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Blast-wave Model Calculation of v2 including Resonance Decays

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Blast-wave model

- not a real hydrodynamic model which freeze-out continuously
- Thermal model + transverse expansion

  - snap shot at thermal freeze out (T, β, μ_q, μ_s)
- Works very well in fitting p_T spectrum
- Cylindrical geometry
- Extended to fit both ratio and p_T spectrum

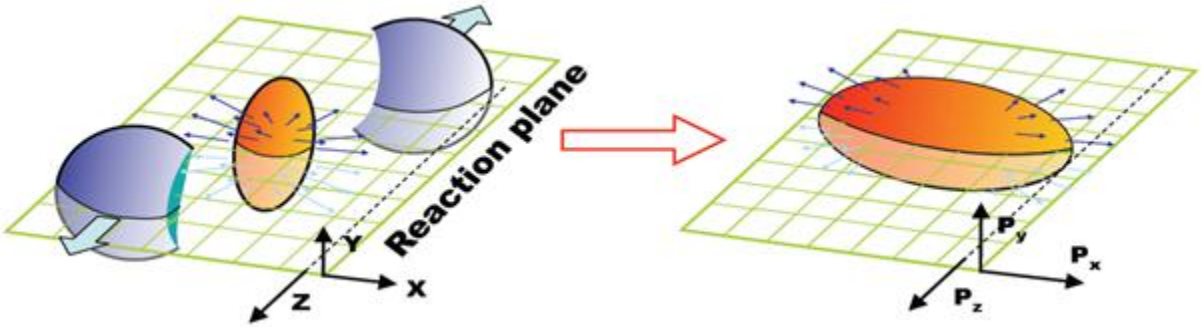
Suk Choi & K.S.Lee, prc84, 064905, 2011

- We want to extend this model to fit v_2 with resonance contribution.

S. Schlichting, S. Pratt,Phys.Rev.C83:014913,2011
F. Retiere, M. Lisa, Phys.Rev. C70 (2004) 044907

V2(elliptic flow)

- probes the early geometry in hydrodynamic evolution.
- Initial spatial anisotropy ⇒ final momentum anisotropy



$$\frac{dN}{d(\varphi-\varphi_R)} \propto 1 + 2v_1 cos(\varphi - \varphi_R) + 2v_2 cos(2\varphi - 2\varphi_R) + \cdots$$

Elliptic flow as a result of transverse expansion

- Linear increase with pT in the low pT region
- Mass ordering

Ollitrault

- Saturation – due to shear viscosity
  - role of bulk viscosity recently discussed
- Resonance contribution destroys elliptic flow and may cause saturation.

❖ Effect of Resonance contribution to saturation of v2 has been investigated in this work.

Hadron spectrum in blast-wave model
- Cooper-Frye formula

$$\frac{d^2N}{m_T dm_T dy d\phi} = \frac{d_i}{(2\pi)^3}\int_{\Sigma_f} p^\mu d\sigma_\mu \exp(-\frac{p^\nu u_\nu(x)-\mu}{T})$$

$$= \frac{Vd_i}{2\pi}\int d\eta \int r dr m_T \cosh(y-\eta)\int d\phi \times$$

$$\exp(-\frac{m_T \cosh(y-\eta)\cosh\rho - p_T \sinh\rho\cos(\phi-\varphi)-\mu}{T})$$

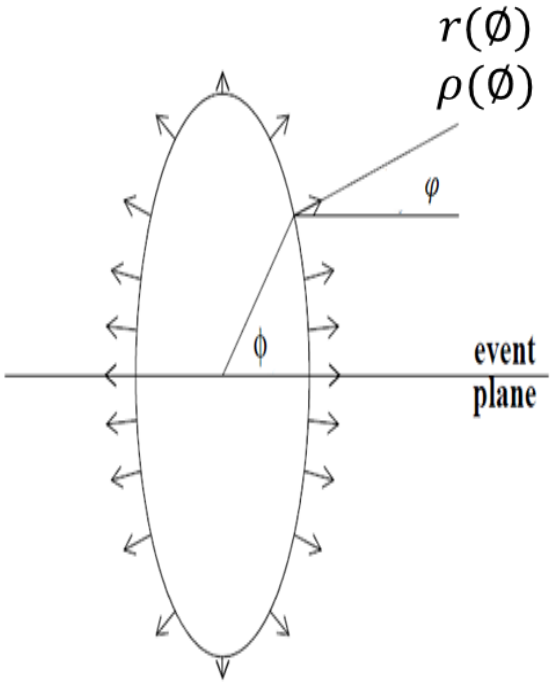
H. Dobler, J. Sollfrank, U. Heinz, P.L. B457,353(1999)
Schnedermann, Sollfrank, Heinz

