EiC CaloReview

Close-Out

December 6 – 8, 2022

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December 6-8, 2022

Reminder on Schedule

Day 1: December 6

08:00	→ 08:30	**Executive Session** Closed Session ECal / HCAL EIC Project TR Join ZoomGov Meeting https://bnl.zoomgov.com/j/1612342243?pwd=ZVhFMVBqNDRPMWpFKzNwazY2VmtiZz09 Meeting ID: 161 234 2243 Passcode: 079651 **Speaker**: Committee and Project
08:30	→ 09:00	**Welcome and Introduction to EIC Project** **Speakers**: E. C. Aschenauer (BNL), Rolf Ent (Jefferson Lab)
09:00	→ 09:30	**Electromagnetic Calorimetry Overview and Requirements** **Speaker**: Alexander Bazilevsky (BNL)
09:30	→ 10:00	**Hadronic Calorimetry Overview and Requirements** **Speaker**: Alexander Kiselev (BNL)
10:00	→ 10:30	**Overall Detector Integration Status and CAD Design** **Speakers**: Rahul Sharma (BNL), Roland Wimmer
10:30	→ 10:50	Coffee Break
10:50	→ 11:10	**Backward Hadron Calorimetry detector upgrade** **Speaker**: Leszek Kosarzewski (Czech Technical Univeristy in Prague)
11:10	→ 11:50	**Backward Electromagnetic Calorimetry detector and integration** **Speakers**: Carlos Munoz Camacho (IJCLab, CNRS/IN2P3), Julien Bettane (IJCLab) Backward_ECAL_fin...
11:50	→ 12:30	**SciGlass-Based Barrel Electromagnetic Calorimetry detector and integration** **Speakers**: Joshua Crafts (affiliate@jlab.org;member@jlab.org), Tanja Horn (Cath)
12:30	→ 13:00	**Imaging-Calorimeter Barrel Electromagnetic Calorimetry alternate option** **Speaker**: Maria Zurek (Argonne National Laboratory)
13:00	→ 14:00	**Executive Session – Discussion**

Day 2: December 7

08:00	→ 08:30	**Barrel Hadronic Calorimetry detector and upgrades** **Speaker**: John Lajoie (Iowa State University)
08:30	→ 09:10	**Forward Electromagnetic Calorimetry detector and integration** **Speaker**: oleg tsai (ucla)
09:10	→ 09:50	**Forward Hadronic Calorimetry detector and integration** **Speaker**: Friederike Bock (ORNL)
09:50	→ 10:10	**Calorimetry Electronics Overview** **Speaker**: Fernando Barbosa (JLab)
10:10	→ 10:25	**Forward Electromagnetic Calorimetry electronics** **Speaker**: Gerard Visser (Indiana University)
10:25	→ 10:40	**Forward Hadronic Calorimetry electronics** **Speaker**: Norbert Novitzky (ORNL)
10:40	→ 11:00	Break
11:00	→ 14:00	**Executive Session** Closed Session ECal / HCAL EIC Project TR Join ZoomGov Meeting https://bnl.zoomgov.com/j/1612342243?pwd=ZVhFMVBqNDRPMWpFKzNwazY2VmtiZz09 Meeting ID: 161 234 2243 Passcode: 079651 **Speaker**: Committee

Day 3: December 8 12:00: Closeout

General Remarks

We thank you very much for

- **the efficient organisation of the review**
- **the excellent presentations given by the team**
- **the open and fruitful discussions**

We congratulate you for

- **the great achievements documented in the presentations**
- **the exciting phase your groundbreaking experiment is entering**

We are happy to help you with your further progress.

Review Charge Questions (1)

1. Are the technical performance requirements appropriately defined and complete for this stage of the project?

- Requirements are not fully clear for all systems

2. Are the plans for achieving detector performance and construction sufficiently developed and documented for the present phase of the project?

- Some steps are missing in plans of new systems to ensure performance - see recommendations

3. Are the current designs and plans for detector and electronics readout likely to achieve the performance requirements with a low risk of cost increases, schedule delays, and technical problems?

- At the current phase the risks are not yet fully assessed, in particular for new systems - see recommendations

Review Charge Questions (2)

4. Are the calorimeter fabrication and assembly plans consistent with the overall project and detector schedule?

- Time schedules contain float and match the overall project, but risks of manufacturing for new systems are not yet assessed, and QC plans are at an early stage.

