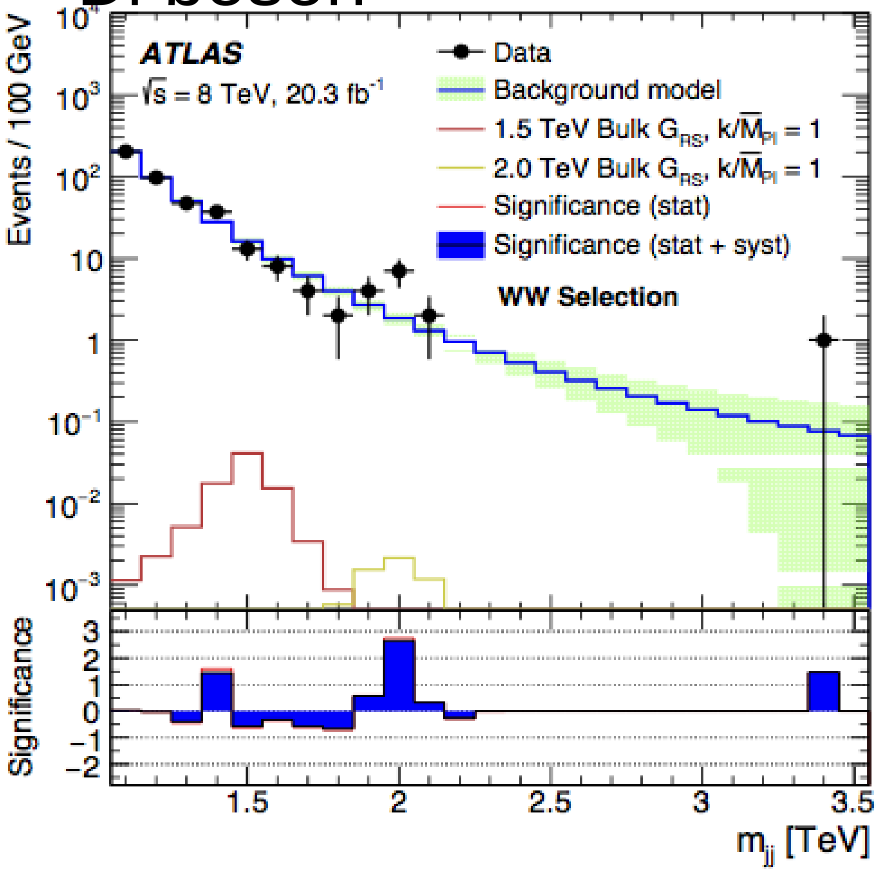


Gone with the anomalies

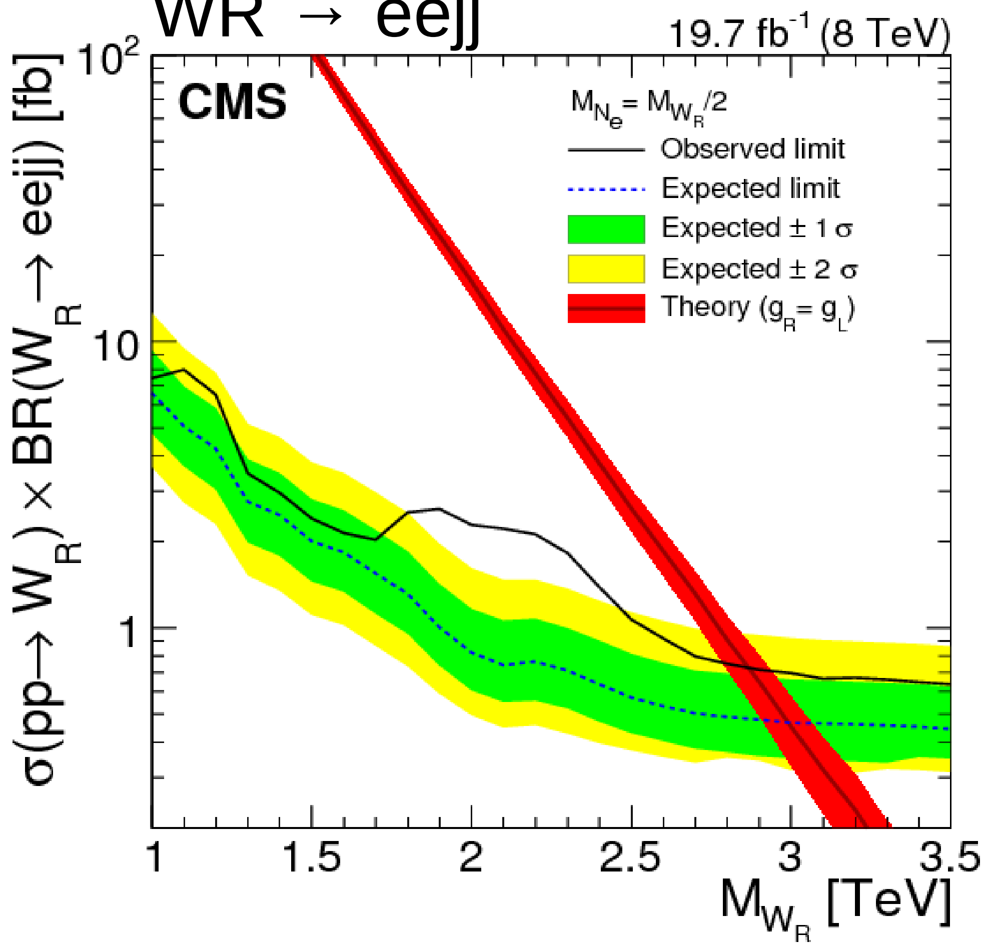
750GeV diphoton



Di boson



WR → eejj



Some good insight and ideas are left in your mind.

The Atomki anomaly (→Talk by Prof. Tait)

1504.01527: A. Krasznahorkay et al.

