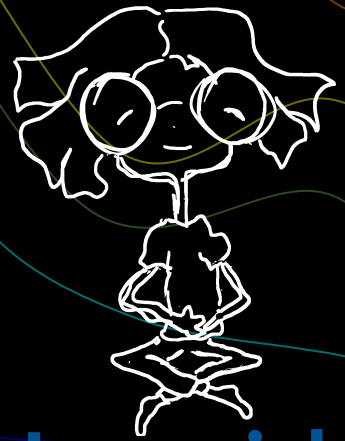
Se-**Rn**-dipitous Seque-LZ



Imperial College London

Radon mobility in the LZ detector

Nicolas Angelides

IOP APP - 4th of April 2022

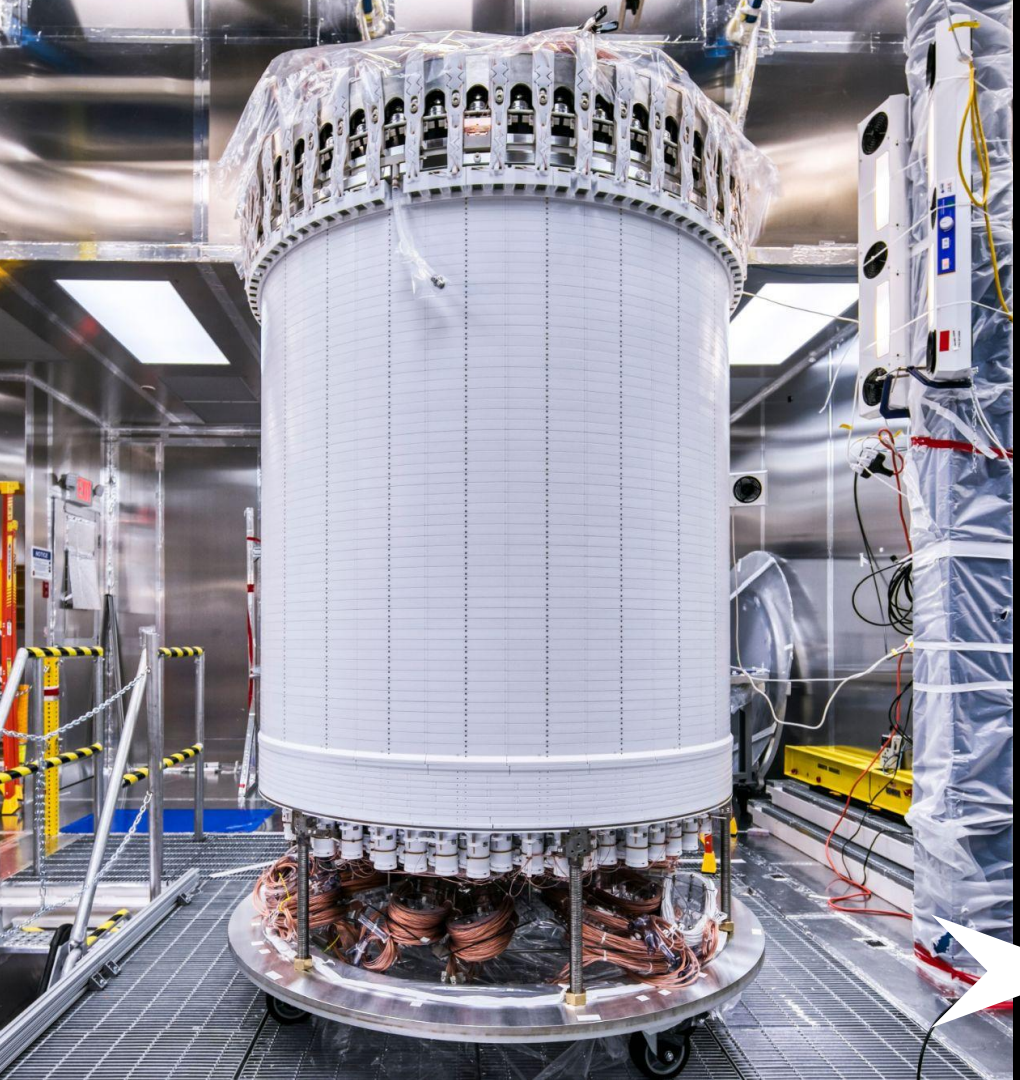
Imperial College London

In this talk:

- The LZ experiment
- Significance of radon backgrounds
- First look at radon in LZ
- Decay of ^{222}Rn and ^{218}Po
- Radon mobility in liquid xenon
- Liquid flow and radon distribution

From collaborators:

Amy C. - The LZ Experiment
Albert B. - Photon Detection
Aiham AM. - Saturation Corrections
Zhaozhen T. - Majornon sensitivity
Jordan P. - Stats FlameNEST
T. Marley - Migda effect setup
Ishan K. - Accidentals with Neural Nets
Kelsey C O.-M. - Next gen
Jo O. - LZ Poster

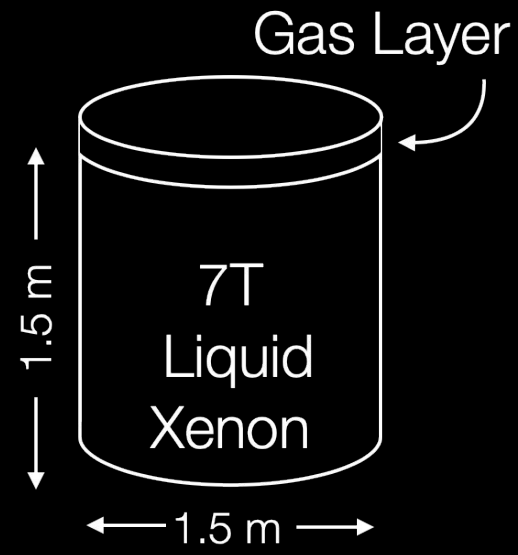


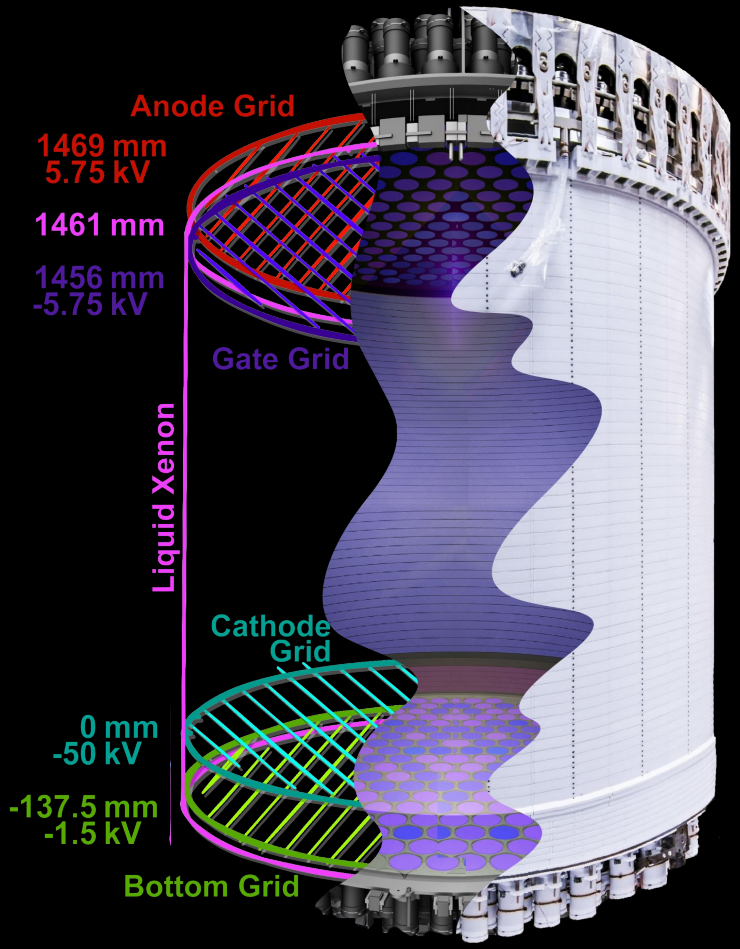
Currently collecting
science data
4850 ft underground
at the Sanford
Underground
Research Facility

