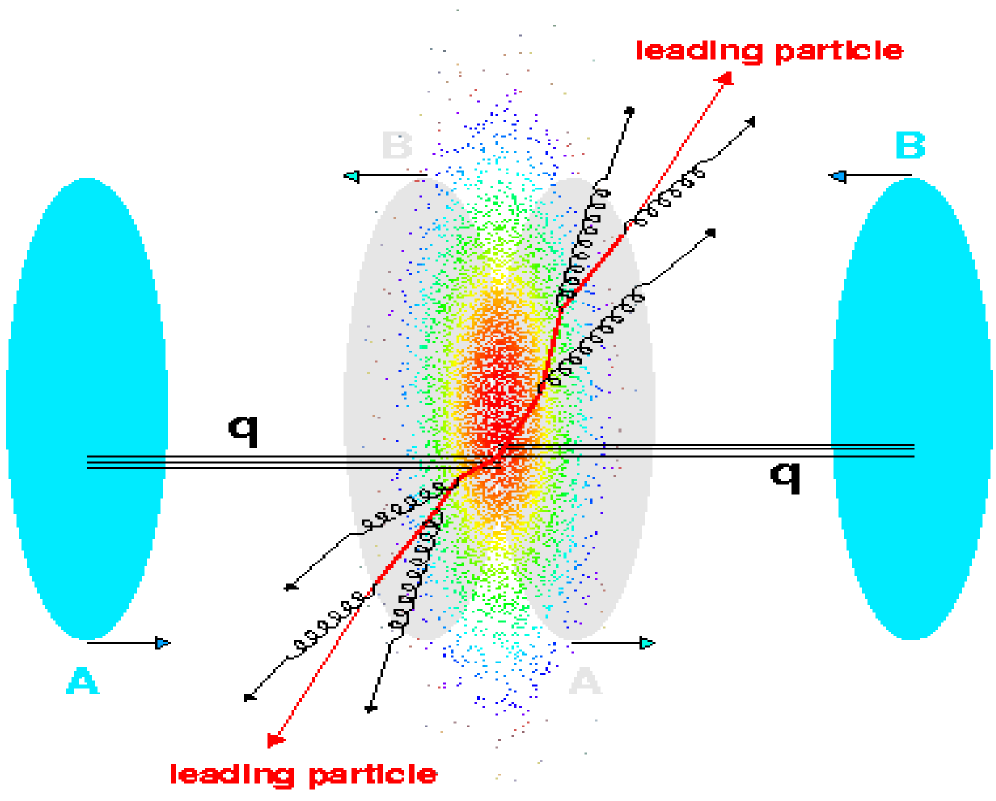
Partonic Hard Scattering in Heavy Ion Collisions



Hard scatterings:

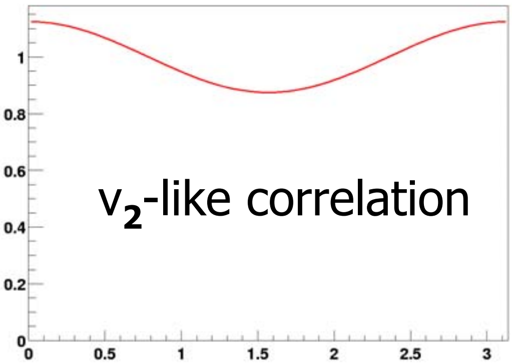
- high Q^2 transfer →small α_s (pQCD regime)
- early in collision→probe early stages of the nuclear medium
- energetic partons: probe the partonic density of the hot QCD medium (QGP) via dE/dx (gluon radiation)

Produce correlated jets of hadrons that manifest themselves through:

- near-angle azimuthal correlations
- back-to-back azimuthal correlations

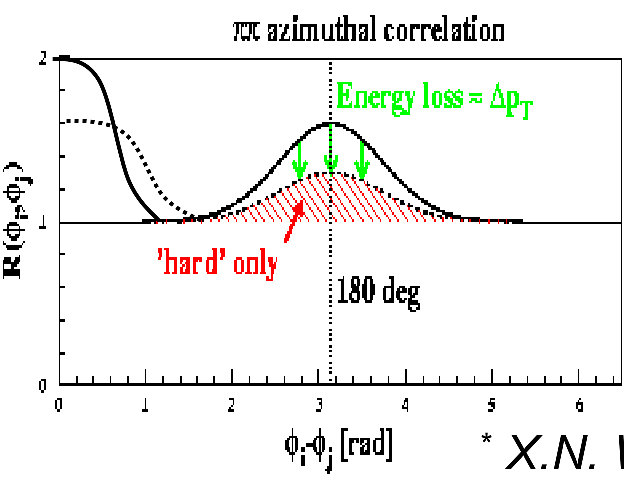
Two-Particle Azimuthal Correlations

Are sensitive to two types of processes:



