High-p_T correlations in STAR

What we've learned, and new results

Dan Magestro, The Ohio State University
for the STAR Collaboration

Hard Probes 2004

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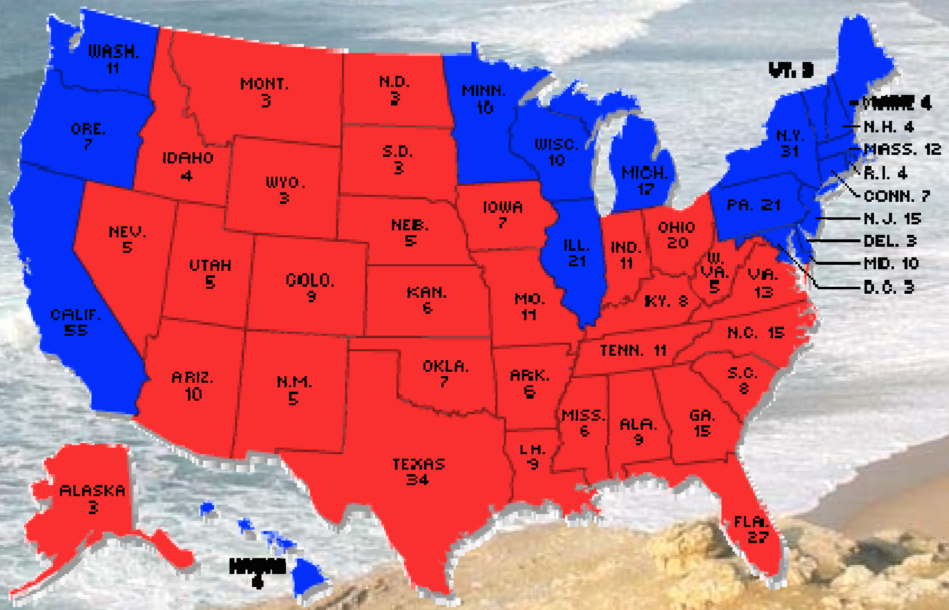

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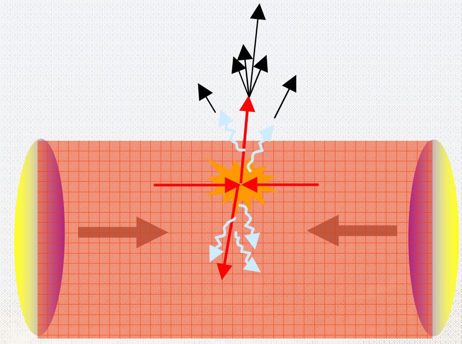
- **What we know from $\Delta\phi$ correlations**
- **Particle-identified $\Delta\phi$ correlations**
- **First results for near-side $\Delta\eta$ correlations**
- **Evidence for medium-induced energy loss**

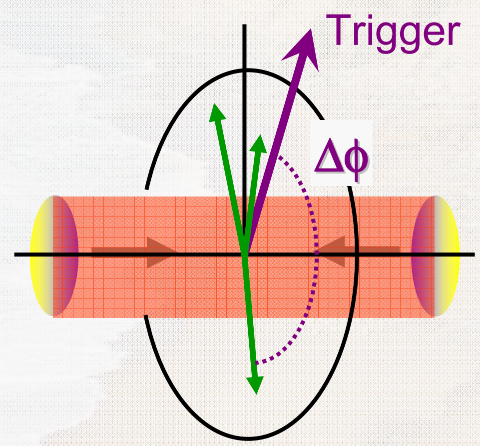
Hard Probes 2004

High p_T correlations in HI collisions

- **Motivation**
  - Extract information about the hard sector in AA by statistical means

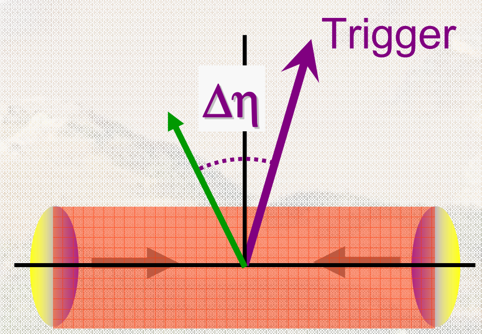
Jets →	production/suppression, modification, flavors, etc.
Event →	early expansion, anisotropy, medium effects, etc.





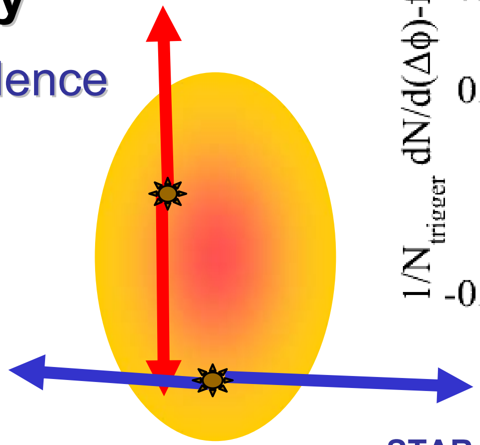
- **General technique**
  - Correlate high-p_T trigger particles with associated particles above given threshold
  - Primary correlation variables: $\Delta\phi$, $\Delta\eta$

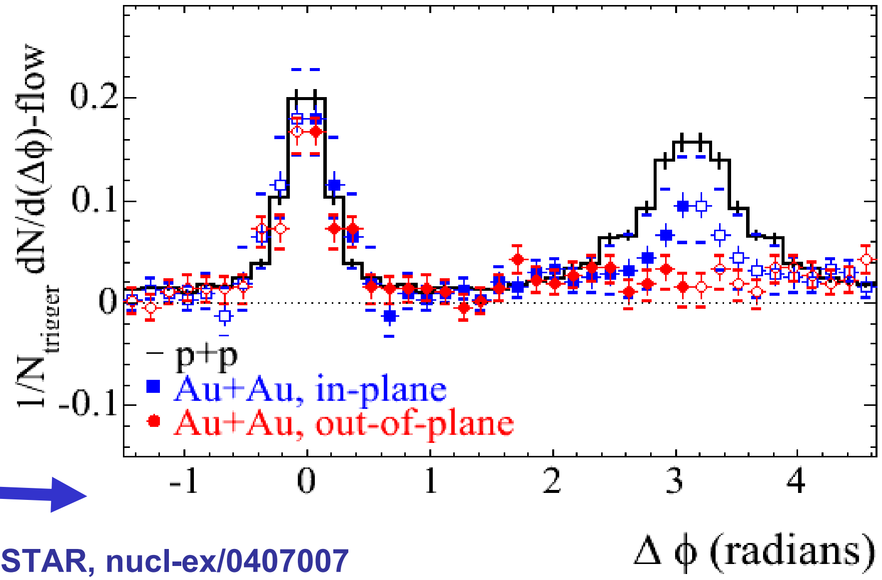
Event wise →	system, centrality, beam energy, reaction plane
Track wise →	trigger & associated particle p_T, flavor, charge sign



Δφ correlations: a solid foundation

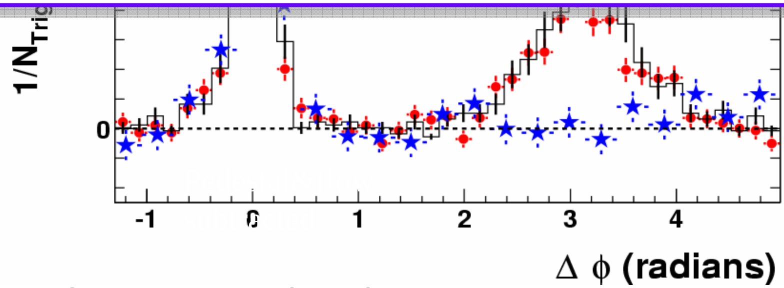
- **New: Amount of suppression sensitive to geometry**
  - Path length dependence of energy loss → jet quenching



