Event-plane dependent away-side jet-like correlation shape in AuAu collisions at $\sqrt{s_{NN}} = 200$ GeV from STAR

Liang Zhang

(for the STAR collaboration)

Central China Normal University

&

Purdue University

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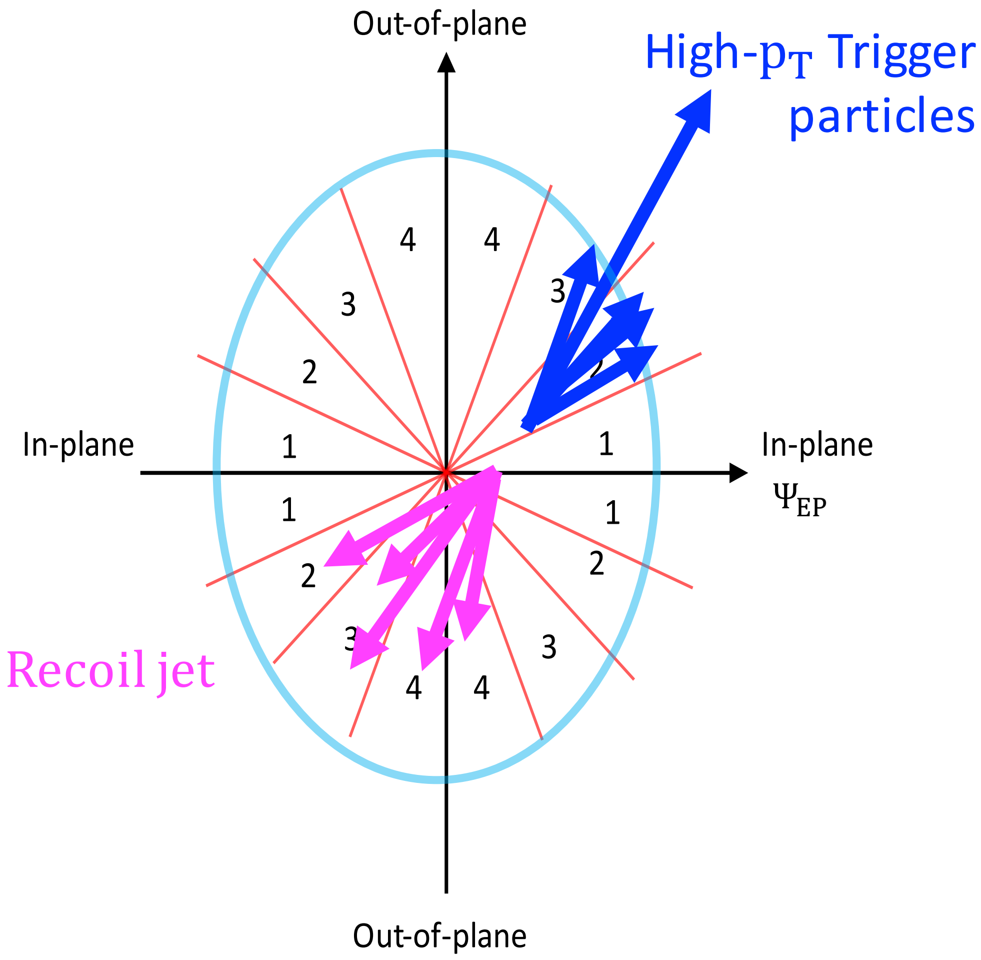
Outline

- Motivation
- Background subtraction
  - Large recoil transverse momentum (P_x) to enhance away-side jet population in acceptance.
  - Flow background subtraction
- Event-plane reconstruction with Beam-Beam Counters
- 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 in relativistic heavy-ion collisions due to jet-medium interactions.

- In-medium path length of the recoil (away-side) parton is expected to depend on its emission angle w.r.t. the event-plane in non-central Au+Au collisons.

