1. ACCELERATOR

1.1 PELLETRON

1.1.1 OPERATIONAL SUMMARY

S Chopra

The 15 UD Pelletron accelerator performed satisfactorily, from April 2011 to December 2011. Beams were delivered to users in different beam lines up to 27th December 2011. On 28th December 2011, during a beam run, charging chain #1 broke, resulting in a long tank opening maintenance. After completion of maintenance and conditioning, beam runs again started from 20th March 2012 onwards. The detail of this maintenance is mentioned in maintenance section. The operational summary of the accelerator from April 2011 to March 2012 is mentioned below.

Total No. of Chain Hours	=	6935 Hours
Total Beam utilization	=	4098 Hours
Machine breakdown	=	0090 Hours
Accelerator Conditioning	=	0355 Hours
Beam Change Time	=	0013 Hours
Tank opening maintenance	=	1715 Hours
Beam tuning time	=	248 Hrs.
Experimental setup time	=	046 Hrs.
Accelerator set up time after maintenance	=	58 Hrs.

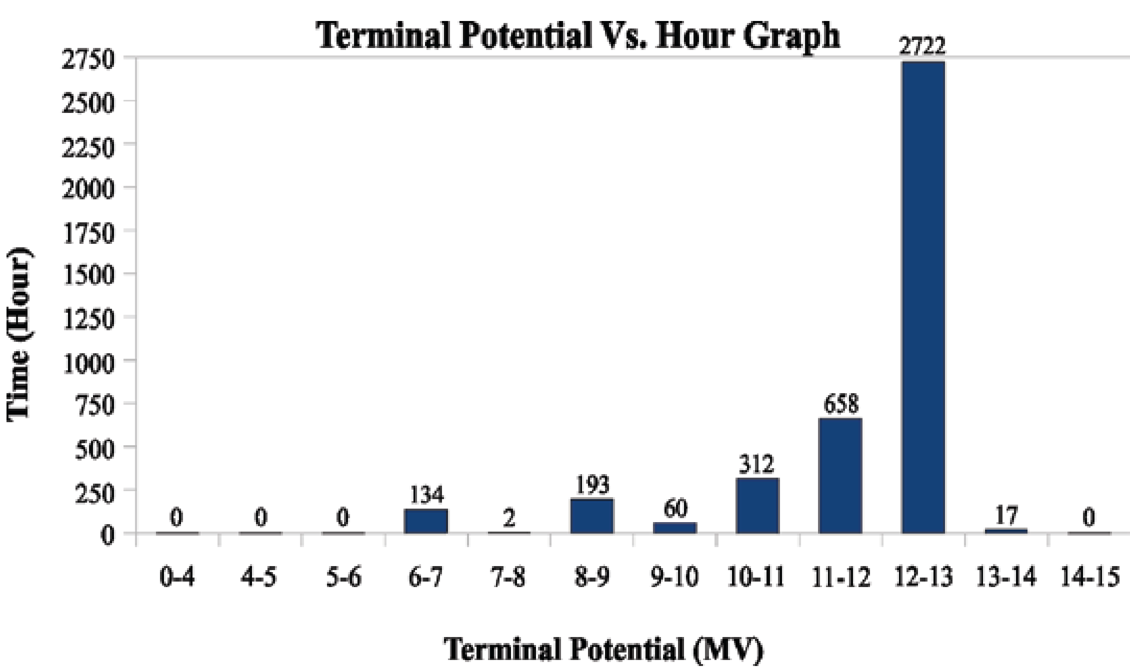

Fig. 1.

Total number of 512 shifts was used for experiment during mentioned period. Out of these 512 shifts, 136 shifts were used for pulsed beam users. The machine up time for this period is 98.70% and the beam utilization is 59.09%. The voltage distribution graph of Terminal Potential used for different experiments during above mentioned period is shown in figure 1. ^{48}Ti, 10^+, 147 MeV dc beam was delivered to user at maximum terminal potential 13.43 MV and ^{6}Li, 2^+, 20 MeV dc beam at the minimum terminal potential of 6.61 MV. Maximum terminal voltage achieved during conditioning in this year was 15.1 MV.

