PION PRODUCTION

MEASUREMENT NEAR THRESHOLD OF $^9Be(^3He,\pi)$ TO THE A = 12 ISOBARIC TRIPLET BY RECOIL DETECTION

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The study of near-threshold, pion production reactions to discrete states by measuring the recoils with the large solid angle IUCF QQSP spectrometer and a heavy ion focal plane detector[1] is a favorable method, because angular distributions over a wide or complete range can be obtained for several reaction channels simultaneously with a single angle and magnetic field setting.

The maximum scattering angle Θ_{1max} of the recoils in the pion production reactions considered is about 6° or half of the QQSP horizontal angle acceptance of 11.5°. Therefore, the incident beam must leave the spectrograph through the "0°" port. The beam is bent slightly in traversing the field of the first dipole of the split pole and in traveling about 28 cm in the reduced field region between the poles. The beam deflection limits the field level which can be applied without losing too much beam at the exit port. The maximum rigidity of the recoil particles, which can be analyzed at the focal plane within the given range of momenta (p/p_o = 0.83 ... 1.35, where p_o means the momentum with nominal radius ρ_o = 0.36 m) is, thus, also determined. For the recoils considered, maximum transmission through the port has been achieved by setting the spectrograph to $\Theta = -5.7°$. Thus particles with $\Theta_1 = 0°$ and Θ_{1max} appear at the low end and in the middle of the acceptance range respectively. The part of the beam current hitting the end of the port was monitored by insulated iron blocks. A 2.1 m long horizontally-widened vacuum box with the Faraday cup at its end has been connected to the port and shielded by a 1 m layer of iron and concrete.

For calibrating the detector the recoils from the reactions $^6Li(p,\pi^\circ)^7Be$ and $^7Li(p,\pi^-)^8B$ were measured. This was done with a 171.15 MeV p-beam and a 0.3 mg/cm^2 natural C-target. Detection of the high flux of α-particles (3 kHz at 15 nA beam current) was suppressed by raising the discriminator level of the E-and ΔE-signals.

All "pionic fusion" measurements were made using a 198.5 MeV ^3He beam. The reactions leading to ^{12}B, ^{12}C, ^{12}N recoils (corresponding to π^+, π°, π^-, respectively), were investigated with several types of Be targets, including two thicknesses of self-supporting targets, and others with 0.5 mg/cm^2 Au backing. Furthermore, some beam time was spent with such other targets as ^{11}B, ^{12}C, Li_2O and melamine[2] to study the feasibility of detection of still heavier recoils.

Since the September data-taking run we have analyzed only the longest run with the 0.5 mg/cm^2 Be target. For Z identification $\sqrt{E\cdot\Delta E} \propto Z \sqrt{m}$ was calculated from the E and ΔE signals. Both signals were corrected for the angle of incidence of the particles, measured relative to the normal to the focal line. The angular range is 29° to 63°. The angle is determined by measuring the particle position x_1 in the focal plane and x_2 at a location 4.4 cm behind it.

The position and angle information was calibrated prior to the run by means of one of the two lines of a ThC α source which was put at the target position. Gains and offsets of x_1 and x_2 were obtained by measuring the event positions with different fields and using the correlation between p/p_o and actual focal plane position which is known from beam optical calculations.

A one-dimensional window on Z=5 and 6 was set in the $\sqrt{E\cdot\Delta E}$ spectrum, which was accumulated using only angles in the above mentioned range. A two-dimensional window on mass 12 was set in the $E(x_1)$-histogram, which was sorted with angle and Z conditions. In Fig. 1 is shown the resulting angle versus x_1-histogram, which was obtained with Z, mass, and angle conditions. The curve a and the half ellipses b and c correspond to kinematic calculations using the angle and x_1 parameters which were obtained from the measurement with the α source. There would appear to be events in excess of background on the locus a) corresponding to the $^9Be(^3He,\pi^+)^{12}B$ bound states. The ^{12}C-events disappear, as they should, when the Z-window is set on Z=5. Some of the Z=6, A=12 events may come from the "pionic fusion" reaction because they appear to follow the curves b and c, especially at small p/p_o. The spallation background from beam-induced breakup of heavy impurities in the target gives events distributed over the plane and sets a lower limit to the observable cross section by this method. For a rough analysis the curve a was subdivided into three equal angle parts corresponding to center of mass scattering and solid angles of θ = 7.5°, 23.2°, 41.8° and $d\Omega$ = 0.11 sr, 0.38 sr, 0.59 sr. The solid angle at 41.8° is slightly reduced by the ± 50 mr axial angle aperture at the spectrometer entrance. The preliminary $d\sigma/d\Omega$-values are 0.7, 0.6 and 0.4 nb/sr. $d\sigma/d\Omega$ for the π^+, $^{12}B^{5+}$ – reaction could be slightly too high due to events from the $\pi°$, $^{12}C^{5+}$–and $\pi°$, $^{12}C^{5+}$ (15.11 MeV) – reactions which lie close to curve a. The integrated charge for this spectrum was 1.4 m Coul. The efficiency of the position wires was measured to be 59 percent and dead time losses were calculated to be 50 percent. There is a hint of structure in Figure 1 corresponding to another half ellipse with a center at $p/p_o \approx 1.28$ attributed to ^{11}B recoils which appear in the spectrum because of imperfect mass separation. Such ^{11}B recoils could result from the $^9Be(^3He,n\pi^+)^{11}B$ reaction, where the neutron, which is evaporated during or after the emission, carries little momentum. Resonant excitations of ^{11}B with neutrons around 1 MeV are known.[3]

