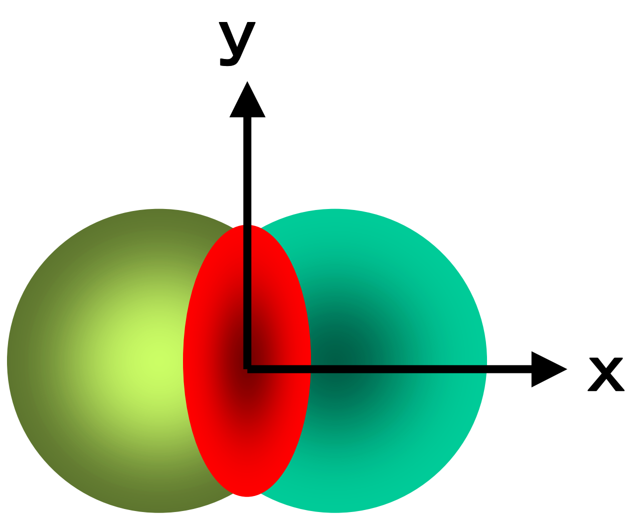
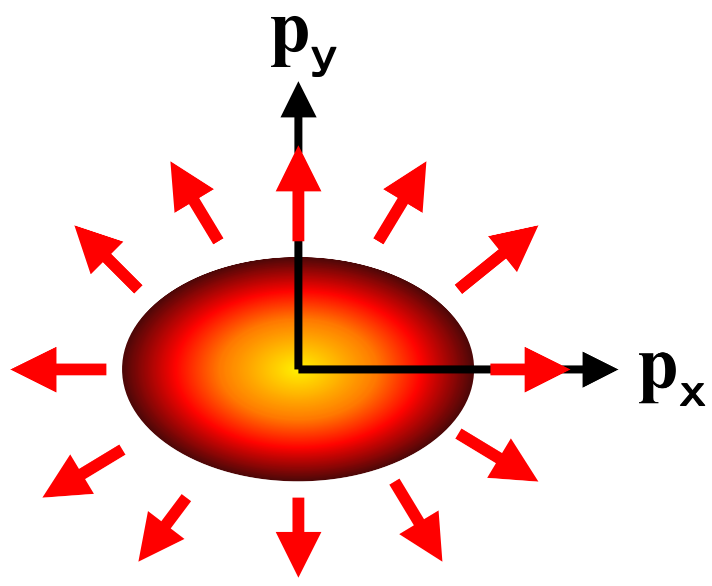
Identified particle elliptic anisotropy in 200 GeV Au+Au collision at RHIC-PHENIX

Shingo Sakai
Univ. of Tsukuba
for the PHENIX Collaboration

Introduction





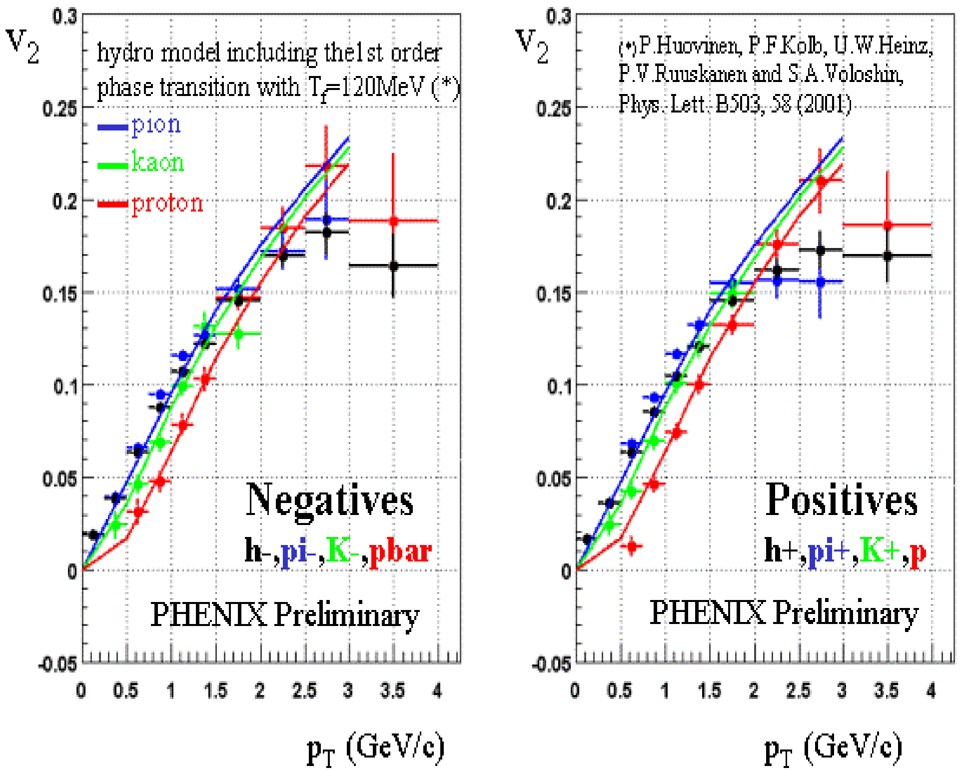
The azimuthal anisotropy of particle emission is sensitive to the early stages of system evolution

$$\frac{dN}{d\varphi} = N_0 (1 + 2 v_1 \cos(\varphi) + 2 v_2 \cos(2\varphi) + \dots)$$

Motivation

v_2 of identified hadrons

Au+Au at sqrt(s_{NN})=200GeV
min. bias r.p. $|\eta|$=3~4



- $v_2^{\pi} > v_2^{K} > v_2^{p}$ at low p_T (<1.5GeV/c)
- $v_2^{\pi} < v_2^{p}$ at p_T >2.5GeV/c

⇩

How about heavier particle ?

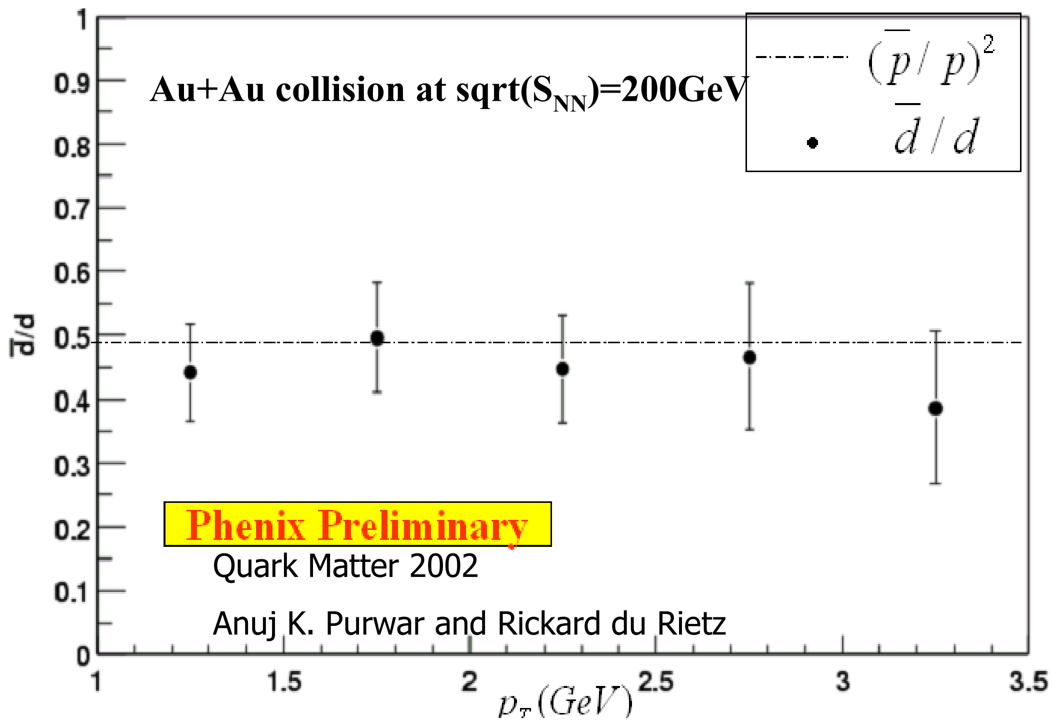
Measure v_2 of deuteron + anti-deuteron in 200 GeV Au+Au collision at RHIC-PHENIX

