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Superconducting LINAC and High Current Injector (HCI) activities

All five cryostats of the Superconducting Linac have been working successfully. Various beams have beam accelerated through them. In three accelerating modules of Linac, 22 out of total of 24 resonators (3x8) were installed. All of them worked and produced accelerating fields. Linac operation is planned from November'12 to February'13. Beams viz. ^{16}O, ^{28}Si, ^{30}Si, ^{48}Ti, ^{107}Ag and ^{127}I are planned to be accelerated and to be delivered for Nuclear Physics and Materials Science experiments. A new frequency tuner based on Piezo actuator was successfully tested on four resonators. The fabrications of vanes, support and other components of Radio Frequency Quadrupole (RFQ) are nearing completion. High power testing are being planned. The fabrication of first Drift Tube Linac (DTL) is in advanced state of completion. The high temperature superconducting electron cyclotron resonance ion source (HTS-ECRIS) has been in regular operation. The high voltage platform for HTS-ECRIS is being fabricated. It is expected to be available for installation in March'13. The ion-optical design for HCI beam transport system is completed.

Neutron Detector Array Project

The DST funded project of setting up a large neutron detector array at IUAC is progressing well. The mechanical structure has been built & installed at the beam hall. The mechanical assembly to mount 100 detectors is a metallic geodesic dome structure with hubs and links built using mild steel. Detectors will be mounted at a flight length of 175 cm from the target. The first phase of the project will have 50 neutron detectors, each detector a 5"x5" liquid scintillator type BC501A coupled to a 5" photomultiplier multiplier tube. A 100 cm diameter spherical vacuum chamber has also has been installed in the beam line.

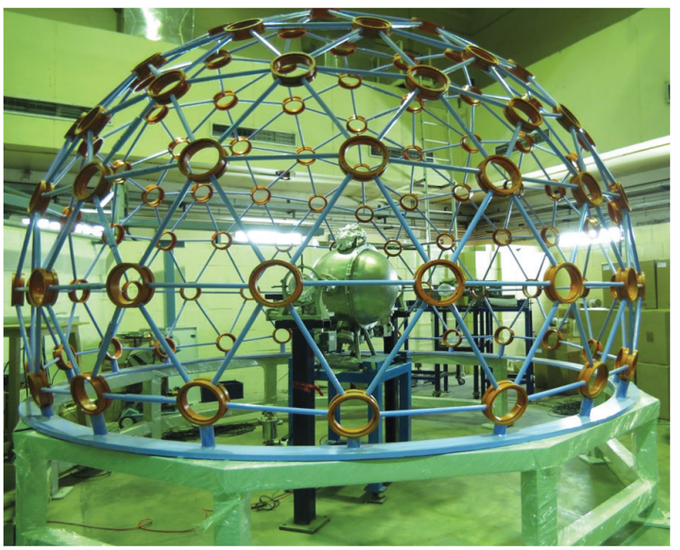


Fig.1 : Geodesic Dome Structure

All 50 detectors for the first phase has been procured and tested in the laboratory. The test was carried out using homemade electronics for n- γ pulse

shape discrimination (PSD) and timing performance characteristics with standard gamma ray as well as neutron sources. Though the detectors and PMTs are all identical, the operating voltage varied slightly among detectors. Nominal operating voltage on each detector was determined by keeping the anode signal amplitude for ^{137}Cs gamma rays around 450mV for best timing & zero-cross separation. The custom made PSD module contains the integrated electronics for n-γ discrimination, time of flight and energy. It is a single width NIM module having two independent channels that can accept signals from two detectors. For each detector, the anode and dynode (through a charge sensitive pre amplifier) signals are fed to the inputs of the PSD module which process them and provide energy, constant fraction timing and a time to amplitude signal corresponding to zero-crossing time distribution for n -γ separation at its outputs. Other logic signals and monitoring signals are also provided on its front panel. Total 50 channels of PSD modules have been fabricated and tested for its performance.

