Wavelength Shifter Deposition for DEAP-3600

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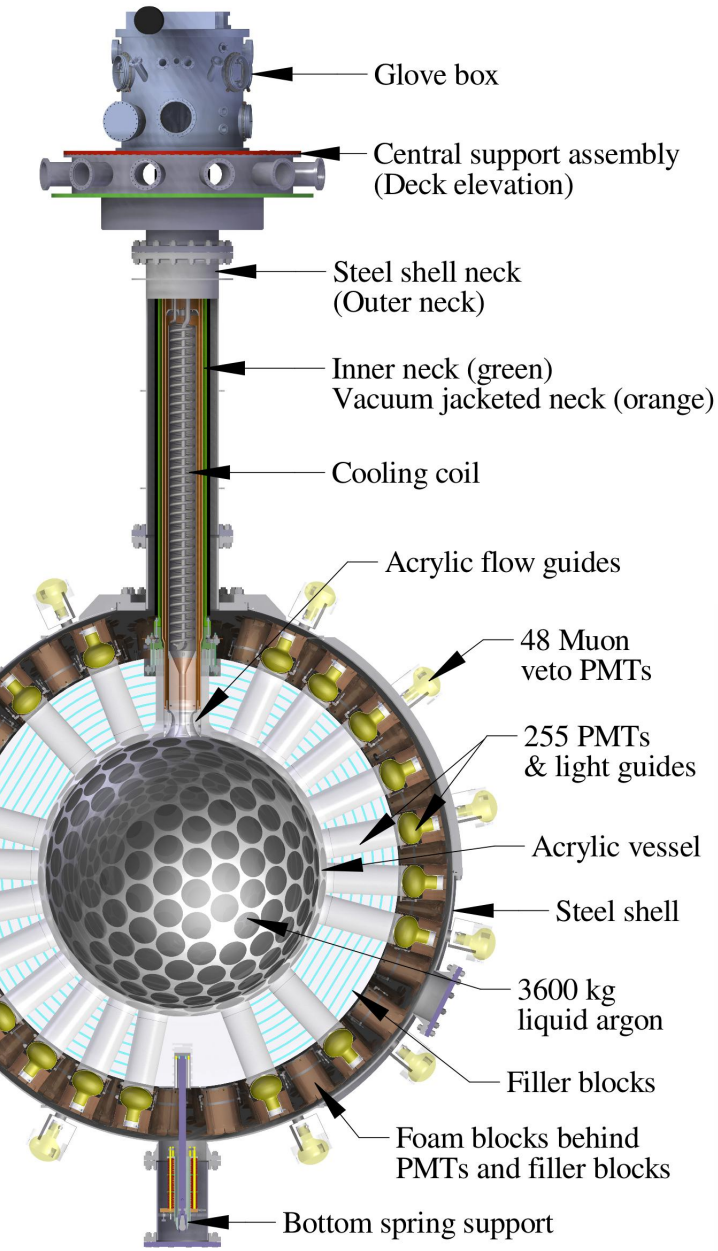
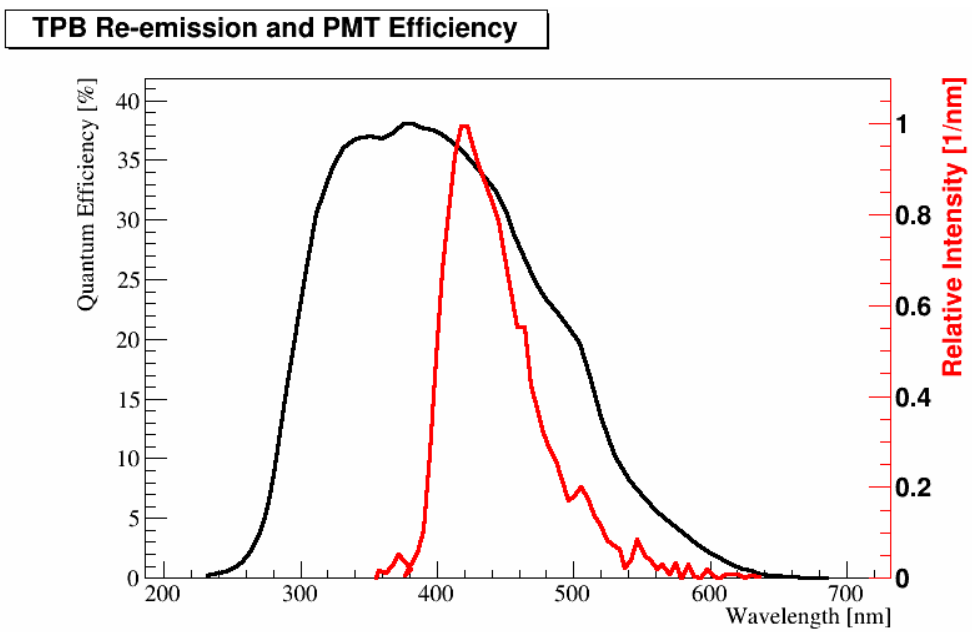
Outline

