1. ACCELERATOR

1.1 PELLETRON

1.1.1 Operational Summary

R Joshi

Performance of 15 UD Pelletron accelerator was quite satisfactory from 1st April 2015 to 31st March 2016 with few breakdowns which were resolved properly. There were total three tank opening maintenance, one scheduled and two unscheduled, during this period. The details of the tank opening maintenance are mentioned in maintenance section. The operational summary of the accelerator from April 2015 to March 2016 is shown below.

Total No. of Chain Hours	=	7121 Hours
Total Beam utilization	=	4262 Hours
Machine breakdown	=	0181 Hours
Accelerator Conditioning	=	0667 Hours
Tank opening maintenance	=	1317 Hours
Beam tuning time	=	0296 Hours
Experimental setup time	=	0098 Hours
Accelerator set up time after maintenance	=	0085 Hours

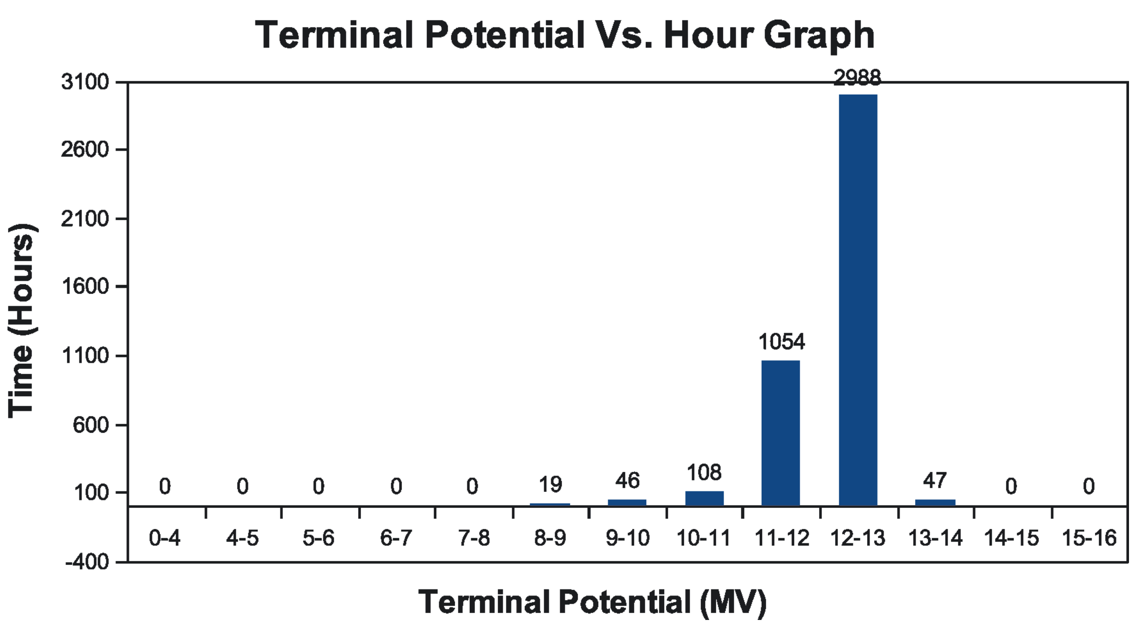

Fig. 1.1.1 Terminal potential vs. hour graph

The total numbers of shifts used for experiment during the mentioned period was 533, out of which 164 shifts were used for pulsed beam users and 369 for DC beam users. The machine up time for this period is 97.46% and the beam utilization is 59.85%. The voltage distribution graph of Terminal Potential used for different experiments during above mentioned period is shown in Figure 1.1.1. $^{16}O^{7+}$, 105 MeV dc beam at maximum terminal potential

13.13 MV and $^{28}Si^{7+}$, 70 MeV pulsed beam at the minimum terminal potential of 8.76 MV were delivered to user. Maximum terminal voltage achieved during conditioning in this year was 14.5 MV. Figure 1.1.2 shows the Chain hours utilization for the mentioned period.

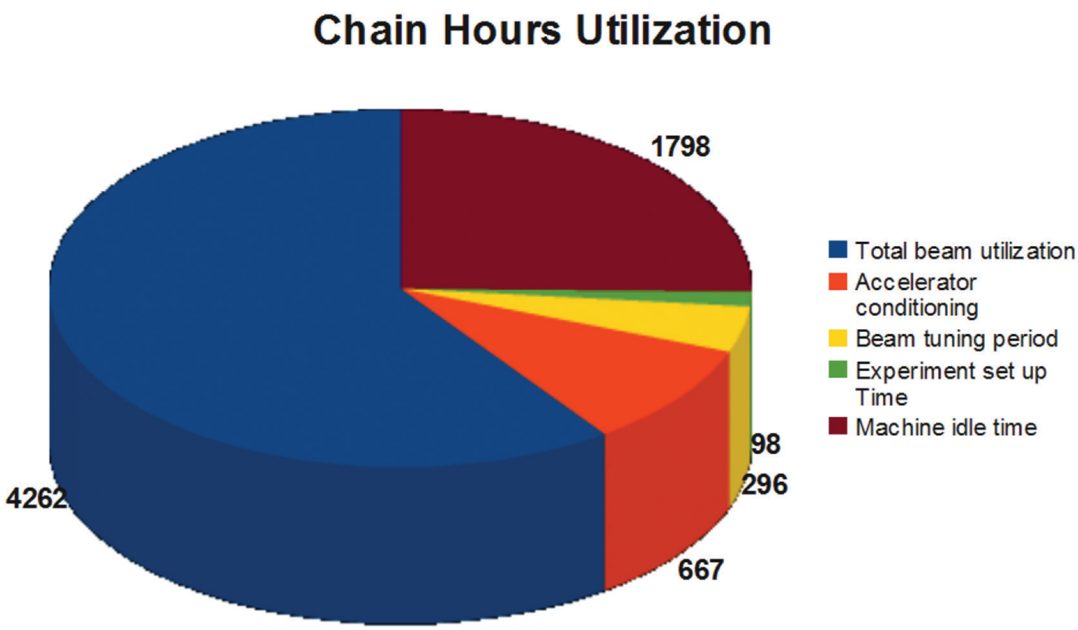

Fig. 1.1.2 Chain Hours Utilization

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)
^{7}Li	0.96%	^{35}Cl	2.01%
^{12}C	2.56%	^{37}Cl	1.99%
^{13}C	0.58%	^{48}Ti	21.18%
^{14}N	1.63%	^{51}V	0.63%
^{16}O	5.03%	^{56}Fe	1.55%
^{18}O	3.19%	^{58}Ni	18.02%
^{28}Si	12.71%	^{63}Cu	2.42%
^{30}Si	2.14%	^{107}Ag	12.77%
^{31}P	0.09%	^{197}Au	10.53%

The Pi-chart in Figure 1.1.3 shows the distribution of delivered beam species during beam run from 1st April 2015 to 31st March 2016.

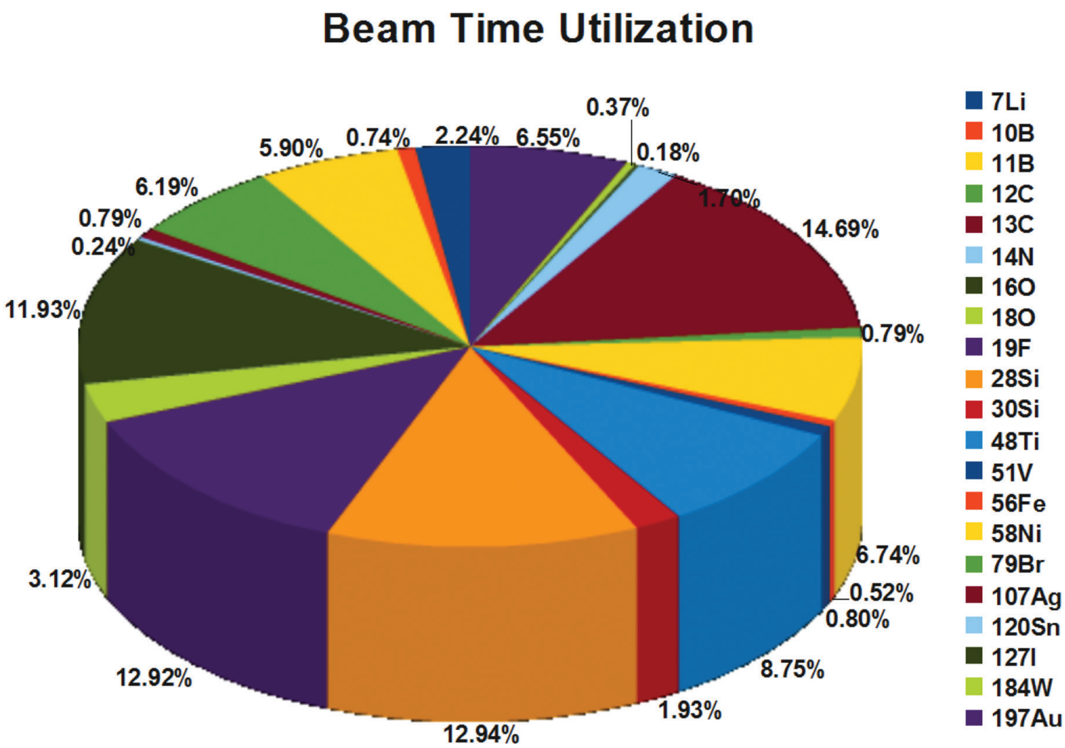

Fig. 1.1.3 Beam Time Utilization

1.1.2 Maintenance and Development Activities

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There were total three scheduled tank opening maintenance. The first two maintenance were unscheduled, the third one was scheduled. Details of the maintenance are given below.

