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

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for the PHENIX Collaboration

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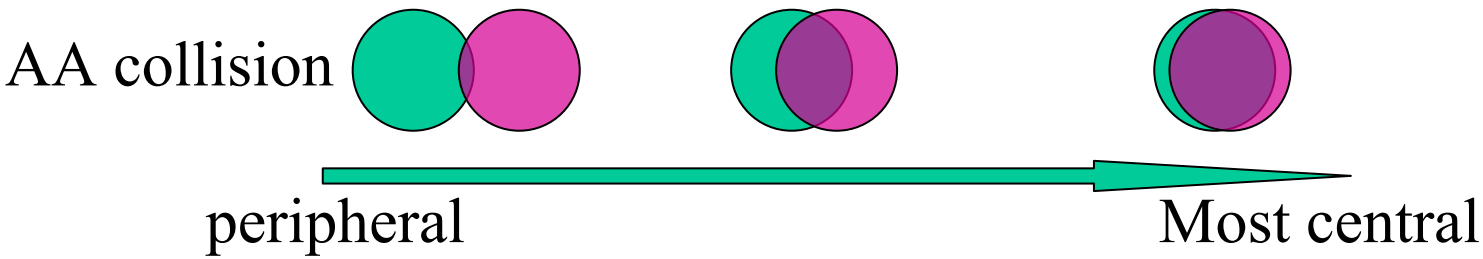
PHENIX

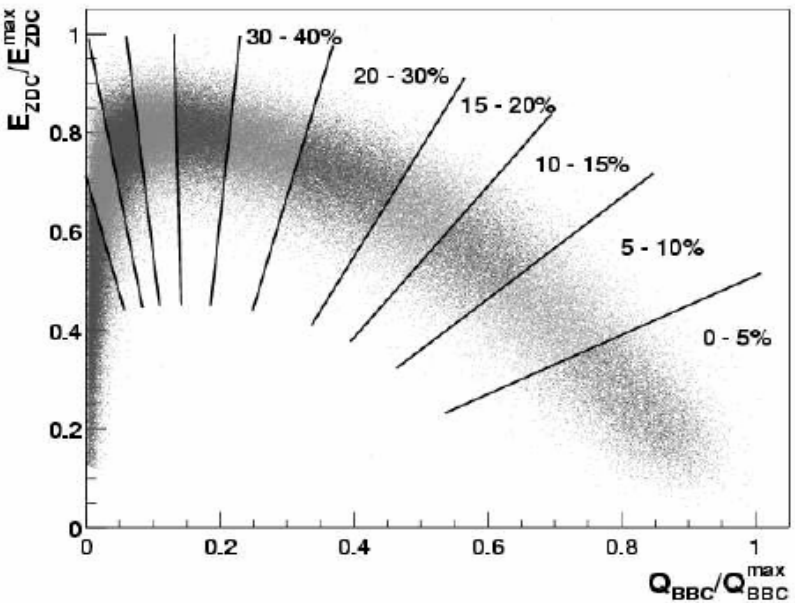
Outline

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

Centrality and Nuclear modification factor



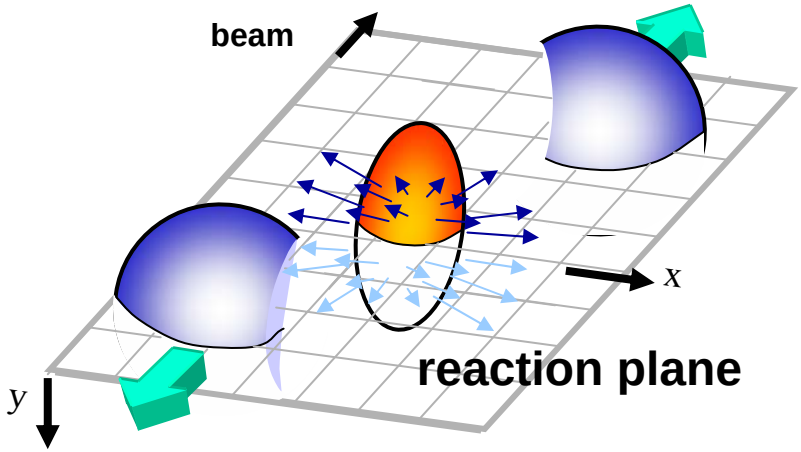
Centrality definition in PHENIX

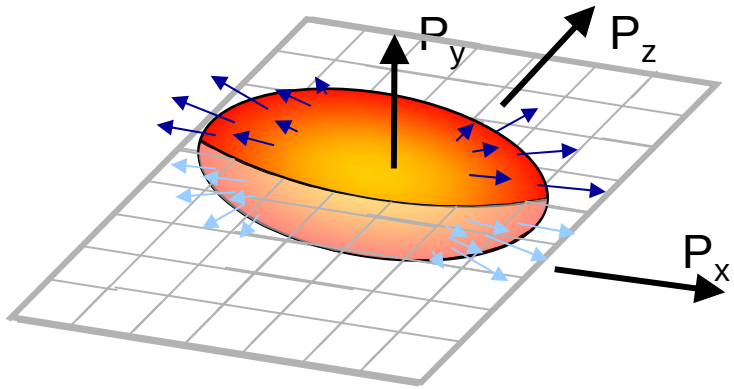


- N_{part} (number of participants): Number of incoming nucleons which in the overlap regions
- N_{coll} (number of binary collisions): Number of inelastic nucleon + nucleon collisions
- Nuclear modification factor:

