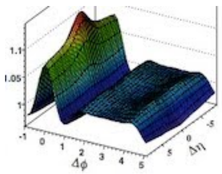
Flow and Jet-correlation

ShinIchi Esumi
Univ. of Tsukuba

Flow originated from initial geometry
Expansion and freeze-out geometry
Jet and multi-particle correlation
Jet-correlation with respect to geometry
Influence on bulk property



2nd Workshop on Initial Fluctuations and Final Correlations

August 11 - 14, 2013, Chengdu, China

筑波大学
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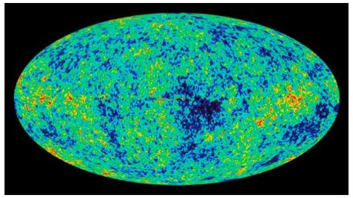
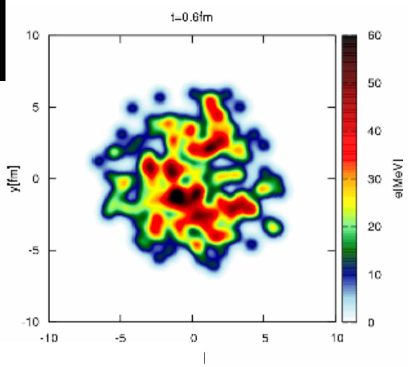
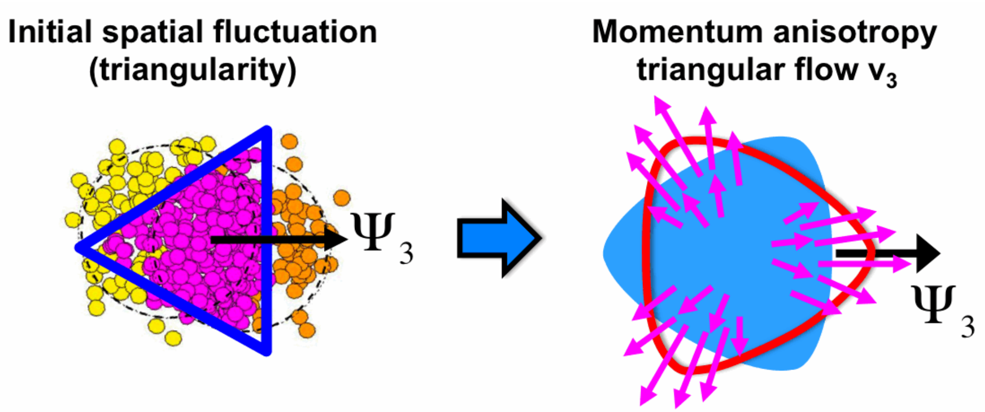
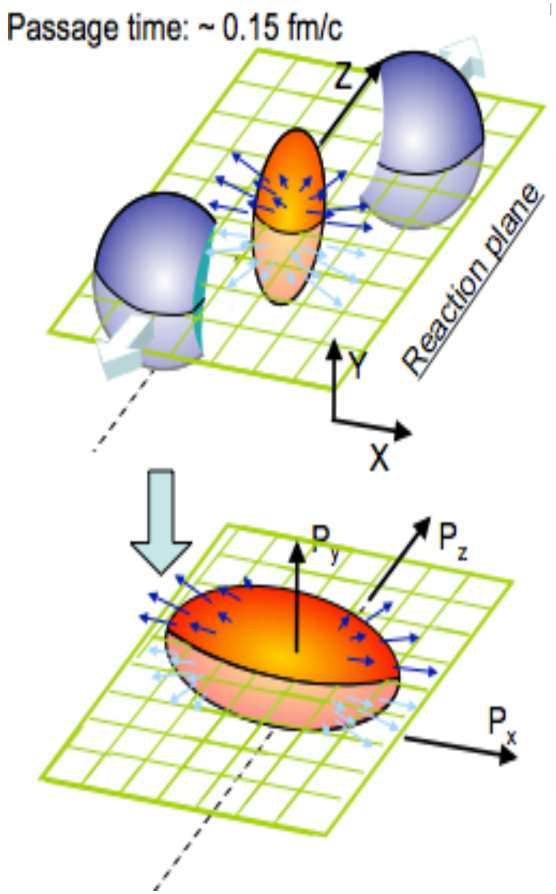
Higher harmonic order collective expansion of QGP

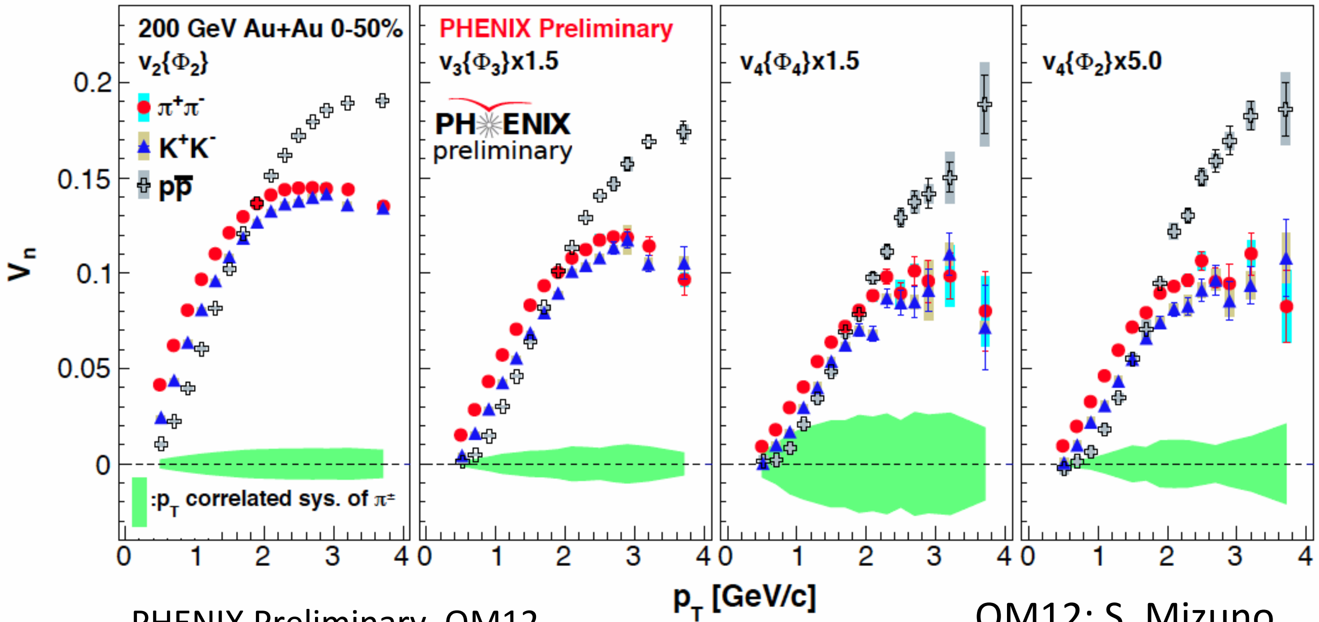


WMAP







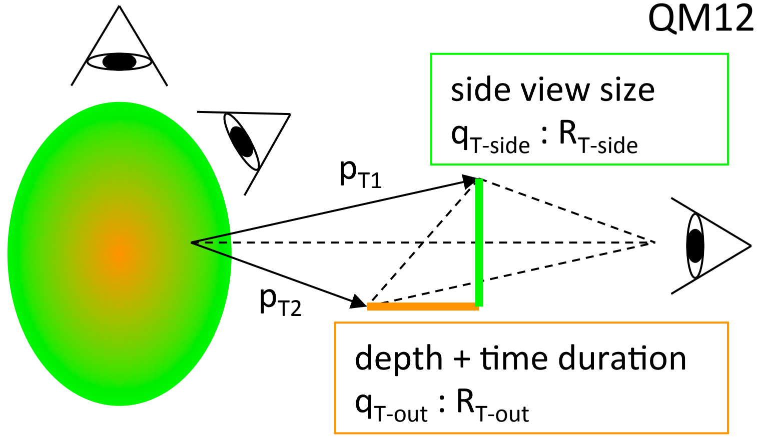


PHENIX Preliminary, QM12

QM12: S. Mizuno

Source geometry (size, shape and time duration) at the end of freeze-out via two particle quantum interferometry (HBT measurement)

