Evidence for New Structures in ^{17}O

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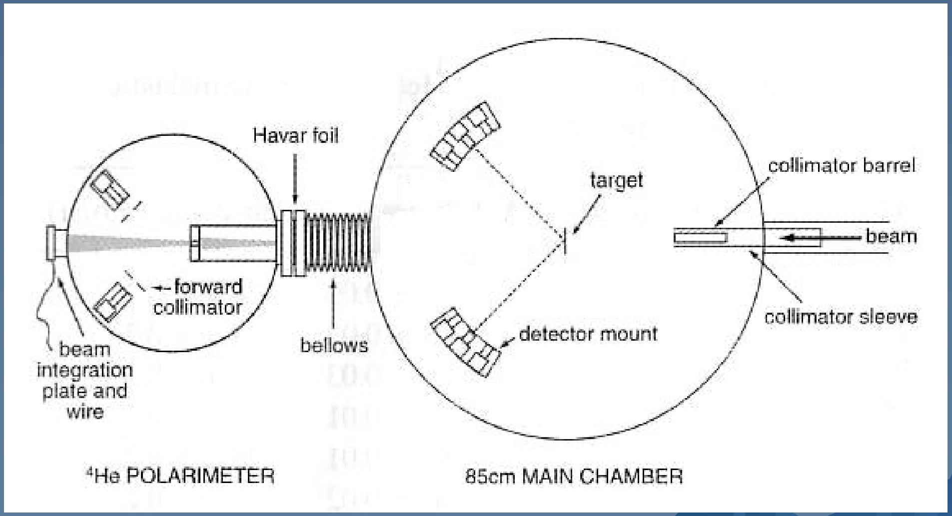
Outline

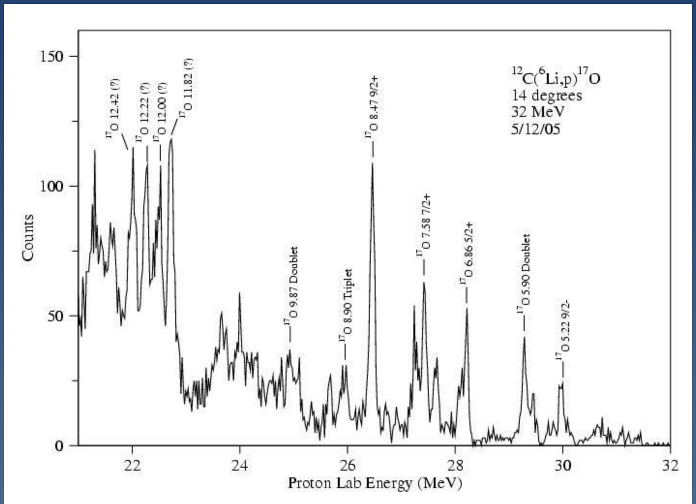
- Experiments
- Evidence for direct cluster transfer reaction mechanism
  - Selective Population
  - Excitation Function
  - DWBA Calculations
    - Characterization of states
- But really, why do we care?
- Conclusion

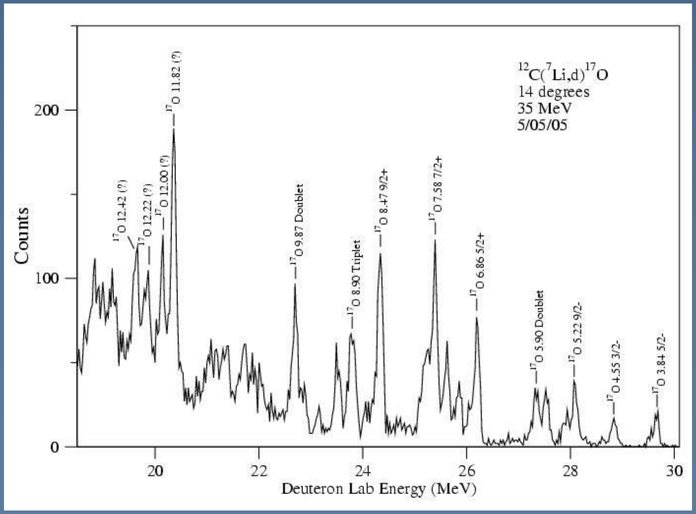
Experiments

- Conducted at the John D. Fox Superconducting Accelerator Laboratory
- $^{12}C(^{7}Li,d)^{17}O$
- $^{12}C(^{6}Li,p)^{17}O$
- $^{13}C(^{6}Li,d)^{17}O$
- $^{16}O(d,p)^{17}O$
- Used chamber setup below