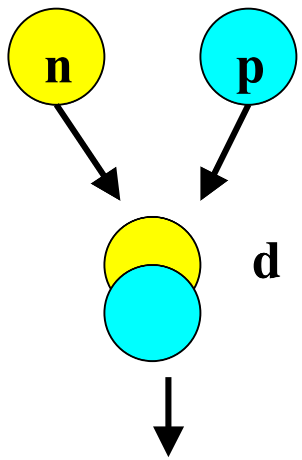
Coalescence model

-Coalescence model-

deuteron and anti-deuteron produce the coalescence of the individual nucleons

$$E_d \frac{d^3 N_d}{dp_d^3} = B_2 \left(E_p \frac{d^3 N_p}{dp_p^3})^2 \right)^2 \quad (p^d = 2p^p)$$





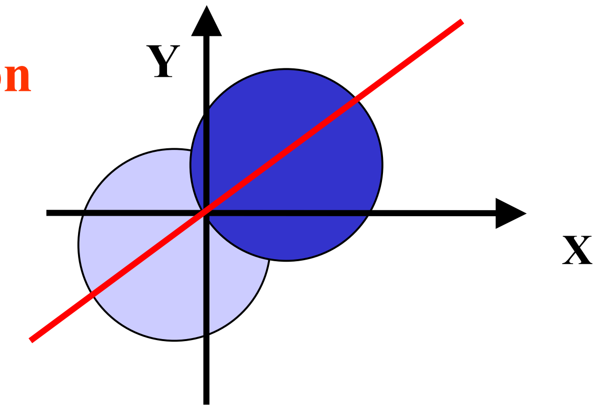
$$\boxed{v_2^d(p_t) = 2v_2^p(p_t/2)}$$

Method

-Reaction plane method-

Measure azimuthal angle of each particle respect to the reaction plane

Reaction Plane



$$\Psi = \left(\tan^{-1} \frac{\sum_i w_i \sin(2\phi_i)}{\sum_i w_i \cos(2\phi_i)} \right) \Big/ 2$$

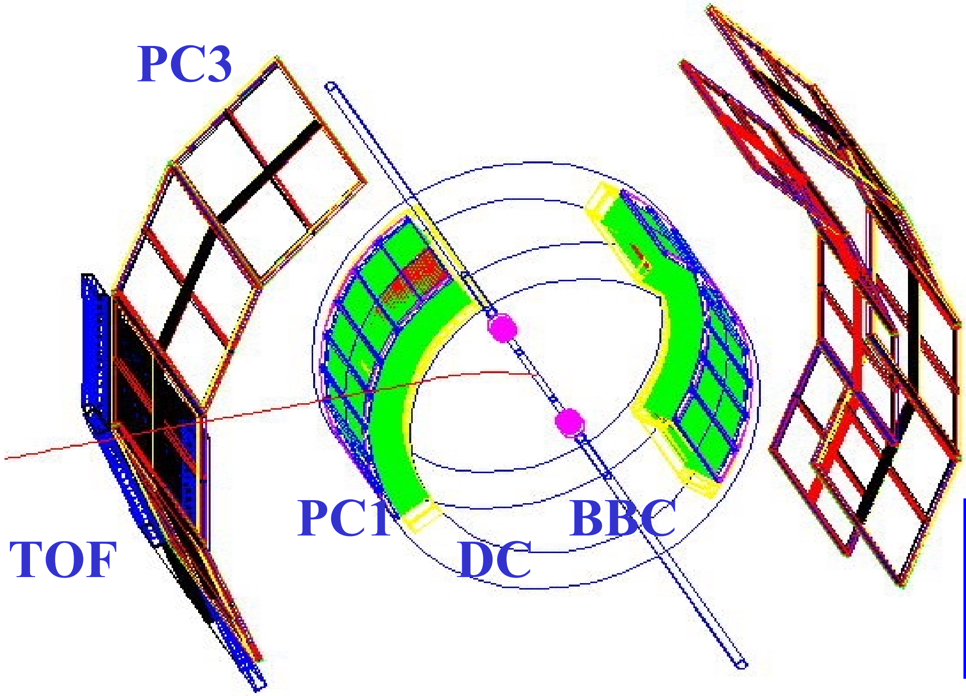
σ =<cos(2(Ψ_m-Ψ_{real}))>
= {<cos(2(Ψ_A-Ψ_B))>}$^{1/2}$

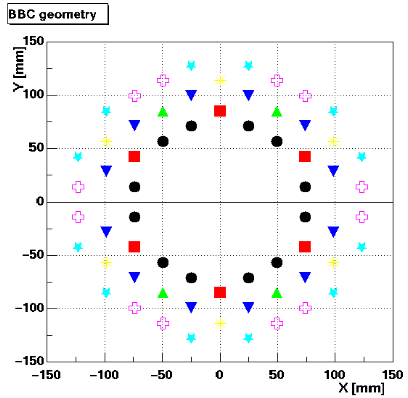
$$\frac{dN}{d(\phi - \psi^{obs})} = N_0 (1 + 2 v_2^{obs} \cos[2(\phi - \Psi^{obs})])$$

