Measurement of Cherenkov Radiation in Liquid Xenon: The LOLX Experiment

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WNPPC

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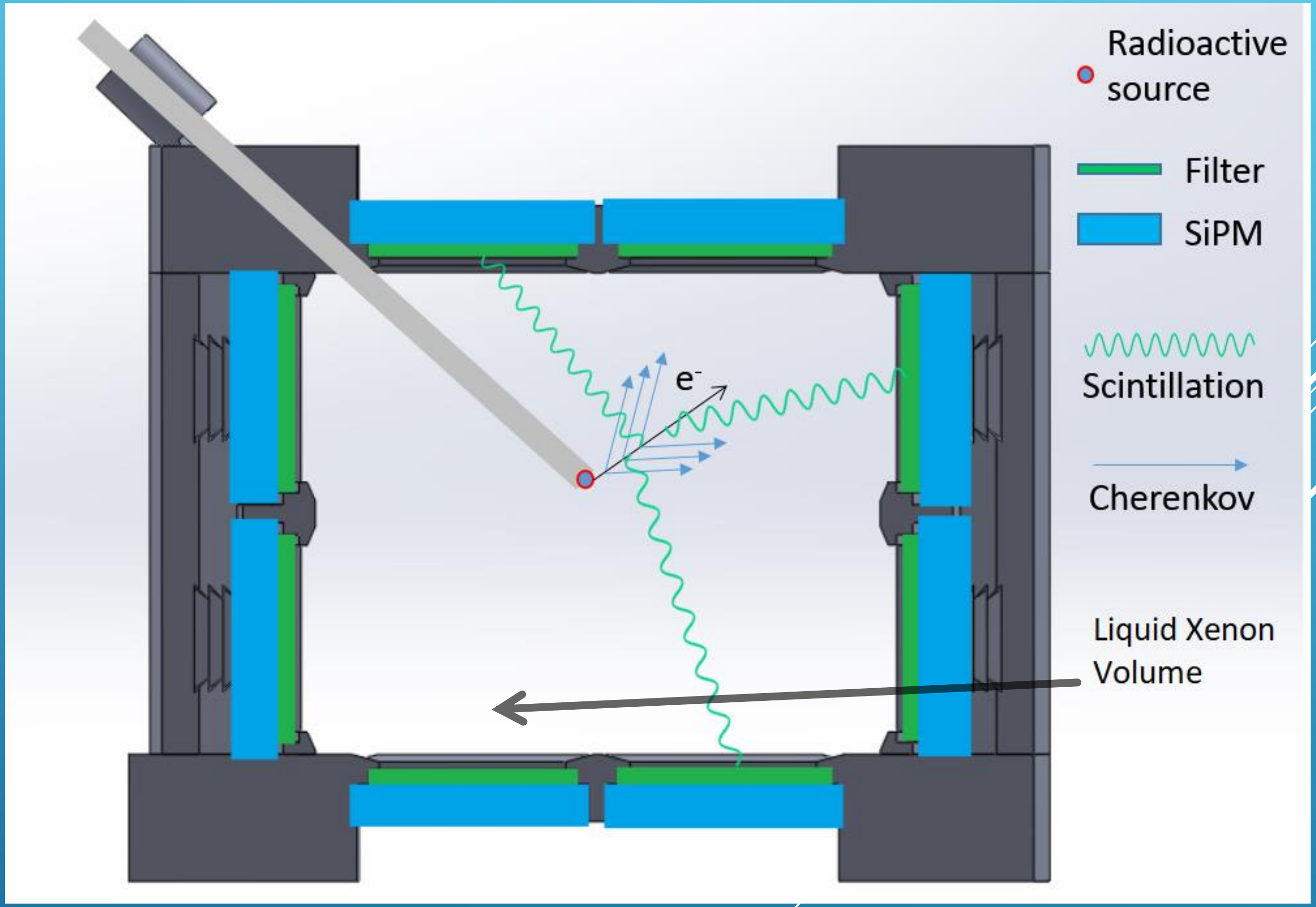
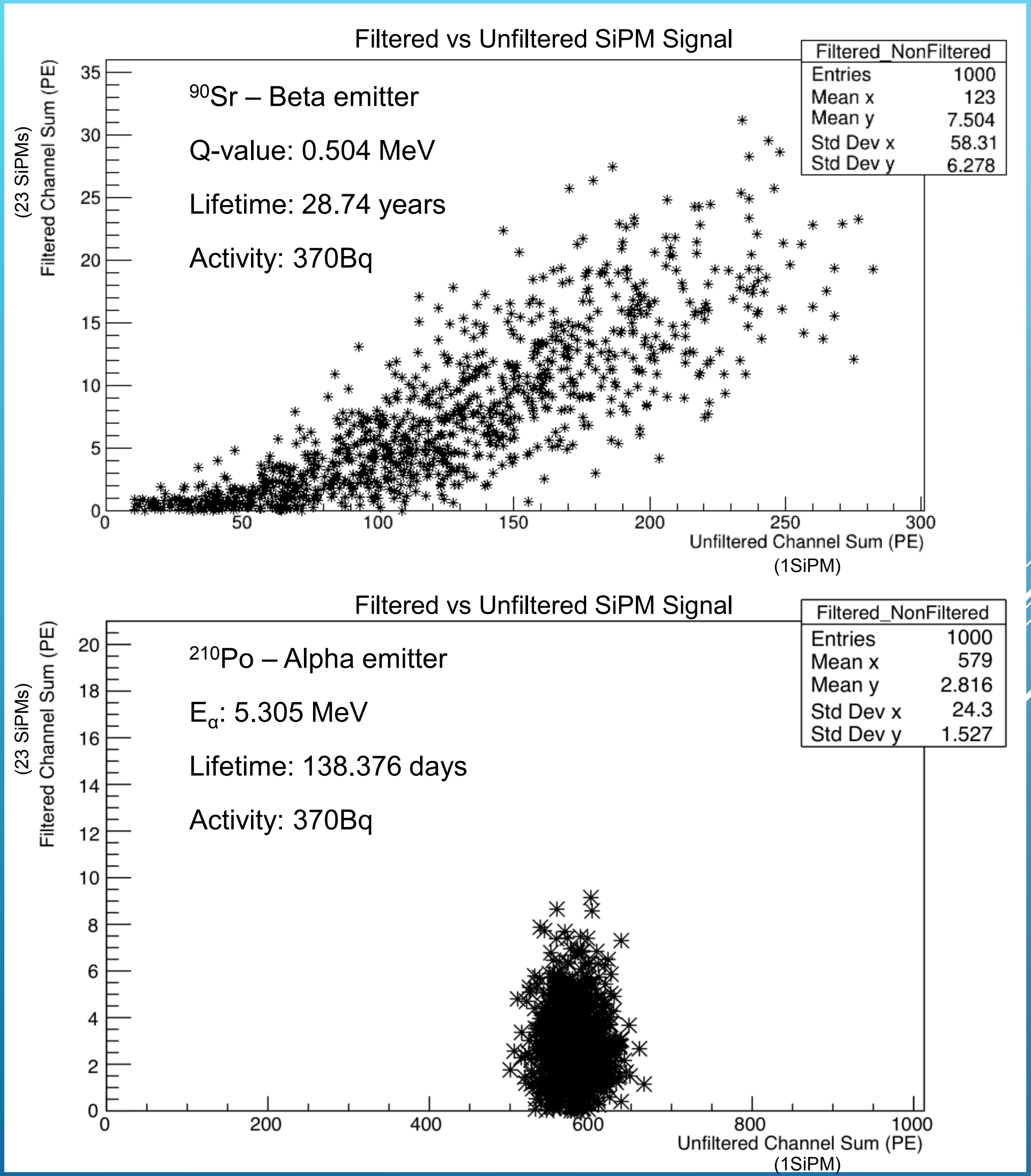
Physics Goals

