Event-plane dependent away-side jet-like correlation shape in Au+Au collisions at 200 GeV from STAR

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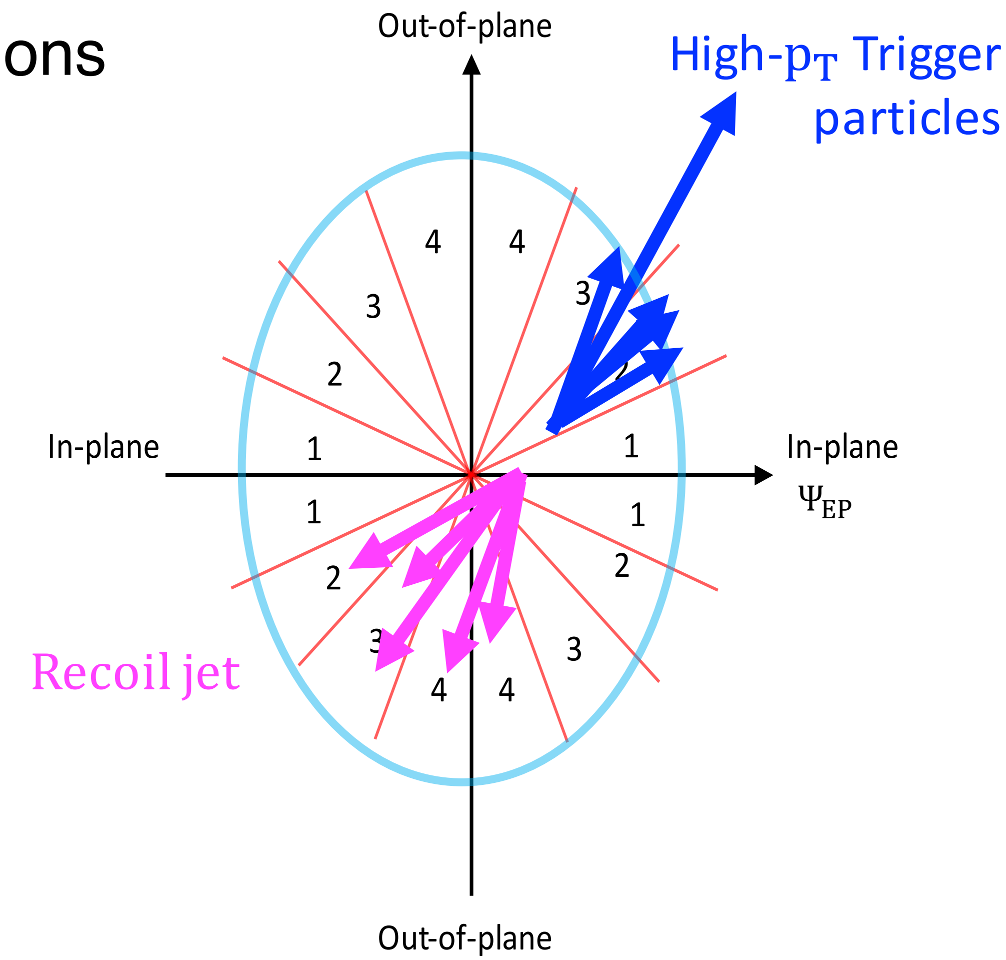
Outline

- Motivation
- Background subtraction method
- Event-plane reconstruction at forward rapidity
- Results
  - Measured event-plane dependent away-side correlations
  - Unfolding methodology for event-plane resolution
  - Resolution-corrected event-plane dependent away-side correlations
- Summary

Motivation

- Jets are modified through jet-medium interactions in relativistic heavy-ion collisions
- Jet modification depends on path length, which is emission-angle dependent in non-central heavy-ion collisions
- Away-side jet spreads in Δη for dihadron: flow background removal is challenging

