CEvNS in dark matter experiments

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What is the deal about CEvNS?

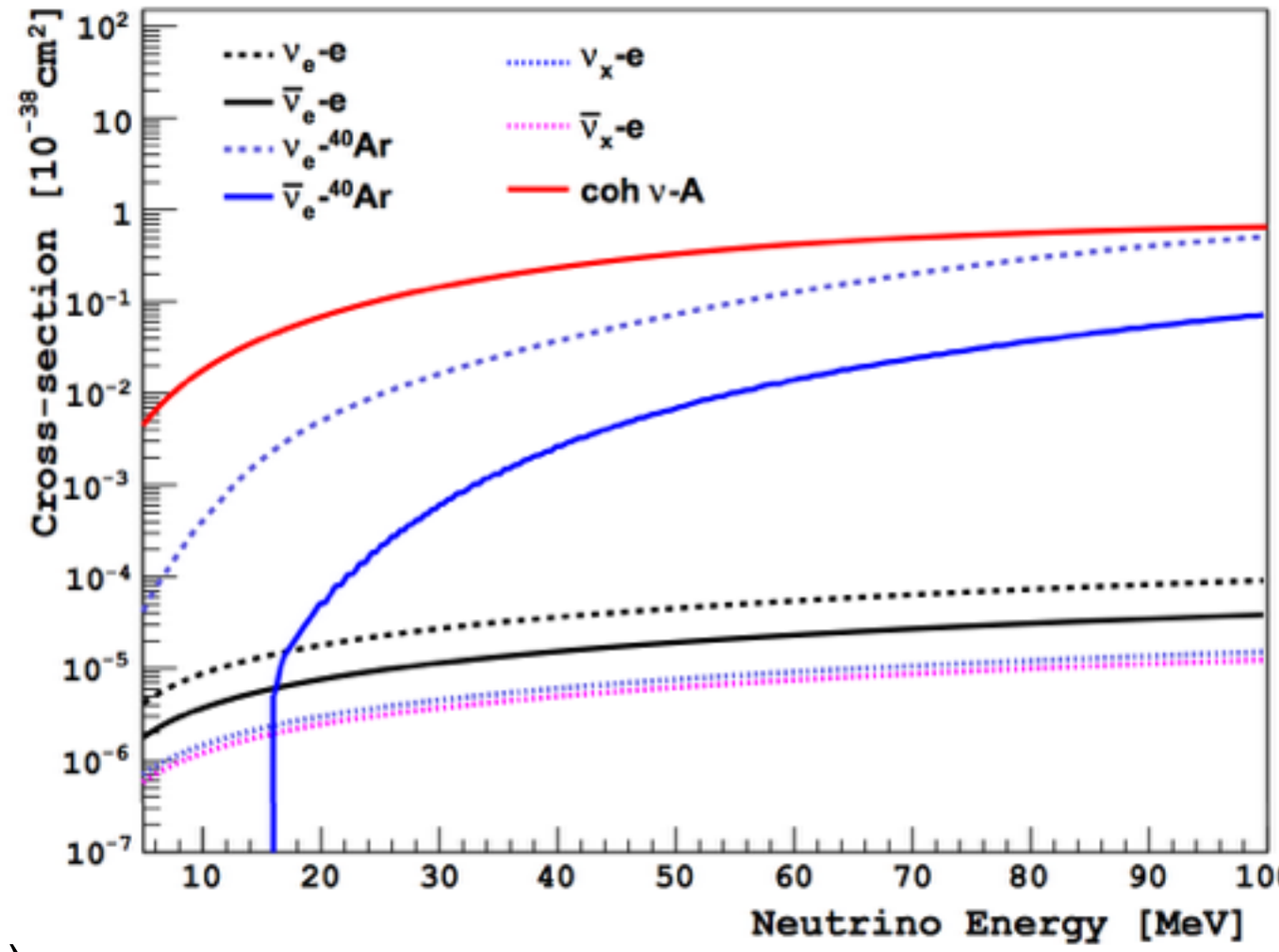
Low momentum transfer neutrino scattering on nucleus (low q^2)

Neutrino scatters coherently on nucleus:

$n_{nucleons}$ x charge^2 << ($n_{nucleons}$ x charge)^2

Large cross section (for neutrino standards)

Difficult: neutral current only, low q^2 = low deposited energy



Freedman 1973

The differential cross section for $\nu + A \rightarrow \nu + A$ is

$$\frac{d\sigma}{dq^2} = \frac{G^2}{2\pi} a_0^2 A^2 e^{-2bq^2} \left[1 - q^2 \frac{2ME + M^2}{4M^2E^2}\right]$$

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Some opportunities with coherent scattering

Neutrino interactions with nucleus

Weak scale non-standard interactions

Light new physics

Solar neutrinos

Sterile neutrinos

MiniBooNE anomaly

...