The total duration of beam run for mentioned period is 4197 hrs. Duration of run time in percentage for different ions is shown in table 1.

Table 1

Beam Delivered	Utilization (%age of total time)	Beam Delivered	Utilization (%age of total time)
^{6}Li	2.35%	^{30}Si	6.70%
^{7}Li	1.39%	^{31}P	3.79%
^{10}B	2.68%	^{32}S	2.13%
^{11}B	0.08%	^{35}Cl	0.10%
^{12}C	10.34%	^{48}Ti	1.25%
^{13}C	0.61%	^{56}Fe	1.72%
^{14}N	2.75%	^{58}Ni	9.37%
^{16}O	10.37%	^{79}Br	0.46%
^{18}O	5.59%	^{107}Ag	13.88%
^{19}F	6.33%	^{197}Au	5.90%
^{28}Si	12.22%		

1.1.2 MAINTENANCE AND DEVELOPMENT ACTIVITIES

S Chopra, R Joshi, S Gargari, M Sota, S Ojha, V P Patel, R P Sharma, J Prasad, R Kumar, M P Singh, N S Panwar, S Mohan, Suraj Kumar, Pranav Singh, D Kabiraj, Abhilash, P Barua and A Kothari

There was only one tank opening maintenance in the mentioned period due to breaking of chain #1. This maintenance was from 28th December 2011 to 9th March 2012. Although this maintenance was for breakdown of charging system, routine maintenance jobs like, terminal foil stripper loading, column support post and accelerating tube resistors maintenance, in tank ion pump maintenance and maintenance of rotating parts inside tank, were also carried out. Apart from routine maintenance jobs few major maintenance jobs were also carried out, which are listed below.

Major maintenance jobs during scheduled tank openings:

The major maintenance jobs carried out are listed below:

1. Charging system maintenance

The charging chain #1 broke after the operation of around 100.000 hours. The breaking of chain was due to loosening of mounting bolts of doubler inductor in charging system #1. All four (two in terminal and two on the motor side) 6" inductors surface also got damaged in this accident. Big dents were also noticed on the semiconducting band of both the pulleys. Damaged surface of all four inductors were buffed for better finish and these finished inductors were used in charging system #1. Both the damaged pulleys were also replaced by new pulleys and the broken chain was replaced by a new charging chain for charging system #1. This charging system was tested mechanically and ran for four overnights to allow the elongation of chain #1. Two pellets were removed from chain to compensate its elongation. The charging system #1 was then tested electrically and ran with CPS value of 6 kV for ten overnights During this overnight testing, chain #1 got further elongated and another two pellets were removed for its elongation compensation. Now total number of 621 pellets is there in charging chain #1. A pick off wheel for suppressor inductor in terminal was also replaced.

The routine maintenance of charging system #2 was also carried out. Semiconductor band of both the pulleys of both the charging systems were oiled with TP oil to reduce the friction between pulley and chain. Alignment of few idler wheels was also adjusted. Both the chains were properly cleaned and checked thoroughly.

2. Maintenance of Rotating parts inside accelerator tank

All the rotating parts inside tank were checked thoroughly for maintenance. In this maintenance, bearings of total number of twenty five separator boxes were replaced, twelve in low energy side and thirteen in high energy side. Two locally fabricated separator box in low energy side (between unit #4 – 5 and unit #5 – 6) were replaced by new boxes from NEC. Also a cracked rubber coupler in a separator box between unit #27 – 28 was replaced by a new rubber coupler. All the motors inside tank were properly greased.

3. Replacement and shorting of Column Support Posts

Five out of eighteen gaps of CSP were shorted in unit #11, due to cracks in ceramics, to avoid their further damage. Three of the CSPs needed replacement and were replaced by new ones. Two new column support post gaps were shorted, one in low energy side and other in high energy side. Gap #18 of post P-2 in unit #3 measured 2 G ohm and gap #9 of post P-1 in unit #21 measured 1 G ohm. A few cracks were observed in both of these gaps.

At present, a total of 15 gaps are shorted in low energy side and 11 gaps are shorted in high energy side of accelerator.

