Absorption of Fermionic Dark Matter by Nuclear Targets

Jeff A. Dror, Gilly Elor, & RM

PRL **124** 181301 [1905.12635]
JHEP 02 (2020) 134 [1908.10861]

+= Tien-Tien Yu

(in prep.)

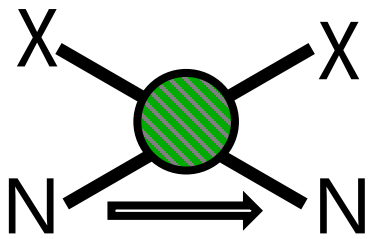
PHENO 2020, 5/4/20

The WIMP Paradigm

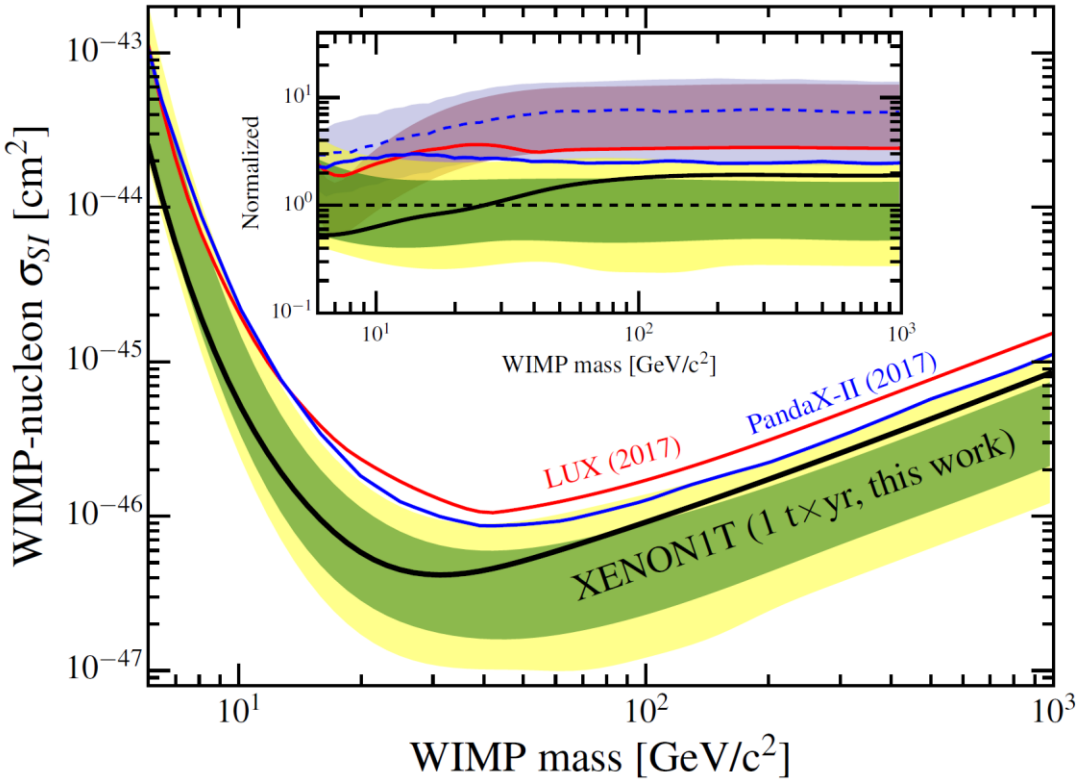
Fermion

