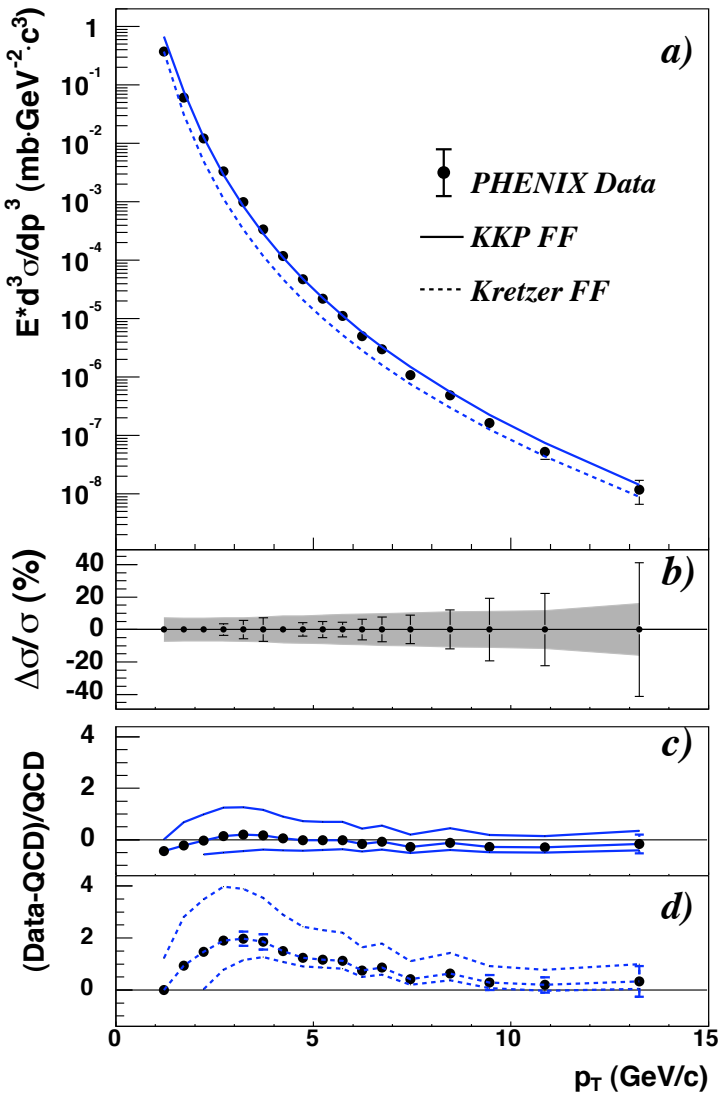
Identified Particle Correlations at RHIC: Medium Interactions & Modified Fragmentation

Anne Sickles

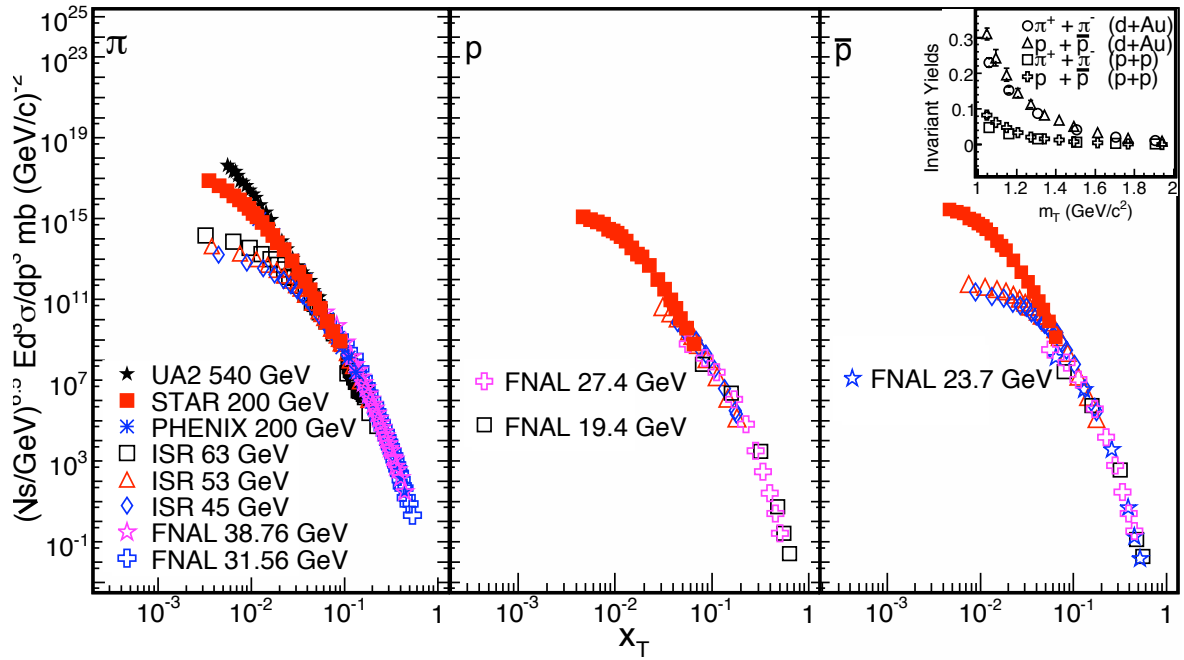
August 8, 2007

p+p: Limits of Hard Scattering Picture



PHENIX PRL 91 241803 (2003)

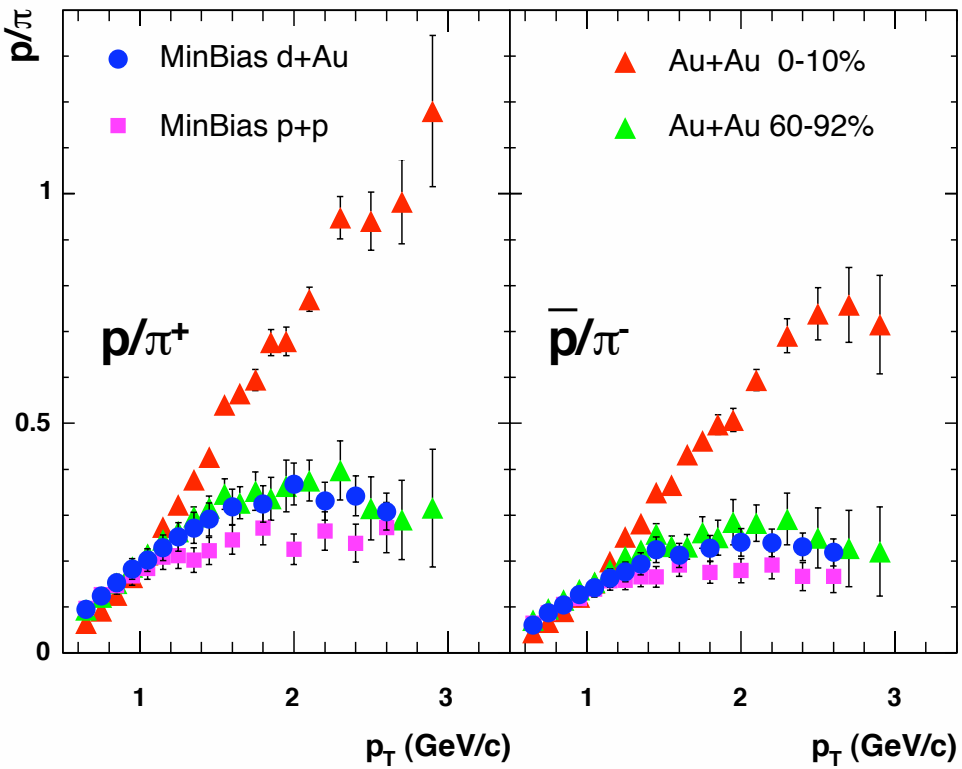
$x_T = 2p_T/s^{1/2}$



STAR PLB 637 161 (2006)

NLO pQCD and x_T scaling describe the p+p data down to $p_T \sim 2$GeV/c

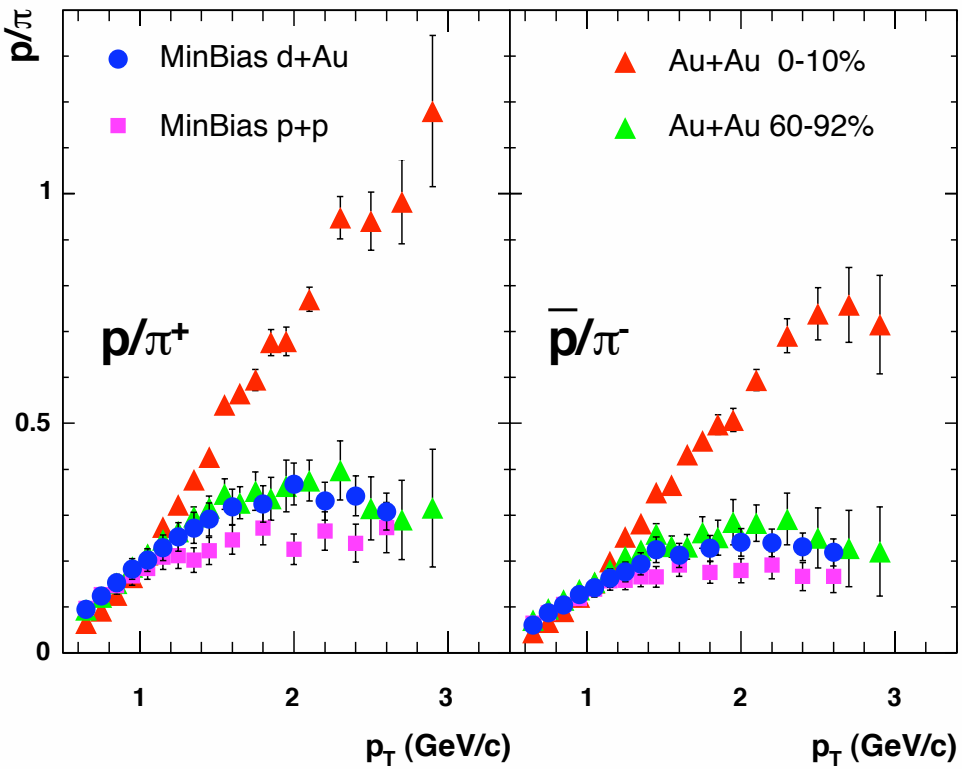
Heavy Ions: Soft Physics @ Higher p_T?

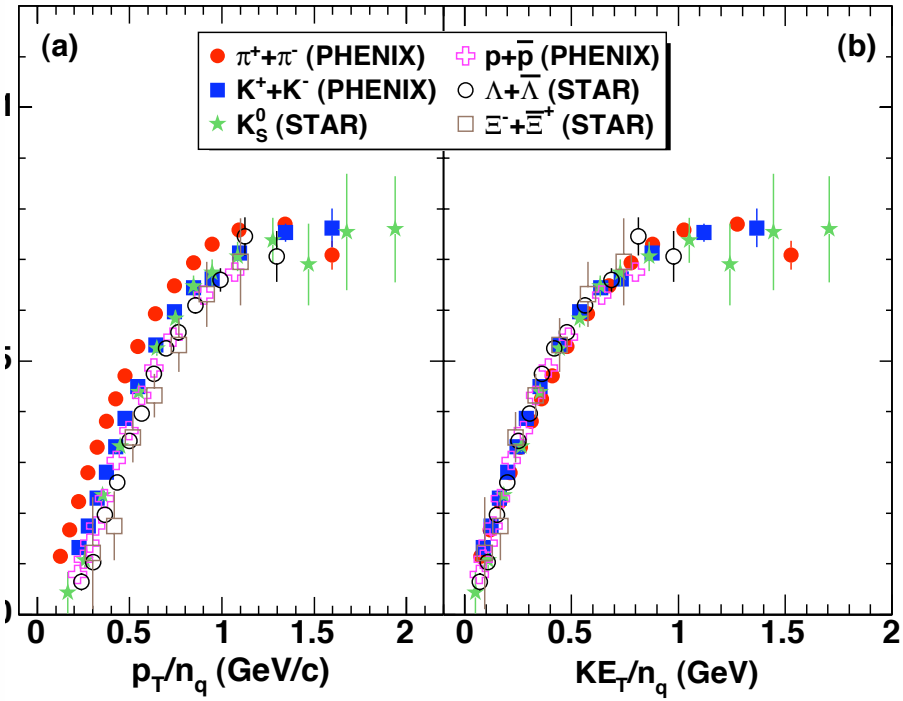


fragmentation particle ratios extends to p_T ~ 5 GeV

PHENIX PRC 74 024904 (2006)

Heavy Ions: Soft Physics @ Higher p_T?





fragmentation particle ratios extends to p_T ~ 5 GeV

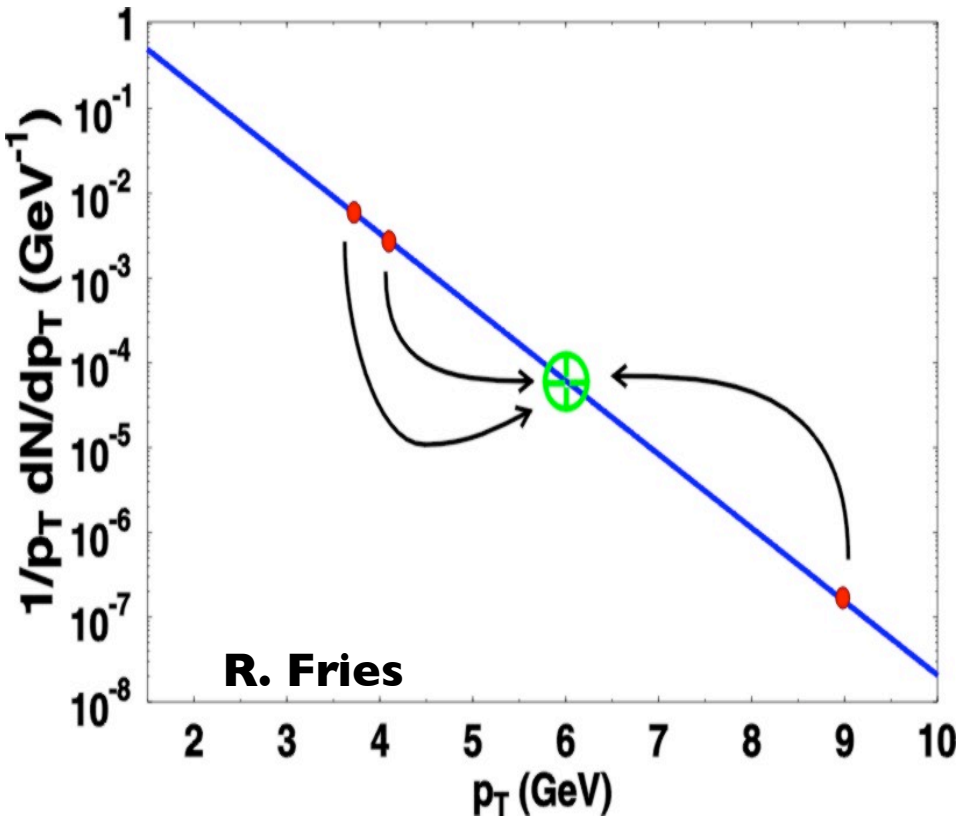
Quark Number Scaling of v2 extends to p_T ~ 4-6 GeV

PHENIX PRC 74 024904 (2006)

PHENIX PRL 98 162301 (2007)

