Evaporation residue gated GDR studies in ^{19}F+^{27}Al reaction at E(^{19}F)∼125 MeV

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Introduction

The study of the giant dipole resonance (GDR) built on excited states in light nuclei can address the Jacobi shape transition from oblate to highly deformed triaxial (almost prolate) shape at high angular momentum. This has been reported [1–3] in some nuclei with mass A∼45. Many of these are singles measurements in which a contribution from the non-compound nuclear reactions cannot be ruled out experimentally. The reported measurements in [1] were, however, made in coincidence with a characteristic evaporation residue gamma ray. The evolution of the GDR strength function with angular momentum at a particular compound nuclear excitation energy has not yet been systematically addressed. The tagging on the angular momentum is done via the measurement of the associated low-energy γ-multiplicity. The low-multiplicity events are generally more affected by contributions from non-fusion events. A measurement made in coincidence with the fusion-evaporation residues can address the issue of shape evolution in a cleaner manner. In this paper we report such a measurement for the compound system ^{46}Ti.

Experimental Details

The experiment was performed using a pulsed, collimated 125 MeV ^{19}F beam from the Pelletron Linac Facility, Mumbai bombarding a 0.63 mg/cm^2 Al target. The mean excitation energy and the maximum angular momentum in the compound nucleus (CN) were ∼98 MeV and ∼36$\hbar$, respectively. High energy γ-rays in the energy range of ∼4 to 30 MeV were detected in an array of seven close packed BaF_2 detectors. The neutron-γ discrimination was made through the time of flight (TOF) measurement with respect to the beam pulses. Measurements were made in coincidence with a low energy γ-ray multiplicity detector array consisting of 38 hexagonal bismuth germanate (BGO) detectors and also a parallel plate avalanche counter (PPAC) of annular geometry placed at 0° with respect to the beam direction. The fusion evaporation residues (ER) were detected in the PPAC over the angular range of ∼4−12° and identified by their TOF from the target. The details of all the detector systems are given in [4].

Results and Discussion

The ER-gated γ-spectra are free of any contribution from 1) low mass impurities like carbon and oxygen, 2) deep inelastic processes or 3) fission-like processes. Fig. 1 shows the ratio of the singles and the ER-gated spectra for various folds. Fold is defined as the number of BGO-detectors in coincidence (within 50 ns) with the event detected in the BaF_2 detector. The importance of making ER-gated measurements is demonstrated in the figure, particularly, for lower folds.

Fig. 2 shows the ER-gated γ-spectra in terms of the divided plots obtained after dividing with a calculated spectrum with no GDR excitation and matched at ∼7 MeV. These

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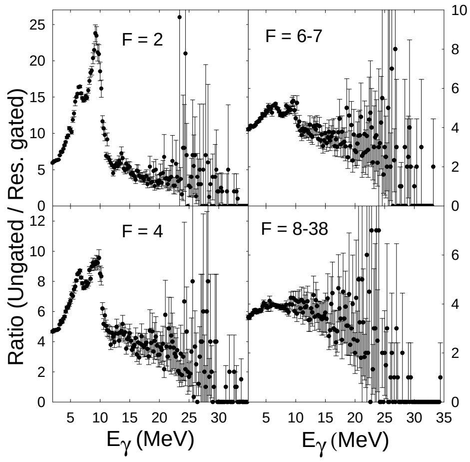

FIG. 1: Ratio of ungated to ER-gated spectra for various folds F.

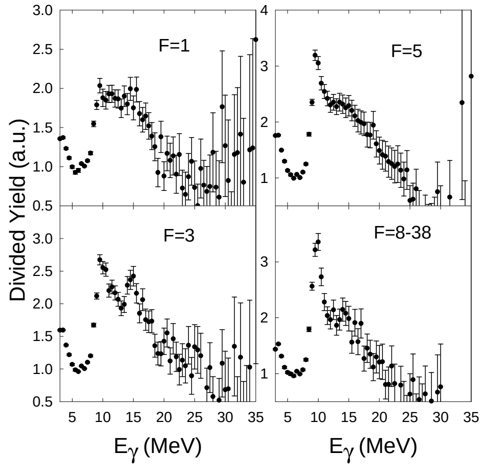

FIG. 2: Divided plots for various folds F.

plots, which represent the gross feature of the GDR strength function, show many interesting aspects. A component at E_γ $\sim$10 MeV becomes prominent at higher folds. Another component at E_γ $\sim$15 MeV appears to be prominent at the intermediate fold windows. The higher energy part of the strength function is almost similar for all fold windows. A low energy component can arise from the vibration along an elongated axis and the present observation would then suggest that such a large deformation evolves with angular momentum. However, the structure at $\sim$15 MeV appears difficult to explain. The higher energy part corresponds to the GDR energy generally expected for this light mass region.

The appearance of a low energy structure around 10 MeV has been reported [1, 3] and conjectured to be due to the Jacobi transition which should manifest at a high angular momentum of $\sim 28\hbar$ in the present mass region. Although the present data could indicate a continuous evolution towards such a shape, a mapping of fold to angular momentum in the CN (J_{CN}) is required to address this. In this light system, a low fold event could arise also from a high J_{CN}. A Monte Carlo CASCADE calculation was done to calculate the J_{CN} distribution for different fold windows with the condition of accompanying high energy γ-rays. For the γ-ray energy of 9 to 11 MeV, corresponding to the prominent structure observed, the fraction of the J_{CN} population above $27\hbar$ increases from $\sim$0.2 to $\sim$0.5 for the fold window changing from 1-1 to 8-38. The present observation is, therefore, not inconsistent with a reasonably sharp Jacobi transition at the expected angular momentum. More exclusive measurements in coincidence with α-particles and/or covering a wide range of bombarding energies may address the issue in more detail. It will be interesting to follow the evolution of the width of the low-energy component with temperature.

Acknowledgments

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