Centrality Dependence of Two-Particle Correlations in Heavy Ion Collisions

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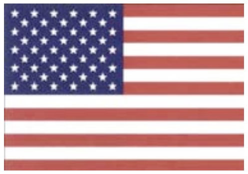
For the PHOBOS Collaboration

PHOBOS Collaboration

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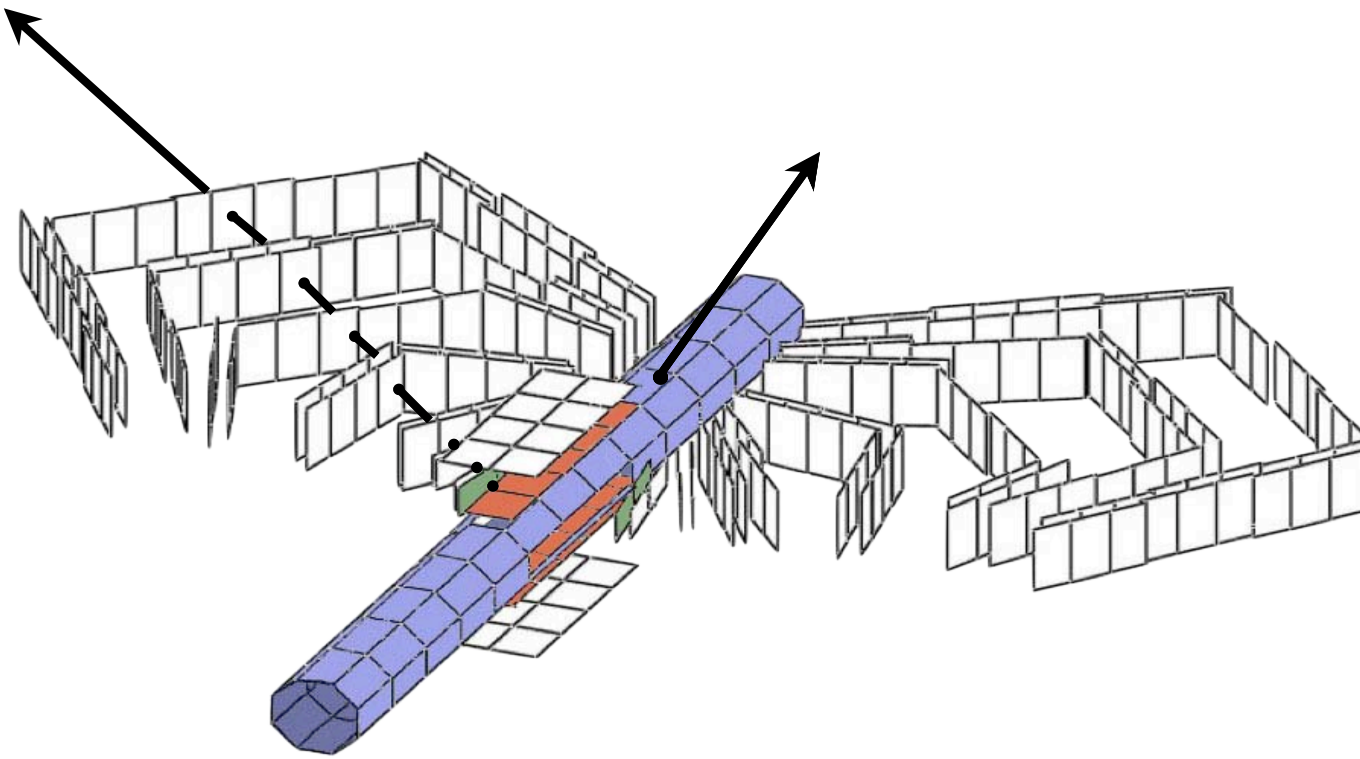
Talk Roadmap

- Introduction to correlations in PHOBOS
- Correlations using a "trigger" track with p_T>2.5 GeV/c
- Correlations between inclusive particles (no high p_T cut)
- Effects of limited pseudorapidity acceptance
- Summary

Detector



* Pat Summitt: U. of Tenn. women's basketball coach 1005 career wins!!

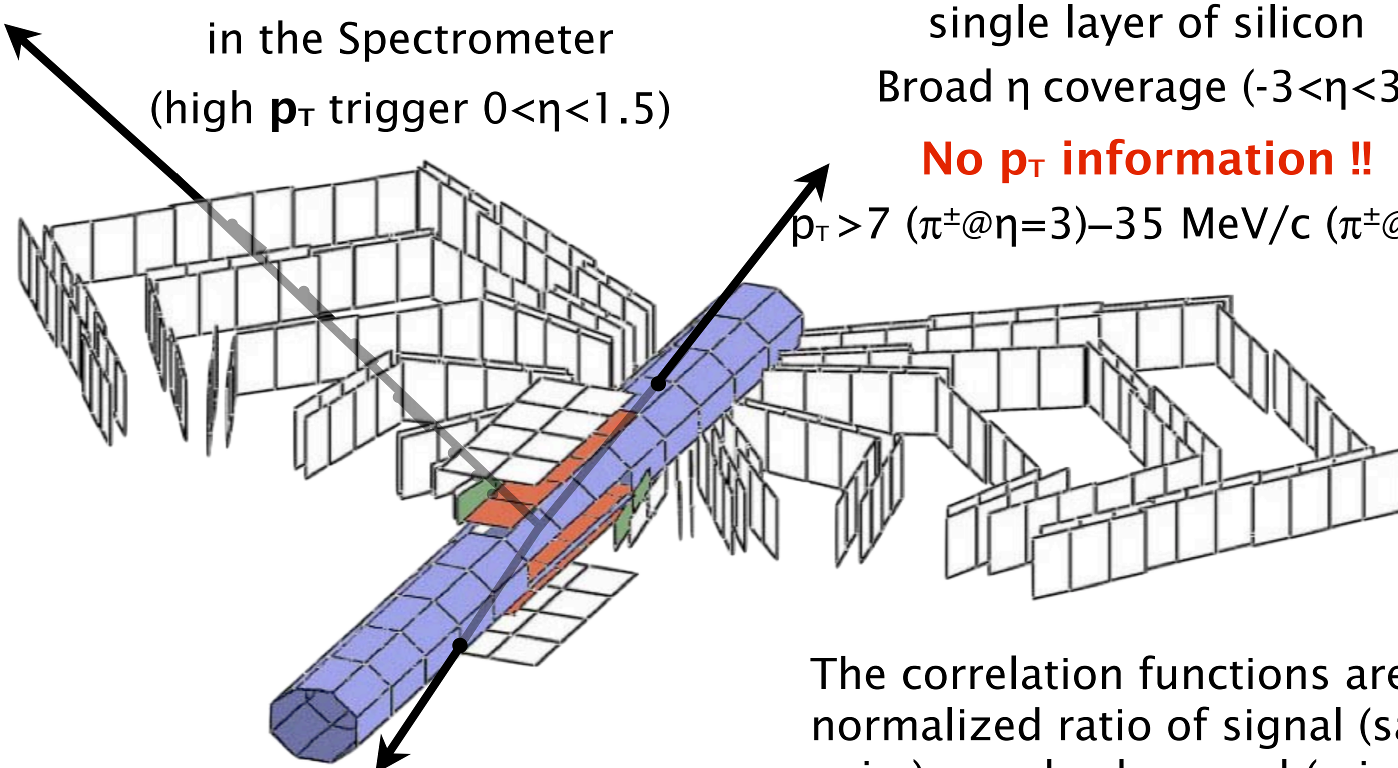
Correlation Measurements

Triggered Correlations:
"Trigger" particles detected
in the Spectrometer
(high $\mathbf{p_T}$ trigger $0<\eta<1.5$)

Associated particles detected in a
single layer of silicon
Broad η coverage ($-3<\eta<3$)

No p_T information !!

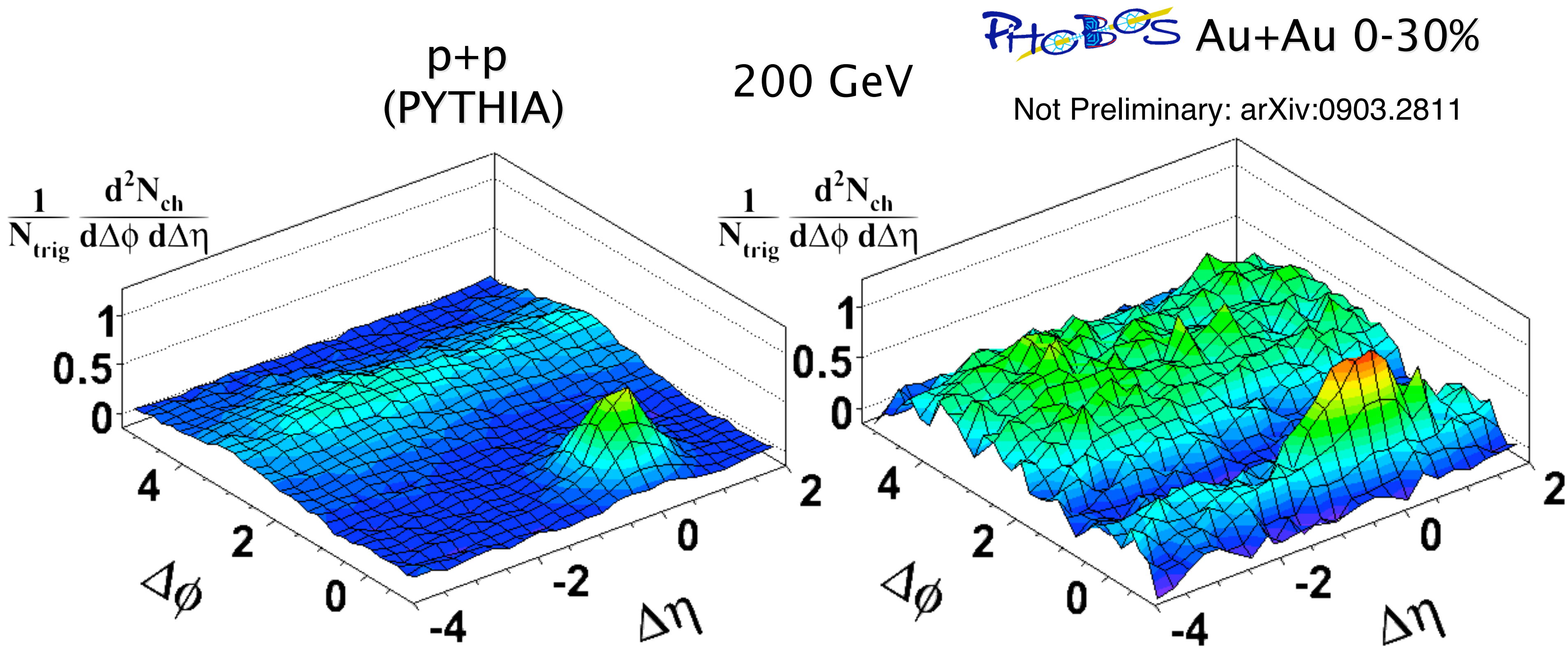
$p_T > 7$ ($\pi^{\pm}@\eta=3$)–35 MeV/c ($\pi^{\pm}@\eta=0$)



Inclusive Correlations:
Pairs start with an inclusive
particle detected in a single
layer of silicon ($-3<\eta<3$)

The correlation functions are the suitably normalized ratio of signal (same-event pairs) over background (mixed-event pairs). The effect of elliptic flow is removed either by subtraction (triggered correlations) or by integrating over $\Delta\phi$ (inclusive correlations).

