



Measurements of φ meson from hadronic and leptonic decays at RHIC by PHENIX

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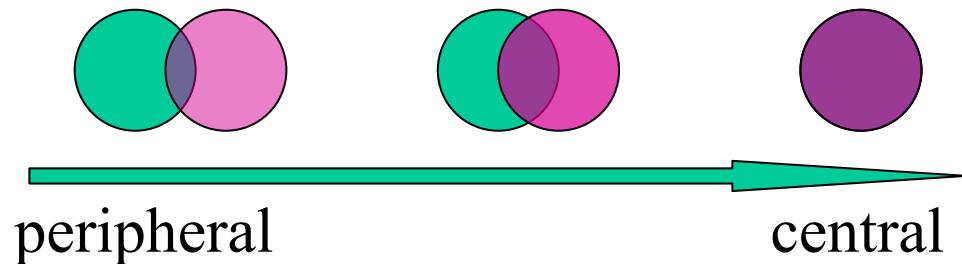
for the PHENIX Collaboration



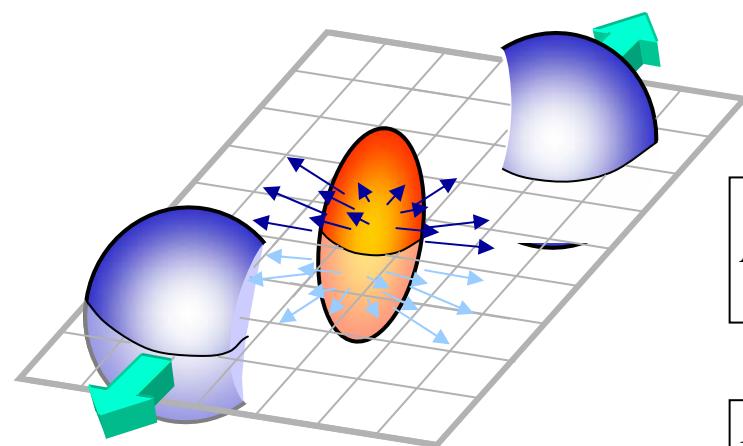
Outline

- *Observer and Motivation*
- *PHENIX capability to measure the phi*
 - *PID ability*
 - *Background*
- *Results*
 - *Line shape*
 - *Spectra*
 - *Integrated yields and temperature slope*
 - *Nuclear modification factor*
 - *Elliptic flow*
- *Conclusions*

➤ Centrality and Nuclear modification factor



➤ Reaction plane and elliptic flow



ψ_R : Reaction plane

N_{part} : number of nucleus which take part in collisions

N_{coll} : number of binary collisions

Nuclear modification factor:

$$R_{AA} = \frac{d^2 N^{AA} / dp_T dy}{\langle n_{\text{coll}} \rangle \cdot d^2 N^{pp} / dp_T dy}$$

$$E \frac{d^3 N}{d^3 p} = \frac{1}{\pi} d^2 \frac{N}{dp_T^2 dy} [1 + 2v_1 \cos(\phi - \Psi_R) + 2v_2 (2[\phi - \Psi_R]) + \dots]$$

$$v_2 = \langle \cos(2[\phi - \Psi_R]) \rangle$$

A golden probe

- ❖ *The lightest ($s\bar{s}$) vector meson mass~1.019GeV*
- ❖ *Life time $\tau \sim 41fm/c$*
- ❖ *Similar mass with the baryon proton*

At lower p_T region (decay inside medium):

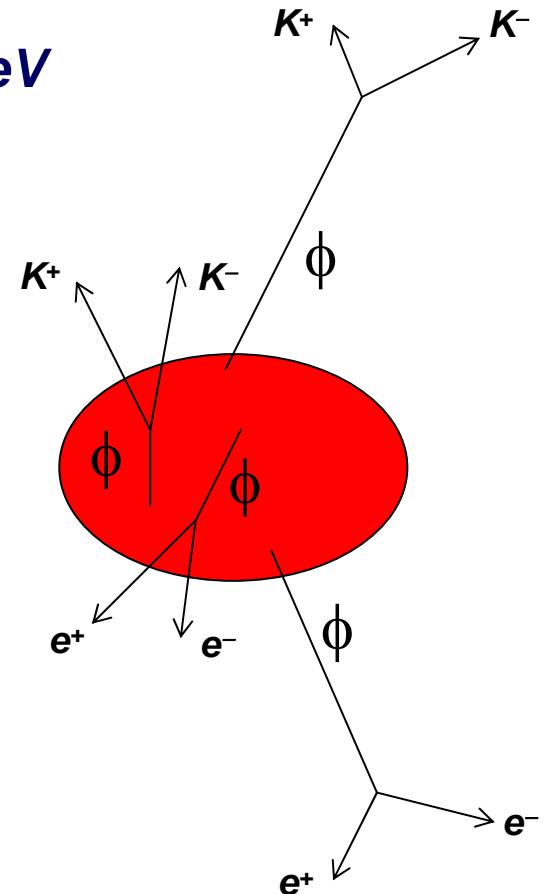
Hot (Au+Au) or cold (d+Au) medium effect