~10 GeV-10 TeV

Stable

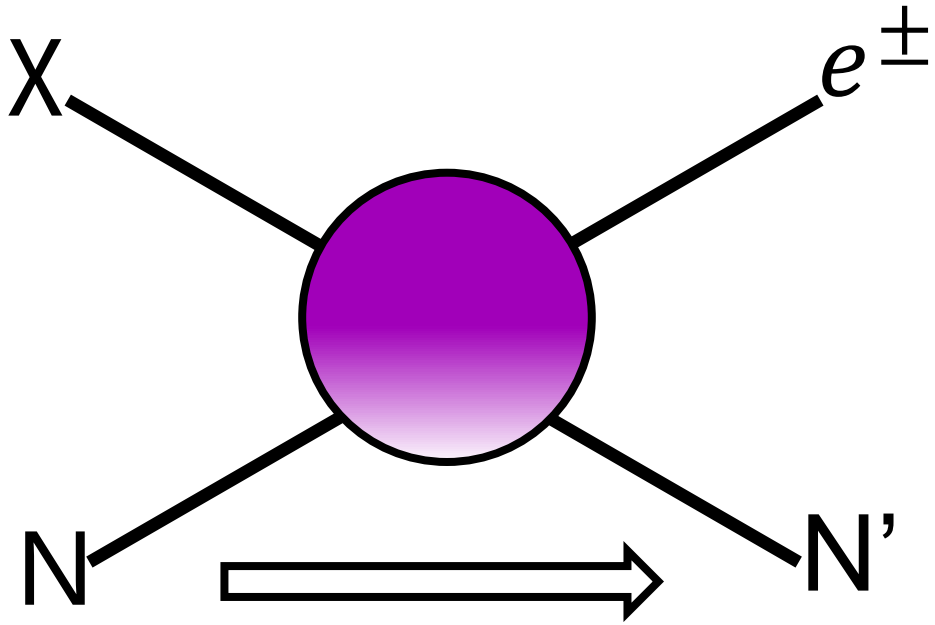


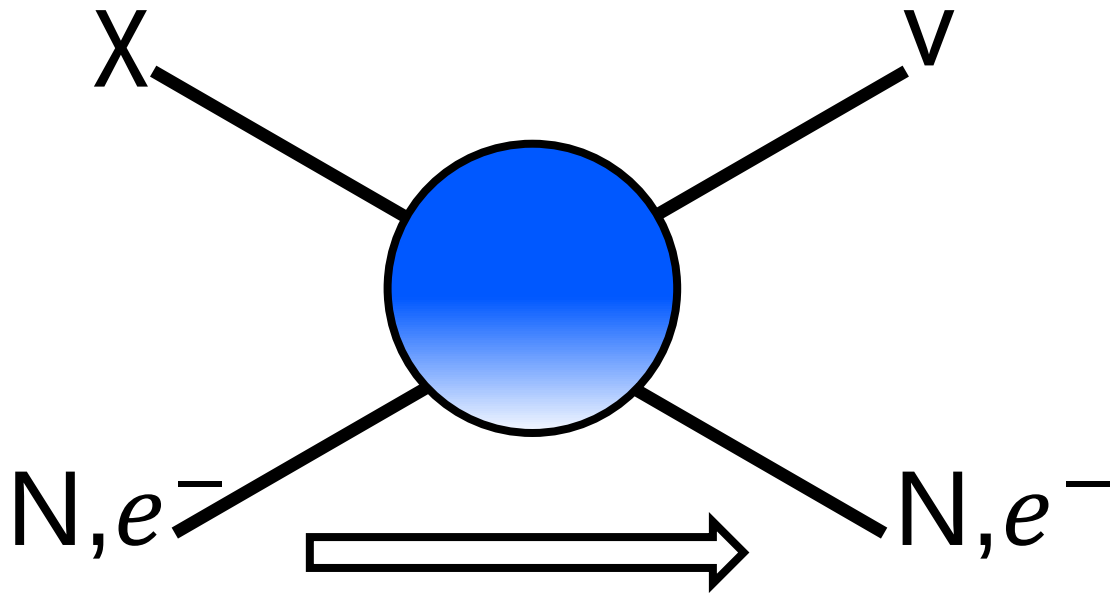
$$E_R \sim \frac{\mu^2 v^2}{2M_N}$$



XENON Collaboration, E. Aprile *et al.*, "Dark Matter Search Results from a One Ton-Year Exposure of XENON1T", *Phys. Rev. Lett.* **121** (2018), no. 11, 111302