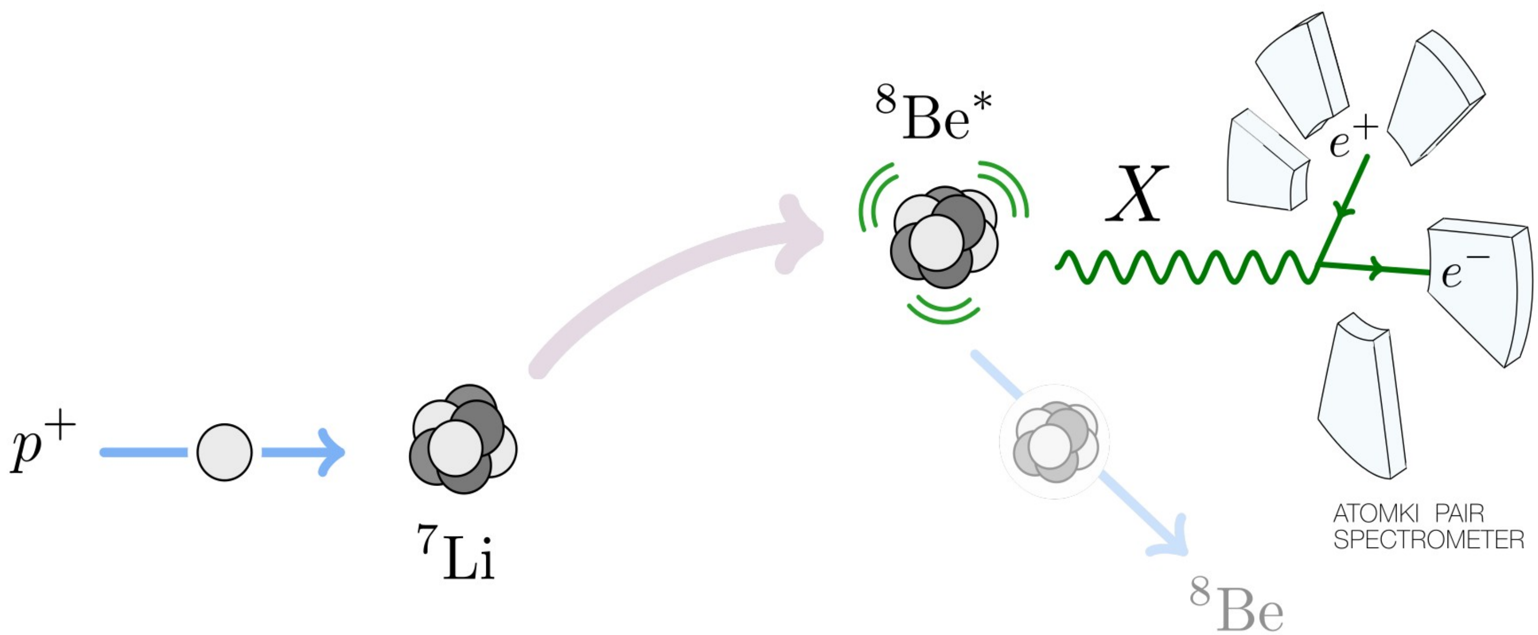


Fig. by J. L. Feng

- $m_X = 16.7 \pm 0.35_{\rm stat} \pm 0.5_{\rm sys}\ \text{MeV}$

The Atomki anomaly (→Talk by Prof. Tait)

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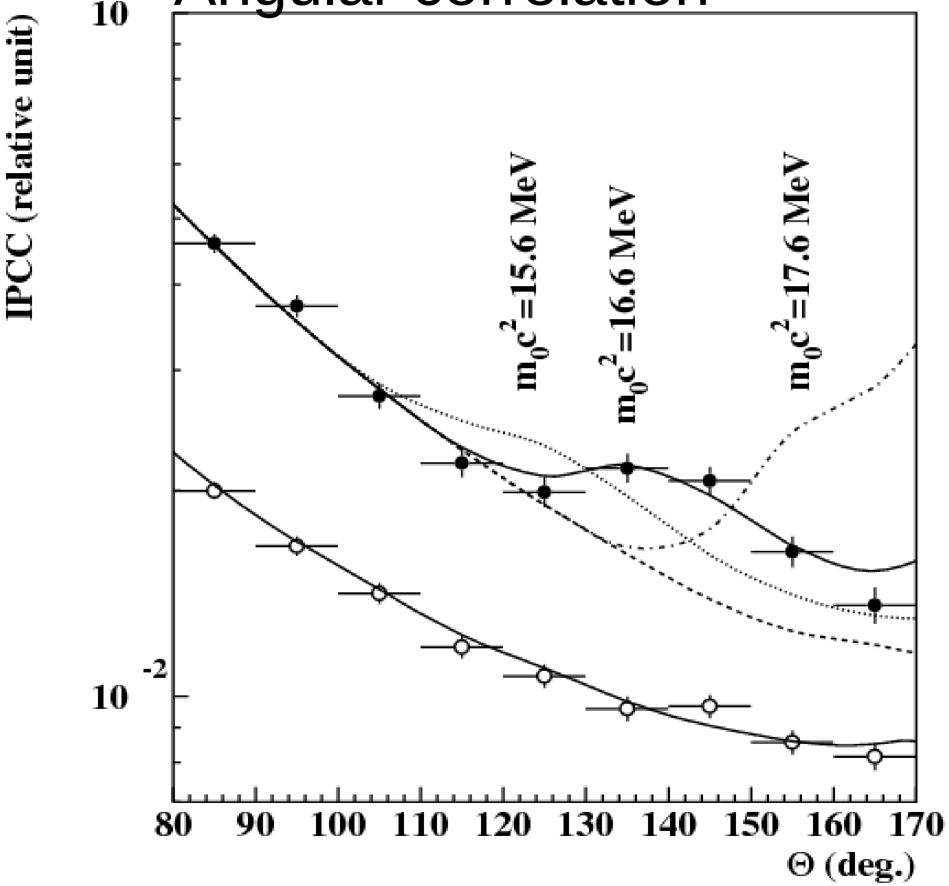
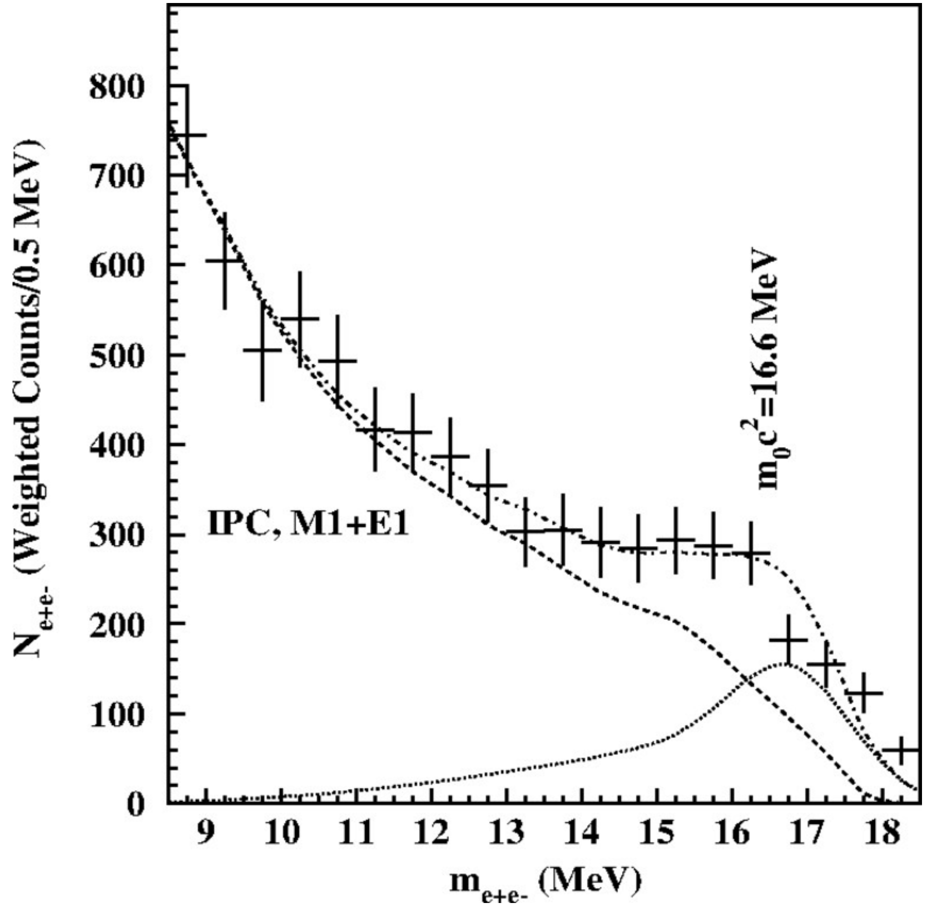
Angular correlation



