

Future analysis will focus on trying to understand quantitatively what fraction of the observed deviations from free-scattering analyzing powers may be attributable to kinematic transformations, associated with averaging over finite regions of the Fermi momentum (especially, the transverse momentum component) distribution of the struck proton. To aid in this assessment, we will compare the data obtained for different regions of struck nucleon momentum. Residual, non-kinematic, deviations might arise from distortion effects or from medium modifications (including off-shell behavior of the NN interaction); distinguishing between these sources can only be done within the context of a comparison with specific model (e.g., semi-infinite slab model<sup>5</sup>) calculations.

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## $\sigma$ , $A_y$ , and $D_{NN'}$ MEASUREMENTS OF THE GIANT RESONANCE REGION IN $^{208}\text{Pb}$ USING 200 MeV PROTONS

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The study of isoscalar giant resonances has been an important area of research in nuclear physics. When a new accelerator or detector system become operational, a challenge to such devices is to further extend our knowledge of these collective excitations of the nucleus. Most proton inelastic studies of giant resonances have been carried out with experimental resolutions of 70 to 200 keV and have been aimed primarily at defining global properties. These studies have provided the location, strength and width of the isoscalar  $L=2$  giant quadrupole and  $L=3$  giant octupole; and in  $^{206,208}\text{Pb}$  the  $L=4$  giant hexadecapole has been established.

One of the outstanding questions that remains in this field is why hadronic studies have not yet observed the fine structure of the giant quadrupole resonance in  $^{208}\text{Pb}$  that is seen in high resolution (40-50 keV) electron scattering studies.<sup>1</sup> To date the "best" attempt to observe this fine structure was an experiment performed at LAMPF using 334 MeV protons detected by the HRS with an energy resolution of 70 keV.<sup>2</sup> No structure was observed.

Using the K600 magnetic spectrometer and its Focal Plane Polarimeter (FPP), we have performed an experiment at IUCF, one of whose goals was to search for this structure. A resolution of 40 keV was obtained. Data were taken at 8, 10, 12 and 15°, covering 2 to 24 MeV of excitation. The unpolarized yield data taken at 8° is shown in Fig. 1, along with electron data from ref. 1. As can be seen the proton data exhibits to a large extent the same structure observed in the electron scattering. A close examination of Figure 1 reveals that there is an energy shift between the two data sets. At the present time we are working on various methods in order to improve our energy calibration.