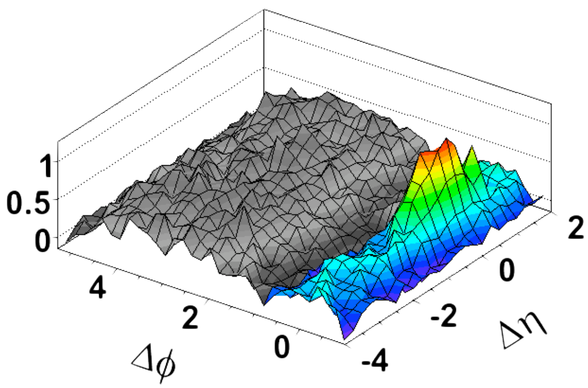
Correlations with p_T>2.5 GeV/c Trigger

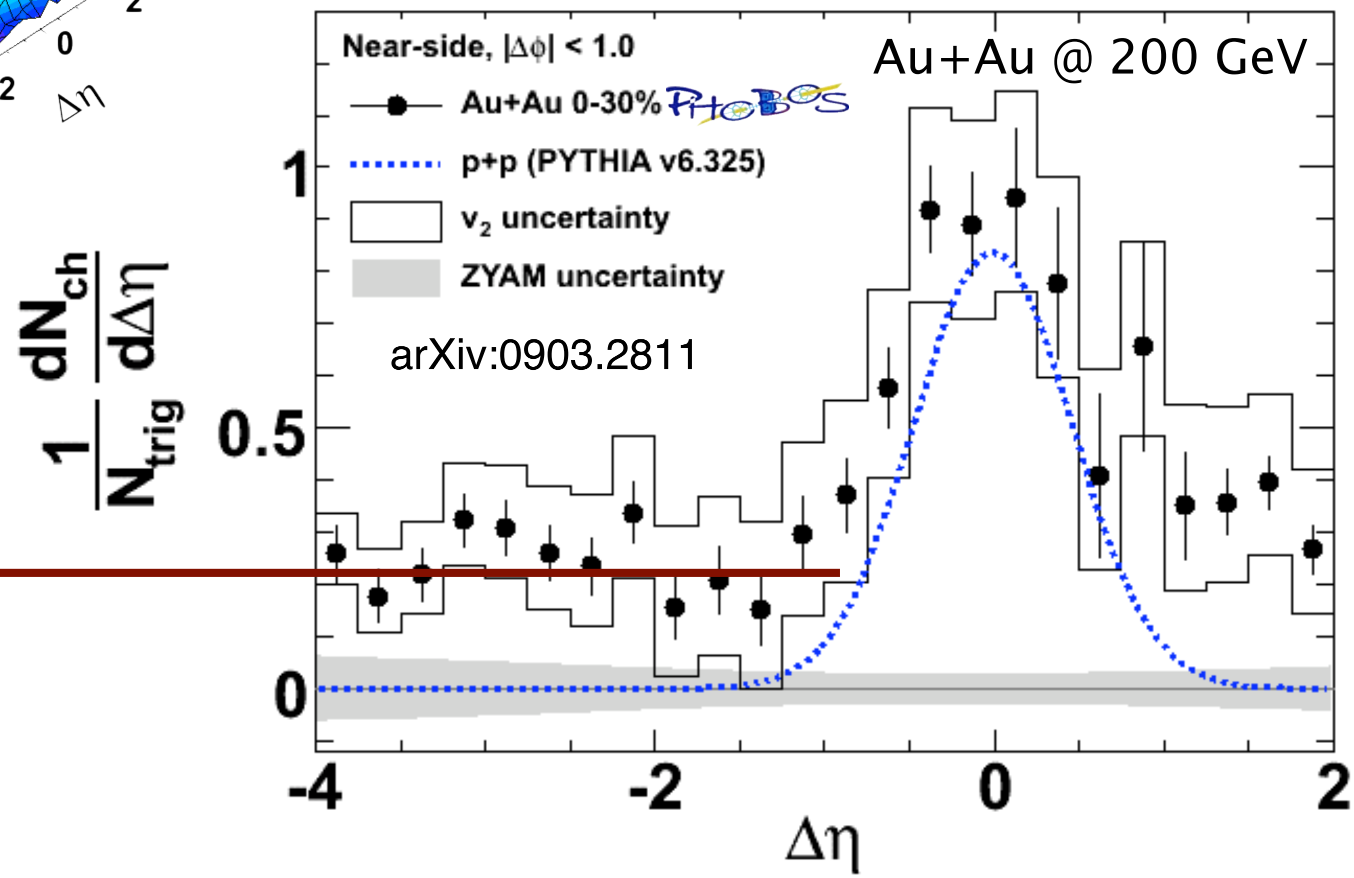


p_T^{trig} >2.5 GeV/c
p_T^{assoc} > 7–35 MeV/c ($\pi^{\pm}$)

NB: PYTHIA closely matches STAR data at mid-rapidity for a similar set of p_T cuts

