Identified Particle Correlations from STAR

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High-p_T & Jet Physics

2005 RHIC & AGS Annual Users' Meeting
June 20 - 24, 2005

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    - *pp* 200 GeV
    - *AuAu* 200 GeV
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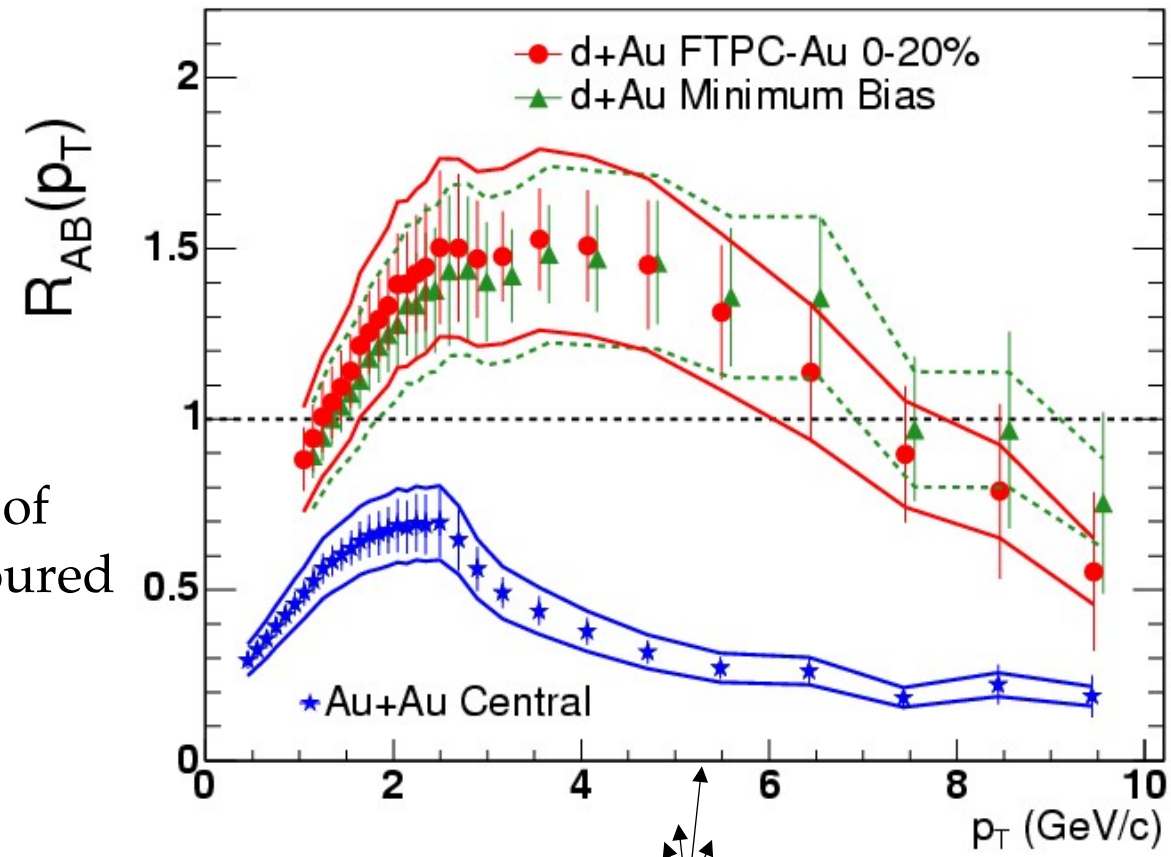
    - *dAu* 200GeV
- Summary and Outlook

Motivation I

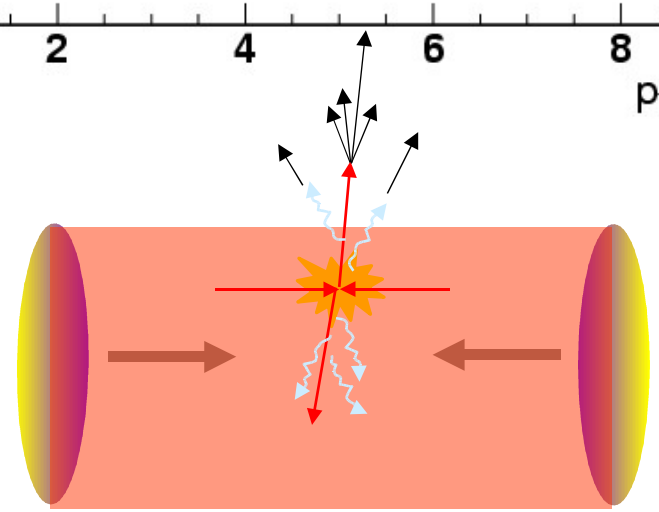
High-p_T suppression is medium induced

- Spectra from *AuAu* collisions at RHIC show high-p_T suppression
- Fragmentation products of hard partons are suppressed by final state effects
- Attributed to strong interactions of the hard parton in the dense coloured medium.



$$R_{AB} = \frac{\dfrac{d^2 N}{2\pi p_T dp_T dy}}{T_{AB}\, d^2 \dfrac{\sigma_{inel}^{pp}}{2\pi p_T dp_T dy}}$$

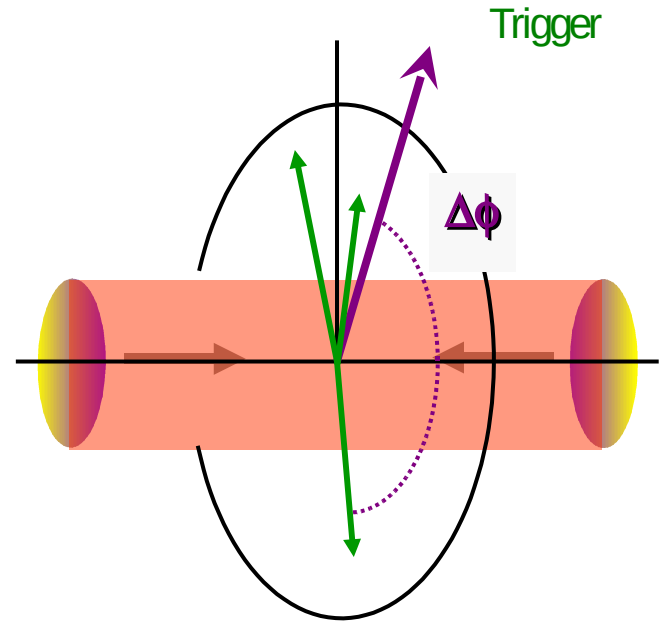
$$T_{AB} = \frac{N_{bin}^{mean}}{\sigma_{inel}^{pp}}$$

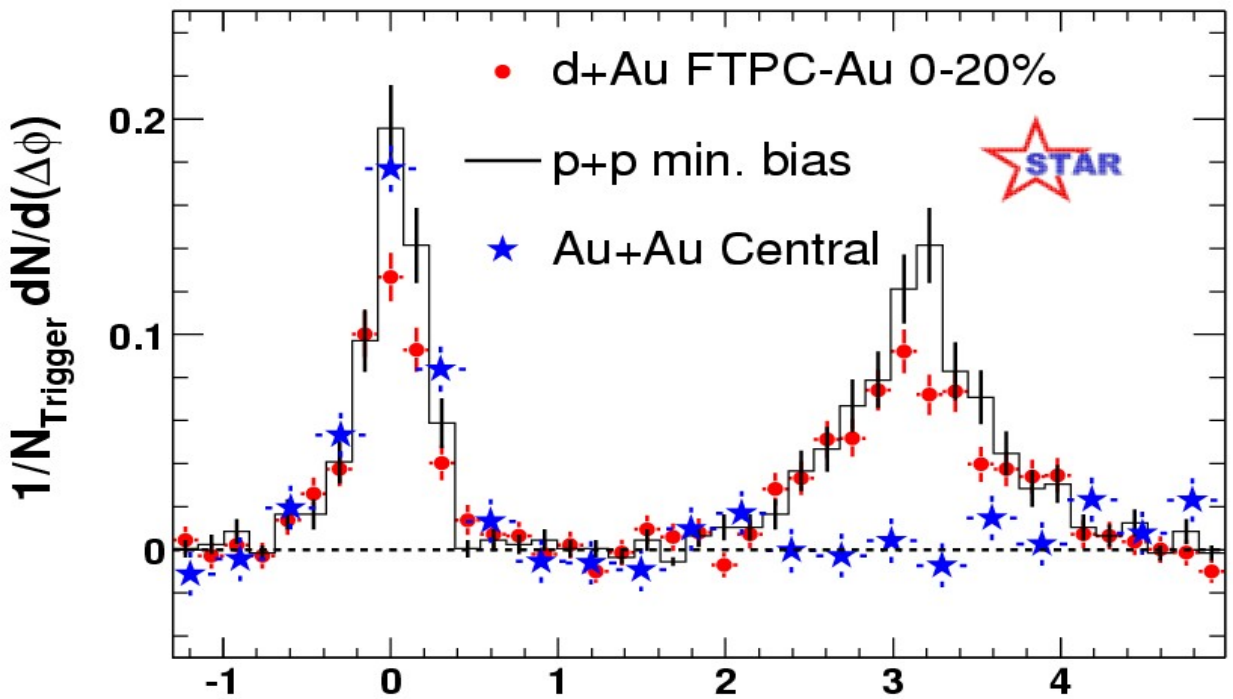


Motivation II

- Correlate high-p_T trigger particle with associated particles in some p_T window

Jets can be reconstructed statistically



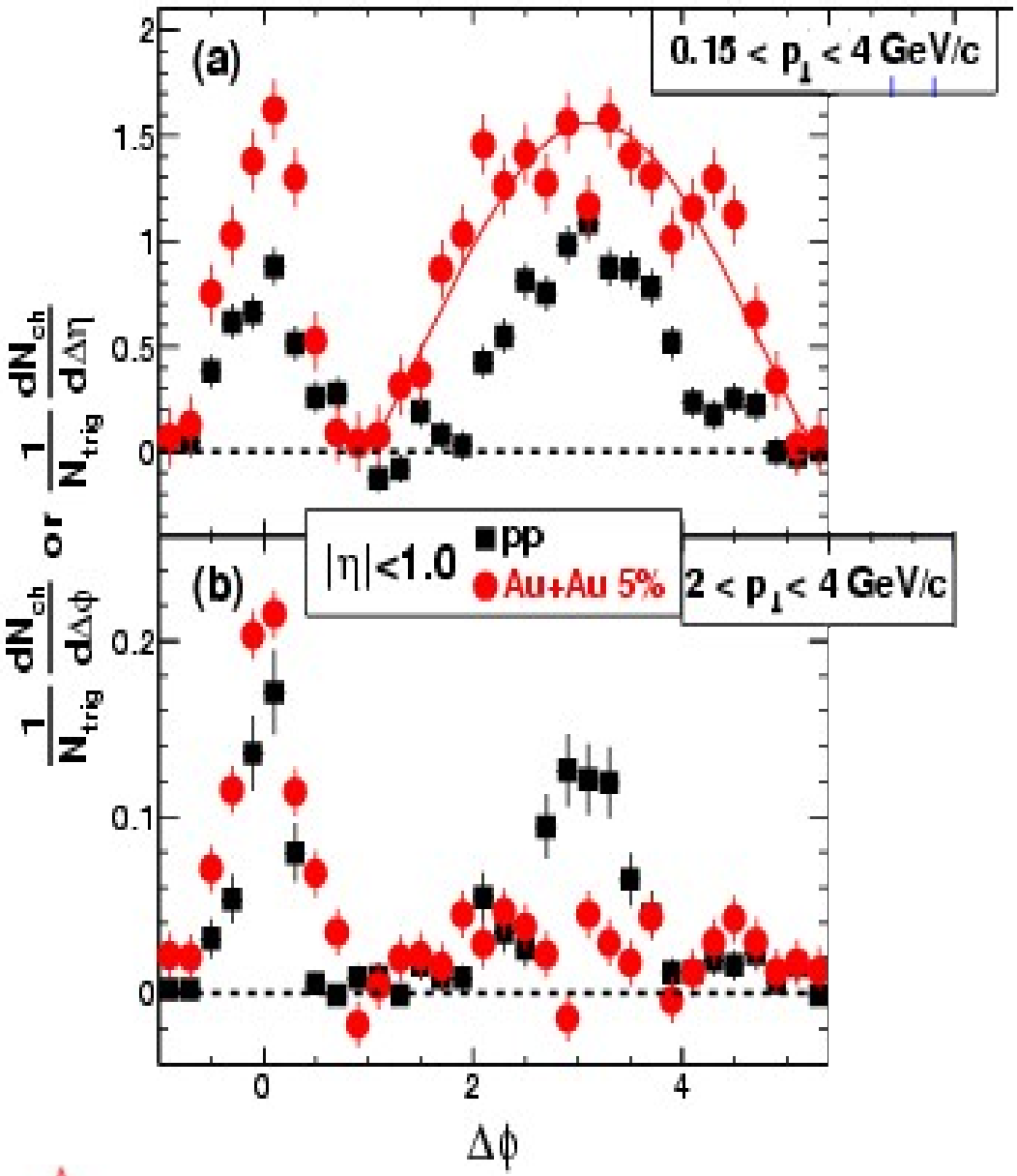


$4.0 < p_T$ trigger < 6.0
$2.0 < p_T$ assoc. < 4.0

- Double peak jet structure in *pp*, *dAu*
- Near-side similar to *pp* and *dAu*
- Away-side jet disappears in *AuAu*

