Low mass dilepton production at RHIC energies

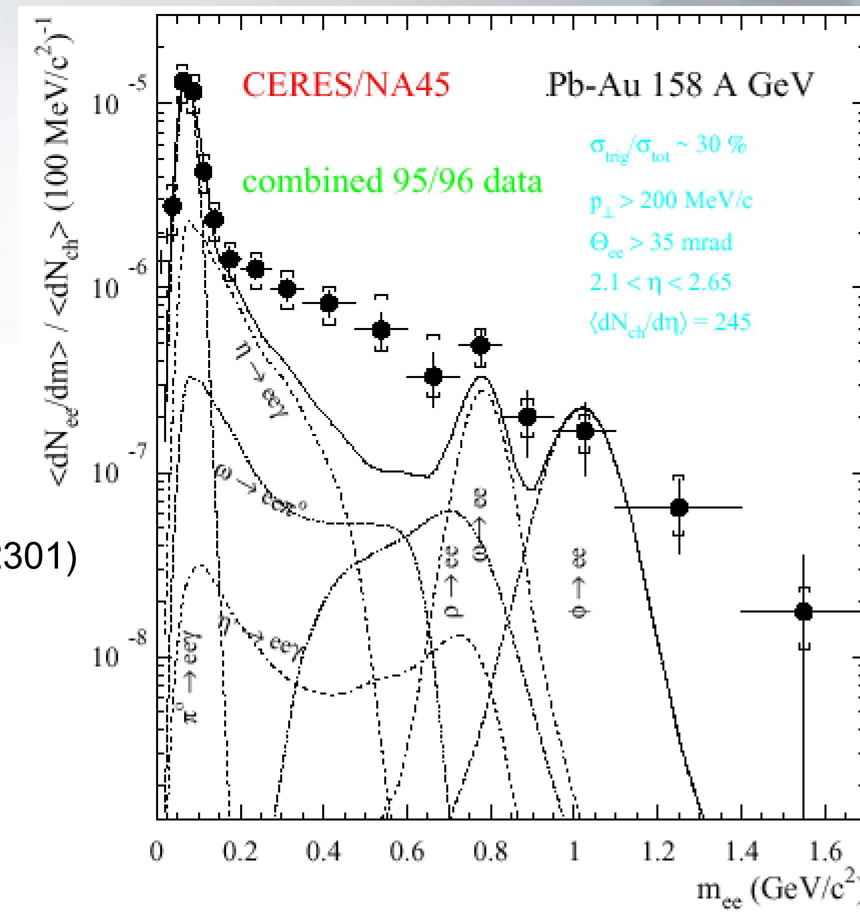
K. Ozawa for the PHENIX collaboration

Missing information at RHIC

- Contents of my talk

- Chiral symmetry restoration
  - Low mass vector mesons
- Thermal radiation
  - Dilepton continuum

CERES shows enhanced dilepton spectrum



At RHIC,

$\rho \to \pi^+\pi^-$ at STAR (Phys. Rev. Lett. 92, 092301)

$\phi \to K^+K^-$ at PHENIX (nucl-ex/0410012)

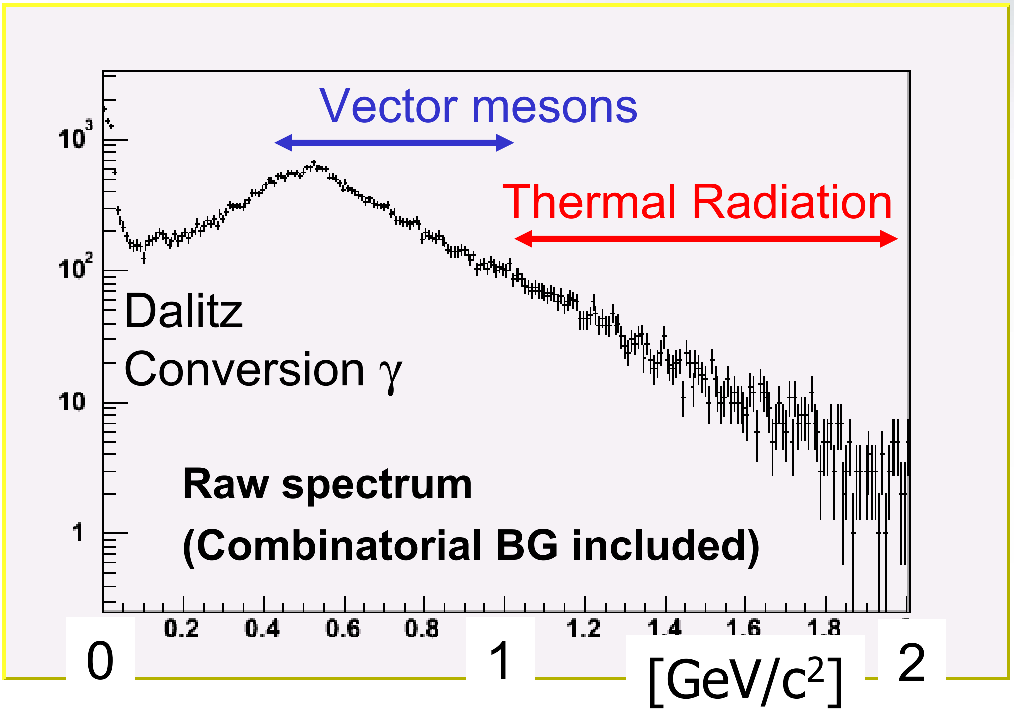
STAR (nucl-ex/0406003)

Dilepton spectrum is needed.

PHENIX is designed to carry out such measurements.

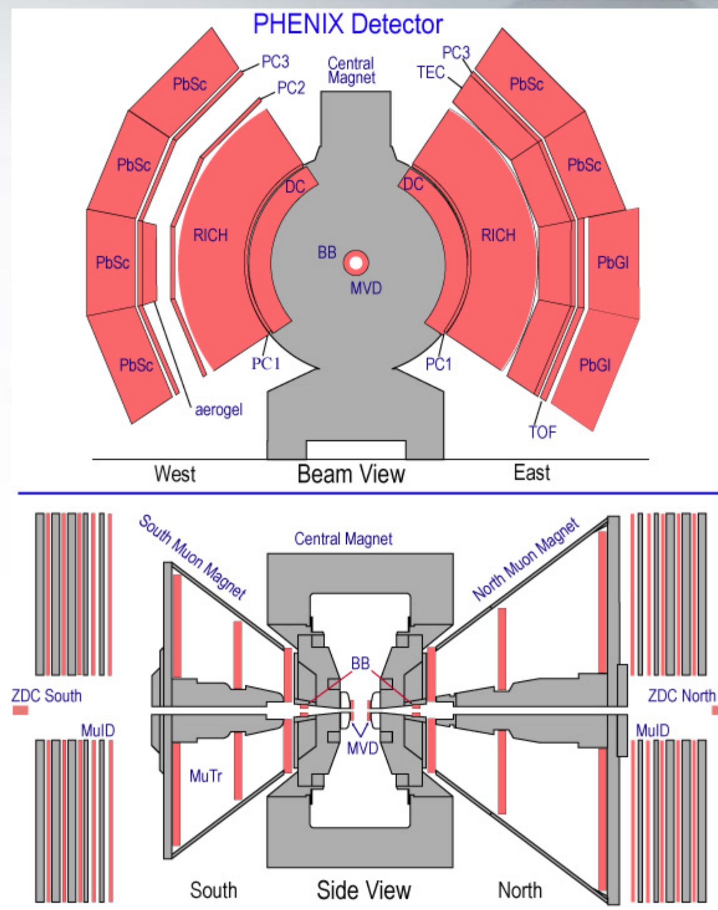
Current results are shown in this talk.

PHENIX experiment



Invariant mass spectrum of e^+e^- in PHENIX

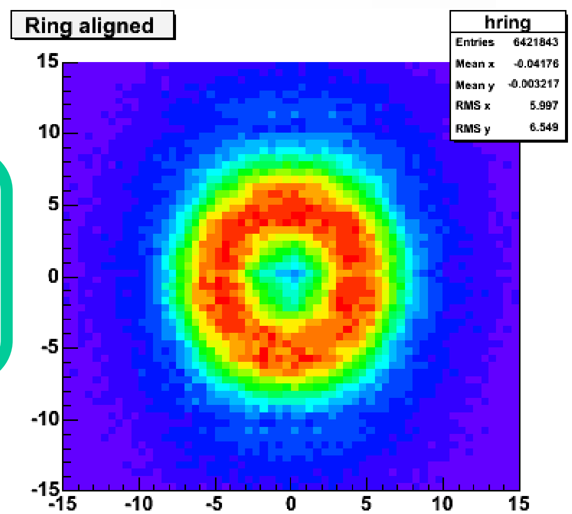
PHENIX can measure electrons in central region and muons in forward region.