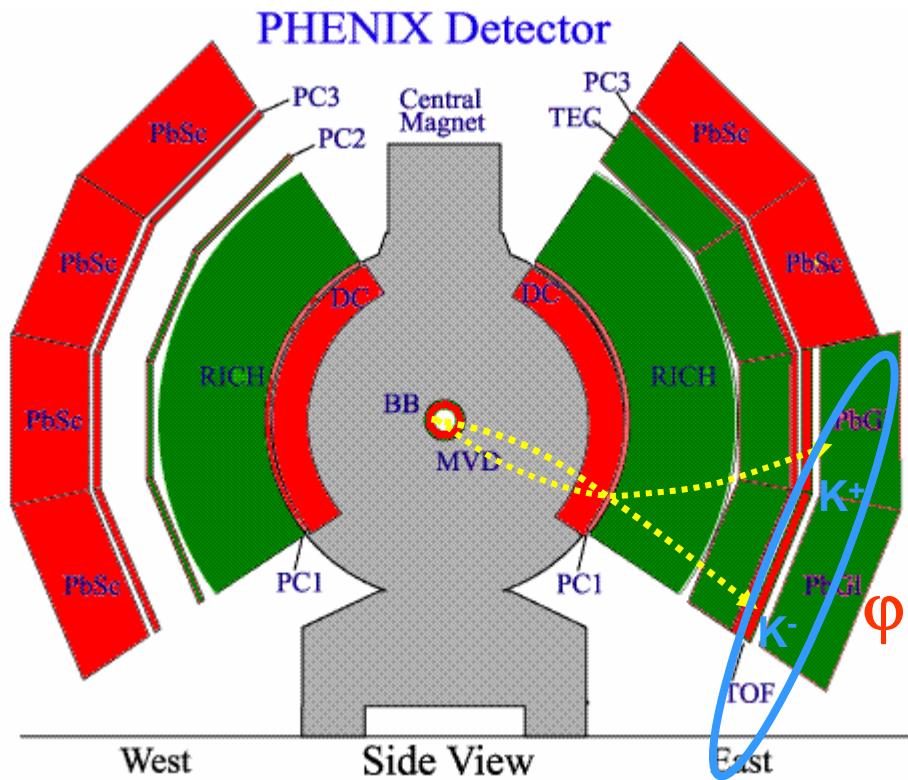
- ✓ Mass centroid & width
- ✓ Branch ratio

At intermediate p_T (decay outside medium):

Medium dynamics and particle productions

- ✓ Nuclear modification factor
- ✓ Elliptic flow v_2





BBC (vertex) $dz = 0.5\text{cm} \dots 2\text{cm}$

BBC (trigger) $\epsilon = 50\% \dots 92\%$

DC/PC1 (tracking) $d_{p_T}/p_T \sim 1.0\% \cdot p_T + 0.7\%$

EMC (calorimetric) $dE/E \sim 8.1\% / \sqrt{E} + 3.0\%$

EMC (t.o.f.) $d\tau \sim 500 \text{ ns}$

EMC (e/ π rejection) ~ 10

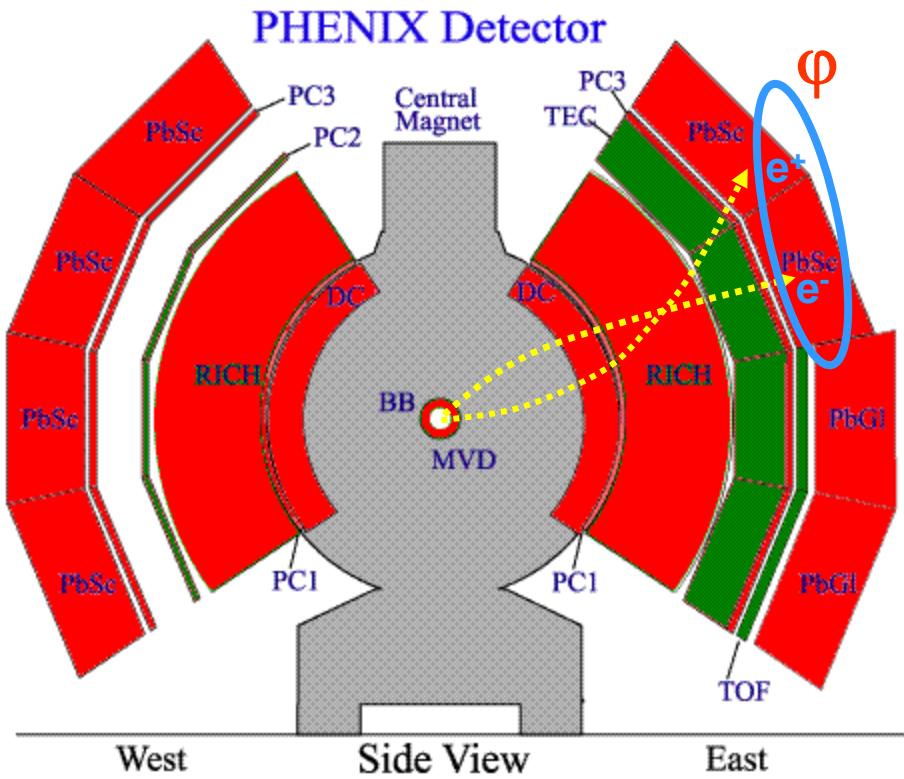
TOF $d\tau < 100 \text{ ns}$

RICH (e/ π rejection) > 1000

PHENIX acceptance :
 $-0.35 < \eta < 0.35$
 $2 \times 90^\circ$ for two arms

$\varphi \rightarrow K^+K^-$
 $\varphi \rightarrow e^+e^-$

$BR = 49.2 \pm 0.7\%$
 $BR = 2.97 \pm 0.04 \cdot 10^{-4}$



BBC (vertex) $dz = 0.5\text{cm} \dots 2\text{cm}$

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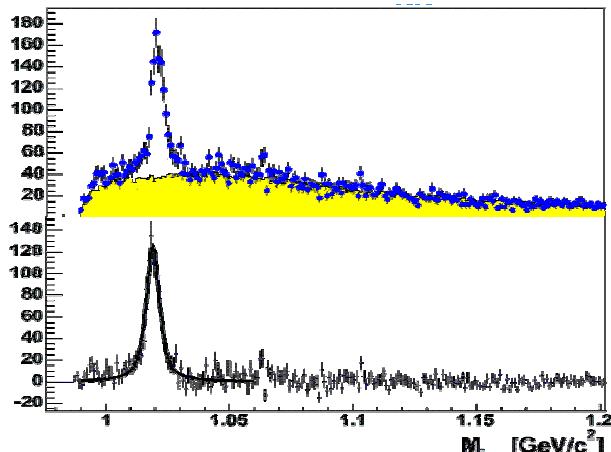
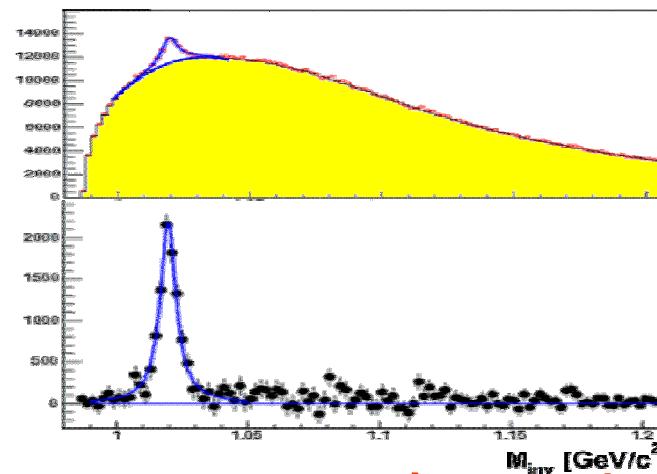
$2 \times 90^\circ$ for two arms

