2. ACCELERATOR AUGMENTATION PROGRAM

2.1 LINAC

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2.1.1 Activities related to superconducting Linear accelerator

To boost the energy of ion beam from the existing 15 UD Pelletron, the first module of the superconducting linear accelerator (consisting of total three modules) is commissioned at IUAC [1,2,3]. Recently the complete operation of the linac had been demonstrated with the superbuncher (SB), a single accelerating module and the Rebuncher (RB) cryostat. The other two linac cryostats and the required 16 resonators to be installed in those two cryostats are in the final stage of fabrication and expected to be installed by the end of 2008.

2.1.1.1 Off-line (without beam) cold test of the resonators in superbuncher, linac and Rebuncher cryostat to test the different modified accessories of the resonators

In 2006, beam was accelerated by five out of eight installed resonators in the first module of linac [4]. At that time, the rebuncher resonator was not installed. So time width of the bunched beam at the location of user's scattering chamber could not be compressed. Last year, resonators each having accelerating field up to ~ 3.5 MV/m had been installed in rebuncher cryostat. Out of two resonators installed in RB cryostat, one resonator was fabricated in-house at IUAC. The rebuncher cryostat along with the couple of resonators prior to its closing is shown in fig 1.

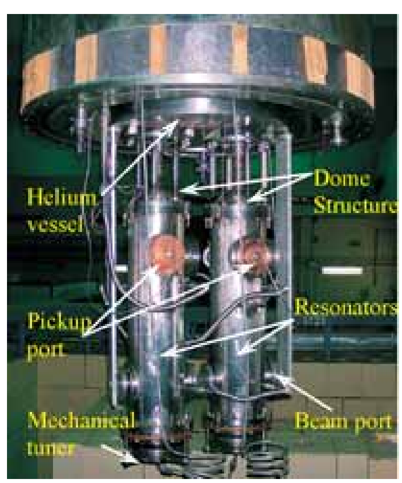

Fig. 1. A couple of Quarter Wave Resonators (QWR) installed in the rebuncher cryostat prior to cold test

During several cold tests, a new design of the power coupler, already fabricated in last year (shown in figure 2), was tested with the two of resonators in RBC. Subsequently, the new power couplers were installed in other resonators in linac and superbuncher (SB) cryostats. Replacement of the power and pick-up cable with 100% shielded cable was another major task accomplished in this period. This replacement was necessary to reduce the RF leakage from 95% shielded cables used earlier. During these off-line tests, the Belleville washers in the slow tuner fixtures were replaced by SS-springs (figure 3) and were successfully tested with the superconducting resonators of SB, linac and RB cryostats. With SS-springs, the frequency range had been increased by a factor of two compared to the frequency range measured with the old fixture. During two successful off-line tests in April and July 2007, the average fields obtained from the linac resonators are shown in figure 4.

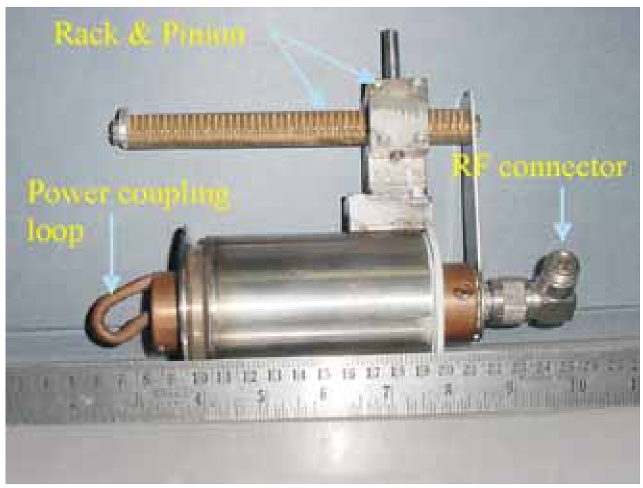

Fig. 2. The new drive coupler which is now installed in all the resonators in SB, linac and RB cryostats

Fig. 3. The first picture shows the slow tuner fixture with Belleville washers (old design). The second picture shows the washers are replaced by SS-springs (new design)

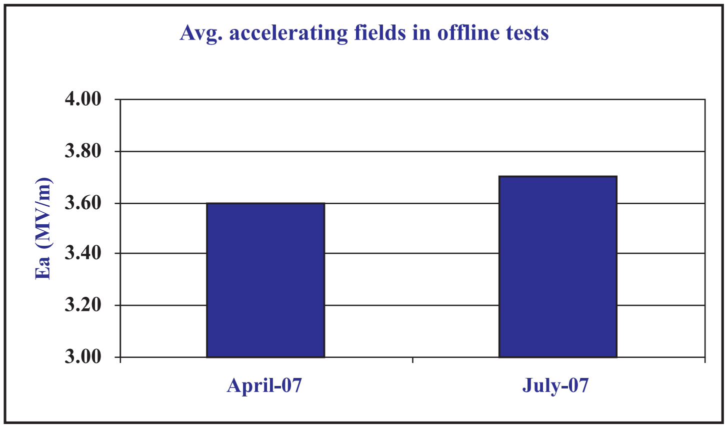

Fig. 4. Average accelerating fields of linac resonators during off-line tests in April and July 2007

2.1.1.2 On-line beam acceleration with superbuncher, linac (the first module) and Rebuncher

Towards the end of last year, all the modifications in the resonator accessories were tested and the resonators in SB, linac and RB cryostats, were made ready for beam acceleration. In November 2007, 130 MeV $^{28}Si^{+10}$ beam from Tandem was initially pre-bunched by the Multiharmonic buncher with the dark current removed by the high energy sweeper and a time width of ~ 1.1 ns was obtained at the entrance of the SB resonator. By carefully adjusting the phase and amplitude of the superbuncher resonator, a time width of ~ 250 ps had been measured at the entrance of linac cryostat with the help of cooled thin (50 mm) surface barrier detector. The time widths of the beam bunch with the resonator in SB 'Off' and 'On' condition are shown in fig 5. The beam of 250 ps was then injected into the seven resonators of linac cryostat and a total energy gain of about 28 MeV was measured from all the resonators of linac cryostat by another thick surface barrier detector (300 mm) installed at the exit of linac. The energy spectrum of the beam from the Pelletron and after every resonator in linac is shown in fig 6.

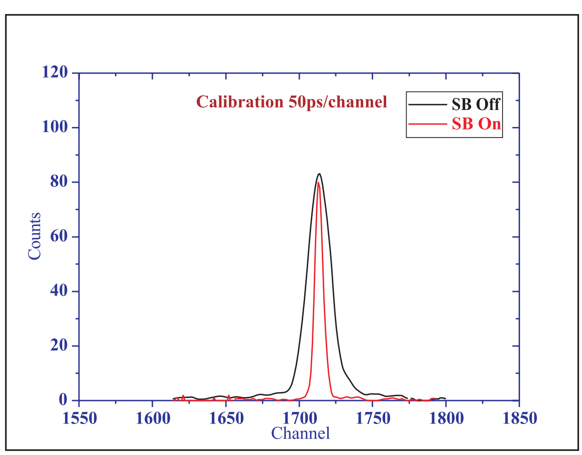

Fig. 5. The time spectrum of the bunched beam at the entrance of linac resonators

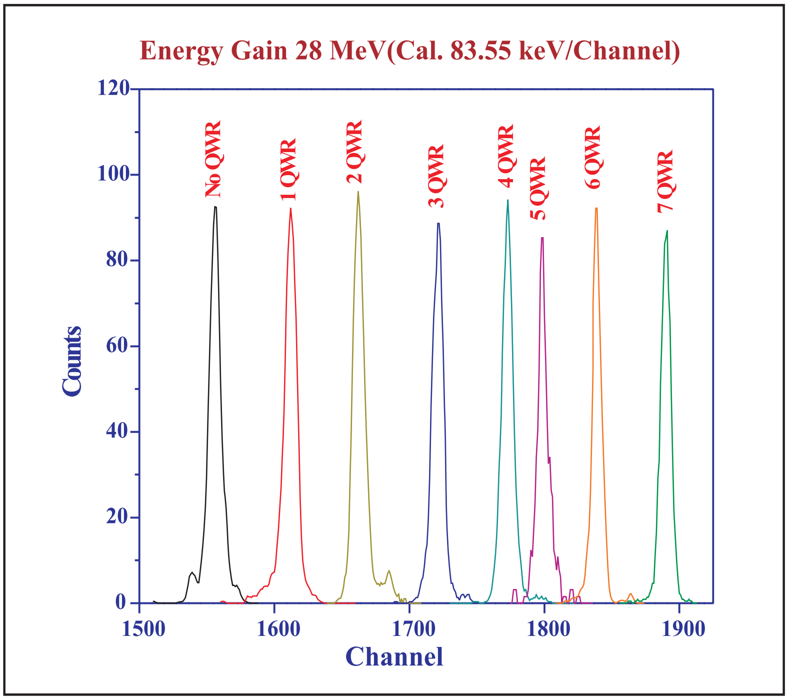

Fig. 6. The energy spectrum of the beam from the Pelletron and after turning on the seven resonators one by one in linac cryostat

The beam was then transported up to the rebuncher which was located about 14 meters down the line from the first linac cryostat. With the help of the switcher magnet, beam was further tuned up to the location of an experimental scattering chamber, at about 13 meters from the rebuncher cryostat. A pair of thick (300 mm) and thin surface (40 mm) barrier detectors cooled to subzero temperature were installed in the scattering chamber to measure the energy and time width of the beam bunch.

By optimizing the reference phase of a single resonator of the RB cryostat and then by changing the amplitude of the accelerating field, time width of the beam bunch as measured by the detector at the scattering chamber could be compressed from 1.1 ns to ~ 400 ps. A nominal accelerating field of ~ 1.7 MV/m was found to be adequate from a single resonator of the rebuncher cryostat to re-bunch the beam at the experimental chamber. The time width of the beam bunch with the single rebuncher resonator Off and On condition is shown in fig 7. With a more systematic approach to vary the bunching field of the rebuncher in smaller steps and proper adjustment of the nuclear electronics, the time width of the beam bunch could be matched with the value obtained at the entrance of linac by the SB.

In December 2007, 100 MeV $^{16}O^{+8}$ beam from Pelletron, pre-bunched by MHB and low energy chopper, a time width of ~1.0 ns was injected into SB. The resonator in SB had produced a time width of ~160 ps at linac entrance and finally after acceleration by seven resonators in linac, a total energy of 120 MeV was obtained at the exit of linac. The average field obtained from the resonators was ~ 3 MV/m from beam energy calibration. This beam was then re-bunched by a resonator in RBC and a time width of ~ 500 ps with 120 MeV was delivered at the experimental chamber. The beam was then used for about a week by an experimental group to study fusion-fission reaction dynamics using neutron multiplicity measurement.

The fabrication of the second and third linac modules with sixteen resonators is going on in full swing. These modules are expected to be installed in the beam line within a year.

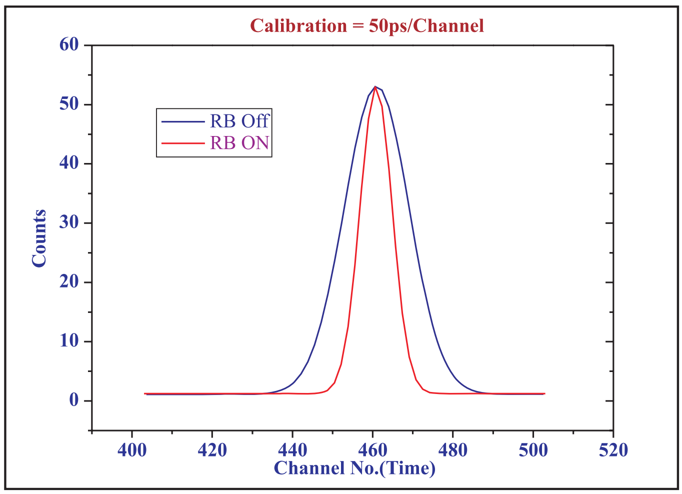

Fig. 7. The time spectrum of the bunched beam at the location of the user's scattering chamber with rebuncher off and on

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[3] S.Ghosh, R.Mehta, G.K.Chowdhury, A.Rai, B.K.Sahu, A.Pandey, D.S.Mathuria, S.S.K.Sonti, K.K.Mistry, P.Patra, S.Ojha, A.Sarkar, R.Joshi, P.N.Prakash, A.Mandal, D.Kanjilal and A.Roy, Proc. of Indian Particle Accelerator Conference 01-05 March, 2005, Kolkata, India, page 48.

