University of Washington Nuclear Physics Laboratory

STAR Level 1 and 2 Trigger Calibration for Anomalous Event Selection

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1 Introduction

The information available for trigger decisions at level 1 and 2 come from certain fast detector systems in the STAR detector. For the baseline detector information comes mainly from hit counts obtained from the coarsely segmented central trigger barrel or CTB and from the somewhat more finely segmented main TPC wire chambers or MWC. With the EM calorimeter upgrade there would be available neutral and charged energy distributions with considerably finer segmentation. In either case the acceptance of these detectors is certainly restricted to $|\eta| < 2$ but with complete ϕ coverage.

Given these limitations there is need to develop triggering algorithms that use all the information content of the various detector yields to form trigger decisions, within the bandwidth and processing power available with the STAR trigger system. We have approached this problem earlier by developing an autocorrelation analysis technique which can quantitatively measure the deviation of a hit distribution from some standard distribution (the null hypothesis).

More recently I have begun a general study of multiparticle correlation analysis techniques as they might apply to particle and energy distributions in nucleus-nucleus collisions. These techniques contain autocorrelation analysis as a special case. I have connected such correlation analysis to information theory, and especially information entropy measures. These results will be presented elsewhere.

In this paper I consider only a system of generator (HIJET) events augmented by various amounts of anomalous stopped energy in various configurations, described in **??**, and the trigger algorithm represented by the system of autocorrelation and power spectrum analysis described in **??**. The specific goal of this paper is to outline a calibration process for this trigger algorithm from which the ability of the algorithm to reject normal events in a representation space of anomalous events can be determined.

2 Pattern Space

As mentioned above the goal of the autcorrelation analysis is to measure quantitatively the deviation of a hit distribution from some standard distribution (the null hypothesis). The deviation measure can be made multidimensional and can be used to span a space called a pattern space. Within this space events consistent with the null hypothesis ('normal' events) should be concentrated in a localized subvolume, and departures from the null hypothesis or norm should be dispersed from this region depending on the degree of deviation. It is possible then to provide cut surfaces within this space to select prescaled fractions of events which fall into the variously defined acceptance regions.

This procedure is general enough to provide the ability to form a trigger selection hierarchy *on line* in response to observed distributions of normal and possibly anomalous events at detector startup. This flexibility is especially important since at this time there are no *specific* models for anomalies that might be associated with color deconfinement, and that might manifest themselves in anomalous multiplicity and energy distributions. In fact it may be in the nature of any such anomalies that they follow scaling laws such as are found in self-organized critical systems, in which case classical triggering techniques which look for specific topological features would not be applicable.

