Interplay of correlations & fluctuations at RHIC — What do we learn?

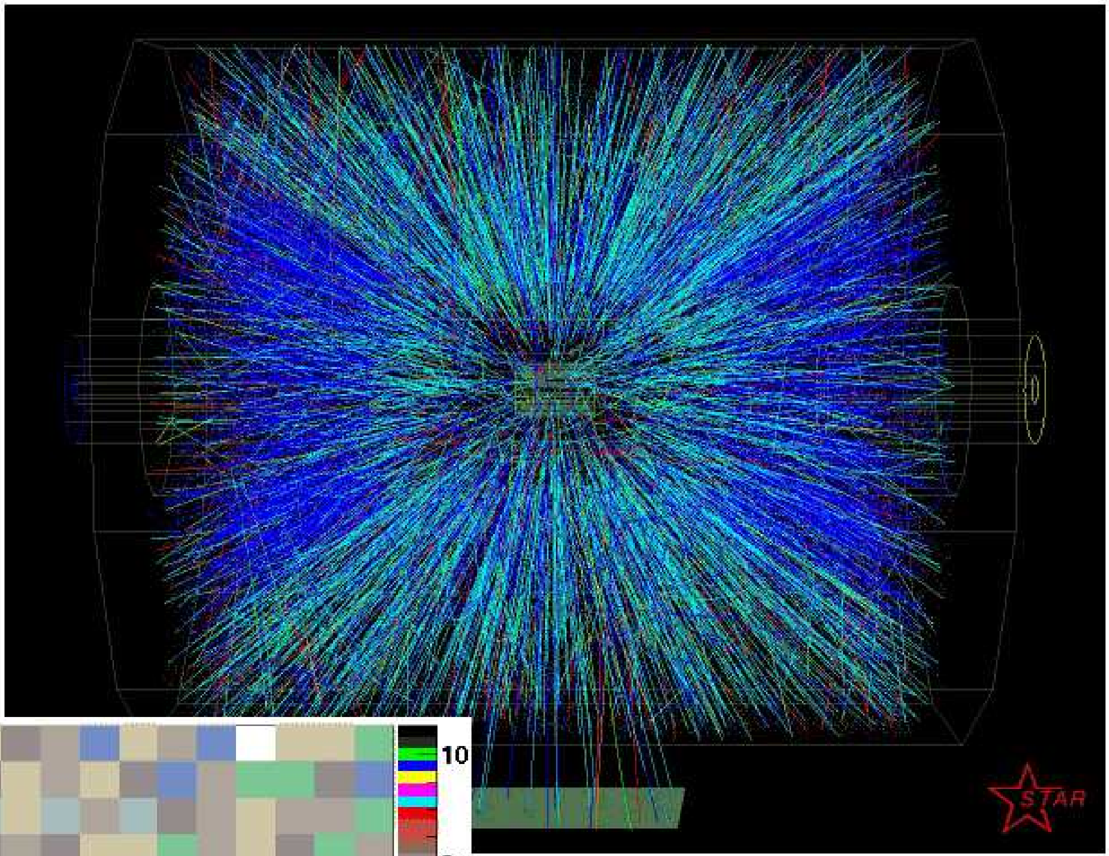
Mikhail Kopytine (Kent State University)

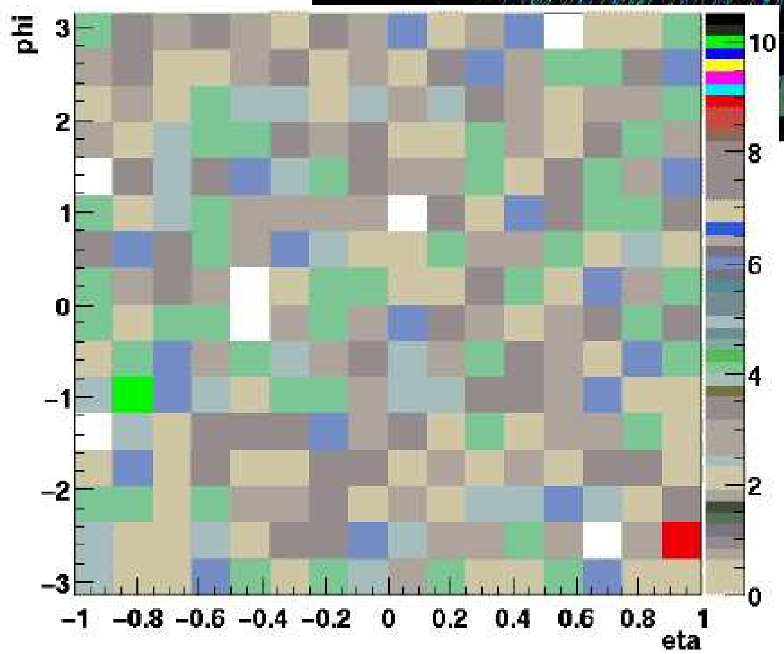
for the STAR Collaboration

Argonne National Laboratory – USA, Brookhaven National Laboratory – USA, U. of Birmingham – UK, U. of California, Berkeley – USA, U. of California, Davis – USA, U. of California, Los Angeles – USA, Carnegie Mellon U. – USA, Creighton U. – USA, Laboratory for High Energy, JINR – Russia, Particle Physics Laboratory, JINR – Russia, U. of Frankfurt – Germany, Indiana U. – USA, Institute de Recherches Subatomiques – France, Kent State U. – USA, Lawrence Berkeley National Laboratory – USA, Max-Plank-Institute für Physik – Germany, Michigan State U. – USA, Moscow Engineering Physics Institute – Russia, City College of New York – USA, Ohio State U. – USA, Pennsylvania State U. – USA, Institute of High Energy Physics – Russia, Purdue U. – USA, Rice U. – USA, Universidade de Sao Paolo – Brazil, SUBATECH – France, Texas A & M – USA, U. of Texas – USA, Warsaw U. of Technology – Poland, U. of Washington – USA, Wayne State U. – USA, Institute of Particle Physics – China, and Yale U. – USA

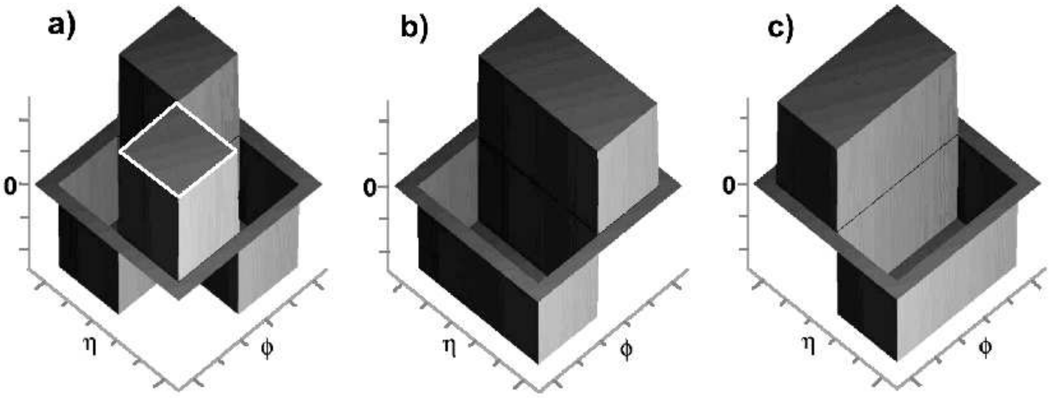
Correlations & fluctuations... how to learn anything?

