ECal Installation

Don Jones

SBS Weekly meeting

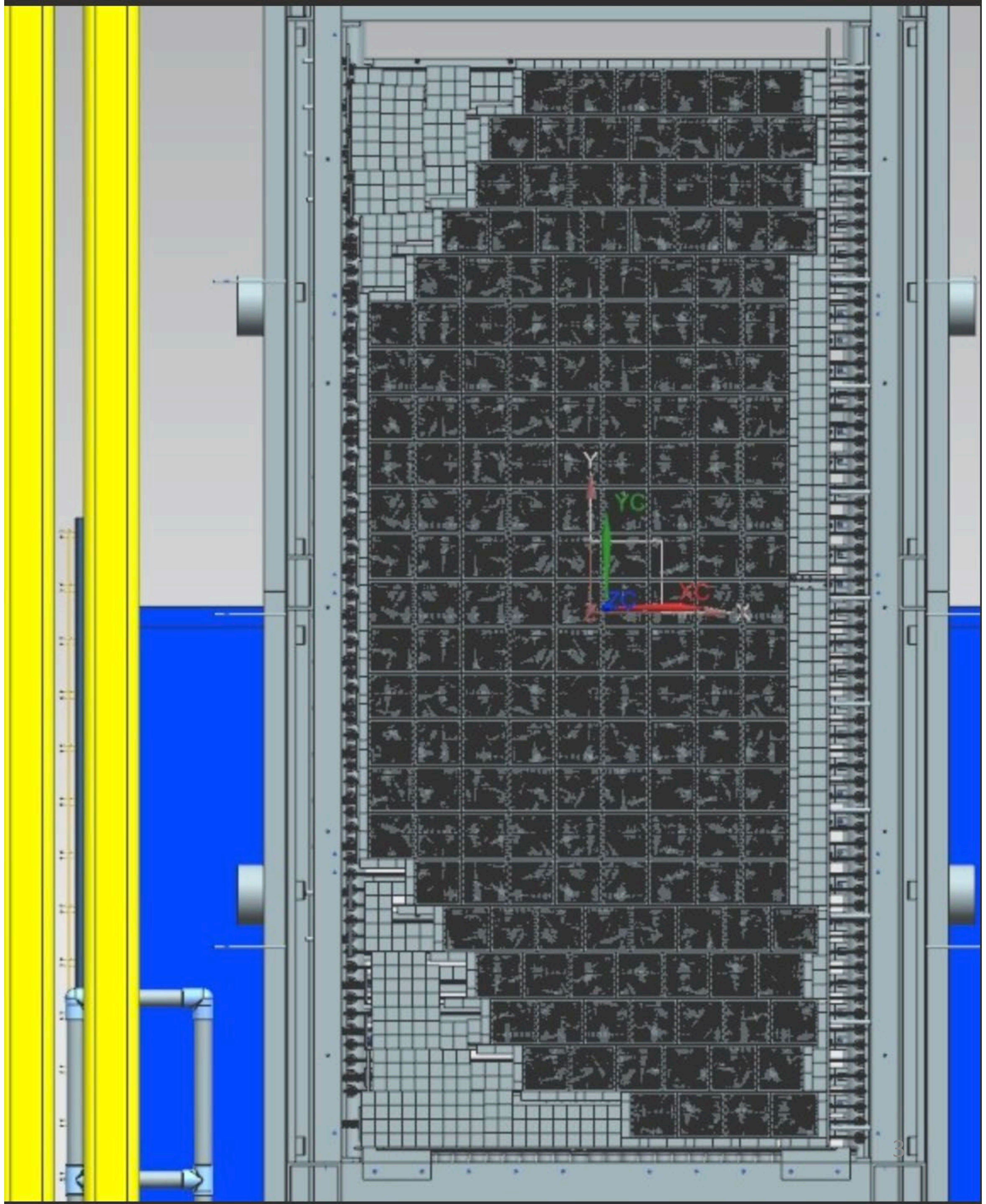
Mar 29, 2023

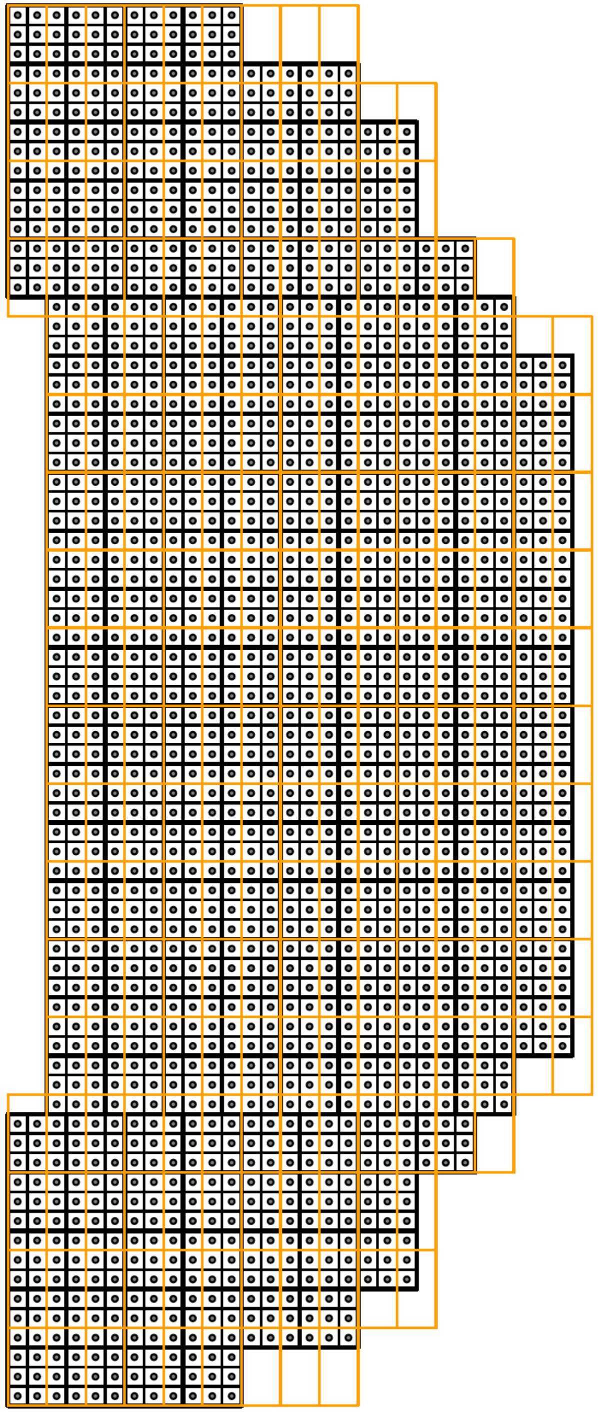
Rough schedule

- April-May Hall open for GEp and other work
- May 29-July 21 Crane repair. Other work can also be done in the hall just needs to be coordinated
- July 21 - Aug 10th Get the hall ready for beam. We will try and start beam as soon as reasonable.
- Gives some buffer to finish the crane work.
- Aug10th - Oct 2nd Run GEn and A_LL experiment
- Oct 2nd - Jan 30th deinstall polarized target and install cryotarget etc for GEn-Rp
- Jan 30th - Feb 26th Run GEN-RP and K_LL
- Feb 27th - Aug 23th Install GEP
- Aug-Dec run GEp

ECal overview

- 184 supermodules
  - Each with 9 crystals and 9 PMTs
  - 5"x 5"
  - 23 tall (9.6') and 9.5 (4.0') wide in active area
- Frame sits on elevated (3' tall) platform.
  - Frame further elevates active area so that bottom row is 5' off the hall floor and the detector is centered on beam line 10' off the floor
- Inactive crystals used for stacking support
- Will be located at three different angles and distances from target so entire platform on Hilman rollers





General considerations

- Due to space constraints onsite, installation will primarily happen in the Hall
- Will have to work around crane repair activity this summer and break for running GEn/ALL (Aug-Sept 2023) and GEn-RP/KLL (Feb 2024)
- Electronics, cables, patch panels and rack space currently used by BigBite, GRINCH and Hodoscope will be repurposed for ECal
    - Much of the activity will be compressed into the Spring and Summer of 2024
    - Limited in the amount of early electronics we can hook-up/pre-install
- ECal is just one arm of a complex experimental installation.
    - Need to coordinate activities between different parties to ensure we aren’t hindering each other’s progress.
    - To the best extent possible, map out daily activities in advance and distribute to other teams with possible overlapping or colliding goals