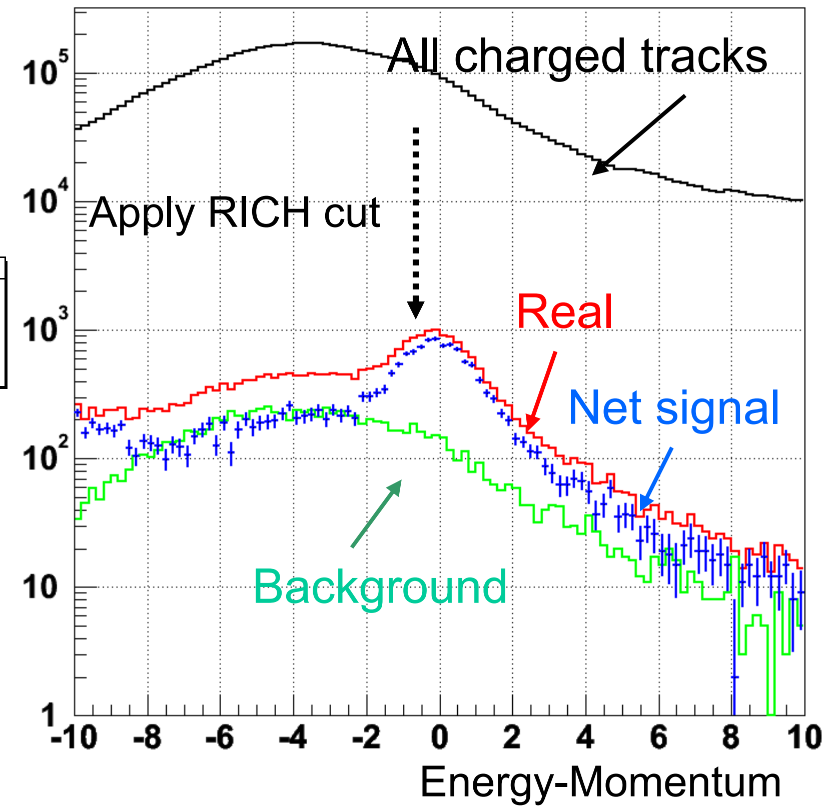
Electron measurement in PHENIX

- PHENIX achieved good electron measurements.
  - Single electron measurements show **charm production yield**.
- Electron identification is done by RICH and Energy-Momentum matching

Acceptance
$|y| < 0.35$
$p_T > 0.2$ GeV/c



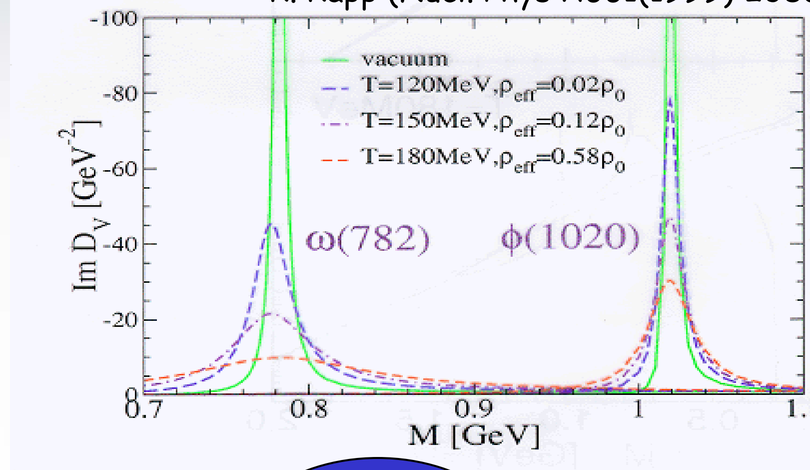
RICH ring shape

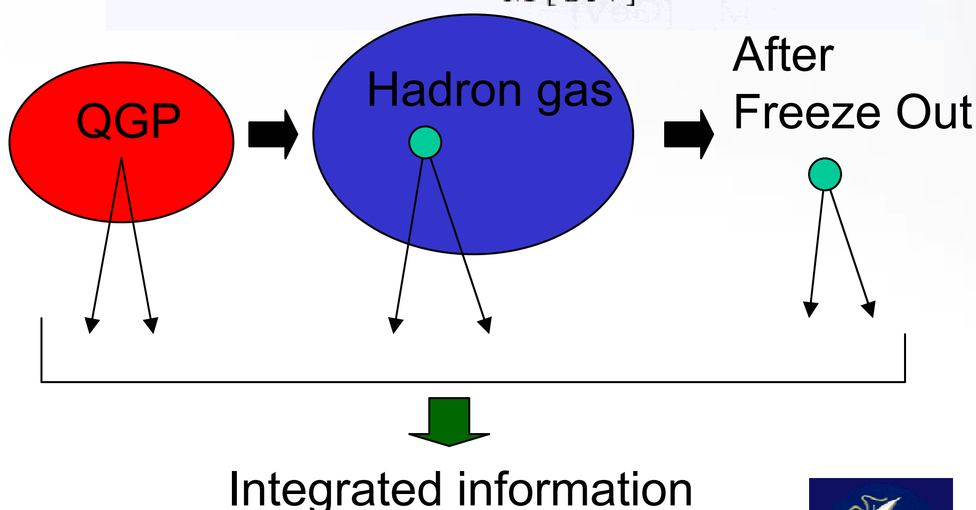


Chiral Symmetry in Hadronic matter

- As a signal of chiral symmetry restoration
  - Measure vector mesons
  - Mass shift or modification is expected
- Lepton decays become good probes
  - Not interacting "strongly."
  - However, we can see integrated information from all stages of collisions.
    - QGP, Mixed, Hadron gas
- Other baseline measurements are important.

R. Rapp (Nucl. Phys A661(1999) 238c





Observables in vector meson measurements

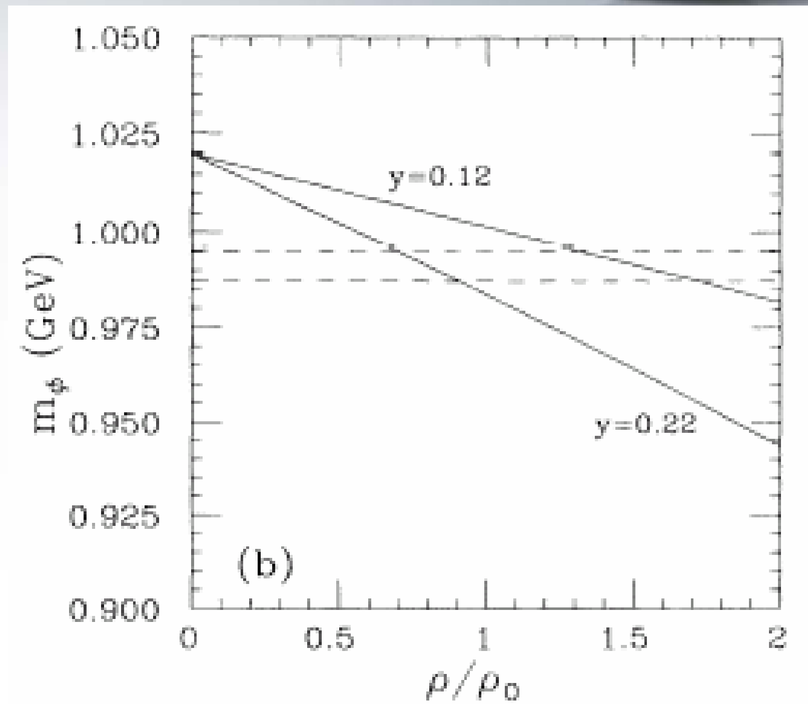
- Line shape
  - Direct measurements
- Yield
  - Q value of $\phi \to KK$ is small

$$\frac{BR(\phi \to ee)}{BR(\phi \to KK)}$$

  - Should be sensitive to mass changes in either ϕ or K

Lissauer and Shuryak, Phys. Lett. **B253**, 15 (1991).

- pT slope
  - Difference between hadron decays and lepton decays
  - It could show the difference of collision stage.