- DEAP-3600 Overview
- Wavelength Shifter Coating Requirements
- Deposition Source and Testing
- DEAP-3600 Deposition
- Witness Sample Analysis
- Conclusions

Dark Matter Experiment using Argon Pulse-shape Discrimination

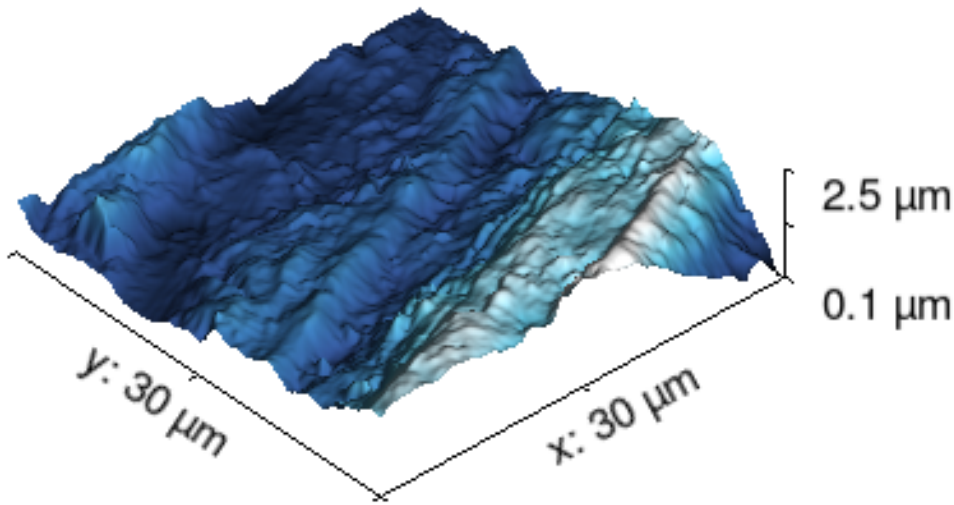


- 3250 kg single phase liquid argon (1000 kg fiducial)
- SI dark matter search with sensitivity: 10^{-46} cm^2 for 100 GeV/c^2 WIMP
- Pulse-shape discrimination
  - discriminate β/γ vs. n.r.
- Ar scintillation at 128 nm
  - Wavelength shift with TPB



Coating Requirements

- Not reintroduce surface activity
- Pure (clean) TPB
- Cover surface morphology: sanded inner surface
  - $\sim$ 1–2 µm roughness features.
  - No exposed acrylic grooves
  - Influences detector light yield



