1. ACCELERATOR

1.1 PELLETRON

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1.1.1 Operational Summary

Performance of 15 UD Pelletron accelerator was quite satisfactory from 1st April 2016 to 31st March 2017. There were a few breakdowns which were resolved at the earliest. In this period there were three tank openings, two scheduled and one unscheduled. The details of the tank opening maintenances are mentioned in maintenance section. The operational summary of the accelerator from April 2016 to March 2017 is mentioned below.

Total Chain Hours	=	6435 Hours
Total Beam utilization	=	4427 Hours
Machine breakdown	=	0099 Hours
Accelerator Conditioning	=	0765 Hours
Beam Change Time	=	0011 Hours
Tank opening maintenance	=	1719 Hours
Beam tuning time	=	0184 Hours
Experimental setup time	=	0051 Hours
Accelerator set up time after maintenance	=	0144 Hours

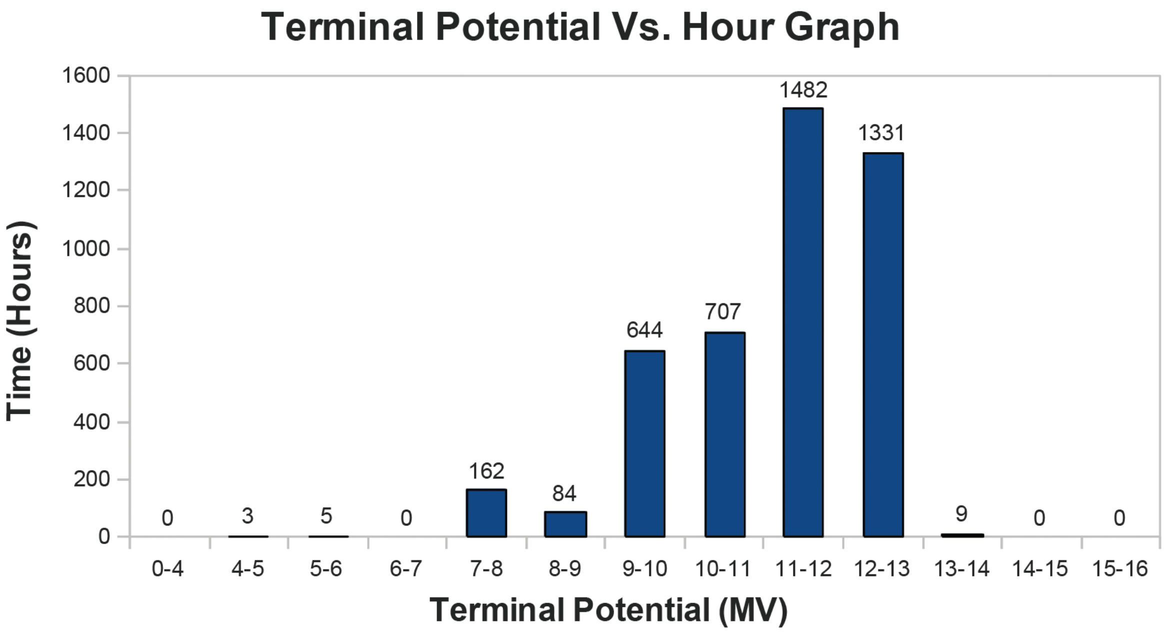

Fig. 1.1.1 Terminal potential vs. hour graph

553 shifts were utilized for experiments out of which 92 shifts were used for experiments with pulsed beam and 461 shifts for experiments with DC beams. The machine up time for this period was 98.46% and the beam utilization was 68.80%. The voltage distribution graph of Terminal Potential used for different experiments during above mentioned period is shown in figure 1.1.1. 120 MeV, 8+, ^{19}F delivered at terminal potential of 13.33 MV and 20MeV, 3+, ^{7}Li delivered at terminal potential of 4.98 MV were maximum and minimum operating terminal potential at which the beam was delivered to user. Maximum terminal voltage achieved during conditioning in this year was 14.6 MV. Figure 1.1.2 shows the Chain hour utilization for the mentioned period.

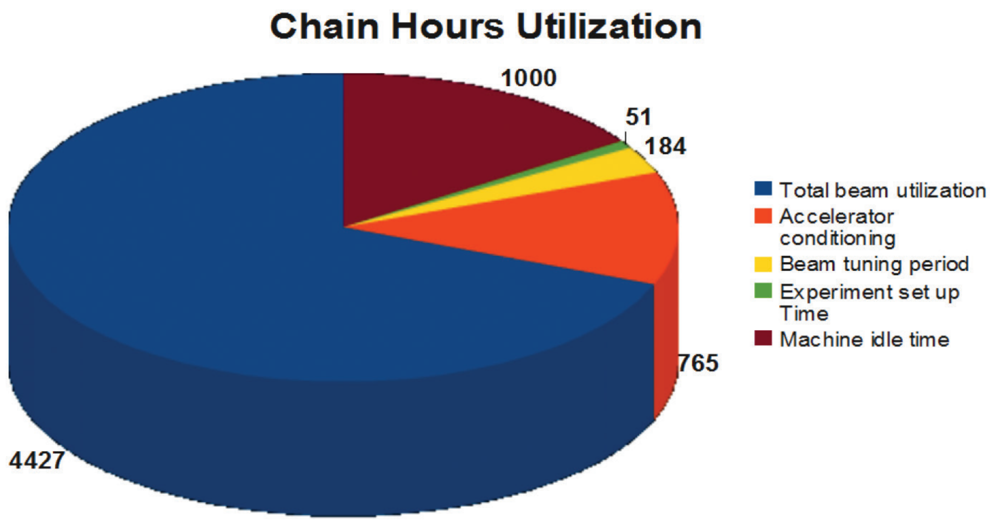

Fig. 1.1.2 Chain Hours Utilization

Duration of beam run time in percentage, for different ions species, is shown in table 1.

Table 1 : Ion beam run time in percentage

Beam Delivered	Utilization (%age of total time)	Beam Delivered	Utilization (%age of total time)
^{6}Li	2.42%	^{19}F	9.08%
^{7}Li	5.20%	^{28}Si	1.66%
^{9}Be	1.82%	^{31}P	0.28%
^{11}B	2.35%	^{48}Ti	1.14%
^{12}C	10.90%	^{58}Ni	1.06%
^{13}C	10.76%	^{63}Cu	2.76%
^{14}N	0.31%	^{107}Ag	8.74%
^{16}O	25.67%	^{197}Au	5.34%
^{18}O	10.50%		

Figure 1.1.3 shows the distribution of delivered beam species during beam run from 1st April 2016 to 31st March 2017.

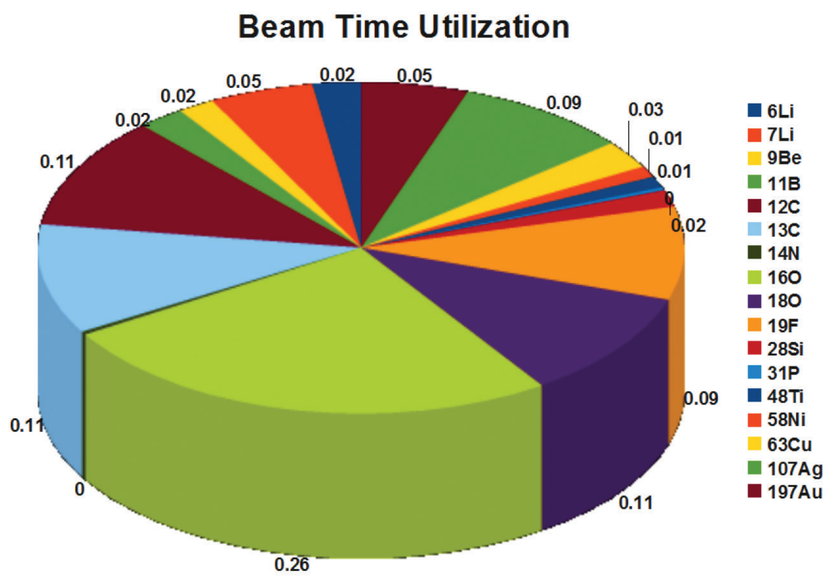

Fig. 1.1.3 Beam Time Utilization

1.1.2 Maintenance and Development Activities

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There were three tank opening maintenances in the last academic year. The first and third maintenances were scheduled and second one was unscheduled. Details of the maintenances are mentioned below.

A) SCHEDULED TANK OPENING MAINTENANCE

The first tank opening maintenance of the academic year was a scheduled one. The 15 UD Pelletron accelerator operated for the users' experiment during the period 10th November 2015 to 12th May 2016. The 15 UD Pelletron accelerator was shut down for scheduled maintenance from 12th May 2016 to 14th June 2016. Second scheduled tank opening maintenance was performed from 27th January 2017 to 1st March 2017 after operating it for user experiments from 7th July 2016 to 25th January 2017. Brief description of maintenance job carried out during these schedule maintenances are described below.

