System size dependence of two-particle correlations in p+p, Cu+Cu and Au+Au collisions

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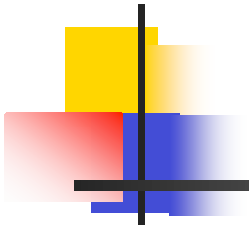
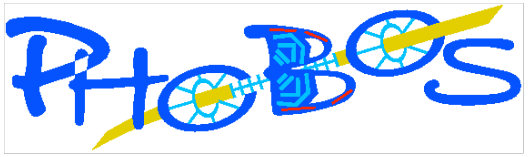
for the PHOBOS Collaboration

20th International Conference on Ultra-Relativistic Nucleus-Nucleus Collisions (Quark Matter 2008), Feburary 4-10, 2008, Jaipur, India





Collaboration

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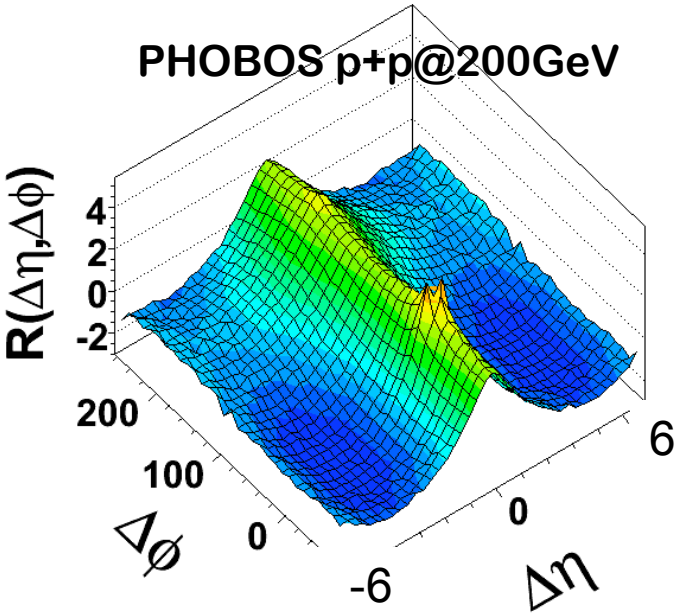
9 PhDs in progress !

Physics Motivation

Two-particle correlation function



$\begin{pmatrix} \Delta\eta=\eta_1-\eta_2 \\ \Delta\phi=\phi_1-\phi_2 \end{pmatrix}$

Phys. Rev. C75(2007)054913

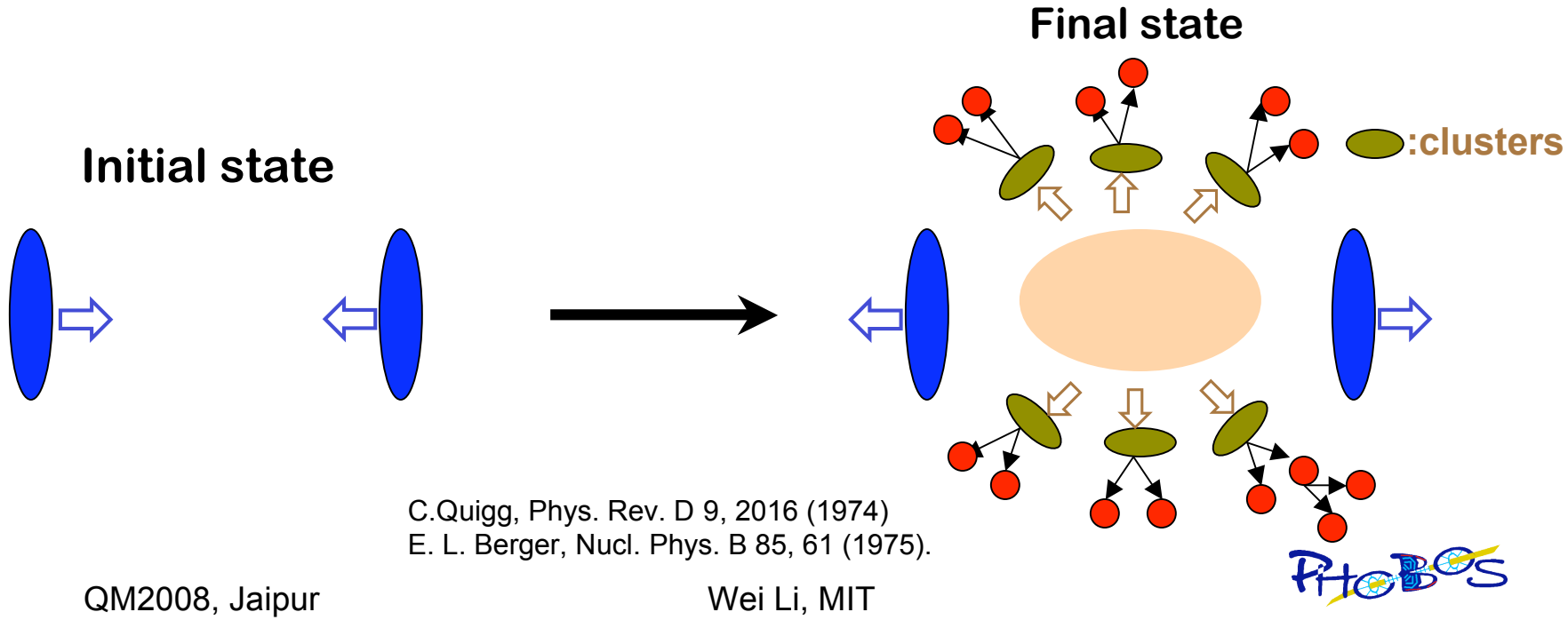
No high p_T trigger!
(soft physics)

- In p+p, particles tend to be produced in a correlated fashion (clusters).
- Systematic studies in Cu+Cu and Au+Au provide essential information on hadronization.

Physics Motivation

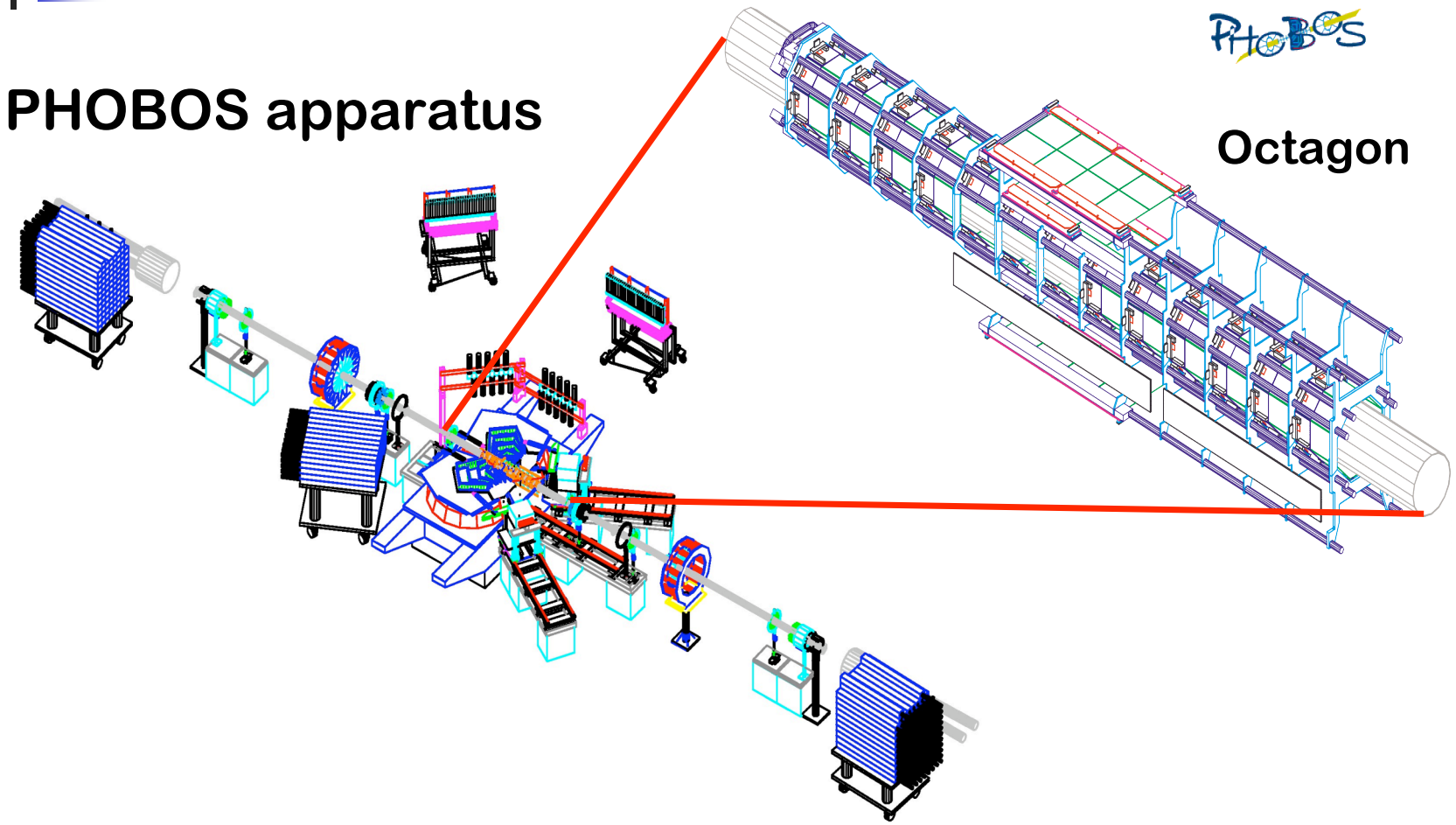
Isotropic cluster model:

- Hadronization proceeds via clusters.
- Clusters are emitted independently.
- Clusters decay isotropically in the c.m.s into hadrons.



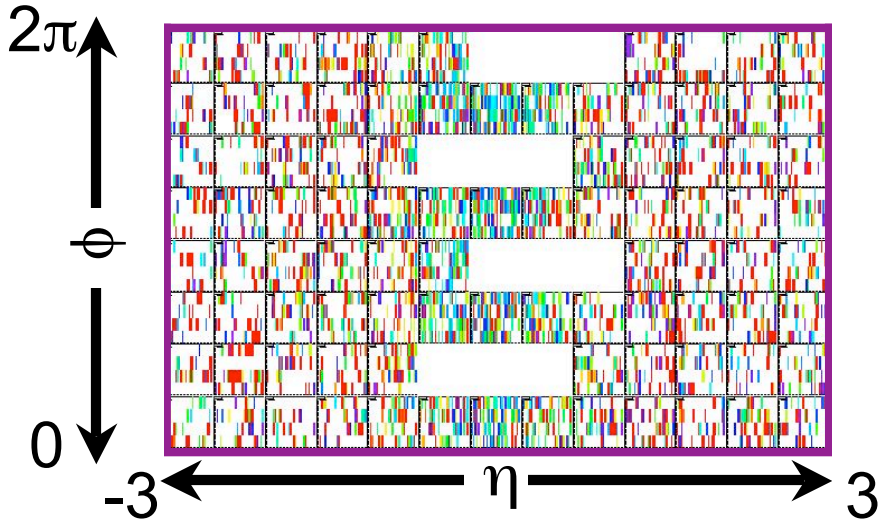
C.Quigg, Phys. Rev. D 9, 2016 (1974)
E. L. Berger, Nucl. Phys. B 85, 61 (1975).

