Dust Assay and Cleaning Methods for the LZ Project

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The LUX-ZEPLIN (LZ) dark matter detector will be a dual-phase Xe TPC with a 5.6 tonne fiducial volume located at the Sanford Underground Research Facility. It is important for low-background experiments, including LZ, to limit the amount of dust on detector surfaces. We use optical and fluorescence microscopy to assay of dust levels on LZ surfaces with sensitivity below 100 ng/cm^2. This assay allows testing of cleaning methods including ultrasonic cleaning, manual wiping, CO_2 “snow" cleaning, and First Contact™ Polymer.

Optical Imaging

We use a microscope with a camera attachment to take a series of images from a sample each with an area of approximately 1 mm^2.

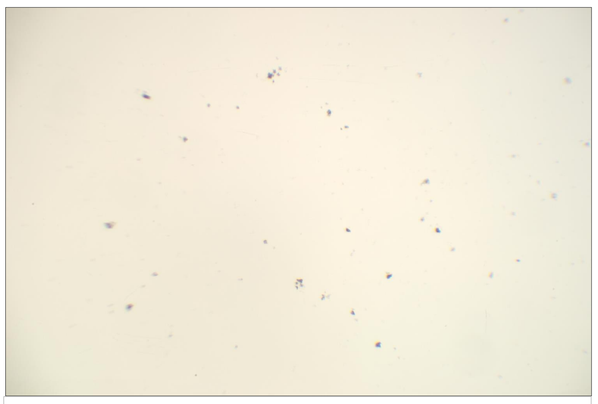
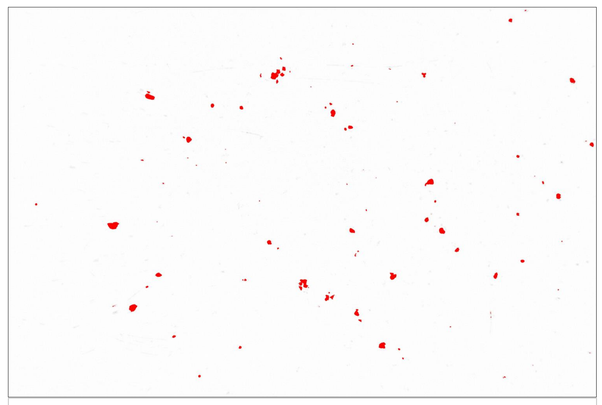
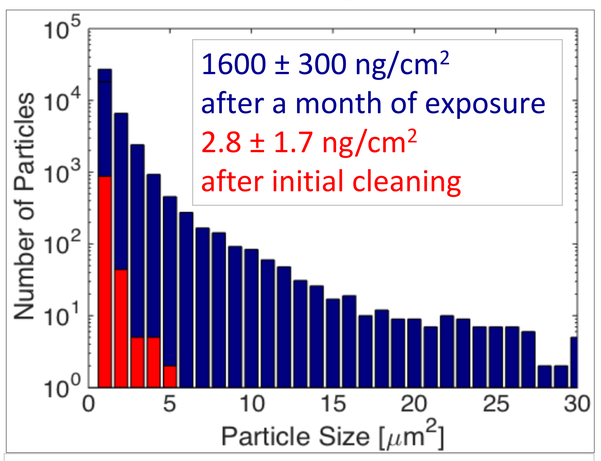


Image of dust under a microscope

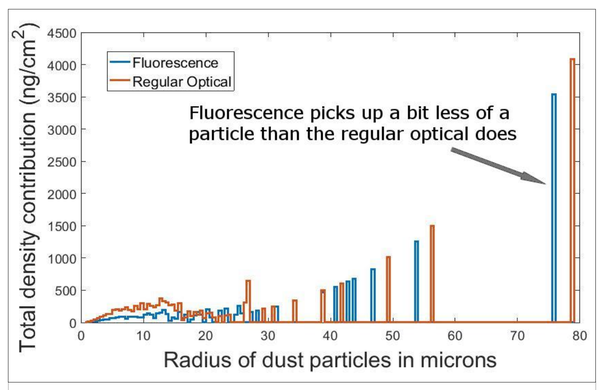


Identifying individual particles

We process the images to locate individual dust particles then analyze the data. We remove particles from the camera and microscope lenses and calculate dust density.



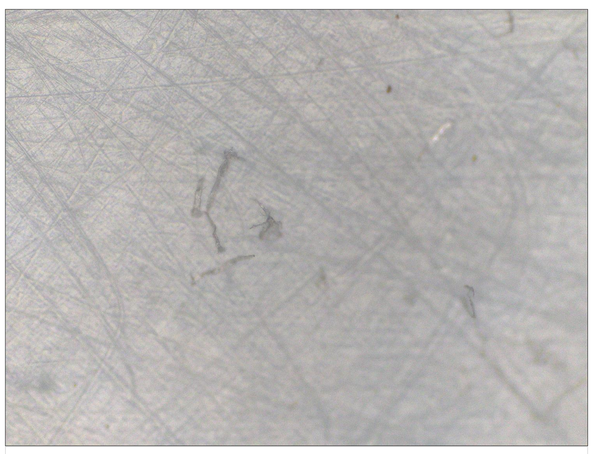
Effectiveness of glass slide cleaning



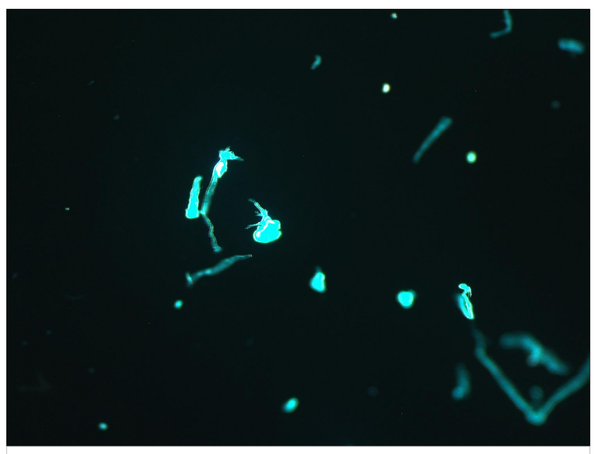
Glass slide under fluorescence and regular optical microscopy

