New Physics in a Hidden Sector

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IPP Townhall July 15, 2020

The Standard Model Works!

$$\mathcal{L}_{SM} = -\frac{1}{4} G_{\mu\nu} G^{\mu\nu} - \frac{1}{4} W_{\mu\nu} W^{\mu\nu} - \frac{1}{4} B_{\mu\nu} B^{\mu\nu}$$

$$+ |D_\mu H|^2 + \mu^2 |H|^2 - \lambda |H|^4$$

$$+ \bar{u}(i\not{\partial} - m_u)u + \bar{d}(i\not{\partial} - m_d)\bar{d} + \bar{e}(i\not{\partial} - m_e)e + \bar{\nu} i\not{\partial} \nu$$

but there are issues!

$$+ \frac{ig}{\sqrt{2}} (\bar{u}\ \bar{c}\ \bar{t}) \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \not{W}^+ (1-\gamma^5) \begin{pmatrix} u \\ c \\ t \end{pmatrix}$$

$$+ (\lesssim 10^{-10}) \frac{g_s^2}{32\pi^2} G_{\mu\nu} \tilde{G}^{\mu\nu} + \text{many other terms} \ldots$$

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$$\mathcal{L}_{SM} = -\frac{1}{4} G_{\mu\nu} G^{\mu\nu} - \frac{1}{4} W_{\mu\nu} W^{\mu\nu} - \frac{1}{4} B_{\mu\nu} B^{\mu\nu}$$

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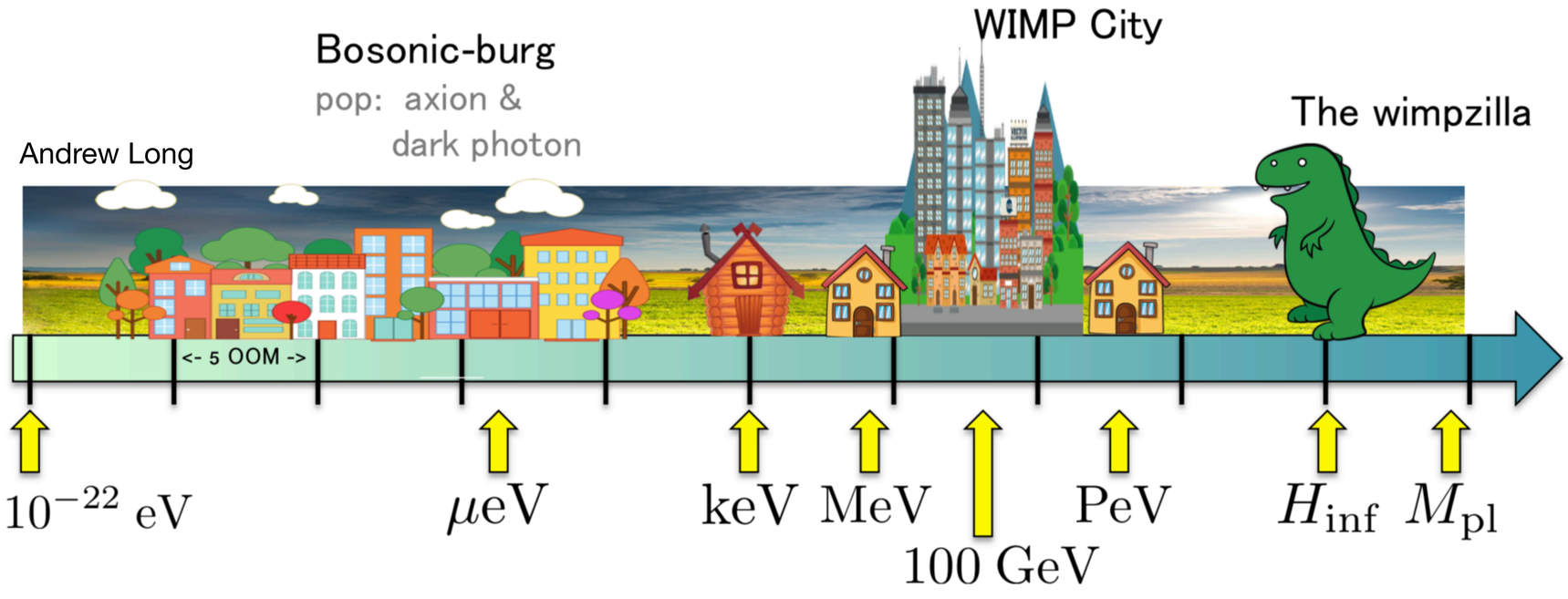
Such as:

No Dark Matter

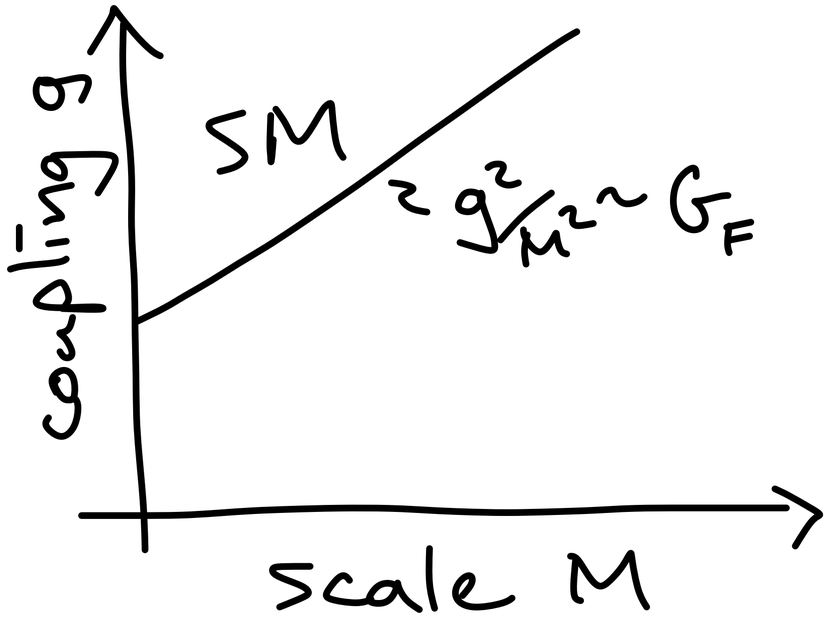
So what do we know about DM?

- cold, i.e. nonrelativistic (massive)
- doesn't interact (nongravitationally) too much

What's its mass?