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Based on a bunch of papers: 1202.6073, 1604.01025, 1807.09877, 1809.06385

Dark matter and neutrino physics

1) Low threshold
2) Low background
3) ton or kton scale
Neutrino detector or
DMDD? Both!

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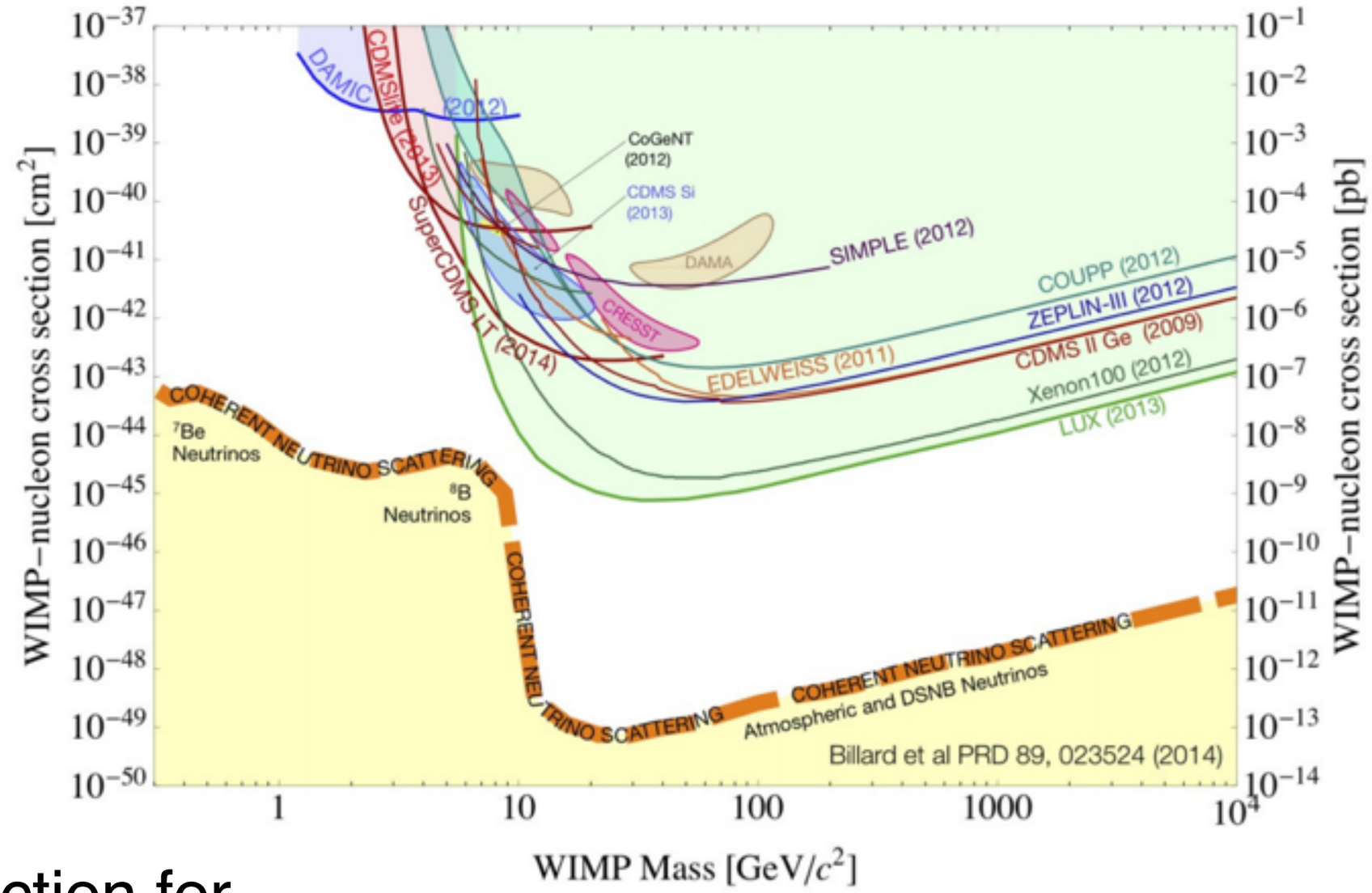