Collective (flow) phenomena induced by pressure gradients; they generate a $\mathbf{v_2}$-like correlation that dominates at low momenta:

$$C(\Delta\phi)_{flow} \propto (1 + 2\, v_2^{\ 2} \cos(2\Delta\phi))$$



The back-to-back and near-angle peaks are generated by hard (point-like) processes; they may* be reduced by energy loss

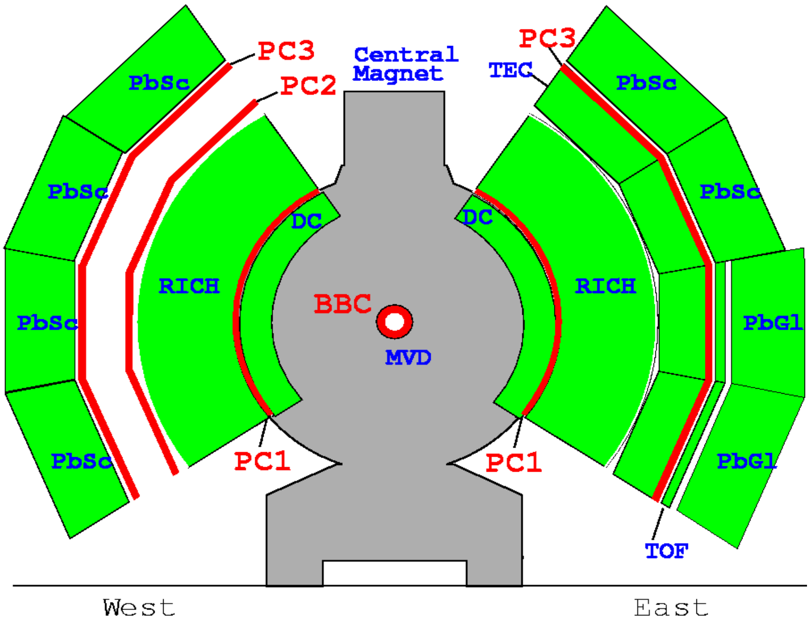
* *X.N. Wang, Phys.Rev.Lett.81:(1998)2655*

There are two basic types of two-particle correlations:

- assorted $p_\perp$ correlation (closer to reaction-plane analyses). It is more sensitive to flow-like correlations.
- fixed $p_\perp$ correlation: both particles are in the same $p_\perp$ bin. It is more sensitive to jet-like correlations.

In this paper we will use fixed $p_\perp$ azimuthal correlations to extract the properties of the near-angle peak.

Details of the analysis (I)



PHENIX Run2 Detector

- 30M minimum bias events analyzed
- -30 < collision vertex < 30 cm
- Central arm tracks
  - High quality drift chamber (DC&PC1) tracks
  - Match within 2σ in Δφ and Δz in pad chamber 3 (PC3)
  - Ring Imaging Cherenkov (RICH) veto of electrons from conversions
  - For tracks with $p_\perp$>4GeV/c we require EmCal Energy >1GeV (vetoes fake high-$p_\perp$ tracks, from decays and conversion electrons).
- Correlation functions
  - mixed events from similar beam-vertex $|\Delta Z_{vertex}|$<5cm and centrality |ΔCentrality|<10%

Details of the analysis (II)

Possible contributions to the near-angle peak (other than jets):

- conversion $e^{\pm}$: since they "see" a small region of the magnetic field, they are wrongly reconstructed as high-$p_{\perp}$ tracks; they are efficiently reduced by the RICH veto and the energy cut.
- weak decays (K^0_S, Λ): their contribution is not significant in the $p_{\perp}$ region presented here. Also, they produce a narrower peak than jets.
- random background: reduced by the outer detector (PC3) tight matching.