particle emission

$$\boxed{v_2 = v_2^{obs} / \sigma}$$

PHENIX detector





64 pmts in each BBC

Beam Beam Counter (BBC)
$|\eta|$=3-4

Tracking

DC+PC1+PC3 ⇨ **p, ϕ**

PID **･･･ TOF**

$$m^2 = p^2\{(\mathrm{TOF}/L)^2 - 1\}$$

3 units of rapidity away

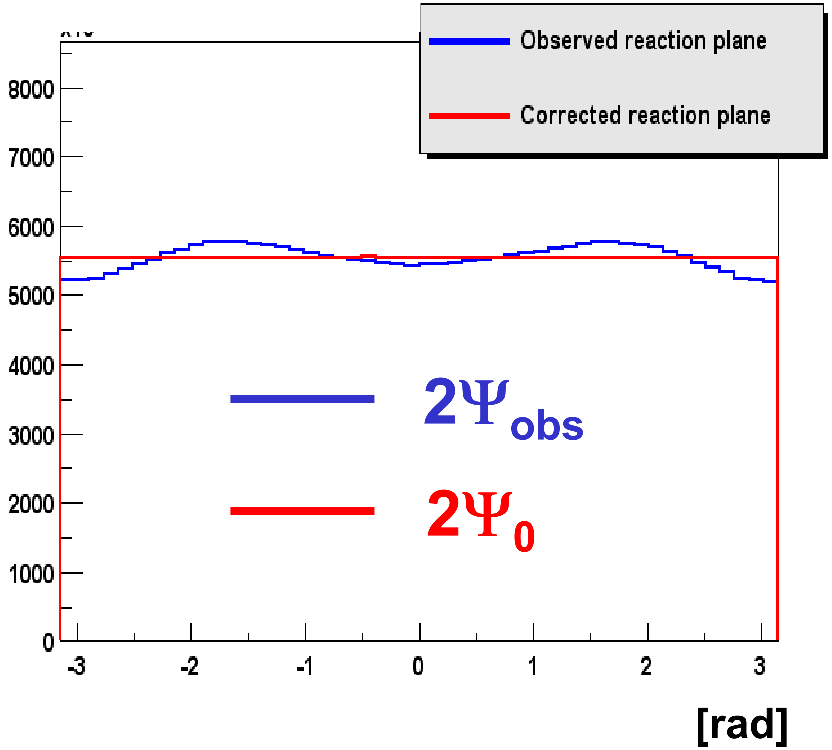
from the mid-rapidity

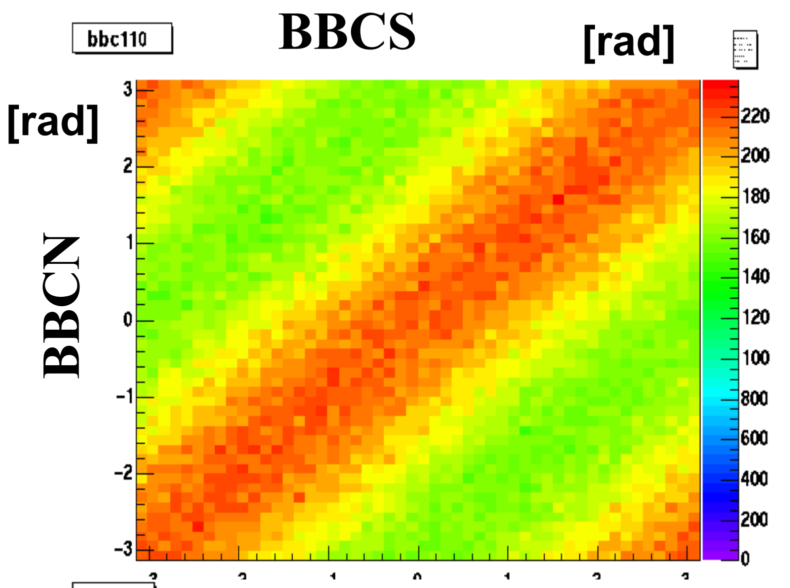
⇩

Less ***non-flow*** contribution

HBT、jet、resonance decay

Reaction plane distribution



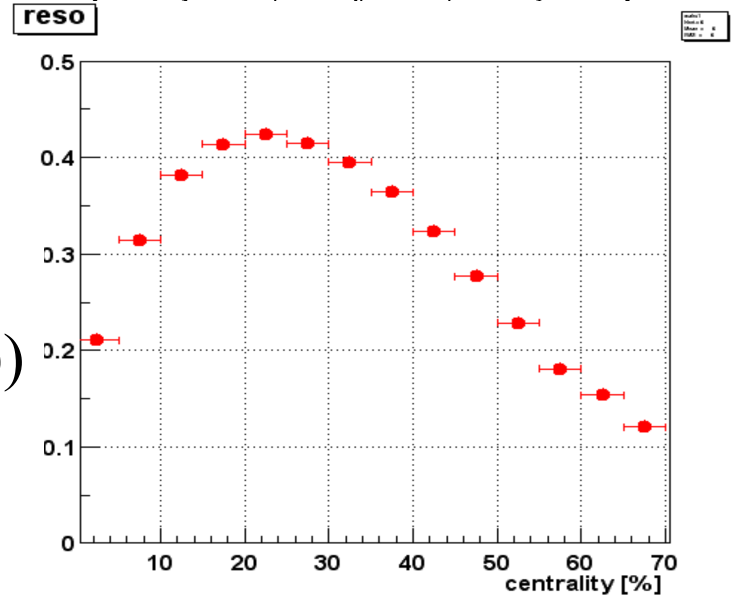


$2\Psi_0 = 2\Psi_0^{obs} + \Delta\Psi_0$

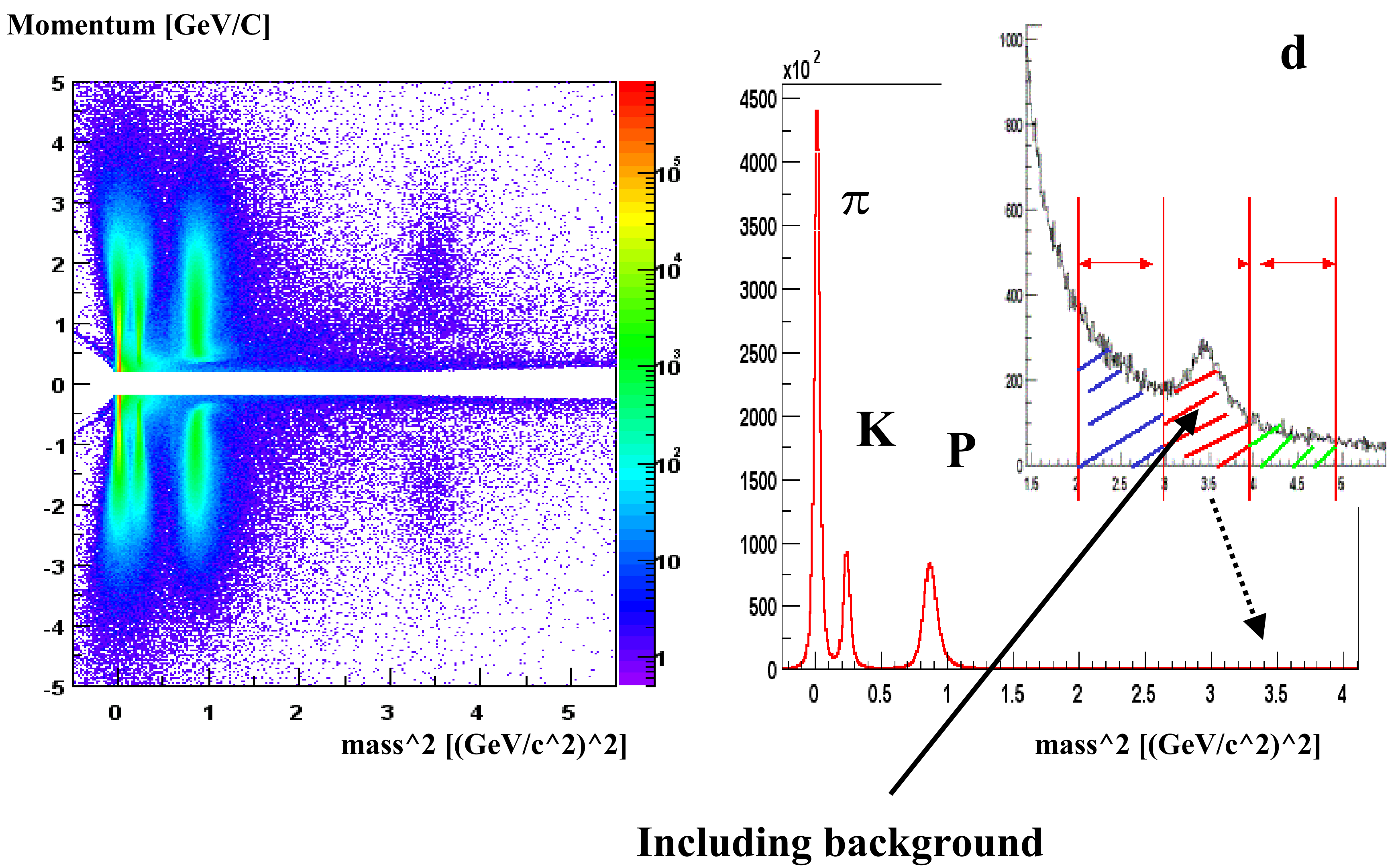
$\Delta\Psi_0 = \Sigma(A_n\cos(2n\Psi_{obs}) + B_n\sin(2n\Psi_{obs}))$