T.Hatsuda and S.Lee

(Phys.Rev.C46-R34-38, 1992)

Experimental techniques

Line Shapes
Yield
pT slope

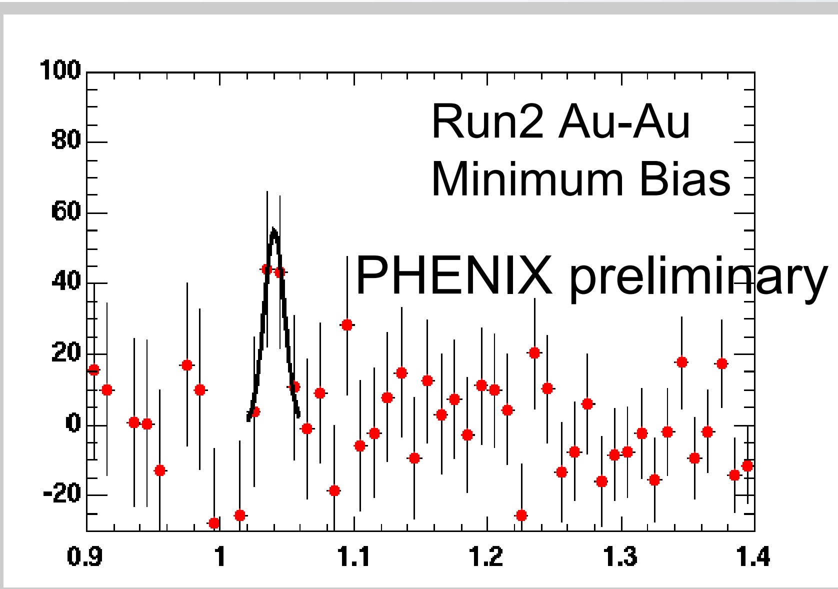
X

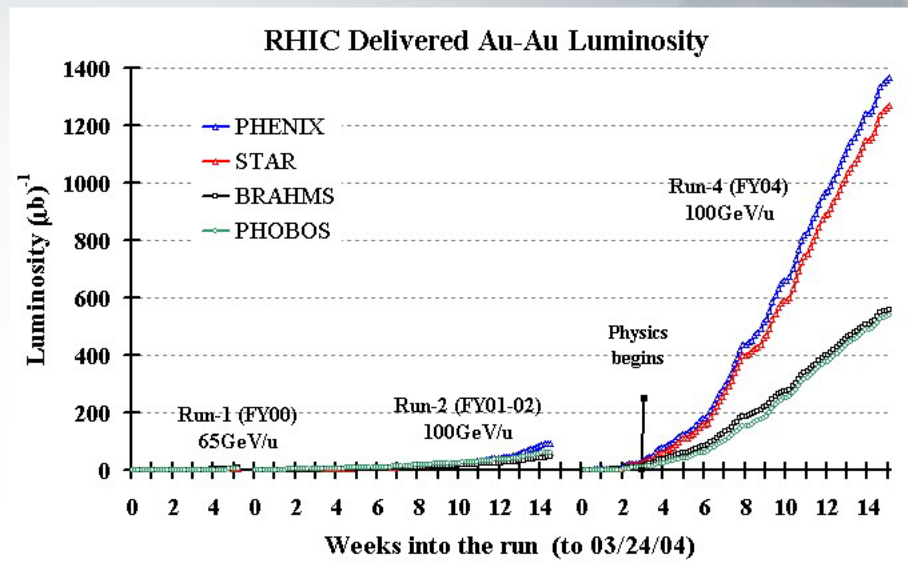
Compare with other baseline measurements
- d-A or p-p results
  - Extract expected signals without any "hot" nuclear matter effects.
- Hadron decays
  - $\phi \rightarrow K^+K^-$, $\rho \rightarrow \pi^+\pi^-$
  - Information from other collision stage.

Centrality dependence
- Another baseline measurements in peripheral collisions.

$\beta\gamma$ dependence
- Slowly moving mesons have more effects.

Measurements of ϕ in AuAu





$$\text{Signal} = 101 \pm 47\,(\text{stat})^{+56}_{-20}\,(\text{sys})$$

Too large error to discuss line shape and yield

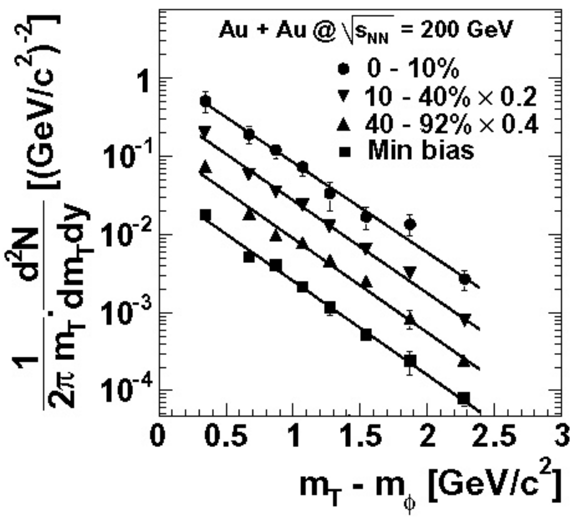
Need more statistics

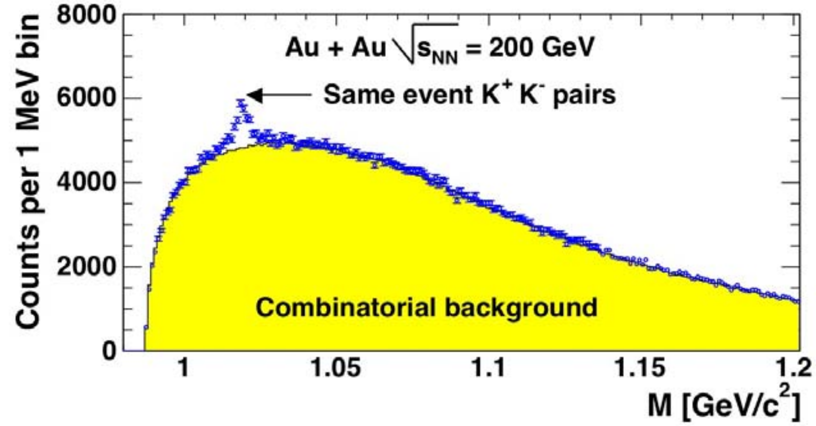
In Run4, 20 times larger luminosity is accumulated.

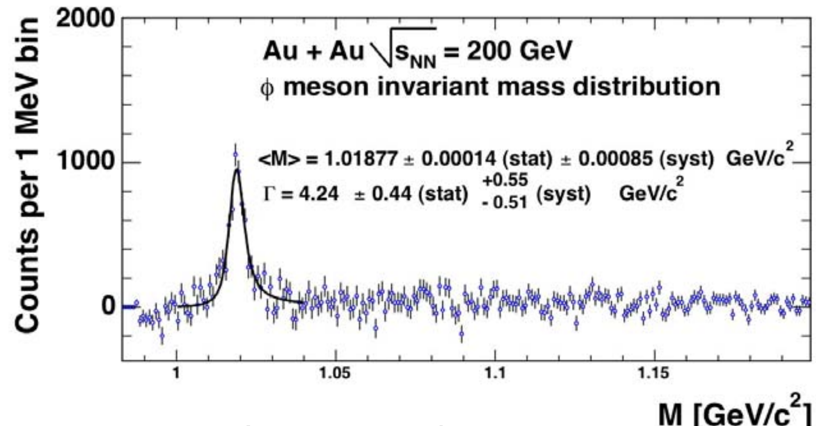
- 2 times larger pair acceptance
- less background due to absence of multiplicity detector

