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Selection of Rare AuAu Events at Trigger Level 0

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Abstract

This work verifies previous calculations [1] for the separation of events with isospin fluctuations or anomalously low transverse momenta from standard AuAu events with more up-to-date simulations and more realistic assumptions for Bose Einstein and Chiral Condensates. Trigger capabilities using EMC and CTB for these kinds of anomalous events are shown.

1 Introduction

One aim of STAR is the search for signatures of the Quark-Gluon-Plasma (QGP). An observable related to the GQP is the isospin content of an event. Bjorken predicts that the ratio of charged particles to neutral particles may fluctuate due to the production of a highly excited, colorless system whose isospin orientation may be arbitrary [2]. These kinds of anomalous events are called (Disoriented) Chiral Condensates.

Another hint for the existence of the QGP is the emission of identical pions from a source whose density exceeds the critical density at which quantum interference and symmetrization effects become strong. One observable resulting from this effect is a reduction in the momenta of the produced pions [3]. These kinds of events are referred to as Bose Einstein Condensates.

Previous calculations using the event generator FRITIOF [1] predict a very good selection of rare AuAu events like the ones described above, but these simulations were done for only 10 events of each kind and with a not yet very detailed STAR geometry in GEANT. The simulations presented here verify these plots, but show a picture that is not as optimistic regarding the selection of these rare events.

2 New Simulations

For these new calculations the full simulation chain including HIJING, GEANT and TAS was used. The statistics was enhanced from 10 events of each sort in the CDR [1] to 50-70 events. Standard central ($b = 0 \cdots 2.5\ fm$) HIJING AuAu events were manipulated to obtain anomalous events as follows; for Chiral Condensates 50% of the charged pions were changed to π°, whereas for Bose Einstein events the momenta of all pions were reduced by 30% and (in contrast with the Bose Einstein events in the CDR [1]) 30% more pions with low momenta were added. These manipulations were done with the program readhij.f [4] which in addition throws away every particle with $|\eta| \geq 1$. The response of the EMC and the CTB to these kinds of phenomena is shown in Fig. 1 in which the energy deposited in the scintillator of the EMC is plotted versus the charged particle multiplicity in the CTB for standard HIJING AuAu events, Chiral Condensates, and Bose Einstein Condensates at $\sqrt{s} = 200\ GeV$. The points lie along straight lines. The values for a larger impact parameter range ($b = 0 \cdots 14.0\ fm$) for standard AuAu events show that these lines go through the origin. Centrality of the events can be guaranteed by either a cut at the CTB multiplicity or the energy in the EMC.

Fig. 1 makes it clear that the crucial parameter for separating anomalous events from standard AuAu events is the energy deposition in the EMC per charged particle in the CTB. In fig. 2 a) this parameter is shown for the events plotted in fig. 1. Fig. 2 demonstrates that a separation using EMC and CTB information is possible at the trigger level. On Day-1 STAR won't have a full barrel EMC; probably a quarter of the EMC towers will be operational at this time. Fig. 2 b) shows what this would mean for the separation of rare AuAu events. The resolution decreases but triggering on anomalous events should still be possible. The mean and RMS values for the distributions in fig. 2 can be found in tab. 1. The mean values for E_{EMC}/N_{CTB} are the slopes of the straight lines in fig. 1.
The event variation around the lines in fig. 1 which is also reflected in the width of the distributions in fig. 2 can not be explained by means of detector resolution. Assuming a CTB resolution of 2% for AuAu events [5] and $\Delta E/E = 16\%/\sqrt{E} \approx 0.5\%$ for the EMC [1] the relative error for the energy in the EMC per particle in the CTB is $\sqrt{(2\%)^2 + (0.5\%)^2} = 2.06\%$ for a single event and $2.06\%/\sqrt{N} < 0.3\%$ for the mean value. That is one order of magnitude smaller than the width of the distribution in fig. 2.

There are various predictions for the behavior of Chiral Condensate events [6] and only experiments will tell the true nature of this effect. In fig. 3 some other assumptions for Chiral Condensates are compared with the above assumption that 50% of the charged pions will convert to neutral pions.

One unknown parameter for Chiral Condensation is the strength of the isospin fluctuation, i. e. the percentage of charged pions which convert to neutral pions. Assuming a

conversion of only 40% or 20% of the charged pions the energy per particle distributions shift toward the distribution for standard AuAu events. This effect is demonstrated in fig. 3 a).