Components for installation and assembly

1. ECal supermodule stack
   - Install frame on platform
   - Install lifting assembly for moving supermodules into place
   - Stack crystals+ supermodules
   - Assemble heating system
   - Install insulation and light-tight enclosure assembly
   - Install PMTs + bases carefully documenting the position of each individually calibrated PMT in the matrix
   - Install light guide cooling system
   - Install frame + patch panels for PMT signal+HV cables
   - Map and label HV and signal cables
   - Install HV boxes outside enclosure
   - Route HV lines to boxes
   - Route signal cables to Front End racks
   - Test heating system meets requirements in full set up

Components for installation and assembly

2. Front end electronics
    - Install racks on platform and power them up
    - Install NIM crates + cooling fans + patch panels
    - Create channel map for each PMT to summing module channel
    - Attach cables to proper summing modules
    - Create map and label PMT to patch panel channels
    - Build ribbon cables and attach from to patch panels
    - At the earliest possible, check each of the 1656 individual PMT and HV channel by reading them out on an oscilloscope at the patch panel. Repair/replace (cables, PMTs, bases as needed)

Components for installation and assembly

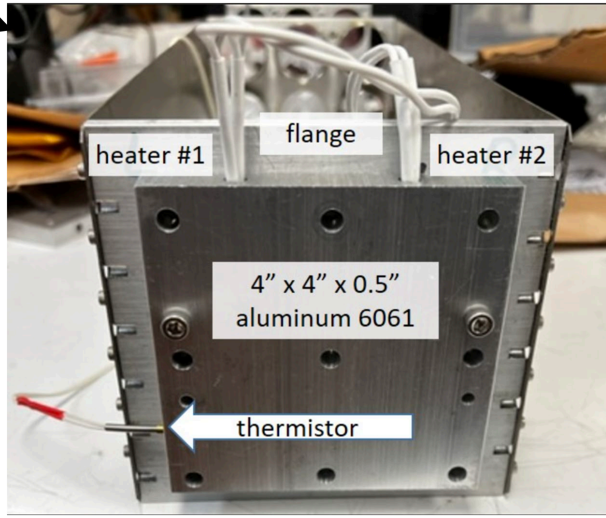
5. HV system installation
   - Make remaining 24 pin HV cables and break out boxes
   - Route 75m cables from racks near detector to SHV panel boxes in DAQ bunker
   - Install SHV supplies + modules in racks in DAQ bunker
   - Create map for SHV panels to supply channels
   - Run SHV cables from patch panels to modules
   - Test each channel and replace modules as needed
6. Test entire HV + readout chain using cosmics
7. Gain match using cosmics (do we need cosmic paddles for a trigger?) and input from simulation using procedure similar to the one used in calibrating BigBite