Five-particle reactions

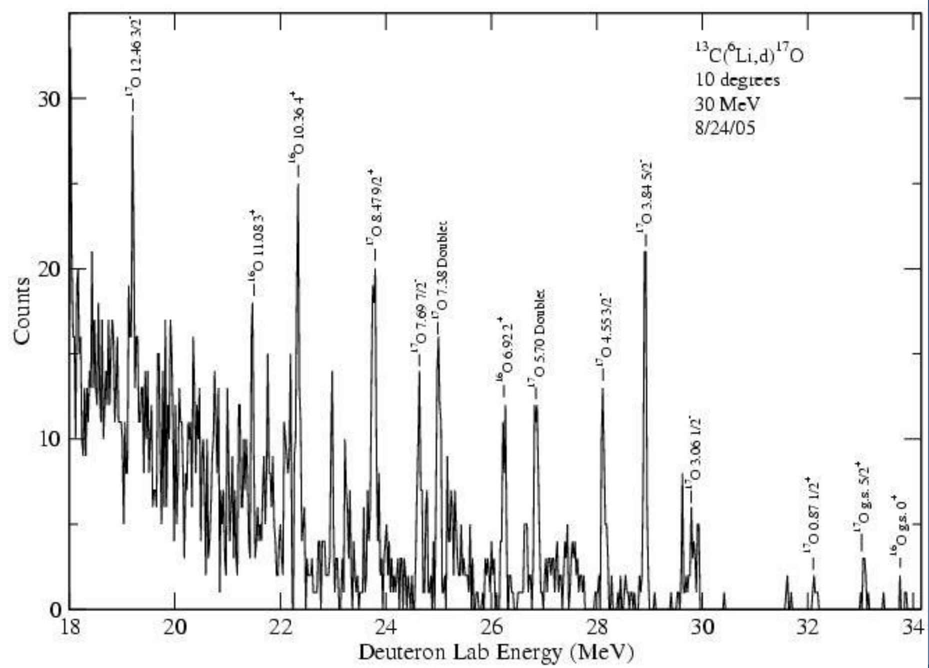




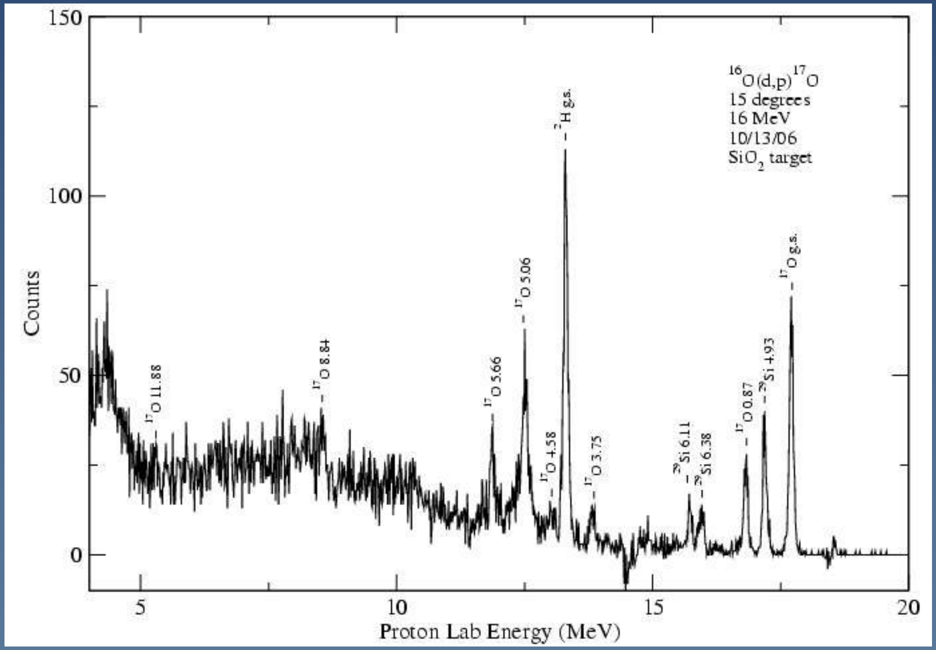
- $^{12}C(^{6}Li,p)^{17}O$ in the energy range 26-32 MeV and $^{12}C(^{7}Li,d)$ in the energy range 32-35 MeV
- Strongly populated states seen at 11.815, 12.00, 12.22, and 12.42 MeV
  - Spin and parities unknown for these states
- Selective population is evidence that these are direct cluster transfer reactions

