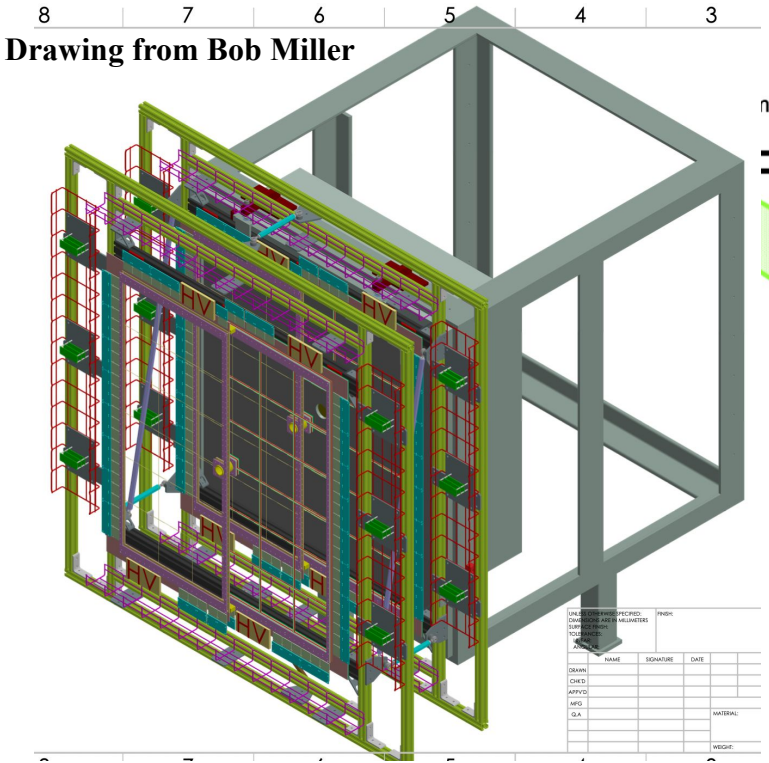
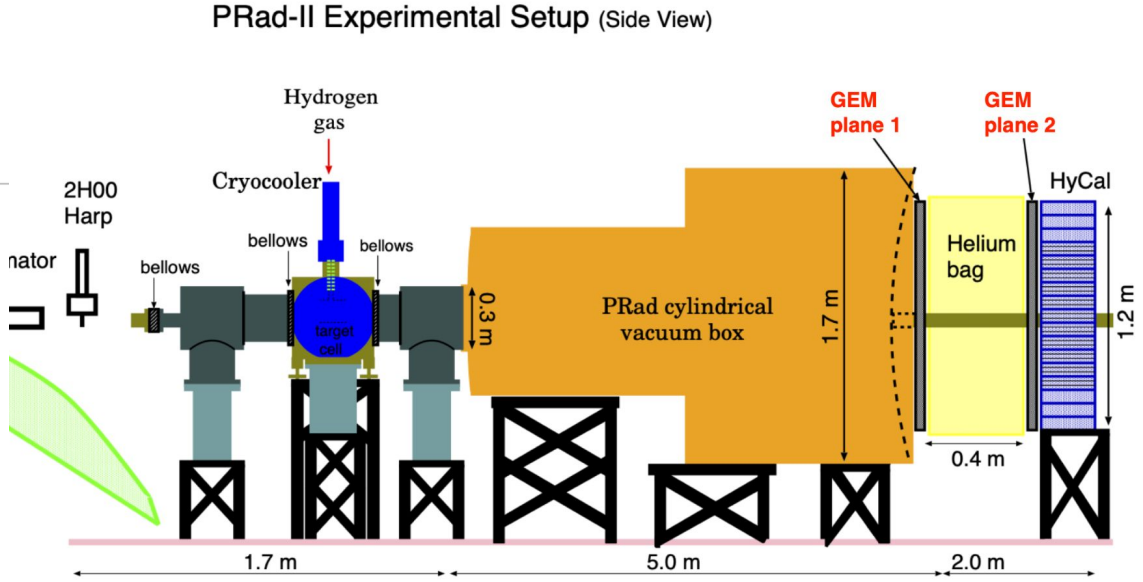
GEM EEL Test Update

Xinzhan Bai
On behalf of the PRad-II/X17 GEM working group

PRad-II/X17 Collaboration Meeting
Sep 12, 2025

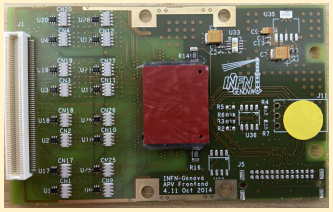
GEM Setup for PRad-II/X17





- 4 GEM detectors – 2 layers
- Layer separation – 40 cm
- Detector structure same with PRad-I
- Detector support frame mounted on HyCal

