अन्तर–विश्वविद्यालय त्वरक केन्द्र
Inter-University Accelerator Centre
(विश्वविद्यालय अनुदान आयोग का स्वायत्त अंतराविश्वविद्यालय केन्द्र)
(An Autonomous Inter-University Centre of UGC)
Post Box 10502, Aruna Asaf Ali Marg, New Delhi - 110 067
Ph: 11-26893955, Fax: 26893666, Website: www.iuac.ernet.in

The Operation of the Complete Superconducting LINAC

To boost up energy of ion beam from the existing 15 UD Pelletron, a superconducting linear accelerator is being commissioned at IUAC. At present LINAC consists of a superbuncher cryostat (SB) having a single quarter wave resonator (QWR), a LINAC cryostat having eight QWRs (before the last run, a single resonator was unloaded due to a leak problem) and a rebuncher (RB) cryostat having two QWRs. The other two LINAC cryostats and the remaining 16 resonators are in the final stage of fabrication and expected to be installed at the middle of next year.

During the operation of LINAC, in the past, we experienced various problems like requirement of large amount of RF power (200-300 W) to lock the frequency and amplitude of a superconducting resonator, decrease in accelerating field of QWR during operation in LINAC cryostat, lack of reliability of the movement of the drive coupler, insufficient or non-reproducible tuning range of the mechanical tuner, and cross talk problems between RF signals of different resonators in the LINAC cryostat.

A novel method of damping the mechanical vibration by introducing ordinary SS-balls inside the central conductor was implemented to reduce the power requirement and now the resonators are being locked repeatedly with a power of $\leq$100 watts. Decrease in accelerating field is believed due to bubble formation on the top of QWR leading to inadequate cooling during continuous operation. This was solved by incorporating dome structure on top of the QWR to increase the buffer stock of liquid helium and free upward movement of the bubbles. In the last few cold tests all the old drive couplers and the fixtures of the mechanical tuner were replaced by the new modified ones and as a result, the movement and the frequency range problems were solved. To tackle the cross talk problem, all the 95% shielded RF cables were replaced by 100% shielded cables and that eliminated the cross talk problem almost completely.

In last November 2006, beam was accelerated by five out of eight installed resonators in LINAC. At that time, the rebuncher resonator was not installed. So time, width at the location of user's scattering chamber could not be compressed. This time a couple of resonators both having accelerating field up to ~ 3.5 MV/m had been made operational in rebuncher cryostat. The rebuncher cryostat along with the couple of resonators prior to its closing is shown in Fig 1.

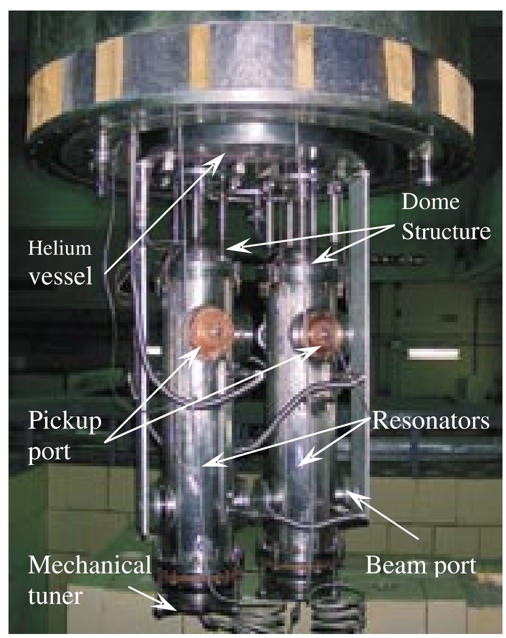


Fig.1. A couple of Quarter Wave Resonators (QWR) installed in the rebuncher cryostat prior to cold test

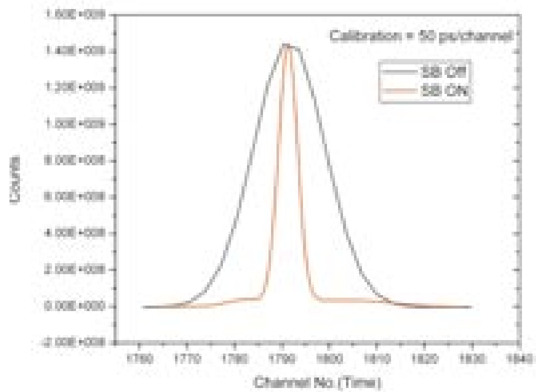


Fig.2. Time spectrum of the bunched beam at the entrance of LINAC resonators

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 resonator of the SB cryostat. 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 thin (50 μm) surface barrier detector cooled to subzero temperature. The time widths of the beam bunch with the resonator in SB Off and On condition are shown in Fig 2. 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 μm) 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 3.