Experimental setup



Experimental setup

PHOBOS Octagon detector:



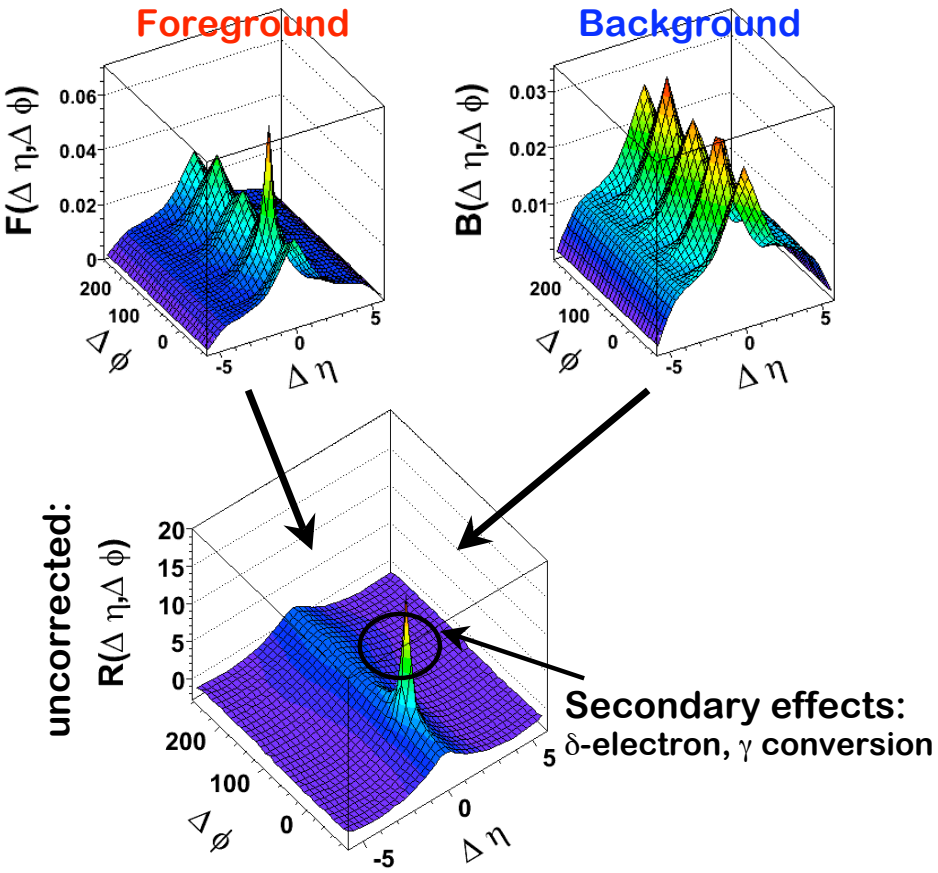
- **Uniquely large acceptance:**
  - **-3<η<3 and almost full azimuthal angle ϕ.**
- **Single-layer silicon detector:**
  - **Only (η,ϕ) of all charged particles (no p_T information).**

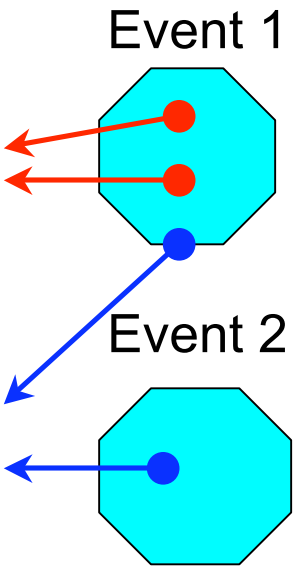
Methodology

Two-particle correlation function:

$$R(\Delta\eta,\Delta\phi) = < (n-1)\left(\frac{F_n(\Delta\eta,\Delta\phi)}{B_n(\Delta\eta,\Delta\phi)} - 1\right) >$$

(multiplicity independent!)



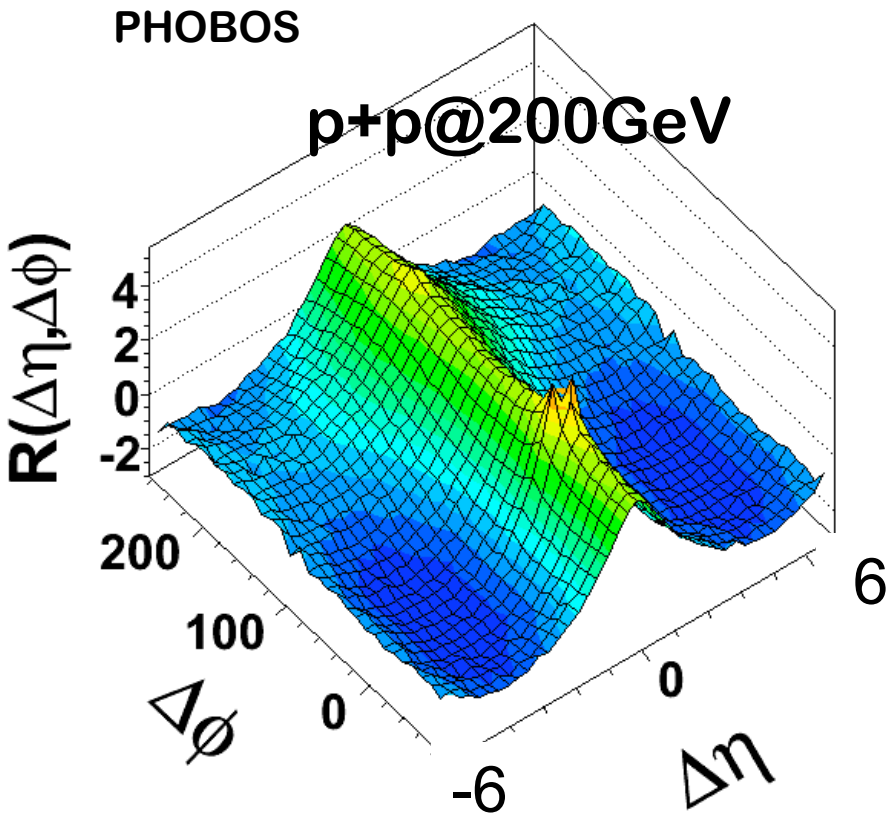


Foreground: $F_n(\Delta\eta,\Delta\phi)$
(correlated + uncorrelated pairs):

Background: $B_n(\Delta\eta,\Delta\phi)$
(uncorrelated pairs):

- **MC correction for secondary effects**
- **Occupancy corrections in A+A**

Cluster-like correlation structure



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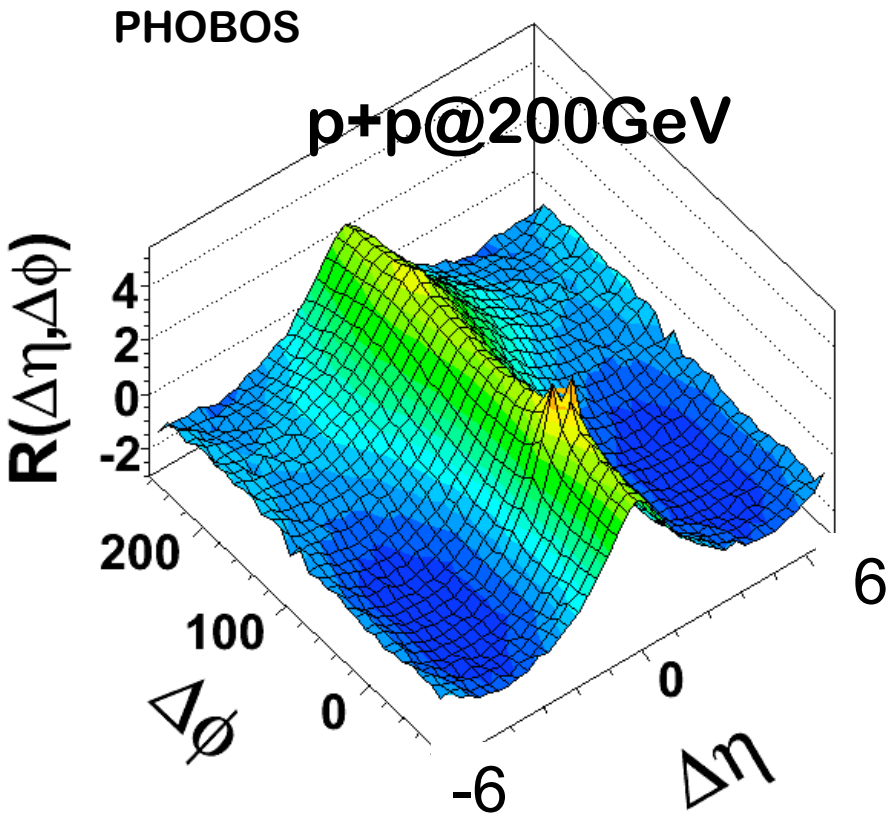
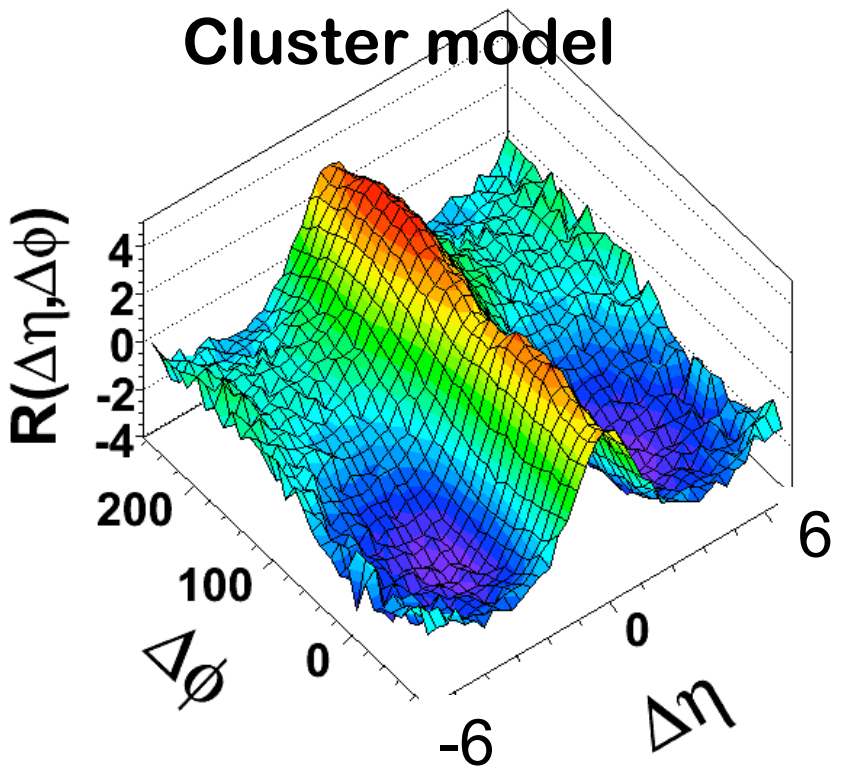
Cluster-like correlation structure