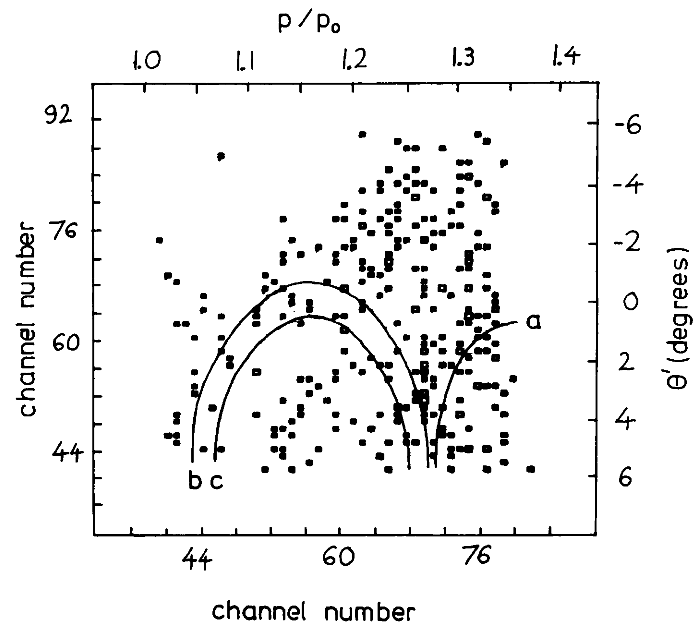

Figure 1. Scattering angle versus position histogram. θ_1' means the angle in the lab system measured from the spectrometer symmetry axis (scattering angle $\theta_1 = 5.7° - \theta_1'$). The variable p/p_o is the path radius relative to the nominal value 0.36 m. The curves are kinematics calculation results for the reactions:
a. $^9Be(^3He,\pi^+)^{11}B^{5+}$g.s.; b. $^9Be(^3He,\pi°)^{12}C^{6+}$g.s.
c. $^9Be(^3He,\pi°)^{12}C^{6+}$(15.11 MeV).

The Munich group would like to thank W. Benenson, who suggested measuring heavy ion pion production using the recoil method.

1) J.R. Erskine et al., Nucl. Instr. and Methods 135, 57 (1976).

2) The self supporting Be targets were manufactured by H. Adair, ORNL, Be on Au was made by H. Maier, Sektion Physik der LMU, Munich, Li_2O and Melamine by P. Maier - Komor, Physik - Department der TUM.

3) F. Ajzenberg-Selove, Nucl. Phys. A248, 1 (1975).

THE DOMINANCE OF HIGH-SPIN TWO-PARTICLE ONE-HOLE TRANSITIONS IN (p,π^-) REACTIONS

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In the process of attempting to extend earlier measurements for (p,π^-) ground-state transitions[1] to different mass regions, we have recently discovered a striking and unexpected systematic feature of (p,π^-) spectra on many target nuclei: a dominant fraction of the total yield to discrete states is often concentrated in one or a few states in a narrow region of excitation energy (E_x). Initial systematics for these dominant transitions were established by measuring broad-range (p,π^-) spectra with the QQSP magnetic spectrograph for bombarding energies in the range E_p=183-206 MeV, using Director's discretionary beam time during the period when the polarized ion source was being repaired. Representative forward-angle spectra for six targets are shown in Fig. 1. Qualitatively similar concentrations of strength have been observed for several other targets in each of these mass regions. E_x for the dominant states varies slowly with mass, from ~ 6-7 MeV for 1p-shell targets to ~3 MeV in the Zr region. The forward-angle cross sections vary rapidly, but not always monotonically, with neutron excess, and appear to be maximized when

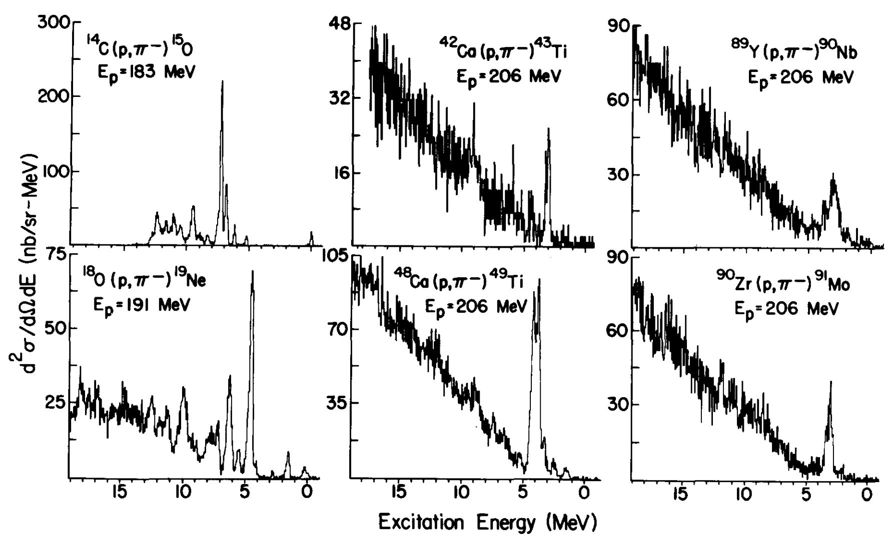

Figure 1. Spectra for the (p,π^-) reaction on several targets at θ_{lab}=30° (28° for the ^{14}C target), showing strong selective excitation of one or a few low-lying states.