Setup for tile testing

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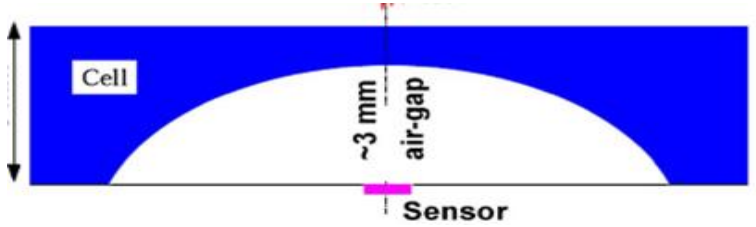
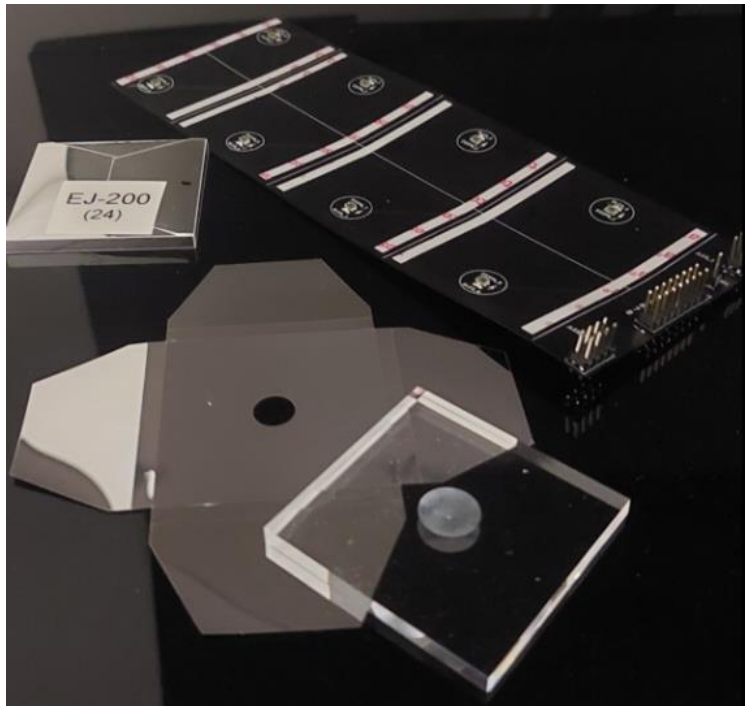
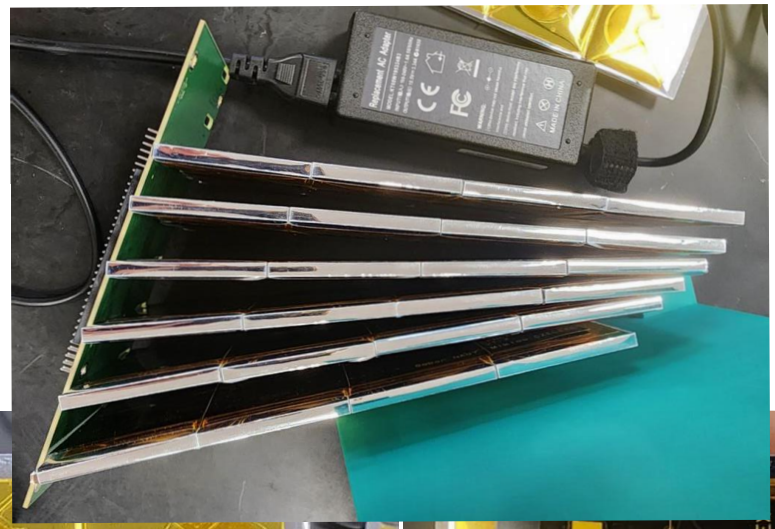
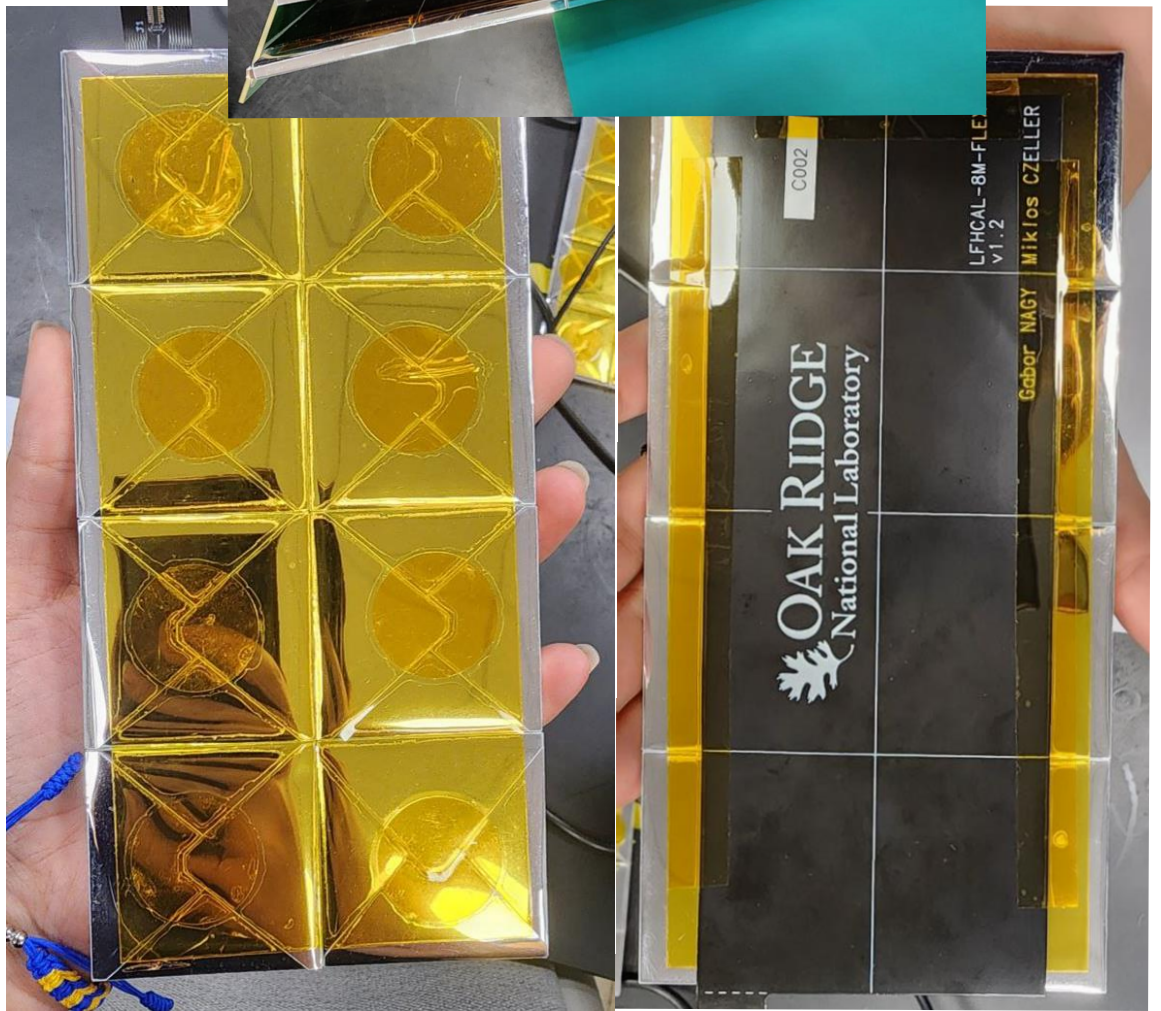
LFHCAL tiles

- CALICE AHCal inspired SiPM-on-tile approach
- Tiles and SiPM from Oak Rige for initial tests
- Concave tile





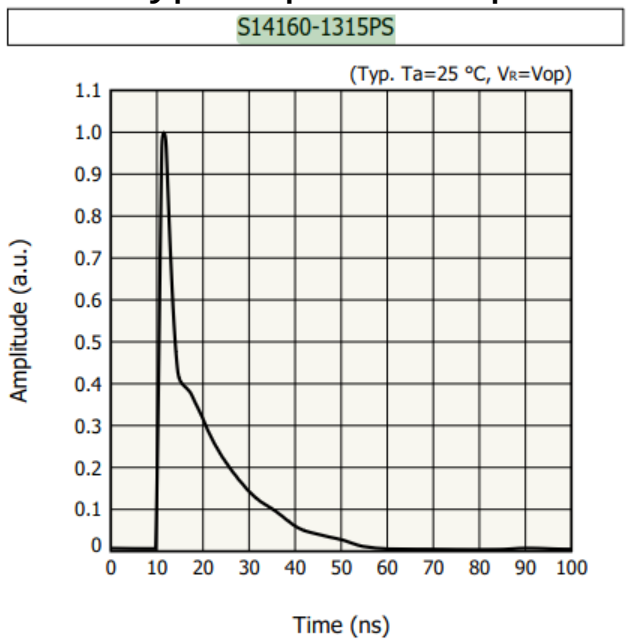




SiPM on PCB board

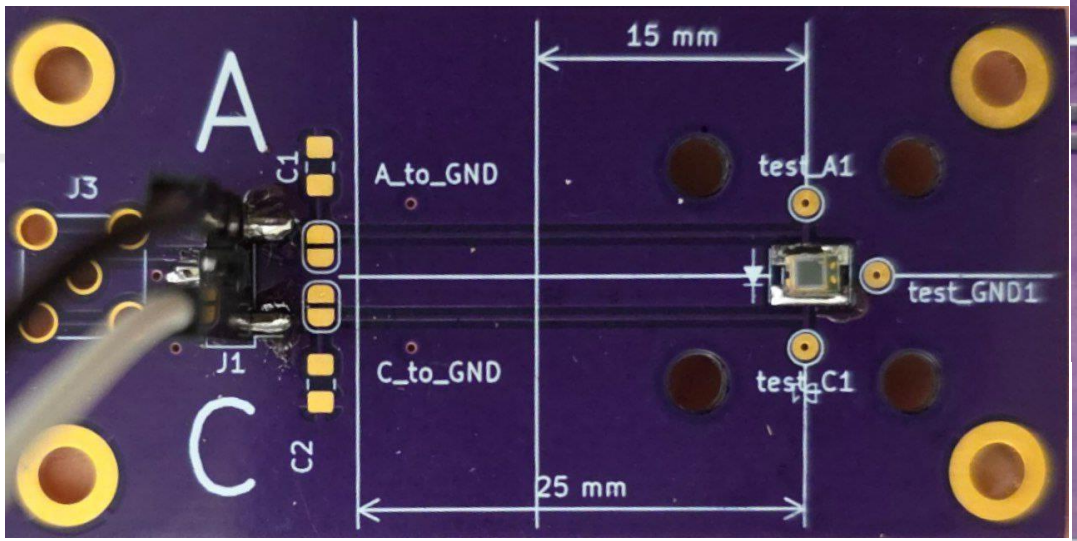
- S14160-1315PS
- Photosensitive area (mm): 1.3 × 1.3
- Number of pixels: 7284
- Breakdown voltage (V): 38 ± 3

