MASTER

Experiments Using the TASS and HISS
Spectrometers at the Bevalac

Progress Report

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During the preceding year the LSU intermediate energy nuclear physics group has been participating in the construction and calibration of the Two-Armed-Spectrometer-System (TASS) at the Lawrence Berkeley Laboratory and in mounting the first experiment to be carried out on TASS. The TASS collaboration includes the following physicists:

<u>LBL</u>	<u>LSU</u>	<u>Clerment-Ferrand</u>
J.V. Geaga (now at UCLA)	J.M. Engelage	G. Roche
J.W. Harris (now at GSI)	C.L. Ruiz	
H.G. Pugh	P.N. Kirk	
L.S. Schroeder		
R. Treuhaft		

It is with considerable pleasure that we announce the end of the data collection phase of the experiment as of late January, 1981.

The experiment was motivated largely by the early work of Komarov and collaborators in the Soviet Union. The interesting feature of Komarov's experiment was that protons detected in his apparatus could be attributed to the reaction $p + d^* \rightarrow p + p + n$, where the symbol d^* is used to denote a deuteron, or at least a two-nucleon correlation, inside a complex nucleus. The significance of this result is that if the interpretation were correct, nuclear physicists would have at their disposal a convenient and powerful new tool for investigating two nucleon correlations within complex nuclei.

In order to specify the kinematics for the reaction $p + d^* \rightarrow p + p + n$ completely it is necessary to prescribe values for five independent variables. We choose these five independent variables to be p_b , θ_b , ϕ_b , ϕ_f , and θ_f , where the subscripts "b" and "f" are used to denote the protons detected in the backward arm of the spectrometer and the forward arm, respectively. Specifically we choose $\theta_b = 120^\circ$, $\phi_b = 180^\circ$, and $\phi_f = 0^\circ$. In Fig. 1 we

Fig. 1

show p_f , the momentum of the forward moving proton, as a function of θ_f and p_b . The number beside each of the five egg shaped contours is the value of p_b for the contour. In addition, the reader's attention is directed to a point located at $\theta_b \approx 10.4^\circ$ and $p_f \approx 1.64$ GeV. This point represents the limit of the physical region, and it corresponds to the kinematics of elastic p-d scattering. Komarov positioned his apparatus so that the acceptance included the elastic point and found a substantial cross section there.

Dr. Jorge Geaga and Dr. Lee S. Schroeder suggested that Komarov's results could be extended by detecting both protons in the final state of the reaction and that TASS would be an ideal facility for performing such a coincidence experiment. The experiment was subsequently proposed by Dr. Geaga and Dr. Schroeder and approved for running in the spring of 1979.

The experiment is rather straightforward conceptually. If the process $p + d^* \rightarrow p + p + n$ really does occur with substantial probability within complex nuclei, then we should be able to detect the two protons in the final state by setting the two TASS magnets in such a way as to accept points along any kinematically allowed contour, such as those shown in Fig. 1. This we have done.

Because the data acquisition ended so recently we are still in the early stages of data analysis, and we shall leave unanswered for now the question as to whether or not our data support the model of Komarov. What we shall do is to present a table of our data points and exhibit a selection of histograms and scatter plots to demonstrate that the equipment functioned properly and that it was reasonably calibrated. Mr. Robert Treuhaft, the thesis student affiliated with the collaboration, will present data at the

forthcoming Baltimore meeting.

Our data points are listed in Table 1. Most of our data were logged in the coincidence mode, but we did log some data in the singles mode in order to establish continuity with previous experiments. Table 1 does not include calibration runs in which we used a CH_2 target to measure p-p elastic scattering.

In Fig. 2 we exhibit a time-of-flight spectrum that shows the relatively good signal to noise ratio we obtained in this experiment. Along the abscissa of this figure is plotted the difference between the times of arrival for signals from two of our counters. One counter was in the forward arm of the spectrometer and the other counter was in the rear arm. Along the ordinate is plotted the number of events per interval. For real events the difference between the times of arrival was constant, or nearly so, but for random coincidences that difference was distributed uniformly in time. The signal due to real coincidences is clearly visible as a large peak located at zero on the abscissa. The incident intensity during the run from which this histogram was extracted was 8×10^9 protons per spill, so we are well pleased with this result.