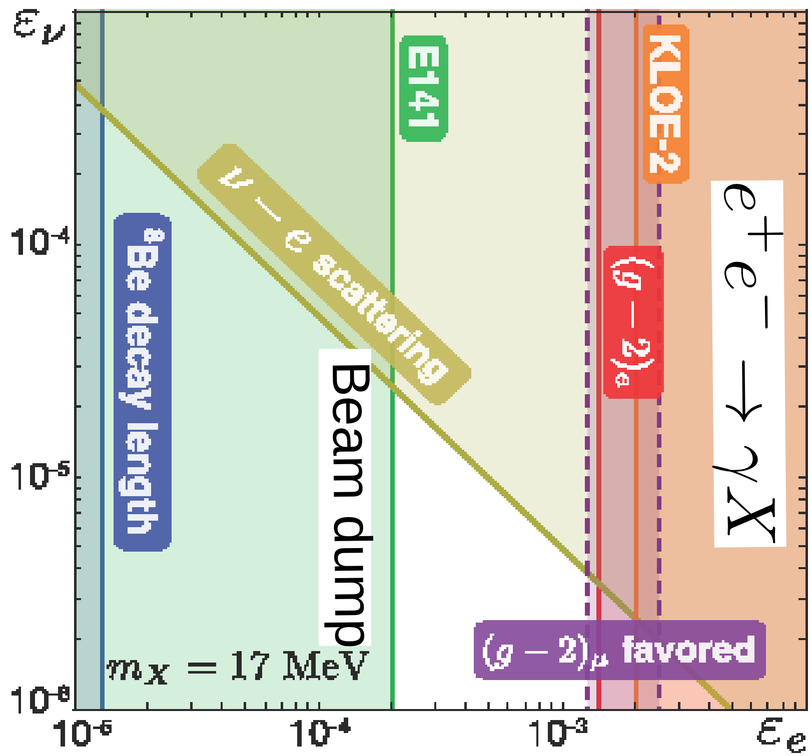
Invariant mass



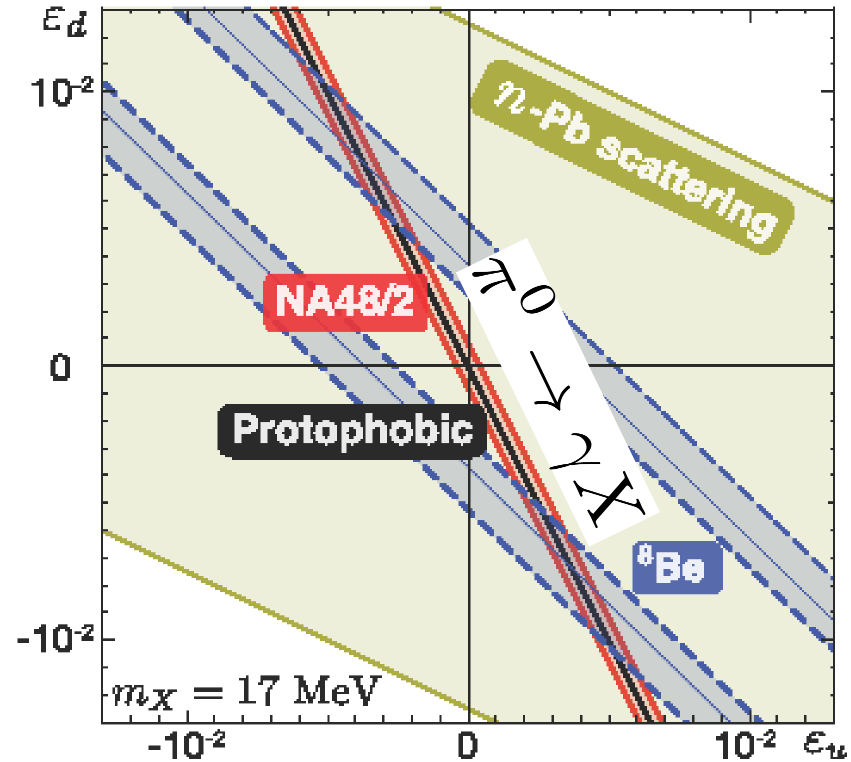
- $m_X = 16.7 \pm 0.35_{\rm stat} \pm 0.5_{\rm sys}$ MeV

Experimental constraints

1604.07411, 1608.03591: J. L. Feng, T. M. P. Tait et al.



