STUDIES OF RELATIVISTIC HEAVY ION COLLISIONS

Annual Progress Report

July 1, 1990-July 31, 1991

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ANNUAL PROGRESS REPORT AND RENEWAL PROPOSAL FOR THE PERIOD JANUARY 1, 1992 THROUGH DECEMBER 31, 1992:

ABSTRACT

We expect to complete the observations of lepton pairs with incident protons on proton and deuteron targets. The early results indicate an important fraction due to processes other than bremsstrahlung. Further high statistic runs on heavier targets (Ca on Ca) are scheduled for 1992 and possible runs for heavier ions. We expect to participate in the running and analysis for these experiments and help prepare for upgrades of the DLS system.

The Hopkins group is an active member of a collaboration preparing proposals for RHIC (STAR). Our main interest is the behavior of quarks and gluons traversing the high density medium that ultimately appear in the form of jets. A program of studying the behavior of multilayer mirrors for Ring Imaging systems that can be utilized for both triggering and Cerenkov Ring determination will continue.

INTRODUCTION

This is the second year of our 3-year program that was outlined in our proposal presented this past year. Our emphasis remains the study of observables that act as probes of the medium produced in the collisions of heavy ions. The overall program had a number of complementary aspects.

I. The study of lepton pairs from relativistic nuclear processes as penetrating probes of hot dense matter

We have spent a great deal of time using proton and deuteron targets with incident proton beams at the DLS, mainly to understand lepton pairs whose origin is in a bremsstrahlung process. The light collision partners should show a high cross-section for this mode with deuterium since the dipole origin of the bremsstrahlung is, in principle, absent in p,p collisions. Our high-statistics initial run at LBL at 2 and 5 GeV incident protons was completed and the analysis is now in progress. Preliminary results indicate that a fraction of lepton pairs appear from processes other than bremsstrahlung and that the relative cross-section for the deuteron relative to the proton is, on the average, somewhat less than a factor of 2. This surprising result seems to indicate that there may be important hadronic origins of the pairs. A second run has been approved and planned for the fall of 1991.

An earlier run using Ca projectiles on a Ca target is now being analyzed by our group.* These data should begin to bear on the question of phenomena, such

*PhD dissertation of Robert C. Welsh, JHU

as pion annihilation, etc., that one may expect from collisions with multihadron production. Future runs with Ca have been approved and will be scheduled sometime in the spring of 1992. Some data were also taken with the very heavy ion projectile Nb, and future runs along this line will probably take place in 1993.

The present program emphasizes high statistics runs so that one could determine the production of lepton pairs as a function of many independent variables beyond the effective mass spectra. Some improvements in the Dilepton Spectrometer are being discussed, and we expect to take part in the design and construction of such facilities, especially those involving the Cerenkov triggers.

II. The final analysis of our run at BNL studying the polarization of lambda produced with heavy ion collisions, as a probe of the sea, is now complete and is being prepared for publication.

A preliminary result given at a Brookhaven Workshop was published in the proceedings and in our Annual Report of 1990 (DOE/ER/40413-3). The results seem to indicate an effective reduction in the polarization relative to that in proton nucleus production. The diquark, the progenitor of a lambda, acts as a probe of the hot medium produced in the collision and could be a useful tool in future high energy studies of this kind. We are joining a collaboration that is submitting a letter of intent covering, in addition to this question, studies of exotic products from heavy ion collisions. A copy of this letter of intent is Section VI of our Annual Report Appendix.

III. We have been participating in a program to study the behavior of multilayer mirrors that have wideband ultraviolet reflectivity and excellent transmission in the visible region.

These properties allow one, in principle, to use the visible for trigger and the reflected ultraviolet for Ring Imaging to identify the trajectory of leptons, for example. At Hopkins we have constructed a phototube array for the visible as a part of an apparatus that would be a prototype of such a system. We have been especially fortunate to obtain from the University Research Instrumentation Program of the DOE a grant for doing optical studies of mirrors useful for Cerenkov radiation. This system includes a spectrograph and a special system for studying the mirrors and other properties of Cerenkov gases.

