

Chroma Simulation of SiPM Stave Testing for nEXO

Sophie G elinas

Supervisors: Thomas Brunner & David Gallacher

CASST 2024

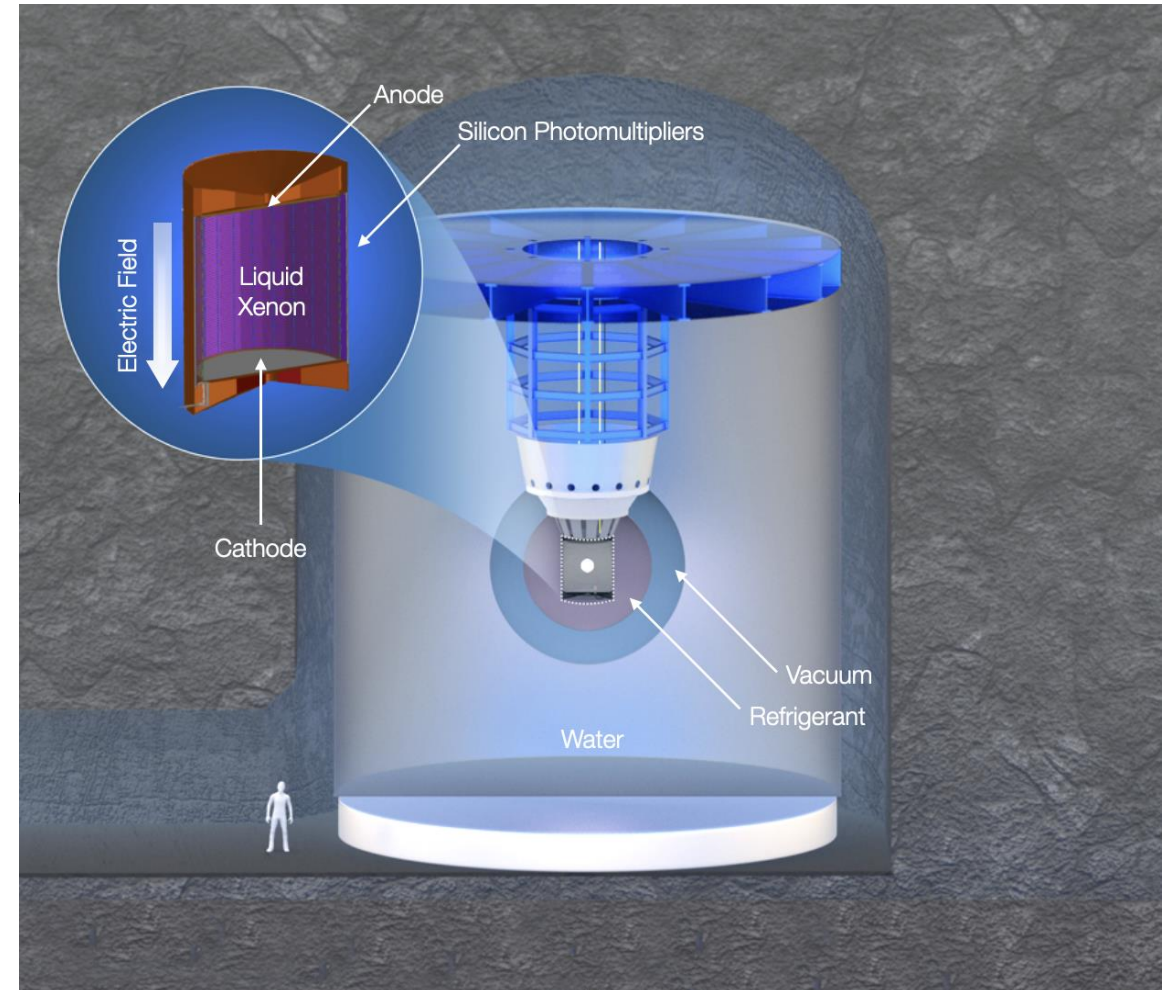


McGill
UNIVERSITY



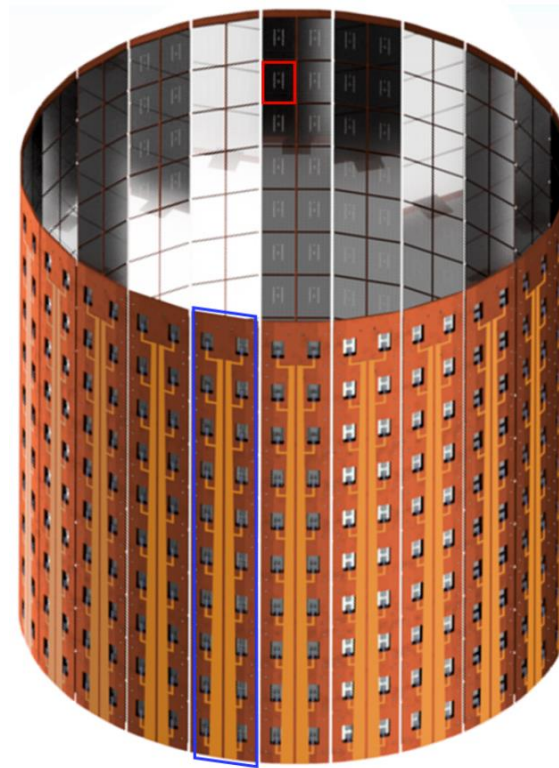
nEXO: Searching for $0\nu\beta\beta$

- nEXO is searching for neutrinoless double beta decay ($0\nu\beta\beta$) in liquid xenon
 - Implies physics beyond the Standard Model
- Detector proposed to be built at SNOLAB

