ISOSPIN RESPONSE OF THE ^{4}He CONTINUUM

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Experiment 307 is an angular correlation measurement of the ^{4}He(p, p′N) reaction at proton bombarding energies of 100 and 150 MeV. The goals of the experiment are to attempt to understand the origin of the anomalous cross-section ratio $\sigma(\gamma, \mathrm{p})/\sigma(\gamma, \mathrm{n})$ observed for the E1 response of ^{4}He. To achieve that objective, we are exciting the ^{4}He continuum in the region of the observed asymmetry with intermediate-energy protons and observing ^{3}He/^{3}H ions coincident with scattered protons. This is equivalent to observing the neutron and proton decays of the ^{4}He continuum excited by proton inelastic scattering. Detection of the recoiling ions eliminates systematic errors in the neutron/proton decay comparison due to neutron-detection efficiency. The momentum transfer is chosen to preferentially excite the ΔL=1 portion of the ^{4}He response function. Angular correlation measurements are intended to ascertain the fraction of the response function at a given value of ω (the energy loss) which corresponds to the excitation of the E1 resonance. This is a necessary measurement because of the greater complexity of the continuum response excited in proton inelastic scattering relative to photoabsorption. This experiment is a followup on a previous measurement which observed an asymmetry in the cross section ratio for p$-^3$H and p$-^3$He coincidences strikingly similar to the photoabsorption results.

Progress in 1987 on E307 was in the area of the construction of the detector apparatus and some amount of in-beam testing. A schematic of the experimental setup is displayed in Fig. 1. The basic components are solid-state detector telescopes intended to observe inelastically-scattered protons and low-pressure horizontal-drift multiwire chambers backed by silicon-surface-barrier ΔE and Si(Li) E detector arrays designed to measure the recoiling ^{3}He and ^{3}H ions. The recoil-detection system is enclosed within the target-gas chamber to minimize the energy loss of the low-energy ions. The detector system is left/right symmetric to minimize systematic errors. The apparatus is mounted in the 1.6 m diameter vacuum chamber.

Protons of energies, $T_p \leq 150$ MeV, are observed in solid-state detector telescopes mounted on the remotely-controlled moveable arms in the 1.6 m chamber. The angular range of these ejectile arms is $15^o \leq \theta \leq 35^o$. The large angle limit is due to the recoil detectors occluding the view of the detector telescopes. The telescope consists of a pair of position-sensitive silicon detectors (PSD) followed by high-purity intrinsic Ge detectors which stop the protons and provide a high-resolution measurement of their kinetic energy. Events originate along an extended source from the beam path through the gas target. A pair of PSD measures the horizontal and vertical angles of the scattered particles. The event origin along the extended source is reconstructed from this information.

The PSD are large-area (6.25 cm^2), 0.1 cm thick passivated silicon detectors. One face