Fermionic "Absorption" DM





$$\frac{1}{\Lambda^2}[\bar{\chi}\Gamma_\mu e][\bar{n}\Gamma^\mu p] + \text{h.c.}$$

$$\frac{1}{\Lambda^2}[\bar{\chi}\Gamma_\mu \nu]\left[\bar{\psi}_T\Gamma^\mu\psi_T\right] + \text{h.c.}$$

robertmcgehee at berkeley dot edu

Decay Constraints

$\chi \to e^+ e^- \nu$

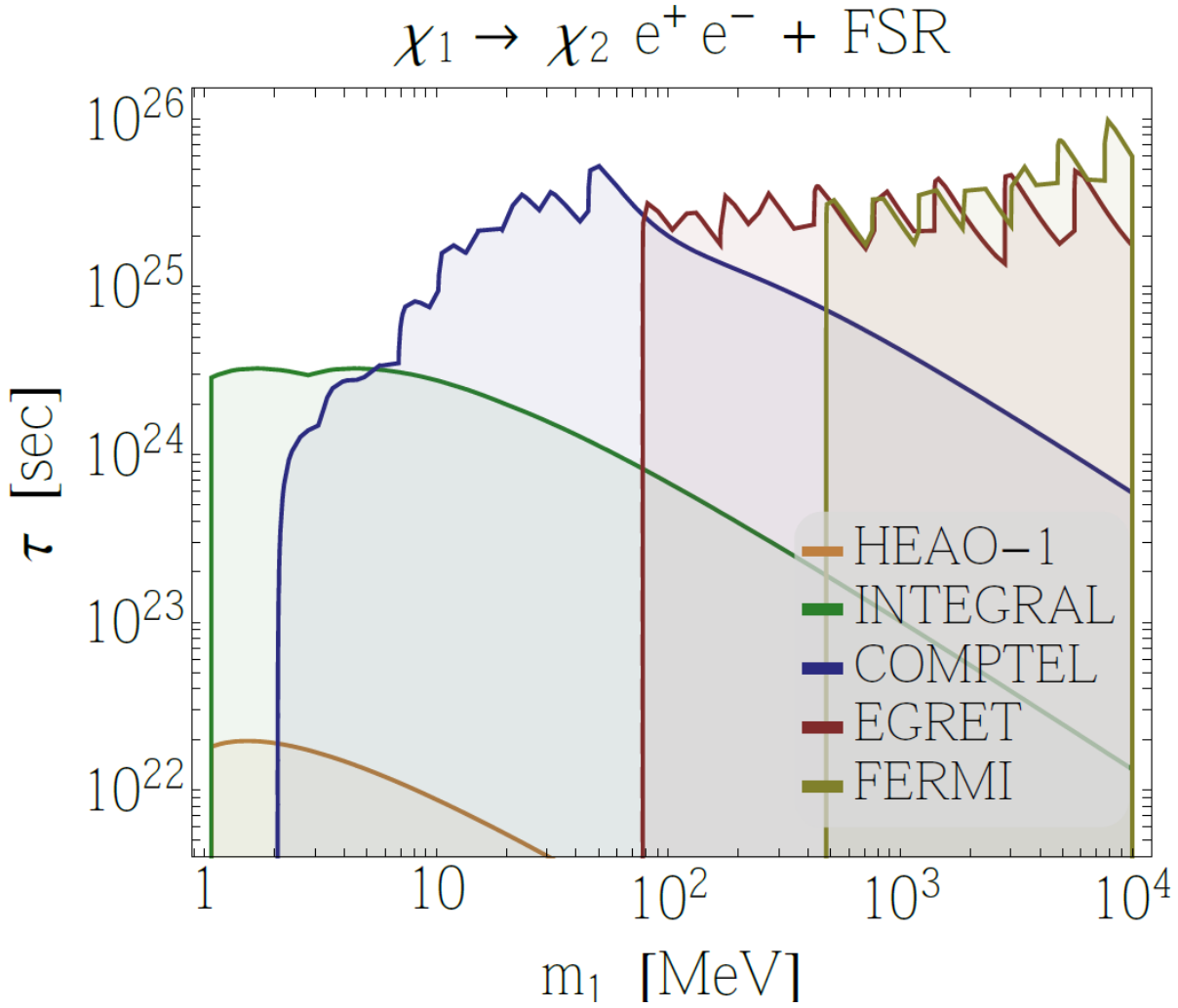
$\chi \to \nu\nu\nu$