5. Are the plans for detector integration in the EIC detector appropriately developed for the present phase of the project?

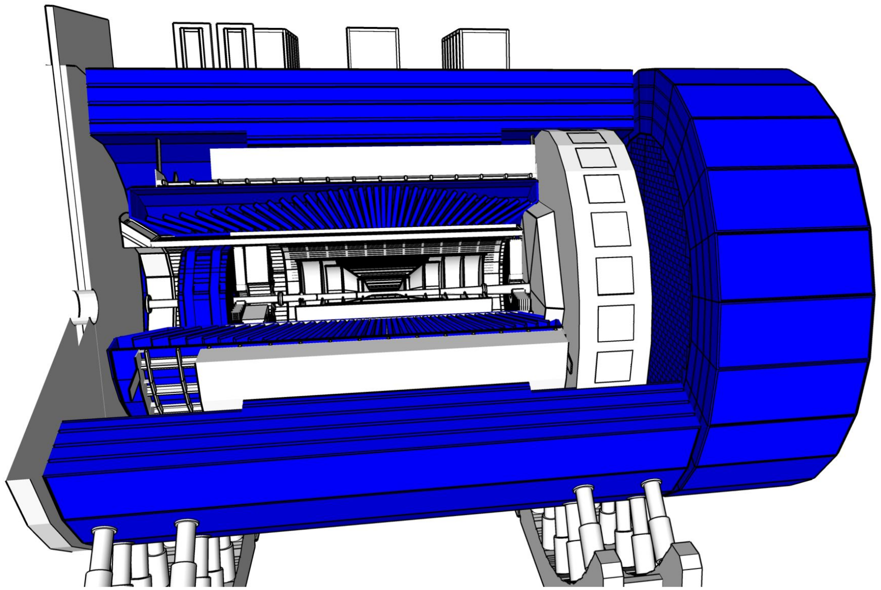
- Detector integration is mostly based on placeholders, as designs are not yet fixed.

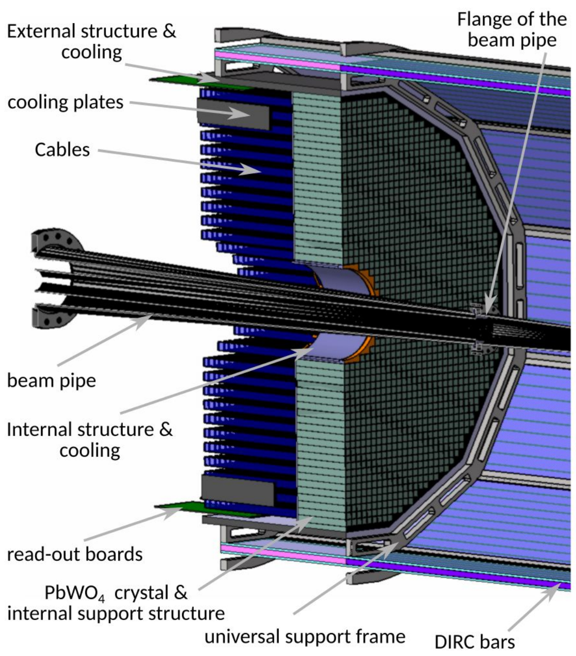
6. Have ES&H and QA considerations been adequately incorporated into the designs at their present stage?

- Some systems consider ES&H and QA appropriately and should serve as examples to other systems.

General Findings

- Shape overall is good
- There seems to be enough float in the project
- Two different Barrel Ecal Designs
- Full detector simulations for physics performance studies using complete events are just now becoming available
    - important for establishing a more direct relationship between physics performance and detector design choices
- We heard reports from these projects:
    - Backward calorimeter (EEMCAL)
    - Backward hadron calorimeter
    - Two Barrel Electromagnetic calorimeter designs
    - Forward calorimeters (SciFi/W, LFHCAL)
    - Electronics
    - Integration





Backward ECal (eEEMCAL)

