L03-94008

LBL-31583

Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

Presented at the Quark Matter 1991 Conference, Gatlinburg,
TN, November 11–15, 1991, and to be published
in the Proceedings

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M.A. Bloomer, P. Jacobs, and the WA80 Collaboration

December 1991

Prepared for the U.S. Department of Energy under Contract Number DE-AC03-76SF00098

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This work was supported by the Director, Office of Energy Research, Division of Nuclear Physics of the Office of High Energy and Nuclear Physics of the U.S. Department of Energy under Contract DE-AC03-76SF00098

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Abstract

Nonstatistical or "intermittent" fluctuations of charged particle multiplicities have been investigated at the CERN SPS with the WA80 multiplicity array for ^{32}S+S and ^{32}S+Au collisions of varying centrality. Within the phase space domain studied there is no evidence for intermittency in these collisions beyond that accounted for by FRITIOF filtered through a full detector simulation.

The occurence of large fluctuations of charged particle density in small regions of phase space has been observed in many types of high energy collisions [1]. Following an analogy to hydrodynamic turbulence first proposed by Bialas and Peschanski [2], the observed multiplicity fluctuations are termed "intermittent" if the scaled factorial moments of the multiplicity distribution $\langle F_q \rangle$ exhibit a power-law dependence on the phase space bin sizes, e.g. in rapidity: $\langle F_q \rangle \propto \delta y^{-f_q}$, as $\delta y \to 0$. The scaling exponent f_q measures the strength of the intermittency: if f_q=0 then the particle production is completely uncorrelated, i.e. Poisson. Enhanced multiplicity fluctuations in heavy ion collisions are particularly interesting since this might signal the presence of mixed phases of QGP and hadronic matter [3]. Recent high energy heavy-ion emulsion experiments [4] report growth of the scaled factorial moments for pseudorapidity intervals from $\delta\eta = 1.0$ down to $\delta\eta = 0.1$, but with limited statistics. This collaboration previously reported a strong intermittency signal for ^{16}O+Au collisions [5], but that analysis needs to be redone due to an error in the track reconstruction algorithm.

We present an intermittency analysis for heavy ion collisions with high statistics for data taken during August 1990 at the CERN SPS with the WA80 multiplicity detector. The setup of WA80 for this run is described in ref. [6]. A "horizontal-vertical" factorial moment analysis was performed using tracks within the intervals $2.12 \leq \eta \leq 2.57$ ($\Delta\eta = 0.45$) and $-110^\circ \leq \phi \leq 110^\circ$ ($\Delta\phi = 220^\circ$). These intervals were successively divided by integers: $\delta\eta = \Delta\eta/m$, for a one-dimensional (1D) analysis in η (similarly for ϕ), and $(\delta\eta = \Delta\eta/m) \simeq (\delta\phi = \Delta\phi/8m)$ for a two-dimensional (2D) analysis in η-ϕ, where $m = 1, 2, \ldots 8$. The centrality of events was determined using the forward energy as measured by the Zero-Degree Calorimeter and the transverse energy as measured by MIRAC. A full Monte Carlo simulation of the detector and surrounding material was also implemented using FRITIOF v1.7 and GEANT v3.14. It included detailed modelling of local variations in the response of the detector, extracted from the actual physics runs. Simulated events were fed through the same analysis chain to facilitate direct comparison with the data.

Figure 1 displays the dependence of $\langle F_2 \rangle$ on $\delta\eta$ and $\delta\phi$. The data are shown as solid circles while the Monte Carlo simulations are the open circles. The panels on the left are for a 1D analysis in η, while the panels on the right are for a 2D analysis in both η and ϕ. The error bars shown are statistical only. The slopes of the 1D data are consistent with zero or less than zero; the "sagging" of the moments for small values of $\delta\eta$ is a known detector effect discussed below. For the 2D plots, the first seven data points actually correspond to a 1D analysis in ϕ. The sagging is even more pronounced for the 2D analysis. The 2D peripheral ^{32}S+S data show a significant increase with decreasing $\delta\eta\delta\phi$, but this trend disappears for the central ^{32}S+S and ^{32}S+Au data. The Monte Carlo results are superimposed on the data, multiplied by a constant close to unity in order make them fit on the same plot. In all cases, the trend of the moments are reproduced well by the simulation.

A two-dimensional extension of the alpha model [2, 7] for simulating intermittency in both η and ϕ was developed in order to study how detector response and limited acceptance impede the measurement of intermittency. Figure 2 shows $\ln\langle F_2 \rangle$ versus $-\ln(\delta\eta\delta\phi)$ for the alpha model, within the interval $1.5 \leq \eta \leq 4.5$ and with complete azimuthal coverage, and taking $dN/d\eta = 100$. Assuming a perfect detector (open circles), we recover the same intermittency strength as put in the alpha model. The WA80 multiplicity detector has a two-track resolution of $\simeq$ 5 cm or $\approx$ 0.05 units in pseudorapidity, due to the finite

