First Measurement of J/ψ Anisotropy by PHENIX Experiment at RHIC

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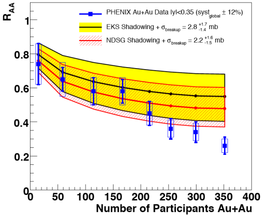
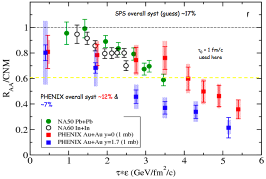
J/ψ Production Results in Au + Au at $\sqrt{s_{NN}} = 200$ GeV .

- PHENIX results indicate J/ψ suppression is larger than the current cold nuclear matter extrapolation at central and forward rapidities
- However, the magnitude of this suppression at mid-rapidity is similar to what was observed in lower energy experiments at SPS [Eur. Phys. J.,C39,335]
- Charm coalescence could produce more J/ψs at RHIC than SPS energy



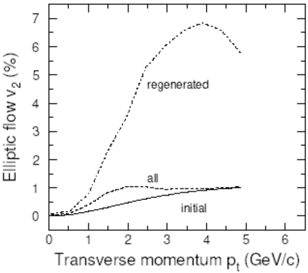
nucl-ex/0711.3917 and Mattews Wysocki talk



Mike Leitch at QM06

J/ψ ANISOTROPY IS SENSITIVE TO CHARM COALESCENCE.

- Non-photonic electron measurements show the presence of considerable flow of charms quarks
- J/ψs formed by coalescence of charm quarks will show similar flow
- Primary pQCD J/ψs carry small v_2 ($\sim 2\%$)
- v_2 measurement can gauge the primary/regenerated J/ψ ratio



v_2 at b=7.8 fm [PRL97,232301].

Some Definitions.

The particle angular distribution ϕ around the reaction plane of the collision Ψ can be described by [PRC70,064905]

$$\frac{dN}{d\left(\phi-\Psi\right)} = \frac{1}{2\pi}\sum_{n=-\infty}^{+\infty} v_n e^{in(\phi-\Psi)} \quad (1)$$

$$\frac{dN}{d\left(\phi-\Psi\right)} = \frac{1}{2\pi}\left(1+2\sum_{n=1}^{+\infty}\left[v_{c,n}cos(n(\phi-\Psi))+v_{s,n}sin(n(\phi-\Psi))\right]\right)$$

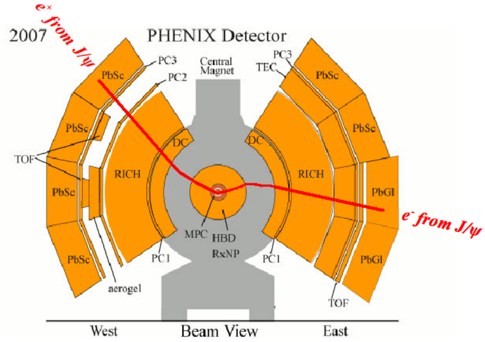
For short lived particles and symmetric colliding systems, $v_{s,n}=0$. Hence, the first asymmetric term is

$$\frac{dN}{d\left(\phi-\Psi\right)} = A(1+2v_2 cos(2(\phi-\Psi))) \quad (2)$$

where $v_2 = \langle cos(2(\phi-\Psi))\rangle$. Experimentally, we measure an inclusive invariant mass spectrum (foreground) that includes the J/ψ signal and background, thus the actual signal can be extract by

