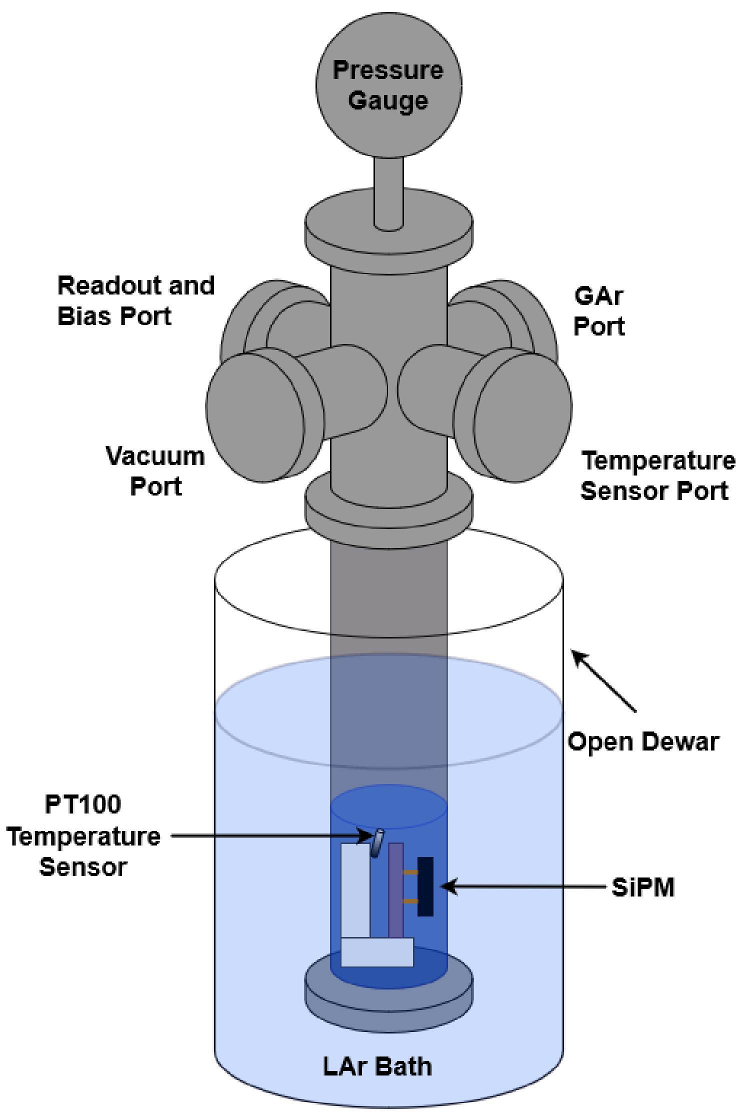
Liquid Argon Lab Instructions

This liquid argon lab is the bare-minimum setup that one needs to be able to detect radiation with liquid argon. When a particle deposits energy in the argon medium, it excites and ionizes the argon atoms. In the absence of an electric field, the ionized argon atoms recombine to form more excited argon atoms. These excited argon atoms then go on to form excited Ar^{*}_{2} molecules, which then de-excite to produce light of ~128 nm, which can be collected via a photosensor. In this lab, we use a Hamamatsu VUV S13370 silicon photomultiplier (SiPM) which is directly sensitive to argon light. In order to create the proper conditions to detect argon scintillation light, we will need:

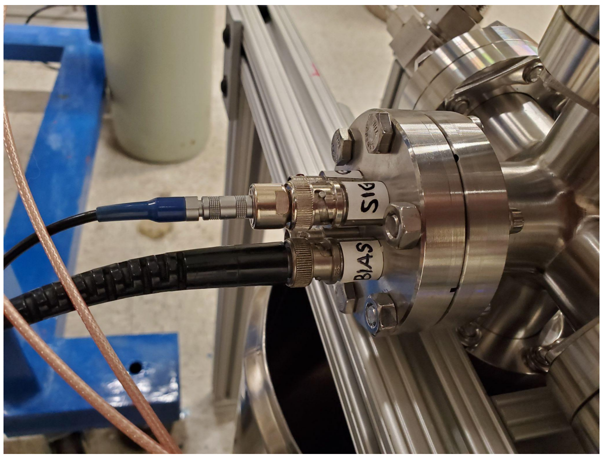
- High purity gas argon
- A vacuum environment to ensure that the SiPM is housed solely in argon
- (Impure) liquid argon to cool the high purity gas argon
- A temperature sensor to ensure that the gas argon has been cooled