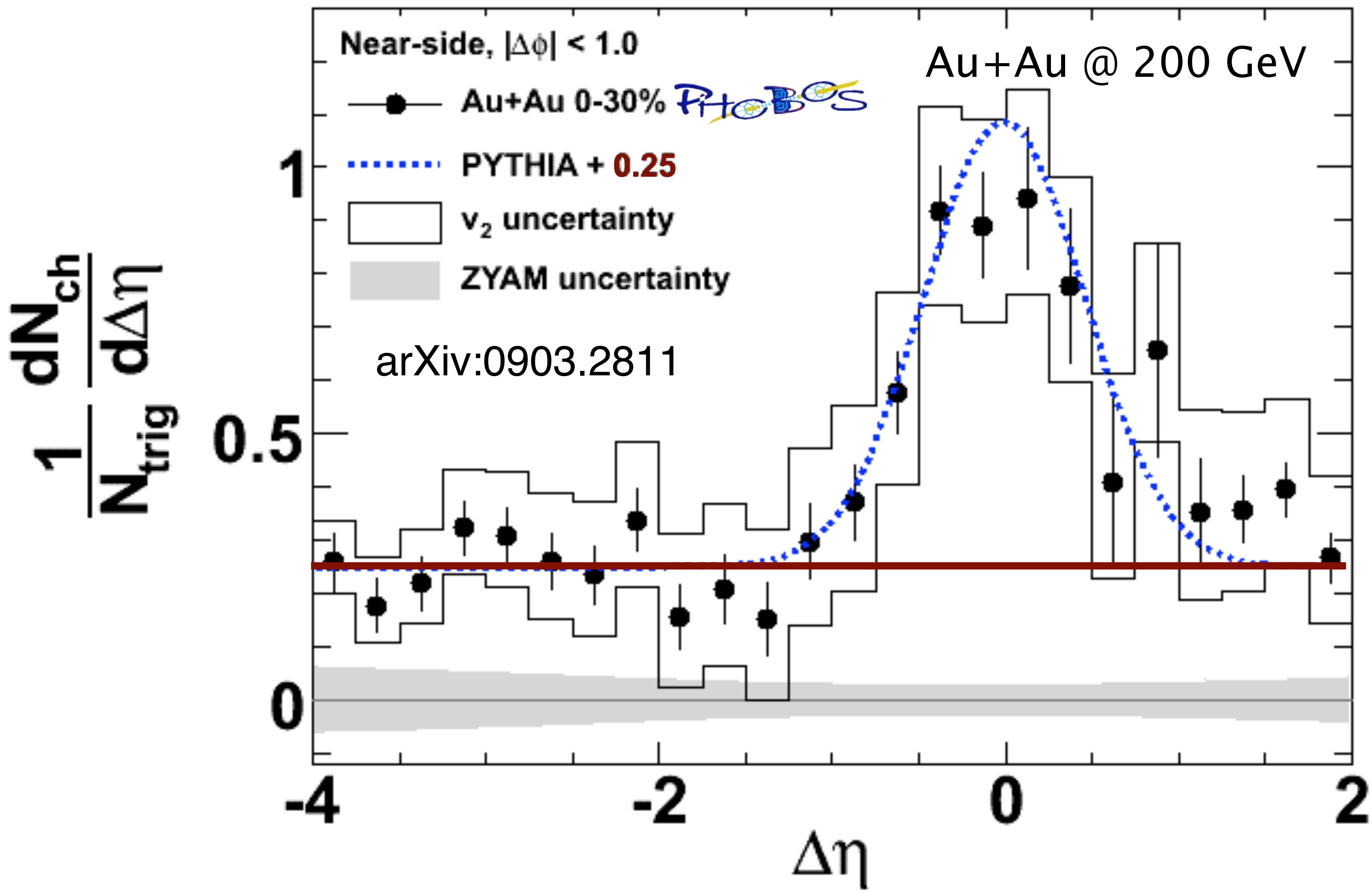
“Ridge” at small Δφ: Extent in Δη



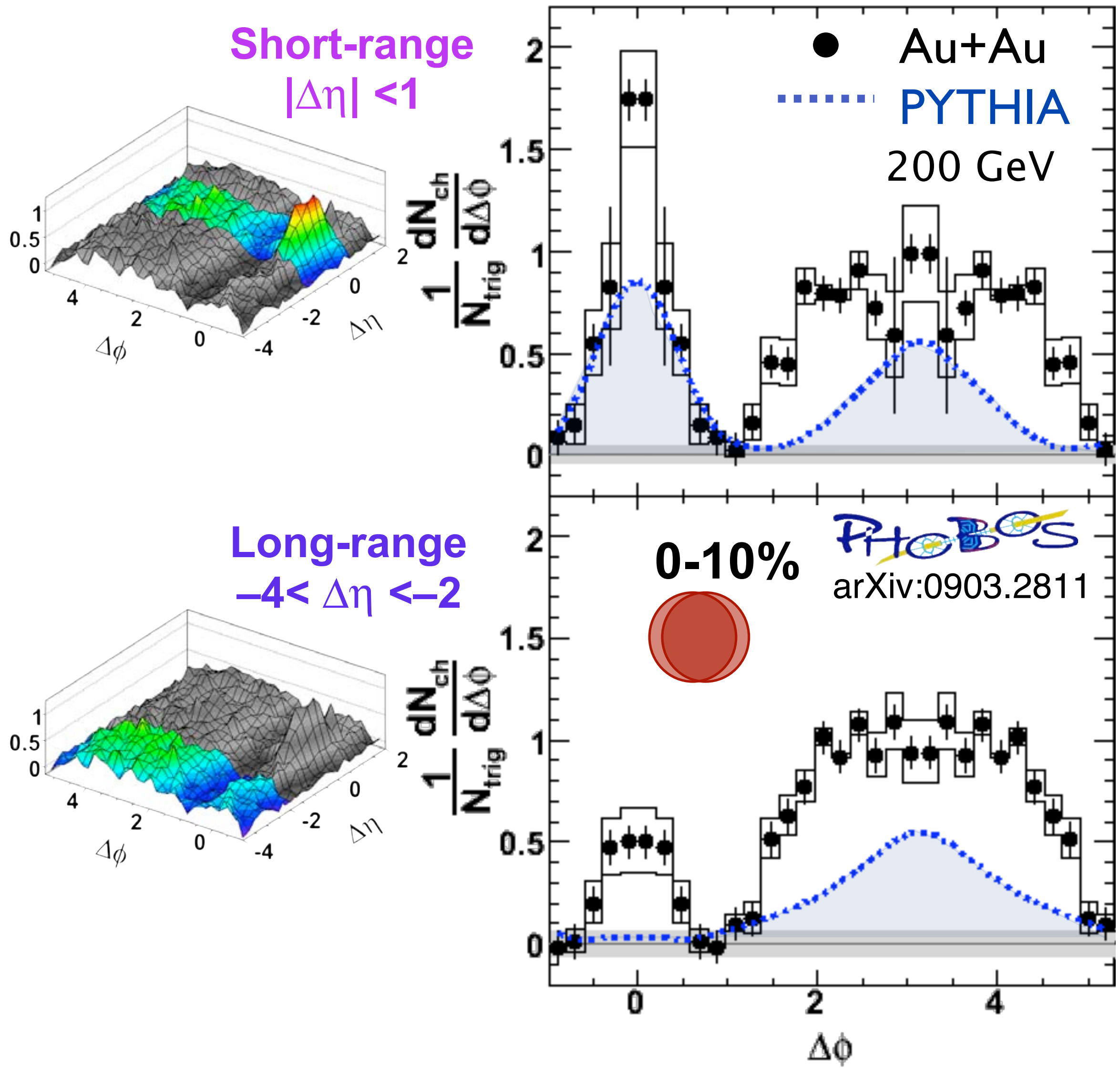


Long-range ridge yield

Actually an Extended "Ridge" plus a Peak

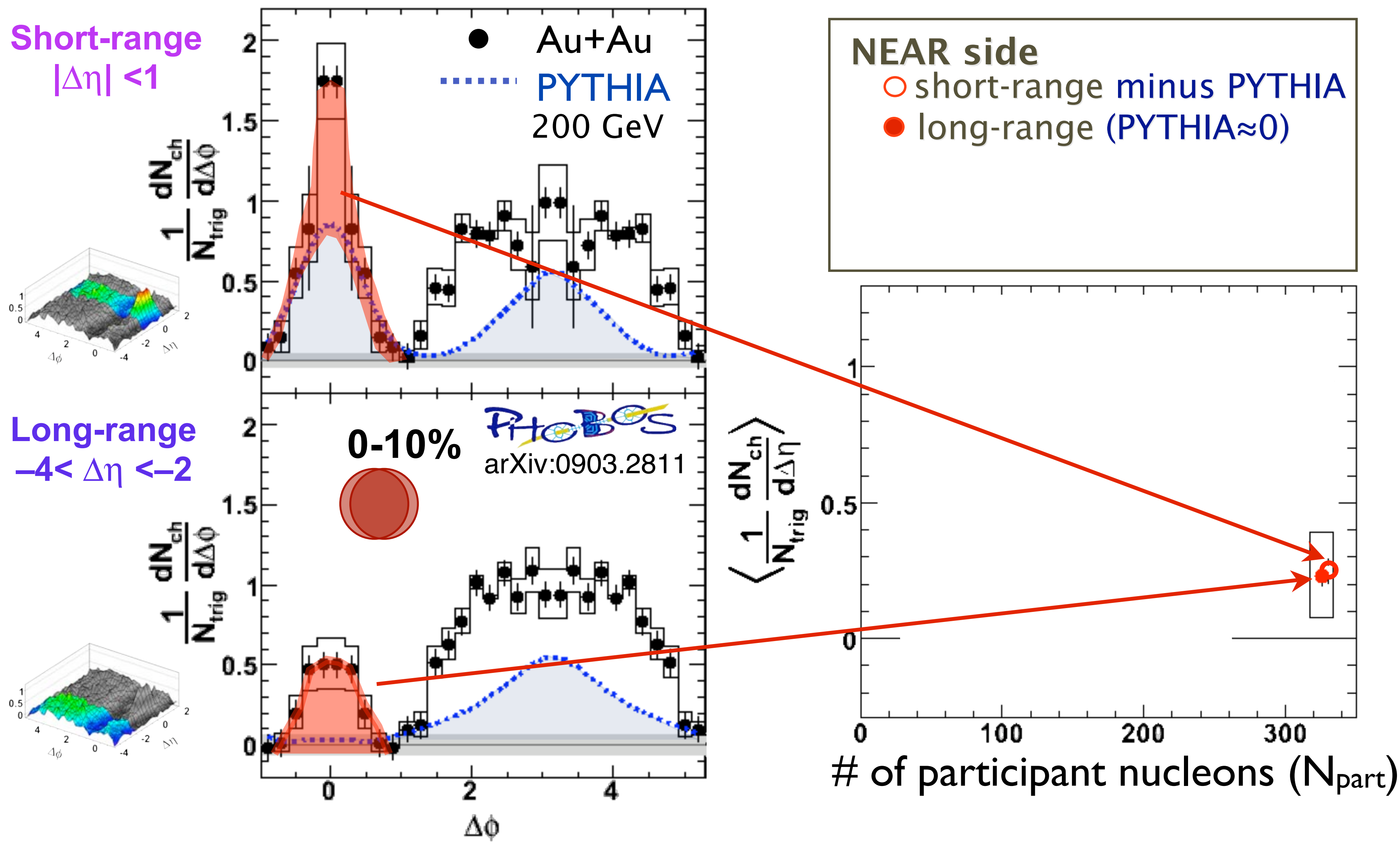


Integrated Ridge Yield: |Δη|<1 vs –4<Δη<–2

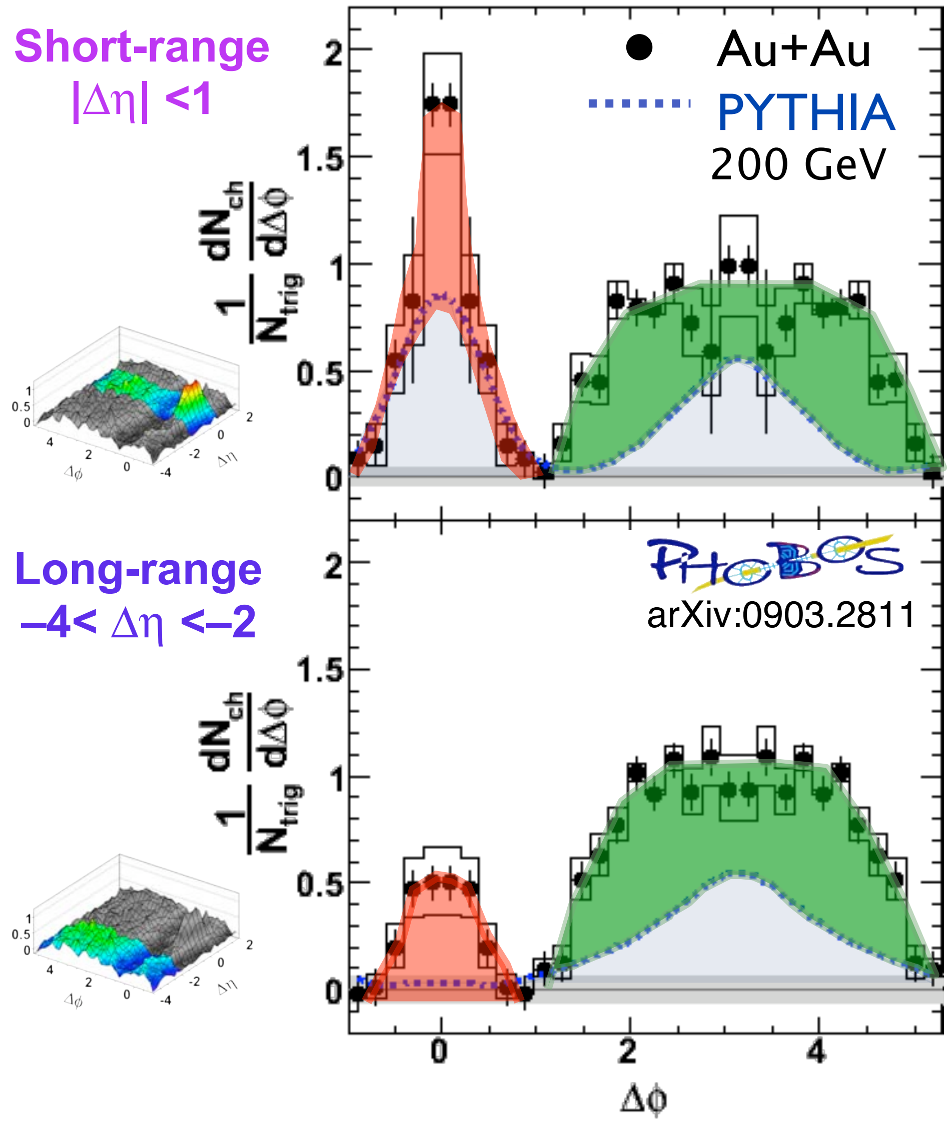


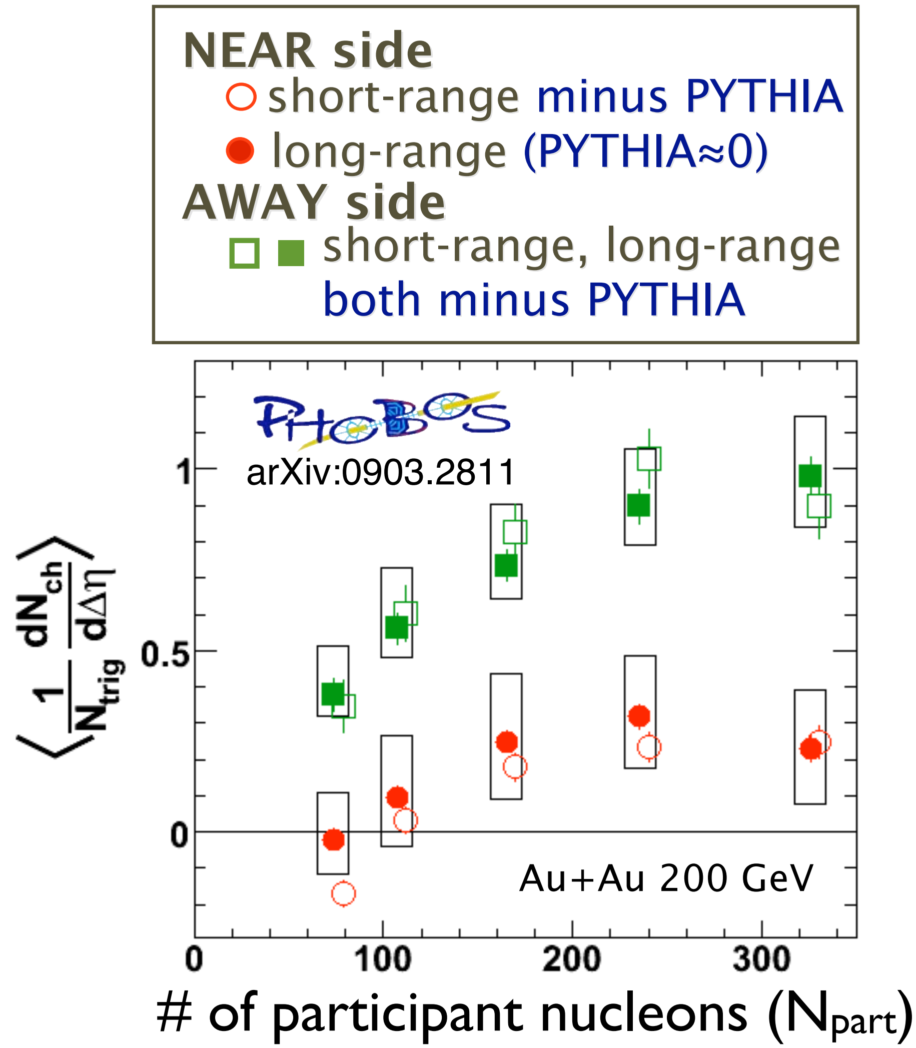
Project 2D correlation onto Δφ axis. Subtract out the Pythia peaks and then plot versus centrality for short- and long-range