1) First Tank opening maintenance (unscheduled)

The first tank opening maintenance of the academic year, 1st April 2015 to 31st March 2016, was unscheduled. This unscheduled tank opening maintenance occurred after three months of satisfactory operation of 15 UD Pelletron accelerator, from 14th January 2015 to 14th April 2015. It lasted for 21 days (from 18th April 2015 to 9th May 2015). There were two reasons for this maintenance. First, sparking in unit #1 which lead to fluctuation in pulsed beam operation with large FWHM and the second, bad stripper foils in terminal and High Energy Dead Section (HEDS) area. In addition, lots of sparking was noticed across G P Tube in ion source at ~200 kV of deck potential. The works carried out during this maintenance are described in the following:

i) Stripper foil loading in terminal and HEDS

Fresh stripper foils were loaded in terminal and HEDS. Stripper foils, of two different makes, were installed in terminal. They are: LPA type from Munich (22 nos.) and IUAC make (141 nos.). Out of the 141 IUAC make foils, 49 were of normal thickness and 92 were thinner. In addition, 178 IUAC foils were also loaded in HEDS.

ii) Repairing of Upper Column Current Read Back

The first 3 G CSP gap resistor, in unit #1, got damaged due to sparking during routine operation. This sparking resulted as the clamp, which holds this resistor to the CSP electrode, slipped out. This damage resulted in the fluctuation in upper column current and hence fluctuation in pulsed beam operation. The mounting arrangement was changed for this resistor assembly to solve the problem.

iii) Accelerating Tube Gaps Resistance Measurement

To ensure the linearity of the potential gradient across the accelerating tube gaps, resistance across the accelerating tube gaps from unit #1 to 30 was carried out. All the accelerating tube gaps were measured between 2.5 to 3.5 G Ohm. This is essential for the stable pulse beam operation especially for LINAC runs.

iv) Charging System Maintenance

Lots of idler dust was observed in HES of machine. Three of the idler wheels in charging system got damaged. All of these three damaged idler wheels were replaced by new idler wheels. The terminal was shorted to ground. The chain #1 was run to check alignment of each replaced idler wheels, which was satisfactory. A lateral crack was developed in one of the nylon link of charging chain #1. The cracked link was replaced by a new nylon link. The limit switch, installed at the bottom of charging chain #1, got damaged during the changing of the damaged nylon link, which was also replaced. All the idler dust was cleaned and all the mounting nuts and bolts of both the charging systems on terminal and tank bottom side were checked and were tightened, where required. Both chain pulleys in terminal were oiled with TP oil for smooth sliding between chains and pulley. All the nylon links in both the chains were inspected for cracks but none were found. Both the charging systems were cleaned, operated and tested for mechanical stability and found satisfactory. After preliminary inspection, both the chains were kept ON overnight. After the overnight running of the chains, the alignment of all the idler wheels and pick up wheels and the condition of the chains were checked and found satisfactory.

Both the charging chains were run with the terminal shorted and CPS ON (for both the charging systems electrically). The charging currents, for both the charging systems, at different CPS voltages, were checked. It was observed that the charging current of charging chain #2 was fine but the charging current in chain #1 was quite low at lower CPS but gradually increases as CPS went up. To investigate this, the doubler effect in charging chain #1 was studied. It was observed that there was no doubler effect till CPS=2 kV but it started appearing at 3 kV and slowly increased as the CPS increased. The problem was investigated thoroughly and damage in doubler pick up wheel was detected. The problem got resolved by changing it.

2) Second Tank Opening Maintenance (Unscheduled)

This unscheduled maintenance was held after a week from the last unscheduled tank opening maintenance. Unit wise conditioning of the machine, after the last unscheduled tank opening maintenance (April 2015) to condition the terminal for high voltage was in progress. Conditioning of both LES and HES was going on simultaneously. During conditioning of unit #8 and unit #23, it was planned to short all the units and make only unit #8 and 23 live. For this, shorting rod operation was started in LES. While pushing the rods back into the accelerator tank, the nylon rod broke in unit #1. Hence, this unscheduled maintenance resulted. It lasted for four days (14th May 2015 to 17th May 2015).

i) Repairing of Shorting Rod

Rings in unit #1, 2, 3 18 and 19 were removed for maintenance. The nylon shorting rod, which got bent in unit #1, was cut into two pieces and taken out. The shorting rod guide (spring loaded contact) between unit #1 and 2 was replaced as it got damaged. This contact lost its spring action which resulted in obstruction for the shorting rod during its insertion. Shorting rods were inserted from LES shorting rod drive to assure the proper alignment of shorting rod spring loaded contacts in LES. Shorting rods were also inserted from HES shorting rod drive also to check alignment of spring loaded contacts on unit castings.

ii) HV Breakdown Test of CSP Gaps

HV breakdown testing for unit #1, 2, 3, 18 and 19, where rings were removed for shorting rod maintenance, was done. Most of the CSP gaps were withstanding between 10 kV and 11 kV.
After both of these maintenances, the problems related to pulsed beam runs got rectified. The beam was delivered to users after energy boosting through LINAC. All the runs were quite stable.

3) Third Tank Opening Maintenance (Scheduled)

The Pelletron accelerator was operated satisfactorily, for users' experiment, from 21st May 2015 to 27th September 2015 after the last unscheduled tank opening maintenance. It was taken for maintenance on 28th September 2015. This was the scheduled maintenance and lasted for 1 month (28th September 2015 to 28th October 2015).

4) Jobs before tank opening

a) Testing of the tank motors

Line currents of all five motors in the tank (both chain motors, both rotating shaft motors and blower motor) were measured at CPS of 2 kV and 7 kV with terminal potential of 1.98 MV and 10.81 MV respectively. This was done to check the condition of all five motors at different loads and found quite satisfactory.

b) Testing of Earthquake RAMs (EQ RAMs)

The functioning of EQ RAMs was tested before tank opening at actual conditions. The EQ RAMs were pressurized at 210 psi with SF_6 gas. Both the chain motors, both the rotating shafts and blower motor were put ON and the 10.81 MV of TP was achieved at CPS = 7 kV. The lid of EQ sensor box, in control room was opened to check the condition of EQ sensor. When the lid was kept back, the EQ sensor generated signal and EQ RAMs got fired and RAMs traveled towards terminal. All in tank motors (both chain motors, both rotating shaft motors and blower motor) tripped OFF as soon as the EQ RAMs got actuated. The EQ sensor was then reset in the control room and EQ RAMs were retracted in 272 MSL. (IVth floor). After retraction the SF_6 gas pressure dropped down to just below 180 psi. All motors in the tank could be restarted only after the retraction of EQ RAMs. This test confirmed the satisfactory working of the EQ RAMs.

Routine maintenance jobs like, foil stripper loading in terminal, 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 major maintenance jobs were also carried out, which are listed below.

Major maintenance jobs during scheduled tank opening maintenance:

1. Charging system maintenance

Routine maintenance for both the charging systems was carried out. Condition of all the idler wheels was assessed. Idler wheels on up-charge side and down-charge side of chain #1 were found to be worn out in unit #18 and 22 respectively. The condition of the Idler wheels in charging system #2 was found to be satisfactory. Both the chains ran and condition of all idler wheels for both the charging system was checked in running condition. Charging chain #1 was touching none of the idler wheels except one idler wheel in unit #18 in down – charge side. This idler wheel was touching the chain #1 once in a while. Charging chain #2 was touching two idler wheels. The movement of all the idler wheels was smooth.

Condition of nylon links for both the charging chains was also inspected for cracks. Only total nylon links were suspected to be defected in chain #2. Both of those damaged nylon links were replaced by new links. Performance of both the charging systems was checked electrically at different CPS from 2 kV to 7 kV and it was satisfactory. RPM for both the charging systems was checked and it measured ~590.

All the mounting nuts and bolts in both the charging systems were checked and tightened, where required. The condition of all the inductors, pick off wheels and pulleys, for both the charging systems was also checked. Both the chains were cleaned. Both the charging systems were kept ON for four overnights to check its mechanical performance. No idler dust was observed. Both the chains were properly cleaned and checked thoroughly. Semiconductor band 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. 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. Rotating shafts drive alternator housed in both dead sections and terminal which generate local power for devices in both dead sections and terminals were checked. Separator boxes are used for mounting of these rotating shafts.

All the rotating parts inside tank were checked thoroughly for maintenance. Bearings of total number of twelve separator boxes were replaced with new ones - seven in low energy side and five in high energy side. All the repaired separator box assemblies were installed back after maintenance.

3. Generating Voltmeter (GVM) Maintenance

In the existing GVM assembly there was a default reading of ~0.7 MV even when both the charging chains were OFF. This could be due to some background noise. Hence it was decided to change GVM motor. The bearing of the old GVM motor was replaced with a new one. The motor was kept running overnight. The RPM measured for this repaired motor was 3001. The GVM motor was removed from tank body and got replaced. After replacement it was tested. Now the default reading of GVM (with both chains OFF and terminal grounded) is 0.001 MV.

4. Corona probe maintenance

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

5. Stripper foil loading in terminal

Fresh stripper foils were loaded in terminal. This time only Munich made LPA stripper foils of thickness ~4 μg/ cm^2 were loaded in terminal section.

6. Voltage read problem of EQX D-1 (-XkV)

There was no voltage read back of -XkV of EQX quadrupole. The problem was thoroughly investigated. The Light Link (LL) box, in Low Energy Dead Section (LEDS) LEDS area, was opened and its mother board was found to be damaged. Few PCB tracks in the mother board got opened. All the PCB tracks were repaired, the LL box was assembled back and tested but still there was no read back for -X voltage read. Thorough investigation and study lead to conclude that, according to the circuit diagram, the LL channel which has to be used for EQX-D1 (-X) read back is being used to read the ion pump pressure read in LEDS (IP D1-1). As the pressure read in LEDS area is more important parameter, hence the read back circuit arrangement was kept as it is which means that EQX-D1 (-X) read back channel is still being used for IP D1-1 pressure read.

7. Repairing of Column Support Post (CSP) gaps

The condition of CSP and accelerating tubes should be good for stable operation of the accelerator. Each and every CSP and accelerating tube ceramic gaps must have high insulation (in the order of hundreds of Giga-ohm) and be able to handle the rated high voltage without breakdown. If the condition of any of these gaps is not good, the high voltage, which accelerates the ion beam, will collapse.

During inspection, it was found that a total number of four CSP gaps were not in good condition in this maintenance. Four of the CSP gaps, two in LES and two in HES, were measuring lower insulation across their gaps. These gaps were in unit #4, 7, 18 and 28. Cracks were observed on ceramic surface across the faulty CSP gaps in these units and none of those gaps could be repaired, hence all those gaps were shorted. So now, a total number of 33 CSP gaps have been shorted, 17 in LES and 16 in HES section.

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 was done. Two numbers of ion pump controllers and a Sublimator pump controller were also repaired. Apart from these few other maintenance works were also carried out which are mentioned below.

2. Maintenance related to different devices

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

3. Pneumatic testing of SF_6 gas reservoir tanks

According to 'The Static and Mobile Pressure Vessels Rules 1981' it is mandatory to perform Pneumatic testing for all 5 nos. of SF_6 storage tanks in every five years. Hence, the pneumatic test of all 5 nos. of SF^6 storage tanks was done from 18th January 2016 to 17th February 2016. The yearly testing of safety valves, corresponding to all 5 SF_6 storage tanks, is also mandatory. Apart from this pneumatic test, yearly testing of safety valves had also been done. The test results for all of these tests were satisfactory. The test reports were submitted to the Petroleum and Explosives Safety Organization (PESO) and the certificate to use these storage tanks was renewed.

1.1.3 Ion Source Activities

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The ion source operation was quite satisfactory from April 2015 to March 2016. During the mentioned period, MC-SNICS was opened twice, once for regular maintenance work and secondly for breakdown maintenance.