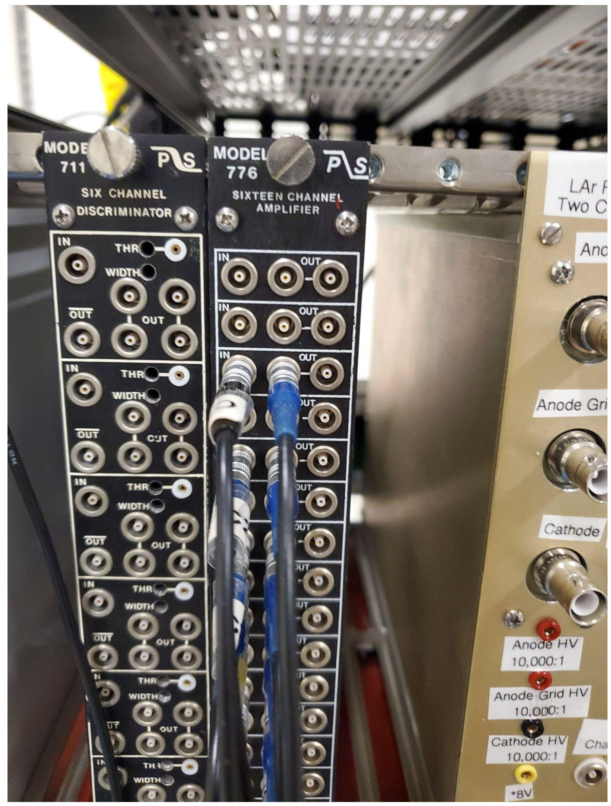
Setup



Section 1: Room Temperature SiPM

SiPMs are a type of avalanche photodiode. This means that once a sufficiently high electric field is achieved (by applying a voltage), one electron can be accelerated to free more electrons, which can then free more electrons … This process is called **avalanche**, and is how SiPMs convert an impinging photon into a current.