Neutrino floor

DM-nucleus cross section for which the solar neutrino background hinders the experimental sensitivity

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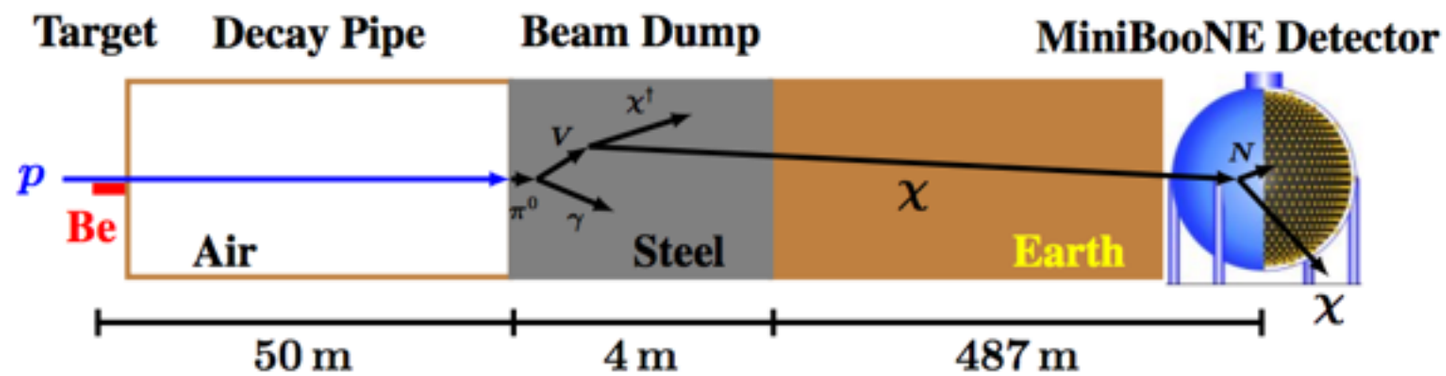

