THE PHYSICS OF THE PHENIX MUON ARMS

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Overview

- The PHENIX Muon Arms
- Heavy Ion and Spin Physics Programs
- Expected Performance
- Construction Highlights
- Related talks:
  - Muon Tracker Large Cathode Strip Chambers (D. Lee)
  - Muon Identifier Design & Construction details (V. Cianciolo)
  - Spin Physics Program (K. Kurita, 9:36 am Wednesday)

The PHENIX Muon Arms

- To provide the muon detection for both the relativistic heavy ion and spin physics programs of PHENIX

- Muons:
  - arise from several processes (vector mesons, charm, γ^*)
  - leave point of creation with “no” further interaction
  - can be detected with $\approx 10^{-4}$ pair background

- 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.

- *Muon arms approved for construction in 1996!*

- *Muon Identifier must be installed by September 98!*

Heavy Ion Physics Program

- Primary goal is to detect new phase of matter, the Quark Gluon Plasma (QGP), and measure its properties via simultaneous measurements of various signatures.

- Muon Arms are a major contributor to the total physics program.

- Will be used to measure the production of vector mesons decaying into dimuons in heavy ion collisions for masses ranging from the ϕ to the Υ.

- Measurement of the differential suppression of J/ψ and ψ' production will provide information concerning "deconfinement," *i.e.* screening of the QCD potential.

- Two muon arms provide large acceptance for high mass pairs at central rapidity – very important for these important scarce events.

