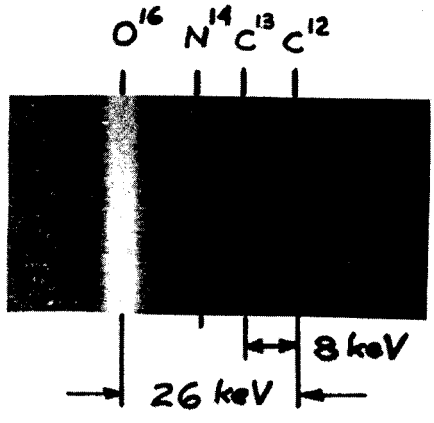
# High Resolution Inelastic Scattering

J. Nolen

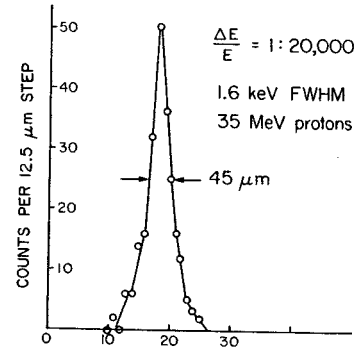
During the past year, several groups within the laboratory have continued high resolution studies of the (p,p') reaction at 30 and 35 MeV beam energies. The work of Wagner and Crawley on $^{207}Pb$, $^{208}Pb$, and $^{209}Bi$ was completed and submitted for publication during this period. The microscopic analysis was done in collaboration with Hammerstein and McManus. An experimental resolution of 6 keV at 35 MeV was obtained in this work with typical target of 200 $\mu g/cm^2$ thickness. Preliminary spectra on $^{238}U(p,p')$ have been obtained by Boyno, et al. with 6 keV resolution at 35 MeV with much thinner targets. Target making problems have temporarily slowed this experiment. Currently in progress, and described elsewhere in this year's progress report, is a continuation of the (p,p') studies on N=82 by Austin and Rossner with a resolution of 3-4 keV FWHM at 30 MeV beam energy.

A study of $^{40}Ca$ with 4.5 keV resolution at 35 MeV was recently completed and submitted for publication by Nolen and Gleitsmann. The emphasis was on measuring the cross sections to previously unresolved particle-hole states in order to test the forces used in microscopic (p,p') calculations. An analysis with the new realistic interaction recently derived by Borysowicz, McManus, and Bertsch was quite successful and has been submitted to the Amsterdam Conference (September 1974). A continuation of this work into a much more complicated shell model region has just begun with preliminary work on $^{24}Mg(p,p')$. States up to 1-2 MeV above the analog state at 9.52 MeV will be studied. The extent to which coupled channels effects are needed over and above large basis shell model wave functions and a conventional microscopic analysis will be investigated.

In a recent test run a resolution of 1.6 keV at 35 MeV (1 part in 20,000) FWHM was obtained with a 20 $\mu g/cm^2$ carbon target (see figure). This represents a factor of 2 improvement over the previous best resolution. About 1/3 of this improvement came from further reduction of the spectrograph aperture from 0.3 msr to 0.06 msr while the majority was due to better filtering of the deflector power supply output. Deflector ripple, unlike rf ripple, adds to the incoherent spot size and cannot be eliminated by dispersion matching in the spectrograph.




(a) Proton groups photographed from the nuclear emulsion through a microscope. They represent 35 MeV protons elastically scattered at an angle of 10° from the isotopes indicated. Individual tracks are not at all distinguishable in the $^{12}C$ peak due to its extremely high intensity.




(b) A scan of an elastically scattered proton indicating an energy resolution of 1.6 keV full width at half maximum.

# Inelastic Proton Scattering from $^{140}$Ce and $^{142}$Nd at Ep=30 MeV

H. H. Rossner and S. M. Austin

In a (p,p') study of the N=82 nucleus $^{138}$Ba at Ep=30 MeV,[1] it was found that microscopic DWBA calculations based on the wavefunctions of Wildenthal gave a good description of the shapes of the angular distributions, but severly underestimated the magnitude of the cross sections, unless an effective charge was included to account for the effect of core excitation. This effective charge turned out to have approximately the same magnitude for the two lowest lying states of $J^{\pi}=2^{+}$, $4^{+}$ and $6^{+}$, i.e. it appeared to be independent of state and multipole. However, the prescription failed for $^{144}$Sm, presumably because the basis space is quite restricted in this case. We hope to modify the shell model basis in a smooth way as the number of protons outside the $^{132}$Sn closed shell increases, to see whether a similar compact description of the core excitation in terms of a single effective charge is possible. To obtain data for comparison with these calculations, we are extending the previous measurements to $^{140}$Ce and $^{142}$Nd.

