nEXO Stave Testing for $0\nu\beta\beta$ Decay

Maharyta Sulaieva

Department of Physics
McGill University
Supervisor: Thomas Brunner

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Subtle foreshadowing

Figure: Vacuum chamber compared to a human

ν ?

$2\nu\beta\beta$

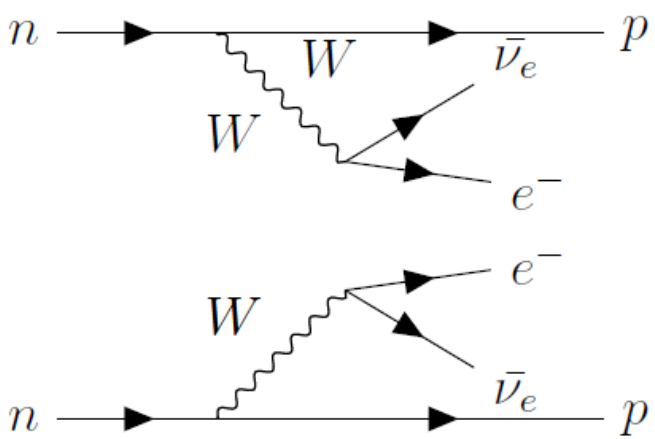


Figure: The Feynman diagram for two neutrino double beta decay

$$(Z, A) \rightarrow (Z + 2, A) + 2e^- + 2\bar{\nu}_e$$

$$2n \rightarrow 2p + 2e^- + 2\bar{\nu}_e$$

$$T_{1/2} \approx 10^{20} yrs$$

$0\nu\beta\beta$

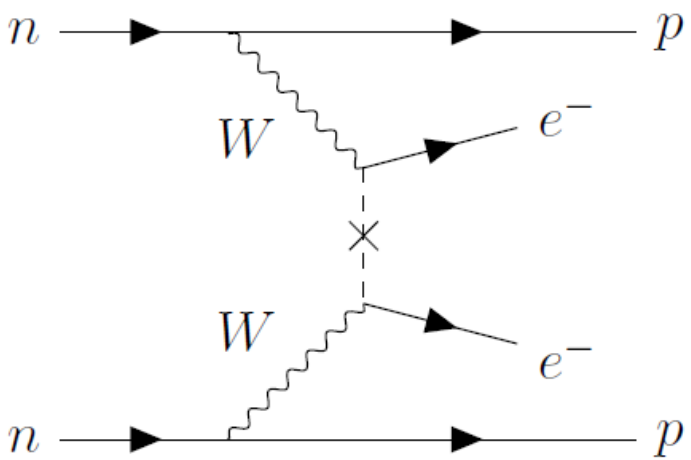


Figure: The Feynman diagram for neutrinoless double beta decay

$$(Z, A) \rightarrow (Z + 2, A) + 2e^-$$

$$n + n \rightarrow p + p + 2e^-$$

$$T_{1/2} > 10^{26} yrs$$

How can we detect it?

Why ^{136}Xe?

Energetically forbidden β decay

Relatively large Q-value: $Q_{\beta\beta} = 2458.10 \pm 0.31 keV$

Noble gas

$$^{136}Xe \rightarrow ^{136}Ba^{2+} + 2e^{-}$$

What can we detect?

Ionization signal

Scintillation signal, 175nm

SiPM

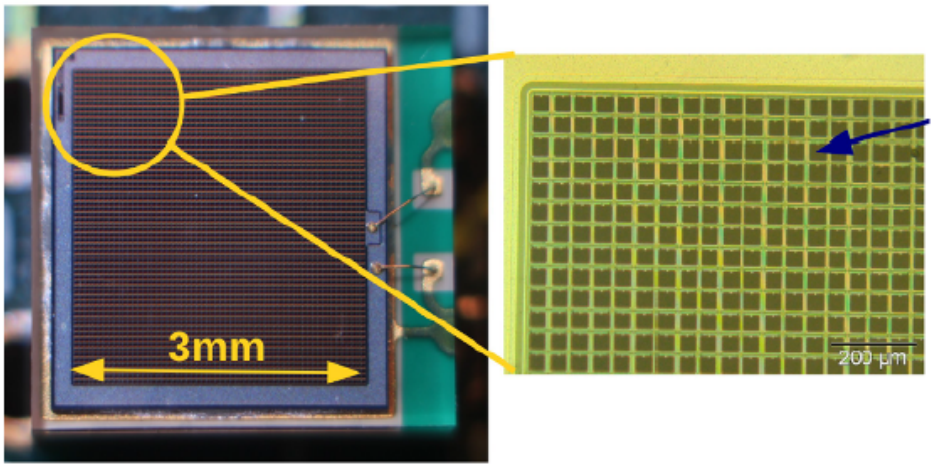


Figure: SiPM with zoom on the individual SPADs

SiPM Advantages:

- Low dark count rate
- High photon detection efficiency
- Low correlated avalanche rate
- Low intrinsic radiopurity

nEXO Experiment

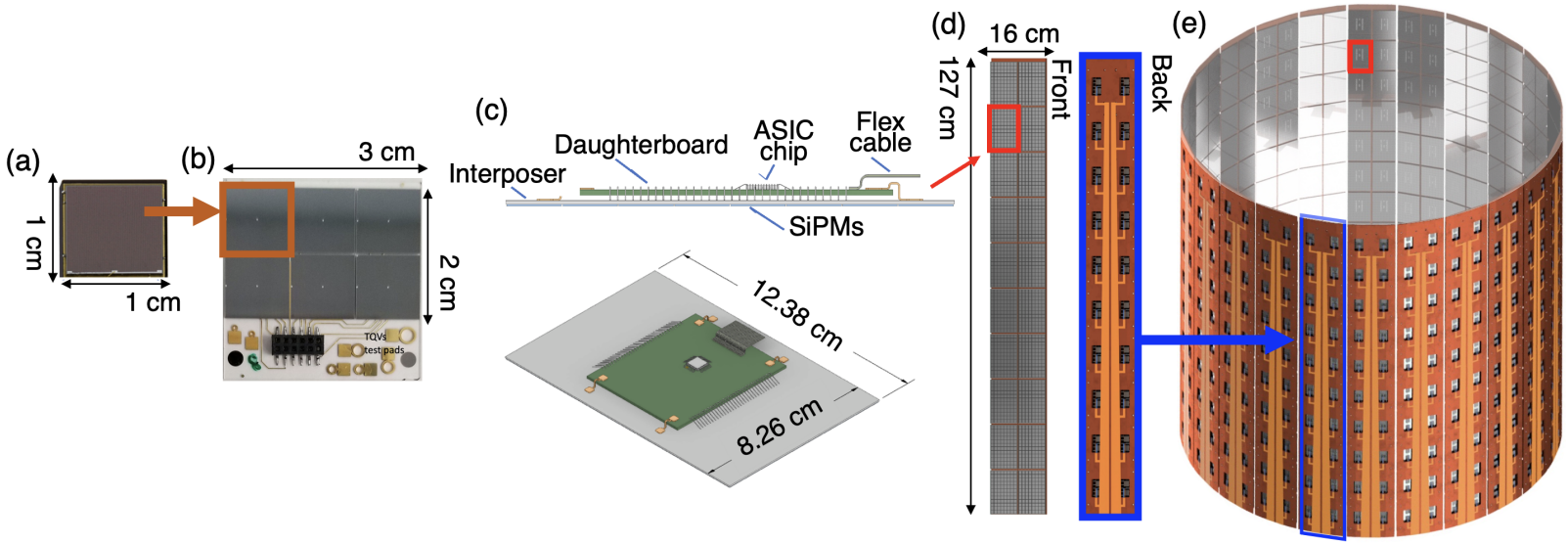


Figure: nEXO photon detection system:(a) 1×1 cm^2 SiPM. (b) Fused silica board containing a single 3×2 cm^2 area readout channel comprised of six 1×1 cm^2 SiPMs. (c) Side and top views of a tile module. (d) Rendering of a single stave. (e) Full detector configuration.

Source: [1]

