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^{8}Be-DECAY OF THE ^{24}Mg 46.4 MeV RESONANCE

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$^{8}Be_{gs}$ coincidences with ^{12}C, $^{8}Be_{gs}$ and α-particles produced in the ^{12}C +^{12}C interaction at 65 MeV have been measured in a wide in-plane angular range. The 3- $^{8}Be_{gs}$ final state is found to be produced, even if poor statistics prevent any identification of the ^{16}O states involved in the first stage of the process. The $^{8}Be_{gs}$ - α and $^{8}Be_{gs}$ - ^{12}C coincidence yields are found to be to ^{12}C and ^{16}O excited states, decaying into the $^{8}Be_{gs}$ +α and ^{12}C +α system, respectively.

Whether the 46.4 MeV resonance in ^{24}Mg [1 - 11] can be associated with the formation of a linear 6α chain is still an open question. From the first experiments on the $^{12}C[0_2^+]$ + $^{12}C[0_2^+]$ exit channel [1, 2] of the ^{12}C + ^{12}C interaction it was deduced that a configuration of 6α on a line was formed, which subsequently decays into two shorter 3α chains. Later experiments showed that the same resonance (or at least a resonance at the same energy) could decay into different less deformed channels, like, for example, the $^{16}O_{gs}$+$^{8}Be_{gs}$ one. If this chain is formed, it is expected to decay into channels with extremely high degree of deformation. For example the linear configuration may break up asymmetrically into the $^{8}Be_{gs}$+$^{16}O^{*}$ or the α + $^{20}Ne^{*}$ systems, where $^{16}O^{*}$ and $^{20}Ne^{*}$ keep the shape of four or five α on a line, respectively. No clear evidence has been found up till now for this kind of decay, which is the reason of the experiment here reported.

The experiment was performed at the tandem of the Laboratori Nazionali del Sud, in Catania with a 65 MeV ^{12}C beam delivered on a Carbon target. The reaction products were detected by a set of Dual Position Sensitive Detectors (DPSD) at 17, 32, 47, -20 and -35^{0} with respect to the beam direction. Each DPSD consisted of two rectangular Position Sensitive Detectors (PSD) assembled in close geometry. They were able to detect the coincident α-particles coming from the decay of ^{8}Be nuclei. From the position and energy information of the two particles detected in each PSD one can build the spectrum of their relative energy, thus identifying the $^{8}Be_{gs}$ from the known relative energy of the emitted α-particles of 90 keV (fig. 1). Thus the acquisition system was triggered by the coincidence of one pair of particles detected in a DPSD and at least another particle detected in another PSD.

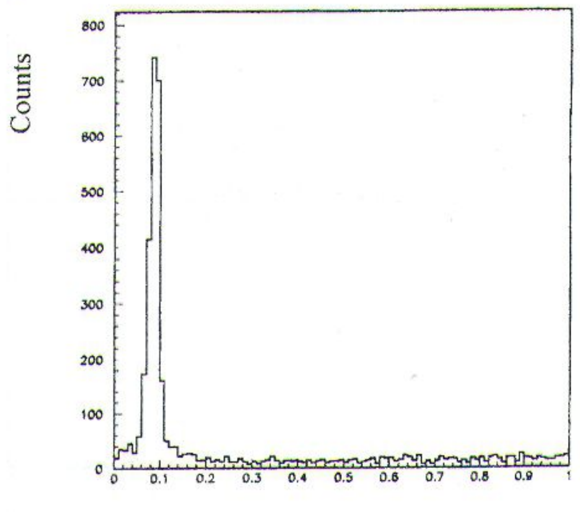

Fig. 1.Typical spectrum of relative energy of two particles detected in coincidence in two halves of DPSD. The peak at 90 keV comes from 2-α decay of $^{8}Be_{gs}$

