

TDR effort, progress report calorimetry WG

O.Tsai 5/20/24

- Second meeting on April 10'th – agreed to hold progress report meetings every 6 weeks or so.
- Third meeting of calorimetry WG on May 15'th. Discussed reports from 4 out of 6 subsystems.
- Missing BEcal hold workshop at the same time (provided slides), BHcal (busy with sPHENIX), no update.

The screenshot shows a Safari browser window displaying an email from Indico. The email is titled "EPIC calorimetry bi-weekly meeting" and is dated Wednesday, May 15, 2024, from 12:30 PM to 2:05 PM US/Eastern. The meeting is held on Zoom with the following details:

- Description:** <https://ucla.zoom.us/j/93509495629?pwd=U3J3UkNRSWFBQU5CVm0ybTdwa3JtQT09>
- Meeting ID:** 935 0949 5629
- Passcode:** 887933

The meeting agenda is as follows:

Time	Topic	Speaker	Duration
12:30 PM → 12:40 PM	TDR preparation forward HCal	Friederike Bock (ORNL)	10m
12:40 PM → 12:50 PM	TDR preparation nEcal	Carlos Munoz Camacho (JCLab, CNRS/IN2P3), Justin Frantz (Ohio University)	10m
12:50 PM → 1:00 PM	TDR preparation BEcal	Maria Zurek (Argonne National Laboratory)	10m
1:00 PM → 1:10 PM	TDR preparation nHCal	Leszek Kosarzewski (Ohio State University)	10m
1:10 PM → 1:20 PM	TDR preparation bHCal	Stefan Bathe (Baruch College, CUNY, & RBRC)	10m
1:20 PM → 1:30 PM	TDR preparation forward Ecal	oleg tsai (ucla)	10m

The desktop background shows a dock with various applications including Safari, Mail, Messages, Photos, Calendar, and several productivity tools. The system tray at the bottom indicates the date is Monday, May 20, 2024, at 6:55 AM.

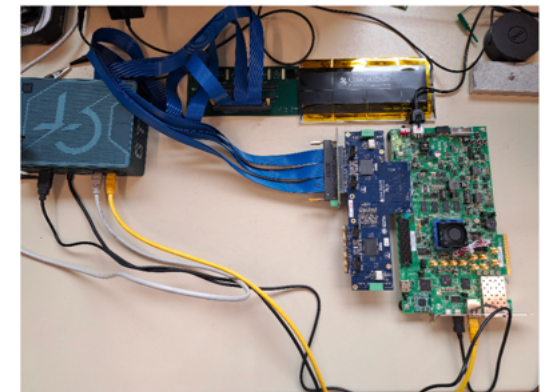
- **Detector design**
 - ▶ Overview
 - ▶ Detector requirements
 - ▶ Radiation requirements
 - ▶ Test beam results (10/24?)
- **Performance**
 - ▶ Single particle studies w/ and w/o other detectors in front
 - ▶ Clusterization (07/24)
 - ▶ Full event reconstruction (09/24?)
 - ▶ Jet performance? (09/24?)
- **Mechanics**
 - ▶ Internal module structure (8M, 4M, insert)
 - ▶ Stacking plan
 - ▶ Seismic (07/24) & load deformation studies
 - ▶ Scintillator performance (07/24)
- **Read-out electronics**
 - ▶ SiPM boards (8M, 4M (10/24) & insert modules (??/??))
 - ▶ Transfer boards (11/24)
 - ▶ Summing stage (11/24)
 - ▶ FEB for LFHCal & insert modules (10/24)
- **Cooling**
 - ▶ Heat load simulations (08/24)
 - ▶ Cooling system for insert modules? (??/??)
- **Calibration system**
 - ▶ LED system (11/24)
 - ▶ temperatur monitoring (??/??)
- **Integration (??/??)**

Some dates still need to be defined.

Irradiation campaign at UC Davis. May 15-16
ePIC calorimetry and electronics colleagues.