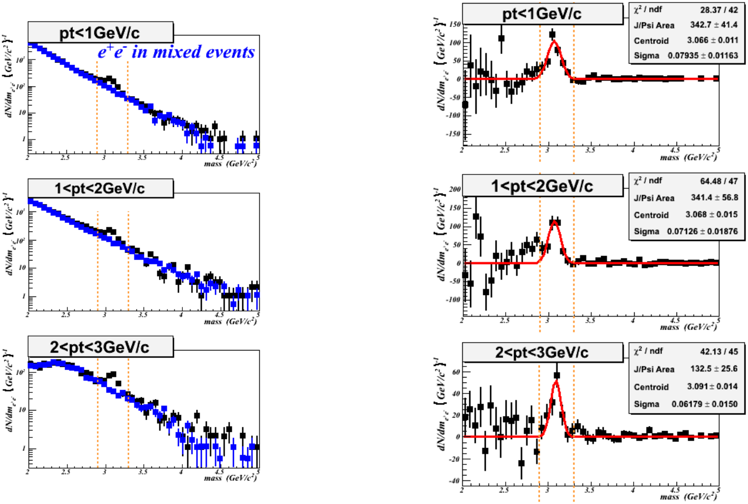
$$v_2^{fg} N^{fg} = v_2^{bg} N^{bg} + v_2^{S} N^{S} \quad (3)$$

DATA SET.



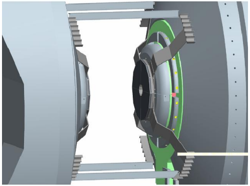
- $2{\times}10^9$ events analyzed at this time (42% of total Run7 data)
- J/ψ are identified by their di-electron decay in PHENIX central arms: $|y| < 0.35, \Delta\phi = 2 \times \pi/2$
- Electron identification performed by Ring Image Cherenkov (RICH) and Electromagnetic Calorimeter (EmCal) detectors

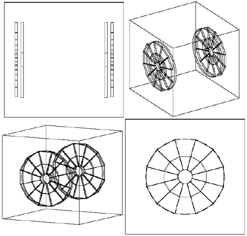
J/ψ Signal in 20<centrality<60%.



887 ± 73 J/ψs in 20-60% centrality events

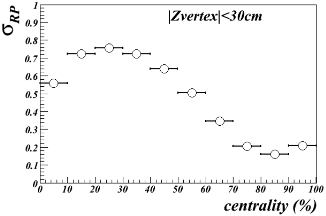
Reaction Plane Detector.





$1.0 < |y| < 2.8$

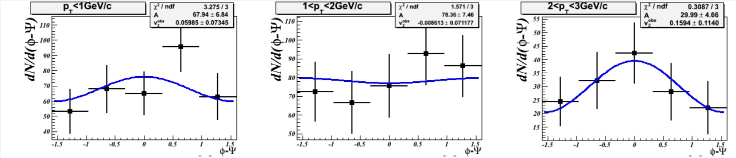
Reaction Plane resolution



The real v_2 is obtained from the observed one v_2^{obs} by $v_2 = v_2^{obs}/\sigma_{RP}$

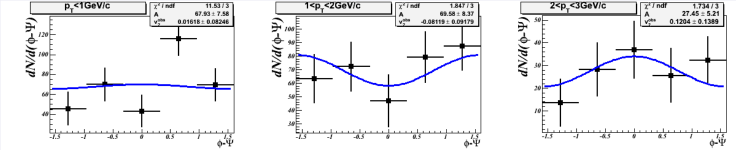
Methods to Remove Background I.

$\phi - \Psi$ mixed event subtraction



The $\phi - \Psi$ distribution in J/ψ invariant mass region is subtracted by the same from e^+e^- pairs in mixed events.

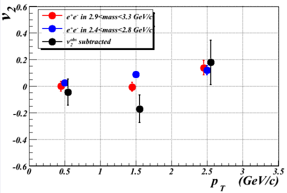
$\phi - \Psi$ like-sign subtraction



Similarly to the previous one but using $e^+e^+ + e^-e^-$ pairs in the same event

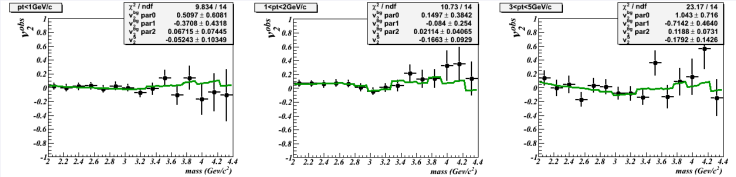
Methods to Remove Background II.