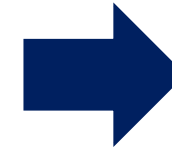


SiPM Stave Testing

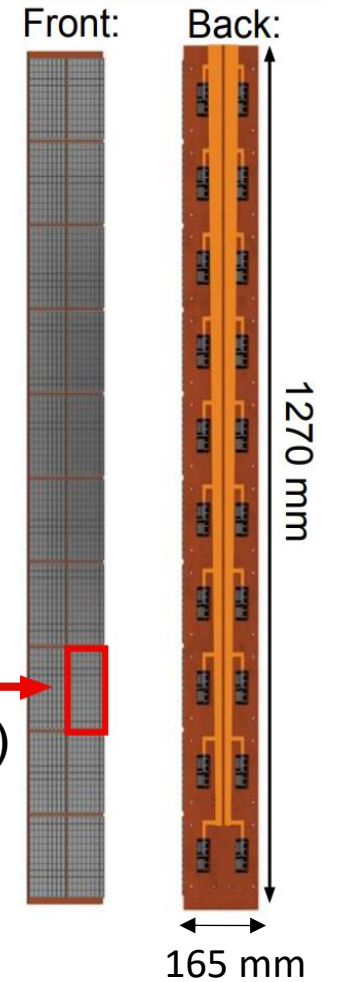
- SiPM: silicon photomultiplier
 - Single-photon sensitive light sensor
 - Tiles of SiPMs form staves
- Stave testing chamber and procedure are being developed



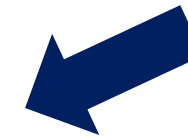
46,000 SiPMs
24 staves



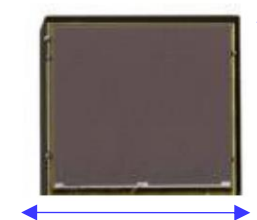
Stave
(1920 SiPMs)



Tile
(96 SiPMs)