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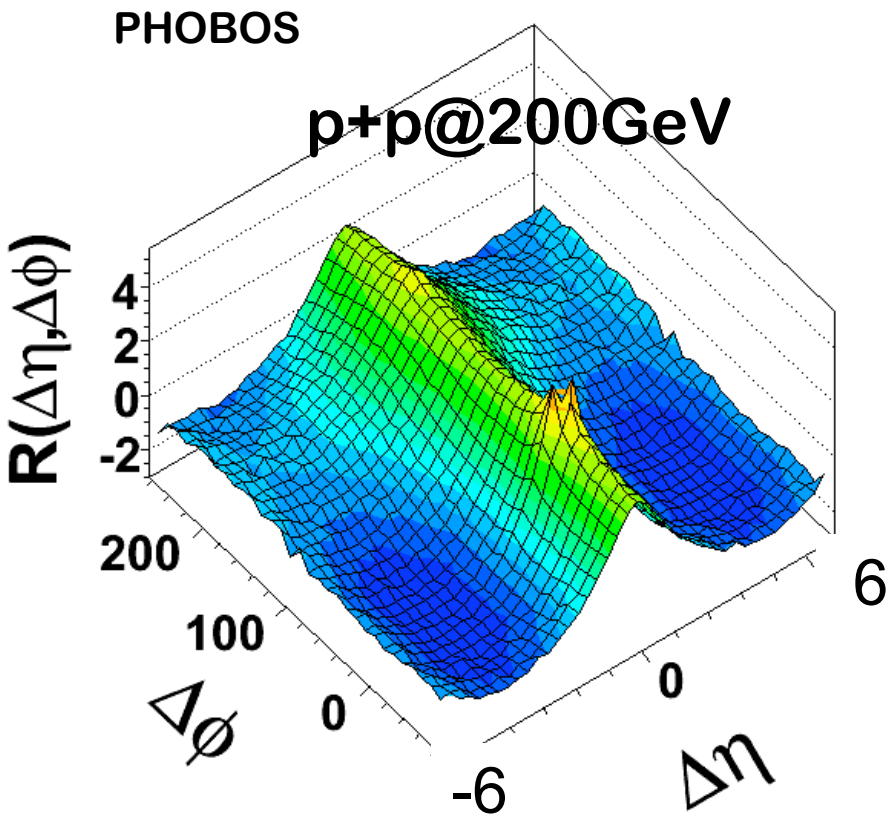
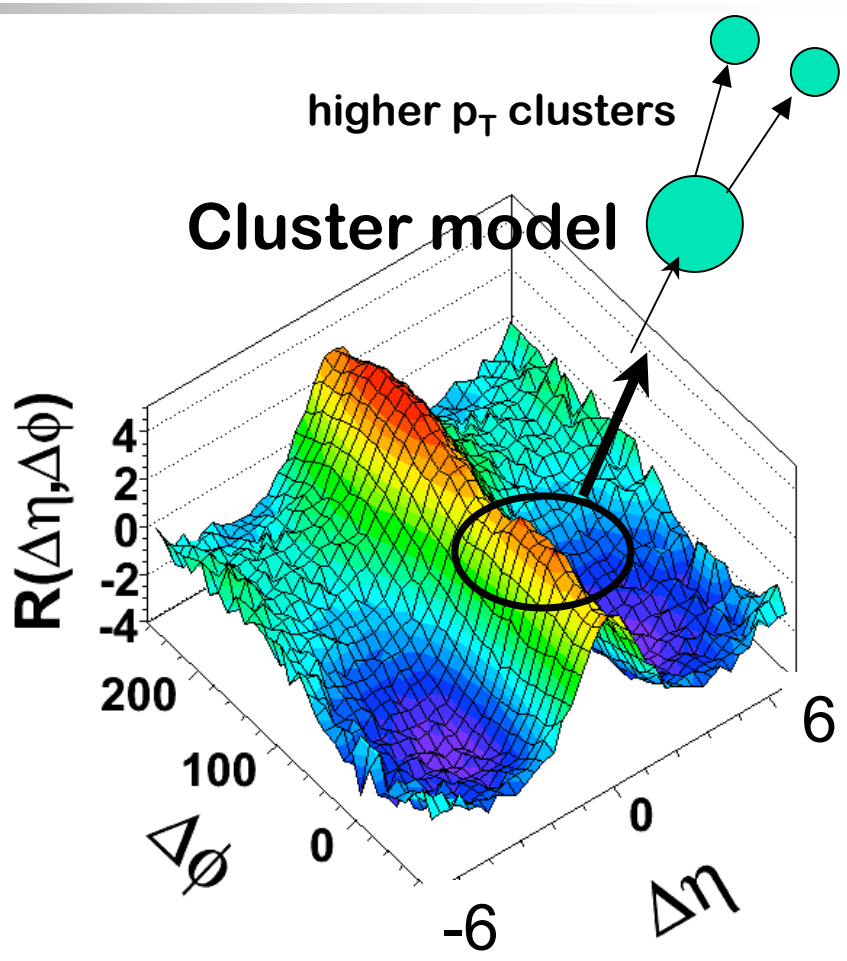
Cluster-like correlation structure





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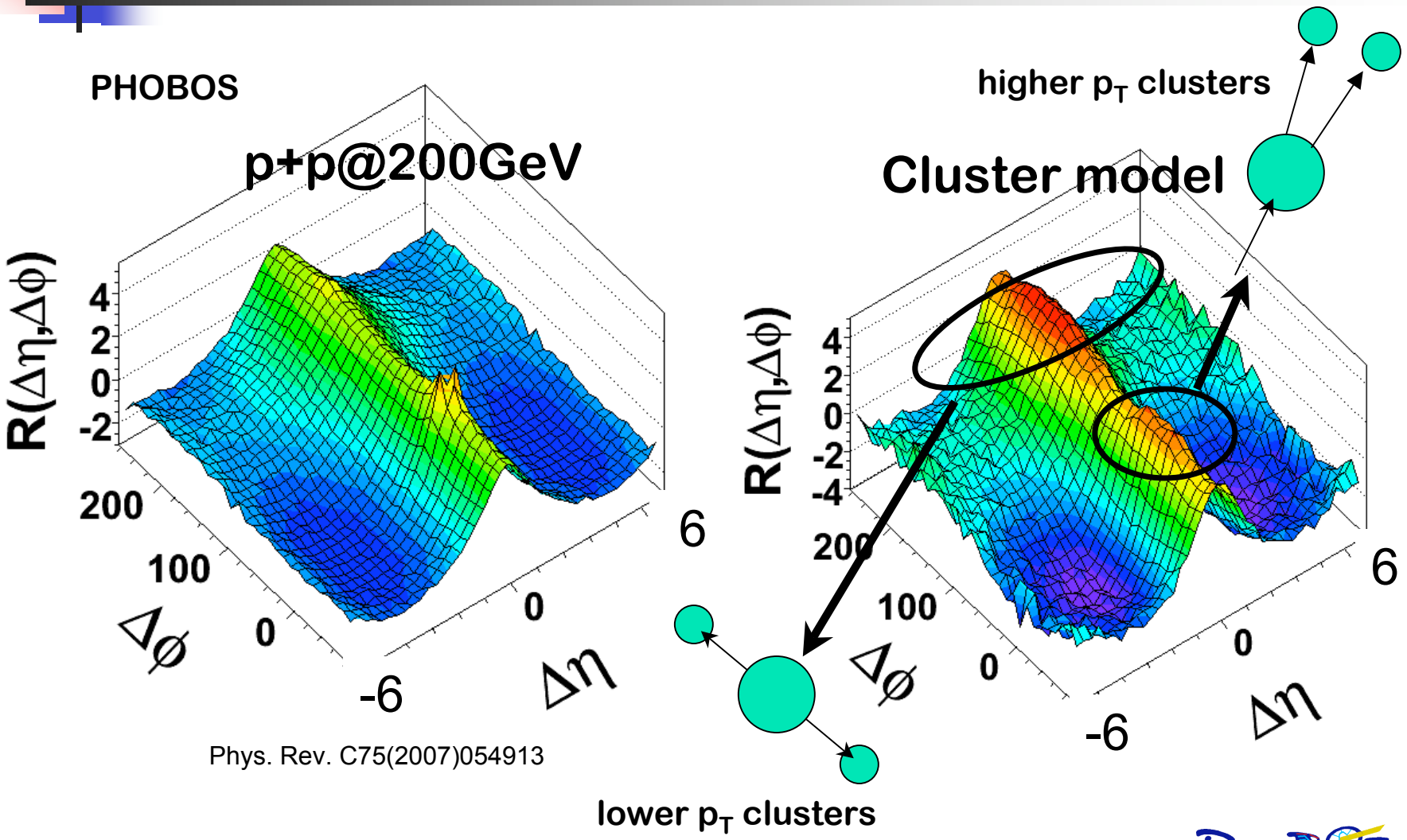
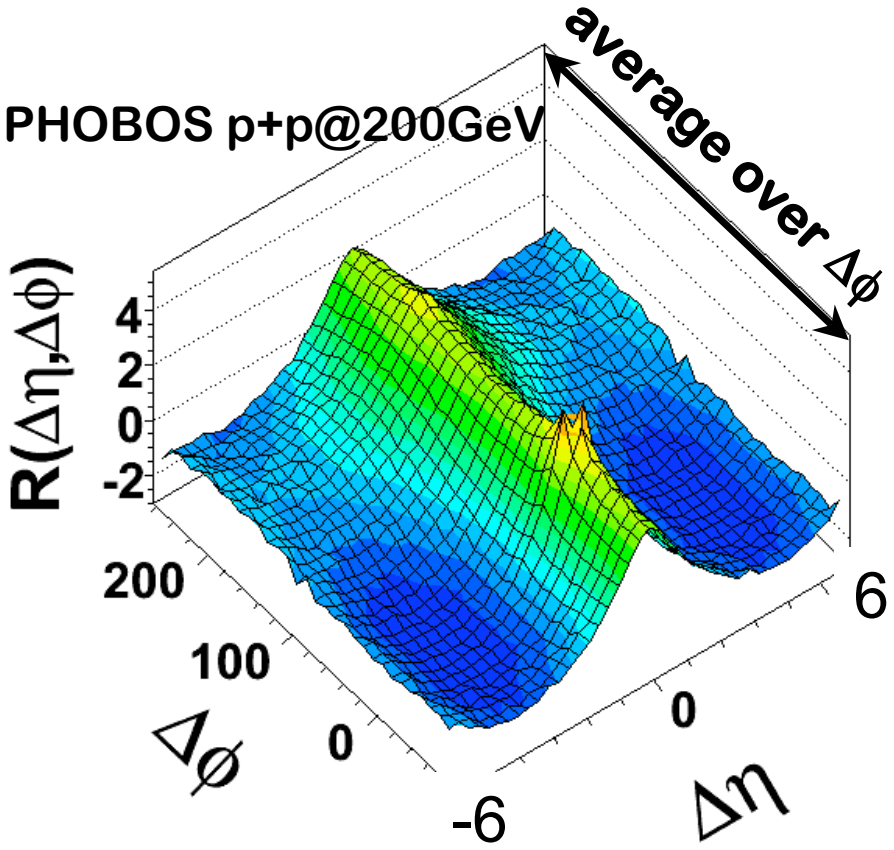
Cluster-like correlation structure