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

Elliptic flow: v_2





Spatial space asymmetry → momentum space asymmetry

pressure gradient

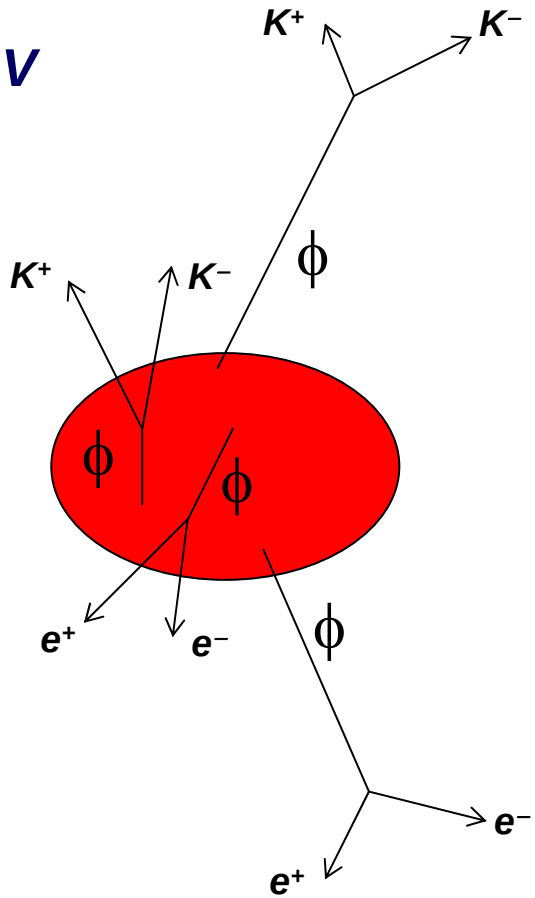
$$E\frac{d^3N}{d^3p} = \frac{1}{\pi}d^2\frac{N}{dp_T^2dy}\left[1+2v_1\cos(\varphi-\Psi_R)+2v_2(2[\varphi-\Psi_R])+\ldots\right]$$

$$v_2 = \left\langle\cos(2[\varphi-\Psi_R])\right\rangle$$

Elliptic flow(v_2) :a measure of anisotropic magnitude in the momentum space

A golden probe

- ***The lightest ($s\bar{s}$) vector meson mass~1.019GeV***
- ***Life time τ ~ 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

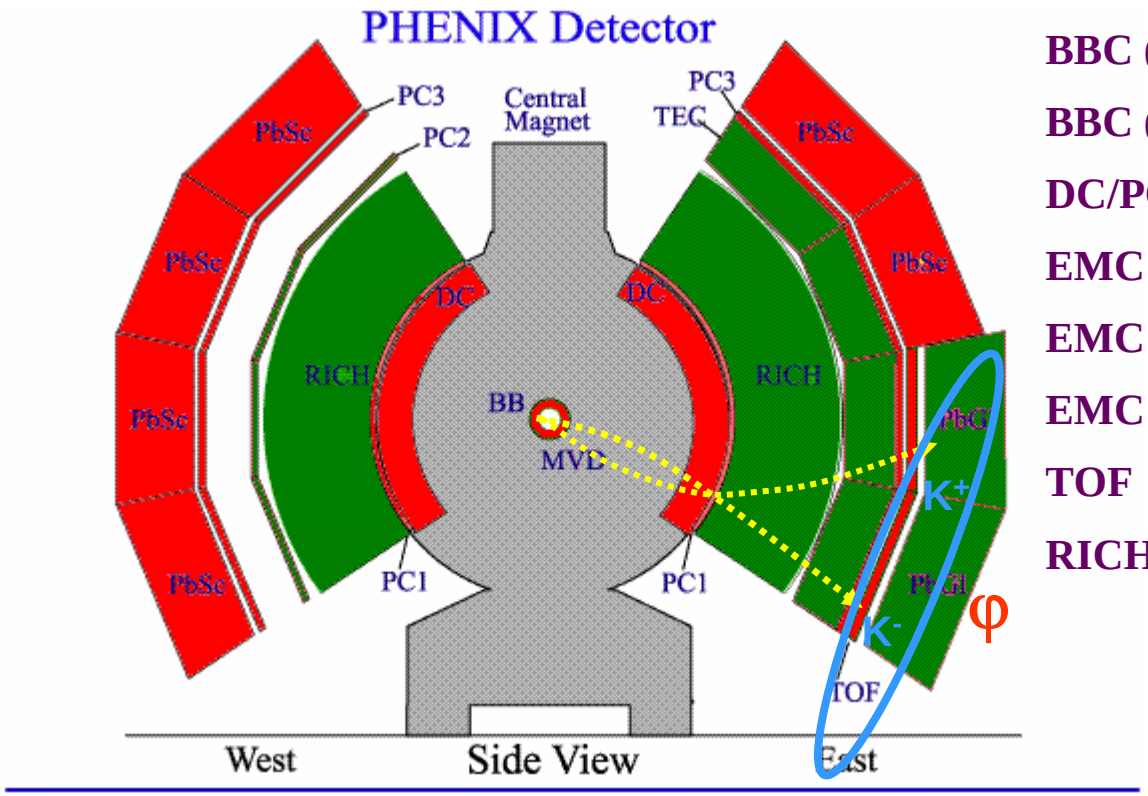
At intermediate p_T (decay outside medium):

Medium dynamics and particle productions

✓Nuclear modification factor

✓Elliptic flow v_2

PHENIX Experiment



BBC (vertex)	dz = 0.5cm… 2cm
BBC (trigger)	ε = 50%… 92%
DC/PC1 (tracking)	$dp_T/p_T \sim 1.0\% \cdot p_T + 0.7\%$
EMC (calorimetric)	$dE/E \sim 8.1\%/\sqrt{E} + 3.0\%$
EMC (t.o.f.)	$d\tau \sim 500$ ns
EMC (e/π rejection)	~10
TOF	$d\tau < 100$ ns
RICH (e/π rejection)	>1000