The source was opened in the month of April 2015, for routine maintenance. All the electrical connections of ion source were removed and the source was vented with Argon gas and Cesium was disposed of in water. After venting the source, the MC-SNICS source was removed from line and opened. It was noticed that the ceramic studs holding the immersion lens had a layer of cesium on the ceramic surface. This made insulation between ground and immersion lens weak, hence all the ceramic parts were replaced with new ceramic studs. The source was fully dismantled part by part and source body, ionizer and other components were cleaned properly. The source was assembled back and aligned with the help of the alignment kit. The source was then installed back on the high voltage deck. After the installation of the source on the deck, it was loaded with new cesium 5 gm. ampule. Finally the source was loaded with the cathodes and tested for regular operation.

The second opening, in June 2015, was for a break-down. During a beam run it was noticed that there was no beam from ion source as ionizer (filament) was not drawing any current. Before opening the source the ionizer power supply was checked and it was found to be working. Hence, it was decided to open the source. All the electrical connections of the ion source were removed and the source was vented with Argon gas. The Cesium was kept under Argon environment. After venting the source, MC-SNICS was opened and it was noticed that the ionizer had broken down. The ionizer was replaced with a new ionizer and the source was properly cleaned. The source was assembled back and aligned with the help of the alignment kit. The source was then installed on the high voltage deck. The cesium was also loaded. The source performance was tested after this maintenance work and it was found satisfactory.

Lots of sparking was noticed across G P Tube in ion source at ~200 kV of deck potential. This led to instability in the beam from the ion source, particularly in case of pulsed beam. All the GP tubes were thoroughly cleaned but the sparking problem could not be solved completely. Further investigation revealed that the ceramic surface of all the five G P Tubes were in bad shape as black dust had got deposited on it. The external ceramic surface was getting shorted due to the black dust. All the G P Tubes were in use since their installation in early 1990s. Hence, all five G P Tubes were replaced with new tubes, during April 2015 maintenance, to solve the problem. After replacing all five G P Tubes, the HV deck could hold ~360 KV without any spark.

Thorough cleaning of HV deck, multiplier stack and filter stack of HV power supply was carried out. Apart from this, conditioning of HV deck was also done. For smooth and effective operation of MC-SNICS source, the cathode wheel had been loaded, whenever required.

1.1.4 Beam Pulsing System

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Operation

1310 hours of beam time was used for pulsed beam runs using Multi Harmonic Buncher (MHB) along with low energy chopper and traveling wave deflector. All the pulsed beams from Pelletron, were utilized by users to perform experiments in different experimental lines. The beams bunched for the experiments were ^{16}O, ^{18}O, ^{28}Si, ^{30}Si, ^{35}Cl, ^{37}Cl and ^{48}Ti.

^{16}O and ^{28}Si beam was used for the testing of MHB along with chopper for 3 hours and 8 hours respectively. Ninety seven hours of pulsed beam from Pelletron was utilized by users to perform experiments in HYRA lines with the repetition rate of 1μs and 2μs.

The remaining 1202 hours of pulsed beam was utilized for LINAC operation. Out of this, 132 hours were used for LINAC tuning and for the remaining 1070 hours beams were delivered to users after boosting beam energies using LINAC. Energies of ^{28}Si, ^{30}Si, ^{35}Cl, ^{37}Cl and ^{48}Ti beams were boosted by using LINAC.

All the pulsed beam runs were quite stable. The traveling Wave Deflector (TWD) was used to get different repetition rates of pulsed beam, whenever needed.

Maintenance

a) Chopper maintenance

During routine operation of chopper, fluctuation in the chopped width was experienced. This problem was investigated during April 2015 maintenance. The chopper tank circuit is driven by 100W, 4 MHz.

RF amplifier. The amplifier was tested with 50 Ω pure resistance dummy load connected at its output stage and tuned for maximum power transfer. The output was stable. The output of this amplifier was then disconnected from dummy load and connected to the chopper tank circuit. The tuning of the chopper tank circuit was checked, which was found to be satisfactory. It was observed that in this condition, the output wattage of the amplifier continuously fluctuated by more than 5%. The problem of output fluctuation was investigated and concluded that the two pentode valves (6146B), V2 and V3, at the final stage of amplifier have become weak. Therefore both these valves were replaced by new valves. The 100W, 4 MHz., RF amplifier was tested and kept ON for around 48 hours after maintenance. It worked properly and it was found that the problem of fluctuation had got solved.

Another 100W, 4 MHz., RF amplifier, used for buncher (LIB and HIB) was also tested. The feedback loop switch of amplitude control board of this amplifier was in closed condition without any feedback input connected. This can generate a fluctuating dc level at the output of the amplitude control board. This switch was then switched to open condition and the amplifier output with 50 ohm dummy load was checked. After tuning its output stage with dummy load, its output was connected to chopper tank circuit. This amplifier was kept ON for an overnight and no fluctuation at its output power was noticed.

b) Traveling Wave Deflector (TWD) maintenance

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

1.1.5 Low Energy Negative Ion Implanter Facility

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The low energy negative ion implanter facility continued to be used for ion implantation experiments regularly throughout this academic year. The facility operated smoothly. The user community in this facility comprises of 16 different colleges, universities and institutes. Around 510 samples were implanted with ion fluence varying from 1x1010 to 2x1017 ions/cm^2. The ion beams delivered during this period were ^{7}Li, ^{27}Al, ^{28}Si, ^{31}P, ^{48}Ti, ^{58}Ni, ^{59}Co, ^{63}Cu, ^{107}Ag and ^{197}Au. The energies of the ion beam were in the range 25 to 200 keV. Almost all the scheduled beam times (AUC 56, AUC 57 and AUC 58) and few approved beam times requested by the users, were successfully performed.

Apart from the ion implantation experiments, few ion beams were tried to develop as per users' requirement. The vacuum around the analyzer magnet goes bad when ions with high mass with low energy are accelerated through this facility. Because of its high divergence angle, some portion of the ion beam collides with the magnet. As an improvement to the facility, two new turbo pumps were installed in the beam line and accordingly, interlock system was changed. This has resulted in maintaining good vacuum, approx. ~ $5x10^{-7}$ T during the beam run. The control system was upgraded by adding new features like remote change of the cathode sample position from the control console. The read backs of ion source vacuum and oven temperature were brought to the control console page. In the experimental chamber side, the target ladder movement control system was shifted and installed in the control console rack to make it more user friendly. As a result, the overall operation of the facility improved. Regular routine work and maintenance were performed as per requirements.

There were few breakdown maintenances. The Ionizer (filament) in the source broke open while the facility was in operation. The source was dismantled to replace it. All the source components were cleaned thoroughly. The source was assembled with a new ionizer assembly. In addition, a vacuum leak was detected at the Ionizer power supply feed through. The leak was sealed by spraying high vacuum sealant. The sealant, if sprayed near insulating area, may short (or weaken) the insulating portion (ceramic insulators). Therefore, proper precautions were taken while spraying the sealant. The vacuum of the source region improved to $1x10^{-6}$ T.

Another problem encountered was the changing of cathode in reverse direction. Cathode could not be changed in reverse direction. The problem was thoroughly studied and it was found that the position of the piston, which is responsible for the movement of cathode wheel in reverse direction, was not properly aligned. Its position was aligned to solve the problem of reverse movement of cathode wheel.

The smooth run of the source is observed with stable and good vacuum after solving these problems.

Ion Implantation Experiments using Negative Ion Implanter facility and its RBS results

The measured experimental RBS spectra for 70keV Au- ion implanted in quartz substrate with different ion fluence confirms the presence of Au particles with a projected range of 35 nm inside the substrate. This is well matched with the SRIM calculated value of 34.7 nm. No other contamination other than the substrate (^{28}Si, ^{16}O) can be seen from the RBS spectra. The good uniformity of the ion implantation on the sample surface area up to 15 mm x 15 mm is also achieved using an electrostatic scanner in front of the target chamber.

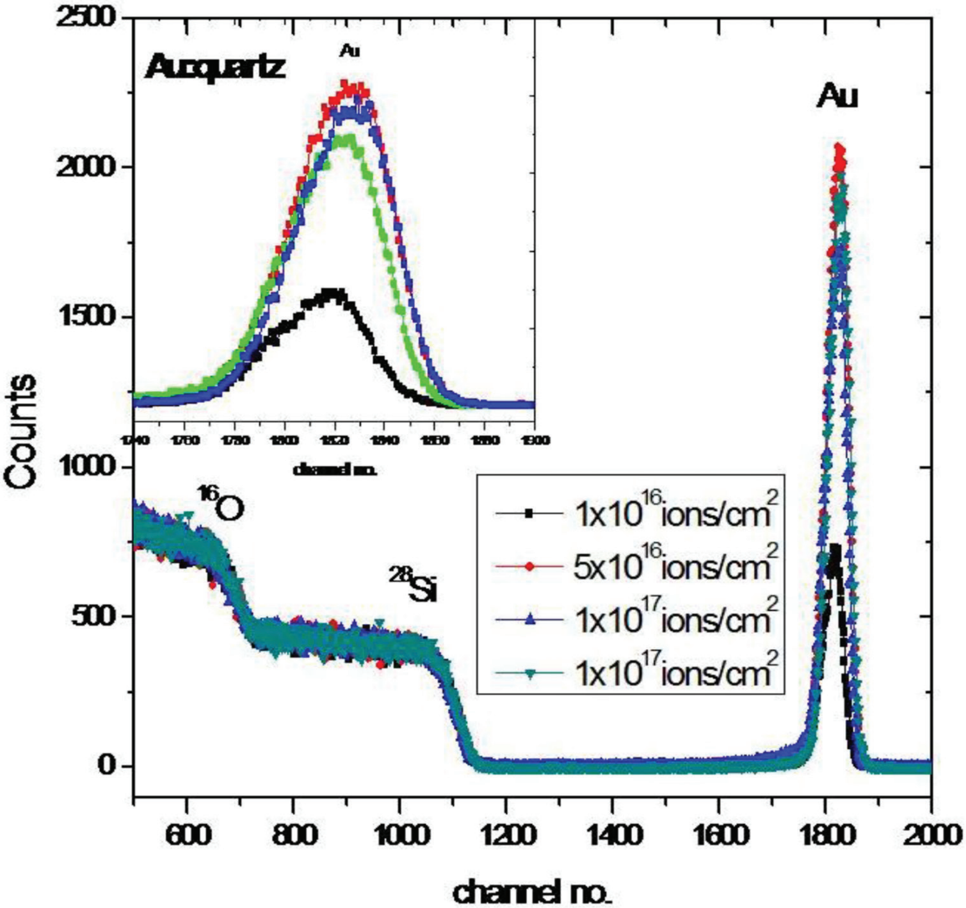

Figure 1.1.4: RBS spectra for 70keV Au- ion implantation in fused quartz substrate with ion fluence from $1x10^{16}$ ions/cm^2 to 1×10^{17}ions/ cm^2.

