Jet and Flow analysis at RHIC and LHC

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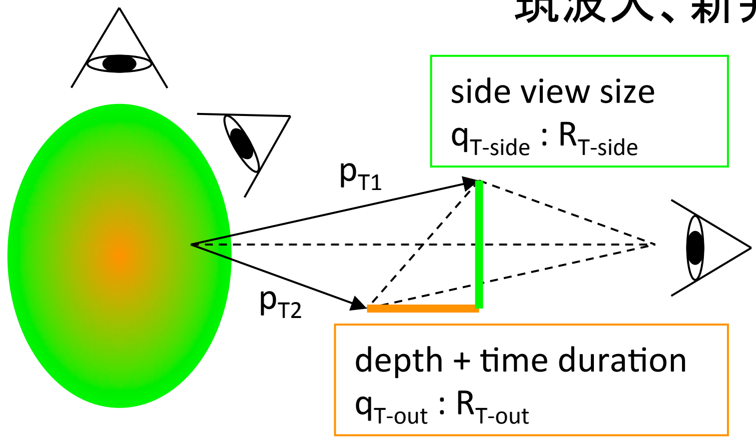
Source size/shape measurement with HBT
Energy loss and jet quenching
Small but high multiplicity system
Interplay between soft and hard
relation to collective event anisotropy

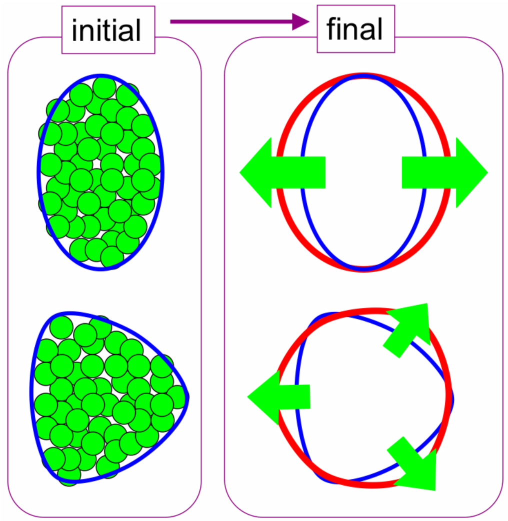
筑波大、新井田貴文

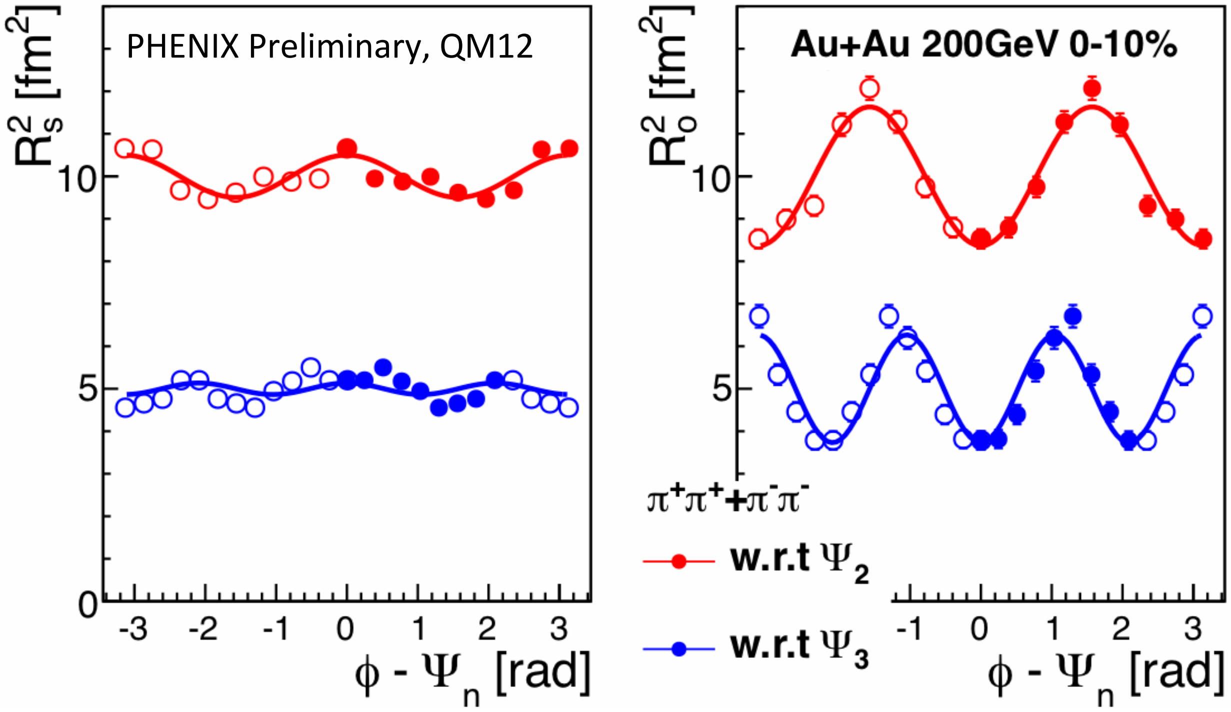
Source geometry (size, shape and time duration) at the end of freeze-out via two particle quantum interferometry (HBT measurement)

$R_{T\text{-side}}$, $R_{T\text{-out}}$ vs $(\phi-\Phi_2)$, $(\phi-\Phi_3)$
$R_{T\text{-side}}^{oscill.} < R_{T\text{-out}}^{oscill.}$ for n=2,3 (central)



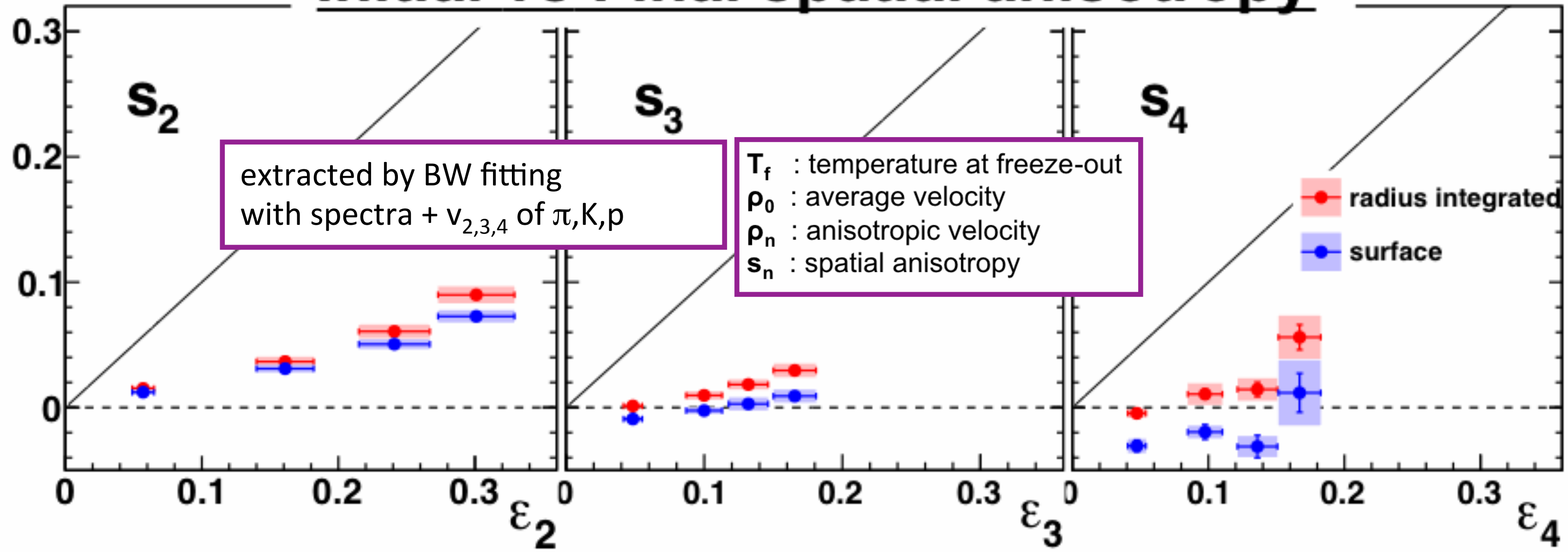
together with $v_n(p_T)^{PID}$ fitting with Blast Wave