Motivation III

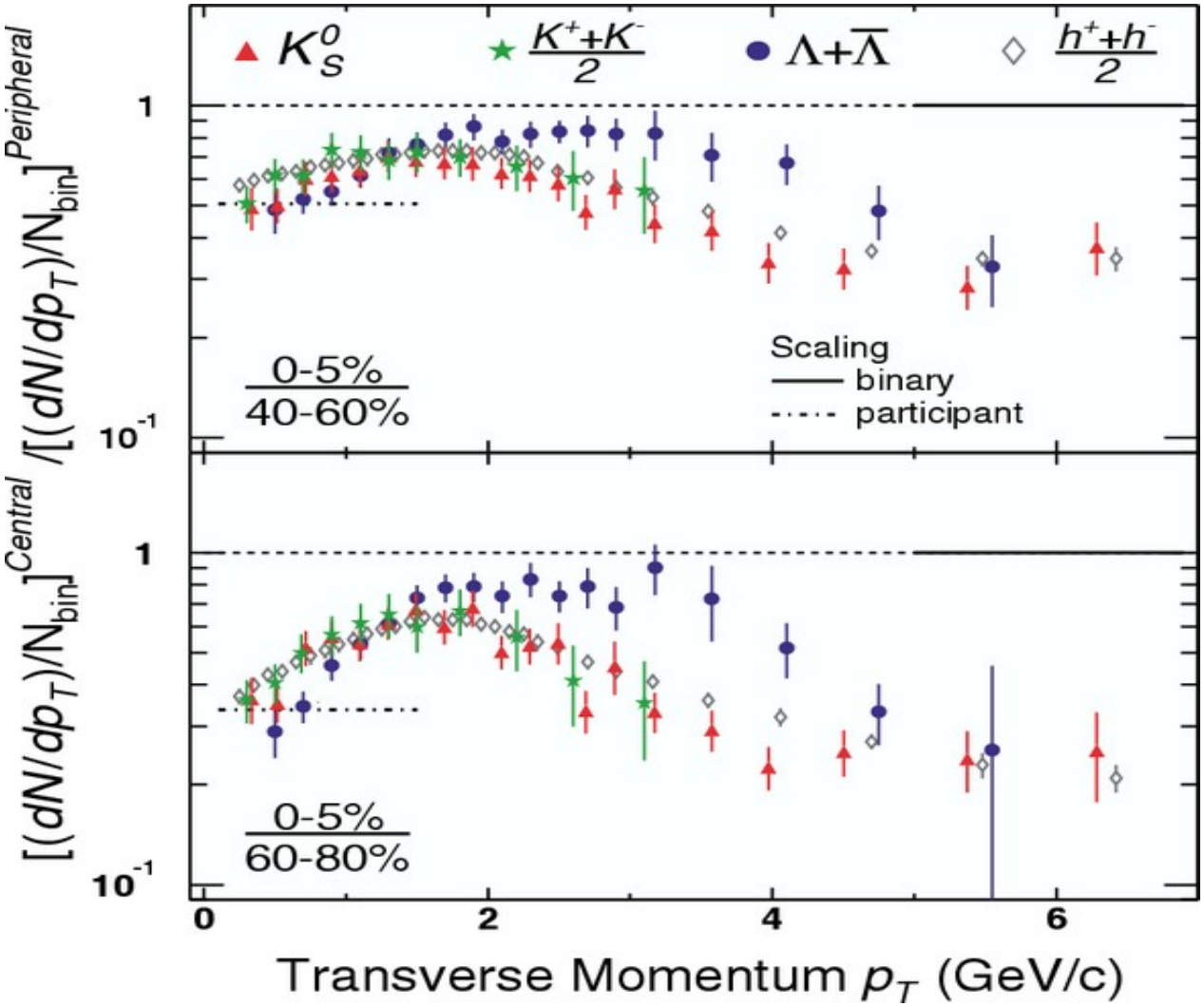
Away-side jet products are softened



- Reconstruct correlated yield by lowering associate p_T threshold
- Studies of the correlated yield reveal properties of the medium
- Novel structure in away-side structure seen
- Larger multiplicities in near- and away-side compared to *pp*

Motivation IV

Baryon/meson difference may lead to different correlation structures

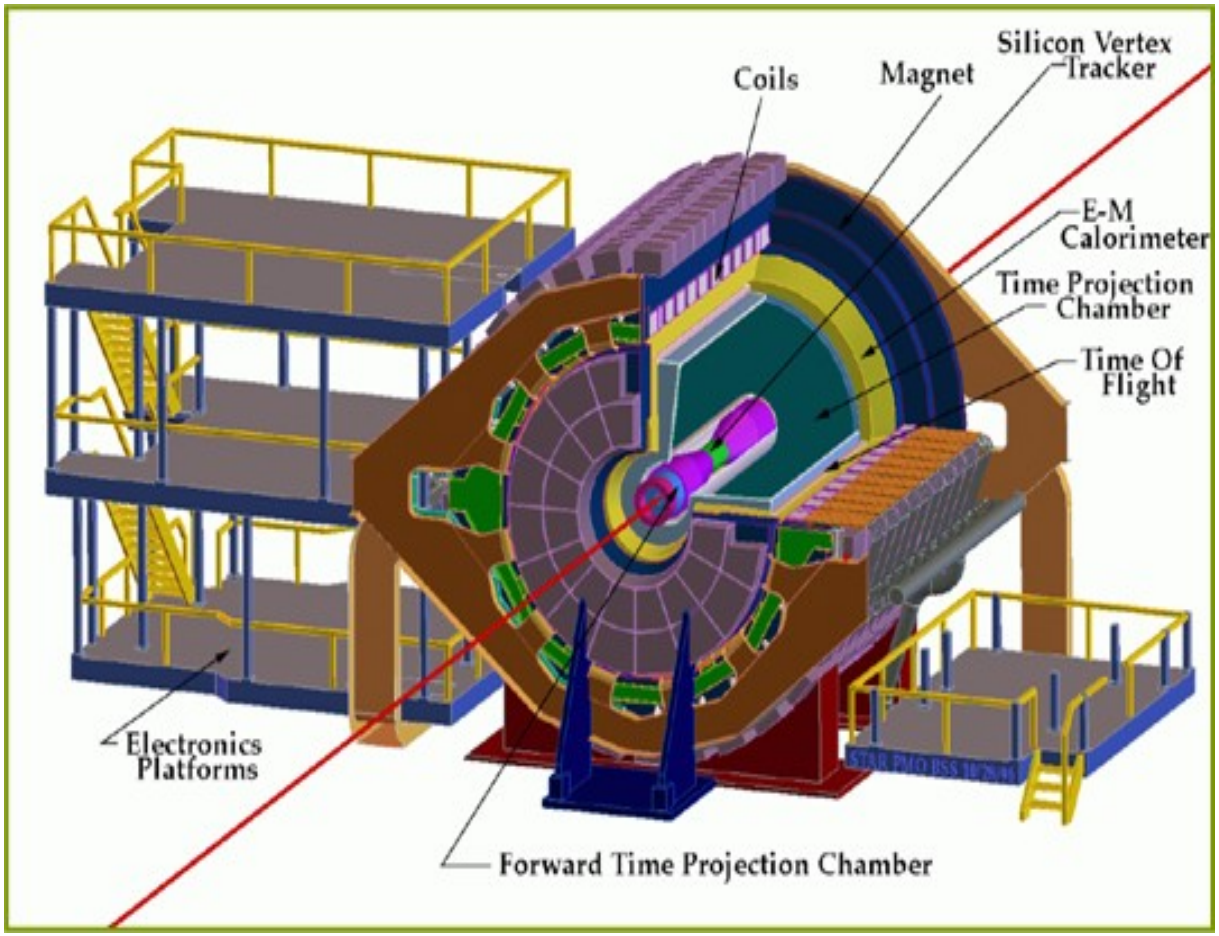


PRL 92 (2004) 052302

- Baryons and mesons behave differently at intermediate p_T
- Coalescence models relate yields to mixture of thermal and shower quarks
- Hard partons modify available quarks for coalescence – near and away
- Investigate if triggering on a baryon/meson changes structure

STAR

Solenoidal Tracker At RHIC



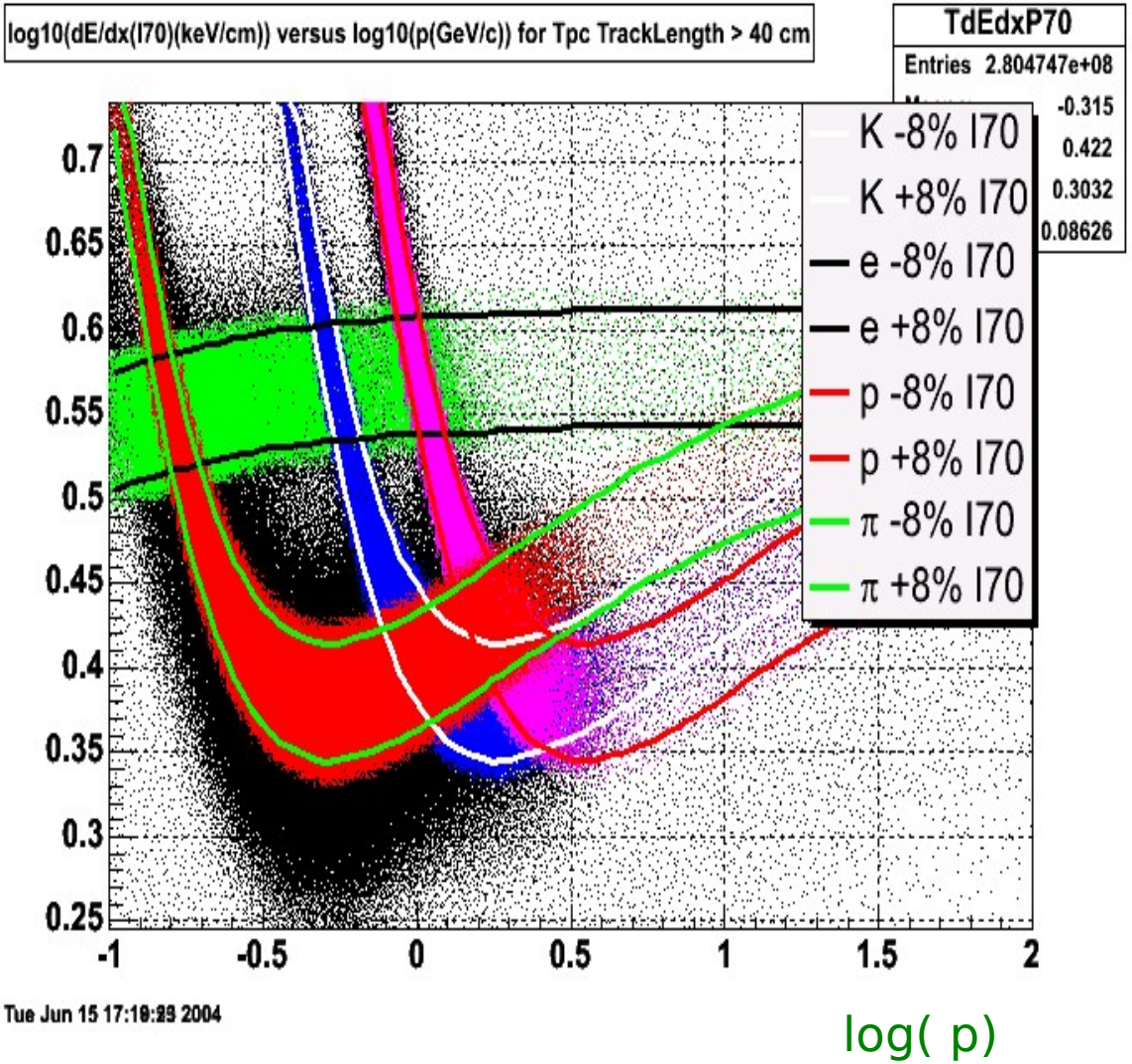
- All results are from data taken with the STAR detector at RHIC
- Primary source of information is the large Time Projection Chamber (TPC)
- All PID techniques discussed here based on TPC tracking information
- Datasets:
  - *AuAu* 200GeV
  - *dAu* 200GeV
  - *pp* 200GeV

$\pi^{+/-}$, p,$\overline{p}$ Triggers

- Non-strange trigger particle
  - *AuAu* 200 GeV

PID Method

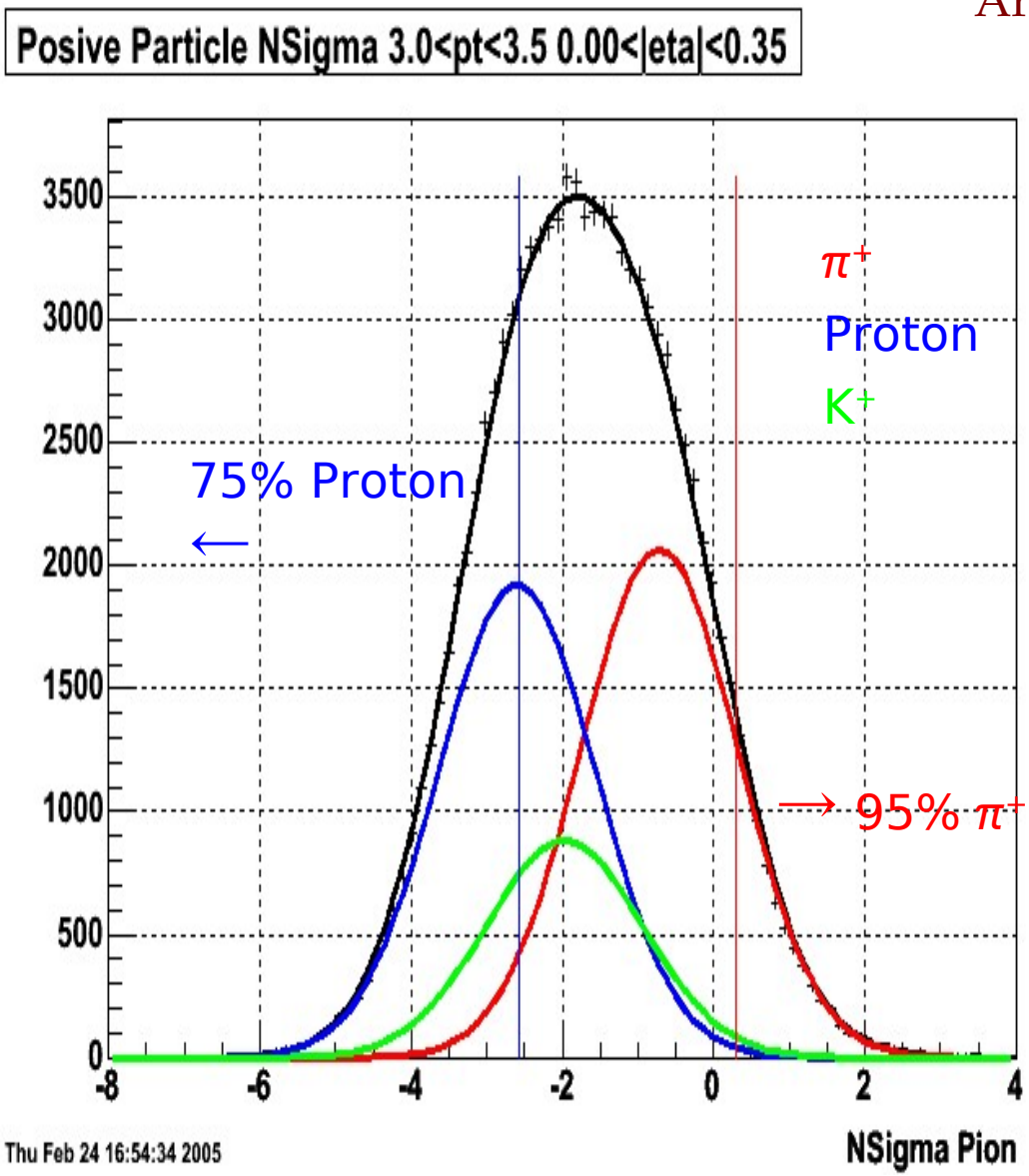
dE/dx used in relativistic rise region



- dE/dx bands merge above 1 GeV/c
- Use particle ratios and Gaussian shapes to characterise band
- Fit projection of band in p_T window to get particle yields