Integrated Ridge Yield: |Δη|<1 vs –4<Δη<–2

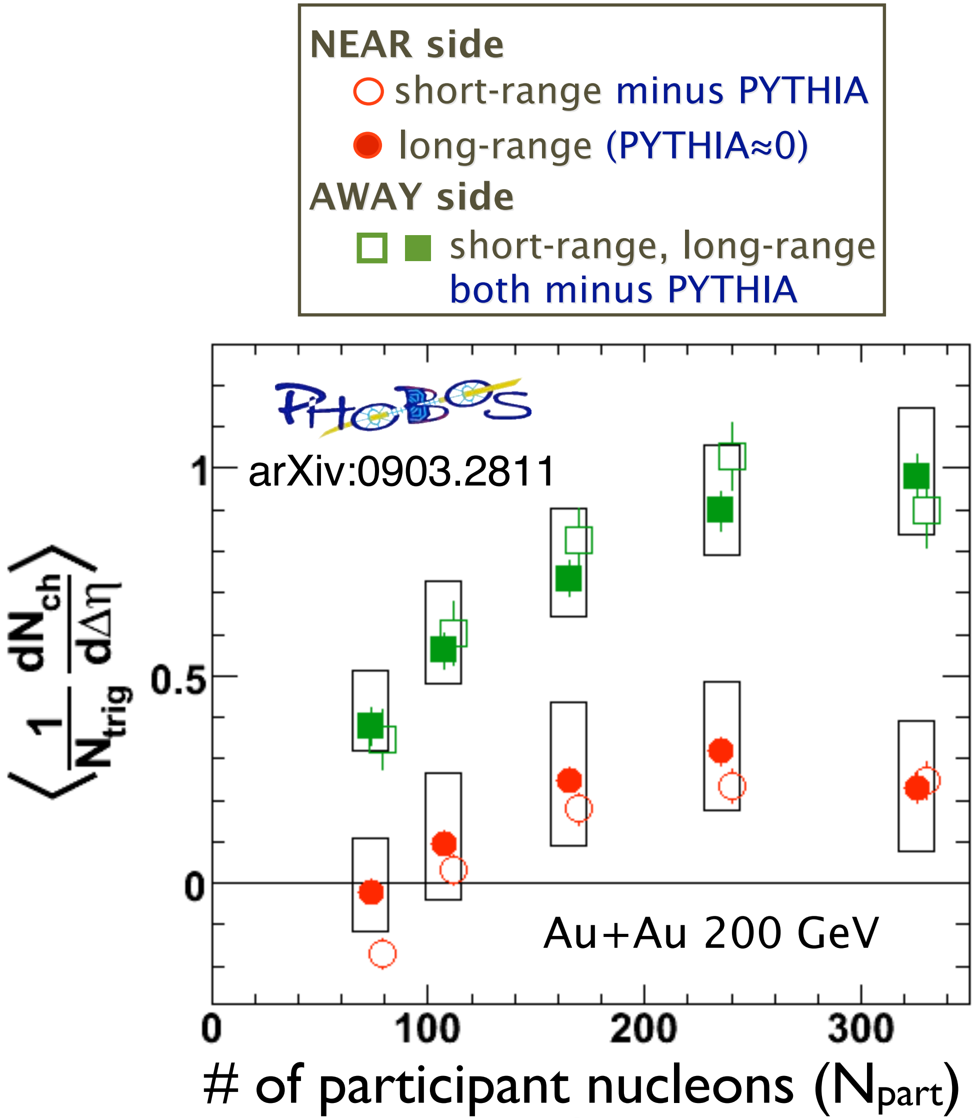


Integrated Ridge Yield: |Δη|<1 vs –4<Δη<–2



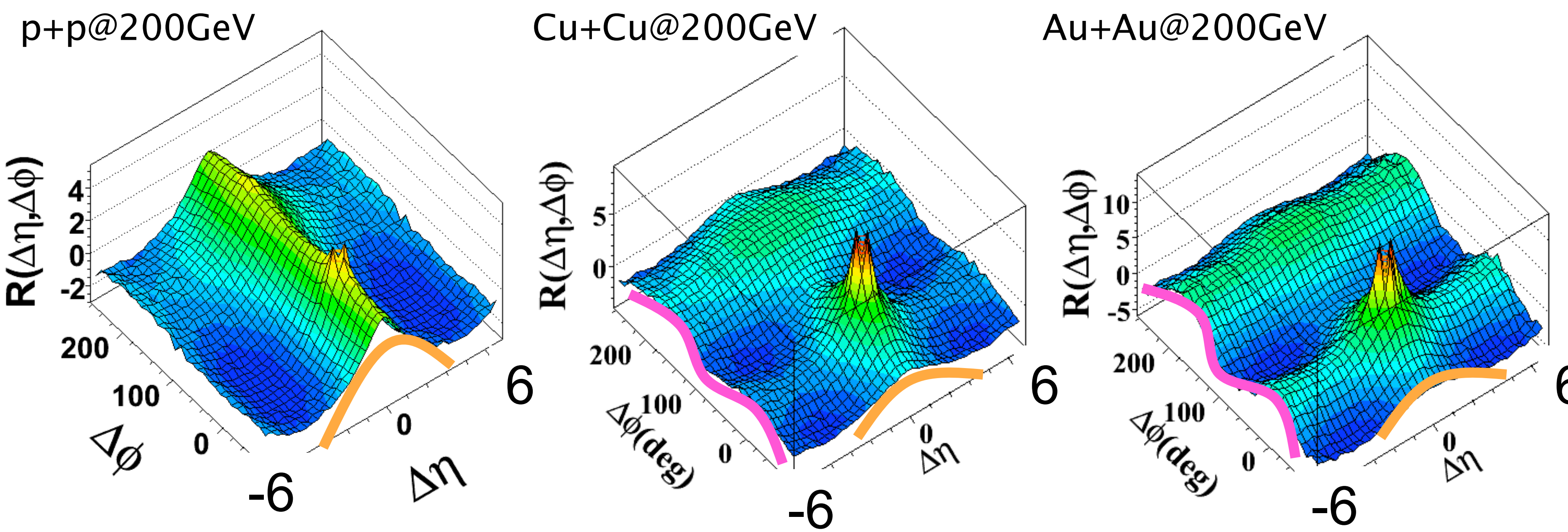


Triggered Correlation Observations



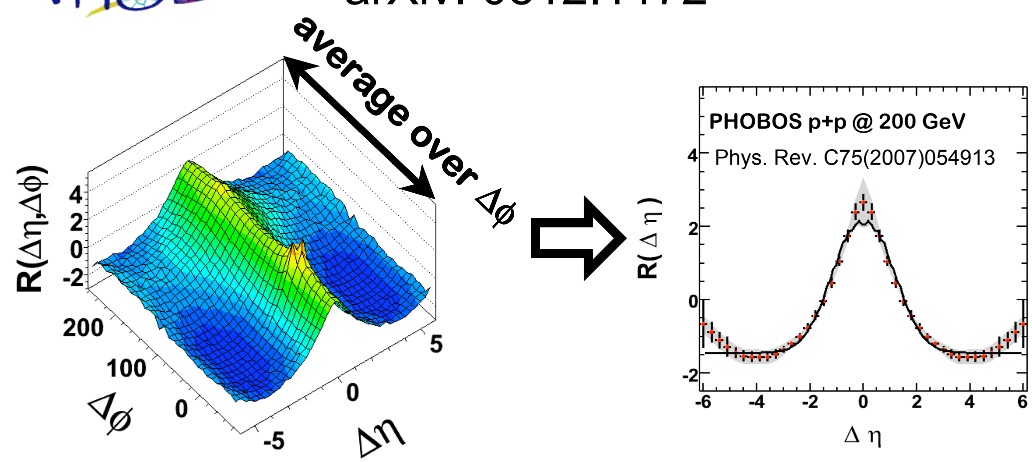
- Near side (small $\Delta\phi$) ridge yield extends to at least $|\Delta\eta|\sim 4$
- Short-range ($|\Delta\eta|<1$) and long-range ($-4<\Delta\eta<-2$) ridge yields are very similar in size at all centralities
- Ridge disappears for N_{part} below about 80
- Excess yield on the away side ($\Delta\phi\sim\pi$) is also uniform in $\Delta\eta$ and decreases for more peripheral collisions

Inclusive 2-Particle Correlations



Phys. Rev. C75(2007)054913 arXiv: 0812.1172

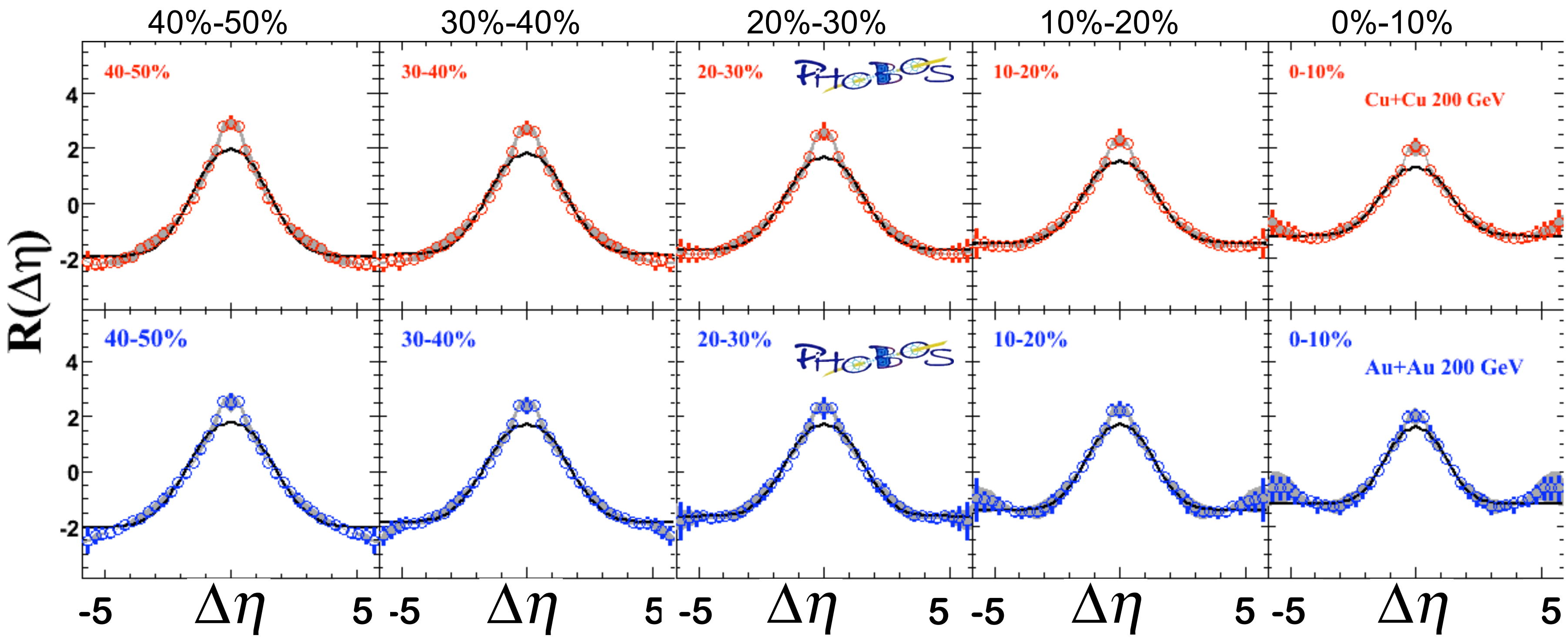
Project onto Δη axis and fit with a simple parameterization of a cluster model



Cluster Model Fit to Inclusive Correlations

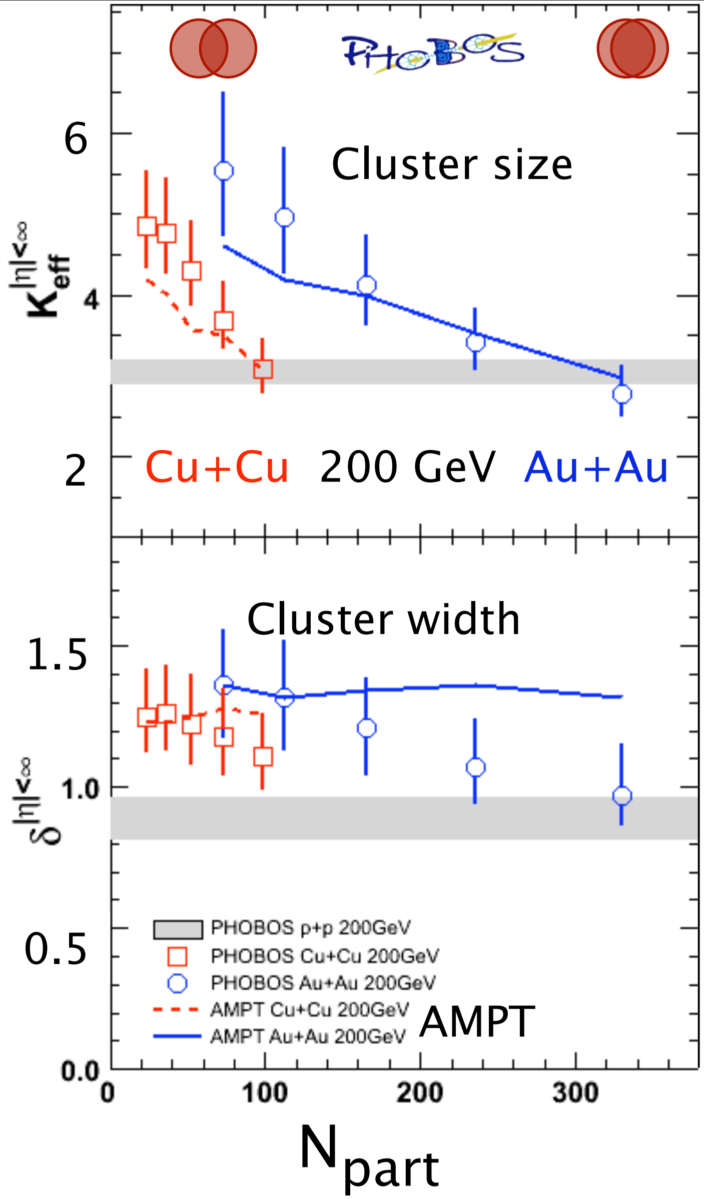
Two-particle Δη correlation function

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

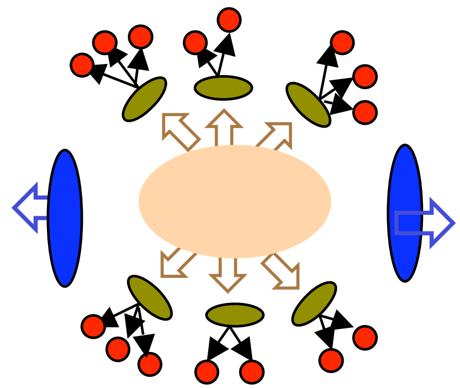


(scale errors are shown as grey bands)

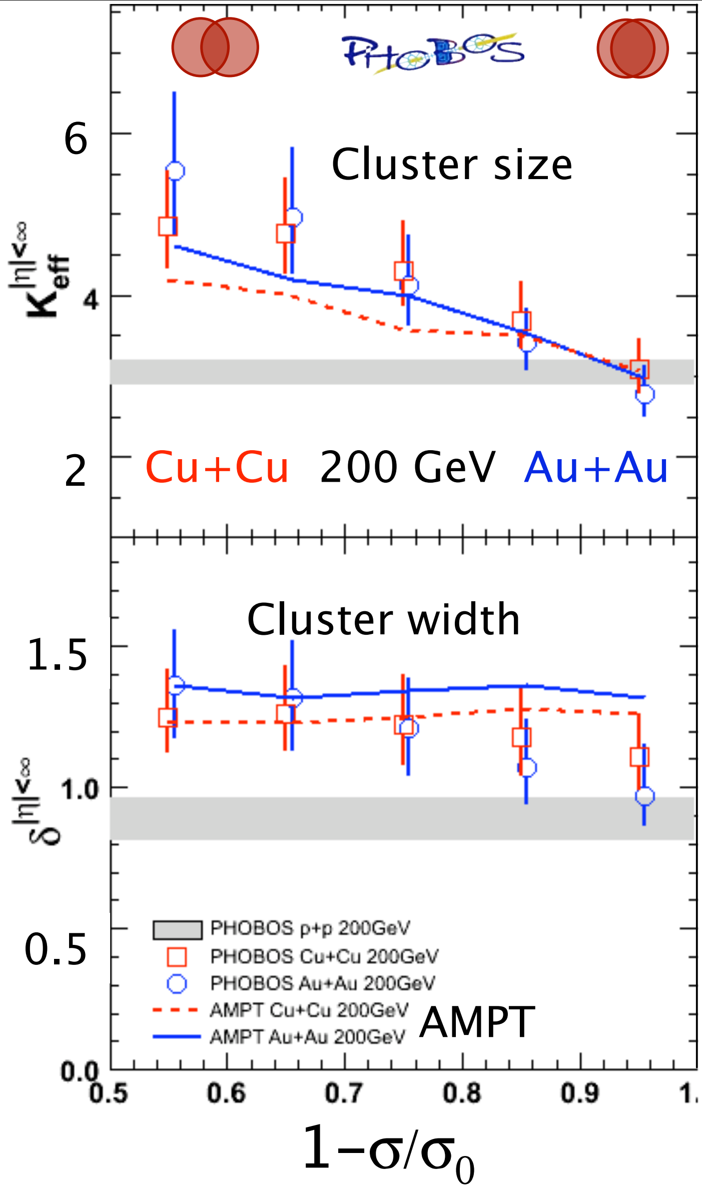
Inclusive Correlation Results



Cluster sizes (number of particles in a cluster) are large: Up to ~5 charged particles (after correction for η acceptance, see later discussion).



