PHENIX Overview

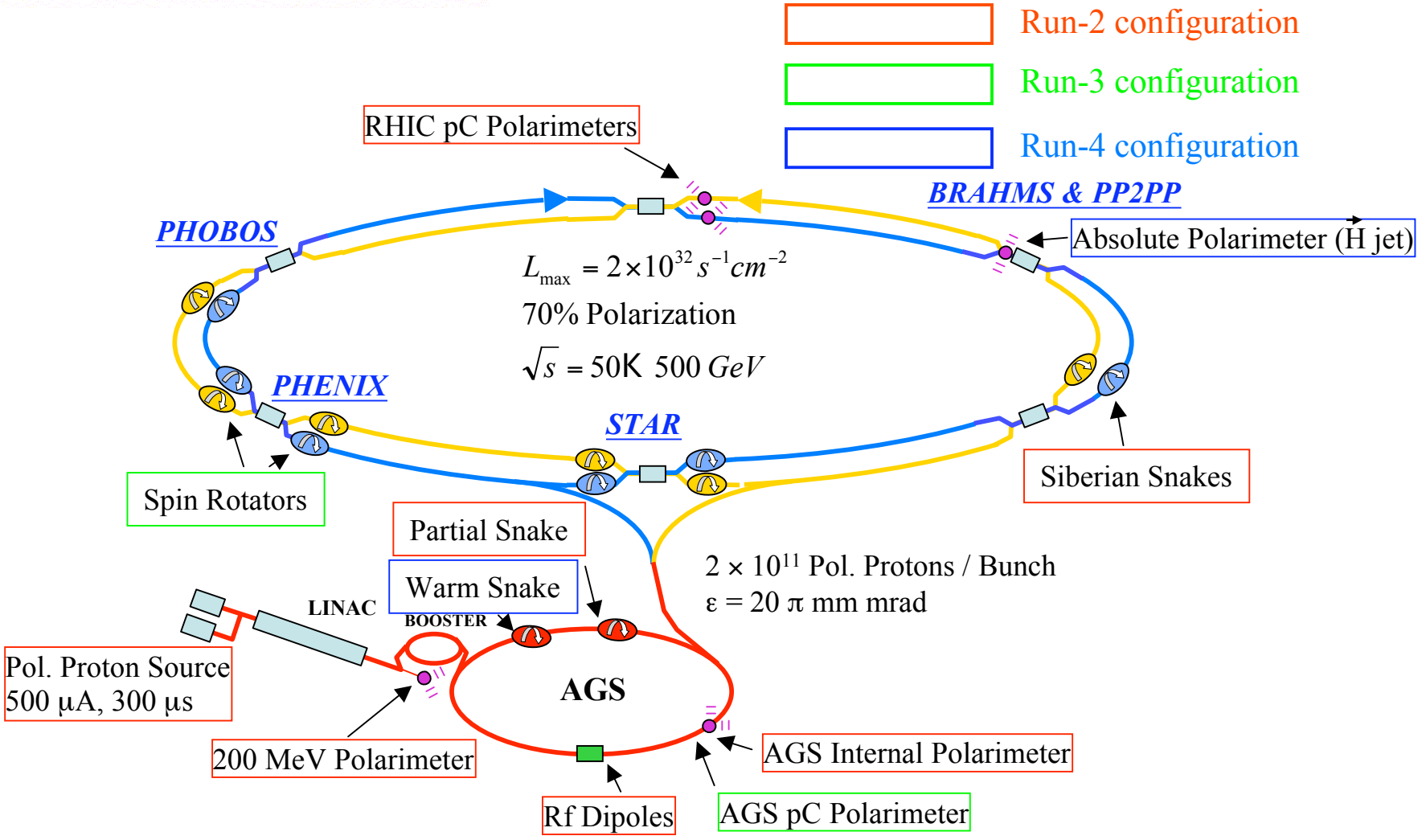
Doug Fields

UNM/RBRC

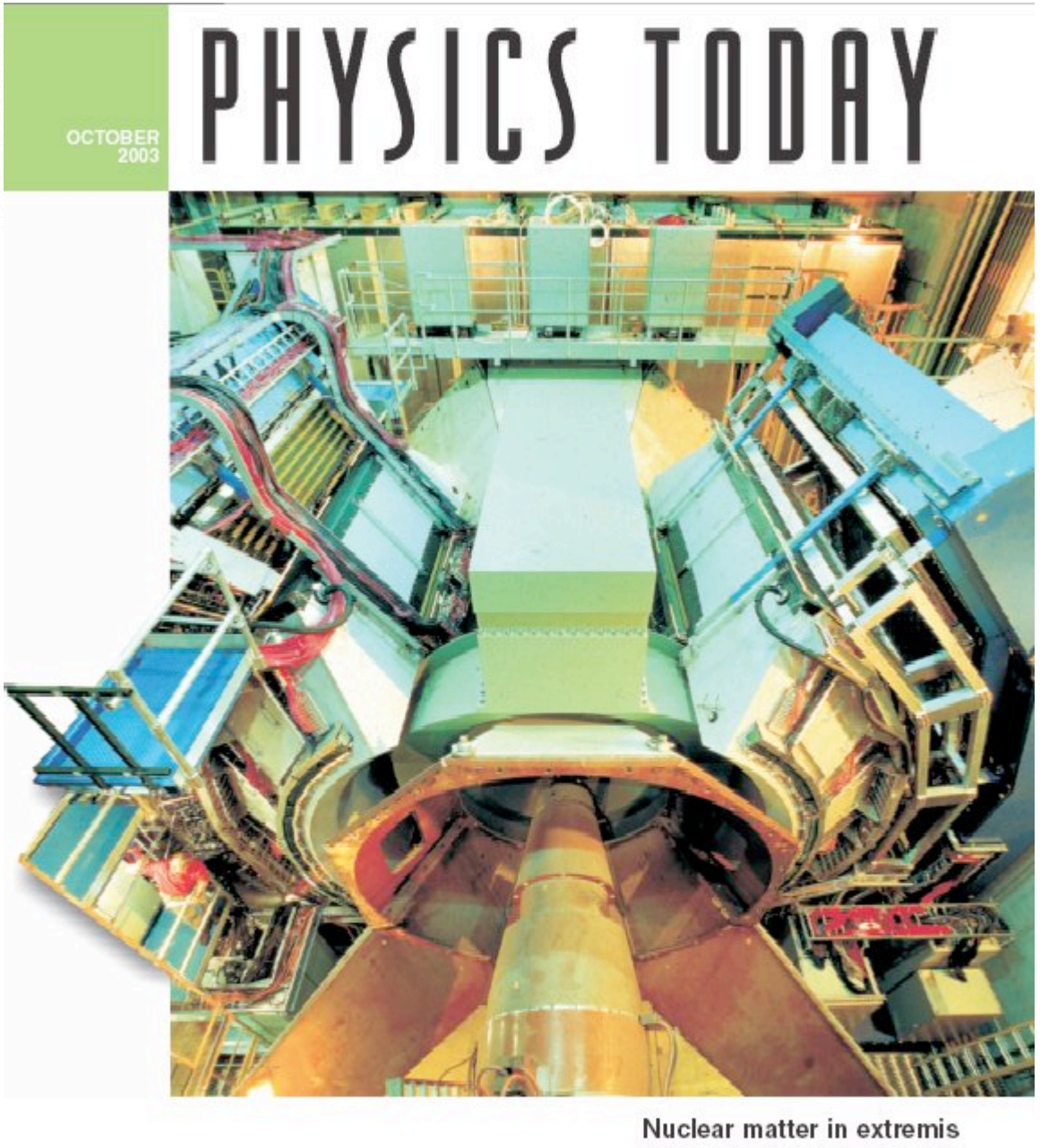
Abhay Deshpande

SUNY-SB/RBRC

RHIC Spin


Run-2 configuration
Run-3 configuration
Run-4 configuration
RHIC pC Polarimeters
BRAHMS & PP2PP
Absolute Polarimeter (H jet)
PHOBOS
$L_{max} = 2 \times 10^{32}\, s^{-1} cm^{-2}$
70% Polarization
$\sqrt{s}$ = 50K 500 GeV
PHENIX
STAR
Spin Rotators
Siberian Snakes
Partial Snake
Warm Snake
2 × 10^11 Pol. Protons / Bunch
ε = 20 π mm mrad
LINAC
BOOSTER
Pol. Proton Source
500 μA, 300 μs
AGS
200 MeV Polarimeter
AGS Internal Polarimeter
Rf Dipoles
AGS pC Polarimeter

