Backward Hadronic Calorimeter

Status and plans

Leszek Kosarzewski

The Ohio State University

nHCal DSC meeting 18.12.2024

THE OHIO STATE UNIVERSITY

Outline

Status

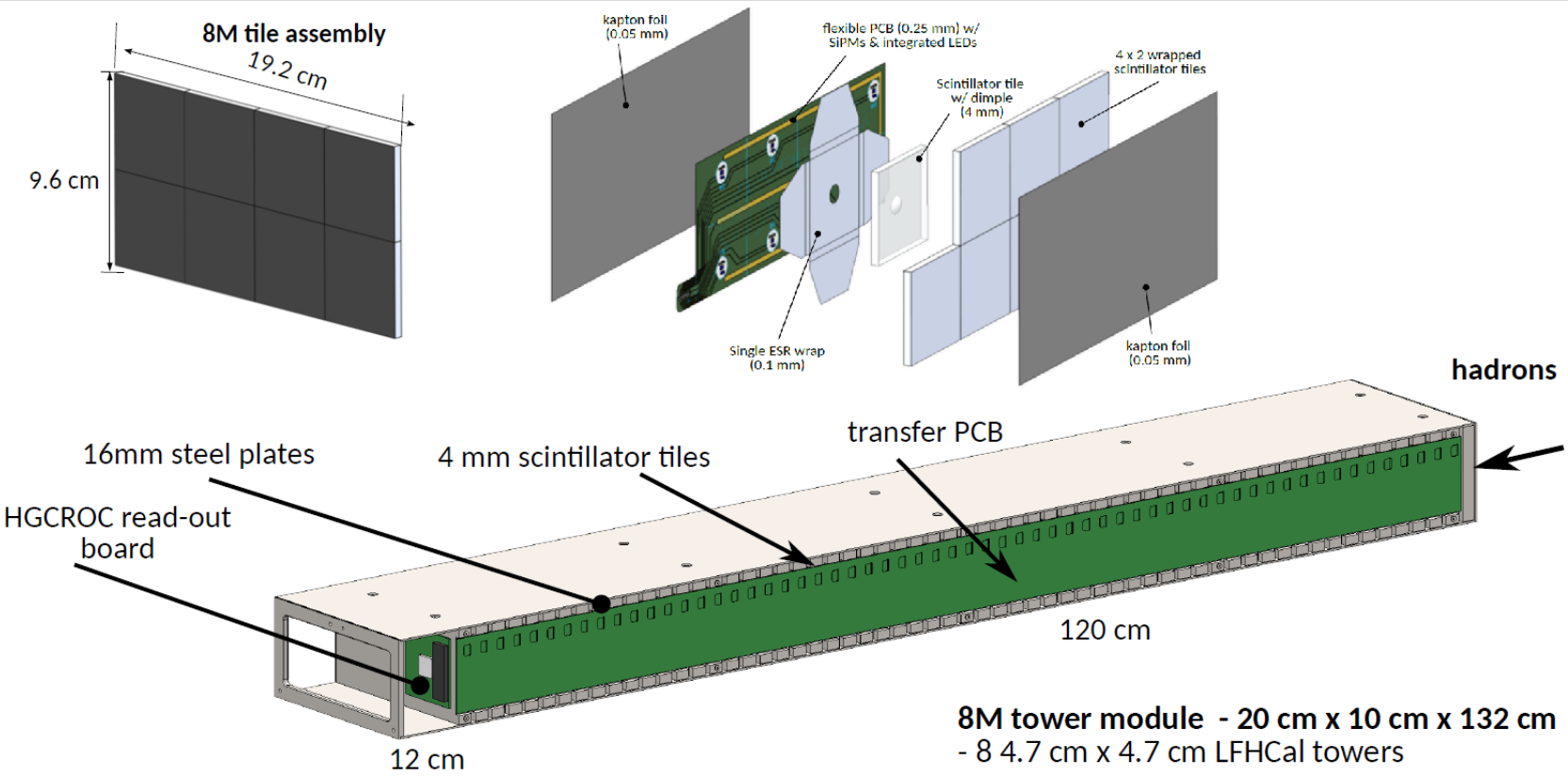
- Basic pre-TDR completed - Congratulations!
  - **Zenodo v1:** `https://doi.org/10.5281/zenodo.14328280`
  - **Review of v1:** `https://docs.google.com/spreadsheets/d/1mineH2breuoVui-uZm1ZYSraRquLjM9oOY4w2ASdvtA/edit?usp=sharing`
  - No feedback from official review yet, but looks good enough compared to rest
  - Please check repositories here and add your codes to reproduce the plots by the end of December
  - **Repositories located here:** `https://github.com/orgs/OSUNuclearPhysics/repositories`
  - Need to add you there to users - contact me
- **Created a links page (use it!):** `https://docs.google.com/spreadsheets/d/1m6NzPk4mfQI8YQE8cwO9sLJyKp5iH6pqttPGqYzTmZ8/edit?usp=sharing`

