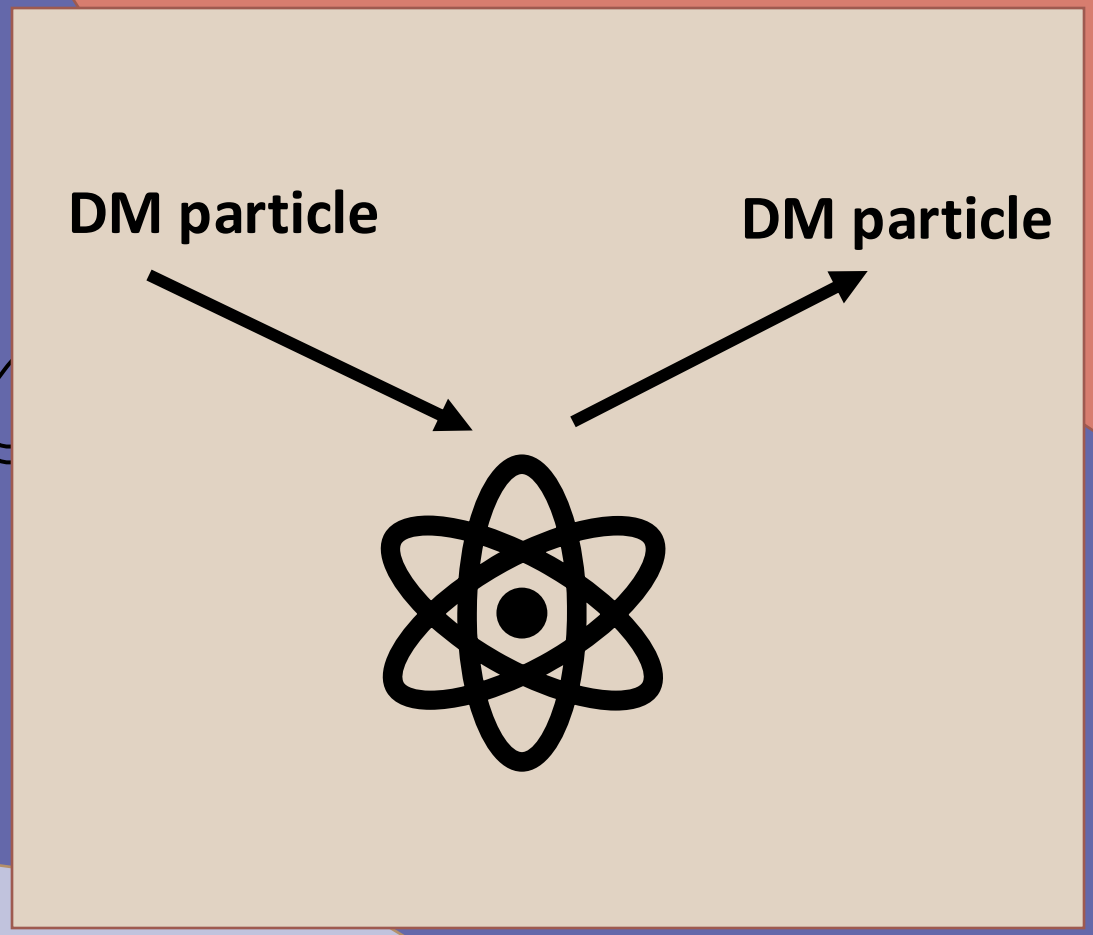
Setting sails into the unknow
or
How to build a detector for the invisible

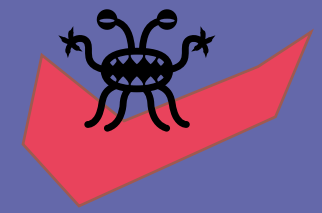
Online Seminar for Teachers: Dark Matter
30th Oct 2024
Dr Theresa Fruth

ARC CENTRE OF EXCELLENCE FOR DARK MATTER PARTICLE PHYSICS

Dark Matter Treasure Map

The tested realm





The fog

Dark Matter Treasure Map

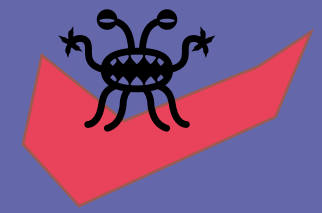
The tested realm

More likely to interact

Lighter

Heavier

Less likely to interact



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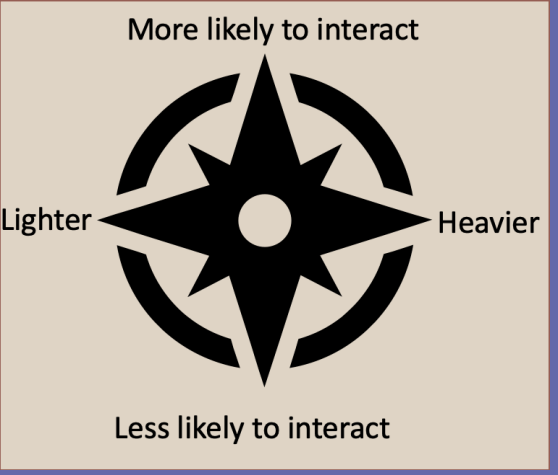

The tested realm

The sea of unexplored parameter space

The fog

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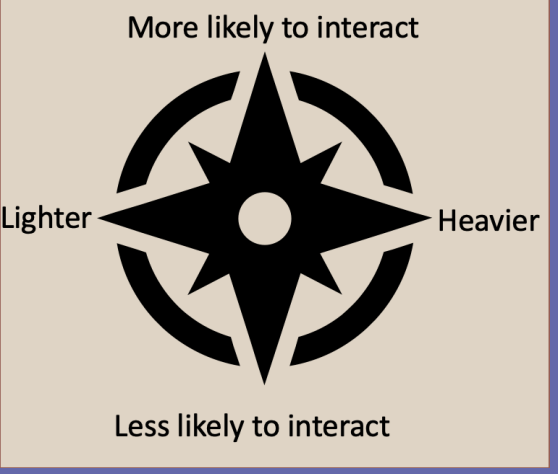

