High-p_T Triggered Correlations over a Broad Range in $\Delta\eta$

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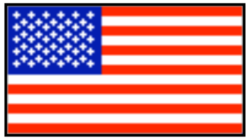
for the PHOBOS collaboration

The PHOBOS Collaboration

Burak Alver, Birger Back, Mark Baker, Maarten Ballintijn, Donald Barton, Russell Betts, Richard Bindel, Wit Busza (Spokesperson), Vasundhara Chetluru, Edmundo García, Tomasz Gburek, Joshua Hamblen, Conor Henderson, David Hofman, Richard Hollis, Roman Hołyński, Burt Holzman, Aneta Iordanova, Chia Ming Kuo, Wei Li, Willis Lin, Constantin Loizides, Steven Manly, Alice Mignerey, Gerrit van Nieuwenhuizen, Rachid Nouicer, Andrzej Olszewski, Robert Pak, Corey Reed, Christof Roland, Gunther Roland, Joe Sagerer, Peter Steinberg, George Stephans, Andrei Sukhanov, Marguerite Belt Tonjes, Adam Trzupek, Sergei Vaurynovich, Robin Verdier, Gábor Veres, Peter Walters, Edward Wenger, Frank Wolfs, Barbara Wosiek, Krzysztof Woźniak, Bolek Wysłouch

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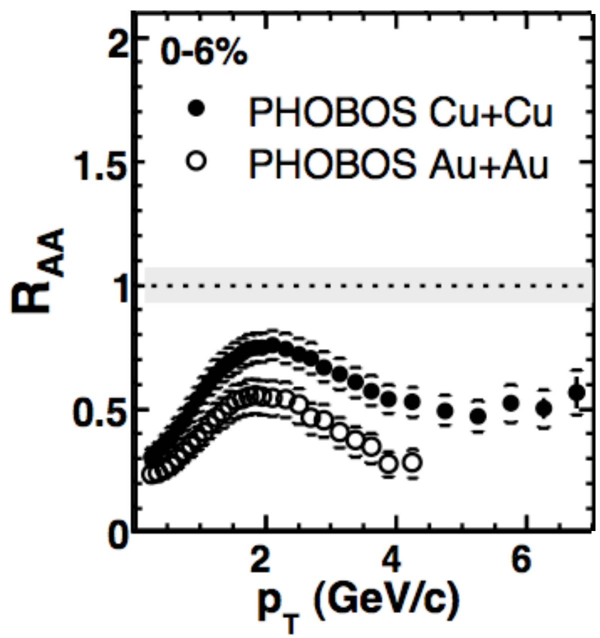
Motivation

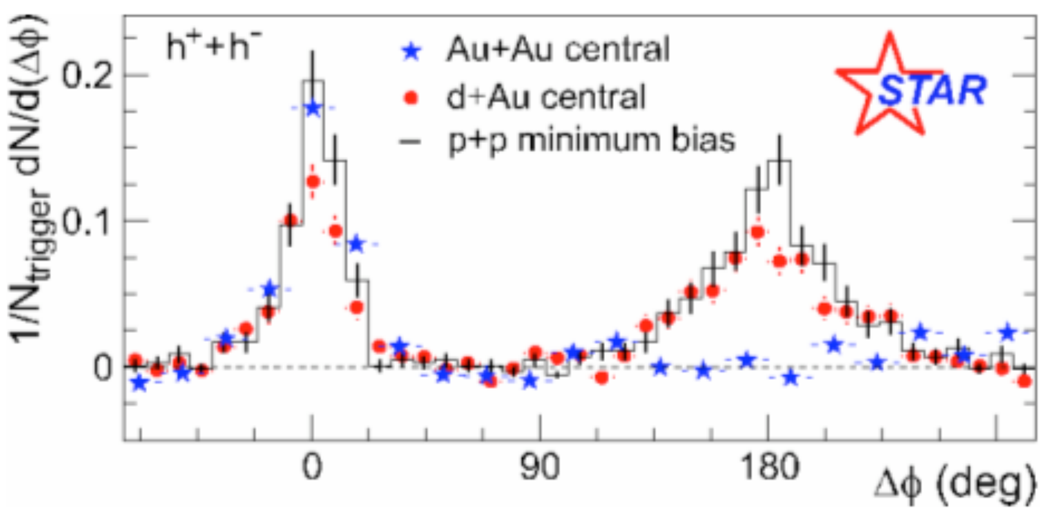
One of the most fundamental discoveries at RHIC is that partons strongly interact as they traverse the produced medium

- single-particle spectra (R_{AA})
- high-p_T azimuthal correlations

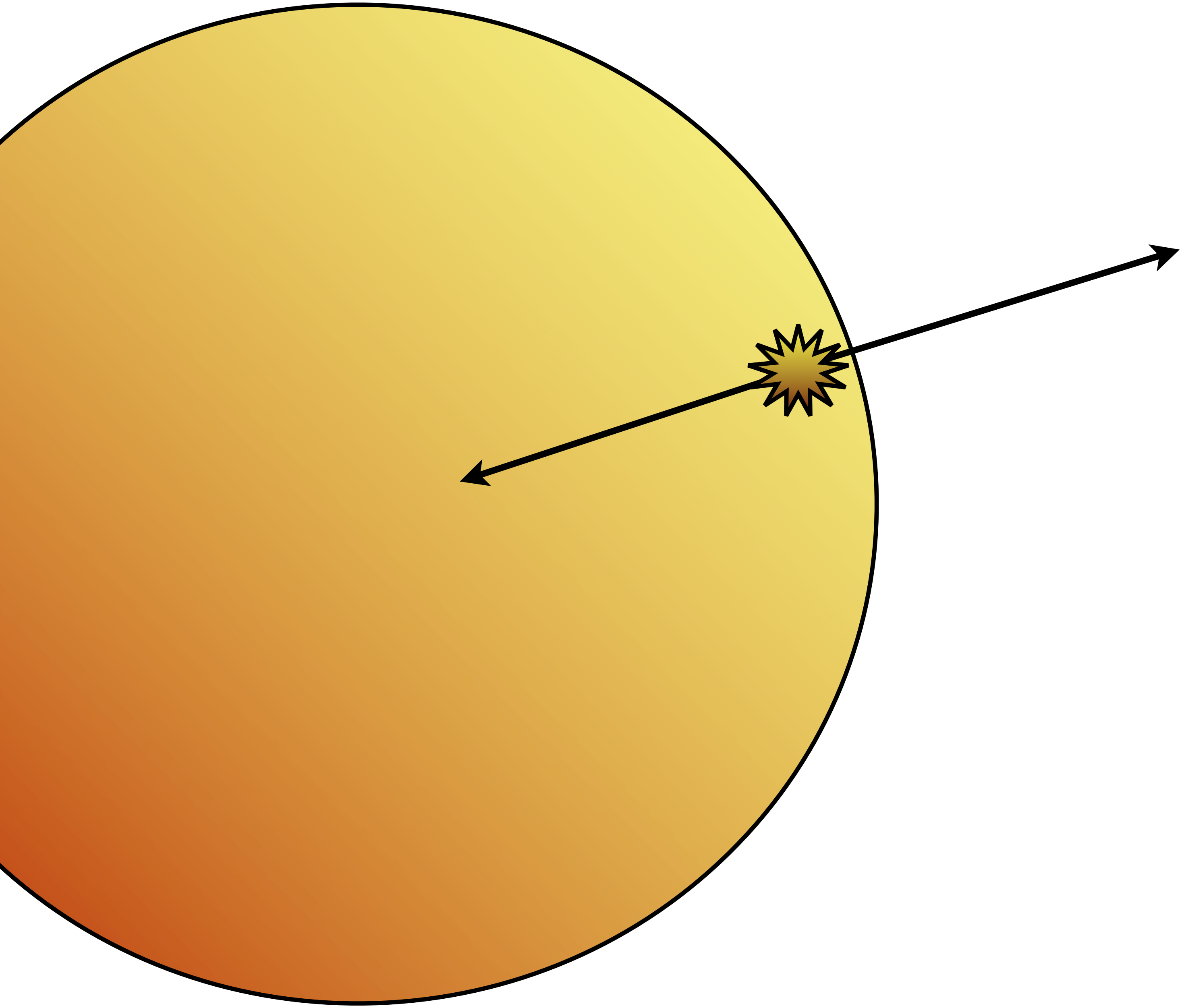
PHOBOS, PRL **96**, 212301 (2006)



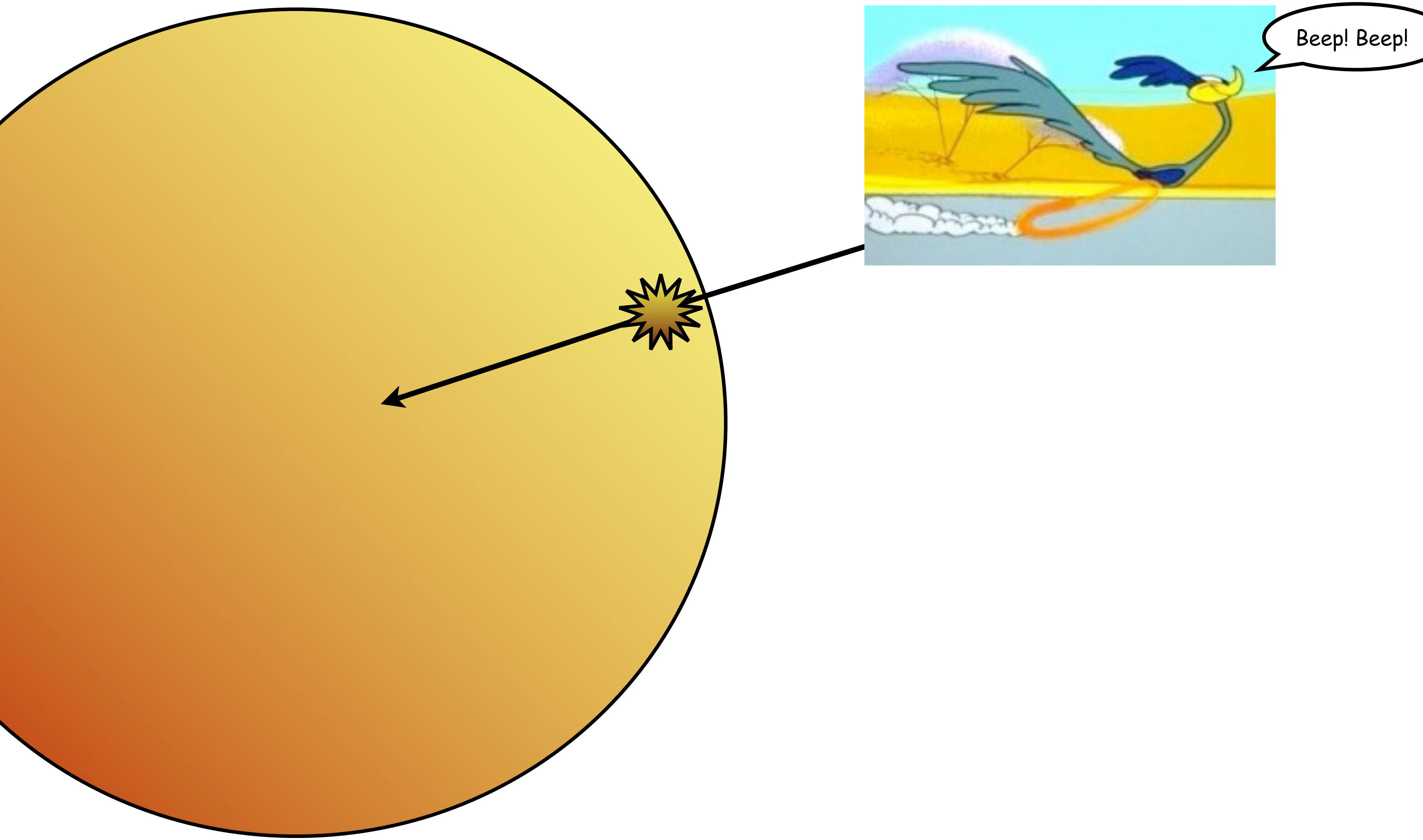
STAR, PRL **91**, 072304 (2003)