Elliptic coefficient from hadron spectrum
- coefficient of 2nd harmonics

$$v_2 = \frac{\int \left(\frac{d^3N}{m_T dm_T dy d\phi} + reso.contr. \right) \cos 2\phi d\phi}{\int \left(\frac{d^3N}{m_T dm_T dy d\phi} + reso.contr. \right) d\phi}$$

Geometrical structure at f.o.

- Elliptical sub-shell of the source



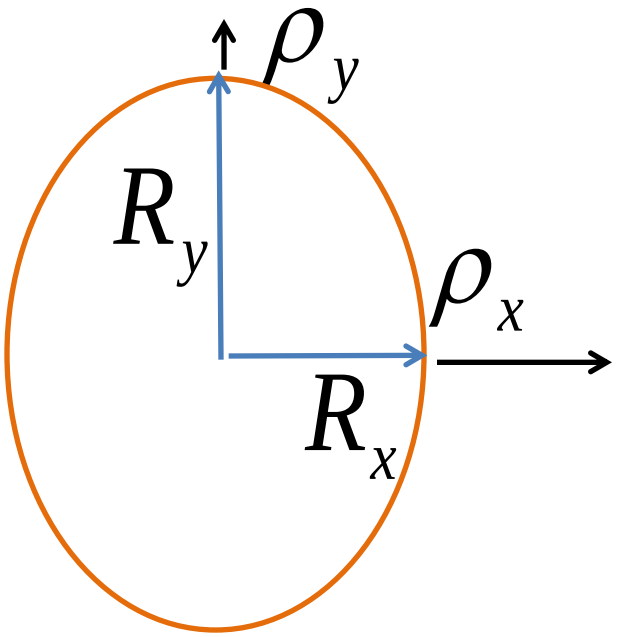
- Freeze-out radius

$$r = \frac{r_x r_y}{\sqrt{r_x^2 \sin^2\varphi + r_y^2 \cos^2\varphi}}$$

- Transverse rapidity

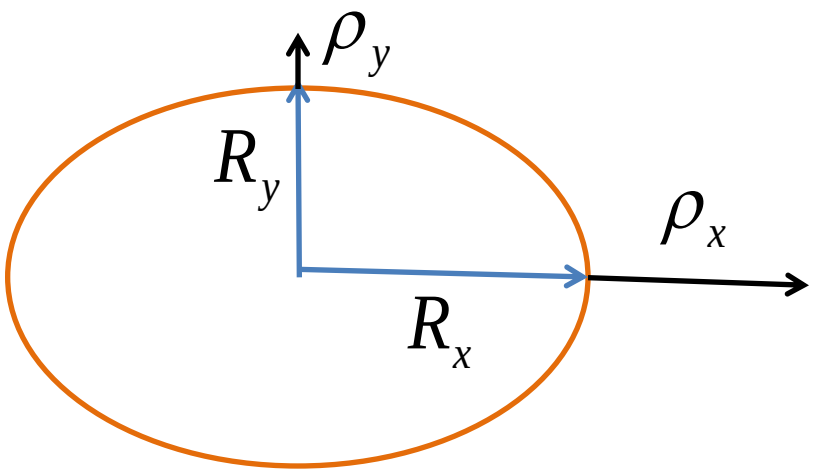
$$\rho = \frac{\rho_x \rho_y}{\sqrt{\rho_x^2 \sin^2\varphi + \rho_y^2 \cos^2\varphi}}$$