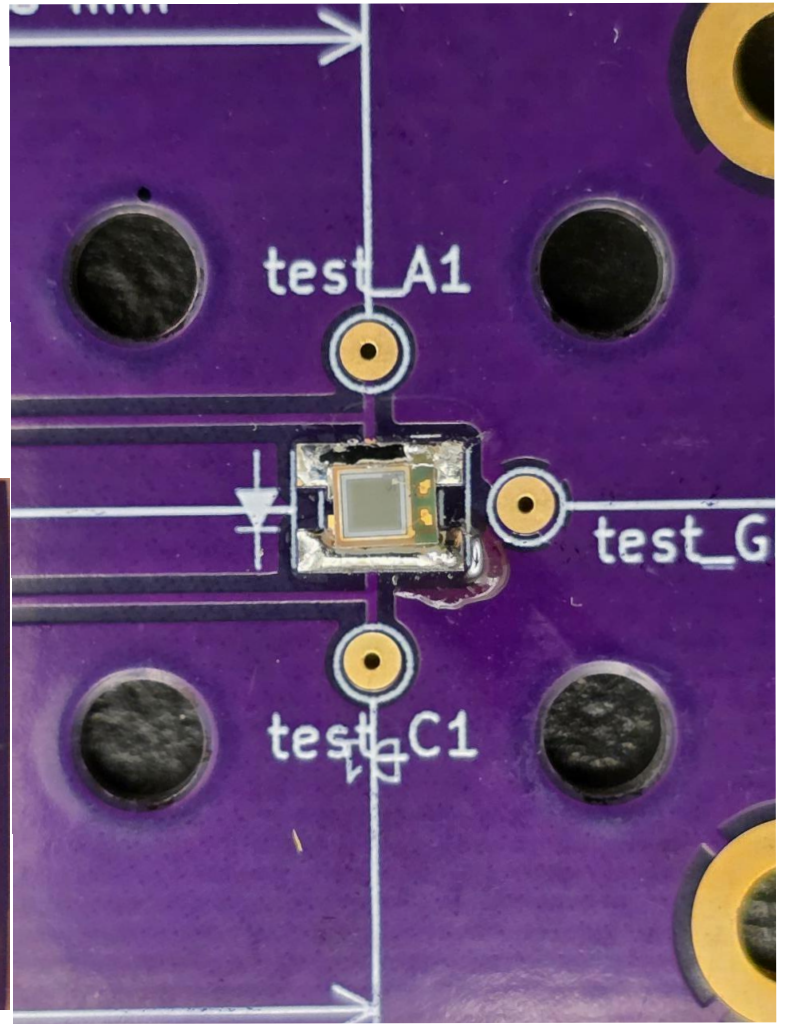
Typical pulse shape



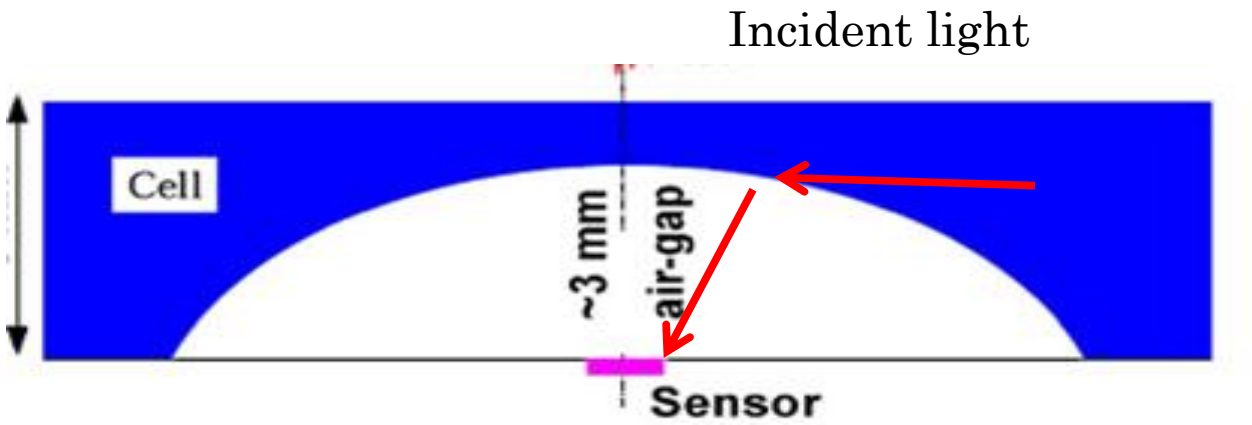
Applications

- High energy physics experiments
- Fluorescence measurement
- Flow cytometry
- DNA sequencers
- Environmental analysis





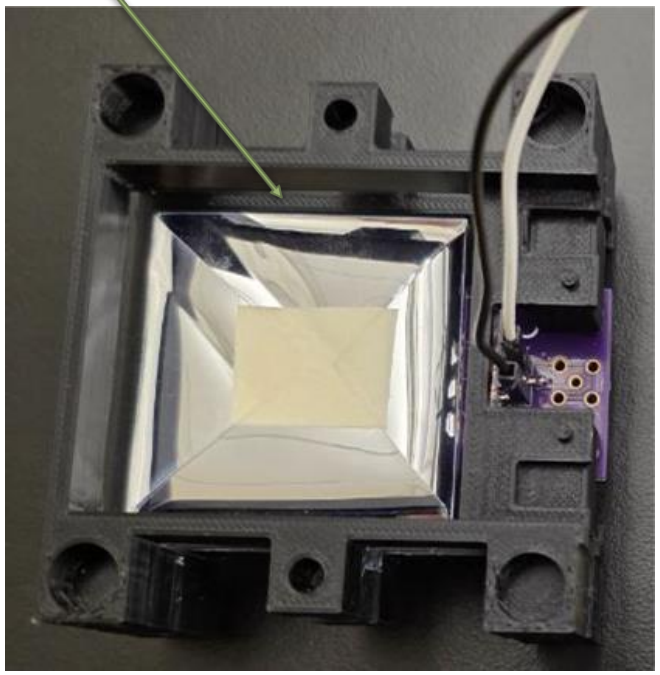
How is the SiPM physically connected to the tile?

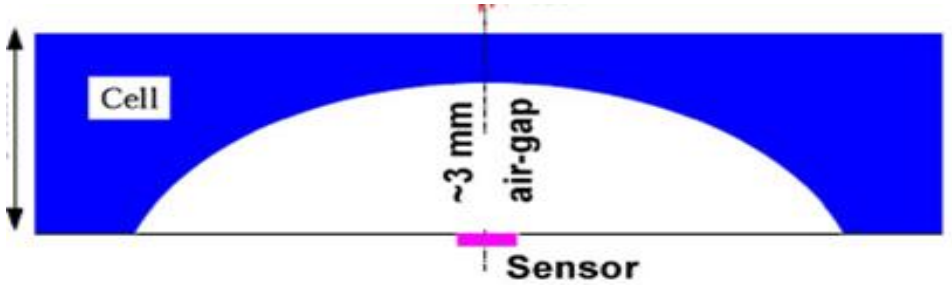


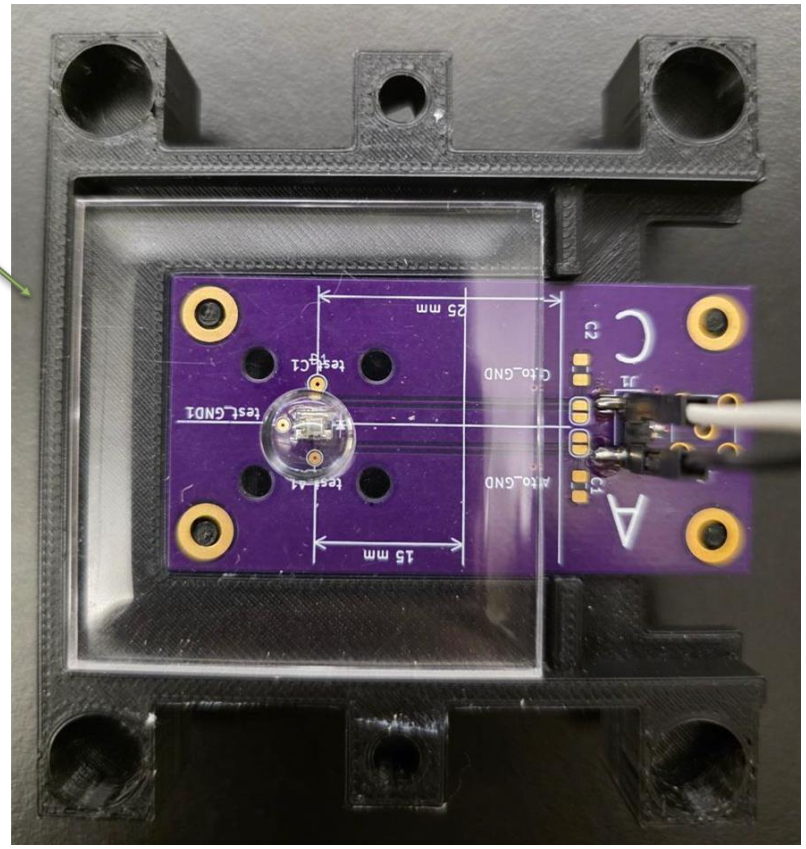
- In this configuration there is no physical connection between SiPM and tile
- The spherical hollow acts like an optical lens
- It causes photons that scatter inside the tile to be redirected downward toward the SiPM located underneath
- This design increases the probability that light generated far from the SiPM still reaches it, helping recover signal from across the tile

How is the SiPM physically connected to the tile?