$$6.1 \times 10^{-5} \leq |g_e| \leq 4.2 \times 10^{-4}$$

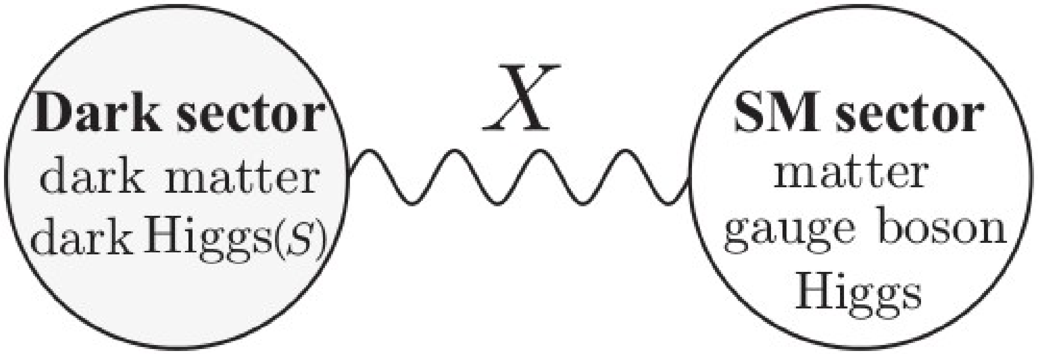


$$6.1 \times 10^{-4} \leq |g_n| \leq 3.1 \times 10^{-3}$$

- Protophobic: $|g_p| \leq 3.6 \times 10^{-4}$
- Prity conservation and exp. bounds → Spin-1.

Weakly interacting light particle

The protophobic vector **+** The dark matter



- U(1)$_X$ charged/neutral dark matter models.

► Compatibility with the thermal relic scenario.

Models

$$\mathcal{L}_X = -\frac{1}{4}X^{\mu\nu}X_{\mu\nu} + |DS|^2 + \mu_S^2|S|^2 - \frac{\lambda_S}{2}|S|^4 + \mathcal{L}_{\rm DM}$$

Parameters: $g_X,\ m_X,\ m_s$

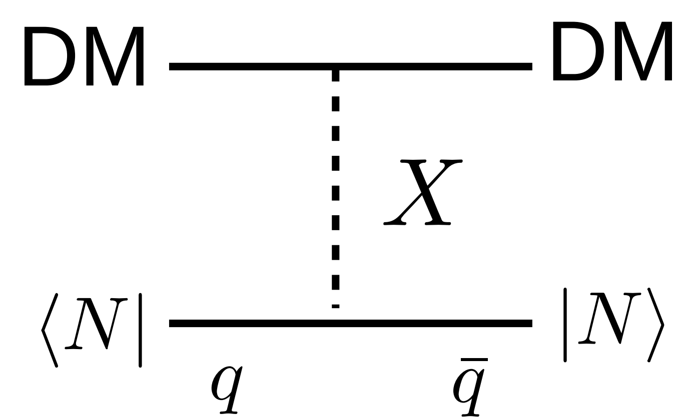
$\mathcal{L}_{\rm DM}$	Scalar	Fermion
Charged	$\varphi \quad \varphi^*$	$\xi \quad \bar{\xi}$
Neutral	ϕ	$\chi \quad (\psi \quad \bar{\psi})$

(Neglect interactions with Higgs)

U(1)x charged dark matter

- Direct detection

  Very strong constraint.



- Annihilation

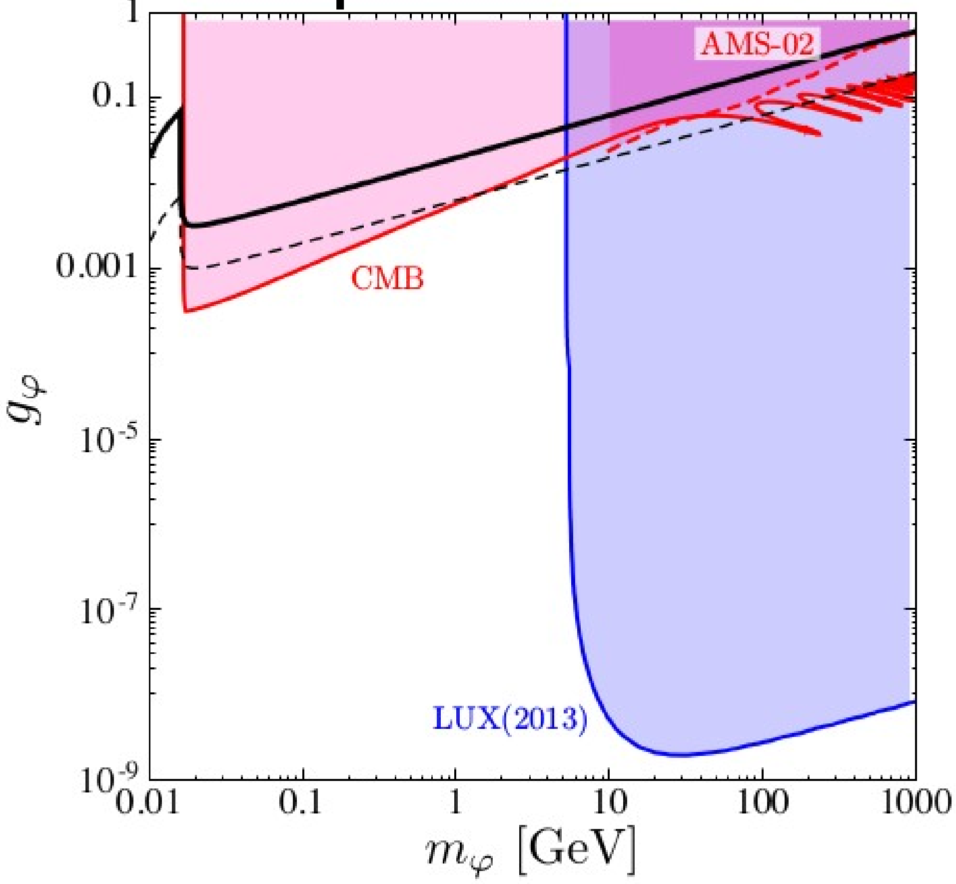
$$\varphi\varphi^* \to XX \qquad \xi\bar{\xi} \to XX$$
$$\to ss \qquad \to sX$$