- Independently measure Cherenkov and VUV scintillation light with silicon-photomultipliers (SiPMs) and optical filters.
- Characterize liquid xenon scintillation.
- Measure the energy resolution using only light.
- Verify photon propagation in GEANT for nEXO.
- Explore the possible use of 3D printed materials for nEXO.



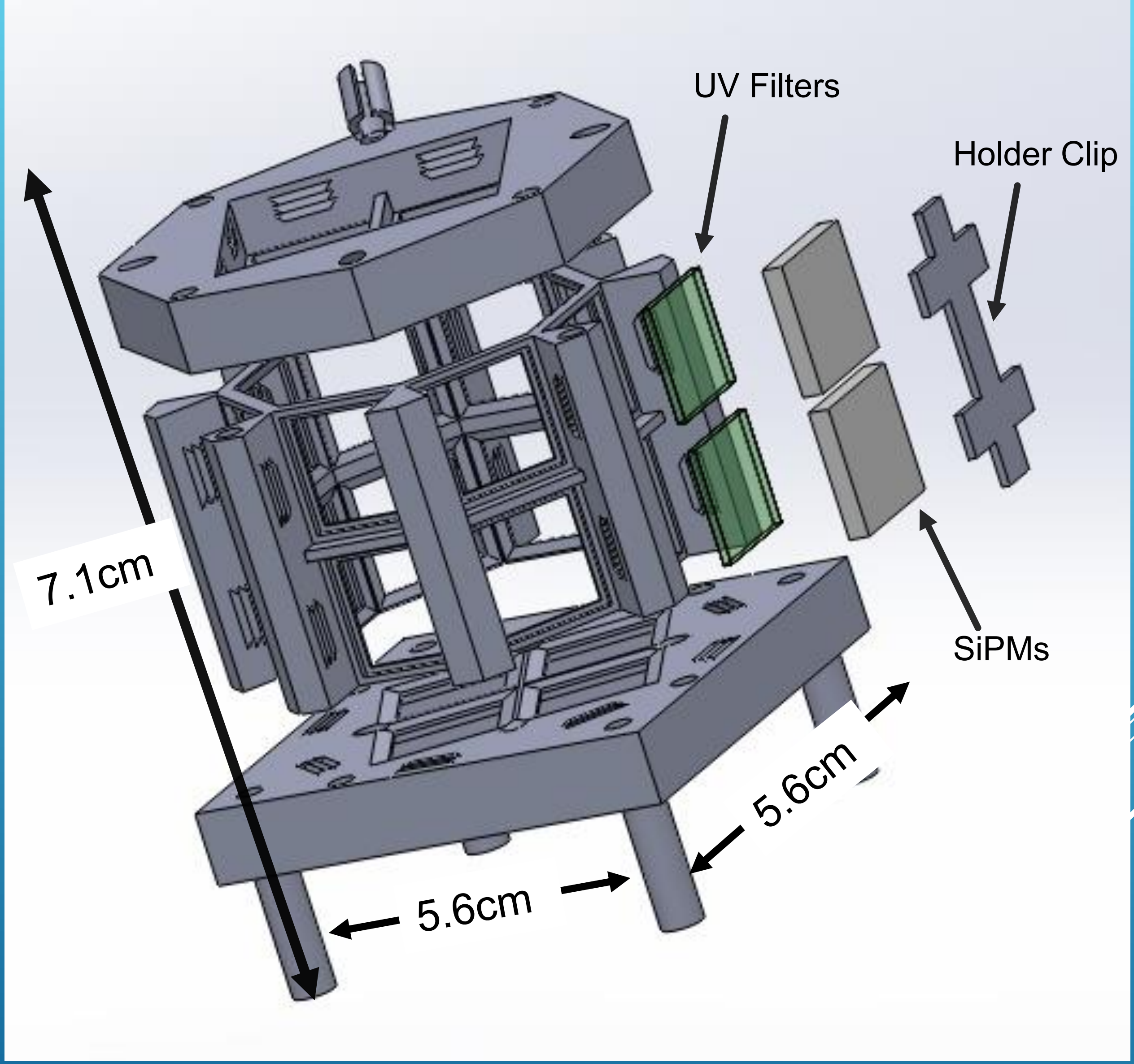
Initial Photon Simulations

- Simulated photon propagation in liquid xenon in GEANT to see if detection of Cherenkov photons was possible.
  - Using both ^{90}Sr and ^{210}Po radioactive sources.
- Increasing total signal in unfiltered channel for a beta decay also leads to an increase in the Cherenkov signal.
- ^{210}Po simulations suggest that the previous observation is not due to VUV light leakage but actual Cherenkov photons.