More likely than a conversion of every pion are isospin fluctuations only for pions with low momenta. The effect of the assumption that only pions with momenta less than a certain maximum convert is pictured in fig. 3 b), where $|p| \leq 500\ MeV$ means that the $\approx 63\%$ of all pions with the lowest momenta show a isospin fluctuation, whereas only about 34% of the pions have momenta less than 300 MeV and were changed to π° in this case.

Another unknown parameter is the rate of Chiral Condensates in comparison to the rate of standard AuAu events. There may be only a small percentage of all events that have isospin fluctuations. Fig. 4 illustrates the separation of the different types of Chiral Condensates shown in fig. 3 when standard AuAu events are scaled to 10^8 events (28 hours at 1000 Hz) and Chiral Condensates are scaled to $10^7 \ldots 10^5$ events, i. e. a ratio of standard to Chiral Condensate events of $10\% \ldots 0.1\%$ is assumed.

Table 1: Mean and RMS values for the energy per particle distributions in fig. 2 from PAW

	full barrel		1/4 barrel	
	Mean/MeV	RMS/MeV	Mean/MeV	RMS/MeV
Bose Einstein Condensates	24.09	0.72	6.025	0.349
standard AuAu events	27.83	0.95	6.963	0.397
Chiral Condensates	30.33	1.26	7.581	0.456

3 Conclusions

The discussed simulations show that the selection of rare AuAu events is not as easy as previous simulations using standard FRITIOF events [1] would imply, but triggering on anomalous events should still be possible depending on the strength of the phenomena. The simulations make clear that both EMC and CTB information are necessary for the selection of anomalous AuAu events at trigger level 0.

The variations in the behavior of the events can not be explained by detector resolution, but are a true physical effect.

References

[1] The Electromagnetic Calorimeter for the Solenoidal Tracker At RHIC(STAR) - A Conceptual Design Report, PUB-5380, September, 1993

[2] J.D. Bjorken, Acta Physica Polonica **B32**, 637 (1992)

[3] S.Pratt, Phys. Lett. **B301**, 159 (1993)

[4] readhij.f - Program for manipulating standard HIJING AuAu events, ©G. Westfall 1995, changed B. Hübner 1996

[5] P. Yeppes, private communication

[6] S. Gavin, A. Gocksch and R. D. Pisarski, Phys. Rev. Lett. **72**, 2143 (1994)