PID Method

Arbitrary sample purity at the expense of statistics

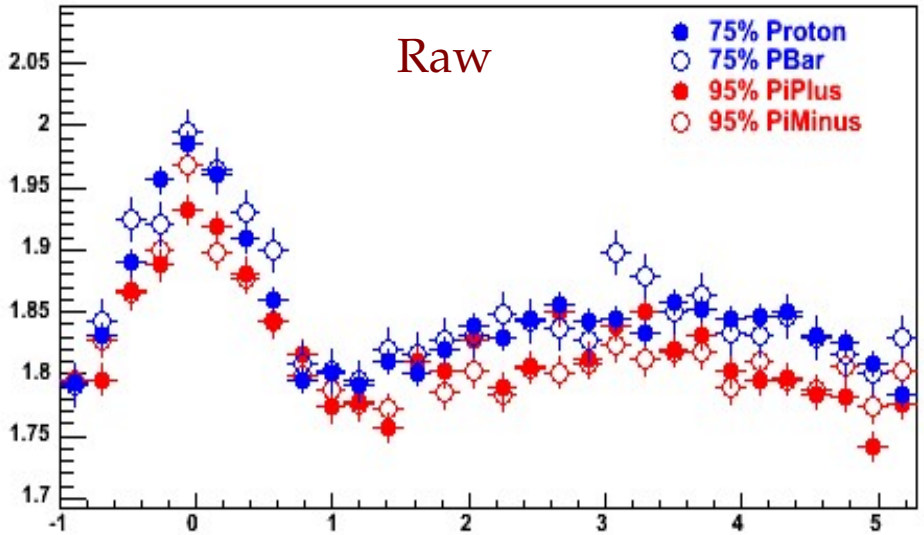


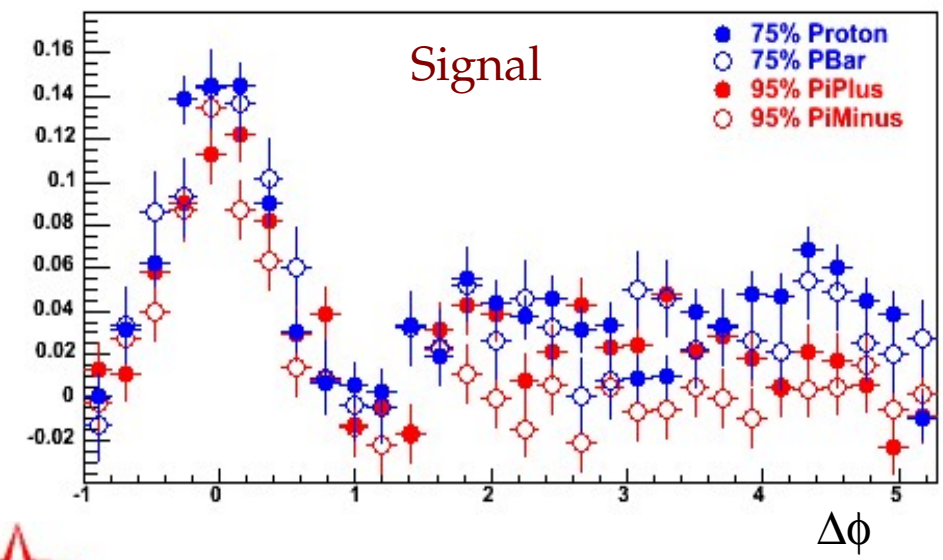
- A cut on number of sigma from pion band can give ~pure samples of $\pi^{+/-}$ and $p,\bar{p}$
- For this study cuts give
  - 75% pure $p,\bar{p}$
  - 95% pure $\pi^{+/-}$

Cental *AuAu* 200 GeV

v_2 modulated background must be removed

$3.0 < p_T$ trigger < 4.0
$2.0 < p_T$ assoc. < 3.0

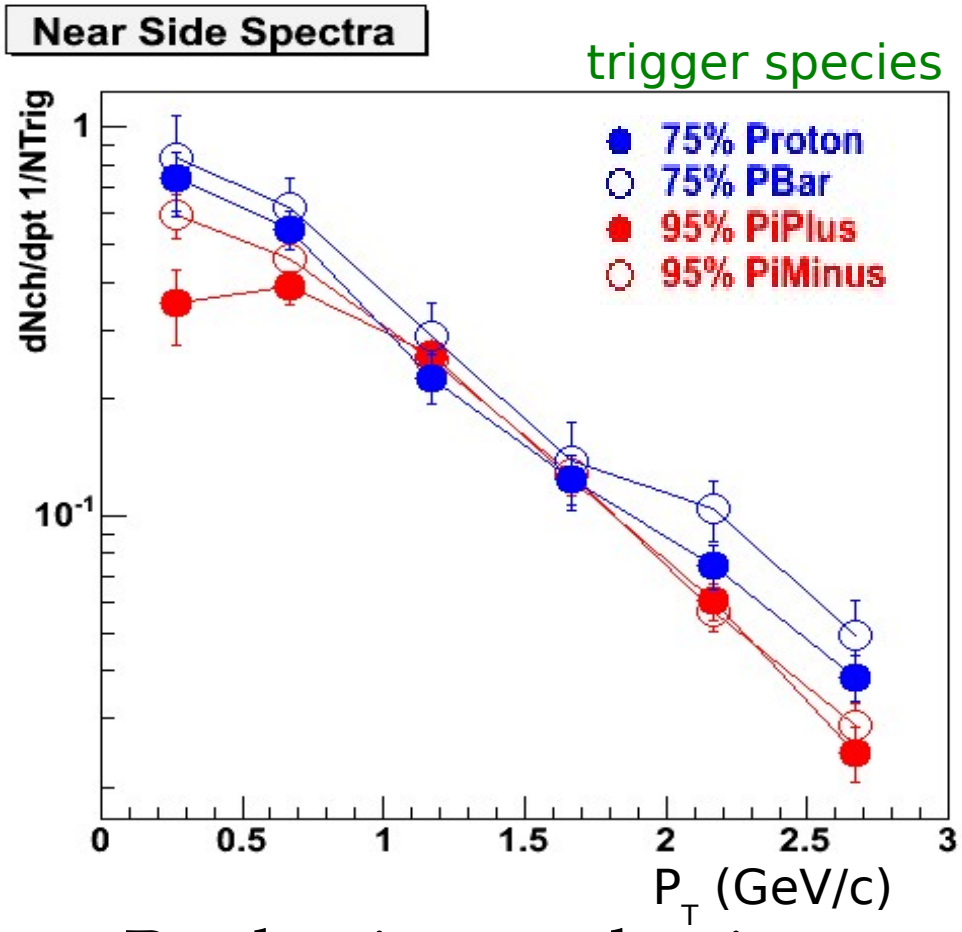


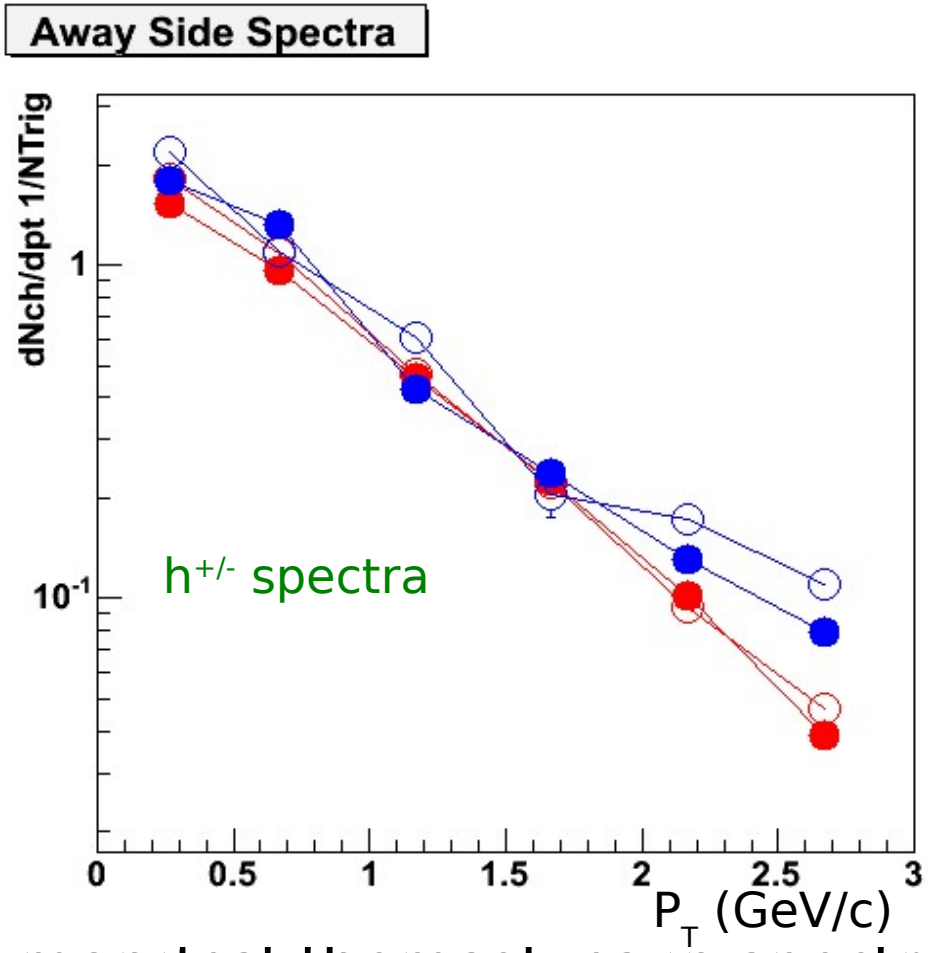


- Example raw Δφ distribution
  - Identified trigger
  - $h^{+/-}$ associated
- Mixed event background does not contain v_2
- v_2 modulated mixed event removal
- Away side structure is broad and small

dAu 200GeV Spectra

Spectra show little trigger species dependence

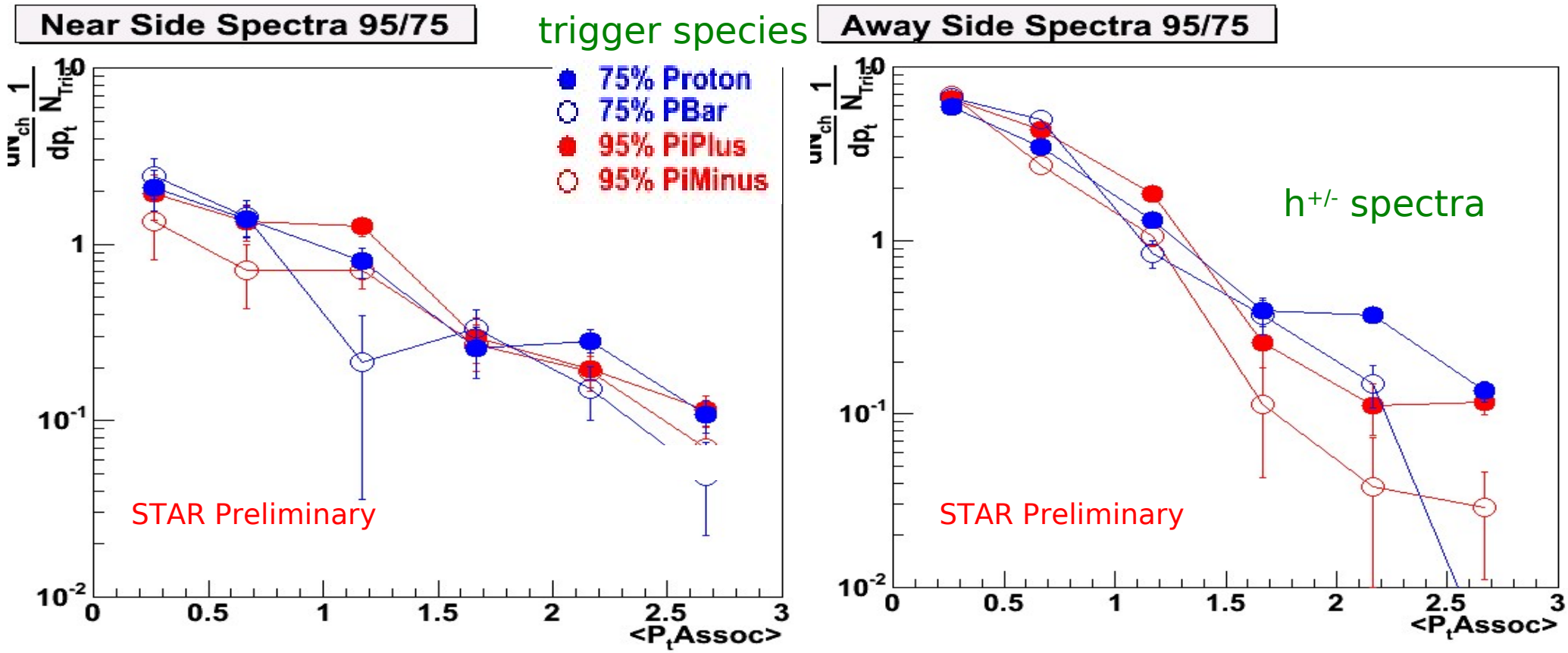




- Production mechanisms may manifest themselves in spectra
- Near-side yields lower
- Trigger species dependence not in evidence

AuAu 200GeV Spectra

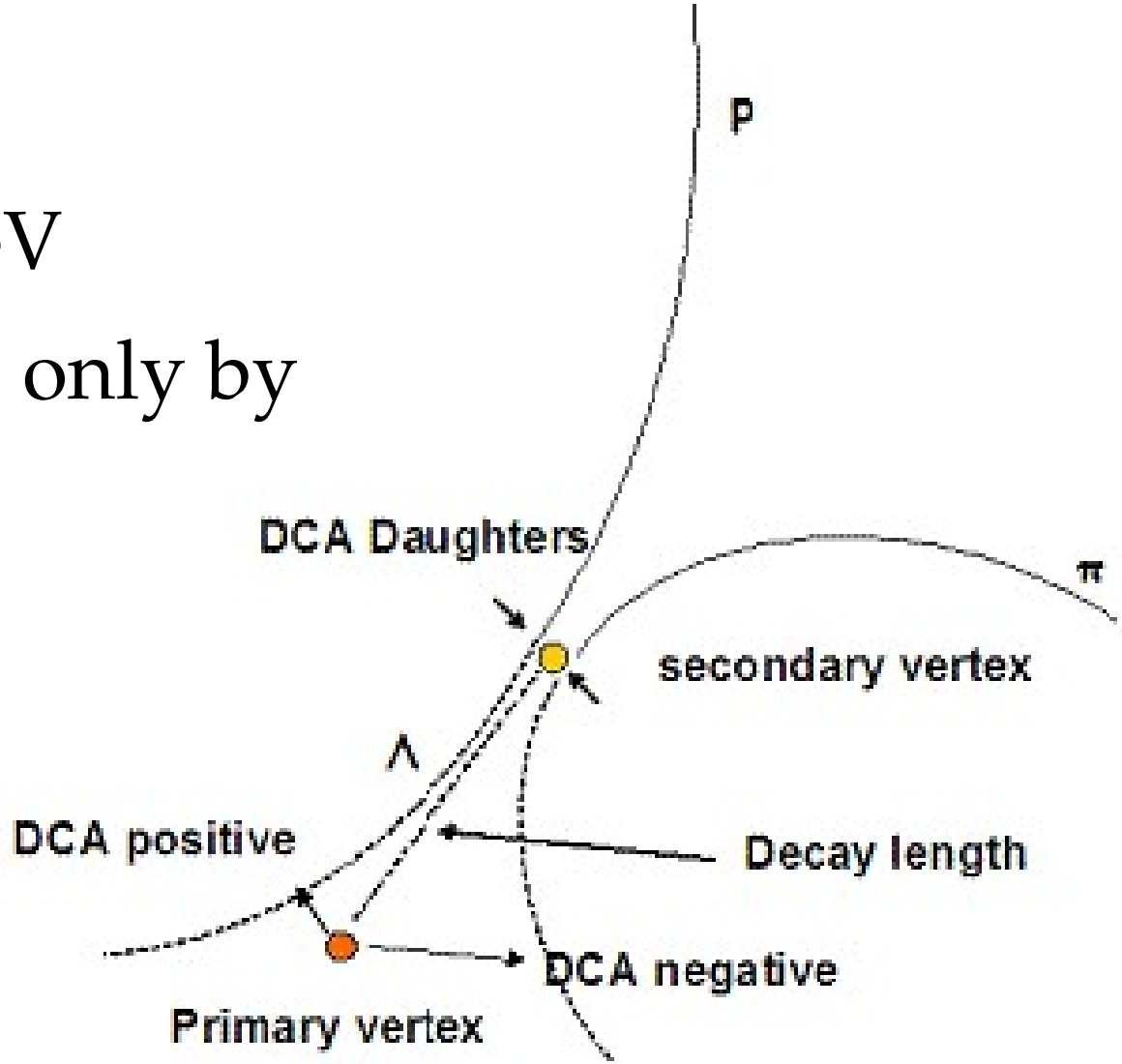
Spectra show little trigger species dependence



