LoLX light only liquid Xenon

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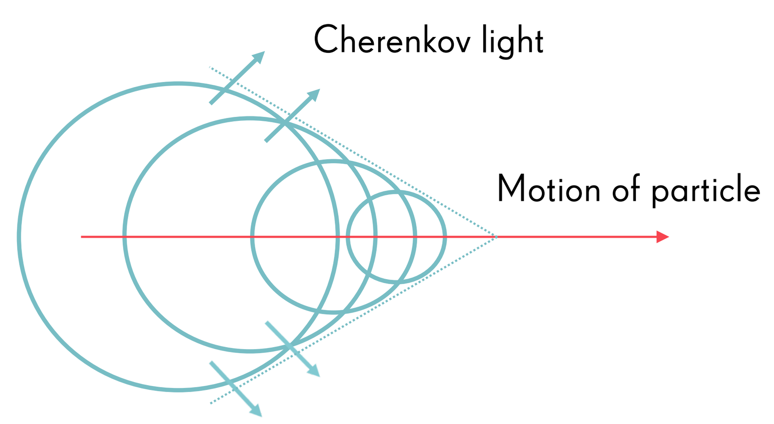
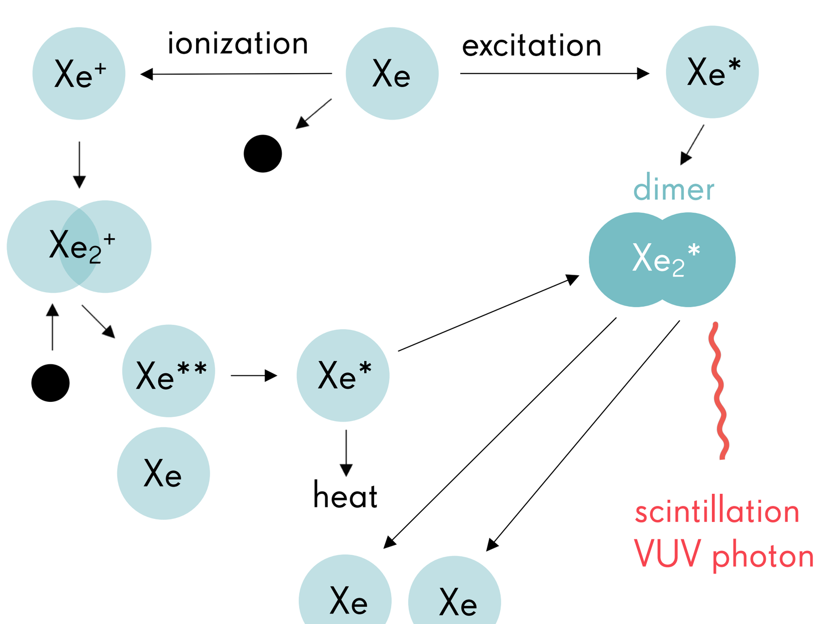
Background

LoLX is a single phase detector with no applied electric field built to investigate **Cherenkov** light independently of **scintillation** light in liquid ^{136}Xe (LXe) to develop better background rejection techniques in rare event searches.



Cherenkov light is emitted when a charged particle travels faster than the speed of light in that medium.

Scintillation light is emitted when excited dimers decay to ground state from the singlet or triplet state which have lifetimes of 2-4 ns and 21-28 ns, respectively, in LXe.



Different particles have unique singlet to triplet ratios which allow for pulse shape discrimination (PSD).

Physics Motivation

1. Investigate Cherenkov light as a method for gamma background rejection in **neutrinoless double beta decay (0νββ).**

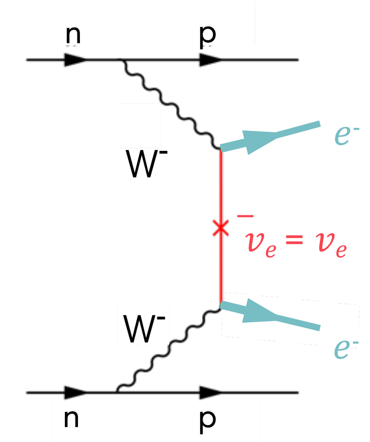


Fig. 1: 0νββ, a lepton-violating process, occurs if the neutrino is Majorana (i.e. the neutrino is its own antiparticle).