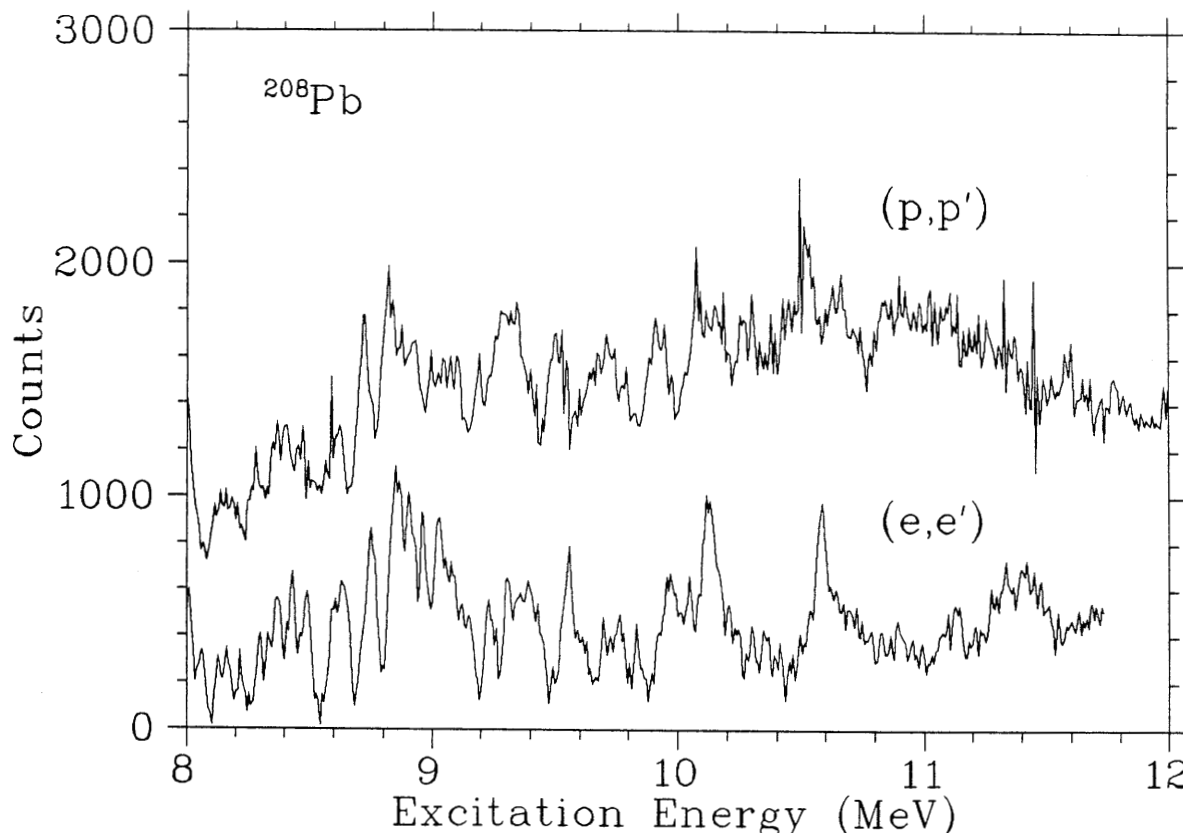


Figure 1. Comparison of present (p,p') data to that of the (e,e') data from ref. 1. The (e,e') data has had the isovector giant dipole and isoscalar giant monopole responses subtracted.

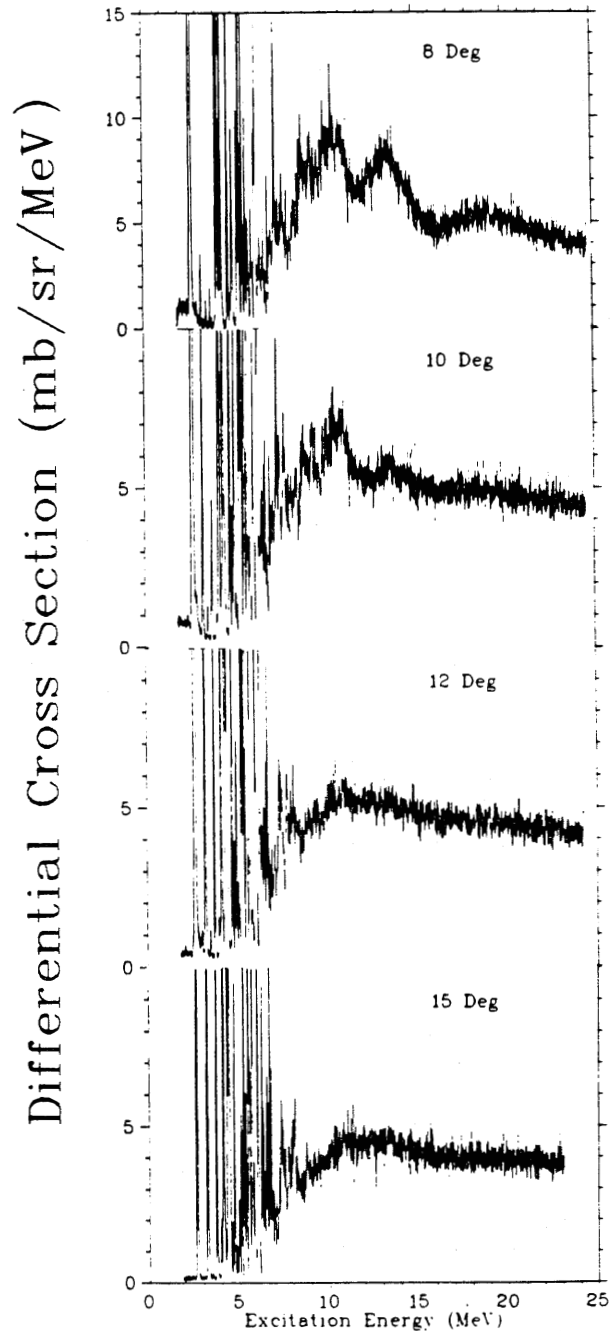
The kinematic region where the electron data was taken strongly favors the excitation of the isoscalar giant quadrupole resonance (ISGQR). No higher multipoles or isovector resonances would be excited. The isovector force for proton scattering at 200 MeV and at 8° is too weak to excite any isovector resonances so these will not contribute to the spectra. The similarity of the electron and proton data implies that most of the structure seen in the proton data is also related to the ISGQR. Differences between the two could be attributed to higher multipoles, namely the  $2\hbar\omega$   $L=4$ , excited in the proton experiment.