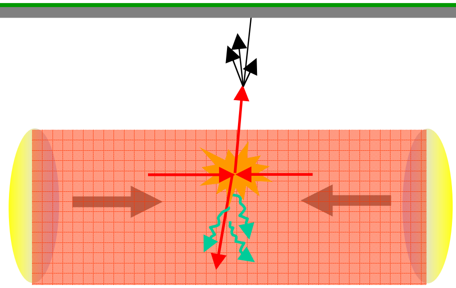


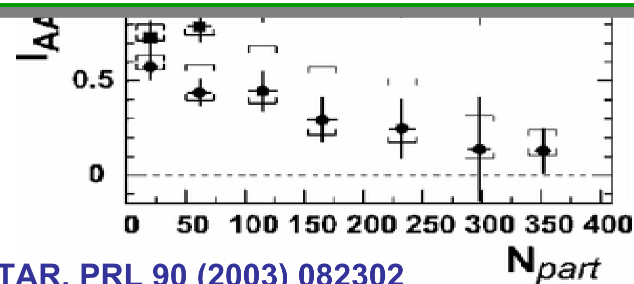
STAR, nucl-ex/0407007

- Fits into jet-quenching picture



STAR, PRL 91 (2003) 072304

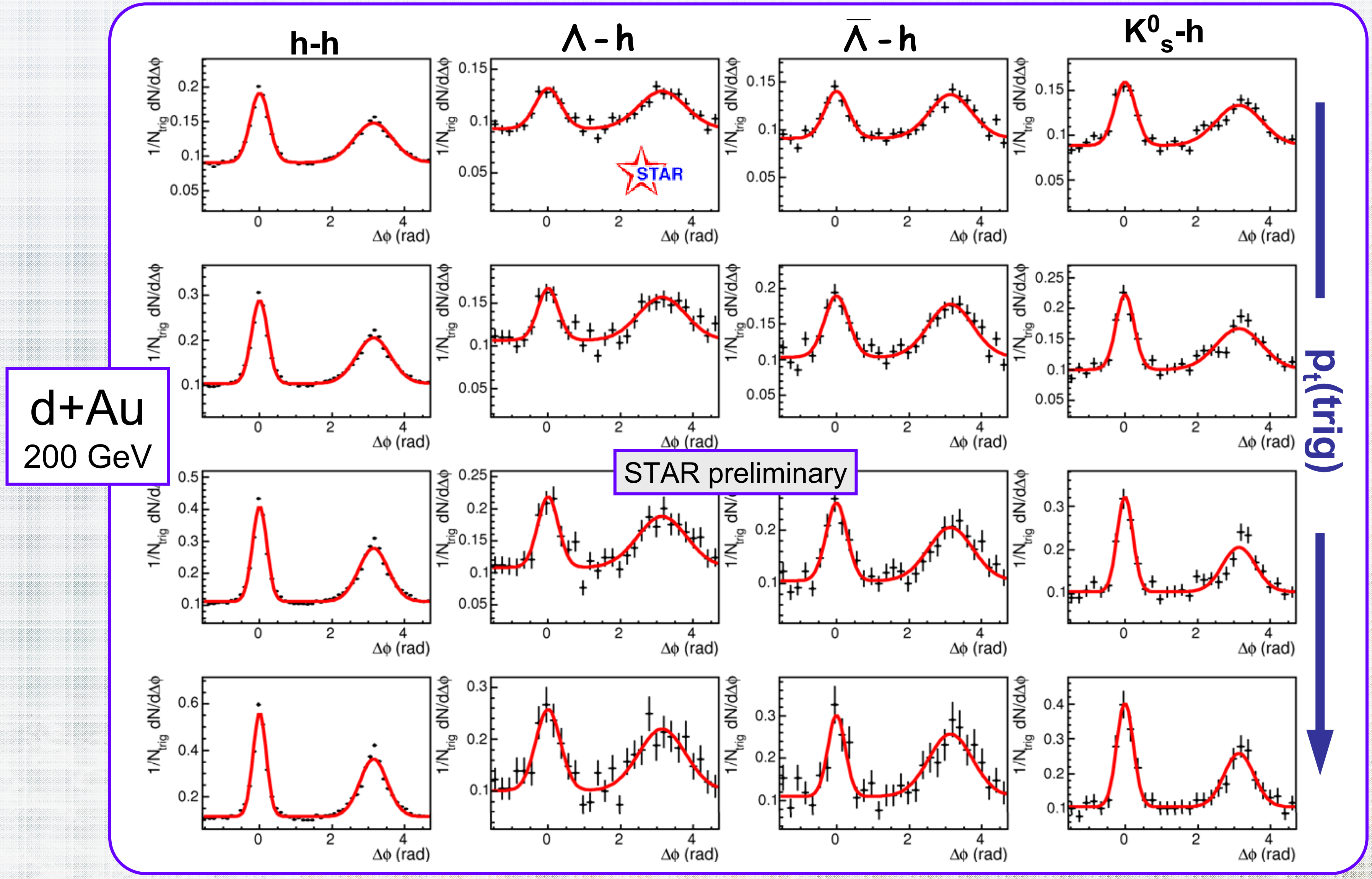




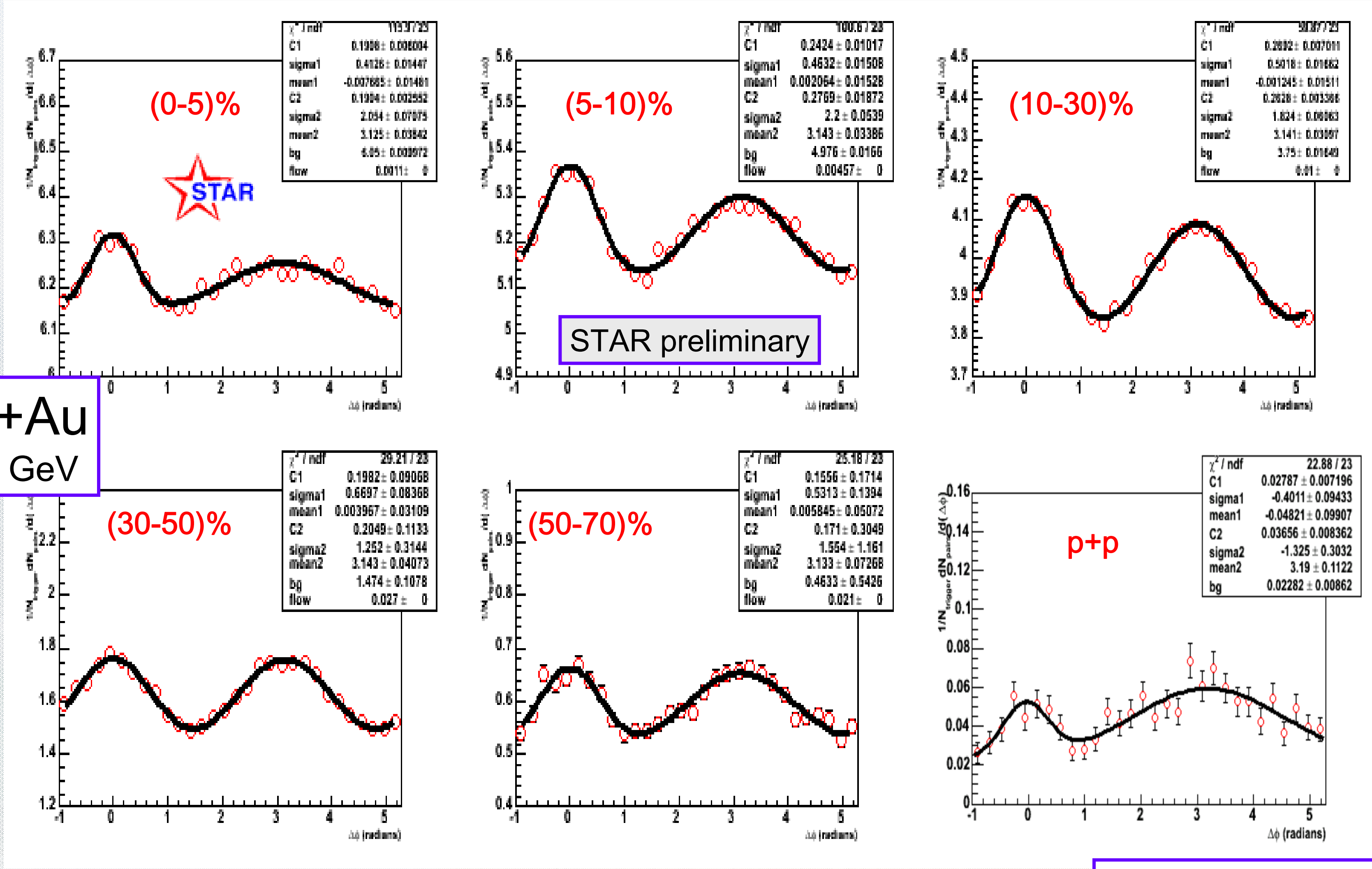
STAR, PRL 90 (2003) 082302

$\Delta\phi$ correlations: flavor dependence - 1

- Systematic studies underway with Λ, K^0_s as trig, assoc. particles



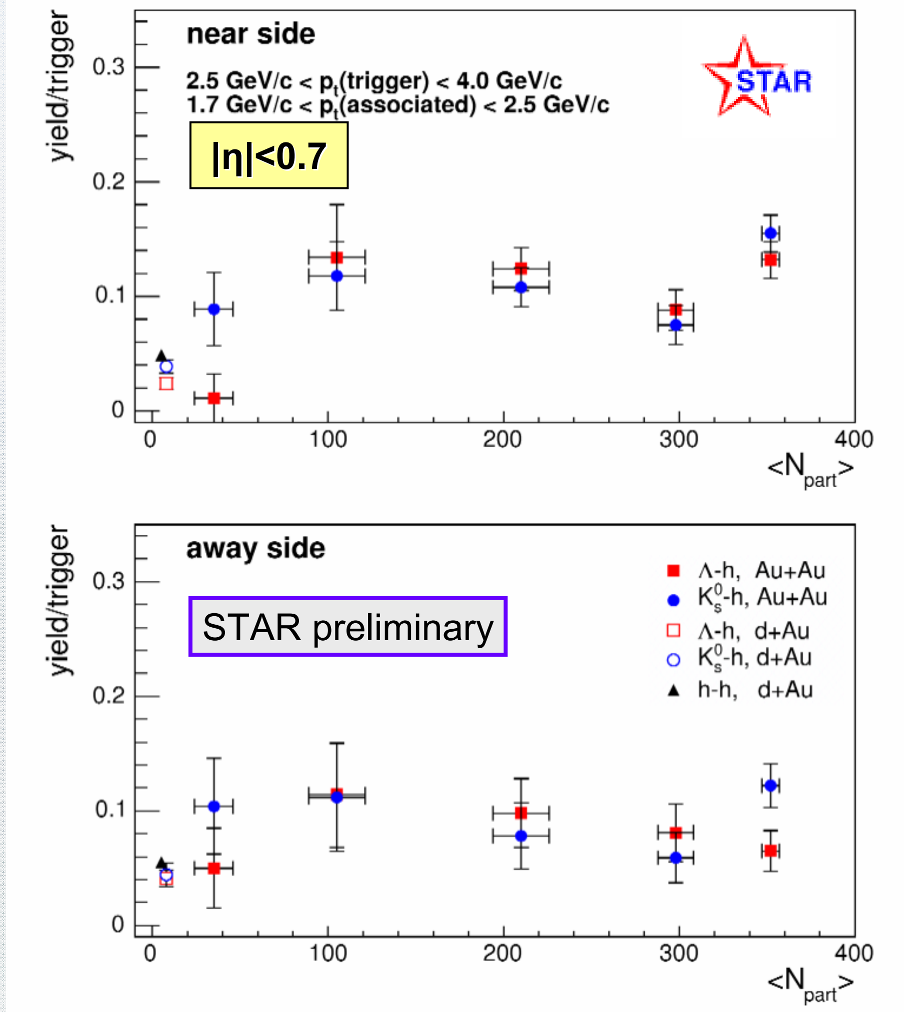
Δφ correlations: flavor dependence - 2

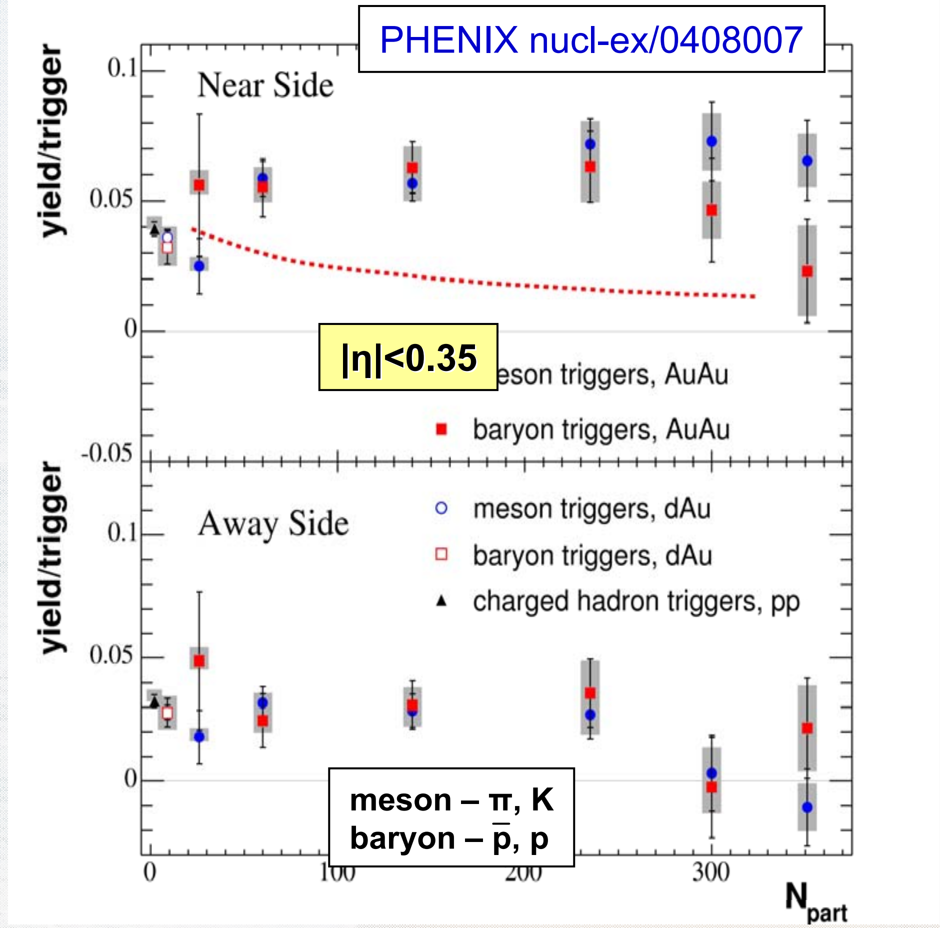


Au+Au
200 GeV

1.5 < p_T(trig) < 3 GeV
1.5 < p_T(assoc) < 3 GeV

STAR vs PHENIX Δϕ correlations in Au+Au

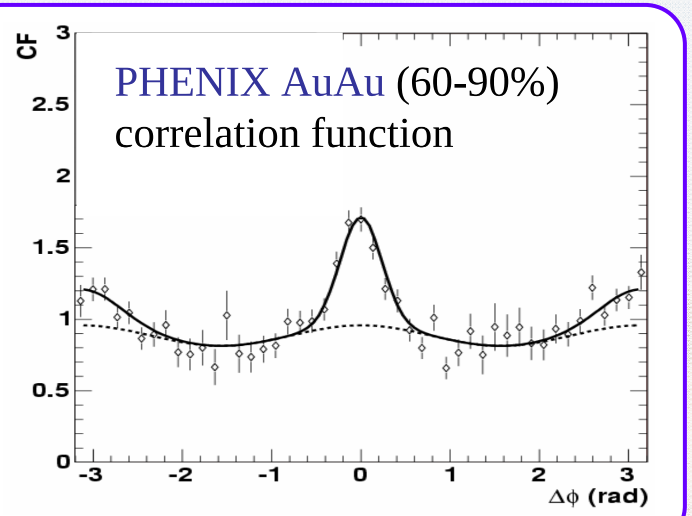




- **Difference in STAR/PHENIX yields due to various |η| windows**
  - Slight increase of the near-side yield in mid-central Au+Au collisions in comparison to p+p and d+Au

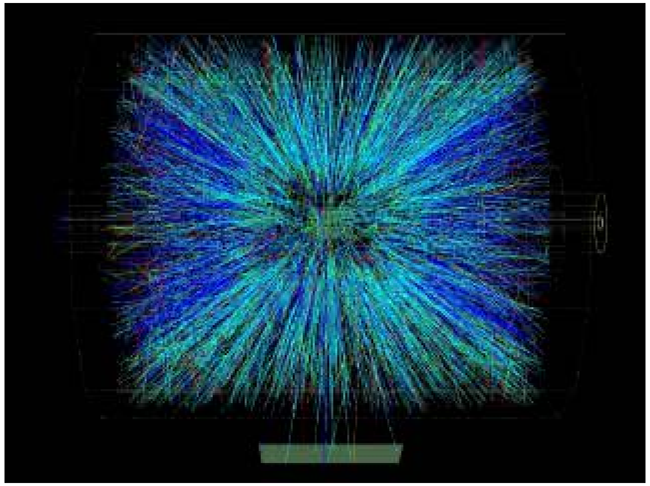
What about Δη correlations?

