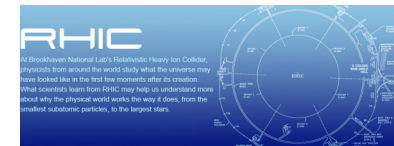
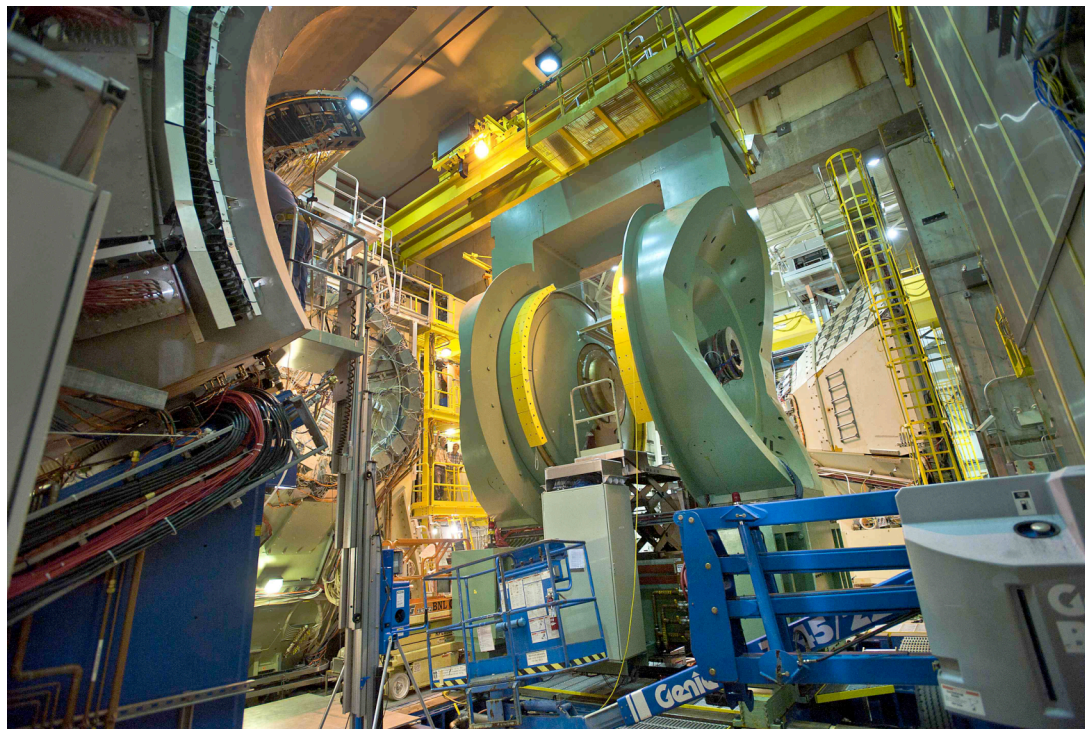
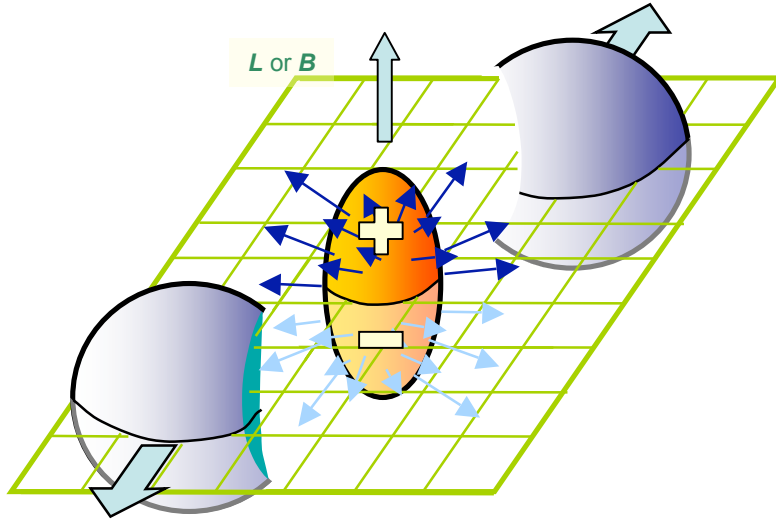


Charge asymmetric correlation measurement as a possible signature of Local Parity Violation in 200GeV Au+Au collisions at RHIC-PHENIX

Shinichi Esumi for the PHENIX collaboration
Inst. of Physics, Univ. of Tsukuba





directed plane Φ_1 (spectators) : Global P.V.
elliptic plane Φ_2 (participants) : Local P.V.

$$\frac{dN_{\pm}}{d\phi} \propto 1 + 2v_1 \cos(\Delta\phi) + 2v_2 \cos(2\Delta\phi) + \dots$$

$$+ \boxed{2a_{1,\pm} \sin(\Delta\phi)} + \dots, \quad \Delta\phi = \phi - \Psi_{RP}$$

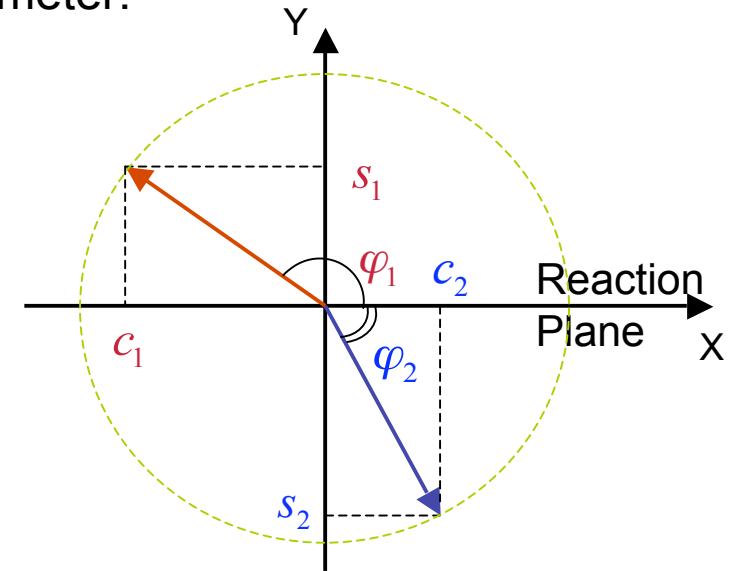
$$\langle \cos(\phi_{\alpha} + \phi_{\beta} - 2\Psi_{RP}) \rangle =$$

$$= \langle \cos \Delta\phi_{\alpha} \cos \Delta\phi_{\beta} \rangle - \langle \sin \Delta\phi_{\alpha} \sin \Delta\phi_{\beta} \rangle$$

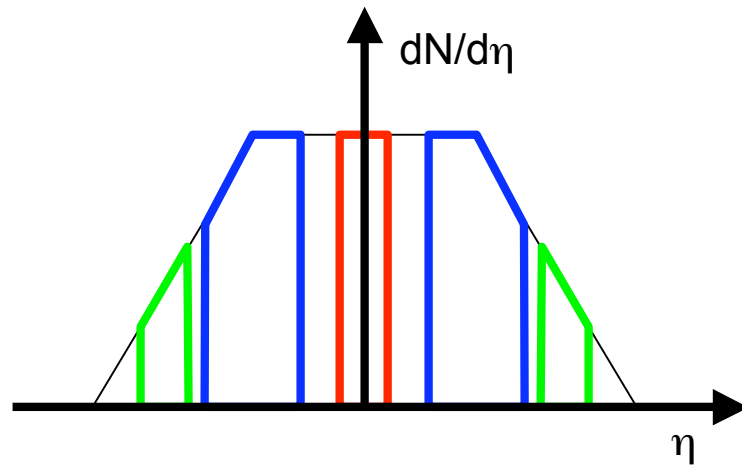
$$= [\langle v_{1,\alpha} v_{1,\beta} \rangle + B^{in}] - [\boxed{\langle a_{\alpha} a_{\beta} \rangle} + B^{out}].$$

$$v_1 = 0, B^{in} \approx B^{out}$$

This is two particle correlation measurement with respect to the reaction plane $\langle \cos(\phi_A + \phi_B - 2\Phi_{R.P.}) \rangle$, which is sensitive to the local parity violation, but this variable would be affected by many other effects. Therefore we are not intending to claim an observation of the violation, but just to present the measured correlation parameter.



