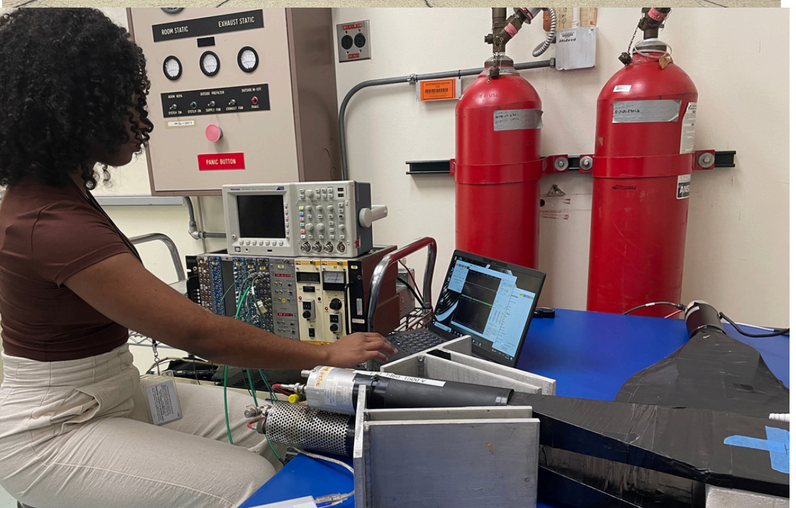


DEVELOPMENT OF A COSMIC RAY TRIGGER FOR QUALITY CONTROL OF HGCAL SCINTILLATOR TILE-MODULES

Mentee: Danielle Nunez (Randolph College, Right)

Mentor : Daniel Guerrero (Fermilab, Left)

*HGCAL Team: Greg Alley (Centre), Jim Freeman, Harry Cheung, Joe Pastika (Fermilab scientists)

Fermilab

USCMS/PURSUE

RANDOLPH COLLEGE

Overview

- Introduction + Motivation
- Trigger System Strategy and Design
- Commissioning Trigger System
- Conclusion and Prospects
- Summer Side Quests 

Cosmic Rays

- **Cosmic Rays**

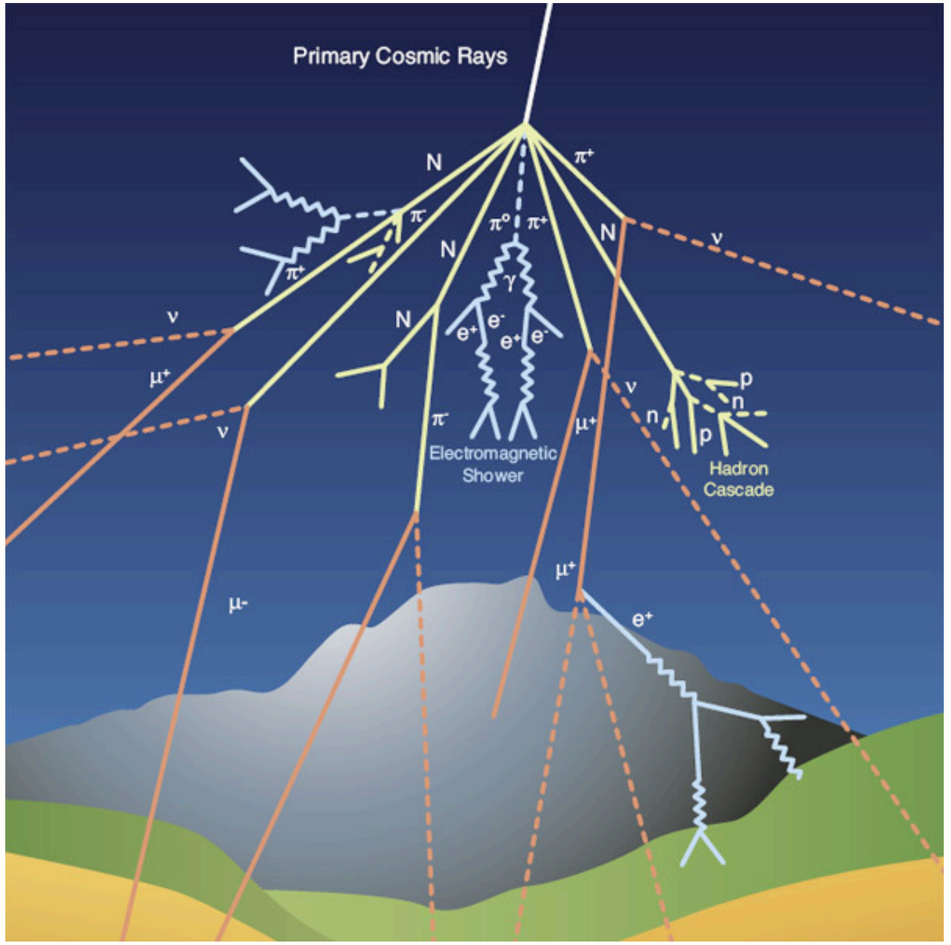
  - A cosmic ray is a high-energy particle that originates from outer space and travels through the universe at nearly the speed of light.

  - When these cosmic rays collide with particles in the Earth's atmosphere, they create other particles, including muons, which can reach the Earth's surface.

