

# Status and Prospects of Kamioka Cryolab

*Suerfu Burkhant*

*QUP, KEK*

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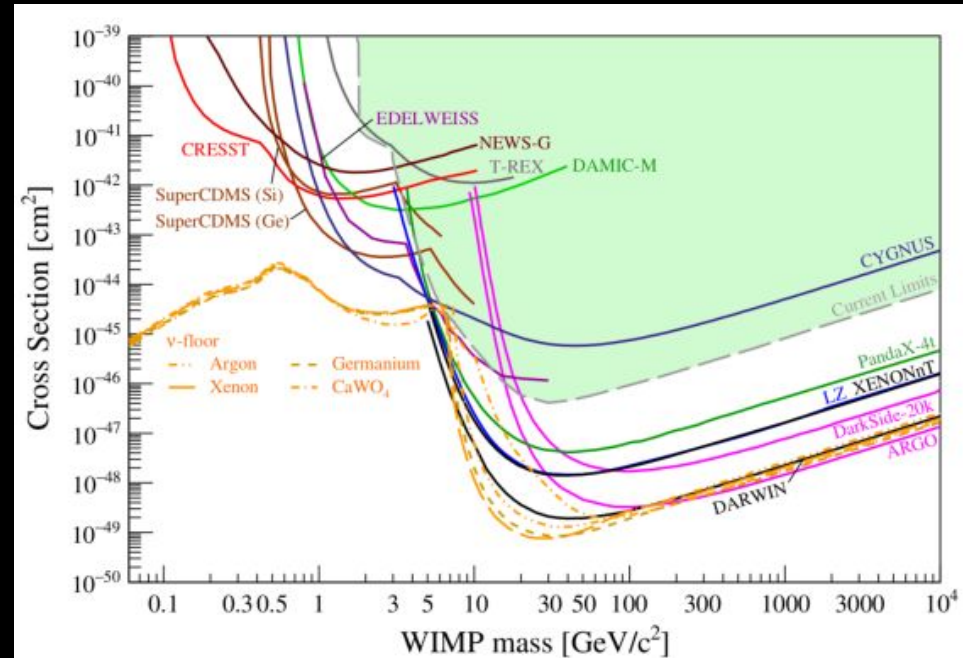
*TAUP2025 @ Xichang*



# Light Dark Matter, What and Why?

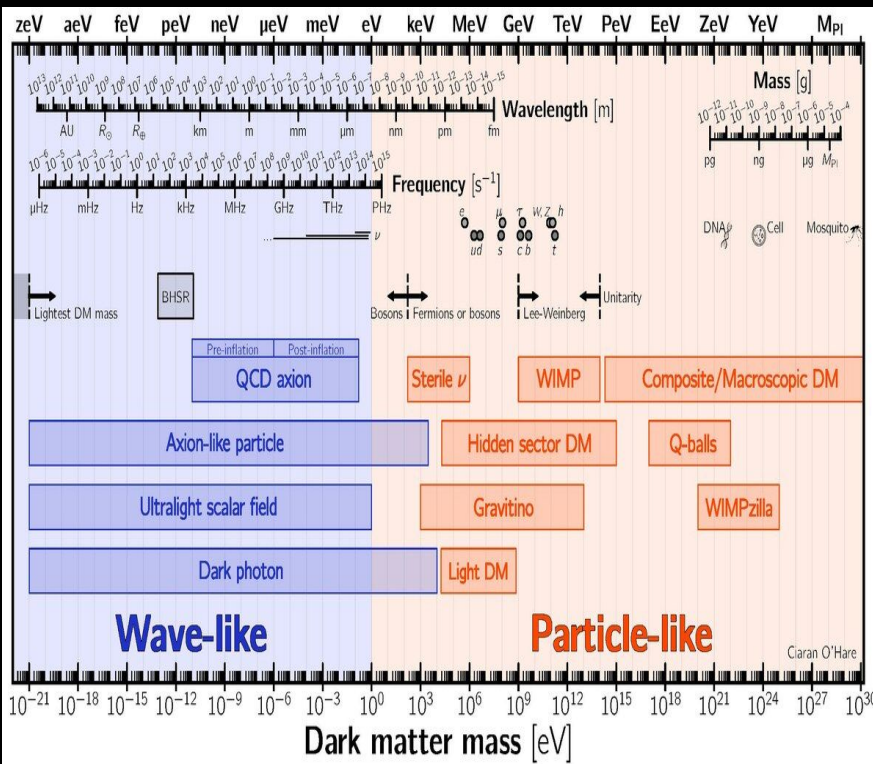
Revisiting dark matter production theory.

