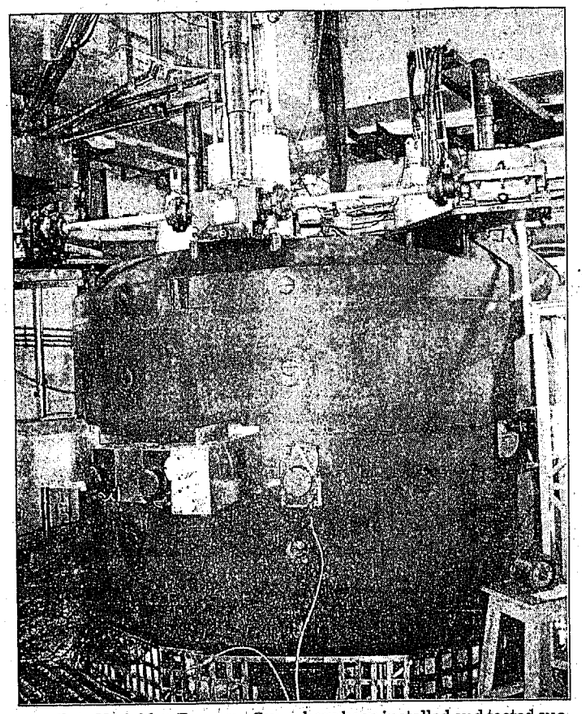
Variable Energy Cyclotron Centre



The Variable Energy Cyclotron Centre at Kolkata is a premier institute in the country for research in nuclear sciences and with excellent infrastructure for advanced research and development in the field of accelerator technology. This centre indigenously developed the first big accelerator in the country, the room temperature cyclotron, VEC, with K =130 during seventies (commissioned in 1977). After delivering light ion beams to the users for almost twenty years, it went through major modifications in 1997 and has undergone several changes. It is now delivering variety of heavy ion beams utilising Electron Cyclotron Resonance(ECR) ion sources. It has planned to use the cyclotron, eventually, as the primary beam source for Radioactive Ion Beam (RIB) facility in the near future.

VECC, with its vast experience and expertise in the areas of accelerator design, fabrication and operation, took up the challenging task of constructing the first superconducting cyclotron in the country about ten years ago. The superconducting cyclotron is now almost at its commissioning stages. Most of the sub-systems have been installed and tested successfully. It will provide beams of energy up to 80 MeV/nucleon for fully stripped light ions. Beams of ~10 MeV/nucleon will be available for very heavy ions.

Radioactive Ion Beams (RIB) are now indispensable tools for new areas of research in nuclear sciences. They provide the possibilities of studying structure of unstable nuclei that are highly neutron rich or proton rich. An ISOL-based RIB facility is under construction at VECC. Several systems and components of this facility have already been tested and installed. Accelerator Driven Subcritical Systems (ADSS), to generate clean nuclear power, require a proton driver accelerator capable of delivering 1GeV energy and several megawatts of beam power. Cyclotron is one of the very promising options. Studies on using cyclotrons to achieve high power proton beam has been undertaken at the Centre. At present we are developing high current ion source and injection system for a 10 MeV injector cyclotron.