$$\varphi \rightarrow K^+K^-$$

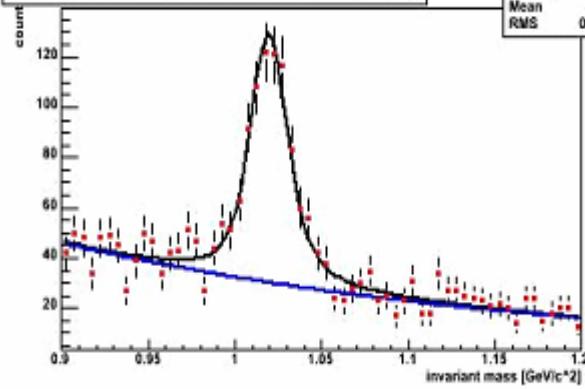
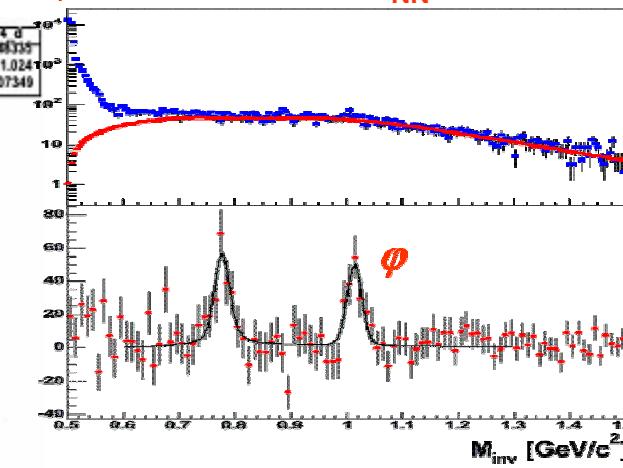
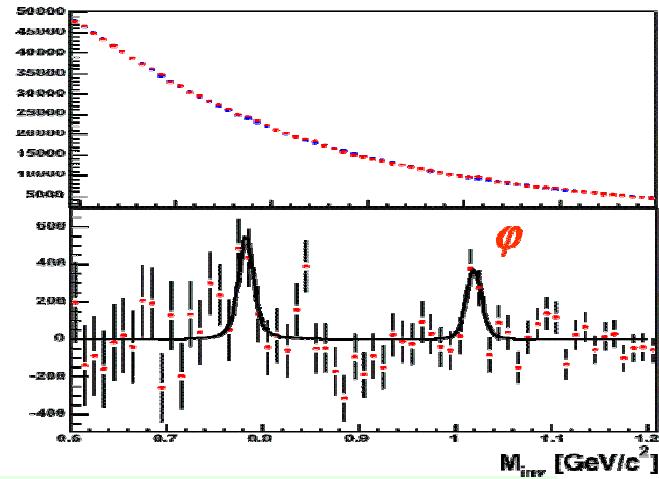
$$\varphi \rightarrow e^+e^-$$

$$BR = 49.2 \pm 0.7\%$$

$$BR = 2.97 \pm 0.04 \cdot 10^{-4}$$

 $\varphi \rightarrow K^+K^- d+Au \sqrt{s_{NN}}=200 \text{ GeV}$  $\varphi \rightarrow K^+K^- Au+Au \sqrt{s_{NN}}=200 \text{ GeV}$  $\varphi \rightarrow e^+e^- p+p \sqrt{s_{NN}}=200 \text{ GeV}$

Invariant mass at Minimum Bias

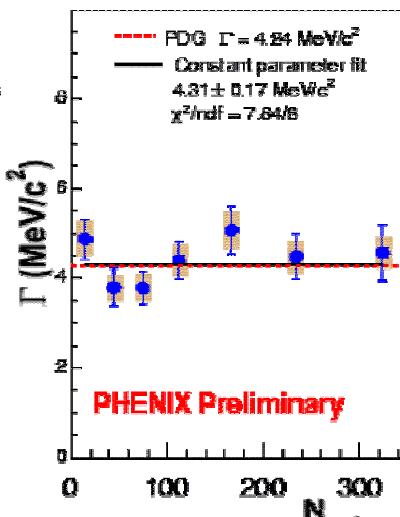
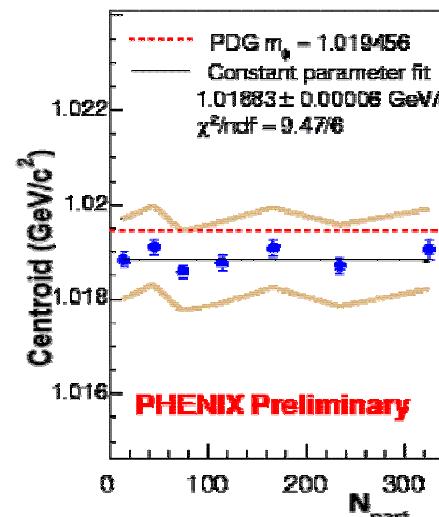
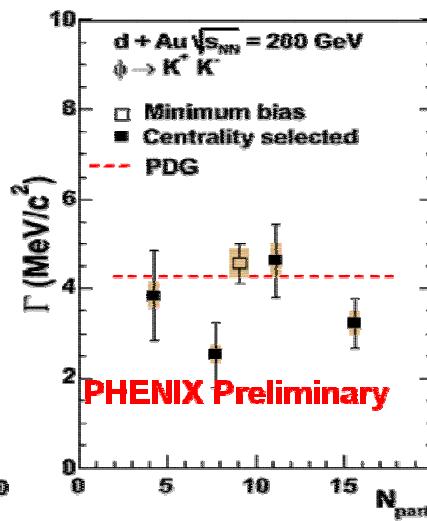
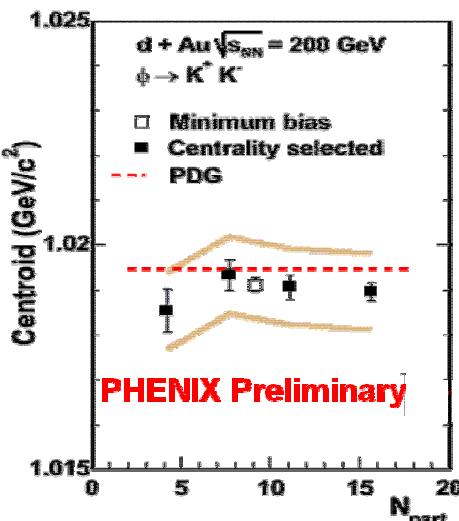
Invmass 74 d
Entries: 65335
Mean: 1.0241
RMS: 0.07349 $\varphi \rightarrow e^+e^- d+Au \sqrt{s_{NN}}=200 \text{ GeV}$  $\varphi \rightarrow e^+e^- Au+Au \sqrt{s_{NN}}=200 \text{ GeV}$ 