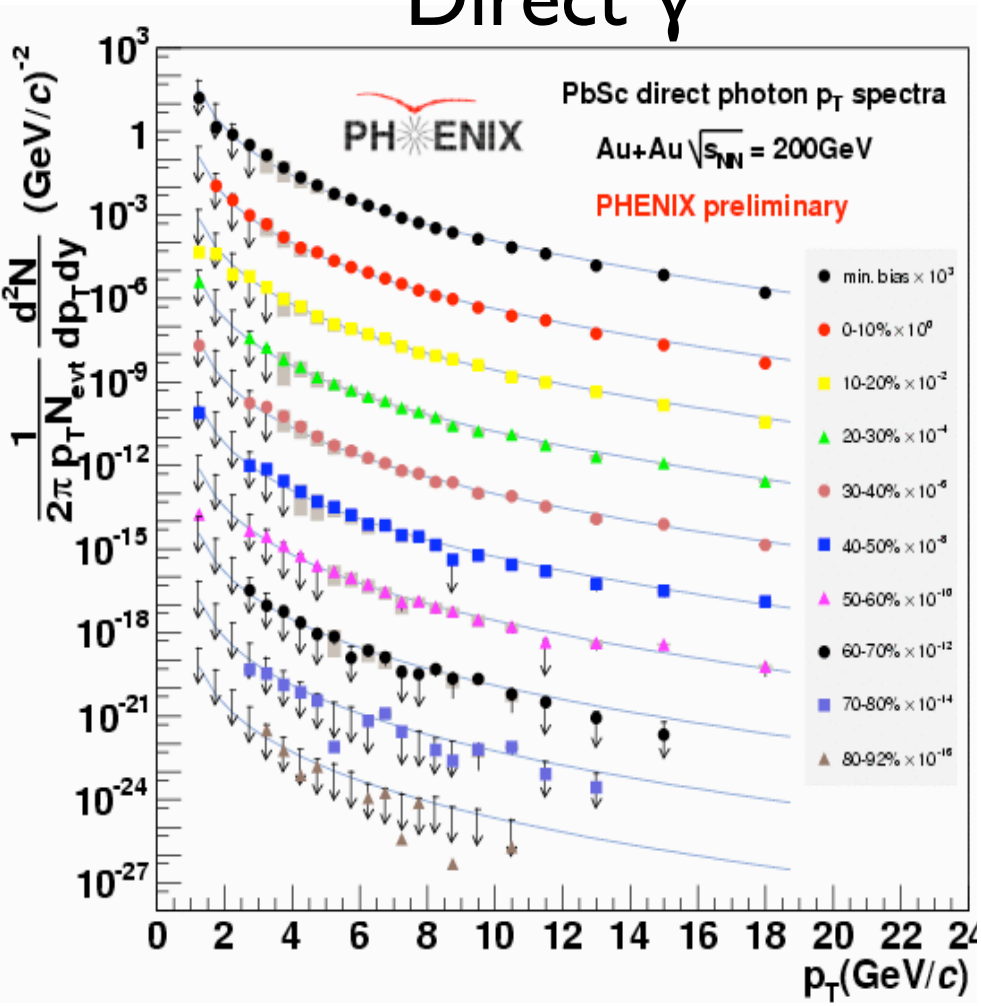
Natural Explanation: Recombination Models

- quarks close together in phase space come together to form final state hadrons
- resulting hadron at higher p_T than parent partons, in contrast to fragmentation
- dominates for exponential parton p_T spectra
- implies partonic degrees of freedom and a QGP (Fries et al, PRL 90 202303 (2003))



hard scattering still happens...

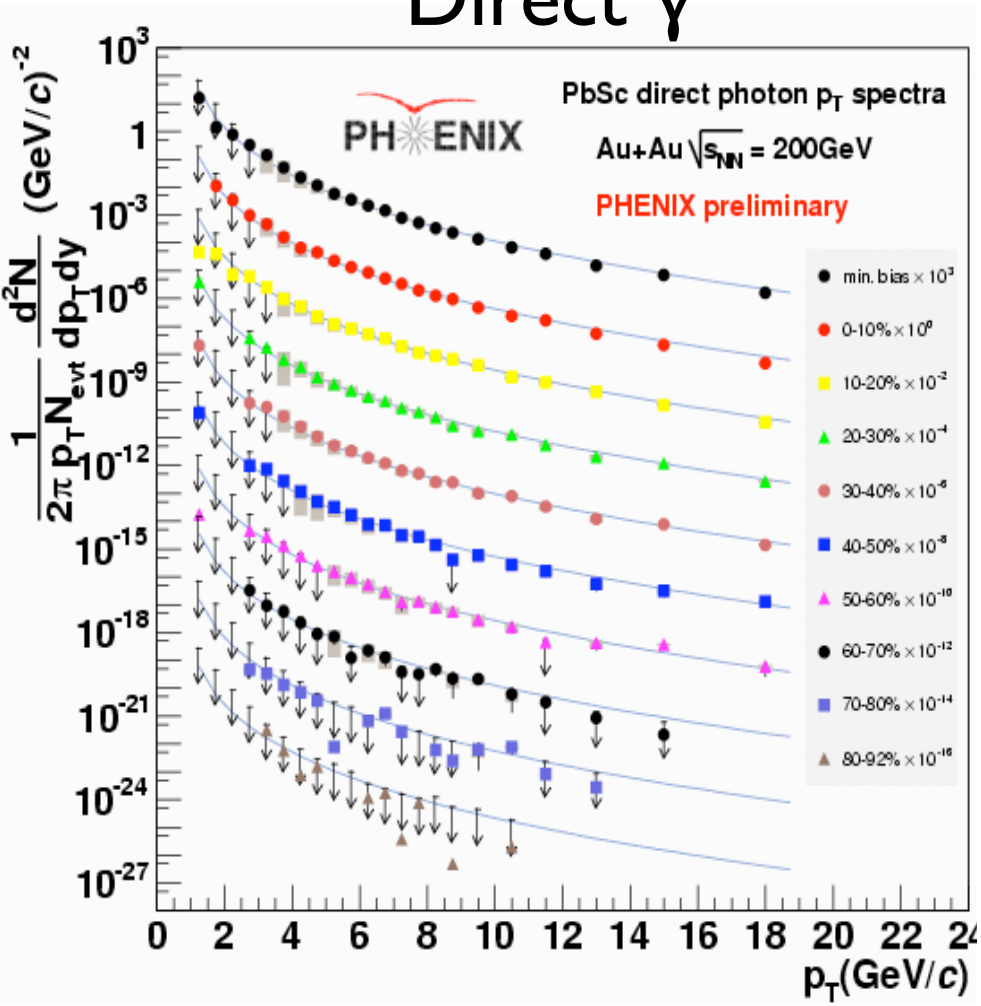
Direct γ



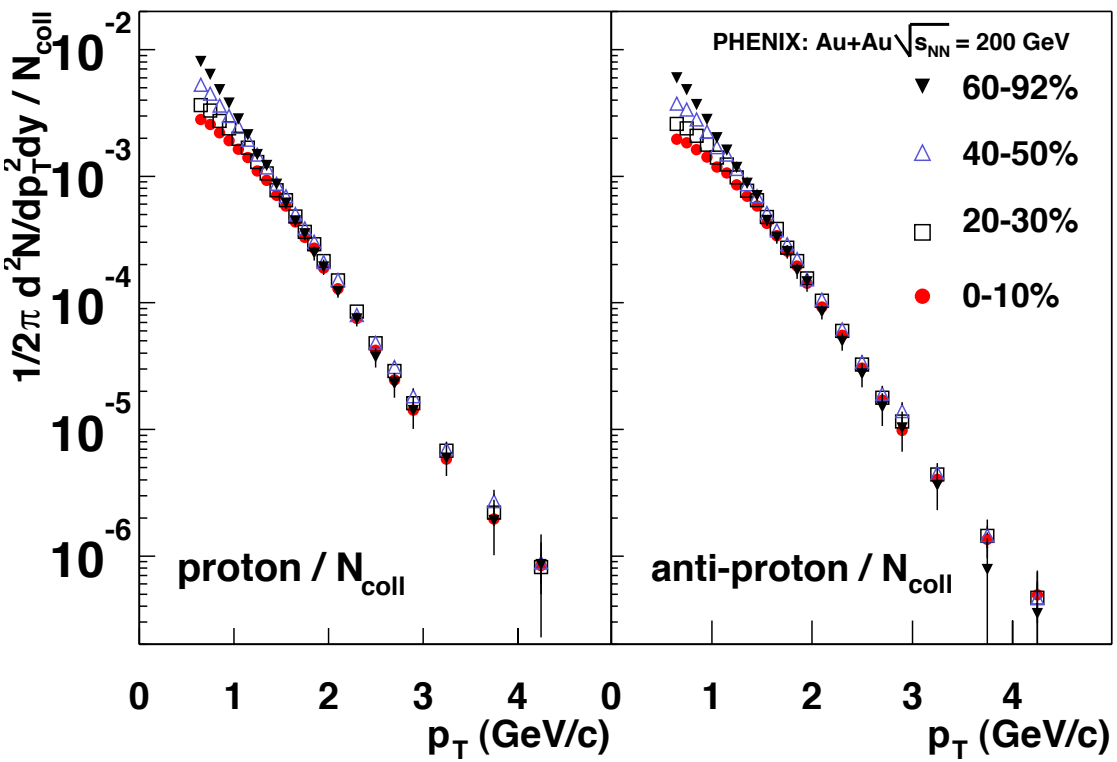
PHENIX PRL 94 232301 (2005)

hard scattering still happens...

Direct γ



...and even the baryons look hard at times...

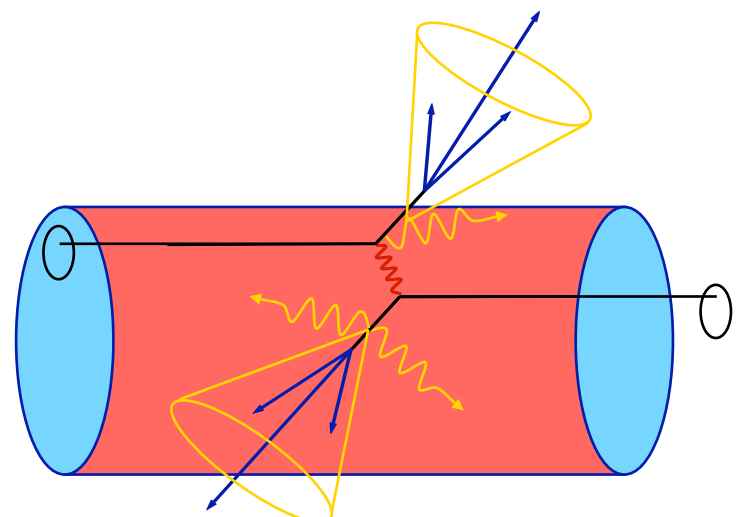


PHENIX PRL 94 232301 (2005)

PHENIX PRL 91 172301 (2003)

Looking at the Whole Picture

- single particles:
  - energy loss,
  - changes to particle ratios,
  - biased toward surface
- near side correlations:
  - changes to fragmentation,
  - different surface bias than single particles
- away side correlations:
  - biased toward long medium path lengths,
  - energy loss & changes to fragmentation