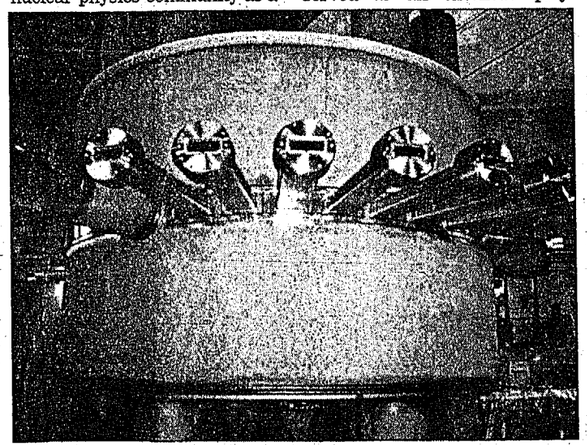
K-130 CYCLOTRON

The Variable Energy Cyclotron (VEC) at Kolkata is a medium energy, azimuthally varying field (AVF) cyclotron. It can accelerate protons up to 60 MeV, deuterons up to 65 MeV and heavier ions up to ~ several hundreds MeV energy. Varying both the magnetic field and the radio frequency (RF) electric field used for acceleration can vary the particle energy. The design of the VEC is based on the 88-inch cyclotron operating at Lawrence Berkeley National Laboratory and a similar machine operating at Texas A&M University in USA with modifications incorporated for facilitating indigenous fabrication. The cyclotron is an assembly of various subsystems such as magnet, RF system, power supplies, ion source, injection and extraction system, vacuum and control systems, beam transport and data processing systems etc. The RF system of the cyclotron consists of the dee, the dee stem, the fixed and movable panels, all enclosed in a large vacuum chamber and a high power tetrode (RCA4648) based final amplifier (MOPA system). It has a frequency range of 5.5 MHz to 16.5 MHz and a working voltage of 70 kV (max.). Frequency variation is accomplished by using panel movement. The H shaped DC electromagnet with pole diameter of 224 cm and weighing 262 tons is the heaviest component of the cyclotron. The working pressure inside the machine is of the order of ~ 1 x 10-6 torr, which is obtained by using two freoncooled 89 cm oil diffusion pumps acked by roots and rotary pumps. Scientists from various research organisations and universities of the country are regularly using heavy ion beams accelerated by VEC for basic science experiments.

SUPERCONDUCTING CYCLOTRON

The success achieved and experience gained with the commissioning and streamlining of VEC, has motivated the accelerator scientists at VECC to further extend their R&D activities. They started searching for a machine for heavy ion beams in the range of ~ 80-100 MeV/nucleon energy. Two options were available at that time: to develop a separated sector cyclotron or a superconducting cyclotron. A systematic and rigorous study was carried out on both the options. The technological chalenges involved and an opportunty to develop and learn a new technologies in the cryogenic field, motivated us to choose the superconducting cyclotron option. This cyclotron is presently under construction and is nearing the commissioning stages.

The superconducting cyclotron has bending limit, Kbend, of 520 and focussing limit, Kfocus, of 160. It will deliver heavy ion beams of 80 MeV/nucleon energy. Such beams are presently not available in the country. The basic design features of this machine are similar to the superconducting cyclotrons operating at the Michigan State University and Texas A&M University in USA. It is being constructed, primarily, for nuclear physics experiments with heavy ion beams at intermediate energies. In conjunction with an advanced ECR ion source, this cyclotron can deliver a variety of ion species with energy suitable for a new class of experiments. It is expected to satisfy the experimental nuclear physics community as a whole. Scientists and engineers of VECC have recently commissioned largest superconducting magnet of the country. This magnet weighs about 100 tonnes and about 300 litres of liquid helium, continuously keep the excitation coils (weighing about 7 tonnes) at -269 degrees centigrade temperature. Most parts of the magnet were made, indigenously.



