Search for the 'Ridge' in d+Au Collisions at RHIC by STAR

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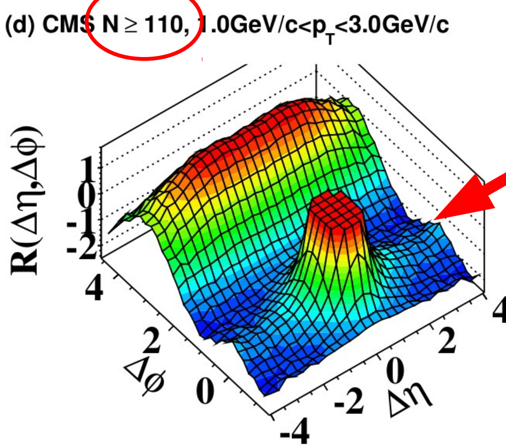
Overview

- Motivation
- Dihadron Correlations
  - High-multiplicity vs low-multiplicity
  - TPC-TPC ($\Delta\eta$~1.5) and TPC-FTPC ($\Delta\eta$~-3)
- Summary

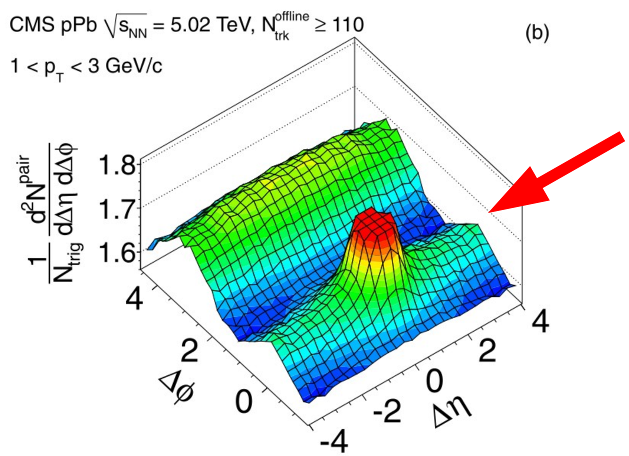
Ridge in p+p, p+Pb at LHC

CMS pp JHEP 09 (2010) 091

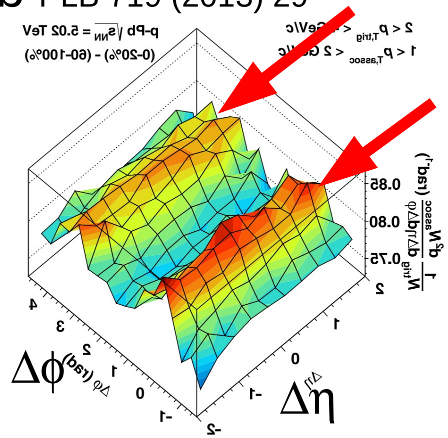


Near-side Ridge

CMS pPb PLB 718 (2013) 795

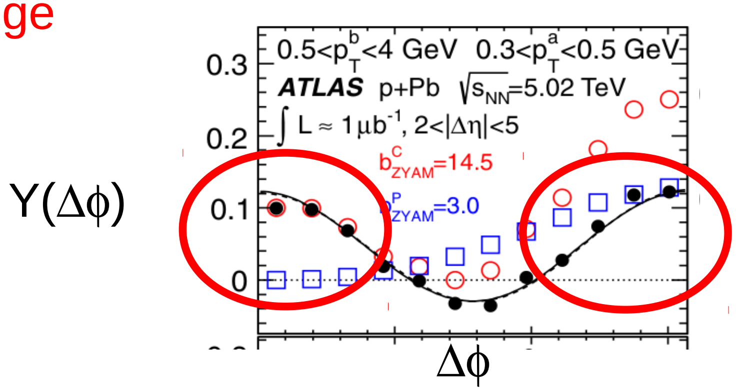


ALICE pPb PLB 719 (2013) 29



Double Ridge

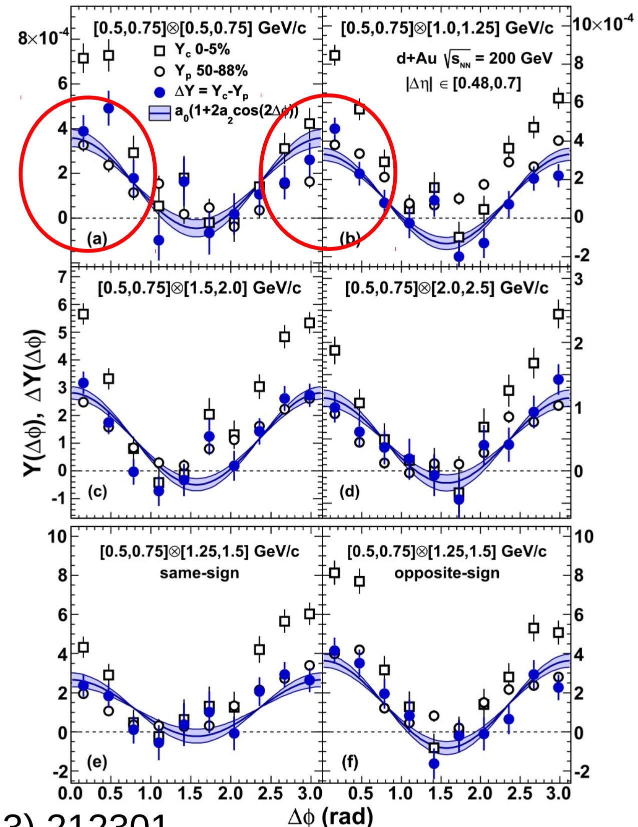
ATLAS pPb PRL 110 (2013) 182302



- Ridge observed in high-multiplicity pp and pPb events
- High-multi.− low-multi. (for jets) → double ridge in pPb

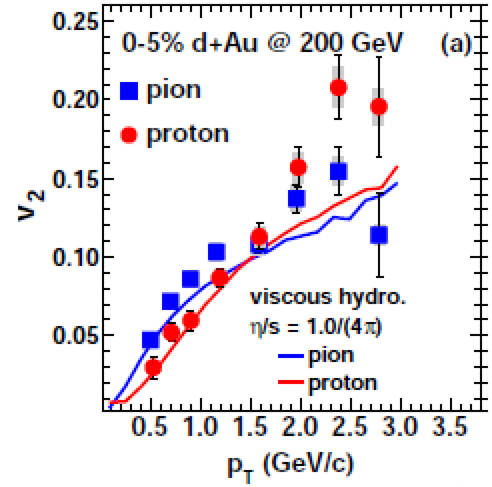
Ridge in d+Au at RHIC?

PHENIX d+Au Double Ridge



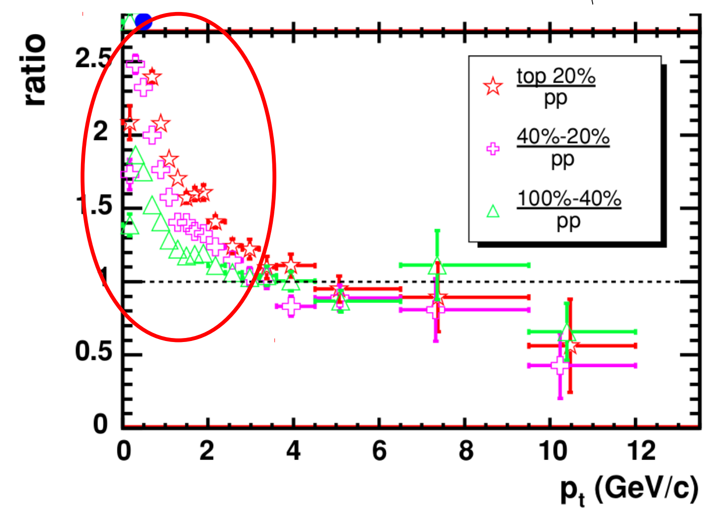
PRL 111 (2013) 212301

PHENIX d+Au Finite v_2



arXiv 1404.7461v1

STAR d+Au vs p+p $\left\langle \sum \cos\left(2\left(\varphi_{p_t}-\varphi_i\right)\right)\right\rangle$

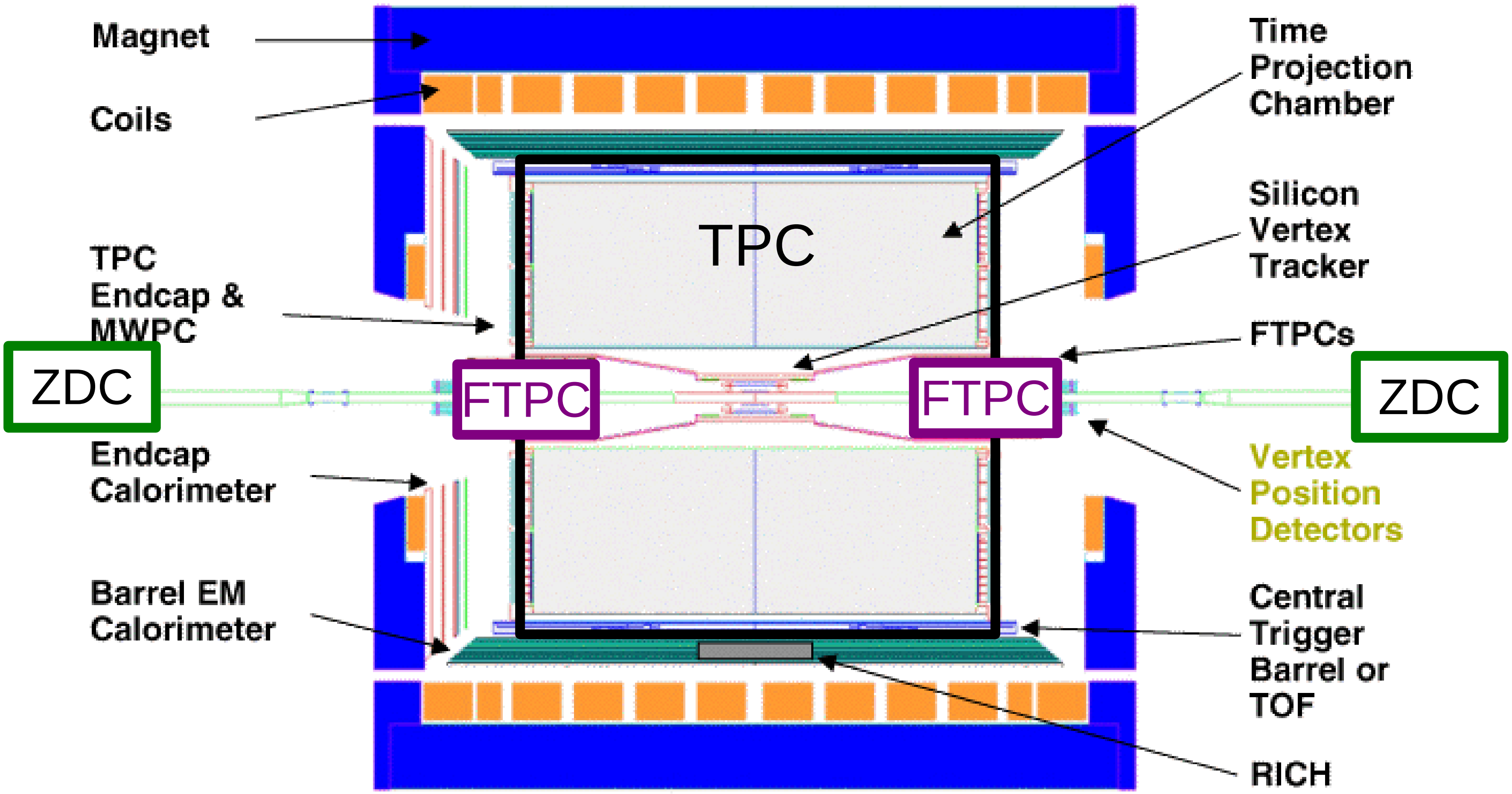


PRC 72 (2005) 014904

Physics mechanisms

- Hydro?
- CGC?

