OAK RIDGE National Laboratory

Month 11, 2025, ePIC DAQ

PED request: gRDO development and CALOROC-based FEB for detectors

PRESENTED BY

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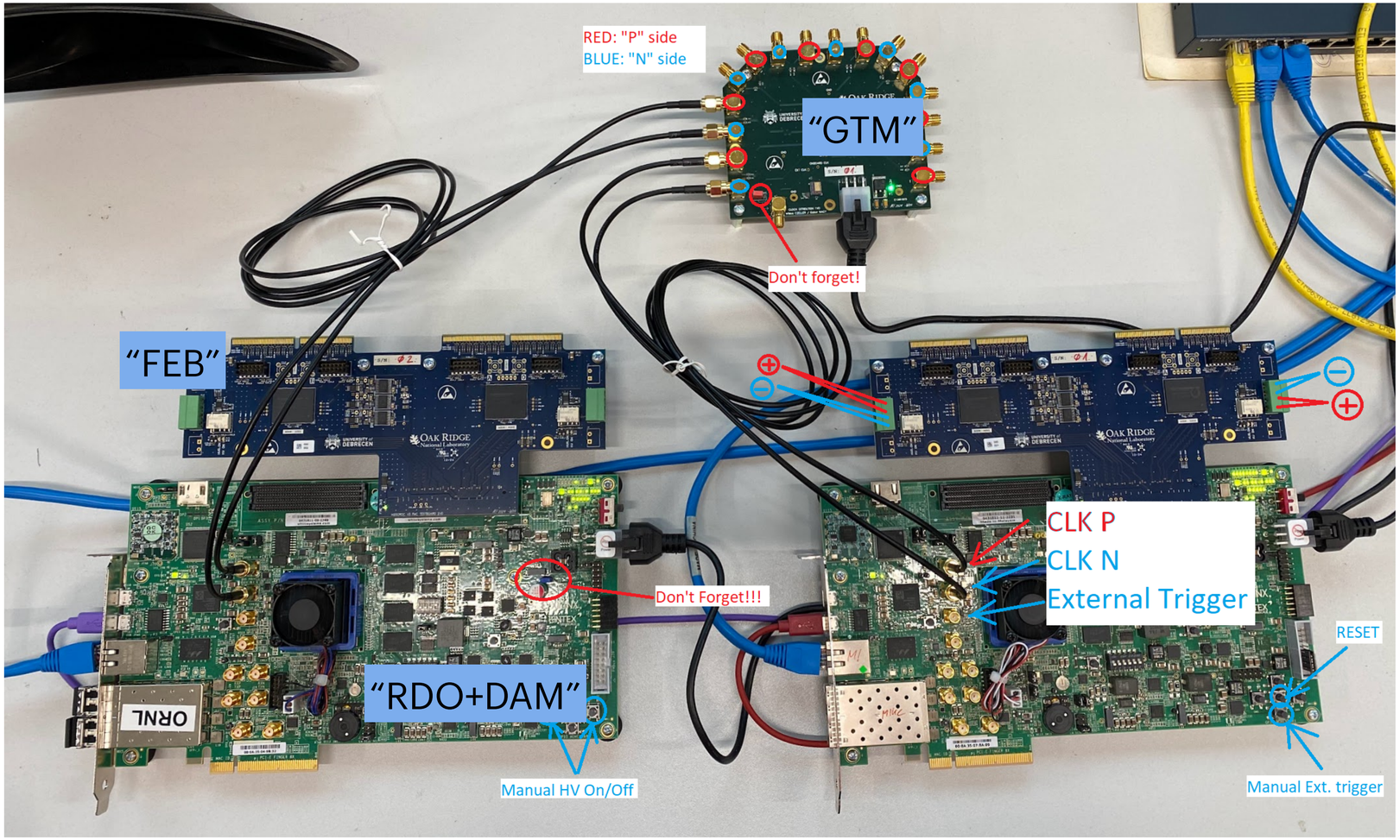
ORNL

