# Detecting & Training

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August 13, 2025

Do you remember how you **learned** to read?

# The Mechanics of a Germanium Detector

# What are Germanium Detectors?

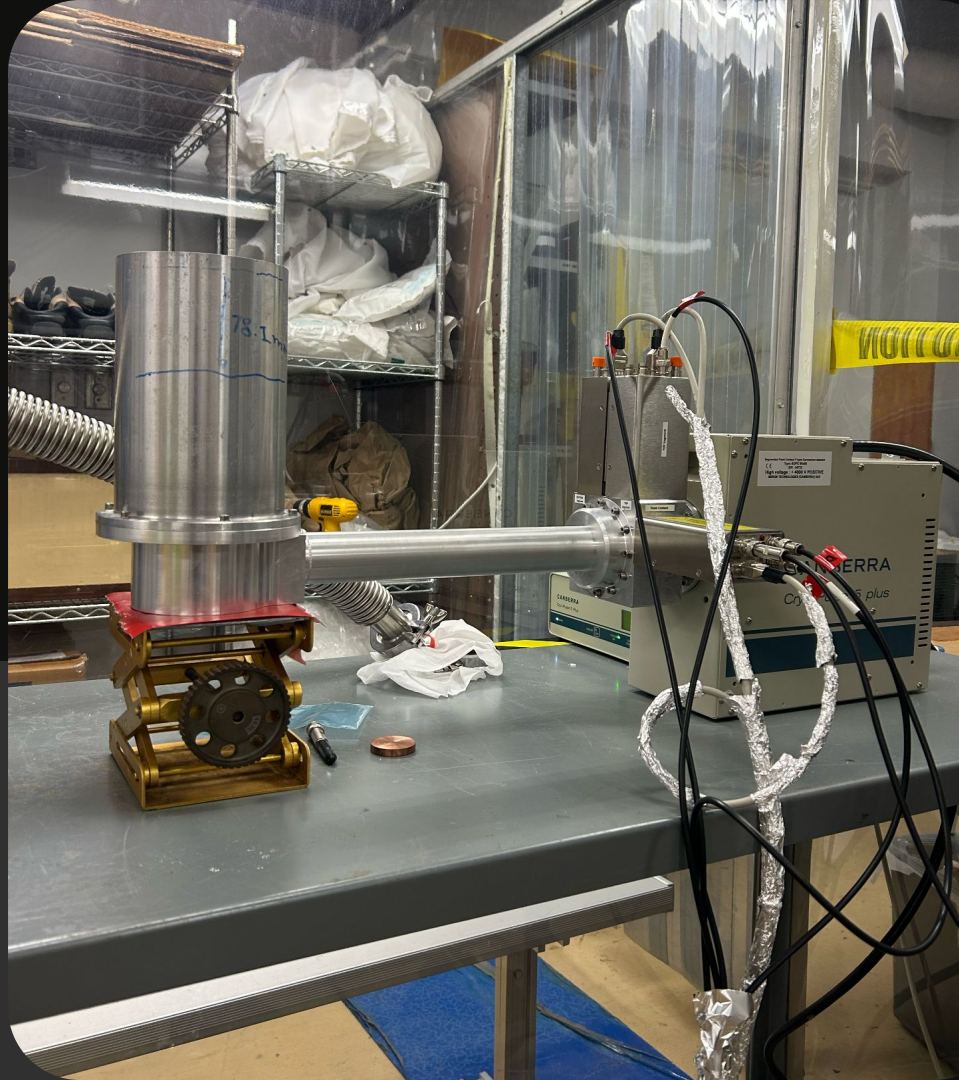
- Germanium Crystal contained in a cryostat
- Consists of two terminals
  - Causing current to flow in one direction
- Specialized semiconductor diodes with a p-i-n structure
  - Will explain a p-i-n structure next