Strategic shift to low-mass DM

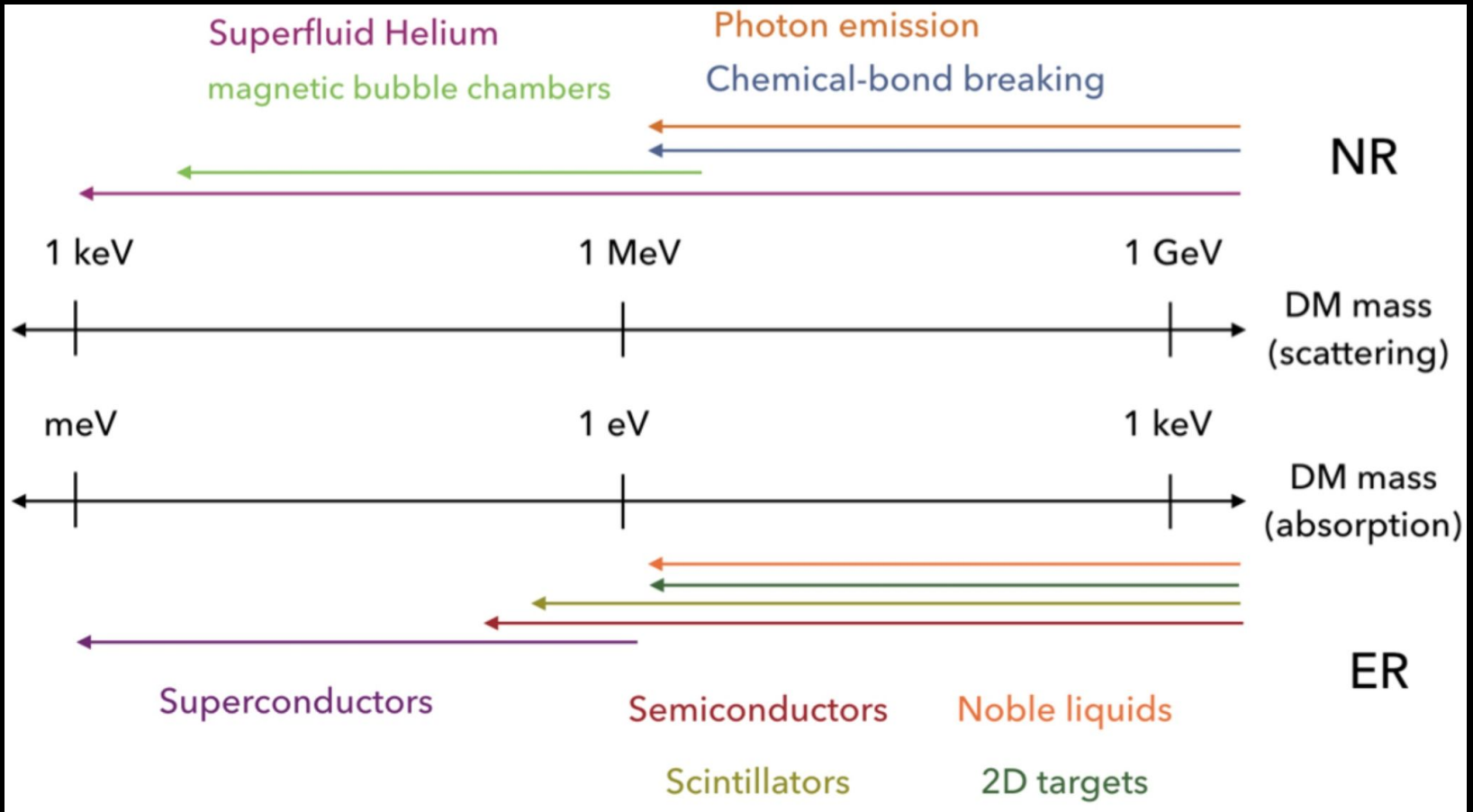


Novel technologies are required:

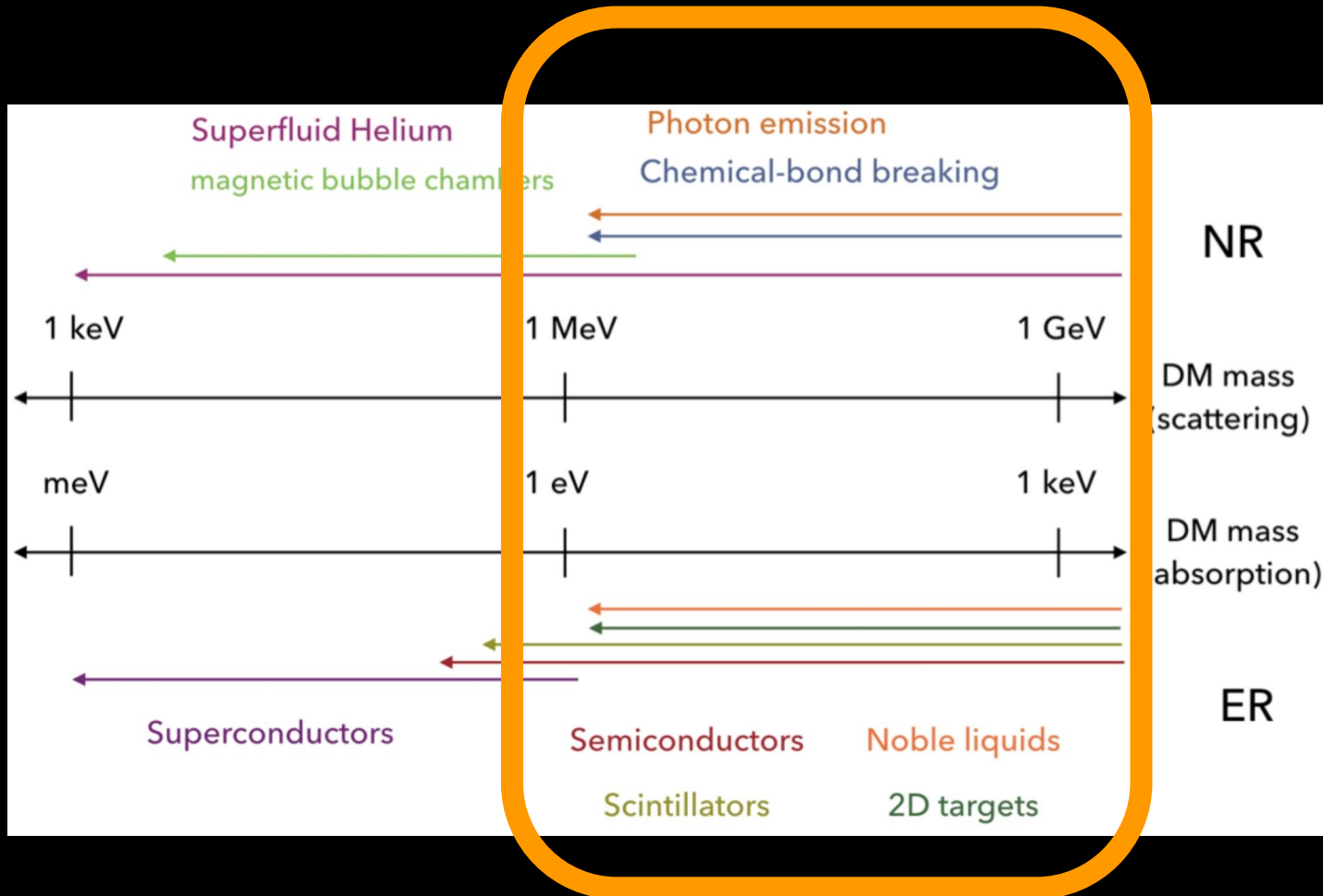
- detecting small amount of energy deposits
- material dependence must be considered



