Listening for dark matter

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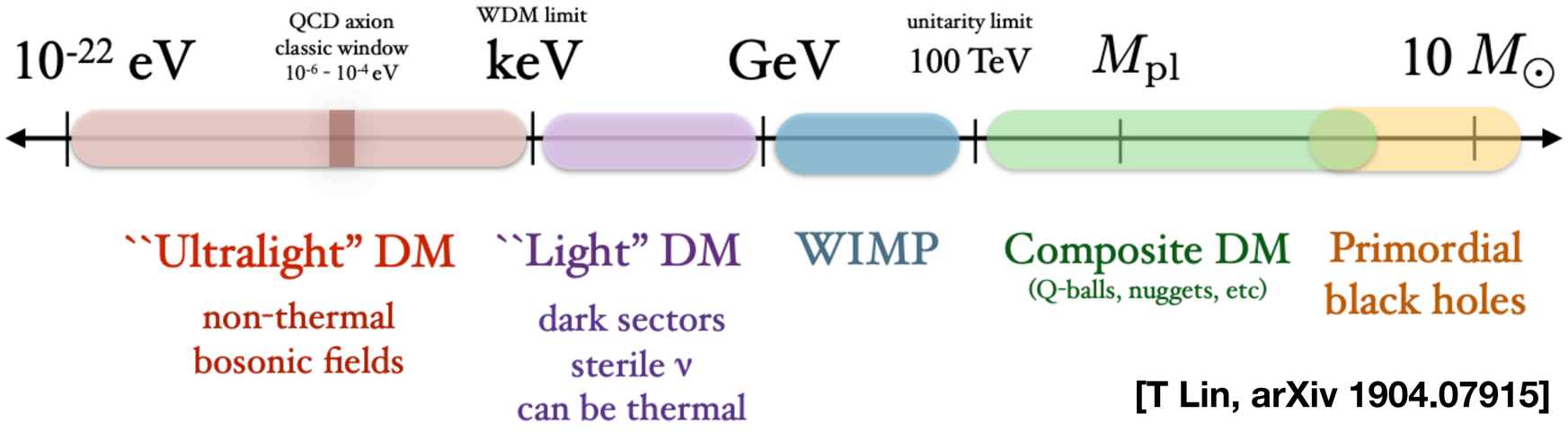
Gong Talk, YTF 2023, IPPP Durham

What do we know?

$$\Omega_{\rm CDM} h^2 \sim 0.120 \pm 0.001$$

[Planck, 2018]



[T Lin, arXiv 1904.07915]

What are Direct Detection (DD) experiments sensitive to?

σ_χ ✗

$\frac{\sigma_\chi}{m_\chi}$ ✓

Why? Density of DM is **fixed**

↓

Higher mass, lower number density $n_\chi \sim 1/m_\chi$

↓

Experiment with **higher exposure required** to constrain **same cross section**

Macroscopic Dark Matter

- **General class** of DM with:
  - Planck-mass (or above) $m_\chi \gtrsim M_{pl}$ - often parameterised in grams (!)
  - DM nucleon cross section is roughly that of the geometric cross section $\sigma_{\chi N} \approx \sigma_{\chi,geo} \equiv \pi R_\chi^2$.
  - R_χ encodes the macro geometry (from being constituent DM) and absorbs any short range interaction - correction to the geometric radius

Who has large exposure experiments?

- Proposition for **acoustic neutrino experiments.**
- Designed to find low number density UHE Neutrinos
- Showers created from PeV-EeV (10^{15} - 10^{18} eV) neutrinos could create a detectable pressure wave from **thermo-acoustic heating.**

Energy Deposition Density

$$\nabla^2 P(\mathbf{r},t) - \frac{1}{c_s^2}\frac{\partial^2 P(\mathbf{r},t)}{\partial t^2} = -\frac{\alpha}{C_p}\frac{\partial^2 q(\mathbf{r},t)}{\partial t^2}$$

Acoustic pressure

What experiment can be done?