### Key Parts

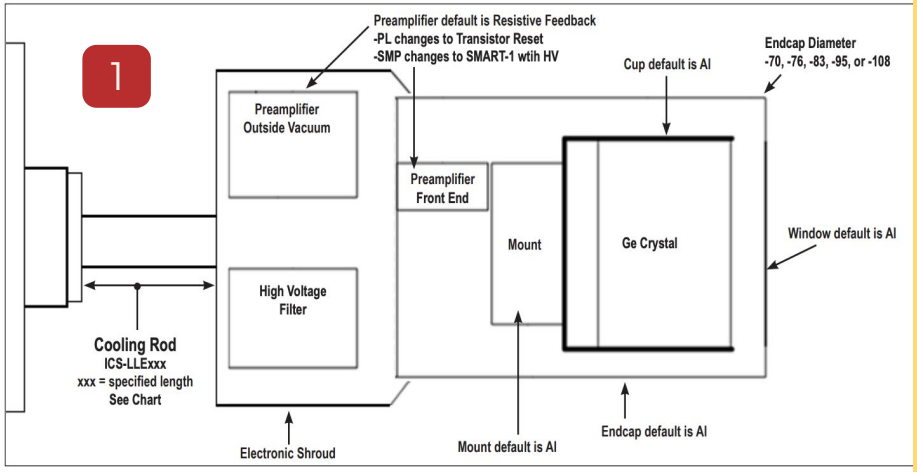
- Pumps
- Vacuum
- Voltage Filters
- Mount
- Cryostat

### Cryostat

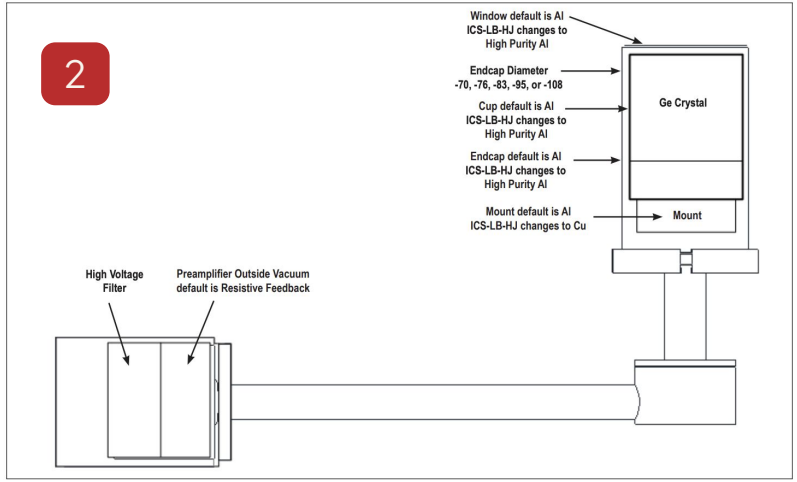
- Contains the Germanium Crystal
- Liquid Nitrogen has a temperature of 77 K (-196 C)