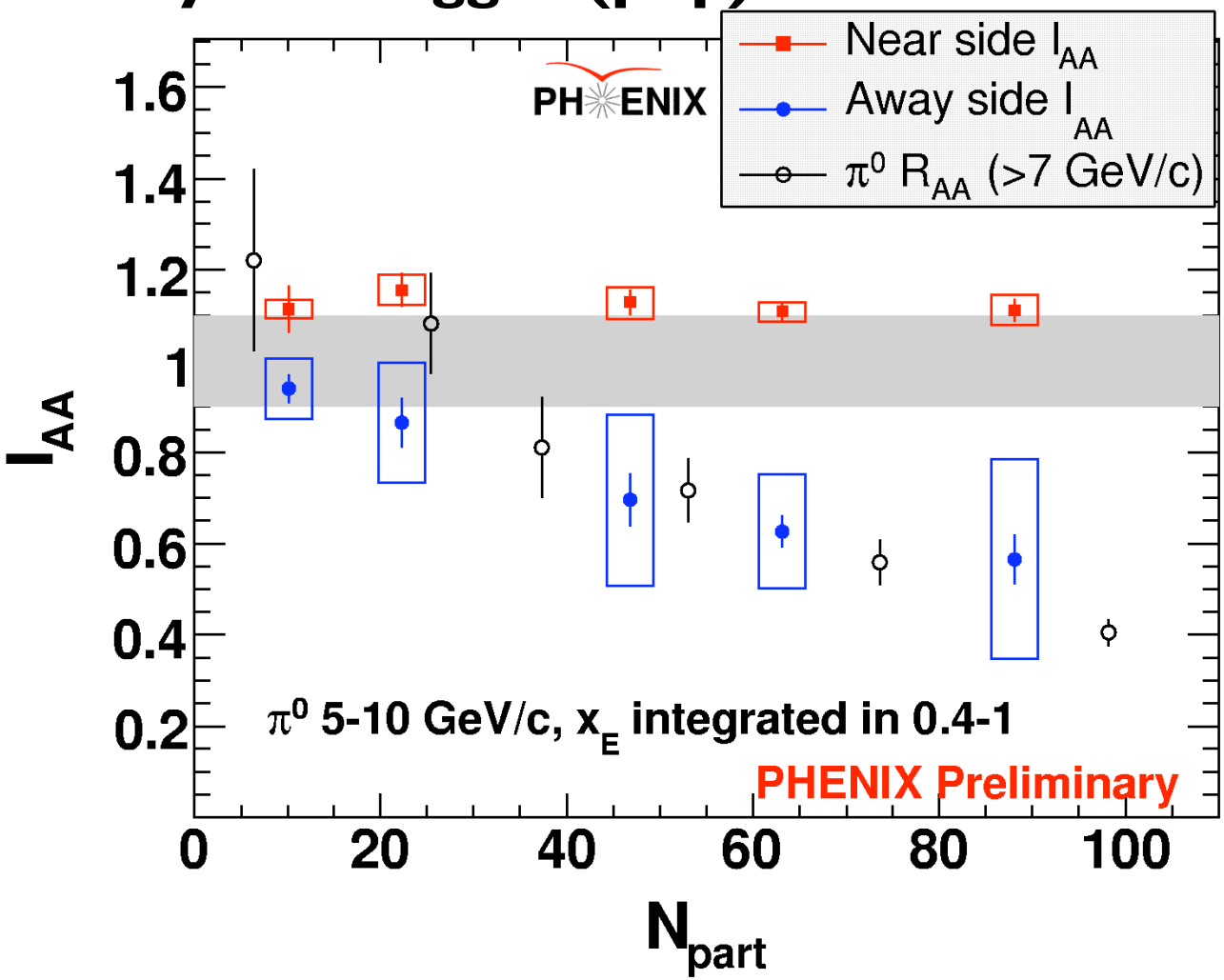


Correlations Between High and Intermediate p_T Hadrons

High p_T: Near Side Nearly Unmodified Fragmentation

$$I_{AA} = \frac{\text{yield/trigger (Cu+Cu)}}{\text{yield/trigger (p+p)}}$$

Cu+Cu, 200GeV

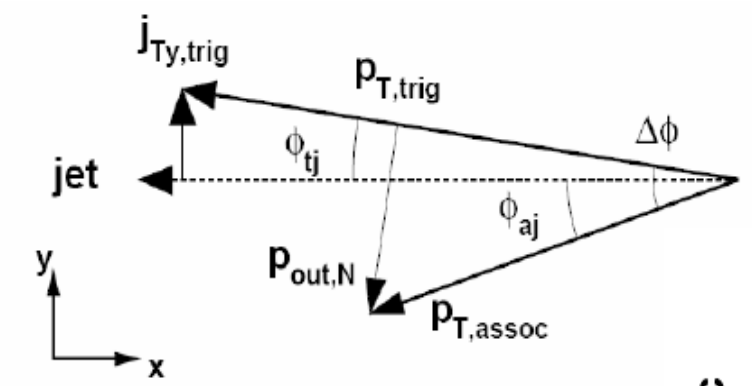


conditional yields constant: vacuum fragmentation

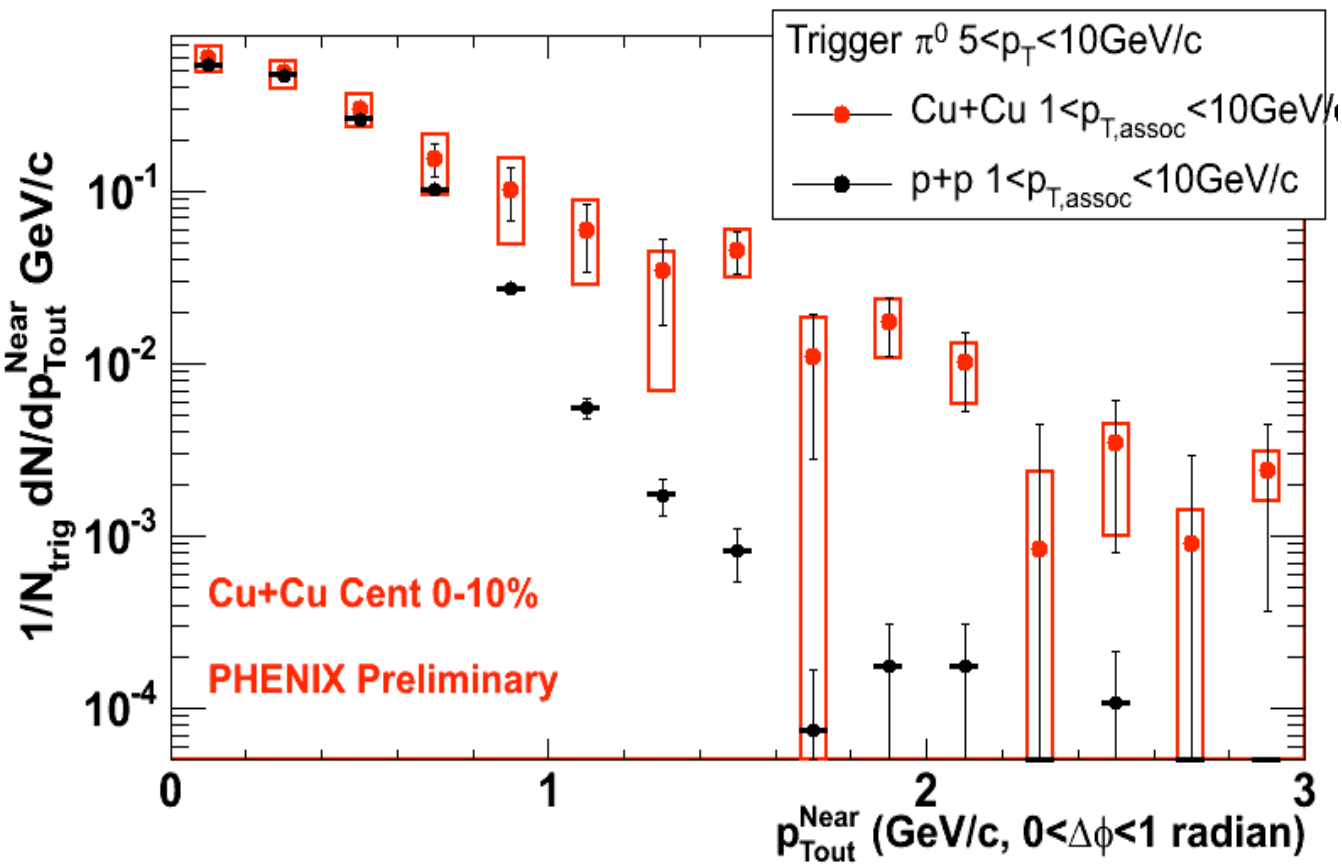
single particle suppression: energy loss

J. Jia, QM2006

A Closer Look at Cu+Cu



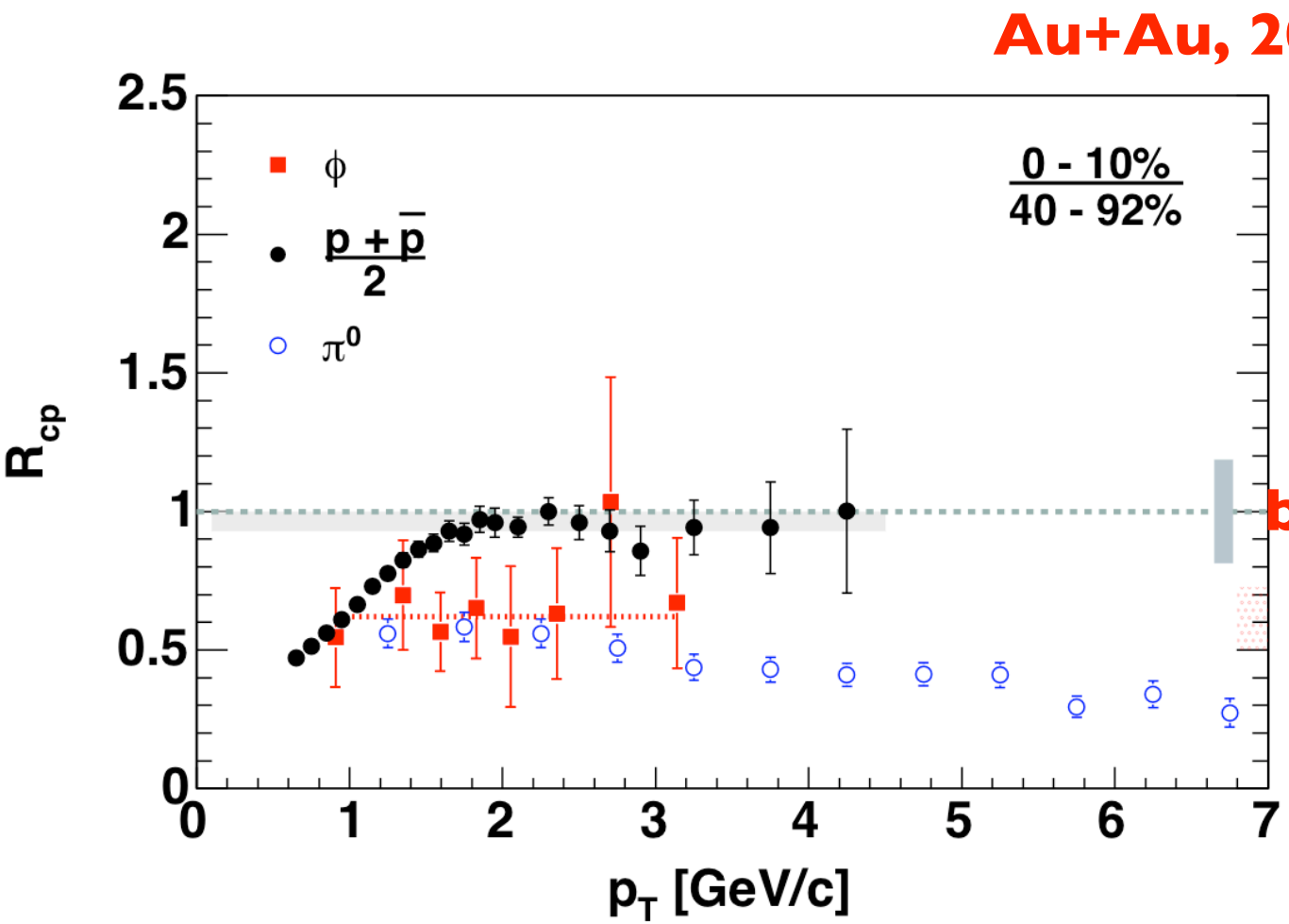
$$p_{Tout} = p_{T,assoc} \sin(\Delta\phi)$$



H. Pei, SQM2007

Correlations Between Hadrons @ Intermediate p_T

Intermediate p_T: Single Particles



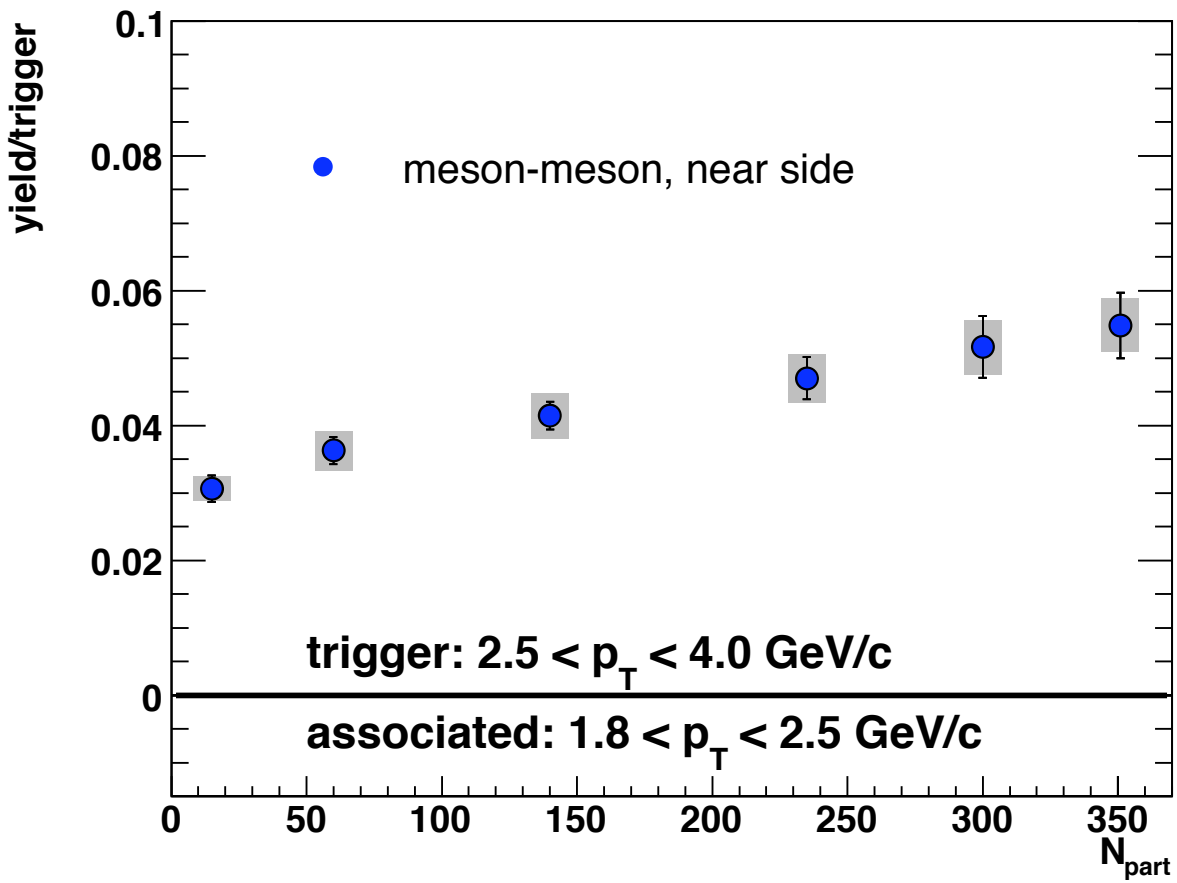
baryons: ~unsuppressed

mesons: suppressed

PHENIX PRC 72 014903 (2005)

Intermediate p_T: Conditional Yield

mesons: yield suppressed, yield/trigger enhanced



Au+Au, 200GeV

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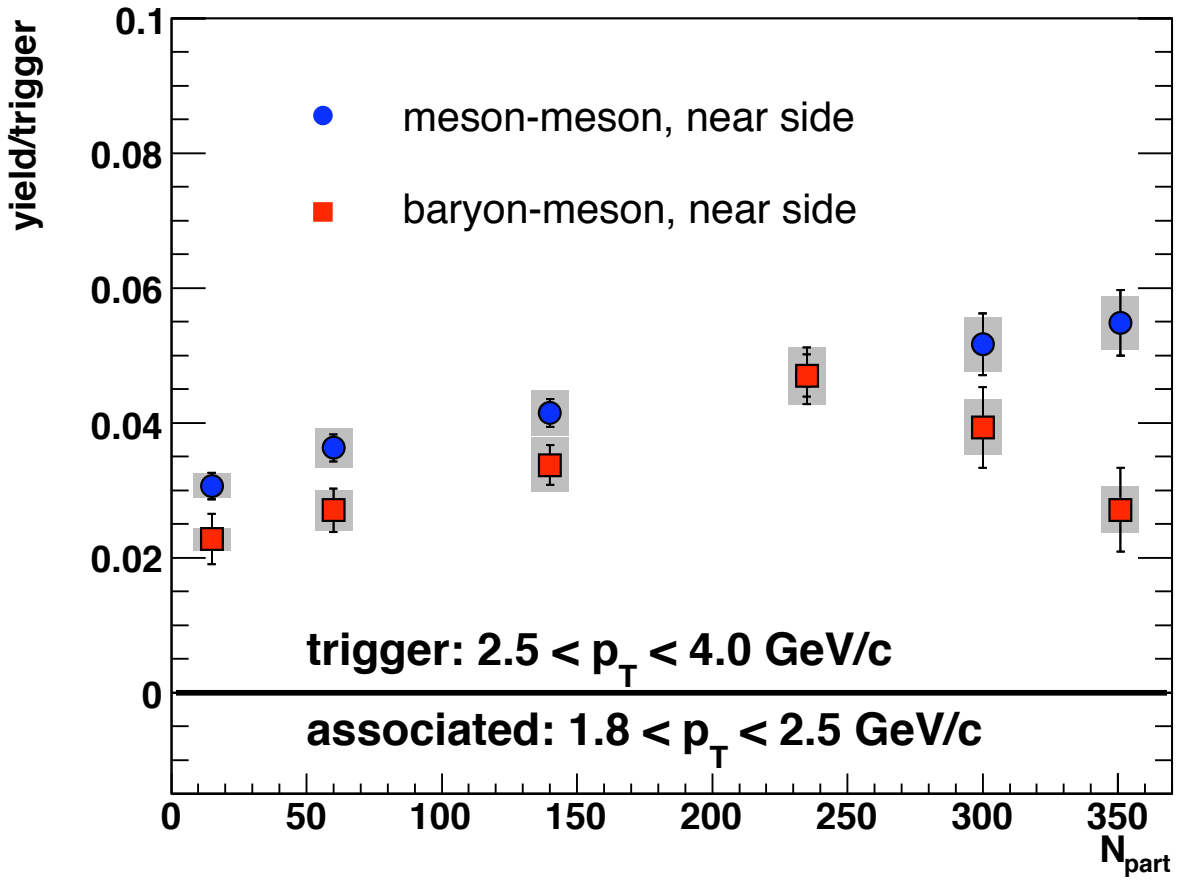
Intermediate p_T: Conditional Yield

mesons: yield suppressed, yield/trigger enhanced

baryons: yield scales with Ncoll, yield/trigger enhanced



Au+Au, 200GeV

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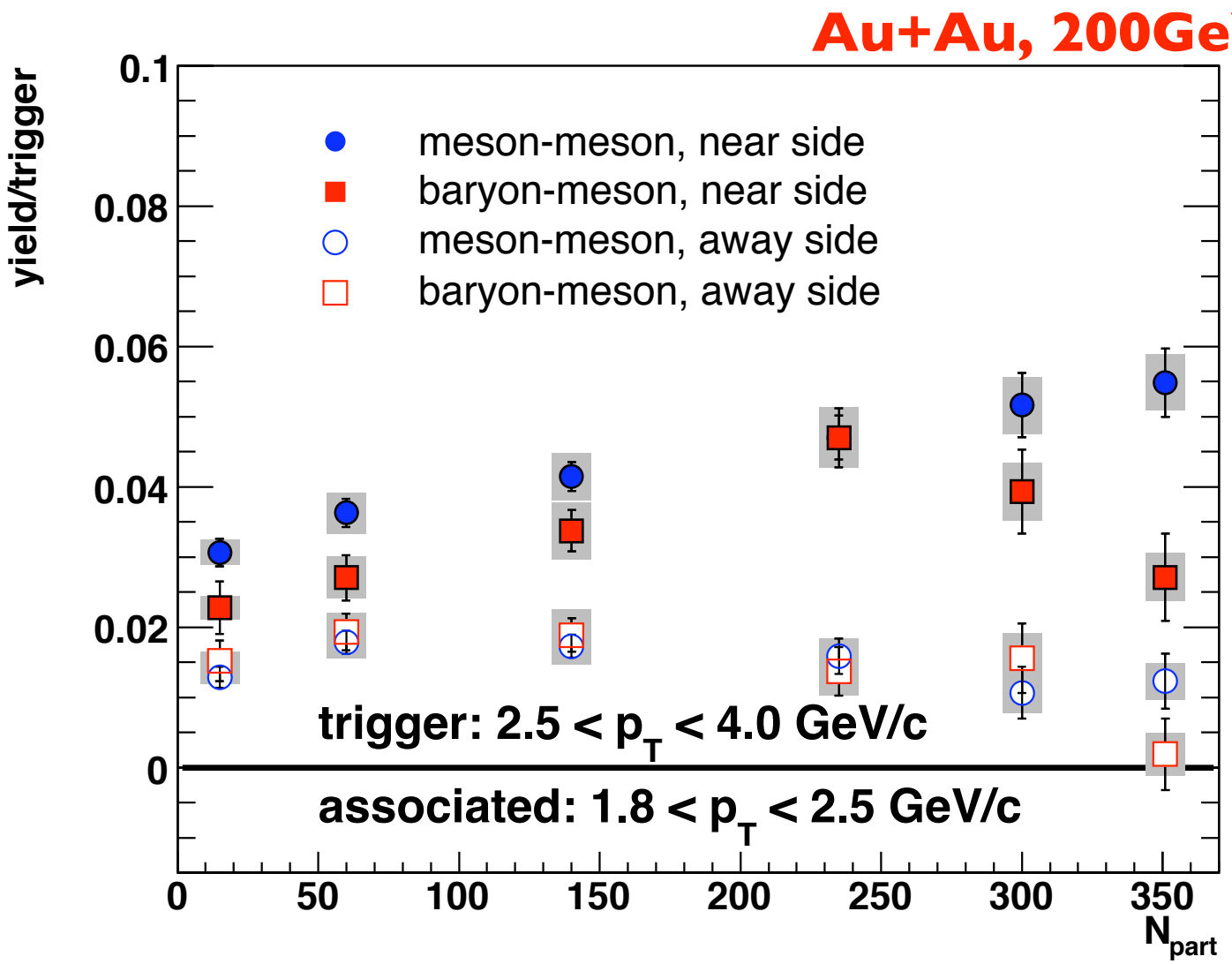
Away Side Yields



