OAK RIDGE National Laboratory

LFHCAL Test Beams – The Past, The Present, The Future

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(for everyone involved in LFHCAL)

ORNL is managed by UT-Battelle LLC for the US Department of Energy

U.S. DEPARTMENT OF ENERGY

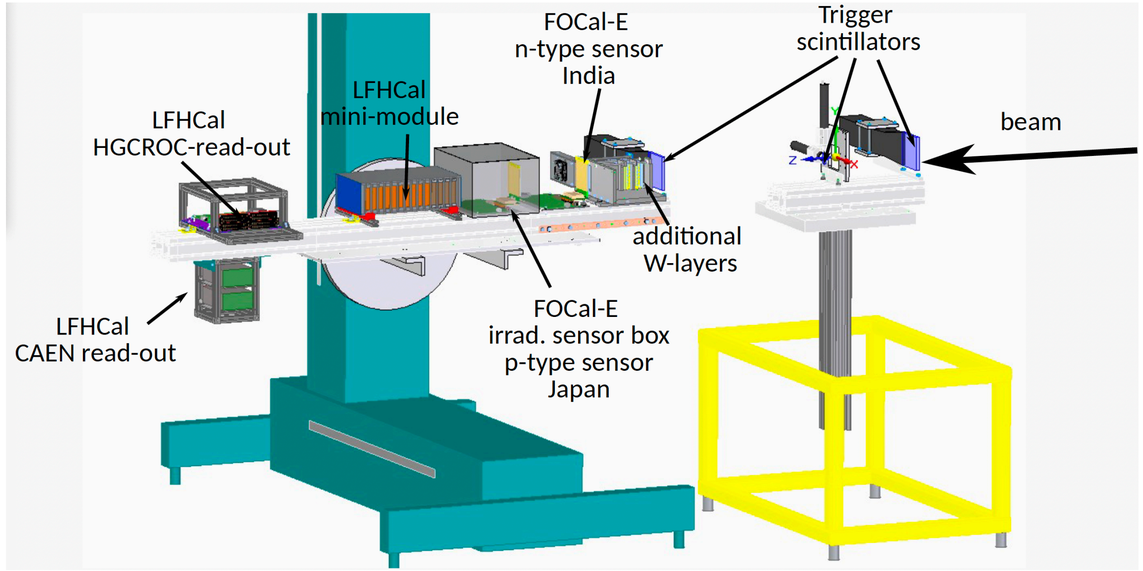
The Premature Summary

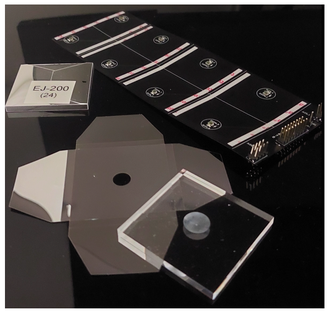
- 2023: mini-LFHCAL @ CERN SPS
  - 10 layers
- 2024: LFHCAL @ CERN PS
  - 65 layers, single full module
  - Single channel CAEN + HGCROC readout
- 2025: LFHCAL @ CERN
  - 8*65 layers, 8 full modules
  - Summed HGCROC readout

The 2023 Testbeam

2023 LFHCal Test Beams at CERN

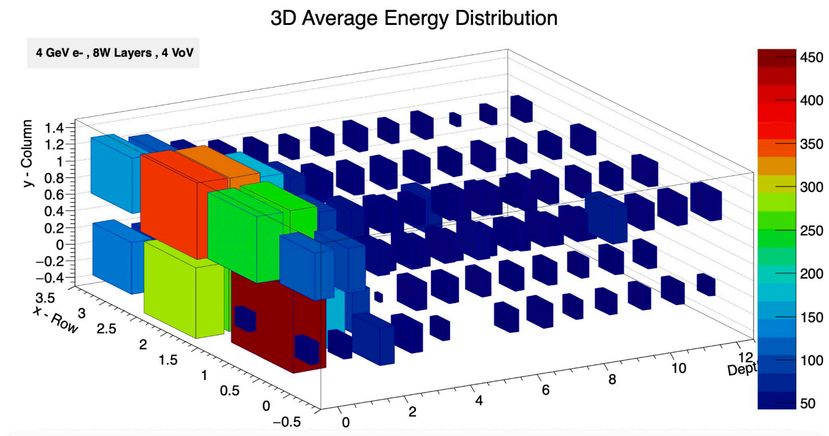
- **SPS: September 6th - 13th, 2023**
- **PS: October 11th - 18th, 2023**
  - Parasitic to FoCal-H/FoCal- E
  - Maximum 14 layers of 8M tile assembly
    - September: without absorber layers
    - October: with absorber layers
      - 4 tungsten, 10 steel
  - Read-out: CAEN DT5202 64 channel CITIROC or H2GCROC
- **Expected Measurements**
  - Per tile light yields
  - Shower profile measurements with different absorber
  - Tile cross-talk estimates
  - Testing SiPM-H2GCROC setup
  - Leakage measurements (when placed behind FoCal-H)

