Status report of Variable Energy Cyclotron at Kolkata

P.S. Chakraborty*, B. Shoor, R.C. Yadav, T. Bhattacharjee, A. Roy, B.Ch. Mandal, S. Chattopadhyay, S. Bandyopadhyay, A. Polley, A. De, M. Dutta, S.K. Pattanayak, A. Mandal, S.K. Thakur, M. Das, S. Som, G. Pal, S. Pal, A.S. Banerjee, R. Dey, S. Saha, C. Mallik & R.K. Bhandari

Variable Energy Cyclotron Centre, 1/AF, Bidhannagar, Kolkata - 700064, INDIA

** email: prodyut@vecc.gov.in*

Introduction

The variable energy cyclotron at Kolkata also known as K-130 cyclotron was the first large circular accelerator indigenously developed and commissioned in 1977. Up to middle of nineties, cyclotron was extensively utilized for doing research in nuclear physics, radiochemistry, radiation damage studies and other related areas using an internal hot cathode PIG ion source. The projectiles were alpha, proton and deuteron. Then in late nineties, the cyclotron started accelerating high charge state light heavy ions using an indigenously developed 6.4 GHz ECR ion source. Later on another ECR ion source of 14.4 GHz was coupled to it. Since ECR ion sources were located outside the cyclotron, beam was injected into the cyclotron through an axial injection line. The K-130 cyclotron after accelerating high charge state light heavy ions for about 10 years was shut down in early 2007 for large scale changes of cyclotron sub-systems under 'Modernization of VEC Technical Systems' program [1]. This is because most of the cyclotron sub-systems were prone to failure frequently as these systems were very old and their maintenance was also getting difficult as spares were not readily available. These problems were hampering smooth cyclotron operation and experiments as well.

Modernization

Under the modernization program, the major task was to make suitable modifications for converting this cyclotron as primary source of beams for producing exotic nuclei for radioactive ion beam facility. Some of the modernization activities are mentioned below.

a) Since this cyclotron will be used as primary source of beams (alpha and proton) for the radio-active ion beam facility, the central region geometry has been modified [2]. This geometry will enable us to operate internal PIG ion source for producing alpha and proton beams.

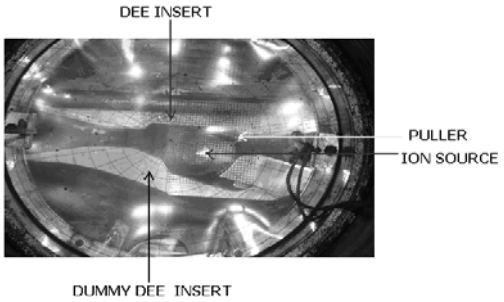

Fig. 1 Modified central region geometry

b) The new magnet power supplies (main magnet, trim coils, quadrupole magnets, steering magnets, switching magnet) have been installed at the newly renovated pit area and made computer control of the above power supplies from the control console.

c) New filament p/s and screen p/s have been developed and fabricated in house for RF system.

d) The relay-based interlock system has been up-graded with the Programmable Logic Controller (PLC) based safety interlock system connected with the RF system.

e) Two new 36-inch gate valves for two main diffusion pumps have been installed which has improved the quality of the vacuum. Up-graded to PLC based control of vacuum system operation is working satisfactorily.

f) Air conditioning system has been upgraded at vault, pit and caves.

g) Major modification in control console incorporating computerized control of most of the sub-systems.

h) The vault and pit floor have been epoxy painted and false flooring done for the keeping the power supplies.
i) Installation of new freon units for vacuum system.
j) Major modifications of LCW systems and Electrical system to incorporate the above changes.
k) Disconnecting axial injection line of 6.4 GHz ECR ion source and 14.4 GHz ECR ion source from the cyclotron.
l) The new ion source p/s supply and deflector p/s are made computer control. Software developed for deflector electrode conditioning, which takes care of sparks, arcs and electrode voltage. The advantage of the software is that conditioning can be done in a much better way without damaging the electrodes.
m) New vacuum chamber for the 159.5 degree analyzing magnet through which beam will be transported in achromatic mode to radio-active ion beam facility.

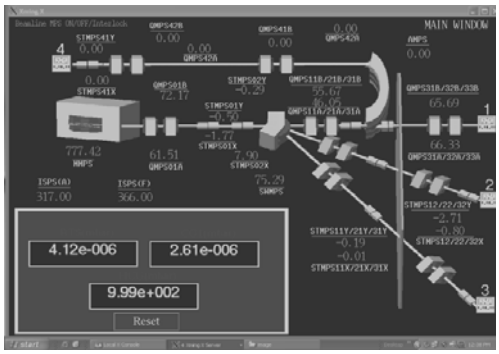

Fig.2 MMI interface showing three beam lines and the feeder line leading to RIB target

Synchronization

The above activities were huge and many difficulties did crop during the modernization program. In June 2009, pressure in the resonator tank was obtained ~ 6 x 10^{-6} Torr and subsequently different system operation was started. The systems were made on sequentially and synchronized operation of various systems started on November, 2009. Internal beam was developed in the middle of December 2009 with high neutron flux and gamma radiation**.** Extracted beam of 35 MeV alpha was obtained in January, 2010 shown below in the inset.

Fig.3 Cyclotron and the extracted beam

Utilization

The first experiment after modernization program started on 8th February, 2010. Since then cyclotron is running continuously except for periodic maintenance, planned up-gradation activities, leak in the resonator etc. In the year 2010-2011, the cyclotron has delivered alpha and proton beams on target for more than 3500 hours. At present the following ions with beam energy and current are available from K-130 cyclotron for performing experiments.

Ions	Energy (MeV)	Extracted Beam cur.	Beam current on Target
Alpha	30 - 60	8.5 µA	3.0 µA
Proton	7.5 - 18	25.0 µA	10.0 µA

The stability of beam on target has improved greatly after the modernization activities. Alpha beam energy up to 65 MeV has recently been developed and will be delivered to target as and when required. Alpha beam of energy of 5.5 MeV to 7.2 MeV has also been developed by harmonic mode of operation and can be utilized for the experiments.

References

[1] C. Mallik et.al, proceedings of InPAC-2011.
[2] P.S. Chakraborty et.al, proceedings of InPAC-2011.