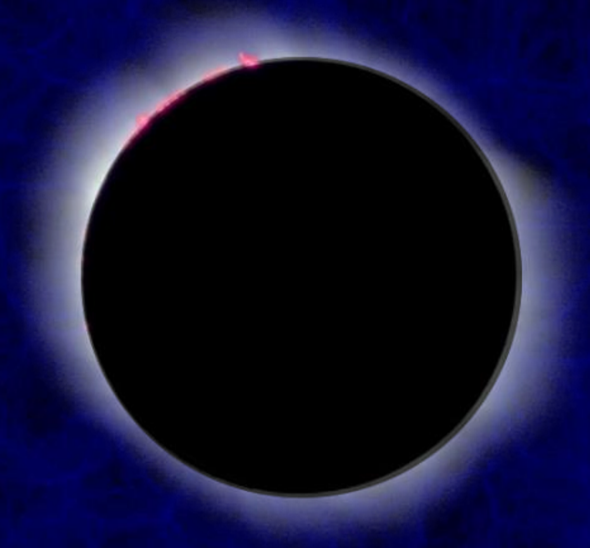
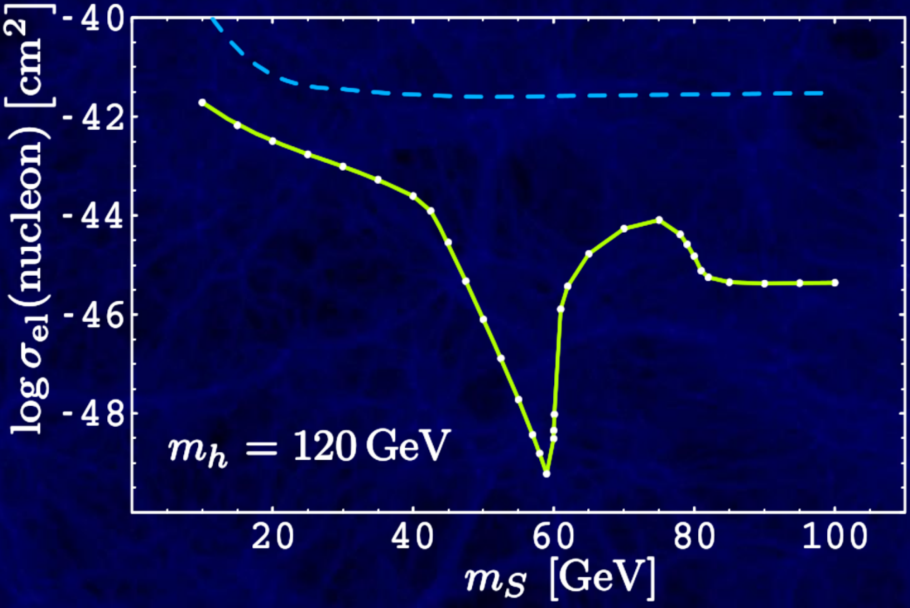
DARWIN
Liquid Xenon Rare Event Observatory

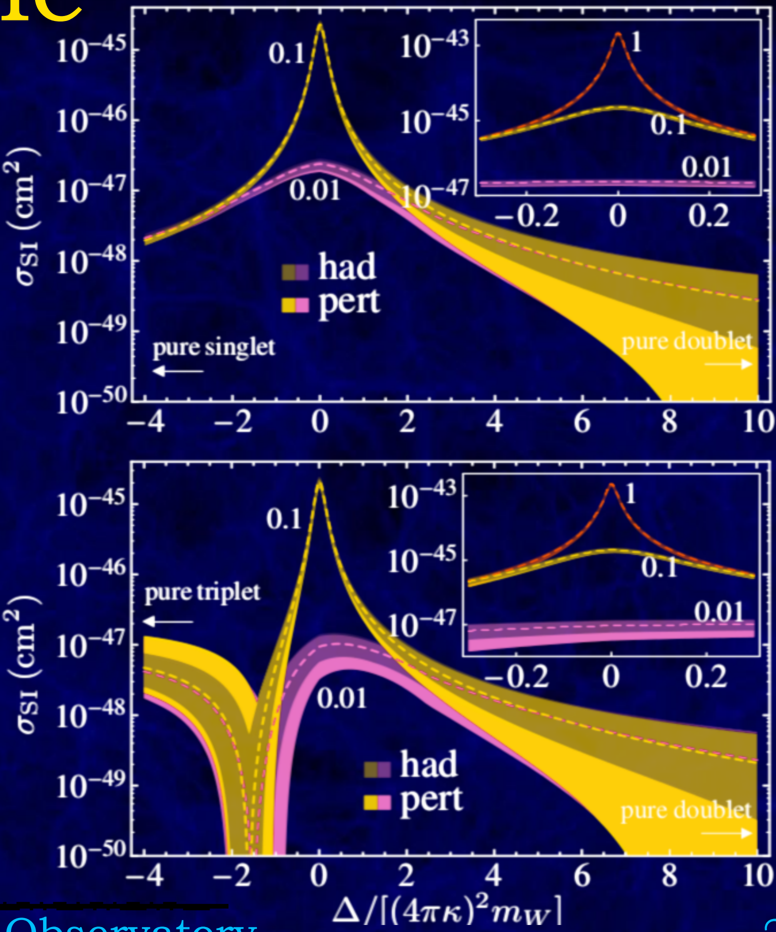


Rafael F. Lang
Purdue University
rafael@purdue.edu
for the DARWIN consortium
TAUP, July 2017