1.2 SUPERCONDUCTING LINEAR ACCELERATOR (SC LINAC)

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1.2.1 Operational status of the Superconducting Linac

The superconducting (SC) linac of IUAC consists of five cryostats containing 27 niobium quarter wave resonators. Energized ion beams from Pelletron which are further augmented by the SC linac are being delivered routinely for scheduled experiments since 2008. Over the years, ion beams from ^{12}C to ^{107}Ag have been accelerated through the linac and delivered for experiments. The maximum energy gain from three accelerating modules was measured to be 8.8 MeV/charge state. The minimum time width obtained at the user's experimental chamber was found to be 185 pico-second by operating both the resonators in the rebuncher cryostat [1].

During the last linac run in 2015, the accelerator was operational for four months and accelerated beam was delivered in two different beam lines of HYbrid Recoil Mass Analyser (HYRA) and National Array of Neutron Detectors (NAND). Various developmental jobs associated with improving the operational efficieny of linac was also accomplished in the same duration. During the beam acceleration, the number of Quarter Wave Resonators (QWRs) used in Superbuncher, three linac accelerating modules and the rebuncher cryostat are one, seven, eight, seven and two respectively. A single resonator in linac-1 could not be used during acceleration and one empty slot remains in the third accelerating module. The details of the beam parameters are given in Table-1 [2].

Table 1. Details of the ion species delivered for scheduled experiments after acceleration through Pelletron and SC linac

Beam	Pelletron Energy (MeV)	Δt at LINAC entrance	Energy Gain (MeV)			LINAC Energy (MeV)	Total Energy (MeV)	Beam line	No. of Shifts
			LC#1 (QWRs used)	LC#2 (QWRs used)	LC#3 (QWRs used)		Pelletron + LINAC		
$^{28}Si^{12+}$	130	130 ps	37.98 (7 QWR)	33.62 (8 QWR)	9.28 (3 QWR)	80.9	210.9	HYRA	> 21
$^{30}Si^{12+}$	130	74 ps	38.11 (7 QWR)	10.73 (2 QWR)	-- (No QWR)	48.8	178.8	HYRA	
$^{35}Cl^{13+}$	150	265 ps*	42.2 (7 QWR)	38.86 (8 QWR)	28.33 (7 QWR)	109.4	259.4	HYRA	> 21
$^{37}Cl^{13+}$	150	164 ps	42.88 (7 QWR)	37.51 (8 QWR)	14.58 (4 QWR)	95.0	245.0	HYRA	
$^{48}Ti^{15+}$	168	114 ps	51.01 (7 QWR)	45.36 (8 QWR)	35.25 (7 QWR)	**131.7**	**299.7**	NAND HYRA	> 90 > 30

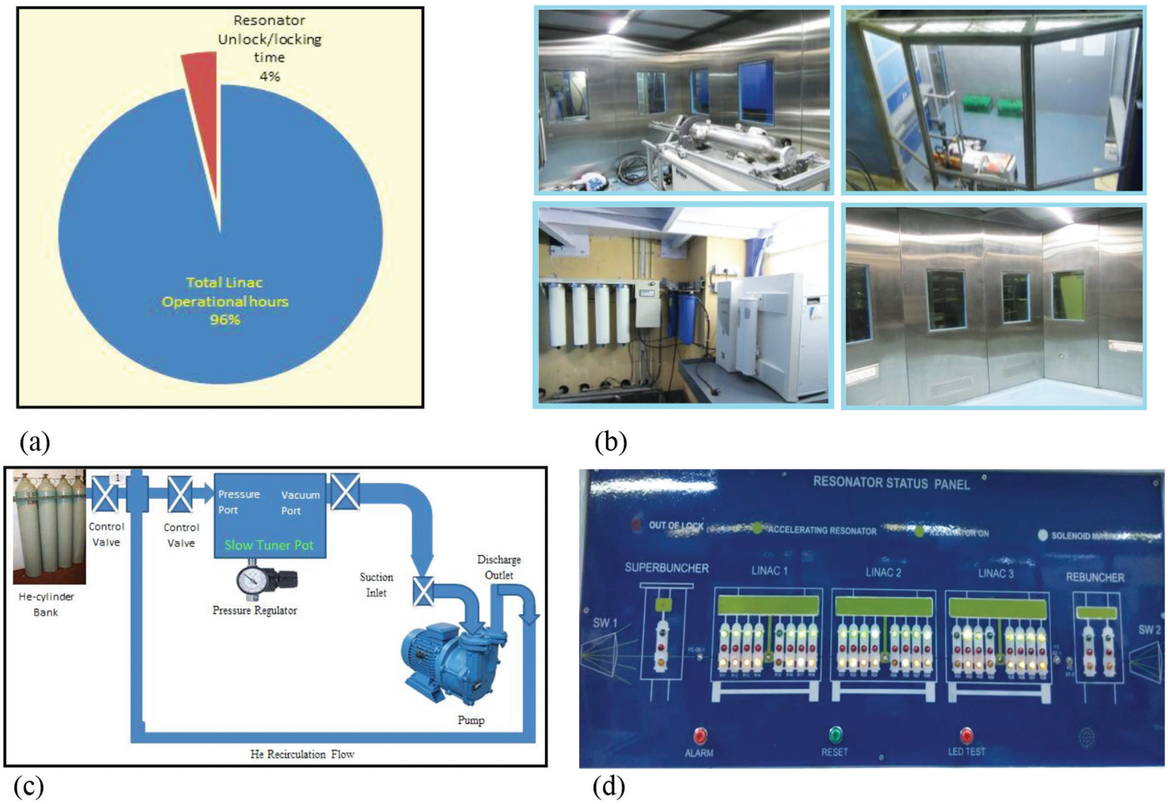

Fig. 1.2.1 (a) Pie chart for the linac up-time, (b) clockwise - the high pressure water rinsing facility, the resonator assembly room, the linac servicing area and the RO/Super-Q plant, (c) the closed loop helium gas circulation system for the mechanical tuner of SC resonator and (d) the status display used during linac operation.

This is the first time at IUAC when SC linac was operational for the longest period (~ 4 months) and the uptime of the linac system was found to be 96%, with only 4% of the total time lost due to trouble shooting mostly related to unlocking of the SC resonators (Figure 1.2.1(a)).

1.2.2 Developmental activities accomplished to improve the performance and the reliability of SC linac

A. Commissioning of a Class-100 clean room and a high pressure rinsing system

A couple of class-100 clean rooms at both ends of the linac servicing area (which is a class-5000 clean room) have been commissioned and operational for performing high pressure rinsing (HPR) of the niobium resonator at 80 bar water jet pressure with 18 Mμ-cm deionized water. HPR on a single resonator has already been performed and improvement in its performance will be tested soon. Pictures of the HPR room, the linac servicing area, the resonator assembly room and the RO/Super-Q plant are shown in Figure 1.2.1(b) in clockwise direction.

B. Implementation of piezoelectric actuator based mechanical tuner and PWM control based pneumatic tuner to improve the dynamics of control

To improve the frequency/phase locking mechanism of SC resonators, an alternate tuning scheme using piezoelectric actuator based tuner, acting in the range of milliseconds has been developed, tested and implemented on all the resonators in the 2^{nd} and 3^{rd} accelerating modules [2]. Since the mechanism is faster than the original gas based tuning system, it is capable of maintaining 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. In addition to making the system more robust, these effects lead to a substantial reduction in the required RF power during operation.

Since the design of the first accelerating module is slightly different than the other two modules, the piezoelectric actuator based tuning mechanism cannot be implemented in the resonators in this module due to space restrictions. So the control scheme of the existing gas operated tuners was improved using a pulse width modulation (PWM) based control mechanism. The new control is based on two pulse operated proportional valves operated in closed loop to maintain constant gas volume inside the slow tuner bellows. 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 from frequency unlocking and reducing the RF power requirement. The new system has been implemented and successfully used in four resonators during beam acceleration.

C. Implementation of a closed loop system of the helium gas operated tuning mechanism

During the last linac operation, out of 8 QWRs in linac-1, 4 were operated using the old tuning mechanism and the remaining 4 were operated by the improved PWM based tuning mechanism. Both the systems needed pure helium gas which in the past was supplied either from a helium gas cylinder or from the boil-off gas from the liquid helium plant. Both the tuning mechanism need constant purging of helium gas and the extra gas has to be taken out by a vacuum pump. In the past, it was tried to recover this helium gas but due to practical difficulties the recovery was not efficient. So a closed loop system connecting the suction and the discharge port of the vacuum pump was developed to recirculate the same gas into the tuning system. The pipe diameter and the throttling of the valves in the closed loop system had to be chosen / adjusted properly to maintain the proper compression ratio. The picture of the closed loop system is shown in Figure 2.1.1 (c). The improved version of gas purging system saves huge amount of money required for buying pure helium gas, reduces the human effort to replace the helium cylinders in the cylinder bank and nullifies the possibilities of mixing helium gas with air.

D. Use of Optimum Phase Focussing (OPF) concept during linac operation

During the last linac operation, OPF combinations were used to control the time width of the beam bunch below 1 ns at the experimental station [2]. In many cases, in addition to the OPF, the rebuncher resonator was also used. Where necessary, the resonators installed in the rebuncher cryostat can be used to focus the beam (longitudinally) at the experimental station. However, only one resonator at a nominal field of ~ 2 MV/m was found to be sufficient to keep the time width about 1 ns. The OPF combination was also used routinely to increase the beam transmission between the exit of linac and the experimental station.

E. Installation of the linac operation display

A LED display (Figure 2.1.1(d)) to show the status of the complete linac during its operation and beam acceleration has been developed and installed in the control room. From the display, one can know the status of all the 27 resonators along with the information about their phase and amplitude lock status. It has got the provision for audio as well as visual alarm to inform the unlocking status of the resonators.

F. Installation of two Capacitive Pick-Up units in the beam line

Two capacitive pick-ups (CPU) were installed at the exit of the beam line to measure the energy of the accelerated beam by 'Time of Flight' technique. During the last linac operation, a few energies of the ion beam were measured by the two CPUs and the result was compared with the measurement done using the solid state detector. The two results were found to be within 7%. More experiments are necessary to exploit the full potential of the CPU devices.

REFERENCE

[1] S.Ghosh et al. Proceedings of 27th Linear Accelerator Conference, Geneve, Switzerland, 31 Aug – 5 September 2014, page-640.

[2] S. Ghosh, et al. Proceedings of Indian Particle Accelerator Conference-2015, Mumbai, December 21-24, 2015, page-85.

1.2.3 Superconducting niobium resonators

P.N.Prakash, K.K.Mistri, S.S.K.Sonti, A.Rai, P. Barua and J.Sacharias

The two SSR1 Niobium Single Spoke Resonators constructed by IUAC for the PIP-II project (Proton Improvement Plan-II) were tested in the vertical test stand (VTS) at Fermilab. At 2K, both the resonators exceeded the nominal PIP-II design goal of 10 MV/m accelerating gradient at a quality factor of $>5\times10^9$. It is planned to have at least one IUAC built SSR1 resonator installed in the PIP-II Injector Experiment-PXIE cryomodule after the installation of the outer helium vessel on the resonator. Under the Indian Institutions and Fermilab Collaboration (IIFC), a 650 MHz, β=0.6 single cell niobium cavity has been jointly developed by IUAC and Variable Energy Cyclotron Centre (VECC), Kolkata, which has been sent to Fermilab for testing. Construction of half a dozen spare quarter wave resonators (QWRs) for the superconducting linac has started. The High Vacuum Furnace facility at IUAC has been upgraded. Initial planning for upgrading the Surface Preparation Lab has begun.

