Quintuple GEM CsI Ring Imaging Cherenkov Detector

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Abstract

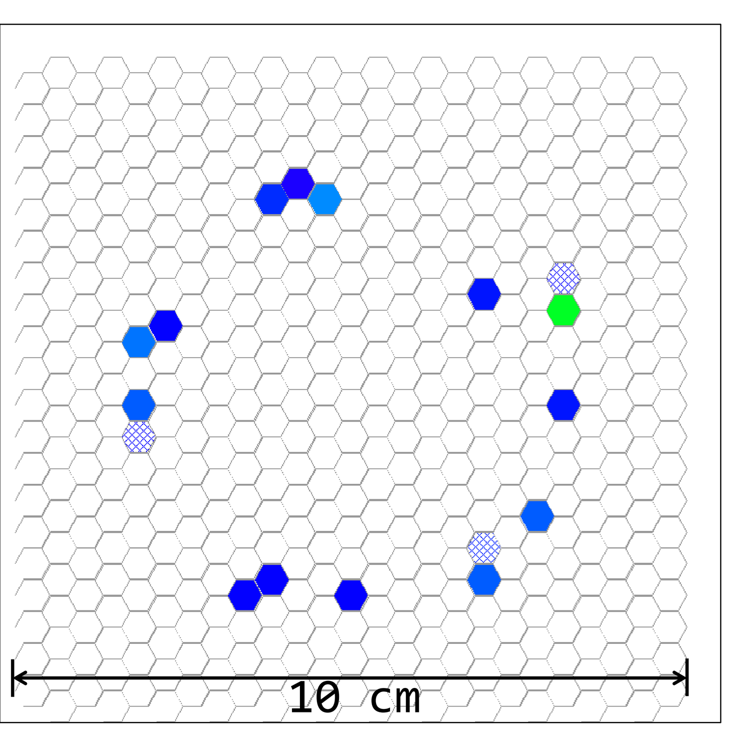
This research presents performance capabilities of an R&D endeavor to develop a quintuple Gas Electron Multiplier (GEM) RICH detector, whose purpose is to resolve particle velocity at high momenta (~60 GeV/c) for future use in an EIC environment. We demonstrate detector performance via the detection of Cherenkov rings on a hexagonal array of readout pads, from which we obtain a course resolution measurement of ring radius, and a count of photons per ring. The experimental results presented herein were performed at the newly established End Station Test Beam (ESTB) Facility at the Stanford Linear Accelerator Center (SLAC) in Menlo Park, CA, and demonstrates successful use of the facility by the inaugural group of outside users.

Motivation

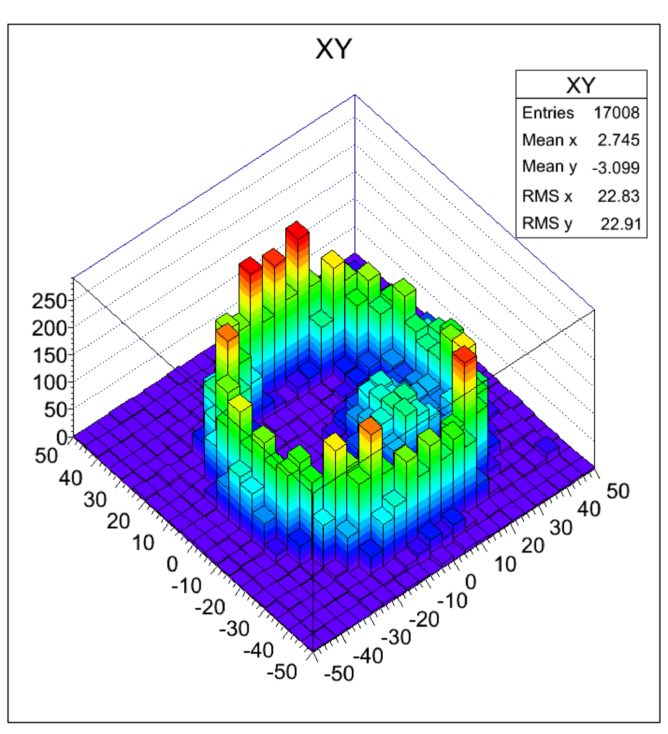
The Quest for a Better RICH: The current state of the art for RICH detectors stands to be improved. Present-day RICH detectors in use at existing collider facilities are large, employ many expensive photomultiplier tubes, are limited in velocity resolution for higher momenta particles by the index of refraction of the radiating gas. Lower n reduces photon yield which can best be recouped in the deep UV, where Cherenkov radiation is strongest. Here, we push the boundaries of the state-of-the-art in RICH design, embarking on a quest for a smaller, more affordable, more flexible, more precise RICH detector.