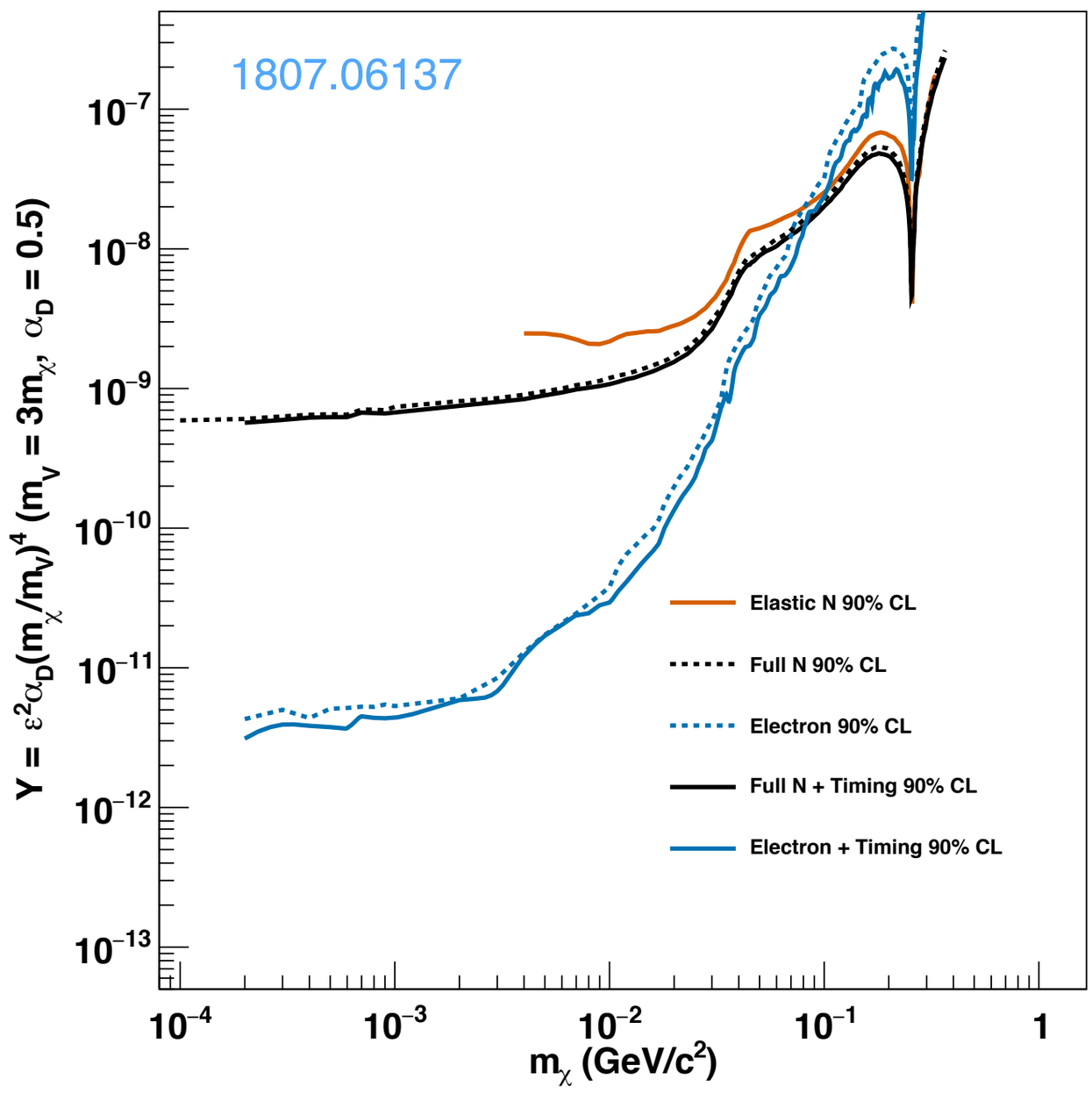

Boosted DM searches

DM can be produced in neutrino beams from π^0 decays and interact at neutrino detectors like a NC events

Dark matter and neutrino physics

signal ⟷ **background**

What can be learned about
neutrinos in dark matter detectors?

Standard solar model
(opacity, metallicity, neutrinos)

BSM physics
(light mediators)

Standard model
(Coherent ν-N, $\sin^2\theta_w$)

For the other topics, see Cerdeño et al 1604.01025

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1809.06385

How high is the neutrino floor?

C. Bœhm,[1,2,*] D.G. Cerdeño,[3,†] P. A. N. Machado,[4,‡] A. Olivares-Del Campo,[3,§] and E. Reid[3,¶]

New physics in the neutrino sector may increase the neutrino floor in dark matter detector

How much can it be increased?

Highly model dependent questions…

Use reasonable UV models to estimate

Case studies:

Germanium	SuperCDMS
Xenon	XENON1T, LZ, DARWIN
Helium	NEWS-G

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1) Take (UV) reasonable a new physics case
2) Get all constraints possible
3) See how the neutrino floor can be enhanced

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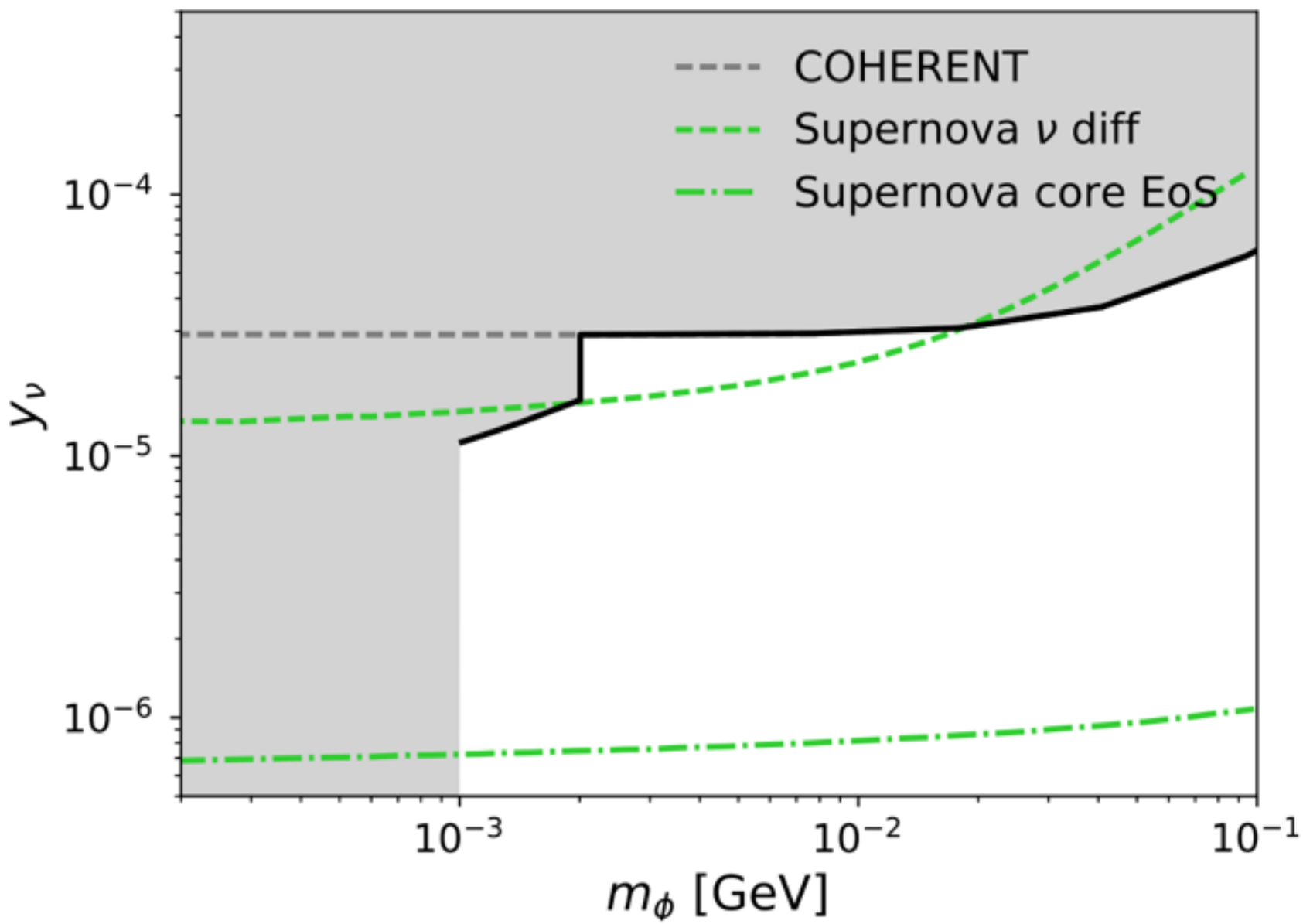