$^{13}C(^{6}Li,d)^{17}O$

- Note that while there is selective population of states, the states between 11.815 and 12.42 MeV are not seen



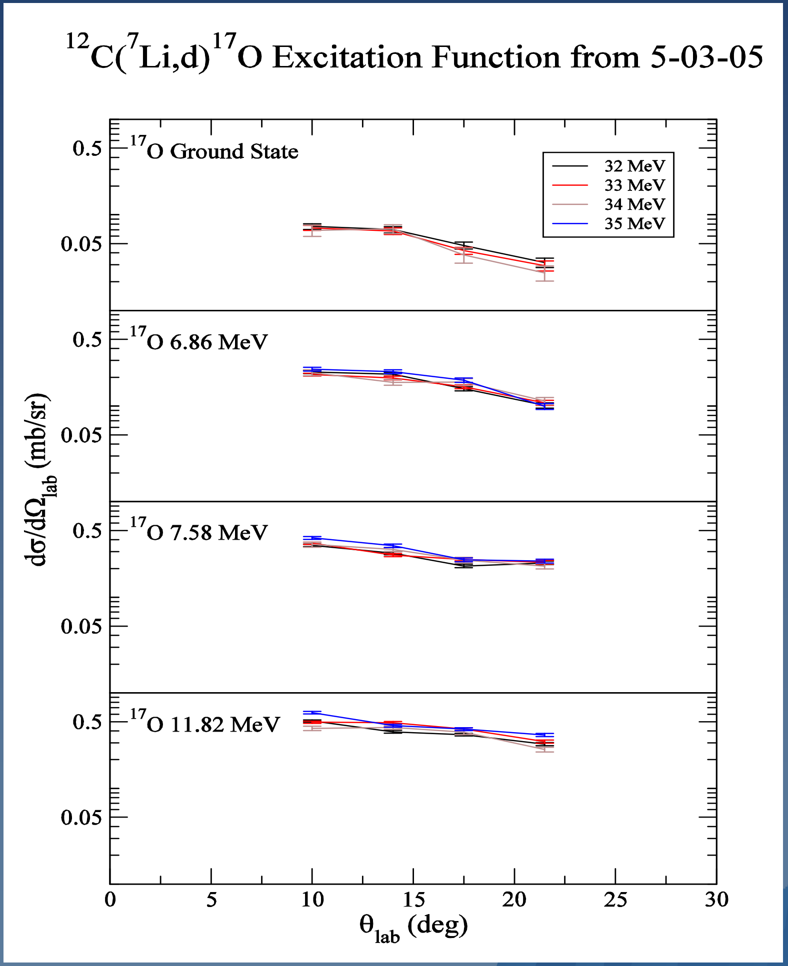
$^{16}O(d,p)^{17}O$



- Final experiment run to measure the reaction $^{16}O(d,p)^{17}O$ at a high enough energy to populate the states above 11 MeV
- Done to be sure that these states were not strongly populated with this reaction, as that would imply that they also have single-particle strength
- To obtain this spectrum, a spectrum from the reaction $^{12}C(d,p)$ was normalized to, and subtracted from, the original SiO_2 spectrum