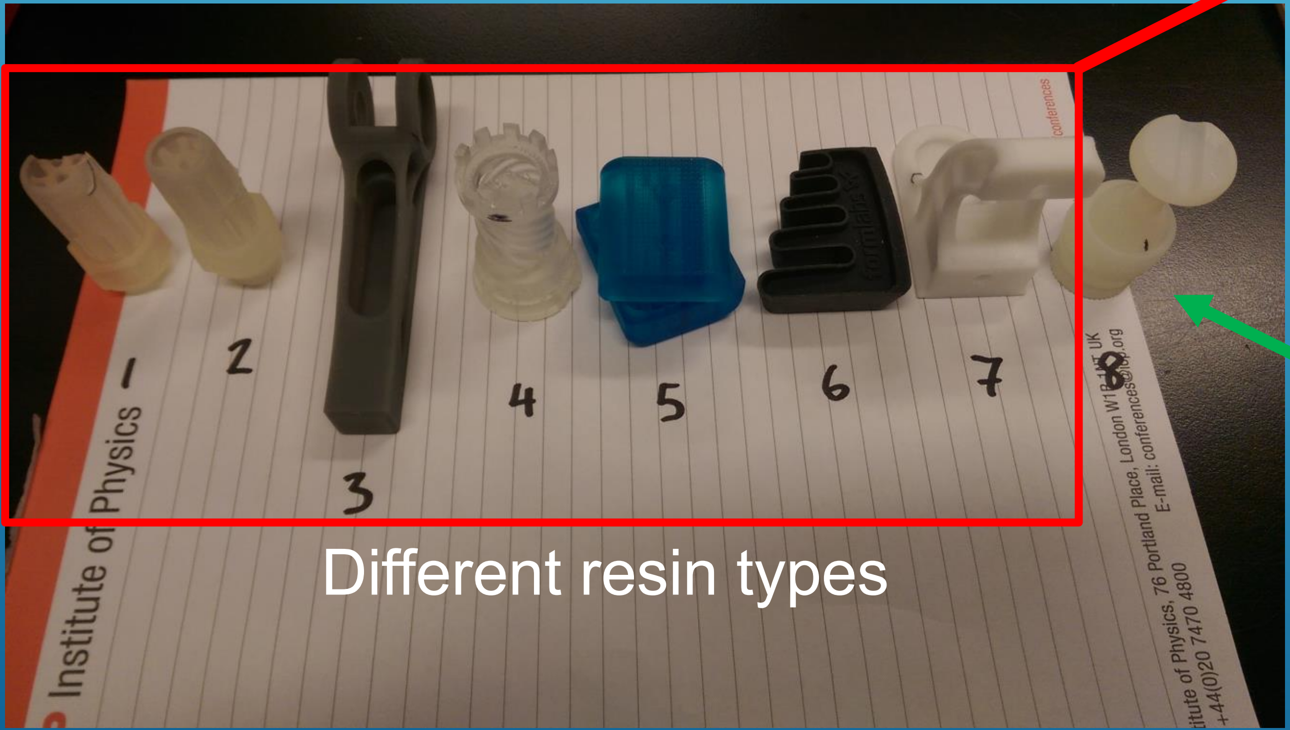
Physical Design

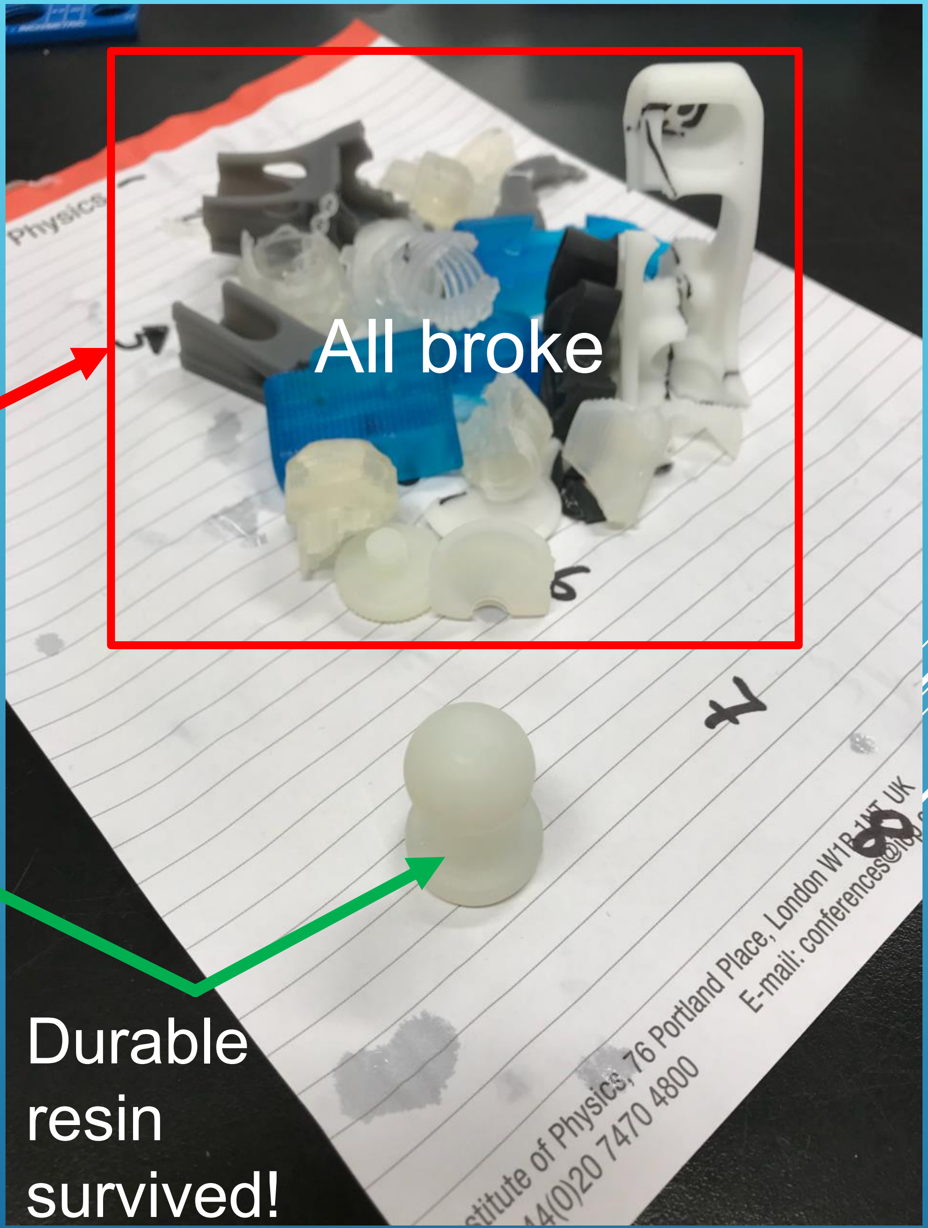
- The physical design is a cylindrical cage with the ability to hold 24 SiPMs and filters.
- Has holders for radioactive source needles and laser fibre entry ports.
- The whole assembly fits in a 5.6cm x 5.6cm x 7.1cm volume.