Parameterize cluster properties



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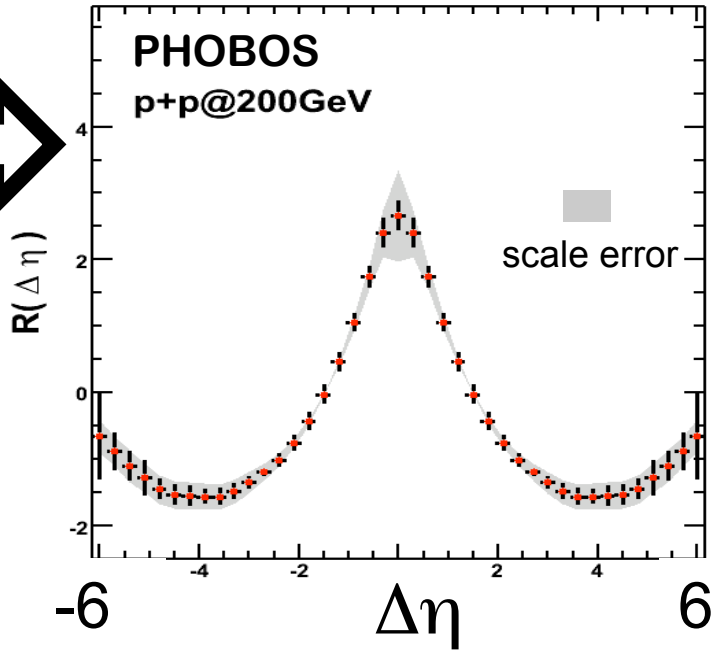
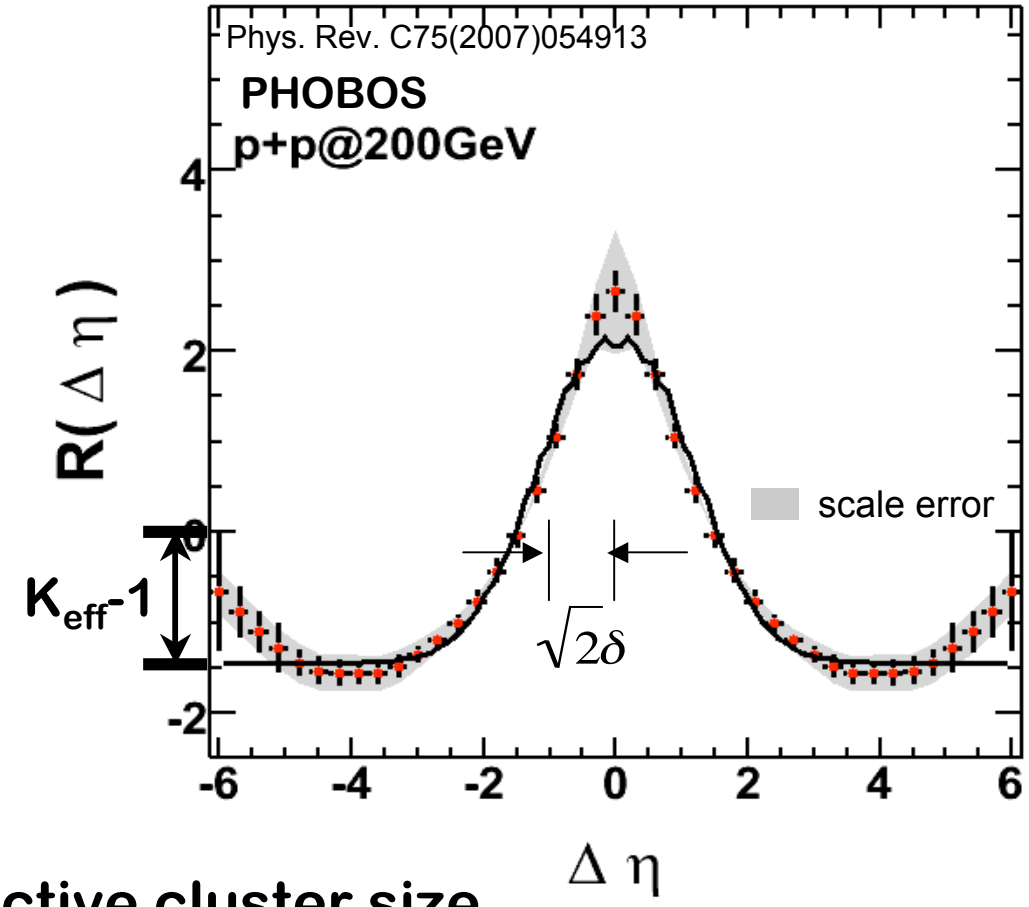
Two-particle Δη correlation function:



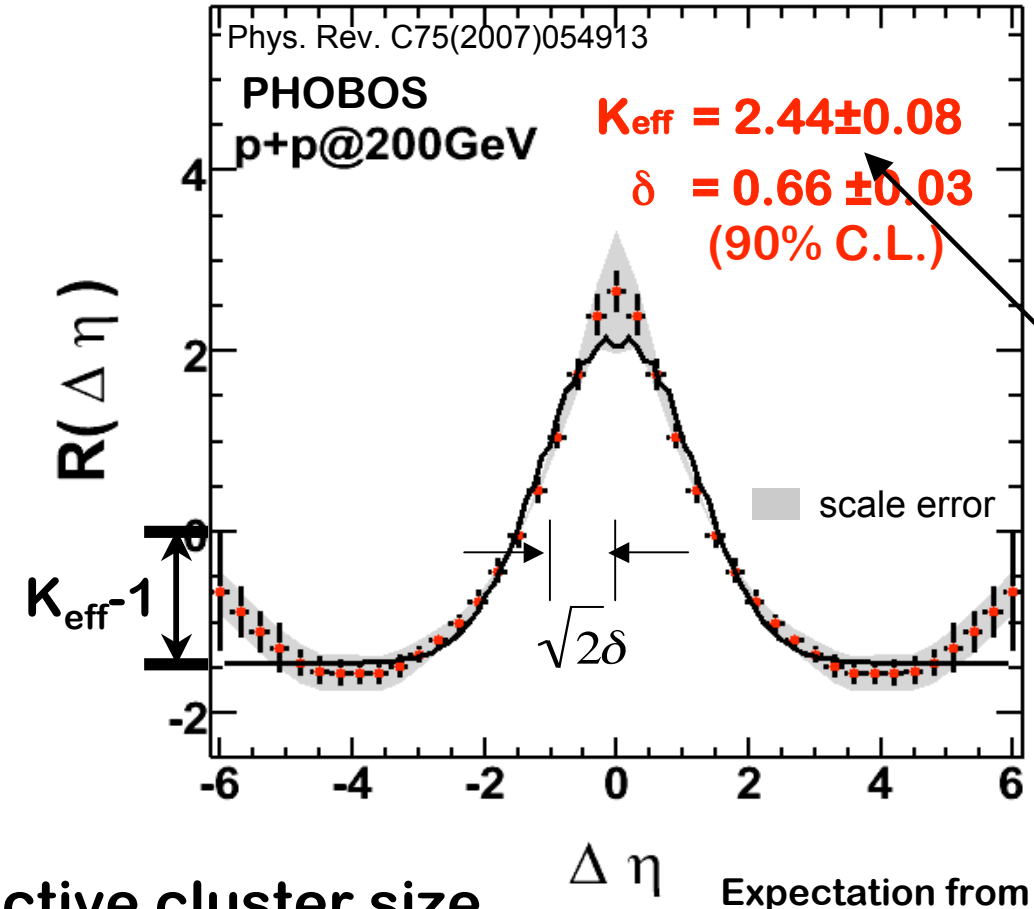
short-range Δη correlations

Cluster size and decay width in p+p



K_{eff} : effective cluster size
δ: cluster decay width

Cluster size and decay width in p+p



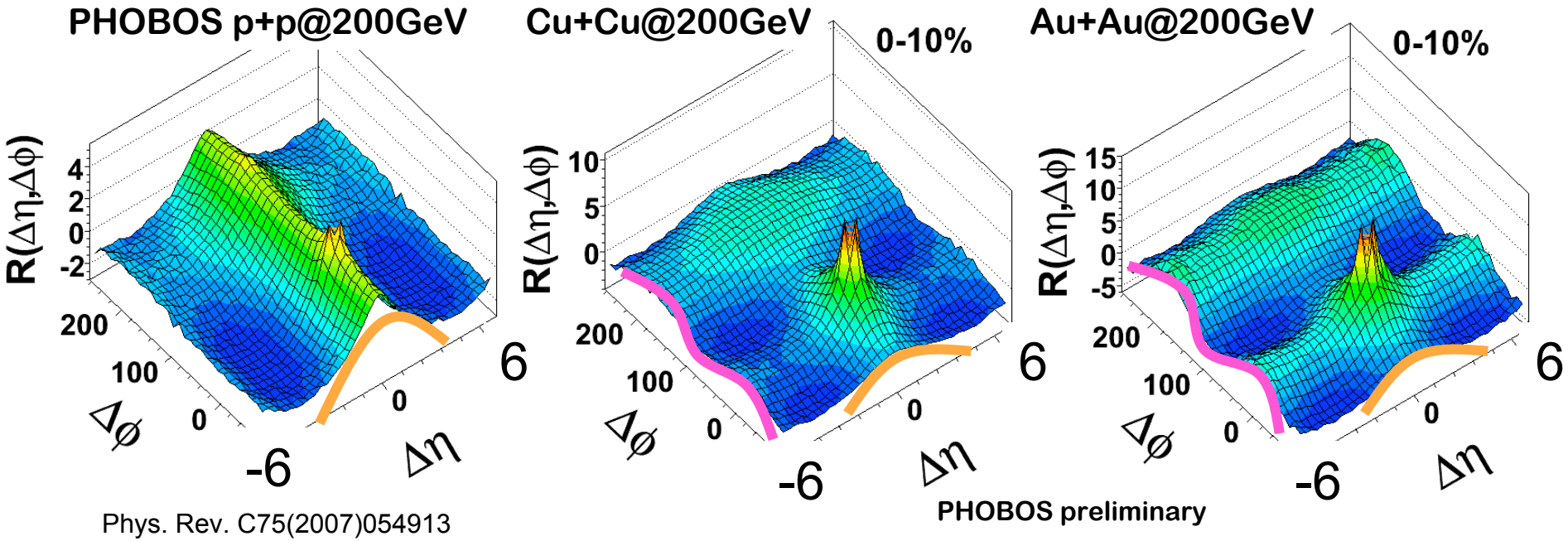
Due to limited acceptance, true cluster size could be slightly larger (approximately 5-20%).

On average, every charged particle is correlated with about another 1.5 particles!

K_{eff} : effective cluster size
δ: cluster decay width

Expectation from resonance model: K_{eff} ~ 1.7 (UA5, Z. Phys. C 37:191, 1988)

Two-particle correlations in Cu+Cu and Au+Au



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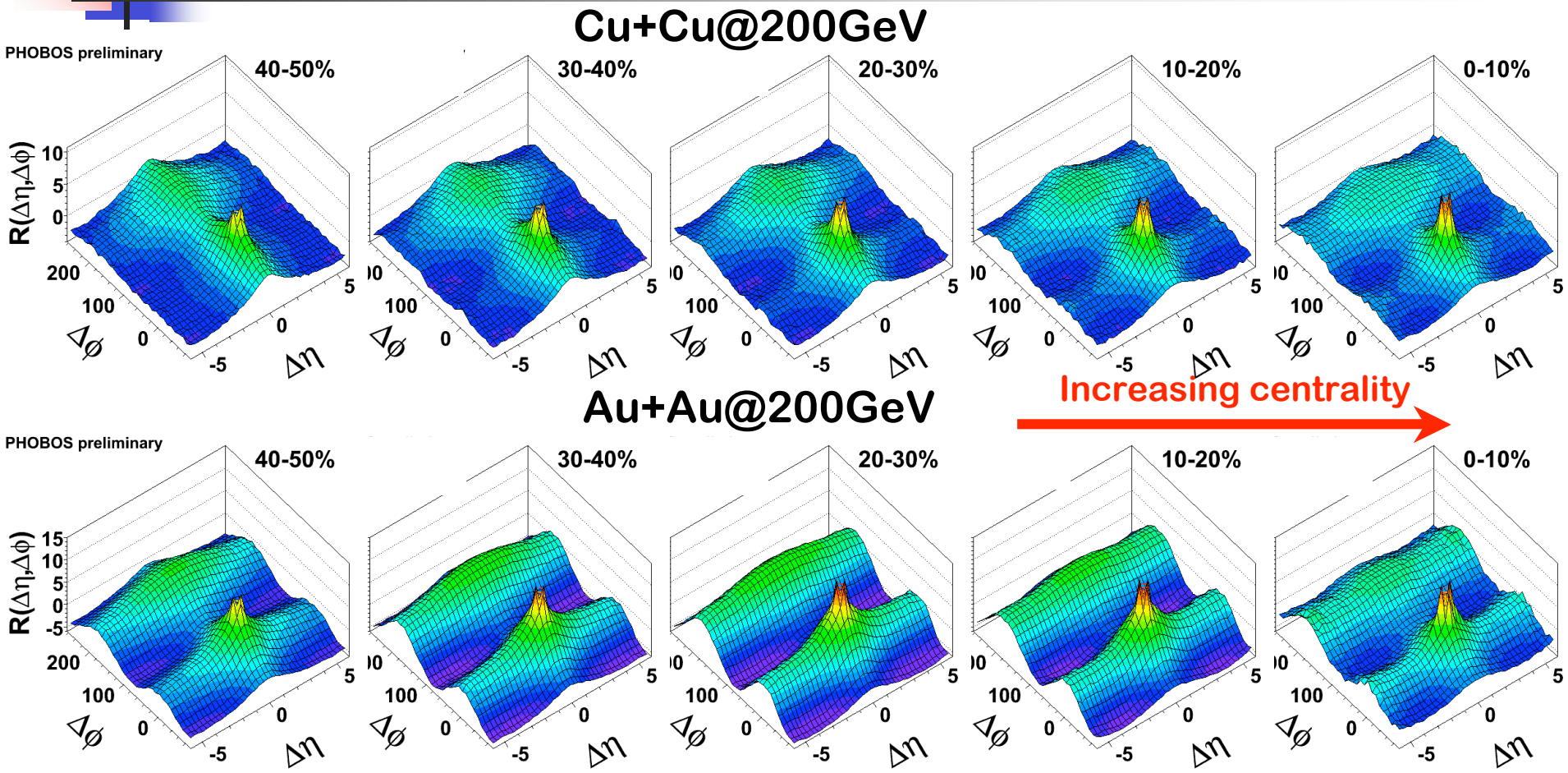
- **Similar short range cluster-like structure in A+A as in p+p.**
- **Elliptic flow over large range of $\Delta\eta$ in A+A.**