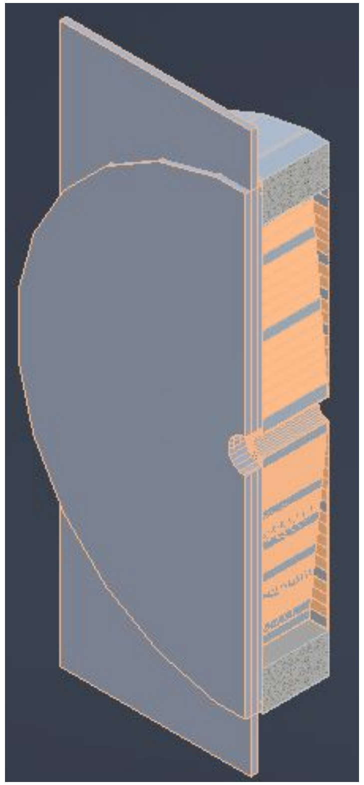
All

Backward ECal - EEMCAL

- Findings
  - Project centrally crucial for success of EiC Physics program: detection of scattered electron
  - PWO is an established technology and is the best choice for this sub-detector
  - Position resolution missing
  - Readout with matrix of SiPM
  - Material in front of EEMCAL unclear
  - e/pi still a factor 10 to improve although not critical

- Comments/Concerns
  - Temperature stability is very crucial for long-term operation and has to be verified
  - Avoid heating of crystals due to front-end electronics
  - No thermal insulation (0.5°C <-> 1.2% light yield adding to rest of constant term)
  - Front-end electronics to be decided
  - Avoid fixations with nuts in forward part, use fixed conical bolts
  - The availability of PWO can be a major risk (single supplier of high-quality material!)

- Recommendations
  - Prepare a system test with close-to-final electronics
  - Assess impact on physics output due to temperature instabilities
  - Procure PWO crystals as soon as possible as it is a long lead item (~700 crystals/year)

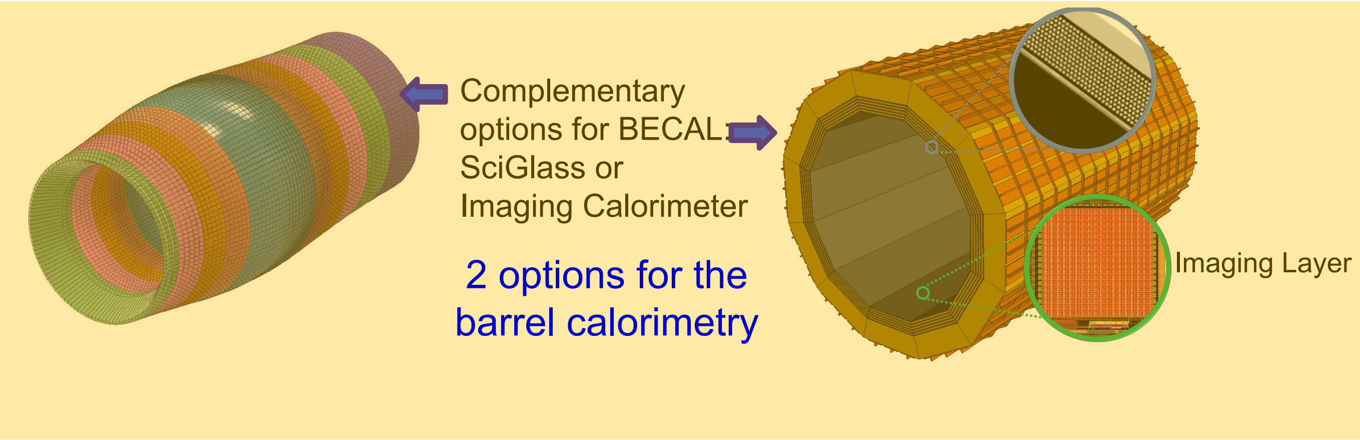


Backward HCal

All

Backward HCal – Tail Catcher

- Findings
  - Locations of SiPM not yet clear
- Comments/Concerns
  - Make the detector easily removable to access Backward EMCal readout
- Recommendations
  -



Barrel EMCal

All

Barrel ECal – SciGlass

- Findings
  - Advanced mechanical design, based on experience from CMS and PANDA
  - New material SciGlass as more cost effective material compared to other crystals like PWO
  - Goal $7\%/\sqrt{E}$ and e/h 10^{-4}
  - 3x3 matrix $2x2x40cm^3$ prototype straight, baseline design: $4x4x40cm^3$ tapered