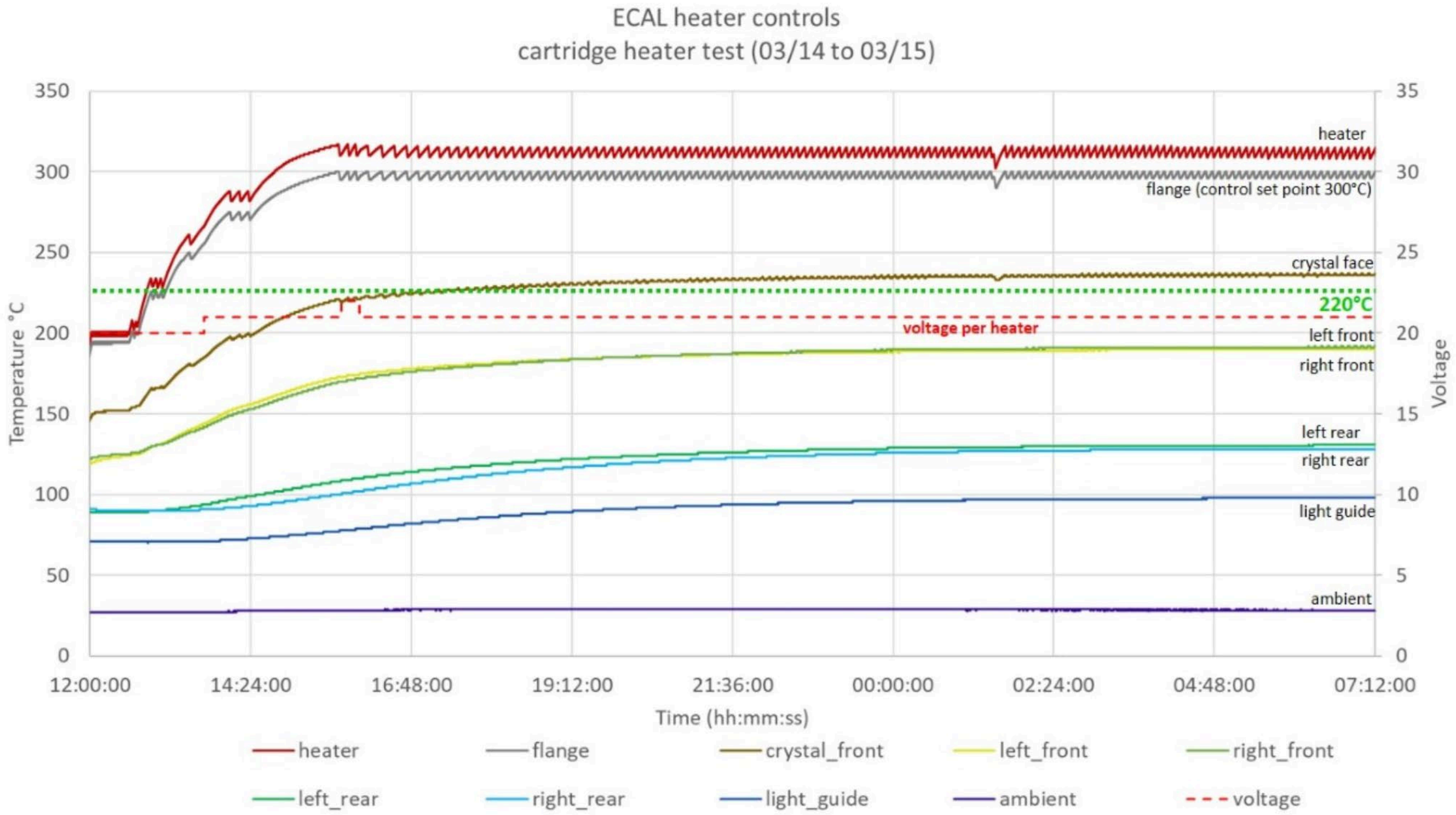
Components for installation and assembly

3. Signal cables from Front End to DAQ bunker
   - 1656 long cables
   - Have a combination of 110m, 100m and 75m cables
   - Making 800 more 75m cables
   - Label and test
   - BNC to BNC going from FE patch panel to DAQ patch panel
4. DAQ electronics
   - Going with FADC-based system
   - Install 7 VME crates (up to 256 channels per crate) for 104 FADCs + 1 VME crate for trigger supervisor
   - Install 1 VXS crate + 1 NIM crate for scalers
   - Install patch panels (combination of BNC to LEMO for LEMO-LEMO cables and BNC to BNC for BNC to LEMO cables)
   - Check signals at patch panels
   - Create map from patch panel to FADC channel
   - Install cables from patch panels to FADCs documenting relative cable path length from PMT to DAQ for each channel and grouping similar lengths into the same module

Ongoing efforts: heating tests

- Jack Segal strongly recommends using 48 VDC heaters to stay below safety thresholds→requires increase in current by factor of 6
- DSG has completed two iterations of the heating test with a single supermodule
  1. Silicone heaters stuck to front surface (max rated temp 250 degC). Monitored heater temp only and reached >220 degC with 92 Watts
  2. Cartridge heaters (24 VDC) in aluminum plate. Required 315 degC on heater to reach 220 degC on crystal face.