Two-particle correlations in Cu+Cu and Au+Au



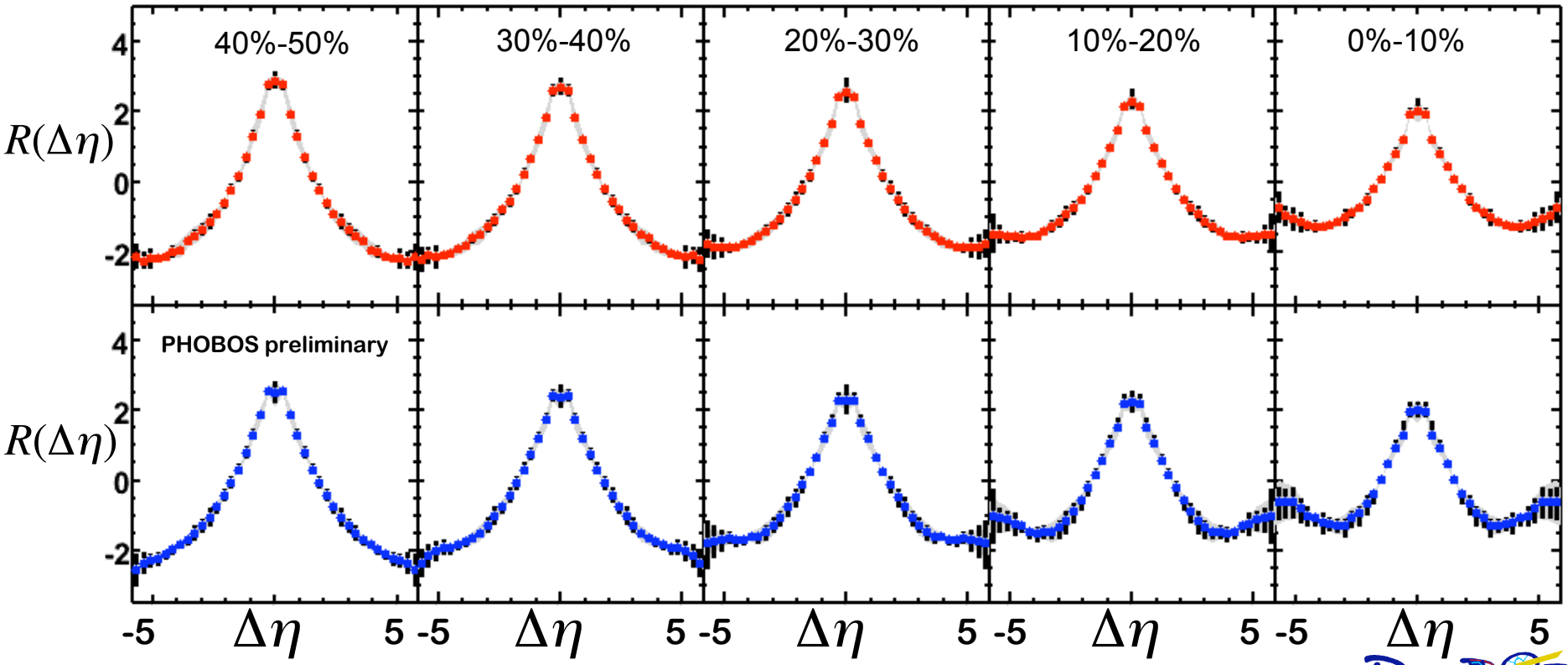
v_2 component: $\langle 2(n-1)v_2^2 \rangle$

Cluster parameterization in Cu+Cu and Au+Au

Two-particle $\Delta\eta$ correlation function

(scale errors are shown as grey bands)

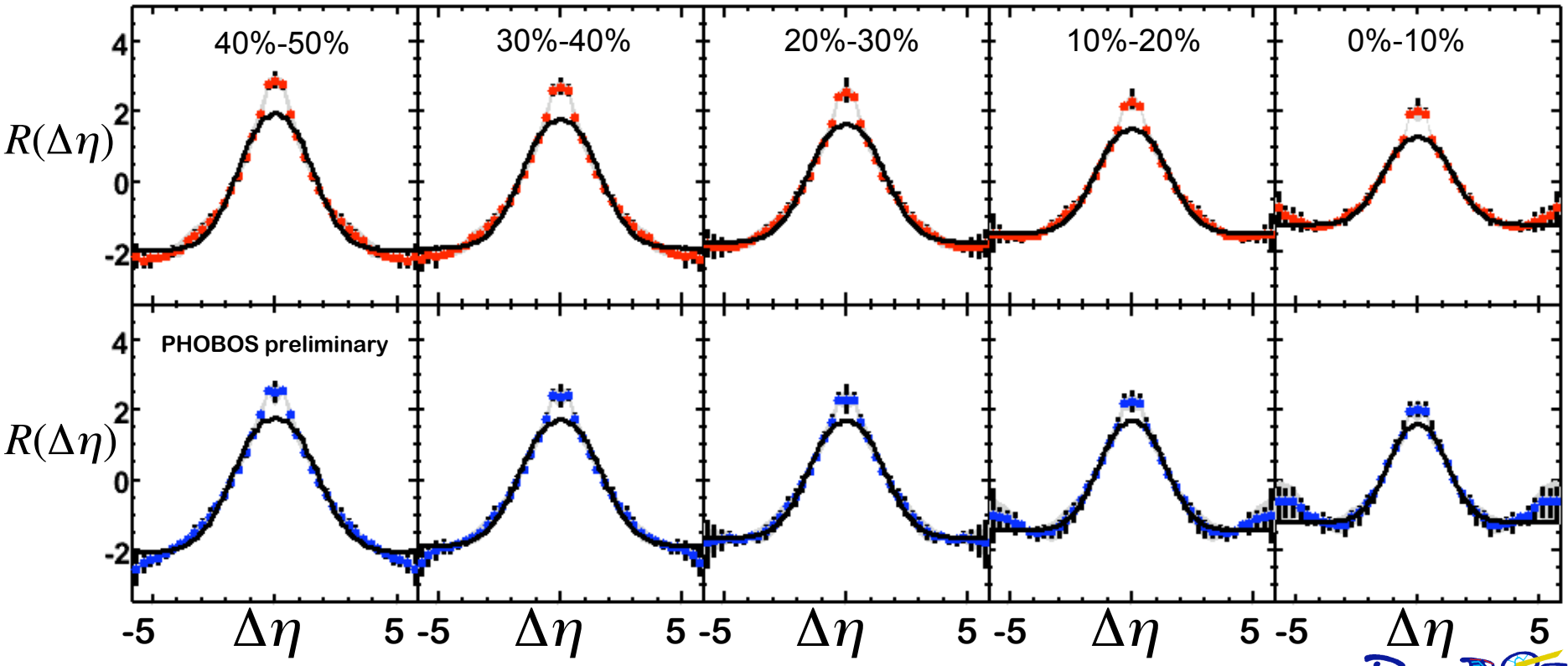
- Cu+Cu@200GeV
- Au+Au@200GeV



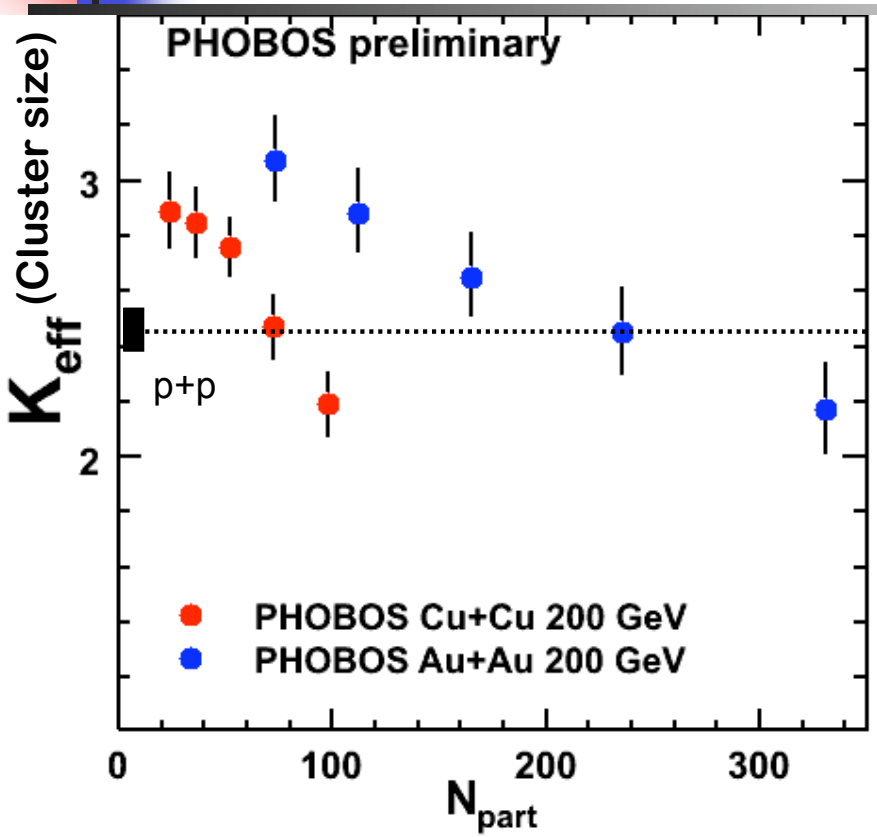
Cluster parameterization in Cu+Cu and Au+Au

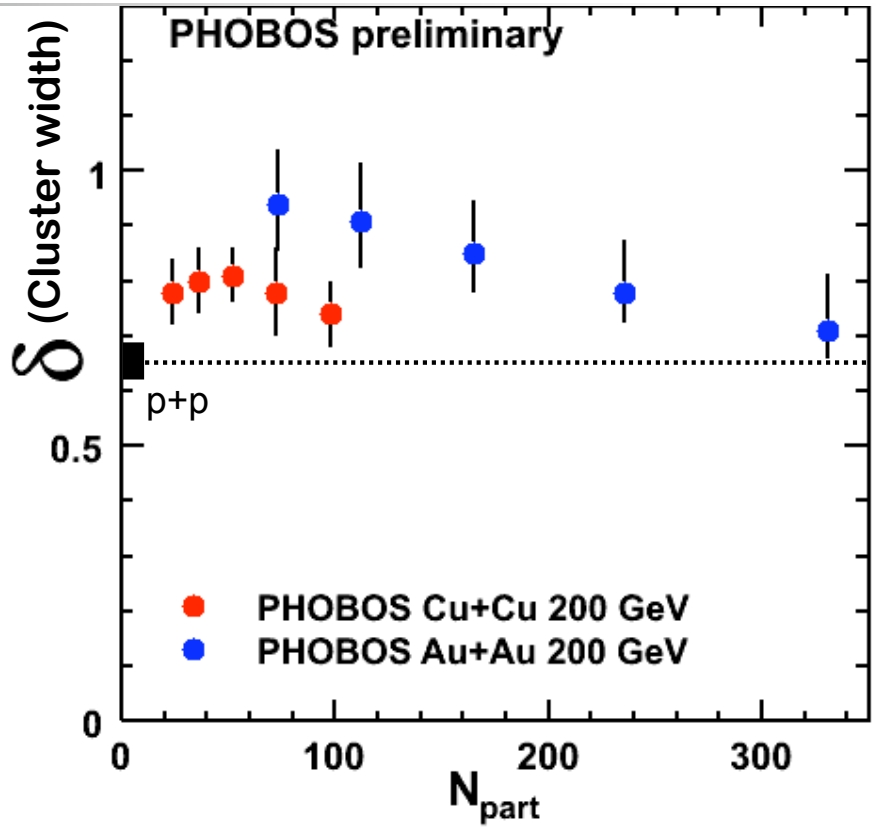
Extracting cluster parameters from
two-particle $\Delta\eta$ correlation function
(scale errors are shown as grey bands)