$\chi \to \gamma\nu$

$\chi \to \gamma\gamma\nu$

$\chi \to \gamma\gamma\gamma\nu$

Essig, Kuflik, McDermott, Volansky, Zurek [1309.4091]



robertmcgehee at berkeley dot edu

“Direct” Constraints

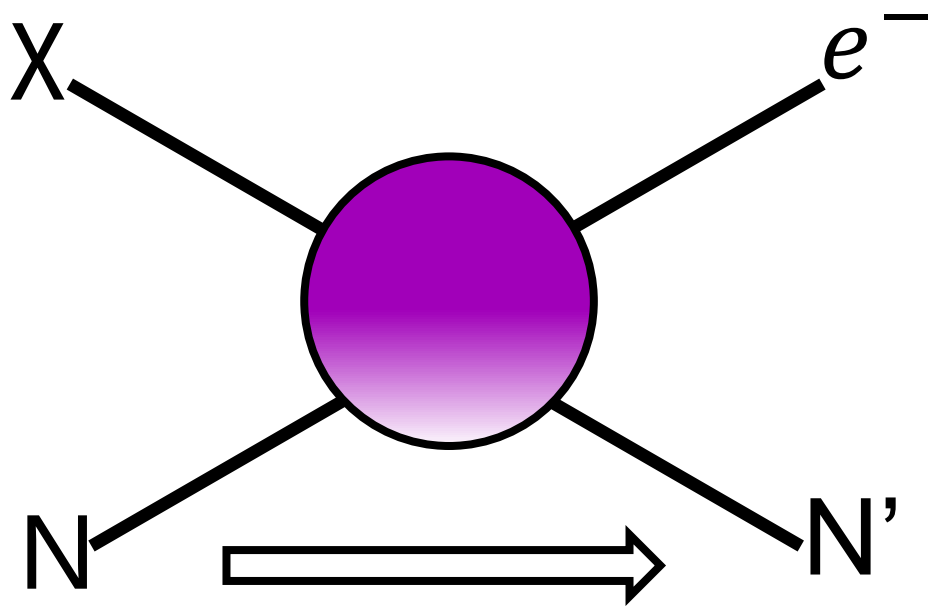
“Direct” → don’t rely on X being DM

LHC constrains mediator $\Lambda \gtrsim 3\ \mathrm{TeV}$
(Belyaev et al [1807.03817])