Light scalar

see e.g. Farzan et al 1802.05171

- universal Yukawa
- Lepton number violating coupling

Main constraints:
- COHERENT
- Supernova
- BBN

Reasonable UV? …

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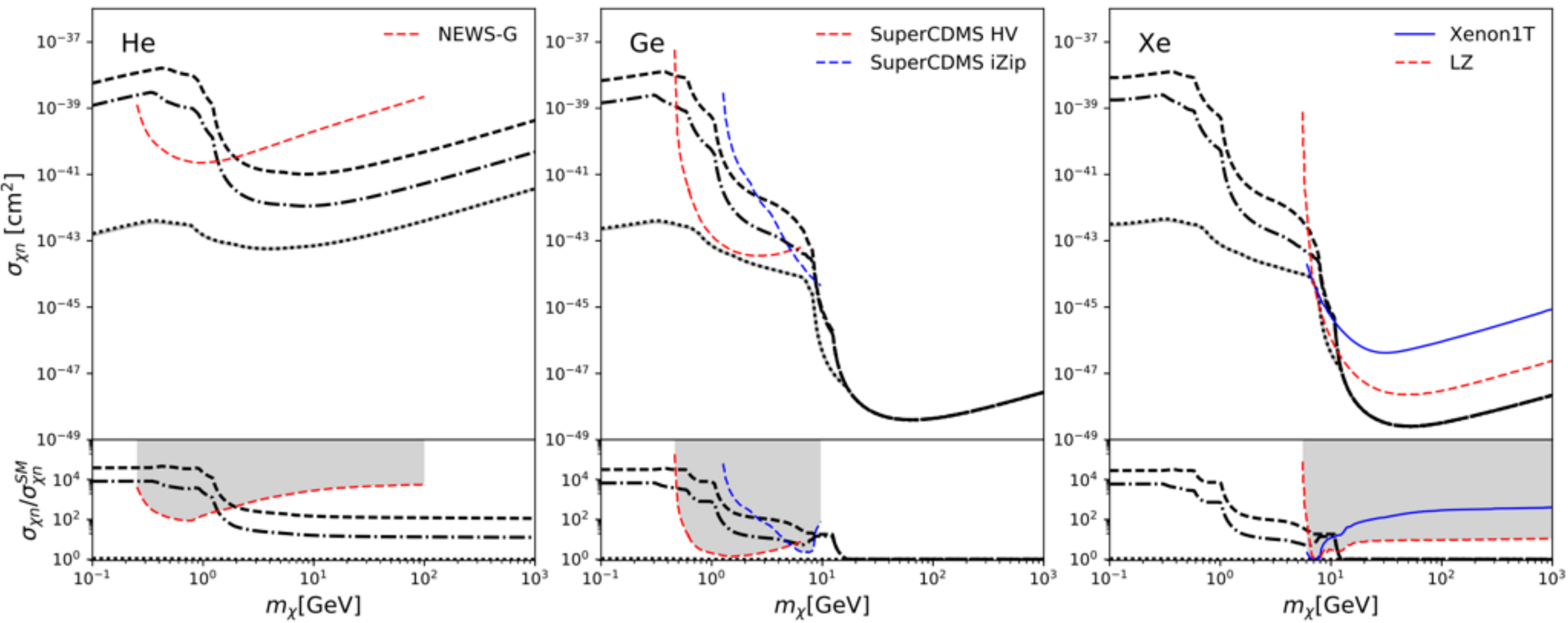
Huge enhancement: SN constraints ignored