- Discrete Wavelet Transform $\Rightarrow$ power spectra of local track density fluctuations
- 'thermal' reference = mixed events
- How does the medium change with initial conditions ? In this language:
  - thermalization: reality $\rightarrow$ reference
  - correlation: reality $<$ reference
  - fluctuation: reality $>$ reference (e.g. jets)




phi
eta
3
2
1
0
−1
−2
−3
−1
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
0.8
1
10
8
6
4
2
0

$F^{\lambda}_{m,i,j}(\phi,\eta)$–Haar wavelet basis in 2D:



scale fineness (m), directional modes of sensitivity (λ), track density $\rho(\eta,\phi,p_T)$.

Basic observables:

Power of local fluctuations, mode λ:

$$P^{\lambda}(m) = \frac{1}{2^{2m}} \sum_{i,j} \langle \rho, F^{\lambda}_{m,i,j} \rangle^2, \quad (1)$$

Dynamic texture:

$$P^{\lambda}(m)_{true} - P^{\lambda}(m)_{mix} \quad (2)$$

"incoherently" normalized:

$$(P^{\lambda}(m)_{true} - P^{\lambda}(m)_{mix})/P^{\lambda}(m)_{mix} \quad (3)$$

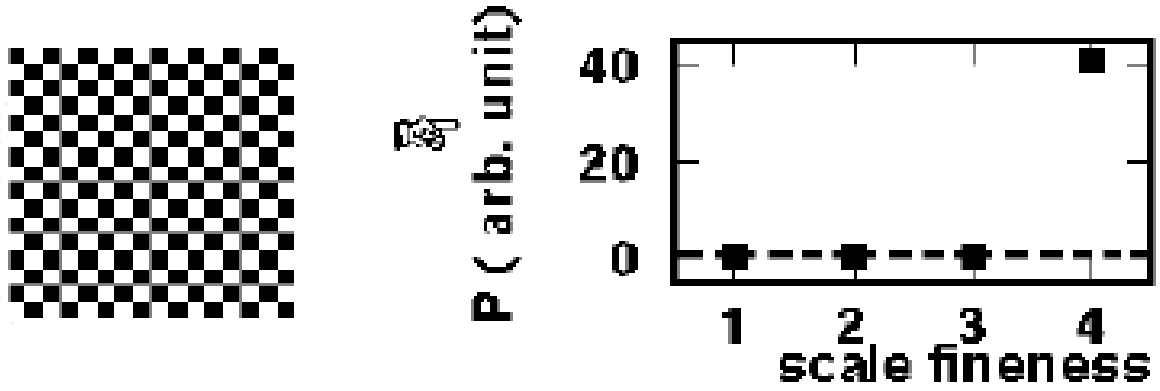
"coherently" normalized:

$$(P^{\lambda}(m)_{true} - P^{\lambda}(m)_{mix})/P^{\lambda}(m)_{mix}/N, \quad (4)$$

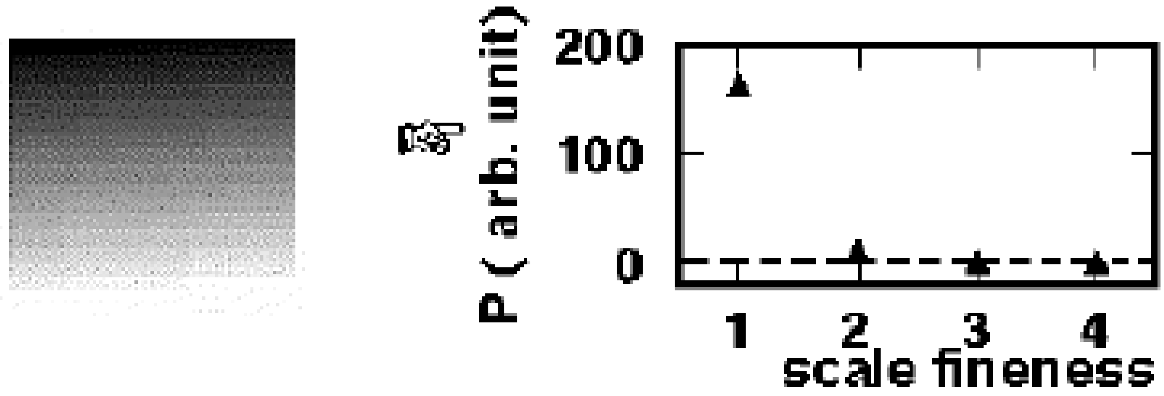
where N is (sub)event (p_T bin) multiplicity

Scale is localized:

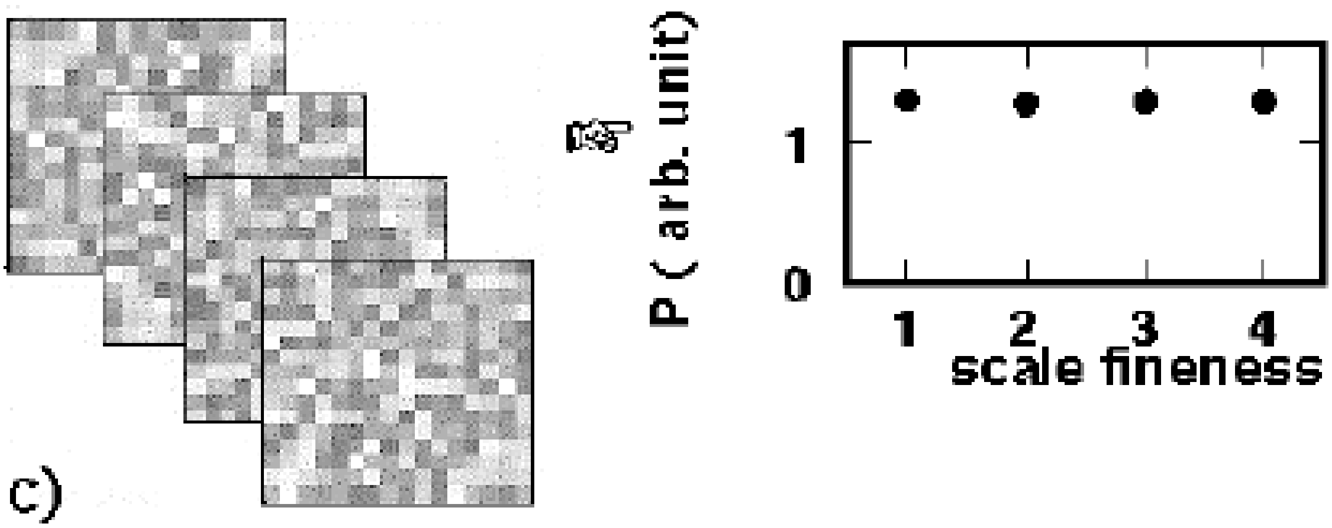
a)

