Charge-to-Neutral fluctuation in AuAu collisions at forward rapidity at RHIC

Prithwish Tribedy (for the STAR collaboration) [1*]
Variable Energy Cyclotron Centre, 1/AF Bidhan Nagar, Kolkata-700064, India

Introduction

Event-by-event fluctuation of the ratio of multiplicities of charged and neutral particles at forward rapidity in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 & 39 GeV has been studied. As the detected charged and neutral particles are mostly from the charged pions and the decay of neutral pions respectively, this analysis addresses isospin fluctuation of pions. Signals of anomalous fluctuation in the relative pion production of different isospin predicted to occur for a system going through the QCD chiral phase transition[1]. This is expected to appear in the form of charged and neutral anticorrelation and has been searched previously in SPS (Pb+Pb) and Minimax (p+p) experiments. Our study in the STAR experiment at RHIC includes measurements of charged particles and photon multiplicity using the Forward Time Projection chamber (FTPC) and the Photon Multiplicity Detector (PMD) respectively.

Experiment

The measurement of charged and photon multiplicities is done within pseudo-rapidity interval of -3.7 $< \eta <$ -2.8. For the measurement of charged tracks using FTPC the quality criteria used for charged track selection are, DCA<3 cm, 0.1< p_T <1.5 GeV/c, and number of fit points >5. For photon-hadron discrimination, we apply a threshold on PMD clusters of 6×MIP(Minimum ionizing particle) energy deposition and select clusters with number of cells > 1. The collision centrality determination is done from the uncorrected multiplicity distribution of the charged

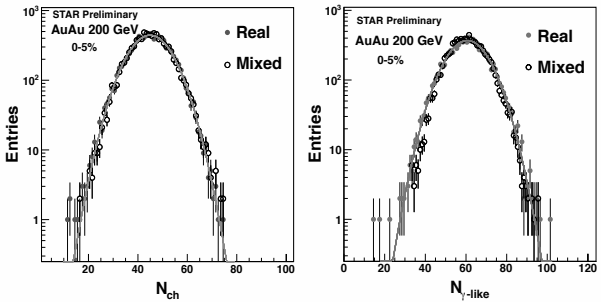

FIG. 1: Multiplicity distribution of charged particles and photons respectively for 0-5% top centrality. The solid lines represent Gaussian fits to Real event data points.

tracks measured by Time Projection Chamber (TPC). For mixed event analysis we keep total number of raw tracks of FTPC and clusters of PMD to be constant. We mix events in a given centrality and with collision vertex bin of 10 cm. All the simulations using different event generators like AMPT, UrQMD and HIJING [4] are done using similar kinematic cuts as used for data. The observables for charge-to-neutral fluctuation have to be robust against detector efficiencies and at the same time sensitive to small signals of $\gamma - \mathrm{ch}$ correlation. The observable $\nu_{dyn}^{\gamma-\mathrm{ch}}$ was introduced in Ref [2] and is defined as

$$\nu_{dyn}^{\gamma-\mathrm{ch}} = \frac{\langle N_{\mathrm{ch}}(N_{\mathrm{ch}}-1)\rangle}{\langle N_{\mathrm{ch}}\rangle^2} + \frac{\langle N_\gamma(N_\gamma-1)\rangle}{\langle N_\gamma\rangle^2} - 2\frac{\langle N_{\mathrm{ch}}N_\gamma\rangle}{\langle N_\gamma\rangle\langle N_{\mathrm{ch}}\rangle}$$

which for Poissonian case should give zero. The variable $r_{m,1}$, introduced in Ref[3] is defined as

$$r_{m,1}^{\gamma-\mathrm{ch}} = \frac{\langle N_{\mathrm{ch}}(N_{\mathrm{ch}}-1)..(N_{\mathrm{ch}}-m+1)\,N_\gamma\rangle\langle N_{\mathrm{ch}}\rangle}{\langle N_{\mathrm{ch}}(N_{\mathrm{ch}}-1)..(N_{\mathrm{ch}}-m)\rangle\langle N_\gamma\rangle}.$$

It is designed such that for all the moments it gives a value equal to 1 for Poisson case and higher order moments show larger sensitivity to signals.