SiPM

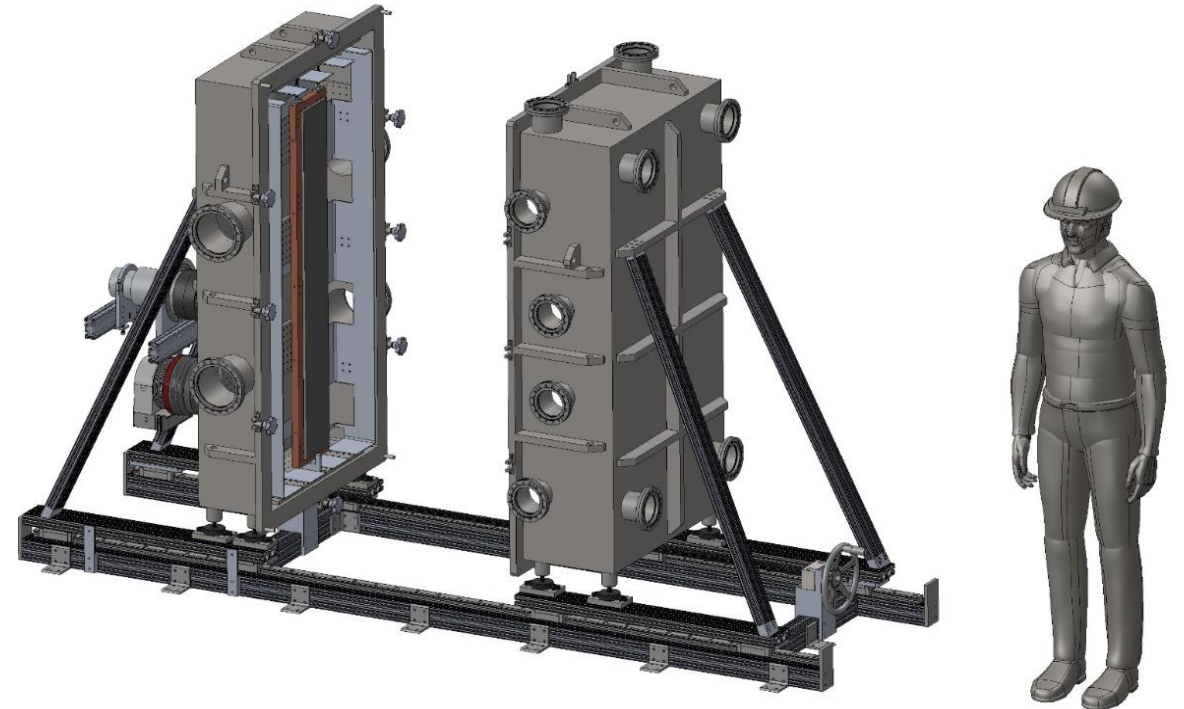


1 cm

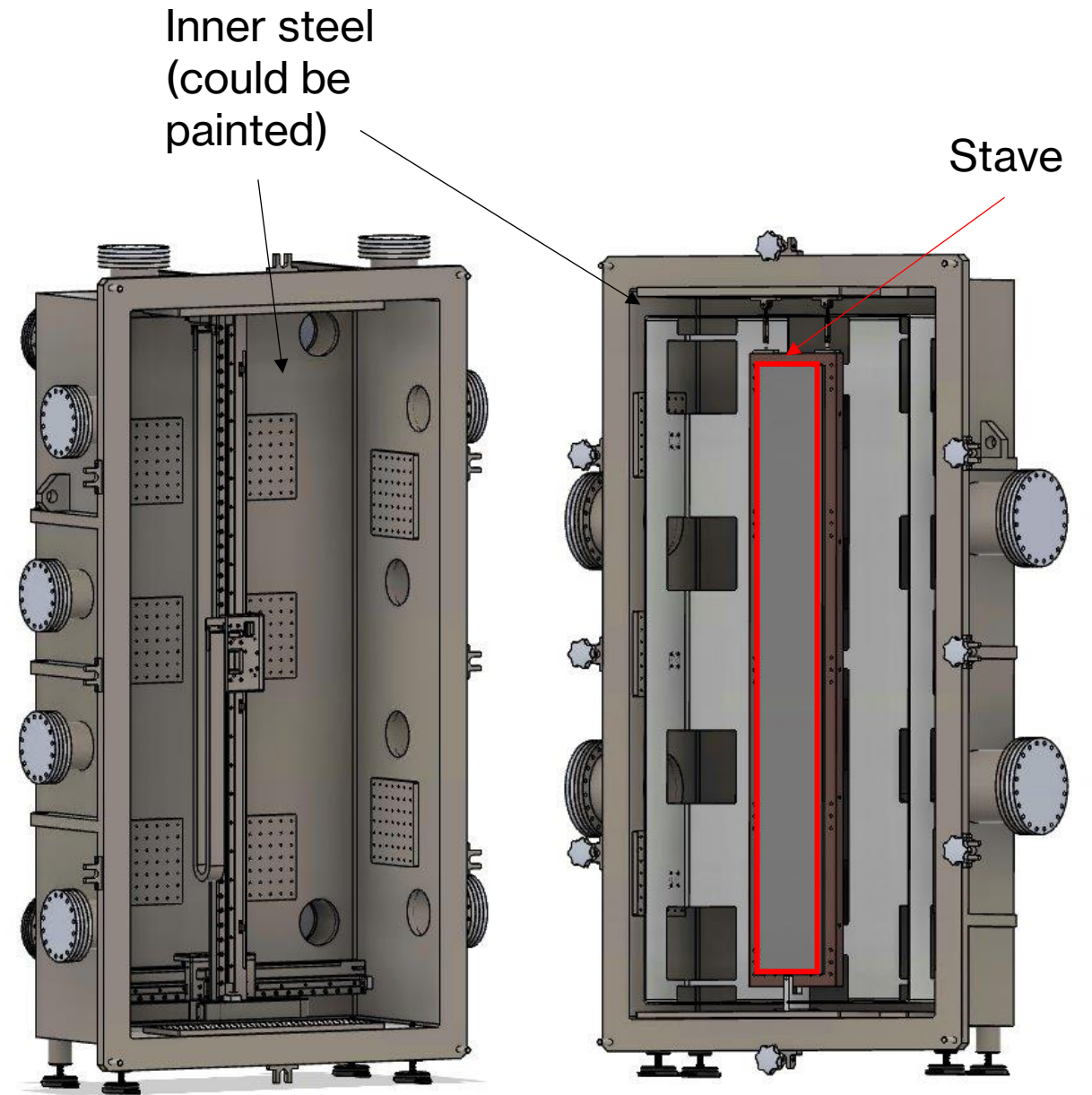
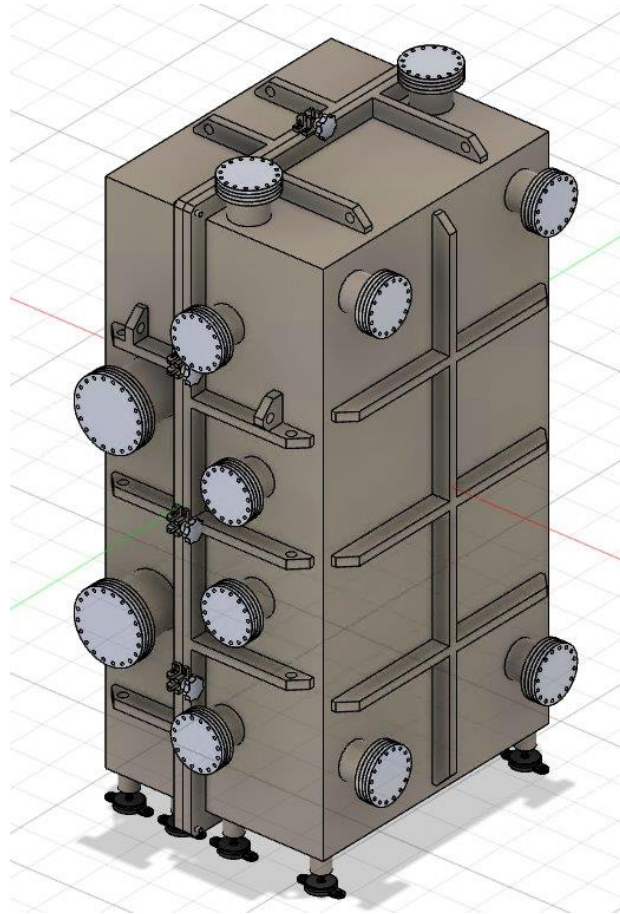
1 cm

Simulation Goals

- Set up simulation of test chamber in Chroma
 - GPU-accelerated photon transport simulation
- Characterize light transport in test chamber
 - Benchmark to compare to data
 - Investigate effect of the chamber's reflectivity on detected photons



Building the Detector



Building the Detector

- Optical properties for 175 nm light (scintillation in liquid xenon)
- Photon generation approximates diffuse light source