3D Printed Materials

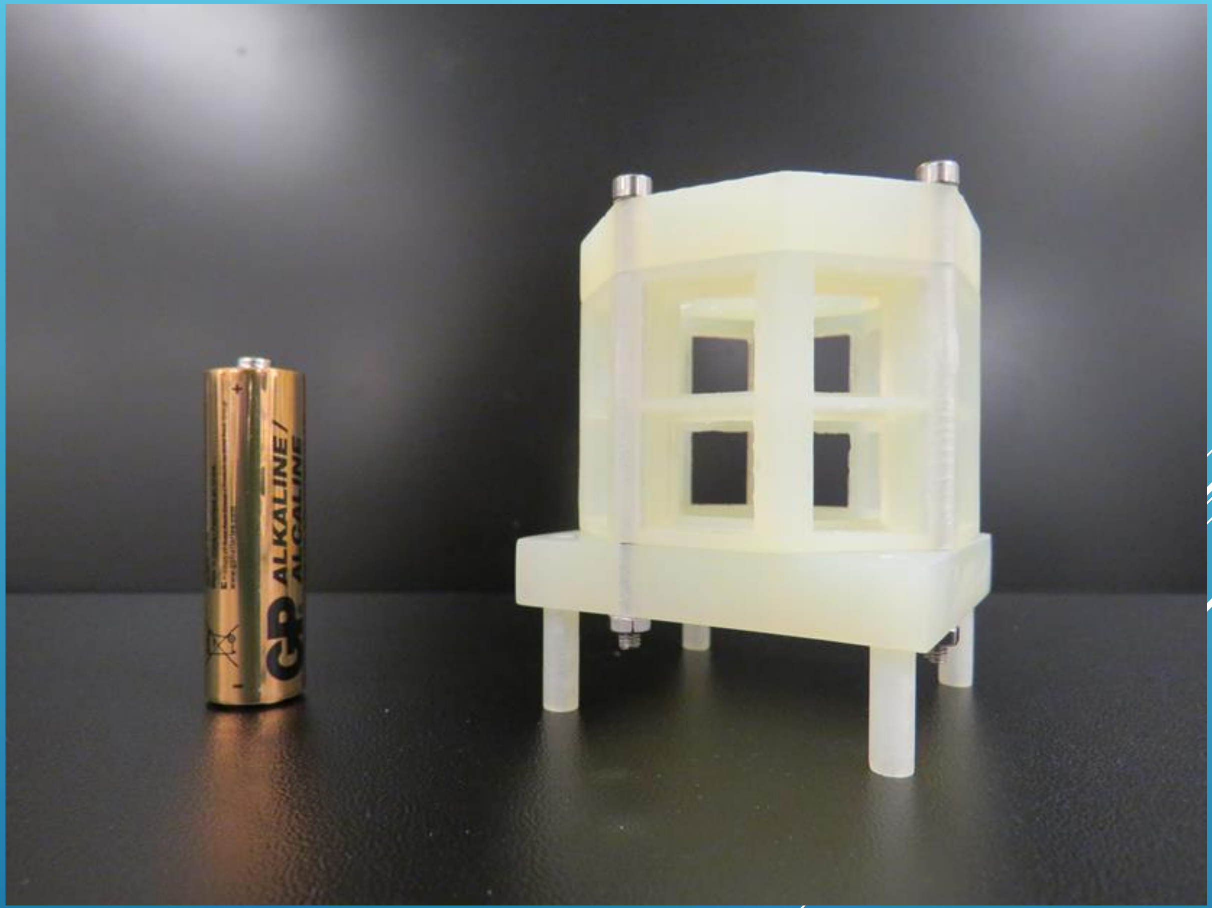
- Tested various acrylic based resins from Formlabs to scout vacuum and cryo-compatible candidates for LOLX.
- Only "Durable" resin resisted multiple cooling cycles without suffering structural damage.