- Spectra softer in *AuAu* than *dAu*
- Near-side yields lower
- No species dependence

Λ, $\overline{\Lambda}$ and K^0_S Triggers

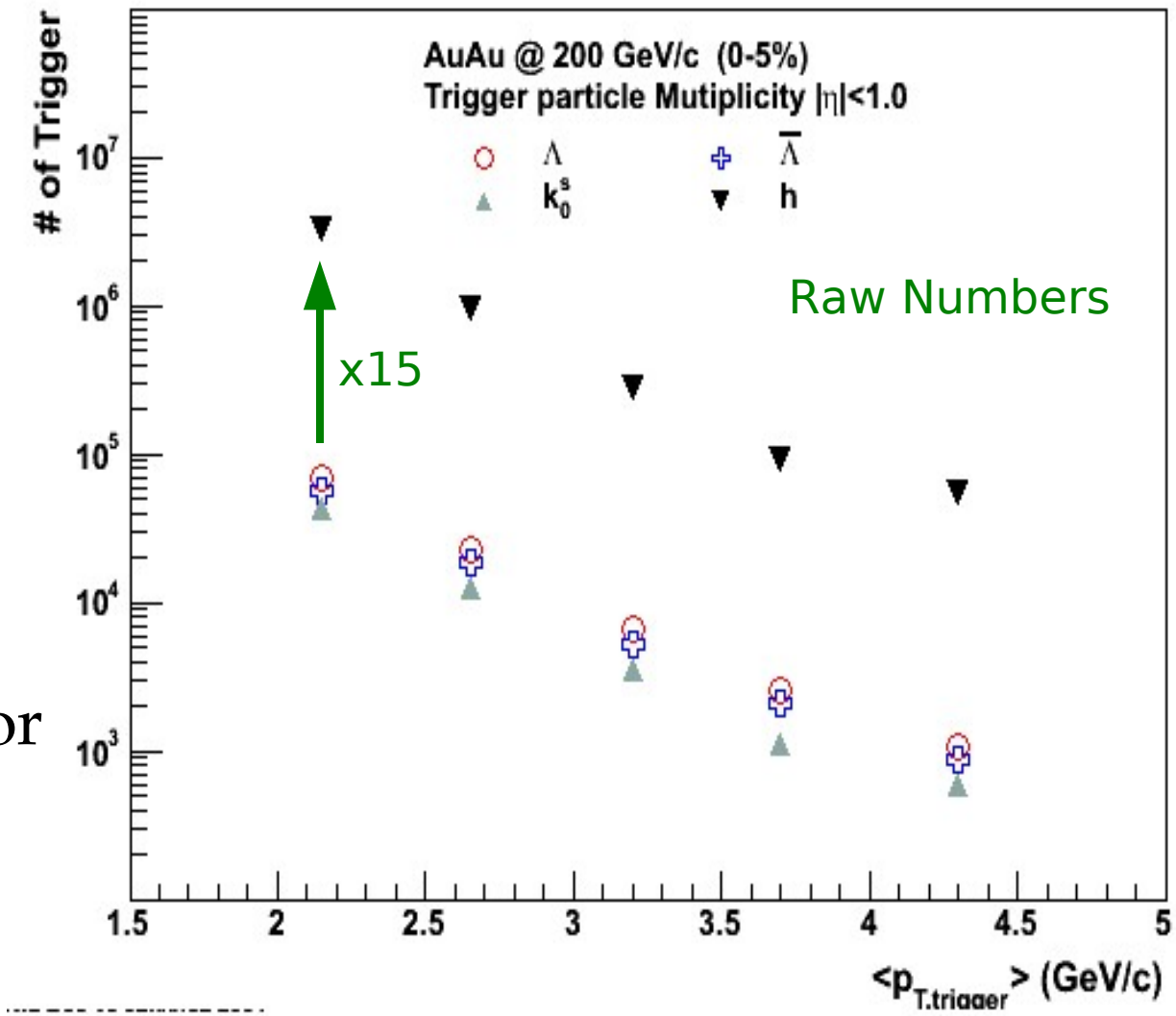
- Strange Trigger Particles
  - *pp* 200 GeV
  - *AuAu* 200 GeV
- Trigger p_T limited only by statistics



Trigger Yields

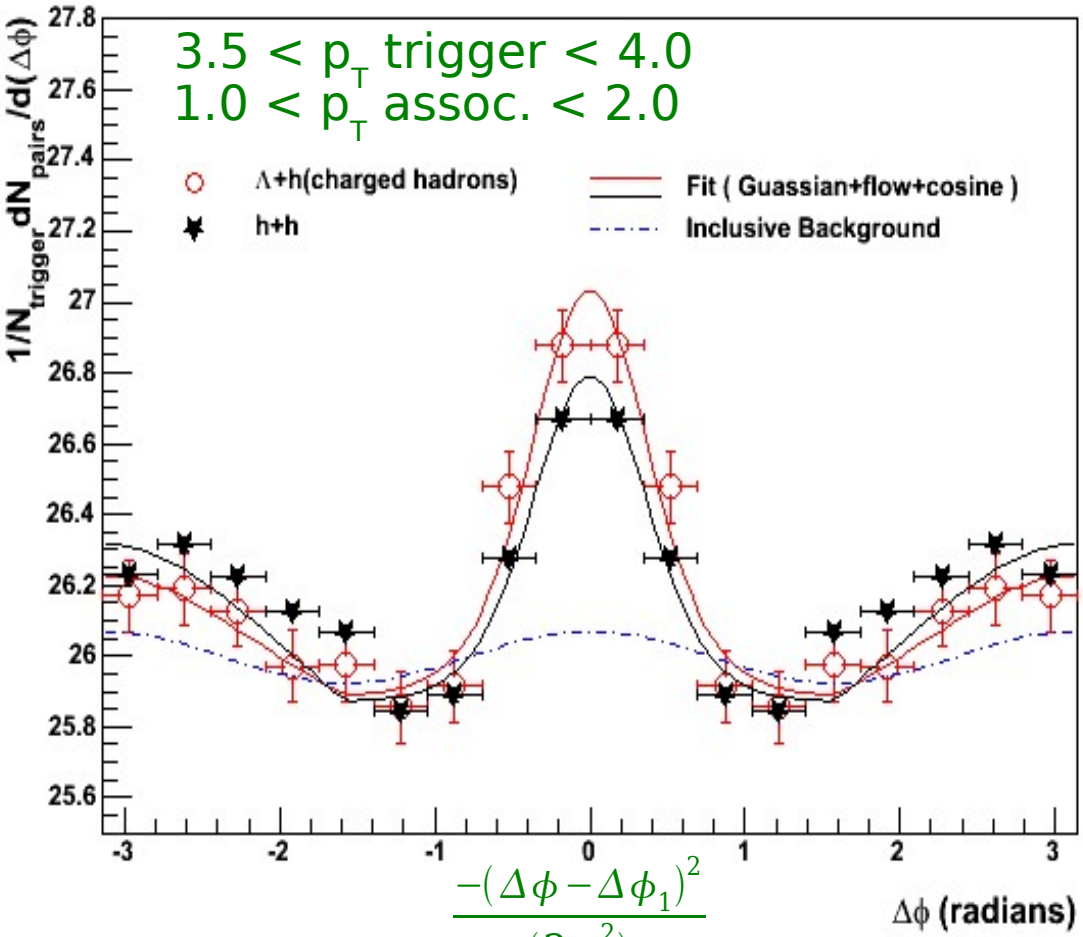
Comparable triggers for all species

- Use topological techniques to reconstruct trigger particles
- Technique is limited only by statistics and not PID capability
- Comparable triggers for all species found up to 4.5 GeV/c



Method for *AuAu* I

Fit both peaks and underlying event



- Raw distribution has large uncorrelated background and v_2 contribution

- Two methods used to fit

Near side
Away side
Background

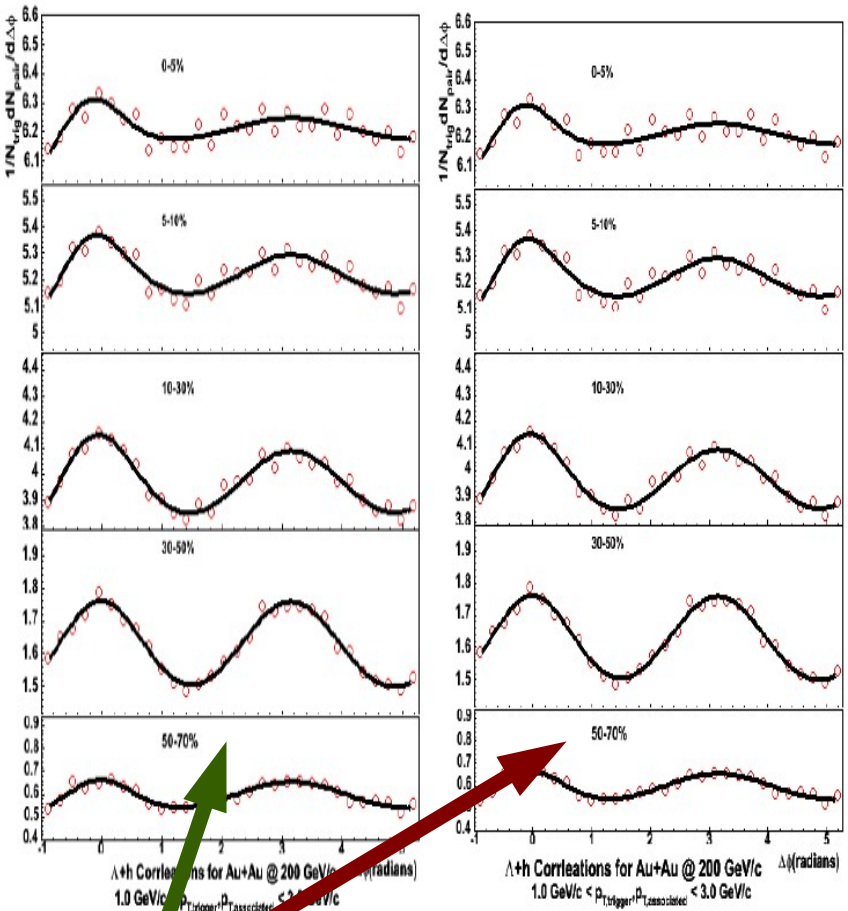
$$F(\Delta\phi) = a_1 e^{\frac{-(\Delta\phi-\Delta\phi_1)^2}{(2\sigma_1^2)}} + B(C\cos(\Delta\phi) + 1 + 2v_2^{trigger} v_2^{assoc.} \cos(2\Delta\phi))$$

OR

$$F(\Delta\phi) = a_1 e^{\frac{-(\Delta\phi-\Delta\phi_1)^2}{(2\sigma_1^2)}} + a_2 e^{\frac{-(\Delta\phi-\Delta\phi_2)^2}{(2\sigma_2^2)}} + B(1 + 2v_2^{trigger} v_2^{assoc.} \cos(2\Delta\phi))$$

Method for AuAu II

Both fitting techniques do equally well



- The data can be fitted equally well with either function
- This is independent of centrality

$$F(\Delta\phi) = a_1 e^{\frac{-(\Delta\phi-\Delta\phi_1)^2}{(2\sigma_1^2)}} + B(C\cos(\Delta\phi) + 1 + 2v_2^{trigger} v_2^{assoc.} \cos(2\Delta\phi))$$

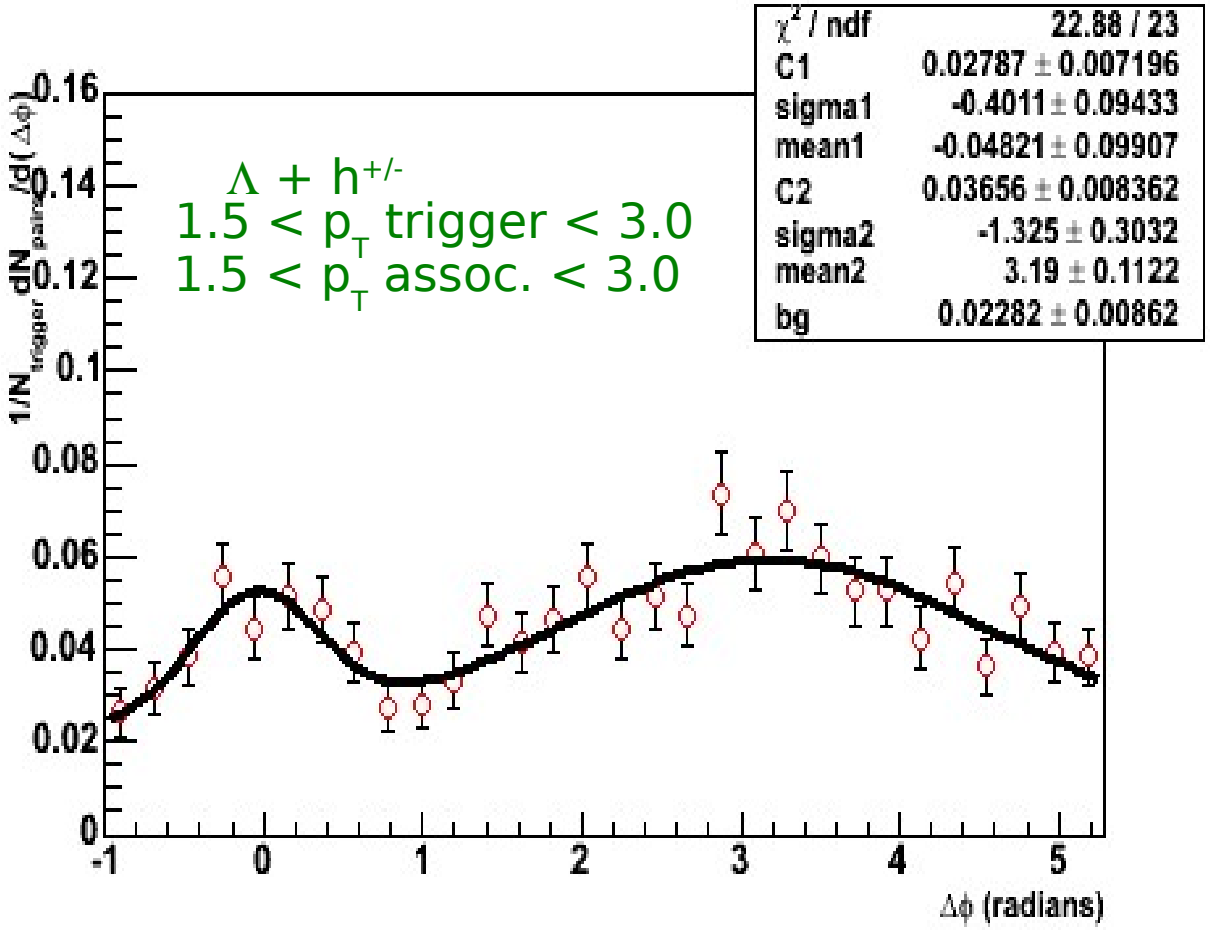
OR

$$F(\Delta\phi) = a_1 e^{\frac{-(\Delta\phi-\Delta\phi_1)^2}{(2\sigma_1^2)}} + a_2 e^{\frac{-(\Delta\phi-\Delta\phi_2)^2}{(2\sigma_2^2)}} + B(1 + 2v_2^{trigger} v_2^{assoc.} \cos(2\Delta\phi))$$