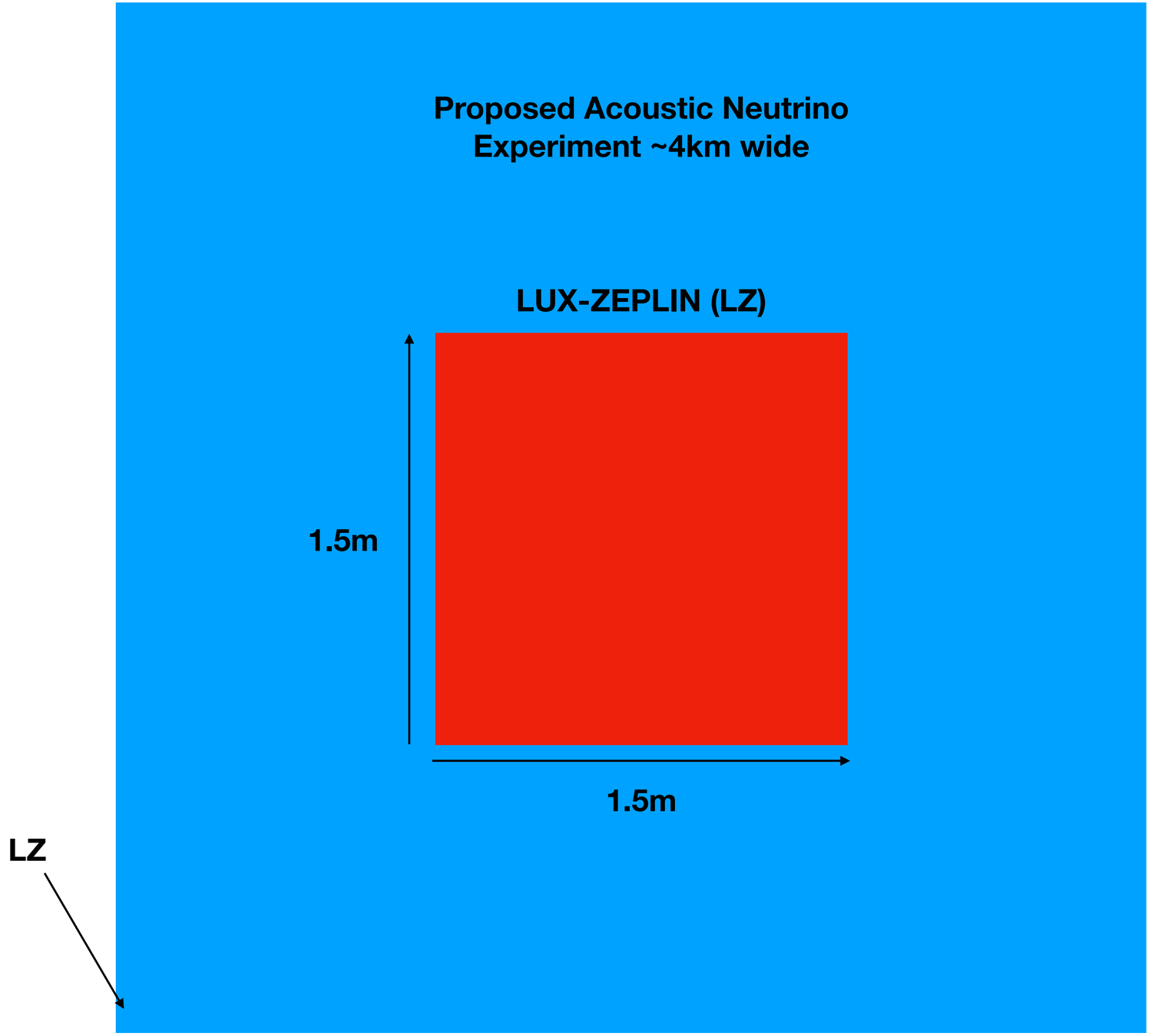
- Idea: Instrument **up to 100km^3 of water** (albeit ambitiously) with sensitive hydrophones to detect the resulting pressure wave

