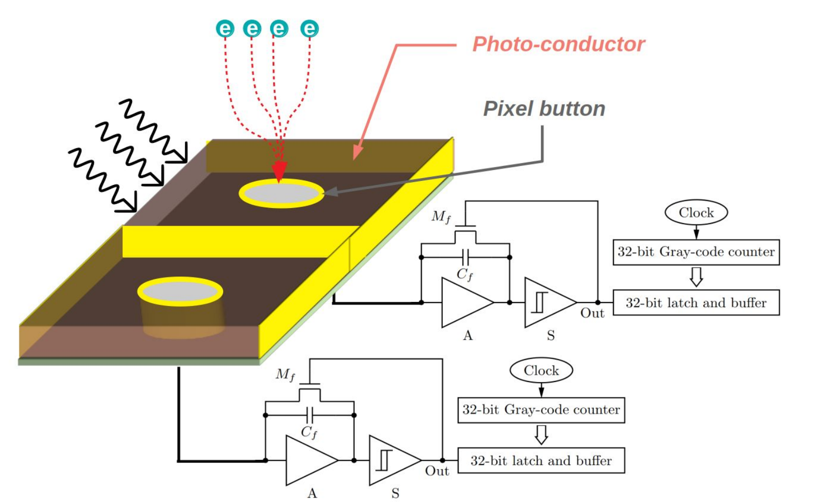
Photon Detection Work and Ideas at UTA

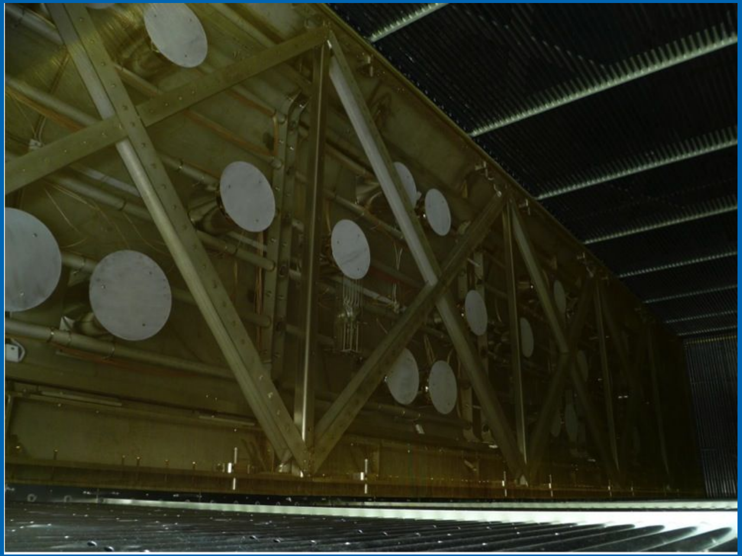
Jonathan Asaadi & Abbey Raymond

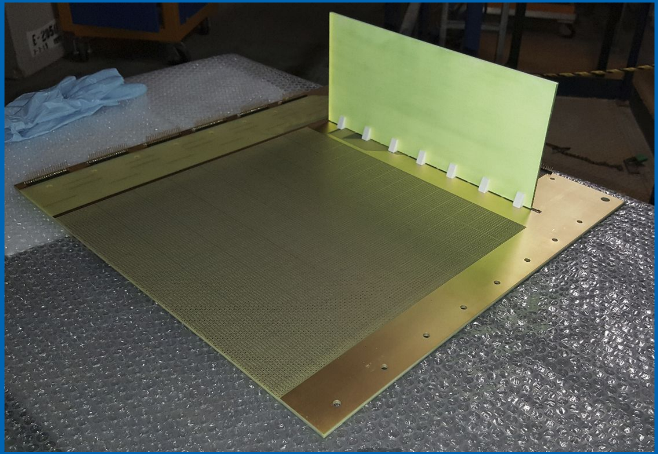
(in collaboration with Q-Pix Photon Detection Group)