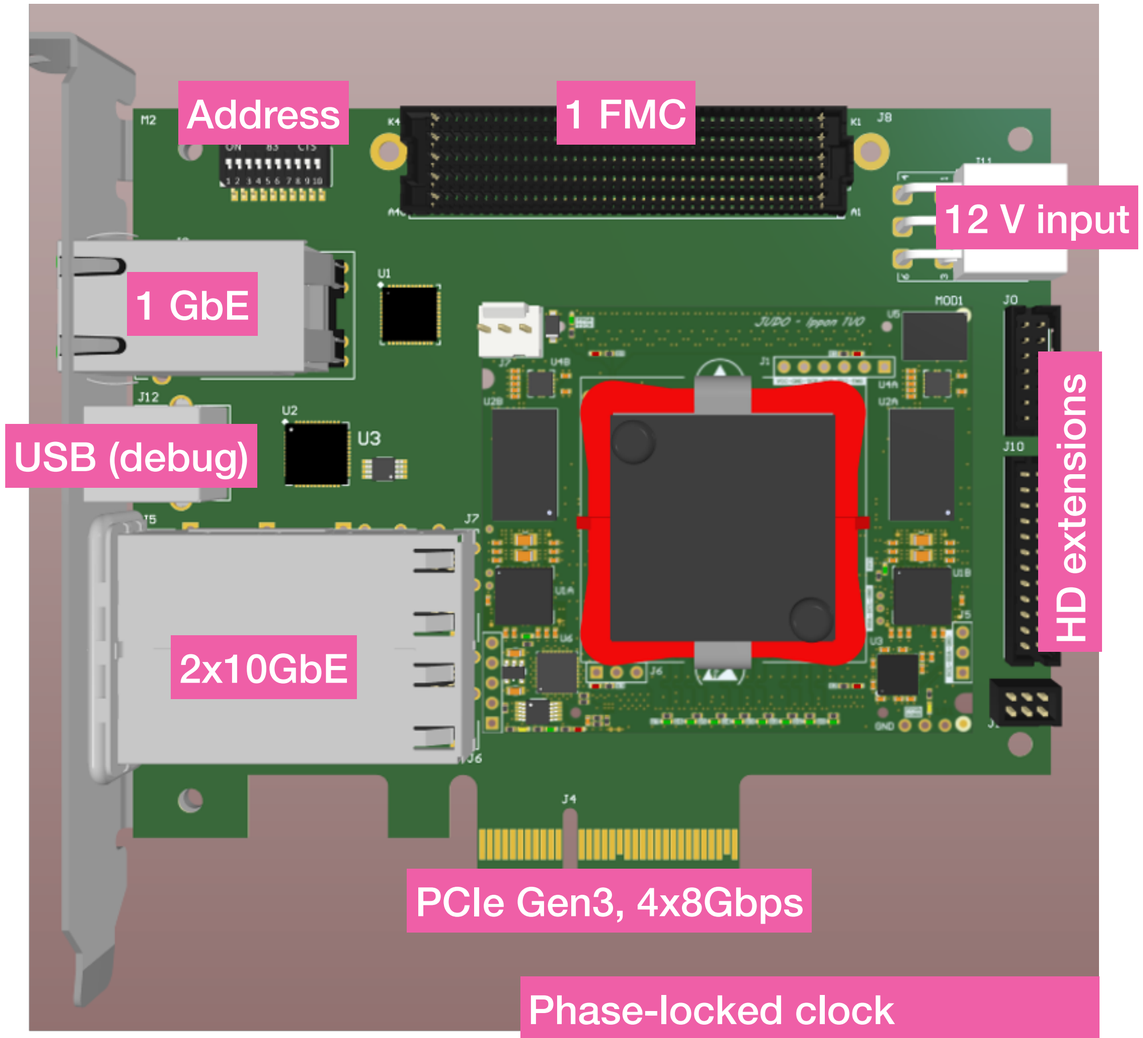
Where are we at



We have a protoboard2.0 supported from the eRD109:

- Containing 2 H2GCROCs
- KCU firmware for readout
  - Now upgraded to 10Gbps readout
  - 2 protoboard per KCU is supported
- We produced ~20 protoboards, all calorimeters have a board
- Clock board, interface boards, trigger boards, cables, etc
  - These are supporting the readout, but it is also 'work and money'

Generic RDO (gRDO)



Generic RDO board:

- Mezzanine for the FPGA is prepared. Only input is 12V power and the rest is on the board
  - Two types with different memory unit. Large memory might be needed for the aggregation work
- Baseboard needs some extra work
  - This is for basic testing, can be changed further
- In-limbo since last year, but it could be produced in 2 weeks