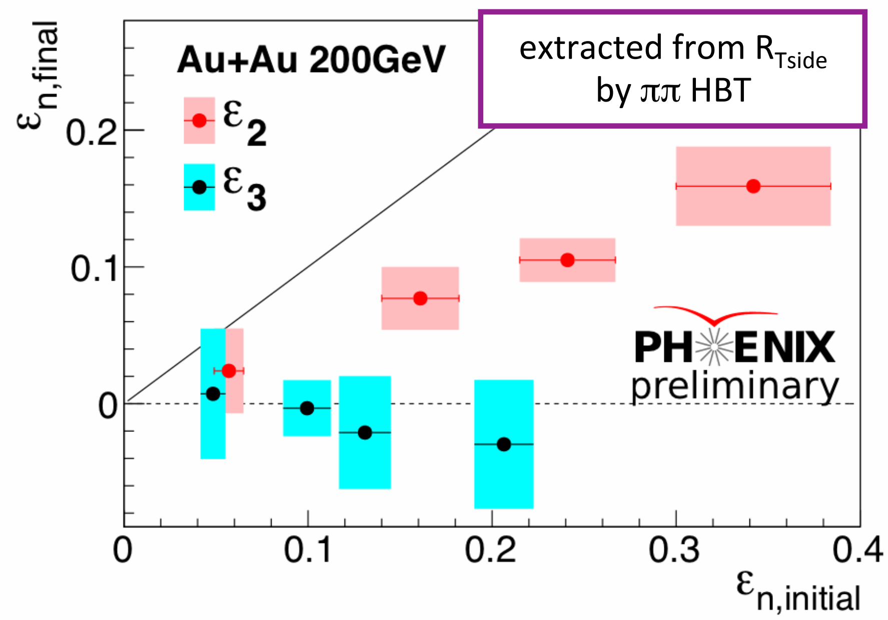


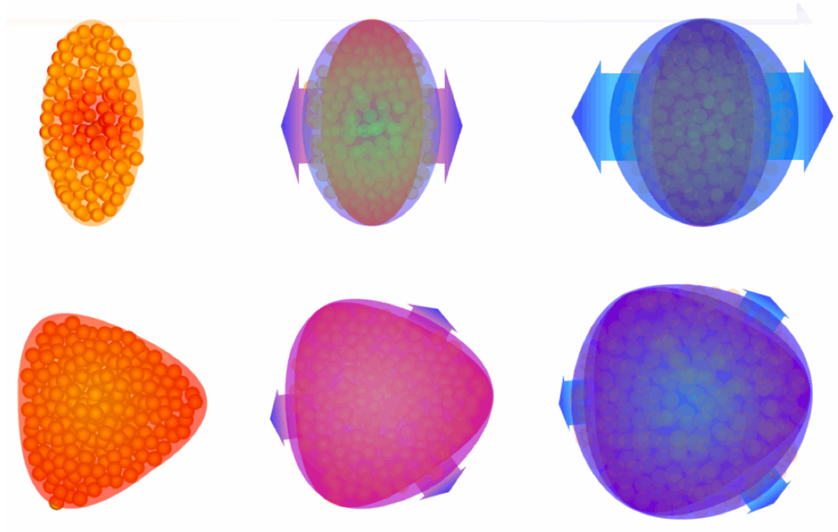


Initial vs Final spatial anisotropy

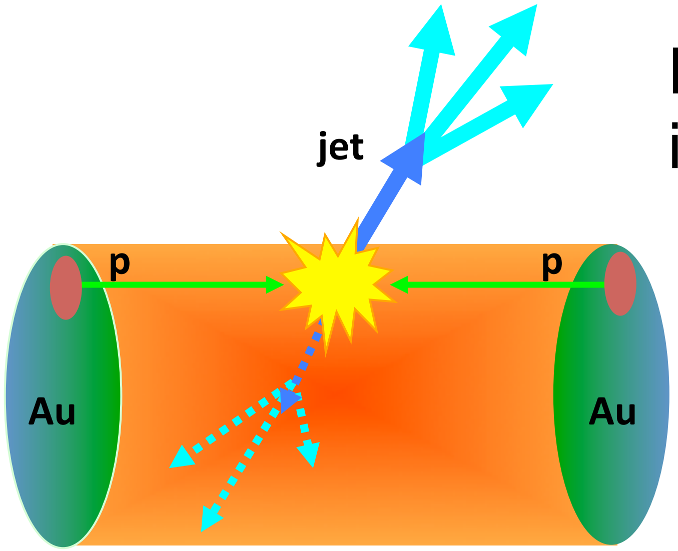
PHENIX, QM12

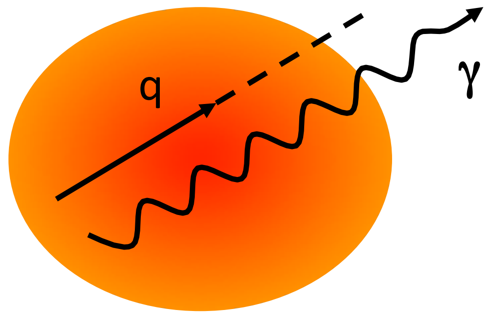




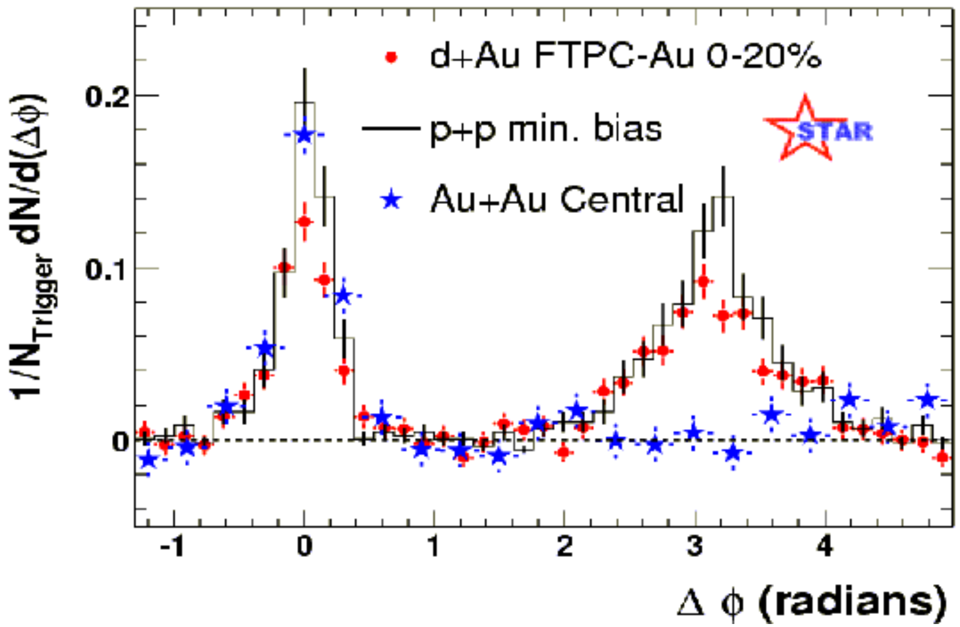


Energy loss (jet quenching) in QGP





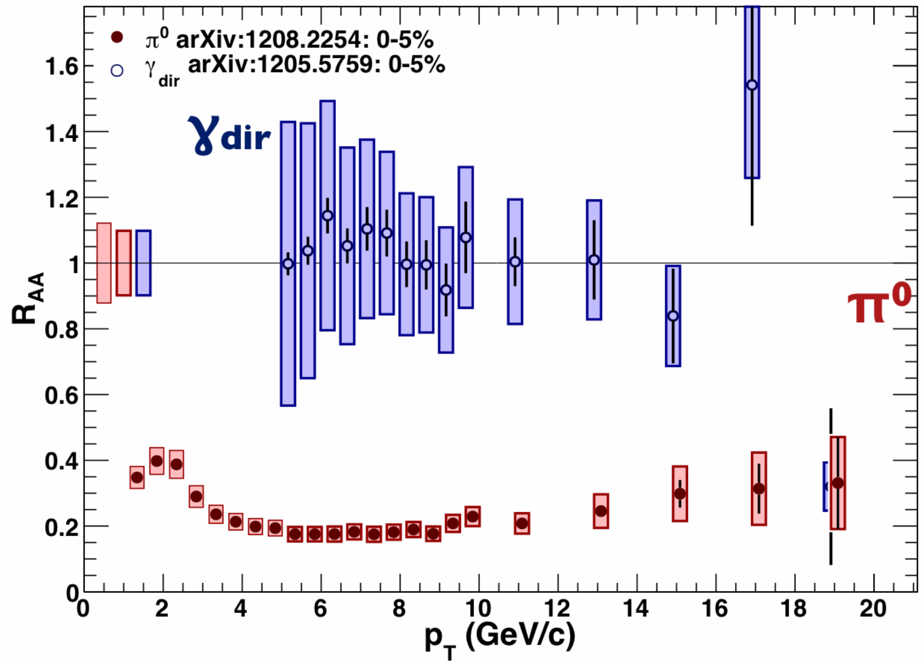
Phys. Rev. Lett. 91, 072304 (2003)

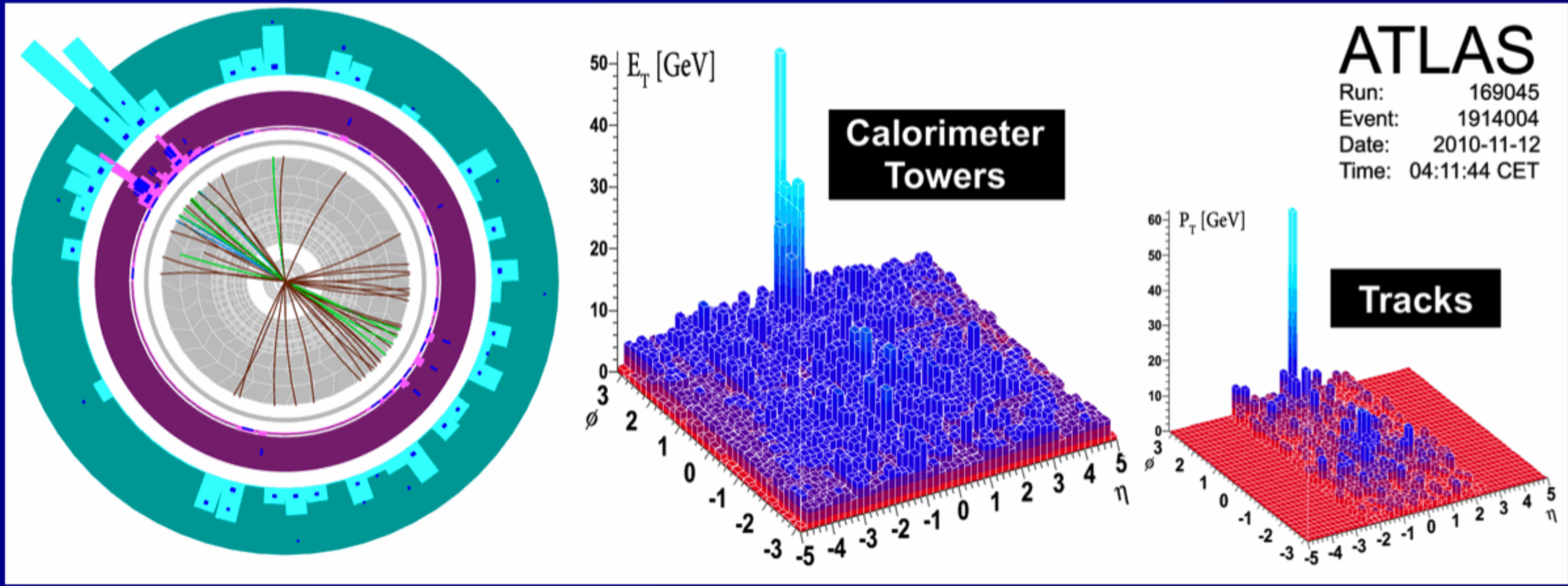


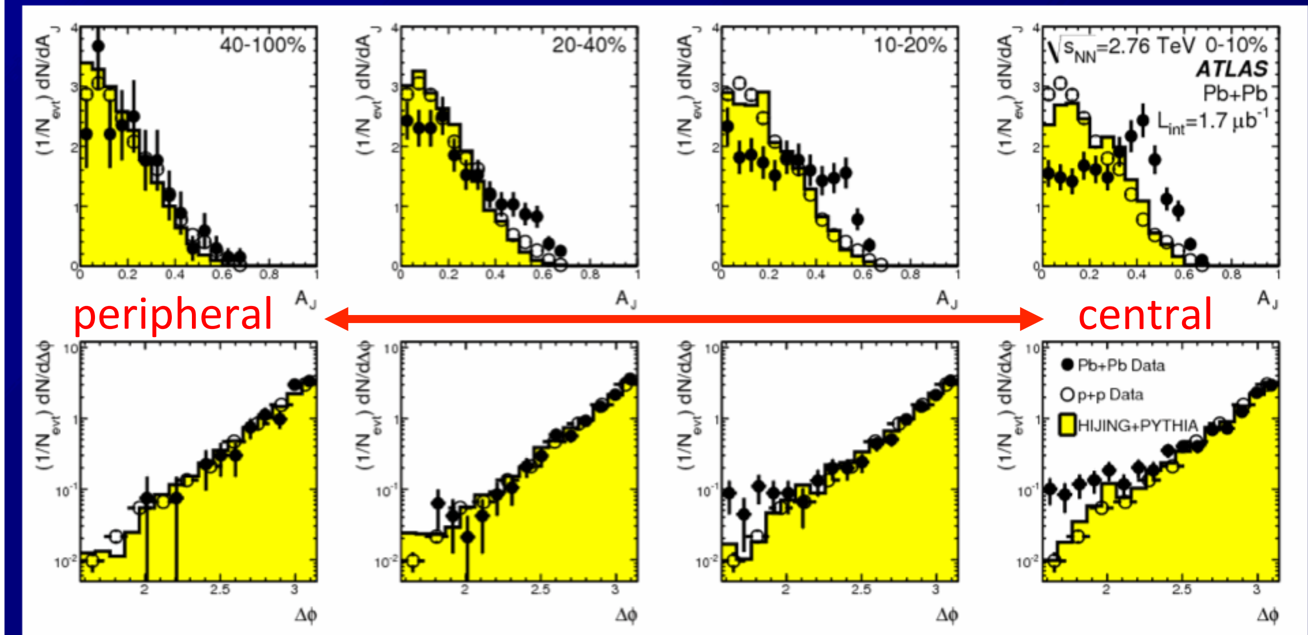
central Au+Au

arXiv: 1208.2254

PRL109, 152302 (2012)