Nature Sets the Scale

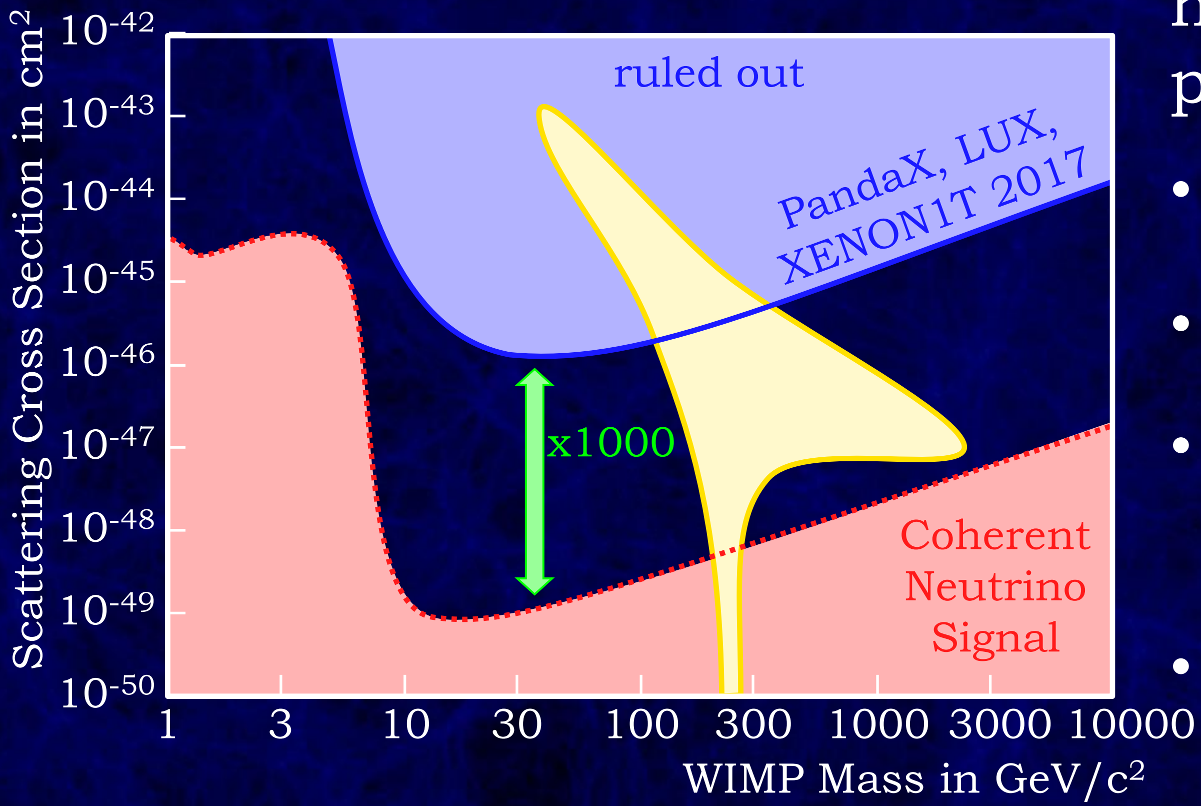
Burgess + 0011335





Hill&Solon 1309.4092

WIMPs: Best Motivated Target Still



highly motivated parameter space, e.g.

- SUSY etc.
  here: arxiv hep-ph/0001005
- Higgs Portal
- inelastic couplings (box) to Z, W^{+-}, H
- generic $\sigma \sim \frac{(\varepsilon g_2)^2}{m_\chi^2}$

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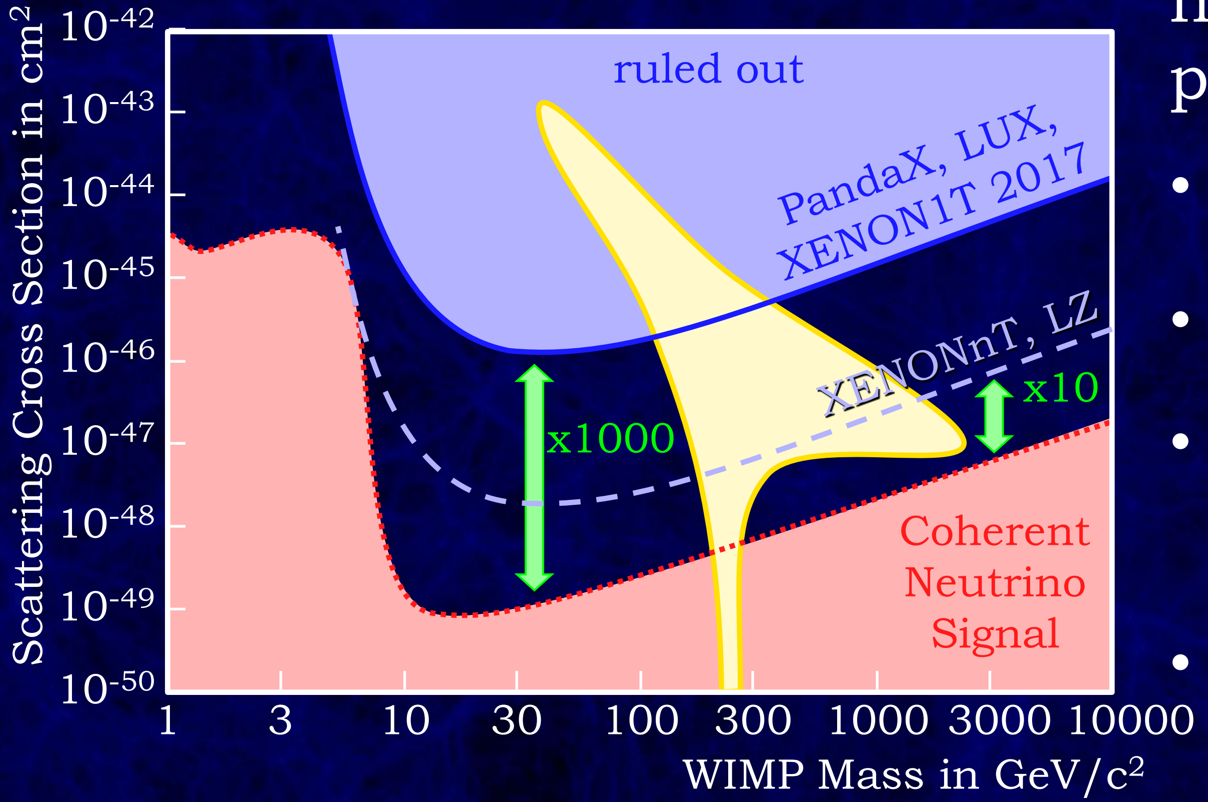

