Are five tonnes of xenon enough?

Prof. Simon Viel

(Carleton University)

Neutrinoless double beta decay in liquid xenon – Next generation experiment workshop

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Arthur B. McDonald
Canadian Astroparticle Physics Research Institute

Are five tonnes of xenon enough?

- Hinchliffe's rule:
  - If a research paper's title is in the form of a yes/no question, the answer to that question will be "No".

IS HINCHLIFFE'S RULE TRUE? *

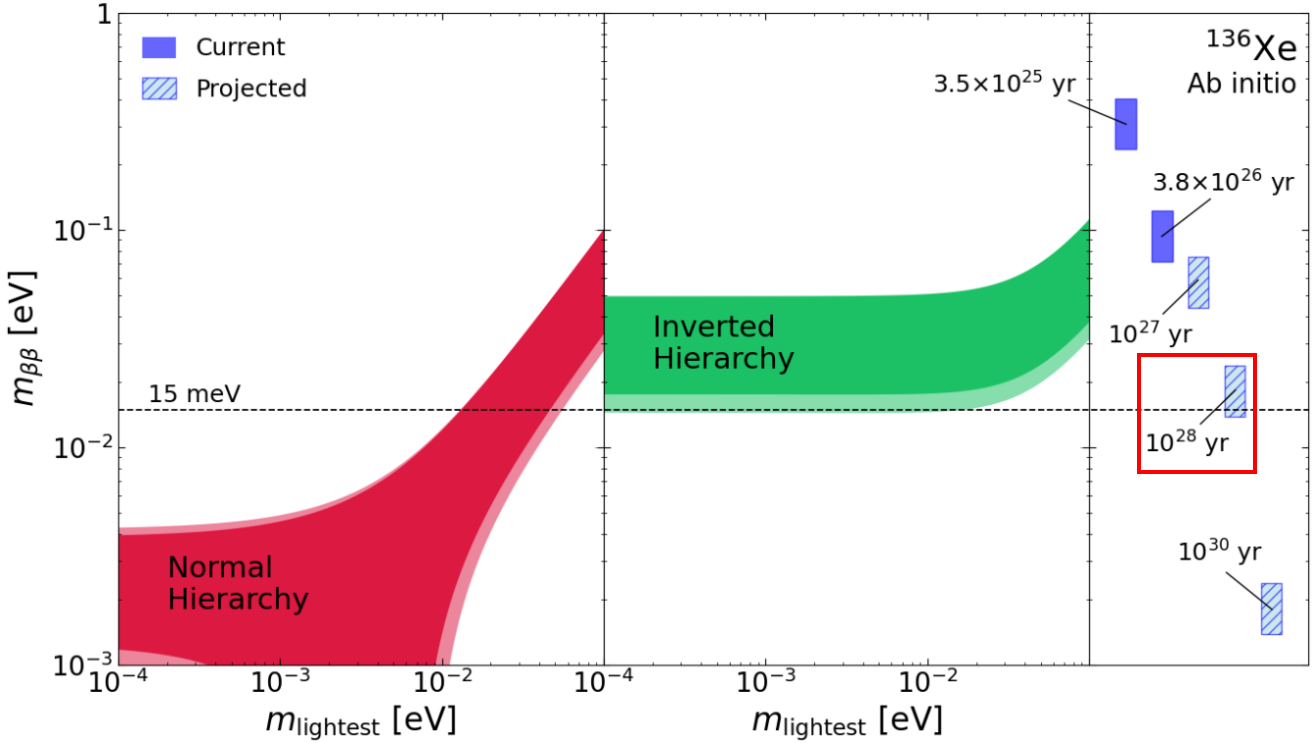
Boris Peon

Abstract

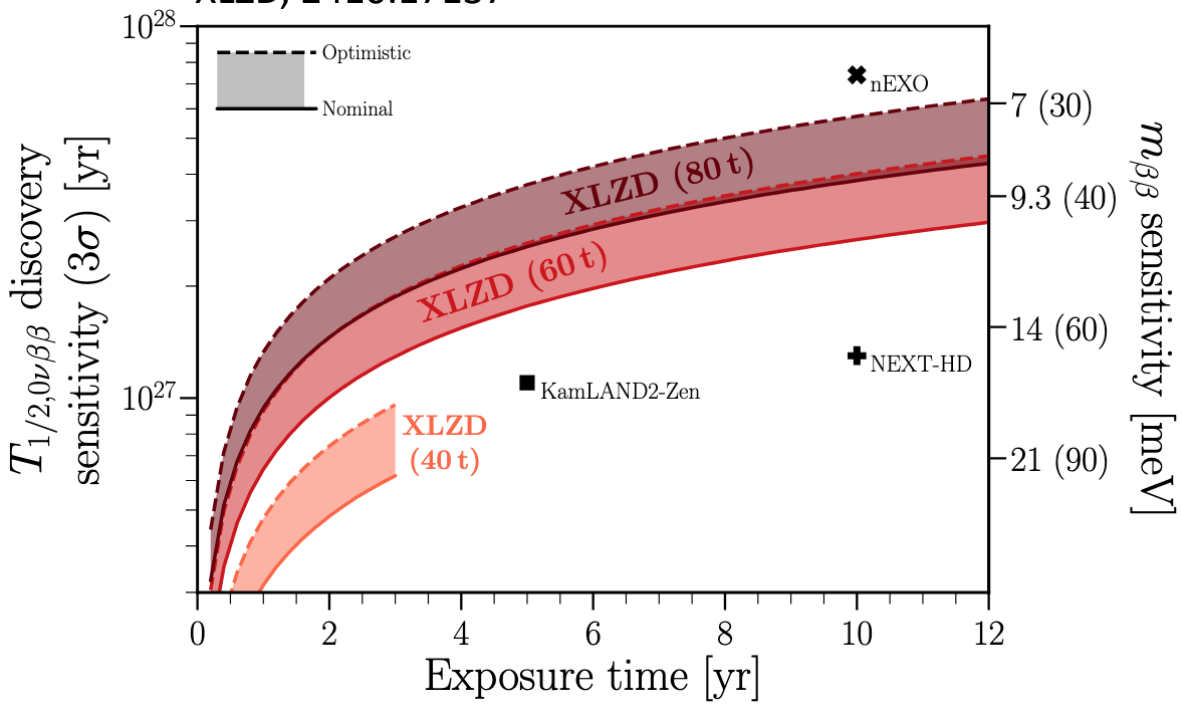
Hinchliffe has asserted that whenever the title of a paper is a question with a yes/no answer, the answer is always no. This paper demonstrates that Hinchliffe's assertion is false, but only if it is true.

On neutrinos and lobster

Figure courtesy of TRIUMF ab initio theory group (2025)