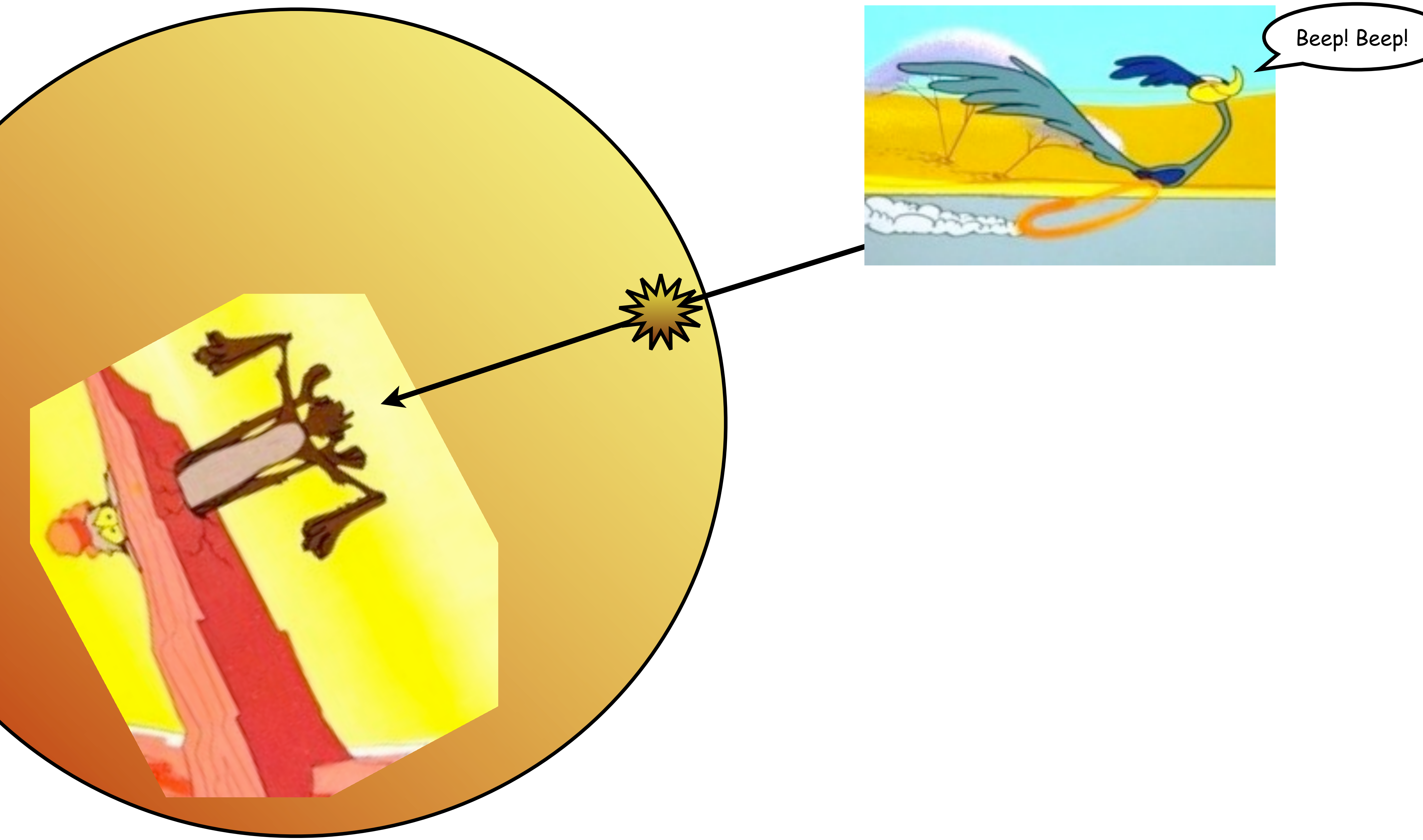
High p_T Associated Particles



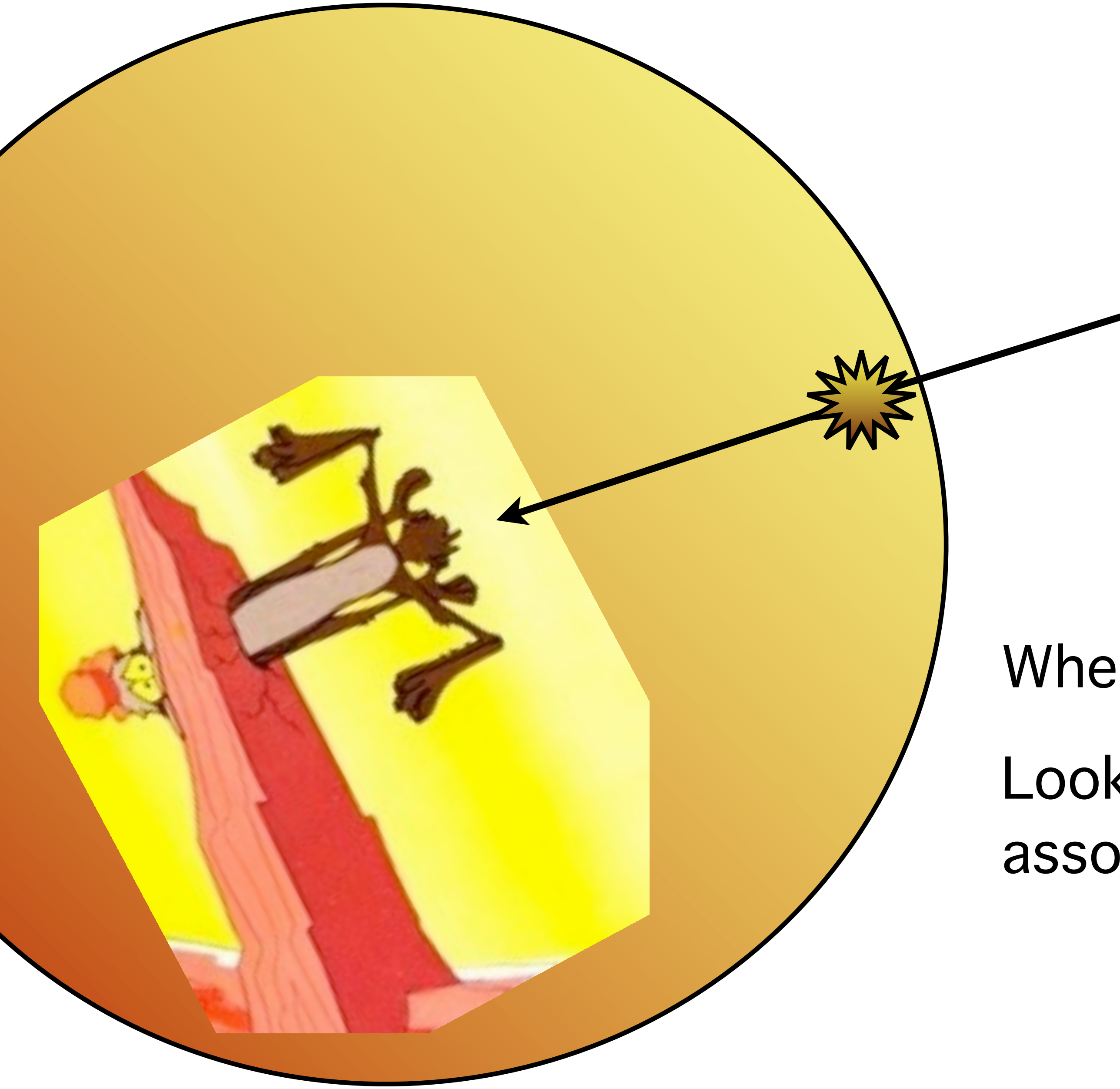
High p_T Associated Particles

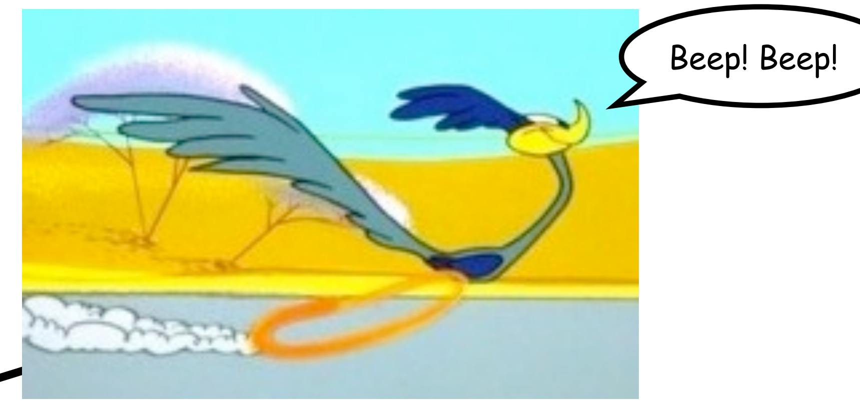


High p_T Associated Particles



High p_T Associated Particles





Where does the energy go?

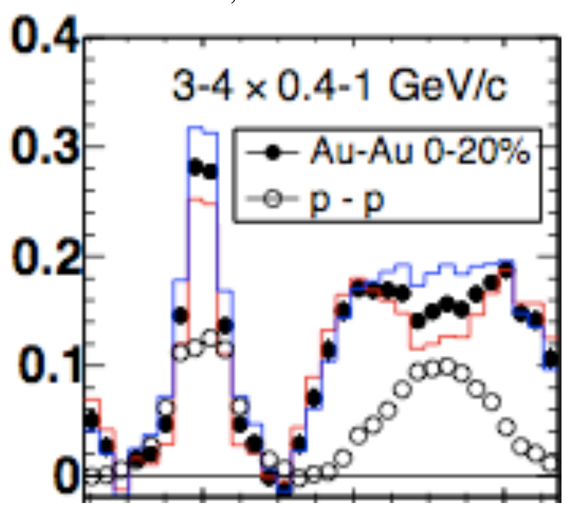
Look at lower momentum associated particles.

Lower p_T Associated Particles

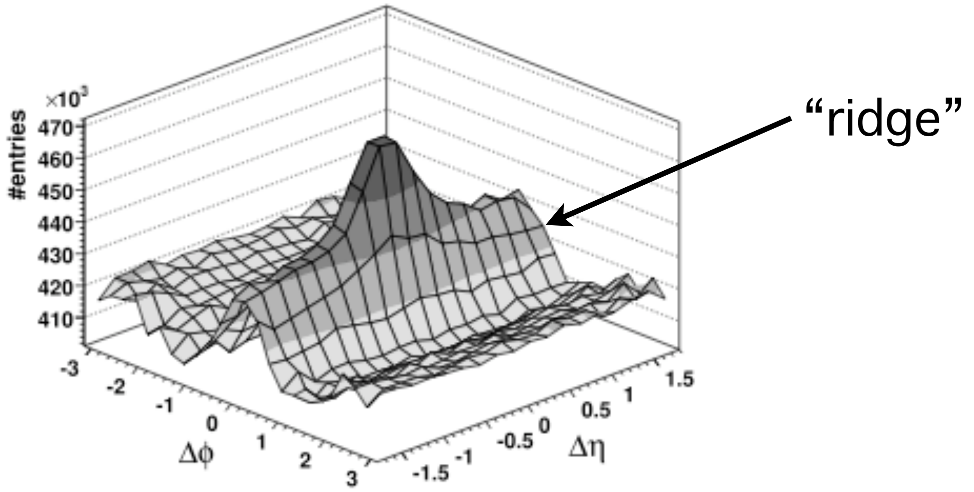
Existing triggered correlation measurements show novel features in heavy-ion collisions

- ✓ broadening in $\Delta\phi$ of away-side compared to p+p
- ✓ enhanced correlation ("ridge") at $\Delta\phi$=0 and large $\Delta\eta$

PHENIX, arXiv:0705.3060v2



STAR, arXiv:nucl-ex/0701074v2



Theoretical Interpretations of Ridge

Very different proposed mechanisms qualitatively describe "ridge" at $|\Delta\eta|<2$

- Coupling of induced radiation to longitudinal flow
  Armesto et al., PRL 93, 242301
- Recombination of shower + thermal partons
  Hwa, arXiv:nucl-th/0609017v1
- Anisotropic plasma
  Romatschke, PRC 75, 014901
- Turbulent color fields
  Majumder, Muller, Bass, arXiv:hep-ph/0611135v2
- Bremsstrahlung + transverse flow + jet-quenching
  Shuryak, arXiv:0706.3531v1
- Splashback from away-side shock
  Pantuev, arXiv:0710.1882v1
- Momentum kick imparted on medium partons
  Wong, arXiv:0707.2385v2

Goal

- Use the uniquely broad acceptance of the PHOBOS multiplicity detectors to measure the ridge at large $\Delta\eta$
- Constrain the possible explanations for correlated particle production far in rapidity from a high-p_T trigger