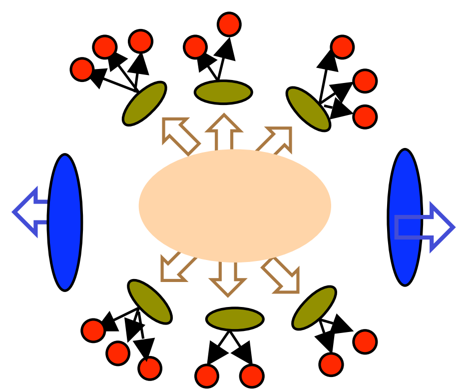
Inclusive Correlation Results



Cluster sizes (number of particles in a cluster) are large: Up to ~5 charged particles (after correction for η acceptance, see later discussion).

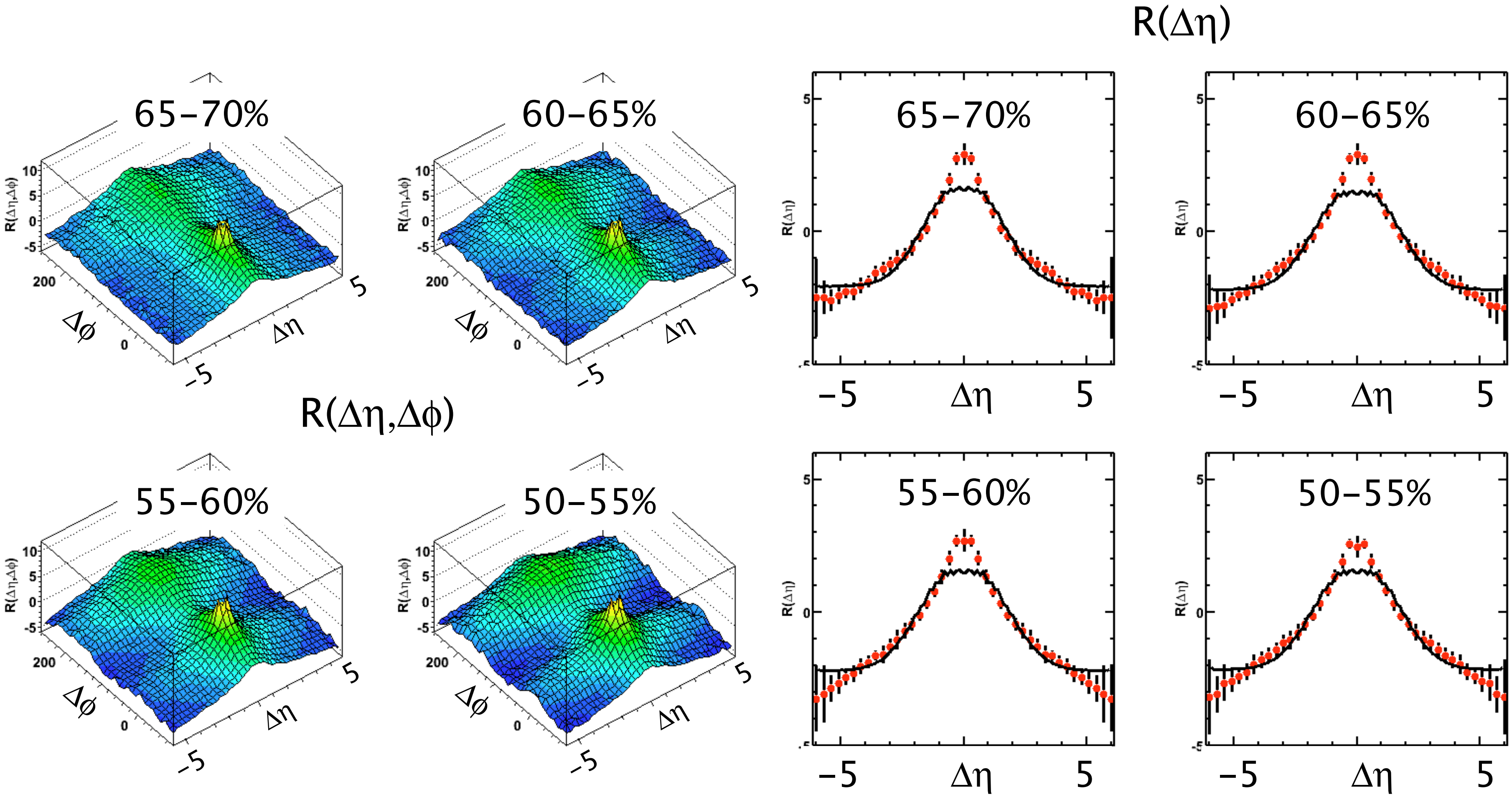
Cluster size scales with fractional cross-section.

Model studies suggest that centrality dependence is due to the hadronic cascade phase and that cluster size is strongly dependent on string fragmentation parameters