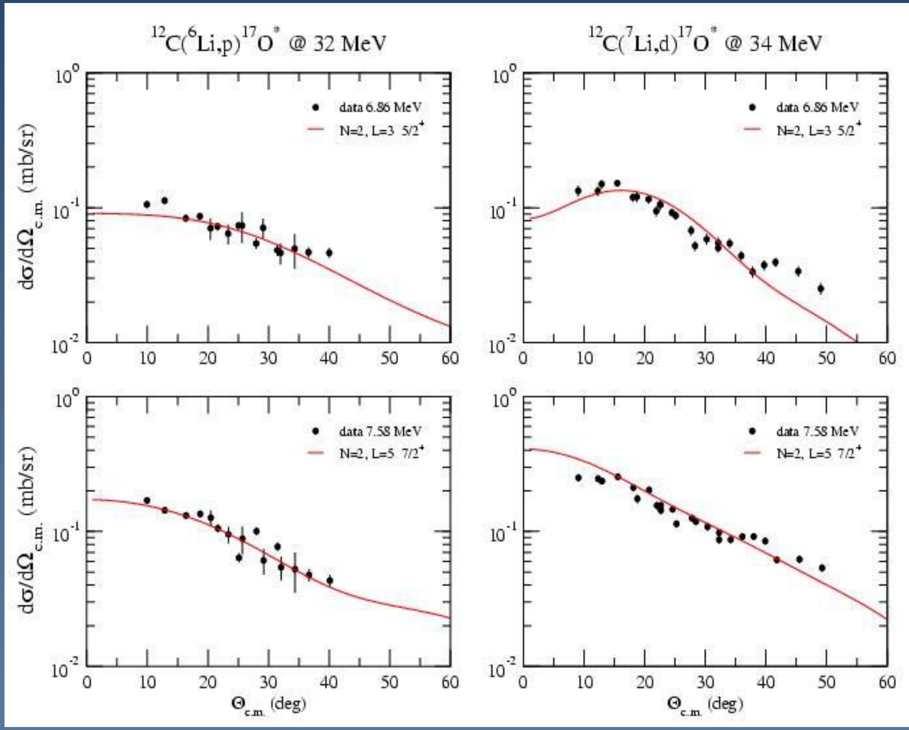
Excitation Function

- Provides additional evidence for direct cluster transfer
- Total cross section constant with respect to energy



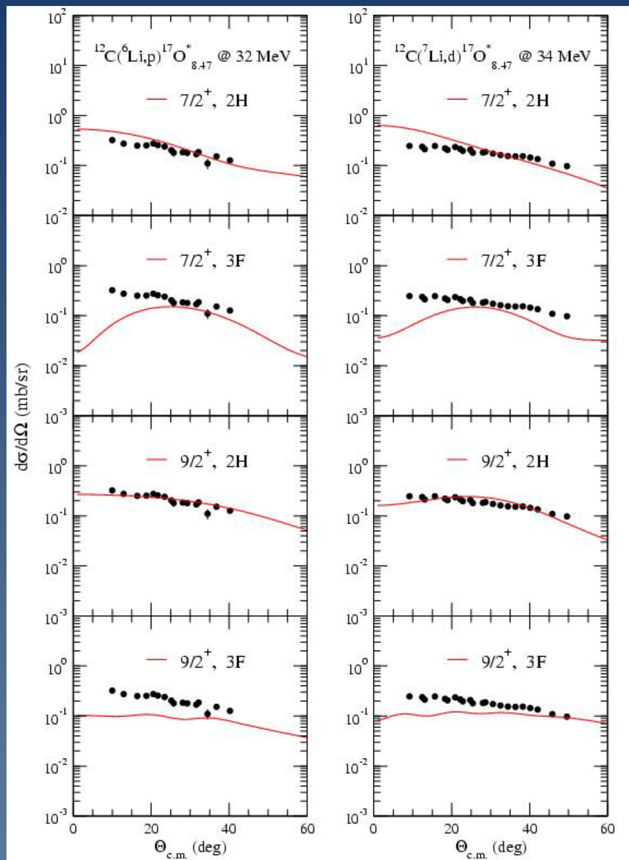
DWBA Calculations

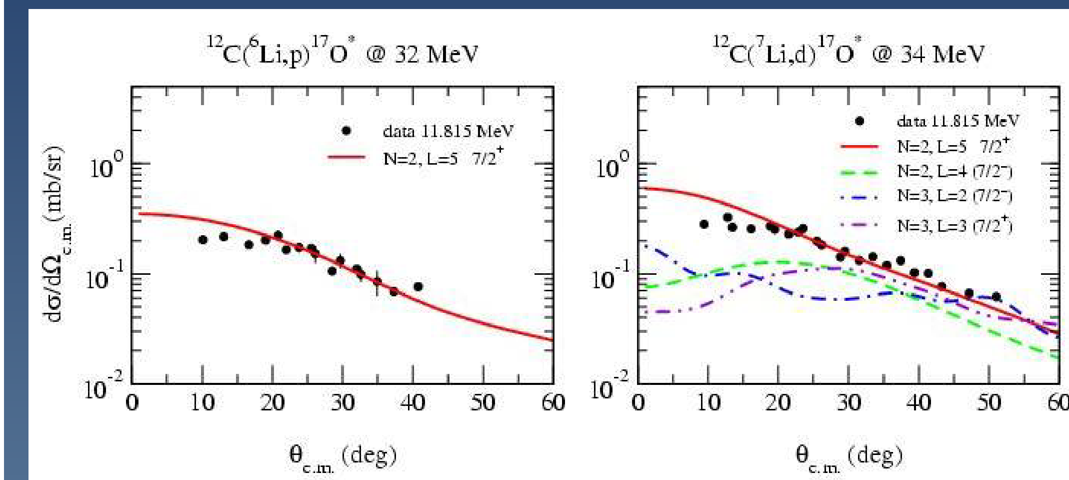
- Performed with FRESCO[1]
- Calculations for the 6.86 and 7.58 MeV states for both reactions[2,3,4]
  - Well known spins and parities of $5/2^+$ and $7/2^+$ respectively
  - 6.86 MeV: $(1p_{1/2})^4(1d_{5/2})^1$
  - 7.58 MeV: $(1p_{1/2})^2(1d_{5/2})^3$