[https://urldefense.com/v3/__https://photos.app.goo.gl/Gcfpyd5meKbRW7Y7__!!P4SdNyxKAPE!BxPyHGTxb8LFLhO6j5ulPDMon3gqobwGMiSnDz23K3b8XSmsSWauTWNHhK9BIn8sEnmkjSxwaXHstI8y6TBInSffC7X6Q2fhD0cY\\$](https://urldefense.com/v3/__https://photos.app.goo.gl/Gcfpyd5meKbRW7Y7__!!P4SdNyxKAPE!BxPyHGTxb8LFLhO6j5ulPDMon3gqobwGMiSnDz23K3b8XSmsSWauTWNHhK9BIn8sEnmkjSxwaXHstI8y6TBInSffC7X6Q2fhD0cY$)

- First version of LED system currently under test at CERN
- First "short" long-PCB board being tested
- Updated version of SiPM flexes & FEB under test
- Insert test beam on-going in STAR hall



Backward Ecal Updates for “Red” TDR Summary Items

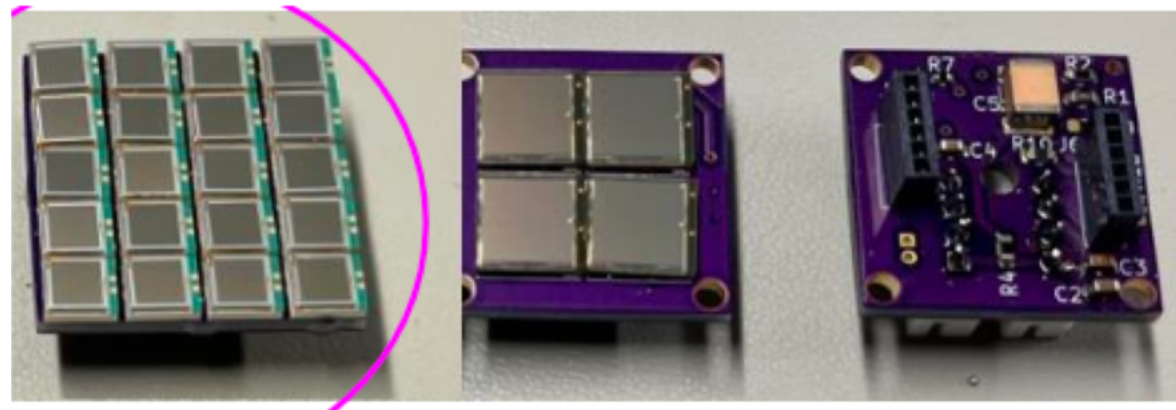
(Blue: updates since last report)

Detector design

- Test beam results – these are for integrated performance and full readout chain
 - Crystal+SiPM readout module tests planned for Fall’24 (DESY, JLab) Beam test request DESY: Late Oct-Nov 2024.
 - [5x5, 25 channel prototype design by JCLab/Orsay](#) : Can reuse existing MIT 5x5 prototype e.g. crystals
 - NSF proposal—still awaiting decision; Alt beam test readout funding:
 - Identifying individual group funding for putting in ~immediate siPM order as to receive in time for assembly in September time-frame. (minimum 12 -channels-worth needed.)
 - Starting process with Sasha Bazilevsky now for obtaining project funding for adapter board fabrication/assembly, FEB, ...

Read-out

- Radiation tests – these are for the SiPMs
 - Successfully responded to sooner-than-expected timeline for UC Davis Irradiation Tests. TODAY currently finishing 2nd day participation in these tests today (UCR, Ohio U, Gerard/IU, Tim Carmada BNL) !!!
 - Full report in future from UCR later
 - Our group irradiated different single area/pixel size choices and 20-3mm² full adapter board design
 - Recent first results from new prototype 20-3mm siPM’s
 - More on siPM decision on next slides
- FEB
 - Summer 2024 , Tests: Fall 2024
 - Because of focus on UC Davis irradiation testing, expect to turn to more detailed FEB planning soon
 - Testbeam : exploring full Readout chain important for precision calorimetry.



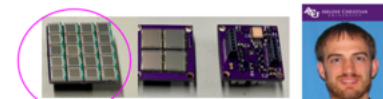
nEcal siPM’s Irradiation – Finalized Exposures

	Beam Flux (cm-2 s-1)	Time (seconds)	Total Fluence (cm-2)	MeV n equiv fluence	Number of SiPMs/board
1a	1.00E+08	540	5.40E+10	8.10E+10	Whole board of 20-3015 sipms
	1.00E+08	540	5.40E+10	8.10E+10	3 S14160-3010PS (3mm, 10um pitch)
1b	1.00E+08	540	5.40E+10	8.10E+10	2 S14160-3015PS (3mm, 15um pitch)
	1.00E+08	540	5.40E+10	8.10E+10	2 S14160-6015 (6mm, 15um pitch)
2	1.00E+07	540	5.40E+09	8.10E+09	3 S14160-3010PS (3mm, 10um pitch)
	1.00E+07	540	5.40E+09	8.10E+09	2 S14160-3015PS (3mm, 15um pitch)
	1.00E+07	540	5.40E+09	8.10E+09	2 S14160-6015 (6mm, 15um pitch)
3	1.00E+07	35	3.50E+08	5.25E+08	2 S14160-3010PS (3mm, 10um pitch)
	1.00E+07	35	3.50E+08	5.25E+08	2 S14160-3015PS (3mm, 15um pitch)
	1.00E+07	35	3.50E+08	5.25E+08	2 S14160-6015 (6mm, 15um pitch)

