System Size and Energy Dependence of Elliptic Flow

Alice C. Mignerey, University of Maryland
for the PHOBOS Collaboration

Collaboration (August 2005)

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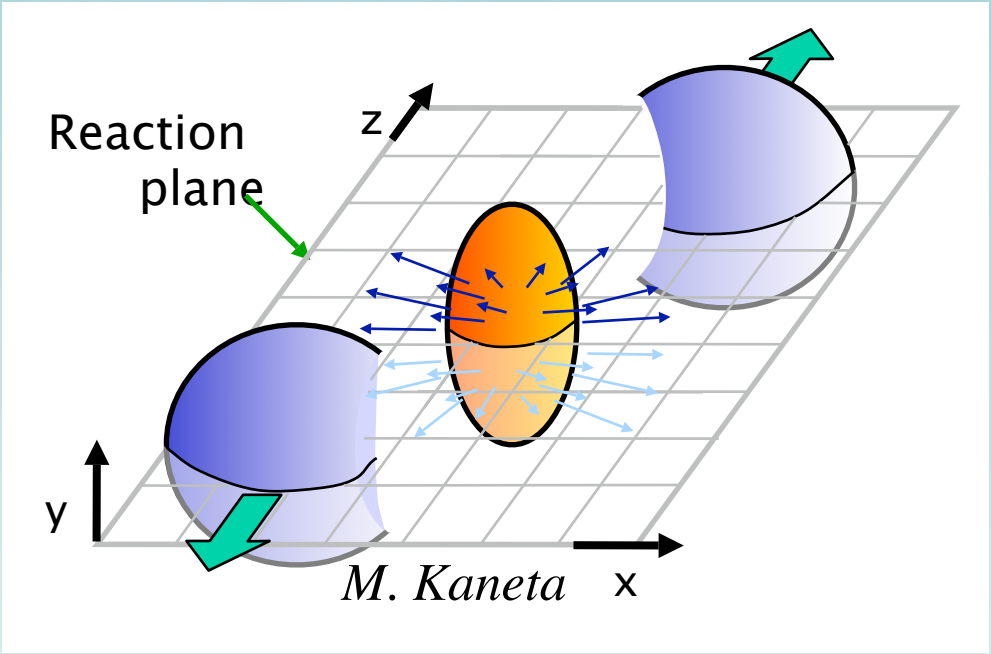
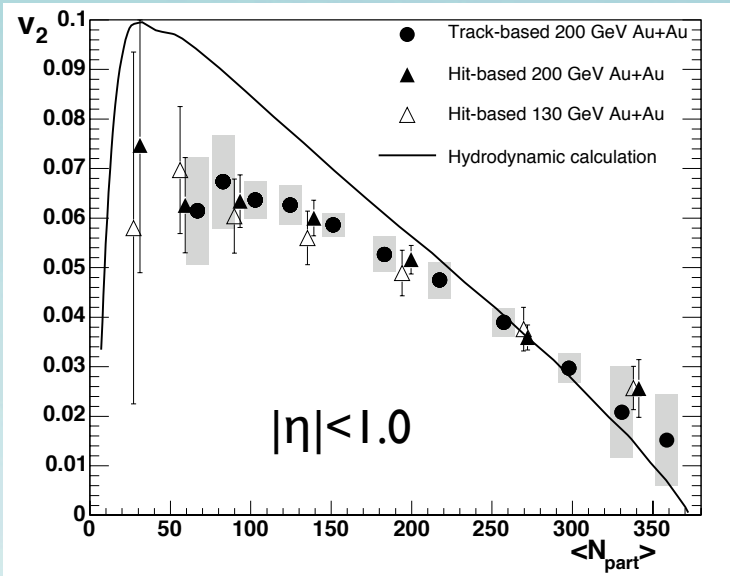
UNIVERSITY OF MARYLAND
BROOKHAVEN NATIONAL LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
UNIVERSITY OF ILLINOIS AT CHICAGO
UNIVERSITY OF ROCHESTER

Past Studies of Elliptic Flow of charged hadrons in Au–Au Collisions

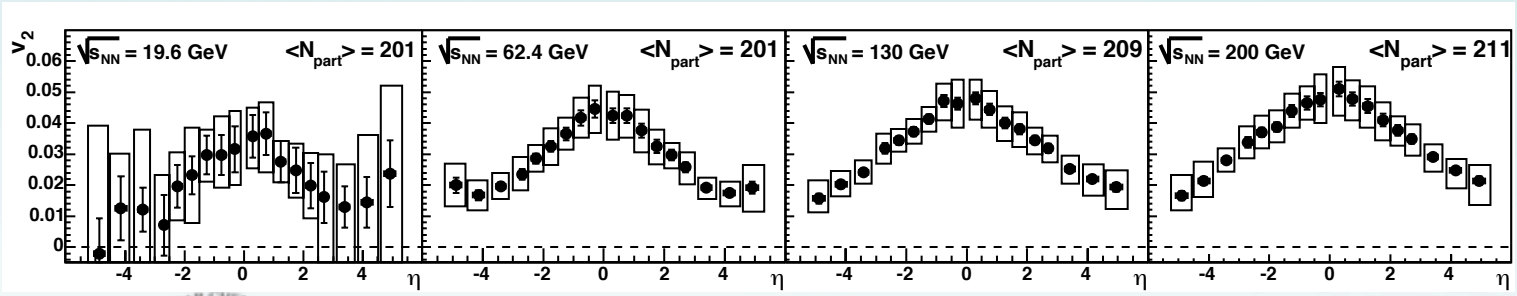


Centrality Dependence



B.B. Back *et al.* (PHOBOS Collaboration), nucl-ex/0407012

Energy and η dependence



Error bars: 1σ statistical
Error boxes: 90% C.L systematic

Centrality range
0-40%

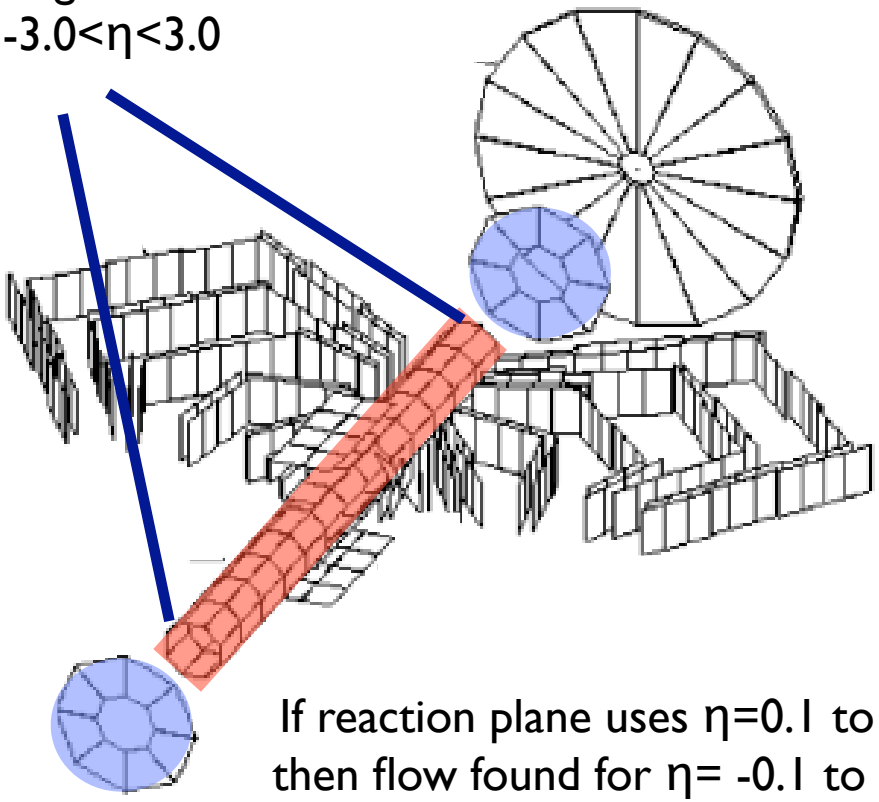
B.B. Back *et al.* (PHOBOS Collaboration), Phys. Rev. Lett. **94**, 122303 (2005)