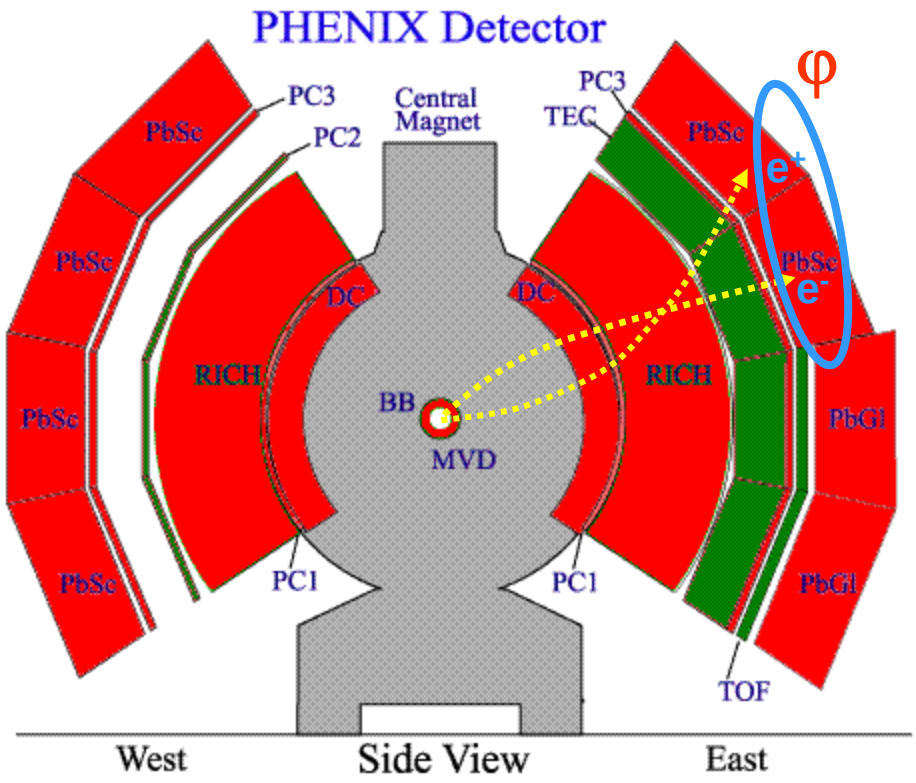
PHENIX acceptance :

$-0.35 < \eta < 0.35$

2×90^o for two arms

$\varphi \rightarrow K^+K^-$	BR = 49.2 ± 0.7%
$\varphi \rightarrow e^+e^-$	BR = 2.97 ± 0.04 10^{-4}

PHENIX Experiment



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φ - meson measurements

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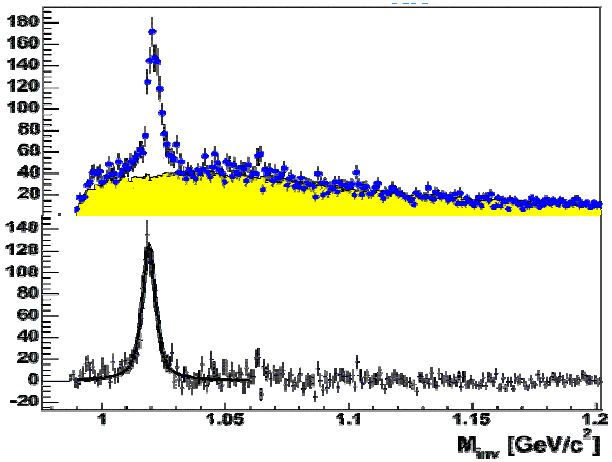
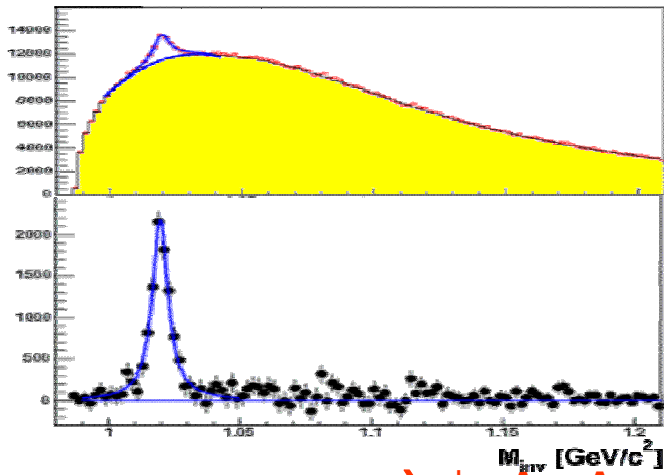
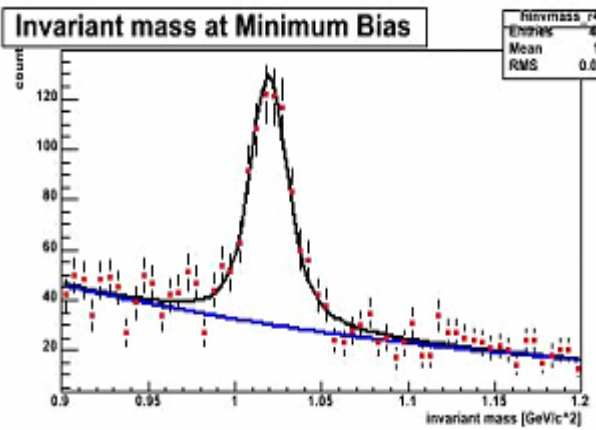
$\varphi \rightarrow K^+K^-$ d+Au $\sqrt{s_{NN}}$=200 GeV



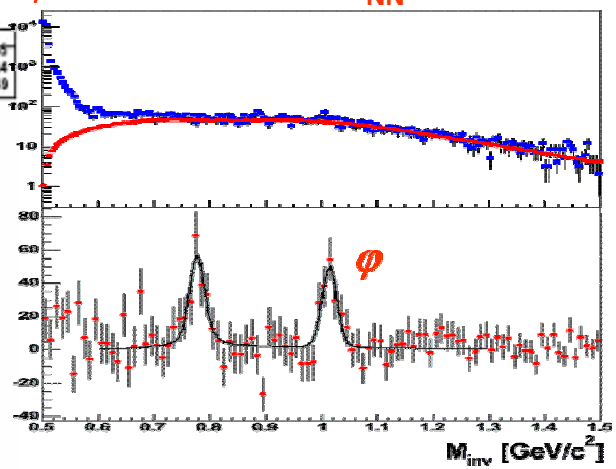
$\varphi \rightarrow K^+K^-$ Au+Au $\sqrt{s_{NN}}$=200 GeV



