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Fabrication of ZnO-PTFE material for use in LUX-ZEPLIN dark matter detection experiment to flag lead-210 alpha decays through scintillation

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What I will be talking about

- What is Dark Matter?
- The LUX-ZEPLIN Experiment
- Radon impurity is causing false detections
- ZnO-PTFE or Scintillating Teflon
- The Mold
- The Teflon
- The Dark Box
- What’s Next?

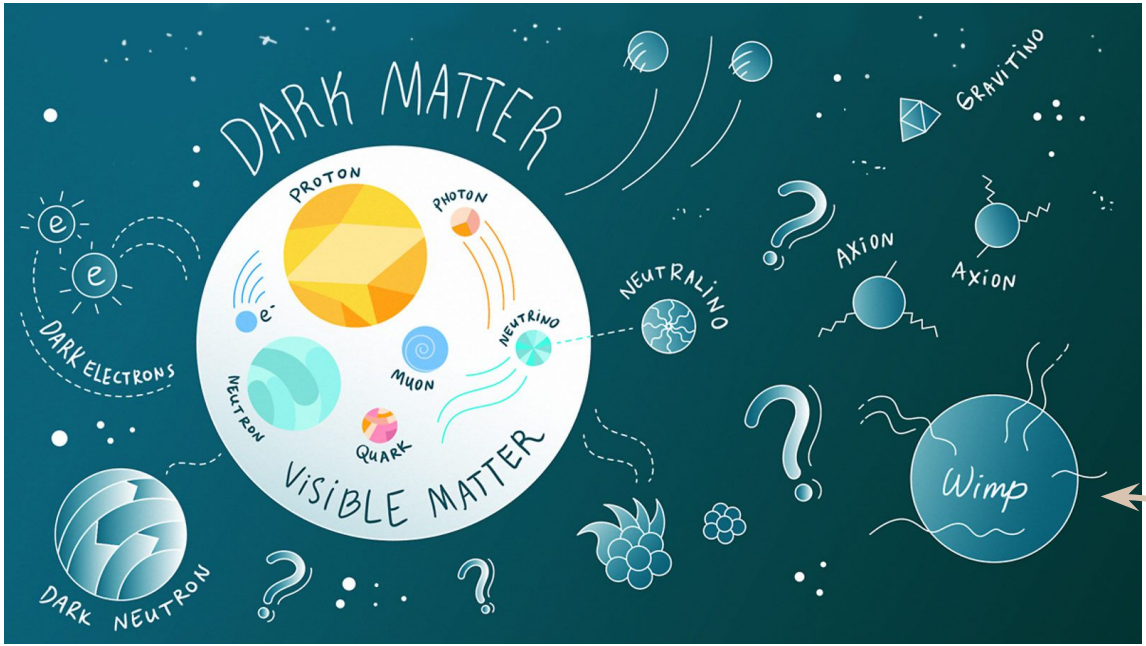
What is Dark Matter?

It makes up about 85% of all matter in the universe.

We have yet to directly detect it.

If we haven't detected it how do we know it's there?

Why is it important to detect dark matter?



Stands for **W**eakly **I**nteracting **M**assive **P**article (This is the one we're looking for)

Fig 1. A diagram showing the theorized particles in the universe and the ones we have been able to detect [Four things you might not know about dark matter | symmetry magazine]

The LUX-ZEPLIN Experiment

- The LUX-ZEPLIN experiment uses a Time Projection Chamber or TPC
- TPC is basically a large tank of liquid xenon
- Works based in the time differential between two signals