[1]I.J.Thompson, Comp. Phys. Rep. 7, 167 (1988), [2]M.F. Vineyard, J. Cook, K.W. Kemper, and M.N. Stephens, Phys. Rev. C 30, (1984), 916, [3]N. Keeley, K.W. Kemper, Dao T. Khoa, Nucl. Phys. A726 (2003) 159, [4]T.K. Li, D. Dehnhard, Ronald E. Brown, and P.J. Ellis, Phys. Rev. C13 (1976) 55

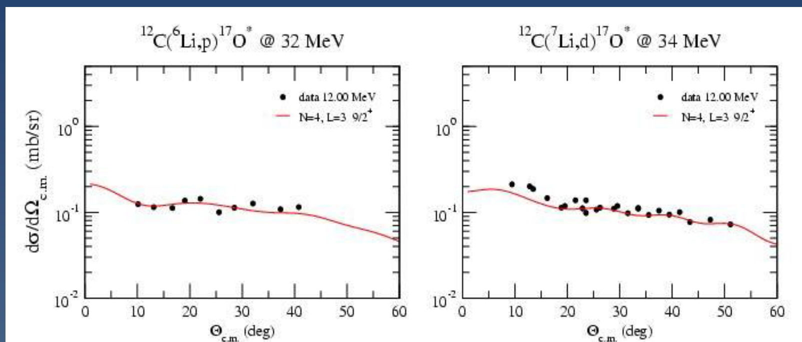
DWBA Calculations (cont'd)

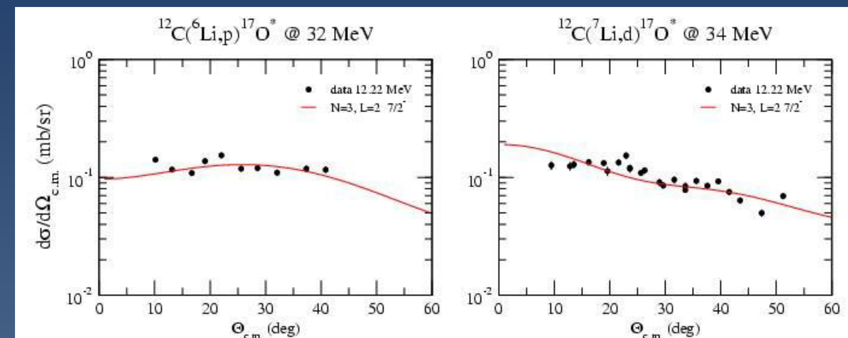


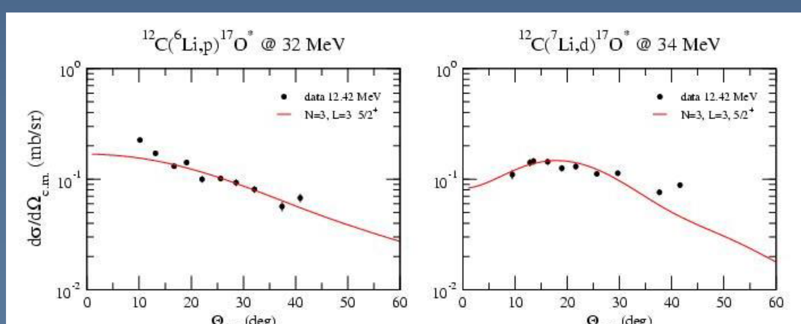


- Various calculations for the 8.47 MeV ($9/2^{+}$) level from both reactions – $(1p_{1/2})^2(1d_{5/2})^3$
- Calculations for the 11.815 MeV ($7/2^{+}$) level, shown with various N and L values – $(1p_{1/2})^2(1d_{5/2})^3$

DWBA Calculations (cont’d)