PHENIX measures clear signal of $\varphi \rightarrow K^+K^-$ in all collision systems
Measurement of $\varphi \rightarrow e^+e^-$ is complicated by combinatorial background

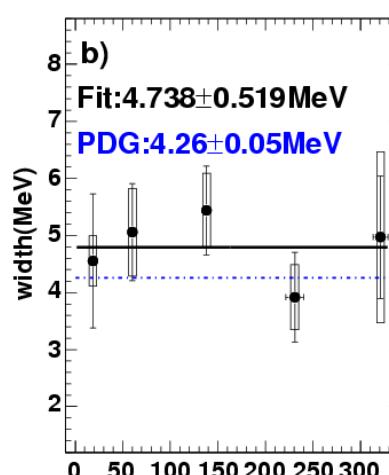
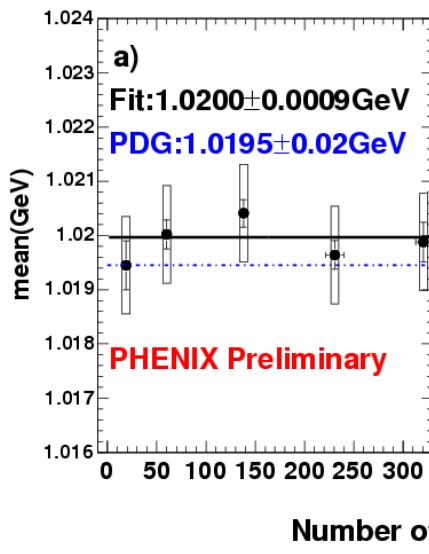
Line shape