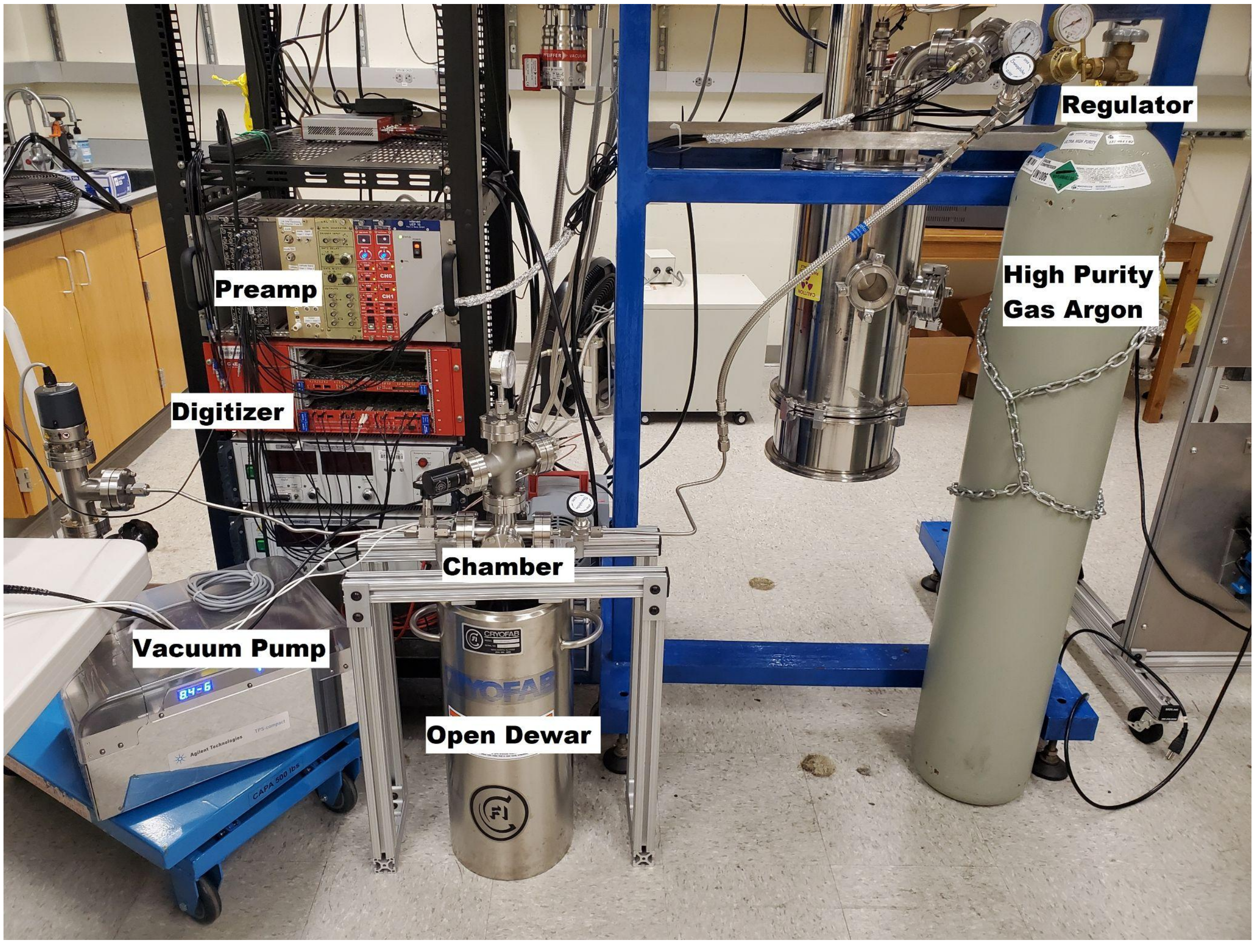




Bias and signal feedthrough	10x Linear amplifier

- Connect the banana to BNC cable from the power supply to the BIAS feedthrough
- Connect the signal output to the 10x linear preamplifier
- Connect the preamplifier to the oscilloscope
- Start applying a bias voltage up until ~53V
    - What do you see?
- Now, slowly raise the voltage above 53V
    - What do you see?
    - Why is it so noisy?
- Turn off the voltage for the next section

Section 2: Vacuum, Gas, and Cryogenics



Before filling the chamber with gaseous argon, we will need to pump a vacuum

- Open all valves *except* the swagelok valve connected to the regulator
- Start pumping
- Wait until pressure inside is ~1E-6 Torr
- Close the vacuum valve

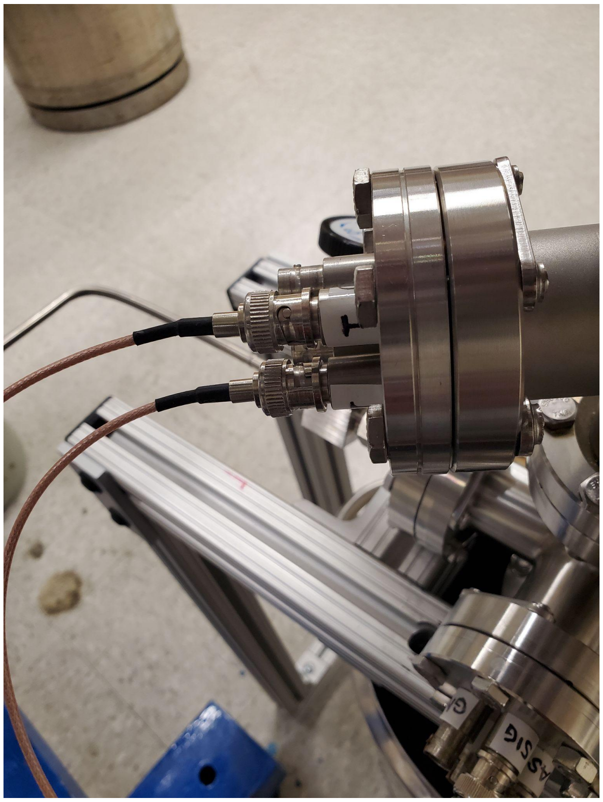
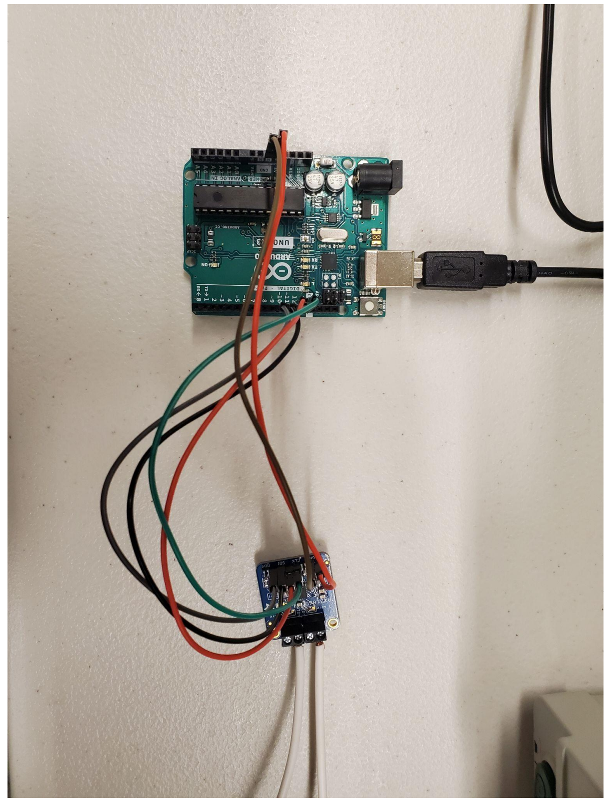
Now we will fill from a high pressure gaseous argon bottle. These bottles come with a *regulator*, which intakes a high pressure at the bottle side, and outputs a lower pressure at the chamber side for filling.