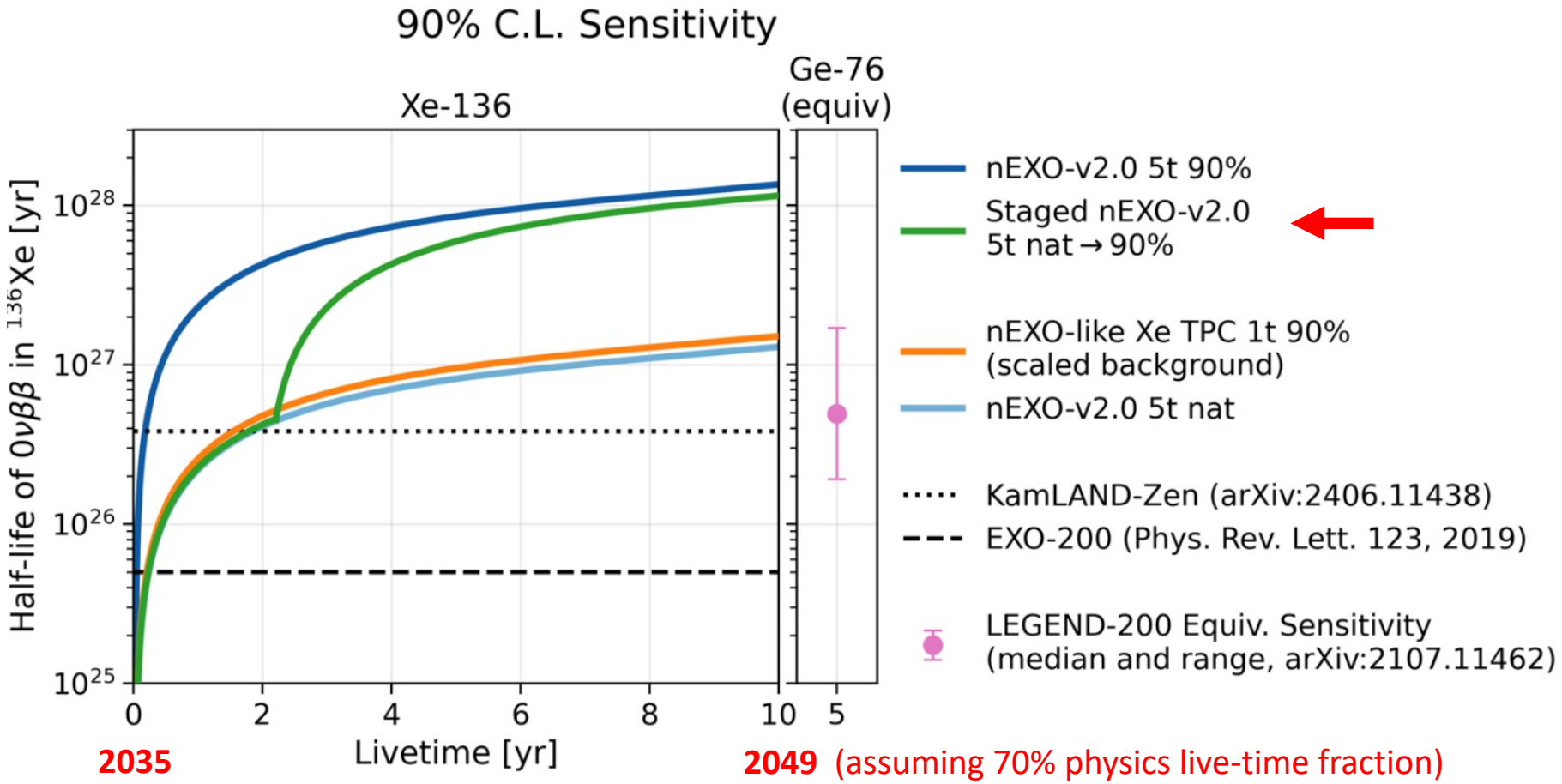


XLZD, 2410.17137



- We will know the neutrino mass ordering *relatively soon*. It may be normal.