d+Au $\sqrt{s_{NN}}=200$ GeV

Au+Au $\sqrt{s_{NN}}=200$ GeV

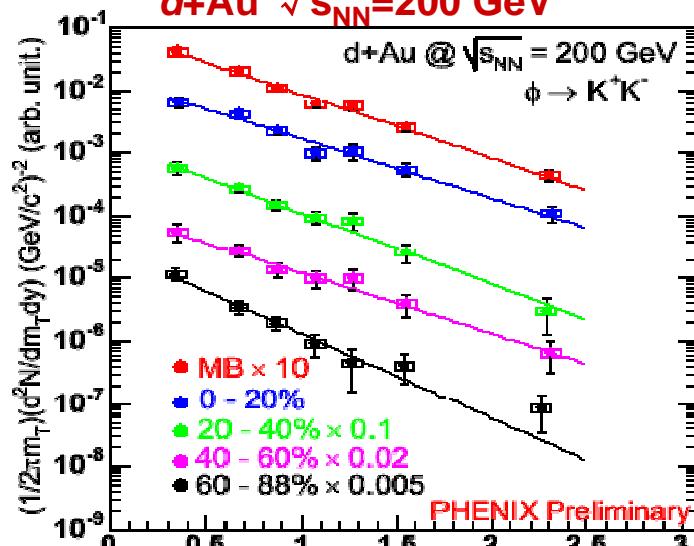


$\sqrt{s} = 62.4\text{GeV}$ Au + Au

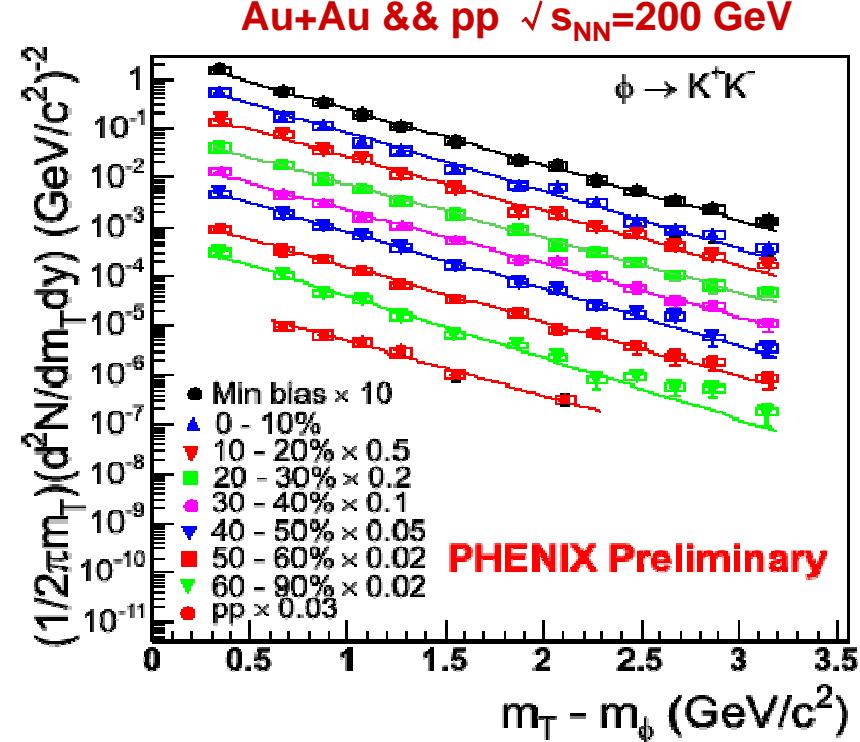
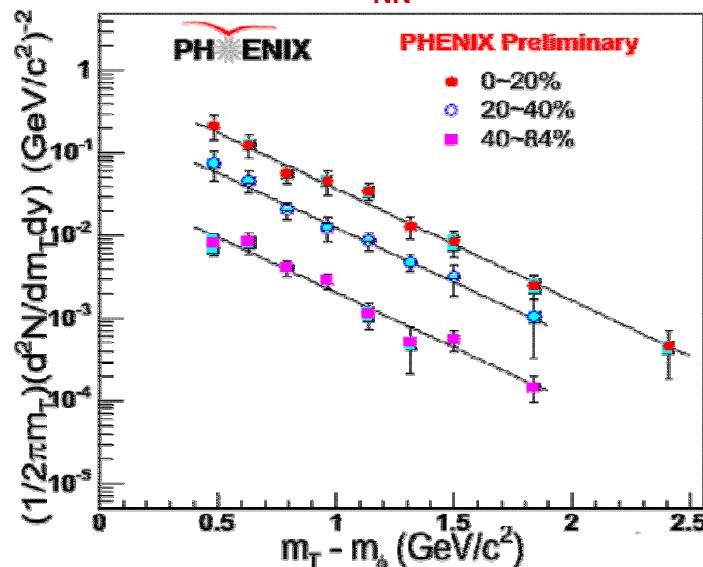


❖ The mass centroid and width of ϕ meson obtained by KK channel do not depend on centrality

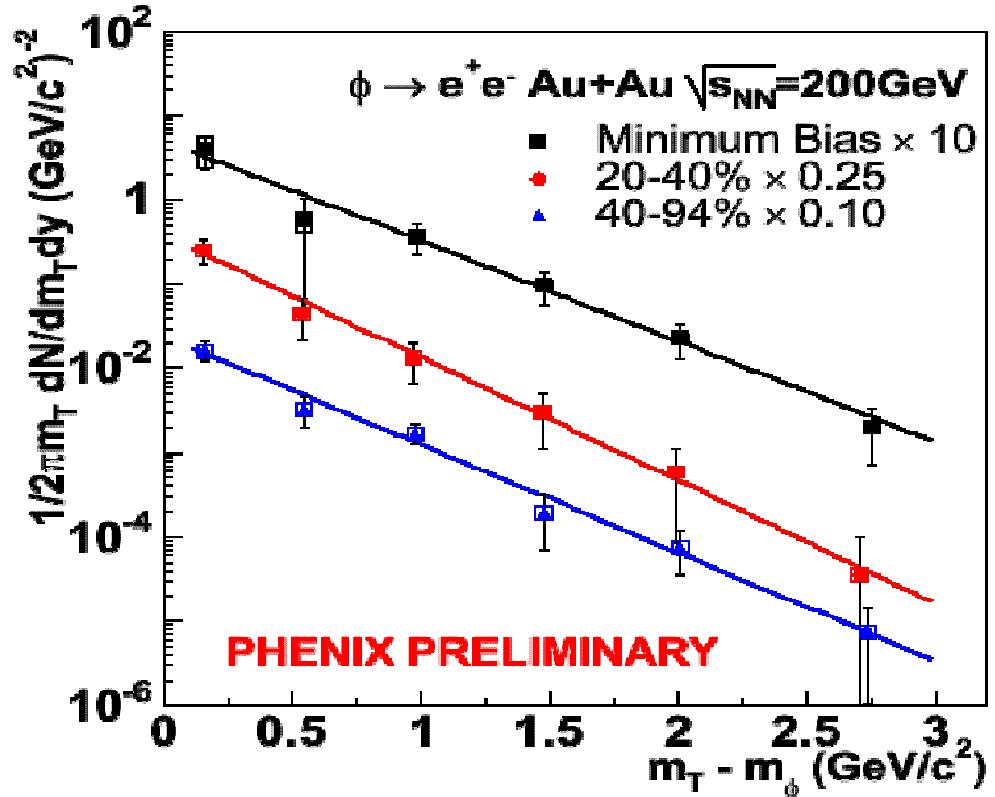
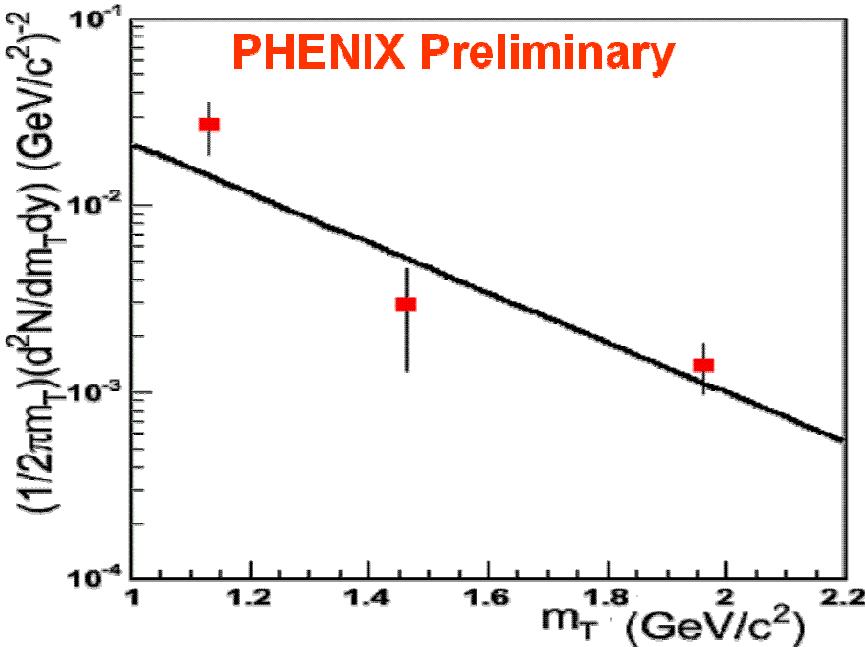
❖ All mass centroid and width in all systems show agreement with PDG



