SiPM Read Out options for EEEMCAL prototype beam tests at Jefferson Lab

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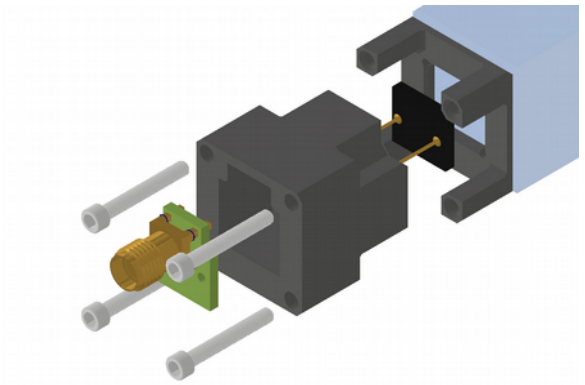
for EEEMCAL consortia

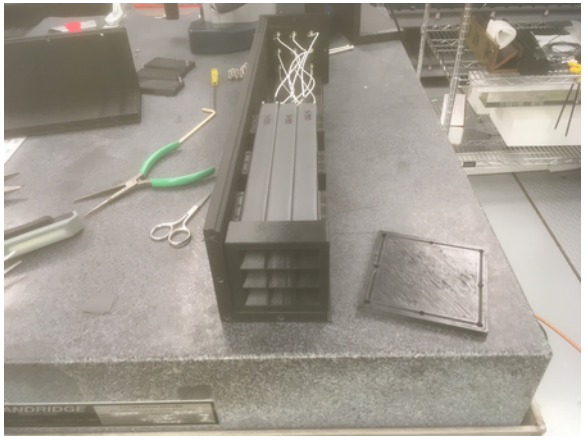
ATHENA Calorimetry WG meeting August 23 2021

EEEMCAL 3x3 PWO prototype SiPM based

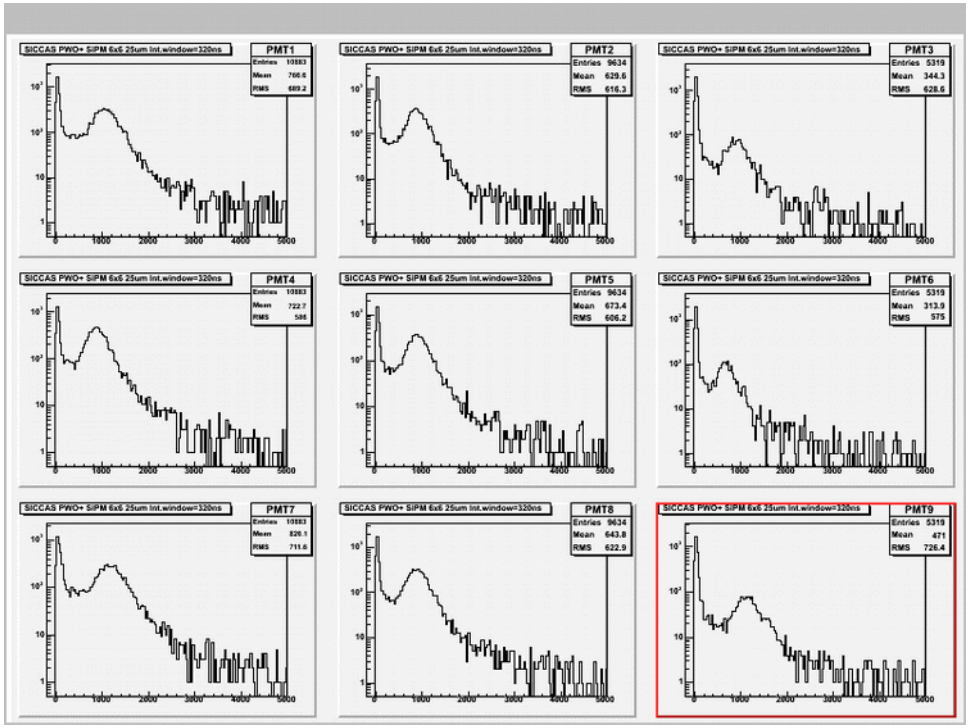
Goal of the tests: Optimize and test SiPM readout chain with new generation PWO crystals