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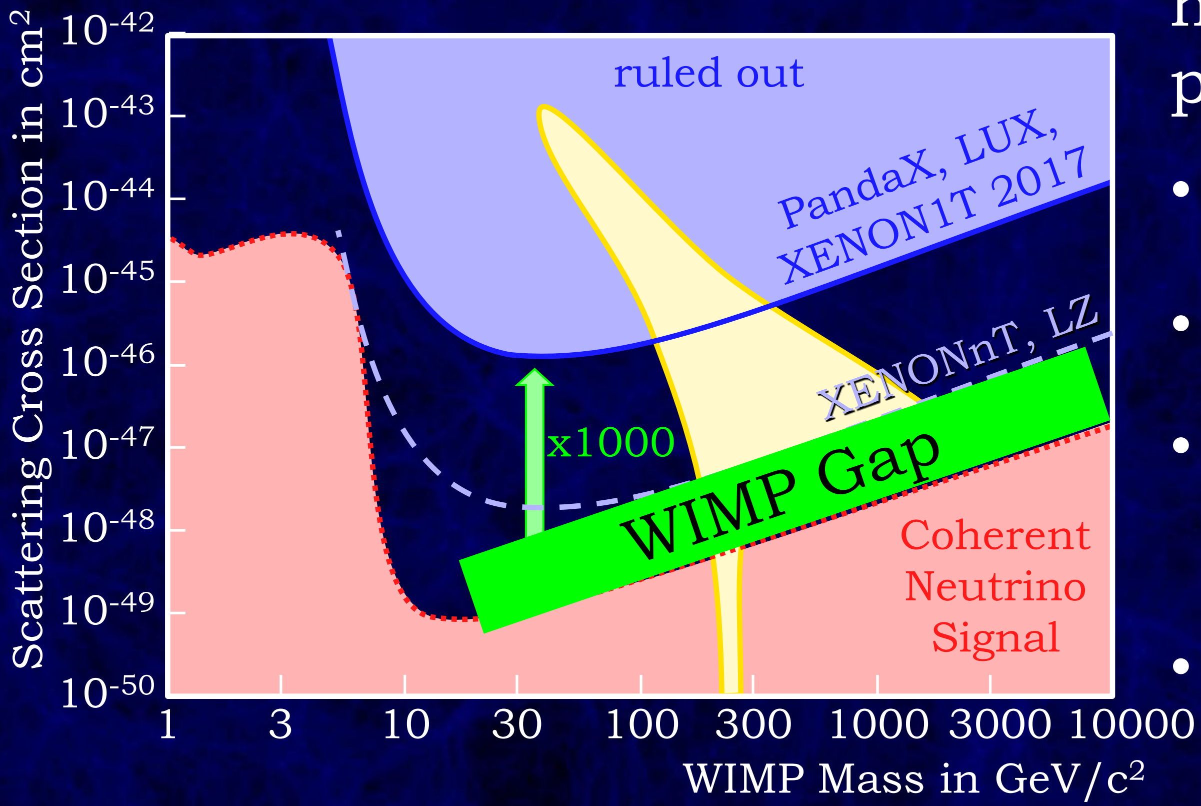
Probe WIMPs down to Neutrinos



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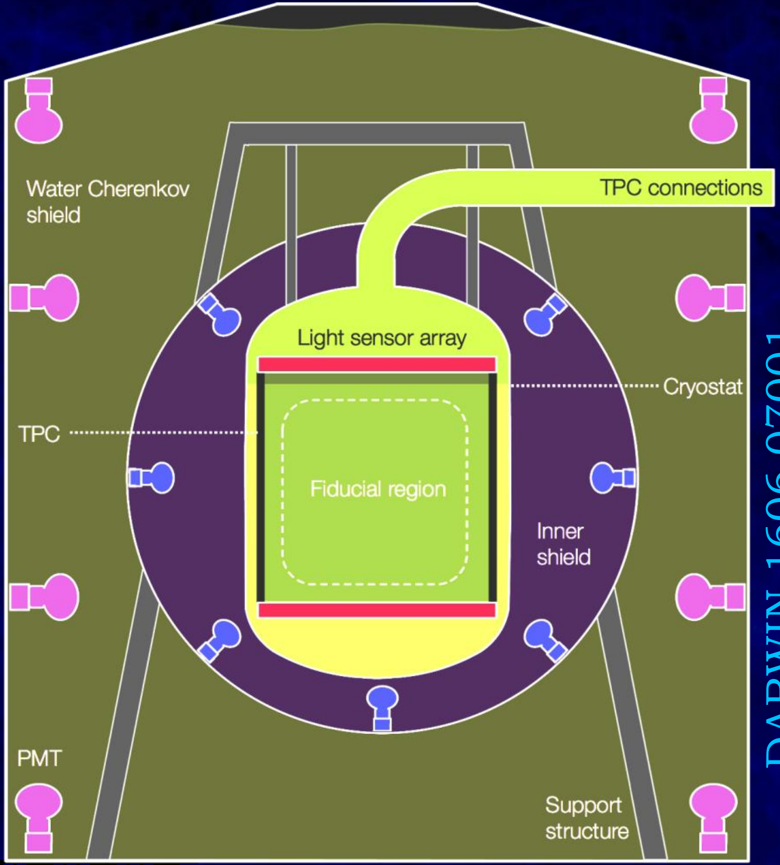
Conceptual Design

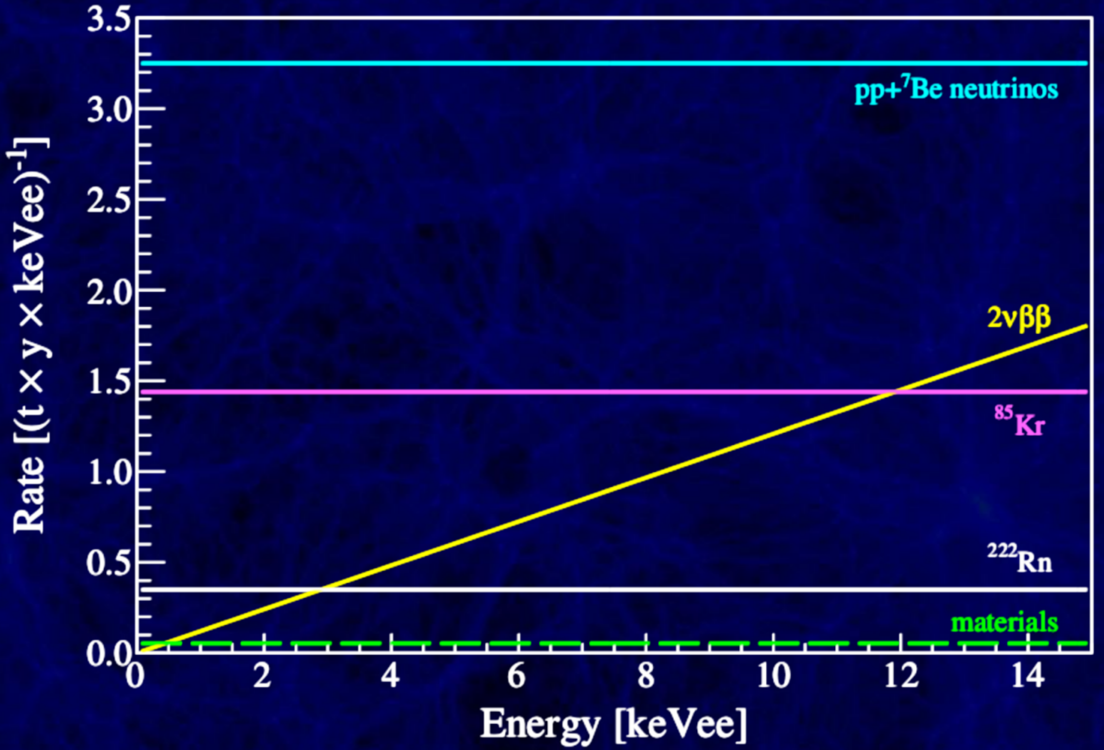
- Based on proven technologies
- Water Cherenkov shield
- Liquid scintillator neutron veto
- 40 ton liquid xenon TPC
- 2.6m height & diameter
- ~1800 3” or ~1000 4” PMTs
- Exposure >5 years