$$A_J = \frac{E_{T1} - E_{T2}}{E_{T1} + E_{T2}}$$

$$E_{T1} > 100\ GeV$$

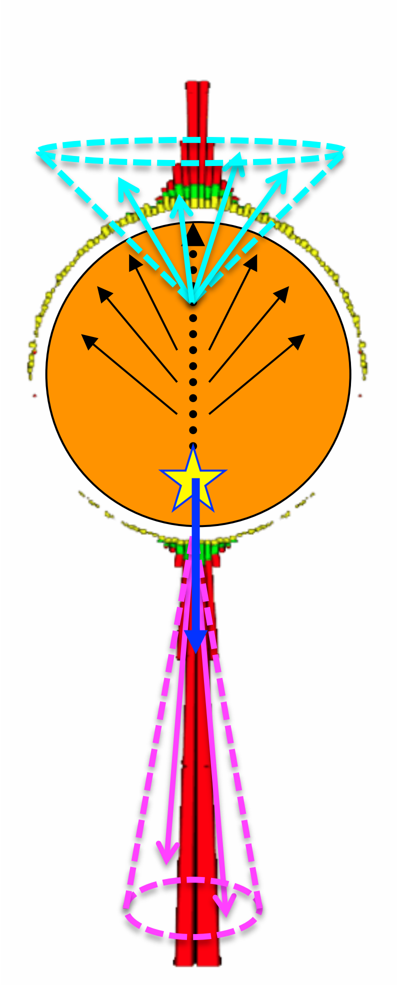
$$E_{T2} > 25\ GeV$$

Di-jet asymmetry : A_J

LHC-ATLAS, arXiv : 1208.1967v2

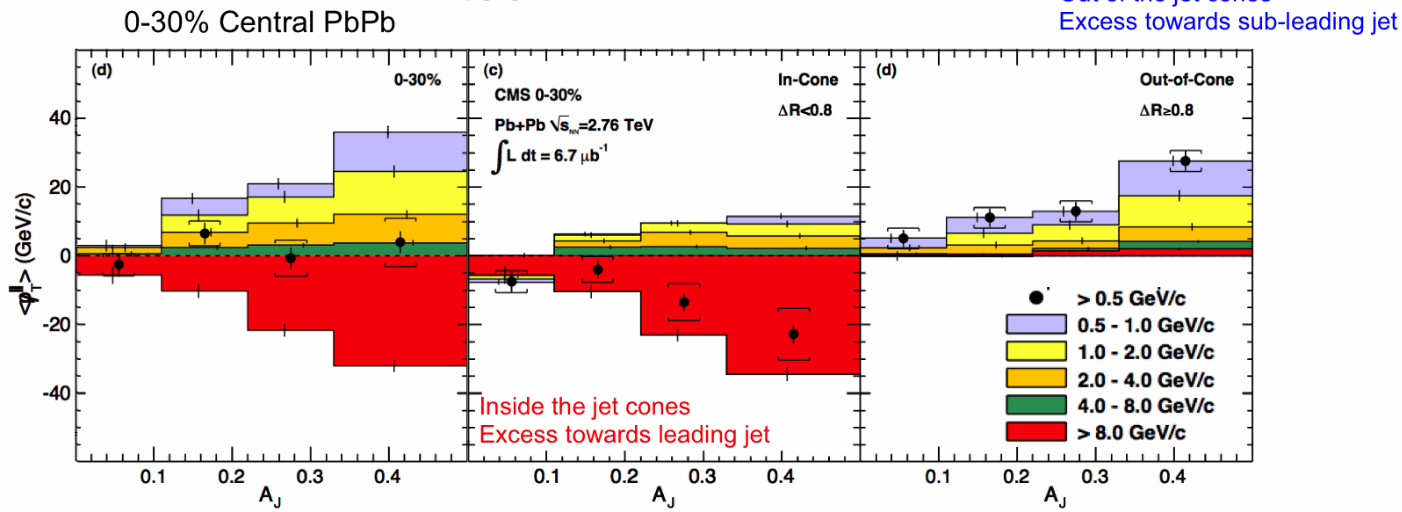
Re-distribution of the lost energy from the jet quenching

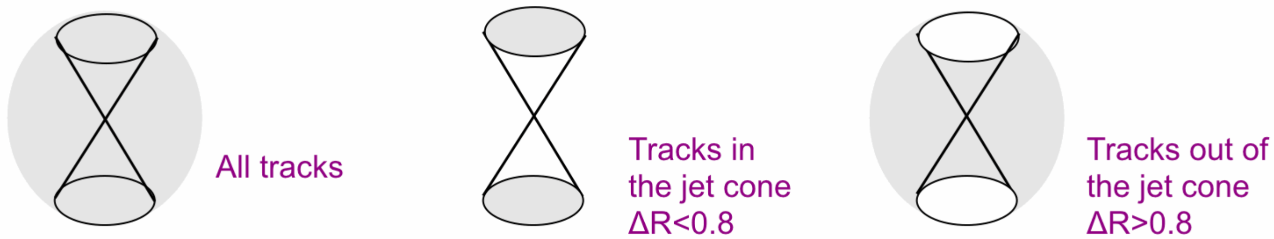
LHC-CMS, PRC84 (2011) 024906



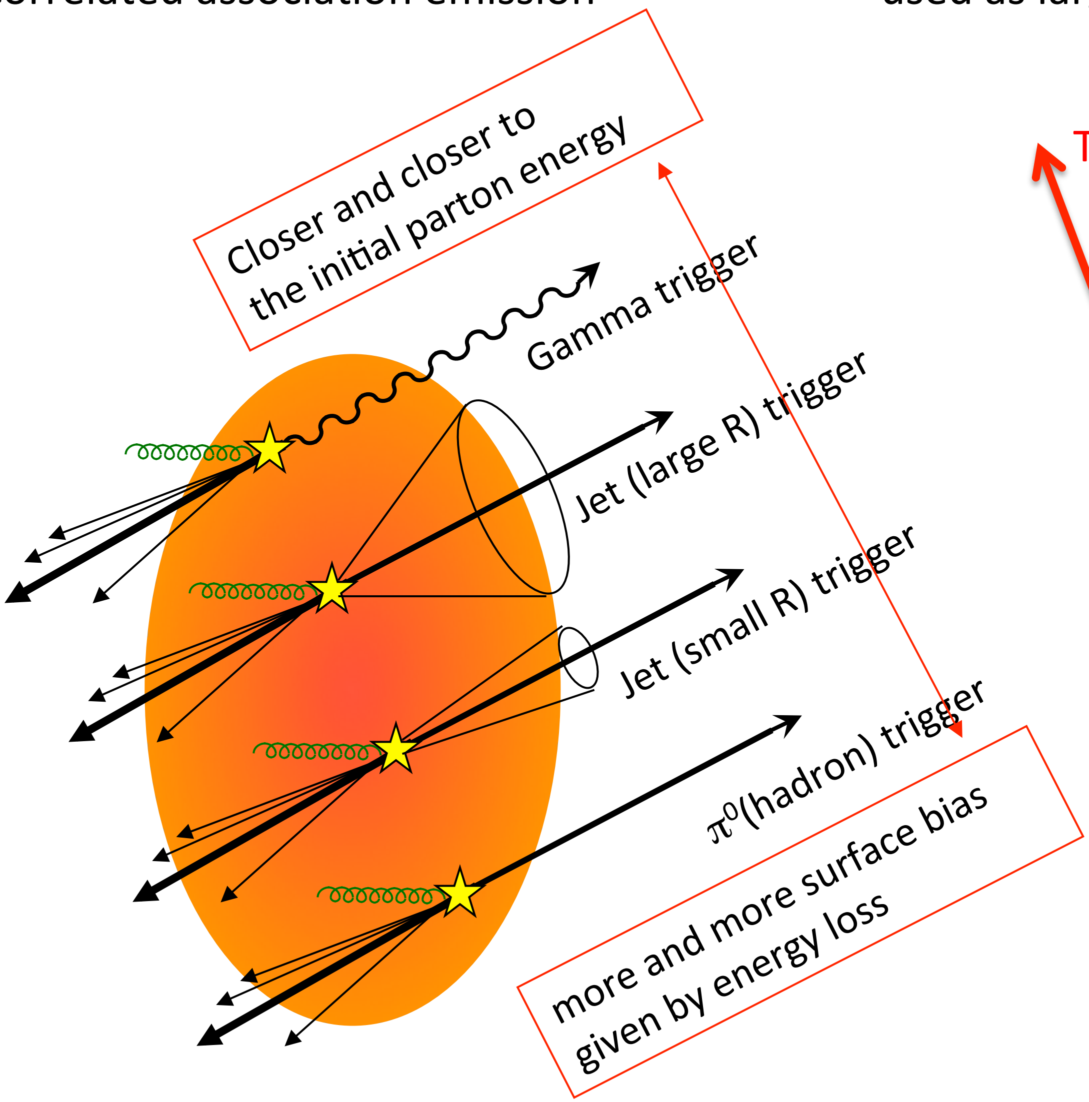
Missing $p_T^{||}$:

$$\not{p}_T^{||} = \sum_{\text{Tracks}} -p_T^{\text{Track}} \cos\left(\phi_{\text{Track}} - \phi_{\text{Leading Jet}}\right)$$

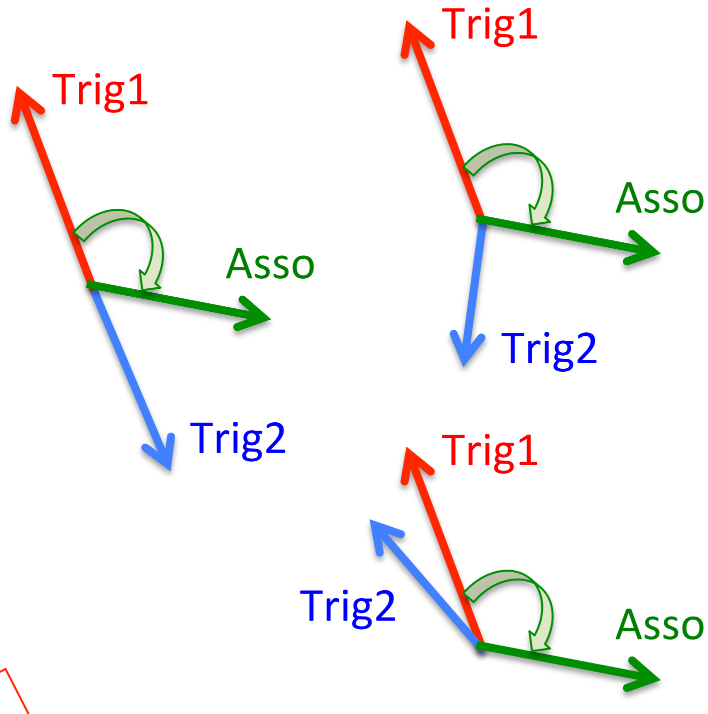




Use photons, Jets, single hadrons as trigger in order to look at correlated association emission



