

PROTON INDUCED π^- PRODUCTION FROM ${}^7\text{Li}$

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Light nuclei offer, in principle, some advantages in microscopic calculations of the pion production process. The small number of nucleons involved makes full shell model calculations tractable and reduces the importance of pion rescattering effects.

Thus, light nuclei should minimize the nuclear structure and pion distortion uncertainties that normally plague (p,π) calculations and allow a more clear cut test of other parts of the reaction process. Lithium 7 is the lightest target for which the (p,π^-) reaction leads to a final nucleus that is bound.

During the course of (p,π^-) experiments on sd-shell nuclei,¹ the ${}^7\text{Li}(p,\pi^-){}^8\text{B}_{\text{g.s.}}$ reaction was used for energy calibration of several spectra. Fig. 1 shows a typical ${}^7\text{Li}(p,\pi^-)$ spectrum, which contains three sharp peaks corresponding to well resolved states

of known spin and parity in ${}^8\text{B}$. Because of the high yield, it was possible to obtain complete angular distributions of the differential cross section for these three states during the course of sd-shell (p,π^-) studies with a relatively small amount (~ 1 shift) of beam time. This occurred during the period following the ion source fire when a polarized beam was not available. The angular distributions for all three states [which have the same $(p_3/2)^4$ configuration] are shown in Fig. 2.

1) J.J. Kehayias, R.D. Bent, M.C. Green, M. Hugi, H. Nann and T.E. Ward, Studies of ${}^{18}\text{O}(p,\pi^-){}^{19}\text{Ne}^*$ and ${}^{26}\text{Mg}(p,\pi^-){}^{27}\text{Si}^*$ Reactions with 200 MeV Polarized Protons, Contribution to this Annual Report.

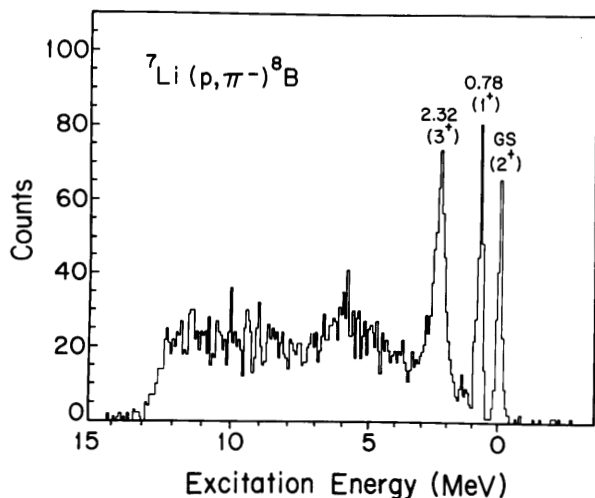


Figure 1. ${}^7\text{Li}(p,\pi^-){}^8\text{B}$ spectrum at $T_p^{\text{Lab}} = 205$ MeV and $\theta_{\pi}^{\text{Lab}} = 30^\circ$.

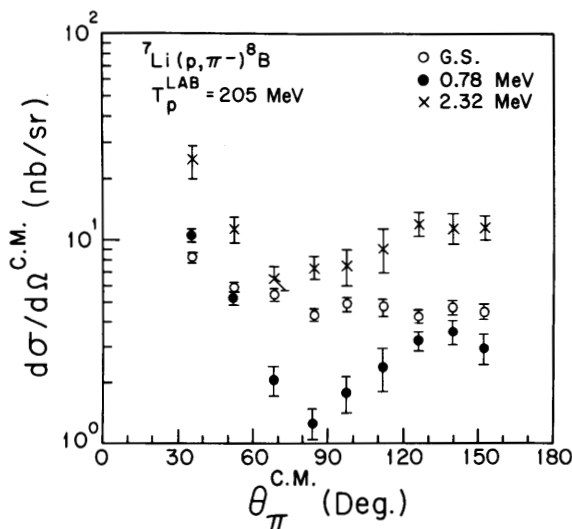


Figure 2. Angular distributions of differential cross sections for the ${}^7\text{Li}(p,\pi^-){}^8\text{B}$ reaction to three states of the final nucleus. The error bars include both statistical and background subtraction uncertainties.

PION PRODUCTION TO THE CONTINUUM

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Nuclear pion production has turned out to be a difficult process to understand because of the complex interplay between the reaction dynamics and nuclear structure effects. It has been suggested¹ that studies of pion production to the continuum, where the high momentum (~ 550 MeV/c) incident nucleon does not have to be "caught" by the nucleus, may help elucidate the reaction mechanism by reducing the nuclear structure uncertainties.

We have measured differential cross sections for (p, π^\pm) transitions to the continuum for several targets covering a wide mass range. The large momentum bite ($P_{\max}/P_{\min} = 1.6$) of the QQSP spectrometer is ideal for continuum studies, allowing about a 25 MeV range of excitation energy of the residual nucleus to be recorded at a single magnetic field setting of the spectrometer. Figure 1 shows some of the spectra obtained. The data are preliminary and have not yet been corrected for non-linearities in energy calibration and variation in pion detection efficiency across the focal plane. For most of the spectra, measurements were made for more than one spectrometer field setting. The resulting overlapping spectra will allow extraction of information about the higher part of the continuum and also will make possible corrections for local variations in detector efficiency. Additional data have been taken with polarized beam, which will provide information about the analyzing power in the continuum.