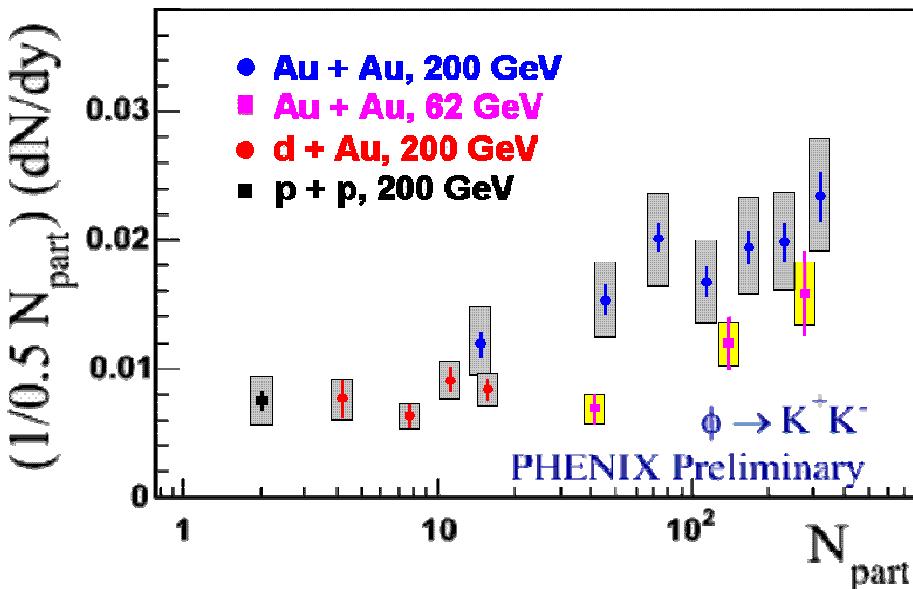
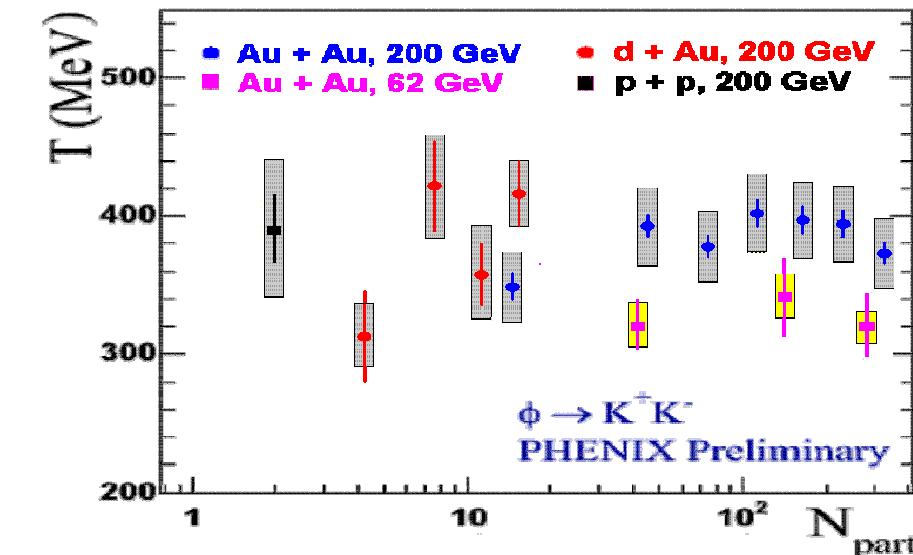
$Au+Au \sqrt{s_{NN}}=62 \text{ GeV}$



PHENIX has a complete set of measurement of $\phi \rightarrow K^+K^-$ with EMCal and TOF detectors