Light Detection

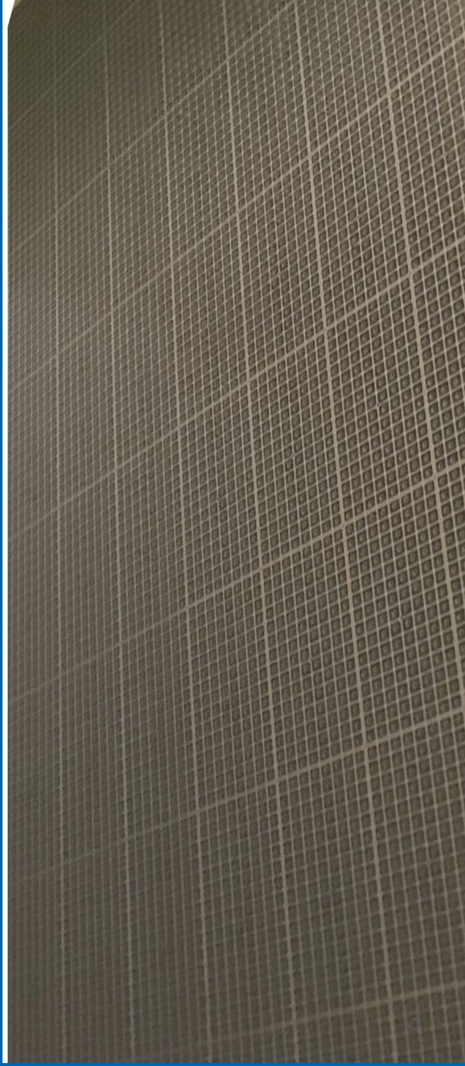
- **Conventional LArTPC's use the semi-transparent wires to their advantage and place their photon detectors behind the wire planes**
- **Pixel detectors have an opaque charge collection surface making use of this solution impossible**
  - Alternative mounting schemes have been / are being explored
- **How do you turn a vice into a virtue?**





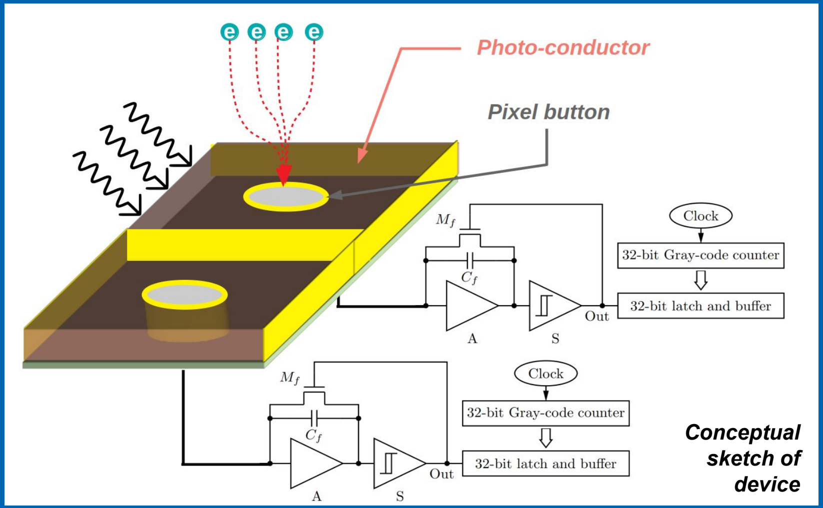
Pixels which also are photo-sensitive?

- **What if the whole APA could collect light?**
- **A pixel plane sensitive to UV photons and ionization charge SIMULTANEOUSLY would be a major breakthrough**
  - Your effective instrumented area becomes enormous!
  - Even if the device has low efficiency you have a huge gain
  - Q-Pix could be an "enabling technology" to realize this for LArTPC's