DARWIN 1606.07001

Background: pp solar ν signal

Schumann+ 1506.08309



pp ν signal

^{136}Xe (assumes ^{nat}Xe)

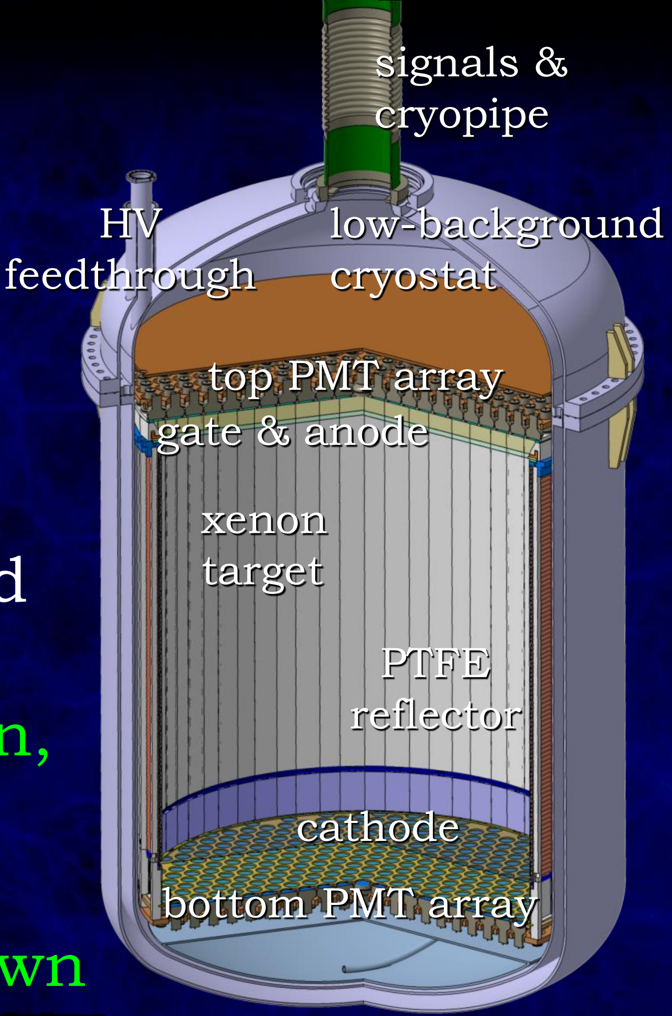
0.1ppt ^{nat}Kr (half XENON1T design)

0.1μBq/kg ^{222}Rn (1% XENON1T design)

materials fiducialized

Challenges & Status

- Xenon - long lead time. Re-use existing experiments' inventories
- High Voltage - 0.5kV/cm drift requires 130kV. 100kV shown, improved electrode design
- Purity – remove electronegative and radioactive contaminants. Liquid recirculation, online cryodistillation, surface treatment, fluid motion
- Discrimination – collect exposure faster. 10^{-5} at 50% acceptance shown



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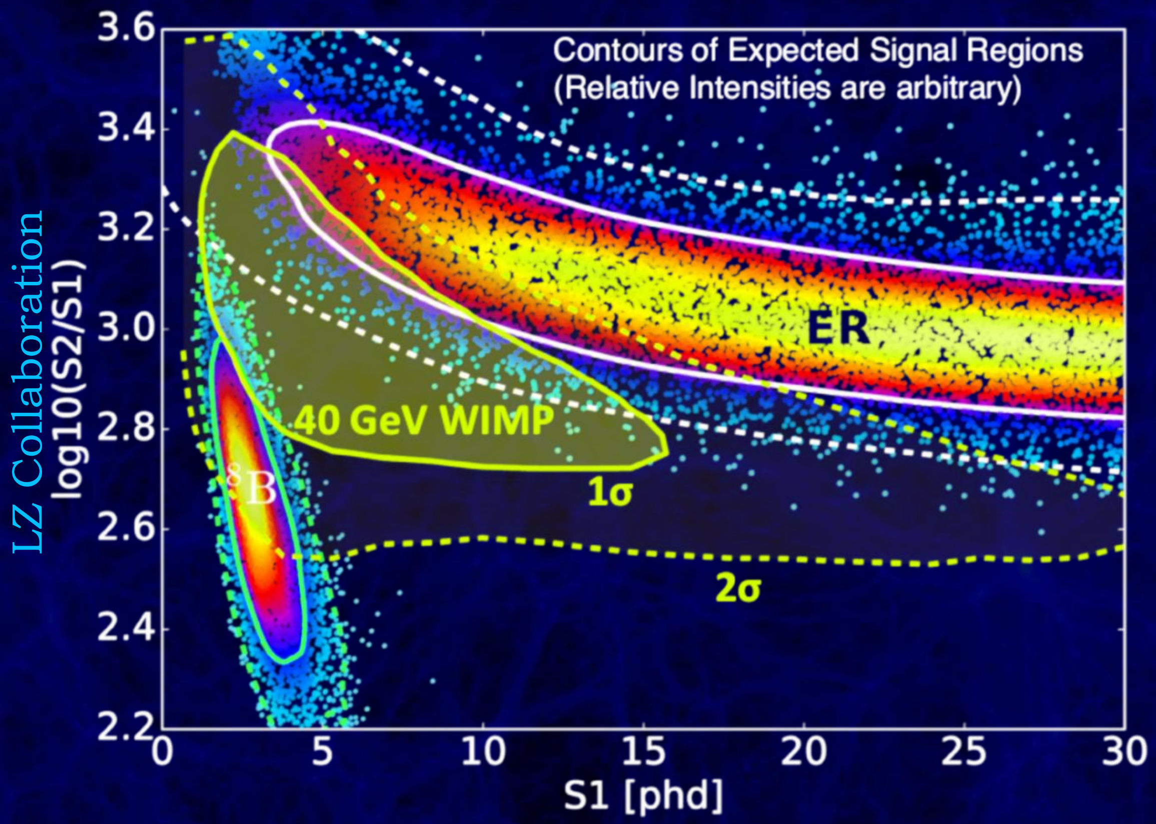
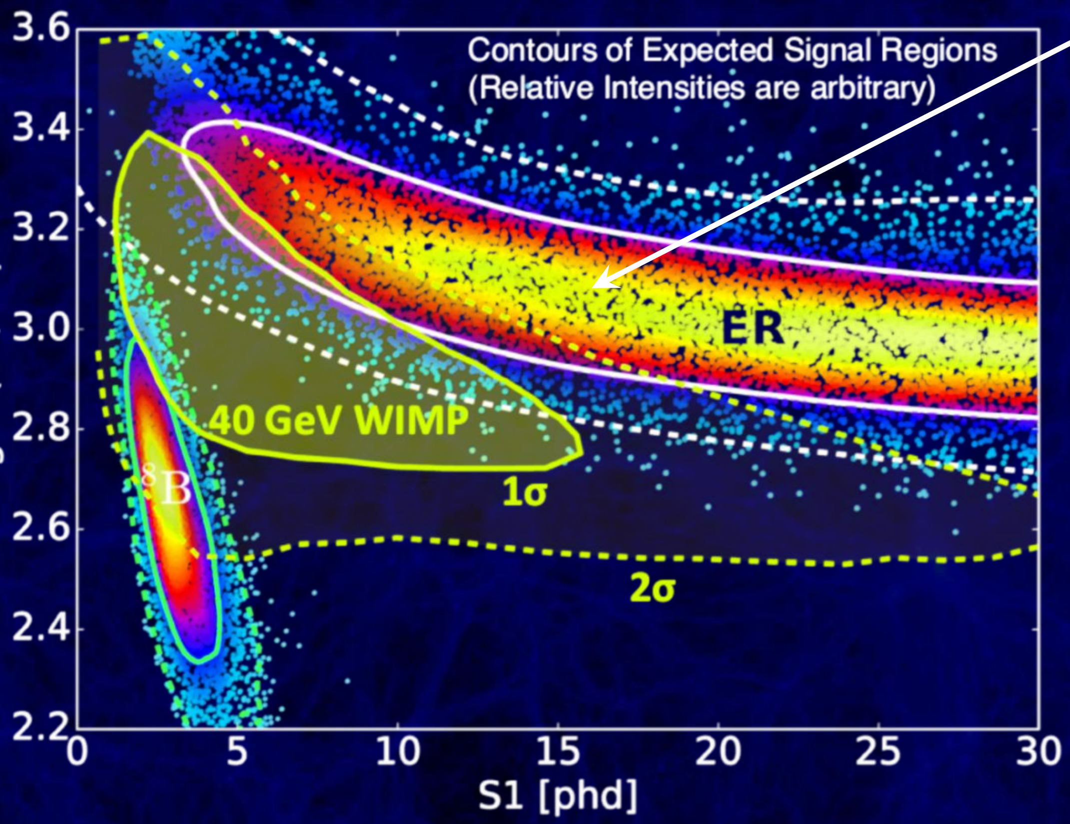
K.Ni et al.