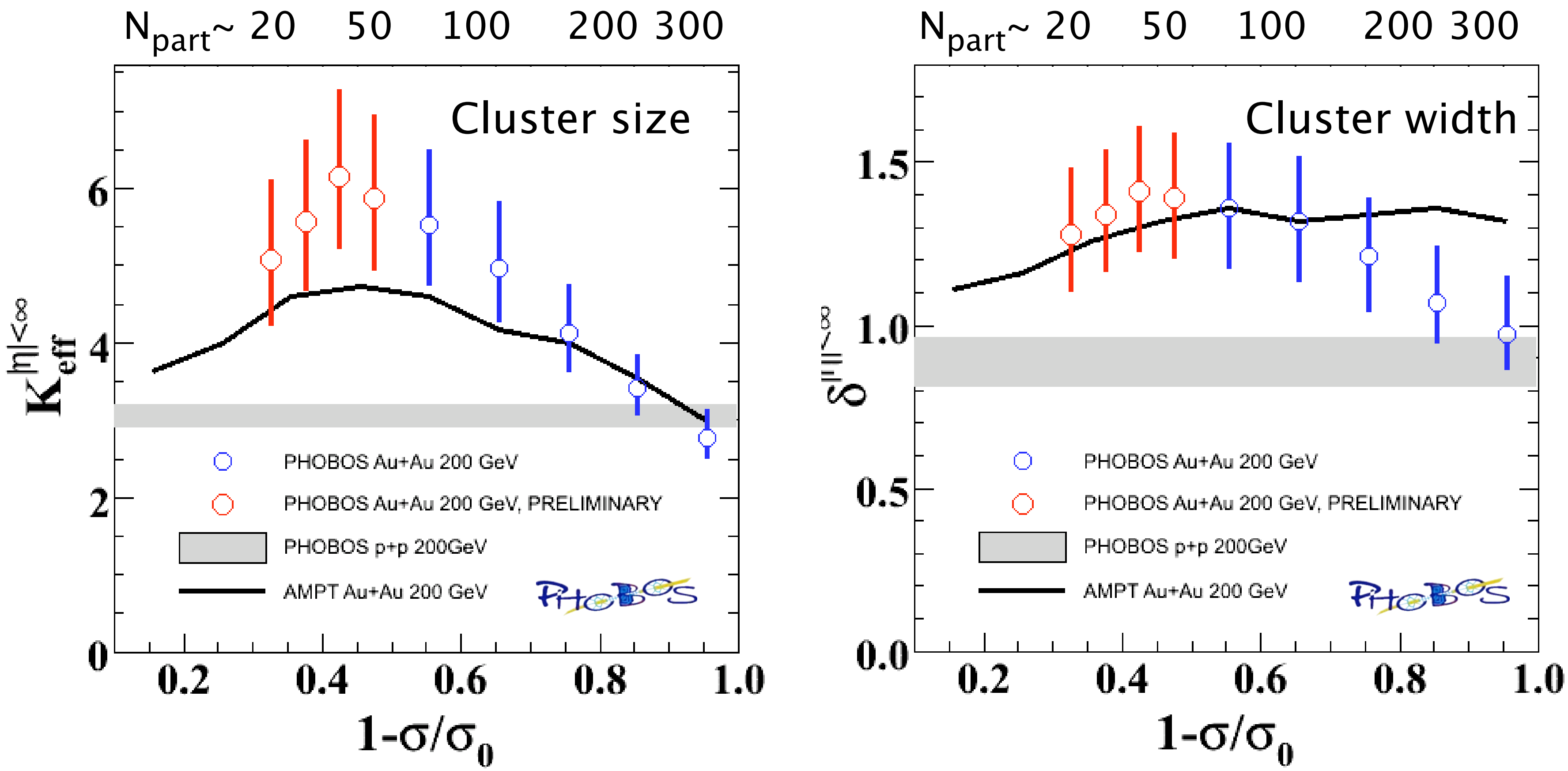
New Inclusive Correlation Result

Au+Au @ 200 GeV: Peripheral collisions



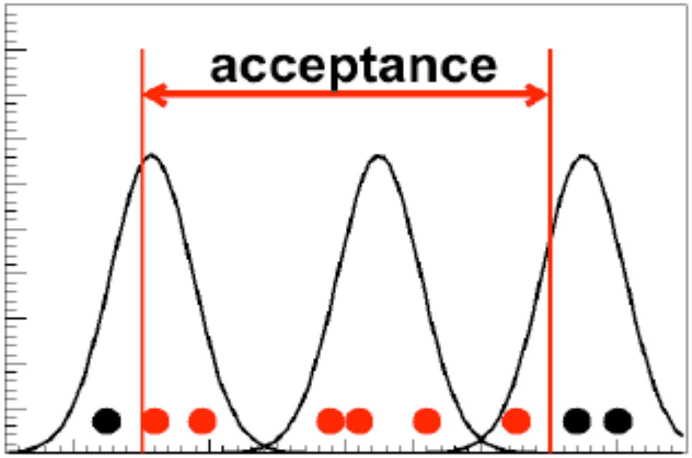
Expanded 2-Particle Correlation Result

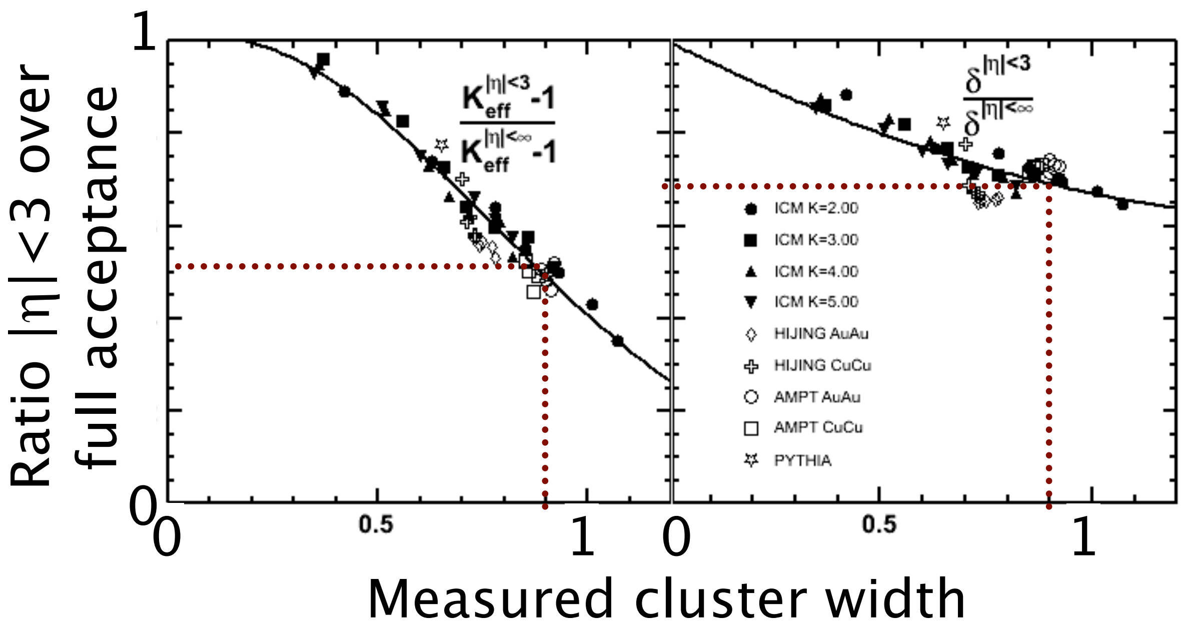
Au+Au @ 200 GeV



Acceptance Effect on Correlations

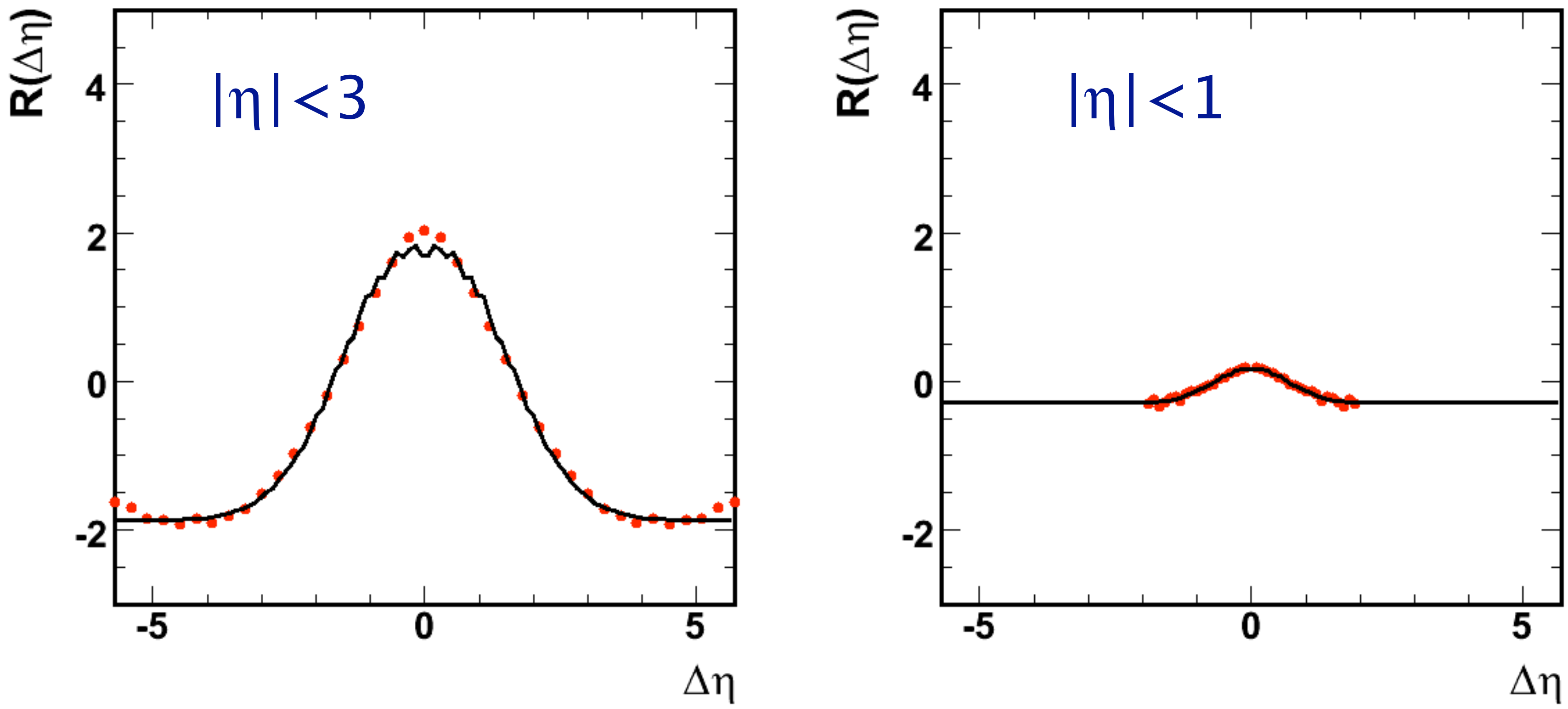
Limited η range causes loss of correlated particles leading to ***smaller*** measured sizes and widths for the clusters.





For A+A data in the range |η|<3, the correction is roughly a factor of 2 for the cluster size and 40% for the cluster width.

Cluster Fits to MC in $|\eta|<3$ and $|\eta|<1$

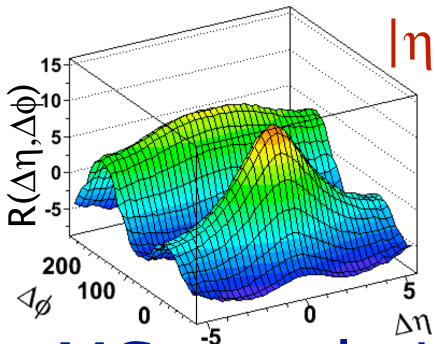


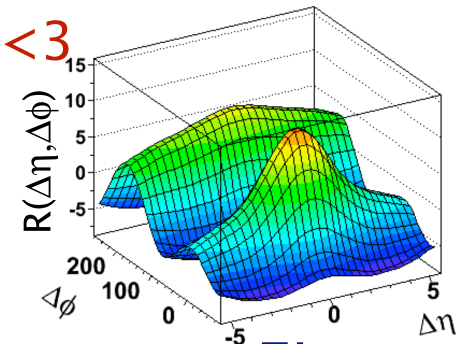
Identical MC independent cluster model events thrown into different detector acceptances and then fit with the simple cluster parameterization.

MC Study of Acceptance Effect

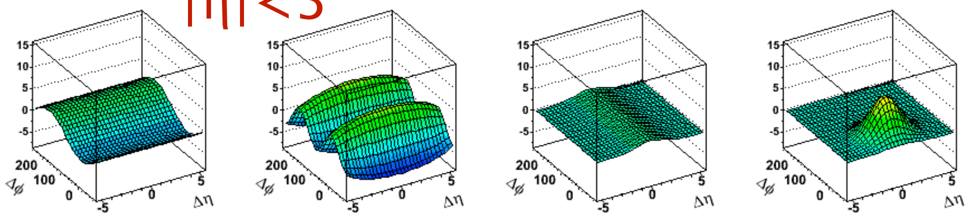
Events from cluster model plus flow are fit with a multi-component parameterization (similar to arxiv:0806.2121v2)

|η|<3





|η|<3

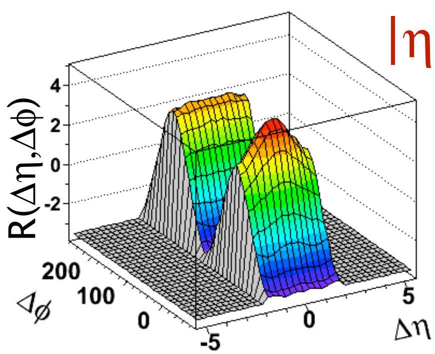


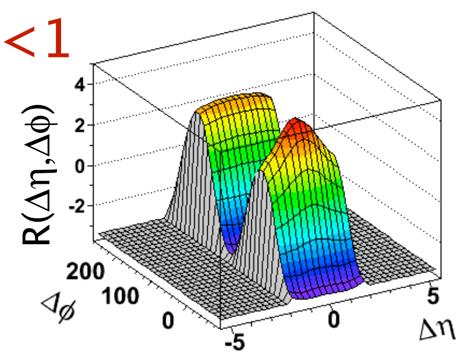
MC correlation

Fit

Individual components

|η|<1





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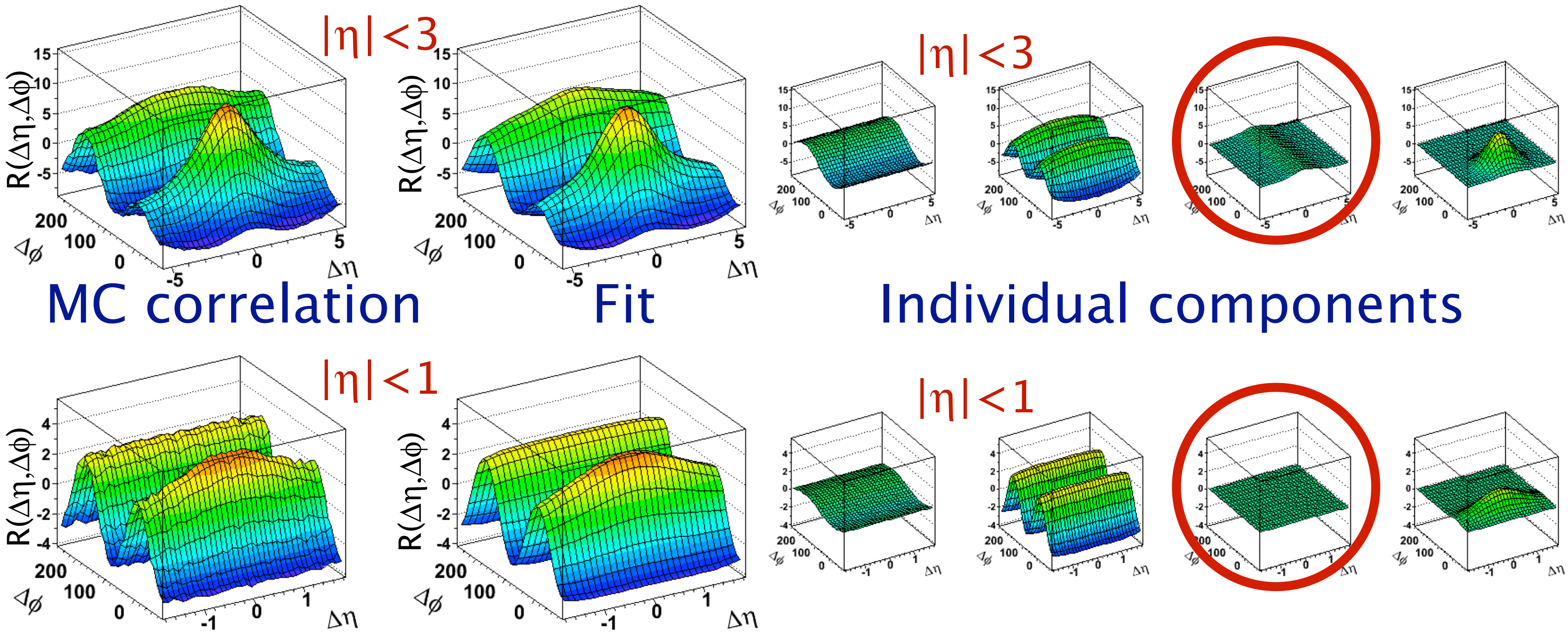
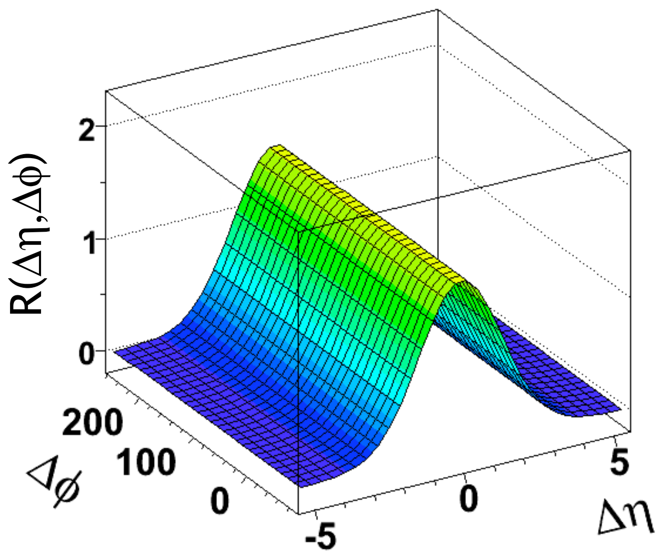


Note the almost complete disappearance of the 1D $\Delta\eta$ component in the reduced acceptance case