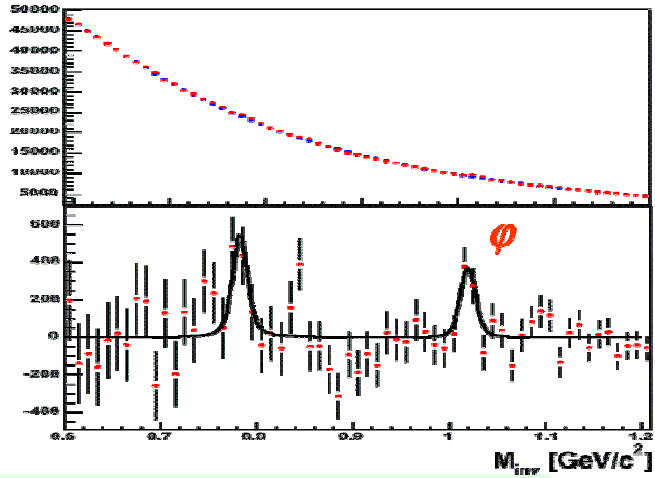
$\varphi \rightarrow e^+e^-$ p+p $\sqrt{s_{NN}}$=200 GeV



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



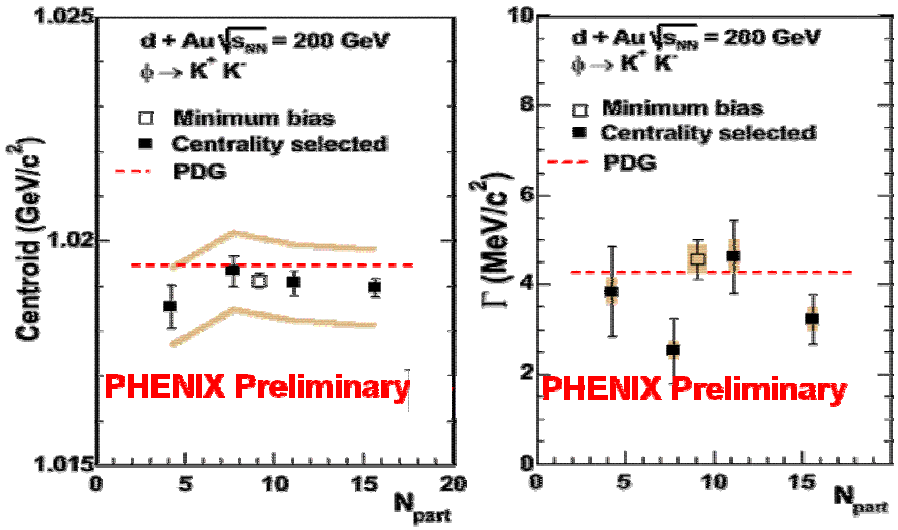
$\varphi \rightarrow e^+e^-$ Au+Au $\sqrt{s_{NN}}$=200 GeV



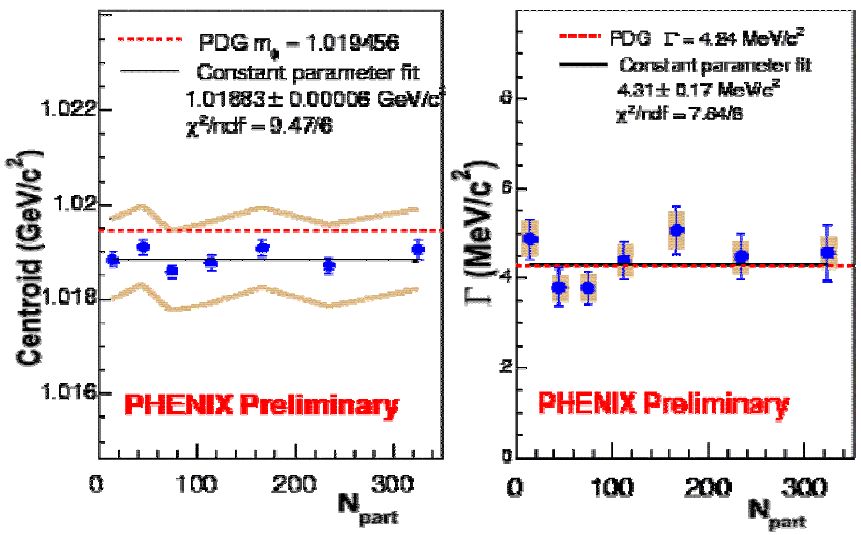
PHENIX measures clear signal of φ→K^+K^- in all collision systems
Measurement of φ→e^+e^- is complicated by combinatorial background