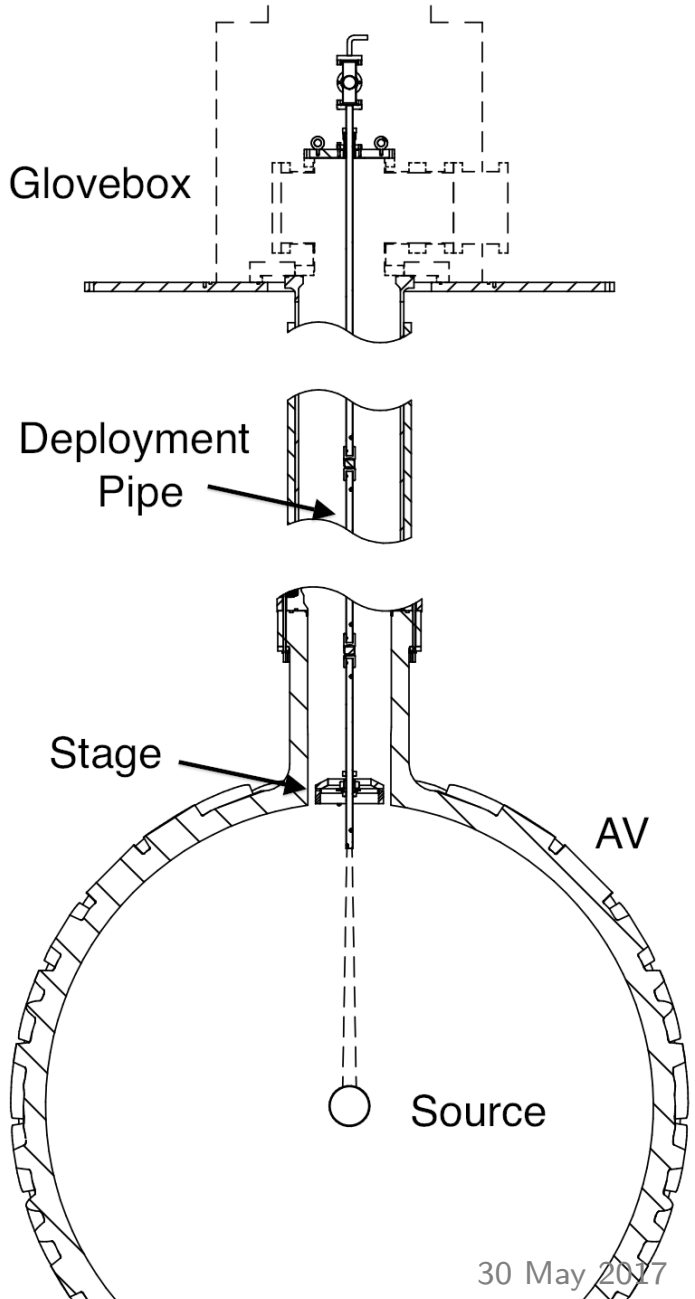
AFM image of sanded acrylic.

Source Construction

- Machined from 316 stainless hemispheres
- Copper crucible heated by Watlow coil heater
- Geometric scattering inside source produces uniform out-going flux

DEAP-3600 Deposition

- Sealed environment: work through glovebox, purged with radon-scrubbed boil-off nitrogen
- TPB kept vacuum sealed after arrival until deposition
- AV vacuum bake: lowers gas load, desorbs water (quenching, delaminating)