away side yields can't know what the near side looks like

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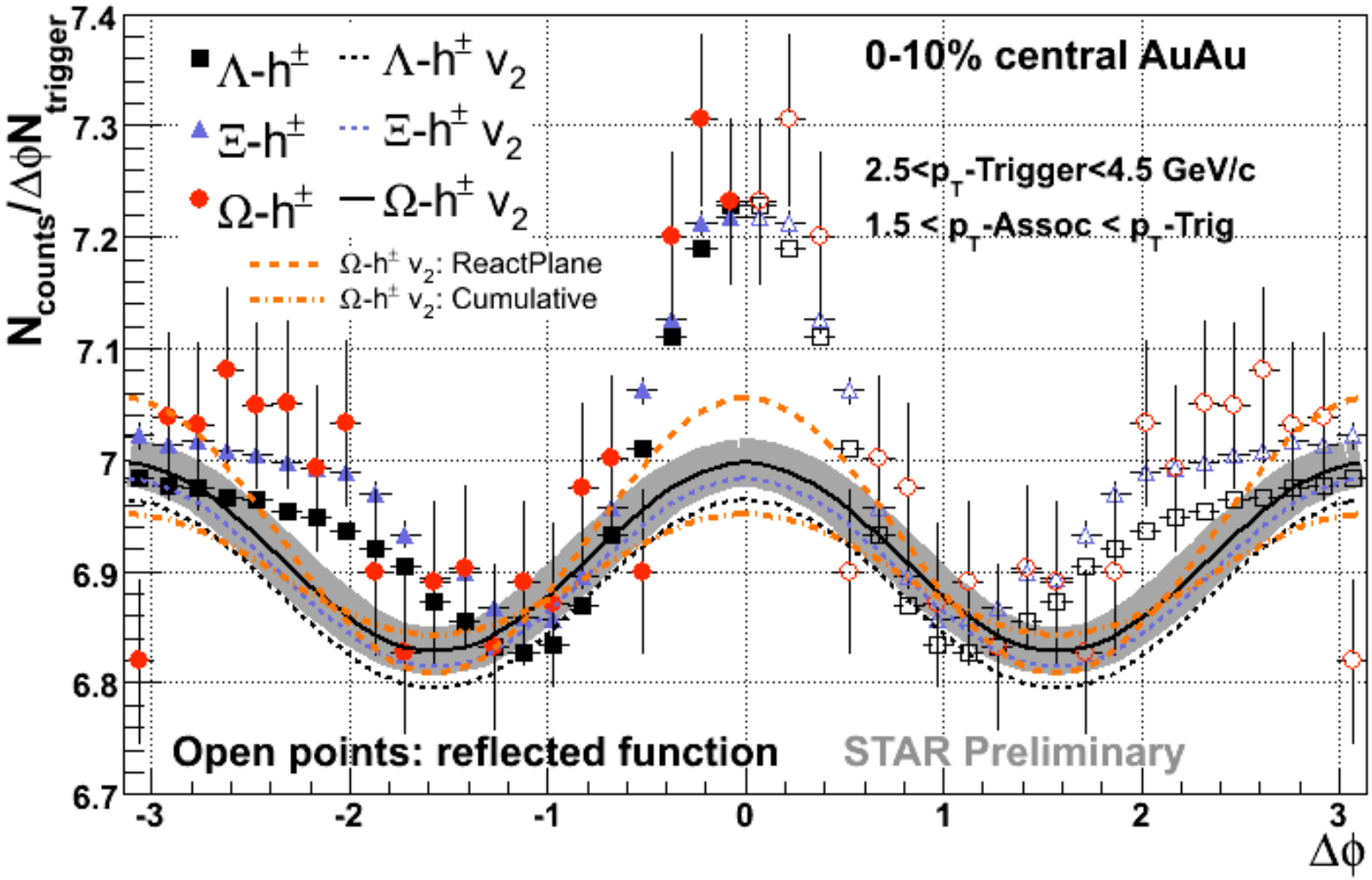
(Multi-)Strange Correlations



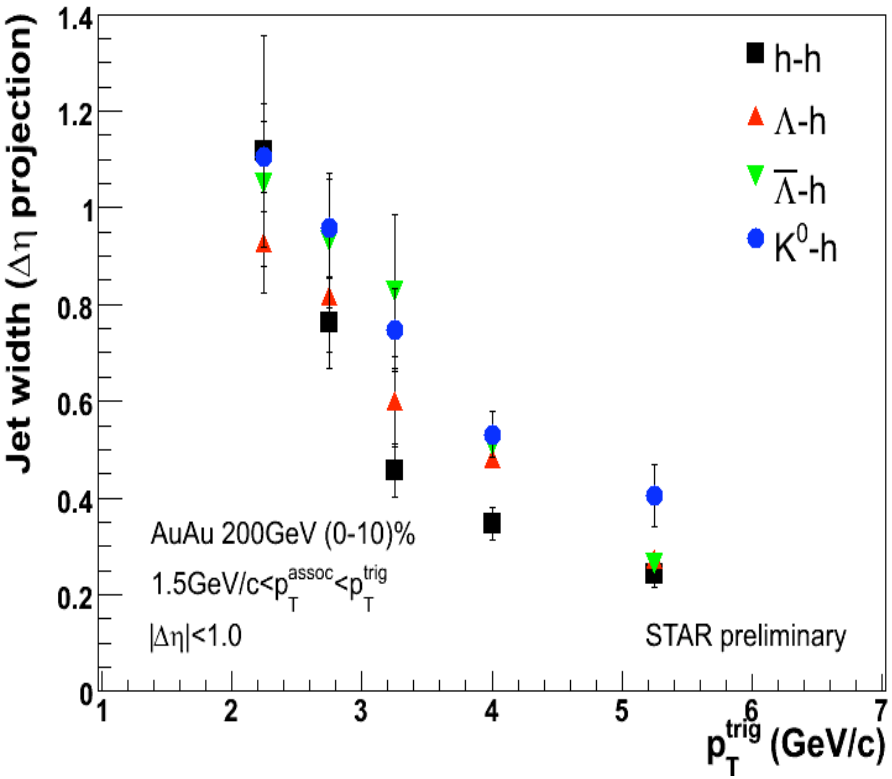
Correlations independent of trigger strangeness content

J. Bielcikova, QM06

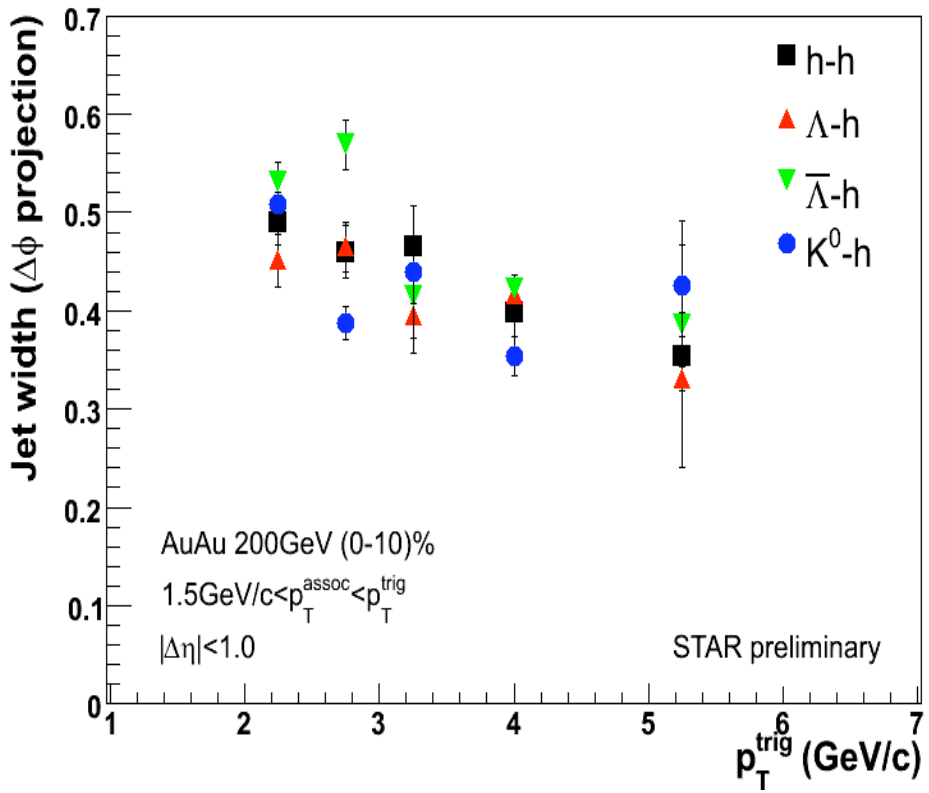
Strange-hadron Correlations: Jet Widths

Au+Au, 200GeV, Ridge Subtracted

Δη Width



ΔΦ Width

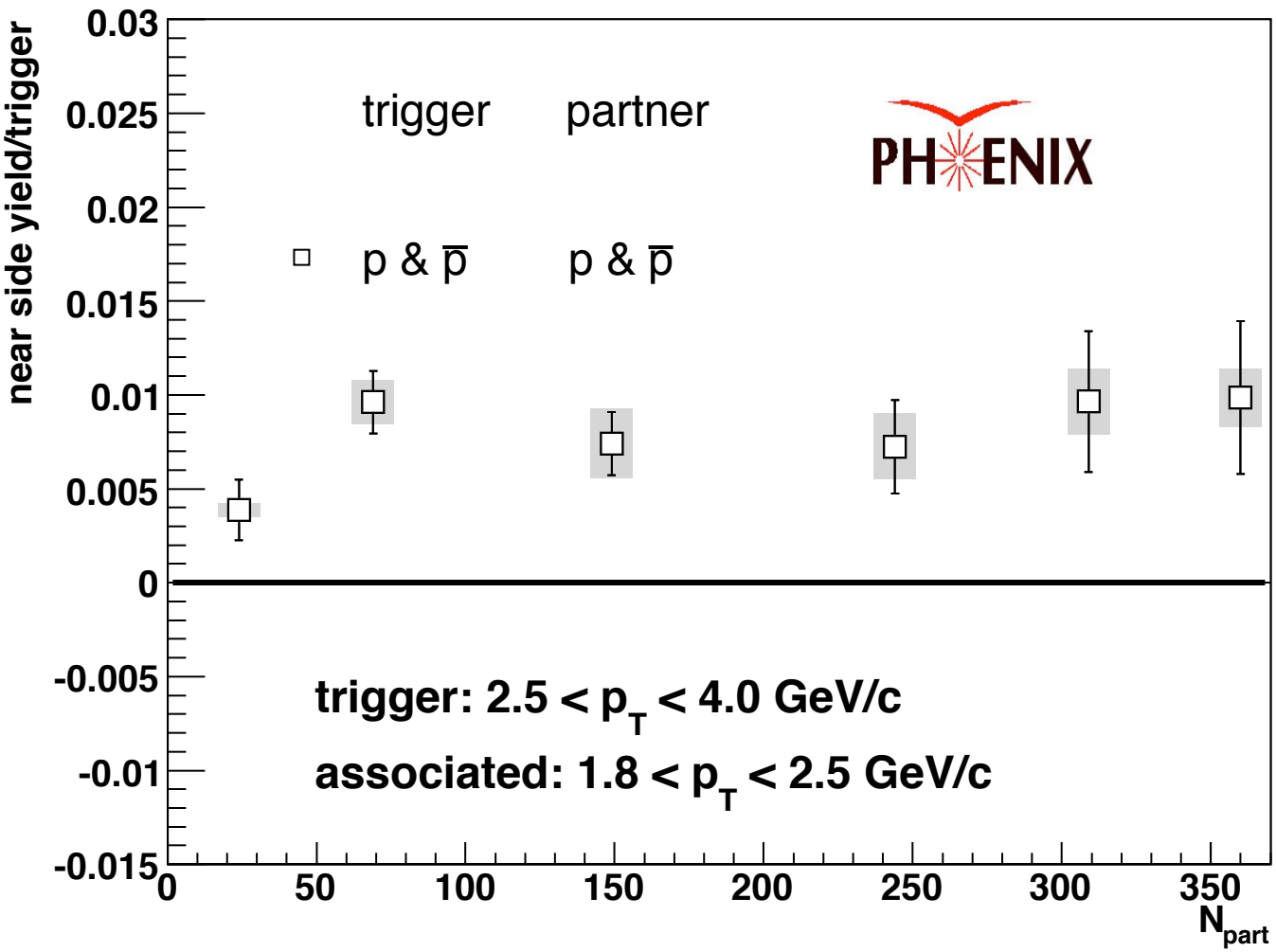


No trigger dependence to jet widths

M. Bombara, SQM07

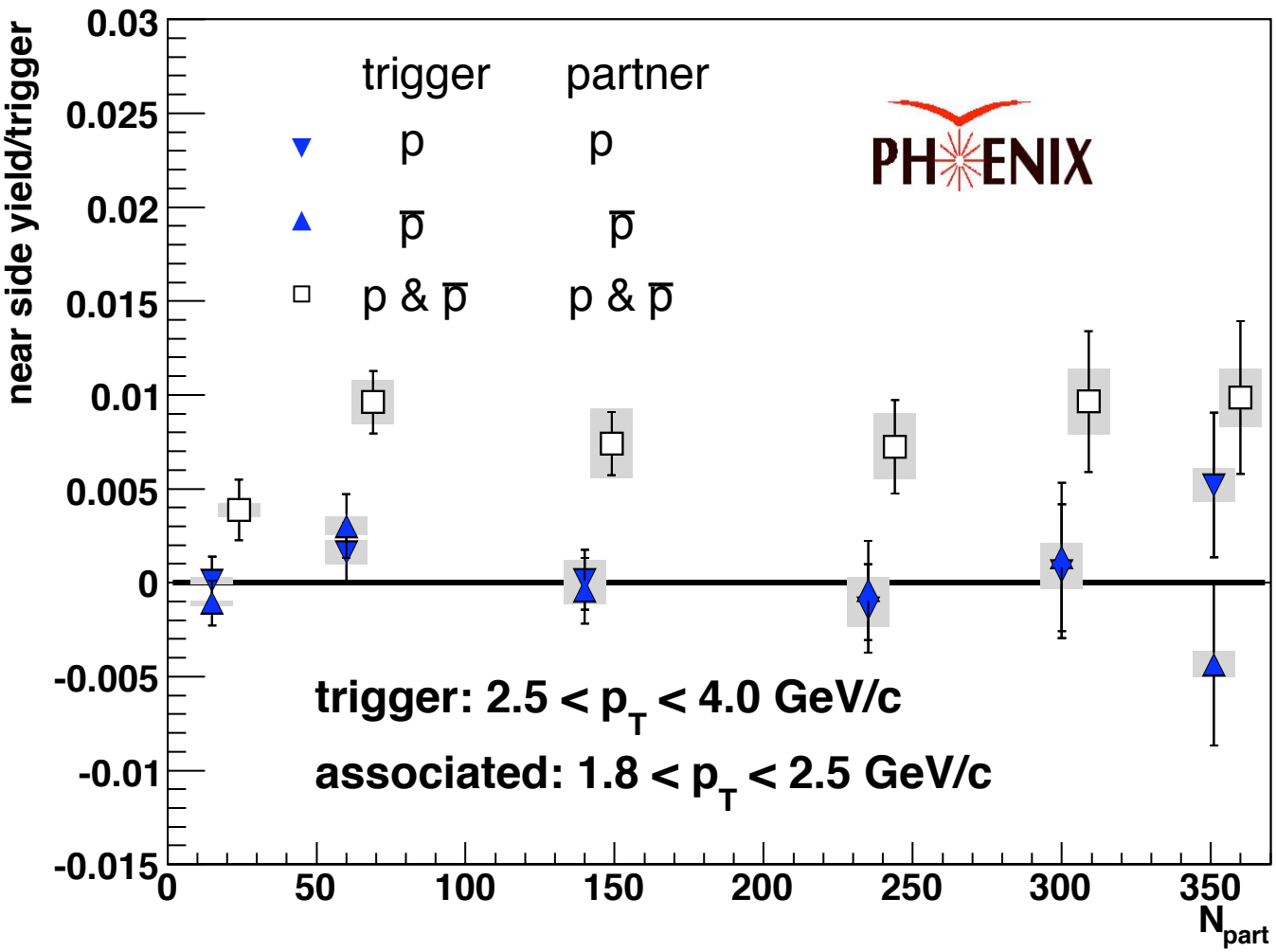
What about the baryons?