4. Replacement of equipotential rings screws

After January 2011 tank opening maintenance, beam instability was noticed in beam runs due to instability in terminal voltage caused by fluctuations in charging current of chain #2 as soon as it reached ~18 micro amp. Problem was found to be due to discharge paths developed in unit #22. Shorting of unit #22 solved the problem and beam runs were quite stable and smooth. Hoop screw resistance measurement was done in unit #22 during this maintenance. Four of them were measuring few Mega ohms, four of them were measuring in kilo ohms range and two of them were open. All these ten hoop screws were replaced by new one after cleaning the hoop threads.

5. Accelerating tube gaps cleaning

Number of accelerating tube electrodes in entire machine were cleaned thoroughly with scotch brite and alcohol. All of these electrodes were dirty with lots of spark marks.

6. Stripper foil loading in terminal and post acceleration section (FS 04-1)

This is the first time when all the stripper foils loaded in terminal are from LPA Munich.

New stripper foils of different thickness are also loaded in stripper foil assembly in vault area after analyzer magnet (FS 04-1). Foil stripper at this location is utilized for delivering beam of high charge states at same energy and to study charge state distribution of ions with energy more than 1 Mev / Nucleon. It is planned to utilize these foils for separating beams with same M/q for AMS and other applications.

7. Welding of support arm

A part of welding joint of one of the support arm at tank bottom got opened. This welding joint was repaired to see the effect of this welding joint, the level of all castings from unit #1 to 30 was checked with the help of spirit level. All the levels were found to be fine.

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. Four Sublimator pump controllers and two ion pump controllers were repaired. Apart from these few major maintenance work was also carried out which are mentioned below.

a) Replacement of ion pump (IP 03-1)

Post acceleration ion pump in 03 area (IP 03-1) was not working as it got damaged due to continuous loading due to a leak in the pendulum valve.

This ion pump was replaced by an old ion pump of 240 l/s capacity, which was repaired by cleaning and electro polishing the inner surface of chamber. New elements were installed in this chamber and the ion pump was assembled back. This ion pump was then tested to hold vacuum in the order of 10-8 T.

b) Installation of a manual valve

Pendulum valve BLV 03-1 was positioned between tank bottom and 03 area to isolate high energy side of accelerator. As BLV 03-1 was removed due to leaks, a manual type 100 CF Ultra High Vacuum (UHV) Valve was installed in its place.

2. Faraday Cup maintenance

During one of the beam runs, faraday cup in post acceleration section (FC 03-1) stopped functioning. It was found that central conductor of MHV connector got shorted to body of faraday cup. This problem was rectified by replacing the head assembly of the faraday cup (FC 03-1).

1.1.3 ION SOURCE ACTIVITIES

S Chopra, R Joshi, S Gargari, M Sota, S Ojha, Pankaj Kumar, V P Patel, J Prasad, R Kumar, M P Singh, N S Panwar, S Mohan, Suraj Kumar and Pranav Singh

The ion source operation was quite satisfactory from April 2011 to March 2012. The ion source was opened thrice, once for regular maintenance and twice for breakdown maintenance.

1. Maintenance work

a) Routine maintenance

Routine maintenance work for ion source was carried only once, in May 2011. All the electrical connections of ion source were removed. The source was removed from line and taken out from deck for maintenance. The source was dismantled and all of its parts were cleaned. After cleaning of all the parts, the source was assembled again and the alignment was done with the help of alignment jig. The ionizer along with its few ceramic components was also replaced as those were dirty. Quantity of 5 g of fresh cesium was also loaded in the cesium reservoir.

2. Breakdown maintenance

During the reported period the ion source breakdown maintenance was done twice and they are mentioned below.

a) Cathode was not holding the voltage

In August 2011, the source started giving problem after a long run of Sulphur beam. The cathode current was following the filament current and finally the cathode was not holding required voltage. The source was opened to solve the problem. After opening it was observed that lot of unwanted flakes were shorting the cathode wheel, the filament body and the cesium focus lens. The cesium focus lens and the filament cover were replaced to solve the problem.

b) Cesium focus electrode was not holding the voltage

Another breakdown of source was encountered in September 2011. The cesium focus electrode was not holding the potential. This time also the reason was the operation of source for the production of Sulphur beam of high current. The source was opened again and cleaned to solve the problem. Some components were also replaced.

c) Electronics related problems

Some electronics related problems were also encountered in the source during above mentioned period. Extractor power supply failed twice and both the time it was replaced.