The $^{140}$Ce targets were prepared by vacuum evaporation of isotopically enriched (99.7%) $^{140}CeO_2$ from a graphite boat onto a target backing consisting of a 5 $\mu g/cm^2$ carbon foil plus a 3-5 $\mu g/cm^2$ thick formvar layer. The $^{142}$Nd targets were fabricated by heating isotopically enriched (99.9%) $Nd_2O_3$ and Th powder in a tantalum tube, causing reduction of the compound and simultaneous evaporation of the metal onto a 20 $\mu g/cm^2$ carbon foil. For both targets, the total thickness was in the range from 50-100 $\mu g/cm^2$.

Using dispersion matching methods and the online tuning technique of Blosser, et al.,[2] the exposures have been taken on nuclear emulsions (KODAK 25$^{+}\mu$NTB) in the Enge split-pole spectrograph, obtaining a typical resolution of less than 5 keV (FWHM). A preliminary sample spectrum is shown in Figure 1. The values of the excitation energies, taken from Ref. 3, correspond to the previously known states in $^{140}$Ce.

To obtain a normalization for the plate data, the strong collective states $2^{+}$ and $3^{-}$ have been separately measured at forward angles with a position sensitive wire proportional counter in the spectrometer focal plane. The corresponding angular distributions and the optical model prediction for the elastic scattering using the Becchetti-Greenlees parameters are shown in Fig. 2.

These results are preliminary, as the emulsions exposed at other angles are still in the process of being scanned.

REFERENCES

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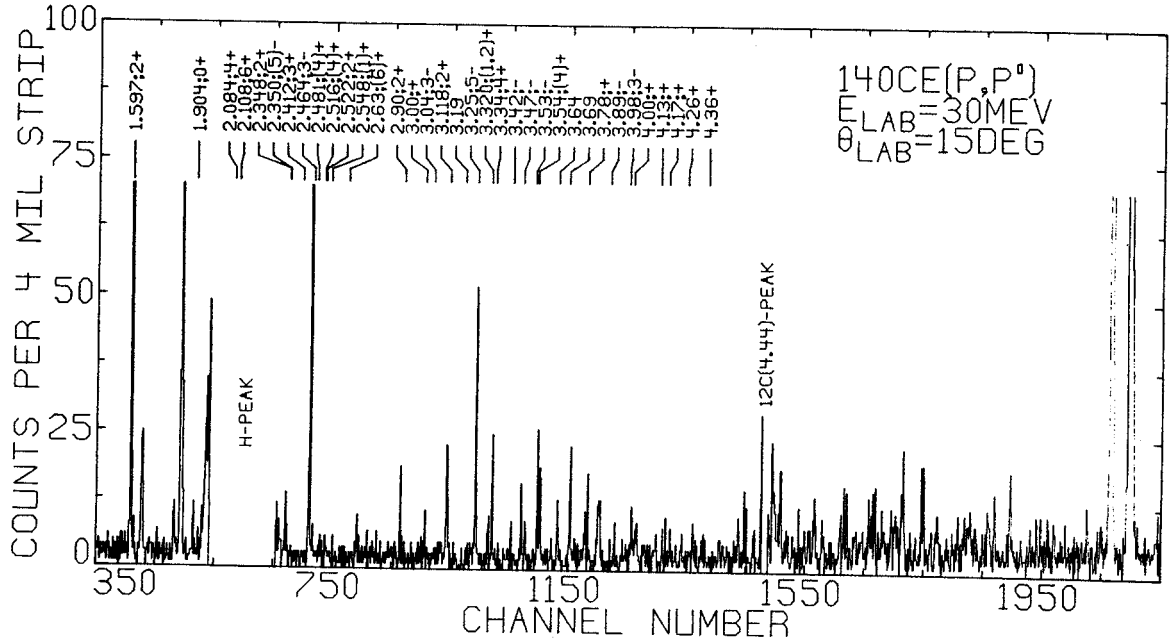