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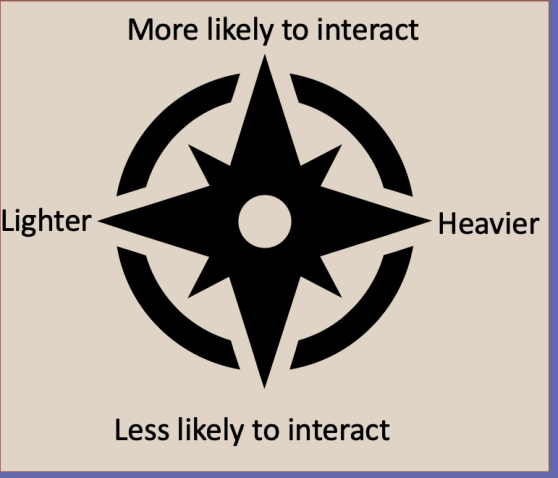

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Dark matter might be here. We don't have access to this space yet

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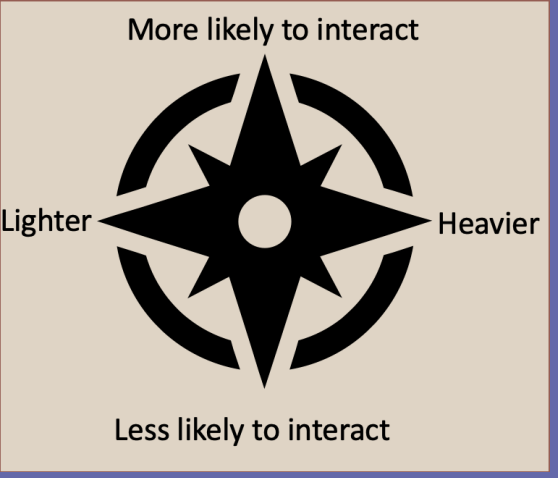

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Once we reach this far down, we will start detecting neutrinos and this "fog" will bring new challenges for our searches.

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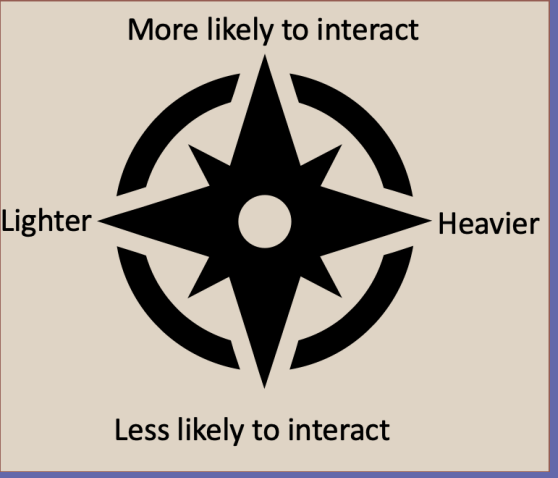

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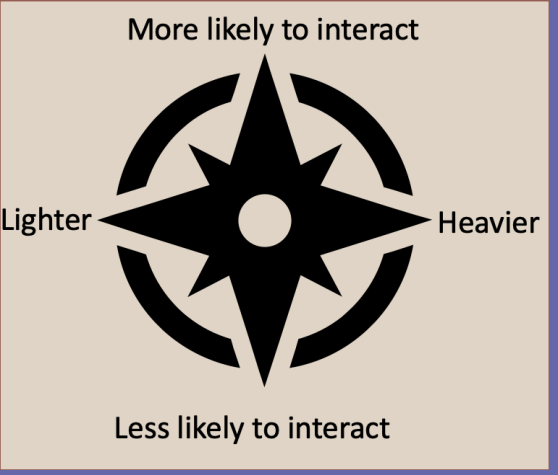

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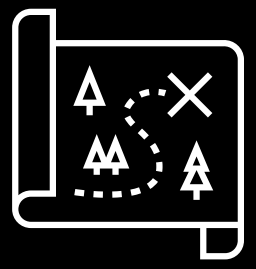

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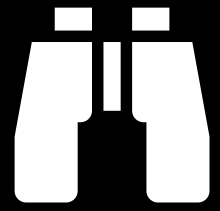
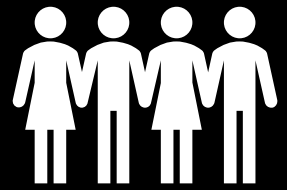
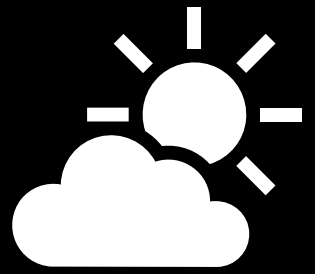


Eyes



Crew



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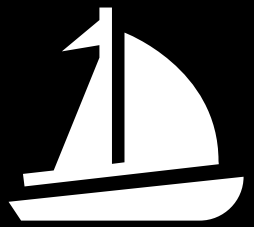
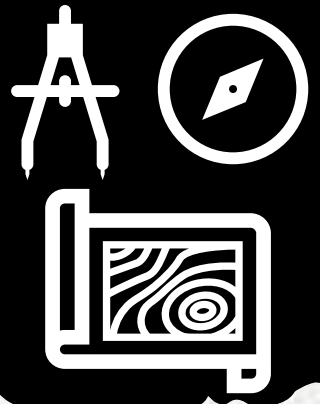


