

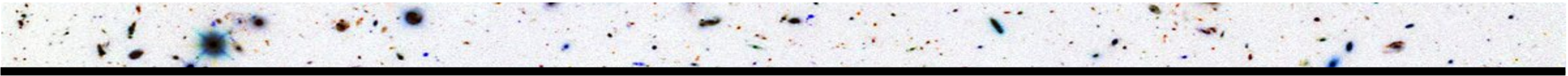
XLZD RARE EVENT OBSERVATORY FOR DARK MATTER AND NEUTRINO PHYSICS

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Imperial College London & STFC Rutherford Appleton Laboratory

15th September, 2026

SECOND WORKSHOP ON NEUTRINOLESS DOUBLE BETA DECAY IN XENON, MANCHESTER, 14-18 SEPTEMBER 2026



RARE EVENT OBSERVATORY BASED ON THE NOBLE LIQUID XENON

Dark Matter

LZ ([2609.02823](#))

“Who ordered this?”

WIMPs

GeV

Inelastic
Axion-like particles
Planck mass
Dark photons



Science White Paper (2023)

OPEN ACCESS

IOP Publishing

J. Phys. G: Nucl. Part. Phys. 50 (2023) 013001 (115pp)

Journal of Physics G: Nuclear and Particle Physics

<https://doi.org/10.1088/1361-6471/ac941a>

Topical Review

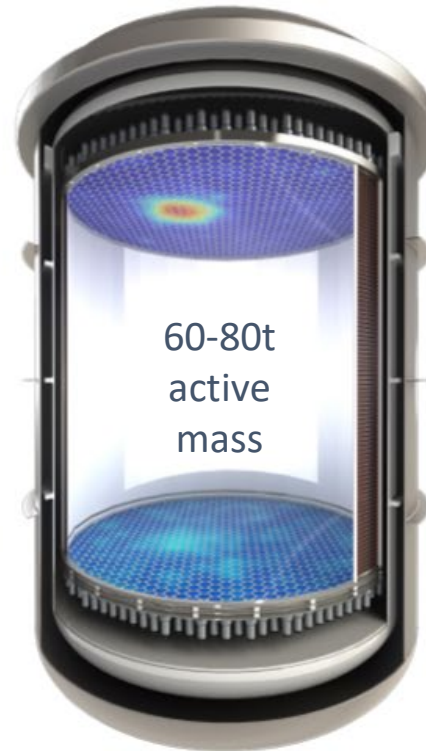
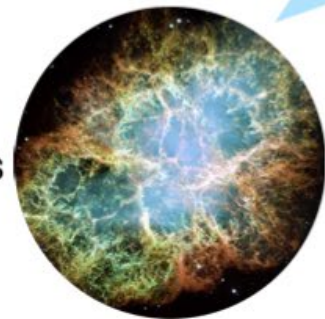
A next-generation liquid xenon
observatory for dark matter and neutrino
physics

[2410.17137](#)

XLZD Design Book
(experimental strategy)

Supernovae

Early alert
Supernova neutrinos
Multi-messenger
astrophysics



Neutrino nature

Neutrinoless double
beta decay
Neutrino magnetic
moment
Double electron
capture



[2410.19016](#) ONBB sensitivity

Also, see Aiham's LZ talk Thursday

B-8 via CEvNS by LZ ([2608.29450](#)),
XENONnT ([2604.06002](#)) & PandaX-4T)

Sun

pp neutrinos
Solar metallicity
 ^7Be , ^8B , hep



pp solar neutrino detection by XENONnT ([2608.29450](#))

XENON + LUX-ZEPLIN + DARWIN + FRIENDS & RELATIONS

XLZD

- Consortium of X+LZ+D collaborations formed in 2021
 - Think Manchester United joining forces with Manchester City...
- Unified scientific collaboration formalised in 2024
- Many new institutes joined since, notably from Canada, and more continue to join
- Approaching 500 scientists and engineers in over 80 institutes in 17 countries
- Conceptual Design activities ongoing across all 13 work packages

