

CONTINUUM PION PRODUCTION

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Most  $(p,\pi)$  studies at IUCF have concentrated on exclusive pion production leading to discrete states of the residual nucleus. Data on continuum production are relatively scarce. It has been pointed out<sup>1</sup> that continuum measurements may be useful in elucidating the complicated  $(p,\pi)$  reaction mechanism because of their expected insensitivity to the details of nuclear structure.

In order to explore the A-dependence of proton-induced pion production to the continuum,  $(p,\pi^\pm)$  measurements were made<sup>2</sup> for  $^{12,13}\text{C}$ ,  $^{40}\text{Ca}$ ,  $^{90}\text{Zr}$  and  $^{208}\text{Pb}$  targets with a 190 MeV unpolarized proton beam at  $\theta_{\pi}^{\text{lab}} = 45^\circ$ . Fig. 1 shows the double differential cross sections plotted as a function of laboratory pion kinetic energy. Each plotted point corresponds to seven channels of raw data. This bin size represents

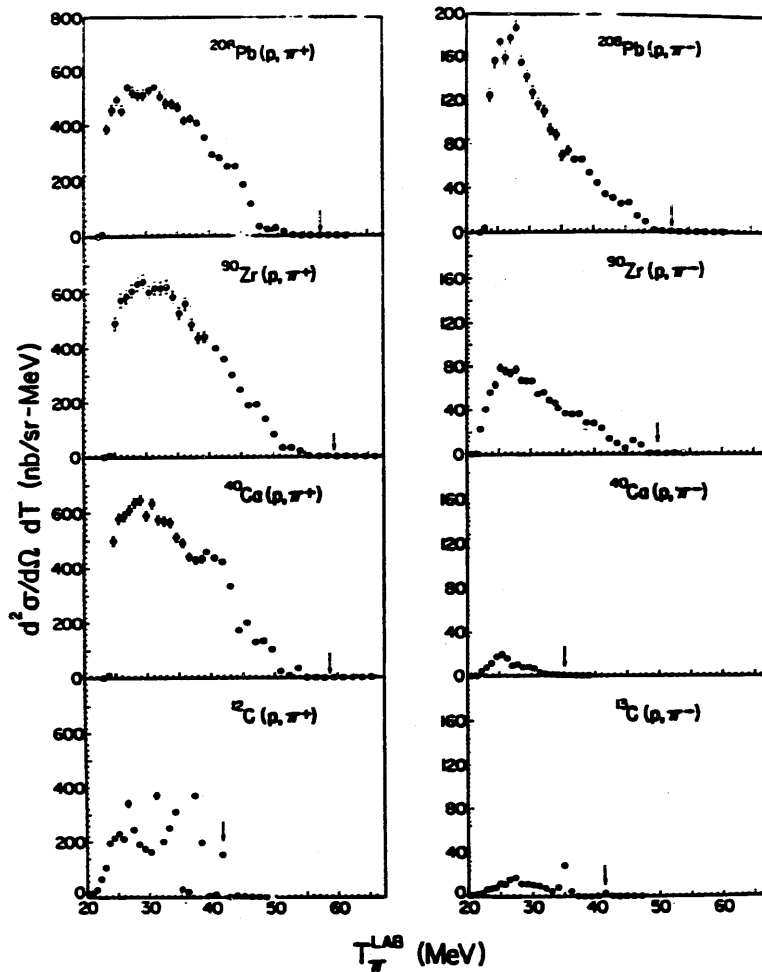


Figure 1. Corrected continuum spectra plotted as  $d^2\sigma/d\Omega dT$  vs the laboratory kinetic energy of the pion. All the spectra were taken at  $T_p^{\text{lab}} = 190$  MeV and  $\theta_{\pi}^{\text{lab}} = 45^\circ$ .

an energy-averaging interval which varies from about 0.6 MeV at the lowest pion energies to about 1.3 MeV at the highest pion energies. The arrows indicate the position of the ground state transitions. Notice that there is a factor of four difference between the vertical scales for  $(p, \pi^-)$  and  $(p, \pi^+)$ . The instrumental cut-off appears at about  $T_{\pi}^{\text{lab}} = 25$  MeV, which allows only a small portion of the continuum to be observed for the  $^{12}\text{C}(p, \pi^+)$  and  $^{13}\text{C}, ^{40}\text{Ca}(p, \pi^-)$  reactions.

A systematic trend is immediately apparent from the data: the cross section in the continuum region increases markedly with target mass for negative pion production, but is almost independent of A for positive pion production. This behavior is quite different from that observed for pion production leading to discrete

final states, for which  $\pi^-$  yields are almost independent of A (for light targets) and  $\pi^+$  yields decrease with increasing A.<sup>2,3</sup> The cascade model calculations of Long, Sternheim and Silbar<sup>4</sup> indicate that charge exchange processes may be responsible for  $\pi^-$  enhancement in the continuum.

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#### A TWO-NUCLEON MODEL CODE FOR THE $(p, \pi)$ REACTION

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As 1983 draws to a close, our two-nucleon model (TNM) computer program for calculating  $(p, \pi)$  cross sections and analyzing powers is within a few months of completion. 1984 should see this program operational and actively pursuing a systematic testing of the physics involved in the  $(p, \pi)$  process. The ideas of this model have been reported previously.<sup>1-4</sup>

We have included all of the resonant p-wave part of the interaction, which is thought to be dominant at IUCF energies except very near threshold. This includes projectile and target emission diagrams, along with their corresponding antisymmetrization diagrams. In order to fully test this part of the interaction, we

will not include the s-wave piece initially. We will therefore look at data produced by protons with energies extending from at least 10 MeV above pion production threshold on up to 250 MeV. Initial state interactions are included via a standard proton distorted wave. Higher order corrections for rescattering of the outgoing pion will be included via a  $\pi$ -nucleus optical potential or using a local density approximation for self-energy corrections of the intermediate isobar. This last step is all that remains to be finished on the code.

Execution time for the program has been optimized to enable the user to run large numbers of case