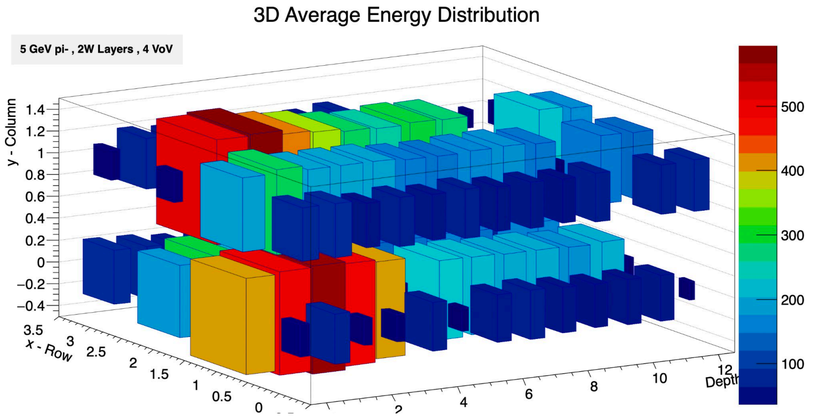


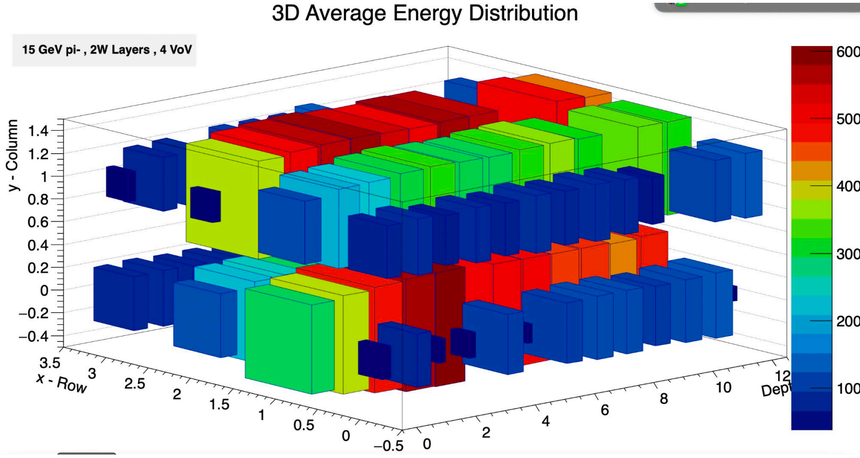


LFHCal Test Beams at CERN

- **October:**





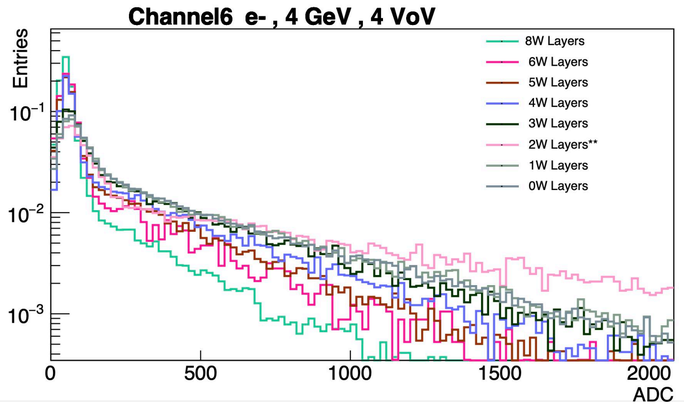


- **September Campaign:**
  - Full V_{ov} scan
  - Gain scan
  - Position scan
  - FoCal-H Leakage measurement

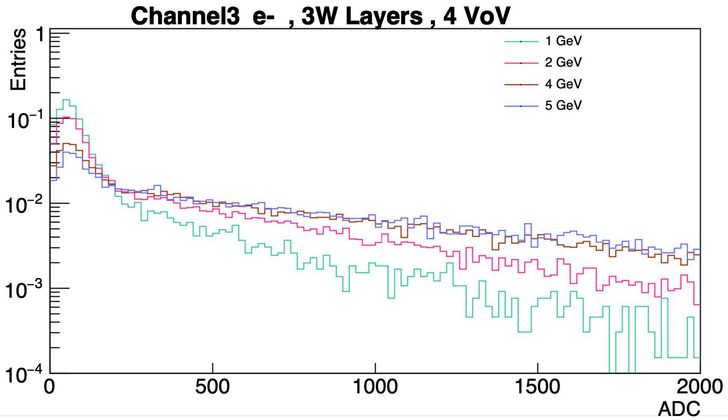
- **October Campaign:**
  - Full V_{ov} scan (e^-/π^-)
  - Gain scan
  - Scan with additional tungsten plates in front (e^-)
  - e^- shower (1 - 5 GeV)
  - π^- shower (5, 10, and 15 GeV)