PHENIX



PHENIX

12 Countries; 57 Institutions; 460 Participants*

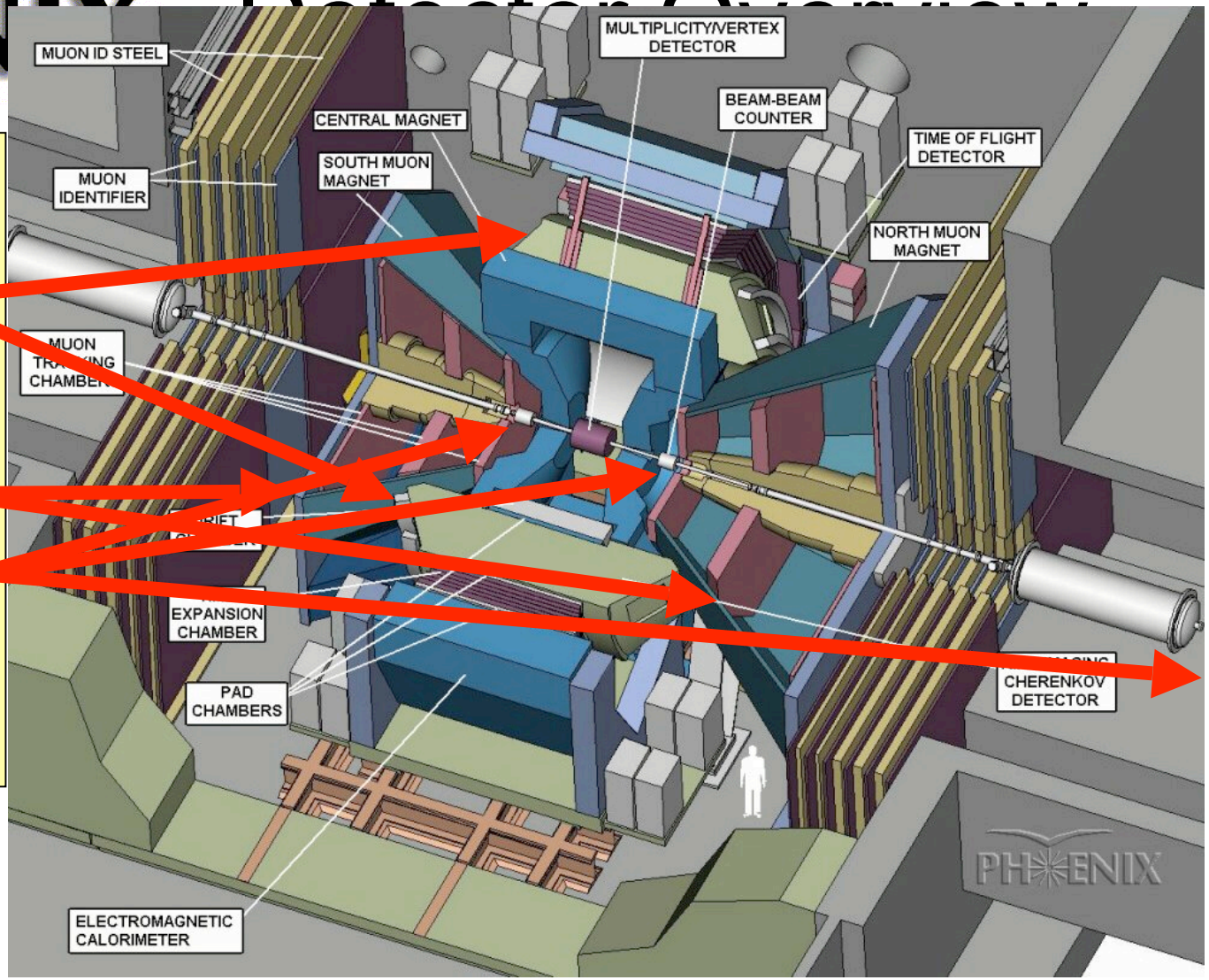
Brazil	University of São Paulo, São Paulo
China	Academia Sinica, Taipei, Taiwan
	China Institute of Atomic Energy, Beijing
	Peking University, Beijing
France	LPC, University de Clermont-Ferrand, Clermont-Ferrand
	Dapnia, CEA Saclay, Gif-sur-Yvette
	IPN-Orsay, Universite Paris Sud, CNRS-IN2P3, Orsay
	LLR, Ecòle Polytechnique, CNRS-IN2P3, Palaiseau
	SUBATECH, Ecòle des Mines at Nantes, Nantes
Germany	University of Münster, Münster
Hungary	Central Research Institute for Physics (KFKI), Budapest
	Debrecen University, Debrecen
	Eötvös Loránd University (ELTE), Budapest
India	Banaras Hindu University, Banaras
	Bhabha Atomic Research Centre, Bombay
Israel	Weizmann Institute, Rehovot
Japan	Center for Nuclear Study, University of Tokyo, Tokyo
	Hiroshima University, Higashi-Hiroshima
	KEK, Institute for High Energy Physics, Tsukuba
	Kyoto University, Kyoto
	Nagasaki Institute of Applied Science, Nagasaki
	RIKEN, Institute for Physical and Chemical Research, Wako
	RIKEN-BNL Research Center, Upton, NY
	University of Tokyo, Bunkyo-ku, Tokyo
	Tokyo Institute of Technology, Tokyo
	University of Tsukuba, Tsukuba
	Waseda University, Tokyo
S. Korea	Cyclotron Application Laboratory, KAERI, Seoul
	Kangnung National University, Kangnung
	Korea University, Seoul
	Myong Ji University, Yongin City
	System Electronics Laboratory, Seoul Nat. University, Seoul
	Yonsei University, Seoul
Russia	Institute of High Energy Physics, Protovino
	Joint Institute for Nuclear Research, Dubna
	Kurchatov Institute, Moscow
	PNPI, St. Petersburg Nuclear Physics Institute, St. Petersburg
	St. Petersburg State Technical University, St. Petersburg
Sweden	Lund University, Lund
USA	Abilene Christian University, Abilene, TX
	Brookhaven National Laboratory, Upton, NY
	University of California - Riverside, Riverside, CA
	University of Colorado, Boulder, CO
	Columbia University, Nevis Laboratories, Irvington, NY
	Florida State University, Tallahassee, FL
	Georgia State University, Atlanta, GA
	University of Illinois Urbana Champaign, Urbana-Champaign, IL
	Iowa State University and Ames Laboratory, Ames, IA
	Los Alamos National Laboratory, Los Alamos, NM
	Lawrence Livermore National Laboratory, Livermore, CA
	University of New Mexico, Albuquerque, NM
	New Mexico State University, Las Cruces, NM
	Dept. of Chemistry, Stony Brook Univ., Stony Brook, NY
	Dept. Phys. and Astronomy, Stony Brook Univ., Stony Brook, NY
	Oak Ridge National Laboratory, Oak Ridge, TN
	University of Tennessee, Knoxville, TN
	Vanderbilt University, Nashville, TN

*as of July 2002

PHENIX Detector Overview

Multi-purpose experiment:

- **Central Spectrometer**
  - **Electrons**
  - **Photons**
  - **Hadrons**
- **Forward Spectrometer**
  - **Muons**
- **Very Forward Detectors**
  - **Triggering**
  - **Centrality**
  - **Polarimetry**

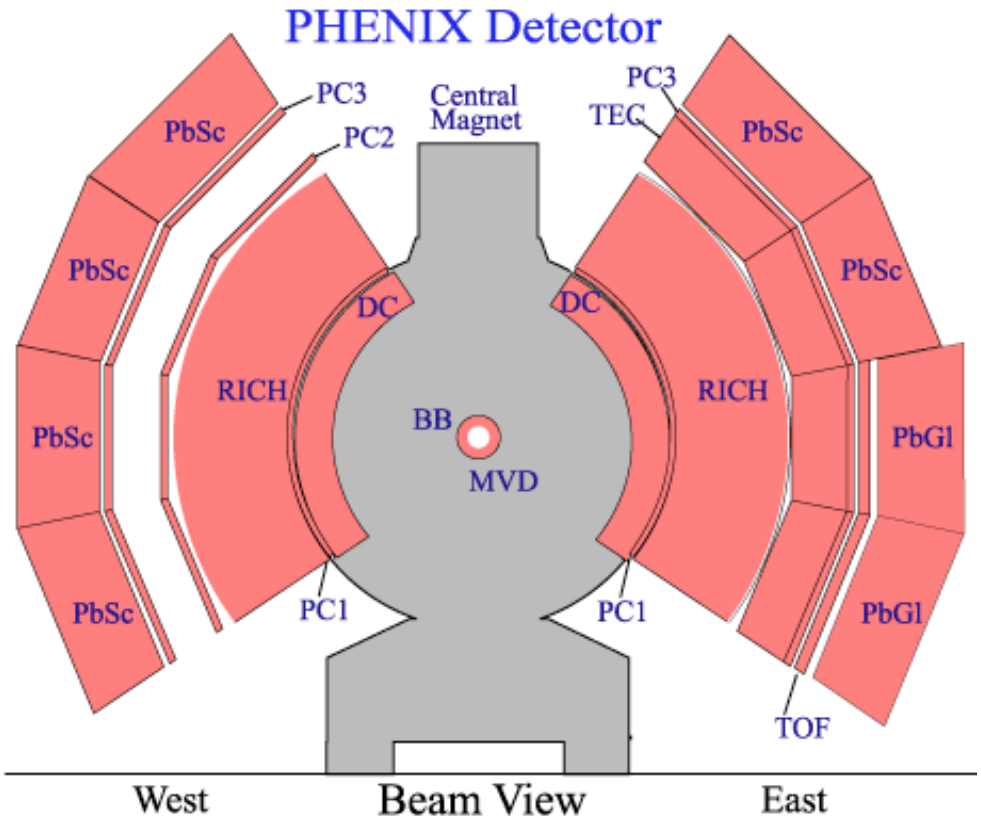


Spin Physics Overview

• Physics – Signal	• PHENIX can see
• Single transverse-spin asymmetry – neutron – π^0 – charged hadron – single muon from π decay – transversity	• – neutrons in ZDC/SMD – $\gamma\gamma$ in EMCal – charged hadron (BBC / Central) – single muons in Muon Arms – A_T, A_{TT} Drell-Yan di-muons
• Gluon polarization – jet production/direct photons – open heavy flavor – J/ψ	• – leading high p_t in Central Arms – e, μ, eμ, $\mu\mu$, and D$\rightarrow\pi$K – ee, $\mu\mu$ in Central and Muon Arms
• Flavor decomposed quark polarization – $W^{\pm}$	• – high p_T $\mu^{\pm}$ in Muon Arms