We also use two physics cuts to asses the jet/non-jet contributions:

- $|\Delta\eta|>0.35$, $(q_1q_2)=(+\,+)(-\,-)$, named here the kinematically disfavoured jet-like near-angle because hadrons from jets cluster in pseudo-rapidity space and come with opposite charge
- $|\Delta\eta|<0.35$, $(q_1q_2)=(+\,-)$, named here the kinematically favoured jet-like near-angle

Extraction of the near-angle peak

The correlation is calculated with a mixed event technique:

$$C(\Delta\phi) = \frac{N_{\text{real}}(\Delta\phi)}{N_{\text{mixed events}}(\Delta\phi)} \qquad \Delta\phi = |\phi_1 - \phi_2|$$

with both the "real" and "mixed" $\Delta\varphi$ distributions normalized to unity. Then it is fitted with a flow-like term (cosine modulation) and a jet-like term (gaussian around $\Delta\varphi=0$):

$$N\left[1 + 2v_2^2\cos(2\Delta\varphi)\right] + \sqrt{\frac{\pi}{2}}\frac{Y}{(1-Y)\sigma}e^{-\frac{1}{2}\left(\frac{\Delta\varphi}{\sigma}\right)^2}$$

where Y is the relative yield (*area of near-angle peak divided by the total area of the correlation function*) and σ is the width of the near-angle peak; v_2 gives the strength of the cosine modulation.

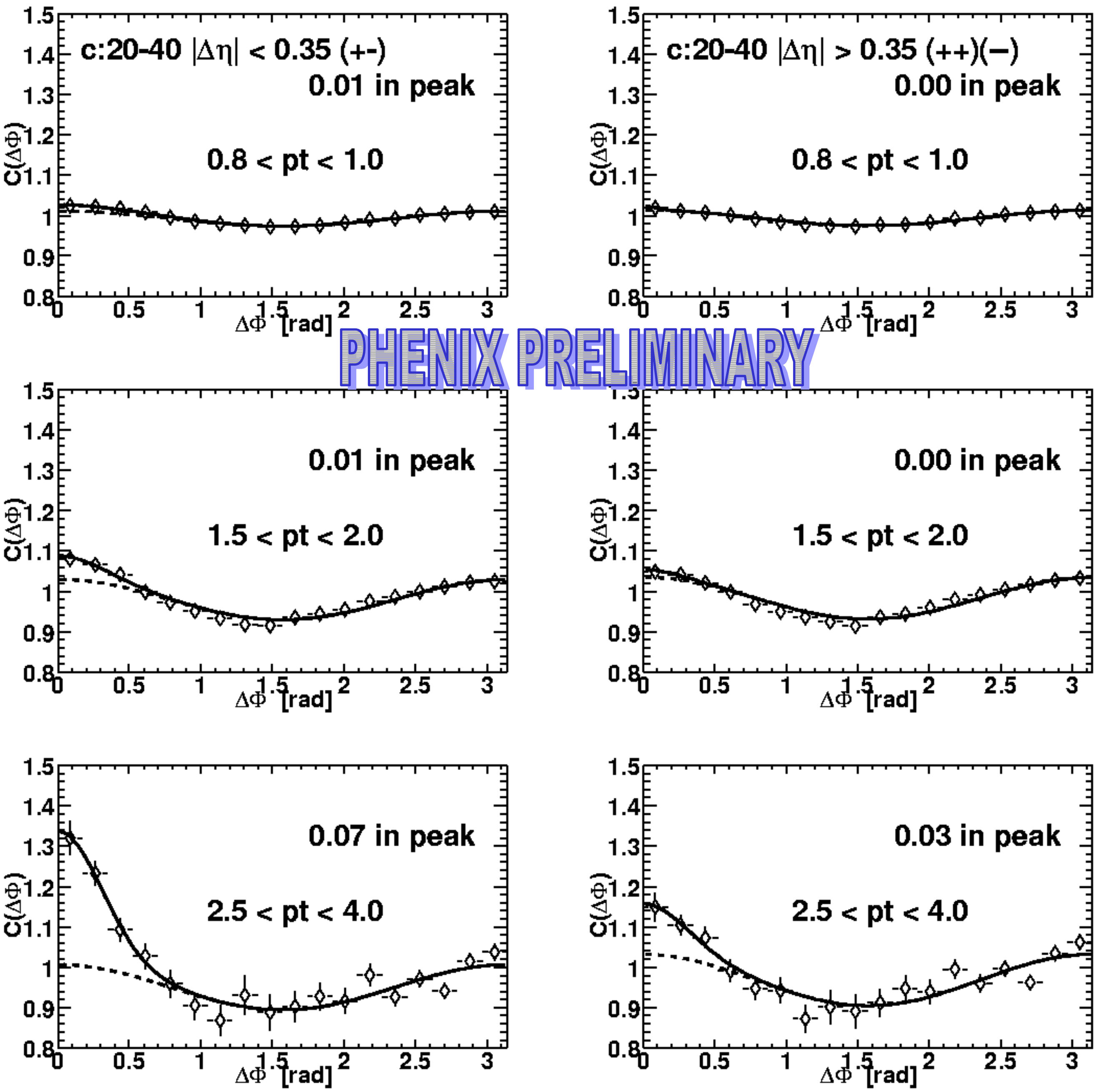
Slide 8 shows two sets of χ^2-contour plots for the same $p_\perp$ bin, but different centralities (most peripheral and most central). The fitted v_2 becomes consistent with 0 at high- $p_\perp$ in central events.

