Lessons from Phobos

Wit Busza

on behalf of the PHOBOS Collaboration

PHOBOS Collaboration



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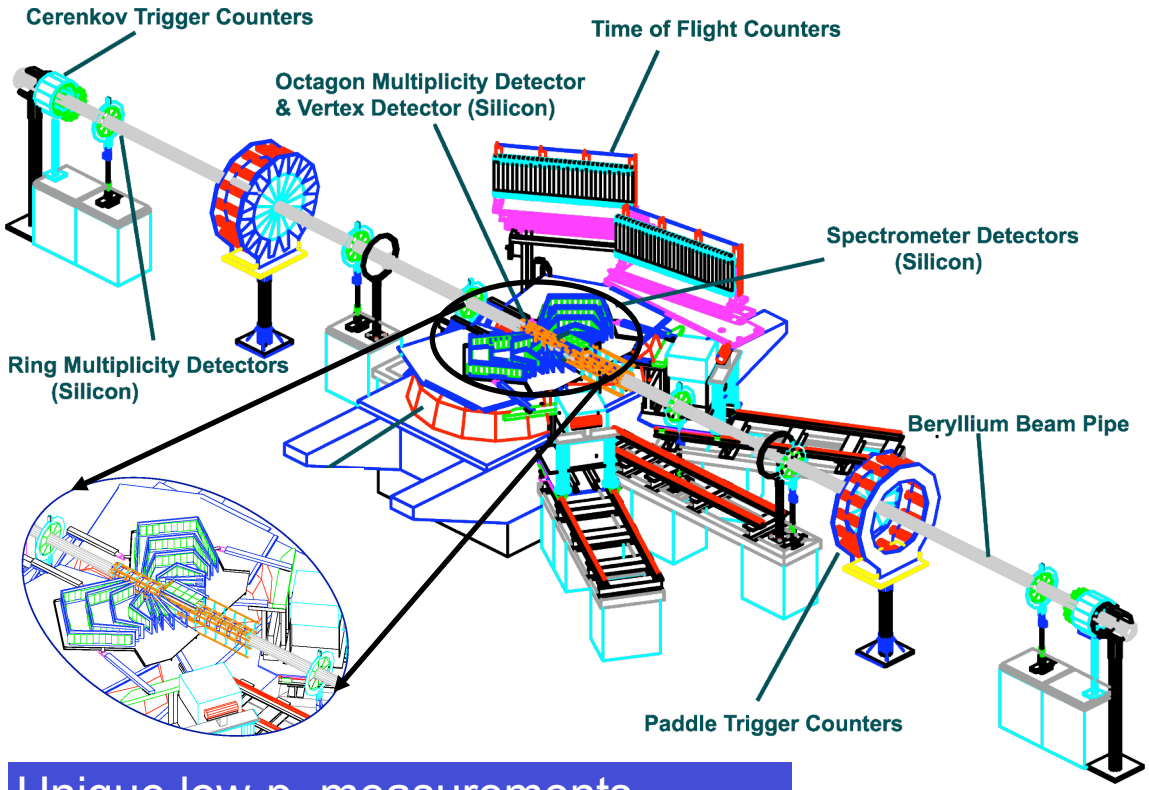
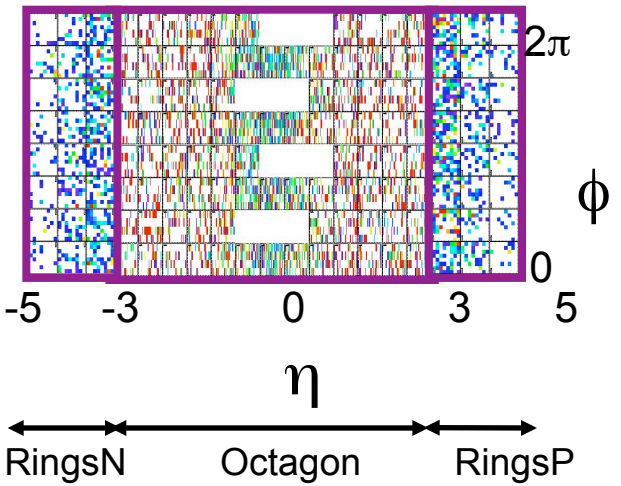
*spokesperson

Large acceptance for N_{ch}

$-5.4 < \eta < 5.4$ ($0.5^o < \theta < 179.5^o$), $0 < \phi < 2\pi$





Vertex+Spec fill the Octagon holes

Unique low-p_T measurements

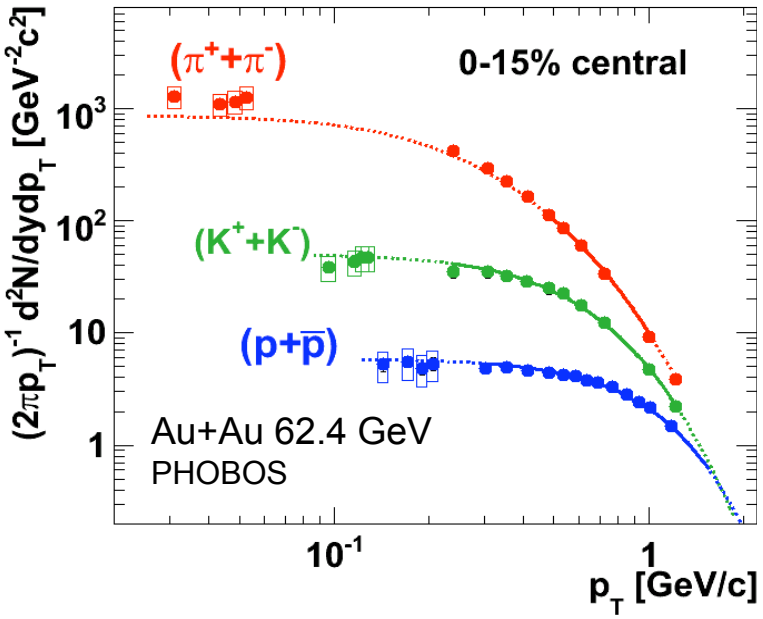
Lesson #1

At RHIC there is no anomalous production of low p_T particles

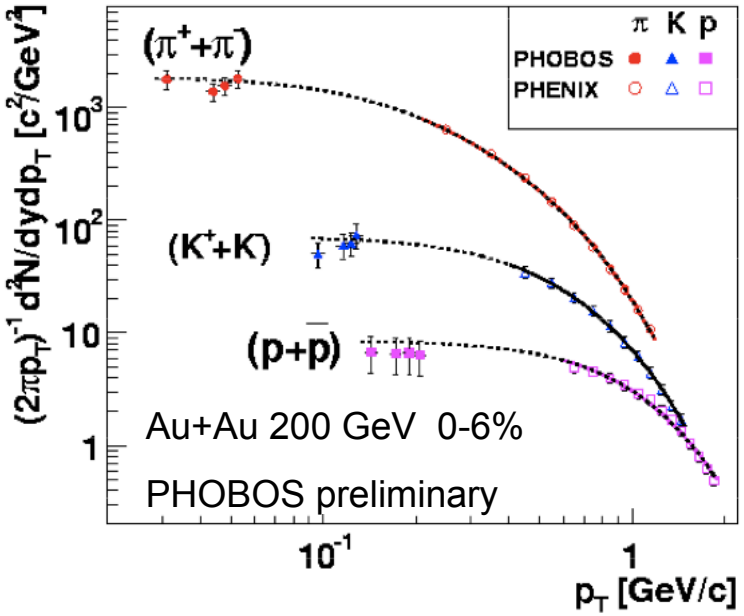
- Sensitivity to phenomena coherent over large distances (eg DCC's) a design feature of PHOBOS

Energy and centrality dependence of low-p_T spectra

Phys. Rev. C75, 024910 (2007)



Gburek, QM 2008



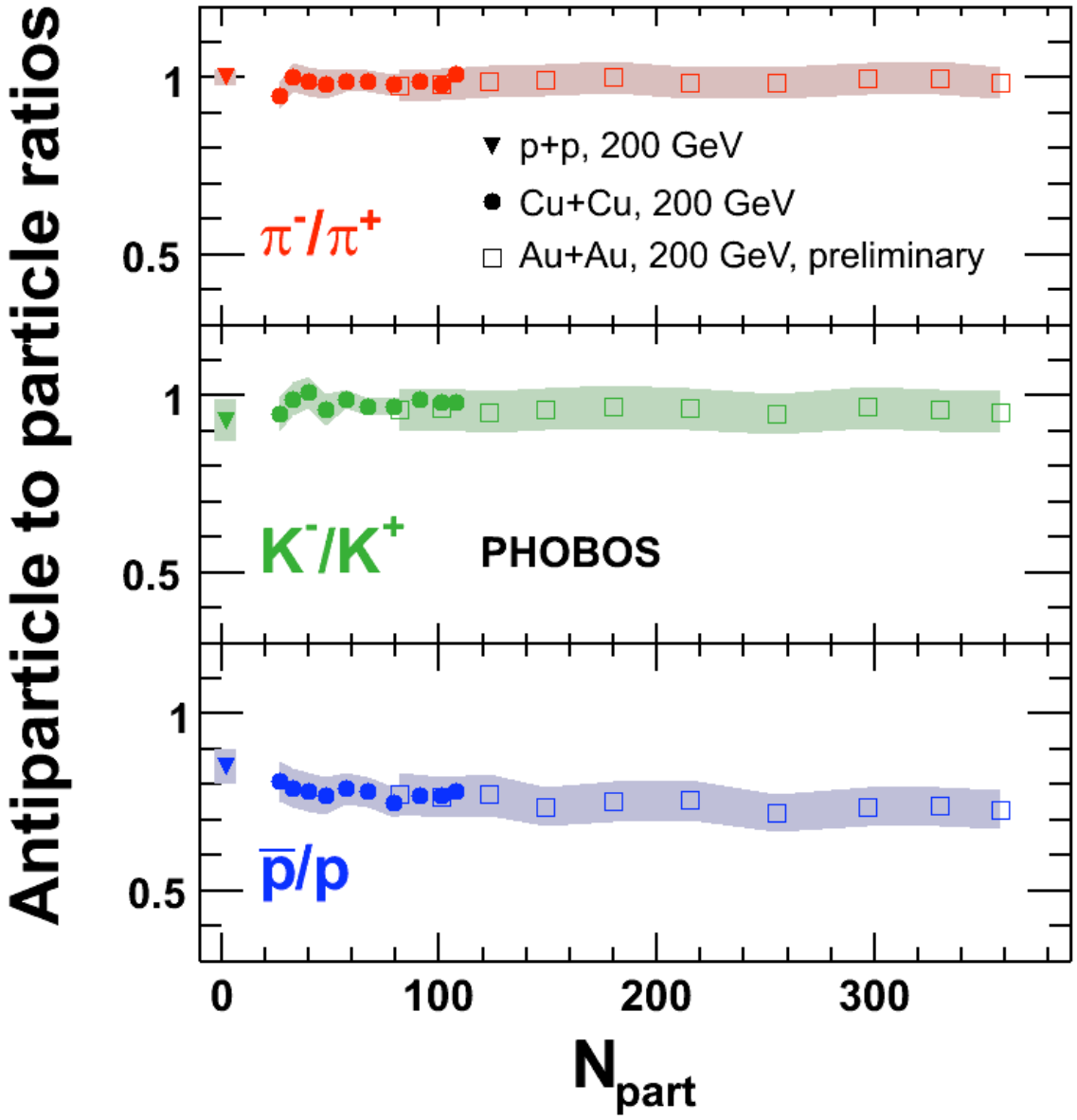
No anomalous low p_T enhancement

Lesson #2

Although at RHIC at mid-rapidity a zero net baryon density is not reached, the ratio of particles to antiparticles is already independent of the colliding systems

- Why does more material not lead to stronger stopping?