Plans

1. Complete ongoing studies
   - Diffractive dijets
   - Position resolution
   - Jets with neutrals
   - Vector meson reconstruction
   - Scattered electron ID
   - Tile tests
2. ePIC Collaboration meeting 2025.1.20-24
   - `https://agenda.infn.it/event/43344/`
   - None from the OSU or UIUC plans to participate
   - Good opportunity for CTU in Prague to represent us
   - Self-nominated contributions are a god way to go
   - **Interesting workfests:**
     `https://agenda.infn.it/event/43344/page/9444-workfest-descriptions`
     - Integration
     - Tracking Projections/Resolution at hpDIRC
     - Exclusive, Diffraction and Tagging WG
     - Jets and Heavy Flavor Workfest
3. Organize construction of prototype and beam tests
   - LFHCAL group plans to organize a readout electronics and testbeam workshop at ORNL sometime in spring
   - We should participate
4. Start working on the remaining topics
5. Check alternative KLM-type design

- Warsaw University of Technology may provide a bachelor student to work on a technical topic (or master on more advanced)
  - Diploma thesis proposals February-March for bachelors
  - Masters: May

Prototype construction

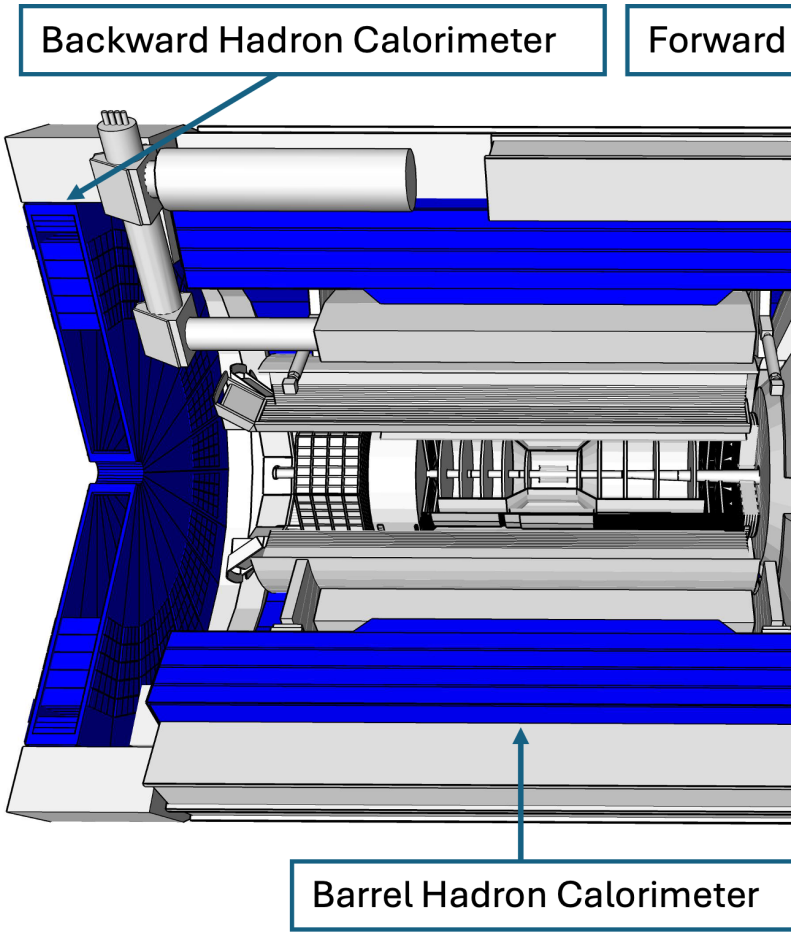


- LFHCAL module designs: `https://indico.bnl.gov/event/25021/`
  - Direct: `https://indico.bnl.gov/event/25021/attachments/57749/99174/8M%20Tower%20Assem_Combined_Oct1.pdf`
- Reuse spare LFHCAL module? Eg. place tiles at the beginning and ignore the rest.
  - The absorber plates have different thickness and are fixed, so we have to fill the gaps with steel.
  - Modules produced with electron beam welding in a vacuum.
- Produce our own module? Most likely.