Measuring Flow in PHOBOS

Hit-Based Method

$|\eta|<5.4$

Octagon covers
$-3.0<\eta<3.0$

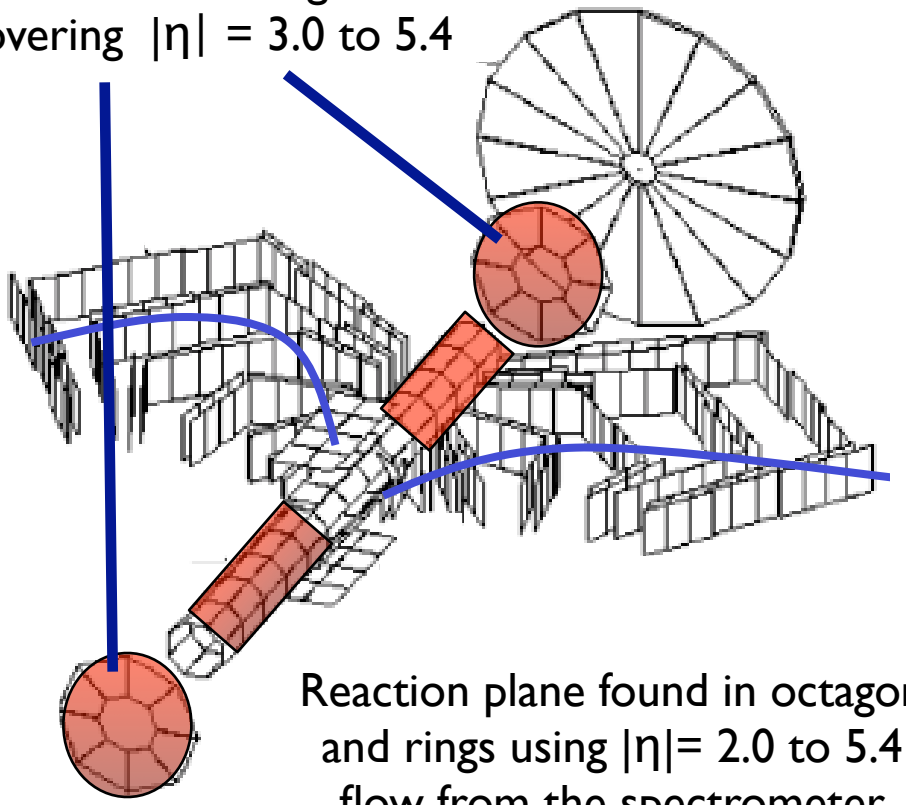


If reaction plane uses η=0.1 to 3.0
then flow found for η= -0.1 to -3.0

Track-Based Method

$|\eta|<1.0$

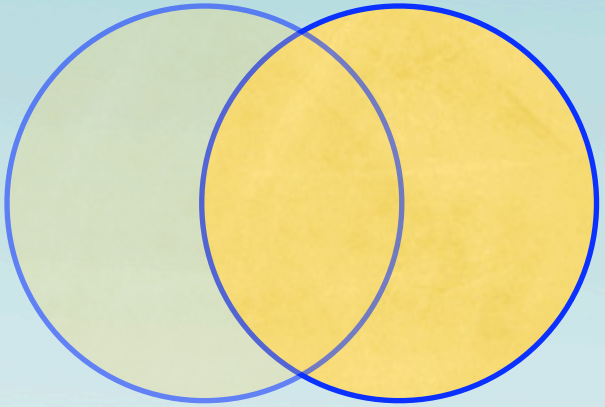
3 sets of Rings
covering $|\eta|$ = 3.0 to 5.4



Reaction plane found in octagon
and rings using $|\eta|$= 2.0 to 5.4
flow from the spectrometer

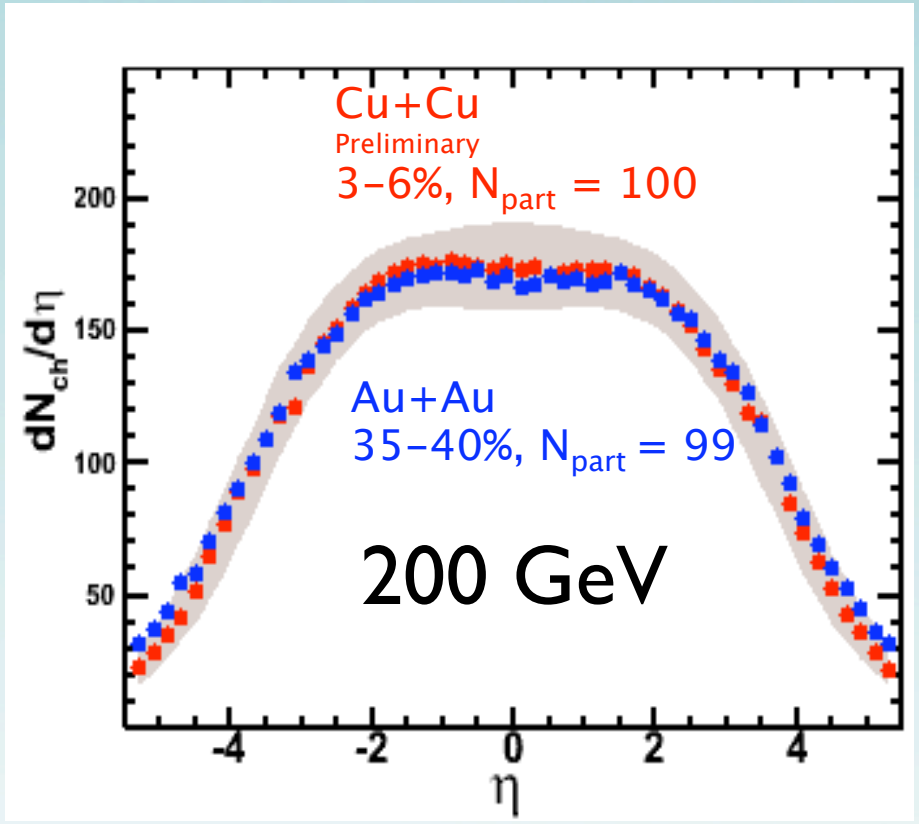
System Size Dependence for Cu–Cu and Au–Au