Main LZ detector fully assembled in Rn-reduced surface assembly lab

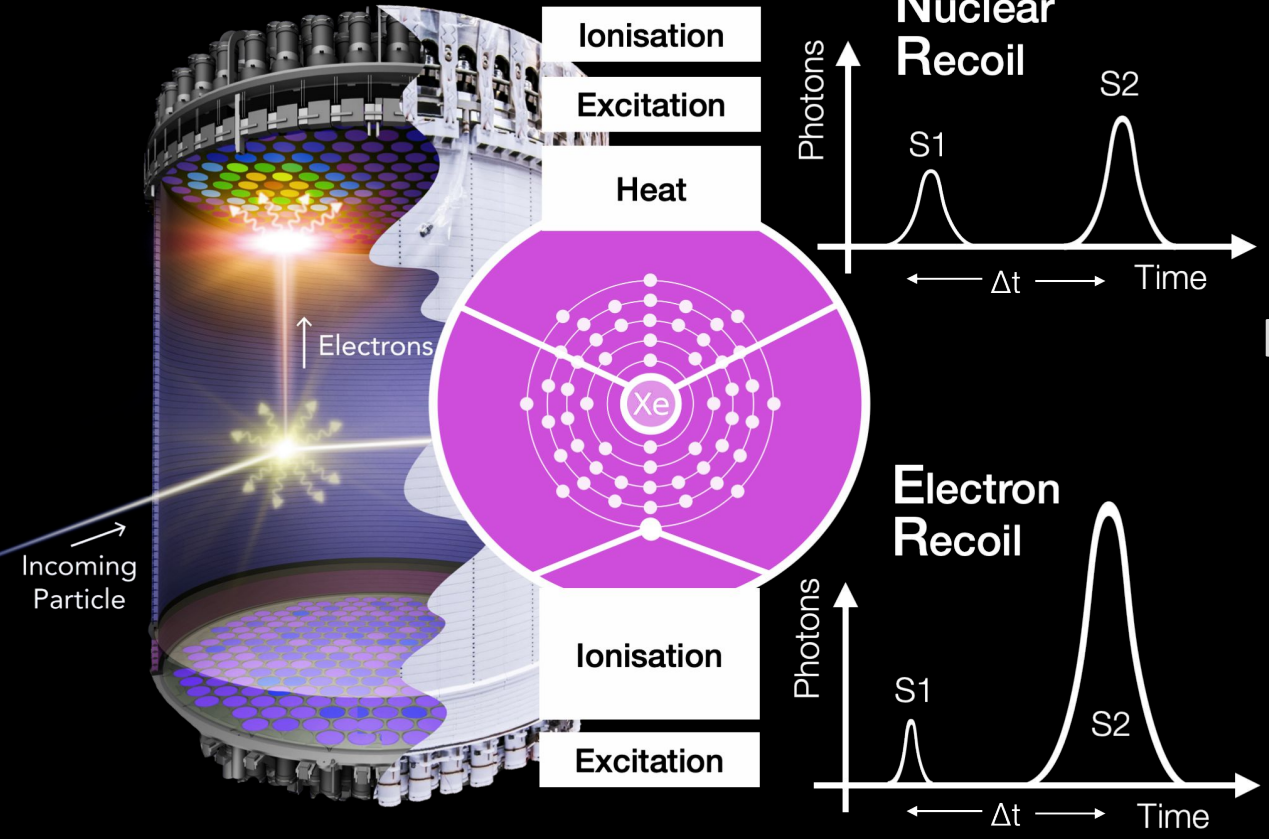
Top PMT array during mating with the TPC and the **Bottom PMT array**

Time Projection Chamber



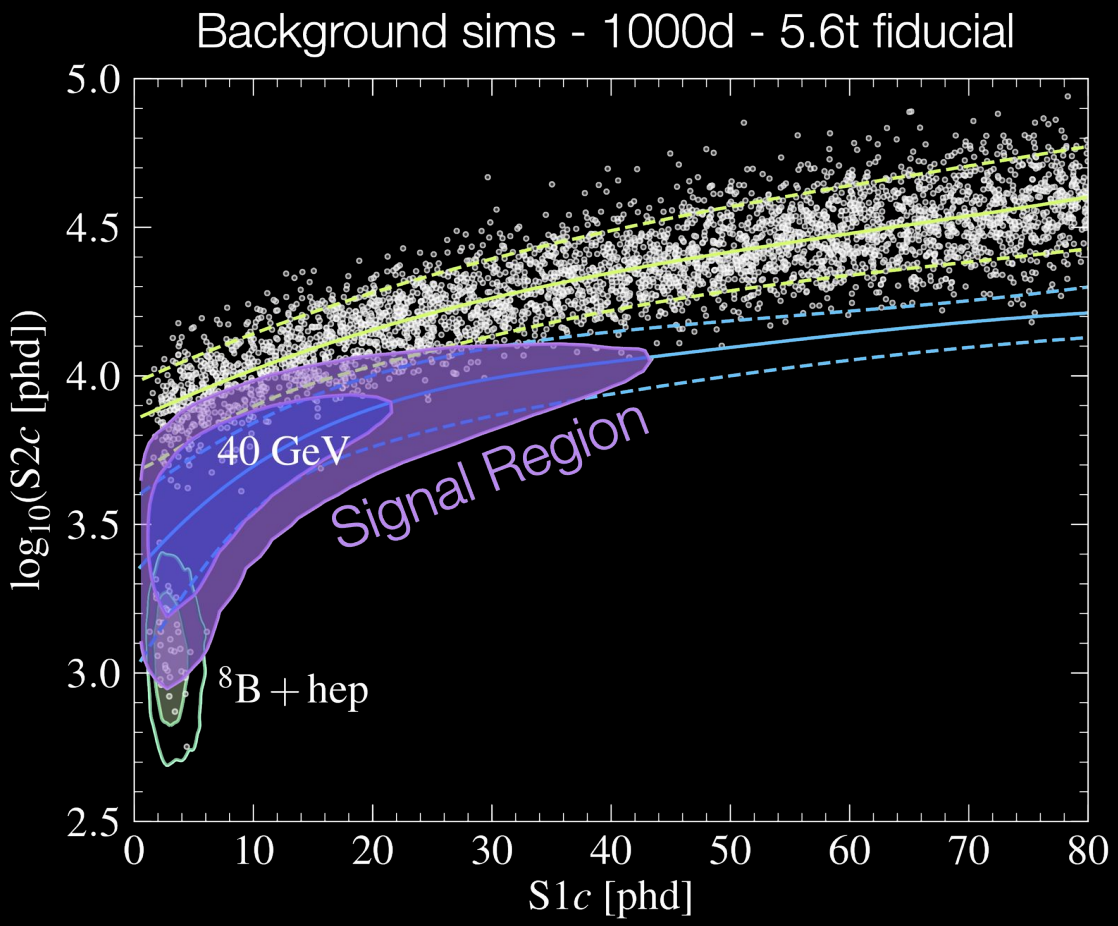


100x more sensitive than predecessor (LUX 250kg)



Characteristic ratio of observables for **Signal-like (NR)** and **BG-like (ER)** interactions

PMT hit pattern & Δt reconstruct position



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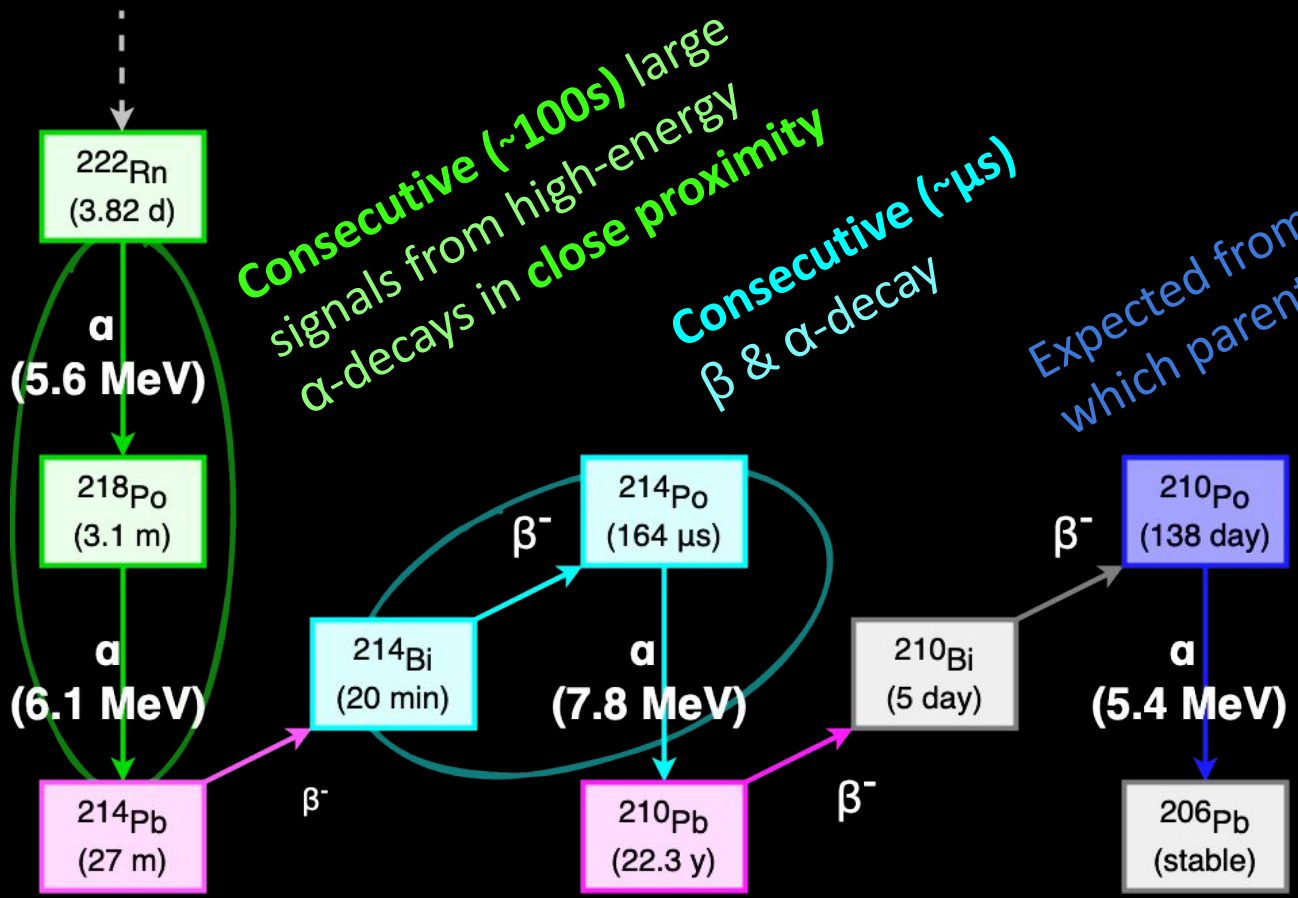
Low energy ERs **leak into WIMP signal region**