Three Low-Energy Signal Regions



demonstrated discrimination $>10^{-5}$ driven by light yield and field uniformity

Three Low-Energy Signal Regions

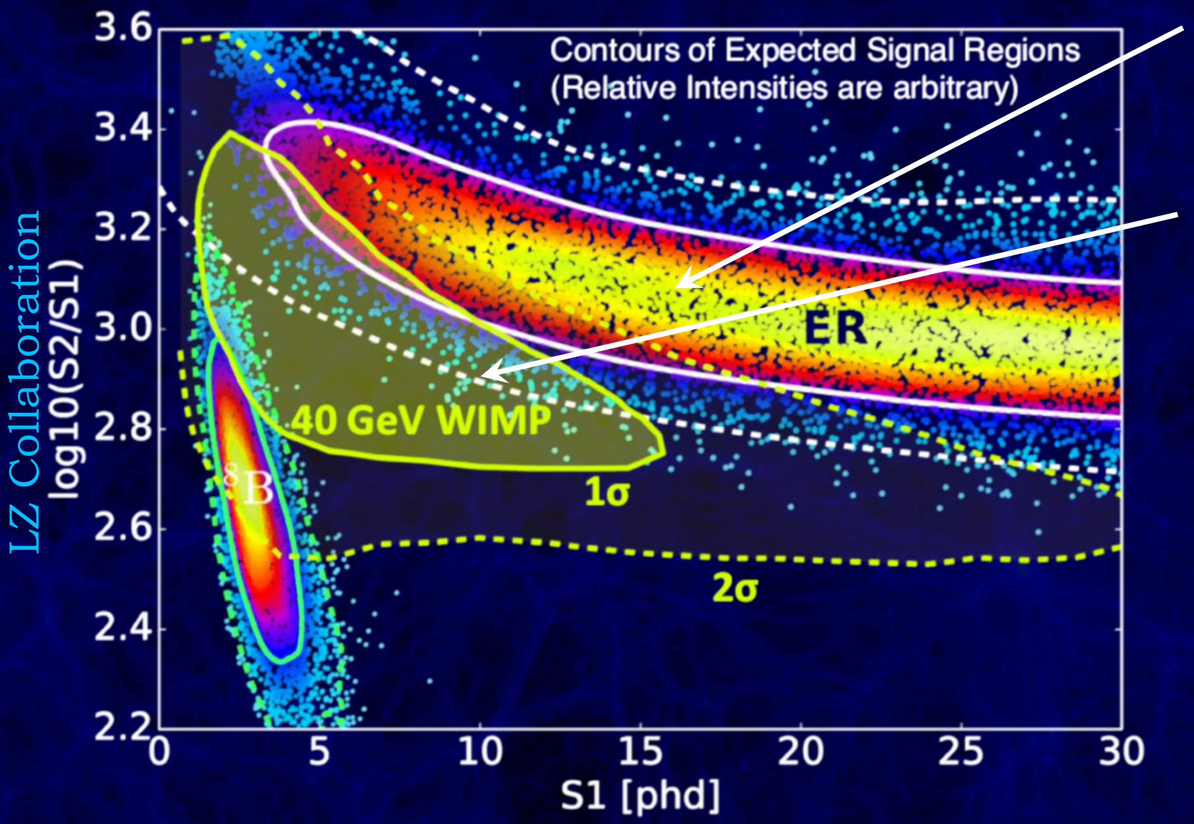


LZ Collaboration

electronic recoils: measure pp solar ν

demonstrated discrimination >10^{-5} driven by light yield and field uniformity

Three Low-Energy Signal Regions



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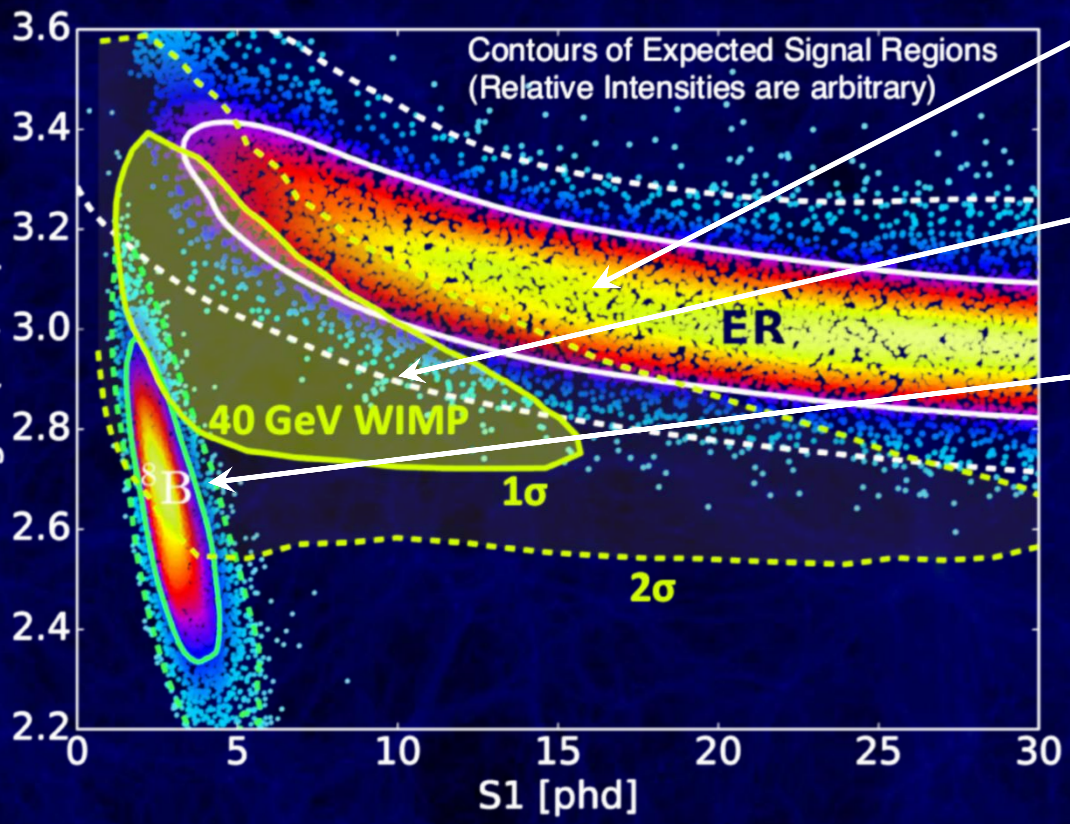


LZ Collaboration

electronic recoils: measure pp solar ν