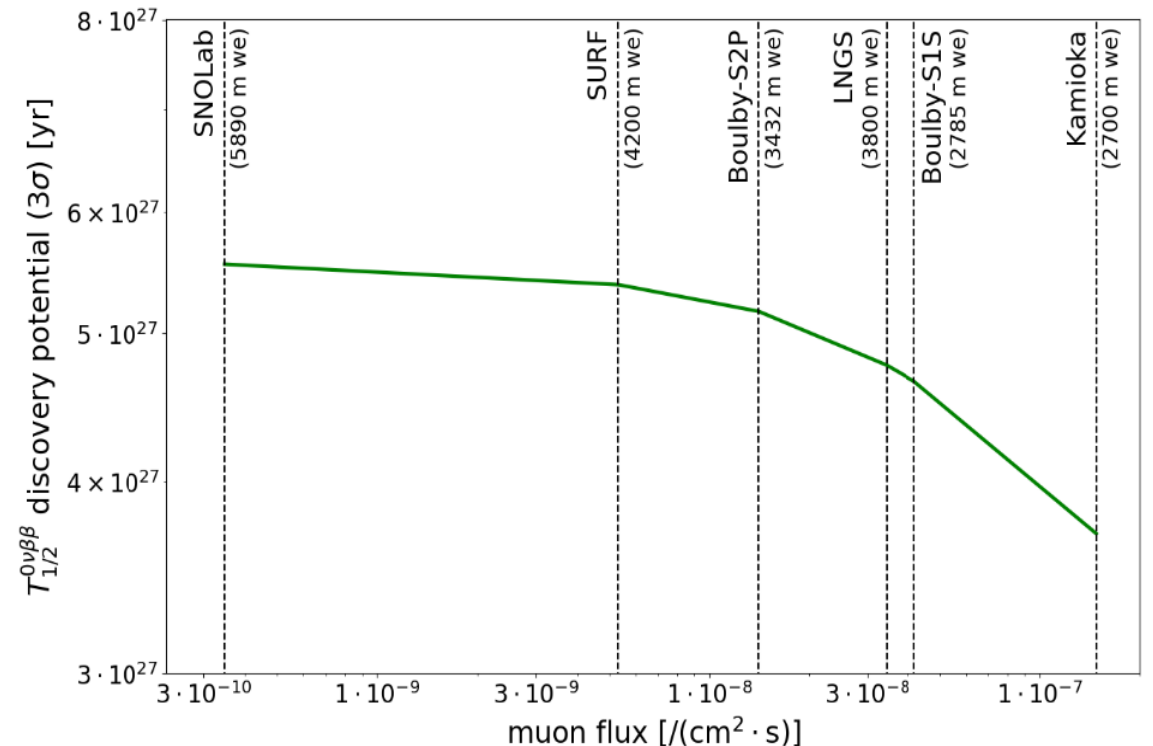
XLZD and 0NBB decay

- Collaboration has agreed to elevate 0NBB decay to a primary science requirement
- Much work to be done in this area: if you are interested in joining us, please reach out!



HOST LABORATORY

- Five underground laboratories expressed interest in hosting
- Four were shortlisted after careful internal process: Boulby, LNGS, SNOLAB, SURF
- Site selection will be mostly not in the hands of physicists: we can deliver our science at all these four sites



EXPERIMENTAL STRATEGY

Baseline [[2410.17137](#) XLZD Design Book]