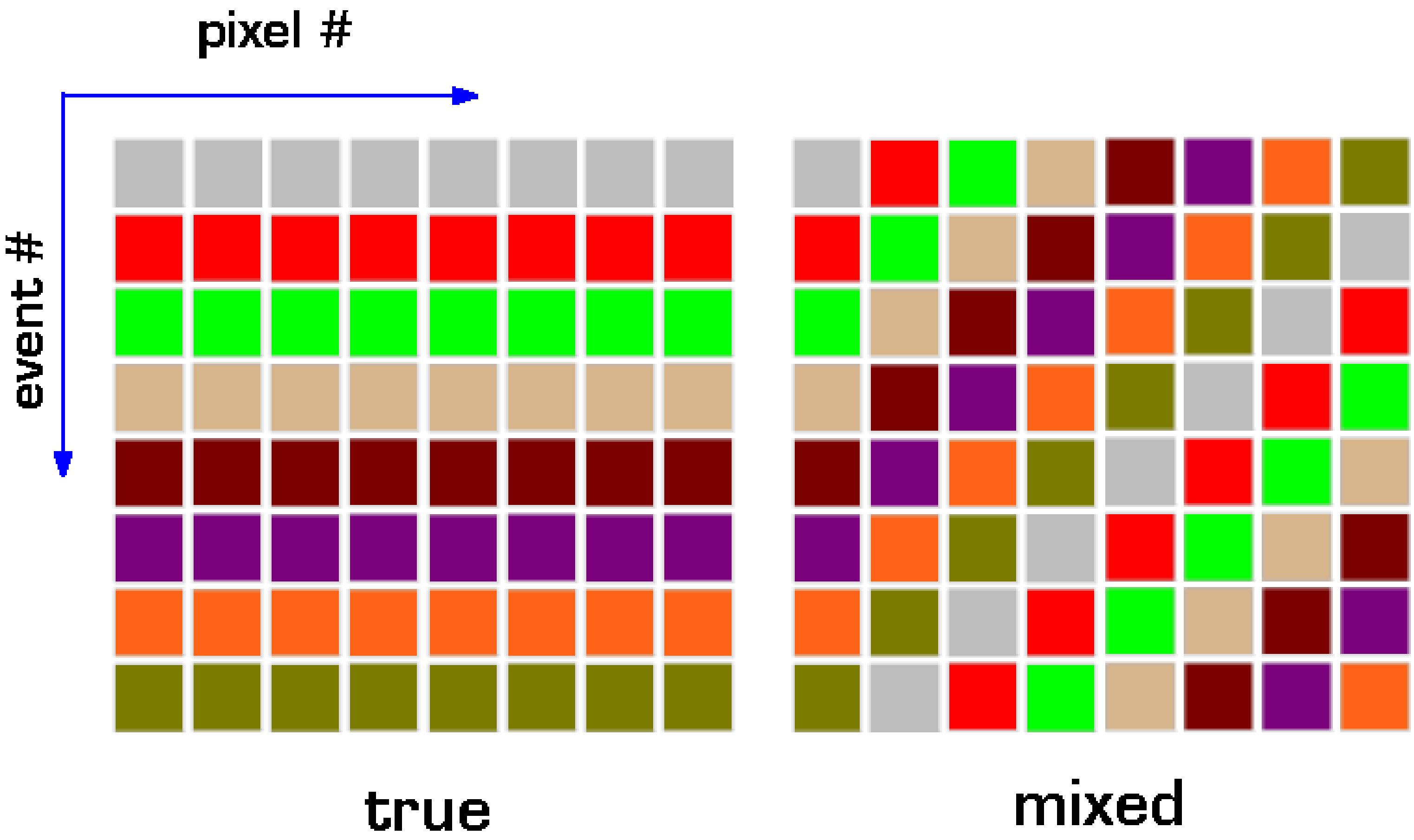


b)



c)





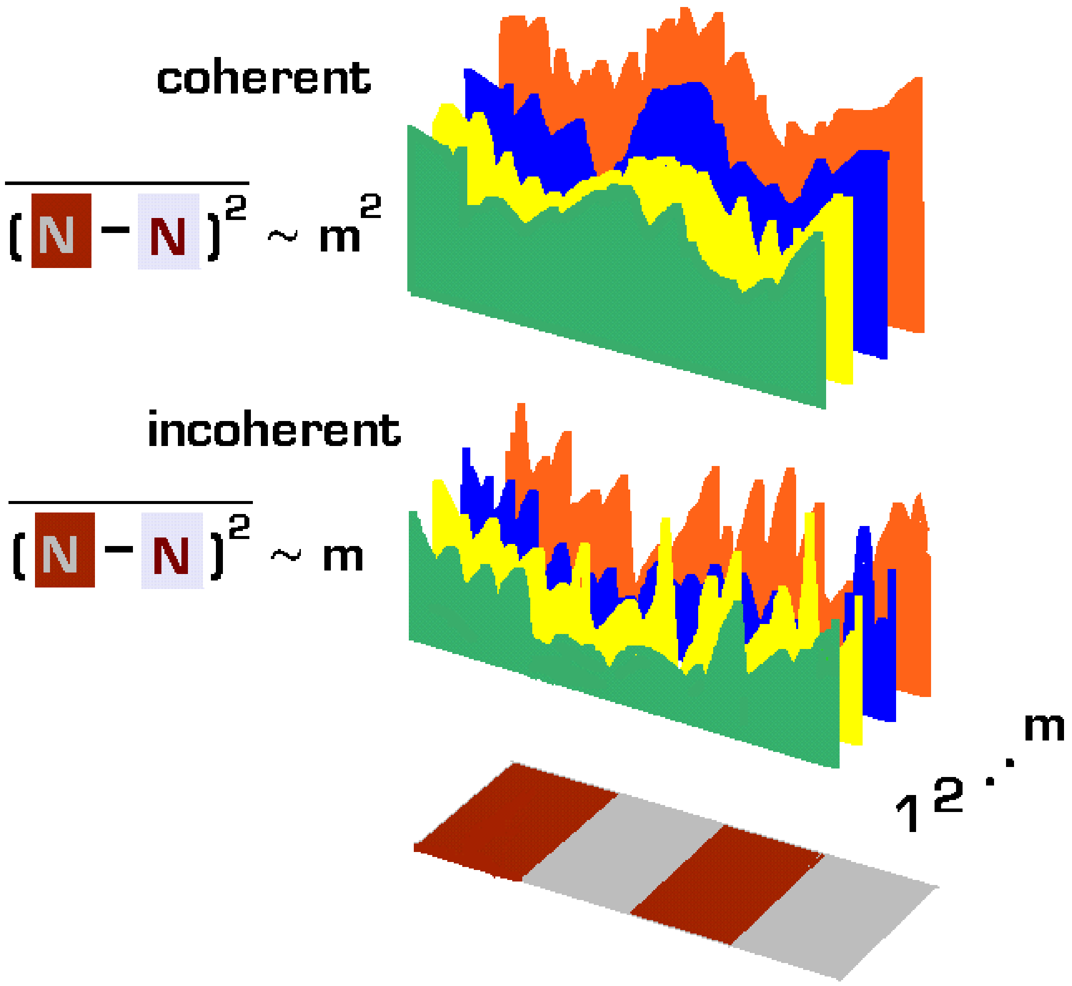
Event mixing scheme:

– no pixel is used twice

– not more than one pixel from any given true event per mixed event

– no mixing of "different" events: multiplicity, vertex

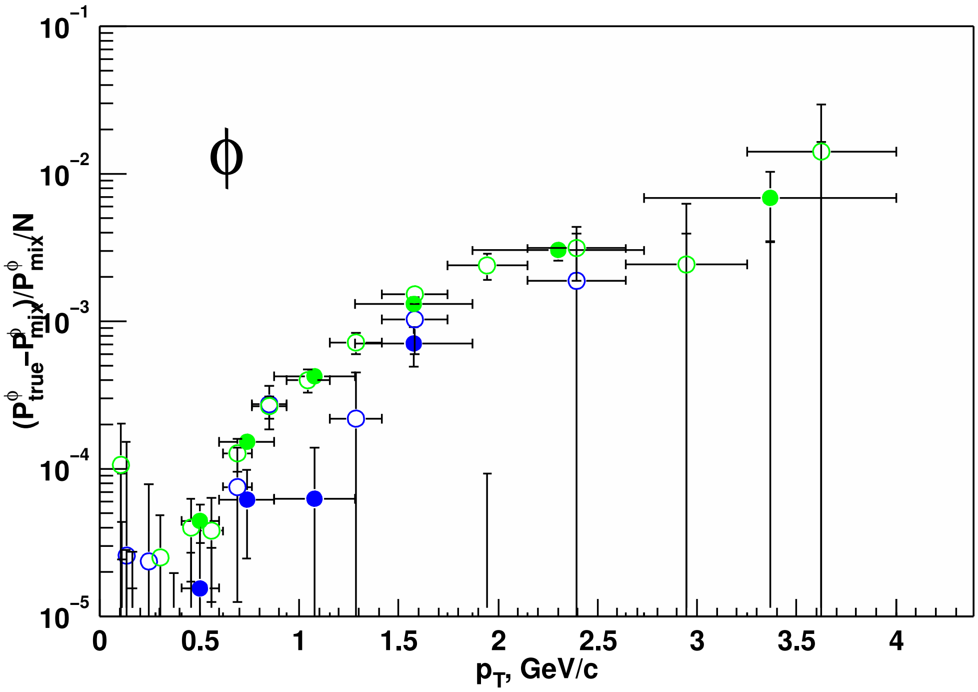
With n pixels, need $\geq n^2$ events per event class.



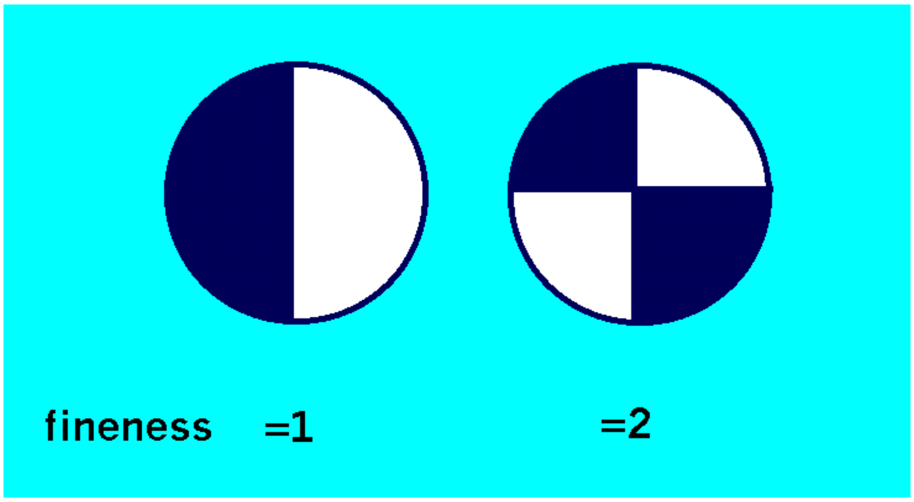
Proper **normalization** ⇒ results independent of bin size or subevent multiplicity.

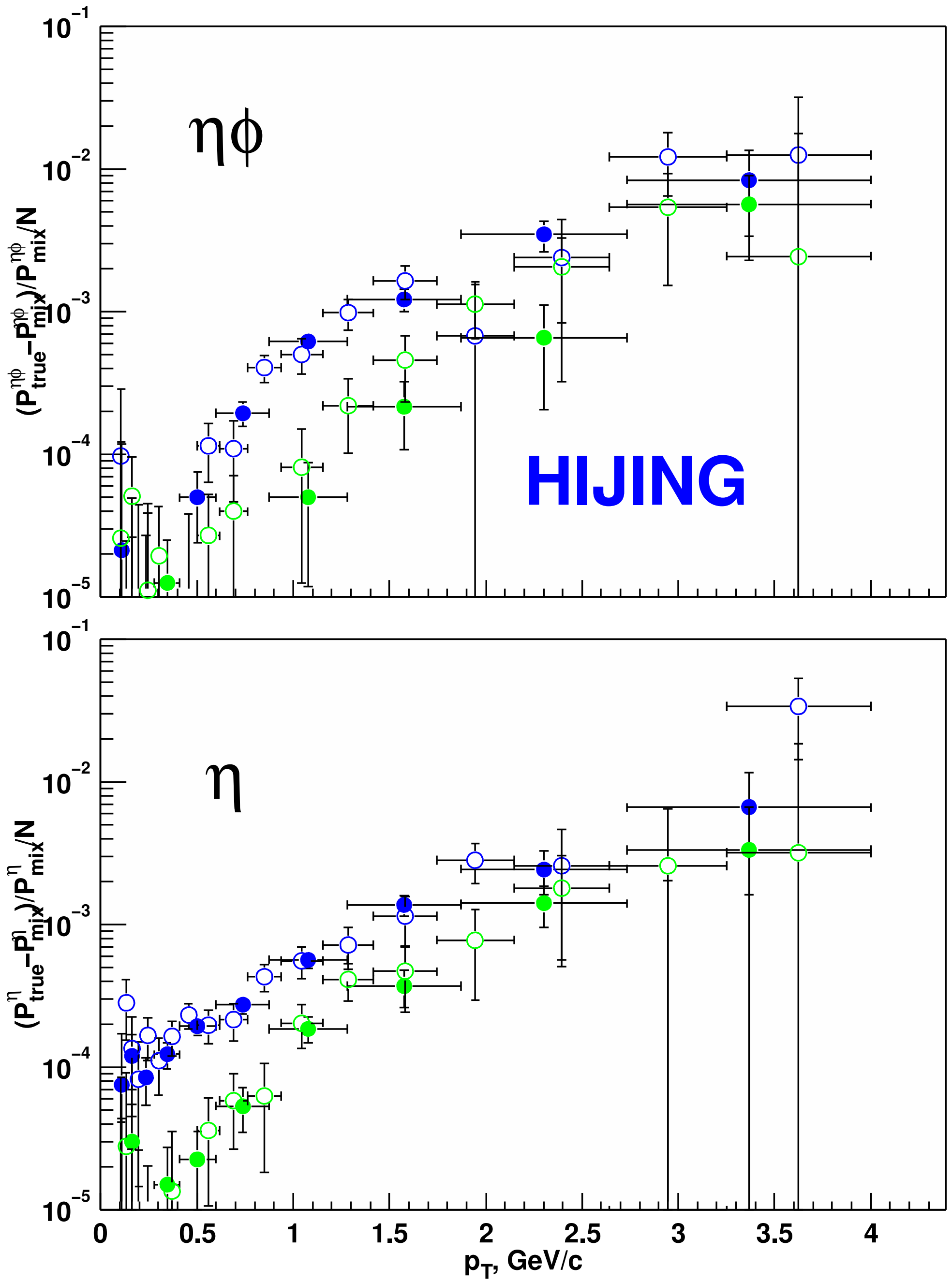
Coherent: $(P^{\lambda}(m)_{true} - P^{\lambda}(m)_{mix})/P^{\lambda}(m)_{mix}/N$,

Incoherent: $(P^{\lambda}(m)_{true} - P^{\lambda}(m)_{mix})/P^{\lambda}(m)_{mix}$