Tests performed before tank opening

a) Testing of charging currents of both the charging chains:

The assessment of the condition of both the charging chains was performed before both scheduled maintenance. The Terminal of 15 UD was shorted to ground by using shorting rods. Both the charging chains were operated and their charging currents were observed at different Charging Power Supply (CPS) values. It was observed that the condition of both the charging chains is almost same. Charging chain #1 could carry ~48 µA current at the CPS of 21 kV and its current starts fluctuating at CPS values beyond 21 kV, whereas, charging chain #2 could carry ~48 µA at the CPS of 23 kV and its current started fluctuating at CPS value above 23 kV.

b) Dew point measurement of SF_6 gas:

Dew point of SF6 gas inside Pelletron Accelerator Tank (PAT) was measured and it was ~-32.5 deg C.

c) Testing of Earthquake RAMs (EQ RAMs):

Before second scheduled tank opening maintenance, functioning of EQ RAMs were tested under actual conditions. The EQ RAMs were pressurized with ~217 psi with SF_6. Both the chain motors, rotating shafts and blower motor were put ON and Terminal voltage was set at 9.5 MV with CPS = 7 kV. The earth quake sensor box, in control room, was hammered gently, with a mallet, to generate the effect of earth quake. The EQ sensor generated signal leading to actuation of RAMs. They moved towards terminal. This caused tank spark and all five in-tank motors got tripped off. The EQ sensor was then reset from control room and EQ RAMs were retracted back. SF_6 gas pressure in EQ RAMs cylinder dropped to ~180 psi. This test confirms the satisfactory working of EQ RAMs.

Miscellaneous maintenance jobs like, foil stripper loading in terminal and High Energy Dead Section (HEDS), column support post and accelerating tube resistors maintenance, in tank ion pump maintenance and maintenance of rotating parts inside tank, were carried out in this scheduled maintenance. Apart from routine maintenance jobs few other major maintenance jobs were also carried out, which are listed below.

Major maintenance jobs during scheduled tank opening maintenance:

1. Charging system maintenance

Condition of both the charging systems was assessed. The high voltage Terminal was grounded by connecting it with tank body, so that terminal should not accumulate any charge when chains are running. Condition of all idler wheels and chains for both the charging systems was checked with chains in running condition. During second maintenance, condition of all the three idler wheels for chain #1 was bad as they were worn-out. Hence, all those three wheels were replaced and aligned. Condition of all the inductors, pick off wheels and pulleys, for both the charging systems were also inspected and found satisfactory. Condition of all the nylon links, for both of the charging chains, was inspected for cracks and no crack was found.

Semiconductor bands of all the pulleys of both the charging systems were oiled with TP oil to reduce the friction between pulley and chain. Pillow blocks and chain motors of both the charging systems were properly greased. A very thin layer of sticky dust generated from idler wheel, on chain #1 was noticed. Both the chains were cleaned and kept in running condition for THREE to FOUR nights to check its mechanical performance which was found to be satisfactory. Electrical performance of both the charging systems was also checked, at different CPS from 2 kV to 7 kV, and it was found to be satisfactory.

During first maintenance, a large humming sound was heard at the time of stopping of chain #1. Both the charging systems were checked in side terminal area. The bearings of both pick up wheels, for doubler and suppressor, got damaged in the charging system #1 resulting in the humming sound. Both the damaged pick up wheels were replaced by new ones to solve the problem. The charge pick up pulley, for suppressor, of charging system #2, in terminal area, was also replaced by new one as its bearings got dried up. All the nuts and bolts for both the charging systems, in terminal area and at tank bottom, was checked and tightened, if required. The ground connection of terminal was disconnected. This completed the charging system maintenance.

2. *Maintenance of Rotating parts inside accelerator tank*

Thorough maintenance of all the rotating parts, such as charging chain motors, rotating shaft motors, separator box assemblies for rotating shafts and blower motor was done. Alternators, housed in both dead sections and terminal, are driven by rotating shafts. These alternators generate local power for devices in both dead sections and terminal. Separator boxes are used for mounting of these rotating shafts.

All the rotating parts inside tank were checked thoroughly for maintenance. During first maintenance, bearings of thirteen separator boxes were replaced, three in low energy side and ten in high energy side. Bearings of these assemblies were replaced by new bearings except of two separator boxes in HES. Those two separator boxes were replaced by new assemblies as they were beyond repair. Apart from this, alternator of T – 2 area was also replaced by new alternator as its bearing went bad. The removed alternator will be repaired later.

During second maintenance, bearings of eighteen separator boxes were replaced, eleven in low energy side and seven in high energy side. Bearings of these assemblies were replaced by new bearings. A rubber coupler, in one of the assemblies in low energy side, broke and was replaced by a new one.

All the repaired separator box assemblies were installed back and aligned after maintenance. All five in-tank motors (2 chain motors, 2 rotating shaft motors and a blower motor) were greased properly.

3. *Stripper foil loading in terminal and HEDS*

Fresh stripper foils were loaded in terminal and HEDS. During first maintenance, carbon LPA Stripper foils, of Munich make, were installed in terminal and IUAC made carbon stripper foils were loaded in HEDS area. During second maintenance only IUAC made ~4μg/cm2 thick carbon stripper foils were loaded.

4. *Repairing of Column Support Post (CSP) gaps*

The condition of CSP and accelerating tubes should be good for stable operation of tandem accelerator. They should be able to handle rated high voltage without breakdown. If the condition of any of these gaps is not good, the high voltage field, which accelerates the ion beam, will collapse.

During first maintenance, a vertical crack on ceramic surface across gap #2 in unit #22 was observed. This gap was shorted. In total 34 CSP gaps were shorted; 17 in LES and 17 in HES. None of the CSP gaps were shorted during second maintenance.

5. *Corona probe maintenance*

The condition of all seven corona probe needles was good. Therefore, none of the corona needles were replaced.

6. *Generating Voltmeter (GVM) maintenance*

Reading of installed GVM assembly was continuously fluctuating at the SF6 gas pressure above ~77 psig in Pelletron Accelerator Tank (PAT). Hence, 15 UD accelerator was operated at the pressure of 75 psig for its smooth operation. This problem was due to bad GVM assembly. During second maintenance, new GVM assembly, procured from NEC, was installed in place of faulty one. GVM motor was switched ON after installation and its RPM is checked which was 3008. The reading of GVM at control console DPM was -.022 MV and was stable without any fluctuation. After maintenance, the GVM electronics was re-calibrated according to new GVM assembly. This new GVM assembly is now working perfectly even at PAT pressure ~90 psig.

7. Gas stripper maintenance

The metering valve associated with gas stripper was not working during second maintenance. It is required to control the flow of nitrogen gas for gas stripper at terminal. The problem was investigated and was detected in gas valve control card. This card was replaced to solve the problem. The faulty card was later repaired. After solving the problem, working of Gas Stripper was checked thoroughly and it worked satisfactorily.

Other maintenance outside Pelletron Accelerator tank

1. Maintenance of Vacuum related components

Routine maintenance of all ion pumps and sublimator pumps along with their controller were performed. Two numbers of ion pump controllers and a sublimator pump controller were also repaired.

2. Maintenance related to different devices

The breakdown maintenance of different devices, such as Beam Line Valves (BLVs), Faraday Cup controller, power supplies, CAMAC control system etc., was also done.

B) UNSCHEDULED TANK OPENING MAINTENANCE

This unscheduled maintenance was held after eleven days of first scheduled tank opening maintenance. Full column conditioning of machine, after the last scheduled tank opening maintenance (May 2016), to condition the terminal for high voltage, was in process. There was a tank spark at terminal potential of ~13.2 MV. After this tank spark, none of the devices installed in terminal and HEDS area were operating from control room. This indicated that all three bunches of fiber optic cables, responsible to carry control signals for devices in terminal and HEDS, got damaged. After ensuring the damage of all fiber optic cables, the tank was opened for breakdown maintenance. This caused unscheduled maintenance which lasted for 08 days (25th June 2016 to 2nd July 2016). All the units in high energy side of machine were thoroughly cleaned as most of them had lots of dust due to damage of fiber cables. All the damaged bunches of fiber optic cables were replaced with new bunches.

1.1.3 Ion Source Activities

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The ion source operated satisfactorily from April 2016 to March 2017. Beam of various ion species, in the energy range of 130 to 230 keV, were delivered routinely for the scheduled experiments. During this period, there were two breakdown maintenances; first one was for repairing the gate valve of the ion source and second for cleaning einzel lens assembly.

The first maintenance was performed on 31st May 2016, to repair a pneumatic gate valve which is used to isolate ion source housing assembly from the cathode wheel mount assembly during the process of loading of new cathodes. As the valve developed a leak, air entered into the MC – SNICS source during one of the cathode loading exercise. This caused oxidation of upper layer of cesium and the vacuum of the ion source beam line went bad. The source was opened to repair the gate valve. The valve was dismantled and it was found that the rubber O-ring got displaced from its original sealing position. The O-ring was re-positioning and valve was assembled back. The source was assembled back and aligned with the help of alignment kit. The source and the valve were re-installed back on the beam line. A new cesium 5 gm ampule was loaded in the cesium reservoir and the source was loaded with new cathodes. The source was tested and operated satisfactorily for regular operation.

The second maintenance, in the month of February, 2017, was carried out for cleaning the einzel lens assembly. The performance of the einzel lens got deteriorated limiting the high voltage holding capability of extractor electrode to ~5kV. As a result, the extractor voltage had to be compromised to a lower value than optimized value. This restricted the optimum amount of beam current from ion source. The high voltage stack of extractor power supply frequently got burnt. The possible causes such as defective extractor power supply, cesium contamination from the source towards the lens assembly and the general purpose accelerating tubes (GP Tubes) were checked subsequently. The gap insulation of the einzel lens got deteriorated. Lots of sparking was noticed around 210 kV of deck potential across the GP tube gaps. Few damaged resistances of GP tubes were found. Therefore, all the GP tubes ceramic gaps were properly cleaned and defective resistors were replaced with the new ones. A spare einzel lens assembly was sand blasted and cleaned thoroughly with alcohol and then baked in an oven, at 100ºC for 1 hour. This einzel lens was then assembled and the alignment was done with the help of alignment kit. The gap insulation of the cleaned einzel lens improved to a range of few tens to hundreds MW.