Experimental Setup

High p_T trigger tracks

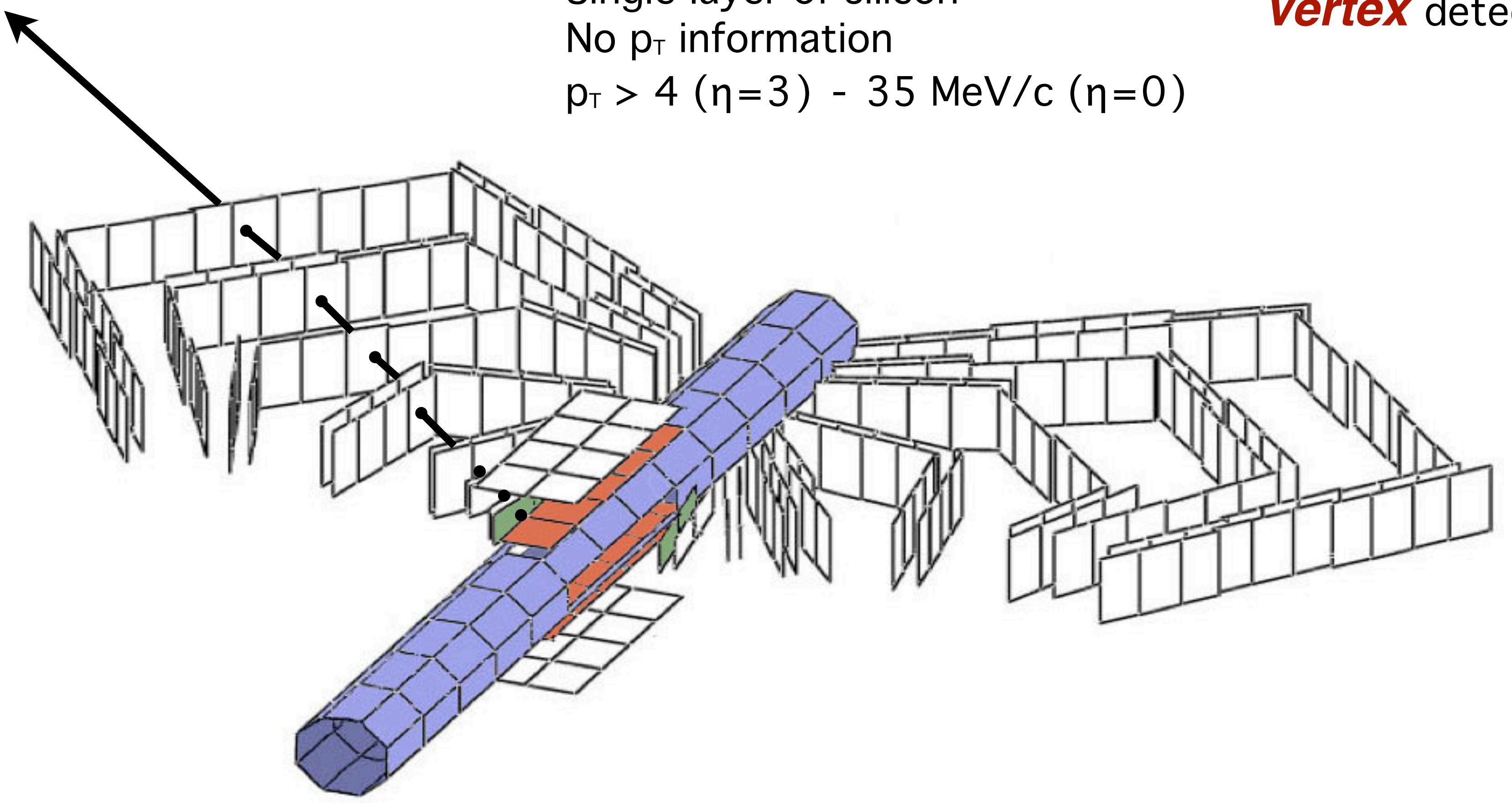
$p_T > 2.5$ GeV/c
$0 < \eta_{trig} < 1.5$

Associated hits

Full ϕ coverage
Broad η coverage $(-3<\eta<3)$

Single layer of silicon
No p_T information
$p_T > 4$ $(\eta=3)$ - 35 MeV/c $(\eta=0)$

Octagon holes are filled using hits from the first layers of the ***Spectrometer*** and ***Vertex*** detectors



Constructing the Correlation

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

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

$V = \langle v_2^{trig} \rangle \langle v_2^{assoc} \rangle$

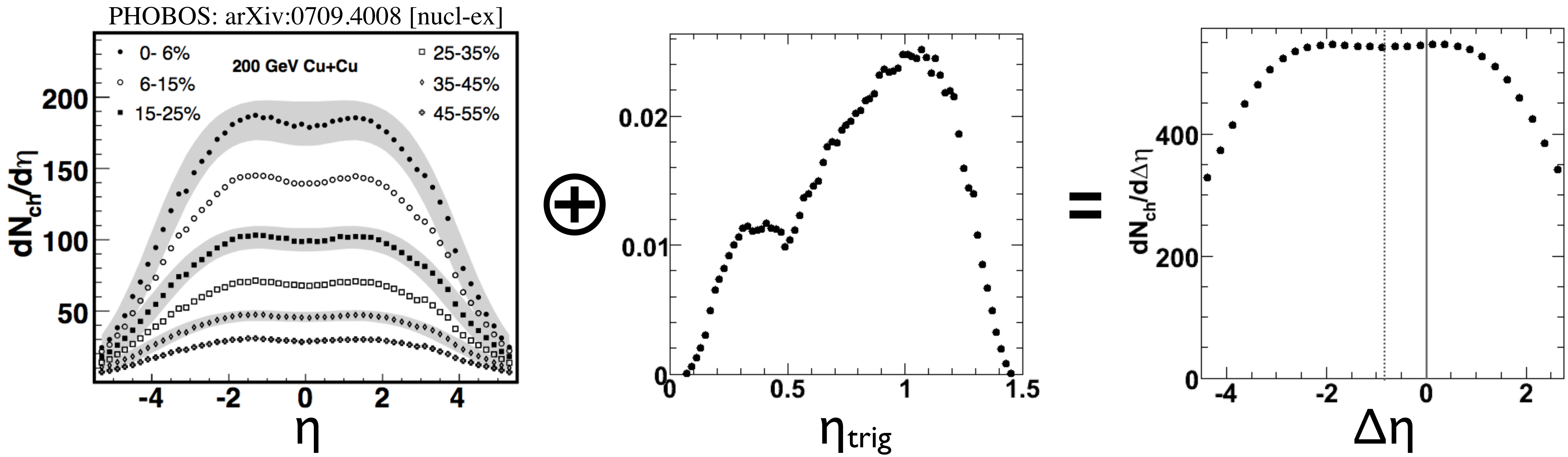
Acceptance corrected mixed-event pairs (per trigger)

Signal/Background
Detector acceptance cancels in the ratio

Modulation from elliptic flow

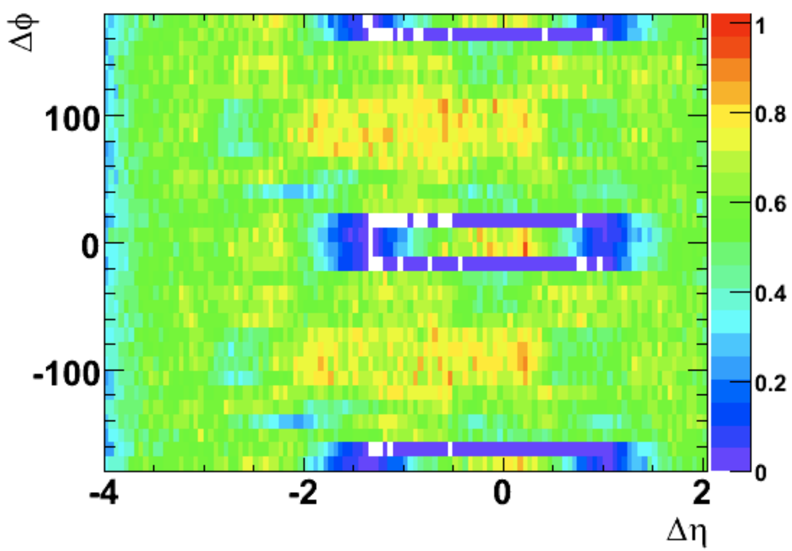
1. Normalized Background

- $B(\Delta\eta)$ is the per trigger mixed-event pair distribution corrected for the pair acceptance
- In other words, it is the corrected single-particle distribution ($dN/d\eta$) convoluted with η_{trig}



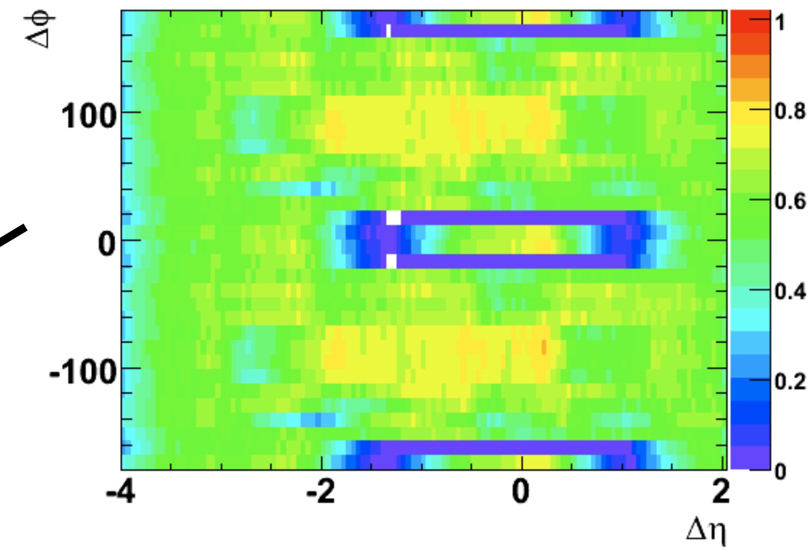
2. Signal and Mixed Events

$s(\Delta\phi,\Delta\eta)$

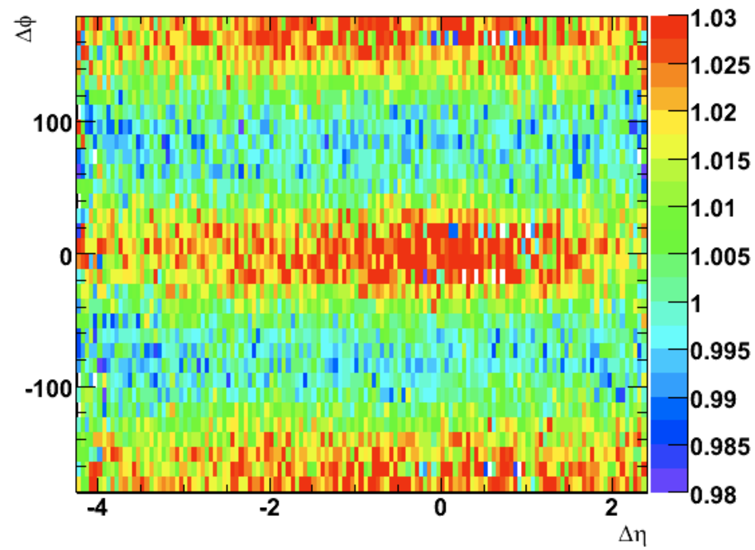


15-20% central
3mm < v_z < 4mm

$b(\Delta\phi,\Delta\eta)$



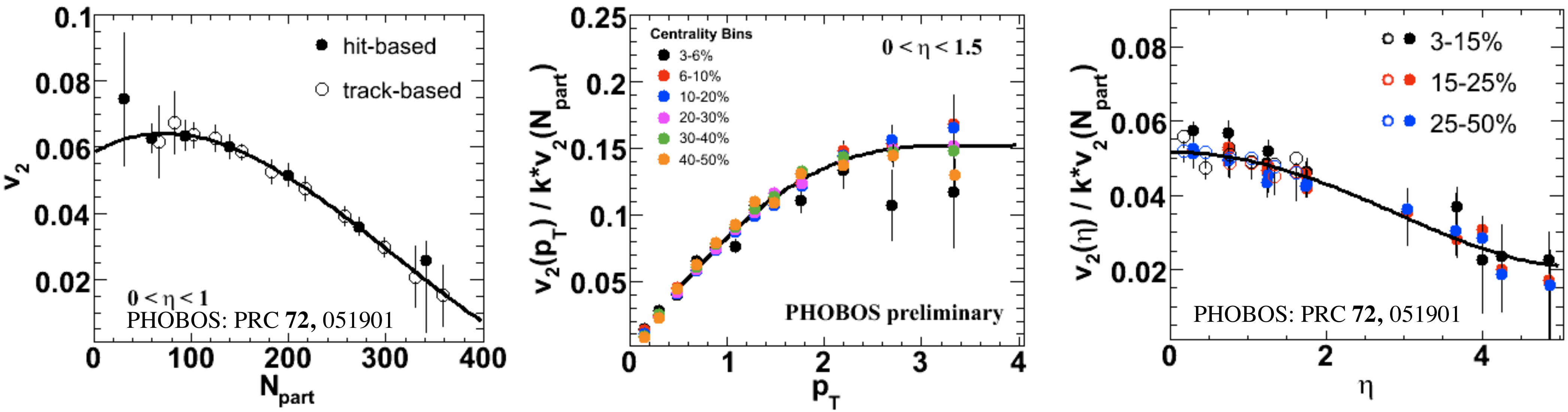
$$\frac{s(\Delta\phi,\Delta\eta)}{b(\Delta\phi,\Delta\eta)}$$



averaged over
-15cm < v_z < 10cm

3. Estimating Flow Term

- Parameterize published PHOBOS measurements as $v_2(N_{part}, p_T, \eta) = A(N_{part})\ B(p_T)\ C(\eta)$