Results & Analysis

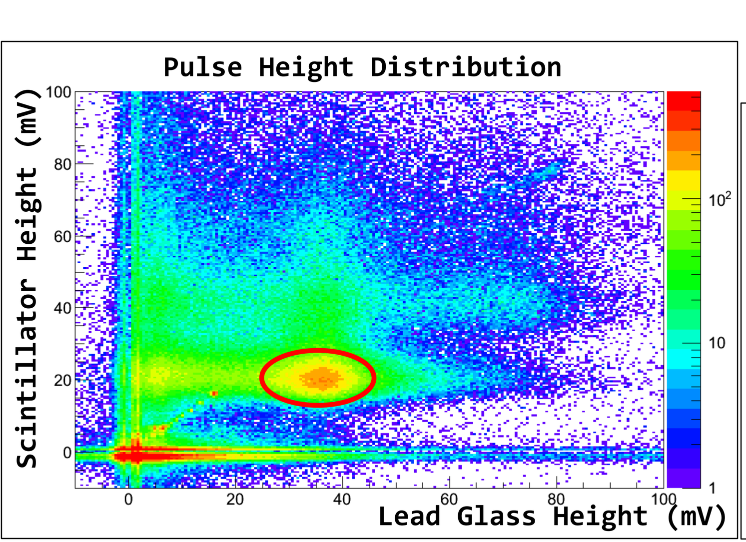
A 5 Hz, 9 GeV electron beam was directed toward the apparatus. The electrons created Cherenkov radiation as they travelled through the CF4 in the detector. These photons were converted to electrons by a CsI photocathode. That electron signal was multiplied by the GEM stack and collected by the readout electronics. Data acquisition is handled by an SRS and software developed at Brookhaven National Lab.



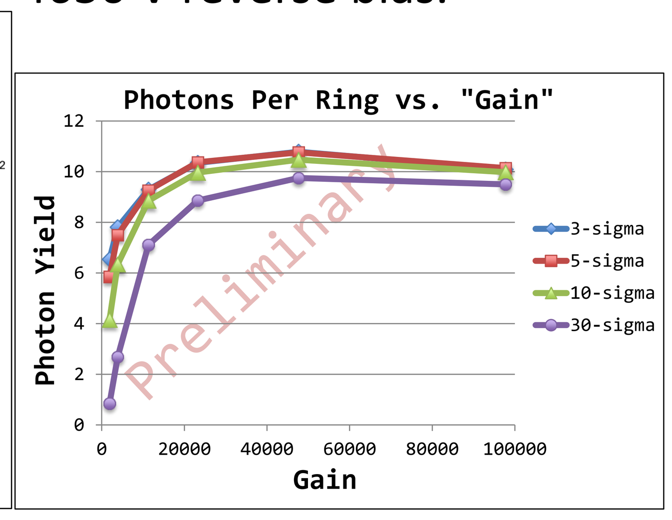
A single Ring: Software generated printout of of the charge accumulated by each hexagonal readout pad. Pulse heights are indicated by a combination of colored and hashed hexagons. Data collected at 4750 V reverse bias.



Integrated Ring: Shows uniform position sensitivity of the detector. The outer ring is produced by the Cherenkov photons. The blob interior to the ring is ionization from the electron beam. Data collected at 4650 V reverse bias.