LFHCal Test Beams at CERN (CAEN Readout)

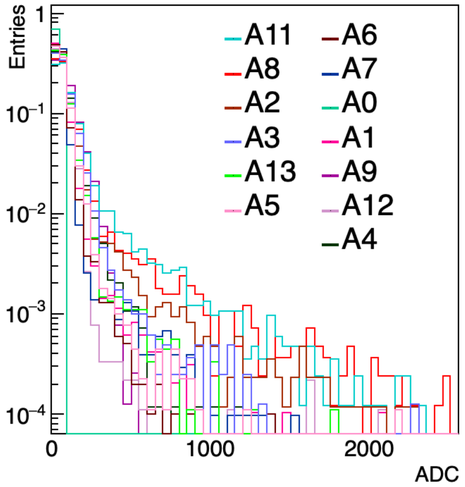
Tungsten layer scan



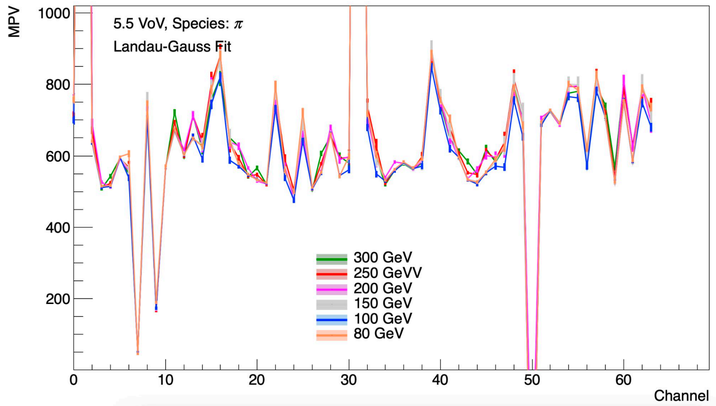
e^- energy scan



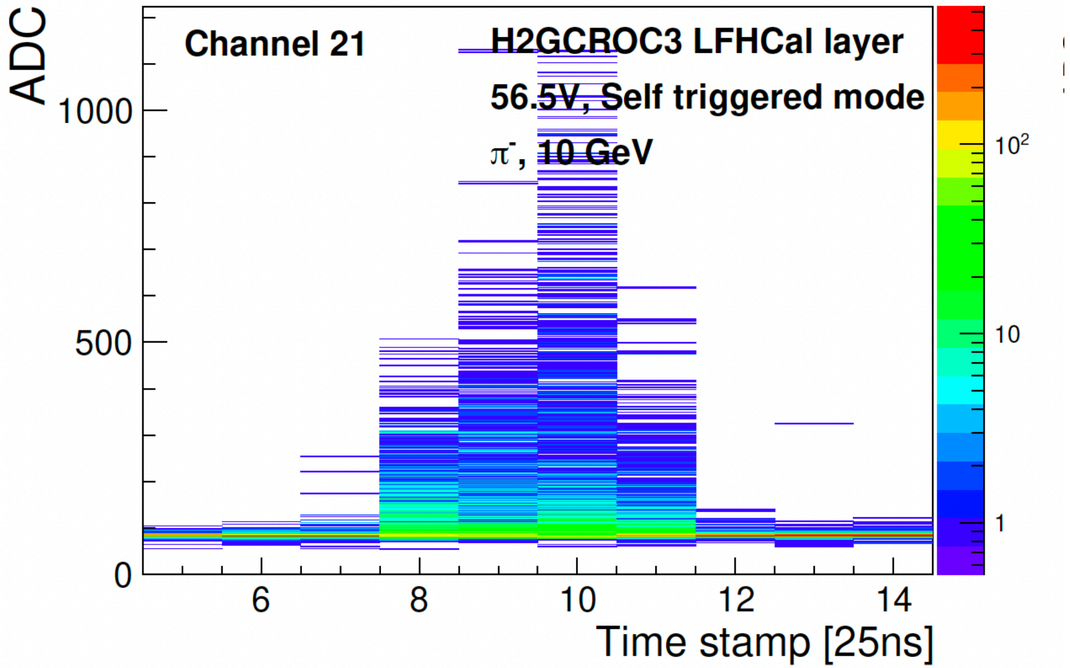
e^- shower development

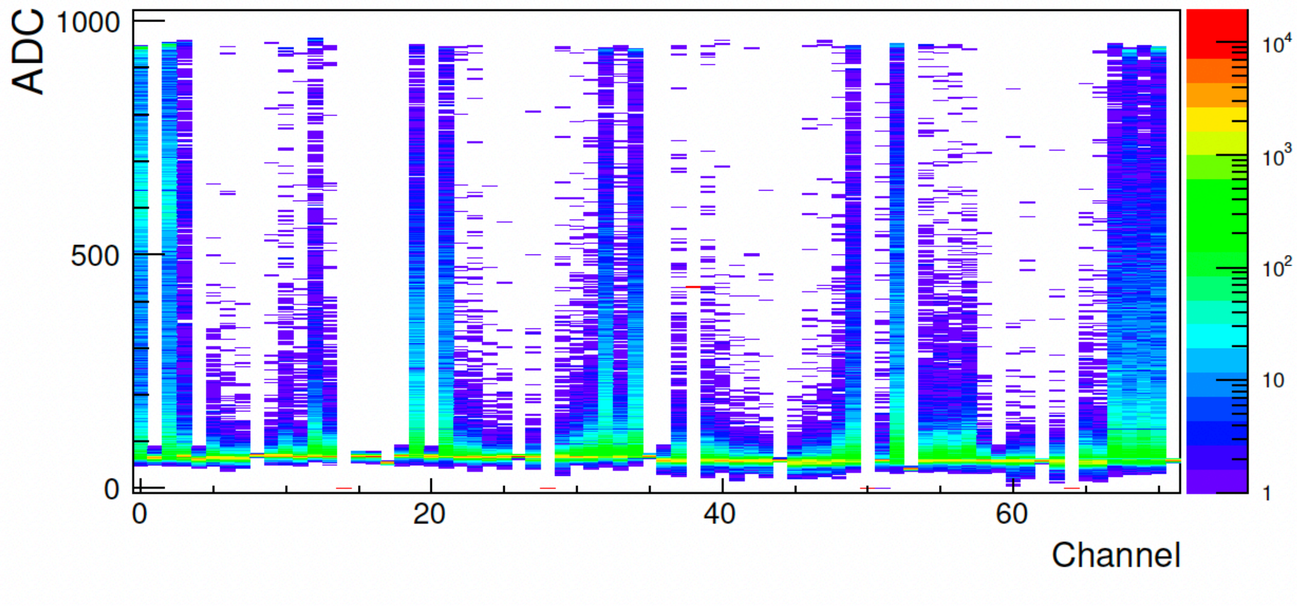


Scintillator MIP response



LFHCal Test Beam: H2GCROv3a First Results