Centrality dependence of particle ratios near mid rapidity



Phys. Rev. C 77, 061901(R) (2008)
Phys. Rev. C 71, 021901(R) (2005)

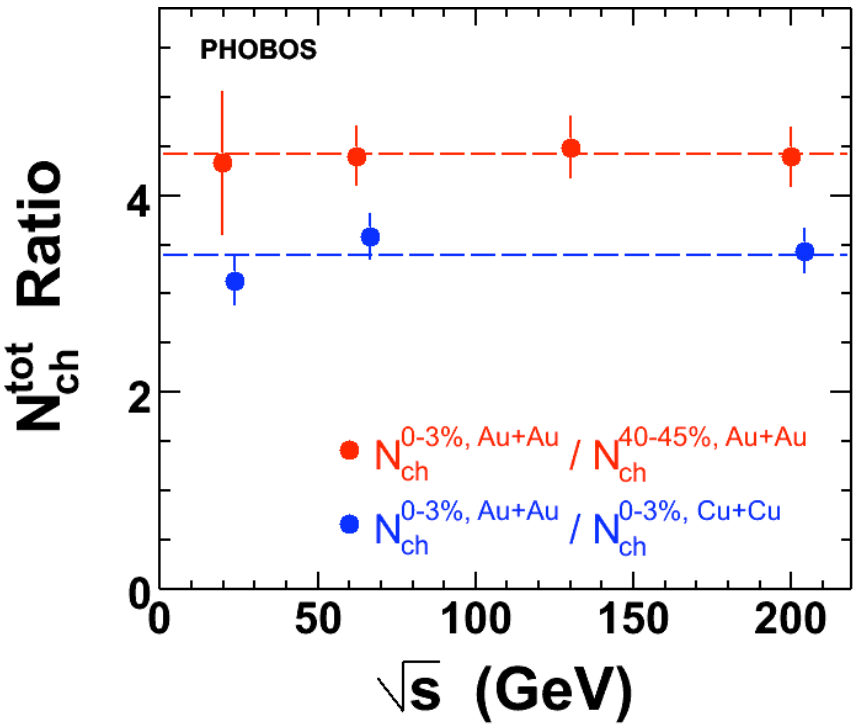
Lesson #3

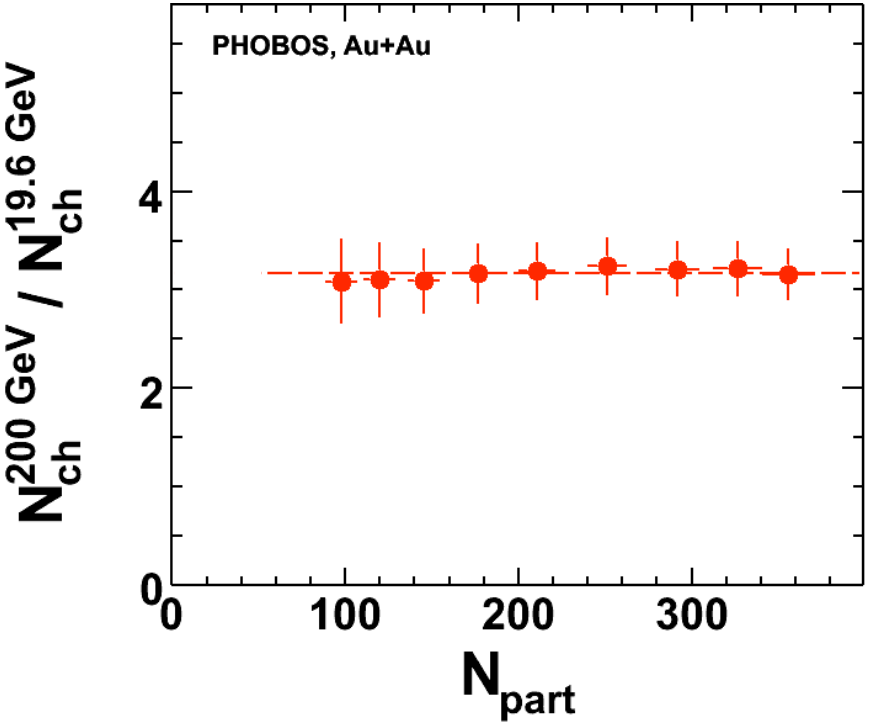
Energy and system dependences factorize

- i.e. the energy dependence of the global features of the data is independent of the colliding systems
- the system dependence of the global features is independent of the energy

- energy/system “factorization” is not expected
  - ratio of hard to soft collisions increases with energy

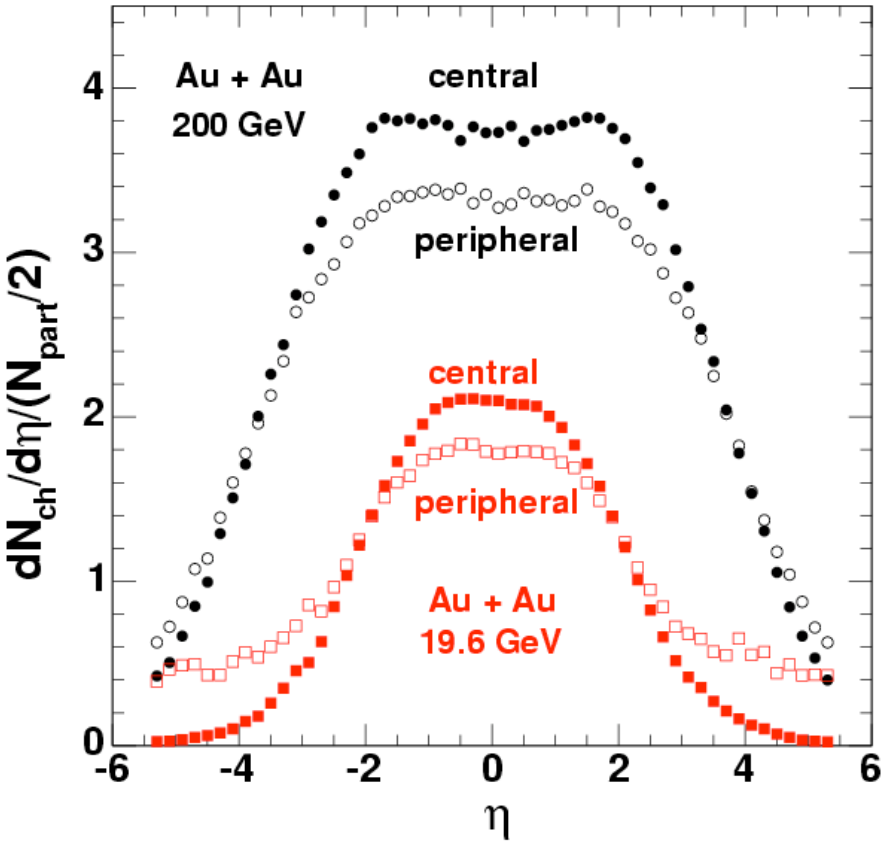
Factorization of energy and system dependence of total charged particle production





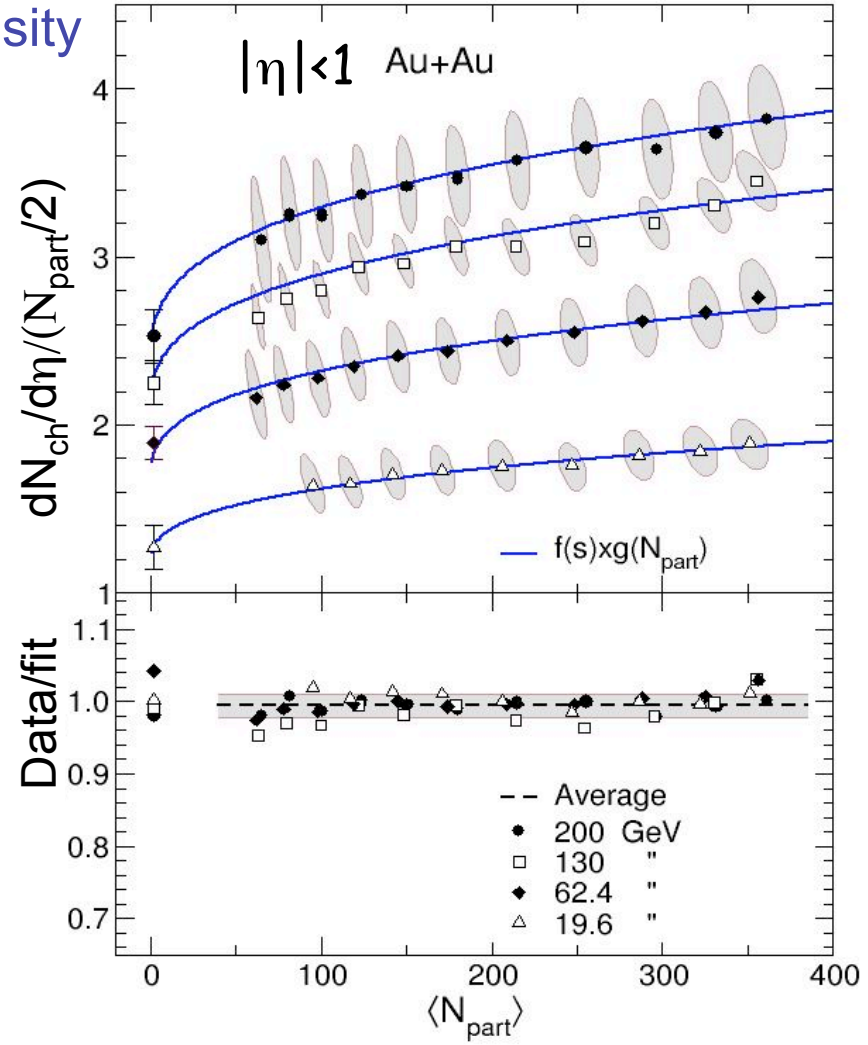
Data: arXiv:0709.4008 (nucl-ex)

Factorization of energy and system dependence of mid rapidity particle density



Nucl.Phys. A715, 65 (2003)