Position resolution improvement

1. Check if using max energy deposit in the first layer improves position resolution
2. Do 3D clustering
   - Store subclusters for every layer
   - Code for BIC from Sylvester: `https://eicweb.phy.anl.gov/EIC/juggler/-/blob/main/JugReco/src/components/ImagingClusterReco.cpp`
   - Fit a line through the clusters across the layers (and compare to a reco track)
3. Independent vs. integrated readout from layers
   - Affects 3D clustering etc.
   - If removed, most likely no effect on energy resolution
   - Can reduce channels by factor of 10
4. Machine Learning reconstruction - revisit later

Detector thickness in z



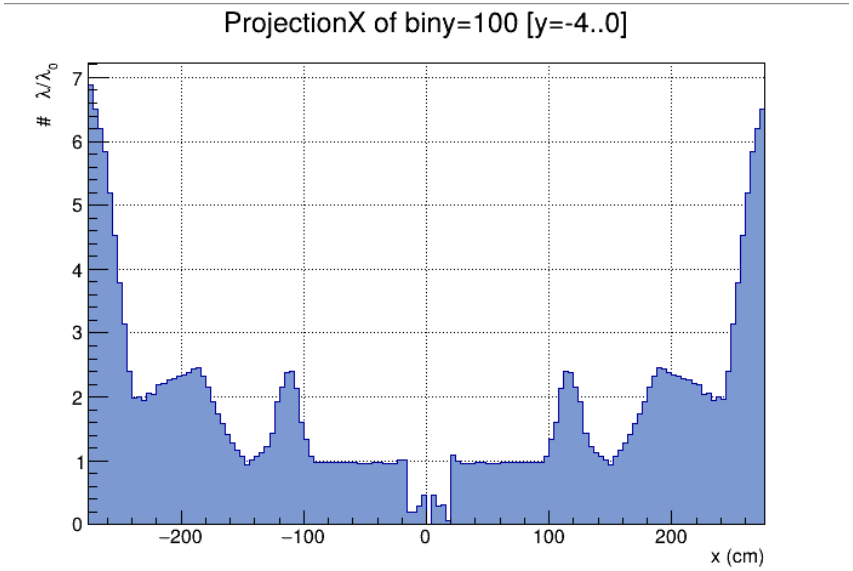
1. Can we extend from 45 cm in z to eg. 70 cm?
   - Limited by oculus and room for electronics
   - Increases cost - estimate?
   - Improves energy resolution - quantify?
   - Other benefits?

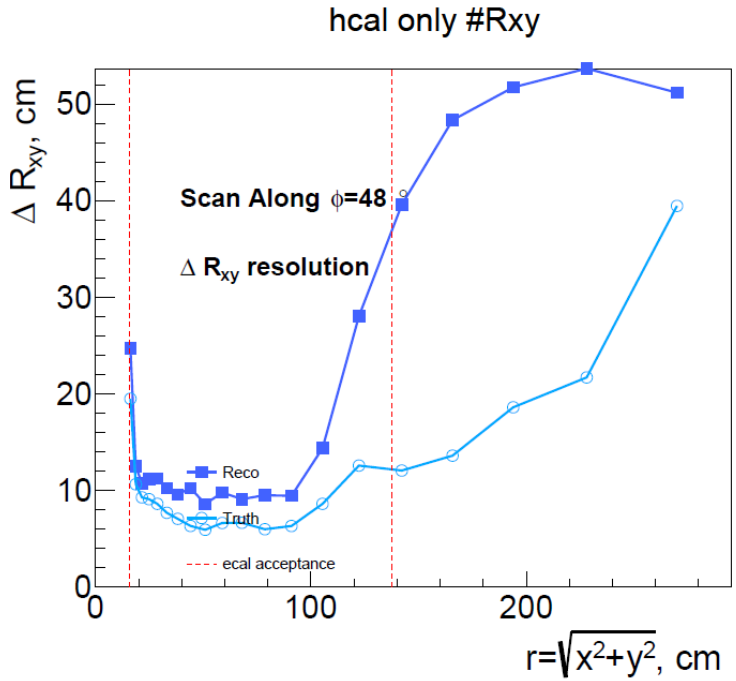
Additional charged veto and SMD layer

1. Investigate if adding extra scintillator layer as a charged veto helps isolate neutral showers
2. This extra layer needs to be thicker eg. $2\,\mathrm{cm}$ to leave enough signal
3. Can have better granularity than standard tiles