~70% of BGs from **^{214}Pb β-decay (Radon chain)**



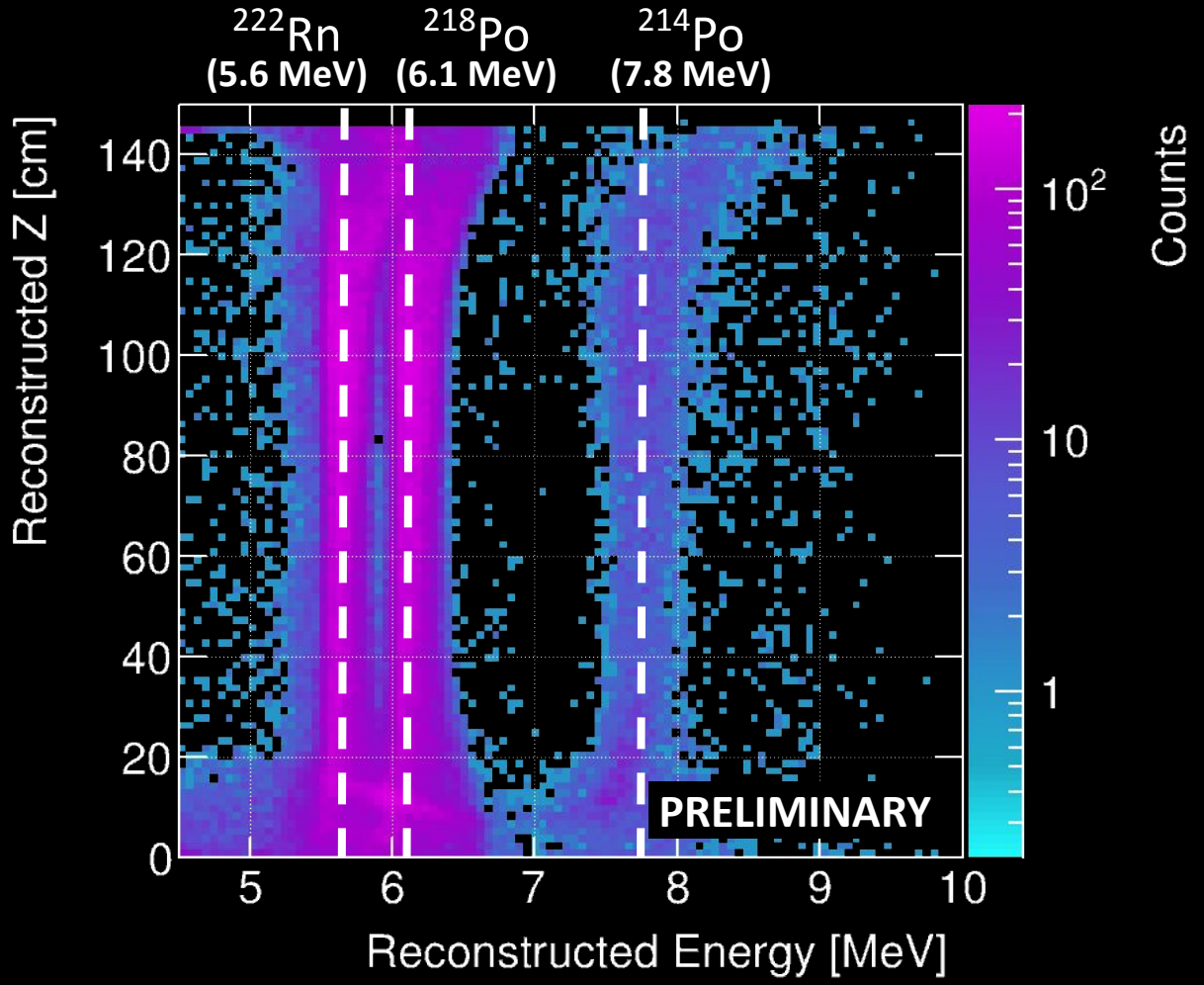
Consecutive (~100s) large signals from high-energy α-decays in **close proximity**

Consecutive (~µs) β & α-decay

Expected from **surfaces** which parent plated-out on

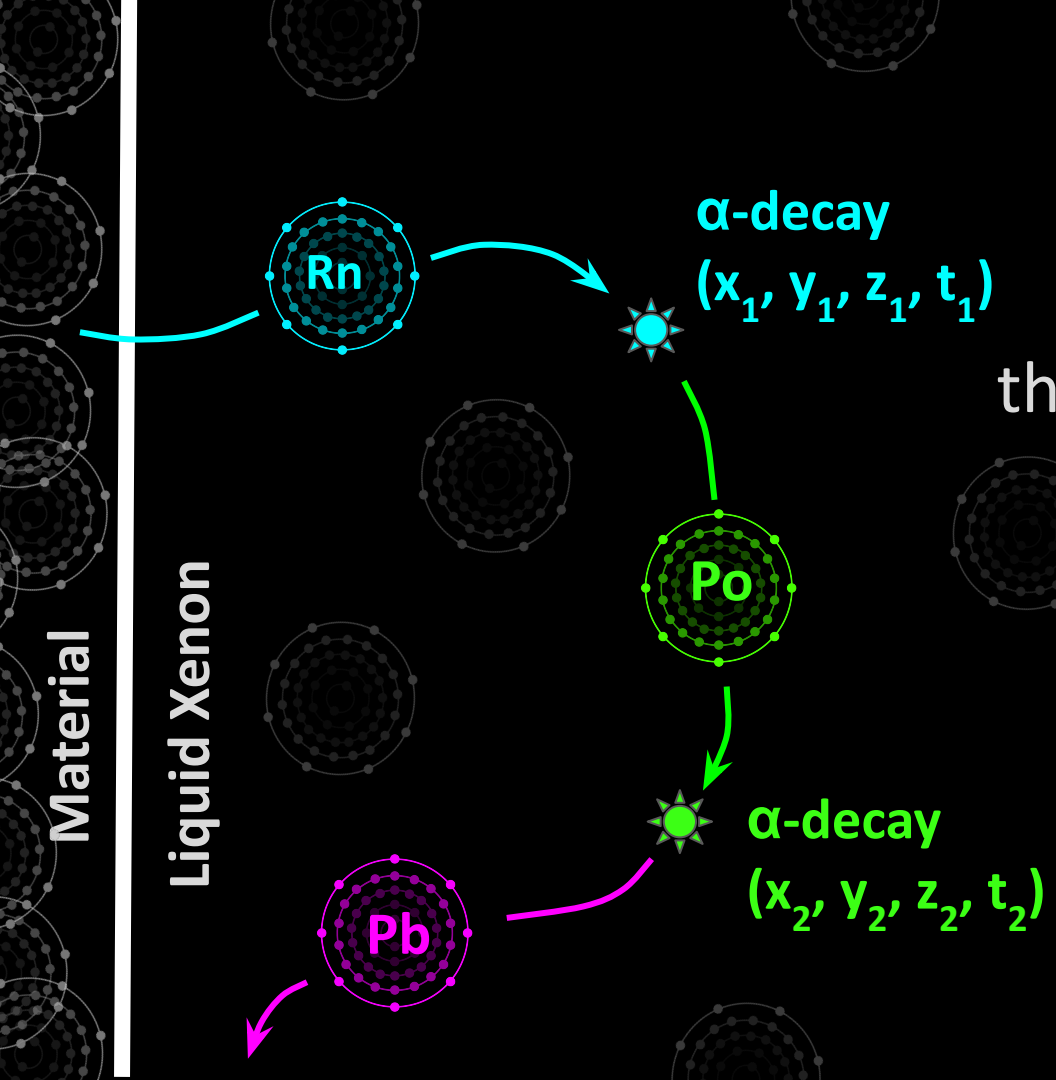
Radon is **emanated** from detector material and **mixes with the liquid xenon**

β-decay with **naked** branch (no accompanying gamma) resulting in **low energy recoils**