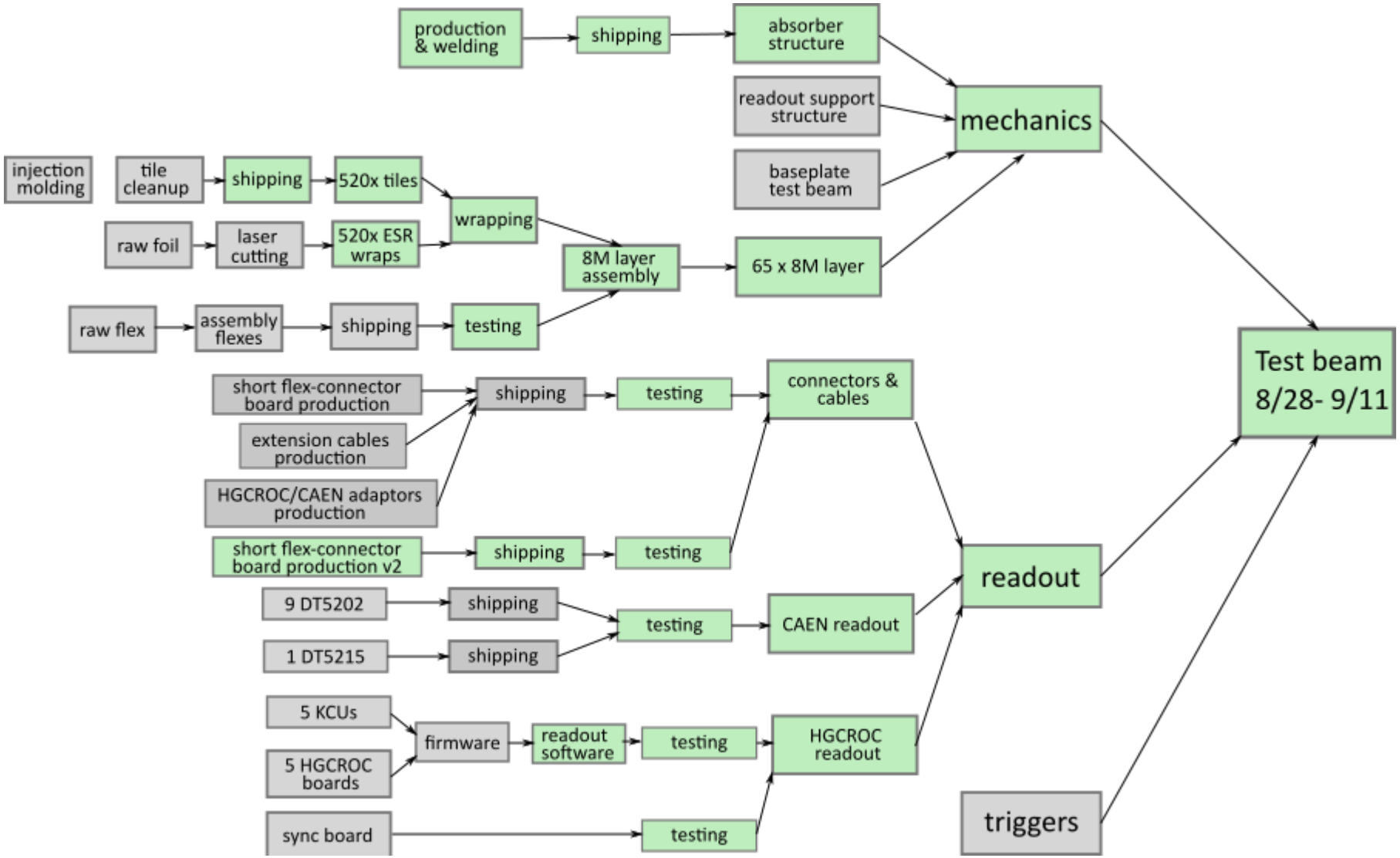




- H2GCROC read-out ready by last 1.5 days of October campaign
- Self-triggered data was acquired
- PS beam stop during last evening kept externally triggered setup from operating

The 2024 Testbeam

LFHCAL Prototype: Status at a glance

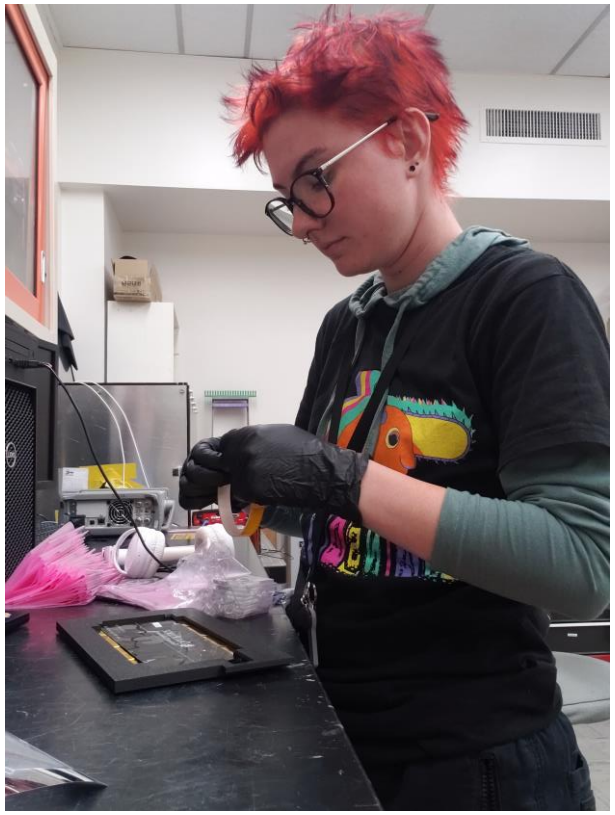