Front End Board - some of the challenges

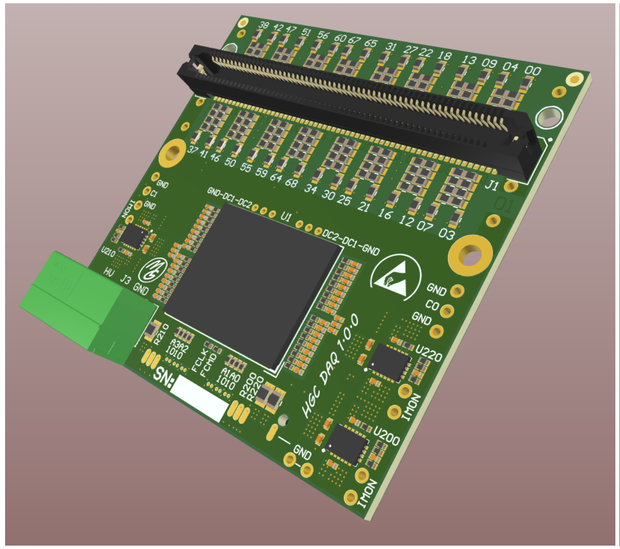
We need to test and adopt the CALOROC for each detector:

- Summing board for BIC and LFHCal detectors
- BHCal, no constraints on the size of the boards
- BIC:
  - Very strong size constraints
  - Provide also power (DC-DC) to the Astropix - need to synchronize with the NASA team too
- LFHCal + insert:
  - Constraints on the size of the board
  - Insert provides a big question - the electronics is exposed to high synchrotron radiation or we need to put in cooling
- nHCal:
  - Need to figure out the number of channels and then we can go on
- EEEMCal + ForECal:
  - Just optional checks and development

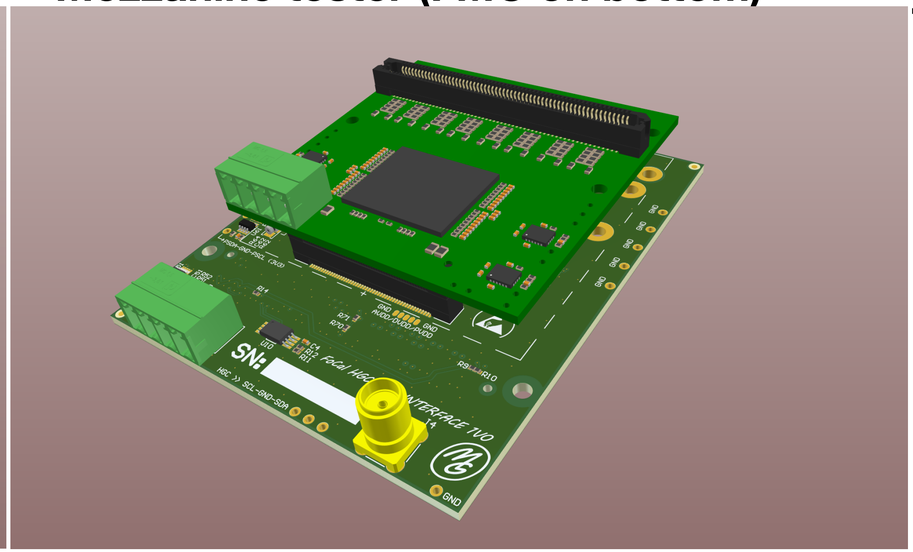
Need to have real detector tests on test benches in order to see the true responses and provide improvements also to the CALOROC preamp and feedback to the ASIC developers

New H2GCROC/CALOROC readout board

H2GCROC mezzanine



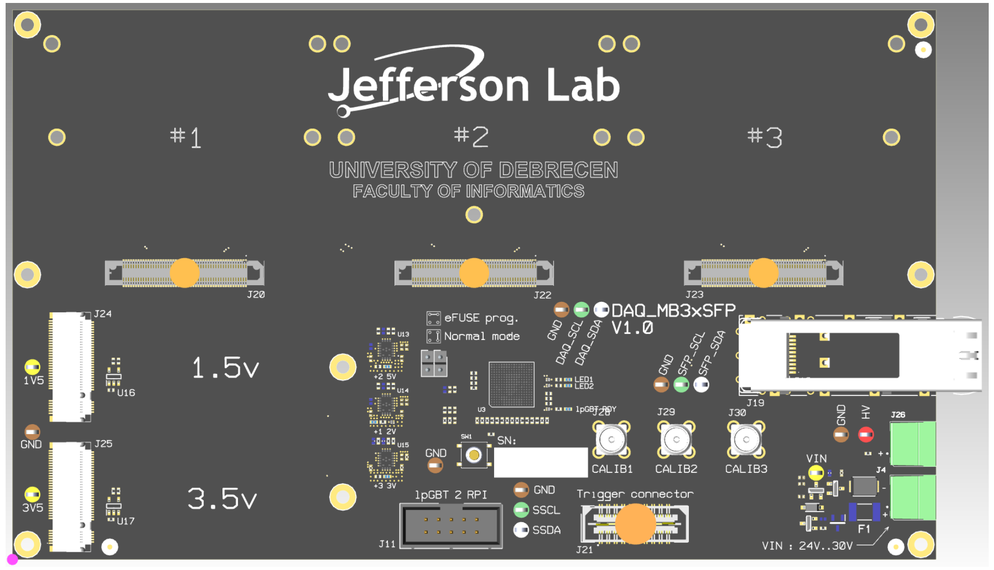
Mezzanine tester (FMC on bottom)