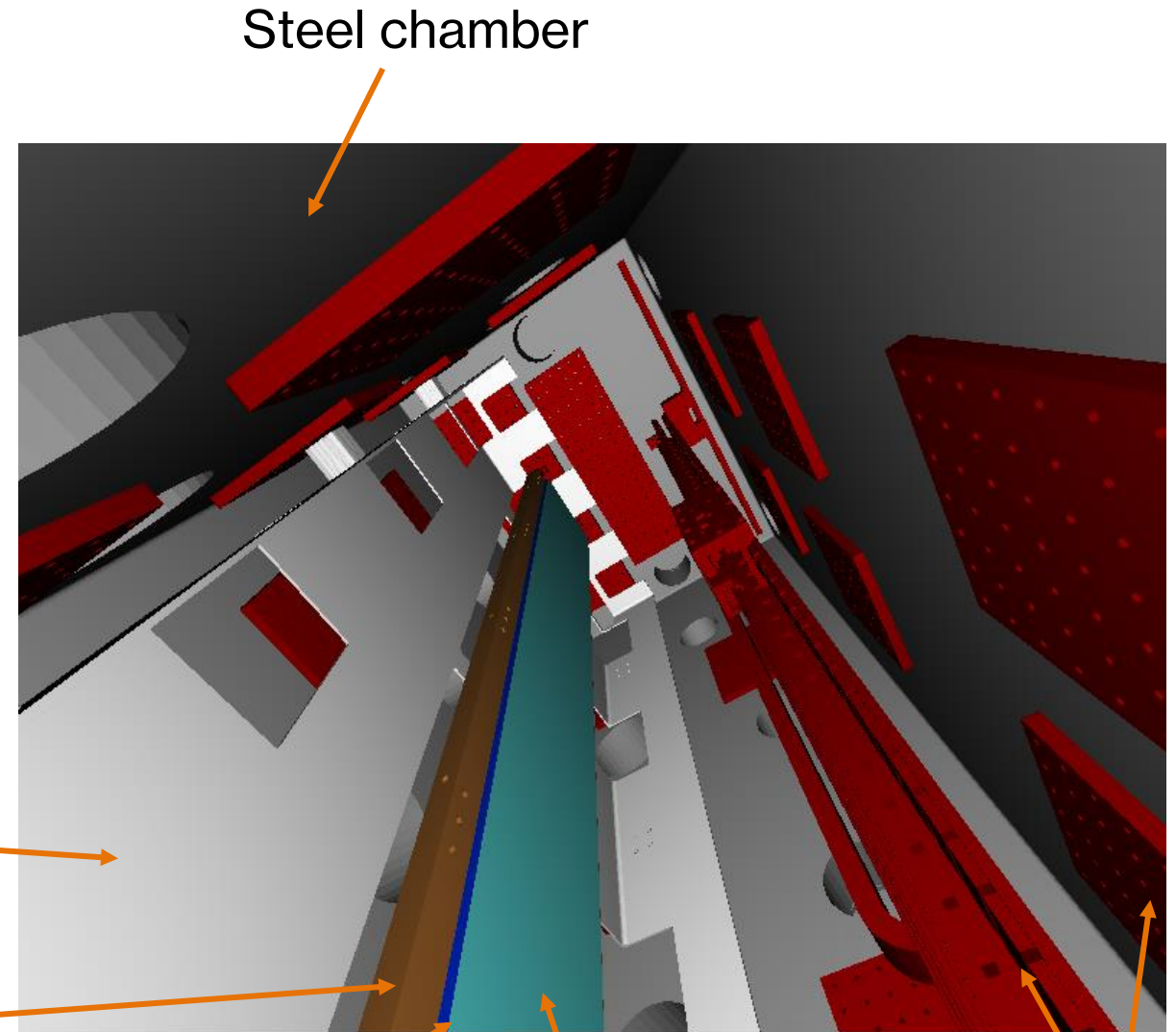
Aluminum heat shield

Copper cooling plate

Silicon stave