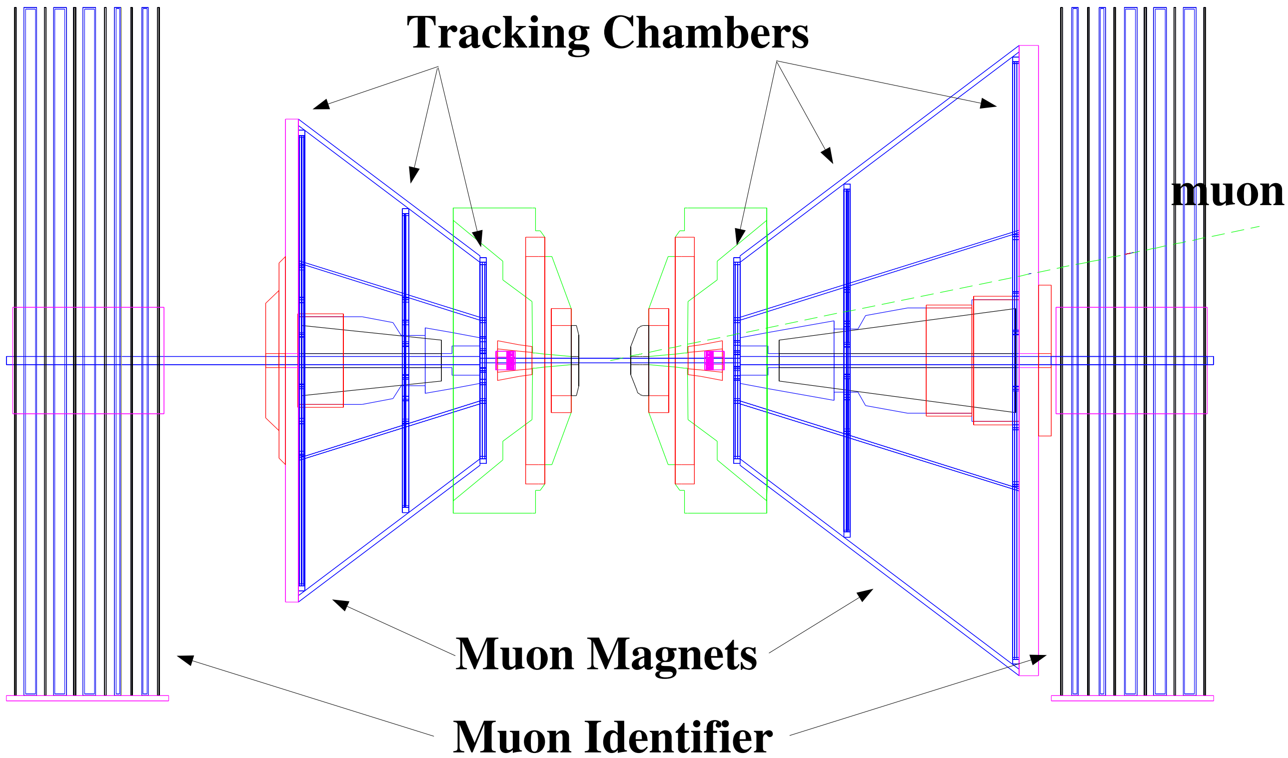
Spin Physics Program

- Goal is to understand the contributions of the spin of sea quarks and the polarization of gluons to the total nucleon spin.

- Longitudinally or transversely polarized $p + p$ 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.

- Dimuons and high p_t single muons are detected to measure helicity dependent cross sections (beam proton spins aligned or anti-aligned) such as the polarized Drell-Yan process, vector boson production, and polarized gluon fusion.

- Muon spectrometer with two arms has a greatly enhanced detection capability for large $M/\sqrt{s}$ muon pairs, where polarization effects are likely to be maximal.



- Each arm of the Muon Tracker comprises three stations of tracking chambers inside the end-cap muon magnet. Each station has three planes of cathode strip chambers. This measures the momentum and a 3-dimensional trajectory.

- CSC with analog readout

- 100 μm resolution goal

- Stereo readout to counteract projective ambiguities

Muon Identifier

- Each arm of the Muon Identifier comprises 5 gaps instrumented with plastic proportional tubes interleaved with 4 layers of steel. This tells us if it's a muon and where it is quickly for triggering.

- Steel absorber serves as a "filter" for muons.

- Sufficient pointing accuracy to match unambiguously with muon tracker tracks

- Require over 10 year longevity for all components

- Chose plastic proportional tubes (Iarocci LSTs at reduced voltage in proportional mode)

- Eight wires in each tube are ganged together into one readout channel to allow for low resolution tracking and to provide signals for the first and second level muon triggers.

- x-y readout of 8.5 cm wide tubes with readout from one end

Expected Performance

- Level-1 trigger simulations indicated that muon identifier will be able to efficiently identify muons and not have an unacceptable rate due to expected backgrounds

- 10^{-4} π/μ rejection ratio

- Simulated mass resolutions and acceptances:

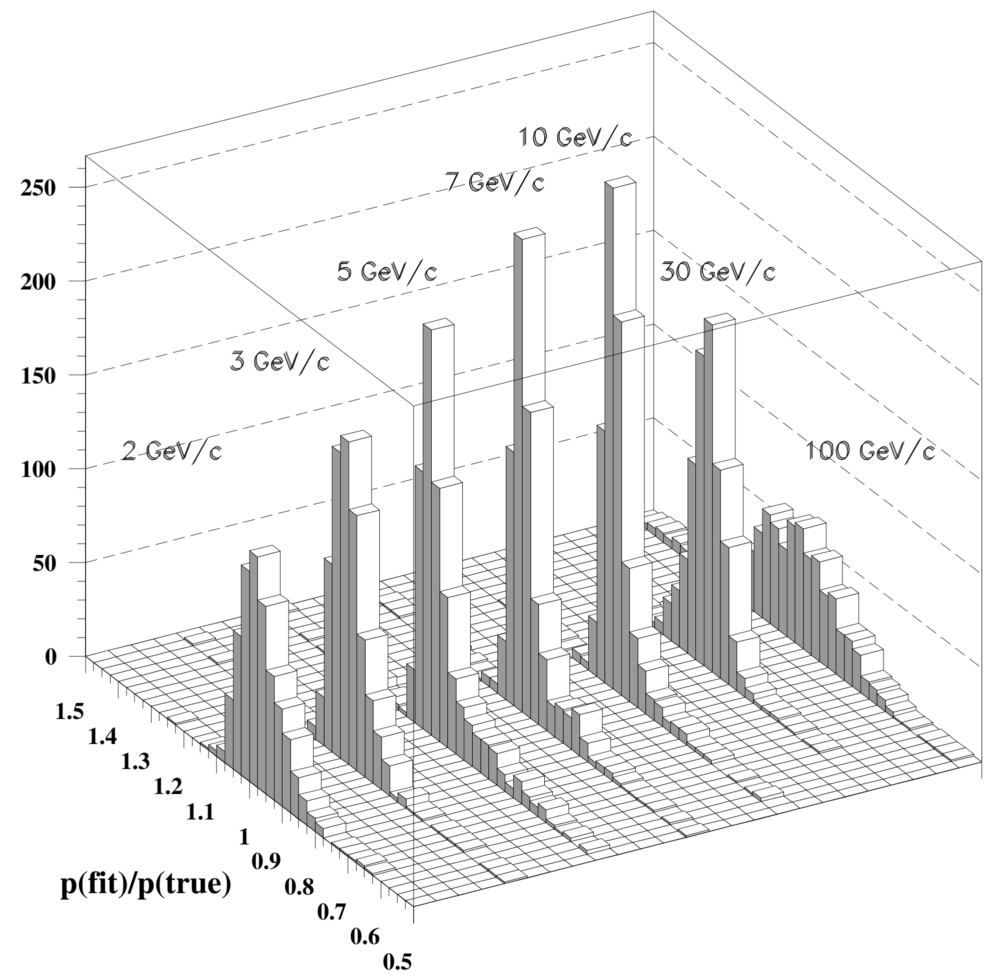
Particle	Mass Resolution (MeV/c^2)	Acceptance (%)	Events/year in North Arm
ϕ	60	0.58	4×10^4
J/ψ	105	4.3	6.7×10^5
ψ'	105	4.3	1.2×10^4
Υ	180	3.0	382

- 0.6 million J/ψ per arm per RHIC-year of $Au + Au$ collisions (at design luminosity of 2×10^{26} $cm^{-2}s^{-1}$)