Failure of cathode power supply was encountered once. This power supply was also replaced to solve the problem. All the faulty power supplies were repaired afterwards.

d) Problem related to General Purpose Tube (GP tube)

G.P. Tube was not holding the required potential. Sparks across the GP tube electrodes were noticed. It was observed that surface of resistances mounted across these gaps got damaged severely probably due to moisture. All the faulty resistances were replaced. Maintenance work on dehumidifier was also carried out which improved the humidity level.

For smooth and effective operation of MC-SNICS source, the cathode wheel had been loaded for regular and AMS runs, whenever required.

1.1.4 BEAM PULSING SYSTEM

R Joshi, M Sota and A Sarkar

Operation

1089 hours of beam time was used for pulsed beam runs using multi harmonic buncher (MHB) along with low energy chopper and traveling wave deflector. Out of 1089 hours of pulsed beam time 701 hours of pulsed beam was delivered to users, after boosting beam energies using LINAC. Energies of ^{19}F, ^{28}Si, ^{30}Si and ^{31}P were boosted by using LINAC.

For remaining 388 hours, pulsed beam from Pelletron, was utilized by users to perform experiments in different experimental lines. The beams bunched for these 388 hours were ^{12}C and ^{18}O. All the pulsed beam runs were quite stable. Sometimes little fluctuations were observed in chopped beam which could be rectified by adjusting the chopper parameters.

Maintenance

Routine maintenance of chopper was carried out. In this maintenance, tuning of output of 100 W, 4 M Hz. amplifier for 50 Ω pure resistive load, was done for maximum power transfer. Thereafter, 50 Ω pure resistive load was disconnected and chopper tank circuit was connected at the output of chopper amplifier. Now, chopper tank circuit was tuned according to output of chopper amplifier for maximum power transfer and minimum reflected power.

As some drift in chopped beam was observed during normal beam run, a long term stability test of chopper was also done. This stability test was carried out for four days continuously. All the DC supplies in 100 W rf power amplifier were checked for ripple. All of them were fine. The stability test was first done with 50 Ω pure resistive load at the output of amplifier and then with actual chopper tank circuit load. With 50 Ω pure resistive load, no amplitude drift, at the output, was noticed but with actual load some amplitude drift was noticed. This drift was not continuous. This needs further investigation.

1.1.5 DEVELOPMENT ACTIVITIES

S Chopra, R Joshi, S Gargari, M Sota, S Ojha, K Devarani, V P Patel, R P Sharma, J Prasad, R Kumar, M P Singh, N S Panwar, S Mohan, Suraj Kumar and Pranav Singh

The development activity done during the mentioned period is mentioned below.

Installation of new modified MC – SNICS source

The MC – SNICS source was operating satisfactorily since 2002. Although this source worked fine, it had some operational problems. The operational problems mainly encountered were the shorting of einzel lens and General Purpose tube (GP tube). The cesium handling, while loading cesium into cesium reservoir, was quite cumbersome. Also the connection of cathode power supply to cathode was floating type. This sometime creates the contact problem.

As NEC, USA developed a new MC – SNICS source which was modified to take care of all the problems discussed above. This modified 40 samples MC – SNICS source uses solid samples only. Its modification is based on the development carried out by different AMS groups. It was decided to replace existing MC – SNICS source by modified one. Therefore, this modified source was tested and procured from NEC, USA. It has been installed in the month of February 2012.

The salient features of this modified source are -

1) The new source has spherical ionizer which focuses the cesium beam at the cathode material so that 90 to 95% of the cathode material can be used effectively.

2) Instead of cesium focus lens the new source has cesium flow diffuser and immersion lens assembly. The cesium diffuser diverts cesium only to the surface of the spherical ionizer. This reduces the probability of shorting of einzel lens assembly and GP tube assembly.

