Facility at CIRUS Reactor for Prompt γ- spectroscopy of Fission Fragments

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Introduction:

Prompt gamma spectroscopy of a nucleus gives direct information on nuclear excited states, which is related to the shape and structure of the nucleus [1-5]. Presently, much effort is being devoted to producing and studying the properties of nuclei with high neutron excess, with the aim of testing the influence of these extra neutrons on nuclear properties. Several experiments on neutron-rich fission fragment spectroscopy studies have been carried out using radioactive sources and accelerator facilities employing γ-γ coincidence technique [1-4]. There is limited information on thermal neutron induced spectroscopy studies. The experimental data is still rather scarce, that spurred us to carry out a study of the neutron-rich nuclei using thermal neutron induced fission reactions [6,7]. Here we report the facility developed at CIRUS reactor, BARC for on-line fission fragment spectroscopy studies.

The setup at CIRUS reactor is developed to study the properties of the neutron-rich fragments produced in fission and also nuclear spectroscopy studies after beta decay. The fission fragment spectroscopy (FFS) facility has combined beam-line radiation shielding for background neutron and gamma rays at beam hole E-18 of CIRUS reactor along with Solid State Physics Division (SSPD) neutron radiography setup. The schematic diagram of the experimental set up is shown in fig.1. The size of CIRUS beam hole E-18 is 100 mm diameter. The beam hole starts at a distance of 40 mm from the core edge. A collimator made of MS tube, ID 80 mm and length 100 cm is inserted in the tube from outside.

Detector setup details:

The SSPD setup has composite shielding structure of 800 mm thick consisting of SS, paraffin wax and lead all around with one side having removable shielding block on rail to facilitate access to target position. The composite shielding structure is made of Paraffin of 150 mm thick, stainless steel of 100 mm, borated wood of 400 mm thickness, lead of 150 cm thickness and over all shielding dimension is 1380 mm x 2080 mm and height 1500 mm. A conical hole of 10 mm has been provided in the rear wall in axial direction to provide neutron beam to Nuclear Physics Division (NPD) facility at a height of 1250 mm at the centre of rear wall. The shielding in the NPD facility has 150 mm paraffin plus 40 mm steel in radial direction (190 mm thick composite shield at both sides of target station) and 300mm paraffin plus 50mm lead plus 30mm steel in the axial direction (390 mm thick composite shield in the rear of sample station and a beam catcher of size 200 x 200 x 200 mm^3 for the direct neutron beam). The FFS setup is covered by shielding material for stopping the scattered neutrons inside the shielding material as shown in Fig.1.

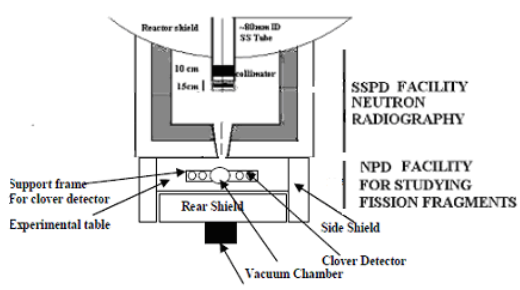

Fig.1 Schematic diagram of the experimental setup.

In the experimental setup radiation mapping has been carried out. The radiation background outside the chamber was in the acceptable limit. In order to reduce gamma background at the detector position, an arrangement was made with bismuth crystal and lead granules enclosed inside a conical shaped aluminum structure. This has reduced the gamma background to 20-30 mR at detector position.

Neutron flux mapping was carried out (with the help of RSSD and RPDD, BARC) using two different neutron activation techniques on ^{197}Au. In one experiment a bare and also a cadmium covered gold foils were irradiated at the target location for 30 min at the reactor power of 20 MW which were thereafter retrieved for γ counting after beta decay. The induced gamma activity was counted using a High Purity Germanium Detector (HPGe) after a suitable cooling time. The photo peak activities obtained were used to obtain the reaction rate taking corresponding to emitted gamma ray of energy 411.8 keV. In another experiment the measurement of delayed gamma rays using $4\pi\beta$-γ coincidence measurement provide the thermal neutron flux at the target location. Both measurements yielded ~ $8x10^7$ thermal neutrons per cm^2 at the target position. After placing a Bi-plug (diameter=70 mm and length=50 mm) at the exit point of the SSPD setup, the background has been reduced substantially and the neutron flux is reduced to 4 $x10^7$.The beam dimension was determined with a neutron radiography setup (neutron scintillator and CCD camera). The beam is almost circular with diameter ~ 1 cm (shown in Fig 2(a)) and has been measured without and with a rubber piece of diameter 5mm as shown in Fig. 2(b).

At present we have procured two clover detectors and coincidence setup has been made for studying the gamma spectroscopy. The setup will be upgraded with addition of two more Clover detectors.

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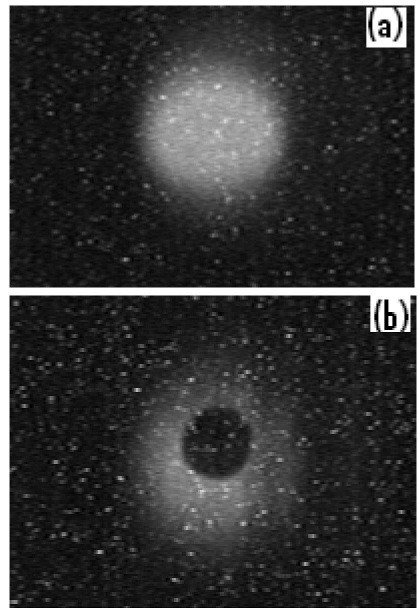

Fig.2 (a) Neutron beam spot without and (b) with borated rubber absorber of 5 mm diameter.

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