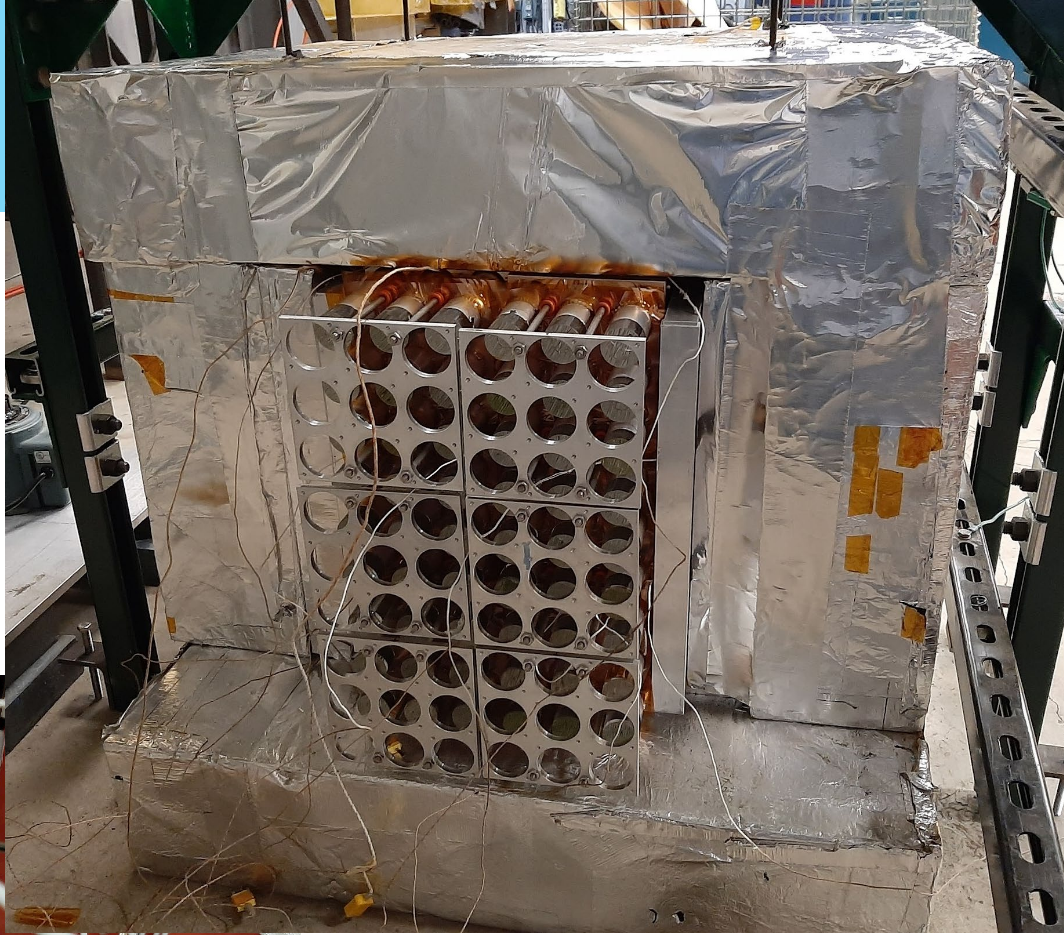


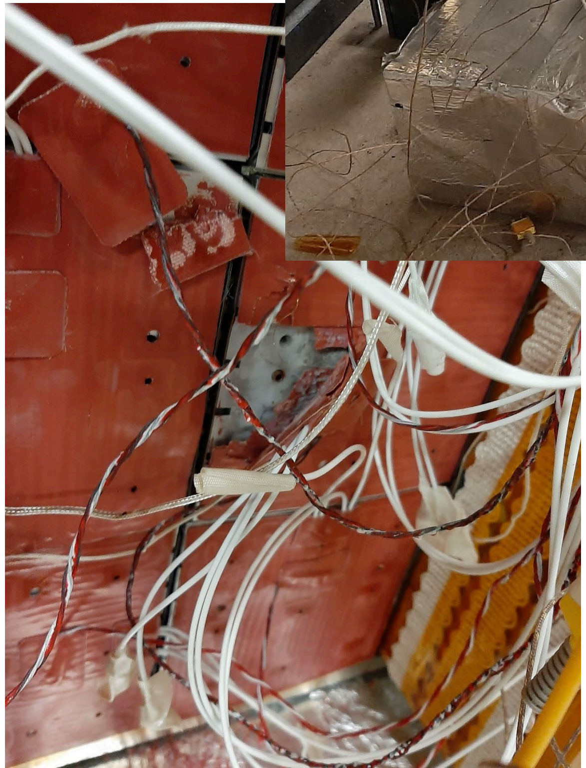


Ongoing efforts: heating tests

I completed a test using the same silicone heaters on a 6 supermodules prototype but only monitoring crystal temperatures

- Reached ~220 degC on front face with 125W
- Don’t know how hot heaters got, but deterioration evident post-test so likely exceeded rated temperature
- Determined these heaters will not be sufficient