3) The cesium line has been replaced by vacuum insulated cesium feed line. Vacuum insulated feed line allows normal operation with an oven temperature of 90 degree C instead of 130 degree C. Due to this lower temperature operation, cesium does not migrate to the einzel lens and GP tube assemblies.

4) The cesium reservoir and the cesium oven heater have been modified. This modification allows to drop 5 g. ampule of cesium directly into the reservoir, which was not possible in old source. This makes the cesium handling easier. One 5 g. ampule will last, for normal operation, for 10 to 11 months.

5) Modification has also been incorporated to remove the floating contact to cathode wheel. The cathode contact is no longer done in the vacuum, as it was in old source. This modification makes the cathode contact more positive and also there is no need to break the vacuum in case of any cathode contact problem.

1.2 LOW ENERGY ION BEAM FACILITY (LEIBF)

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1.2.1 OPERATION

The old LEIBF [1] has been upgraded and installed in the beam hall (L shape) of materials science building of Inter University Accelerator Centre (IUAC). Three dedicated experimental beam lines, a double storey 400 kV high voltage platform, a large acceptance analyzing cum switching magnet and a computer automated measurements and control (CAMAC) system are special features of the upgraded LEIBF. The layout of new LEIBF is shown in figure 1. The inset shows the 10 GHz all-permanent-magnet electron cyclotron resonance (ECR) source along with peripheral electronics on high voltage platform.

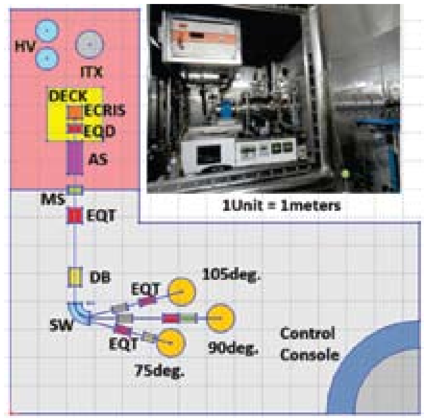


Fig. 1: Layout of new LEIBF. All permanent-magnet-ECR source along with peripheral electronics on high voltage platform are shown in inset.

The installation of new LEIBF has been completed in October 2011. Since then, facility is being used regularly to deliver the beams for the research proposals approved (~ 60) in the workshop held during 22-23 October, 2011 at IUAC. The preliminary beam tests in terms of optics and currents were quite satisfactory. A typical profile of 215 keV O^+ beam and beam spot (~ 4 mm) on target are shown in figure 2 (a) and 2(b) respectively.

Fig. 2: a) A typical profile of 215 keV O+ beam b) Beam spot on the target

Table 1 shows the charge state distribution (CSD) of oxygen ECR plasmas at E/q = 215 kV (platform voltage = 200 kV and extraction voltage = 15 kV). The input RF power was set at 20 W and gas pressure was optimized for maximum yield of singly charged ions. Up to +6 charge state, we could obtain reasonable good beam current. A few molecular beams were also observed in the plasma.

Ion Beams	Currents (eμA)
O^+	28.8
O^{+2}	5.73
O^{+3}	2.07
O^{+4}	0.43
O^{+5}	0.03
O^{+6}	0.02
O_2^+	4.00
OH^+	3.10
H_2O^+	0.38

Table 1: CSD of oxygen ECR plasma at E/q = 215 kV. The source parameters are optimized for maximum yield of singly charged ions

The quadrupole doublet on high voltage platform, accelerating column and quadrupole triplet in the pre-analysis section are used to focus the beam at the object plane of the analyzing magnet. The ion optical simulations show that this combination of lenses focuses the beams of different charge states at different points. This important point should be taken into consideration while delivering the beams of higher charge states with maximum intensities. The tests on the optimization of the beams of higher charge states at high E/q values are being done. Apart from the beam tests, various beams have been successfully extracted for conducting regular experiments (~ 11 so far), mainly on nano patterning on semiconducting surfaces, formation of ion beam induced amorphization, defect induced room temperature ferromagnetism in ZnO, light ion induced semiconductors on insulators via ion cut process, formation of Van der walls solids, conduction mechanism in alkali metals doped polymers.

