nEXO Projects:
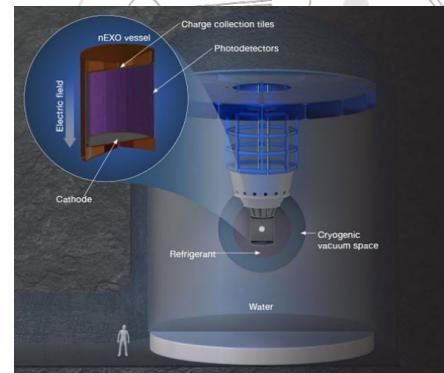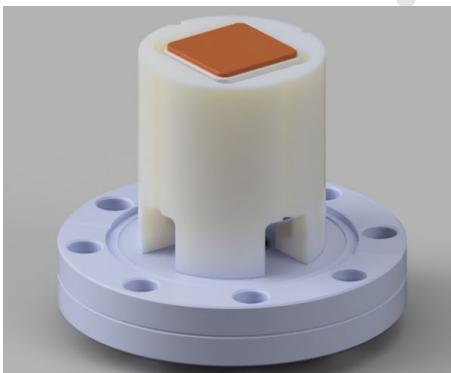## Enriched Xenon Observatory

Xenon Purification

Ameera Elgonemy
Mentors: Peter Rowson, Brian Mong,
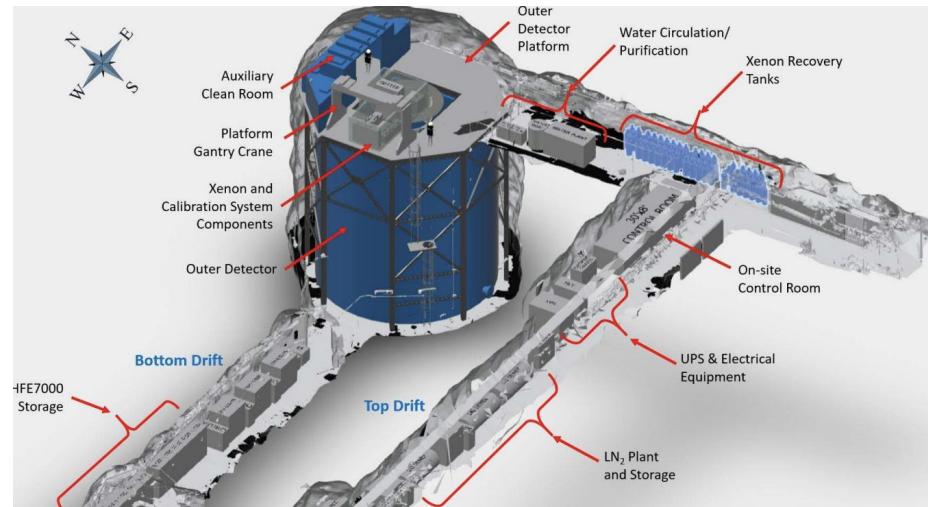Sander Breur

8/4/2022

SLAC NATIONAL ACCELERATOR LABORATORY

Stanford University | U.S. DEPARTMENT OF ENERGY

nEXO

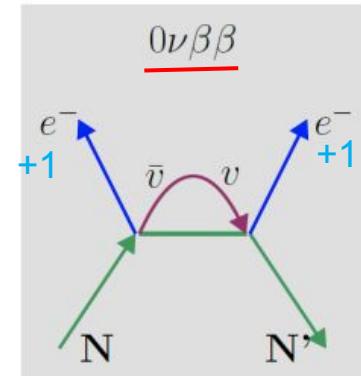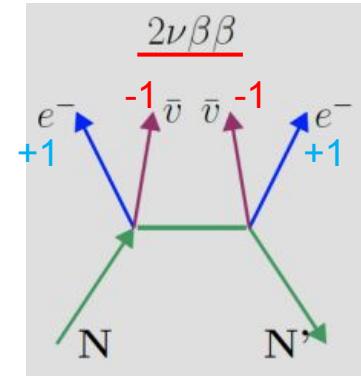## Neutrinoless Double Beta Decay (0νββ)