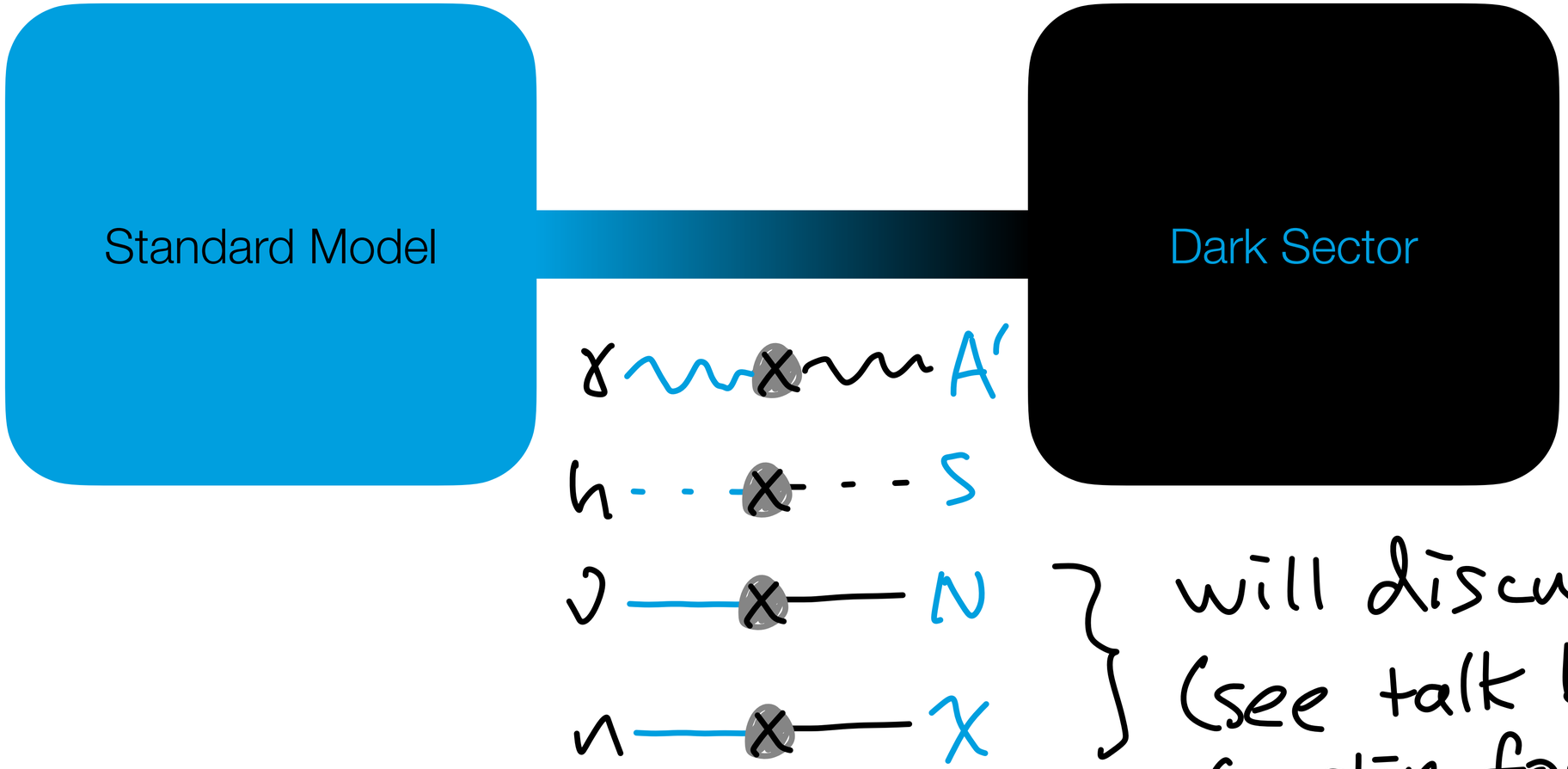


Life on the (SM) frontier



How can we have new physics at low scales without messing up SM??

Portals, or how to (not too feebly) couple light new physics to the SM



} will discuss these (see talk by D. Curtin for others)

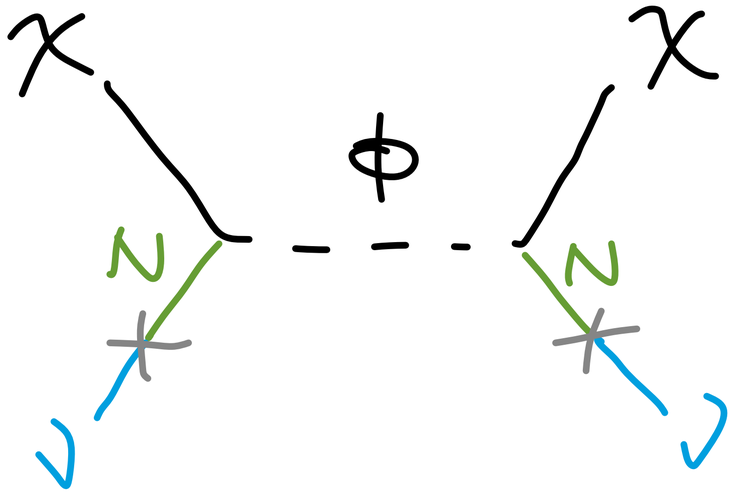
ν Portal

$\mathcal{L} \supset -y \bar{L} H^* N - g \bar{N} \Phi X \rightarrow -m_D \bar{\nu} N - g \bar{N} \Phi X$