PLB 649 (2007) 359-369



What about the baryons?

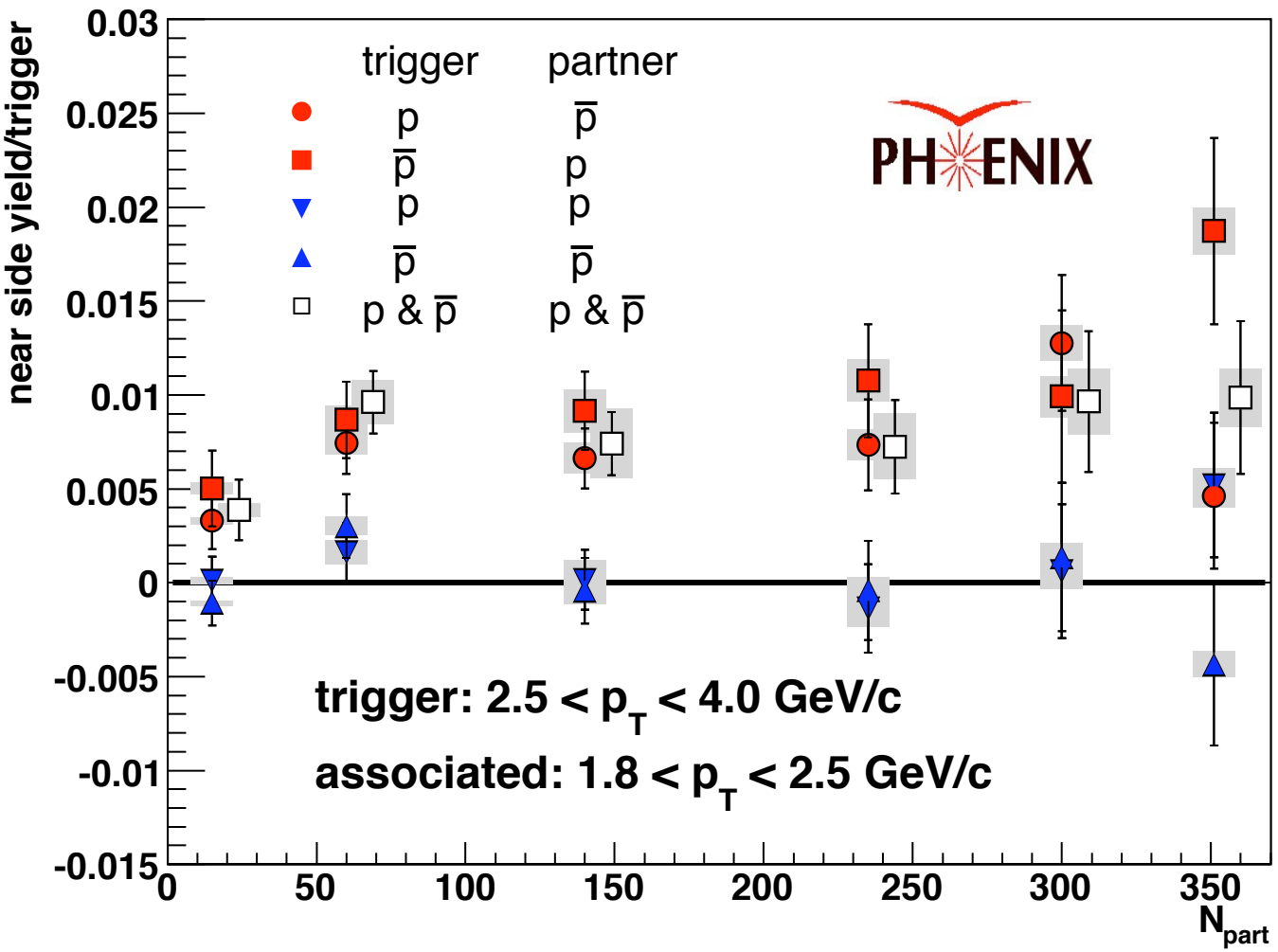
PLB 649 (2007) 359-369



same sign pairs:
NO CORRELATION

What about the baryons?

PLB 649 (2007) 359-369



opposite sign pairs: CORRELATED

same sign pairs: NO CORRELATION

$\bar{p}/\pi$=0.25 **$\bar{p}/\pi$=0.8**

p-$\bar{p}$ pair correlations nearly independent of baryon excess

Recombination & Jet Correlations

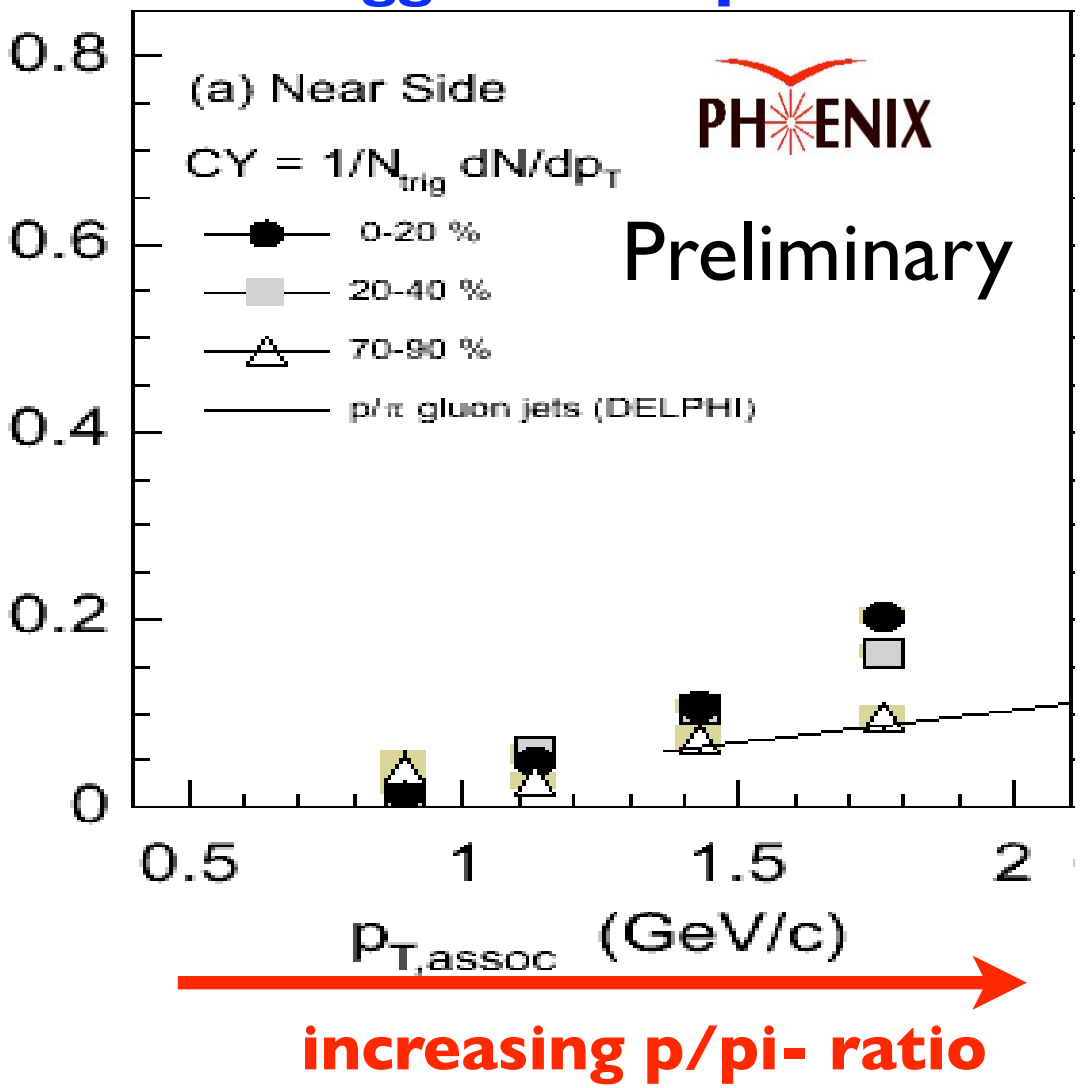
- incorporating hard physics into reco models: partons associated with a hard scattering recombine with medium partons (Ko et al, Fries et al & Hwa et al)
  - wouldn't recombination wash out the charge ordering of the p/pbar correlations?
    - does the surface bias for near side correlations minimize sensitivity to recombination?
  - what about the away side correlations? baryon & meson triggers are consistent
  - do the correlations break the v_2 scaling?
- are there other ideas which can explain the data?

need calculations that explain all the data with one set of parameters

What's the Particle Composition of the Jets?

Extra Baryons in Near Side Jets...