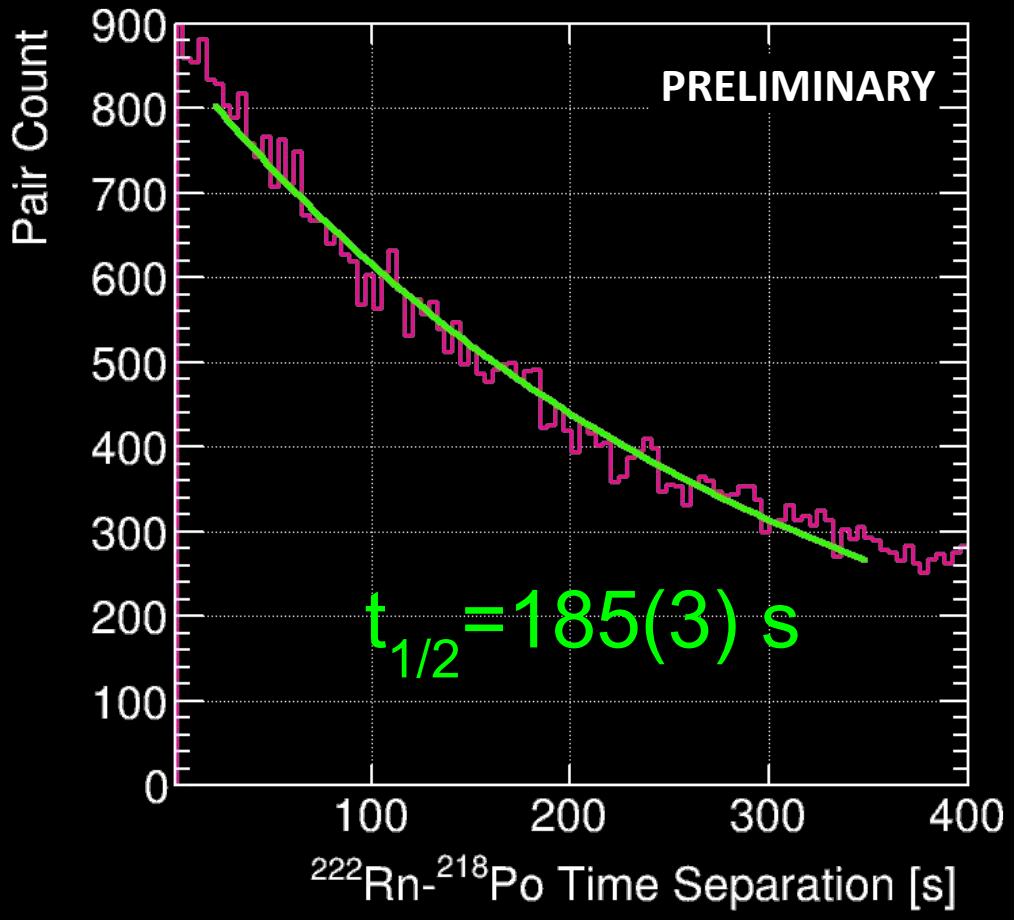
Early science data used in studying radon chain α-decays

Activity is within expected range



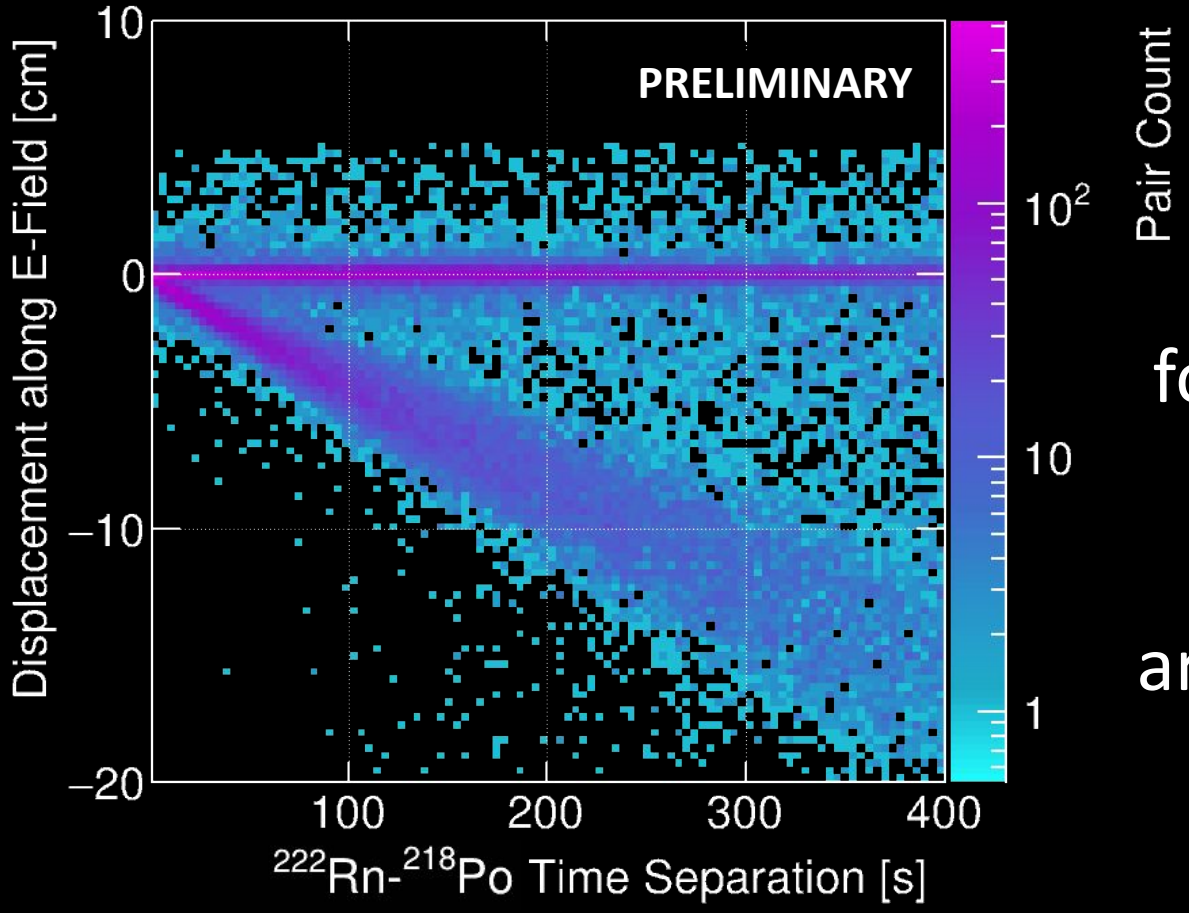
Each radon atom goes through a **sequence** of decays

^{218}Po with half-life 3.1m decays in **close succession and proximity** with parent, both with **large signals**



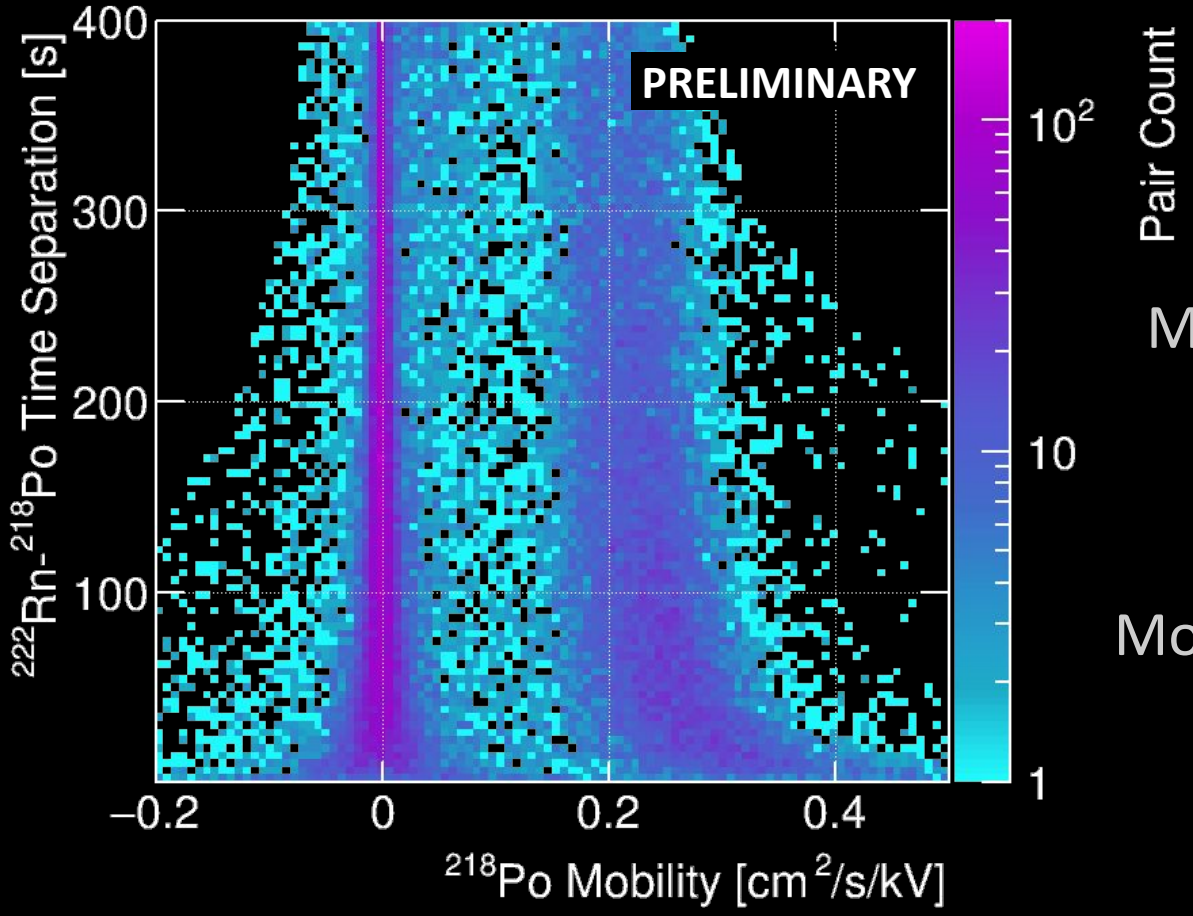
^{222}Rn-^{218}Po decay sequels (**pairs**) can be formed from LZ data

