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August 13, 1994

Dr. David L. Hendric
Director
Division of Nuclear Physics
Department of Energy
Washington, DC 20545

Dear Dr. Hendric:

I am submitting the progress report of our grant no. **DE-FG02-90ER40566** under the project **"Interaction of Relativistic Gold and other Heavy Nuclei"** from March 15, 1993 through March 14, 1994.

At the APS meeting held in Washington in April, 1993, we presented two papers on heavy ions:

(1) Entropy and Fractal Characteristics of Multiparticle Production at the Relativistic Heavy Ion Interactions
(2) Fragmentation of ^{197}Au projectile at 11.4A GeV in Nuclear Emulsion

In the second paper we showed how we can determine the charges of the projectile fragments by gap and δ-ray densities. Preliminary results on the determination of charges were shown in a three- dimensional representation. To produce such a diagram, the data generally is obtained from electronic detectors, an expensive process. We presented it with careful work through emulsion techniques for the first time. Our preliminary results on fragmentation agree with the data of the Au beam taken at low energy ~600A MeV. For a minimum bias sample, the identification of PFs will help us to analyze completely the peripheral interactions of the Au beam.

Earlier this year, I gave an invited talk at the **Second International Conference on Physics and Astrophysics on Quark-Gluon Plasma** held in Calcutta, India. The topic of my talk was "**Pseudorapidity-Interval Dependence**

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Multiplicity at Relativistic Energies." A part of this work is published in *Physics Letter B294, 27 (1992).*

We have extended this work to the highest energy beams. Multiplicity distributions of shower particles were produced in high energy collisions of ^{128}Si at 14.5A GeV, ^{32}S at 200A GeV, ^{16}O at 200A GeV and 60A GeV. We have studied these distributions in small pseudorapidity intervals of the forward and backward hemispheres in their perspective of Negative Binomial Distribution. Different multiplicity parameters have been computed for the two hemispheres separately and their variations with the phase space interval size have been studied. This work is presented in a recent paper entitled "**Multiplicity Distributions in High Energy Heavy Ion Collision**", by A. Mukhopadhyay, P.L. Jain and G. Singh, and has been accepted in *Nuovo Cimiento (1993).*

We have also submitted the following papers for publication:

(1) **Fractal Analysis of Projectile Fragments in Nuclear Collision at 1-2A GeV**
P.L. Jain, G. Singh and A. Mukhopadhyay. Accepted in *Nuclear Physics A,* 1993.

(2) **Cluster Formation at High Energy Collisions**
A. Mukhopadhyay, G. Singh and P.L. Jain. Accepted in *Journal of Physics G,* 1993. Formation of clusters in high energy p-nucleus interactions at 800 GeV an ^{4}He-nucleus interactions at ≈11A GeV and ≈ 140A GeV has been investigated with the technique of pseudorapidity gap distributions. The existence of many particle short range correlations are observed in all cases. The estimated cluster sizes are larger in ^{4}He-nucleus data than those of p-nucleus.

(3) **Factorial Moments and Multifractal Analysis at Relativistic Energies**
P.L. Jain, G. Singh and A. Mukhopadhyay. Accepted in *Rapid Communications, Physics Review C,* 1993. Modified methods for computing multifractal moments G_q and scaled factorial moments F_q, in terms of a new scaled variable X suggested by Bialas and Gazdzicki, have been employed to study the self-similar behavior of particle production in interactions ^{28}Si at 14.5A GeV, ^{16}O at 60 and 200A GeV, and ^{32}S at 200A GeV with nuclear emulsion. Power law dependencies of the moments on the number of bins M of the new variable (X), have been observed in the data.

One of the important topics in heavy ion collision is to look for the non-statistical multiplicity fluctuations in small intervals of pseudorapidity, which could give a sign of deconfined phase of quark gluon plasma leading to intermittent behavior. Bialas and Peschanski have proposed an analysis of the pseudorapidity density distributions in terms of normalized factorial moments to study intermittency. But it has been cautioned by Carruthers et al. that the intermittency phenomenon could be understood in terms of conventional short range Bose-Einstein correlations, the Hanbury-Brown Twiss (HBT) effect or the Goldhaber (GGL) effect for identical particles, where cumulant amounts of order greater increase, they will reflect the presence of more violent bulk fluctuations preceding hadronization. Hence, the study of two or three particle correlation functions in heavy-ion experiments needs a careful consideration.

For these reasons we have been recently working on two and three particle correlations among shower particles produced in central collisions of ^{32}S and ^{16}O at 200A GeV, ^{16}O and ^{28}Si at 14.5A·GeV with nuclear emulsion. The existence of short range correlations are observed in all interactions but the pattern of the ^{32}S data is quite different from the others, particularly at a very narrow region of pseudorapidity and azimuthal angle spaces. As the density of shower particles in the central collisions of Au beam is very high, so it may be worth while to explore the presence of a very narrow correlation peak in the Au data. So at present we are working on Au beam stacks which has been developed recently. We shall report our findings with time. The details of our present and future research programs for the next three years are given in the attached proposal for your kind consideration.

Sincerely yours,

P.L. Jain
Professor and Director of High
Energy Experimental Laboratories