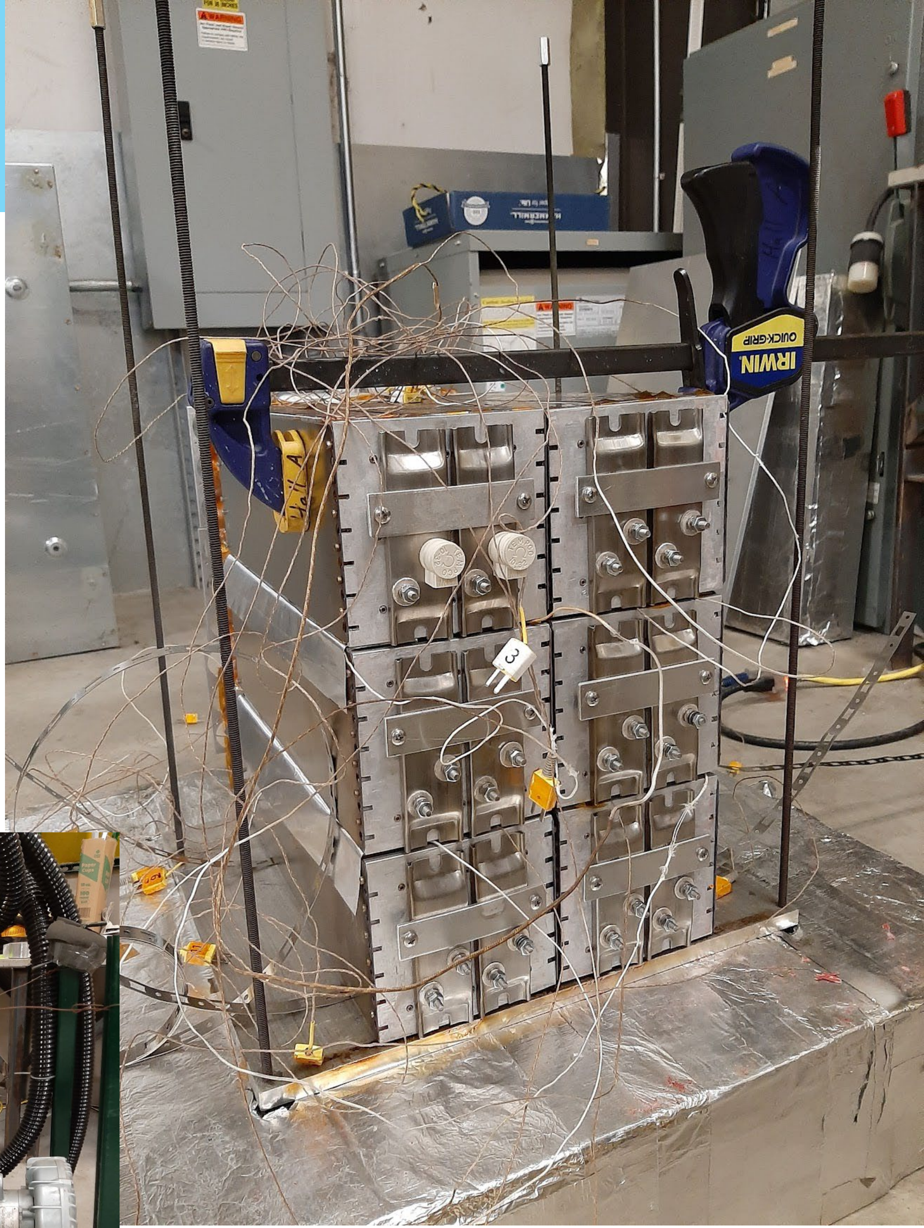
Ongoing efforts: heating tests

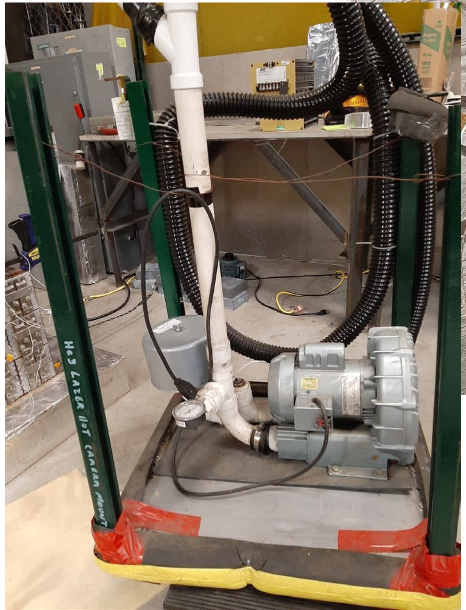
Final 6 supermodule prototype test using 120 VAC plate heaters currently being built

- Will monitor crystal and heater temperatures
- Include light guide cooling
- Side heaters will also be employed

Once we have demonstrated (in early to mid April) we can reach the desired temperatures, heaters (either plate as shown here or cartridge as used by DSG) will be custom ordered at 48 VDC and the power we need.

Want all components designed and ordered by June if possible





Ongoing efforts: ECal platform

Platform, frame and components moved to hall

Will be assembled soon on beam left

Installation of supermodules will start once assembly is complete

Ongoing efforts: cables, HV boxes, etc.

- Need 22 more 48 channel HV boxes. Mindy is engaged in building these.
- Several more 24 pin cables being built. Waiting for part to arrive (late April).
- ~1000 75m cables being cut and will have to be BNC terminated
- Light guide cooling system design being completed and will be ordered soon
- PMTs gain individually measured and base construction nearing completion at JMU
- All major components ordered. Efforts to locate and ensure anything neglected is located or ordered soon and on time.
- Laying out all electronics components and their locations and mapping all signal and HV paths

Big picture installation timeline

Now April-July 2023

- Conclude heating tests and order all heaters and connectors required.
- Ensure all remaining elements of ECal + enclosure are designed and ordered
- Move 5 HV racks and install in DAQ bunker, power up and install all crates, modules and patch panels. Install cables from module to patch panels.
- Get training for scissor lift and elevated working with harness
- Install supermodules, thermocouples and heaters
- Locate place and install heater power supplies and wire them up
- Develop controls for heater
- Install PMTs+bases and rear patch panel assembly
- Complete insulation + enclosure installation

Big picture installation timeline

Oct 2023 – Jan 2024

- Install HV cables from patch panel on rear of ECal HV boxes just outside enclosure
- Install signal cables from patch panel on rear of ECal to Front End summing/amplifying modules
- Install Front End electronics
- Complete enclosure installation including rear panels and test for light tightness
- Do high-temperature tests of oven. May have to work weekend/evening during initial heat up since there are usually strong odors during the first few hours that could annoy others working in the area.
- Completely connect HV chain from supplies to PMTs
- Test each channel using cosmics and oscilloscope at Front End patch panels