Method for *pp*

In *pp* a Gaussian away-side is expected

- *pp* correlations well fitted by two Gaussians on a constant pedestal
- Away-side broader, biased towards harder fragmentation on near-side and nuclear k_T



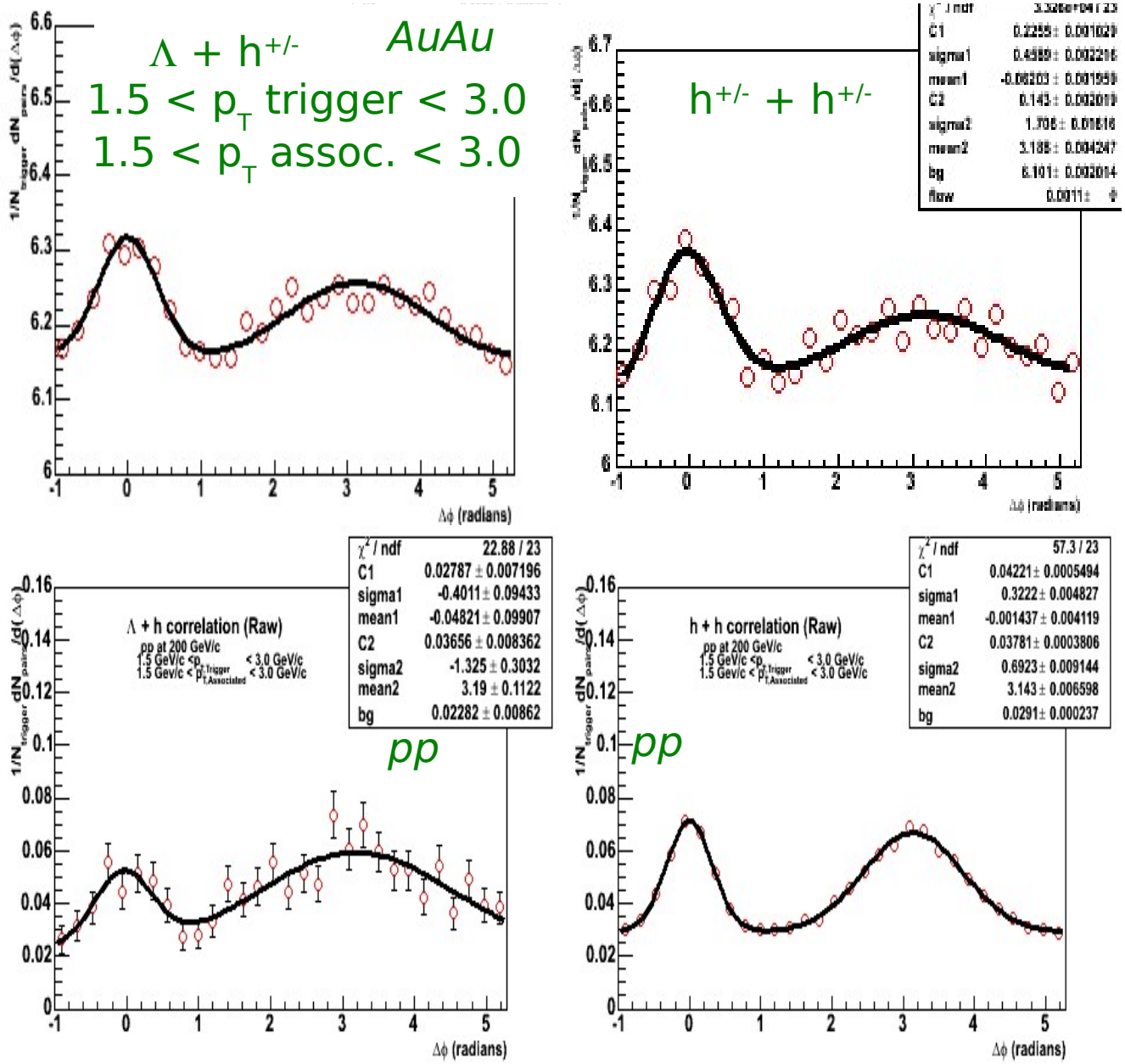
Near side
Away side
Background

$$F(\Delta\phi) = a_1 e^{\frac{-(\Delta\phi-\Delta\phi_1)^2}{(2\sigma_1^2)}} + a_2 e^{\frac{-(\Delta\phi-\Delta\phi_2)^2}{(2\sigma_2^2)}} + B$$

AuAu Near-side Yields

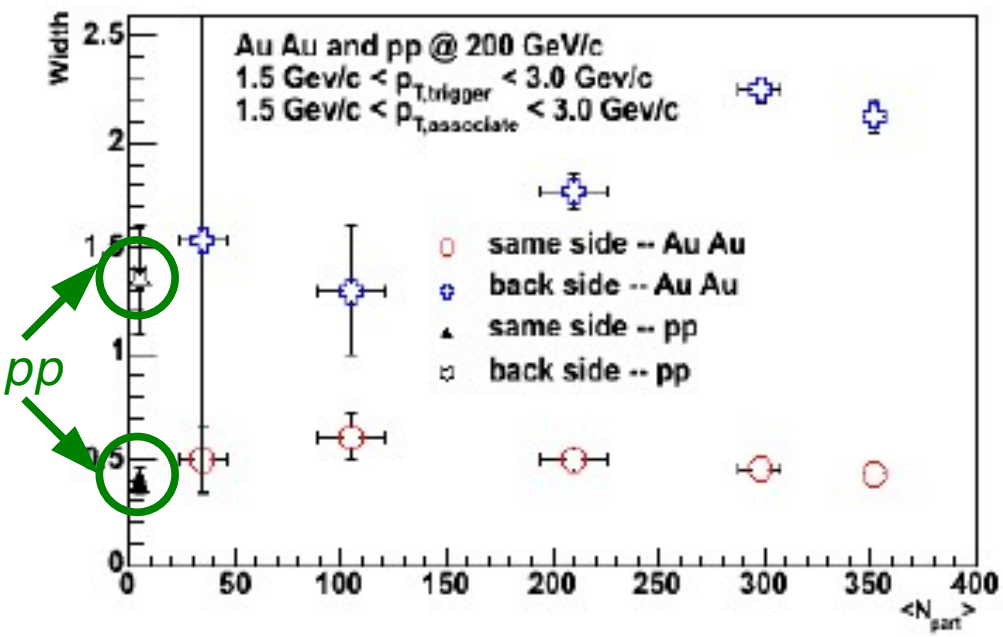
For all triggers *AuAu* has larger near-side yields

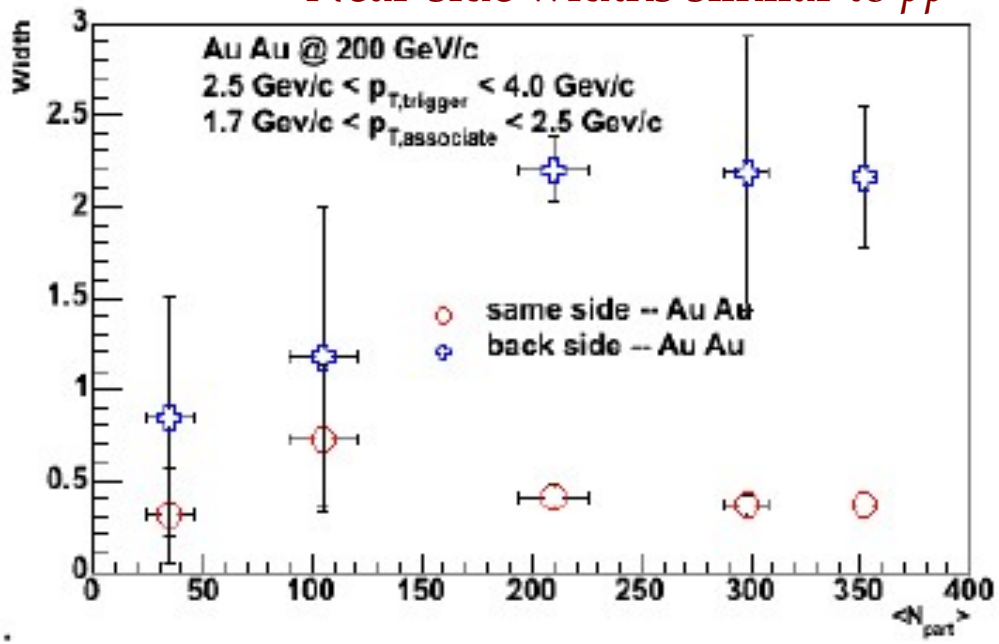
- Near-side yield is larger in *AuAu* than *pp*
- Independent of trigger p_T or trigger species



Correlation Widths

Near-side widths similar to *pp*



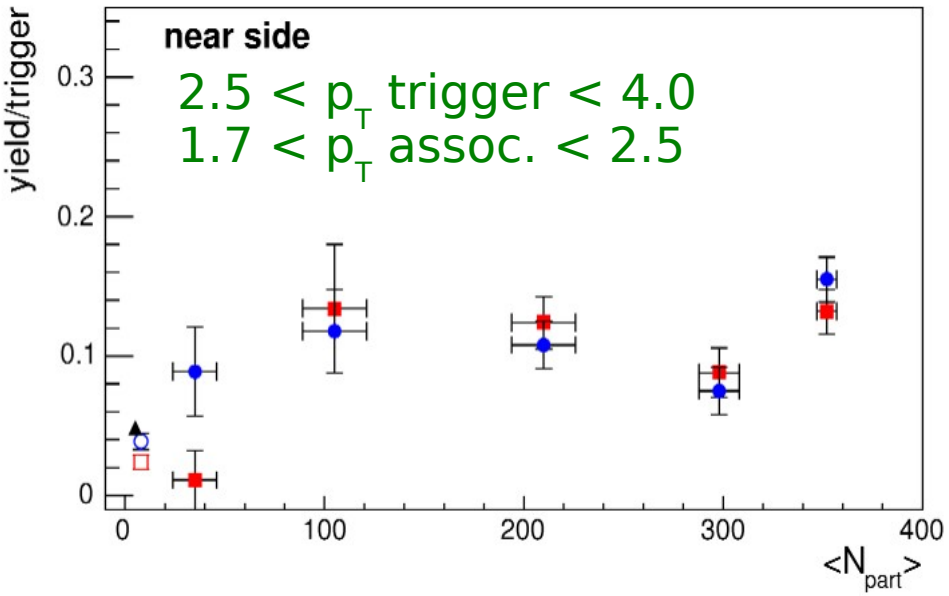


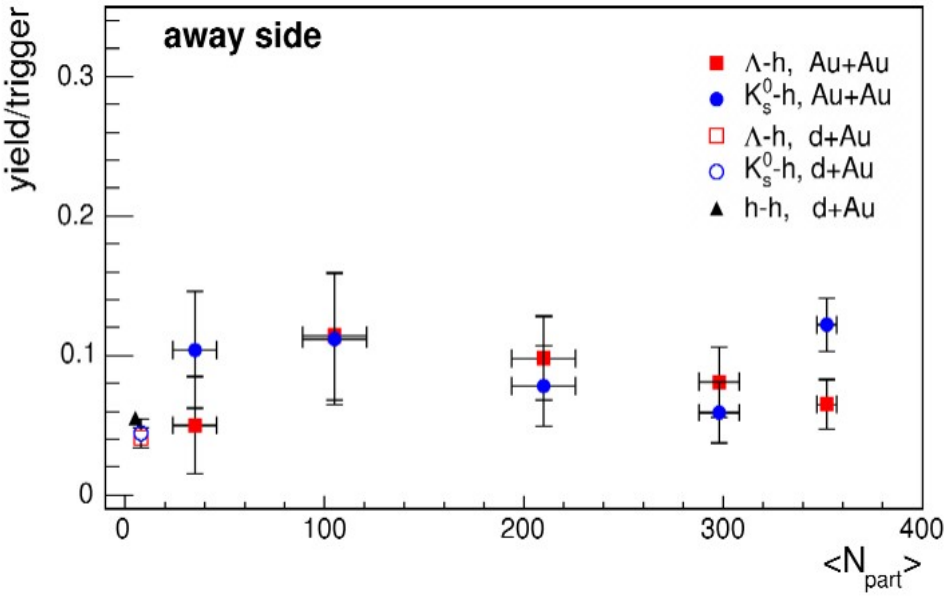
- Near-side widths similar to *pp*
- Away-side widths broadened with increasing centrality
- Independent of trigger p_T

Centrality Dependence of Yields

Near-side yields larger

- Yield per trigger may exhibit a dependence on centrality
- Smaller away-side yield at intermediate p_T for all centralities
- No significant species dependence evident