- nEXO is being built at SNOLAB in Sudbury, Canada

  - Underground facility

  - Tonne-scale, multinational

  - Will be live for 10 years

  - **Will potentially determine whether or not neutrinos are Majorana particles, meaning they are their own antiparticle**
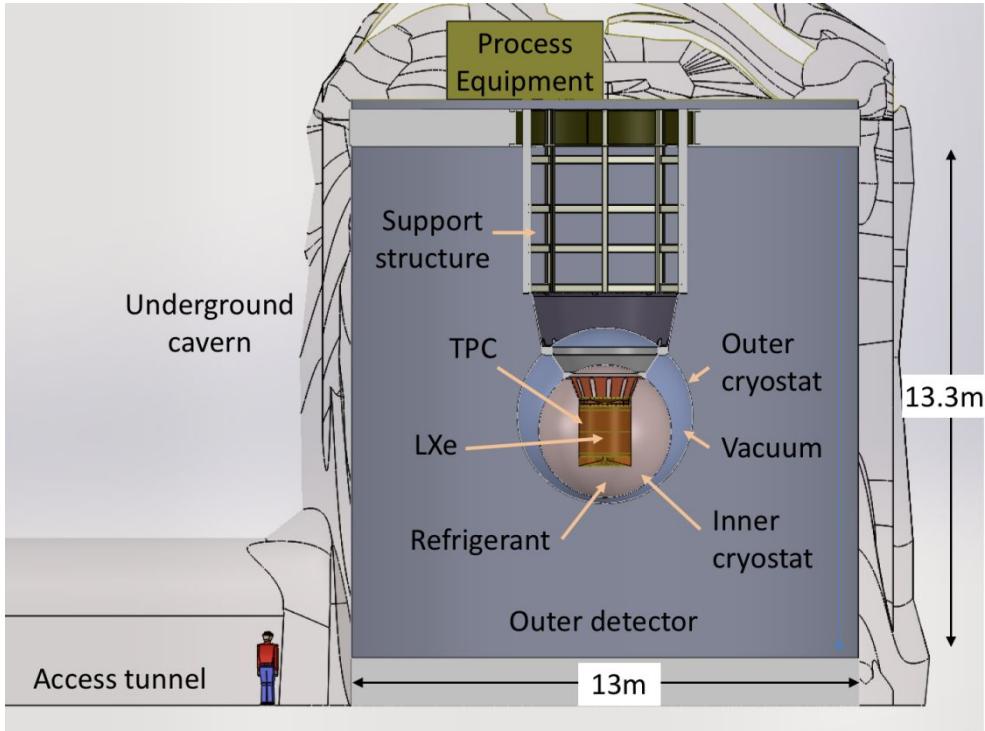
nEXO Motivation

Neutrinoless Double Beta Decay (0νββ)

- Standard Model (SM) of particle physics does not predict Majorana particles

  - If 0νββ (a theoretical process) occurs, neutrinos must be Majorana

    particles

  - Total lepton number is conserved in SM

- 0νββ is a process that violates lepton number conservation

  - 2νββ has lepton number of 0, 0νββ has lepton number of 2

  - Lepton number conservation violation ⟶ matter-antimatter
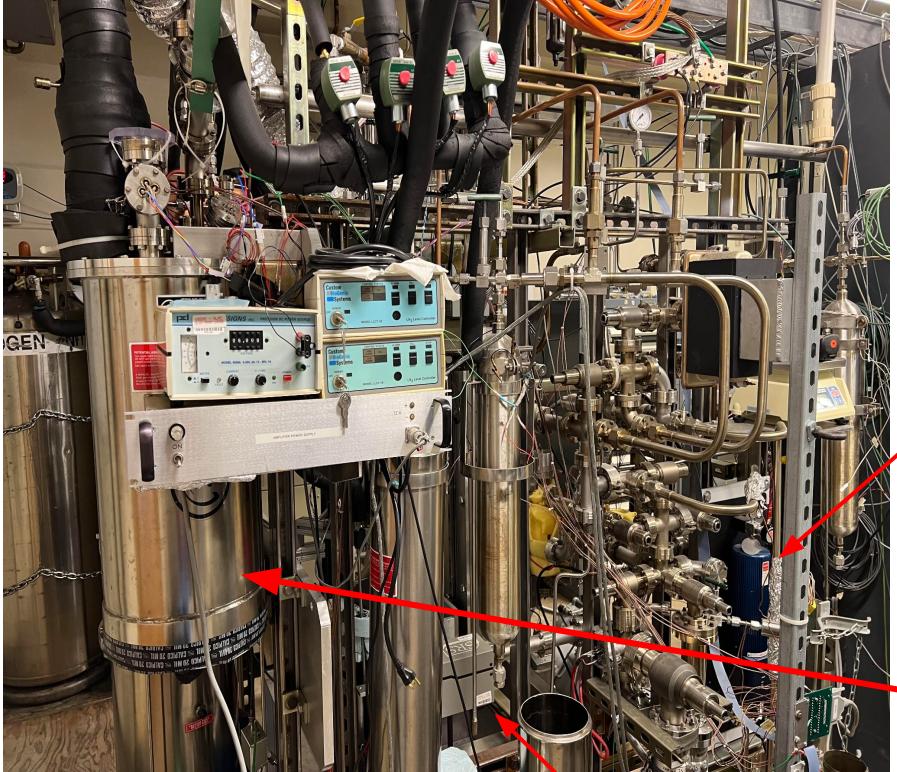
    asymmetry