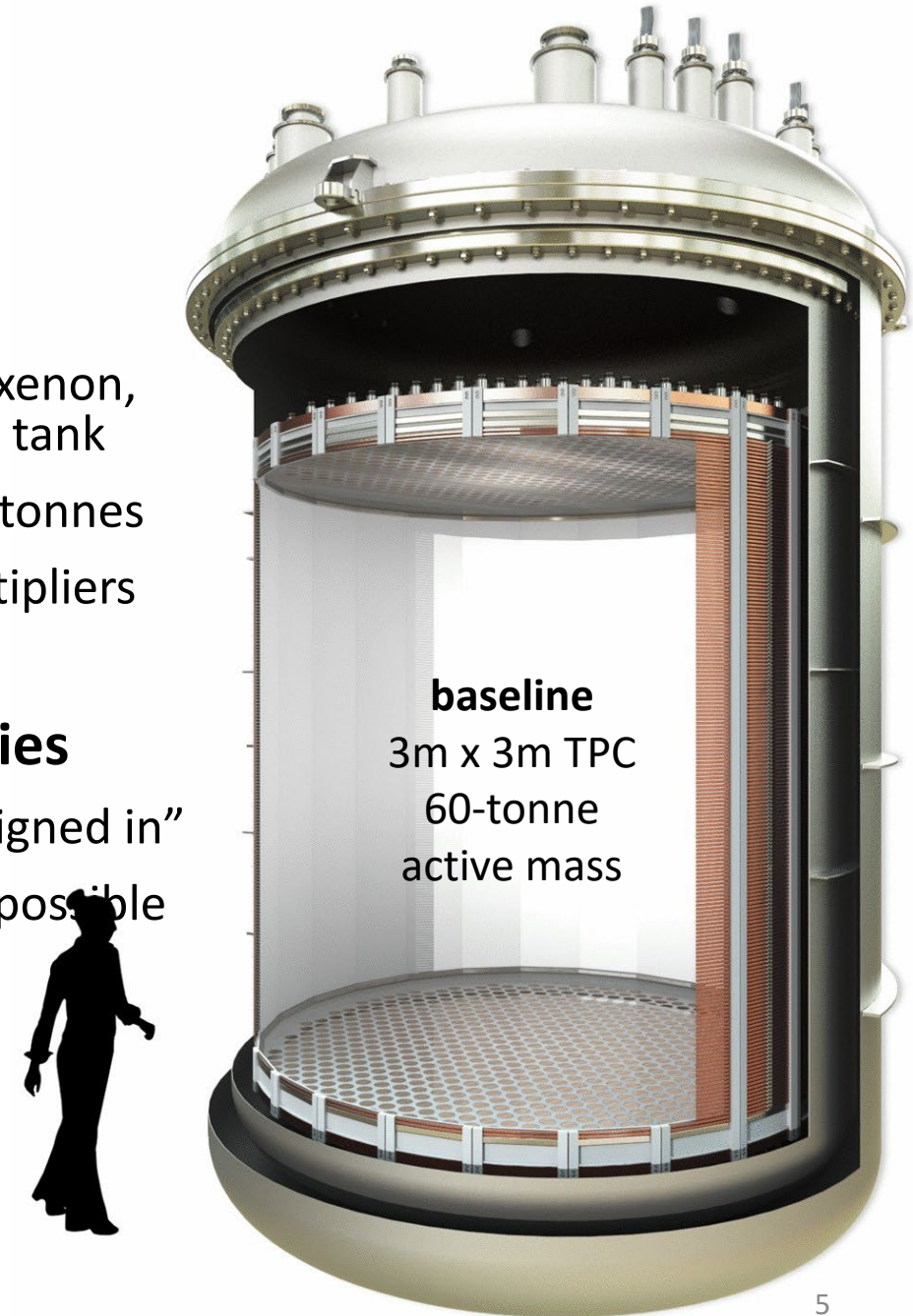
- Dual-phase xenon TPC with 60 tonnes of “active” mass of natural xenon, surrounded by a Skin Detector and an Outer Detector, 12 m water tank
- Fixed TPC diameter at 3 m, nominal height 3 m for 1x1 ratio at 60 tonnes
- Photosensors: 2- and 3-inch ultra-low-background VUV photomultipliers

Infrastructure designed to manage risks and opportunities

- 80-tonne TPC (3m→4m height) to meet 0NBB goal of 10^{28} yr “designed in”
- Early science & performance verification with smaller payloads is possible