[4] IUAC Annual Report 2006

2.1.2 Superconducting Niobium Resonators

P.N.Prakash, S.S.K.Sonti, K.K.Mistri, J.Zacharias, D.Kanjilal and A.Roy

Production of fifteen niobium quarter wave resonators for the second and third linac modules is nearing completion. Initial work for the construction of two single spoke resonators for the proton driver linac at Fermi National Lab has started. Repairing of two ANL built and one indigenously built resonator is also nearing completion.

Resonator Production for the 2nd & 3rd Linac Modules

The production of fifteen niobium quarter wave resonators for the 2nd and 3rd linac modules is nearing its completion. Last year a major effort went into electropolishing all the niobium assemblies, viz. the Outer Housings, Loading Arms, Drift Tubes and Top Flanges. Each assembly was electropolished to remove approximately 150 m from the surface. Wherever possible multiple assemblies were electropolished in a single setup to increase efficiency and save time. After electropolishing, welding of the major assemblies began for completing the bare niobium resonators. This work, however, was done systematically to ensure that the RF frequency scatter was kept to a minimum. The length of the Resonator's Central Conductor primarily decides the RF frequency. Initially a single resonator was completed and its frequency was measured. Based on this data two more resonators were completed and their frequencies were measured. Finally, the Central Conductor length was further fine tuned and the remaining twelve resonators were completed. Although this took longer than that required for finishing all the resonators together, it helped in achieving the frequency close to the desired value in most cases. Figure 1 shows the niobium Top Flanges and figure 2 shows the niobium Central Conductor assemblies after electropolishing. Closure welding on half a dozen resonators has been done to complete the bare niobium portion of the resonators. The remaining resonators are also ready for the final welding.

Fabrication of the niobium Slow Tuner Bellows began as the electropolishing work on the major resonator assemblies neared completion. The slow tuner is mounted at the open end of the resonator. In order to determine the open-end length of the housing for providing appropriate capacitive loading and therefore the required tuning range from the slow tuner, we have decided to complete one slow tuner assembly. This work is presently nearing completion. Simultaneously several components for the remaining slow tuner bellows have been machined and formed.

The stainless steel outer jackets (helium vessel) have been fabricated and electropolished. They have been cut into two halves for the clamp shell assembly. Other items for the outer jackets, such as the top domes, CF flanges and pre-cool channels have also been fabricated.

Fig. 1. Niobium Top Flanges after electropolishing. Twelve, out of the fifteen, flanges are shown

Fig. 2. Niobium Central Conductor assemblies. Twelve, out of the fifteen, assemblies are shown

Single Spoke Resonators

IUAC has agreed to fabricate two Niobium Single Spoke Resonators operating at 325 MHz, b=0.22, for the Proton Driver Linac of a High Intensity Neutrino Source at Fermi National Accelerator Laboratory, USA as a collaborative program. Figure 3 shows an exploded view of the single spoke resonator. The fabrication will be done similar to the IUAC quarter wave resonators, i.e. the machining, sheet metal forming and fitting of the niobium components will be carried out by a commercial vendor. The electron beam welding, electropolishing and heat treatment will be done using the existing facilities at IUAC. Several technical discussions have been held with the outside vendor to identify the required tooling (dies and machining fixtures). Fabrication of the tooling will start shortly and the actual resonator fabrication will begin after that.

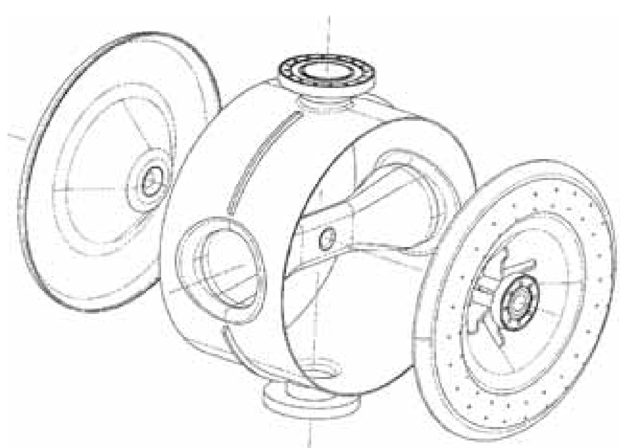

Fig. 3. Niobium Single Spoke Resonator, b=0.22, f =325 MHz

2.2 CRYOGENICS

T.S. Datta, J.Chacko, A .Choudhury, J. Antony, M. Kumar, S. Babu, S.Kar, R.S.Meena and A. Roy

In this academic year, four cold tests have been performed for resonators in the beam line cryostats of Rf-Superconducting LINAC. Beam was accelerated through the 1st Linac module twice in this year. Some user experiments had also been performed using the accelerated beam of LINAC. Performance of beam acceleration tests is reported in Linac section.

2.2.1 Cryogenic Facility

I. Liquid Helium Plant

The helium plant was operated five times and out of which four runs were in close loop mode for off-line testing of the resonators and beam acceleration through Linac. Estimated total production of LHe was ~ 100000L and the running hour is 1100hrs which is almost same as last year as shown in fig. [1]

Fig.1. Bar Chart of Liquid Helium Production

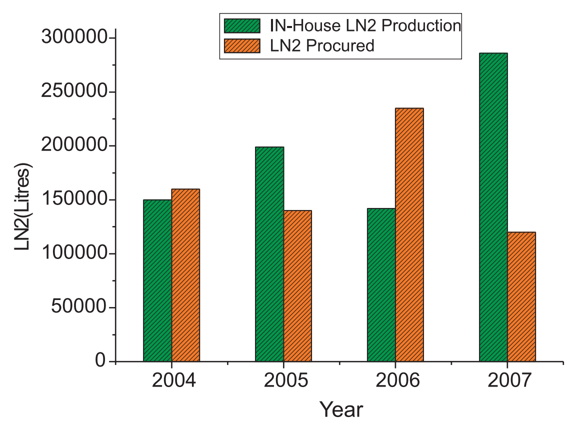

Fig. 2. Bar Chart of Liq. Nitrogen Production &Procurement

II. Liquid Nitrogen Plant

The demand for the liquid nitrogen was increased significantly on account of prolonged offline test, beam acceleration test of LINAC and large number of germanium detectors installed in the newly developed INGA facility. The estimated liquid nitrogen production was 2,86,000 L which is much higher than last year which is shown in the fig. [2]. The in-house LN2 production has been increased due to the up-gradation of the LN2 plant by installing higher capacity PSA system and running both cryogenerators simultaneously. LN2 procured from outside vendor was ~1,20,000 L which is significantly lower than last year. It has been measured that when the amount of nitrogen vapour returning to the suction of the LN2 plant increases, the production rate is enhanced provided the return temperature is close to 86K. Fig.[3] shows the profile of the LN2 production rate.

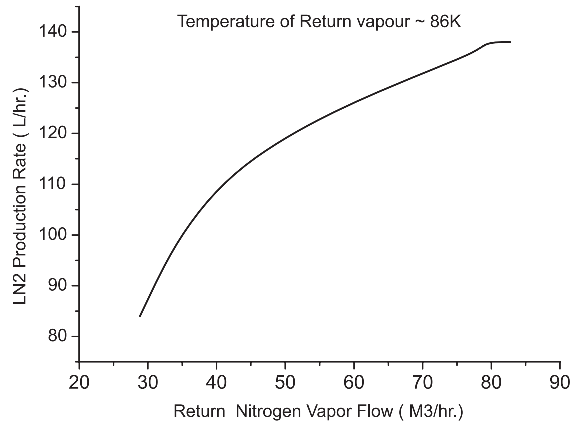

Fig. 3. The dependency of LN2 production rate on the return gas temperature

III. Helium Gas Purifier and Recovery System

Leak developed in critical position of the automatic purifier was rectified and it was re-integrated with the helium recovery system after few thermal shocks at high pressure. In this year 1900M3 of helium gas has been purified by using both automatic and manual purifier. The amount is less in comparison to the last year because of the close loop runs in this year. There was less number of open loop helium cooling for STC and MLI test set up.

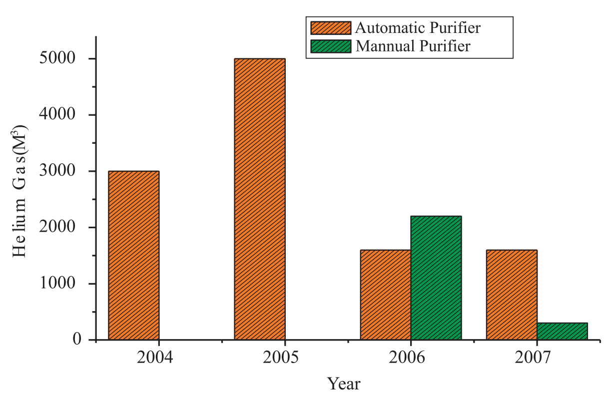

Fig. 4. Bar Chart of Helium gas purification

2.2.2 Performance Report of Cryostats

I. 1st LINAC Module

Four cold tests have been performed with 8-QWRs in the 1st Linac module. The beam was accelerated through the Linac twice in this year.

I.1 Helium Precooling of LINAC Module

A new cooling scheme has been incorporated in the 1st Linac module. Once the resonators are precooled upto 150K by forced flow of nitrogen, liquid helium is forced to flow through the precooling channel of resonators along with the direct liquid helium filling to it's LHe vessel and resonators. Hence the cooling time between 150K to 4.2K for eight resonators have been reduced to 9 hrs. Figure [5] shows the difference in cooling time for both with and without helium precooling.

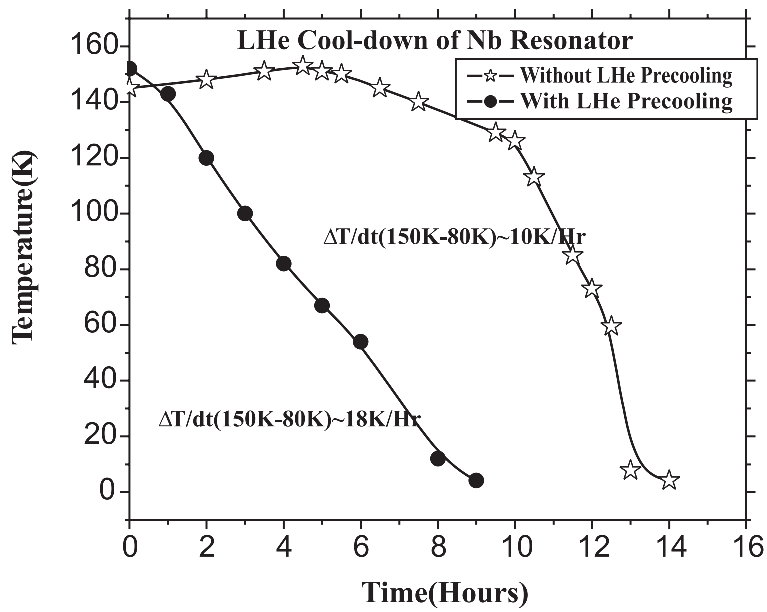

Fig. 5. The cooling profile of resonator with and without liquid helium precooling

II. 2nd and 3rd LINAC module

The development of the 2nd and 3rd Linac module has been started in this academic year. Some significant modifications have been incorporated for these two modules based on the operational experience of 1st module. One of the major modifications is the change in methodology of liquid helium(LHe)cooling, LHe will directly be delivered at the bottom of resonator through a LHe-manifold inside the LHe vessel instead of top LHe filling at the existing module. There is also provision for helium vapour precooling by circulating the evaporated helium vapour through the precooling channel of the resonators. The support structure has also been modified to achieve better temperature for resonator -support bar, two stainless steel rails will be used instead of the rectangular aluminum bar. Therefore the cooling of the bar will be faster as the specific heat of SS is less than that of aluminum and the total cold mass is also reduced. Two SS sheets used for the support structure will be replaced by the cross-SS tubes and rods. Finally the LN2- forced flow cooling of copper thermal shield will be replaced by the therosiphon cooling as described in gravity cooling experimental set up (2.2.4.I).