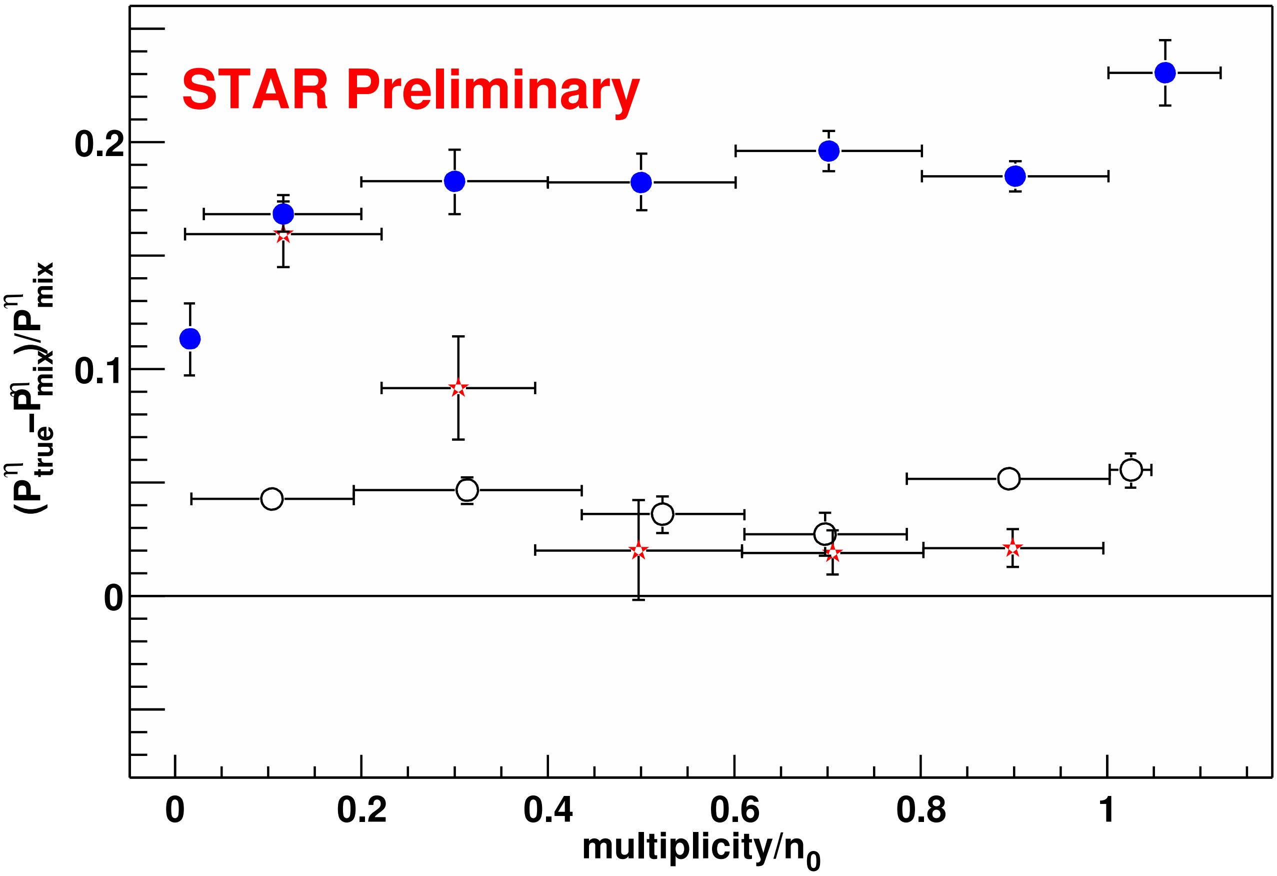


HIJING – azimuthal back to back ($\delta\phi = \pi/2$) correlations (scale $\delta\phi = \pi/2$ is enhanced!). ●, ○, $\delta\phi = \pi$; ●, ○, $\delta\phi = \pi/2$.