Mass Centroid and Width

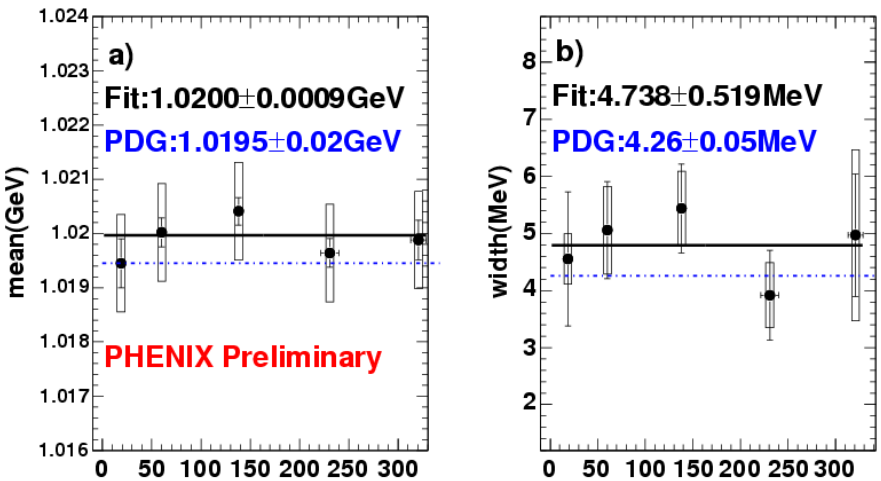
d+Au $\sqrt{s_{NN}}$=200 GeV



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



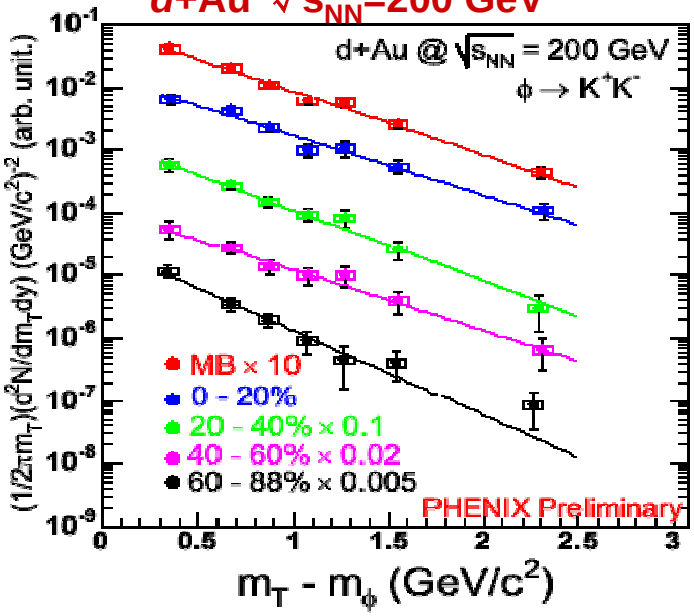
$\sqrt{s}$ = 62.4GeV Au + Au



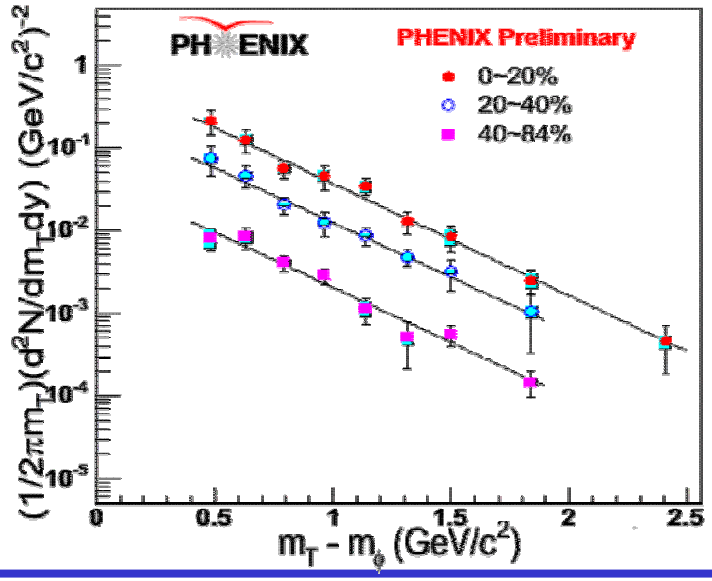
- The mass centroid and width of φ meson obtained by KK channel do not depend on centrality
- All mass centroid and width in all systems show agreement with PDG