$A_n = -2/n * \langle\sin(2n\Psi_{obs})\rangle$

$B_n = 2/n * \langle\cos(2n\Psi_{obs})\rangle$



PID

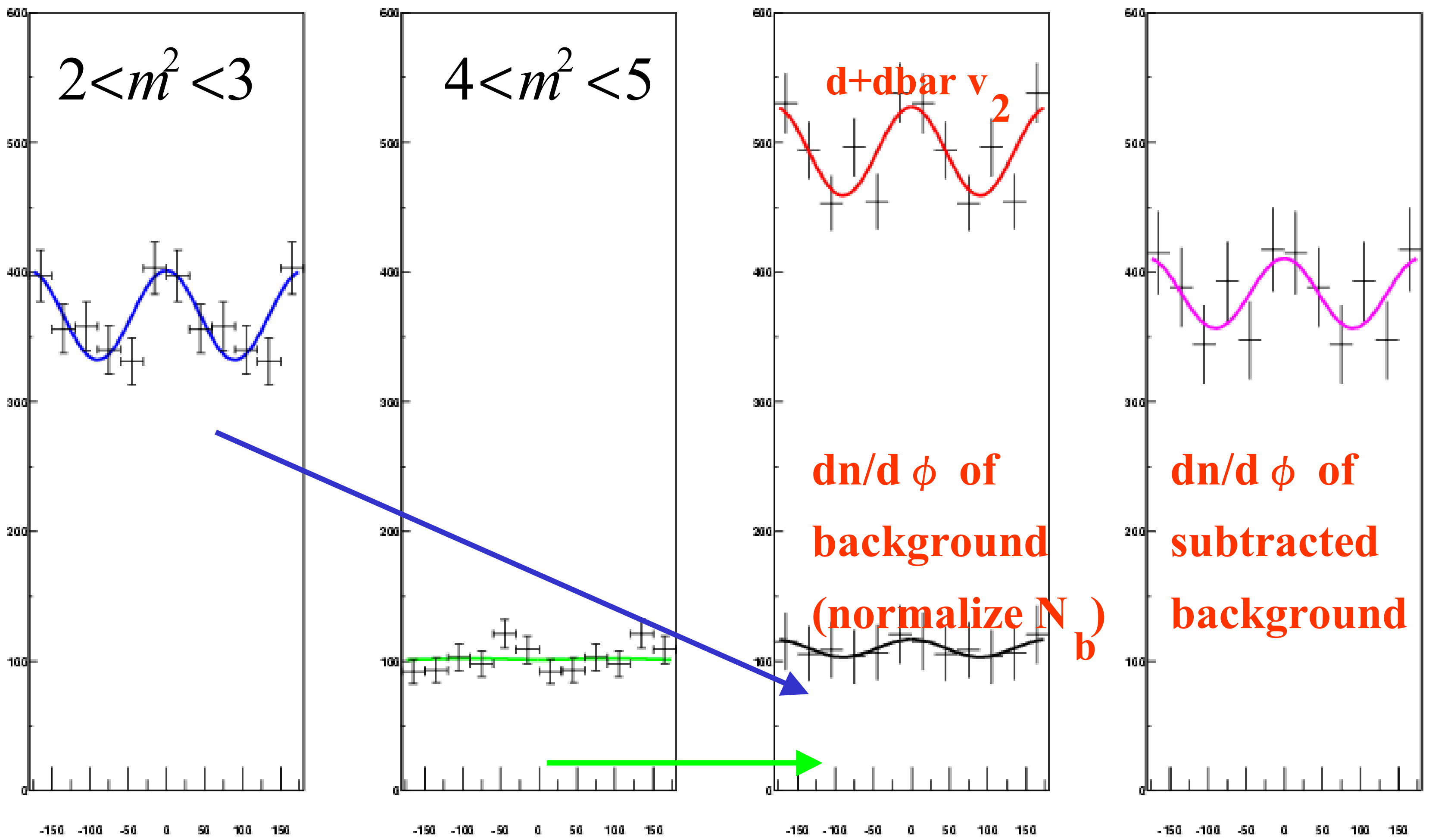


Momentum [GeV/C]
mass^2 [(GeV/c^2)^2]
x10^2
π
K
P
d
mass^2 [(GeV/c^2)^2]
Including background