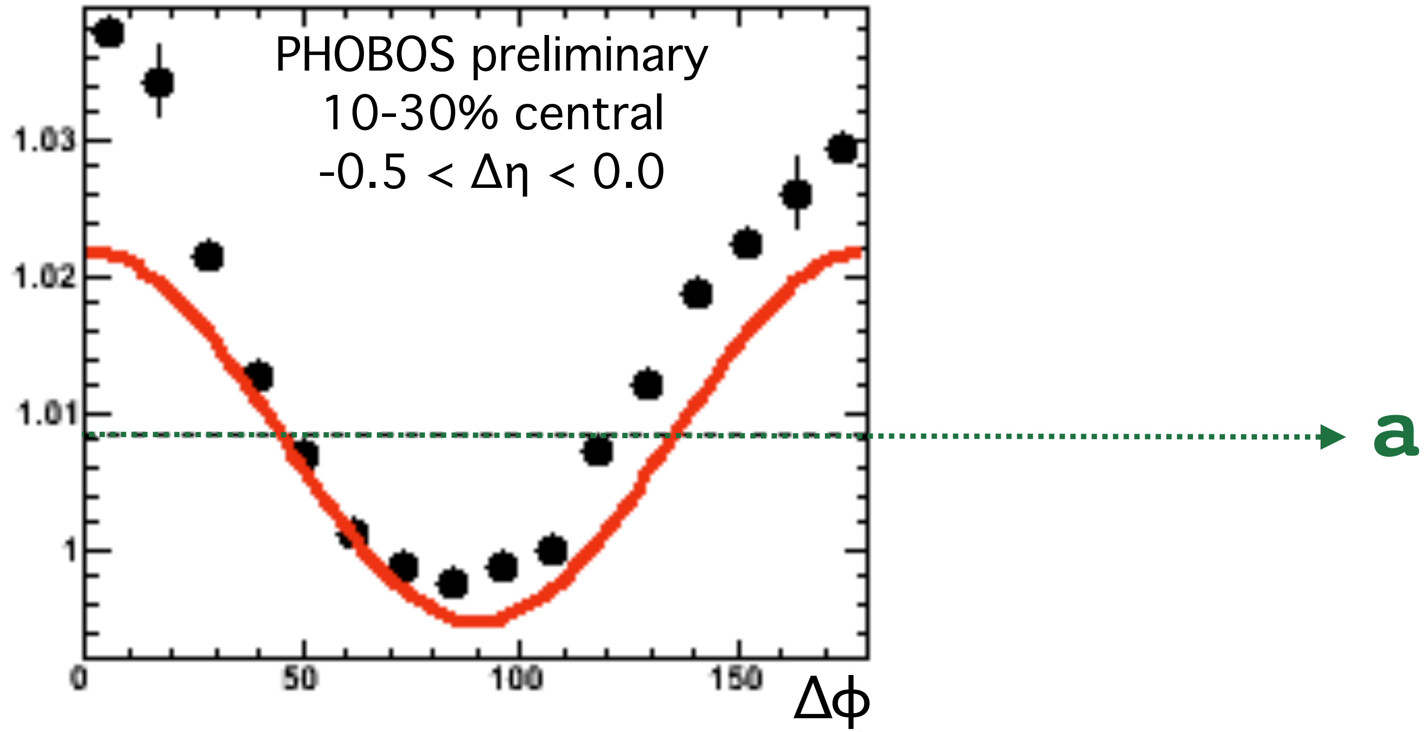
- Correct $v_2(N_{part}, \langle p_T^{trig} \rangle, \eta_{trig})$ for occupancy and $v_2(N_{part}, \langle p_T^{assoc} \rangle, \eta_{assoc})$ for secondaries

$$1 - 2V(\Delta\eta)\cos(2\Delta\phi)$$

$$V = \langle v_2^{trig} \rangle \langle v_2^{assoc} \rangle$$

Flow subtraction

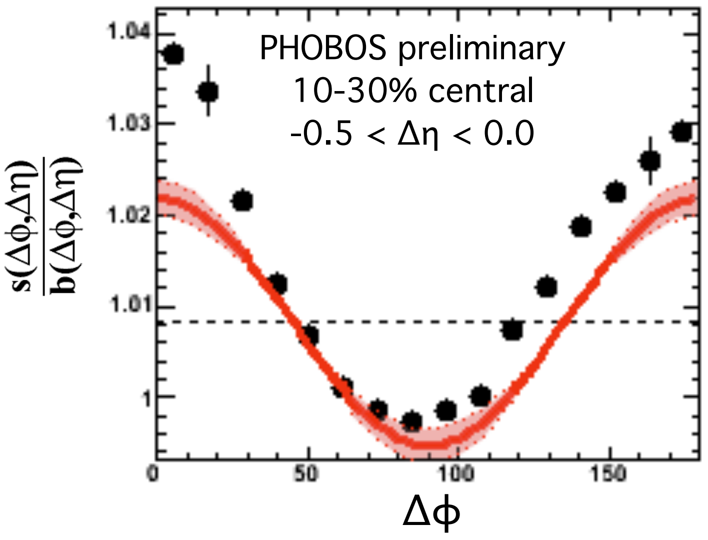
$$\frac{s(\Delta\phi,\Delta\eta)}{b(\Delta\phi,\Delta\eta)} - a\,[\,1 - 2V(\Delta\eta)\cos(2\Delta\phi)\,]$$

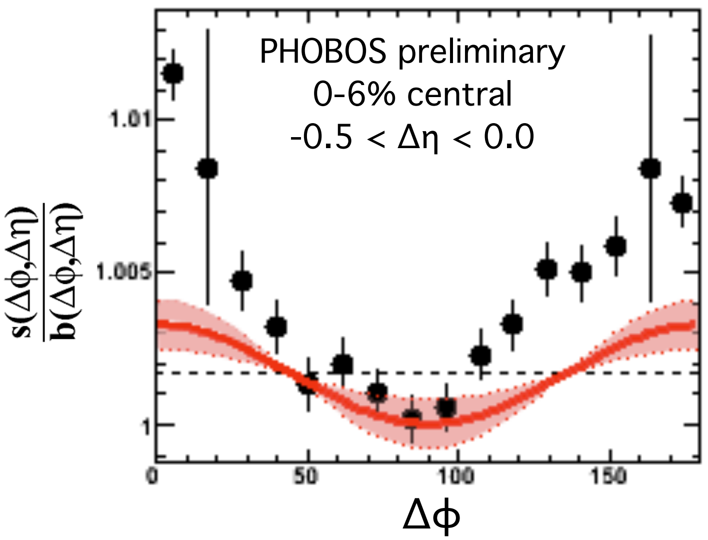


The scale factor, **a** , is calculated such that the yield after subtraction is zero at its minimum (ZYAM) Ajitanand et al. PRC **72**, 011902(R) (2005)

Systematics

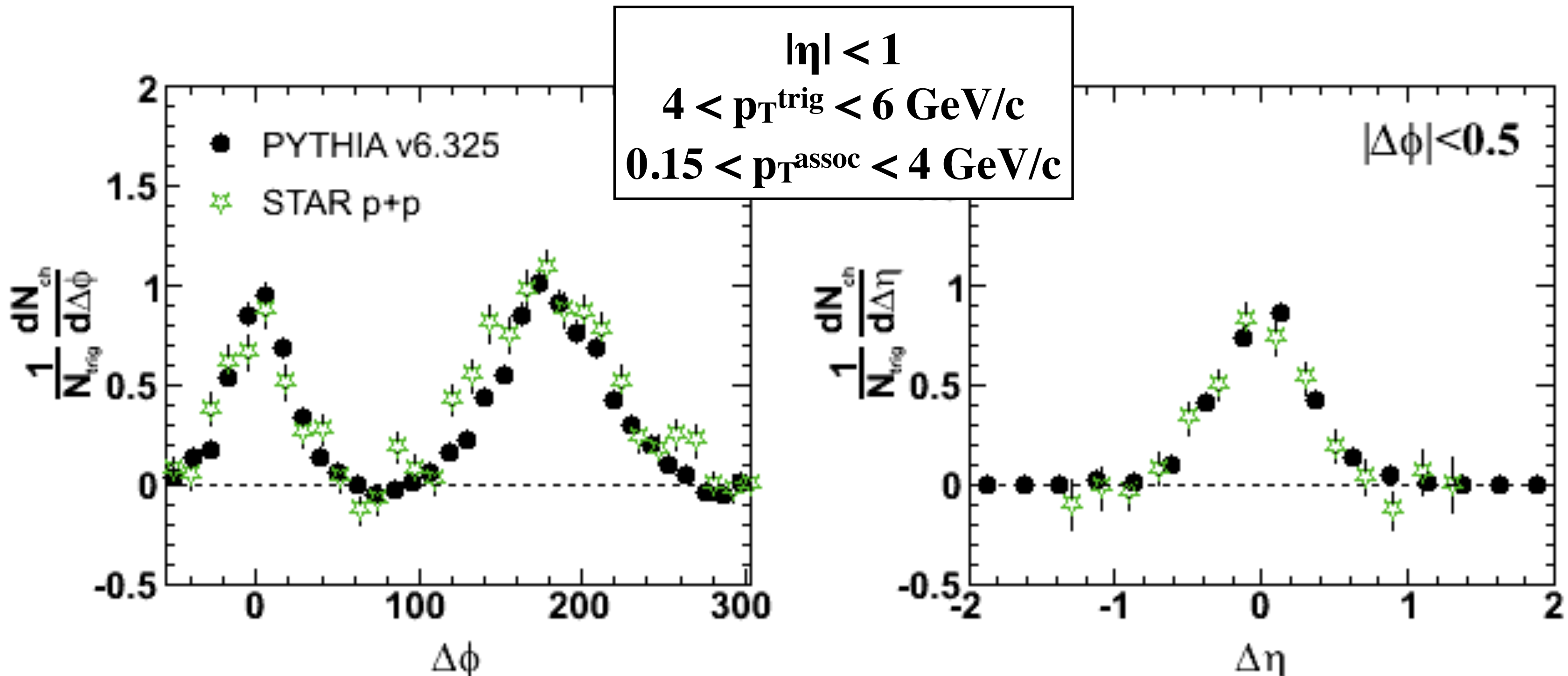
- The dominant systematic error in this analysis is the uncertainty on the magnitude of $v_2^{trig}\, v_2^{assoc}$
    - ~14% error on $v_2^{trig}\, v_2^{assoc}$ (η=0)
    - ~20% error on $v_2^{trig}\, v_2^{assoc}$ (η=3)
    - In the most central collision -- where flow is small compared to the correlation -- the error on $v_2^{trig}\, v_2^{assoc}$ can exceed 50%.





PYTHIA p+p reference

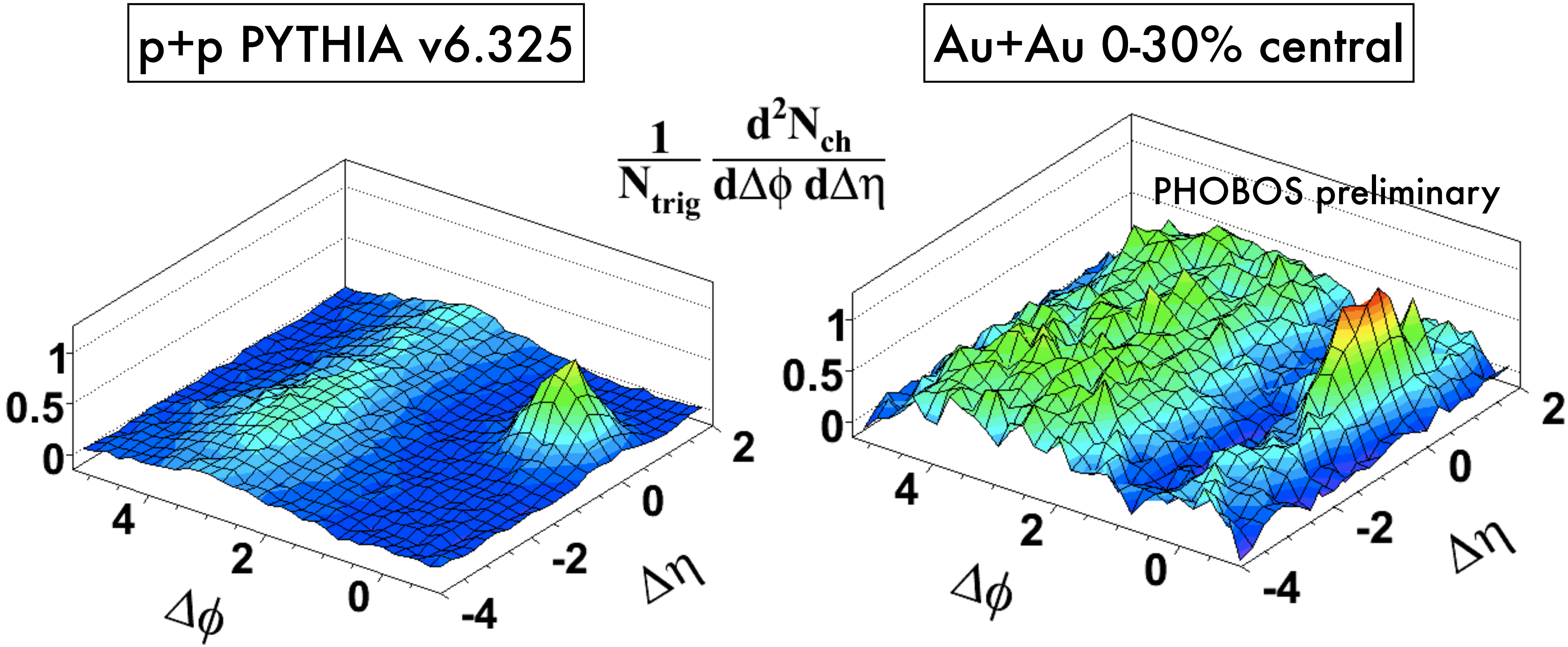
- PHOBOS is limited by statistics in p+p
- We will compare our Au+Au results to PYTHIA, which reasonably reproduces STAR p+p data