- In this configuration there is no physical connection between SiPM and tile
- Unwrapped Tile on top of the SiPM
- Wrapped Tile on top of the SiPM





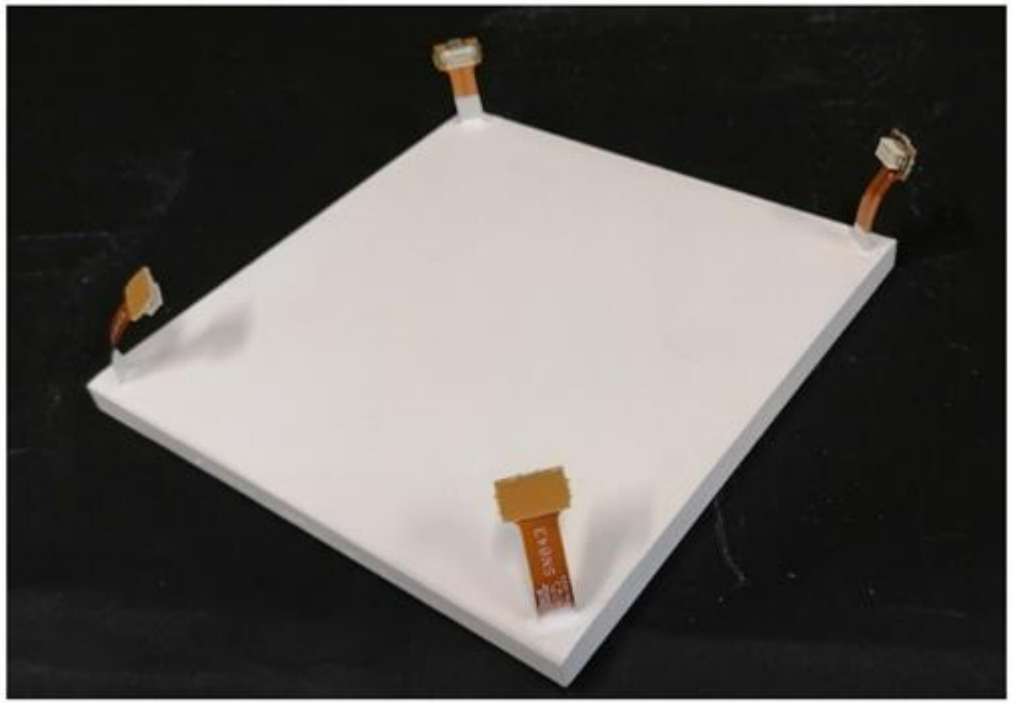


Why is the spherical hollow visible in the unwrapped tile you hold in your hand not visible in the photo with the different tile sizes / thicknesses?

- As tile size increases, the SiPM-on-tile approach becomes less effective due to:
  - Uniformity degrades with larger tiles
  - The optical features become less prominent in large tiles due to longer photon travel paths and increased internal scattering
- As alternative we going to test different SiPM placement

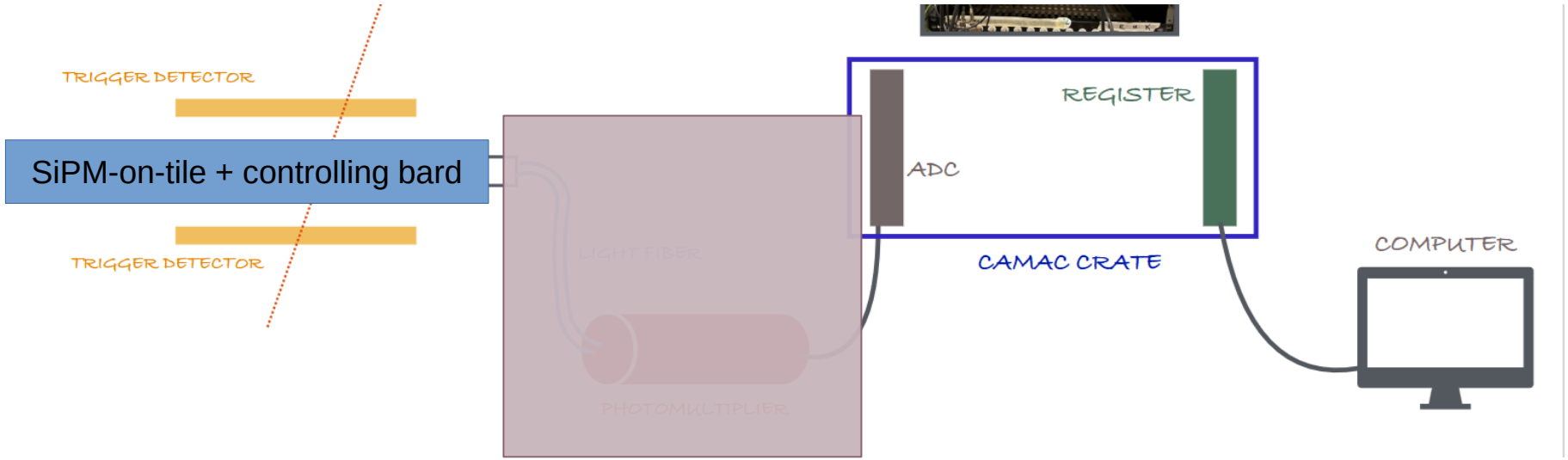
Wrapping: alternative

- Even small tiles are difficult to wrap perfectly, often leaving gaps at the corners and air gaps, folds, or wrinkles which can scatter light unpredictably
- Edge artifacts can lead to position-dependent signal variations → worse uniformity
- Over time, adhesive tapes can peel or degrade, especially with temperature changes or humidity
- Larger tiles make this problem worse, creating bigger unwrapped areas
- Instead of foil wrapping, a white reflective paint can be used, for example
  - Four SiPMs are attached to flex cables, which are glued into grooves at the tile corners for optical readout.

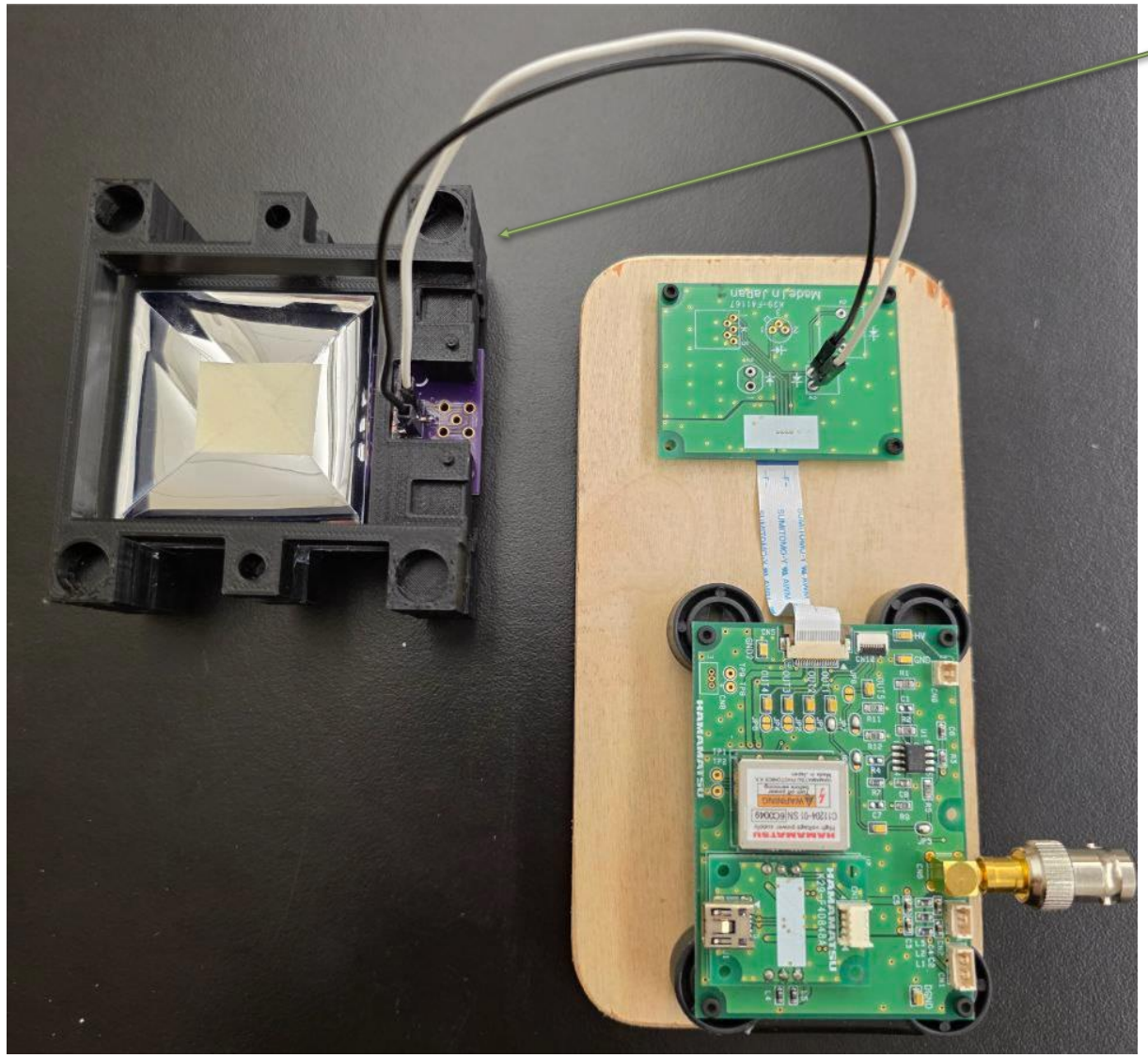


Is the controlling board an explicit component of the sketch Maria showed last Tuesday, page 5 of the slides uploaded to the nHCal indico? Is it shown in any of the photos of the muon telescope?