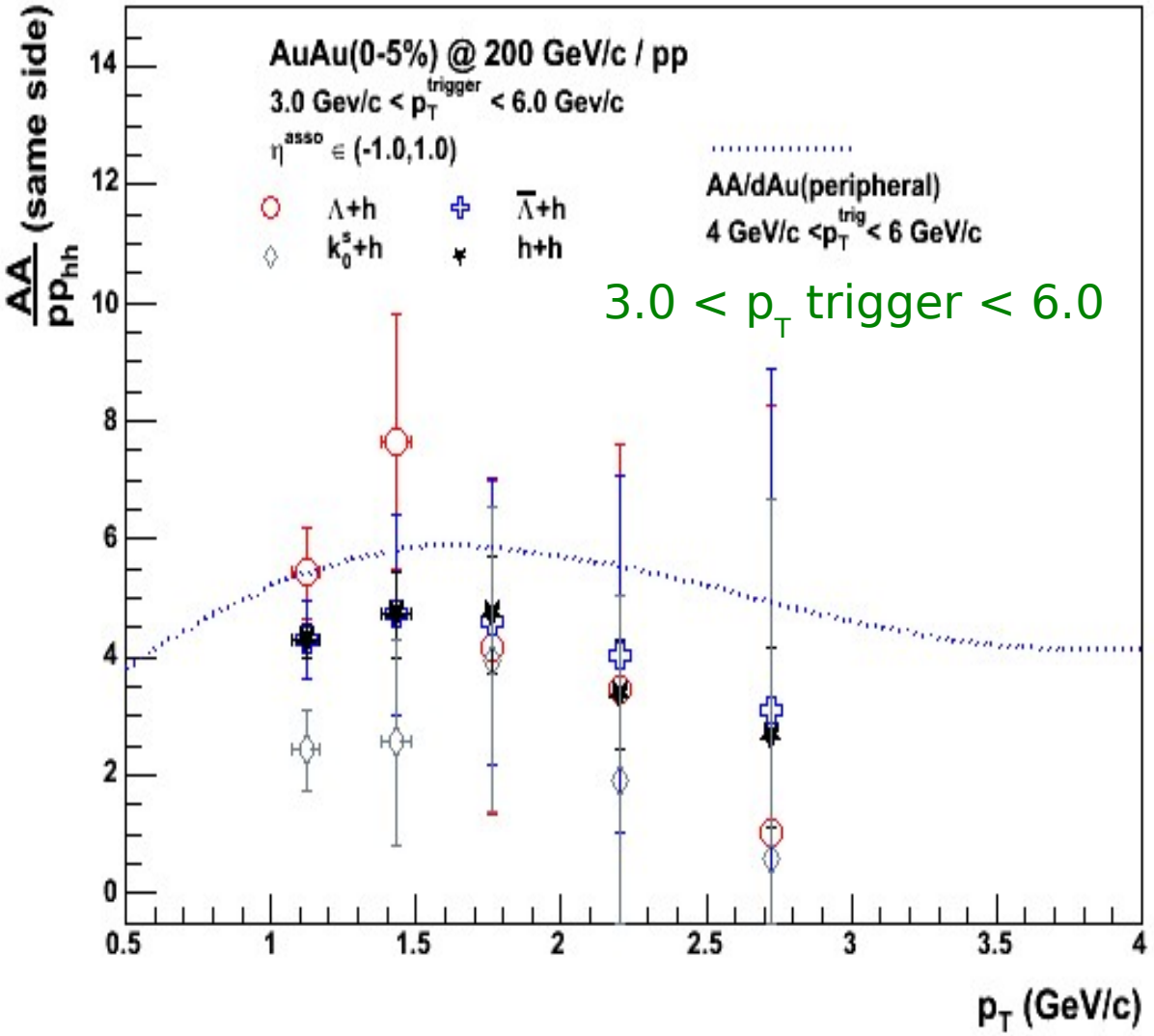




Ratio of Yields in *AuAu* to *pp*

- p_T dependence of ratio of *AuAu* yield to *pp* yield
- *AuAu* yield higher than *pp* yield for all p_T – approaches 1
- Statistics limited

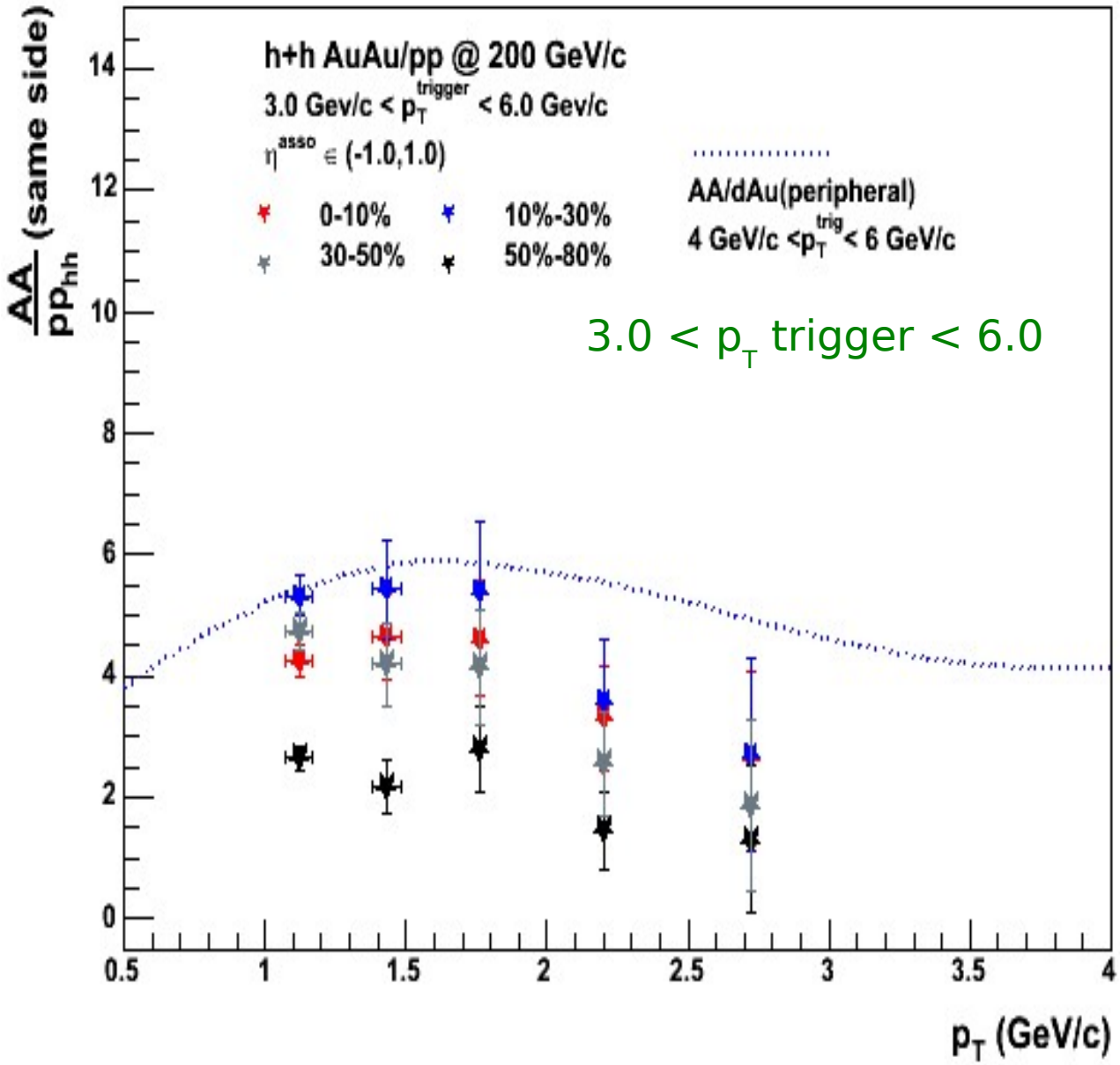
Yields approach *pp* result as p_T increases



Centrality Dependence for $h^{+/-}$

We have observed the same behaviour for $h^{+/-}$

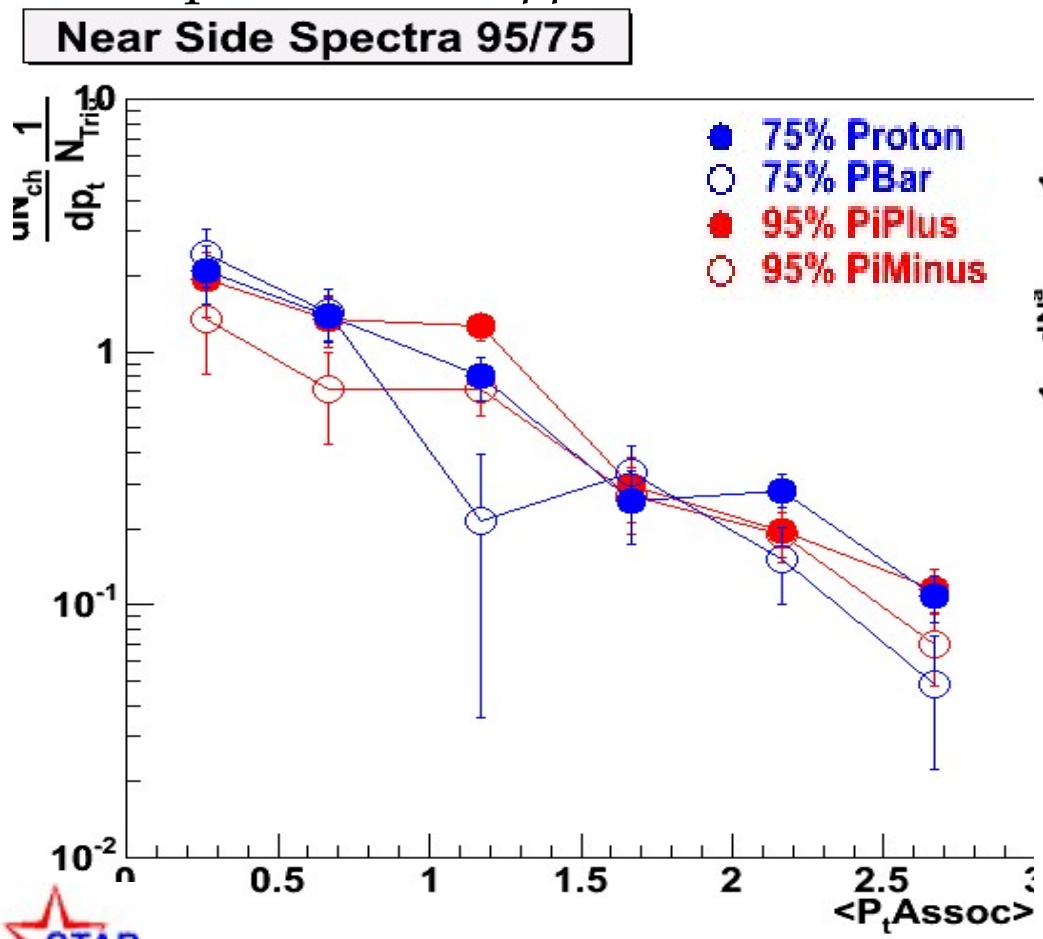
- Charged hadrons show similar behaviour at all centralities
- As p_T increases yields approach *pp* values

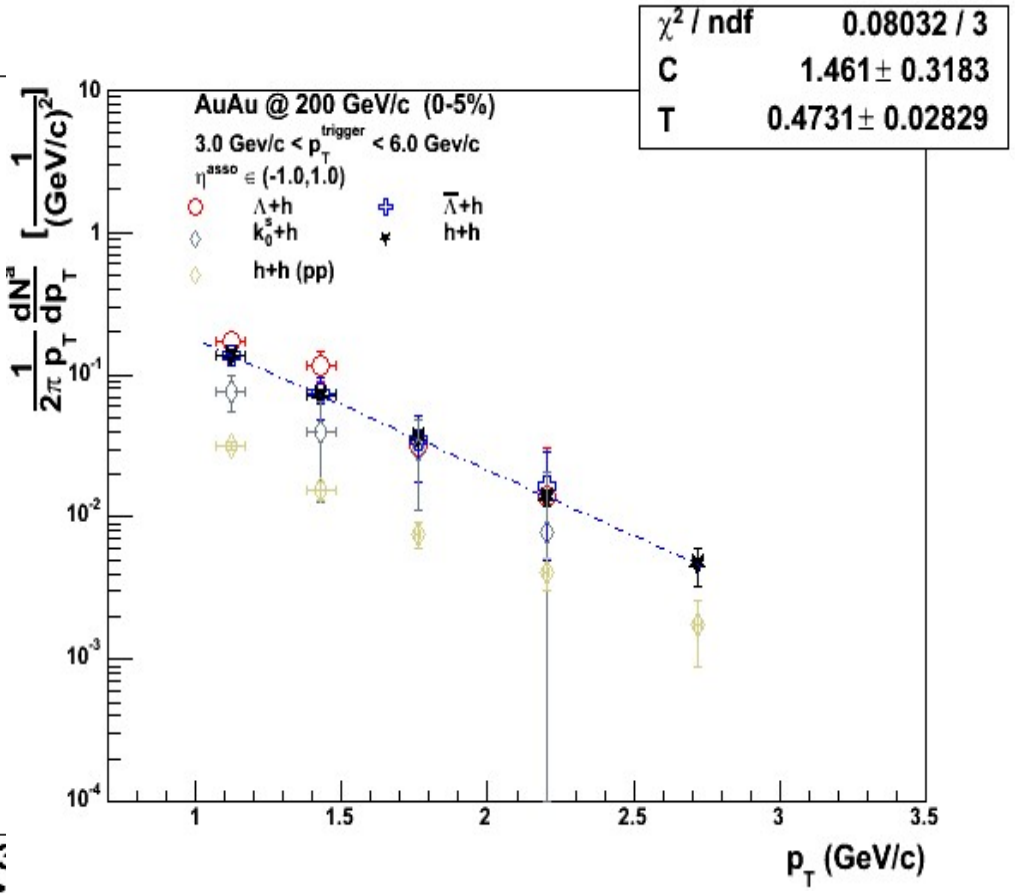


Near-side Spectra for Central Events

Central near-side spectra

- Spectra largely independent of trigger species
- Improved statistics will allow a more differential study
- Slope similar to *pp*