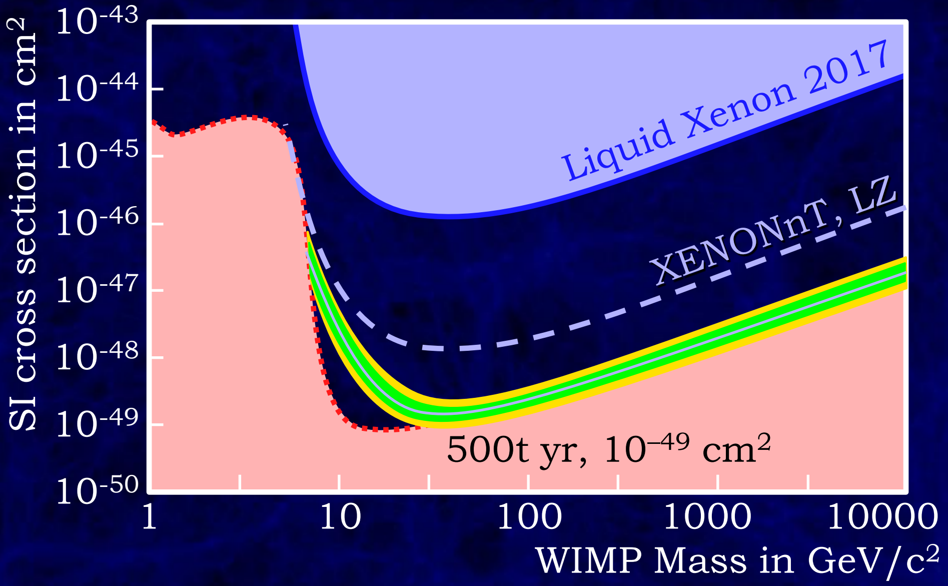
nuclear recoils search WIMPs

nuclear recoils: measure ^8B solar ν

demonstrated discrimination >10^{-5} driven by light yield and field uniformity

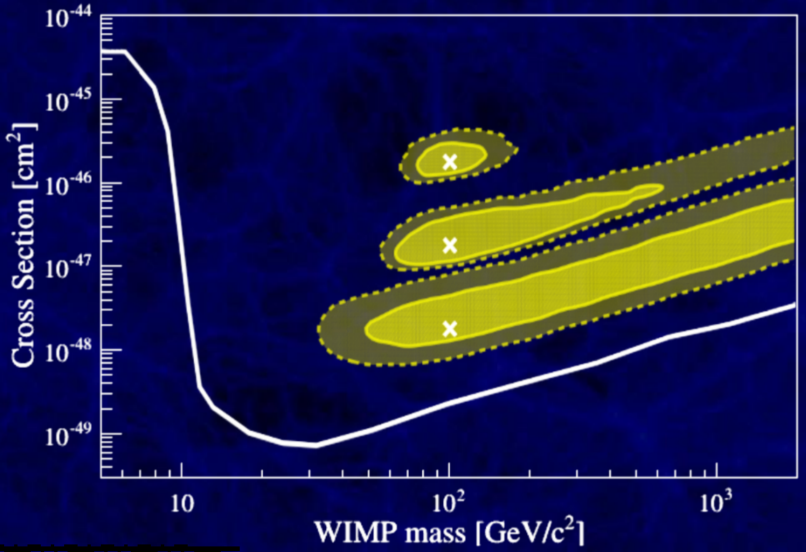
WIMP Sensitivity & Reach

Schumann+ 1506.08309



with signal, measure

- SI & SD couplings
- WIMP mass
- first halo properties



Newstead+ 1306.3244

includes all backgrounds, 99.98% ER rejection @30% NR acceptance, likelihood with combined energy scale 5-35 keV$_{nr}$ and light yield 8 PE/keV