- **Cu+Cu@200GeV**
- **Au+Au@200GeV**



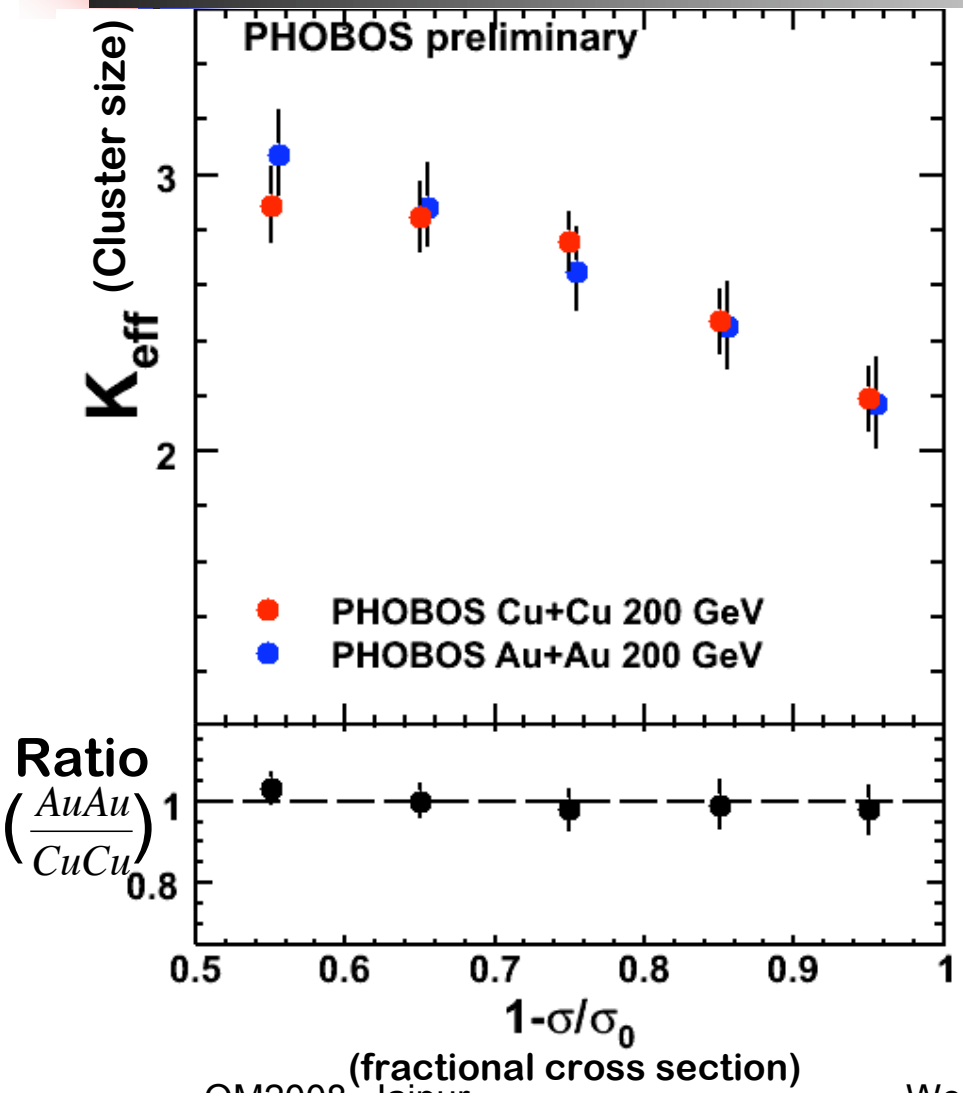
Clusters in Cu+Cu and Au+Au





- Cluster size decreases with N_{part} in A+A.
- Au+Au and Cu+Cu have different cluster size at the same N_{part}.
- Enhancement of cluster from p+p to peripheral A+A.

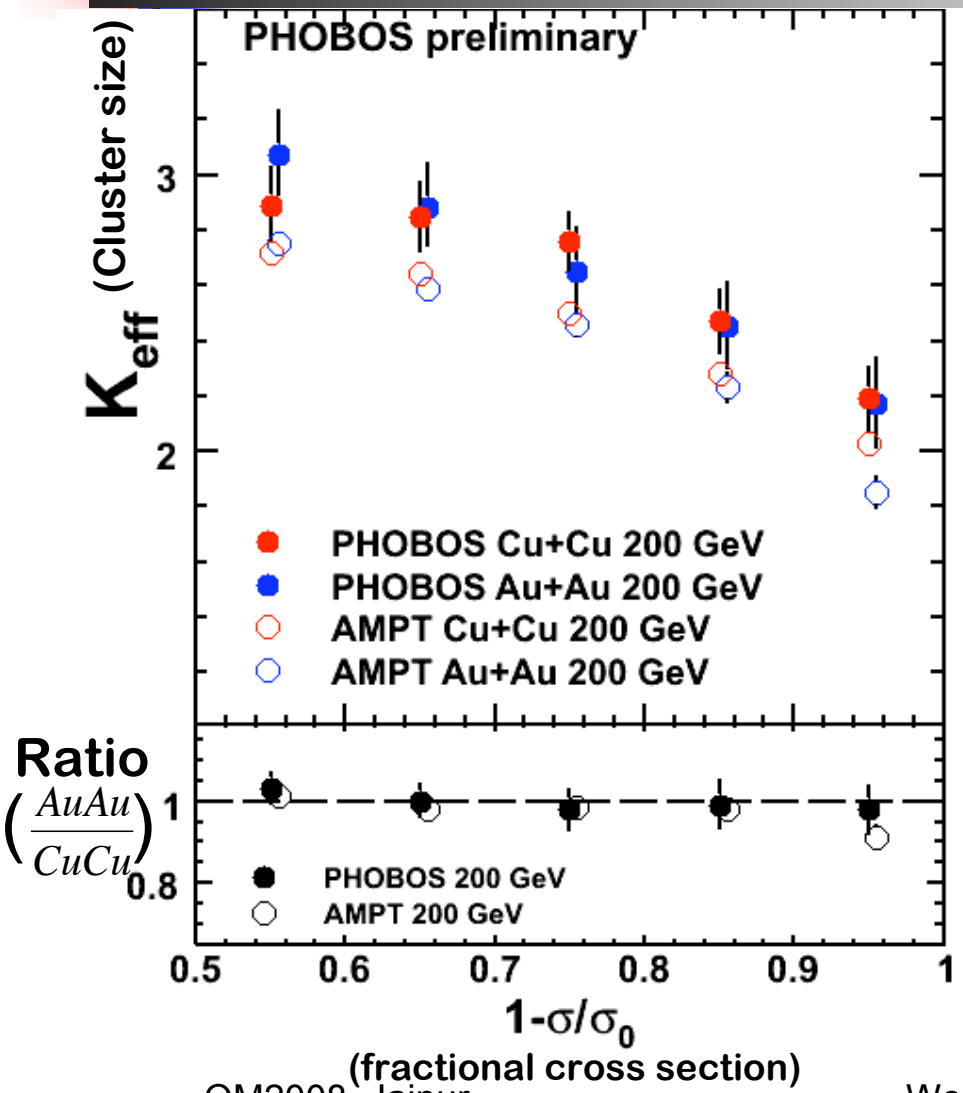
Clusters in Cu+Cu and Au+Au



$1-\sigma/\sigma_0$: fraction of total inelastic scattering cross section.

Cluster size scales with collision geometry!

Clusters in Cu+Cu and Au+Au



$1-\sigma/\sigma_0$: fraction of total inelastic scattering cross section.

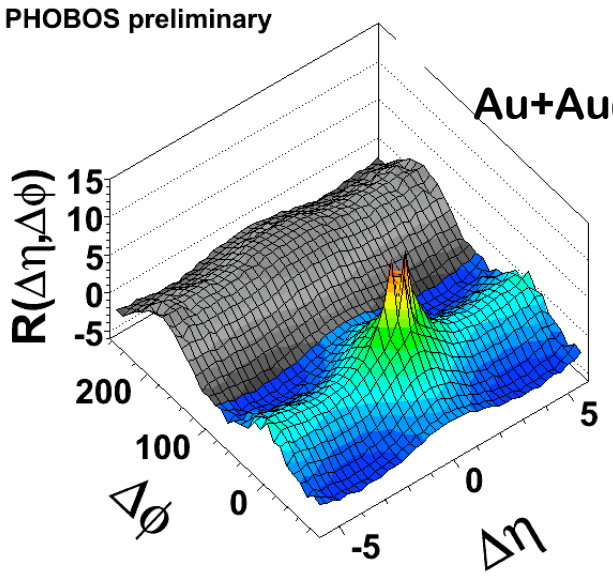
Cluster size scales with collision geometry!

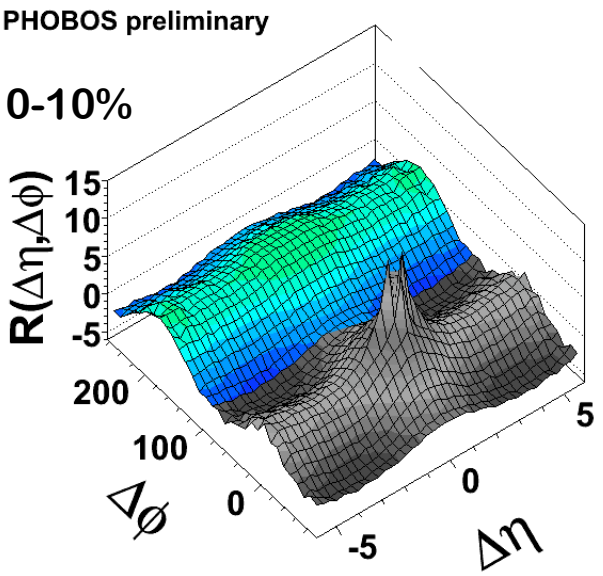
Model comparison:

- Intriguingly, AMPT shows similar geometry scaling of cluster size.
- The decrease of cluster size with centrality in AMPT is related to hadronic rescattering processes.