In Fig. 3 we show a time-of-flight spectrum for the rear arm. Only singly charged particles with momenta in the range between 680 and 720 MeV are included in this histogram. The spectrum is dominated by the proton peak, but there is clear evidence for deuterons also. The number of events per bin is plotted along the ordinate, and the channel number of the time-to-digital converter (TDC) is plotted along the abscissa.

TABLE I

Trigger Mode	Rear Momentum	Rear Angle	Forward Momentum	Forward Angle	Target	Number Triggers
coincidence	550	120°	600	10.4°	C	9,906
"	"	"	1200	"	"	17,411
"	"	"	"	"	CD ₂	23,634
"	"	"	"	"	Cu	17,886
"	"	"	"	"	Pb	2,657
"	"	"	"	"	none	4
"	"	"	2100	"	C	11,450
"	400	"	400	45.02	"	10,959
"	"	"	"	"	CD ₂	19,259
"	"	"	"	"	Cu	7,625
"	"	"	"	"	Pb	10,391
"	"	"	900	"	C	23,533
"	"	"	"	"	CD ₂	25,545
"	"	"	"	"	Cu	5,509
"	"	"	"	"	Pb	9,082
"	"	"	"	"	C	2,068
"	"	"	"	"	C	5,381
forward singles			900	10.4	C	11,375
"			"	"	none	1,871
"			1200	"	C	29,753
"			"	"	"	729,745
"			"	"	Cu	30,259
"			"	"	none	1,671
rear singles	500	120°			C	13,678
"	"	"			Cu	169,056
"	"	"			none	3,314
"	750	"			C	16,410
"	"	"			Cu	54,513
"	"	"			none	3,065
"	1100	"			C	11,273
"	"	"			Cu	22,872
"	"	"			none	3,015

Fig. 2

Fig. 3

Figure 4 shows a mass spectrum for particles detected in the forward arm of the spectrometer. The number of events per mass interval is plotted versus the mass of the detected particle. There were no multiwire proportional chambers in the forward arm in this experiment so that the mass resolution suffers somewhat. Nevertheless, we have obtained a clear separation between protons and pions. The central momentum setting of the forward magnet was 400 MeV during the run for which this histogram was compiled.

Figures 5 and 6 show mass spectra for particles detected in the rear arm of the spectrometer. In each histogram the number of events per mass interval is plotted versus the mass of the detected particle. The central momentum for the data displayed in Fig. 5 was 750 MeV, and for the data displayed in Fig. 6 the central momentum was 1100 MeV. Both spectra exhibit clear peaks due to protons and deuterons, but Fig. 6 also contains a peak due to tritons! In neither histogram does the mass spectrum extend below 500 MeV because the number of pions found in the rear arm at these momenta was negligible.

In Fig. 7 we show a scatter plot of pulse height, plotted on the ordinate, versus time-of-flight, plotted on the abscissa. The pulse height was recorded in one of the counters that defined the entrance aperture to the rear arm of the spectrometer, and time-of-flight was the measured transit time through the rear arm. Only real events with measured values of p_b between 700 and 800 MeV are included in this plot. The two large concentrations of crosses correspond to protons and deuterons, and we are pleased with the clear separation between them.

In Fig. 8 is shown a scatter plot of measured momentum in the rear arm

Fig. 4

Fig. 5

Fig. 6

Fig. 7

versus time-of-flight in the rear arm. The central momentum of the rear magnet was 750 MeV during the run for which this scatter plot was constructed. Once again there is a clear separation between protons and deuterons, and there is even a hint of tritons.

Finally in Fig. 9 we present a scatter plot of mass of the particle in the rear arm versus mass of particle in the forward arm. During the run for which this scatter plot was constructed the central momentum of both magnets was 400 MeV, so that some pions were detected in the rear arm as well as the front arm. The scatter plot contains several distinct groups of crosses that correspond to coincidences between pions and protons, protons and protons, protons and deuterons, and even a few pions and deuterons.

In conclusion the preceding year has been an agreeable one for us. We are pleased with TASS, pleased with our success in mounting the experiment, and pleased with the collaboration that we have set up with Dr. Schroeder and Dr. Pugh at LBL. Perhaps most of all we are pleased with the solid foundation we believe we have established for future experiments at LBL and especially for the exciting new dilepton experiment that is now being planned.

Fig. 8

Fig. 9