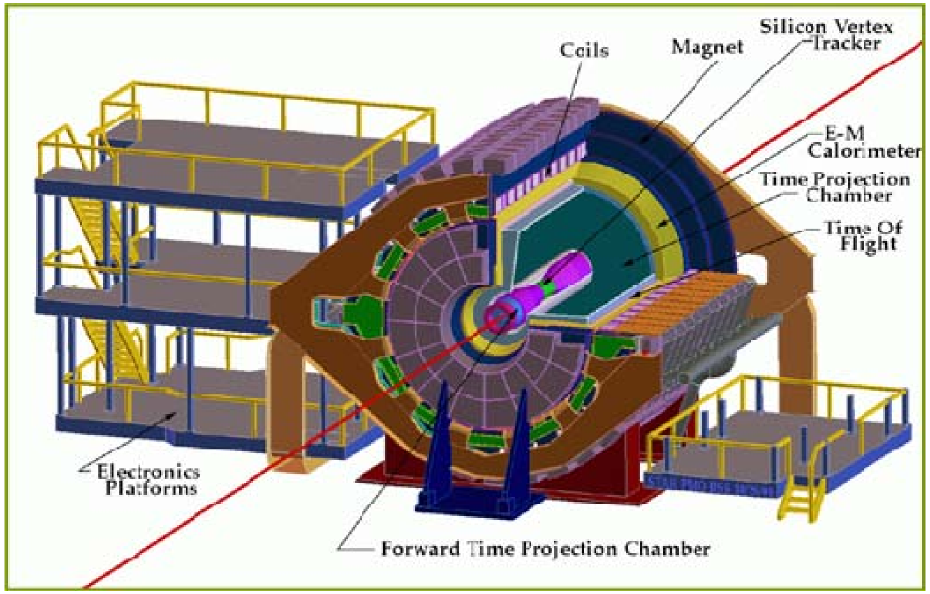
- **Azimuthal correlations hampered by v_2**
  - v2 affects both yield, width determination
  - Background normalization difficult
  - Δη cleaner observable for both



J. Rak, Nuclear Dynamics Workshop, Jamaica

- **STAR → large acceptance enables multi-differential study**





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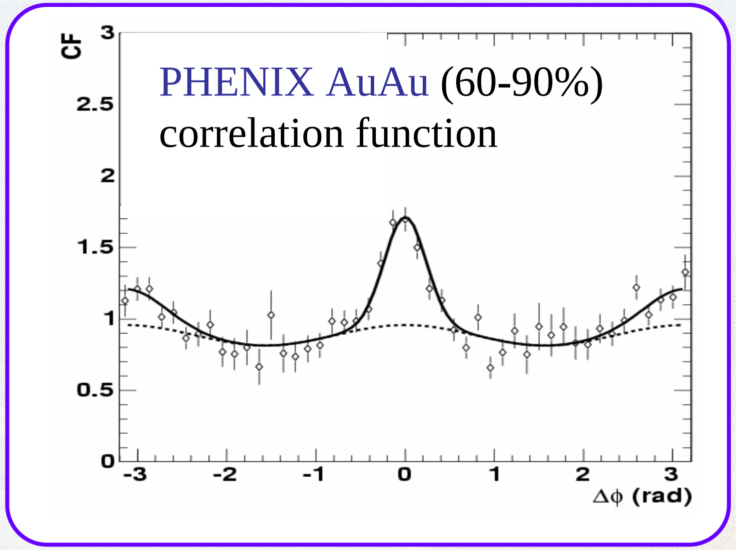
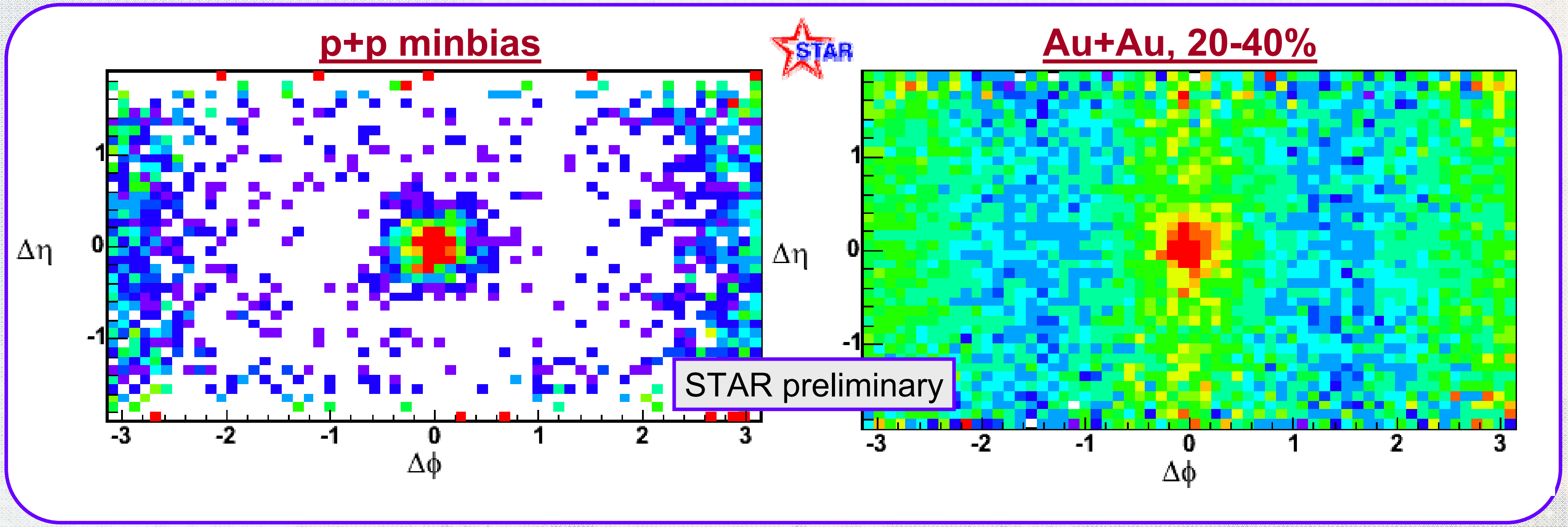


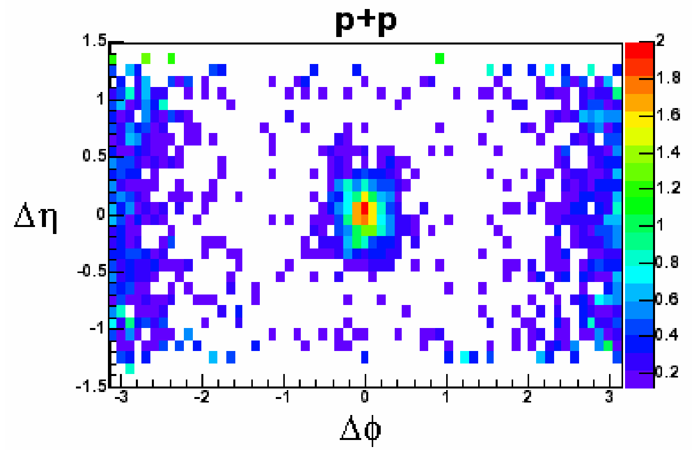
J. Rak, Nuclear Dynamics Workshop, Jamaica



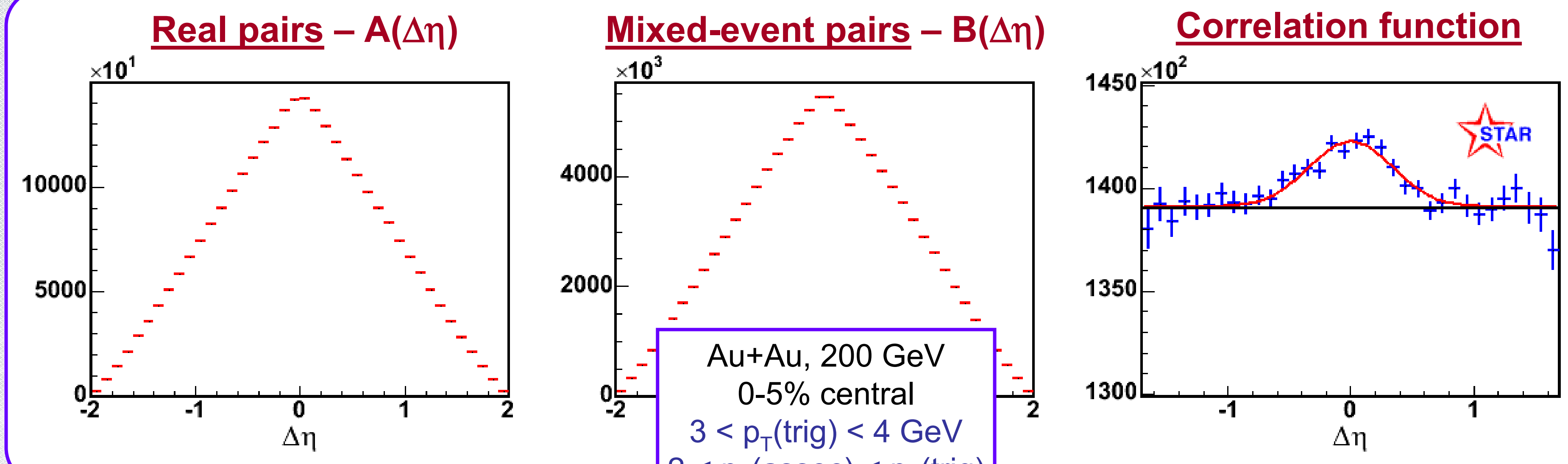
Δη correlations: analysis method

1. **Isolate near-side with window in Δϕ**
2. **Use event-mixing to account for pair acceptance**
3. **Assume Gaussian correlation shape**

$$\frac{A(\Delta\eta)}{B(\Delta\eta)} \propto U + C\exp\left[-(\Delta\eta)^2/2\sigma^2\right]$$

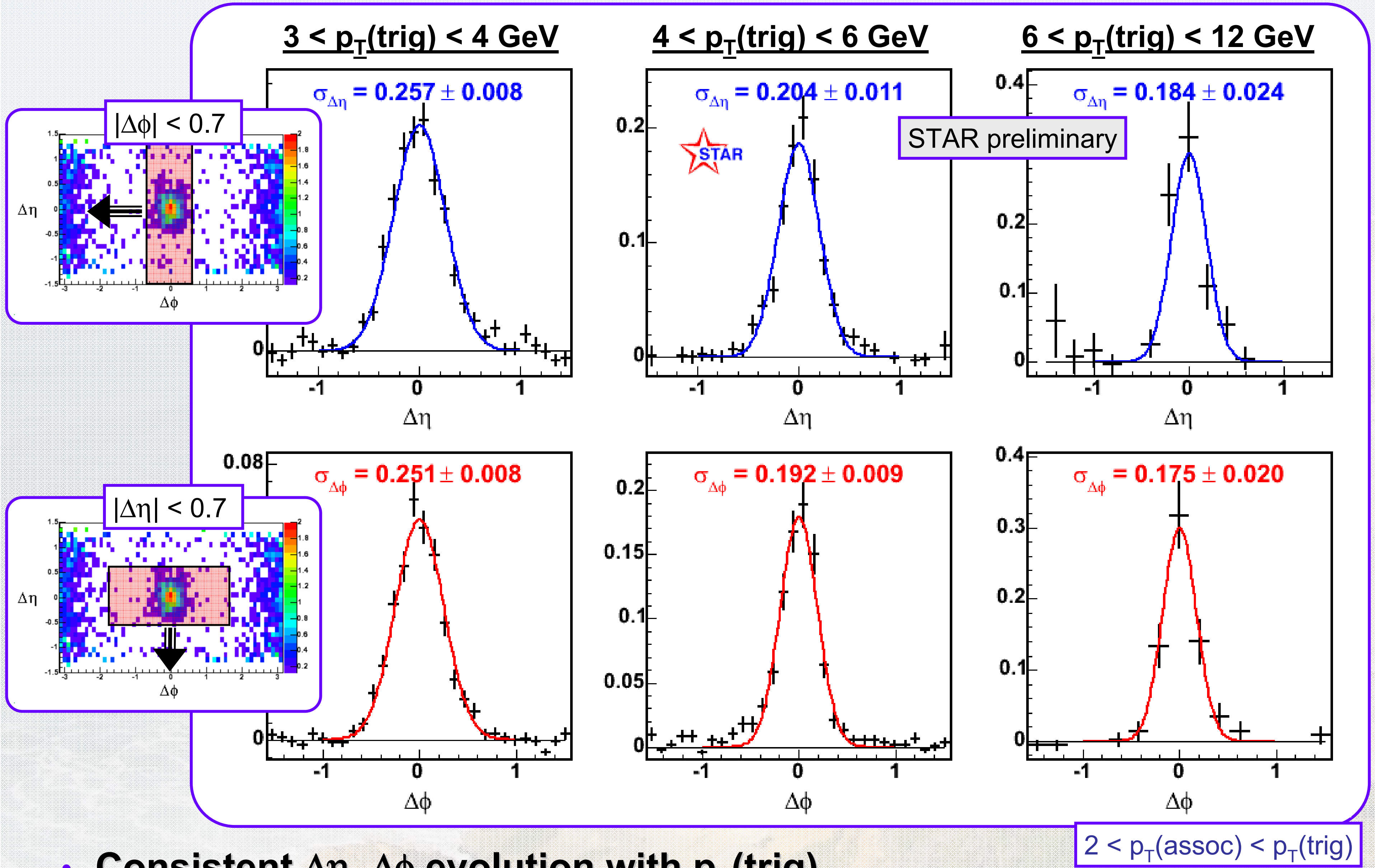


Example



Au+Au, 200 GeV
0-5% central
$3 < p_T(\text{trig}) < 4$ GeV
$2 < p_T(\text{assoc}) < p_T(\text{trig})$
$|\Delta\phi| < 1.0$