Detector Overview

- West Arm
- tracking:
  - DC,PC1, PC2, PC3
- electron ID:
  - RICH,
  - EMCal
- photons:
  - EMCal



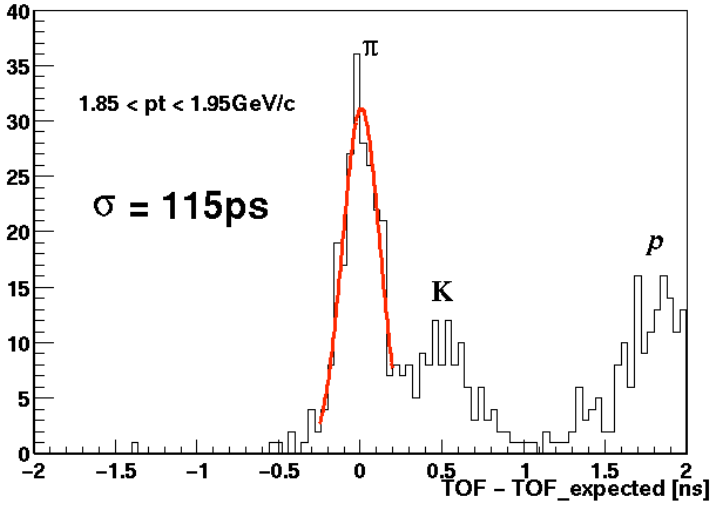
- East Arm
- tracking:
  - DC, PC1, TEC, PC3
- electron & hadron ID:
  - RICH,TEC/ TRD,
  - TOF, EMCal
- photons:
  - EMCal

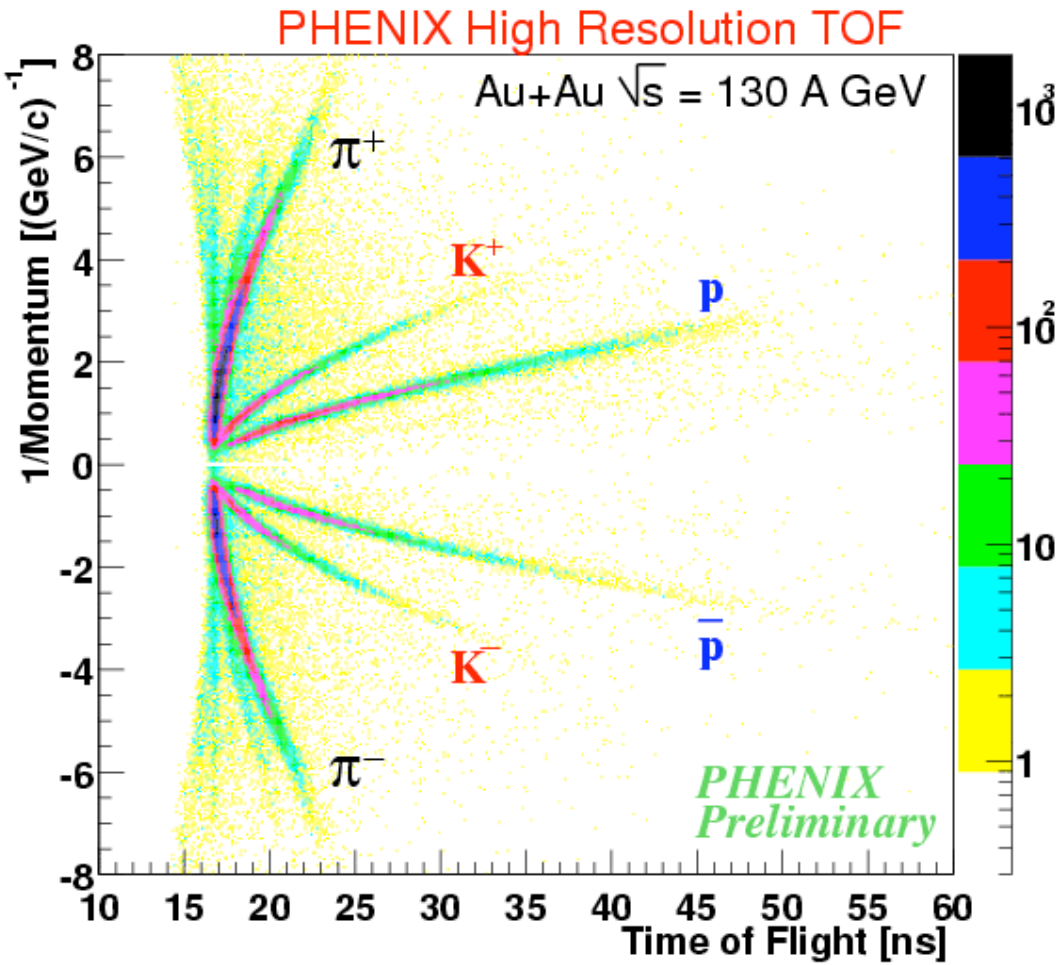
Fingerprinting Particles

Combined

- Tracking
- Beam-Beam Counter
- Time-of-Flight array

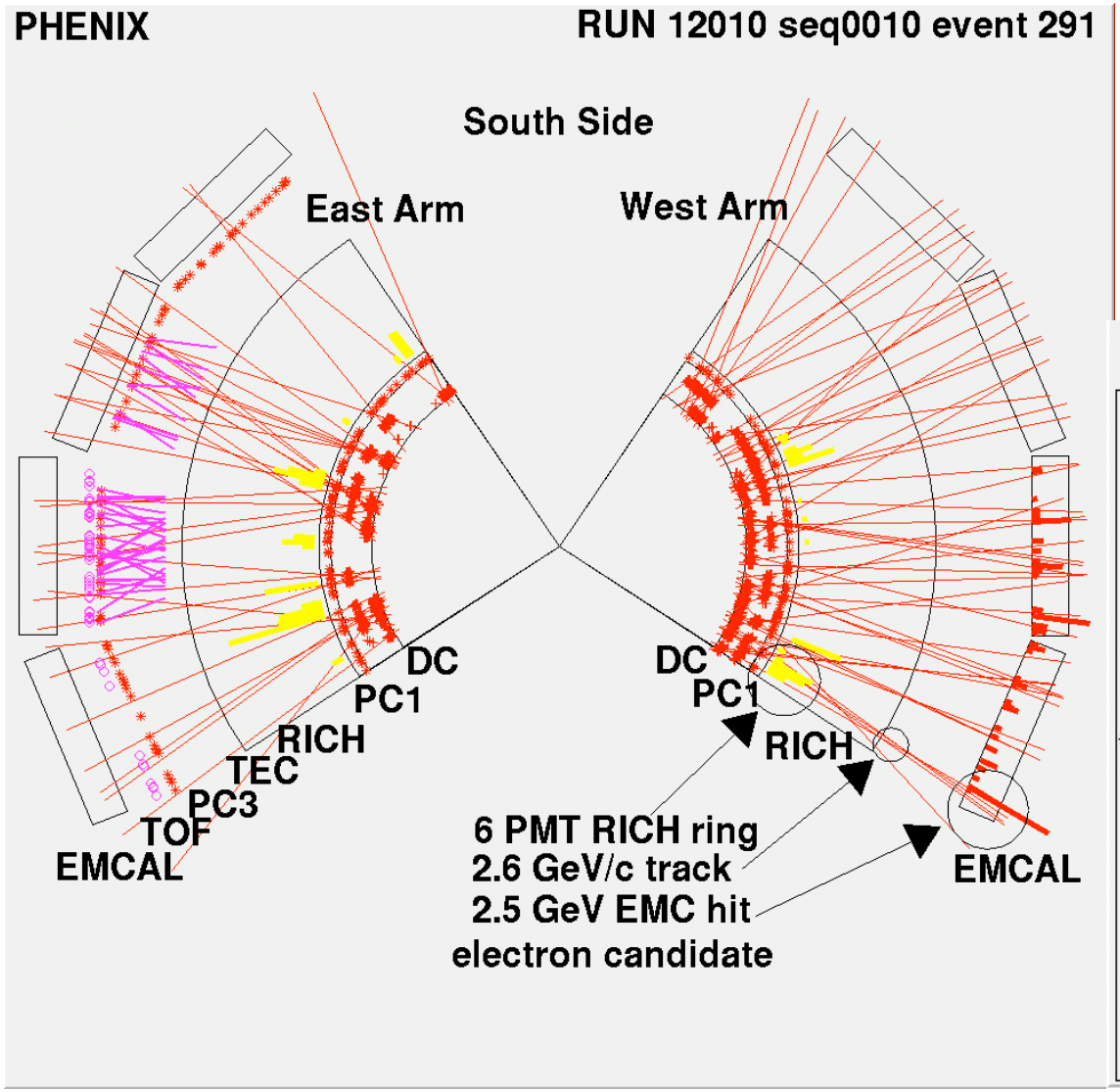
provides excellent hadron identification over broad momentum