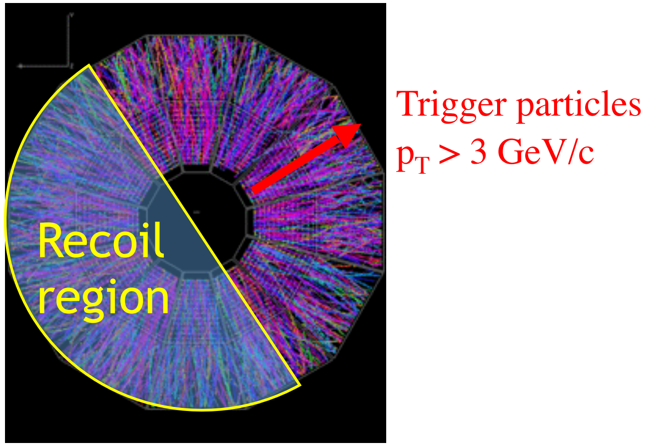


Enhance jet population

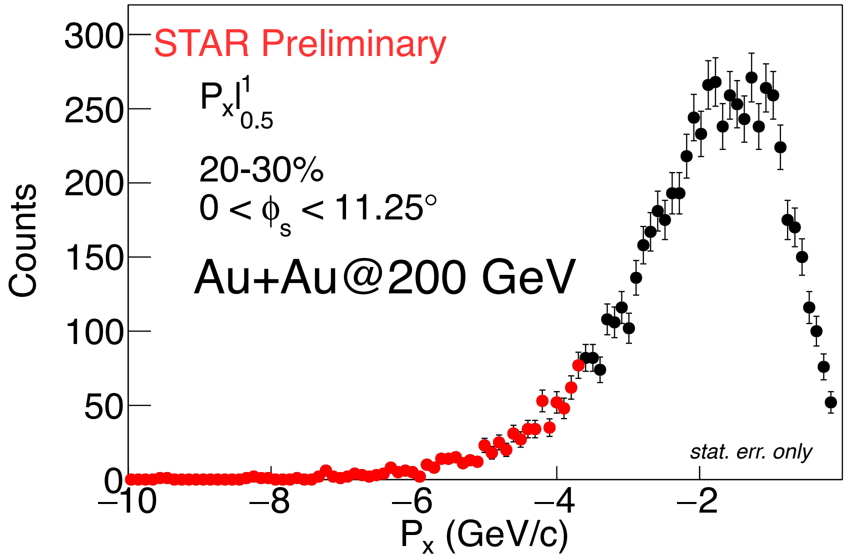
P_x : projection of away-side p_T onto trigger axis

$$P_x|_{\eta_1}^{\eta_2} = \sum_{\eta_1<\eta_a<\eta_2,|\phi_a-\phi_{trig}|>\frac{\pi}{2}} p_T^a \cos(\phi_a - \phi_{trig})\frac{1}{\epsilon}$$

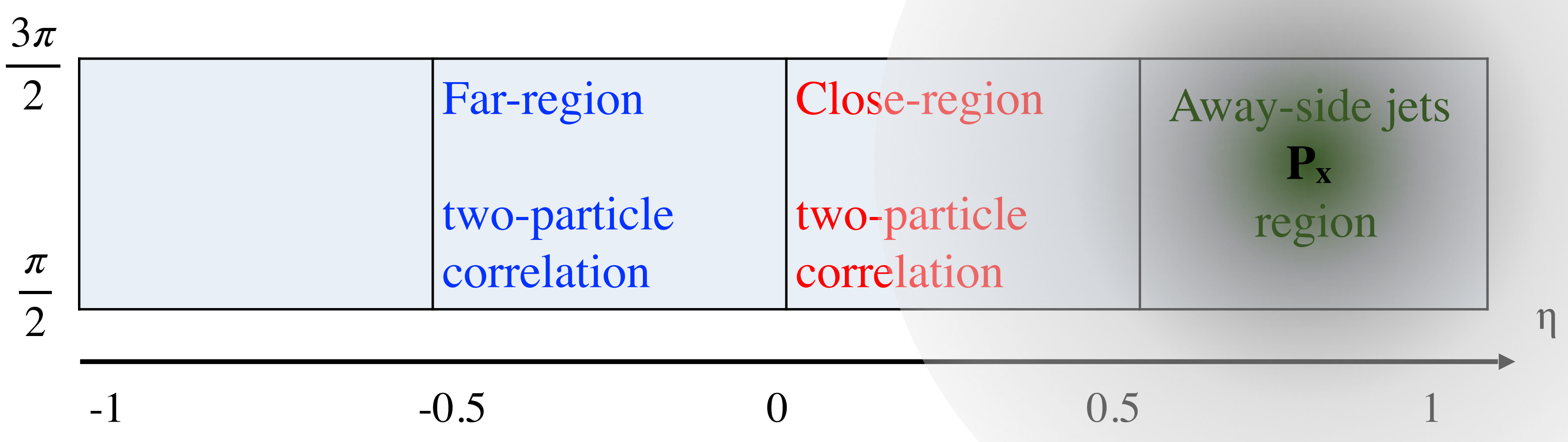
ϵ:single-particle acceptance efficiency



For each centrality,
cut on 10% left tail of P_x distribution to enhance away-side jet population in (η_1, η_2) acceptance



Flow background subtraction



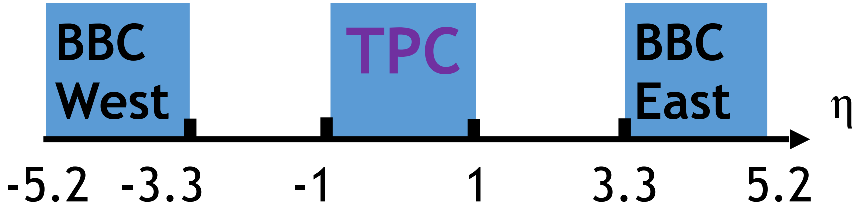
Analyze two-particle correlation in close-region and far-region respectively

Flow contributions to close region and far region are equal

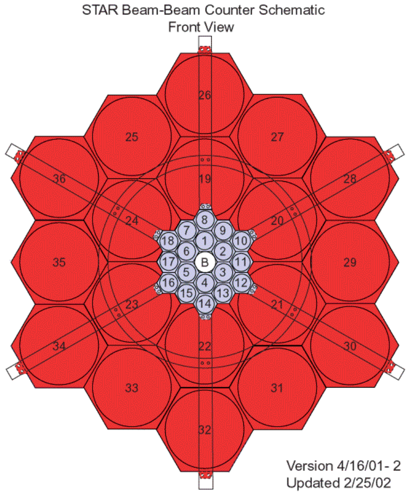
Close-region 2p corr.= flow + near-side jet-like + away-side jet-like * $\textbf{fraction}_{\textbf{close}}$
Far-region 2p corr. = flow + near-side jet-like + away-side jet-like * $\textbf{fraction}_{\textbf{far}}$
Difference = away-side jet-like * fraction