nEXO Systems

Experiment will be conducted in the SNOLAB underground facility

- TPC contains 5 tonnes of ultra-pure liquid xenon (enriched in ^{136}Xe)
- Two electrons resulting from 0νββ are detected by observing their decay energy of ~2.6 MeV

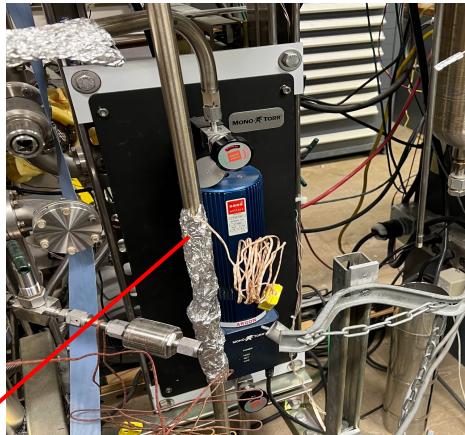**0νββ has a half life longer than the age of the universe** - extremely rare event

- nEXO is an ultra-low background experiment
- Sources of background must be minimized (U, Th, gammas, Radon, eg.)
- We want **electronegative** purity and **radio** purity
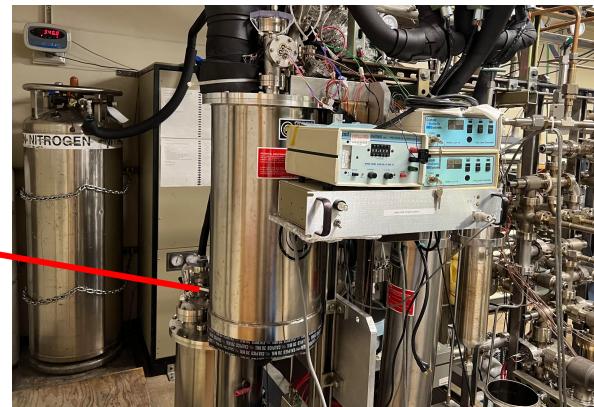
Xenon Circulation/Purification