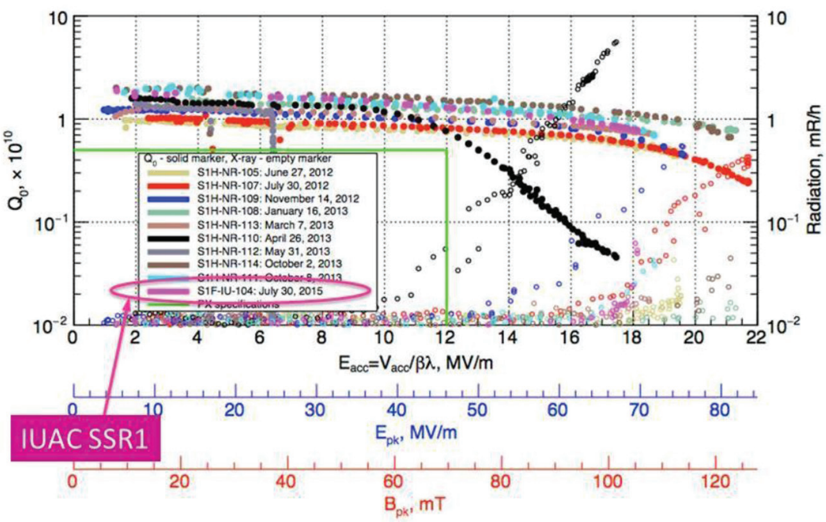

Fig. 1.2.2 Performance of IUAC built SSR1 Niobium Single Spoke Resonator S104 at 2K along with several other resonators tested at Fermilab

1.2.3.1 Niobium Single Spoke Resonators - SSR1

The two SSR1 Single Spoke Resonators (β=0.22, f=325 MHz), named S103 and S104, developed by IUAC for the PIP-II project were tested in the vertical test stand (VTS) at Fermilab, USA. S104 was the first to be tested. Prior to testing, it was processed following the standard recipe that included buffered chemical polishing (BCP) to remove ~120-150 μm followed by high pressure rinsing (HPR), 600 °C bake, light BCP to remove 20-30 μm, HPR and 120 °C bake. At 2K, the resonator easily exceeded the PXIE design goal of 12 MV/m at $Q_0>5\times10^9$, eventually reaching the maximum gradient of 18 MV/m, before quenching. The resonator did not require any special handling or second processing, which indicates that the handling, fabrication and processing at IUAC was excellent. In Figure 1.2.2, the performance of S104 along with several other SSR1 resonators tested at Fermilab, is shown.

The second SSR1 resonator, S103, was tested afterwards. It was processed similar to S104. However, during the final processing of the resonator a bolt hole in the beam port flange got damaged, which had to be repaired. Subsequent leak tests indicated a vacuum leak from this flange, which required the copper gasket to be replaced once before the leak could be resolved in the second attempt using an Indium coated copper gasket. In cold tests at

2K the resonator exceeded the PIP-II design goal of 10 MV/m accelerating gradient at $Q_0>5\times10^9$, but marginally fell short of the PXIE design goal of 12 MV/m at $Q_0>5\times10^9$. In Figure 1.2.3, the performance of SSR1 S103 resonator is shown. The plot clearly indicates heavy field emission beyond 8 MV/m accelerating gradient (Q drop) as manifested in the large X-Ray radiation measured outside the VTS cryostat.

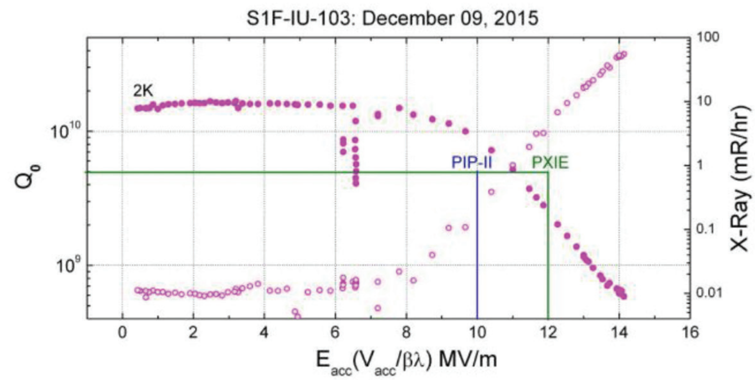

Fig. 1.2.3 Performance of IUAC built SSR1 Niobium Spoke Resonator S103 at 2K

The general consensus is that since S103 had to be opened twice to fix the vacuum leak, the cavity might have got contaminated which resulted in the heavy field emission. With additional processing, mainly HPR, the cavity is expected to perform similar to S104. It should be noted that the low field quality factor of S103 is not very different from S104.

1.2.3.2 Single Cell Niobium Low Beta Cavity

Under the Indian Institutions and Fermi Lab Collaboration (IIFC), Variable Energy Cyclotron Centre (VECC), Kolkata and IUAC have developed a β=0.61, 650 MHz single cell niobium low beta cavity (LBC). In addition to sharing its facilities, IUAC also shared its technical expertise with VECC for developing the cavity. The cavity components were formed and machined by VECC while the electron beam welding (EBW) was done by IUAC. The half cells of the cavity were joined together at the equator by welding from outside (non-RF side) and inside (RF side). This resulted in the two iris joints to be done as full penetration welds from outside. In Figure 1.2.4, the first niobium cavity developed, is shown. The cavity has been sent to Fermilab for processing and testing at 2K. It is planned to build a second single cell niobium cavity by performing the equator EBW from outside (non-RF side) as a full penetration weld and instead weld the iris joints as partial welds from outside (non-RF side) as well as inside (RF side). This procedure will help in the eventual goal of developing a 5-cell niobium cavity.

Fig. 1.2.4 First 650 MHz, β=0.61 niobium single cell low beta cavity

1.2.3.3 Facility Upgradation

The facilities to fabricate superconducting niobium resonators at IUAC were commissioned almost 15 years ago. In the last couple of years several sub-systems, especially electronics items, have started to show ageing effects. Most of them have become obsolete, making it extremely difficult to find replacements or spares. In order to maintain the in-house capability to develop niobium resonators, it was felt that these facilities needed to be upgraded / modernized / over-hauled. This year, the upgradation of the high vacuum furnace (HVF) has been done. In order to integrate the HVF facility with the adjacent surface preparation lab (SPL), a brick wall was constructed to isolate the entire area from the nearby utility equipment. This has resulted in more storage area for the DI water plant and the acid refrigerator, both of which are presently inside SPL. In a bid to cut the dust level in the HVF room, some other civil works were also done by closing all the windows with a brick wall, installation of a false ceiling and air conditioners. At the same time, two additional acid storage rooms were created for the safe storage of fresh and used acids. All the vacuum pumps, valves, gauges, interlock wiring, cooling water system, high current transformers etc. in the HVF were serviced and over-hauled. The control system was modernized by installing new PLCs, PC & SCADA software. Several non-functional meters, gauge controller etc. were replaced with new ones. A new residual gas analyzer (RGA) is being procured for on-line monitoring of the partial pressures of gases during the heating cycle.

1.2.3.4 Spare QWRs

Construction of six spare quarter wave resonators (QWR) for the superconducting linac has started. They will also be useful for conducting offline development works. The resonators are expected to be ready by the end of 2017.

1.3 LOW ENERGY ION BEAM FACILITY

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

1.3.1 Operation

The status of the electron cyclotron resonance ion source (ECRIS) based new low energy ion beam facility (n-LEIBF) in terms of the development of gaseous beams of highly charged positive ions and the beam delivery for the experiments in all three beam lines (at 75°, 90° and 105°) has been excellent during the current academic year (2015-2016). About 65 users from various universities and research institutes availed the beam time during March 2015 to February 2016. The ion beams of various charge states of H, He, C, N, O, Ar, Kr and Xe were mainly used for the experiments. For the high energy experiments in materials science with high ion fluences, the gas mixing and frequency tuning techniques were employed to enhance the beam intensities. A typical charge state distribution of krypton and oxygen in pure and mixed ECR plasma, and influence of frequency tuning on the intensities of highly charged argon ions are shown in Figure1.3.1 and Figure 1.3.2, respectively.

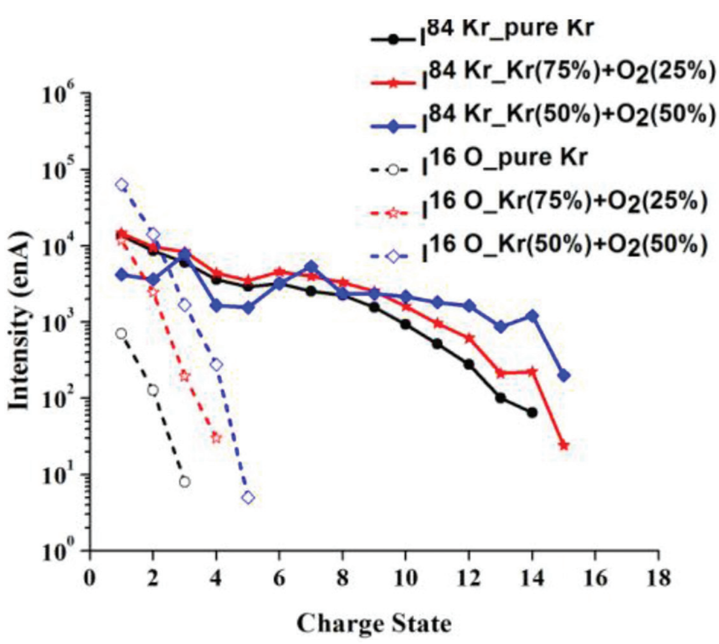

Fig. 1.3.1 A typical charge state distribution of the krypton showing the influence of the oxygen mixing on the higher charge states.

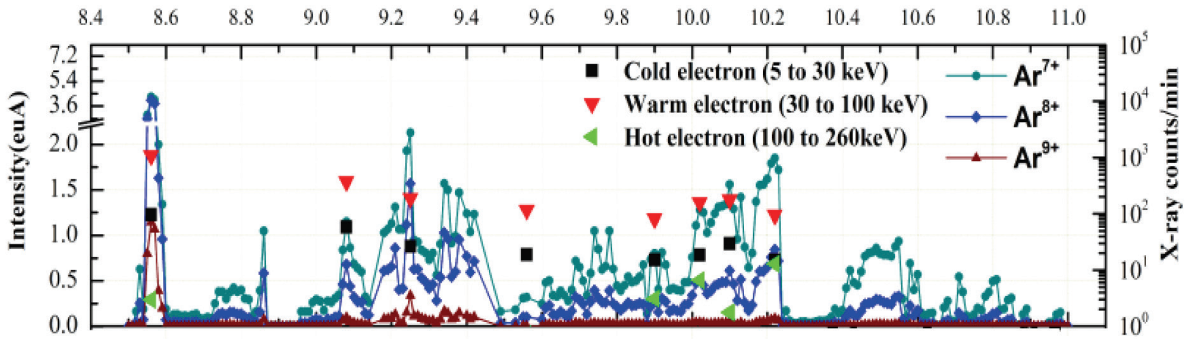

Fig. 1.3.2 The effect of frequency tuning on the intensity of highly charged argon ions. The electron energy distribution deduced from Bremsstrahlung spectra is also given.