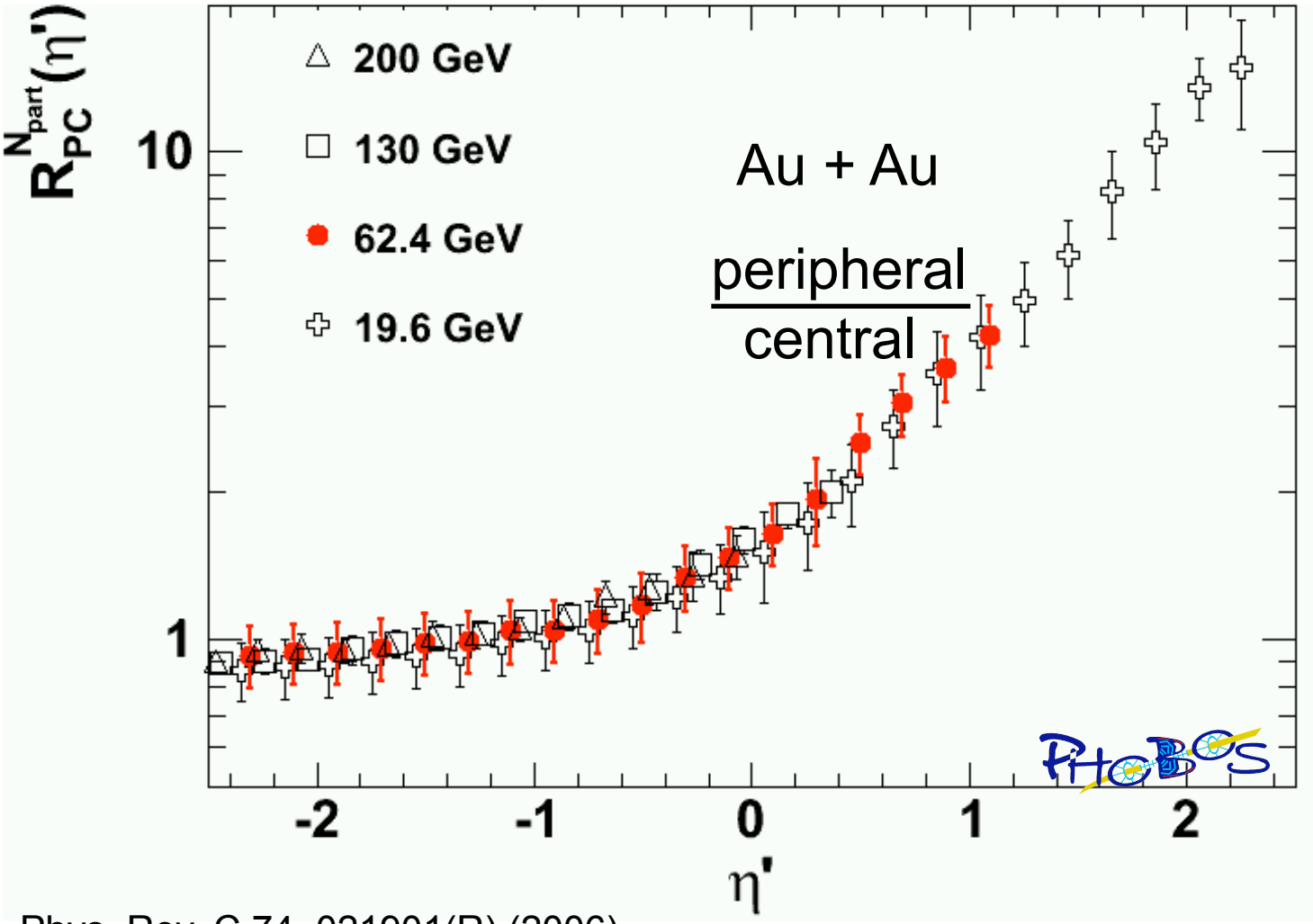
PRL 91, 052303 (2003)



Data: PHOBOS, PRL 97, 012301 (2006);
PRC70,021902(R) (2004);
PRC65, 061901(R) (2002)

fit: B.Back, Big Sky (2007)

Factorization of energy and system dependence of particles produced in the fragmentation region of one nucleus

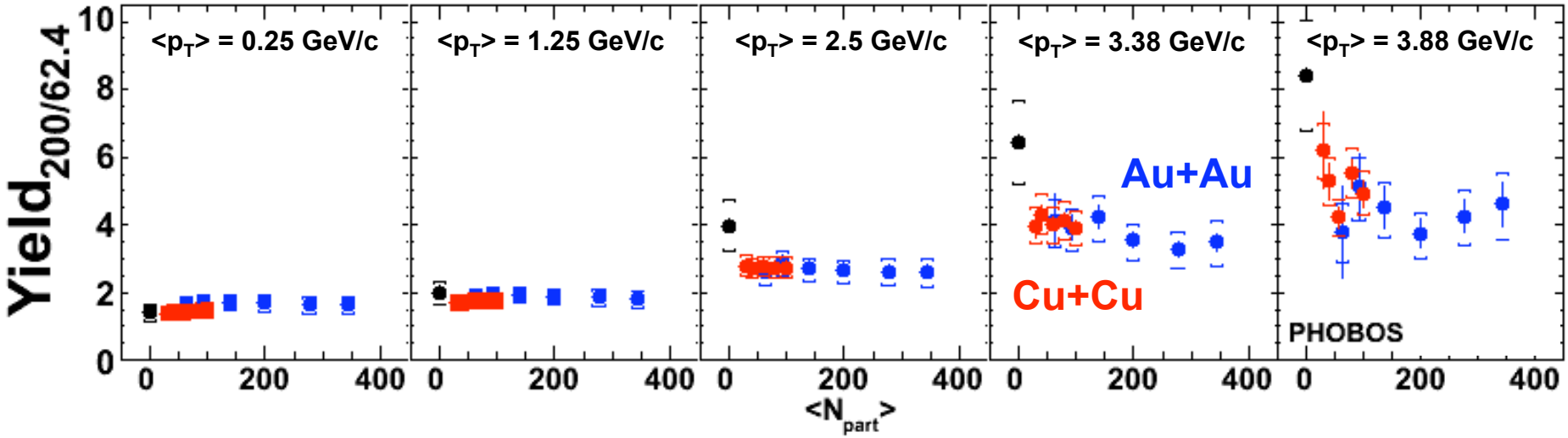


Phys. Rev. C 74, 021901(R) (2006)

arXiv:0709.4008 [nucl-ex]

Factorization of energy and system dependence near mid rapidity for particles produced with different P_T

Ratio of charged hadron yields comparing 200 GeV to 62 GeV



Au+Au: PHOBOS, PRL 94, 082304 (2005)

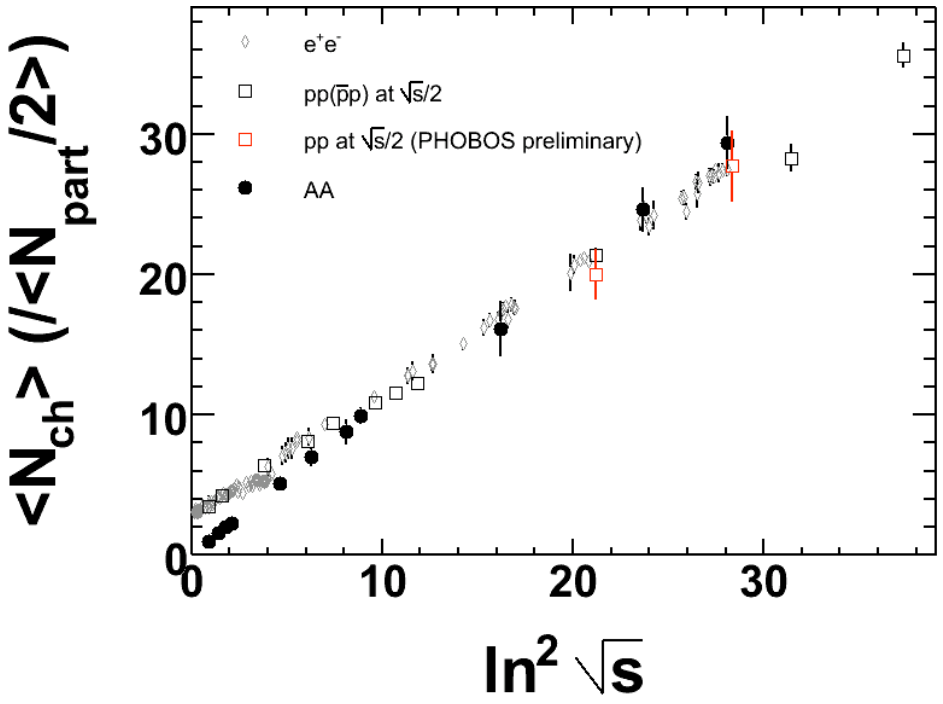
Lesson #4

Total particle production in e^+e^-, pp, pA and AA insensitive to colliding systems

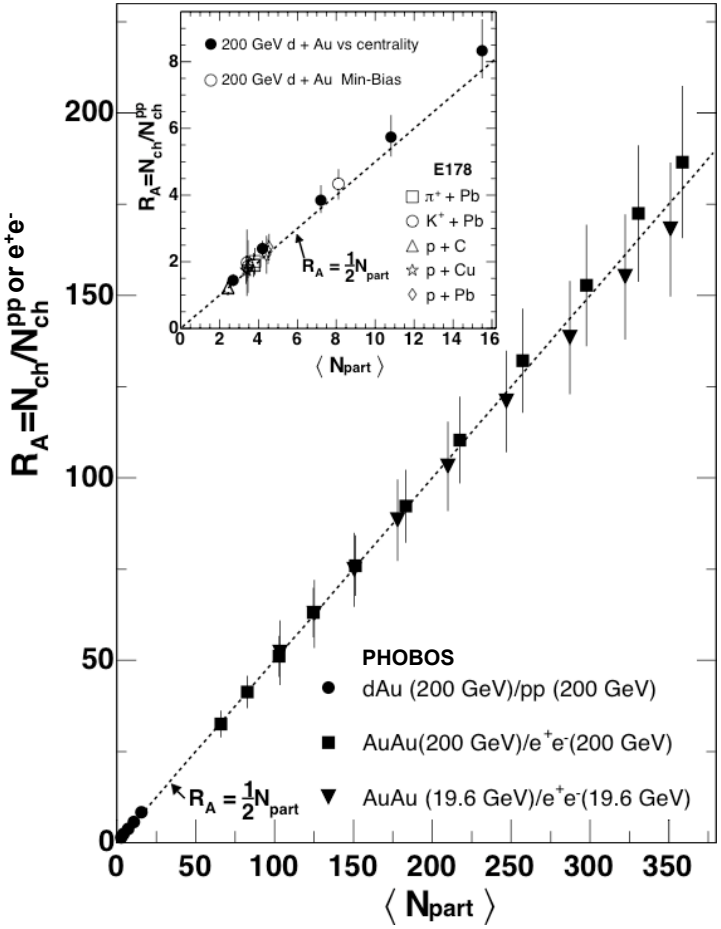
- In our current understanding of AA collisions the intermediate state is very different for high and low energy collisions
- Similarly for e^+e^-, pp and AA collisions
- What is the mechanism that makes the total particle production insensitive to the intermediate state?

