GEMs, Cabling, Software, APVs, Schedule

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Report

- **Activities since July 2024 – see Ryan's comprehensive slides**
- **Further commissioning activities – Fall 2024**
- **Electronics and readout upgrade**
- **Tasks to be done, timeline, scenario**

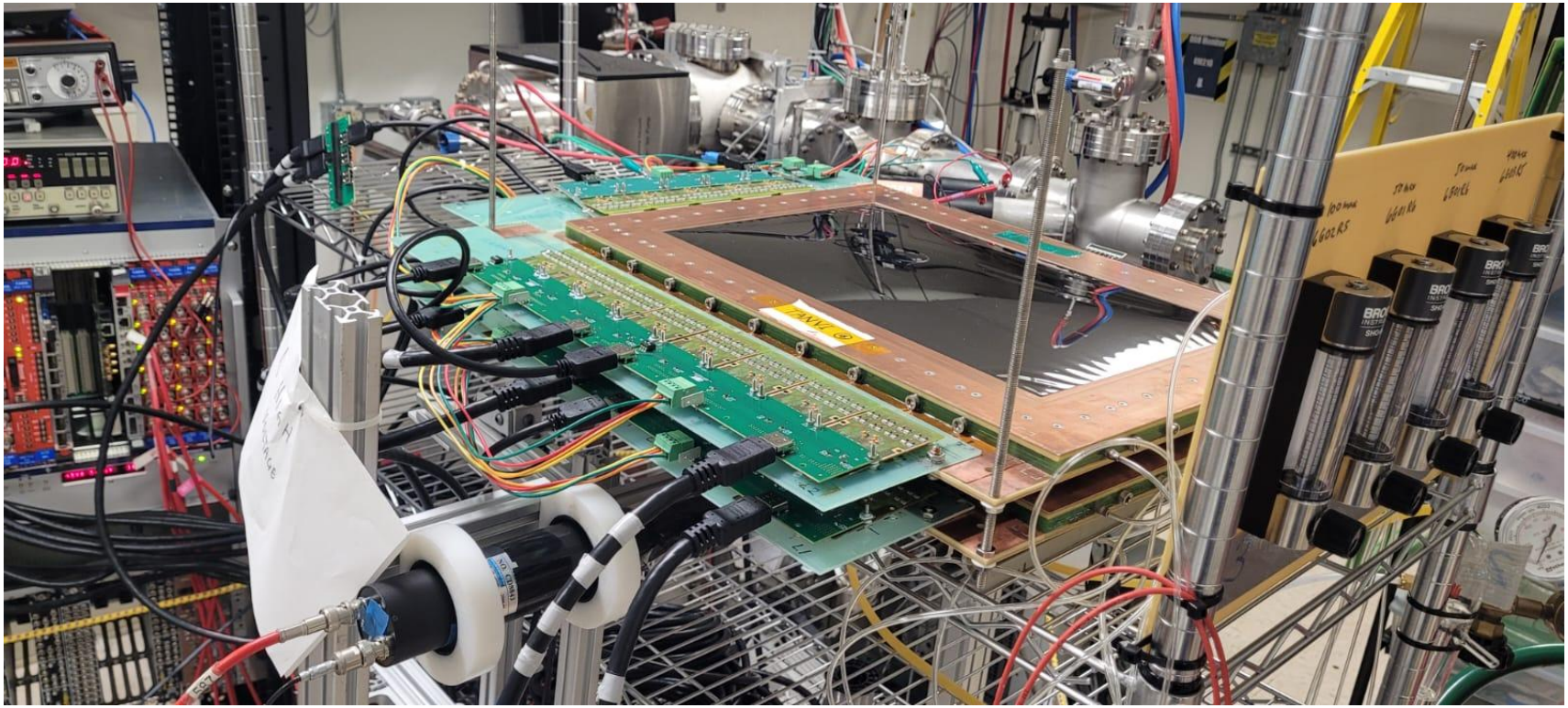
- **People of the Group**

  Dr. Ryan Richards – postdoc, joined Sep 2023
  Dr. Dulitha Jayakodige – postdoc, joined Jan 2025
  (Ryan+Dulitha = 0.5 FTE for DL, 0.5 FTE JLAB/SBS, 1.0 FTE MUSE)
  Manjukrishna Suresh – PhD student since Fall 2020, joined DL May 2023
  (Qualifier June 2024 + January 2025)

  Tanvi Patel – PhD student on MUSE since Fall 2017, GEMs
  Sarashowati Dhital – PhD student on SBS since Spring 2021, GEM experience
  Angel Christopher – MS student on MUSE since Fall 2023, GEM analysis
  Anne Flannery – PhD student on MUSE and Jlab/VITA trainee
  Eric Pierce – PhD student on SBS since Fall 2024
  Krystal Scott – undergrad (junior), PSI Summer 2023; MIT Summer 2024

Two-GEM test stand from Summer 2024

Two GEM Stand



Three centimeter gap between the two GEMs. Top APV electronics - MPD Slot 3, Bottom - MPD Slot 4, Same trigger fed into both MPDs.