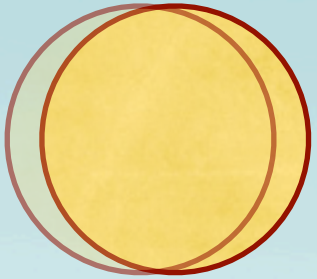
Comparing the number of participants



Mid-central Au-Au

<Npart>
99
35-40%





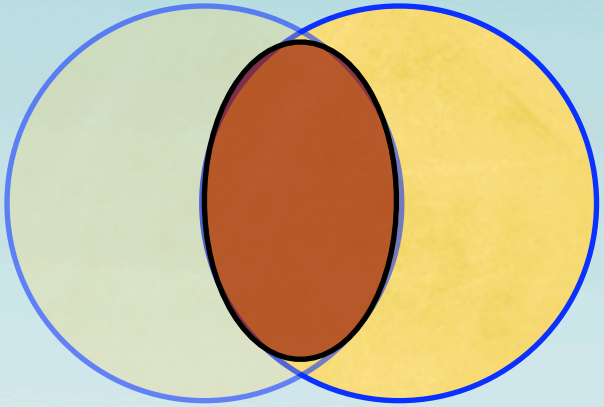
Central Cu-Cu

<Npart>
100
3-6%

G. Roland *et al.*, Proc. QM2005, nucl-ex/0510042 and
B.B. Back *et al.* (PHOBOS Collaboration), PRL 91,052303 (2003)

System Size Dependence for Cu–Cu and Au–Au

Comparing the number of participants



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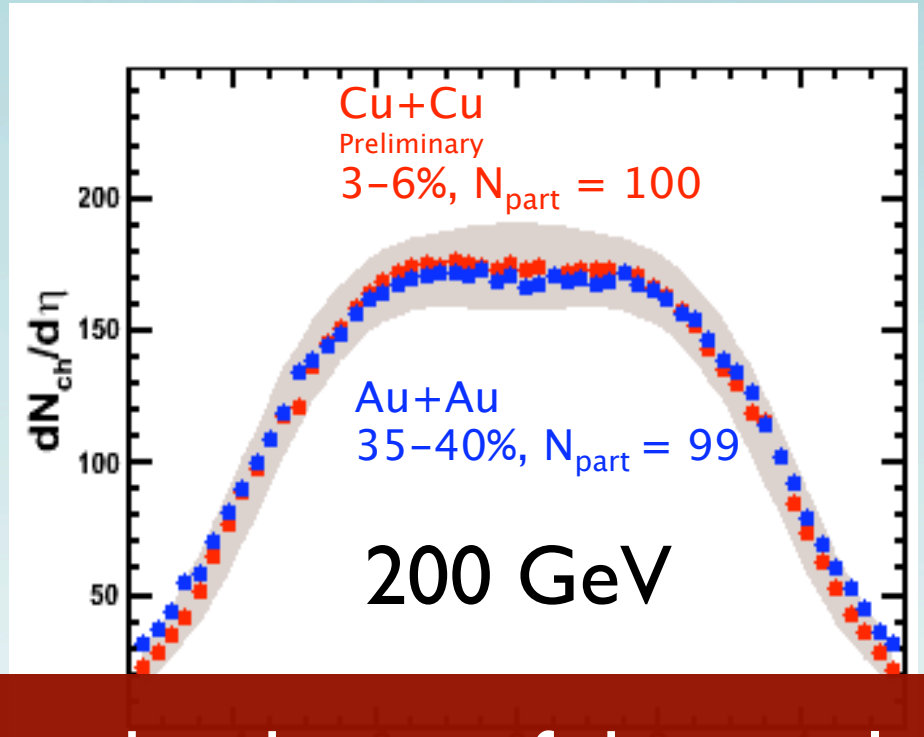
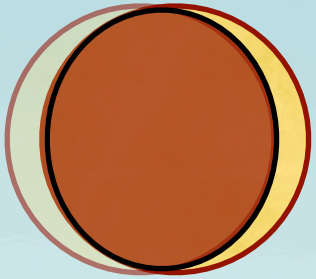




Central Cu-Cu

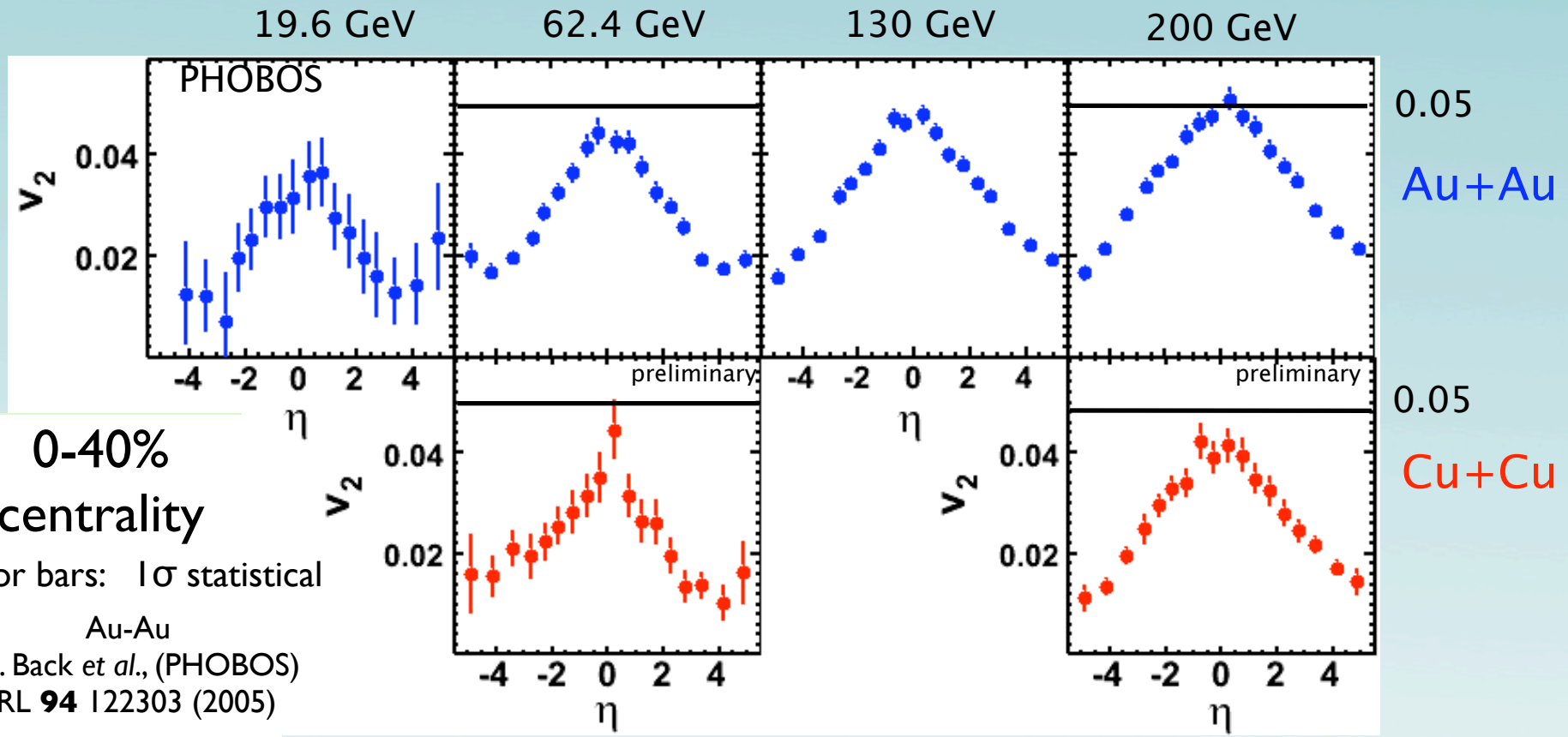
<Npart>
100
3-6%

But the shapes of the overlap regions are very different

G. Roland *et al.*, Proceedings of Quark Matter 2005

Elliptic flow of Cu–Cu compared to Au–Au

η dependence



0-40% centrality

Error bars: 1σ statistical

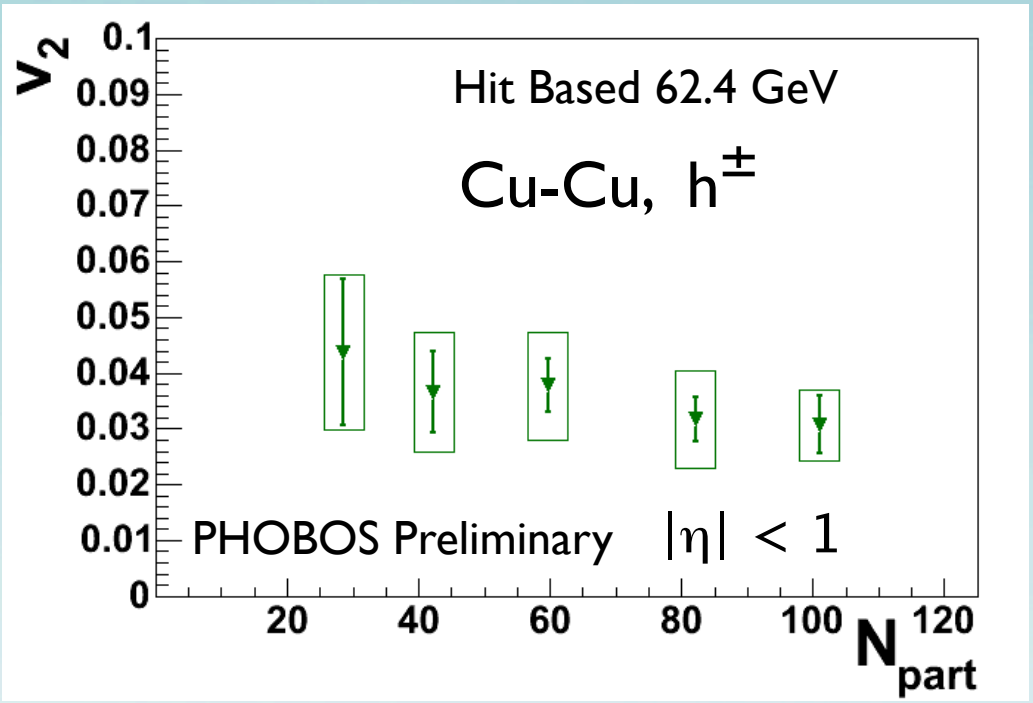
Au-Au
B.B. Back *et al.*, (PHOBOS)
PRL **94** 122303 (2005)

