We have made a preliminary measurement of the pion cross section (~20 nb/sr) was observed for the exclusive $^3\text{He}(^3\text{He},\pi^+)^6\text{Li}$ and $^4\text{He}(^3\text{He},\pi^+)^7\text{Li}$ reactions at $T(^3\text{He}) = 283$ MeV (94 MeV/nucleon). This is quite a large cross section at such a low energy (~30 MeV above threshold) and transferred momentum (~3 fm$^{-1}$). The cross section for the $^6\text{Li}(^3\text{He},\pi^+)^9\text{Be}$ reaction at 270 MeV bombarding energy was found to be about 100 pb/sr, which is more than two orders of magnitude smaller than that for $^3\text{He}$ and $^4\text{He}$ targets. The transferred momentum in this case is about 3.6 fm$^{-1}$.

In the KDH model, one expects strong selection rules reflecting the structure of the specific state in which the final nucleus is left. Strongly excited states should be those whose cluster structure matches the entrance channel fragmentation. We therefore chose the $^{12}\text{C}(^3\text{He},\pi^+)^{15}\text{N}$ reaction for our initial experiment to look for enhanced transitions to the 10.7 MeV ($9/2^+$) and 15.4 MeV (13/2$^+$) states in $^{15}\text{N}$, which are believed to have a 3-nucleon cluster structure.

Fig. 1 shows the $^{12}\text{C}(^3\text{He},\pi^+)^{15}\text{N}$ spectrum obtained during a ~2 hr run with an average beam current of about 300 enA. We saw no evidence above background (~50 pb/sr) for transitions to bound final states, but a substantial yield was observed to the continuum. Checks were made to demonstrate that the counts in the continuum were due to pions and not positrons. The reaction mechanism for continuum production may be different from that responsible for transitions to bound final states, where a very large momentum transfer (~850 MeV/c) must be absorbed by the nucleus.

These results do not contradict the KDH model, since this model predicts a very rapid decrease in cross section with increasing target mass, largely due...
to the increase in momentum transfer. The background level in Fig. 2 is about equal to the cross section observed at Orsay for the $^6\text{Li}(^3\text{He},\pi^+)\text{Be}$ ($E_\pi=0-3.0$ MeV) reaction and hence is a good deal larger than that expected for $^{12}\text{C}(^3\text{He},\pi^+)\text{N}$. The background could be reduced in future runs by optimizing the scintillator thicknesses in the focal plane detector array.

Fig. 2 shows the momentum transfers for the $^3\text{He}$, $^6\text{Li}$ and $^{12}\text{C}(^3\text{He},\pi^+)$ reactions, and the $^{16}\text{O}(p,\pi^+)\text{O}$ reaction for comparison. According to the KDH model, the cross section for the coherent "pionic fusion" process should increase as the bombarding energy, and hence the momentum transfer, is decreased — until the point is reached (~30 MeV above threshold) where phase space dominates. Measurements of the energy dependence of the $^3\text{He}\pi$ reaction would shed light on the nature of the multi-nucleon pion production process and provide guidance for further theoretical developments.


3) Y. Le Bornec and N. Willis, ibid p. 155.