# Characterization of Liquid scintillation detectors using $^{252}$Cf source

Vishal Desai, B.K.Nayak, A.Saxena, Y.Sawant* and S. Kailas

*Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA*
**LEHIPA project, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA*

## Introduction

Study of prompt neutron emission spectra in fast neutron induced fission reaction is of topical interest because of its importance in engineering and design of new reactors for nuclear energy production, based on fast neutron induced fission [1]. There are limited data available on prompt neutron emission spectra in fast neutron induced fission with actinide targets. Therefore a systematic study of prompt neutron energy spectrum and their multiplicities in fast neutron induced fission with actinides over an energy range of neutron from few eV to several MeV is important. We have taken up a program to carry out prompt fission neutron energy spectra measurements for $^{232}$Th and $^{238}$U fast neutron induced fission at Folded Tandem Ion Accelerator, B.A.R.C. In order to carry out such experiments, we require well calibrated neutron detectors whose efficiency to be known well as a function of incident neutron energy. Recently we have procured twenty numbers of NE213 detectors of size 5.0 inch diameter and 2.0 inch thickness for the neutron detector array development. The detection efficiency of these detectors depends on neutron energy, the actual threshold, the size of the detector and the surrounding material near the detector [2]. In the present work, we report the characterization of these detectors, in which, their response to n-$\gamma$ discrimination and efficiency have been investigated using $^{252}$Cf source. The prompt neutron energy spectrum for spontaneous fission of $^{252}$Cf has been determined by neutron time-of-flight (TOF) measurement.

## Experimental Set-up

The detector efficiency measurement as function neutron energy have been carried out using $^{252}$Cf source with fission trigger taken by two different ways: (i) direct fission fragment detection by small ionization chamber with $^{252}$Cf source holder served as one of the electrodes. This detector was operated in air with bias of 450V applied between the two electrodes and (ii) Fission fragment detection by fragment gamma rays using Barium fluoride Scintillation detector. Both the fission and neutron detectors were mounted at the height of 1.5m above the floor in an experimental hall with minimum material surrounding the detector. This reduces the contribution from scattered neutron during measurements. The Pulse shape discrimination is employed in case of NE213 neutron detector to discriminate between gamma and neutron signals using Mesytec MPD-4 Module. The neutron time of flight (TOF) technique is employed for neutron energy measurement. The coincidence measurements were carried with the start signal taken from neutron detector and the stop signal from ionization chamber or $BaF_2$ detector is taken for TOF measurement.

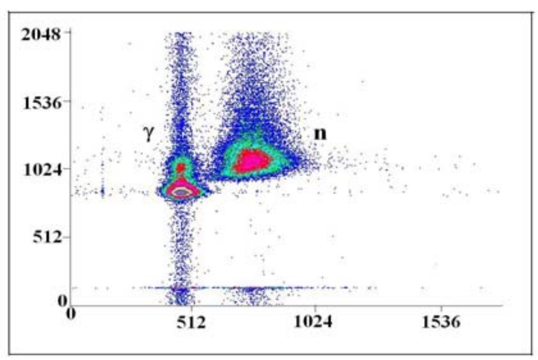


**Fig.1** TOF versus Pulse shape spectrum.

A typical two-dimensional TOF versus pulse shape plot is shown in Fig.1, and the Fig.2 shows a TOF spectrum at 1.0 m flight path, for the case where fission trigger is taken from ionization chamber detector. The TOF spectra have been converted into energy spectra, using the prompt -$\gamma$ peak position in the TOF spectrum as the time fiducial.

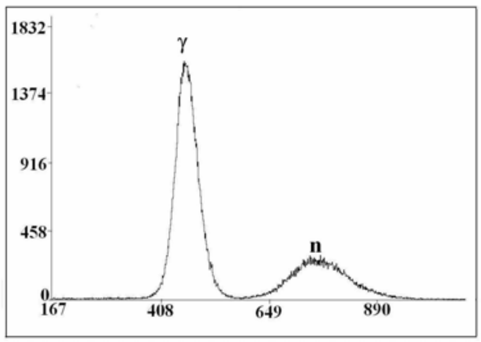


**Fig. 2** A typical Time-of-Flight Spectrum obtained at 1.0 m flight path in case of fission fragment detection by ionization chamber

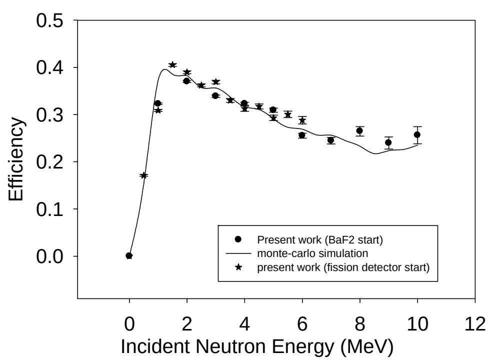


**Fig.3** Evaluated neutron efficiency for NE213 Detector and Monte Carlo simulation

## Results and Discussions

The detector efficiency is determined by dividing the neutron energy spectrum per fission by expected energy distribution for $^{252}$Cf as given below from Ref.[3]:

$$N(E) = \frac{2\sqrt{E}\,\exp(-E/T_m)}{\sqrt{\pi}\,(T_m)^{3/2}} \,,$$

where $T_m$, is the effective maxwellian temperature, which is taken to be 1.47 MeV for spontaneous fission of $^{252}$Cf .

The results of the efficiency measurements for fission trigger taken from both ionization detector and $BaF_2$ are shown in Fig.3. The experimental efficiency as a function of neutron energy is observed to be consistent with the prediction of Monte Carlo Simulation code for a threshold equivalent to 140keV as shown in Fig.3. The detector efficiency corrected, neutron energy spectrum for spontaneous fission of $^{252}$Cf is also shown in Fig.4.

## Conclusion

We have carried out the efficiency characterization of NE213 neutron detectors by two different fission triggers for TOF measurements. The results for both the methods are in good agreement with each other and also with the predictions of Monte Carlo simulation. In the planned experiment the fission ionization chamber will be used for fission trigger by replacing $^{252}$Cf source with actinide target. The mono-energetic neutrons for the experiment will be produced by $^7$Li(p, n)$^7$Be reaction.

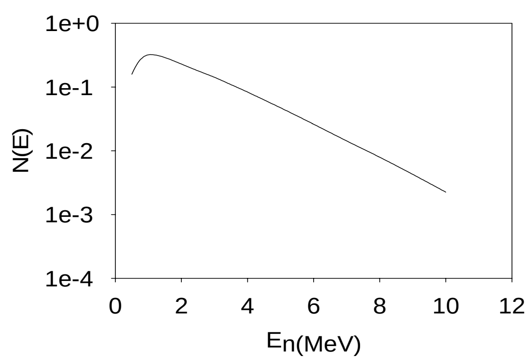


**Fig. 4** Neutron energy spectrum of $^{252}$Cf source.

## References


[1] S.Noda, R.C.Height, R.G.Nelson, M. Devlin and J.M.O'Donnel. Phys. Rev.**C83** 034604(2011).

[2] J.Cub, E.Finckh, K.Geissdorfer, R.Lin and J.Strate, Nuclear Instrumentation and Methods in Physics Research **A274** (1989) 217-221 and references therein.

[3] D.G.Madland and J.R.Nix, Nucl. Sci. and Eng. **81**,213 (1982)