Conclusions for *AuAu* Results

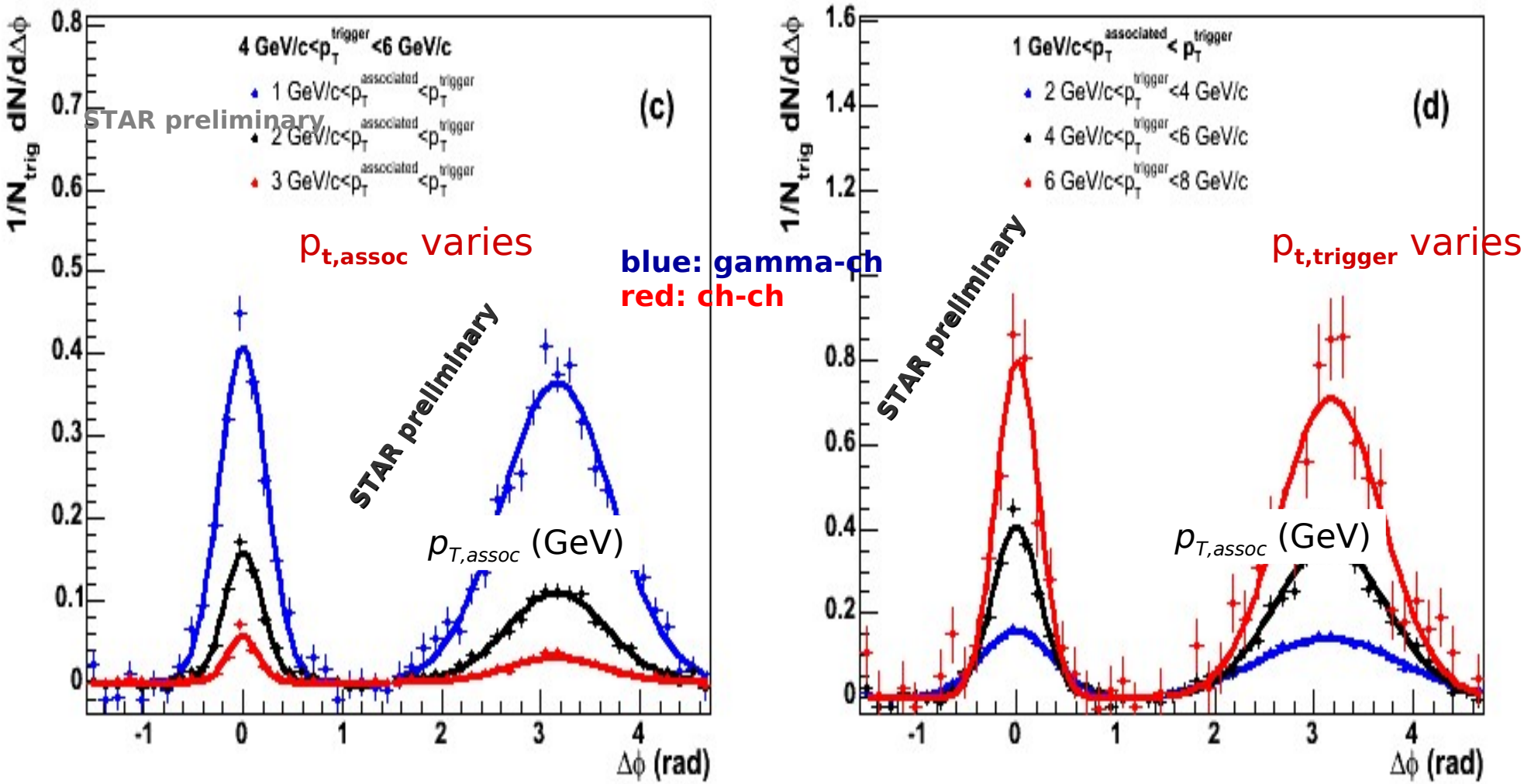
- Feasibility of multiple identified triggers in *AuAu* demonstrated
- Near-side yield greater than *pp*
- Associated spectra largely independent of trigger species
- Improved statistics available (Run IV) and will allow improved studies

γ Triggers in *dAu*

- Higher p_T than other identified triggers
- *dAu* is our baseline for *AuAu* study

Distributions in *dAu*

Expected jet-like near and away structures



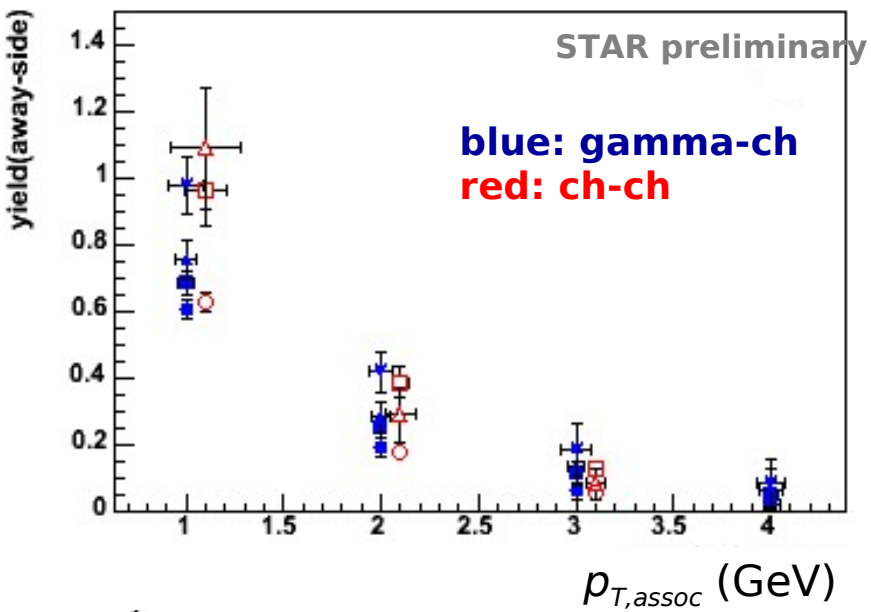
- Triggers dominated by π^0 decays
- Away-side yields larger and widths broader

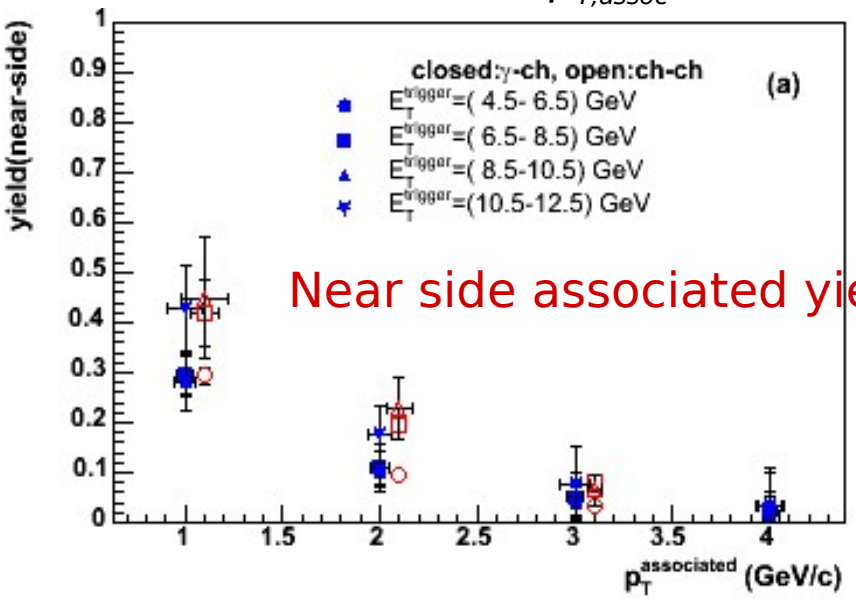
Near- and Away-side Yields

Results consistent with $h^{+/-}$ measurement

- Away-side yield is larger and broader as in *pp*
- Results similar to $h^{+/-}$
- This gives a reference for similar studies in *AuAu* from the Run IV dataset

Away side associated yield





Near side associated yield

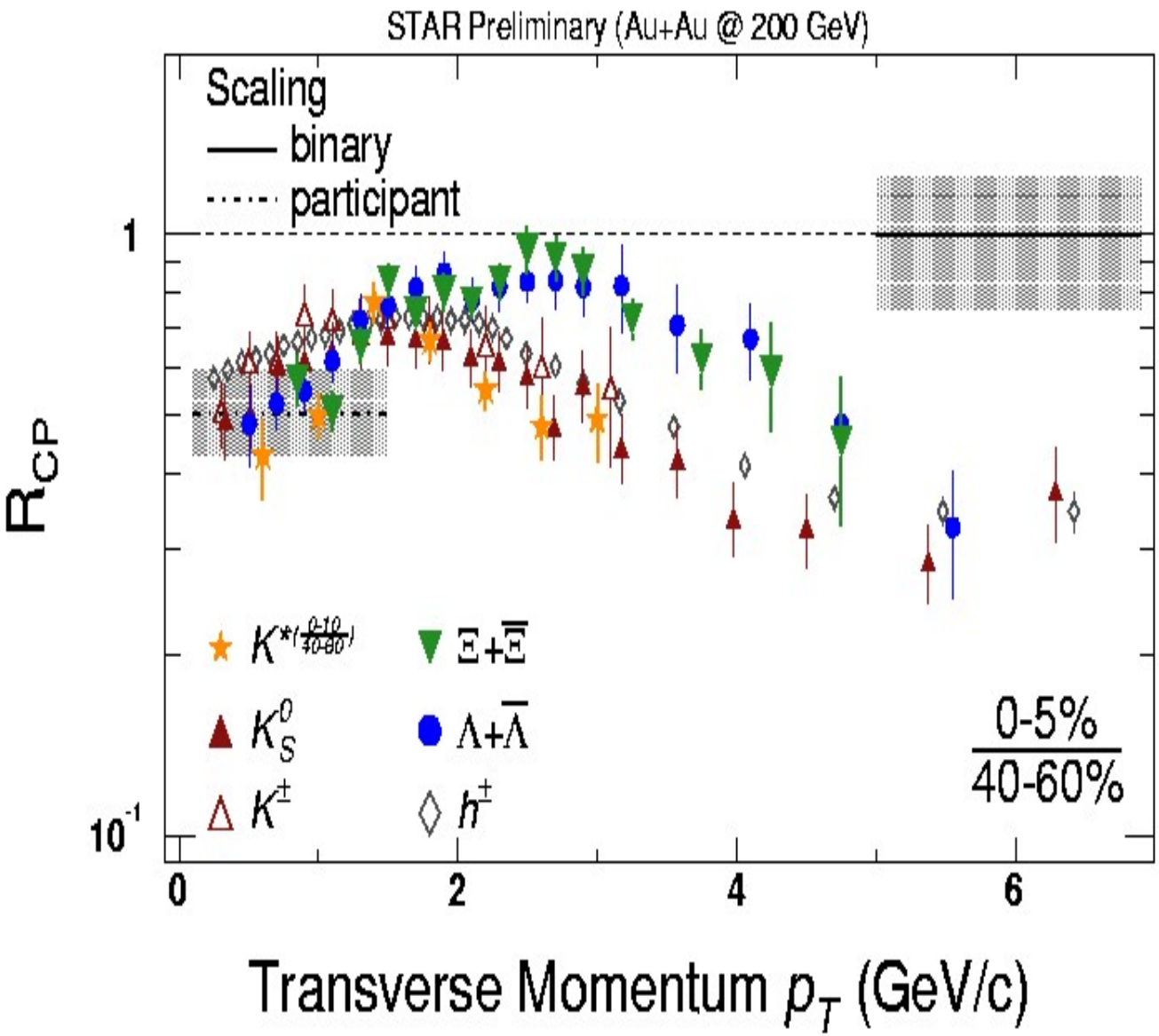
Summary and Conclusions

- Identified particle correlations are feasible
- Near-side yields larger than *pp*
- Away-side yields larger at low to intermediate p_T
- Associated spectra do not exhibit significant trigger species dependence
- All results will be much improved with Run IV statistics – wait for QM05!

End

Motivation IV

Baryon/meson difference may lead to different correlation structures



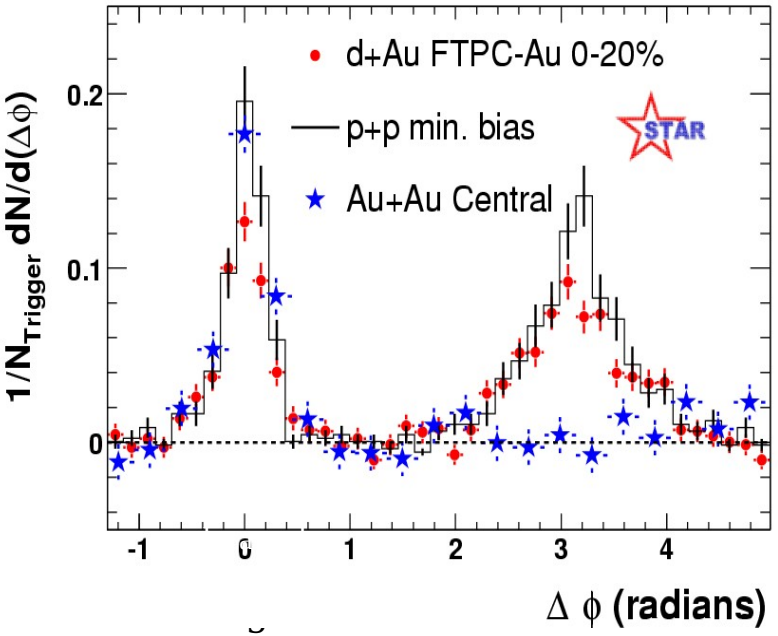
- Baryons and mesons behave differently at intermediate p_T
- Coalescence models relate yields to mixture of thermal and shower quarks
- Hard partons modify available quarks for coalescence – near and away

Motivation II

Near-side correlation is jet-like

Phys. Rev. Lett. 90 (2003) 082302

- Verify that trigger particle is indeed fragmentation of a hard parton
  - near-side shape
  - I_{AA}
- Away-side structure completely modified relative to *pp*
- Away-side hard parton interacted strongly with medium
- Tag this probe to study the interaction of parton and medium



Correlations V: *soft sector* df

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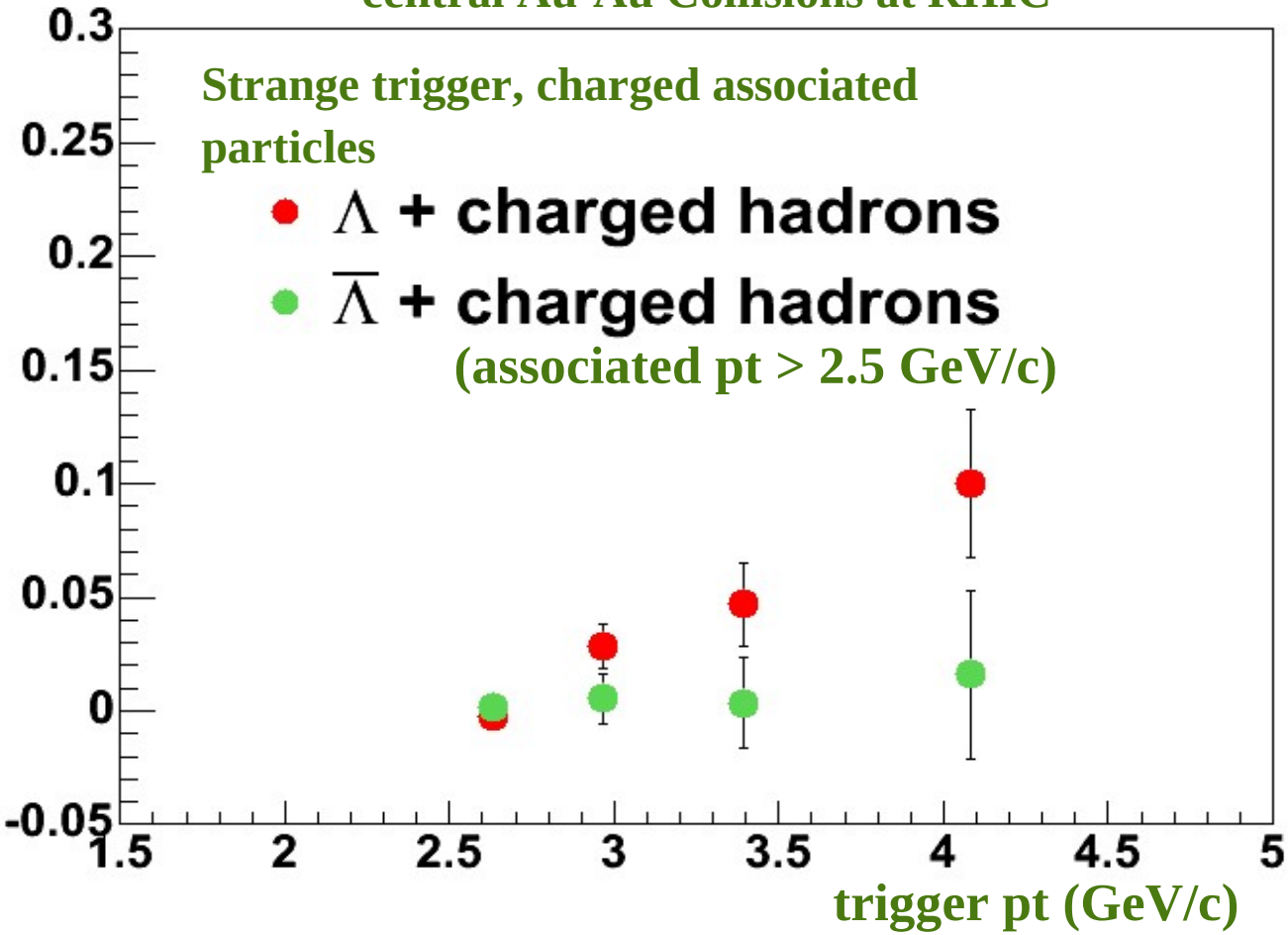
- Motivation