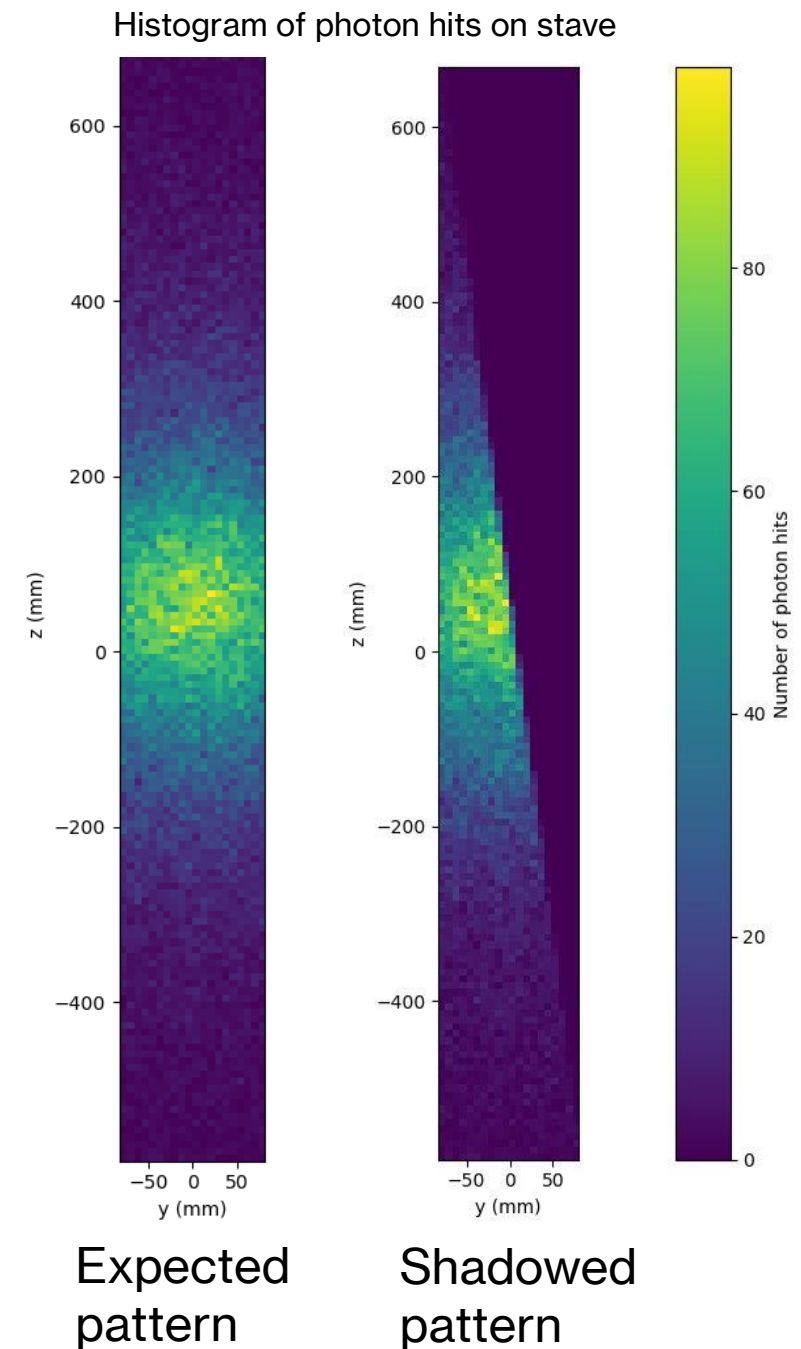
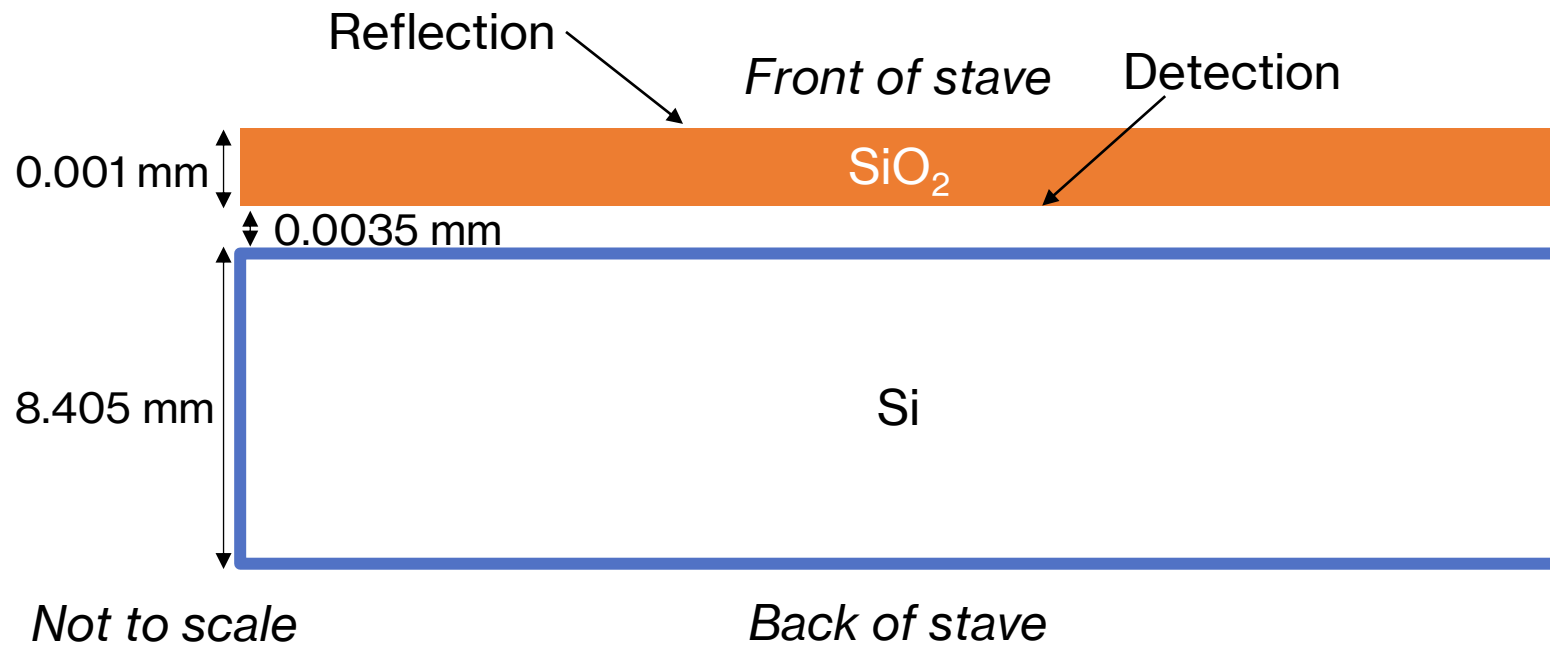
Silicon dioxide layer