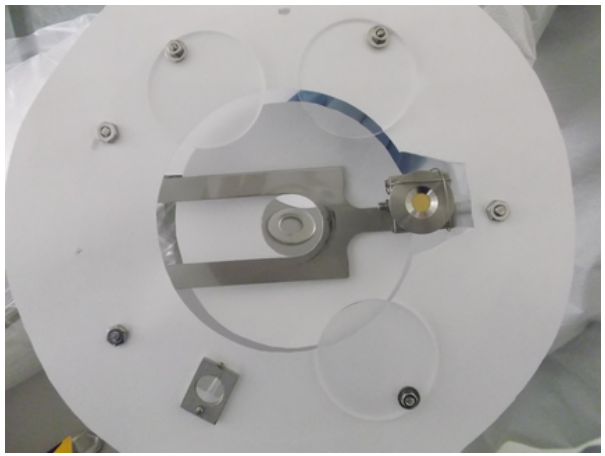
DEAP-3600 Deposition

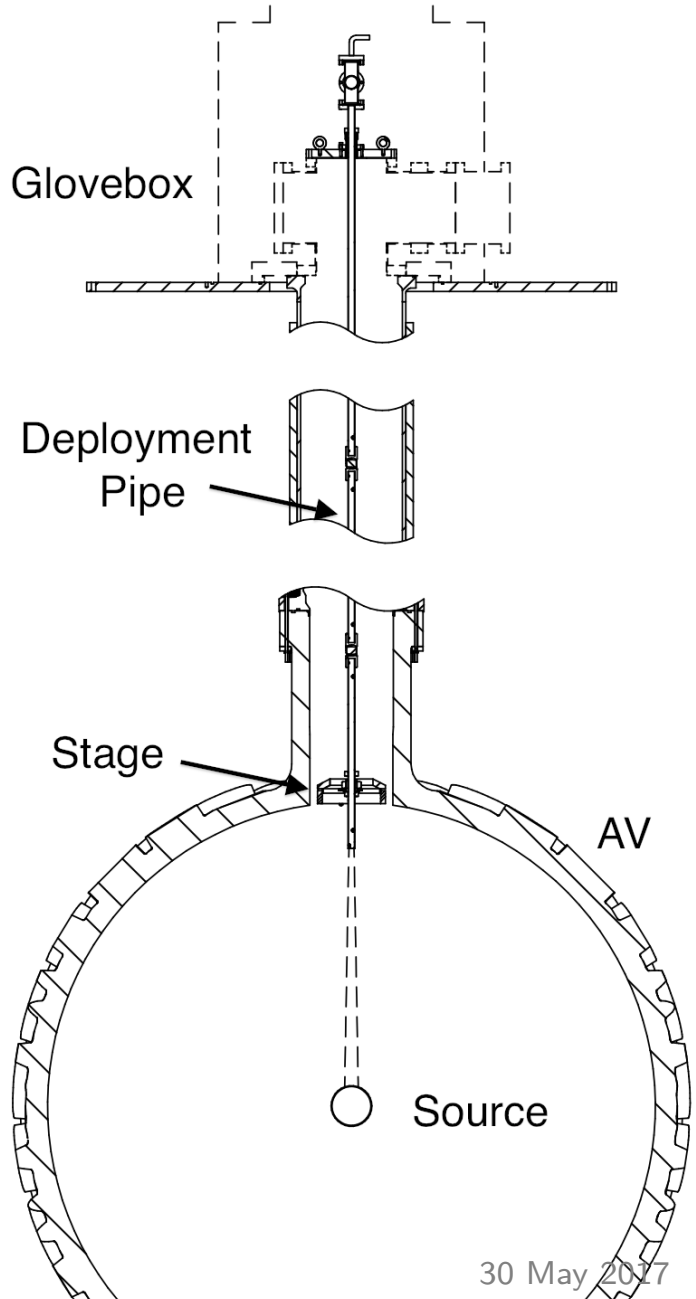
Depositions:

1st 19 June 2015: 14.0 ± 0.1g

2nd 27 June 2015: 15.4 ± 0.1g

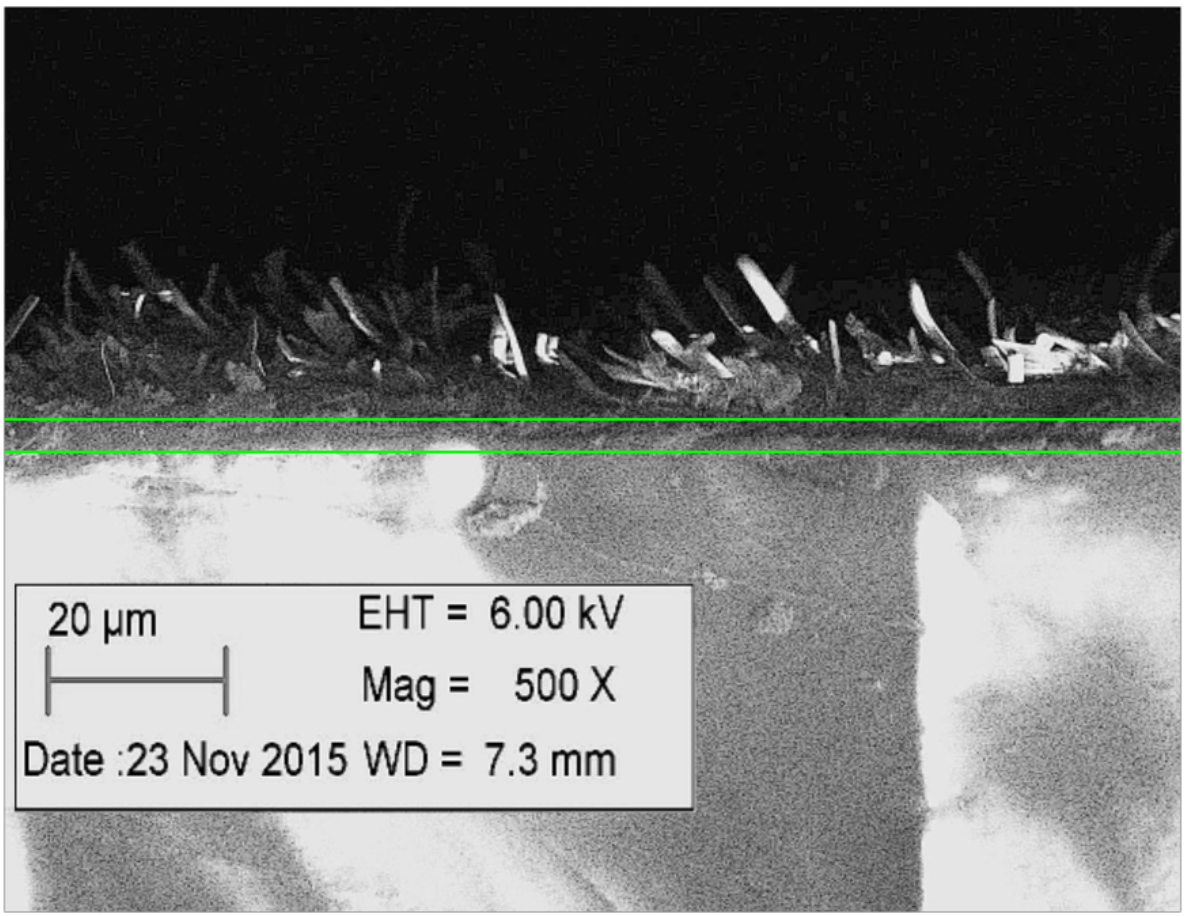
Acrylic slides were attached under deployment stage to act as witness samples.