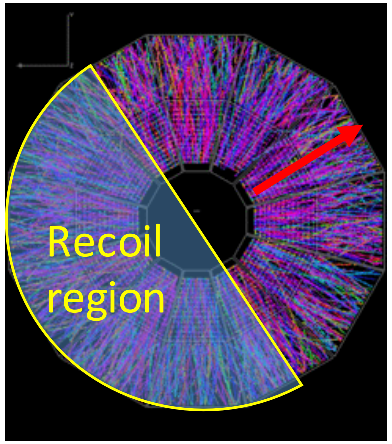


Large recoil transverse momentum

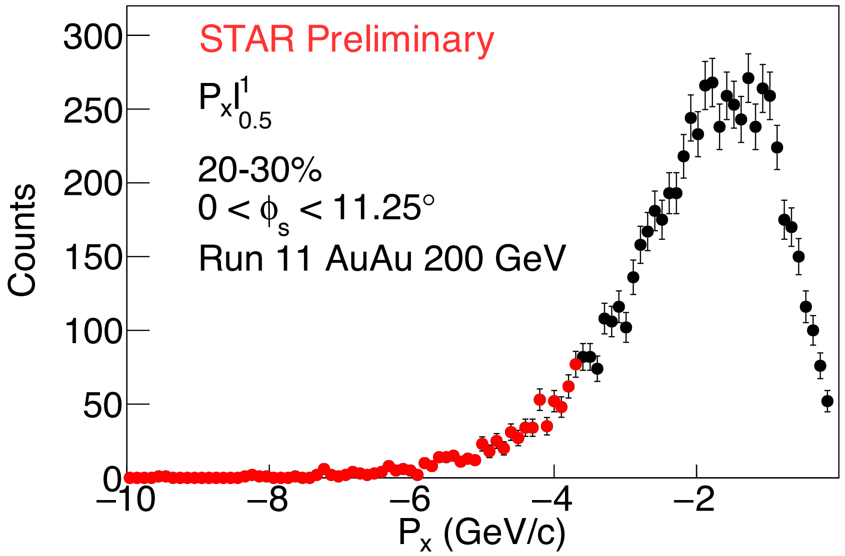
P_x: projection of away-side p_T onto trigger axis.

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

ϵ: single-particle acceptance efficiency.

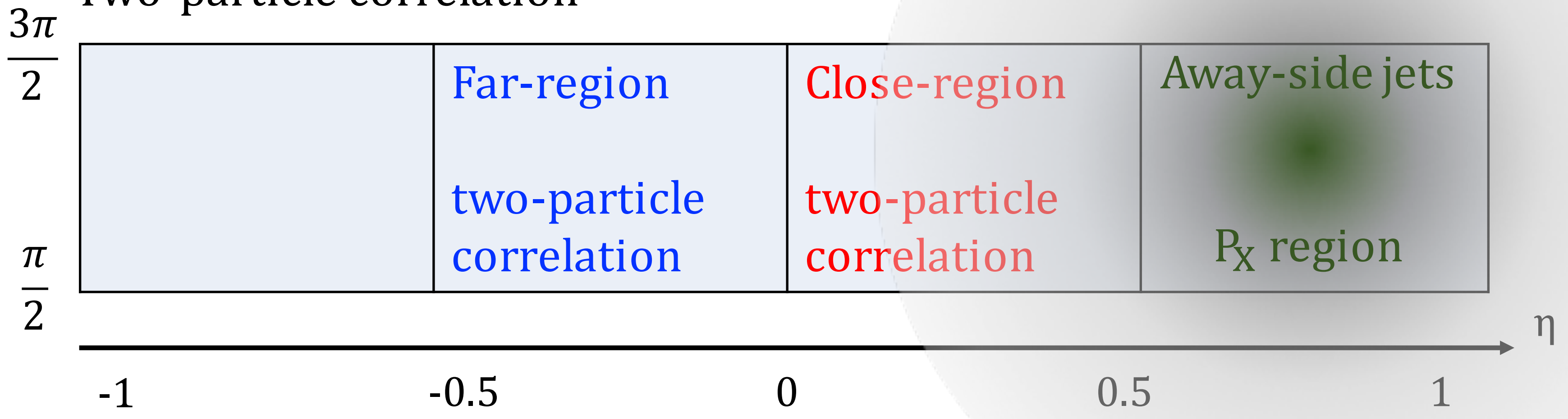


For each centrality, cut on the left tail of the distribution (10% of events) to enhance the away-side jet population in acceptance



Flow background subtraction

Two-particle correlation



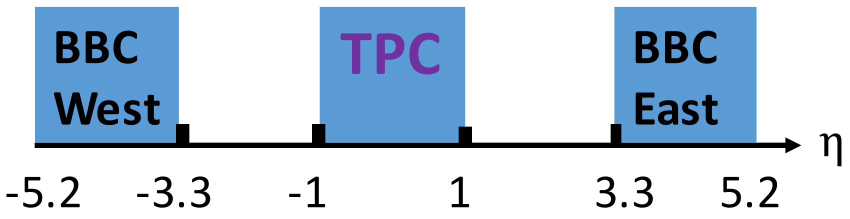
Analyze two-particle correlation in close-region and far-region respectively.

Flow contributions to close region and far region are equal.

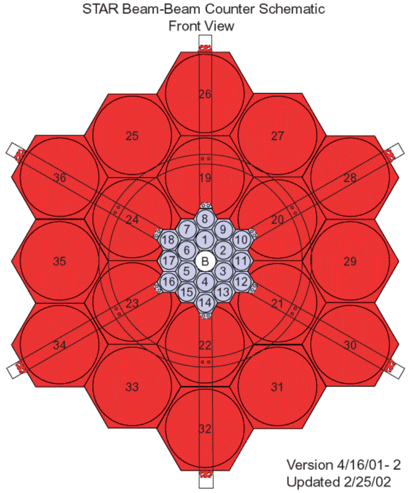
Close-region 2p corr.= flow + near-side jet-like + away-side jet-like * $\text{fraction}_{\text{close}}$
Far-region 2p corr. = flow + near-side jet-like + away-side jet-like * $\text{fraction}_{\text{far}}$
Difference = away-side jet-like * fraction