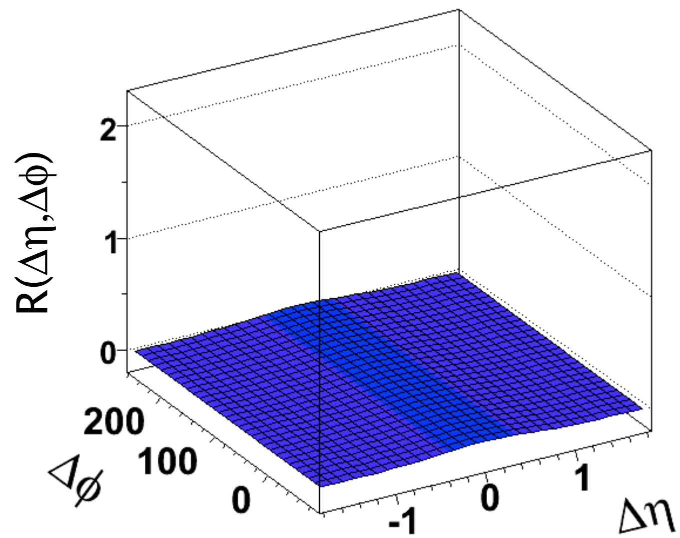
MC Study of Acceptance Effect

Events from cluster model plus flow are fit with a multi-component parameterization (similar to arxiv:0806.2121v2)

$|\eta|<3$



$|\eta|<1$



Note the almost complete disappearance of the 1D $\Delta\eta$ component in the reduced acceptance case

Summary

- Correlations in Au+Au @ 200 GeV using a trigger particle with p_T>2.5 GeV/c show a "ridge" of enhanced yield at small $\Delta\phi$ which extends to at least $|\Delta\eta|=4$
  - Appears to be a constant "ridge" under Pythia-like fragmentation
  - Effect seems to disappear for N_{part} below about 80
- Inclusive 2-particle correlations suggest that particles are emitted in very large "clusters" whose size scales with the geometry of the collision as opposed to N_{part}
- Quantitative interpretation of any correlation result needs to take into account the effect of η acceptance
  - For example comparing to models or comparing &

Backup Slides

Construction of Correlated Yield

$$\frac{1}{N_{trig}} \frac{d^2N_{ch}}{d\Delta\phi\, d\Delta\eta} = B(\Delta\eta)\left\{ \frac{s(\Delta\phi,\Delta\eta)}{b(\Delta\phi,\Delta\eta)} - a(\Delta\eta)\left[1 + 2V(\Delta\eta)\cos(2\Delta\phi)\right]\right\}$$

$\frac{s(\Delta\phi,\Delta\eta)}{b(\Delta\phi,\Delta\eta)}$ **Raw correlation**: ratio of per-trigger same event pairs to mixed event pairs

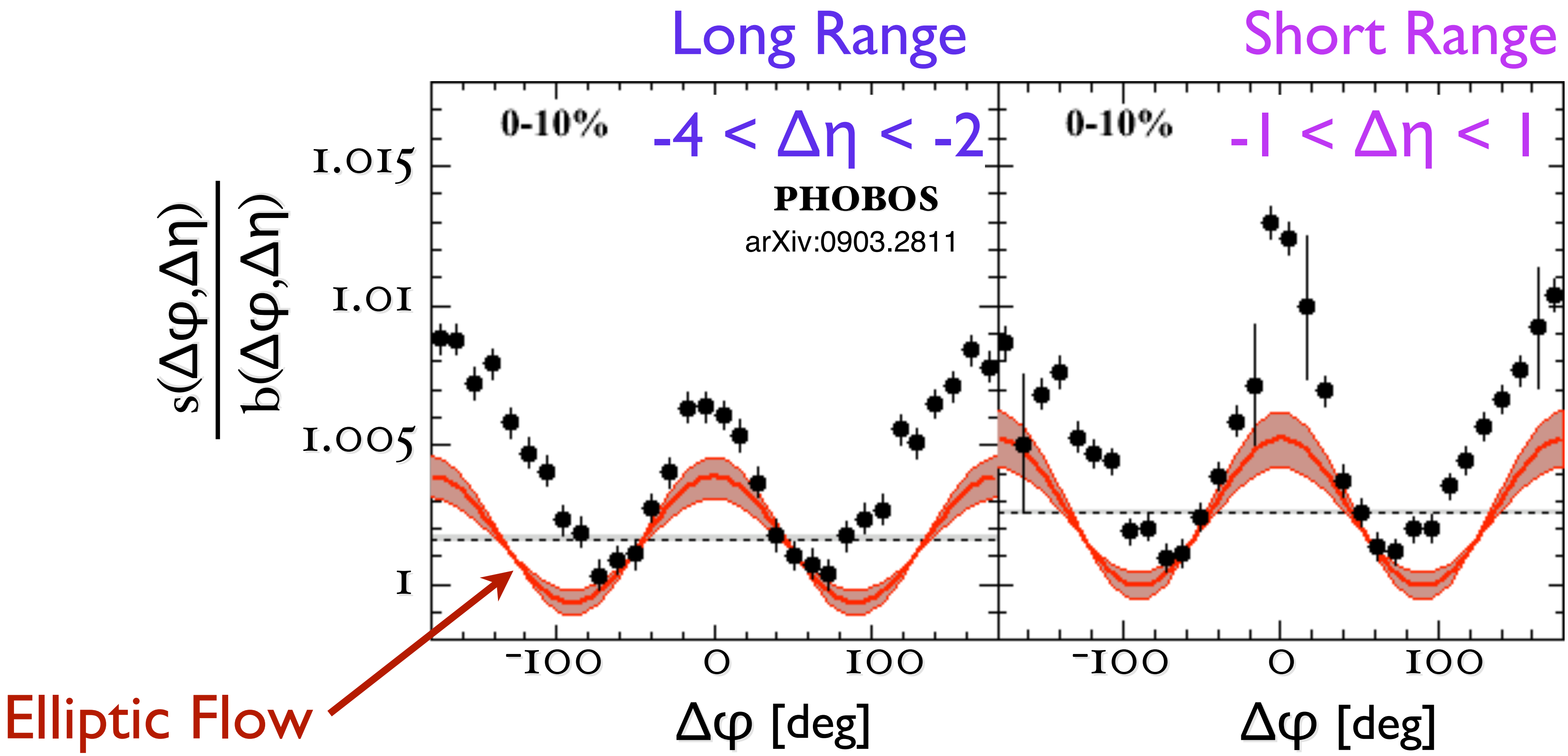
$1 + 2V(\Delta\eta)\cos(2\Delta\phi)$ **Elliptic flow**: $V(\Delta\eta) = \langle v_2^{trig} \rangle \langle v_2^{assoc} \rangle$

PHOBOS Phys. Rev. C **72**, 051901(R) (2005)

$a(\Delta\eta)$ **Scale factor**: accounts for small multiplicity difference between signal and mixed events

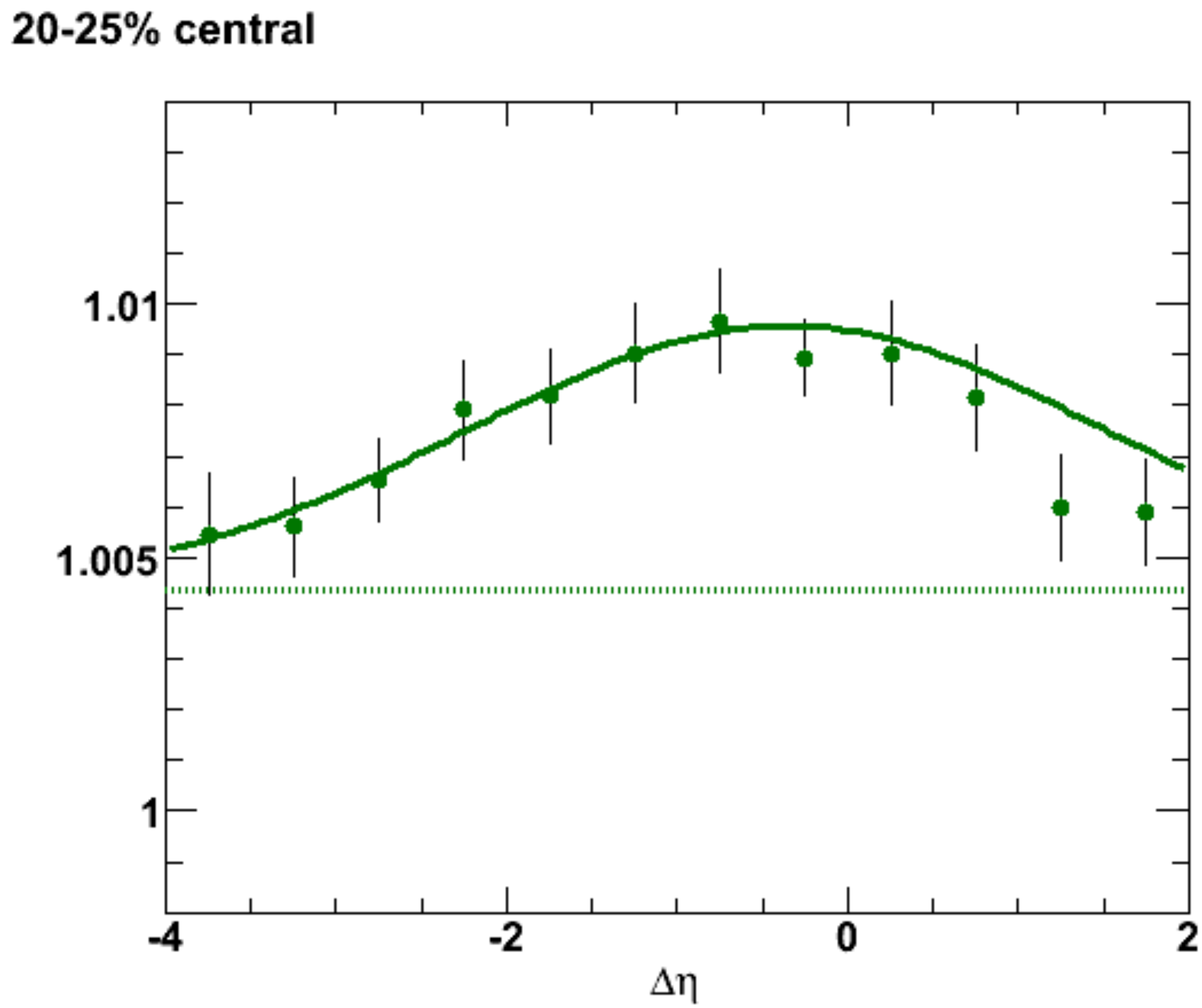
$B(\Delta\eta)$ **Normalization term:** relates flow-subtracted correlation to correlated yield