Light Detection

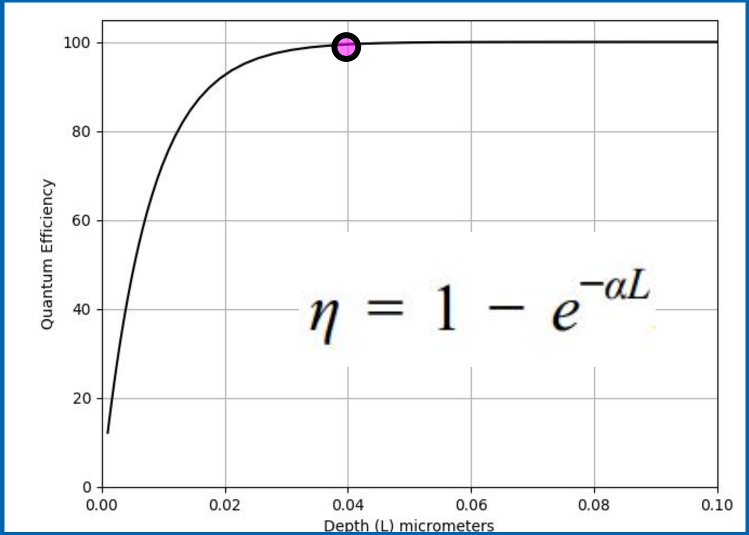
- One very "blue sky" idea currently being considered is to see if the same pixels which collect ionization charge can be used to detect UV photons

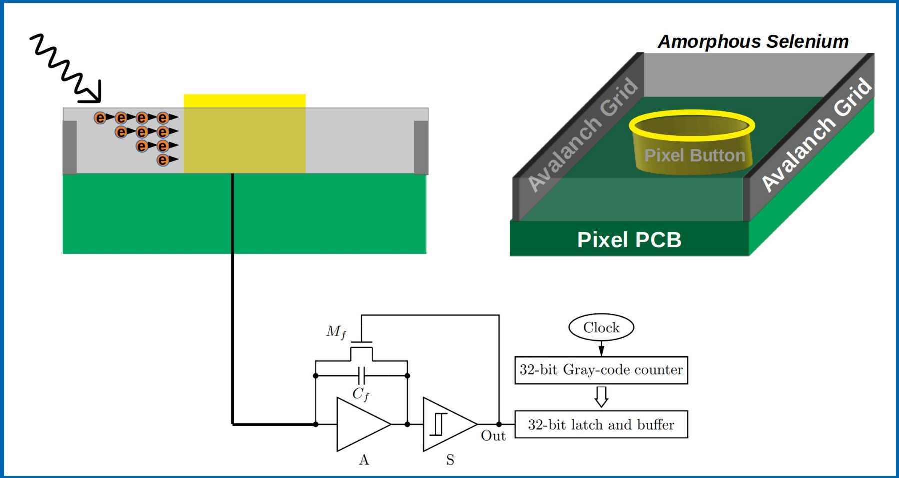


  - Currently exploring different thin-film photo-conductors which may offer an opportunity
    - Exploring amorphous Selenium's properties
      - Commonly used in X-Ray digital radiography devices
    - Recently became very interested in Pyroelectric Photodetectors
      - "Pyro-Phototronic" devices seem very promising and have been operated in cryogenic environments very recently
- **If realized, offers a transformative opportunity in LArTPC's**

Amorphous Selenium

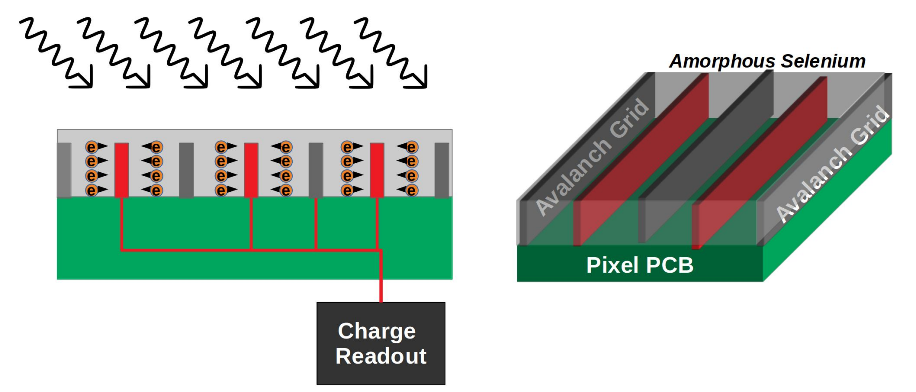
- **Literature search suggests the absorption coefficient for a-Se at 128nm is 130 μm^{-1}**
- **This would suggest a 1μm thick thin film would already be >99% QE for converting light to charge!**
- **Moreover, gain in the a-Se is possible with the application of moderate E-field**
  - Early calculations suggest $\mathcal{O}$(100) - $\mathcal{O}$(1000) electrons per pixel pad for $\mathcal{O}$(MeV) levels of activity