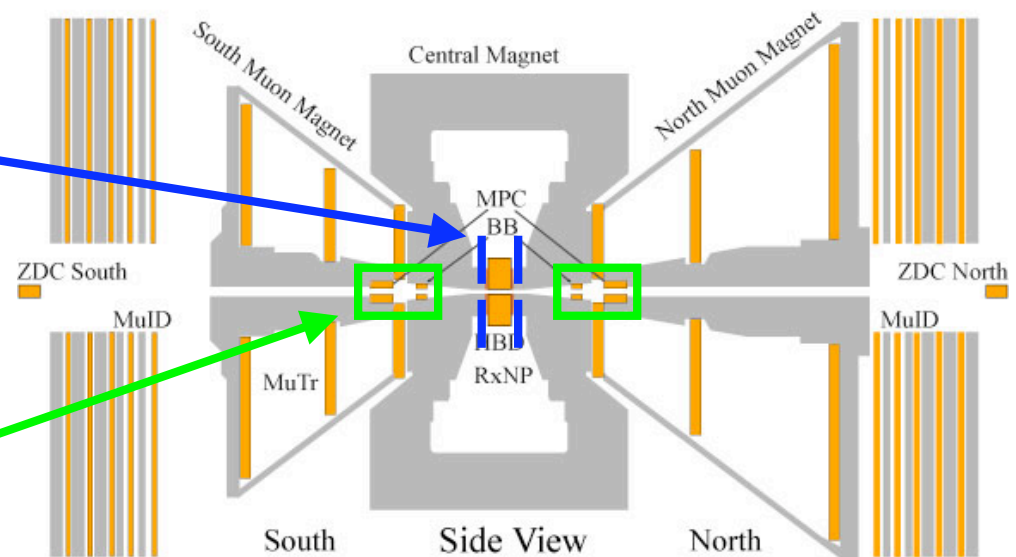
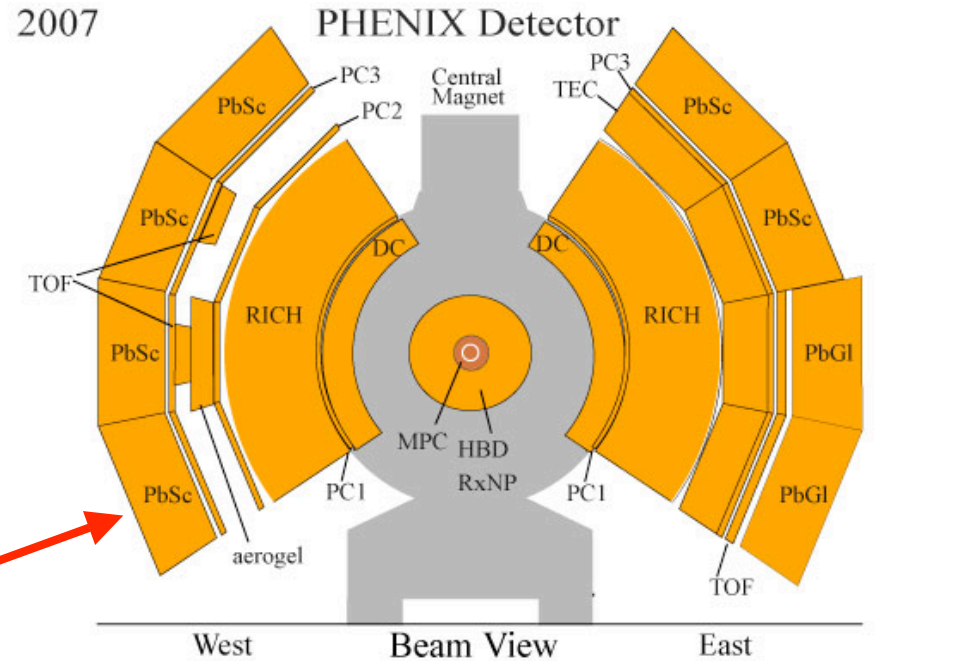
acceptance correction with event mixing
reaction plane resolution correction



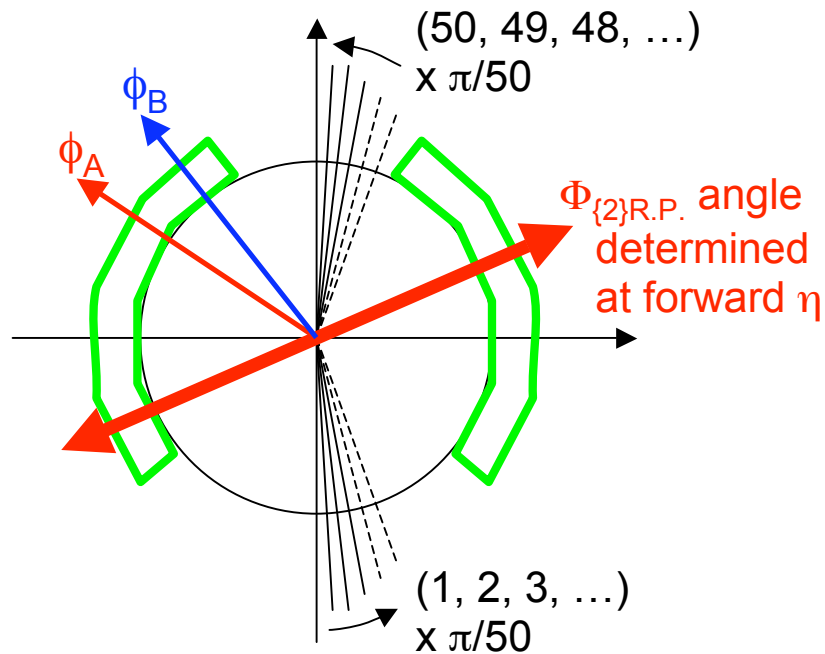
Charged Particle Tracks
 $|\eta| < 0.35$, $\pi/2 \times 2$ arms
 Central Arm Spectrometer (DC, PCs)

Mid Reaction Plane
 $1.0 < |\eta| < 2.8$, $0 < \phi < 2\pi$
 Reaction Plane Detector (RXN)

Forward Reaction Plane
 $3.0 < |\eta| < 3.8$, $0 < \phi < 2\pi$
 Beam Beam Counter (BBC)
 Muon Piston Calorimeter (MPC)



Event mixing with fine bin in laboratory R.P. angle $\Phi_{\{2\}}^{\{\text{forward } \eta\}}$



For a given particle ϕ_A in an event with $\Phi_{\{2\}R.P.}$ angle, another particle ϕ_B is taken from a different event with a similar $\Phi_{\{2\}R.P.}$ angle.

event mixing in

centrality: 10 bins [0-100%]

z-vertex: 10 bins [-30~30cm]

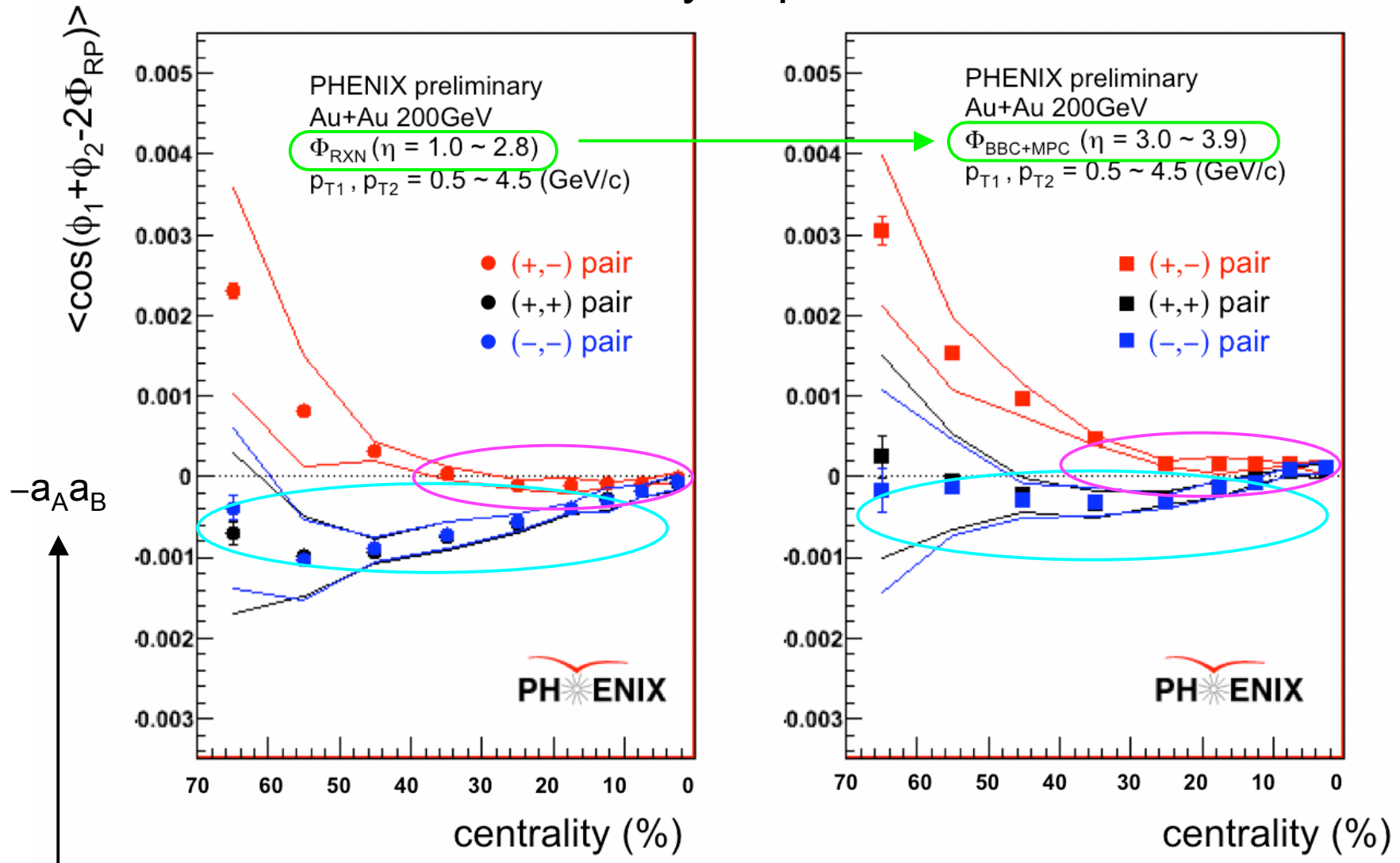
reaction plane: 50 bins $[-\pi/2 \sim \pi/2]$

mixed event within the same event class of (cent, z-vtx, $\Phi_{\{2\}R.P.}$) in order to take into account the acceptance as well as residual flow effects to be removed.