STAR Detector



- Large STAR acceptance

TPC: -1<η<1

FTPC: 2.8<|η|<3.8

Centrality	TPC	FTPC-Au	ZDC-Au
0-20%	$N_{ch} \geq 29$	$N_{ch} \geq 17$	$ADC \geq 128$
40-100%	$N_{ch} \leq 19$	$N_{ch} \leq 9$	$ADC \leq 116$

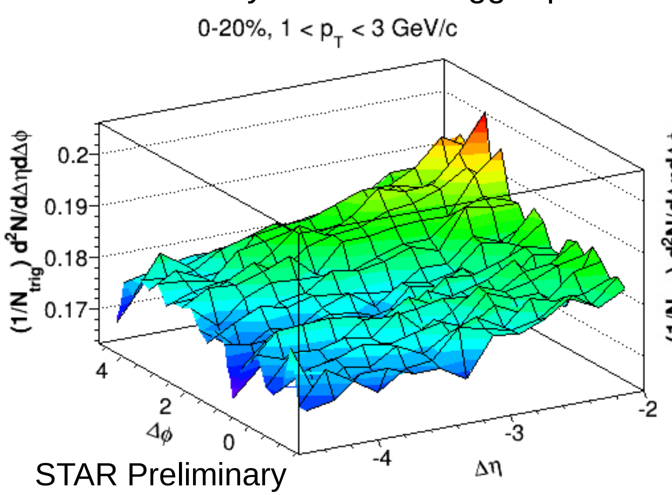
Dihadron Δη–Δϕ Correlations

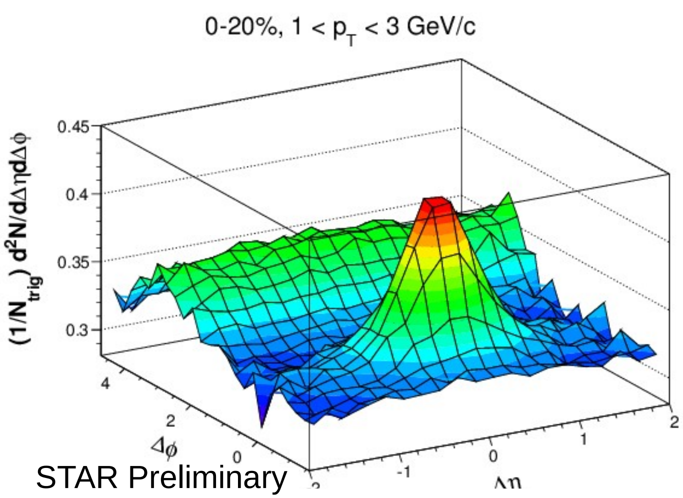
d+Au@200 GeV Run3

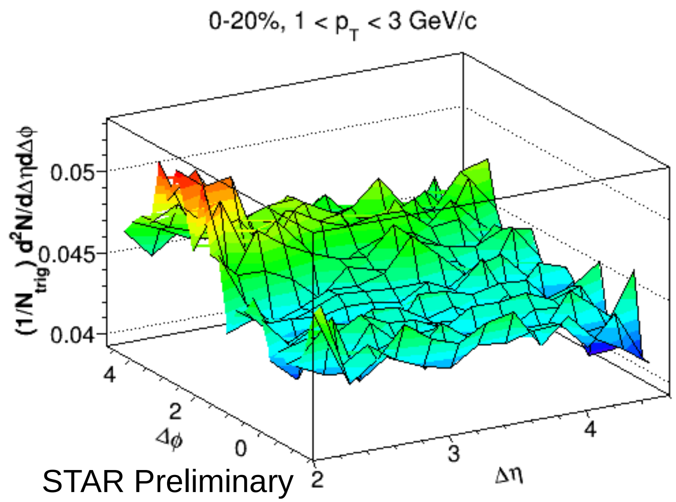
p_T: [1,3]x[1,3] GeV/*c*

Trigger-Associate

Normalized by number of trigger particles







TPC-FTPC (Au-going)

-4.5<Δη<-2

ZDC Energy

TPC-TPC

-2<Δη<2

FTPC Multiplicity

TPC-FTPC (d-going)

2<Δη<4.5

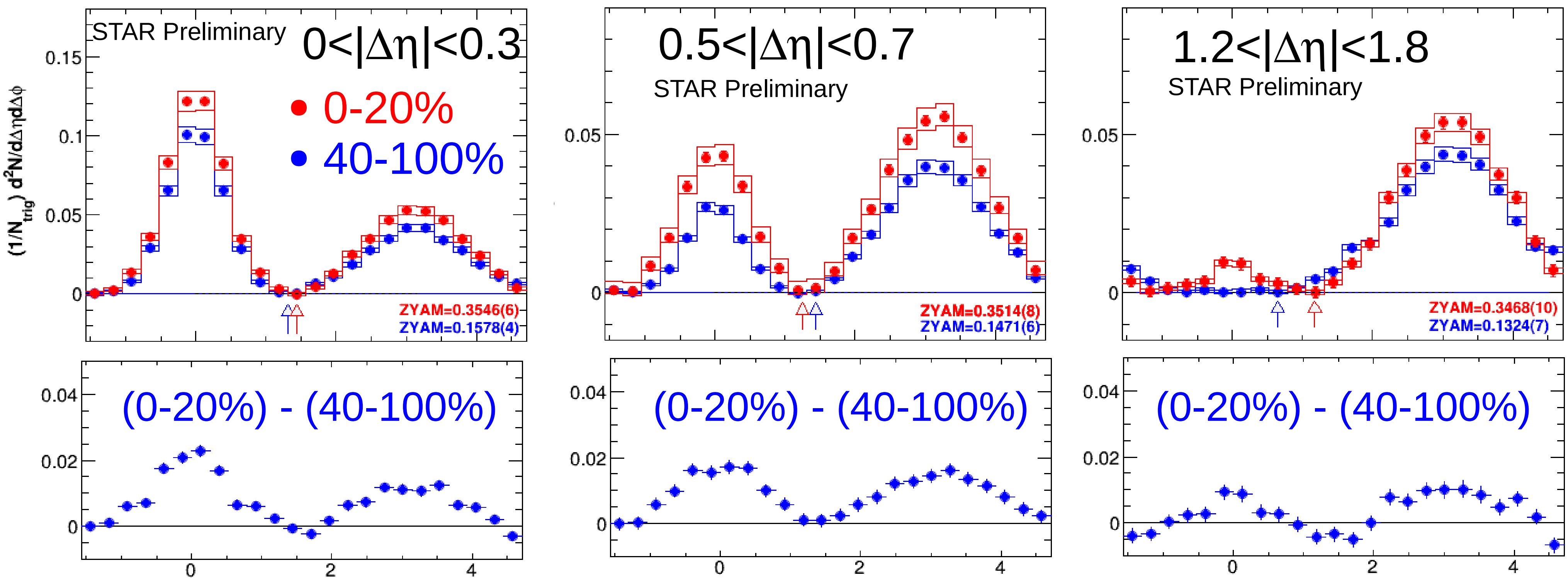
ZDC Energy

- Background subtracted by Δη-dependent Zero-Yield-At-Minimum (ZYAM) method

TPC-TPC Δφ Correlations High- vs Low-mult.

d+Au@200 GeV

p_T: [1,3]x[1,3] GeV/*c*
FTPC Multiplicity

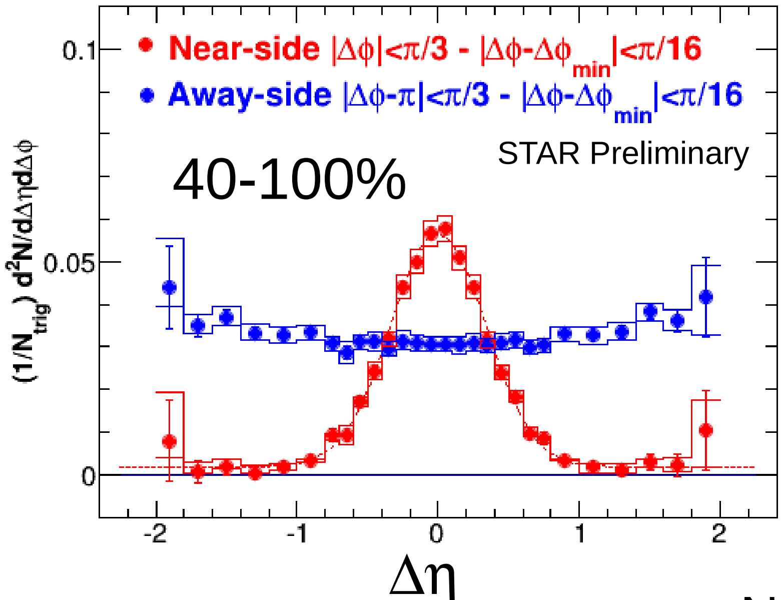


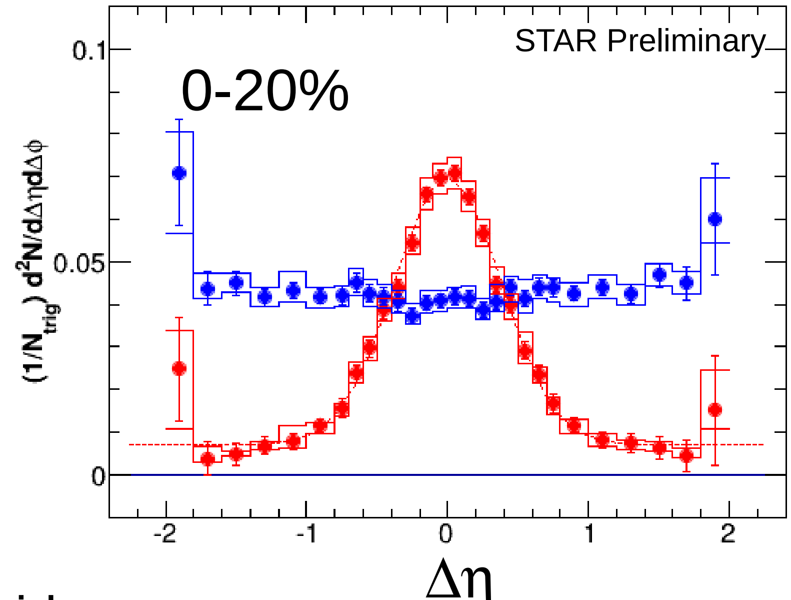
- high-mult. (cent.) > low-mult. (peri.) on both near-side and away-side.
- central - peripheral = "double ridge"

Near-side Ridge in High-multiplicity

d+Au@200 GeV

p_T: [1,3]x[1,3] GeV/*c*
FTPC Multiplicity





40-100%	Near-side Gaussian + Pedestal Fit	0-20%	
Y = 0.0459(10)		Y = 0.0594(18)	Gaus. area
σ = 0.336(6)		σ = 0.382(9)	Gaus. width
Ped = 0.0019(4)		Ped = 0.0070(8)	Pedestal
χ^2/ndf = 19/25		χ^2/ndf = 19/25	

- Finite pedestal → Near-side Ridge
- Different jet shapes and yields between cent. and peri.
  → Multiplicity selection bias? Jet energy, fragmentation?