The mezzanine:

- 10 H2GCROC3D mezzanines will be produced
- One mezzanine == 64 channels
- Once CALOROC is available:
  - Make mezzanines with CALOROC
- Mezzanine Tester:
  - Connect to an FPGA FMC connector (e.g. KCU105, RDO, etc)
  - Individually testable setup
  - Can be used for small setup as is
    - LED tester for example

Baseboard for 3 mezzanines



Step forward:

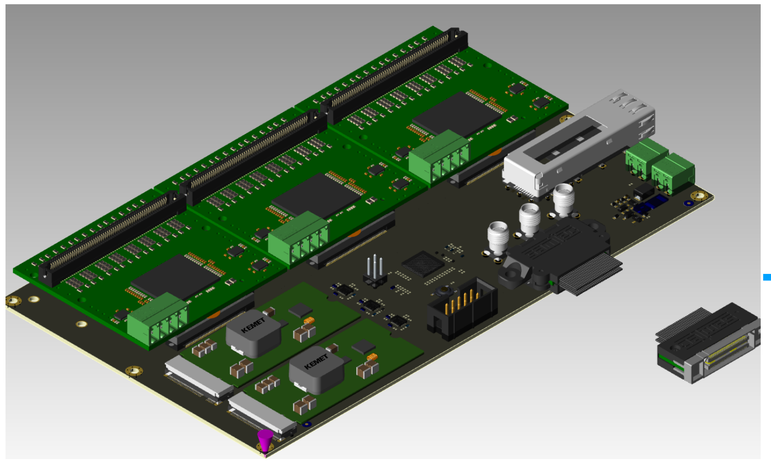
- Can take 3 mezzanines:
  - Does not matter H2GCROC or CALOROC mezzanine
  - Both has 2x1.28 Gbps data lines
- First test article for all FEB
  - 1 LpGBT can take 3 ROCs
  - 1 SFP+ —> 10 Gbps output
  - 2 DC/DC bPOL48 converters
  - All radiation tolerant (SPF+?)

Integration to the full readout chain

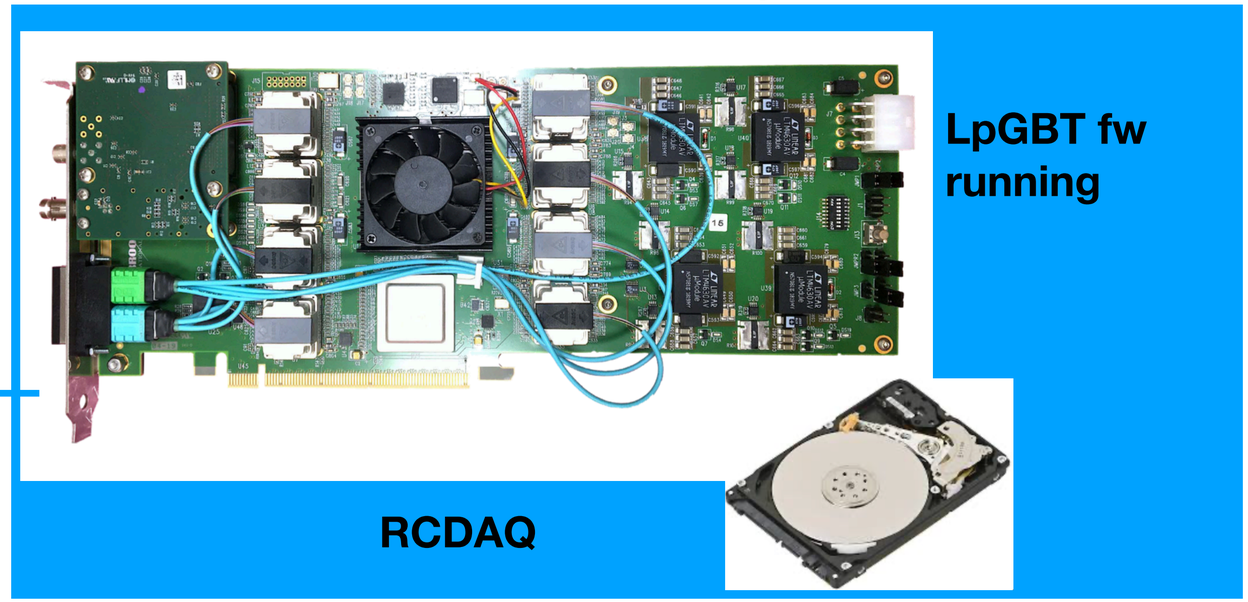
Setup a full readout chain:

- FEB's —> gRDO —> DAM boards
  - Here we can use the existing FELIX-712
  - H2GCROC board is in production - easy to change to CALOROC once the chip is available
  - Large scale tests and firmware development is needed

Step 1 - direct connection



10Gbps fiber



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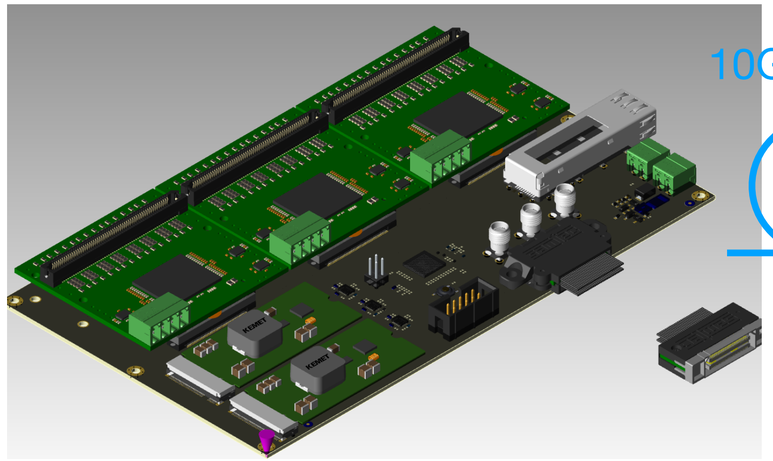
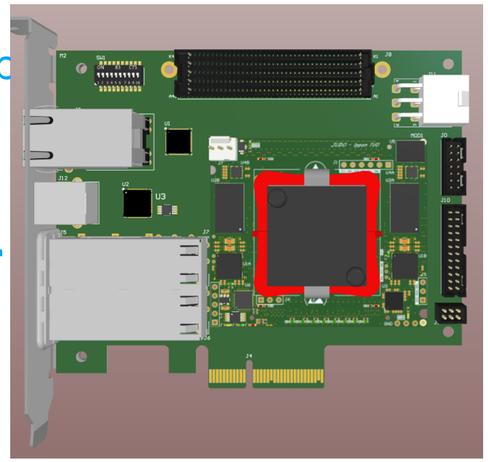
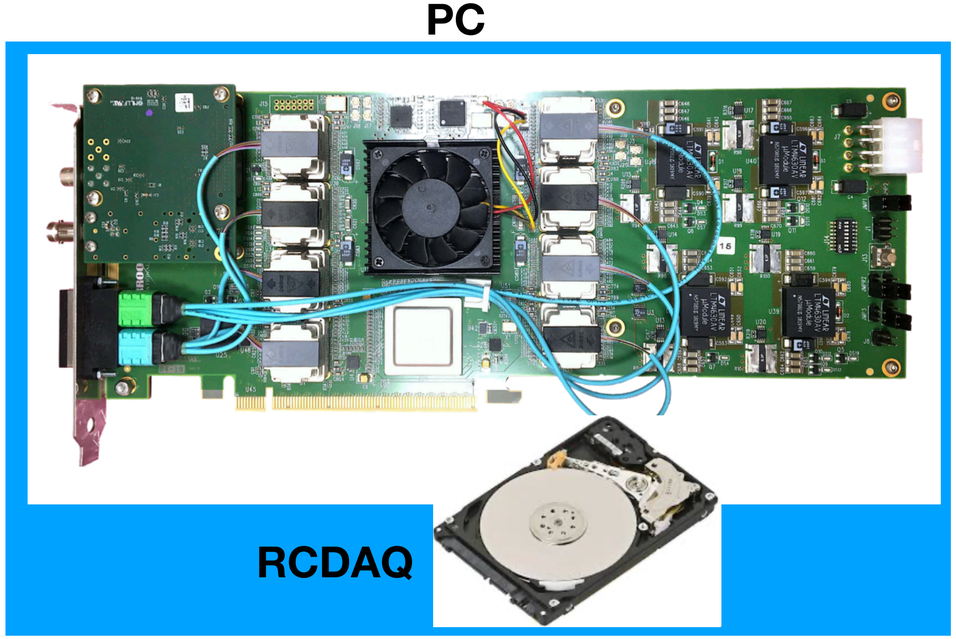
Step 2 - full chain test