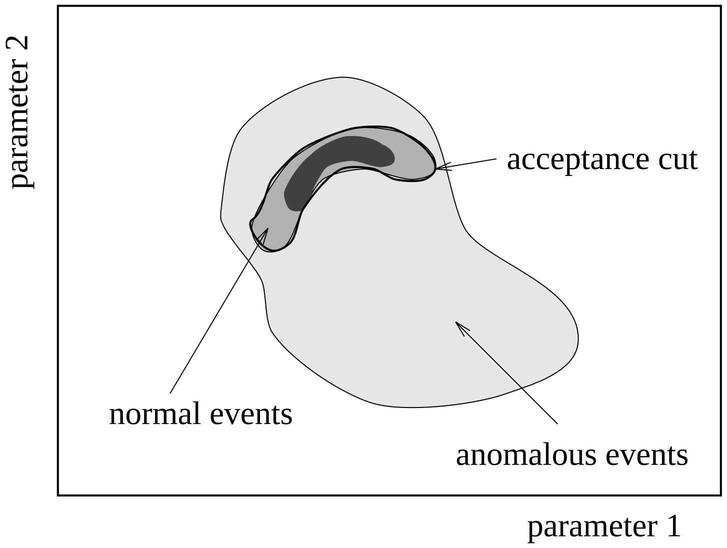

Figure 1: Pattern space

3 Normal and Anomalous Events

We can choose a population of *normal* events from any one of several event generators such as HIJING, HIJET, FRITIOF, VENUS, etc. For each such generator the chosen state of the generator can be represented by a fixed point in a state space (e.g., central event b=0, defined collision system, energy, etc.) For each fixed point in this state space there is a distribution of points in some *pattern space* (determined by the combination of a simulated detector system and some analysis algorithm) which displays the 'normal' fluctuations inherent in the collision process as modeled by the event generator. If the pattern space is formed optimally or efficiently from the information provided by the detector the point set representing the population of generated 'normal' events may be quite compact in this space. Different generators should be represented by somewhat different distributions in this space.

To determine the selection efficiency of the trigger algorithms considered here we need to produce an ensemble of *anomalous* events in which energy has been redistributed at critical epochs in the collision, as modeled by the event generator. Any such redistribution must satisfy basic conservation laws, but otherwise may represent foreseeable processes such as anomalous stopping or fluctuations in the gluon field distribution which may be connected with the onset of global color deconfinement. The consequence of such redistribution in various observed particle or energy distributions then gives evidence of an anomalous event.

4 Anomaly Space

The nature of the energy redistribution in these generated anomalous events must be represented by another parameter space - anomaly space: for instance the total amount of energy redistributed

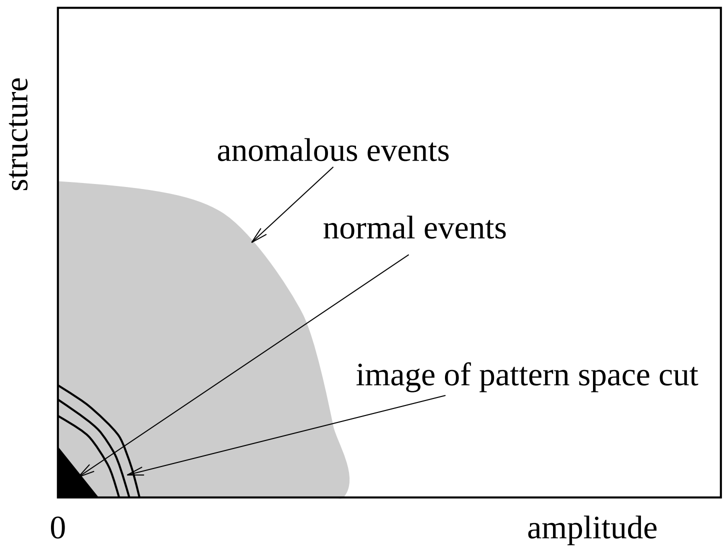

Figure 2: Anomaly space

(amplitude) and one or more measures of the structure of the redistribution (some moments or Fourier components for instance). Normal events would be represented by the point at the origin in this space, and the anomalous event generator should produce an ensemble of events distributed over some subvolume of this space including the origin as part of the calibration procedure. It is in an anomaly space of one kind or another that one can compare models of color deconfinement which manifest emergence of correlation.

5 Pattern-Space Cut

As described above we expect the set of normal events to be contained in a compact subvolume of pattern space in case the transformation to this space is efficient. Any such transformation must be tunable to explore the efficiency of the transformation. As part of the trigger function we can then construct a cut surface defining the boundary of this subvolume. Events that fall inside the cut can then be rejected or prescaled at a rate corresponding to the total taping bandwidth assigned to such events. Those events that fall outside the cut boundary and accepted as anomalous events consist of normal events in the tail of the distribution and perhaps some population of 'true' anomalous events. The boundary must be large enough to keep the normal events within the required bandwidth. However, the larger the boundary the less sensitive the trigger algorithm will be to anomalous events of a certain 'amplitude' or degree of structure. It is this sensitivity that must be explored by a simulation program as described here.