Figure 2 shows the double differential cross section data at all of the angles that we measured. The absolute cross section normalizations were calculated using measured values for the dead-time, wire chamber efficiencies, total charge accumulated, solid angle

Figure 2. Double differential cross section data for  $^{208}\text{Pb}$  at all of the angles measured in the present experiment. The  $8^\circ$  and  $10^\circ$  data clearly show the ISGQR located near 10.6 MeV and the combination of the IVGDR and ISGMR located near 14 MeV.

of the aperture to the entrance of the K600, and the target thickness. The thickness of the target used in the experiment was measured by Bill Lozowski of the IUCF target lab using an alpha range method. Using this normalization method we compared our measured cross section angular distributions for the  $3^-$ , 2.615 MeV,  $2^+$ , 4.085 MeV,  $5^-$ , 3.20 MeV, and the  $5^-$ , 3.71 MeV states to DWBA collective model calculations using well known hadronic deformation parameters<sup>3</sup> obtained from a global analysis of various data sets. Our measured cross sections for the low lying states agree within the uncertainty of the data and of the calculations to the above mentioned collective model calculations. We therefore feel confident in our cross section measurements to the 10–12% level. The next step in the analysis of the cross section data is to search for consistent peaks in the data from angle to angle and from this to obtain cross sections and analyzing powers for these structures in the hope of determining the various multipole strength functions.

In this experiment we have also measured the normal spin-transfer component  $D_{NN'}$ . This will allow us to study the spin response of  $^{208}\text{Pb}$  from the low lying states up to approximately 24 MeV. Preliminary spin-flip probabilities ( $S_{NN'} \equiv (1 - D_{NN'})/2$ ) and spin-flip cross section spectra are shown in Figure 3. Our data is of sufficient statistics so that our  $S_{NN'}$  results at  $8^\circ$  and  $10^\circ$  are shown in 200 keV bins with statistics near  $\pm 0.05$  while the  $12^\circ$  and  $15^\circ$  data are presented in bins of 275 keV. Unfortunately, the data do not extend to small enough scattering angles to allow the study of M1 excitations. However,



