This shows that the (p,π) reaction can distinguish between mathematically dissimilar optical potentials that give the same elastic scattering. Thus, the (p,π) reaction may provide useful constraints on the pion nucleus optical potential beyond those provided by pion elastic scattering.

We emphasize the preliminary nature of these results. More detailed studies, which will include an investigation of relativistic effects in the incident proton channel, are in progress.

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EXPLORATION OF (p,π^0) AS A WAY OF STUDYING PIONIC ATOMS

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The 1s level of pionic atoms is not known for elements beyond aluminum. In conventional studies of pionic atoms the pion is captured into an outer atomic level and cascades down. But already for Z about ten absorption from the 2p level is appreciable, and it increases rapidly with Z. No results are available for Z greater than 12. One would like to know the strong-interaction shifts and widths in the 1s states for larger Z.

It is possible to make pionic atoms in a different way, as entrance-channel resonances in proton-nucleus collisions. At an appropriate energy below the threshold for making free negative pions in a (p,π^-) reaction, the pion can be created in an atomic level. The cross section can be estimated from the free cross section above threshold and the properties of pionic atoms.[1] This is an example of a threshold phenomenon with an attractive Coulomb field.[2] Some related possibilities have been discussed by Kilian.[3]

Detection of the pionic atom resonance is the primary difficulty. The dominant decay mode is presumably by emission of two fairly fast nucleons or clusters, followed by evaporation, and is difficult to pull out of the general background of proton-induced reactions at the necessary proton energies of about 140 MeV. Some initial attempts made in this lab have not been encouraging.[4] For light targets the resonance may be seen in proton elastic scattering at backward angles, but the resulting narrow resonances imply a cooler experiment. A proposal for such an experiment, by Meyer, et al.,[5] has been approved.

When the pionic atom nucleus has $Z > N$ the system can decay into a π° and the nuclear analog state. One can then in principle detect the pionic atom resonance as a feature in the (p,π°) excitation function of that analog state. We report here some prelminary explorations of the feasilibity of such an experiment, using the reaction $^{42}Ca(p,\pi^\circ)^{43}Sc(19/2^-,3.12\ MeV)$. The intermediate pionic atom state in this case would be $^{43}Ti(19/2^-,3.07\ MeV)$, which, with a π^- in the 1s state, would occur at a proton bombarding energy of about 146.7 MeV.

A 30 mg/cm^2 target of ^{42}Ca was bombarded with protons at eight energies between 144.2 and 148.2 MeV. The lead glass detectors described by Pickar[6] were arranged in a horizontal plane around the target, four on each side of the beam, at polar angles of 57°, 85°, 113°, and 141°. A coincidence between one detector on the left and one on the right was required. Two plastic scintillators close to the beam pipe at the entrance to the apparatus helped greatly in improving the beam tune and reducing halo. A third plastic scintillator served as a beam monitor. Cuts on the energy signals, on the time relative to the beam, and on the time difference between the left and right signals were used in the analysis. An example of a set of time difference spectra is shown in Fig. 1.

Some relative π° yields are shown in Fig. 2. Neutral pions from excitataion of the $19/2^-$ state should show up at an opening angle ($\phi\gamma\gamma$) of 134°. These preliminary runs were, of course, too short to show a perturbation of the excitation function by the pionic atom resonance.

In general the results of these runs were encouraging, but indicate the need for:

1. better definition of the opening angle between the gamma rays,
2. improved photon energy resolution,
3. inclusion of a charged-particle veto to reduce low-pulse-height events in the detectors, and
4. longer running time to get better statistics.

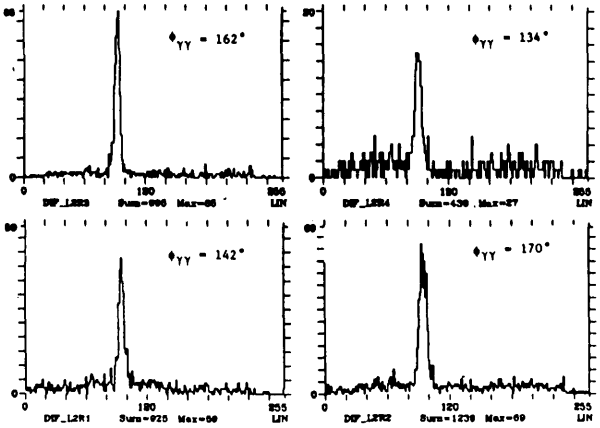

Figure 1. Time difference spectra at E_p = 148.2 MeV for the second left detector combined with each of the right detectors. The difference opening angles correspond to different π° energies, with larger opening angle implying lower π° energy.

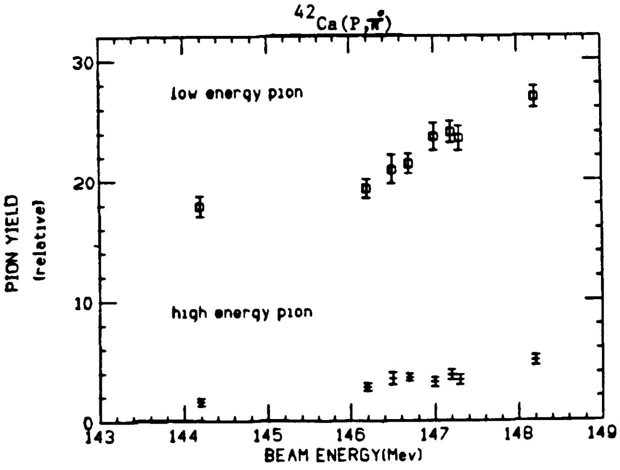

Figure 2. Relative π° yield vs. beam energy for selected pairs of detectors. The yield of low-energy pions ($\phi\gamma\gamma$ = 170°) is greater than that for higher-energy pions ($\phi\gamma\gamma$ = 134°).

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