Selection purity is evaluated through the observed pair separation (^{218}Po half-life = **186s**)



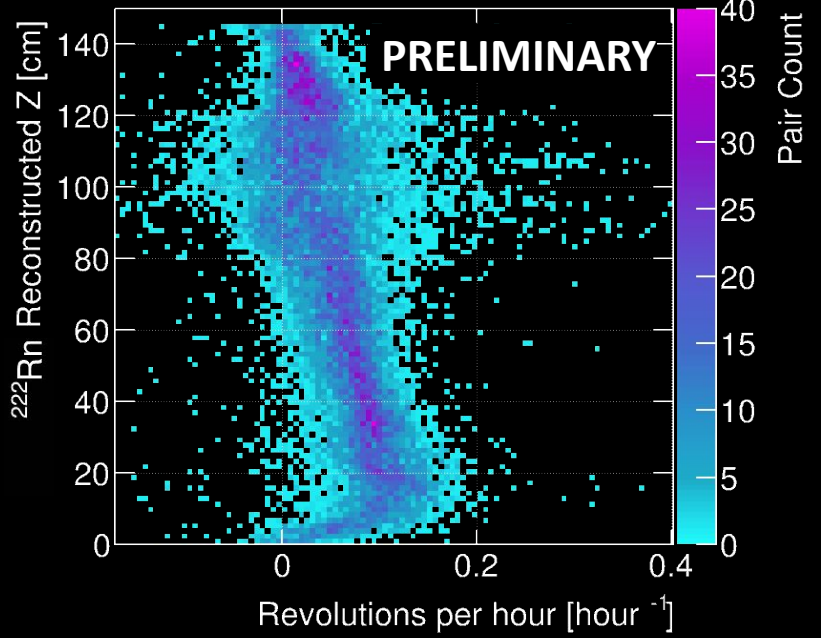
Neutral ^{218}Po follow the liquid flow

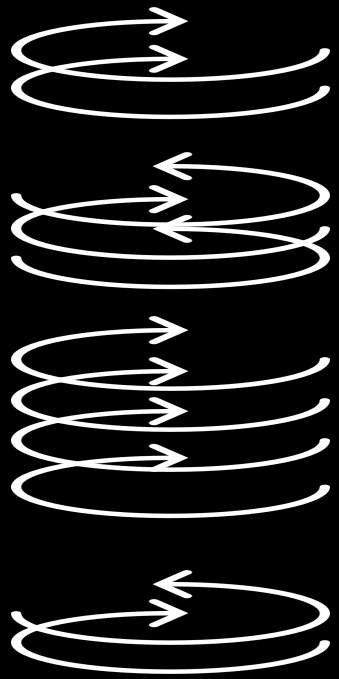
Charged ^{218}Po are swept by the field



Observed:
Mobility=0.22(4) cm2/s/kV
Charge Frac = 46(3) %

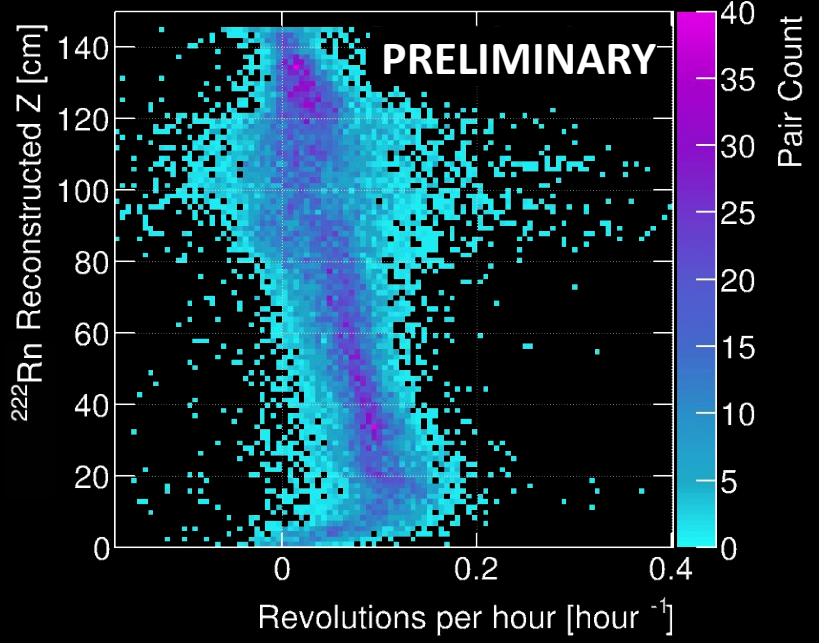
Literature (EXO-200):
Mobility=0.219(4) cm2/s/kV
Charge Frac = 50(3) %

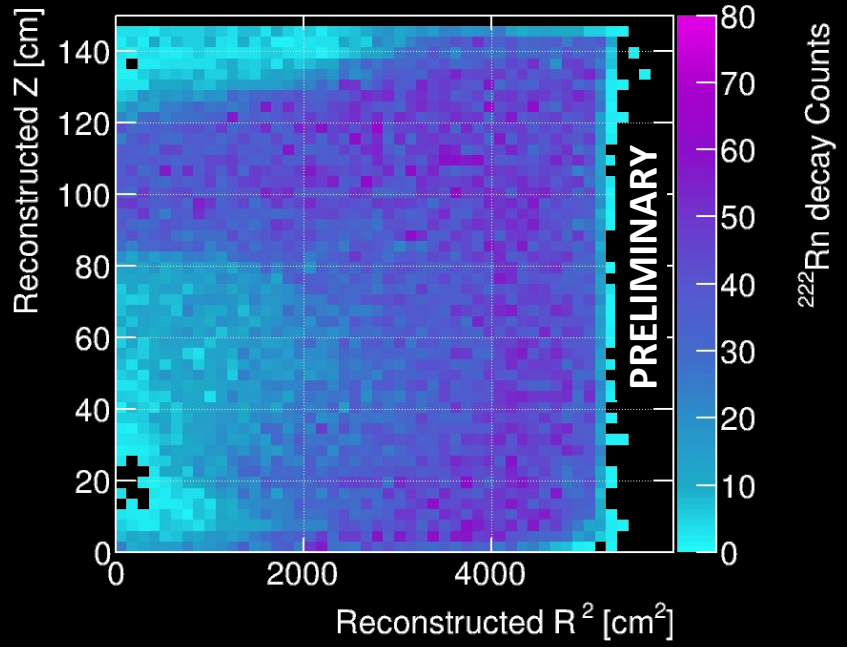




Neutral ^{218}Po pairs reveal structure in observed **azimuthal fluid flow** as well

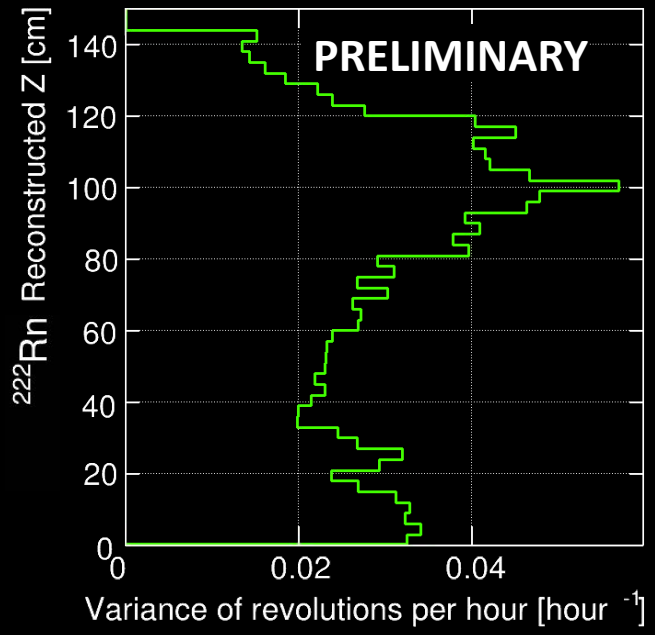
Azimuthal flow appears to correlate with **non-uniformities in ^{222}Rn spatial distribution**