1. Revisit option of adding an SMD layer with high position resolution
2. Initially no plans to reuse STAR EEMC SMDs, because of too low light yield
3. Similar idea to KLM
4. Another option to use smaller tiles

High material impact on shower reco

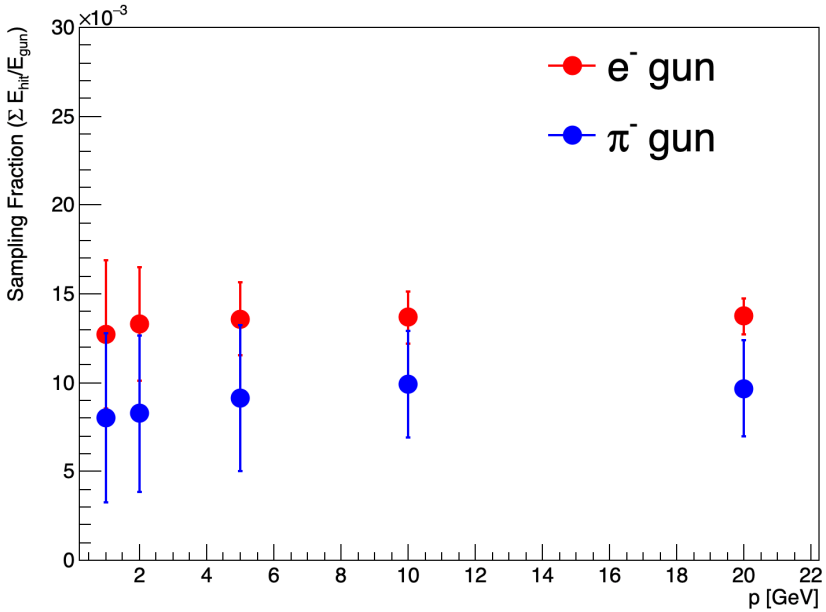




full epic

- Investigate impact in more details
  - Basic distributions, hits etc. vs. radial distance
  - Check the true stop vertex of MCparticle
- Try to determine optimal clustering parameters
- If needed revisit position resolution study with full geometry