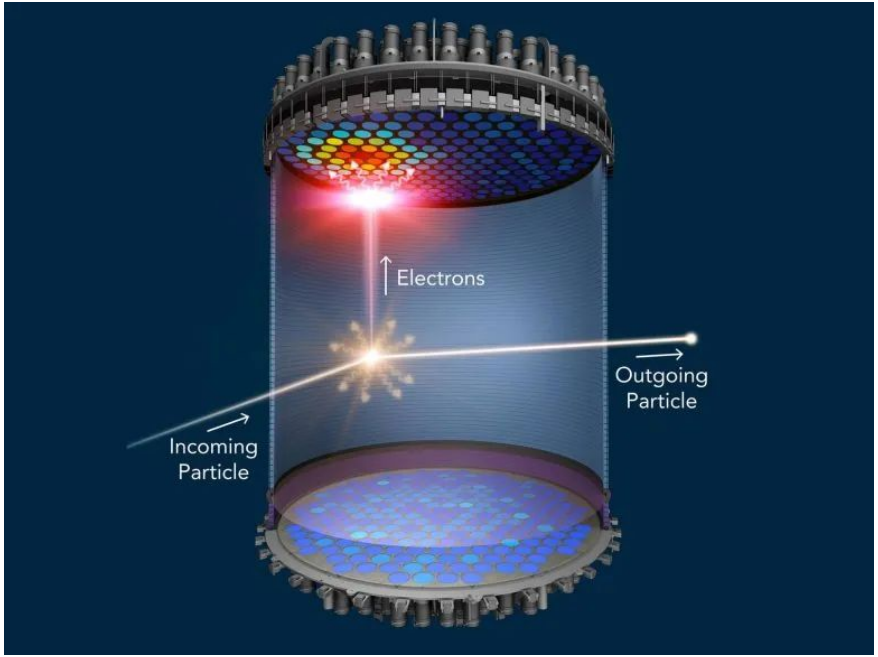


Fig 2. Diagram of the LZ-TPC showing how the detector works when a particle comes into the detector. Sensitivity of the LUX-ZEPLIN experiment to rare Xenon decays

Radon impurity is causing false detections

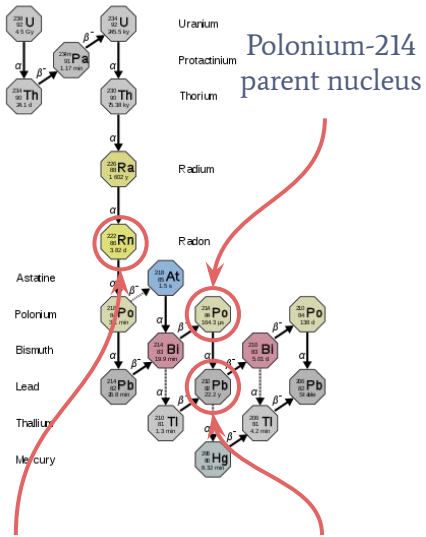
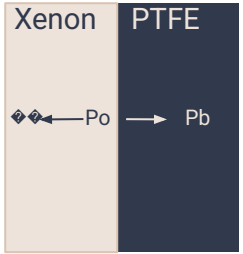


Fig 3. This diagram shows the decay chains and the relevant isotopes that are apart of and how they are related to each other. Decay chain - Wikipedia

- A common impurity of xenon, ^{222}Rn isotope rapidly decays to ^{210}Pb isotope.
- ^{214}Po parent nucleus of ^{210}Pb hugs walls of the detector.
- Daughter nucleus will either go directly into the wall or out into the xenon following an alpha decay.

Scenario 1 : Alpha goes into Xenon

- Alpha energy signature is much bigger than a WIMP
- **Fine**



Scenario 2 : Alpha goes into wall (made of PTFE or Teflon)

- Pb recoils into xenon
- Similar energy signature to a WIMP
- **Big Problem**

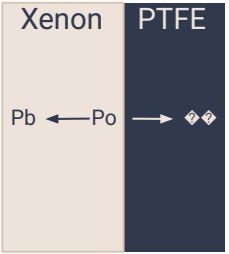


Fig 4. This diagram shows the two possible scenarios of an alpha decay of ^{214}Po. The one on the right being an issue because of the similar energy signature between ^{210}Pb and that of a WIMP.

ZnO-PTFE or Scintillating Teflon

- What does scintillating mean?
- What if the material of the wall was scintillating?
- How would we make teflon scintillating?
- Can we make it ourselves?

A synonym for scintillate is sparkle. A scintillating material will “sparkle” or emit a photon when struck by a charged particle.

If we were to do this, the material would in theory produce a detectable signal when struck by an alpha particle.

The scintillator we decided on was ZnO or Zinc Oxide. It comes in a powder form and is a highly dangerous nano-particle.