* measure $F_{AB} = \langle \cos(\phi_A + \phi_B - 2\Phi_{\{2\}R.P.}) \rangle$ and for F_{+-} , F_{++} and F_{--} for both real and mixed pairs

* take a difference between real and mixed, then correct for R.P. resolution: $(F_{\text{real}} - F_{\text{mixed}}) / \text{Res}_{R.P.}$

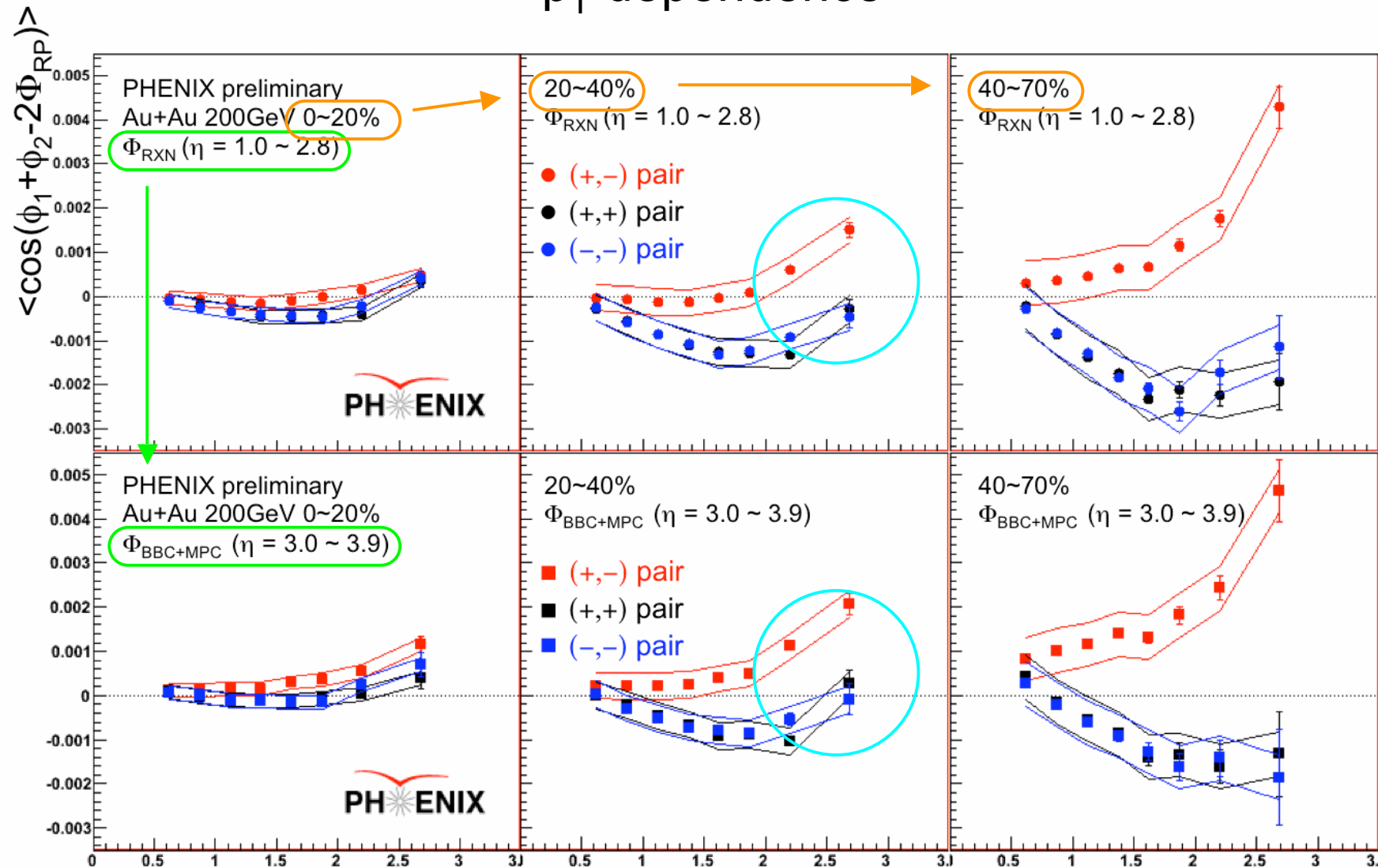
Centrality dependence



negative values for like sign pairs

suppressed magnitude for un-like sign pairs in central

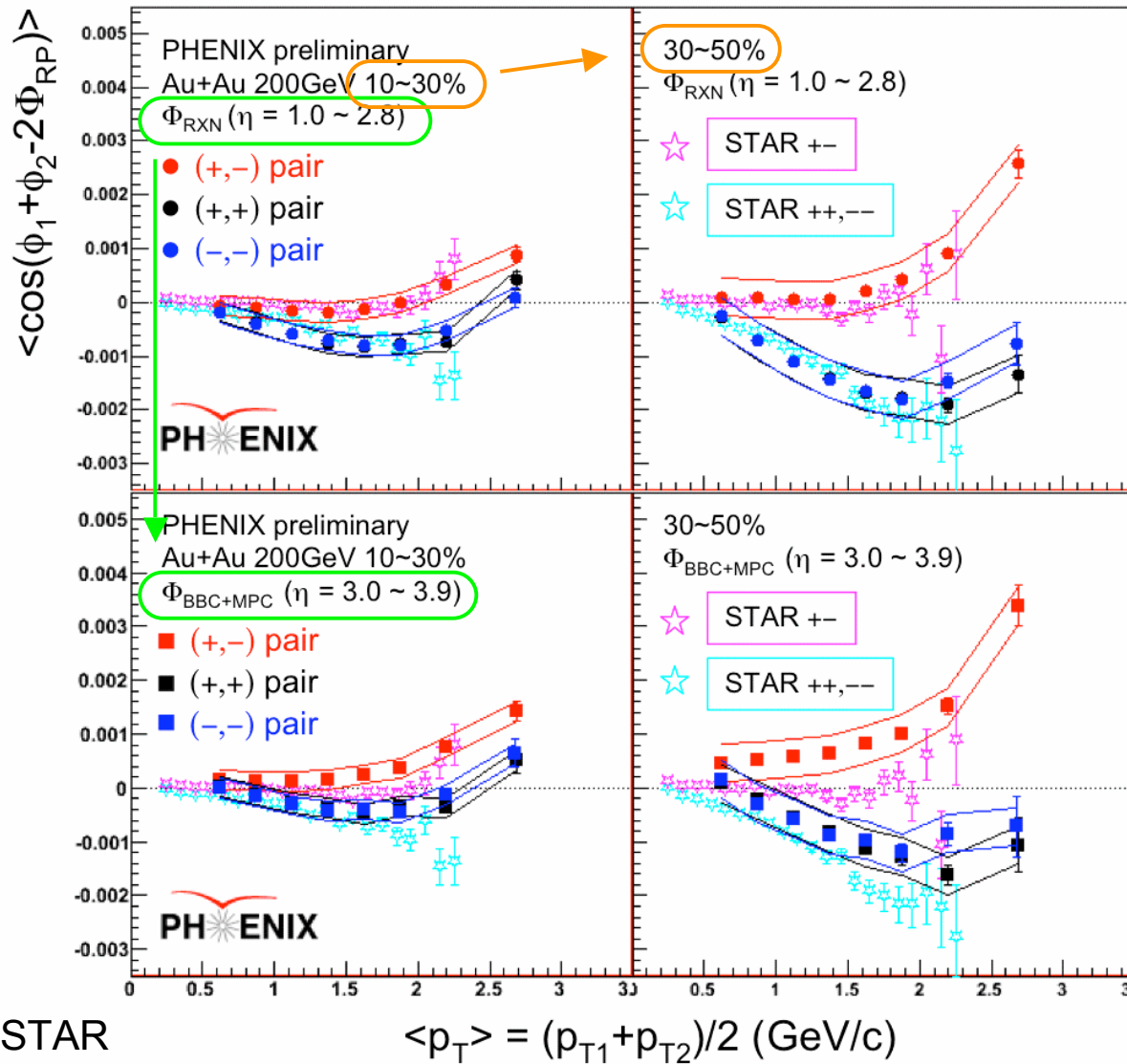
p_T dependence



correlations goes up at higher p_T
stronger signal for peripheral

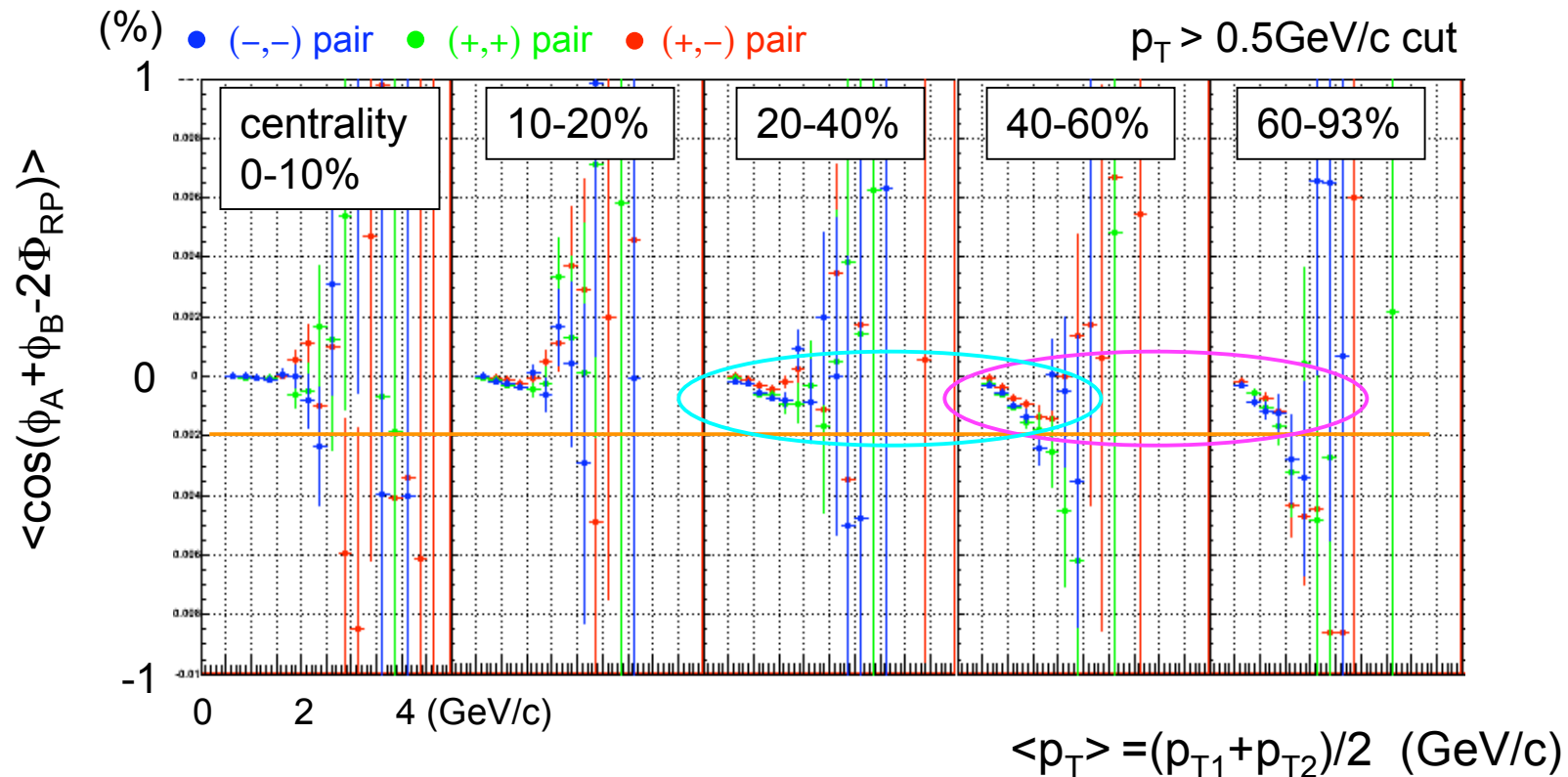