nEXO Experiment

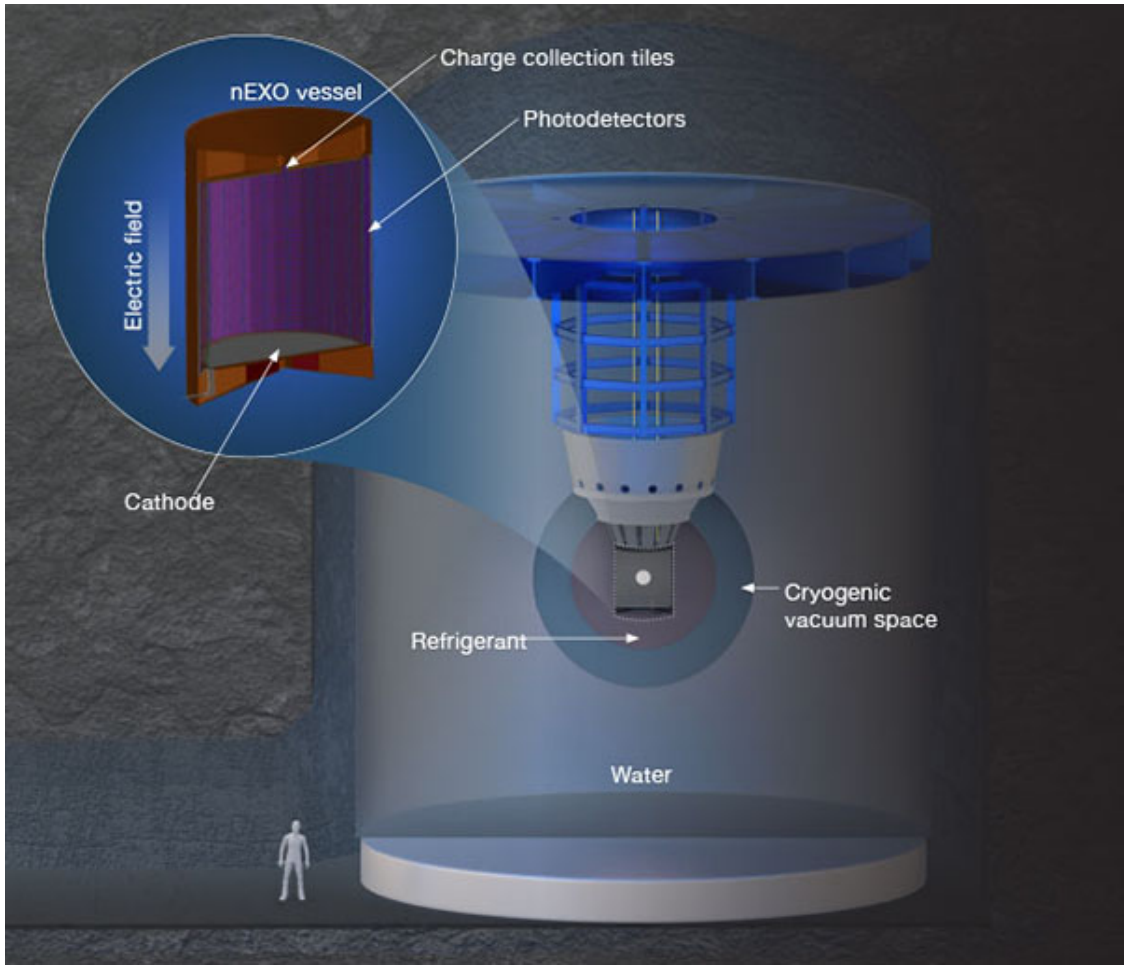
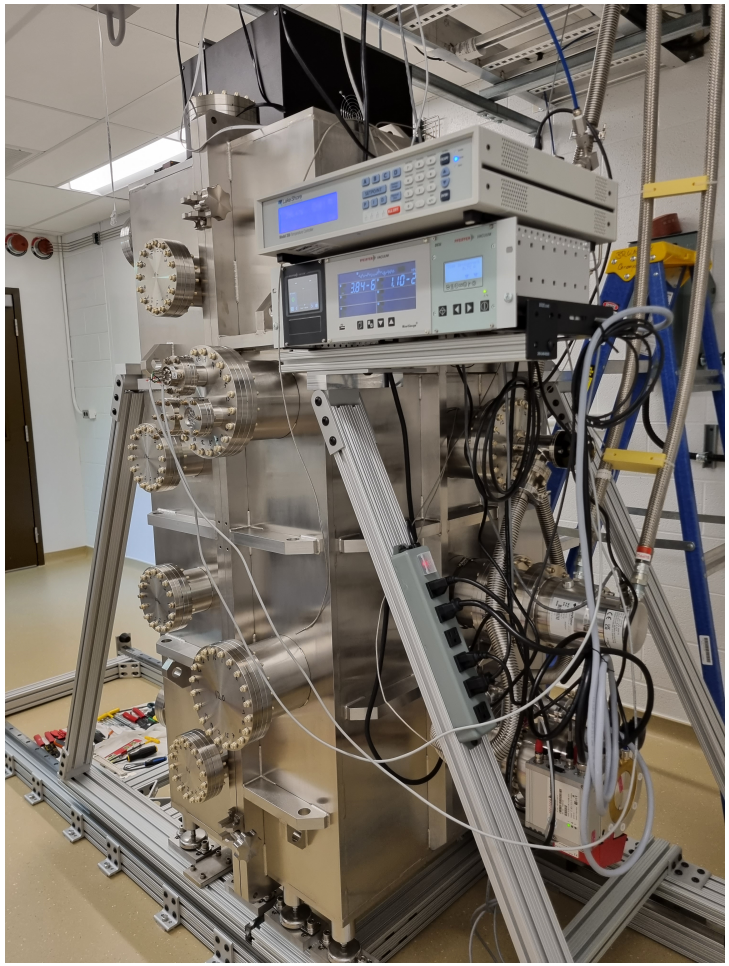


