Analysis method to extract possible ridge and flow signal in small systems and application to high multiplicity events in 510 GeV p+p collisions at RHIC PHENIX experiment

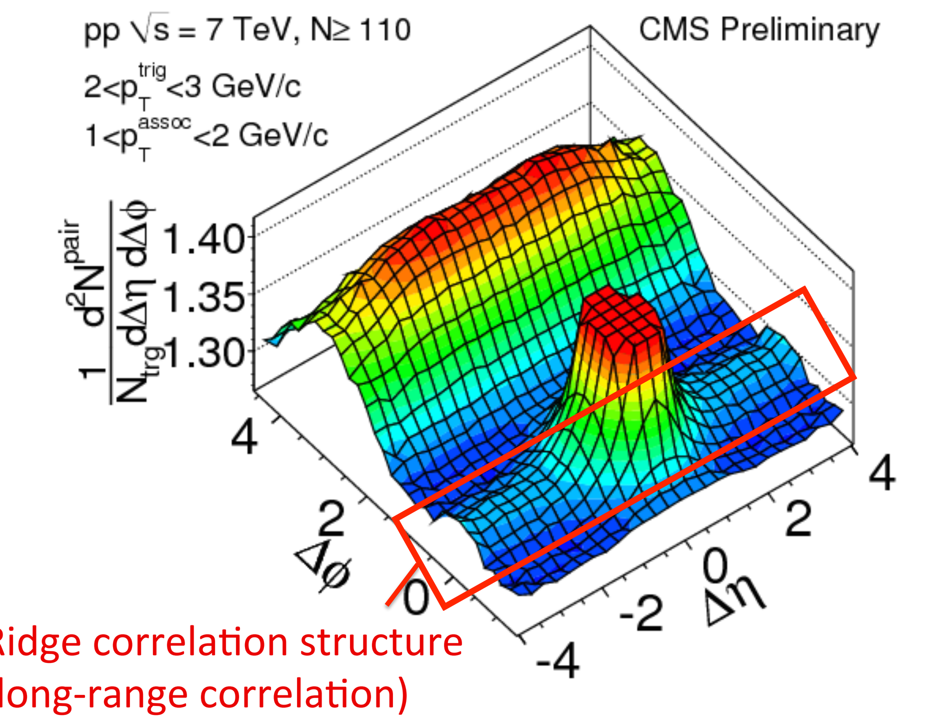
Yusuke Fukuda for the PHENIX Collaboration (Univ. of Tsukuba)

Introduction

Elliptic flow and ridge-like correlation have been observed in heavy-ion collision and they are considered as important probes for understanding the hydrodynamic properties of Quark-Gluon-Plasma. The ridge and v_2 are also measured in d+Au and ^{3}He+Au collisions at RHIC, and in p+p and p+Pb collisions at LHC, therefore these observation have raised a great interest whether a similar hot and dense matter observed in heavy ion collision is also formed in small systems or not.

510 GeV p+p collisions were operated at RHIC in 2013. So far there are no results on correlations in p+p collisions at RHIC yet. However, p+p at 510 GeV collisions provide the highest multiplicity p+p collisions at RHIC, so comparison of p+p measurements of azimuthal anisotropy at different energies could provide an important insight on multiplicity and collision energy dependent studies with small collision systems. This poster shows some analysis methods and simulation results in p+p collision at 500 GeV and 200 GeV.

arXiv:1107.2196 [nucl-ex] (2011)

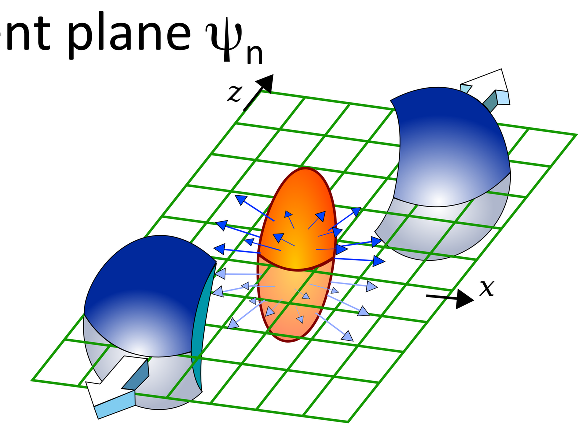


Ridge correlation structure (long-range correlation)