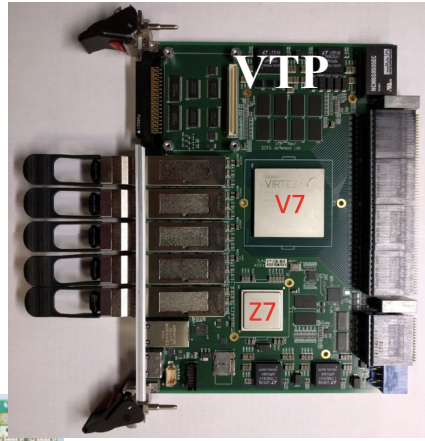
MPD-based GEM Readout System



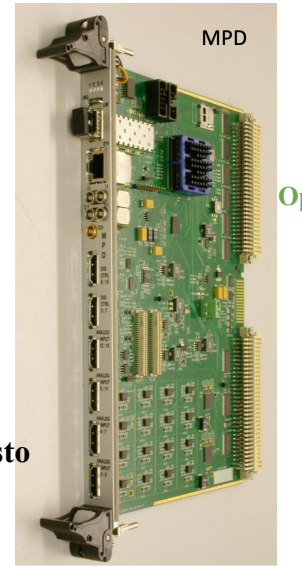
- **128 analog ch / APV25 ASIC**
- **3.4 us trigger latency** (analog pipeline)
- Capable of sampling signal at 40 MHz
- Multiplexed analog output (**100 kHz readout rate**)

MPD modules designed for SBS Program

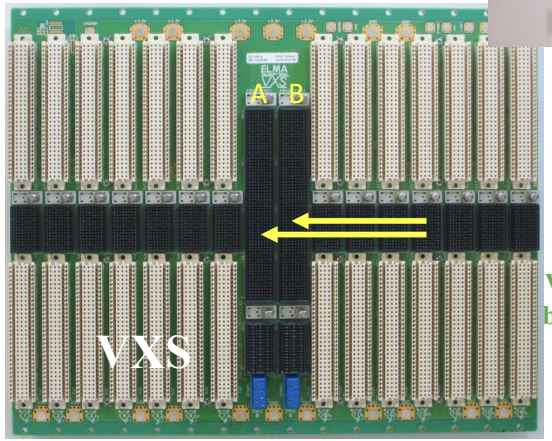
- Up to 15 APV cards on a single module
- 2 ns time resolution (APV clock synchronization)
- Arriga GX FPGA 128 MB DDR2-RAM
- **Online zero suppression**



HDMI



Optical fiber 2Gbps



VXS bus – 20 Gbps bandwidth (4 lanes)