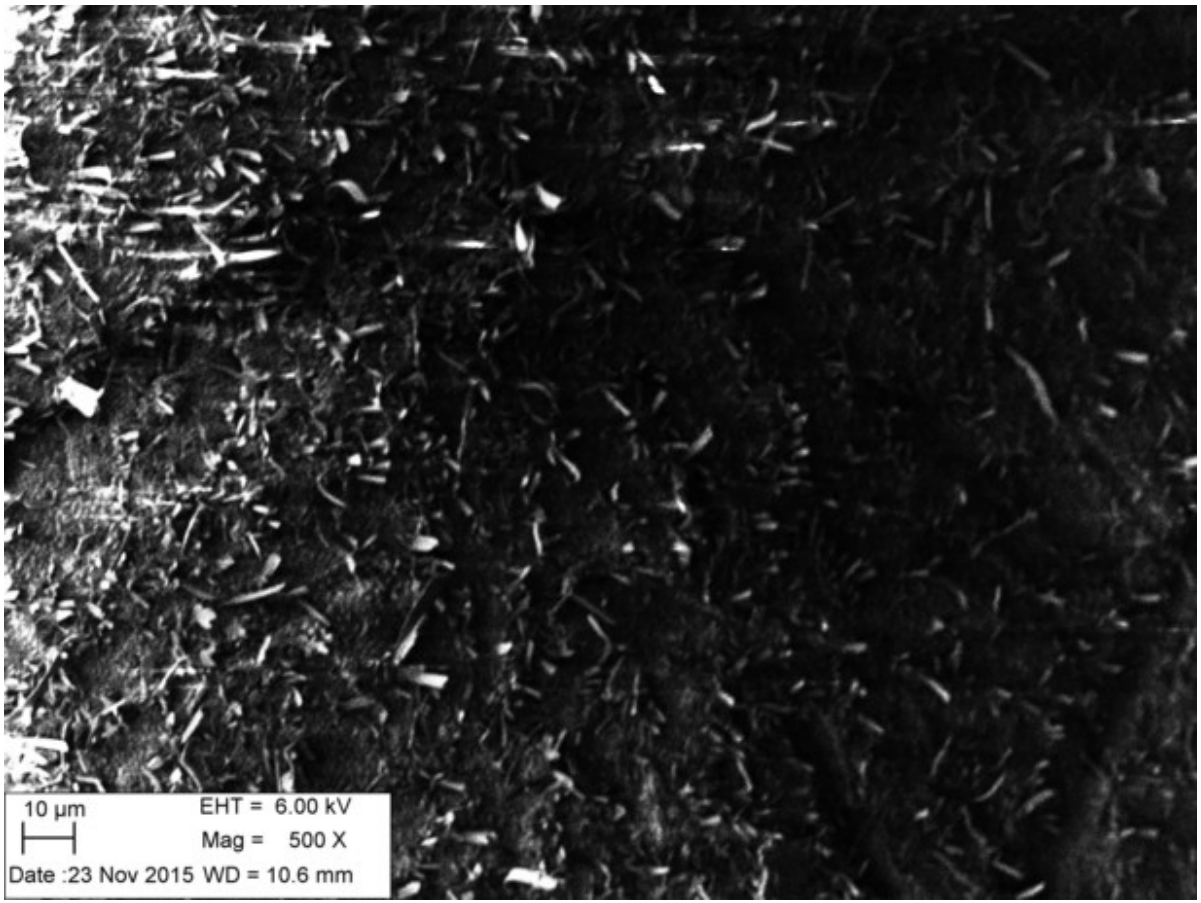
Witness Samples

- Samples analyzed with SEM and optical microscope
- Fluorescence microscopy to directly excite sample coating



Profile SEM of cleaved witness sample.