2.2.3 Other Projects

I. DST Project on Development of Cryofree superconducting magnet with Room temperature bore

A project on development of cryogen free superconducting magnet system with room temperature bore has been sanctioned by Dept.of Science and Technology. The magnet has been designed for 6Tesla and the designing of the cryogen free system is based on the energy balance diagram shown in fig [6].

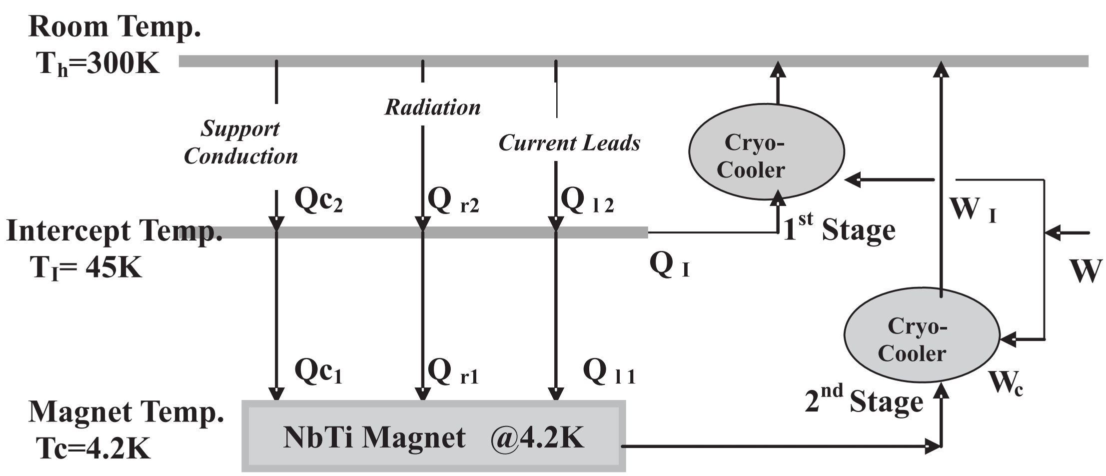

Fig. 6. The energy balance diagram of cryogen free magnet system with two stage cryocooler

Major Scope of work:

1. Design of a 6 T Superconducting magnet (using NbTi conductor) with a 70 mm inner bore.
2. Design of cryostat with minimum heat load, to house the above magnet with a room temperature access of 50 mm.
3. Integration of the system (intermediate thermal shield with 1st stage and the magnet with the 2nd stage) with two stage GM cryocooler of capacity 35W@ 50K and 1.5K@4.2K.
5. Detailed calculations of the heat load to the two stages of the CCR to be carried out and optimized.
6. Technique to join current leads (copper leads to the HTS leads and HTS leads to the magnet) to be developed so as to have lowest possible contact resistance and techniques for good thermal anchoring and electrical isolation of the HTS current leads.
7. The whole system to be assembled and tested performance at least for 100 hours.

II. BRNS Project on Helium Gas separation by using membrane

In Indian context, Monazite sand is the potential source of helium gas compared to natural gas. Early reports on monazite sand estimates that the crude gas could be obtained 20%-30% and rest is air. Based on the input values, a feasibility report on separation of helium from air by using cascade system of pressure swing adsorption (PSA) and membrane module was submitted to BRNS. The project initially has been sanctioned for helium separation by using membrane only.

A process schematic with crude gas, membrane module along with analytical measurement system is planned. Exploration of suitable membrane module is under progress.

2.2.4 Other Developments

I. Gravity Cooling Experimental Set up

The new flow scheme has been proposed for the thermal shield cooling of 1st Linac module based on the experience of gravity cooling experimental set up. Figures [7.a] and [7.b] show the present flow scheme in 1st Linac module and the proposed one for 2nd and 3rd module. The thermal contact conductance (TCC) has been measured for each copper clamp which provides thermal and mechanical anchoring of the copper shield with the tube through which LN2 is flowing at 78K. The TCC is 2W/clamp/K.

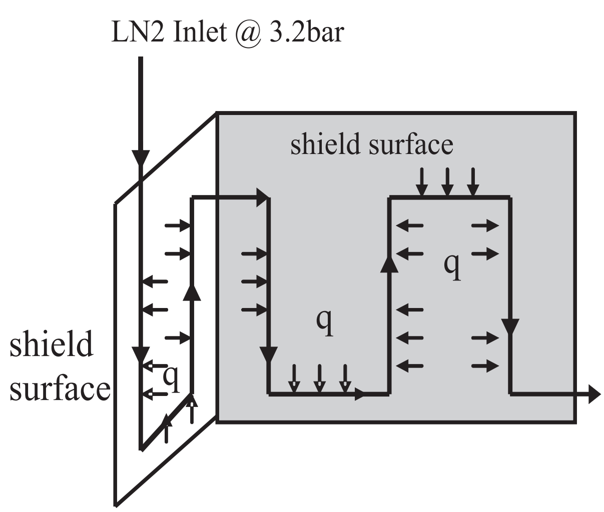

Fig. 7a. Present forced flow shield cooling scheme [series flow]

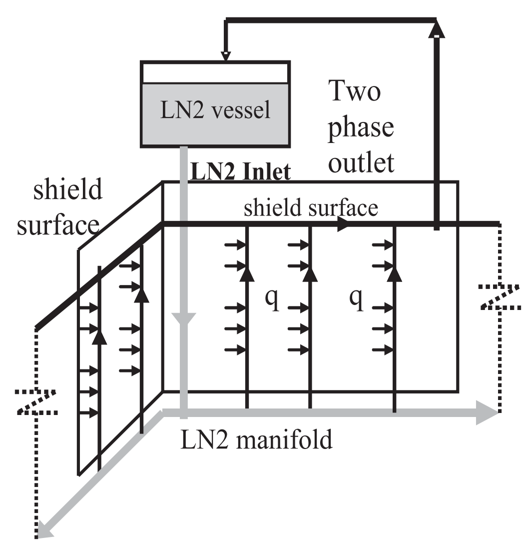

Fig.7b. Proposed thermosyphon flow scheme for shield cooling [parallel flow]

The thermal cooling requirement of actual copper shield for 2nd and 3rd cryomodules has been scaled down using the performance of these copper clamps in the above test set up.

II. Cryocooler Test Setup (CTS)

Some new techniques to provide good thermal contact and electrical isolation for the HTS current leads has to be implemented in the cryogen free magnet system. Therefore a two stage cryocooler based test set up has been developed to do the experiments on the thermal contacts at the temperature range 4.2K to 50K.

Some experiments on thermal contact resistance between Aluminum nitride and copper or aluminum, thermal conductivity of aluminum nitride have also been planned in this test set up. The CTS has been shown in fig.[8]. Sumitomo made two stage GM cryocooler (SRDK 415D) has been installed in the CTS. The refrigeration capacity is 35W@50K at the 1st stage and 1.5W @4.2K. The setup is now going through the initial performance test.

Fig. 8. Cryocooler test set up

Development of cryocooler based helium liquefier to validate the helium re- liquefaction system for superconducting quadrupole magnet has also been planned in this test set up. The design for the helium reliquefaction system is going on.

2.3 RF ELECTRONICS

A. Sarkar, S. Venkataramanan, B.K. Sahu, A. Pandey and B.P. Ajith Kumar

2.3.1 Status Report of the Multi-harmonic Buncher & the High Energy Sweeper and associated jobs

The multi-harmonic buncher (MHB) was operated along with the low energy chopper (LEC) to provide 4 MHz pulsed beams to GPSC beamlines for 3 different users (Hardev Singh of Punjab University, T. Ghosh of VECC and E. Prasad of Calicut University). In Hardev Singh's run ^{12}C and ^{19}F beam pulses with FWHM ~ 0.8 ns and 1 ns respectively were delivered. During T. Ghosh's run ^{11}B and ^{14}N with FWHM ~ 1ns were delivered. In E. Prasad's run ^{16}O beam with 1ns FWHM was provided. Apart from these, this system was also used for few shifts to deliver ^{19}F beam with 1.2ns FWHM to user S. Nath in HIRA beam line.

For the first time MHB & LEC were operated to deliver beam to Linac beam line for user Bivash Behera of Punjab Univesity. For all linac runs normally high energy sweeper is used. But as the user required 4 MHz beam pulses, low energy chopper had to be used during this run. The sweeper was not operated. ^{16}O beam with 1ns FWHM was provided during this run.

2.3.2 VHF Preamplifier for Linac Phase Detectors

In Linac of IUAC, the beam energy is stabilised and controlled accurately by phase locking of resonators with incoming beam phase and magnitude. RF phase detectors placed at critical locations in beam line are used for deriving phase and magnitude information of beam to be delivered. Thus picked up RF signals are suitably filtered, boosted and fed to closed loop control circuit. The Pre amplifiers have 2 stages of CATV block (QBH2832-M/s.Remec) in cascade and filtered with two stage bandpass filter with passband at 48.5MHz [4]. These units have the following specifications and 3 such units have been delivered and being used with Linac successfully.

Gain	:	+60 dB
Bandwidth	:	6 MHz
Centre Frequency (fc)	:	48.5 MHz
Harmonics	:	- 58dB (2nd)
Noise floor	:	- 64dB @ 48.5 MHz
Supply voltage	:	+24V / 2A

2.3.3 New Developments in resonator control Scheme

The resonator control scheme is being used extensively with the present pelletron control system to accelerate the heavy ion beam from tandem through Linac for user experiments. The feasibility study to automate the phase and amplitude lock of resonators is carried out. The RF power read back during lock condition and also during cavity conditioning is added for remote monitoring using a 16 channel RF power linearizer box along with CAMAC ADC. A stepper motor control scheme with CAMAC control interface is developed for the movement of RF drive couplers from remote locations. It will be integrated with the present control scheme soon. The control set up for re-buncher cryostat is also added to the existing control scheme

A wire less transmission point is set up along with existing control network. This enables us to access the control system page from any location in data room and adjacent areas using wireless access.

2.3.4 Development of 291 MHz VHF Amplifier

A VHF amplifier has been developed for the study of higher harmonics coming from the Superconducting QWR. It has filter sections followed by four stages of amplification. It has been designed for amplifying very weak signals (-80 dBm to -40 dBm). The overall gain of the amplifier is 60dB. It offers 65dB attenuation to 97MHz signal. This amplifier has been tested and found to be working satisfactorily.

2.4 BEAM TRANSPORT SYSTEM

A.Mandal, Rajesh Kumar, S.K.Suman, Mukesh Kumar and Sarvesh Kumar

Beam Transport System laboratory takes care of regular maintenance, design and development of Accelerator beam Transport System. Several magnets and power supplies for them have been indigenously developed. Besides, BTS laboratory has also been developed different type of high voltage, high current power supplies and other useful instruments for most important projects running at IUAC and their mass production have been done by BTS lab to substitute the import to save huge money and ease of maintenance.