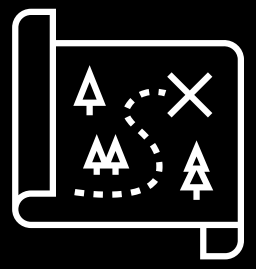
Vessel



Mapping tools

The Crew

- LZ collaboration
- 250 + scientists, engineers, technicians
- From US, UK, Portugal, Korea and Australia



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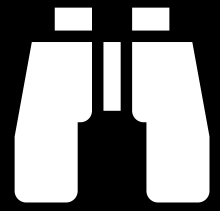

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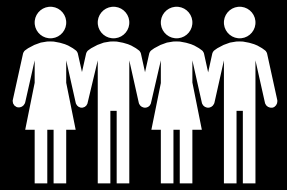

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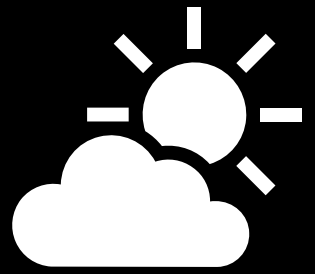

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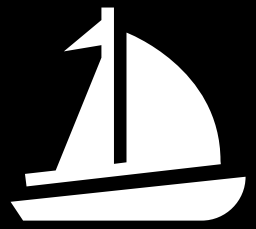

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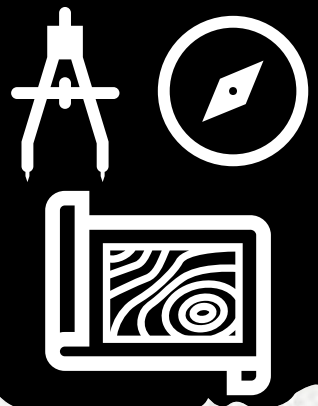
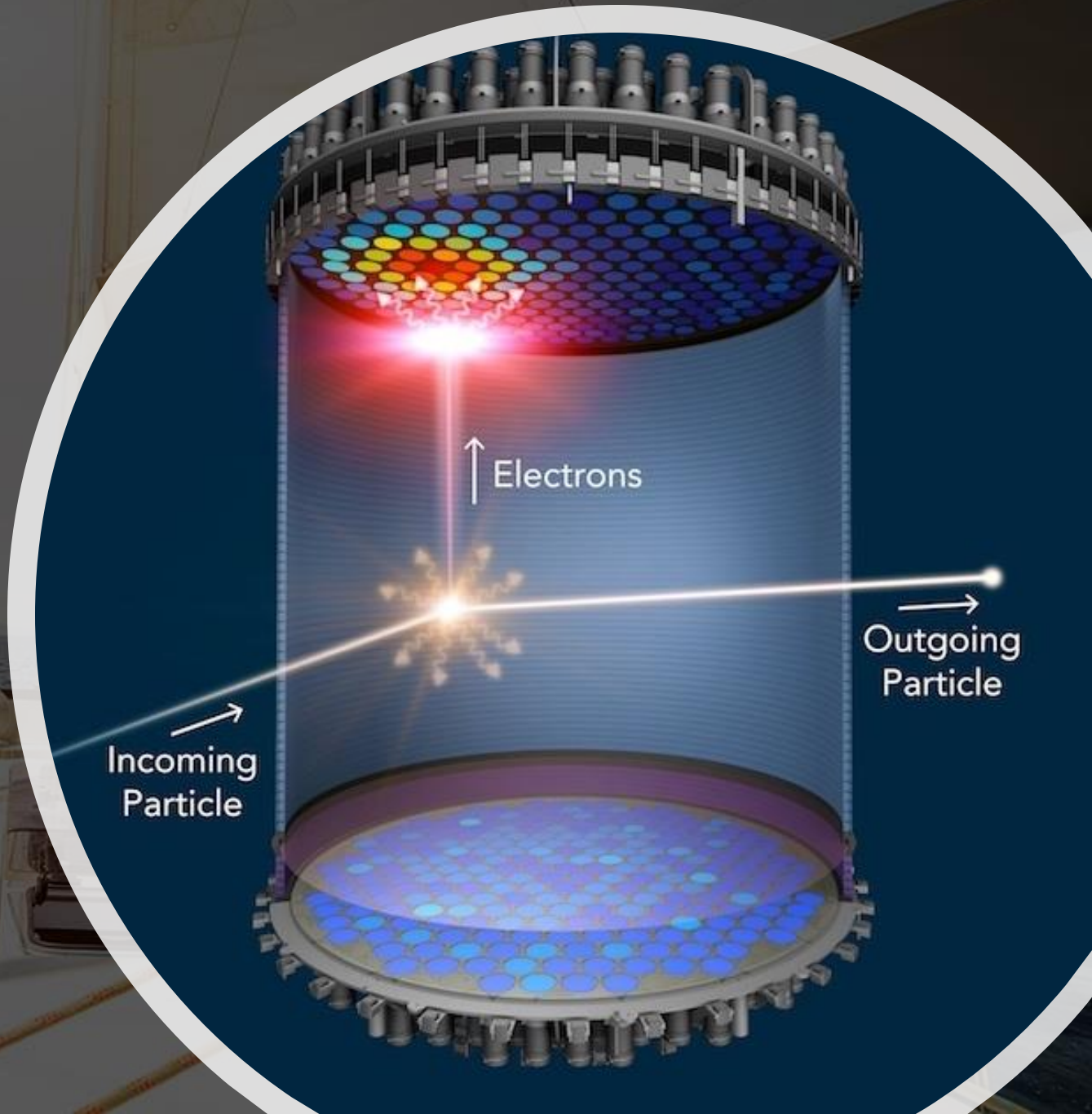
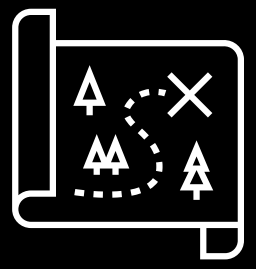