Steel gantry, breadboards



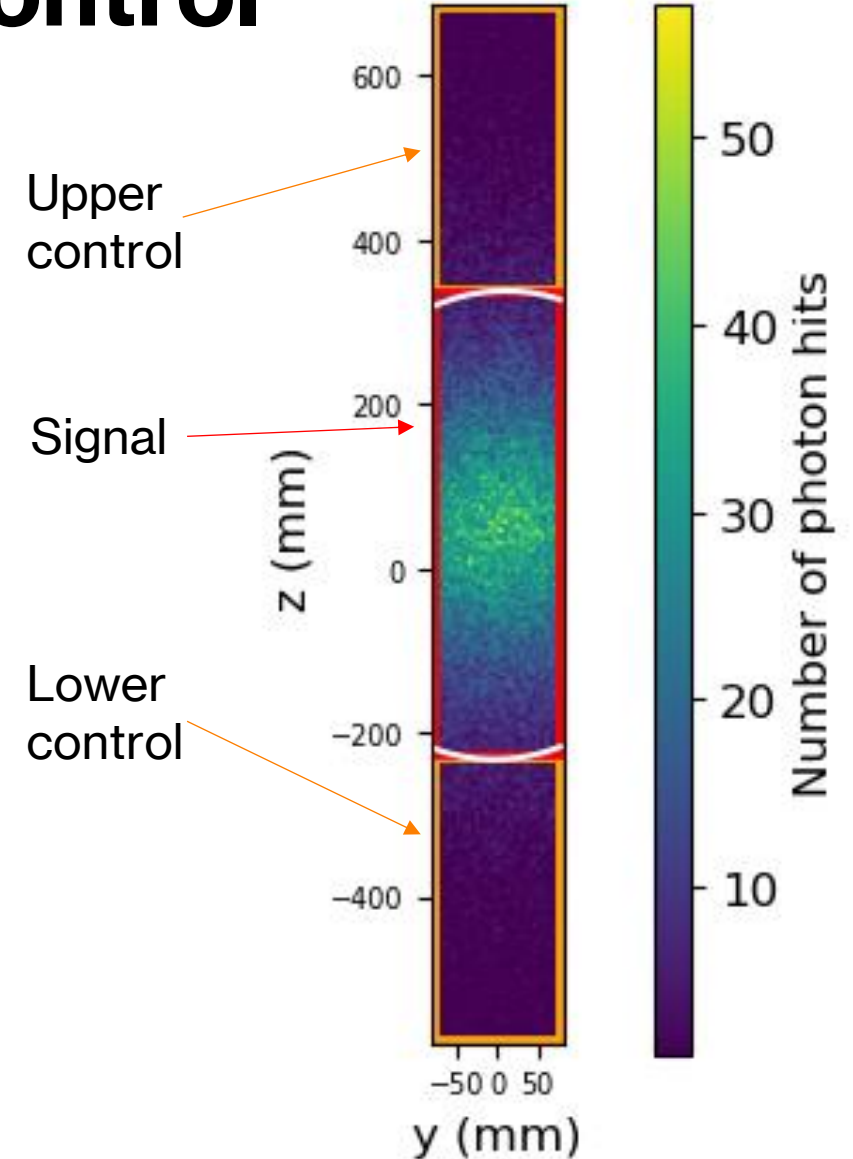
Detector Geometry

- Implementing SiO_2 reflection layer requires a gap between surfaces to avoid shadowed stave



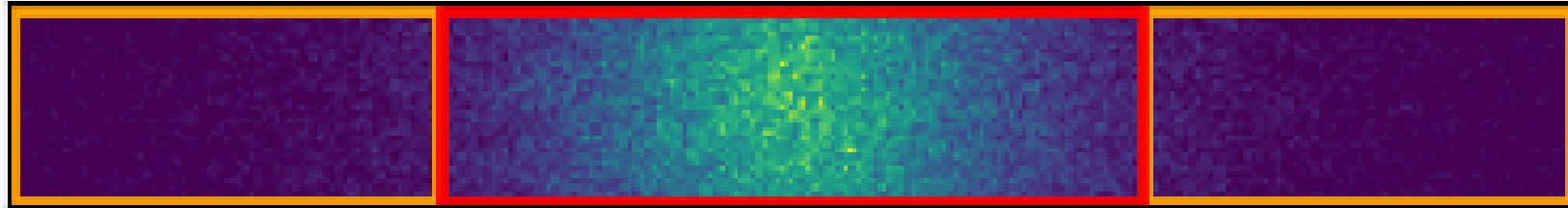
Reflectivity Study: Signal & Control

- 100% photon detection (counting photon hits on stave)
- Benchmark run with default optical properties of steel
- Three regions defined based on Gaussian fit

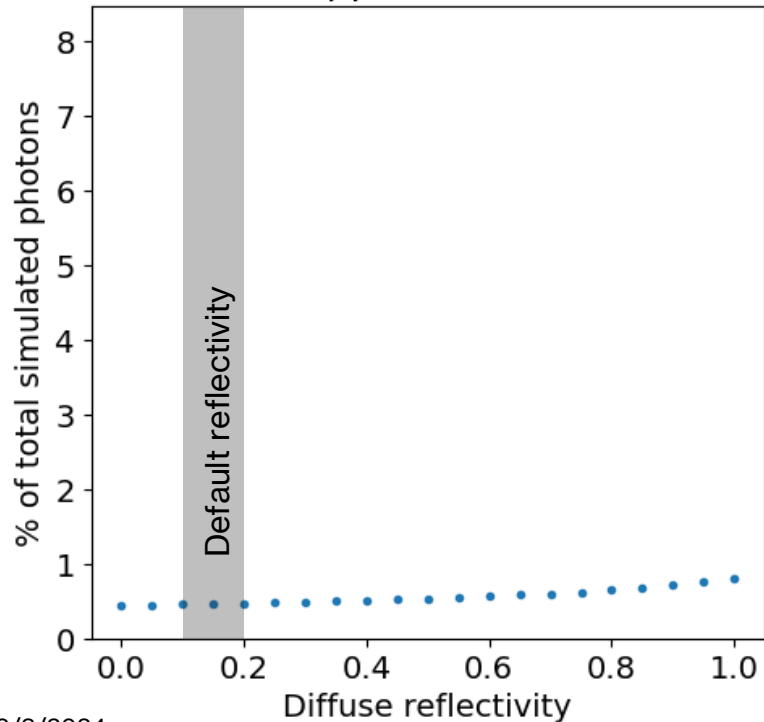


Histogram of photon hits on stave

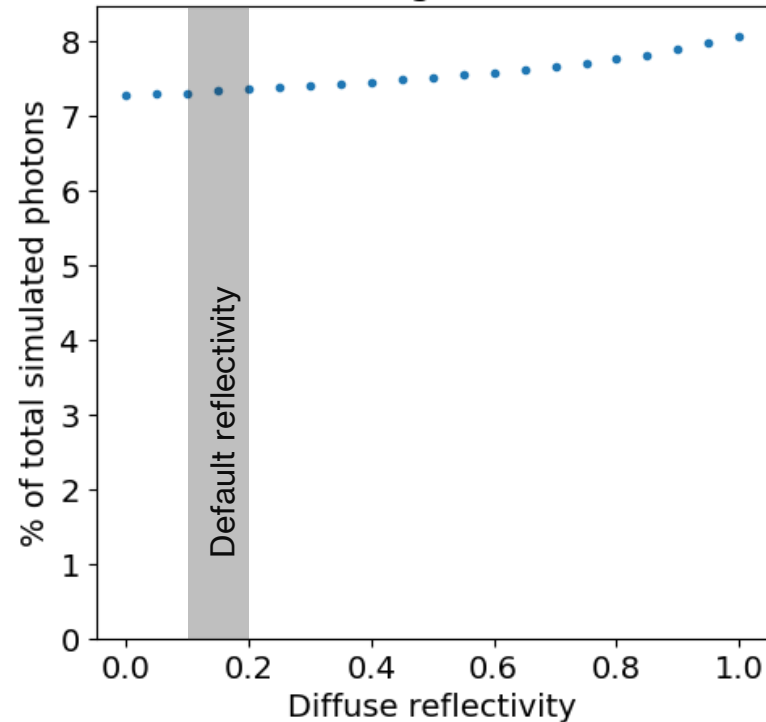
Reflectivity Study: Counting Photon Hits