Teflon can be purchased in a powdered form and can be molded and formed by being subjected to ~4500 psi and ~700℉

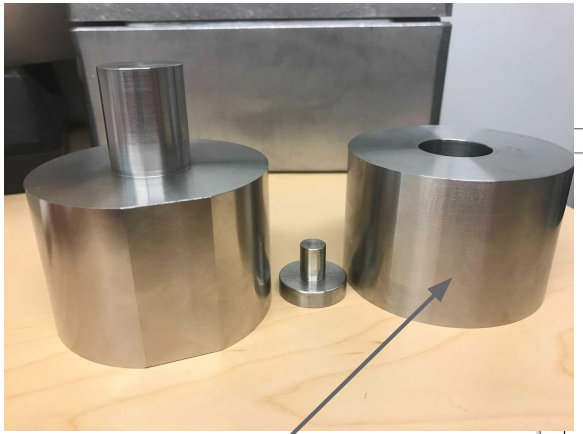
The Mold

Design Description

- Mold for a 1” diameter teflon disk about 2-3 mm thick

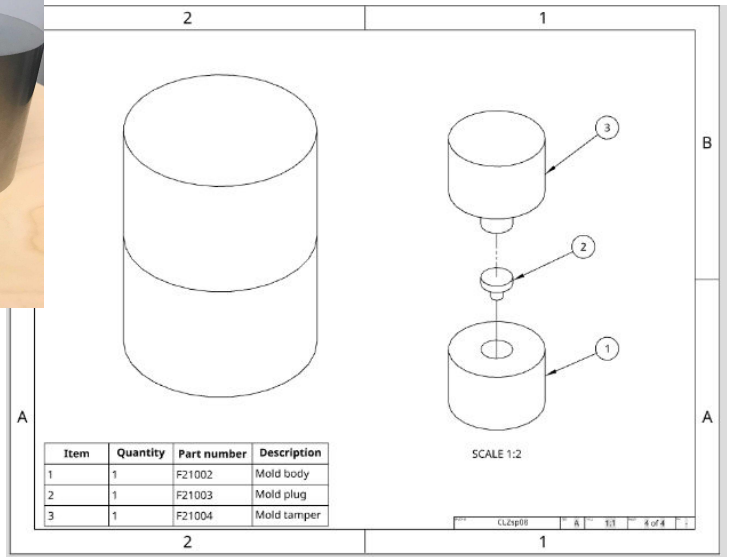
Design Constraints

- Withstand ~4500 psi without deformation
- Withstand ~700℉ without deformation
- Must be able to remove the teflon disk



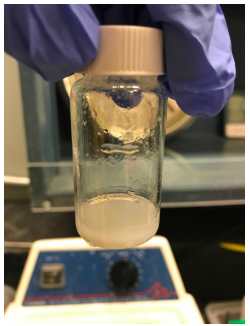
304 stainless steel

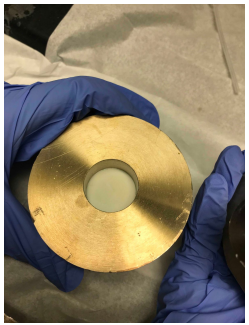
Fig 5. Assembly drawing and exploded view of mold (right). Image of fabricated mold (left).

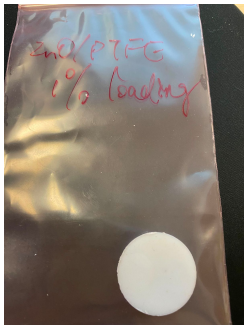


Item	Quantity	Part number	Description
1	1	F21002	Mold body
2	1	F21003	Mold plug
3	1	F21004	Mold tamper

Making the Teflon, a simplified timeline







Make PTFE without ZnO

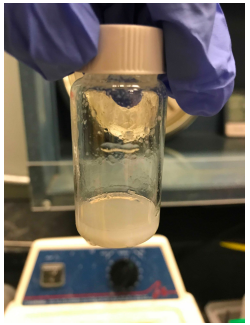
- Fast Recipe
- Slow Recipe

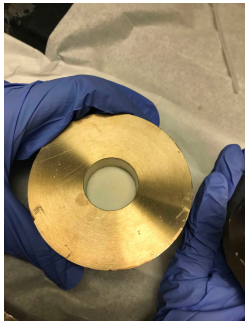
Make ZnO-PTFE at 10% concentration

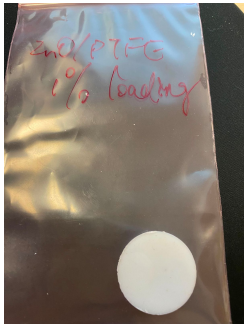
- Combine both powers in acetone to make a homogenous mixture

