Design and fabrication of 4π Clover Detector Array Assembly for gamma-spectroscopy studies using thermal neutrons

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Introduction:

Nuclear spectroscopy has been studied earlier from the measurement of prompt gamma rays produced in reactions with thermal neutrons from CIRUS reactor [1,2]. For studying the prompt γ-spectroscopy using thermal neutrons from Dhruva Reactor, BARC, the development of a dedicated beam line (R-3001) is in progress [Figure 1]. In this beam line a detector assembly consisting of Clover Ge detectors will be used. This experimental setup will be utilized to investigate nuclear structure using prompt (n,γ) reactions and also to study the spectroscopy of neutron-rich fission-fragment nuclei.

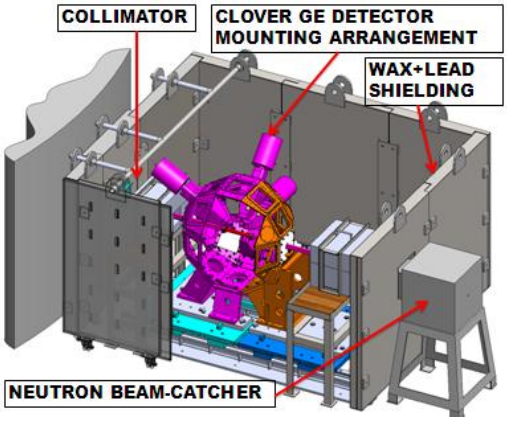


Fig.1 Schematics of 4π gamma "Clover Detector Array Assembly" for the beam line

Mechanical design of the Clover Detector Array Assembly:

The complete assembly consists of specially designed spherical polyhedron shaped detector mount, supports and base movement mechanism [Fig. 2]. The detector mount consists of three types of basic modules to accommodate 32-detectors in spherical array. The fixed supports and movable bases along with base movement mechanism are provided to hold and move the modules assembled in two unequal parts for closing and separating. Separation of these two separately assembled parts is required to fix target and other accessories inside the detector assembly. During the experiment, the closing of these two parts is required to give spherical shape to the detector array assembly. The target is mounted at the centre of the experimental setup and is aligned with the beam line coming out from the reactor core. The experimental set up is also designed and fabricated for ease of assembly and disassembly.

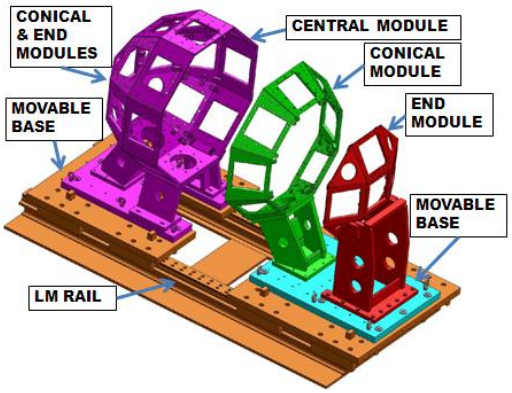


Fig. 2 Modules of spherical polyhedron detector mount.

Each module as shown in figure 2, are made of appropriate size and shape of plates with edges machined to match the adjacent module at specified angle to provide desired shape of spherical polyhedron after assembly. As stated earlier, this spherical polyhedron shaped detector mount is designed, fabricated and assembled in two unequal parts. The central and two other adjacent modules (one conical and

one end modules) are assembled to form bigger half [Fig.s 2 & 3] of the spherical polyhedron and is mounted on one of the movable base with the help of fixed supports.

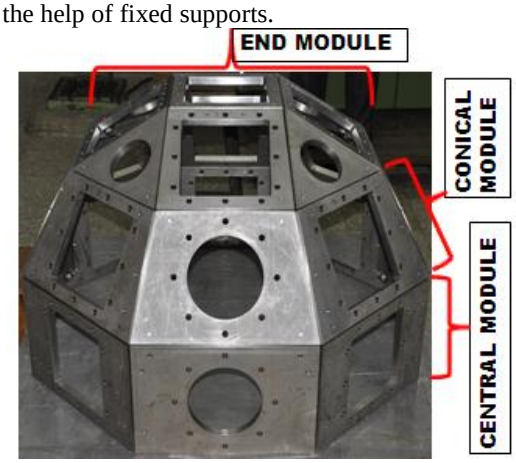
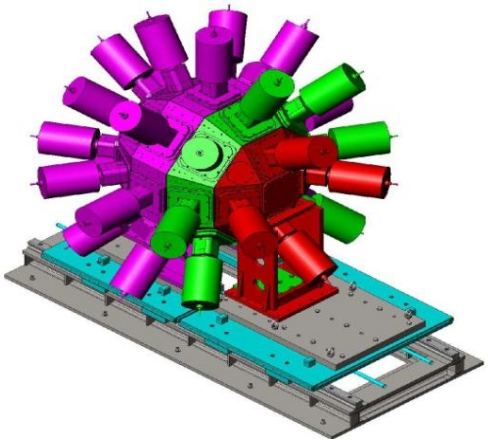


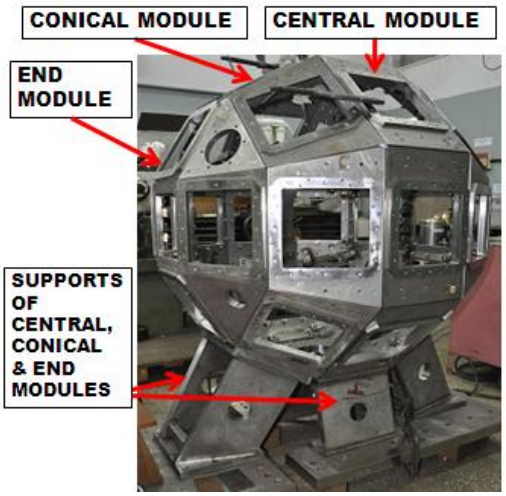
Fig. 3 Photograph of bigger half of the spherical polyhedron detector mount.

Whereas, the other two modules (one conical and one end module) are assembled to form the other (smaller) half of the polyhedron and is mounted on the other movable base. Each base plate carrying one of the unequal parts of the spherical polyhedron detector mount are fixed on Linear Motion (LM) guide. The LM guide holds and provides smooth precise linear motion to each part of the detector mount on the LM rails. Ball screws with handles are mounted to provide appropriate motion to the movable bases in both the directions to close and open these parts. Both the parts are bought closer to form perfect spherical polyhedron shape during experiment. However, they can be separated by moving apart with the help of handles and ball screws to create sufficient separation between them for mounting the target and other related accessories. The LM rail is fixed on a platform which can be adjusted and kept on the ground after aligning the detector mount axis with the beam line axis. Figures 4(a) and 4(b) show the 3-D model and photograph of detector mount and its modules in assembled condition.

Fabrication of plates for detector mount, its assembly and verification of centre of the each module as well as full assembly was challenging. Various jig and fixtures were designed, fabricated and used to achieve the spherical polyhedron shape with desired accuracy. It has been measured that the projected center line of all the detector mounting plates meet at the center of this spherical detector array within an accuracy of 2 mm.



(a) 3-D model of detector mount



(b) Photograph of assembled detector mount

Fig. 4 Spherical polyhedron detector mount.

Acknowledgement:

We are grateful to all the supervisors and the technicians of the TPD workshop who helped in fabrication and assembly of the system.

References:

[1] D.C. Biswas, et al., Nucl. Instr. and Meth. A 703 (2013) 163

[2] S. Mukhopadhyay et al., Phys. Rev. C 85, 064321 (2012).