HEPCAT Summer School Instructions

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Introduction

Motivation and Aims

- General Idea
  - Build a photon detector using a cryogenic chamber housing a Silicon Photomultiplier (SiPM)
  - Read out liquid argon (LAr) scintillation light using the detector
- Aims
  - Get hands on experience with vacuum and cryogenic systems
  - Be familiar with noble liquid scintillators and photodetectors
  - Deal with signal readout and preliminary processing (LabView)
  - Data analysis of the amplitude/area spectra of SiPM signals

Introduction

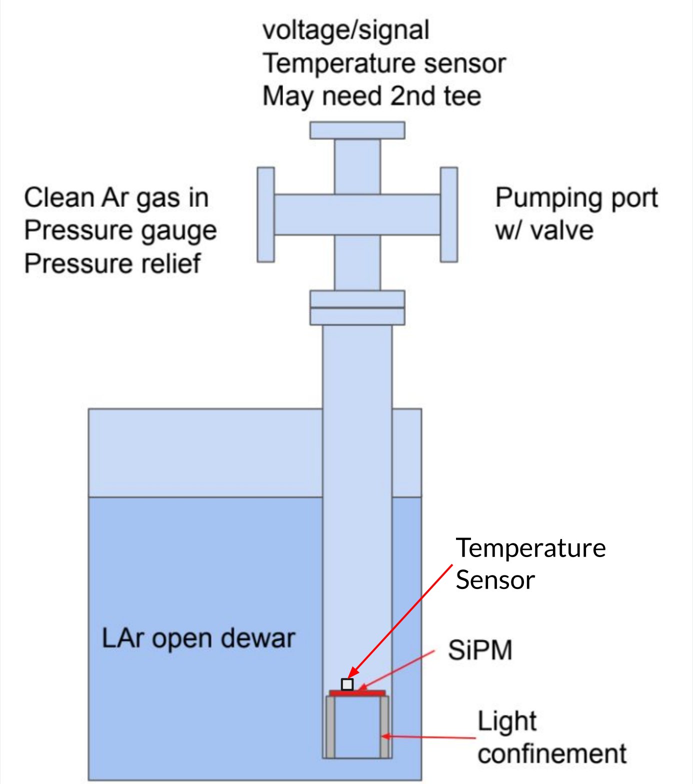
Basic Setup

- Basic Steps
  - Build a cryogenic vacuum chamber with gas Argon (GAr) and vacuum input, install SiPM and temperature sensor inside it
  - Maintain vacuum inside the chamber and pass electronics from the inside to the outside
  - Condense GAr into liquid argon (LAr) inside the chamber
  - Read out LAr scintillation light using the detector with and without a radioactive source
  - Perform simple data analysis

System Overview

Vacuum and Cryogenic system

- Vacuum
  - All conflat (CF) or VCR components for high vacuum
- Cryogenic (LAr) system
  - Passive cooling with LAr bath
  - Small LAr volume for quick condensation process
  - SiPM for direct LAr scintillation light detection
  - RTD temperature sensor located around the SiPM to monitor the LAr level
  - No complex gas handling

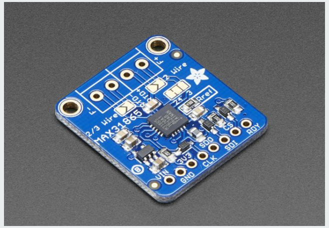


System Overview

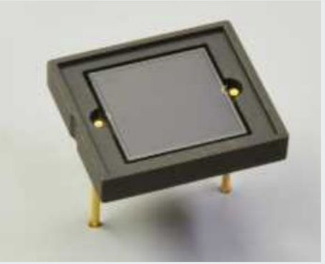
Temperature Sensor and SiPM

- Temperature Sensor
  - PT100 RTD is a resistor that changes resistance with temperature, and is used to read temperature
  - Read the temperature through Arduino
- SiPM
  - Hamamatsu 13370
  - UV sensitive to LAr scintillation light (~ 128 nm)
  - Customized PCB board for signal readout