Baseline $\phi \rightarrow$ KK in AuAu

- dN/dy (MB)
  1.16 +- 0.17 +- 0.19
- T (MB) (MeV)
  380 +- 18 +- 22





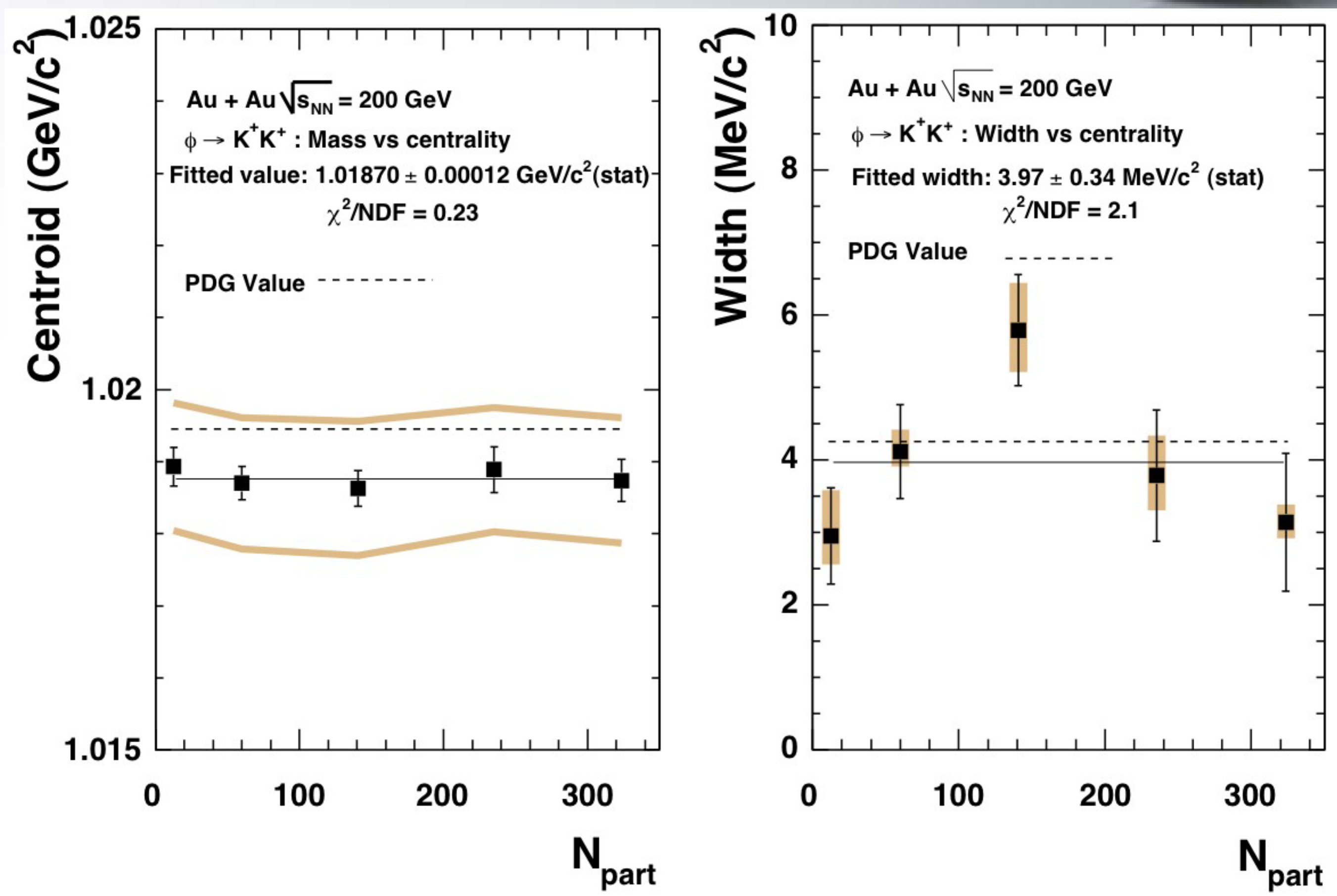


Ready for comparison with ee mode

(PHENIX, nucl-ex/0410012)

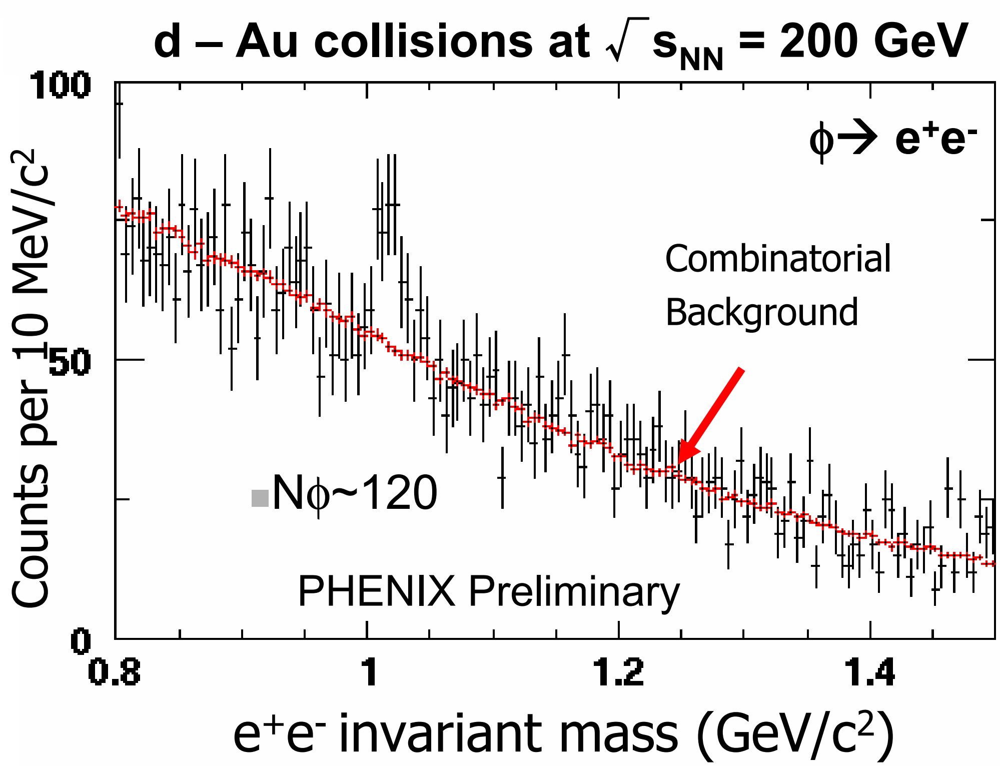
Line shape in $\phi \rightarrow KK$

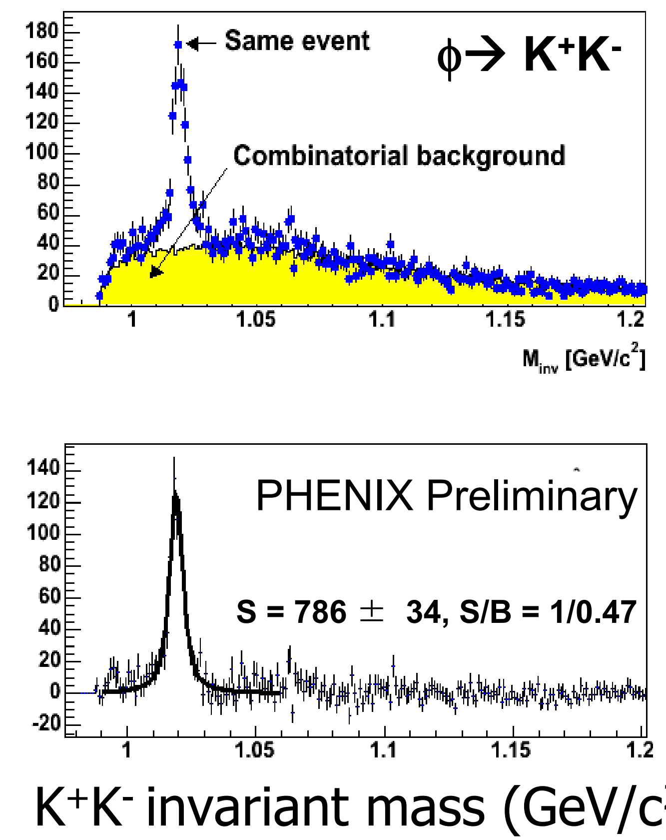
- Consistent with PDG values within the statistical and systematic errors.
- No significant change between centrality bins.
- Measured ϕ mesons are produced in the last stage of collision and/or in the surface of the matter.



(PHENIX, nucl-ex/0410012)

Another baseline - dAu





To settle cold nuclear matter effect, Both $\phi \rightarrow e^+e^-$ and $\phi \rightarrow K^+K^-$ are measured in d-Au collisions and results are compared.

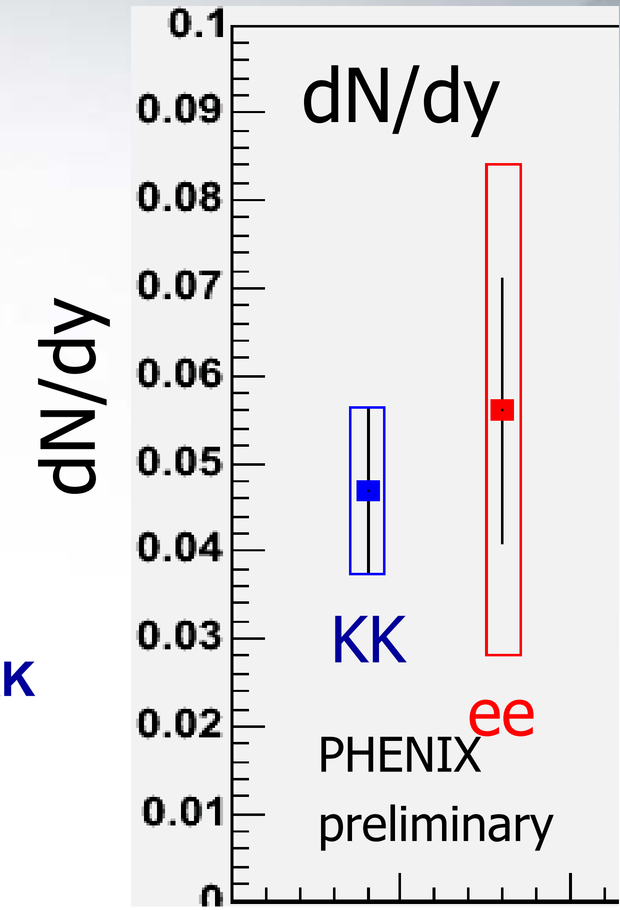
dN/dy in dAu

- dN/dy is compared between ee and KK.