Pulse Height Distribution: Scintillator vs. Lead Glass. The region circled in red shows the correlation between the two signals which represent when one electron passed thru the detector.



Gain Curve: Presents photon yield (as determined by a crude cluster algorithm) as a function of gain. Photon yield saturates for gains above 30,000.

The Instrument

A 1-meter long stainless-steel cylindrical chamber is connected to recirculating gas system. Secured at one end is a 7-inch mirror with a MgF2 thin-film coating, specially designed to reflect in the deep UV where Cherenkov radiation is brightest(to maximize photon yield). Readout electronics and the GEM stack adorn the opposite end of the cylinder.

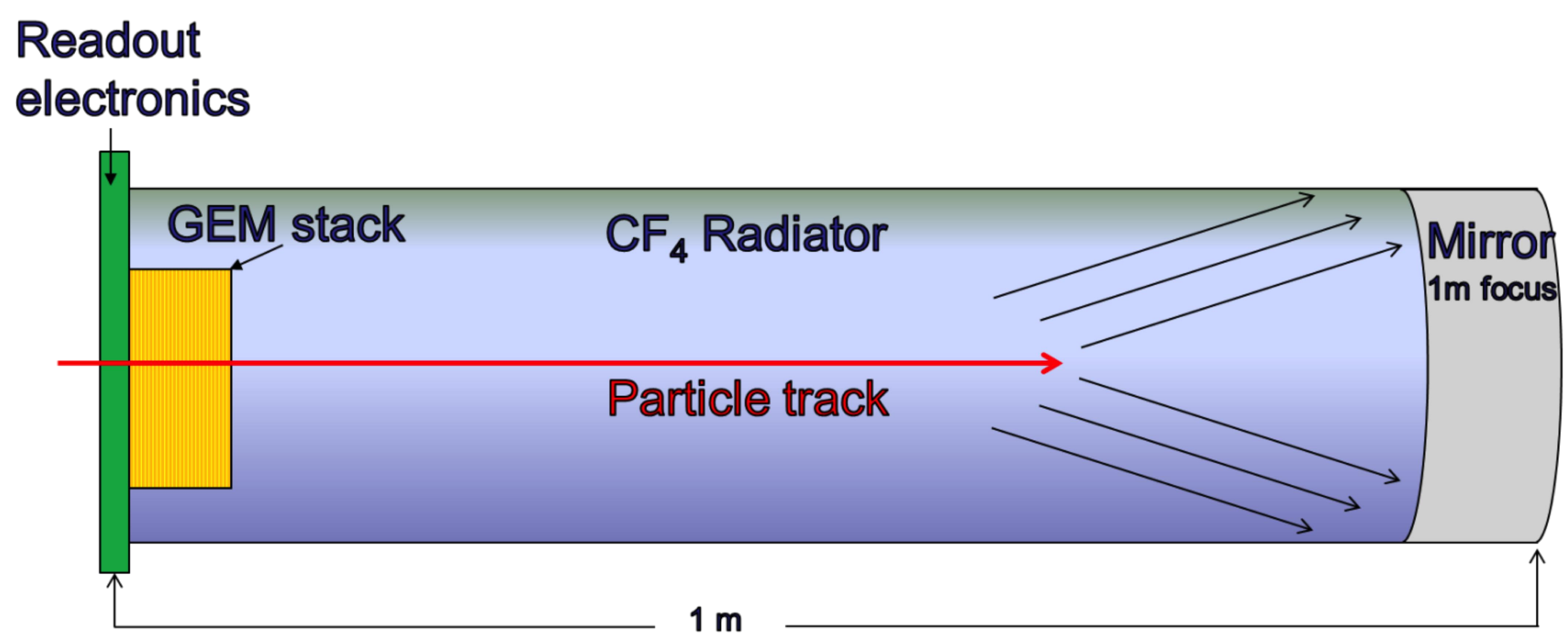
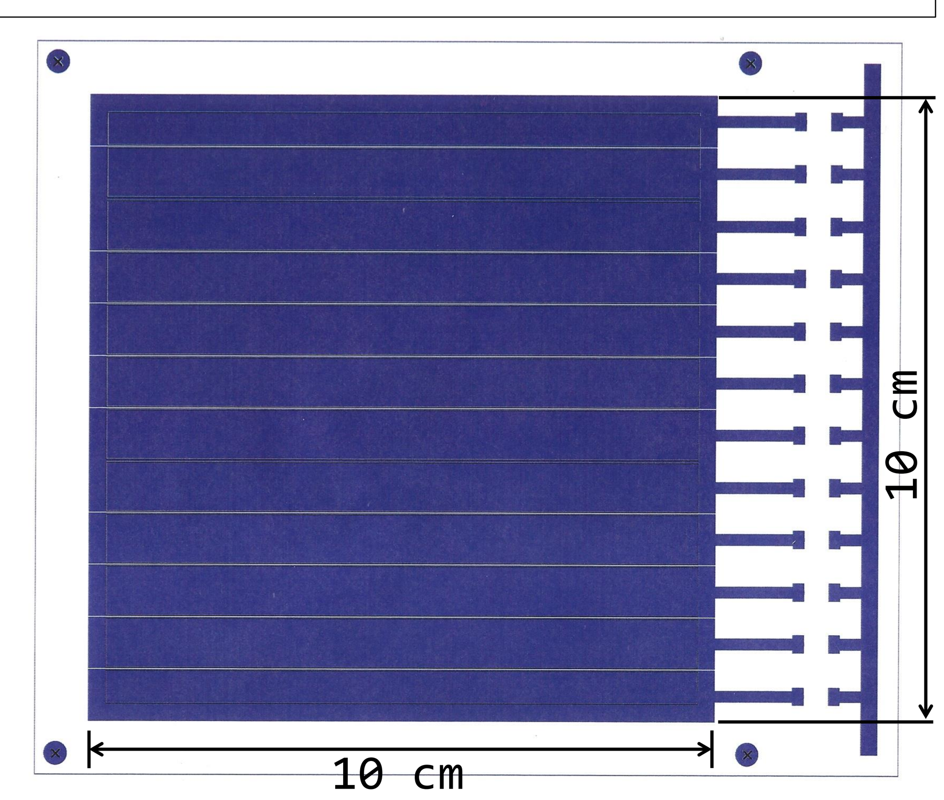