We have also, in collaboration with J. Vavra at SLAC, begun to study detectors with needle-like anode systems that would have good spatial resolution

and be useful for Ring Imaging detectors. A short description of this latter system is given in our Annual Report Appendix.

IV. We have participated in other experiments related to heavy ion collisions in general, and a complementary experiment involving antiprotons that create hot spots in heavy nuclei upon stopping.

The former involves a collaboration using TPCs as detectors at BNL. (See, for example, S. Eiseman et al., Physics Letters B248, 254 (1990).) This work is of interest for several reasons: it shows the feasibility of TPC detectors in high multiplicity environments and aids the understanding of the strangeness component of secondaries in heavy ion collisions, again a possible measure of quark-gluon plasma behavior. The latter project completed a run in June, 1991, using an antiproton beam at Brookhaven. The Hopkins group participated in the original experiments and provided some of the detectors for the most recent one.

New experiments with polarized proton projectiles producing hyperons, which were important to our group to establish the characteristic of the diquark as a parent in lambda production, were approved. It is unlikely, however, that this program will be implemented in the near future. All the previous results have been published and were included in previous Annual Reports.

V. In the past year our group has been active in discussions of a possible RHIC detector, with a collaboration that has recently taken the acronym of STAR.

This is a detector based on a solenoidal magnet, encompassing a TPC for tracking. We have taken the task of studying the feasibility of detecting jets and/or high p_T hadrons whose progenitors are quarks or gluons that have undergone a hard collision. These quarks and gluons must pass through a medium created in the central rapidity region. The Bjorken mechanism predicts a substantial reduction of the energy loss of these quarks in a QG plasma relative to that in a hadronic medium and could, in principle, reveal the existence of the plasma by the observation of the lack of quenching. This is a very detailed question of production and practical detection of jet-like final states. Dr. T. Hallman, who has begun to undertake this work at Hopkins, will continue this effort at LBL under the auspices of the heavy ion group at Berkeley. We expect to continue our activities in this area and help in the preparation of a proposal for a RHIC experiment.

In summary, for 1992 we propose to participate in the dilepton program at LBL as our major activity. We now have the computer facilities at Hopkins to play a major role in analysis. We expect the completion of the proton and deuteron runs and the initiation of Ca on Ca runs to begin in this period. A decision to upgrade the DLS will be taken in the fall of '91 and we expect to participate in the design and construction of these proposed new detector elements. We also expect to be fully active as a member of the STAR collaboration for a RHIC experiment. Our immediate interest is to help in the simulation of jet physics that could be studies as an integral part of the experimental program being planned by this collaboration.

A major activity at Hopkins will be the completion of a spectrograph and an optical system to study the geometrical, optical and spectral behavior of multilayer mirrors and the study of the spectral properties of scintillations from Cerenkov gases, showing the molecular excitation of the medium. This latter work may be crucial for the design of Cerenkov systems, where very high multiplicity of charged particles are expected should the cross-section for scintillation be very high.

Our budget includes only a modest amount for new detector instrumentation. We expect, however, in our third year to participate in prototype construction for RHIC detectors. Professor Leon Madansky, Principal Investigator, has devoted fifty percent of his time and effort to the project and expects to continue at this level of effort. We have prepared an Appendix to this Annual Progress Report that gives the results of our work this past year in more detail.

LIST OF PUBLICATIONS DURING THIS GRANT PERIOD;

- K. J. Foley et al., "Studies of Multiparticle Production in Heavy Ion Collisions Using a Time Projection Chamber," Nuclear Physics B16 (1990) 405.
- P. A. Seidl et al., "Low-Mass Dileptons in pA and AA Collisions," Nuclear Physics A525 (1991) 299c.

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