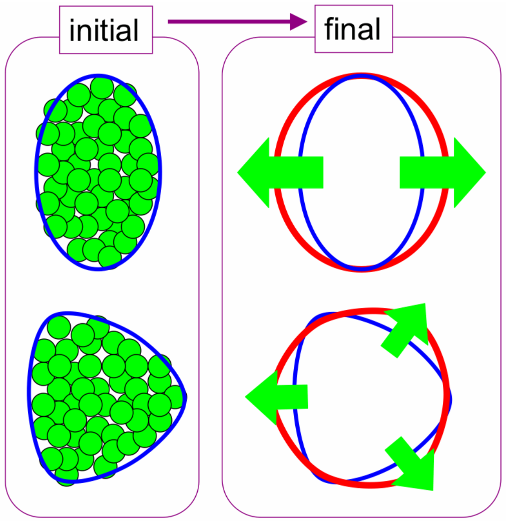
QM12: T. Niida

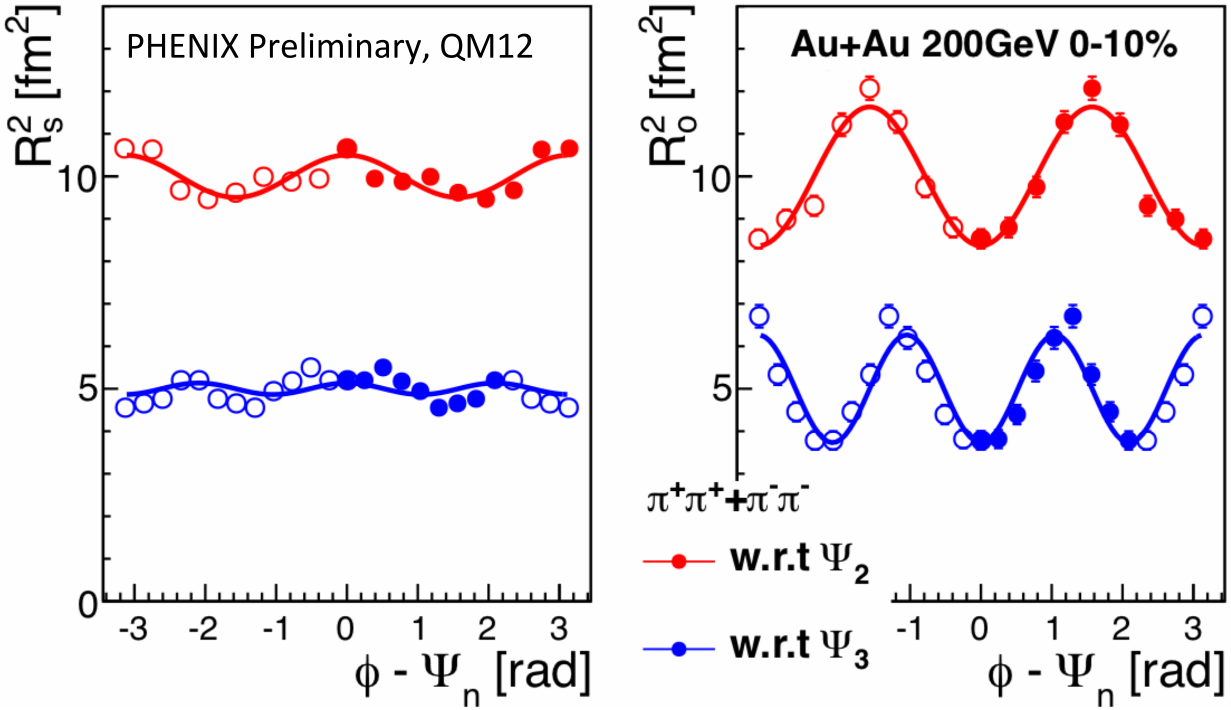


$R_{T\text{-side}}$, $R_{T\text{-out}}$ vs $(\phi-\Phi_2)$, $(\phi-\Phi_3)$

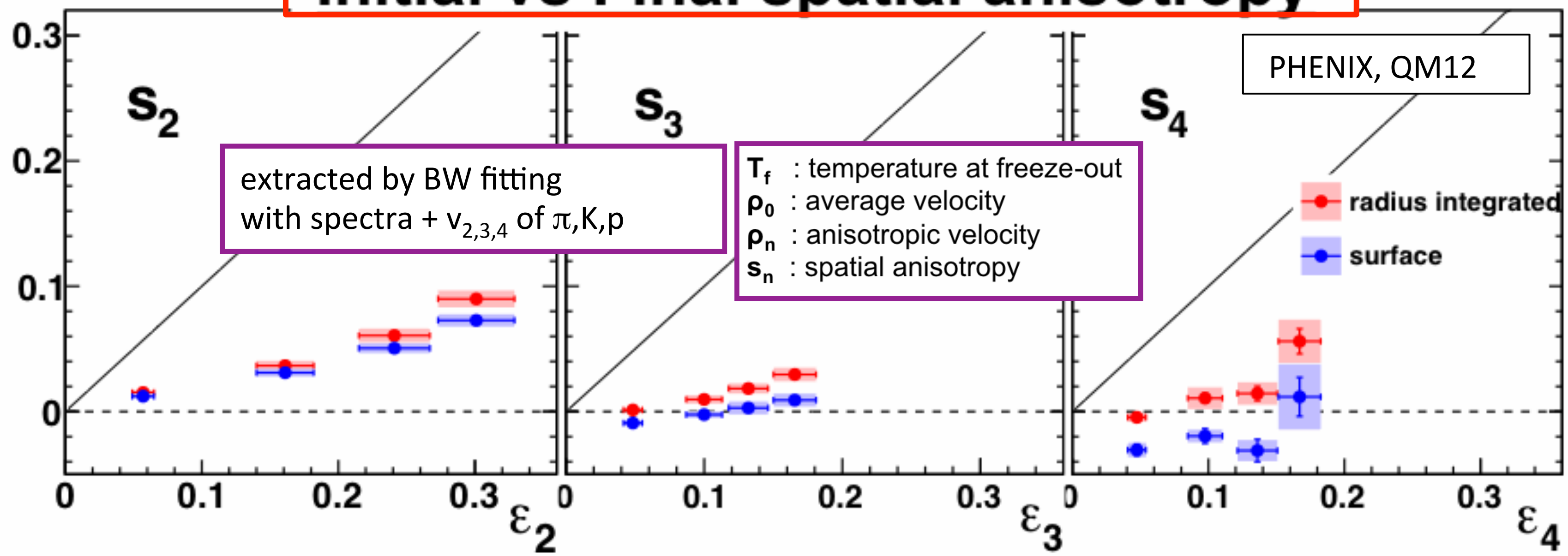
$R_{T\text{-side}}^{\text{oscill.}} < R_{T\text{-out}}^{\text{oscill.}}$ for n=2,3 (central)

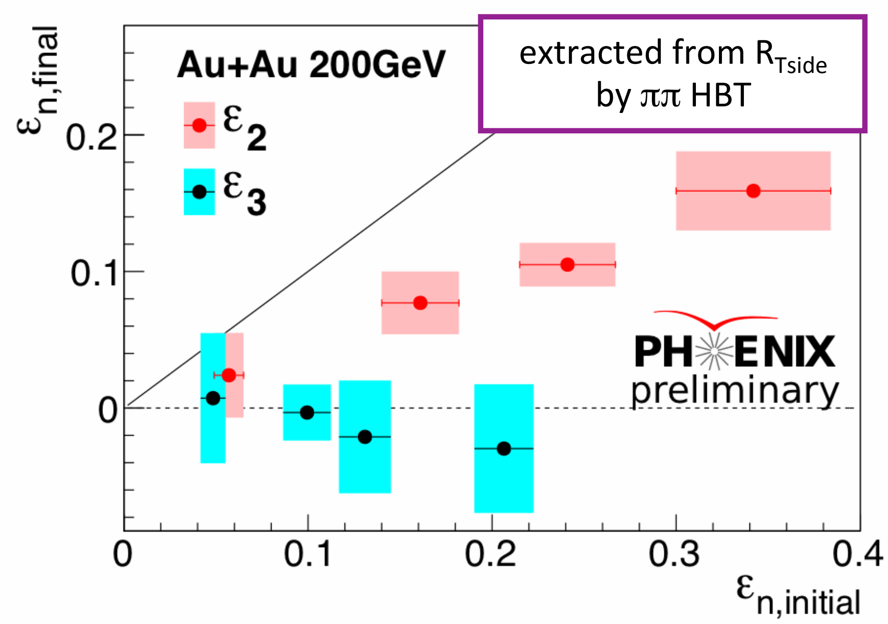
together with $v_n(p_T)^{PID}$ fitting with Blast Wave