Photo from Manju

- **Slide from Ryan July'24**

Ryan's bottom line from Summer 2024

Further Commissioning Tasks/Outlook/Summary

- We fixed the mapping.
- Currently commissioning the GEMs as a rigid object. Exploring and developing the analysis to explore correlations and find the efficiency (Next few weeks)
- Vary the HV for one layer to probe how the efficiency changes with the HV. Data will be taken in the next few days/week
- Everything that has been presented, currently uses one sample. Need to modify the frontend, data structure and analysis to accommodate this. I see this as a fall project.
- Systematic studies on the flow rate. How does the gain, efficiency vary with the flow rate (Next few weeks).
- Fix the HV connection and mount an SHV socket on the side. Next few weeks?
- Investigate the dead sectors on the two GEMs. We can read the pedestals just fine. Investigate the pedestal widths (data exists).

- **Slide from Ryan July'24**

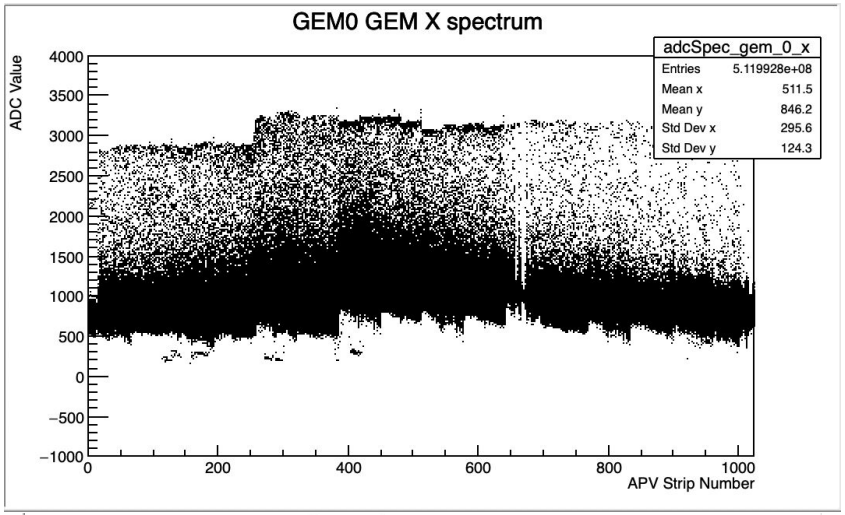
Fall 2024 updates

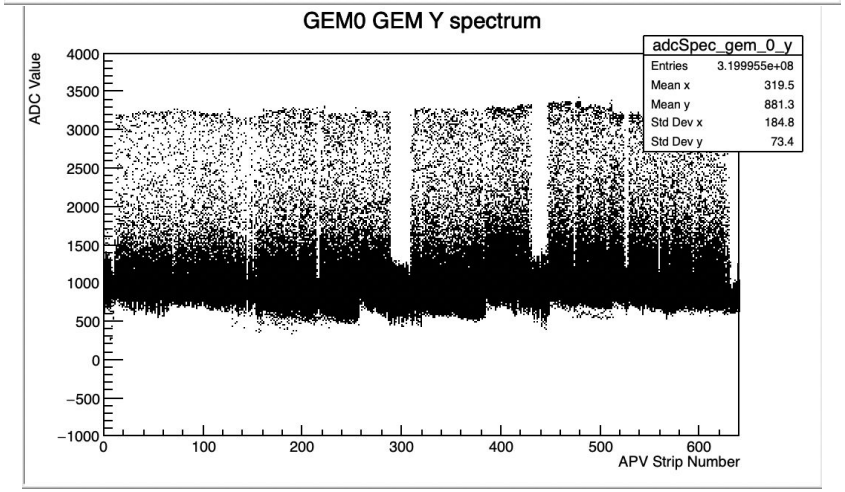
- **August: Ryan at PSI on MUSE shifts**
- **September: Urgent issue of cable length validation for 20m. Obtained set of six longer, poorer-quality 20m cables from Hall A**
- **Tested and established that configuring APVs worked fine, trigger mode fine. Some DAQ instabilities. Could be trigger latching related. Could be due to more noise spoiling logical signals.**