Less huge enhancement: SN EoS "constraints" ignored

No enhancement: All SN constraints taken into account



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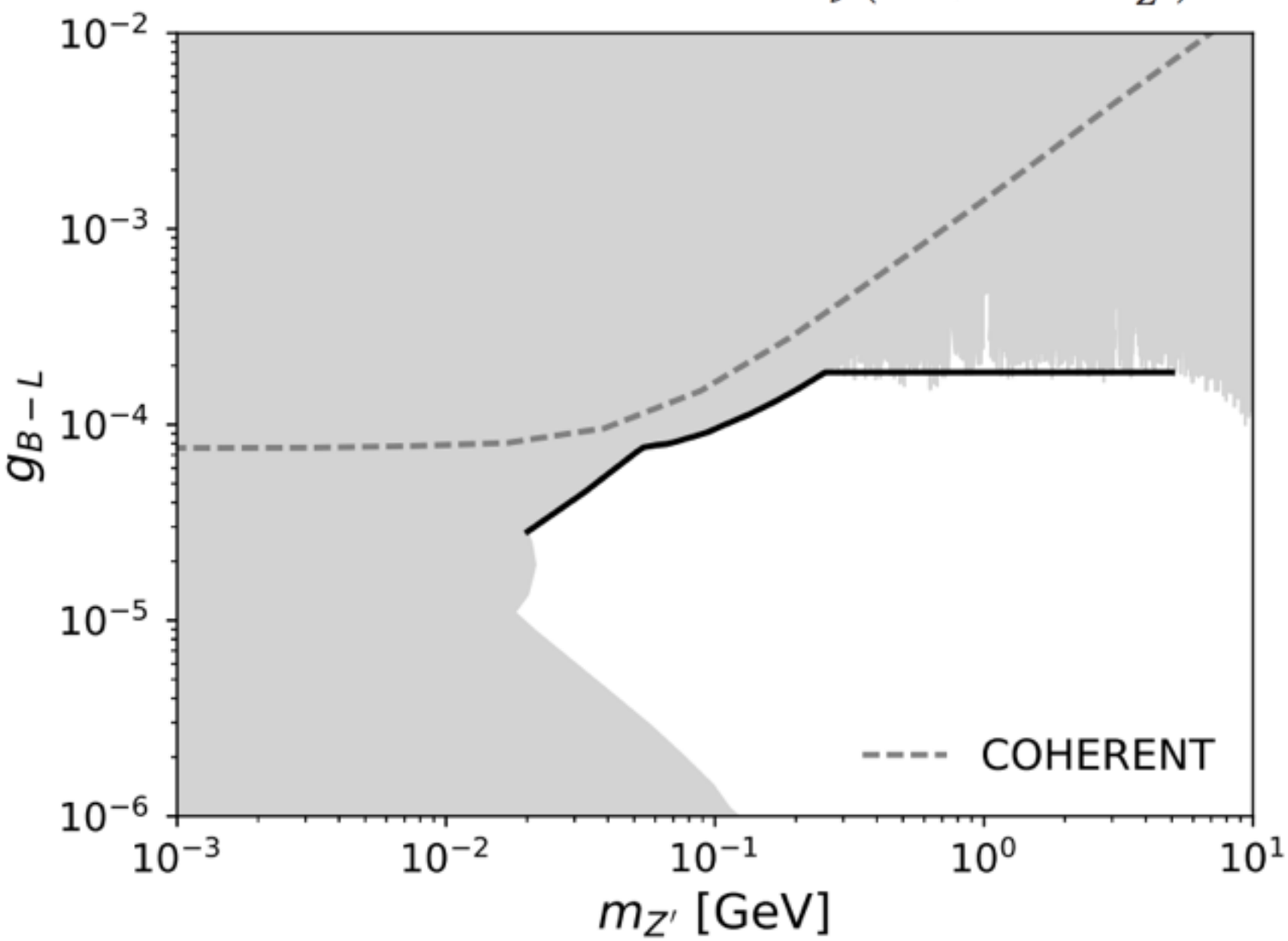
Gauged B-L