- It's worth thinking now about scalability, on the 2050 timescale

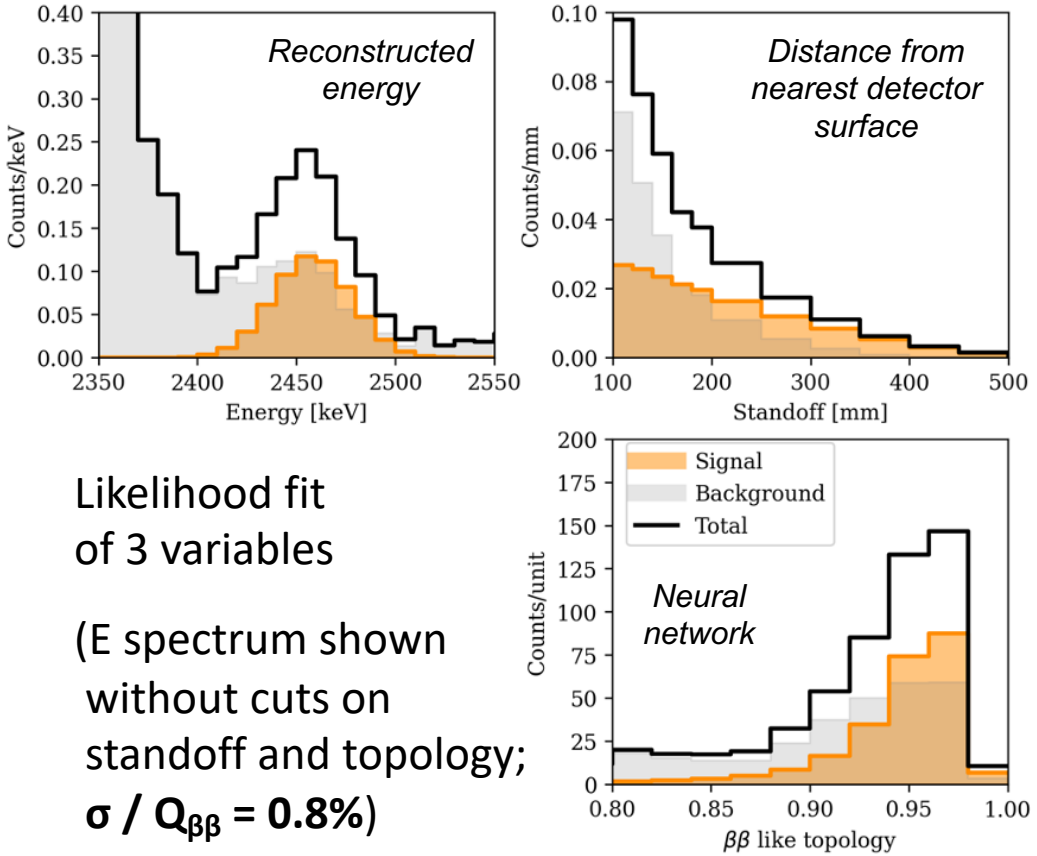
On alternative timelines and a phased approach