- No, here is the more right way to show it
- Also, there is no fibers+PMT → instead we have SiPM-on-tile

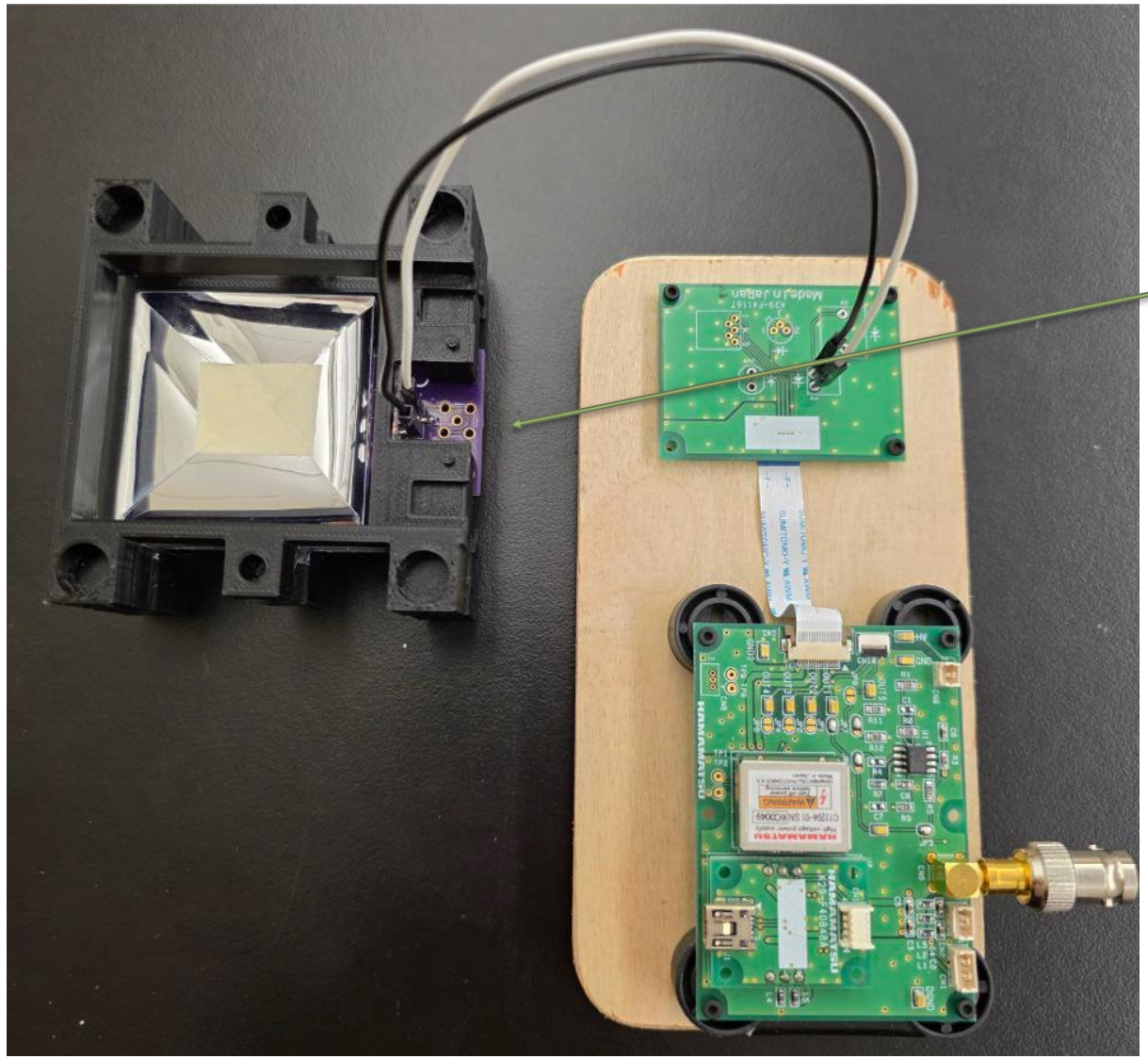


SiPM control board



- The black 3D-printed housing holds a scintillator tile with reflective coating
- The purple PCB next to the tile hosts the SiPM socket and initial signal routing
- Hamamatsu Readout Module (C11204-01)
  - SiPM bias voltage generator
  - Amplifier chain: SiPM current pulses to voltage signals
  - Analog output (SMA): connector sends analog signal to scope/DAQ
  - USB control
  - Flat ribbon cable interface

SiPM control board



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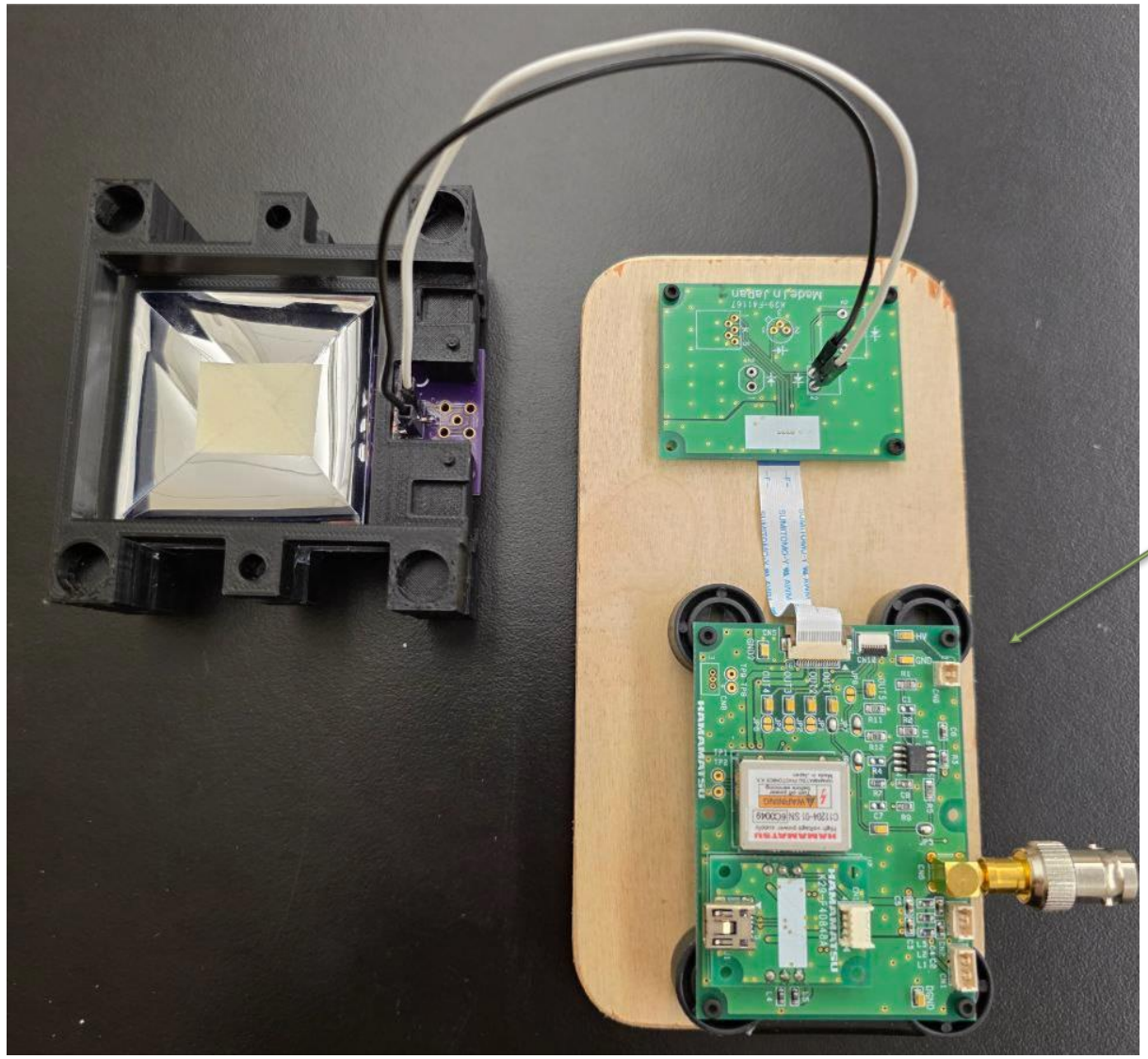

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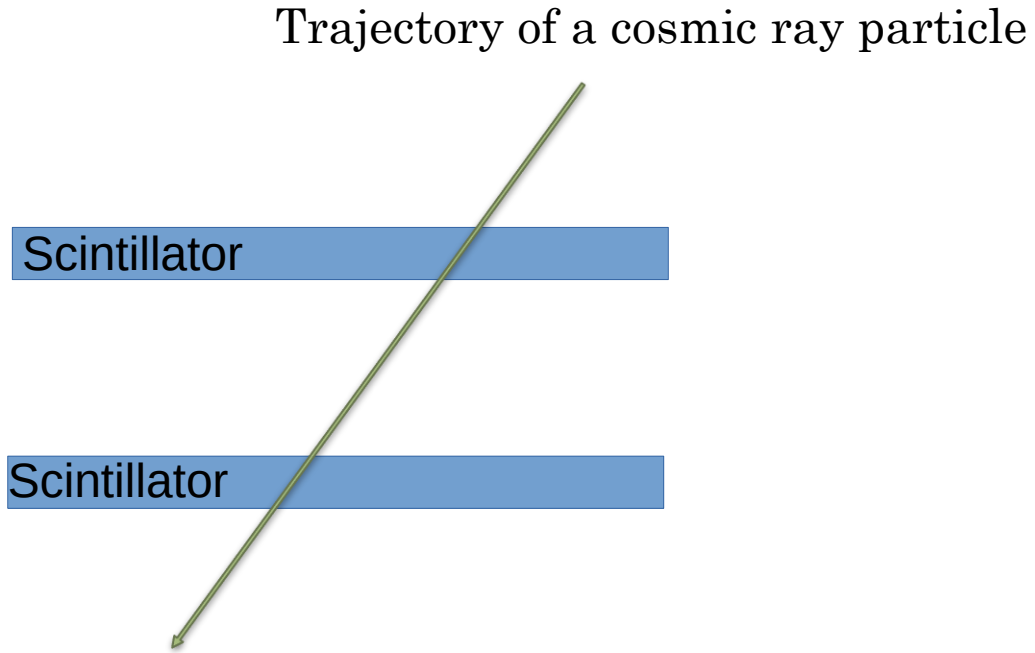
Initial testing: the idea