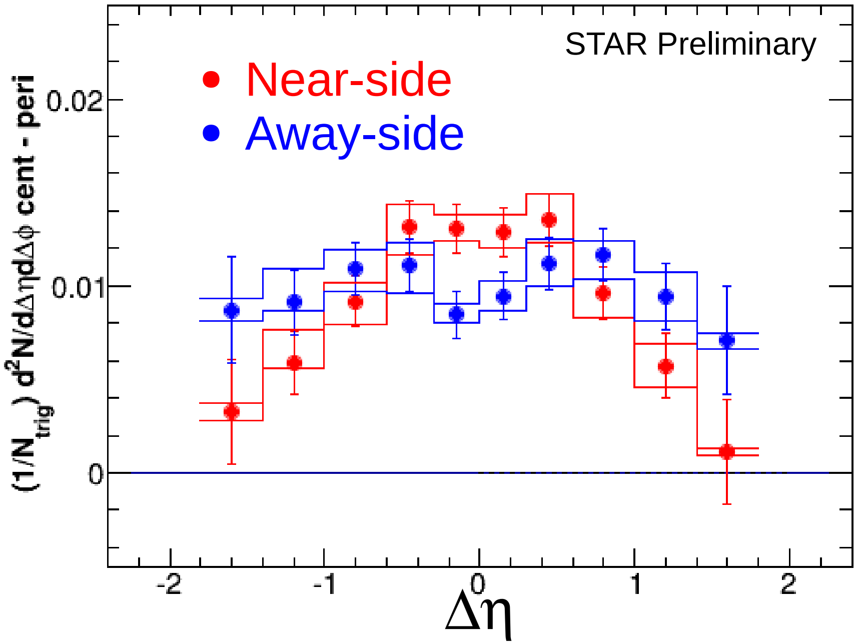
Away-side Ridge?

d+Au@200 GeV

p_T: [1,3]x[1,3] GeV/c
FTPC Multiplicity

- Cent. - peri. ≠ Cent. - Jets residual of jets

(0-20%) - (40-100%)



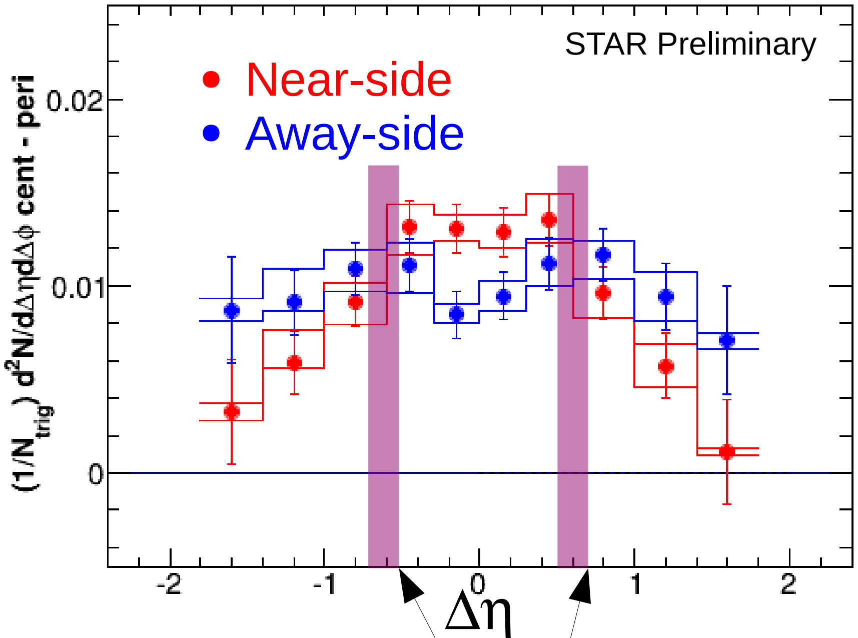
Away-side Ridge?

d+Au@200 GeV

p_T: [1,3]x[1,3] GeV/c
FTPC Multiplicity

- Cent. - peri. ≠ Cent. - Jets
  residual of jets

(0-20%) - (40-100%)



|Δη| used in PHENIX's paper
Same near-side and away-side
PRL 111 (2013) 212301

No Away-side Ridge

d+Au@200 GeV

p_T: [1,3]x[1,3] GeV/*c*
FTPC Multiplicity

Do first-order correction: same jet yield

Assume:

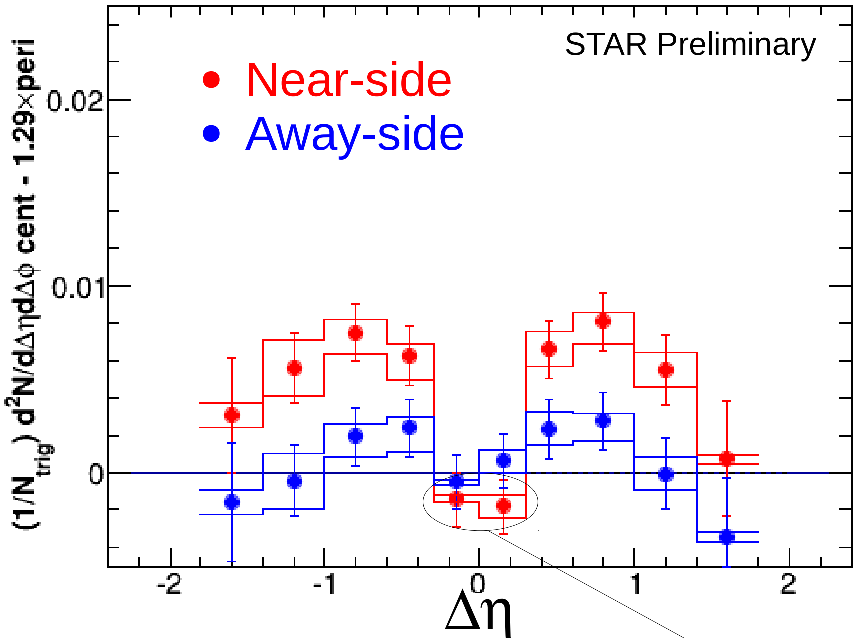
- Peri. correlation has jets only.
- Away-side jet yield $\propto$ near-side jet yield

$Y^{Cent.}$, $Y^{Peri.}$: near-side jet yields

R = $Y^{Cent.} / Y^{Peri.} = 1.29 \pm 0.05$
(Away-side ratio: 1.32±0.02)

Cent. - R×Peri≈ Cent. - Jets

(0-20%) - 1.29 x (40-100%)



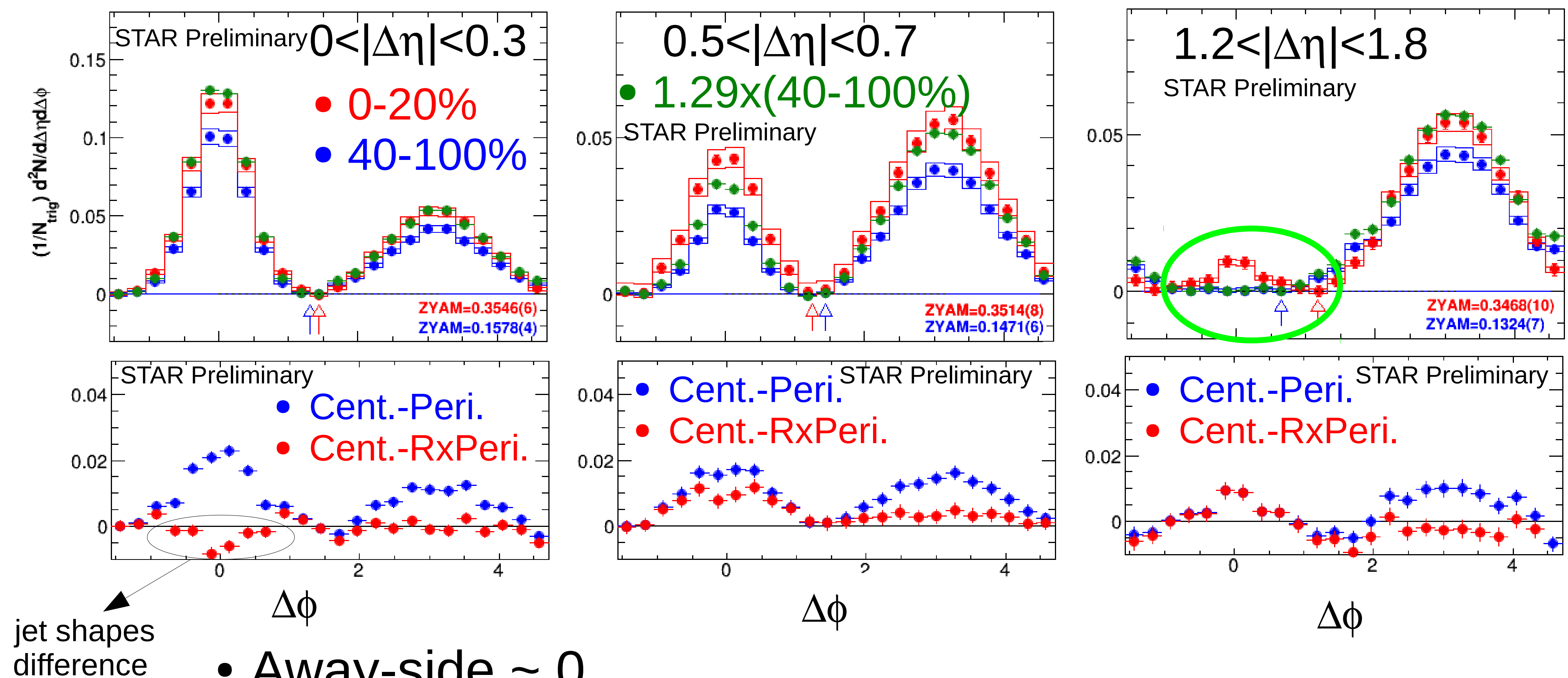
near-side jet shapes difference

- Away-side ~ 0 → No Double Ridge in d+Au@200GeV

TPC-TPC Δφ Correlations High- vs Low-mult.