Witness Samples

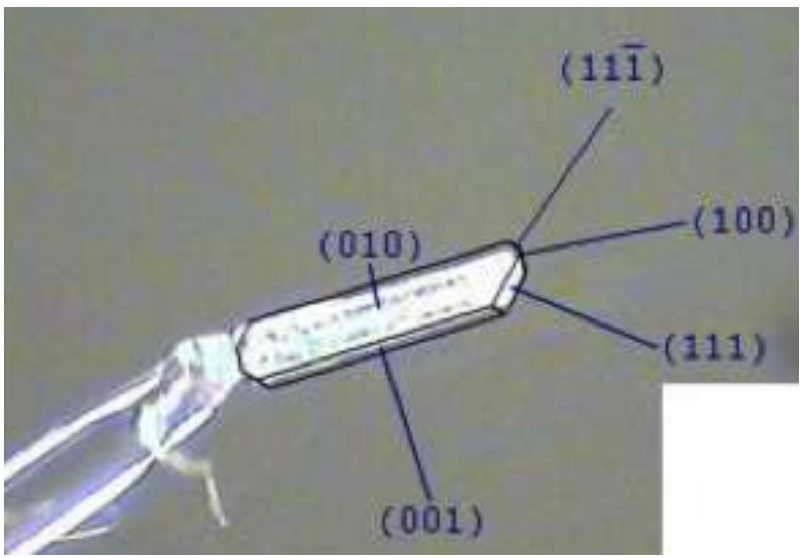


Aerial SEM scan showing the distribution of α–TPB structures.

α–TPB

Polymorphism: the ability to exist in different crystalline structures for the same solid material

α–TPB: most commonly encountered polymorph: sublimation followed by slow cooling

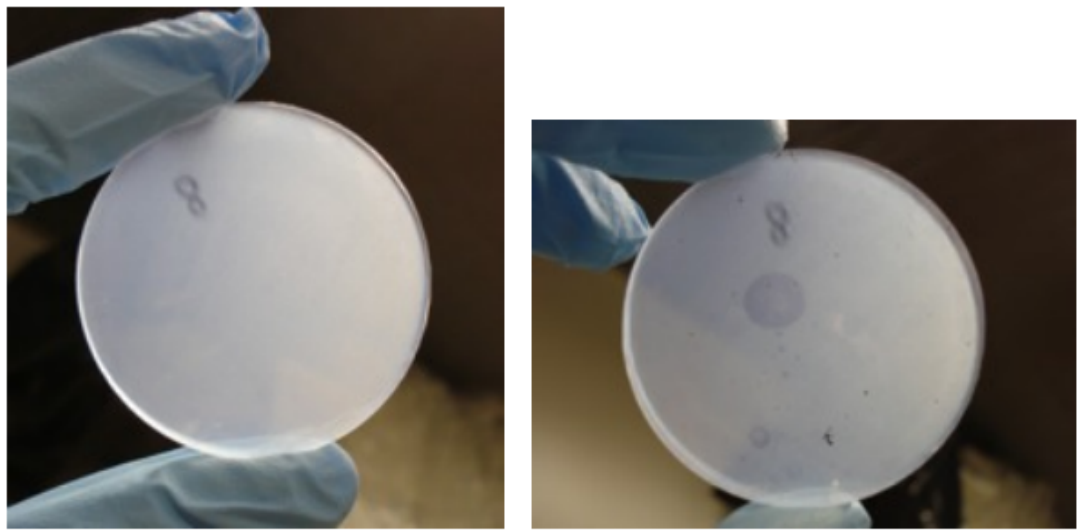


Bacchi et al. (2014) Cryst. Eng. Comm. 16 supplemental material

Zoom of DEAP sample under SEM.

Cryogenic Stability Tests

TPB is mechanically stable under exposure to cryogen
– Delamination observed if TPB exposed to high humidity



Early TPB test samples before (L) and after (R) exposure to liquid nitrogen without controlling humidity.

Stability of α–TPB structures
– Temperature cycling with 2 LAr fills
– Optically-identified α–TPB structures present before and after LN_2 dunk tests indicate stability

Conclusions

- Wavelength shifting required to view Ar VUV scintillation
- TPB coating: 3 μm X 9 m^2
- SEM and optical imaging of witness samples corroborate a 3 μm thick coating
- α–TPB structures present in samples are cryogenically robust
  - Search for particulates in bulk LAr volume data in progress.

Broerman et al. (2017) JINST 12 P04017