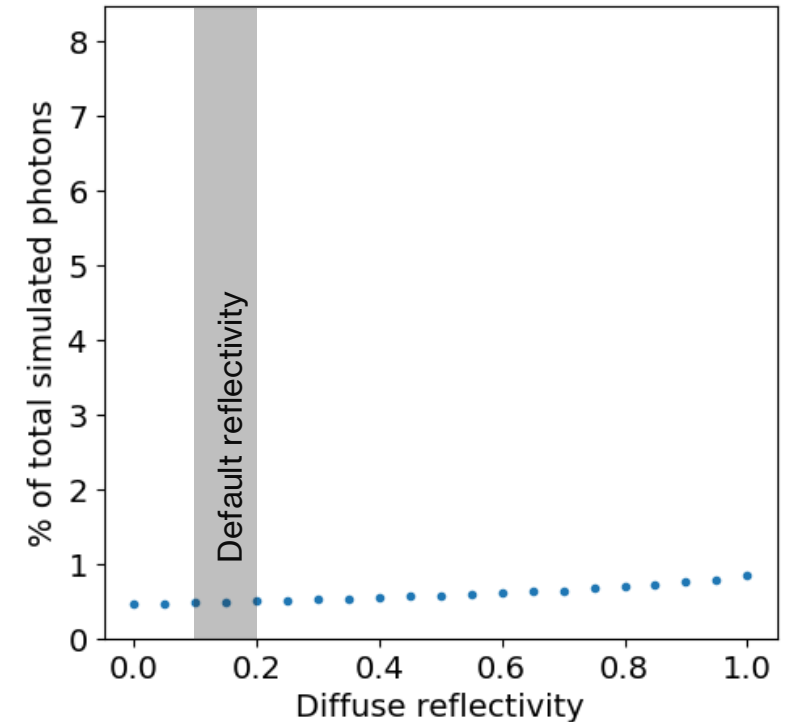
Upper control



Signal

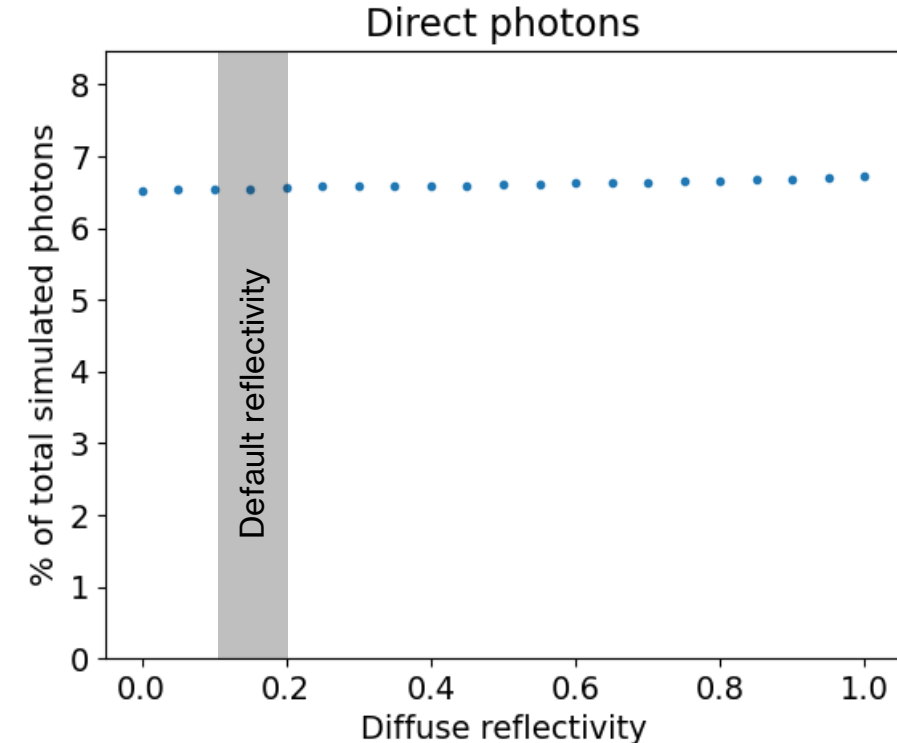
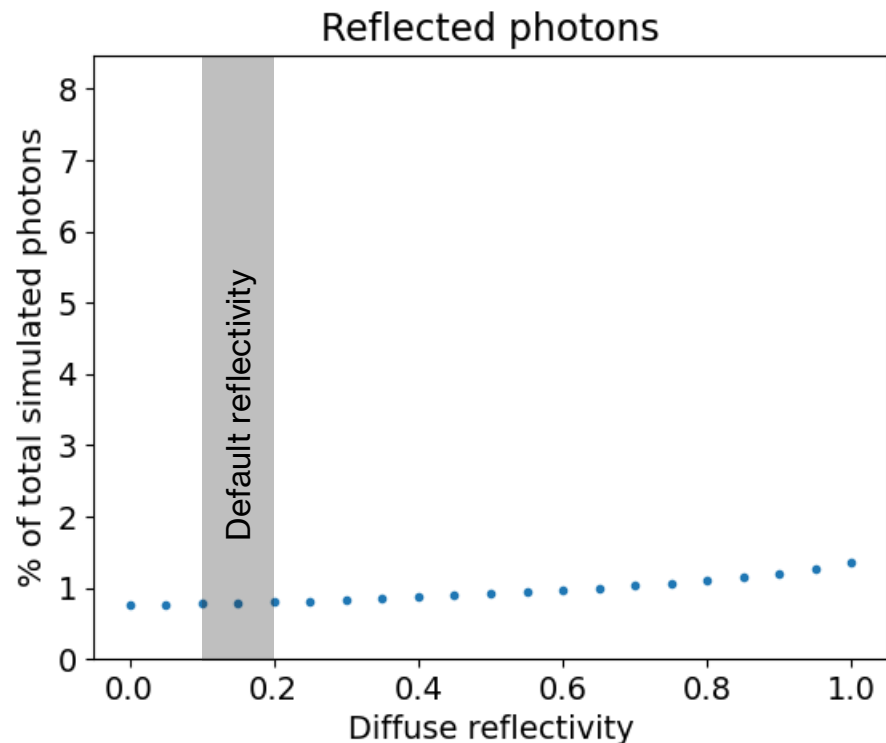