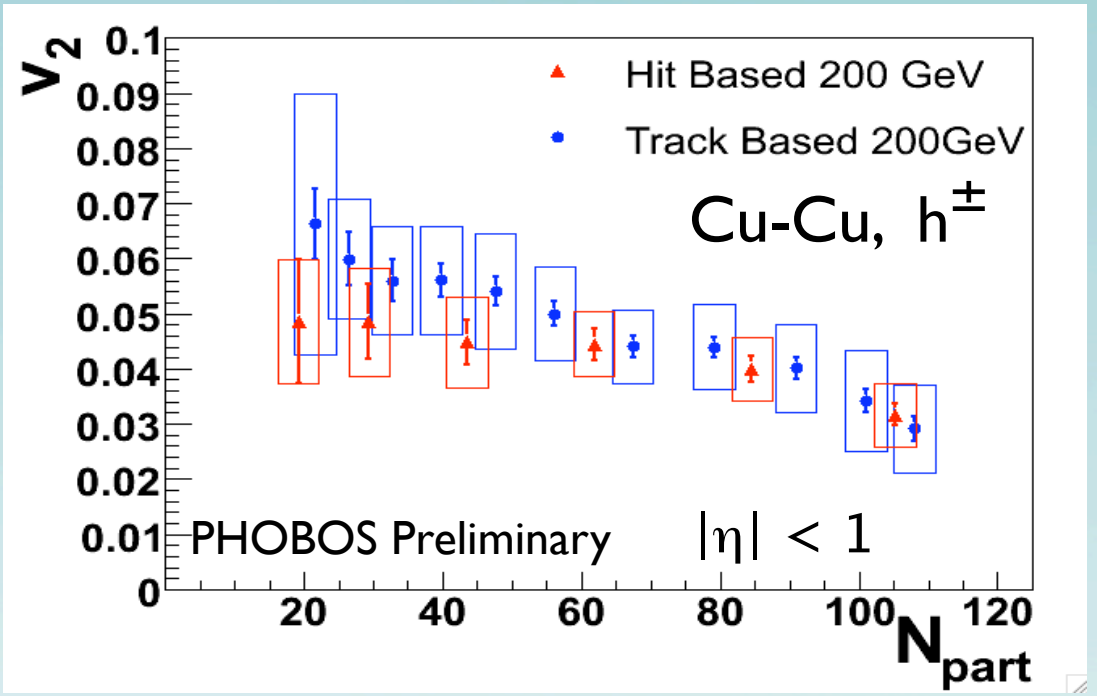
Cu-Cu
S. Manly *et al.*, Proc. QM05, nucl-ex/0510031

Cu-Cu about 20% lower than Au-Au

Elliptic flow of Cu-Cu – centrality dependence

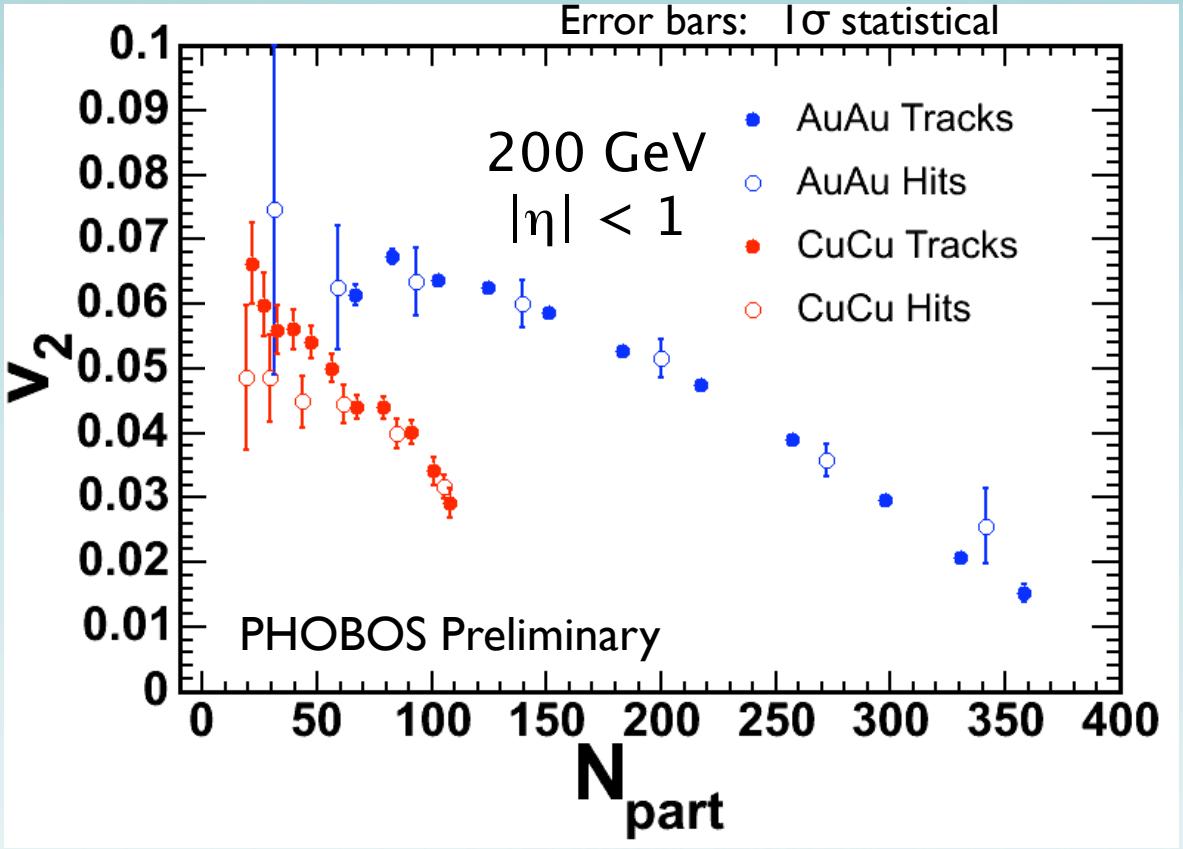
Error bars: 1σ statistical
Error boxes: 90% C.L systematic





S. Manly *et al.*, Proc. QM05, nucl-ex/0510031

Comparison of Cu–Cu and Au–Au



Important features:

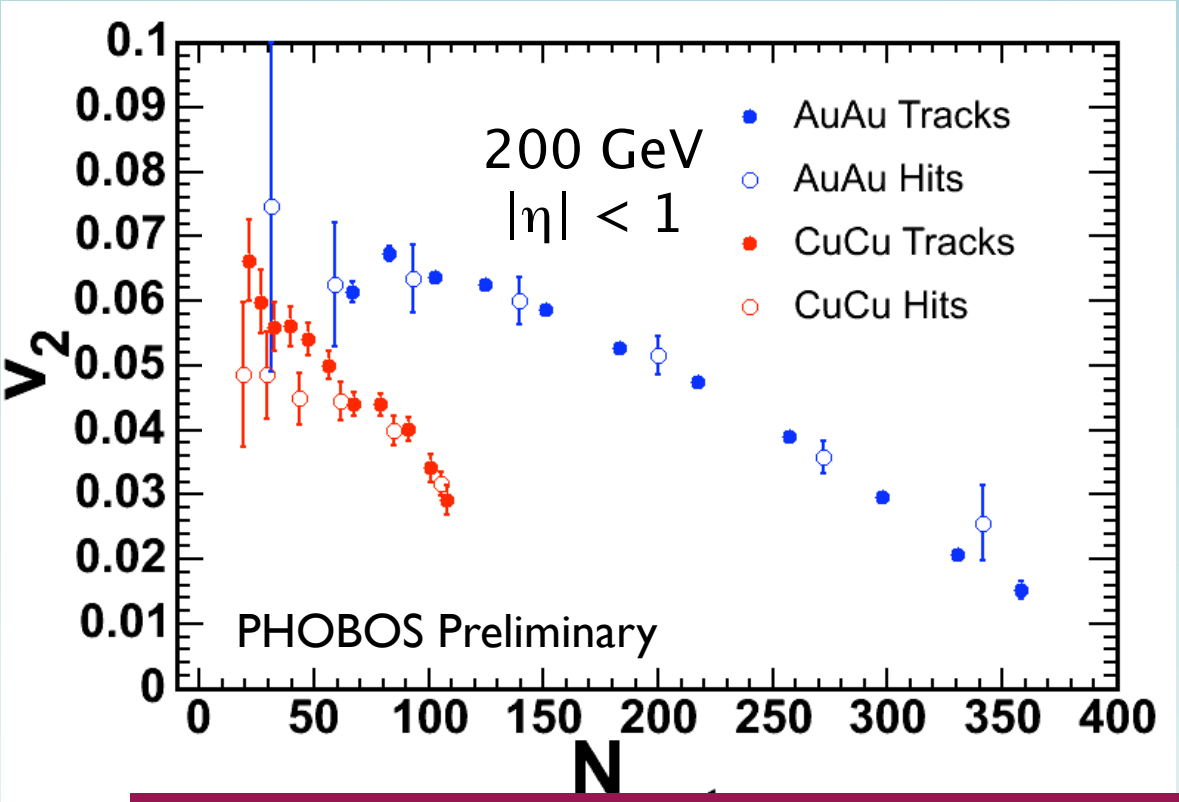
Very different elliptic flow for the same Npart - But remember these had very different overlap geometries

CuCu flow still significant at most central collisions

Au-Au: B.B. Back *et al.* (PHOBOS Collaboration), nucl-ex/0407012

Cu-Cu: S. Manly *et al.*, Proc. QM05, nucl-ex/0510031

Comparison of Cu-Cu and Au-Au



Important features:

Very different elliptic flow for the same Npart - But remember these had very different overlap geometries

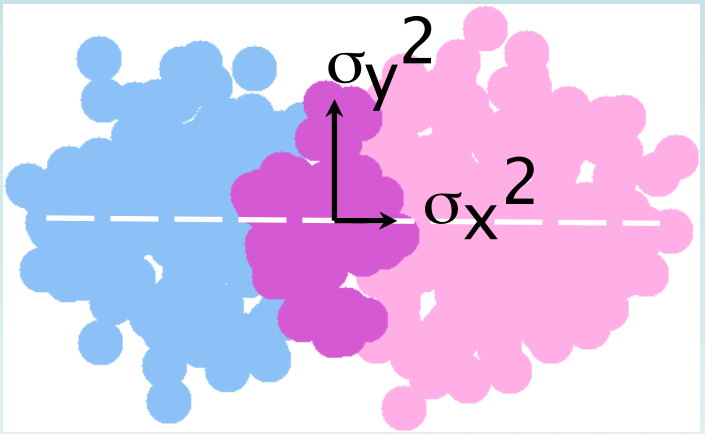
CuCu flow still significant at most central collisions

Can we understand this in terms of geometry?

Eccentricity - ε

a representation of geometrical overlap

$$\varepsilon = \frac{\sigma_y^{\,2} - \sigma_x^{\,2}}{\sigma_y^{\,2} + \sigma_x^{\,2}}$$



Au-Au collision
with Npart = 78

Au-Au collision
with Npart =64

Eccentricity – ε

a representation of geometrical overlap

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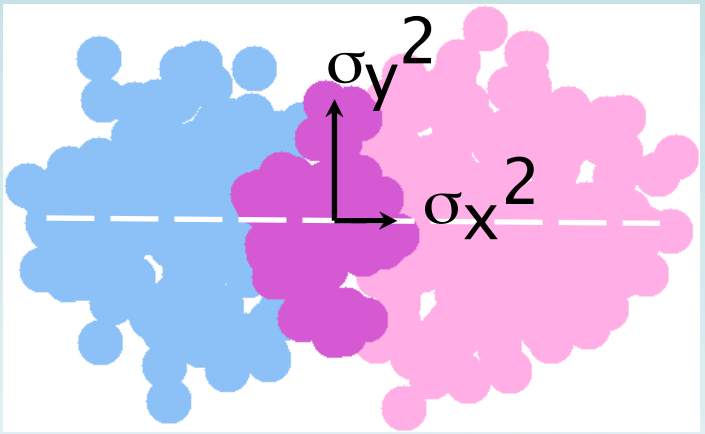
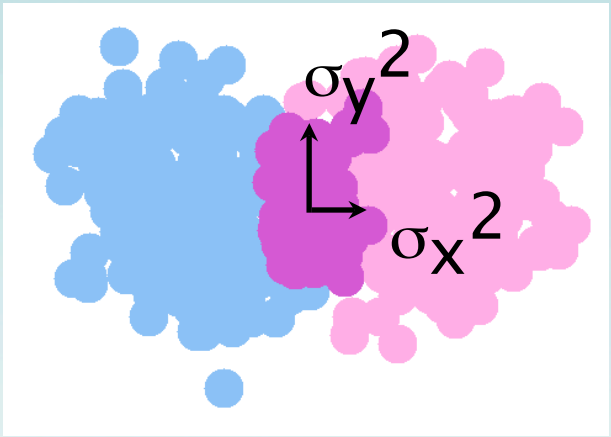


