
Information and Announcements



Nuclear Science Centre - An advanced Accelerator based Inter-University Research Centre at New Delhi

Introduction

Nuclear Science Centre (NSC) is the country's first inter-university research facility established after the change of UGC Act by University Grants Commission. It is situated at New Delhi in a 25-acre land donated by Jawaharlal Nehru University. Its objective is to provide to the vast university community, facilities for internationally competitive research in basic and applied sciences with high energy charged particle beams. The experimental facilities have been conceived and set up in close association with the

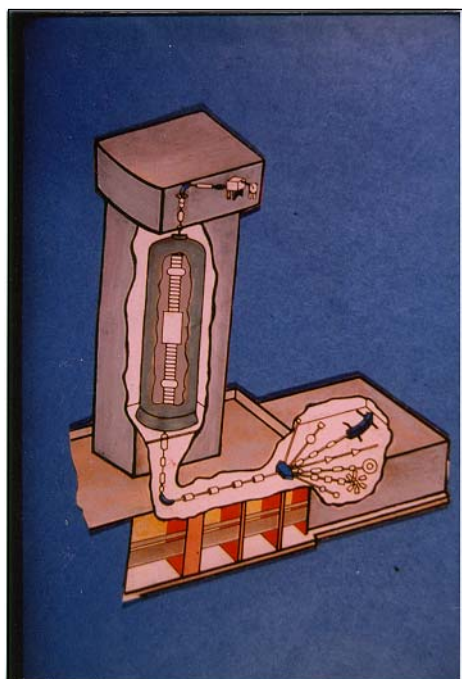


Figure 1. Cut out view of accelerator and experimental hall.

universities. NSC facilities have been operating round-the-clock since its commissioning in 1990. Continuous efforts are made for upgradation to keep them up to international standards and to achieve improved performances.

Facilities available at NSC

NSC presently has a Tandem Van de Graaff accelerator (15 million volt (MV) Pelletron) and state of the art experimental facilities (*Figure 1*). Here ion sources produce negatively charged ions (from hydrogen to uranium, except argon, krypton and xenon) which are injected into the accelerator after proper mass selection. The accelerator imparts energy to the charged particles in two stages (in Tandem), first the acceleration of the negatively charged

particles upto a positive high voltage terminal (whose potential can be varied between 4 MV and 15 MV) and then acceleration of the same ions after converting them to high positive charge by an electron stripping mechanism. The energy amplification in the second stage depends on the number of electrons removed. The beam, after energy analysis, can be switched into any one of the seven experimental lines. The entire path of the beam is maintained at high vacuum (pressure about 10 to 12 orders of magnitude below atmospheric pressure) to avoid loss of particles (or energy) due to collision with air molecules. Energies of the order of few tens to few hundreds of MeV with energy spread less than 20 keV can be obtained with intensities of the order of 10^9 to 10^{12} particles per second for experiments. Beam pulsing system enables us to give beam packets/bursts to carry out timing or life-time measurements. The beam packets have about 1 nano-second time-width and excellent time correlation between successive packets whose separation can be varied from 250 nsec in multiples of two.

The experimental facilities include, (i) a dedicated radio-biology set up where the beam can be brought out into the atmosphere through a foil for irradiating live samples/cells, (ii) a small utility chamber where irradiation of materials and X-ray measurements can be carried out, (iii) a world class recoil mass separator named Heavy Ion Reaction Analyzer (HIRA) that can pick out particles of interest, which are sparsely formed in nuclear reactions, amidst a sea of unwanted background particles, (iv) a dedicated materials science set up with on-line monitoring for controlled irradiation of materials and planned addition of a goniometer for channeling and in-situ sample preparation, surface modification by ion beam irradiation and surface characterisation using a scanning tunneling microscope, (v) an atomic physics coincidence set up SCORPION for identifying and quantifying the various charge exchange processes in single collision condition between projectile (beam) and target species, (vi) a 12-element, good resolution Gamma Detector Array (GDA) along with a 14-element gamma multiplicity filter to study the gamma transitions in unexplored nuclei at high angular momentum and planned charged particle detector array to augment it for suppression of unwanted reaction channels and, life-time measurement set-up (vii) a large General Purpose Scattering Chamber (GPSC) for nuclear scattering experiments and hydrogen depth profiling by Elastic Recoil Detection Analysis (ERDA) and (viii) a High Energy Gamma Ray Spectrometer (HiGrasp) for studying Giant Dipole Resonance (GDR) decay in nuclei. Recently, HIRA and GDA have been coupled together to form a powerful combination for residue tagged high spin spectroscopy of weakly populated nuclei amidst other strong channels (*Figure 2*).

The accelerator and experimental facilities are supported by utility divisions and support laboratories such as Health Physics, Detector Lab., Ion Source Development Lab., Magnet Lab., Vacuum Lab., Target Preparation Lab., etc. The machine control, data