STAR, PRL **95,** 152301 (2005)

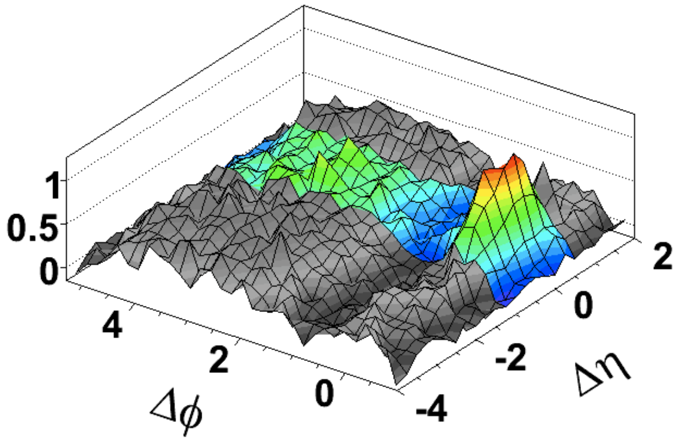
Results

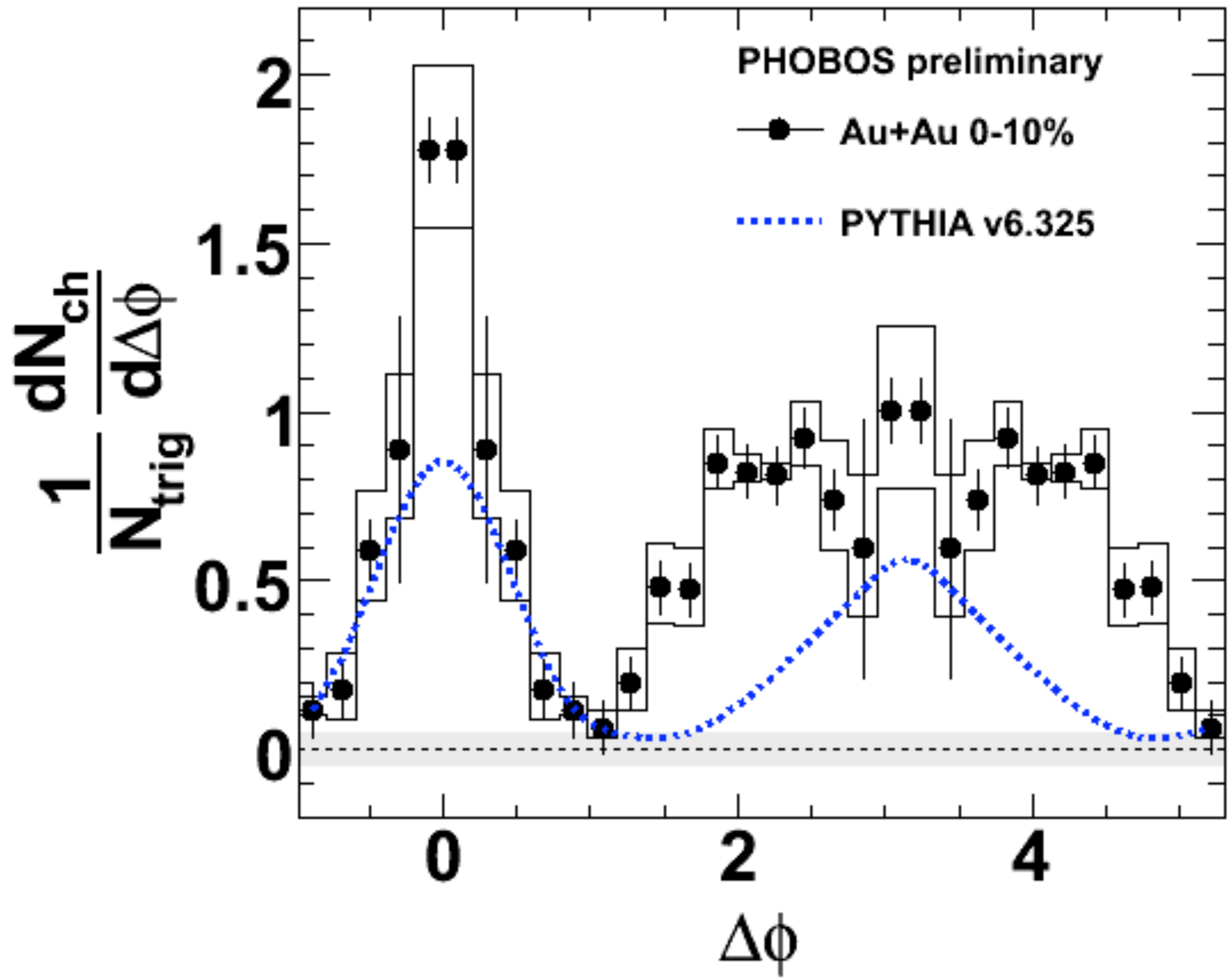
$p_T^{trig} > 2.5$ GeV/c
$p_T^{assoc} \gtrsim 20$ MeV/c



A Closer Look

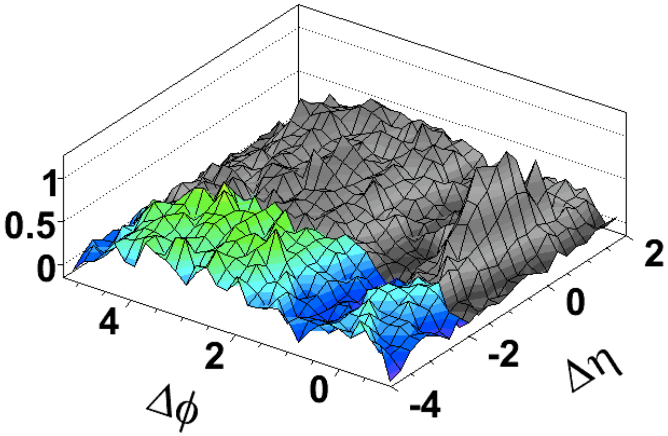
Correlated yield at short-range (|Δη| < 1):

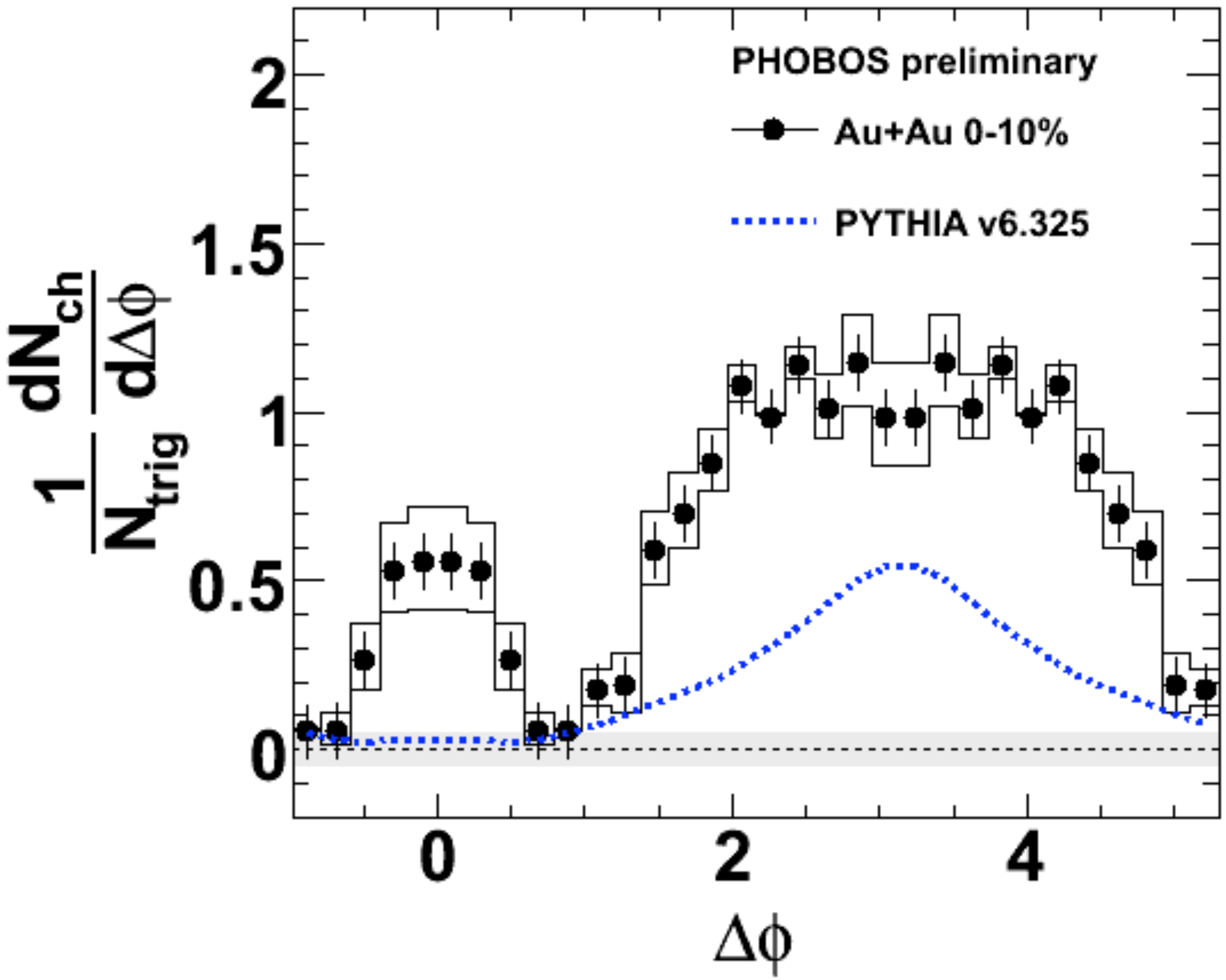




The Ridge Continues...

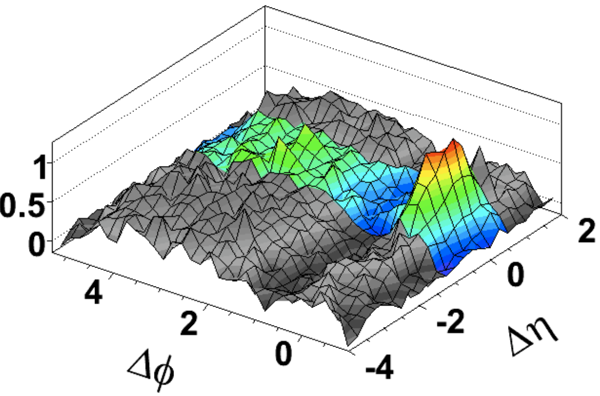
Correlated yield at long-range ($-4 < \Delta\eta < -2$):