$$\langle p_T \rangle = (p_{T1} + p_{T2})/2 \text{ (GeV/c)} \quad p_{T1}, p_{T2} = 0.5 \sim 4.5 \text{ (GeV/c)}$$

Comparison with STAR results



comparable to STAR
measurements

AMPT simulation (with string melting)



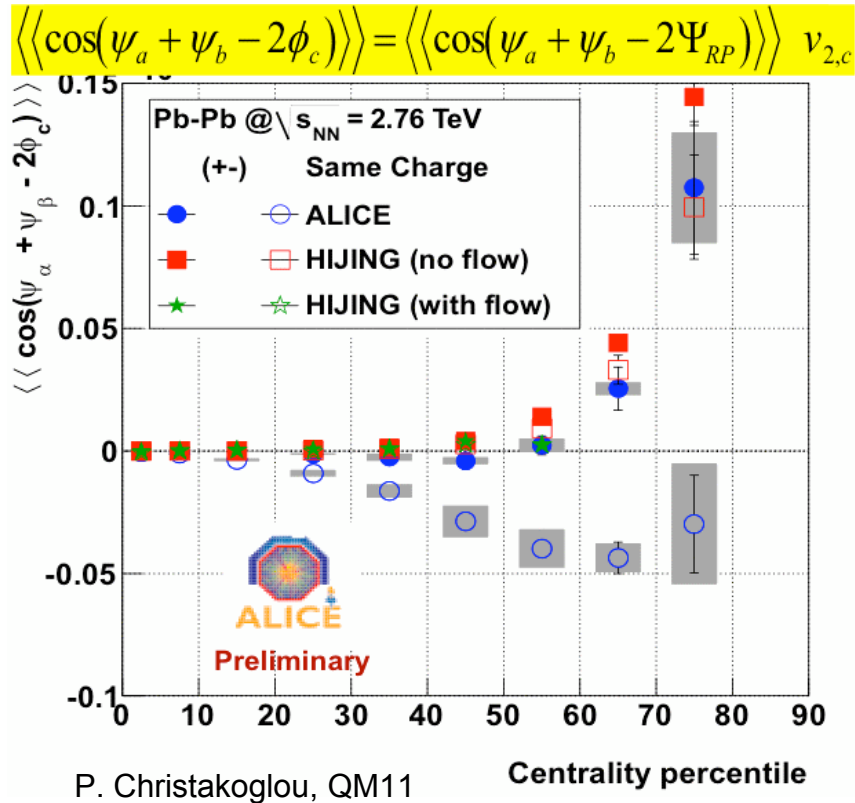
similar magnitude for like-sign pairs $\sim 0.2\%$ at 2 GeV/c

negative values also for un-like-sign pairs

some similarity $(+- > ++, --)$ to experimental data

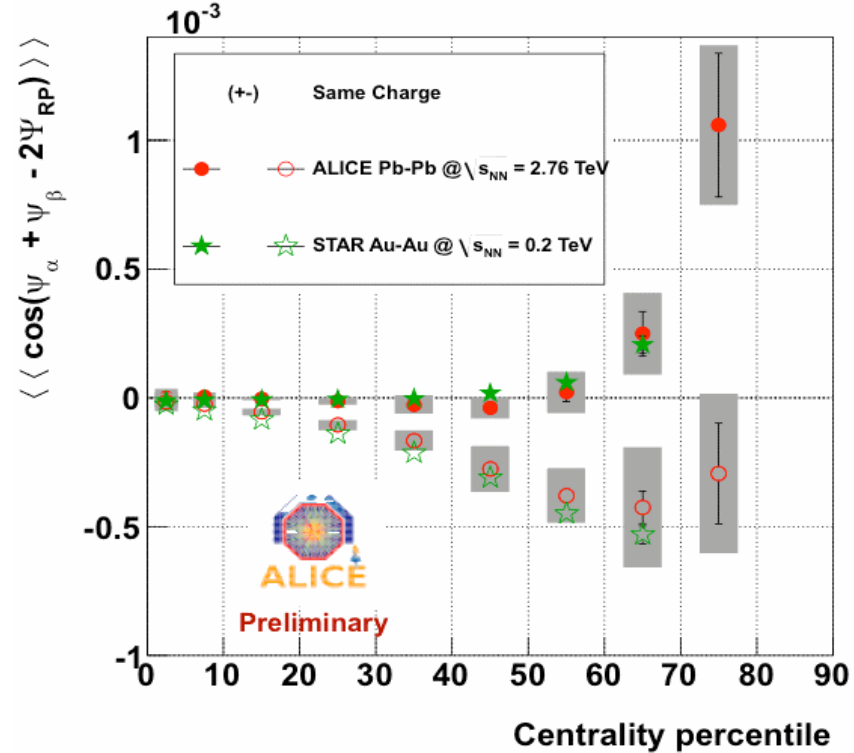
Comparison with LHC results

S. A. Voloshin, Phys. Rev. C **70**, 057901 (2004).



STAR Collaboration: Phys. Rev. Lett. **81**, 251601 (2009)

STAR Collaboration: Phys. Rev. C **81**, 054908 (2010)

