Jeopardy Proposal for the Remaining Six Days of the g3 Experiment

Original Experiments:

91-014: Quasi-Free Strangeness Production in Nuclei
93-008: Inclusive Eta Photoproduction in Nuclei
93-044: Photoreactions on ^{3}He

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Proposed Experiment on ^{12}C and Its Extension to Pb

The g3 group of experiments was approved for 25 days of beam time—13 days for ^{3}He and 6 days each for ^{4}He and ^{12}C. The ^{3}He part was run in December 1999, and was so successful that we were able to use the last part of this scheduled time (g3a) to perform the ^{4}He part of the experiment as well. Thus, at the cost of only about half of the approved beam time, about ¾ of the experimental data have been obtained.

There remains the ^{12}C part (g3b) to be completed, and this is what we currently propose to do. However, because we found in our earlier run that we were able to take data at a rate greater than that originally anticipated, we would like to add a foil of ^{Nat}Pb to the carbon (graphite) foils in our target and obtain data on this heavy nuclear target simultaneously with those on our ^{12}C target. We compute (see below) that by apportioning our counting rates in the ratio of roughly ^{12}C:Pb = 2:1, we can obtain the required data on both, wholly within the originally approved beam time of 6 days.

The use of the nucleus as a highly-condensed-matter laboratory is an important component of the Jefferson Lab physics program. In it one can study the modification of the elementary amplitudes for many processes by the strongly interacting nuclear medium. At the present time, we have obtained an enormous amount of real-photon data on the proton (g1) and a large amount on the deuteron (g2) as well, from which one can extract the elementary amplitudes on the proton and the neutron. As we are now seeing from the ongoing analysis of the g3a data (see below), we have ample data on ^{3}He and ^{4}He as well. What is lacking, obviously, are data on heavier nuclei.

The binding energy per nucleon, mean radius, and density for ^{2}H, ^{3}He, ^{4}He, ^{12}C, and ^{208}Pb are given in the following table:

Nucleus	Binding energy per nucleon (MeV)	Mean radius (fm)	Density (nucleons per cubic fm)
^{2}H	1.11	2.0	0.06
^{3}He	2.57	1.8	0.12
^{4}He	7.07	1.6	0.23
^{12}C	7.68	2.3	0.24
^{208}Pb	7.86	~6.0	0.23

It is clear from these values that if we wish to study the density dependence of an interaction, we should compare the data for ^{2}H, ^{3}He, and ^{4}He, whose sizes are not very different but whose densities vary by a factor of about 4. This we are already doing, using the data from g2 and g3a. But if we wish to study the size dependence of an interaction, we should compare data for ^{4}He, ^{12}C, and Pb, whose densities (or binding energies/nucleon) are about the same, but whose radii vary by a factor of about 4. An example where density dependence is our prime concern is the issue of three-body forces, whose range is much shorter than two-body forces, and whose study therefore requires that the incoming short-wavelength photon interact with the three nucleons when they are close together. We can carry out such studies with our existing data. But for those interactions the study of which depends critically on the mean free path of a particle in nuclear matter, such as the interaction of photoproduced kaons, etas, or Deltas with nucleons, we require data obtained with larger target nuclei.