All four initial exposures completed yesterday, possibly one more re-irradiation today after post-testing. Post-testing all remaining also underway.

same exposure time

siPM Further Updates



Other recent updates:

- First test results from new 20-3mm² siPM prototype adapter boards presented by [Larry Isenhower Abilene Christian University](#) [Larry: extended 4-6mm design (help from IU), had fabricated, reflow soldered siPM’s at ACU!]
 - This board was irradiated yesterday. Expect followup results on soon
- Ardavan/Hamamatsu: expect similar-to-recent, up to 4 month siPM delivery time. Current Testbeam Strategy : decouple siPM ultimate decision - make initial decision for fast purchase in order to receive remaining needed numbers of siPM’ for October testbeam.
- Testbench developments underway for this summer (ACU, Lehigh, Ohio U) finalized siPM decision results also for testing of testbeam orders late summer.
- siPM Model Choice/Decision Considerations:
 - Tradeoff’s pixel pitch/sizes: dynamic range, resolution, linearity, characteristics near-low E threshold (5 MeV)
 - At low energies photostatistics are most important (Crytur modeled SiPM characteristics and found PDE difference - points to 15um SiPM). Lowest energy expected 50-100 MeV for shower (per tower 5 MeV)
 - At higher energies (GeV scale) the constant term dominates, which is dominated by linearity.
 - Larger 6x6mm SiPM have higher capacitance. Putting SiPMs together into a matrix (needed for large area homogeneous blocks) may further increase capacitance. Could point to 3mmx3mm size as the best choice.
 - Irradiation tests carried out: developing projections for estimating the largest impact of radiation damage on resolution in the low signal size regime. Highlighting need for UC Davis test results.

Barrel Imaging Calorimeter.

- Detailed Update.
- All categories requiring more work to completion have dates and assessments of manpower and resources.

N.B. Very good structured report, suggest to others to follow.

Performance

- Performance
1. Performance with *most up to date geometry/envelopes* 🚧
 - a. Energy resolution, Position resolution,
 - b. e/pi separation, gamma/pi0 separation
 2. Beam test benchmarking (e resolution) 🚧
 3. Literature benchmarking (pion response) 🚧
 4. Backgrounds ✖

Tasks	Time	Missing Workforce/Resources
1a and 1b	June 2024 (repeated depending on implementation of design)	FTEs on reconstruction algorithms implementation and validation.
2	August 2024	
3	October 2024 (depending on beam test success)	
4	November 2024	Requires input from background task-force and work on reconstruction algorithms.

TDR Structure

- ✅ ready to write
- 🚧 partially ready to write
- ✖ lots of to do

Design

- Overview ✅
- Detector Requirements ✅

Performance

- Performance with *most up to date geometry/envelopes* 🚧
 - Energy resolution, Position resolution,
 - e/pi separation, gamma/pi0 separation
- Beam test benchmarking (e resolution) 🚧
- Literature benchmarking (pion response) 🚧
- Backgrounds ✖

Sector Design, Mechanics and Integration

- Sector design and construction 🚧
- Tracker mechanics ✖
- End-of-sector box mechanics 🚧
- Deflection studies ✖
- Barrel assembly and integration tooling 🚧

AstroPix Wafers & Modules

- AstroPix characteristics and readiness ✅/🚧
- Automated wafer testing 🚧
- Module & stave design 🚧
- Stave bus design ✖
- Module assembly and scalability ✖

End-of-sector Box and Readout

- SiPMs characteristics ✅/🚧
- SiPM boards and FEB 🚧/✖
- LED system ✅/🚧
- Tracker End-of-tray card (RDO) ✖
- Slow controls (temperature, humidity) 🚧