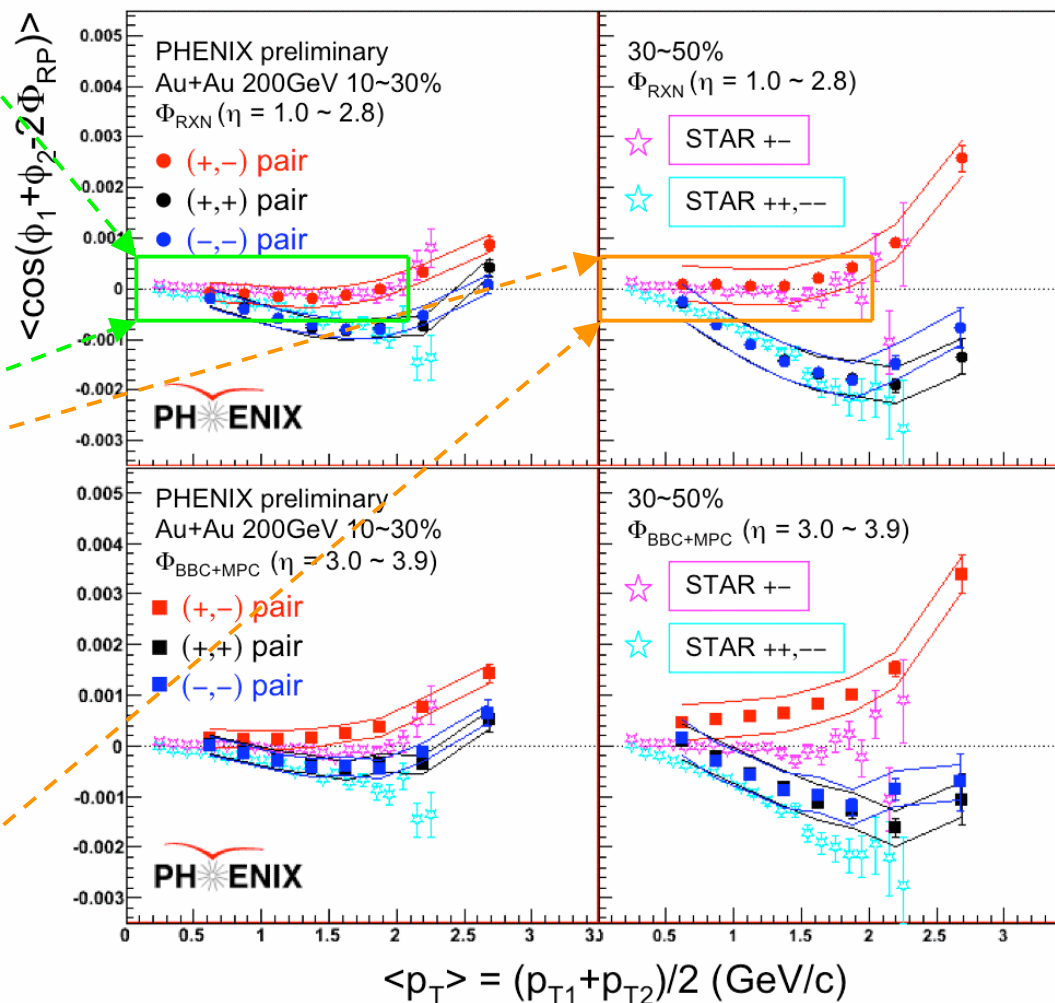
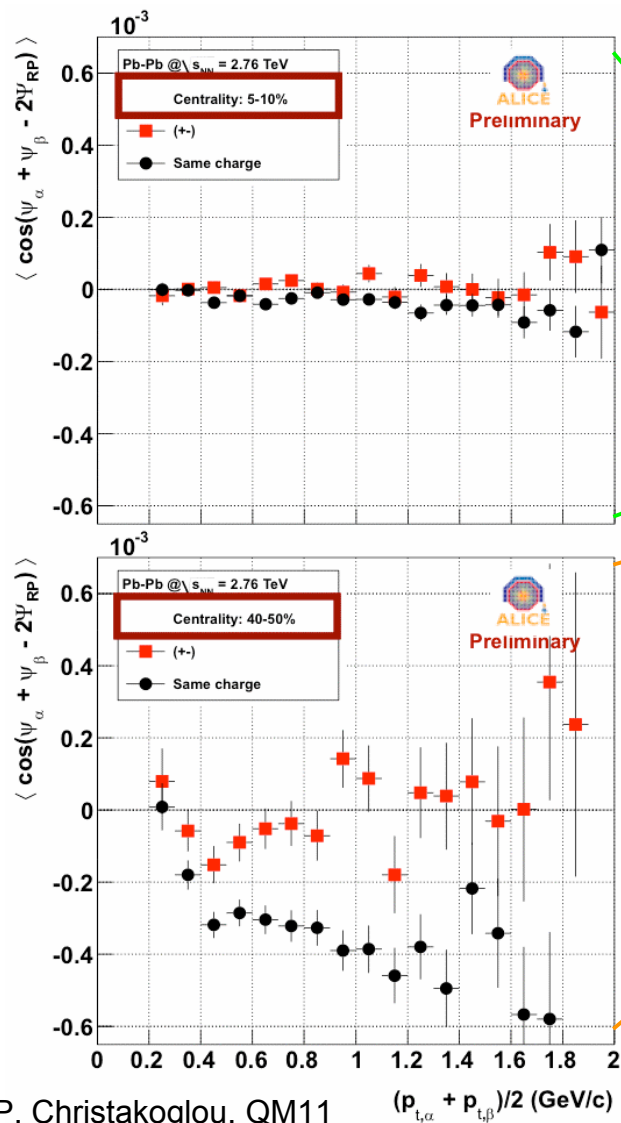


very similar results between RHIC and LHC energies

smaller signal for a given p_T
at LHC than at RHIC?

Comparison with LHC results

--- p_T dependence ---



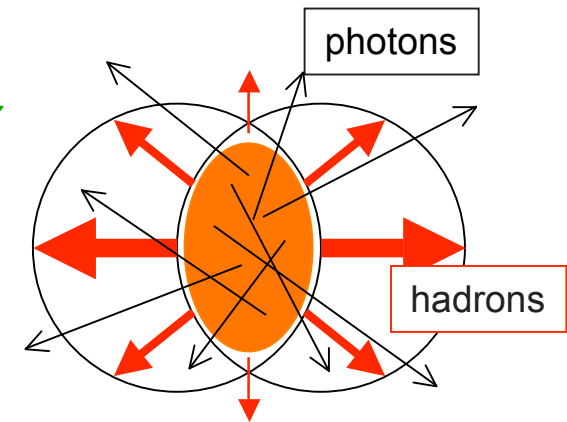
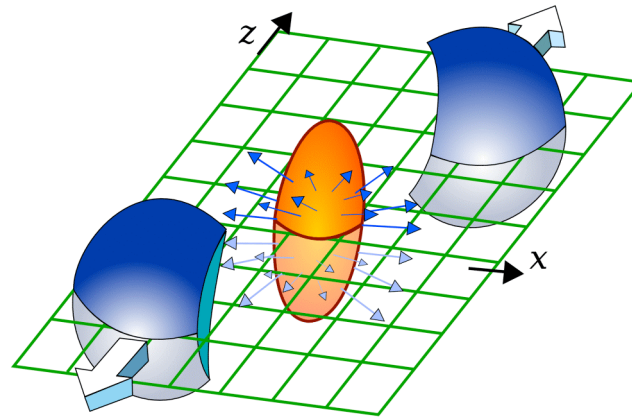
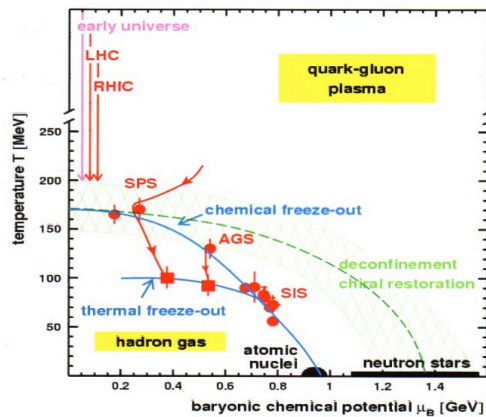
P. Christakoglou, QM11

Summary

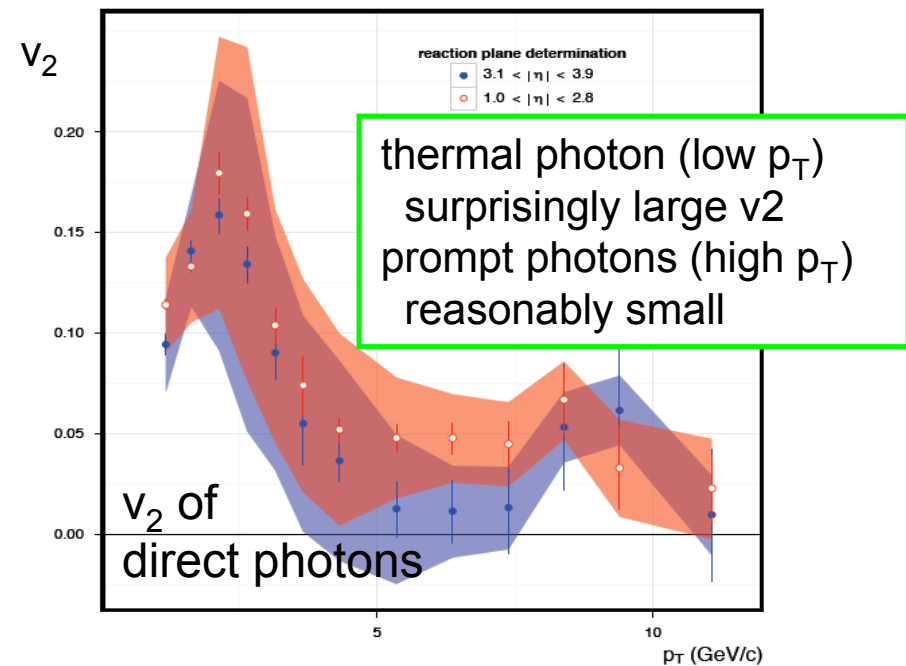
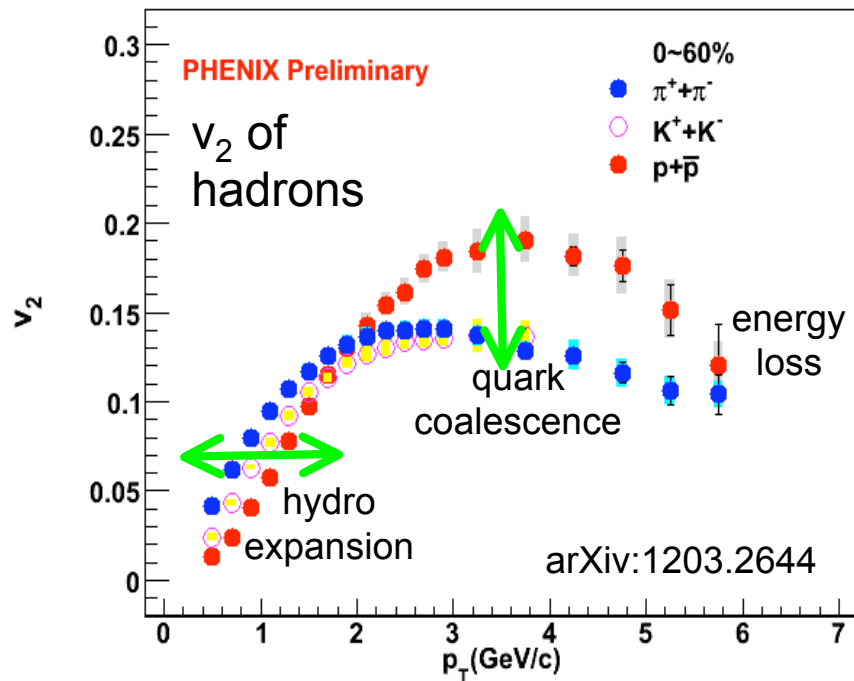
Charge dependences of the 2-particle and R.P. correlation are observed similarly in various experimental studies...