## Streamline Detector Capsule for Integrated Cryocooling System with External Preamplifier (ICS-E)



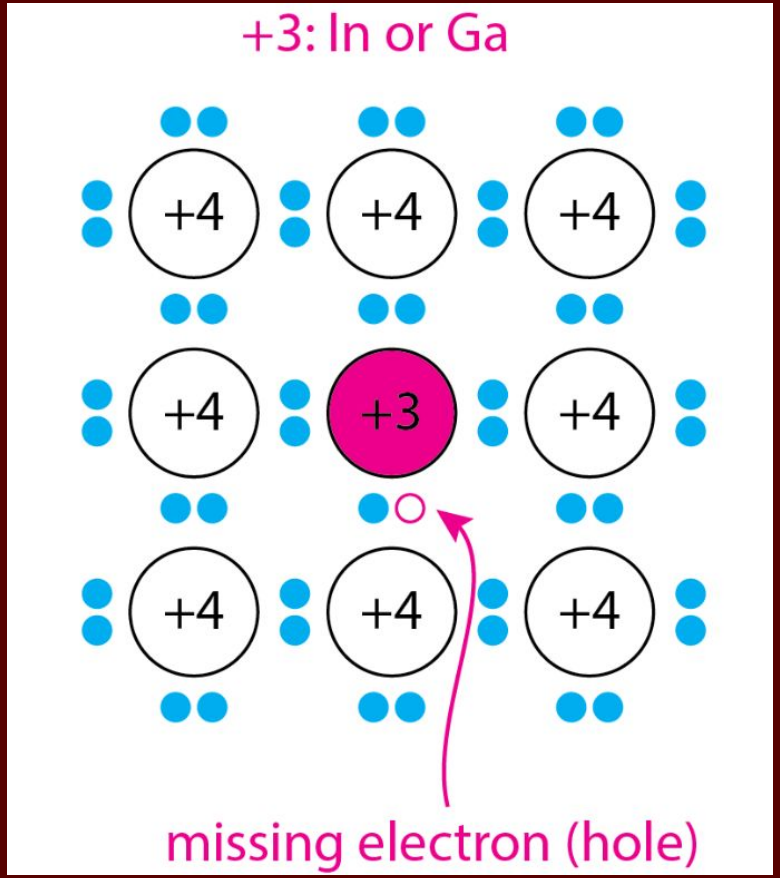

## Streamline Detector Capsule for Integrated Cryocooling System with Remote Preamplifier (ICS-HJ)



# How Germanium Detectors Conduct Rare Event Searches

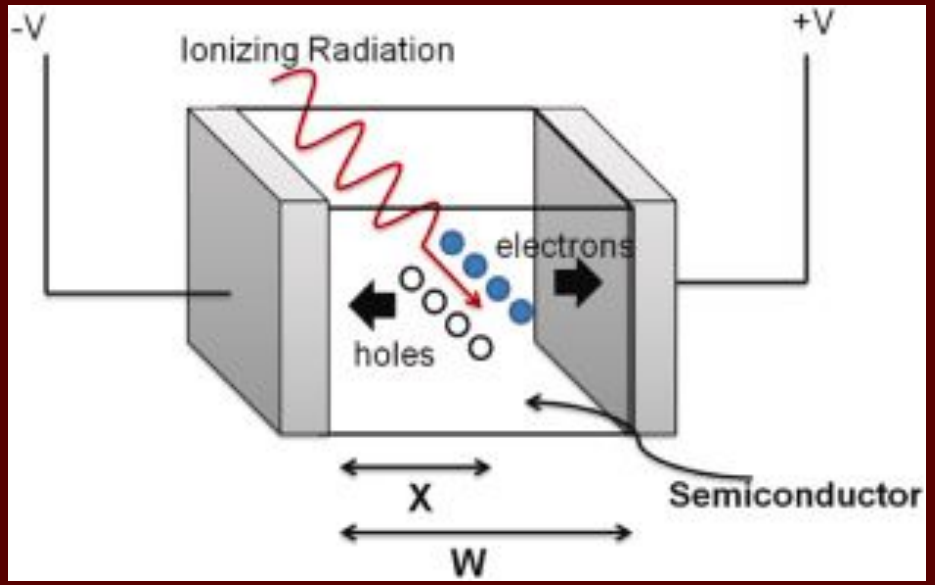
# P-type Layer

- Germanium with added impurities
  - Group 13 elements
- Ge “borrows” an electron creating a “hole”
- Increased electric conductivity