Large Sommerfeld enhancement with X

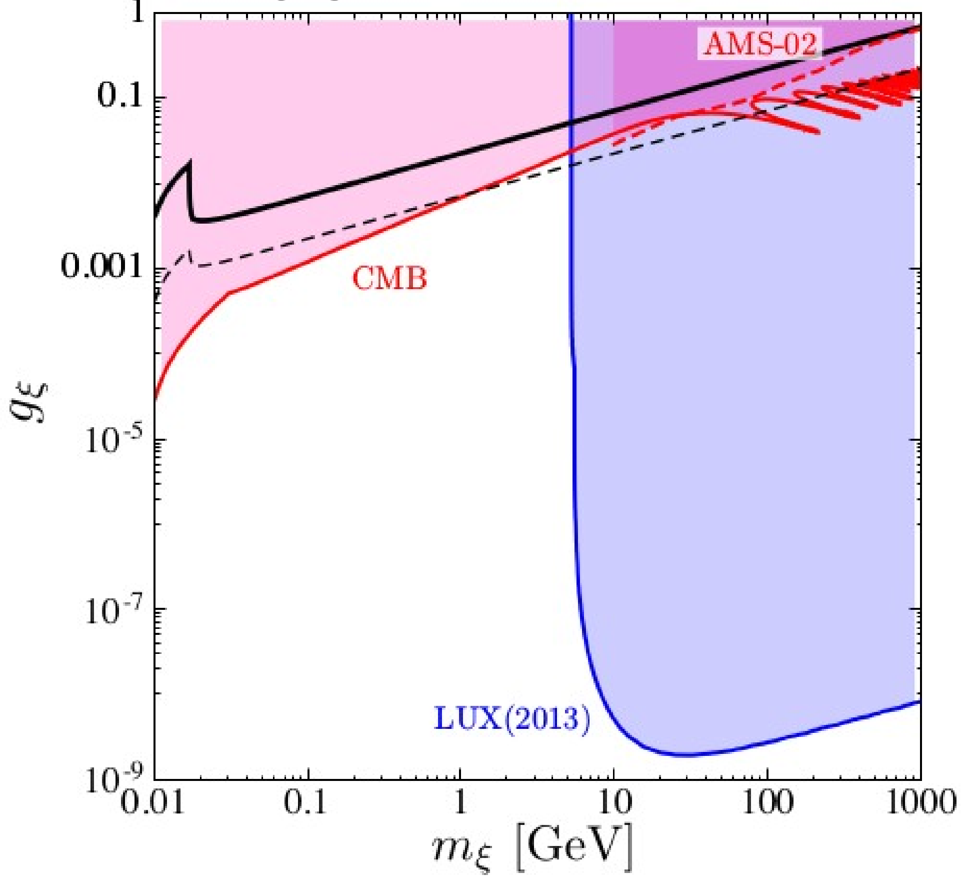
▶ Indirect bounds become stronger.

Results of charged models

Complex



Dirac



- Thermal relic scenario is almost excluded.

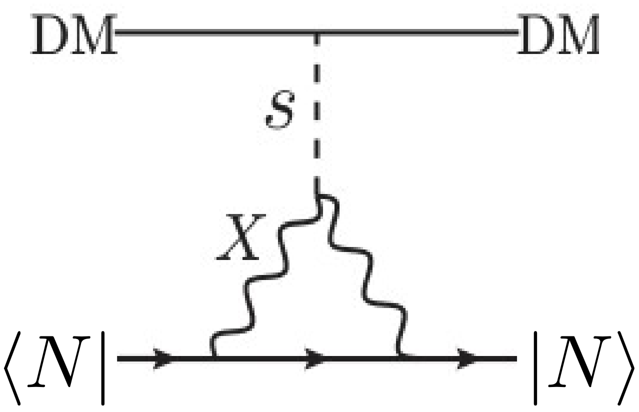
(Exception Jia+ 1608.05443)