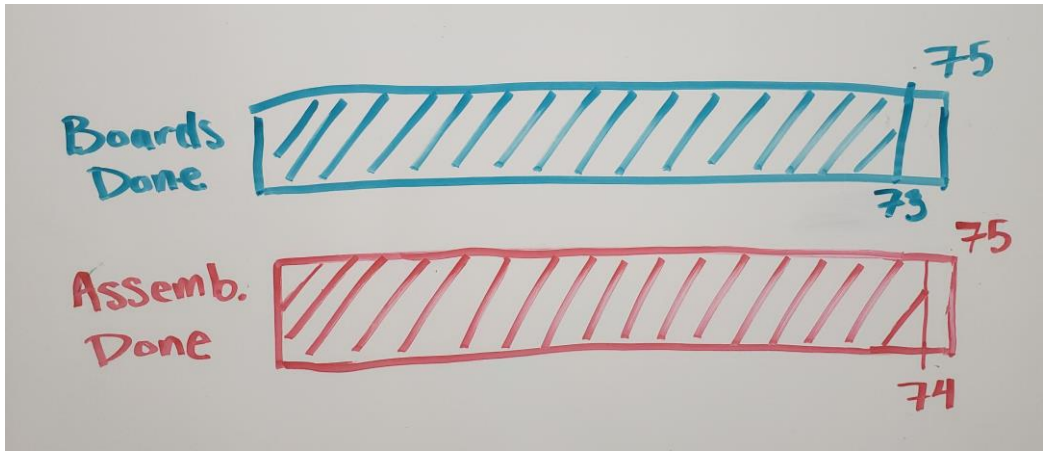
LFHCAL Prototype: Mechanics

- First mechanics module available, almost on its way to CERN

LFHCAL Prototype: Scintillator Layers

- All tiles available at ORNL (with many thanks to Valpo!)
- ORNL summer interns Droc and Hagen (both UTK) have assembled and tested 73 scintillator layers