d+Au@200 GeV

p_T: [1,3]x[1,3] GeV/*c*
FTPC Multiplicity



- Away-side ~ 0
- Near-side: finite at Δη ≈ 1.5

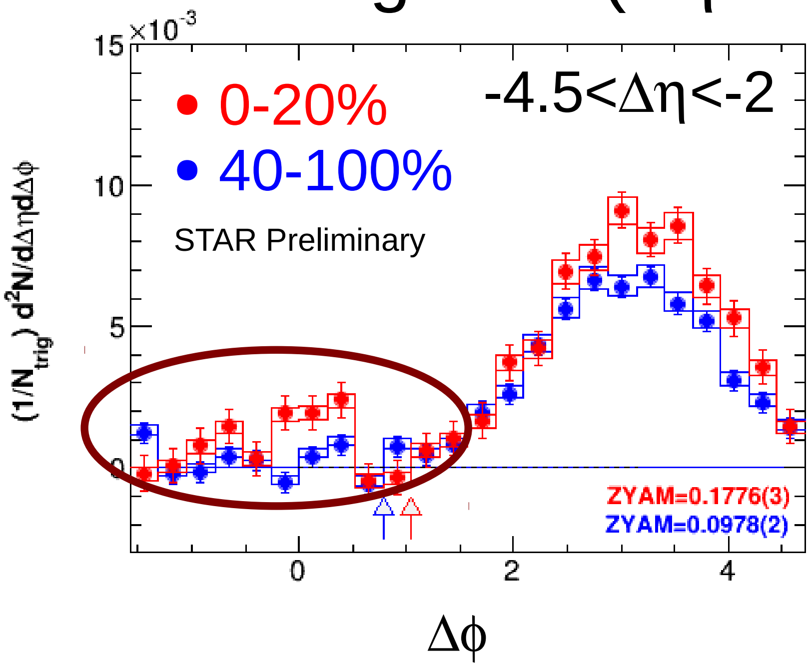
  → How about even larger |Δη| ≈ 3?

TPC-FTPC: High-. vs Low-multiplicity

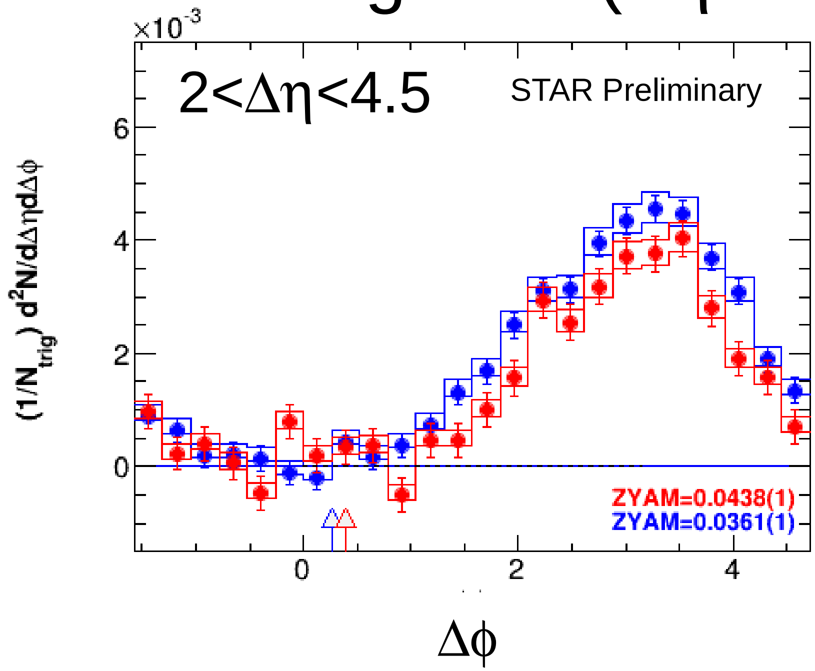
d+Au@200 GeV

p_T: [1,3]x[1,3] GeV/c
ZDC Energy

Au-Going Side ($\Delta\eta \approx -3$)



d-Going Side ($\Delta\eta \approx 3$)



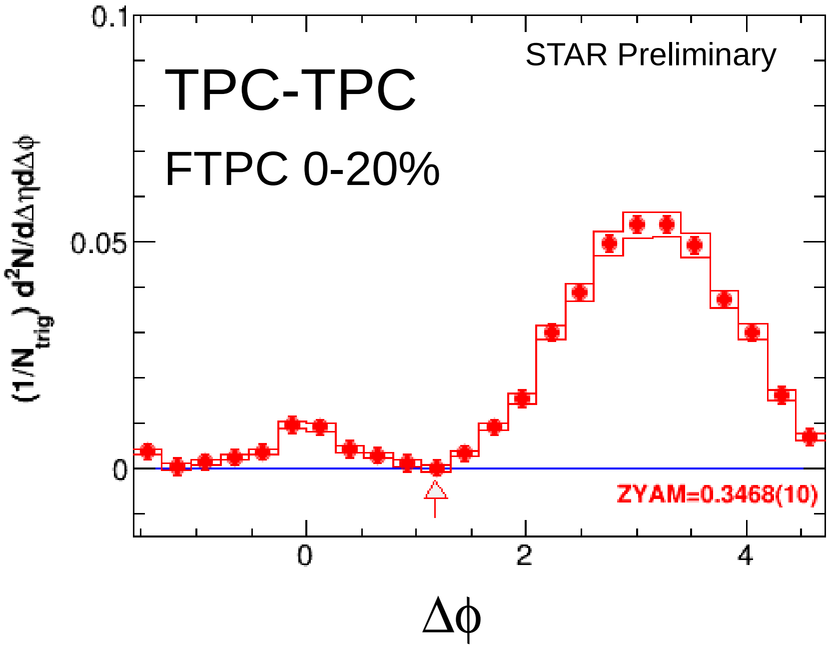
- Away-side: enhanced at Au-going side; depleted at d-side.
- Near-side: finite for FTPC Au-going side ($\Delta\eta \approx 3$) in high-multiplicity collisions.

Recap: Near-side in High-multiplicity

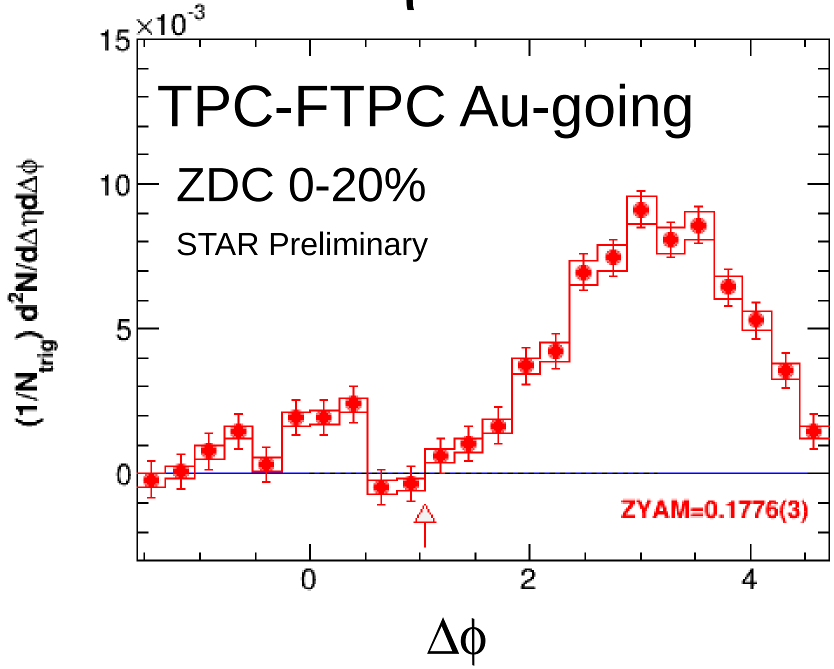
d+Au@200 GeV

p_T: [1,3]x[1,3] GeV/*c*

$\Delta\eta \approx 1.5$



$\Delta\eta \approx -3$

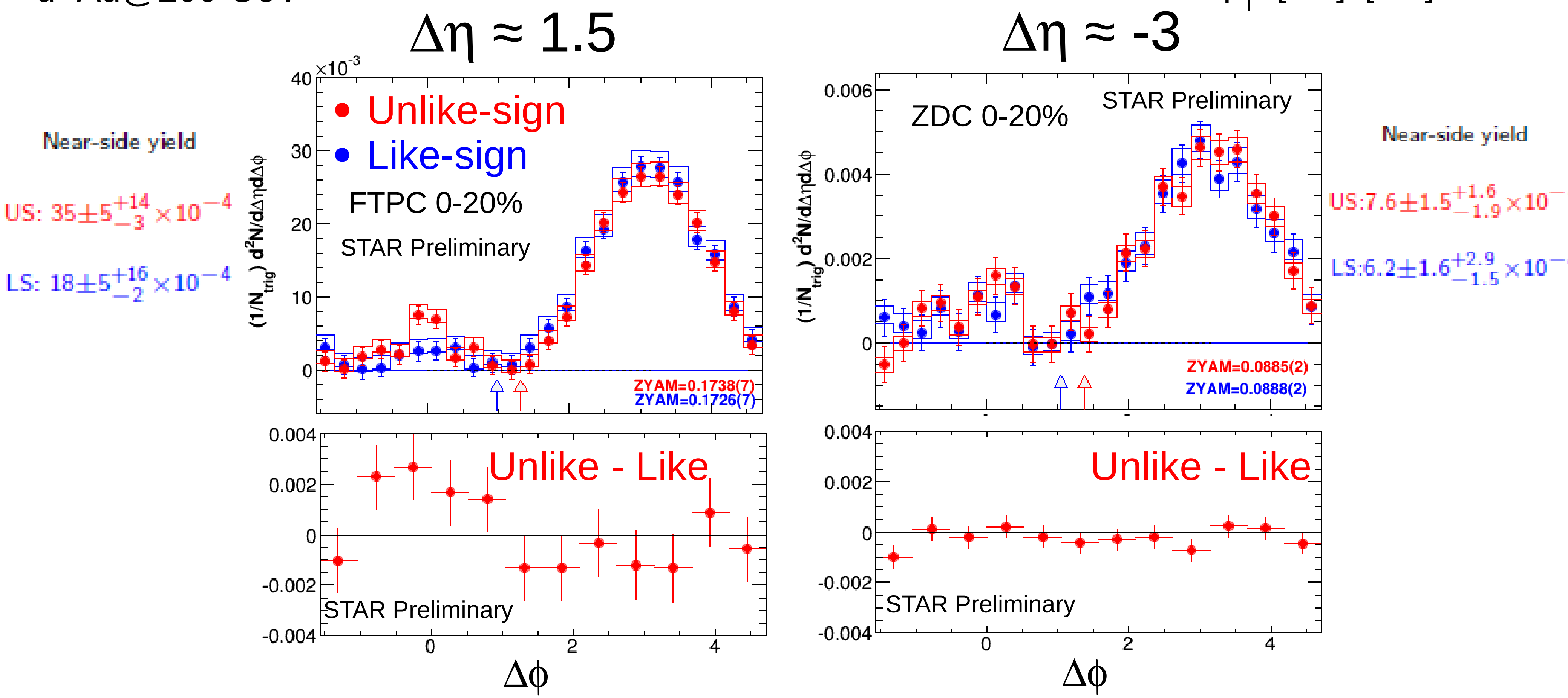


- Long-range near-side correlations are observed in both TPC-TPC and TPC-FTPC
- What could be the the physics mechanism?
- Study charge combinations