Mapping tools

The Vessel

- Xenon is a noble gas
- If a DM particle collides with a Xe nucleus, we will see a faint flash of light
- Any radioactivity in Xenon decays away relatively quickly





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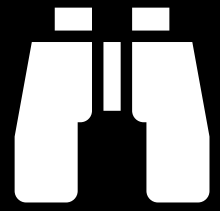

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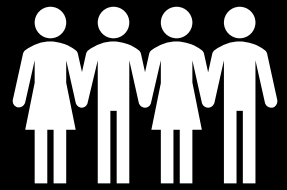

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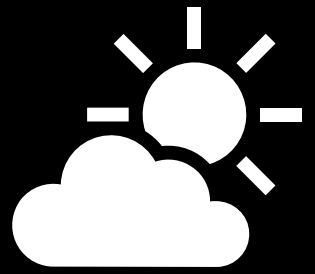

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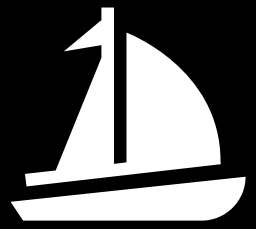

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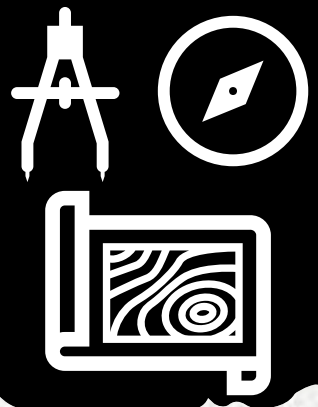
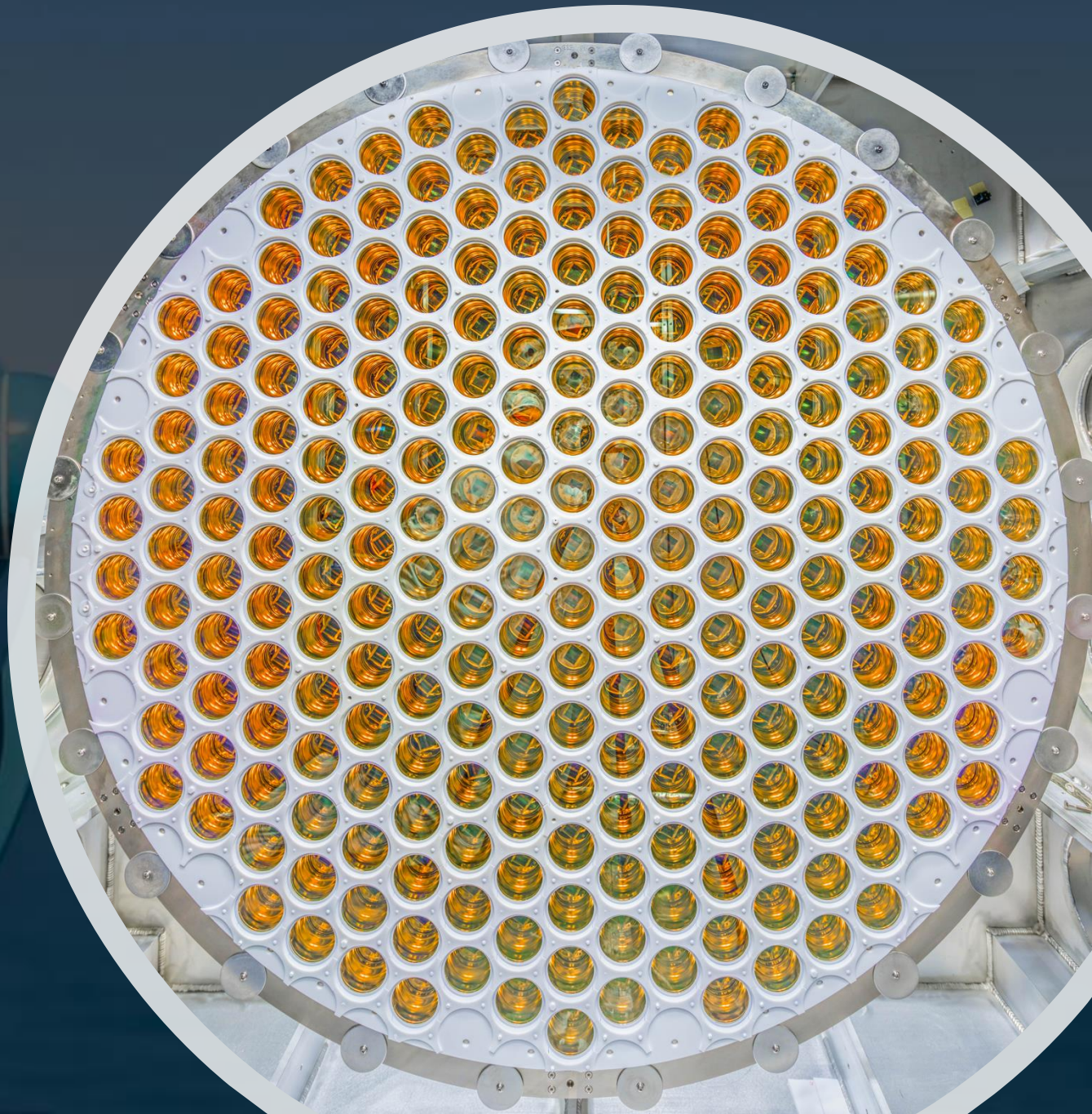
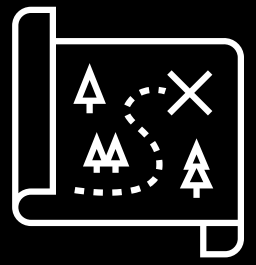