Figure: 5000 kg of LXe enriched to 90% ^{136}Xe, 165 K, 50 000 SiPMs

Source: https://nexo.llnl.gov/nexo-overview

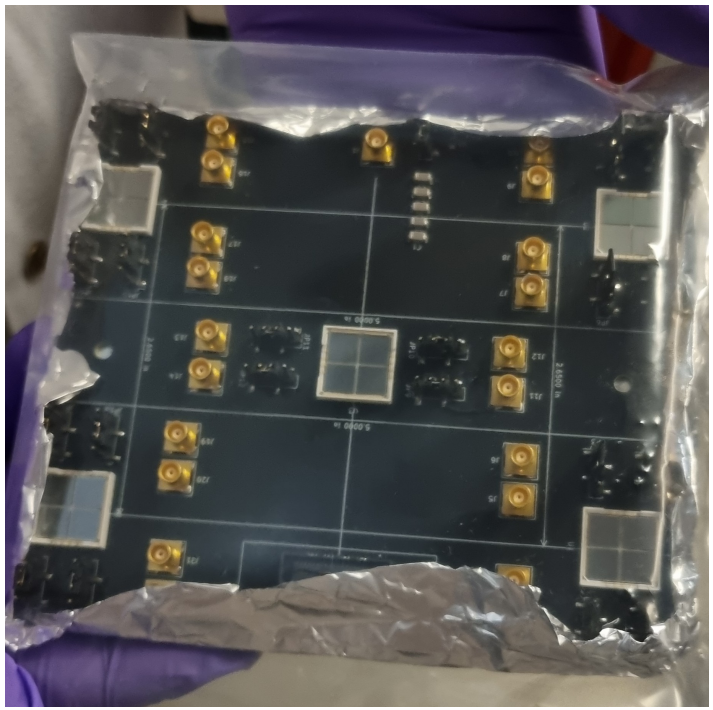
Stave Testing

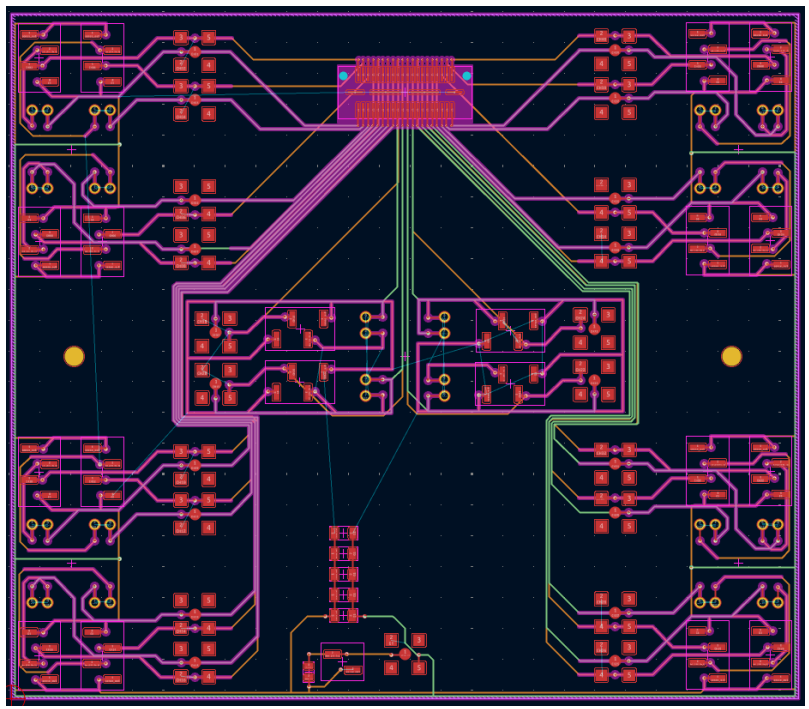


Stave testing

Project Goals

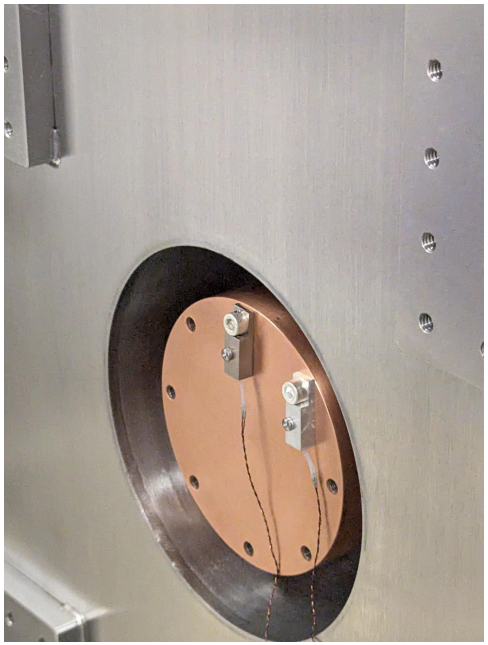
- Install optical rail system
- Test the PCB