Unlike-sign vs Like-sign

d+Au@200 GeV

p_T: [1,3]x[1,3] GeV/c

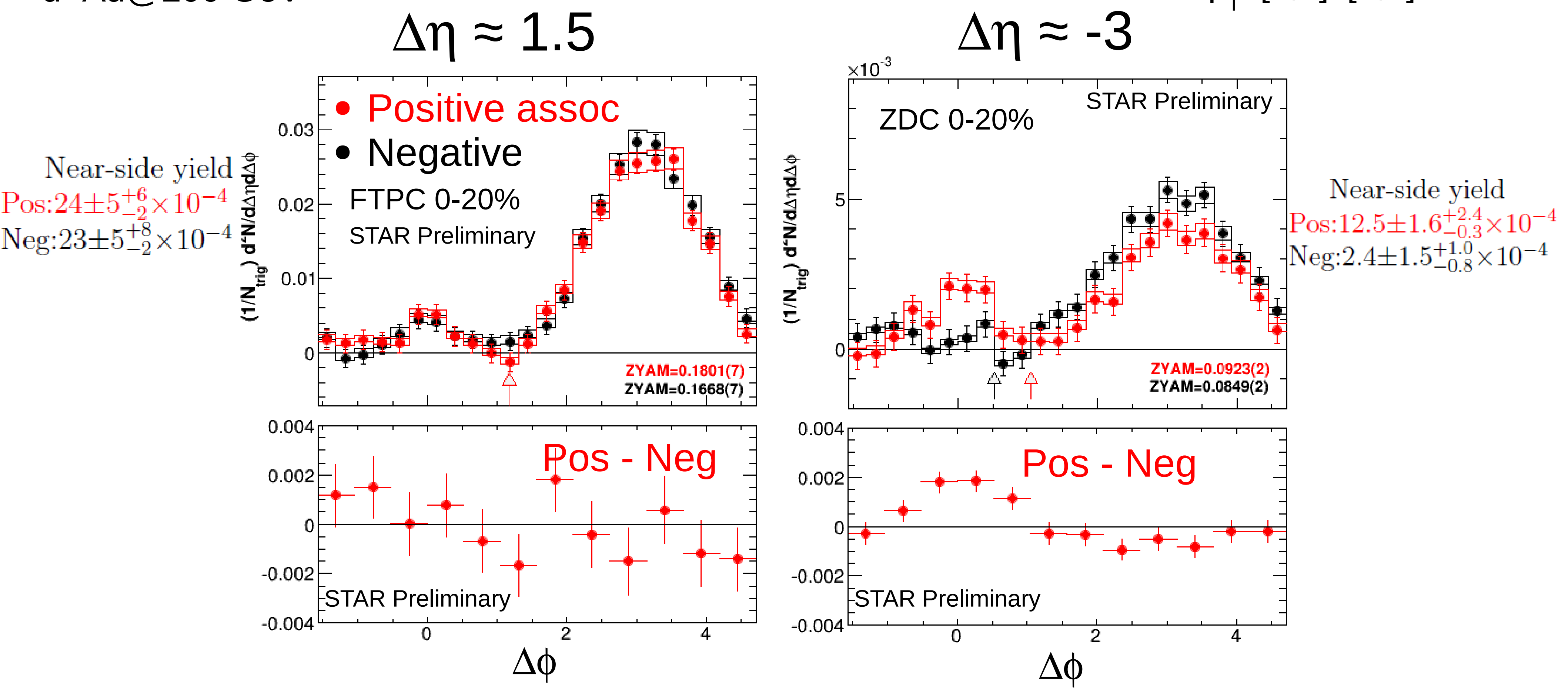


- Δη ≈ 1.5 near-side: unlike-sign > like-sign
  → Jet-like feature?
- Δη ≈ -3: No difference.

Associated Particle: Positive vs Negative

d+Au@200 GeV

p_T: [1,3]x[1,3] GeV/*c*



- Δη ≈ 1.5: No difference.
- Δη ≈ -3 near-side: positive associated particles only
  → Transport protons?

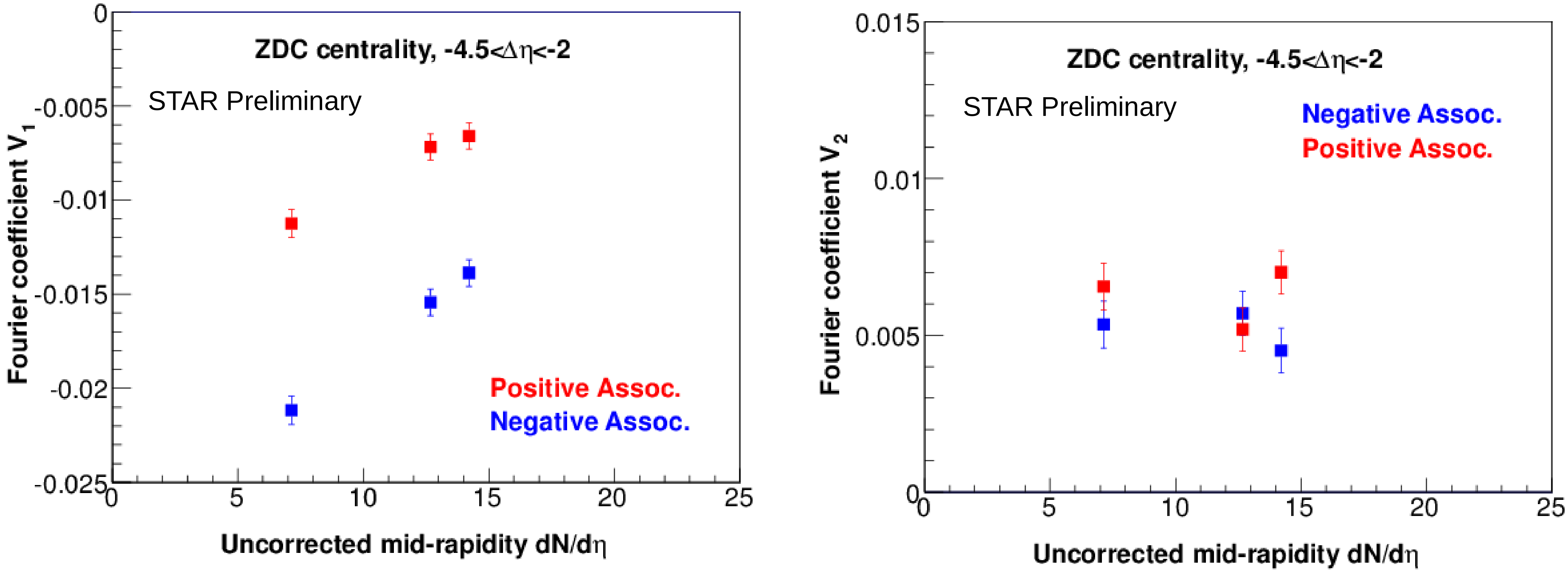
V_n for Pos. vs Neg. Associated Particles

d+Au@200 GeV

p_T: [1,3]x[1,3] GeV/c

$$\frac{dN}{d\Delta\varphi} = N\left(1+2V_1\cos(\Delta\varphi)+2V_2\cos(2\Delta\varphi)\right)$$ for TPC-FTPC

No ZYAM background subtraction.



- V_1 are different for positive and negative associated particles despite similar multiplicity
- V_2 are somewhat different, but big difference in V1
- V_n may not be meaningful in d+Au collisions @200 GeV

Summary

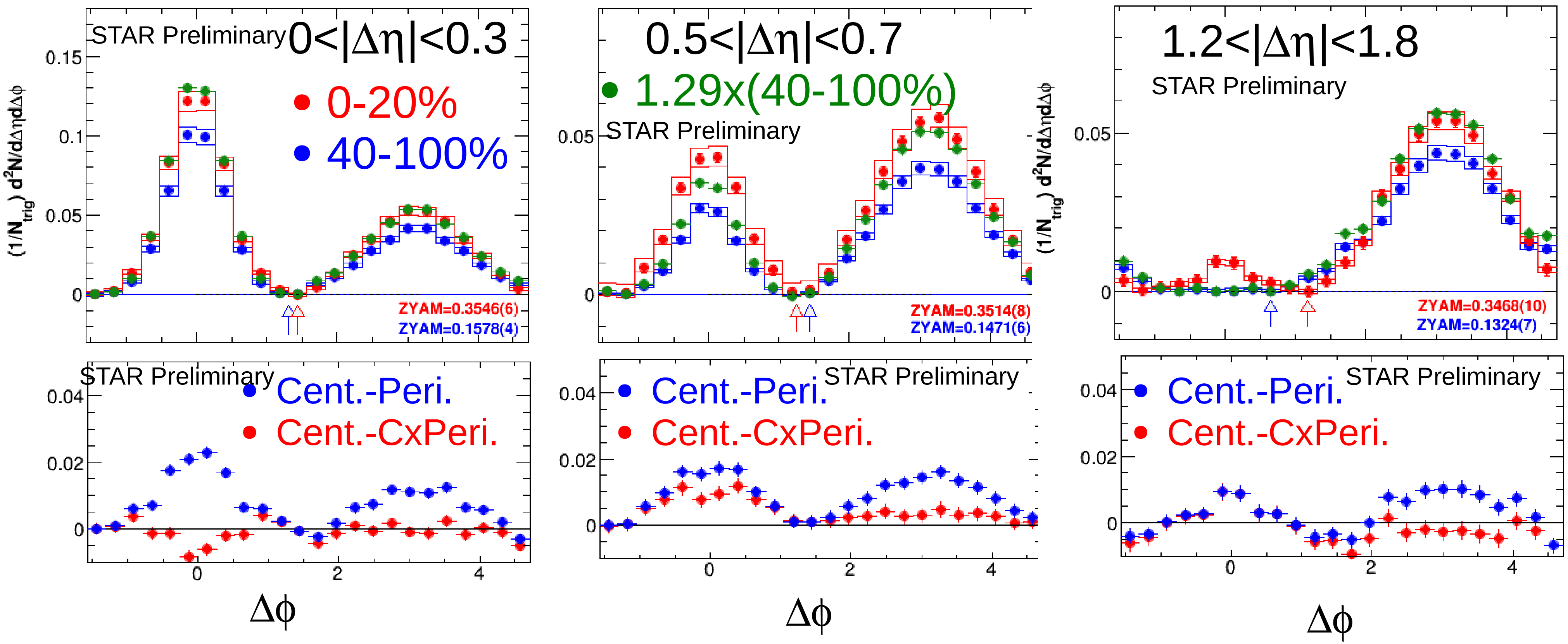
- Jets yield and shape difference observed in low- and high-multiplicity d+Au@200 GeV
- Away-side ~ 0 after jet difference corrected - No double ridge
- Finite near-side long-range correlations – Ridge observed by STAR.
  - $\Delta\eta$ ~ 1.5 : unlike-sign > like-sign → jet-like?
  - $\Delta\eta$ ~ -3: from positive associated particle only → transport protons?
- The near-side ridge may be due to physics mechanism other than flow. STAR does not observe elliptic flow in d+Au.