Mapping tools

The Eyes

- Need to detect very faint light
- Using Photomultiplier tubes (PMTs)
- These convert a single photon into many electrons and therefore a measurable electrical signal





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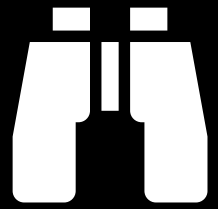

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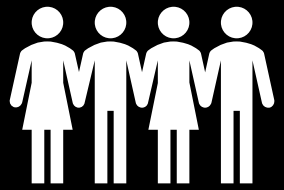

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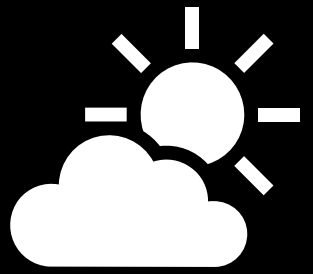

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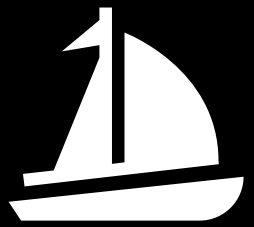

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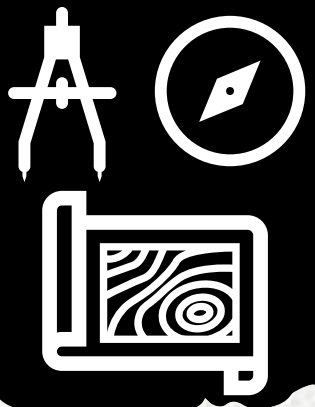

Mapping tools

Excellent background conditions

- The signals we're trying to detect are very faint, need to reduce backgrounds
- Need to screen materials for radioactivity
- Need to avoid dust and radon in the detector

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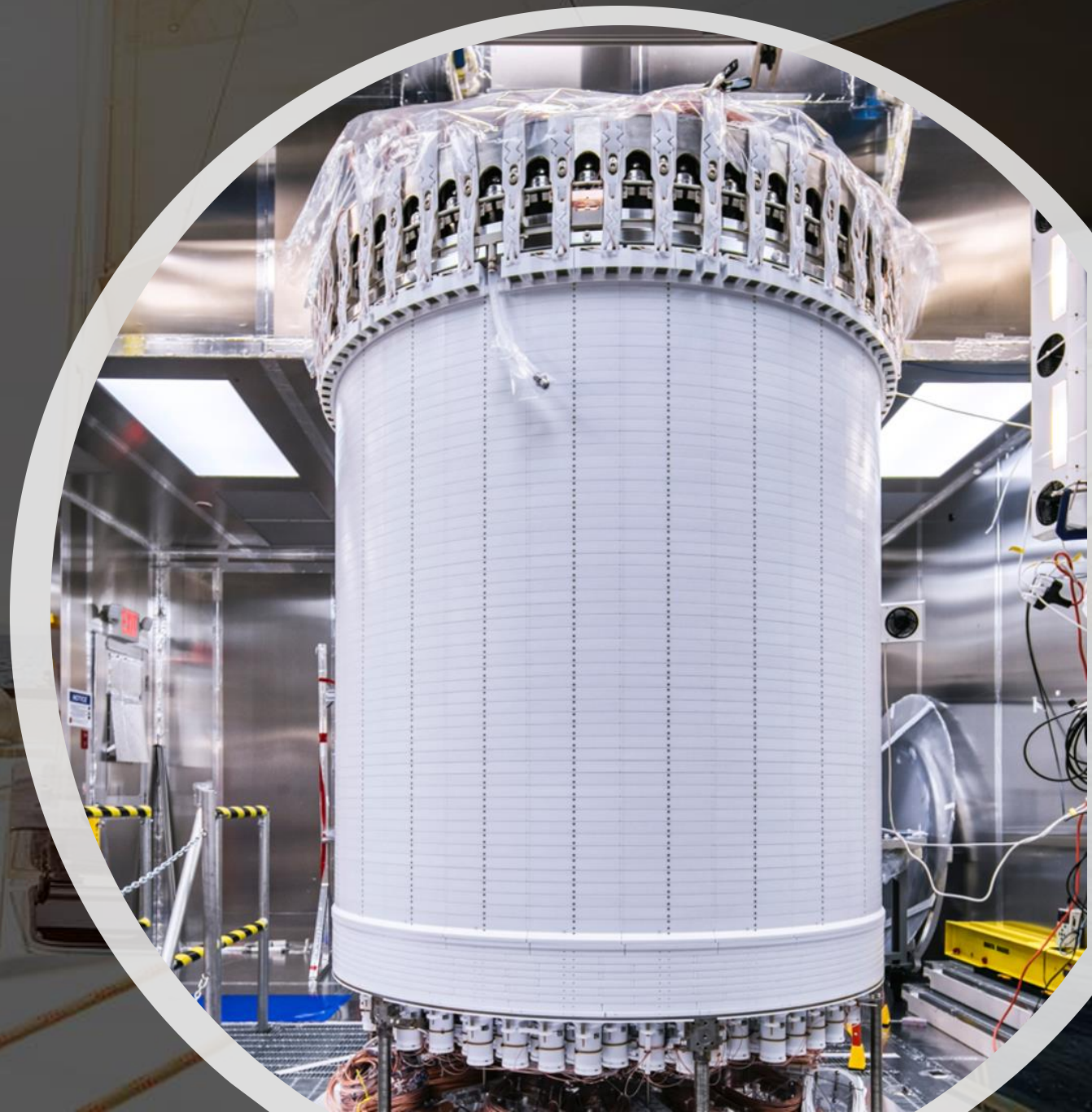
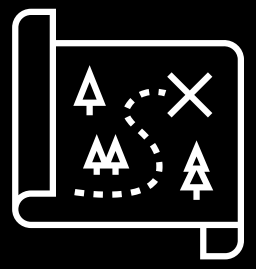
Excellent background conditions