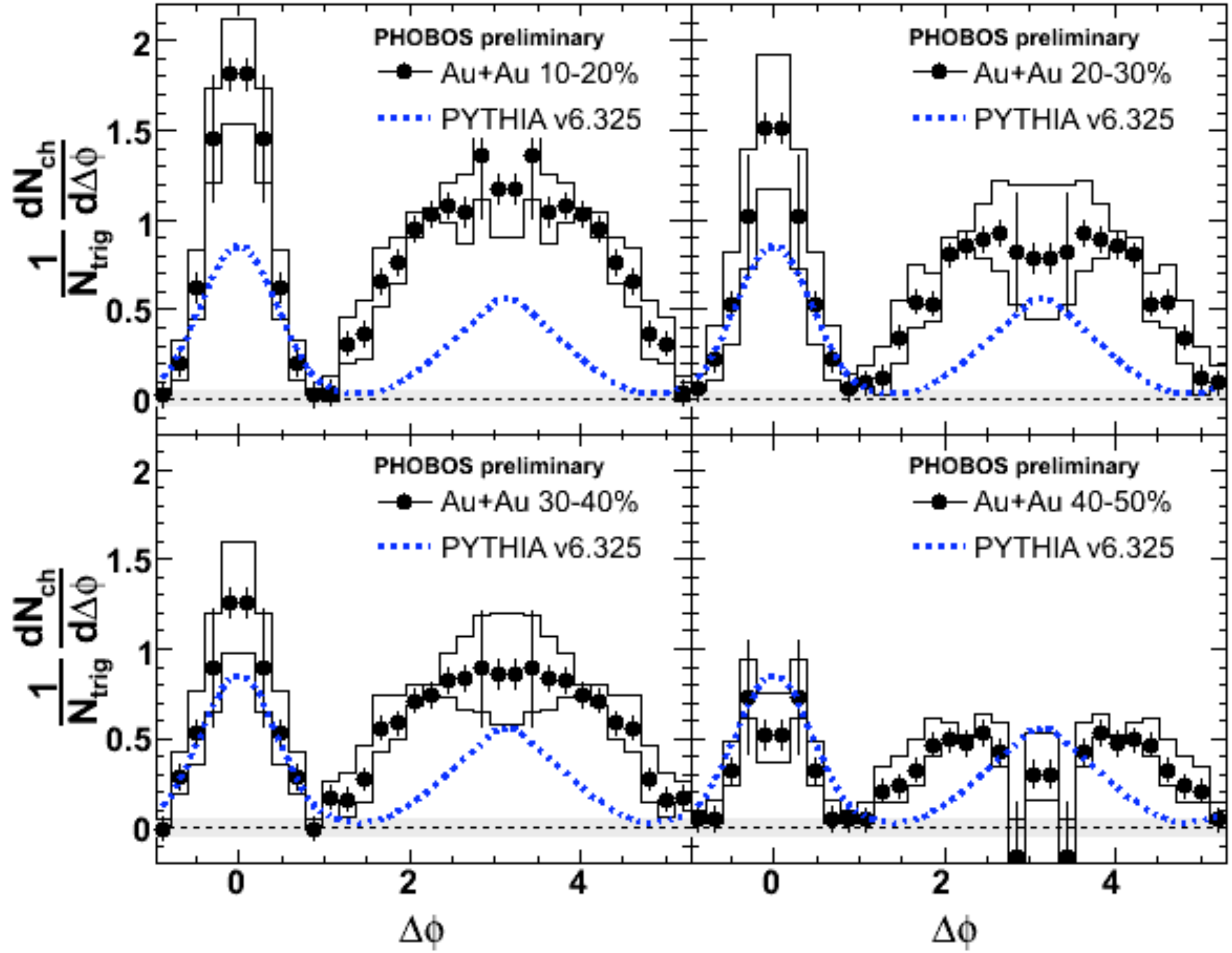




Short-Range Centrality Dependence

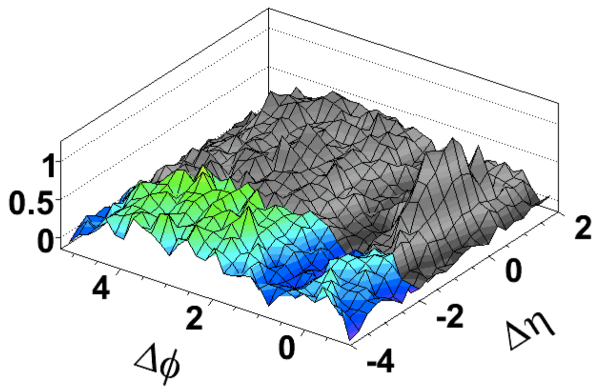
|Δη| < 1

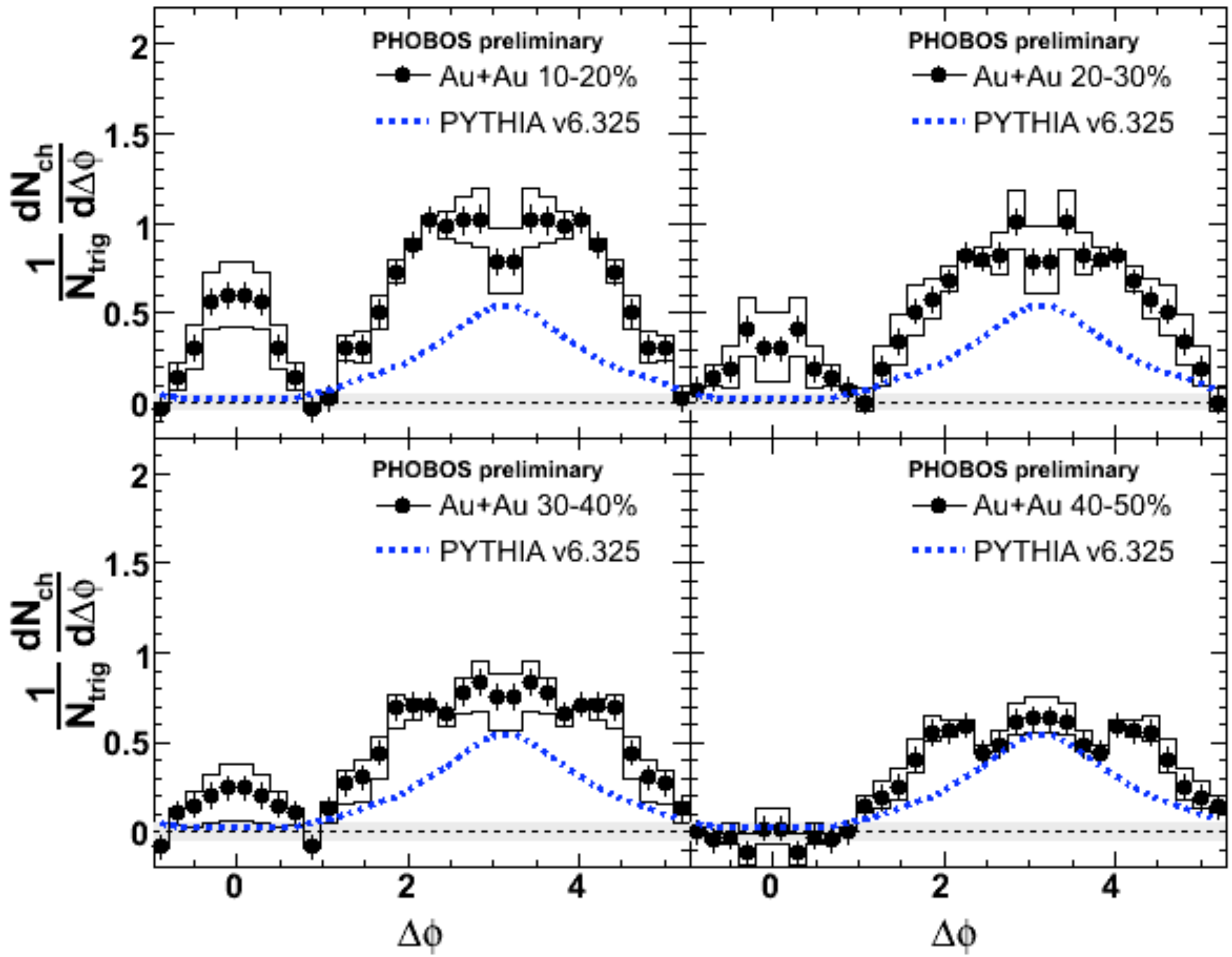




Long-Range Centrality Dependence

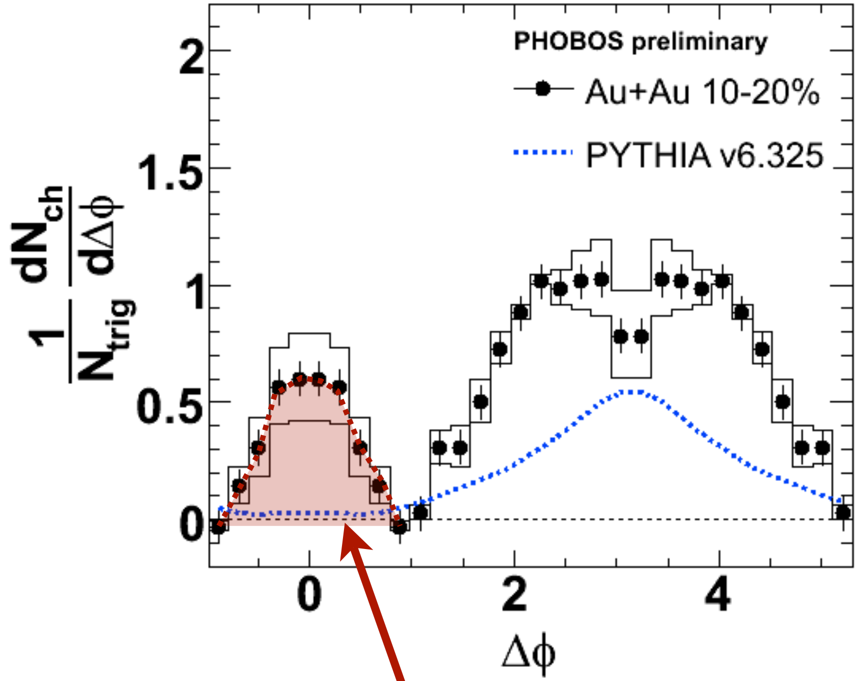
-4 < Δη < -2





Integrated Ridge Yield

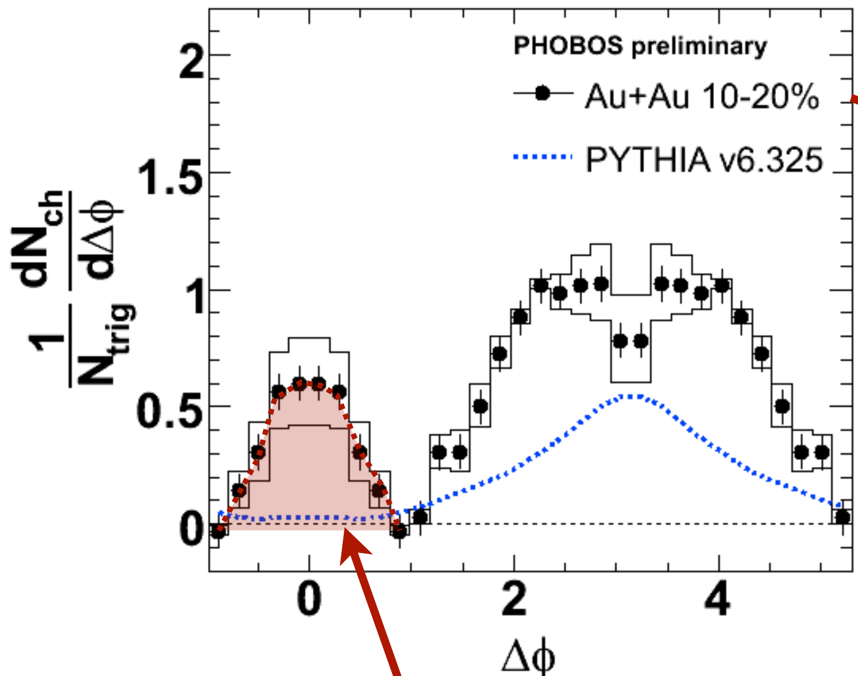
-4 < Δη < -2



Integrate ridge over |Δϕ| < 1

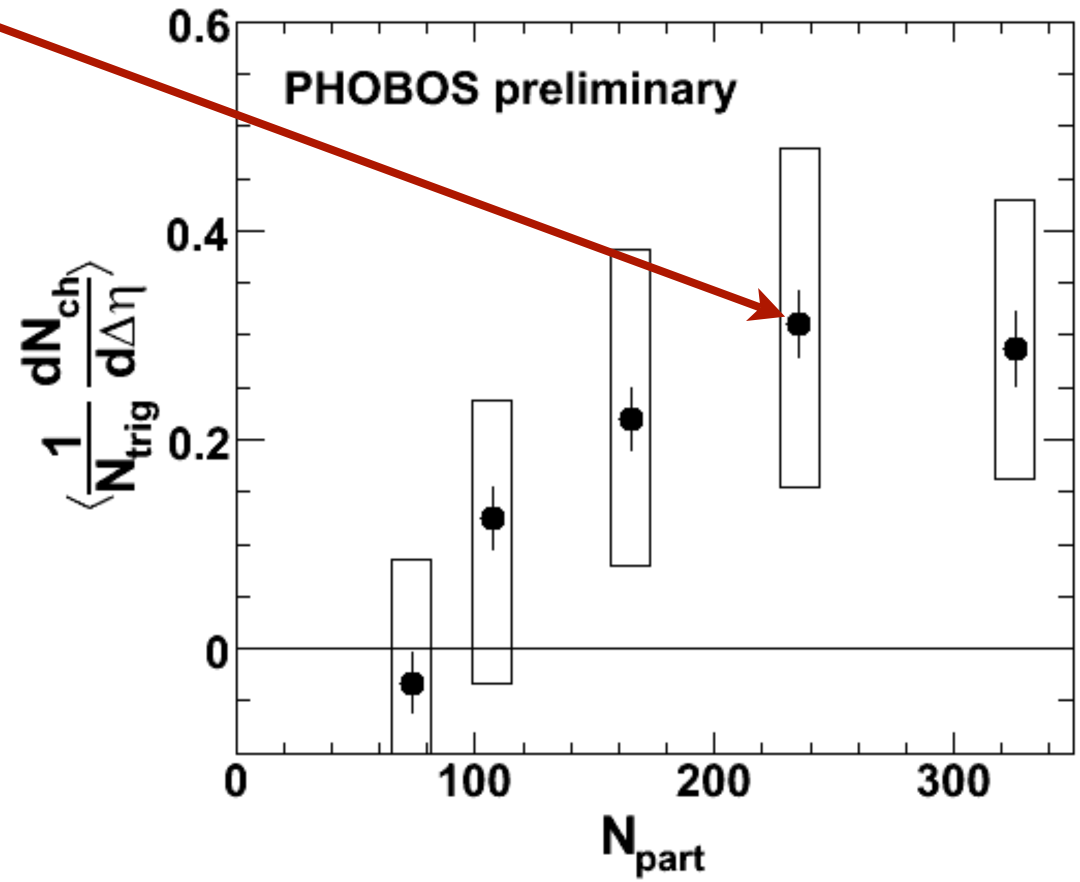
