1.3 Electromagnetic Calorimetry

The ECCE electromagnetic calorimeter system consists of three components to address the needs of high precision electron detection and hadron suppression in the backward, barrel, and forward directions as required by the Yellow Report.

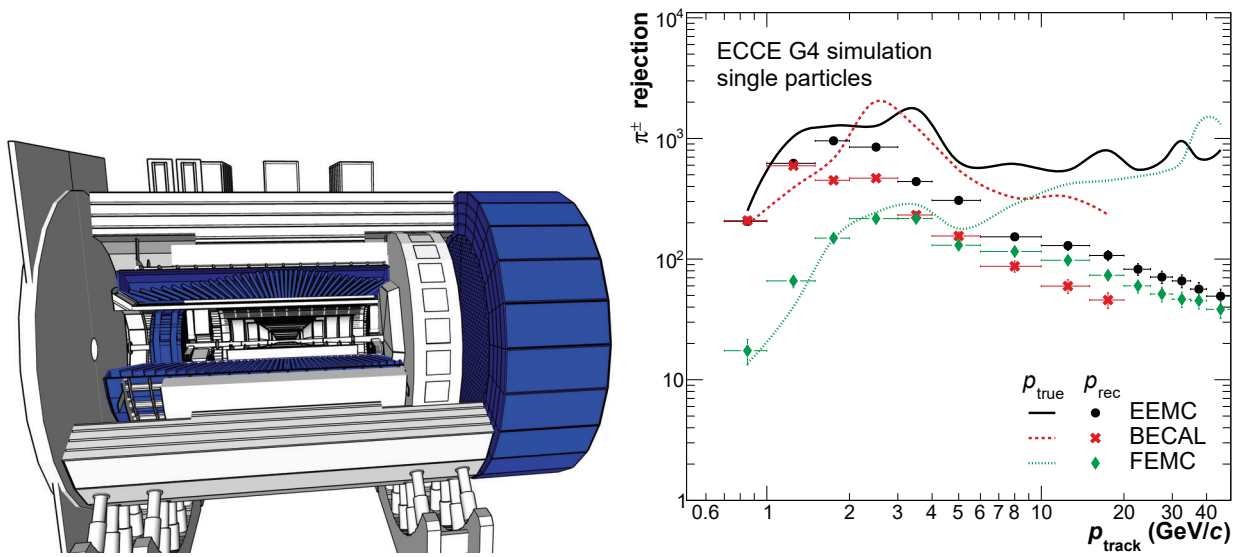

Figure 1.10: Performance of the EM calorimeters: (left) The electromagnetic calorimeters in ECCE. (right) (right) Pion rejection factor for the different EMCALs with $E/p > 1 - 1.6\,\sigma_E/E$ ($\varepsilon_e \approx 95\%$).

1.3.1 Electron Endcap EM Calorimeter (EEMC)

The EEMC is a high-resolution electromagnetic calorimeter designed for precision measurements of the energy of scattered electrons and final-state photons in the electron-going region. Based on the EIC Yellow Report the requirement on high energy resolution is driven by inclusive DIS where precise determination of the scattered electron is critical to determine the event kinematics.

The EEMC has been designed to address the requirements in the EIC Yellow Report. The baseline design of the EEMC is based on an array of approximately 3000 lead tungsten crystals (PWO) of size $2 \times 2 \times 20$ cm^3 ($\sim 22X_0$) and transverse size equal to its Moliere radius [1, 2] readout by SiPMs The expected energy resolution for PWO crystals is $2\%/\sqrt{E} + 1\%$ based on the Yellow Report. Fig. 1.11 shows the EEMC configuration and its performance in the ECCE detector.

The choice of technology and overall design concept is similar to that in the EIC Yellow Report. It is common for all three proto-collaborations, and has been further developed since the Yellow Report by the EEEMCAL consortium with details summarized in an Expression Of Interest in 2021 [ADD REFERENCE: https://indico.bnl.gov/event/8552/contributions/43186/attachments/31241/49300/EIC.EoI-EEEmCal-10312020.docx]. Since the total detector radius is smaller than that of the Yellow Report reference detector the ECCE design includes PWO only. The EEEMCAL Consortium is planning to support one or more EIC detectors as needed and is therefore part of multiple detector proposals.

The EEEMCAL team has begun to organize activities into mechanical design, scintillator, readout, and software/simulation among the collaborating institutions. Pre-design activities of the mechanical support structure commenced in 2021 and a document on mechanical design and integration has been prepared [ADD REFERENCE: J. Bettane, C. Munoz-Camacho, EEEMCAL-Mechanical Design & Integration, available at: https://wiki.jlab.org/cuawiki/index.php/EEEMC_Documents]. The concept is based on models of existing detectors that the team has constructed, and in particular the Neutral Particle Spectrometer at Jefferson Lab [1].