- Need to shield against cosmic rays
- Experiments typically take place in underground laboratories
- LZ is in an old goldmine in South Dakota

The LZ Expedition

- International team of scientists
- 7 tonnes of liquid Xenon
- 494 light detectors
- 1 mile underground
- All materials were screened, and the detector was assembled in a cleanroom





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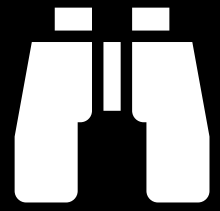

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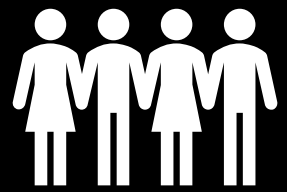

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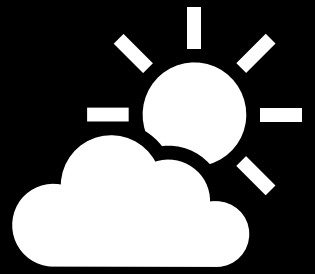

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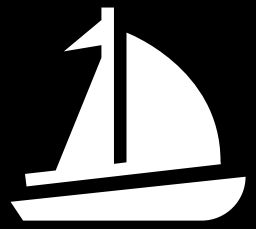

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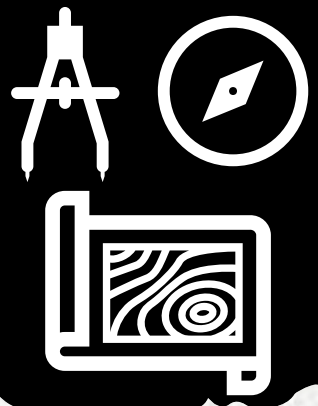
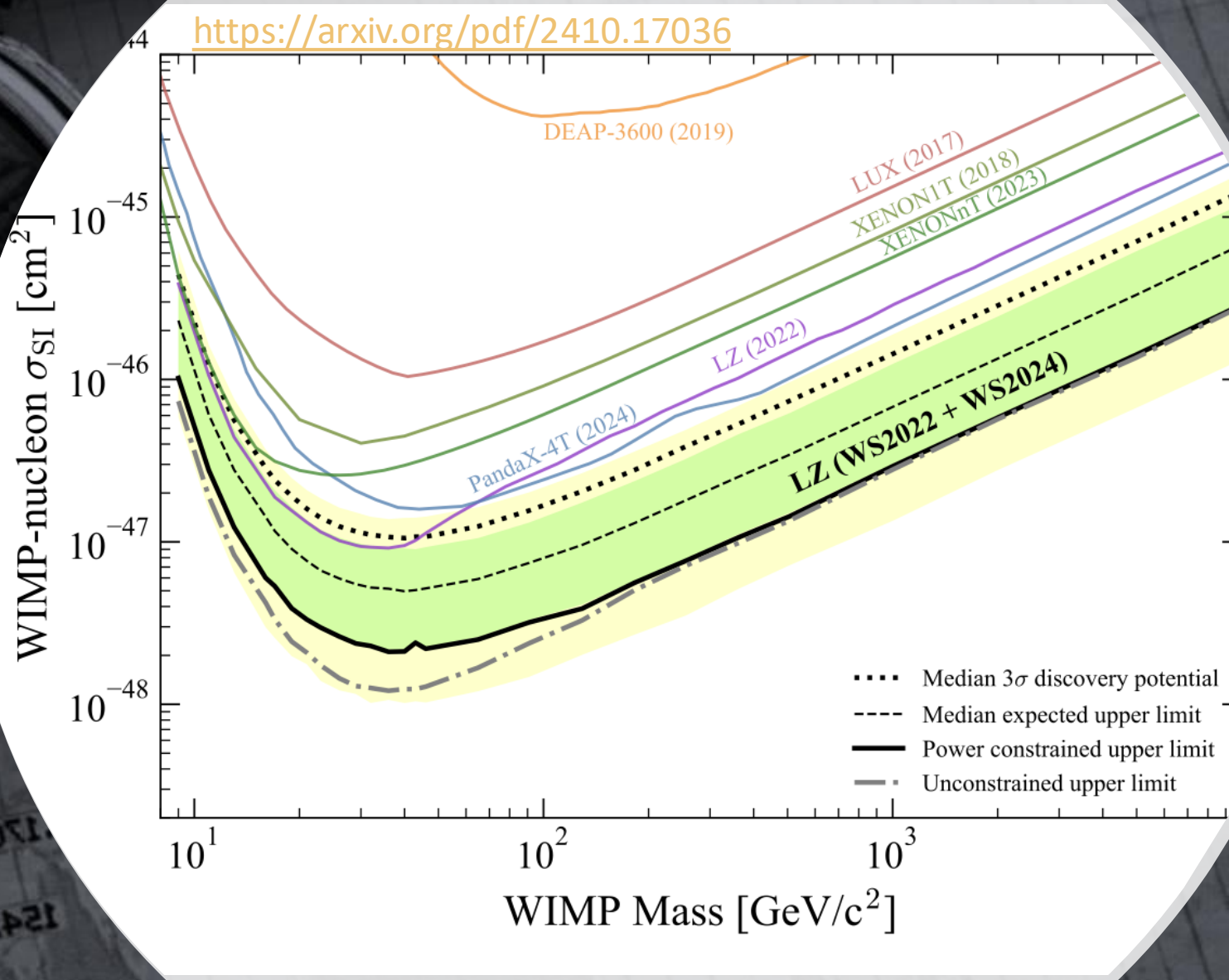


