# Cluster Structure of $^{19}F$ Nucleus from $^{19}F(^{16}O, 2^{16}O)$ Knockout Reaction.

B. N. Joshi[1,*] Nishant Kumar[1], G. K. Prajapati[1], L. S. Danu[1,2], Y. K. Gupta[1,2], S. Mukhopadhyay[1,2], B. V. John[1,2], and Arun K. Jain[1]
[1] *Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai and*
[2] *Homi Bhabha National Institute, Training School Complex, Mumbai*

$^{19}F$ Nucleus has been of interest for the understanding of the nuclear synthesis and abundances in the cosmos[1]. Ground state of $^{19}F$ is $\frac{1}{2}^{(+)}$ and is expected to be $2S_{1/2}$ proton state rather than a $1d_{5/2}$ proton state according to a standard shell model with spin orbit interaction. It has also been considered to be a $^{16}O$+$t$ and $^{15}N$+$\alpha$ cluster structure with binding energies of 11.7 MeV and 4.7 MeV respectively. The $^{16}O$+$t$ structure is more strongly bound in L=0 and N=3 ($^{16}O$+$t$) relative motion, with L-being orbital and N being radial quantum number. Lower separation energy for $\alpha$+$^{15}N$ cluster structure is expected to dominate with L=1 and N=3 ($\alpha$+$^{15}N$) relative motion quantum number.

The $t$- and $\alpha$- pickup or transfer direct reactions could not ascertain the preferred clustering component or spectroscopic factor from these direct reactions. This is due to the well known uncertainties of the residual interaction as also the optical potentials involved in the DWBA-calculations. In recent years the heavy cluster knockout reactions have been found to be more reliable as the Finite Range (FR)-Distorted Wave Impulse Approximation (DWIA) calculations have been perfected. This is because more reliable t-matrix effective interactions could be generated from the realistic interactions between heavy ions. [2–4]

This recent development of the FR-DWIA formalism and the FR-DWIA code has prompted us to undertake the $^{19}F(^{16}O, 2^{16}O)^3H$ knockout reaction at $E_0$= 87 MeV to deduce the $^{16}O$+$t$ cluster contribution to the ground state of $^{19}F$ nucleus. A symmetric coplanar experiment with the two

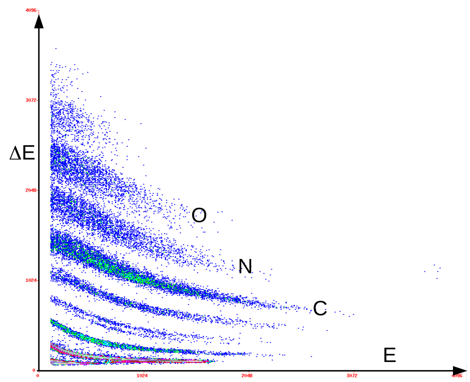


FIG. 1: A two dimensional particle identification plot ($\Delta E$ versus $E$) from the 87 MeV $^{19}F(^{16}O, 2^{16}O)^3H$ reaction with carbon backing.

$^{16}O$ detected at $40.6^0$ in coincidence (which contains the zero recoil momentum of the triton at $E_1$=$E_2$= 37.5 MeV). A beam of $^{16}O$ of average current $\sim$ 5 pnA bombarded on LiF target of thickness 350 $\mu g/cm^2$ . The LiF target has a backing of Au, Al and C of thickness 300 $\mu g/cm^2$, 80 $\mu g/cm^2$ and 20 $\mu g/cm^2$ respectively. The two detector telescopes $T_1$ and $T_2$ comprised of 15 $\mu m$ $\Delta E$ and 300 $\mu m$ $E$ Si-surface barrier detectors. These telescopes were kept at 31 cm from the target, with a collimator of 7 mm diameter. This setup provided a good enough solid angle of 0.4 $mSr$ and a reasonable angular resolution of $\pm$ $0.64^o$. A monitor detector with collimeter of 1 mm diameter was kept at a $20^0$ at a distance of 40 cm from the target for measuring the beam current.

The separation of the $O$ and $N$ elements was quite good in the present experimental

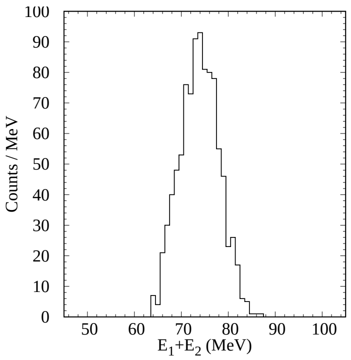


FIG. 2: Summed Energy ($E_1$+$E_2$) spectrum for the 87 MeV $^{19}F(^{16}O, 2^{16}O)^3H$ reaction.

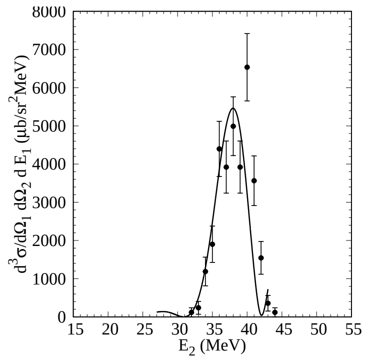


FIG. 3: Energy sharing spectrum for the 87 MeV $^{19}F(^{16}O, 2^{16}O)^3H$ reaction. Solid line shows PWIA calculations

setup (See Fig.1 $\Delta E$ vs $E$ plot).The summed energy spectrum is shown in Fig.2. A peak at $E_1$+$E_2$ $\sim$ 75 MeV in the summed energy spectrum is seen. A slice of this summed energy spectrum corresponding to $\pm$ 1 MeV give rise to an energy sharing distribution which is seen in Fig.3. It shows a peak at zero recoil momentum position ($q_R$=0). We fit this energy sharing spectrum with L=0 knockout of $^{16}O$ in the $^{19}F(^{16}O, 2^{16}O)^3H$. A Plane Wave Impulse Approximation (PWIA) fit is shown in Fig.3 with these L=0 distribution.

A peak is also seen at the right side of the PWIA distribution. This peak may be attributed to the $^{19}F^*$ resonance, through $^{19}F$+$^{16}O$ $\rightarrow$ $^{19}F^*$ ($^{19}F^*$ $\rightarrow$ $^{16}O$+$t$) + $^{16}O$. The resonance energy of $^{19}F^*$ will be equal to $E_{Relative}$-$Q$ value of the reaction = ($\frac{3}{16}\times$ 36+11.7 MeV= 18.7 MeV) in $^{19}F^*$ which has a structure of $t$+$^{16}O$. This excitation is not a very high excitation energy and can very well be separated from a lot of resonances seen in the spectrum of $^{19}F^*$. For separating this resonance contribution from the direct knockout contribution one can perform the procedure as described as (Contribution in the same symposium) event mixing technique where the resonance contribution is possible to separate from the direct knockout contribution[5]. In a nut shell this procedure randomizes the fixed relative energy of the two $t$+$^{16}O$ motions. Thus reducing the contribution of such a fixed relative energy by distributing individual energies of the three particles over the whole available energy range. We represent the results corresponding to the pure direct $^{16}O$ knockout compared with the PWIA. A FR-DWIA study will provide us with the $t$+$^{16}O$ spectroscopic factor for $^{19}F_{(g.s)}$

The event mixing method described here can separate the resonance breakup contributions from the direct knockout components.
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* Electronic address: bnjoshi@barc.gov.in

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