$\varphi \rightarrow e^+e^-$ Spectra $d+Au \sqrt{s_{NN}}=200 \text{ GeV}$ 

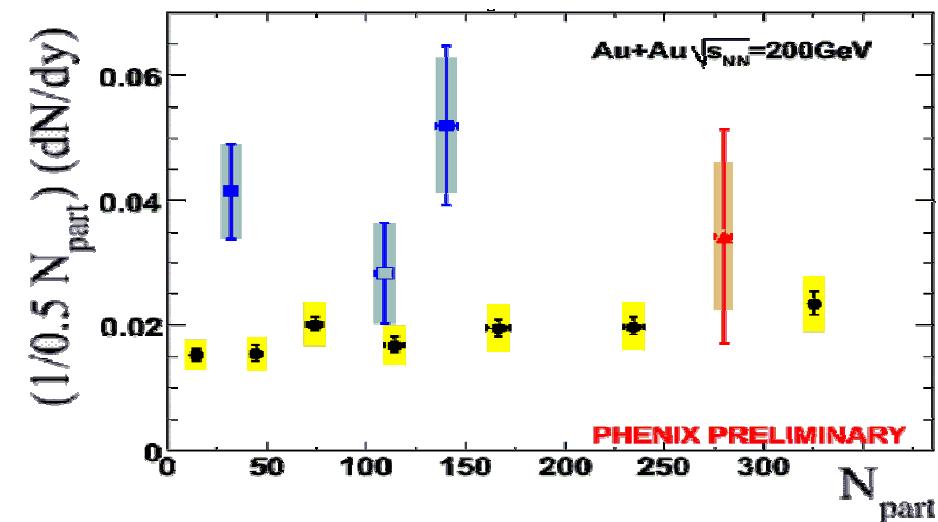
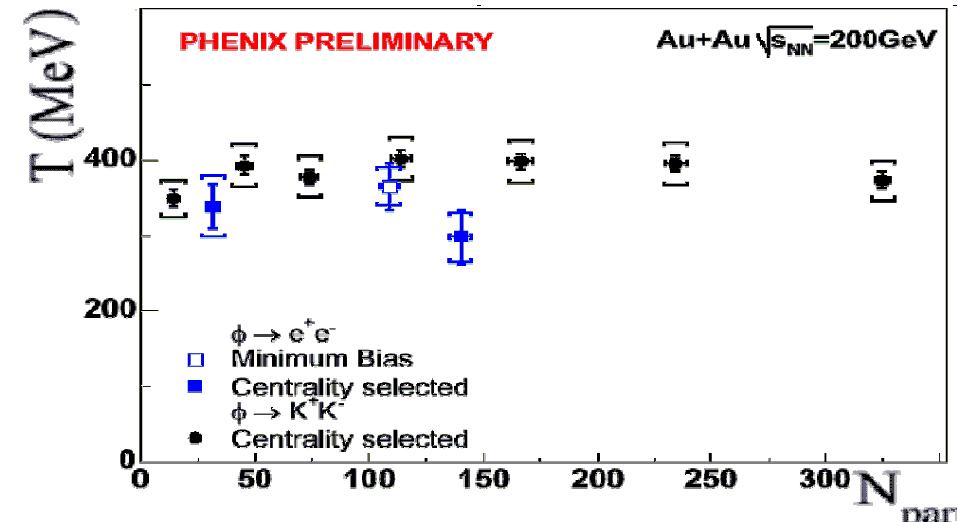
PHENIX also has a complete set of measurement of $\varphi \rightarrow e^+e^-$ with EMCal detectors



$$\frac{dN / dy}{2\pi(m_\phi + T)T} \exp(-m / T)$$

$$m = m_T - m_\phi$$

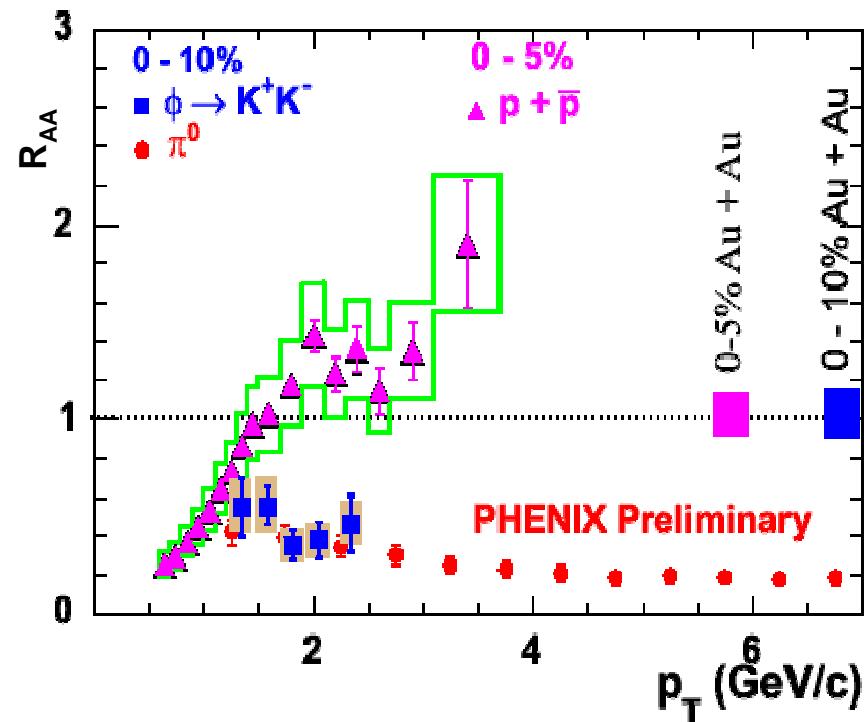
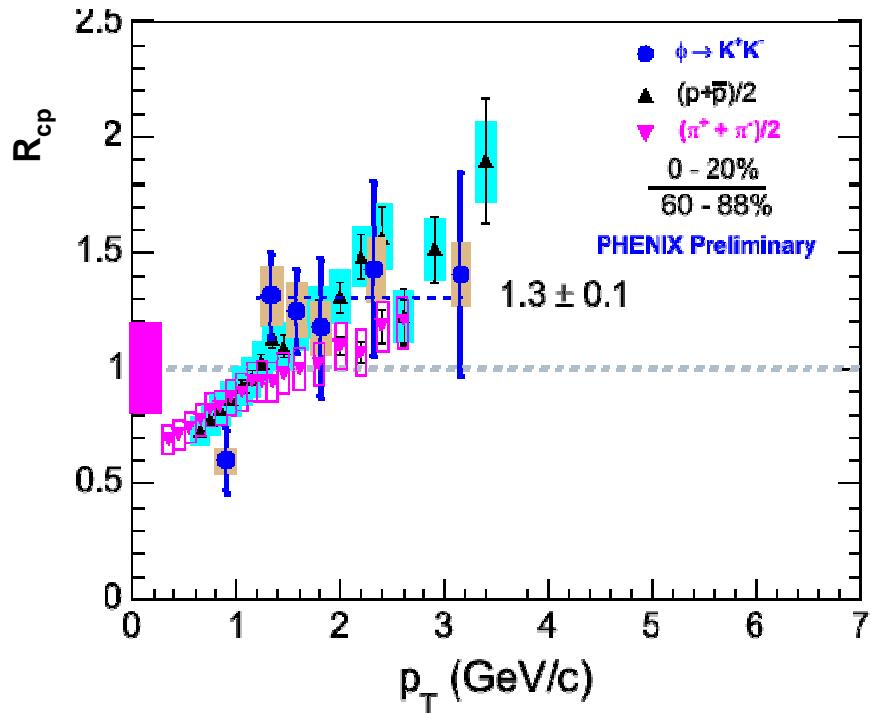
- Temperature slope and integral yield are obtained from m_T exponential function
- T obtained by hadronic channel is approximately constant with N_{part} at $\sqrt{s_{\text{NN}}} = 62, 200 \text{ GeV}$
- Yield grows both with $\sqrt{s_{\text{NN}}}$ and N_{part}



✓ The temperature measured from leptonic channel is almost consistent with the hadronic channel

✓ The leptonic channel's yield is a little higher than hadronic channel.