From the events corresponding to the detection of four particles in two DPSP's we selected the $^{8}Be_{gs}$-$^{8}Be_{gs}$ coincidences by gating on the relevant 90 keV peaks in the relative energy spectra. The resulting total Q spectrum is showed in fig. 2. At −15 MeV it is clear the presence of the peak corresponding to emission of three $^{8}Be_{gs}$. The bump at more negative Q-values is due to detection of particles other than α's, to excitation of the undetected ^{8}Be at 3MeV, or to processes with more than three particles in the final state. Even if the peak at −15 MeV is a clear evidence of ^{24}Mg decay into 3 $^{8}Be_{gs}$, no information can be drawn from the present data on the intermediate $^{8}Be_{gs}$+^{16}O stage. In particular we cannot deduce any conclusion on the levels of $^{16}O^*$ involved in this sequential decay, since the spectrum of the $^{8}Be_{gs}$-$^{8}Be_{gs}$ relative energy (i.e. $^{16}O^*$ excitation energy) contains no meaningful peaks, due to the poor statistics.

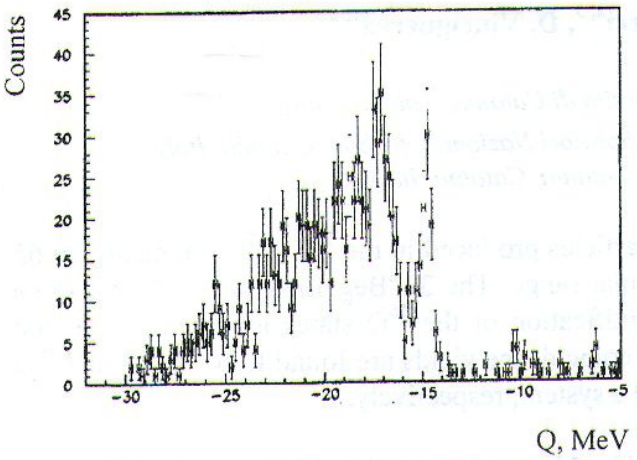

Fig. 2. Q spectrum deduced from the coincidence detection of two $^{8}Be_{gs}$

Only kinematic identification is possible for a particle detected in a single PSD in coincidence with $^{8}Be_{gs}$. By assuming for it a given mass (4 or 12 here) one can plot the quantity (E_3 − Q) as a function of P^2_3, where E_3 and P_3 are the energy and the momentum of the third undetected particle, and Q is the three body Q-value. The events for which the mass assumption is a correct fall on a straight line, with a slope proportional to the inverse of the undetected particle [12], and thus can be selected for further analysis.

This procedure was applied twice for mass 4 and 12 respectively, in order to deduce information on the ^{12}C+α+$^{8}Be_{gs}$ final state. The deduced Q-spectra are shown on fig. 3 for both cases.

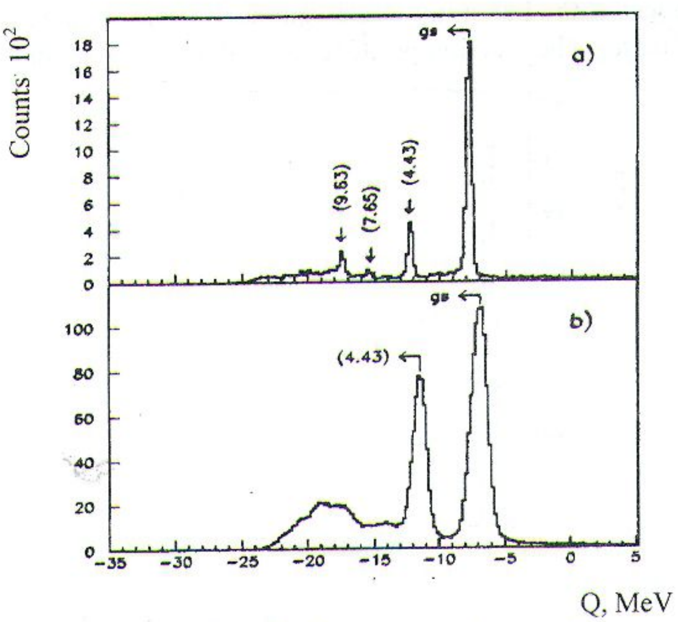

Fig. 3. Examples of Q spectra deduced from the coincidence detection of one $^{8}Be_{gs}$ with one stable unidentified particle detected in one half of DPSD. In Fig. 3,a (3,b) kinematics has been reconstructed and events have been selected under the assumption of mass 4 (12) for unidentified particle.