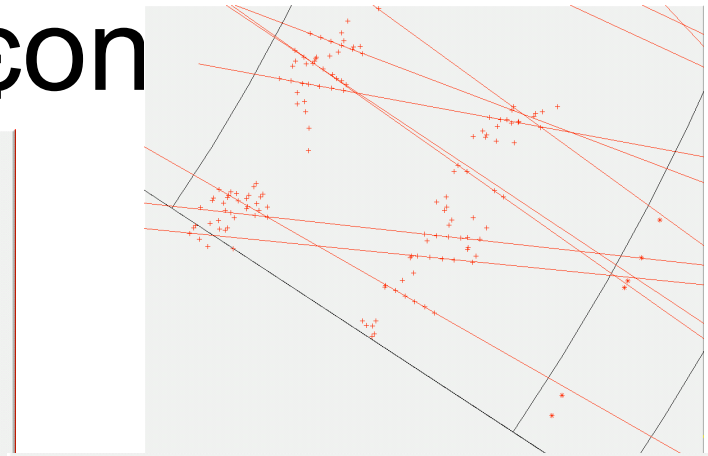


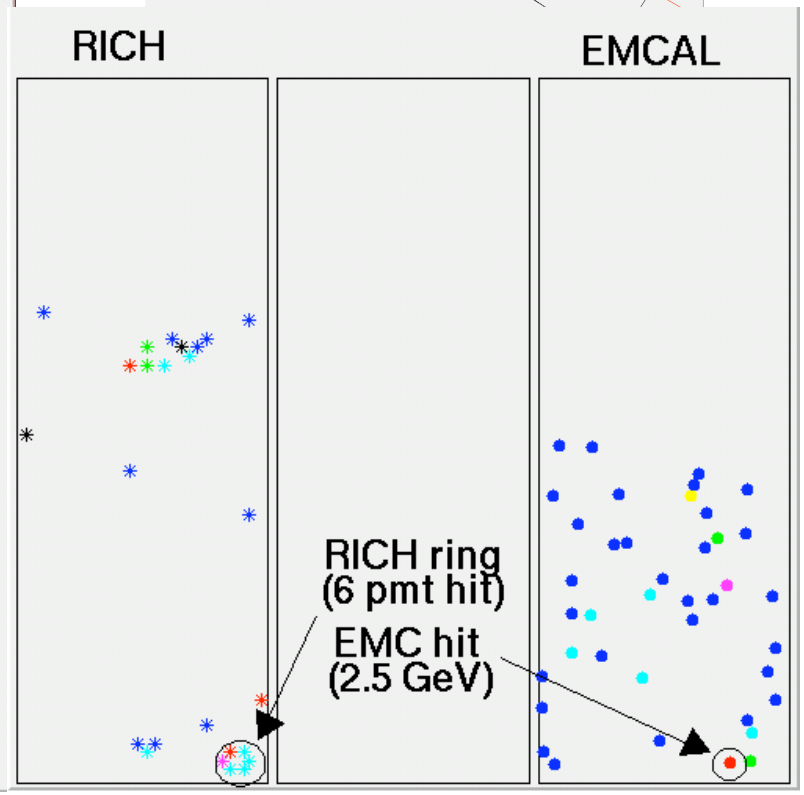


All sub-systems in con

High p_T electrons in PHENIX:

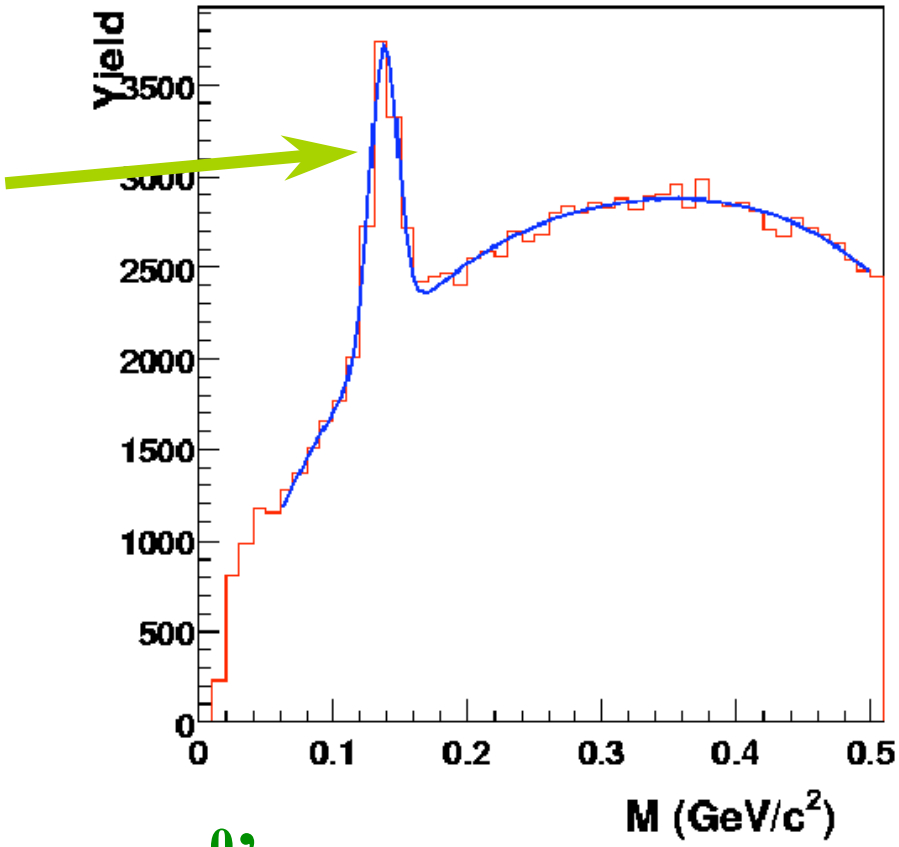






Energy Measurements

- Measured with "electromagnetic" calorimeter
  - Superb E-M calorimeter
  - With a well-understood response to soft charged hadrons