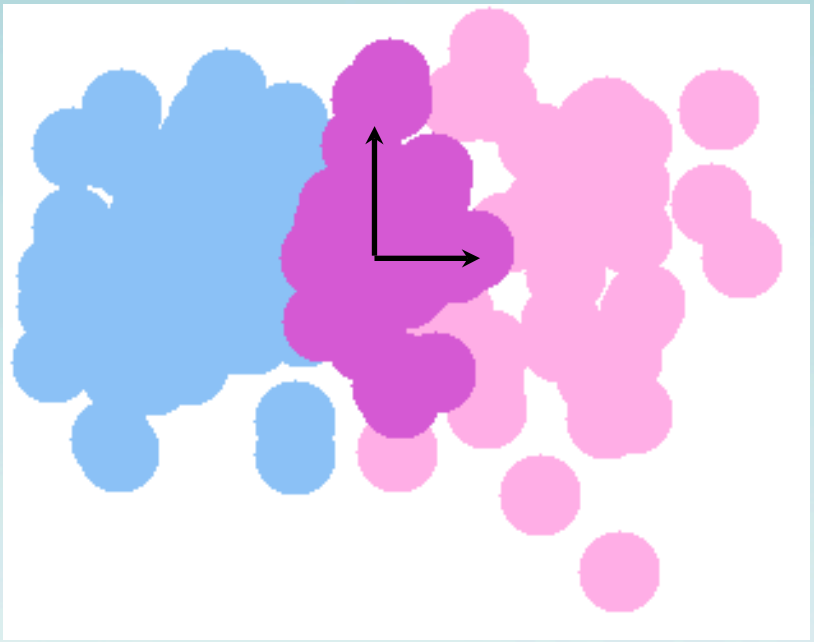
Au-Au collision
with Npart = 78

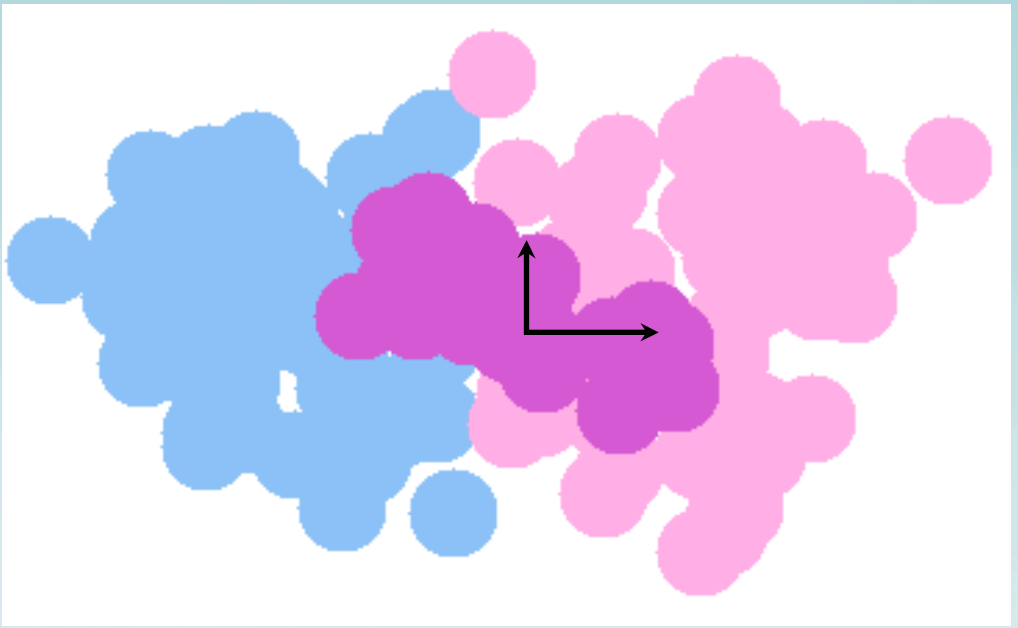


Au-Au collision
with Npart =64

Sample of Cu-Cu collisions

Gives negative eccentricity ε





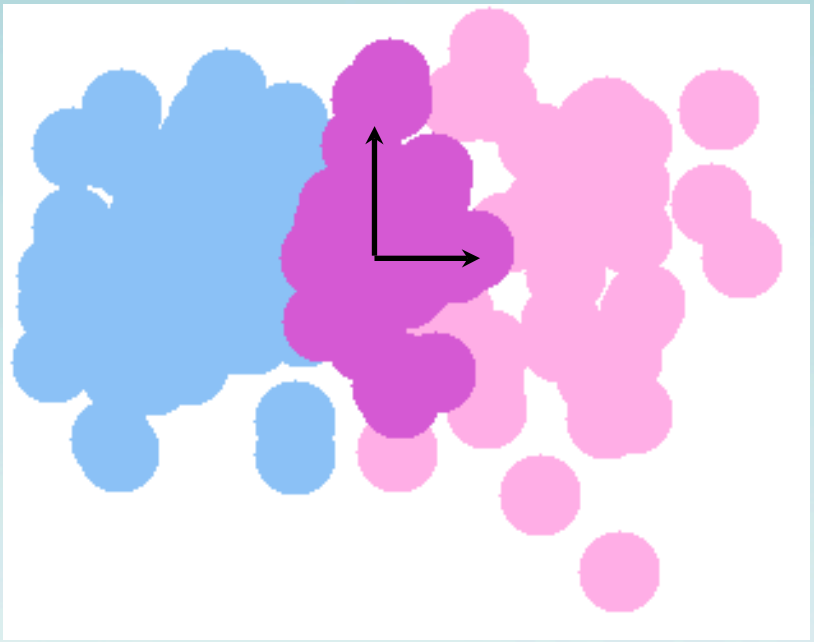
Cu-Cu collision with Npart = 33

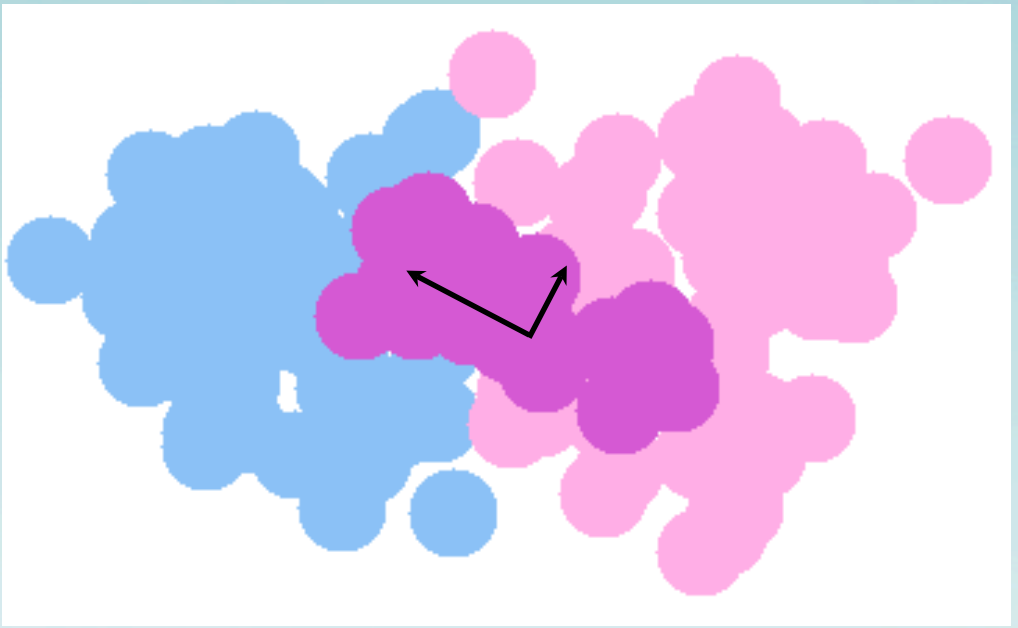
Cu-Cu collision with Npart = 28

$$\varepsilon = \frac{\sigma_y^{\,2} - \sigma_x^{\,2}}{\sigma_y^{\,2} + \sigma_x^{\,2}}$$