2.4.1 Beam Optics for LEIBF Facility in New Low Energy Ion Beam Laboratory

The Beam Optics of LEIBF Facility has been carried out for all the three beam lines 75^0, 90^0, 105^0 using TRANSPORT Code up to first order. The beam optics is based on the parameters: emittance = 100 pi mm-mrad and M/q =96, E =300kV. However we found that to transport beam of lower energy from ECR, we need to reduce emittance as shown in table -1. A typical beam optics simulation for 30 kV & 300kV for 90^0 beam line is shown in figure-1. The layout design of different components based on the ion optical design is as shown in figure-2.

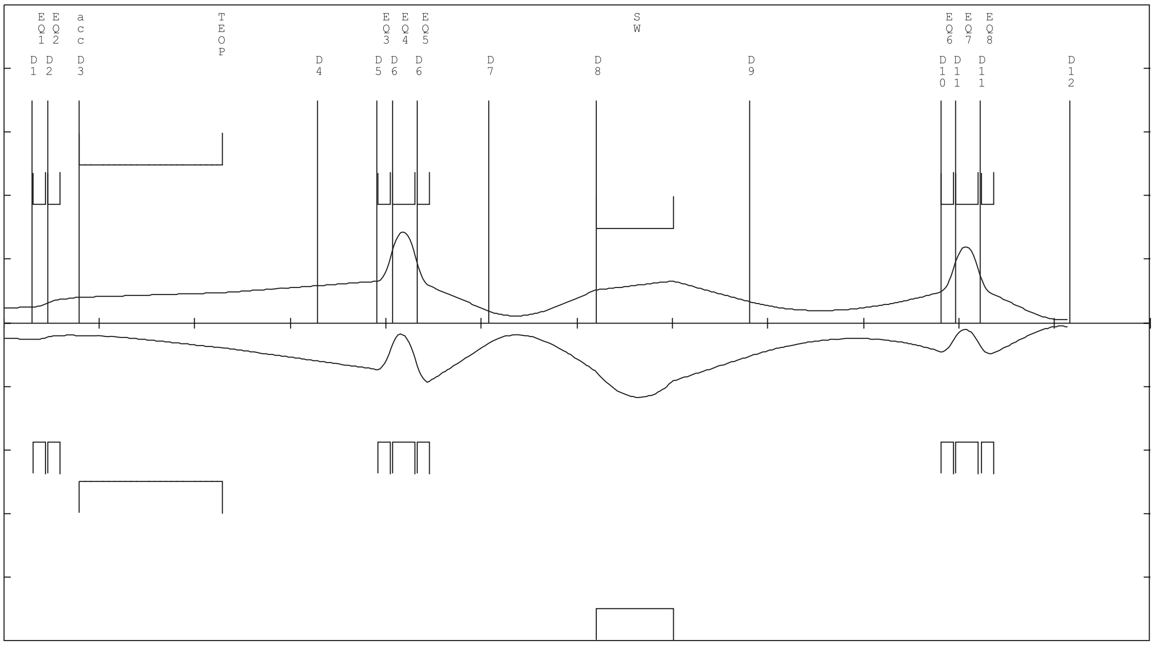

Fig. 1a. Beam Optics of 90^0 beam line using TRANSPORT code at 30 kV

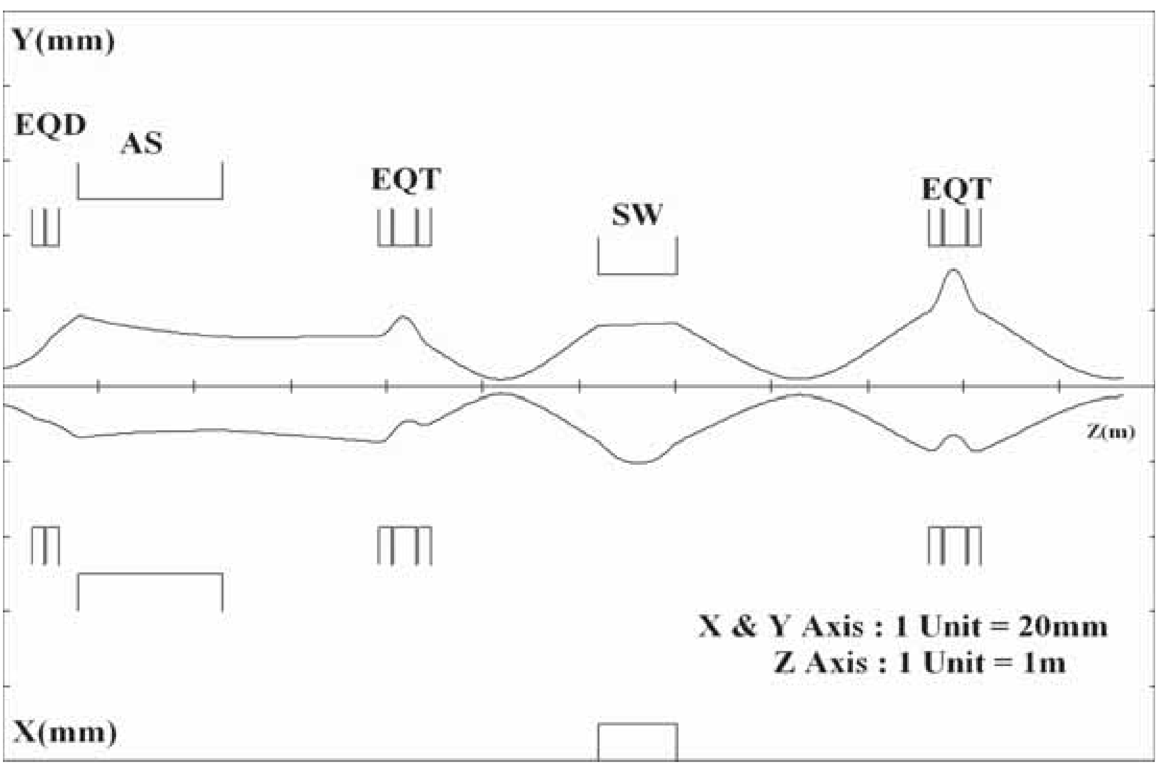

Fig. 1b. Beam Optics of 90^0 beam Line using TRANSPORT code at 300kV after adjusting beam diagnostics components

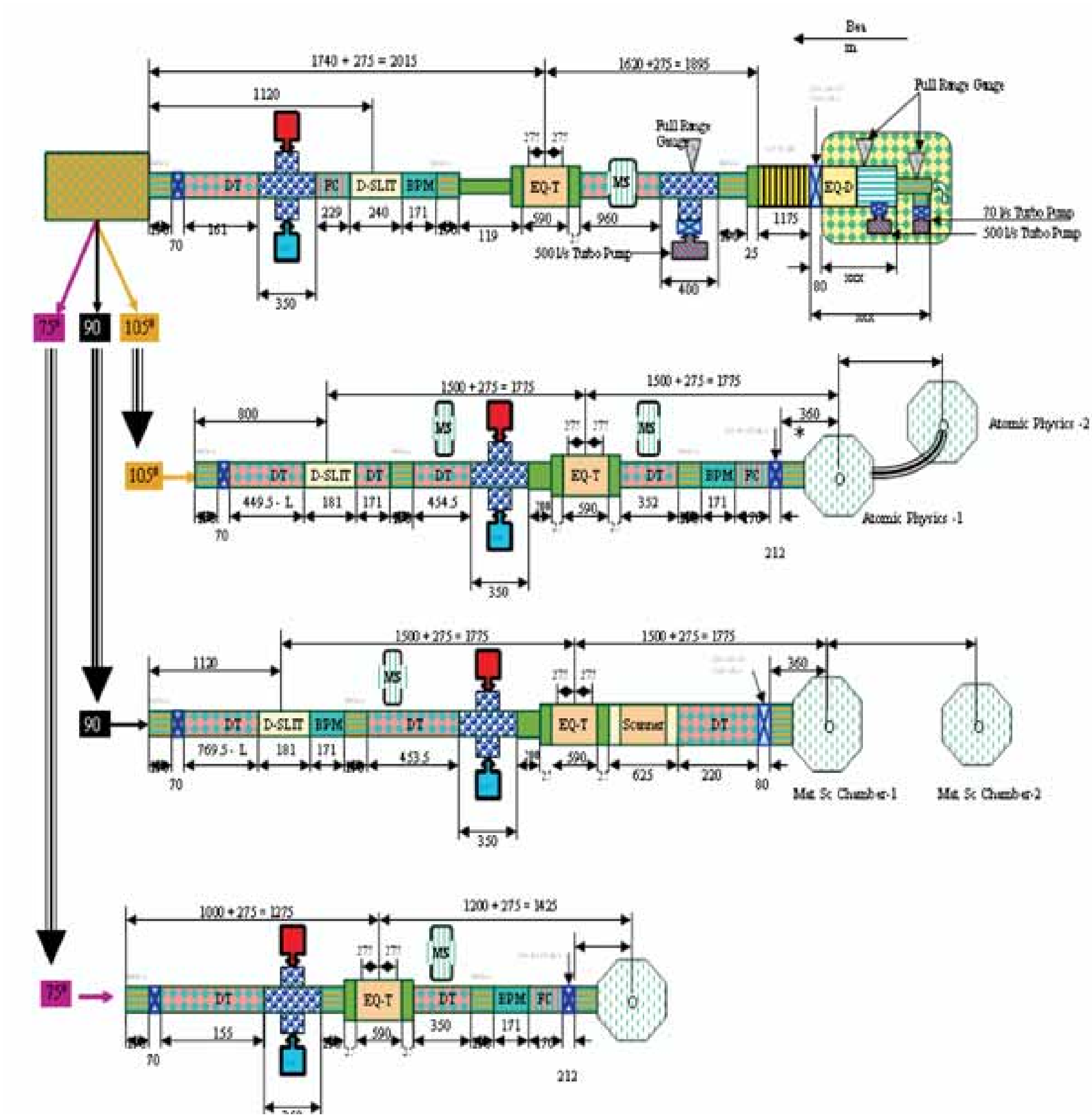

Fig. 2. Component Layout of New LEIBF Facility

2.4.2 Design of Switching Magnet for LEIBF

The beam optics of switching magnet has been carried out by using simulation program TRANSPORT and GIOS. Simulation Results are presented here for all the beam lines. The order for fabrication of Switching Magnet was placed to Danfysik Denmark. The hardware design of the magnet was done using 3D TOSCA program. The magnet has been successfully tested and measured results are compared with specified values. The test results agree well with the specified values.