6 Cut Image in Anomaly Space

Assuming a certain rejection rate for normal events defines in some sense the required cut boundary in pattern space. We now must find the image of this cut boundary in anomaly space. From

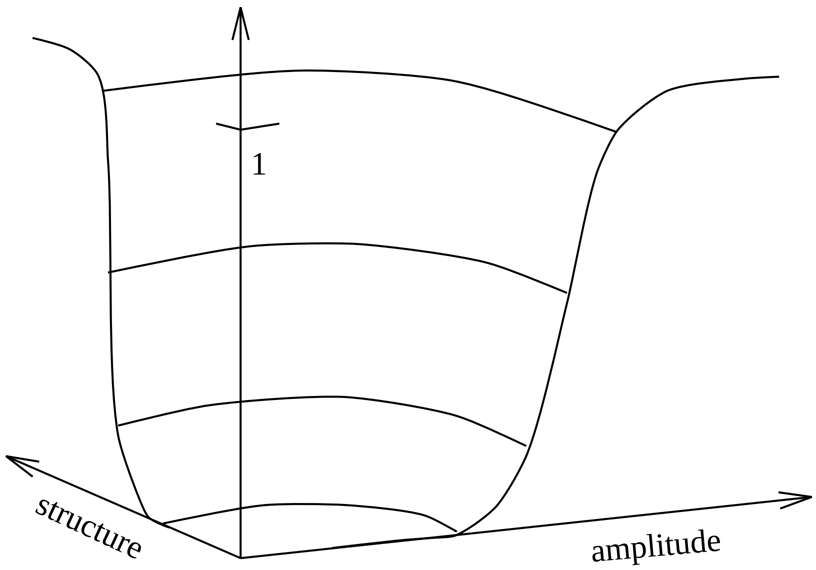

Figure 3: Acceptance surface in anomaly space

this image we can express the general sensitivity of the trigger algorithm to anomalies involving nonstandard redistribution of energy.

The process involves generating a population of anomalous events from a region of anomaly space near the cut border. These events are then processed through the trigger algorithm and accepted or rejected. One then plots an acceptance surface in the anomaly space which is the ratio of those anomalous events that passed the trigger algorithm to total anomalous events generated. This surface then completely characterizes the trigger efficiency for events in this anomaly space. For a given color deconfinement model one can estimate the likely corresponding region in anomaly space and whether such events can be separated from normal events by the trigger algorithm.

7 Calibration Program

First, a set of normal generator events must be run through a GEANT representation of the trigger detectors, which should produce hit distributions on (η, ϕ) space within the detector acceptance. The trigger algorithm, operating on these hit distributions, must then be tuned (null hypothesis determined) so as to achieve a maximum density of the normal event point set in the pattern space for the algorithm. Note that this may not be the optimum null hypothesis for selecting anomalous events. A compromise must be reached between a compact set of normal events and a dispersed set of anomalous events. Thus, a retuning of the null hypothesis may be required as a subsequent optimizing step. An acceptance cut surface must then be defined in pattern space which provides sufficient rejection of normal events.

Second, a set of anomalous events must be produced which more or less uniformly samples a region of anomaly space including the origin. These events must then be passed through GEANT and the trigger algorithm, including the acceptance cut established above. This set will provide a rough determination of the image of the acceptance cut in anomaly space when the accepted anomalous events are plotted in this space.

Finally, a significant ensemble of events from the region near the acceptance cut image in anomaly space should be generated and analyzed in an identical way in order to characterize this cut image in some detail. From this population one can define an efficiency or acceptance surface in anomaly space which characterizes the tuned trigger algorithm.

8 Relation to Final Data Analysis and Interpretation

It should be emphasized here that level 1 and higher trigger algorithms are really the first stages of data anlysis. The trigger algorithms that we are testing here are part of a general correlation analysis in which the information entropy represented by the collision products will be determined quantitatively and will provide a substantial basis for testing collision models. Information entropy as a 'thermodynamic' quantity, as much as temperature (p_t spectra) and chemical potential (flavor abundance), is an important characteristic of the collision process and should be characterized for all collision models. This view of triggering is somewhat in contrast with previous triggering algorthms for low multiplicity events in which specific topologies or cuts on simple parameter distributions are used to provide a trigger decision.