Sample of Cu-Cu collisions

Principal axis transformation





Cu-Cu collision with Npart = 33

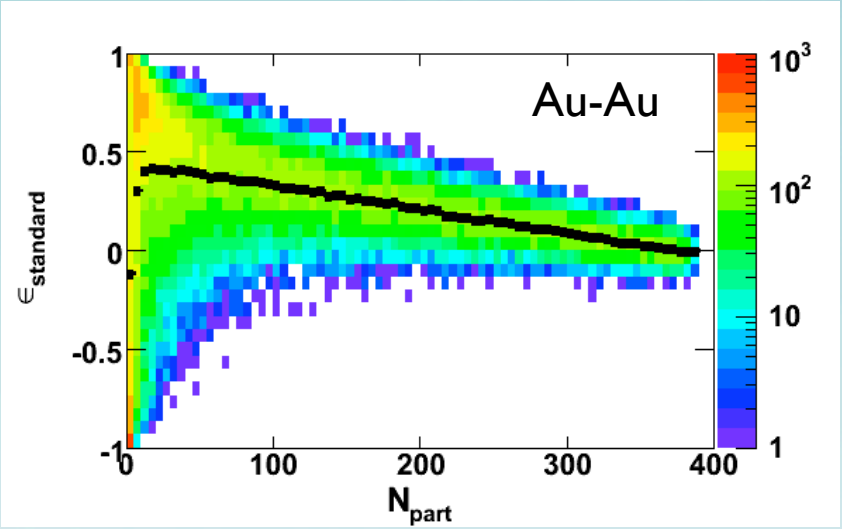
Cu-Cu collision with Npart = 28

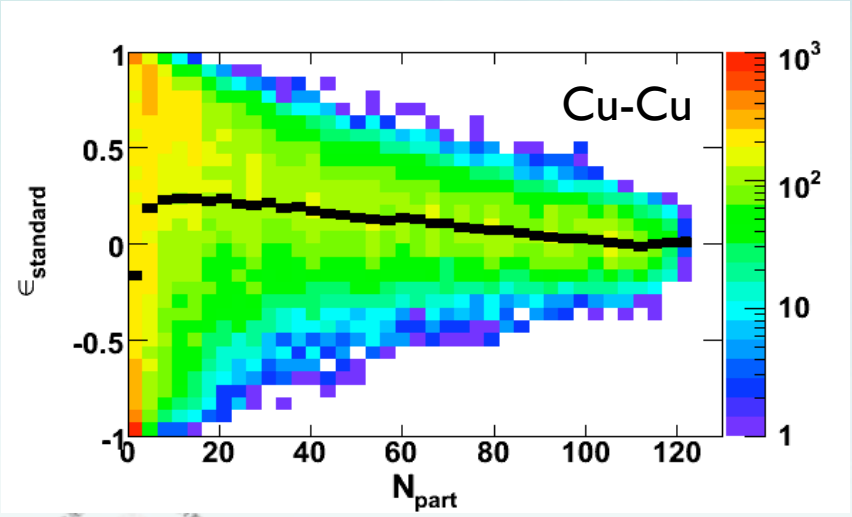
$$\varepsilon = \frac{\sigma_y^{\,2} - \sigma_x^{\,2}}{\sigma_y^{\,2} + \sigma_x^{\,2}}$$