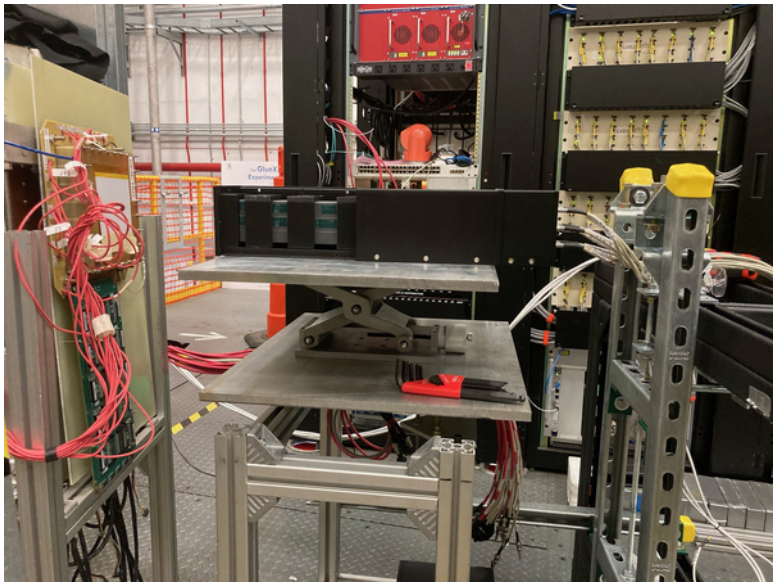


- **Improved prototype with new SiPM based assembly**
- **Same size 3D printed frame as PMT based version**
- **Two piece SiPM holder concept developed**
- **Holders are 3D printed (PLA plastic)**
- **PEEK plastic will be used in real detector**
- **Silicon based glue for frame, no SiPM glueing to crystal**
- **SiPM soldered to circuit board with SMA connector**
- **25um cell SiPM for beam tests installed (75um second option)**
- **LEMO output at the detector patch panel (BIAS/Preamp or Waveboard application)**



Configuration #1: BDX Bias/Preamp boards Readout of SiPM EEEMCAL





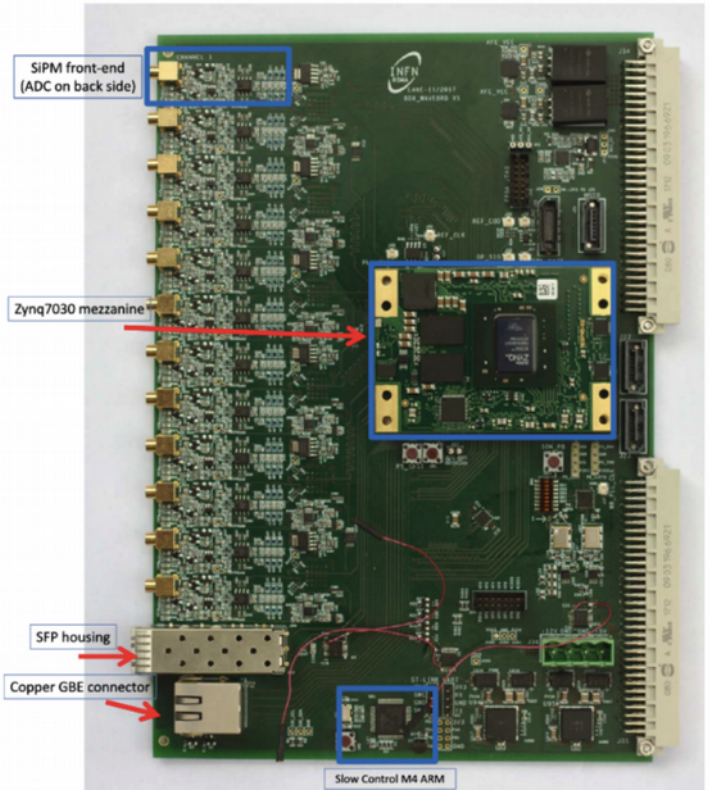
Configuration #2: BDX SRO Waveboard tests with EEEMCAL prototype in HallD