Similarity of total particle production in e^+e^-, pp, πA, KA, pA and AA collisions

2-900 GeV energy range



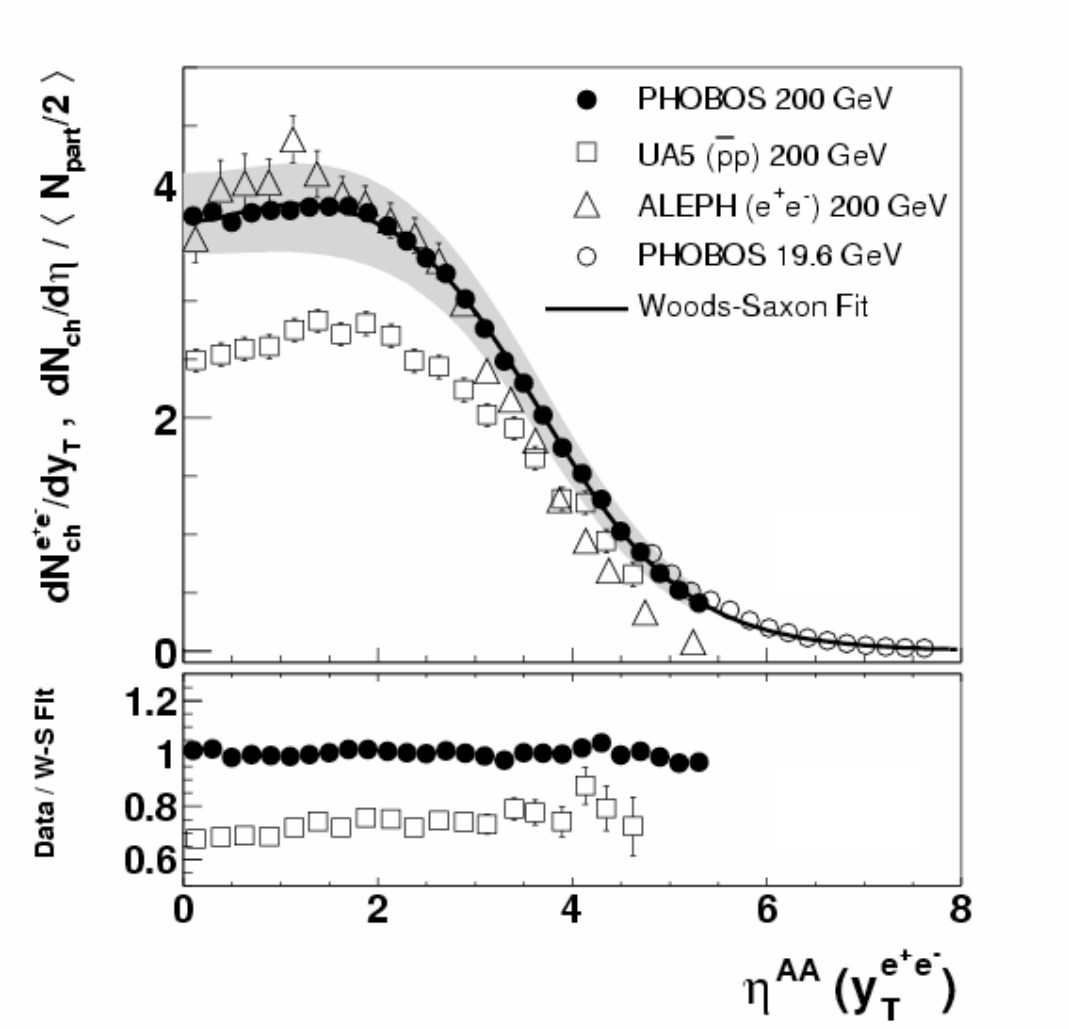
10-200 GeV energy range
2-350 N_{part} range



PHOBOS: Nucl. Phys. A 757 28 (2005)
E178: PRL34(1975)836
WB Acta. Phys.Pol.B35(2004)2873

* See poster of J.Sagerer

Similarity of e^+e^-, pp and AA pseudorapidity distributions



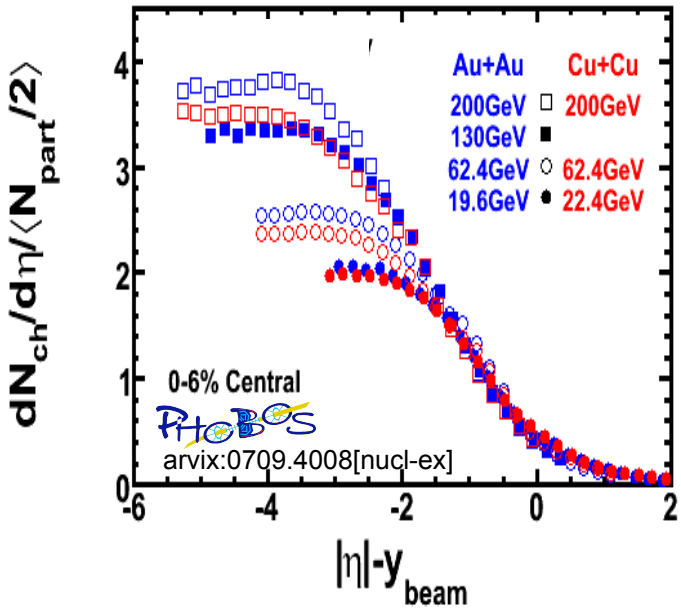
Phys. Rev. C74, 021902(R) (2006)

Lesson #5

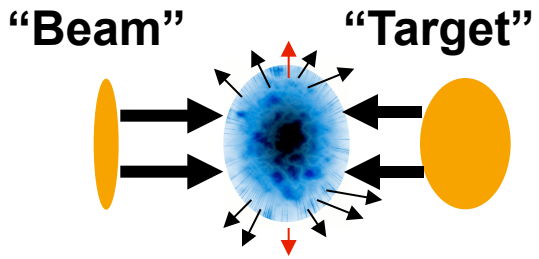
The production process shows signs of significant saturation during the early stages of the collision

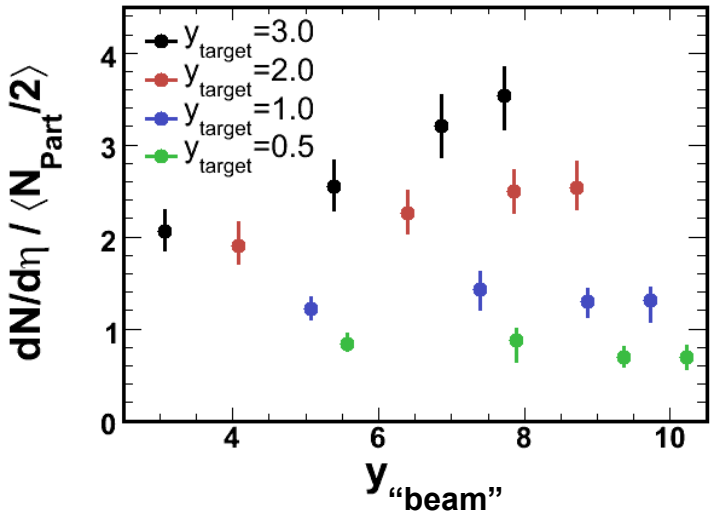
- Direct manifestation of saturation of particle production comes from extended longitudinal scaling
- Indirect evidence comes from the low value of the number of particles produced

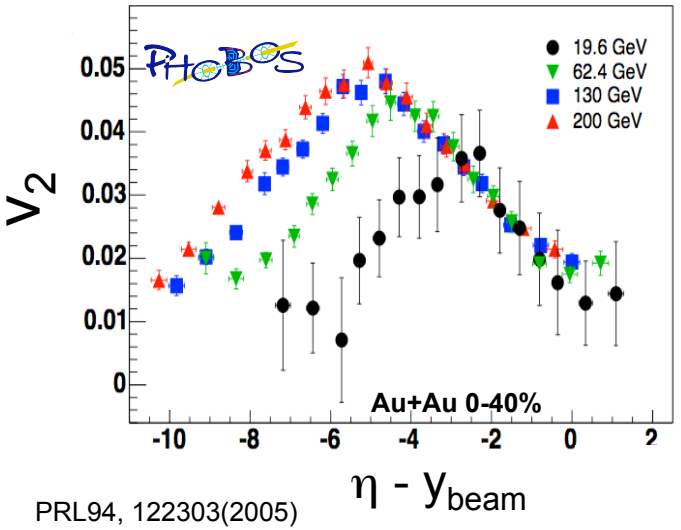
Direct manifestation of the saturation of particle production

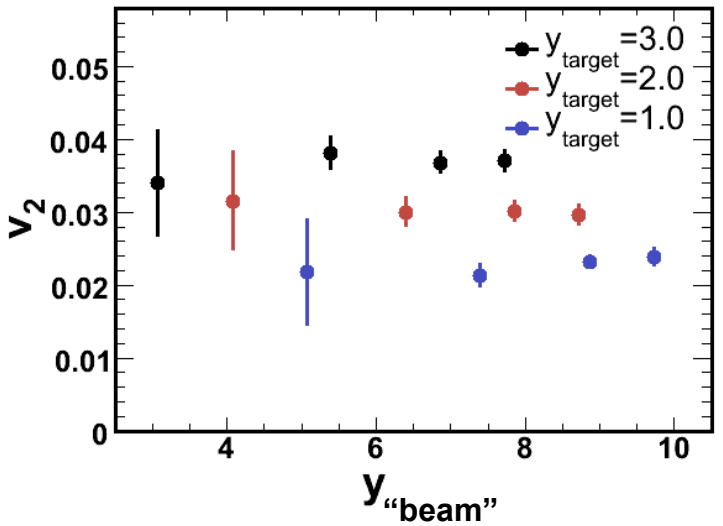


Taking y≈η



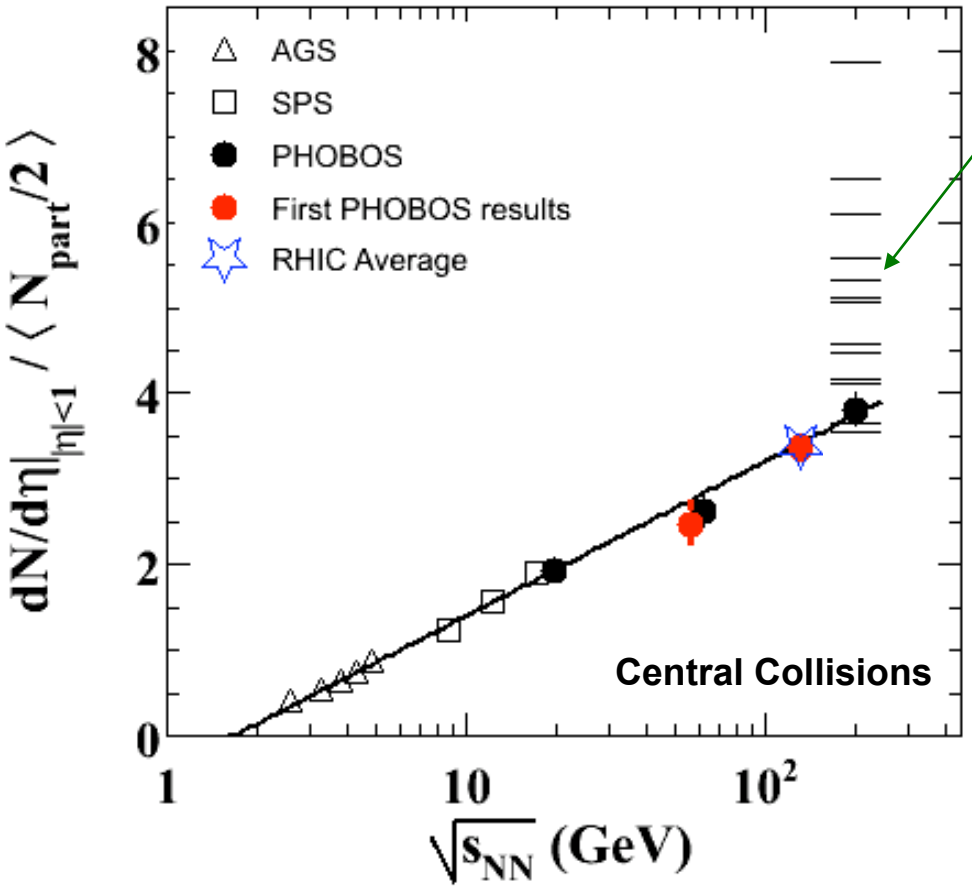






PRL94, 122303(2005)