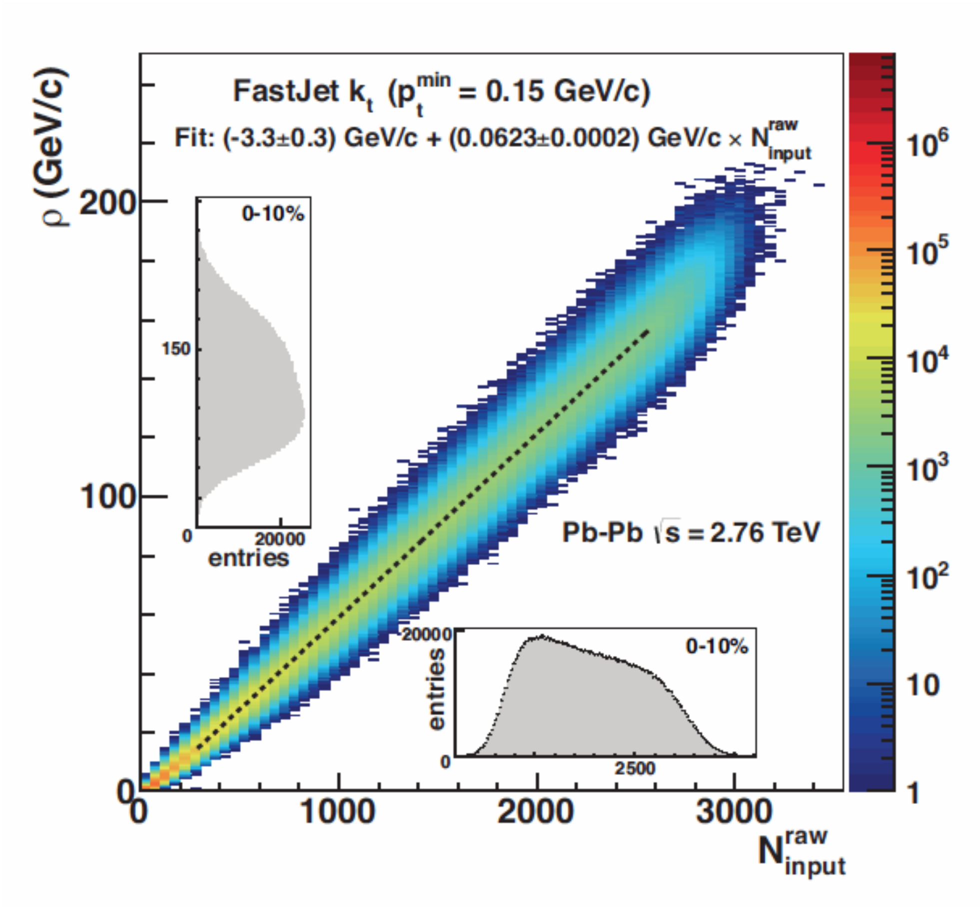
Multi-particle correlation like 2+1 particle correlation analysis (Trig1, Trig2, Asso) can be used as largely modified jet and di-jet signal.

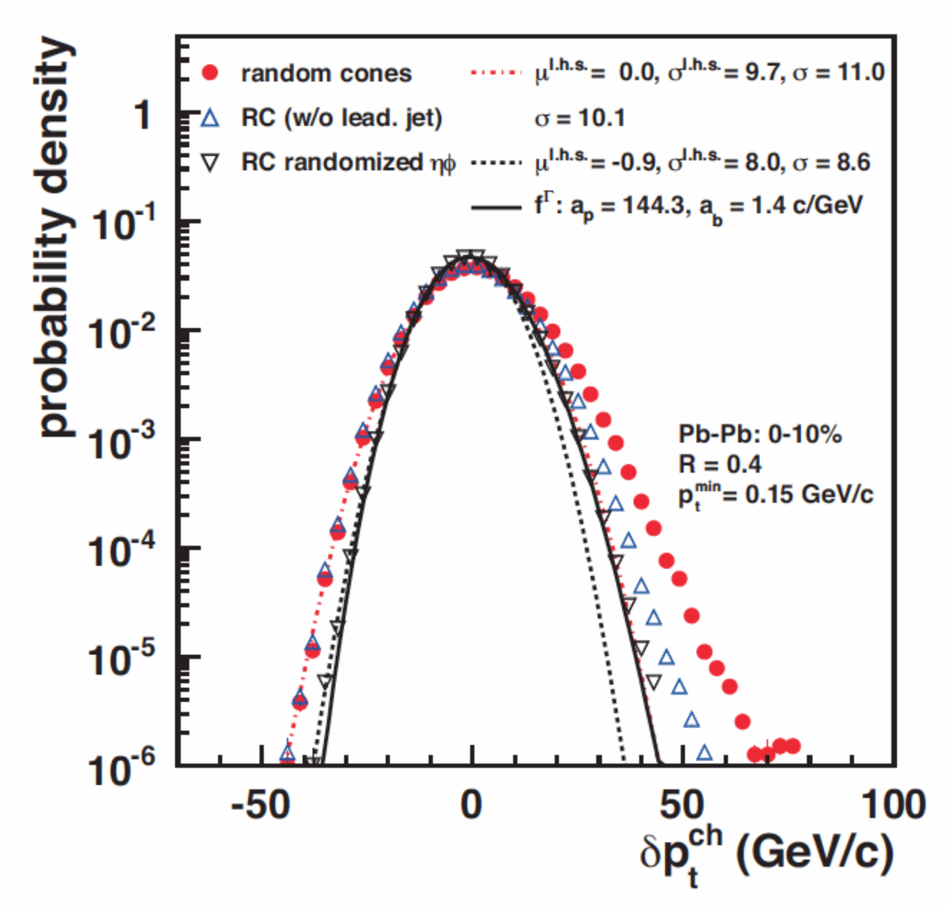


Use “Trig2 relative to Trig1”
as jet trigger condition,
and look at distribution :
“Associate relative to Trig1”
without jet-reconstruction bias

LHC-ALICE, JHEP03 (2012) 053

Background Fluctuation in Jet energy





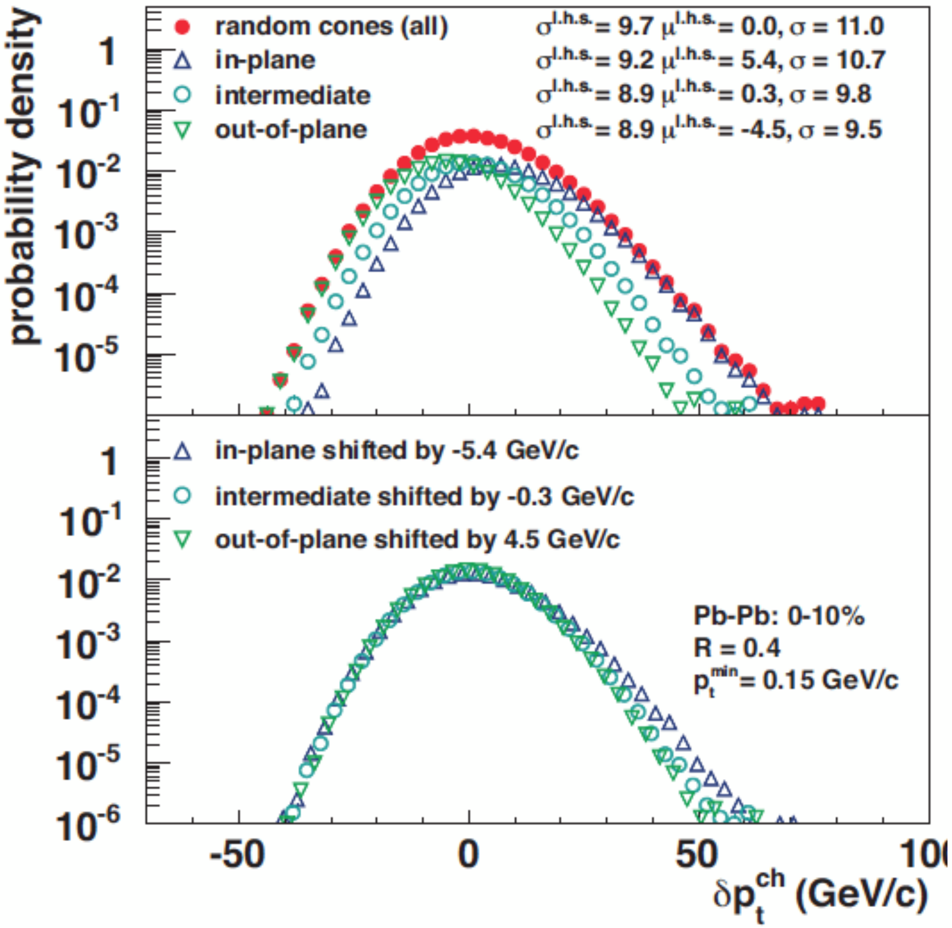
$$p_T^{Jet} = p_T^{rec.\ Jet} - \rho\ Area^{rec.\ Jet}$$

