

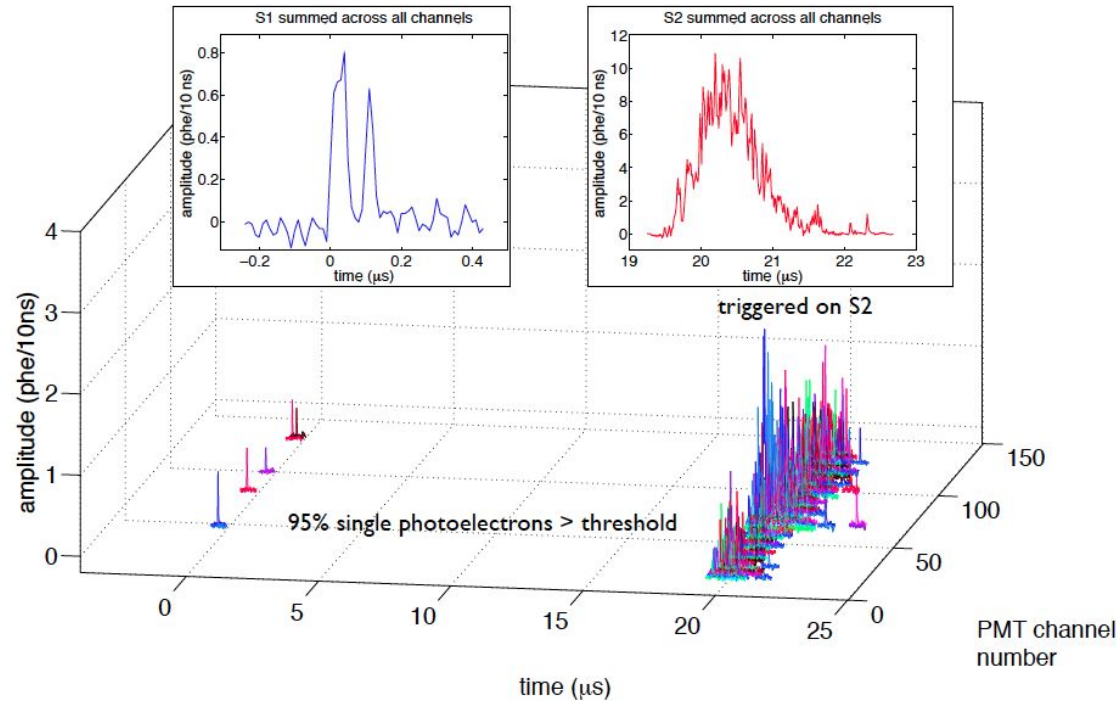
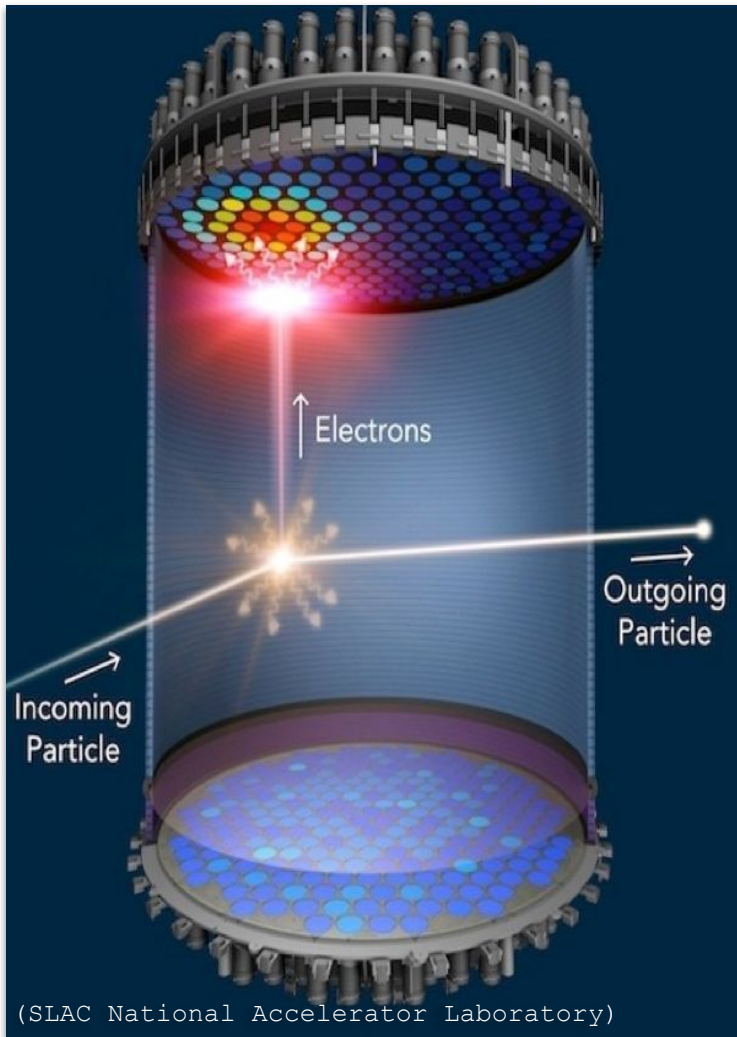
XLZD: A Future Dark Matter and Rare Physics Observatory