Mapping tools

First results

- Current status of the expedition after 280 live-days
- Reached into new unchartered territory
- Did not find anything new (yet?)
- The search continues

https://arxiv.org/pdf/2410.17036



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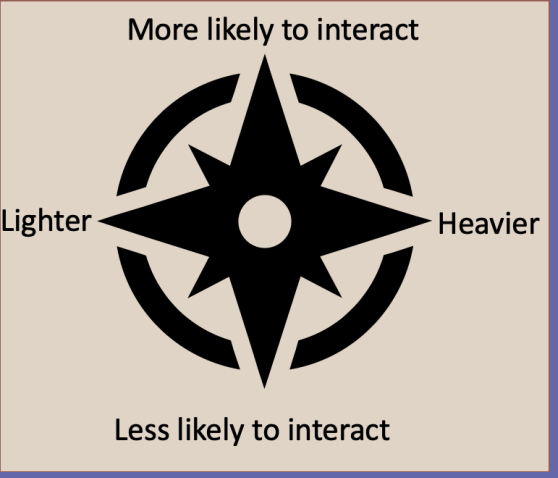
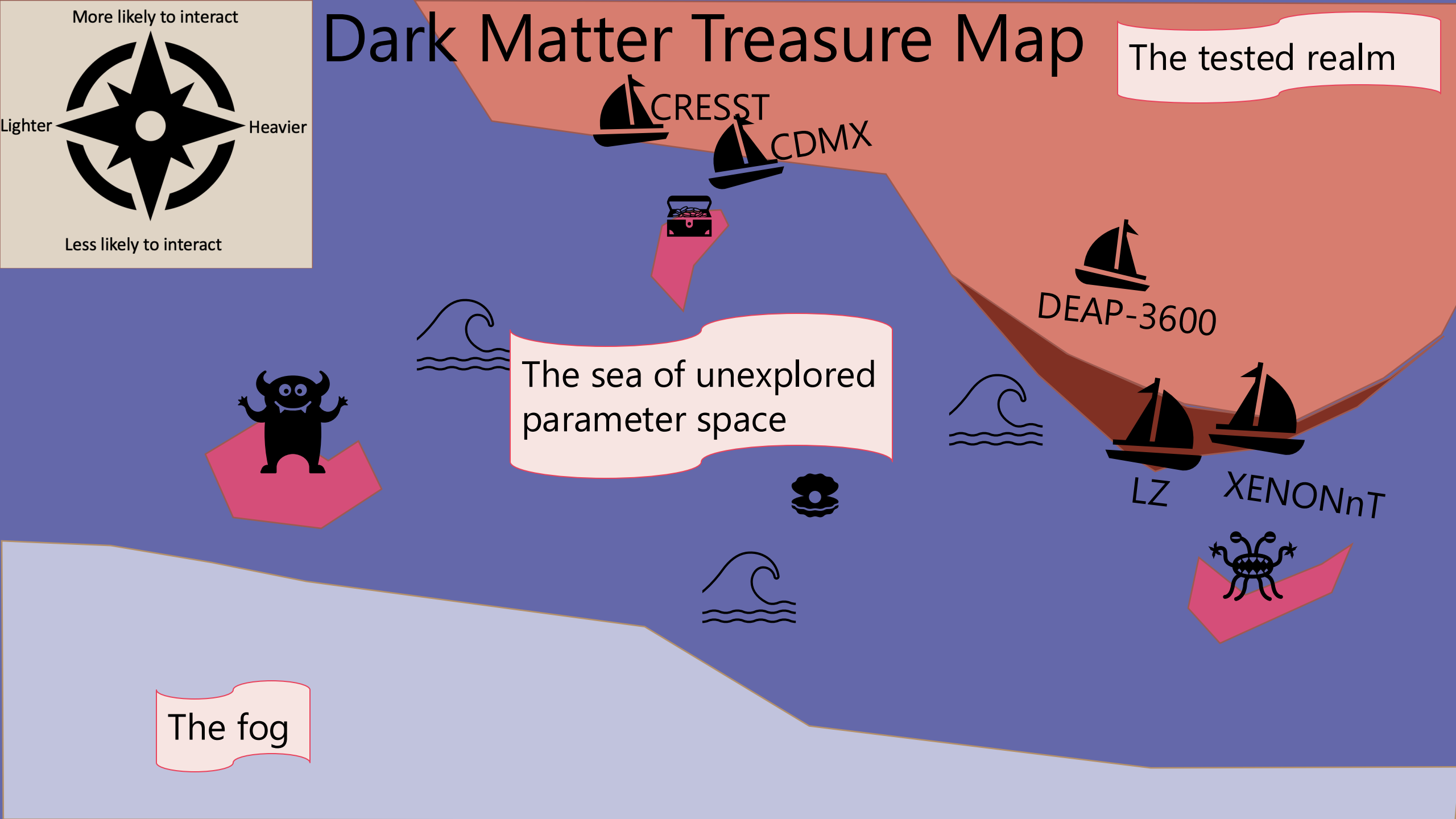