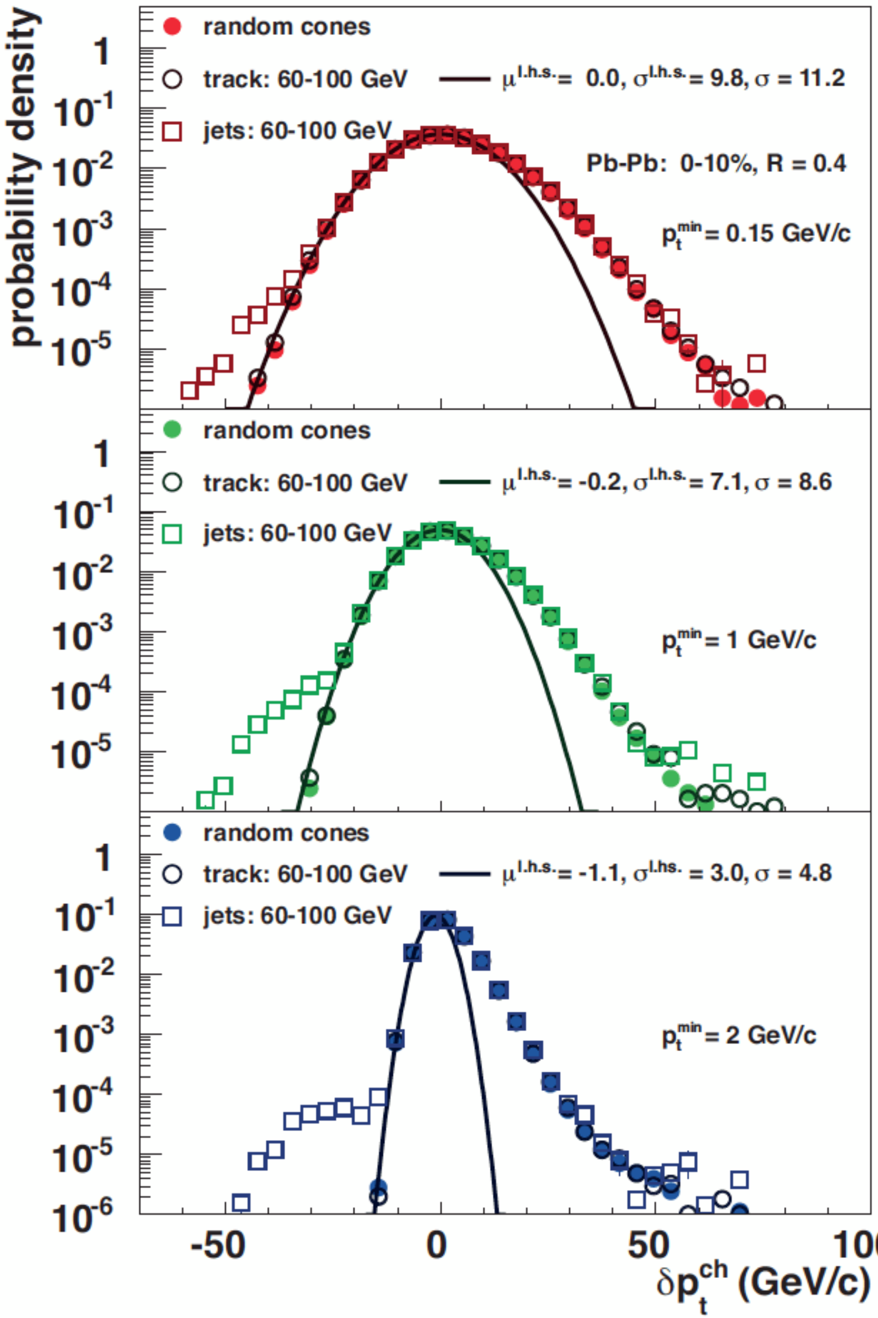
Area(πR^2)~0.5 for R~0.4

$$\delta p_T = \Sigma_{ran.}\ p_T - \rho\ A$$

Event plane and pT threshold effects on
Jet energy determination

LHC-ALICE, JHEP03 (2012) 053





Energy resolution of Jet energy LHC-ATLAS, arXiv : 1208.1967v2

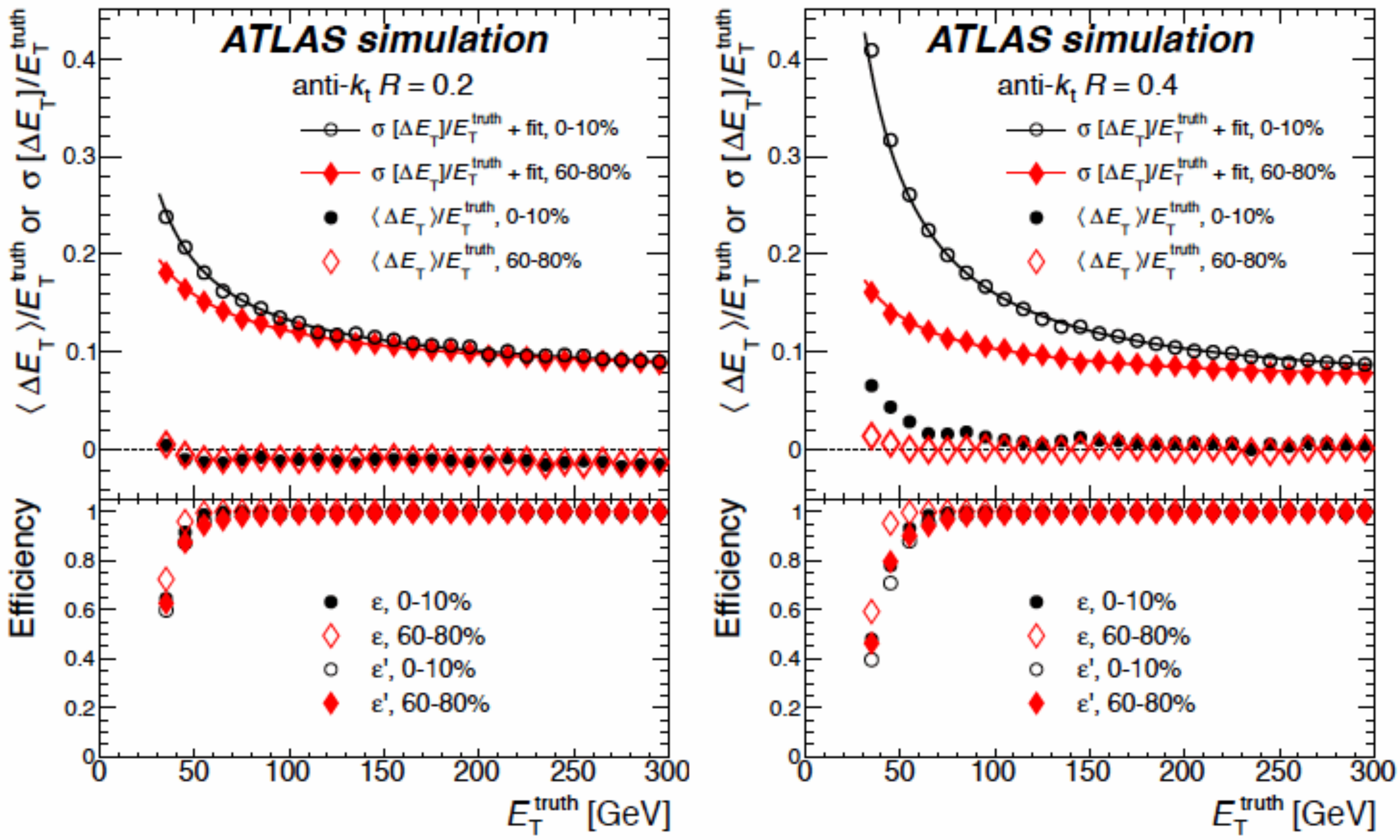


Figure 1: Results of MC evaluation of jet reconstruction performance in 0–10% and 60–80% collisions as a function of truth jet E_T for $R = 0.2$ (left) and $R = 0.4$ (right) jets. Top: jet energy resolution $\sigma[\Delta E_T]/E_T^{truth}$ and jet energy scale closure, $\langle \Delta E_T \rangle / E_T^{truth}$. Solid curves show parameterizations of the JER using Eq. 4. Bottom: Efficiencies, ε and ε', for reconstructing jets before and after application of UE jet removal (see text for explanation), respectively.

Jet cone radius dependence of fluctuation

LHC-ATLAS, arXiv : 1208.1967v2

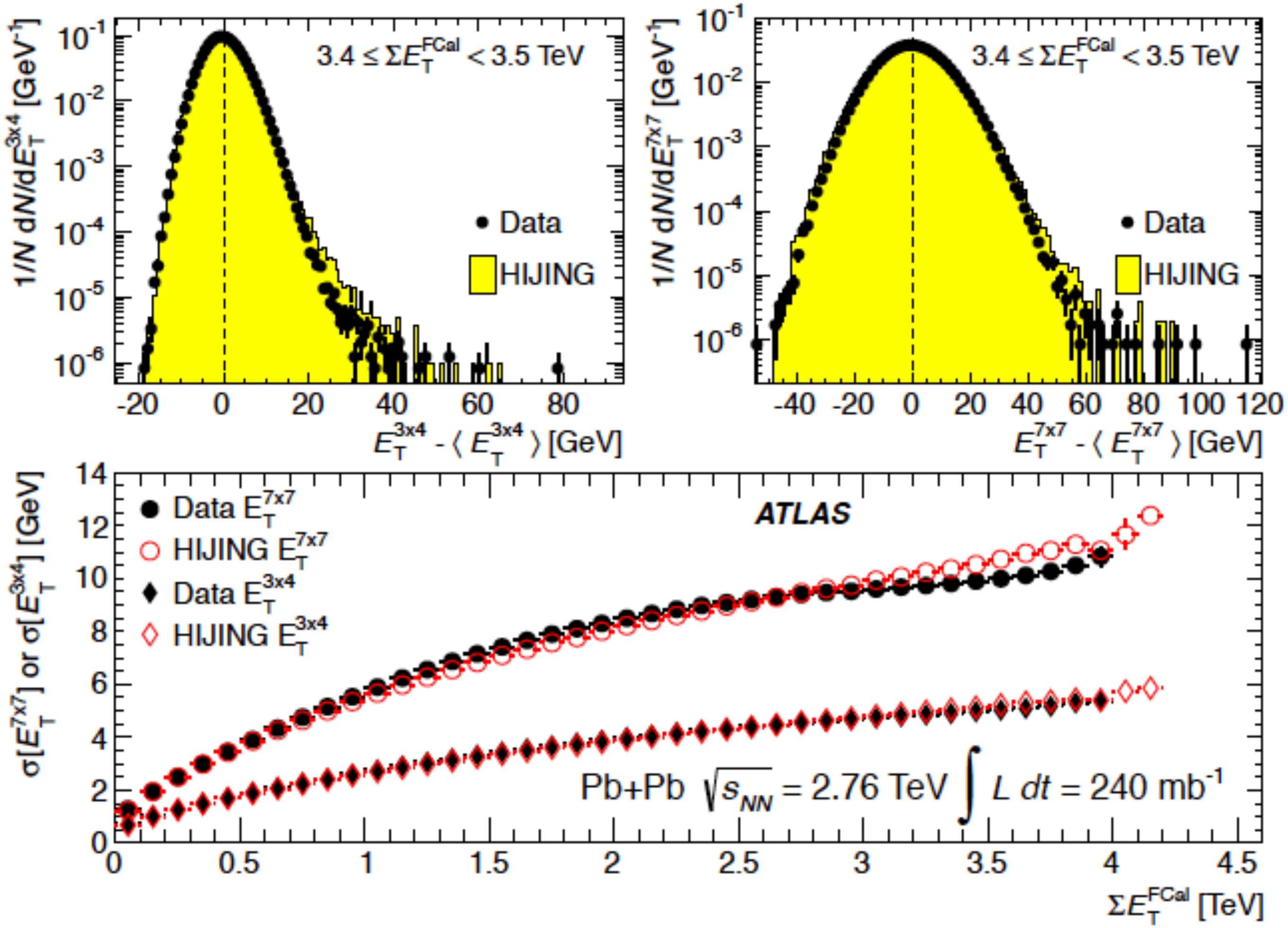


Figure 2: Top: Representative distributions of $E_{\mathrm{T}}^{3\times4} - \langle E_{\mathrm{T}}^{3\times4}\rangle$ (left) and $E_{\mathrm{T}}^{7\times7} - \langle E_{\mathrm{T}}^{7\times7}\rangle$ (right) (see text for definitions) for data (points) and MC (filled histogram) for Pb+Pb collisions with $3.4 \leq \Sigma E_{\mathrm{T}}^{\mathrm{FCal}} < 3.5$ TeV. The vertical lines indicate $E_{\mathrm{T}}^{3\times4} - \langle E_{\mathrm{T}}^{3\times4}\rangle = 0$ and $E_{\mathrm{T}}^{7\times7} - \langle E_{\mathrm{T}}^{7\times7}\rangle = 0$. Bottom: Standard deviations of the $E_{\mathrm{T}}^{3\times4}$ and $E_{\mathrm{T}}^{7\times7}$ distributions, $\sigma[E_{\mathrm{T}}^{3\times4}]$ and $\sigma[E_{\mathrm{T}}^{7\times7}]$, respectively, in data and HIJING MC sample as a function of $\Sigma E_{\mathrm{T}}^{\mathrm{FCal}}$.