Cooling

- Cooling system design 🚧
- Global heat load simulations ✖

System Testing

- System Calibration ✖
- System QC ✖
- System Demonstration 🚧/✖



May 14-17

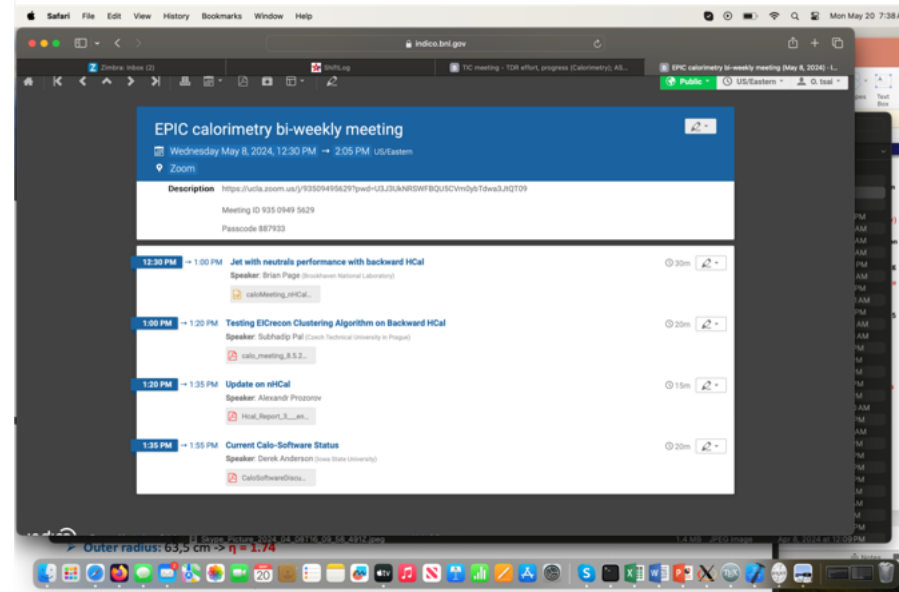
- Critical topics for TDR are better defined now compare to last meeting.
- Assessments of required manpower and help form collaboration were shown.
- Timeline to complete some tasks presented.
- UIUC joining efforts.

Crucial topics for TDR - needed help

- 1 Make sure track-cluster matching works **In principle can be completed by 2024.7.1, Need only close cooperation with tracking and clustering experts - Derek offered help**
- 2 Do a realistic jet study with neutrals and track-cluster matching, subtracting charged track energy from clusters. Use full DIS events from simulation campaign. **In principle can be completed by 2024.12.1 0.5 FTE for 2-4 months needed to help Brian, because he is overwhelmed with other tasks**
- 3 Do a 2-track resolution study. Here we have 2 options:
 - Use realistic DIS events from simulation campaign. Select neutron clusters and check the distance from other track projections or clusters. Study eta/radial dependence, phi-integrated.
 - Do a 2 track simulation and reconstruction. Check the distance of clusters vs. eta/radius and the 2 particle separation.
- 4 Study muon ID efficiency and purity in DIS events with vector mesons produced. Look for MIP tracks with MIP energy deposits in EMcal and HCal. (No manpower here!) **CRUCIAL: In principle can be completed by 2024.11.1 No manpower: 0.5 FTE for 1-3 months needed to start work**
- 5 The above steps should determine the optimal tile size. The tile performance will be tested at OSU with cosmic rays. Compare it to optical photon transport simulation. This will determine the technology choice.
- 6 Detector requirements **CRUCIAL: In principle can be completed by 2024.11.1**
- 7 Mechanics (TBD by the design) **No manpower, but we can get a mechanic at OSU: need 1-2 FTE months to meet deadlines by end of 2024 (work may be underestimated)**
- 8 Electronics and calibration (TBD by the design) **In principle help by Norbert and LFHCal - need 0.5-1 FTE months to meet deadlines by end of 2024**
- 9 Integration (TBD by the design) **Hard to estimate, but may need a few FTE**

nHCal TDR planning

- Detector design
 - Overview
 - **Detector requirements CRUCIAL: In principle can be completed by 2024.11.1**
 - Radiation requirements
 - **Test beam results (planned next year)**
- Performance
 - **Single particle studies In principle can be completed by 2024.9.1**
 - **Clustering (basically ok) Some work needed in coordination with splitting TF by 2024.9.1**
 - **Neutral jet reconstruction (coordinate with Brian) CRUCIAL part to be completed by 2024.10.1**
 - **Vector meson reconstruction with dimuons No manpower, need 0.5-1.5 FTE months**
- Mechanics (TBD by the design) **No manpower - need help to meet deadlines by end of 2024**
 - **Module structure**
 - **Assembly**
 - **Support structures**
 - **Seismic and load deformation studies (coordinate with other subsystems)**
 - **Scintillator performance**
- Readout (waiting for design - to be coordinated with Norbert) **CRUCIAL to follow after Neutral jet performance studies**
 - **SiPM boards**
 - **FEB design**
 - **Connection topology**
- Cooling **No manpower, not crucial**
 - **Heat load simulation (coordinate with other subsystems)**
 - **NO cooling needed**
- Calibration (waiting for design - to be coordinated with Norbert) **CRUCIAL to follow after Neutral jet performance studies**
 - **LED system**
 - **Temperature monitoring**
- **Integration**
 - from previous work
 - **ready to write up**
 - **partially to write up**
 - **lots of work required**