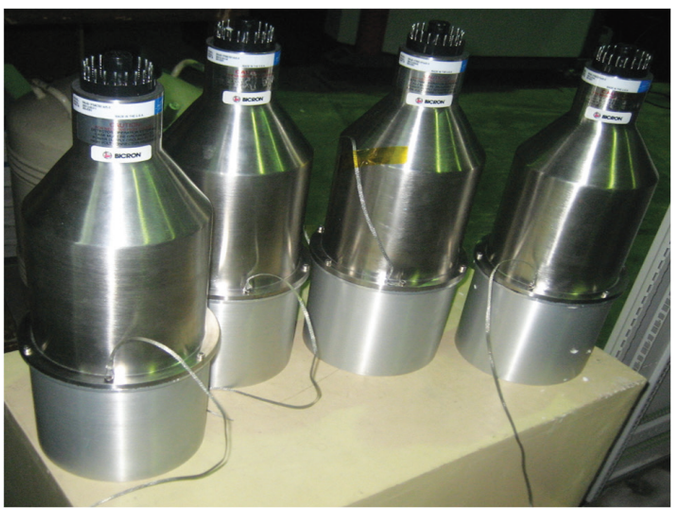


Fig. 2 : BC-501A Detectors

The PMTs are normally operated below -2000 volt. To apply the high voltages, homemade voltage divider bases have been fabricated, which contains the high voltage resistive divider circuit compatible to R4144 tube. The base also contains an integrated charge sensitive pre - amplifier for dynode signals. To take care of the large number of high voltage channels required for the full array, custom made compact high voltage power supply has been made at IUAC. The high voltage (0-2000 V) is generated using commercial DC-DC high voltage converter chip (PICO make) mounted on a control board that can be controlled over a private Local Area Network. The digital section of this board consists of a microprocessor and an Ethernet controller where as the analogue section contains one 12-bit digital to analog converter. Each board has its own unique MAC and IP address so that each can be specifically selected at a time for read & writes operations. A 24 channel power supply system has been assembled in a 2U box (19" rack mount) and tested successfully. Total three such boxes will be used for biasing all the detectors. A graphical user interface developed in Qt framework is used to control the high voltages over the network.