# How to detect light dark matter?

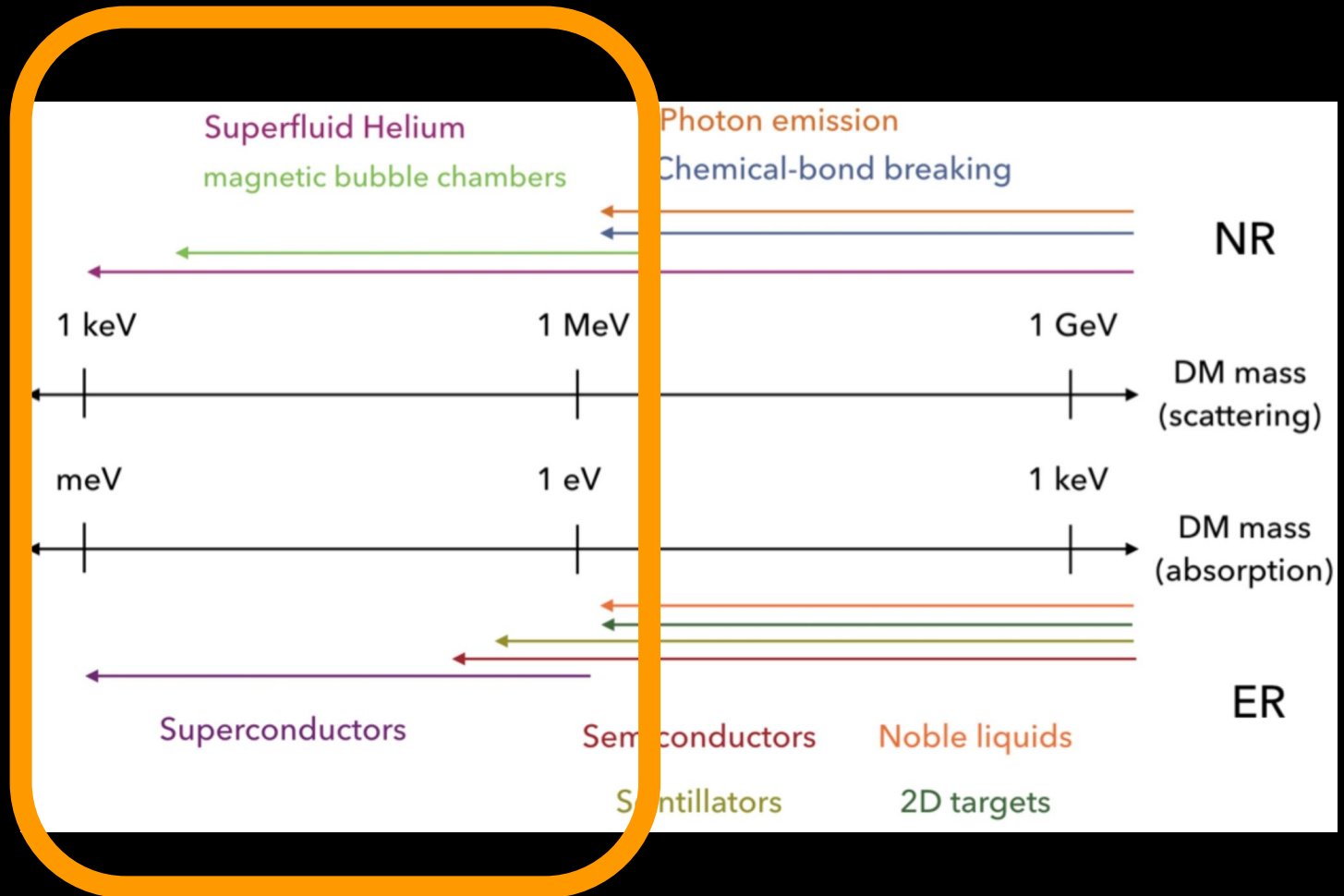


# How to detect light dark matter?



Semiconductor/Noble Liquid: mature technology, established experiment, few choices.

# How to detect light dark matter?



Emerging field, new technology, lots of opportunities, but requires sub-K temperature underground.

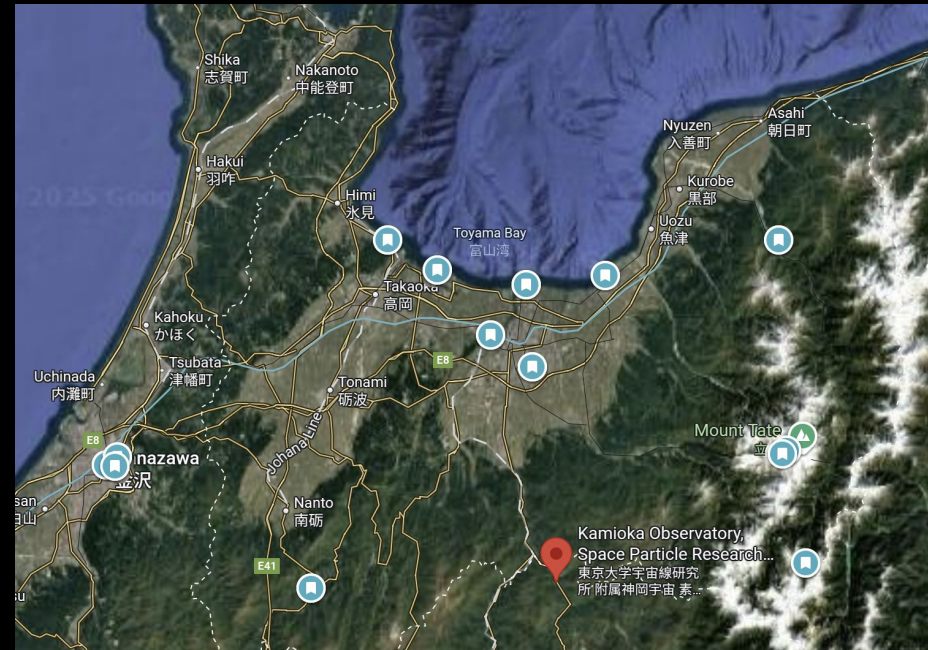
# Approach to light dark matter

## Cryogenic:

- superconducting gap is  $\sim \text{meV}$
- *ADR, dry-DR, wet-DR?*

## Low-background:

- shielding
- *low-background materials?*
- underground



*Si, GaAs, Sapphire, Graphene,  
NaI, Al, TiN, Dirac/Weyl metal, ...*

Target mass: can be small, but must cover different possibilities

*It seems the only viable solution at present is to install a DR in an underground site and operate within shielding.*