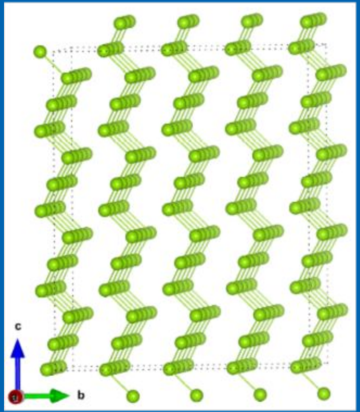


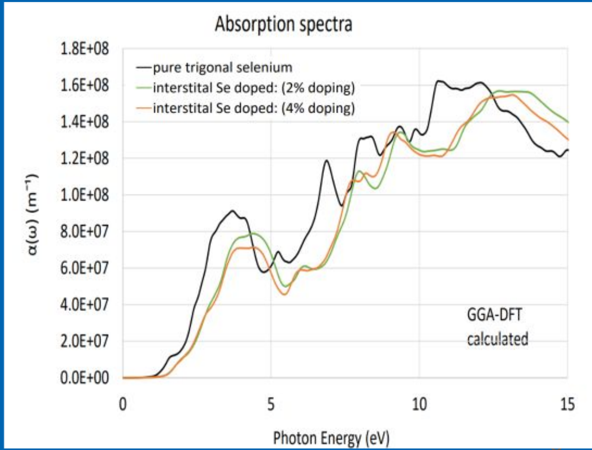
Amorphous Selenium

- **Prototype board's being prepared at UTA to test the viability of this idea in liquid argon and with VUV light**
  - See Abbey's portion of the talk next and Elena's talk later today



- **Ongoing simulation work from UTA condensed matter theorist will help us understand alternative doping methods and opto-electronic properties to optimize for**



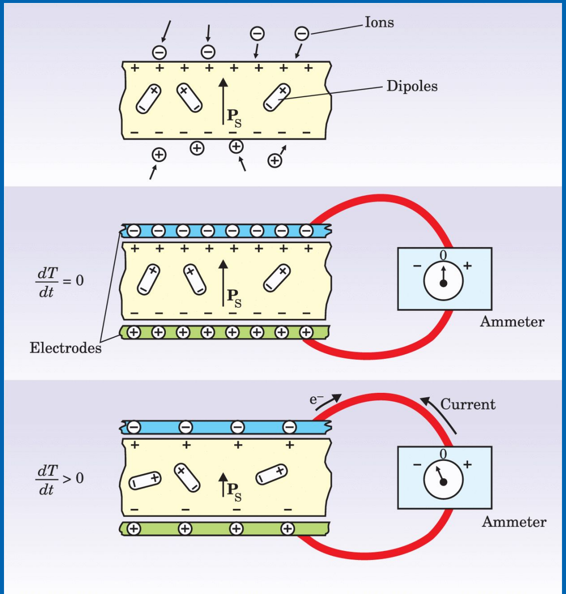


Pyroelectric Photodetectors

Effect originates from the spontaneous polarization of the material (e.g. PZT, CdS, and ZnO) that, in the absence of an electric field, lead to surface charges within the material