- **Detection**

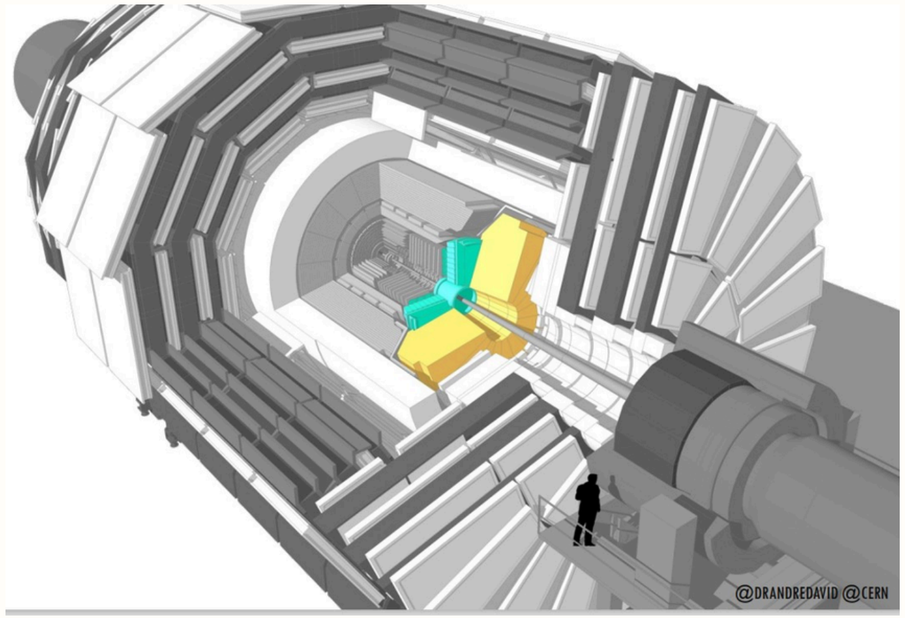
  - Cosmic muons are used to test the performance of particle detectors.

  - At sea level, the detection rate is approximately 1 muon per square centimeter per minute per steradian.



CMS High Granularity Calorimeter

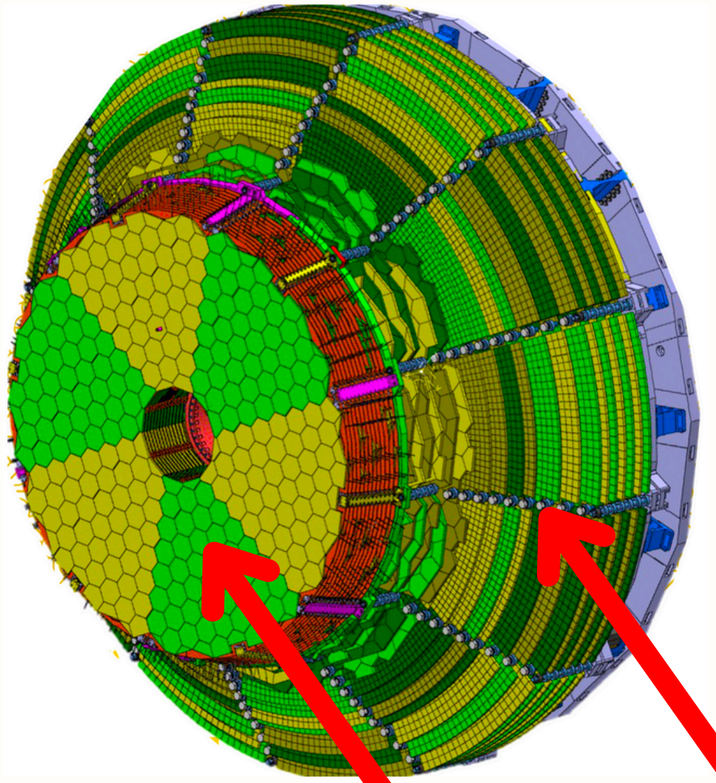
Current Calorimeter:



This Calorimeter will not be able to sustain the operation conditions of the HL-LHC.

- High Radiation levels
- High particle multiplicity

Future Calorimeter(HGCAL):



Silicon (EM) calorimeter

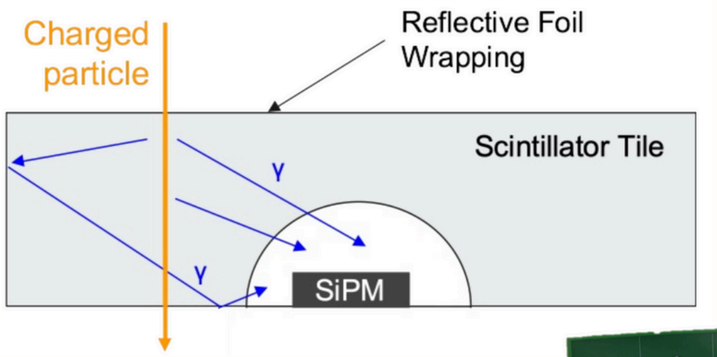
Si and Si+Scintillator layers in back (hadronic) calorimeter

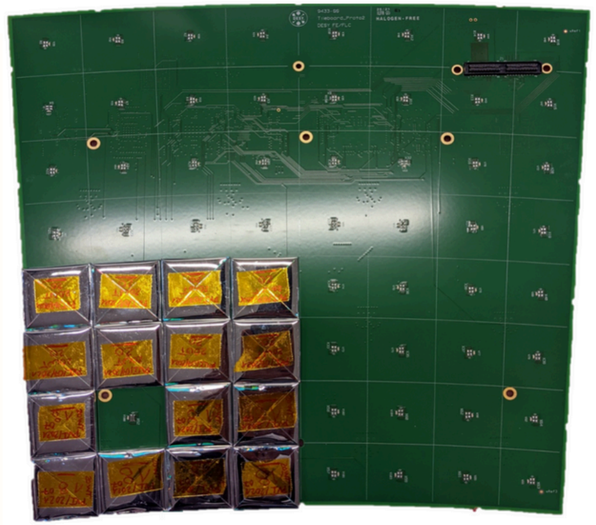
Characteristics :

- Higher radiation tolerance.
- Better 3D granularity
- Precise Timing
- More information at trigger level