1.2.2 MAINTENANCE

A travelling wave tube (TWT) based 200 W @ 10 GHz amplifier is used to develop the ECR plasma. This module is interlocked with vacuum inside plasma chamber. The regular operation of amplifier requires efficient cooling conditions in the ion source room. Very common faults associated with this particular module during operation are: filament not ready, cathode under voltage, low collector voltage etc. With spares electronics, engineering staff is capable of rectifying these problems.

The other maintenance works include repairing of

- High voltage safety interlock system
- Magnetic steerer and scanner power supply in pre-analysis section of LEIBF
- Log amplifier module to read current at Faraday cup

1.2.3 DEVELOPMENT

First time, the facility has been used to irradiate the large size (2” in diameter) wafers. A wide beam entry port, a magnetic scanner (built in-house) and a special beam profile monitor installed just after experimental chamber have been used for this purpose. This technique is quite useful for layer transfer on foreign substrates. Other major LEIBF associated development work includes:

- A dedicated experimental chamber in 90^0 beam line for implantation/irradiation purpose
- Six faces target holder for mounting large number of samples
- Mechanical assembly for precision rotary and liner (up/down) movement of target holder
- Mounting of CCD camera for viewing the beam on the target
- In-house high voltage safety interlock system
- CAMAC based control system for beam lines and analyzing magnet
- Fabrication and design of water cooled magnetic steerers and scanner power supplies
- Fabrication and assembly of electric quadrupole triplets and doublets
- Data acquisition system to study molecular dissociation dynamics in 105^0 line

REFERENCE:

[1] Development of metallic ion beams using ECRIS, P. Kumar, G. Rogrigues, P. S. Lakshmy, D. Kanjilal, Beer Pal Singh, R. Kumar, Nucl. Instr. and Meth. B, 252 (2006) 354

1.3 PELLETRON ACCELERATOR RBS-AMS SYSTEMS (PARAS)

1.3.1 OPERATION

Sunil Ojha

1.7 MV Pelletron accelerator and RBS facility was fully operational and performed quite well from April 2011 to March 2012. Around 2000 samples from 35 different Institute, University and college were analysed in this period. Most of these were simple RBS measurements performed with 2MeV He+ ions to analyse film thickness, composition analysis of samples and ion beam induced diffusion and sputtering measurements. Quantitative analysis of oxygen in high Z substrate were carried out at O(α,α) resonance reaction. This occurs at 3.037 MeV. Helium beam is delivered from accelerator at terminal potential approximately 1.505 MV. Channeling of Si (doped and undoped), InP, GaAs, GaN, STO, LaO, YBCO and TiO_2 were carried out for users. These measurements were done at room temperature and samples were both irradiated and pristine. Analysis of data is carried out.

1.3.2 MAINTENANCE AND DEVELOPMENT

Sunil Ojha, S Gargari, R Joshi, M Sota, Bishamber Kumar, R P Sharma, V P Patel, J Prasad, R Kumar, M P Singh, N S Panwar, S Mohan, Suraj Kumar, Pranav Singh, S Chopra and D.Kanjilal

In the academic year 2011-12 maintenance of ion source of RBS facility was carried out twice. Both of these were scheduled maintenance. Besides this there were two major breakdown in Pelletron accelerator which were quickly fixed and made operational.

Charge exchange RF source has operational lifetime of 1400 -1500 Hours. It has been reported in literature that this source becomes unstable due to wearing out of different its parts and / or chocking due to rubidium compounds. Last year source was rebuild twice, first in the April 2011 and then in October 2011. This maintenance was done after observing the instability in ion source and decrease in beam production from it.

Generating voltmeter (GVM) to measure terminal voltage of 1.7 MV Pelletron accelerator, stopped functioning. Its maintenance was performed without actually opening up of accelerator tank. The insulating gas was pumped into storage tank and GVM was removed. It was noticed that its bearing has gone bad. Bearing was replaced and GVM was tested and installed back on the accelerator tank. Terminal voltage was calibrated initially by tuning beam through switcher magnet set for known energy. Fine calibration was done by carrying out ^{16}O (α,α) resonance reaction at 3.037 MeV.