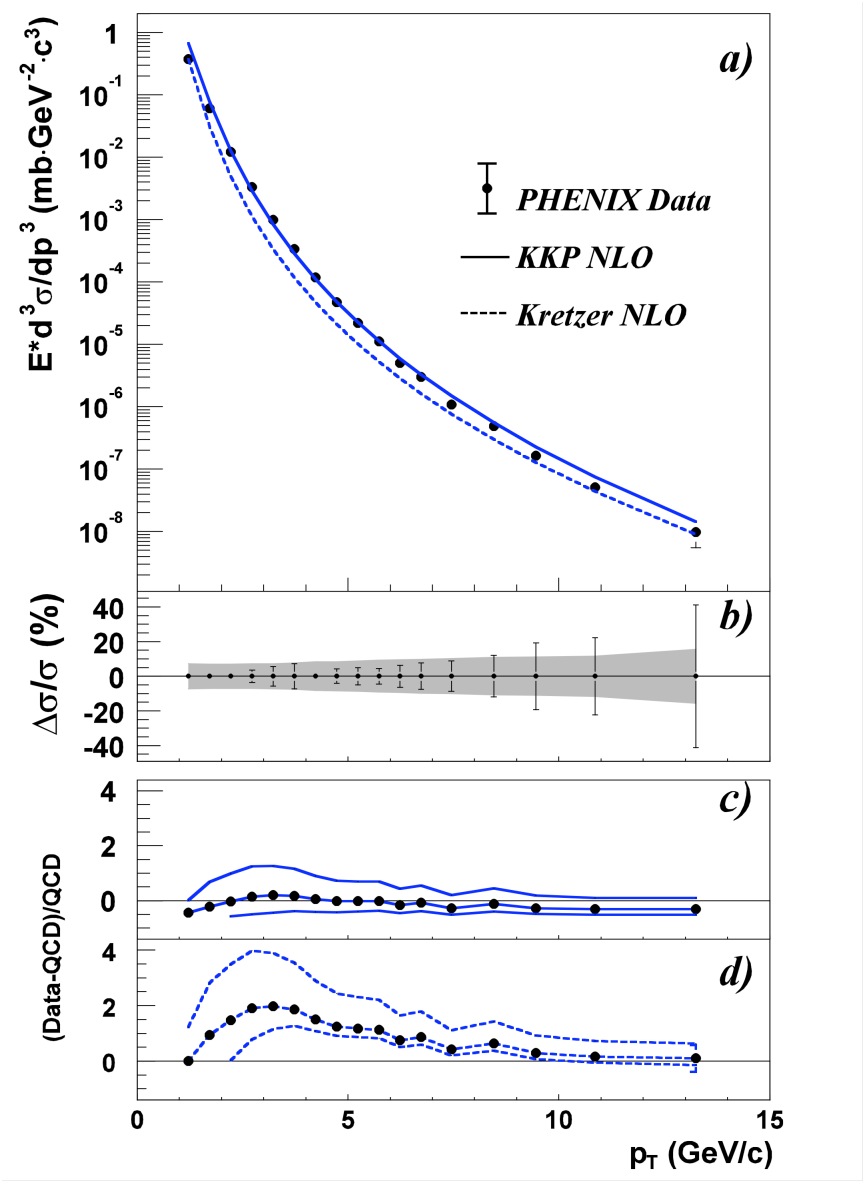
π^0's

p_T>2 GeV

Gluon Polarization

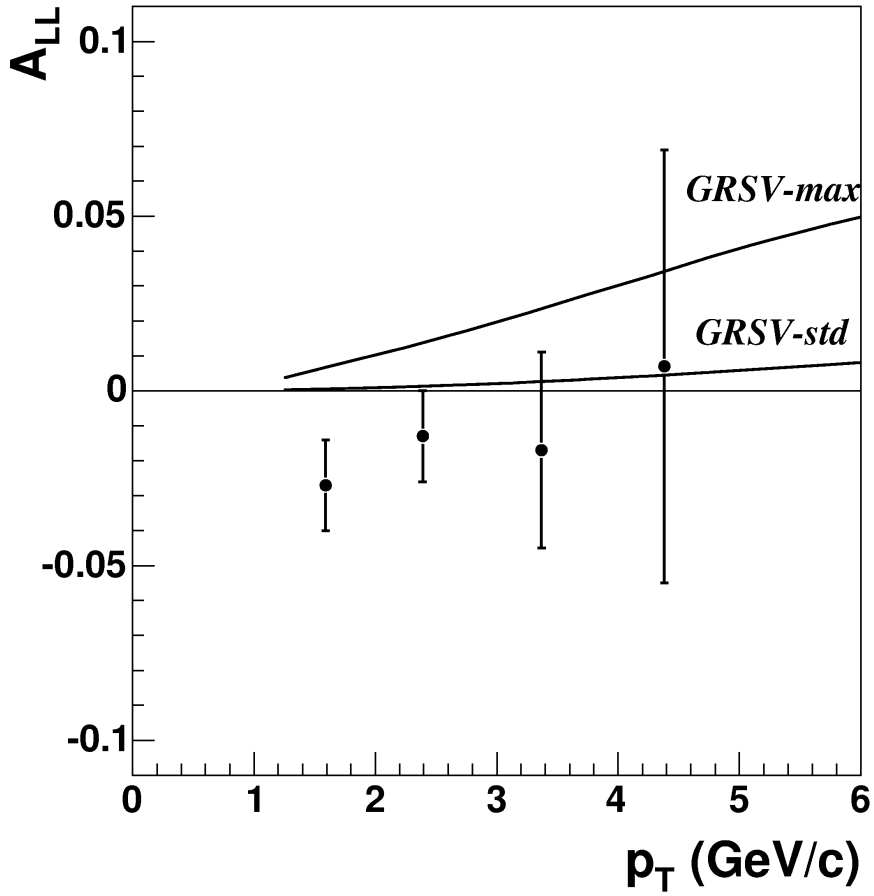
- Next step: Measure cross-section as a test for perturbative QCD at $\sqrt{s} = 200GeV$.
- In Run-02, precise measure of π^0 cross-section.
- Agreement with pQCD indicates we can extend A_{LL} analysis to lower p_T, important for increasing statistical precision with Run-3 data set.

Phys. Rev. Lett. 91, 241803 (2003)



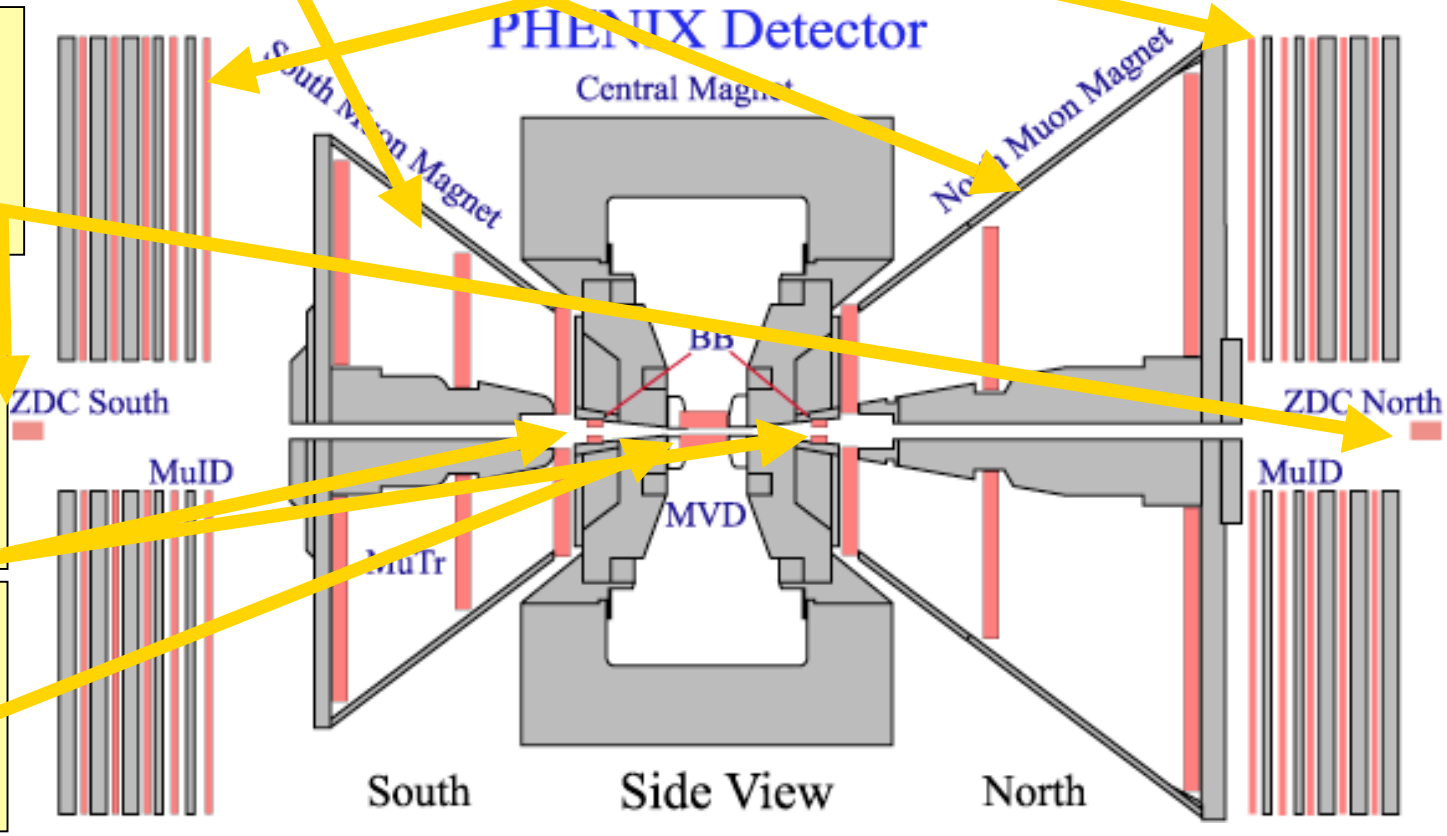
Gluon Polarization

Submitted to Phys. Rev. Lett.