Figure 1: Schematic of the radiator chamber.

Building a Better GEM Stack:

Destructive sparking between the conductive layers on a single GEM was a severe problem on a previous design. Two steps were taken address the sparking issue:

- First was to segment the 10 cm x 10cm active area of the GEM to reduce the stored energy by a factor of 12.
- Second was to achieve better spark detection with a resistive divider chain and a capacitive pickoff at the bottom of the stack, which allows direct monitoring of the charge deposited in an event, and would allow for controlled tripping in a spark condition.



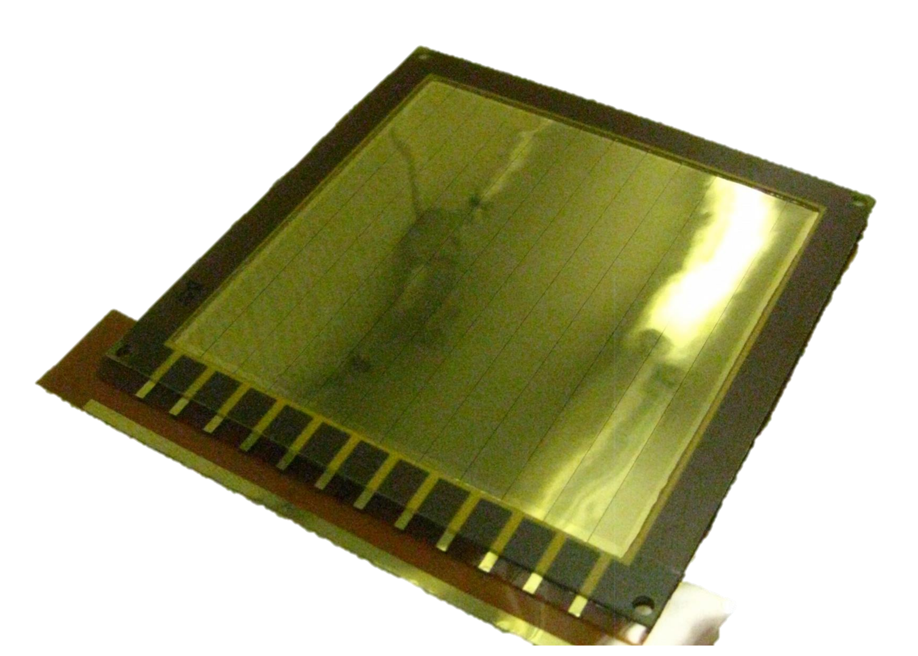


Figure 2 Top: Schematic of segmented GEM foil.
Figure 2 Bottom: Photo of actual framed GEM.