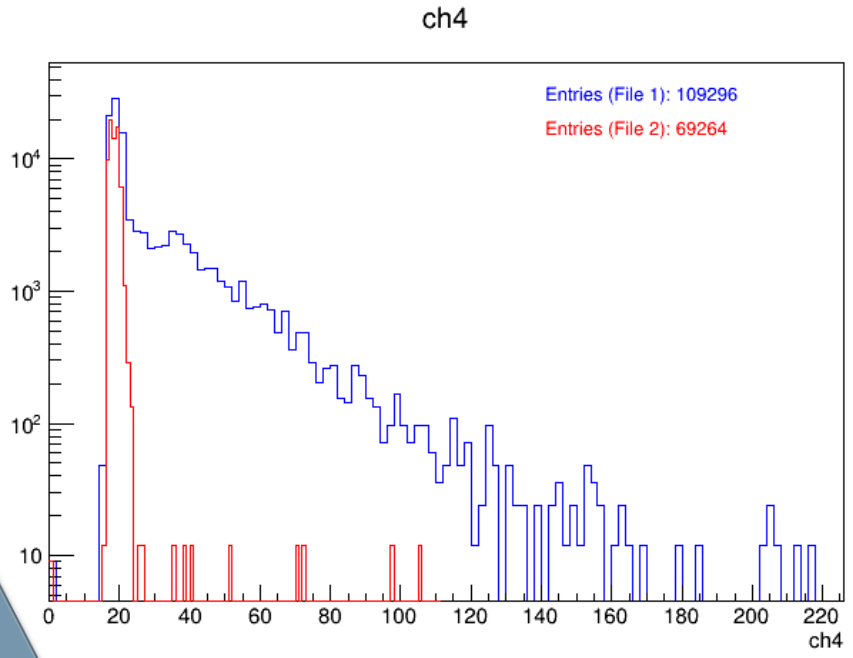


Cosmic ray testing setup

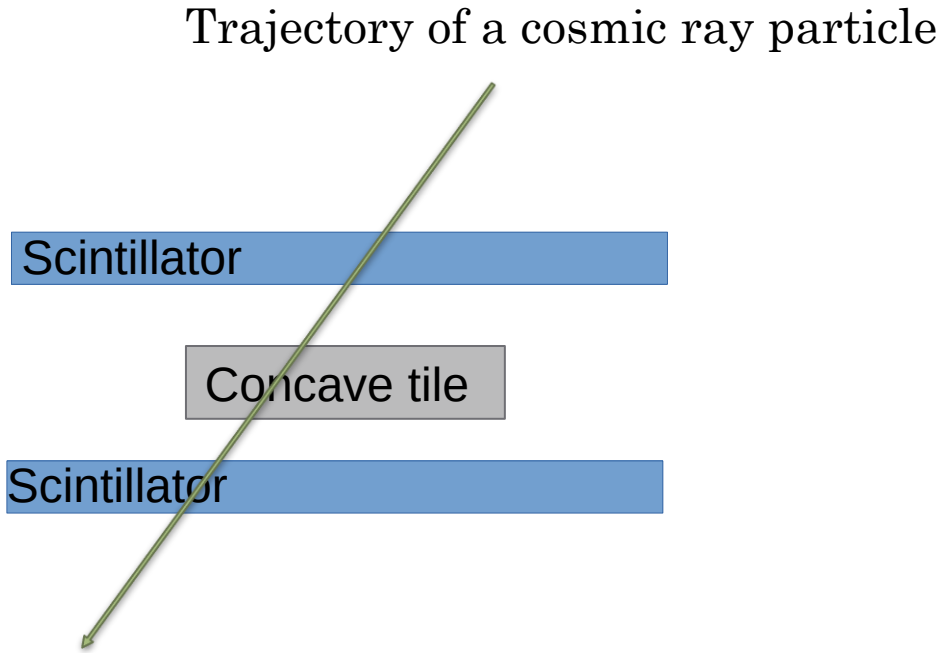
- A simple muon telescope:
  - Two scintillators placed above and below the test tile
- Trigger condition:
  - A valid event occurs only when both scintillators detect a signal in coincidence
- If there is no coincidence:
  - Ignore the event as background

Setup: muon telescope

Background Data



Oak Rige tiles testing



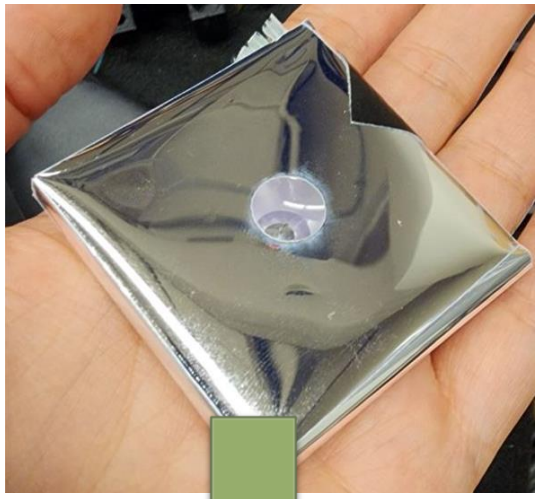
Cosmic ray testing setup

- A simple muon telescope:
  - Two scintillators placed above and below the test tile
- Trigger condition:
  - A valid event occurs only when both scintillators detect a signal in coincidence
- When a coincidence is detected:
  - Open the gate to read out the signal from the concave test tile
- If there is no coincidence:
  - Ignore the event as background

Setup: muon telescope

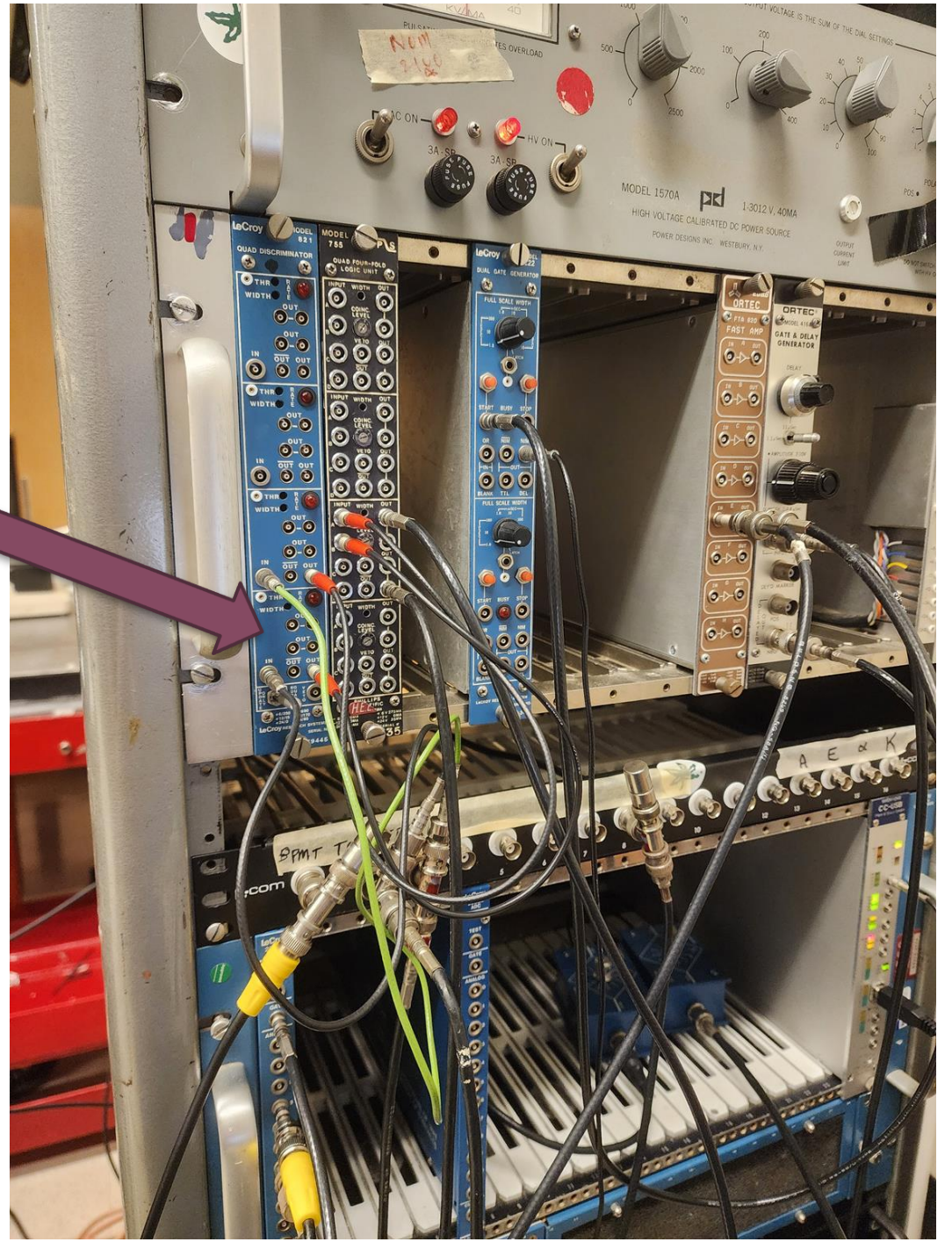
Putting SiPM-on-tile in between triggering scintillators → data from tile

Background Data



Electronics

- Scintillator on Top → PMT → Discriminator
- Scintillator on the Bott → PMT → Discriminator
- → Coincidence (AND logic)
- → Gate signal
- → CAMAC ADC integration window