Forward EMCal TDR. Contents

DRAFT

1. Executive Summary.

- 1.1 ePIC Experiment
- 1.2 Forward Electromagnetic Calorimeter
- 1.3 W/ScFi technology
- 1.4 SiPM Photo Detectors
- 1.5 **Electronics** <- July 2024
- 1.6 **Mechanics and Integration**
- 1.7 Calibration and Monitoring
- 1.8 Simulations
- 1.9 Performance
- 1.10 Conclusion

2. Design Considerations

- 2.1 introduction, EM and hadronic particle reconstruction
- 2.2 Acceptance Considerations
- 2.3 Resolution Considerations
- 2.4 Environment

- 2.4.1 Surrounding Detectors
- 2.4.2 Rates and Occupancy
- 2.4.3 Operation Considerations

3. Production and Assembly

- 3.1 **Production Schemes**
- 3.2 **Assembly Schemes**
- 3.3. **QA**

4. Production 2x2 tower block details

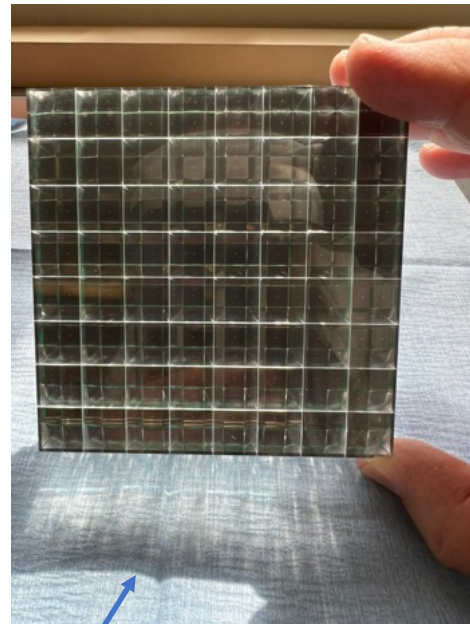
- 4.1 Scintillation Fibers
- 4.2 Tungsten Powder
- 4.3 Glue materials

5. Installation 4x4 towers block details

- 5.1 Design
- 5.2 Assembly steps
- 5.3 Stress tests

6. Light Guide Design <- June 2024

- 6.1 **Design Considerations**
- 6.2 **Efficiency and Uniformity of light collection**
- 6.3 **Bench test measurements**



7. Photo Detectors

- 7.1 SiPMs introduction
- 7.2 Characteristics
- 7.3 Radiation Damages
- 7.4 SiPM ordering
- 7.5 SiPM currying board design
- 7.6 SiPM boards QA and calibrations
- 7.7 SiPM boards mounting on light guides

8. **Electronics.** <- July 2024

- 8.1 General EMcal Readout Scheme
- 8.2 **Preamplifier Shaper (Requirements, Specifications, Implementation (RSI))**
- 8.3 **ADCs (RSI)**
- 8.4 **SiPM biasing (RSI)**
- 8.4 **FEB (RSI)**
- 8.5 **SPICE Simulations and Bench Test Results**
- 8.6 **Signal routing and Cabling**
- 8.7 **Cooling**
- 8.8 **Slow Controls**

9. **Mechanics, Integration, Installation**

10. Calibration and Monitoring

- 10.1 **Calibration with Physics**
- 10.2 **Monitoring with LED system**

11. Simulations

- 11.1 **Acceptance (barrel/endcap region)**
- 11.2 **Resolutions (energy, position)**
- 11.3 **Effects of dead material upfront on performance**
- 11.4 **Dynamic range, rates**
- 11.5 **Pi0/gamma discrimination with ML**

12. Performance

- 12.1 **Test beam results with prototypes.**

13. Collaboration

14. Safety

15. Schedule

Got support from the project to advance mechanics and integration

Legend:

Black – ready for writing/previous works

Red – on-going R&D 106/109

Brown – require more work, engineering support, PD

Green- progress from last report

Summary:

- Second meeting on April 10'th – agreed to hold progress report meetings every 6 weeks or so.
- Third meeting of calorimetry WG on May 15'th. Discussed reports from 4 out of 6 subsystems.
- Missing BEcal hold workshop at the same time (provided slides), BHcal (busy with sPHENIX), no update.
- A steady progress toward TDR shown by almost all subsystems.