BBC event-plane Ψ_2 determination

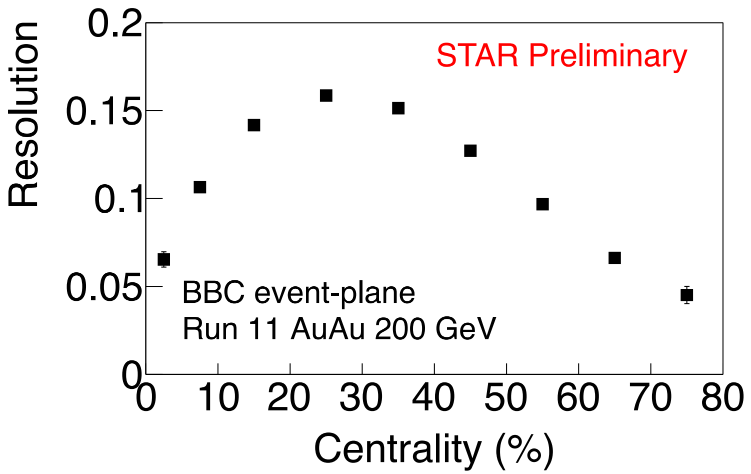
(a)



(b)



(c)



Large η gaps between BBCs and TPC

Minimal non-flow between trigger particles and BBC

$$\Psi_2 = (\tan^{-1}\frac{Q_{2y}}{Q_{2x}})/2,$$

$$Q_{2x} = \sum_i w_i \cos(2\phi_i)$$

$$Q_{2y} = \sum_i w_i \sin(2\phi_i)$$

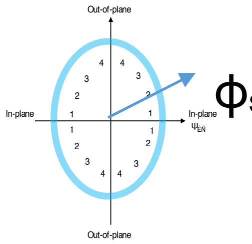
w_i: ADC signal weight

$$R \approx \sqrt{2\cos 2(\Psi_2^{East} - \Psi_2^{West})}$$

Raw event-plane dependent correlations

Close-region

Far-region