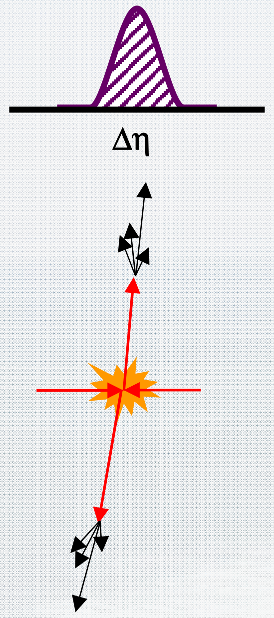
p+p 200 GeV: near-side, Δη vs Δφ



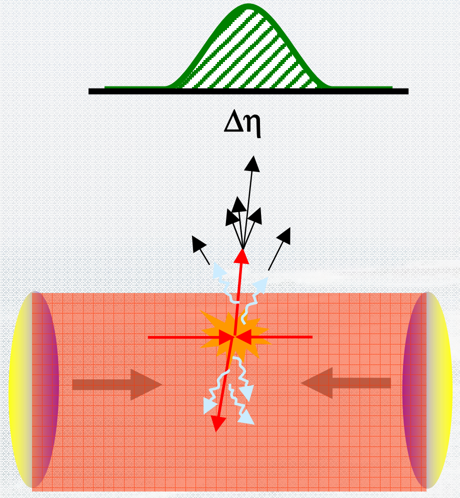
- Consistent Δη, Δφ evolution with p_T(trig)

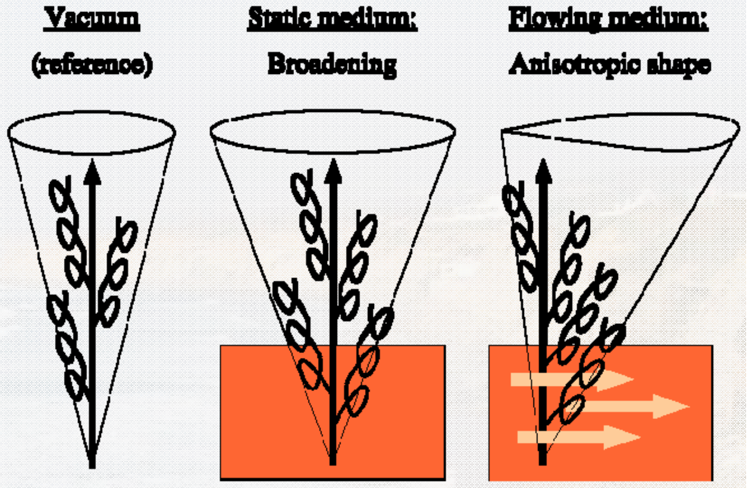
Δη: What do we expect for Au+Au?

p+p



Au+Au central broader?



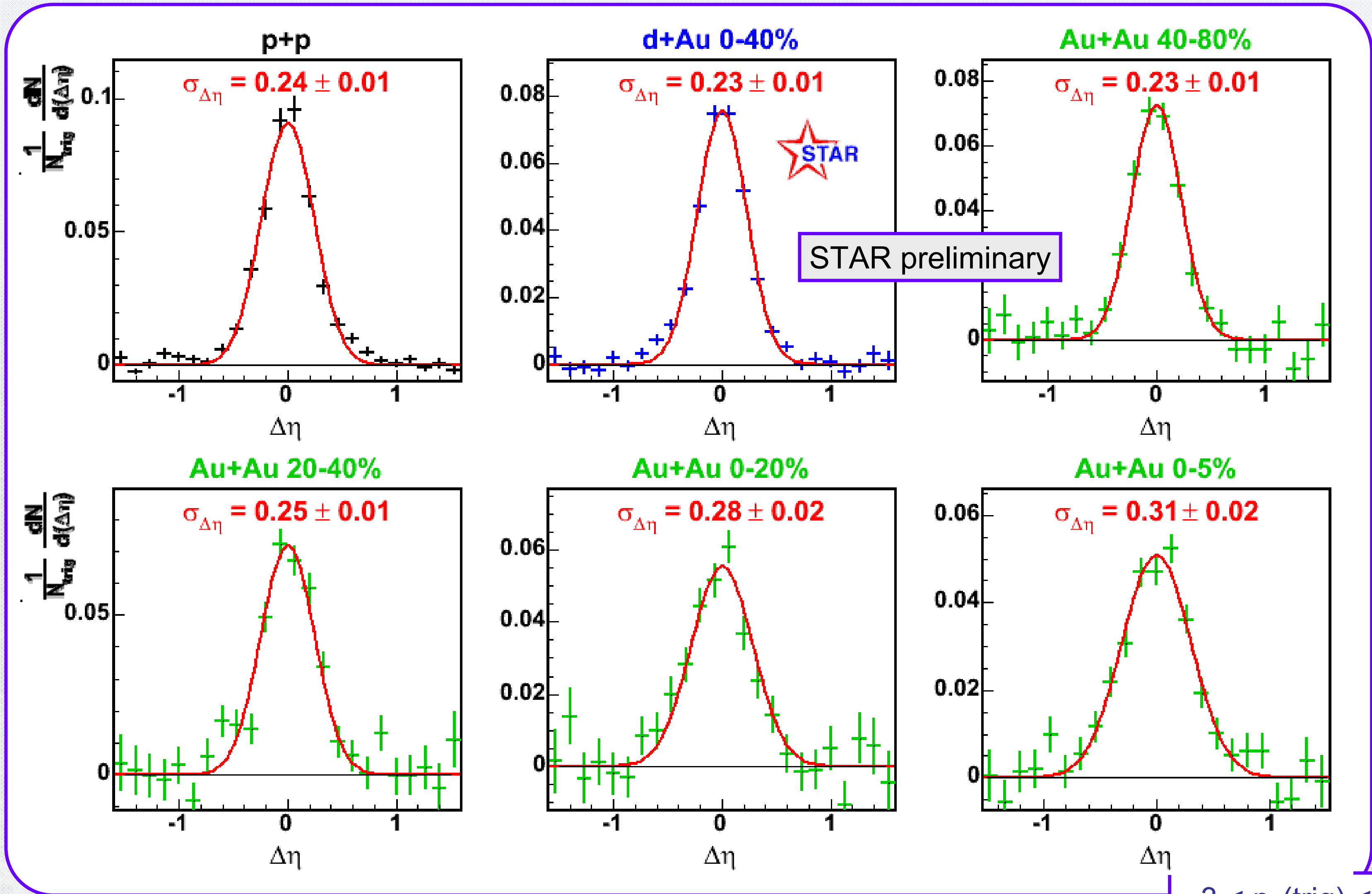


Armesto et al, nucl-ex/0405301

- p_T(trig) dependence of near-side peak due to less well-defined jet axis

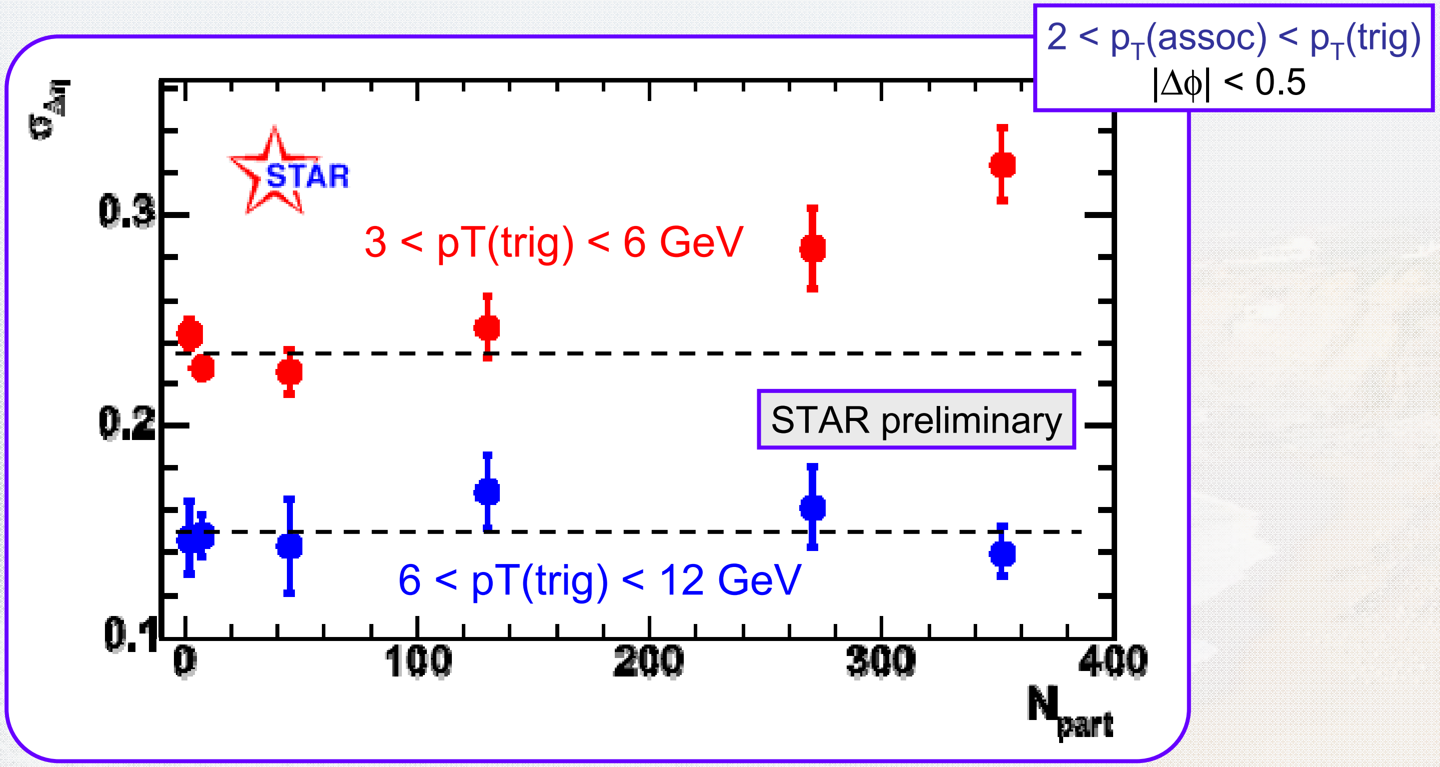
- Medium causes apparent “stretching” of jet cone along boost direction?
- Radiated gluons in the medium yield a broader jet cone?
- Would p_T(assoc) threshold cut away yield from radiated gluons?