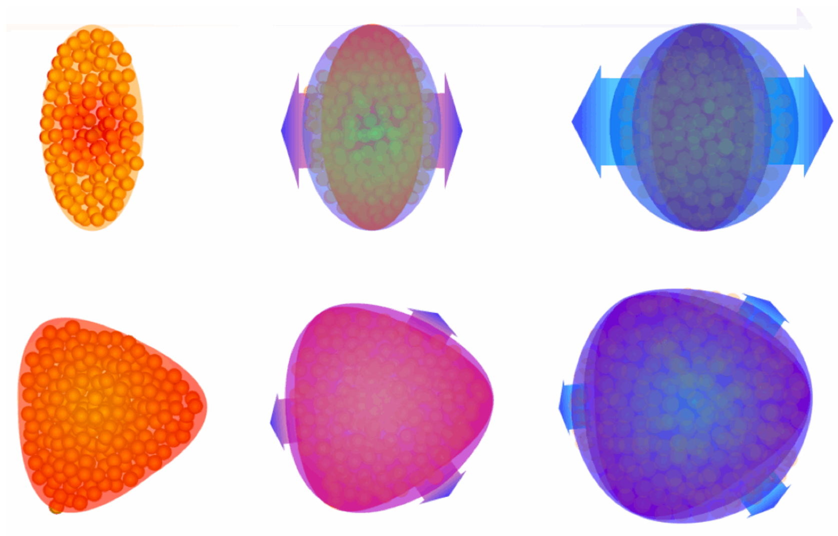




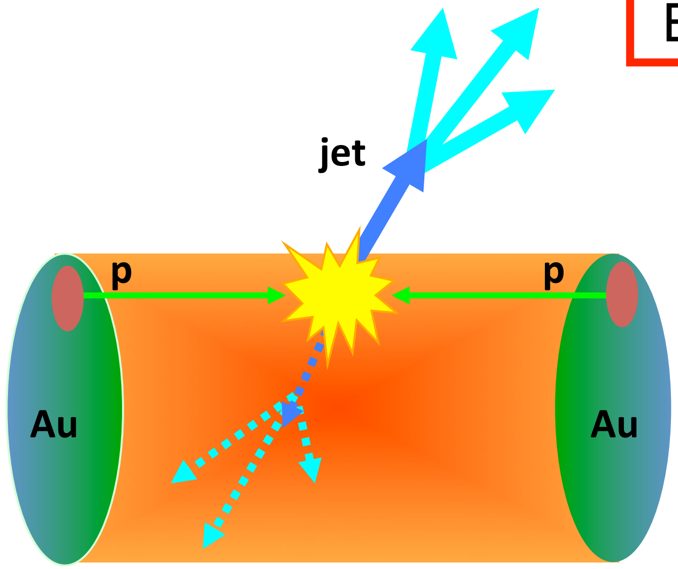
Initial vs Final spatial anisotropy

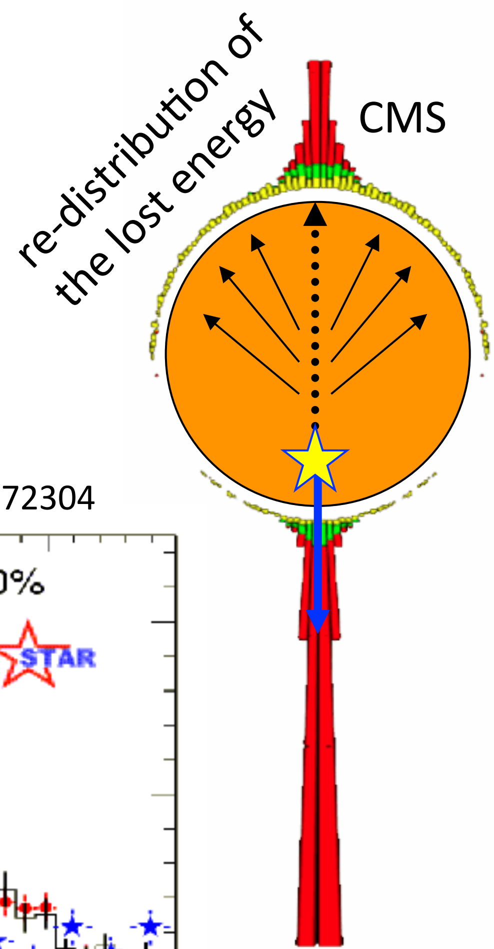




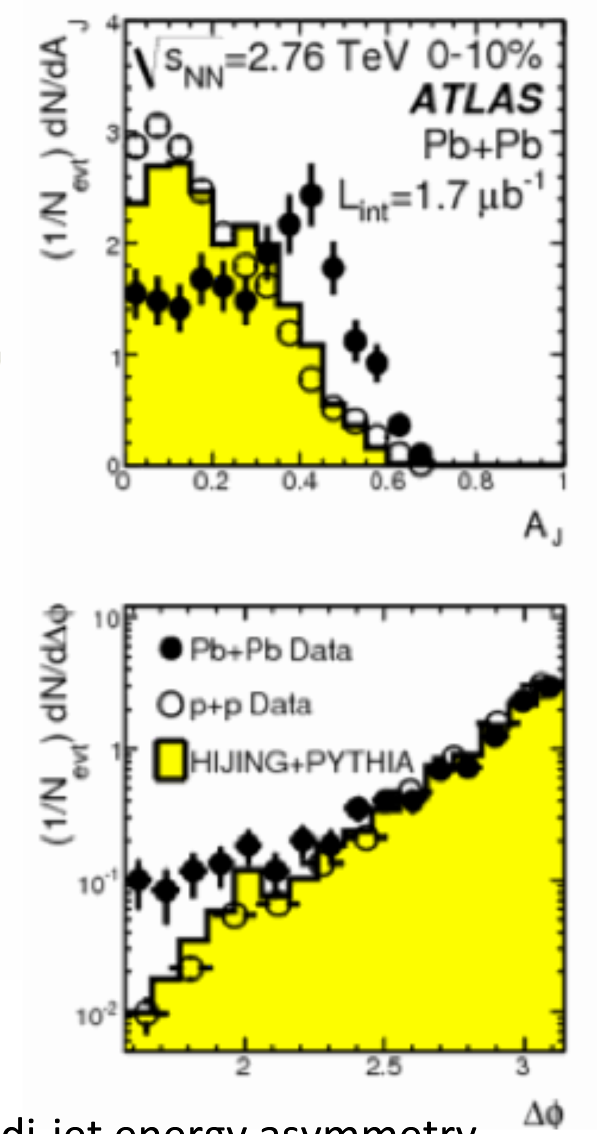


Energy loss (jet quenching)



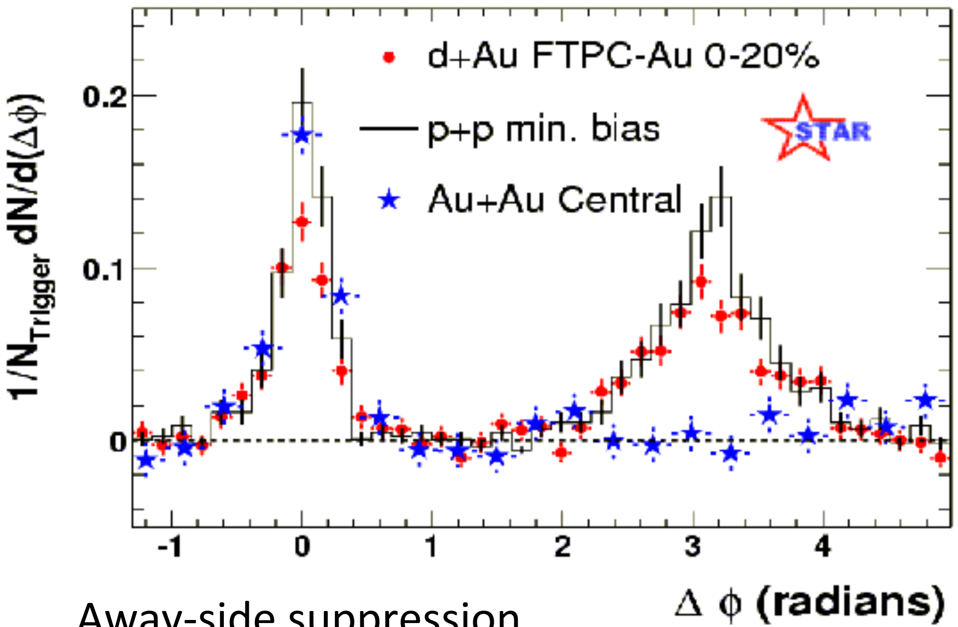


Phys. Rev. Lett. 105 (2010) 252303



di-jet energy asymmetry

Phys. Rev. Lett. 91 (2003) 072304

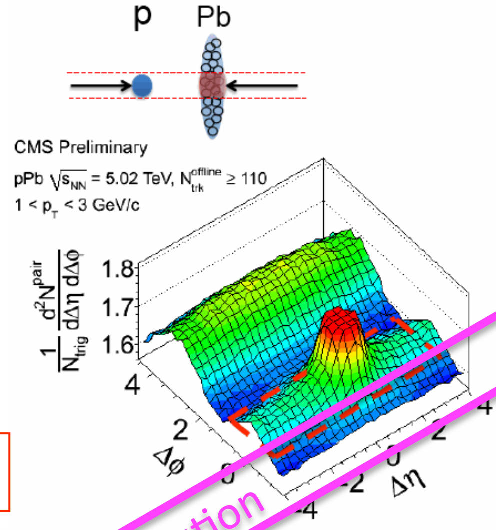


Away-side suppression

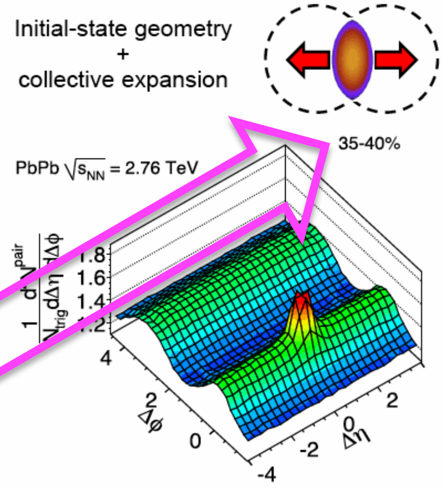
Ridge structure or v_n

A small but high-temperature/density system might be created in high multiplicity pp and pA collisions…
--- centrality and p_T dependences ---
Are they collective/expanding?

High mult. p+A



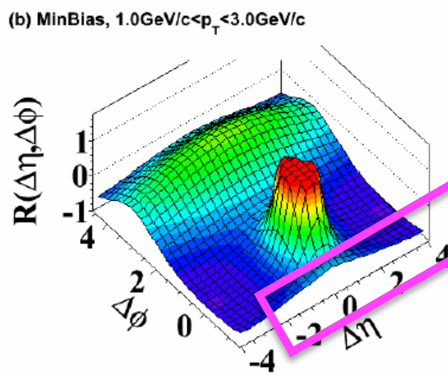
A+A



shape evolution

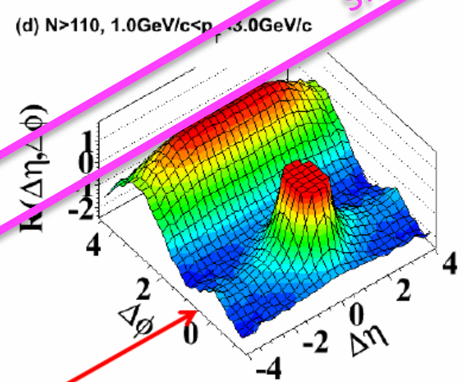
Min. bias p+p

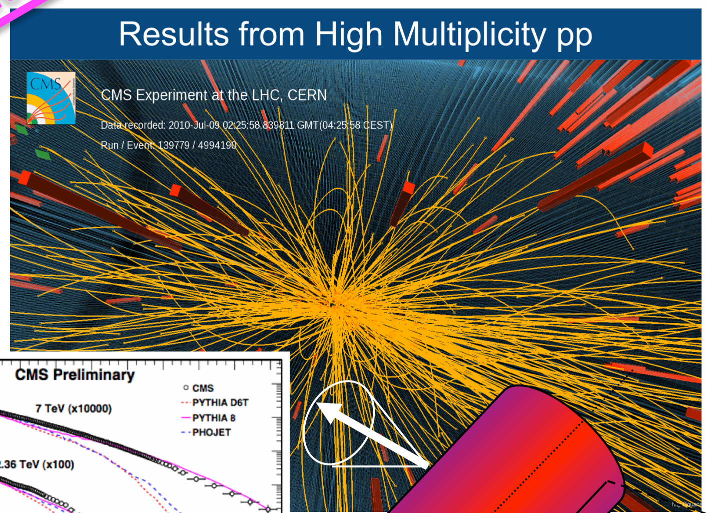
Minimum Bias
no cut on multiplicity

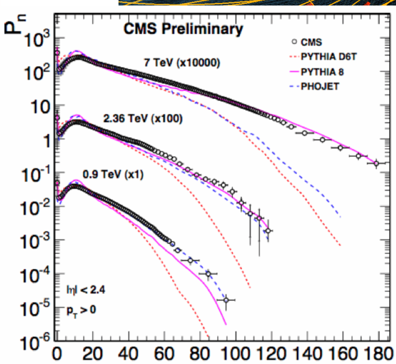


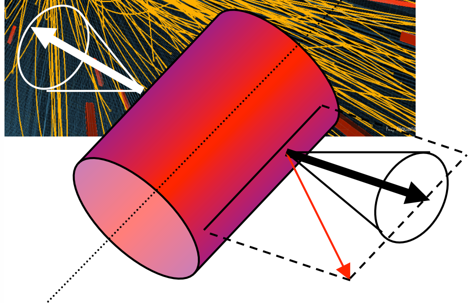
High mult. p+p

High multiplicity data set
and N>110









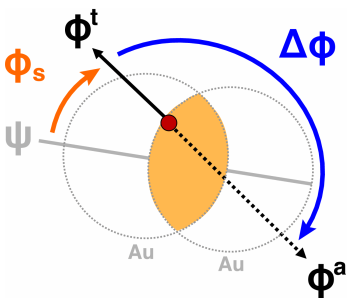
New "ridge-like" structure extending to large Δη at Δφ ~ 0