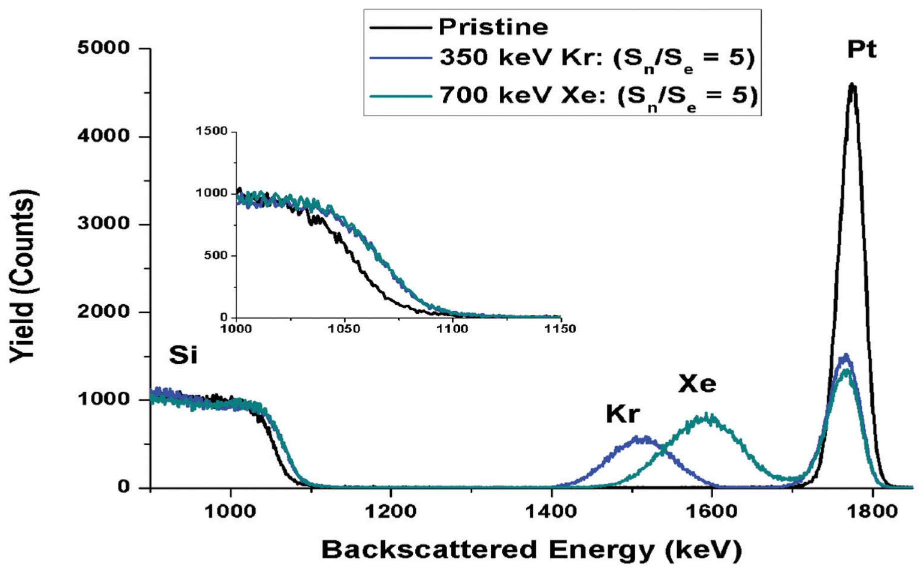

Fig. 1.3.3 The RBS spectra of Pt:Si thin films irradiated with low energy Kr and Xe beams. The zoom image of Si edge is shown in the inset.

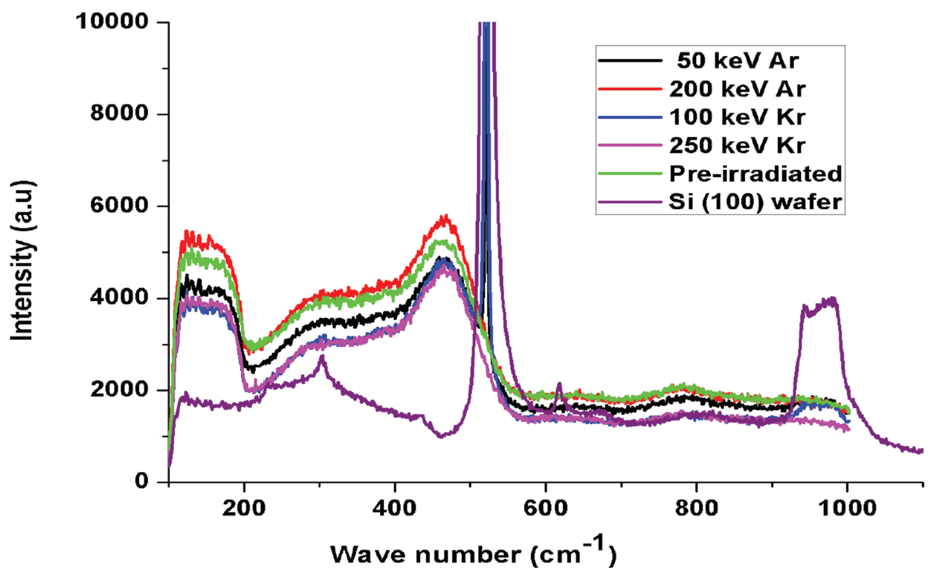

Fig. 1.3.4 Re-crystallization of a-Si by the irradiation of 100 keV Kr ions

1.3.2 Maintenance

During the current academic year, as such there has not been any major break down in the facility except the failure of the fiber optical cable controlling the extractor and Einzel power supplies at the high voltage platform. Repeated sparks during the source operation at limiting platform voltage seem to be the main reason for the cable damage. A view of the damaged fiber optical cable is shown in Figure 1.3.5. The damaged cable was replaced with a new one and the source operation was continued for regular experiments.

Fig. 1.3.5 A view of the damaged fiber optic cable

The presence of carbon in the ion source is detrimental to the production of high intensity of highly charged ions. Therefore, delivery of carbon beam is planned accordingly. The ion source needs to be cleaned after the experiments with carbon beams are over. The view of the ionization chamber before and after cleaning is shown in Figure 1.3.6.

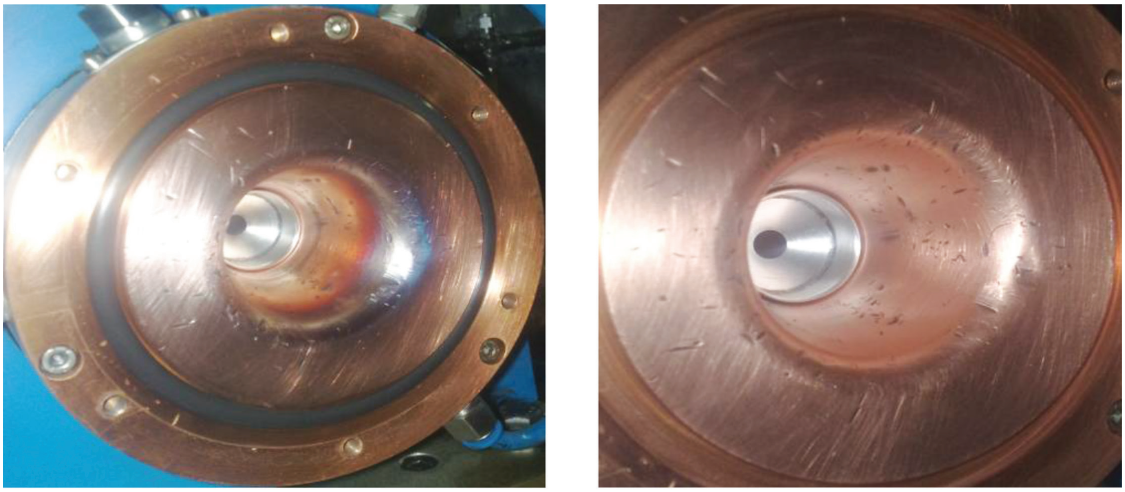

Fig. 1.3.6 A view of ionization chamber; left) before cleaning, right) after cleaning

1.3.3 Development

In spite of Cu, an Al made bias tube was used in the frequency tuning experiments. The role of the bias tube mounted at the injection side of the ion source is to reflect back the escaping low energy electrons into the main plasma. Nevertheless, the continuous condition of the Al made bias tube by the striking hot electrons and ions helps in maintaining a high secondary electron emission yield (in comparison to other metals) on the oxidized Al surface and hence the choice of Al. The 75° beam line is ready for the surface science experiments with a few eV to hundreds of eV ions.

1.4 PARAS

1.4.1 Operation

The 1.7 MV Pelletron accelerator for Rutherford backscattering facility was in regular operation all year round. More than 1850 measurements of 70 users from 35 Universities, colleges and institutes were made with their participation.

RBS and Channeling measurements were performed in Silicon single crystal on different axis (100 and 111) to understand defect evaluation on low energy ion implantation and molecular epitaxial growth of GaN on Si substrate. Channeling and Oxygen resonance measurements were performed in Al_2O_3 single crystals. Nitrogen resonance measurement were performed on nitrogen implanted silicon crystal and thin film grown on SiO_2. To quantify concentration of oxygen with respect to depth in silicon samples, oxygen resonance measurements were carried out with increasing energies (Figure 1.4.1).

Several measurements were performed on thin targets to be used in nuclear physics experiments to analyze their purity and estimate accurate thickness of film and carbon capping. ERDA for Hydrogen depth profiling in thin films grown on Si Substrate were performed simultaneously d   1ng RBS measurements.

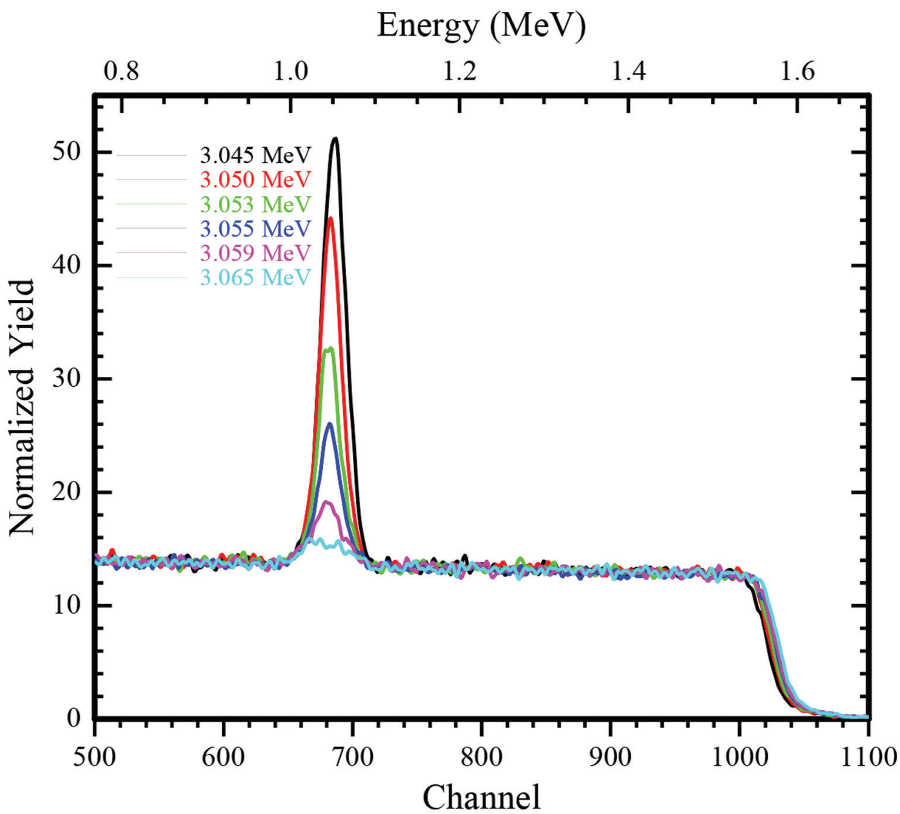

Fig 1.4.1 RBS Spectra of Oxygen resonance on Silicon substrate with increasing energy

1.4.2 Maintenance

1.4.2.1 Ion Source Maintenance

Ion source maintenance of RBS facility was performed twice last year. The major cause of breakdown of the RF charge exchange ion source in RBS facility is choking of apertures due to rubidium. During second maintenance, the entire ion source was dismantled to clean up the gap lens installed in the low energy section of RBS facility. This was done as the voltage holding capacity of gap lenses deteriorated with time. The gap lens was cleaned at high pressure rinsing facility at IUAC and later dipped in alcohol for 2 days. The voltage holding capability of the lens improved substantially (Table 1.)