$\Delta\eta$: system, centrality dependence at 200 GeV



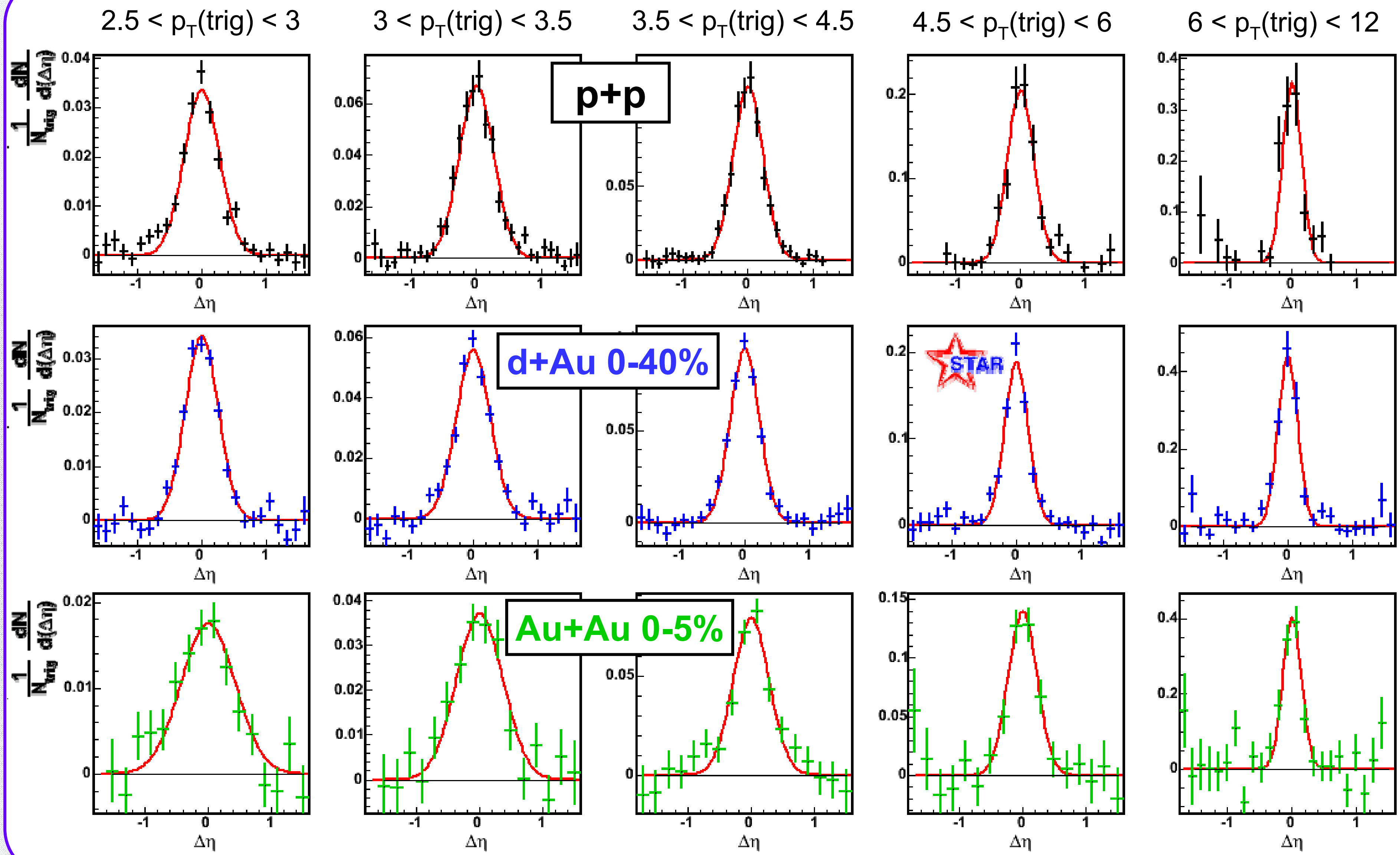
$3 < p_T(\text{trig}) < 6$ GeV
$2 < p_T(\text{assoc}) < p_T(\text{trig})$
$|\Delta\phi| < 0.5$

$\Delta\eta$: system, centrality dependence at 200 GeV



- $\sigma_{\Delta\eta}$ **increases from p+p to central Au+Au at lower p_T(trig)**
  - Higher p_T(trig) flat across all centralities
  - Systematic error not assigned (fit range, $\Delta\phi$ projection window)

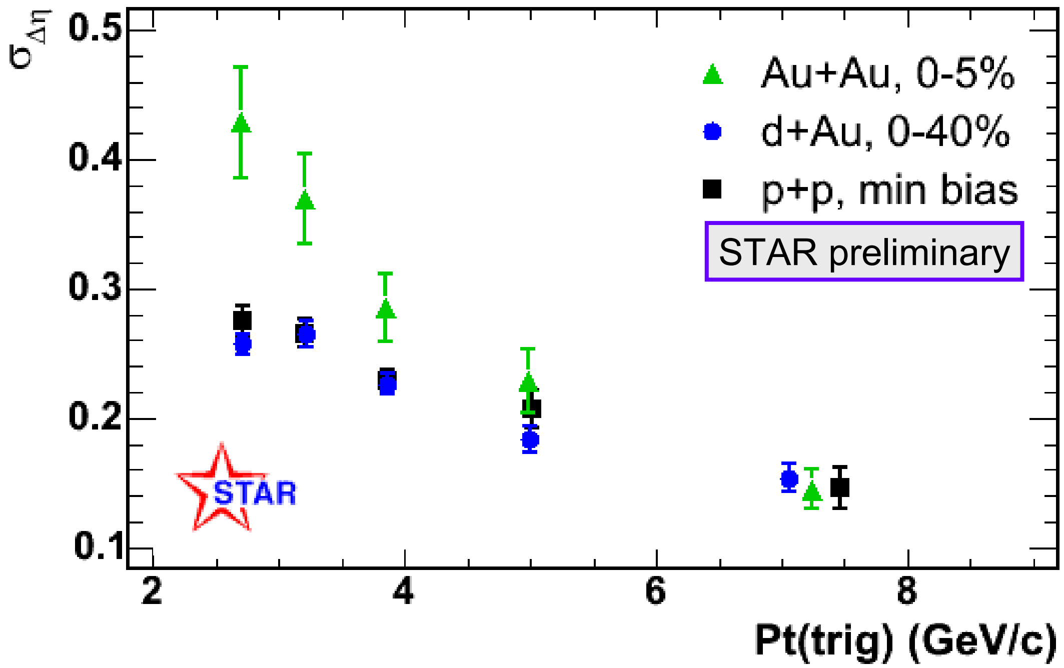
$\Delta\eta$: p_T(trig) dependence



2 < p_T(assoc) < p_T(trig)
$|\Delta\phi|$ < 0.7

STAR preliminary

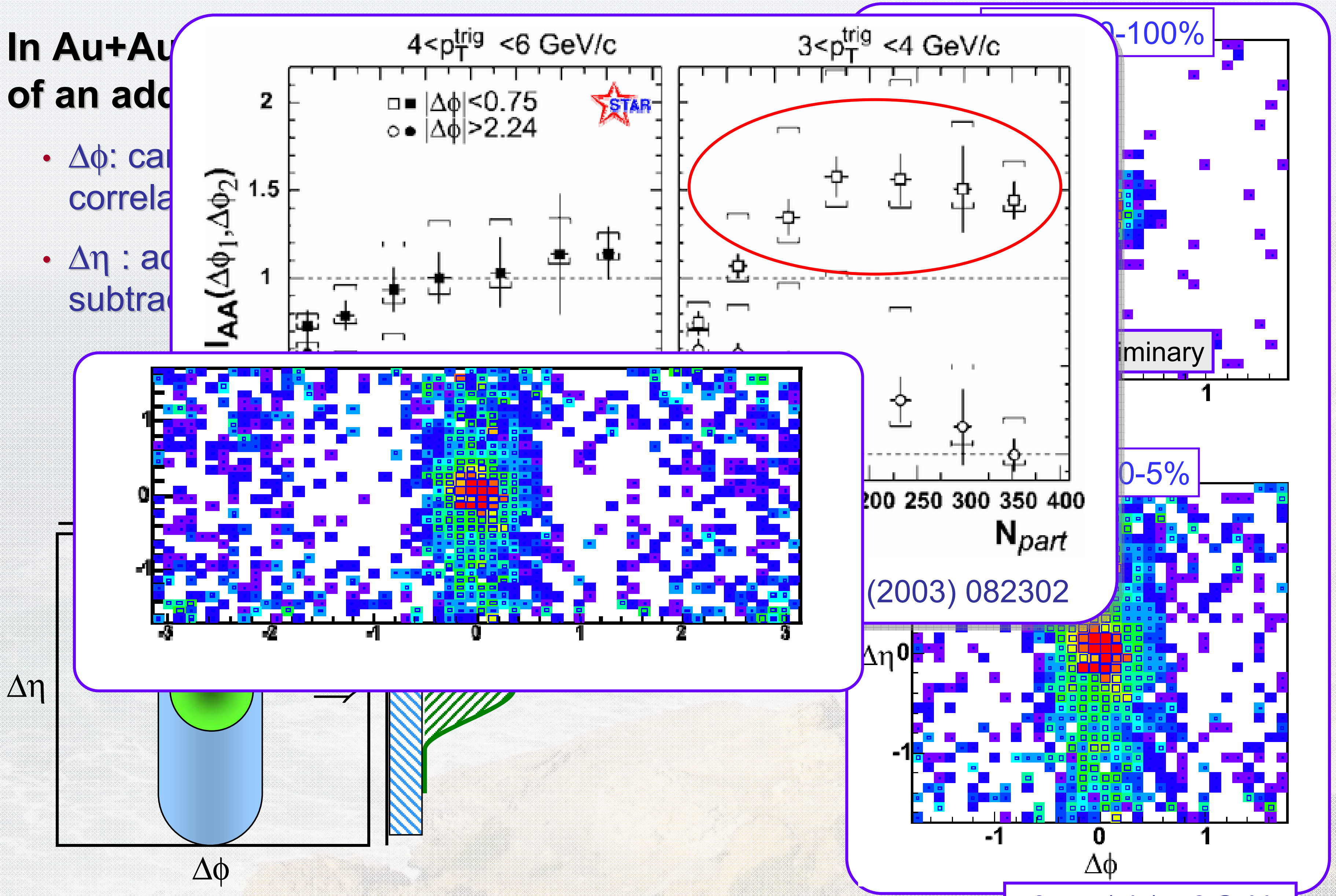
$\Delta\eta$: p_T(trig) dependence of width



- **Broadening in Au+Au compared to p+p, d+Au**
  - Difference grows with decreasing p_T(trig)
  - The three systems are consistent for largest p_T(trig) bin [$6<p_T<12$ GeV]
  - Systematic error not assigned (fit range, $\Delta\phi$ projection window)

Extracting near-side jet yields - 1

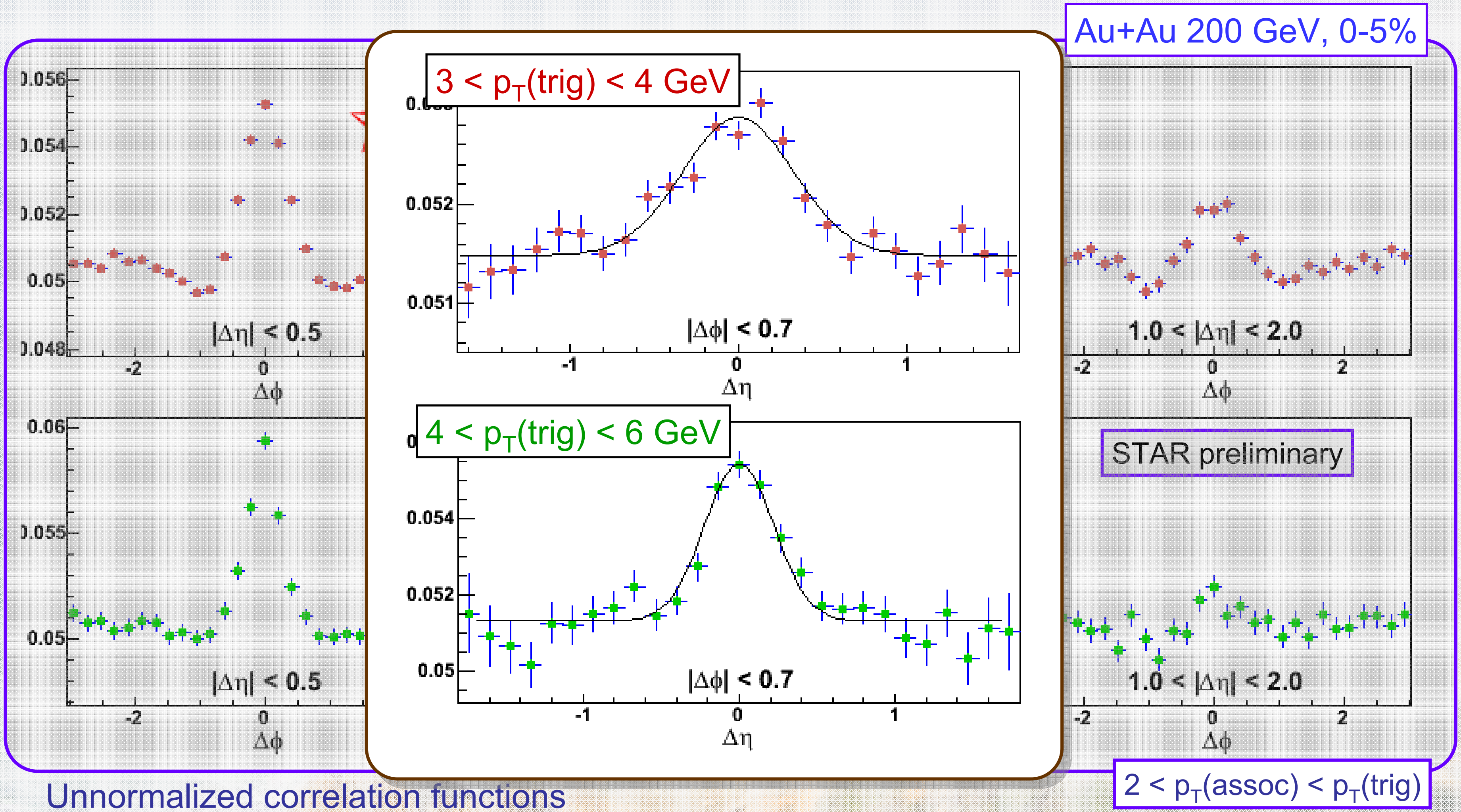
- **In Au+Au ... of an add...**
  - Δφ: ca... correla...
  - Δη : ad... subtrac...