- Open the GAr bottle, you should see a high pressure on the bottle-side gauge
- Turn the regulator valve *clockwise* to increase the output pressure
- Turn the regulator valve *counter-clockwise* to decrease the output pressure
- Fill to ***below*** 6 psi gauge pressure on the chamber-side pressure gauge
    - If you fill above 6 psi, the check valve will release GAr

To cool the high purity GAr in the chamber to LAr, we fill LAr from the big bottle

- The TA will do this, stand back and watch

- Once the open dewar is filled with LAr, start the temperature sensor arduino script

	
Temperature sensor feedthrough	Arduino readout of temperature sensor

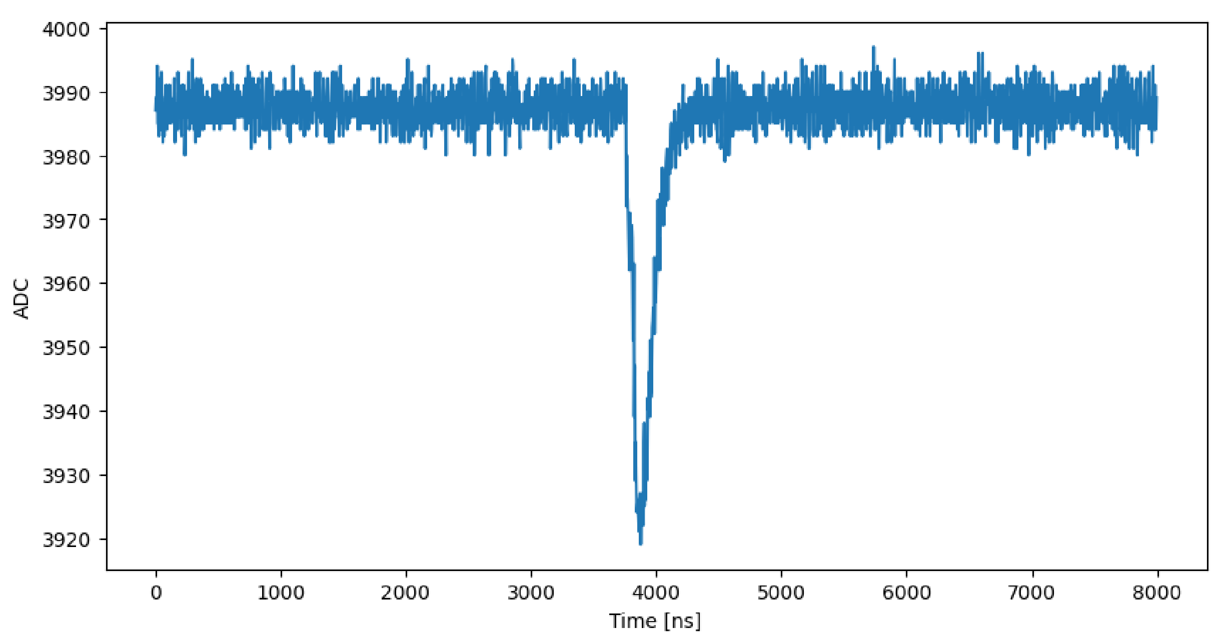
- Fill more GAr while monitoring the temperature
- As the chamber cools down, turn on the SiPM again past 53 V
    - Now what do you see? Is it as noisy as the room temperature SiPM?
- Once the temperature is around -186 C, the gas has condensed and the chamber is filled with LAr!

Section 3: Data Acquisition

There are a few ways one can take data, including ways to only save good (i.e. above threshold) signals and discard baseline noise. If there is time to play with that, we may. But for now, we just use the digitizer to take waveforms

- Data taking script: `zledump`
- When data taking, the script reads the *configuration file*, which tells the script how to program the digitizer
- Digitizer basics:

- Trigger: Threshold that the signal needs to pass in order to acquire the waveform
  - Post-trigger: The percentage of the waveform that is kept *after* the trigger
  - ADC counts: Analog-to-digital converter counts. We are using a 12 bit digitizer, so the height of the waveform ranges from 0 to $2^{12}-1=4095$ with a 2 V range
- To run the script: `./zle_exe [config] [number of events] [output directory (JUST the directory)] [tag (the type of data you are taking)] [events per segment]`
- To analyze/process the data, run the notebook: `hepcat_notebook.ipynb`



`Example waveform acquired by the digitizer`

  - Analysis tasks you can try:
    - Trigger low, find the peaks, calculate the area of the peaks, plot them in a spectrum
      - What should you see?
    - Trigger high, look at the high energy events from argon scintillation light. See if you can calculate PSD!