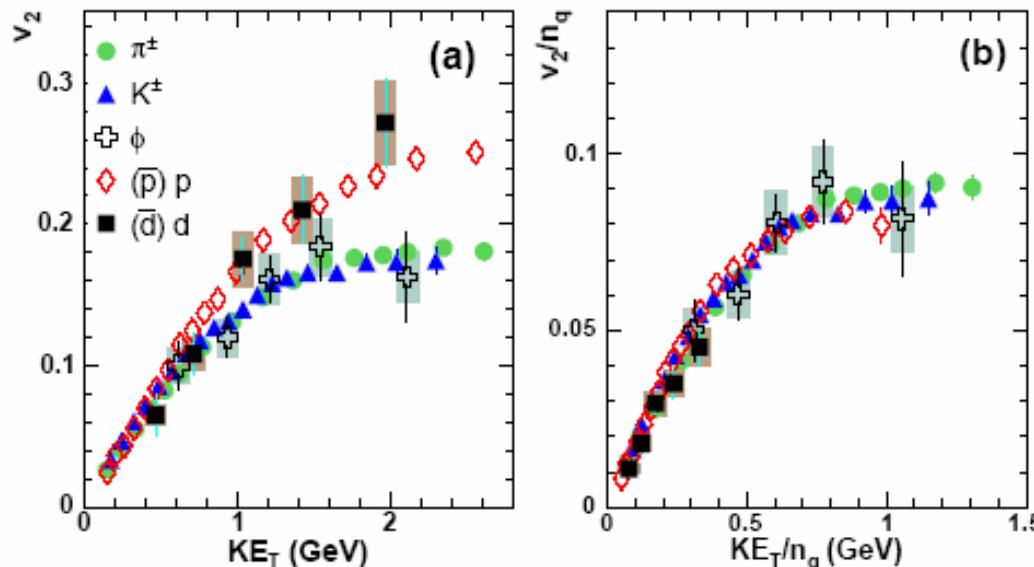
✓ More accurate measurement is required to confirm whether there is branch ratio modification



- R_{dA} from ϕ mesons are around 1.3 ± 0.1
- The R_{AA} for ϕ mesons close to the π meson while not the proton. It indicates that the baryon abnormal in intermediate p_T is related to the number of constituent quark while not particle mass

Elliptic flow v_2

Au+Au $\sqrt{s_{NN}}=200$ GeV



PHENIX,nucl-ex/0703024

$$kE_T = m_T \cdot m$$

N_q : number of constituent quark

❖ The elliptic flow of ϕ meson has been obtained by hadronic channel. The results follow the number of constituent quarks scaling at 200GeV AuAu collisions.

❖ The interesting leptonic channel results will be obtained in the future.



Conclusion

PHENIX has measured the ϕ production by hadronic and leptonic channels from pp, dAu to AuAu.

❖ Hadronic channel:

- 1) The mass centroid and width of ϕ are consistent with PDG value from pp, dAu to AuAu.
- 2) The $dN/dy/N_{\text{part}}$ grows with collision energy and centrality while temperature slope are kept constant
- 3) The nuclear modification and elliptic flow of phi meson indicate the particle production are mainly from constituent quark recombination at intermediate p_T in 200 GeV Au+Au collisions

❖ Leptonic channel:

Preliminary dN/dy in e^+e^- decay channel at low p_T is higher than the dN/dy from K^+K^- channel. Current measurements need improvement on the background conditions and more data.



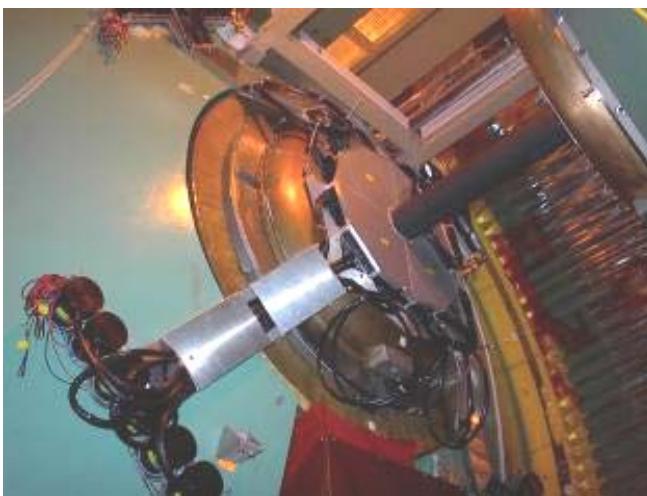
Upgrade of PHENIX



HBD: Suppress background level by a factor of ~ 100 in $\phi \rightarrow ee$ measurements



TOFw: More statistics of ϕ meson at intermediate and high pT



RxNP: The reaction plane resolution will be enhanced to 70%

- University of São Paulo, São Paulo, Brazil
- Academia Sinica, Taipei 11529, China
- China Institute of Atomic Energy (CIAE), Beijing, P. R. China

- Peking University, Beijing, P. R. China
- Charles University, Faculty of Mathematics and Physics, Ke Karlovu 3, 12116 Prague, Czech Republic
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- Banaras Hindu University, Banaras, India
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- System Electronics Laboratory, Seoul National University, Seoul, South Korea
- Yonsei University, Seoul 120-749, Korea
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- Joint Institute for Nuclear Research (JINR-Dubna), Dubna, Russia
- Kurchatov Institute, Moscow, Russia
- PNPI, Petersburg Nuclear Physics Institute, Gatchina, Leningrad region, 188300, Russia
- Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Vorob'evy Gory, Moscow 119992, Russia
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