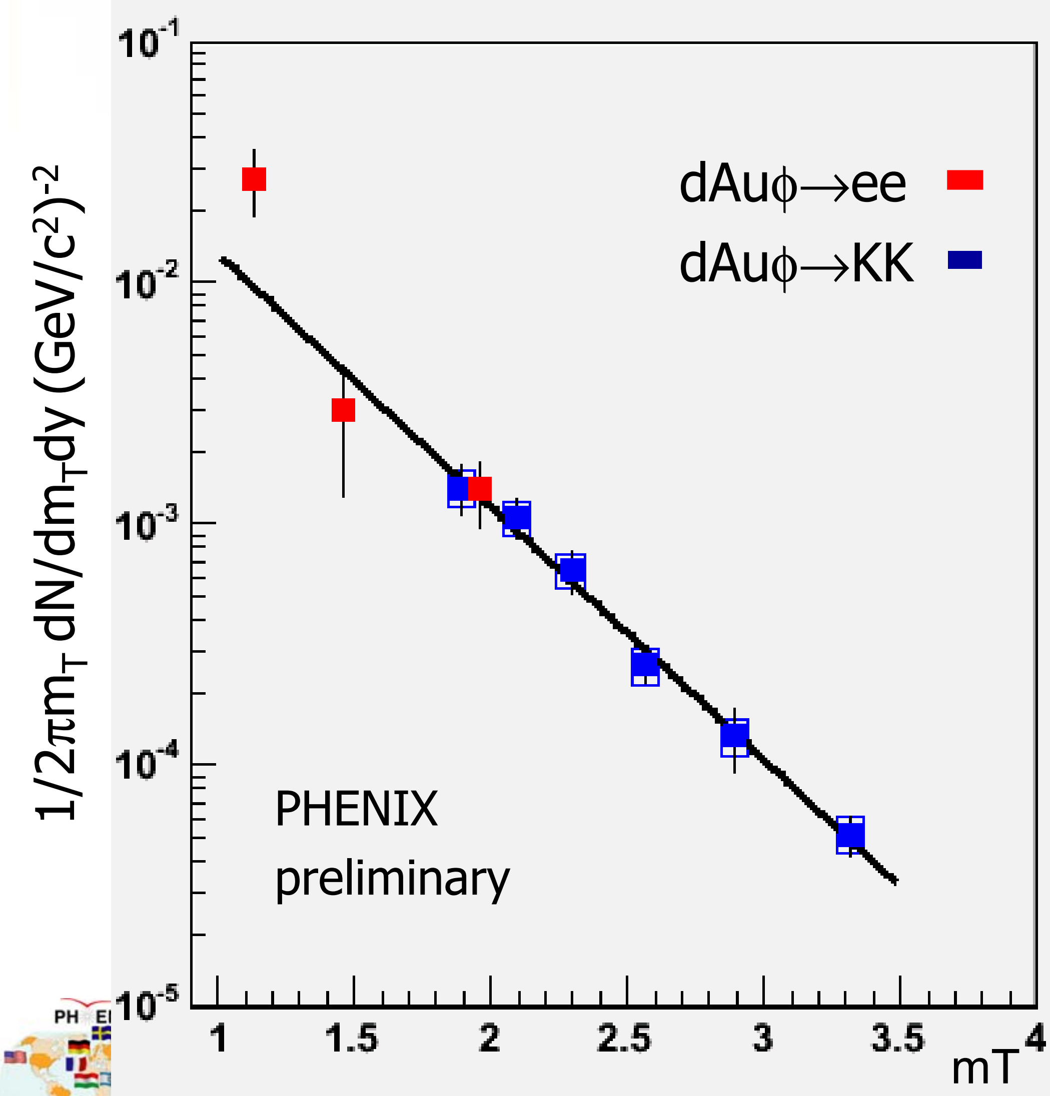
KK channel
dN/dy = 0.0468 +/- 0.0092(stat)
(+0.0095,-0.0092) (syst.)

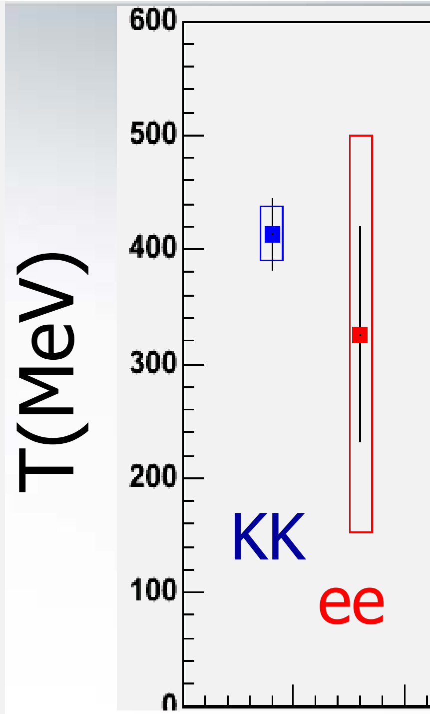
ee channel
dN/dy=.056±.015(stat) ±50%(syst)

No significant difference between ee and KK within statistical and systematic errors.



No difference in mT slope (dAu)





KK channel

T (MeV) = 414 +/- 31 (stat) +/- 23 (syst)

ee channel

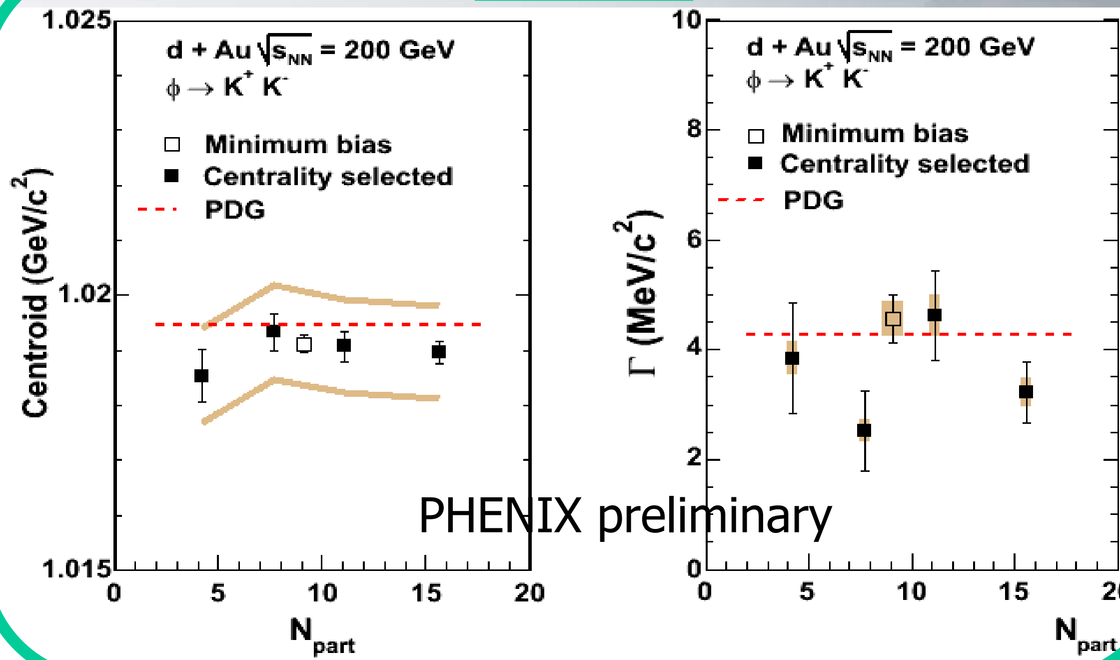
T (MeV) = 326 +/- 94(stat) +/- 53%(syst)

Line shape in dAu

$\phi \rightarrow ee$

- Spectrum is fitted with relativistic B-W and Gaussian
  - Width of B-W is fixed (Γ=4.46 MeV)
- Results
  - M=1.0177 $\pm$ 0.0023 GeV
  - σ_{exp}=8.1 $\pm$ 2.1 MeV
    - **Consistent with expected resolution**
  - χ^2/DOF=13.6/13

$\phi \rightarrow KK$



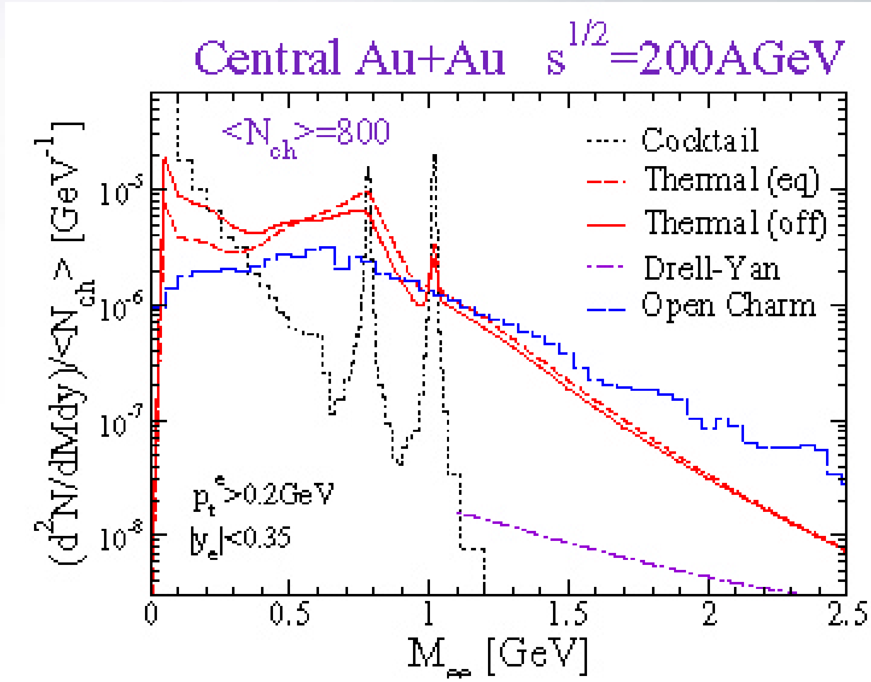
If the resolution of ee and KK is taken into account, they are consistent with PDG value.