Building 84 EXO lab

Current xenon purifier
- Goal is to make system **electronegative** pure, i.e. remove electronegative contaminants (oxygen, nitrogen, water vapor)
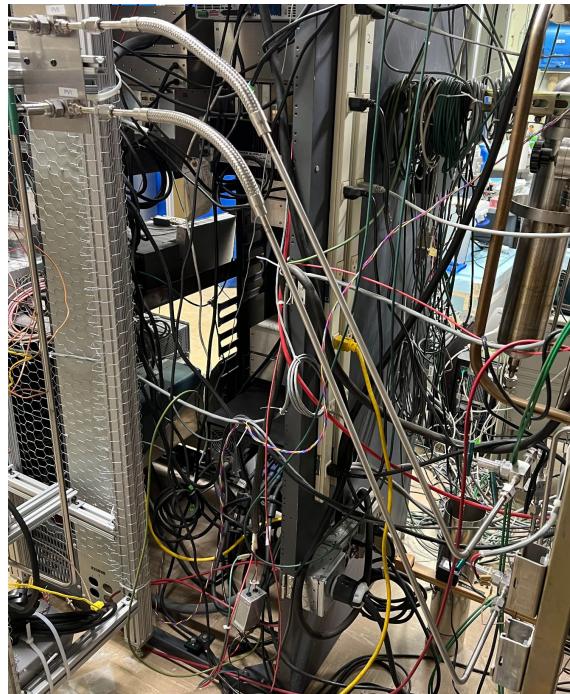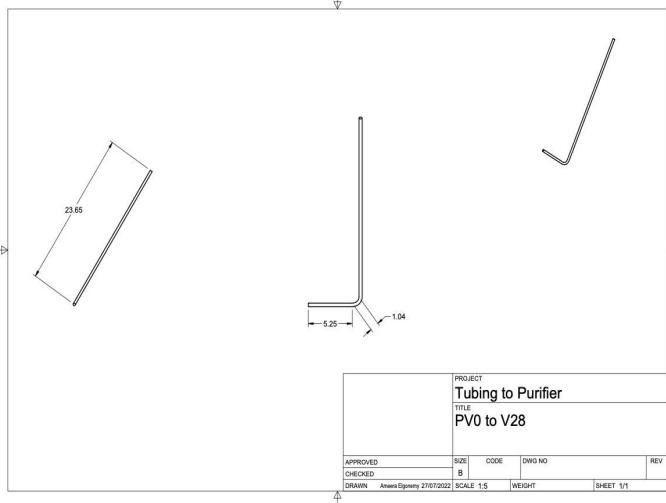
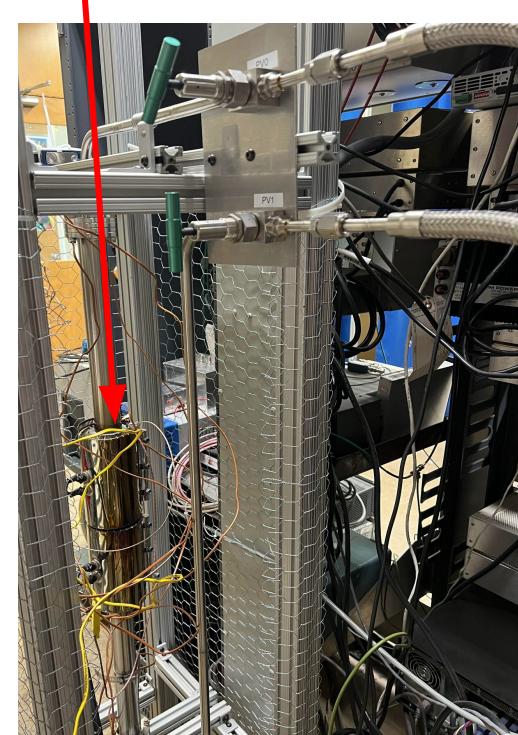Xenon Purity Monitor (XPM) inside of cryostat can

RGA (Residual Gas Analyzer)

New Xenon Purifier

Testing new Stanford custom-built purifier

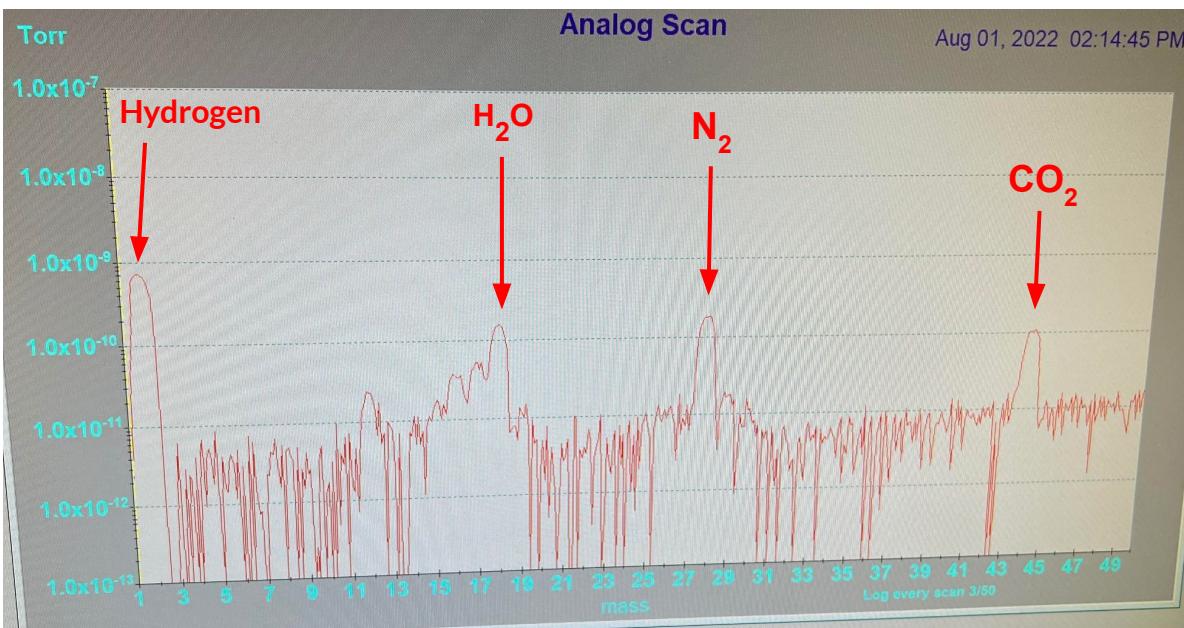Part drawing of a line to new xenon purifier:

New Purifier

- Purifier uses heated zirconium getters
  - React with electronegative impurities
  - Promise ppt purity

New Xenon Purifier
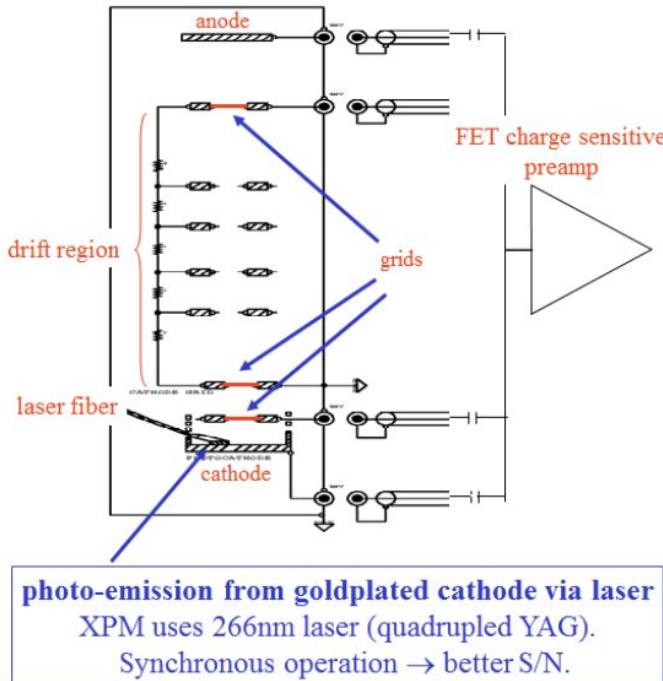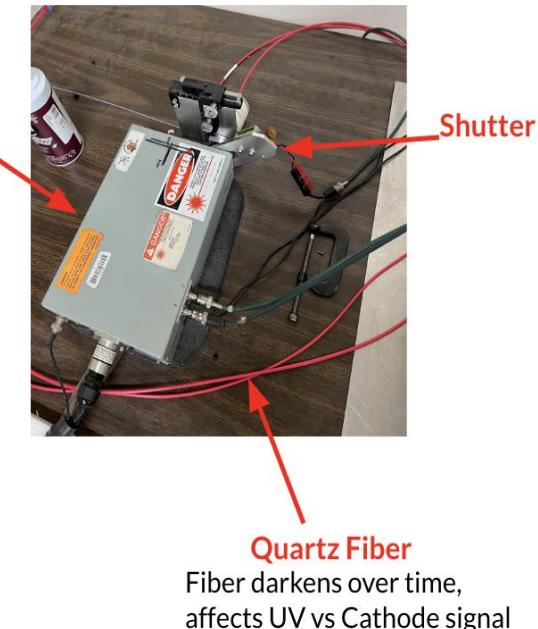
RGA (Residual Gas Analyzer)