Indirect evidence of saturation



Models predating data

Nucl. Phys. A747(2003)28

Lesson #6

There is clear evidence of a non-trivial correlation between particles separated by large rapidities

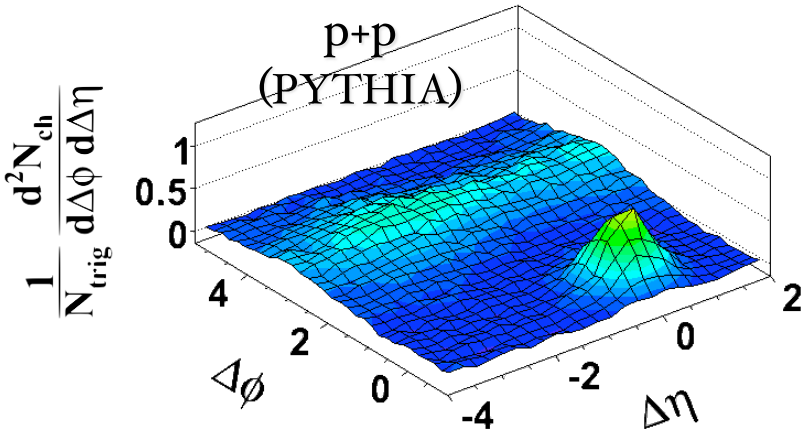
- Particles with different rapidities are produced at different space-time
- Correlations must be produced at early times

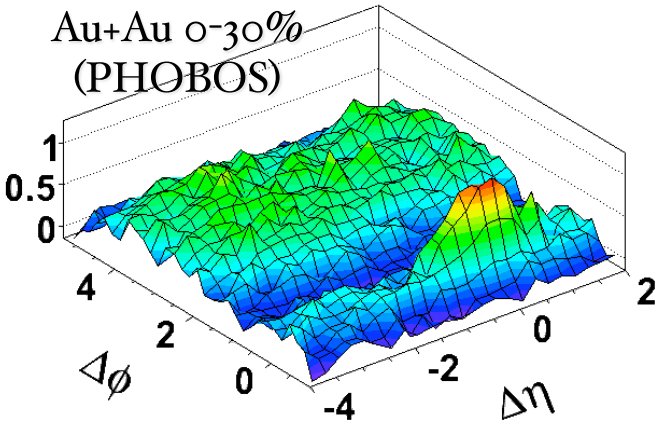
* See G. Stephans' talk on correlation studies in PHOBOS

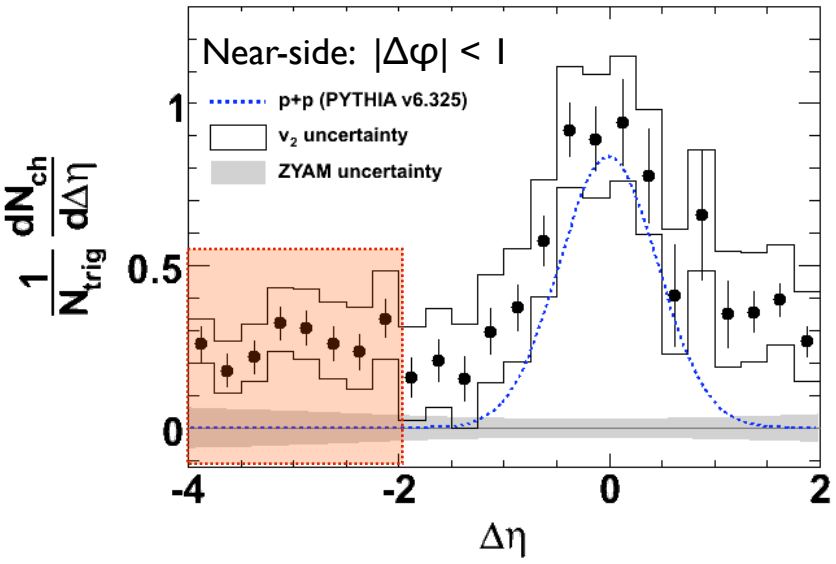
PHOBOS ridge studies

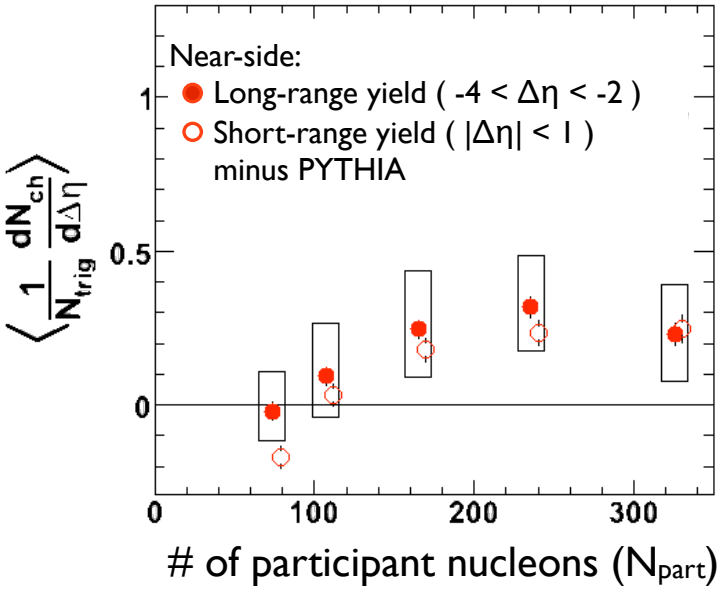
(triggered 2-particle correlations)

p_T^{trig} >2.5 GeV/c
p_T^{assoc} > 4 - 35 MeV/c





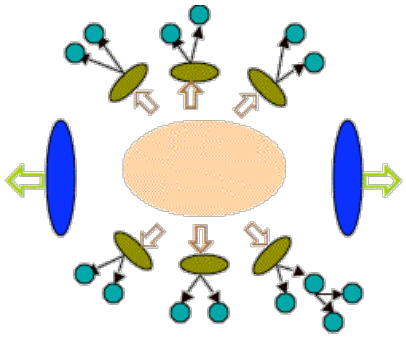




arXiv:0903.2811 [nucl-ex]

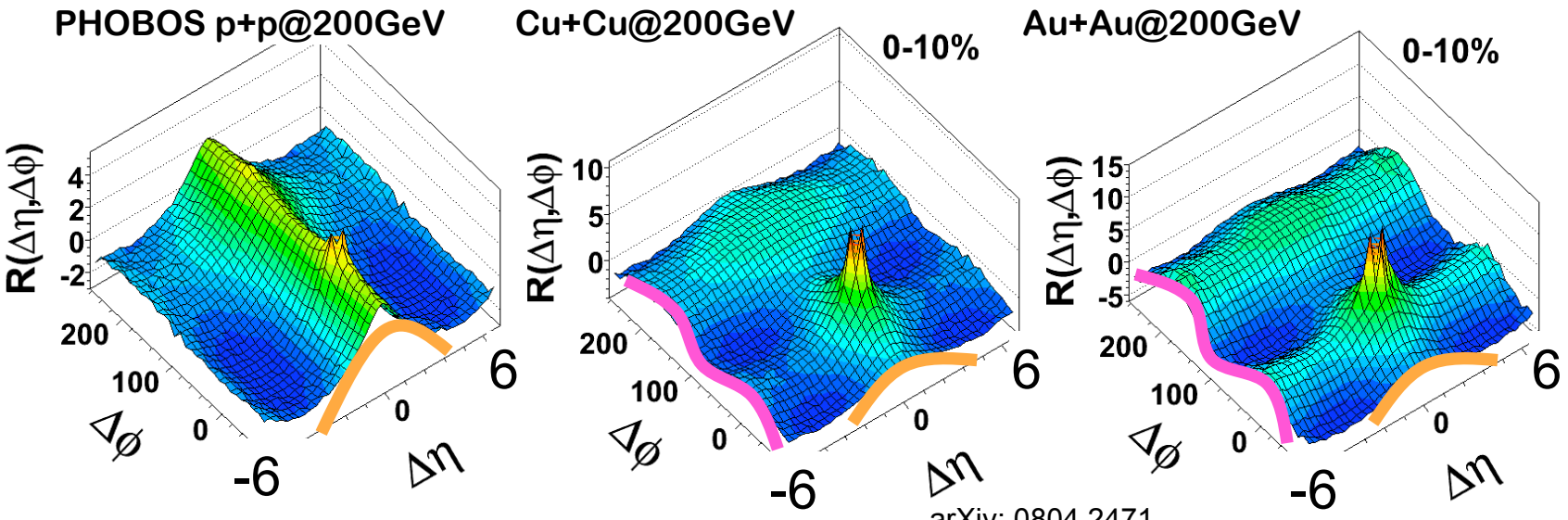
Lesson #7

In RHIC collisions the final state decays into clusters which break up into an unexpectedly large number of particles, covering a broad range of rapidities and azimuthal angles. Furthermore the number of correlated particles is N_{part} dependent



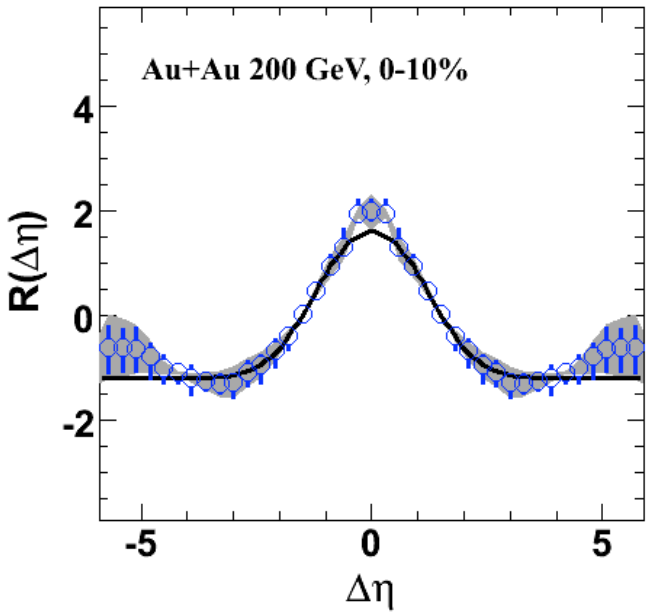
- Up to 8 correlated particles
- Mass of decaying system must be many GeV
- String origin?