The error bars on the extracted quantities contain statistical errors and systematical errors estimated by varying the input parameters of the fit.

Mid-Central Fixed $p_{\perp}$ Correlation Function

Kinematically favoured jet-like near-angle (see Slide 4 for comments)

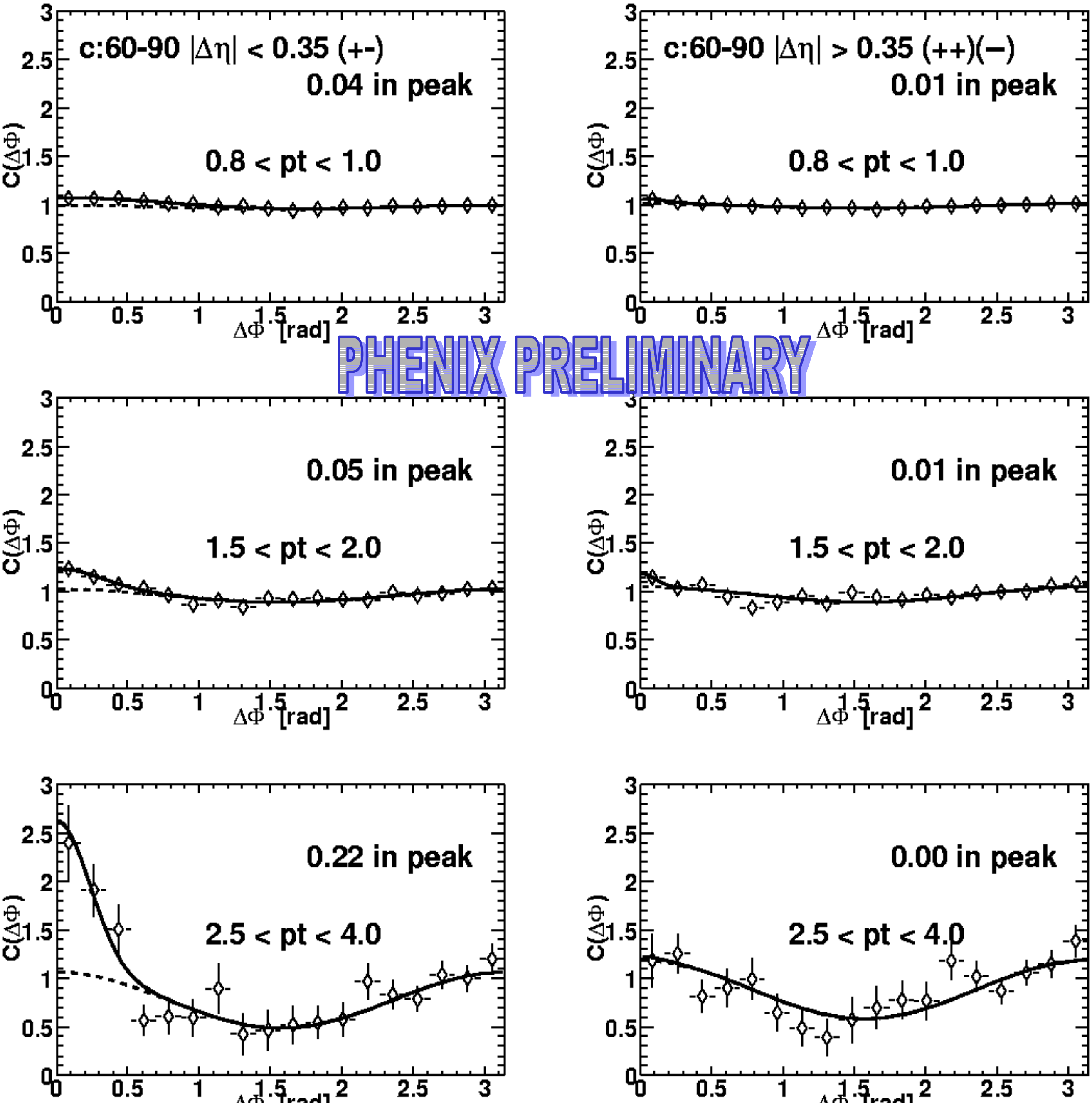
Kinematically disfavoured jet-like near-angle (see Slide 4 for comments)