Scintillator Tile Modules

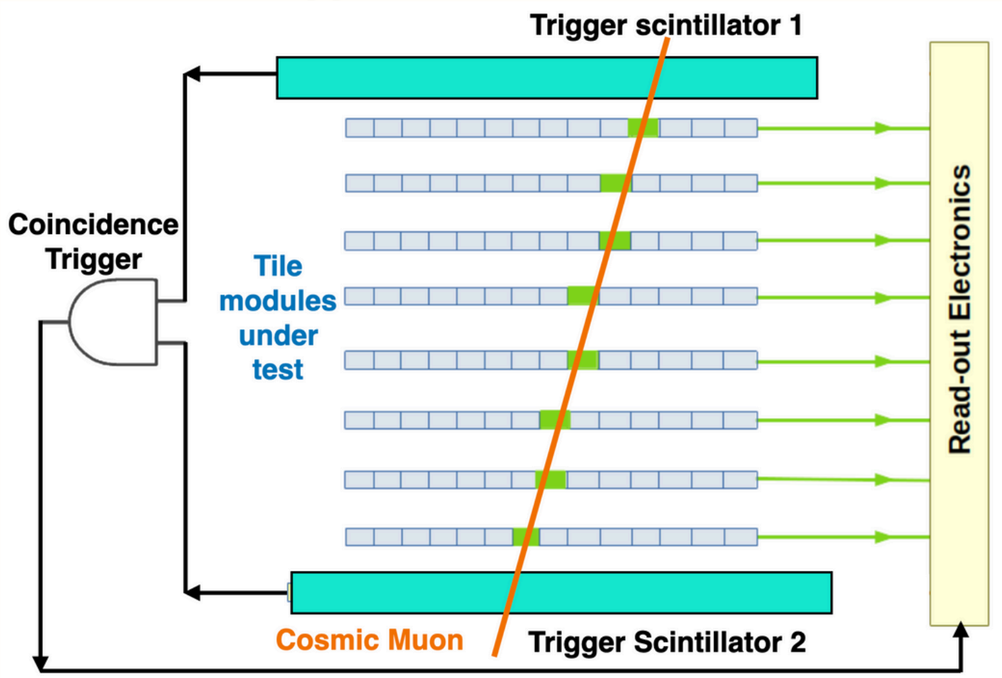
- HGCAL scintillator section: **SiPM on tile technology.**
- Fermilab will assemble 2000 tile modules.





Scintillator Tile-module

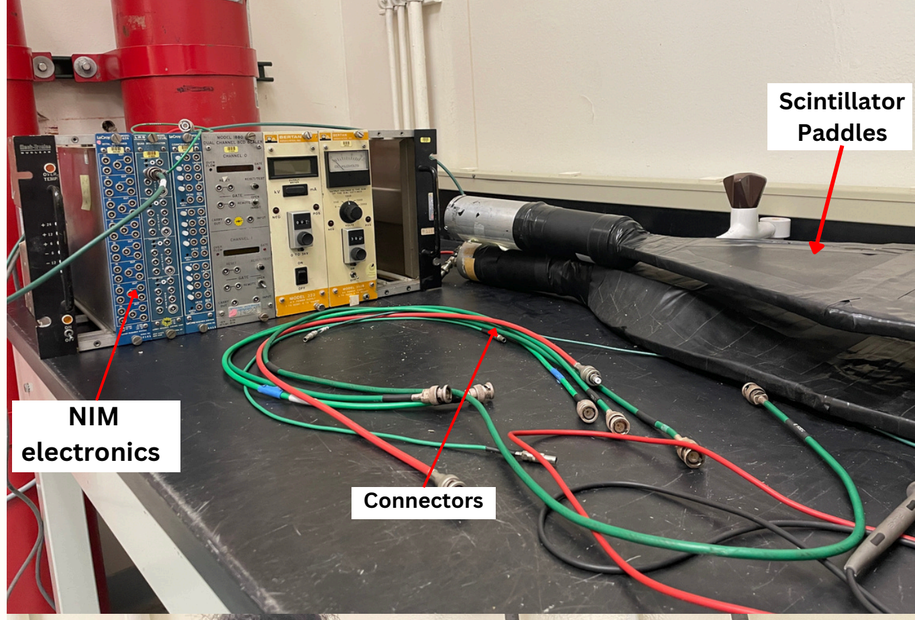
- Quality control procedures (Thermal cycling, and Electrical Validation) will be done in each Tile Module.
- The electrical functionality will be tested using a **multi-module cosmic ray test stand.**
- **I will be developing the first prototype of this cosmic ray coincidence trigger.**



Summer Road Map

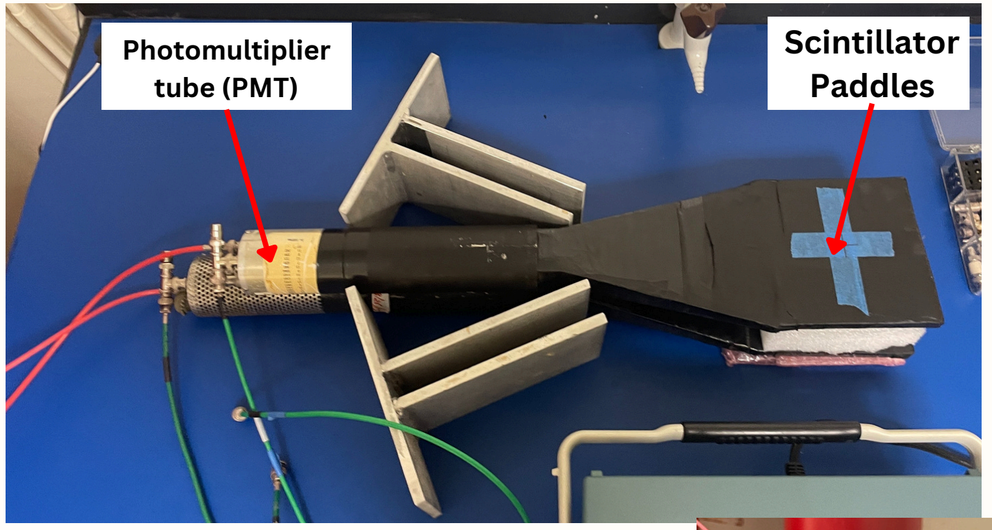
Goal: Develop a proto-type cosmic ray trigger system for multi module test stand at Fermilab, Lab 6.