Investigate the aggregation ratio (4:1)

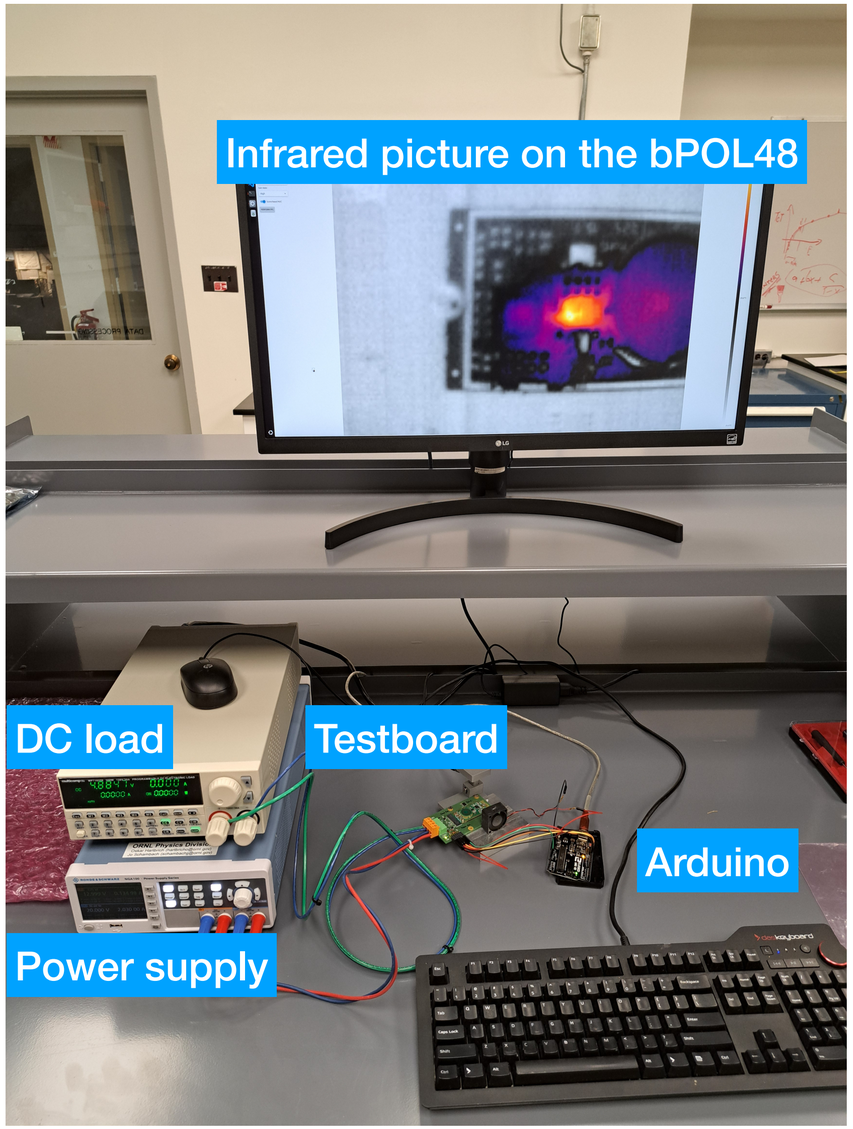


10Gbps fib

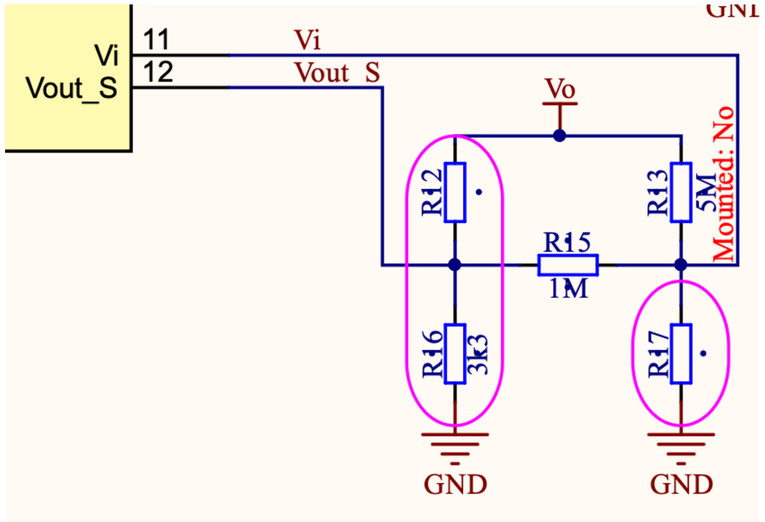




bPOL48 testing stand (DC/DC converter)