Completed Cryostat assembly with the median plane penetrations

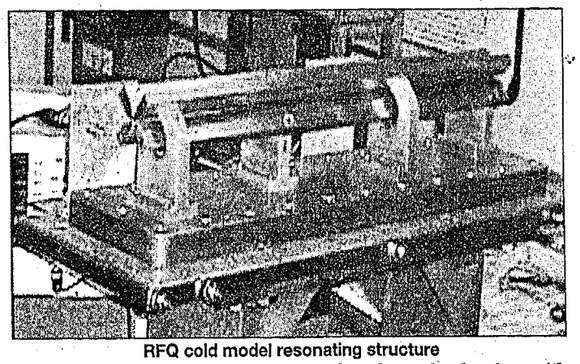
RADIOACTIVE ION BEAM FACILITY

The physics experiments with the Radioactive Ion Beams (RIB) are the emerging frontier in nuclear physics and allied sciences. It is expected to address some very basic questions regarding the nature of nuclear interaction, the origin of elements in the universe etc. Moreover, some very new and productive research can be carried out in applied sciences utilising the RIB. The development of accelerator facilities for producing RIB is the major activity in all the leading nuclear physics laboratories around the world. Technologically, the development of an RIB facility is extremely challenging which involves extensive R&D, and VECC accepted this challenge in 1998 to build an ISOL-post accelerator type RIB facility with VEC as the primary beam source. Historically, the concept of an RIB facility at VECC originated from the construction of a He-jet ISOL facility in high bay area of the cyclotron building. Several interesting physics experiments have been carried out using this facility with the VEC beam. It has also served as an excellent 'playground' for developing the RIB-related accelerator systems.

MEDICAL CYCLOTRON

The VEC Centre is setting up a medical cyclotron facility in Kolkata. The main objective of the facility will be to produce radioisotopes and, subsequently, the radiopharmaceuticals, which will be used in nuclear imaging for medical diagnostic purposes.

Both SPECT as well as PET isotopes will be produced at this facility. The facility will also be used for various research and development purposes. Material sciences studies will be a major R&D type utilisation of this cyclotron.



RFQ cold model resonating structure

Medical cyclotron will be able to deliver proton beam with up to 30 MeV energy and up to 500 microamperes beam current.

Two simultaneous proton beams will be possible to extract from the machine. The extracted beam energy will be adjustable from 15 MeV to 30 MeV and the beam current will also be tuneable. Contract for installation of the cyclotron and related facilities has recently been awarded to M/s. Ion Beam Applications (IBA), Belgium. Necessary infrastructure for operating this state-of-the-art machine is being developed, indigenously. This facility will start functioning in about two years from now near the Peerless hospital. Recovery and analysis of Helium from hot spring and Seismic monitoring activities Scientists at VECC, are also engaged on a project of recovery and purification of helium collected from hot springs of Bakreshwar and Tantloi. Helium is an essential commodity in many modern technological process and research work particularly in atomic energy. Its usefulness combined with its general scarcity has made it a strategic material.

After purification to cryogenic grade (99.995%), it will be utilised in the superconducting cyclotron and hence will reduce the burden of import by a substantial amount.

A prototype plant to recover helium from natural gas is being set up by VECC/SINP as part of a DST-ONGC project at Kuthalam in Pondicherry.

Scientists of VECC and SINP have also set up an advanced experimental facility at Bakreswar, Birbhum for Geochemical observations to be used as precursors to earthquake and volcanism with the help of Department of Atomic Energy and Department of Science and Technology, Government of India.

The volatile entities, namely radon, gamma and helium concentrations are considered as geochemical signals for the purpose. Data are taken round the clock (24x7) and with the help of VSAT facility transferred to VECC/SINP campus at Kolkata for analysis. In the recent past precursory signals obtained have been successfully correlated with the subsequent occurrence of seismic disturbances especially around the eastern and south eastern regions.

BASIC RESEARCH IN NUCLEAR SCIENCE

The nuclear theory group of the Variable Energy Cyclotron Centre, Kolkata has made path-breaking contributions to various branches of nuclear science.

From a beginning of just one person in 1970s, the group has steadily developed into a leading group in the country today, with seminal contributions to almost the entire range of nuclear physics, viz., low energy nuclear reactions, nuclear structure, deep inelastic collisions, fission, liquid to gas phase transitions, nuclear matter, equation of state, mass formulae, neutron stars, relativistic heavy ion collisions, medium modification of hadron properties, quark gluon plasma, and cosmology of early universe.

One of the most remarkable predictions of the group; radiation of single photons as a signature of quark gluon plasma have been experimented at CERN Geneva and Relativistic Heavy Ion Collider at Brookhaven.

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