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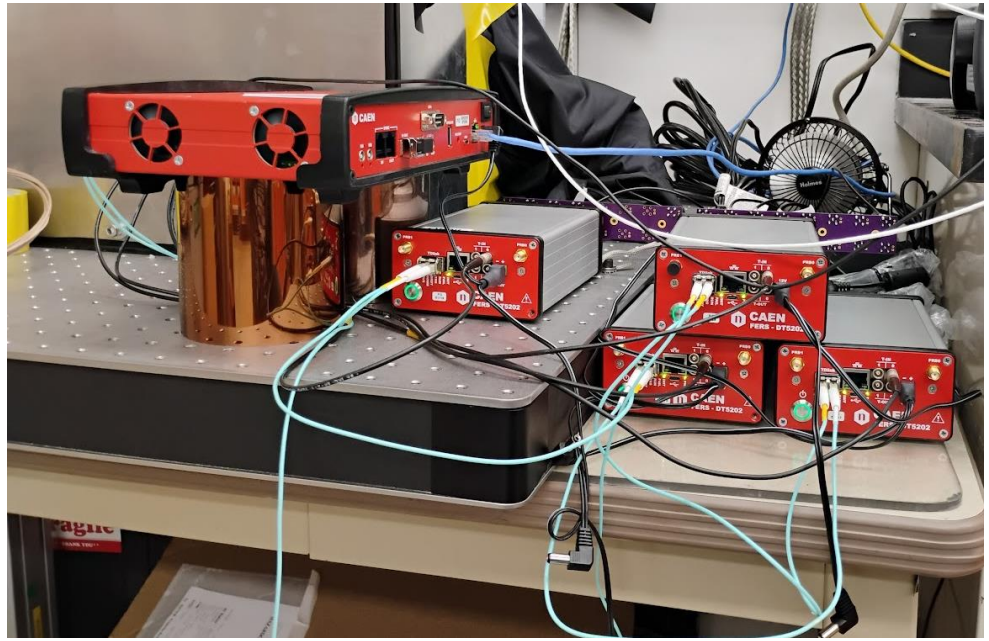
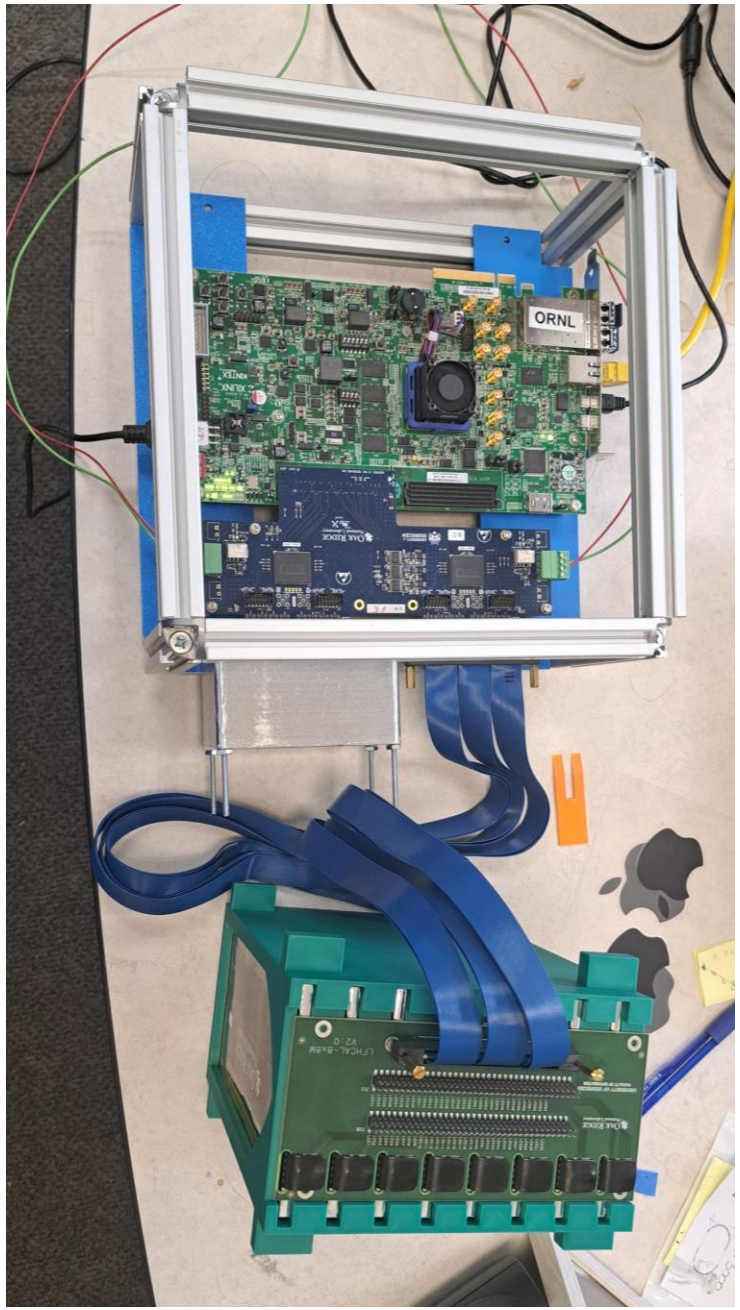
LFHCAL Prototype: CAEN Readout