Azimuthal anisotropy

The number of emitted particles is defined by following formula and azimuthal anisotropy of elliptic flow is defined as a correlation between azimuthal angle of particle ϕ and event plane ψ_n

$$\frac{dN}{d\phi} \propto 1 + \sum_{n=1} 2v_n cos(n[\phi - \psi_n])$$

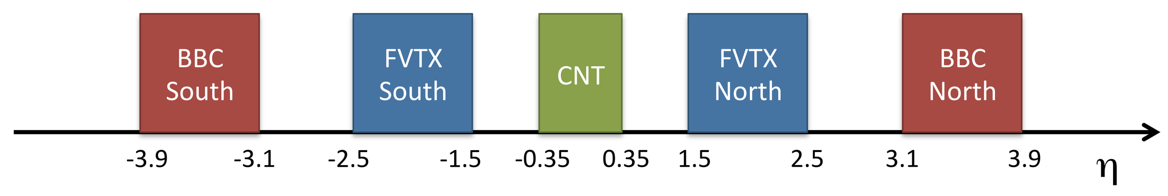


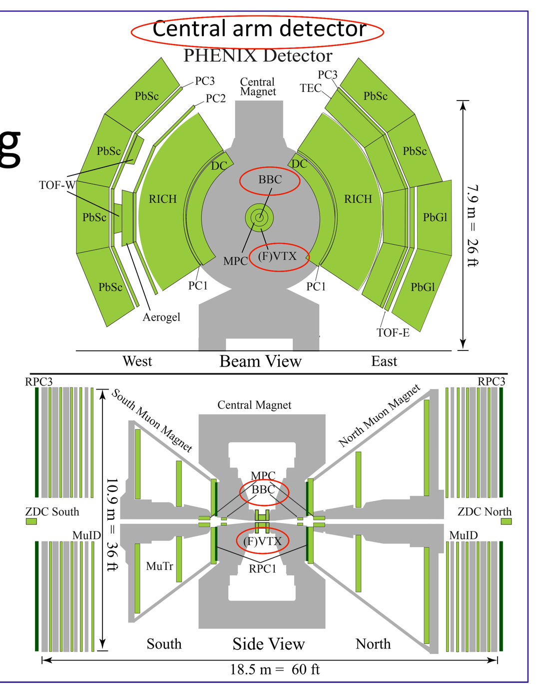
where term of n=2 express intensity of Elliptic anisotropy. (Elliptic flow)

PHENIX detector

In order to see long-range correlation , the following detectors are used in this analysis.

- Central arm detector(CNT) $|\eta|<0.35$
- Forward vertex detector(FVTX) $1.5<|\eta|<2.5$
- Beam-Beam-counter(BBC) $3.1<|\eta|<3.9$





Method

Two-Particle correlation method

Correlation function is defined as a function of relative azimuthal angle and rapidity differences between trigger particle and associate particle.

$$\Delta\phi_{ij} = \phi_{i,asso} - \phi_{j,trig}$$
$$\Delta\eta_{ij} = \eta_{i,asso} - \eta_{j,trig} \quad i,j: event\ number$$

The i=j event is called Real event and the i ≠ j event is called Mixed event. In order to remove the effect of acceptance and efficiency of detectors from signals, distribution of Real event is divided by that of mixed event.

$$C(\Delta\phi) = \frac{Y_{Real}(\Delta\phi)}{Y_{Mix}(\Delta\phi)} \frac{\int Y_{Mix}(\Delta\phi) d\Delta\phi}{\int Y_{Real}(\Delta\phi) d\Delta\phi}$$

Reference fitting method

Unmodified jet contribution is subtracted from correlation function.