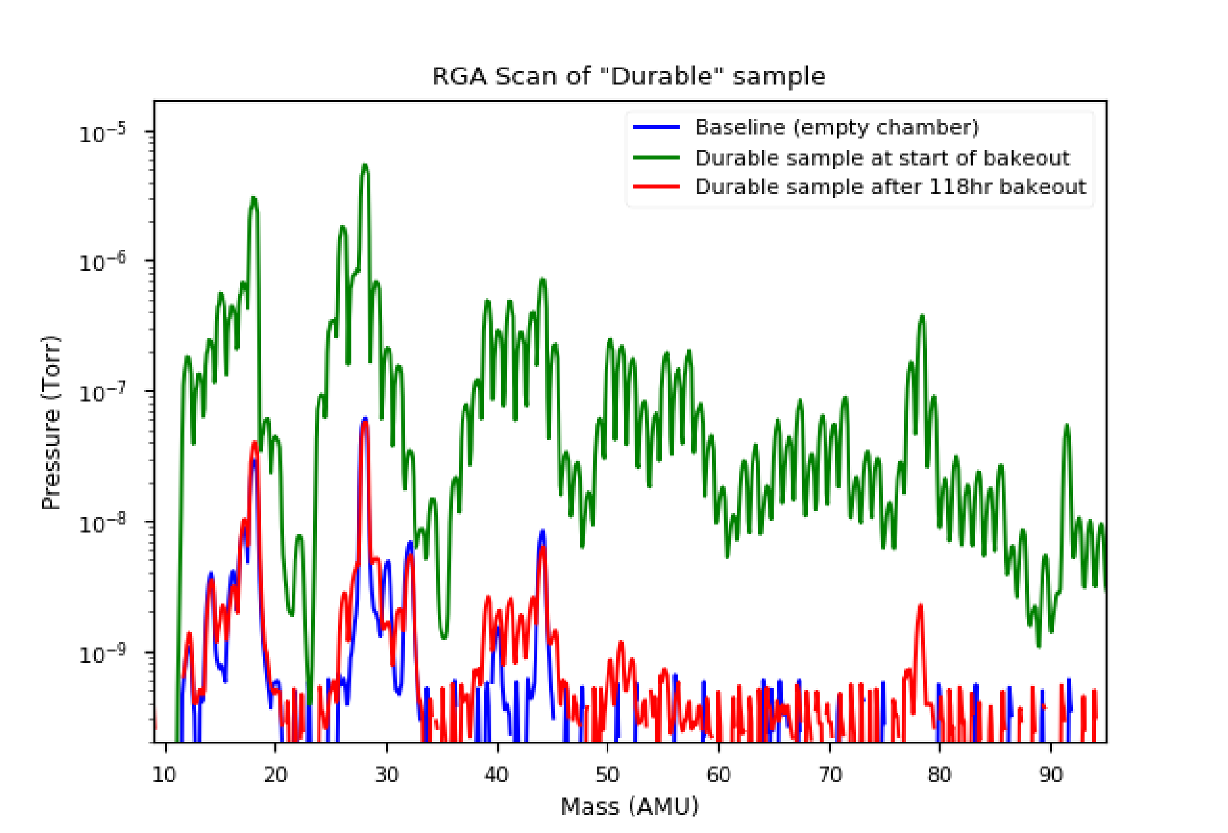
3D Printed Materials

- Performed cryogenic tests on 3D printed physical design made of “Durable” resin.
  - Slow cooldown through exposure to LN2 vapour.
  - Followed by full submersion in LN2.
- Despite more complex geometry and thinner cross-sections than test sample no damage was noticed.
- A 1.5% shrinking due to cooling was measured.



