Design and fabrication of a scattering chamber and associated mechanical systems for the BARC Charged Particle Detector Array

Bency John[1],* S. Sunil Kumar[2], and Manish Kumar[2]
[1]*Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai – 400085*
[2]*Mechanical Design and Prototype Development Section, Bhabha Atomic Research Centre, Mumbai – 40008.*
** email: bjohn@barc.gov.in*

Introduction

A charged particle detector array (CPDA) which can provide Z and energy information of nuclear reaction products is under construction in the recently upgraded BARC-TIFR Pelletron-LINAC Facility, Mumbai. This array will be used for investigations in fusion-fission dynamics, nuclear structure at elevated temperatures and angular momenta, exotic nuclear clusters, and related fields. The array has been designed to have large solid angle coverage with high-performance low-cost charged particle detector systems. The present paper describes the unique design of the CPDA vacuum chamber and associated systems, and their features that aid different coincidence experiments and also the chamber fabrication experience.

For a comparison, the main characteristics of charged particle detector arrays existing in laboratories around the world can be classified as: 1) Large 4π arrays for multi fragmentation studies that requiring complete exclusive reconstruction of emitting sources. *e.g.* INDRA, CHIMERA, NIMROD, FAUST 2) 4π charged particle detector array as an ancillary detector for gamma spectroscopy *e.g.* NORDBALL, GASP, GAMMASPHERE, EUROBALL 3) Arrays for special purposes *e.g.* MEGHA, AMPHORA, ISOLDE Silicon Ball

The first category of arrays cater to experiments in the Fermi energy regime, where violent heavy ion collisions produce many particles in each event. Experimental setups of this research line can be quite complex if the experiment aims to collect the most complete information about the collisions. Mass, charge, and energy information of all the reaction products, from light particles to intermediate mass fragments(IMF) up to evaporation residues, with high angular precision (<1°) and 4π coverage is usually aimed at. In the second category, an array of charged particle detectors with a geometrical coverage close to 4π is used with an efficient germanium detector array. Attributes for the charged particle array in the second category are a minimum interference with gamma detection, a count rate capability not limiting data rate of the gamma array and a very good identification of alpha and proton events within the whole range of evaporation spectra. The third category– where the present CPDA also falls– in most cases are upgrades of detector systems that cater to variety issues in nuclear dynamics and structure, and they are not necessarily (close to)4π systems. For example the MEGHA array has 44 three-detector-telescopes (gas-silicon-CsI) mounted suitably for nuclear cluster-breakup studies. Similarly, one investigation the ISOLDE Si-ball has been engaged is the study of β-delayed multi-particle decays. In the first two categories, the geometrical configuration of charged particle detectors is more or less singular (being 4π setups) where in the third, multiple configurations *can be* set to reach experimental goals.

Mechanical design of the CPDA:

The BARC-CPDA has been designed to have three basic configurations and one of them, the spherical configuration, is shown schematically in Fig.1. Thin walled hemi-spherical lids and flange cover plates (not shown in Fig.1) will ensure vacuum. Expanded views of the spherical mount and the detector module are shown to illustrate design concepts. Detector modules can be held on to circular rails by brackets and the modules can be fixed at any angle within the range provided by the rails.

Detector modules can be held similarly inside the central cylindrical part. First element of the detector module will be at a distance of 18.5 cm from the center. The range of angles that can be covered is from 10° to 170°. Maximum solid angle that can be covered in this configuration is 1520 msr (12% of 4π). If needed, the total solid angle coverage can be improved by bringing the rails closer.

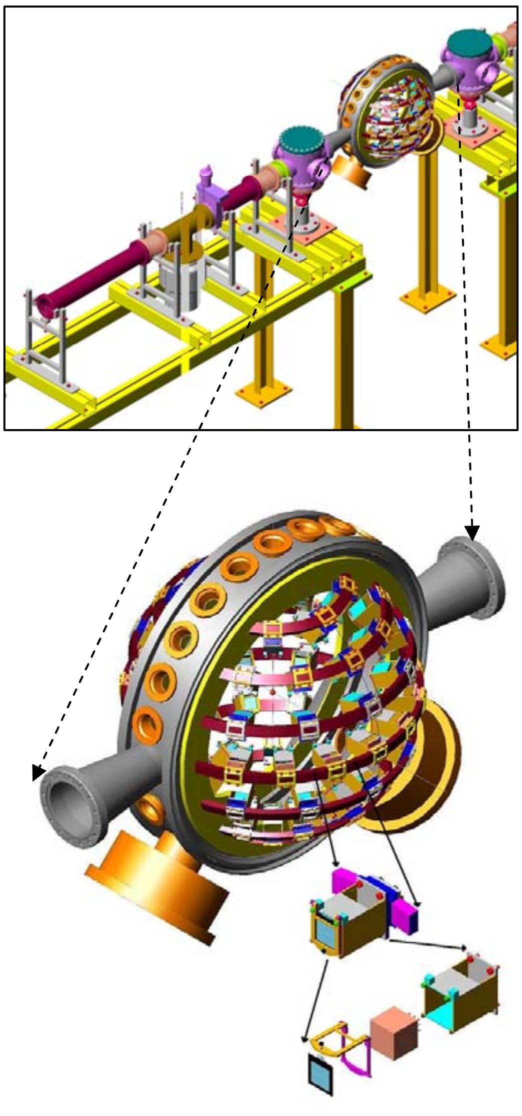

Fig. 1. Schematic of the CPDA. Expanded views of the spherical mount and the detector module are shown below.

By removing a part of the hardware, a second configuration, namely hemisphere, can be arrived at as illustrated in Fig.2(a). In this figure, charged particle detector modules are covered by a hemispherical and a flat lids. The flat lid has a central thin area (2mm steel) of 20 cm diameter. This configuration will have a solid angle coverage of only 930 msr for charged particles. Reconfiguring this way has a major advantage that a gamma detector array can be brought closer to target position while still maintaining a reasonable solid angle coverage for charged particle detectors.

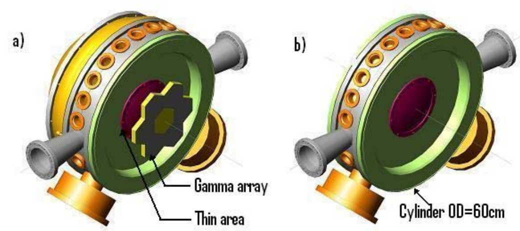

Fig.2. Schematic of hemispherical and flat configurations of the CPDA

In experiments where a further improvement of geometrical efficiency for a gamma array is desired, a third configuration can be arrived at as shown in Fig.2(b). Here, charged particle detectors are retained only in the cylindrical portion and the flat lids cover both sides of the chamber. Gamma array can be brought closer from either sides. Further details on the general design and on the associated component design along with fabrication details will be presented. Typical physics applications of the new design will also be presented. Some details on the detectors and associated electronics that will be used in the CPDA can be obtained from Ref.[1].

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Reference

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