- Start with as large a target of natural xenon as possible, to allow upgrade path
- "5t 90%" enough in principle to reach $T_{½} = 10^{28}$ years. What about starting with > 5 tonnes LXe?

On resolution and radioactive background control

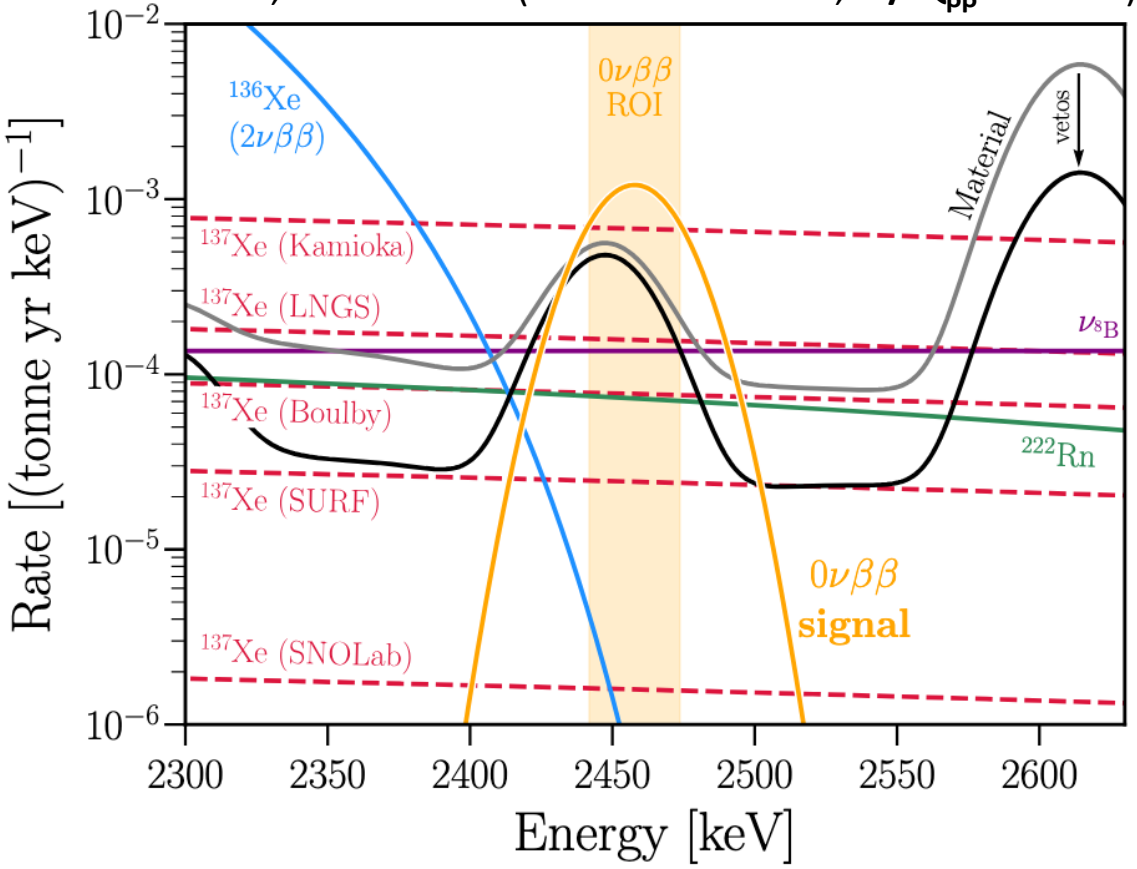
nEXO, J. Phys. G: Nucl. Part. Phys. 49, 015104 [extra material]



Likelihood fit of 3 variables

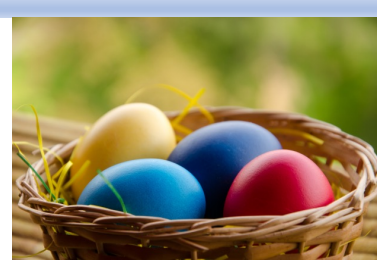
(E spectrum shown without cuts on standoff and topology; **σ / $Q_{ββ}$ = 0.8%**)

XLZD, 2410.17137 (in fiducial volume; **σ / $Q_{ββ}$ = 0.65%**)



- Expected sensitivity of nEXO design is better, despite having *less* ^{136}Xe isotope than XLZD
- Is there a path to improving sensitivity to 0νββ in a 60-80 tonnes nat. LXe TPC?