Preliminary analysis indicates that the angular distribution of the differential cross section for (p, π^-) transitions to the continuum is similar to that for the strong transitions to the low-lying stretched

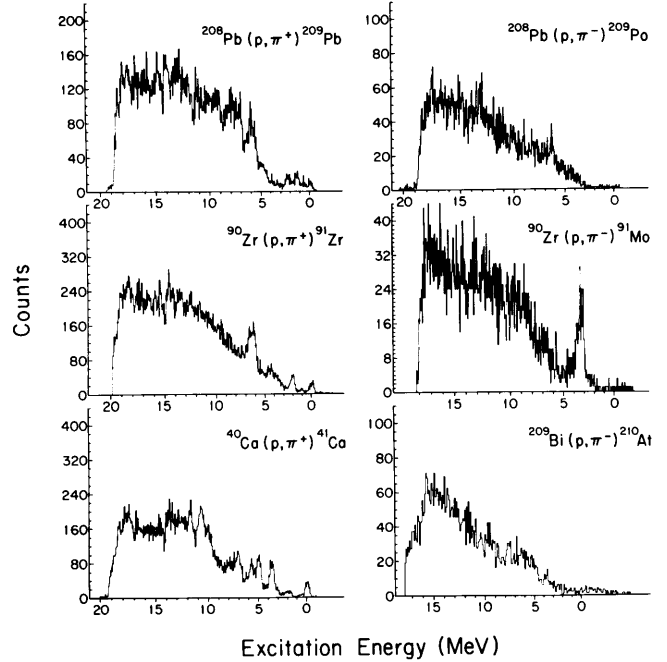


Figure 1. Selected (p, π^+) and (p, π^-) spectra. $T_p^{\text{Lab}} = 190$ MeV and $\theta_\pi^{\text{Lab}} = 45^\circ$ for all except $^{209}\text{Bi}(p, \pi^-)$, for which $T_p^{\text{Lab}} = 192$ MeV and $\theta_\pi^{\text{Lab}} = 30^\circ$.

$2p-1h$ states. This suggests a similarity in the reaction mechanism for pion production to discrete and continuum states.

Figure 2 shows the π^- spectrum from the $^{209}\text{Bi}(p, \pi^-)^{210}\text{At}$ reaction calculated by Gibbs² in a model in which target emission is the total mechanism for negative pion production. He assumed that the negative pion is produced from one of the neutrons in the target and that the cross section to a state at a given energy can be represented (on the average) by the cross section to a "typical" state which, for simplicity, he chose to have a pure two proton particle - one neutron hole configuration $\{[(1h_{9/2})^{-1} 2g_{9/2}]_0^- \times 2g_{9/2}\}_{9/2}^-$. The density of "typical" states at high energies where Pauli exclusion

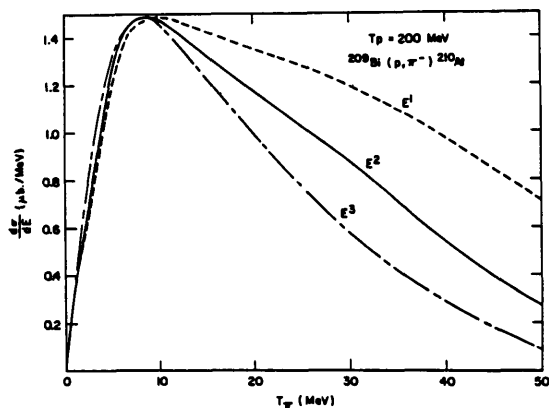


Figure 2. Calculated spectrum for negative pion production from protons on ^{209}Bi . The curves labeled E^1 and E^3 are shown to estimate sensitivity to the level density assumption. [Taken from Ref. 2].

effects should be unimportant was taken to vary as the energy raised to the number of "particles" minus one; i.e., as E^2 . To make the energy density more realistic at low energies the form $\rho(E) = 0.004 (E + 15)^2$ was used. The spectrum calculated using this function is labeled E^2 in Fig. 2. Also shown, for comparison, is

the shape of the spectrum for two neighboring powers (normalized to the same peak value). There is a very noticeable difference in these curves, indicating that the number of nucleons involved in the pion production process affects the shape of the continuum in a rather direct way. Although the E^2 spectrum shape is similar to what we have observed for the $^{209}\text{Bi}(p, \pi^-)^{210}\text{At}$ and $^{208}\text{Pb}(p, \pi^-)^{209}\text{Bi}$ reactions (see Fig. 1), corrections for variations in detector efficiency and energy non-linearity must be applied to the data before meaningful comparisons can be made. Nevertheless, we are hopeful that a detailed analysis of the data together with more refined calculations will shed light on the (p, π) reaction mechanism.

- 1) G.E. Walker, Pion Production and Absorption in Nuclei, ed. R.D. Bent (American Institute of Physics Conf. Proc. No. 79, New York, 1982) pp. 270, 430.
- 2) W.R. Gibbs, *ibid*, p. 313.