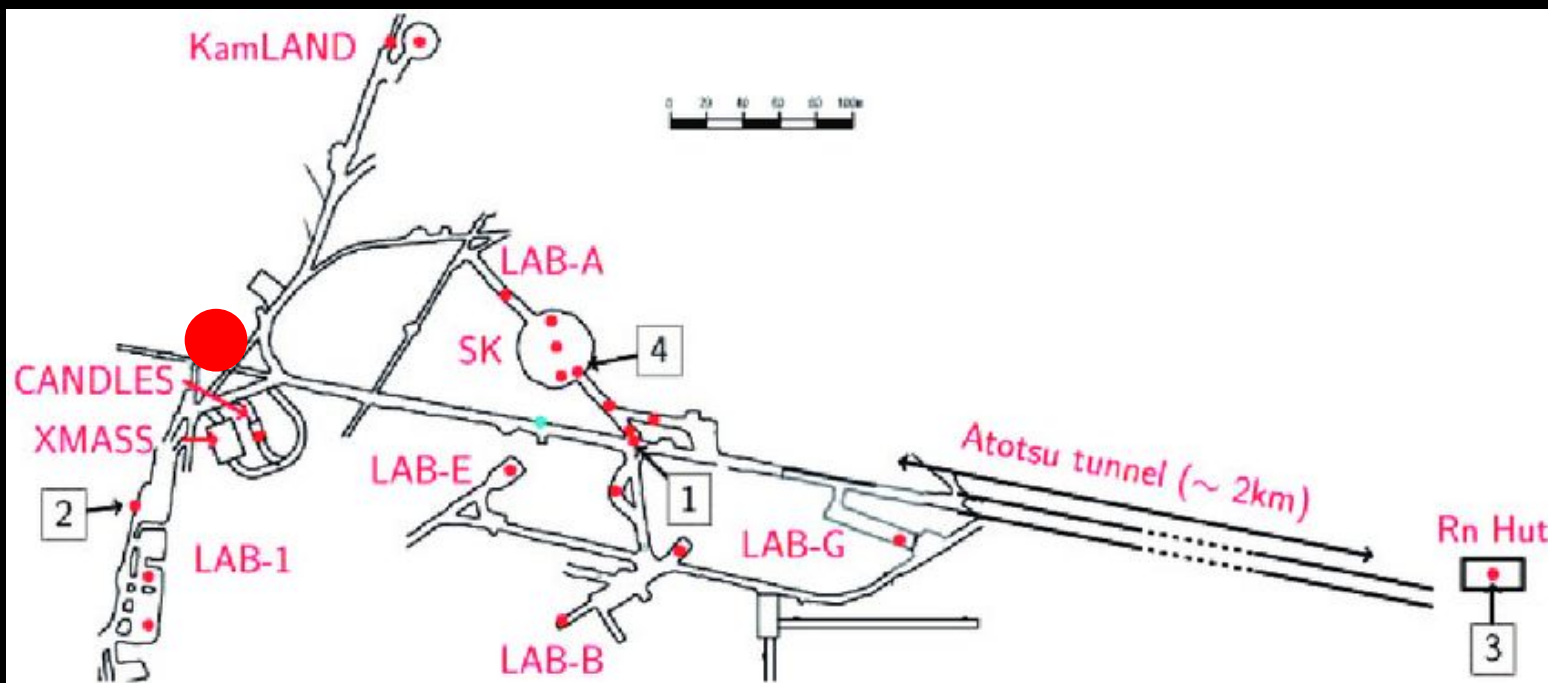


# Kamioka Light Dark Matter Project

Initiated with a US-JP proposal and a collaboration between QUP, KEK and RCNS, Tohoku University.

Experimental site located near KamLAND LS distillation system.

Dilution fridge provided by QUP, relocation completed November, 2024.



# DR Relocation to Kamioka



*After an intense half year,  
relocation completed  
in November, 2024*

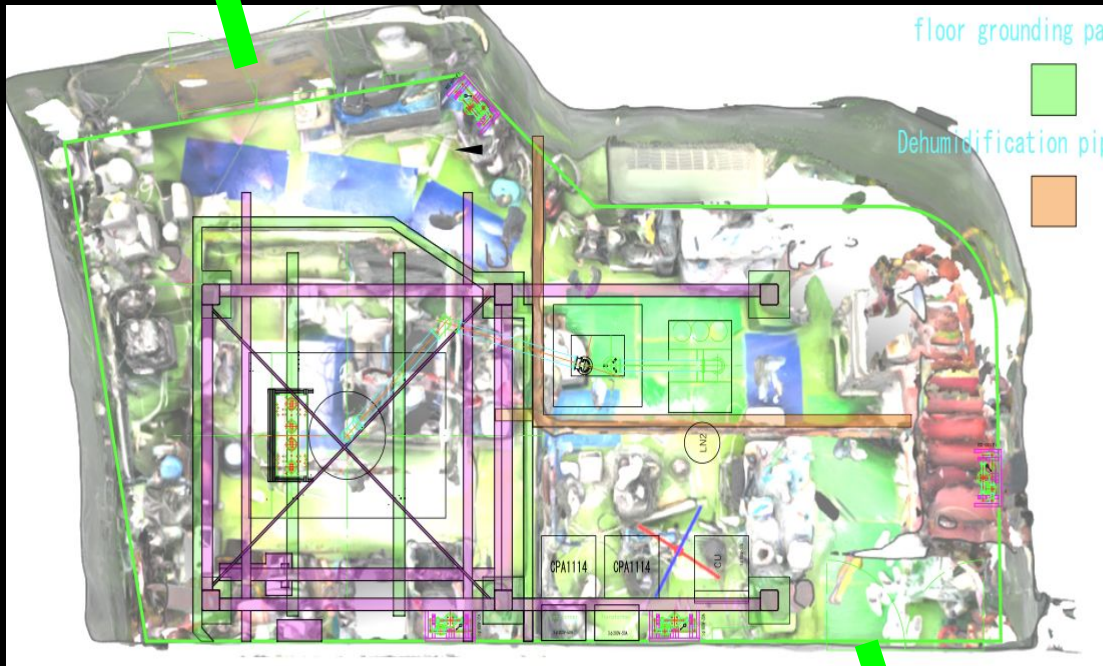
*DR successfully cooled down to  $\sim 10$  mK*



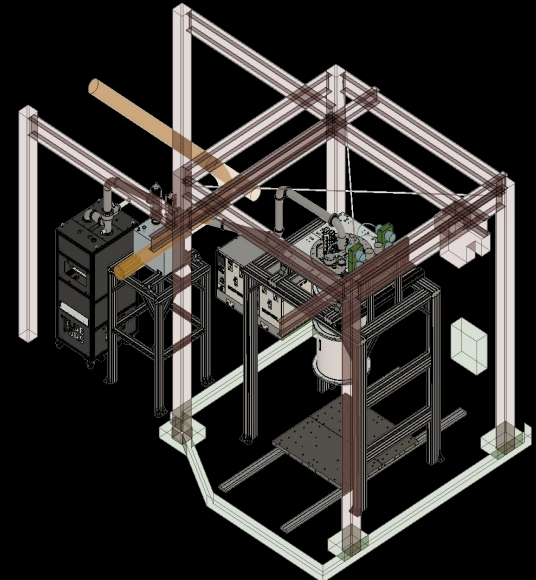


# Where are we now?

door to  
another hall



entrance



# Where are we now?

Shielding design close to final.