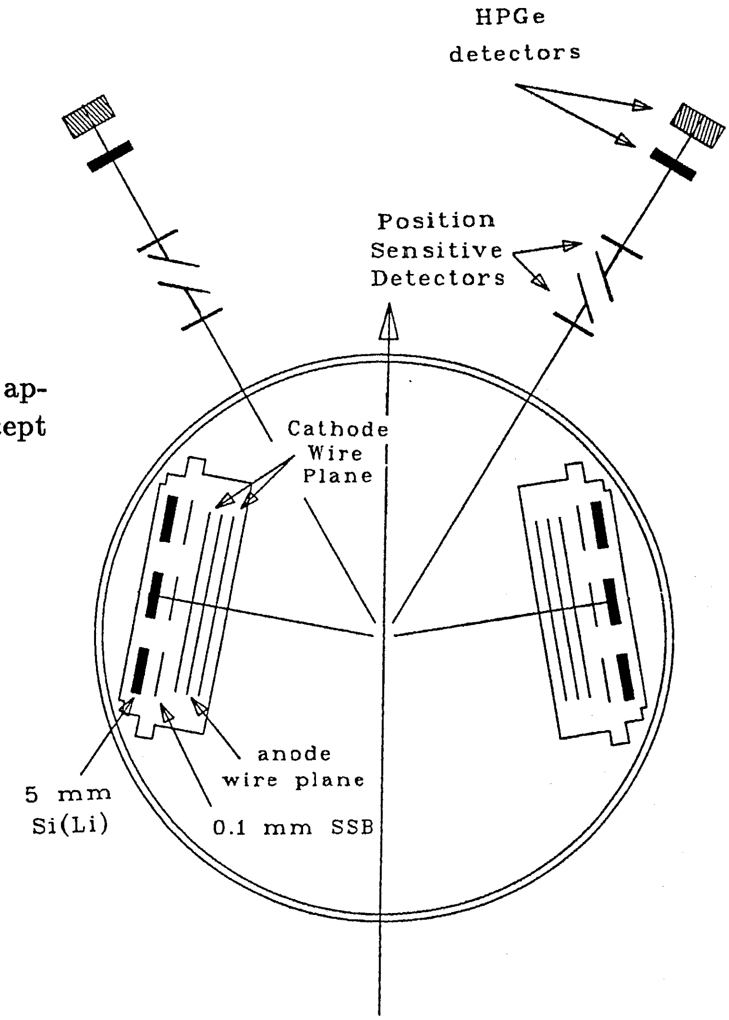

Figure 1. Schematic of E307 detector apparatus. All distances are to scale except separations between pairs of PSD.

of these detectors is a resistive layer which divides the ionization charge providing two-dimensional position information. The position-response is non-linear and is determined from the geometry of the grounded electrodes mounted at the edges of the detectors. It is calibrated by illuminating the detector with an ^{241}Am source through a mask of 100 holes arranged in a square grid. Fig. 2 displays the calibration data from one of the PSD. The non-linearities are parabolic in both horizontal and vertical coordinates. These data can be fitted using the known location of the holes to linearize the detector response. Overall position resolution is 200 μm.

The gas target is mounted at the center of the 1.6 m scattering chamber. The target chamber is a 30.5 cm diameter by 30.5 cm tall right circular cylinder. The beam enters through a 5 cm diameter circular window. Inelastically scattered protons exit the chamber through a 5 cm tall window that subtends scattering angles between $\pm 90°$. The windows are 25.4 μm Kapton foils epoxied to the inside of the chamber walls. These windows have been tested to pressure differentials in excess of 800 T. At the center of the chamber is a hub around which two moveable arms rotate. Presently, there is no remote control of the moveable arms. Mounted to the moveable arms are the recoil detectors (described

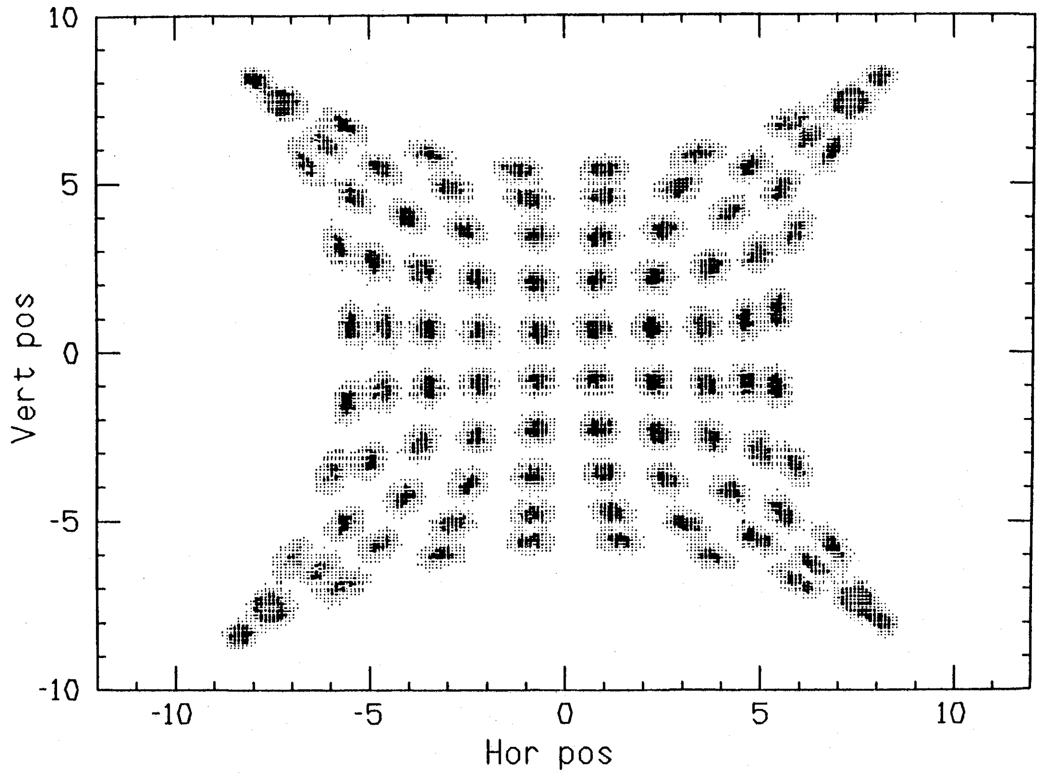

Figure 2. Calibration data for PSD. Displayed is the detector response to illumination by a ^{241}Am α–source through a square grid of 100 holes.