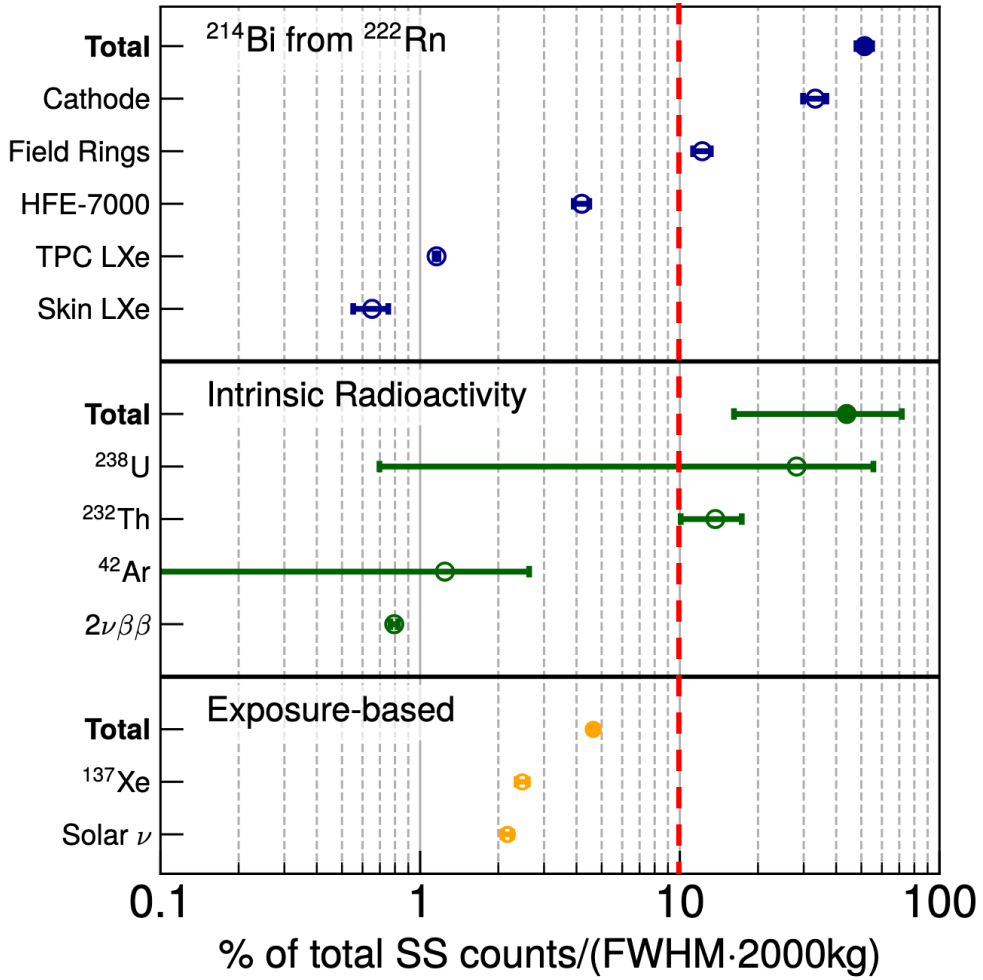
On convergence and collaboration

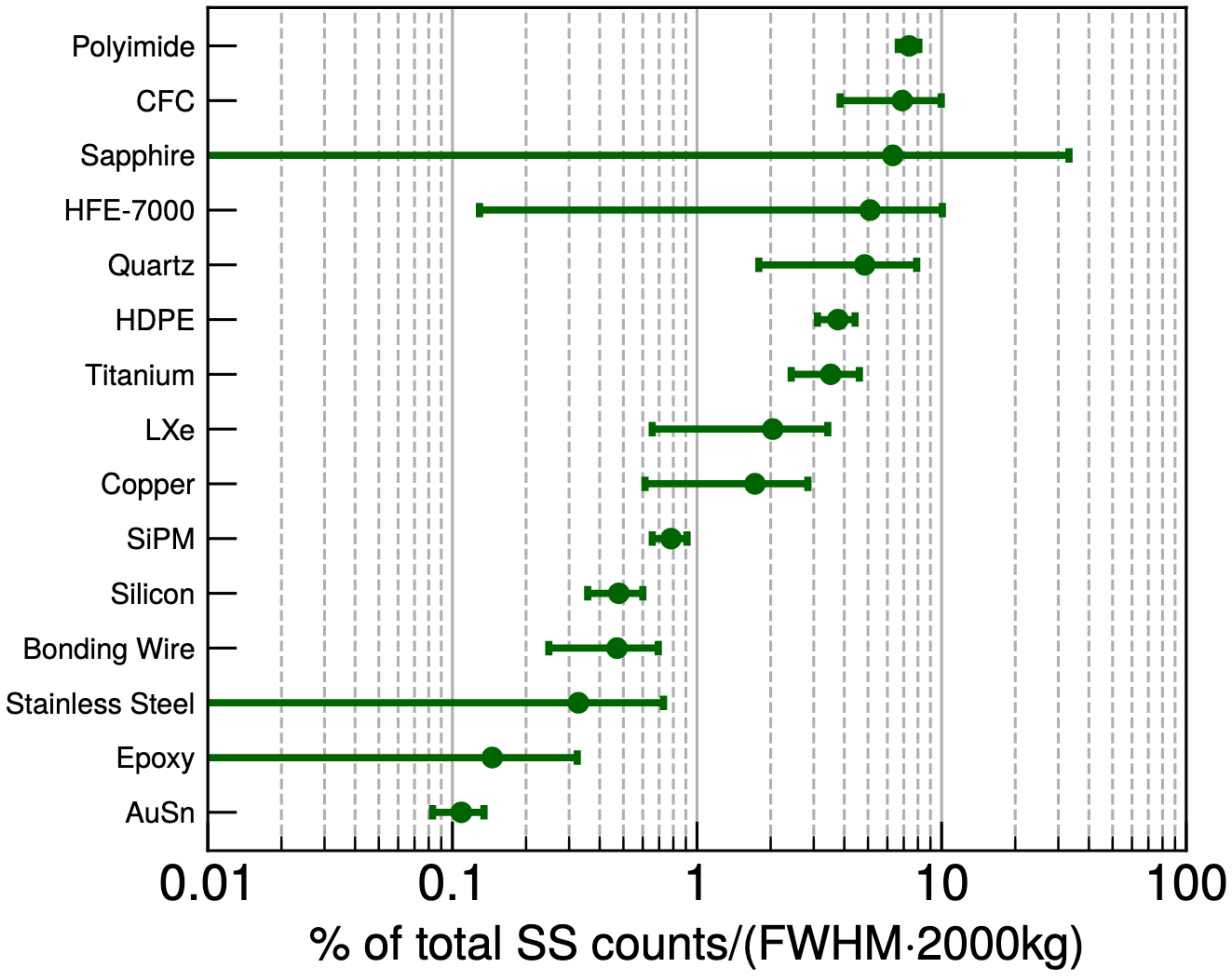


- nEXO design is optimized for 0νββ sensitivity… XLZD design is not
  - For attracting researchers whose focus is 0νββ in xenon, would XLZD welcome design contributions aiming to **improve 0νββ sensitivity**?
    - Without compromising sensitivity to DM – better radio-purity can only help
    - Or is the current XLZD design considered frozen? (In which case there's less room for us)
  - Are XLZD members willing to make SNOLAB their top choice, if Canadians join? (Not clear)
  - Are Canadians ready to help build XLZD? (In the SNOLAB Cryopit, yes? Elsewhere, I guess not?)
- Blue sky: Can we envisage a future run with enriched xenon?
  - "Absorb EXO into the acronym of acronyms" (**EXLZD** ?!)
  - Would need investments to boost xenon extraction in partnership with commercial plants
  - Sensitivity to $T_{½} = 10^{29}$ years: can we ever get the **backgrounds** that low?
    - Otherwise… we'd be deciding that 10^{28} years is the limit, and then 5 tonnes of ^{136}Xe *may be enough*

Bonus slide: nEXO background model

nEXO, J. Phys. G: Nucl. Part. Phys. 49, 015104





I've drawn a dashed line at 10% of design background. Very challenging.