- Have 9 DT5202 on hand:
  - 5 at ORNL, x at Yale, x at CERN, x at Valpo
- DT5215 data concentrator available at ORNL
  - Have tested various chain configurations of up to 4 DT5202 units successfully.
  - The usual software and firmware woes, but seems stable.



LFHCAL Prototype: HGCROC Readout

- HGCROC readout works.
  - HGCROC tested in May beam time with FOCAL modules, working well!
- (Most) necessary hardware ready and available



LFHCAL Prototype: Status Summary

- All the showstoppers that lead to the cancellation of the last beam time have been rectified.

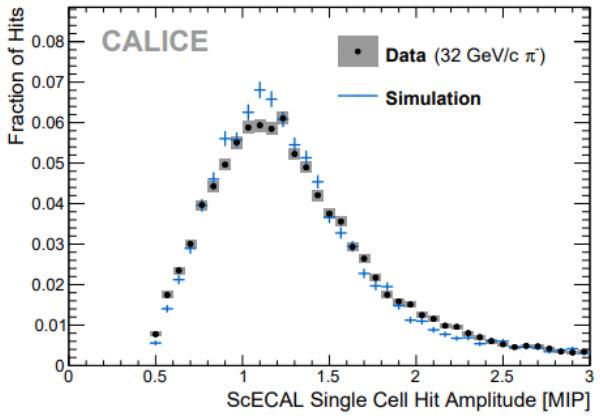
- Let's go to CERN!

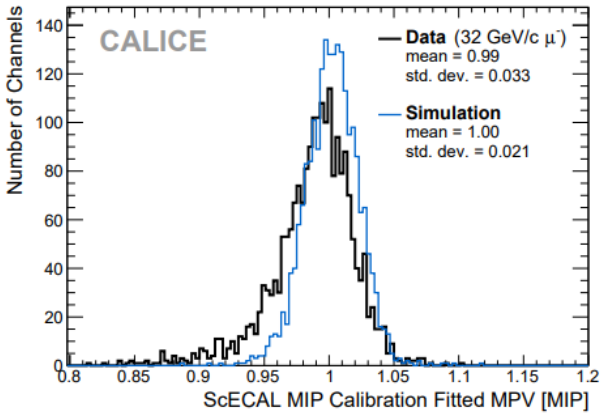
LFHCAL Prototype: The Plan

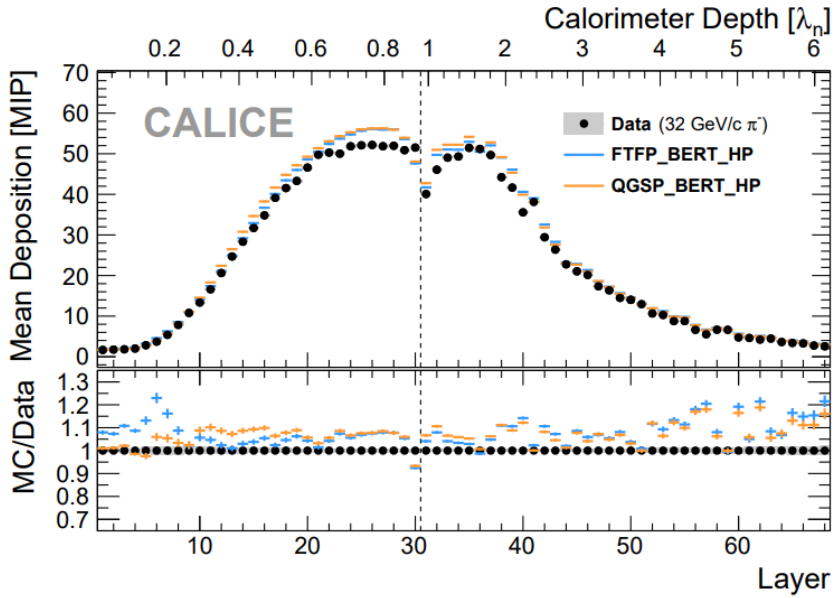
- Two continuous weeks of beam time at CERN PS.
- **August 28-September 11**
- First week: HGCROC Readout
- Second week: CAEN DT5202 Readout