- **Why not also look for macro dark matter?**

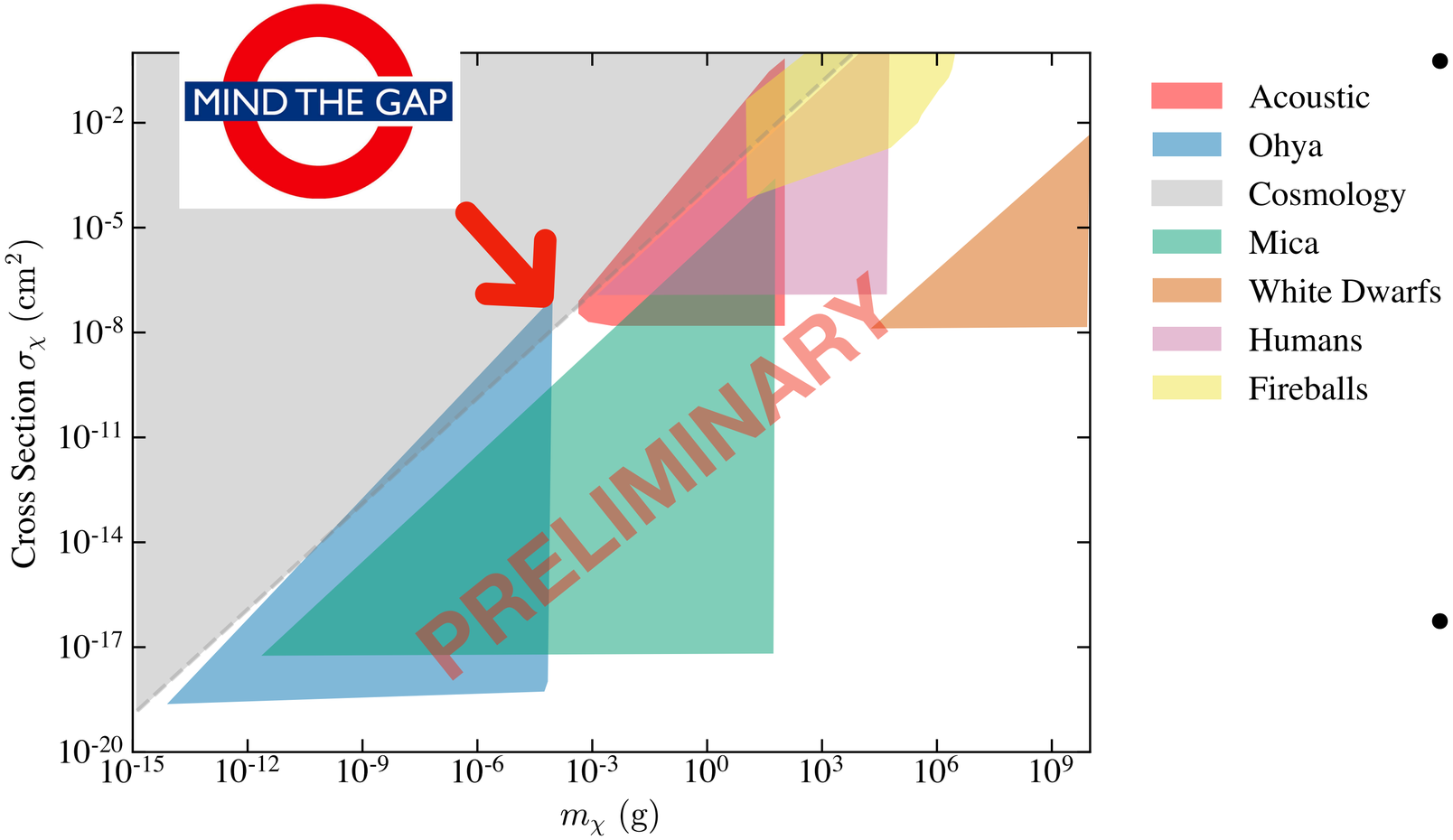
$$\left(\frac{dE}{dx}\right)_{\text{water}} = \rho_w \sigma_\chi v_{\chi i}^2 \exp\left(-2\frac{\sigma_\chi}{m_\chi}\rho_w L\right)$$

Thermoacoustic Heating (meat of calculation)

$$P(\mathbf{r}, t)$$


Proposed Acoustic Neutrino
Experiment ~4km wide
LUX-ZEPLIN (LZ)
1.5m
1.5m
LZ

Sensitivities



- With hydrophones available **right now**, bounds lie mostly within already excluded space
  - Mica [1] and Humans [2] bounds overlap
- **Better hydrophone sensitivity = better cross section sensitivity - could plug the gap!**

[1] D. M. Jacobs, G. D. Starkman, and B. W. Lynn, Macro dark matter (2015).
[2] J. Singh Sidhu, R. J. Scherrer, and G. Starkman, Death and serious injury from dark matter (2020)

Punchline

Macro dark matter, despite its low number density, could be detected in proposed acoustic neutrino experiments!

Thank you for listening