BDX experiment at Jefferson Lab

https://indico.cern.ch/event/803690/contributions/3572798/attachments/1916342/3168330/DeNapoli-NEPLES2019.pdf

FEE & DAQ

A multi-channel FEE and digitizer board developed for BDX



Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment
Volume 936, 21 August 2019, Pages 286-287

A low cost, high speed, multichannel analog to digital converter board

F. Ameli [a], M. Battaglieri [b], M. Bondì [c], M. Capodiferro [a], A. Celentano [b], T. Chiarusi [d], G. Chiodi [a], M. De Napoli [c], R. Lunadei [a], L. Marsicano [b], P. Musico [b,R], F. Pratolongo [b], L. Recchia [a], D. Ruggieri [a], L. Stellato [a]

Show more

- Highly configurable
- FEE included on-board
  - 12 ch individually controlled
  - SiPM connected through coaxial cables and MCX connector
  - dual gain amplifiers
  - bias generated on-board (up to 100V, resolution <50mV)
- Sampling unit
  - resolution 12 or 14 bit
  - sampling frequencies of 65, 125, 160, and 250 MHz
- Timing
  - external clock/time-stamp (GPS)
  - Phase Locked Loop to multiply the input clock and distribute to each ADC and to the FPGA
- Board control
  - commercial FPGA for Data collection and manipulation
  - separated M4 ARM processor for the control of the many ADCs, HV regulators etc
  - Slow control EPICS interface
- VME connection only for power (+5V,+12V) (bus not used) and mechanical support
- Board cost depends on the configuration (range 1.5-3 k€/board)

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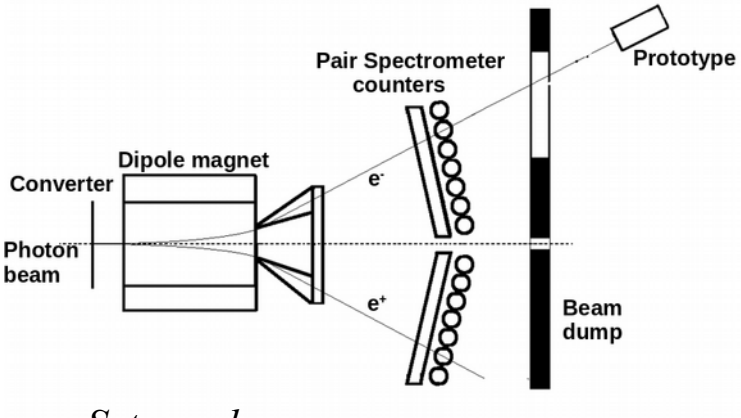
Configuration #2: BDX SRO Waveboard tests with EEEMCAL prototype in HallD

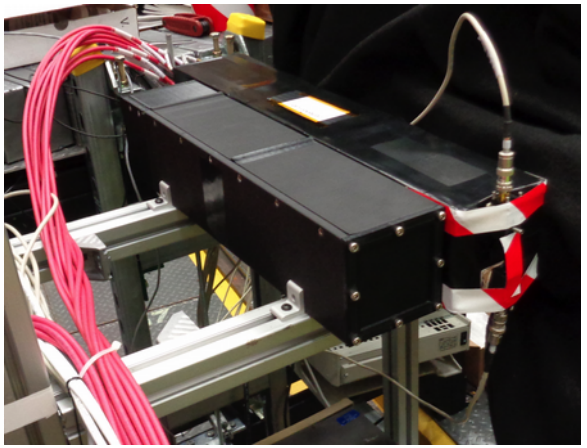
Goal of the tests: test/optimize the entire readout: preamps, fADC or Waveboard digitizers in combination with streaming DAQ system