The source was vented with the Argon and opened. The einzel lens assembly was also removed from the beam line. After dismantling the source, the entire dirty source components including ionizer assembly were sand blasted and cleaned with alcohol. The components were baked in oven at 100ºC for 1 hour. The source housing along with its cesium line was cleaned with alcohol and dried using hot air blower. The source was assembled by aligning its components with an alignment kit and mounted back to the beam line. A new 5 g cesium ampule was loaded. Required cathode samples were prepared and loaded. The source was tested and operated satisfactorily for regular operation.

It was observed that the extractor power supply was failing, if the ion source deck was operating above ~220 kV. This implies that the frequent failure of extractor power supply could be discharge in HV deck power supply at higher potential. Hence, it was decided to operate HV deck power supply below 200 kV. The strategy helped and extractor power supply did not fail after that. Further investigation is still needed to solve this problem completely. Therefore, an old high voltage multiplier and filter stacks were thoroughly cleaned. Presently used high voltage multiplier and filter stacks were replaced by those cleaned multiplier and filter stacks. The HV multiplier stack and filter stack which were removed were also thoroughly cleaned.

Ion source HV deck was thoroughly cleaned. The GP tubes were conditioned for improving high voltage holding capability. Finally, it could hold up to 280kV with stability. Regular routine work and maintenance were performed as per requirement. New cathodes (samples) were loaded in cathode wheel, whenever required.

1.1.4 Beam Pulsing System

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Operation

Multi Harmonic Buncher (MHB) along with low energy chopper was operated for 736 hours for delivering pulsed beam to the users. The Traveling Wave Deflector (TWD) was also used whenever different repetition rates of pulsed beam, other than 250 ns, required. The pulsed beam from Pelletron, were utilized by users to perform their experiments in different experimental lines. Ion species bunched and delivered to the users were ^{16}O, ^{18}O, ^{19}F and ^{28}Si.

511 hours of pulsed beam from Pelletron, were utilized by users to perform experiments in HIRA and HYRA experimental lines with repetition rate of 1μs and 2μs.

All the pulsed beam runs were quite stable.

Pulsing system Maintenance

a) Chopper maintenance

The routine maintenance of chopper was carried out. Dummy load comprising of 50 Ω pure resistance was connected at the output of amplifier and output stage of amplifier was tuned for maximum power transfer. The output of amplifier was then disconnected from dummy load and connected to tank circuit of chopper. Chopper tank circuit was then tuned for maximum power transfer from chopper amplifier. The chopper tank circuit could be tuned to get maximum forward power of ~20 W with reflected power of ~0.5 W. The chopper amplifier was kept ON for two days to check its stability which was up to the mark.

b) Traveling Wave Deflector (TWD) maintenance

The routine maintenance of TWD was carried out. In this maintenance, all the control electronics and switching amplifier electronics were checked. The performance of TWD electronics was satisfactory.

1.1.5 Low Energy Negative Ion Implanter Facility

G Raturi, J Singh, Pranav Singh, S Kumar, S Mohan, N S Panwar, M P Singh, R Kumar, J Prasad, M Archunan, V P Patel, Rajveer, K Devarani, M Sota, A Kothari, R Ahuja, P Barua, D Munda, K Singh, S Ojha, S Gargari, R Joshi , S Chopra and D Kanjilal

1. Operation

The operational status and ion beam delivery of the implanter facility had been excellent for this academic year (2016-2017). About 24 users from different colleges, universities and institutes availed the beam time from April, 2016 to March, 2017. Altogether, there were 26 runs. The particulars about the implantation experiment performed during this period are given below:

- Number of beam run: 26
- Total number of shifts utilized: 78
- Total number of samples implanted: 520
- Ion fluencies used: $1x10^{11}$ to $1x10^{17}$ ions/cm^2
- Ion species utilized: ^{7}Li, ^{12}C, ^{16}O, ^{27}Al, ^{28}Si, ^{31}P, ^{32}S, ^{48}Ti, ^{56}Fe, ^{58}Ni, ^{59}Co, ^{63}Cu, ^{107}Ag, ^{197}Au
- Energy range of delivered beams: 20 to 200 keV

2. Maintenance

The facility had a smooth run, cathode sample loading and regular cleaning were carried at regular intervals. Major maintenance was carried out for breakdown of ionizer in ion source and a failure in the CAMAC control system.

a) MC – SNICS maintenance

Ion source breakdown maintenance of implanter facility was performed once. The source was opened in the month of November, 2016 mainly to replace the damaged ionizer assembly. The electrical connections were removed. The source was vented with Argon. Cesium reservoir was removed from the source and kept it under argon environment. The insulation capability of ceramic gaps of einzel lens were checked and found them satisfactory. Therefore, only the ion source was dismantled to clean up its entire source components. These components were sand blasted, cleaned with compress air, bathed in alcohol and then finally baked them in an oven at a temperature of 100ºC for 1 hour to remove the moisture absorbed on the surface. The source was assembled with a new ionizer and its alignment was done carefully using alignment kit. The ion source assembly was installed back in the beam line. Vacuum leak checking was carried out. Electrical connections were restored and vacuum was created. After achieving low $x10^{-6}$ torr vacuum, the source was baked systematically. The source was tested and operated satisfactorily for regular operation.

b) Control system maintenance

i) Other breakdown maintenance performed was of control system. Control system of the ion source was not functioning. The problem was traced to the damaged ADC module. A fan was installed in high voltage deck area to give air flow to the spark protection module and other high voltage power supplies to avoid such damages caused by heat.

ii) In another occasion, during the experiment, ion beam was not reaching the experimental chamber. The problem was analyzed in electrostatic quadrupole triplet (EQ 02-1) located in front of the chamber. EQ 02-1 was not working as there was no output from all the power supplies of this quadrupole. A spark protection card, corresponding to quadrupole EQ 02-1, broke down. This faulty spark protection card was replaced to solve the problem. Apart from these breakdown maintenance works, Regular routine work and maintenance were performed as per requirements.

3. Facility Upgradation

a) Target ladder with new movement mechanism

This year, the target ladder assembly had been upgraded. Some of ion implantation experiment demand for rotational movement as they require energized ion beam implanted into the samples at particular angle. The old one had no provision for rotation, thereby making it extremely difficult to perform such kind of experiments. Moreover, it could accommodate only 5 samples at a time of sizes 15mm x 15mm. After every 5 samples got implanted, lots of time was wasted in interruption of vacuum, unloading and loading of new samples, mounting the ladder to the chamber and subsequently, creation of vacuum to the chamber. Therefore, it was felt that the ladder needs to be upgraded to fulfill all these necessities. Hence, a new target ladder incorporated with rotational and linear drive motion had been installed in the target chamber. It has four faces; each face can have 5 samples making it capable of holding 20 samples at a time.

In order to integrate rotary and linear manipulator to the target chamber, broadly, two major jobs were carried out. First, the mechanical mounting assembly for the rotary and linear manipulator to the chamber lid; and second, an entirely new target ladder along with its suppressor assembly have to be mounted. The vertical height must be kept identical to that of the old one. In the first case, the mechanical mounting assembly and its components that comprises of three adapters were designed. The lid of the target chamber was modified to adapt to the new system. All fabrication works were carried out at IUAC workshop. The fabricated components were cleaned with alcohol in ultrasonic cleaner and then tested them for any presence of vacuum leak. The modified lid chamber was placed on the chamber with its lifting arrangement fitted on it. Its landing on the chamber was carefully checked and adjusted. The adapters were mounted on the lid. Vacuum leak check was performed at every step. Finally, the rotary manipulator was installed. In the second case, a rectangular cuboids shaped copper target ladder was designed in such a way that it can accommodate at least 28 samples (i.e. 20 samples + 4 viewers + 4 conducting spaces meant for measuring ion beam current at target ladder itself). It has a hollow structure to have light weight. Its linear motion is achieved using a linear motion feed through (LMFT) drive. The copper target ladder had been insulated from LMFT using a Teflon rod. Proper care was taken while fixing the ladder, Teflon rod and LMFT end straight. A new suppressor and its insulation assembly were designed and fabricated. All the components were assembled as per designed and installed. Finally, the target ladder was aligned using the view port perpendicular to the beam direction. After installing the new ladder assembly completely, many tests were conducted to check the accuracy of the faces in rotations and linear movement. When the ladder was moved linearly from the first to the 5th sample, we observed approximately ~2 mm displacement towards left side in two opposite faces of the copper target rod. Linear movement in other two faces was acceptable. The target ladder manipulator for rotational movement was found satisfactory. The linear motion of the linear motion feed through (LMFT) was controlled using a controller while rotational movement was done manually. The interfacing of controller to the LMFT was developed and linear drive motion using the controller was tested. It was working smoothly. The interfacing to the computer to operate the movement of ladder through control console page will be developed later.

b) Auto shutting down of Negative Ion Implanter Facility

Another up gradation in the facility was that of control system. Shutting down of the whole beam line in the odd hours after completion of each and every experiment was a tedious job. It took at least one and half hour for proper shutting down of the source as it normally runs at high temperatures for high fluence implantation experiments. Moreover, it was routine job, as the system run regularly for the sanctioned beam time. Therefore, shutting down of the whole beam line was systematically planned and written in a software program. The program was written giving appropriate cooling time and waiting time of the oven and line heater of the source. In addition to this, closing of beam line valve, putting in of FC cups, and putting off of analyzing magnet were incorporated. After installing the program, many tests were conducted to fulfill the requirements of the shutdown procedure and we had practically observed the parameters. With this program, the manual shut down of the whole beam line at the odd hours is no more required and all process is systematically performed via a single command. As a result, overall operation of the facility was improved.