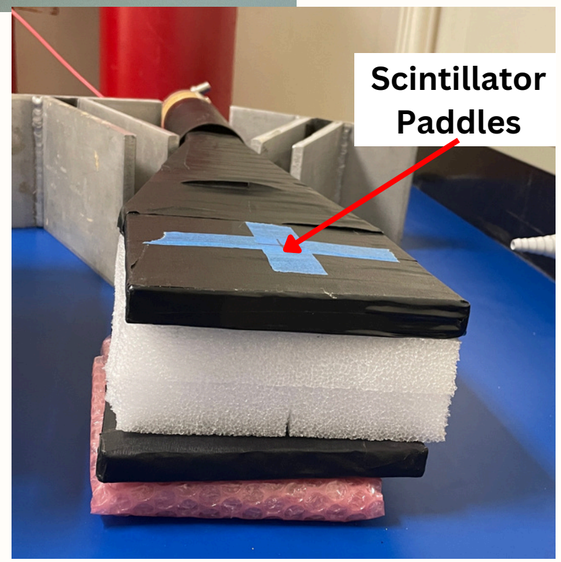
- Test individual scintillator paddles and photo tubes using oscilloscope.
- Put together instrumentation for the cosmic ray experiment (scintillator paddles, photo tubes and data acquisition/ NIM electronics)
- Set up a double coincidence trigger read out electronics.
- Commission of cosmic ray trigger.



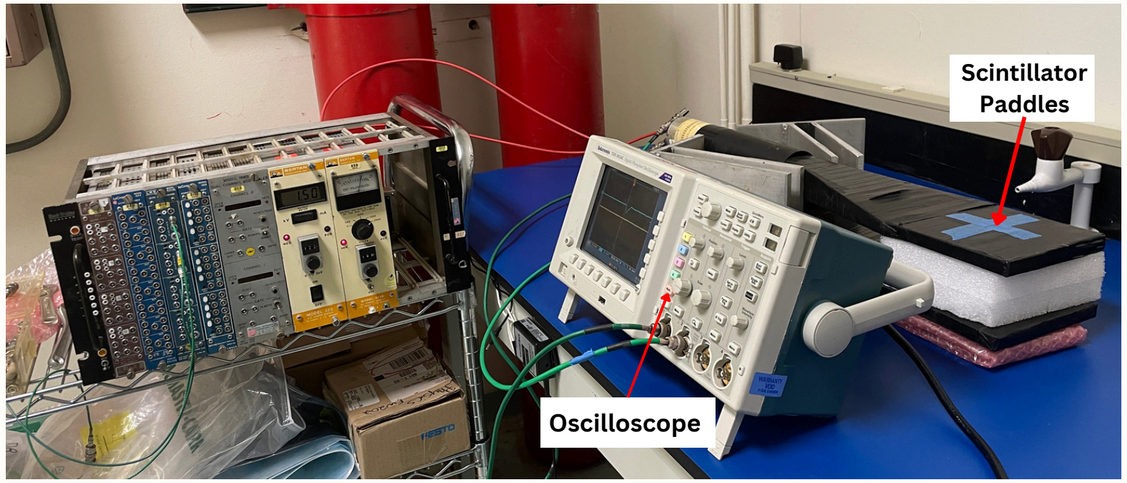
Scintillator Trigger Paddle Testing

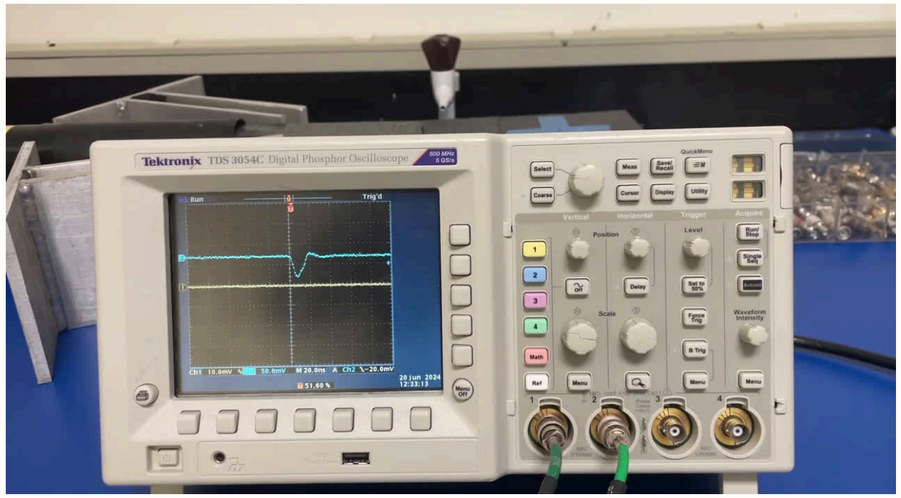
Paddles' Set Up:



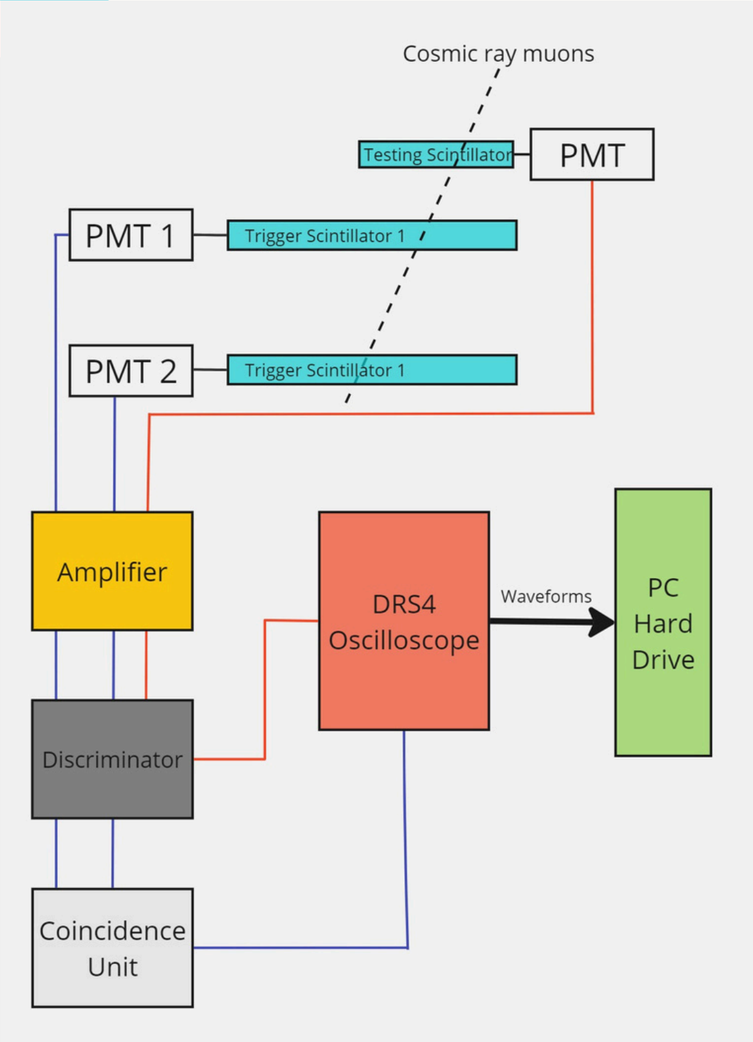


Operation Set Up:

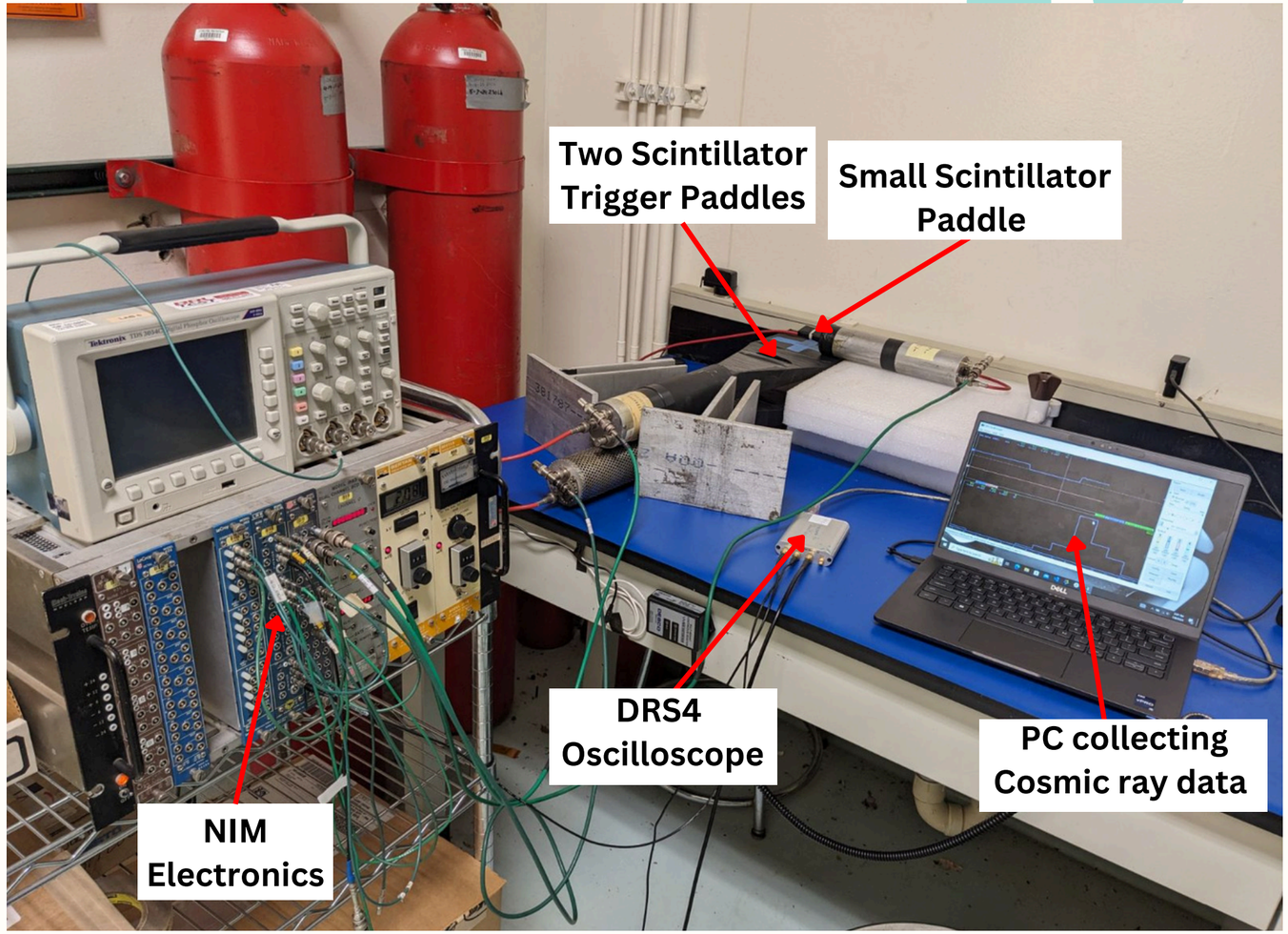




Design



Conceptual Design

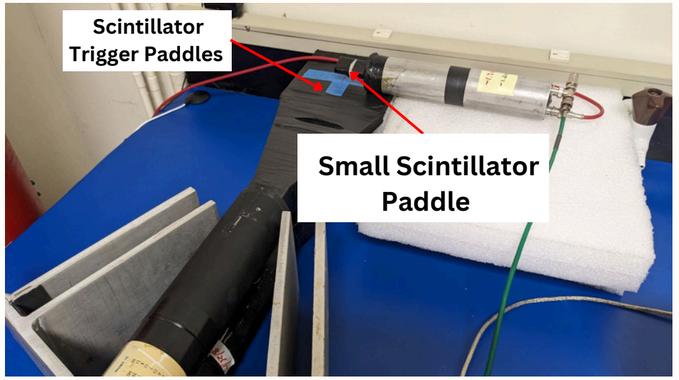


Cosmic ray trigger test stand at Fermilab

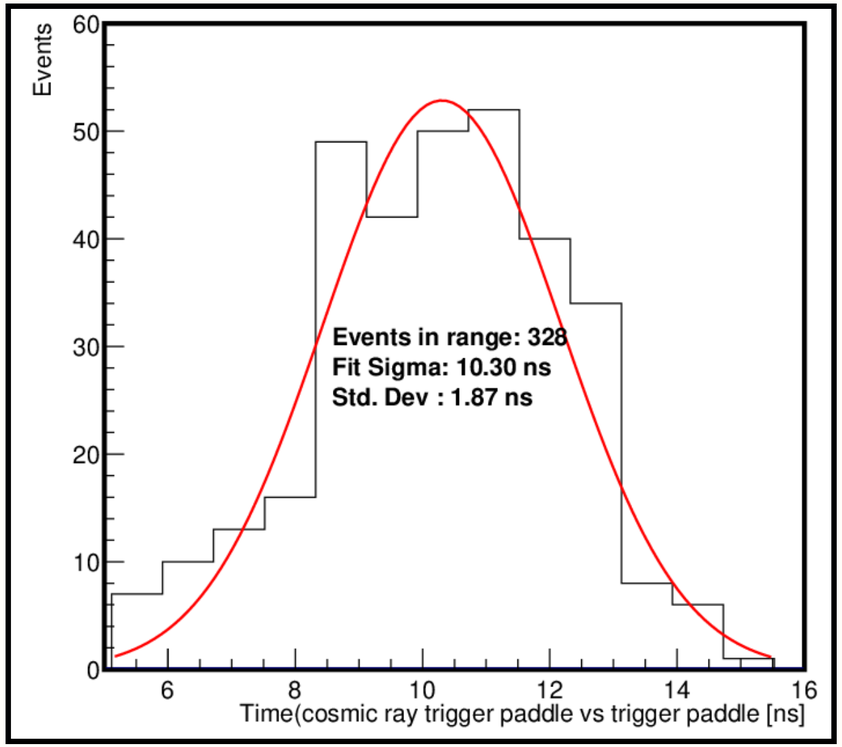
Cosmic Ray Trigger Commission

Timing capabilities:

- A small scintillator paddle (1 in X 1 in) was placed over the trigger paddles (6 in X 6 in) .
- Time delays were recorded between the small scintillator paddle and the trigger paddles using a DRS4 oscilloscope.
- 328 cosmic ray events were collected (~1 muon/min).
- The data was analyzed using ROOT software.
- A Gaussian fit to the data showed the average time delay to be around 10.3 nanoseconds (ns) with a 1.9 ns time resolution.



Small scintillator with trigger paddles

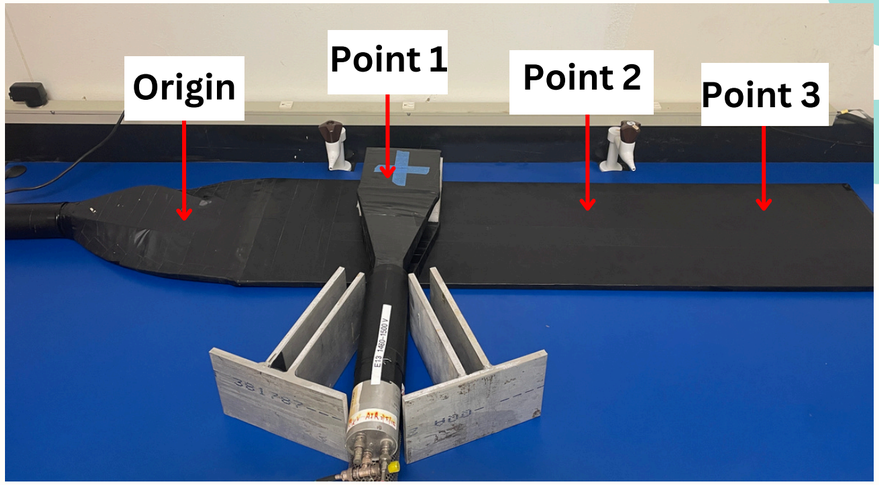


Timming of Trigger System

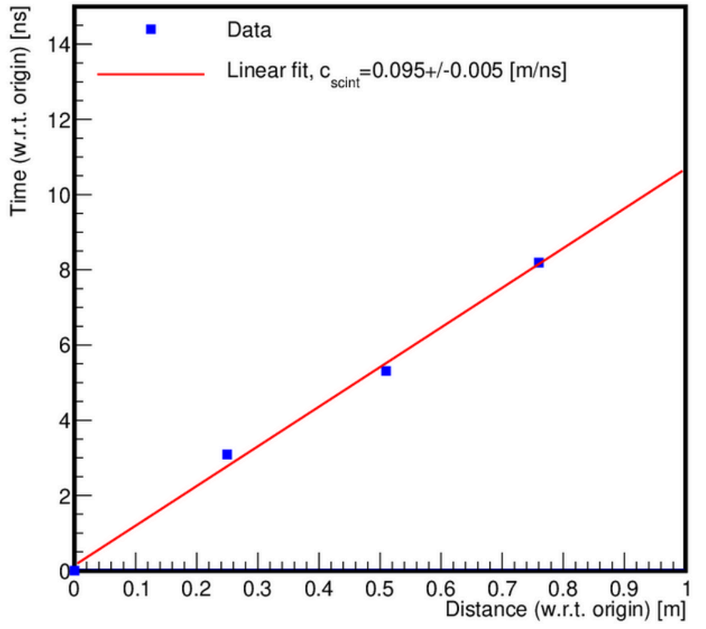
Cosmic Ray Trigger Commission

Measurement of the speed of light in a plastic scintillator:

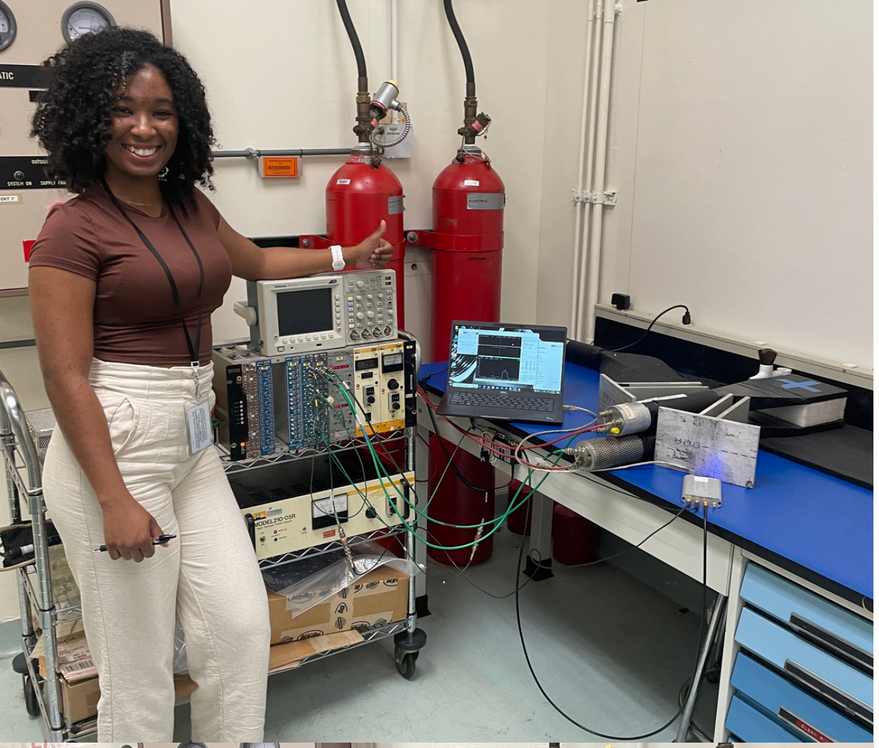
- A large plastic scintillator (12 in X 53 in) was placed under trigger paddles (6 in X 6 in).
- Time delays were recorded at different points along the scintillator using a DRS4 oscilloscope.
- 500 cosmic ray events were collected at each point.
- The data was analyzed using ROOT software.
- A linear relationship was found between the change in distance and the change in time.
- The speed of light in the plastic scintillator was measured to be 0.095 meters per nanosecond (m/ns), which is consistent with the expected value of 0.15 m/ns.



Plastic scintillator with trigger paddles



Speed of light in plastic scintillator paddle

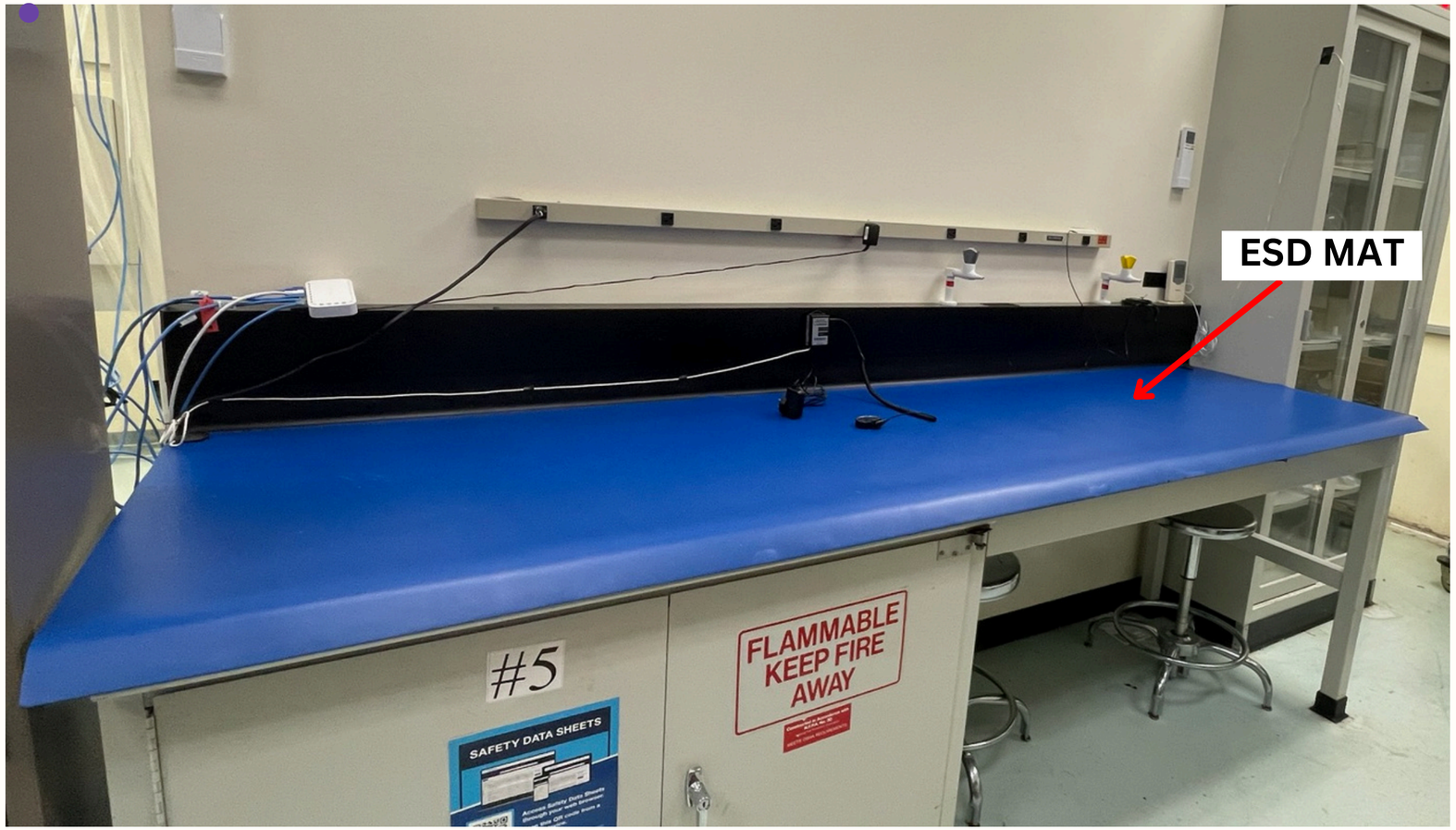


Conclusion and Prospects

- The first prototype for the cosmic ray trigger stand was built and is operational at Fermilab, Lab 6.
- The test stand was commissioned using two experimental tests: time delay and speed of light in a plastic scintillator
- In the coming months, the signal from the cosmic ray trigger will be integrated into the multimodule test stand.
- This trigger system will be used to commission a second-generation trigger, which could include larger scintillator paddles to cover a larger area.