Integrated Ridge Yield

-4 < Δη < -2



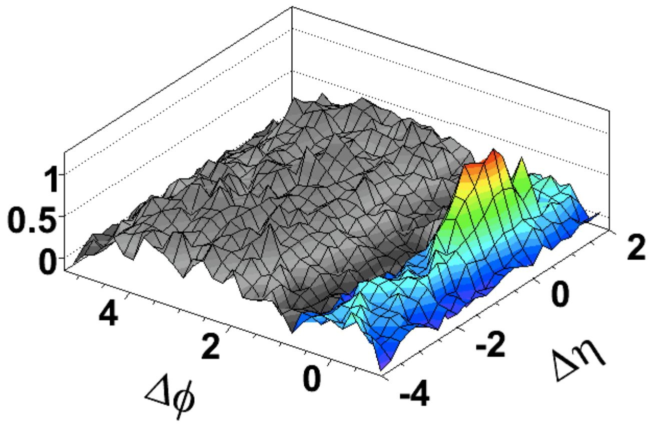
Integrate ridge over |Δφ| < 1

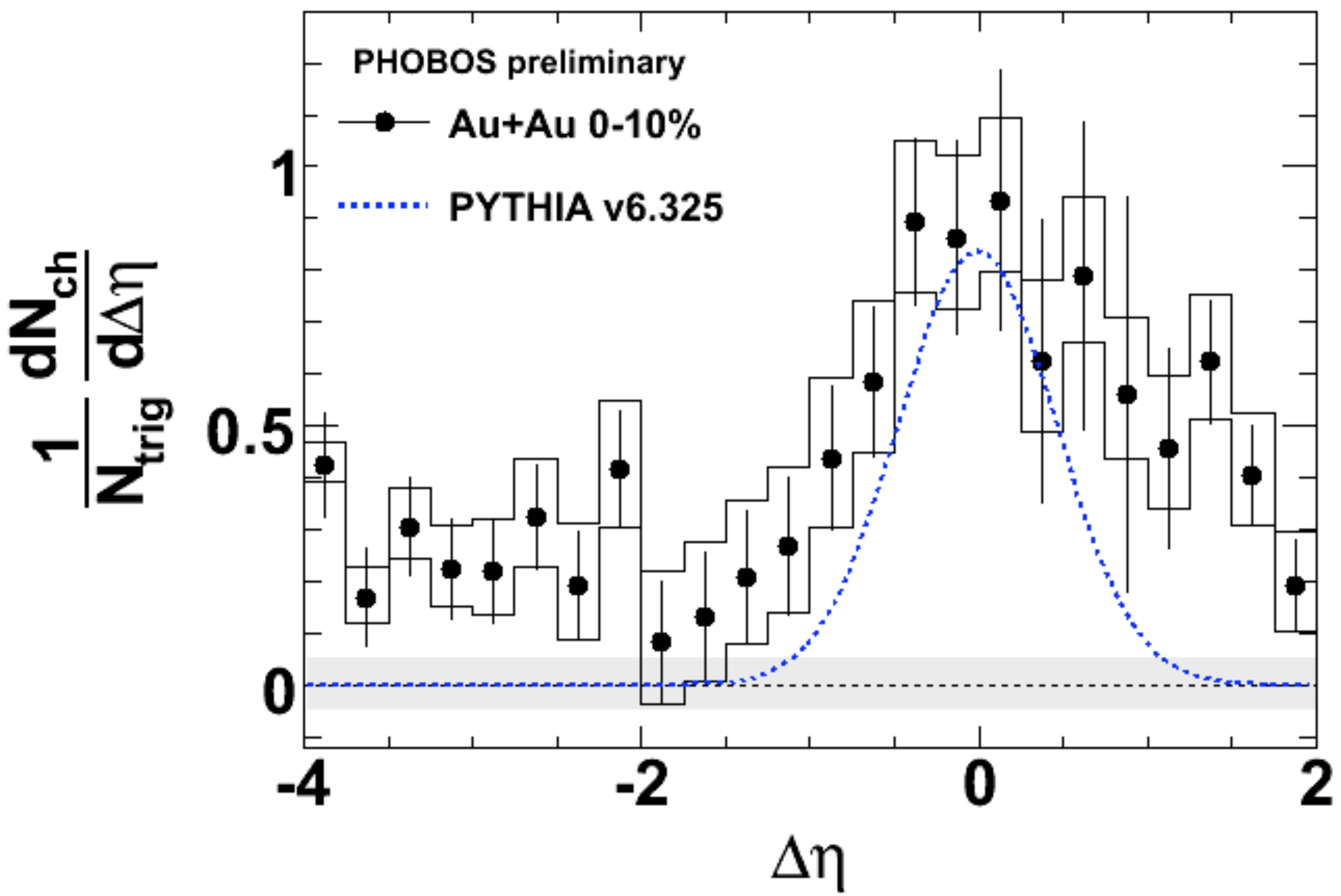
|Δφ| < 1



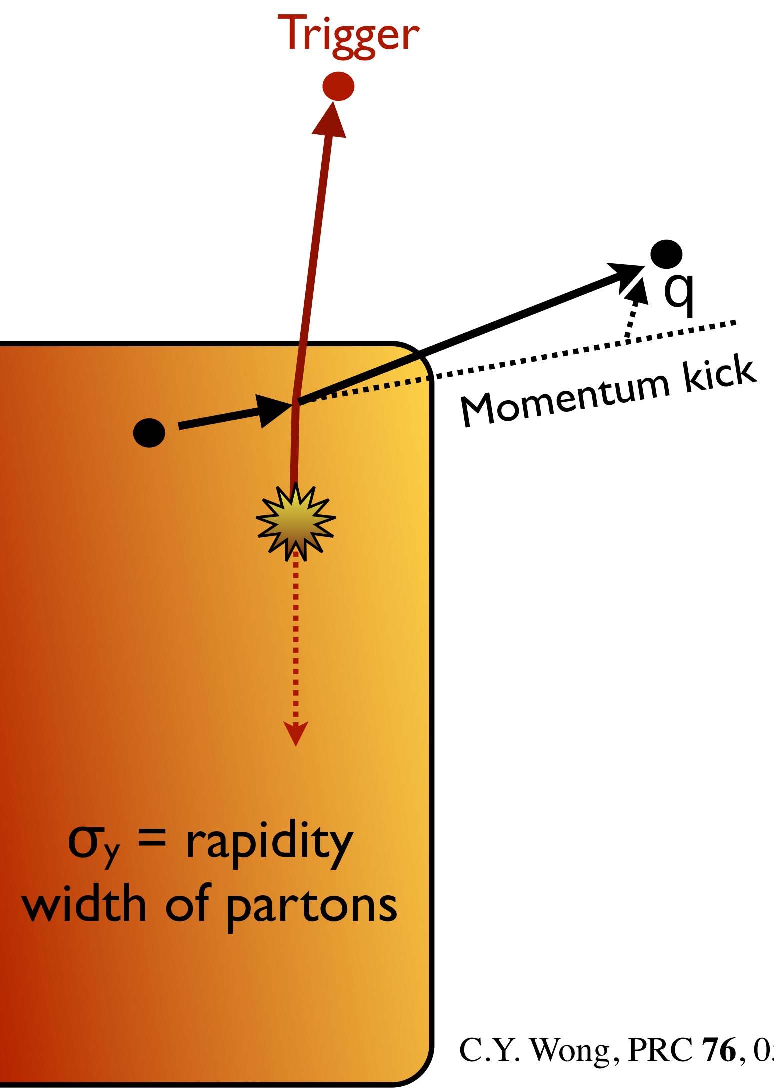
Ridge Extent in Δη

Correlated yield on near-side (|Δϕ| < 1):



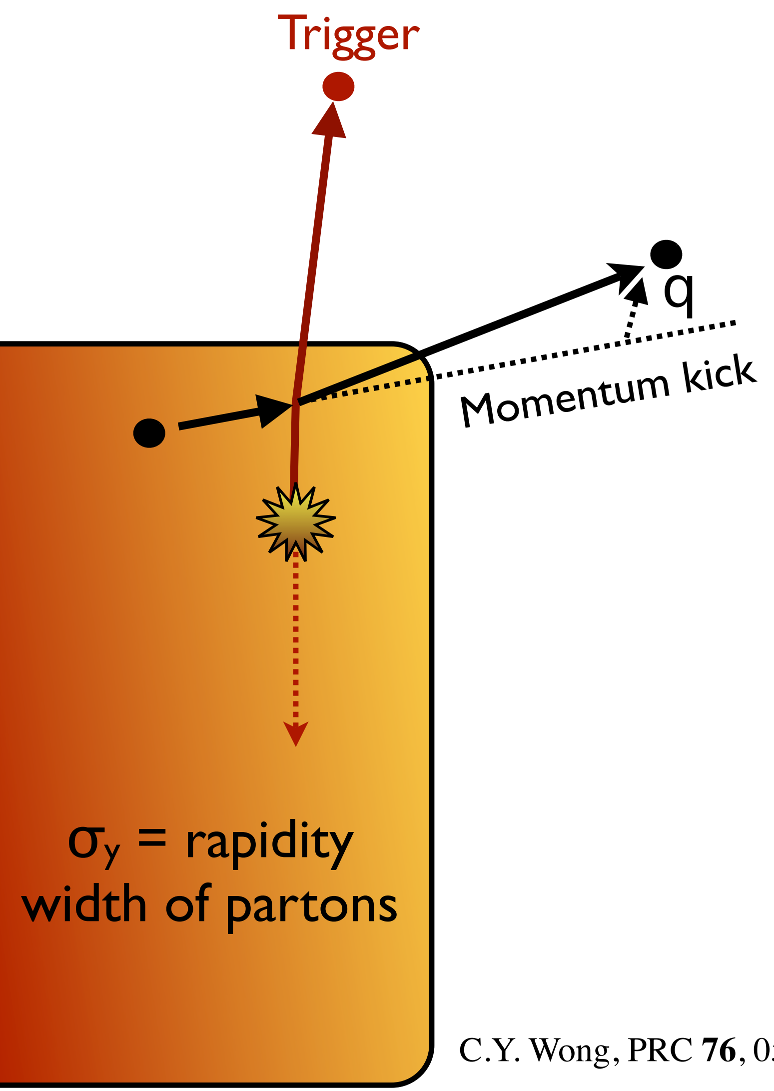


Comparison to Predictions



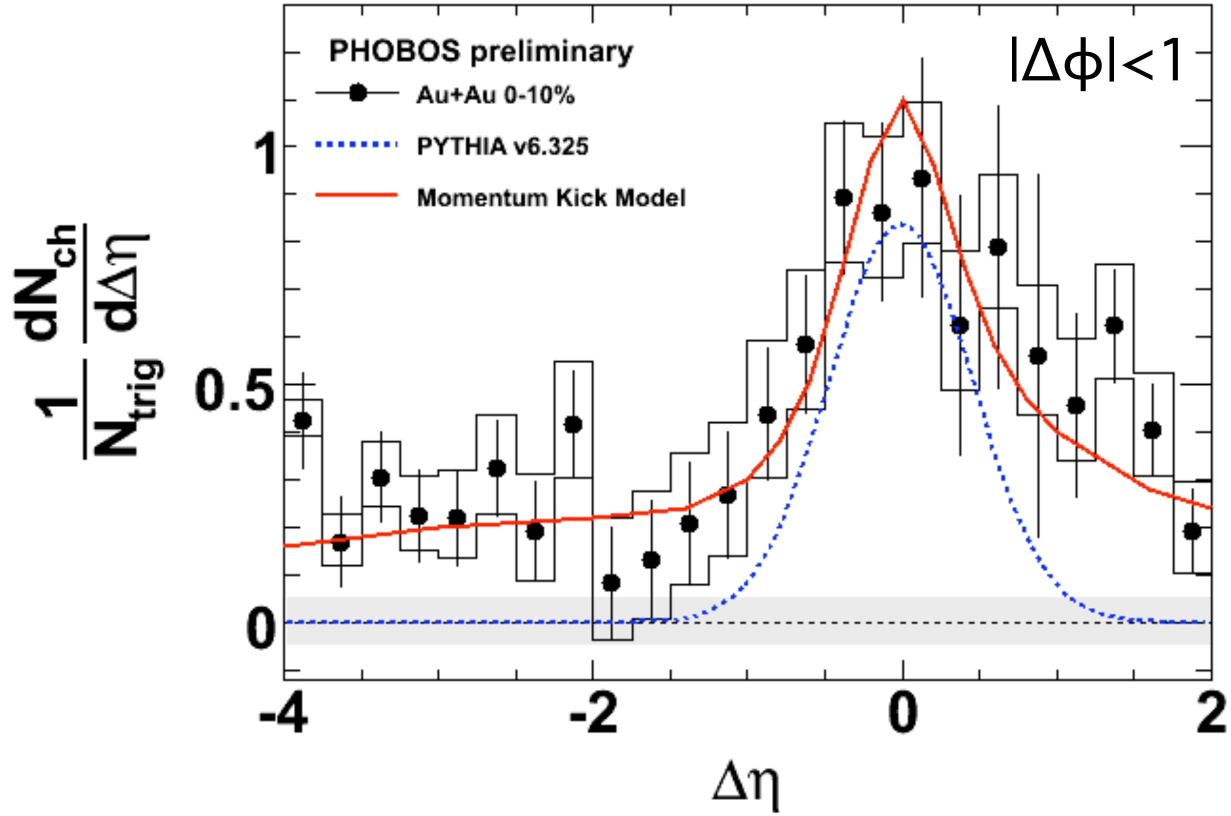
C.Y. Wong, PRC **76**, 054908 (2007)