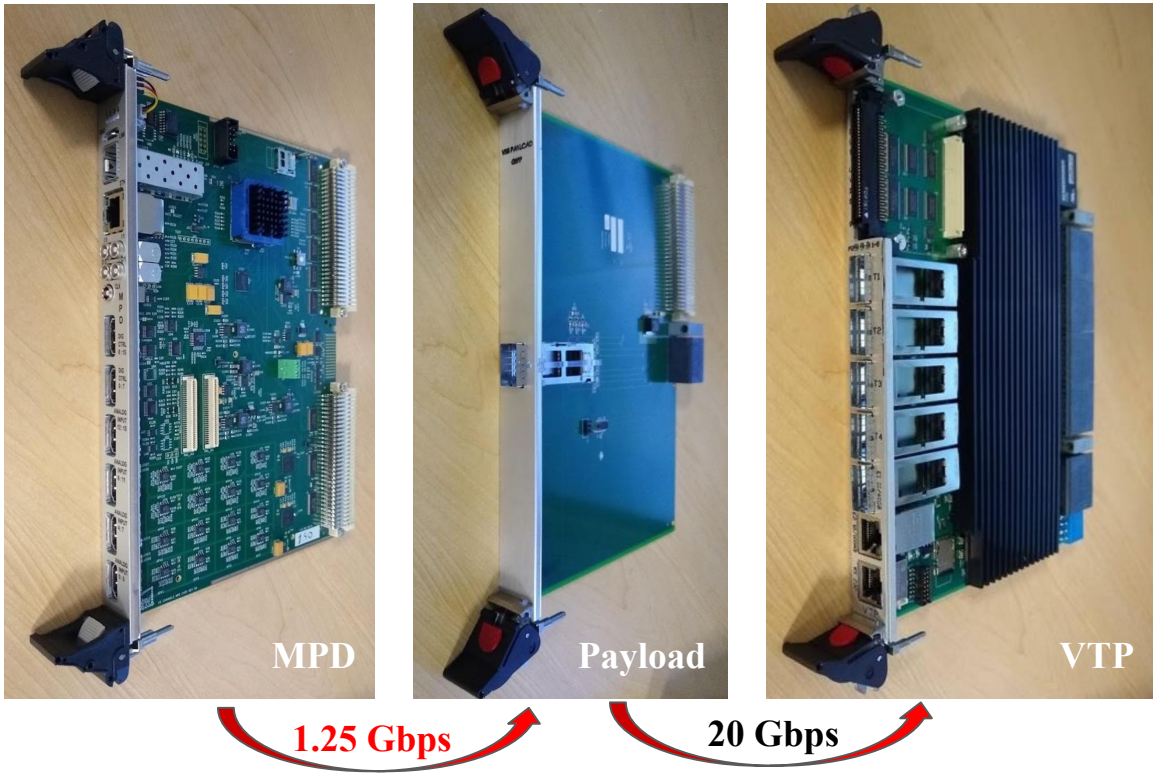
Aurora Protocol

CODA

Paolo, Evaristo (INFN)

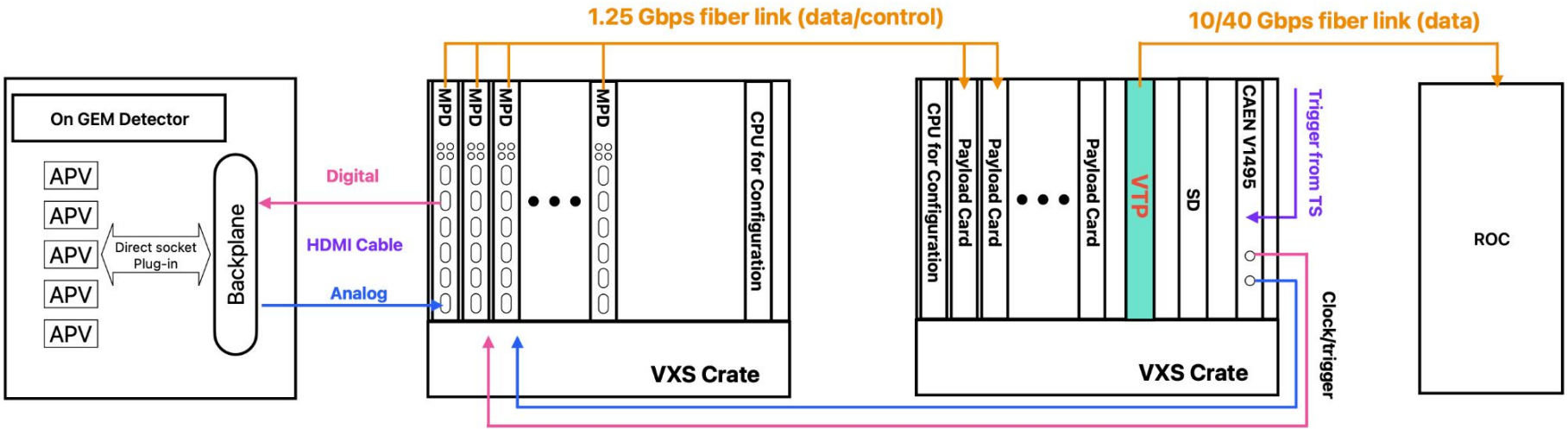
DAQ Bottleneck

- Current SBS MPD use 1.25 Gbps link to VTP, after 8/10 bit encoding, results to 1 Gbps actual data bandwidth
- In SBS experiments, 15 APVs per MPD, 5 KHz event rate
- To reach 25 KHz event rate for PRad-II
  - Reduce load to 3 APVs per MPD
  - Tested up to 25 KHz in UVA



DAQ Overall Architecture – EEL Setup

- A dedicated VME crate for supplying powers to MPD modules
- VTP, payload cards, SD, CAEN V1495 modules located in a VXS crate for trigger, clock, and data processing
- Before installation in Hall B, test and implement all optimizations in EEL