Peripheral Fixed $p_{\perp}$ Correlation Function

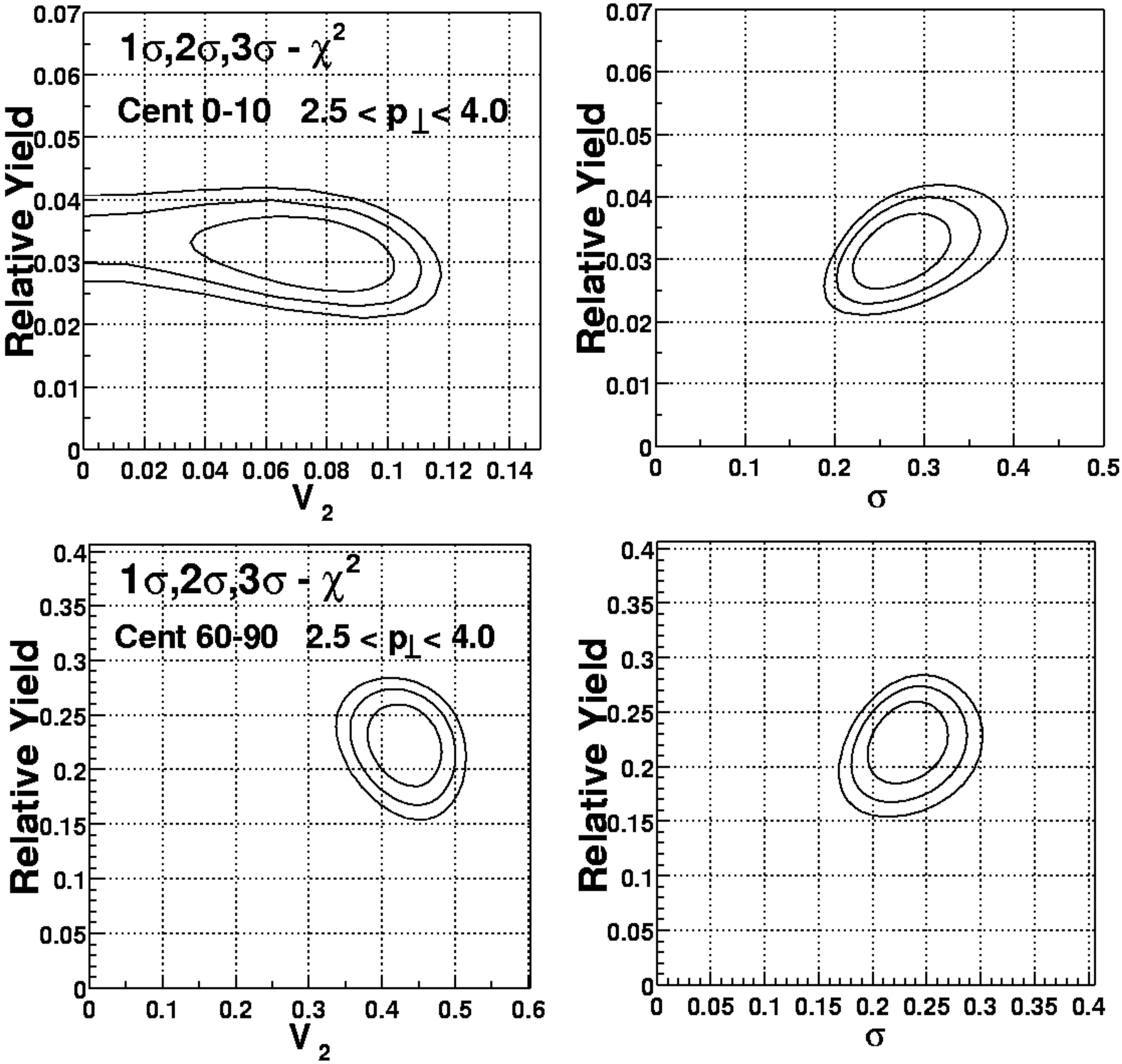
Kinematically favoured near-angle peak
(see Slide 4 for comments)