We understand this technology

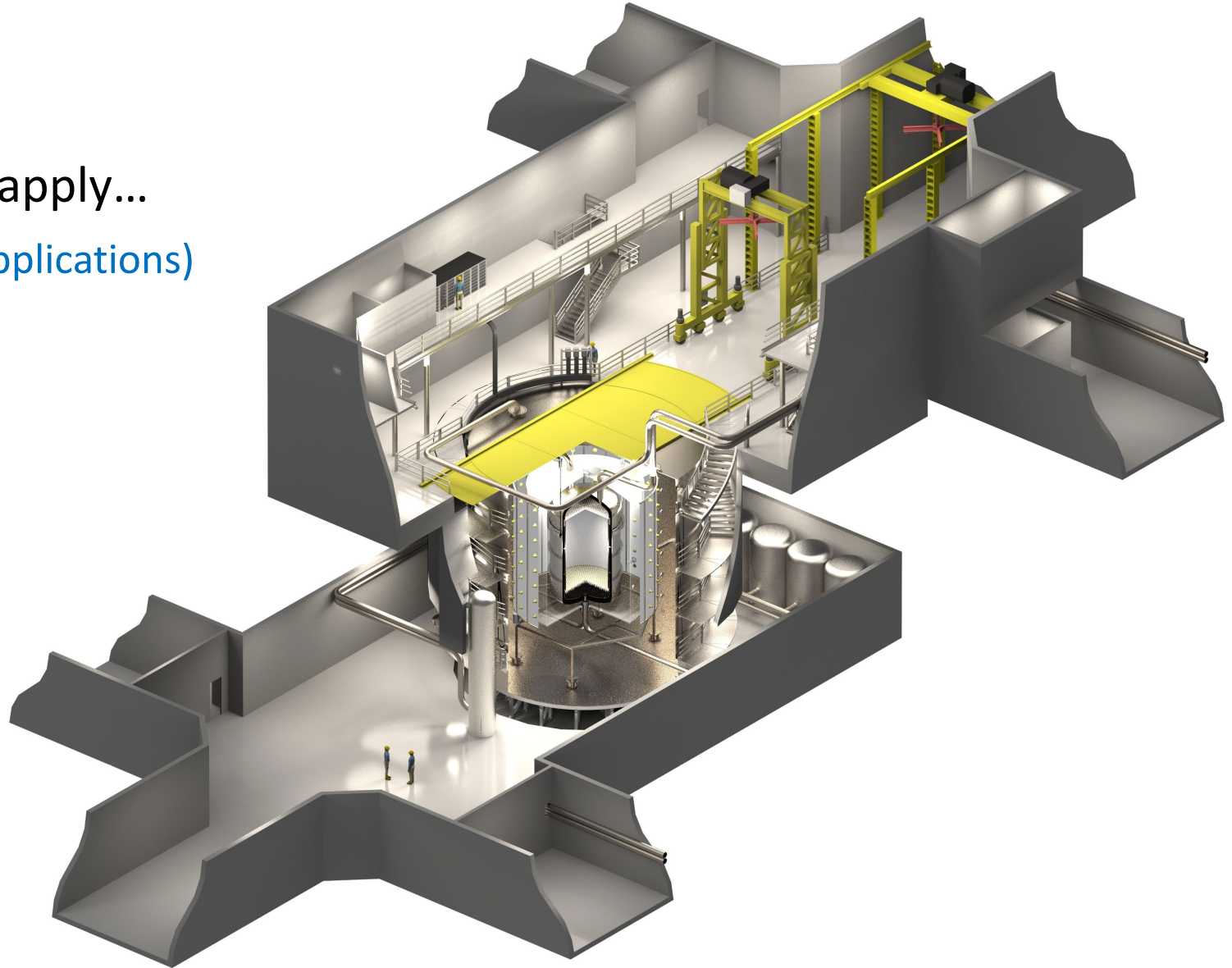
- Many DM searches delivered over the last 20 years
- 0NBB decay searches now emerging from these experiments too



TIMELINE

“Credible” timeline, usual caveats apply...

- Conceptual Design 2026/27 (funding applications)
- Site selection 2027-28
- Preliminary Design 2028/29 (baseline)
- Start of Construction 2029/30
- Start of Operations 2035
- Operations 15 years, nominally



CONFIGURING THE XLZD PROJECT FOR 0NBB DECAY

Requirements

- The science we want to do must be captured in formal project requirements: our metric for success
- **XLZD will have two top-level science requirements: on dark matter and on 0NBB decay sensitivity**
- We have not set numbers for 0NBB decay sensitivity yet; we will have a requirement and a goal
- Informed by an early study from 2024 plus detailed work ongoing now
- The 0NBB requirement must align with the experimental baseline, the goal will require we go beyond