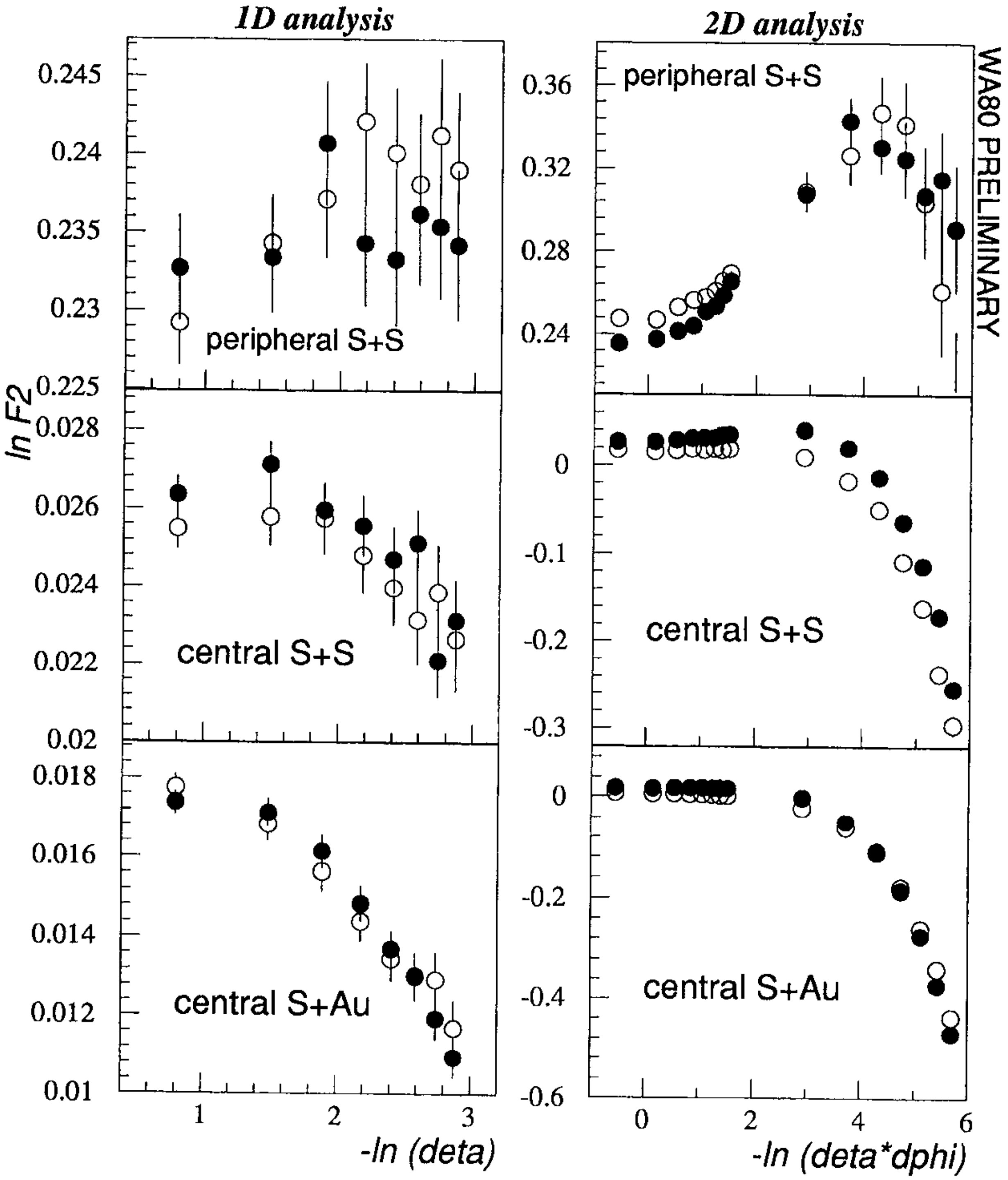

Figure 1: $\ln\langle F_2\rangle$ versus $-\ln(\delta\eta)$ (left panels) and $-\ln(\delta\eta\delta\phi)$ (right panels) for various systems and triggers. Solid circles: data. Open circles: Monte Carlo.

size of a signal left by the passage of a charged particle. If we now demand in the alpha model simulation that particles separated by less than the two-track resolution be merged into single tracks (solid circles), the moments for small values of $\delta\eta\delta\phi$ "sag" in the same manner as in the data. This effect cannot be caused by very small bin population, in

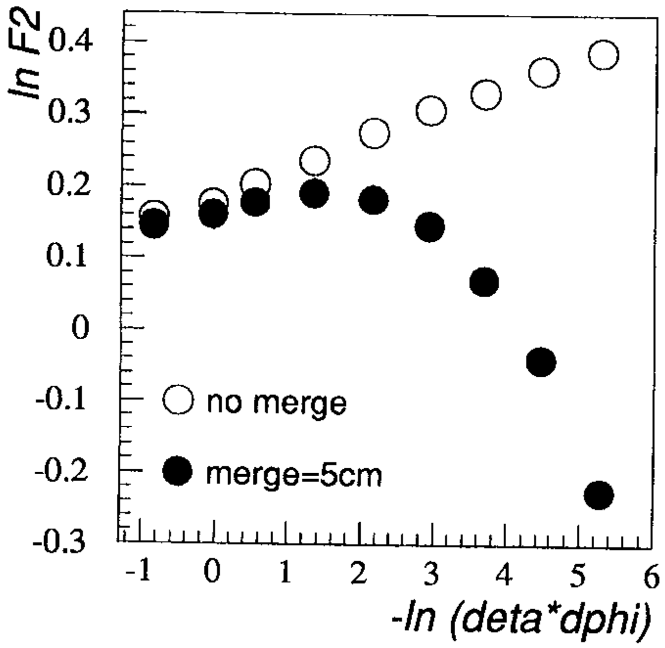

Figure 2: $\ln\langle F_2\rangle$ versus $-\ln(\delta\eta\delta\phi)$ for 2D alpha model simulation. Open circles: perfect detector response. Solid circles: two-track merging radius of 5 cm.

contradiction to ref. [7]. Note that the sagging starts at a bin width of $\delta\eta = \delta\phi \sim 0.5$, which is much larger than the two-track resolution. Separately varying the detector efficiency or η-ϕ acceptance has little or no effect on the calculation of the moments. Hence we conclude that the single most important detector effect is the finite two-track resolution.

Based on the agreement of the data with our Monte Carlo, we conclude that no "new" physics is needed to explain the measured scaled factorial moments.

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