Parameters	Specified Values	Measured Values
B_{max} (T)	1.5@240Amps	1.55@240Amps
Entrance Angle (deg.)	29.1	29.05
Exit Angle (deg.)	17.3,30.6,42.9	15.95, 30.66, 43.09
L_{eff} (mm) from pin hole	95 (Entrance) 95,95,115 (Exit)	96 (Entrance) 95.78, 96.4, 113.28 (Exit)
Homogeneity (center)	1*10-3 over +/- 40 mm	7*10-4 over +/- 65 mm

Fig. 3. Comparison of measured values of Parameters of Switching Magnet with specified values

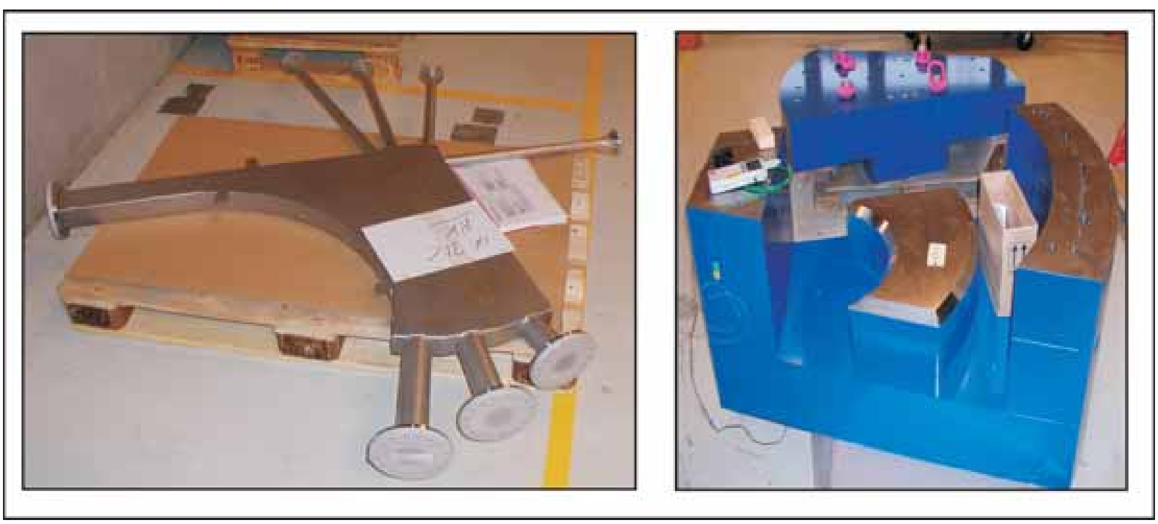

Fig. 4. Chamber and Pole Design of Switching Magnet

2.4.3 Beam Optics of High Current Injector

Beam Optics of Low Energy Section of High Current Injector up to RFQ has been done using Magnetic Quadrupole Doublet (MQD) and Triplet (MQT) at the extraction side using TRANSPORT code. The initial Beam parameters are A/q =10, Voltage = 60kV, emittance=200 pimmmrad. A typical beam optics simulation using TRANSPORT code is shown in figure 5.

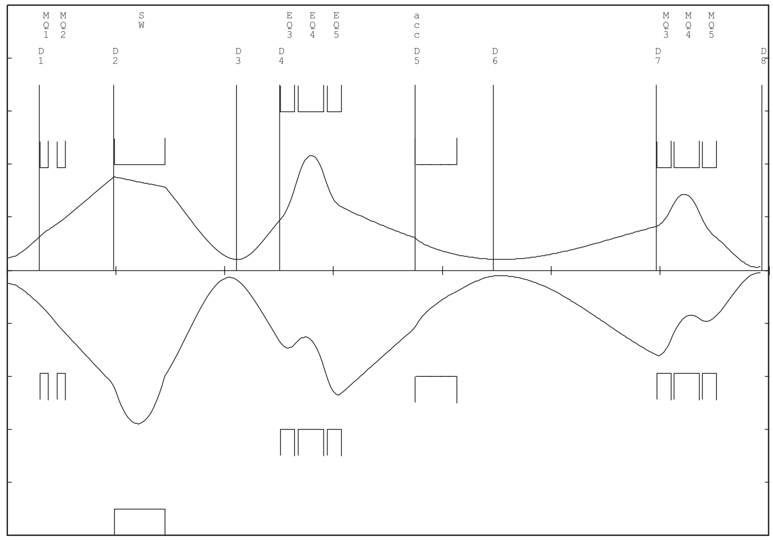

Fig. 5. Beam Optics of HCI from source to RFQ entrance at 60keV energy using TRANSPORT code using MQD at the extraction side

2.4.4 Fabrication of Spark Counter Chamber

Five Spark counter boxes have been fabricated having lots of flexibilities as mentioned in its features. The alpha particle is one type of emission that is possible from the nuclei of some atoms. This activity allows us to investigate how far these alphas can travel in air and other materials using spark counter.

Features of Spark Chamber

- Distance of Source from Anode wire can be adjusted to find the maximum counts position.
- Gap between the anode wire and cathode can be adjusted in order to vary the electric field between them.
- Height of source can be adjusted.
- Spark counter box is shielded by acrylic sheet from every side for radiation prevention.

2.4.5 Power Supplies for HYRA Quadrupoles

Fabrication of four numbers of high current high stability power supplies have been completed for HYRA facility. These magnet power supplies are DC current regulated supplies designed for applications requiring very high stability, high current combined with reliability. The power supply control electronics has been designed in modules for ease of maintenance. The advantages of indigenous developed are adequate control over spare availability and maintenance.

Output Specifications:

1.	Power range	:	10kW- 12kW
2.	Current range	:	300A
3.	Voltage range	:	32V and 42V
4.	Long term stability (8hrs)	:	10 PPM
5.	Line regulation (10% slow)	:	1 PPM
6.	Output ripple	:	20mV
7.	Ramp time (zero to full scale	:	10-100 sec.
8.	Current setting resolution	:	15 PPM (16 bit)

Input Requirements:

●	AC Mains Input	:	410V, 3 Phase, 50Hz
●	Input Power	:	12kW
●	Cooling Water	:	14 Ltr. / Min

Operational Features:

●	Regulation topology	:	Linear series transistor bank
●	Regulation Feedback	:	DCCT Transducer
●	Current Setting	:	16 bit DAC (15PPM)
●	Control	:	Local/ Remote (CAMAC)

Protection Features:

- Input Inrush current control,
- All power components are water cooled,
- 10 nos of interlock for safe operation- input over current & phase fail, Output over current, 0% TF, Regulation Fail, Load line, MPS Temperature, Magnet Temperature, Water flow.

Fig. 6. HYRA Quadrupole Power Supply

2.4.6 BGO / ACS Detector Bias Supply for INGA

40 nos. of high voltage power supplies have been indigenously developed and fabricated for biasing the BGO detectors in INGA at IUAC. These are 230VAC powered housed in double width NIM module which works on switch mode amplitude modulation technique operating at 24kHz. It provides extremely stable, low noise high voltage output upto 3 kV, 10 mA that is required to bias BGO ACS detector. Power supply has two regulation loops, one to control power dissipation and other to regulate output voltage. Many components have been customised to make the supply compact. EMI shielding and high voltage insulations are used to have low noise and to avoid local discharges. Power supplies are protected for over load and short circuit.

Specifications:

• Output Voltage Range	:	0 – 3kV
• Output Current Range	:	0 - 10mA
• Load Regulation	:	0.003%
• Long term drift	:	0.035% / 8 hrs
• Output Ripple	:	~20mVpp @ 50Hz
• Output Noise	:	±10mV @ 25KHz

Features:

- Selectable output polarity,
- Simultaneous output voltage & current display,
- Overload and short circuit protection,
- External control input for output voltage setting,
- Two parallel SHV outputs on rear panel.

2.4.7 Germanium Detector Bias Supply for INGA

50 nos. of high voltage supplies have been indigenously developed and fabricated at IUAC for biasing the germanium detectors for INGA facility. These are single width NIM based power supply which works on switch mode technique and high voltage is generated by Cockroft Walton multiplier. The power supply has an automatic output ramping facility where output always starts at zero volt and then ramp up to the value set by the front panel potentiometer at the chosen ramping rate. This feature protects detector while biasing with selectable ramping rate to prevent damage due to sudden voltage changes. This also saves time to bias multi-detector arrays consisting of large number of detectors. The commercially available bias supplies do not have this feature. Power Supplies are protected for over current and output short circuit.

Specifications

• Output Voltage range	:	0 – 5 kV
• Rated output current	:	0 – 50 uA

- Output stability : 0.1% (8 hrs)
- Noise and ripple : < 8 mVpp
- Output ramp Up/Down rate : 165 Volt per minute.

Features

- Selectable output polarity
- Reset button to start power supply
- Ready indication when set output achieved
- Output ramp Up/Down/Pause facility while ramping

2.4.8 Pre-amplifier Power Supply for INGA

15 nos. of portable pre-amplifier power supply have been developed and fabricated in house for INGA facility at IUAC. These are voltage regulated linear power supplies ideally suited for providing power to pre-amplifiers in remote locations. The power supply provides four highly stable and low noise output voltages to six pre-amplifiers through standard 9-pin connector on the rear panel. Each of the four series regulator circuits is identical in operation. The regulator operates in two modes. First and normal is the voltage regulation mode, second is the current foldback or current limiting protection mode. Second mode provides power limiting and protection to the regulator circuitry, when excessive current demands are removed; the regulator resumes the voltage regulation mode.

Specifications

- Outputs : +12V/ 1A , +24V/1A, -12V/ 1A,-24V/1A
- Load Regulation : < ±0.005 %
- Stability : ±0.01% per 12 hrs
- Noise & ripple : < 2mVpp
- Temp. coefficient : 0.001%°C (up to 40°C)

Safety features

- Input current limit : A fuse and a varistor
- Output current limit : Foldback current limit at 150%. Recovery is automatic
- Thermal protection : When heatsink temperature exceeds 80 ºC, a thermal switch turns off the power supply

2.4.9 1kV/20uA Surface barrier detector bias supply (Prototype development)

A prototype high voltage power supply has been developed for surface barrier detector and any other detectors which requires less than 1kV and upto 20uA current. The final development and its mass production will be done in future for neutron arrays project. This is a switch mode power supply which works on pulse amplitude modulation technique and provides necessary latchable safety interlocks viz. vacuum shutdown, power resume, overcurrent and output short.

The power supply has either polarity of high voltage that is selectable by internal jumper and polarity indication is provided on front panel of power supply. The bias voltage and current is also measured simultaneously on front panel.

Specifications

- Voltage range : 0-1kV
- Current range : 0-20uA
- Regulation : < 0.002%
- Ripple : <3mVpp @ 50Hz
- Noise : 2mV@ 25kHz
- Power requirements : +/- 24V, +/- 12V

Fig. 7. 1kV/20uA Surface barrier detector bias supply

2.4.10 Electric Field Vs Polarization Loop Tracer instrument

The Electric Field Vs Polarization Loop Tracer instrument has been developed for material science laboratory for ferroelectric Material Characterization purpose. This instrument is suitable for measurement of polarization, remanent polarization, sample resistivity, linear stray capacitance of ferroelectric materials with respect to applied electric field. The linear parameters of sample such as resistivity and stray capacitance can be compensated to measure polarization accurately.

Specifications

- Bias Voltage : 0-5kVpp / 50Hz
- Resistive compensation range : 5 M ohm and above
- Capacitive compensation range : Less than 100pF

Fig. 8. Electric Field Vs Polarization Loop Tracer

2.4.11 G.M Counter Interface for Phoenix system

A low cost and compact G.M. Counter module have been developed for Phoenix (Teaching Lab.). This is an interface module to GM tube. It consists of a 2.5kVDC regulated power supply, pulse detector/ shaper circuit and GM Tube. The high voltage is generated by dc to dc converter using a +/- 5VDC input. Pulse corresponding to the detected particle is fed to the Phoenix module for counting the pulse and plots graph in computer. The G.M Counter module have following specifications & features.

- HV DC Supply range : up to- 2.5kV / 50uA
- HV Regulation : 0.04%
- Power Requirement : 5V, 200mA
- TTL Pulse to Phoenix
- Suitable for other radiation monitor

Fig. 9. G.M Counter Interface for Phoenix

2.4.12 1kW (10V/100A) power supply for super conducting Magnets

There are requirement of fifteen super conducting magnet power supplies for HYRA super conducting quadrupole , Cryogenic and material Science super conducting solenoid magnets. A switch mode power supply has earlier been developed by BTS group for LINAC solenoid magnet. This year one more similar power supply has been assembled for super conducting magnet and it is decided to fabricate the required quantities in house. For that most of components have been sourced and procured or order has been placed. The complete assembly details, drawings and scope of works have been documented and assembly process will start very soon.

Output Specifications

- Voltage Range : 0-10V
- Current Range : 0-100A
- Load regulation : 0.15%
- Line Regulation : 0.1% (190-253Vac)

- Stability(current) : 0.05%(for 8 hrs)

Input Specifications

- Voltage : 190-253 VAC , single phase
- Cooling : Forced air cooling

Features

- Compact.
- Remote control facility.
- Parallel and series operation to get several KW of power in master slave mode.