Big picture installation timeline

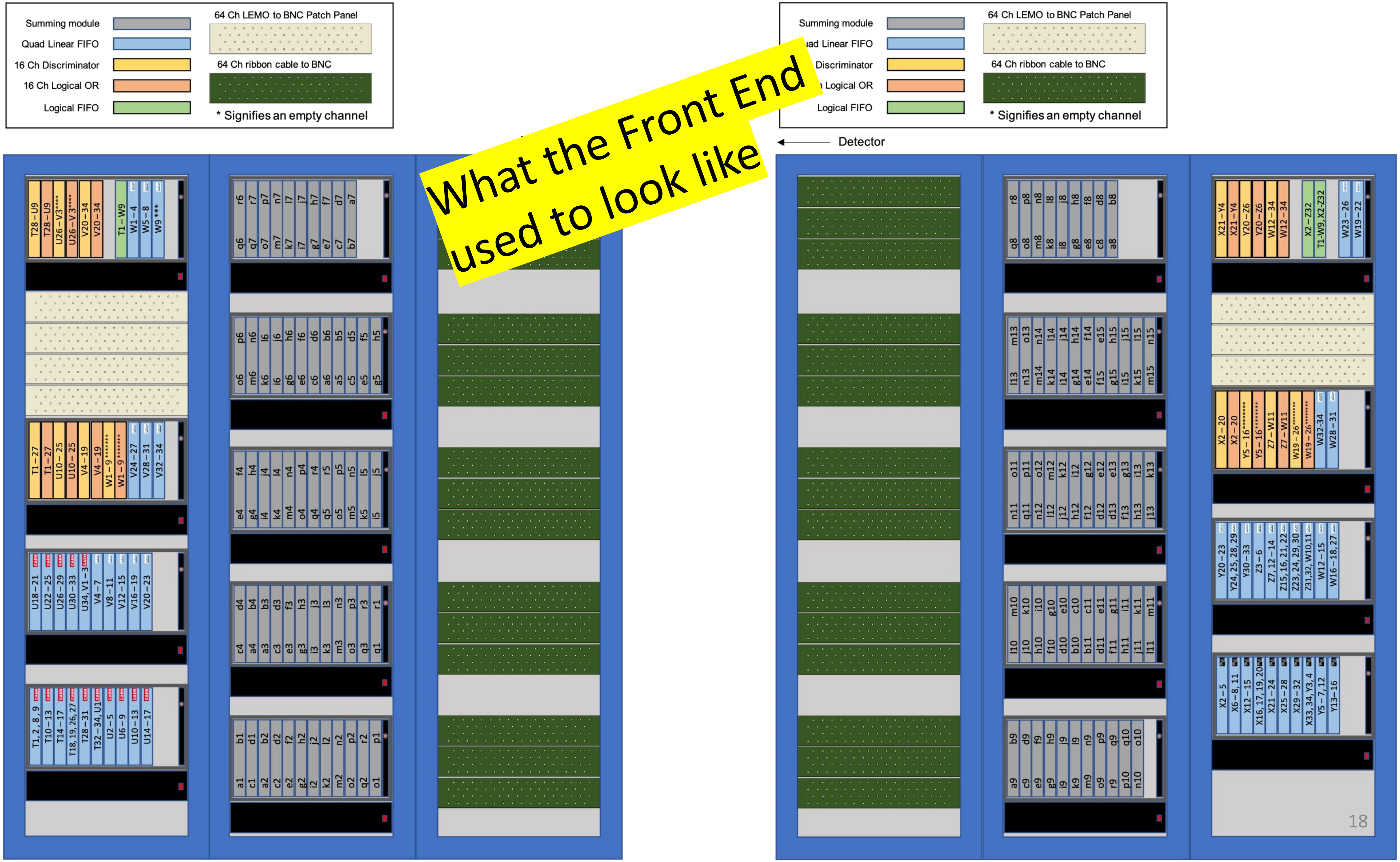
Mar – July 2024

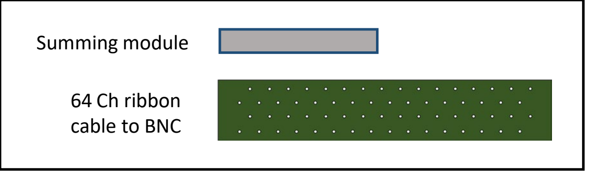
- Un-install and decable BigBite+GRINCH+Hodo
- Get all FADCs (new ones + NPS + BigBite)
- Install DAQ: 7 VME crates+FADCs, 1 trigger supervisor crate, scaler crate
- Run 1656 long cables from Front End to DAQ bunker
- Install patch panels for signal cables
- Install short BNC to LEMO or LEMO to LEMO cables from patch panels to FADCs
- Test, test, test