Simulations can not easily explain the measurements...

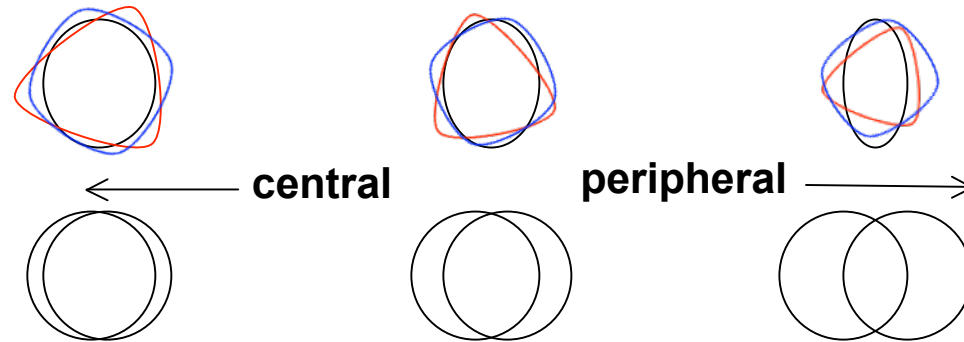
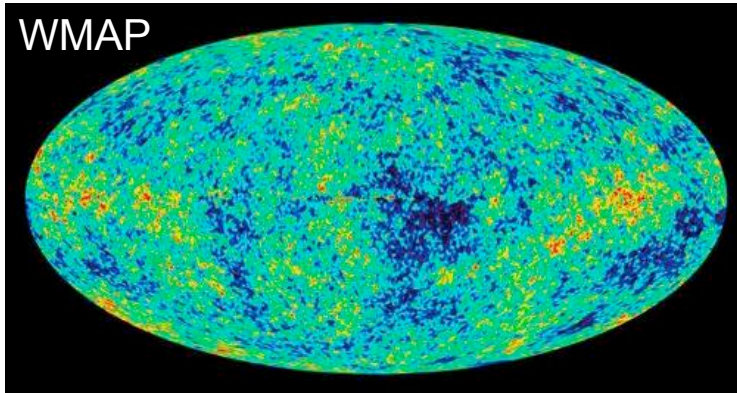
Collective expansion and freeze-out



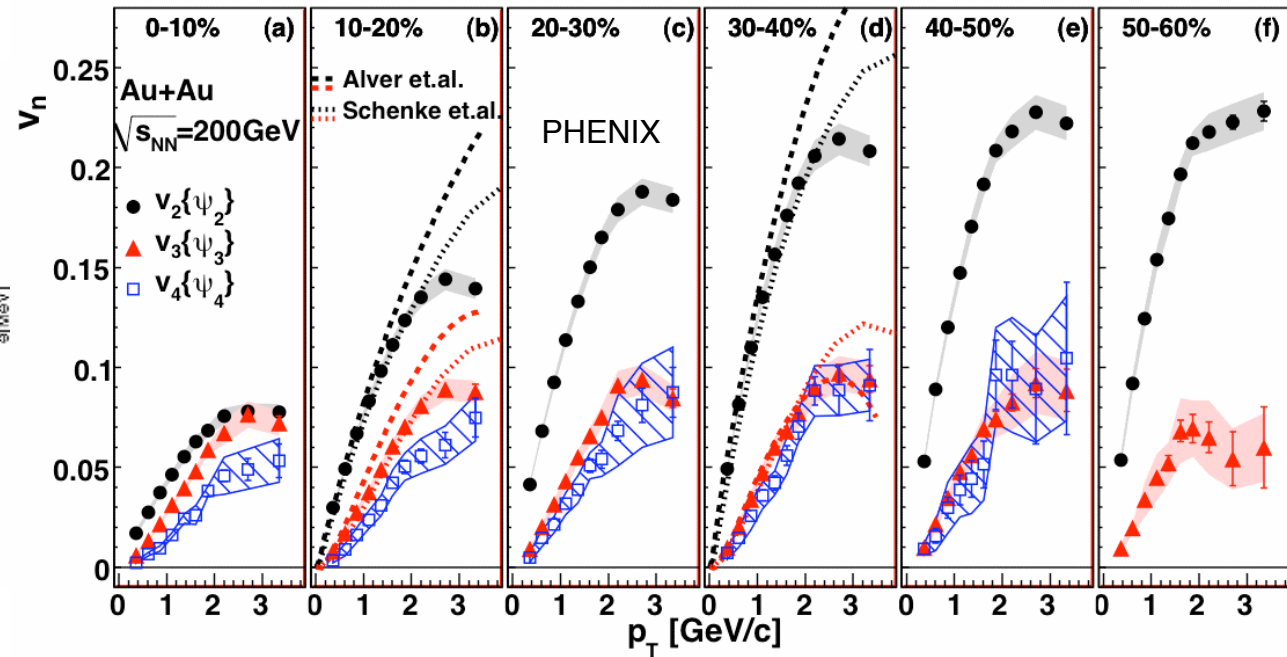
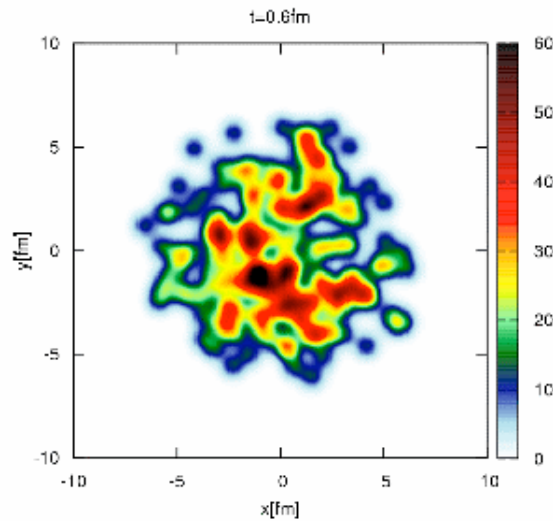
arXiv:1105.4126