$\phi \rightarrow K^+K^-$ Spectra

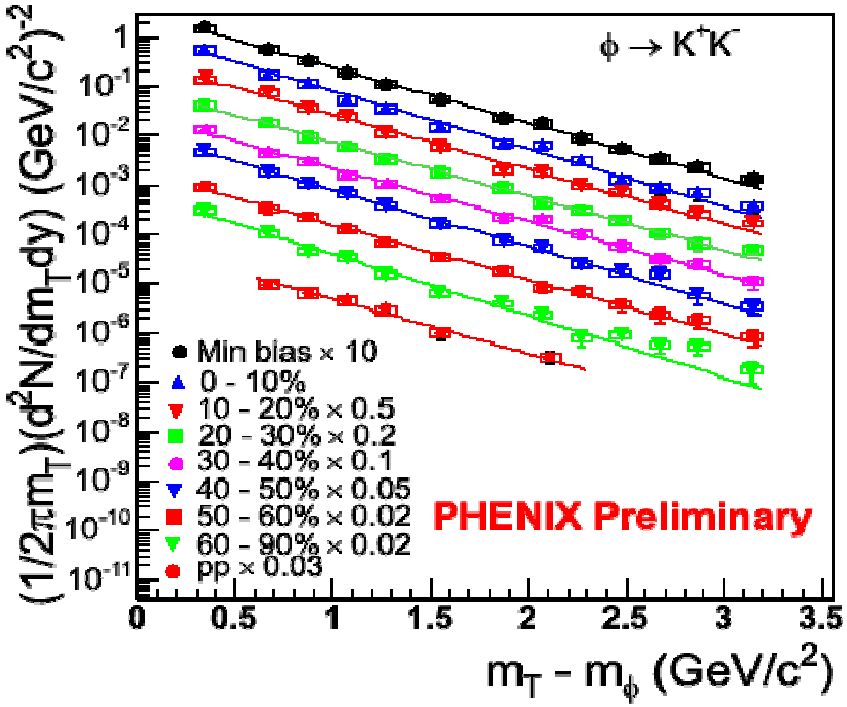
d+Au $\sqrt{s_{NN}}$=200 GeV



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



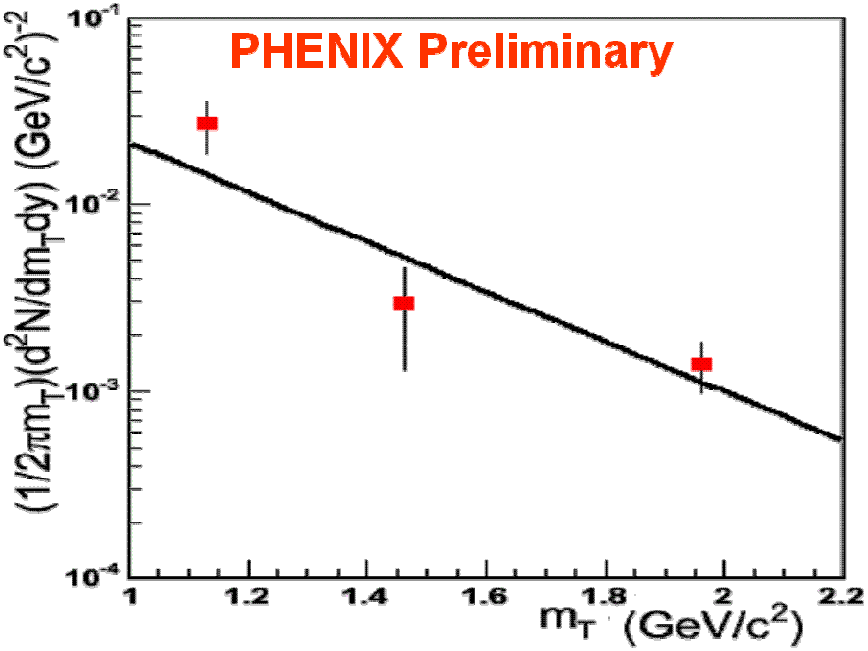
Au+Au && pp $\sqrt{s_{NN}}$=200 GeV

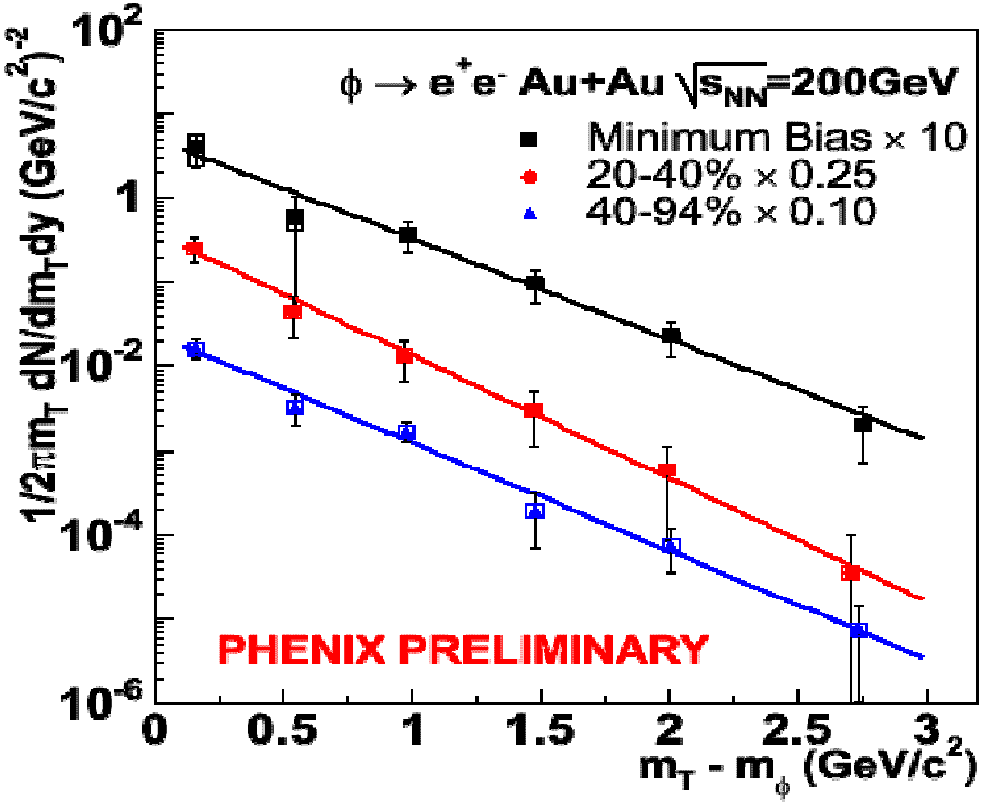


PHENIX has a complete set of measurement of $\phi \rightarrow K^+K^-$ with EMCal and TOF detectors