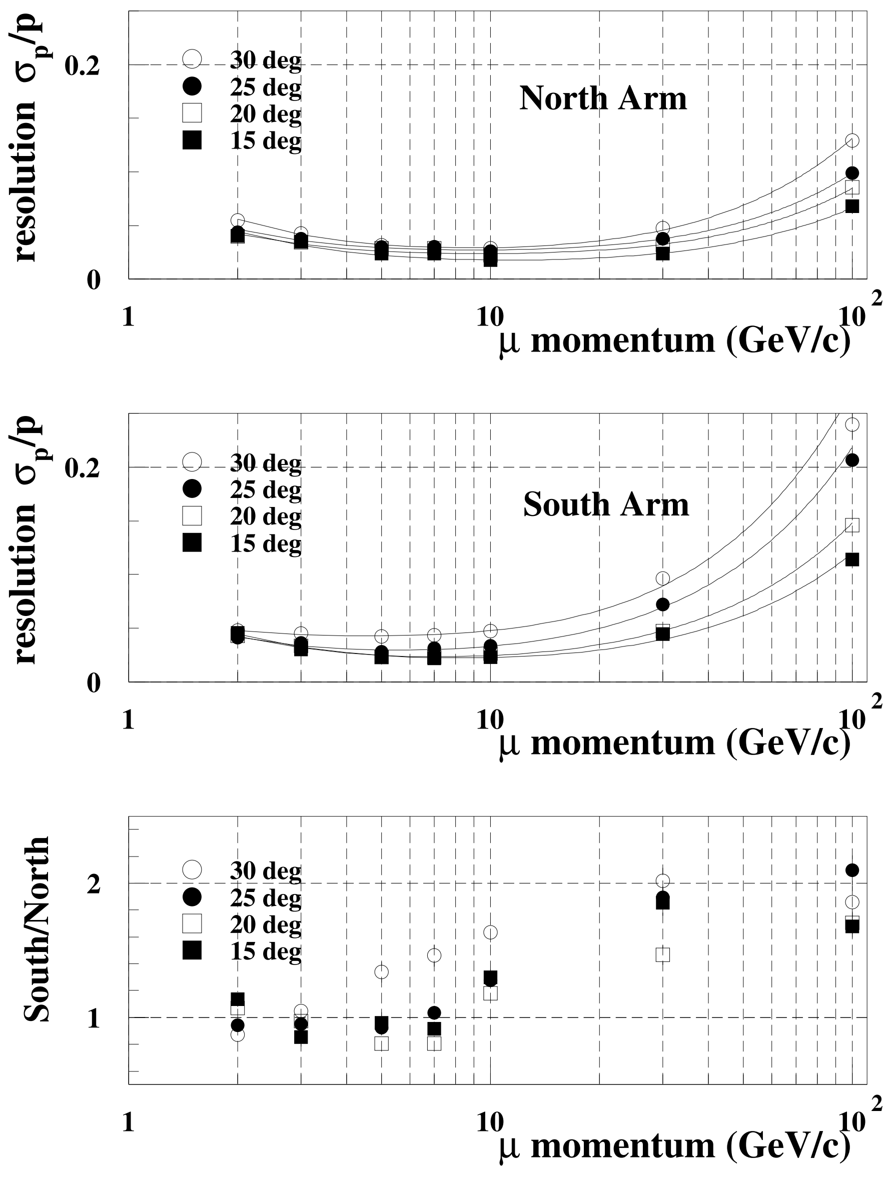
- 293 Υ per year with one muon in each arm