dN/dϕ distribution

$2.0<p<3.0$

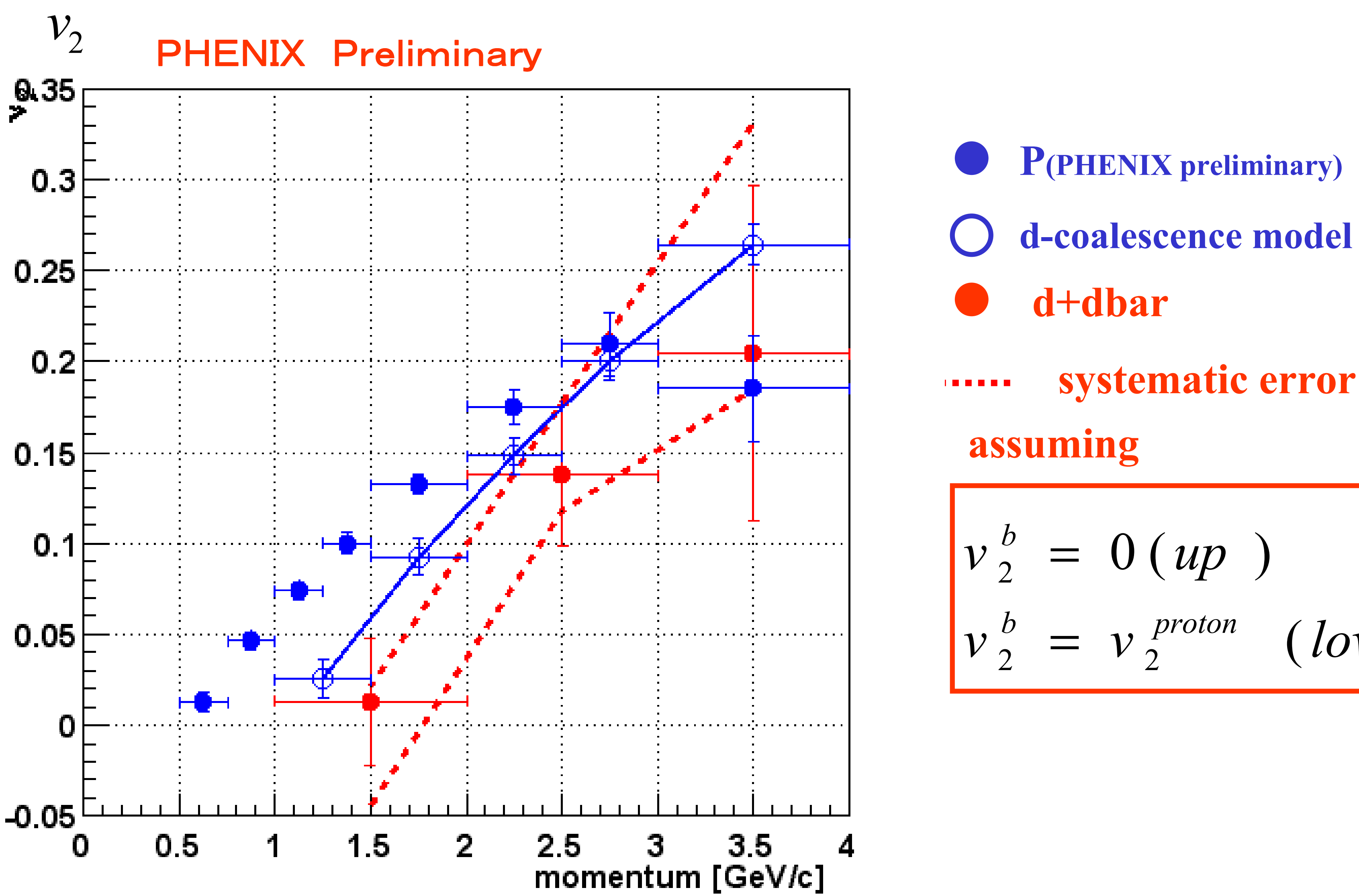
dn/d ϕ



$$fit : N_0(1+2v_2^{fit}\cos(2(\varphi-\psi)))$$

Φ - Ψ

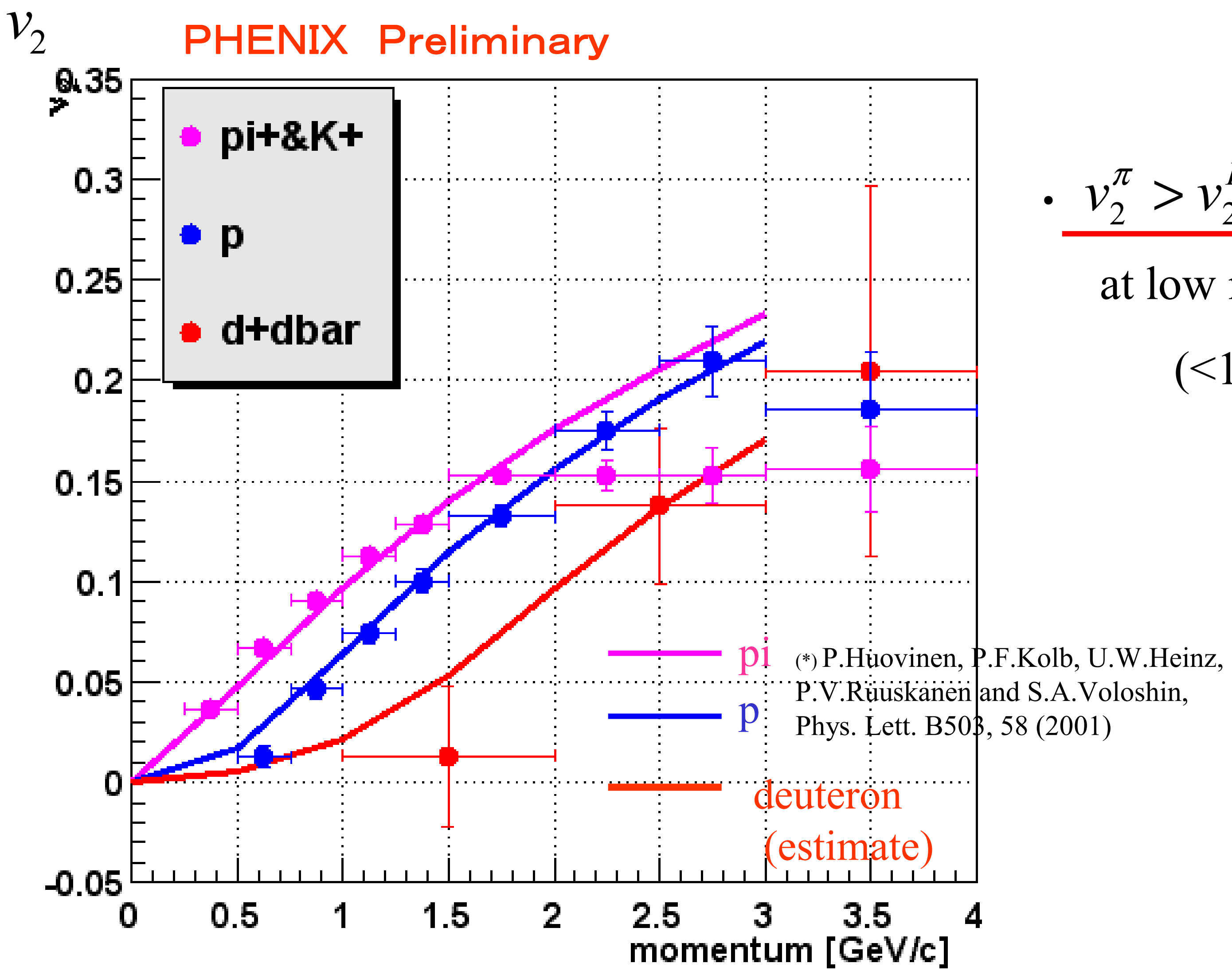
Compare with theory



assuming

$$v_2^b = 0 \ (up)$$
$$v_2^b = v_2^{proton} \ (low)$$

PID v_2



- $v_2^{\pi} > v_2^{K} > v_2^{p} > v_2^{d}$

  at low momentum

  (<1.5GeV/c)

Summary

・deuteron + anti-deuteron (d+dbar)elliptic anisotropy are measured respect to the reaction plane

・ v_2 of d+dbar is estimated taking into account background

・ $v_2^{\pi} > v_2^{K} > v_2^{p} > v_2^{d}$ at low momentum (<1.5 GeV/c)

・ Coalescence model & hydro model is comparable v_2^{d} within error bar (sys.+stat.)

Coalescence model(2)

$$\left(\frac{dN^d}{d\phi}\right) = \alpha\left(\frac{dN^p}{d\phi}\right)^2$$

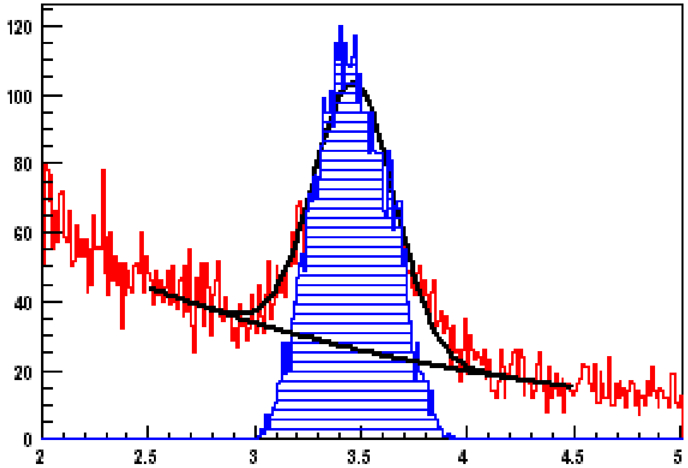
$$\left(1+\sum 2v_n^d \cos(n\phi)\right) = \alpha\left(1+\sum 2v_n^p \cos(n\phi)\right)^2$$

$$\cong \alpha\left(1+\sum 2(2v_n^p)\cos(n\phi)\right)$$

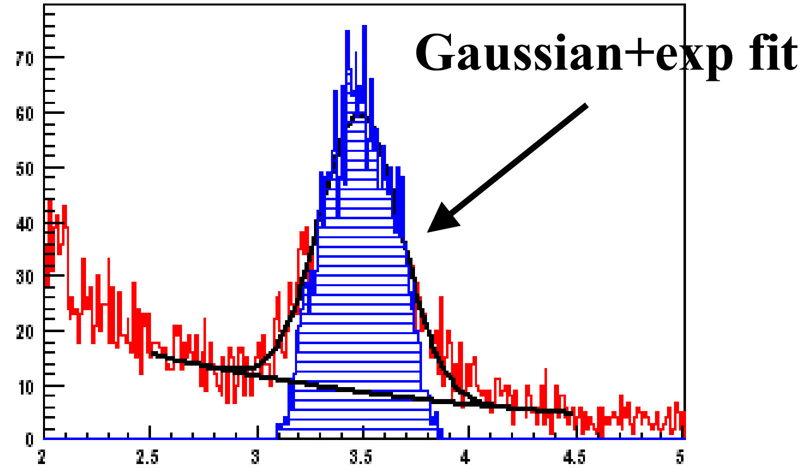
$$\boxed{v_2^{deuteron}(p_t) = 2v_2^{proton}(p_t/2)}$$

d+dbar

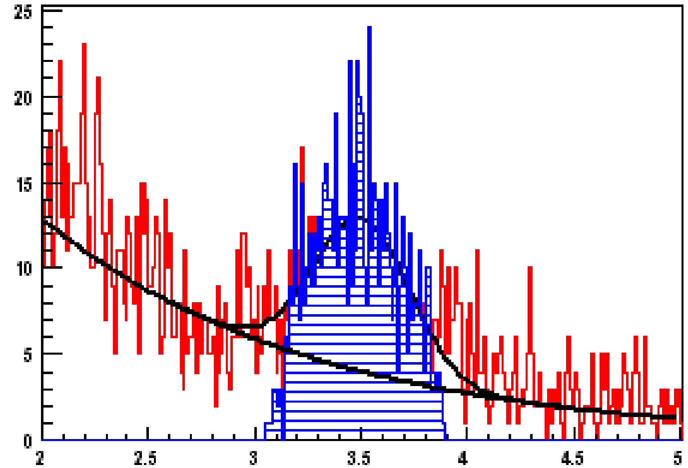
(1.0<p(GeV/c)<2.0)



(2.0<p(GeV/c)<3.0)



(3.0<p(GeV/c)<4.0)