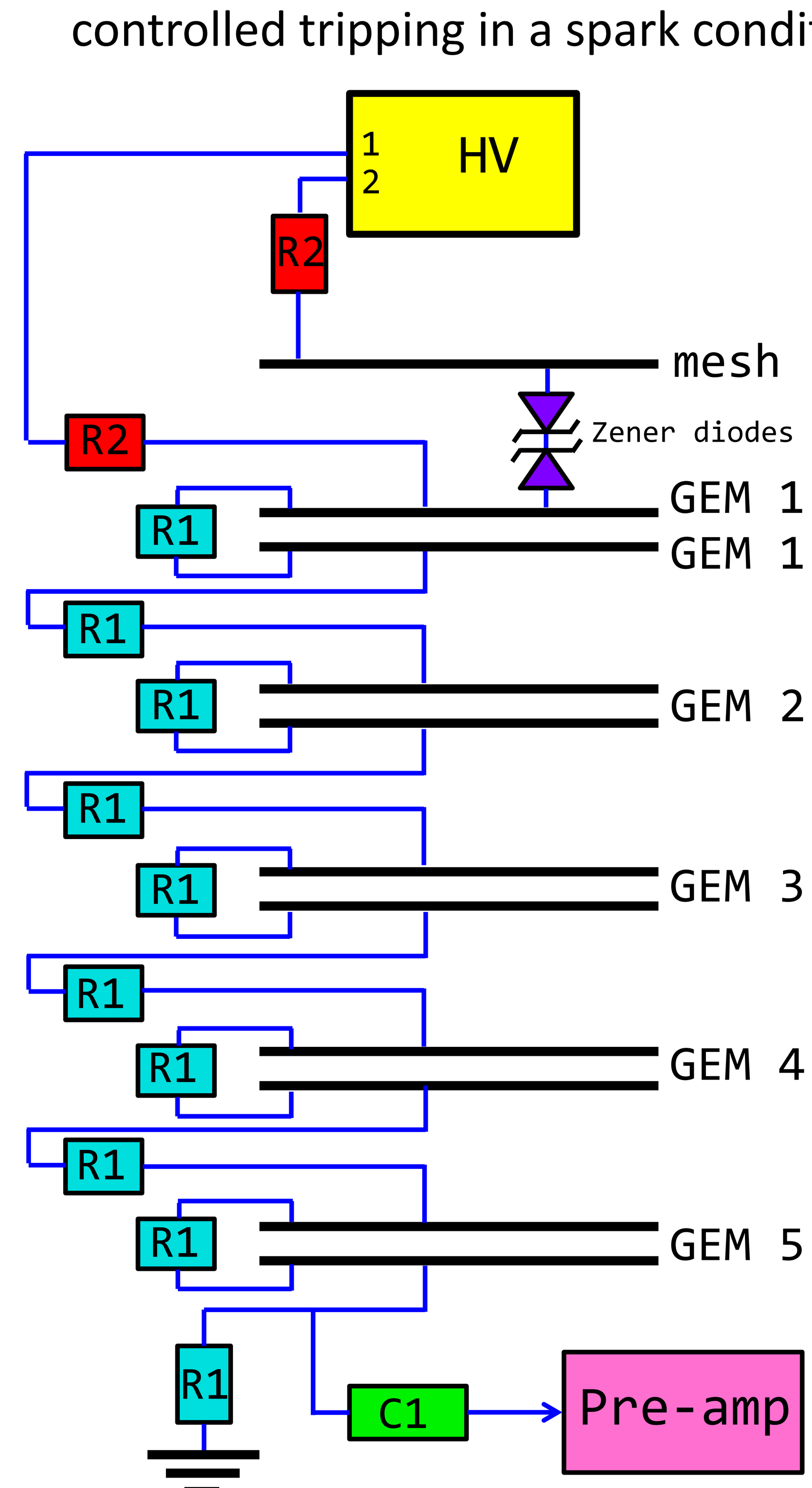


Figure 3: Schematic of GEM circuitry, including protection resistors and capacitor for monitoring sparks and pick-off signal.