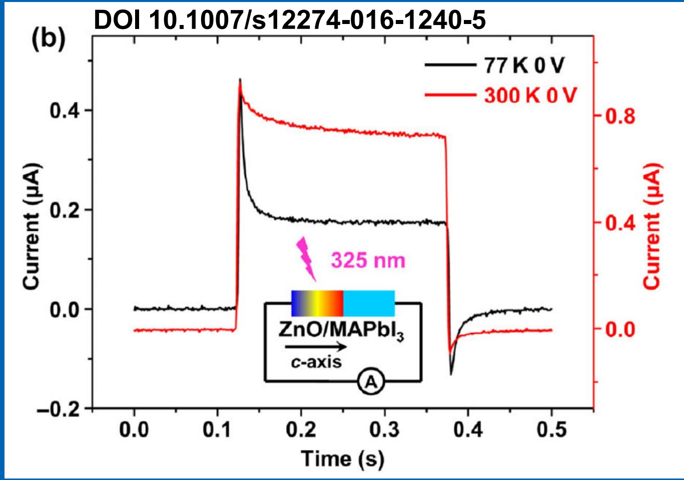
External surface will capture free charges from the environment in order to become electrically neutral

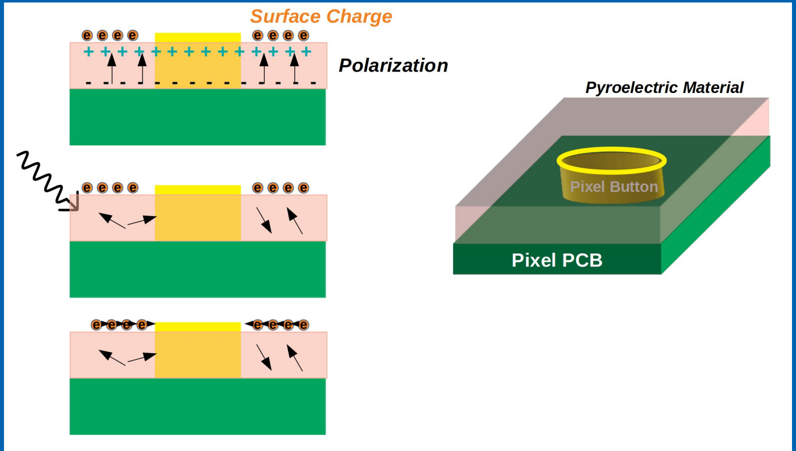
When the temperature of the material increases ``rapidily'' the spontaneous polarization decreases simultaneously. However, the charge captured on the surface typically has a low mobility which one can exploit to create a `pyroelectric current'



Pyroelectric Photodetectors

- **These materials have seen a lot of advancement in recent years towards becoming photodetectors**
    - Thanks to Alex (ANL) for bringing these devices to our attention
- **Many recent advancements include:**
    - Tests in cryogenic environments exposed to UV light (325nm)
    - Improved response times to the 10-100 of ns timescales
    - Integration into CMOS device
- **Offers another interesting opportunity!**