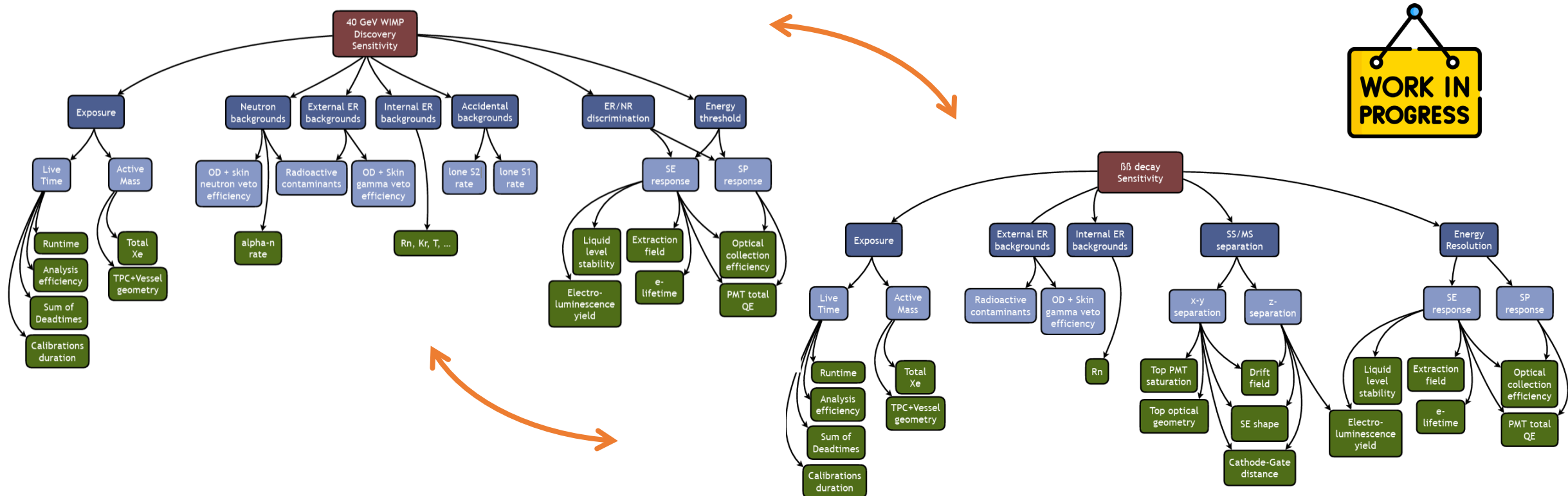
Goals

- Need path to achieve project goals with additional funding secured in a timely fashion
 - 80-tonne TPC (~100 tonnes of xenon), more aggressive backgrounds, other improvements
- Technical innovation and judicious material selection can enable this over the next few years
- Proposals can be brought into the baseline where their performance, cost, schedule & risk justify this

REQUIREMENTS, REQUIREMENTS, REQUIREMENTS...

CDR is all about “building the instrument that meets the scientific requirements”

We are developing this story, doing the detailed work needed to assign well-motivated numerical values to the top-level requirements and goals, to fully understand the flow-down to the technical subsystems, and to identify any potential conflicts



Neutrinoless double beta decay sensitivity of the XLZD rare event observatory

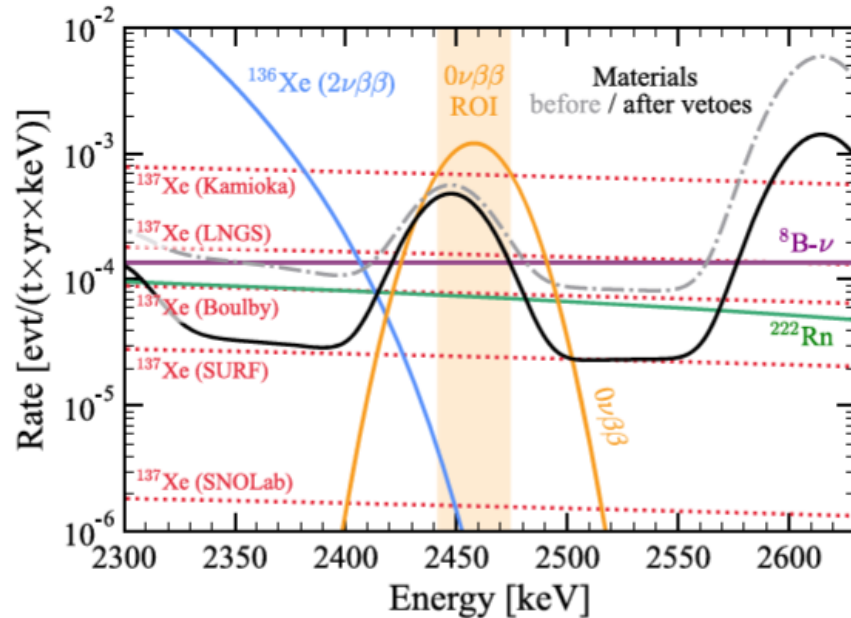
To cite this article: J Aalbers *et al* 2025 *J. Phys. G: Nucl. Part. Phys.* **52** 045102