Initial fluctuation followed by collective expansion



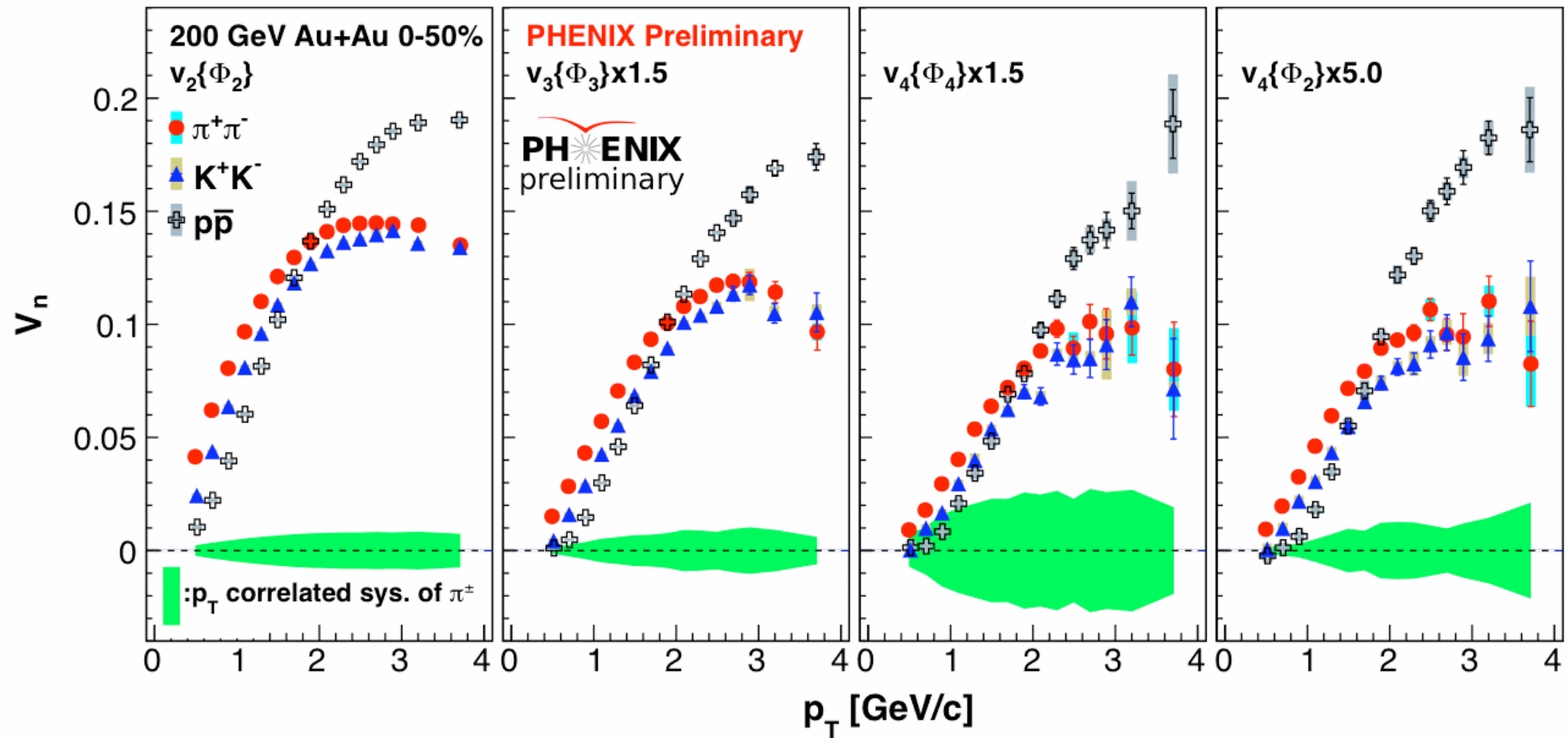
initial density distribution



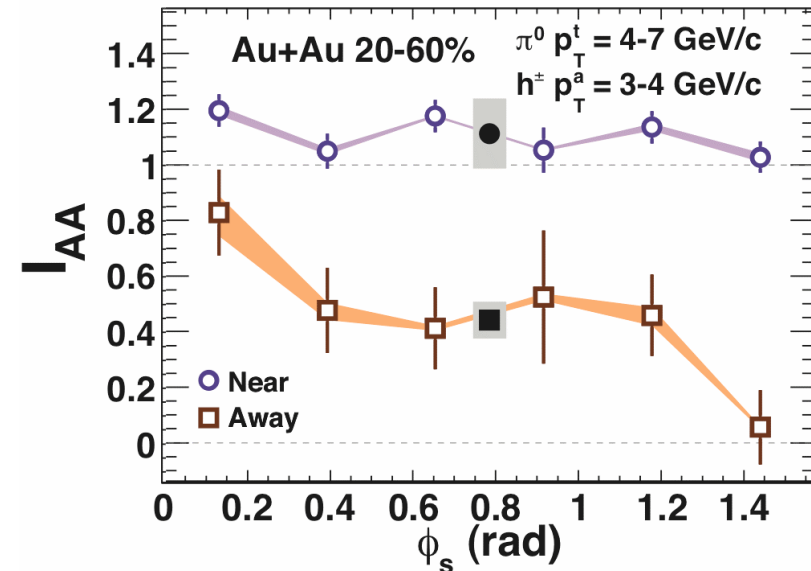
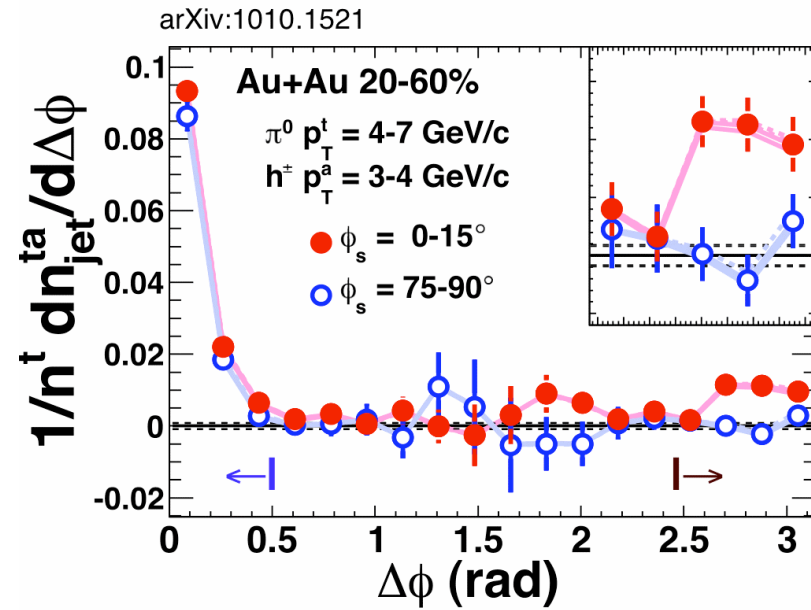
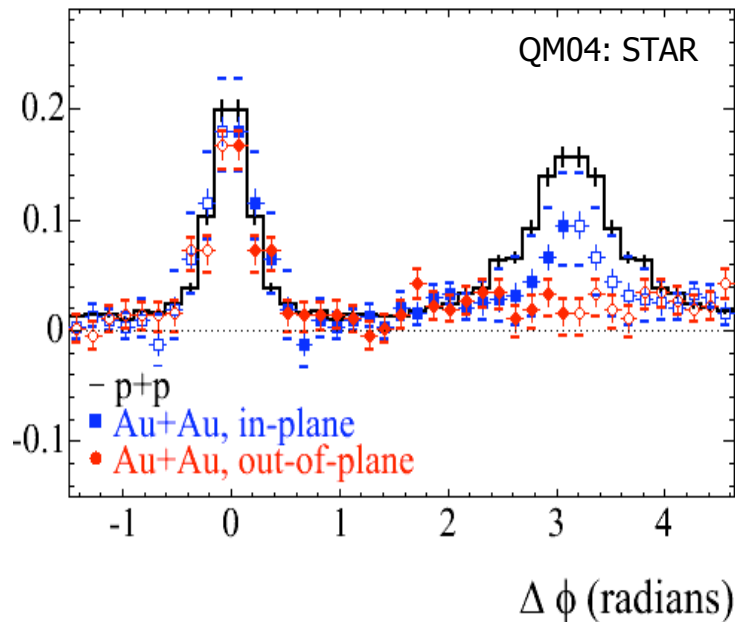
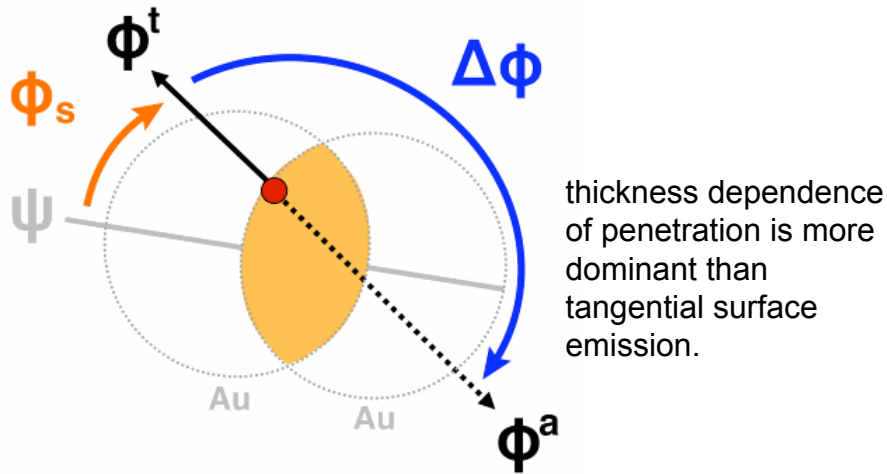
determination of initial conditions and hydro-dynamic parameters of QGP