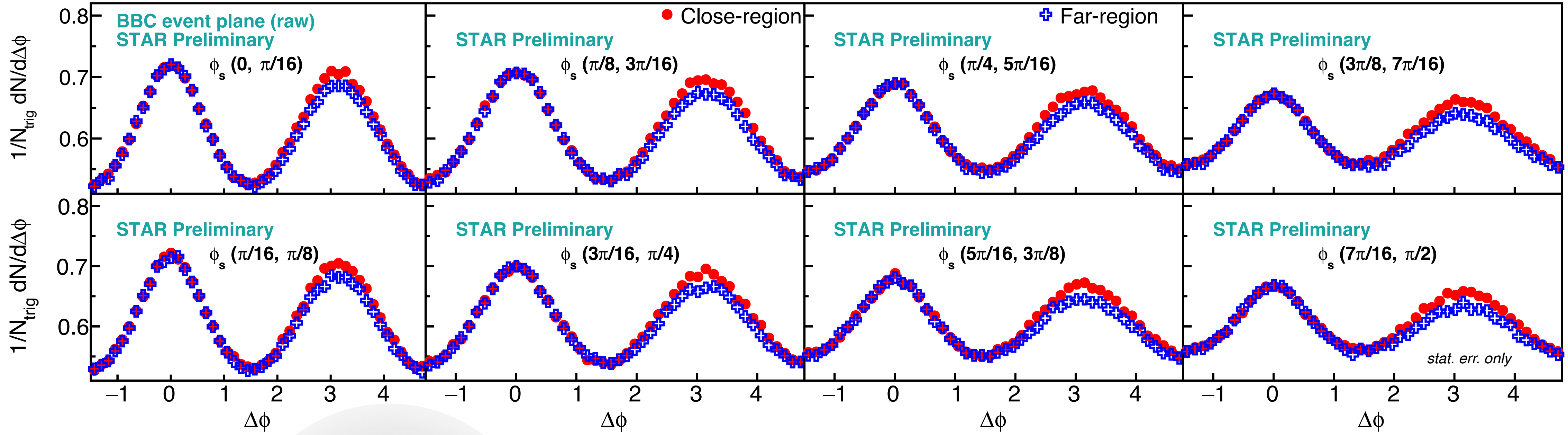
$\phi_s = \phi^{trig} - \Psi_{2,\,EP}$

20-60% Au+Au@200GeV

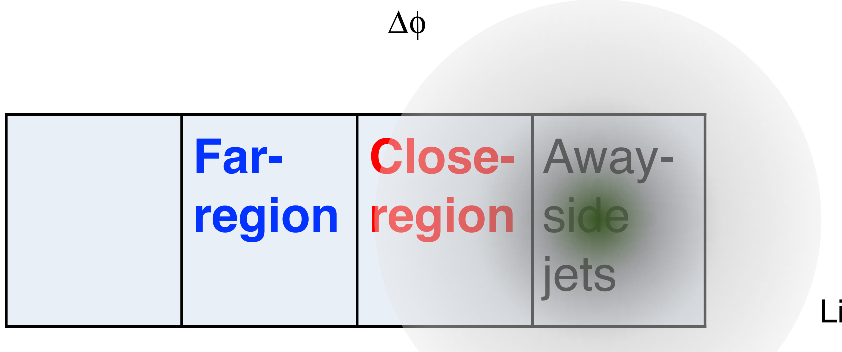
$3 < p_T^{trig} < 10$ GeV/c

$1 < p_T^{assoc} < 2$ GeV/c

In-plane → out-of-plane

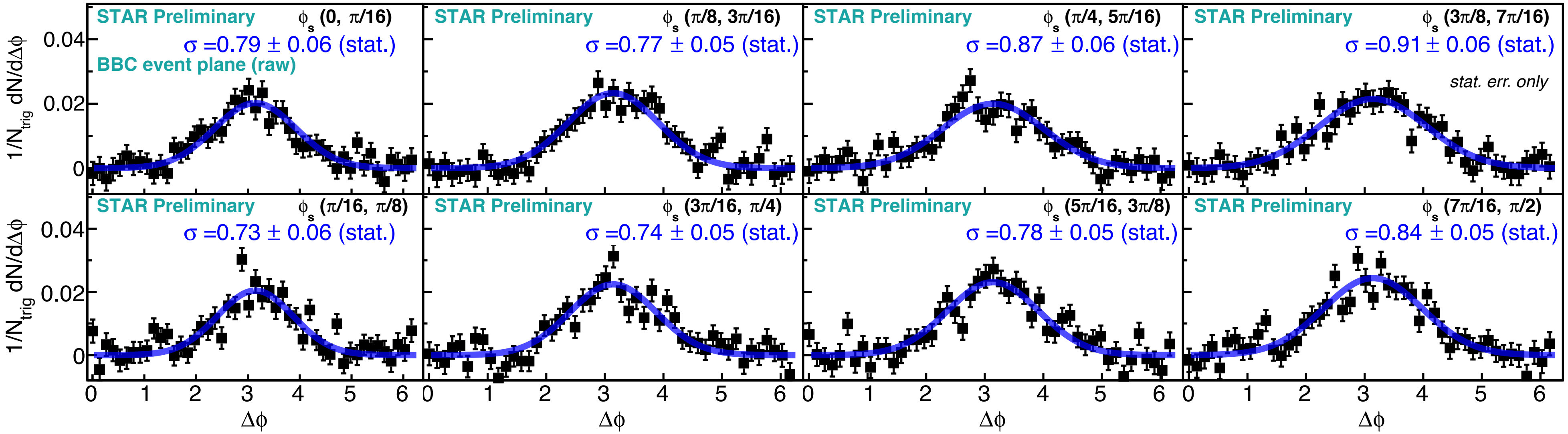


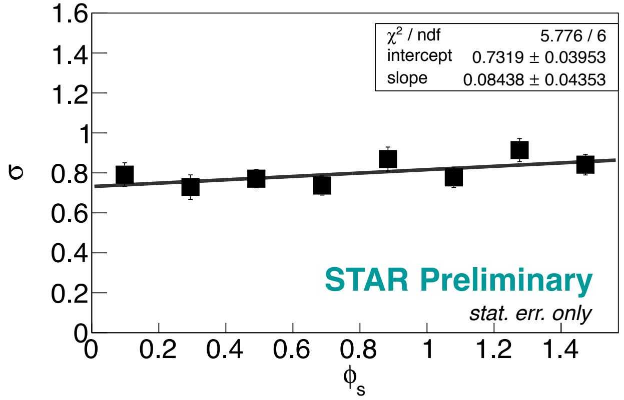
$\Delta\phi = \phi^{assoc} - \phi^{trig}$



Away-side correlation shape (Close – Far)

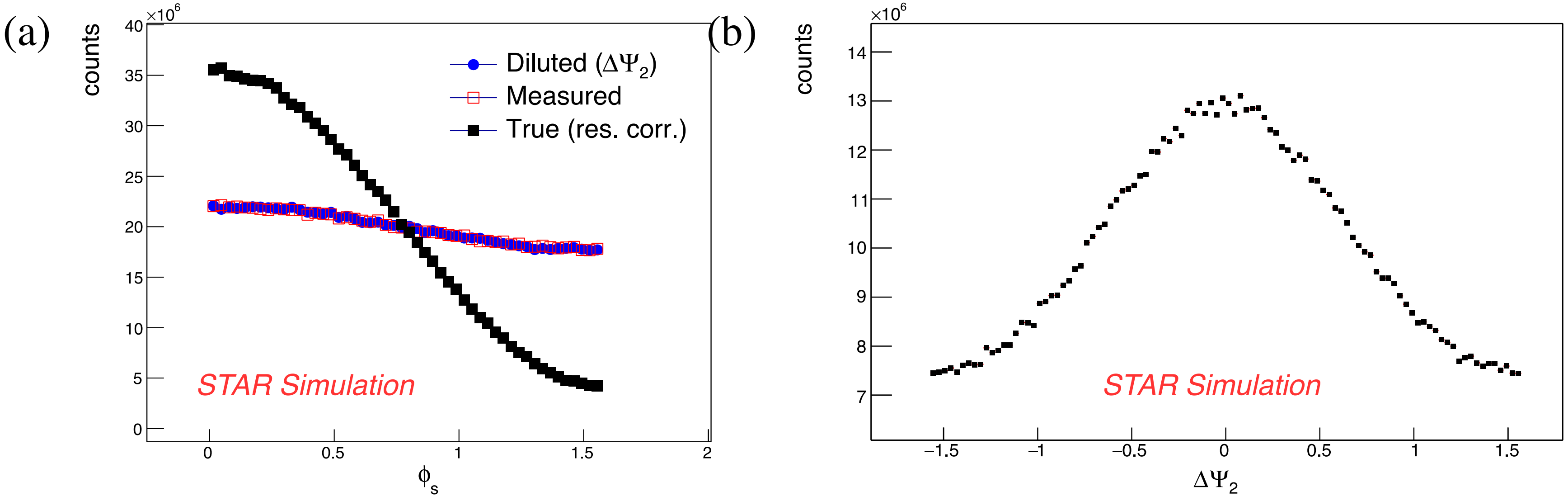
20-60% Au+Au@200GeV $3 < p_T^{trig} < 10$ GeV/c
$1 < p_T^{assoc} < 2$ GeV/c