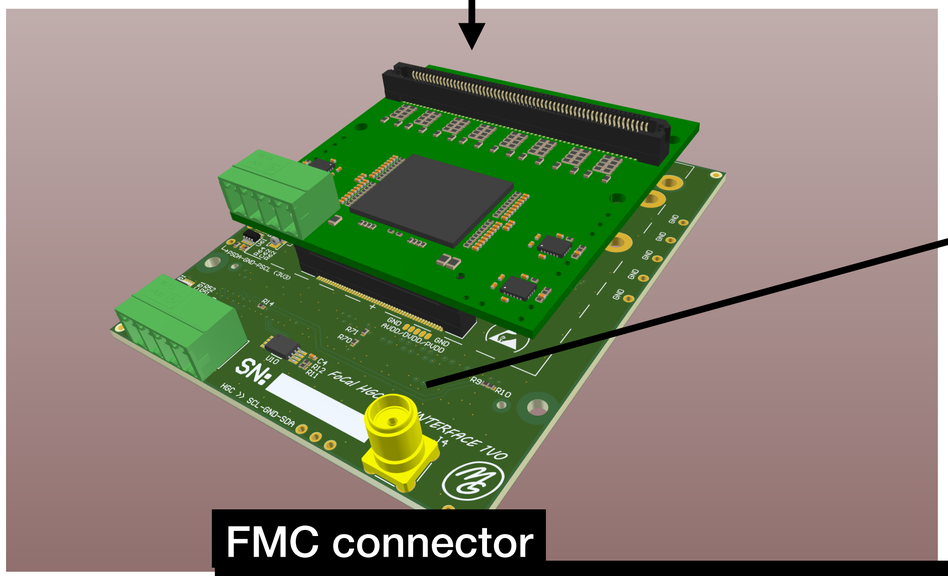
- This current mezzanine is maxed out at 5A
  - Do not apply more
- Two mezzanines (third sent to Gerard):
  - One is a aircoil from CERN
  - One is a iron-powder thing
- DC/DC programable load
- Power Supply (max 2A input)
- Arduino to monitor everything, temperature, power
- Infrared camera, just to see the heat sources