JHEP 09 (2010) 091, Eur. Phys. J. C 72 (2012) 2012
Phys. Lett. B 718 (2013) 795-814

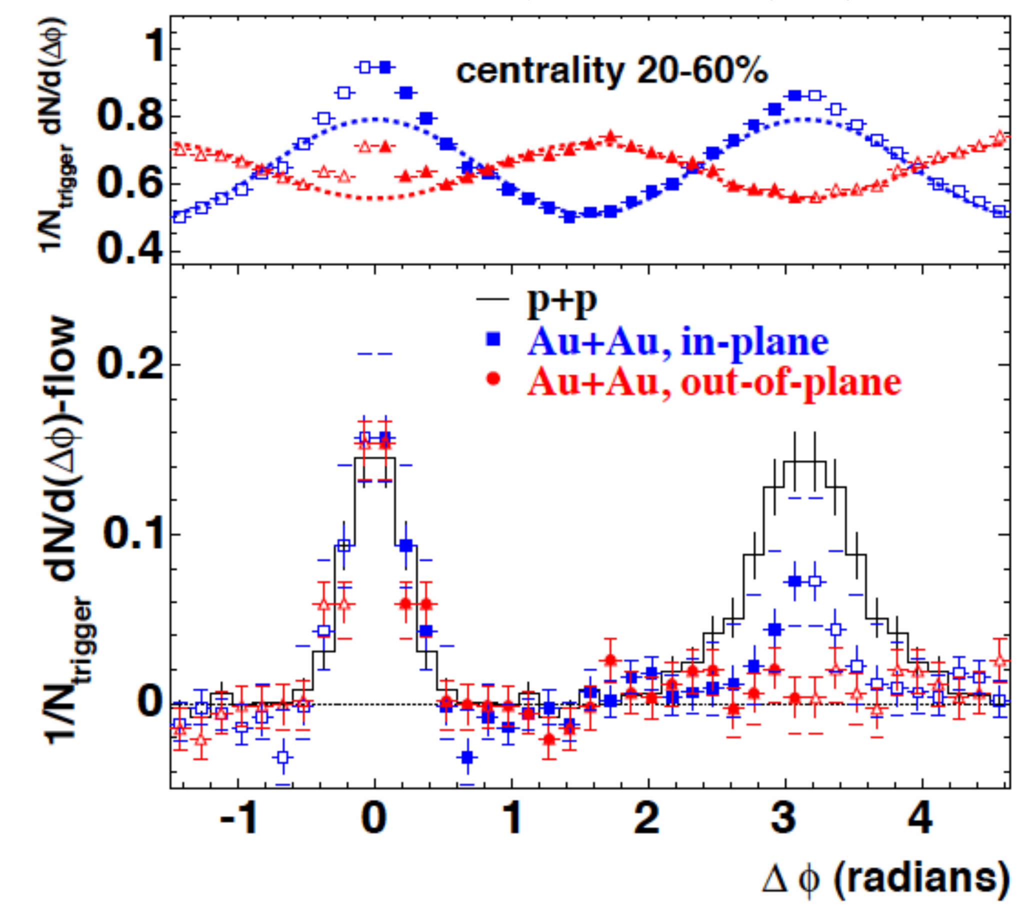
CMS

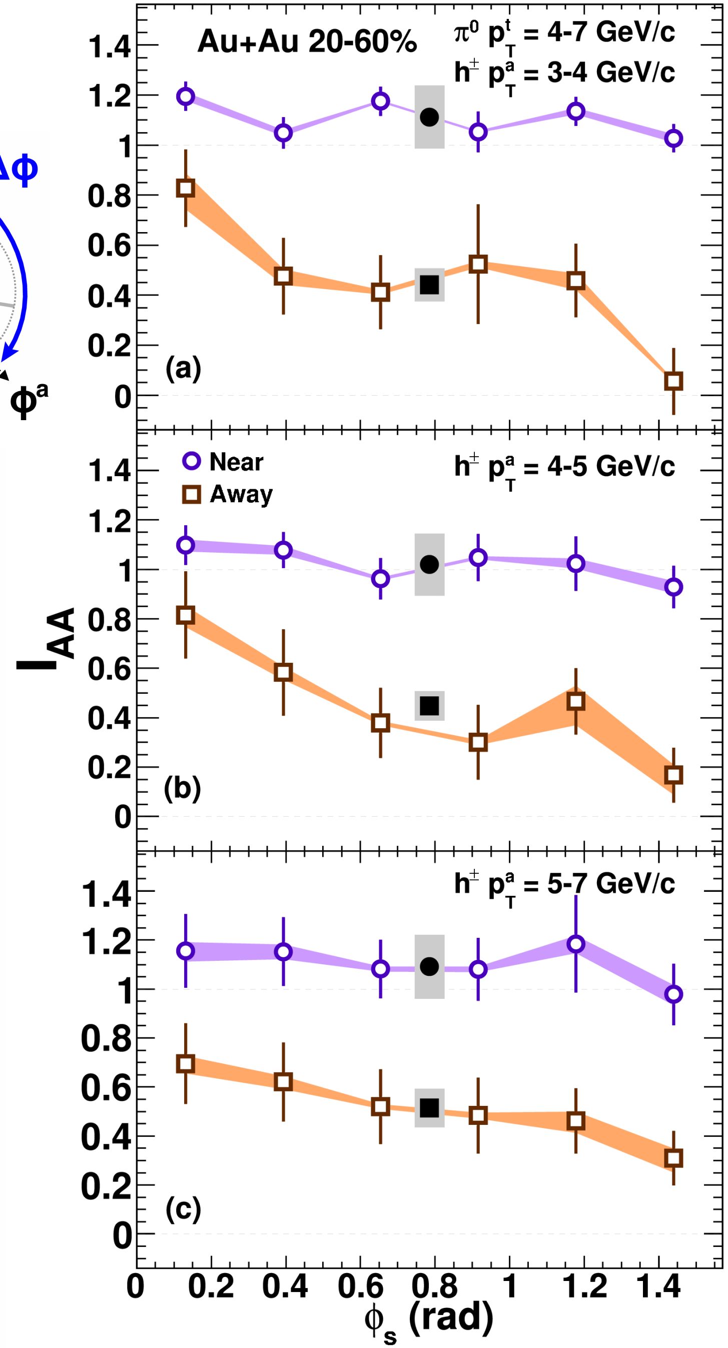
Angle (Length) dependence of di-hadron correlation

- high p_T single/jet suppression
- high p_T di-hadron/di-jet suppression
- High p_T v_2



Phys. Rev. Lett. 93 (2004) 252301

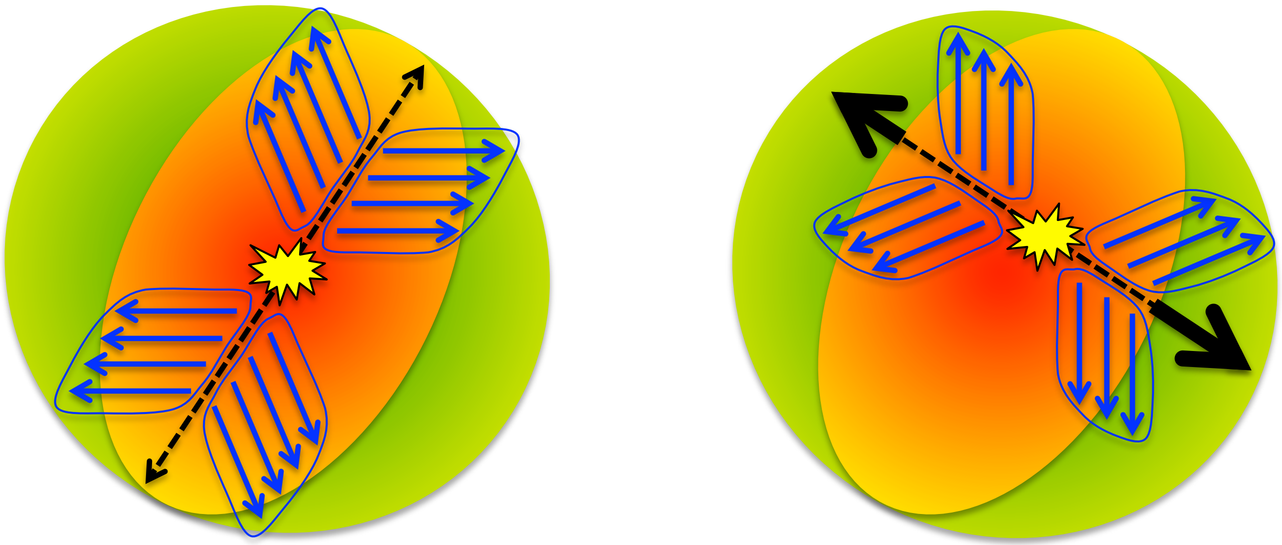




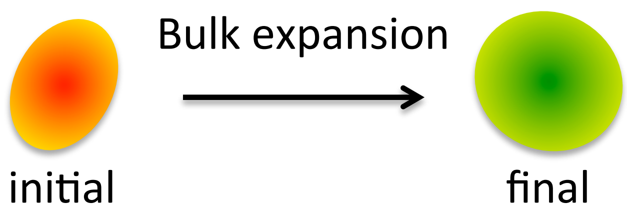
Phys. Rev. C 84 (2011) 024904

Path length (angle w.r.t. Φ_n) dependence of energy-loss would be a dominant source of high p_T or reconstructed jet v_n.