Improve sampling fraction calculation

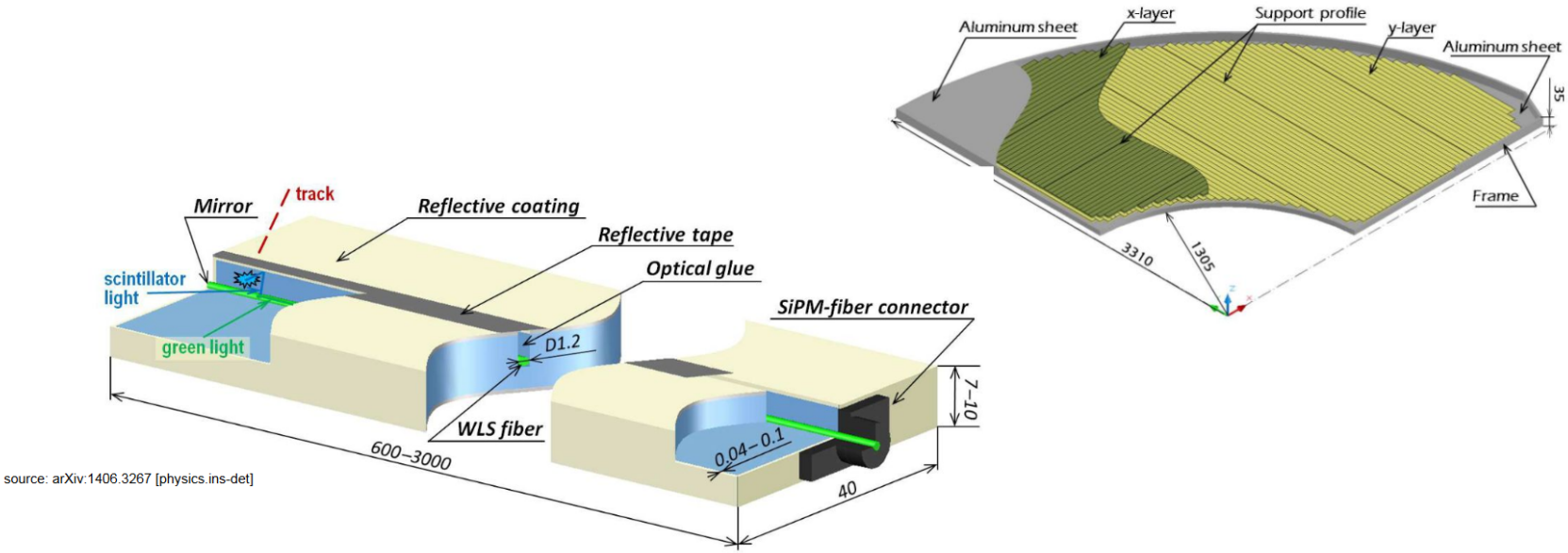


Particle	Momentum (GeV/c)	Sampling Fraction (%)	Uncertainty (%)
Electron	1.0	1.28	± 0.42
Electron	2.0	1.33	± 0.31
Electron	5.0	1.36	± 0.21
Electron	10.0	1.37	± 0.15
Electron	20.0	1.37	± 0.10
Pion	1.0	0.79	± 0.46
Pion	2.0	0.83	± 0.44
Pion	5.0	0.91	± 0.40
Pion	10.0	0.98	± 0.31
Pion	20.0	0.96	± 0.27
Neutron	1.0	N/A	N/A
Neutron	2.0	0.40	± 0.32
Neutron	5.0	0.67	± 0.30
Neutron	10.0	0.79	± 0.30
Neutron	20.0	0.84	± 0.39

Table 1: Sampling Fraction of nHCal for Different Particle Species

- Revise sampling fraction calculation using actual energy deposits in absorber and scintillators
- Looks like sampling fraction may decrease at lower energy
- Larger differences expected for pions and neutrons at lower energy
- Try to optimize it towards measurements of $\approx 1\,\mathrm{GeV}$ neutrons
- Add uncertainty on sampling fraction to eicrecon

Belle II KLM (K_L and muon detector)



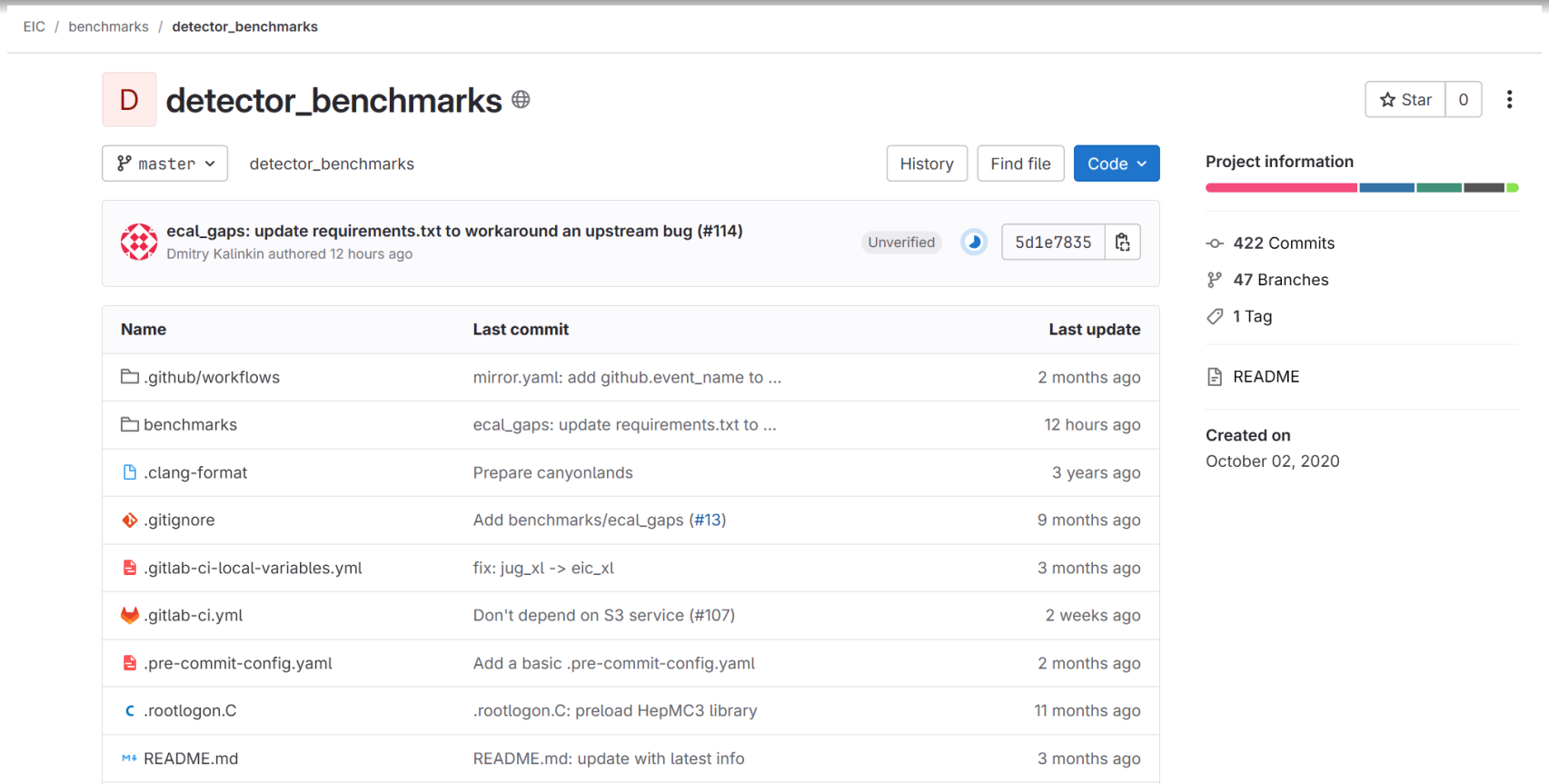
Schematic structure of the Belle II KLM scintillator setup