What the Front End used to look like

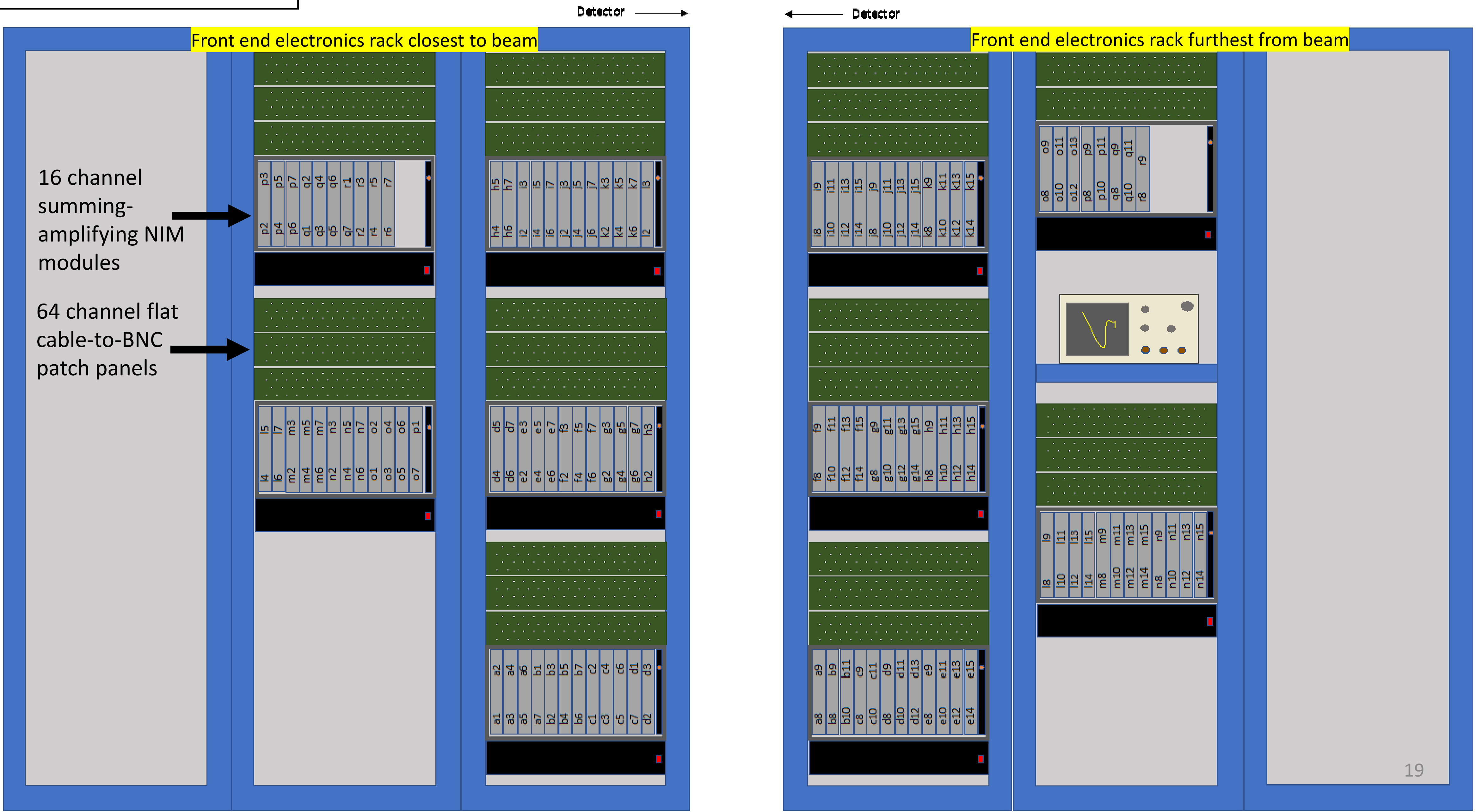
Front end electronics rack closest to beam

