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Future Upgrades for the PHENIX Experiment at RHIC: From sPHENIX to ePHENIX

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The PHENIX Experiment at RHIC is planning a series of major upgrades that will enable a comprehensive measurement of jets in relativistic heavy ion collisions, provide enhanced physics capabilities for studying nucleon-nucleus and polarized proton collisions, and allow a detailed study of electron-nucleus collisions at a future Electron Ion Collider (eRHIC) at Brookhaven. These upgrades will include a number of major new detector systems. The first stage, sPHENIX, will utilize the former BaBar solenoid magnet and will include two new large calorimeters, one electromagnetic and another hadronic, for measuring jets in heavy ion collisions. These calorimeters will cover a region of ±1.1 in pseudorapidity and 2pi in phi, and will result in a factor of 6 increase in acceptance over the present PHENIX detector. Plans are also being developed to add a preshower detector in front of the electromagnetic calorimeter and additional tracking inside the magnet. The current RHIC schedule would allow the installation of sPHENIX to take place starting around 2017-2018 and begin taking data ˜2020. Following this, RHIC would be transformed into an Electron Ion Collider and additional detectors would be added to sPHENIX to convert it to ePHENIX which would serve as a detector for eRHIC. This would involve adding additional tracking in the form of a central TPC and a system of GEM trackers, a high resolution crystal endcap calorimeter, a forward electromagnetic and hadronic calorimeter, and a set of particle id detectors, including a DIRC, a gas RICH and an aerogel detector. This talk will discuss the evolution of the current PHENIX detector to sPHENIX and ePHENIX, the R&D that is being pursued to develop the various detectors that will be needed, and the opportunities and challenges for each of their technologies. A separate contribution to this conference will describe the central electromagnetic and hadronic calorimeters for sPHENIX, including results from a recent beam test of prototypes of both of these detectors at Fermilab.

Summary

The PHENIX Experiment has been running at RHIC since 2000 and has accumulated a wealth of data on relativistic heavy ion collisions, nucleon-nucleus collisions and polarized proton collisions. It is one of the major RHIC experiments that contributed to the discovery of the Quark Gluon Plasma and is still in operation today. It has been focused on the systematic study of the QGP near its critical temperature using a variety of different probes, but questions such as how and why the quark-gluon plasma behaves as a perfect fluid in the vicinity of strongest coupling (near 1–2 Tc) can only be fully addressed with jet observables at RHIC energies which probe the medium over a variety of length scales. Comparing these measurements with ones probing higher temperatures at the LHC will provide valuable insight into the thermodynamics of QCD.
PHENIX in its present form covers roughly half of the full azimuthal acceptance and 0.7 units of rapidity with a suite of different detectors, including an electromagnetic calorimeter. In order to increase this coverage for a complete systematic study of jets, the PHENIX Collaboration is proposing a new upgraded detector, sPHENIX, that will utilize the former BaBar solenoid magnet and instrument it with two new calorimeters, one electromagnetic and one hadronic, that will cover the full azimuth and 2.2 units of rapidity. The hadronic calorimeter will be a steel plate and scintillating tile design that is read out with wavelength shifting fibers and silicon photomultipliers (SiPMs). The EMCAL will be a tungsten-scintillating fiber design that will also be read out using SiPMs. There are also plans to add a silicon-tungsten preshower detector in front of the

EMCAL. The initial tracking system for sPHENIX will utilize the existing PHENIX silicon vertex detector, and will add additional silicon tracking layers in the future.

The current plan is to run with the existing PHENIX detector through 2016 followed by the installation of sPHENIX in 2017. Data taking with sPHENIX would begin ~ 2020 and last 2-3 years. This would then be followed by the transition of RHIC to an Electron Ion Collider (eRHIC), which would collide electrons, initially up to 10 GeV, with hadrons up to 250 GeV and heavy ions up to 100 GeV/A. eRHIC will allow a detailed study of the spin and momentum structure of the nucleon, an investigation of the onset of gluon saturation in heavy nuclei, and the study of hadronization in cold nuclear matter. sPHENIX will also be transformed into a new enhanced detector, ePHENIX, that will provide the necessary capabilities to study this new physics. This will include the addition of a high resolution crystal calorimeter in the electron going direction and a forward spectrometer in the hadron going direction. The forward spectrometer will consist of an EMCAL and HCAL, similar in design to the central sPHENIX calorimeters, along with a gas RICH that utilizes a photosensitive GEM detector and an aerogel Cherenkov detector. The central region will be augmented with a fast drift TPC with a GEM readout and full azimuthal coverage a DIRC detector. Additional GEM trackers will also be added to the central, forward and backward going regions. The plan would be for eRHIC and ePHENIX to start taking data sometime in the mid to late 2020's.

This talk will describe the long range plans for RHIC and the PHENIX detector, but will focus mainly on the new detectors and technologies that are planned for sPHENIX and ePHENIX. The two new calorimeters for sPHENIX have already undergone considerable design and prototypes of each detector have been constructed. These prototypes will be tested at Fermilab in February 2014 and preliminary results from these tests should be available by the time of the conference. The calorimeters and the test results will be described in a separate contribution to the conference.

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