# LAr SiPM Lab Instructions

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# Objective

- To read the scintillation light of liquid argon using a 4-channel SiPM
- To understand how to put together a chamber which can be pumped to a vacuum
- To understand how to fill gas Argon and condense it into liquid Argon
- To read out the signals of a SiPM and do some analysis such as a gain calibration, seeing a difference when a Cs137 source is brought close, Xenon doping (if time permits) etc.

# Our Chamber

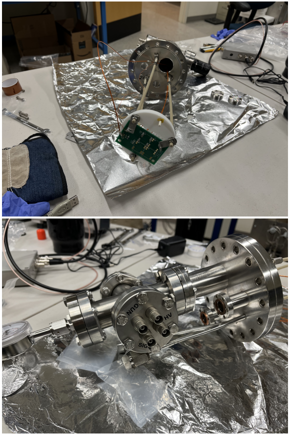


Figure 1: Top: contents of the chamber. Bottom: feedthroughs for the connections of the thermistor and SiPM.

- The chamber houses: A SiPM and board, thermistor, pressure gauge, pressure release valve, and a voltage feedthrough
- Chamber is sealed for vacuum with Conflat (CF) flanges
- Vacuum pump connects to one pipe, gas Argon bottle connects to the other
- Inner chamber is housed in a dewar containing liquid argon for cooling

# Filling and Cooling Instructions

- The vacuum pump should have been on overnight to be around $10^{-5} - 10^{-6}$ Torr
- Close the vacuum pump valve (the black knob) if not closed already
- The contents of the inner chamber will outgas, causing an increase in the vacuum pressure, wait for it to stabilize
- Fill the outer chamber with liquid argon (**wear gloves!**)
- Fill the inner chamber with gas argon from the bottle, to increase the flow, turn the regulator in the direction of "increase"
- **Make sure the pressure gauge on the inner chamber does not reach past 140kPa!**
- The SiPM will be covered by LAr once the temperature sensor sees roughly -186 to -185 C

# SiPM Overview

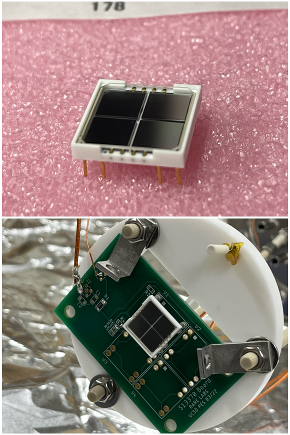
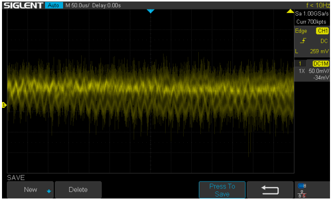


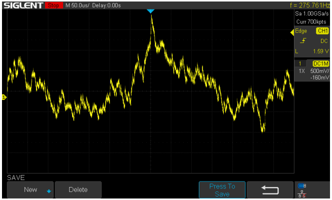

Figure 2: Top: 4-SiPMs together with a quartz window. Bottom: Board which connects the SiPMs all together in parallel.

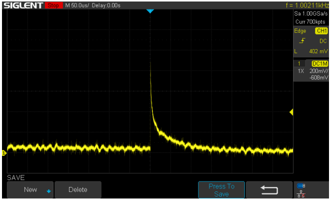
- **Silicon Photomultipliers** (SiPMs) are avalanche photodiodes which work by applying a strong reverse bias
- A strong reverse bias $\implies$ strong electric field in the depletion region $\implies$ avalanche when photons strike the surface of the SiPM
- High dark current due to thermal fluctuations, **must be operated at cold temperatures**

# SiPM Operating Instructions





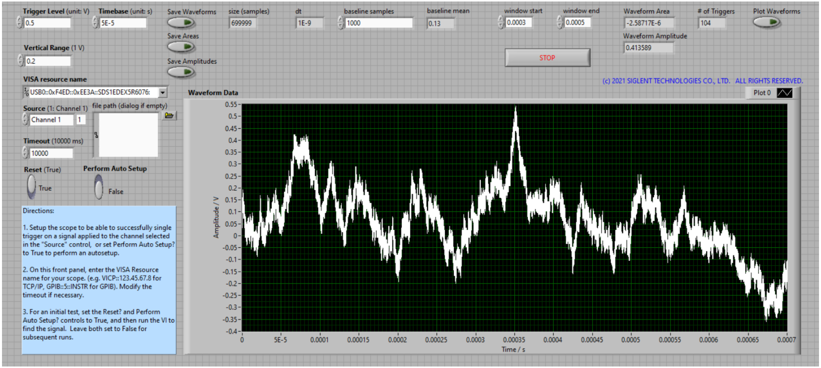



# SiPM Operating Instructions

- SiPM only produces a signal past the breakdown voltage **(around 53V for this model)**, current rises exponentially past this point
- See the screenshots above for example signals
- At 0V (top left), all we see is noise
- Just below the breakdown voltage (52V, top right) we see a bit of a signal at room temperature
- At and past the breakdown voltage (54V and 56V respectively, middle row), we see a large, noisy signal **at -40C** due to a large leakage current
- Once cooled to -178C, we see the signal at 56V is much cleaner (bottom plot)

# Labview Instructions



# Labview Instructions

- Trigger level: the trigger of the waveforms, only signals higher than the level will be shown
- Timebase / vertical range: the length of the time / voltage of a single square on the oscilloscope
- Size: how many samples you have in total ($size * dt = full\ time\ window$)
- Baseline samples: how many sample you want to use for the calculation of the baseline mean
- window start & end (unit: s): the window you want to select to calculate the area or amplitude of the waveforms

# Data Taking

- Before taking data, ensure that you see the similar waveforms at: room temperature, lower temperature and till the liquid Ar temperature ($\sim$ -186 C) and make screenshots
- Take $\sim$4000 events at liquid Ar temperature (Set 1)
- Take $\sim$4000 events at liquid Ar temperature with a Cs137 gamma source (Set 2)
- Take $\sim$1000 events at liquid Ar temperature but with high trigger (make the data taking rate lower than the maximum rate Labview could do), record the time used to take the events (Set 3)
- Take $\sim$1000 events at liquid Ar temperature but with high trigger and with the Cs137 gamma source, record the time used to take the events (Set 4)

# Data Analysis

- Perform a gain calibration by plotting the areas in histograms and use multi-gaussian to fit it (with Set 1)
- Compare Set 1 and Set 2 and see if there is scintillation light from liquid argon
- Use the time used to take Set 3 and Set 4 to calculate the high trigger rate with and without the Cs137 source, show if there is scintillation light from liquid argon