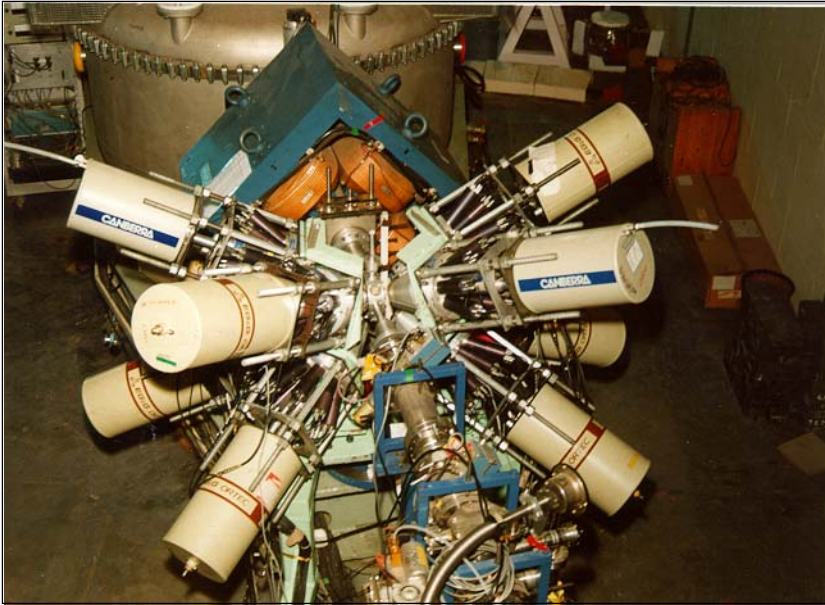


Figure 2. HIRA-GDA combined experimental facility.

acquisition during experiment and the later analysis are done using computers. NSC also has a round-the-clock library facility with important journals and books.

The technologies and expertise obtained in such a laboratory are widespread and cover fields such as charged particle beam optics, ion source and accelerator, magnets, high voltage, vacuum, fibre optics, thin film, radiation protection and survey, particle and gamma/X-ray detectors, mass spectrometer, CAMAC instrumentation, NIM electronics, advanced data acquisition, computer control, simulation packages for analysis/predictions and advanced computation.

Augmentation Programme

There is an on-going plan to use superconducting linear accelerator modules to produce particles with much higher energies and create new frontiers in research, for which a collaborative effort is under way with Argonne National Laboratory, USA. This has opened up new areas of expertise in RF electronics, superconducting cavities and cryogenics.

In keeping pace with accelerator augmentation, several advanced experimental facilities are planned (proposals submitted to DST for funding) such as a large GDA consisting of 56 elements, a spin spectrometer consisting of 72 elements, a neutron detector array of 8 elements and a prototype radioactive ion beam facility by upgrading HIRA.



Possible Applications in Physics

Heavy ion beams are useful in forming nuclei with high excitation energy and large angular momentum. Exotic nuclei, far from the valley of stability, can be formed in fusion reactions. The energy loss of a few hundred MeV of heavy ions in a medium is mainly due to the electronic part which causes considerable modification in crystal lattices. Such ions lose most of the energy towards the end of their track giving rise to the so called *Bragg peak* which is useful in selecting the depth at which irradiation effect should be maximised without affecting the other layers. The above properties of accelerated heavy ions and the available experimental facilities open up a wide range of applications in physics as follows:

Nuclear Physics: Elastic and inelastic scattering, break-up reactions, Coulomb-nuclear interference, fusion and transfer reactions below Coulomb barrier, fission reactions, micro-second isomeric transitions, GDR decay, high spin spectroscopy, life-time measurements (nano- and pico-second), nuclear level density measurements, light charged particle and neutron evaporation studies.

Atomic Physics: Direct ionization, electron capture and transfer ionization processes in single collision conditions, multiple ionization using X-ray studies.

Materials Science: Characterisation by ERDA, hydrogen depth profiling, irradiation effects on strength and corrosion in materials, modifications of material properties due to electronic excitation/ionization by swift heavy ions, vortex localization by columnar defects in high T_c superconductors, effects on photoluminescence in porous silicon on irradiation.

Radio-biology and Radiation Chemistry: Cell survival on irradiation, primary free radical studies in irradiated samples, effect of radiation on selectively permeable membranes.

Opportunities for New Entrants

The NSC user family has grown to 47 universities, 26 colleges, 9 other teaching institutions and 19 research/development institutes spread across the country. Project proposals for beam-time usage can be submitted in prescribed format twice a year (before May 15 and Oct.31). These are scrutinised by experts and members of the Accelerator Users' Committee (AUC) after a brief oral presentation of each proposal. The sanctioned beam-time is subsequently allotted giving sufficient time for the user who could also take the help of a Local Experimental Co-ordinator (LEC) at NSC. UGC provides separate funding to university projects for NSC Pelletron utilization. Limited posts are available for visiting scientists for either extended or spread-out stay at the NSC. Many university



students work towards their doctoral degrees in experimental fields using the accelerator facility. NSC also conducts a Ph.D. programme with semester-wise teaching schedule. The teaching programme is also open to scholars from other universities. M.Sc. students are encouraged to join a two week programme in which they get hands-on experience in laboratory work. Acquaintance programmes are conducted at various zones for college teachers and students about research possibilities. An international workshop and many national workshops have been conducted here. NSC reaches out to its users and other interested people periodically by way of Newsletters, Annual Reports, Brochures, etc. National Science Day is celebrated every year by inviting college students for lectures and demonstrations using high energy beam. Those interested in any of the above programmes may contact:

The Coordinator, Academic Cell
Nuclear Science Centre, Post Box 10502, New Delhi 110 067, India.
email: info@nsc.ernet.in



N Madhavan is a Scientist with the Nuclear Science Centre for the past 11 years. He has made significant contributions in the design and commissioning of the country's first recoil mass separator HIRA, in combining the two major experimental facilities HIRA and GDA and in helping the NSC user community in the utilization of these world class facilities. His interests include beam optics and nuclear reactions.

Address for Correspondence

N Madhavan
Nuclear Science Centre
P.B. 10502
Aruna Asaf Ali Marg
New Delhi 110 067

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