2.4.13 Resonator Heater Power supply

50 nos. of resonator heater power supplies have been fabricated this year for heat load balancing of Linac cryostat. This is a crate based modular type current regulated power supply which will be used to power 10R heater mounted on resonator cavity. The custom made crates for these power supplies have also been developed. The crate provides housing and power source for nine RHPS module. The power supply has following specifications and features.

- Output current : 0 – 1A
- Rated output voltage : 12V
- Output stability : 0.01%
- LCD panel meter for output power measurement
- Remote ON/OFF control and readback
- No output "ON" indication if load is disconnected

2.4.14 Servicing and maintenance support

BTS group provides time to time service and maintenance support for the following instrument.

- Target lab Vacuum unit deposition power supplies
  E-Beam source power supply (Model- TT3/6,Telemark)
  Atom Beam Source power supply (Model-850, Atomtech)
  e-Gun power supply (Model-922-0020, Varian)

- High voltage detector bias power supplies
  Quad 1kV Bias supply (Model-710,EG&G Ortec)
  5kV Detector Bias Supply (Model-659 EG&G Ortec)
  3kV Detector Bias Supply (Model-556, EF&G Ortec)

- CAMAC Crate power supplies
  CAMAC Crate (Model-1502, Kinetic)
  CAMAC Crate (Model-6700-SCB, Bira Systems)

2.5 10 GHZ ELECTRON CYCLOTRON RESONANCE (ECR) ION SOURCE BASED LOW ENERGY ION BEAM FACILITY (LEIBF)

P. Kumar, G. Rodrigues, P. S. Lakshmy, U. K. Rao, Y. Mathur and D. Kanjilal

The performance of LEIBF [1] has been satisfactory in academic year 2007-2008. Various gaseous and metallic beams were extracted from the ion source and delivered successfully for experiments related to materials science, atomic and molecular physics. The facility, LEIBF, is unique in the sense that it can deliver ion beams in the energy range of a few tens of keV to a few MeV. This energy range is most suitable for investigating many research problems in various fields of science, specially in materials science. Due to the fact that metal nanocomposites are being used extensively in new technology, development of metallic ion beams has been of our interest during last few years. For this purpose, plasma sputtering, micro-oven [2] and metal ions using volatile compounds (MIVOC) [3] methods have been used. In case of MIVOC, beam intensities of metallic ions were noticed higher compared to others methods. However, continuous source operation, lower beam intensities and associated fluctuations in beam intensities were major issues in developing metallic ions beams. These issues were studied in details by operating ion source with different parameters [4]. Further, we could explain the reduction in the intensities of low charge state metallic ions (in case of micro-oven) by the introduction of thermally generated electrons from the metal surface and shielding effect of background ECR plasma. Apart from the gaseous beams, metallic beams which were developed successfully are Ni, Fe, Cu, Sn and Mn. The possibility of doing Rutherford backscattering spectroscopy (RBS) using 600 keV carbon and 800 keV nitrogen beams was looked into. However, new additions (a double slit installed just before implantation chamber) are required in order to get good mass resolution for RBS. For user support, we have a high vacuum chamber for implantation/irradiation and special sample holders for mounting large numbers of samples. We have provision for heating the samples at a maximum temperature of 500^0C and cooling the samples at LN_2 temperature.

The regular check of electronic and mechanical components installed in beam line and ion source resulted in minimal maintenance work during last academic year. Major maintenance works during last year were the repairing of gas dosimetry valve controller and beam profile monitor (BPM) installed in post analysis section of LEIBF.

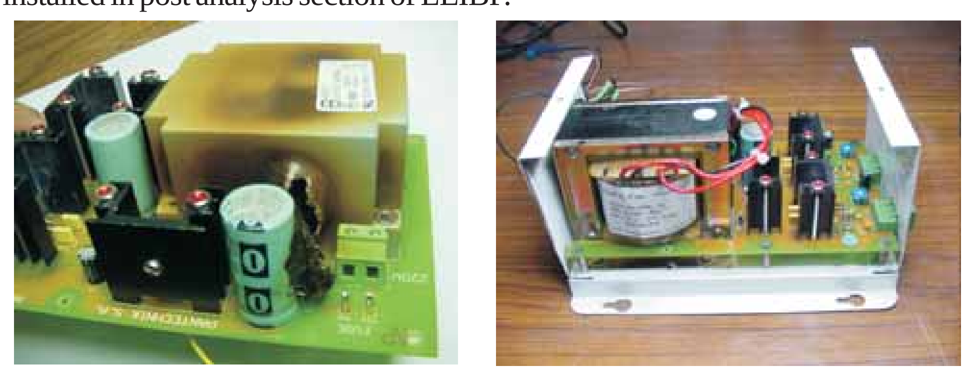

Fig. 1. (a): (Left) PCB of gas controller valve (before repair); (b): (Right) PCB of gas controller valve (after repair)

Due to high backing pressure, scroll pump installed on high voltage platform was replaced and repaired by vacuum group. Oil of all rotary pumps installed in beam line was changed after completion of recommended hours. The source and beam line pressures are low 10^{-7} and high 10^{-8} mbar respectively. The transformer, which was found burnt, mounted on the PCB of gas controller valve and its replacement on same PCB are shown figure 1 (a) and 1 (b) respectively.

Apart from production and delivery of ion beams for user experiments, we preformed an experiment where we have used 100 keV Ni ions for fabricating Ni nano-clusters inside quartz. The implantation was done at room temperature using five different fluences ranging from $5x10^{15}$ ion/cm^2 to $2x10^{17}$ ion/cm^2. The ion current density of 2.8 μA/cm^2 was maintained during the implantation of samples. The implanted samples were post annealed at 600^0C. The formation of magnetic and metallic Ni nanoclusters was evidenced by UV-Visible Spectroscopy, Magnetic Force Microscopy (MFM), Atomic Force Microscopy (AFM), X-Ray Absorption Spectroscopy (XAS), Zero Field Cooled (ZFC) and Field Cooled (FC) magnetization measurements.

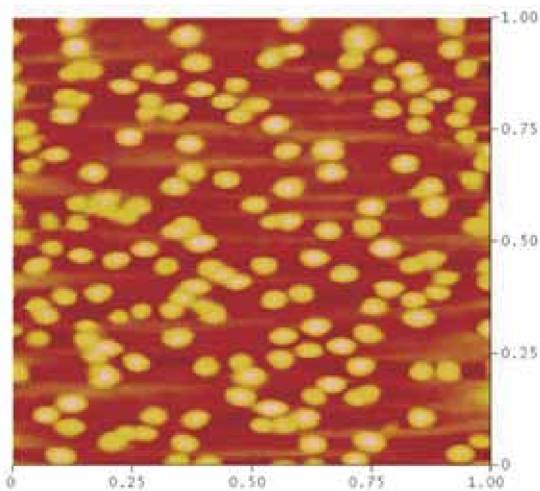

Fig. 2. AFM image of the sample for ion fluence of $5x10^{16}$ ions/cm^2

At optimum ion fluence of $5x10^{16}$ ions/cm^2, nano structures of Ni, nearly uniform in size and magnetic in nature, were synthesized in quartz matrix using low energy ion implantation. Fluence dependent growth of these nono-clusters was also seen. At ion fluence of $5x10^{16}$ ions/cm^2, cluster size of 25 nm was estimated using the value of blocking temperature from magnetic measurements. The nono-cluster, inside the quartz, were present in the form of NiO at ion fluence of $2x10^{17}$ ions/cm^2 and was confirmed by XAS measurements. The surface structure due to the growth of buried nano-clusters at $5x10^{16}$ ions/cm^2 is shown in figure 2.

The facility is presently being planned to be shifted to the new LEIB room for further expansion of the facility. An additional beam-line will open up new research areas. A new DANFYSIK switching magnet with three beam exit ports has been positioned to couple the experimental beam-lines. A new, modified, high voltage platform in a 'two-deck' configuration has been installed. A view of the new switcher magnet and the high voltage platform positioned in the new LEIB room is shown in figure 3. Few of the modifications to the facility will be improved vacuum conditions for long transport lines to minimize charge exchange, improved optics especially in the extraction region of the source, and additional focusing between the 300 kV accelerating column and switching magnet.

Fig. 3. Left: New switcher magnet ; Right: 300 kV high voltage platform

The LEIBF has been operational almost full time for delivery of various ion beams for experiments related to materials science, atomic and molecular physics. The typical experiments, which were carried out, include synthesis of nano structures and dilute magnetic semiconductors (DMS), ion beam re-crystallization, phase formation, structural changes in polymers, ion beam mixing, fundamental ion-matter interactions, molecular dissociation by ion beams etc. Such experiments resulted in large number of publications in international referred journals. More than one dozen Ph.D scholars completed their Ph.D using this facility. We also conducted a two days workshop (21-22 February 2007) to discuss possible internationally competitive experiments using LEIBF. The facility is in regular operation and is being used by researchers/users from all over India and abroad.

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2.5.1 Development Of *In-situ* Deep Level Transient Spectroscopy (DLTS) System At IUAC

Sugam Kumar, C.P. Safvan, Sandeep Malik and D. Kanjilal

Deep Level Transient Spectroscopy (DLTS) has been established as a unique and powerful tool for the study of electrically active defects in semiconductors. The DLTS method is based on capacitance transients produced by thermal emission of carriers from the deep levels within the depletion region in a reverse biased diode. DLTS is being setup in material science beam chamber in beam hall one to perform *in-situ* experiment on Au/n-Si (100) Schottky diode at varying beam fluence.

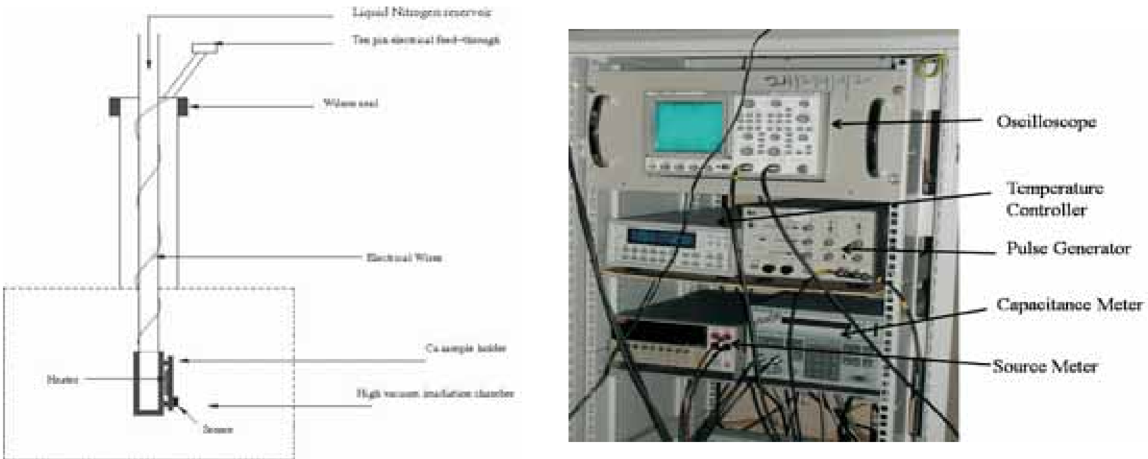

Fig.1. Sample holder and Electronic equipments, which are interfaced for measurements of DLTS signals

The DLTS system is based around the Boonton 7200 capacitance meter. The Boonton 7200 has a fast response and recovery time lesser than 50ìs after an overload condition. A Hewlett Packard HP 8012B pulse generator is used to supply the filling pulse (pulse width range: 10ns to 1s) through the capacitance meter to fill the traps in space charge region. The capacitance transient of the sample is measured by the Boonton 7200 and fed to the SCB-68 box inputs of the Data Acquisition Card (DAQ) NI PCI-6251. This has an onboard NI-PGIA 2 amplifier designed for fast settling times at high scanning rates, ensuring 16-bit accuracy even when measuring all channels at maximum speeds. LabVIEW (version 7.1) was used to create a VI to read the capacitance transient from Boonton 7200 capacitance meter. The oscilloscope allows us to view both, the train of pulses and the capacitance transients produced. The sample was mounted on sample ladder in irradiation chamber and the temperature is read and controlled by a Lakeshore model 331-temperature controller through general-purpose interface bus (GPIB) interface.