Improvement to water cooling system in progress.

SQUID electronics currently commissioning.

Gamma background assay completed. Data analysis underway.

Neutron background measurement ongoing.

Background MC model currently being updated.

First Science Run in collaboration with TESSERACT Collaboration.

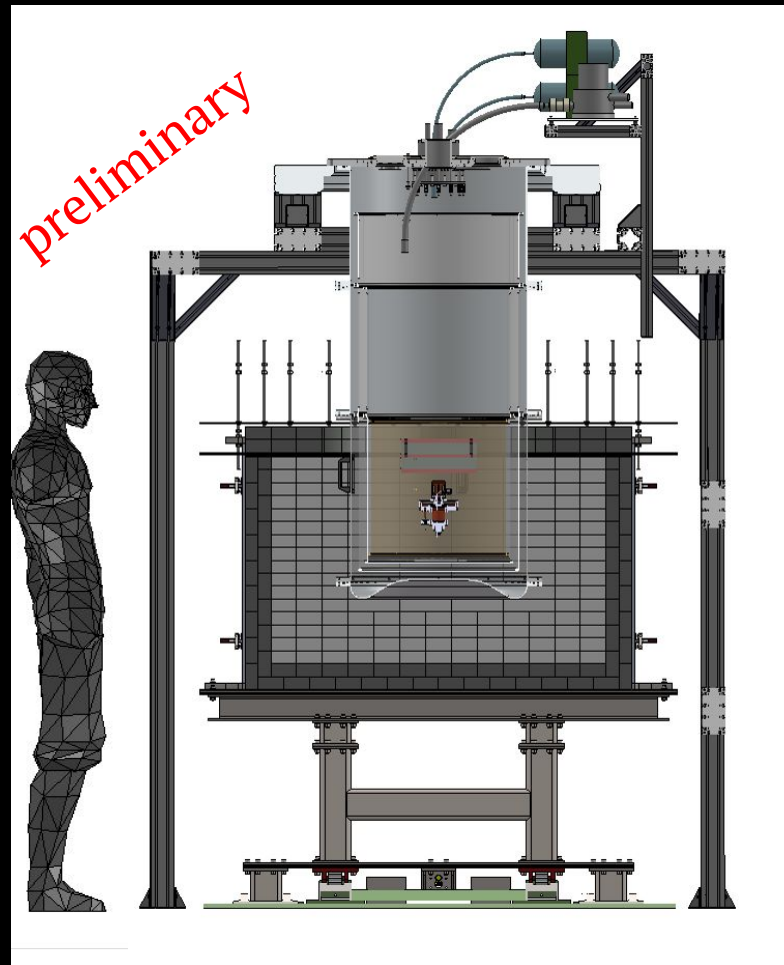
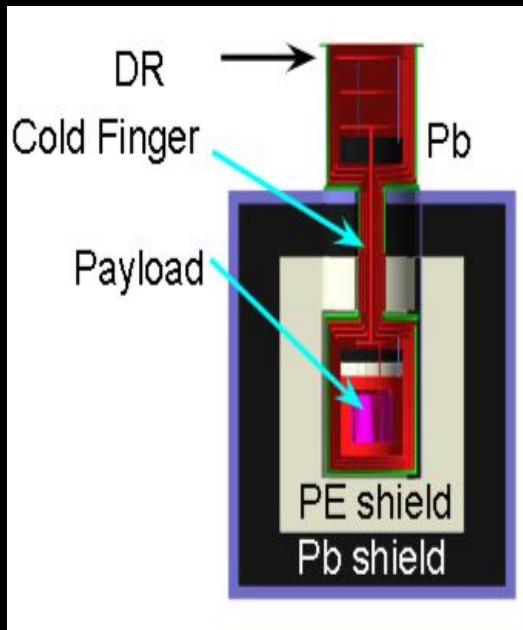
Second Science Run with light dark matter search with TES.

# Shielding Concept

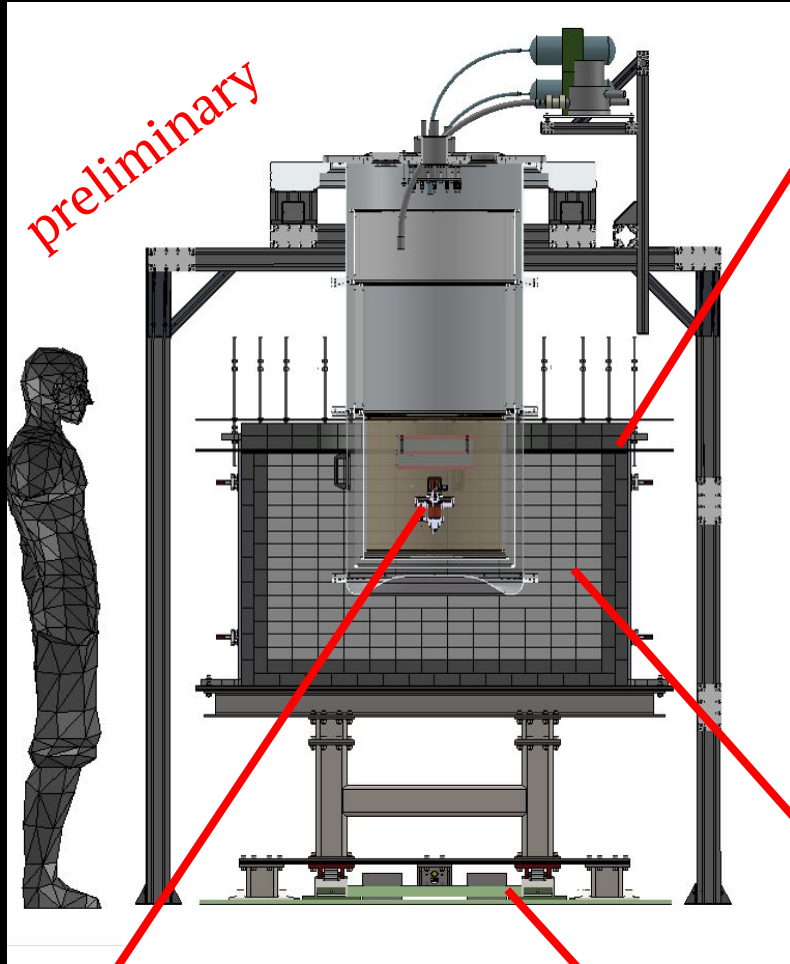
Initial design concept: a bottleneck design to reduce line-of-sight