Many Dark Matter Channels

Anything that interacts with electrons or nuclei really:

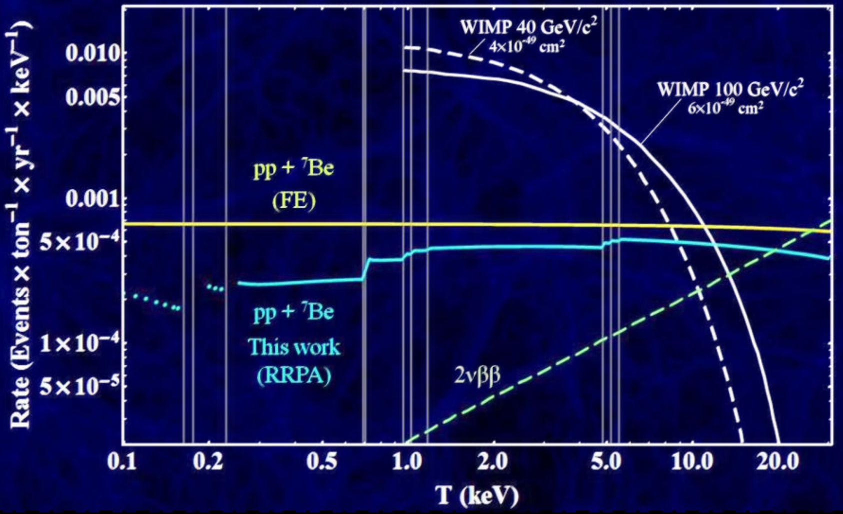
- spin-independent & spin-dependent WIMPs
- inelastic and general EFT couplings
- S2-only for GeV WIMPs
- with Bremsstrahlung searches for 100 MeV WIMPs
- leptophilic dark matter, axial-vector interactions
- Axion-like particles and Solar axions
- SuperWIMPs
- dark photons
- keV sterile neutrinos

Solar Neutrino Elastic Scattering

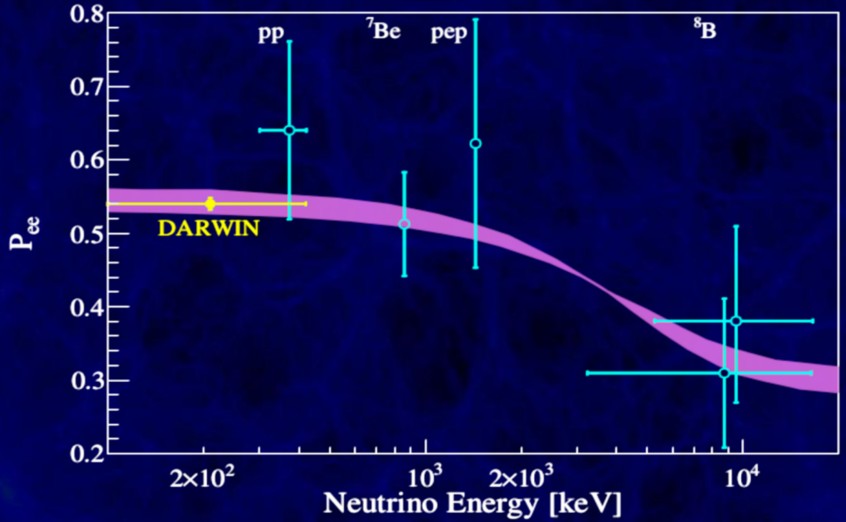
3 (keV t yr)$^{-1}$ from pp $\nu_e + e^- \rightarrow \nu_e + e^-$

extra 8% from ^{7}Be

flux known to 2% but free electron approximation bad:



Chen+ 1610.04177



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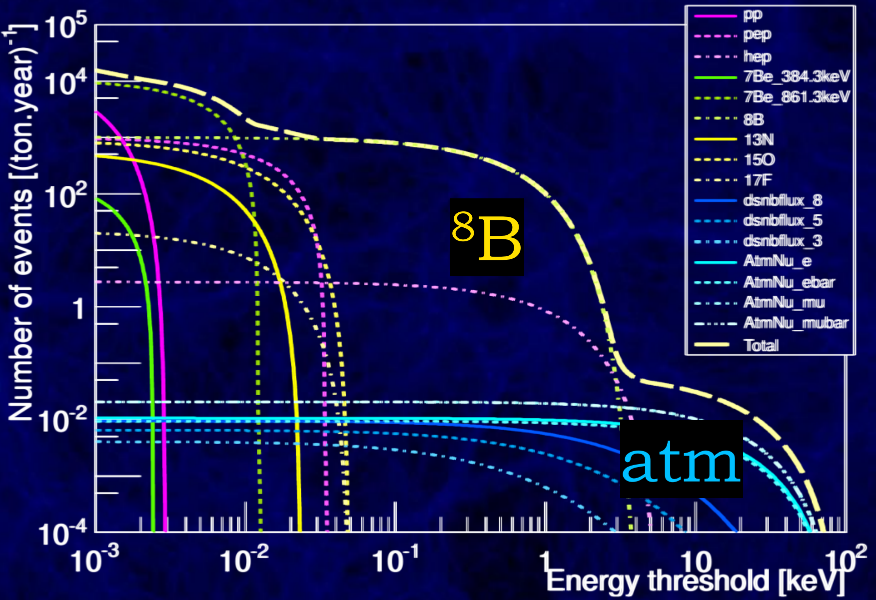
- Refine solar models
- Measure $\sin^2\theta_W$ to ~1%
- Measure ^{7}Be ν flux

Coherent Neutrino Nucleus Scattering

$\nu_x + N \rightarrow \nu_x + N$

once transferred momentum $p > \hbar / r_{\text{nucleus}}$

get same coherence effect as for WIMPs: $\sigma \propto A^2$



90 ^{8}B ν from Sun/t/yr
above 1keV$_{nr}$:
solve solar metallicity

3×10^{-3} atmospheric ν/t/yr
above 3 keV$_{nr}$:
probe at low energies

Billard, Strigari & Figueroa-Feliciano 1307.5458

DARWIN 1606.07001 Haxton 1208.5723

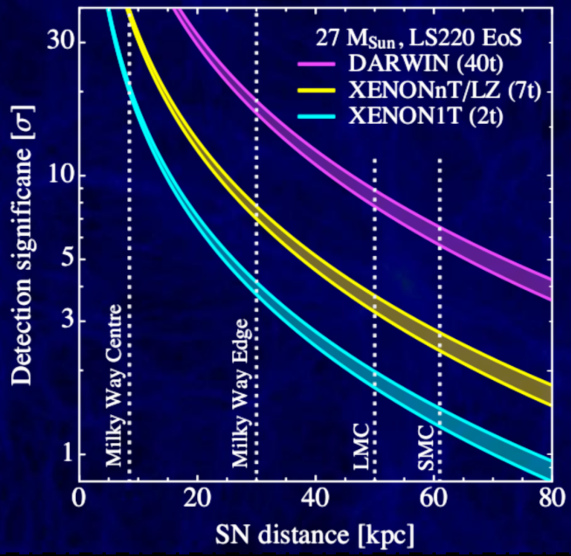
Supernova!