WIN 2025, University of Sussex, 12/06/25

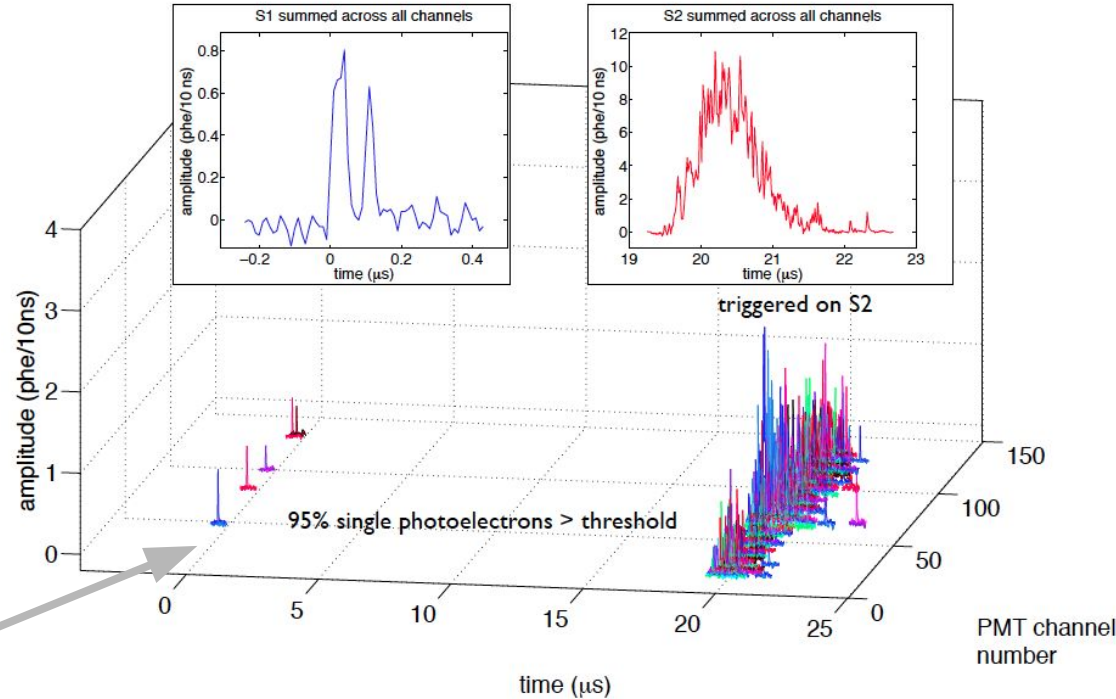
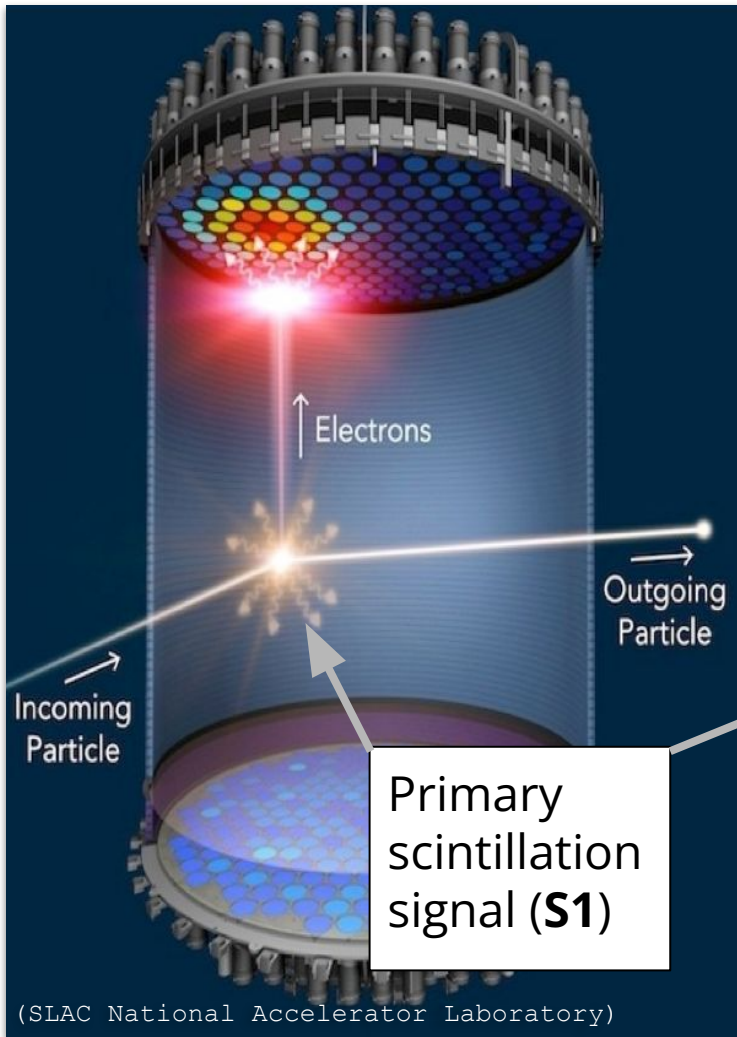
Jim Dobson, King's College London



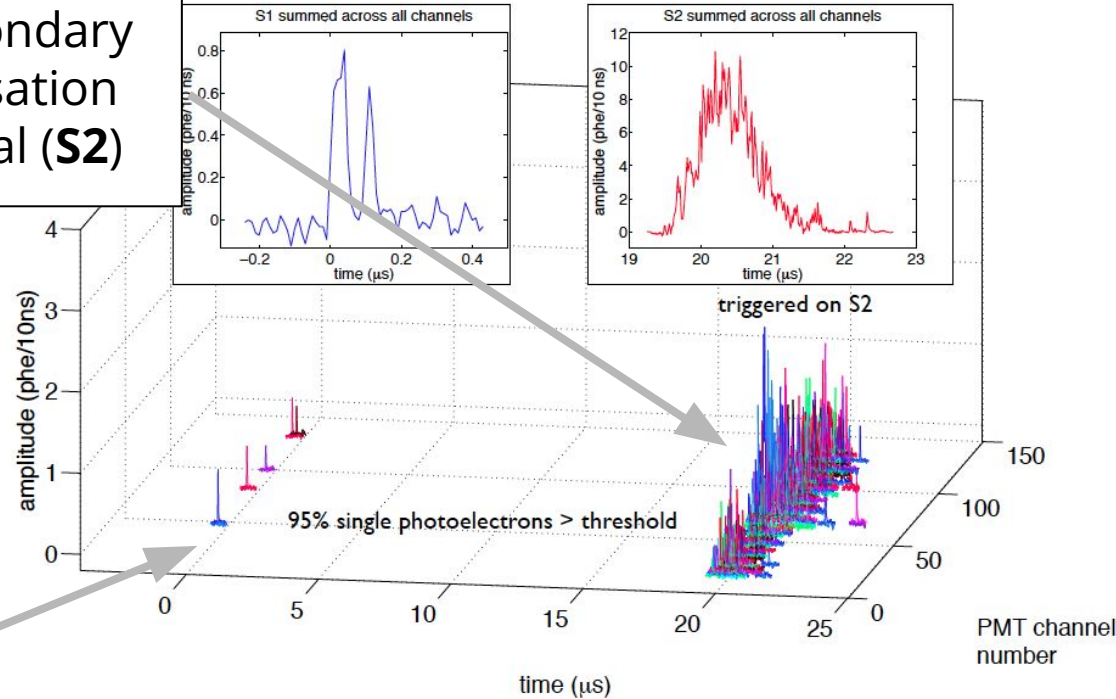
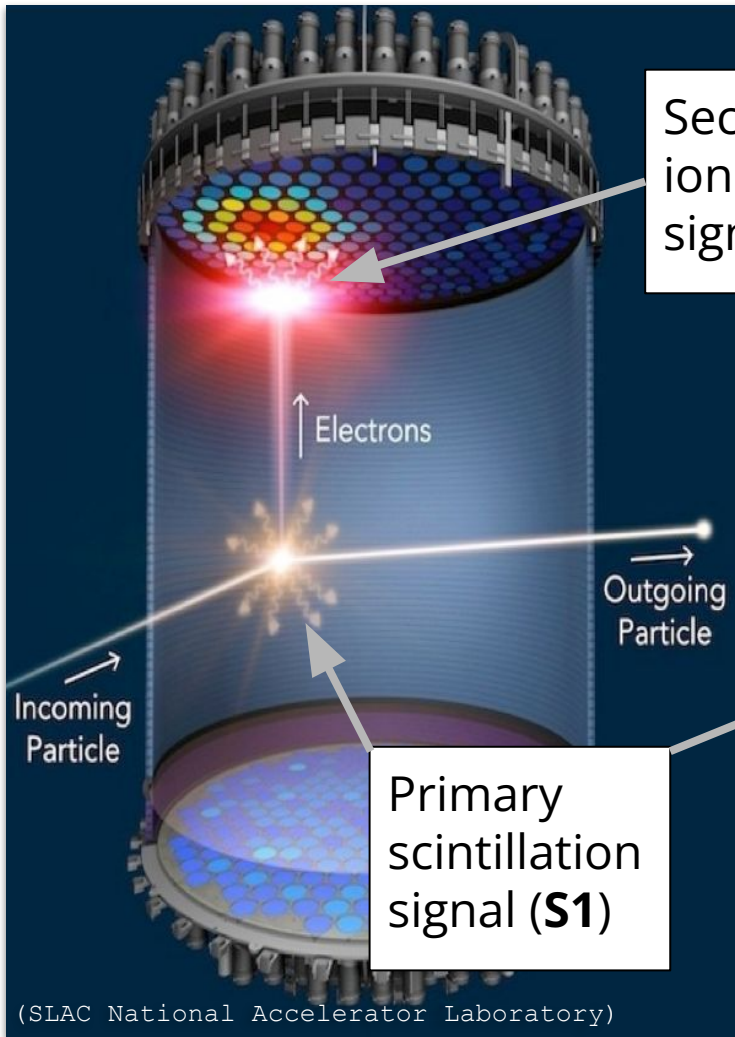
Liquid Xenon Time Projection Chambers