Backup

TPC-TPC $\Delta\phi$ Correlations Cent. vs Peri.

d+Au@200 GeV

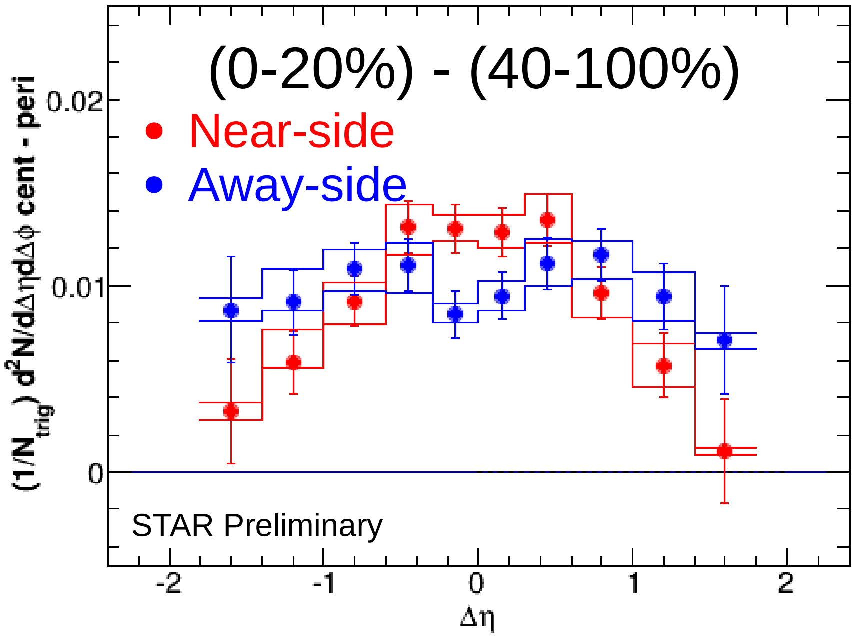
pT: 1-3 x 1-3 GeV/*c*
FTPC Multiplicity



Away-side Ridge?

d+Au@200 GeV

pT: 1-3 x 1-3 GeV/*c*
FTPC Multiplicity



- High. - Low. ≠ High. - Jets$^{High.}$: jet residual
- Do first-order correction with jet yield → Next slide

No Away-side Ridge

d+Au@200 GeV

pT: 1-3 x 1-3 GeV/*c*
FTPC Multiplicity

Assume:

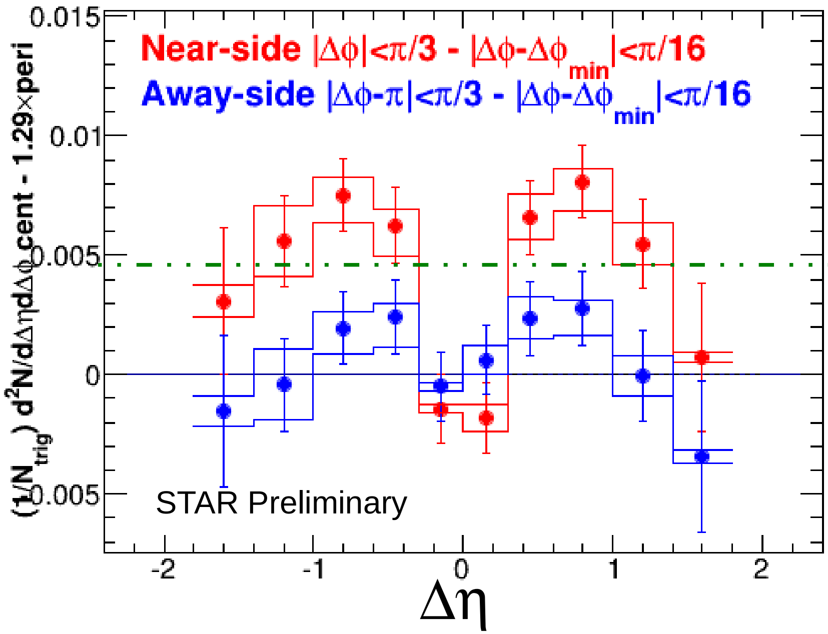
- Peri. has jets only.
- Away-side jet yield ∝ near-side jet yield

$N^{Cent.}$, $N^{Peri.}$: near-side jet yields

R = $N^{Cent.} / N^{Peri} = 1.29 \pm 0.05$

Cent. - R×Peri.≈ Cent. - $Jets^{Cent}$

(0-20%) - 1.29 x (40-100%)



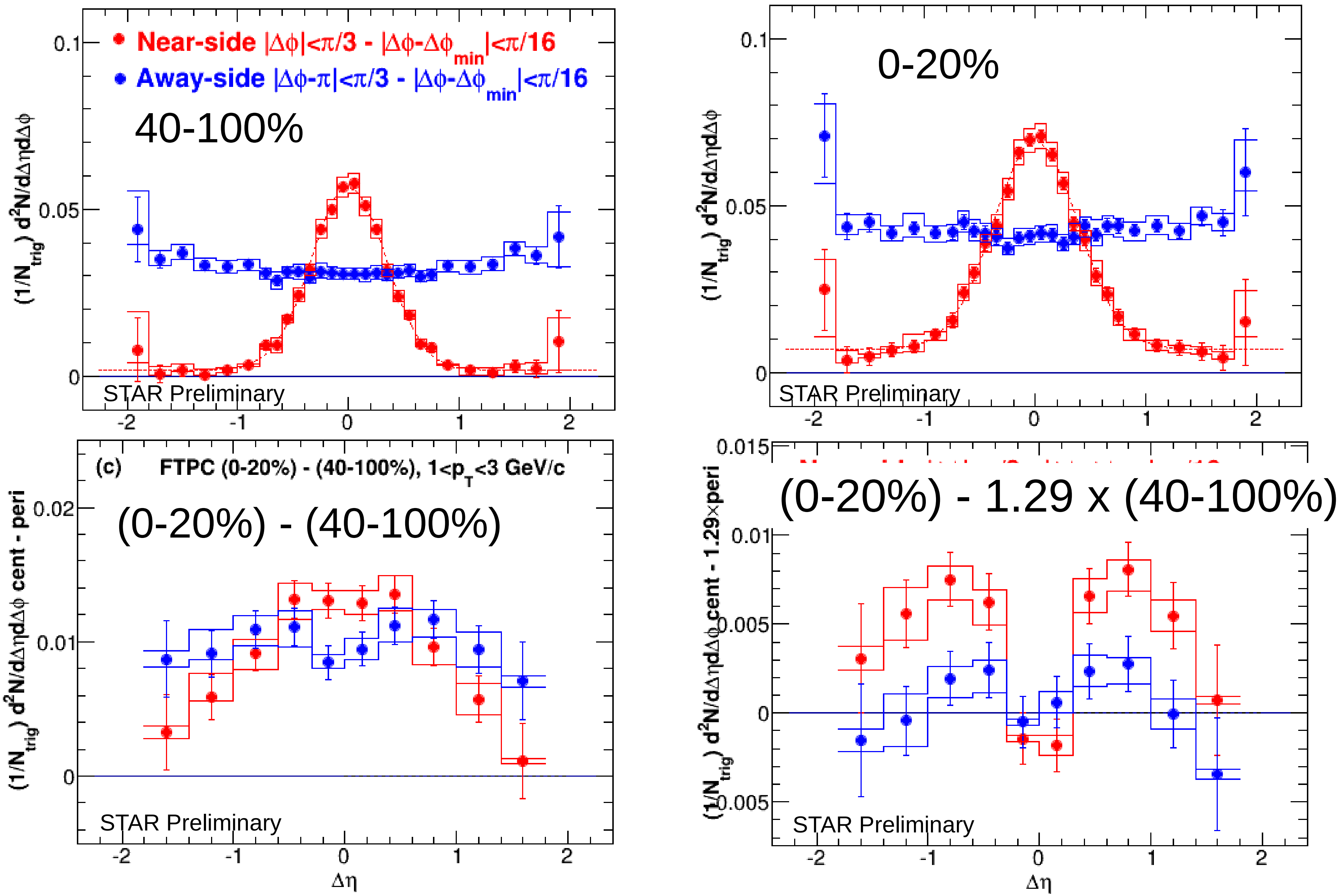
- Away-side ~ 0 → No Double Ridge in d+Au@200GeV
- Near-side: finite at Δη ≈ 1.5

→ How about even larger |Δη| ≈ 3?