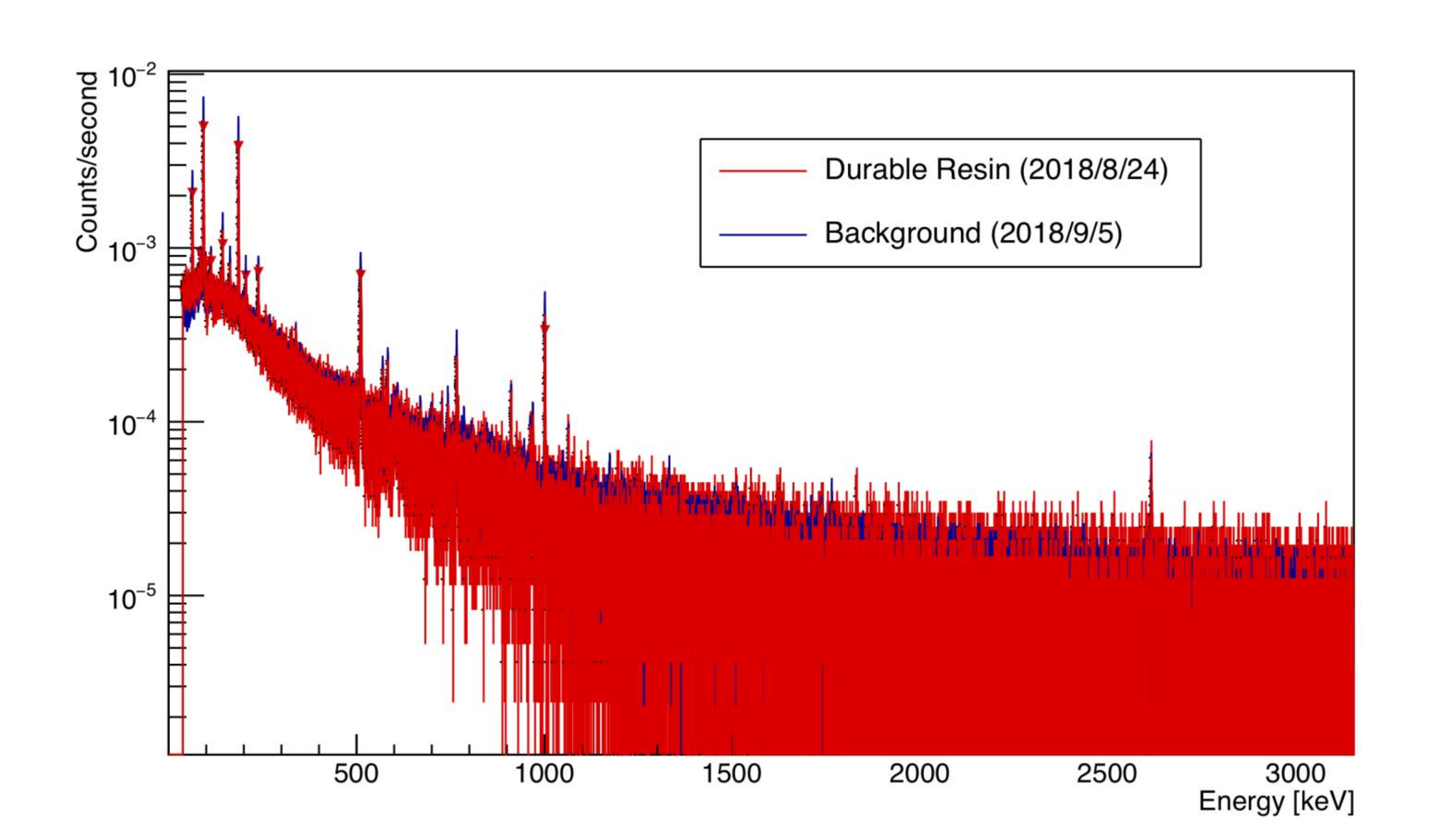
Residual Gas Analysis on 3D Printed Samples

- Performed outgassing tests on resin to determine its vacuum compatibility.
- Need to ensure low outgassing rates since xenon light yield is affected by impurities.
- Investigating best bakeout procedure.
- Performed bakeout in 1 bar of Argon.
- Plastics mainly absorb water.
- Vacuum compatible for LOLX after baking.



Radio-purity Tests

- Testing the radioactivity levels of the resin to see if there are is any non-standard activity.
- After 3 days in Germanium detector, sample signal does not differ too much from background.
- No red flags to raise, but measurement is not conclusive.
- Background rates are acceptable for LOLX.



