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Development of a Crystal Calorimeter for the Electron Ion Collider

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The Electron Ion Collider (EIC) is a new facility that has been proposed in the US to study the structure of nuclear matter with precision electromagnetic probes at sufficiently high energies and with sufficient luminosity to access the gluon dominated regime of QCD with high statistical precision, and with polarized beams to enable a complete picture of the spin structure of the nucleon. Two versions of this facility have been proposed, one at Brookhaven (eRHIC) and another at JLAB (JLEIC), which would have the capability of colliding beams of electrons in the energy range of 5-10 GeV (eventually up to 20 GeV) with heavy ions in the range of 10-110 GeV/A, and with polarized protons up to 275 GeV/c. These facilities will require new detector systems to measure the scattered electron with high precision in order to provide the kinematic constraints to reconstruct the overall event, as well as measure the hadronic fragments from both heavy ion and proton beams, including particle id.

In order to measure the scattered electron at small scattering angles, a high precision electromagnetic calorimeter will be required for the endcap region of the detector in the electron going direction that can provide an energy resolution ˜ 1%/√E + 0.5%. A crystal calorimeter would be the best choice to provide such a high resolution, and there has been considerable experience with such calorimeters over many years. Given the energy range of interest at EIC, lead tungstate (PWO) is one of leading candidates for this calorimeter. The calorimeter would consist of several thousand crystals, each ˜ 20 cm long, similar to the PANDA endcap calorimeter. However, the light yield requirements would be somewhat less demanding than for PANDA due to the higher energy range, and the radiation damage requirements would be far less demanding than for the CMS crystals. The calorimeter would be located inside or just outside the solenoid spectrometer magnet and the readout would therefore have to work inside a magnetic field. Therefore, silicon photomultipliers or avalanche photodiodes would be used to read out the crystals.

A R&D program is being carried out by several groups interested in future experiments at EIC to investigate the requirements of this crystal calorimeter and to study the performance of its various components. We have been working with two principle suppliers of PWO crystals, the Shanghai Institute of Ceramics (SIC) in China and Crytur in the Czech Republic, to obtain high quality crystals with sufficient radiation damage tolerance to meet our requirements. We have also tested crystals in a test beam at Fermilab with a SiPM readout and measured their performance. Finally, we have carried out Monte Carlo simulations to study the requirements for the calorimeter that are needed to measure the scattered electron with sufficient precision in order to make the desired physics measurements. A summary and discussion of all of these topics will be presented at this conference.

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