Near- and Away-side clusters

Study cluster properties differentially in $\Delta\phi$



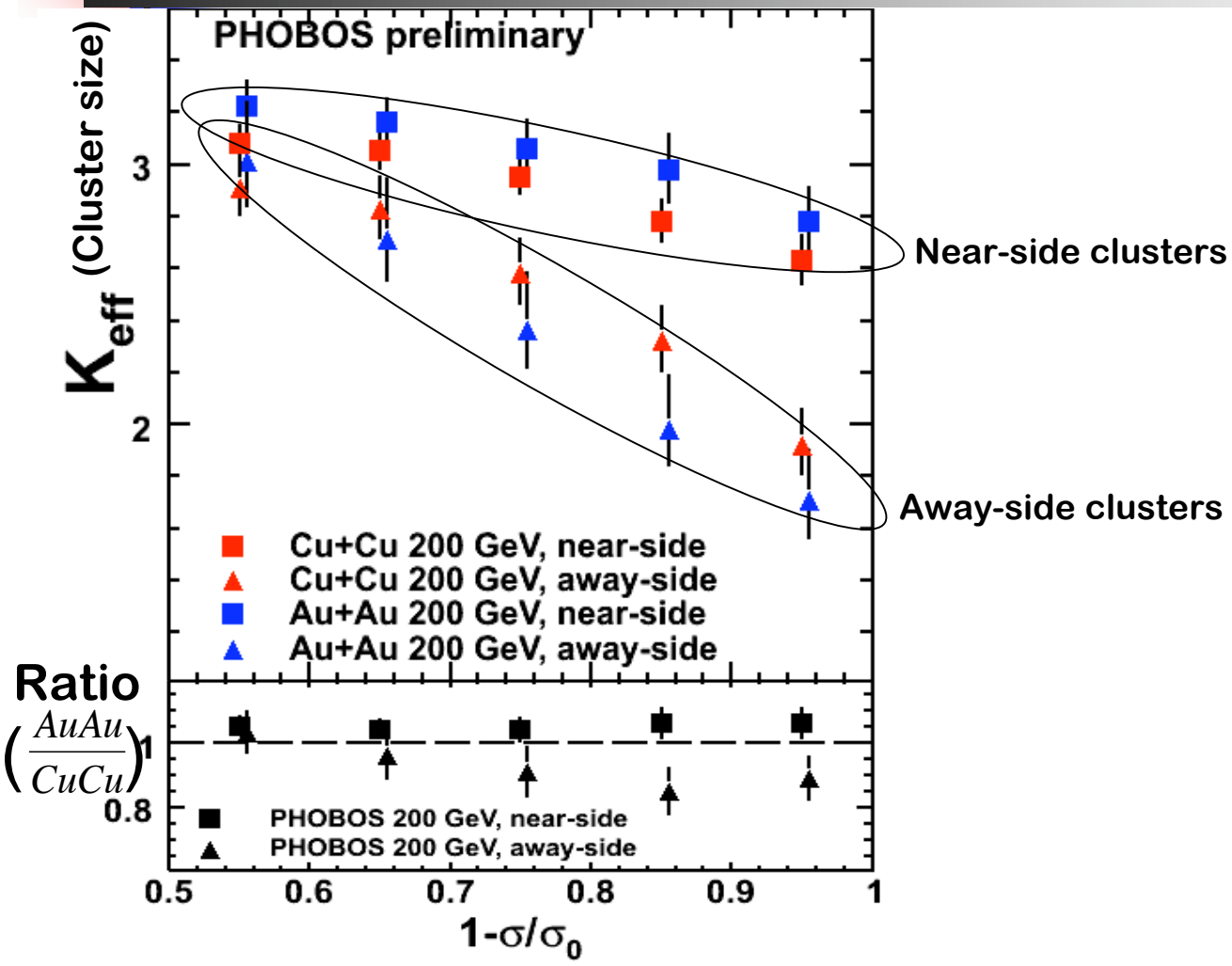


Near-side clusters:
- $0^o<\Delta\phi<90^o$
- higher p_T

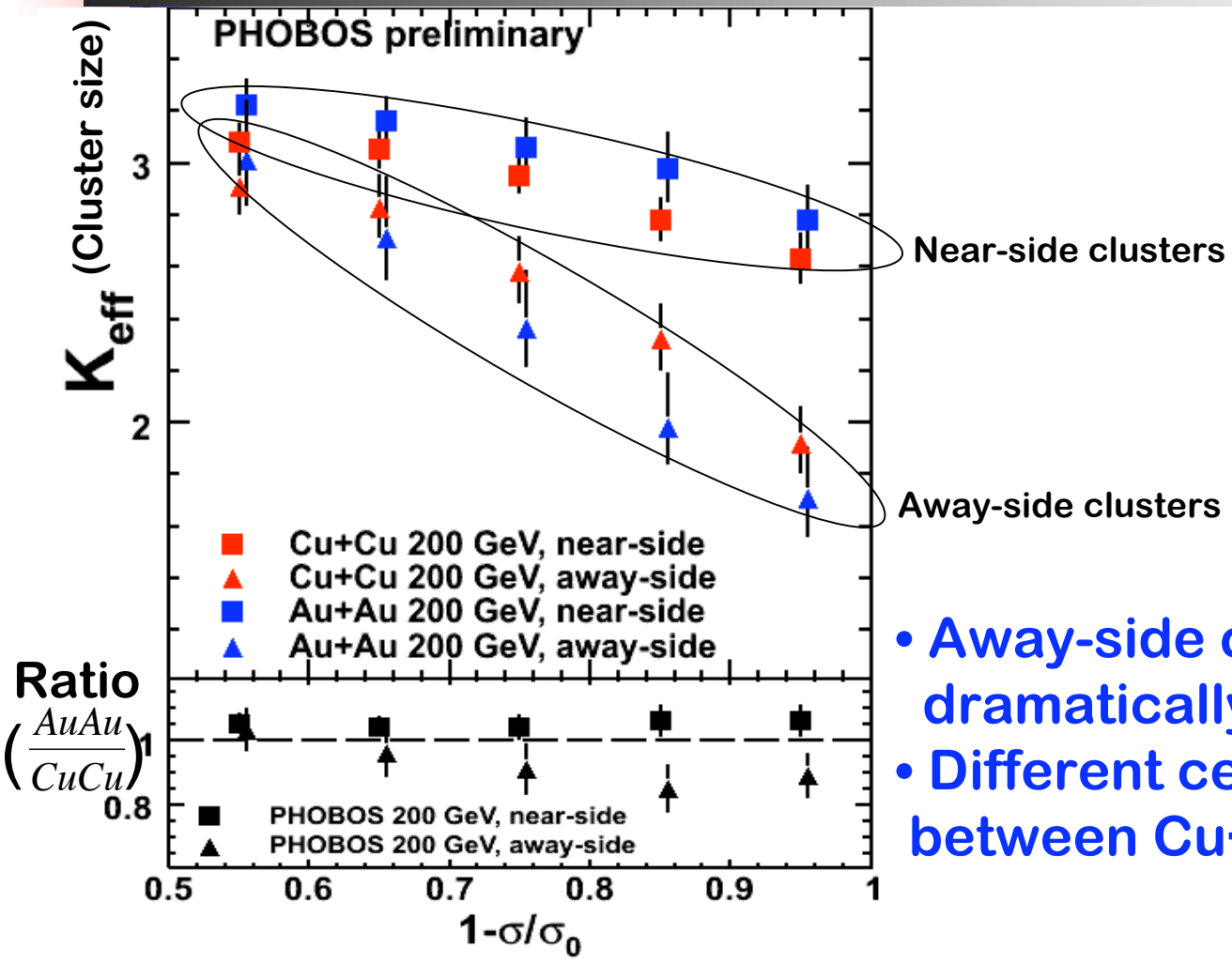
Away-side clusters:
- $90^o<\Delta\phi<180^o$
- lower p_T

Elliptic flow is averaged out by construction.