< selection>

Quality 31 || 63

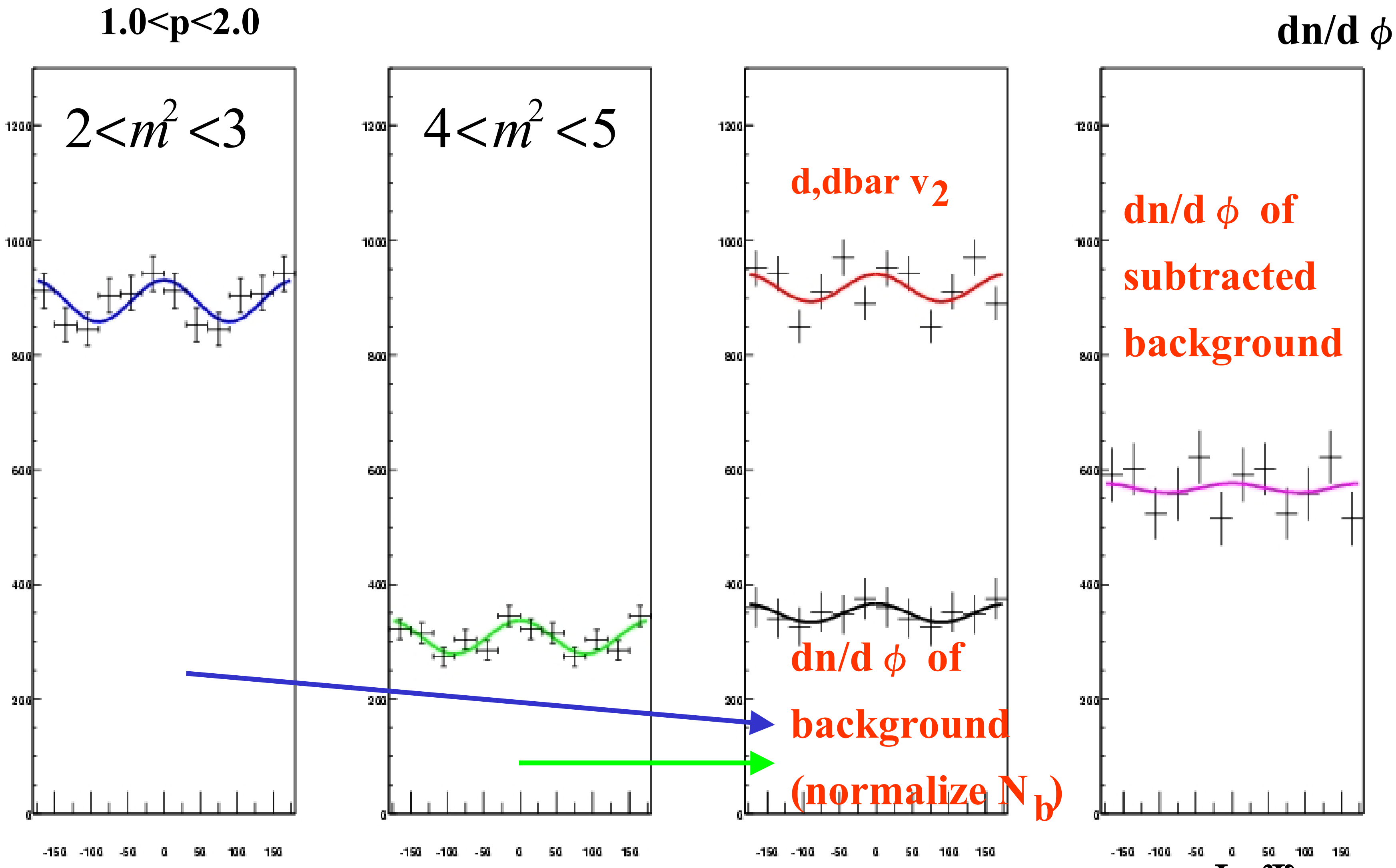
TOF-Track matching cut < 2 σ

PC3-Track matching cut < 2 σ

TOF E loss > 0.0014 Β ^(-5/3)

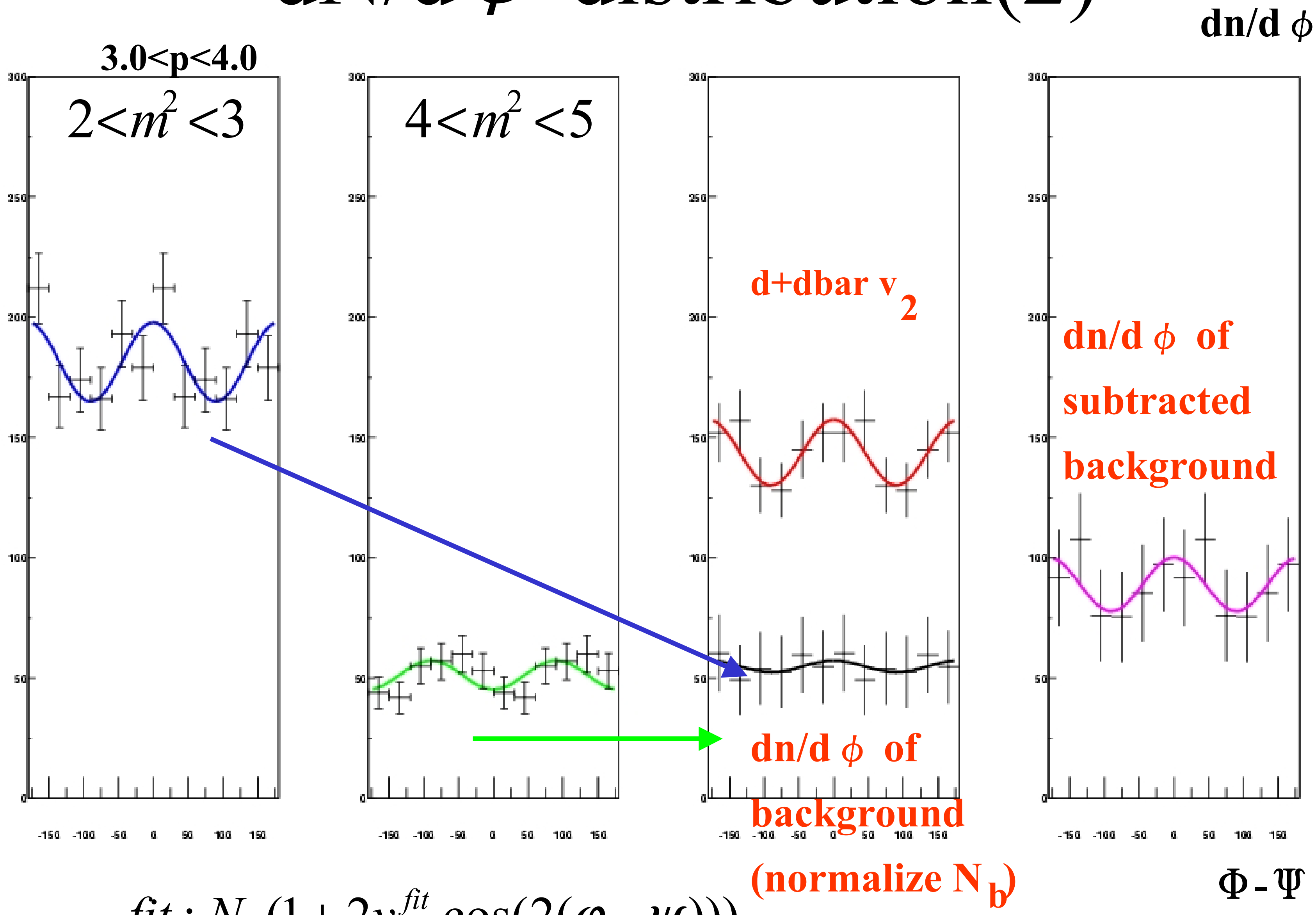
|Mass^2|<1.5 σ (p)

dN/dϕ distribution(1)