Comparison to Predictions



C.Y. Wong, PRC **76**, 054908 (2007)

C.Y. Wong, private communication



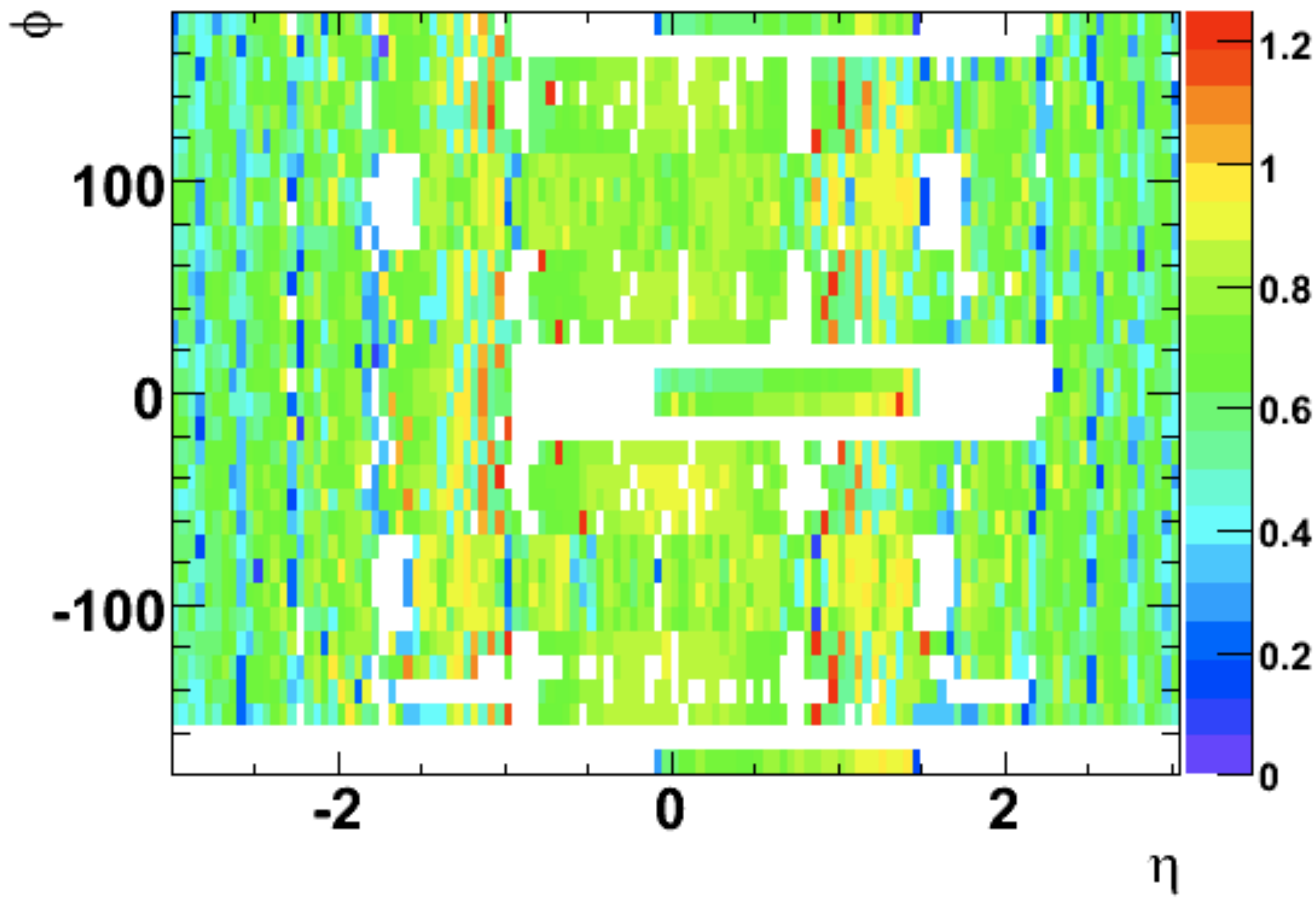
Conclusions

- Broadening of the away-side correlation in $\Delta\phi$ relative to p+p persists over the complete $\Delta\eta$ range
- Correlation at $\Delta\phi=0$ and large $\Delta\eta$ (ridge) persists to $\Delta\eta = 4$
- Ridge yield at large $\Delta\eta$ disappears as one goes from central to peripheral Au+Au collisions

Backup slides

PHOBOS Detector Acceptance

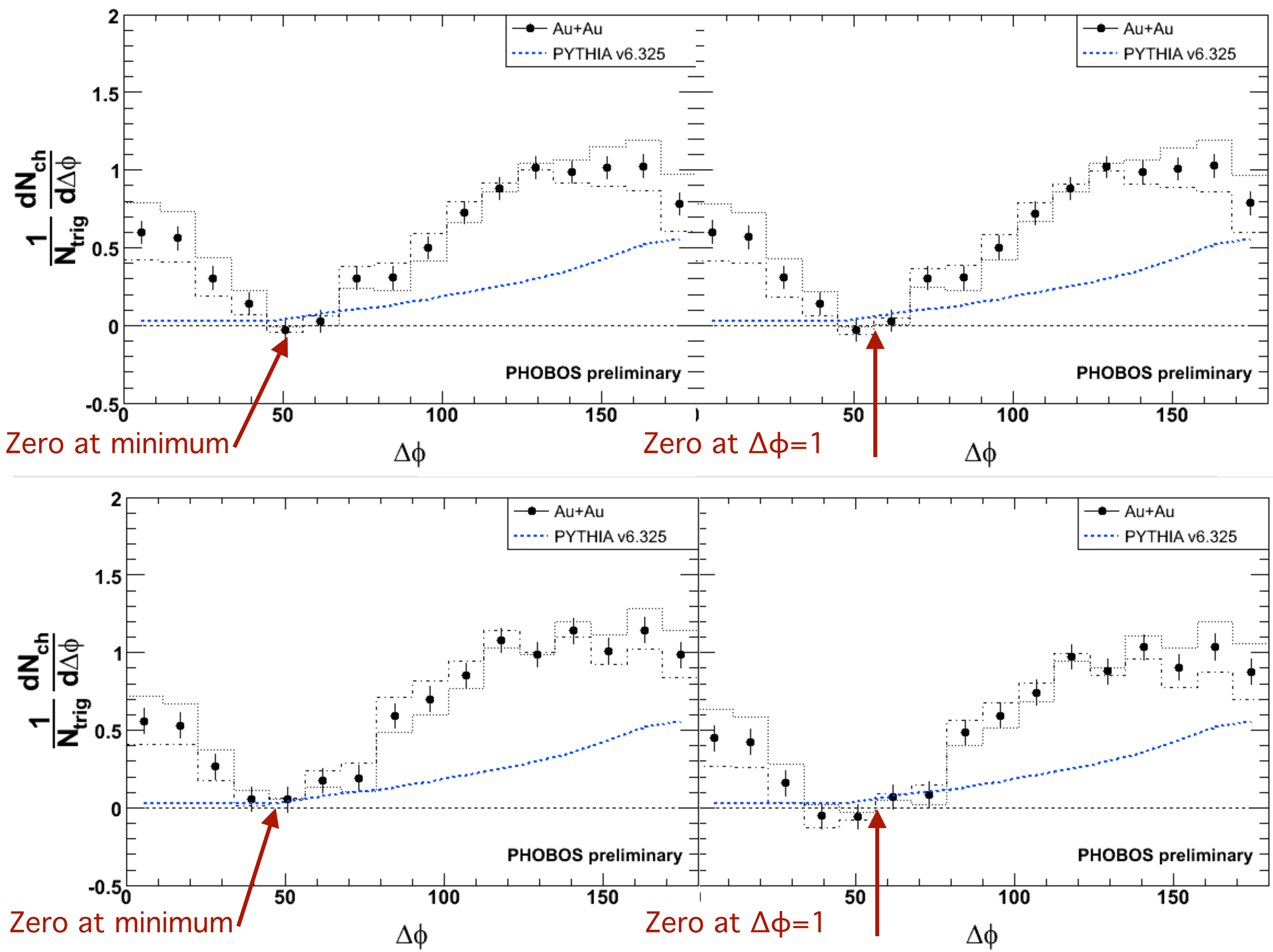
15-20% central
3mm < v_z < 4mm



$-4 < \Delta\eta < -2$ ZYAM vs. ZYA1

10-20%

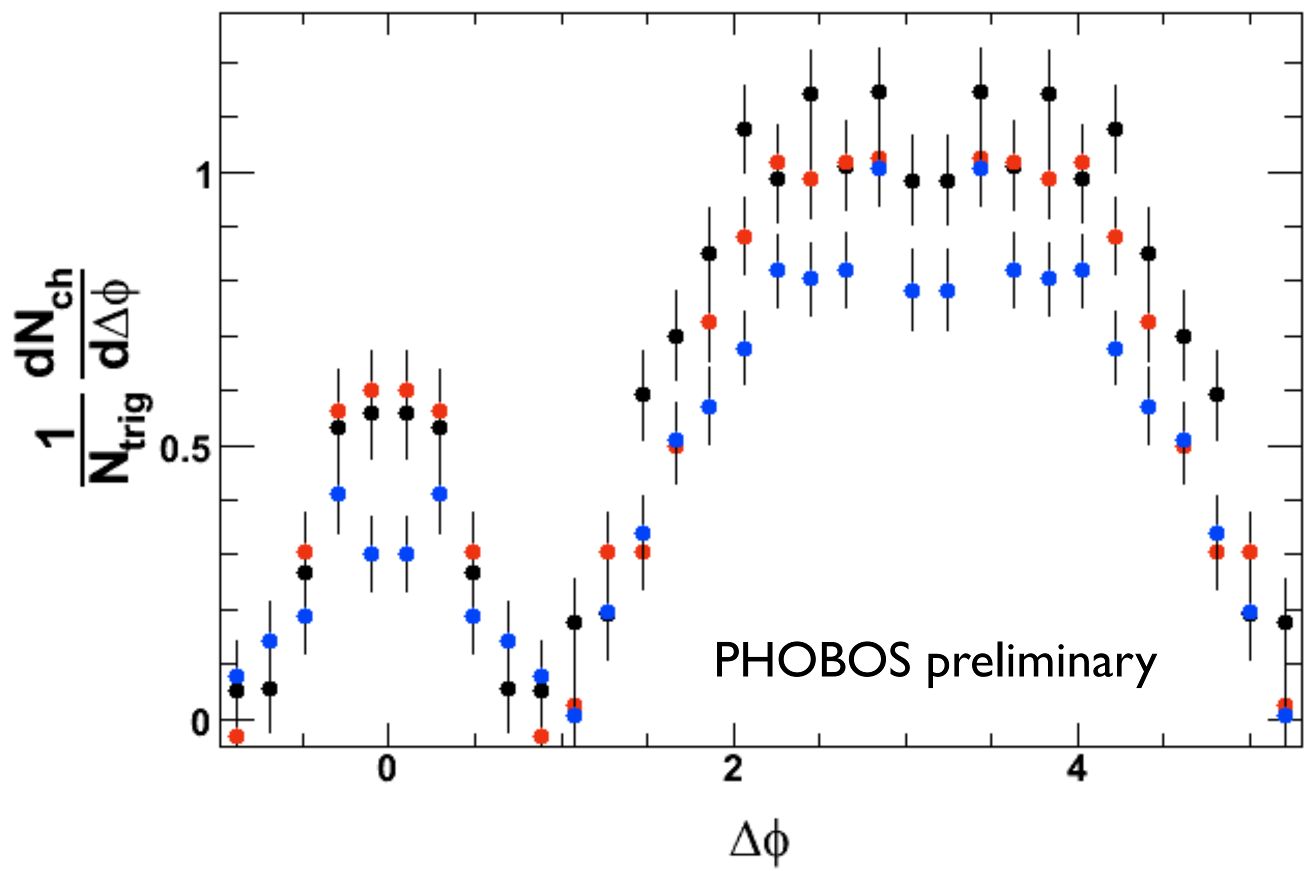
0-10%



Long-Range Correlation

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

0-10%
10-20%
20-30%



η_{trig} versus z-vertex