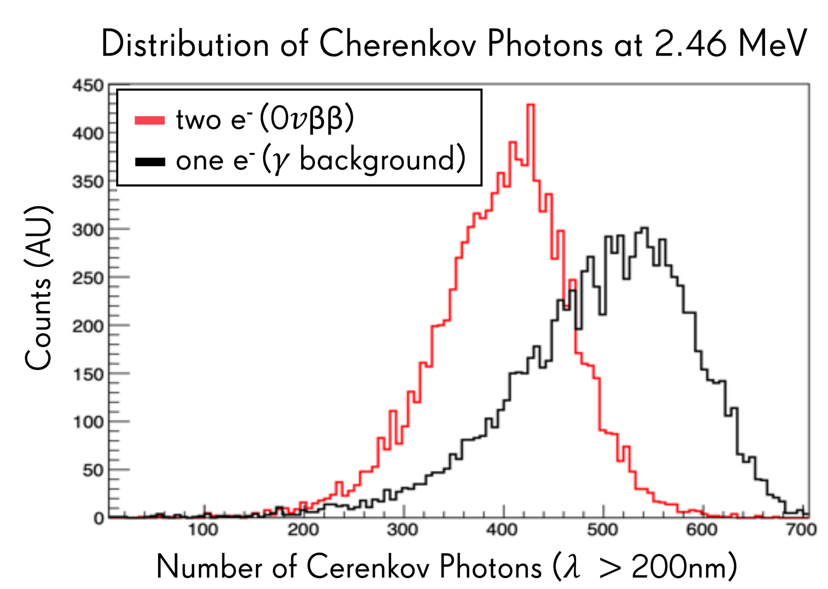


Fig. 2: Single site γ-interactions with energies close to $Q_{\beta\beta}$ = 2458 keV in LXe can be separated from a 0νββ event since more Cherenkov light is emitted by one electron at $Q_{\beta\beta}$ than two electrons sharing the energy. [G. Signorelli]

2. Study the precise timing characteristics of scintillation light to improve upon electron recoil background rejection using **PSD** in **dark matter** searches.