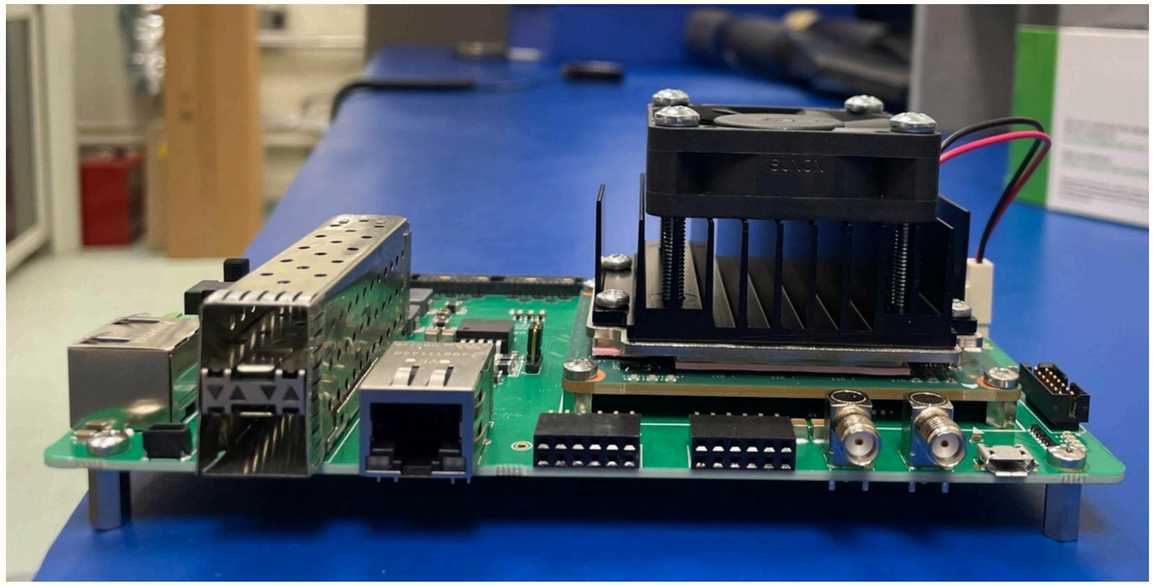
Summer Side Quests 🤵

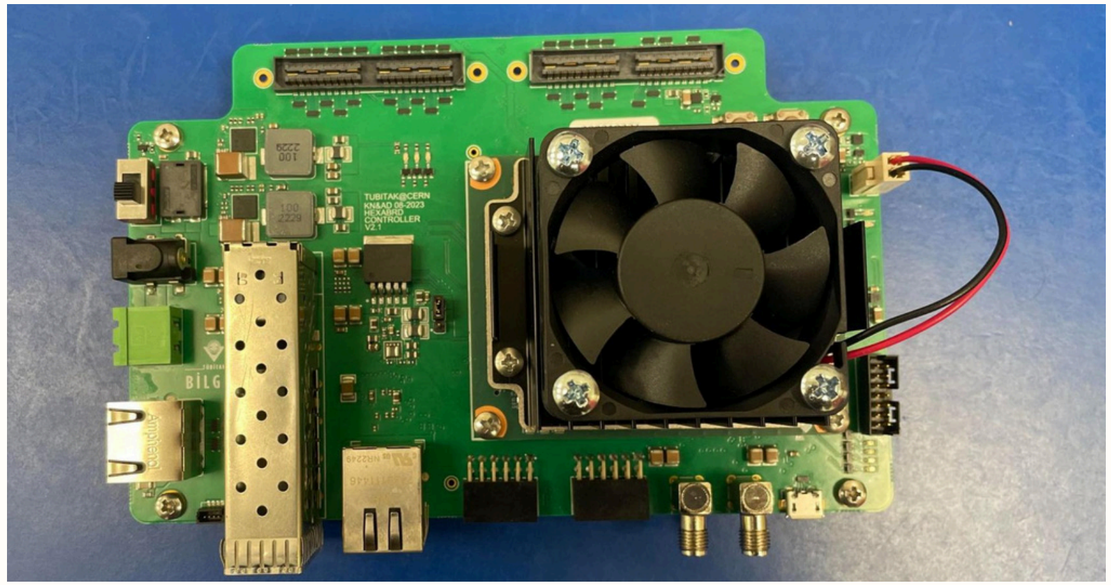
- Instal Electrical Discharge mats (ESD) in Lab 6



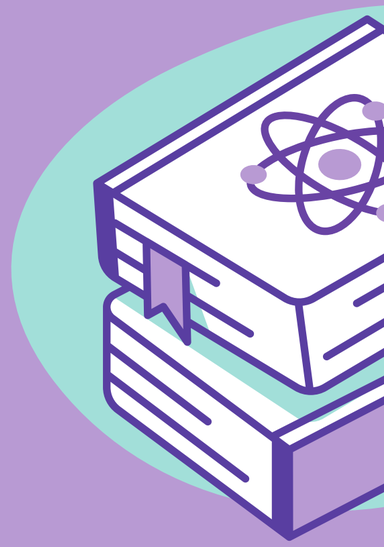
Summer Side Quests 🕺

- Assemble KRIA controller





Link to documentation:
https://docs.google.com/document/d/13FwABFxElWnVvIeaSN9EKKLqg0dUxfsz_N-3nI5yVxA/edit?usp=sharing



THANK YOU

https://www.canva.com/design/DAGL9x0OE_w/fGiC4P-gZUNKti-DjBr8qQ/edit?utm_content=DAGL9x0OE_w&utm_campaign=designshare&utm_medium=link2&utm_source=sharebutton