No significant difference between ee and KK in dN/dy, mT slope, and line shape.

Thermal radiation

- Thermal radiation by the system via quark anti-quark annihilation carry direct information from the matter.
  - Matter is formed
  - Deconfinement
  - Thermalize
- Experimentally, combinatorial background is very large and must be subtracted properly.
- Large physics background comes from charm.
  - Charm production is measured with ~15% accuracy by single electron measurements.

A prediction

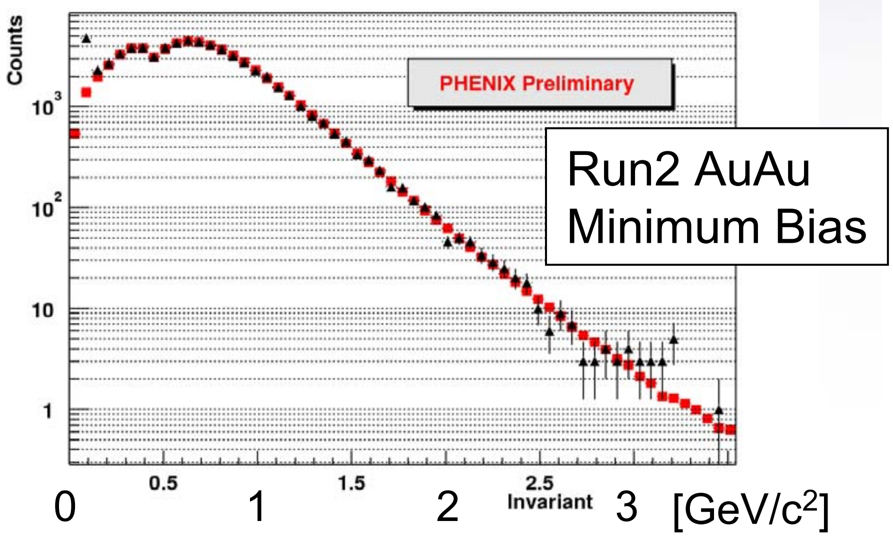


R. Rapp, nucl-ex 0204003

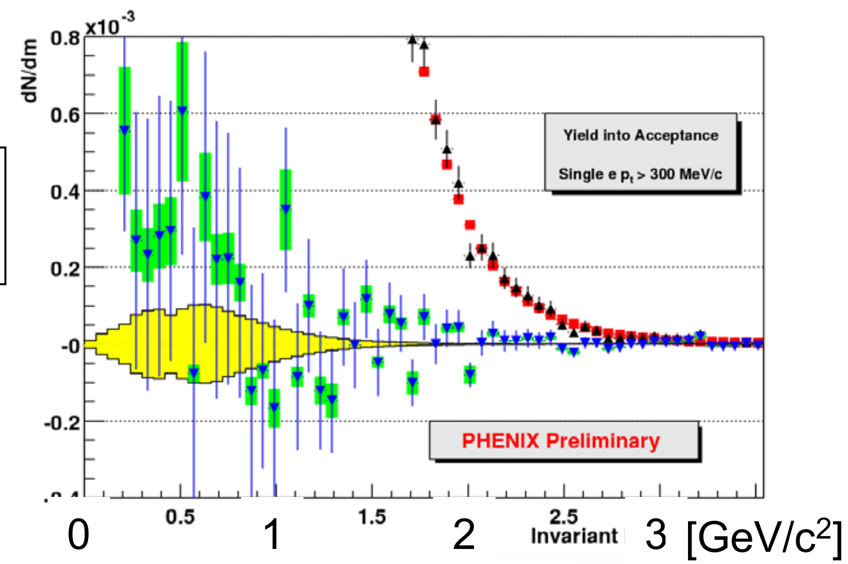
Thermal Radiation - electron

Invariant Mass of electron pair (GeV/c^2)

Real and **Mixed** e^+e^- Distribution



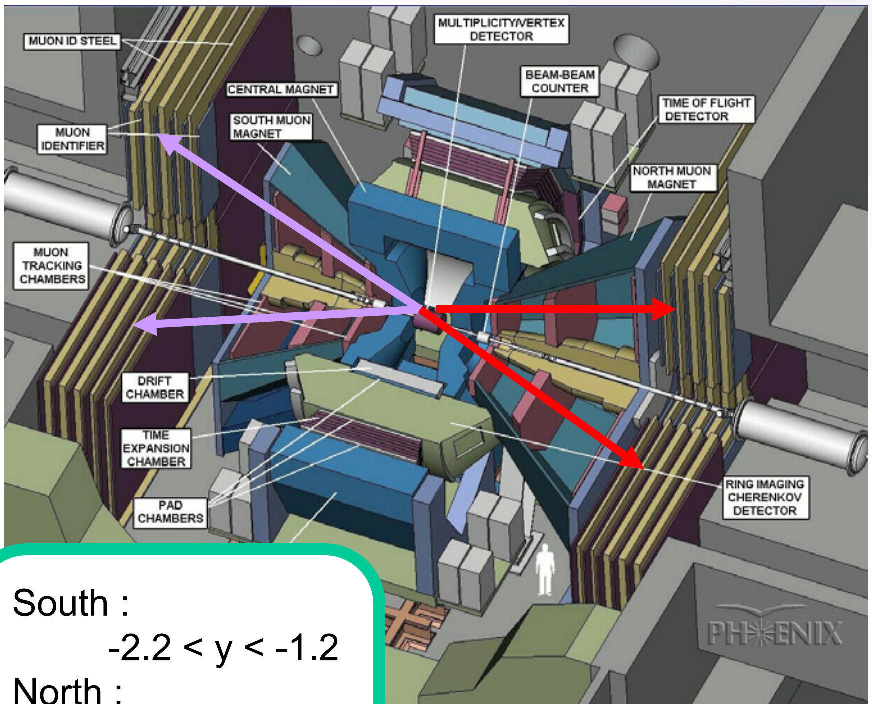
Real - **Mixed** with systematic errors



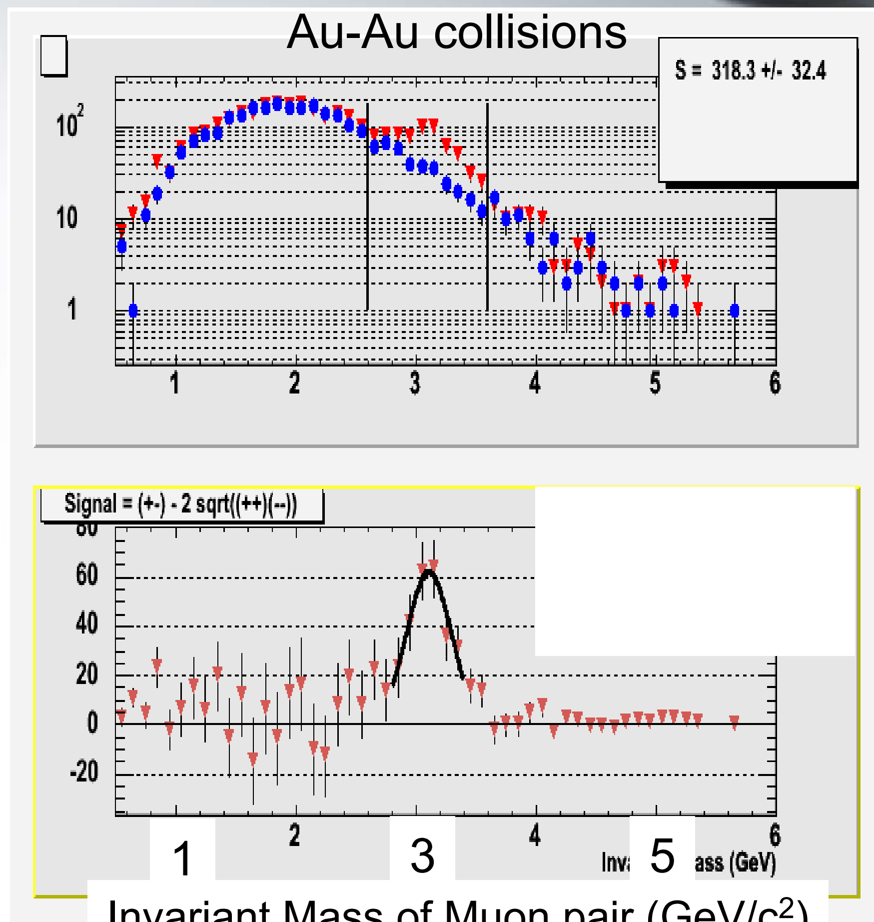
- Combinatorial background is determined with ~1% accuracy in Run3 and Run2 using a mixed event method.
- Analysis of Run4 data is underway.