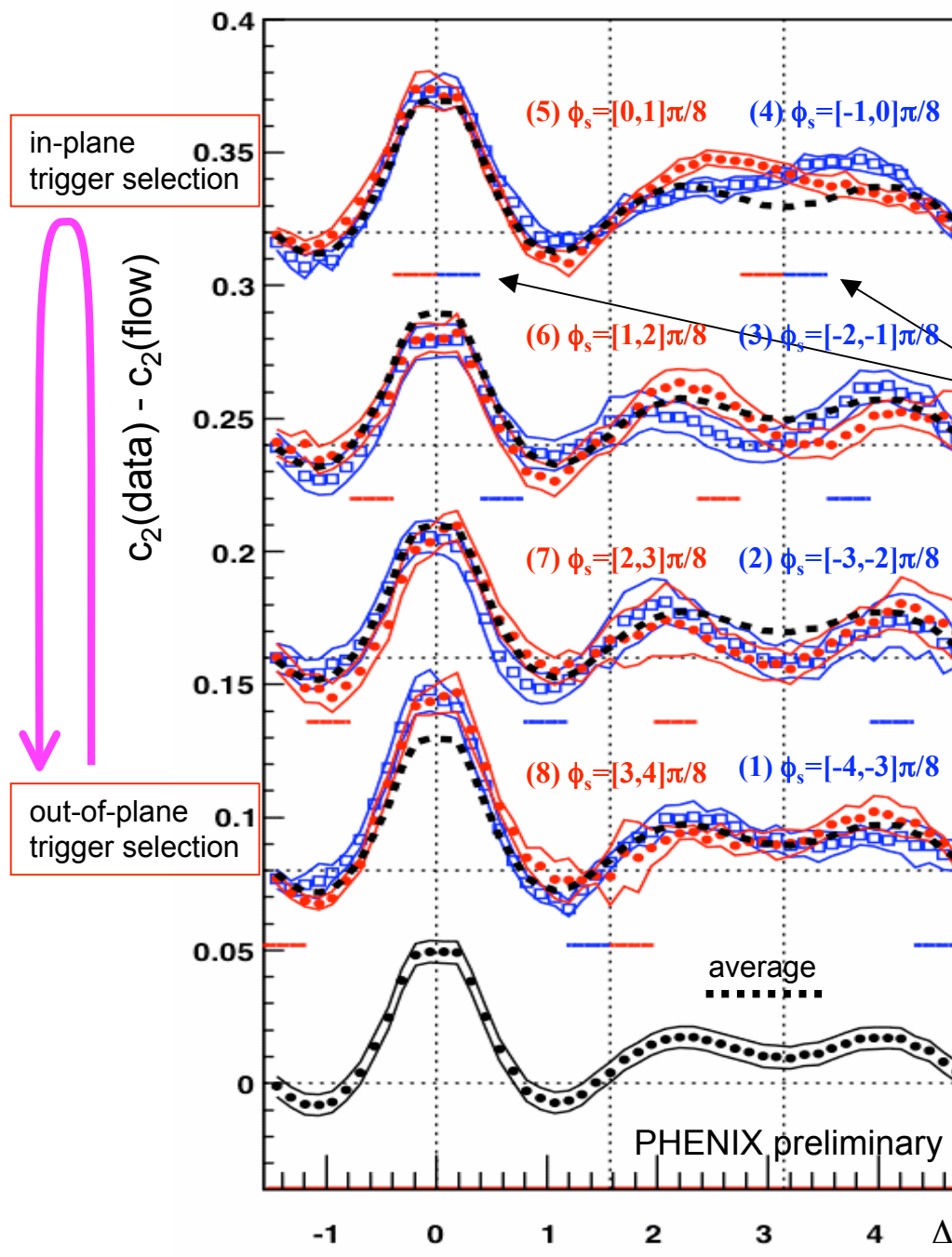
PRL107, 252301 (2011)

Identified particle higher order event anisotropy



Reaction plane (path length) dependent energy loss
 --- one of dominant sources of v_2 at high p_T ---

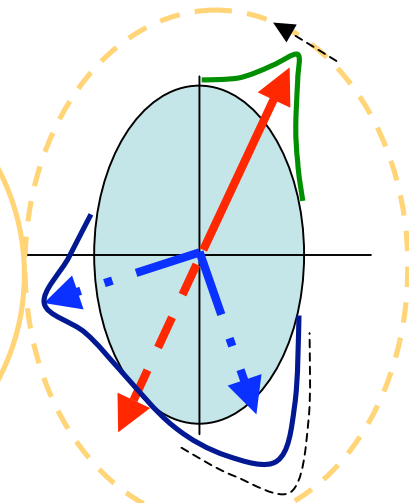
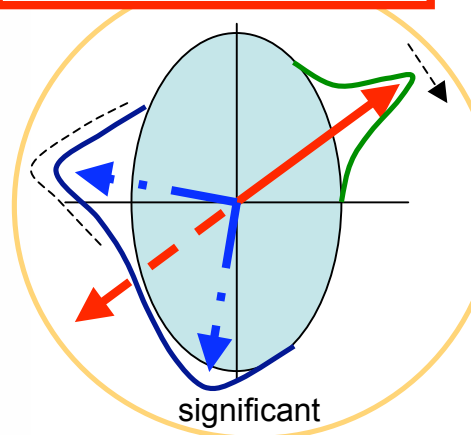
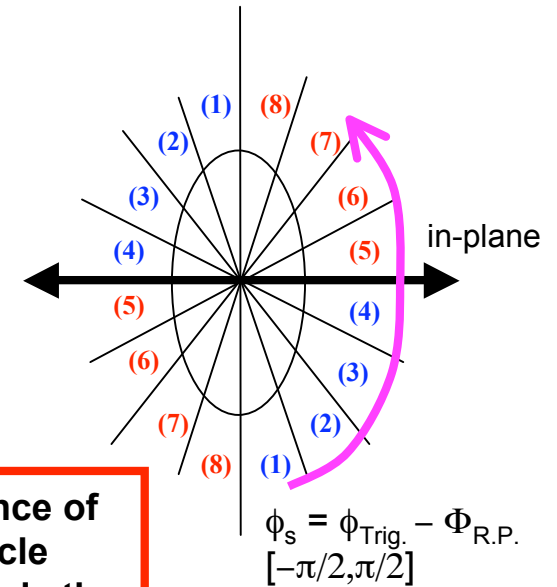




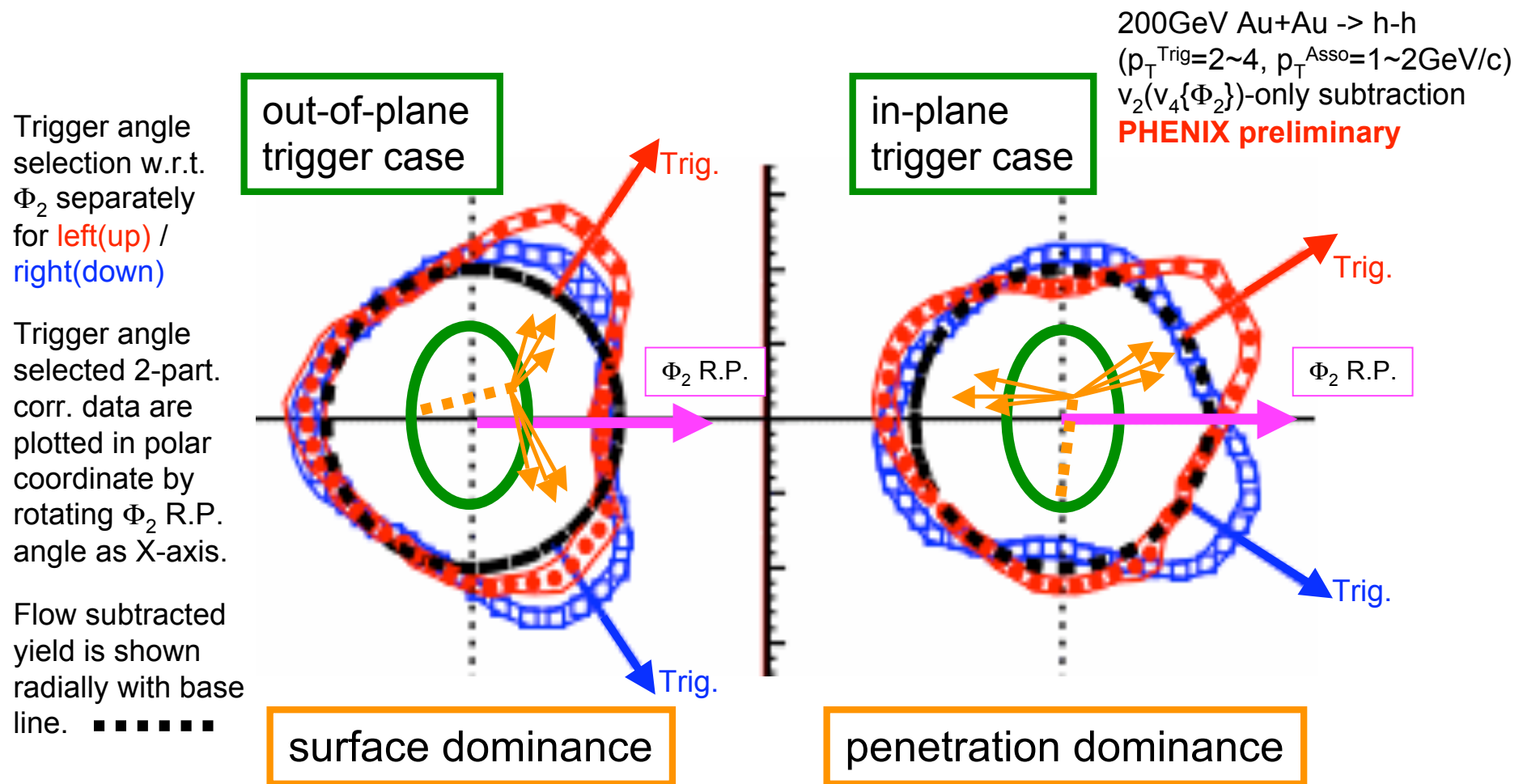
200GeV Au+Au → h-h (run7)
 $(p_{\text{T}}^{\text{Trig}}=2\sim 4\text{ GeV}/c, p_{\text{T}}^{\text{Asso}}=1\sim 2\text{ GeV}/c)$
 mid-central : 20-50%

in-plane
associate
regions

**strong preference of
associate particle
emission towards the
in-plane direction**



Observed left/right asymmetry remains after “the usual/normal” v_3 subtraction.



Two competing processes seen