Peripheral(Low-multiplicity) or MB data

$$f(\Delta\phi) = (C(\Delta\phi) - min)/(max - min)$$

a,b : Free parameters

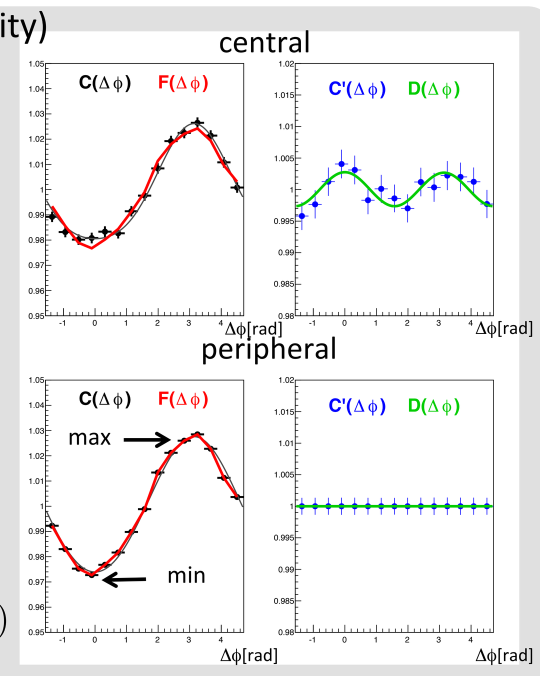
$$F(\Delta\phi) = a + b * f(\Delta\phi)$$

Unmodified jet contribution is subtracted

$$C'(\Delta\phi) = C(\Delta\phi) - F(\Delta\phi) + 1$$

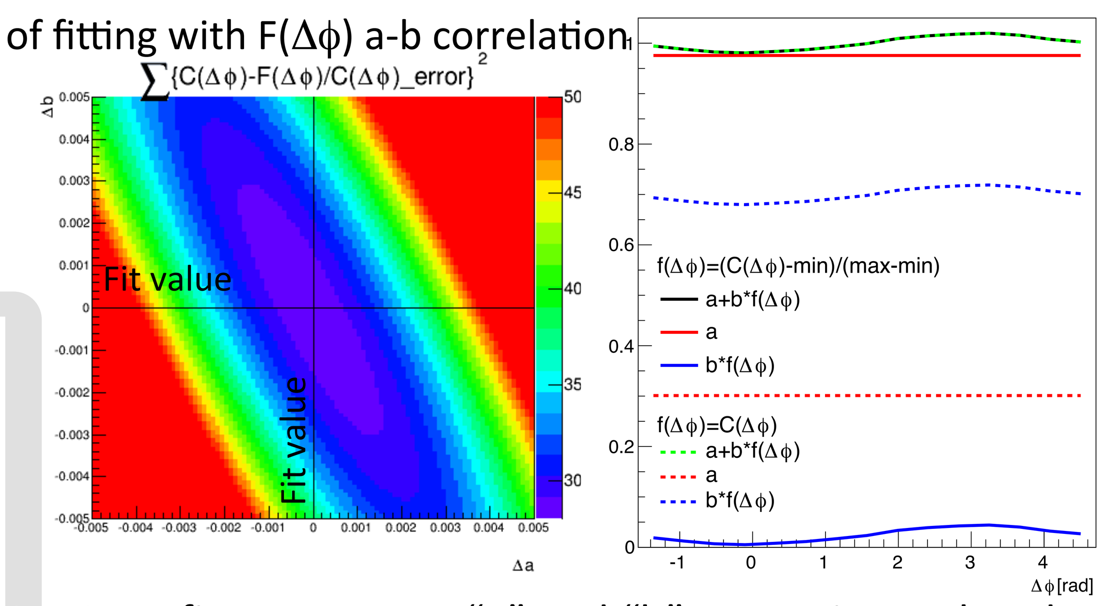
Extract c_n parameters from C'(Δφ) by fitting with D(Δφ)