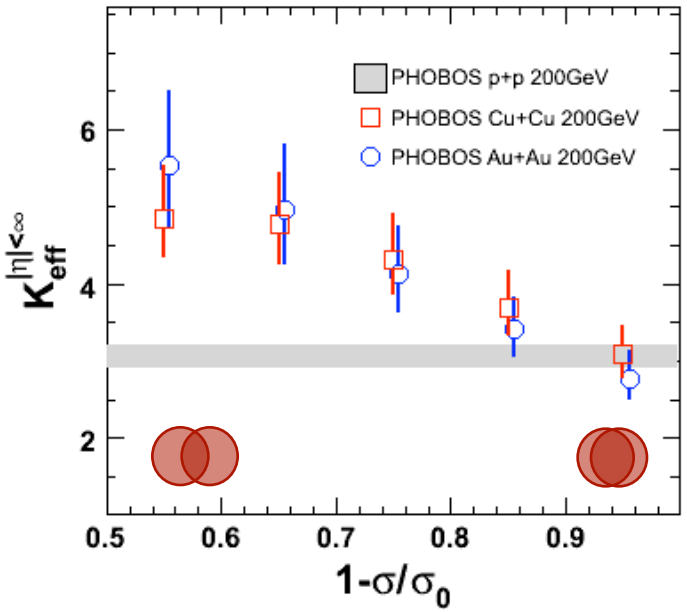
PHOBOS studies of inclusive two-particle correlations



Phys. Rev. C75(2007)054913

arXiv: 0804.2471



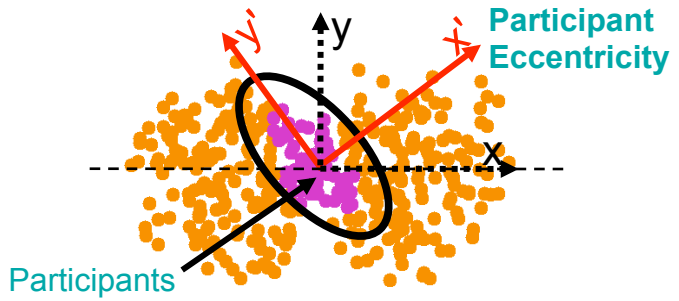


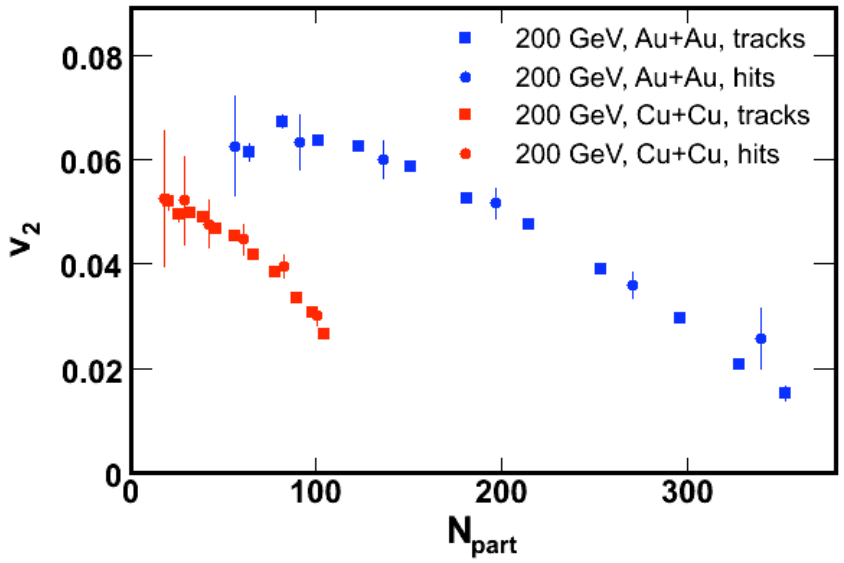
Lesson #8

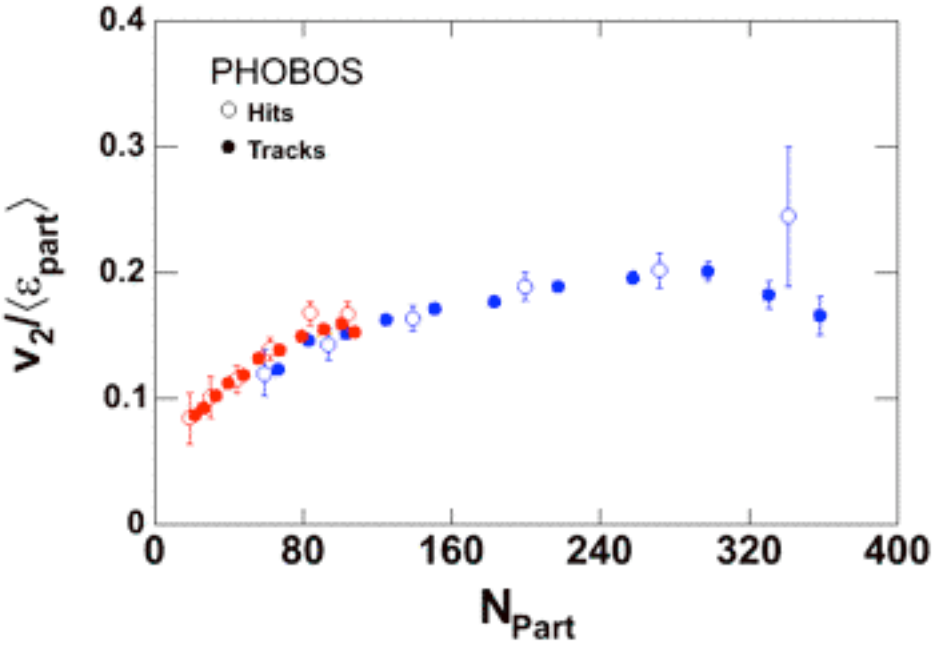
The final distributions of particles often reflect the “geometry” of the colliding systems at the instant of collision, rather than the size of the system

- Event by event shape is important
- Why does cluster size depend on shape rather than on volume?

Event-by-Event geometry dependence of V_2

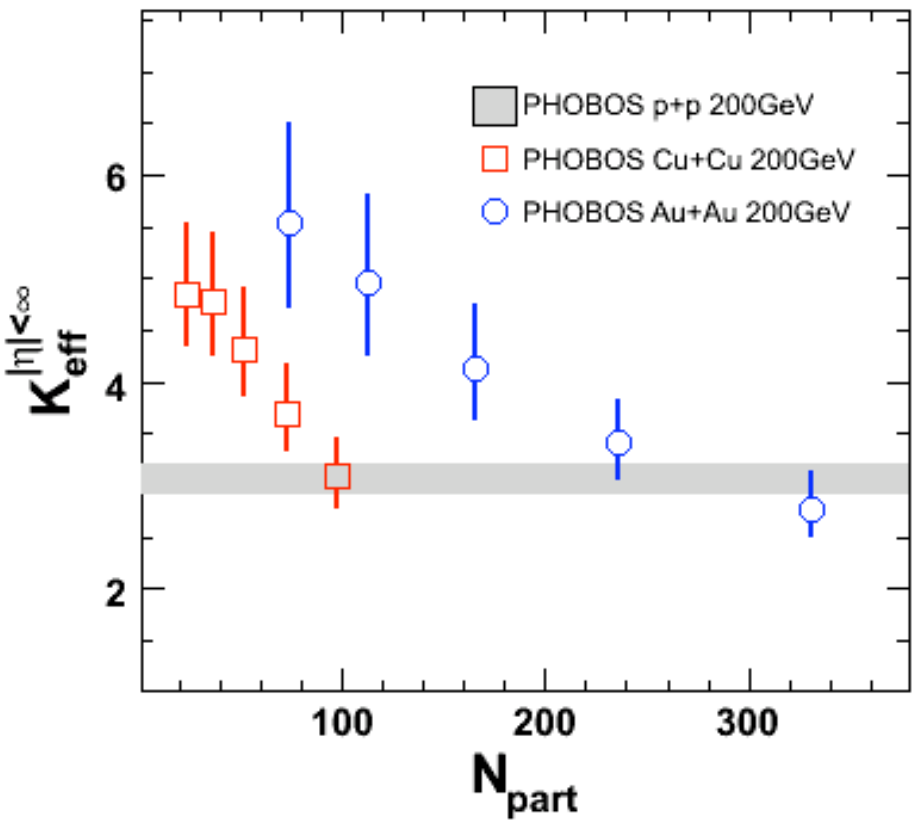


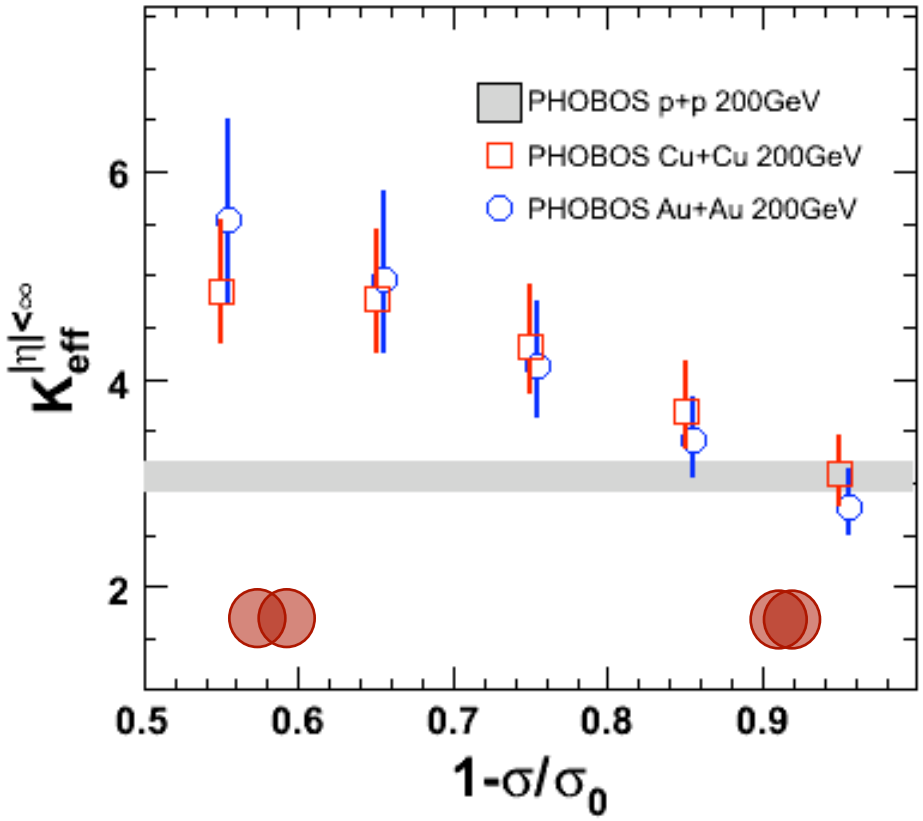




Phys. Rev. Lett. 98, 242302 (2007)