mediator

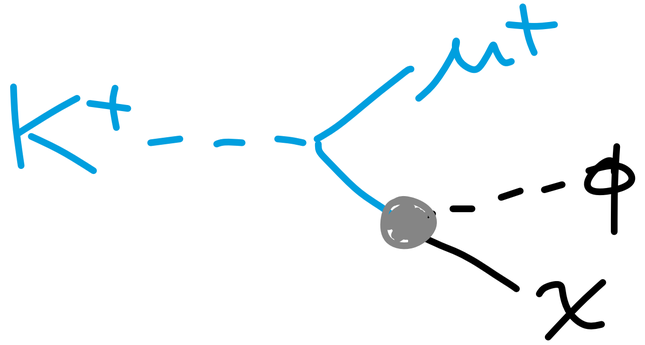
"dark sector"

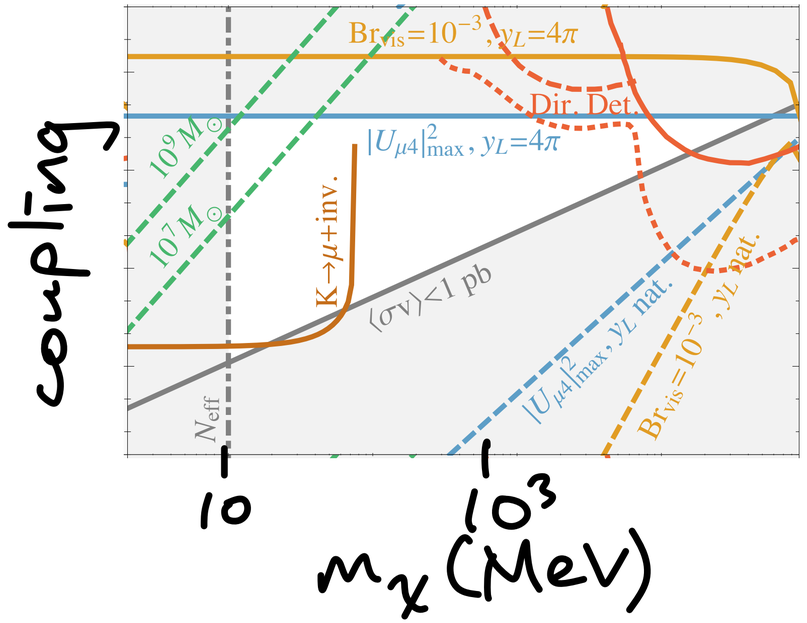
In early universe DM scatters on ν's



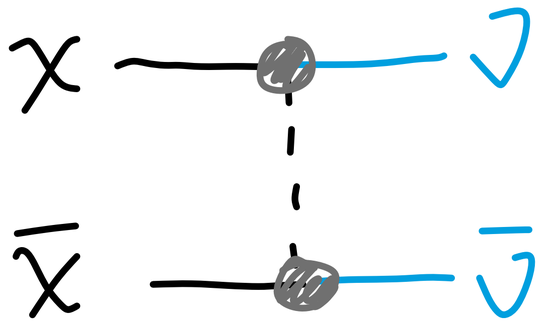
⟹ Affects structure formation

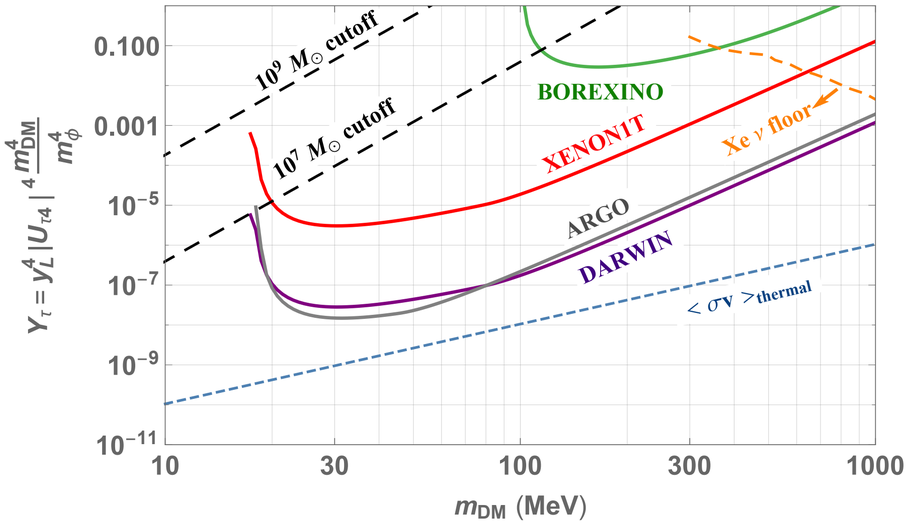
ν Portal-Probes