Depending on the shape (amount and direction: blue part), the lost energy re-distribution should then influence the low to mid p_T v_n and possibly also affect the bulk expansion in the later stage.

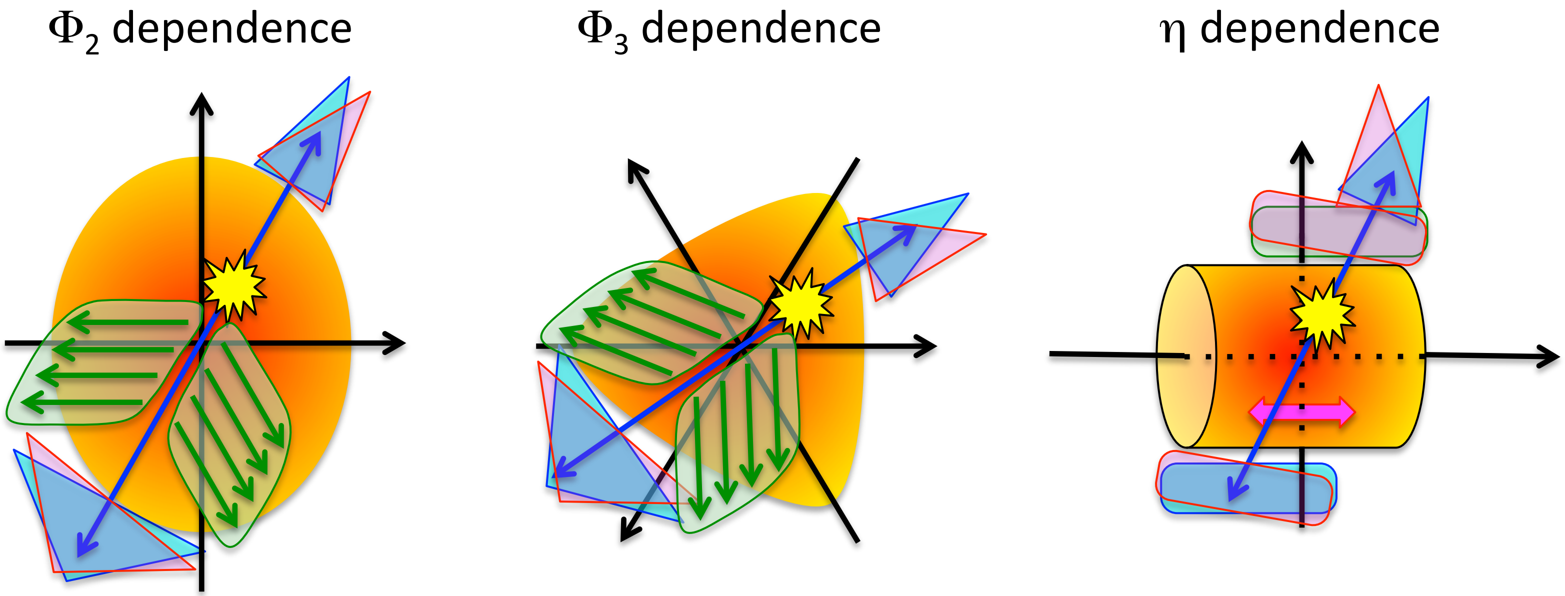


Lost energy from the jet quenching, feed-back into the bulk



Interplay between hard and soft physics

Initial (p-p like) jet shape is given by the jet axis. (blue shape)
(1) How much the jet-shape is modified? (red shape)
(2) How much additional things like ridge and mach-cone are generated including the bulk modification? (green shape)



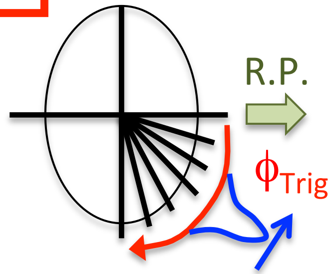
Jet shapes can be asymmetric with respect to the initial jet axis depending on the axis angle relative to Φ_2, Φ_3 … and η.

Left/right asymmetry of Ridge and Mach-cone

QM09: J. Konzer

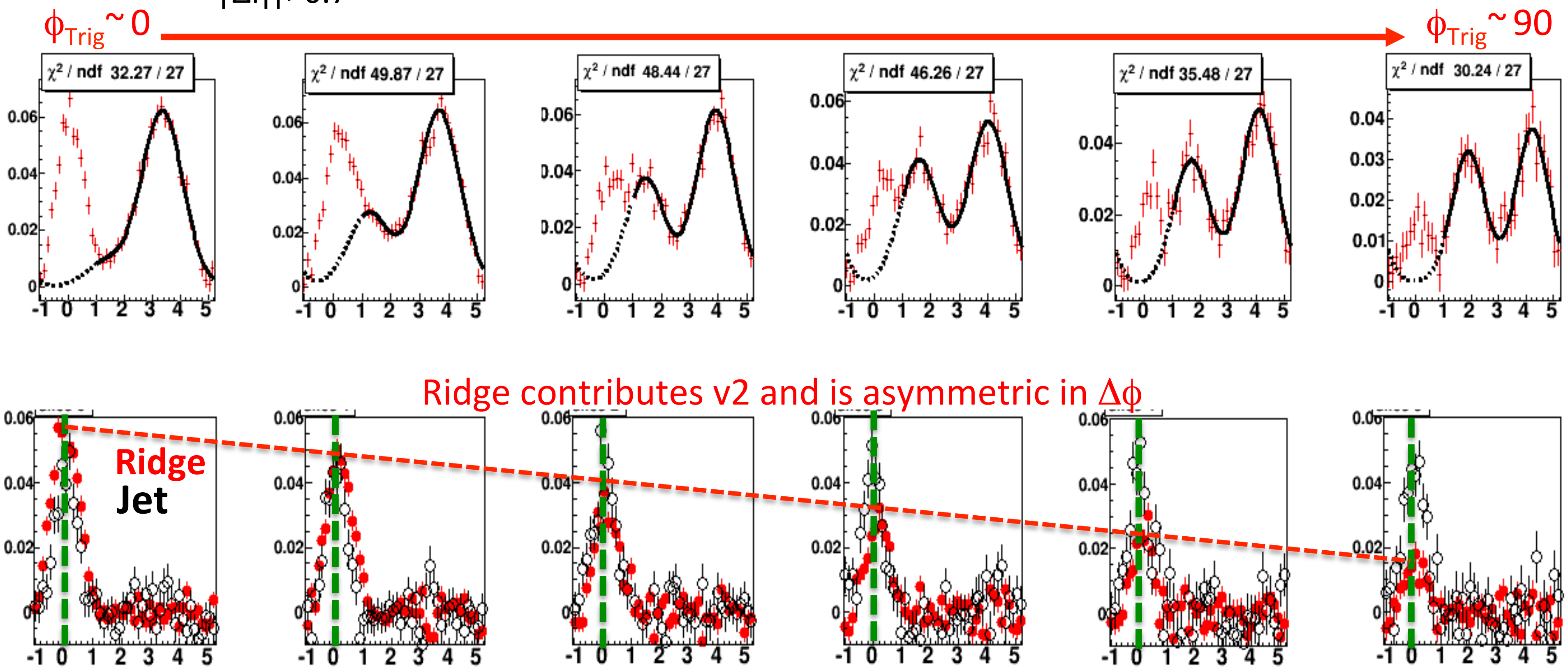
Y(|Δη|>0.7) = **Ridge** + away-side two-Gaussian

Jet = Y(|Δη|<0.7) – Acceptance*Y(|Δη|>0.7)



