The PHENIX Muon Arms Subsystem

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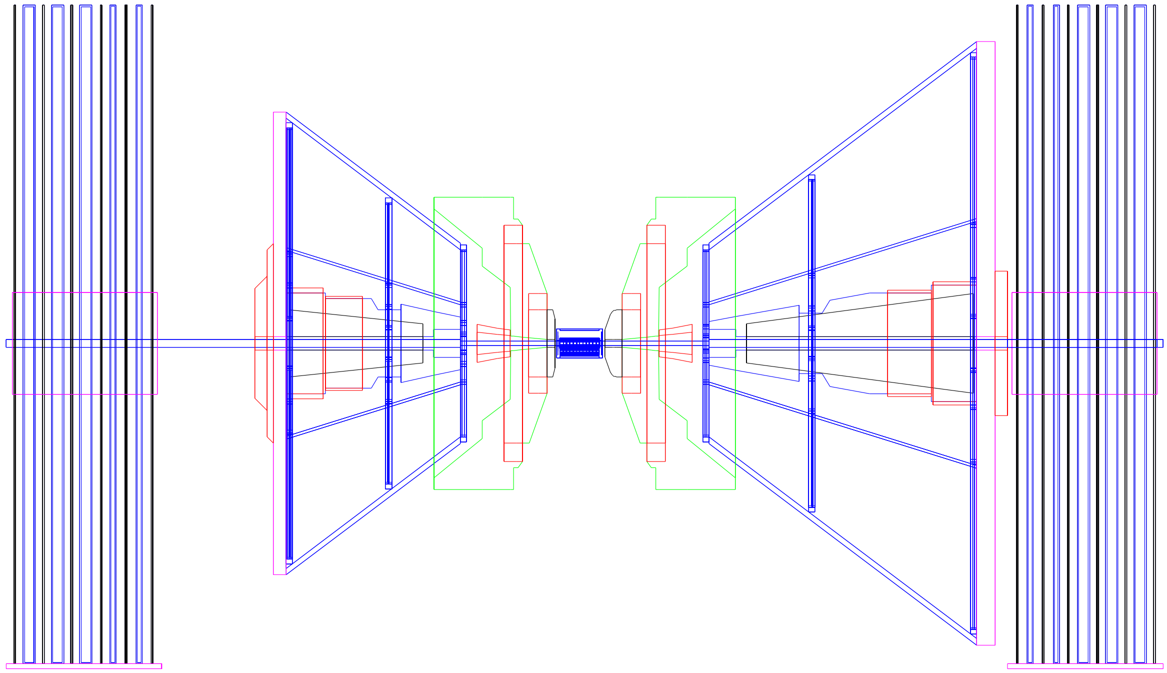
The PHENIX Muon Arms subsystem was recently approved to proceed towards construction. Highlights of the present construction status are presented. Key PHENIX physics goals which rely heavily on the muon arms are discussed.

The purpose of the PHENIX Muon Arms is to facilitate the study of vector mesons decaying into dimuons, to allow the study of the Drell-Yan process, and to provide the muon detection in $D\overline{D} \rightarrow \mu + e + X$ as part of both the relativistic heavy ion and spin physics programs of PHENIX. Each muon arm must both track and identify muons, as well as provide good rejection of pions and kaons; therefore, both a Muon Tracker and a Muon Identifier are needed. Each arm of the Muon Tracker comprises three stations of tracking chambers, with three planes of cathode strip chambers each, mounted inside the end-cap muon magnet. Two different construction techniques are being used for the chambers. The first and third stations are constructed as honeycomb panels with cathode strips on the inside surfaces. The second (central) stations are constructed as stacks of wires and etched foils attached to aluminum frames. The position resolution will be 100 μm per plane which provides a mass resolution sufficient to separate the J/ψ from the ψ' and the $\Upsilon(1S)$ from the $\Upsilon(2S + 3S)$.



Full-scale prototypes are currently being constructed and tested for the muon tracker station 1 honeycomb lattice CSC and the station 2 etched foil CSC. A prototype of the charge-sensitive preamplifier for CSC readout will be made and tested this summer.

The north and south muon identifiers, placed behind the 30 cm magnet endplate, each consist of 6 gaps instrumented with plastic proportional tubes interleaved with 5 layers of steel. Four large plus four small panels are used to tile a gap with tubes. The largest size panel is approximately 4 m x 6 m x 10 cm. The individual tubes are Iarocci limited streamer tubes operated at reduced voltage in order to maximize their longevity. The tubes have a resistive graphite coating on the inner surface that serves as the cathode. The eight wires in each tube are ganged together into one read-out channel to allow for low resolution tracking and to provide signals for the first and second level muon triggers.

A full-scale prototype of a large muon identifier panel is under construction and will be tested this summer. Mass fabrication of certain parts of the muon subsystems will begin in 1997.