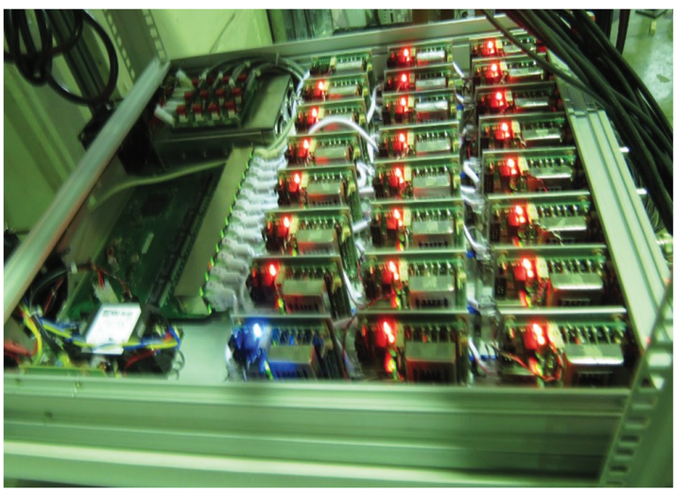


Fig. 3 : High Voltage Power Supply

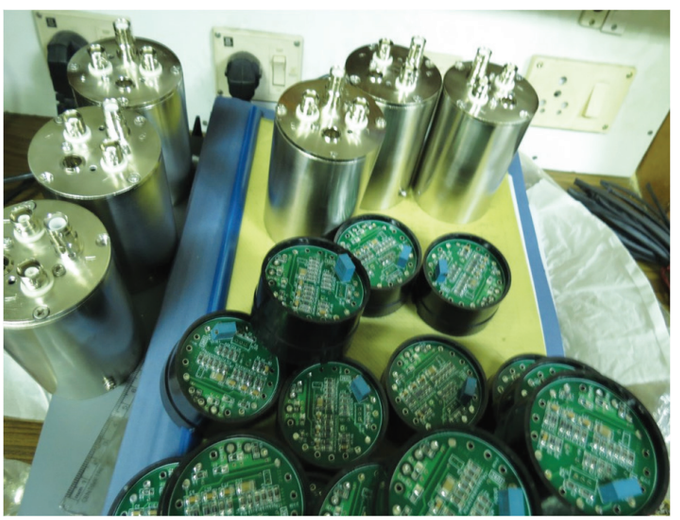


Fig. 4 : PMT Bases

Hybrid Recoil mass analyzer (HYRA)

HYRA gas-filled mode combined with TIFR spin spectrometer has been used in several experiments for excitation function and spin distribution of evaporation

residues following heavy ion induced fusion-evaporation reactions in heavy mass region. Effects of shell closure in target/compound nuclei, entrance channel mass asymmetry, etc. were probed looking for the evaporation residue survival probability and also the extent of its spin population. The successful operation of all the three modules of the superconducting LINAC accelerator has opened up possibilities of forming heavy compound nuclei with more symmetric projectile-target combination and with higher recoil energies. Currently, focal plane decay measurements, mainly gamma decay from long-lived isomeric states, are being carried out with modified focal plane detection setup (figure 1).

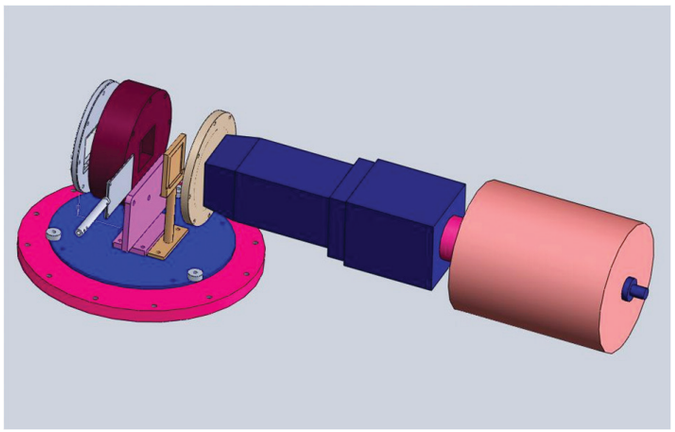


Fig. 1 : Focal Plane Setup : MWPC followed by Silicon & Clover Detecters

HYRA-INGA Experimental Proposal Workshop : A two-day workshop was held at IUAC on September 18-19, 2012 to discuss experimental proposals for using HYRA-INGA combined facility. A total of 22 proposals were presented in the workshop by researchers from India and abroad. The INGA PICC, along with co-opted members, went through the proposals and presentations in detail and placed their recommendations to AUC in the December 2012 meeting at IUAC. Experiments which could be carried out with the intensities and energies of beams possible currently and with available experimental facilities were assigned higher priority. Few experiments which may be carried out using complete INGA with some ancillary detectors, not necessarily HYRA, will be forwarded to TIFR for consideration towards the end of the present campaign there. The TIFR campaign is expected to be over by mid-2013 and, subsequently, the VECC campaign using alpha/proton beams and the IUAC campaign (HYRA-INGA) with heavy ion beams will be taken up simultaneously. In IUAC campaign, 16 clover detectors and up to 3 LEPS detectors will be used along with gas-filled mode of HYRA.