Fall 2024 updates

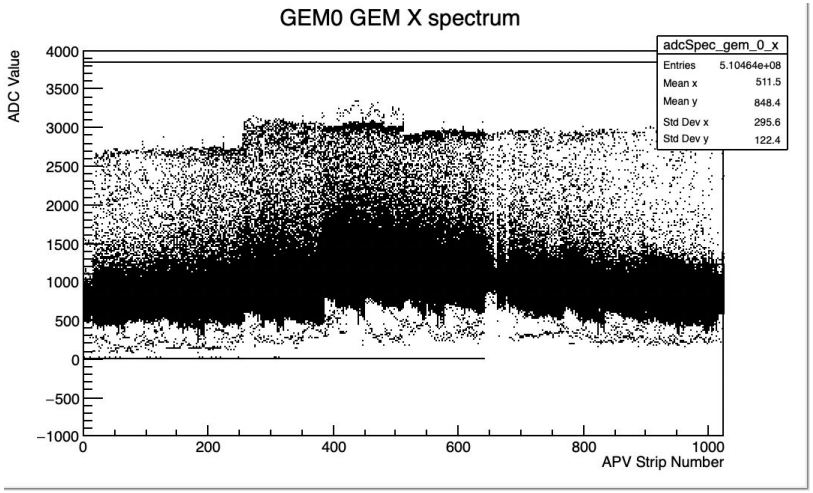
Cosmics at 3,850 V

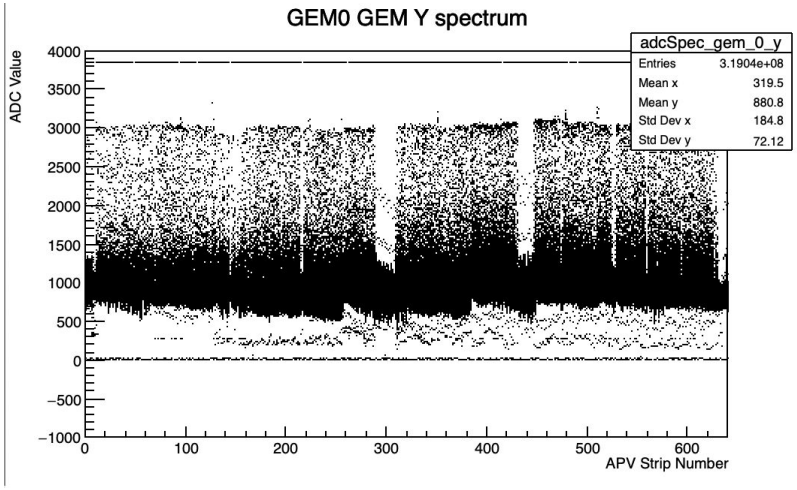
15m, clock phase 35, latency 5





20m, clock phase 20, latency 7





- **Plots from Ryan Oct 23, 2024**

Fall 2024 updates

- August: Ryan at PSI on MUSE shifts
- September: Urgent issue of cable length validation for 20m. Obtained set of six longer, poorer-quality 20m cables from Hall A
- Tested and established that configuring APVs worked fine, trigger mode fine. Some DAQ instabilities. Could be trigger latching related. Could be due to more noise spoiling logical signals.
- **Had to shut down test lab at LERF, special extension until Nov 1.**
  Oct 2: No lab space at JLab without involvement in onsite project.
- **Negotiated with Hall B / PRad2 to use lab space, be associated as a PRad2 satellite group, main focus Jan-July'25 to be on establishing the SSP/VTP optical readout chain, also used at PRad2**
  (Irony: PRad2/X17 main competitor for MUSE and DarkLight)
- **Oct. 4-15: identified new parking spot at EEL PRad2 / SBS areas. When SBS has moved out, can use that area for the actual setup.**
  Oct 24: Vacated LERF lab, all packed up and moved to EEL, condensed.
- **MK in Japan Oct 23-Nov 3, Ryan at PSI Nov 1-14, Thanksgiving Nov 20-Dec 2, MK at PSI Dec 15-22, Christmas break Dec 15-Jan 3**
- **Enormous amount of training requirements (ePAS) for any action or presence. Setup still on condensed footprint presently**