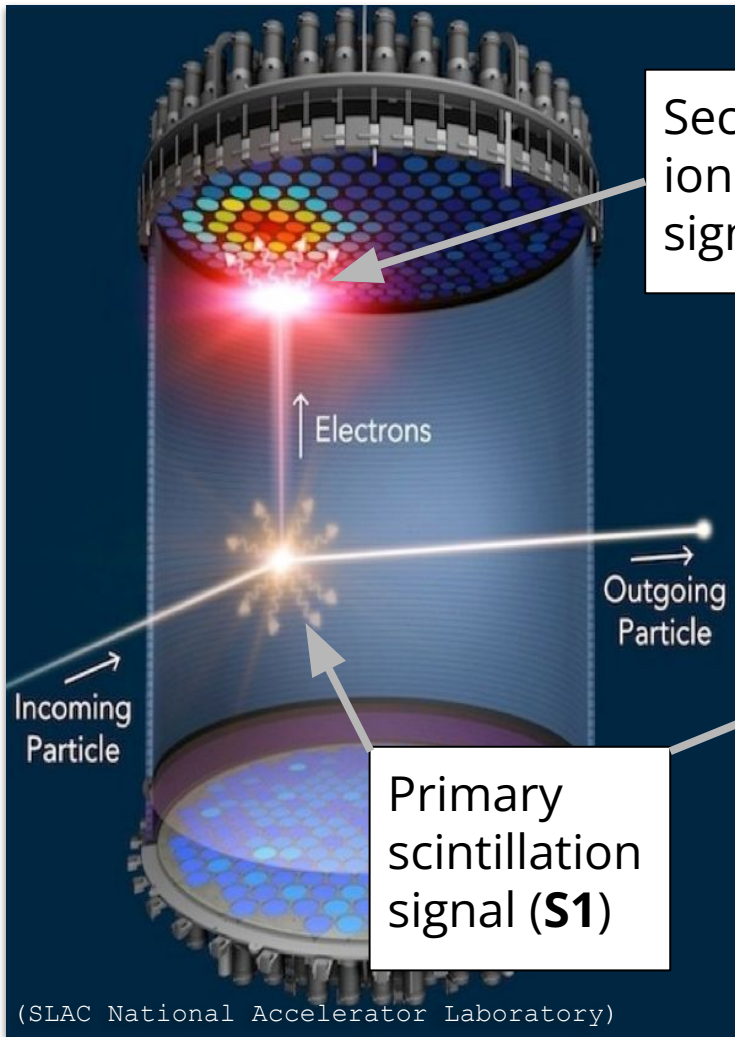
Liquid Xenon Time Projection Chambers



Liquid Xenon Time Projection Chambers

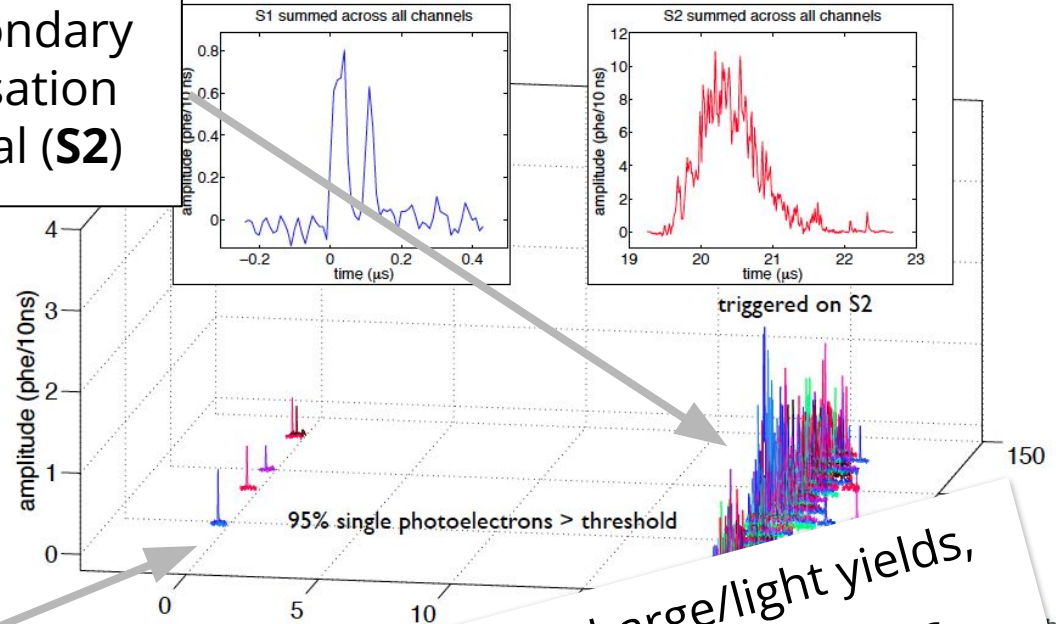


Liquid Xenon Time Projection Chambers



Secondary ionisation signal (S2)

Primary scintillation signal (S1)



Key features: excellent charge/light yields,
 $\sigma \propto A^2$, lack of long-lived radioisotopes,
fiducialisation \rightarrow highly scalable.