hadron trigger: 2.5 < p_T < 4.0GeV/c



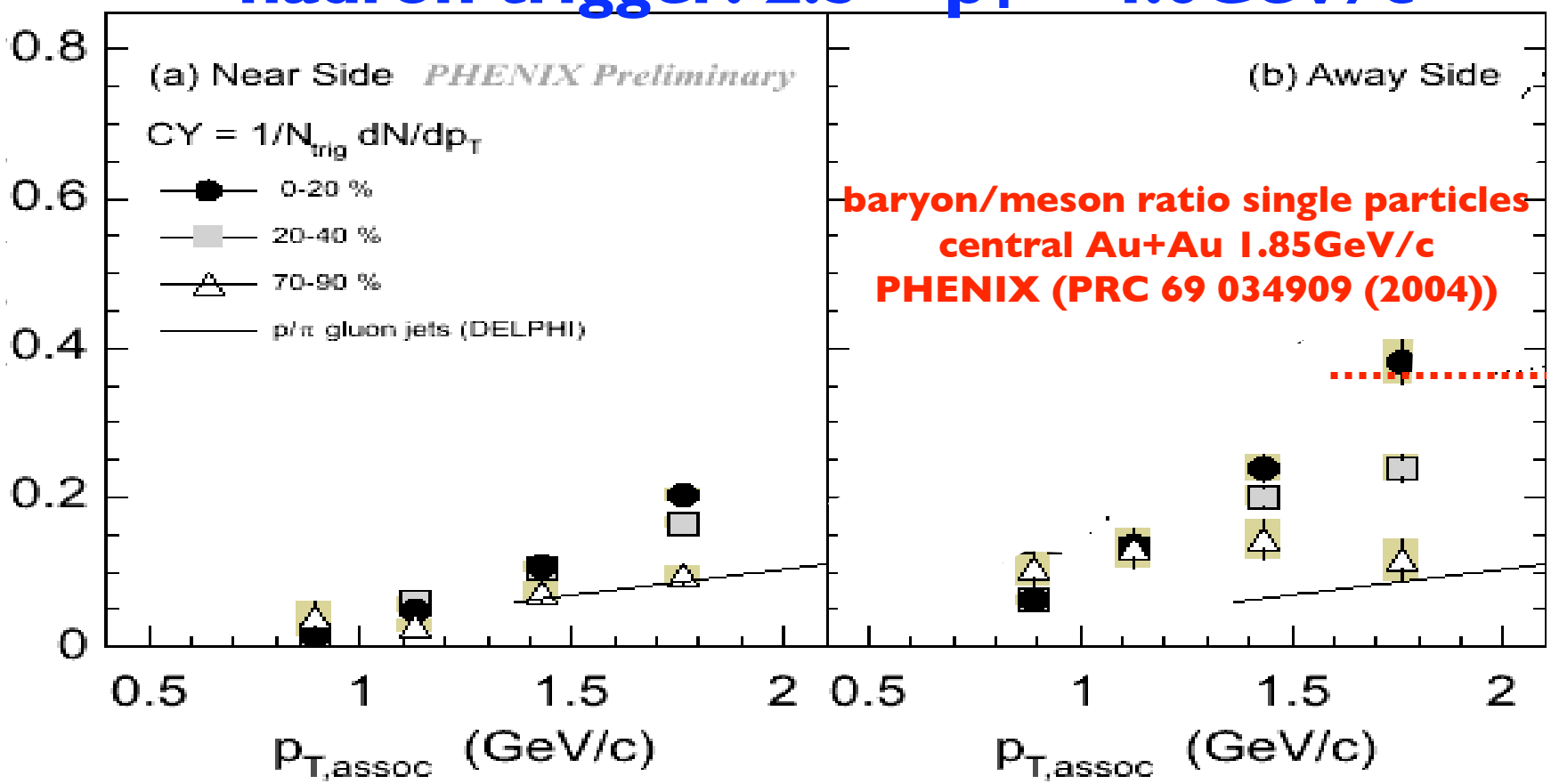
assoc. baryons/assoc. mesons

increasing centrality

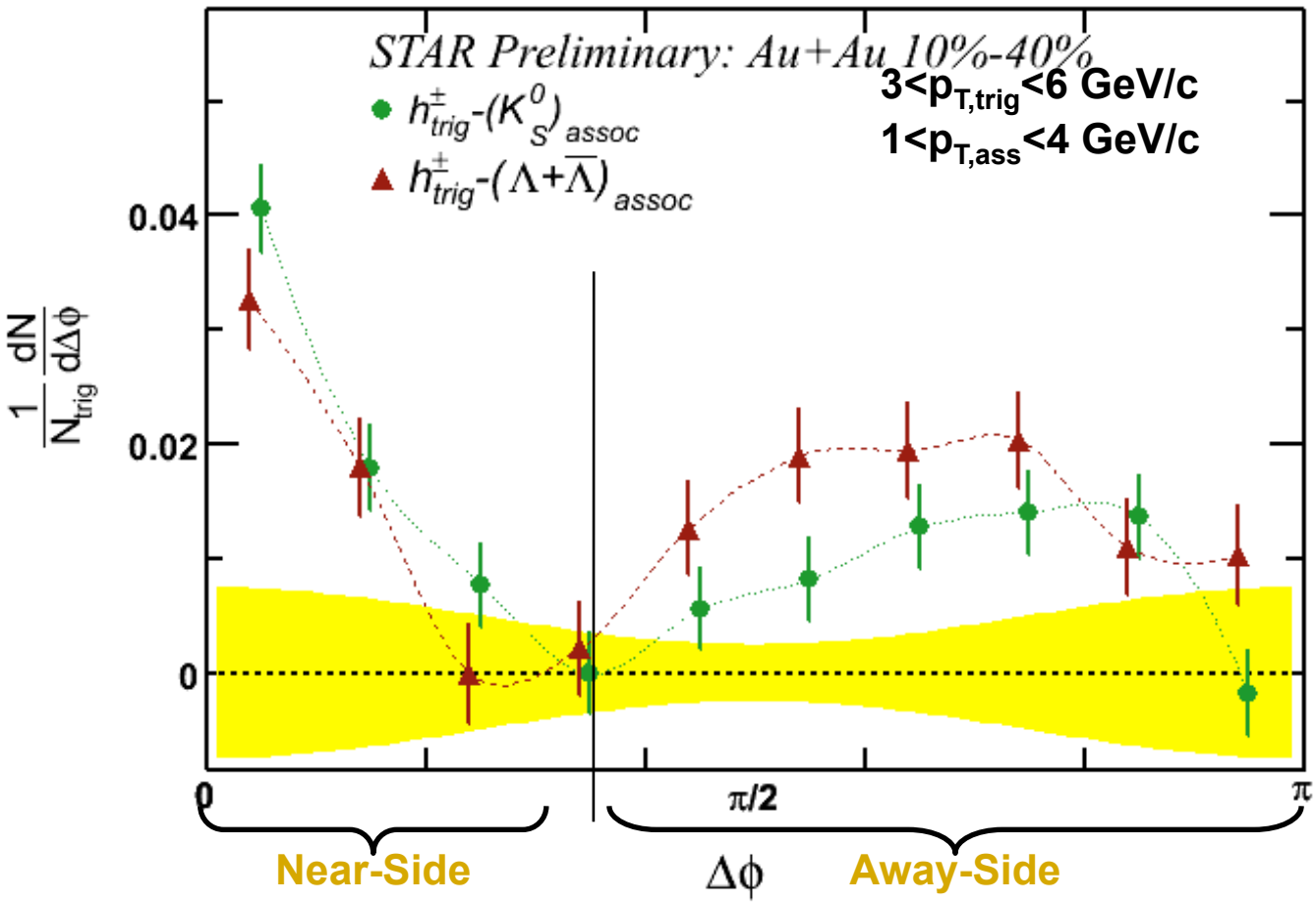
increasing p/pi- ratio

...And Even More Baryons in Away Side Jets

assoc. baryons/assoc. mesons

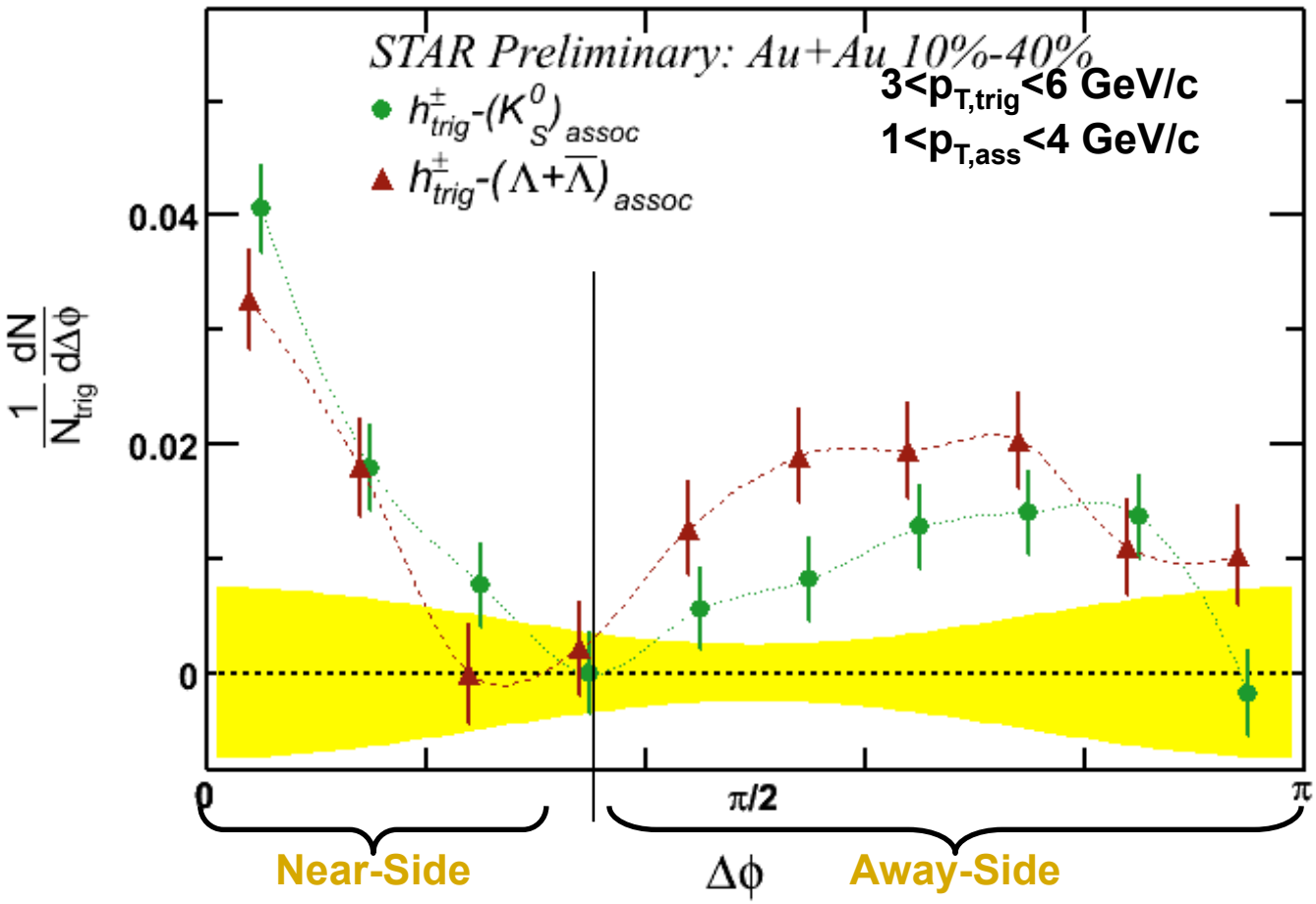


hadron-strange Correlations



J. Zuo SQM07

hadron-strange Correlations



Particle Ratios	Near-Side	Away-Side
$(\Lambda+\bar{\Lambda})$/Ks	0.77 ± 0.12 (stat) 0.18 (sys)	1.7 ± 0.3 (stat) 0.6 (sys)

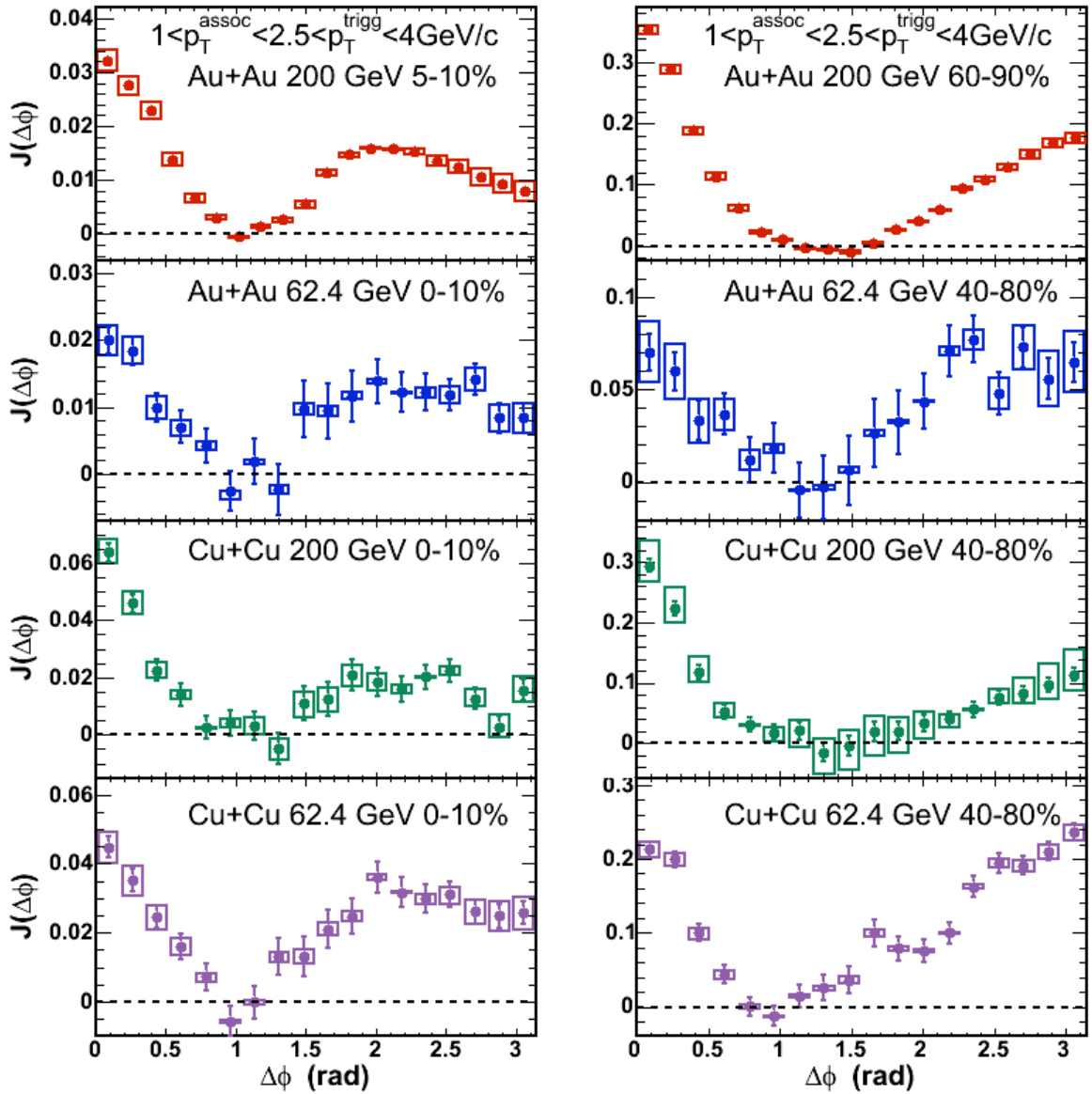
J. Zuo SQM07

What About the Jet Shapes?

Jet Shapes In h-h Correlations

away side region at intermediate p_T hadron-hadron correlations has a modified shape

what do we see with identified particles?

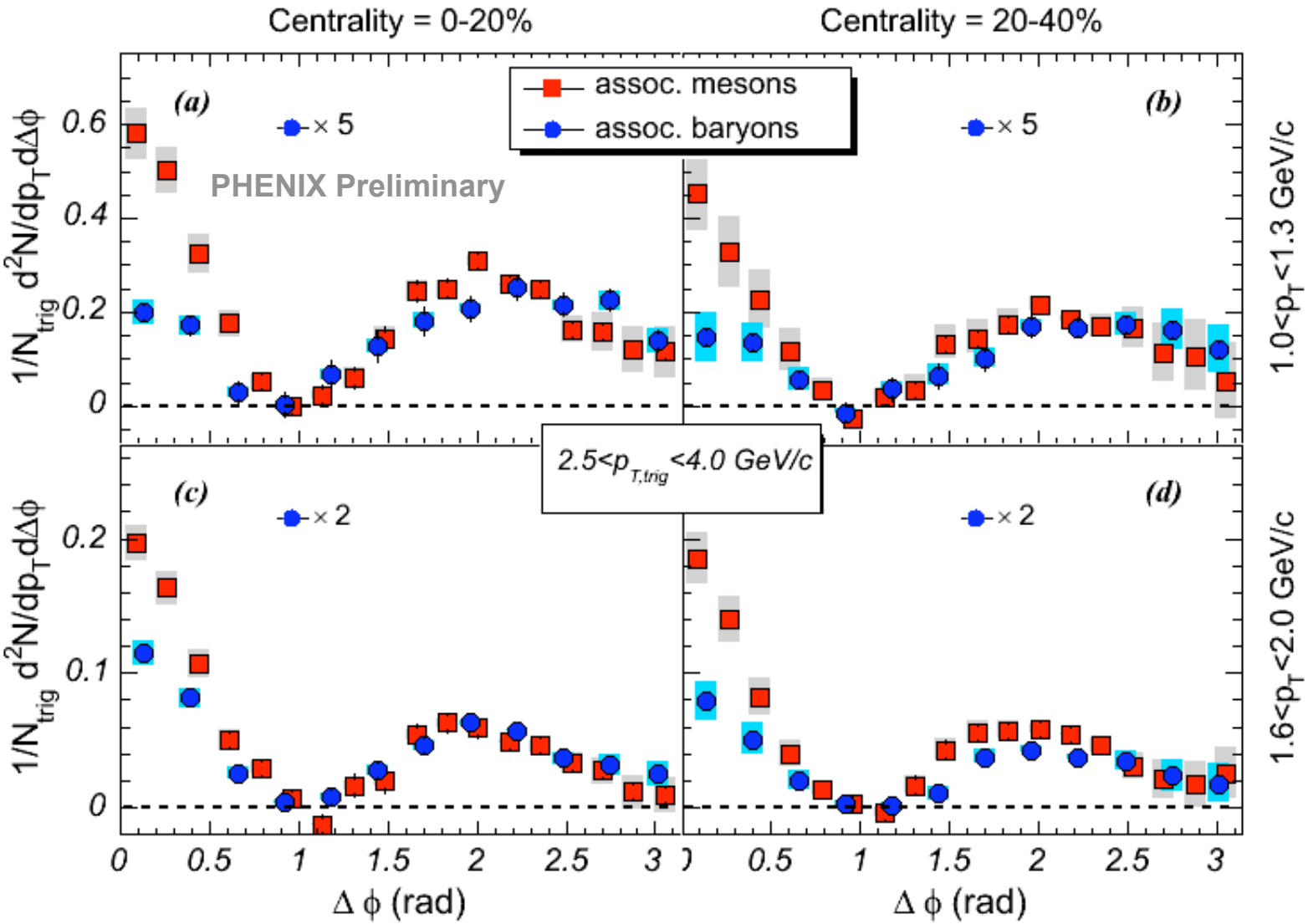


PRL 98 232202 (2007)

Shapes at Intermediate p_T

non-identified hadron triggers

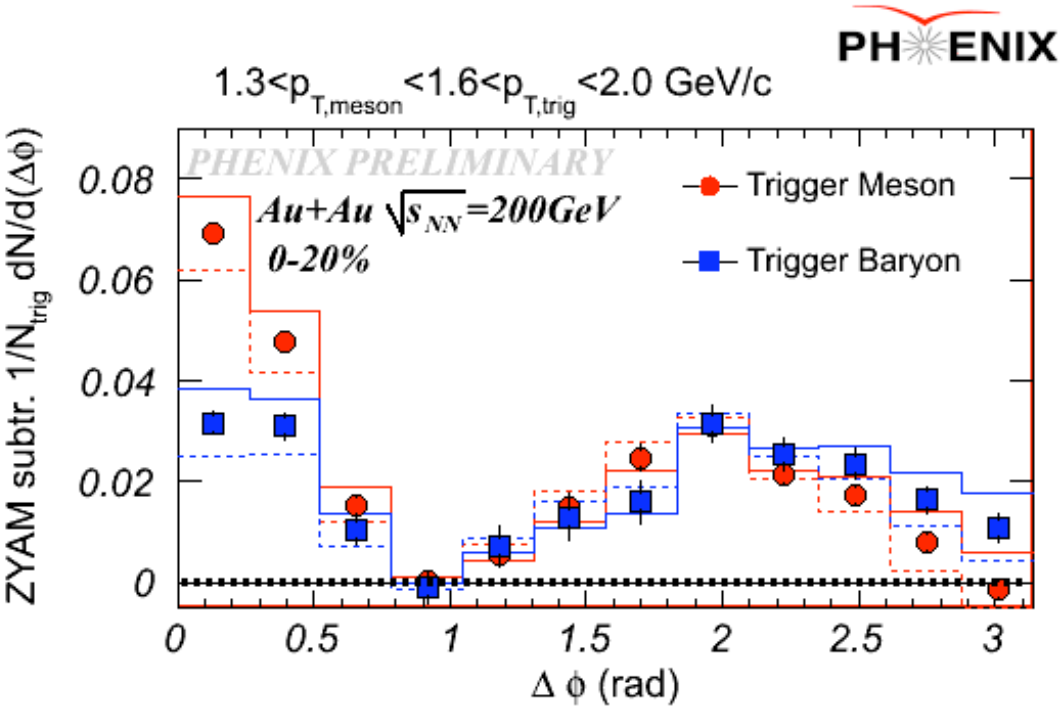
Au+Au 200GeV



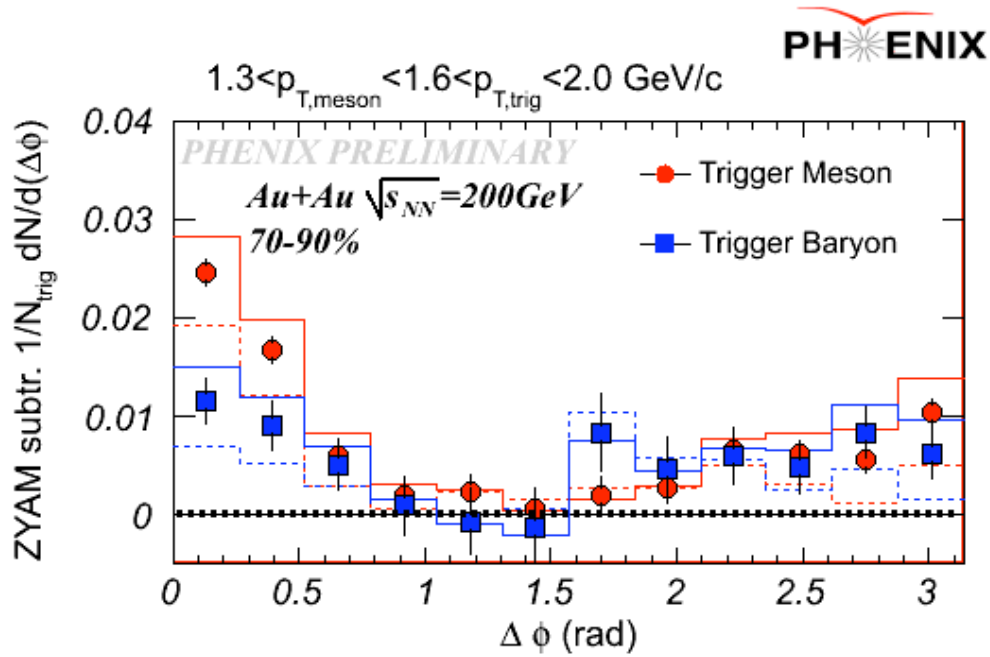
Shapes at Low p_T

Au+Au 200GeV

central



peripheral



trigger: $1.6<p_T<2.0$GeV/c
partner: $1.3<p_T<1.6$GeV/c, mesons

Displaced peak about the same place as at higher p_T

putting it all together...