Apart from ion implantation experiment, development of new beams was carried out to cater needs of increasing demands of users.

1.2 LINAC

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1.2.1 Status of the Superconducting Linac

The superconducting (SC) linac working as the energy booster of the Pelletron accelerator consists of five cryostats containing twenty seven quarter wave resonators out of which twenty four accelerate the ion beam and the remaing three are responsible for longitudinal focussing of the beam. Energized ion beams from Pelletron and SC linac are delivered in different beam lines e.g. Hybrid Recoil Mass Analyser (HYRA) and National Array of Neutron Detectors (NAND) for scheduled experiments. During the last linac operation in 2015, the accelerator was operational for four months and accelerated ion beam was delivered in two different beam lines of HYRA and NAND. During the operation, it was observed that the accelerating field performances of many resonators in second and third accelerating module were not up to the mark and the scope of the improvement might be there especially for the resonators which performed better in earlier ocassions or in the test cryostat.. So a decision was taken to apply more surface treatment on the resonators which had got a good performance in the past but experiencing inferior performances over last few years. The main reason behind this performance degradation is probably the RF surface of the resonators got more and more contaminated over the last few years during the maintenance of the cryostats when the resonators were kept outside for prolonged duration and were undergone frequent venting and evacuation process.

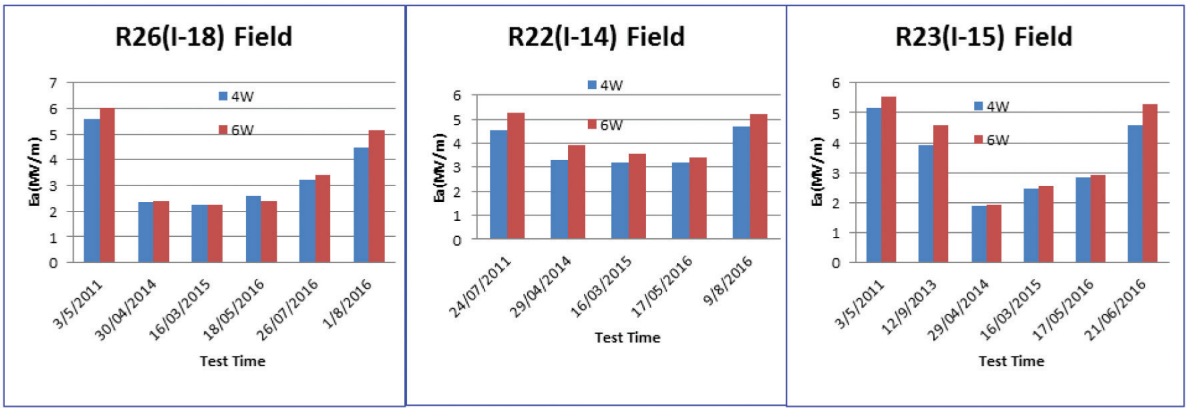

Figure 1.2.1. The accelerating field performances of three resonators during last few years. The last performance (in 2016) of all the three resonators were done in test cryostats and the remaining tests were done in the linac cryostat.

To perform more surface treatment, four resonators were chosen and dismounted from the cryostat and electropolishing was done followed by Ultrasonic rinsing and High Pressure Rinsing (HPR) with deionized ultra pure water. On a few other resonators, only the HPR was applied. After the surface treatment, the resonators were undergone through the performance test in the test cryostat. The sequential performances of a few resonators in last few years (in linac cryostats) and after applying more surface treatment are shown in figure 1.2.1. The last performance tests on the resonators done in 2016 were done in the test cryostats.

These observations clearly shows that there is a substantial improvement of the accelerating field gradients after the additional surface treatement, so it was decided that, at least, the HPR treatment would be applied to all the remaining resonators of the second and third accelerating modules. After performing the HPR on those resonstors inside a class 100 clean room, they were assembled in the same room and then mounted back in their respective cryostats inside a class 5000 clean room along with the other accessories. During this period when the resonators were kept outside the vacum environment pure nitrogen gas was purged through each resonators continuously. The same purging mechanism was also used during the evacuation and venting of the cryostat to reduce the deposition of the flying contaminants on the RF surface of the resonator.

During 2015, the linac was operational with 23 accelerating resonators installed in three cryostats. After the operation was over, one resonator needed to be removed due to the development of vacuum leak. This year, two new resonators received from the resonator fabricarion group were undergone many cycles of electrpolishing followed by Ultrasonic and HPR. The performance of the resonators were first checked in the test cryostat and once the results were found satisfactory, they were installed in the empty slots of the second and third accelerating modules. Final frequency tuning was done using mechanical coase tuner along with piezoelectric actuator based tuner. Finally all the resonators were aligned and both the cryostats were loaded and kept under evacuation.

In the first accelerating module where helium gas based pneumatic frequency tuning mechanism is used, frequency range of one of the resonators had gone to an extreme end and a problem with the mechanical movement mechanism of its tuning fixture was also observed. Both the problems were solved by changing the tuning fixture of the resonator. One of the two resonators in the re-buncher cryostat was also removed to apply additional surface treatment and again re-installed in the same cryostat after electropolishing and high pressure rinsing.

During 2016-17, this was the first time when all the three linac cryostats with 24 resonators were installed in three accelerating modules and they are now waiting for beam acceleration along with the super buncher and re-buncher resonators.

1.2.2 Developmental activities accomplished to improve the performance & reliability of SC Linac

A. Routine operation of high pressure rinsing system in class-100 clean room

During 2015-16, a couple of class-100 clean rooms on both the sides of the Linac servicing area was commissioned to perform high pressure rinsing (HPR) of the niobium resonator at 80 bar water jet pressure with 18 MΩ-cm deionised water. During this current academic year, the facility was used extensively for HPR for all the resonators of second and third accelerating module. A water particle counter was also procured and installed inside the clean room to test the quality of water before doing the HPR. An automated system using microcontroller to perform HPR with variable speed was implemented and it controls IDX-7505 stepper motor controller, relays and limit switches. The system has got inbuilt interlocks and can be controlled from remote location using USB.

B. Re- routing of the RF Cables and signal cables of Linac cryostats for operational flexibility

All the cables connected to the resonators in the Linac cryostats including the power, pickup and various control cables were properly routed through the dedicated cable trays with some RF shielding wherever necessary. This was a long time pending jobs intended to do to make the maintenance and trouble-shooting faster. The powder coated cable trays made from 1.6 mm thick MS sheet were successfully installed for routing various cables like High Power RF, Low Power Pick-up, stepper motor power, limit switch signals, Piezo-tuner voltage and control, etc. A special aluminum shielding arrangement to provide better isolation for Pick-up signals and to avoid interference from high power RF cables was designed and installed. Many patch panels were installed to route signals properly from cryostat top to racks (where different electronic modules are kept) and from racks to instruments.

C. Improvements in the control scheme for better operational efficiency

The first accelerating module uses pneumatic helium gas operated tuners for phase/frequency locking of the resonators. The control scheme of these gas operated tuners were improved with a pulse width modulation (PWM) based control mechanism and the same was successfully tested to phase lock four resonators during the Linac acceleration in 2015. The new control is based on two pulse operated proportional valves operated in closed loop to maintain the constant gas volume inside the bellows of the existing gas based mechanical tuner of the resonator. As the response time of this control mechanism is hundreds of millisecond, it can correct the slow drifts in frequency at a faster rate thereby making the resonators less prone to frequency unlocking and reducing the RF power requirement. In order to implement the PWM based tuner control mechanism on the resonators of the super buncher (SB) cryostat, the first accelerating module and the re-buncher (RB) cryostat, proper electronics modules along with additional mechanical assembly were made and implemented in the current academic year (2016-17). So during the upcoming linac operation, the new PWM mechanism will control all the resonators of SB, linac-1 and RB cryostats.

An alternate tuning scheme using piezoelectric actuator based tuner, acting in the range of milliseconds were already operational in the second and third accelerating modules. Since the mechanism is faster than the old gas based tuning system, it is capable to maintain the mean resonant frequency constant on a faster time scale and also counteracting the microphonics originating due to the excitation of the mechanical modes in the resonator. Calibration and optimization of the control modules are carried out to make the system more rugged as these effects lead to a substantial reduction of the required RF power at the time of operation of a SC QWR.

Earlier the first and third accelerating module were being controlled and operated through VME based scheme whereas the second and the part of the third accelerating module were controlled using CAMAC based control scheme. In order to maintain uniformity and optimization of space, all the Linac modules are to be made operational through VME based control modules. PWM slow tuner based first accelerating module is controlled through a dedicated VME controller whereas piezoelectric slow tuner based second and third modules are controlled through a single VME controller by utilizing the crate to almost its capacity. Fabrication and routing of different cables and VME router board was done for combining control scheme for two cryostats. For remote operation of PWM and piezoelectric based tuners, complete fabrication of 4 nos. of VME based router modules using multi-functional VME 6500 control board were carried out and tested with existing Piezoelectric/PWM Controller. The same had been made operational in Linac cryostats and software interface for client operation was done. For coarse movement of the mechanical tuner attached with the piezoelectric actuator, a python based client server architecture using Rasberry- Pi microcomputer, interfaced with existing stepper motor control was made ready and proper graphical user interface was made for client operation.

In order to avoid exposure to radiation during high power pulse conditioning, remote movement of all the drive couplers of the resonators were implemented along with software interface for pulse conditioning of the resonators from existing Pelletron-Linac control room.