Batell, Han, DM, Shams Esthaghi 1709.07001 (see talk by D. Bryman on NA62)

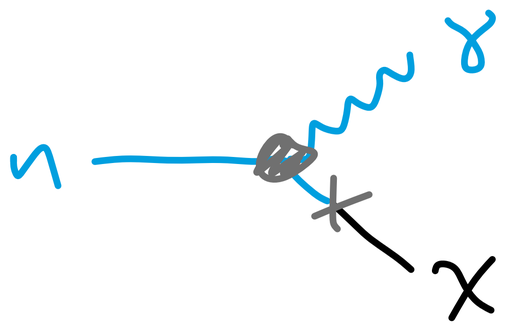




DM & N. Raj 1812.05103

n Portal

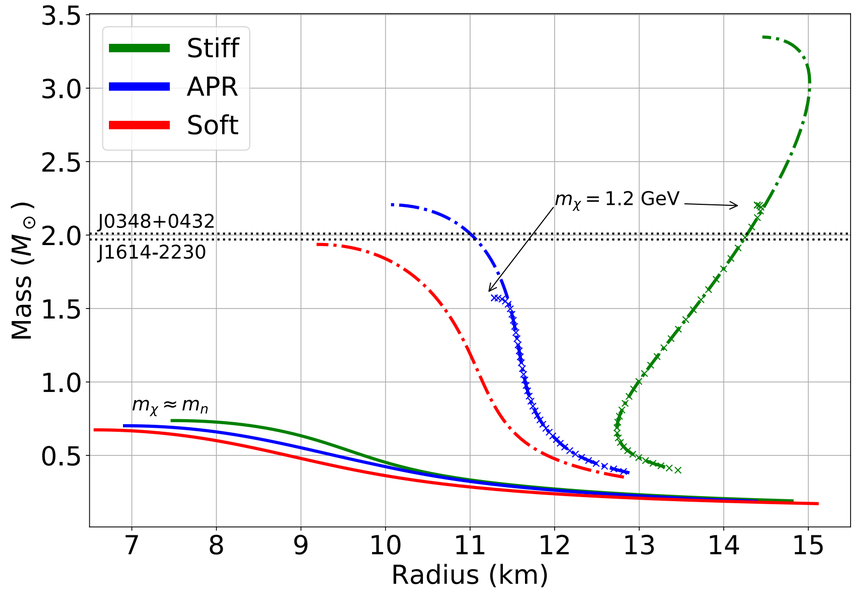
$$\mathcal{L} \supset \frac{1}{\Lambda^2} \bar{u}\bar{d}\bar{d}\chi \to \delta\, \bar{n}\chi$$



