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# Looking at the Energy Resolution Dependence on Temperature of Silicon Photomultipliers


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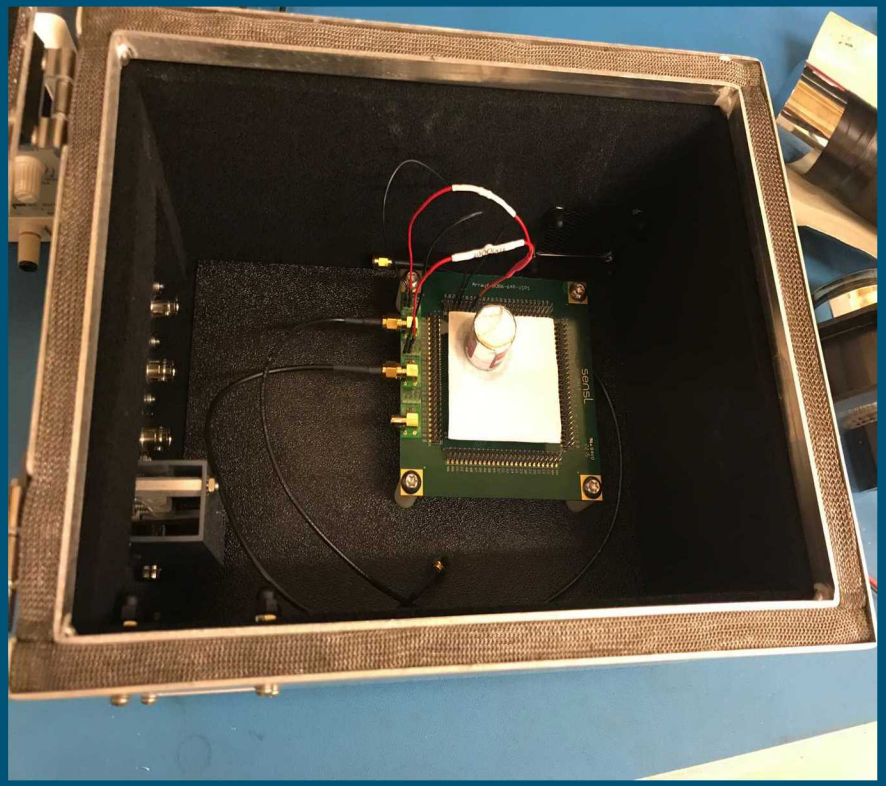
# Summer Fun

*R4607-06 photomultiplier tube*



*8x8 silicon photomultiplier (SiPM) array coupled to CsI crystal inside an electromagnetically shielded dark box*

# Benjamin Godfrey (Org 5877)

- Educational Background
  - BS UC Davis, 2014

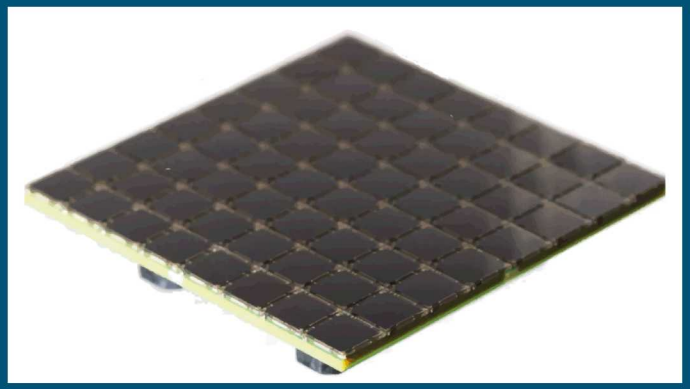
UC DAVIS
UNIVERSITY OF CALIFORNIA

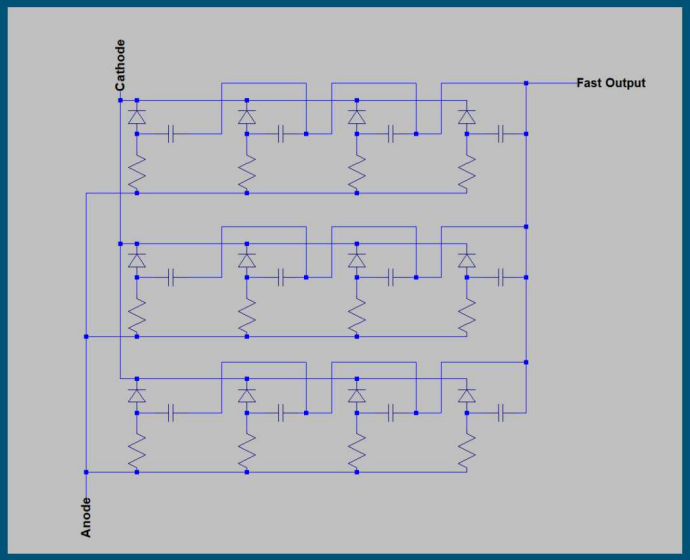
- Division
  - 5877: Systems Technologies Department
  - Mentor: Ben Maestas

- Research
  - Research topic: How does the energy resolution of silicon photomultipliers (SiPMs) vary as a function of temperature?