LFHCAL Prototype: The Goal

- Expose LFHCAL module to muons, electrons, pions in energy range 1-10GeV
- Muons: Cell-by-cell MIP calibration
- Electrons: Response, resolution
  - Single cell hit spectra, SiPM saturation effects
  - + Geant4 comparison
- Pions: no chance to laterally contain pion showers
  - Longitudinal shower profiles, hit spectra
  - + Geant4 comparisons
- Publish in NIM/JINST:
  - Single paper?: construction, beam analysis?
  - Two papers?: construction, lab tests, 2023 beam + 2024 beam







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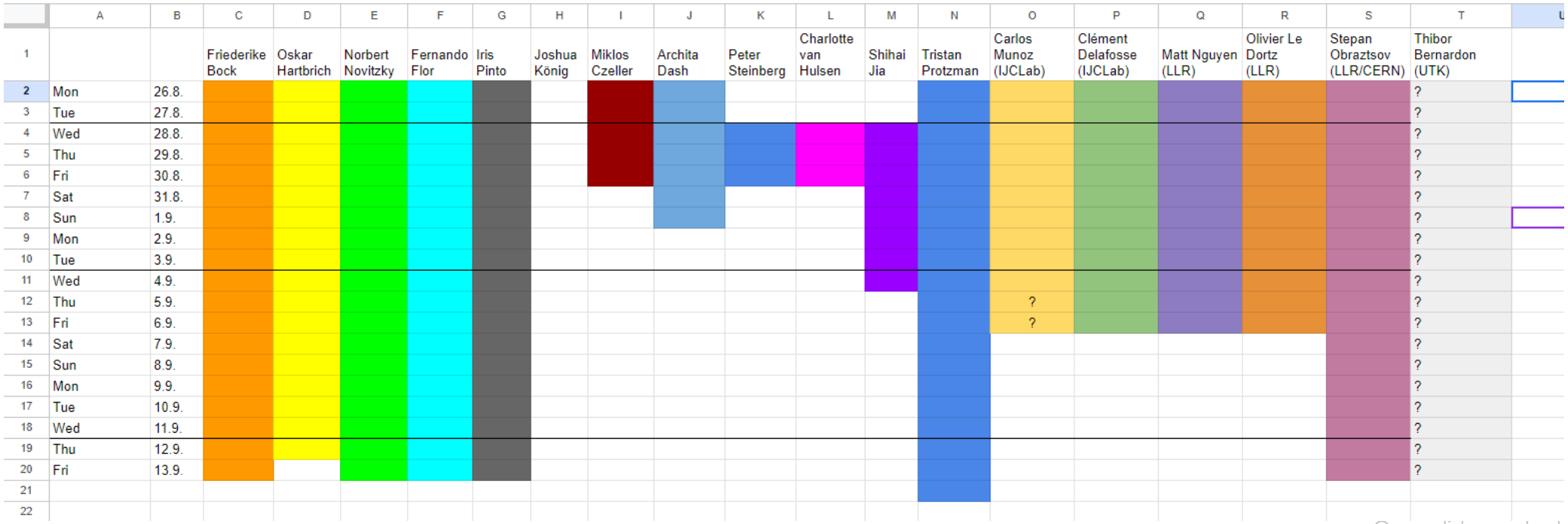
Shifters at CERN

- Lots of people already committed to support
- Can use more folks to join especially in second week
  - https://docs.google.com/spreadsheets/d/1PhS-cNn_RaXAg-ve5m3gGgDljovNYcPcVOQ3fz5_kqo/edit?pli=1&gid=0#gid=0
- Testbeams are exciting fun!
  - Come and join us!



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1			Friederike Bock	Oskar Hartbrich	Norbert Novitzky	Fernando Flor	Iris Pinto	Joshua König	Miklos Czeller	Archita Dash	Peter Steinberg	Charlotte van Hulsen	Shihai Jia	Tristan Protzman	Carlos Munoz (IJCLab)	Clément Delafosse (IJCLab)	Matt Nguyen (LLR)	Olivier Le Dortz (LLR)	Stepan Obraztsov (LLR/CERN)	Thibor Bernardon (UTK)
2	Mon	26.8.																		?
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The 2025 Testbeam

- May (?) 2025: 8 fully equipped LFHCAL modules
  - 40cmx40cm, almost enough for a hadron shower…
  - Full readout scheme test: HGCROC, summing boards
- 8x more of everything
  - Challenge in construction, setup, QA…
  - … and then we need to do two more order of magnitude steps up towards full ePIC LFHCAL
- Software and simulation efforts from 2024 beam will enable 2025 analysis…
  - Should really move towards implementing test beam analysis in eicrecon

Summary

- We will have the first full LFHCAL module in the CERN PS beam from August 28th.
- Come and join us there!
  - It's a great time to get involved, things are getting very real very fast!