- **HallD parasitic test beam area, secondary lepton beam with energy range (3-6) GeV**
- **Trigger based measurement method established with NPS and FCALII prototypes (baseline)**
- **Recently instrumented new prototypes with SiPM or PMT photosensors (3x3 matrix) to measure the performance of the calorimetry scintillator materials PWO and SciGlass**

- **Spring/summer run 2020 HallD tests:**
  - **3x3 PMT based PWO prototype installed. The position aligned and surveyed on micron level**
  - **Baseline calorimeter performance established with trigger GlueX DAQ (parasitic mode)**
  - **Central cell events hits (PS tile 59) correspond to ~ 4.5GeV lepton**
  - **INFN Waveboard ADC instrumented in mini VXS crate for SRO tests**
  - **Scintillator pads in front of central cell installed for software L2 trigger**
  - **SRO DAQ cabled, connected and tested**



Setup scheme



SiPM(left) & PMT(right) cal. prot.

Waveboard

Configuration #2: SRO tests behind Pair Spectrometer in HallD

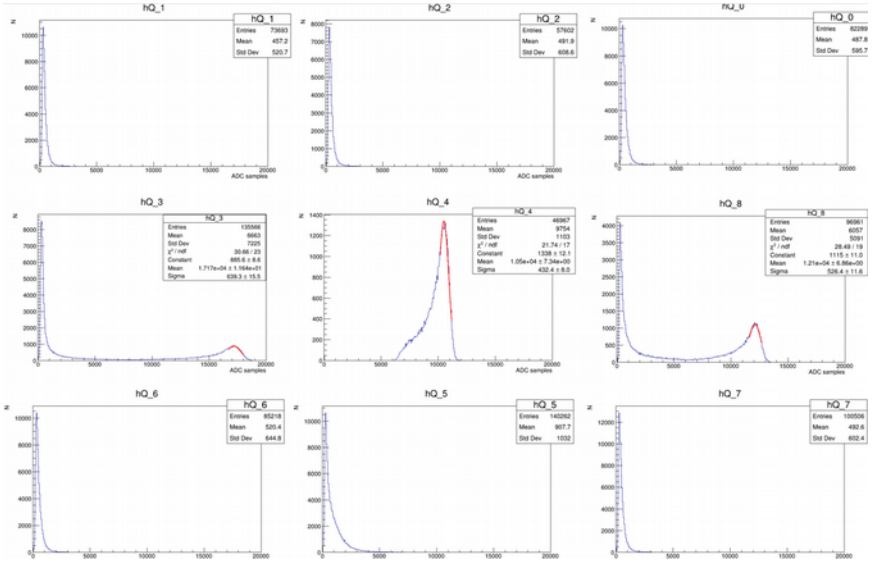
- SRO tests performed during GlueX HighLuminosity run (350nA photon beam)
- Waveboard read-out 9 calorimetry channels (PMT`s) + 2 trigger channels (SiPM`s)
- SiPM`s voltage supply and preamplification directly at the Waveboard
- ~1.5 kHZ rate per channel with BEAM ON , no issues observed
- Waveboard+TriDAS+JANA2 DAQ chain tested

- Beam data acquired:
  - → Binary data (Waveboard stand alone)
  - → Without L2 software trigger (Waveboard+TriDAS)
  - → With different combinations of L2 trigger(Waveboard+TriDAS+JANA2)

- JANA reconstruction and calibration offline plugin update and data analysis ongoing

```
root@wvb_daq_axis:~# ./ReadParam
CRATE#   SLOT#    CHAN#    PEDESTAL*4096    RATE MON (Hz)    START THR        STOP THR
 0x00    0x00       0      0x03D4F9E8               0        0x0000          0x0000
 0x00    0x01       1      0x03D4F9A0            1300        0x3D22          0x3D40
 0x00    0x01       2      0x03D53111             900        0x3D22          0x3D40
 0x00    0x01       3      0x03D51236             400        0x3D22          0x3D40
 0x00    0x01       4      0x03D514CB            2100        0x3D22          0x3D40
 0x00    0x01       5      0x03D4C724             700        0x36B0          0x3D40
 0x00    0x01       6      0x03D5365B            1700        0x3D22          0x3D40
 0x00    0x01       7      0x03D53128            1900        0x3D22          0x3D40
 0x00    0x01       8      0x03D5027F            1700        0x3D22          0x3D40
 0x00    0x01       9      0x03D55563            1400        0x3D22          0x3D40
```