The EEMC is located inside the inner universal ("DIRC") frame . The integration of the EEMC into this frame is only possible if the beam pipe is removed, which implies that the flange must be disconnected. To improve the inner diameter of the EEMC and to improve the acceptance an inner calorimeter is being considered. This option also requires one to modify the overall structure of the EEMC to ensure no significant

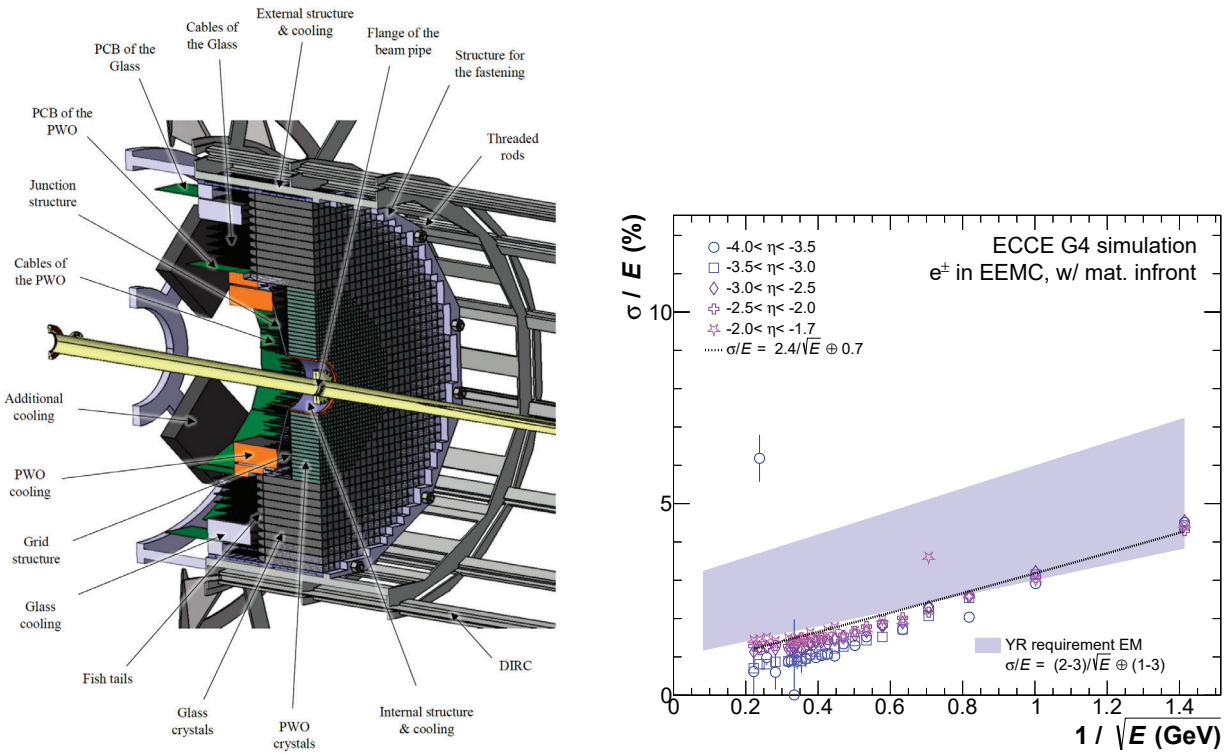

Figure 1.11: (left) The Electron-Endcap Calorimeter conceptual design as prepared by the EEEMCAL Consortium. The EEMC consists of PWO only and uses this design concept; (right) The electron energy resolution of the EEMC compared to the Yellow Report requirement.

gaps in scattered electron detection between electron endcap and barrel. Overall, the inner diameter of the EEMC will depend on the design of the beam pipe, and in particular the angle between the electron and the hadron tube.

A solution for the EEMCAL, which is cost effective, is to replace some outer layers of PWO by SciGlass as is discussed in the EIC Yellow Report.

1.3.2 Barrel EM Calorimeter (BEMC)

The barrel electromagnetic calorimeter (BEMC) is a precision homogeneous calorimeter based on an inorganic scintillator material that produces the shower due to high Z components and the signal (light). This allows a cost-effective solution that provides better resolution and certainly different systematic uncertainties as compared to the reference technology in the Yellow Report. The performance of the BEMC is illustrated in Fig. 1.10.

The BEMC has been designed to meet the requirements in the EIC Yellow report. The reference design of the BEMC is based on an array of approximately 9000 Scintillating Glass (SciGlass) blocks of size 4 x 4 x 45 cm^3. SciGlass has an expected energy resolution of $2.5\%/\sqrt{E} + 1.6\%$ [3, 4], comparable to PWO for a significant lower cost. The energy resolution of the BEMC is shown in Fig. 1.12.

The choice of technology is one of the reference calorimeter technologies from the Yellow Report. The development of SciGlass started with the generic detector R&D [ADD REFERENCES: T. Horn et al., eRD1: EIC Detector R& D Progress Reports 2017-2021]. During this phase the team worked in close contact with producers of SciGlass to establish robust QA protocols at all stages of production to ensure the quality needed for the EIC. The validation of large-scale SciGlass is now part of the ongoing project R&D (eRD105). An initial 40 cm SciGlass bar of high quality has been produced this Fall, and a prototype with nine 20-cm long SciGlass bars recently saw a successful beam test at Jefferson Lab, confirming the expected energy resolution. We expect to produce multiple 45-cm long SciGlass bars shortly.

The BEMC attaches to the outer universal (”DIRC”) frame.

Similar to the homogeneous barrel EM calorimeter at PANDA [5], the BEMC towers are organized in 128 blocks by ϕ slice and 70 blocks in η. Figure 1.12 (left) shows a mechanical drawing cut of the BEMC