PT100 RTD



Arduino

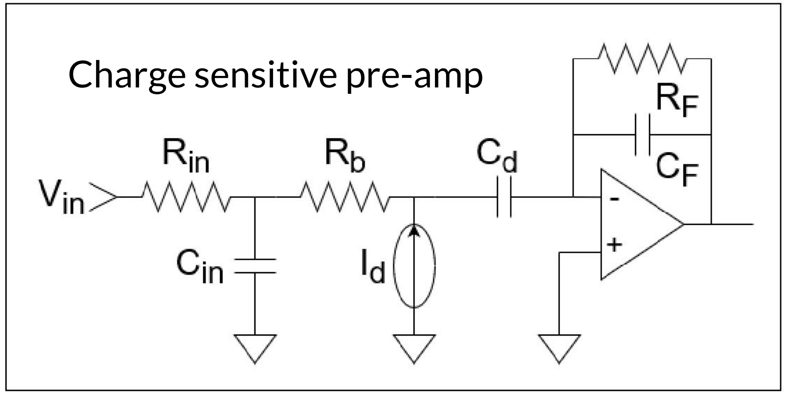


Hamamatsu 13370 SiPM

Electronics and Readout

SiPM Working Principle and Signal Readout

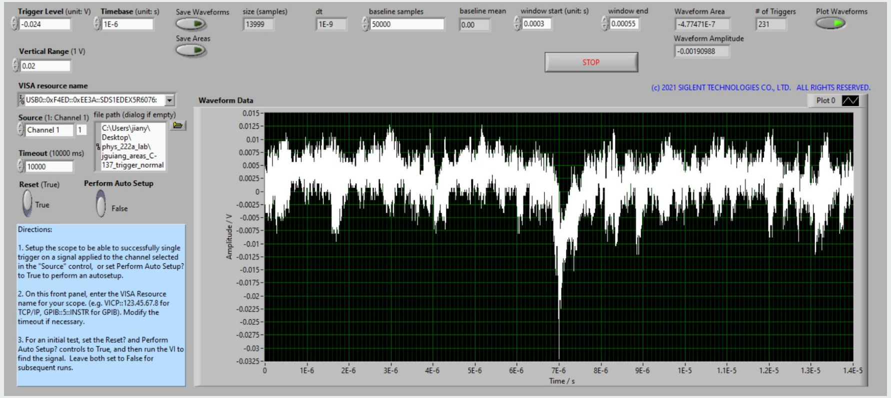
- Working principle
  - SiPM is a diode operated in a strong reverse bias
  - Strong field in the depletion region, which causes avalanche
  - Voltage at which this happens is called the breakdown voltage, and is when we can see light
- Signal readout
  - Charge sensitive:
    - C_d: decoupling capacitor
    - C_F, R_F: feedback capacitor and resistor
    - Signal from the SiPM is amplified and integrated
  - Linear amplifier multiplies pulse by x10



Electronics and Readout

LabVIEW Data Acquisition

- ➢ Oscilloscope
  - ○ Siglent SDS 1202X-E oscilloscope
  - ○ Data acquisition from the oscilloscope through LabVIEW
- ➢ LabVIEW UI
  - ○ Plot triggered waveforms
  - ○ Baseline calculation
  - ○ Save areas, amplitudes and time info. of the signal waveforms
  - ○ Fourier transform and filter provided



Data Taking and Analysis

Data Taking

- Before taking data
  - Find the breakdown voltage at room temperature, and check the noise level
  - Find the breakdown voltage at LAr temperature and apply a ~3V over voltage
    - Over voltage = bias voltage - breakdown voltage
- Data to take
  - Set 1: Normal trigger level, without radioactive source
  - Set 2: High trigger level, without radioactive source
  - Set 3: Normal trigger level, with radioactive source
  - Set 4: High trigger level, with radioactive source

Data Taking and Analysis

Data Analysis

- Single photon analysis
  - In principle, the smallest signal we can see is single photon, and then double photon, triple photon signals ...
- LAr scintillation analysis
  - The data without the radioactive source may come from dark count or background
    - Look at pulse shapes, see if LAr triplet decays are visible
  - Place a radioactive source (662keV gamma line from Cs137)
    - Check for different rates with a high trigger
    - Check for different area spectra with a moderate trigger

Questions to Consider

- ➢ Why is the signal much noisier at room temperature? What's the physical process behind this?
- ➢ Why do some of the LAr signals have a long tail?
- ➢ What is the expected shape of the area/amplitude spectrum?
- ➢ Do we expect a difference in the rate of triggers when we place a radioactive Cs137 source nearby?
  - What about the amplitude/area spectrum?
- ➢ Why can't we see LAr scintillation light with a quartz window?
- ➢ When using a charge sensitive amplifier, does it make more sense to compute the amplitudes or the areas of the pulses?
  - What about a linear amplifier?