INCLUSIVE (p,π^+) CROSS SECTIONS NEAR THRESHOLD

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Angle-integrated (p,π^+) cross sections on several 1p-shell targets have been measured over the energy range $0.5 \lesssim T_p - T_{threshold} \lesssim 10$ MeV by detecting μ^+ decays. For heavier targets, (p,π^+) inclusive cross sections at energies well above threshold are surprisingly different from previous (p,π^0) measurements.

Inclusive (p,π^+) cross sections have been measured near threshold at the Indiana University Cyclotron Facility by stopping the pions in or near the target and counting energetic positrons from $\pi^+ \to \mu^+ \to e^+$ decay. The positrons were detected in plastic Cerenkov counters between 1 μs long beam bursts. Figure 1 shows the measured $^{16}O(p,\pi^+)^{17}O$ excitation function for energies extending downward to the π^+ Coulomb barrier, where only the ^{17}O ground state contributes. Similar measurements were obtained for ^9Be, ^{11}B, ^{12}C, ^{13}C and ^{14}N. Previous $^{16}O(p,\pi^+)^{17}O$(g.s.) angular distribution measurements at T_p=154 MeV have been integrated to obtain a total cross section,[1] which is included in Fig. 1 to extend the ground-state excitation function over a larger energy range.

The energy dependence of the angle-integrated (p,π^+) cross section to a specific final state near threshold should be dominated by the phase space and barrier penetration of the outgoing pion. The solid curve in Fig. 1 is the (arbitrarily normalized) expression $\sigma(p,\pi^+)\alpha(k_\pi/k_p)S(k_\pi)$ where $\hbar k_\pi$ and $\hbar k_p$ are the barycentric momenta; and $S(k_\pi) = 2\pi\gamma/(\exp(2\pi\gamma)-1)$, with $\gamma = Z(e^2/\hbar^2c^2)\frac{E_\pi}{k_\pi}$, is the usual Coulomb factor which approximately accounts for the pion penetrability. The measured ground-state cross sections for all of the light targets have an energy dependence consistent with this expression near threshold.

In order to study the A dependence of inclusive (p,π^+) cross sections, additional targets were run at two fixed beam energies. The results are grouped in

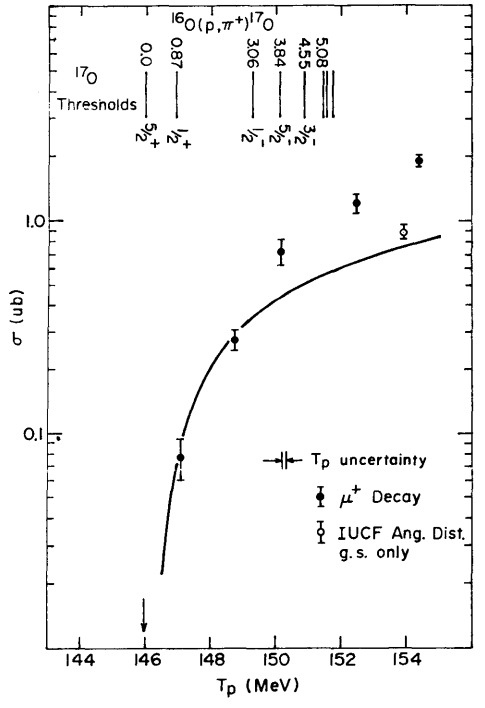

Figure 1. Inclusive $^{16}O(p,\pi^+)^{17}O$ cross section as a function of proton energy in the lab. Solid curve is a Coulomb factor.

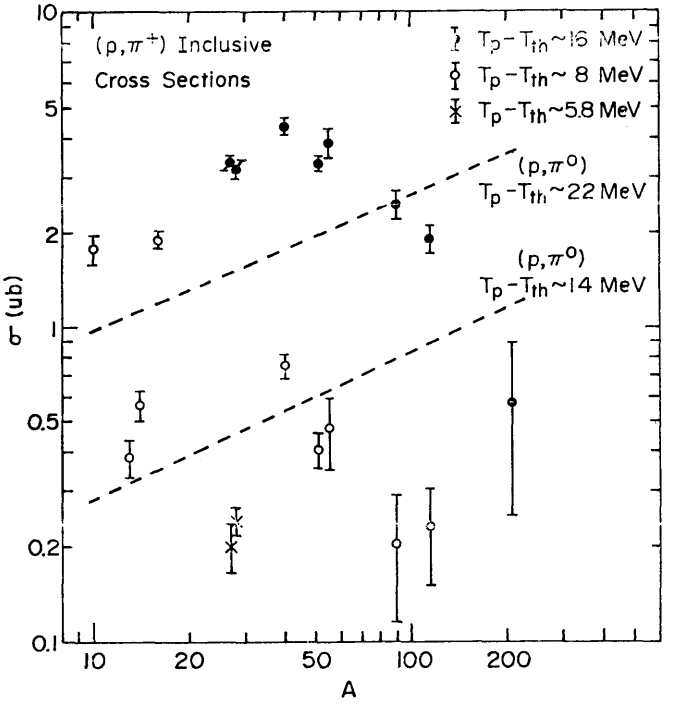

Figure 2. Inclusive (p,π^+) cross sections at nearly constant (± 1 MeV) energy-above-threshold.

Fig. 2 according to excess energy above threshold. In addition to the errors shown, there is a normalization uncertainty of about 10%. The broken lines in Fig. 2 represent the measured A dependence of inclusive (p,π^o) cross sections on many of the same targets at two different beam energies.[2] The obvious decrease of the (p,π^+) cross sections for heavier targets must be due in part to the π^+ Coulomb barrier. However, it is more difficult to explain why the (p,π^+) cross sections are so much larger than the (p,π^o) cross sections for the lighter targets. For example, charge symmetry requires $\sigma(p,\pi^+)/\sigma(p,\pi^o) = 2$ for the $^{40}Ca(p,\pi)$ reaction to $T=\frac{1}{2}$ final states in mass 41, but the experimental ratio at approximately 16 MeV above threshold is roughly 5 even with no Coulomb corrections.

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1) P.H. Pile, Ph.D. thesis, Indiana University, 1978 (unpublished).

2) A.D. Bacher, P.T. Debevec, G.T. Emery, M.A. Pickar, K. Gotow, D.A. Jenkins, and P.L. Roberson, Indiana University Cyclotron Facility Technical and Scientific Report, November 1975 - January 1977 (unpublished), p. 31.