The tested realm

The sea of unexplored parameter space

LZ

The fog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Lighter
Heavier
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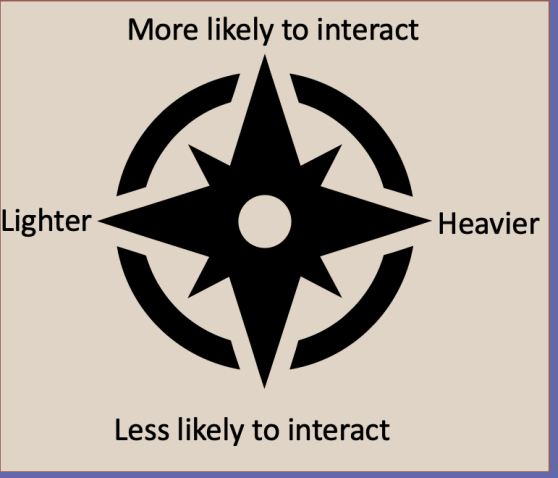

The tested realm

CRESST

CDMX

DAMA/LIBRA

DEAP-3600

The sea of unexplored parameter space

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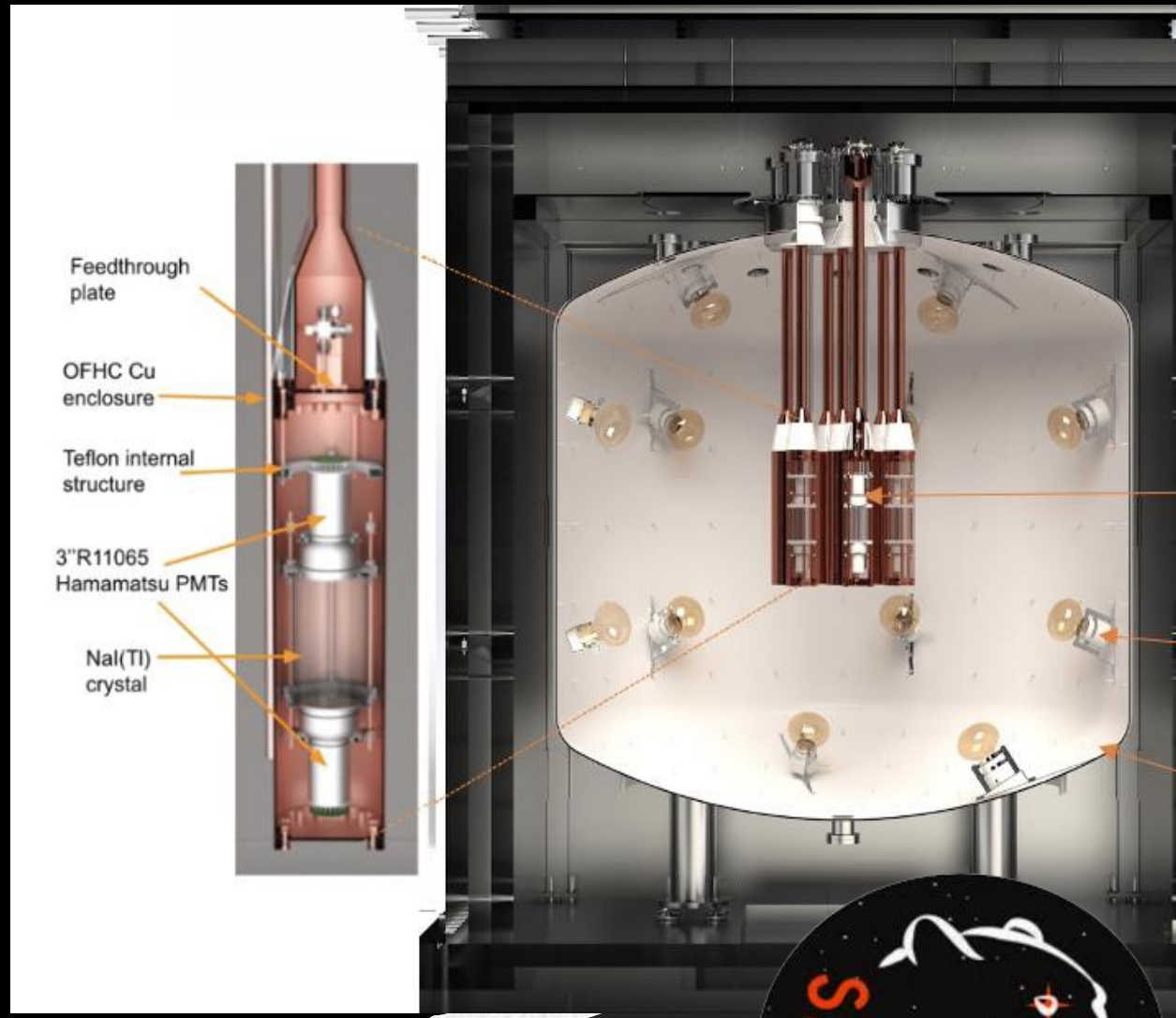
The fog

SABRE

- Aim to test the DAMA/LIBRA claim
- Two detectors:
  - Northern hemisphere: Italy
  - Southern hemisphere: Australia
- Sodium-Iodide crystals as detector medium
- Light sensors (PMTs) to see signal



SABRE

STAWELL UNDERGROUND PHYSICS LAB

SABRE

What will we find and where?

On twitter: @ARC_DMPP @DarkMatterDay @lzdarkmatter

ARC CENTRE OF EXCELLENCE FOR DARK MATTER PARTICLE PHYSICS