HYbrid Recoil mass Analyzer (HYRA) at IUAC – Status Report

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HYbrid Recoil mass Anayzer (HYRA) is a large acceptance mass separator [1] capable of operating in vacuum mode as well as in gas-filled mode. It is designed and being set up at Inter University Accelerator Centre (formerly 'Nuclear Science Centre') for carrying out nuclear reactions and tagged spectroscopic studies and is funded by DST, Government of India. Most of first stage of HYRA (ie. QQ-MD-Q-MD configuration) has been installed and a significant part of second stage has been fabricated.

The total configuration of HYRA is (Q1Q2-MD1-Q3-MD2-Q4Q5) – (Q6Q7-ED-MD3-Q8Q9) with the first stage capable of operation in two modes, namely the gas-filled mode for heavy nuclei detection and as a first stage momentum achromat for the vacuum mode mass spectrometer. Special stoppers at the centre of Q3, where momentum dispersion is large, help in reducing the beam-like particles existing in many charge states while allowing most of reaction products to pass through in inverse kinematics similar to ORNL RMS [2]. The first stage is also useful for the production of light RIBs or secondary beams produced in direct reactions involving, mostly, inverse kinematics. The second stage, which operates only in vacuum mode, provides further background suppression and the spatial dispersion as per the mass (m/q) of the reaction products. It can also be used to select products of interest from the secondary beam initiated collisions.

In order to maximise the solid angle of acceptance in the gas-filled mode, the first two quadrupoles are specially designed superconducting magnets of shorter length and large aperture. They are being developed indigenously using cryogenics expertise at the centre and help from MSU, USA. The poles with hyperbolic pole shapes and the cylindrical yokes have been fabricated. A wire-winding machine with rotation and flip options and the aluminium formers have been designed and indigenously made for winding the superconducting coils. Cryostat design will be frozen after coil winding and fabrication taken up subsequently.

The first stage magnets (2 dipoles and 3 quadrupoles) and the second stage magnets (4 quadrupoles and 1 dipole) have been fabricated and field mapped thoroughly. The parameters extracted are the effective length of the quadrupoles, the

higher order components in quadrupole field, the excitation curve in all magnets, fringing field data for extraction of EFB angles, EFB curvature and EFF-SCOFF shift parameters and the homogeneity contours of the dipoles. The extracted parameters are found to be within specified range and very close to design values. The dipoles are provided with hall probes placed in the homogeneous region, for precise field measurements. Q4 power supply has been indigenously made and tested for stability. Development of additional power supplies (4 Nos. for Q6 to Q9) is in progress and are expected to be ready within 6 months.

The vacuum chambers and support structures for all the magnets are ready. The cross-section of chambers are designed for maximum transmission of reaction products. Quadrupoles Q3 and Q6-Q7 are provided with the option of controlled sideways movement in a reproducible way to create space for focal plane detector system for low energy, heavy residues and large detector array for decay measurements, respectively, both in gas-filled mode. Q3 chamber is provided with welded bellows (200 mm diameter) on either end to allow the sideways movement. MD1 chamber is provided with specially designed, water-cooled tantalum linings on either side to dump the primary beam in the two modes of operation. A movable beam stopper protects the straight through view-port of MD1 from the direct beam.

Sufficient space is provided near the target chamber of HYRA to accommodate the INGA structure with its movement option. INGA, when operated with HYRA, can accommodate 16 Ge clover detectors with ACS. Sufficient space is provided in the hall to extract the residues selected by Q1-Q2-MD1-Q3 through MD2 straight through port for further studies using possible future add-on facilities such as a trap.

The installation and alignment of first stage magnets was carried out completely by IUAC personnel with help from investigators of HYRA project. Presently, the end quadrupoles of the achromat (Q5-Q4) have been installed in place of superconducting quadrupoles to get started with testing of the first stage. The alignment was done sequentially with a precision of better than 100 microns, with each aligned element deciding the direction and position of the next one. After the completion of alignment, the EFF-SCOFF shift was introduced in MD1 and MD2 and the sideways movement of Q3 checked. Due to space limitation, pumping ports for MD1 and MD2 are provided through openings in the yoke and Turbo pumps of 550 l/s capacity are mounted on MD1 and MD2. After elaborate leak checks using helium leak detector, connected to the backing port of MD1 Turbo pump for better sensitivity, and fixing the leaks, vacuum of 7.5×10^{-8} Torr was achieved in the system. In gas-filled mode, the first stage will be filled with helium (of the order of 1 Torr). The gas pressure stabilization is achieved through dynamic control loop and measured precisely using Baratron gauges provided in MD1 and MD2. The target chamber for only HYRA operation is provided with window foil option before and after target position by way of re-entrant cups terminated at the chamber with appropriate flanges. The design helps in changing the foil easily, if required. A few natural nickel window foils of ~ 1.25 mg/cm^2 thickness have been prepared by rolling and tested in-situ successfully. Beam tests of the first stage are planned in the near future.

References

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