$$D(\Delta\phi) = 1 + 2c_1 cos(\Delta\phi) + 2c_2 cos(2\Delta\phi)$$



MB(Minimum Bias)-> BBC charge south > 0 && BBC charge north > 0

χ^2 of fitting with F(Δφ) a-b correlation

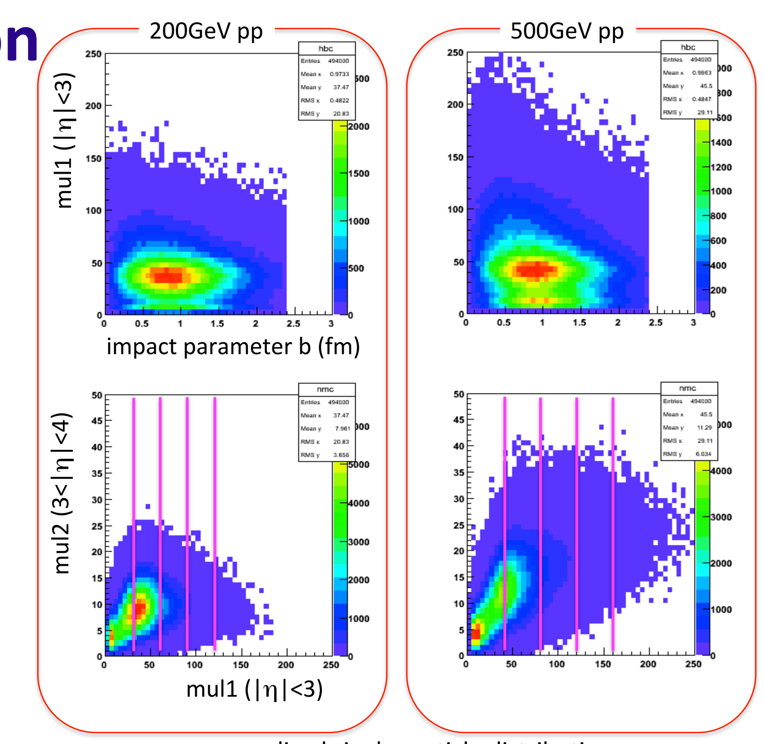


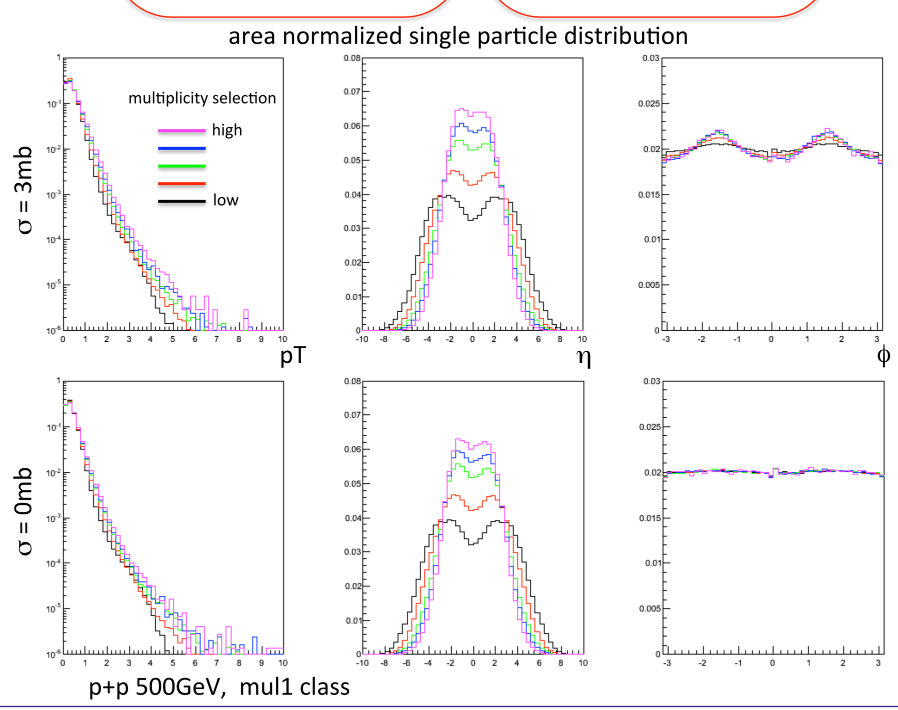
Free fit parameters "a" and "b" are anti-correlated. With re-normalization of f(x), the meanings of a, b parameters of F(x) become clear, a : BG level (uncorrelated part), b : signal level (correlated part). A clear physical separation between correlated and un-correlated signals would anyway not be possible, this is just a mathematical separation to see a small change of correlated signal shape.

Simulation

p+p in AMPT simulation

- beam energy at 200 , 500 GeV
- string melting on with σ = 0 , 3 mb
- multiplicity class mul1 (|η|<3) , mul2 (3<|η|<4)
- particles pairs in |η|<3 , |η|<1 & 3<|η|<4
- η-gap cut 2.5<|Δη|<5.0
- single pT cut pT > 0.2 GeV/c