- Proposal of KLM-type detector for EIC Detector 2
- Advantages: cheaper, better position resolution
- Potential problems (to solve):
  - Long scintillator planks - signal attenuation in WLS may be a problem
  - Non-trivial clustering
- Links:
  - https://indico.cern.ch/event/1238718/contributions/5485996/attachments/2693846/4675083/2nd%20Detector%20KLM%20Warszawa%202023.pdf
  - https://www.jlab.org/sites/default/files/eic_rd_prgm/files/2023_Proposals/EIC_KLM_R_D_Proposal_2023_EICGENRandD2023_18.pdf

Light propagation simulation

- Perform light propagation simulation to check the tile design
- Use it to optimize SiPM mounting
- Use Tracepro or modified Geant4 from Jarda Adam
- `https://github.com/adamjaro/lmon/tree/master`

Benchmarks for CD/CI



EIC / benchmarks / detector_benchmarks

detector_benchmarks

Star 0

master | detector_benchmarks | History | Find file | Code

ecal_gaps: update requirements.txt to workaround an upstream bug (#114)
Dmitry Kalinkin authored 12 hours ago — Unverified — 5d1e7835

Name	Last commit	Last update
.github/workflows	mirror.yaml: add github.event_name to ...	2 months ago
benchmarks	ecal_gaps: update requirements.txt to ...	12 hours ago
.clang-format	Prepare canyonlands	3 years ago
.gitignore	Add benchmarks/ecal_gaps (#13)	9 months ago
.gitlab-ci-local-variables.yml	fix: jug_xl -> eic_xl	3 months ago
.gitlab-ci.yml	Don't depend on S3 service (#107)	2 weeks ago
.pre-commit-config.yaml	Add a basic .pre-commit-config.yaml	2 months ago
.rootlogon.C	.rootlogon.C: preload HepMC3 library	11 months ago
README.md	README.md: update with latest info	3 months ago

Project information

422 Commits
47 Branches
1 Tag

README

Created on
October 02, 2020

- Develop benchamrks for CD/CI
- `https://eicweb.phy.anl.gov/EIC/benchmarks/detector_benchmarks`
- `https://indico.jlab.org/event/420/contributions/8307/attachments/6911/9434/20210504-Automated_workflows.pdf`
- Useful for automated checks: hit distributions, acceptance etc.
- Ideal task for bachelor and undergraduate students
- Potential topic for WUT student

Summary

Conclusions

- Presented status
- Discussed plans for the future
- Organized a list of tasks

BACKUP