Leading Dark Matter (DM) technology above a -few GeV

ZEPLIN-III/XENON10



12 kg (7 kg)

2008

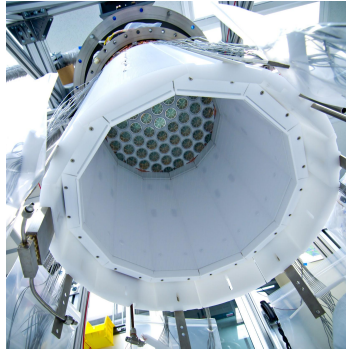
XENON100



62 kg (34 kg)

2013

LUX



250 kg (100 kg)

2016

PANDAX-II



580 kg (362 kg)

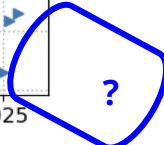
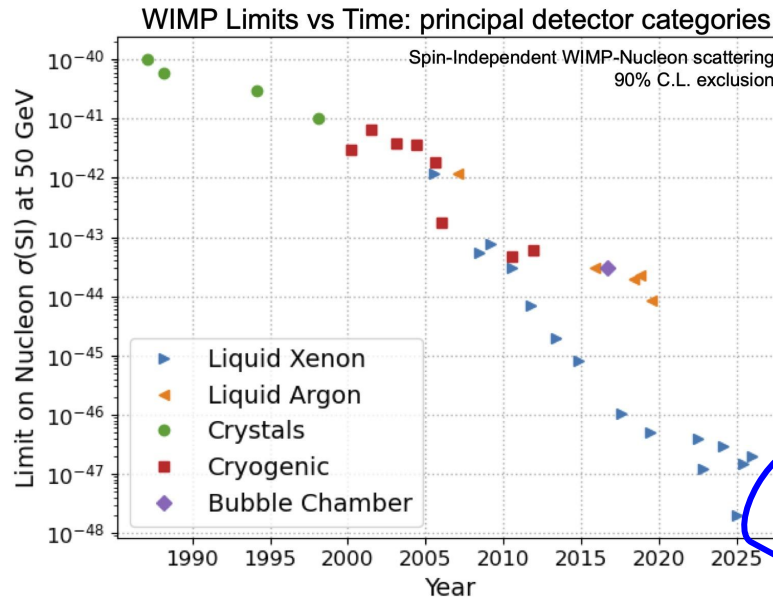
2017

XENON1T



2,000 kg (1,042 kg)

2018



PANDAX-4t/LUX-ZEPLIN/XENON-nT



7,000 kg (5,600 kg)



Leading Dark Matter (DM) technology above a -few GeV

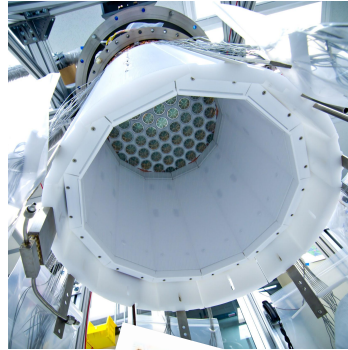
ZEPLIN-III/XENON10

XENON100

LUX

PANDAX-II

XENON1T



12 kg (7 kg)

62 kg (34 kg)

25

580 kg (362 kg)

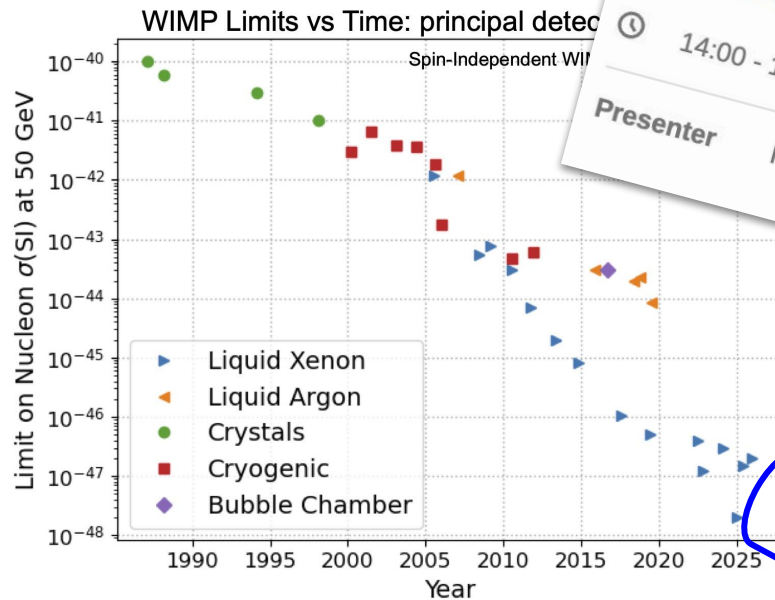
2,000 kg (1,042 kg)

2008

2013

2017

2018



Into the Neutrino Fog:
Latest Results from the
XENONnT Experiment

14:00 - 14:15

Presenter
Kexin Liu

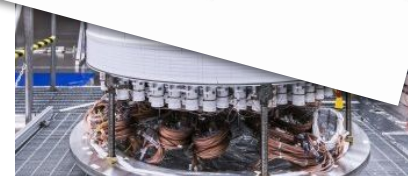
Recent results from the
LUX-ZEPLIN (LZ) dark
matter experiment

14:30 - 14:46

Presenter
Aiham Al Musalhi

LUX-ZEPLIN/XENON-nT

2022-27



7,000 kg (5,600 kg)

XENON LUX-ZEPLIN-DARWIN (XLZD) Collaboration

XENON+DARWIN+LUX-ZEPLIN+new groups → 17 countries, 77 institutes, 440+members



The XLZD detector concept



- Builds on mature technology → combines best of XENON and LUX-ZEPLIN
- ~factor 2 linear scale-up → manageable technical challenges
- 60 tonne active natural LXe target (80t in case of positive funding and market conditions)
- Two arrays 3" low-background PMTs (2362 tubes total)
 - Other sensors under study
- Drift field 240-290 V/cm
- Highly (VUV) reflective PTFE walls
- Radiopure material selection and background mitigation (active veto, online reduction, analysis)

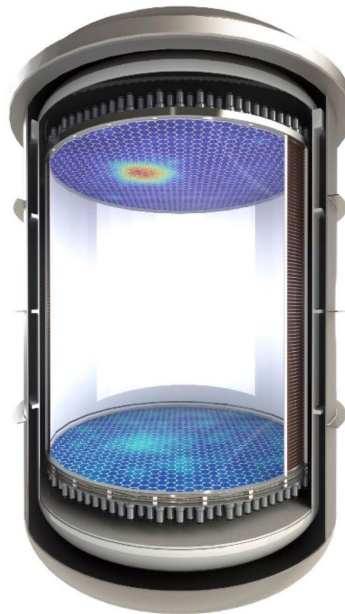
XLZD Design book: [arxiv/2410.17137](https://arxiv.org/abs/2410.17137) (2025)

A Dark Matter and Rare Event Physics Observatory

Ultra-low BG + large exposure + high dynamic range → broad physics programme

Dark Matter:

- WIMP
- Sub-GeV
- Inelastic
- Axion-like particles
- Planck mass
- Dark photons

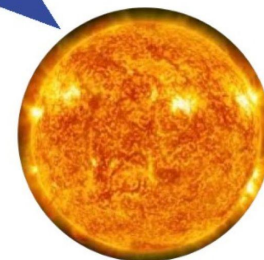
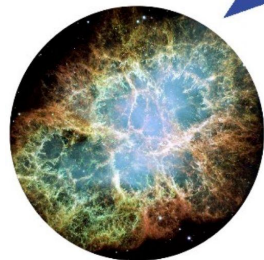


Neutrino nature:

- Neutrinoless double beta decay
- Neutrino magnetic moment
- Double electron capture

Supernovae:

- Early alert
- Supernova neutrinos
- Multi-messenger astrophysics



Solar:

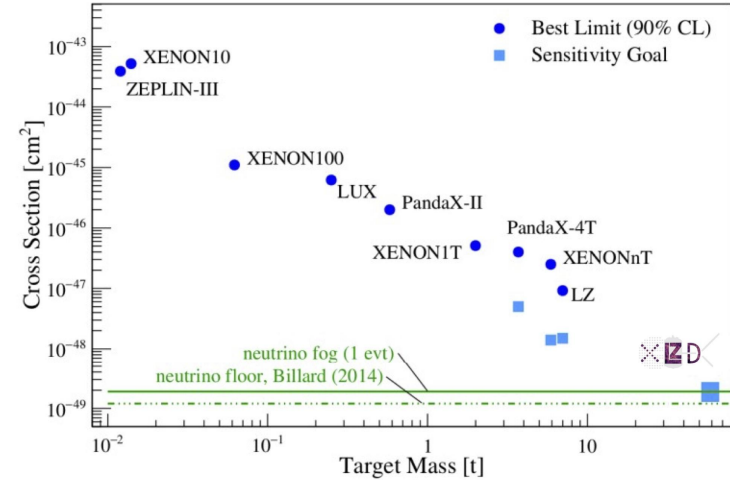
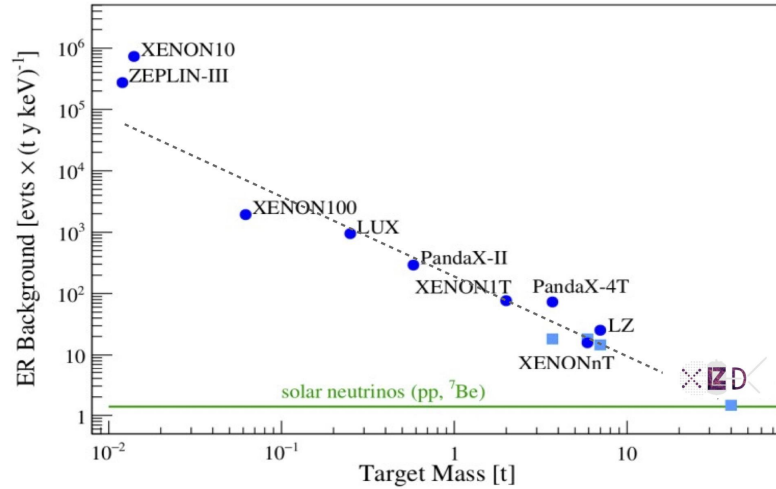
- pp neutrinos
- Solar metallicity
- ${}^7\text{Be}$, ${}^8\text{B}$, hep

Whitepaper: LXe observatory for DM and ν -physics

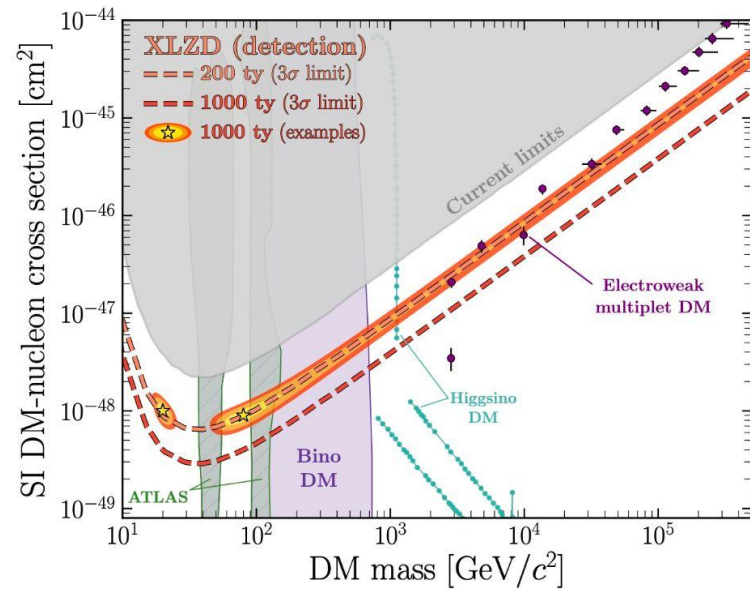
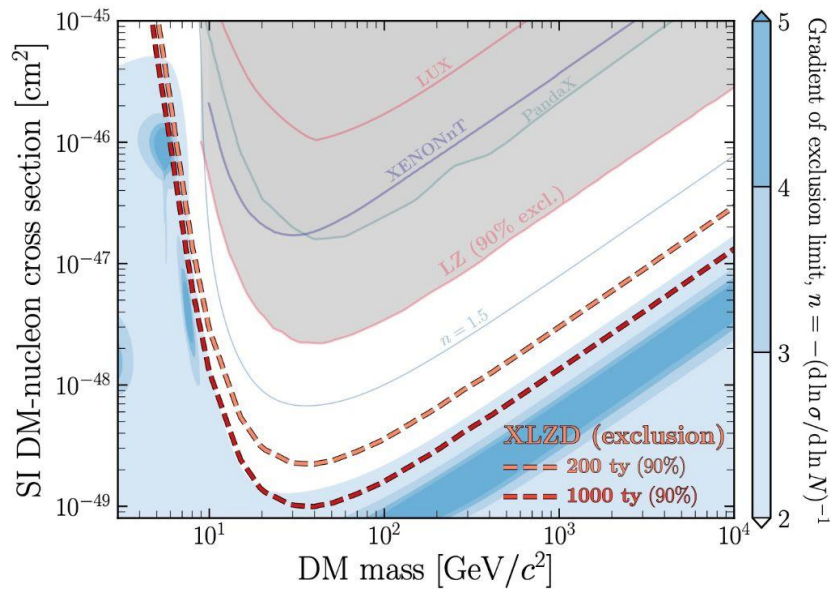
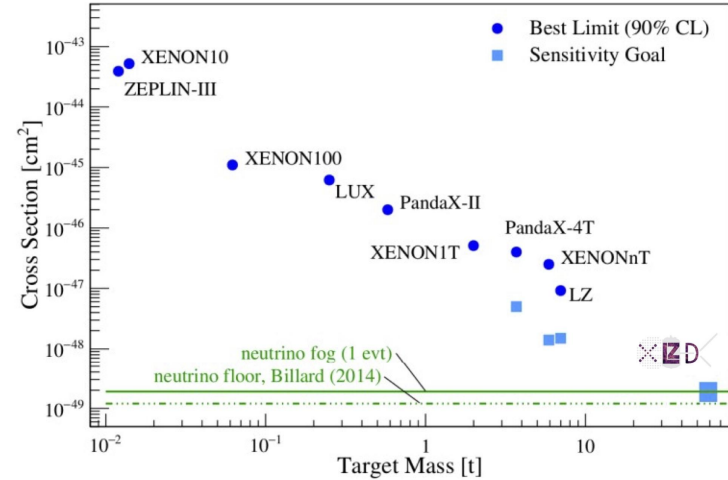
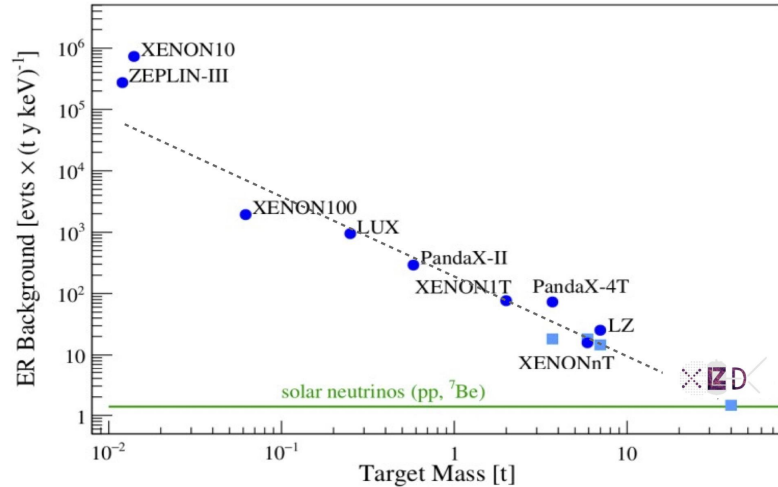
[J Aalbers et al 2023 J. Phys. G: Nucl. Part. Phys. 50 013001](#)