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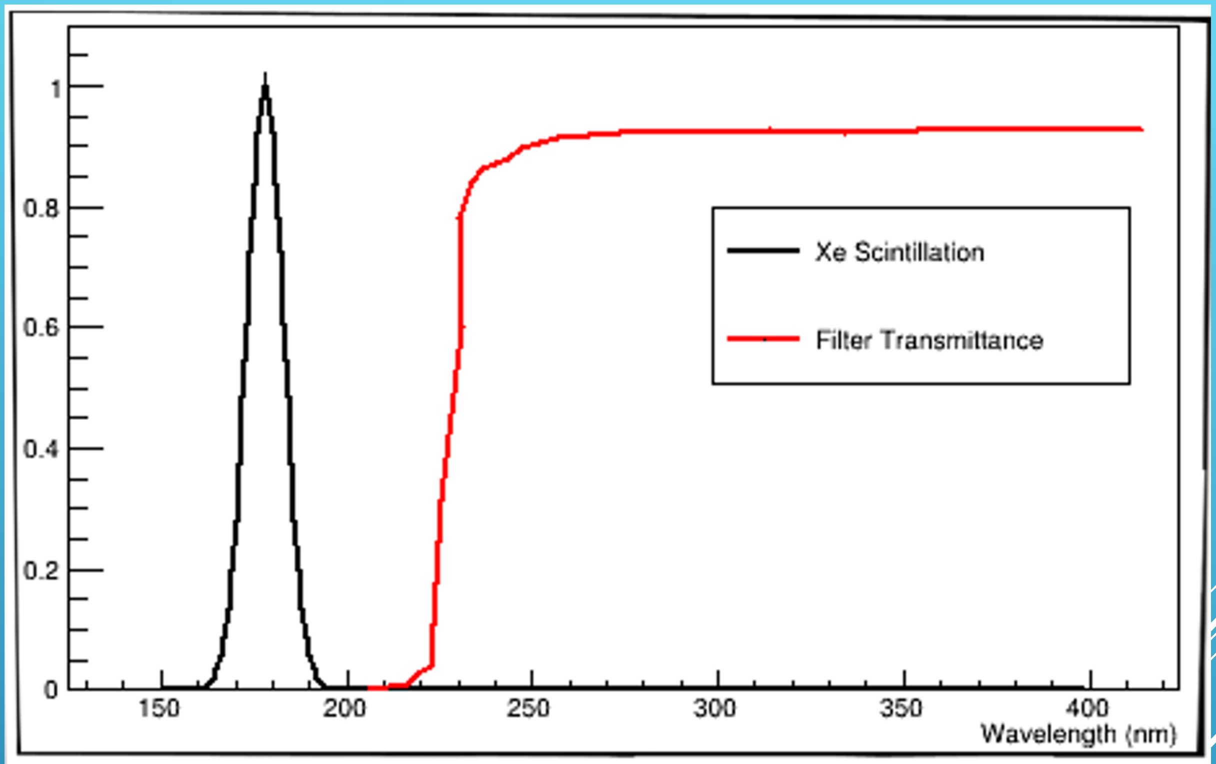
UV Filters and SiPMs

- Using 10CGA-225 filter from Newport to filter out scintillation light.
  - Scintillation light: 165-190nm
  - Cherenkov light: ~100-500nm



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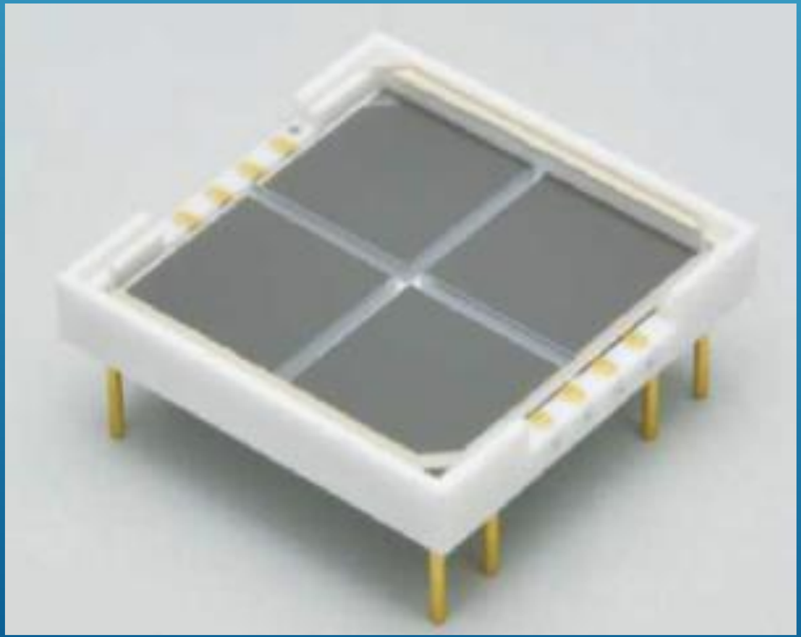

- Hamamatsu VUV4 SiPMs.
- Each package has 4 channels so we can read a total of 96 independent channels.

Outlook

- Liquid xenon commissioning in summer 2019. Cryostat will be located at Carleton University, Ottawa.
- The measurements performed by LOLX will contribute to experiments searching for:
  - Dark matter
  - Neutrinoless double beta decay
- Future developments aim for fast timing optimization for positron emission tomography.

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