3 < p_T(trig) < 6 GeV
2 < p_T(assoc) < p_T(trig)

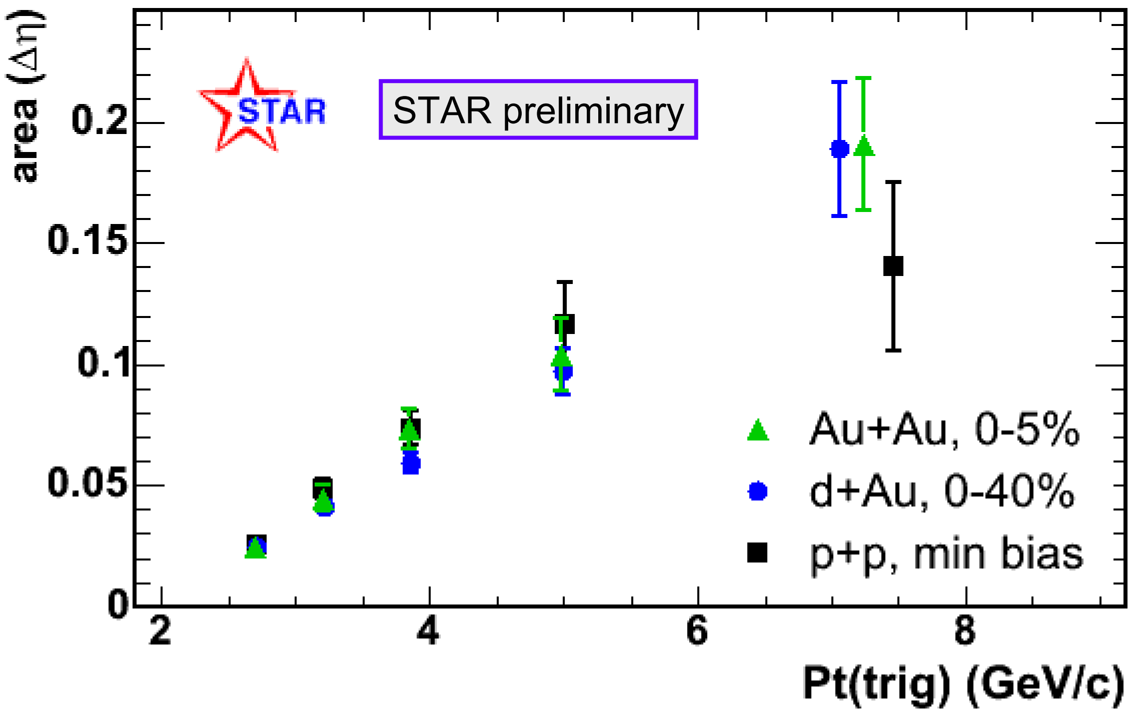
Extracting near-side jet yields - 2

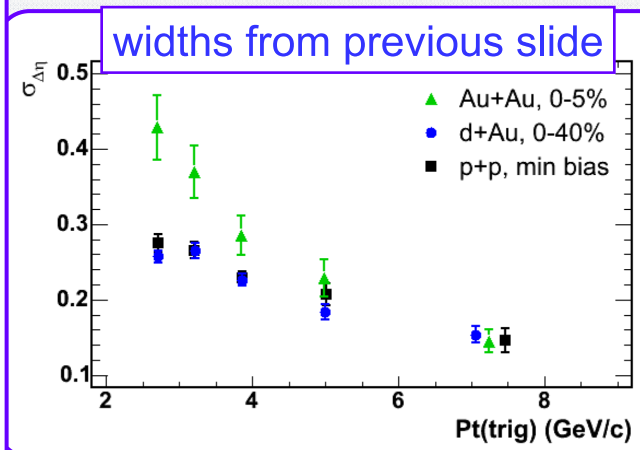
- **Underlying correlation in $\Delta\eta$ persists at higher p_T(trig)**
  - $\Delta\phi$ studies include this additional yield (amount depends on $\Delta\eta$ window)



Unnormalized correlation functions

$\Delta\eta$: p_T(trig) dependence of correlated yield

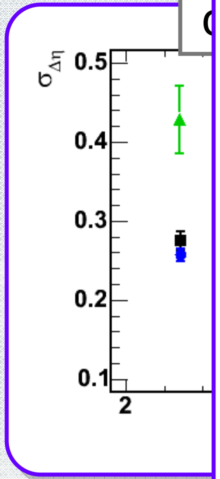




- **Gaussian areas consistent within errors for all p_T(trig)**
  - Yield growth with p_T(trig) → more assoc. particles for higher-p_T parton
  - Correlation yield preserved despite broadening of correlation

Δη : Scenarios - 1

- **Widths inc** ... **tion?**
  - Onset p ... R_{AA})
  - Interme ... n, correlations
  - Higher p ... nucl-ex/0407102



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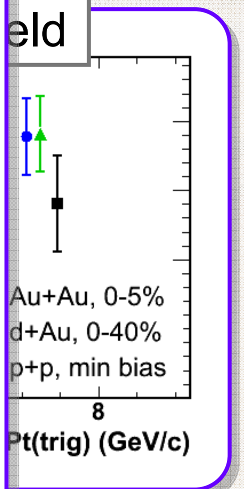

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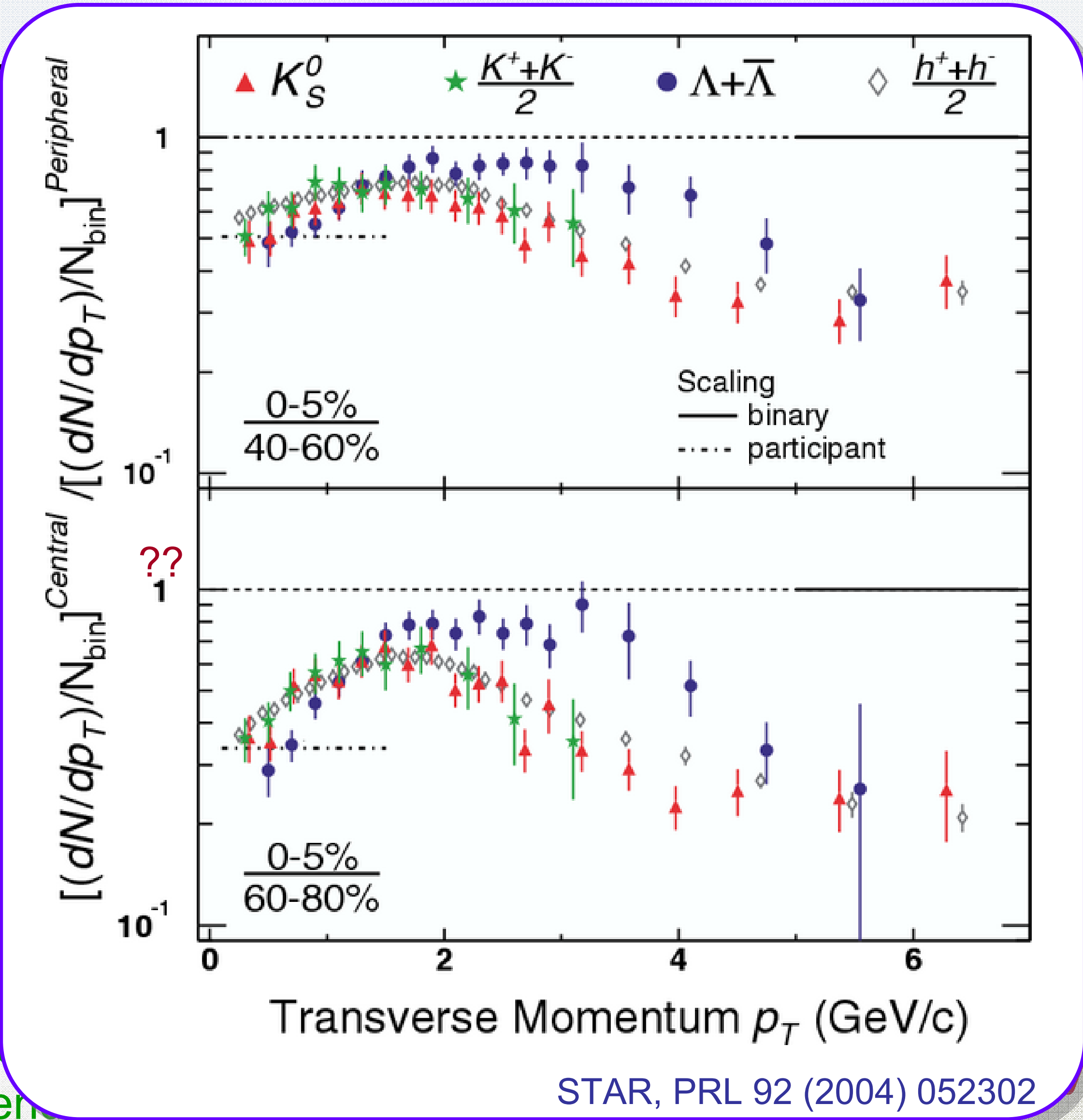
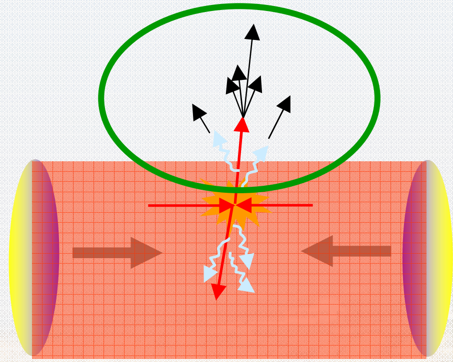


STAR, PRL 92 (2004) 052302

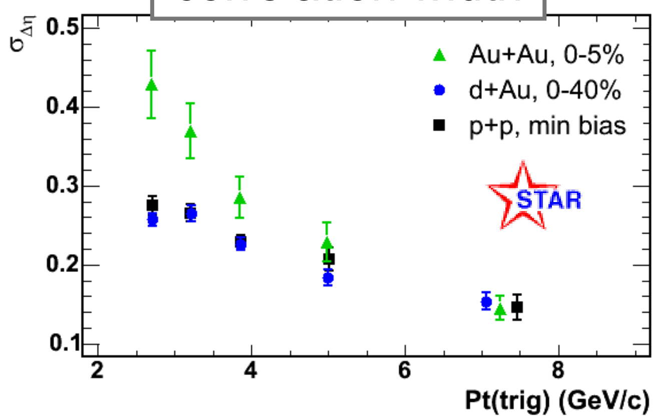
Δη : Scenarios - 2

- **#2: Parton <u>radiates energy</u> before fragmenting?**
  - Gluon bremmstrahlung of hard-scattered parton
  - Parton shifted to lower pT
  - Radiated gluon contributes to broadening

Armesto et al, nucl-ex/0405301
(Talk: Parallel 2B, 17:10)