You can setup the output voltage with the resistors

LED testing setup

Specifically for BHCal



FMC connector

FPGA for readout

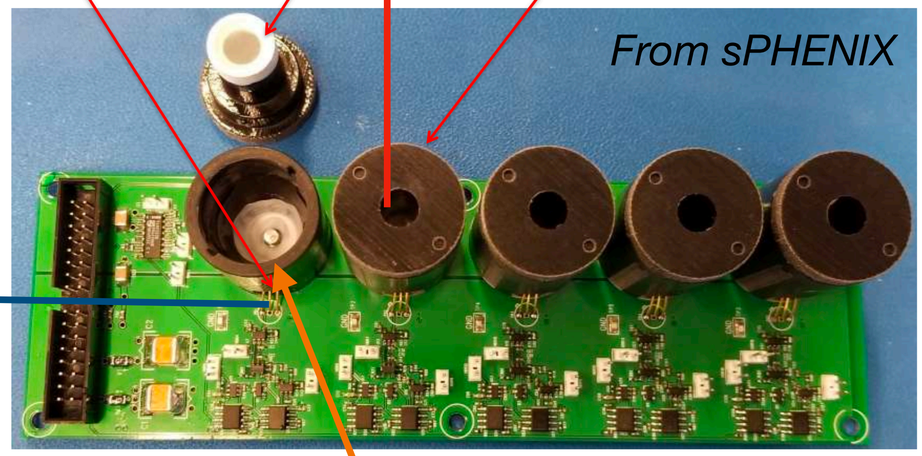
SiPM

Signal response

Tile

Light to the tile via fiber

Light to tile

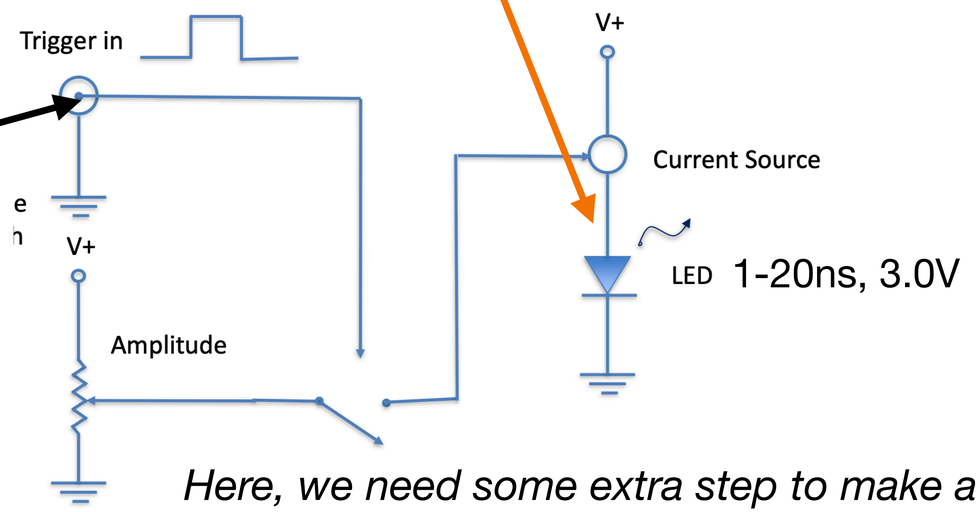


Light from the pin diode

Delay + attenuation

Calibration channel input

The LED for calibration



Here, we need some extra step to make a settable length (via I2C would be the best)

Goals of the tests with different detectors

	Summing circuits	CALOROC A or B	Smallest signal	Largest signal	Gain Conveyor	Preamp settings	Calibration needs
BIC	Yes	?	?	?	?	?	LED on light guide
Barrel HCal	N/A	?	?	?	?	?	LED-fiber delivery
LFHCal	Yes	?	?	?	?	?	SiPM on tile
LFHCal-Insert	N/A	?	?	?	?	?	SiPM on tile
nHCal	?	?	?	?	?	?	SiPM on tile
ZDC	N/A	?	?	?	?	?	SiPM on tile
ForECal (optional)	Yes	?	?	?	?	?	?
EEEMCal (optional)	Yes	?	?	?	?	?	?

Plan to fill the table and much more by end of the year

Funds requested

	FY26	FY27	Total
ORNL time (my time, 15%)	60,000	60,000	120,000
ORNL (material, licenses)	120,000	120,00	240,000
Electrical engineering (2 x full-time, 200%)	336,000	336,000	672,000
Travel (testbeams, meetings, workshops)	20,000	20,000	40,000
Total	536,000	536,000	1,072,000

And yes, I plan to keep it up until start time of ePIC data taking

Milestones and plans (short version)

- Continue support for the H2GCROC testing (hardware, firmware, software)
- Summing circuit development:
  - Passive - January 2026
  - Low power active - December 2026
  - Test and optimize - June 2027
- New readout board for H2GCROC/CALOROC:
  - Design and production of H2GCROC board - December 2025 (Still part of eRD109)
  - Testing and readout - March 2026
  - CALOROC mezzanine and testing - April-May 2026
- Characterization of the CALOROC chips for different detectors:
  - By end of 2026, June 2027 latest - need some hardware from each detector
- LED calibration circuits - February 2027
- Develop generic RDO hardware, firmware, software - December 2025-December 2026
- Full readout chain:
  - First with FELIX-712, then gRDO aggregation, then with GTM, move towards FLX-155 etc etc - February 2026 - September 2027

Summary

- gRDO development and production
  - Include the firmware for LpGBT-based readouts:
    - Aggregation option
    - Follow the RDO-DAM protocol once ready
- FEB development:
  - Test article developments for the CALOROC chip
    - LFHCal, BHcal, nHCal, BIC (maybe also Insert)
  - Readout larger scale chip arrays
  - Slow control for ASICs, LpGBT has 8 ADC's built in for monitoring
  - DC-DC tests and development
  - Calibration circuits (LED-based)

Crossing Calorimeters

- This will benefit all LpGBT-based readouts also: SVT (working with Jo), TOF, etc
  - Common platform for aggregation and communication with the LpGBT-Chip (Chip = CALOROC, Mosaix, EICROC, Astropix, FCFD?)
- Large scale test for stress-testing the system - DAQ development
- ASIC slow-control can be reused in other detectors (python3-based most likely)

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