Make ZnO-PTFE at 1% concentration

Making the Teflon, what really happened





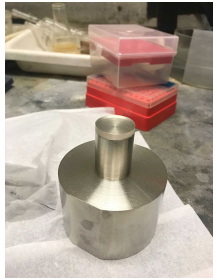


Make PTFE without ZnO
- Fast Recipe
- Slow Recipe

Make ZnO-PTFE at 10% concentration
- Combine both powers in acetone to make a homogenous mixture

Make ZnO-PTFE at 1% concentration

bought the wrong powder



dust/residue baked into sample

acetone discolored the PTFE after sintering

both lid of mold and oven leaving discoloration on PTFE

The Dark Box

Design Description

- Dark box set up to test the scintillation of ZnO-PTFE with radon

Design Constraints

- Must be adjustable
- Must be vacuum sealed
- Orient the photo-sensors toward the PTFE disk

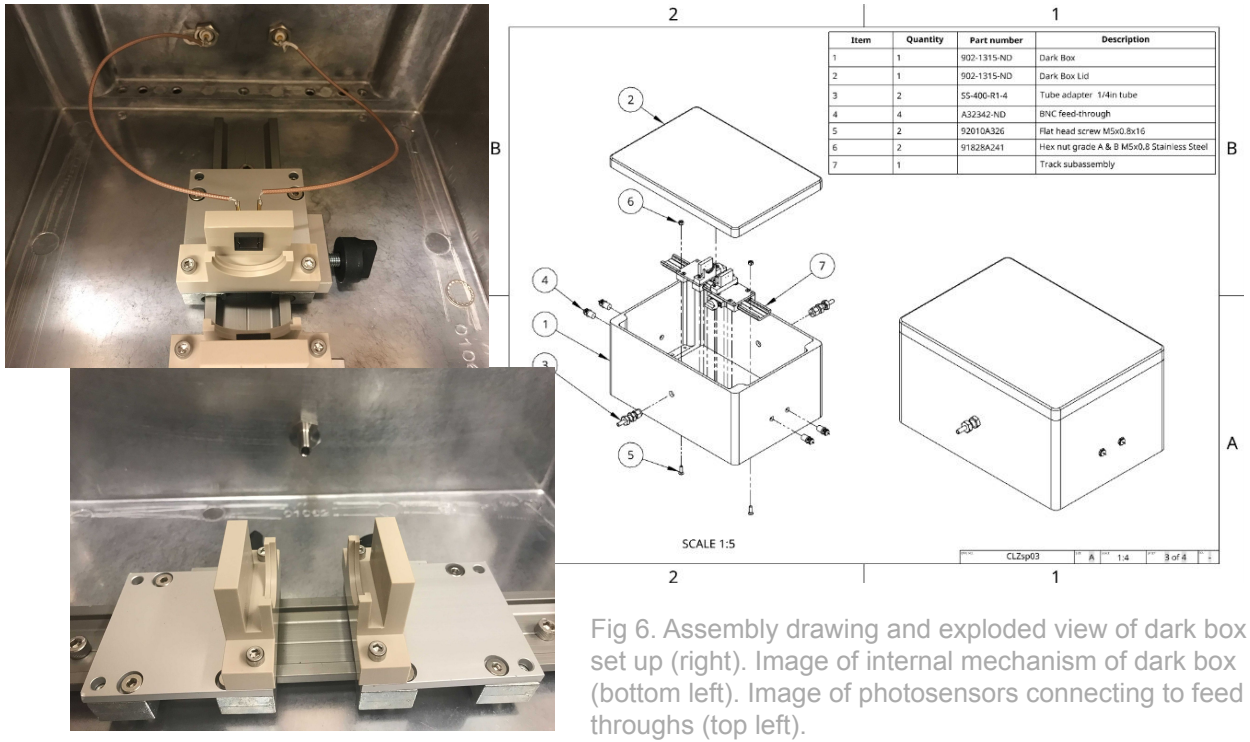


Fig 6. Assembly drawing and exploded view of dark box set up (right). Image of internal mechanism of dark box (bottom left). Image of photosensors connecting to feed throughs (top left).

So, what’s next?

Thank you!

Email with questions.

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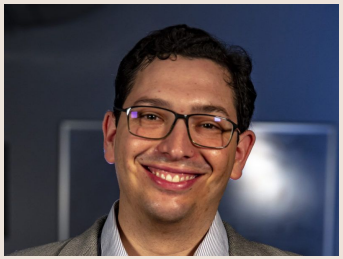

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