DAQ rates with beam ON

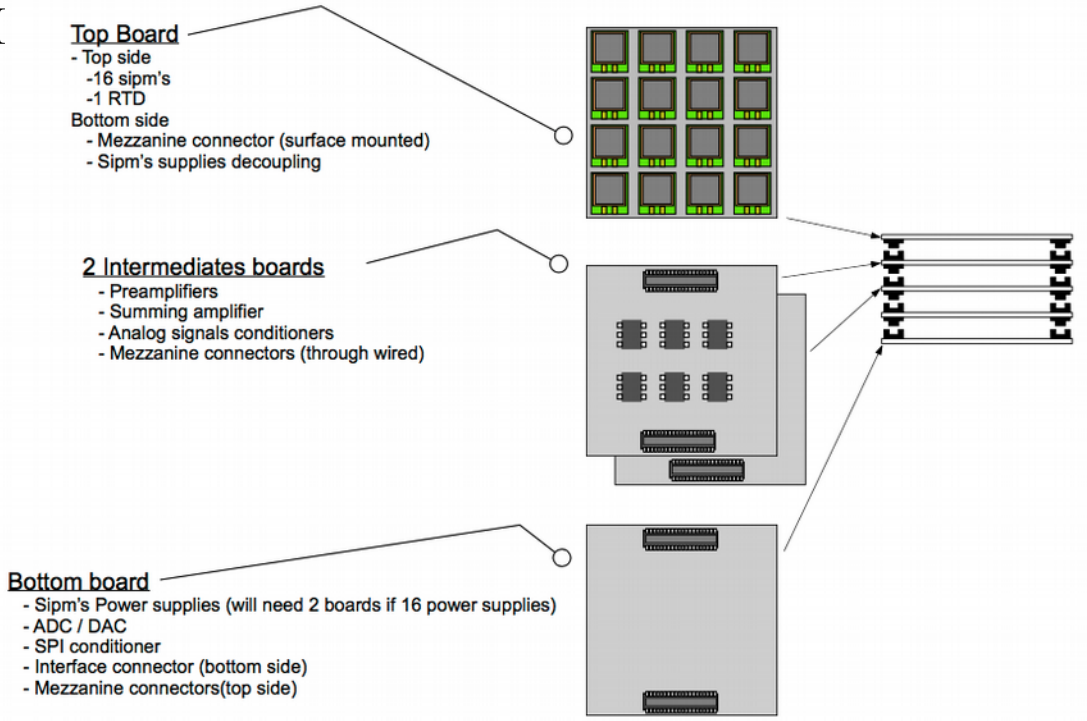


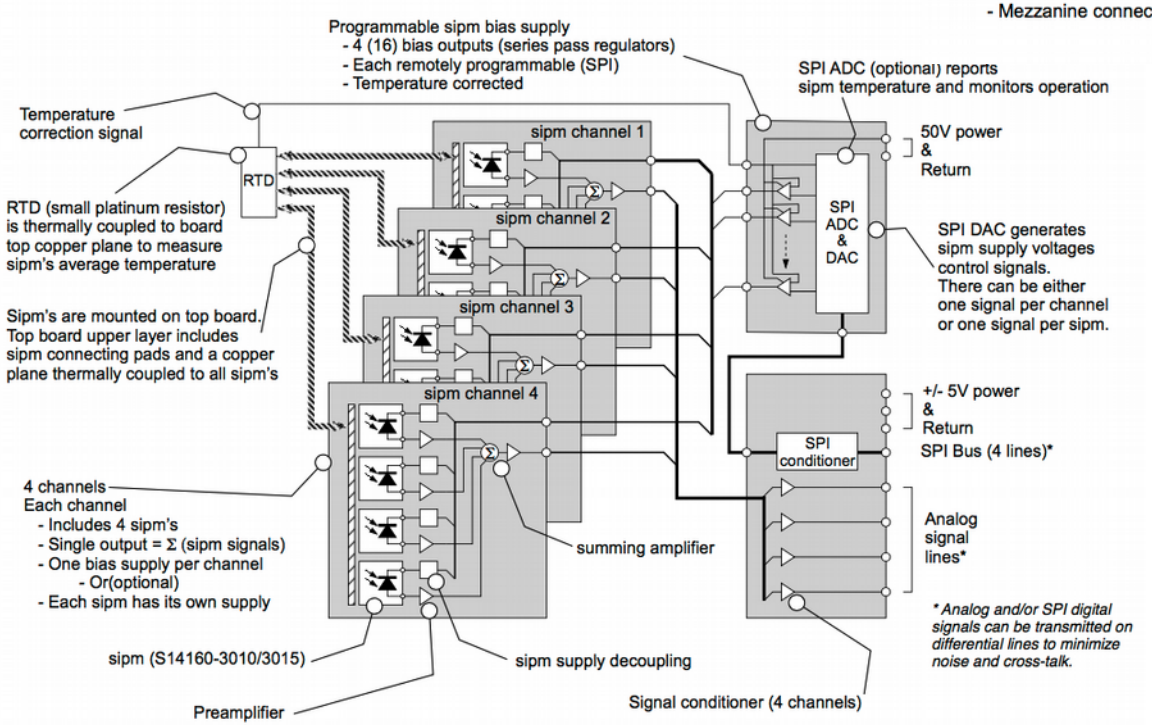
Calorimeter response, channel by channel

Configuration #3: SiPM matrix based 3x3 CRYTUR PWO prototype

Goal of the tests: Optimize and test SiPM matrix readout chain with new generation PWO crystals

- CRYTUR USA concept
- 9 CRYTUR crystals
- 16 SiPMs per crystal
- 3x3 mm^2 SiPMs
- ~90k cells per SiPM
- Plug-n-play prototype
- First working RO version for EIC





- Expect delivery: October 2021
- Direct performance comparison with 3x3 PMT version, INFN SiPM version
- Energy resolution studies
- Noise studies
- Light collection studies
- Linearity studies
- Threshold studies

Considered configuration: SiPMs applications to GlueX Calorimetry

Nucl.Instrum.Meth.A 987 (2021) 164807
Instrum.Exp.Tech. 60 (2017) 3, 322-329
J.Phys.Conf.Ser. 798 (2017) 1, 012223
Nucl.Instrum.Meth.A 896 (2018) 24-42

Electronics Overview TCR
Fernando J. Barbosa
https://halldweb.jlab.org/doc-public/DocDB/ShowDocument?docid=2515