2024 STUDIES

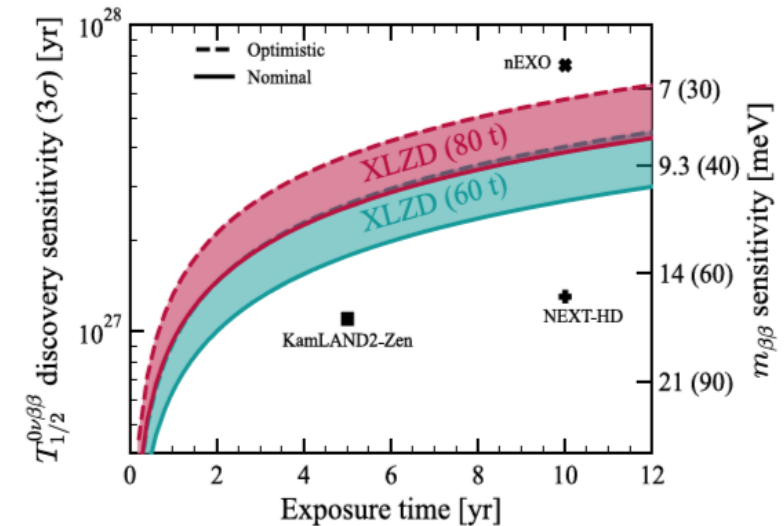
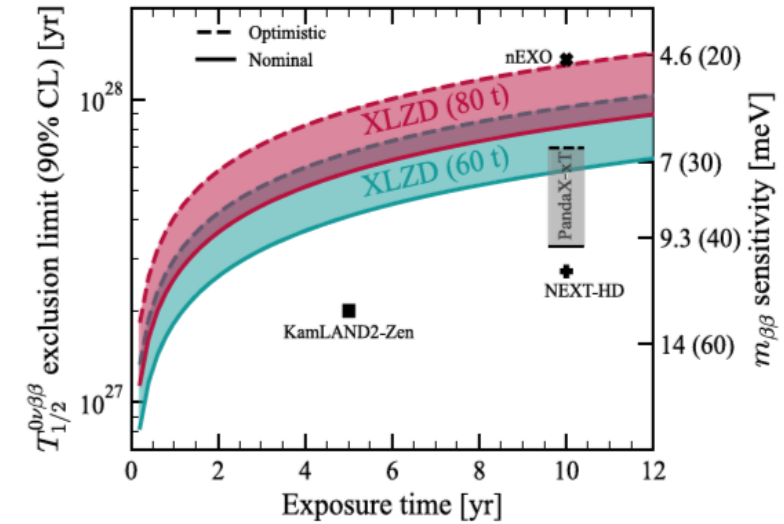
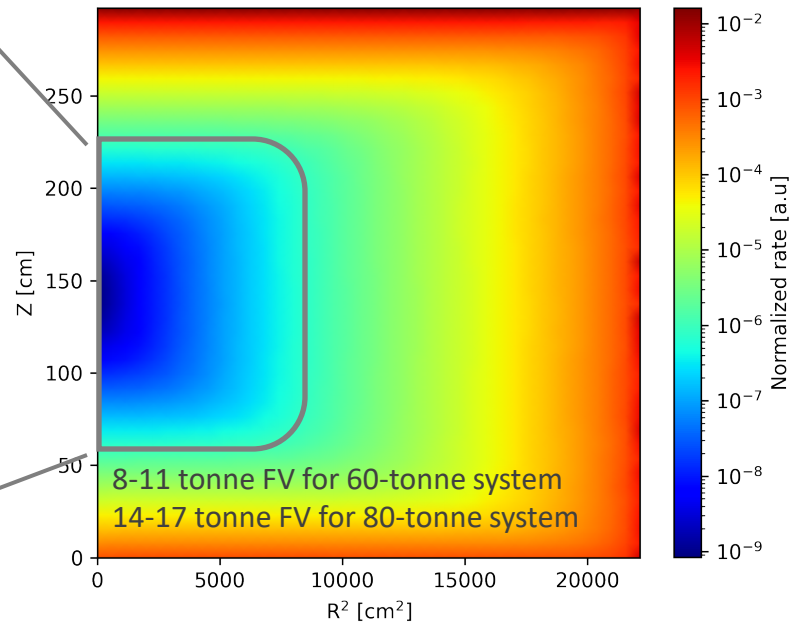
Change in paradigm: trade-off some component radioactivity for additional self-shielding in a natural abundance target