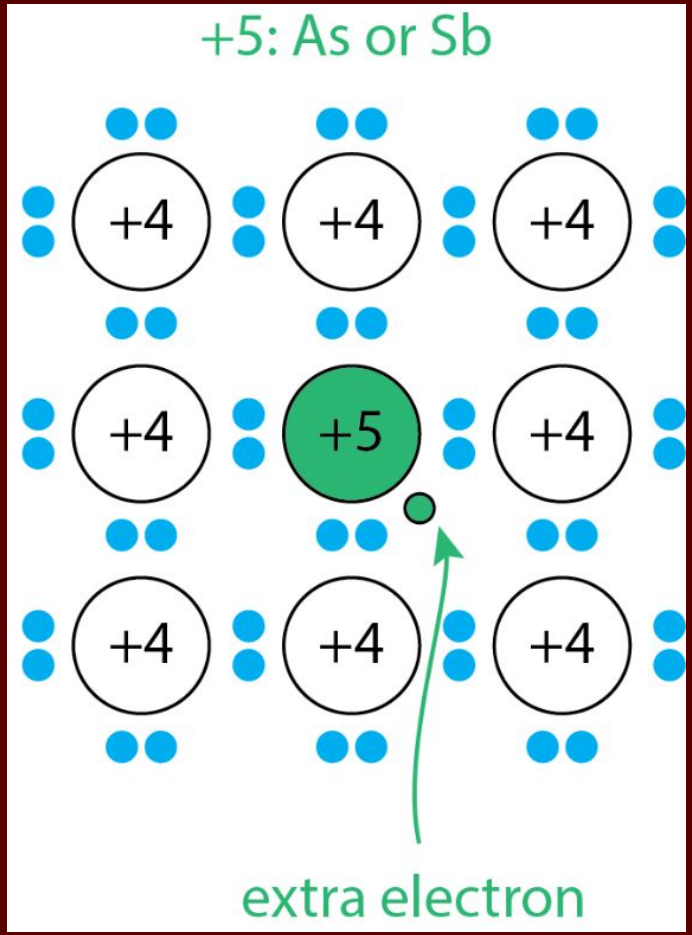
# Intrinsic Layer

- When radiation is deposited the electrons in the Germanium gain energy
- A small pulse of charge is generated by a rare event
- Electrons move to the n-type layer
- Holes drift to the p-type layer



# n-type Layer

- Germanium with added impurities
  - Group 15 elements
- Remaining electron that becomes a free electron
- Free electrons in the n-type layer forming a charge



# What is Noise

Noise

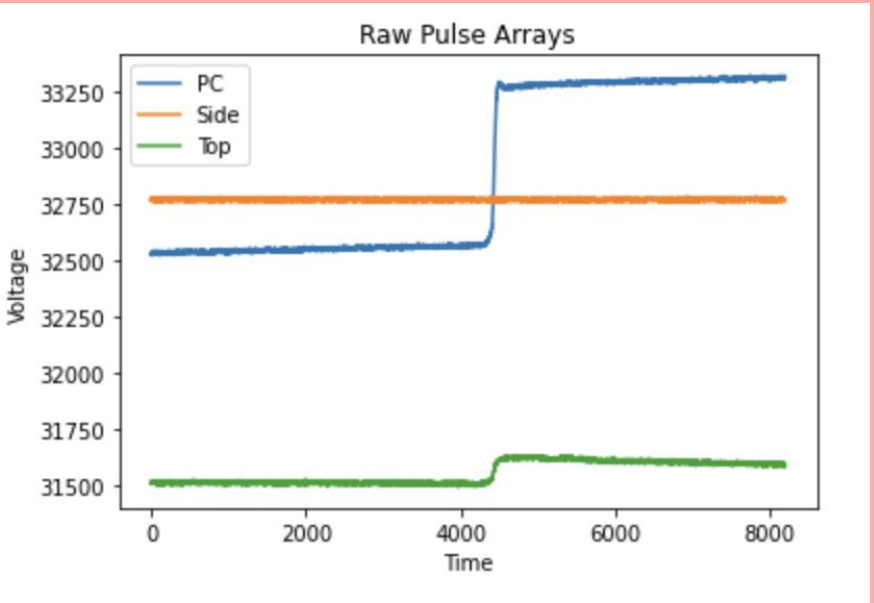
- Unwanted electrical effects and signals
- Two main categories
- Microphonic noise for detectors without liquid nitrogen