Software package LabVIEW has been used for data acquisition, instrument control, and to automate the DLTS system. We have written LabVIEW *virtual instruments* (VIs) for the DLTS experiment, which provides precise instrument control, fast, and accurate data collection, as well as real time display of transient signal. The transient signal from capacitance meter is acquired using DAQ NI PCI-6251with SCB-68 box.

The user is given the option of saving data to a file before starting the data acquisition. The user has to give starting temperature, final temperature, temperature step, stability time, and the positions of cursors to fix the rate windows as the input to the program. The VI has been programmed to collect data until the threshold temperature has been reached. The temperature is ramped as per requirements of the user. The capacitance and capacitance difference at different cursors corresponding to rate windows are saved in file on disc and plotted online on the front panel in different windows. We can fix as many rate windows as we wish, by using cursors on the front panel screen on transient signal. Acquired data is plotted online and stored in the disk for further analysis. The program is written in such a way that it can be redesigned at any stage. We kept the hardware universal i.e. that no hardware change is necessary in order to perform C-V, DLTS & C-T measurement in succession during *in-situ* experiment.

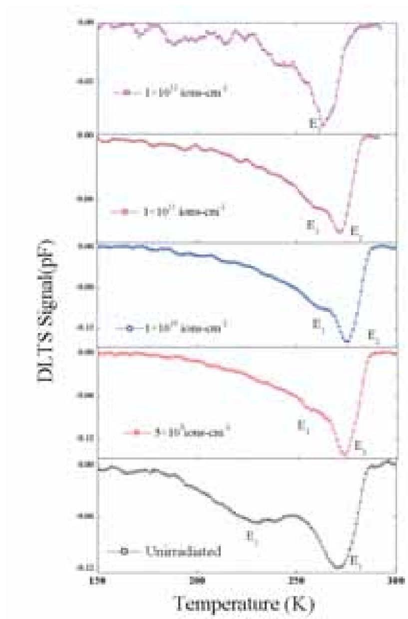

Fig.2. DLTS spectra of unirradiated and irradiated Au/*n*-Si (100) Schottky diode at different ion irradiation fluences

In situ deep level transient spectroscopy has been applied to investigate the influence of 100 MeV Si^{7+} ion irradiation on the deep levels present in Au/*n*-Si (100) Schottky structure in a wide fluence range from $5x10^9$ to $1x10^{12}$ ions cm^{-2}. The swift heavy ion irradiation introduces a deep level at $E_c - 0.32$ eV. It is found that initially, trap level concentration of the energy level at E_c–0.40 eV increases with irradiation up to a fluence value of $1x10^{10}$ cm^{-2} while the deep level concentration decreases as irradiation fluence increases beyond the fluence value of $5x10^{10}$ cm^{-2}.

2.5.2 Surface Analysis System in LEIBF Room 107

L.Nair [1], C.P.Safvan [2] and D.Kanjilal [2]

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An Ultra High Vacuum system for Surface Science experiments has been set up in Room 107 of the new LEIBF building, as part of the collaboration with the Dept of Physics, Jamia Millia Islamia. This system will be connected to the LEIBF beam line once it is moved to the new location. The vacuum system consists of a MDC SSAC 12 surface analysis chamber with sorption pumps, Varian Starcell ion pump, manual gate valve and sample manipulator. UHV conditions have been attained (3×10^{-9} Torr before bakeout), and initial experiments have been done.

Experimental facilities currently available include

a) Auger Electron Spectroscopy : AES of solids is extremely surface sensitive due to the fact that the inelastic mean free path for electrons in matter is less than 10 Å for electrons in the 100-1000eV range. Using our Omicron 150 CMA Electron Spectrometer, electrons with energies in the range 20eV to 3000eV can be analyzed with 0.5% resolution. This instrument has an inbuilt 5 keV electron gun to generate the excitation that results in the Auger electrons, and was interfaced with the PC using the PHOENIX kit and a 16 bit DAC. It is possible to obtain elemental and chemical state information about the atoms on the first few layers of the surface, using this instrument.

b) Power and thermocouple feedthroughs : A custom built sample holder, with in situ sample heating and temperature measurement has been made and installed. High current electrical feedthroughs (up to 60A) for sample heating in vacuum are in place and have been used to obtain atomically clean single crystal surfaces of Si(001)

c) Precision Leak valve: Targeted dosing of purified gases on to surfaces can be achieved in our chamber in a controlled manner using precision UHV leak valves connected to a gas line.

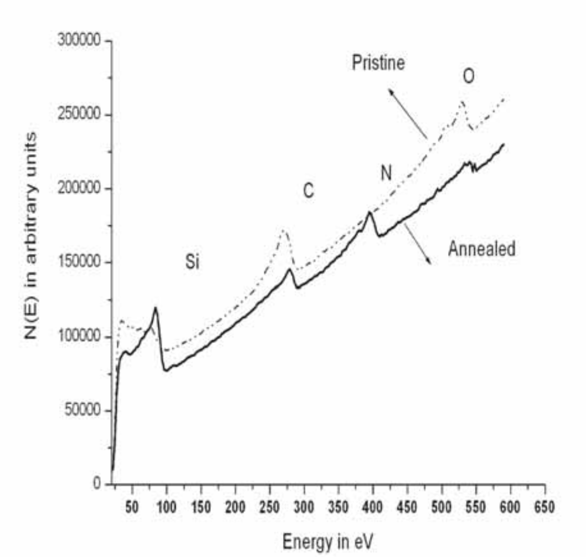

Fig.1. Surface Analysis system and typical Auger Spectra

2.6 HIGH CURRENT INJECTOR

As part of the accelerator augmentation programme a high current injector is being planned that would act as an alternate source of heavy ions for the super conducting LINAC that has come up in beam hall two. The proposed structure consists of a High Tc superconducting magnet ECR source (PKDELIS) followed by a room temperature radio frequency quadrupole accelerator and drift tube linac cavities. The progress of each of these sections is described in detail below.

2.6.1 High Temperature Superconducting ECRIS -PKDELIS and Low Energy Beam Transport System (LEBT)

G.Rodrigues, P. S. Lakshmy, P.Kumar, U.K.Rao, R.N.Dutt, Y.Mathur, A. Mandal, D.Kanjilal

A. Source Operations and LEBT

Fig. 1. PKDELIS ECR source and low energy beam transport

The source and the low energy beam transport section (figure 1) have been in continuous operation with the aim to improve the source performance after a long virtual shutdown period due to problem with the extraction cryo-cooler. Further additions to the source like control system etc, took additional time to really get the source running in terms of computer control. In the course of time, a 60 kV deck was coupled to the source for operating DC bias supplies and associated equipments. Specifically for high voltage applications, 2.45 GHz transmitters are used for easier control. A 60 kV high voltage platform used for operating power supplies at source potential uses these transmitters to communicate to ground potential. Spark protection modules have been incorporated to further protect the modules in the event of a spark. The source performance was degraded by an order of magnitude (comparing Ar^{8+} results with the best beam currents of ~ 700 mA, Rf power 488 W and extraction voltage 22 kV [1,2]) due to severe problems of outgassing from partial melting of the plasma electrode, beam hitting the electrodes during extraction, and in addition to bad vacuum on the injection side. Although the maximum operating extraction voltage was limited to 10 kV, we observed that the transmission through the LEBT was close to 75 % [3]. The LEBT is constantly being improved for better transmission and improved running conditions. These problems are being sorted out during the course of time. After improving and sorting out some of these problems very recently, we easily achieved 70 μA of Ar^{8+} @ 70 Watt RF power (10 kV extraction voltage) immediately after source start-up during outgassing mode in 2 days of running. We expect that this goal of achieving 1 μA/Watt will improve further when the source is conditioned well. The source is expected to improve further after continuous running over a week's time. Figure 2 shows an improved spectrum measured at 20.5 kV extraction voltage, optimised on Ar^{8+} and measured at absorbed RF power of 120 W. A second frequency generator was coupled to the source to see the feasibility of operating in two-frequency mode. This requires modification of the RF injection and removal of transverse to co-axial mode of coupling. Further work is in now in progress.

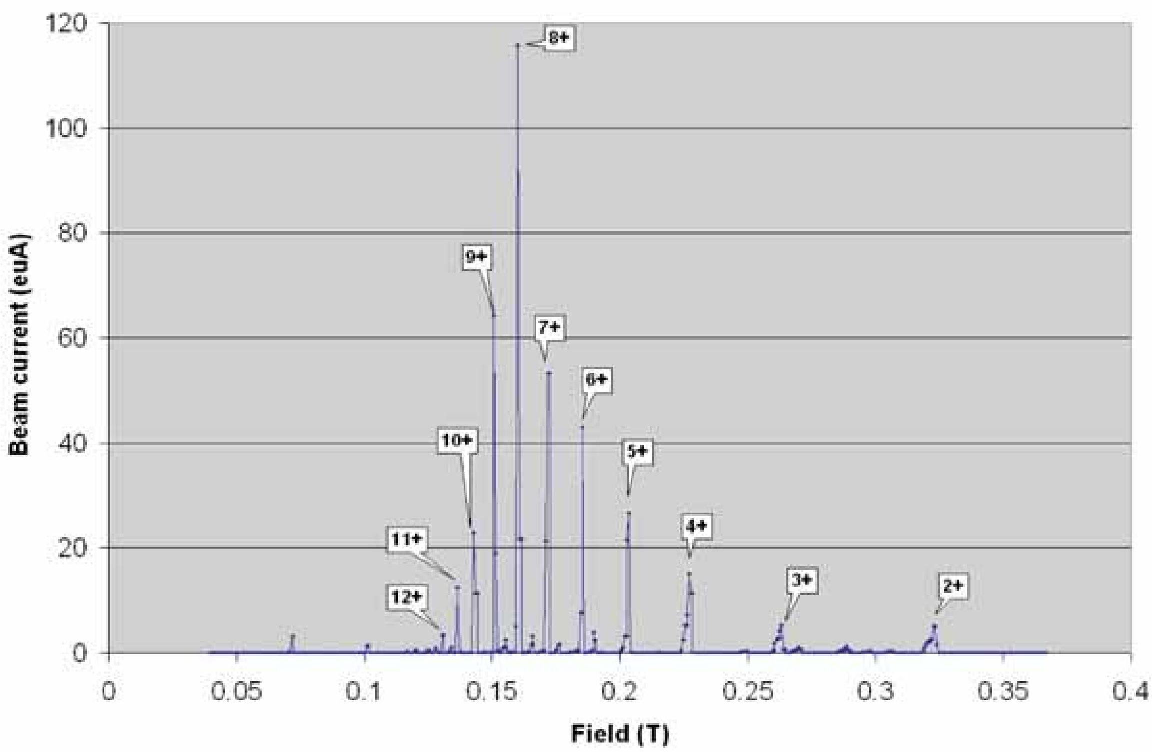

Fig. 2. Typical CSD for Argon optimised on Ar^{8+}

B. Source diagnostics

The x-ray Bremstrahlung measurements are constantly being explored to understand the confinement of the highly charged ions. Earlier, we undertook an experiment to study the x-ray Bremstrahlung with the PKDELIS source but due to problems with the extraction cryo-cooler, the measurements were performed using the NANOGAN source to obtain relevant information. While optimizing a particular charge state in ECR ion source, experimental parameters are adjusted to get a maximum current. The wall Bremsstrahlung components are studied in these cases for understanding the hot electron confinement conditions. Recent analysis of the data gave interesting results [4]. Further measurements have been explored by measuring the spectra as a function of DC bias voltage. We have measured Bremstrahlung x-rays both on the extraction and injection sides using a small silicon PIN diode detector at a fixed RF power of 100 W. We observed the effect of the bias voltage on the x-ray emission on the extraction side (through the analyzing magnet view port) and on the injection side. As the bias voltage was increased up to –200 V, correspondingly the emission of the x-rays reduced on the extraction and injection side. The x-ray emission was found to be the maximum in the case when the bias voltage was zero. Since the efficiency of this detector is poor for high energy x-rays compared to a NaI detector, we could not measure x-rays beyond 100 keV. We find from our spectra that the intensity of low energy x-rays decrease while the higher energy x-rays increase as a function of bias voltage. This may infer that the confinement of the low energy electrons is improving. This asymmetric behaviour in the x-ray energies needs further measurements. Our measurements will be repeated by using a NaI detector to explore the higher energy x-rays.

