# Testing of Gamma Multiplicity Filter Array at VECC with $^{252}$Cf fission source

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## Introduction

The study of the hot giant dipole resonance (GDR) has been a very successful tool in nuclear structure physics for the last 25 years. While the main features are understood, the GDR widths at low temperatures contradict the predictions of the Thermal Shape Fluctuation Model (TSFM) [1]. Thus, more exclusive experiments are required unraveling the effect of T & J on GDR width to understand the nature of the GDR parameter. In near future, we plan to study the effect of temperature on GDR width in fusion reaction with $\alpha$ particles. In this reaction, low angular momentum events will be populated and a high geometric efficiency multiplicity filter will be required for measuring the spin distribution in order to get the accurate J & T information. For this purpose, we have tested our recently fabricated 50-element $BaF_2$ gamma multiplicity filter for low angular momentum measurement with $^{252}$Cf spontaneous fission source. Moreover, only few experiments have been performed to measure the angular momentum populated in spontaneous fission and only an approximate method has been devised which is based on the average number of gamma rays from fission to estimate the gamma ray multiplicity [2].

## Experiment

The multiplicity filter consists of 50 $BaF_2$ detectors each measuring 3.5cm x 3.5cm x 5 cm [3, 4]. The complete setup was arranged in two blocks of 5 × 5 array in castle geometry. Each block was kept on either side of the source at a distance of 5 cm and staggered in order to equalize the efficiency of all the detector elements. The setup covers 56 % of $4\pi$ solid angle. Along with the filter, a part of the LAMBDA [5] array was used to measure the high-energy gamma rays (> 4 MeV) in coincidence with the low energy discrete $\gamma$-rays. An array of 49 detectors arranged in 7 × 7 matrix was kept at distance of 35 cm from the source. The start trigger was taken from the multiplicity filter. Neutrons were eliminated by the time of flight technique and pulse shape discrimination (long/short integration) was applied for pileup rejection in each detector element of the large array. The fold distribution for $^{252}$Cf source was generated applying the condition ($\geq$ 2 fold) and is shown in Fig.1.

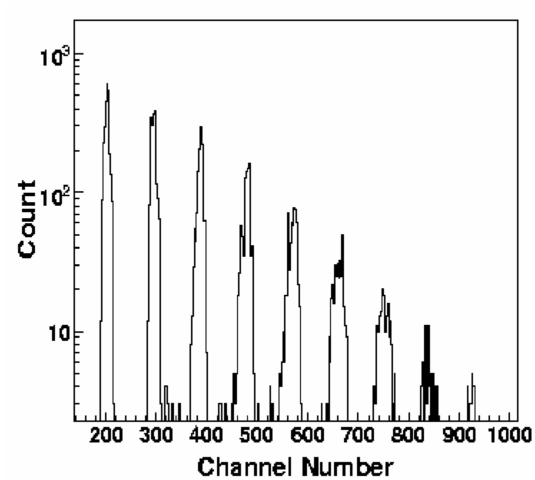


Fig 1. Experimental fold distribution showing folds ≥ 2 for $^{252}$Cf source.

## Extraction of Angular Momentum

The individual experimental folds were mapped into the angular momentum space using the known response of the filter array generated by simulation with GEANT [3]. In this simulation, the experimental conditions were taken into account, which includes the detector thresholds and the trigger logic. Low energy γ-rays of different multiplicities were made to incident on the filter array from the target centre isotropically and the simulated fold distribution was recorded. The multiplicity distribution of the low energy γ-rays was taken as triangular,

$$P(M)=\frac{(2M+1)}{1+exp\{(M-M_{max})/\partial M\}} \qquad (1)$$

where $M_{max}$ is the maximum of the multiplicity distribution and δM is its diffuseness and were found as 9 and 1.8 by fitting the distribution obtained from [2]. The energy distribution was considered Gaussian with peak at 0.65 MeV and width 0.75 MeV. This simulated fold distribution was then compared with the experimentally observed fold distribution using the relation

$$\sum S(F,M)\, P(M) = f_{exp}(F) \qquad (2)$$

where $f_{exp}(F)$ is the experimentally measured fold spectrum and S(F,M) is the response matrix of the multiplicity assembly. The comparison between the experimental fold distribution and simulated fold distribution is shown in Fig.2. The multiplicity distribution for different experimental folds were then generated from the simulation and also the corresponding angular momentum distribution by the expression J= 2M. The incident multiplicity distribution (points) as well as the multiplicity distribution for different fold is shown in Fig.3. The average angular momentum for different fold distribution is given in table 1.

Table 1: Average angular momentum values corresponding to different folds.

| Fold | <J> ħ | δJ ħ |
|---|---|---|
| 2 | 13.2 | 4.9 |
| 3 | 15.8 | 5.1 |
| 4 or more | 20.4 | 6.6 |

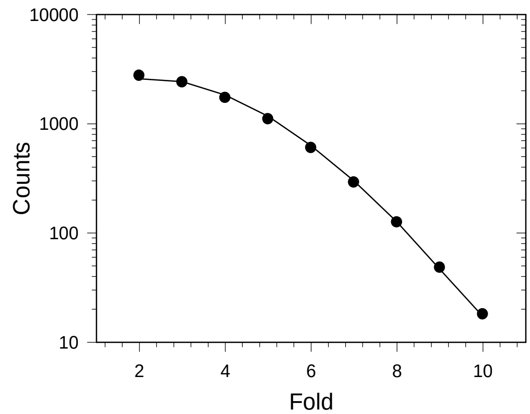


Fig 2. Experimental fold spectrum (points) fitted with GEANT simulation (solid line).

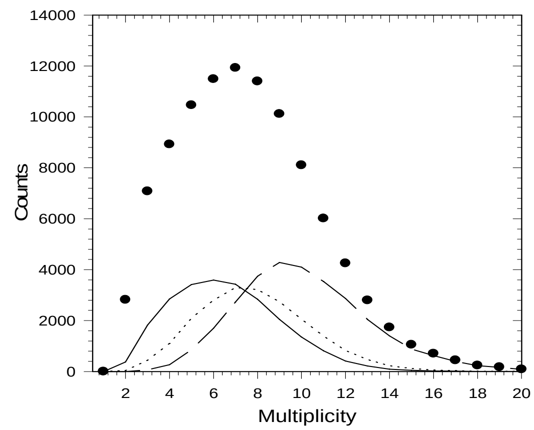


Fig 3. The points correspond to the incident multiplicity distribution used in simulation. The solid line represents the multiplicity distribution for 2 fold, the dotted line corresponds to the multiplicity distribution for 3 fold and the dashed line represents the multiplicity distribution for 4 fold or more.

## References

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