U(1)X neutral dark matter

- Direct detection

  Loop induced process

  Large m_s dependence



- Annihilation

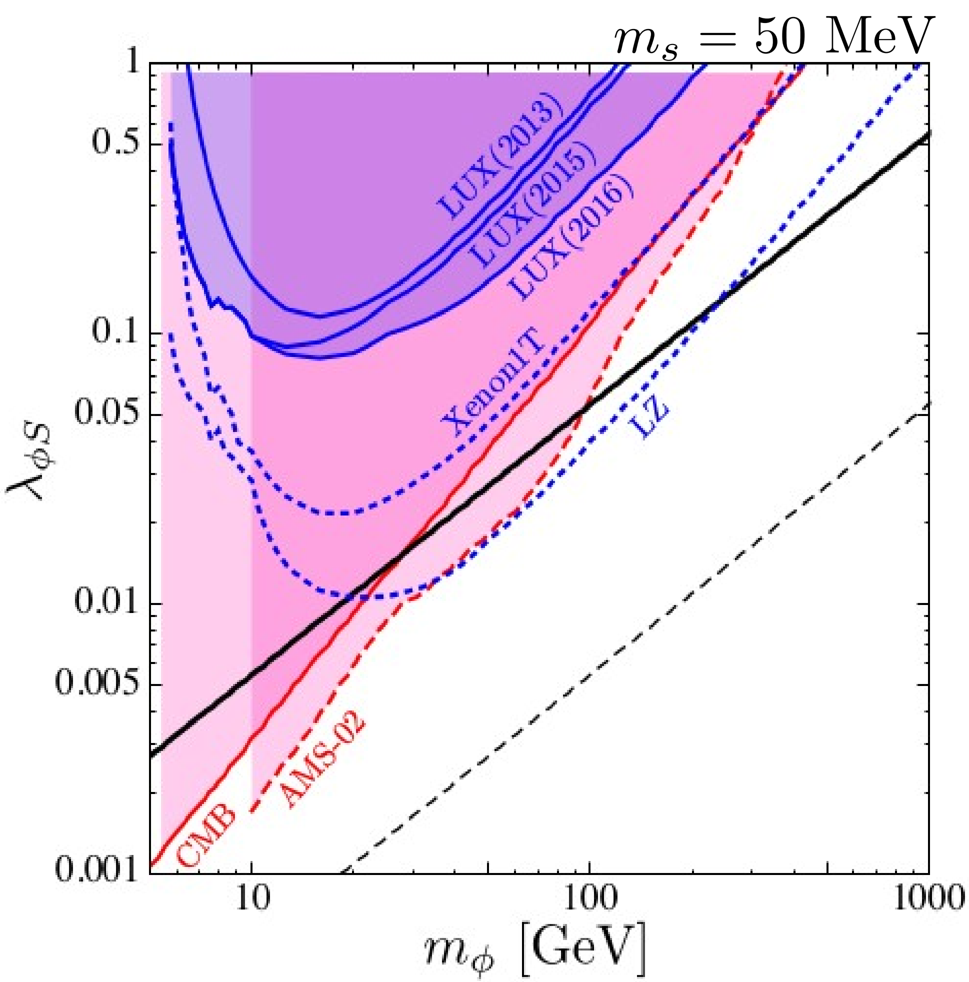
$$\phi\phi \to XX$$
$$\to ss$$

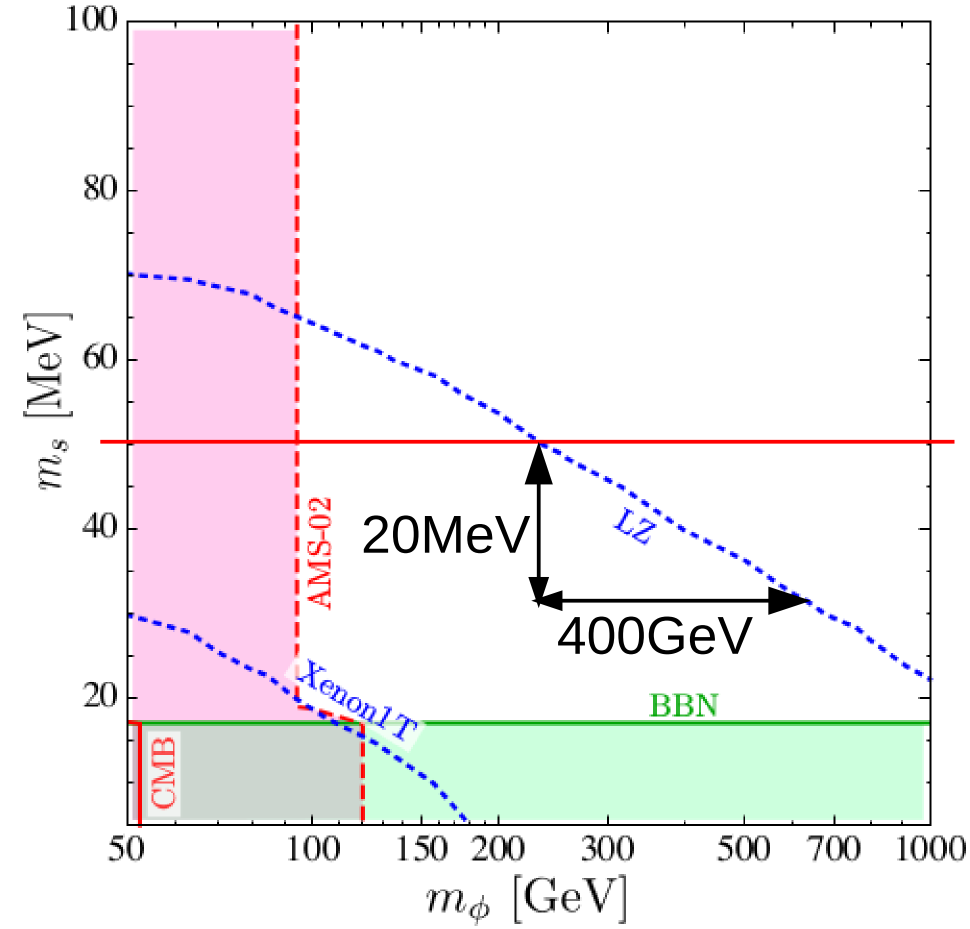
No enhancement

$$\chi_1\chi_1 \to XX$$
$$\to ss$$

By p-wave processes

Real scalar dark matter

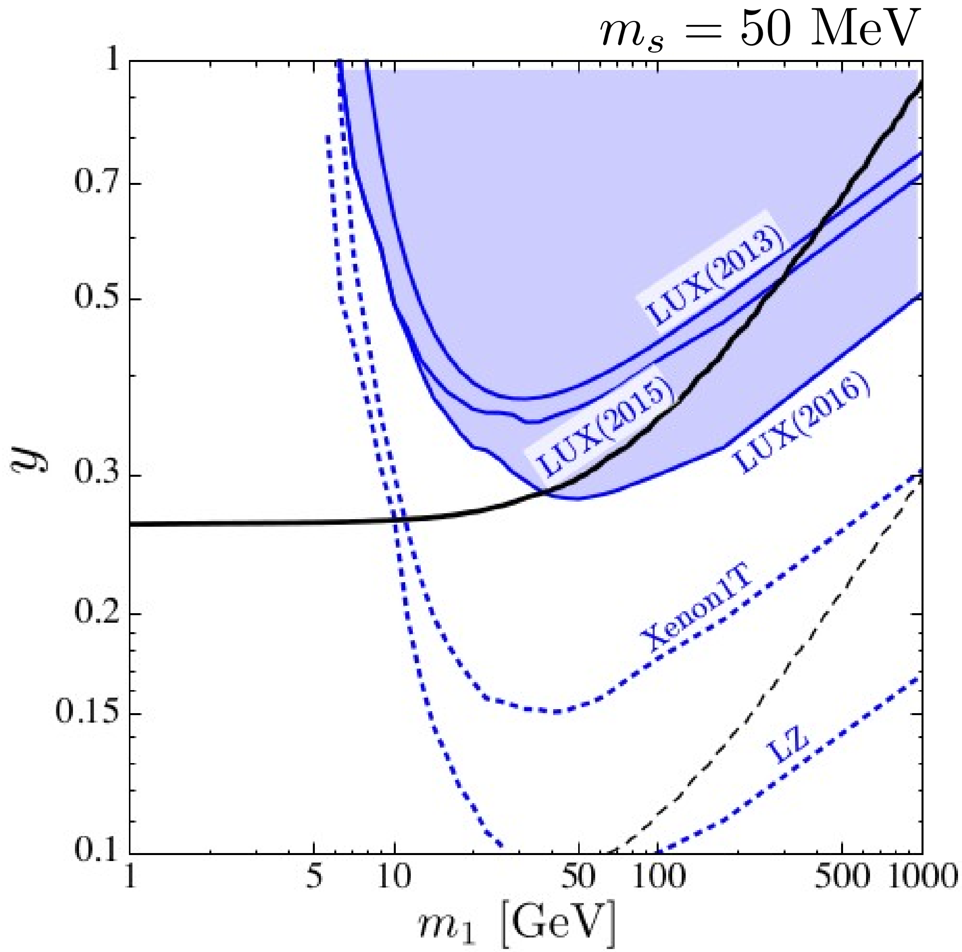


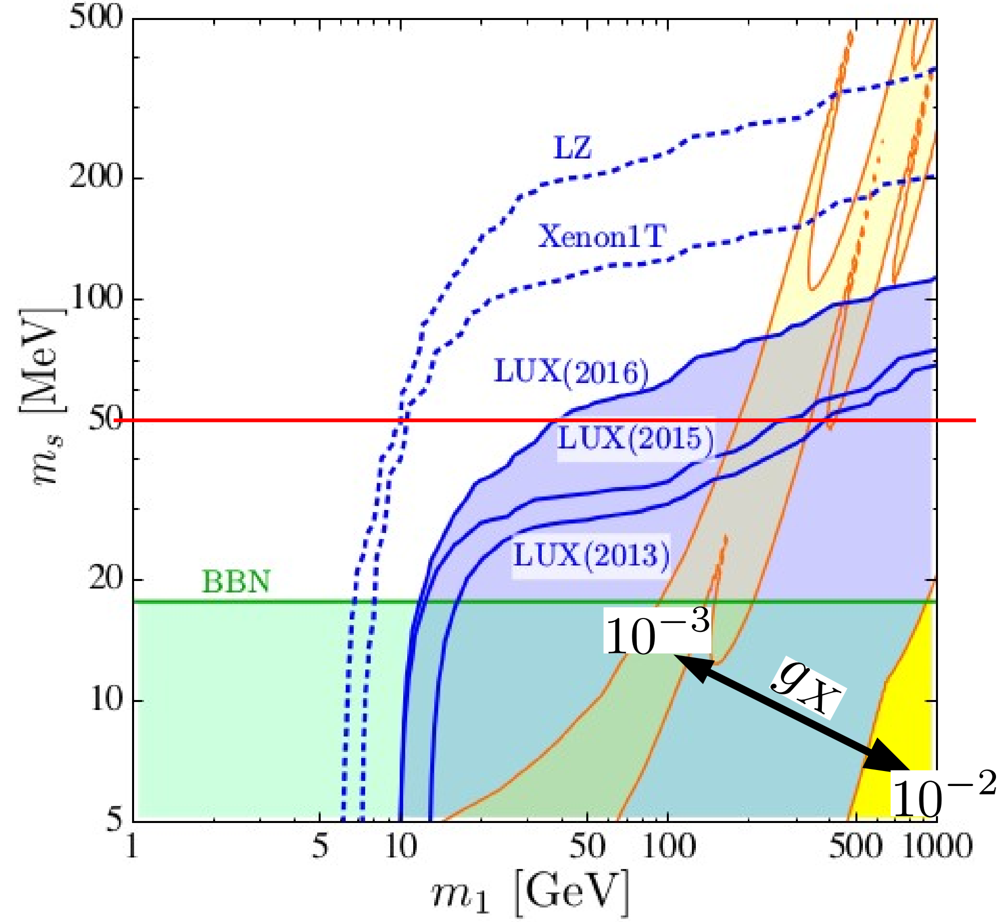