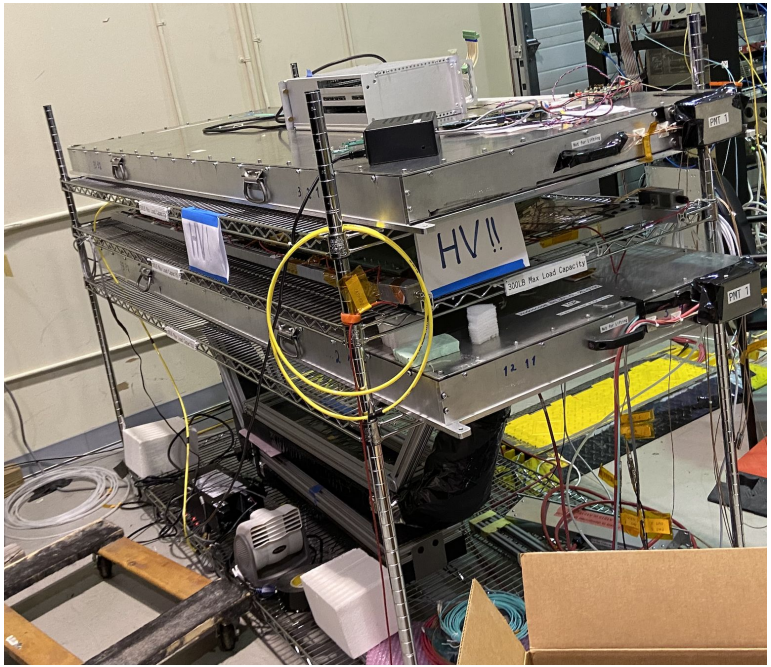
Components for EEL Setup

1. GEM Detector
2. APV and MPD
3. Backplane
4. HDMI Cable
5. VTP crates
6. Low Voltage
7. High Voltage
8. Gas and Gas Panel
9. Trigger
10. DAQ Machine

GEM detector, VTP, Trigger, DAQ machine

2 GEM detectors at JLab (see **Nilanga's talk** for the overall status), VTP crates ready in EEL

Trigger using CLAS12 uRWELL HODO scope (Rafo), DAQ machine – clondaq9 (Sergey)

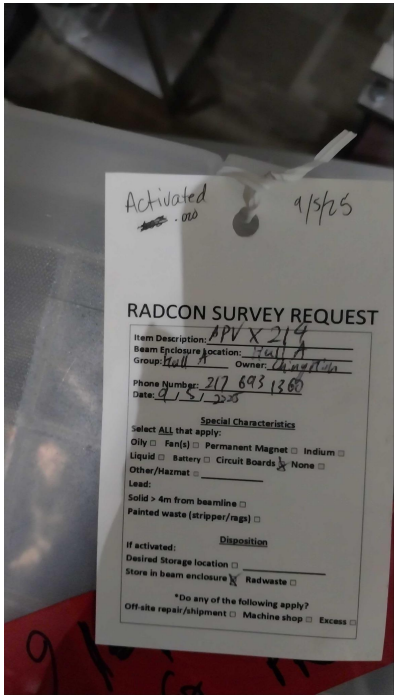


MPD and APV Status

APVs are still radioactive hot, currently in Hall A – Start with LAD APVs in EEL

Move radioactive APVs directly to Hall B

MPD crates not surveyed yet – requested for RadCon – we have a few MPD modules on hand to start with



APVs and MPD crates in Hall A

HDMI Cable Status

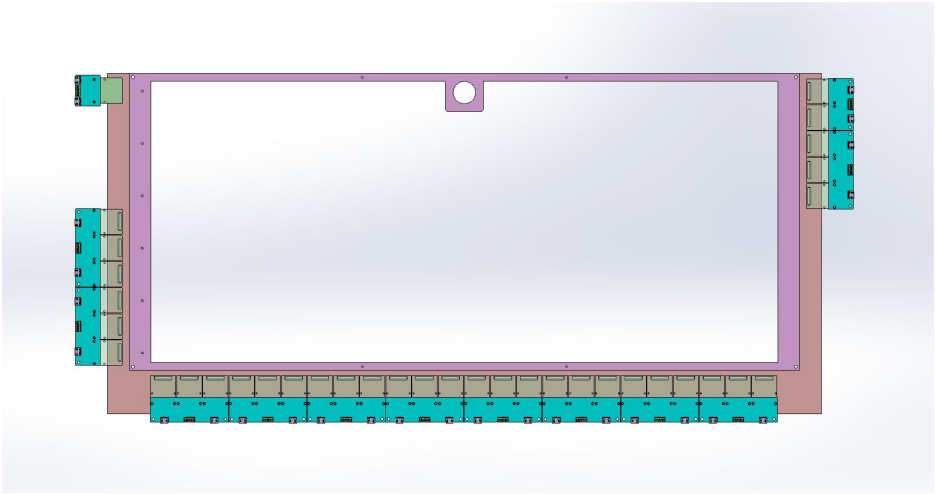
- 200 HDMI cables were prepared for PRad-II from SBS experiments
- All HDMI cables are radioactive hot
- HDMI cables from LAD, backup cables for SBS
- Start with non-radioactive cables (enough for 2 chambers)
- Move these hot cables directly to Hall B

