Backward Hadronic Calorimeter

TDR planning update

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THE OHIO STATE UNIVERSITY

Outline

Work planning towards TDR

Detector design and technology choice:

- Few ideas to present and discuss soon:
  - LFHCAL style with larger tiles (may be costly)
    - Option to use thicker tiles and put SiPM on the side (to be tested with simulation): **0.5 FTE for 1-2 months**
  - Belle-II KLM long scintillator planks with WLS fibers: **0.5 FTE for 1-3 months**
    - $\sim 2\ \mathrm{m}$ length might be an issue due to light attenuation
    - May need different FEB from HGCROC to get the position from the timing
    - HGCROC provides 100 ps timing resolution (3 cm spatial - good!)
  - Tiles with WLS fibers
- TBD based on the results of:
  - Position resolution study
    - CTU in Prague working on that (1-2 months to complete) - **Now needs to include track projections**
    - May need more time and manpower to test different detector configurations: **1.0 FTE 2-4 months**
    - Clustering seems to be good enough, though splitting may need some work (1 month to complete in coordination with splitting task-force) - **may need extra 0.5 FTE for 1 month to complete**
  - Neutron detection study (both RECO hits and ML reco with GNN)
    - Student at OSU looking at RECO hits (1-2 months to complete)
    - Student at OSU working with ML (to present update soon, a few weeks to complete, need more manpower to test different configurations): **1.0 FTE 2-4 months**
    - UNH group working on PID with GNN and possible optimization of geometry based on ML response
    - Update coming soon, but more work may be needed
    - Need more help and coordination with LFHCAL group (still waiting for some answers)
  - Jets with neutron reconstruction
    - Help from Brian, shown first results - **Track projections needs to be included**
    - Every adjustment of geometry needs a new simulation campaign or full event simulation (updates month by month)
    - Can be done at OSU cluster
    - May need more help and manpower here: **0.5 FTE for 2-4 months**

VM reconstruction performance with dimuons

- Not a priority right now
- Study with single muons should not be a problem
- Need manpower for that: **0.5 FTE for 1-3 months**
- May need a dedicated simulation with VM in realistic events for TDR
- Simple study with standalone VM simulation also possible

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

Crucial topics for TDR

Each step depends on each other (assumptions are very optimistic):

1. Make sure track-cluster matching works **In principle can be completed by 2024.7.1** - seems taken care of and on track to completion (**This was not available until recently!**)
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**
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**
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 - 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 months to complete by end of 2024**

Assuming almost no buffer time in case of delays, to make it work.