- Comments/Concerns
  - Relevant parameters for the characterization of SciGlass are missing (light yield, …)
  - Kinetics of glasses not understood => duration of signal? Are there slow components?
  - Confirmation of the homogeneity of transmission and light yield along the 40cm
  - The presented optical longitudinal transmission is not understood
  - There are no data on radiation hardness (em- and hadronic probes)
  - Measure response to electromagnetic **and** hadronic showers

- Recommendations
  - Determine all SciGlass properties relevant for a detailed simulation of light production and propagation

Barrel ECal – Pb/SciFi+Imaging

- Findings
  - Application of AstroPix MAPS ASIC in imaging part
  - Long fibres and lead sheets in main part
  - No full simulation, no prototypes or more detailed engineering test articles yet
  - Potential to leave out MPGD part

- Comments/Concerns
  - Integration and cooling
  - Installation and maintenance of self-supporting barrel is difficult
  - Consider having only Pb/SciFi as backup, simulate resolution

- Recommendations
  - Do full physics simulation as soon as possible
  - Move towards tests of prototypes or more detailed engineering test articles as soon as possible

Barrel HCal

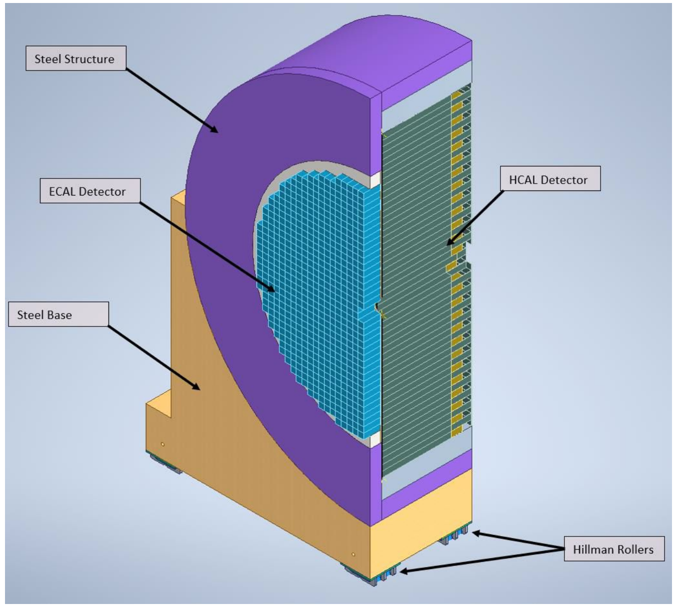
All

Barrel HCal

- Findings
  - Will reuse existing system
  - Tiles will be equipped with new SiPMs and readout
  - Detailed tile map from tests at MEPHI
  - HGCROC in streaming mode

- Comments/Concerns
  - Control homogeneity of tiles
  - Consider 1 HGCROC channel/tile to have longitudinal information to distinguish shower from MIP(μ)
  - Different systematics for positive and negative particles (chirality of setup)

- Recommendations
  - Exploit advantages of HGCROC to have longitudinal information
  - Re-map tiles
  - once full simulations available, study Particle Flow performance of ECAL-Coil-HCAL configuration for jets and muon ID



Forward calorimeters

All

Forward EMCal

- Findings
  - W/SciFi to reach 10%/√E and e/h~1
  - Experience from sPHENIX
  - Well trained team

- Comments/Concerns
  - Inhomogeneity as function of fibre arrangement to be validated in test
  - Readout on front side: light guides, sensors, electronics, cables, cooling
    => Electronics exposed to proton/heavy ion remnant
    => Worsening of elm. resolution