STAR Preliminary
Au+Au 20-60%
$3<p_T^{Trig}<4$ GeV/c
$1<p_T^{Assoc}<1.5$ GeV/c

|Δη|>0.7

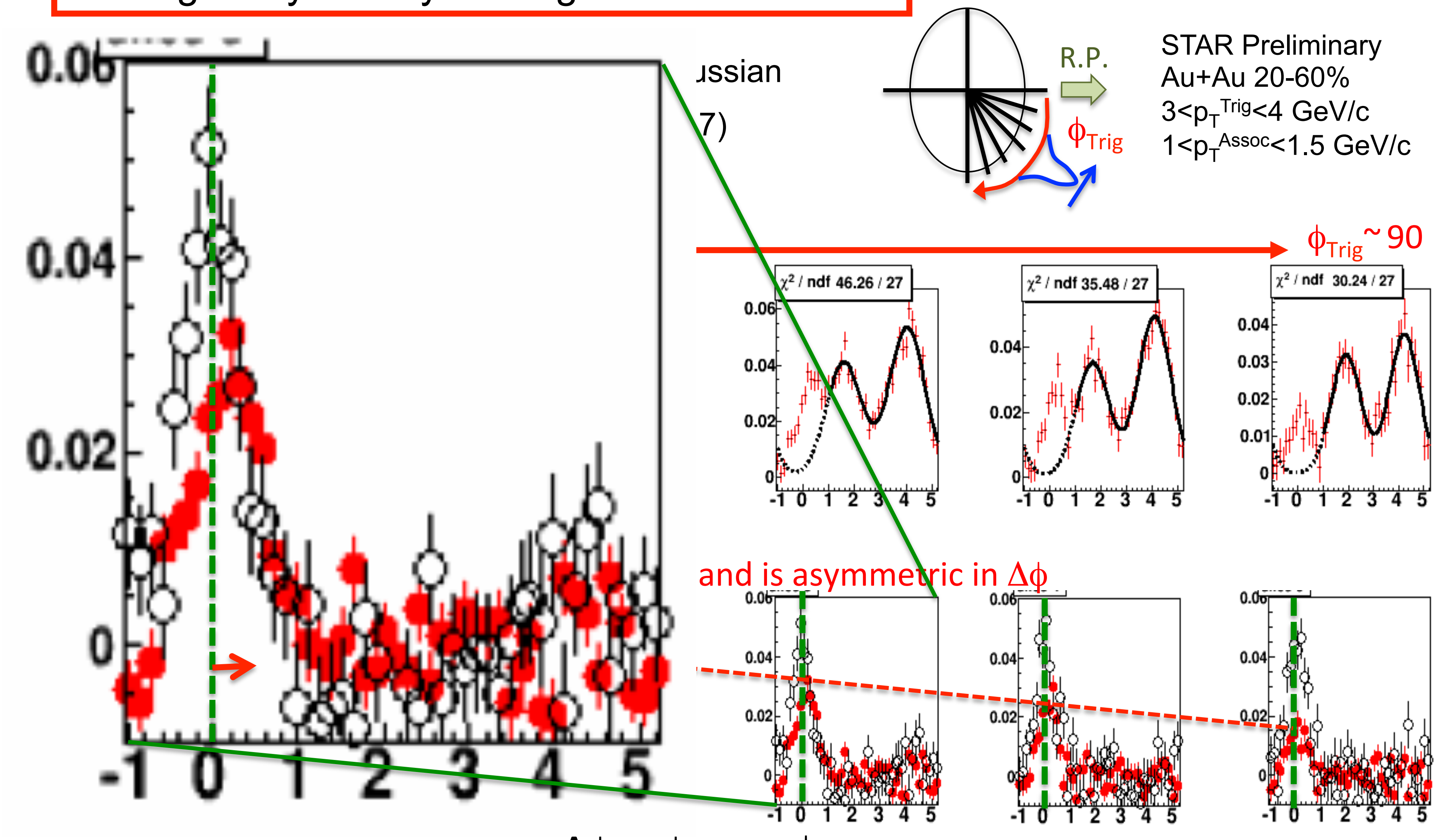


$$\Delta\phi = \phi_{Asso} - \phi_{Trig}$$

v2 subtraction

Left/right asymmetry of Ridge and Mach-cone

QM09: J. Konzer

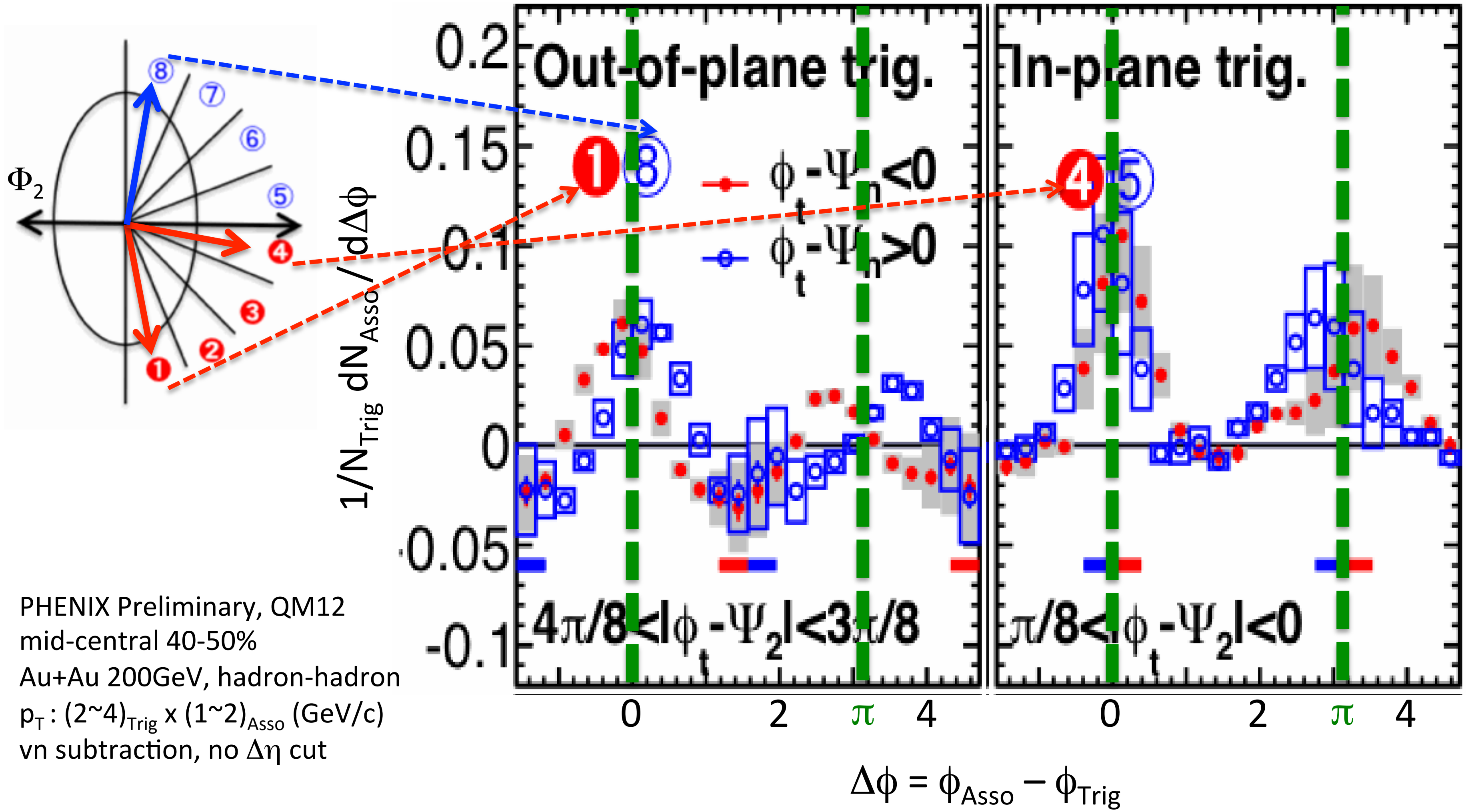


$\Delta\phi = \phi_{Asso} - \phi_{Trig}$

v2 subtraction

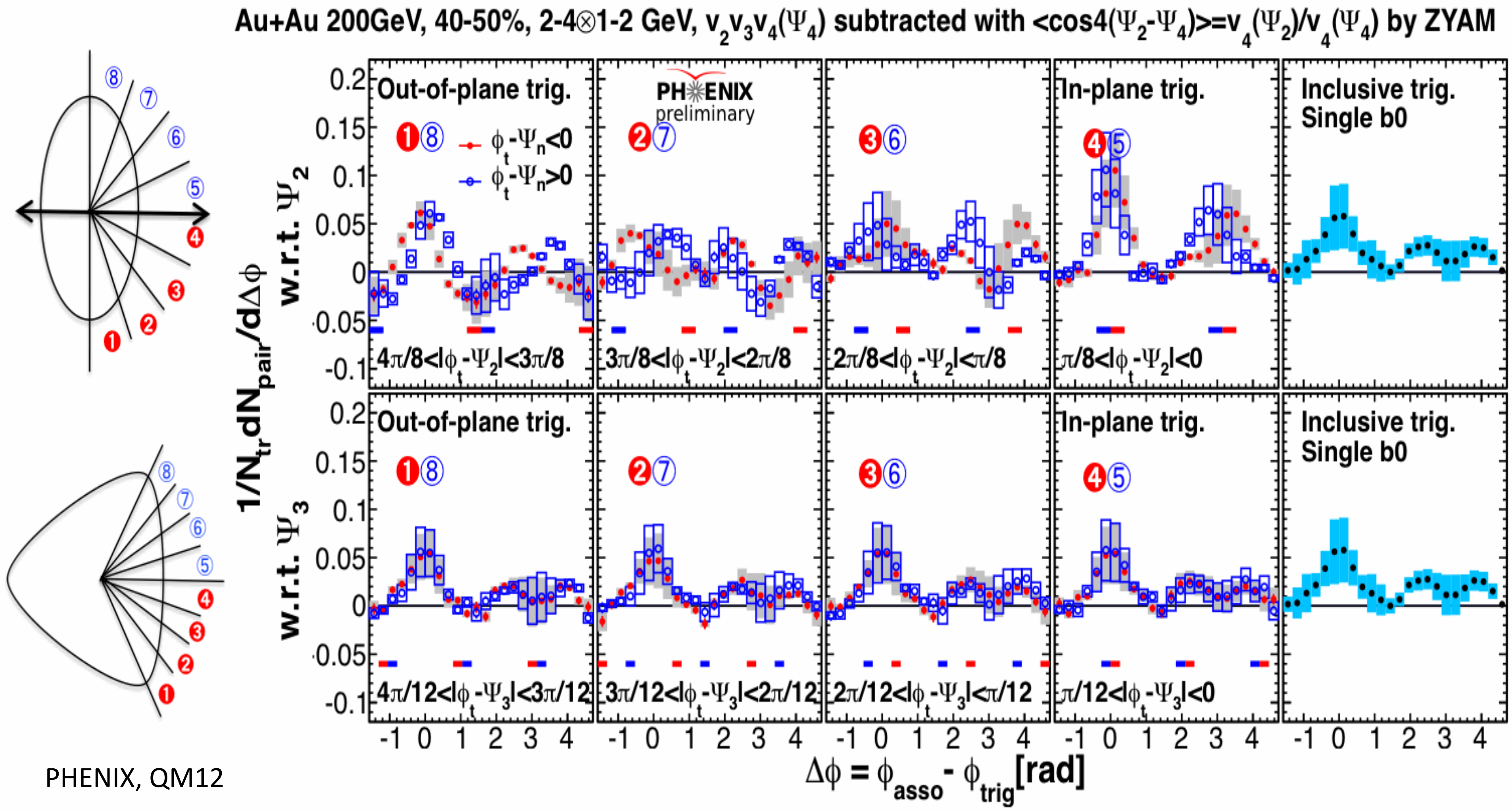
Hard-soft coupling via geometry and expansion

- strong Φ_2 dependence and left/right asymmetry (coupled with energy loss and flow)
- broader out-of-plane correlation than in-plane correlation (re-distribution of lost energy)



PHENIX Preliminary, QM12
mid-central 40-50%
Au+Au 200GeV, hadron-hadron
p_T : $(2\sim4)_{Trig}$ x $(1\sim2)_{Asso}$ (GeV/c)
vn subtraction, no $\Delta\eta$ cut