- Away-side correlation shape (Close - Far)
- Blue curves are Gaussian fits
- Gaussian width (σ) increases with ϕ_s
- Slope = 0.08 ± 0.04
- Poor BBC Ψ_2 resolution, R = 0.136 ± 0.002

Resolution correction (Unfolding)



$$\frac{dN}{d\phi_s} \propto \left(1 + \frac{2v_2}{\mathcal{R}}\cos(2\phi_s)\right),$$

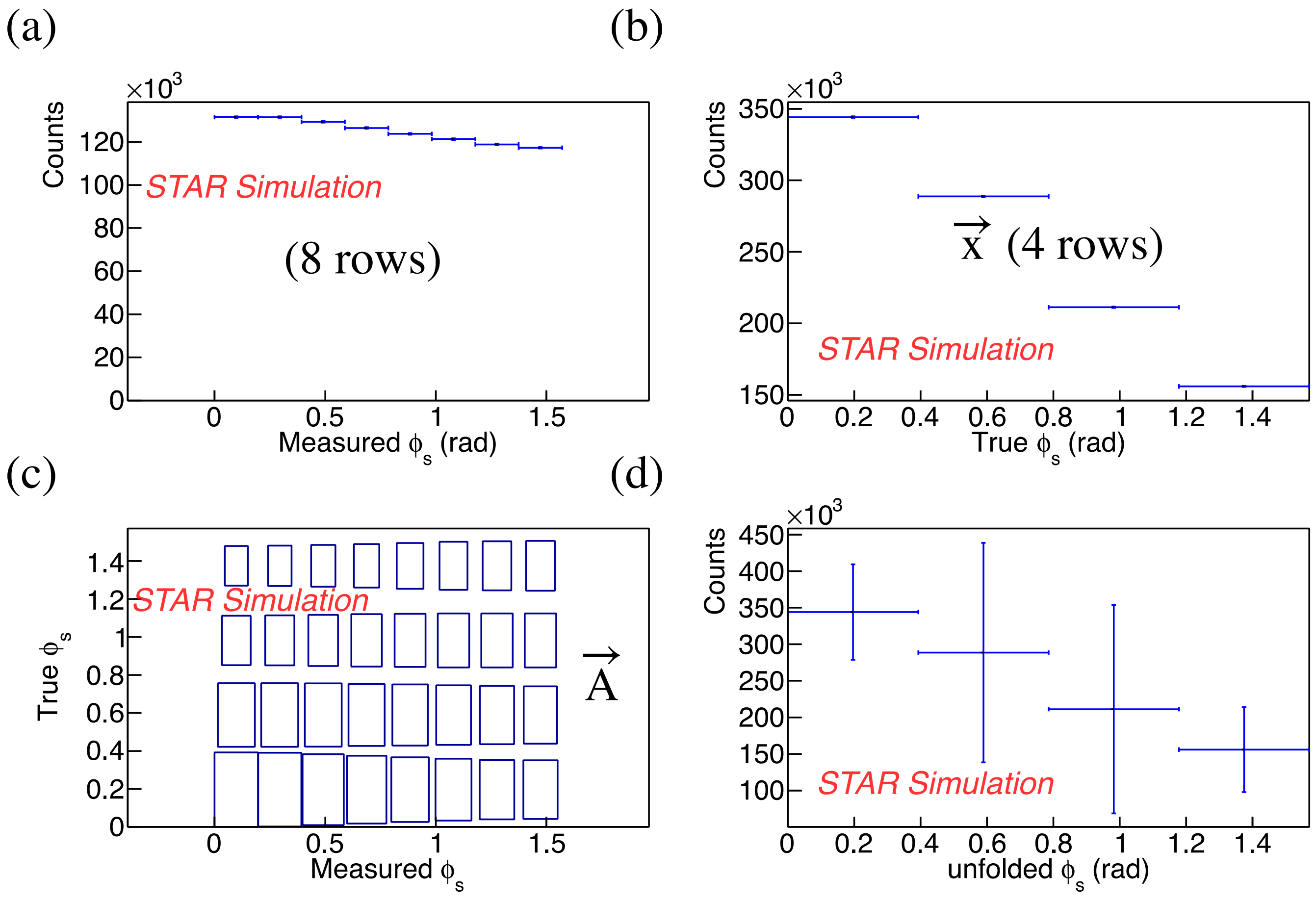
ϕ_s: The separation angle between trigger particles and EP

$$f(\chi, \Delta\Psi_2) = \frac{1}{\pi}\left[e^{-\frac{\chi^2}{2}} + \sqrt{\frac{\pi}{2}}\chi(\cos 2\Delta\Psi_2)e^{-\frac{\chi^2 \sin^2 2\Delta\Psi_2}{2}}\left(1 + \mathrm{erf}\left(\frac{\chi\cos 2\Delta\Psi_2}{\sqrt{2}}\right)\right)\right],$$

and $\chi = \mathcal{R}/\sqrt{\frac{\pi}{8}}$.