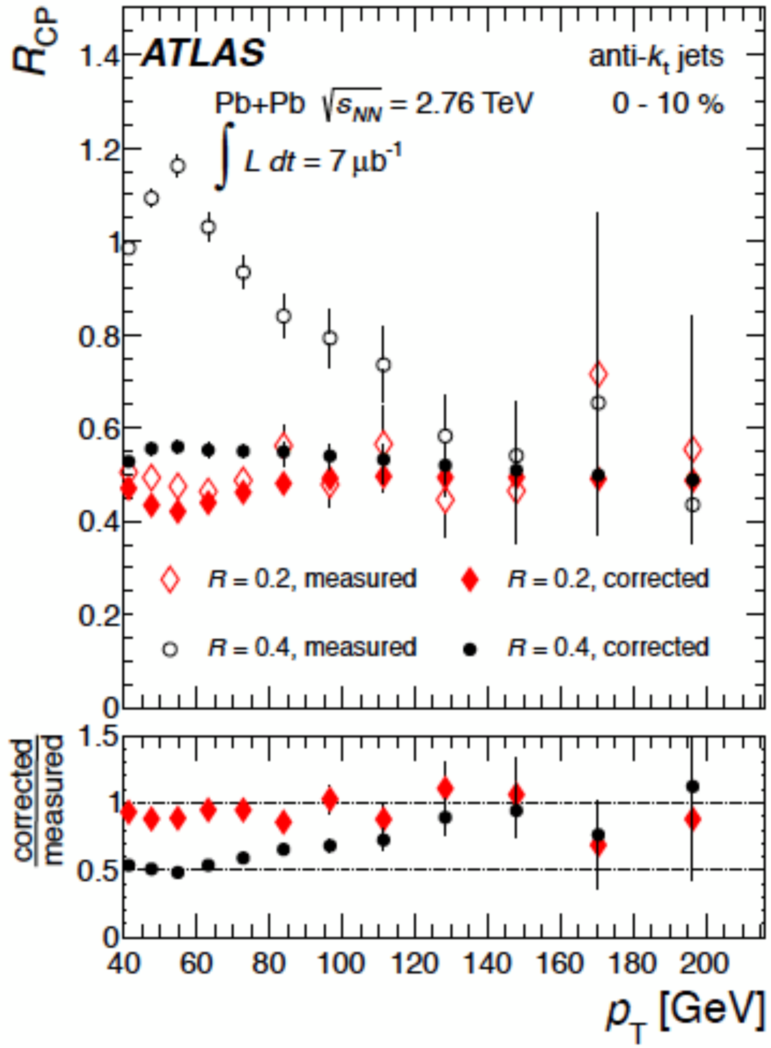


Figure 3: Top: Measured and corrected R_{CP} values for the 0–10% centrality bin as a function of jet p_T for $R = 0.4$ and $R = 0.2$ jets. Bottom: Ratio of corrected to measured R_{CP} values for both jet radii. The error bars on the points represent statistical uncertainties only.

LHC-ATLAS, arXiv : 1208.1967v2

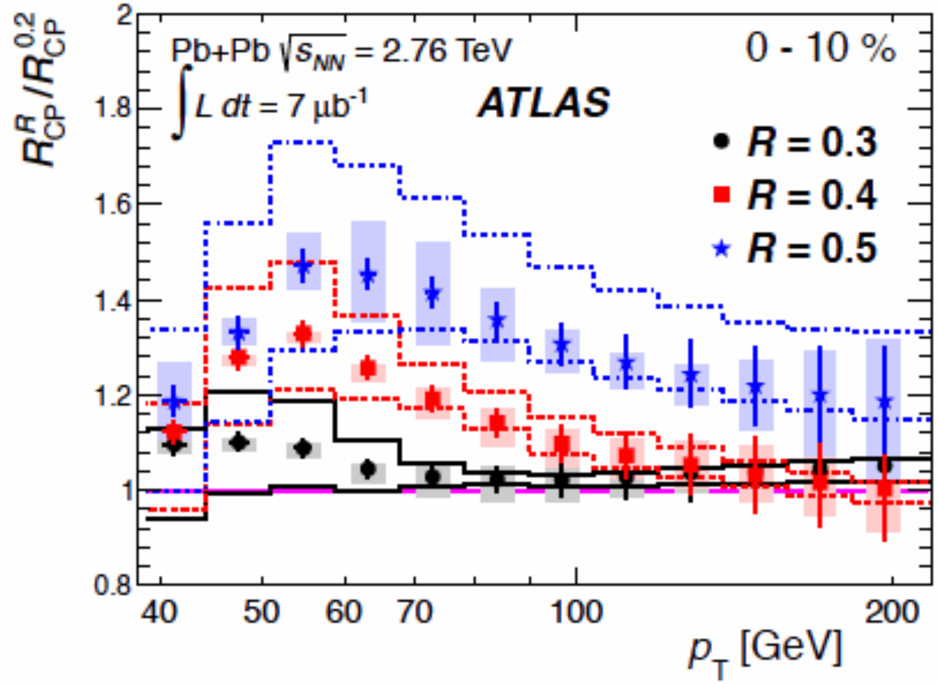
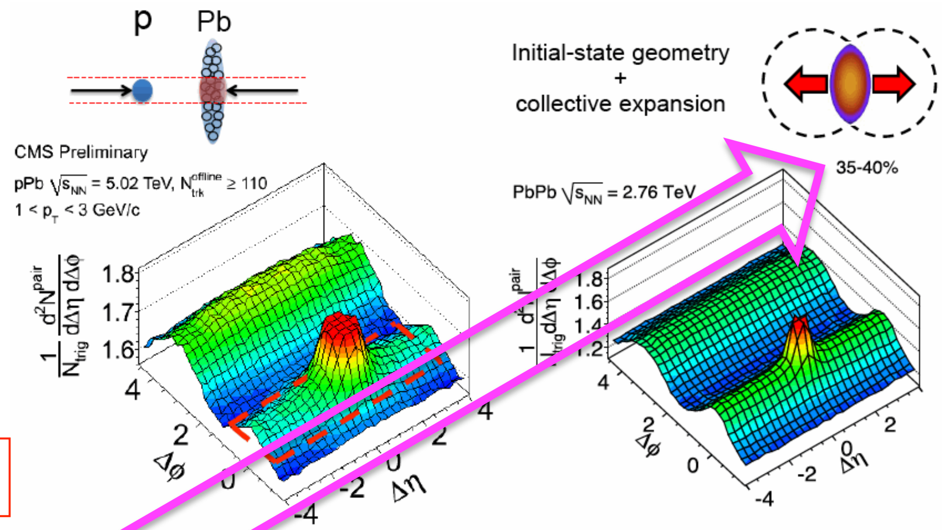


Figure 8: Ratios of R_{CP} values between $R = 0.3, 0.4$ and 0.5 jets and $R = 0.2$ jets as a function of p_T in the 0–10% centrality bin. The error bars show statistical uncertainties (see text). The shaded boxes indicate partially correlated systematic errors. The lines indicate systematic errors that are fully correlated between different p_T bins.

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

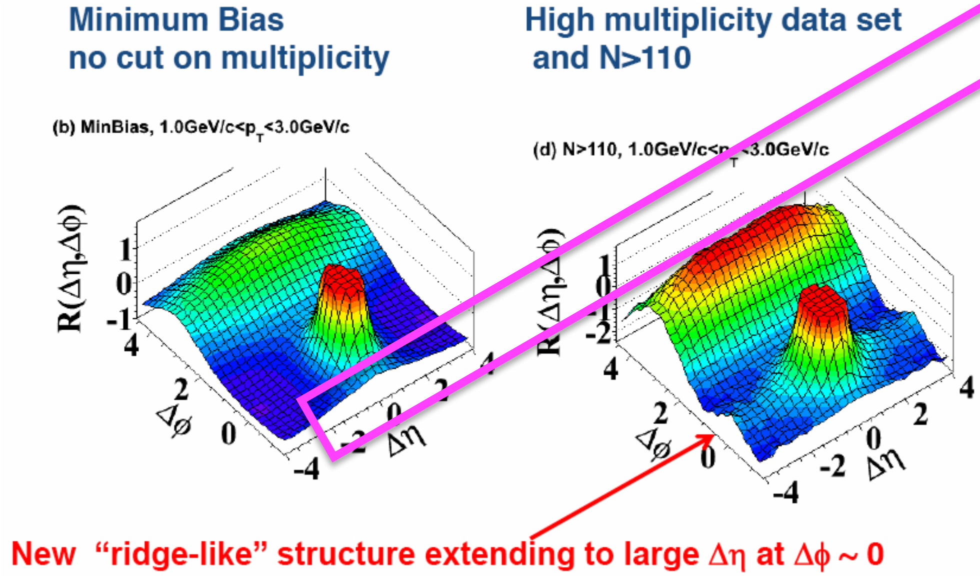
High mult. p+A

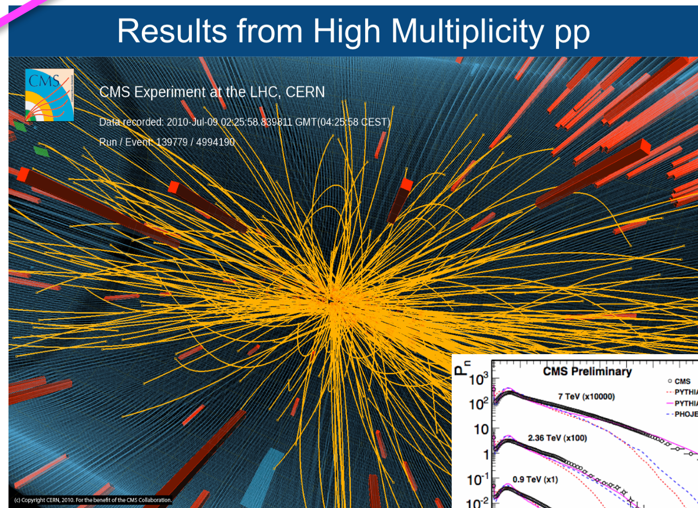
A+A

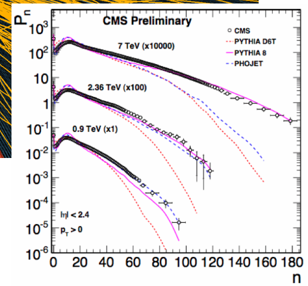


Min. bias p+p

High mult. p+p







2 particle correlation w.r.t. collision geometry and expansion

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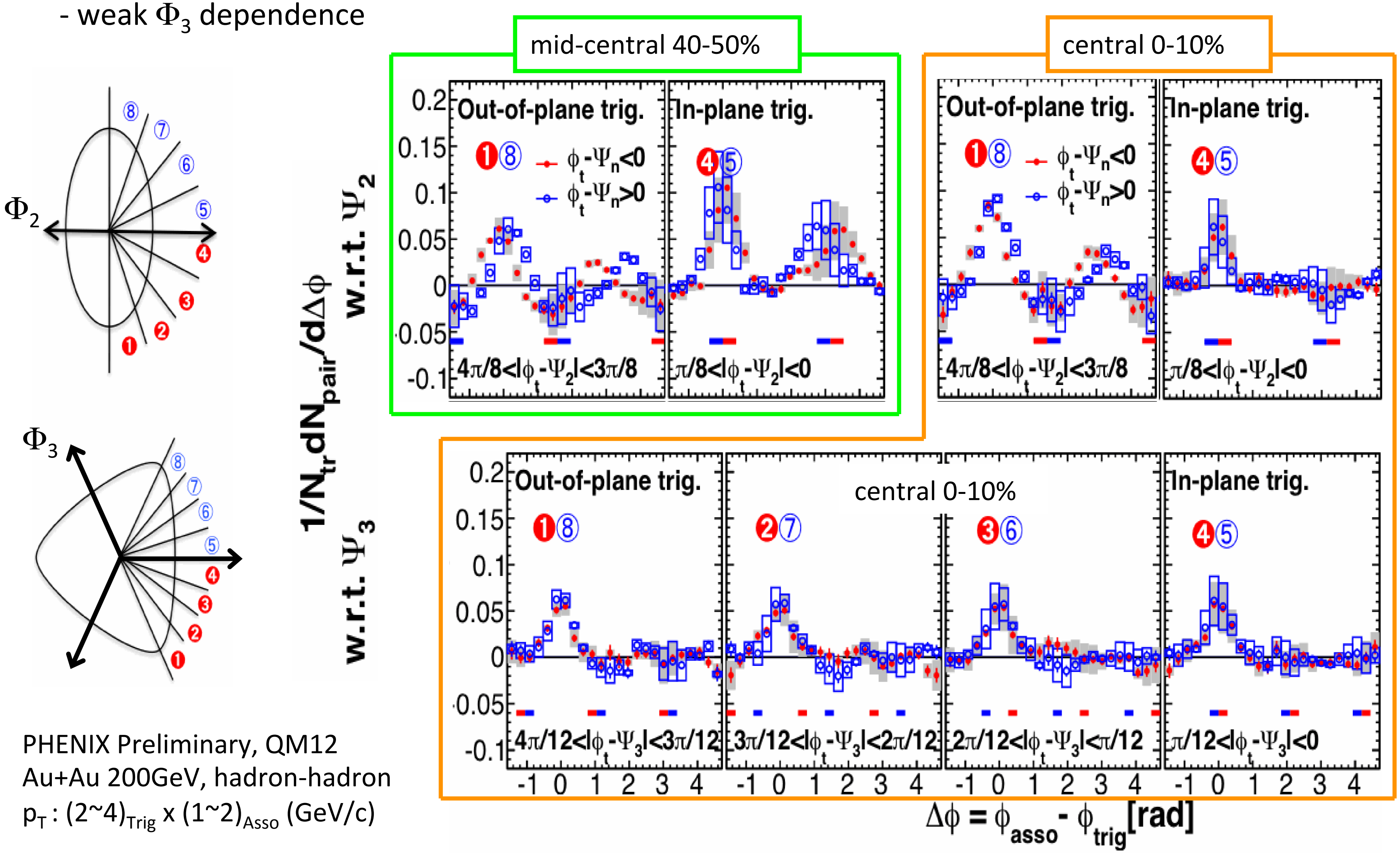
- strong Φ_2 dependence and left/right asymmetry (coupled with energy loss and flow)
- broad out-of-plane correlation enhanced more in central (redistribution and expansion)
- weak Φ_3 dependence