Geometry dependence of cluster size



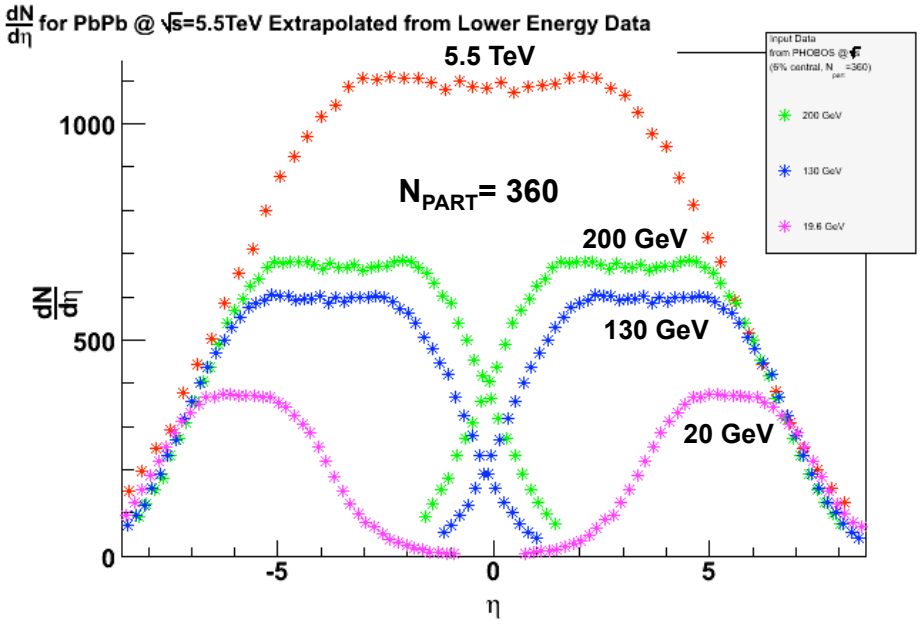


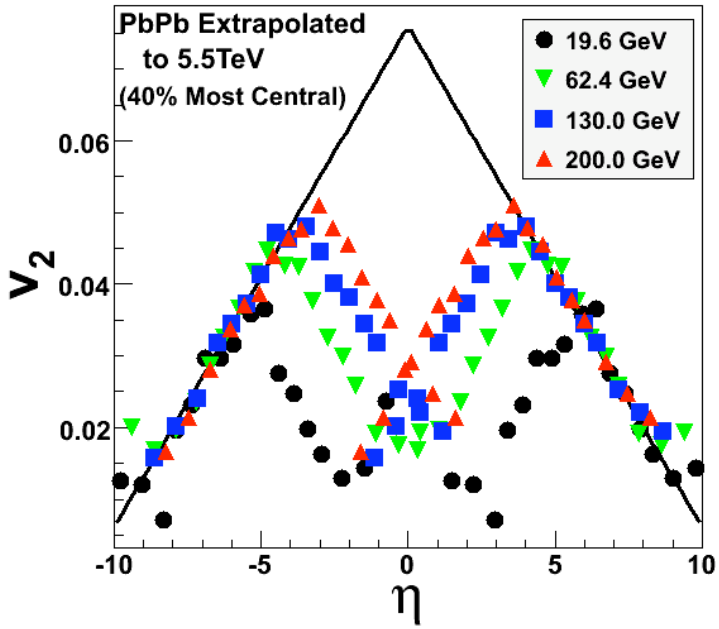
arXiv: 0804.2471

The PHOBOS data can be extrapolated to LHC energies

- Will the features so prominent at the AGS, SPS and RHIC continue to be prominent at LHC?
- If so, what will that imply?

Extrapolation of PHOBOS data to LHC energies





Total charged multiplicity in central (N_{part} = 386) PbPb collisions at $\sqrt{s}$ = 5.5 TeV = 15000 ± 1000

Mid-rapidity dN/dη in central (N_{part} = 386) PbPb collisions at $\sqrt{s}$ = 5.5 TeV = 1200 ± 100

Total charged multiplicity in inelastic pp collisions at $\sqrt{s}$ = 14 TeV (10 TeV) = 60 ± 10 (56 ± 9)

AuAu Data from PHOBOS, Nucl. Phys. A757 (2005) 28

Extrapolation: WB J. Phys. G35, 044040 (2008).

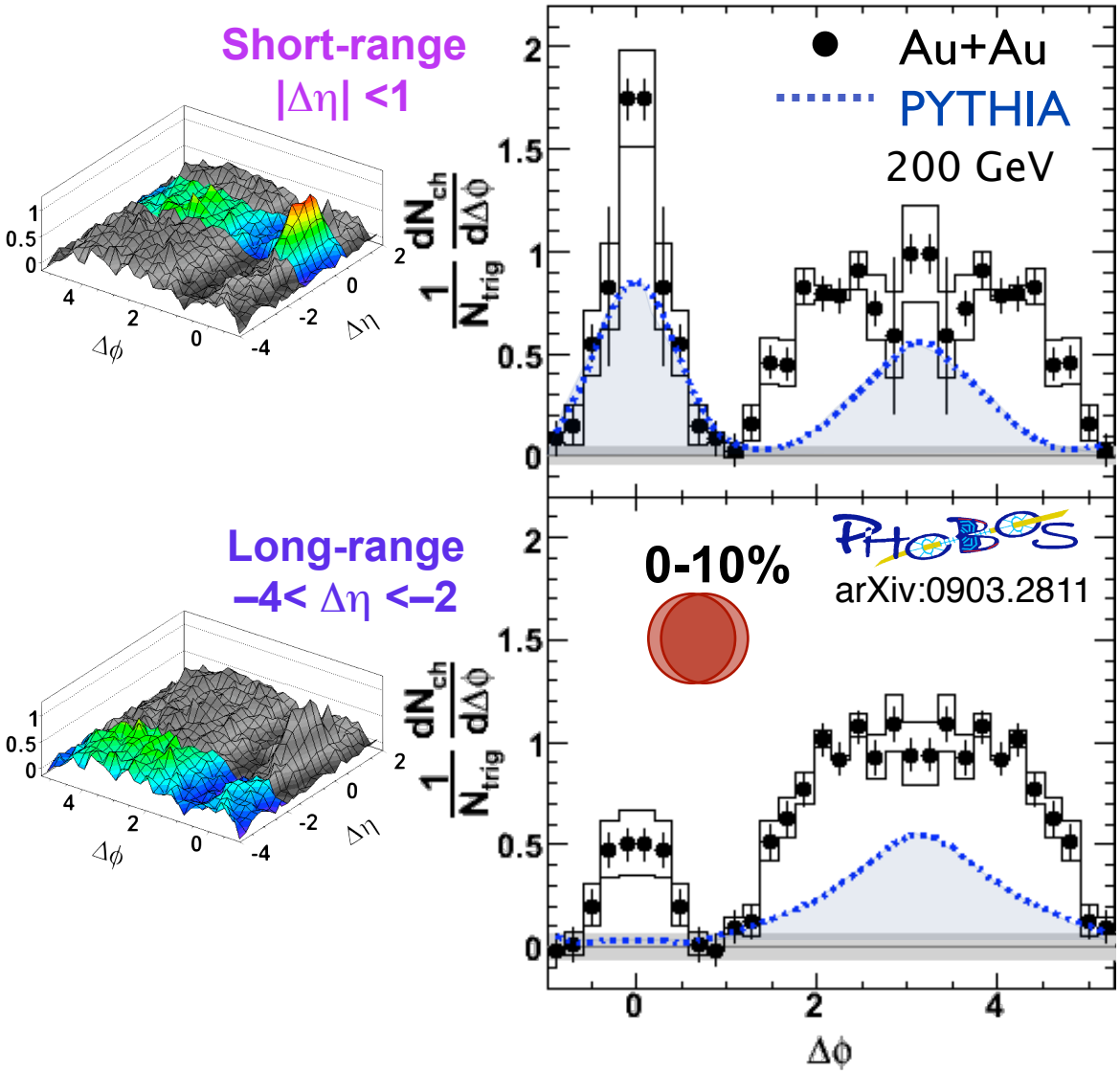
Summary

In addition to significant contributions to the discoveries and evolution of the current picture of RHIC physics

- PHOBOS data has revealed some intriguing features.
- The significance of these features is still not well understood
- It will be interesting and instructive to see if the features seen in PHOBOS data at RHIC will continue to be prominent at LHC.

Backup slides

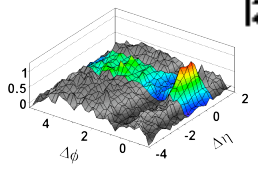
Integrated Ridge Yield: $|\Delta\eta|<1$ vs $-4<\Delta\eta<-2$



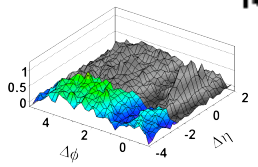
Project 2D correlation onto $\Delta\phi$ axis. Subtract out the Pythia peaks and then plot versus centrality for short- and long-range

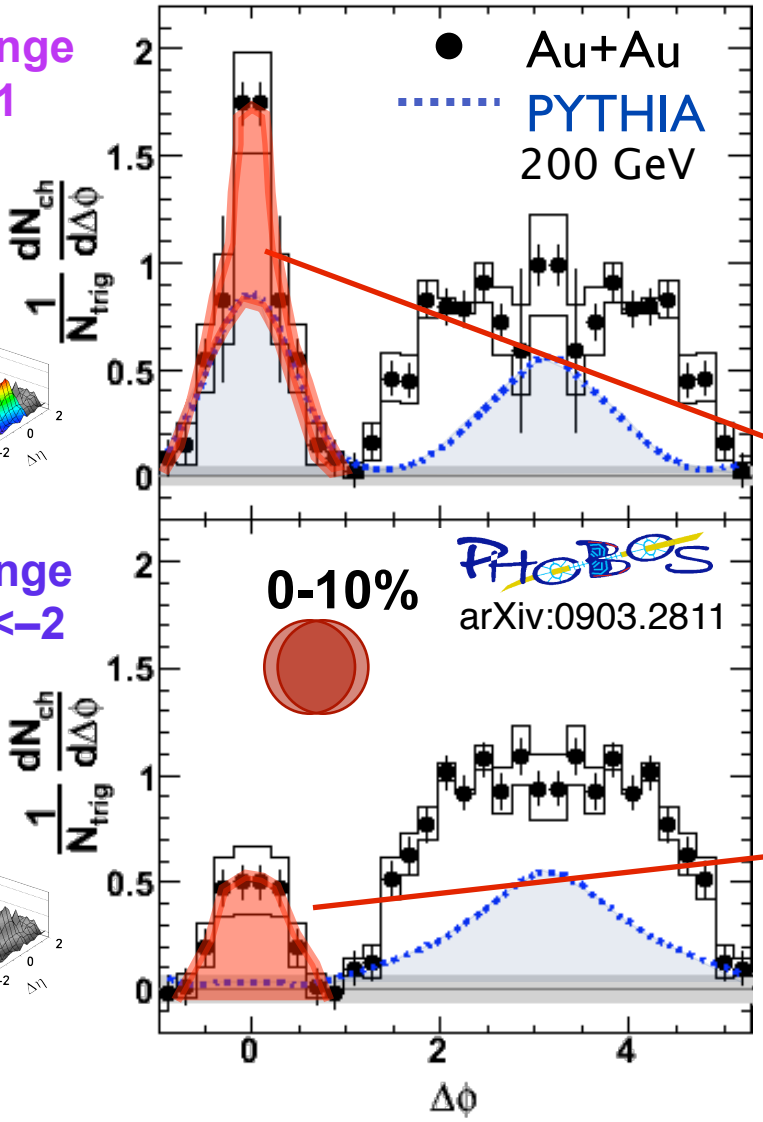
Integrated Ridge Yield: $|\Delta\eta|<1$ vs $-4<\Delta\eta<-2$