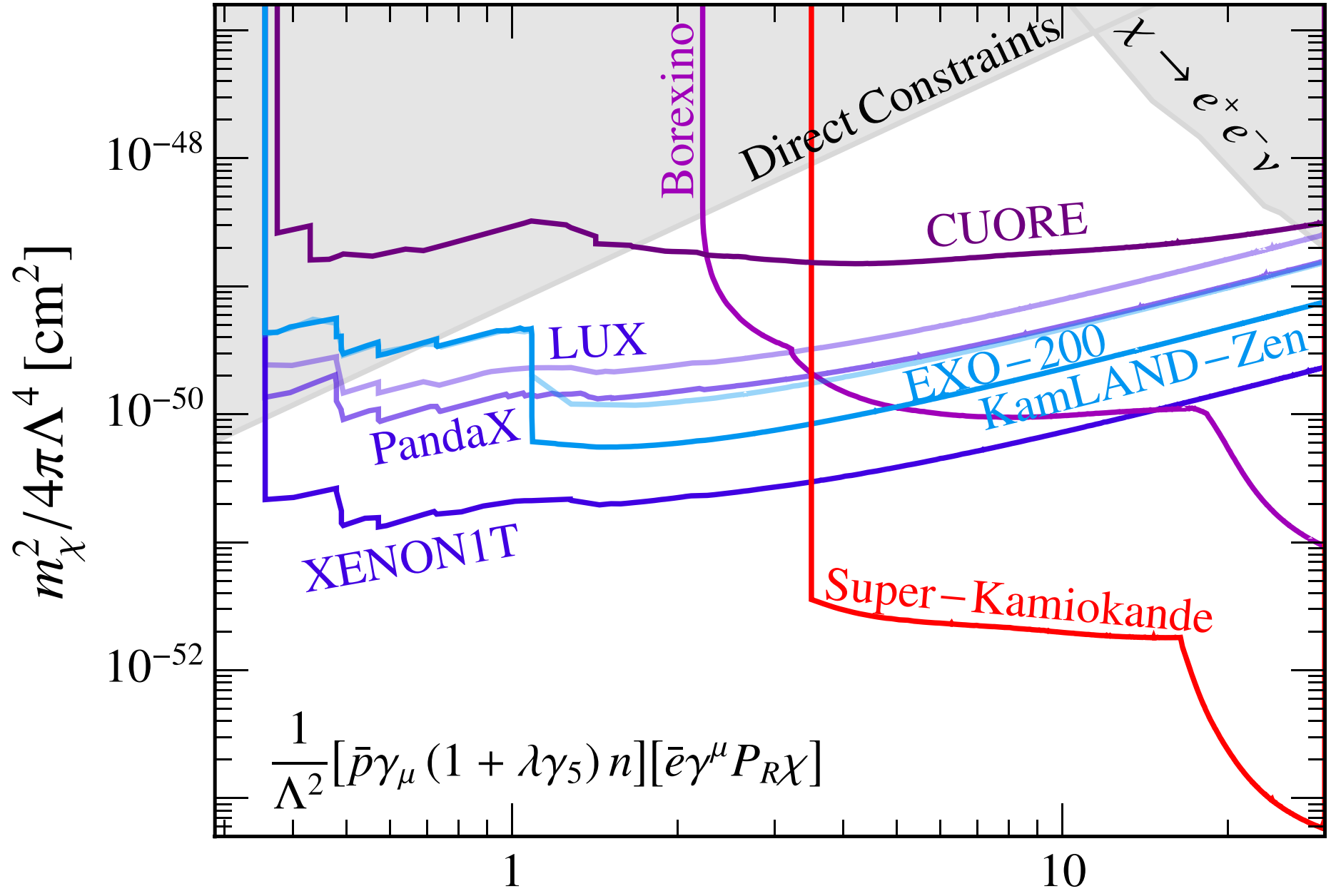
Operator + Model dependent

$$m_\chi \lesssim 100\ \mathrm{MeV}\ \mathbf{and}\ \Lambda \gtrsim 3\ \mathrm{TeV}$$