Other parameters fixed to fit pT and y spectrum



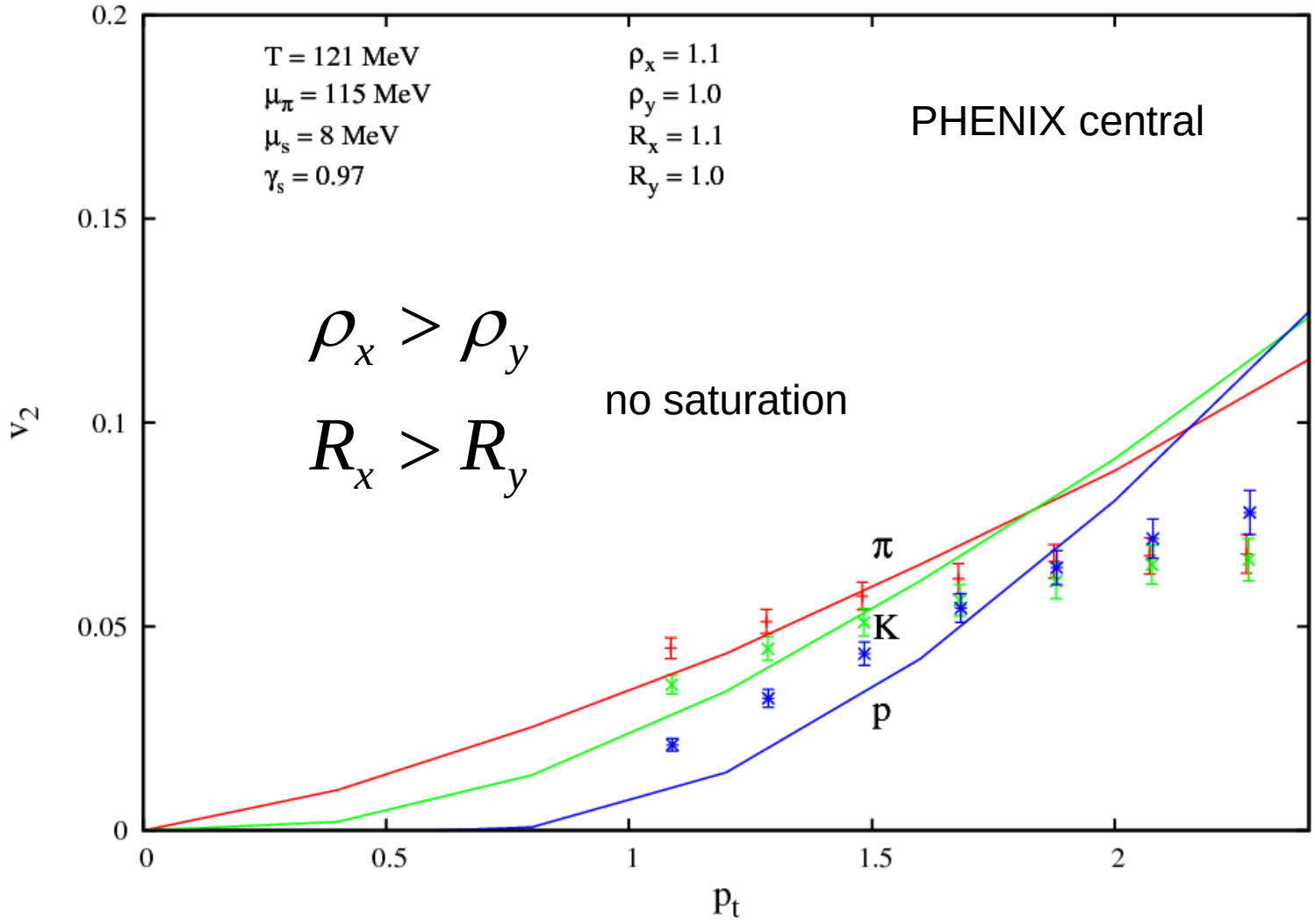
$$\rho_x > \rho_y$$

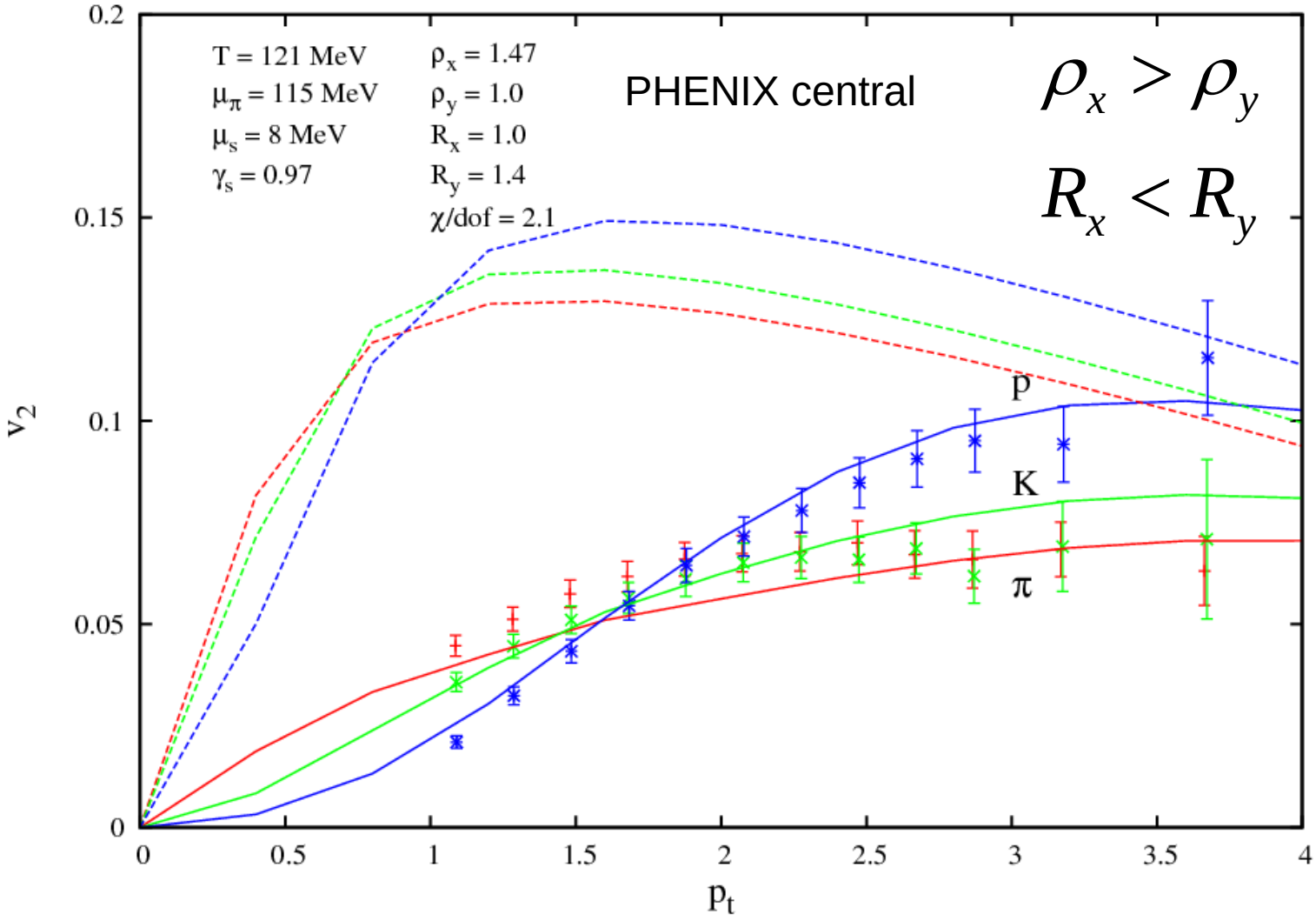
$$R_x < R_y$$



$$\rho_x > \rho_y$$

$$R_x > R_y$$


T = 121 MeV
μπ = 115 MeV
μs = 8 MeV
γs = 0.97
ρx = 1.1
ρy = 1.0
Rx = 1.1
Ry = 1.0
PHENIX central
ρx > ρy
Rx > Ry
no saturation
π
K
p
v2
pt
0
0.05
0.1
0.15
0.2
0.5
1
1.5
2


T = 121 MeV
μπ = 115 MeV
μs = 8 MeV
γs = 0.97
ρx = 1.47
ρy = 1.0
Rx = 1.0
Ry = 1.4
χ/dof = 2.1
PHENIX central
$\rho_x > \rho_y$
$R_x < R_y$
p
K
π
v2
pt
0.2
0.15
0.1
0.05
0
0
0.5
1
1.5
2
2.5
3
3.5
4

