Design for an eRHIC detector based on the sPHENIX detector†

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The PHENIX experiment has recently submitted a plan[1] for a detector design at eRHIC, a version of the Electron Ion Collider (EIC) planned at Brookhaven National Laboratory (BNL) which makes use of one of the current RHIC hadron rings. The EIC will collide polarized electrons with heavy nuclei and polarized protons, with its primary purpose to explore the gluon (the strong force carrier). eRHIC is expected to turn on in 2025.

A detailed description of the EIC physics case has been laid out in the recent White Paper[2]. eRHIC is expected to probe through polarized electron-proton collisions the properties of (sea)quarks and gluons in the nucleon, such as spin, orbital motion and spacial distributions. The kinematic coverage of ePHENIX in parton momentum fraction x and 4-momentum transfer Q^2 is compared to that of other measurements in Fig. 1. Measurements of the gluon helicity over a wide kinematic range will allow unprecedented constraints of the gluon polarization, Δg. In Semi-Inclusive scattering, correlations between transverse momentum of gluons and quarks and the proton spin will be fully explored. Through Deeply Virtual Compton Scattering, eRHIC will measure the orbital angular momentum contributions to the proton spin.

As it will also be able to scatter electrons off nuclei, eRHIC will be able to explore the nature of gluons at high density, where the effects of gluon saturation (when gluon splitting and recombination balance) are expected. By varying kinematics as well as the nuclei species, we will be able to vary the path length of a struck quark through the nuclei, and probe the nature of hadronization in and out of nuclear matter.

The ePHENIX detector design is shown in Fig. 2, and makes use of the BABAR solenoid[3] and the sPHENIX detector upgrade[4] being planned for later this decade. We plan to add a high resolution electromagnetic calorimeter in the electron-going direction for precision measurement of the scattered electron. GEM based trackers will allow for charged sign identification and hadron rejection based on energy to momentum cuts.

In addition to the sPHENIX electromagnetic and hadronic calorimetry, we plan to add a Time Projection Chamber (TPC) for tracking and a Detector of Internally Reflected Čerenkov radiation (DIRC) for hadron particle identification (PID), based on the BABAR DIRC detector. PID in the central barrel allows for measurements of sea quark spin and transverse momentum distributions at low momentum fraction, x.

In the hadron-going direction, new electromagnetic and hadronic calorimeters are planned, as well as additional trackers and PID detectors. The combination of an Aerogel-based Ring Imaging Čerenkov (RICH) detector for low momentum tracks and a gas-based RICH detector for tracks up to ~ 60 GeV/c will allow for measurements at highest and moderate x over the full available Q^2 range.

ePHENIX will be capable of doing the physics possible with eRHIC. Efforts on fully simulating the detector is currently underway.

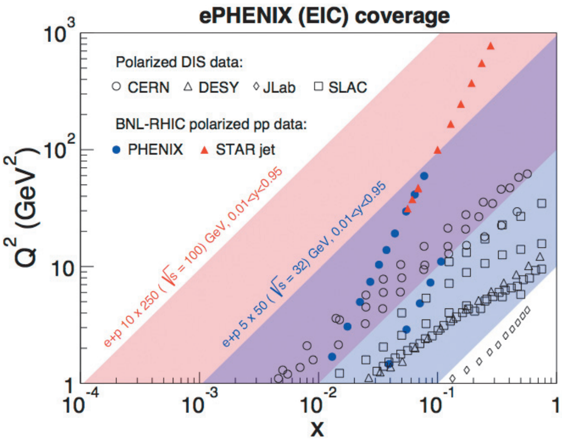

Fig. 1. Kinematic coverage (blue and red bands) expected at eRHIC with the ePHENIX detector for inclusive measurements in electron-proton scattering. Also shown are current world data.

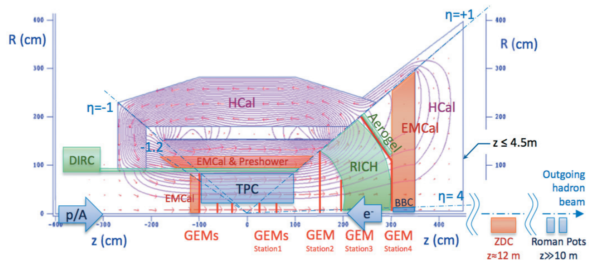

Fig. 2. Design of the ePHENIX detector at eRHIC. The proton/Nuclei beam enters from the left, and the electron beam enters from the right.

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References
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