1.2.3 Superconducting Niobium Resonators

P.N.Prakash, A. Rai, S.S.K.Sonti, K.K.Mistri

The construction of 6 nos. of spare quarter wave resonators (QWRs) for the superconducting Linac has progressed satisfactorily. Some studies have been initiated towards understanding the effect of baking on (fully jacketed) QWRs. Encouraged by the initial results, the low beta resonator has also been heat treated similarly, which has improved its performance. Under the Indian Institutions and Fermilab Collaboration (IIFC), the 650 MHz, β=0.6 single cell niobium cavity developed jointly by IUAC and Variable Energy Cyclotron Centre (VECC), Kolkata, was successfully tested at Fermilab. Planning for upgrading the Surface Preparation Lab, which was not taken up during the academic year, has just begun.

1.2.3.1 Construction of Spare QWRs for Linac

Construction of the six spare QWRs for the superconducting Linac has progressed well. The QWRs are being built both, as spare resonators for the Linac, as well as for conducting offline development work. Several sub-assemblies of the resonators, e.g. loading arms, drift tube cylinders and outer niobium housings, have either been completed or in advance state of completion.

1.2.3.2 Heat Treatment of Fully Jacketed Resonators

With a view to understand the effect of high temperature baking on (fully jacketed) QWRs, some studies have been initiated. Such processes have been routinely applied on TM-class elliptical niobium cavities, but so far no group has carried out a systematic study on TEM-class niobium resonators [1]. For the study, a resonator whose surface got accidently damaged was used. First, a baseline test was conducted to evaluate its performance. The resonator was then warmed up to ~100K and held there for about 8 hours before cooling it back down to 4K. There was 15-20% degradation in the resonator Q, indicating "Q-disease". The fully jacketed resonator was then baked in a high vacuum furnace at a temperature of 650ºC. The partial pressure of hydrogen inside the furnace chamber was monitored and the baking time was adjusted to allow the pressure to fall to the background ($<1\times10^{-9}$ mbar). Figure 1.2.2 shows the RGA spectrum during the

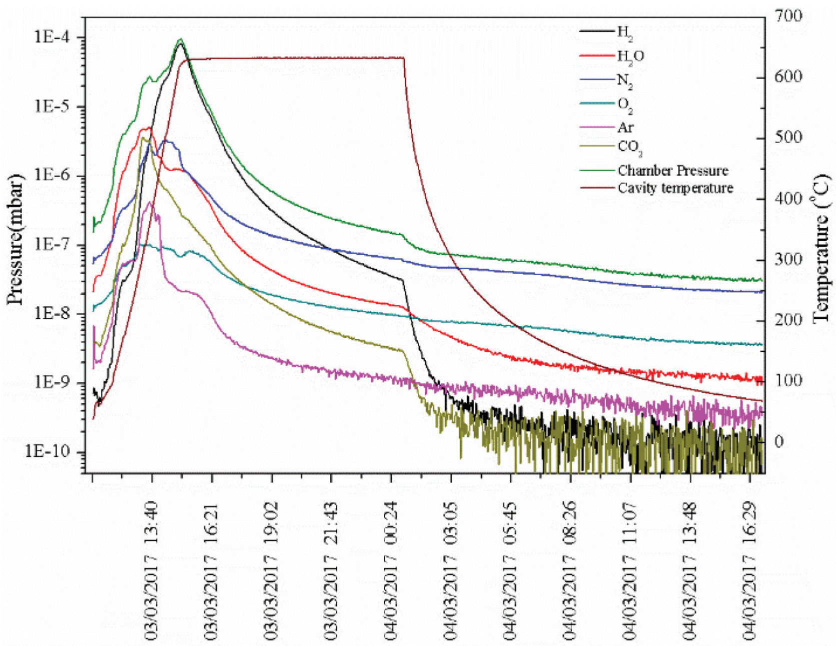

Figure 1.2.2: RGA spectrum during 650ºC bake of the QWR.

baking cycle. Q measurements were done after a fast cooldown (cavity temperature fell from 250 K to 20 K in ~1hr.) to 4.2 K. A substantial improvement in the performance was observed. The accelerating gradient of the cavity increased to 3.86 MV/m at 4 W (Q= 2.51×10⁸) from its pre bake value of 2.6 MV/m at 4 W (Q=1.1×10⁸). To rule out the possibility of any Q degradation due to hydride formation, the cavity was warmed up and held in the temperature zone of 95-110 K for ~ 8 hrs. Thereafter, it was cooled to 4.2 K and another set of Q measurements were made. Surprisingly the quality factor showed further improvement. The cavity field increased by ~12% to 4.33 MV/m at 4 W (Q= 3.16×10⁸). The reason for this anomalous increase is not clear. Figure 1.2.3 shows the Q curves for the QWR before and after the 650ºC bake. More studies have been planned in the future with niobium samples, to gain better understanding of the phenomenon.

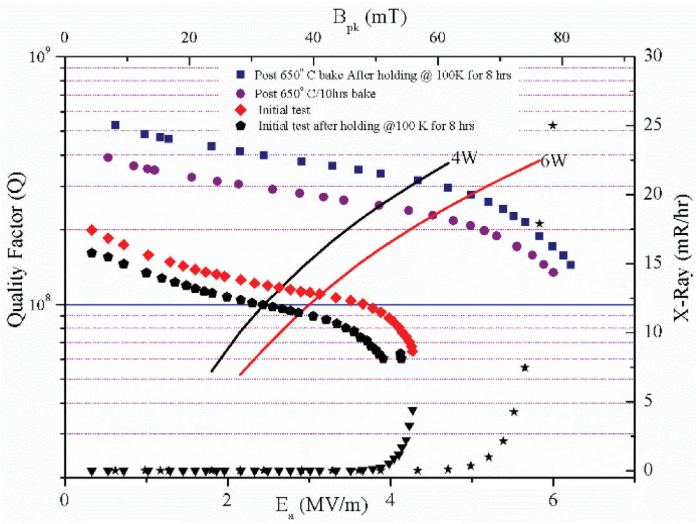

Figure 1.2.3: Q curves for the QWR pre and post 650ºC bake.

1.2.3.3 Performance of the Low Beta Niobium Resonator

Encouraged by the promising results obtained with the QWR reported in the previous section, it was decided to apply a similar treatment on the low beta resonator (LBR). The low beta resonator, as reported in earlier annual reports, was prototyped for use as a velocity matching structure between the High Current Injector (HCI) and the superconducting Linac. In the baseline test of the cavity at 4.2 K, the low beta resonator achieved an accelerating gradient of 8.3 MV/m at 4 W input power (Q=2.73×10⁸). The fully jacketed resonator was then baked at 650 ºC for ~10 hrs (until the hydrogen partial pressure fell to the background level of <1×10⁻⁹mbar) and processed in an identical manner as the QWR reported in the previous section. Subsequent cold test at 4.2 K indicated a significant performance enhancement. The accelerating gradient in the cavity increased to 9.79 MV/m at 4 W (Q= 3.79×10⁸). In fact, the improvement in the quality factor at lower gradients was even more significant - Qat 2.25 MV/m increased by a factor of ~2.5 from 3.94×10⁸ in the baseline test to about 1.03×10⁹ after baking. Increased field emission compared to the baseline test was responsible for the fall in the Q values at higher gradients. This is evident from the X-Ray data in the Q curves of the cavity shown in Figure 1.2.4. It is planned to give the resonator a high pressure rinse (HPR), for which the high pressure wand and its movement mechanism is being modified (the present system is suited to process the QWRs employed in the Linac). This will very likely reduce the Q slope at higher gradients and enable the cavity to reach even higher gradients. There are also plans to do nitrogen doping in these resonators to see its effect on the performance.

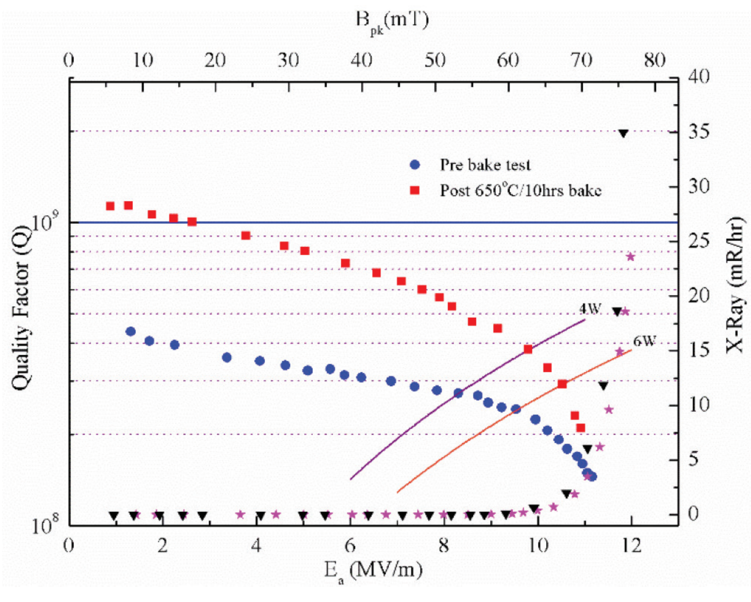

Figure 1.2.4: Q curves for the low beta resonator (LBR) pre and post 650ºC bake.

1.2.3.4 650 MHz Single Cell Low Beta Niobium Cavity

Under the Indian Institutions and Fermi Lab Collaboration (IIFC), Variable Energy Cyclotron Centre (VECC), Kolkata and IUAC had developed a β=0.6, 650 MHz single cell niobium low beta cavity (LBC). The cavity was sent to Fermilab for processing and testing. In figure 1.2.5, the performance of the cavity at 2K is shown.