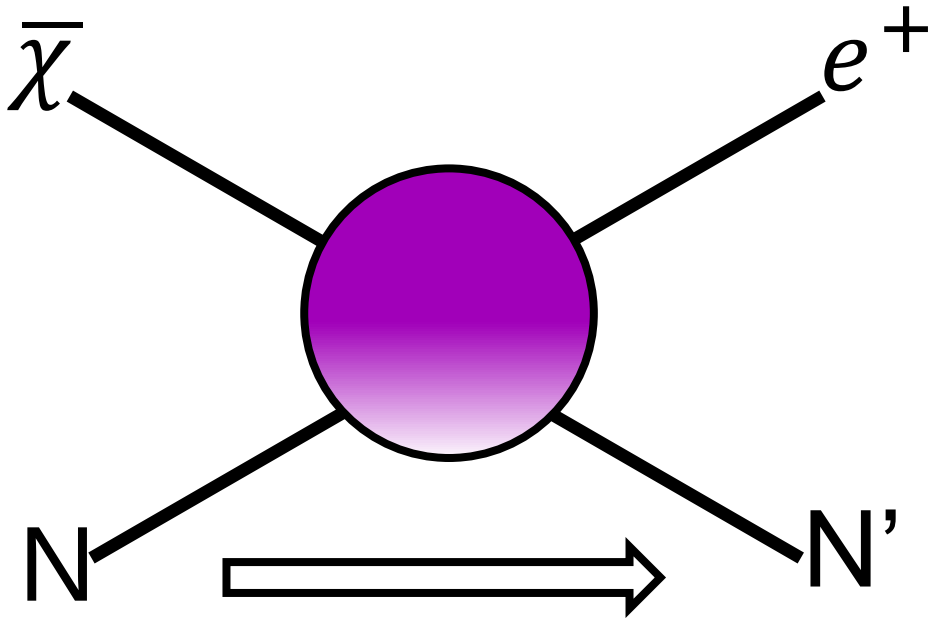
Induced β^- Decays



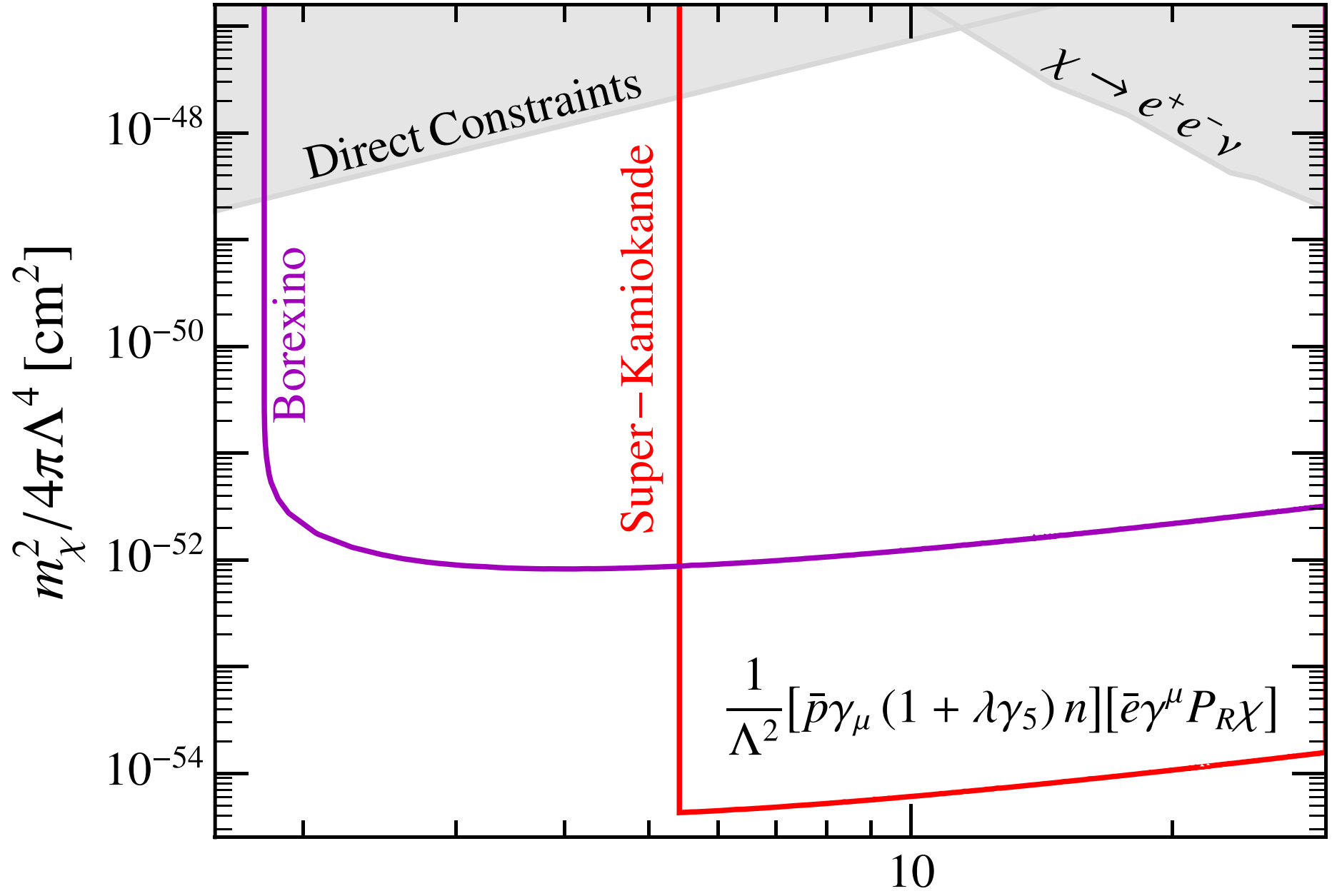
- e^-!
- NR!
- γ!
- N' Decay!