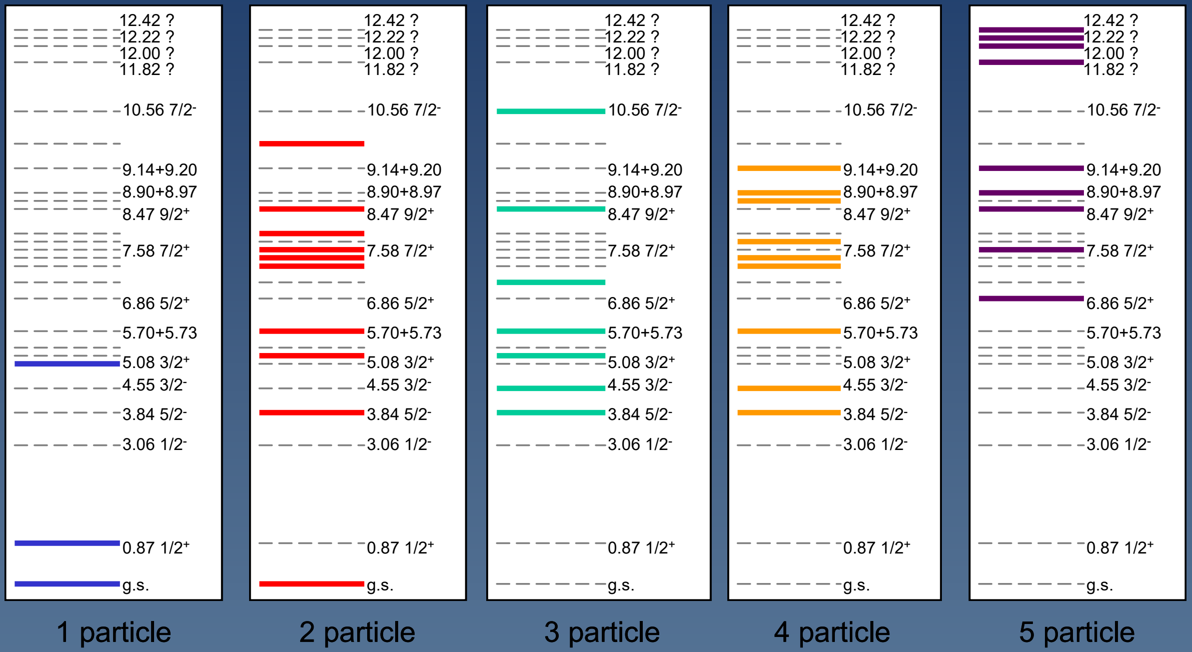


- Calculations for
  - 12.00 MeV ($9/2^+$) – $(1d_{5/2})^5$
  - 12.22 MeV ($7/2^-$) – $(1p_{1/2})^3(1d_{5/2})^2$
  - 12.42 MeV ($5/2^+$) – $(1p_{1/2})^2(1d_{5/2})^3$

Why Bother?

- "How is this research going to help us get to Mars?"
  - Future astronaut
- Cross sections important
- Need good theoretical calculations
- Must understand how the structure of the nucleus behaves

Oxygen 17



- Well understood shell structure at low energies useful for testing current psd shell model calculations
- As excitation energy increases, structure becomes more complex
- Other nuclei around Oxygen 16

Conclusion

- Provided evidence for direct cluster transfer reaction mechanism
  - Important for understanding structure of nucleus
- Preliminary spin, parity, and structures given for various selectively populated states in ^{17}O

Table 4: Summary of the results of the DWBA calculations.

Energy Level (MeV)	J^{π}	Structure Configuration	Transfer Reaction
0.0	$5/2^+$	$(1p_{1/2})^4(1d_{5/2})^1$	single-particle
6.86	$5/2^+$	$(1p_{1/2})^4(1d_{5/2})^1$	five-particle
7.58	$7/2^+$	$(1p_{1/2})^2(1d_{5/2})^3$	five-particle
8.47	$9/2^+$	$(1p_{1/2})^2(1d_{5/2})^3$	five-particle
11.82	$(7/2^+)$	$(1p_{1/2})^2(1d_{5/2})^3$	five-particle
12.00	$(9/2^+)$	$(1d_{5/2})^5$	five-particle
12.22	$(7/2^-)$	$(1p_{1/2})^3(1d_{5/2})^2$	five-particle
12.42	$(5/2^+)$	$(1p_{1/2})^2(1d_{5/2})^3$	five-particle