Front end electronics rack furthest from beam

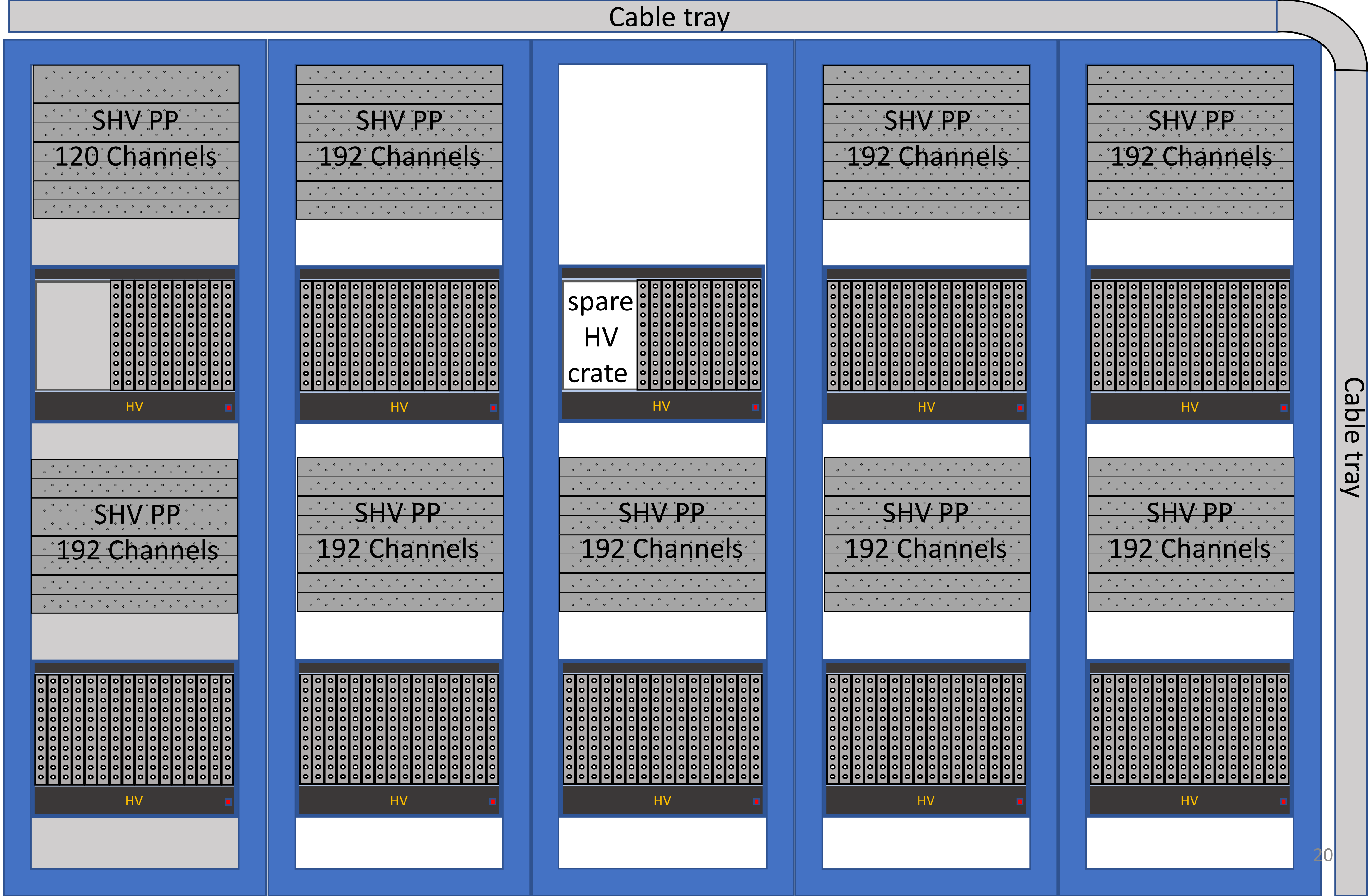




Front End simplified due to FADC readout → trigger now in FPGA

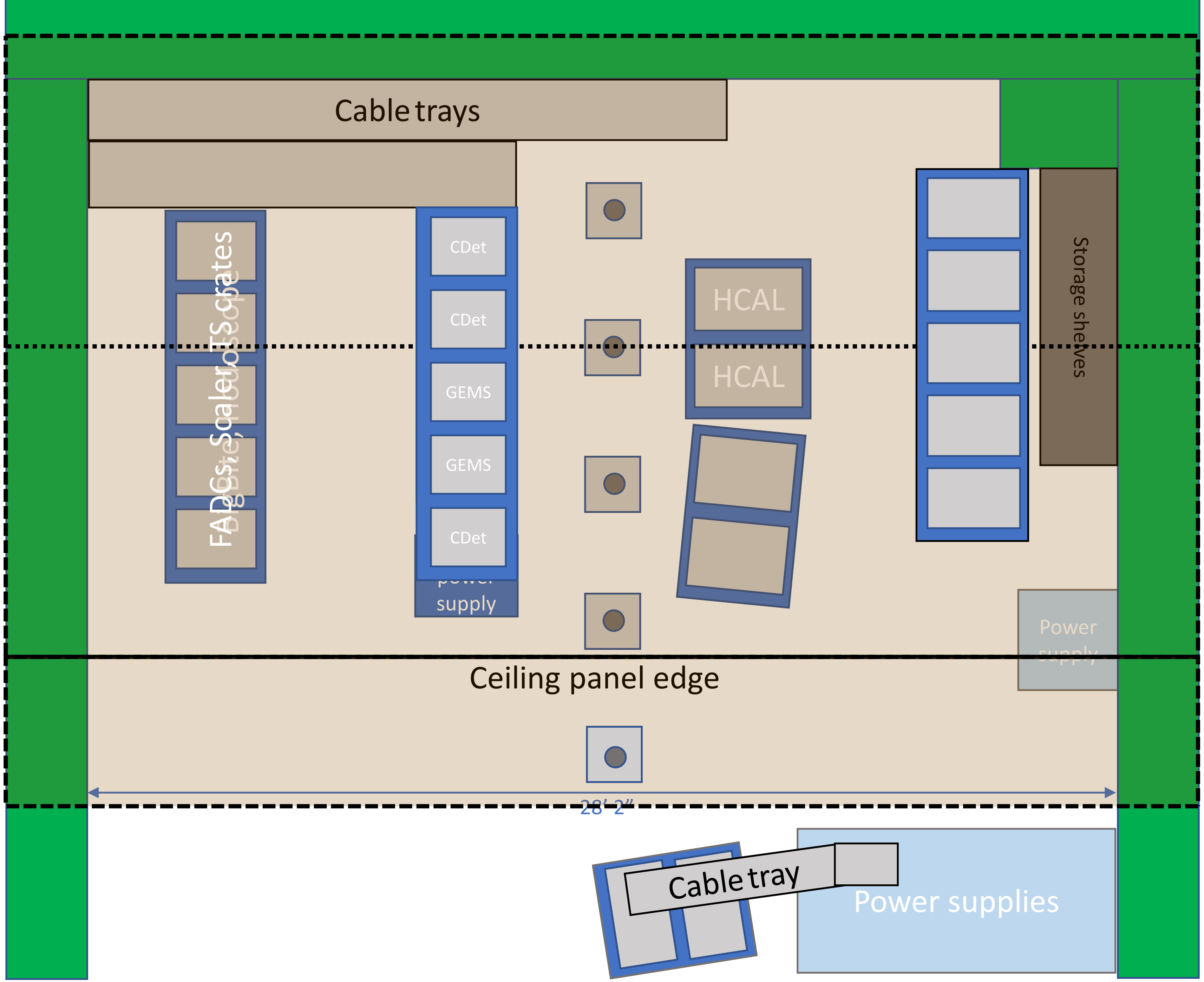


1656 High Voltage Channels over 5 Racks



1656 Channels VME FADCs

DAQ Bunker in Hall



Current layout

Reconfiguration steps

1. Move storage shelves and install 5 racks for HV in their place. Install HV crates and modules in racks (Summer 2023)
2. Move HCal racks slightly to give more room.
3. De-install BigBite and Hodoscope electronics, HV and cabling (April 2024)
4. Consolidate GEM electronics in two racks (April 2024)
5. Move central racks and power supply outward to allow 3 racks for CDET
6. Install Patch Panels, VME crates for FADCs and Trigger supervisor and install scaler crate.
7. Run cables and connect everything up.
8. Add ceiling panels?

Conclusion

- Lots to get done
- Need lots of help (students, postdocs, researchers)
- Great opportunity to get experience with installing a large-scale modern experiment
- Overall picture/plan in place, but details like precise schedule and personnel still need to be worked out.