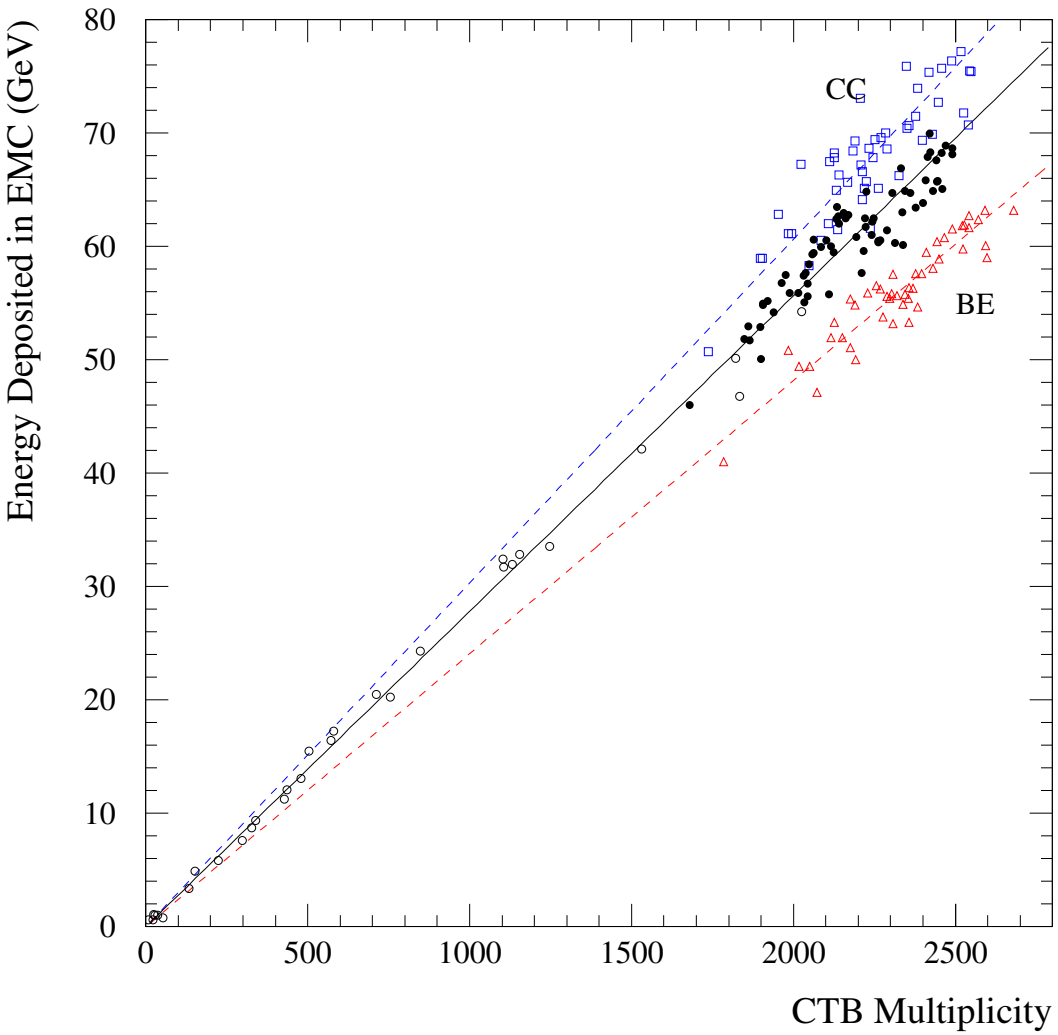

Figure 1: Energy deposition in the EMC (in scintillator only) versus particle multiplicity in the CTB for standard AuAu events (circles, open circles for 30 minimum bias events, filled circles for 70 central events), Chiral Condensates (squares, 50 events) and Bose Einstein Condensates (triangles, 47 events).

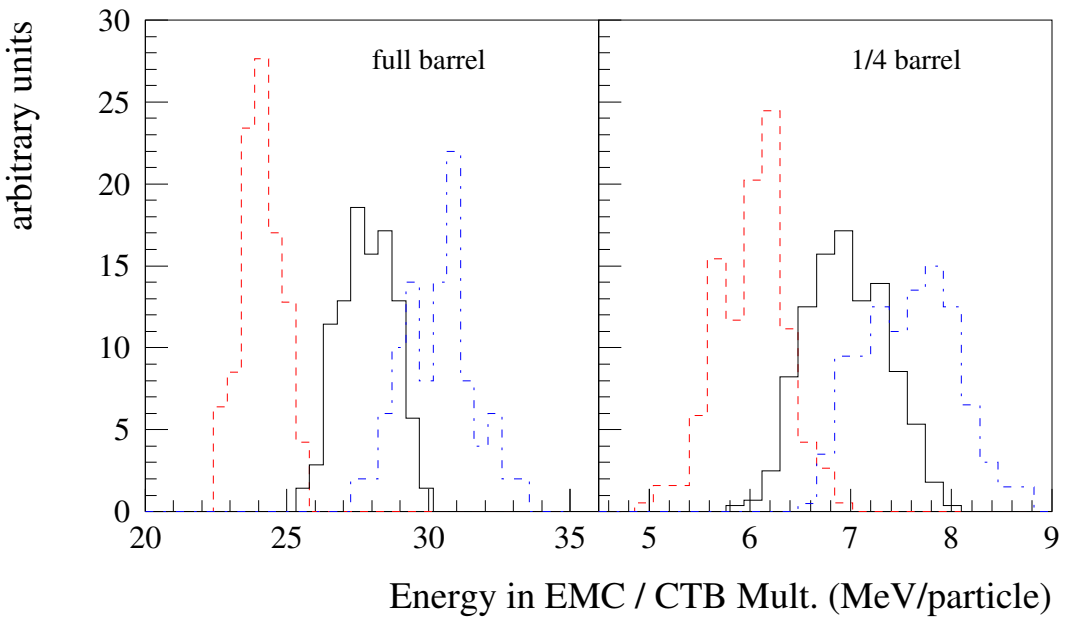

Figure 2: Distributions of energy in the EMC (in scintillator only) per particle in the CTB for standard AuAu events (solid line), Chiral Condensates (dashed dotted line) and Bose Einstein Condensates (dashed line) for the full EMC barrel on the left and for only 1/4 barrel of the EMC available on the right.