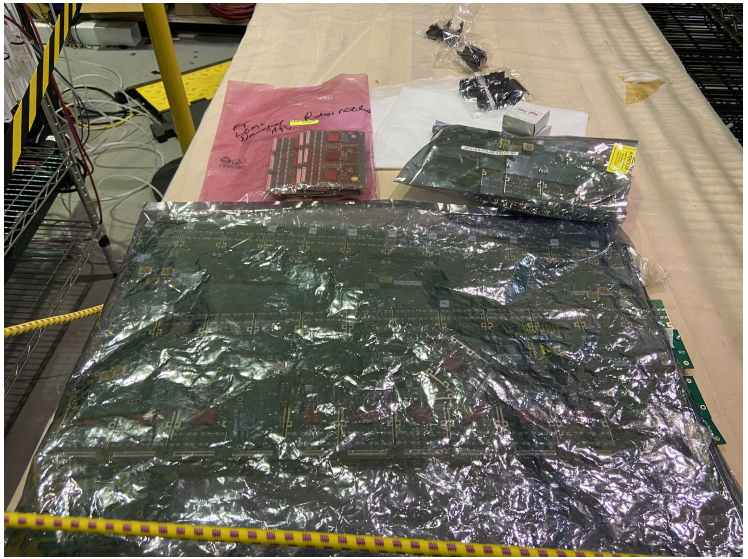
Backplane Status

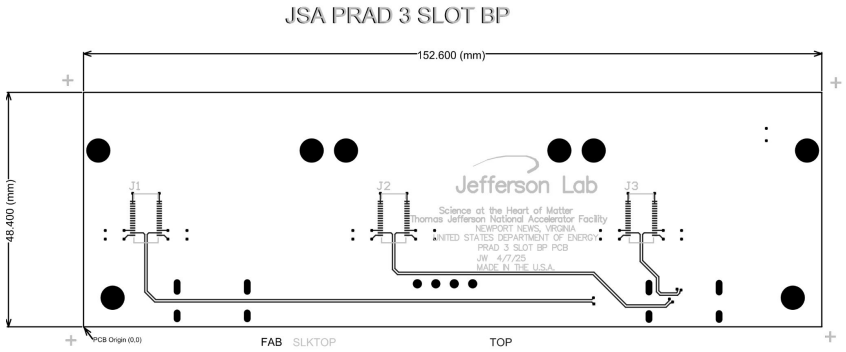
PRad-II will use 3-slot, 2-slot, and 1-slot backplanes

Designed and fabricated by **Jeff Wilson** and **Mark Taylor** – JLab FE Group

All backplanes ready and tested



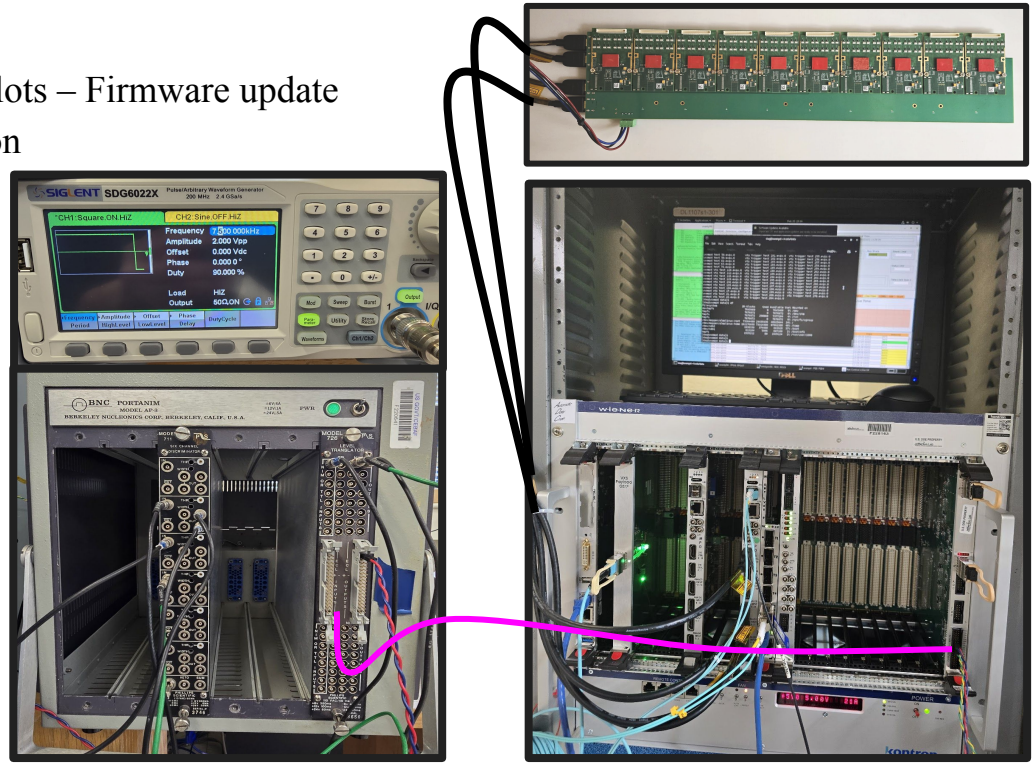




25 KHz Trigger Rate Test at UVA

- Currently **65%** live time at 25 KHz with 6 time samples – can be optimized to reach ~85% live time (**Optimizations to be tested in EEL – Ben Raydo**) **:**
  - Free up MPD resources by unused 12 APV slots – Firmware update
  - Trigger rules, CODA buffer level optimization
  - Theoretical rate limit to be confirmed
- Use 3 time samples – same as PRad – no limit