Timeline, constraints, scenarios

- Further commissioning of Tanvi + Jesmin including DAQ and analysis developments will require ~4 months of focused work (Jan – Apr'25). Ship to TRIUMF in May'25 at the soonest
- Accomplish as many tasks as possible with dual systems at TRIUMF and at JLAB. Angled cables, multi-sample, DAQ stabilization; Dulitha needs to be trained locally
- Need a setup at JLAB also for VXS/VTP upgrade. Return of repaired GEMs not yet scheduled. Ideally accomplish VXS/VTP upgrade still for phase 1. Avoid having no GEM at JLAB.
  If VXS/VTP deliveries are delayed, then only VME readout
- Group is also involved with MUSE and SBS
  MUSE expected to run during June-Dec'25
  SBS GEp to run from Feb 27-July 2, 2025
- Manju, Ryan, M.K. to visit TRIUMF in Summer'25 (May – Aug) to implement remaining setup, and for shifts in Fall'25

THANK YOU!

APVs, MPDs, VME and HDMI

- APV frontend cards connected to backplanes (2x 4-slot bp for 8 APVs on long side, 1x 5-slot bp for 5 APVs on short side). The 5-slot short HDMI is converted to 2 standard HDMI (4+1).
- Six (6) HDMI cables between VME and GEM APV frontend (2x digital, 4x analog). One of the digital lines split to two, to serve three backplanes in total.
- Designed for 10 m, previously operated at up to 20 m length; present cables are 30' (10 m). Also tested 20 m in Sep-Oct'24.

- VME crate (Wiener 64x, Jlab-style) is hosting:
  1x Intel controller (Abaco XVB602) for MPD/APV configuration and VME readout of triggered event data, 1 Gbps ethernet link
  1x Multi-purpose digitizer (MPD) per GEM → 4 MPDs total
  2x CAEN V6533 (power limits use of only 2 HV channels each)
- One VME system, 2 GEMs, with complete readout electronics for 2 GEMs delivered to TRIUMF. Duplicate setup at Jlab.

HDMI Cables

- We want angled cables along the long side with the angle within the plane of the connector (pay attention to 90 vs 270), such that cables can run tightly along the GEM's long edge.
- Add interface board for (4+2) 20-m long HDMI cables near top short edge to host analog and digital patch panels and to interface long analog cables with angled analog cables
  → 2x digital HDMI ~2m long with one or both ends angled and male from long side 4-bp to digital patch panel at interface b.
  → 2x analog HDMI ~2m long with one end angled and male, and one end female from long side 4-bp to interface
- Alternatively, skip interface board, and directly attach:
  → 2x analog HDMI 20m long with one end angled
  As another alternative, use angled brackets and regular cables

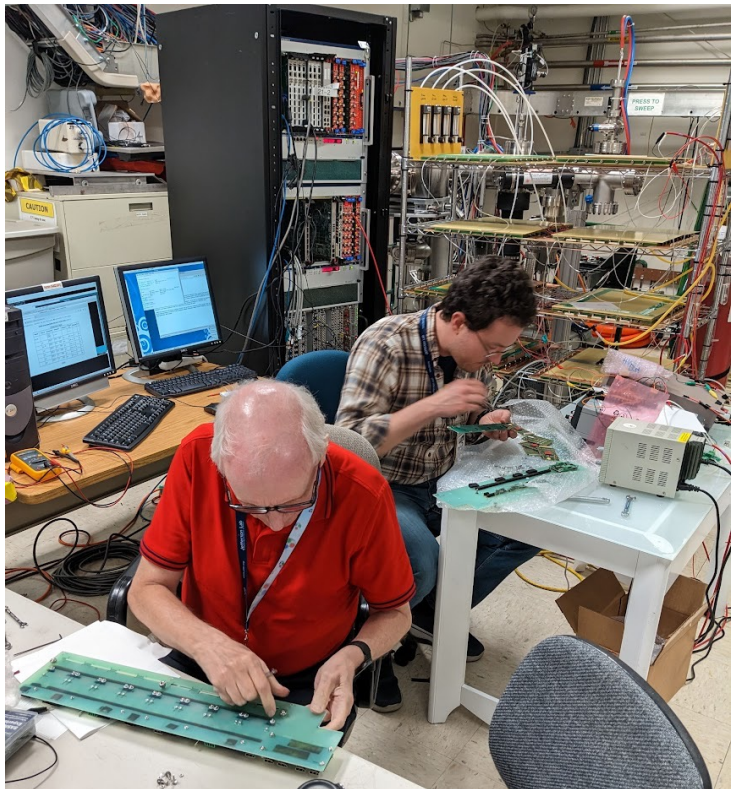
Task: Need to inspect once again carefully the orientation.
Find 20m HDMI's with a single angled end.
Shorter ones are easier to find. Get some brackets for testing.