Conclusion

1. Within a blast-wave model with resonance contribution, elliptic coefficient, v2 measured at RHIC has been studied.

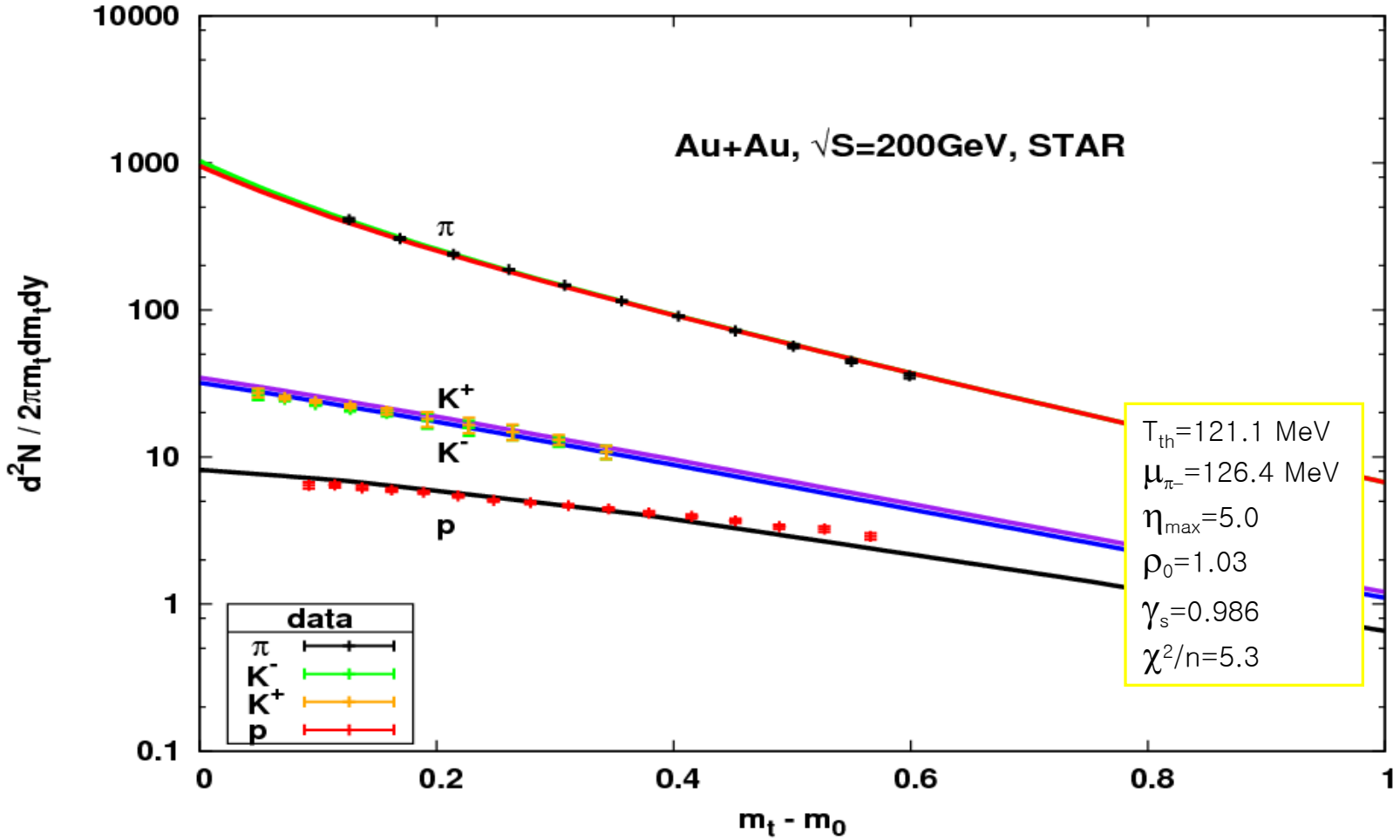
2. V2 develops when $\rho_x > \rho_y$ or $R_x > R_y$.

3. Saturation occurs on when $\rho_x > \rho_y$ and $R_x < R_y$.

4. Resonance decays reduce v2 by more than half. Careful treatment of resonance decay needed.

5. The radii and the transverse expansion rapidities are parameters and whether they are consistent with the hydrodynamic evolution has to be checked. However, in the hydrodynamic calculation freeze-out is continuous.

Results of thermal analysis



Pseudo-rapidity distribution of charged hadrons