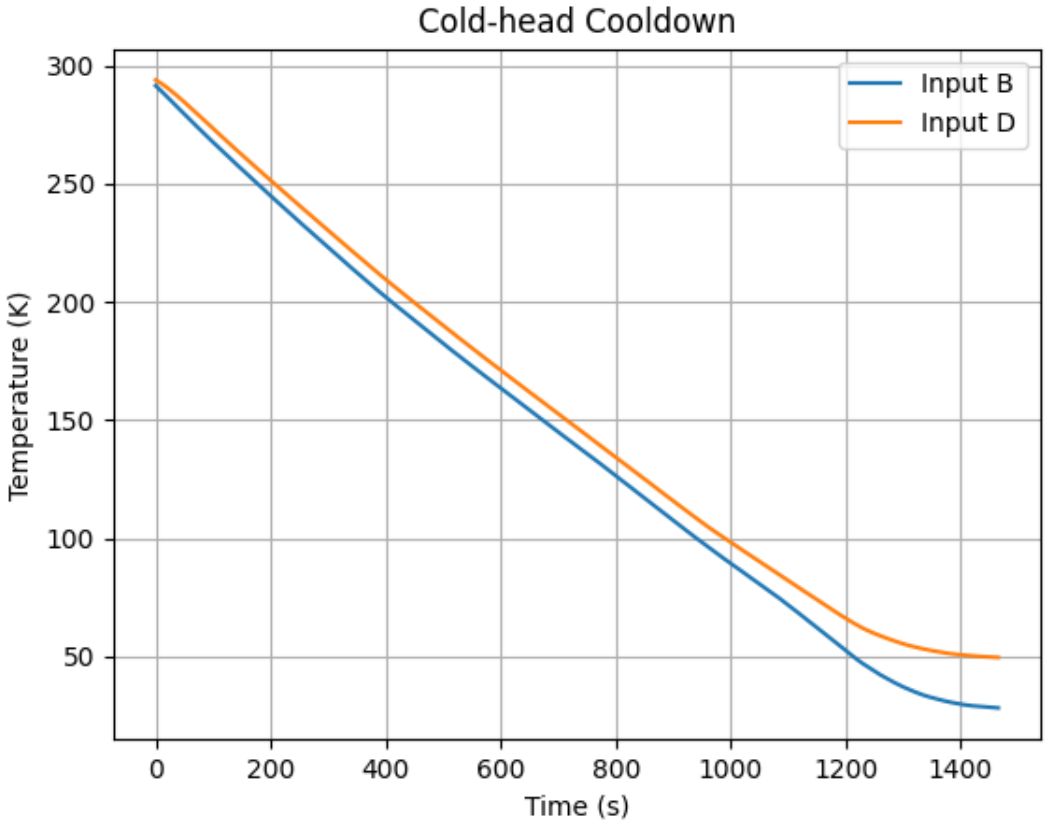




Stave Testing

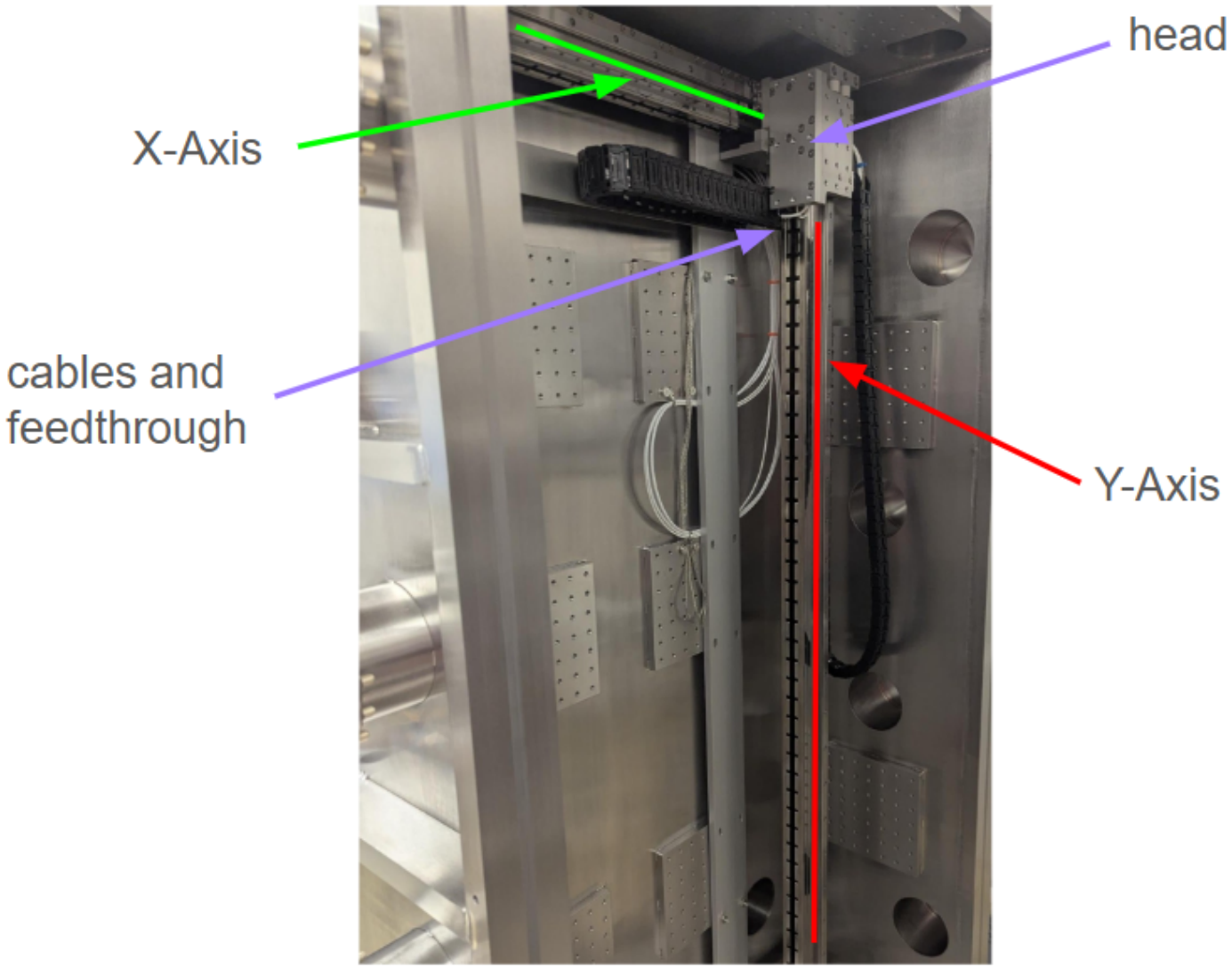
Stave Testing



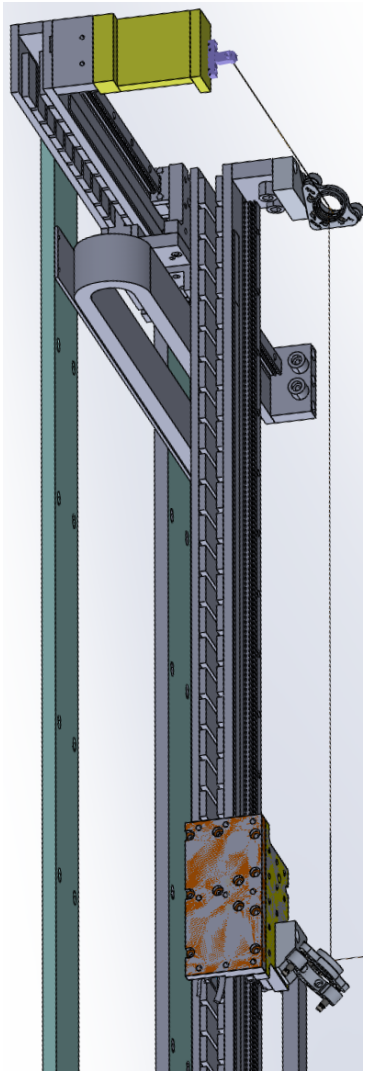


RTDs on the Cold-head and Readout Temperature

Stave Testing



Future Plans



Summary

What's next?

- Establishing the PCB
- Reading the dark current
- Testing SiPMs with laser system

The End!

Thank You!

Marharyta Sulaieva
marharyta.sulaieva@mail.mcgill.ca

References

[1] Watts, M.P., *nEXO photon detection system and read-out electronics*, Journal of Instrumentation, 2025.

[2] G Adhikari, *nEXO: neutrinoless double beta decay search beyond 1028 year half-life sensitivity*, J. Phys. G: Nucl. Part. Phys., 2022.

[3] Stefan Gundacker and Arjan Heering, *The silicon photomultiplier: fundamentals and applications of a modern solid-state photon detector*, Physics in Medicine & Biology, 2020

[4] Peregrina M.M., *Development of an in-Xe-gas Laser Ablation Source for the Ba-tagging technique for nEXO*, 2020