*Electronic address: ptribedy@vecc.gov.in

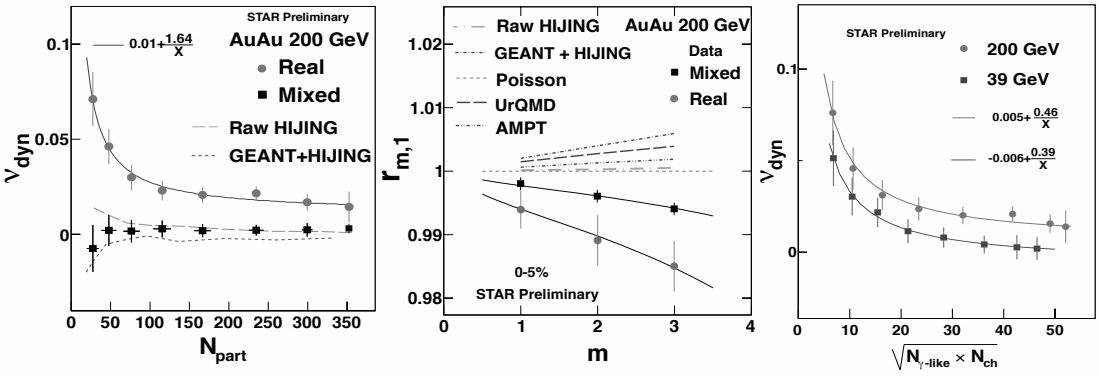

FIG. 2: Left: Variation of $\nu_{\rm dyn}$ number of participants. Middle: Variation of $r_{m,1}$ with its order m. The solid lines represent fits by functional for described in the text. Right: Energy dependance of $\nu_{\rm dyn}$.

Results and discussion

Fig.1 shows the multiplicity distribution of charged tracks and photons-like clusters detected by FTPC and PMD respectively. In Fig.2 left we plot the variable $\nu_{\rm dyn}^{\gamma-{\rm ch}}$ with $N_{\rm part}$ for real and mixed events. We have fitted the data points for real events with a function of the form $A + B/N_{\rm part}$ ($\chi^2/dof = 1.1/6$). In the same plot we show the Raw HIJING and HIJING + GEANT results for comparison. The middle panel of Fig.2 shows the variation of $r_{m,1}$ with its higher order moments for $0-5\%$ centrality. The data points are fitted with a function of the form $1 - m\xi/(m+1)$ with ξ being a free parameter can be shown to be related to strength of anti-correlation[5]. The right plot of Fig.2 shows the multiplicity dependance of $\nu_{\rm dyn}$ for 200 GeV and 39 GeV both fitted with functions of the form $A + B/\sqrt{N_\gamma N_{\rm ch}}$ ($\chi^2/dof = 1.44/6$ & $0.13/6$ respectively). For a given multiplicity $\nu_{\rm dyn}$ is higher for higher energy.

Summary and conclusion

Charge-to-neutral multiplicity fluctuation has been studied in forward rapidity. Data was compared to Raw HIJING, mixed event and GEANT Simulation. Energy dependence of fluctuation variable was studied for 200 GeV and 39 GeV. The variable $\nu_{\rm dyn}$ seems to be close to zero (Poissonian) for HIJING and Mixed-Event. For data it has non-zero values which implies presence of non statistical fluctuation.

The GEANT simulation results are also very close to zero except towards lower centrality it is slightly negative. Which is also consistent with Poissonian case with some contamination effect. The data values are positive which indicate the presence of anti-correlation signal. $\nu_{\rm dyn}^{\gamma-{\rm ch}}$ shows a $A + B/X(X = N_{\rm part}, \sqrt{N_\gamma N_{\rm ch}})$ type centrality dependence for both energies. This dependance is consistent with the prediction of Central Limit Theorem(CLT)[5].

Higher moments of $r_{m,1}$ show opposite trend (slope) compared to different models and GEANT simulation. Data has stronger dependence (higher ξ) than mixed event with m which is consistent with signals of anti-correlation [5]. Both the variables give similar conclusion that we observe a non-zero dynamical signal in the form of anti-correlation and has higher strength for 200 GeV than 39 GeV.

References

[1] J.D. Bjorken, What lies ahead?, SLAC-PUB-5673, 1991.
[2] C. Pruneau *et al.* Phys. Rev. C **66**, 044904 (2002)
[3] T. C. Brooks *et al.* Phys. Rev. D **55**, 5667 (1997)
[4] X. N. Wang *et al.*, Phys. Rev. D **44**, 3501(1991), Z. W. Lin *et al.*, [nucl-th/0411110], S. A. Bass *et al.*, [nucl-th/9803035].
[5] P. Tribedy, S. Chattopadhyay and A. Tang, arXiv:1108.2495