The cavity could easily exceed the design gradient of 17 MV/m at $Q0>1.5\times10^{10}$, producing a gradient of 30 MV/m at $Q0=1.5\times10^{10}$; and eventually achieving a maximum gradient of 34.5 MV/m. This is the highest gradient achieved so far in the world by this type of cavity design. The maximum gradient produced in the cavity was not limited by quenching; rather the available amplifier power was not sufficient to go up further.

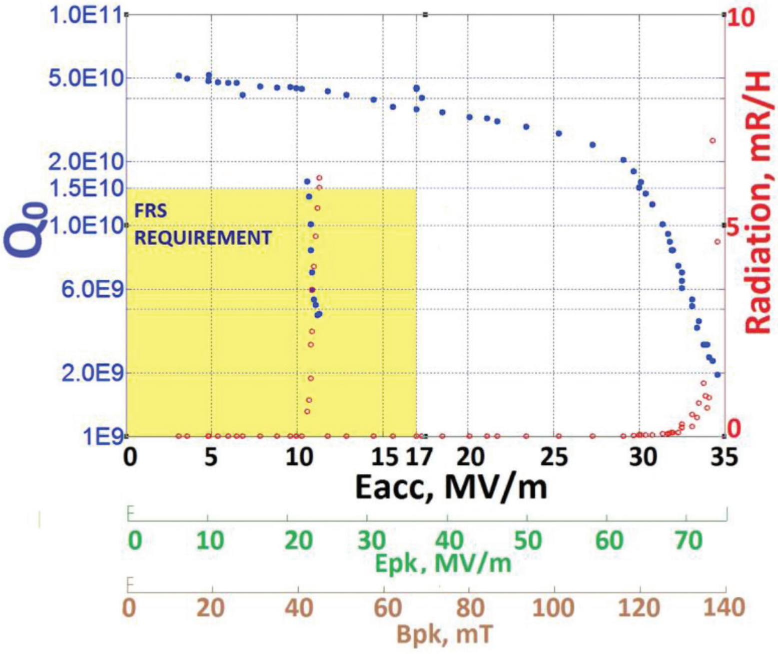

Figure 1.2.5: 2K Performance of the first 650 MHz,β=0.6 single cell niobium LBC.

1.2.3.5 Upgradation of SRF Infrastructure

Upgradation ofthe surface preparation lab (SPL) could not be undertaken during the current academic year due to reasons beyond control. However, this work is now being taken up. It is planned to commission two clean rooms; one of Class-100 for resonator assembly and storage, and the other of around Class-1000 for ultrasonic cleaning and high pressure rinsing of the resonators. Besides this, some modifications in the civil structure will also be done to eliminate/ reduce dust levels inside the lab, as also for the organization of the available space.

1.3 LOW ENERGY ION BEAM FACILITY

Pravin Kumar, Kedar Mal, U. K. Rao and S Chopra

1.3.1 Operation

The performance of electron cyclotron resonance ion source (ECRIS) based low energy ion beam facility (LEIBF) in terms of the development of gaseous beams of highly positive charged ions and the beam delivery for user experiments in all three beam lines (viz. 75º, 90º and 105º) has been continuing in this academic year (2016-2017).All the beam times requested by the users as part of the AUC-58, AUC-59and AUC-60 were successfully delivered.About 36 users (including 28 AUC experiments) from various universities and research institutes availed the beam time during February 2016 to February 2017. The user experiments, done in past three years are shown in Figure 1.3.1.

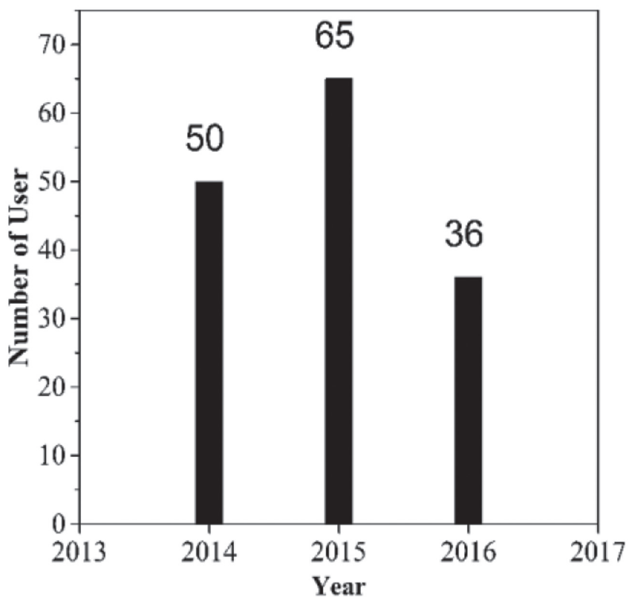

Figure1.3.1 User experiment summary for past three years

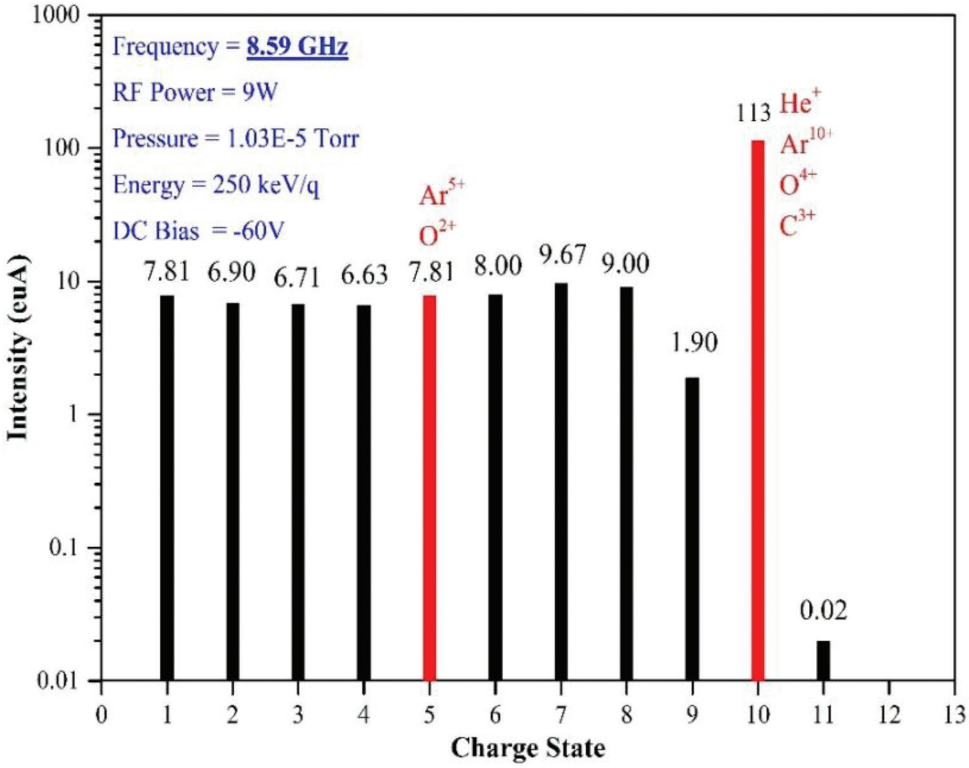

Figure 1.3.2 A typical charge state distribution of the argon showing the influence of the helium mixing on the higher charge states.

Apart from assisting users, we studied Argon ECR plasma with and without gas mixing at different RF frequencies with optimized source parameters and acquired useful data for the feasibility of new experiments. These frequencies are 8.59, 8.68, 9.68 and 10.00 GHz. A typical charge state distribution (CSD) of argon plasma mixed with helium at frequency 8.59 GHz is shown in Figure 1.3.2. The highest intensity of Ar^{8+} was 9 euA with only 9W power. The available beam intensities of different charge states with energy 250 keV/q are shown in Table 1.

Table 1: Intensity (euA) of various ion beams of different charge states extracted from the ECR plasma at moderate platform voltage and RF power

Ions\q	1+	2+	3+	4+	5+	6+	7+	8+	9+	10+	11+	12+	13+	14+	15+	16+	17+	18+	Freq
H	47																		
He	150	18																	
B	4.5	1.5	0.2																
C	15	7		0.5															
N	102	64	29	13	4.73	0.3													9.32
F	11	7	3.5	1.3	0.3														
O	128	72	30	20	8.35	3.23	0.19												9.56
Ne	58.5	29	16	9	7.15	3	0.6	0.14	0.002										8.92
Ar	60	36	17	11		8	9.7	9	1.9		0.09								8.59
Kr	17	14		7.5	6.3			3.3	2.5	2.1	1.8		0.90		0.2	0.07			8.58
Xe	6.5	5		3.7	3.5		2.9	2.5	1.2	0.7		0.45	0.333	0.236	0.15	0.132	0.076	0.044	8.58

1.3.2 Maintenance

In this academic year, there was no major breakdown of the facility and it ran smoothly round the year. We had only small maintenance jobs viz. ion source cleaning, positioning of plasma lens, replacing few scroll pumps and repairing of the RF amplifier.

1.3.3 Development

The existing steerers are all magnetic in Low Energy Ion Beam Facility. We have faced the problem with the main beam line steerer. Since, this facility has ECR ion source which gives several beams with different charge states, high values of currents are required for this steerer's power supply to get the analysed beam of high m/q ratio at the centre of the Faraday cup. As a result, the non-analysed beam is itself dispersed in the main beam line and deteriorates the vacuum. A typical beam profile of non-analysed beam is shown in Figure 1.3.3.Therefore, we have designed an electrostatic steerer for the main beam line and it is under the fabrication process. The inner part of the steerer is shown in Figure 1.3.4.