3. Characterize **crosstalk** between opposing SiPMs which can falsely contribute to signal.

Detector Design

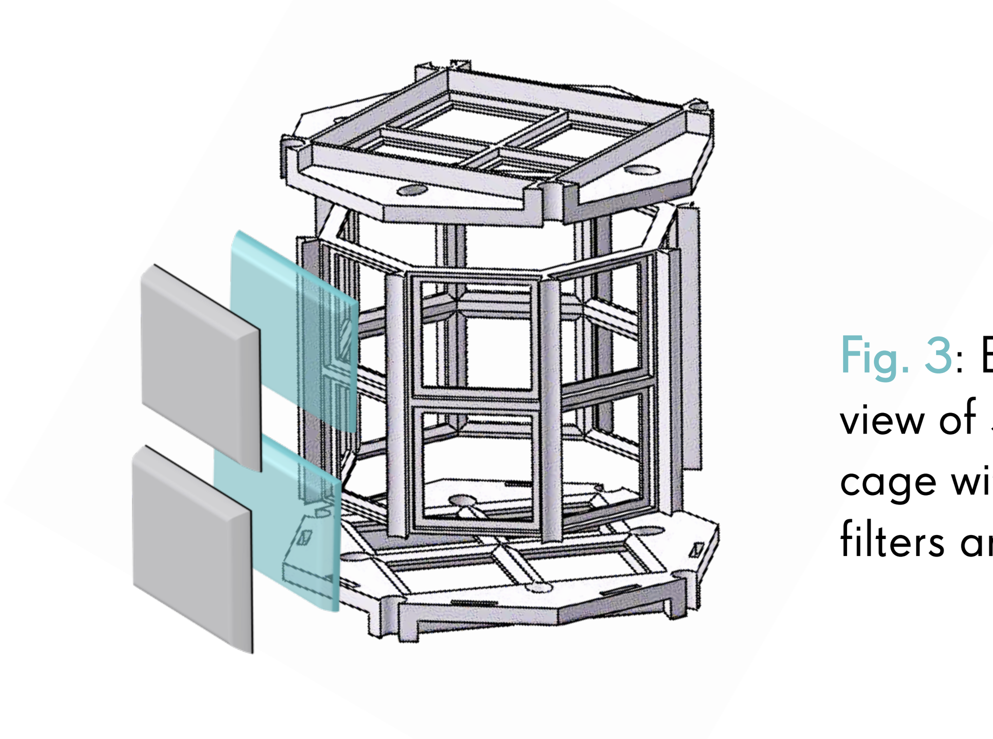


Fig. 3: Exploded view of SiPM cage with optical filters and SiPMs

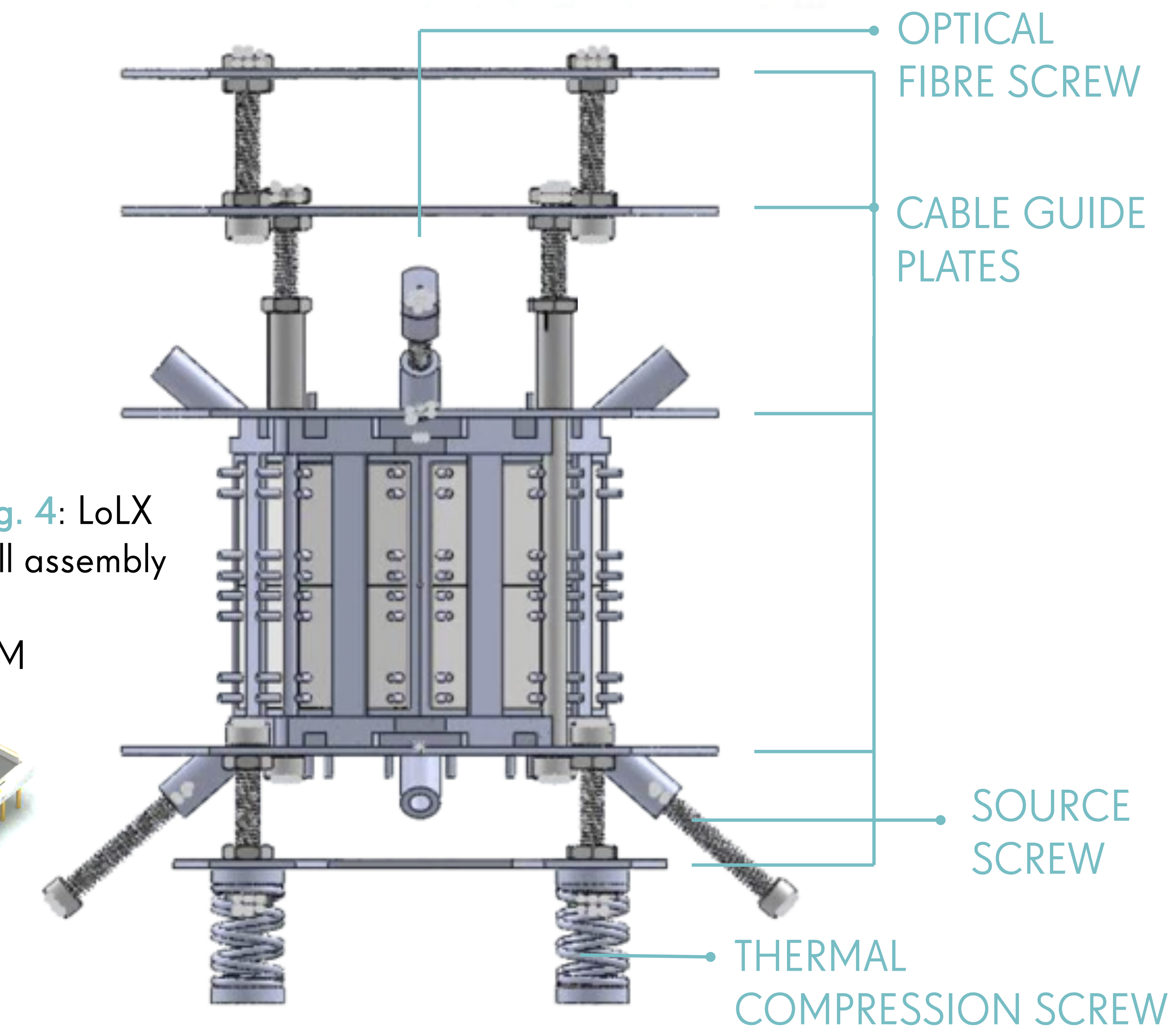


Fig. 4: LoLX full assembly

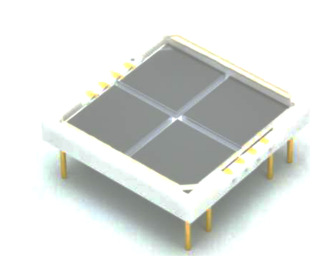


Fig. 5: SiPM

3D PRINTED SIPM CAGE

- Formlabs SLA durable resin
- Survives cryogenic shock
- With 60˚C bakeout, reached vacuum pressure of 10^{-8} Torr

HAMAMATSU VUV4 QUAD SILICON PHOTOMULTIPLIER (SIPM)

- Solid-state photodetector operated in reverse bias, above breakdown voltage
- Photoelectric effect causes charge avalanche