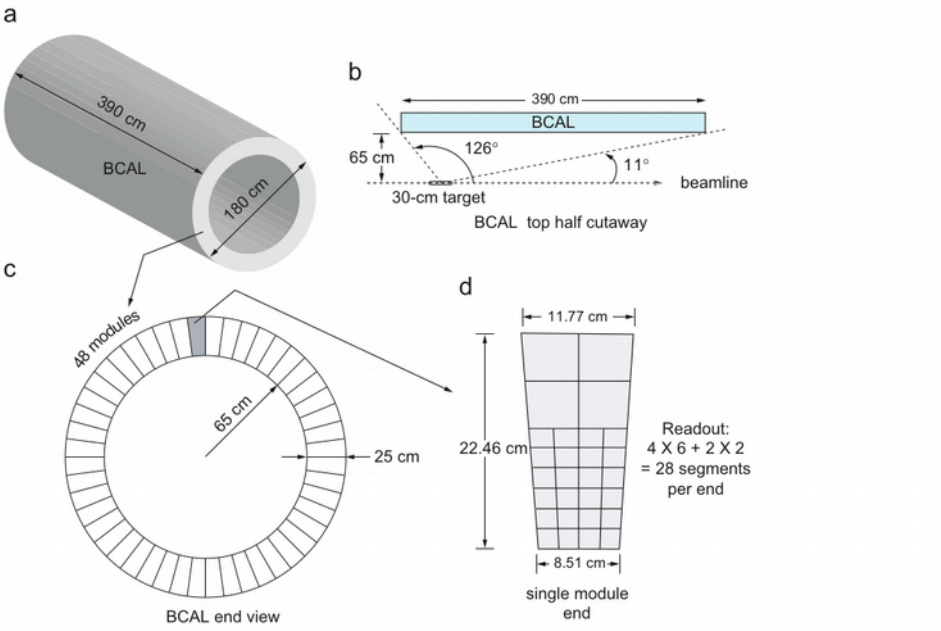
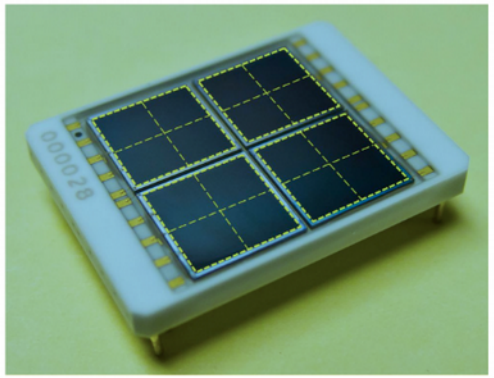


Fig. 2. The GlueX BCAL. (a) BCAL schematic; (b) a BCAL module side view; (c) end view of the BCAL showing all 48 modules and (d) an end view of a module showing read-out segmentation. Details are given in the text.

https://halldweb.jlab.org/doc-public/DocDB/ShowDocument?docid=2913



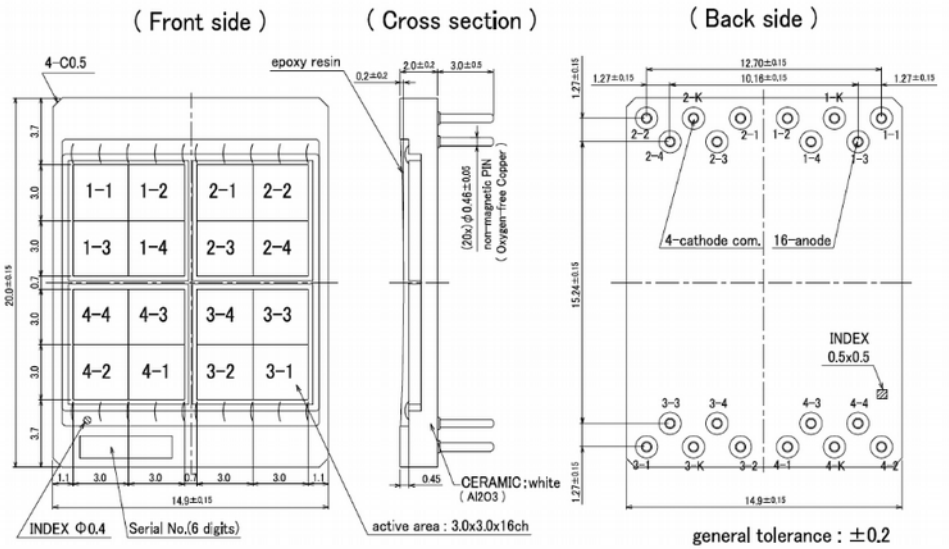


FIGURE 3. Left: photo of SiPM array Hamamatsu MPPC S12045(X) with dashed lines indicating the sensitive tiles. Right: Drawings of SiPM array. Note that the back side behind the active sensors is bare, which allows for direct cooling.

Considered configuration: SiPMs applications to GlueX Calorimetry