- The AMS bound excludes the thermal relic upto 100GeV.
- The dark Higgs mass dependence is large.

Majorana dark matter

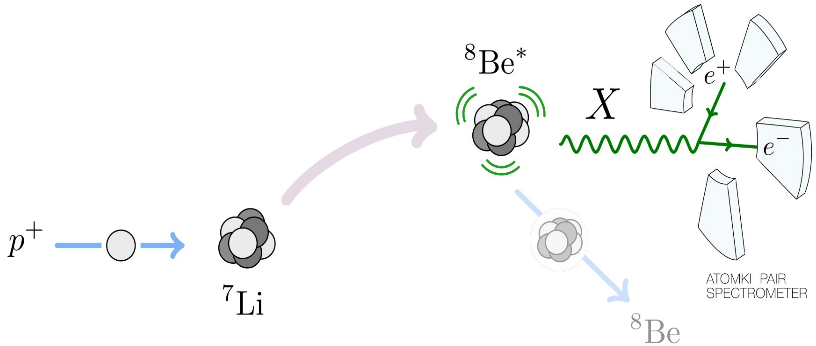
Mass difference is fixed as 100GeV.

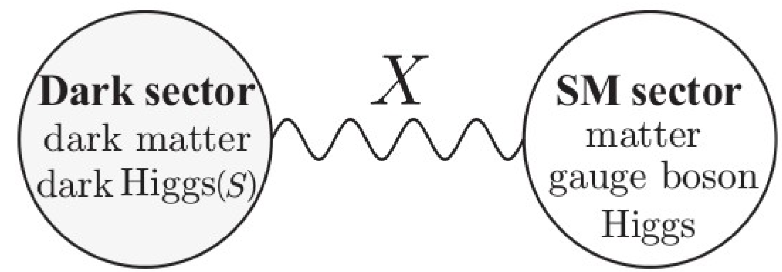




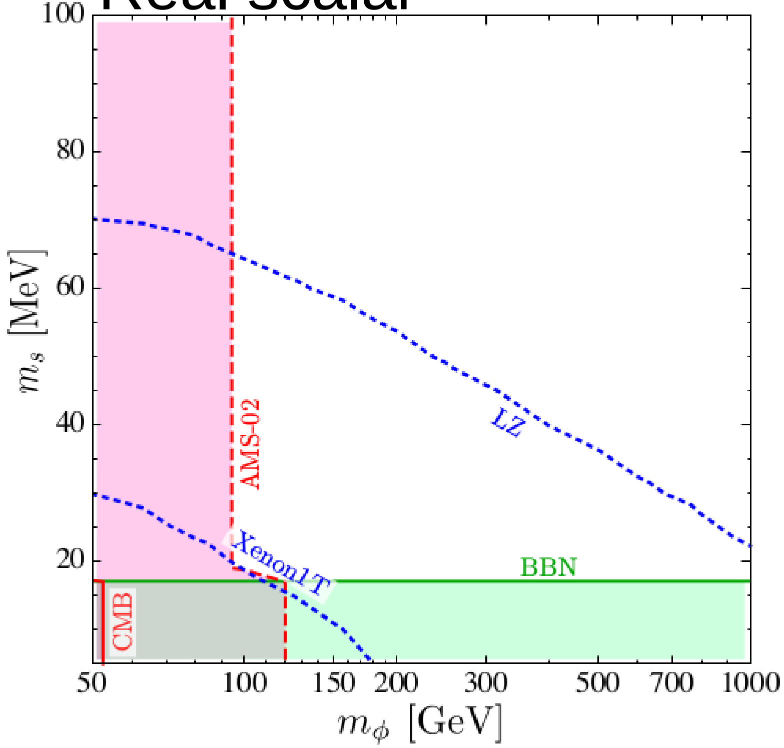
- Recent LUX bound excluded broad region.
- Solve the small scale structure problems with $g_X \sim 10^{-3}$