Event Rate (kHz)	Coda Live time (%)
23.0	95%
24.0	95%
24.2	90%
25.0	65%



HV System Status

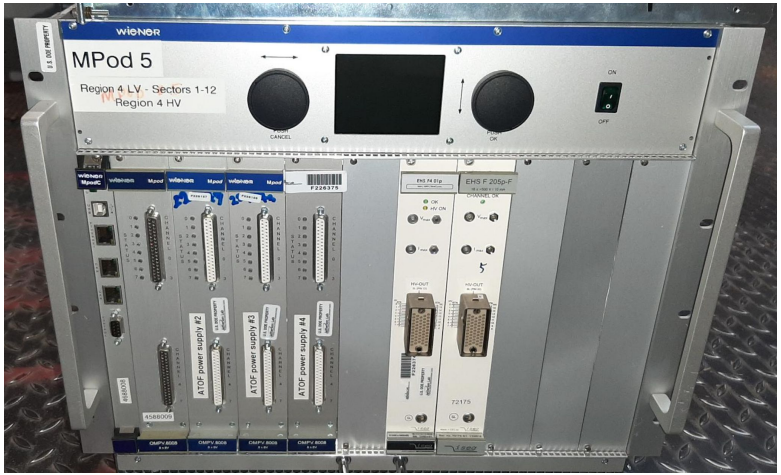
Individual Channel High Voltage Power Supply – CAEN A1515BTG

- ➢ Used in SBS experiments
- ➢ PRad need 2 modules for 4 chambers
  - ○ Each module has 2 channels with 7 outputs each
  - ○ 1 mA max current per output – 3 mA for **HP version**
  - ○ Floating Ground
  - ○ Can trip together
- ➢ Basically Ready