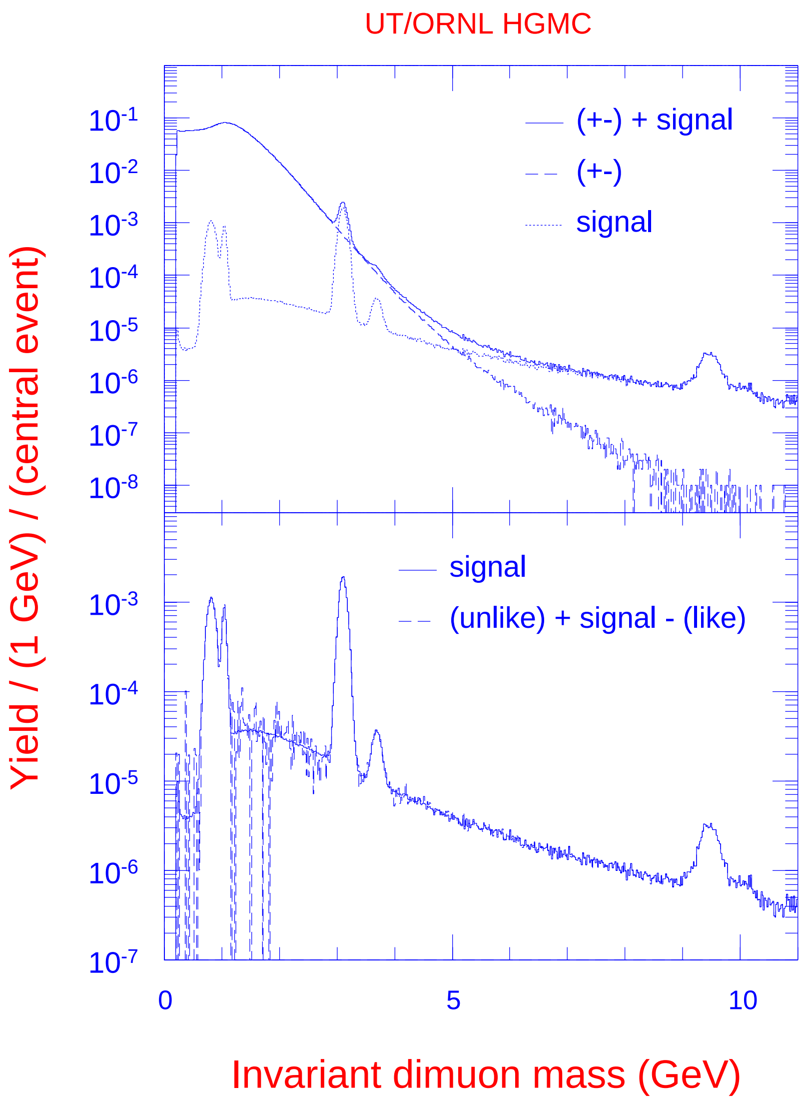
HEAVY ION PHYSICS PROGRAM

The primary goal of the Relativistic Heavy Ion Physics program of PHENIX is to detect the quark-gluon plasma (QGP) and measure its properties with as many different experimental probes as the detector will allow. The Muon Arms are a major contributor to the total physics program. This subsystem will be used to measure the production of vector mesons decaying into dimuons in heavy ion collisions for masses ranging from that of the ϕ to the Υ. Measurement of the differential suppression of J/ψ and ψ' production will provide information concerning "deconfinement," *i.e.* Debye screening of the QCD potential. The two muon arms provide large acceptance for high mass pairs at central rapidity.

The Muon Arms allow study of the continuum dilepton spectra in a much broader region of rapidity and mass than is accessible with the central arms alone. Additionally, the $e\mu$ coincidence using electrons detected by the central arm will probe charm production and aid in the understanding of the shape of the continuum dielectron spectrum. This is because unlike-sign $e\mu$ pairs are primarily from $D\overline{D}$, while like-sign pairs are mainly due to the combinatorial background.

The following table provides the number of detected dimuons per RHIC year (2000 hours at a luminosity of 2.2×10^{27} cm^{-2}s^{-1}) for minimum-bias $Au + Au$ collisions, with $p_\mu > 2$ GeV/c.

	North Arm	South Arm	One in each
ϕ	500k	69.8k	0
J/ψ	1.73M	1.34M	0
ψ'	24.2k	18.7k	0
Υ	4.92k	4.10k	4.06k



TOP: Contributions to the unlike-sign dimuon yield per central event as a function of the invariant mass. The dashed line shows the combinatoric background, the dotted line shows the signal and the solid line their sum. BOTTOM: Results from a like-sign subtraction. The solid line is the assumed signal again; the dashed line is constructed by subtracting the like-sign combinatoric background from the total unlike sign distribution.

This figure is an example of how well the simulated signal can be restored by subtracting the like-sign invariant mass spectrum from the total spectrum. Note the clear separation of the J/ψ from the ψ' in the figure at the bottom.