Momentum Resolution Spectra of
Muon in North Arm @ 30 deg

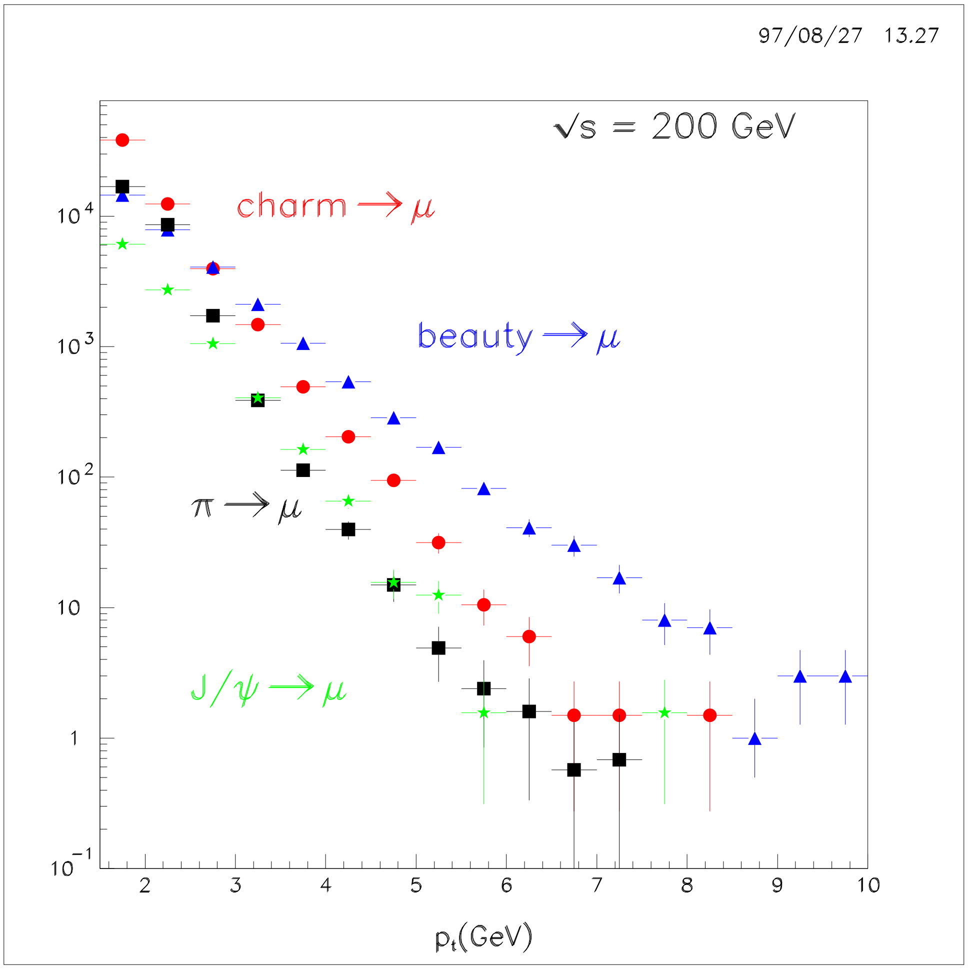
Studied with GEANT based simulation



Muon Arm Performance



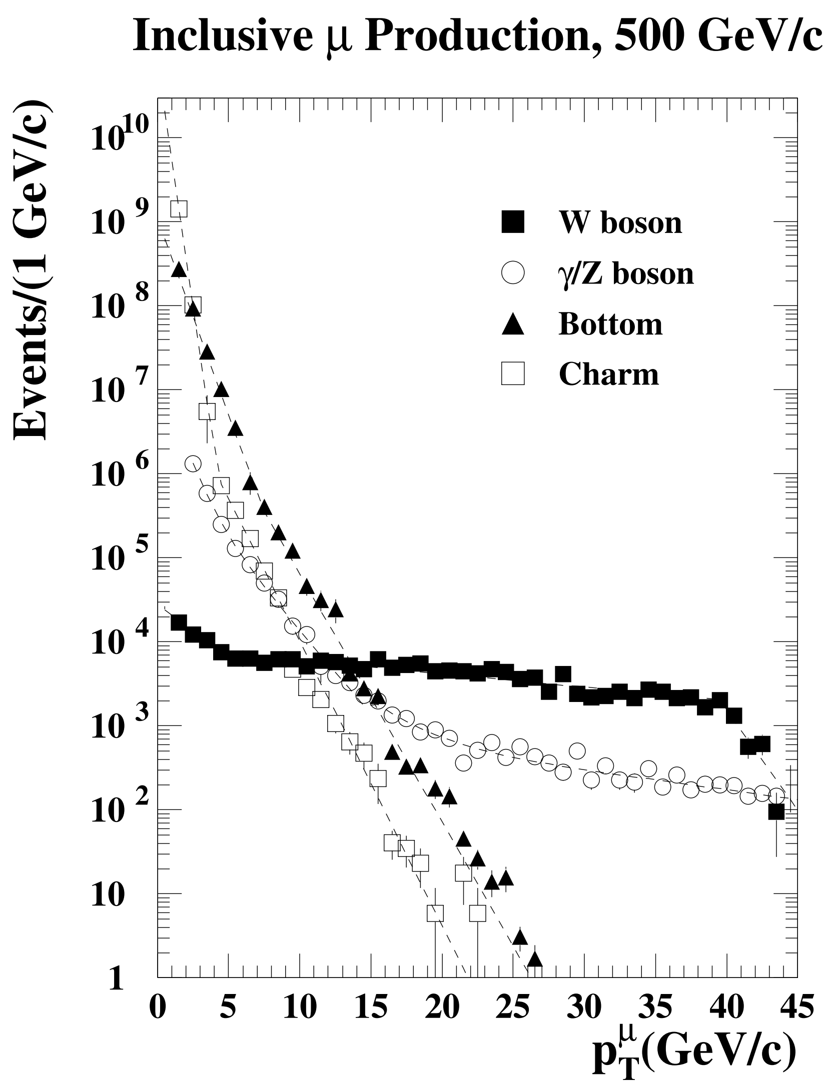
High p_T Single Muons

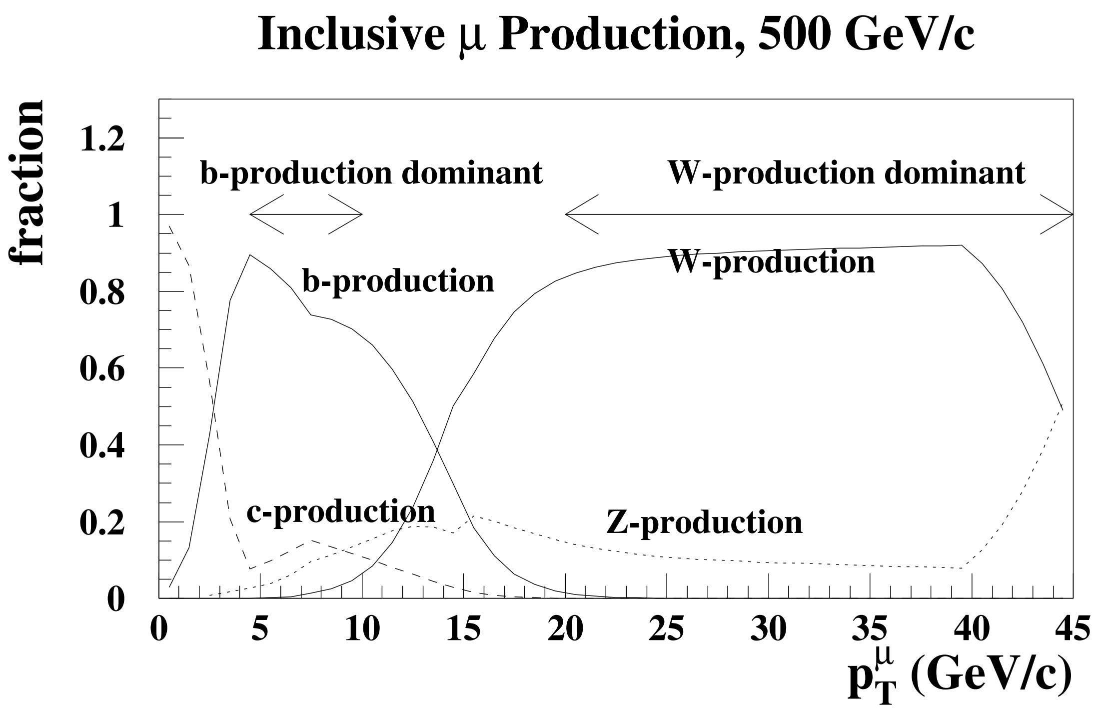


p_T	charm	beauty
> 2	37300	32500
> 4	700	2370
> 6	21	222

- Gluon shadowing factor

- Year-1 luminosity sufficient


Inclusive μ Production, 500 GeV/c
Events/(1 GeV/c)
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
10^{2}
10
1
0
5
10
15
20
25
30
35
40
45
p_T^{μ}(GeV/c)
W boson
γ/Z boson
Bottom
Charm


Inclusive μ Production, 500 GeV/c
fraction
1.2
1
0.8
0.6
0.4
0.2
0
b-production dominant
W-production dominant
b-production
W-production
c-production
Z-production
0
5
10
15
20
25
30
35
40
45
p_T^{μ} (GeV/c)

Construction Highlights

- Assembly factories ramping up at BNL.

- Install first muon identifier panel this January!

- Install last panel by 9/30/98.

- Ready to take data in summer 1999.

Conclusions

- Important physics goals

- Expected performance should enable PHENIX to address the heavy ion and spin physics goals

- Construction project is underway

- Ready to take data in summer 1999