BBC event-plane Ψ_2 determination

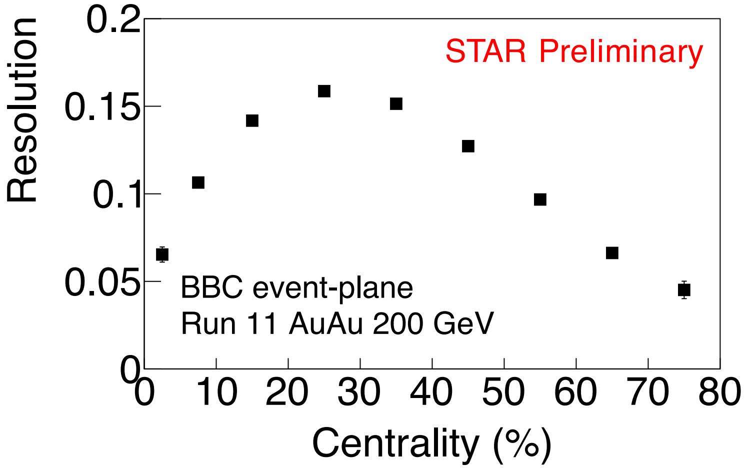
(a)



(b)



(c)



A large η gap between BBCs and mid-rapidity region.

Minimal non-flow correlation (e.g. resonance decays) 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.