The extraction of intense ion beams from a high field ECR into a RFQ channel

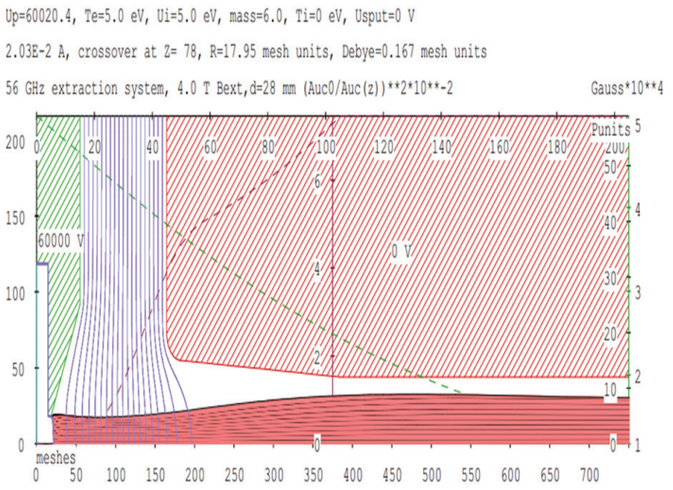


Fig. 1: Combined extraction/matching system for a high performance ECR ion source into a RFQ channnel

The ion current from high intensity ECR sources for highly charged ions becomes limited during extraction by the high space charge. This makes classical extraction systems for the transport and subsequent matching to a RFQ accelerator less efficient and practically impossible. The DPI (direct plasma injection) developed for a laser ion source avoids these problems and uses the combined focusing of the gap between the ion source and the RFQ vanes (or rods) and the rf-focusing of the RFQ penetrating into this gap. For high performing ECR sources, using sc solenoids, in addition to the DPI scheme, also the magnetic stray field of the source may be used to provide focusing against the beam space charge. We have designed and optimized a combined extraction/matching system (figure 1.) for a high performing ECR ion source into a RFQ channel, allowing a beam of about 20 mA highly charged 238U40+ at modest ion source voltages of 60 kV. In order to proceed, we have used the feature of IGUN to take into account the rf-focusing of a RFQ channel (without modulation), the electrostatic field between ion source extraction and the RFQ vanes, the magnetic

stray field of the ECR superconducting solenoid, and the defocusing space charge of an ion beam. We can show that the magnetic stray field (dashed line in green colour, the field values are shown on the vertical axis on the right,) becomes essential for this design and that even small variations of 10% are not acceptable. The normalized rf focusing force parameter is plotted with a red dashed line and corresponding values are shown on the vertical axis in the centre of the plot. This work is still in progress and is in collaboration with Goethe University, and Scientific Software Services, Germany.

Materials Science Facilities

A low temperature Lab has been set up. A closed cycle He cryostat is now installed in this lab and optimized to carry out electrical transport measurements from 10 K to room temperature. The DC sputtering set up was optimized and used for sample preparation by users. The dedicated sample ladder fabricated for in-situ resistivity measurement in Materials Science beam line is now being used in user experiments.

The facility test for in-situ XRay Reflectivity (in-situ XRR) using 200 MeV Iodine beam was performed on Si/W multilayer sample to investigate ion beam induced interface mixing. The high temperature ion irradiation facility in beam hall II was also tested up to a temperature of 1000K. The facility for low temperature in-situ XRD measurement using closed cycle refrigerator (CRR) was used to study ion beam induced amorphization in BaTiO3. The measurements up to 20 K showed that the sample shows higher irradiation resistance at lower temperatures.

The offline testing of signal collection from the sample mounted inside chamber in the beam line for in-situ Raman facility was successfully completed. The photoluminescence set up has been shifted to the materials science building from the beam hall for optimum utilization and its re-installation is under progress. A new mounting stage is being fabricated for the same.

The SEM system was used for cross-sectional elemental mapping using EDS in ZrO/CuO and other bilayer systems.