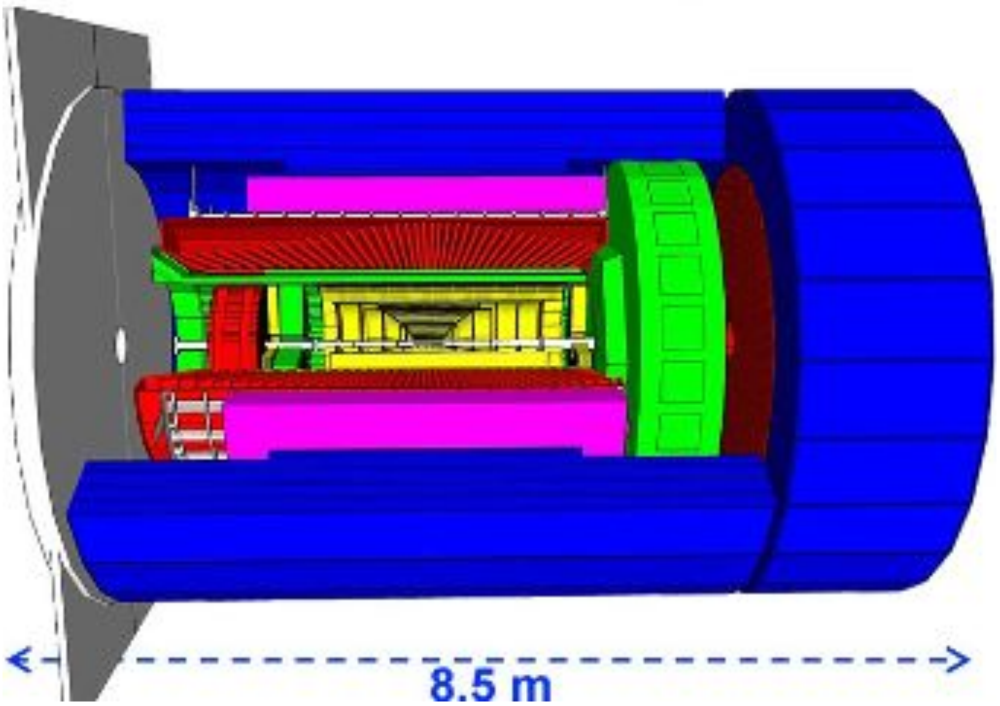
- Recommendations
  - Full simulation with passive structures in front to study effect on resolution
  - beam test of engineered structure including realistic upstream electronics

Forward HCal

- Findings
  - LFHCAL adopted from PSD
  - Steel an W tiles with Scintillator tiles and WLS readout by SiPMs
  - Dynamic range 3MeV - 30GeV
  - Segmented in long. direction
  - No beam test yet
  - MC Response tuned with CALICE Data
  - Effective segmentation (fibre ganging) and dynamic range of front-end electronics not yet optimised

- Comments/Concerns
  - Shift of towers to mount EMCal!? Verify EMCal integration
  - Laser etching is labor intense, presented alternative with molds is promising
  - Concern that super-tiles break at groves => consider smaller super-tiles or single tiles with sliding guides to form larger
  - Carefully plan fibre bending to avoid breakage
  - SiPMs mounted directly on tiles, connected with Kapton strips and possibly electrically ganged, could be a robust alternative
  - Check crosstalk between tiles
  - Consider simulations/tests with W section in front and compare elm. response with and without fibre section

- Recommendations
  - Perform full simulations to optimise electronic segmentation and dynamic range
  -



Integration

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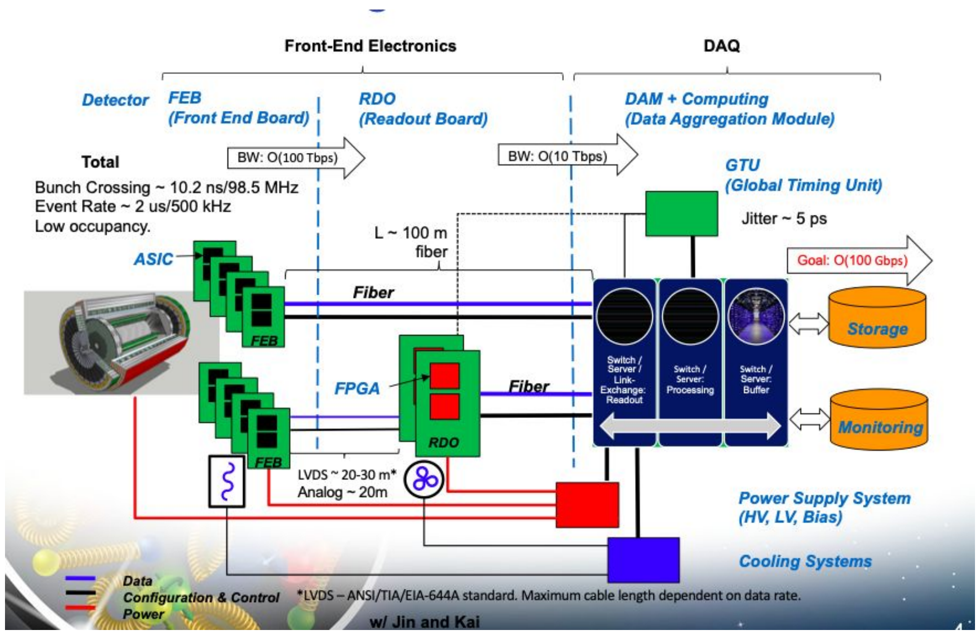
Detector Integration