Short-range
$|\Delta\eta| < 1$

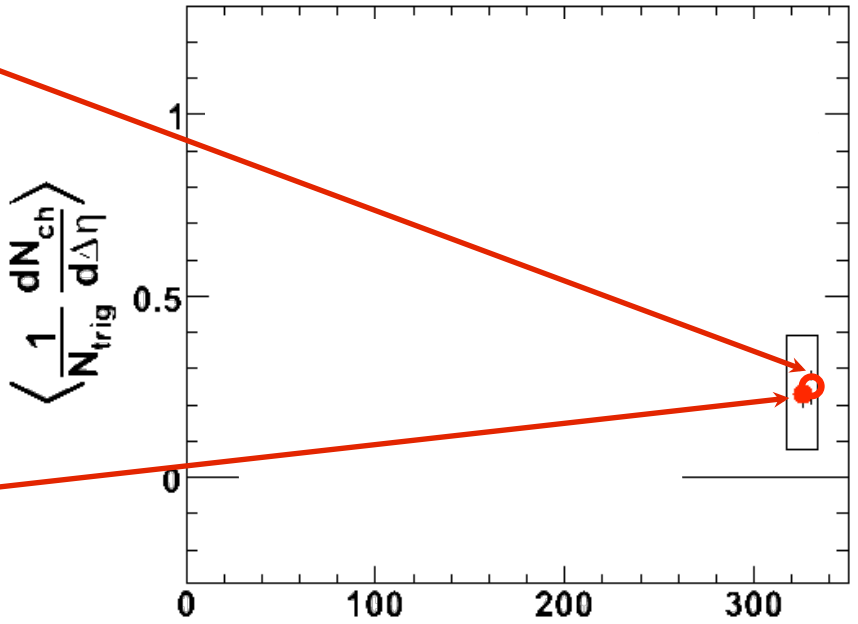


Long-range
$-4 < \Delta\eta < -2$



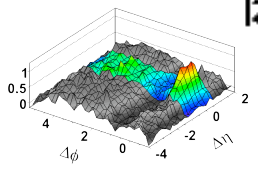


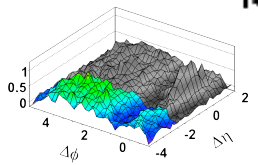
NEAR side
- short-range minus PYTHIA
- long-range (PYTHIA≈0)

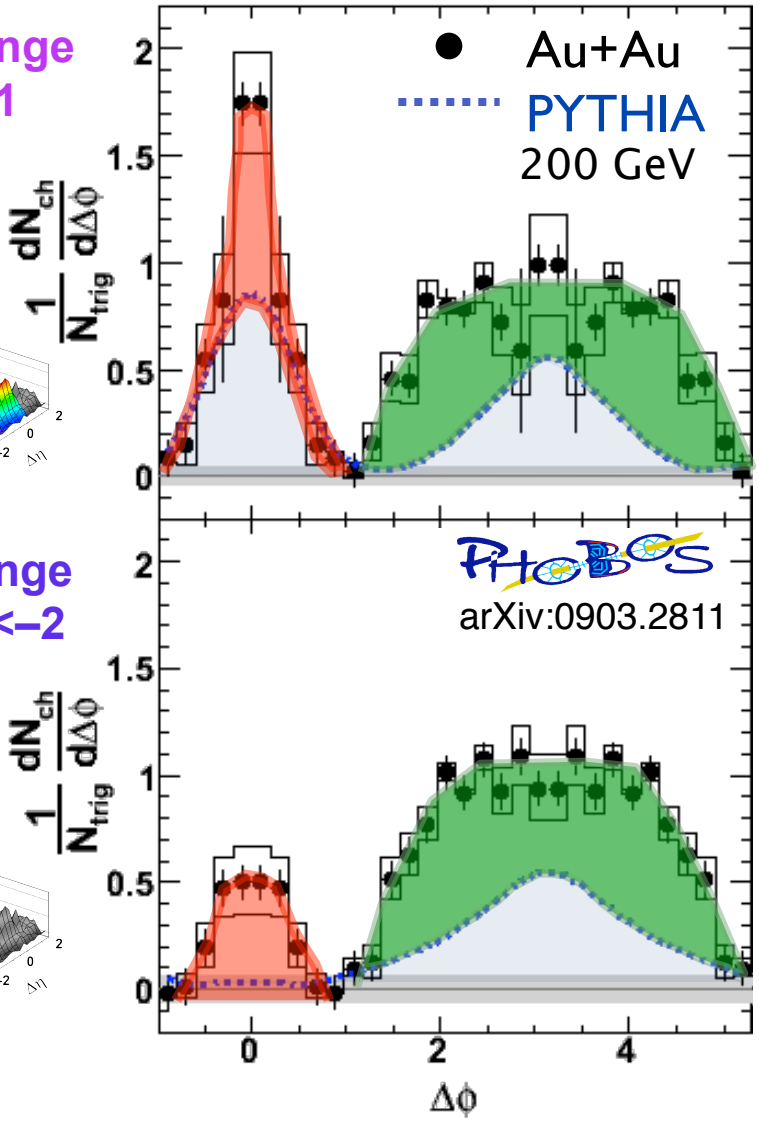


Integrated Ridge Yield: $|\Delta\eta|<1$ vs $-4<\Delta\eta<-2$

Short-range
$|\Delta\eta| < 1$



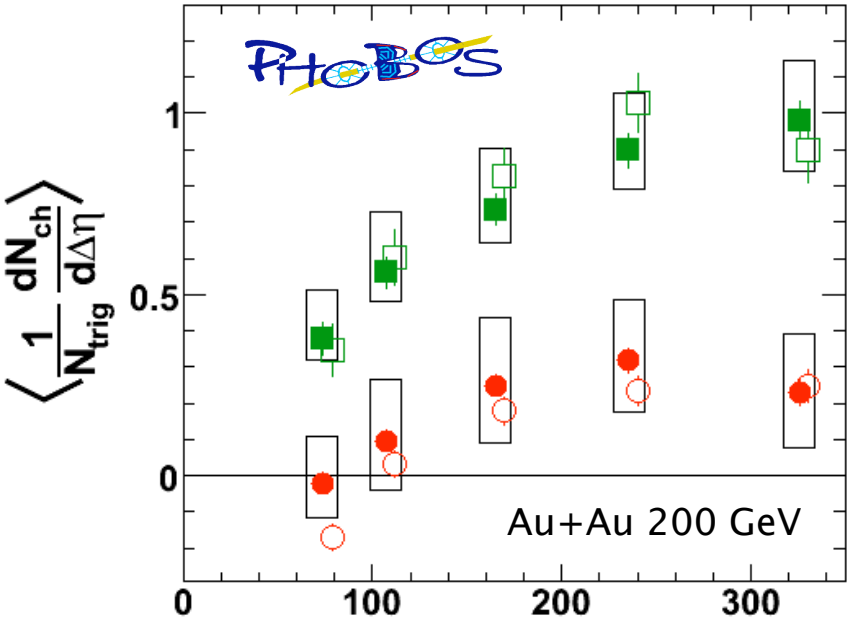




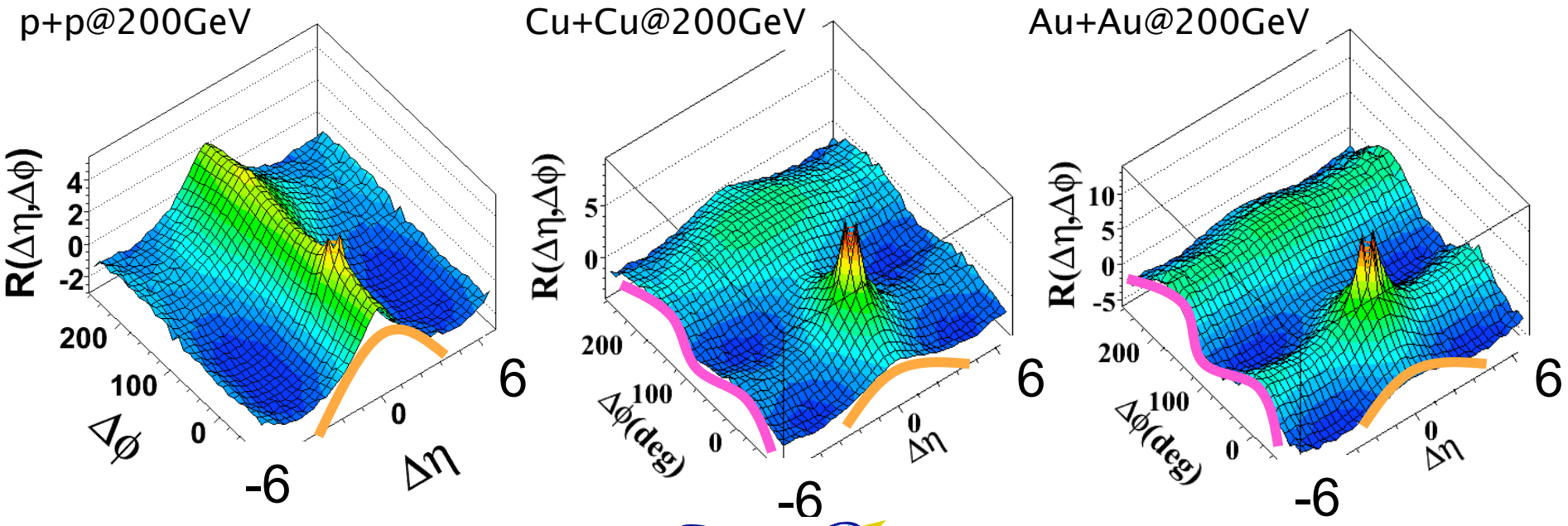
Long-range
$-4< \Delta\eta <-2$

NEAR side
- short-range minus PYTHIA
- long-range (PYTHIA≈0)

AWAY side
- short-range, long-range both minus PYTHIA



Inclusive 2-Particle Correlations



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Project onto Δη axis and fit with a simple parameterization of a cluster model