Subtraction of elliptic flow

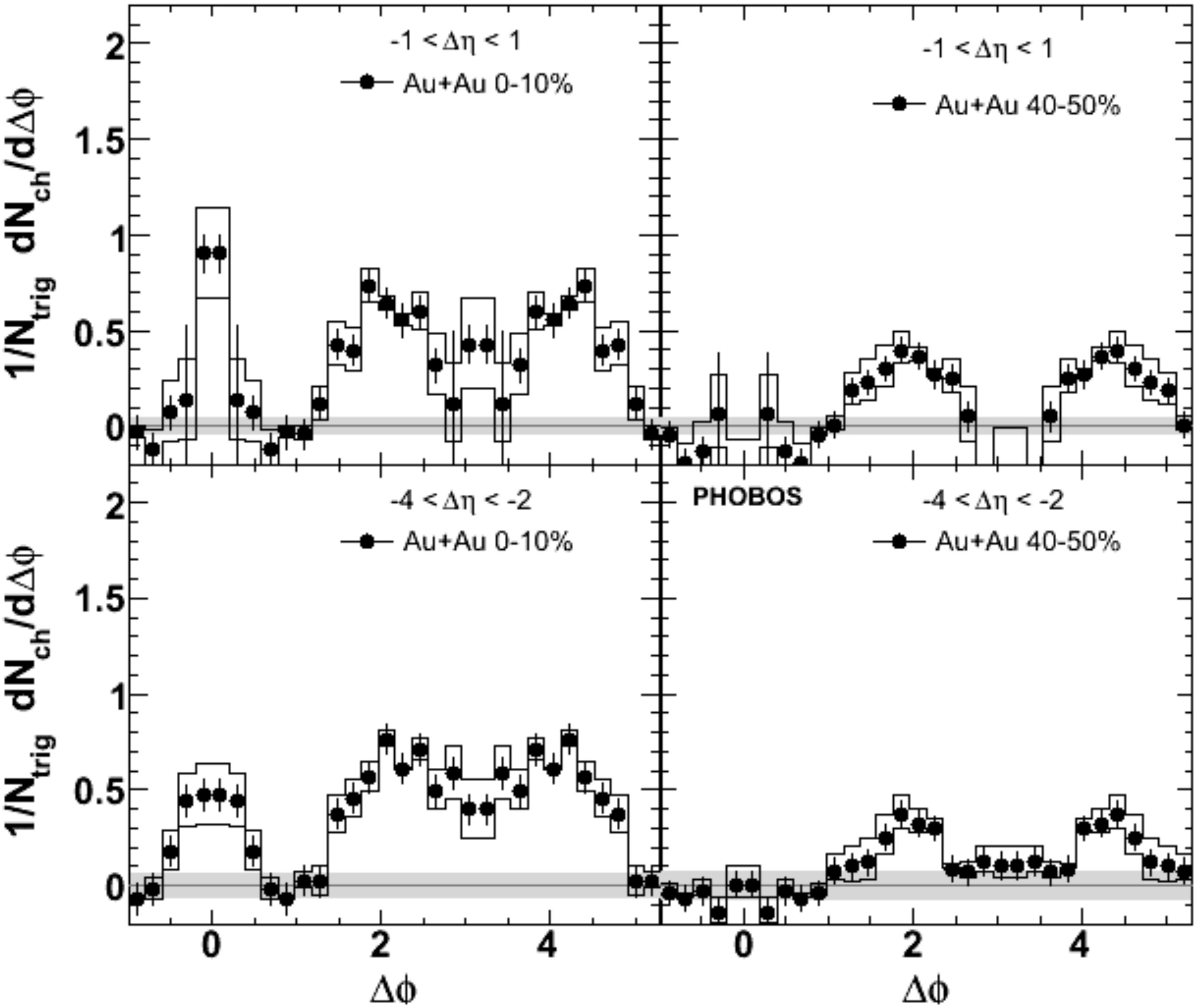


$a(\Delta\eta)\,[1 + 2V(\Delta\eta)\cos(2\Delta\phi)]$

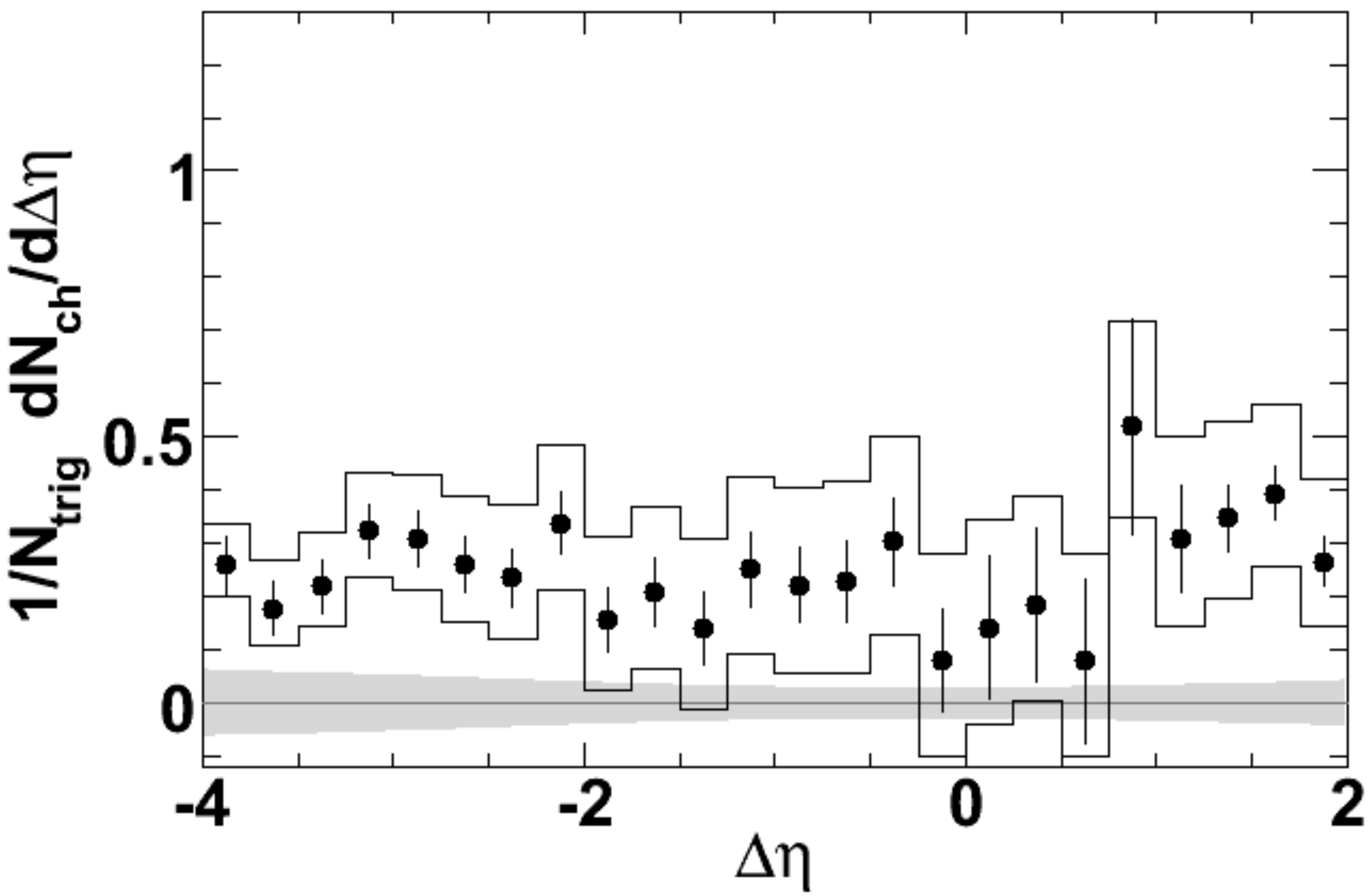
ZYAM Example



Pythia-Subtracted Correlation Functions



Pythia-Subtracted Correlation Functions



Inclusive 2-Particle Methodology

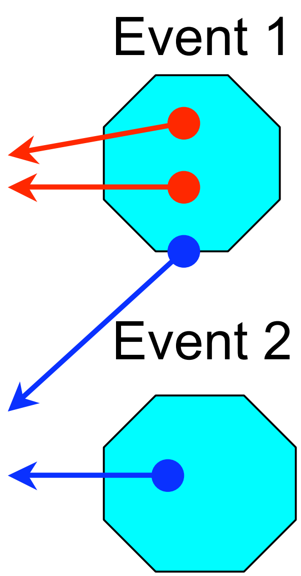
Two-particle correlation function:

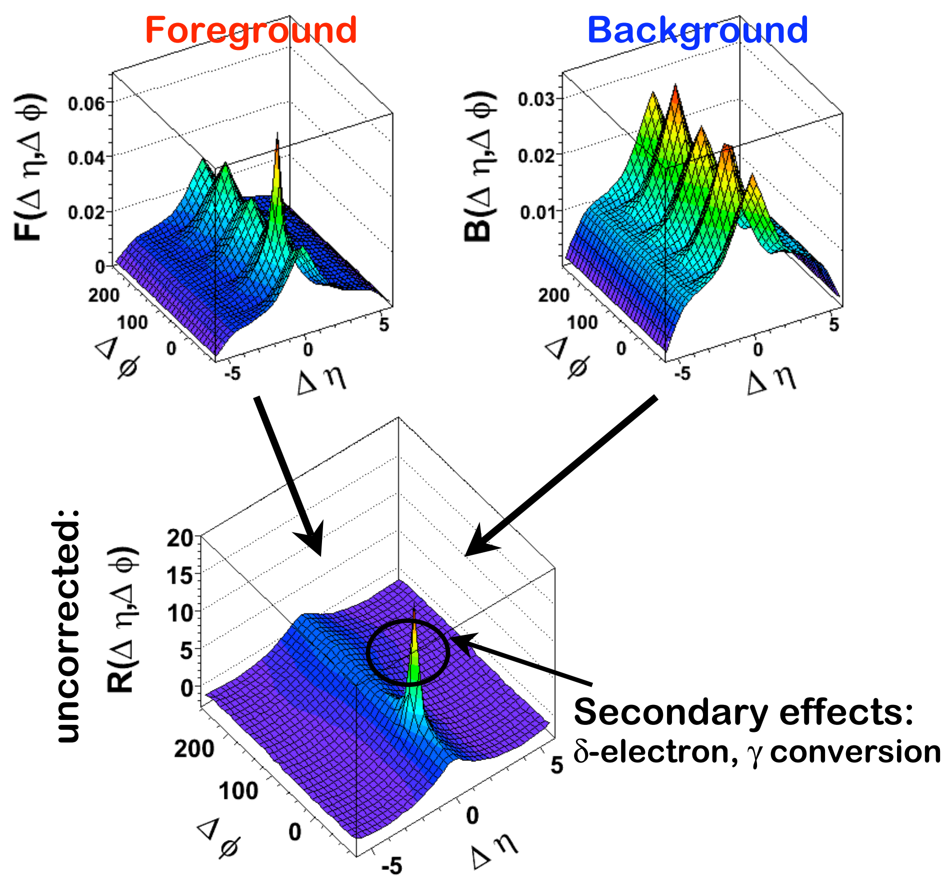
$$R(\Delta\eta,\Delta\phi) = \left\langle (n-1)\left(\frac{F_n(\Delta\eta,\Delta\phi)}{B_n(\Delta\eta,\Delta\phi)} - 1\right)\right\rangle$$

(multiplicity independent!)

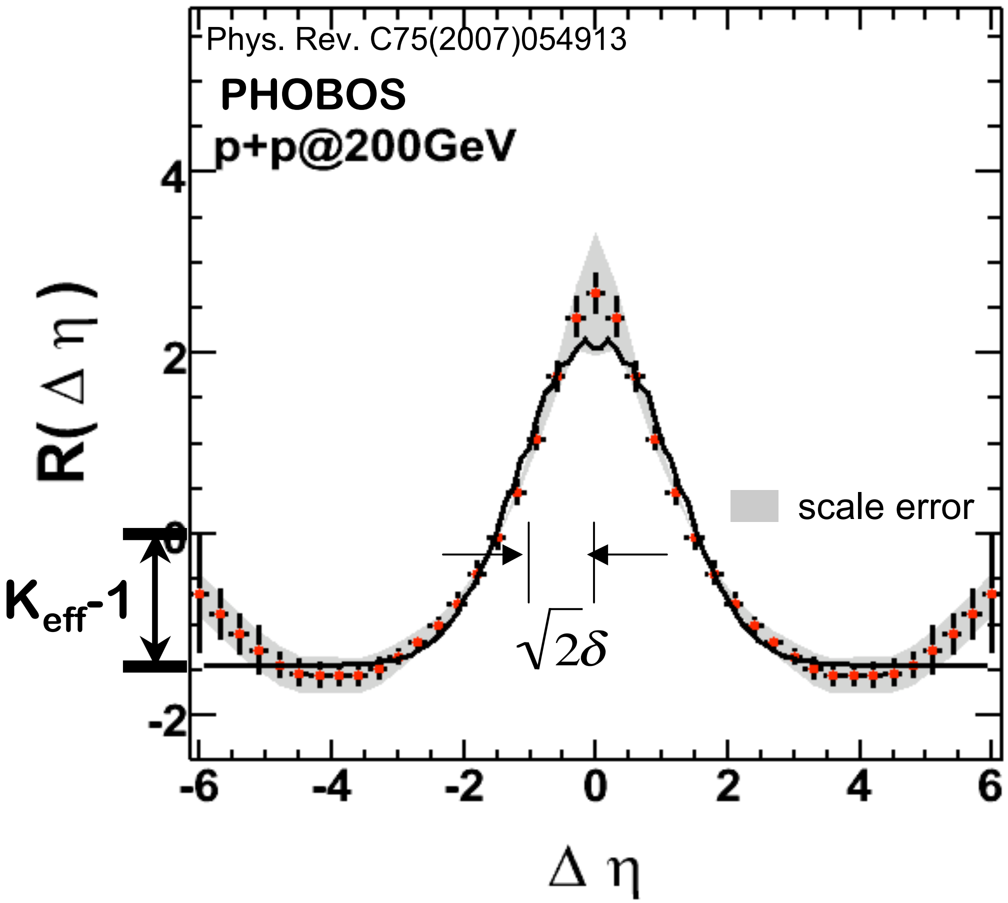
Foreground: $F_n(\Delta\eta,\Delta\phi)$
(correlated + uncorrelated pairs):

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





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



$$K_{eff} = \langle K \rangle + \frac{\sigma_K^2}{\langle K \rangle}$$

$$\delta = \left(\sqrt{K(K-1)}\right)\sigma_{\eta-\eta cluster}$$

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

Expanded 2-Particle Correlation Result

Au+Au @ 200 GeV Not corrected for acceptance