S. Voloshin, Y. Zhang, Z. Phys. C 70 (1996) 665

Resolution correction (TUnfold)



https://root.cern.ch/doc/master/classTUnfold.html

- Histogram (a) and (b) are filled by the data generated by MC
- 2D histogram (c) is regarded as the “probability matrix”, boxes for each row of y can be understood as the probability to migrate to the bin of x
- We again use (a) but as the input. We can obtain the output (d)
- The number of bins after unfolding is half of the input. (8bins -> 4 bins)

$\chi^2_{unfold} = \chi^2_A + \tau^2\chi^2_L + \lambda\sum_i(\vec{A}\vec{x} - \vec{y})i,$
χ^2_A is from a least square minimization
τ^2: regularization strength
χ^2_L for regularization
λ: Lagrangian parameter

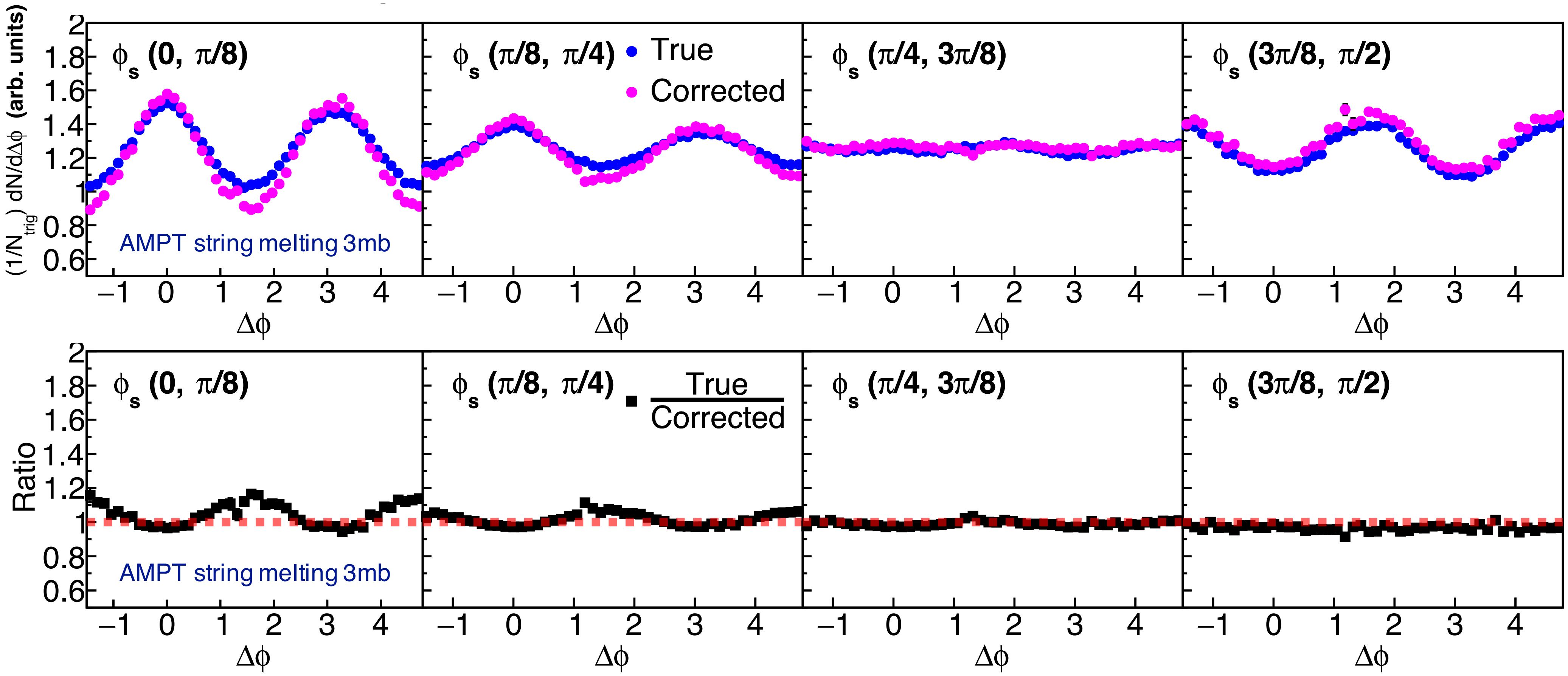
The best value of **τ2** can be obtained from the L curve scan

Closure check

AMPT closure check (Reaction plane in AMPT is given)