Assumptions: LZ/4 and LZ/10 backgrounds, no PLR, 60/80 tonnes, depth

- We are credibly at LZ/4 backgrounds today, from assays in hand
- Mild enrichment could also be considered once putative signal sighted



XLZD / Henrique Araújo

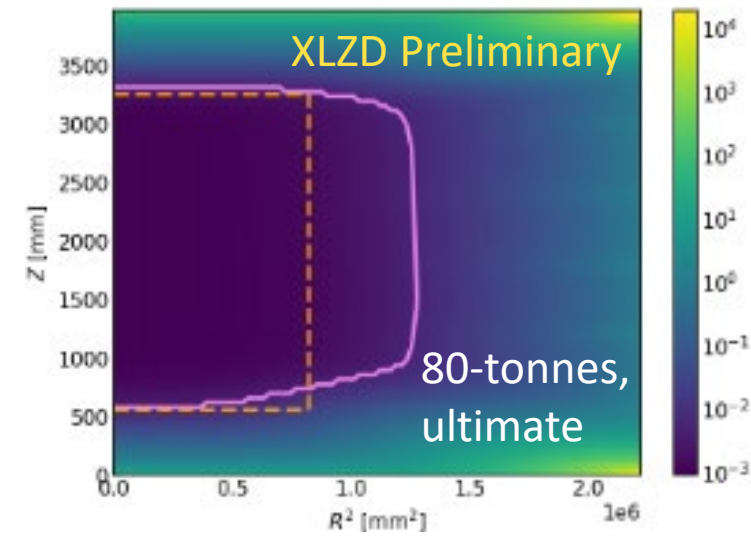
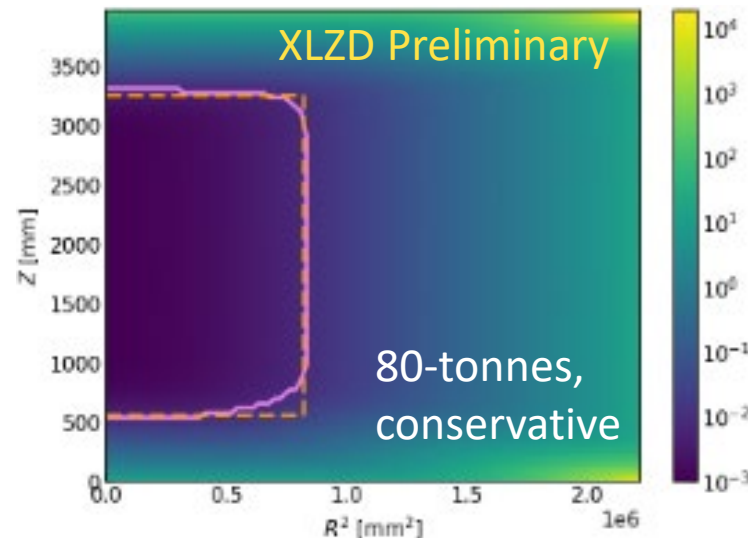


2026 STUDIES



Investigating sensitivity scenarios for 60-tonne and 80-tonne LXe-TPCs

- **Conservative:** assumes LZ cables, LZ Teflon, measured superinsulation, LZ titanium cryostat ($\approx$ 2024 studies)
- **Improved:** nEXO cables, EXO-200 Teflon (10x improvement), 10x reduction in superinsulation
- **Ultimate:** above plus substantial improvement to cryostat (e.g. CVD nickel)



Preliminary conclusion: there is a path to 10^{28} years at 80 tonnes with judicious material selection