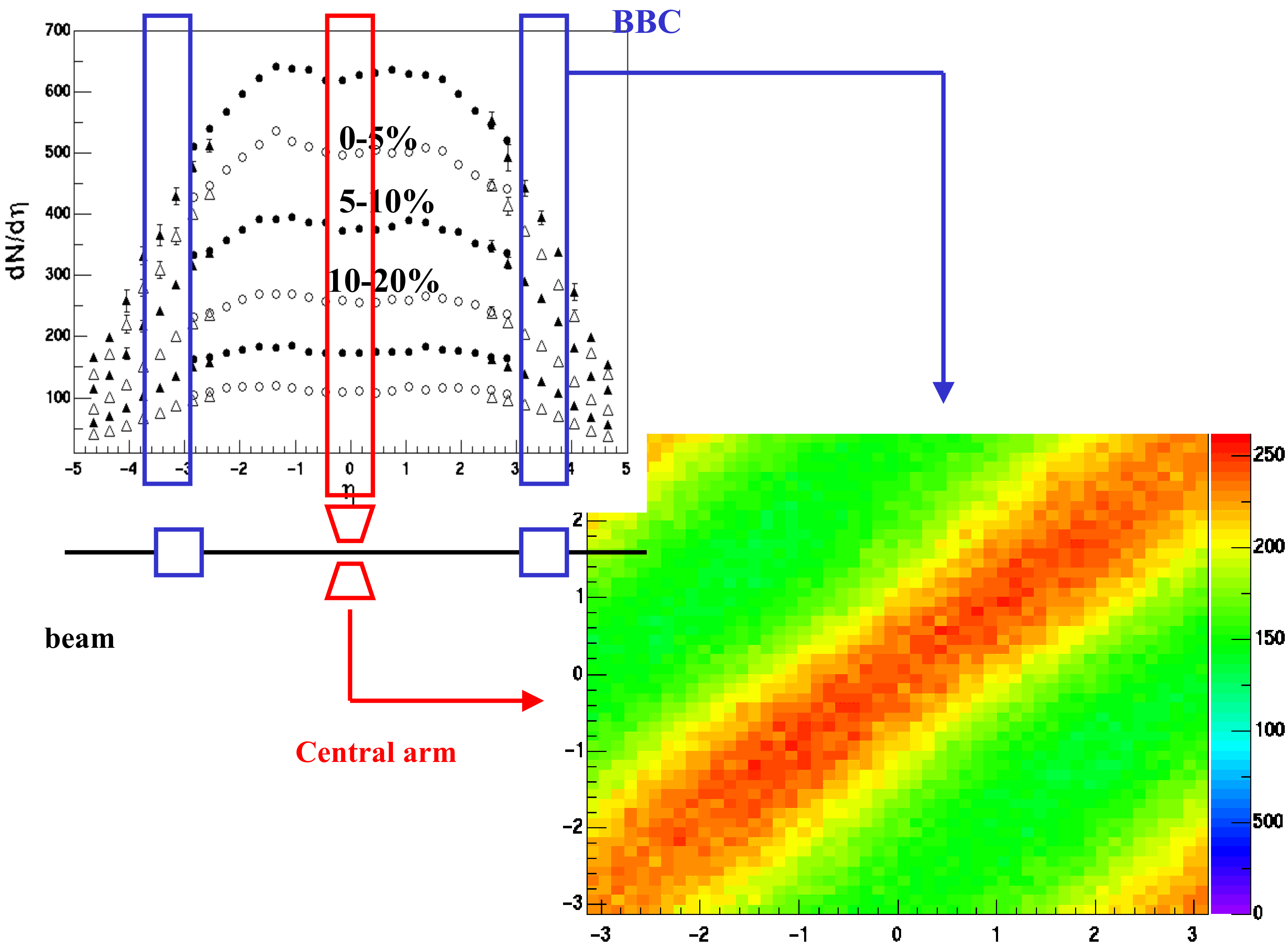


$$fit : N_0(1+2v_2^{fit}\cos(2(\varphi-\psi)))$$

dN/dϕ distribution(2)



$$fit : N_0(1+2v_2^{fit}\cos(2(\varphi-\psi)))$$



BBC
0-5%
5-10%
10-20%
dN/dη
η
beam
Central arm

Resolution

$$\sigma = < \cos(n(\Psi_{measured} - \underline{\Psi_{true}})) >$$

Can't measure

Reaction plane resolution

$$\boxed{< \cos(n(\Psi_A - \Psi_B)) >}$$

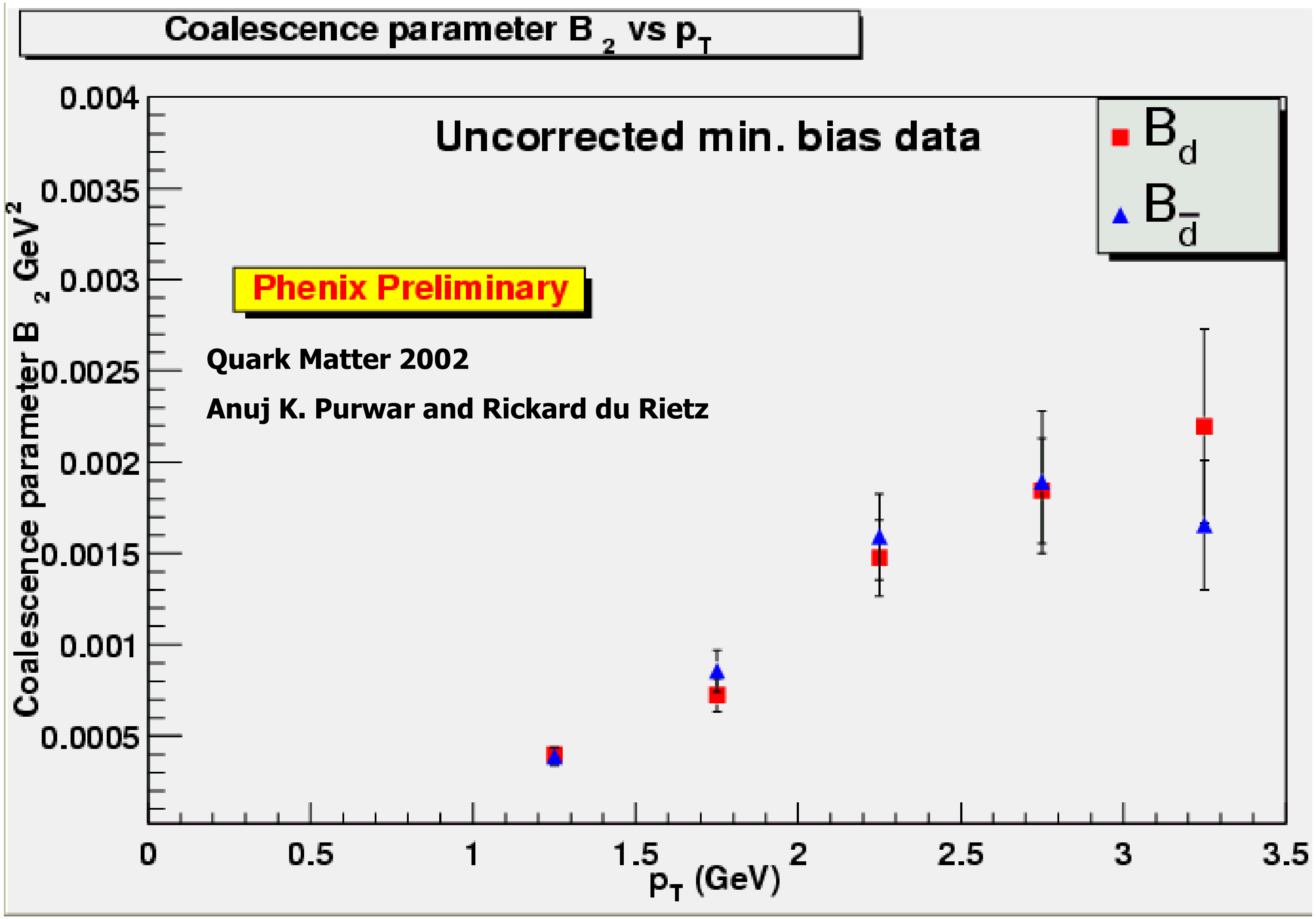
Reaction plane sub-event
(divide one event)