Muon pairs in intermediate region

- PHENIX can measure muon pairs in forward rapidity region.



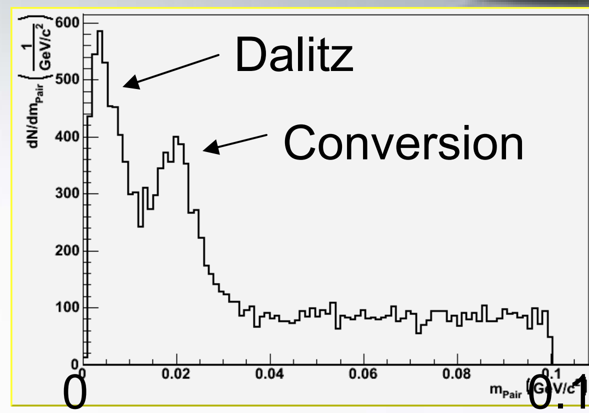
South :
-2.2 < y < -1.2
North :
1.2 < y < 2.4
P > 2 GeV/c
0 < ϕ < 2π



Clear J/ψ peak is already obtained.

Another ability
Photon measurement - conversion

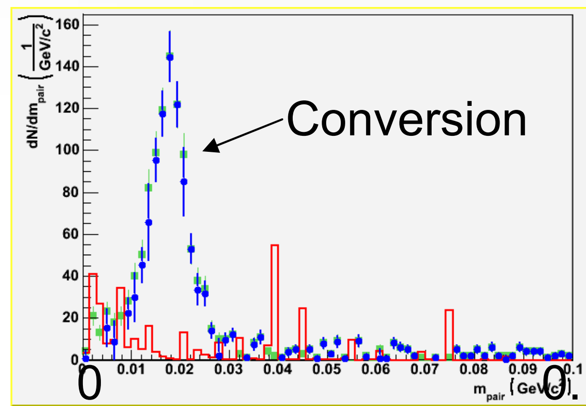
- Measurements using EM Calorimeter are already done and reported by K. Reygers in this conference.
- Amount of photons also can be measured by conversion pairs.
  - Pairs from Dalitz decays are background.
    - Conversion pairs can be selected by opening angle cuts
    - Projection of opening angle to x-y plane is different between Dalitz pairs and conversion pairs.



0 0.1

Apply cut

[GeV/c²]



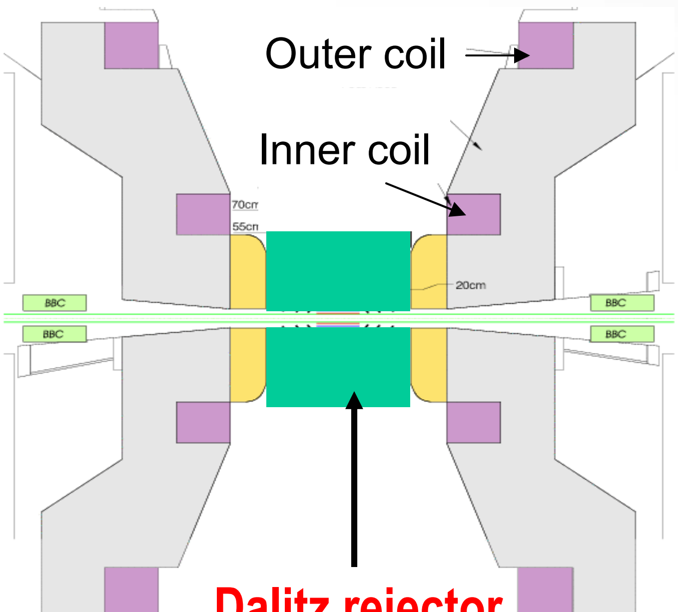
0 0.1

Inv. Mass of e^+e^- [GeV/c²]

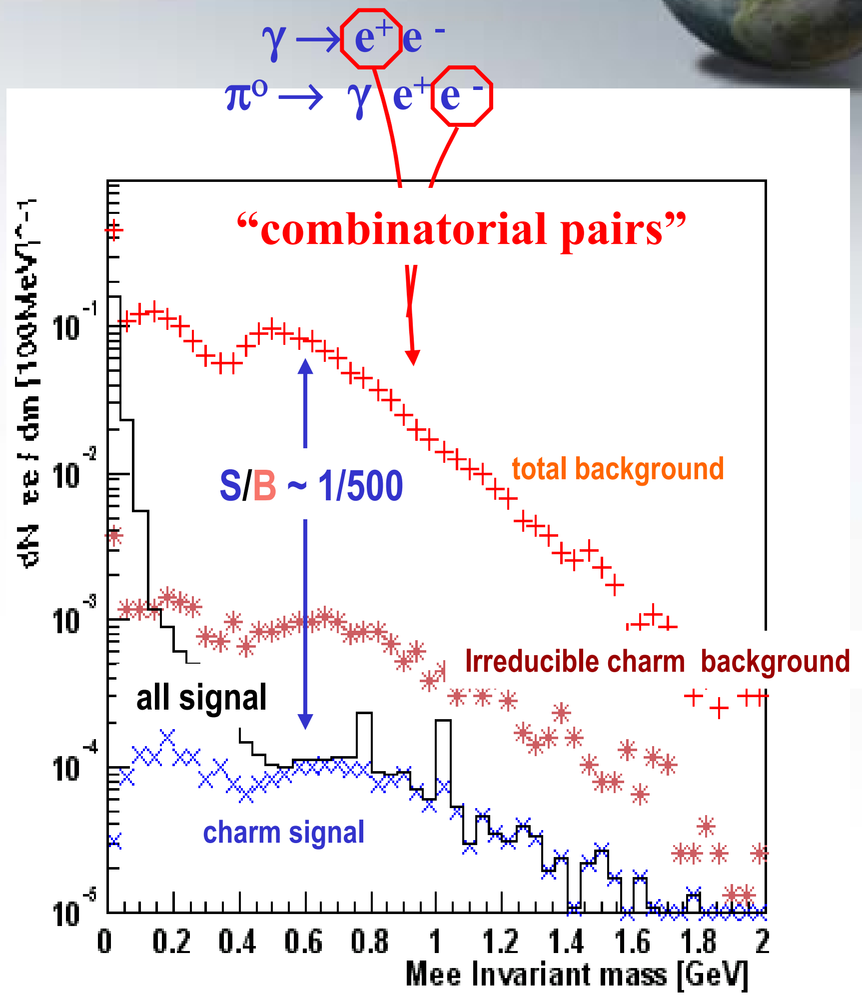
T. Dahms(PHENIX) in DNP

Near Future Upgrade

- For detailed study of dileptons in low mass region, suppression of background is essential
  - Daltz rejector is needed



Dalitz rejector
Hadron Blind Detector



AuAu Most Central collision

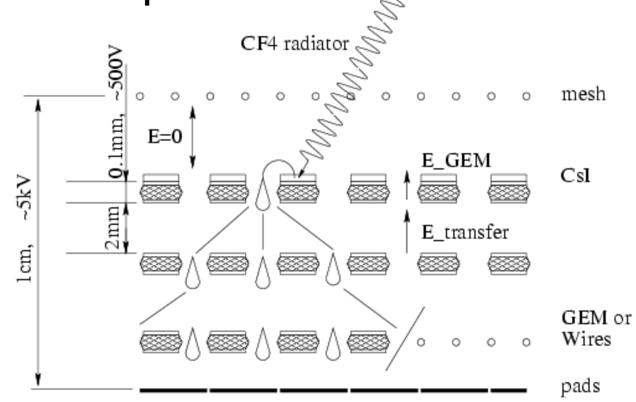
Hadron Blind Detector (HBD)

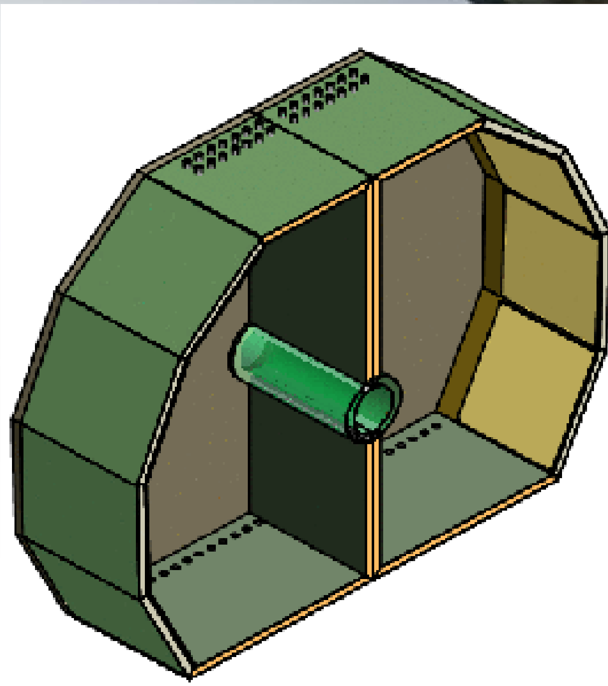
Dalitz rejection via opening angle

- Field-free region to maintain opening angle
- HBD for electron ID

HBD concept:

- windowless Cherenkov detector
- CF4 as radiator (50cm) and detector gas
- Triple GEM with pad readout
- CsI reflective photocathode





R&D at Weizmann institute

- Prototype construction is underway

It will be installed in time of Run6

Summary and Outlook

- Information of chiral symmetry restoration and thermal radiation at RHIC energy is not yet available.
- Baseline measurements, such as $\phi \rightarrow K^+K^-$ and measurements in dAu collisions, are done
- First results on low-mass dileptons from Run-4 Au+Au (2004) and Run-5 Cu+Cu (2005) are expected in the near future.
- For Run6, the Hadron Blind Detector will be installed to the PHENIX spectrometer, which will dramatically reduce combinatorial background.