- Findings
  - For many systems placeholder volumes are used
  - Measurements of electrons and electromagnetic shower is crucial for scientific output

- Comments/Concerns
  - Structured design of supports and services to be entered also in simulation
  - Do load checks and eventually FEM of static and dynamic cases (seismic events, moving detector)
  - Early stage of cabling and detector design

- Recommendations
  - Define tolerances and keep-out volumes to facilitate integration of systems
  - Follow design steps and hardware development with full simulation studies to identify critical aspects of detector design for precision physics



Electronincs

All

Electronics (General)

- Findings
  - All calorimeters will use SiPMs, different numbers of channels, different grouping levels
  - Readout architecture with FEBs, RDOs, and DAMs, GTU for timing
  - Raw rates 100 Tbps, RDO rates 10 Tbps, rate to storage 100 Gbps
  - Standardisation is aimed at wherever reasonably possible

- Comments/Concerns
  - Clock precision 5ps is challenging, careful design of GTU and timing chain with dedicated FPGA clocks and/or jitter cleaners
  - Employ clock from accelerator to structure data
  - Consider DC/DC Converter to reduce power losses and cables cross section
  - How many ASICs will be considered in project, HGCROC may not allow for high resolution
  - SciFi/W - motivate ADC resolution requirement (12/14 bit)?
Is ADC resolution of HGCROC sufficient?
- Recommendations
  -

Electronics (FEMCal)

- Findings
  - Baseline r/o architecture with discrete components, 50Msps ADC and (flash-based) FPGAs
  - No streaming ASIC ready yet, observed ongoing developments Pacific Microchip, Alphacore, SALSA

- Comments/Concerns
  - Cooling not yet worked out
  - Motivate ADC resolution requirement (12/14 bit)?
  - Passive material due to electronics in front of SciFi/W may pile-up
    What about SEU? Even in flash-based FPGA logic can fail with SEU
  - Consider underpressured cooling

- Recommendations
  - -

Electronics (LFHCal) / HGCROC

- Findings
  - Baseline is HGCROCv3, 10 bit ADC + 12 bit ToT for large signals
  - Trigger locally via readout board with channel sum information for hit detection
  - Considered grouping FEB to RDO locally (spider), linearly (snake) or with optical link
- Comments/Concerns
  - High data rate due to missing on-chip hit-detection, hit detection on RDO
  - Is ADC resolution of HGCROC sufficient?
  - Check if max. trigger rate (960kHz) can cause deadtime
  - Consider underpressured cooling
- Recommendations
  - HGCROC - give high priority to feasibility tests for all calorimeters (as above)

General Conclusions

- Findings
  - Optimisation for particle flow still missing
  - Not all requirements for detector performance are clear

- Comments/Concerns
  - A unified readout scheme is helpful
  - Careful choice of SiPM: rad. hard (insensitive against neutrons!), correct pixel size for dyn. range. Characterise before final procurement, sample control (also rad hardness) as part of QA
  - Size of SiPMs to be optimised in view of dynamic range in front-end ASICs

- Recommendations
  - Carry out more simulation and reconstruction studies (particle flow)
  - Construct comprehensive engineering test articles for the detectors where possible, and validate simulations with beam tests
  - Perform risk assessment for new designs
  - Hold next review in person and schedule it sufficiently in advance