$$= < \cos n((\Psi_A - \Psi_{true}) - (\Psi_B - \Psi_{true})) >$$

$$\approx < \cos(n(\Psi_A - \Psi_{true})) >< \cos(n(\Psi_B - \Psi_{true})) >$$

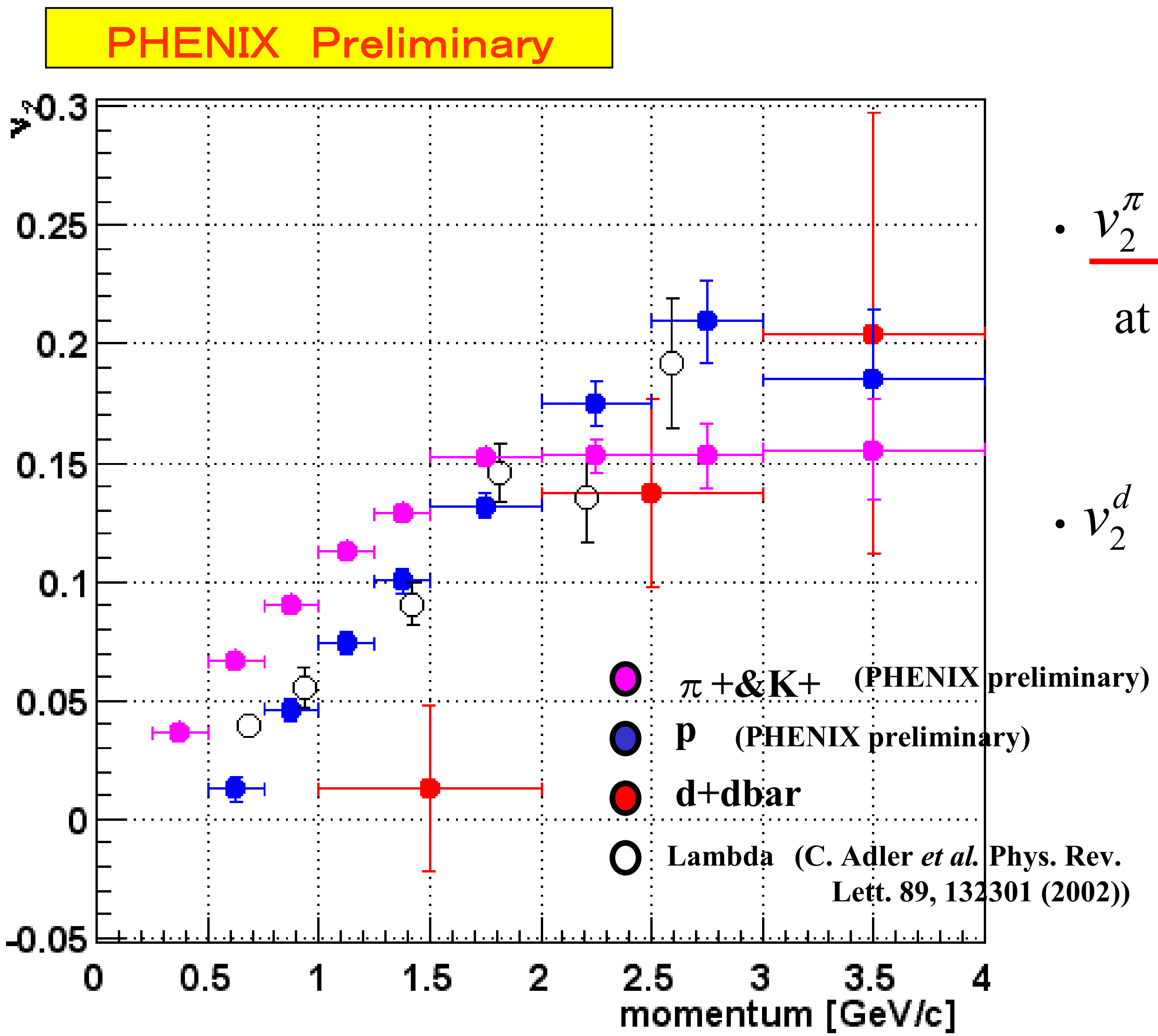
$$\approx < \cos(n(\Psi_A - \Psi_{true})) >^2$$

B_2



Coalescence parameter B 2 vs pT
Uncorrected min. bias data
Bd
Bd̄
Phenix Preliminary
Quark Matter 2002
Anuj K. Purwar and Rickard du Rietz
Coalescence parameter B 2 GeV2
pT (GeV)
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
0.5
1
1.5
2
2.5
3
3.5

PID v_2



- $\underline{v_2^{\pi} > v_2^{K} > v_2^{p}(v_2^{\Lambda}) > v_2^{d}}$

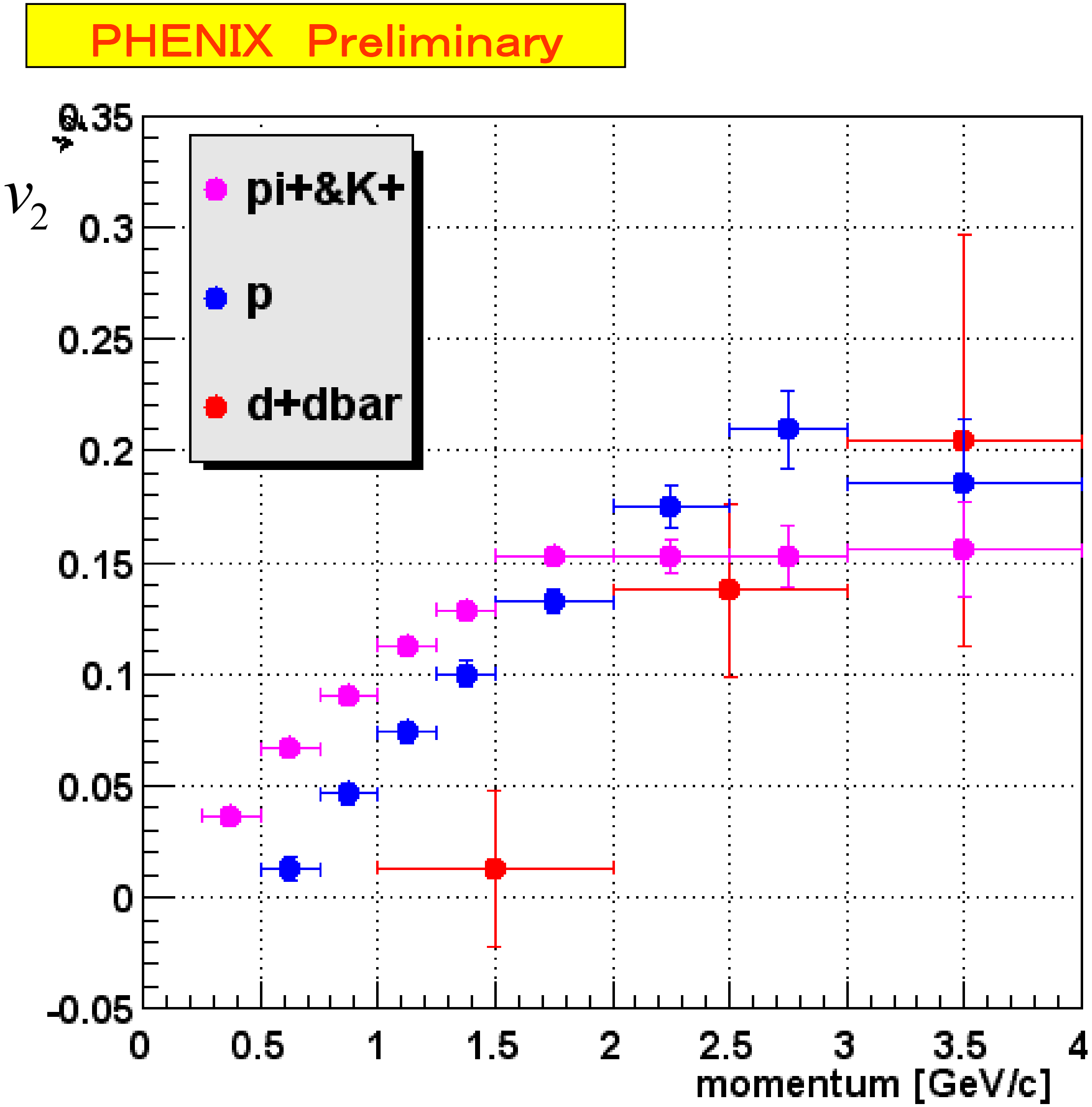
  at low momentum

  (<1.5GeV/c)

- v_2^d doesn't saturate

  (p<3.0 GeV/c)

PID v_2



- $v_2^{\pi} > v_2^{K} > v_2^{p} > v_2^{d}$

  at low momentum

  (<1.5GeV/c)

- v_2^{d} doesn't saturate

  (p<3.0 GeV/c)