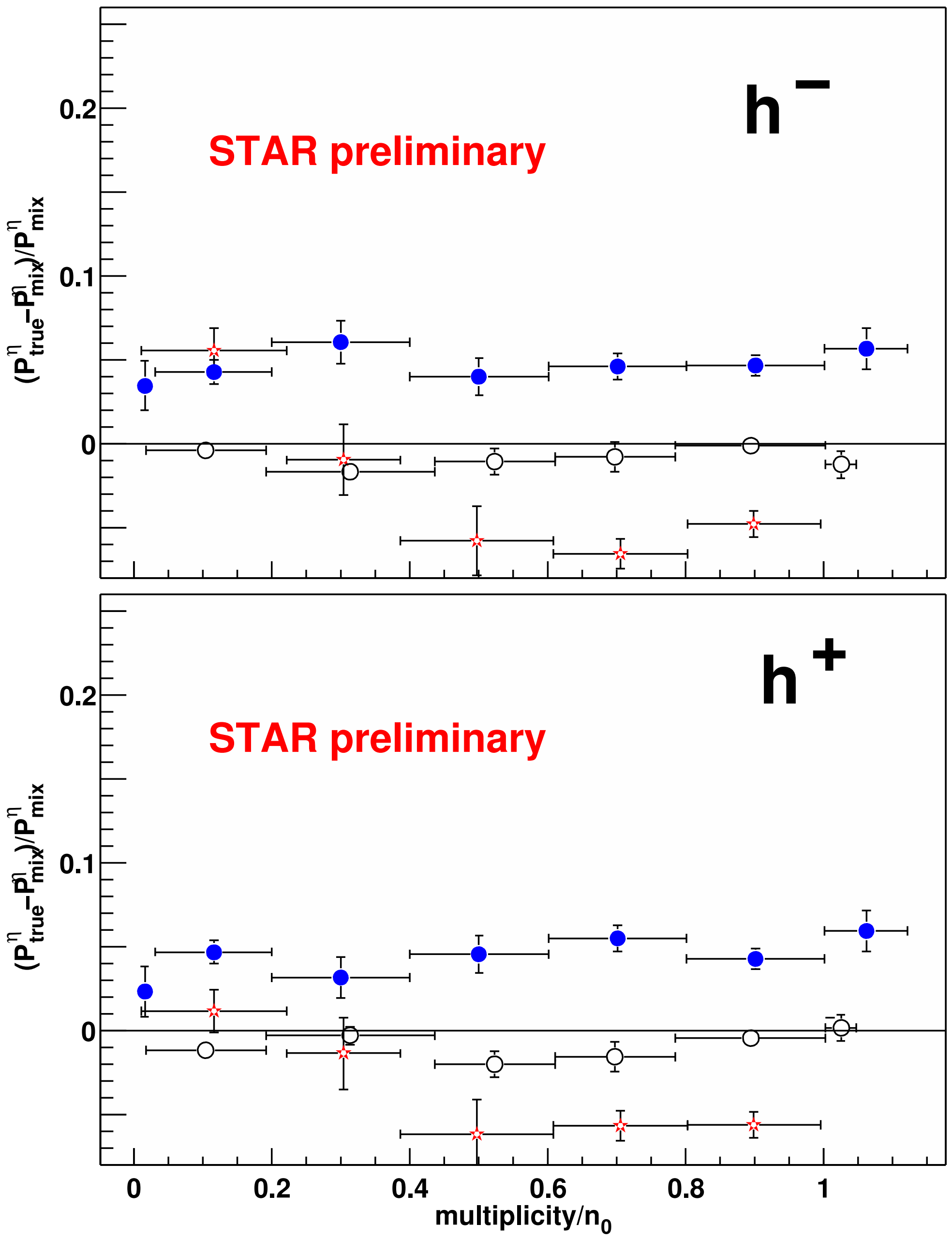




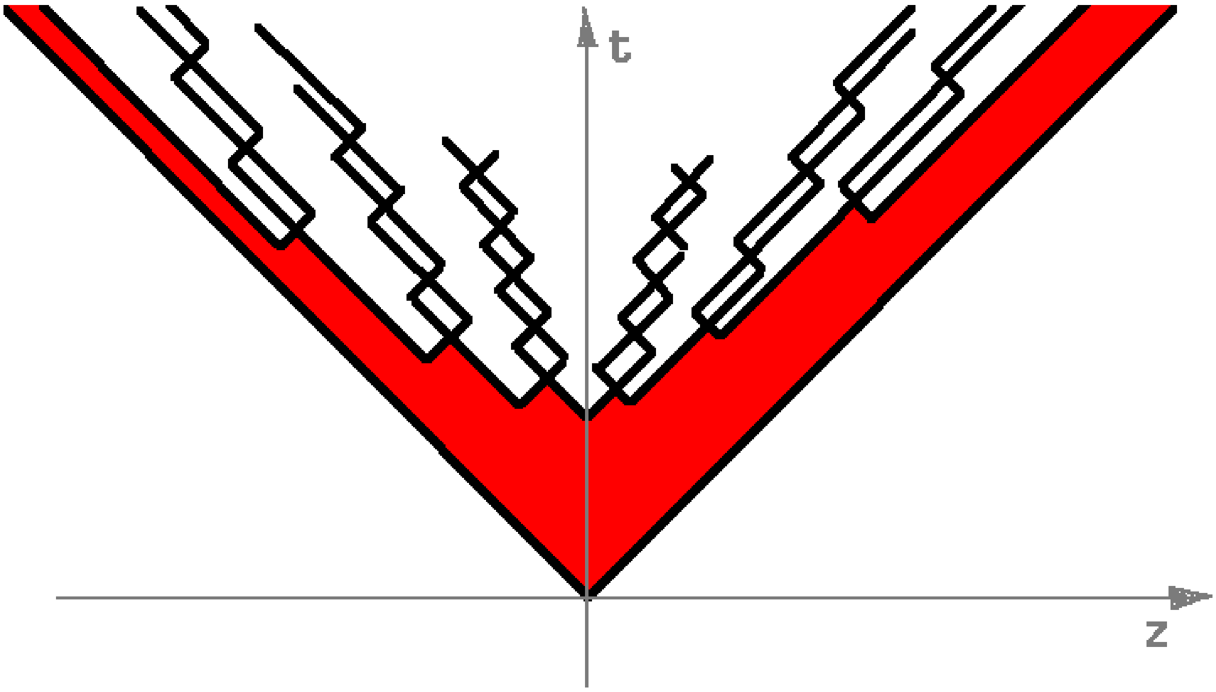
●, ○, $\delta\eta = 1, \delta\phi = \pi$; ●, ○, $\delta\eta = 1/2, \delta\phi = \pi/2$. HIJING shows coherent scaling with p_T bin width



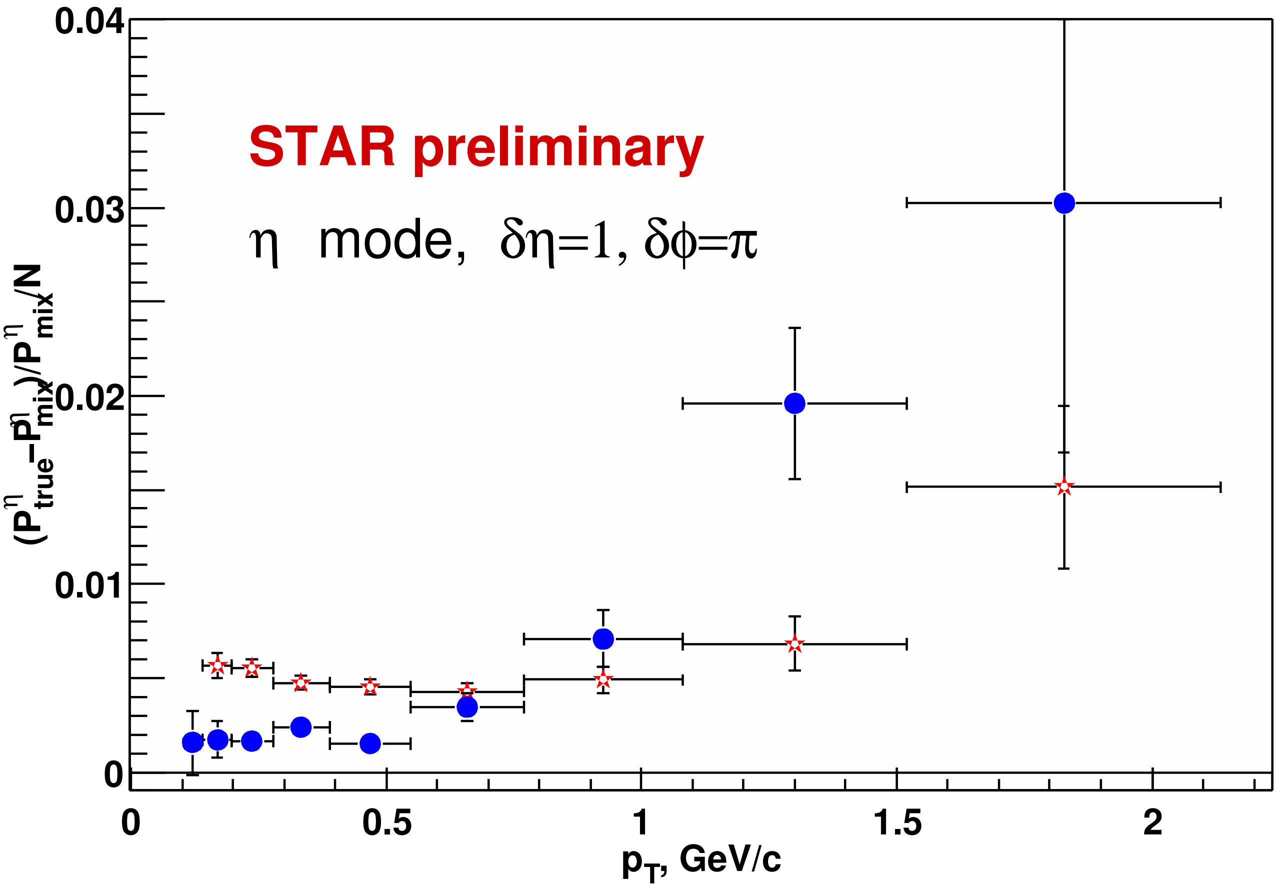
$\sqrt{S_{NN}} = 130$ GeV. $\delta\eta = 1$, **Charged hadrons:** $\star$, STAR; $\bullet$, regular HIJING; $\circ$, HIJING without jets. The HIJING texture is mostly jets. STAR data: a change of regime with centrality.



$\sqrt{S_{NN}} = 130$ GeV, $\delta\eta = 1$, $P_{true} < P_{mix} \Rightarrow$ large scale correlation



Short-range net-charge conservation results in local charge-dependent correlation structure. The difference between HIJING model and STAR data in central events indicates a change in the medium affecting hadronization.