SPIN PHYSICS PROGRAM

Polarized pp collisions at $\sqrt{s}$ from 50 to 500 GeV are to be analyzed to measure the helicity distributions of quarks and anti-quarks and gluon polarization in the nucleon. This information is probed by studying the polarized Drell-Yan process, vector boson production, polarized gluon fusion, and polarized gluon Compton scattering. Antiquark structure function measurements rely on analyzing Drell-Yan and vector boson production data. Gluon polarization measurements rely on analyzing heavy quark, J/ψ, and prompt photon data. Efforts to understand the contributions of the spin of sea quarks and the polarization of gluons to the total nucleon spin should help explain deviation of experimental data from the Ellis-Jaffe sum rule.

A muon spectrometer with two arms has a greatly enhanced detection capability for large $\sqrt{\tau} = M/\sqrt{s}$ muon pairs. It is at large values of $\sqrt{\tau}$ where polarization effects are likely to be maximal. Mass resolution at the Z^0 is approximately 5.3 GeV/c^2 which is quite acceptable for spin physics in this region.

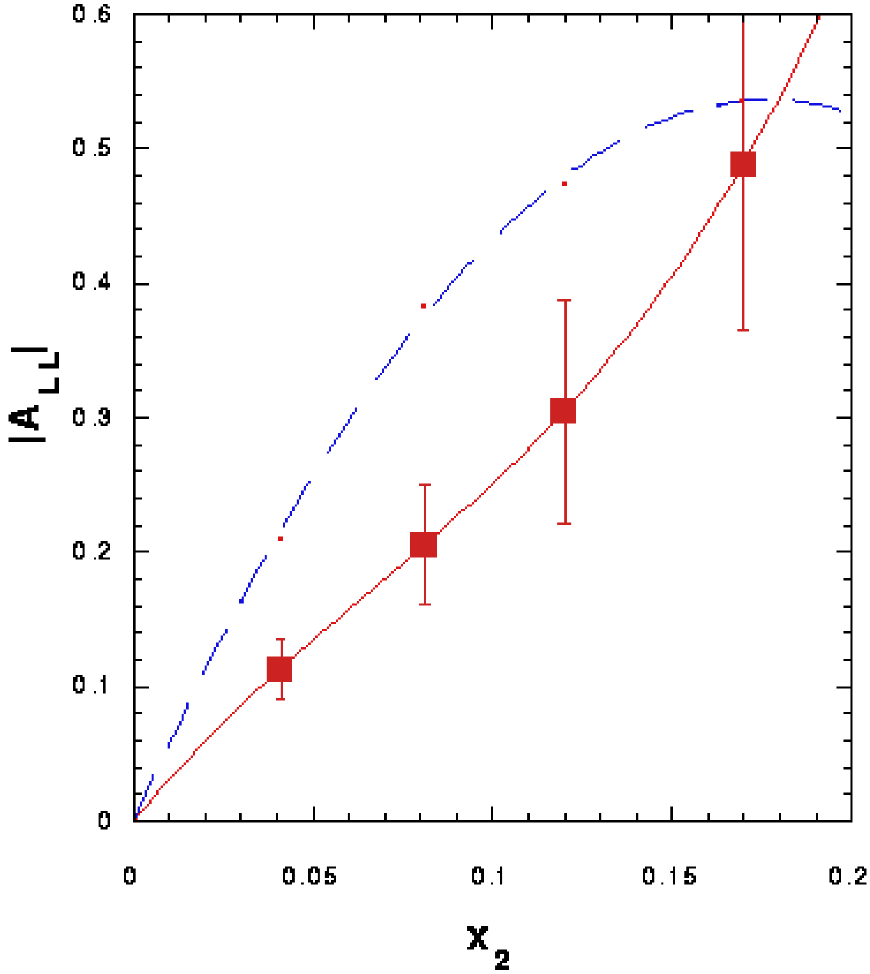
As an example of part of the spin physics program, consider the Drell-Yan process

$$q(x_1) + \overline{q}(x_2) \to \gamma^* \to \mu^+\mu^-$$

for which the longitudinal spin asymmetry is given by:

$$A_{LL}^{DY}(x_1, x_2) = \frac{\Sigma_a\, e_a^2 \Delta q_a(x_1) \Delta\overline{q}_a(x_2) + (2 \leftrightarrow 1)}{\Sigma_a\, e_a^2 q_a(x_1)\overline{q}_a(x_2) + (2 \leftrightarrow 1)}$$

where $\Delta q_a \equiv q_a^+ - q_a^-$. The superscripts refer to parton spin projections parallel $(+)$ or antiparallel $(-)$ to the parent hadron's spin projection.



Two theoretical predictions for $|A_{LL}^{DY}|$ using a model by Bourrely and Soffer. Error bars shown on the lower curve indicate PHENIX's sensitivity based on an integrated luminosity of 2×10^{38} cm^{-2} at $\sqrt{s} = 50$ GeV, yielding 10.8k muon pairs; beam polarizations are taken to be 0.7.

The figure demonstrates how the expected experimental accuracy could be used to distinguish between theoretical predictions. Shown below are the number of Drell-Yan dimuons that would be detected by the PHENIX muon spectrometer for an integrated luminosity of 2×10^{38} cm^{-2} at $\sqrt{s} = 50$ GeV.

Mass Range:	4–6	6–8	8–10	$M \geq 10$
Number of dimuons:	7930	1988	586	285