Planning for TDR effort - Calorimetry

O. Tsai on behalf of the six calorimetry DSCs.

TIC meeting March 18, 2024

Calorimetry WG had two meetings to discuss TDR efforts

https://indico.bnl.gov/event/22281/ 02/07/2024

- discussed charges from TIC to DSCs
- forward HCal and Barrel Ecal
- C/S TDR software needs

Adopted approach by forward HCal group (Friederike), i.e. a single slide with a coded high level contents of TDR to give at a glance sub-system status.

https://indico.bnl.gov/event/22476/. 02/21/2024

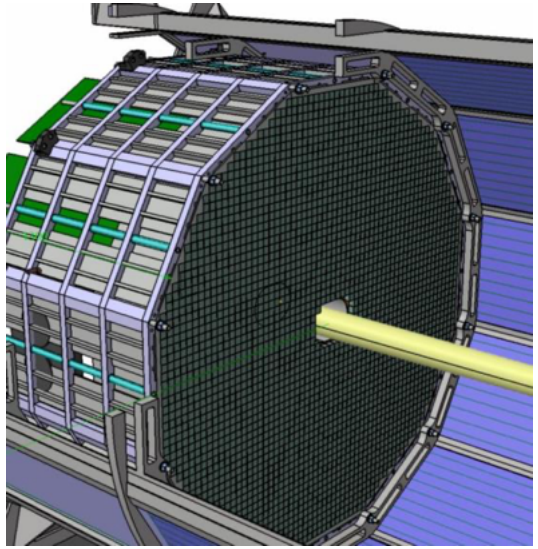
- nECal
- BEcal
- bHCal
- Forward ECal
- nHCal

LFHCal & insert chapter general structure

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

"from previous work"
"ready to write up"
"partially ready to write up"
"lots to do"

Backward ECal TDR planning



- **Detector design**
  - Overview
  - Detector requirements
  - Radiation requirements
  - Radiator (PWO)
  - Test beam results
- **Performance**
  - Single particle studies w/ & w/o material
  - Clusterization
  - Full event reconstruction (including background)
- **Mechanics**
  - Stacking layout
  - Support frame
  - Stress simulation
- **Read-out**
  - SiPM choice
  - Radiation tests
  - SiPM boards
  - FEB
- **Cooling**
  - Heat load simulations
  - Prototype measurements
- **Monitoring systems**
  - LED
  - Temperature
- **Integration**

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TDR Structure

BEcal

✅ 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 🚧/❌

Barrel HCal TDR planning

- Detector design
  - Overview
  - Detector requirements
  - Radiation requirements
  - Test beam/sPHENIX results
- Performance
  - Single particle studies w/ and w/o other material
  - Clusterization (merging)
  - Full event reconstruction
  - Jet performance?
- Mechanics
  - Internal module structure
  - Stacking
  - Seismic and load deformation studies
  - Scintillator performance
- Read-out (same as LFHCal, should be common section)
  - SiPM boards
  - Transfer boards
  - Summing stage
  - FEB
- Cooling (no cooling in sPHENIX; same?)
  - Heat load simulations
  - Colling system not needed
- Monitoring system
  - LED system
  - Temperature monitoring
- Integration (common section?)

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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
    - 1.6 Mechanics and Integration
    - 1.7 Calibration and Monitoring
    - 1.8 Simulations
    - 1.9 Performance
    - 1.10 Conclusion
2. Design Considerations ('Requirements')
    - 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
    - 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
    - 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 Digitizing Module (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

Legend:
Black – ready for writing/previous works
Red – on-going R&D 106/109
Brown – require more work, engineering support, PD, collaboration growing

nHCal TDR planning

I have no prior experience writing TDRs - may need help

- Detector design
  - Overview
  - Detector requirements
  - Radiation requirements
  - Test beam results
- Performance
  - Single particle studies
  - Clustering (to be done soon)
  - Neutral jet reconstruction (coordinate with Brian)
  - Vector meson reconstruction with dimuons
- Mechanics (TBD by the design)
  - 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)
  - SiPM boards
  - FEB design
  - Connection topology
- Cooling
  - Heat load simulation (coordinate with other subsystems)
  - NO cooling needed
- Calibration (waiting for design - to be coordinated with Norbert)
  - LED system
  - Temperature monitoring
- Integration

- from previous work
- ready to write up
- partially to write up
- lots of work required

TDR Input for Software

- **For discussion:** C/S team interested in any additional input on TDR needs, **particularly the data model**
  - Will summarize discussion and identified input at **Feb. 21st C/S meeting**
  - A summary of what's in the data model on the calo. side is in backup

- **Above:** summary of identified data model and reconstruction needs/wants from January CM
  - c.f. this summary of the CM discussion for more details!

Identified Data Model Needs

- Improved truth-Cluster connections
- Anything else?

Identified Reconstruction Needs/Wants

- Clustering implemented in all systems
- Cluster splitting/merging
- ML Integration
- Digitization noise, noise-masking and system-specific digitization model implementations
- Better neutral identification
- Easier access to janadot output

Identified Simulation Needs/Wants

- Enhanced realism in BEMC implementation and implementation of end-of-sector box material
- Dedicated studies of HGCROC vs. waveform digitizer in BEMC
- Physics-driven performance studies for nHCal
- Update ZDC default to SiPM-on-tile
- Enhanced realism in pECal implementation

Takeaways.

1. Overall groups are on track to reach pre-TDR/TDR level by the end of 2024 but it will be tight.
2. Design considerations, justifications, and some implementations coming from YR or past and on-going R&Ds.
3. Common topics, which requires ‘lots of work’ are front end electronics, SiPMs (noise), detailed detector components design/tests etc.. subjects of on-going R&D and PD efforts closely tracked by the project.
4. Integration is another area where all sub-system indicated they need to make a progress, which requires close work with project engineers.
5. Software, no particular showstoppers. Desired improvements are truth-cluster connections, realism of detector models including services, SiPM noise implementations, background.
6. Irradiation tests (SiPMs and some electronics components) need to be performed, on track now.
7. Difficult case is nHCal. Functionality of this detector is quite different from calorimeters used in collider experiments HEP/NP in the past (expertise). To get to pre-TDR/TDR level by the end of 2024 will be very challenging.