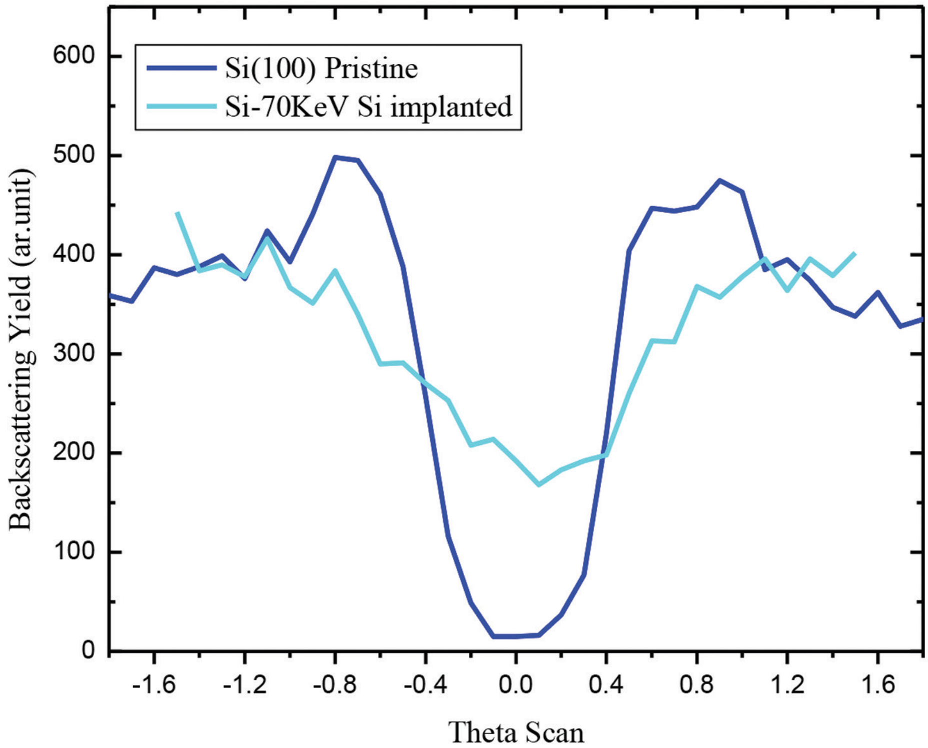

Fig. 1.4.2 Angle Scan of Si single crystal in comparison with surface amorphized by ion implantation.

1.4.2.2 RBS facility maintenance

There were two major breakdowns in the facility last year.

A leak through a high voltage feed thru in the HE section of accelerator tank led to a decrease in the SF_6 gas pressure resulting in instability of the terminal voltage above 1MV. The leak at the HV feed through was confirmed with the formation of bubbles with soap solution. The leaking feed through was tightened which plugged the leak. Dew point measurement for SF_6 was performed. The value was higher than rated for accelerator operation. To improve the dew point new alumina beads were first heated and then filled in dessicator. After 4 days the dew point measurement of SF_6 gas improved.

The turbo molecular pump in injector section was found to be malfunctioning due to problem in bearing. The pump was replaced with another provided by IUAC Vacuum Lab. Bearing maintenance of failed pump is presently underway. Backscattering detector (at 1660) was replaced by new ULTRA™ Alpha Detector (Model number: BU011050300) supplied by AMETEK-ORTEC, with 15KeV resolution for 2 MeV He^+ ions. This improved resolution of spectra.

Table 2: Gap lens resistance measured before and after cleaning

Resistance Before Cleaning	Resistance After Cleaning
366 MΩ	1.3 TΩ
30 MΩ	5 GΩ
156 MΩ	1.2 TΩ
141 MΩ	1.3 TΩ
150MΩ	1.5 TΩ

1.5 ACCELERATOR MASS SPECTROMETRY

Pankaj Kumar, Rajveer Sharma, Sunil Ojha, S. Gargari, R. Joshi, G.S. Roonwal, S.Chopra and D. Kanjilal

A comprehensive ^{14}C AMS facility at IUAC is operational since June, 2015 and it has been utilized by several users. The facility is based on an automated graphitization Equipment (AGE) for sample preparation and a dedicated 500kV Pelletron accelerator for sample measurements. This accelerator is also capable of performing ^{10}Be and ^{26}Al AMS measurements. The clean chemistry laboratory is extensively utilized by various users for the chemical treatment and extraction of ^{10}Be and ^{26}Al from their samples. A brief of the activities performed in last year are explained below:

1.5.1 ^{14}C AMS facility

A new **XCAMS** (**C**ompact ^{14}C **A**ccelerator **M**ass **S**pectrometer e**X**tended for ^{10}Be and ^{26}Al) system was installed in Feb-March 2015. Various XCAMS system components were tested and acceptance tests were followed with the samples prepared at the IUAC graphitization laboratory using Automated Graphitization Equipment (AGE). Precision of better than 0.1% was achieved for modern ^{14}C standard samples. The background values for the blank prepared with dead graphite powder from Alfa aesar was 1x 10^{-15}.

The acceptance tests for ^{10}Be and ^{26}Al were also performed with the samples prepared in clean chemistry laboratory at IUAC. A precision of 1% was achieved in ^{10}Be measurements performed with standard reference material (SRM) 4325 procured from national institute of standard and technology (NIST), USA. The background value with the blank sample SRM 3105a from NIST was 8.5 x10^{-14}.

A precision of about 2% was achieved in ^{26}Al measurements performed with standard sample having a known isotopic ratio of 4.694 x 10^{-12}. The background value with blank Al sample was 8 x10^{-15}. ^{26}Al measurements performed on the standard samples of various concentrations show excellent agreement with their nominal values.

Various other ^{14}C measurements have been performed afterwards and more than 500 samples have been measured till now using XCAMS system. Users from Pondicherry University, Allahabad University, JNCASR, Bangalore, Delhi University, IUAC and French institute of Pondicherry have utilized the XCAMS system.

IUAC will now take part in the international inter-laboratory comparisons. The IUAC AMS facility is recognized by radiocarbon community and a lab code "IUACD" has been assigned.

1.5.2 Clean chemistry lab activities

Clean chemistry lab has been utilized for the chemical treatment and preconcentration of meteoric produced Be, Al from sediment samples. However, extraction of *in situ* produced ^{10}Be and ^{26}Al from quartz bearing rocks was started recently. Conventional methods of quartz digestion involve the use of hot plates inside fume hood. However, we have procured a custom-made microwave based digestion system for faster digestion of hard rock samples.

Preconcentration of in-situ produced ^{10}Be, ^{26}Al using Microwave digester:

Quartz digestion is a rigorous process involving use of strong acids such as HF, conc. HNO_3 and conc. HCl. Conventionally, hot plates are used for quartz digestions by heating quartz powder with appropriate mixture with acids. However, this is a time consuming process and not safe for the user due to the presence of acid fumes in the working area. We are using a custom made microwave digestion system (Milestone srl. Italy) for quartz digestion. (Figure 1.5.1). Microwave digestion is very much time efficient (150 gm/day) in comparison to hot plate digestion (5 gm/day) and also it can be programmed for heating steps (ramp, dwell and cooling). This system also has a scrubber unit which separate acid fumes from the solvent and neutralize them to make working area safer for the user. Silicate fluorides formed during digestion can also be removed in the microwave digestion system by heating the solution with aqua regia at 90°C.

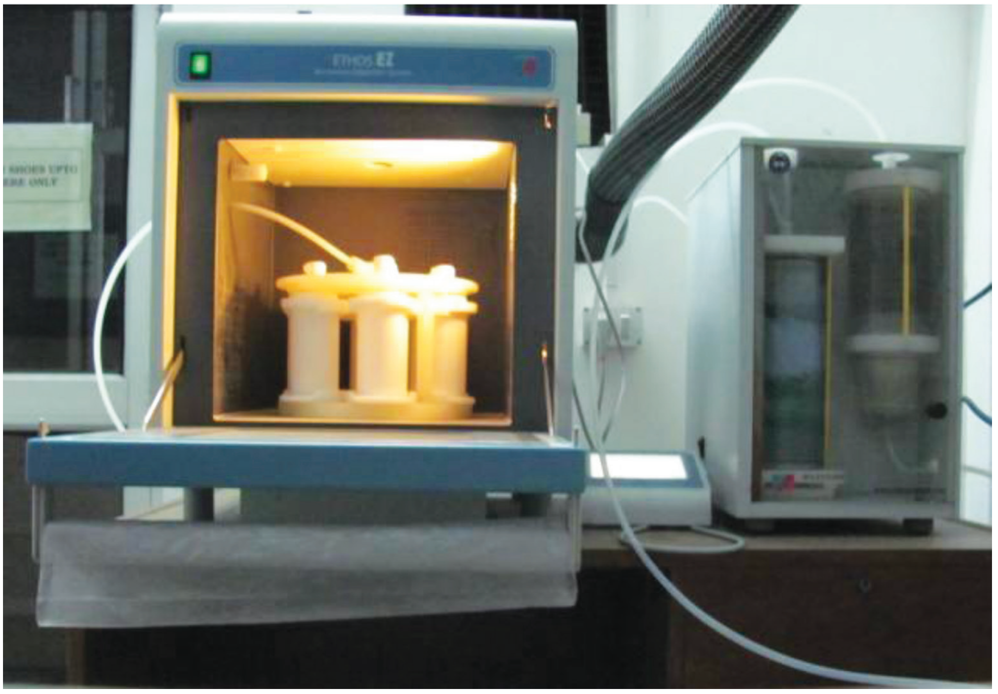

Fig. 1.5.1 Microwave digestion system at IUAC

The typical ion currents from the samples prepared using microwave digestion for $^{9}BeO^{-}$ and $^{27}Al^{-}$ current are 2 μA and 100nA, respectively. The blank values for ^{10}Be and ^{26}Al measurement were found to be 7E-15 and 8E-15, respectively.

Protocol has been prepared and various users have utilized microwave digester for the preconcentration of Be and Al from quartzite samples.

1.5.3 Geochronology Facility at IUAC

Establishment of a national facility for geochronology started in September 2015 with the financial support from Ministry of Earth Sciences (MoES), Govt. of India.