Figure 1

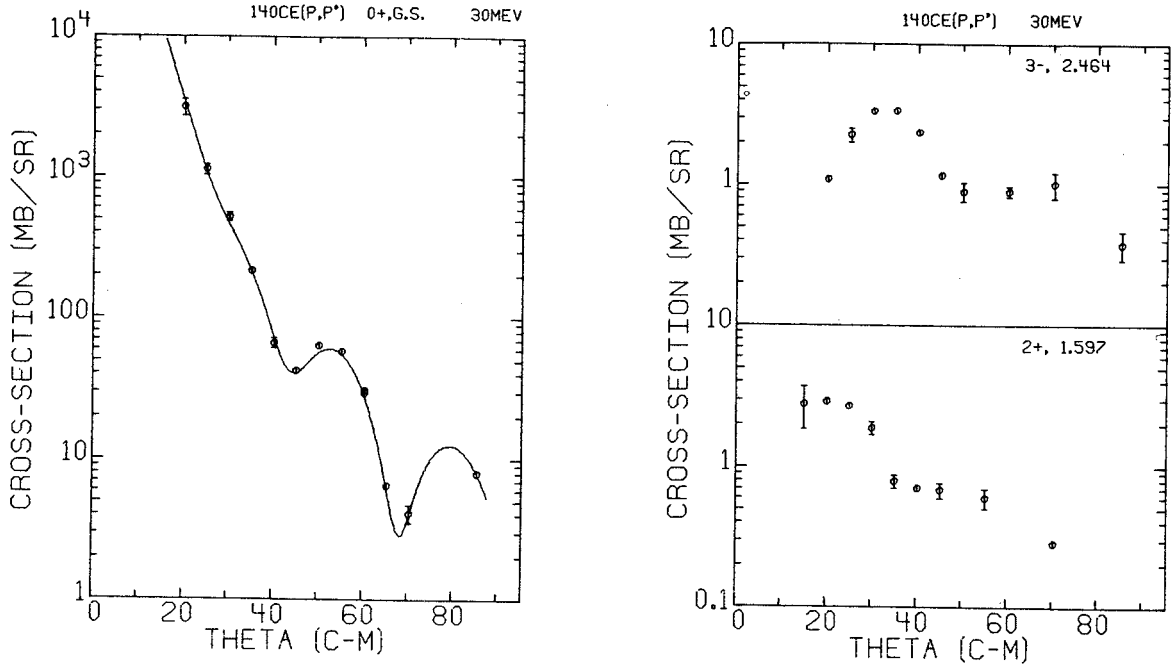


Figure 2

## Development of the Mephisto Code

H. Rossner

The antisymmetrized microscopic DWBA code 'MEPHISTO' of H. V. Geramb has been transferred to the Σ-7 computer of the Cyclotron Laboratory. The inelastic nucleon scattering is assumed to result from the interaction of the projectile with the valence nucleons of the target in the presence of a core. The effective two-nucleon interaction is described by a central spin-and isospin- dependent potential and a noncentral tensor and spin-orbit term with Gaussian- or Yukawa- or more general form. To specify the core polarization operator, the vibrational collective-model approximation is used, including the isoscalar and isovector part, but without any spin dependence. The coupling constants are taken to be complex. Geramb's code extends the widely used direct core polarization corrections to contain exchange terms arising from antisymmetrization of projectile and target nucleons. The exchange core polarization contribution can be interpreted as a two-step resonance process in which collective multipole states in the core subsystem of the target are virtually excited. The importance of these two-step contributions has been demonstrated recently,[1] and the virtual states have been identified as giant multipole resonances.

In the Σ-7 version the code consists of three separate parts:

(1) Calculation of the optical wave functions of the incoming and outgoing particles.

(2) Computation and storage (on disk or tape) of the matrix elements for each single particle transition.

(3) Calculation of polarizations, asymmetries and differential cross sections for the direct and exchange contributions from the single-particle matrix elements.

This segmentation of the code makes it very efficient for fitting procedures, since, for example, the single-particle matrix elements need not be recalculated when the two-body interaction is changed.

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