Brazil: University of São Paulo, São Paulo

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China Institute of Atomic Energy, Beijing
Peking University, Beijing

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Dapnia, CEA Saclay, Gif-sur-Yvette
IPN-Orsay, Universite Paris Sud, CNRS-IN2P3, Orsay
LLR, Ecòle Polytechnique, CNRS-IN2P3, Palaiseau
SUBATECH, Ecòle des Mines at Nantes, Nantes

Germany: University of Münster, Münster

Hungary: Central Research Institute for Physics (KFKI), Budapest
Debrecen University, Debrecen
Eötvös Loránd University (ELTE), Budapest

India: Banaras Hindu University, Banaras
Bhabha Atomic Research Centre, Bombay

Israel: Weizmann Institute, Rehovot

Japan: Center for Nuclear Study, University of Tokyo, Tokyo
Hiroshima University, Higashi-Hiroshima
KEK, Institute for High Energy Physics, Tsukuba
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Rikkyo University, Tokyo, Japan
Tokyo Institute of Technology, Tokyo
University of Tsukuba, Tsukuba
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St. Petersburg State Technical University, St. Petersburg

Sweden: Lund University, Lund

12 Countries; 58 Institutions; 480 Participants*

USA: Abilene Christian University, Abilene, TX
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Florida Technical University, Melbourne, FL
Georgia State University, Atlanta, GA
University of Illinois Urbana Champaign, Urbana-Champaign, IL
Iowa State University and Ames Laboratory, Ames, IA
Los Alamos National Laboratory, Los Alamos, NM
Lawrence Livermore National Laboratory, Livermore, CA
University of New Mexico, Albuquerque, NM
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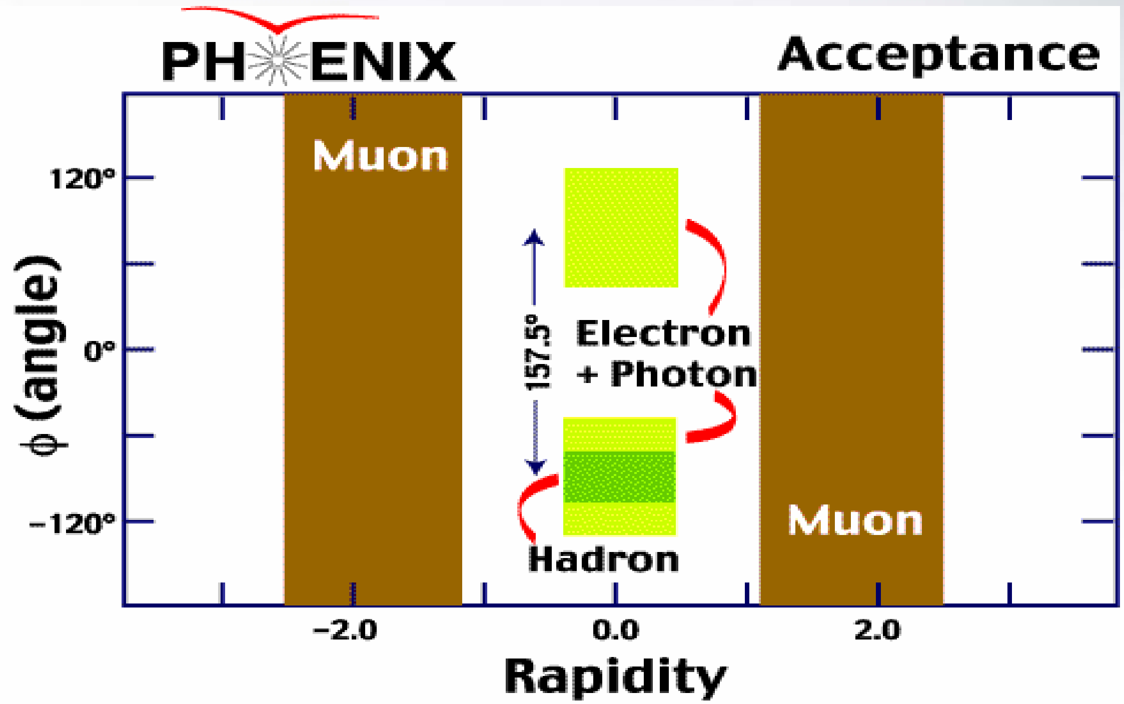
Oak Ridge National Laboratory, Oak Ridge, TN
University of Tennessee, Knoxville, TN
Vanderbilt University, Nashville, TN

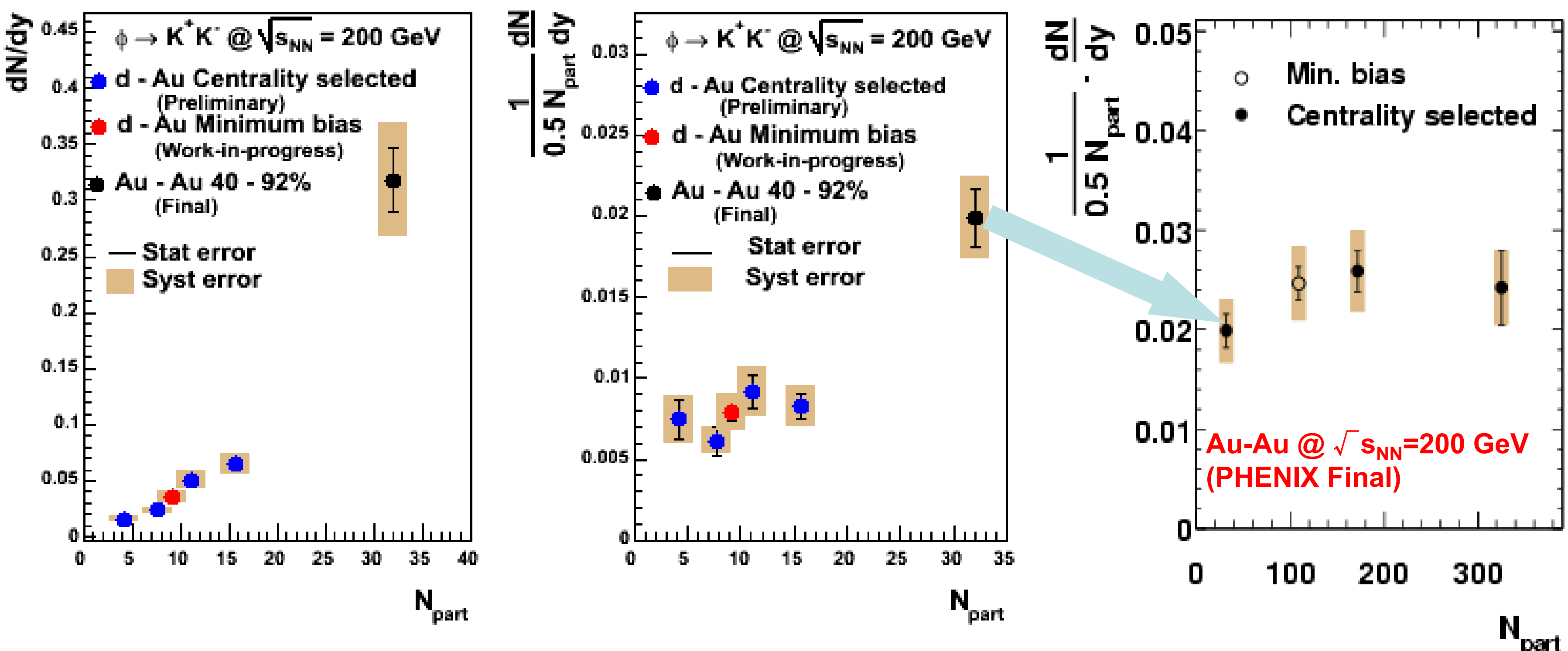
*as of January 2004

Backup

PHENIX Acceptance



Centrality dependence: Yield



➔ dN/dy increases with centrality and from d-Au to Au-Au system.

➔ dN/dy per participant pair is flat for d-Au system within errors, but increases from d-Au to Au – Au system.