Kinematically disfavoured near-angle peak
(see Slide 4 for comments)

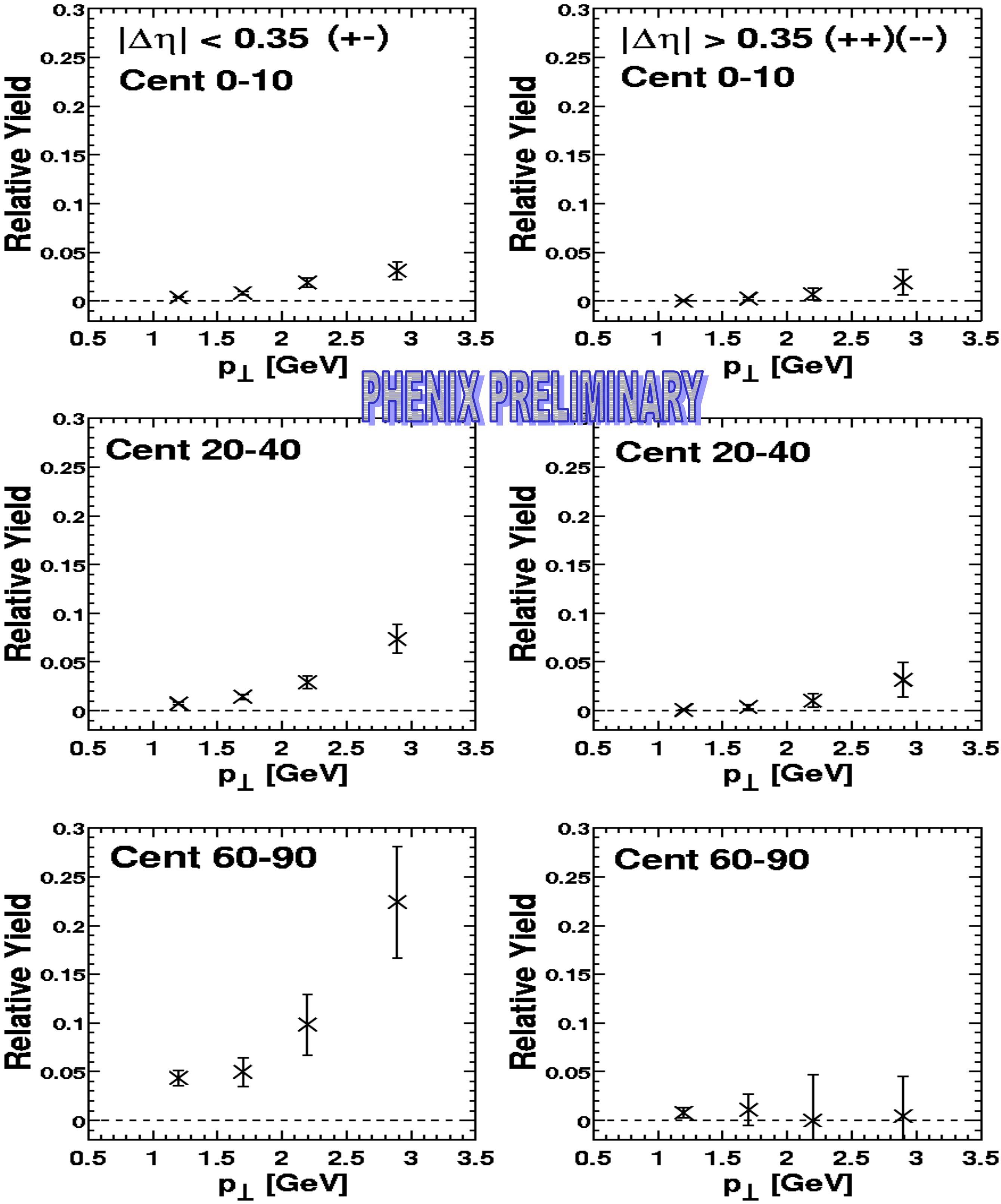