(Same side – away side) two particle correlation strength in central Au-Au Collisions at RHIC



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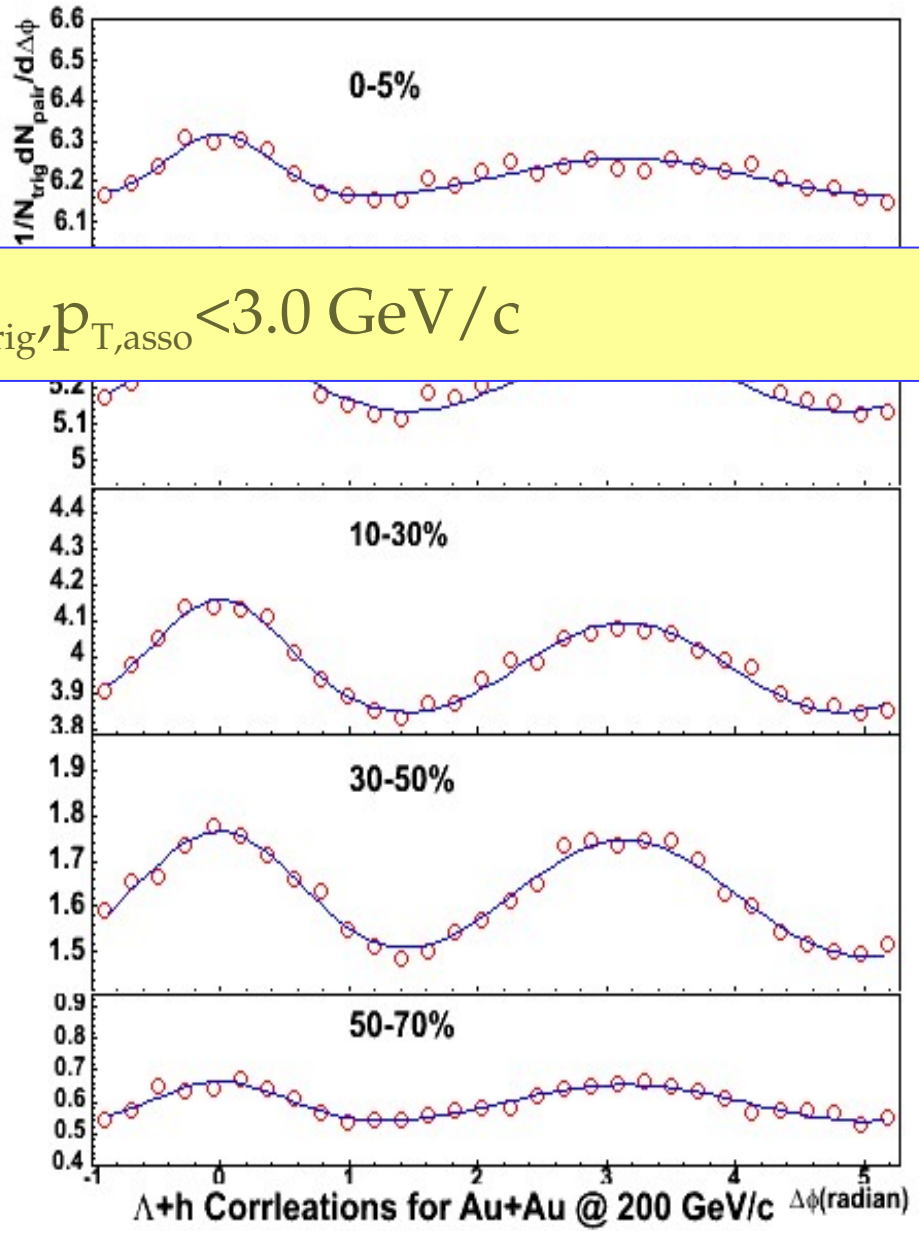
Outlook

Correlations V: *soft sector* df

Near-side yields greater in AuAu than pp

- Motivation
- Methods
- Correlations
  - dh Correlations
  - df Correlations in the "hard sector"
  - df Correlations in the "soft sector"
- Summary and Outlook

$1.5\ \mathrm{GeV}/c < p_{T,trig}, p_{T,asso} < 3.0\ \mathrm{GeV}/c$



AuAu 200GeV

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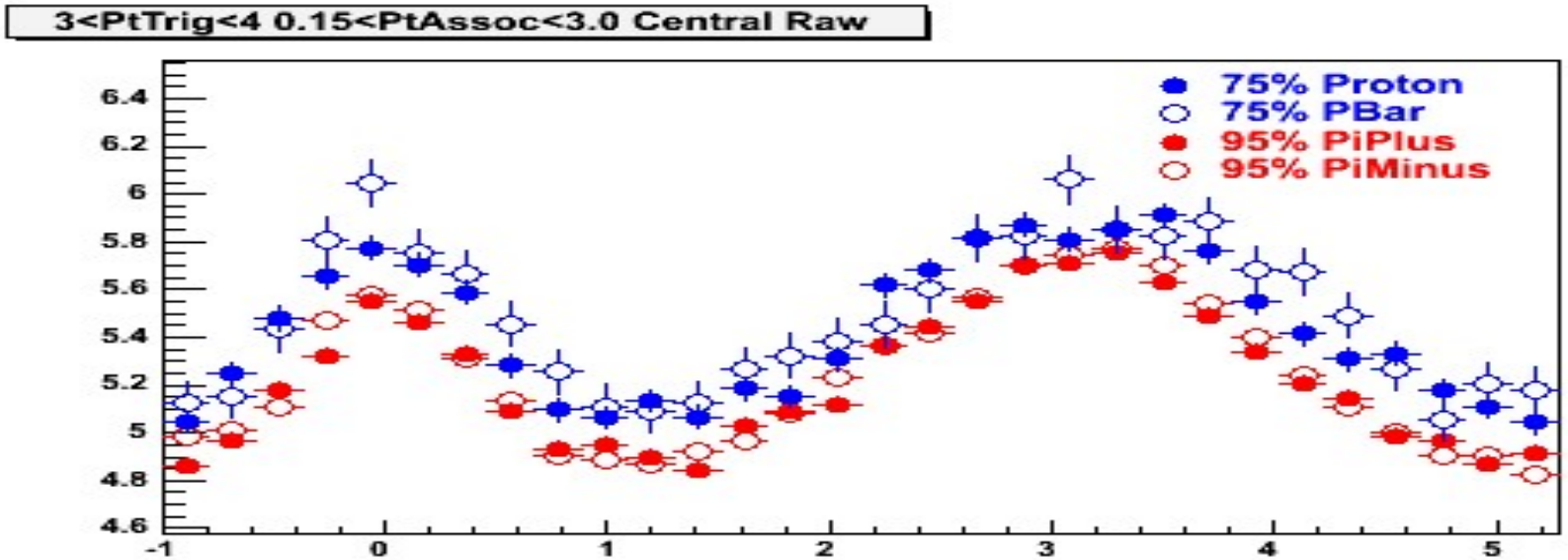
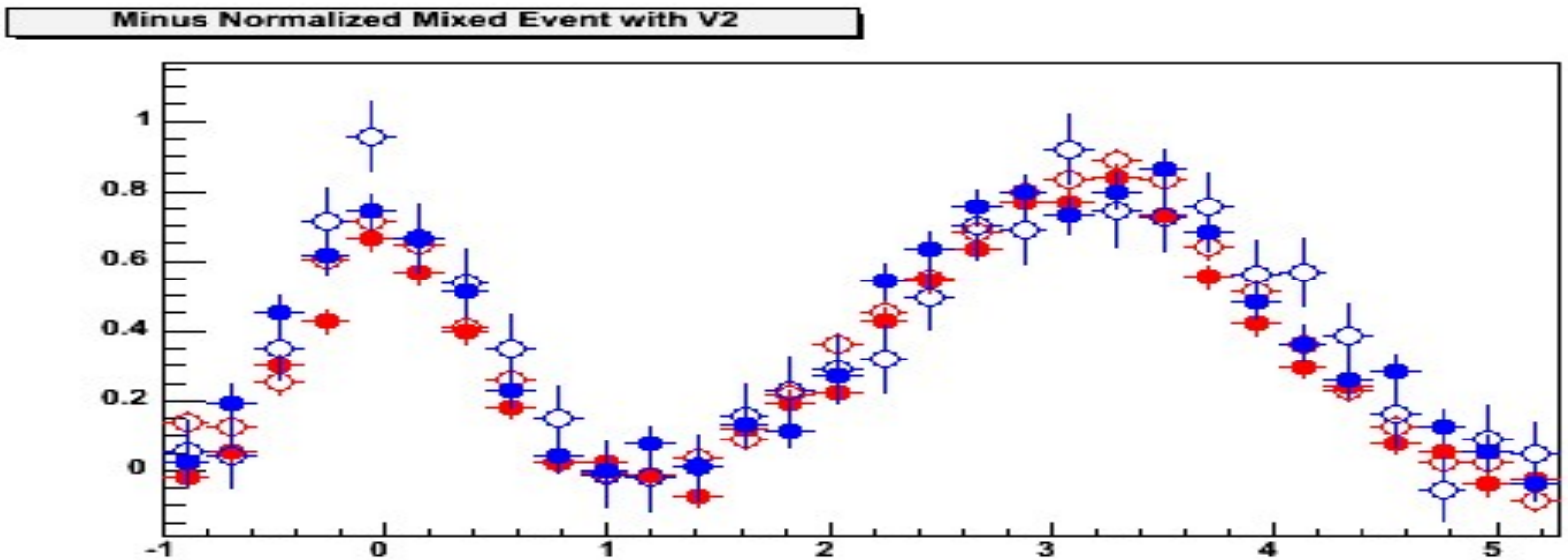
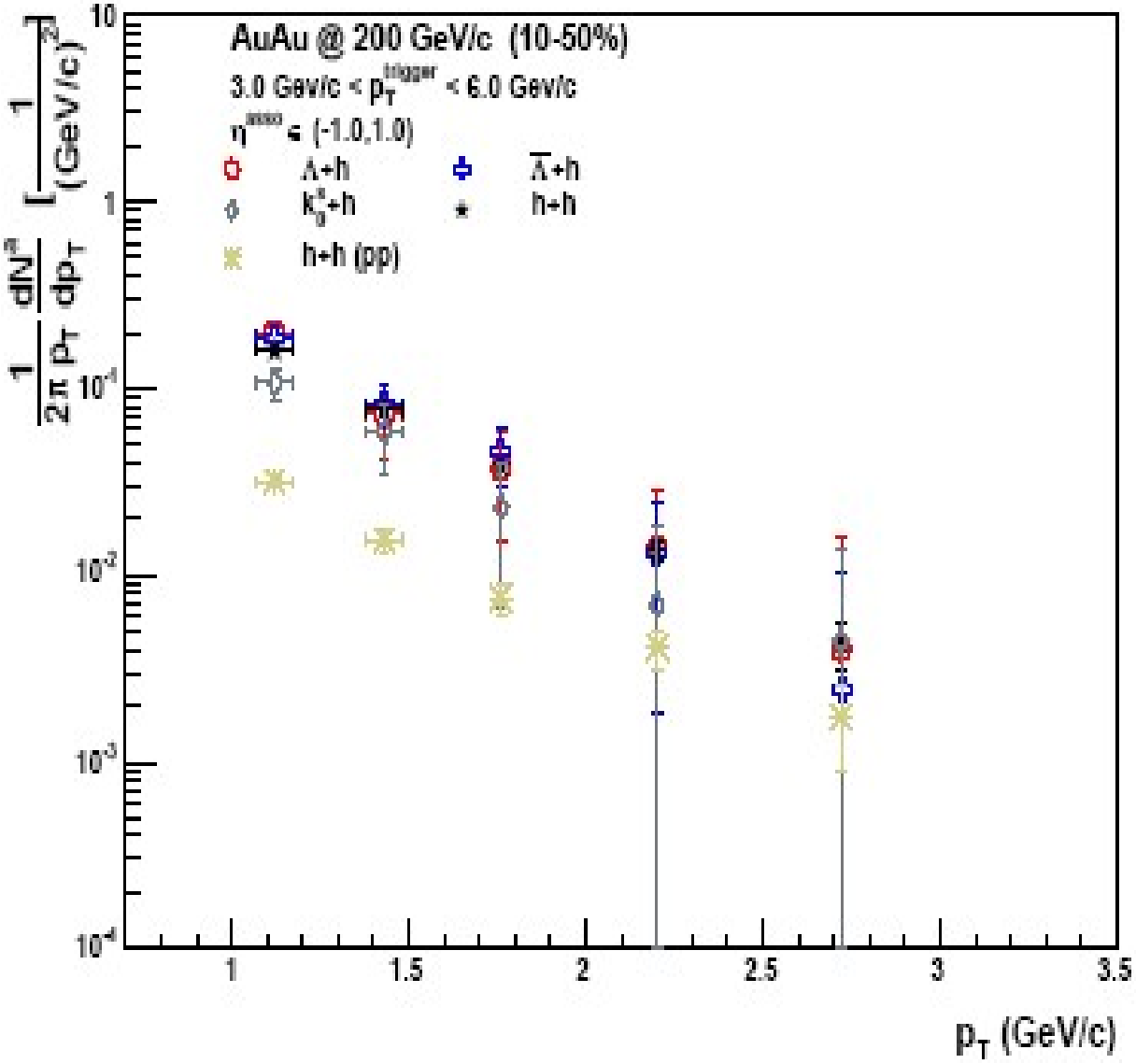




Near-side Spectra for Mid-central Events

Mid-central near-side spectra

- Spectra largely independent of trigger species
- Improved statistics will allow a more differential study