Workshops/Schools/Acquaintance Programs (April – October, 2012)

A one day IUAC acquaintance program was held at the Department of Physics, **Shri Mata Vaishno Devi University** (SMVDU), Katra on 14th June, 2012. Dr. V.K. Dhiman from SMVDU acted as the local convenor. Lectures on experimental facilities and research opportunities at IUAC were delivered by Dr. F. Singh and S. Nath. Prof. Rajnikant and Prof. K.K. Bamzai from University of Jammu also delivered lectures on this occasion. Students and faculty members of SMVDU, University of Jammu and different colleges from the region participated in the program.

A one day Acquaintance programme of IUAC, New Delhi was organized at the Department of Physics, **Saurashtra University,** Rajkot on September 21st, 2012. Prof. D.G. Kuberkar from SU acted as the local convener of the program and organized the program successfully with the help of his active team. Ninety Seven (97) participants comprising of senior faculty members from Saurashtra University, Rajkot, South Gujarat University, Surat, M.S. University, Baroda, Gujarat University, Ahmedabad, Senior College lecturers from Bahauddin Science College, Junagadh, Science Colleges of Morbi, Patan, Himmatnagar, Ahmedabad, Rajkot, Surendranagar etc. and young research students from all over Gujarat, participated in this programme. It was inaugurated by Honorable Vice Chancellor of Saurashtra University followed by the first scientific talk of Dr. Kanjilal. He explained all the facilities available at IUAC, New Delhi and scope for the research activities in various branches of Physics,

Chemistry and Biology. After the lunch session, Dr. Fouran Singh delivered a talk on the various facilities available at IUAC for research in Material Science and shared the latest results obtained as a part of collaborative activities of IUAC with various Indian Universities. One session was devoted to brief presentation by the Senior Physics teachers from Gujarat state such as Prof. N.L. Singh, Prof. R.B. Jotania and Prof. D.G. Kuberkar, who are active users of IUAC facilities. A panel discussion and feedback from all the participants was organized.

A five day school and workshop on "Parallel Computing for Scientific Applications" was organized at IUAC in April 2012. The school was targeted at students and young researchers working on simulations and large scale computing using high performance parallel computing systems, and was intended to ease the learning curve for parallel applications for current and prospective users of high performance computing facilities. While a number of HPC facilities have come up in the country, including at IUAC, the optimal use of these facilities for scientific applications requires knowledge of a parallel programming paradigm not often accessible to users trained in traditional methods. Talks from experts addressed hardware, techniques and resources for parallel scientific computing, including lectures covering shared memory OpenMP and distributed memory MPI parallel implementations, and resource management and scheduling on multi-node clusters. In addition, there were sessions dedicated to computing techniques for DFT and MD calculations. A feature of the workshop was the afternoon sessions given over to hands-on training in the computing methods covered in the theoretical lectures in the morning. A total of twenty two participants from seventeen institutions participated in the workshop.

An international conference on Swift Heavy Ions in Materials Engineering and Characterization (SHIMEC 2012) was organized by IUAC from 9th-12th October, 2012. There were 23 invited talks, 13 oral presentations and 132 poster presentations by over 150 researchers and scientists from around the world. Inaugural plenary talk was given by Prof. Vikram Kumar (IIT-Delhi) and Dr. A. Roy (Director, IUAC) gave an overview of the research being carried out in this field. The contributions discussed irradiation effects with ions of different energies particularly with swift heavy ions. The proceedings of the conference will soon appear in the journal Radiation Effects and Defects. The conference was preceded by an international school on Ion Beams in Materials Science organized from 3rd-8th October, 2012. About 80 students from different countries attended the school in which fundamentals and applications of ion-solid interaction were discussed. Dr. D. K. Avasthi was the chairman and Dr. A. Tripathi was the convener of the events. The concluding remarks on the two events were presented by Dr. A. Benyagoub (CIMAP, France) and Prof. W. Bolse (Universität Stuttgart, Germany).