When mass 4 is assigned to the detected particle, the Q-spectrum shows all the possible excitations of the residual ^{12}C, namely 0, 4.4, 7.6 and 9.6 MeV (fig. 3, *a*). By gating on each of these peaks we found that the α − $^{8}Be_{gs}$ relative energy spectra contains contributions due to formation and decay of $^{12}C^*$ at 7.6 and 9.6 MeV. This channel appears to be dominated by ^{12}C mutual excitation and break-up. The relative weights of the different $^{12}C^*$ - $^{12}C^*$ contributions are consistent with those deduced by previous experiments [3].

When mass 12 is assumed for the unidentified particle, the Q spectrum shows peaks due to ^{12}C particle stable states only (ground state and 4.4 MeV state). The relative energies for all the possible couples of the three final particles were reconstructed and again the contribution of ^{12}C break up into α and $^{8}Be_{gs}$ turned out to be dominant. But in this case another valuable contribution shows up, due to an intermediate $^{8}Be_{gs}$ + $^{16}O^*$ stage, which finally gives place to the $^8Be_{gs}+\alpha+^{12}C$ channel, after decay of ^{16}O into $\alpha + ^{12}C_{gs}$ or $\alpha + ^{12}C_{4.4}$. When the ^{12}C is left in its ground state, the ^{16}O is recognised to decay from states at 10.0, 11.3, 14.3, 15 and 16.5 MeV (fig. 4, *a*). Decay into ^{12}C (4.4 MeV) occurs (fig. 4, *b*) from ^{16}O states at 14.3, 15, 16.3 and 18.2 MeV, with fair overlapping with three of the states producing $^{12}C_{gs}$. On both figures 4, *a* and 4, *b* the dotted lines represent the results of detection efficiency calculations performed by a Monte Carlo code written for the present experiment.