Fluorescence Imaging

Materials are illuminated with UV light which causes dust to fluoresce. A filter blocks the reflected UV while the fluorescent light passes through. We can take images of dust deposition without the texture of the material interfering.



Standard optical image of Teflon surface



Teflon surface under fluorescence

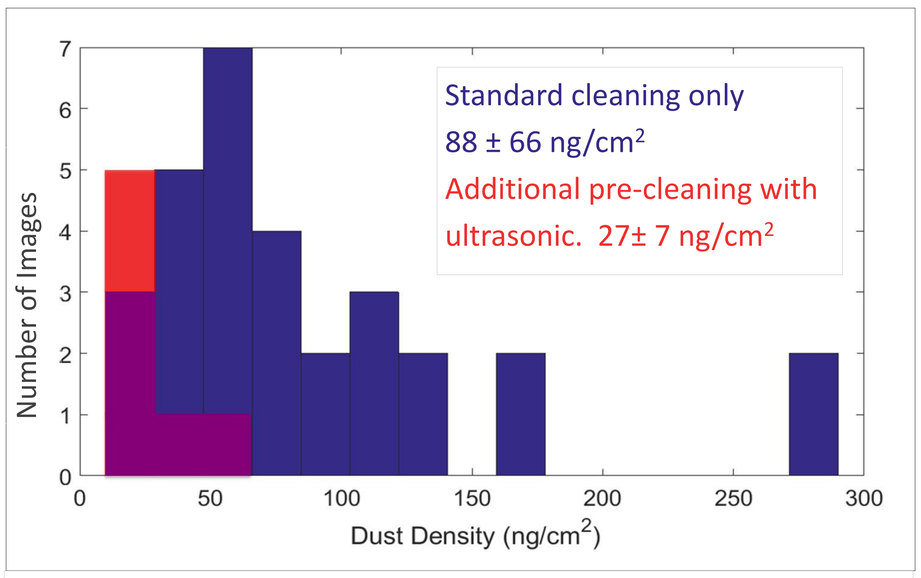
We validated this technique for use on Teflon and titanium

- Compared the dust density of glass slides imaged under both regular optical and fluorescence microscopy
- Imaged Teflon and titanium under both regular optical and fluorescence microscopy
- Compared dusty material to clean material to ensure the material itself wasn’t fluorescing
- Dust densities agree to within a factor of two

We are in the process of testing other materials.

Ultrasonic Cleaning

Our standard cleaning method for all materials is wiping a surface with Isopropyl alcohol, wiping with a dry wipe, and then blowing off the surface with nitrogen gas. Some materials can go in an ultrasonic cleaner.



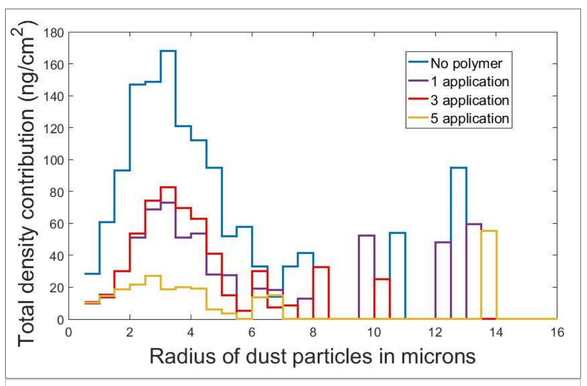
Ultrasonic cleaning using Citronox, 13 minutes at 65° C

Ultrasonic cleaning removes oils and scale deposits that is difficult to remove with alcohol. By pre-cleaning with ultrasonic we can avoid having samples with dust densities in the higher range.

First Contact™ Polymer

First Contact™ was designed for protecting and cleaning telescope lenses. We have also found it to be effective at cleaning materials used in the LZ experiment. We have found certain materials to be very difficult to clean using other methods.

Applying First Contact



Multiple Applications on a PMT

First Contact™ polymer is easy to use and cleans surfaces as well as any other method we have. We brush it on and wait for it to dry, generally 10-20 minutes, then peel it off. It can also be used to protect a surface from further exposure, being easily removed at the last minute leaving the surface very clean. For some surfaces multiple applications may be needed.

Future Work and Conclusions

Other methods of cleaning are being tested. We are beginning the process of testing CO_2 “snow” cleaning. Liquid carbon dioxide expands rapidly forming both gas and tiny crystals. It removes particles by momentum transfer, a freeze fracture effect that helps break contaminates away from the surface, and high velocity gas blows dust away. It’s safe for most materials, doesn’t leave residue on the surface and creates no harmful waste products. We continue to look for and test new methods of cleaning and assaying to reach our goals.

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