Side Bands



Assuming v_2 constant for e^+e^- pairs with mass around the J/ψ range, we obtain v_2^S in equation (3) using v_2^{bg} from e^+e^- pairs with mass [2.4,2.8] GeV/c^2 .

Invariant Mass Fit

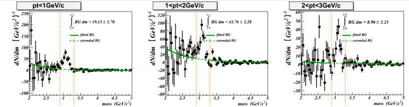


Inherent from (3), the foreground $v_2(M)$ is fitted by $v_2^{fg} = v_2^{bg}(M)\frac{N^{bg}(M)}{N^{fg}(M)} + v_2^S\frac{N^S(M)}{N^{fg}(M)}$ where $v_2^{fg} = a + bM + cM^2$

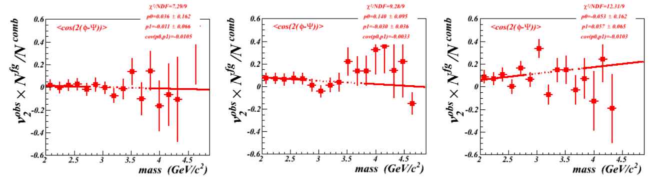
Methods to Remove Background III.

Subtraction of fitted BG. v_2

- we use a more detailed approach for (3): $v_2^{fg}(M)N^{fg}(M) = v_2^{comb}N^{comb} + v_2^{rem}N^{rem} + v_2^{J/\psi}\ N^{J/\psi}$ where the background contains the combinatorial background and remaining contribution (composed by continuum contribution and mixed event normalization residuals)



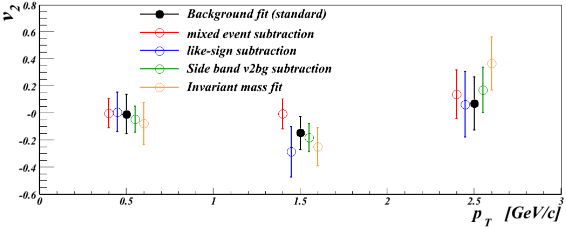
- $v_2^{fg}(M)N^{fg}(M)/N^{comb}(M)$ is fitted by polynomials only out of J/ψ and ψ' mass range.



- v_2^{fg} is subtracted by the fitted function in the J/ψ mass range

This is the standard method chosen for the final points.

Consistency Cross Checks and Systematic Error.

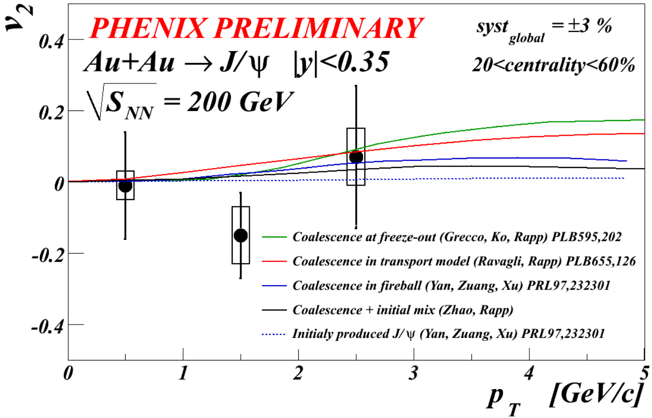


Most of the differences are statistical fluctuations.
Other cross checks were done by variations in:

- electron identification criteria;
- mass ranges in the fits;
- v_2 calculation: fitting $dN/d\left(\phi_{J/\psi} - \Psi\right)$ with (2) or $v_2 = \left\langle cos(2(\phi_{J/\psi} - \Psi))\right\rangle$.
- $v_2^{fg}(M)N^{fg}(M)/N^{comb}(M)$ fit shape: constant, linear and quadratic polynomial

Last two variations were taken into account in the systematic errors.

Current Status of J/ψ v_2 analysis at $|y| < 0.35$.



$$v_2^{J/\psi}(0 - 5GeV/c) = -0.10 \pm 0.10 \pm 0.02$$

Error bars are still too large to make any conclusion.
More data are going to be analyzed and studies about systematics are still on the way. STAY TUNE!