# Research Overview and Motivation

- Silicon photomultipliers (SiPMs)
  - Solid state light detector
  - Alternative to photomultiplier tubes (PMTs)
    - Lower voltage
    - Immune to high electric and magnetic fields
    - High gain
    - **Thermally dependent noise**
- Dark counts
  - Noise events that mimic actual events
  - Exponential dependence on temperature
- Spectroscopy (e.g. neutron or γ) is concerned with the accurate, quantitative study of energy spectra from various radionuclides
  - Would like to maintain accuracy regardless of environmental conditions
- Question: How does the energy resolution of SiPMs (coupled to CsI) depend on temperature, and, specifically, how does it compare to PMTs (coupled to NaI)?

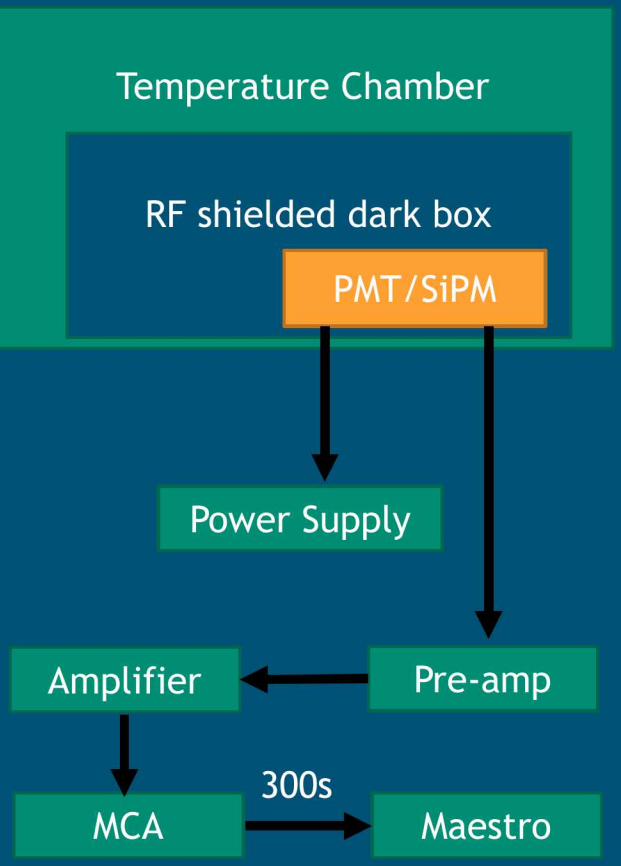





*(Bottom) Simplified circuit diagram of one SiPM composed of many microcells. These SiPMs can be tiled into the (Top) 8x8 SiPM array from SensL*

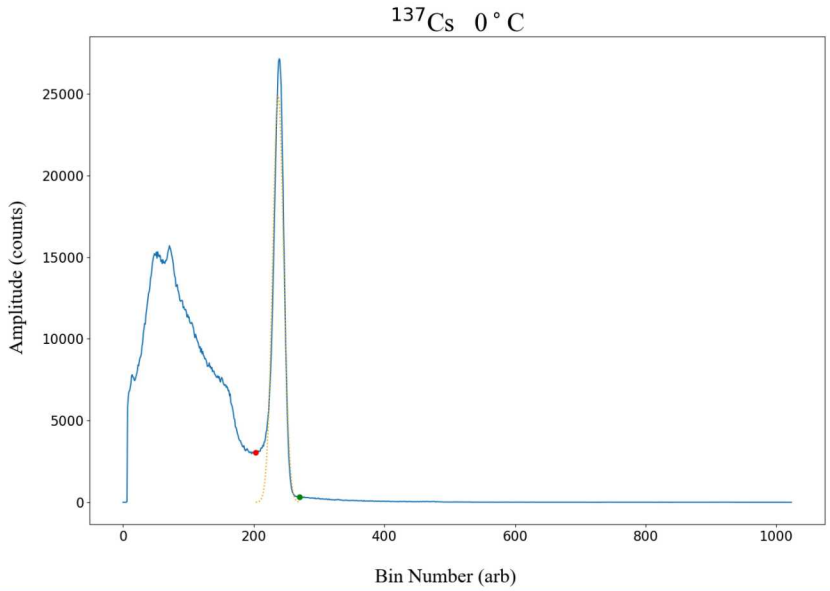
# Research Approach

- Place SiPM/PMT, coupled to scintillator, and dark box in thermally controlled environment
- Using $^{137}Cs$ (placed outside chamber) take 300s of data
- Record data using multichannel analyzer connected to PC
- Repeat process in 10 ºC increments from -30 ºC to 70 ºC
- Repeat process for both SiPM coupled to CsI and PMT coupled to NaI
- Define energy resolution as for a Gaussian $\frac{FWHM}{Centroid} = \frac{2\sqrt{2\ln 2}\ \sigma}{\mu}$
- Plot energy resolution vs temperature for both SiPM and PMT data