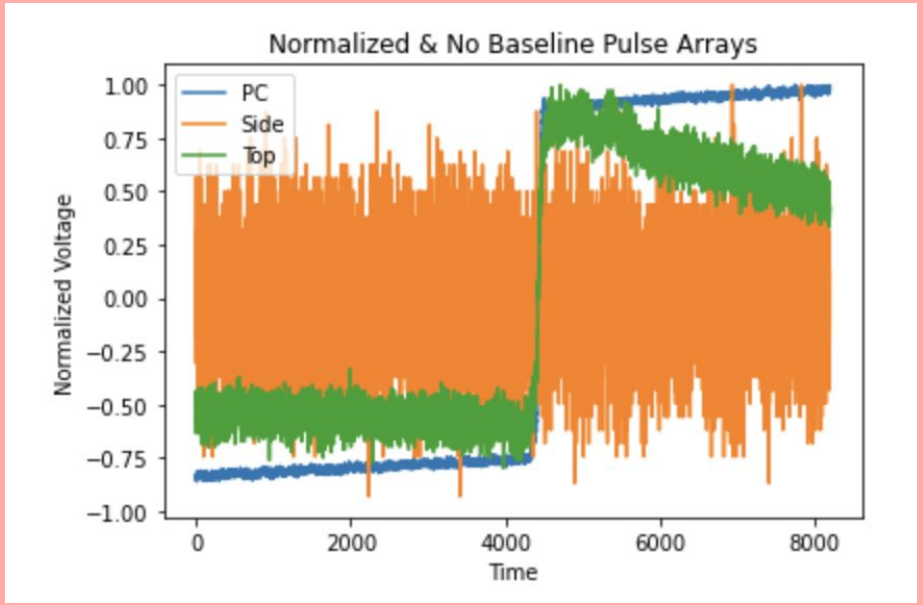
Electronic Noise

- Formed by the generators associated electronics
- Preamplifier
- “Current noise”

Thermal Noise

- Thermal energy of the Germanium causes holes
- Need for liquid nitrogen cooling


Raw Pulse Arrays
PC
Side
Top
Voltage
Time
33250
33000
32750
32500
32250
32000
31750
31500
0
2000
4000
6000
8000


Normalized & No Baseline Pulse Arrays
PC
Side
Top
Normalized Voltage
Time
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
0
2000
4000
6000
8000

# What is Machine Learning

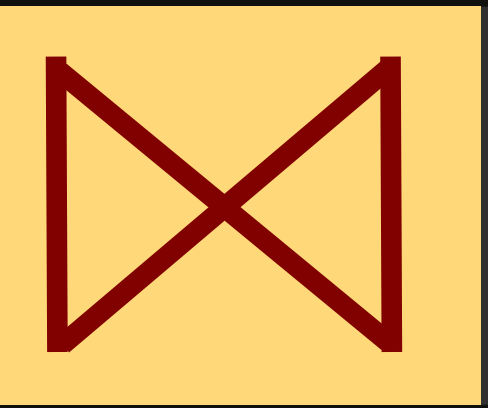
- Field of Artificial Intelligence (AI)
- Used to recognize complex patterns
- Complete tasks without explicit instructions

- Memorized words and rules
- Learned patterns of what words mean and how their meaning changed when placed with other words
- Understood sentences that you haven't been told the meaning of

# What I've Been Working On

## Machine Learning Model

- Bottleneck (hourglass) ml architecture
- Train data and Test data sets
- Fit the size of the data

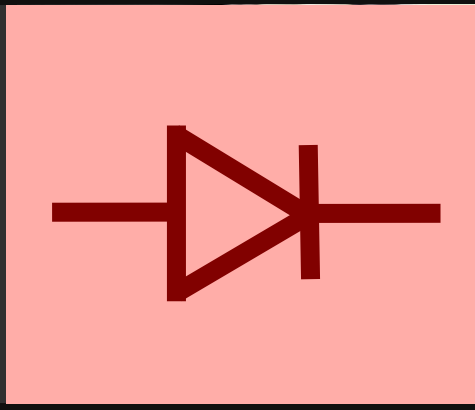


Bottleneck architecture

## Pulses for the Detector

- Simulates a pulse of voltage
- Saved array
- Create pulses of a certain size
    - Voltage, amplitude, period

Semiconductor Diode



# Going Forward

Set up Detector

Ensure the pulses are as desired

Pulses go through the Function Generator and oscilloscope

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Data from the detector gets processed to go through the model

Data is sent through the trained model.

Results are analysed and graphed, the models evaluated.

Thank you!