RGA scan allows us to determine what is present in the xenon circulation system

Scan taken on 8/1/2022 (after lines to new purifier were connected)
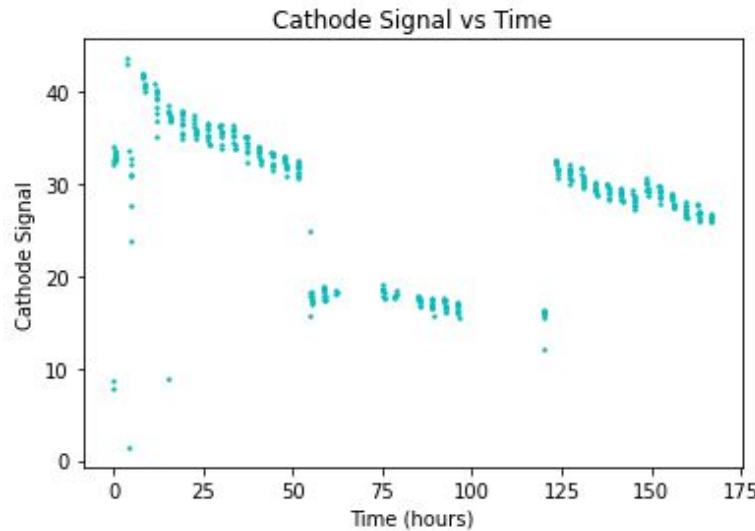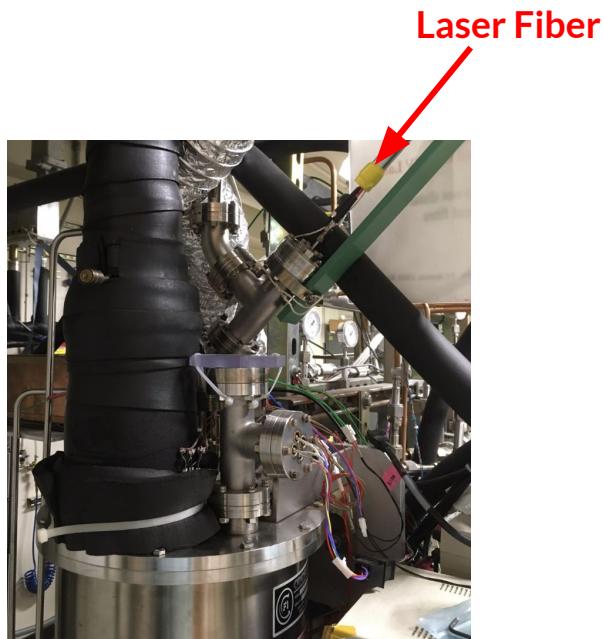
Xenon Purity Monitor (XPM)

Basic Operation

UV Laser

Shutter

Quartz Fiber
Fiber darkens over time, affects UV vs Cathode signal

anode

FET charge sensitive preamp

drift region

grids

laser fiber

cathode

photo-emission from goldplated cathode via laser
XPM uses 266nm laser (quadrupled YAG).
Synchronous operation → better S/N.

- UV Light from laser produces electrons within XPM
  - Electrons drift across electric field, electron attenuation length correlates to electronegative xenon purity (e.g. oxygen)
- Can use cathode signal (how many electrons reach cathode after traveling through laser fiber) to analyze fiber darkening
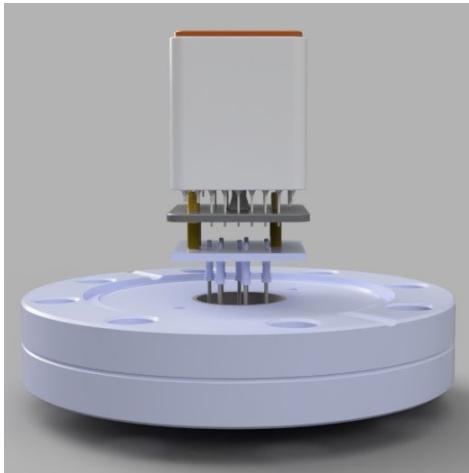
Xenon Purity Monitor (XPM)