see e.g. Harnik Kopp M 1202.6073

$$\frac{d\sigma_{\nu N}}{dE_R} = \frac{d\sigma_{\nu N}^{SM}}{dE_R} - \frac{G_F m_N Q_{\nu N} Q'_{\nu N,v}(2E_\nu^2 - E_R m_N)}{2\sqrt{2}\pi E_\nu^2 \left(2E_R m_N + m_{Z'}^2\right)} + \frac{Q'^2_{\nu N,v} m_N (2E_\nu^2 - E_R m_N)}{4\pi E_\nu^2 \left(2E_R m_N + m_{Z'}^2\right)^2}$$



Main constraints:

- ν-e scattering
- B-factories
- Beam dump

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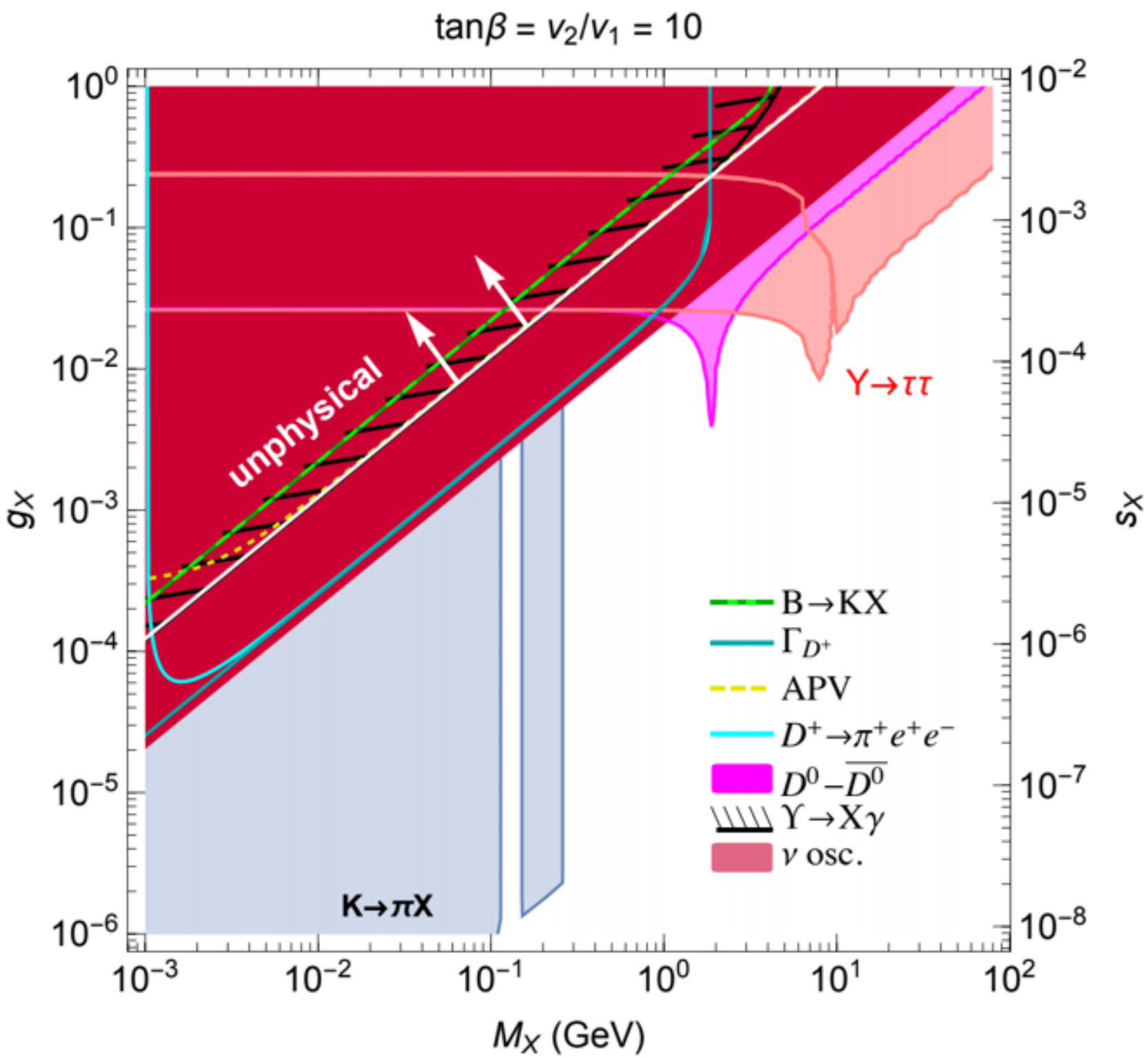