PHENIX Preliminary, QM12
Au+Au 200GeV, hadron-hadron
p_T : $(2\sim4)_{Trig}$ x $(1\sim2)_{Asso}$ (GeV/c)

QM09: J. Konzer

STAR Preliminary

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

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

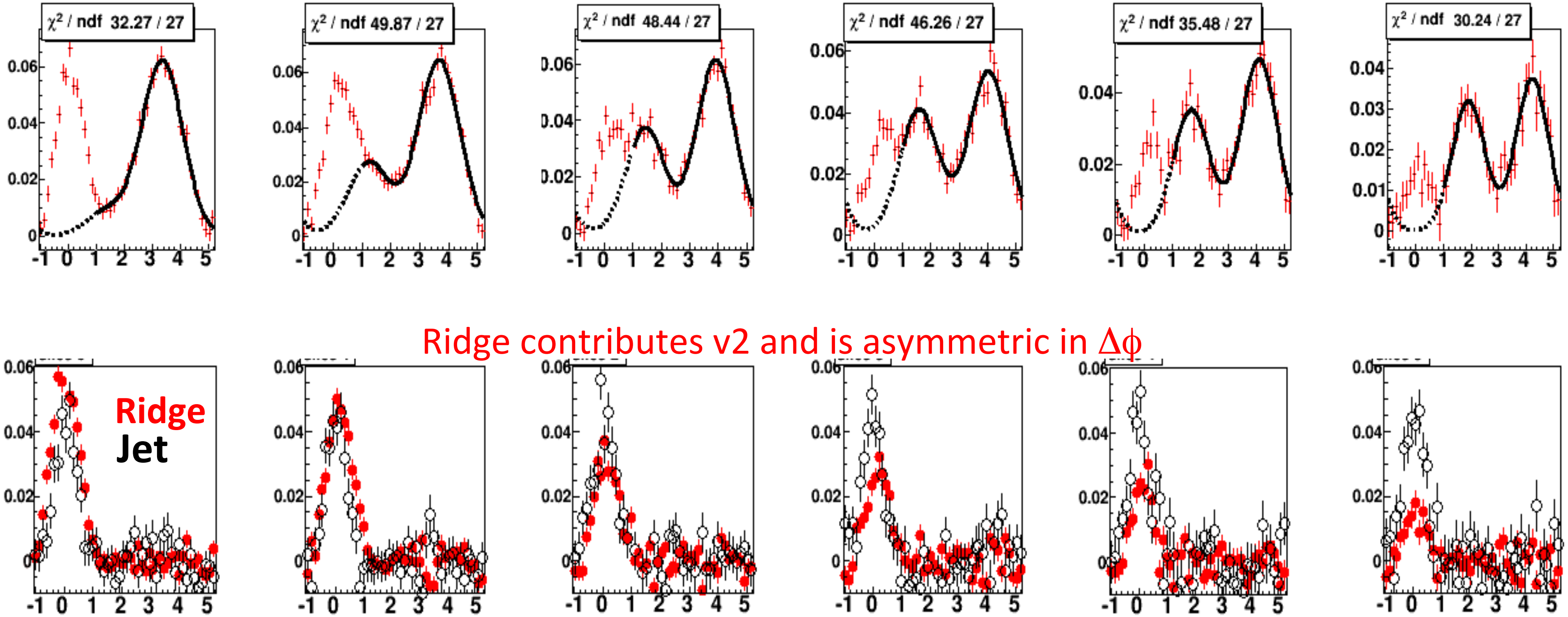
Au+Au 20-60%

$3<p_T^{Trig}<4$ GeV/c

$1<p_T^{Assoc}<1.5$ GeV/c

|Δη|>0.7

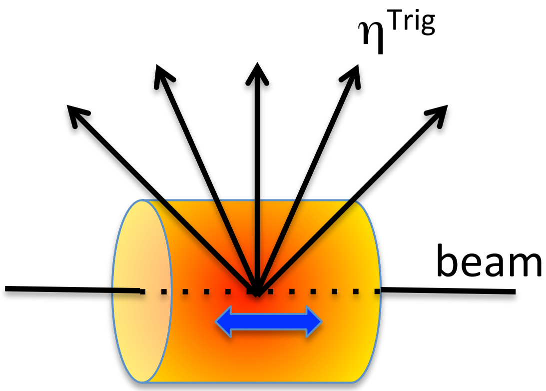
ϕ_S~0 → ϕ_S~90



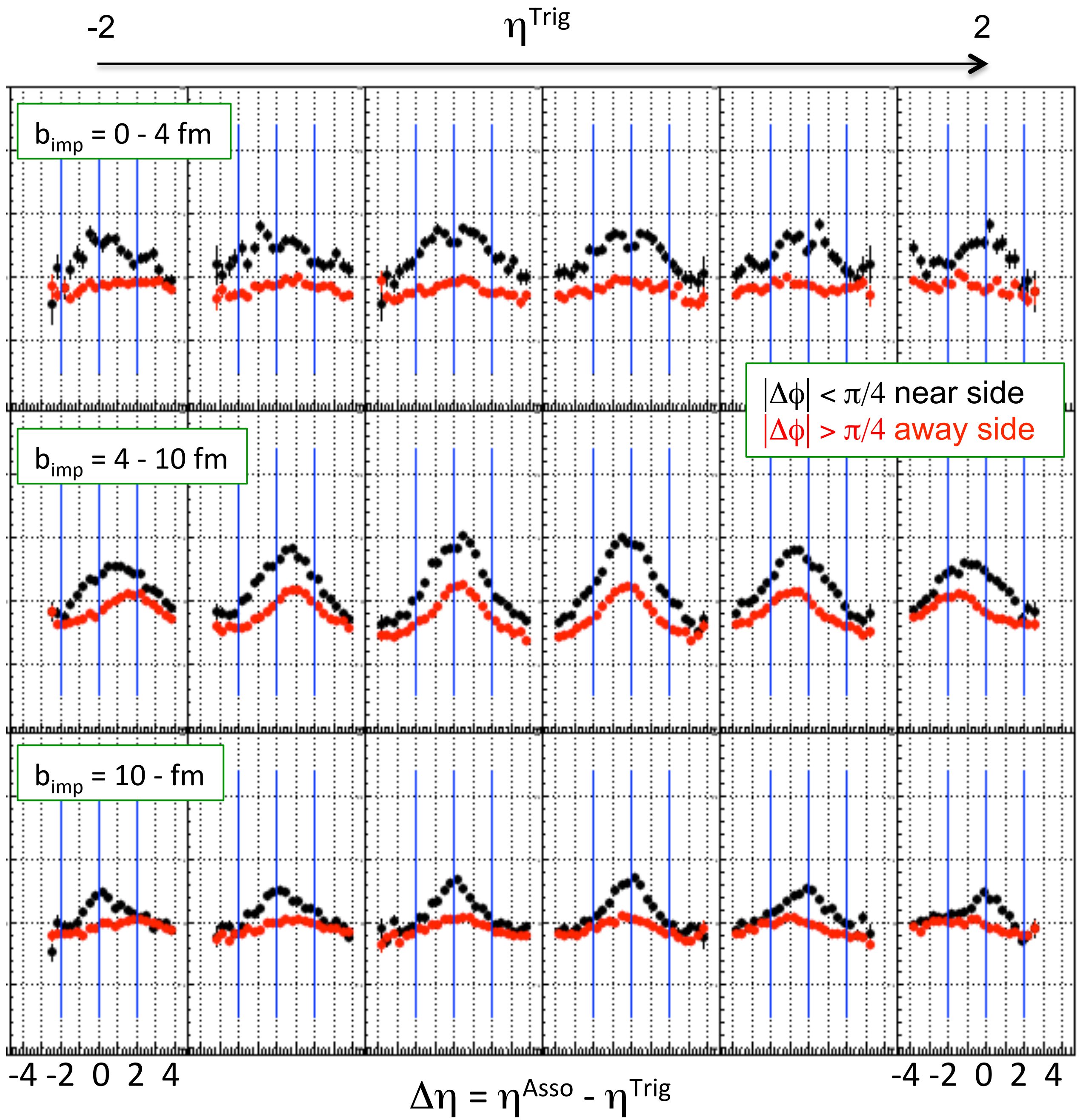
Ridge contributes v2 and is asymmetric in Δφ

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

Associate yield per trigger with AMPT simulation



Look at asymmetry in $\Delta\eta = \eta^{Asso} - \eta^{Trig}$ associate η distribution with respect to trigger η