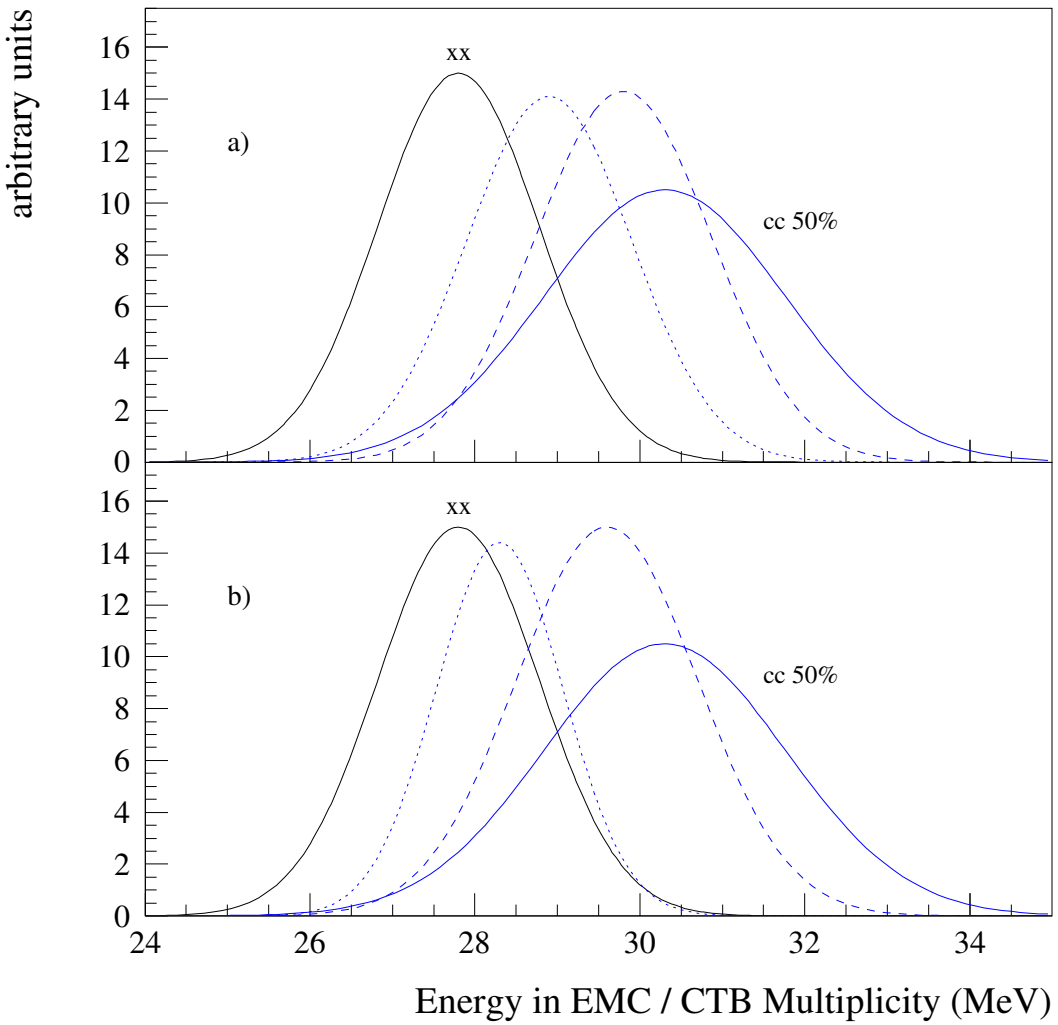

Figure 3: Gaussian fits of the distributions of energy in the EMC (in scintillator only) per particle in the CTB for standard AuAu events (solid line to the left) and different types of Chiral Condensates compared to the assumption of 50% $\pi^{\pm}$ changed to π° (solid line to the right).
a) 40% $\pi^{\pm}$ changed to π° (dashed line) and 20%$\pi^{\pm}$ changed to π° (dotted line)
b) 100% $\pi^{\pm}$ with $|p| \leq 500\ MeV$ changed to π° (dashed line) and 100% $\pi^{\pm}$ with $|p| \leq 300\ MeV$ changed to π° (dotted line)