A brief report on the LEIBF discussion meeting held at IUAC (12th September 2012) : The discussion meeting started at 9:30 hrs with the inaugural speech by Dr. D Kanjilal, program leader, LEIBF. In the inaugural speech, it was pointed out that the features of LEIBF are unique in terms of energy coverage and thus there is a large scope for high quality research with ion beams at a single platform. The existing users were requested to review their research in upgraded version of LEIBF and to point out the facilities required in the beam line for future research activities. First technical session was started with review talk by Dr. Pravin Kumar highlighting new features of LEIBF,

some of the research outputs from LEIBF and finally pointing out a few current research programs with end point energies (< 1 keV and > 500 keV). In their plenary talks, Prof. B K Panigrahi, IGCAR, Kalpakkam and Prof. D C Kothari, Mumbari University, Mumbai covered lots of possibilities in materials synthesis, modification and characterization by low energy ions. They also mentioned that the ions in the energy range available with LEIBF can be used to investigate many hitherto inaccessible problems in materials science. Six invited speakers from existing user community have presented their research works and appreciated the existence of such an accelerator at IUAC. They have really shown systematic findings in focused areas with latest characterization facilities. Two new users (also invited speakers), Dr. A Sarkar, Bangabasi Morning College, Kolkata and Dr. Utpal Joshi, Gujrat University, Gujrat have shown great interest in research with LEIBF. In the closing session, Prof S Dhar, Shiv Nadar University, Noida, who has been invited as an expert, has briefly explained ion assisted mechanisms leading to materials synthesis and modifications. He said that there is a need to understand the capacity of synthesis tools for applied research. Prof. D C Kothari conducted the discussion. Feedback from users was taken into consideration. In brief, separate experimental chamber equipped with synthesis and characterization tools for in-situ measurements is recommended by user community. If necessary, users can also formulate the projects for necessary funding. The idea of attachment and detachment of an experimental chamber (equipped with facilities for a particular research program) to the beam line was appreciated. Students from various places interacted with speakers and participated in the discussion session. A total of 81 participants (27 from outside and 54 from inside) attended in the meeting.

Summer Project for B.Sc. Physics students was conducted successfully. Good response was received from different colleges in Delhi and outside Delhi. Twenty students participated in twenty different projects conducted by IUAC academic staff.

Status of Teaching Lab

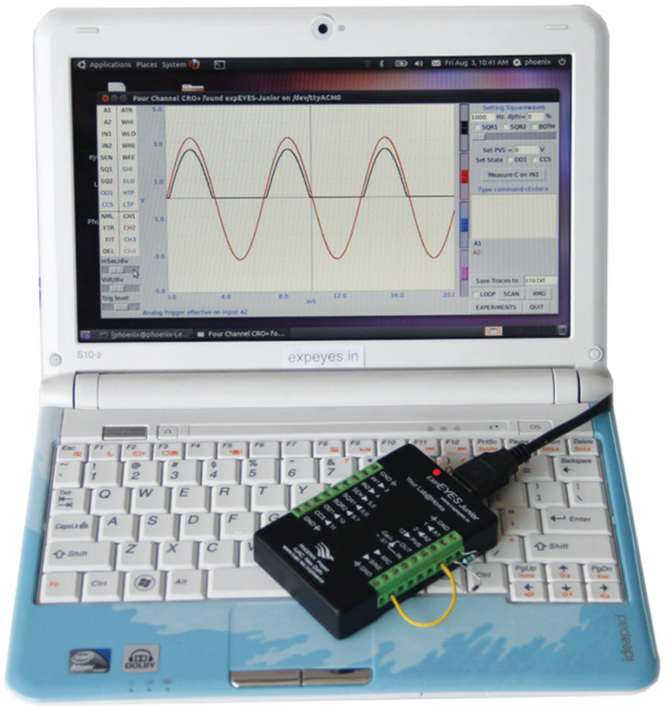


Fig. 1. Study of a p-n junction using expEYES

Development of a new version of the Computer Interface for Science Experiments was completed and made commercially available. This device, called expEYES Junior, is compact unit supporting around fifty experiments. The expEYES interface has got good response from the academic community and more than 500 units have been sold by different vendors during last year. A photograph of the latest device is shown in the figure.