Summary

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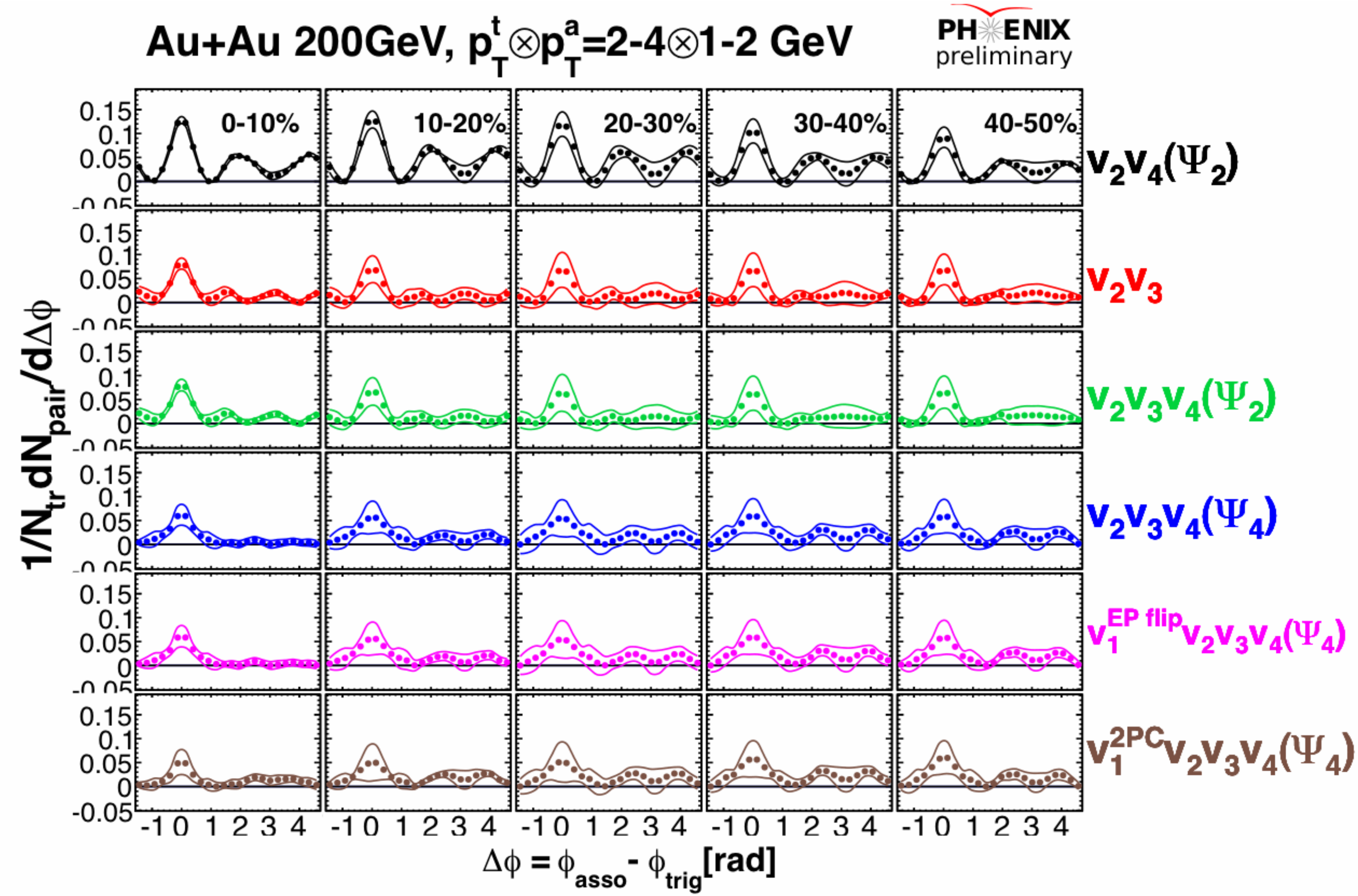
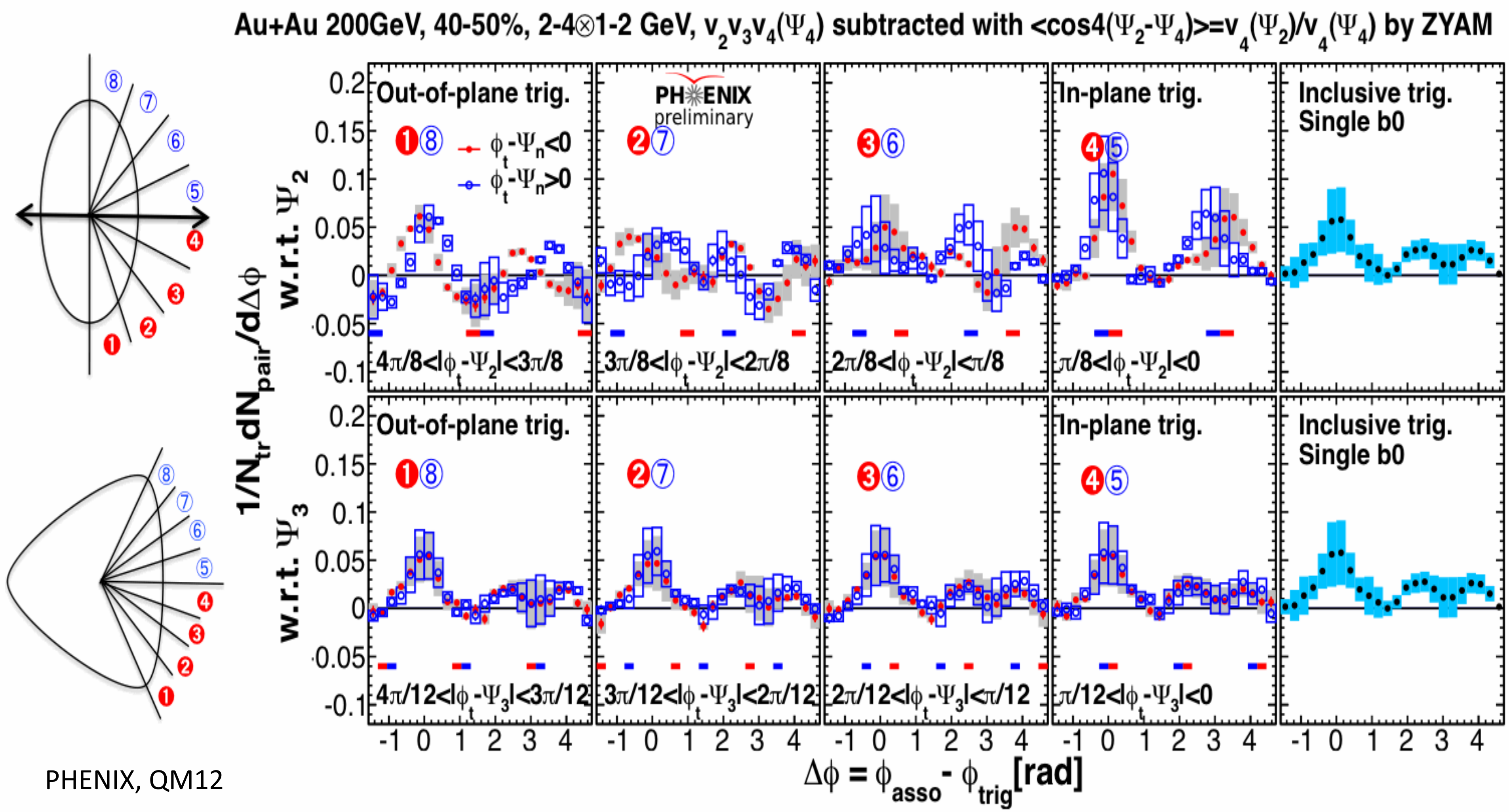
Energy loss and jet quenching
Small but high multiplicity system
Interplay between soft and hard
relation to collective event anisotropy


Au+Au 200GeV, p_T^t⊗p_T^a=2-4⊗1-2 GeV
PHENIX preliminary
0-10%
10-20%
20-30%
30-40%
40-50%
v2v4(Ψ2)
v2v3
v2v3v4(Ψ2)
v2v3v4(Ψ4)
v1^EP flip v2v3v4(Ψ4)
v1^2PC v2v3v4(Ψ4)
1/N_tr dN_pair/dΔφ
Δφ = φ_asso - φ_trig [rad]
0.15
0.1
0.05
0
-0.05
-1 0 1 2 3 4

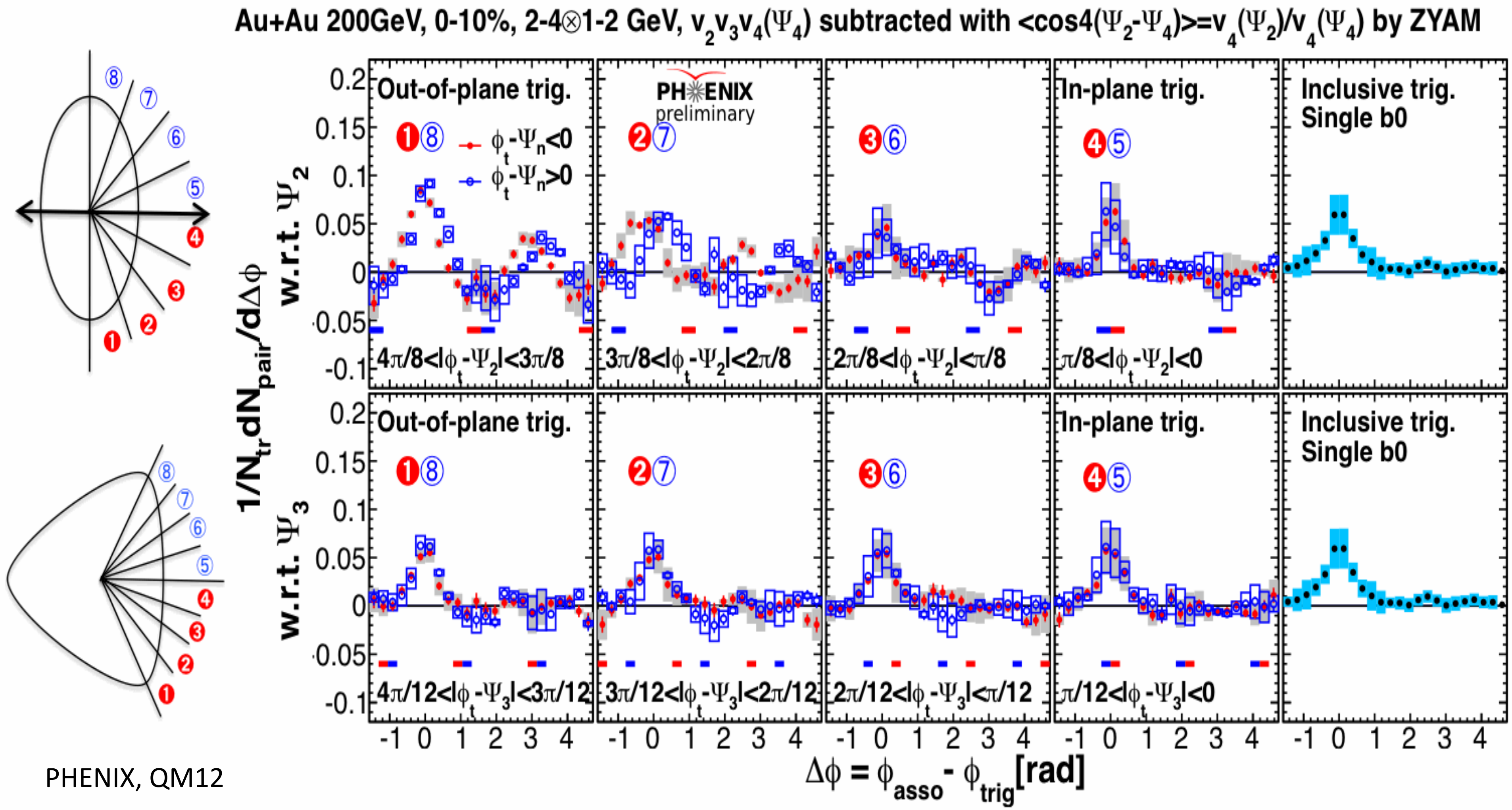
Correlations relative to Ψ_2 & Ψ_3, 40-50%



PHENIX, QM12

mid-central collisions	- strong Φ_2 dependence and left/right asymmetry coupling with geometry and/or expansion - almost no Φ_3 dependence (poor Φ_3 resolution)

Correlations relative to Ψ_2 & Ψ_3, 0-10%



PHENIX, QM12

central collisions

- out-of-plane correlation enhanced
  (strong jet quenching and collective expansion)
- some weak Φ_3 dependence

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