Collaboration Meeting Update

Abbey Raymond

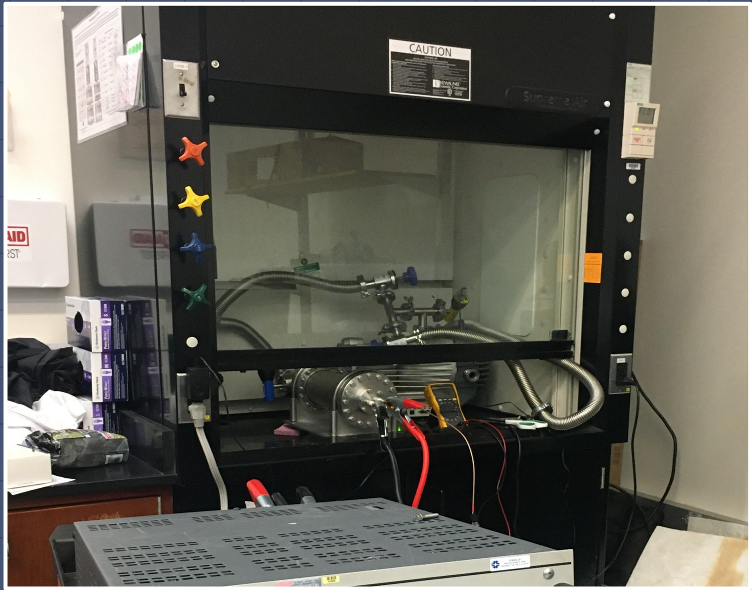
Introduction

- Typical LArTPC’s use cross-wire planes to reconstruct 3D images of particle tracks
- Reconstruction from these planes can be challenging, and large scale projects can be difficult to engineer
  - The ability to read out pixels could ameliorate some of the difficulty, especially if those pixels could also detect UV photons

Amorphous Selenium

- Amorphous Selenium (a-Se) is normally used in X-ray imaging, converting the X-rays to lower energy photos or charge
- If operational in cryogenics, we could repurpose this concept to use as our pixels

The Experiment: Part 1



- Built a basic evaporator
- Plated Selenium onto a 2x2 PCB
- Observed the PCB before and after dipping it into liquid Argon

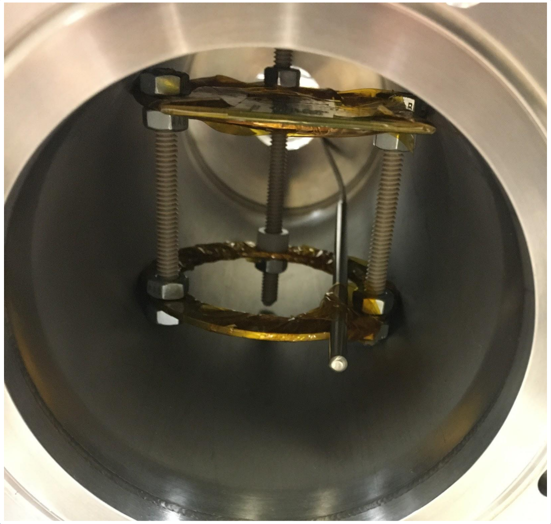


Photo 1: interior mount with thermocouple and PCB

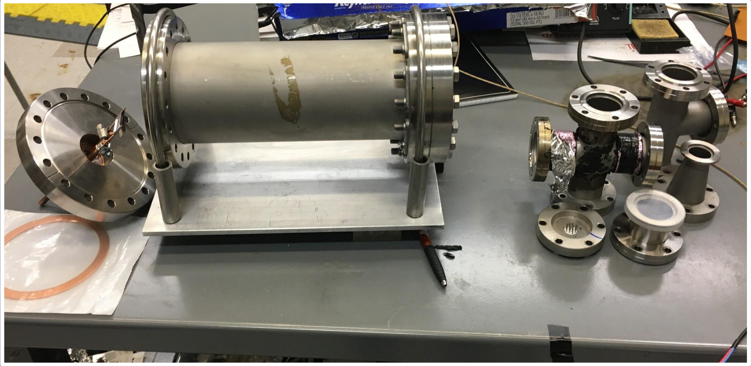


Photo 2: Chamber for the interior mount

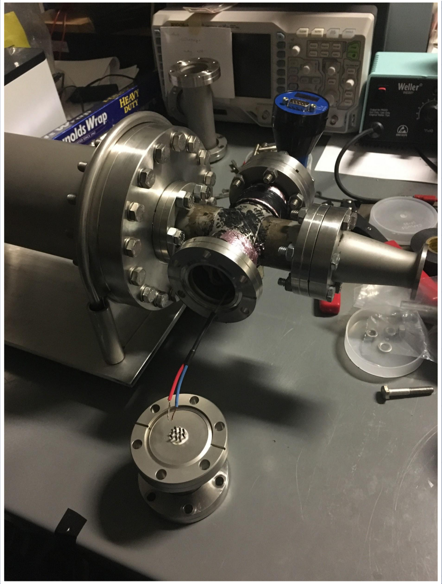


Photo 3: Chamber intersection with a vacuum attachment, thermocouple attachment, and pressure gauge