Around forty teachers attended the "Six Days Training Programs" conduced during May-2012 and Oct-2012. They were trained on computer interfaced science experiments, Python programming for data analysis and visualization and installation of open source educational software. Those who are interested in information about training programs may join the mailing list by registering at the website www.iuac.res.in

Status of 15 UD Pelletron (April 1 to October 31, 2012)

Operation of Pelletron was quite satisfactory from 1st April 2012 to 31st October 2012 with one scheduled and one unscheduled tank opening maintenance of Pelletron accelerator.

On 7th April 2012, it was observed that operation of none of the terminal and HEDS devices inside accelerator tank could be controlled. Problem was investigated and found that all three bunches of fiber cables, responsible to carry control signals for devices in terminal and HEDS, got damaged. This led to unscheduled tank opening maintenance. The tank was opened and all the damaged bunches of fiber optic cables were replaced by new bunches. This unscheduled tank opening maintenance lasted for a week.

The only scheduled tank opening maintenance took place from 11th September 2012 to 18th October 2012. Apart from routine jobs such as resistor network maintenance for column support post and accelerating tubes, CAMAC maintenance, beam line components maintenance and maintenance of all the rotating parts inside accelerator tank, few other major maintenance jobs were also taken up in this maintenance. These maintenance jobs are mentioned below.

Fresh stripper foils were loaded in terminal, HEDS and in post acceleration section (before analyzer magnet). The charging system #1 was rebuild during January 2012 as charging chain #1 broke in December 2011. Elongation in charging chain #1 was noticed during accelerator routine operation. A pellet was cut from chain #1 to take care of this elongation. A thorough maintenance of both the charging systems was also carried out. Three nylon insulator of corona probe were taken out and cleaned thoroughly in ultrasonic bath and then installed back. This was done to avoid the leakage current through these insulators. This leakage current hampers the working of TPS and hence stabilization of terminal potential could not be achieved. A threaded brackets which holds the hoop screw, broke from its welding and got detached from equipotential ring. This bracket was welded.

Before scheduled tank opening maintenance, both the charging systems and working of TPS were tested. The results were satisfactory. Apart from this working of Earth Quake RAMs was also tested. All four EQ RAMS got fired and moved in towards terminal. Also, at the same time all the motors (2 chain motors, 2 rotating shaft motors and a blower motor) got tripped as all of them all interlocked with earthquake RAM activation.

A new modified MC – SNICS source was installed and it became operational in the month of March 2012. This new source worked satisfactorily and after its operation for seven months, it was opened once for regular maintenance work in 1st week of October 2012. The source was vented with argon. The source was opened, cleaned and assembled back. The ionizer assembly was replaced with a new one. Some of the ceramic components were also replaced. The alignment of source was checked and installed back in HV deck. Cesium reservoir with loaded Cs was also installed back. The source was then evacuated. As this was the first maintenance of ion source after its installation, the source was tested again for different elements and the results were satisfactory. During this operational period, the cathode wheel was loaded several times for regular runs and for AMS experiments, whenever required.

Magnetic field readback of dipole magnets in 15 UD Pelletron accelerator was incorporated in control system so that they can be directly read in the computer and can be used for automation purpose. A CAMAC card was developed which reads data sent by Gauss meter using RS232 port and format it to display the magnetic field value in existing control system. Cabling and necessary modification in database of control system was done. Presently, magnetic field, for analyzer and switcher magnets, are being monitored using these CAMAC cards and for injector magnet field will be installed soon.

A new header is installed to new compressed air line for the distribution of compressed air to all pneumatic devices in ion source room (seventh floor). A ball valve is added for each pneumatic device so that each device can be isolated from main compressed line individually, which is quite useful in case of maintenance of individual pneumatic device.