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

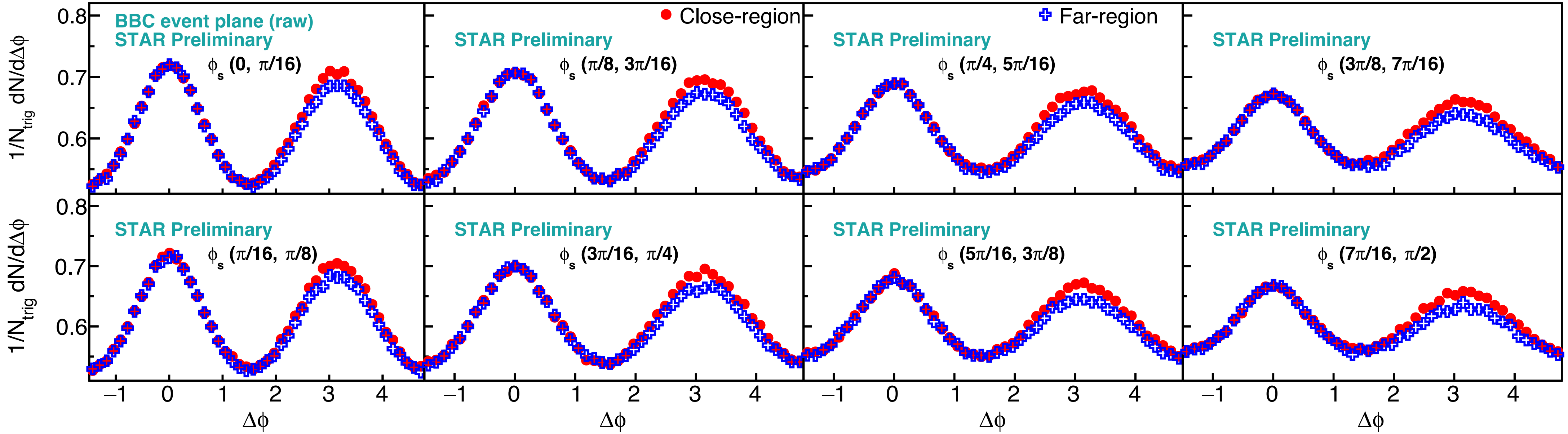
Raw event-plane dependent correlations

Run 11 AuAu 20-60%

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

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

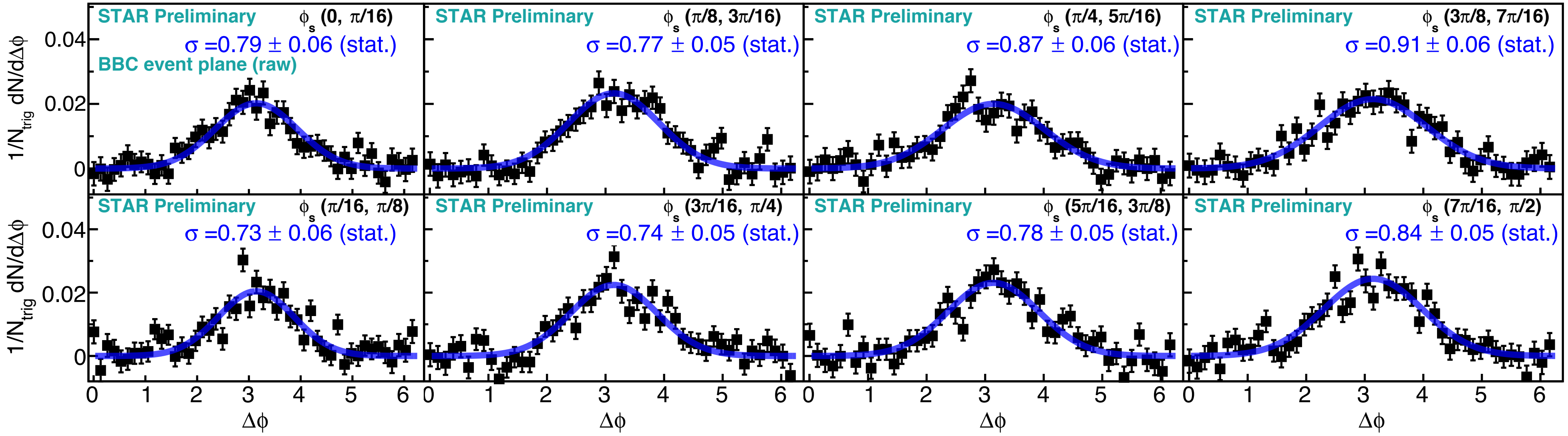
In-plane → out-of-plane

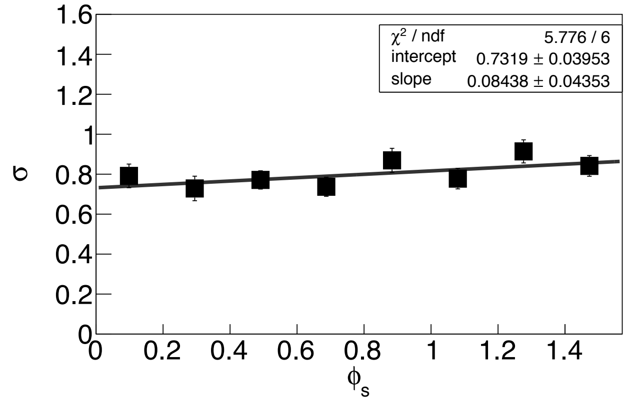


ϕ_s: The separate angle between trigger particle and EP

Away-side correlation shape (Close – Far)

Run 11 AuAu 20-60%, $3 < p_T^{trig} < 10$ GeV/c, $1 < p_T^{assoc} < 2$ GeV/c

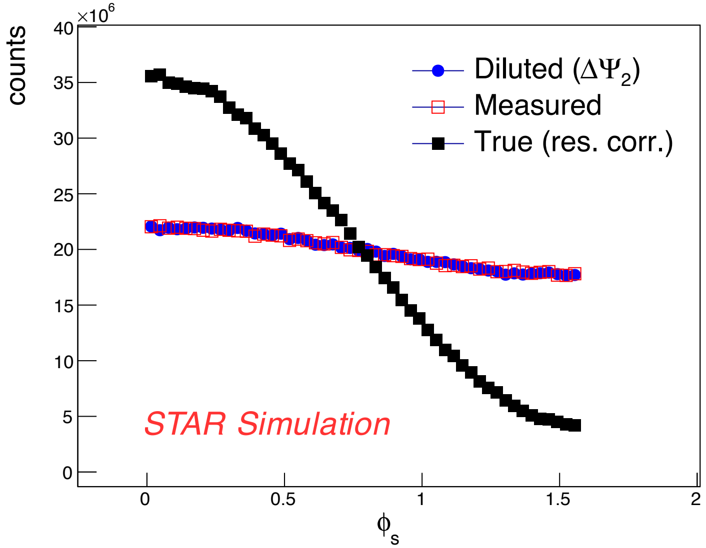




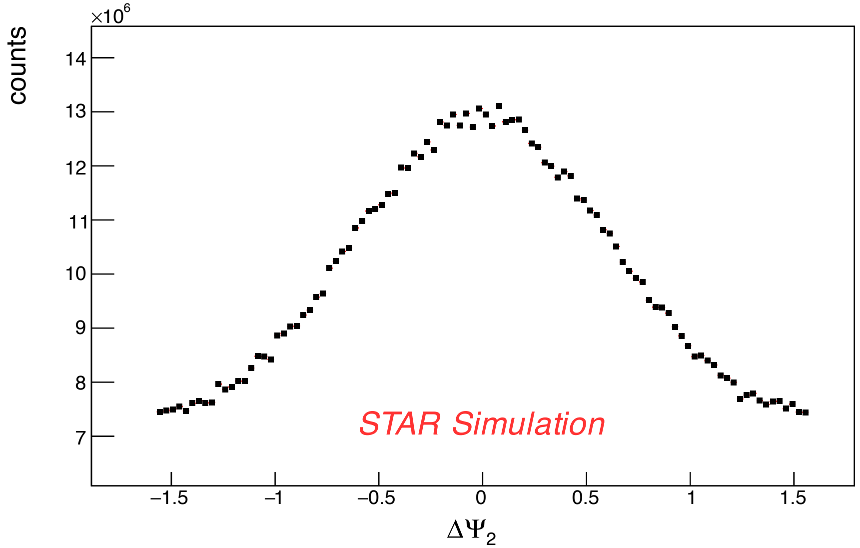
- ➢ Away-side correlation shape (Close - Far)
- ➢ Blue curves are Gaussian fits
- ➢ Gaussian width (σ) increases with ϕ_s
- ➢ Slope ≈ 0.08 (± 0.04) .
- ➢ **Poor BBC Ψ_2 resolution, R =0.136 ± 0.002**