Upgrade for higher readout speed

- Upgrade path for higher readout speed:
  (VME: 1 Gbps / 100 MB/s limit)
  → Use VME only to power MPD; read out optically;
  process MPD data with VTP or SSP on VXS crate, 10 Gbps
  can run 4 MPDs / 6 samples at few kHz w/o zero-suppression
  Event size: 13*6*128*(32/2)*4 = 640 kb → 5 kHz = 3.2 Gbps
- This is the scheme was implemented at SBS
- Worked with Jlab DAQ & Fast Electronics Group
  (A. Camsonne, B. Moffit) to acquire VXS+VTP
- Secured funding and ordered two complete setups
  no deliveries yet
- Established lab space at Jlab and agreed to join PRad2 as a satellite group. PRad2 uses same DAQ layout for large GEMs

Repairs of defective GEMs

- D.H and E.C. visited LERF in 2023
- Found 4 GEMs to be working (enough for DarkLight), 4 having issues: 3 with high dark current, one with a shorted sector
- Should have avoided inverting polarity across GEM foils
- Repairs ($0) possible by shock-ramping.
  If it fails, must replace foils.
  Costs: up to $20k for 4 GEMs
- Shipped to CERN in June 2024
- Inquired Jan 2025, await response
- Expect to return in 2025



Naming of GEMs

GEM naming **by order of assembly**, and **predicted** evolution of quality

1 - Rui (built at CERN, masterpiece)
2 - Michael (our first one, unknown flaws?)
3 - Ishara (second, improved one)
4 - Jesmin (perfect, lots of attention)
5 - Tanvi (perfect, we really figured it out)
6 - Bishoy (becoming routine, not as perfect)
7 - Malinga (losing concentration a bit)
8 - Thir (is this the last one, finally?)

Naming scheme introduced by **Doug** and **Ethan**

GEM 0 – Michael (400 nA)
GEM 1 – Ishara (shorted)
GEM 2 – Thir (ok)
GEM 3 – Jesmin (ok)
GEM 4 – Tanvi (ok)
GEM 5 – Bishoy (1.2 muA)
GEM 6 – Rui (ok)
GEM 7 – Malinga (6 muA)

- **GEM 4 (Tanvi) and GEM 3 (Jesmin) at JLAB**
- **GEM 2 (Thir) and GEM 6 (Rui) at TRIUMF**

- **Ishara shorted; Michael, Bishoy, Malinga with high currents**

High voltage

- Up to 4,300V @ 1mA supplied to passive HV divider on GEM
- Negative HV, from Cathode layer to readout at ground level
- CAEN V6533N VME based (6 channels)
- 9W power limit → use only 2 channels per module;
  Use 2 CAEN modules for 4 GEMs (on hand)
- SHV cables from VME to GEMs, 1 per GEM

Low voltage

- APV frontend cards require 2.5 V + 1.25 V operating voltages, provided by power regulator chip, one per GEM
- LV (4.5-5 V) is supplied to LV regulator board
- 1 regulator per GEM to power 13 APVs (8+5)
- 13 APVs per GEM draw <20A; total setup <100A @ 5V
- Need low-gauge LV cabling (10-12 AWG) to avoid LV drop

- Acquisition of two (plus 1 spare) 2-channel power supplies ongoing (stock items)

Software status

DAQ software:

- **Established DAQ in histogramming mode (“DAQhisto”)**
- **Established GEM readout with MIDAS (using DAQ server) and GEM_frontend (VME client), local area network**
- **GEM_frontend derived from earlier tests at ELPH in 2019**
- **Contains two banks, GEM0 and GEM1, for 2-GEM operation**

Analysis software:

- **Derived initially from ulq2cooker as used at ELPH in 2019 Can analyze raw ADC spectra, and provide pedestal + common-mode subtractions, can do 1D+2D clustering**
- **Addition of multi-sample mode and timing analysis requires modifications of both frontend and analysis code**