PX No. 191 BNL-68077

THE PHENIX EXPERIMENT AT RHIC

Samuel Aronson for the PHENIX Collaboration

International Conference on High Energy Physics
Osaka, Japan
July 27 – August 2, 2000
Proceedings in press

Physics Department

Brookhaven National Laboratory
Operated by
Brookhaven Science Associates
Upton, NY 11973

Under Contract with the United States Department of Energy
Contract Number DE-AC02-98CH10886

BNL-68077

THE PHENIX EXPERIMENT AT RHIC

SAMUEL ARONSON for the PHENIX Collaboration

Physics Department, Brookhaven National Laboratory, Upton, NY 11973, USA

E-mail: aronsons@bnl.gov

PHENIX is a large detector at the Relativistic Heavy Ion Collider (RHIC) at BNL. RHIC and PHENIX have recently operated for the first time, producing and detecting collisions of gold ions at beam energies of 30 and 65 GeV per nucleon. The current performance and future plans of PHENIX and of RHIC are presented.

1 Introduction

PHENIX is one of two large experiments at the BNL Relativistic Heavy Ion Collider (RHIC). With the start-up of heavy ion collisions at RHIC in the summer of 2000, PHENIX has commenced data taking. The physics goals, detector status and early experience with collecting data are described in this paper.

Starting in June 2000 RHIC produced collisions of gold ions at beam energies up to 65 GeV per nucleon. Luminosities of about $5\times10^{25}/\text{cm}^2\cdot\text{sec}$ were achieved. The design goals of RHIC are $5\times10^{26}/\text{cm}^2\cdot\text{sec}$ at 100 GeV/nucleon for heavy ions and $10^{31}/\text{cm}^2\cdot\text{sec}$ at 250 GeV beam energy for polarized protons. Full-energy heavy ion operations and the start of polarized proton running are both expected in 2001. The first run ended in September 2000; RHIC delivered integrated luminosities of 2 to 3 μb^{-1} to each of 4 experiments - BRAHMS, PHENIX, PHOBOS and STAR.

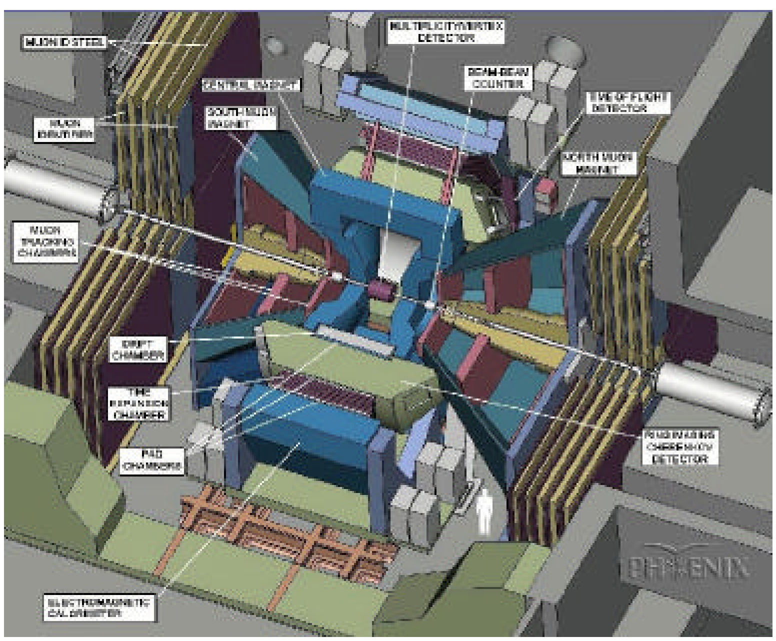


Figure 1.Cutaway view of the PHENIX detector.

2 The PHENIX Detector

The PHENIX detector[1], comprising 4 large aperture spectrometers plus detectors for global event characterization, is depicted in Figure 1. Two central spectrometers view the collision around $\eta = 0$ with high precision tracking, calorimetry and particle identification. Two spectrometers covering the pseudorapidity ranges $1.1 < |\eta| < 2.4$ detect muons. Silicon strip and pad detectors, beam-beam counter (BBC) arrays and zero-degree calorimeters (ZDC) provide collision triggers and charged multiplicity distributions. In all, PHENIX has 12 separate subsystems and about 400,000 channels of electronic readout.

3 Physics Goals

The PHENIX detector design allows for broad research programs in both heavy ion and polarized proton collisions. In relativistic heavy ion collisions, the program is aimed at a study of strongly interacting matter under extreme conditions. In particular, PHENIX will search for and study the so-called Quark-Gluon Plasma (QGP) and the phase transitions that separate the QGP from ordinary hadronic matter. PHENIX is unique among the present generation of RHIC detectors in being able to detect leptons and photons among the particles created in heavy ion collisions. These probes carry information from the early stages of the collision, while hadronic secondaries primarily report on the later stages, after the QGP expands, cools and rehadronizes. Table 1 indicates the probes to which PHENIX is sensitive, and the time-ordered stages of the collision to which they pertain.