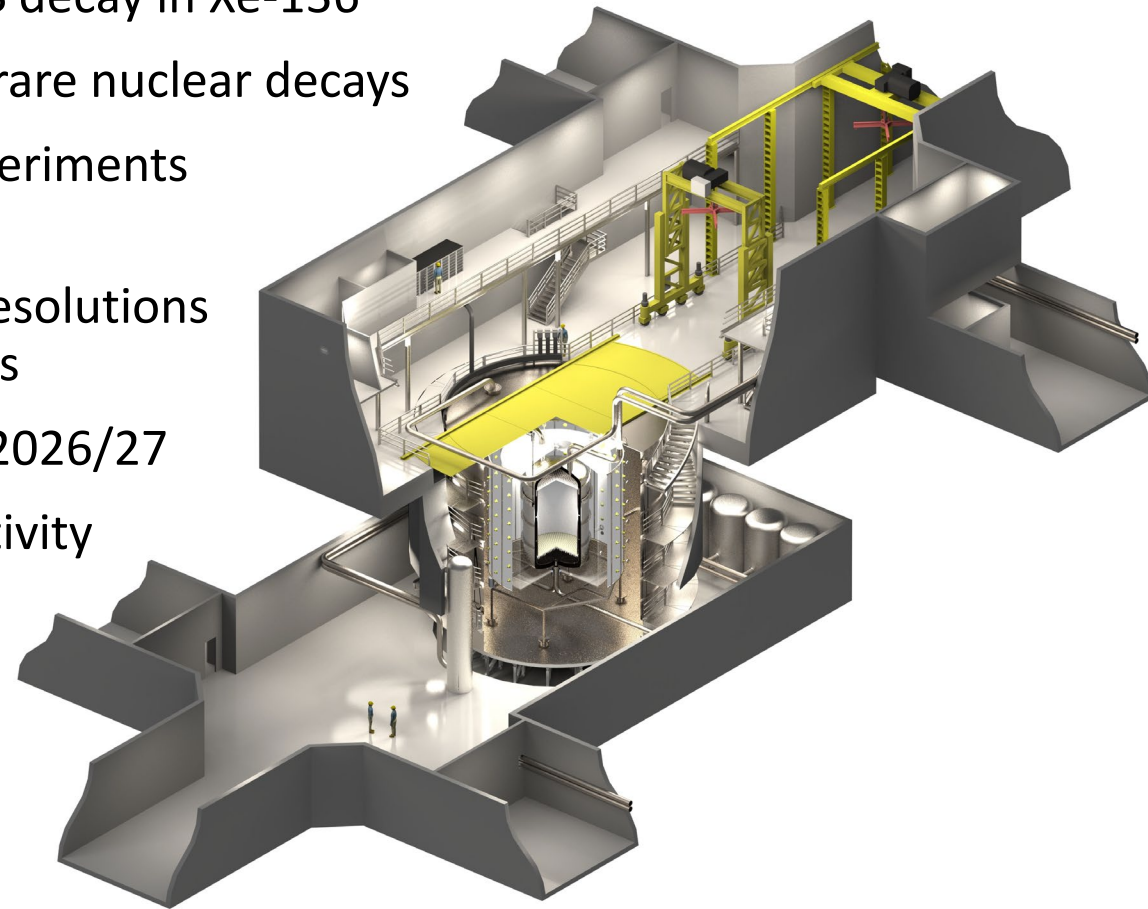
CONCLUSION

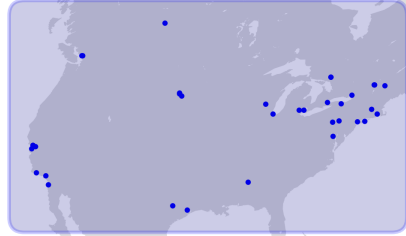
XLZD is a next-generation rare event observatory for dark matter and neutrino physics

- The top-level scientific aims are DM scattering and 0NBB decay in Xe-136
- Other physics goals include astrophysical neutrinos and rare nuclear decays
- XLZD is substantially derisked by the two largest DM experiments operating in real-(under)world conditions
- Key assumptions on backgrounds, energy and position resolutions are being validated now by the “progenitor” experiments
- Working toward Conceptual Design Report & Review in 2026/27

We need to converge on the path to reach the 0NBB sensitivity goal of 10^{28} years

- Much work remains in this area, where our strategy is still evolving within the collaboration
– **join us if you want to contribute!**





Black Hills State University
Brookhaven National Laboratory
Brown University
Bucknell University
Columbia University
Laurentian University
Lawrence Berkeley National Laboratory
Lawrence Livermore National Laboratory
McGill University
McMaster University
Pennsylvania State University
Queen's University
Rice University
SLAC National Accelerator Laboratory
SNOLAB
Sanford Underground Research Facility
South Dakota School of Mines
TRIUMF
The University of Chicago
University of Alabama
University of Alberta
University of British Columbia
University of California, Berkeley
University of California, Los Angeles
University of California, San Diego
University of California, Santa Barbara
University of Maryland
University of Massachusetts
University of Michigan
University of Rochester
University of Texas, Austin
University of Windsor
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XLZD COLLABORATION