Photo 4: Chamber for the interior mount

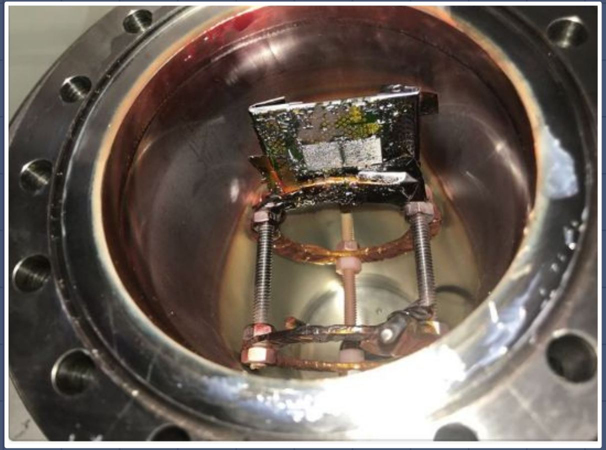
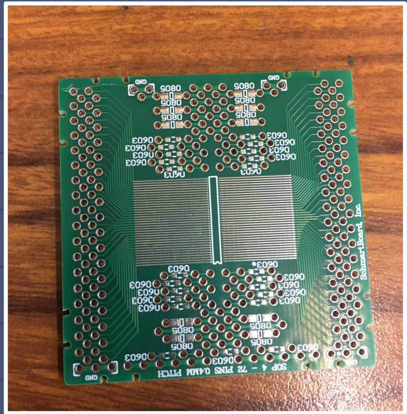


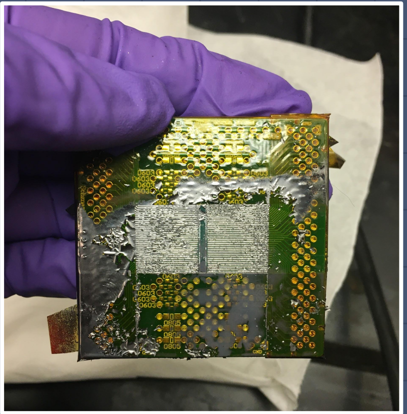
Photo 5: Mount and PCB post-evaporation

Photo 6: Dipping the PCBs into liquid Ar

Results Part 1, Run 1

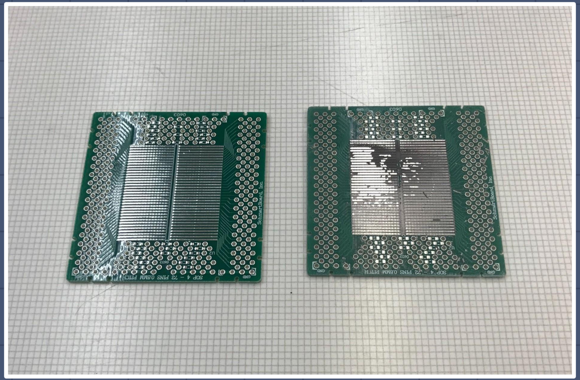
- Parameters
  - 220°C (~9.5 Ω on a multimeter)
  - 200 millitorr
- Board coated with a-Se with some flaking areas
  - Indicates higher heat is necessary
  - **Held up in liquid argon dip**





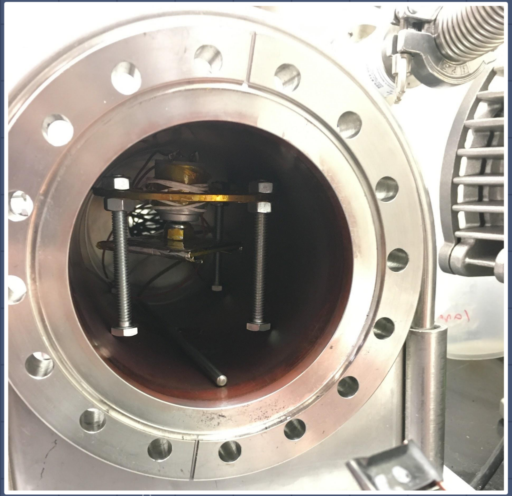
Results: Part 1, Run 2

- Repeated evaporation to 10.5Ω (~243°C)
  - Slight flaking in burned areas
- Increased heat led to a more even thin coat