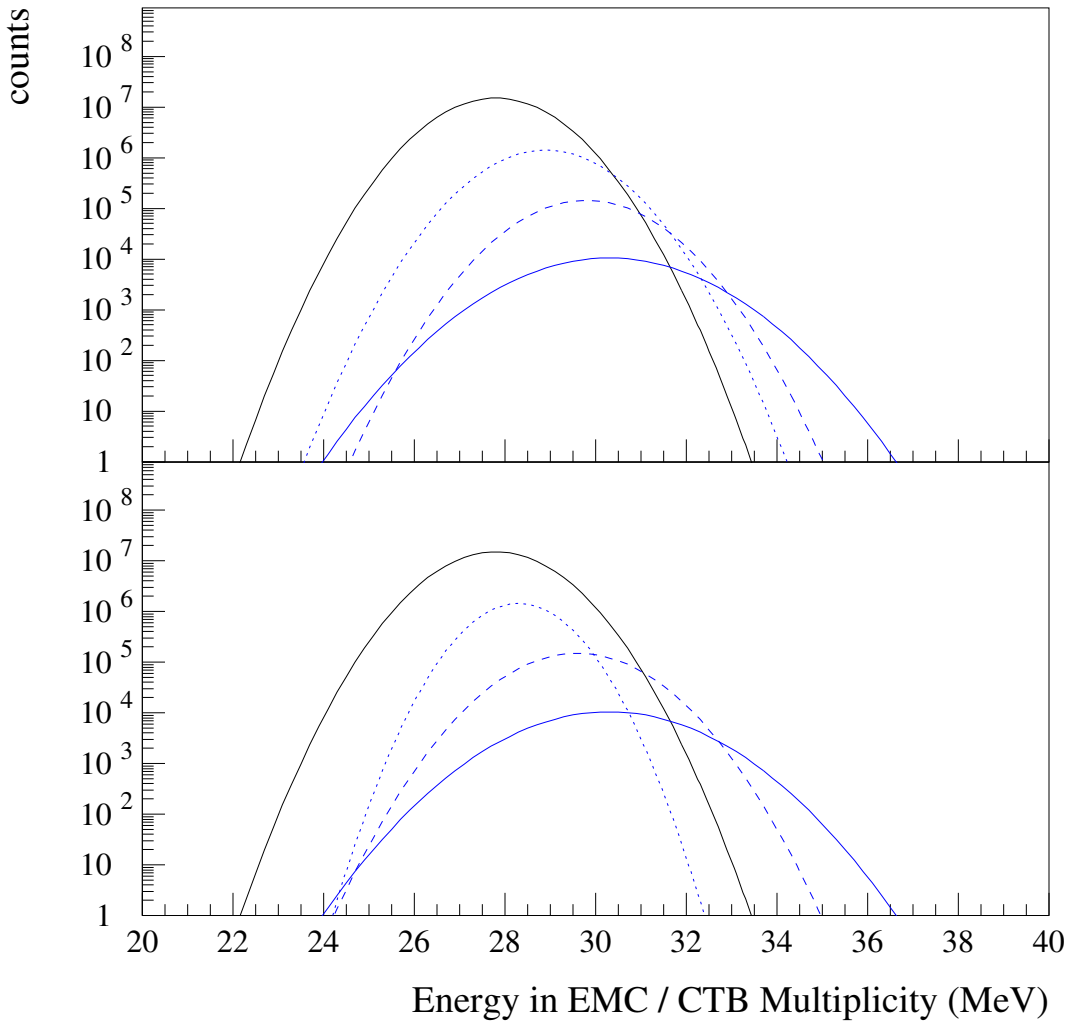

Figure 4: Gaussian fits of the distributions of energy in the EMC (in scintillator only) per particle in the CTB for standard AuAu events (solid line to the left) and different types of Chiral Condensates compared to the assumption of 50% $\pi^{\pm}$ changed to π° (solid line to the right). The standard AuAu events are scaled to 10^8 events, for Chiral Condensates is an effect of 0.1% assumed, i.e. only 10^5 events.
a) 40% $\pi^{\pm}$ changed to π° (dashed line) scaled for an effect of 1% and 20%$\pi^{\pm}$ changed to π° (dotted line) scaled for an effect of 10%
b) 100% $\pi^{\pm}$ with $|p| \leq 500\ MeV$ changed to π° (dashed line) scaled for an effect of 1% and 100% $\pi^{\pm}$ with $|p| \leq 300\ MeV$ changed to π° (dotted line) scaled for an effect of 10%