Potential for transformative discovery in several fundamental physics areas

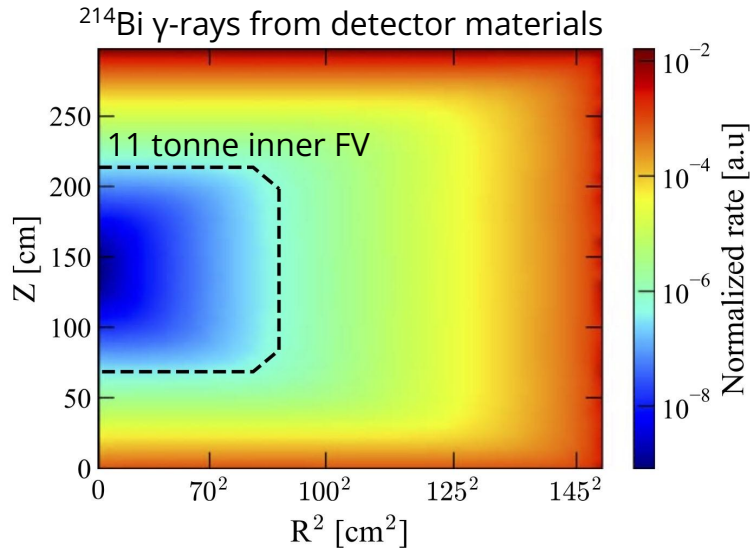
Dark Matter discovery to the ν -fog



Dark Matter discovery to the ν -fog



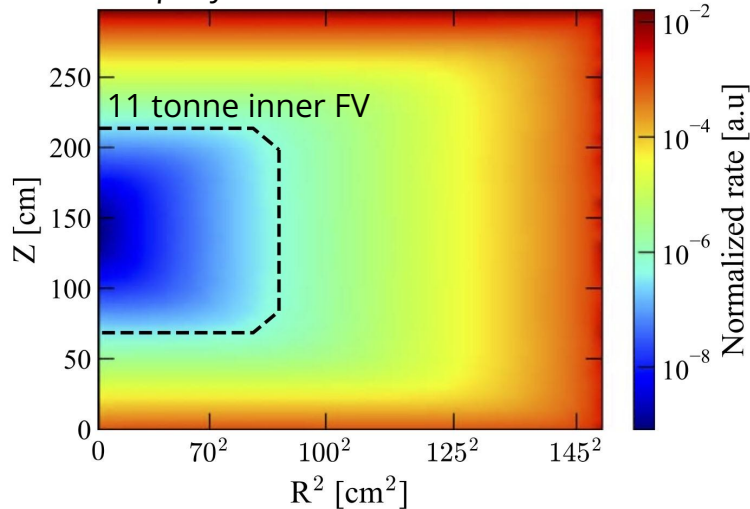
Neutrinoless double beta decay with ^{136}Xe



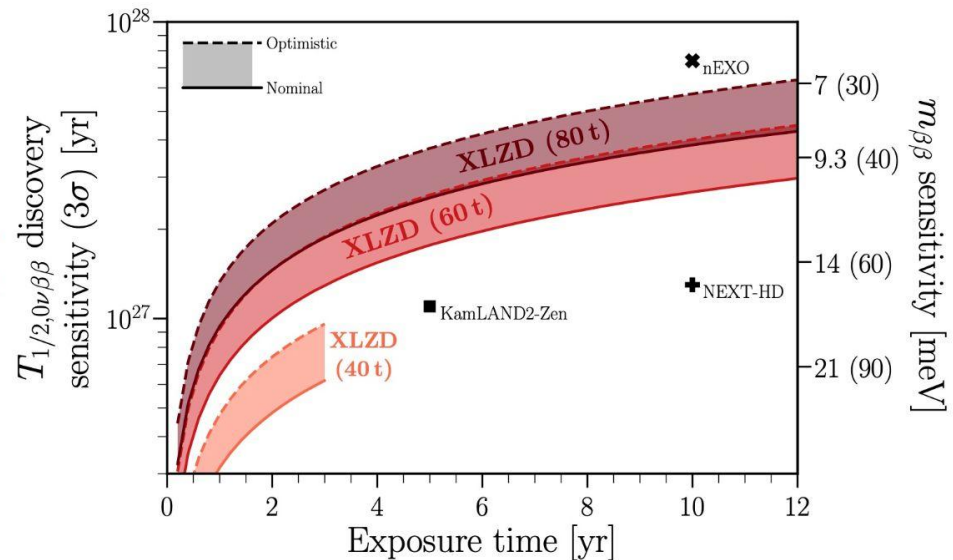
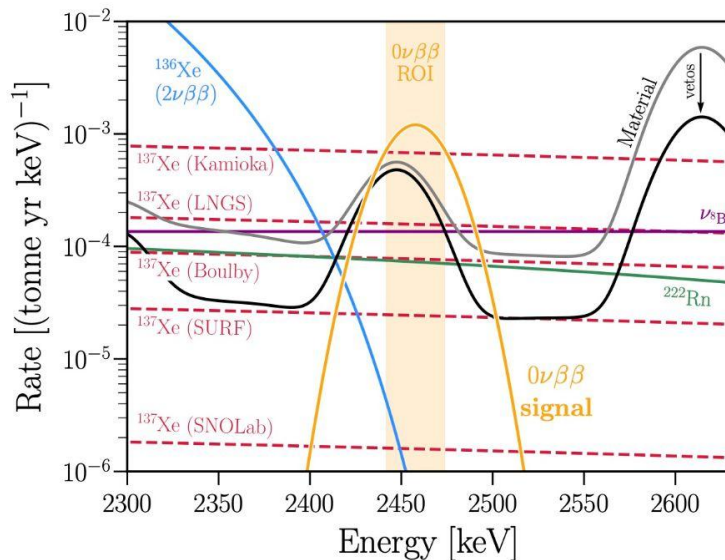
- Natural abundance of ^{136}Xe (8.9%) (could choose to later enrich/deplete)
- Exploit excellent self-shielding \rightarrow search in inner 11 tonne FV
- 10^7 reduction to detector centre
- XLZD $0\nu\beta\beta$ sensitivity paper: [*J.Phys.G 52 \(025\) 4, 045102*](#)