The Experiment: Part 2 (Current work)

- **Goal: create a rotating mount for a spin evaporation**
- Attached a DC motor to a new mount
  - Speeds were adjustable



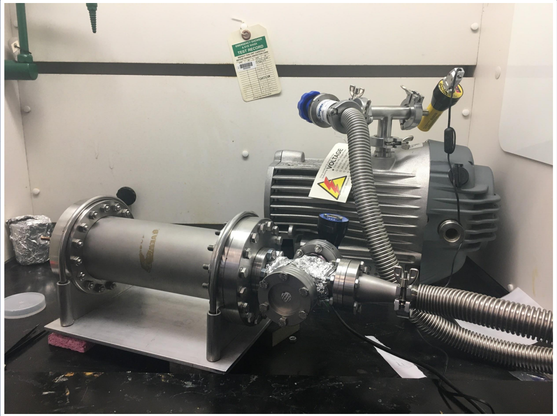


Photo 7: Updated Evaporator

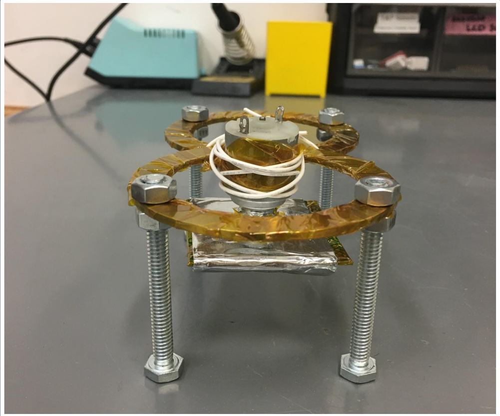


Photo 8: Rotating interior mount

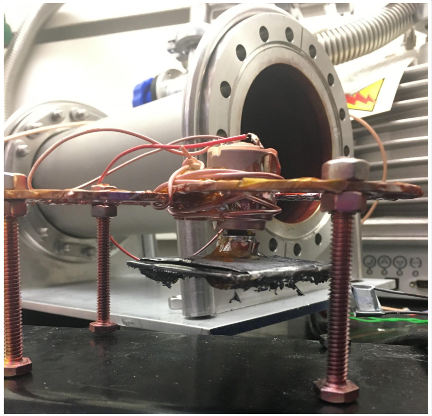


Photo 9: Mount and sample post - evaporation

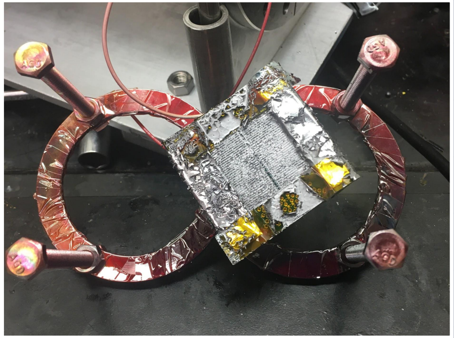


Photo 10: Rotating mount after evaporation

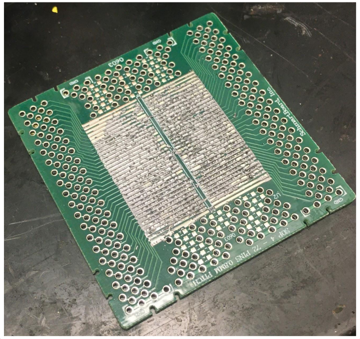


Photo 11: Final Product after rotational

Future Work

- Further optimize evaporator design and function
- Repeat rotational evaporation at a higher temperature
- Bias boards and see if they are capable of seeing a photo-current current in liquid Argon