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- **Yields:** modified pout distribution for high p_T-intermediate p_T correlations, strong centrality dependence when both particles are at intermediate p_T

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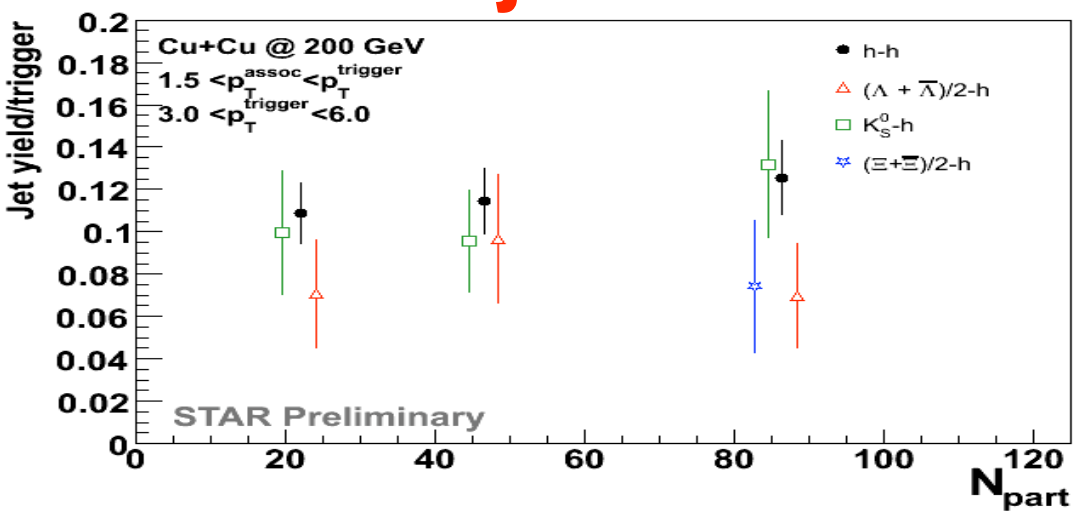
  - changes in particle composition seen along with medium response
- How can we quantitatively understand the wealth of data?
  - need to characterize the correlations more differentially: widths, connections to higher p_T, jet variables

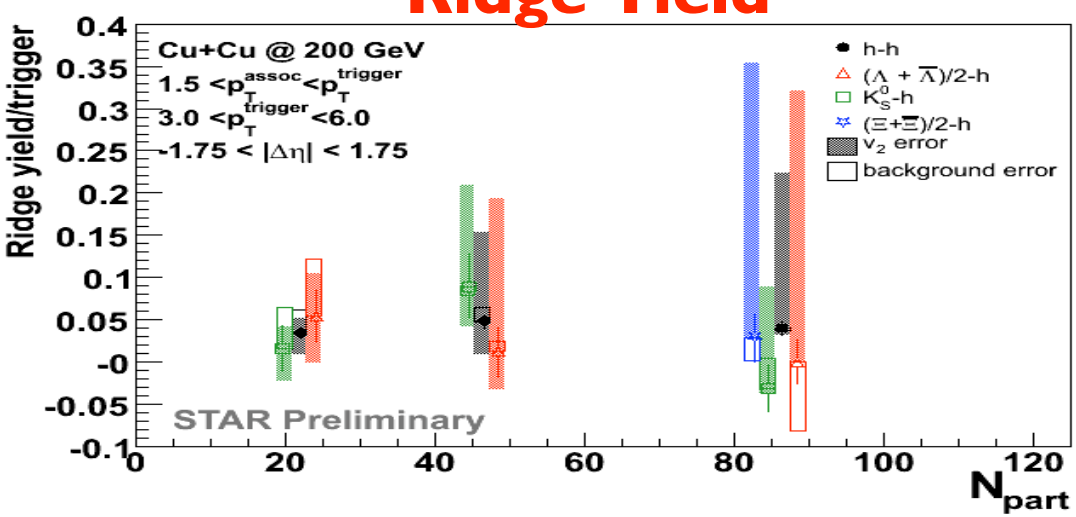
backups

Strange Correlations in Cu+Cu

Jet Yield



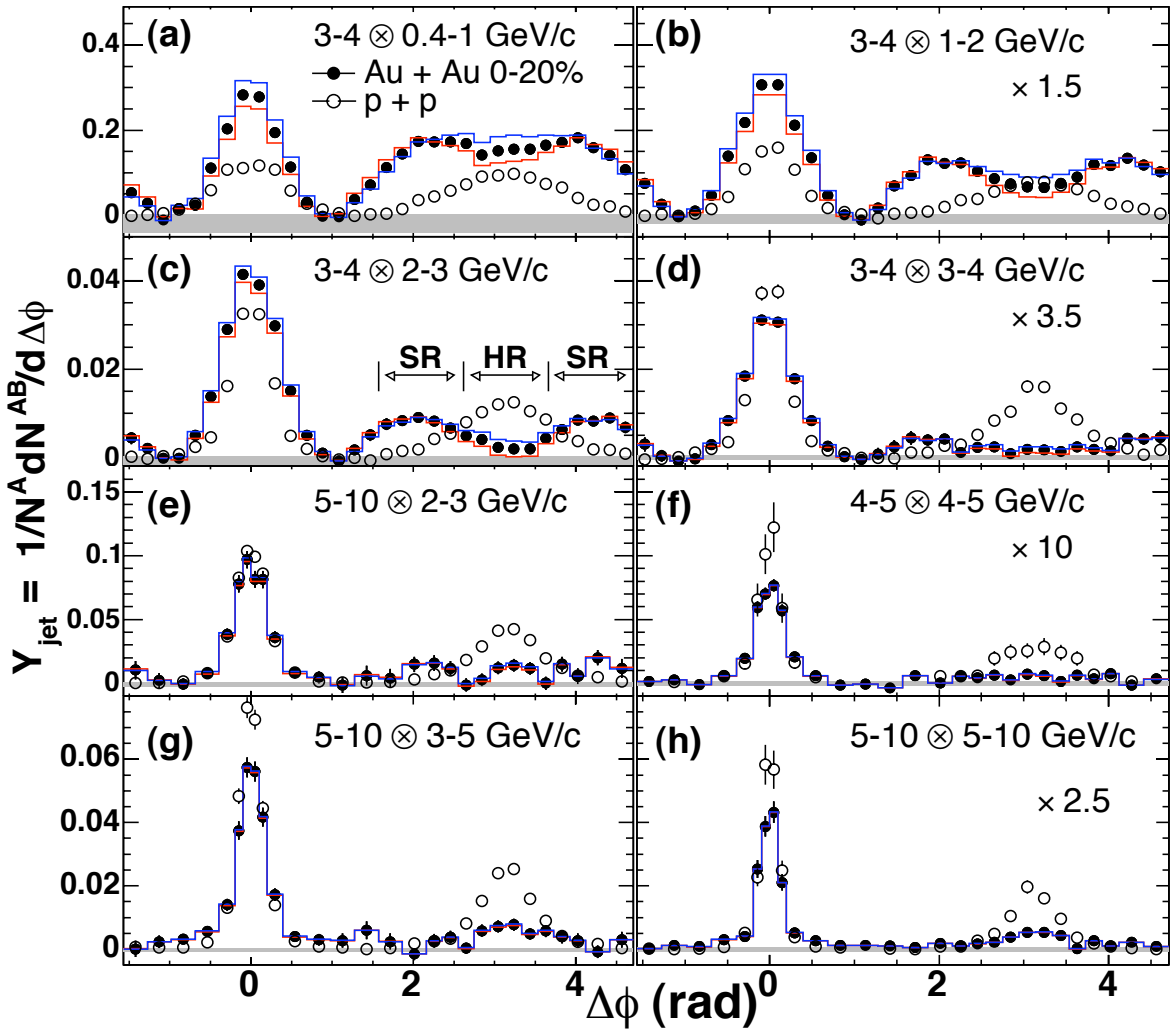
Ridge Yield



- smaller system: a closer look at low N_{part} systems
- no significant baryon/ meson trigger dependence in jet or ridge yield