Maximizes the eccentricity

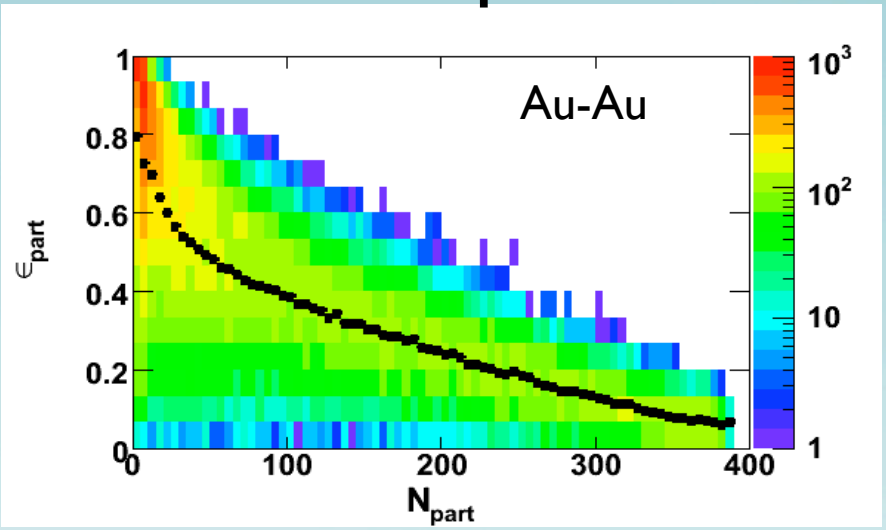
Effect of the eccentricity definition

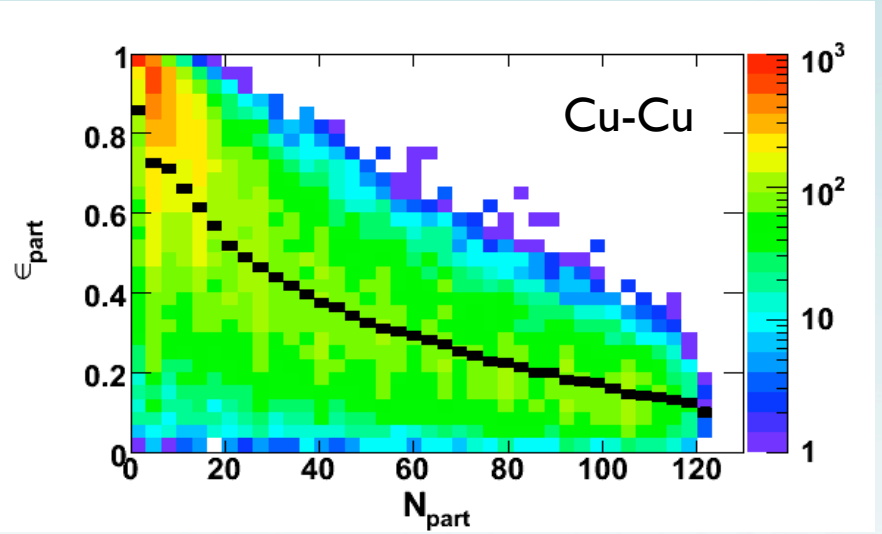
Standard





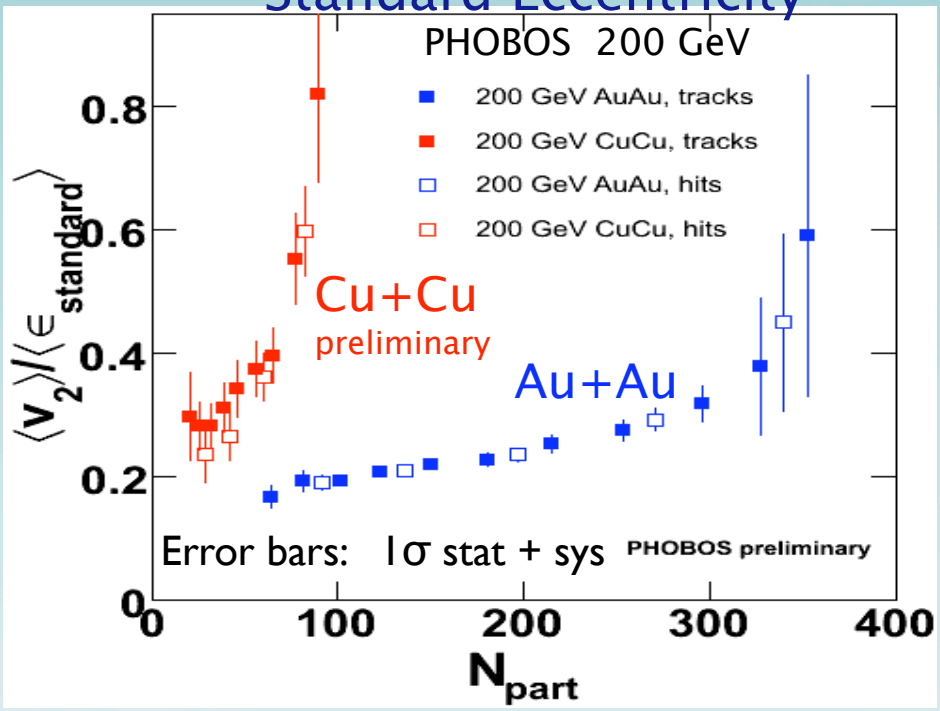
Participant



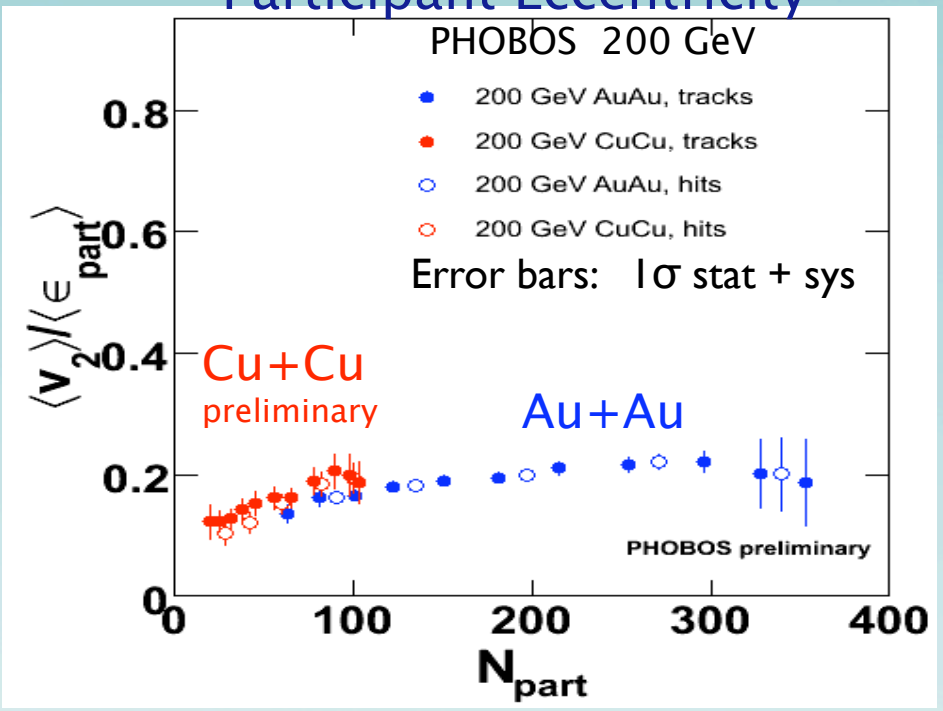


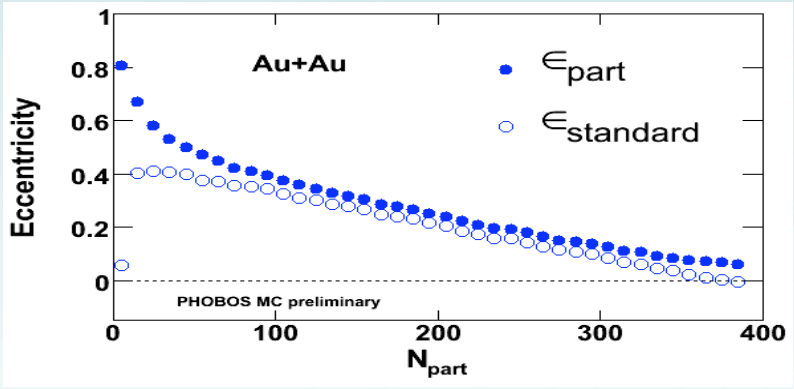
Comparison of standard and participant eccentricity

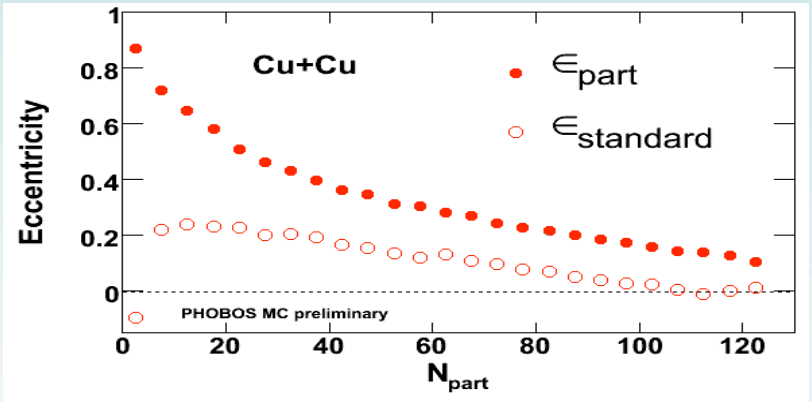
Standard Eccentricity



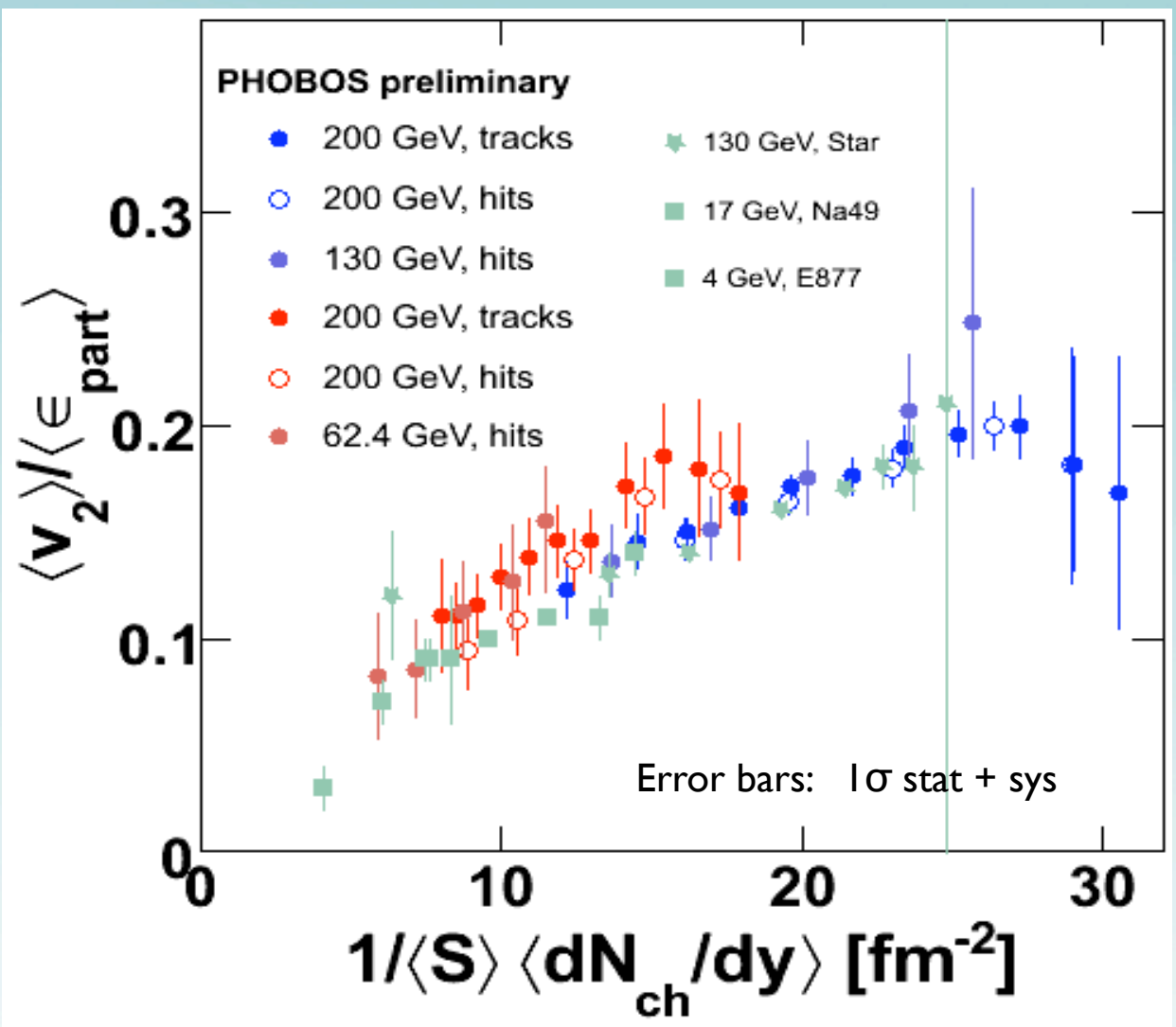
Participant Eccentricity







Comparison between Systems and Energies



(1/<S>)dN/dy scaling:
C. Adler *et al.* (STAR), PRC **66** 034904 (2002)
A.M. Poskanzer and S.A. Voloshin, Nucl. Phys. **A661**, 341c (1999)
J. Barrette *et al.* (E877), PRC **51**, 3309 (1995); **55**, 1420 (1997)

Au-Au: B.B. Back *et al.* (PHOBOS Collaboration), nucl-ex/0407012

Cu-Cu: S. Manly *et al.*, Proc. QM05, nucl-ex/0510031

1/<S> overlap area

measured $dN_{ch}/d\eta$

corrected to dN_{ch}/dy

G. Roland *et al.*, Proc. QM2005, nucl-ex/0510042

Summary and Conclusions:

PHOBOS has measured elliptic flow for charged hadrons in Cu-Cu at 62.4 and 200 GeV as a function of centrality and pseudorapidity

Demonstrated the importance of understanding the geometry - definition of eccentricity

When expressed in terms of PARTICIPANT eccentricity, the centrality dependence of v_2/ε is consistent for Cu-Cu and Au-Au and scales with other elliptic flow measurements at AGS, SPS and RHIC energies