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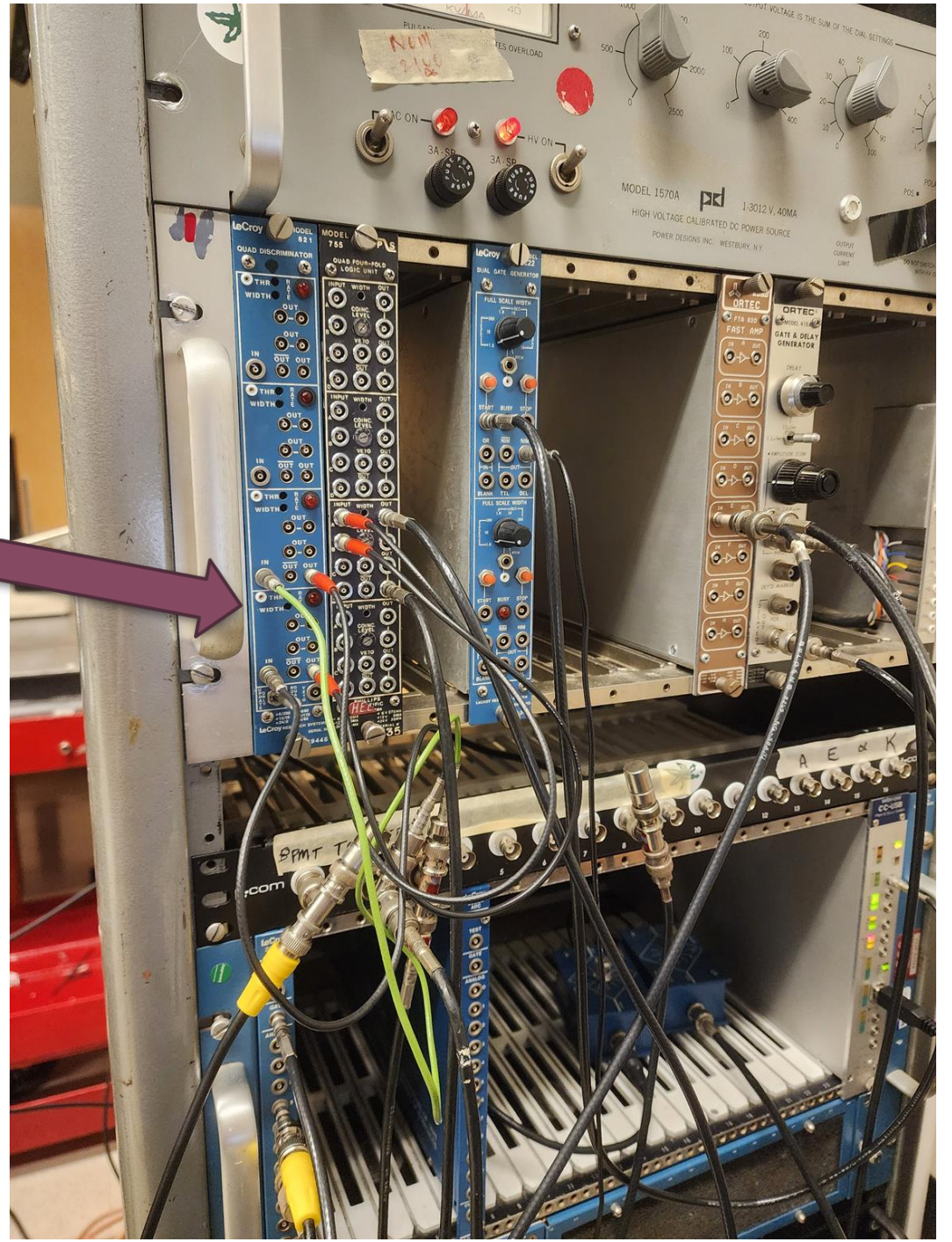

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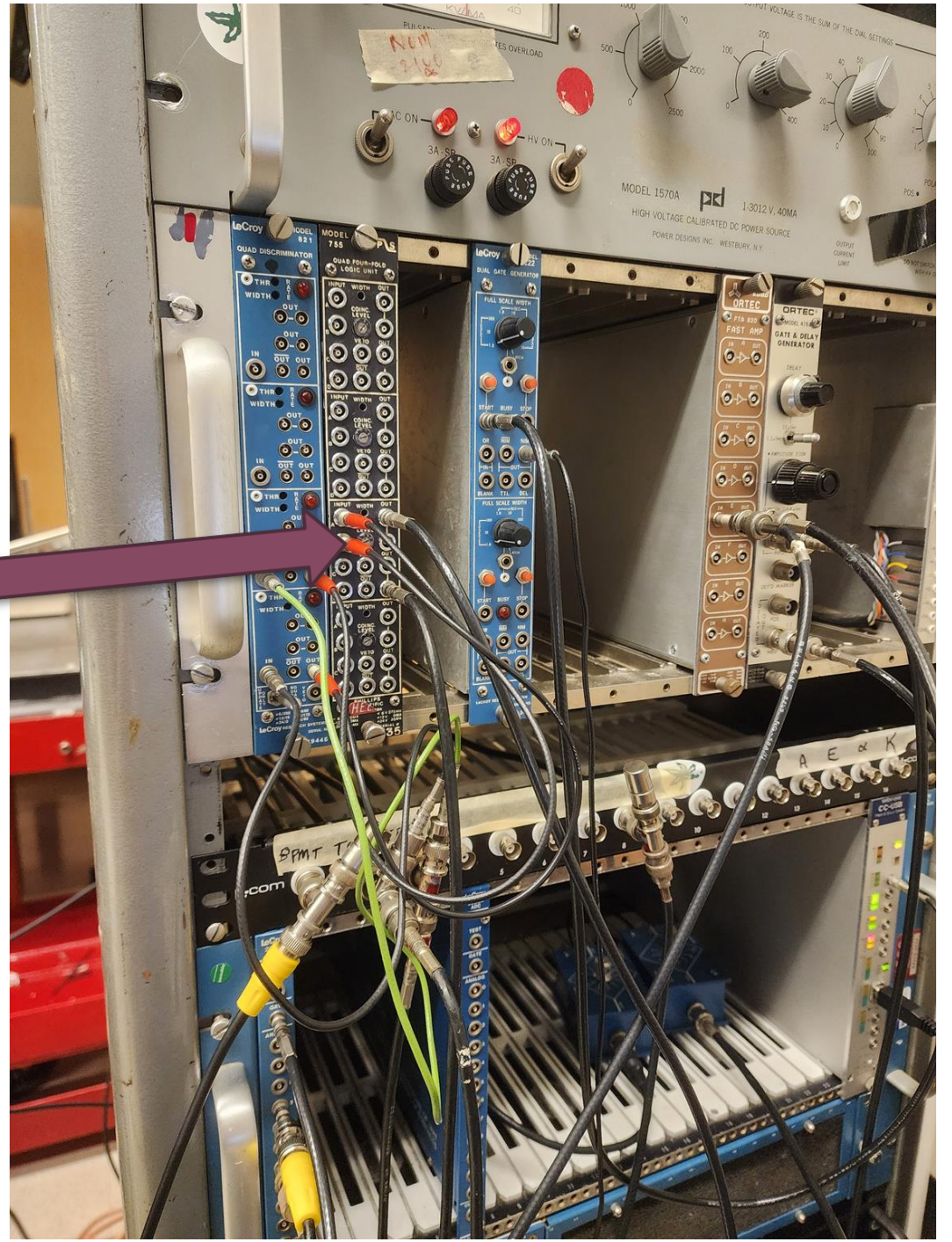

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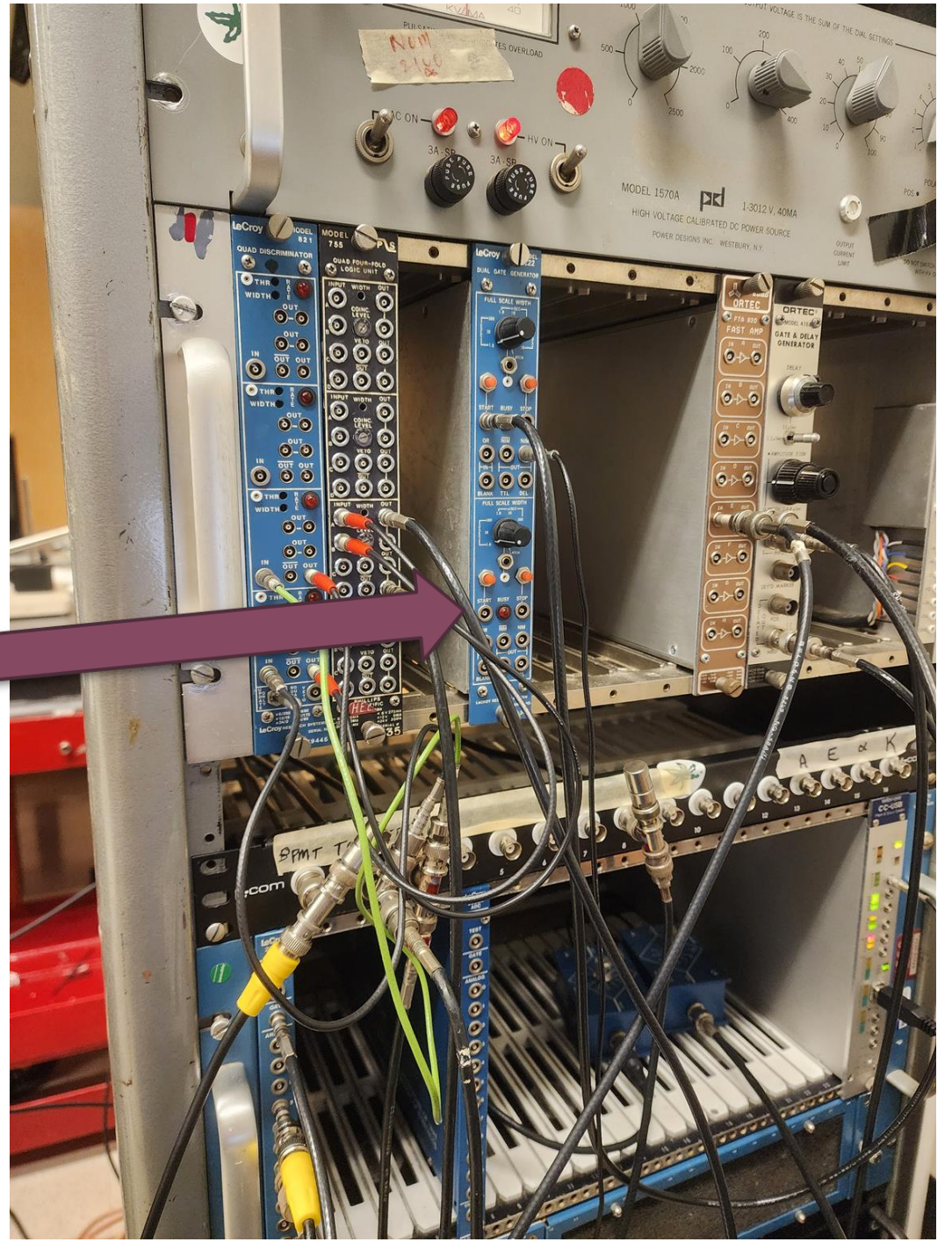