Gauged B_3-L_3

see Babu Friedland M Mocioiu 1705.01822

Z' only talks to e, p, n via Z-Z' mixing (s_X)

Main constraints:

- Neutrino oscillations
- D mixing
- K decays
- Upsilon decays

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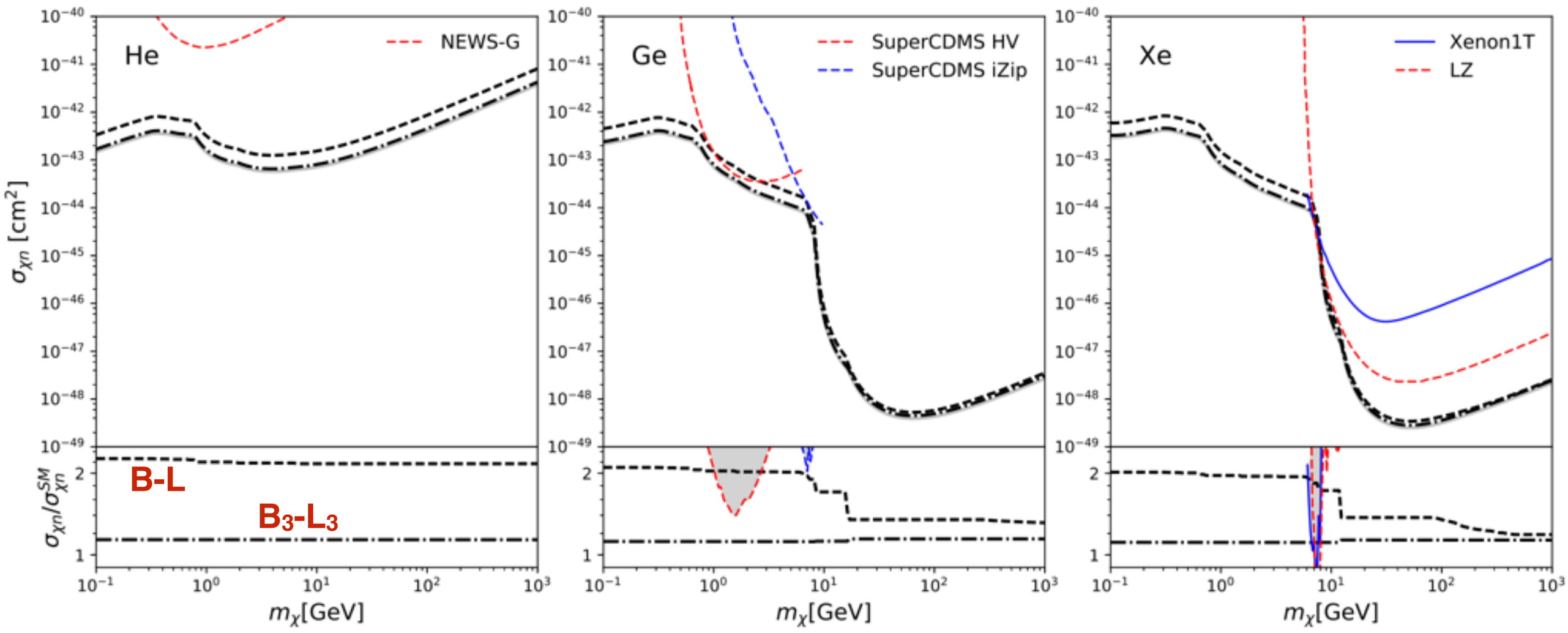

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Conclusions

Very powerful tool to look for standard
and new physics in the neutrino sector

Dark matter DD will soon be sensitive to the neutrino floor

"Reasonable" new physics in the neutrino floor may enhance it
by a factor of ~2.3

With *some extra effort* (avoid SN constraints), the neutrino floor
could go up a factor 10^4

Interesting interplay between DM and ν experiments ahead

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