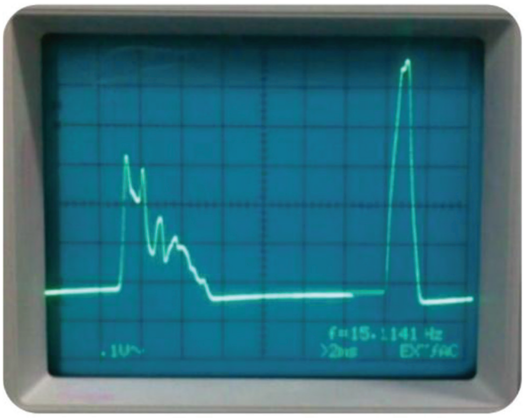

Figure 1.3.3 A typical beam profile of non-analyzed beam

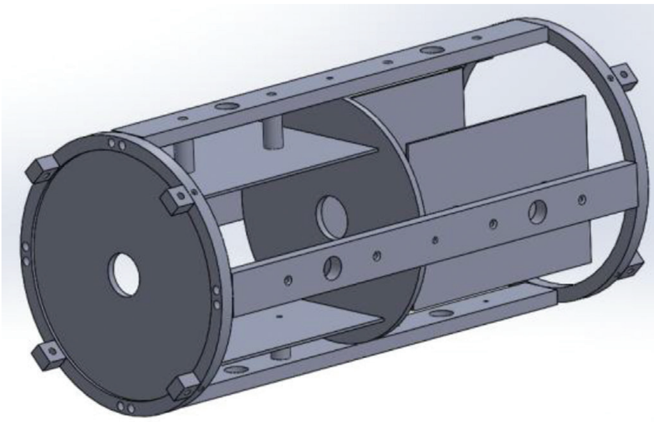

Figure 1.3.4 The inner part of the electrostatic steerer

1.4 PARAS (1.7 MV PELLETRON ACCELERATOR AND RBS ENDSTATION)

G Raturi, J Singh, Pranav Singh, S Kumar, M Nishal, N S Panwar, M P Singh, R Kumar, J Prasad, M Archunan, V P Patel, R P Sharma, Umapathy G R, Rajveer Sharma, Pankaj Kumar, K Devarani, M Sota, S Ojha, S Gargari, R Joshi, S Chopra and D Kanjilal

1.4.1 Operation

1.7 MV Pelletron accelerator for Rutherford backscattering facility was in regular operation all year round. Total 1740 measurements of 66 users from 31 Universities, colleges and institutes were performed.

RBS measurement were performed for thin films on different substrates for finding accurate thickness, composition, depth profiling of the implanted species and effect of high energy ion irradiation on these films. Besides, conventional RBS measurements were also carried out of self supported nuclear physics experimental targets for estimation of accurate thickness of target, backing and capping layers. The presence of impurities such as oxygen in the target were detected and quantified.

RBS Channeling measurements were performed for epitaxial films and implanted single crystal like Si, Al_2O_3, $LaSrAlO_4$ and Multi-junction solar cells. RBS-Oxygen resonance measurements at energy 3.045 MeV were performed in different samples for the detection oxygen in high Z number substrates.

The Hydrogen detection and depth profiling by ERDA are performed with existing setup, using 2.8 MeV He^{2+} beam with SSB detector at forward angel at 30º. The recoil and scattered He^{2+} were stopped in 14 μ Aluminum stopper foil allowing only Hydrogen (H) to reach detector. The qualitative ERDA, Channeling-ERDA in Oxygen resonance mode along with RBS for H depth profiling in Pt(H) island on Fe_2O_3 epitaxial film on Sapphire substrate were performed.

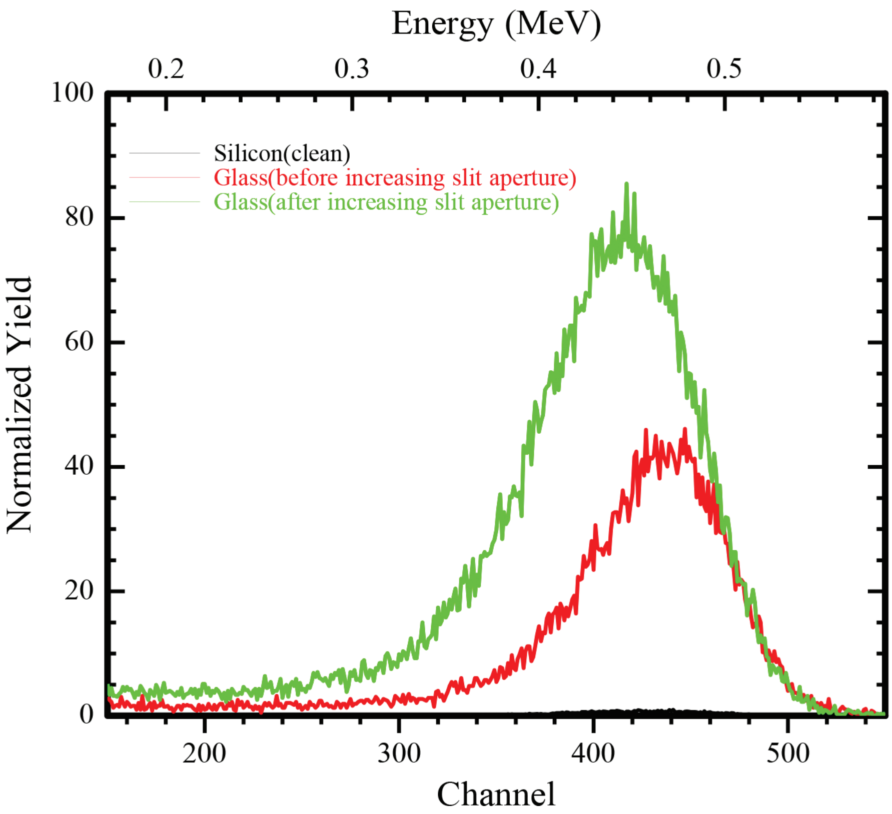

Fig 1.4.1 ERDA spectrum of Au(H) on SiO_2 for two different detector aperture compared with ERDA spectra of cleaned Si.

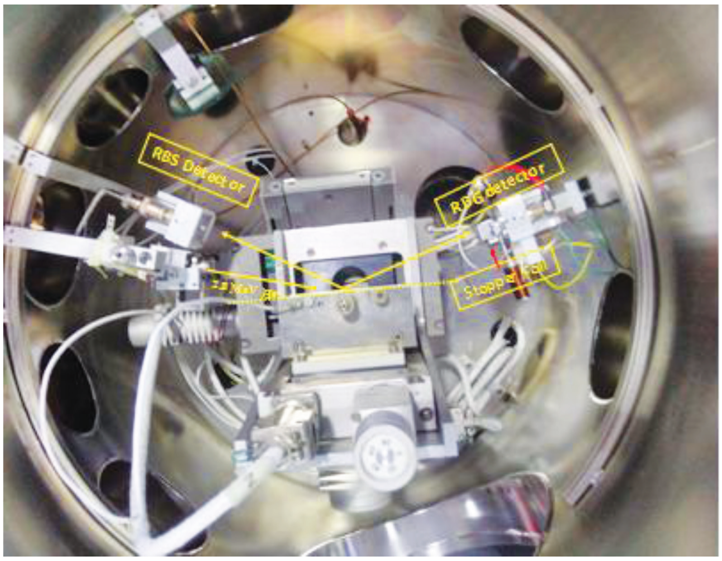

Fig 1.4.2 End station experimental chamber for RBS with ERDA(RBG) measurement setup

1.4.2 Maintenance

1.4.2.1 Ion Source Maintenance

Ion source maintenance and rebuilding of RF charge exchange cell was performed during April and May months. The ion source components including charge exchange cell were opened for maintenance. Residual Rubidium (Rb) properly disposed and choked parts were cleaned and assembled back with new quartz glass tube and extractor aperture.

The leak detection was done prior to fresh Rb loading. More than 10 grams Rubidium was filled in reservoir in inert atmosphere. Rb helps in charge exchange in charge exchange cell of ion source. The aqua colour He plasma formation was seen after few hours of conditioning and continuous extraction of stable He- beam achieved round the year.

1.4.2.2 1.7 MV Pelletron Accelerator and Experimental Endstation Maintenance

The water cooling manifold for quadrupole, selector magnet and end station turbo molecular pump was leaking and chocked. It was made up of aluminum which was corroded and no machining could be performed on it. The manifold as replaced by new one made of stainless steel. The turbo water cooling connecting pipes, which degraded on continuous use, developed a water leak. The cooling water pipes were replaced. The spectroscopic amplifiers for RBS, RBG and P(He)IXE detector were tested. RBS and RBG amplifiers gain is stable throughout measurement. The Ortec 575A spectroscopic amplifier was found to be malfunctioning as increasing trend in gain was observed with time.

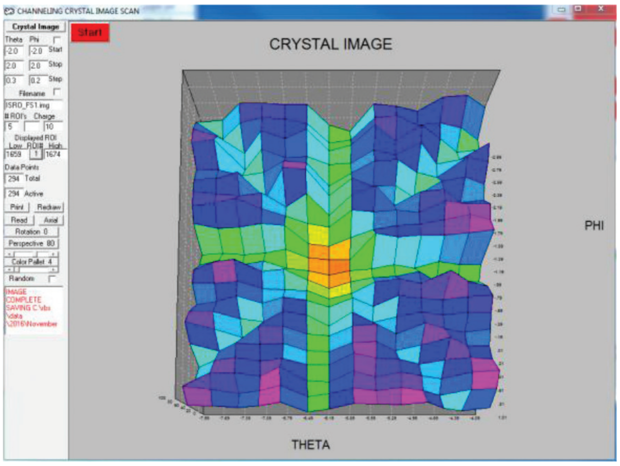

Fig 1.4.3 Image scan of Multi-junction solar.