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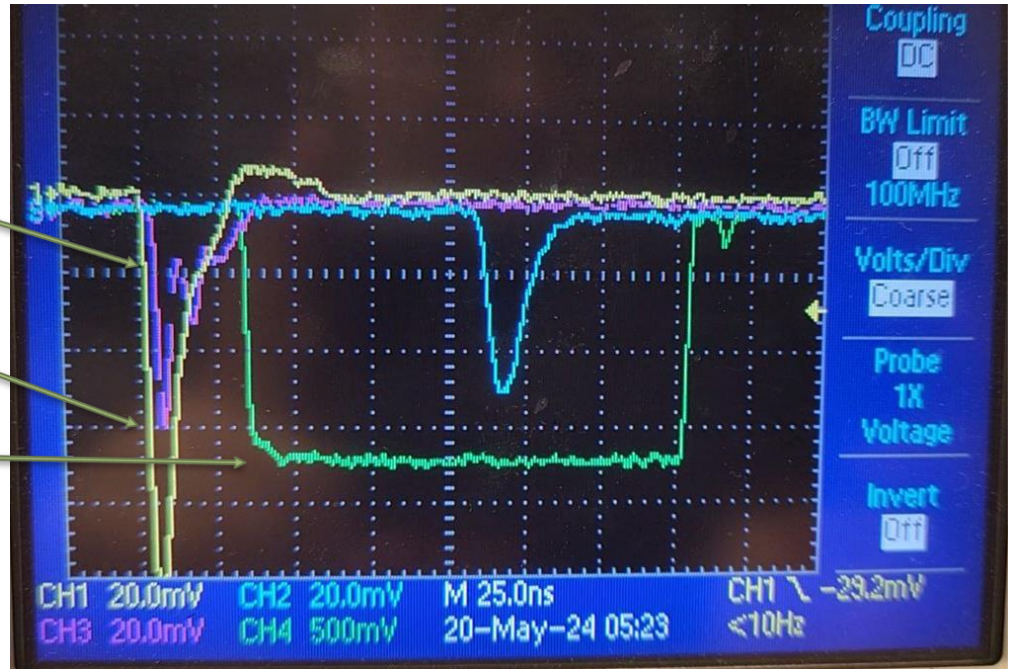
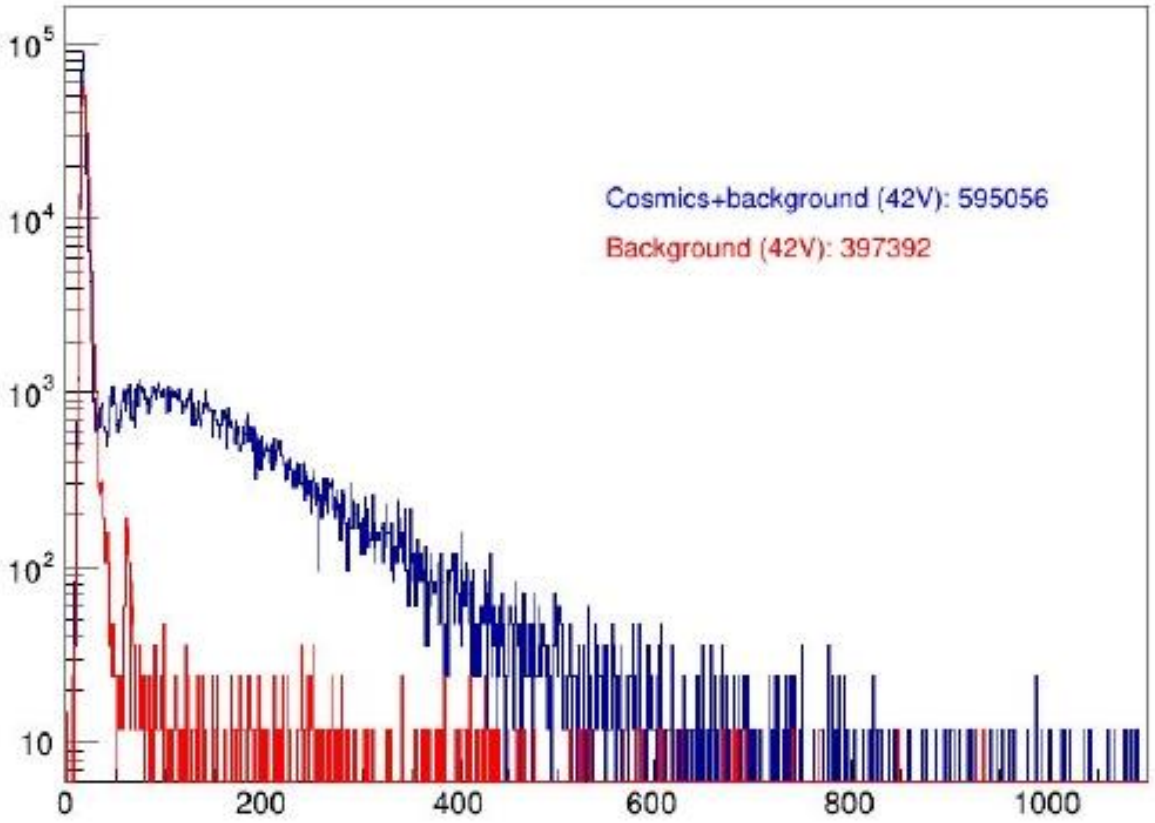
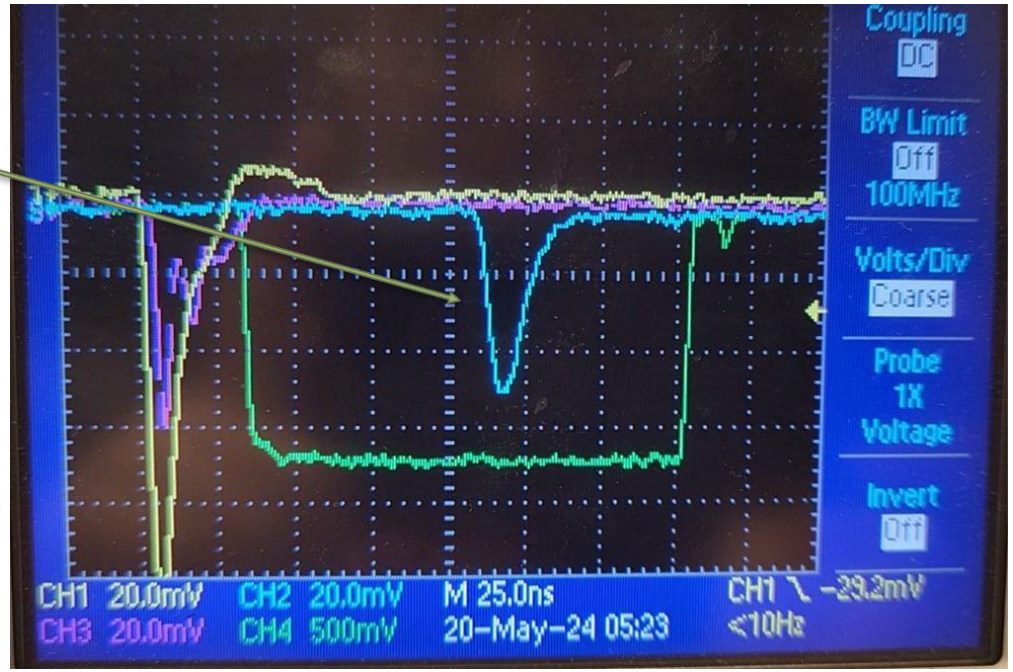


Electronics

- Delayed (by purpose) signal from SiPM-on-tile





Plan

- Cosmics → Sr-90 source
  - Half-life: 29.1 years
  - Mode of decay: Beta radiation