Lower control



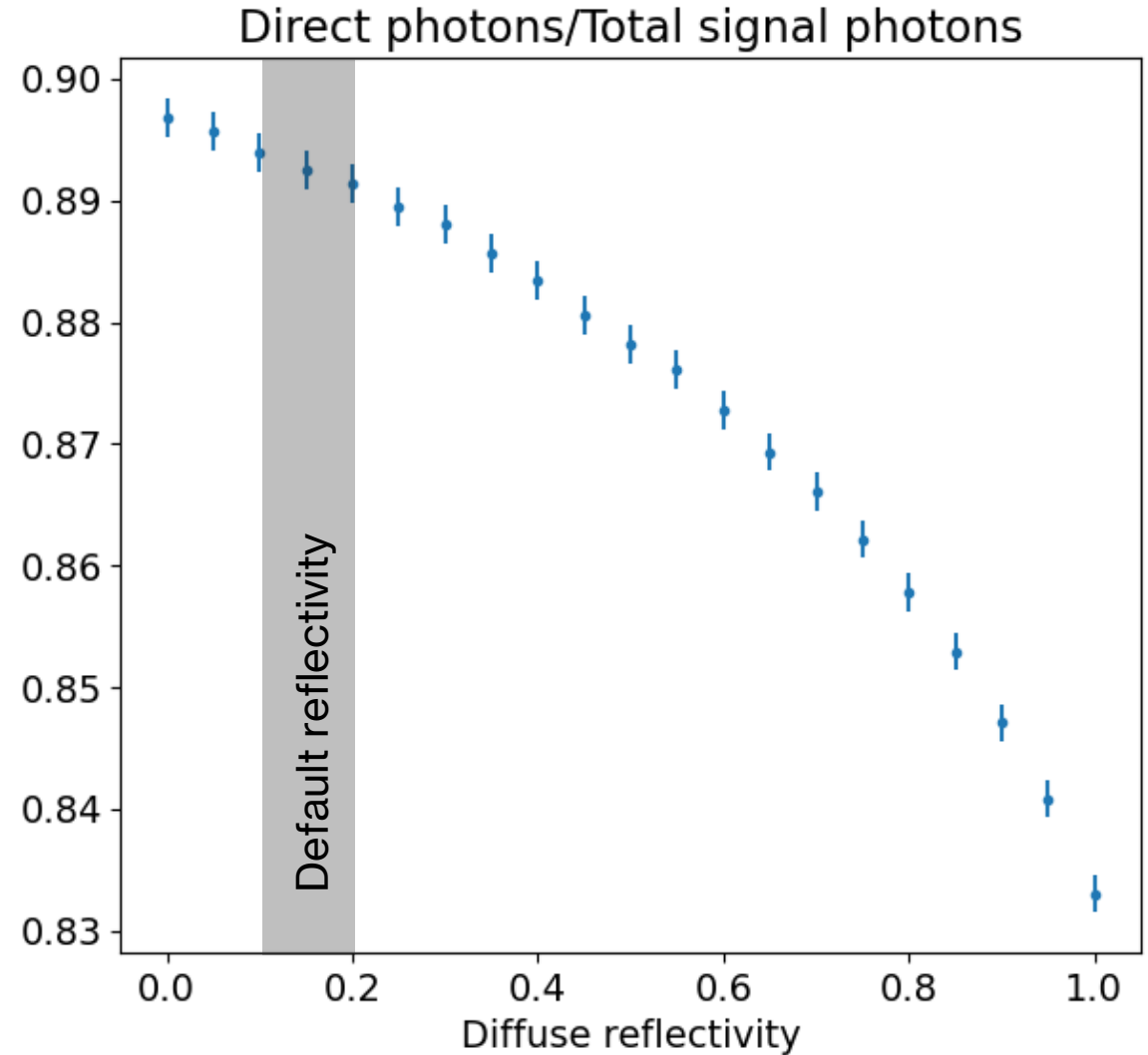
Reflectivity Study: Results

- In signal region:
 - Reflected photons estimated from control region photons
 - Direct photons estimated by subtracting reflected photons from total photons



Reflectivity Study: Results

- Reflected light should not impact measurements.
 - This is a conservative estimate.
 - Not necessary to paint the chamber



Conclusion and Outlook

- Developed Chroma simulation of stave testing chamber for nEXO.
 - Implemented geometry and optical properties of chamber.
- Characterized light transport in test chamber.
 - Simulation can be used as benchmark against results.
 - Investigated ratio of direct to reflected light on the stave.
 - We don't expect reflected light will impact measurements.
- Future work: improvement of direct and reflected photon estimates, other studies of the stave testing chamber (e.g. stave scanning).

Backup

- Assumptions:
 - Control regions have only reflected photons
 - Reflected photons are uniformly distributed along the stave
- In signal region:
 - Reflected photons = control photons $\times \frac{\text{height signal}}{\text{height control}}$
 - Direct photons = signal photons – reflected photons