χ^2-Contours of Correlation Function Fit

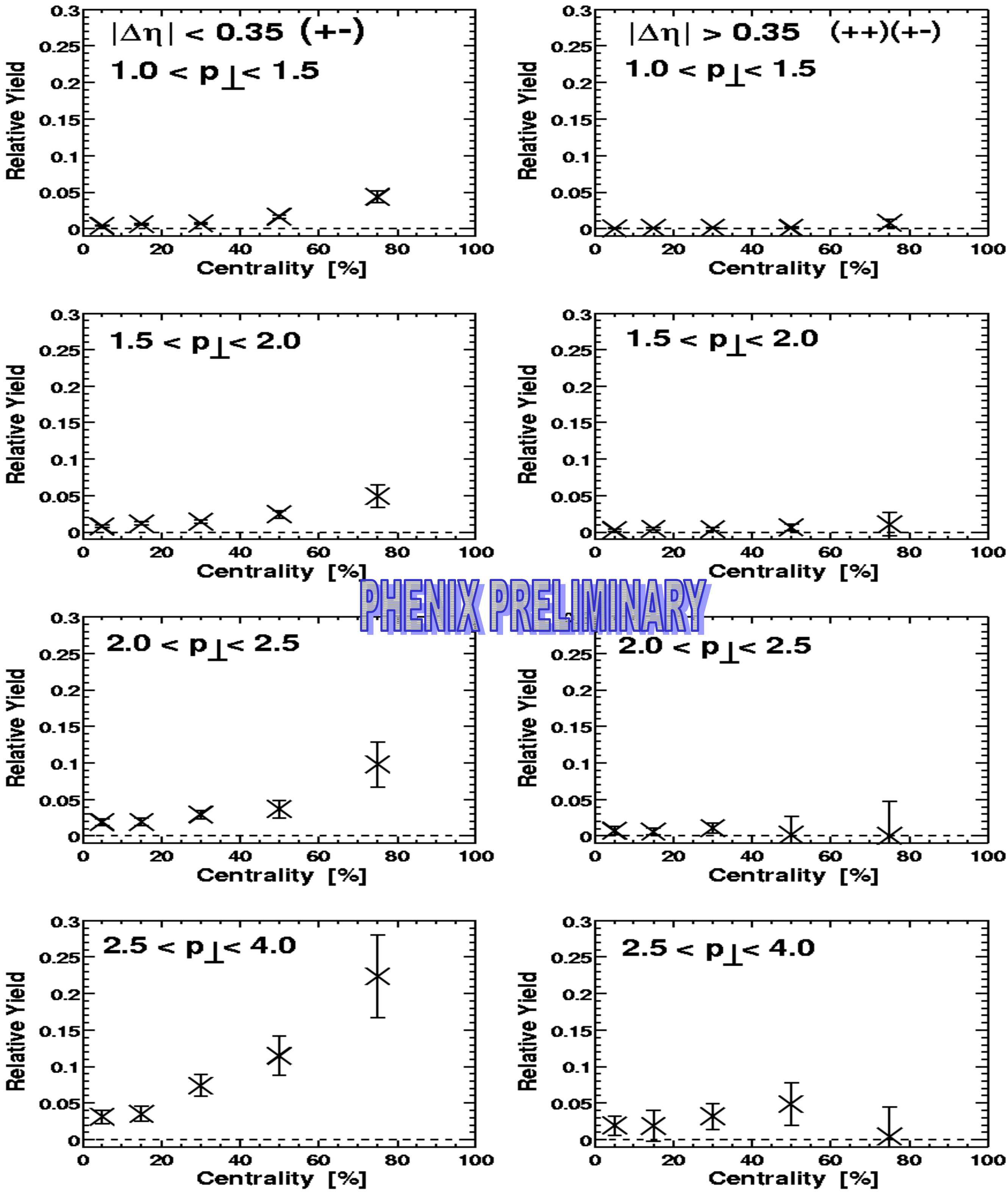
(see Slide 5 for comments)