Neutrinoless double beta decay with ^{136}Xe

^{214}Bi γ -rays from detector materials

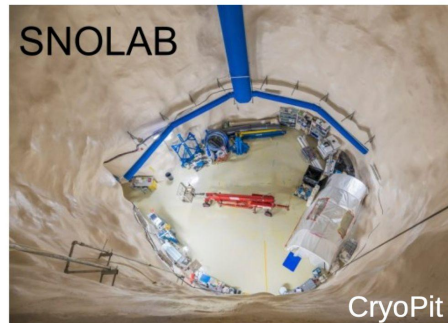
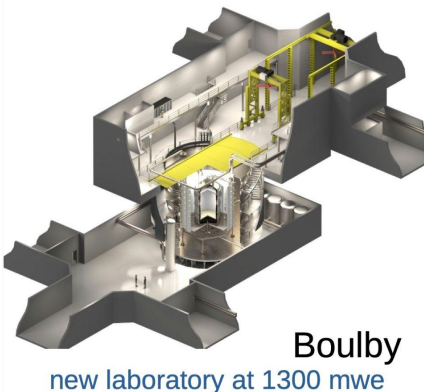


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Siting selection in 2026

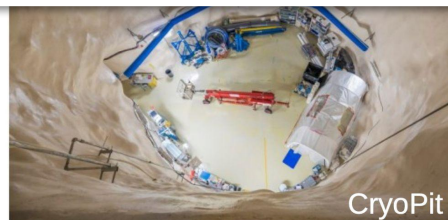
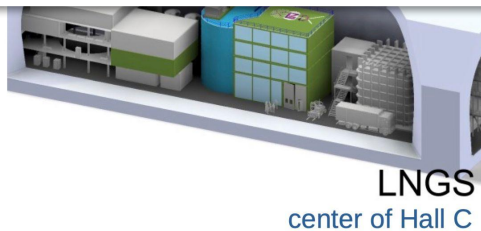
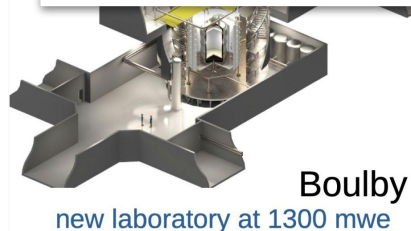
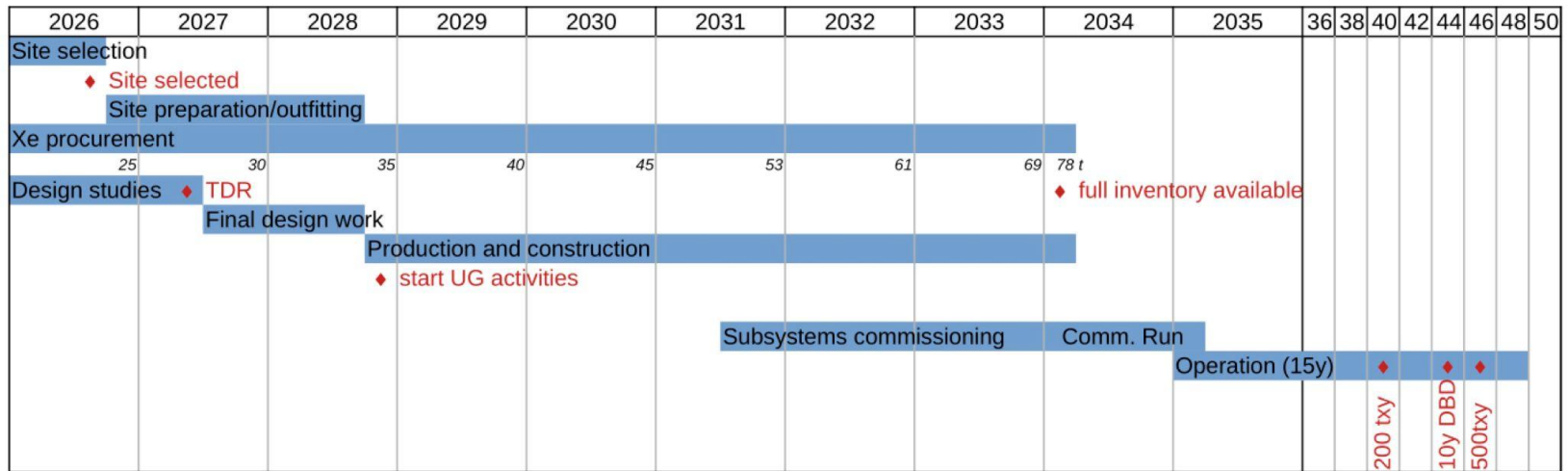
- Host laboratory selection in 2026. Requirements:
 - $0\nu\beta\beta$ drives minimum laboratory depth
 - Lab readiness and country commitment
 - Space+accessibility, underground fabrication/staging (if required)
- Boulby, LNGS, SNOLAB & SURF currently considered
- Task force compiled detailed siting report
- Discussions with laboratories ongoing



Siting selection in 2026

- Host laboratory selection in 2026. Requirements:

Timeline: operation in the 2030s



XLZD@Boulby UK pre-construction project

A quick look at the Boulby site option, as we're in the UK

- UKRI Infrastructure Fund preliminary activity 3.5 yrs in progress (2024-27)
 - Proposed UK scope focussed on hardware suited to host nation, plus industrial, clean UG manufacture and sustainability
 - Conceptual design of UK scope in FY 2025/26
 - Preliminary design of UK scope 2026/27
- 24 UK universities and institutes:

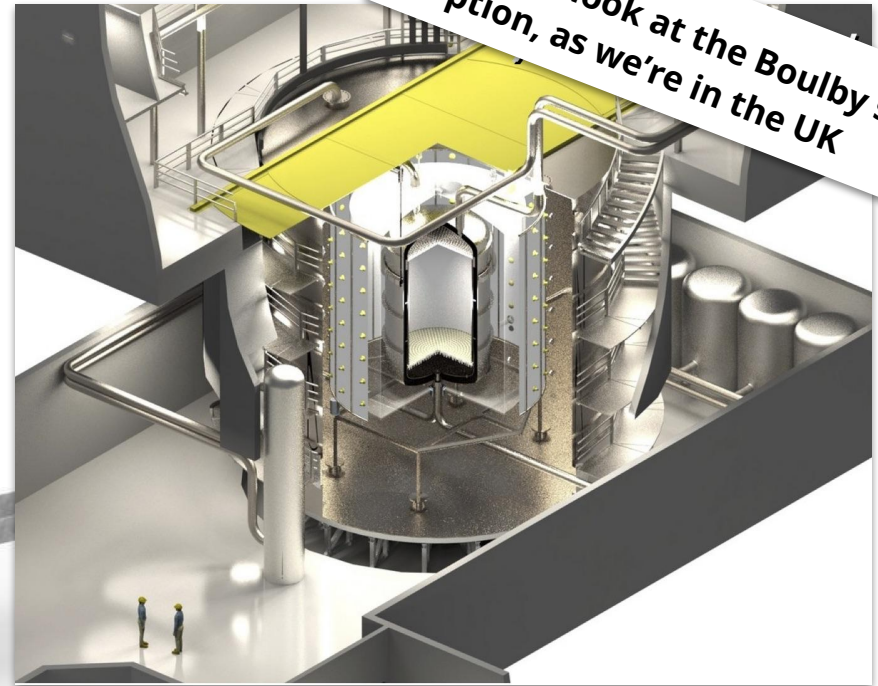
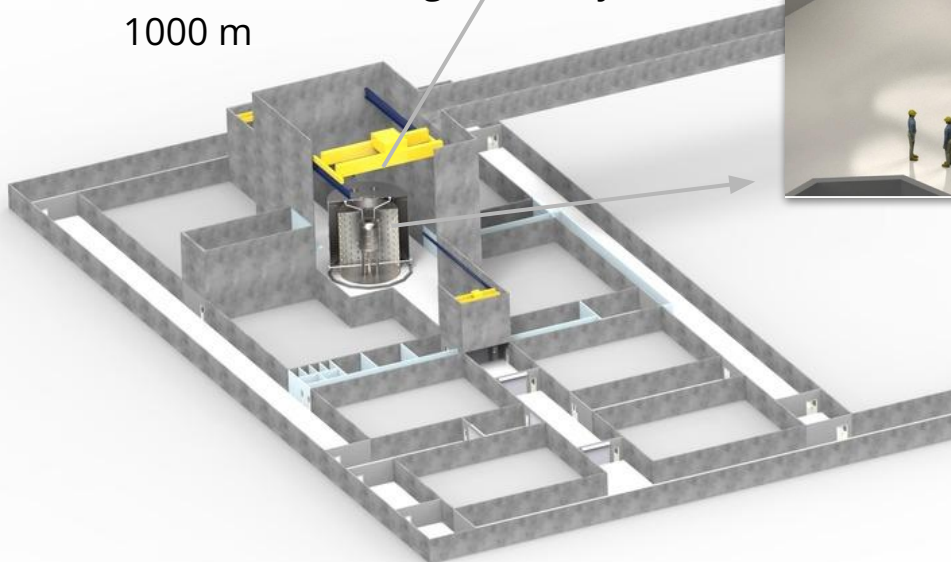


M. Agostini¹, H. M. Araújo², D. Bauer², C. Boehm³, M. Borri⁴, A. Boston⁵, J. Brooke⁶, S. Burdin⁵, X. Calmet⁷, G. Casse⁵, J. Coleman⁵, D. Colling², D. Costanzo⁸, A. Cottle¹, G. J. Davies², A. De Santo⁷, J. Dobson⁹, J. Ellis⁹, M. Fairbairn⁹, H. Flaecher⁶, H. Fox¹⁰, C. Frenk¹¹, C. Ghag¹, A. Green¹², E. Hardy⁵, J. Hays¹³, S. Jones^{8,14}, A. Kaboth¹⁵, A. Khan¹⁶, L. L. Kormos¹⁰, H. Kraus¹⁷, V. A. Kudryavtsev⁸, P. Kyberd¹⁶, M. Labiche⁴, I. Lazarus⁴, P. A. Majewski¹⁸, J. March-Russell¹⁷, C. McCabe⁹, A. Mehta⁵, D. Muenstermann¹⁰, A. StJ. Murphy³, K. Nikolopoulos¹⁹, K. Palladino¹⁷, S. Paramesvaran⁶, C. Patrick³, K. Petridis⁶, T. Potter²⁰, Y. Ramachers²¹, R. Saakyan¹, P. Scovell¹⁸, S. Shaw³, J. Smirnov⁵, M. Spannowsky¹¹, T. J. Sumner², A. Szelc³, D. R. Tovey⁸, Y. Uchida², C. Uhlemann²², M. van der Grinten¹⁸, J. Vosseveld⁶, D. Waters¹, S. West¹⁵, and I. Zavala²³

¹ University College London, ² Imperial College London, ³ University of Edinburgh, ⁴ STFC Daresbury Laboratory, ⁵ University of Liverpool, ⁶ University of Bristol, ⁷ University of Sussex, ⁸ University of Sheffield, ⁹ King's College London, ¹⁰ Lancaster University, ¹¹ Durham University, ¹² University of Nottingham, ¹³ Queen Mary, University of London, ¹⁴ Nuclear Advanced Manufacturing Research Centre, University of Sheffield, ¹⁵ Royal Holloway, University of London, ¹⁶ Brunel University, ¹⁷ Oxford University, ¹⁸ STFC Rutherford Appleton Laboratory, ¹⁹ Birmingham University, ²⁰ Cambridge University, ²¹ Warwick University, ²² Newcastle University, ²³ Swansea University

XLZD@Boulby UK pre-construction project

- XLZD would operate in a new facility (stage 2) at 1300 m depth
- Facility design part of the STFC Boulby Development Project
 - Includes manufacturing “past the bottleneck” in stage 1 facility at 1000 m



A quick look at the Boulby site option, as we're in the UK

In summary

- LXe technology is mature and scalable
- XLZD collaboration formed from current world-leading Xe experiments
- Ambitious plans for a 60-80 tonne LXe-based rare event search observatory
- Broad DM and ν -physics programme → potential for discoveries in several areas of fundamental physics
- At the design phase → site selection in 2026 → operation in the 2030s