Leads to exotic n decay

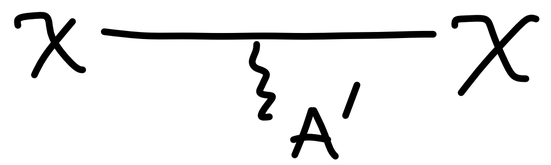
Br ~ 1% can explain n lifetime anomaly

neutron stars important



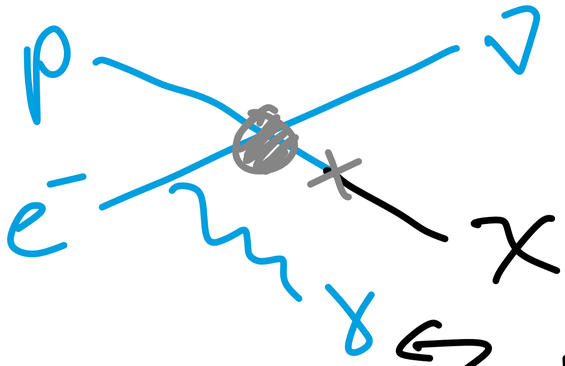
DM, Nelson, Reddy, Zhou 1802.08244 (& others)

See Cline & Cornell

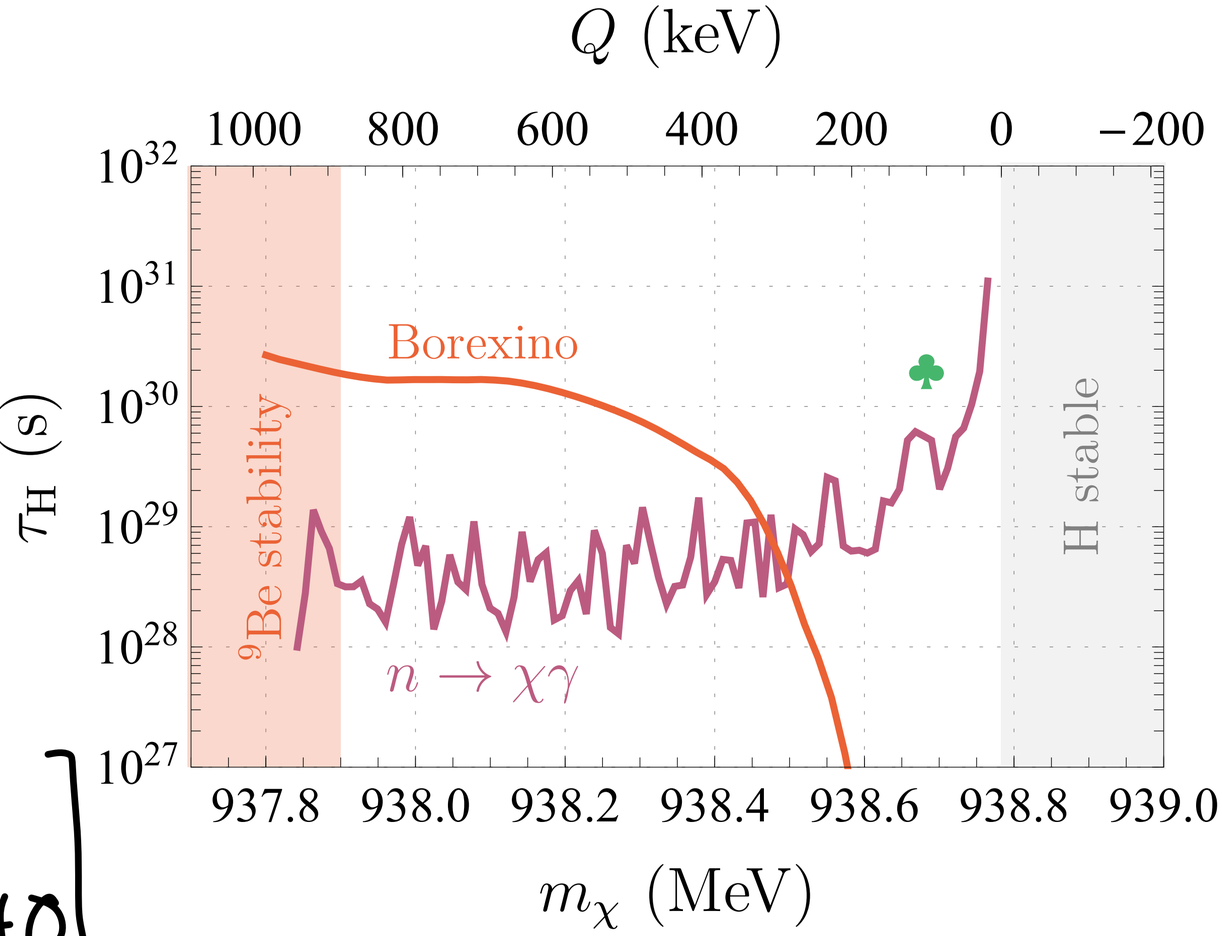


n Portal - Further Probes

Atomic hydrogen unstable:



look for this



[DM, Pospelov 2003.02270
DM, Pospelov, Raj 2006.15140]

Wrap Up

SM is successful but has deficiencies

↳ DM, Baryon Asymmetry, Inflation, ...

We don't have any "no lose theorems"

⇒ need to have an open mind

"Energy frontier" is an obvious place to look

But we need a diversity of expts

⇒ understand range of new physics they are sensitive to!

A Lesson from History?

受入
82-8-54
高エ研図書室

UTLICEPP-82-04
Jun. 1982

"KAMIOKANDE"

- The KAMIOKA Nucleon Decay Experiment -

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KEK, National Laboratory for High Energy Physics
Oho-machi, Tsukuba-gun, Ibaraki-ken 305, Japan