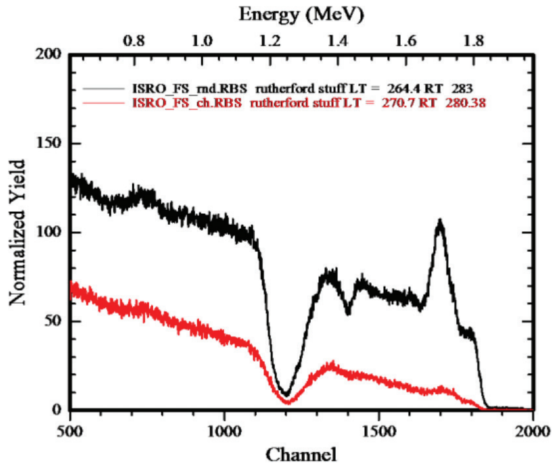

Fig 1.4.4 RBS channeled spectra of Multi-junction solar cell (red) compared with random spectra (black).

1.5 ACCELERATOR MASS SPECTROMETRY

Pranav Singh, N.S.Panwar, Soumya Prakash Dhal, Chinmaya Maharana, Umapathi G R , Rajveer Sharma, M.Sota, Pankaj Kumar, Sunil Ojha, S. Gargari, R. Joshi, S.Chopra, G. S Roonwal and D. Kanjilal

The Accelerator Mass Spectrometry (AMS) facility at IUAC is based on a dedicated 500kV Pelletron accelerator. ^{14}C, ^{10}Be and ^{26}Al are the cosmogenic radioisotopes studied using this AMS facility. A large number of users have used this facility after its commissioning in June 2015. Graphitization laboratory equipped with three units of automated graphitization Equipment (AGE) and one unit of Carbonate handling system (CHS) for processing of carbon containing samples. A clean geochemistry laboratory is used for the chemical processing of ^{10}Be and ^{26}Al samples.

1.5.1 ^{14}C AMS facility

A new **XCAMS** (Compact ^{14}C **A**ccelerator **M**ass **S**pectrometer e**X**tended for ^{10}Be and ^{26}Al) system was installed in Feb-March 2015 and subsequently it is regularly being used by several users from India and a few foreign laboratories. The IUAC AMS facility is given lab code “IUACD” by **RADIOCARBON** community (http://www.radiocarbon.org/Info/Labs.pdf).

Graphitization of organic carbon containing samples is carried out by the automated graphitization equipment (AGE). However, the throughput of one AGE unit is ~21samples/day. On the other hand ion source of accelerator can accommodate 134 samples in one wheel. The throughput of AGE was a limiting factor in matching the user’s demand for higher number of samples for radiocarbon dating. Therefore, to increase the throughput of sample preparation two more similar AGE systems were procured and installed in the month of January 2017. Additionally, for the graphitization of carbonate samples, one Carbonate Handling System (CHS) was also procured and installed. All these systems were tested and being used to graphitized respective samples.

During the last year (April 2016- March 2017), 500 samples were graphitized and dated by measuring their ^{14}C concentration. Samples were of different types such as wood, charcoal, peat, sediments, pollen and also include standards from NIST and IAEA.

The scientific motivation of these studies include; understanding the social, religious, political changes during last millennium from archaeological excavation at Alwar Rajasthan (User: Mr. Mudit Trivedi, University of Chicago, USA), Understanding the ancient metallurgical knowledge of central India (User: Prof. G S Roonwal, IUAC), Recurrence pattern of great earthquake in Nepal Himalaya and Andaman region (User: Prof. C.P. Rajendran JNCASR, Bangalore), Reconstruction of Paleo-tsunami & Paleo-earthquake from Andaman and Nicobar Islands and Himalaya regions (Prof. Javed N. Malik, IIT Kanpur), Reconstruction of Palaeo-southwest monsoon by radiocarbon dating of sediment cores from south Indian lakes (User: Prof. Hema Achyutan, Anna Univ. Chennai), Late quaternary vegetation and climate reconstruction from the Himalayan and Tibetan region. (User: Dr. P.S. Ranhotra, BSIP, Lucknow), Reconstruction of high resolution long term record of palaeoclimate in Kashmir Himalaya, (User: Dr. Jaishri Sanwal Bhatt, JNCASR, Bangalore), Understanding the late quaternary glacial history of Dokriani Bamak Glacier, Western Himalaya (User: Ms. Ipsita Roy, Lucknow University, Lucknow), Understanding the glacial dynamics in northwest Gharwal Himalaya (User: Prof. M.C. Sharma , JNU, Delhi), Signature of earliest human habitation in high altitude Ladakh (User: Dr. S. B. Ota, ASI, New Delhi), Protohistoric chronology of a Harrapan site at lower Drisadvati Valley (Northern Rajasthan) (User: Dr. V N Prabhakar, IIT Gandhinagar), AMS dating of carbon samples from the early historic site of Vadnagar, Gujarat (User : Dr. Madhulika Samanta, ASI Vadodara), Understanding the Carbon dynamics in Coringa (Andhra Pradesh) Mangrove ecosystem (User: Ms. Namrta Priya, JNU Delhi), Palaeoenvironmental studies in Great run of Kachh (User: Mr. Abhishek Kumar, MSU Baroda), and Chronology of sediment core for palaeoenvironmental implications in eastern Arabian sea (User: Mr. K. Neelvannan, Univ. of Madras, Chennai).

1.5.2 Clean chemistry laboratory activities

A total of 130 samples were processed in last eight months by two users from NIO, Goa and MoES/Goa University. The objective of the study performed by the user from NIO Goa is to understand palaeomagnetic variation on ^{10}Be distribution on a time scale of about 100ka. A 10 m core collected from Mahanadi basin was sub-sampled and about 40 samples were processed to extract the Beryllium ($^{10}Be/^{9}Be$) from the authigenic fraction. A group of users from MoES/Goa University had proposed to understand the glacier retreat and advancement in the polar region by using $^{10}Be/^{9}Be$ as a proxy in the authigenic fraction of sediment core samples. A few cores were collected from the lakes of Arctic and Antractic regions and about 90 samples were processed at IUAC. The processed samples will be measured in next cycle of ^{10}Be measurements with XCAMS.

1.5.3 Geochronology Facility at IUAC

The establishment of a national facility for geochronology was started in September 2015 with the support from Ministry of Earth Sciences (MoES), Govt. of India.In March 2016, the order was placed for procuring FsLA-HR-ICPMS (Femtosecond laser ablation high resolution inductively coupled plasma mass spectrometer), ICPMS (Inductively coupled plasma mass spectrometer), XRD (X-Ray diffractometer), WD-XRF (Wave length dispersive X-Ray Fluorescence) spectrometer, FE-SEM (Field emission scanning electron microscope) with CL (Cathodo-luminescence).

The space for the installation of XRD, XRF and SEM with required infrastructure was made ready. All these instruments were delivered in December, 2016. The installation of FE-SEM, WD-XRF and XRD has been completed and all these three systems are in the process of commissioning. The laboratory area for ICPMS, FsLA-HR-ICPMS is being made ready and installation for these instruments will commence soon.

1.6 TABLETOP ACCELERATORS

Raj Kumar, R. Ahuja, C. P. Safvan

1.6.1 Upgradation of 50 kV Tabletop Accelarator

The existing 50 kV tabletop accelerator has been upgraded. The earlier bending magnet provided a field of 1200 to 2400 gauss, which has been upgraded to new bending magnet having a field of 1200 to 2600 gauss.

A new experimental chamber has been designed and installed providing more space & ports. HV toroid has been designed & installed on the ion source for better electric field distribution which has resulted in raising the maximum operating voltage from 50 kV to 60 kV. The accelerator stand has been modified to install the new bending magnet & experimental chamber. Energy table & picture of upgraded version of this accelerator is shown.

Beam Energy Range R=250 mm, Field: 1100 – 2600 G		
Element	Mass	Energy Range (keV)
H^+	1	35 - 60
H_2^+	2	25 – 60
He^+	4	25 – 50
He_2^+	4	50 – 120

Fig. 1.6.1 IUAC's 60 kV Tabletop Accelerator

Fig. 1.6.2 IUAC's 30 kV Tabletop Accelerator

This has been in use throughout the year except during the upgradation time of 3 months.

- Total runs during the year: 27
- No. of users: 15
- Total number of samples irradiated: 206
- Beams provided: H_2^+, H^+ , He^+, He_2^+
- No. of universities/institutes used: 9

1.6.2 Development of 30 kV Tabletop Accelerator

IUAC has designed & developed 30 kV tabletop accelerator, in response to the demand by users for even lower energy, higher mass ion beams. This new accelerator has been designed to provide beams from Carbon to Argon in the energy range of 3.5 keV Argon to 27 keV of Carbon. The new permanent magnet based bending magnet, einzel lens & quadrupole assembly have been designed & developed for this accelerator. The bending magnet has a field of 2100 to 3500 gauss. The energy table & picture of the same is shown.

Beam Energy Range R=250 mm, Field: 2100 – 3500 G		
Element	Mass	Energy Range (keV)
C^+	12	11 – 27
N^+	14	10 – 26
O^+	16	8 – 23
F^+	19	7 – 19
Ne^+	20	6.5 – 18
S^+	32	4 – 12
Cl^+	35	3.8– 11
Ar^+	40	3.5 – 10

This accelerator has been put on use from November 2016. The beams like O^+, N^+, C^+ from 8 keV to 26 keV have been delivered to various users.