Conclusion

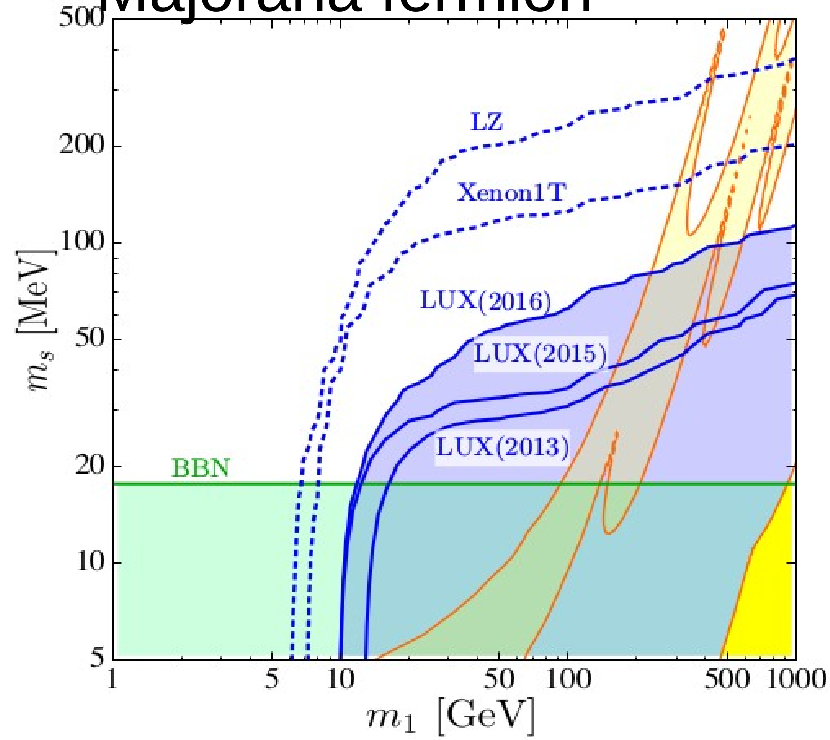




Real scalar



Majorana fermion

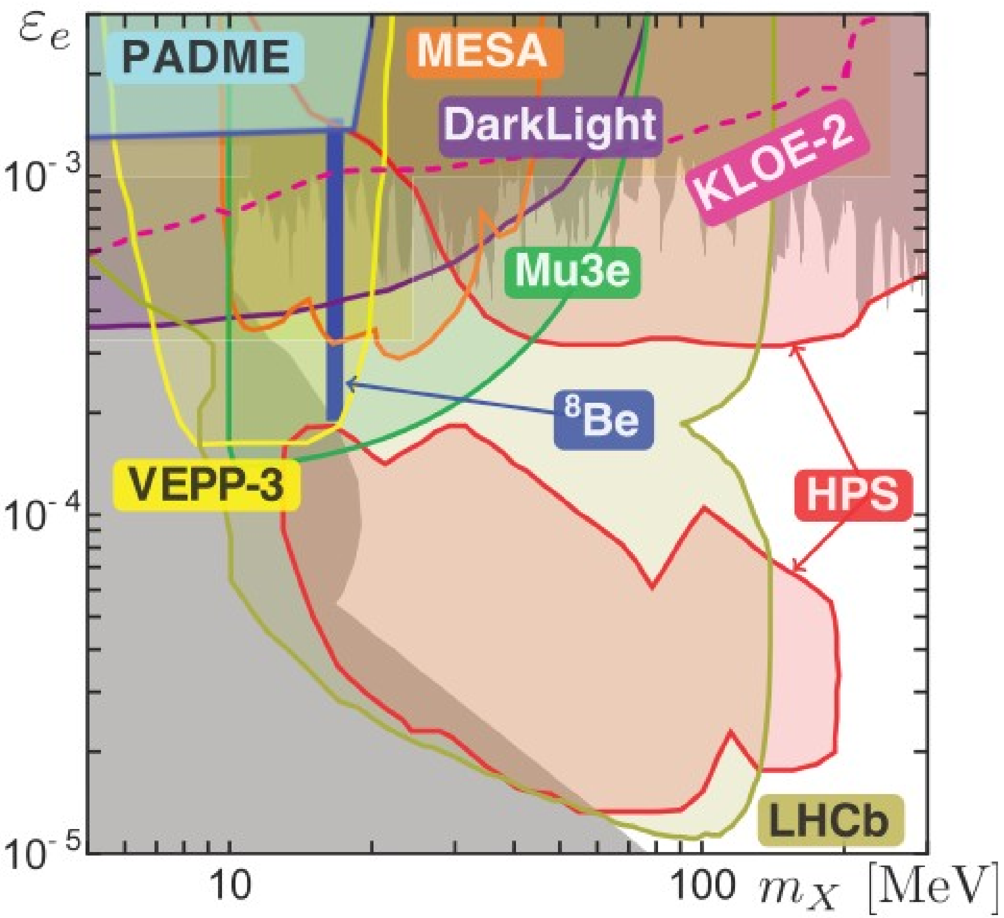


- Weak constraints.
- Large m_s dependence.

- The small scale structure problems can be discussed.

Future prospect

$$\frac{g}{M} \sim \frac{10^{-(4-3)}}{17\mathrm{MeV}} \sim \frac{1}{1.7 \times 10^{1-2}\mathrm{GeV}} \quad \text{(c.f. } \frac{g_2}{\sqrt{2} m_W} \sim \frac{1}{175\mathrm{GeV}} \text{)}$$



Mu3e (2018--)

Associate with μ decay

$\mu \to e\nu\nu X(\to ee)$

VEPP-3 (if accepted 3--4y)

Fixed target: $e^+e^- \to \gamma X$

LHCb (2021--2023)

D-meson decay

$D^*(2007)^0 \to D^0 X(\to ee)$