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

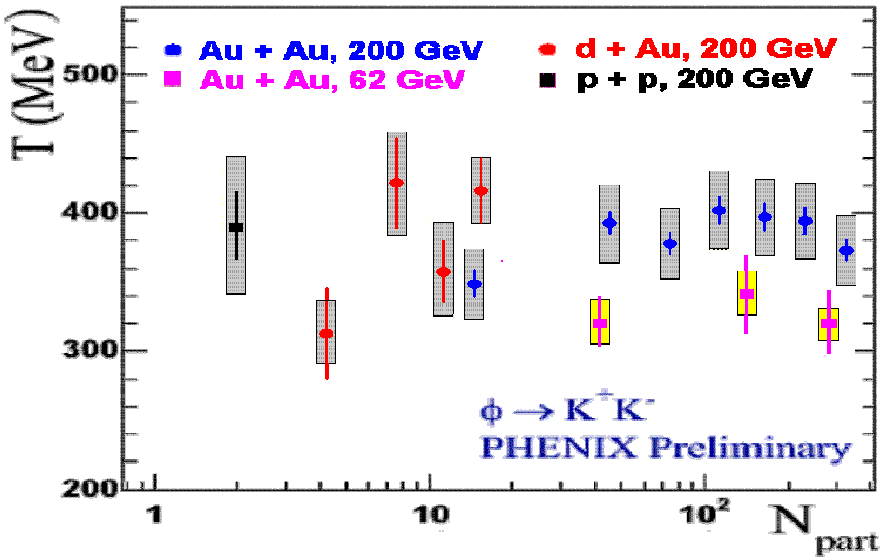
d+Au $\sqrt{s_{NN}}$=200 GeV

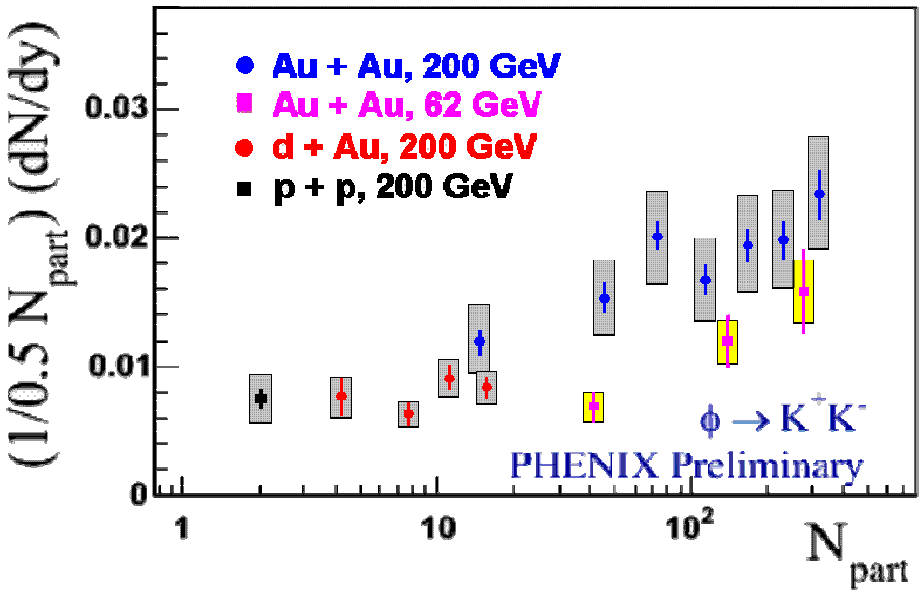




PHENIX also has a complete set of measurement of $\varphi \rightarrow e^+e^-$ with EMCal detectors

Yield and Temperature (I)



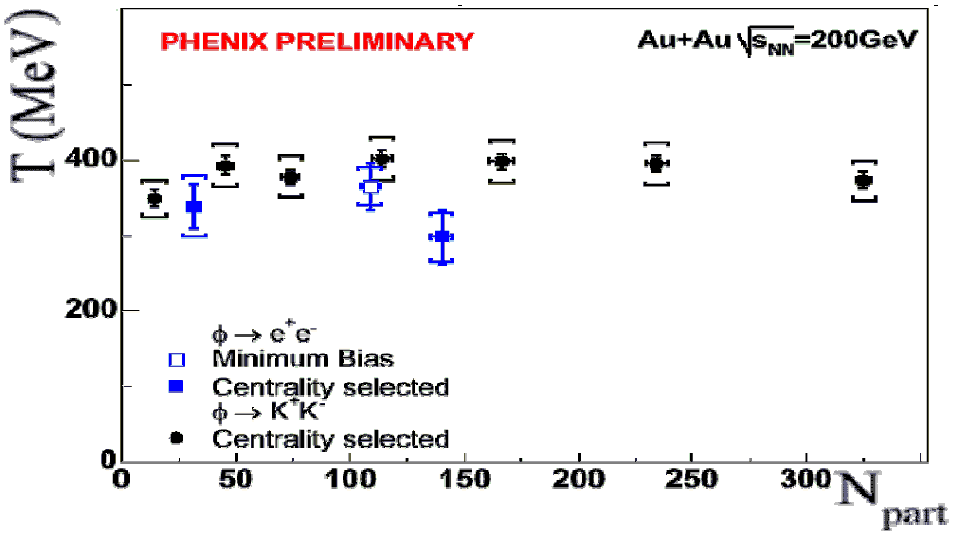


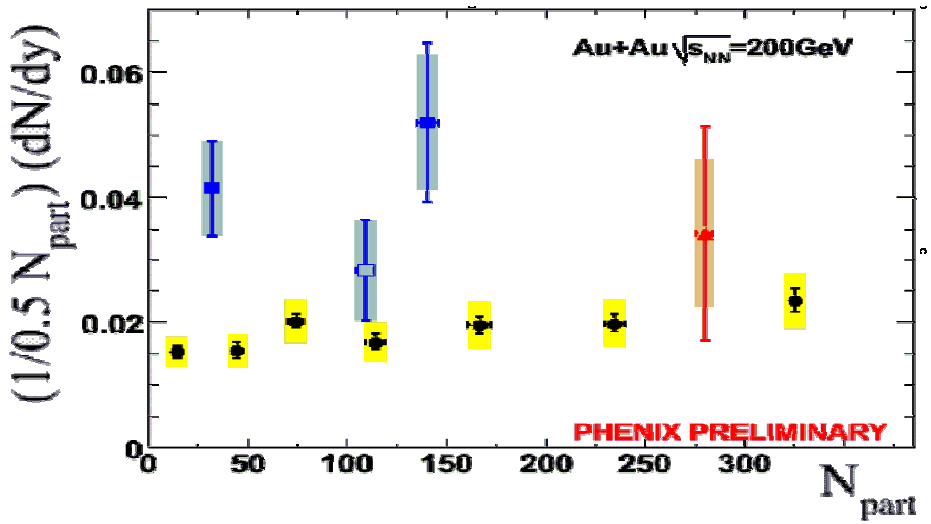
$$\frac{dN/dy}{2\pi(m_\phi + T)T}\exp(-m/T)$$