- Gain of 10^6 electrons allows for single photon counting
- LoLX Phase 1 uses 24 SiPMs = 96 channels

OPTICAL FILTERS

(22) LONGPASS
- Scintillation drowns out Cherenkov at ~175nm
- Filter blocks scintillation, passes Cherenkov

(1) UV BANDPASS
- Passes scintillation, blocks crosstalk photons

(1) NAKED
- Passes scintillation and Cherenkov, sensitive to crosstalk photons

RADIOACTIVE SOURCES

- β source: ^{90}Sr (0.546 MeV ^{90}Sr, 0.94 MeV ^{90}Y decay)
- α source: ^{210}Po (5.3 MeV decay)

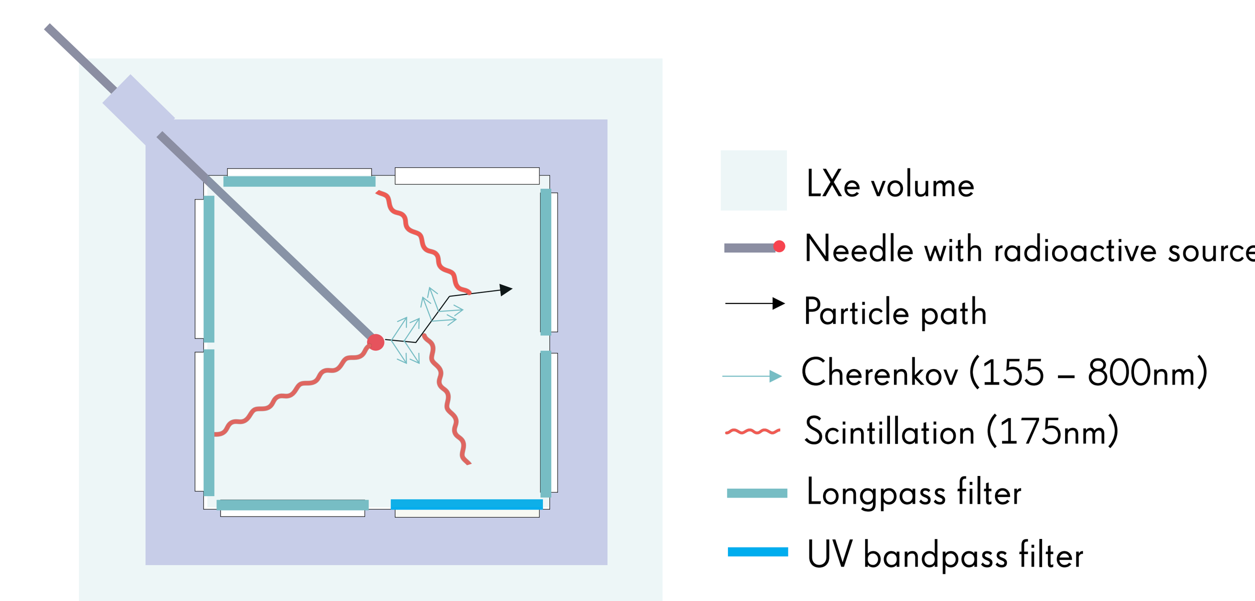


Fig. 6: LoLX cross section

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