Laser Quartz Fiber Data

Laser Fiber

Laser pulses at a frequency of 1 Hz

Darker laser fiber ⟶ less electrons reach cathode
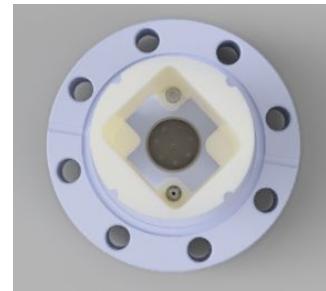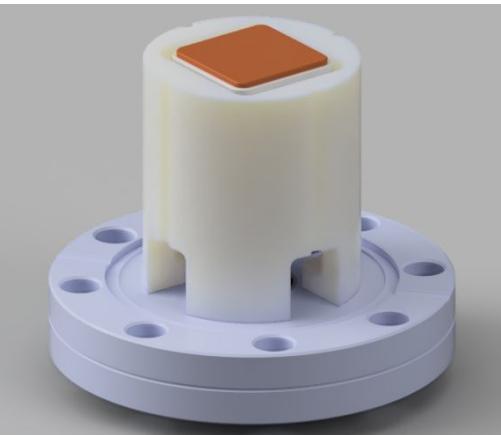
Radon Removal Distillation System
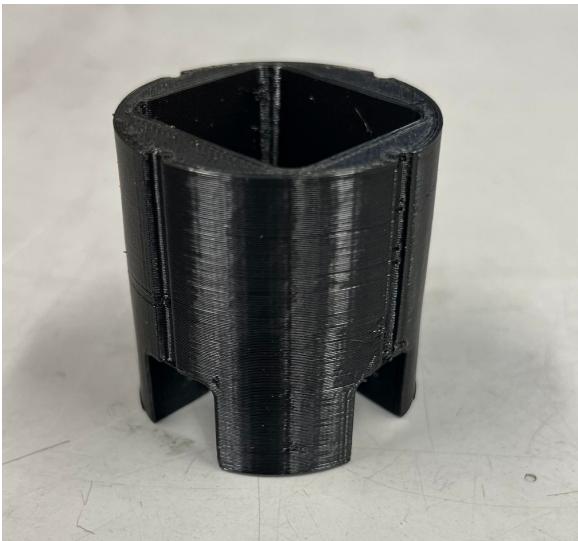
Photomultiplier Tube (PMT) Holder

PMT used for radon distillation system, used for making sure system is **radio** pure by monitoring the amount of radon that's present.
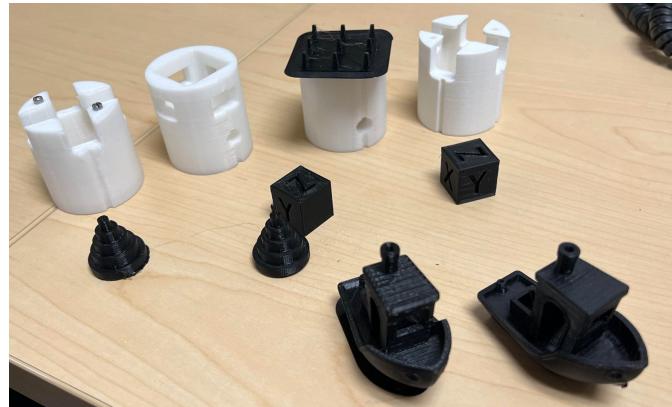
Has been printed in PLA and PETG, will eventually be printed in **resin** (radio pure material)

PMT Holder Printing

PMT Holder printed in PETG

- Stronger and more moisture resistant than PLA
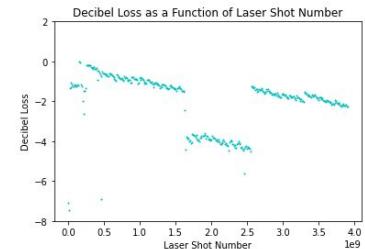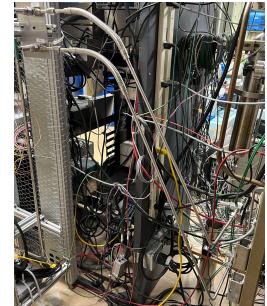 - Also 100% food safe!

PETG test prints and PMT holder iterations

- PETG will be used for applications that need material stronger than PLA
  - i.e. sensor casings

Recap

nEXO's primary goal: detect neutrinoless double beta decay (0νββ) by observing five tonnes of liquid xenon

- 0νββ is incredibly rare, so nEXO is an ultra-low background experiment

    - Liquid xenon must be purified before entering TPC

- Some of my projects:

    - Connecting new Stanford custom-built xenon purifier to current circulation system at SLAC

    - Analyze darkening of XPM laser fiber

    - Design and print holder for PMT using various kinds of filament

Decibel Loss as a Function of Laser Shot Number

Thank you!

https://nexo-shop.fourthwall.com/