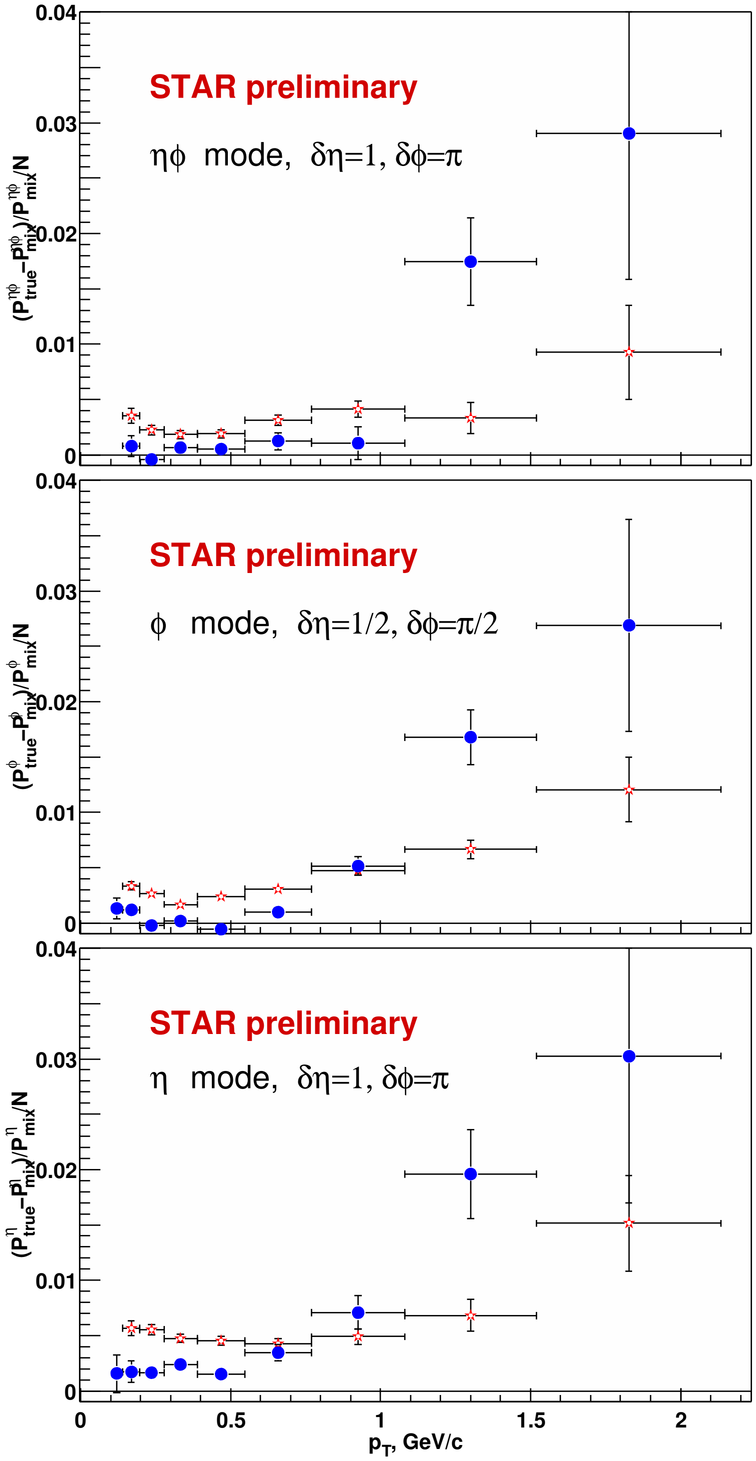


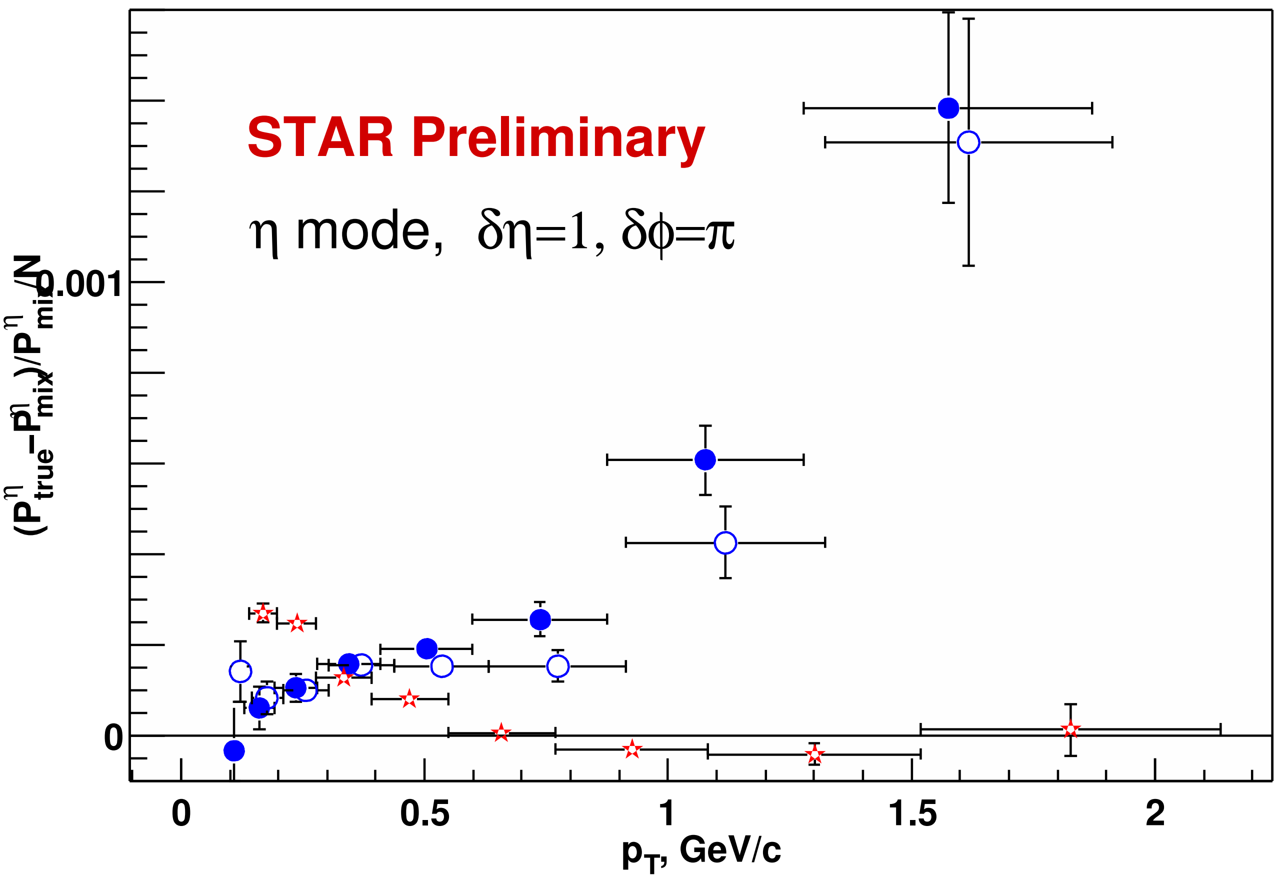
$\delta\eta = 1$ Peripheral $(mult/n_0 < 0.1)$ AuAu events: $\star$,STAR data for $\sqrt{S_{NN}} = 200$ GeV; $\bullet$, HIJING @ same energy.

Peripheral AuAu events:

⋆, STAR;

●, HIJING.





$\delta\eta = 1$, $\star$, STAR $\sqrt{S_{NN}} = 200$ GeV; $\bullet$, regular HIJING; $\circ$, HIJING+jet quenching (both 130 GeV). Central ($0.65 < mult/n_0 < 1.1$) events: Data more 'thermal' at $p_T > 0.6GeV$ $\rightarrow$ dissipation?

Bose-Einstein/Coulomb contribution at low p_T needs to be quantified.

Does jettiness disappear completely ?