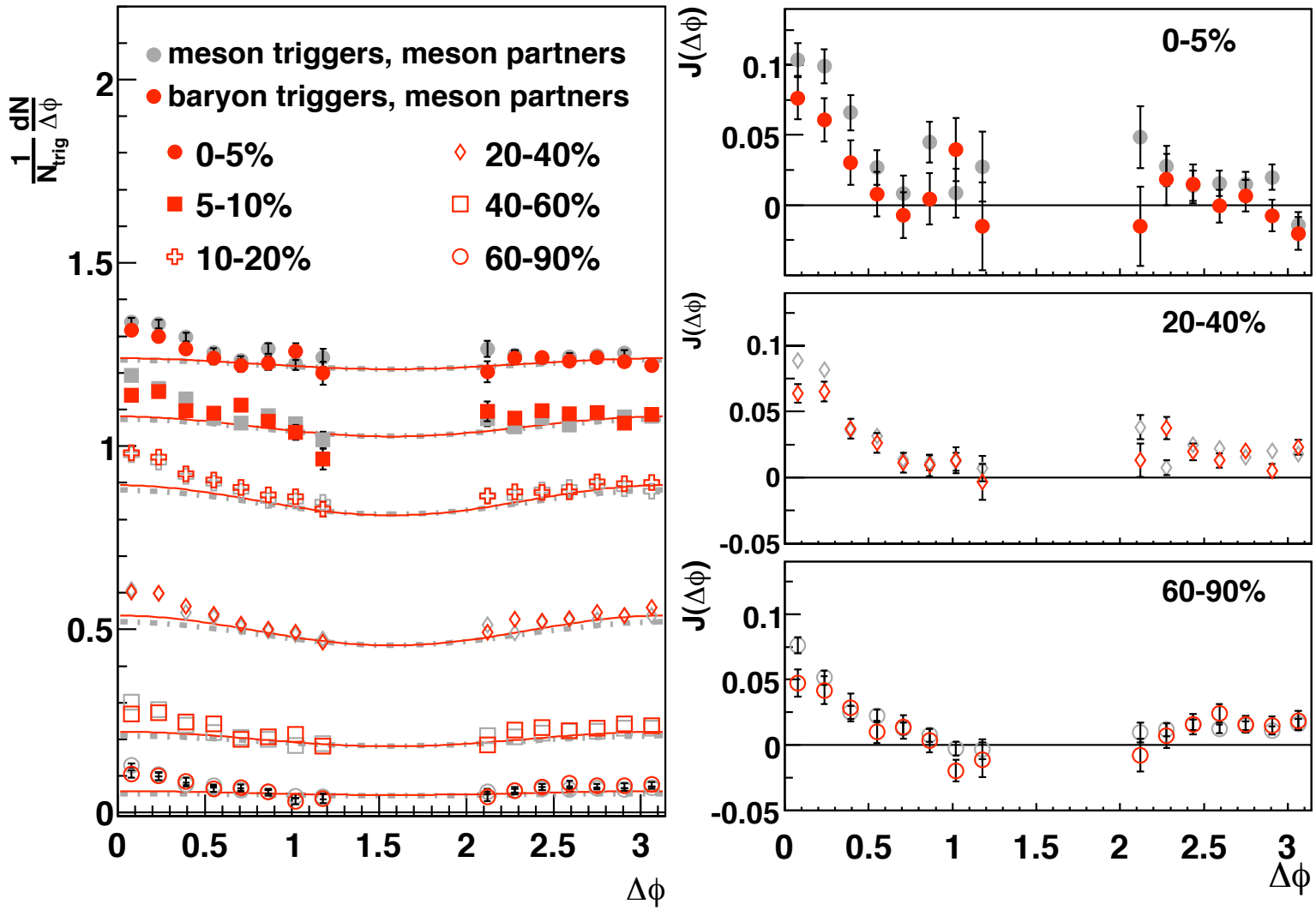
C. Nattrass, SQM07

hadron-hadron correlations



PHENIX 0705.3238 submitted to PRL

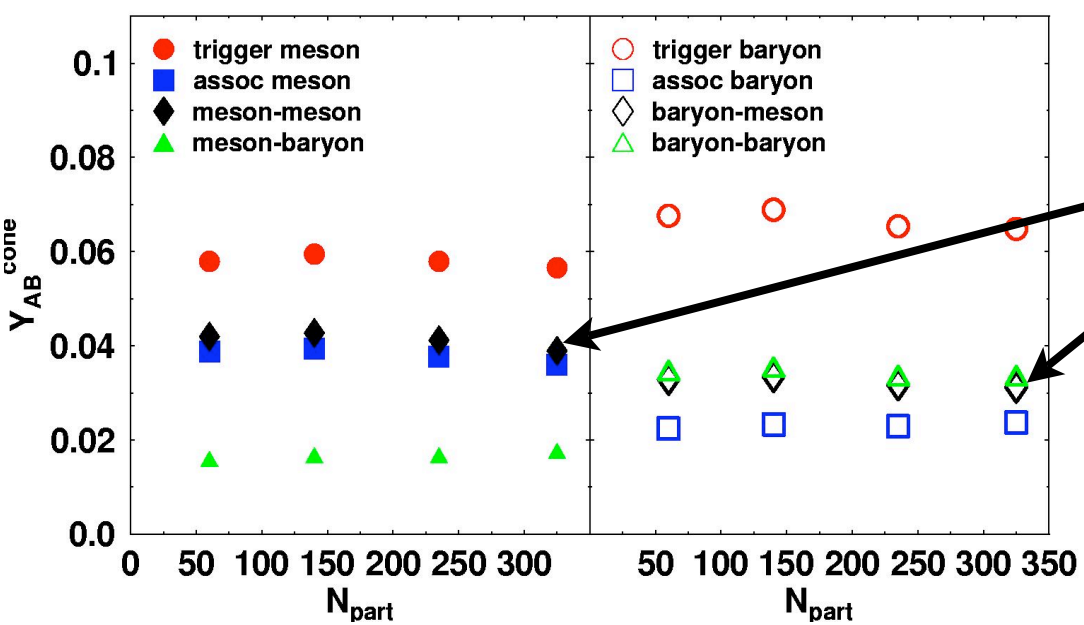
Shapes

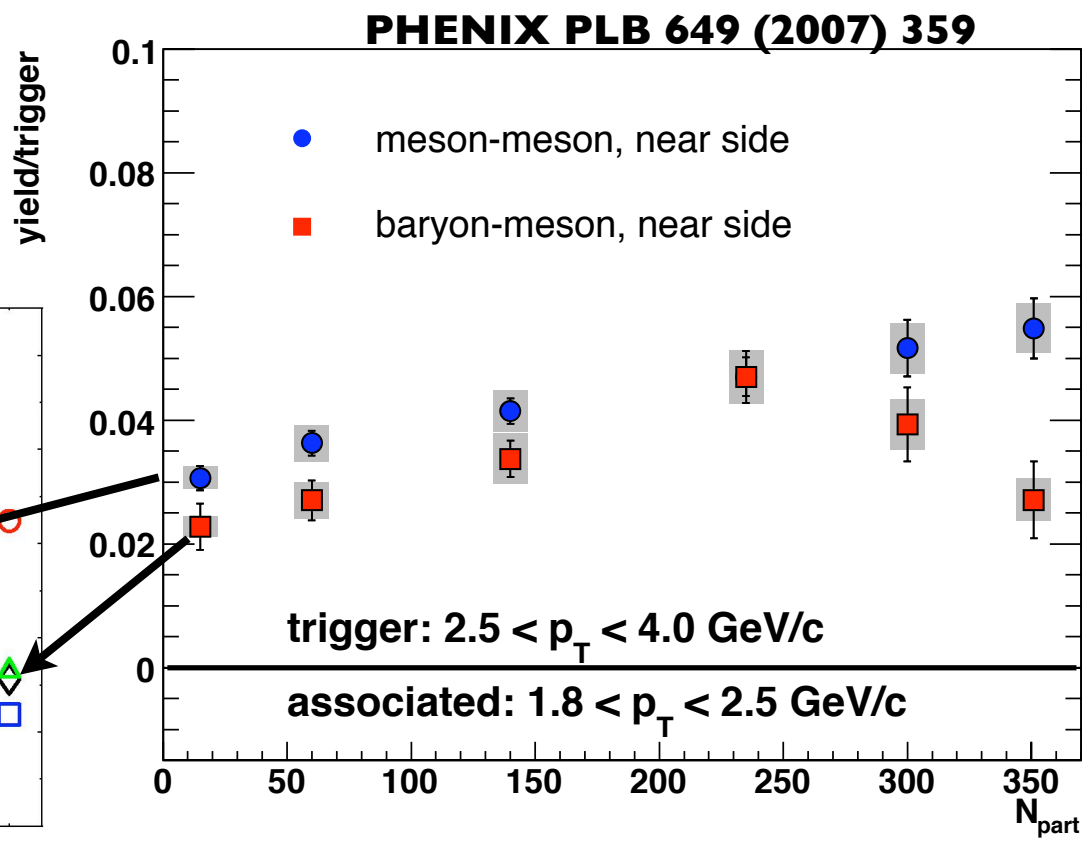


PHENIX PLB 649 (2007) 359

Recombination & Correlations

stronger centrality dependence in the data than calculation

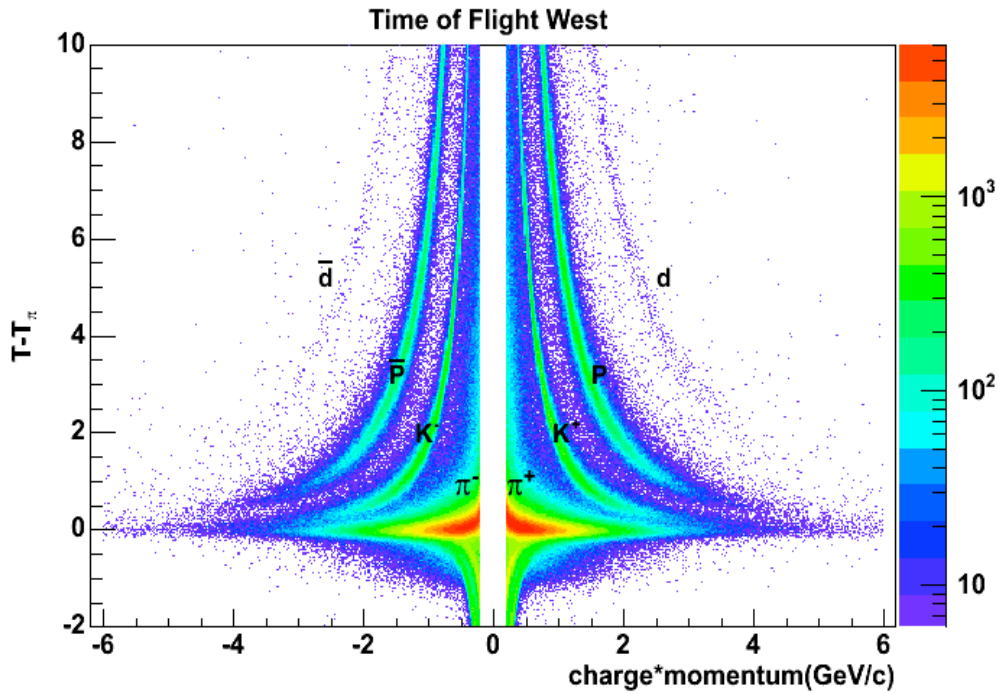




R. Fries, Hard Probes 2006

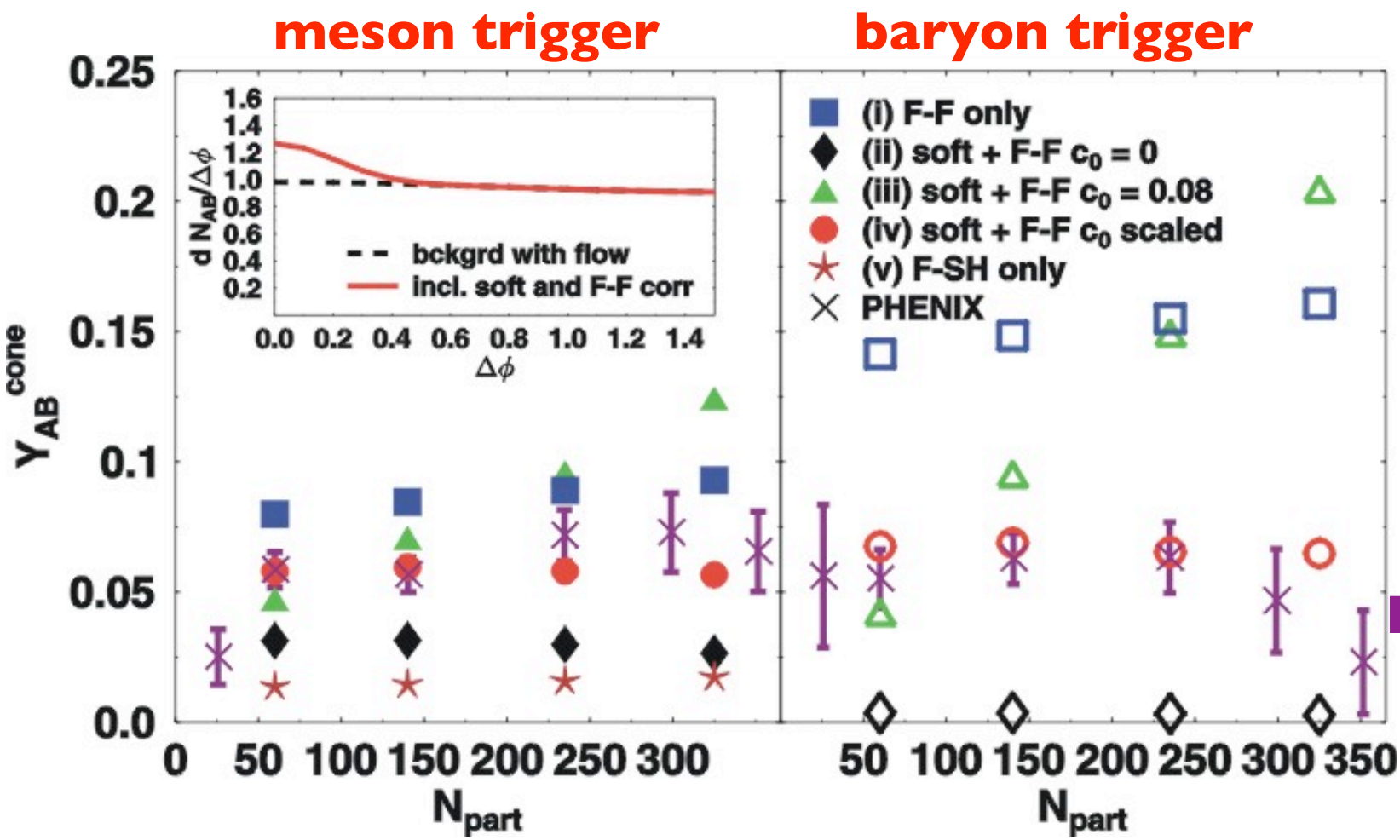
The Future: Better Detectors and More Data

- Run 7 just completed
  - PHENIX took ~5B events, x3 more than Au+Au data shown here
  - TOF West Detector installed
    - 90ps timing resolution, charge particle PID at higher p_T
    - doubles intermediate p_T PID acceptance
    - full azimuthal coverage for identified particle correlations
  - new reaction plane detector will allow more control over medium path length



precision measurements of jet-medium interactions

Recombination Models & Correlations



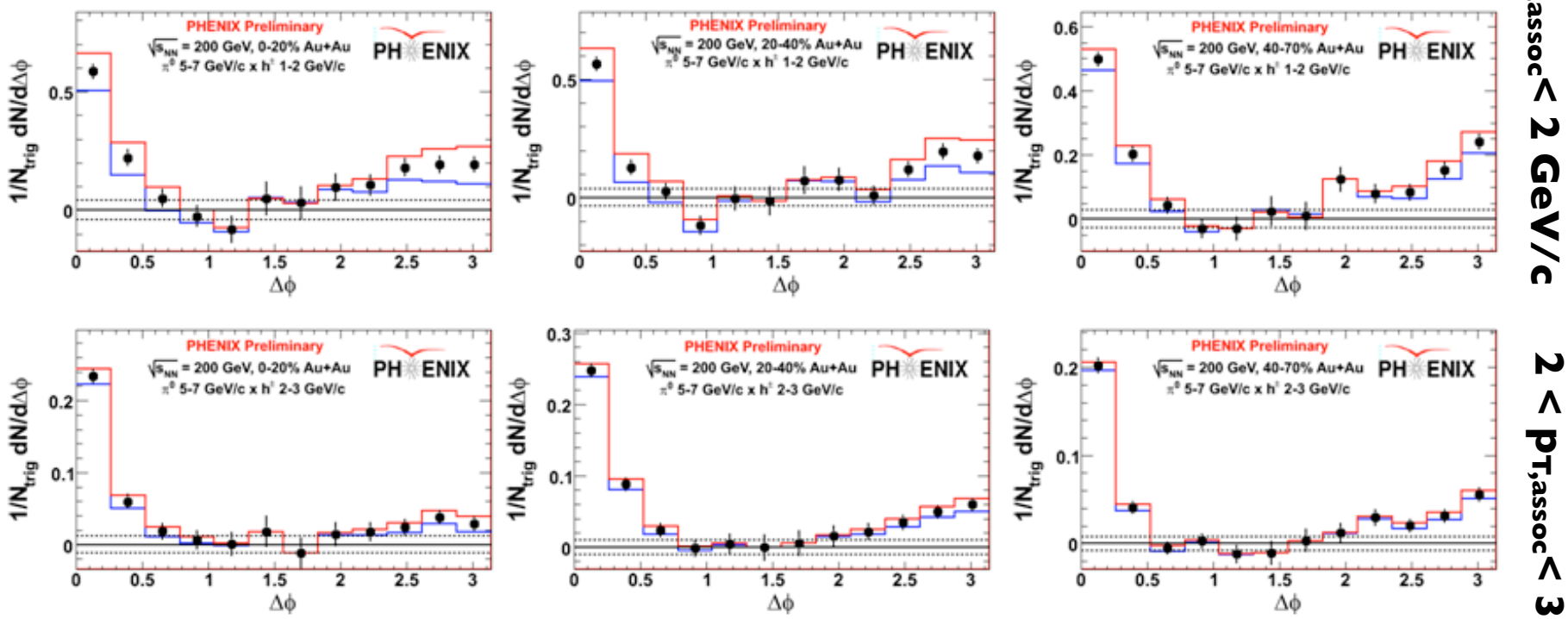
PHENIX, PRC 71 051902

R. Fries, Hard Probes 2006

Au+Au: High p_T

$5 < p_{T,trig} < 7$ GeV/c

0-20% | 20-40% | 40-70%



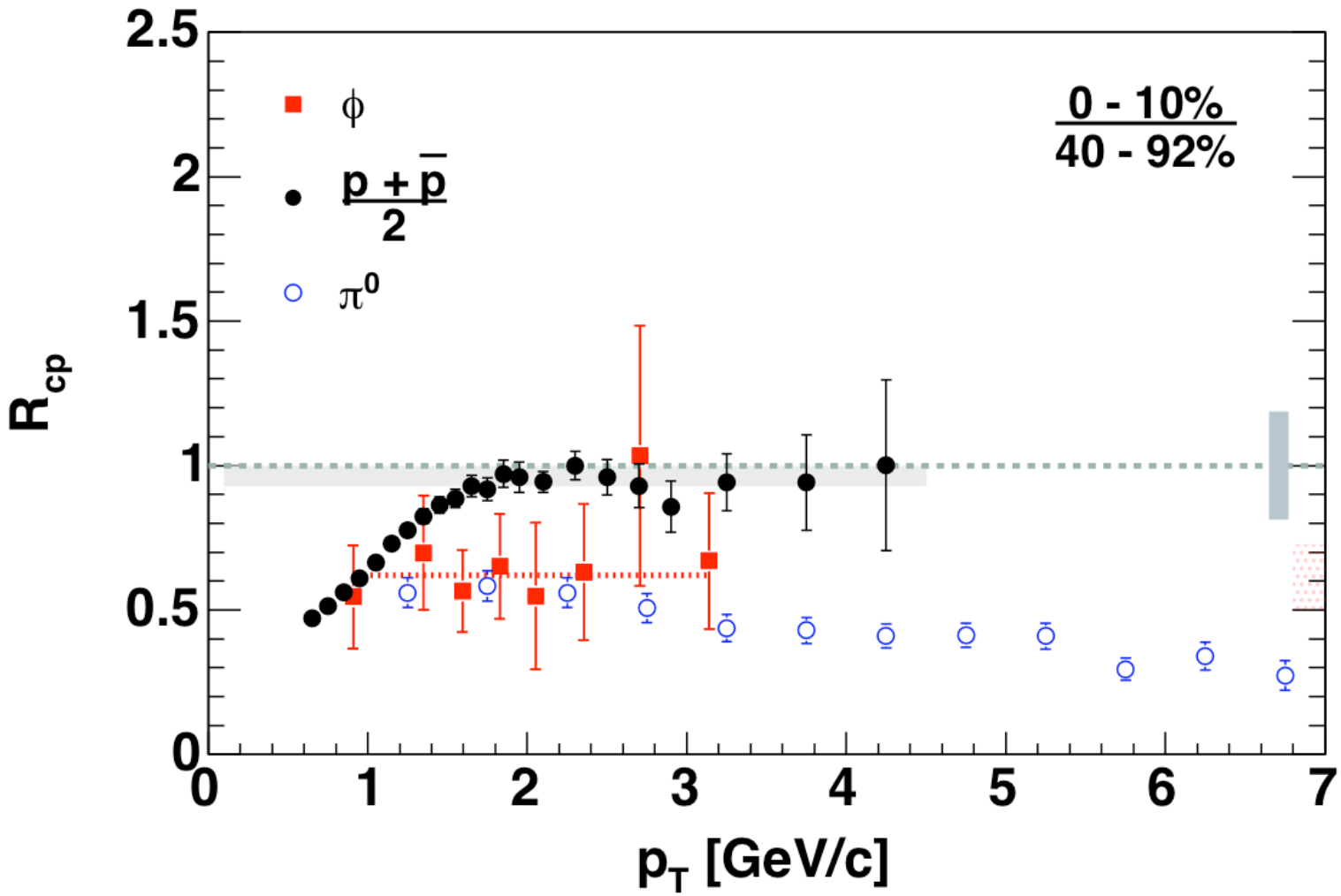
$1 < p_{T,assoc} < 2$ GeV/c

$2 < p_{T,assoc} < 3$ GeV/c

near side yields ~constant over wide centrality range

N. Grau, QM2006

Intermediate p_T: Hadronization



PHENIX PRC 72 014903 (2005)