Pelletron accelerator tank developed a leak due to which pressure of Sulfur Hexafluoride inside tank started decreasing. Leak rate was too small to detect by convention soap bubble test. Leak was located at the O-ring of shorting rod drive with the help of halogen leak detector. After safely pumping of SF6 gas into storage tank, O-ring was replaced. Loss in the gas was compensated by charging of more gas into the SF6 storage vessel from commercial gas cylinders available in stock. Pelletron accelerator tank was once again pressurized at 74 psi with SF_6 gas. Leak testing was done and no leak was found.

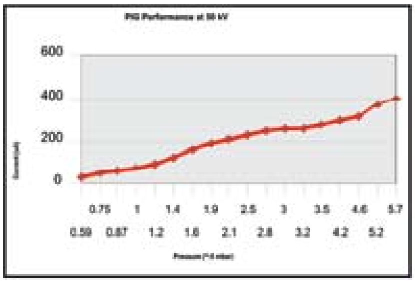
To analyze and interpret RBS data, standard software packages like RUMP and SIMNRA are used. To provide support to the user community, 4 personal computers with the licensed version of these software have been installed.

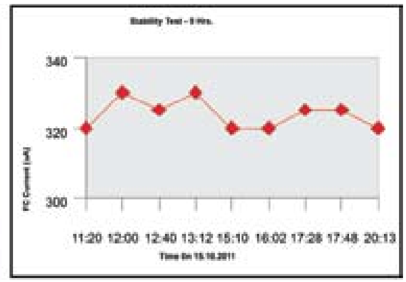
1.4 DEVELOPMENT OF 50 KEV ION ACCELERATOR

Raj Kumar, Rajeev Ahuja, C. P. Safvan

PENNING ION GENERATOR

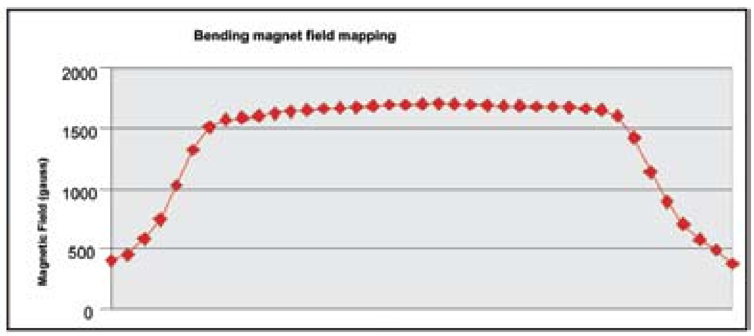
Development of low energy accelerator was started a year ago with a concept of having stand alone table top type machine requiring minimum components & utilities. Cold cathode Penning ion generator has been designed & fabricated in house by IUAC which can deliver Alpha & Proton beams of around 350 uA with acceleration voltage of 50 kV. The source is assembled inside nylon cylinder to provide isolation of 50 kV. The source is assembled by using small permanent magnet, stainless steel cylindrical anode, feed thru's, MS cathode body with face plate, extractor etc. This has been installed on a vacuum chamber with turbo pump, faraday cup, suppressor etc & tested for maximum current of 400 uA. Stability test at 320 uA has been carried out for 24 hrs and found that the source can deliver quite stable current as shown in the following figure.





PERMANENT MAGNET BASED BENDING MAGNET

A bending magnet has been assembled by using pallets of permanent magnet to get a stable field of 1600 gauss as required for accelerator. The magnet has beam pipe of cross section 60X75 mm across the magnet with a bending radius of 200 mm. The poles of magnet have been fabricated in circular shape by using 10 mm thick MS plates. Shorting bolts have been used to vary the magnetic field for beam energy selection. Field mapping has been carried out and found to have quite homogeneous field throughout the poles as shown in the figure.



QUADRUPOLE TRIPLET FOR 50 KEV ACCELERATOR

An electrostatic quadrupole triplet has been designed and fabricated for use in above accelerator. It has poles of 100, 185, 100 mm long with 56 mm radius. The quadrupole has a total length of 421 mm with 60 mm aperture. It has been designed to use a maximum of 3 kV for focusing of 50 keV beam at 450 mm distance.