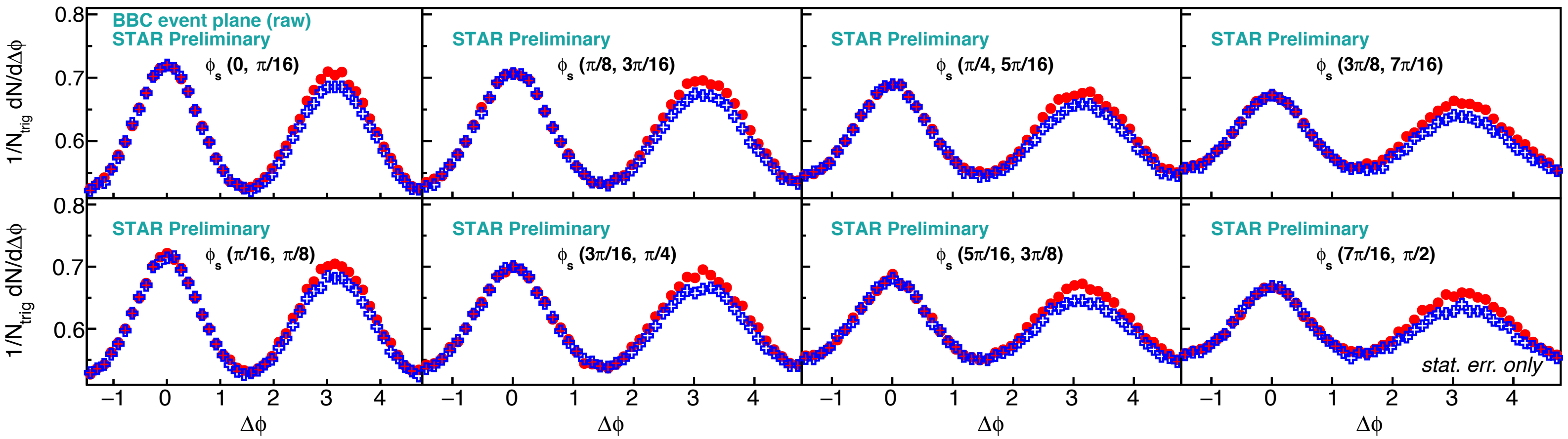
Z.-W. Lin, C. M. Ko, B. A. Li, B. Zhang, and S. Pal, Phys. Rev. C 72, 064901 (2005).

Close- and far-region two-particle correlations are combined

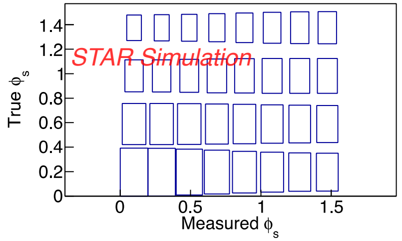


Unfolding procedure

Input:
Raw correlations
(8 raw ϕ_s bins)

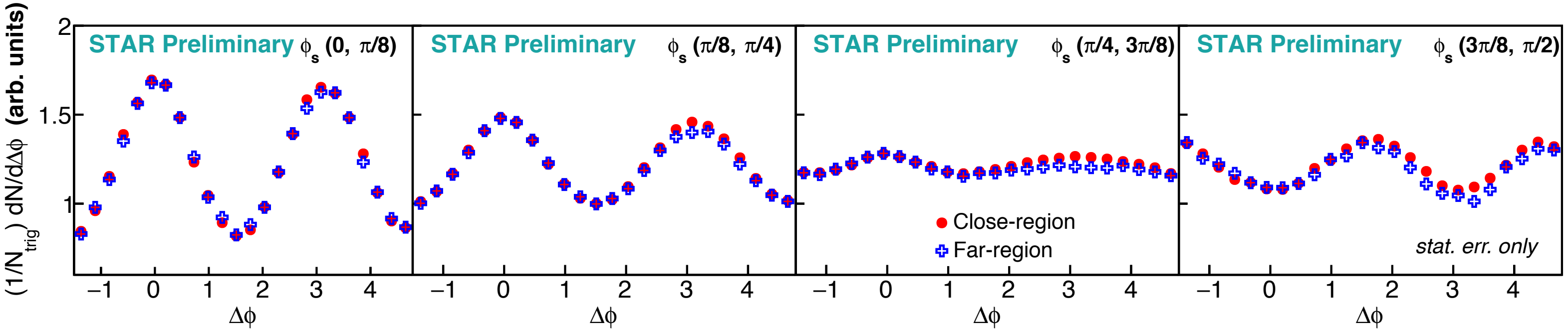


For each Δφ we have $\mathbf{M_U}\,\mathbf{Corr}^{\Delta\phi}_{\mathbf{Meas}}(\boldsymbol{\phi_s}) = \mathbf{Corr}^{\Delta\phi}_{\mathbf{Unfolded}}(\boldsymbol{\phi_s})$



Unfolding response matrix ($\mathbf{M}_U$)
(8 x 4)

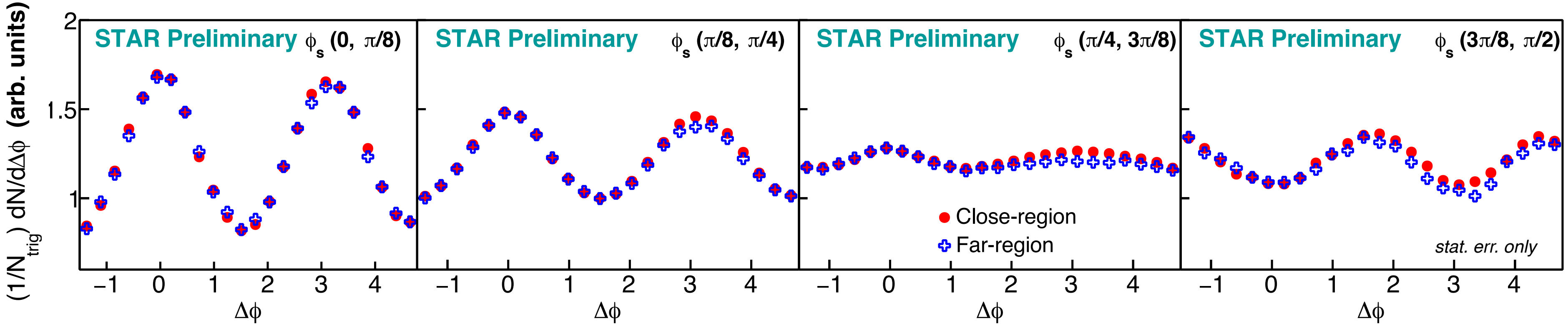
Output:
Correlations corrected for EP resolution
(4 corrected ϕ_s bins)