In polarized proton collisions, the main focus of the PHENIX program is to study

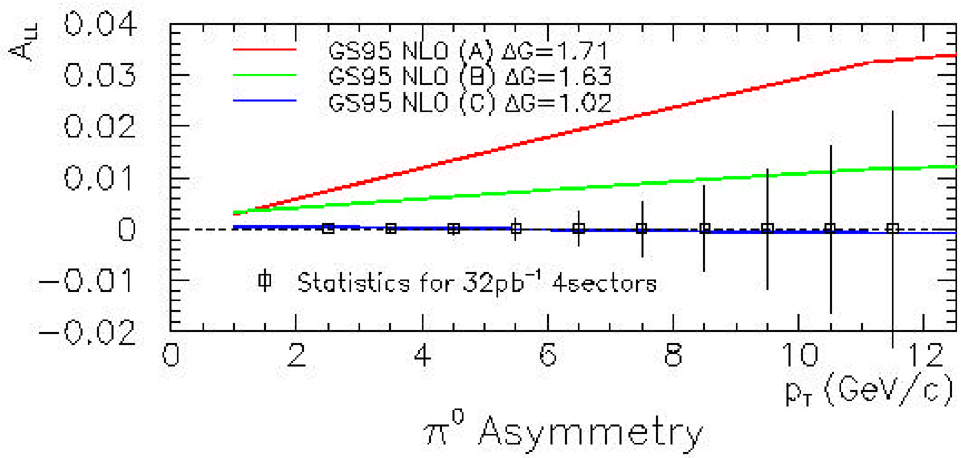
Table 1. PHENIX physics goals ordered by the timescale in the collision from early to late.

TIMESCALE	**PROBE**
Initial collision	**Hard scattering -** single “jet” via leading particle; γ+ “jet”
Deconfinement	**High-mass vector mesons -** J/ψ, ψ' screening; Υ (non) screening
Chiral restoration	**Low-mass vector mesons -** ρ, ω, ϕ mass, width; ϕ branching ratios
QGP thermalization	**Photons -** π^0, η, η'; continuum direct γ **Dileptons -** non-resonant: 1-3 GeV; soft continuum: < 1GeV **Heavy quark production -** open charm; open charm via single lepton

Hadronization	**Hadrons -** HBT interferometry, π/K; - strangeness production; spectra of identified hadrons
Hydrodynamics	**Global variables -** E_T, dN/dy

the spin of the proton. RHIC provides a unique opportunity to study polarized structure functions, including that of the gluons. Very high energy polarized proton collisions also allow PHENIX to use parity violating asymmetries (e.g., in W production) as sensitive probes of new physics. Figure 2 shows the PHENIX statistical power in the measurement of ΔG, the polarized gluon structure function. The curves indicate different possible values of ΔG.

Figure 2. π^0 asymmetry measurement in polarized proton running versus different estimates of ΔG



4 The 2000 Run

In the year 2000 run PHENIX operated its two mid-rapidity spectrometers, with about half their apertures being read out. From mid-June to mid-September RHIC delivered to PHENIX about 3 μb^{-1} of integrated luminosity. From this exposure PHENIX recorded about 3 million events.

Initial analysis of these data indicates very good detector performance and very good correspondence between the subsystems of the mid-rapidity spectrometers. Figure 3 shows a γγ mass distribution from the electromagnetic calorimeter, typical of the performance of PHENIX subsystems in the 2000 run.

With the data collected and reconstructed, PHENIX expects to produce several physics results in the next few months, including:

- $dN_{ch}/d\eta$ in the pseudorapidity interval $|\eta| \leq 0.35$ versus the number of participants;
- $dE_T/d\eta$ versus the number of participants in the same η interval;
- Spectra of identified charged and neutral hadrons out to $p_T > 5$ GeV/c;

• Collective effects such as elliptic flow.

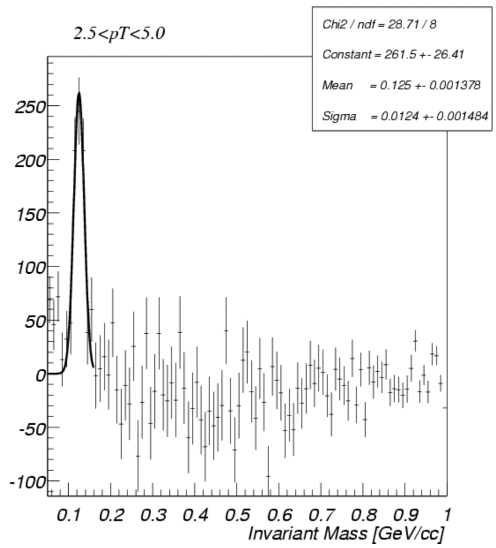


Figure 4. $\gamma\gamma$ invariant mass reconstructed in the calorimeter. Combinatorial background has been subtracted using mixed events.

5 Future Plans, Outlook

Work is now under way to install the first of two muon spectrometers and to complete the readout of the mid-rapidity spectrometers. These enhancements will be in place for the next run, expected to start in March of 2001. Increased aperture in the central arms and the added muon capability will allow PHENIX to start collecting dilepton events, in particular at the J/ψ and ψ′. This will give PHENIX access to one of the most interesting putative signatures of the QGP, suppression of J/ψ and ψ′ production[2] via color screening.

Beyond that, PHENIX will complete its second muon spectrometer and begin on a program of upgrades. These upgrades will primarily target improved particle identification, triggering and background rejection in the lepton signatures. Such detector enhancements, plus increased bandwidth for data acquisition, will allow PHENIX to pursue rare phenomena at the highest luminosities RHIC will eventually deliver.

Acknowledgments

This work is supported in part by grant DE-AC02-98CH10886 from the U. S. Department of Energy

References

1. D. P. Morrison in *Proceedings of the Yamada Conference XLVIII on Quark Matter '97*, eds. T. Hatsuda, Y. Miake, S. Nagamiya and K. Yagi (Yamada Science Foundation and Elsevier Science Publishers, Tsukuba, 1998).
2. T. Matsui and H. Satz, *Phys. Lett.* **B178**, 416 (1986).