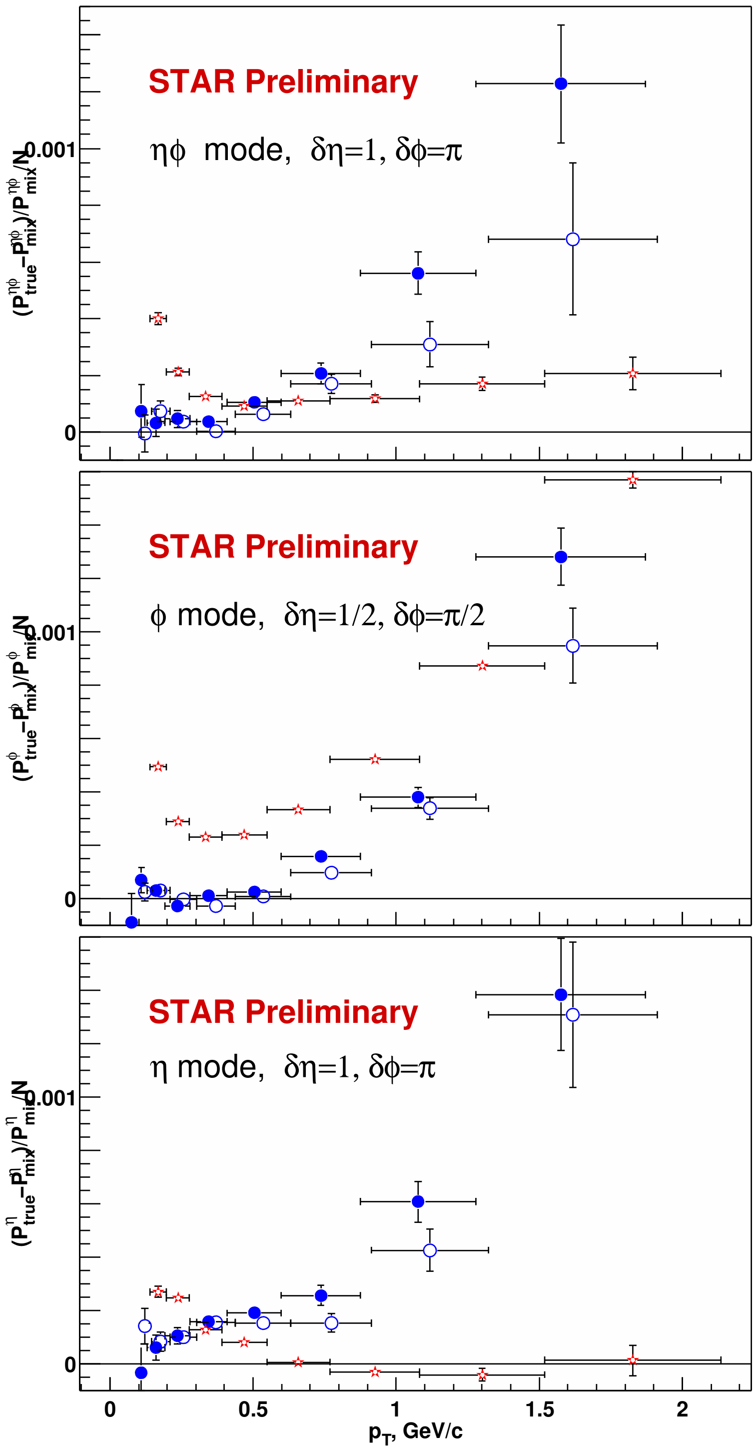
Central sample:

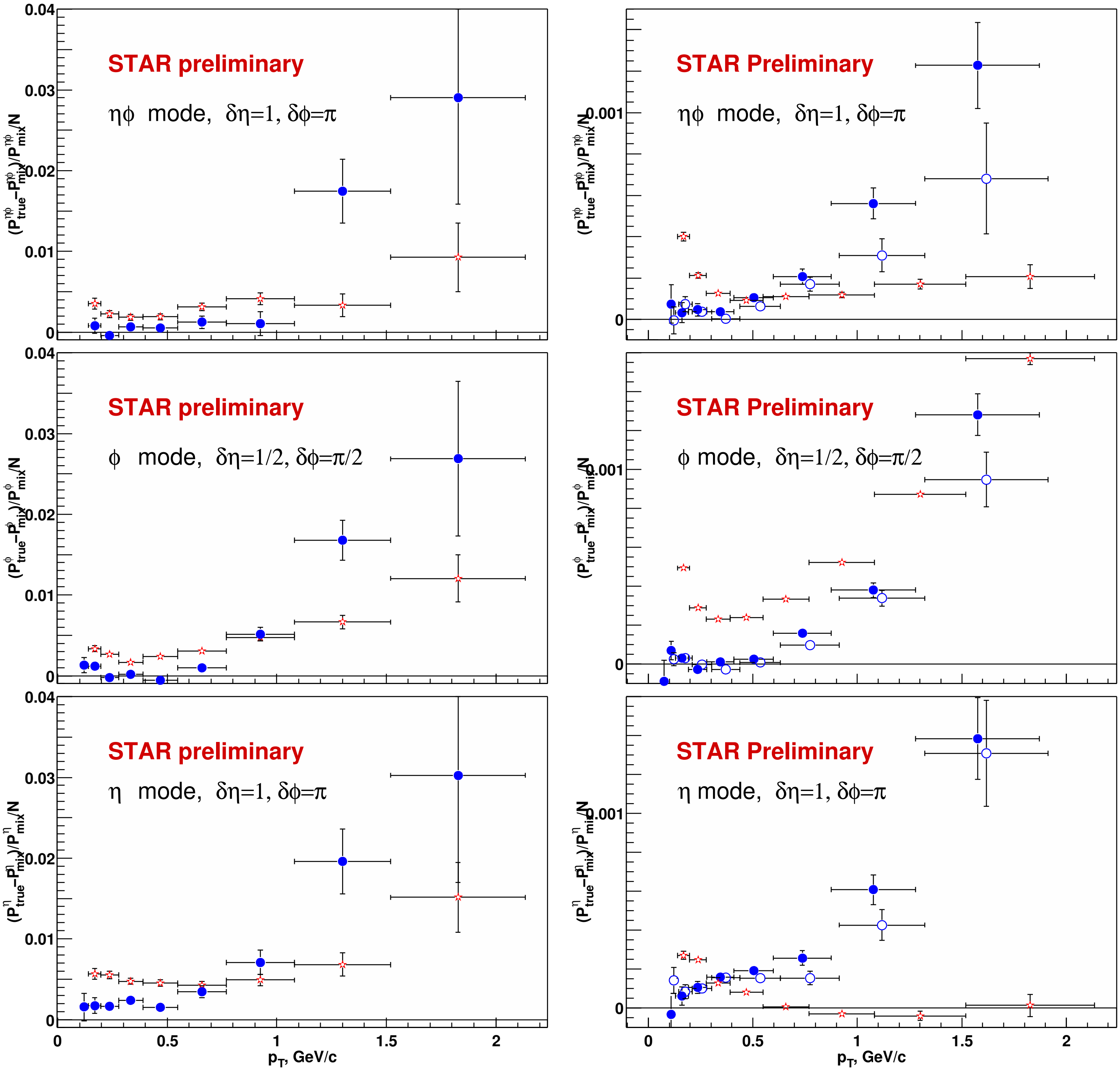
$\star$, STAR (200 GeV);

$\bullet$, HIJING;

$\circ$, HIJING+jet quenching (both 130 GeV).

See elliptic flow + "non-flow" at $\delta\phi = \pi/2$ (scale=2).





Left: peripheral, right: central. ⋆, STAR (200 GeV); •, HIJING; ∘, HIJING+jet quenching.

Conclusions:

– peripheral ($mult/n_0 < 0.1$) data qualitatively agree with HIJING; details of p_T behaviour differ

– large scale correlation (suppressed fluctuation) in η becomes visible in central events.

– p_T-dependence of η-texture: at soft $0.6 < p_T < 2$ GeV, jet texture is modified. At low p_T, need to understand the "HBT" contribution.

– more info:
nucl-ex/0211015, nucl-ex/0211019,

`http://www.star.bnl.gov/~kopytin`