Resolution correction (Unfolding)

(a)



(b)



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

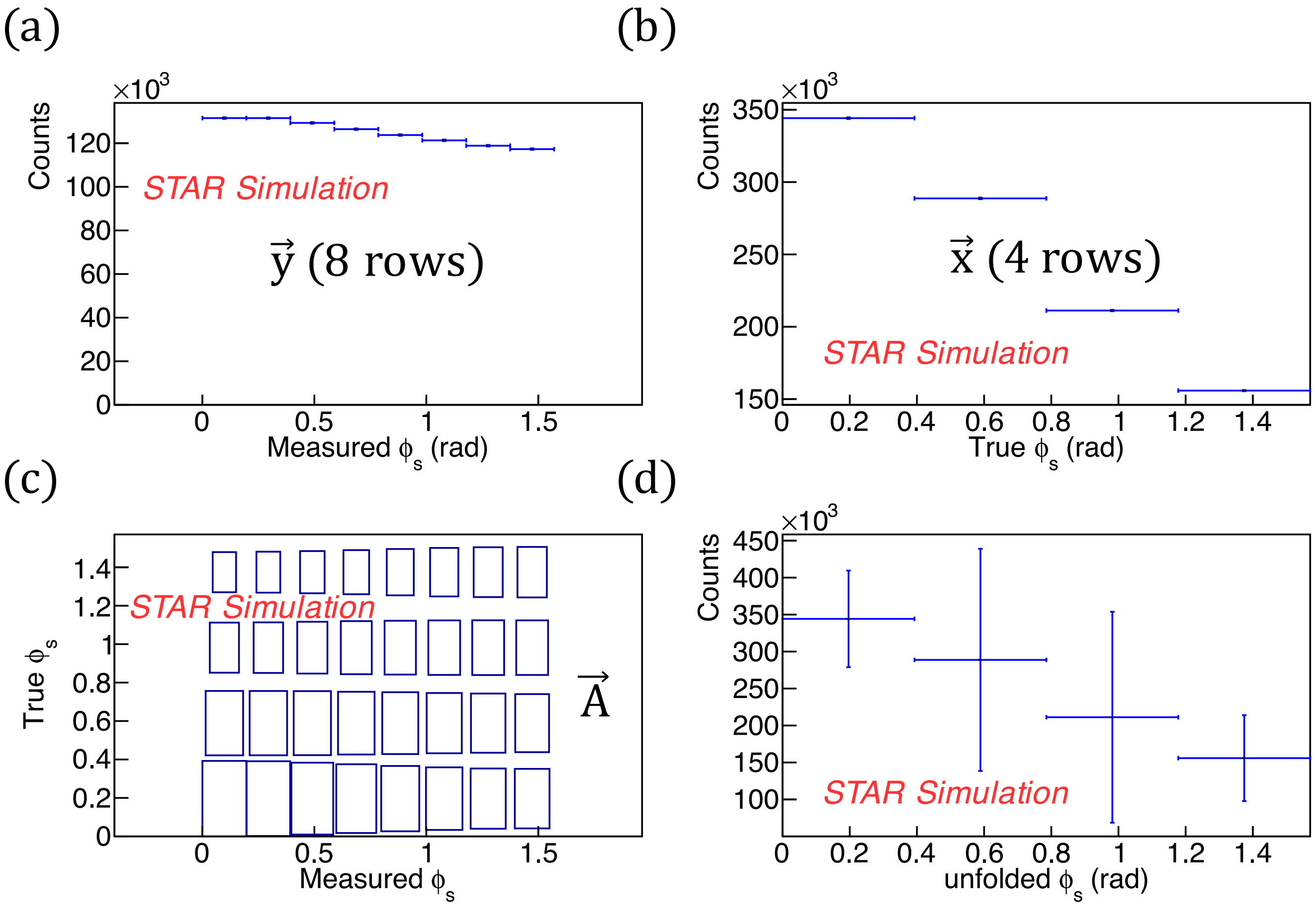
ϕ_s: The separate angle between trigger particles and EP.

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

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

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

Resolution correction (TUnfold)



- 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 τ^2 can be obtained from the L curve scan.