Borexino
Direct Constraints
$\chi \to e^+ e^- \nu$
CUORE
LUX
PandaX
EXO−200
KamLAND−Zen
XENON1T
Super−Kamiokande
10^{-48}
10^{-50}
10^{-52}
$m_\chi^2/4\pi\Lambda^4\ [\mathrm{cm}^2]$
$\frac{1}{\Lambda^2}[\bar{p}\gamma_\mu(1+\lambda\gamma_5)n][\bar{e}\gamma^\mu P_R\chi]$
1
10
m_χ [MeV]

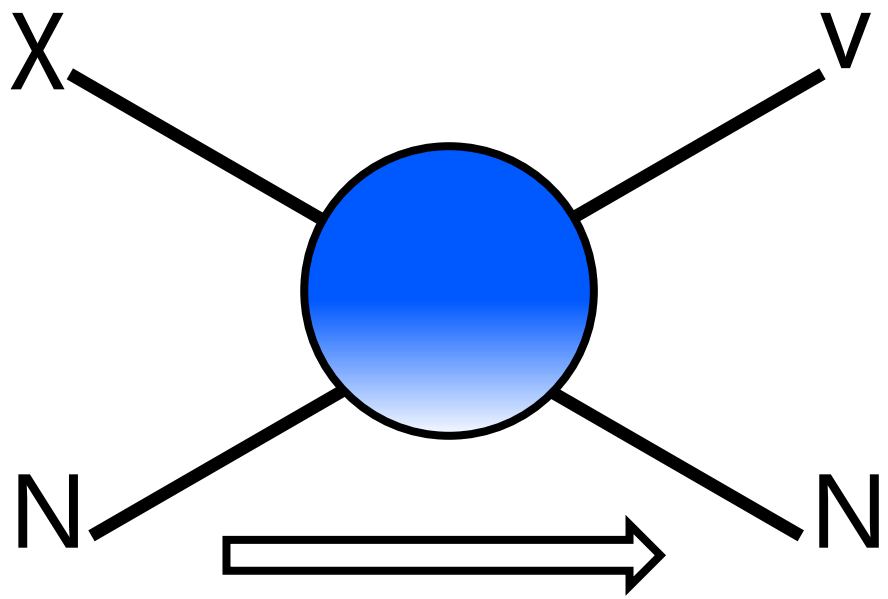
Induced β^+ Decays



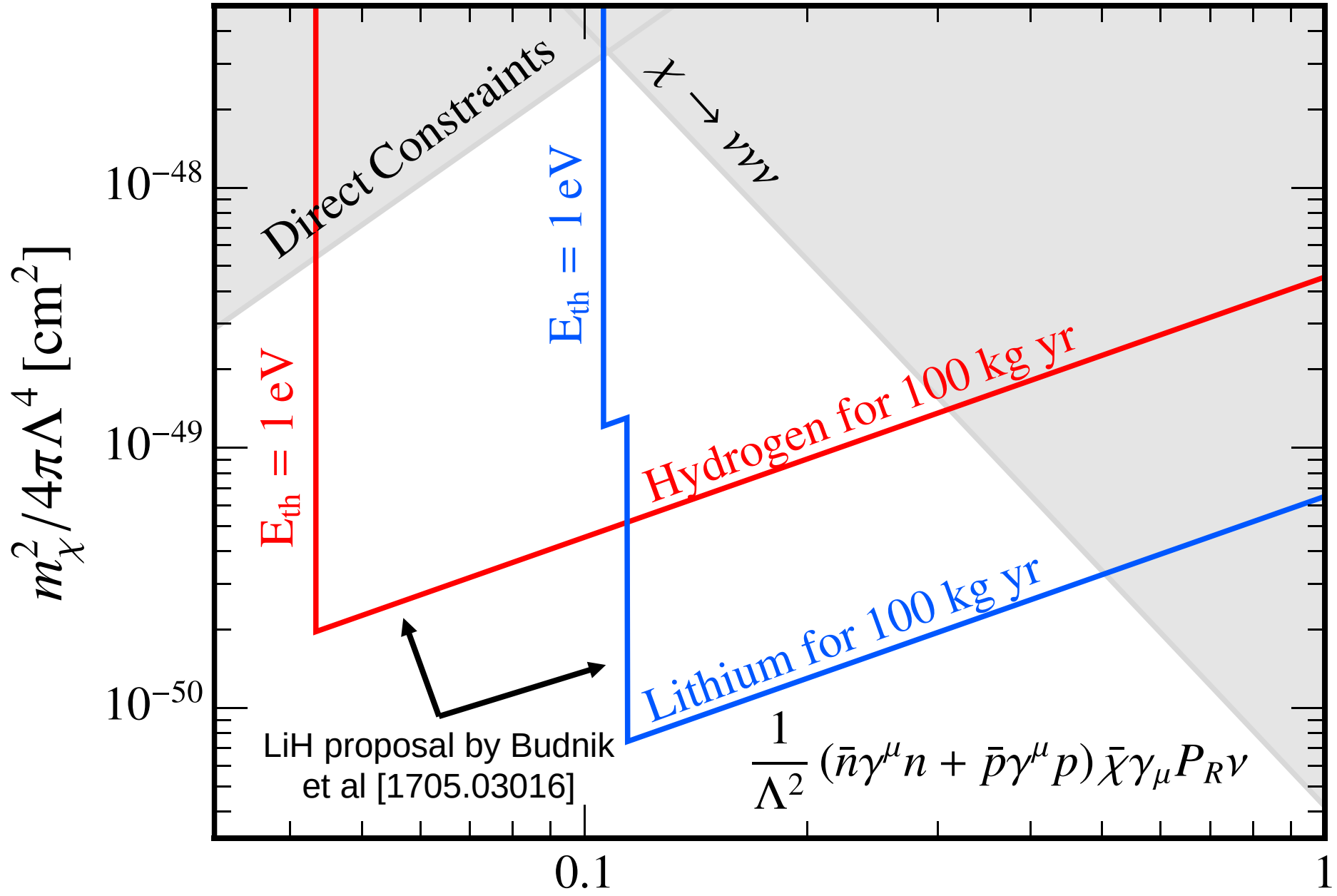
- May be only signal (ADM)
- Focus on Hydrogen


Direct Constraints
$\chi \to e^+ e^- \nu$
Borexino
Super−Kamiokande
$\frac{1}{\Lambda^2}[\bar{p}\gamma_\mu (1+\lambda\gamma_5)\, n][\bar{e}\gamma^\mu P_R \chi]$
10^{-48}
10^{-50}
10^{-52}
10^{-54}
10
$m_\chi^2/4\pi\Lambda^4$ [cm^2]
m_χ [MeV]

Neutral Current Nuclear Recoils



- Peaked NR at $E_R \sim \dfrac{m_\chi^2}{2M_N}$
- Future experiments



robertmcgehee at berkeley dot edu

Summary

Relaxing DM stability assumptions allows for novel signals and operators.

Charged current operators induce $\beta^{\pm}$ decays with NR, $e^{\pm}$, and γ signals.

Neutral current operators yield peaked, correlated nuclear recoil (NR) signals.

New searches at *existing* experiments can probe decades of unconstrained parameter space.

Stay tuned for absorption by electrons!