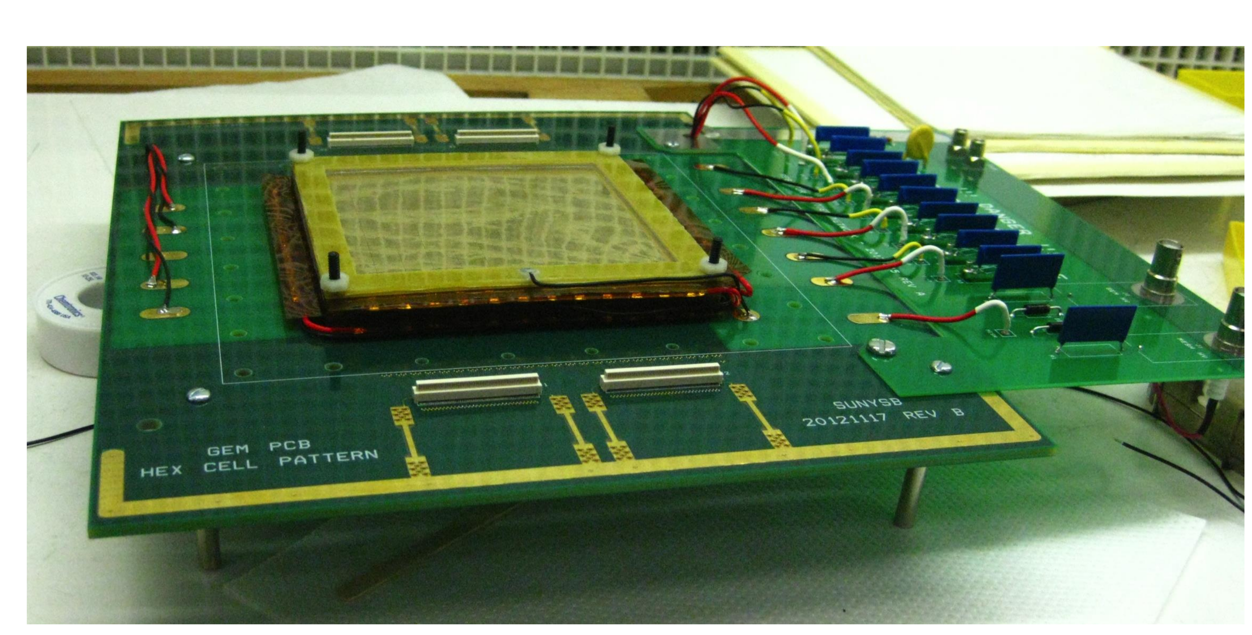


Figure 4: Photograph of actual GEM stack and resistor chain mounted onto signal readout PCB.

Acknowledgements

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