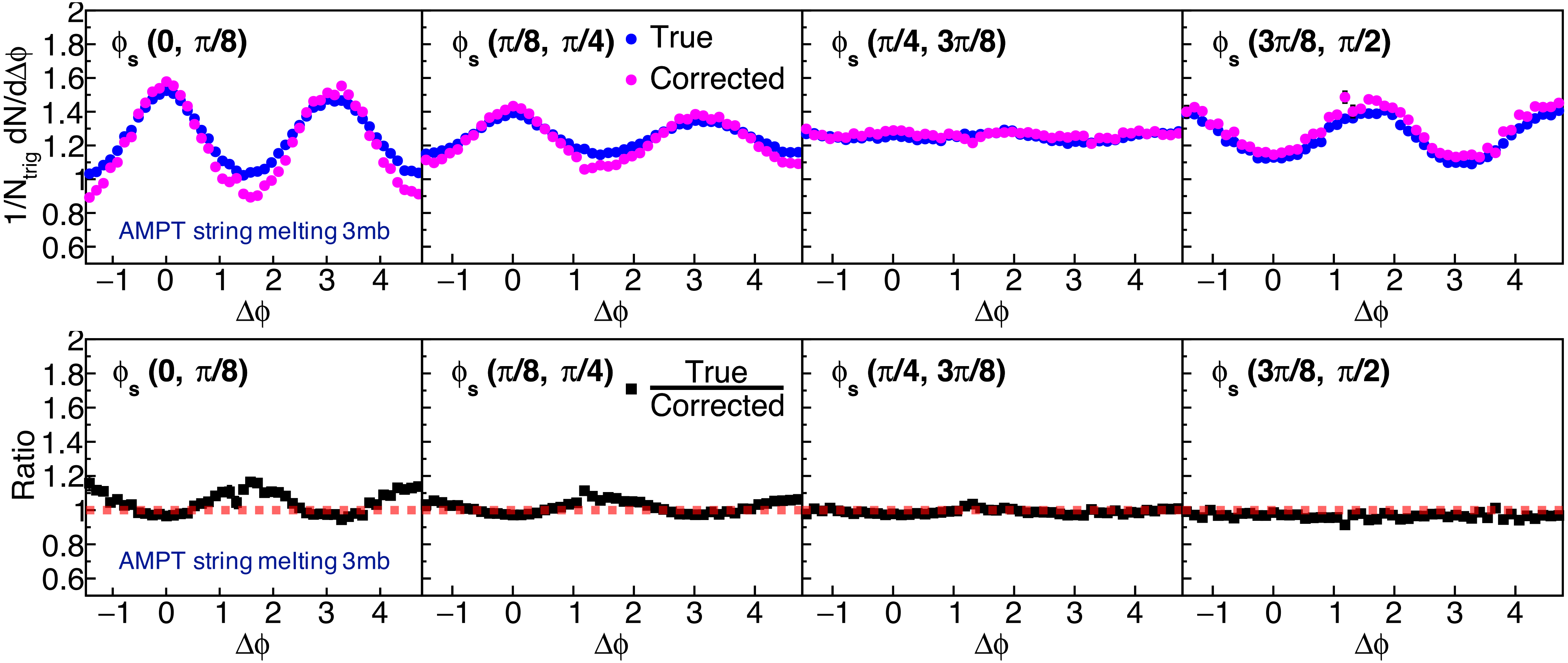
https://root.cern.ch/doc/master/classTUnfold.html

Closure check

AMPT closure check (Reaction plane in AMPT is given)

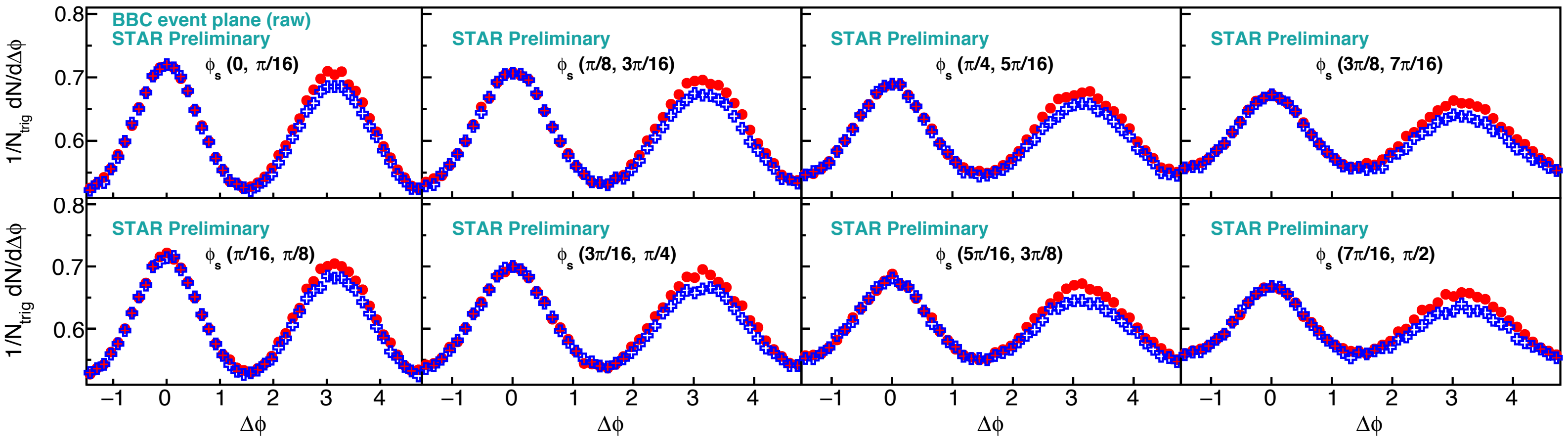
Z.-W. Lin, C. M. Ko, B. A. Li, B. Zhang, and S. Pal, Phys. Rev. C **72**, 064901 (2005).