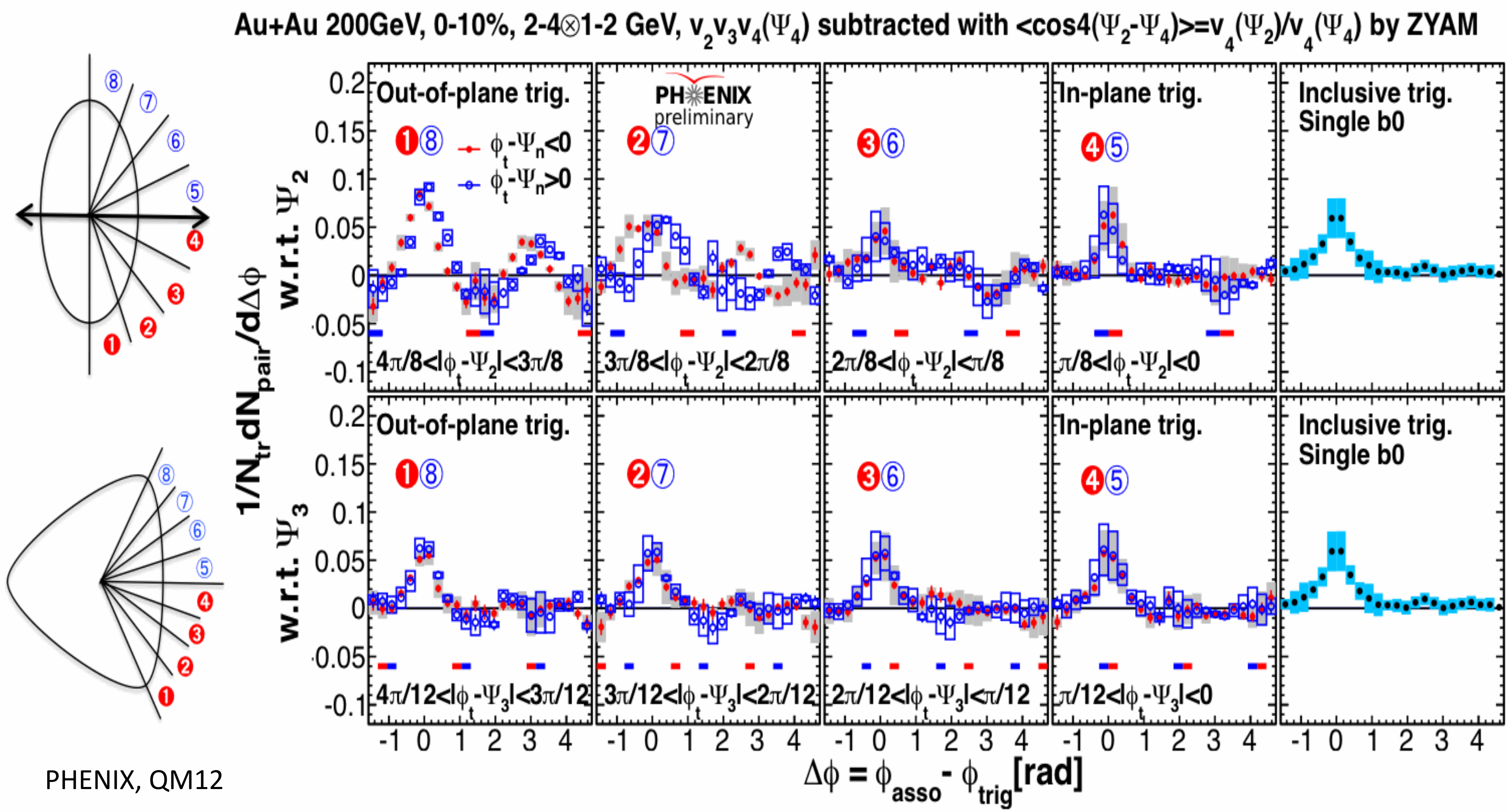
Correlations relative to Ψ_2 & Ψ_3, 40-50%



PHENIX, QM12

mid-central collisions	- driving force of v_2 (enhances v_2) - almost no Φ_3 dependence (poor Φ_3 resolution)

Correlations relative to Ψ_2 & Ψ_3, 0-10%



PHENIX, QM12

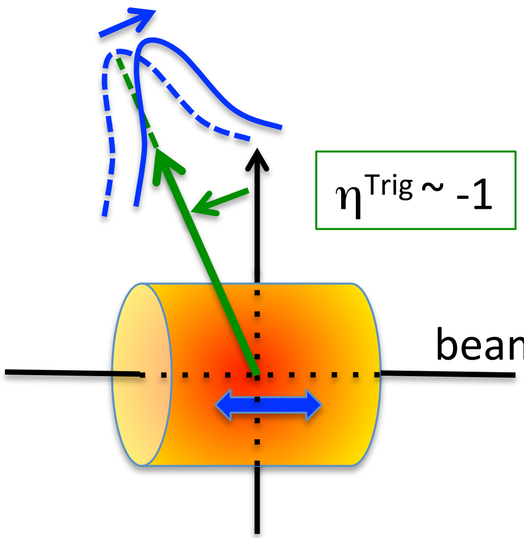
central collisions

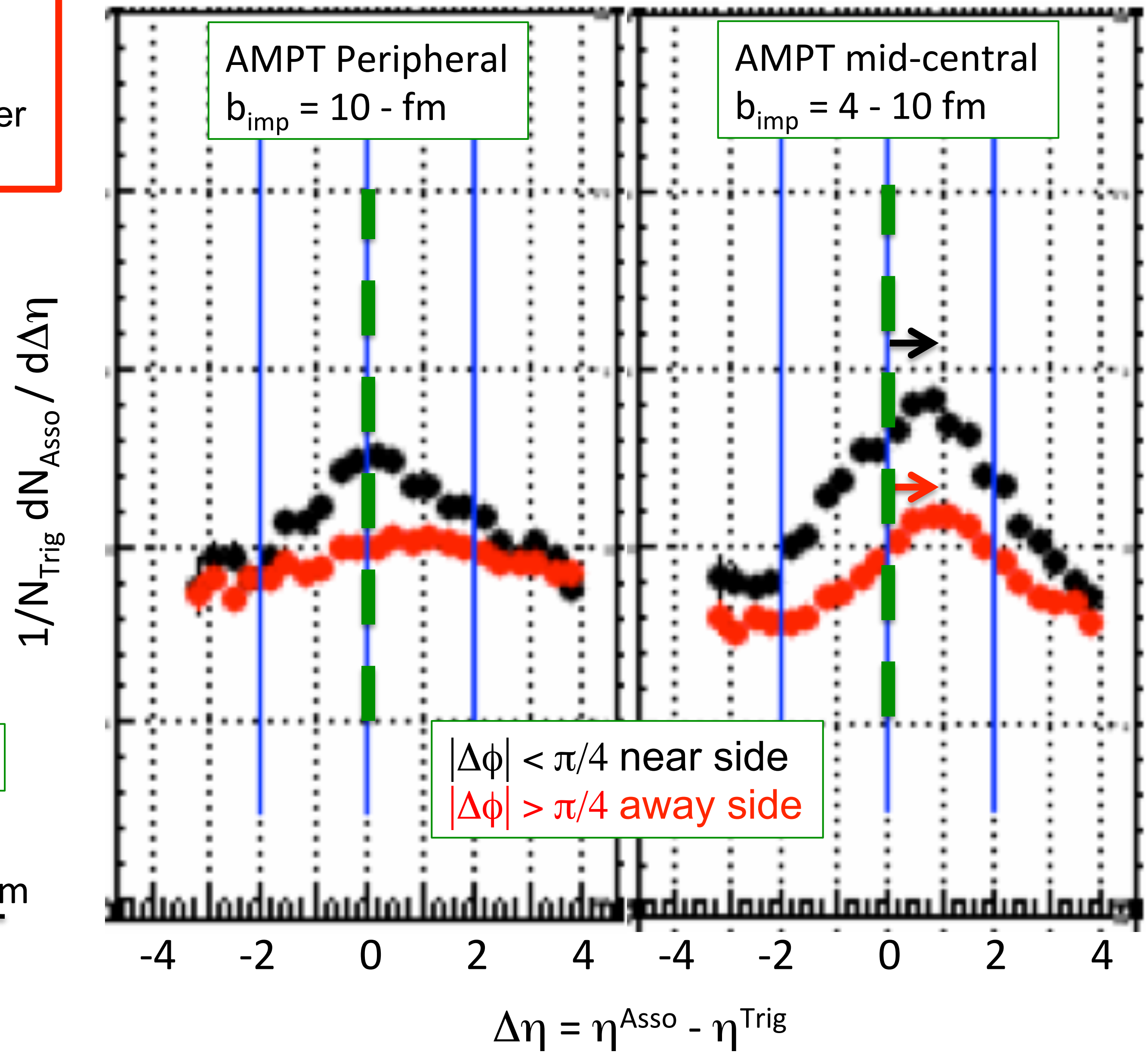
- stopping force of v_2 (suppresses v_2)
- some weak Φ_3 dependence

Trigger η dependence of $\Delta\eta$ distribution

(associate yield per trigger with AMPT simulation)

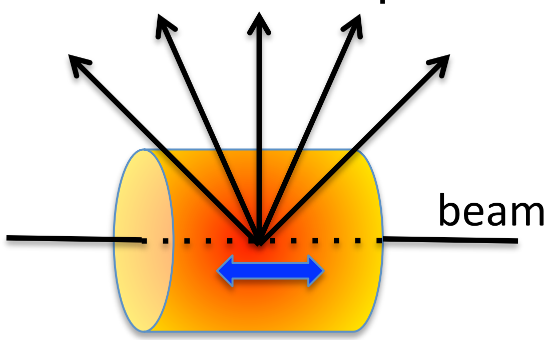
Forward-backward asymmetry is visible at least in AMPT.
Near side $\Delta\eta$ peak is backward shifted w.r.t. trigger η direction.