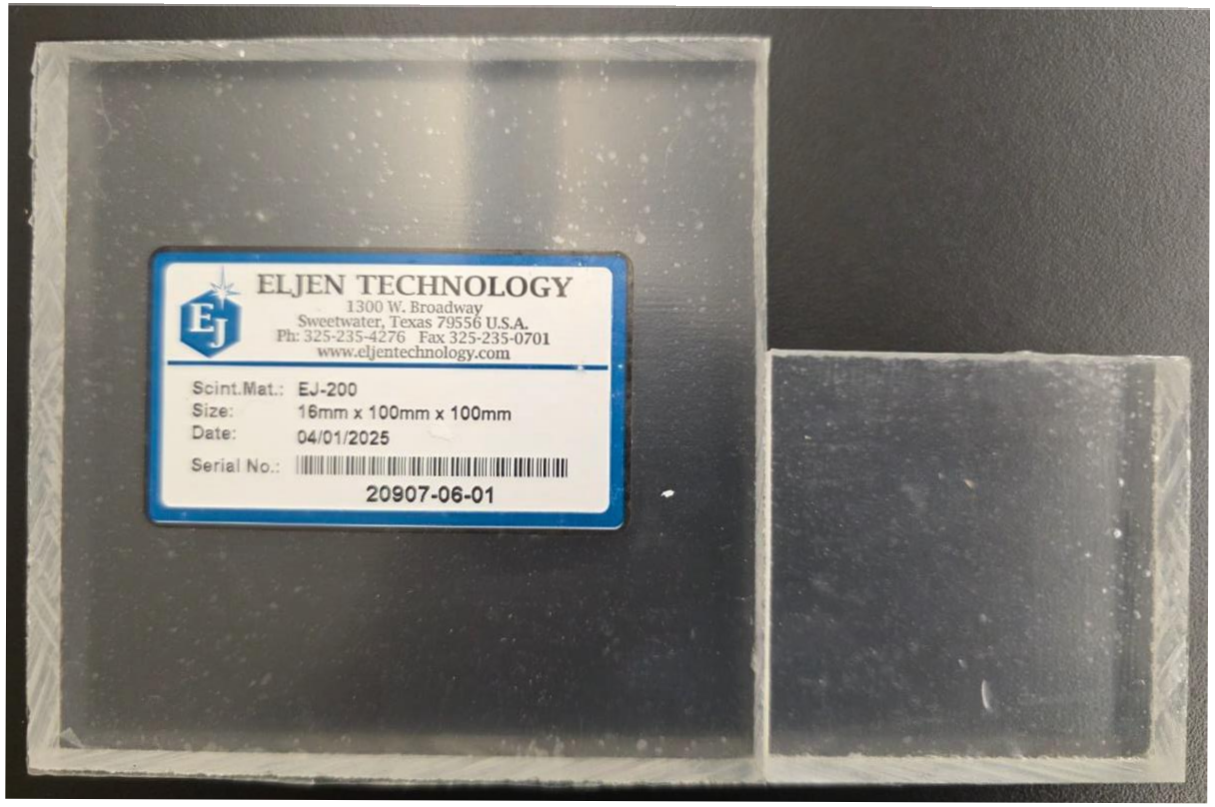
- E < 0.546 MeV $^{90}\mathrm{Sr} \rightarrow {}^{90}\mathrm{Y} + \beta^- + \bar{\nu}_e$

Can penetrate ~1cm of plastic

- E < 2.28 MeV $^{90}\mathrm{Y} \rightarrow {}^{90}\mathrm{Zr} + \beta^- + \bar{\nu}_e$

Plan

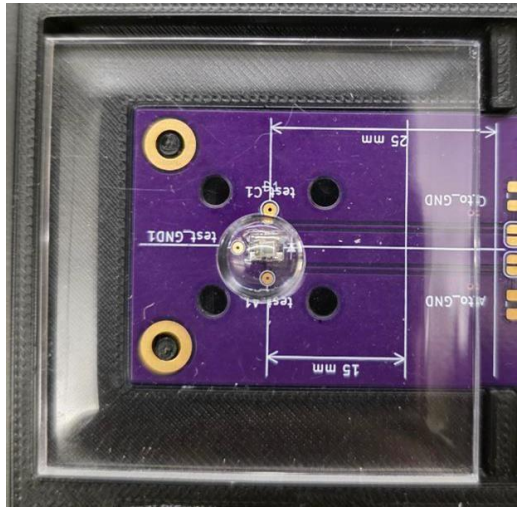
- Vary tile size (5×5 cm², 10×10 cm²)

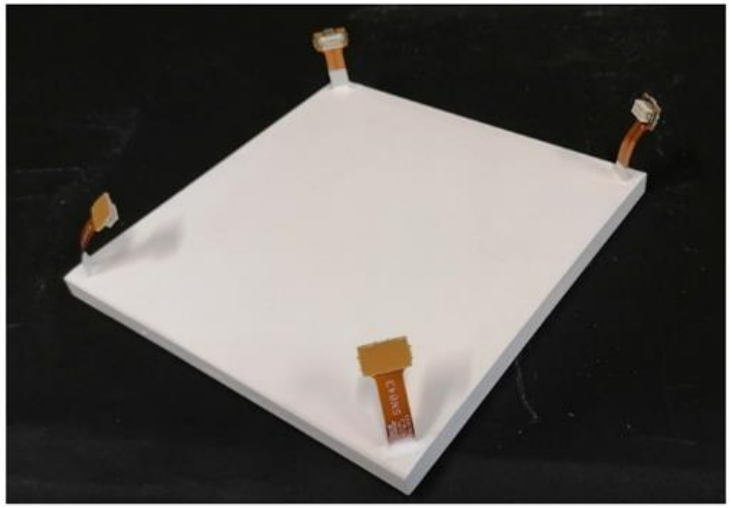


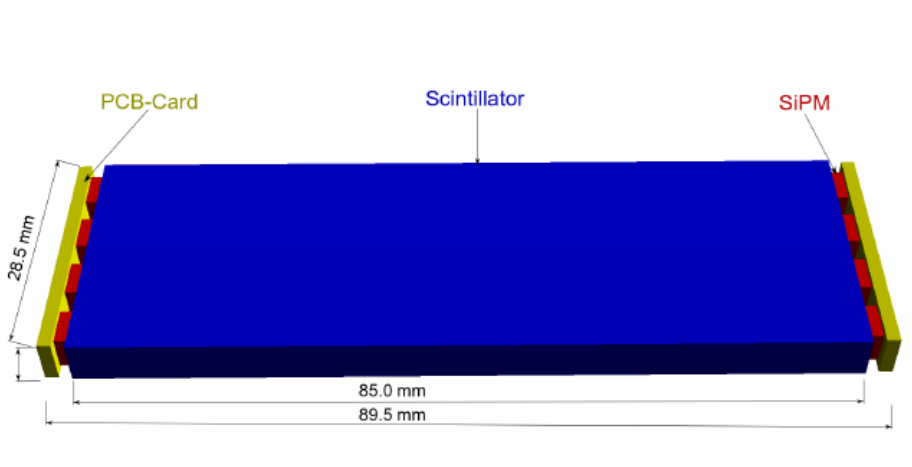
Plan

- Vary tile thickness (4,6,8 mm)

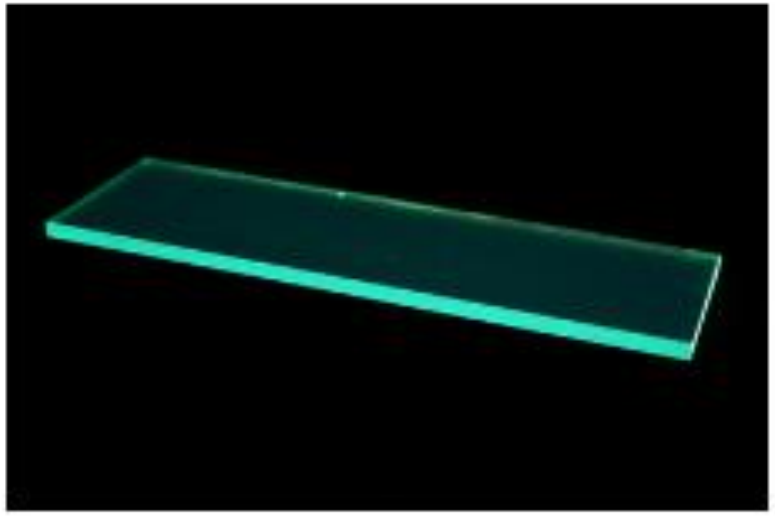
- Vary SiPM placement (center, corner, edge)

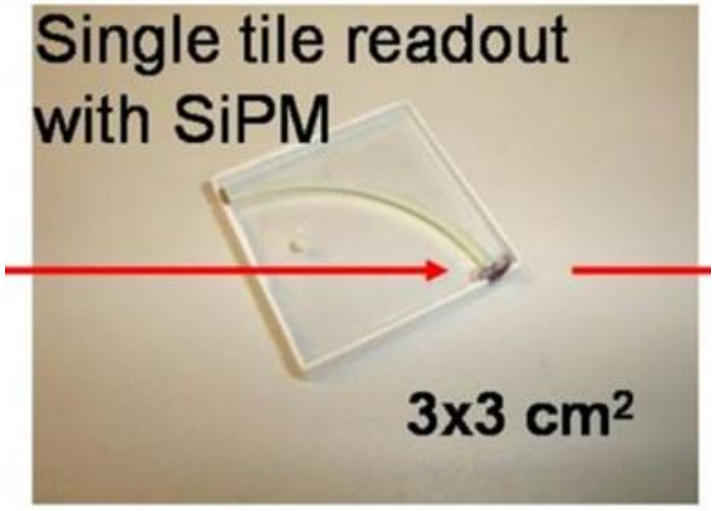


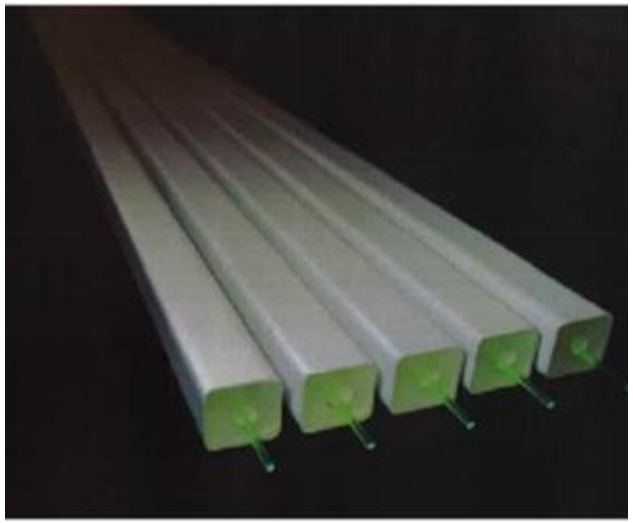




- Vary SiPM placement: with wavelength shifting bars, fibers







Plan

- Cosmics → Sr-90 source
  - Vary tile size (5×5 cm², 10×10 cm²)
  - Vary tile thickness (4,6,8 mm)
  - Vary SiPM placement (center, corner, edge), with wavelength shifting bars, fibers
  - Tile coating (wrapping, painting)
- Check performance:
  - Light yield per MIP
  - Signal uniformity
  - Long range plan: timing resolution, optical cross-talk (if relevant; configuration-dependent)
- Target timeline: ~2 months, aiming for completion by July 11 (ideally)