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

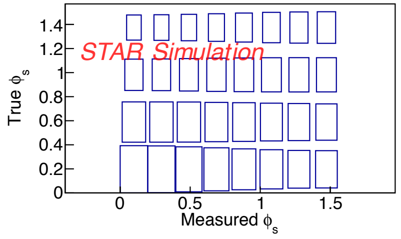


Unfolding procedure

Input:
Raw correlations
(8 raw ϕ_s bins)

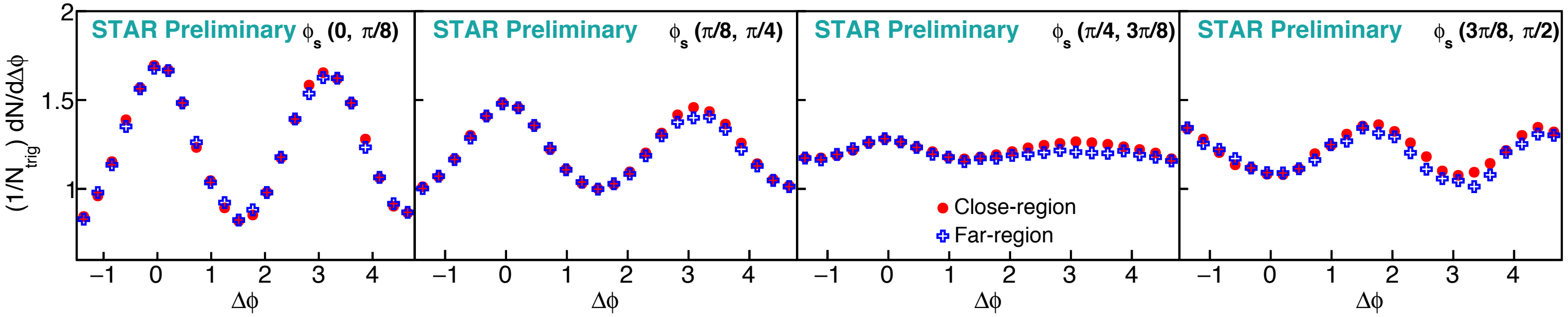


For each $\Delta\phi$ we have $\mathbf{M_U}\ \mathbf{Corr}^{\Delta\phi}_{\mathbf{Meas}}(\boldsymbol{\phi_s}) = \mathbf{Corr}^{\Delta\phi}_{\mathbf{Unfolded}}(\boldsymbol{\phi_s})$