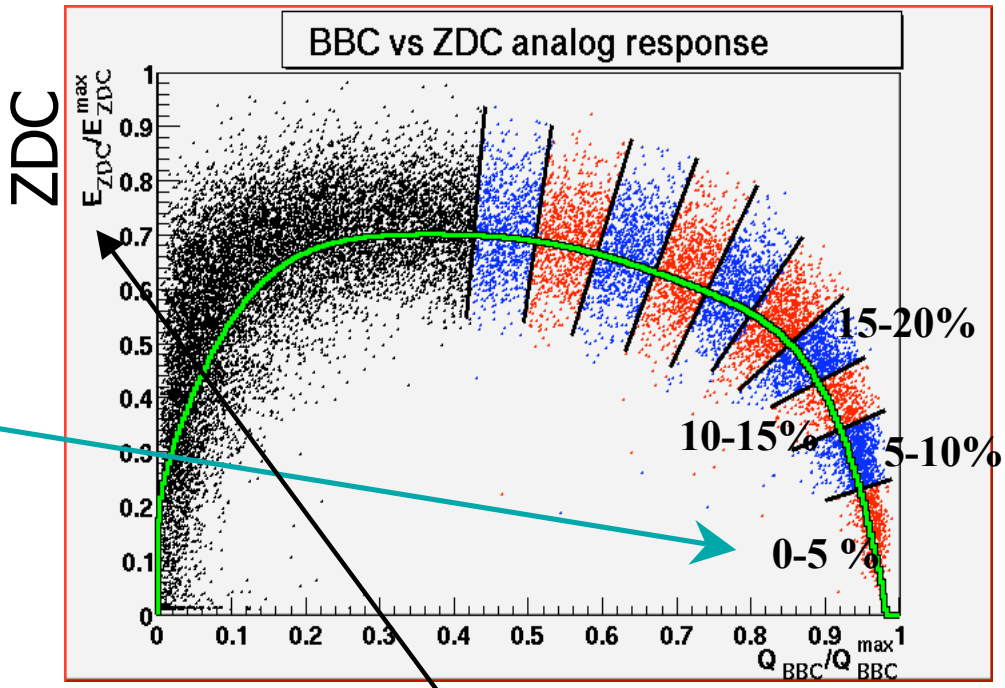
Detector Overview

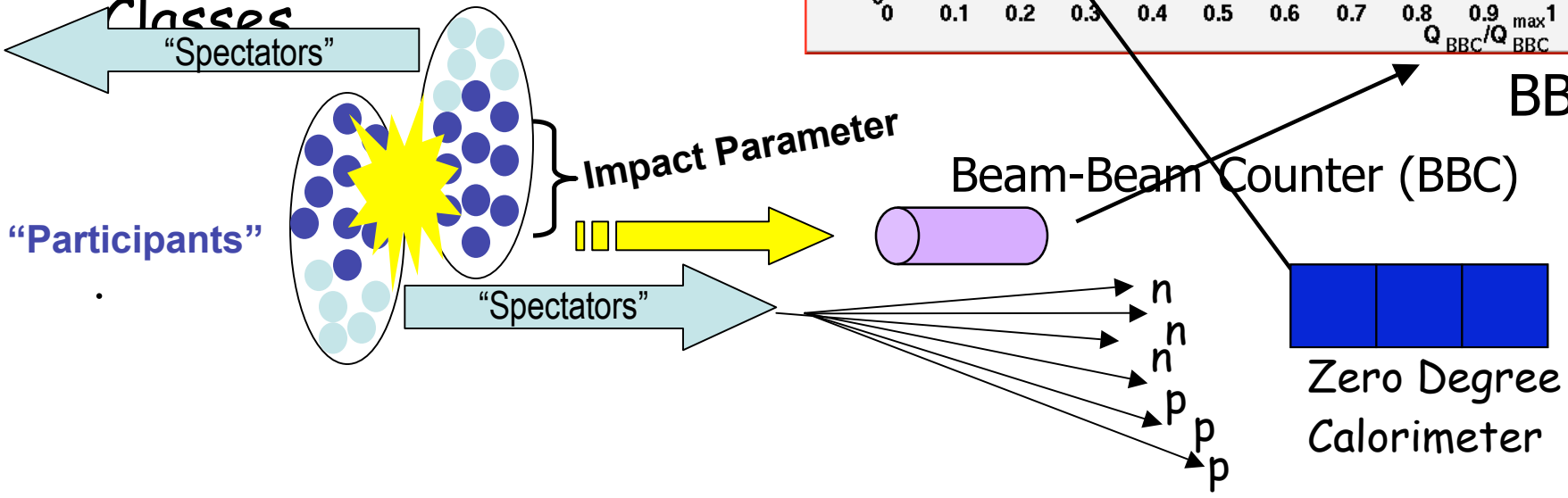
- **Muon Tracking**
  - Radial field magnets
  - 3 stations of cathode strip chambers
  - 100μm resolution/plane = 60μm resolution/station
  - J/Ψ mass resolution = 160MeV
- **Zero-Degree Calorimeters**
  - hadron calorimeter
  - neutron sensitive
- **Beam-Beam Counters**
  - QuartzCherenkov radiators
  - $3.0 < |\eta| < 3.9$
- **Multiplicity-Vertex Detector**
  - Silicon strip
- **Muon Identification**
  - 5 layers of Irocci tubes
  - x-y planes between steel absorber
  - π/μ rejection ~ 10^{-4}



Measuring Initial Collision Geometry

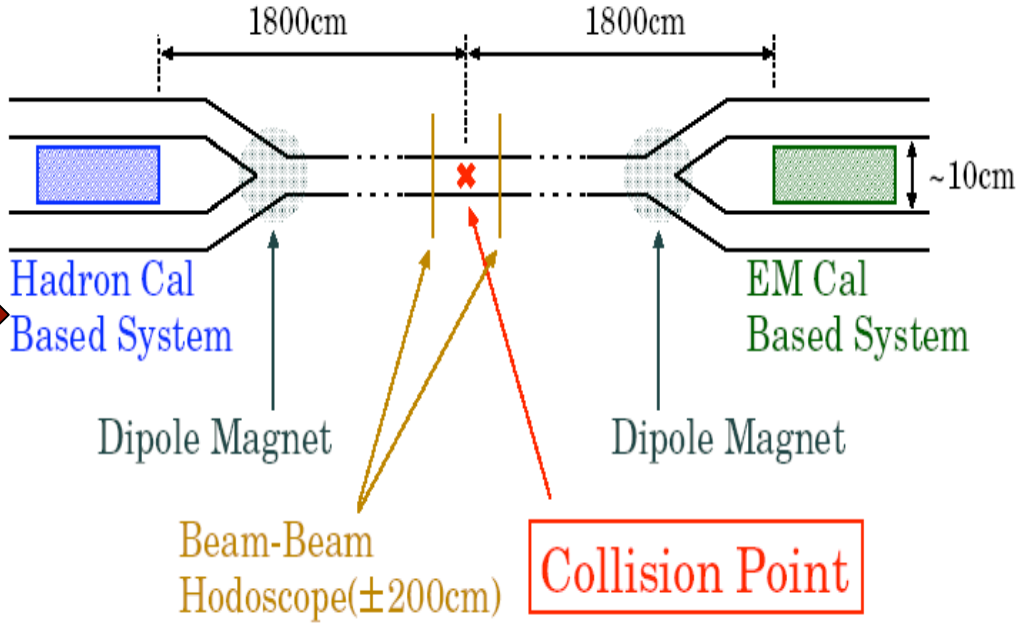
- Zero Degree Calorimeters (ZDC)
  - Sensitive to spectator neutrons
  - common to all four RHIC experiments
- Using a combination of the ZDC's and BBC's we can define Centrality Classes

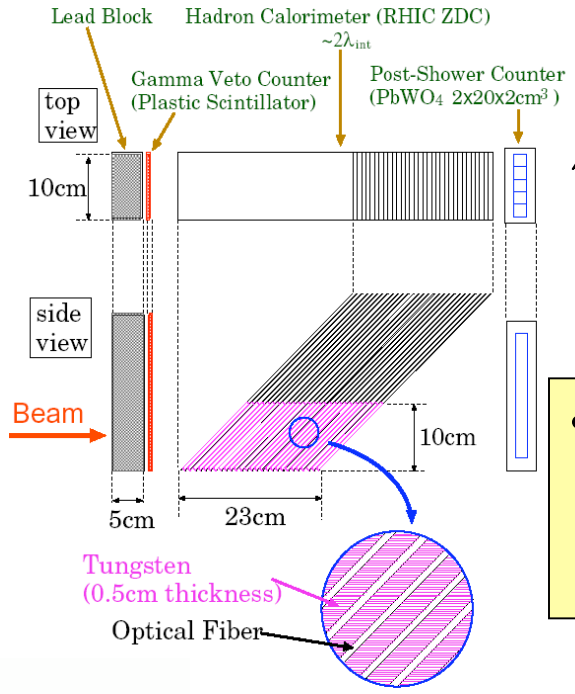




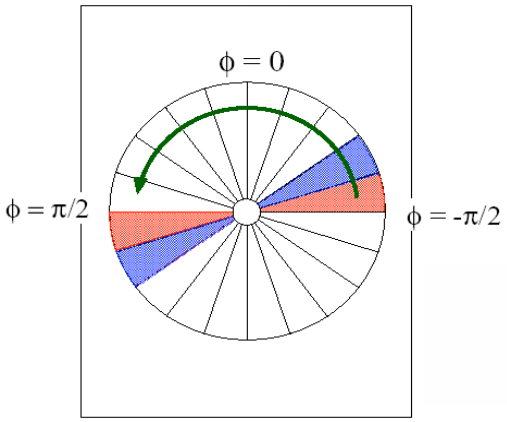
Transverse Spin

- Neutron asymmetry observed in IP12 while testing a local polarimeter designed to look for π^0, γ asymmetries:





- "Left-Right" asymmetry measured for different slices in phi:

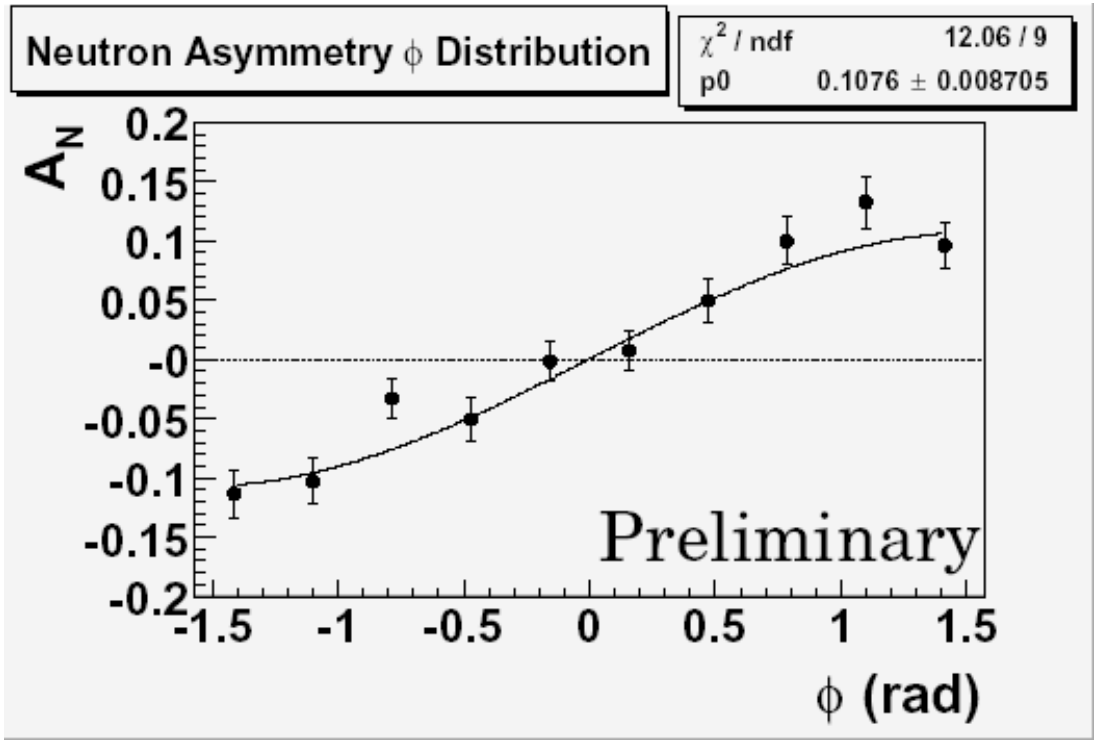


Phi Asymmetry

- Successful measurement of forward neutron asymmetry.
- Understood (?) in terms of single pion exchange.
- Large asymmetry gives good figure of merit for local (PHENIX) polarimetry.

$$A_N = \frac{1}{P_B} \frac{\sqrt{N_{\uparrow L} N_{\downarrow R}} - \sqrt{N_{\uparrow R} N_{\downarrow L}}}{\sqrt{N_{\uparrow L} N_{\downarrow R}} + \sqrt{N_{\uparrow R} N_{\downarrow L}}}$$

calculated using square root formula

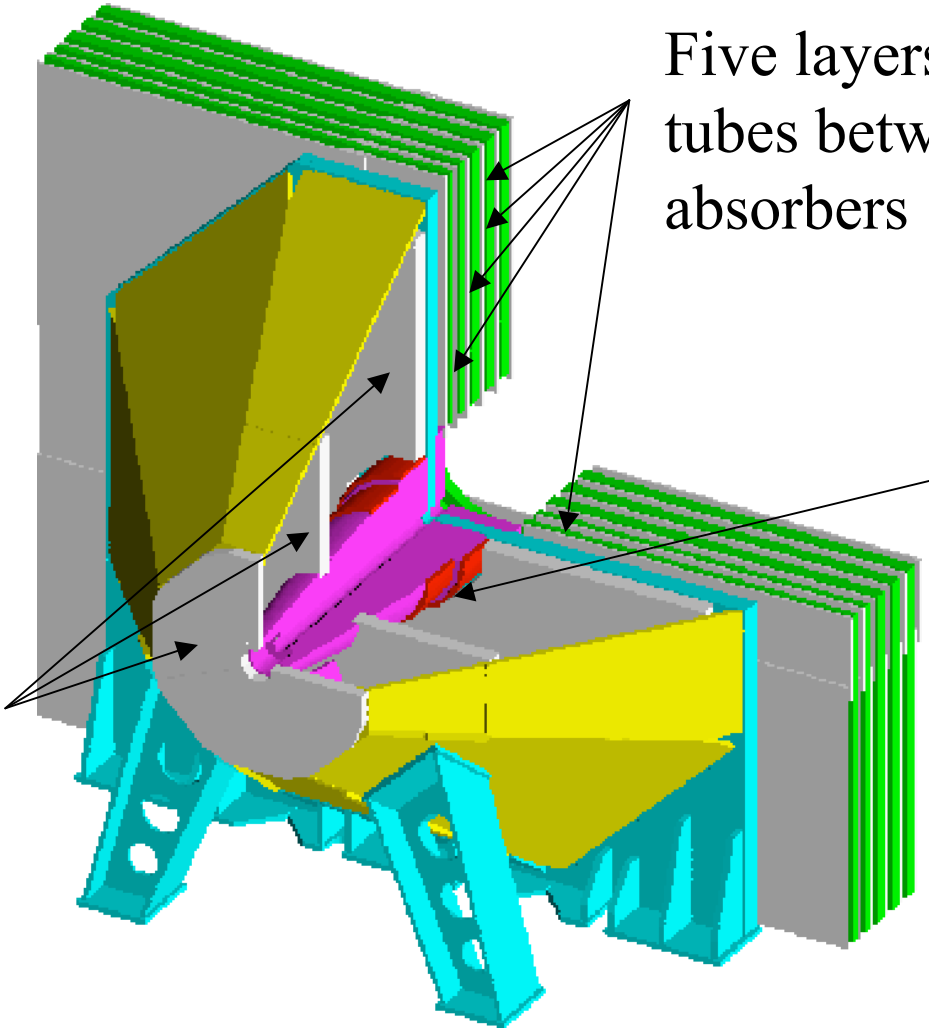


Y. Fukao et al., "Proceedings of the 15th International Spin Physics Symposium (SPIN2002)

Run-02, Run-03 in PHENIX

Muon Arms

Integrated spectrometer to measure a wide range of muon energies



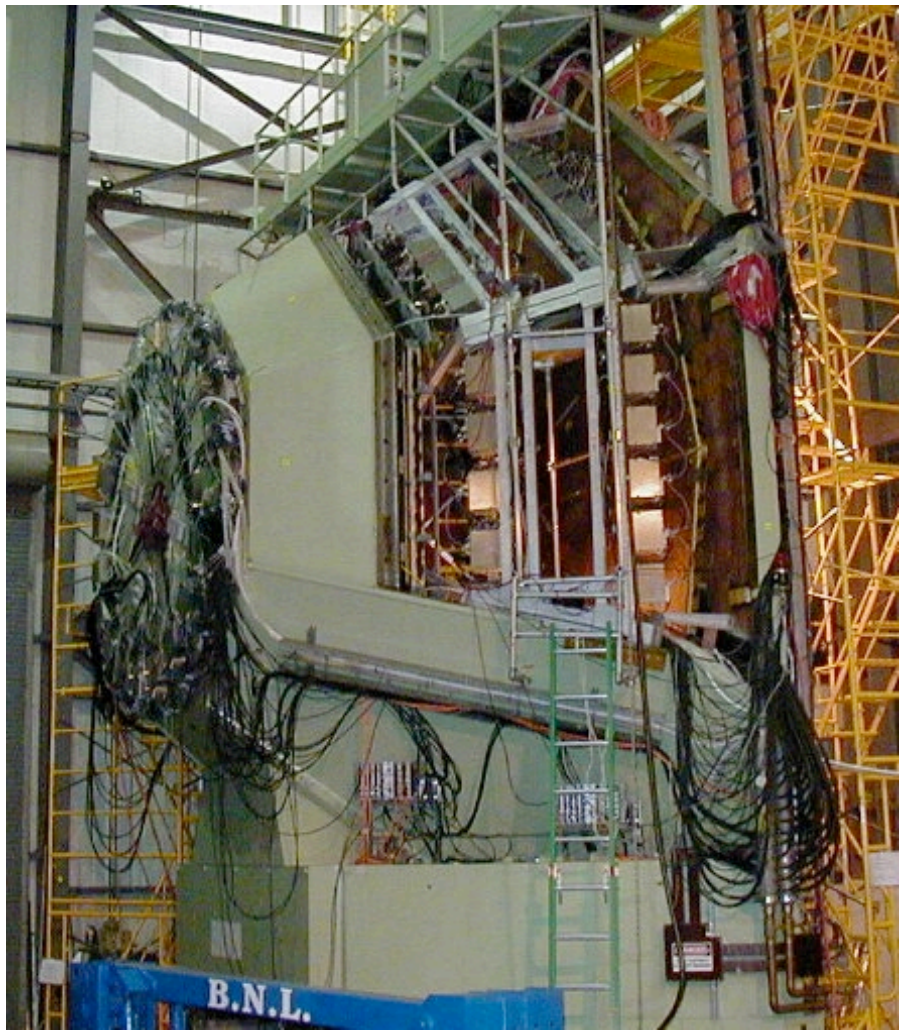
Five layers of Iarocci tubes between steel absorbers

Radial field magnet

Three layers of Cathode Strip Chambers for stations 1 & 2, two layers for station 3.