Backup

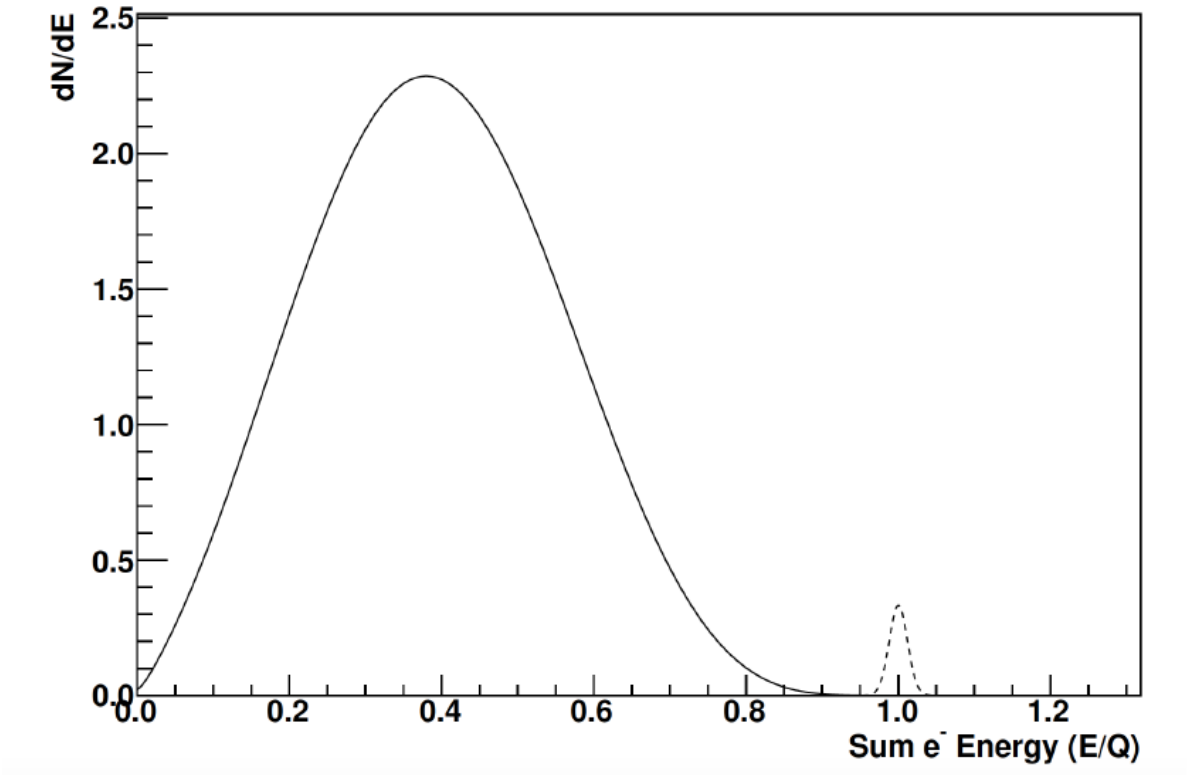
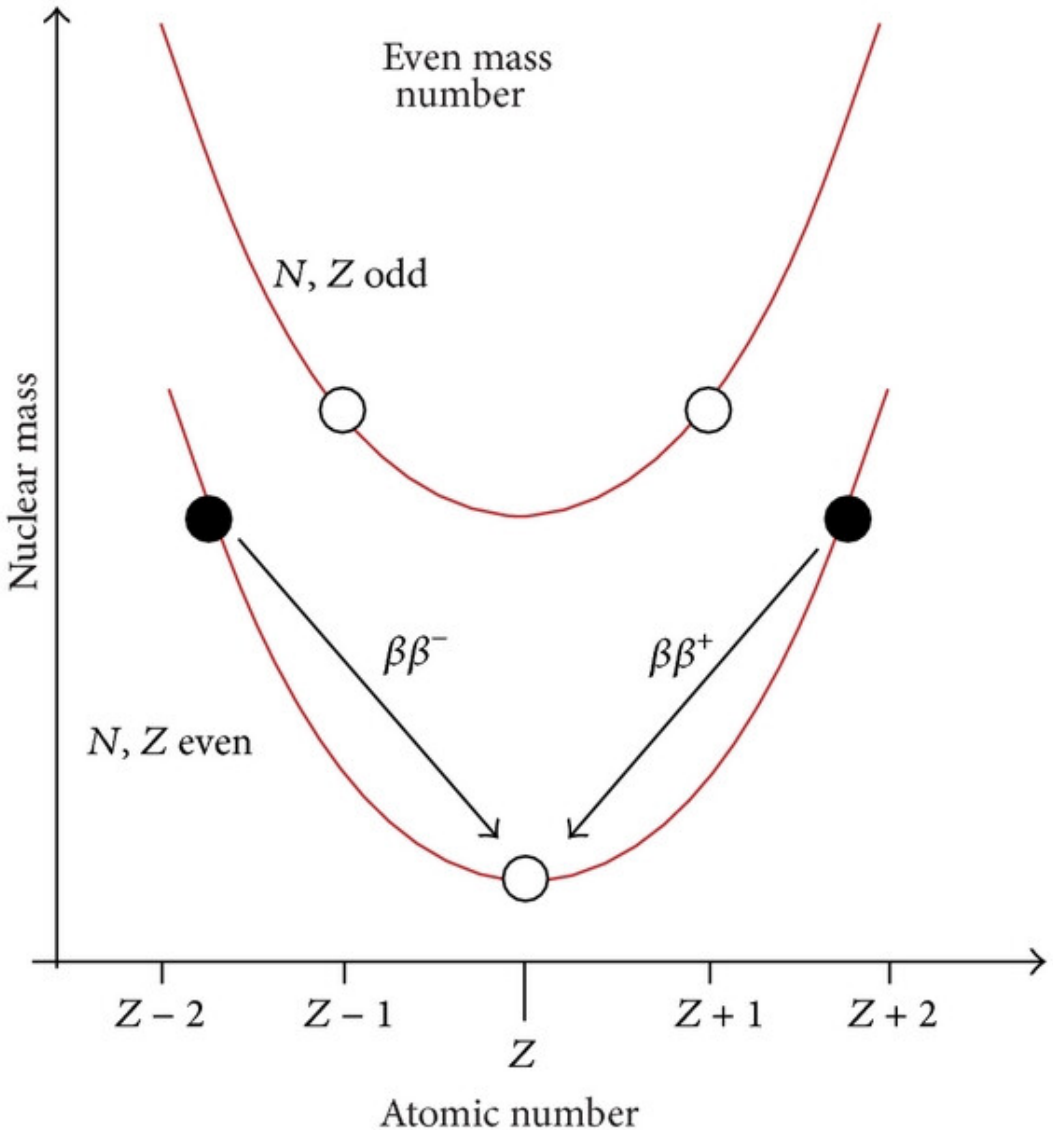


Figure: Electron sum energy spectrum of the two double beta decay modes

Backup


Even mass number
N, Z odd
Nuclear mass
ββ⁻
ββ⁺
N, Z even
Z − 2
Z − 1
Z
Z + 1
Z + 2
Atomic number