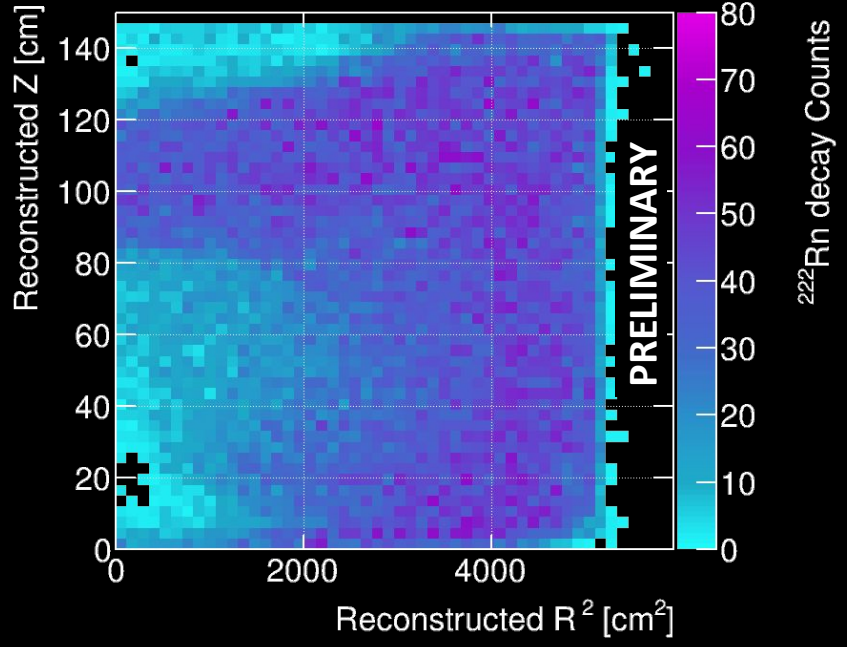




Current and future experiments may achieve

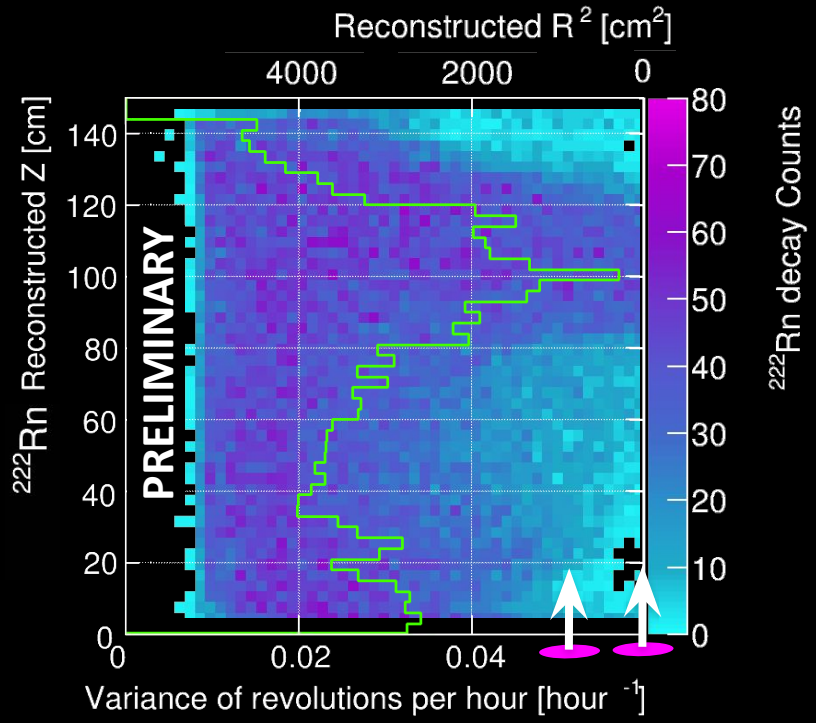
cleaner fiducial volume by manipulating liquid flow