- cost
- complexity
- time to build

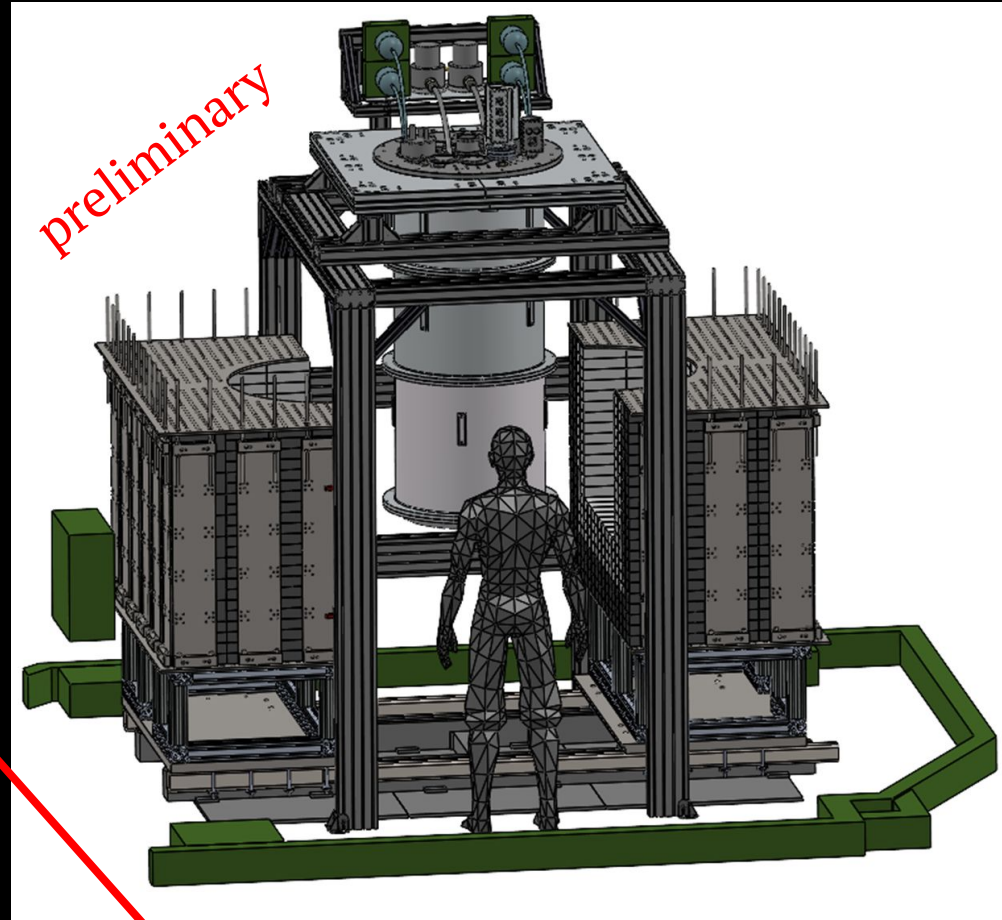
not justified for small exposures



# Shielding Concept



10 cm Pb



20 cm PE

payload

spacer for future  
extension



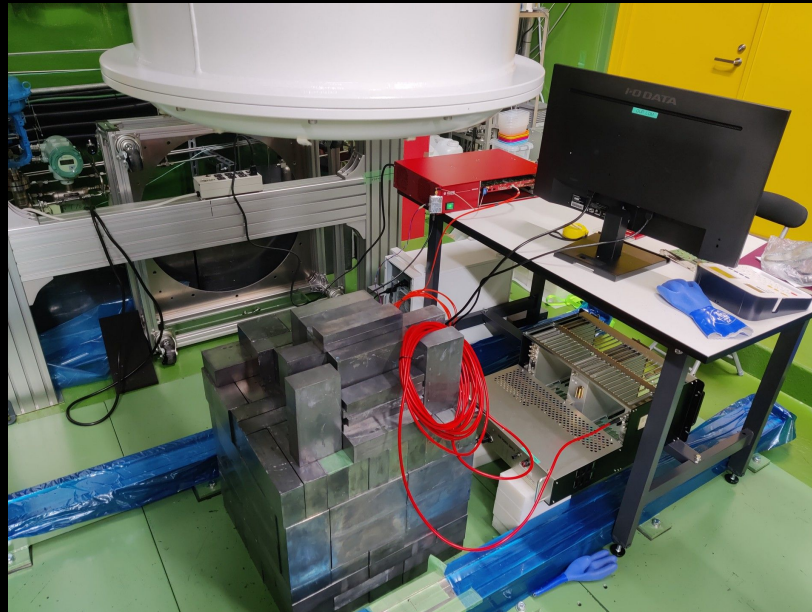
# Gamma Background Measurement with NaI(Tl)

3" NaI(Tl) Crystal shielded with at least 15cm of lead with window in 1 direction.

Custom-made PMT base and preamplifier.