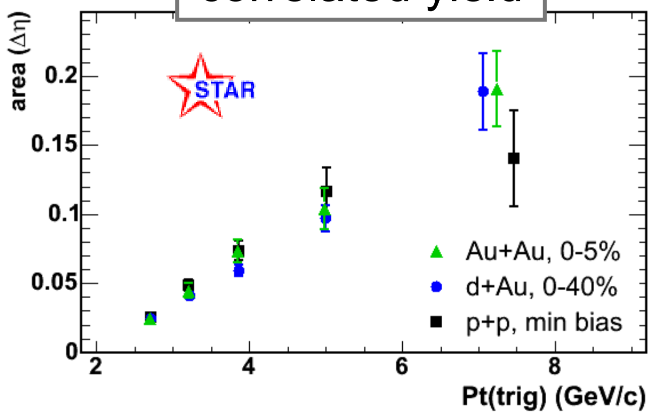


correlation width



✓ could increase width in Au+Au, shift partons to lower p_T

correlated yield



✘ if so, should also cause growth in correlated yield

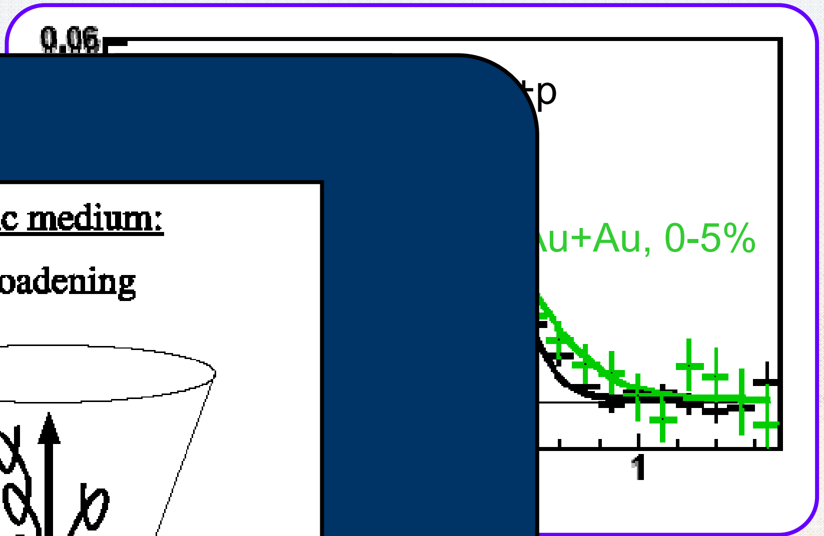
Conclusions

Experimental observations

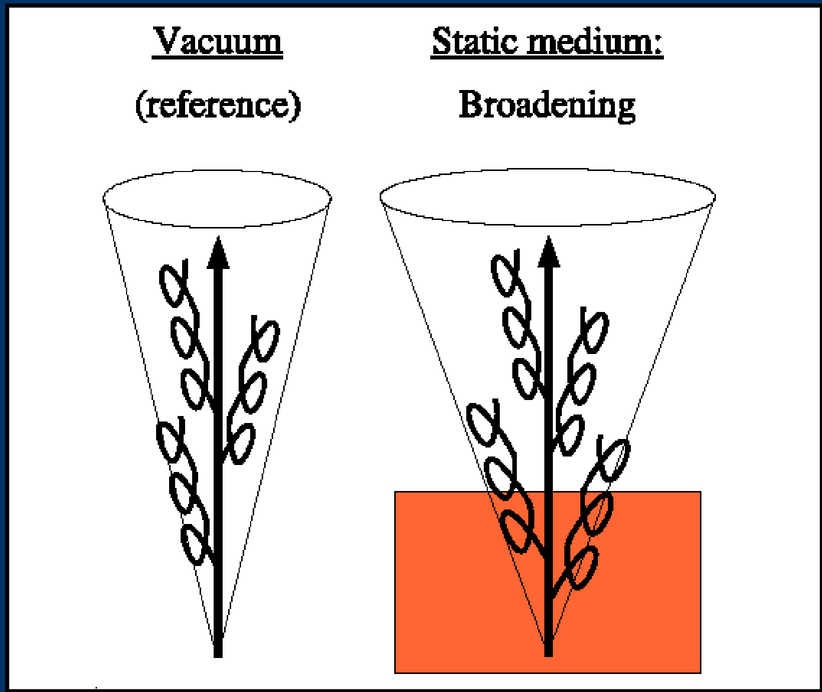
- **Back-to-back $\Delta\phi$ correlations**
  - Suppression of away-side jet → jet quenching picture
  - Suppression dependent on reaction plane orientation
  - No strong flavor dependence at intermediate p_T observed
- **Near-side $\Delta\eta$ correlations**
  - Evidence for near-side jet broadening in central Au+Au
  - Consistent near-side yields for p+p, d+Au, Au+Au at all p_T(trig)
  - p_T(trig) dependence: possible onset of fragmentation dominance ?
  - Underlying, ~flat correlation structure in Au+Au across wide $\Delta\eta$ range

New questions for theorists

- **What ca… quench…**
  - Possi… jet in A… in corr…

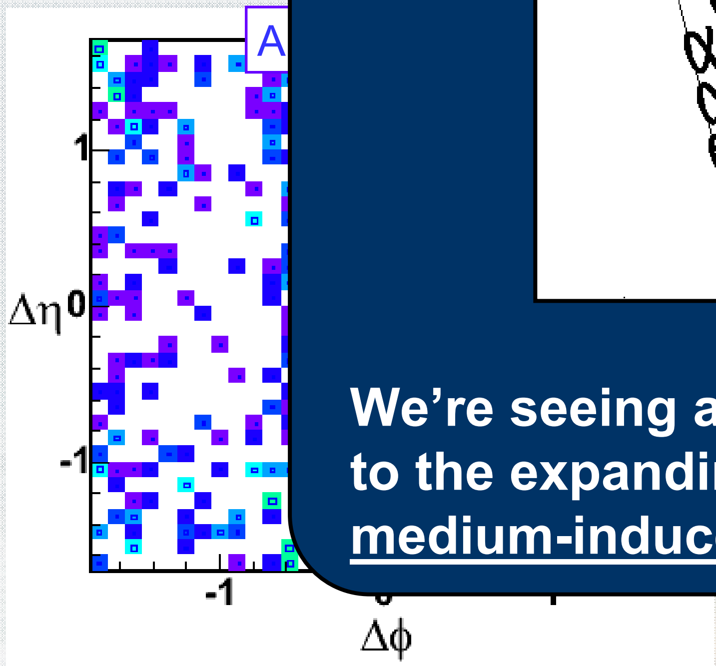


- **My feeling is…**



Armesto et al, nucl-ex/0405301

We're seeing a <u>direct effect</u> of the jet coupling to the expanding medium, i.e. the effect of <u>medium-induced energy loss</u> on the jet



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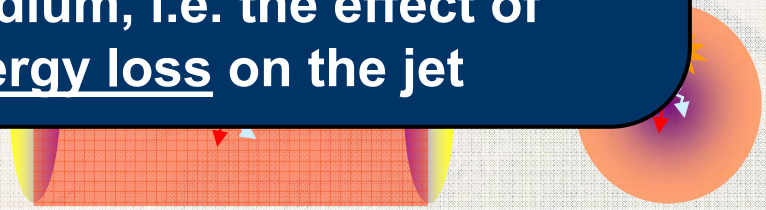
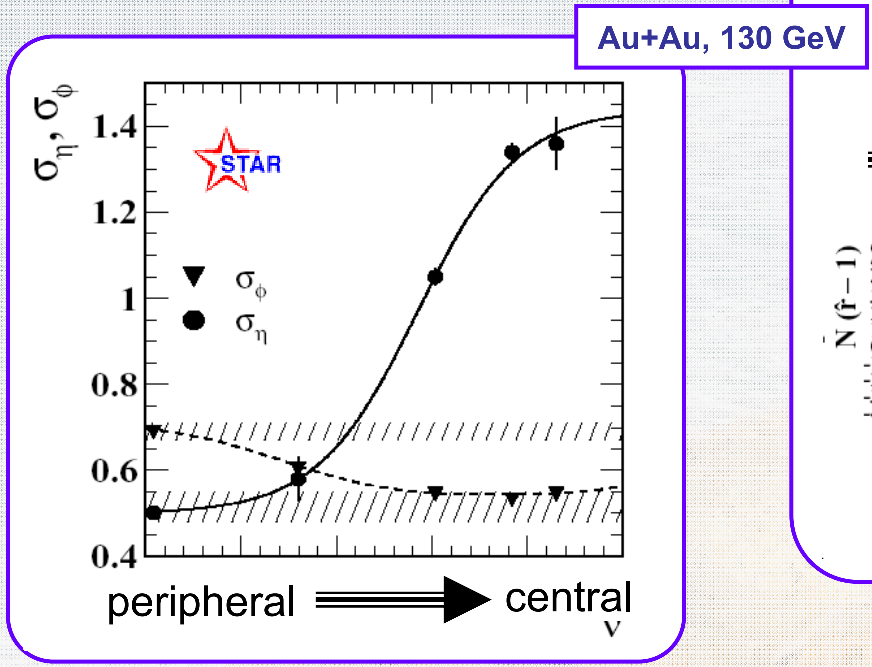
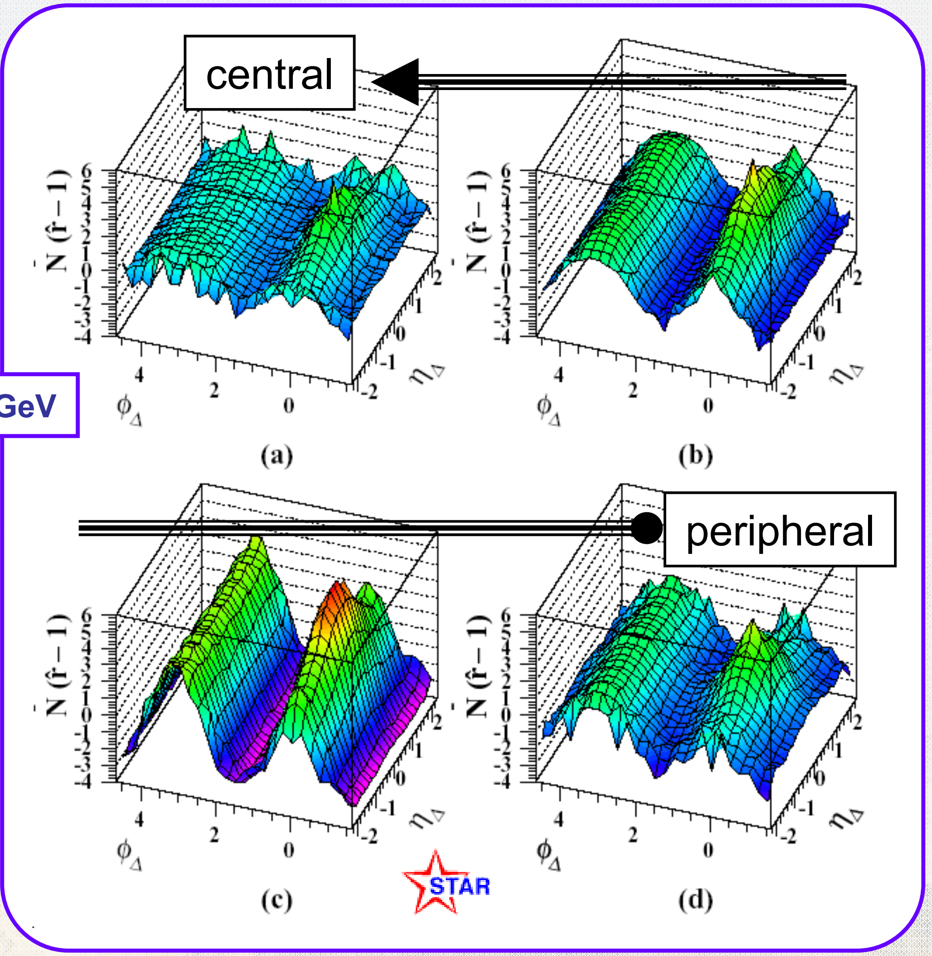


BACK-UPS

In the soft sector...

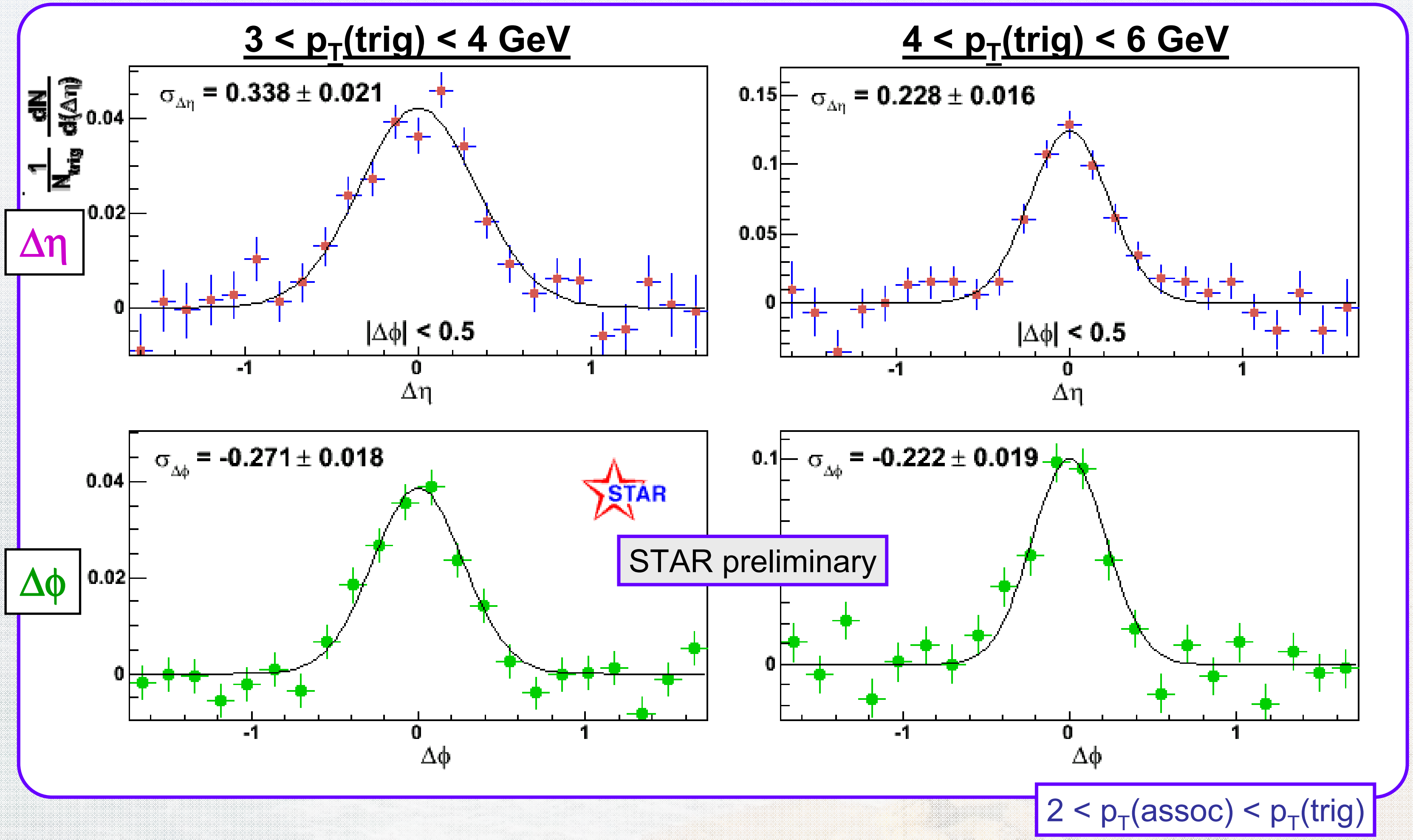
- ($\Delta\eta$, $\Delta\phi$) space for low p_T (< 2 GeV) studied extensively in STAR
  - Broadening of near-side $\Delta\eta$ distribution in central Au+Au attributed to mini-jets
  - Evidence for longitudinal expansion
  - $\Delta\phi$ width decreases slightly from peripheral to central