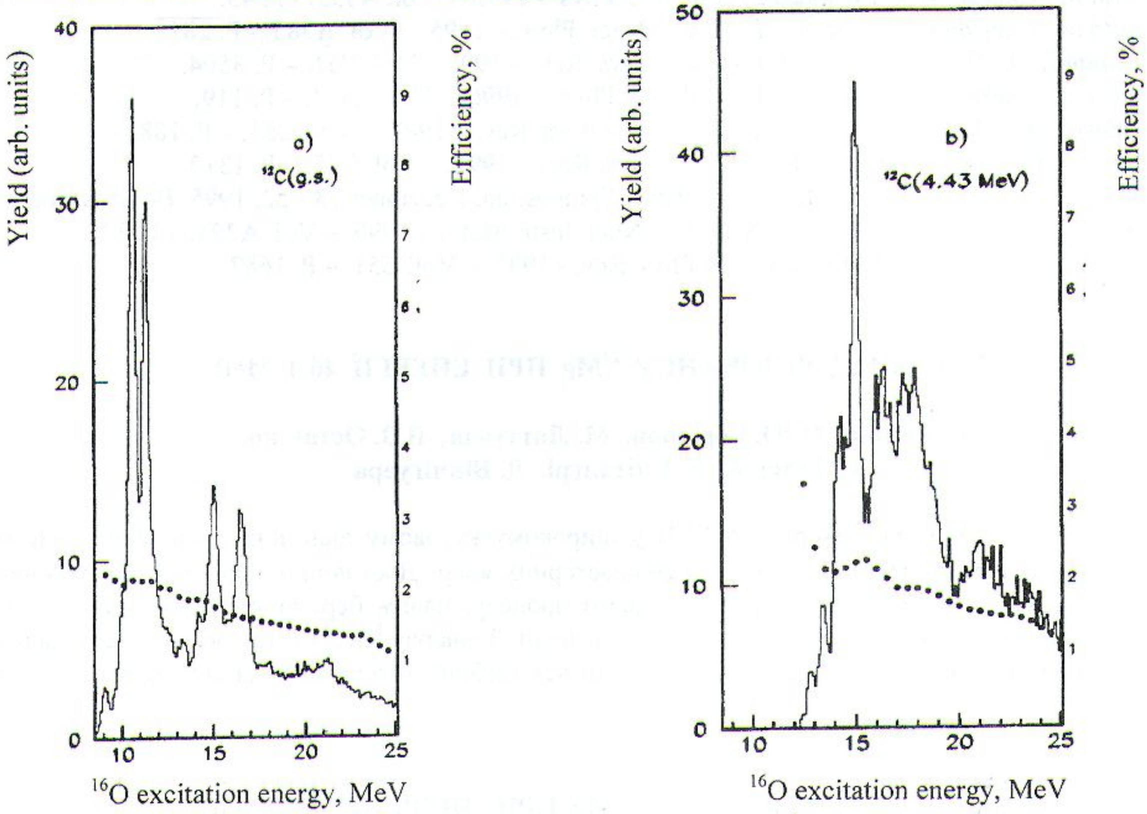

Fig. 4. Projections on the ^{16}O excitation energy axis for events with ^{8}Be-α relative energy larger than 2.8 MeV. Dots show how efficiency varies with relative energy.

Some of the above mentioned ^{16}O states lay above the 4α emission threshold, but anyway no clear correspondence can be found with the states belonging to the very deformed rotational band which is associated with the 4α linear chain [13].

No indication of ^{8}Be-^{12}C resonance is seen in our data and thus we got no evidence for the $\alpha + ^{20}Ne$ decay of ^{24}Mg, which could give a $\alpha + ^8Be + ^{12}C$ final state.

In conclusion new decay modes of ^{24}Mg have been detected in the present experiment, but they are associated with poorly deformed configurations, as can be inferred by the known compact shape of the low lying ^{12}C levels produced in the final state of the reaction. No definite evidence for decay into asymmetric channels retaining the elongated shape of a chain has been found.

The results on the 3 $^8Be_{gs}$ final state suggest the need for further investigation which allows identification of the $^{16}O^*$ states producing this final system. Actually it should be understood if the reaction proceeds through the $^8Be_{gs} + ^{16}O^*$ intermediate system, followed by symmetric break up of $^{16}O^*$ into a pair of $^8Be_{gs}$. The identification of the involved ^{16}O states and their comparison with the known 4α chain rotational band [13] could give in turn new relevant information on the nature of the emitting ^{24}Mg resonance at 46.4 MeV.

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^{8}Be-РОЗПАД РЕЗОНАНСУ ^{24}Mg ПРИ ЕНЕРГІЇ 46.4 МеВ

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У реакції ^{12}C+^{12}C при енергії 65 МеВ у широкому кутовому діапазоні планарної геометрії досліджено на співпаданнях канали виходу α–кластерних ядер. Достовірно знайдено, що можлива реалізація трьох ядер ^{8}Be в кінцевому етапі цього процесу, навіть беручи до уваги доволі бідну статистику при ідентифікації ^{16}O з першого етапу реакції. З аналізу $^{8}Be_{gs}$ - α та $^{8}Be_{gs}$ - ^{12}C співпадань встановлено, що збуджені стани ^{12}C та ^{16}O розпадаються здебільшого через канали $^{8}Be_{gs}$ +α та ^{12}C +α відповідно.

^{8}Be-РАСПАД РЕЗОНАНСА ^{24}Mg ПРИ ЭНЕРГИИ 46.4 МэВ

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В реакции ^{12}C+^{12}C при энергии 65 МеВ в широком угловом диапазоне планарной геометрии исследованы на совпадениях каналы выхода α–кластерных ядер. Достоверно найдено, что возможна реализация трех ядер ^{8}Be на конечном этапе этого процесса, даже если принять во внимание довольно бедную статистику при идентификации ^{16}O с первого этапа реакции. Из анализа $^{8}Be_{gs}$ - α та $^{8}Be_{gs}$ - ^{12}C совпадений определено, что возбужденные состояния ^{12}C та ^{16}O распадаются в основном через канал $^{8}Be_{gs}$ +α та ^{12}C +α соответственно.