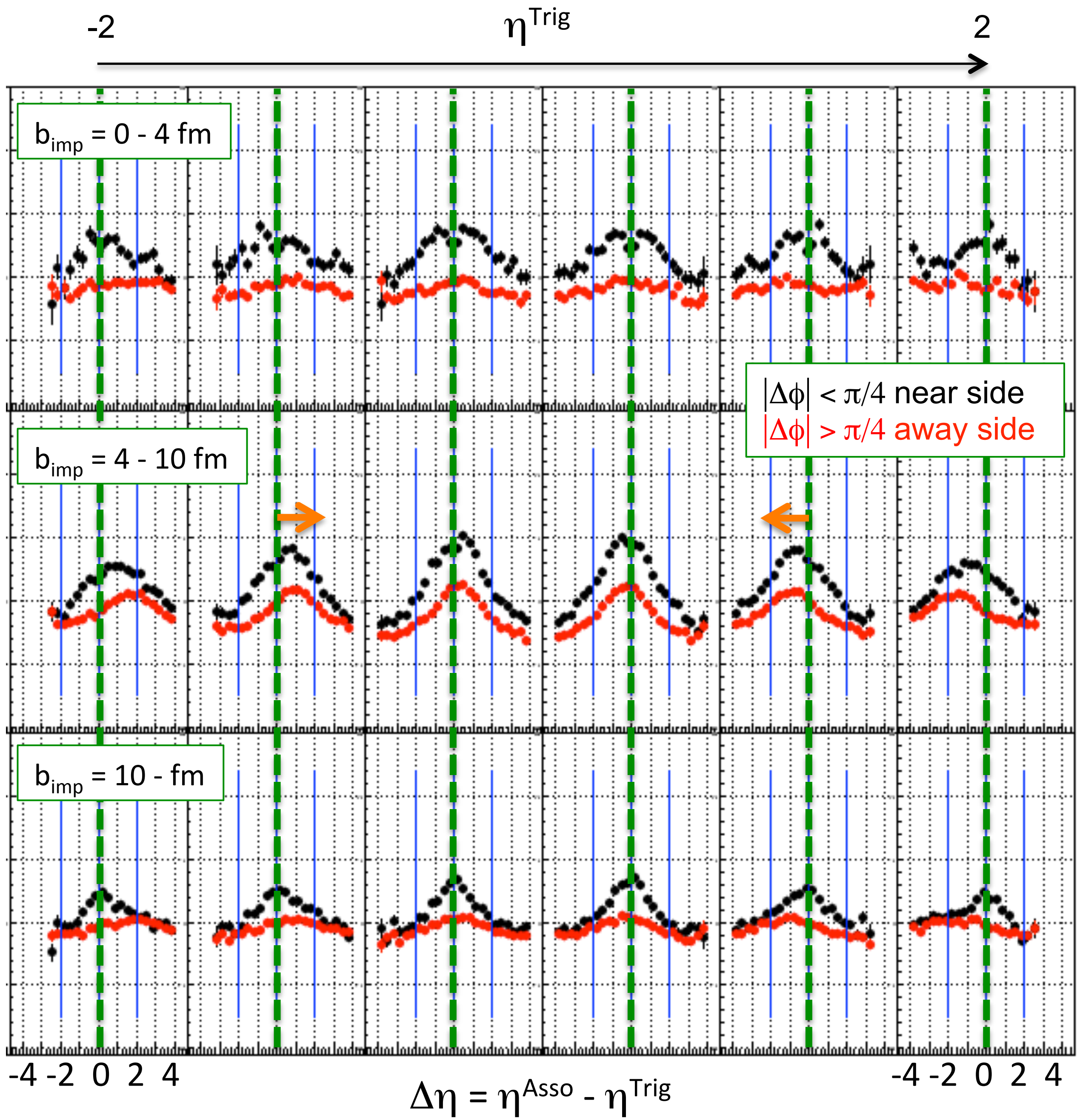




Trigger η dependence of $\Delta\eta$ distribution

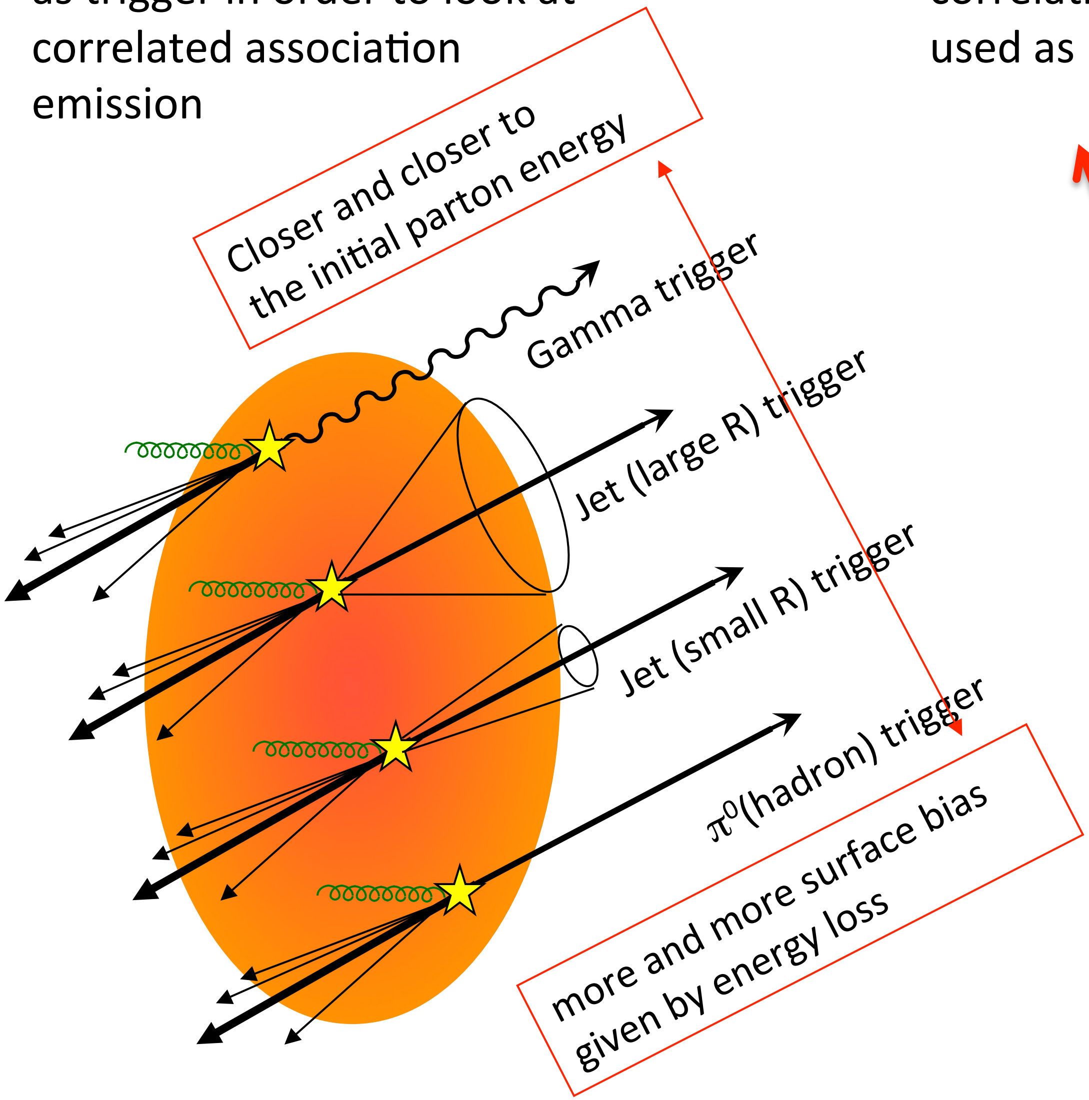
(associate yield per trigger with AMPT simulation)



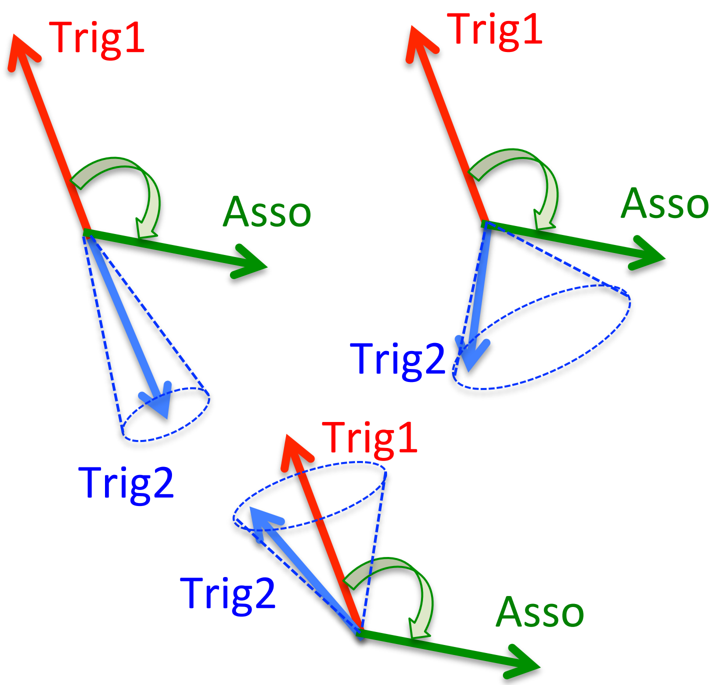


look at the asymmetry in $\Delta\eta = \eta^{Asso} - \eta^{Trig}$ (associate η distribution with respect to trigger η) in order to see the hard-soft coupling with longitudinal density profile and/or expansion

Use photons, Jets, single hadrons as trigger in order to look at correlated association emission



Multi-particle correlation like 2+1 particle correlation analysis (Trig1, Trig2, Asso) can be used as largely modified jet and di-jet signal.



Use "Trig2 relative to Trig1" as jet trigger condition, and look at distribution : "Associate relative to Trig1" without jet-reconstruction bias

To be used for Φ_n and η_{Trig} dependent analysis

Summary

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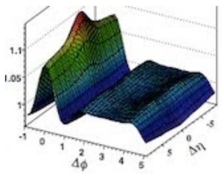
Expansion and freeze-out geometry
Jet and multi-particle correlation
Jet-correlation with respect to geometry
Influence on bulk property



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Y(|Δη|>0.7) = **back-to-back 2 ridges** + away-side two-(left/right) Gaussian