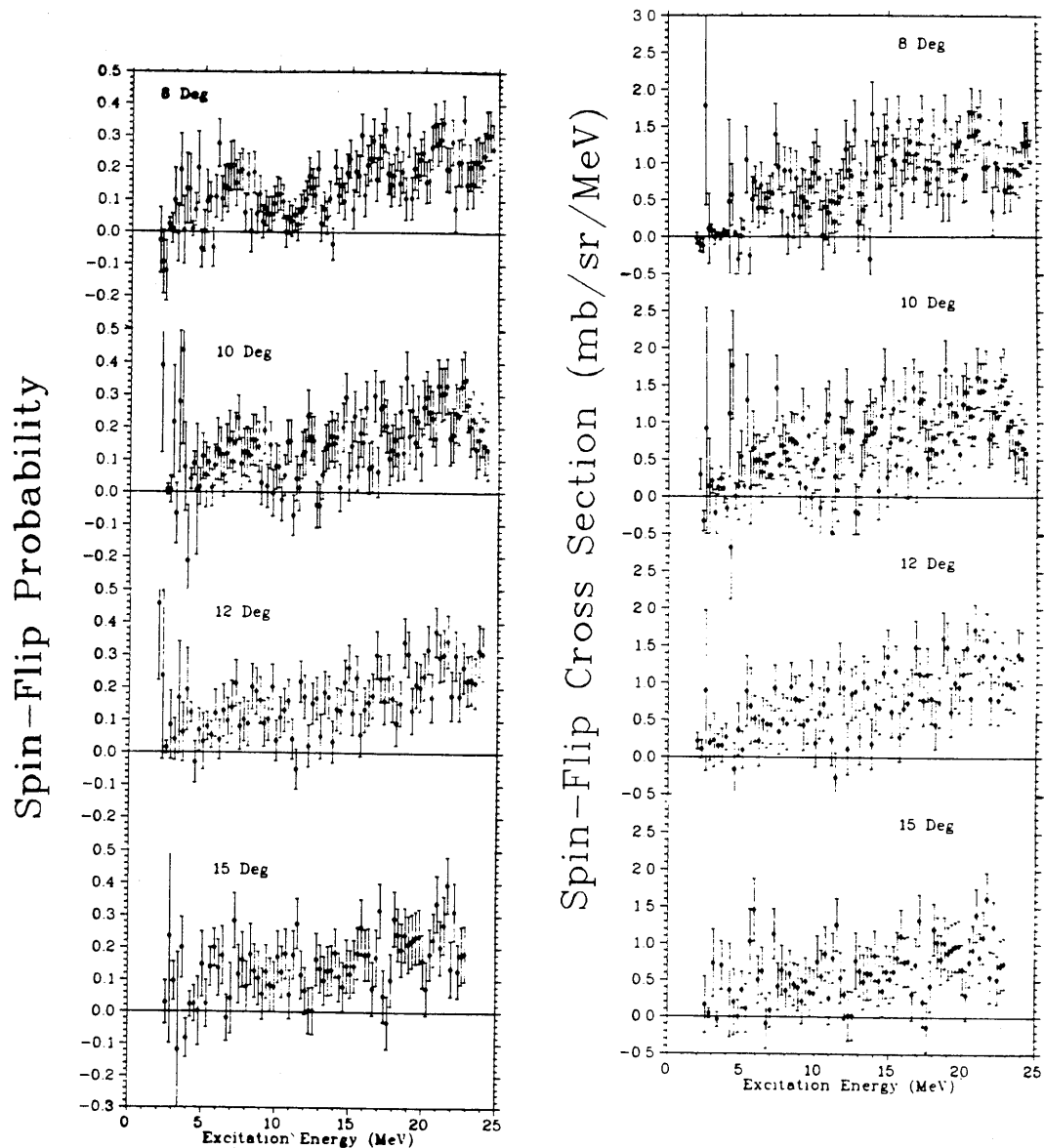


Figure 3. Spin-Flip probability data as measured at all the angles and calculated Spin-Flip cross sections at these same angles. At  $8^\circ$  note the structures in both sets near 7, 10 and 12 MeV.

we may be able to study the spin dipole and the spin quadrupole resonances along with possibly higher multipole spin resonances. Indeed, both the  $8^\circ$  and  $10^\circ$  spin-flip probability data and the spin-flip cross section show a 1 to 2 MeV wide structure located near 12 MeV, and possible structure near 7 MeV, while the  $8^\circ$  data also shows a possible structure near 10 MeV. The nature of these structures is unknown at the present time. The next step in the analysis of the spin-flip data is to compare the data to RPA calculations in order to help understand these possible resonances. The spin-flip data will also allow us to further study the question of why the spin-flip response is large in the continuum region in comparison to the nonspin-flip response.<sup>4</sup>

During the running of this experiment we used 11 of the 21 approved shifts. The remaining 10 shifts will be used to perform measurements similar to the present ones, but at smaller angles. Here the interest is in the M1 states and the spin-dipole resonances, along with an attempt to extract the isovector giant quadrupole resonance, which is mainly Coulomb excited at the smallest angles, and is expected to occur near 20 MeV. These measurements await the completion of the small angle mode for the K600.

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