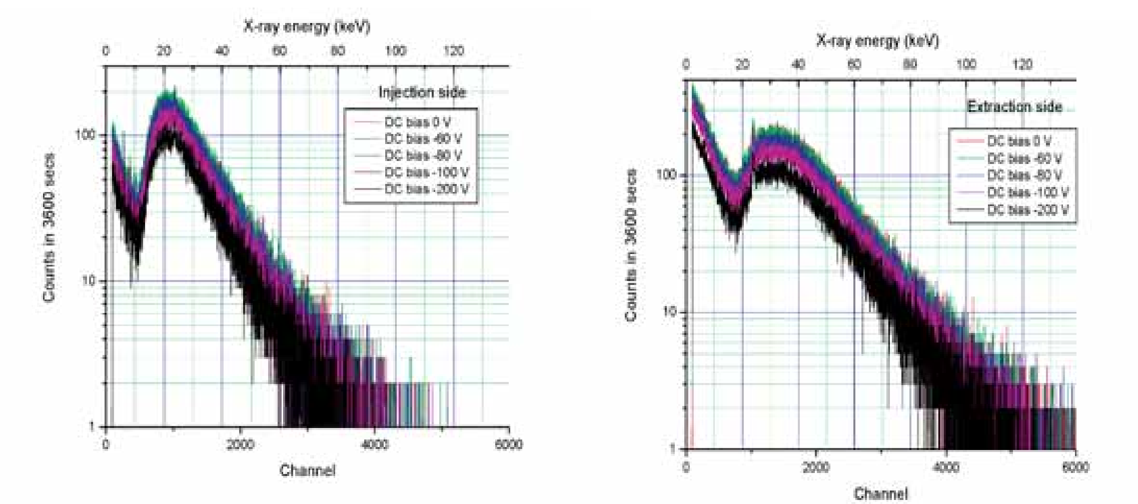

Fig. 3. Bremstrahlung spectra measured on the injection and extraction side as a function of DC bias voltage

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2.6.2 Low Power RF Tests on the 1.17m Modulated Prototype RFQ Accelerator

C.P. Safvan, Sugam Kumar, R. Ahuja, A. Kothari, D. Kanjilal and A. Roy

The proposed 48.5 MHz Radio Frequency Quadrupole (RFQ) is designed to accelerate ions with A/q of 7 from 8 keV/A to 180 keV/A. The RFQ structure is 4 m long with bore radius of 4 mm consisting of four rods supported by vane posts. The whole electrode assembly is inserted in RFQ cavity, which is made of stainless steel. The ion beams produced by the ECR (PKDELIS) source will be injected into the RFQ and be further accelerated to just above 2MeV/A by a drift tube Linac (DTL) working at room temperatures. Velocity matched beam with b= 0.08 will be injected into superconducting LINAC, which will further accelerate the ions to 5MeV/A. Earlier initial unmodulated 1.17 m prototype of the 48.5 MHz RFQ was designed, constructed, installed and studied to determine the final specifications for modulated RFQ accelerator.

This year modulated vanes have been fabricated at IGTR Indore and successfully installed for low power RF tests. A view of the modulated 1.17m RFQ is shown in Fig.1. The cavity is equipped with various ports where the input inductive loop for power coupling and output loop for probe is installed.

Fig.1. General Assembly of the 1.17m modulated RFQ at IUAC

The system is able to achieve high vacuum level (10^{-7} torr) with the help of single turbomolecular pump. The RFQ vanes and vane supports were being fabricated at Indo-German Tool Room Indore and Ahmedabad. The whole electrode assembly is inserted in RFQ cavity.

A fully automated bead puller system is developed. Following the mechanical alignment the vanes were installed with around 150 micron accuracy and the measurement of parameters like resonant frequency (f_0), Quality factor (Q_0), Shunt impedance (R), Power required, Quadrupole symmetry and Electric field mapping is being done. The bead pull and capacitive variation methods are being used with the help of Self Exciting Loop (SEL) and Network Analyzer for the purpose RF parameters measurement. SEL is used to minimise the possible long-term temperature drift while measuring the frequency shift. The high dielectric ruby bead of 2 mm diameter is strung on fishing thread of 0.28 mm diameter.

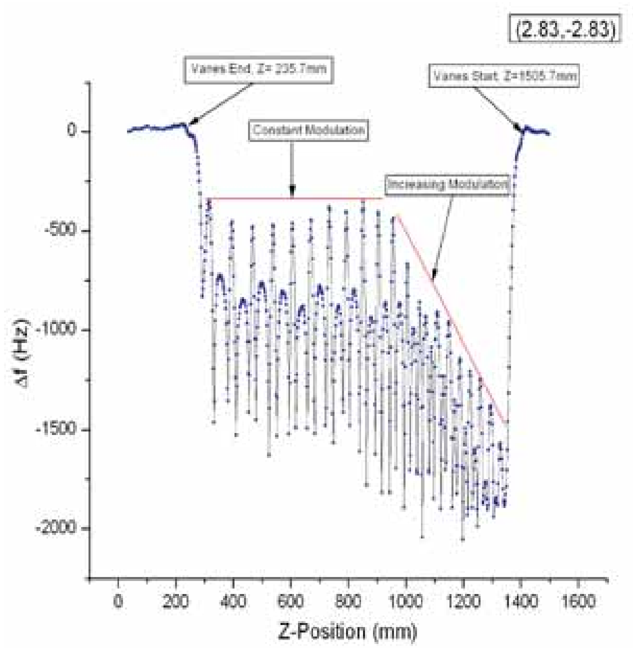

Fig.2. The shift in the resonance frequency of modulated RFQ is plotted vs. cavity length for the fundamental mode TE_{210}

Horizontal field distribution has been mapped with step size of 1mm. Electric field distribution along the length shows the modulation effect. Field height clearly shows the increasing and constant modulation, which is well matched with the simulated modulation. Electric field mapping is done at the centre and eight different positions on the circle of radius 3mm. Results obtained are well satisfactory. The frequency shift along the length of cavity is shown in Fig.2.

The RF parameters measured are listed below. The resonance frequency and intrinsic quality factor measured are 53.02MHz and 2355 respectively, while ideal (simulated) values are 48.5MHz and 4000. Shunt impedance is found to be 23.66 k-ohm as compare to 80 k-ohm, which is, designed value of unmodulated part. Power required to generate 70kV Intervane voltage is coming out to be 43.21kW, while with 30kW of input power, which is also designed input power; 57.8kV of Intervane voltage can be achieved.

Two independent measurements have been done in the azimuthal plane one along the x-axis and other along the y-axis with 0.1mm of small step size to check the quadrupole symmetry and the electric field distribution. The quadrupole electric field strength in quadrant 1 is found to be roughly 2.6% higher while of quadrant 2 is 10.6% lower than the average electric-field strength of the quadrant 3 and 4.

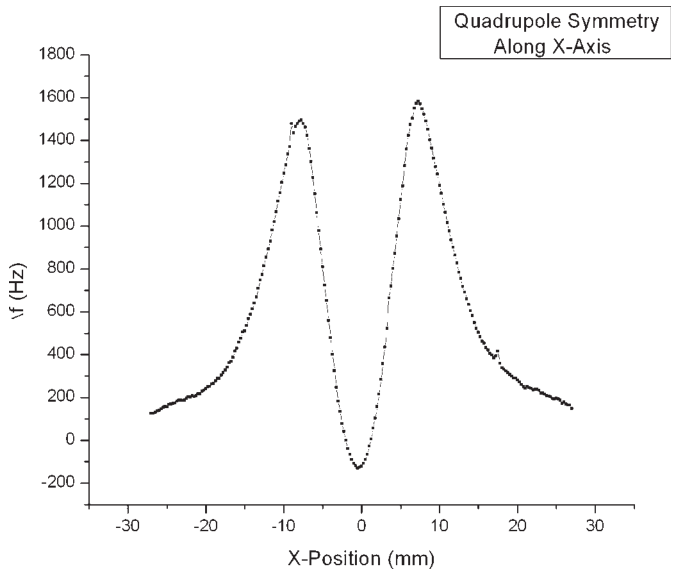

Fig.3. Quadrupole symmetry in azimuthal plane

These results indicate that the distribution of the electric field is symmetrical within the beam radius of 8mm and tend to asymmetrical in region greater than the beam radius, which cause no problem for the beam optics.

In the next year high power RF and actual beam tests are planned.

2.6.3 Status report on the fabrication and testing of the prototype IUAC DTL-IH tank

Jimson Zacharias, B. P. Ajith Kumar, R.V.Hariwal and C. P. Safvan

The High Current Injector comprises of DTL-IH tank after the RFQ for further acceleration of the ions (A/q=7) from the energy E=0.180MeV/nucleon to final energy @ 1MeV/nucleon at room temperature. The ions are injected by the ECR ion source. It is proposed to operate the DTL at frequency 97MHz, which is the frequency of existing LINAC.

The DTL-IH tank is built from a mild steel cylinder and has a dimension of (ID=850mm,L=385mm,Thickness=25mm) having eight CFF ports for various purposes and it has also two rectangular ridge base ports of (200x150mm). The flange sizes for various ports are as CFF 100(4 NOS.), CFF 150 (1 NOS.), CFF 200 (1 NOS.) and CFF 63 (2 NOS.). There are two Lids to close the chamber which has dimension of Diameter D =980mm and Thickness=24mm. The stand for the DTL chamber is made of MS square channel, which can be dismantled, whenever required. Leak test has been done successfully of the whole chamber and the leak rate was found to be 2E-9 mbar.liter/second. The status of IUAC DTL is shown below:

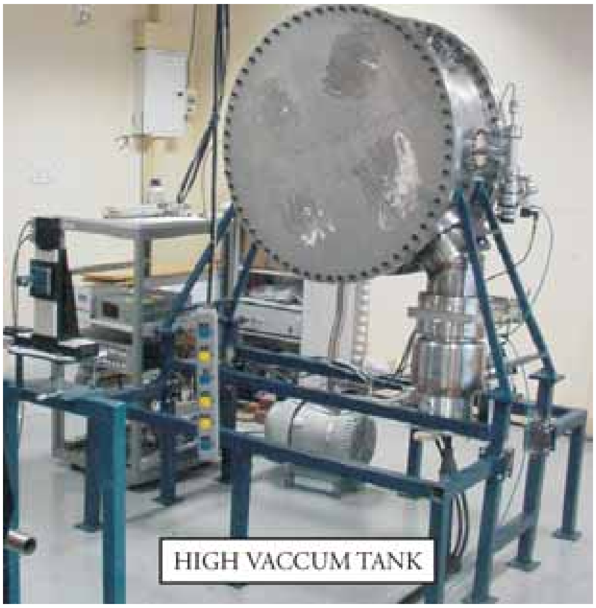

Fig. 1. Status of IUAC DTL

The ultimate high vacuum in the chamber is successfully achieved as 5E-7 mbar with the help of one turbo-molecular pump and one scroll pump. The deformation in the lid due to the pressure differential under vacuum was measured to be 460 micron. The chamber has been fabricated in Don Bosco Technical Institute's workshop. The ridges and stems are being fabricated at IUAC workshop.