Maximum terminal voltage achieved during high voltage conditioning was 15.1 MV. 100 MeV of ^{16}O and 200 MeV of ^{107}Ag beams were delivered to user at the maximum terminal potential of 14.24 MV and 7.2 MeV of 1H beam was delivered to user at the minimum terminal potential of 3.51 MV.

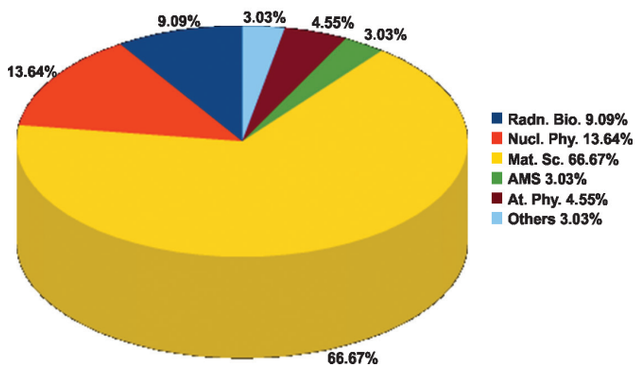
Out of total beam time of 2340 hours, 462 hours of beam time was used for pulsed beam runs using multi harmonic buncher (MHB) along with low energy chopper and traveling wave deflector. ^{12}C, ^{16}O, ^{18}O, ^{19}F, and ^{32}S beams were bunched and delivered to users for different experiments. All the pulsed beam runs were quite stable.

The uptime of machine for this period was 98.49%. The beam utilization time was 59.71%.

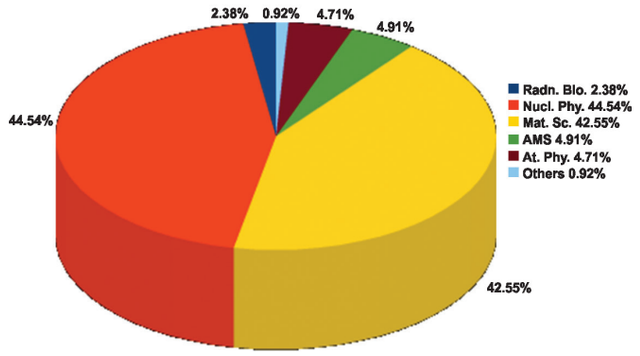
Statistical Summary

Total Chain Hours	=	3919 Hrs.
Beam utilization time	=	2340 Hrs.
Beam change time	=	9 Hrs.
Machine Breakdown time	=	59 Hrs.
Machine scheduled maintenance	=	1080 Hrs.
Accelerator conditioning	=	379 Hrs.
Beam tuning time	=	181 Hrs.
Experimental setup time	=	62 Hrs.
Machine setup and testing time	=	109 Hrs.

Userwise Breakup of Utilized Beam Time (April 2012 to October 2012)



Fieldwise Breakup of Utilized Beam Time (April 2012 to October 2012



User List: April to October, 2012

S. No.	University / Institute / College	Shifts utilized
1.	AIIMS, Delhi	5
2.	Allahabad University	2
3.	Amity University	2
4.	Aligarh Muslim University	16
5.	Anna University	4
6.	Bangalore University	3
7.	BAMU, Aurangabad	3
8.	Baraeli College	2
9.	Banaras Hindu University	20
10.	Delhi University	4
11.	G B Pant University	7
12.	GGSIPU, Delhi	7
13.	Guru Nanak Dev University, Amritsar	11
14.	Hyderabad University	7
15.	IGNOU	3
16.	IIT, Delhi	5
17.	Indian School of Mines, Dhanbad	3
18.	ISRO, Bangalore	8
19.	IUAC	80
20.	Jamia Milia Islamia Univ., New Delhi	2
21.	Jawahar Lal Nehru University	2
22.	Kalyani University	6
23.	Kongunadu Arts and Science College	2
24.	Kurushettra University	3
25.	MANIT, Bhopal	3