Near- and Away-side clusters

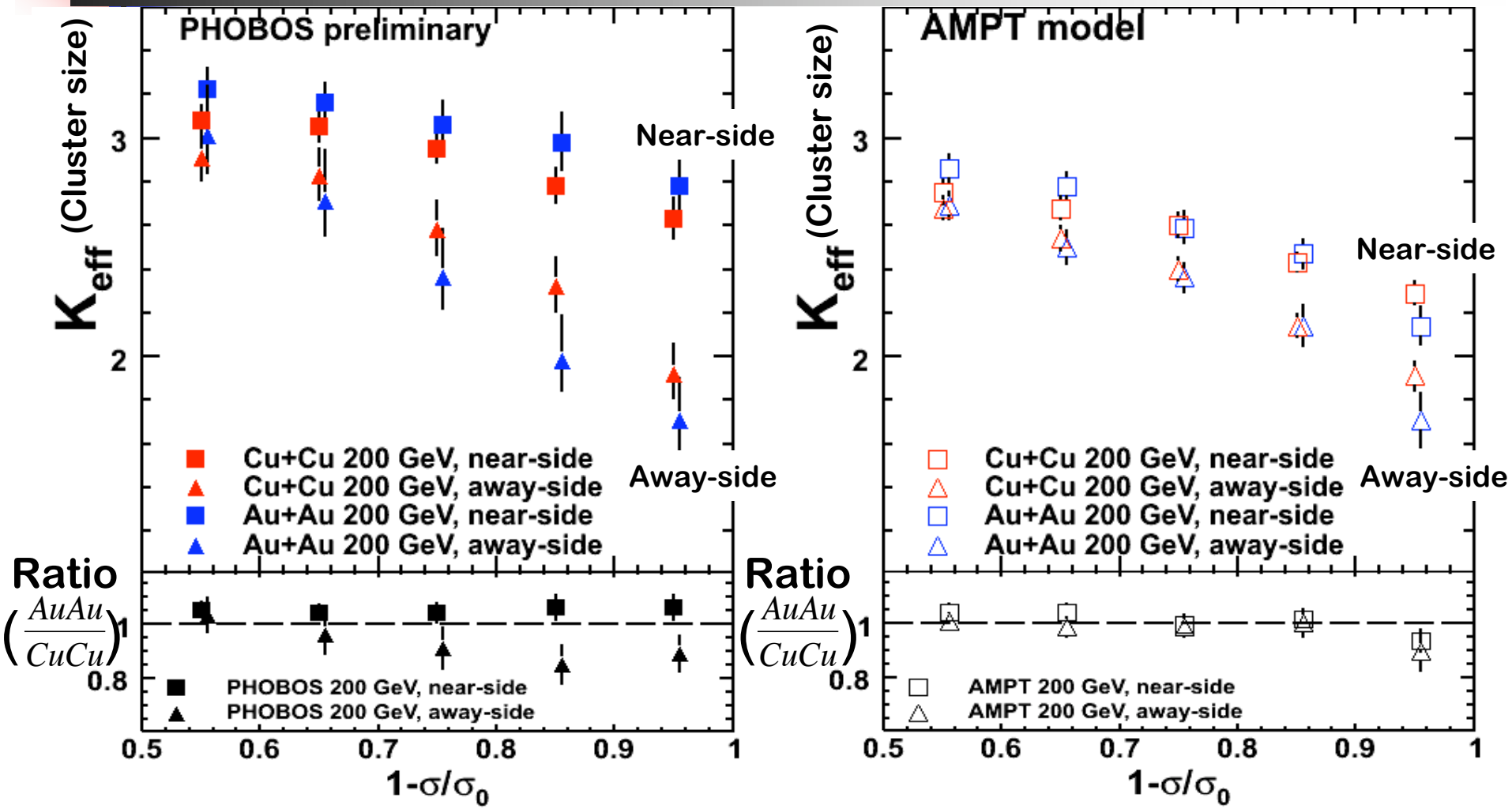


Near- and Away-side clusters



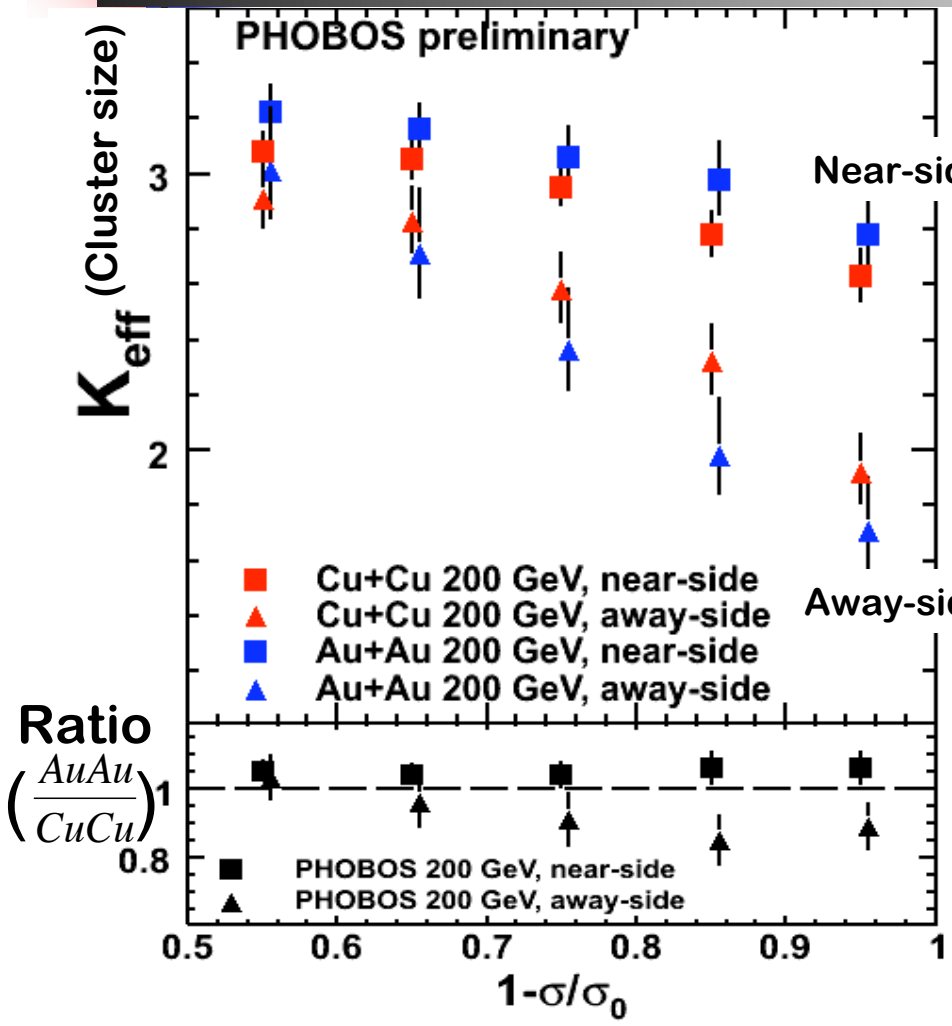
- Away-side cluster size drops dramatically with centrality.
- Different centrality dependence between Cu+Cu and Au+Au

Near- and Away-side clusters



AMPT doesn't quite agree with data.

Near- and Away-side clusters



Possible explanation:
Absorption of cluster decay products?

Summary

- A comprehensive study of two-particle correlations in p+p, Cu+Cu and Au+Au.
- Cluster model fits in p+p, Cu+Cu and Au+Au:
  - Cluster size of 2.44 in p+p.
  - Cluster size scales with system geometry in A+A.
    - Intriguing agreement with AMPT model.
  - Different centrality dependence of near- and away-side clusters.

More model studies are needed to get insights to the features of our results!

Backups

Methodology

Two-particle correlation function:

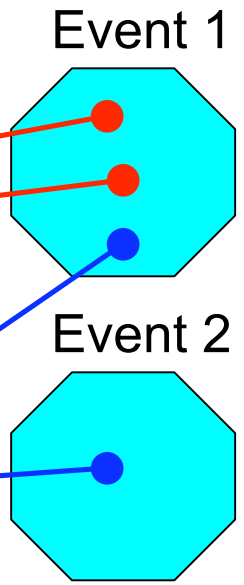
$$R(\Delta\eta,\Delta\phi) = < (n-1)\left(\frac{F_n(\Delta\eta,\Delta\phi)}{B_n(\Delta\eta,\Delta\phi)} - 1\right) >$$

Foreground:

$$F_n(\Delta\eta,\Delta\phi) \sim \rho_n^{II}(\eta_1,\eta_2,\phi_1,\phi_2) = \frac{1}{n(n-1)\sigma_n}\frac{d^4\sigma_n}{d\eta_1 d\eta_2 d\phi_1 d\phi_2}$$

Background:

$$B_n(\Delta\eta,\Delta\phi) \sim \rho_n^{I}(\eta_1,\phi_1)\rho_n^{I}(\eta_2,\phi_2) = \frac{1}{n\sigma_n}\frac{d^2\sigma_n}{d\eta_1 d\phi_1}\bullet\frac{1}{n\sigma_n}\frac{d^2\sigma_n}{d\eta_2 d\phi_2}$$



Parameterize cluster size (multiplicity)

Quantitatively understand cluster phenomena

Two-particle rapidity correlation function:

$$R(\Delta\eta) = \alpha\left[\frac{\Gamma(\Delta\eta)}{B(\Delta\eta)} - 1\right]$$

correlations between particles from one cluster

$$\Gamma(\Delta\eta) \propto \exp\left(-\frac{(\Delta\eta)^2}{4\delta^2}\right)$$

Decay width: $\sqrt{2}\,\delta$

K. Eggert et al., Nucl. Phys. B 86:201, 1975

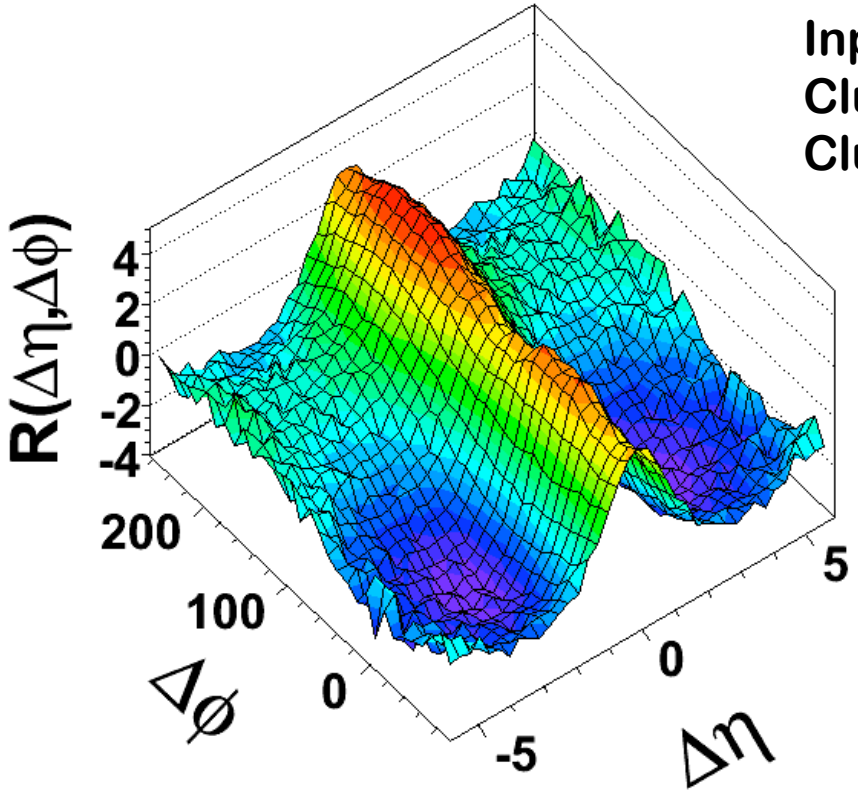
k: cluster size

$$K_{eff} = \alpha + 1 = \frac{< k(k-1) >}{< k >} + 1 = < k > + \frac{\sigma_k^2}{< k >}$$

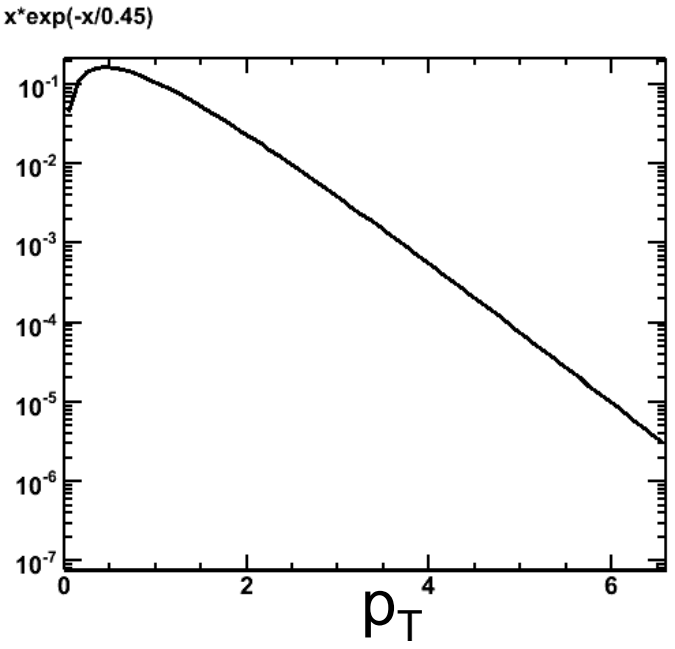
K_{eff} : effective cluster size

$B(\Delta\eta)$**: background distribution**

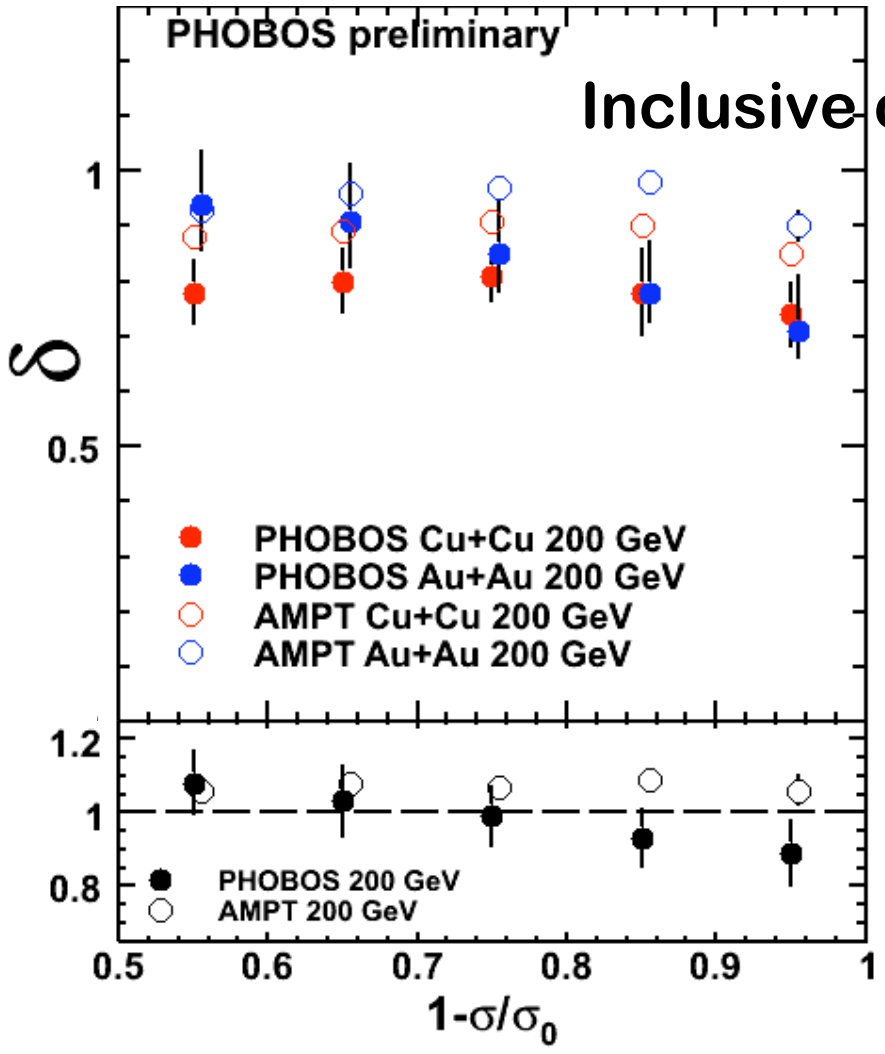
Isotropic cluster model



Input cluster size: K_{eff}=3 (50%), K_{eff}=4 (50%)
Cluster mass: $M_{k=3}$=0.9 GeV, $M_{k=4}$=1.8 GeV
Cluster pT distribution:



Cluster decay width v.s. fractional cross section



Cluster decay width v.s. fractional cross section