The objective of this project is to develop a comprehensive Geochronology facility at IUAC that will permit measurement of quality isotopic data for geochronological purposes including relevant characterization at the highest international level.

This facility will have two major components; AMS for medium and heavy mass range radio nuclides and high resolution SIMS along with other mass spectrometric equipment used in geochemistry and geochronology.

Mass spectrometers and peripheral instruments required for quaternary studies were given priority in the first year of the project and it was decided to procure 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) and AGE (Automated Graphitization Equipment).

The space for the installation of these instruments with required infrastructure is being made ready. The expected date of shipment for all the instruments is in the month of October, 2016 and it is planned that these instruments will be operational in the beginning of next year.

1.6 DEVELOPMENT OF NEW MAGNET FOR 50 KV ION ACCELERATOR

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

The accelerator was in operation throughout the year. There were 32 runs conducted by 17 different users of various universities & institutes. A total of 204 samples were irradiated using H^+, H_2^+, He^+, He^{2+}, C^+, N^+ beams in the energy range of 11 – 96 keV. The list of users, beam & sample details are given in the following table.

Date	Name of User	Affiliation	Beam	Sample	No. of Samples	Objective
16/03/2015	Jyoti	Amity University Manesar	11 keV, N^+	Fe_2O_3 on Silicon, glass & quartz	3	
01/04/15	Ravi Kumar	NPL	40 keV, He^+	Nano diamond	12	
15/04/15	Dr. Laxmi	IUAC	40 keV, He^+	PANI-GNP on glass	12	To study the structural & wettability properties.
20/04/2015	Dr. Laxmi	IUAC	40 keV, He^+	PANI-GNP on silicon	3	To study the structural & wettability properties.
28/04/2015	Pramod Kumar	IUAC	11 keV, N^+	CuO, Cr_2O_3	3	To study the effect of N implantation on the magnetic & magnetotransport properties
29/04/2015	Jyoti	Amity University Manesar	11 keV, N^+	Fe_2O_3 on Silicon, glass & quartz	2	
13/05/2015	H Arul	VIT Vellore	40 keV, H^+	MDP, MN, LHS Organic single crystals	11	To study the

18/05/2015	Ravi Kumar	NPL	11 keV, N^+	Nano diamond	6	To create the vacancies by He ion irradiation to form deffect centres for (N-V) luminosnece studies.
29/05/2015	Ravi Kumar	NPL	40 keV, He^+	Nano diamond	6	
29/05/2015	Ravi Kumar	NPL	11 keV, N^+	Nano diamond	3	
01/06/15	Parswajit	IIT Delhi	40 keV, He^+	ZrO_2 Thin films	5	To examine the erradiation stability.
03/06/15	Parswajit	IIT Delhi	40 keV, He^+	ZrO_2 Thin films	3	To examine the erradiation stability.
10/06/15	Merry Gupta	SLIET Longowal	30 keV, He^+	$CaZrTi_2O_7$ Zirconolite	3	To check the stability & radiation resistance behaviour of nuclear waste form Zirconolite
17/06/15	Ravi Kumar	NPL	40 keV, He^+	Nano diamond	3	
24/06/15	Merry Gupta	SLIET Longowal	30 keV, He^+	$CaZrTi_2O_7$ Zircovolite	2	To check the stability & radiation resistance behaviour of nuclear waste form Zirconolite
15/07/2015	Ravi Kumar	NPL	40 keV, He^+	ND35 OxyHeL	6	For creating defects
05/08/15	Ravi Kumar	NPL	20 &30 keV, He^+	ND35 OxyHeL	7	For creating defects
06/08/15 to 10/08/2015	Ravi Kumar	NPL	50 keV, He_2^+	ND35 OxyHeL	8	For creating defects
17/08/2015	Dr. K. Asokan	IUAC	20 keV H_2^+	Graphene	3	To check electrical conductivity
18/08/2015	Dr. K. Asokan	IUAC	20 keV, H_2^+	Co_2FeSi & Quartz	3	To check electrical conductivity
19/08/2015	Dr. Kamla Rawat	JNU	20 keV, H_2^+	$Na1SiO_2$ Nano clay	6	To develop Cholestrol Sensor
26/08/2015	Parswajit	IIT Delhi	40 keV, He^+	ZrO_3 film on Silicon	4	
03/09/15	Abhimanyu	JNU	20 keV, H_2^+	Sodium & Silica thin films	14	
23/09/2015	Mini Agarwal	AIIMS	14 keV C^+	KCL Nanophosphor, Al_2O_3	6	Creating defects in host lattice to develop dosimeter

05/10/2015 to 08/10/2015	Shiv Kumar Goel	PRL Ahmedabad	20-96 keV H+, H^{2+}, He^{2+}	Silicon Detector	1	To test the detector
02/11/15	Abhimanyu	JNU	20 keV, H_2^+	Nano clay films layered Silicate	16	To develop Cholestrol Sensor
04/11/15	Dr. Nidhi Sekhawat	KUK	30 keV, H_2^+	Ar implanted Silicon	12	To study ion induced exfoliation
05/11/15	Dr. Nidhi Sekhawat	KUK	30 keV, He^+	Ar implanted Silicon	9	To study ion induced exfoliation
08/12/15	Abhimanyu	JNU	20 keV, H_2^+	Nano clay films layered Silicate	18	To develop Cholestrol Sensor
14/12/2015	Ranjeet	Bharthiyav University, Coimbature	11 keV, N^+	Iron Galium	4	
29/12/2015	Mahua Chakarborty	ISM Dhanbad	11 keV N^+	ZnO Thin films	6	To study structural & electrical properties.
25/01/2015	Kashmira Harpale	Pune University	15 keV C^+	Poly Pyrrole Polymer	4	Electrical & electro-chemical studies.

Fabrication, Assembly & Testing of New Bending Magnet for Small Accelarators

A new bending magnet which was designed last year was fabricated, assembled & tested. Permanent magnet pallets of size 12.5x25x50 mm are stacked between the two main poles to create the magnetic field. Each stack has 6 pallets and a total of 42 stacks are used.

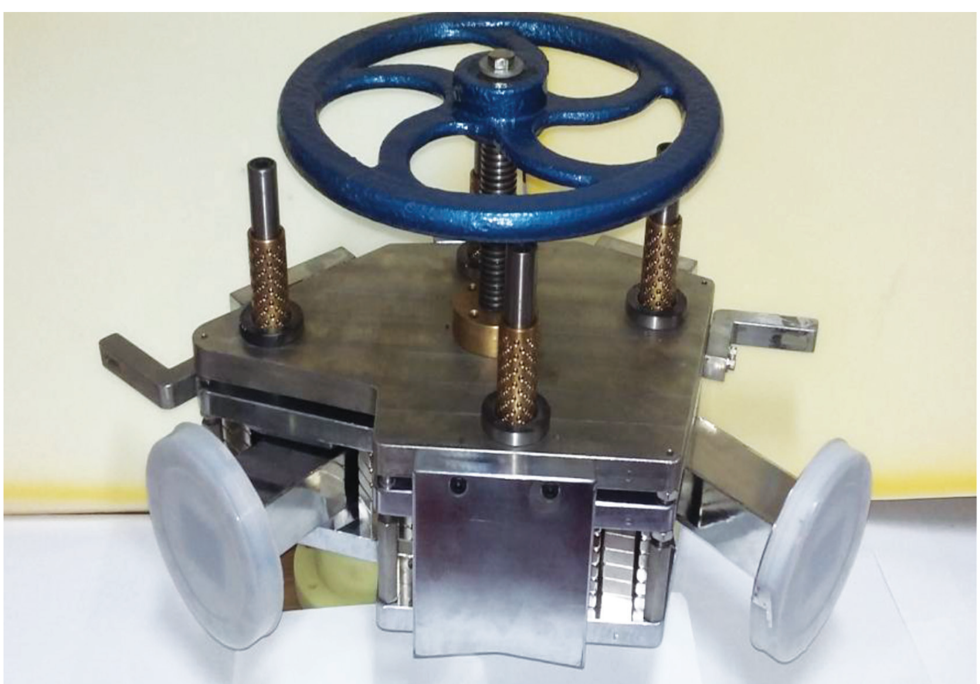

Fig. 1.6.1 New Bending Magnet

The magnet has a bending radius of 250 mm and aperture of 46x56 mm. The new magnet has beam entry and exit angles of 26.5º. The field mapping results shown below indicate that a fairly uniform and variable field of 2100 – 3500 gauss has been achieved.

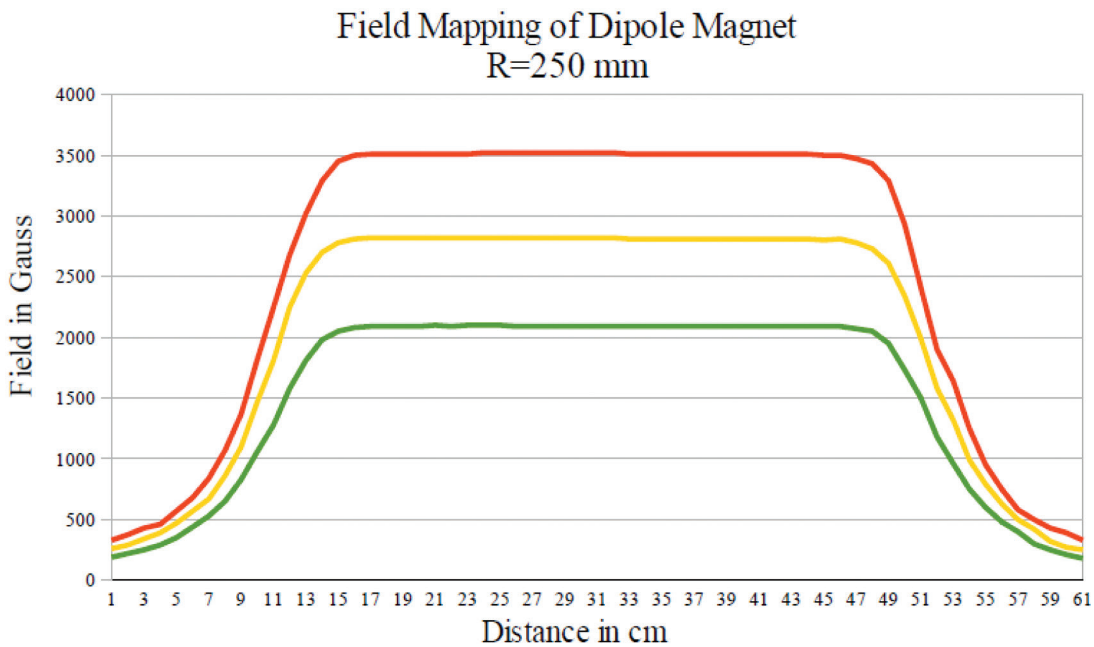

Fig. 1.6.2 Field Mapping