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

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

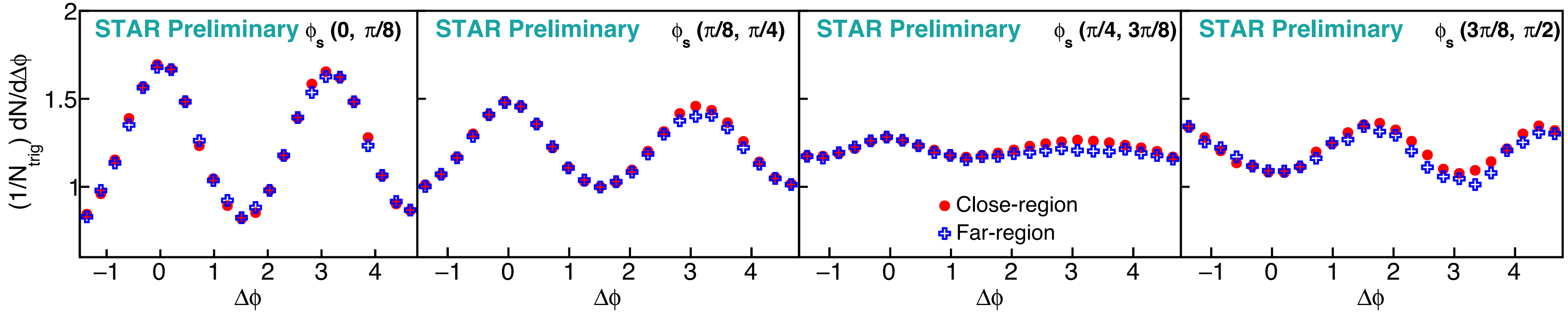


Resolution-corrected correlation functions

STAR

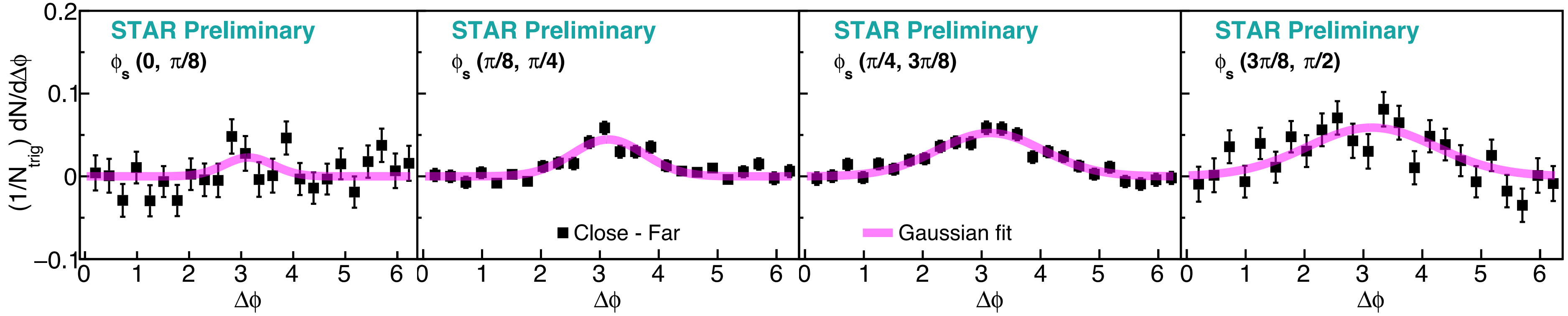
Run 11 AuAu 20-60%, $3 < p_T^{trig} < 10$ GeV/c, $1 < p_T^{assoc} < 2$ GeV/c

Resolution corrected two-particle correlations:



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

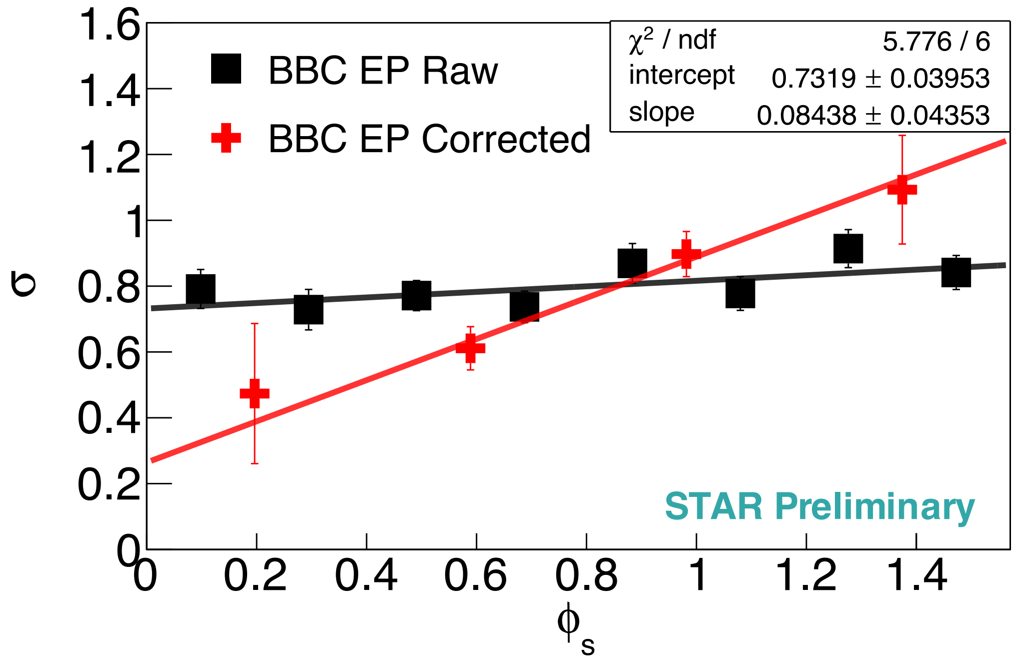
Resolution corrected away-side (close-far) correlations:



Comparison

Run 11 AuAu 200 GeV, 20-60%,

$3 < p_T^{trig} < 10$ GeV/c, $1 < p_T^{assoc} < 2$ GeV/c



- BBC Ψ_2 resolution $= 0.136 \pm 0.002$
- Measured slope $\approx 0.08 \pm 0.04$ (stat.)
- Corrected slope $\approx 0.66 \pm 0.27$ (stat.)

Summary

- We have employed a data-driven method to subtract **away-side** flow background of all harmonics. (Large η gap between P_X and far-region)
- We have reported the measurement of 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 AuAu collisions.
- The 2nd-order EP in our analysis is reconstructed with BBC. We have corrected the EP resolution via an unfolding procedure.
- The width of the away-side jet-like peak is found to increase strongly with ϕ_s which indicates jet-medium interactions.

Outlook:

- ❑ Correlations in different p_T^{assoc} and centrality bins.
- ❑ Comprehensive systematics study.