$\nu_{e,\mu,\tau} + \mathrm{Xe} \rightarrow \nu_{e,\mu,\tau} + \mathrm{Xe}$

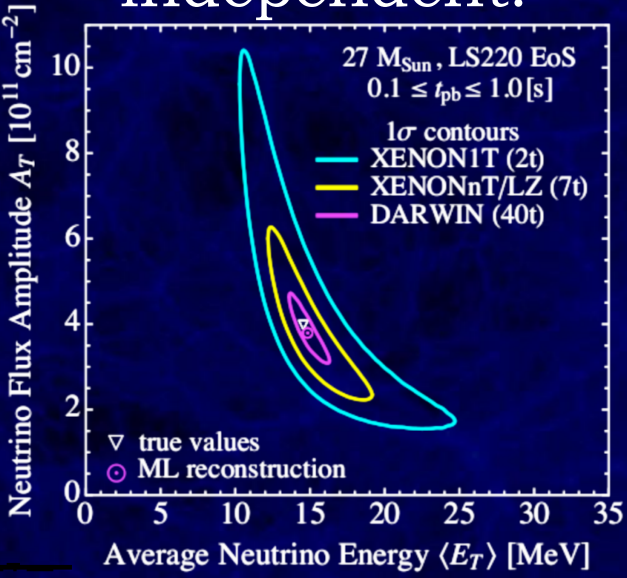
few second burst:
S2 only analysis

CC: $\mathcal{O}(0.1)\bar{\nu}_e$/t
versus
CNNS: $\mathcal{O}(10)\nu_x$/t

sensitivity
out to SMC



flavor-
independent!



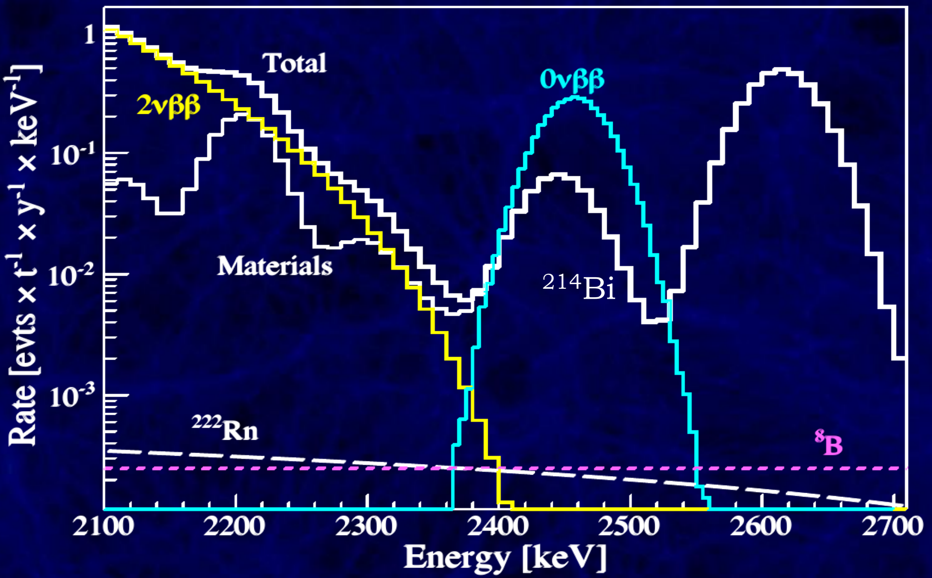
Rafael+ 1606.09243

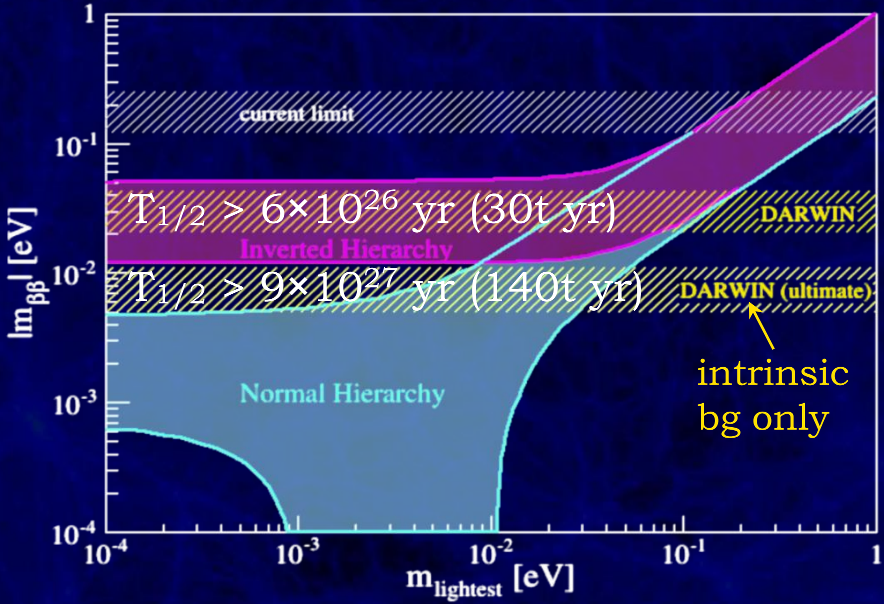
^{136}Xe 0ν2β With ^{nat}Xe Target

$^{136}\mathrm{Xe} \rightarrow {}^{136}\mathrm{Ba} + 2e^-$ (abundance 8.9%, i.e. ~4t in target)

Requires large dynamic range of detector

Baudis+ 1309.7024





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Plus: DEC on ^{124}Xe and ^{7}Be-ν capture on ^{131}Xe

A Xenon Rare Event Observatory

- Close WIMP gap: probe down to atmospheric ν signal
- Use scale-up of proven technology
- Xenon sensitive to wide array of dark matter models including spin-dependent and electron couplings
- ^{136}Xe Double Beta experiment
- pp, ^{7}Be, ^{8}B and Supernova neutrino detector

- Consortium formed in 2009, commissioning ~2025
- Currently 25 groups from 11 countries
- Many expressions of interest - contact us to join

darwin-observatory.org