South Muon Arm

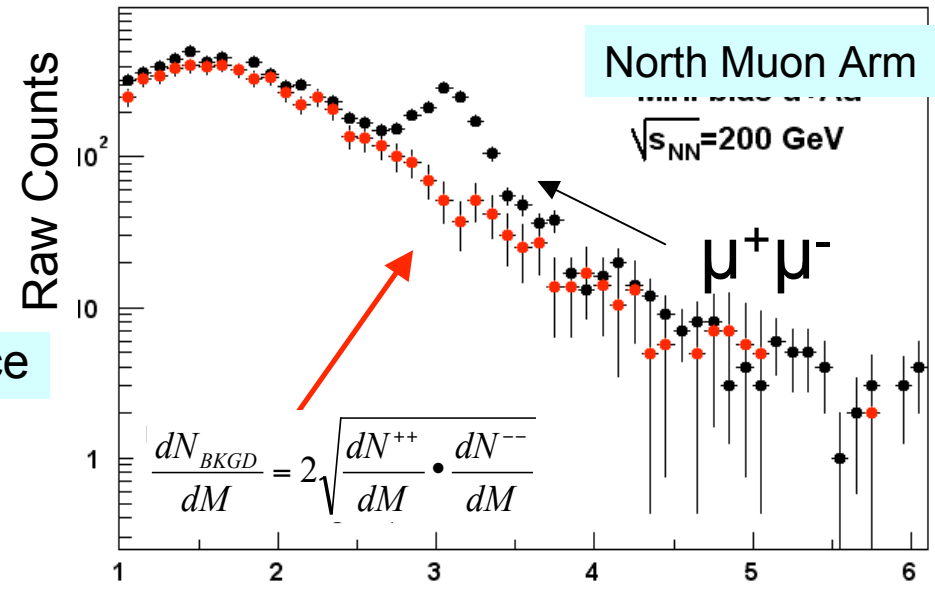
- 3 tracking stations
  - Cathode strip R/O
  - 100μm res./plane
  - 60 μm res./station
- Forward coverage
  - 1.2< |y| <2.3
  - $-\pi < \phi < \pi$
- Mass resolution
  - $\Delta M(J/\psi) = 105$MeV
  - $\Delta M(\Upsilon) = 180$MeV

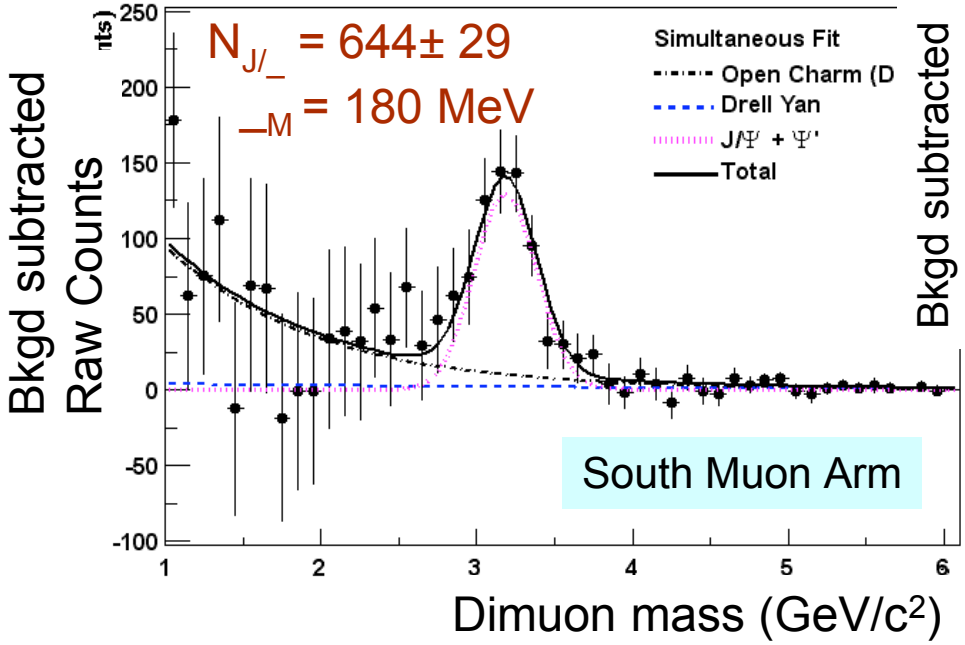


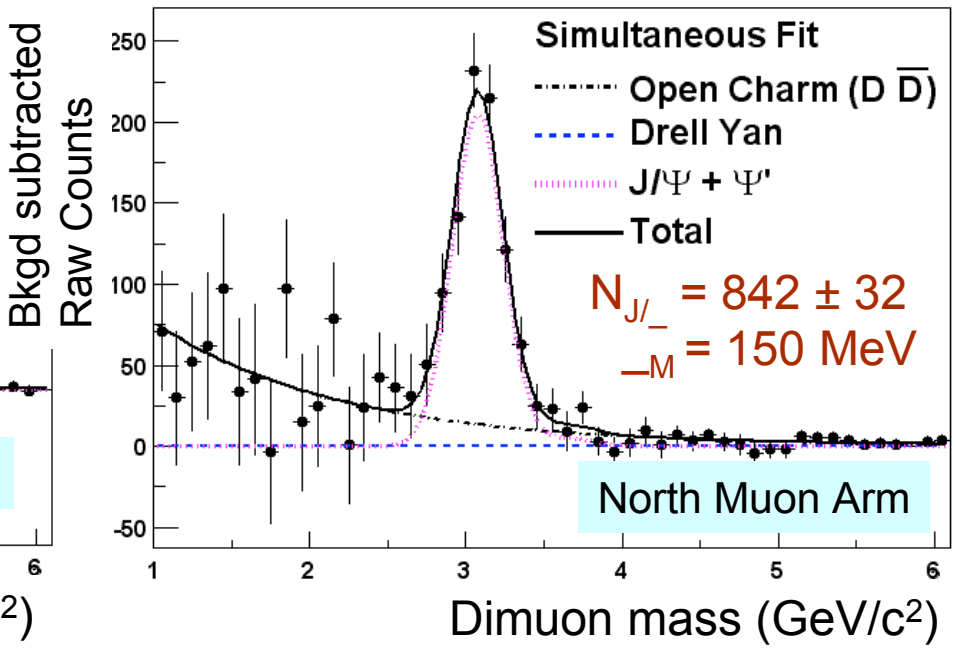
PHENIX J/_'s in d-Au collisions!

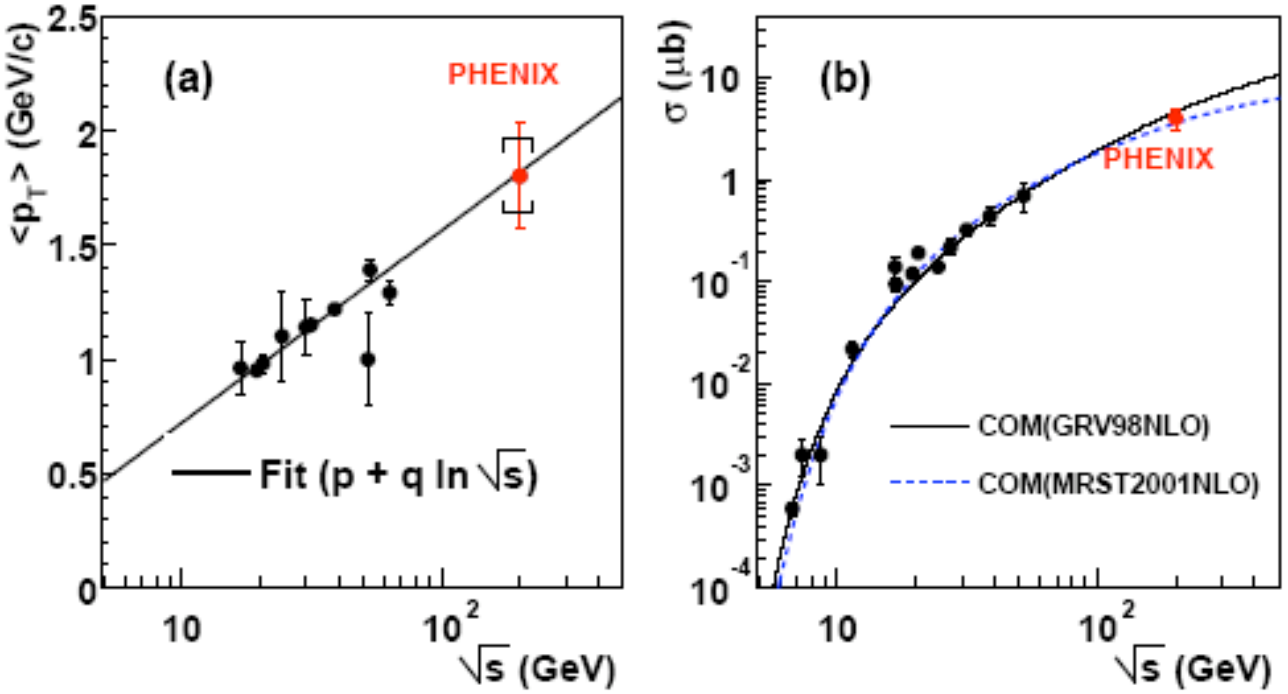
Not corrected for efficiency and acceptance

Signal to background and fitting of all contributions are currently under study









- Phenomenological fit for average p_T; p = 0.531, q= 0.188
- Cross-section well described by Color Evaporation Model.