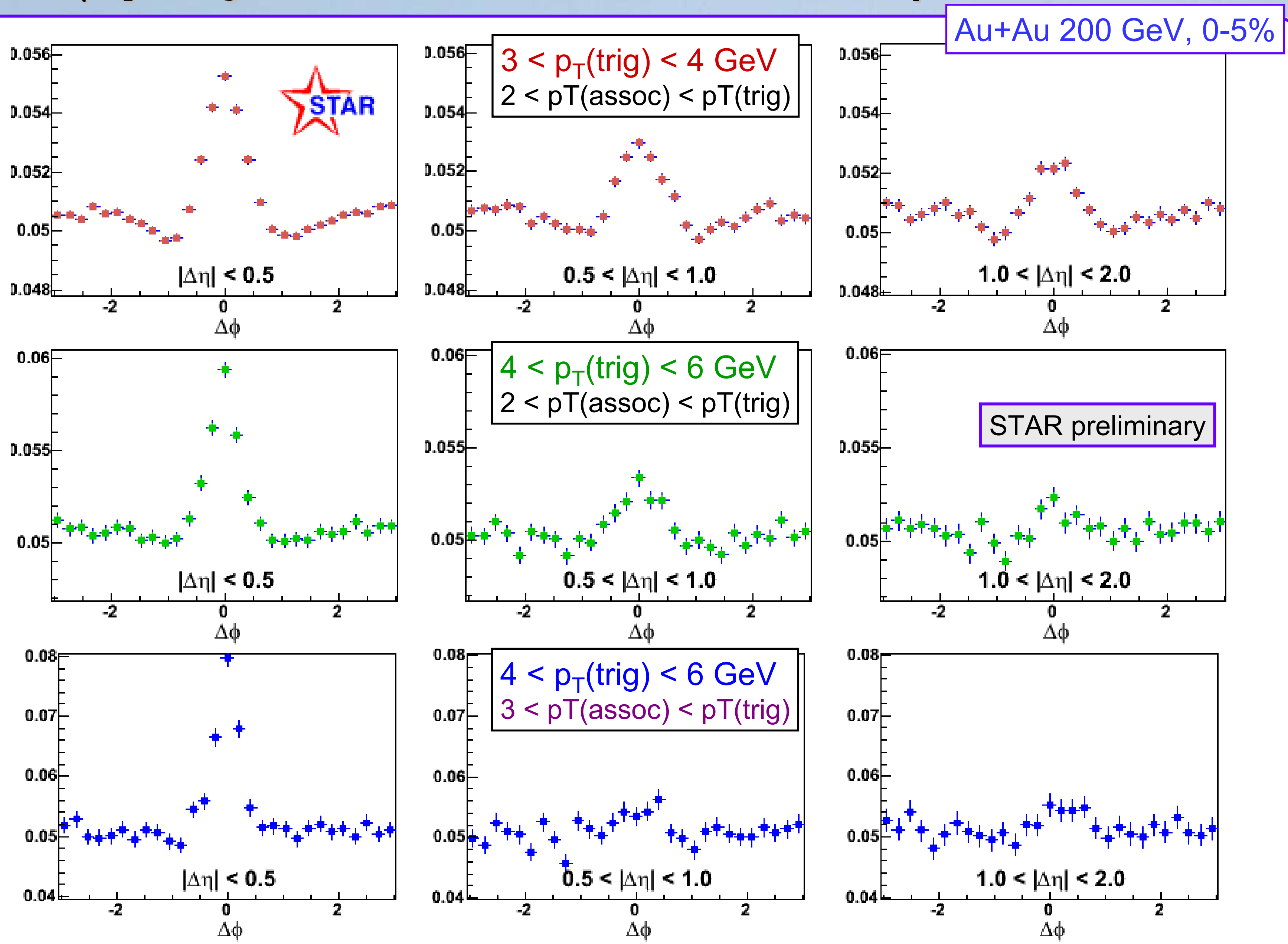
STAR, nucl-ex/0411003, submitted to PRL

$\Delta\eta$ vs $\Delta\phi$ in central Au+Au (0-5%)

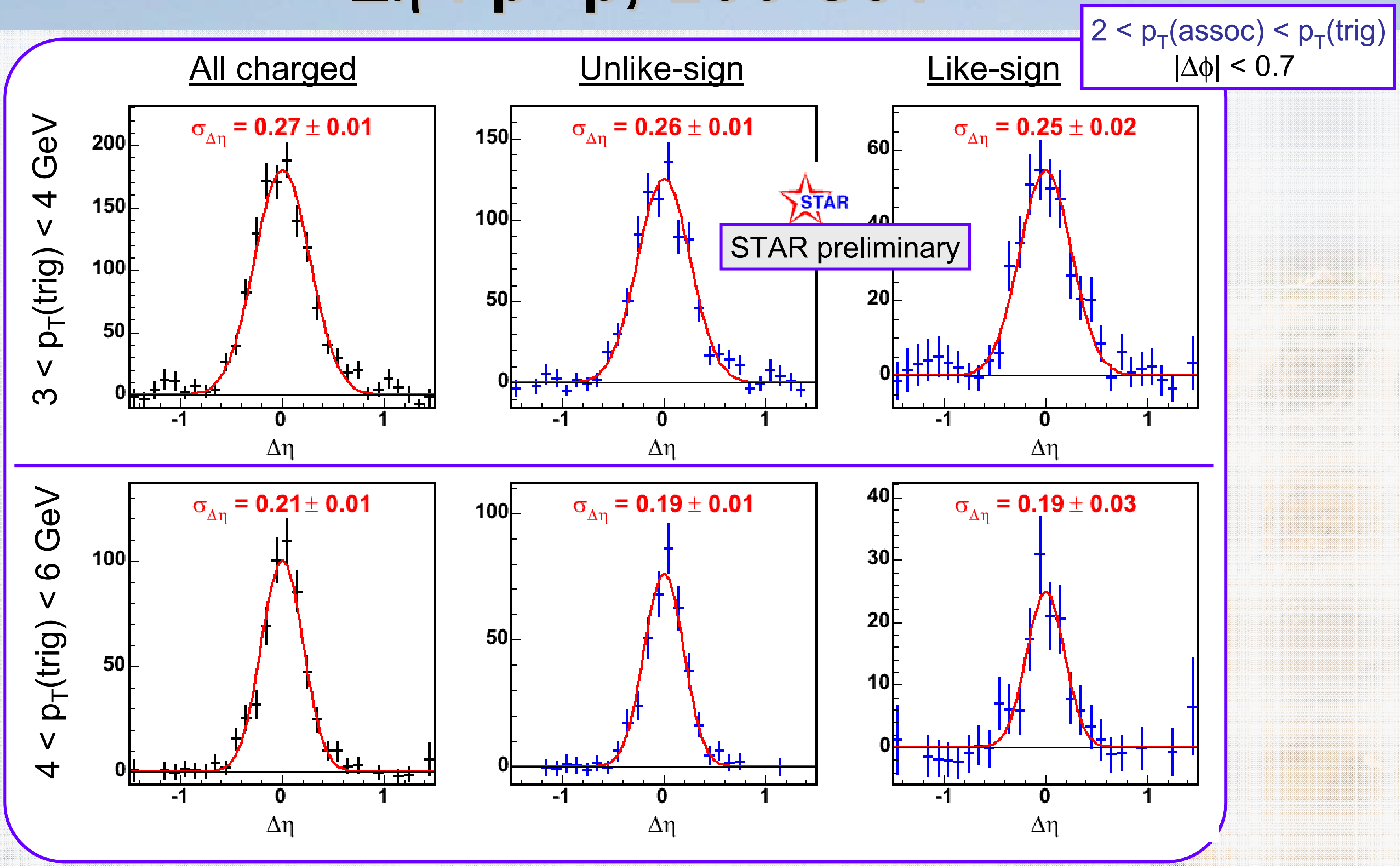


- **Lower p_T(trig) shows $\Delta\eta$-$\Delta\phi$ asymmetry**
  - $\Delta\phi$ determined by subtracting $0.5 < |\Delta\eta| < 1.4$ region from $|\Delta\eta| < 0.5$ region to isolate jetlike correlation (as done in STAR, PRL 90 (2003) 082302)

Δφ projections in different Δη windows



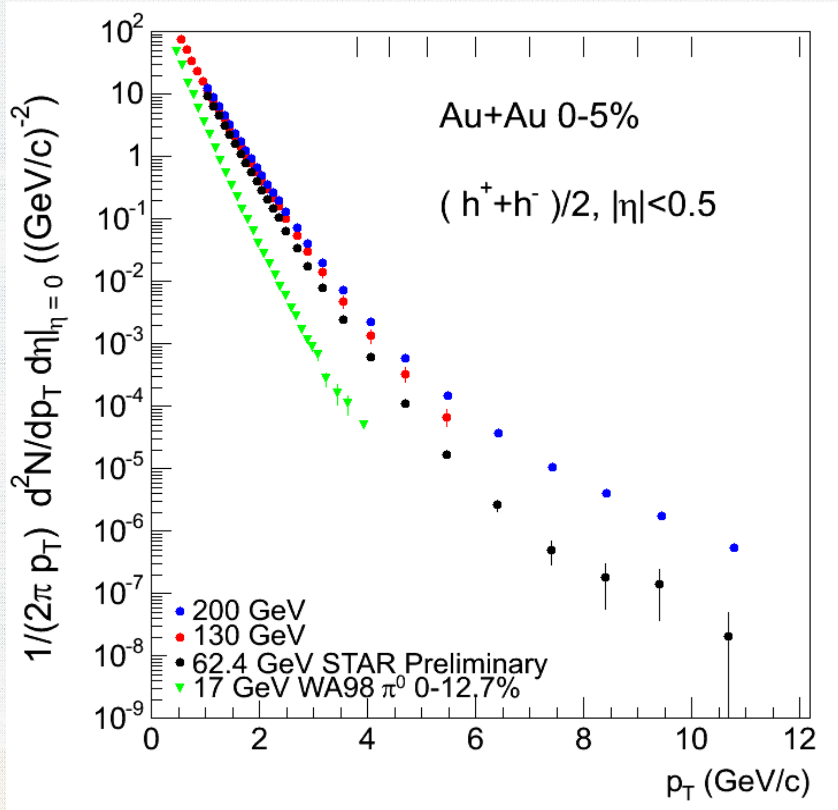
Δη : p+p, 200 GeV



- **Charge-ordering apparent in yields, not in widths (within stats)**
- **Smaller $\sigma_{\Delta\eta}$ for higher p_T(trig) → trigger more aligned with jet axis**

Δφ correlations: 62 vs 200 GeV

- **High-p_T production <u>much</u> reduced at 62 GeV** (see Carl Gagliardi's talk)



$\Delta\phi$ correlations: 62 vs 200 GeV

- **High-p_T production <u>much</u> reduced at 62 GeV (see Carl Gagliardi's talk)**
- **Similar yield on away-side similar yield**
  - Very statistics limited... look to near side – away side
  - Similar suppression at 62 GeV