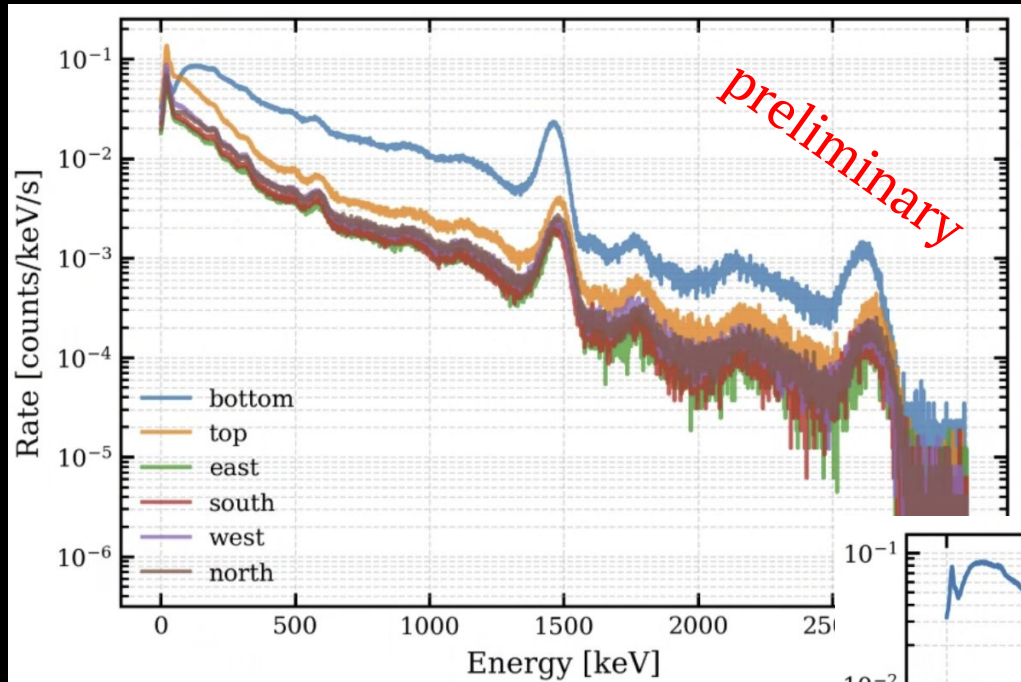
Calibration with Na-22, Co-57, Co-60, Cs-137, Ba-133

2 weeks of data taking.





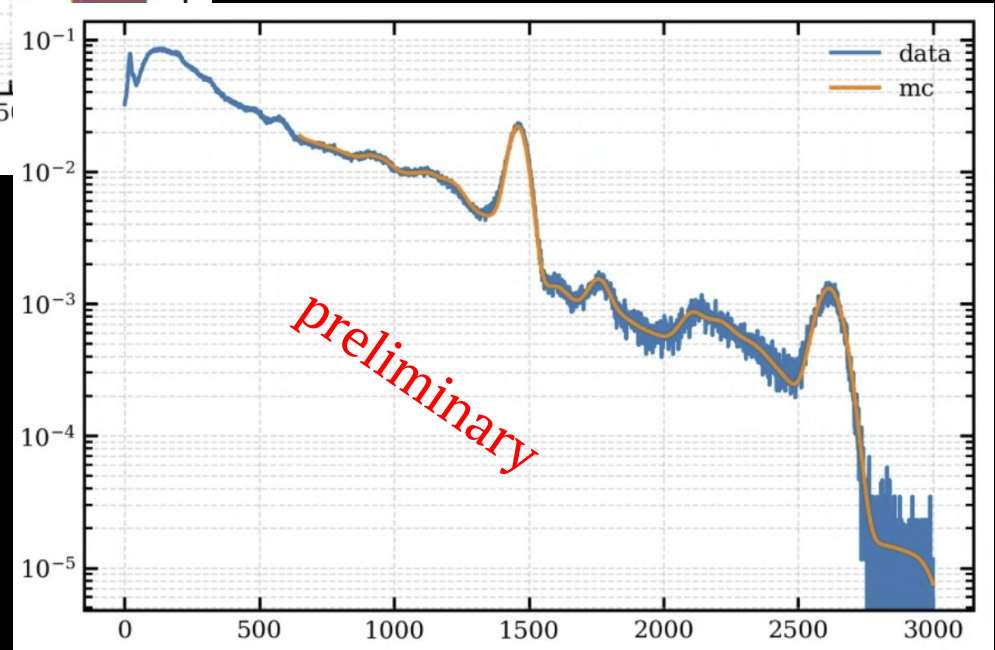
# Gamma Background Measurement with NaI(Tl)



spectral fit of one configuration

a rough estimate consistent with ~4 dru with original design.

MC with new shielding design in progress.