Relative Yields – $p_\perp$ Dependence

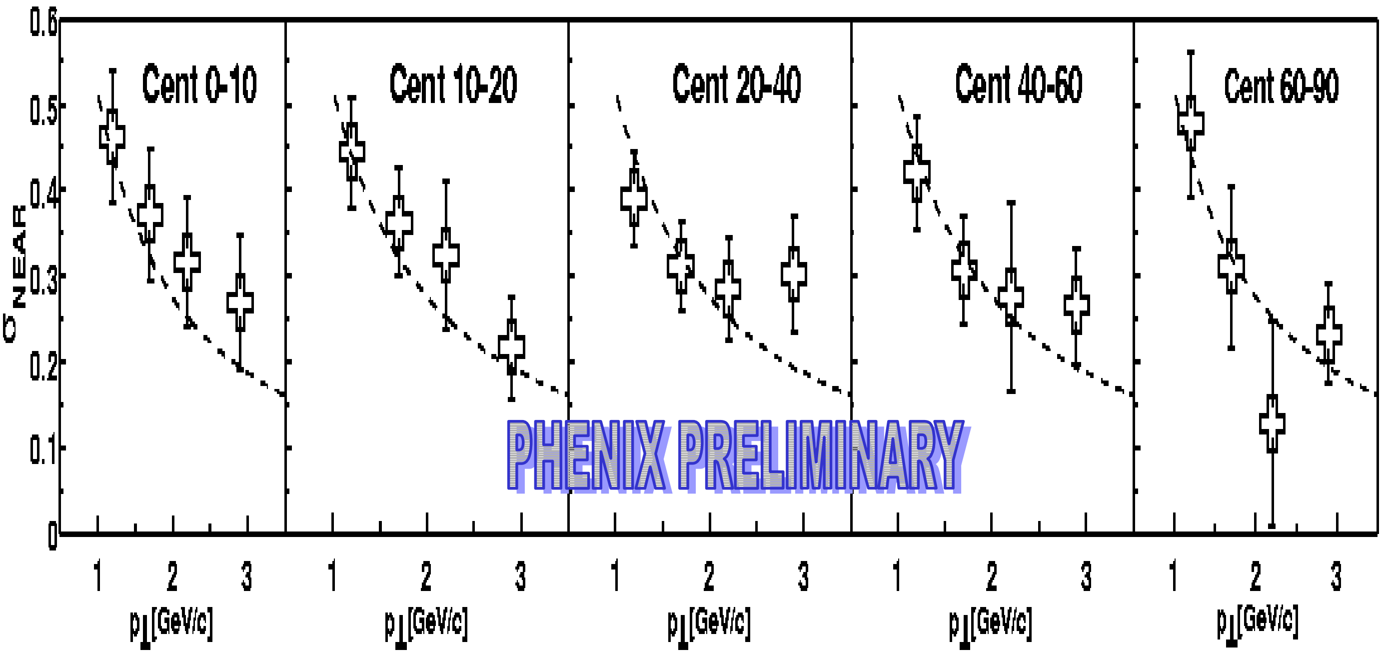


Relative Yields – Centrality Dependence

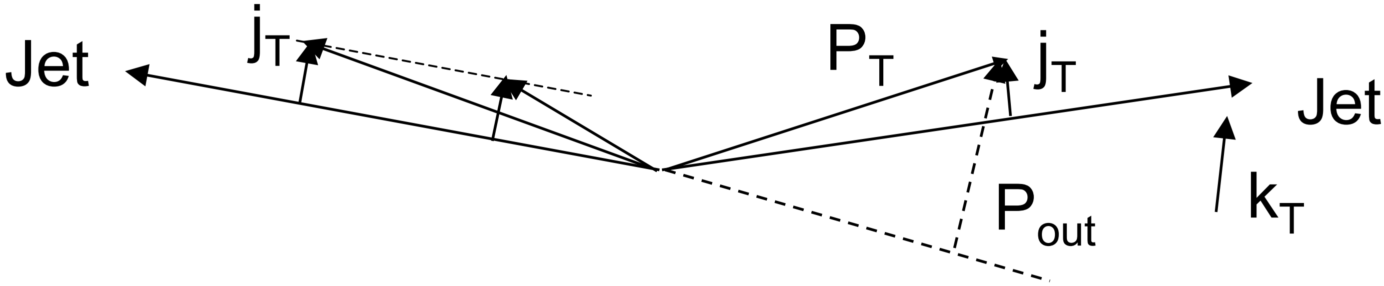


Near-Angle Widths

The extracted width of the gaussian term of the fit to the correlation function is plotted against $p_{\perp}$ and centrality:



The dashed line (not a fit) corresponds to a constant $j_{\perp}$=400 MeV. (transverse momentum with respect to “jet” axis)



Conclusions and Outlook

- Jet-like near-angle structure is observed in two-particle correlations in Au-Au collisions at $\sqrt{s} = 200 AGeV$
- The relative yield increases with both centrality and $p_{\perp}$.
- Near-angle widths also show a $p_{\perp}$ dependence characteristic for jets.
- The study of the near-angle peak in other channels than $h^{\pm}$-$h^{\pm}$ (like π^0-$h^{\pm}$, where it has been already observed with the same data set) will allow us a better extraction of its properties.