Jet Difference in Central and Peripheral

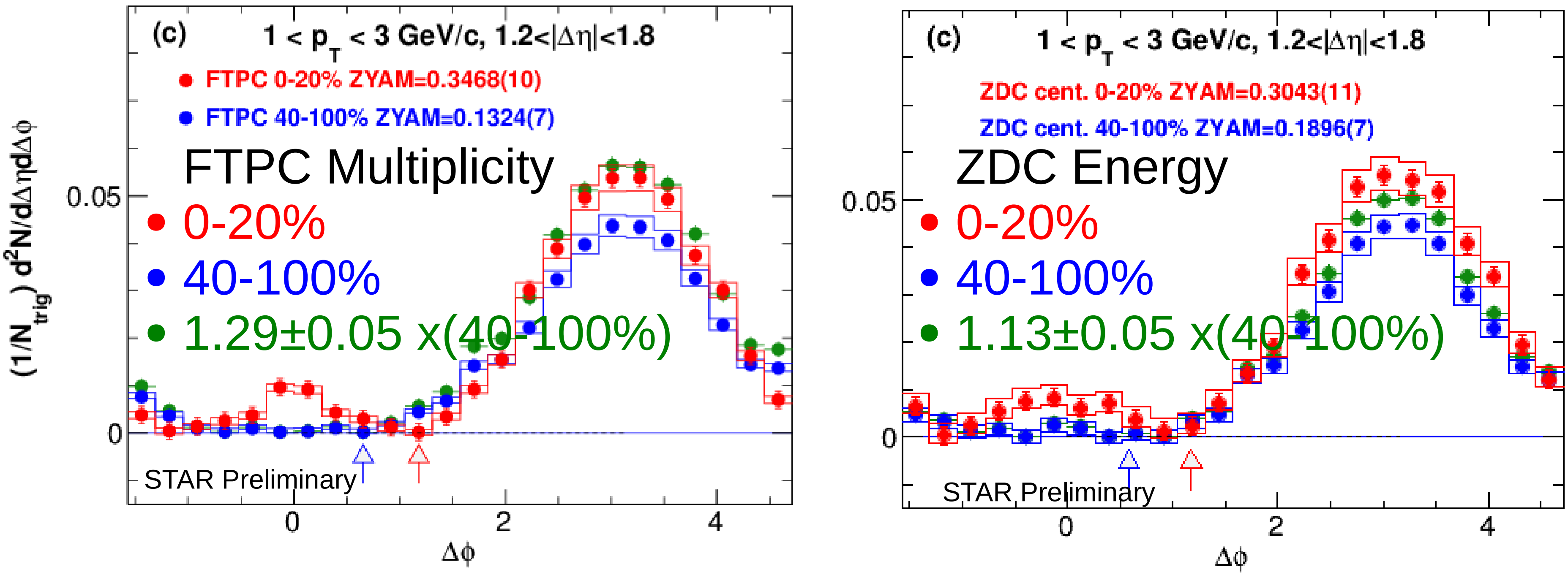
d+Au@200 GeV

pT: 1-3 x 1-3 GeV/*c*



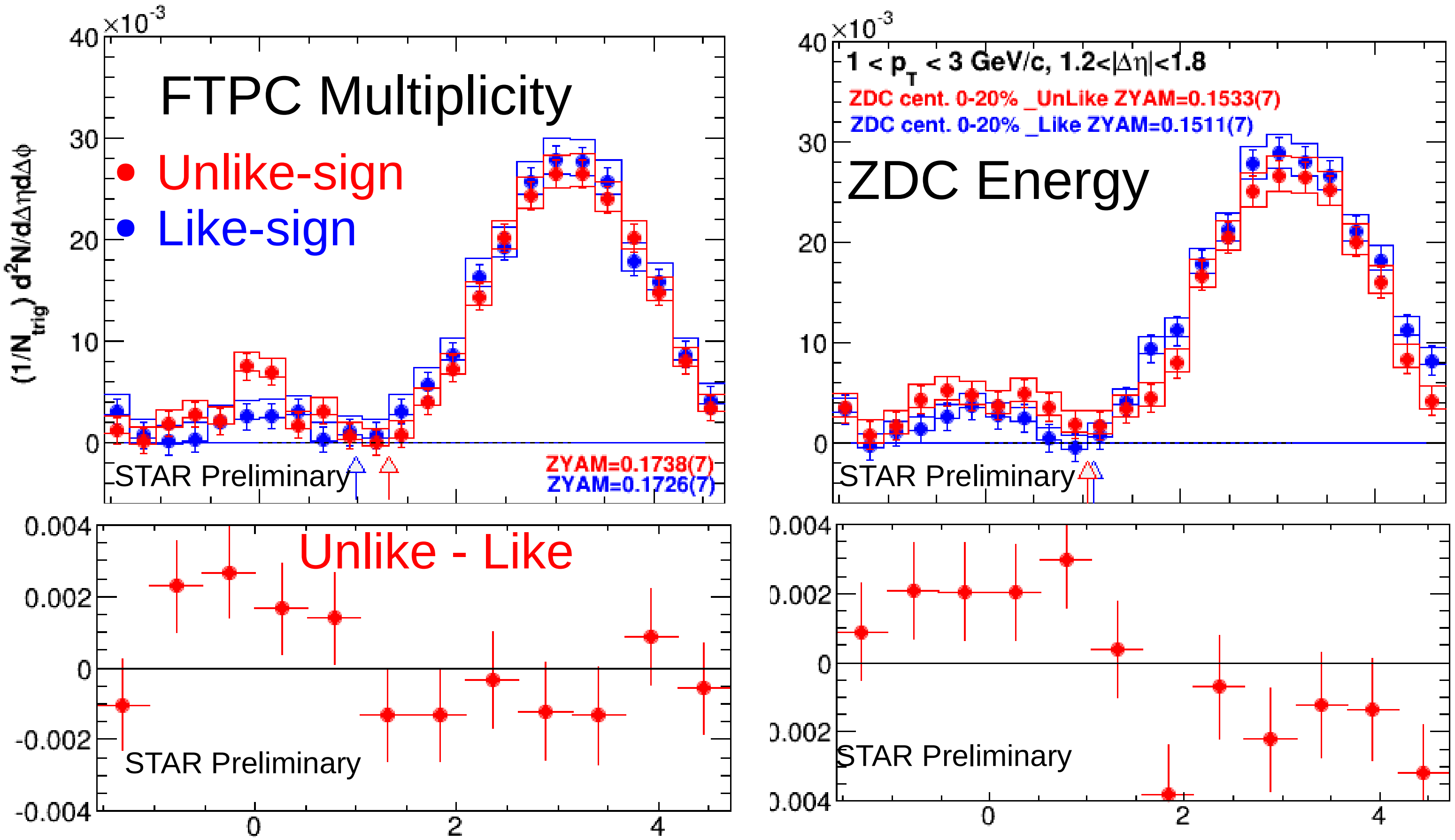
FTPC vs ZDC Energy

TPC-TPC $1.2<|\Delta\eta|<1.8$



FTPC vs ZDC Energy

TPC-TPC 1.2<|Δη|<1.8



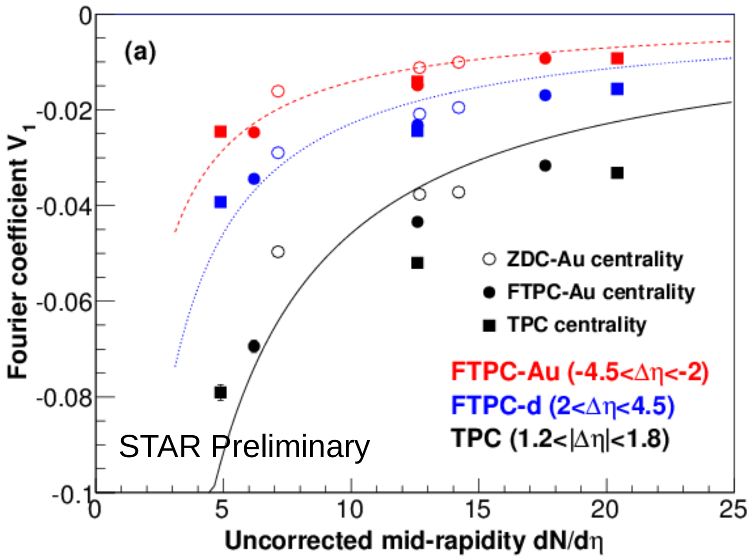
Fourier Coefficients vs. Multiplicity

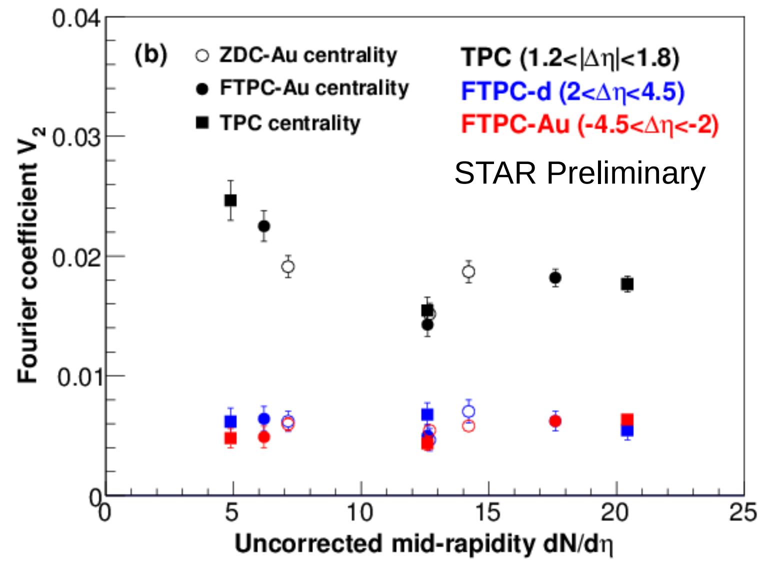
d+Au@200 GeV

pT: 1-3 x 1-3 GeV/*c*

$$\frac{dN}{d\Delta\varphi}=N(1+2V_1\cos(\Delta\varphi)+2V_2\cos(2\Delta\varphi))$$ for TPC-TPC and TPC-FTPC

No ZYAM background subtraction.