$$m = m_T - m_\phi$$

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

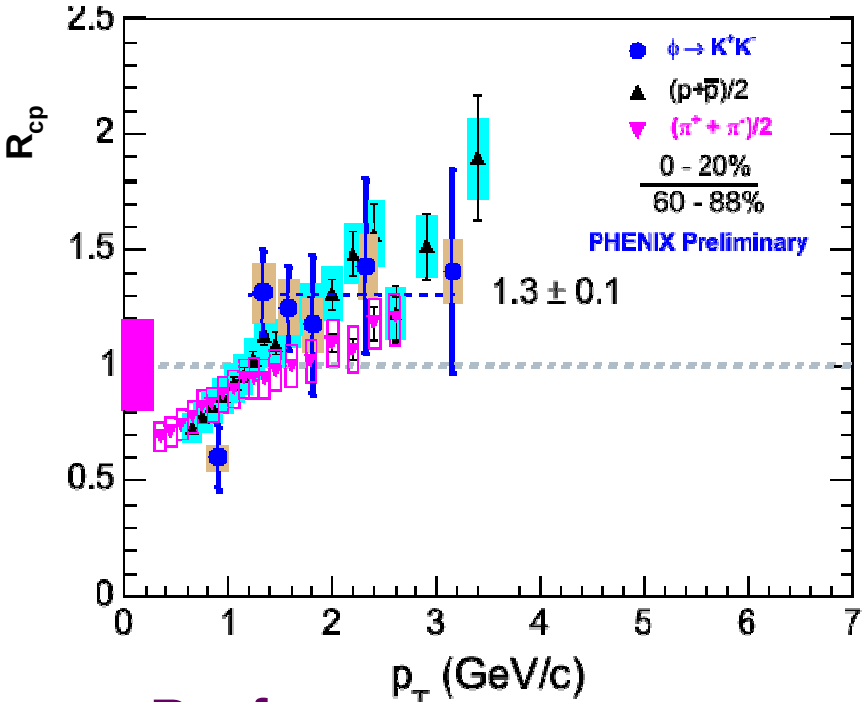
Yield and Temperature (II)

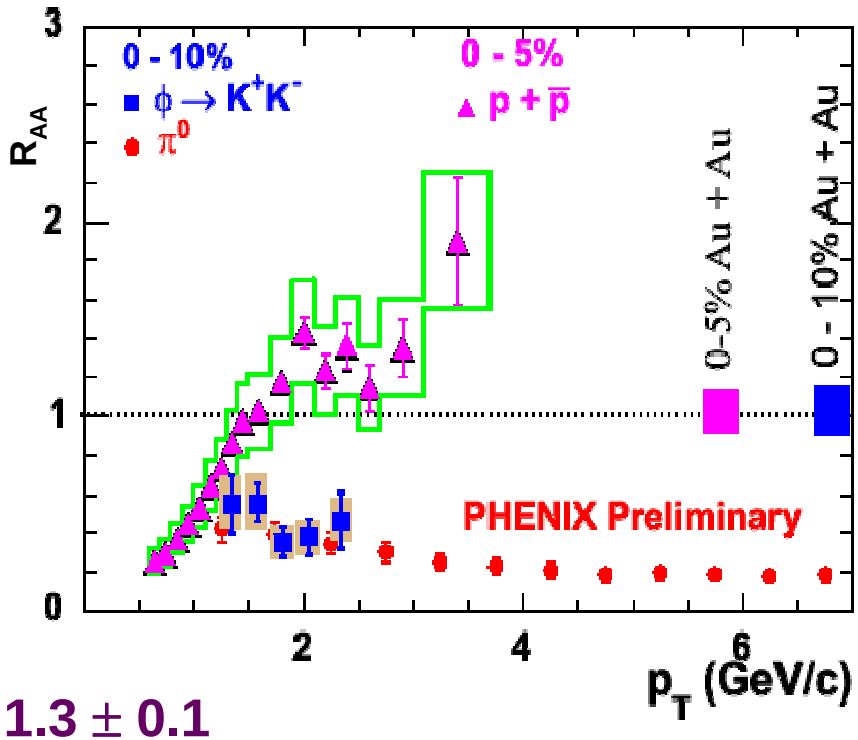




- ✓The temperature measured from leptonic channel is almost consistent with the hadronic channel
- ✓The leptonic channel's yield is a little higher than hadronic channel.
- ✓More accurate measurement is required to confirm whether there is branch ratio modification

Nuclear modification factor

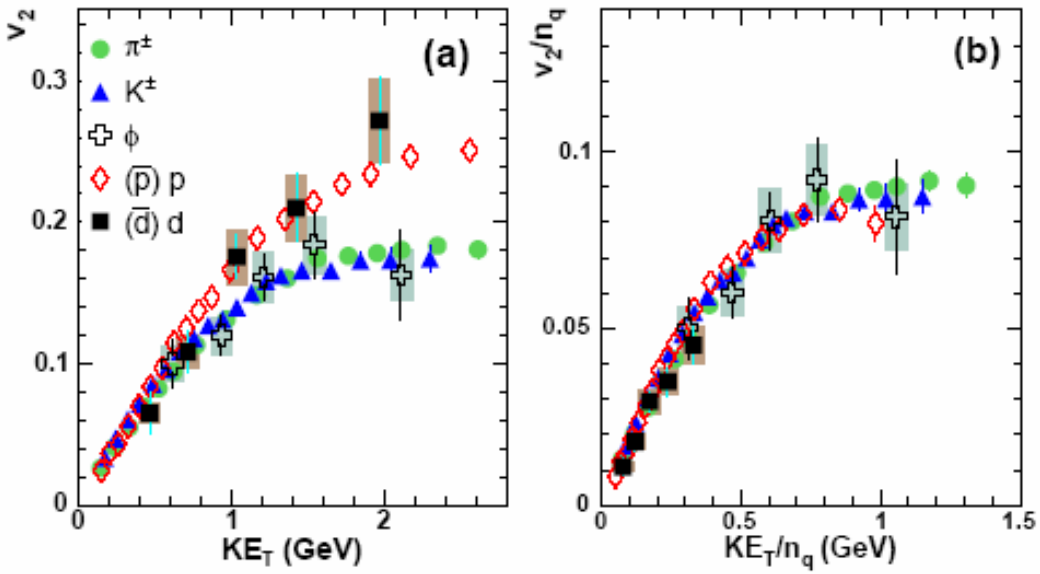




- R_{dA} from φ mesons are around 1.3 ± 0.1
- In AuAu collisions, the proton R_{AA} is large difference with pion in the intermediate p_T
- The R_{AA} for φ mesons close to the π meson while not the proton. It indicates that the baryon abnormal in intermediate p_T is related to the number of constituent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

Elliptic flow v_2

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



PHENIX,nucl-ex/0703024

$kE_T = m_T - m$

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 in 200GeV Au+Au 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 $dN/dy/N_{part}$ 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 φ->ee measurements

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

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

PHENIX

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