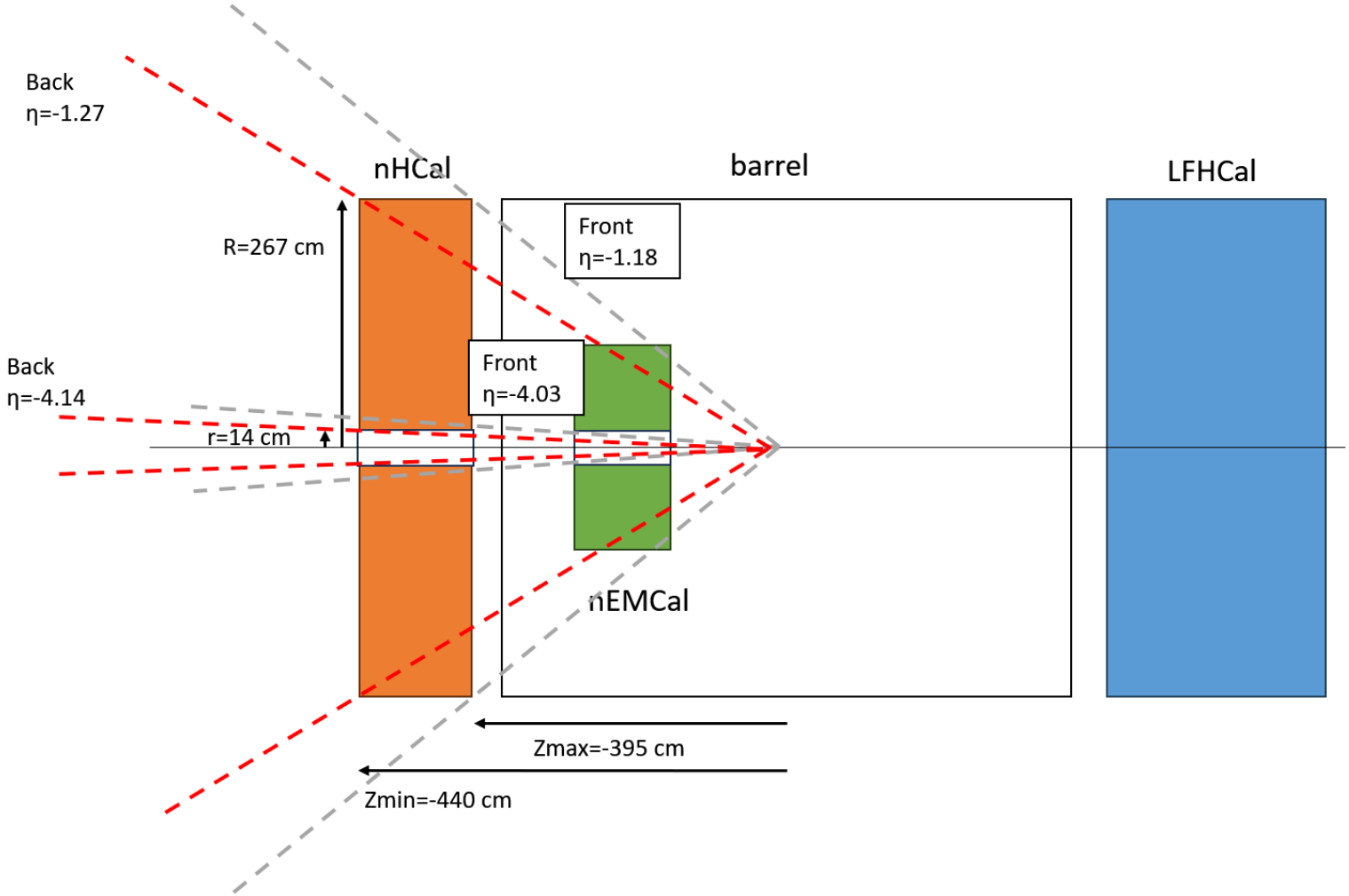
Crucial topics for TDR - needed help

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**

3D clustering and staggered design

- Good idea, but no manpower
- This is definitely worth investigating
  - Better position resolution than conventional design
- Caveat: It will complicate the design and construction

Acceptance check



- Front geometry limit: $-4.03 < \eta < -1.18$
- Back geometry limit: $-4.14 < \eta < -1.27$
- Clusters: $-3.95 < \eta < -1.25$

Manpower shortage and task summary

I have no prior experience writing TDRs - may need help/advice (just good communication, not an extra dedicated person). **This will absorb a lot of time on my side as the leader, so delegating tasks becomes even more important!**

Task	FTE	duration lo [months]	duration hi [months]	FTE*duration lo	FTE*duration hi
Optical simulation of tile performance for SiPM on tile arrangement	0,5	1	2	0,5	1
Belle-II KLM long planks investigation and implementation	0,5	1	3	0,5	1,5
Position resolution study	1	2	4	2	4
Clustering	0,5	2	2	1	1
Shower reconstruction with ML	1	2	4	2	4
Performance of neutral jets reconstruction	0,5	2	4	1	2
Mechanical design	0,5	2	4	1	2
Beam tests - needed later	0,5	1	2	0,5	1
Electronics and calibration	0,5	1	2	0,5	1
Performance of VM reco	0,5	1	3	0,5	1,5
Benchmarks development needed for TDR?	0,5	2	4	1	2
			Sum min and max =	10,5	19

- Extra 10.5-19 FTE-months required before June
- These estimates are mostly to meet TDR requirements at the end of 2024

Summary

- Clear plan towards TDR
- Lots of work required to finalize the design, but we are on the right path
- Minimal required manpower seems available, but need more help with detailed studies
  - **Extra 10.5-19 FTE-months needed**
- Track projections available only recently - this is a crucial part
- A lot depends on the simulation campaign cycle (month by month)
  - Need to complete various steps to be ready for each simulation campaign (risk for the timeline)
  - Make sure the tasks are completed on time
  - We can run our own full simulations at local cluster at OSU

BACKUP

Crucial topics for TDR - 2024.4.10

Each step depends on each other (assumptions are very optimistic):

1. Position resolution study **In principle can be completed by 2024.7.1** - seems taken care of and on track to completion
2. Neutron reconstruction with machine learning **In progress by UNH, but slow, need 2-4 FTE months and better collaboration with LFHCAL**
3. Neutral jet reconstruction performance study **CRUCIAL part to be completed by 2024.10.1, may need 1-2 FTE months, up to a few months according to experts**
4. Detector requirements **CRUCIAL: In principle can be completed by 2024.11.1**
5. Tile design and detector design **CRUCIAL: In principle can be completed by 2024.11.1, but may need extra 1-2.5 FTE months**
6. Mechanics (TBD by the design) **No manpower - need 1-2 FTE months to meet deadlines by end of 2024 (work may be underestimated)**
7. 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**
8. Integration (TBD by the design) **Hard to estimate, but may need a few FTE months to complete by end of 2024**

Assuming almost no buffer time in case of delays, to make it work.

Tile tests and beam tests

- Tile tests with cosmic rays at OSU
  - Preparing test station with SiPMs and tiles (a few weeks to complete)
- Fermilab can provide more tile samples, need to establish contact through LFHCAL group

Beam tests:

- To be planned once the design is finalized
- Need engineering design
  - We should get mechanical engineer at OSU to work with BNL engineers (up to OSU leadership): **0.5 FTE for 2-4 months**
- We may need beams for prototype tests in 2025-2026 and first article in 2026-2027:
  - protons: $0.3 - 20\ \mathrm{GeV}$
  - pions: $0.3 - 20\ \mathrm{GeV}$
  - electrons: $0.3 - 20\ \mathrm{GeV}$
  - Spallation neutrons - unmoderated? $\sim 1\ \mathrm{GeV}$ to test low energy neutron performance
  - **0.5 FTE for 1-2 months** for beam tests

Electronics and calibration

- Electronics coordinate with the LFHCAL group - HGCROC
  - Long scintillator planks with WLS may require alternative solution
- Once design is determined we will provide connection topology to Norbert
- Sparsely placed temperature sensors for temperature monitoring
- LEDs 1/channel to calibrate the response with single photon spectra
- In principle can be taken care of quickly, but it would be good to have a dedicated person: **0.5 FTE for 1-2 months**

Webpage set up - see for up to date info

`https://wiki.bnl.gov/EPIC/index.php?title=Backward_Hcal`

Mailing list

`epic-backward-hcal-l@lists.bnl.gov`

Mattermost channel

`https://chat.epic-eic.org/main/channels/det-hcal-backward`

Institutions

OSU, CTU in Prague, UNH, BNL (help)