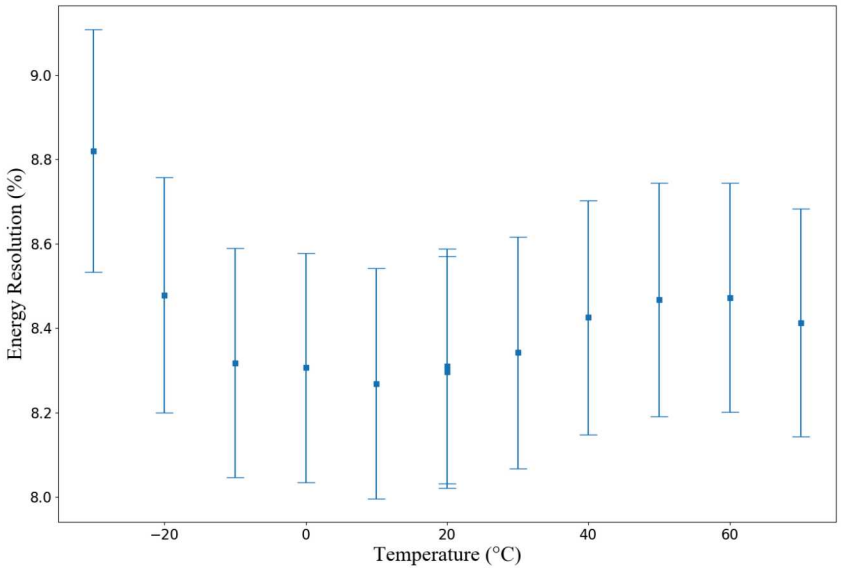

*Block diagram of setup*

# Results (Work in Progress)




*Counts vs bin index for PMT setup recording data from $^{137}$Cs source at 0 °C. Gaussian fitted to the photopeak is shown in orange*

- See ~8.4% energy resolution for PMT setup over a wide range of temperatures
  - Note: PMT setup not in dark box

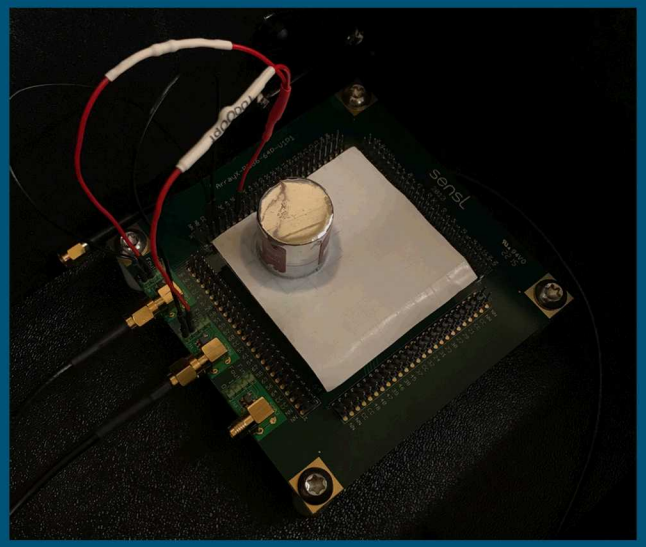



*Energy resolution vs temperature. Error bars are purely statistical. Note that there are two points at 20 °C*

- Currently waiting to take SiPM setup data
  - Waiting for delivery of CsI crystal
  - Waiting for completion of SiPM amplifier

# Conclusions and Future Work

- PMT energy resolution is higher than seen in the literature[1] (suggests that optimization in setup can be made)
- Still lots of measurements to be made
  - Take data with PMT setup in dark box
    - Dark box may significantly attenuate γ's from $^{137}Cs$ source degrading energy resolution
  - Begin taking SiPM data
    - Currently waiting on delivery of CsI crystal
    - Ongoing development of custom amplifier




[1]Moszyński, M., et al. "Temperature dependences of LaBr3 (Ce), LaCl3 (Ce) and NaI (Tl) scintillators." *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* 568.2 (2006): 739-751.