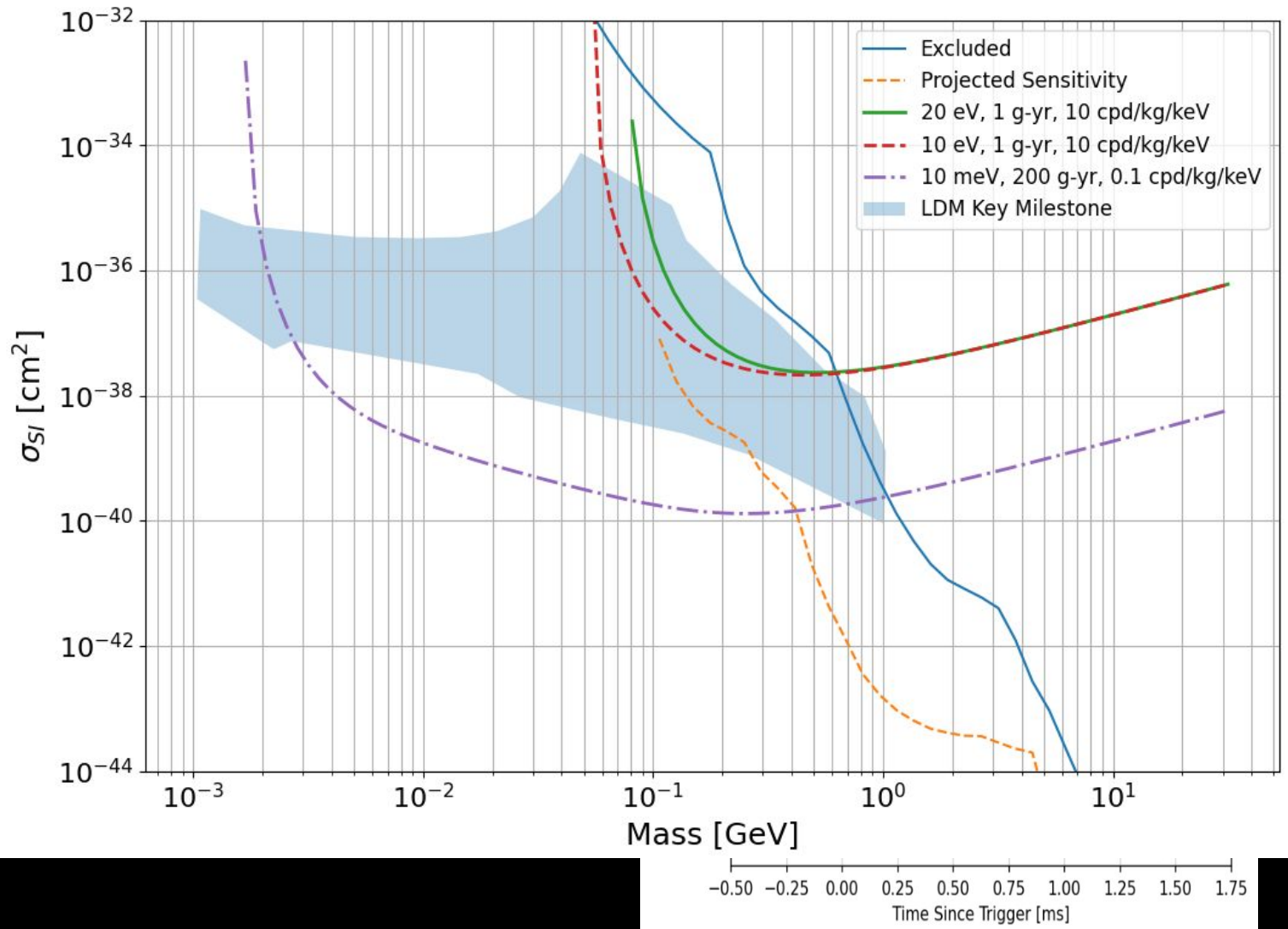


# Science Opportunities

In Phase 1, collaboration with TESSERACT:

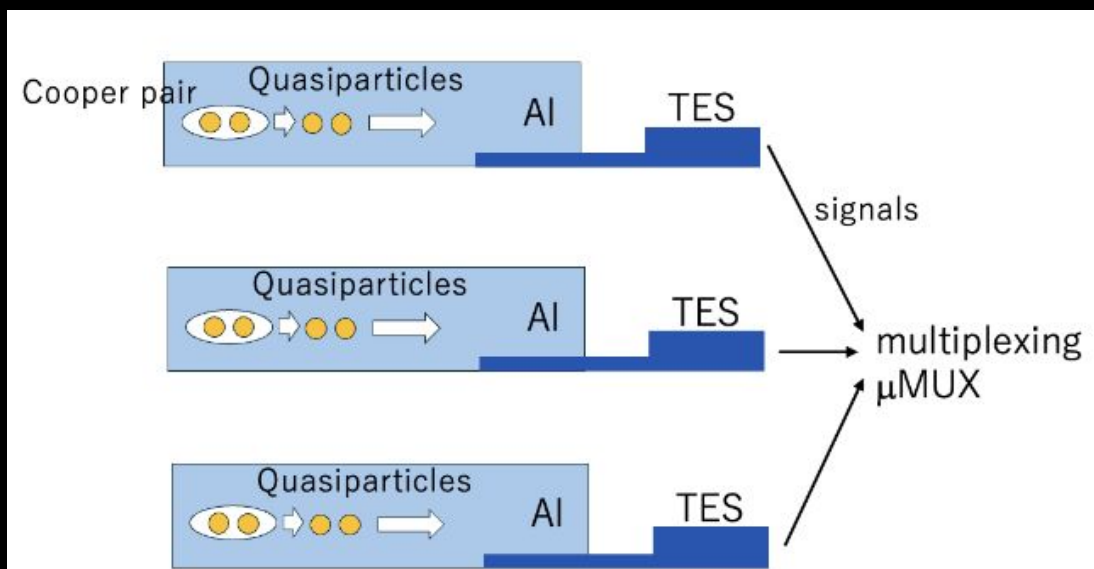
Helium

- t
- g
- e
- r

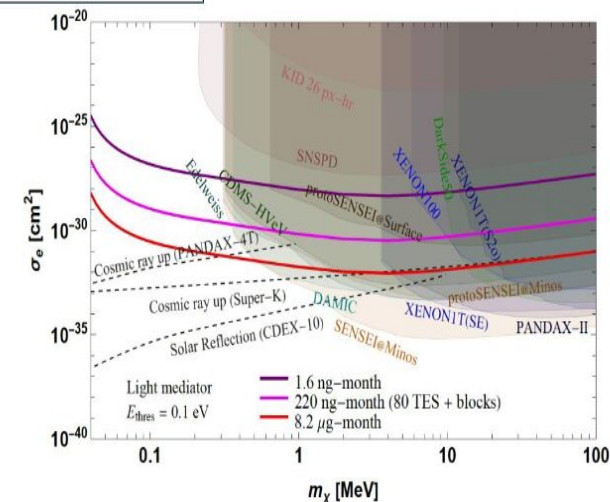


# Science Opportunities

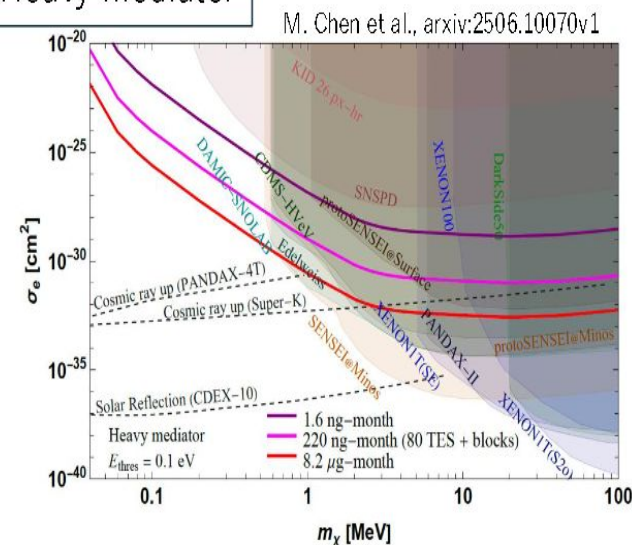
In Phase 2, DM-e scattering with QET + TES:  
 high-resolution, low-threshold optical TES  
 microwave multiplexing  
 quasiparticle entrapment assisted



Light mediator



Heavy mediator



# Take-home Message

- Dark Matter is one of the key questions of modern physics
- In the past few decades, almost all attempts to detect WIMP have failed
- Recently, attention has shifted to alternative DM models, including low-mass dark matter
- QUP's Kamioka LDM Project is a good chance to probe the unknown LDM parameter space for the first time using a low-background & low-temperature setup
- First Phase in collaboration with Spice/HeRALD (TESSERACT), followed by QUP payload.
- This also creates new opportunities for other rare event searches

***Thank You!***