K.Arisaka, T.Fujii, T.Kajita, K.Kawagoe, M.Kobayashi,
M.Koshiba, T.Mashimo, M.Nakahata, A.Suzuki, and Y.Totsuka
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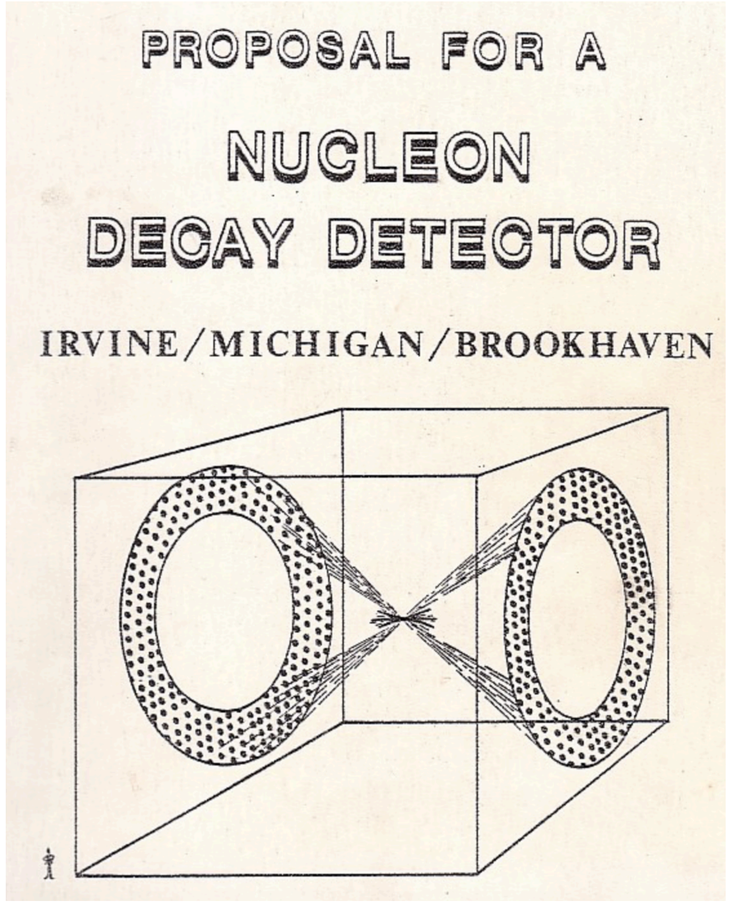
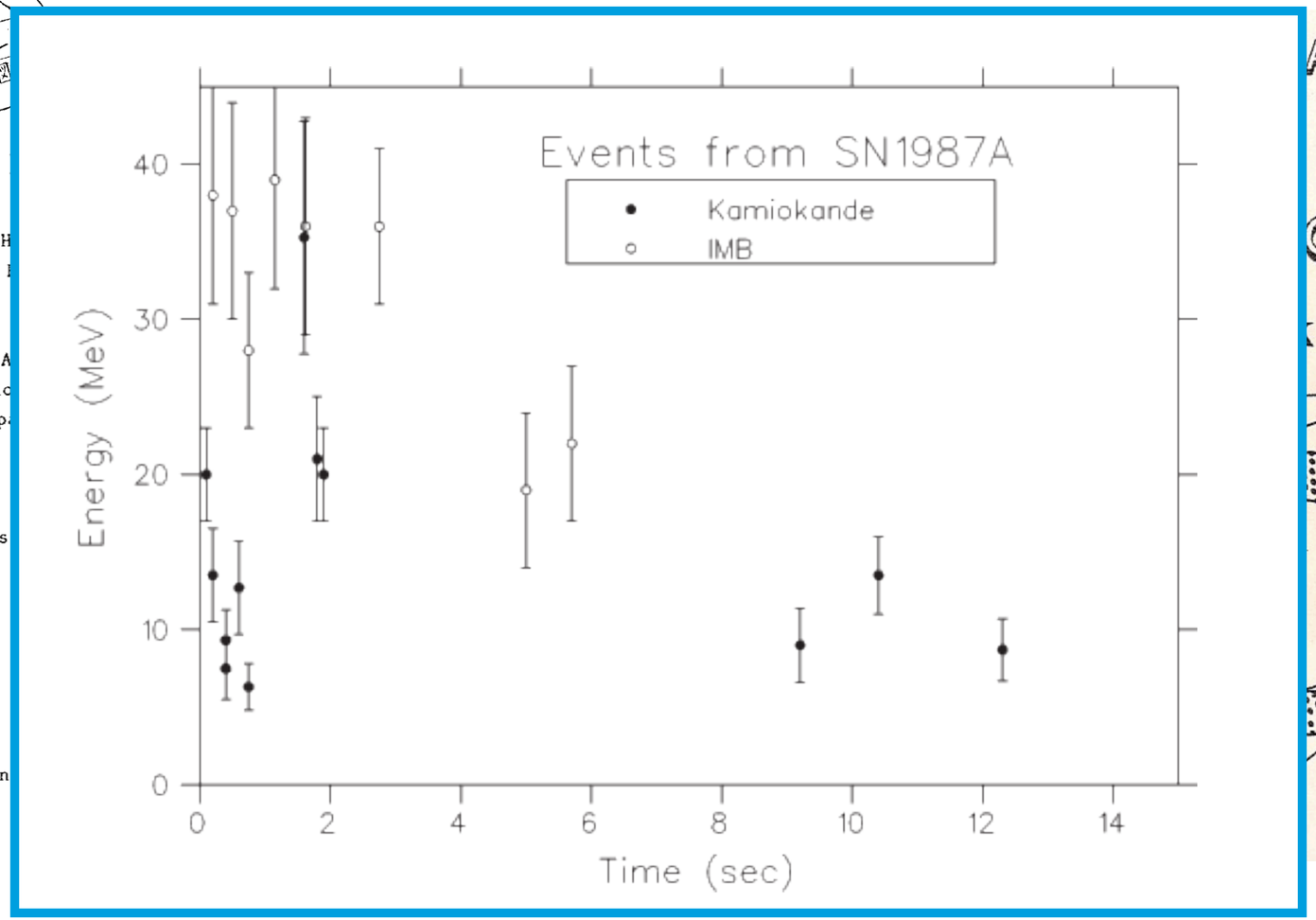
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