below) centered at 85° with respect to the incident beam. Cooling lines for the Si(Li) "E" detectors, gas lines, electrical signal lines, and high-voltage lines are patched through the lid of the target chamber to the recoil detector enclosures. Brass shielding mounted on the inside of the chamber serves the multiple purpose of preventing the recoil detectors and the upstream PSD from seeing particles scattered from the entrance window. A solid target is mounted on a shaft which can be remotely driven into the center of the target chamber. It provides a point source of events for calibration purposes.

The recoil detection system poses a serious challenge due to the large dynamic range of ionization lengths of particles to be detected. Accurate position and energy measurements are required for both ^{3}H and ^{3}He ions up to a maximum kinetic energy of 30 MeV. In principle, the low-energy limit extends to zero-energy particles. To illustrate, if the gas pressure is 200 T, then a 30 MeV triton would lose $\sim$0.04 MeV energy in a 1.27 cm length of C_4H_{10} wire chamber gas. A 2.5 MeV ^{3}He ion loses 1.9 MeV in that same chamber implying roughly a factor of fifty in the variation of energy losses. These requirements have been met by a low-pressure horizontal-drift multiwire chamber backed by an array of silicon ΔE-E detectors.

The drift chamber consists of a plane of alternating anode and grounded cathode wires sandwiched between two grounded cathode planes. Horizontal position measurements are performed by observing the time secondary ionization takes to drift to the nearest anode wire relative to a prompt signal derived from the first silicon detector. This drift time can be calibrated in terms of the position that the primary ion crossed the anode-wire plane. There remains an ambiguity whether the primary ion was left or right of the anode when it crossed the wire plane. The ambiguity can be resolved by measuring the difference of the induced signals at the cathodes on either side of the anode.

The active area of the drift chamber is 3.5 cm $\times$ 10 cm. The anode/cathode wire spacing is 0.5 cm. The distance between the wire plane and the cathode planes is 0.64 cm. Charge-sensitive preamplifiers (Rel Labs, RL-721) are mounted on a printed circuit board to which the wires are attached. The detector is located 9.8 cm from the center of the target chamber thus subtending an angular range of 30^o for events coming from this location. The angular range over which the detector observes recoiling ions is substantially larger due to the extension of the source of events along the beam direction.

All elements of the recoil detector are enclosed in a separate volume. That volume is kept in a low-pressure C_4H_{10} environment. A pressure-regulated gas-handling system maintains a constant flow of C_4H_{10} gas. The chamber gas is separated from the helium target volume by a 1.6 μm aluminized mylar foil. A constant pressure differential of less than 5 T is maintained across the window. The absolute pressure of the target and wire chamber gases is maintained at 200 T to minimize the energy loss of the recoiling mass-three ions.

The entire apparatus was assembled in the 1.6 m scattering chamber for in-beam tests in the fall of 1987. In those tests, the readout electronics for the detector arrays was fully assembled and tuned up. Singles data from all of the detector arms was obtained. Additionally, coincidences between all pairs of detector arms were observed and recorded on event tape for further off-line analysis. Most of the coincidence data were from two-body final states acquired to check the performance of the detector system and for calibration purposes.

Two major problems were discovered during the in-beam tests. First, the high-voltage to the wire chamber was discovered to break down above 600 V when the helium target gas was present. This problem was later found to be due to reliance on gas insulation at the point where connectors were attached to the high-voltage cables. This has been subsequently solved by providing a continuous solid insulation between the ground shield and signal wire of the HV cables. The second problem was inadequate suppresion of delta-rays produced by beam interactions with the target-gas molecules. A substantial rate of electrons were observed in both the upstream PSD on the ejectile arms as well as the forward-angle wires of the drift chamber. A simulation has been performed to establish the origin of the observed electrons and the distribution of flux across the detector system. A magnetic suppression system is being designed to solve this problem. These problems prevented the completion of E307 in the scheduled running period. Calibration data were obtained from a variety of kinematic-coincidence two-body final states. That data will permit evaluation of the performance of the detector system as well as directions to improve the apparatus. We anticipate the next opportunity to assemble the apparatus will be in the fall of 1988.