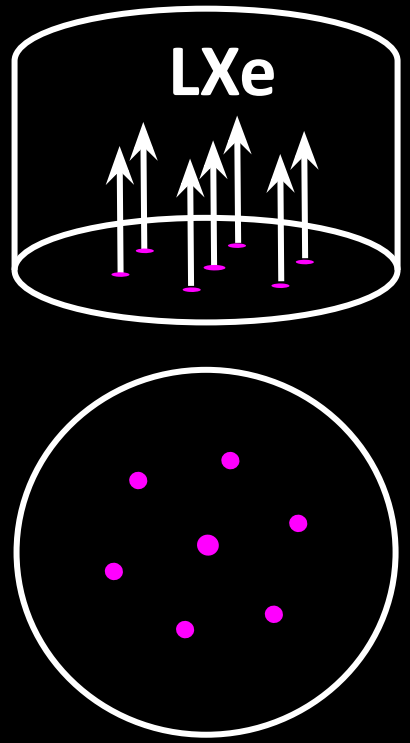




Azimuthal coherence impacts radon distribution

Observations appear stable through science run

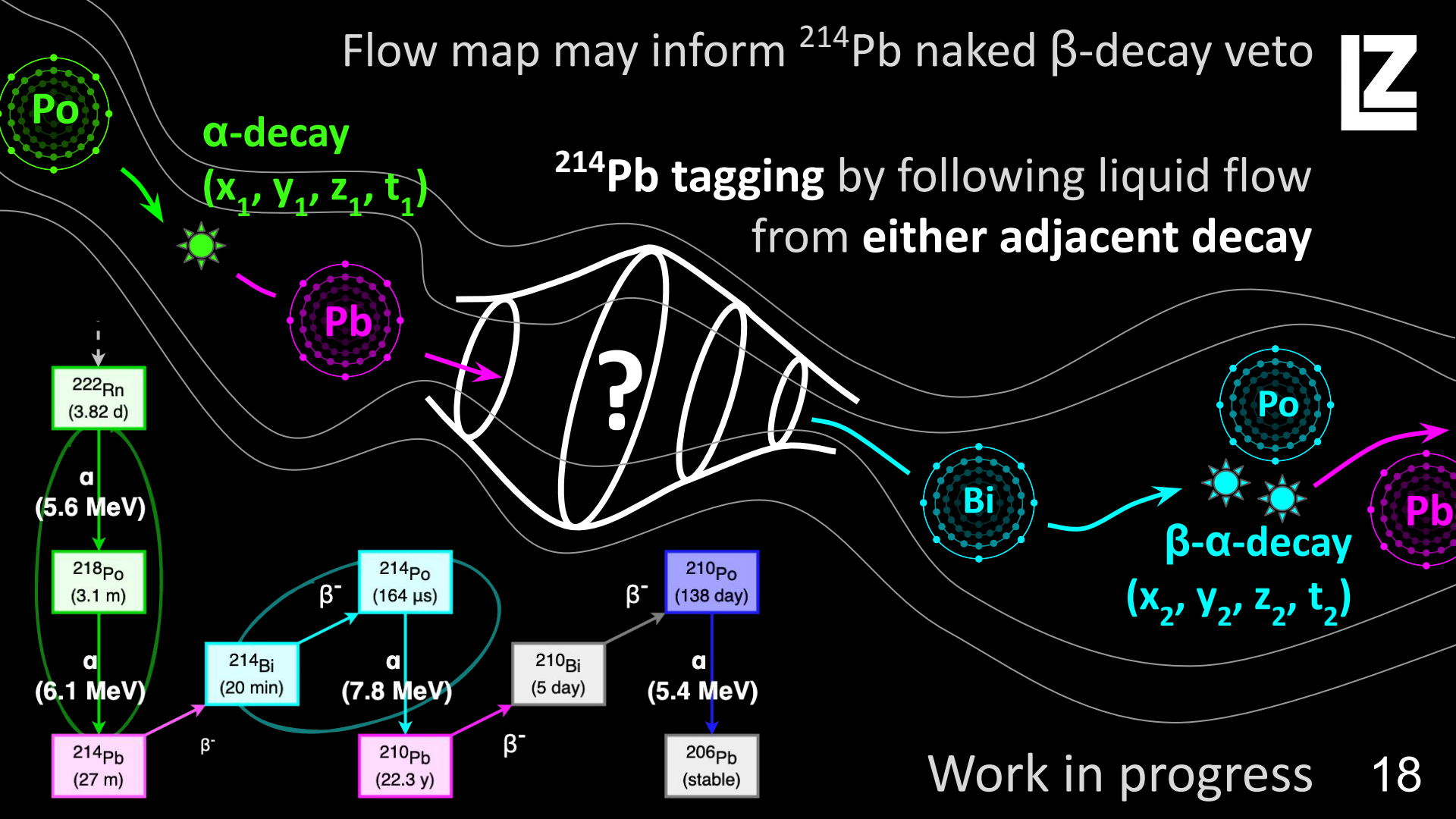




Seven inlets on bottom of TPC through array

Flow rate configurations will be explored in the future

Flow map may inform ^{214}Pb naked β-decay veto

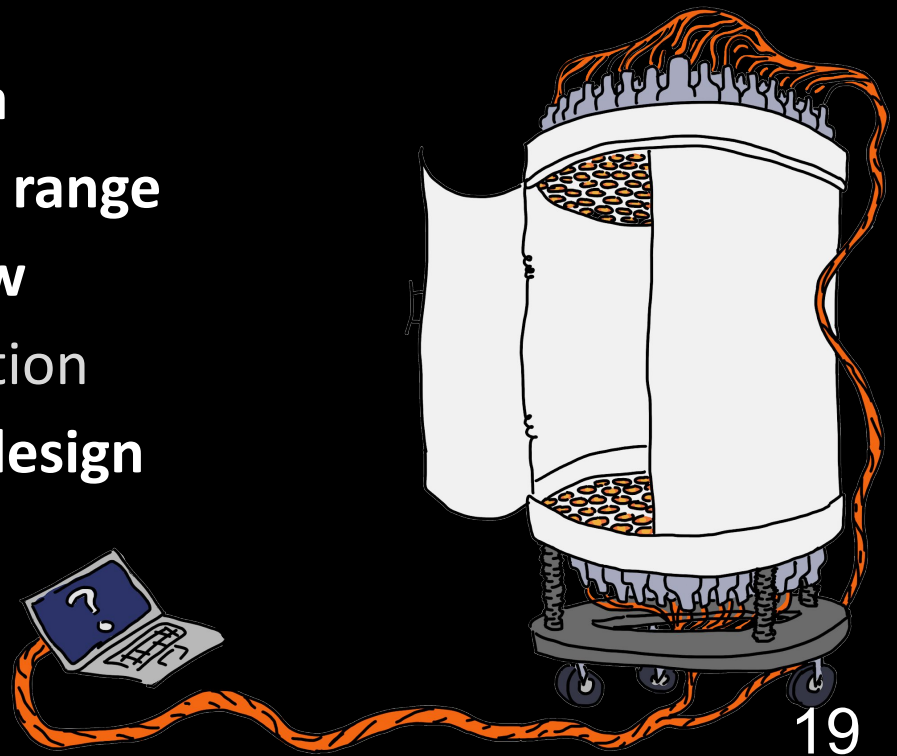


Work in progress

Imperial College London

Summary:

- LZ is currently taking **science data**
- Radon activity is **within expected range**
- ^{222}Rn-^{218}Po decay pairs **probe flow**
- Fluid flow impacts radon distribution
- Implications for **future detector design**
- Flow modeling can be used to **veto radon BGs in LZ**



FCT
Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA

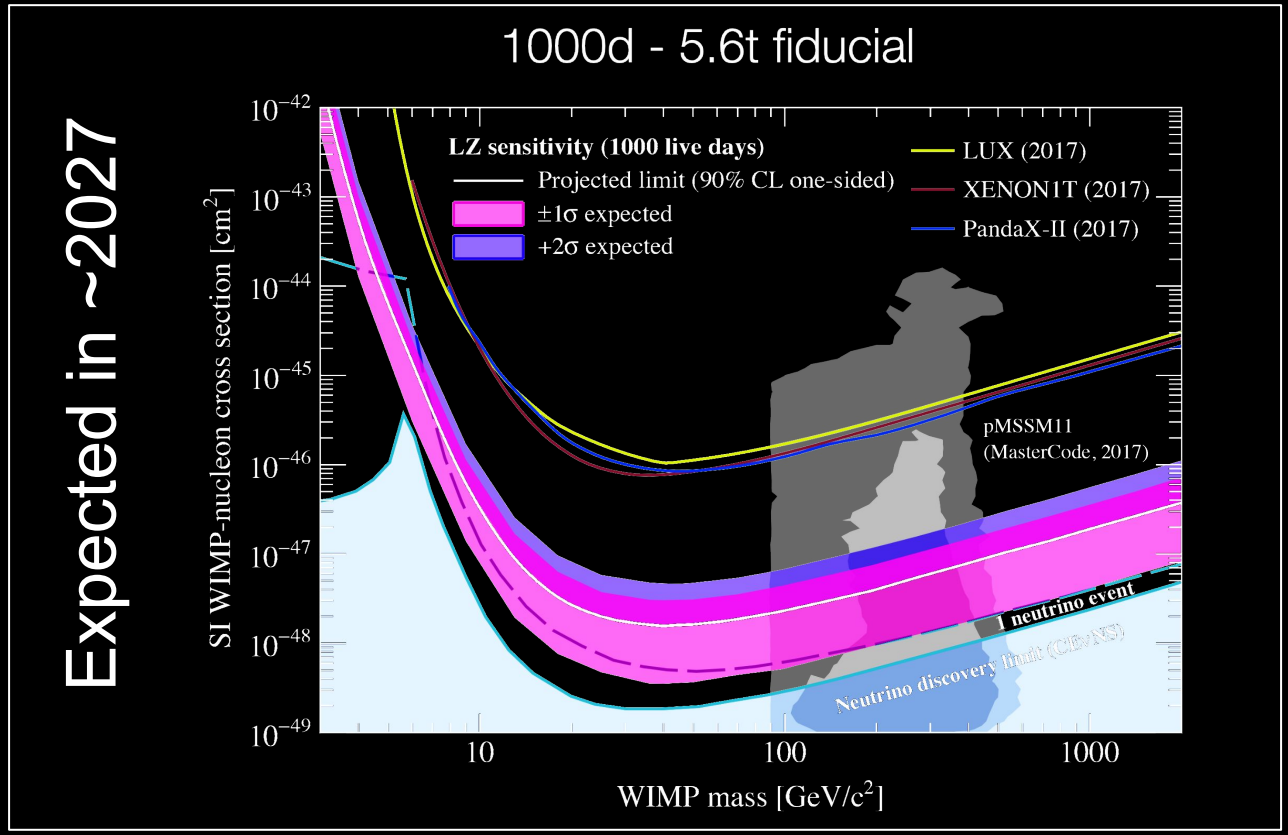
Science and Technology Facilities Council

Institute for Basic Science

Sanford Underground Research Facility

Back-up

World leading results expected in 2022 → (WIMPS, CEνNS, 0$\nu\beta\beta$)



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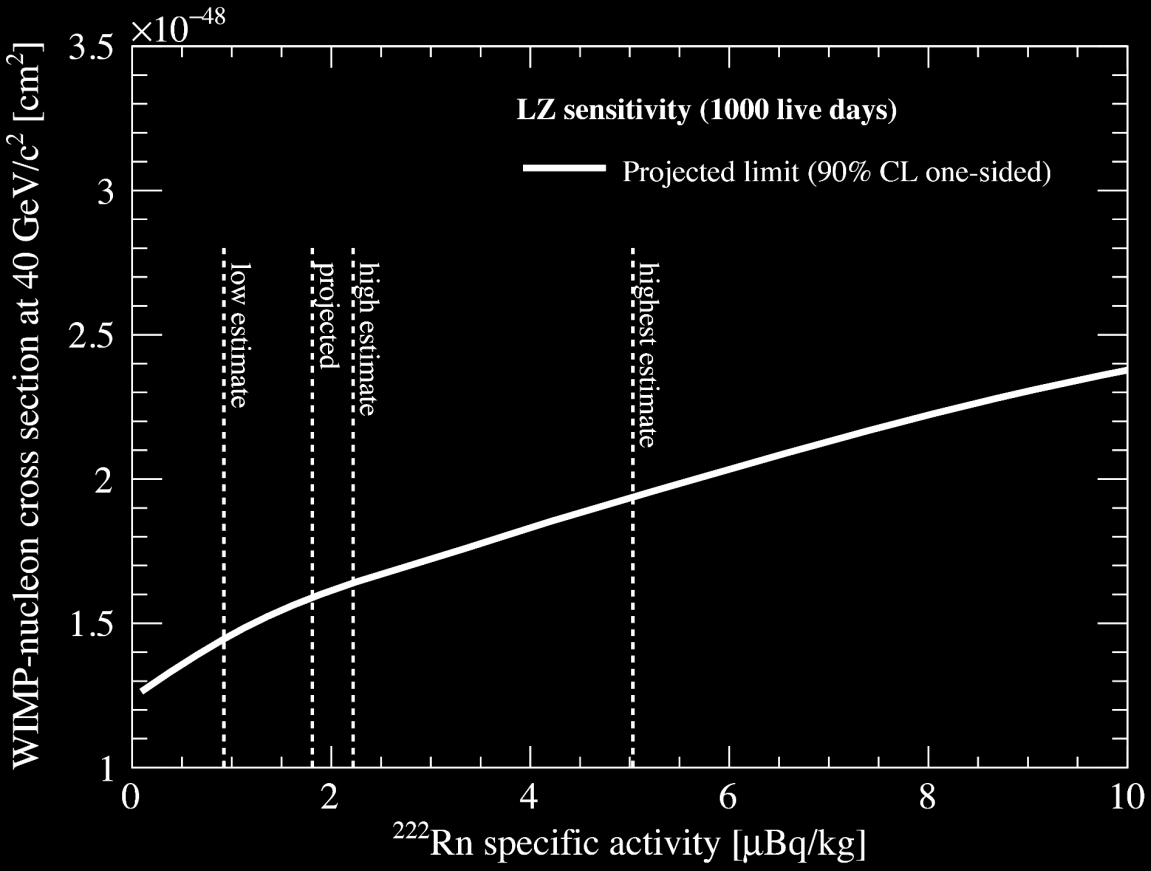
Impact of 222Rn specific activity on projected WIMP-nucleon sensitivity