$$V_1 \approx \frac{1}{Multiplicity}$$

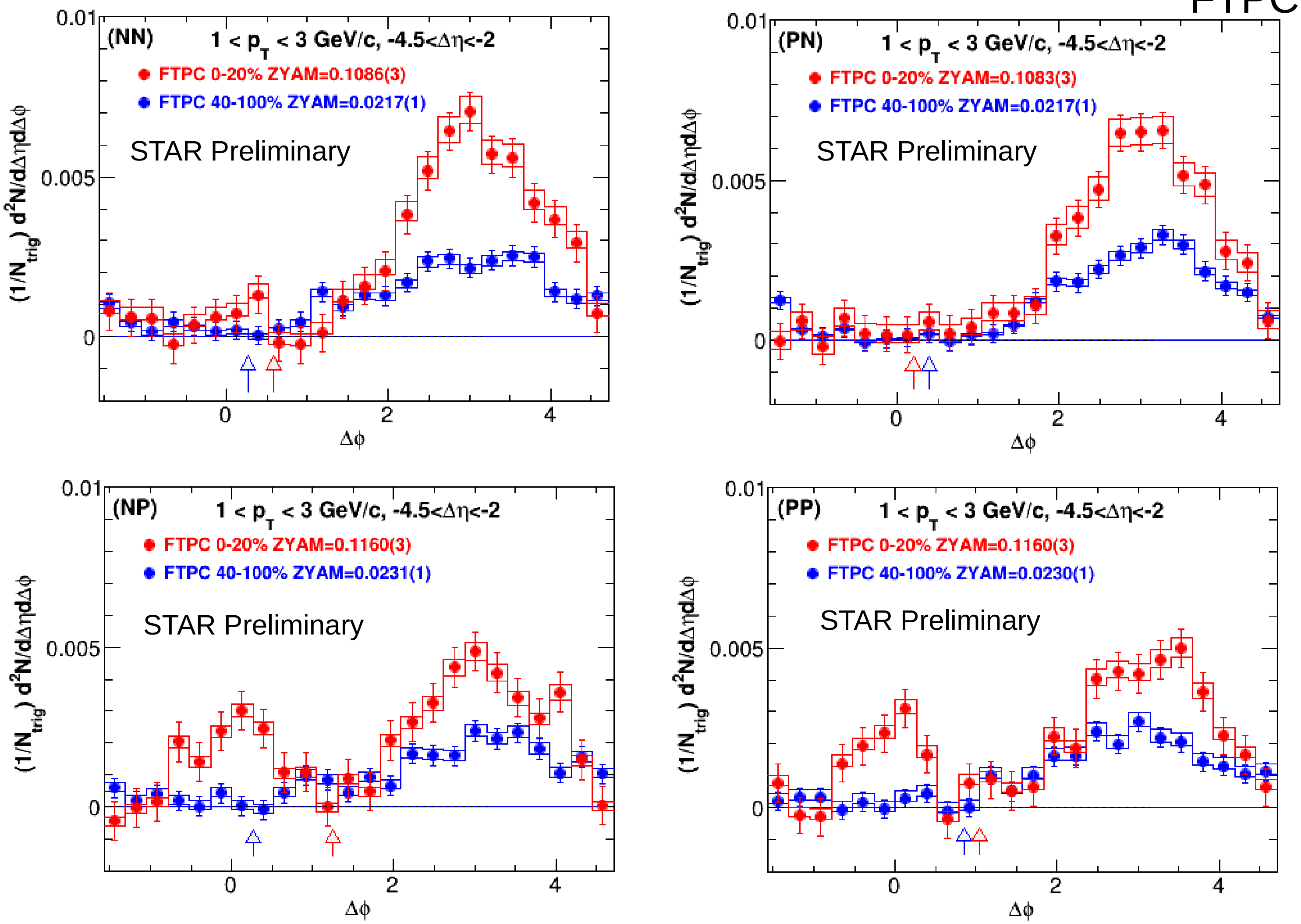
V_2 is constant over multiplicity

- Peripheral dihadron $\Delta\phi$ cannot see V2 modulation because of large V1.

Different Charges Combinations

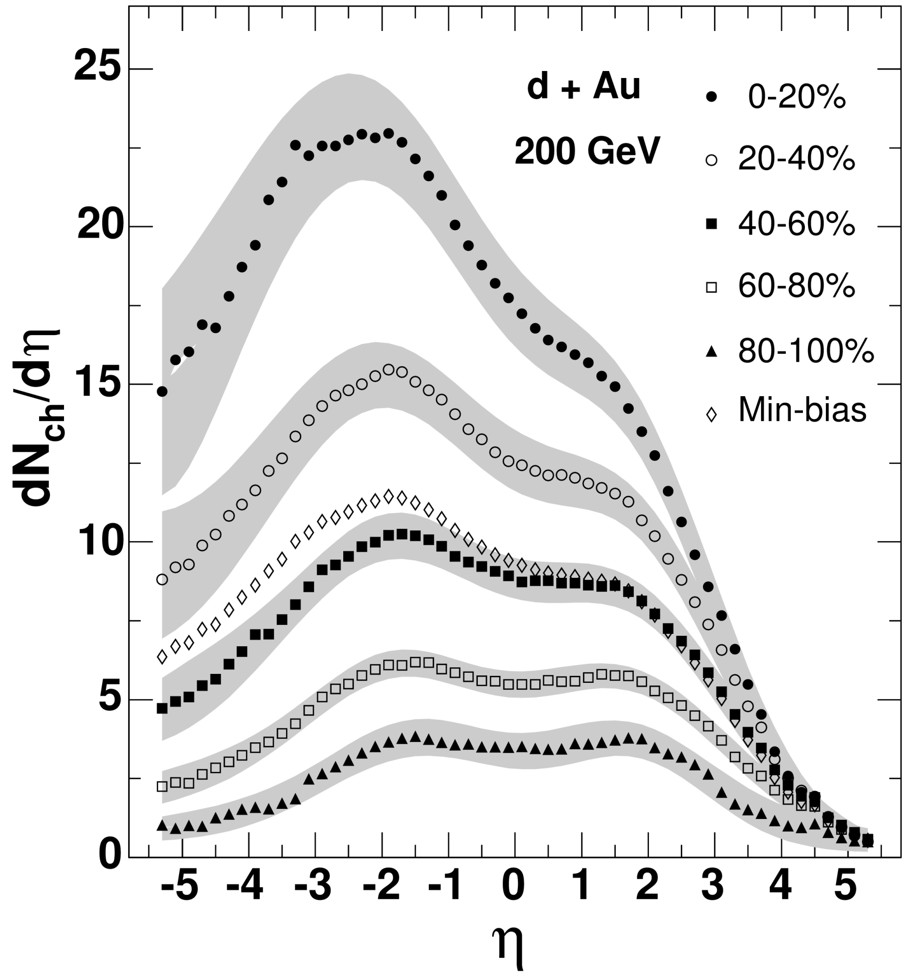
d+Au@200 GeV

pT: 1-3 x 1-3 GeV/*c*
FTPC Multiplicity



Single Particle Dh Distribution

PHOBOS PRC 72 (2005)



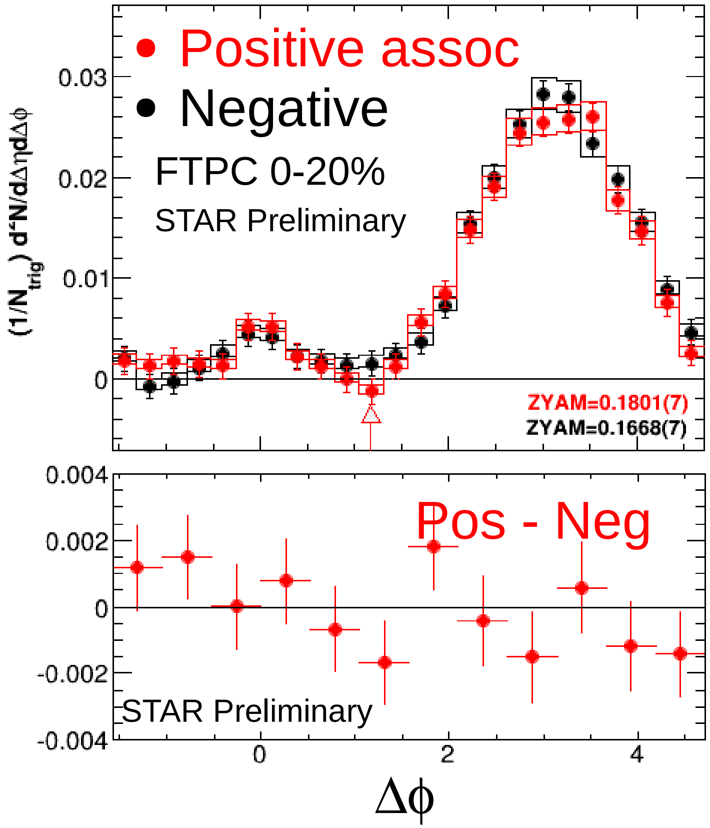
Associated Particle: Positive vs Negative

d+Au@200 GeV

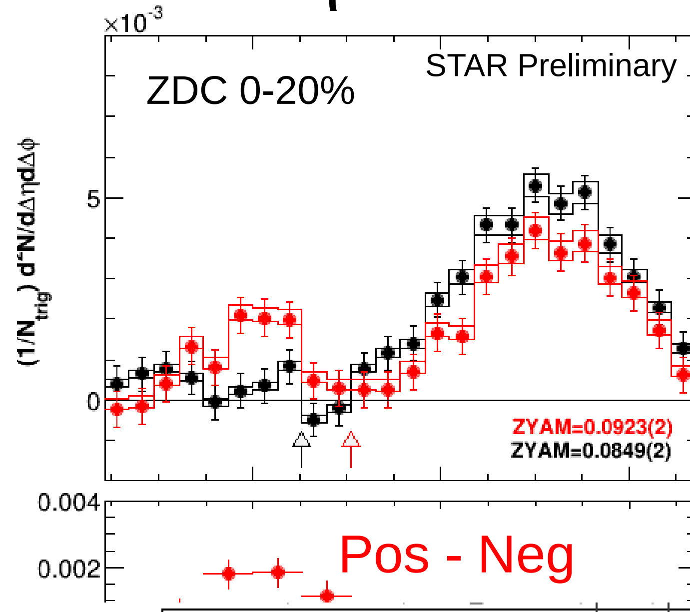
p_T: [1,3]x[1,3] GeV/*c*

$\Delta\eta \approx 1.5$

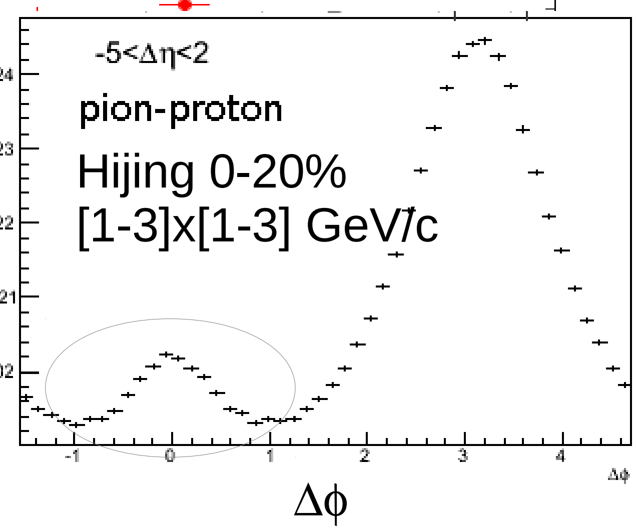
Near-side yield
Pos: $24 \pm 5^{+6}_{-2} \times 10^{-4}$
Neg: $23 \pm 5^{+8}_{-2} \times 10^{-4}$



$\Delta\eta \approx -3$



Near-side yield
Pos: $12.5 \pm 1.6^{+2.4}_{-0.3} \times 10^{-4}$
Neg: $2.4 \pm 1.5^{+1.0}_{-0.8} \times 10^{-4}$



- $\Delta\eta \approx 1.5$: No difference.
- $\Delta\eta \approx -3$ near-side: positive asso
  → Transport protons?