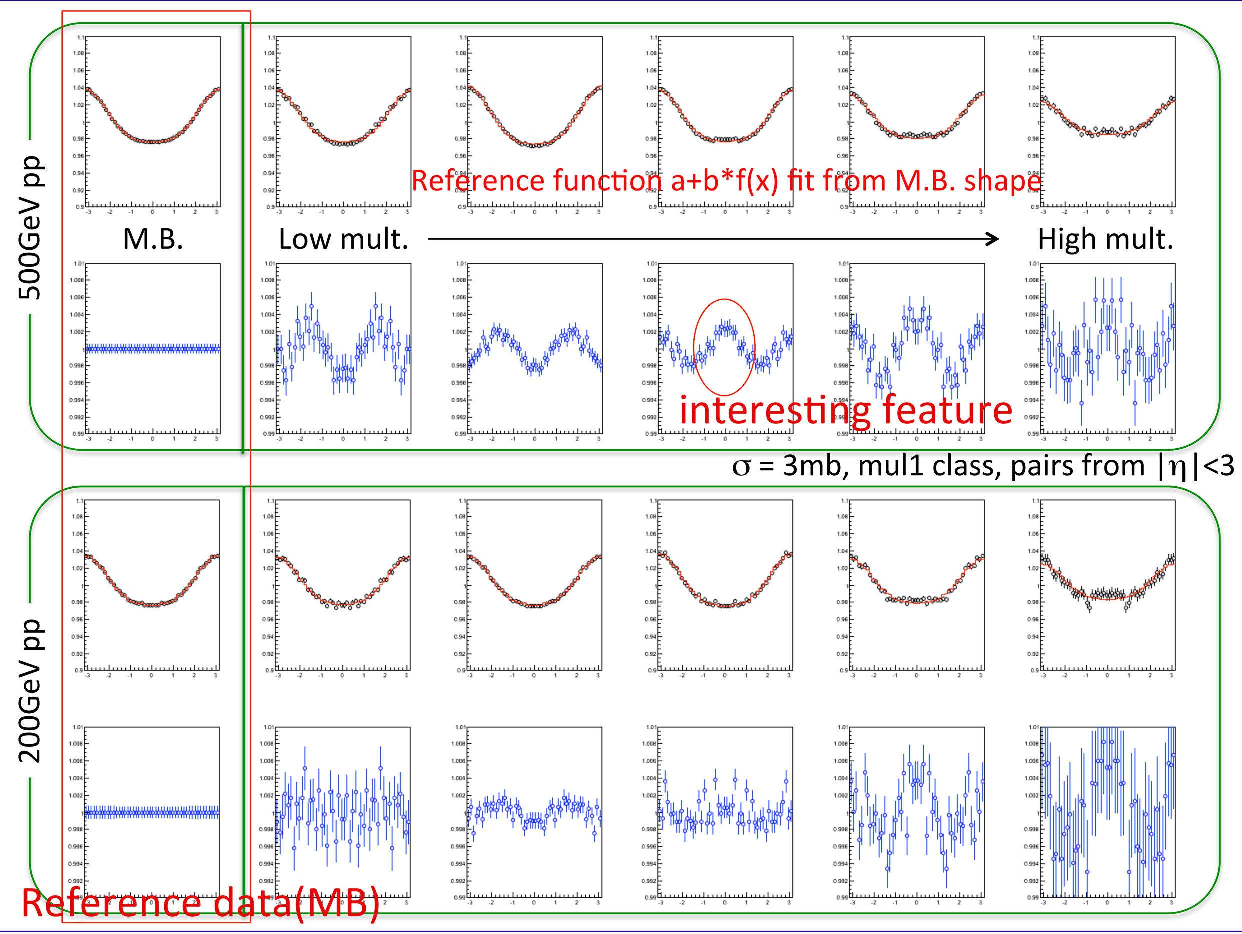




Reference fitting results

With finite partonic cross section(σ ~ 3 mb), change of correlation shape with multiplicity is seen in AMPT. (just like the hydro model calculation in pp)

- Signal becomes larger as multiplicity becomes higher.
- Signal at 500GeV can be seen more clearly compared to 200GeV.



Summary & Outlook

- ✓ Two-particle correlation method and Reference fitting method were presented.
- ✓ Simulation results will be compared to understand mechanism.
- ✓ I'm working on extraction of ridge-like correlation by studying CNT-BBC, CNT-FVTX, BBCs-BBCn, and FVTXs-FNTXn pairs using methods described in this poster.
- ✓ Plan is to extract flow signal and study it in dependence on collision energy, p_T and multiplicity.