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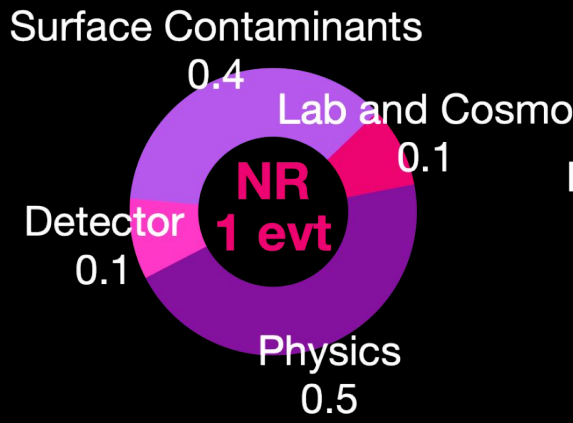
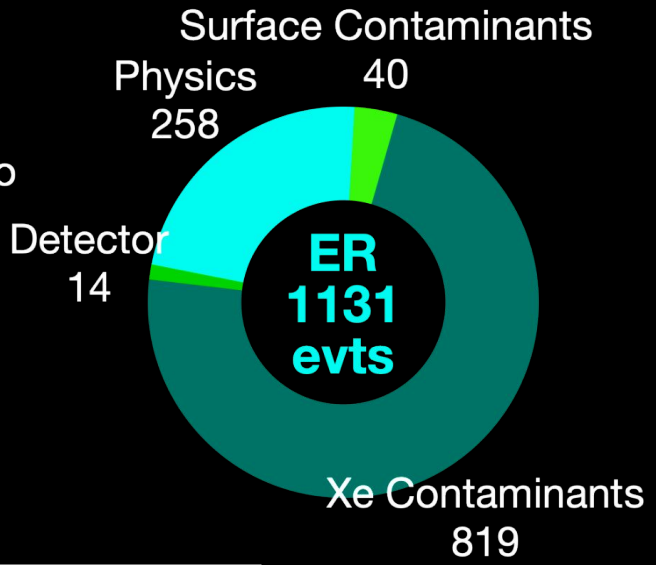
Background Expectation

WIMP ROI - 1000d - 5.6t fiducial





In signal region after cuts

0.52 NR events
5.66 ER events

- **Rn (792)**
- Kr (24.5)
- Ar (2.5)

WIMP ROI BG dominated by radon progeny

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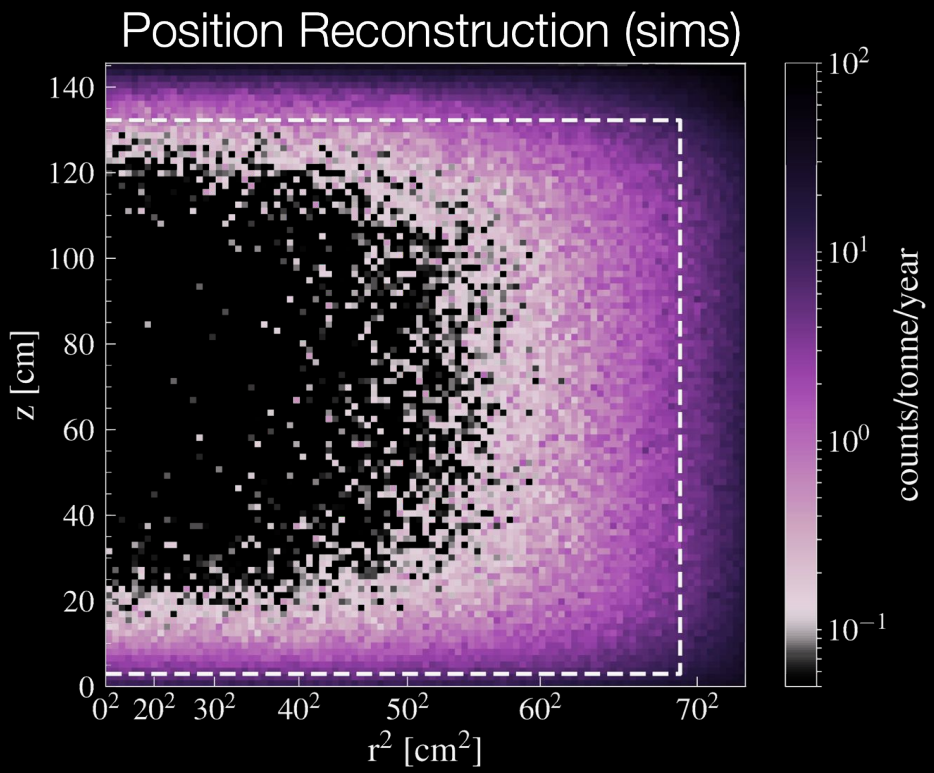

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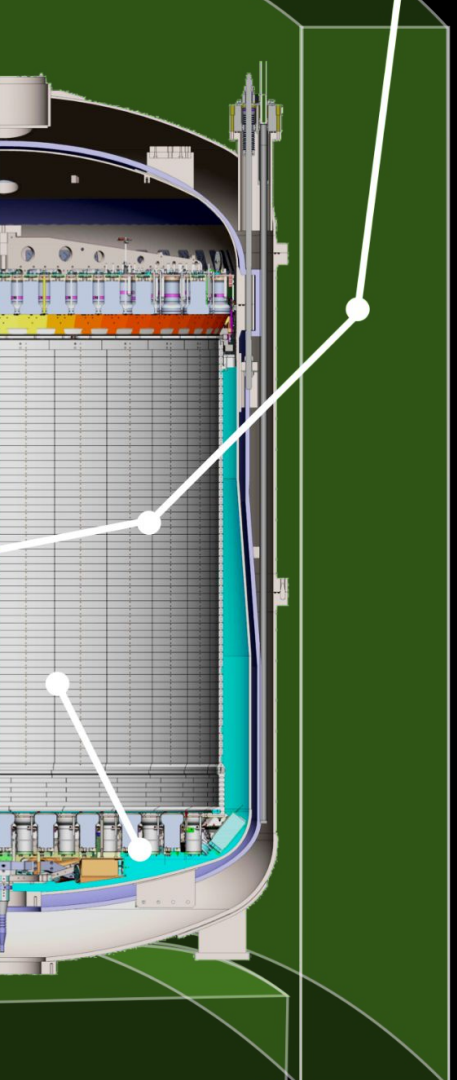
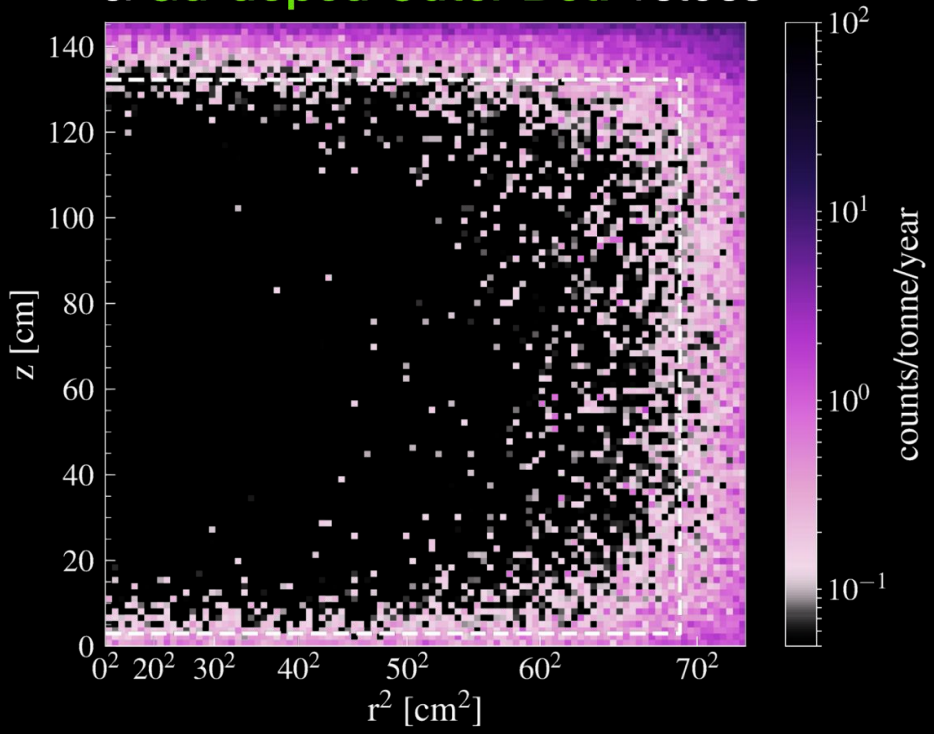


LXe Skin
& Gd-doped Outer Det. Vetoes



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