Low Voltage System Status

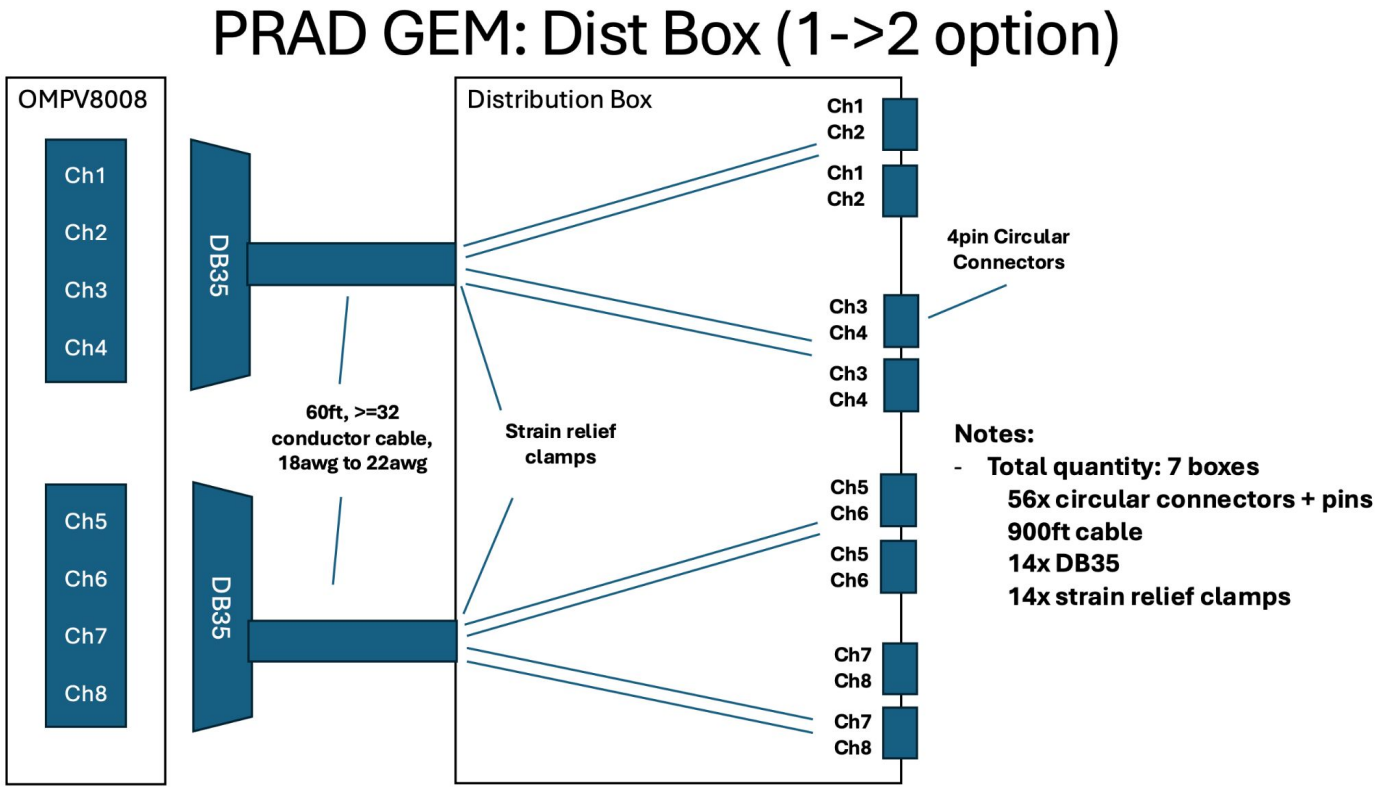
Low voltage module – MPOD OMPV 8008

- Used in Hall B by SVT, ALERT, and others
  - Programmable 0-8 V output
  - 8 independent output channels per module
  - 5 A Max current per output channel
  - Remote sensing – compensate voltage drop over long cables
- PRad-II has **52** backplanes to power up
- In the present plan, PRad-II needs 7 modules, we have 8 available



MPOD LV modules in Hall B – Yuri Gotra

Low Voltage System Status – **Ben Raydo**



4pin Circular Connector

Low Voltage System Status

- Florian used this wiring scheme in Hall B, I have used them in Hall C. We will use these cables to start off in EEL
- Need to start procurement and make these cables for the experiment
- Ben and Mark – JLab FE Group
- How long these cables will be? Where will be the MPOD crates located in the experimental setup relative to the detector?

30 meters long

Gas Status

Gas Mixtures needed in current test plan (not include N2):

	Ar:CO2:Isobutane			Ar:CO2
Ratio (%)	70:28:02	75:23:02	80:18:02	75:25
Quantity (bottles)	2	2	2	7
Operation Days	9	9	9	33

Current availability:

- N2, Ar:CO2 (80:20) – currently available
- All others – pending order

Lead time:

- N2 – 7 days
- Ar:CO2 – 26 days

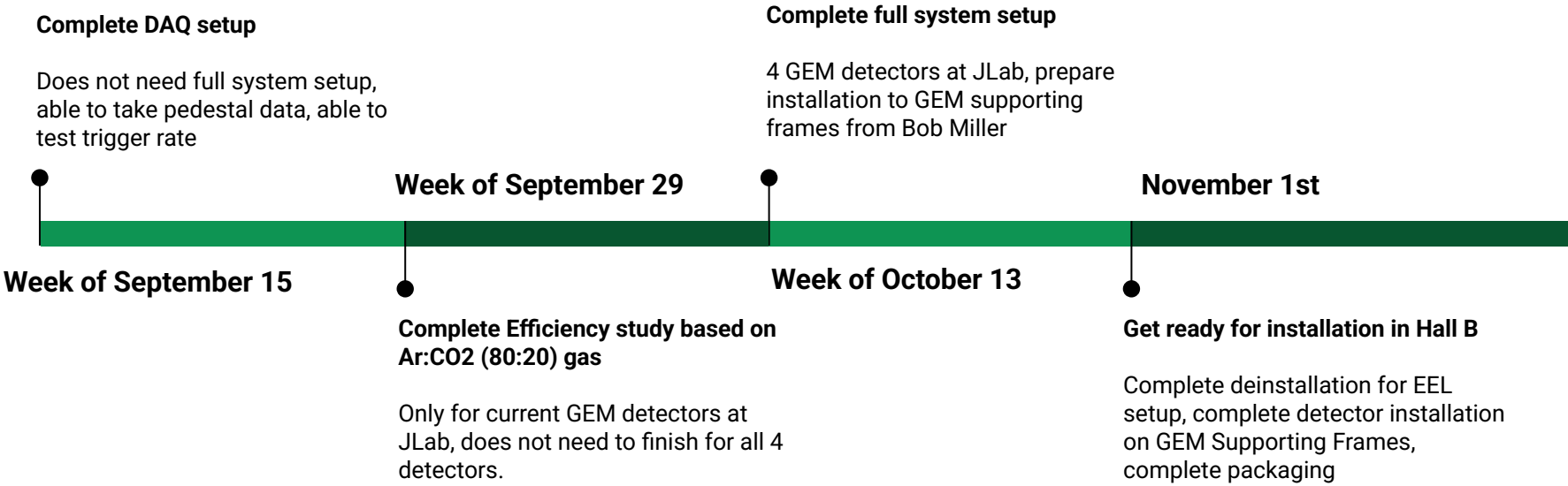
Plan:

- Start with Ar:CO2 (80:20) immediately
- Transition to other gas mixtures once deliveries arrive

➢ Gas Regulator, flow meter panel, tubing – See **Bob Miller Slides** (ready next week)

Tasks and Timeline

1) Test and optimize 25 KHz event rate – increase live time
2) Preliminary detector characterisation (dead sector location, new development, gain, etc)
3) Electronics modules evaluation (rule out unstable APV cards, MPD modules, transceivers, …)
4) Isobutane gas mixture study



See **Nilanga's Talk** for Detailed Timeline

GEM Working group – Personnel (incomplete list)

University of Virginia:

- Professor: Nilanga Liyanage
- Research Assistant Professor: Huong Nguyen
- Postdoc: Asar Ahmed
- Graduate Students: Vimukthi Gamage, Jacob McMurtry, **ViduraVishnavath, Nithya Kularatne**

Jefferson Lab:

- Hall B: Florian Hauenstein, Rafayel Paremuzyan, Sergey Boyarinov, Bob Miller, Denny Insley, Morgan Cook IV, Sara Liyanaarachchi
- FE Group: Ben Raydo, Mark Taylor, Jeff Wilson, Armen Stepanyan
- RD&I: Xinzhan Bai

Big thanks to Alexander Camsonne and Ching Him Leung (Hall C postdoc), who has helped us a lot for the preparation!

Summary

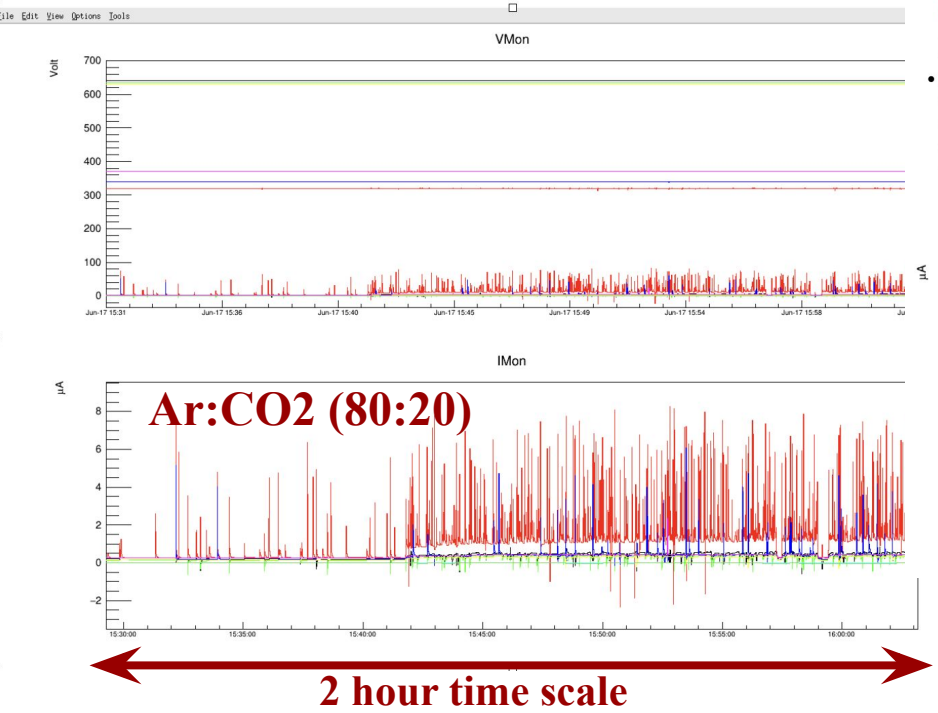
- We collected enough materials for the EEL test, although not materials for full system, but enough to start the setup and test already
- We have gas, including N2 and Ar:CO2 (80:20), good enough for us to start
  - New gas for N2 and Ar:CO2 (75:25) are pending order
- Tight Timeline
- Outlook to the Full system in Hall B
  - Low voltage cable parts procurement – cost estimation on-going
  - Gas line design and more

Backup Slides

GlueX Large GEM-TRD test – **Lubomir**

Tests of large GEM-TRD with GlueX

- When using parallel GEM supply - no drops in the efficiencies but the GEM mini-trips are there



Tests of large GEM-TRD with GlueX

- Solution found: using Ar/CO2/ Isobutane 90/7/3 gas mixture - at the same gain the Iso mixture shows two orders of magnitude less mini-trips - see bottom plot - only several mini-trips over 2h period
- As we operated the detector for four weeks at ~4 sec. trip period, extrapolated in time it means such detector will be operational for thousands of days.