Resolution-corrected correlation functions

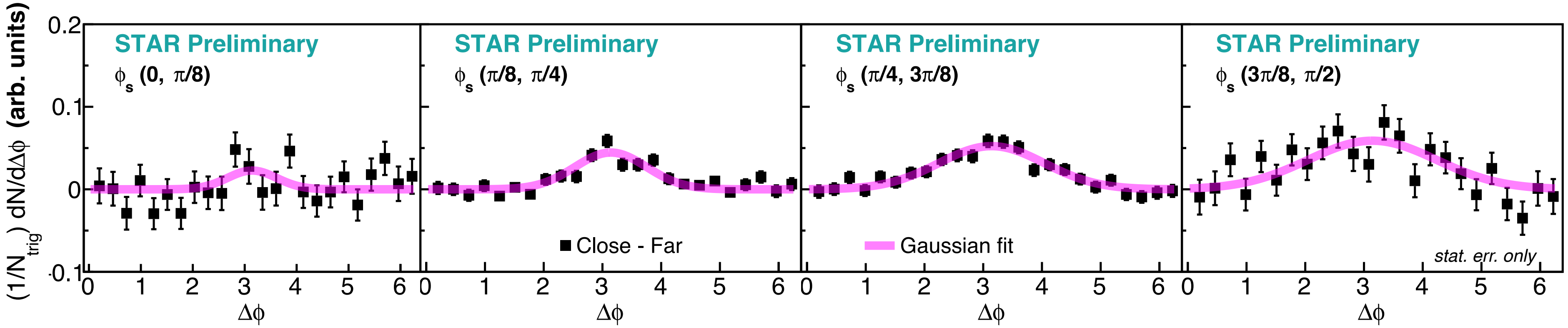
20-60% Au+Au@200GeV $3 < p_T^{trig} < 10$ GeV/c
$1 < p_T^{assoc} < 2$ GeV/c

Resolution corrected two-particle correlations:



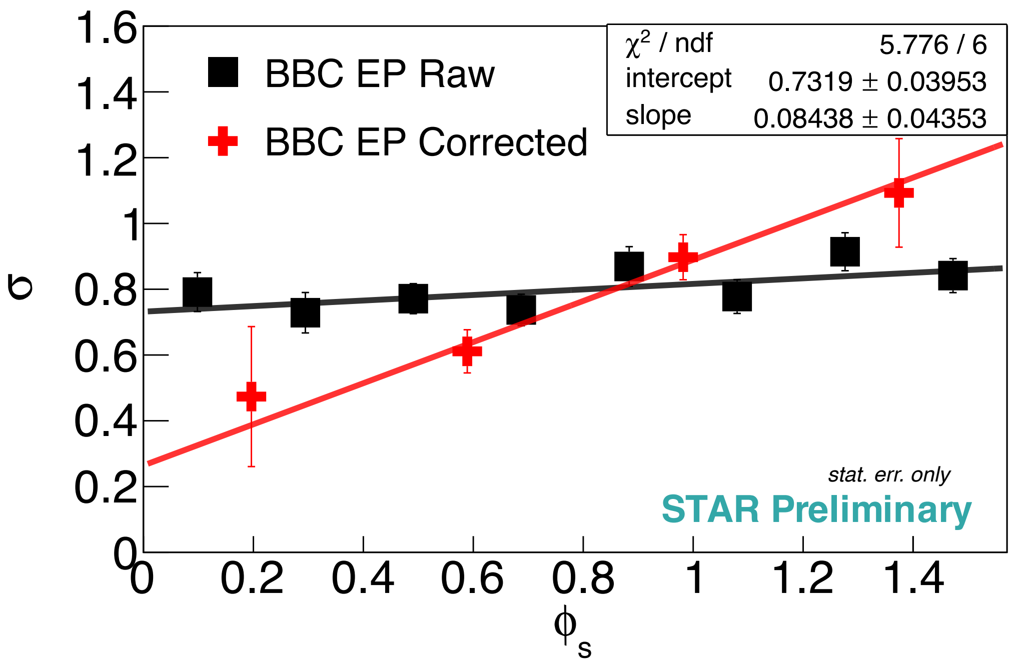
Systematics studies ongoing – expect largely correlated uncertainties that mostly cancelled after subtraction

Resolution corrected away-side (close-far) correlations:



Comparison

20-60% Au+Au@200GeV $3 < p_T^{trig} < 10$ GeV/c
$1 < p_T^{assoc} < 2$ GeV/c



- BBC Ψ_2 resolution = 0.136 ± 0.002
- Measured slope ≈ 0.08 ± 0.04 (stat.)
- Corrected slope ≈ 0.66 ± 0.27 (stat.)

Summary

- Data-driven method to subtract away-side flow background of all harmonics (with large η gap between P_X and far-region)
- Event-plane (EP) dependent two-particle jet-like correlation shape relative to a high-p_T trigger particle ($3 < p_T^{trig} < 10$ GeV/c) in 200 GeV Au+Au collisions are reported
- The 2^{nd}-order EP is reconstructed with BBC
  EP resolution is corrected via an unfolding procedure
- The width of the away-side jet-like peak is found to increase with ϕ_s, which is an indication of jet-medium interactions

Outlook:

- Correlations in different p_T^{assoc} and centrality bins
- Comprehensive systematics study
- Isobar data with Event Plane Detector