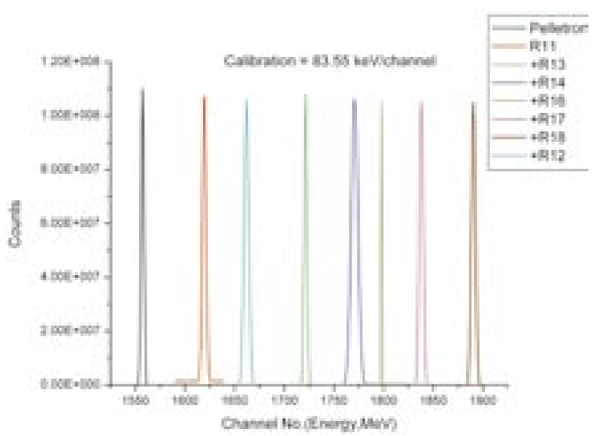


Fig.3. Energy spectrum of the beam from the Pelletron and after turning on the seven resonators one by one in LINAC cryostat

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 μm) and thin surface (40 μm) 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, a time width of the beam bunch 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 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 4. Due to shortage of time towards the end of the experiment, not much effort could be devoted to further reduce the time width. But 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.

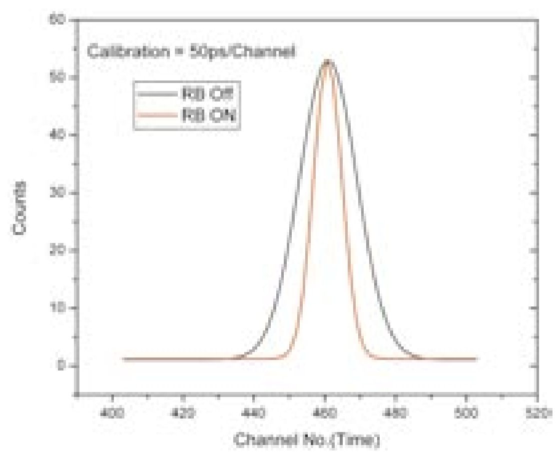


Fig.4. Time spectrum of the bunched beam at the location of the user's scattering chamber with rebuncher off and on

Now the operation of the complete LINAC with superbuncher, a single LINAC cryostat with seven QWRs and rebuncher had been demonstrated. The time bunching by the superbuncher at LINAC entrance and then the acceleration of the bunched beam by the LINAC resonators was already demonstrated in the past. This time, all the seven resonators installed in LINAC took part in the acceleration and then the time width of the beam bunch could be retained by the rebuncher resonator to produce the sub-nanosecond time bunch at the user's experimental chamber.

Prototype RFQ Fabrication

A prototype RFQ model (1/4 length) is being fabricated at IUAC as part of the high current injector project. The low power RF tests were completed last year and this year the modulated vanes have been inspected and received from the Indo German Tool Room in Indore. The extremely precise machining has been completed successfully after many rounds of trial and error, and a final accuracy of 20 microns was achieved over the modulated surface. The photograph shows one of the central vanes and an end vane. The prototype is being fabricated with the vanes having been split into sixteen such pieces. The longest is around half a meter long.

Fig.5: One of the central vanes and an end vane

Apart from the modulated vanes, the water circulation system has been tested under pressure and found to perform satisfactorily. The temperature induced drifts in the resonant frequency were considerably reduced by circulation of constant temperature water through the vanes and posts of the cavity. The next step would be high power RF tests and frequency locking of the cavity with active tuners.

Wireless Control System for PKDELIS ECR Ion Source

A modern DCS wireless based control system for the PKDELIS ECR ion source has been developed. The system uses MODBUS/RTU for data Acquisition module access and OPC technology for data communication to the control client which is a labview SCADA client. The system incorporates an M/q scan which works in close interaction with the data acquisition modules bypassing the OPC server. The complete scan takes minimum time. Integration to the main IUAC control system is achieved by implementing a bridge program to make data available to the main control system in the data format used in the IUAC main pelletron control system. The control system has proven to be low cost, rugged, reliable and flexible. A schematic of the control system is shown in Fig. 6.

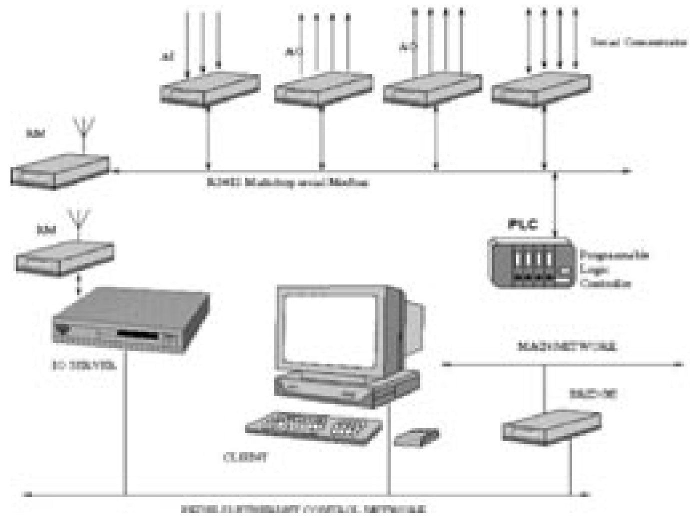


Fig.6: Schematic of the control system

Fig.7: View of MODBUS control modules

A typical charge state distribution optimized on Ar^{8+} is shown in Fig 8. 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. A view of the 60 kV deck coupled to the source is shown in Fig. 9.

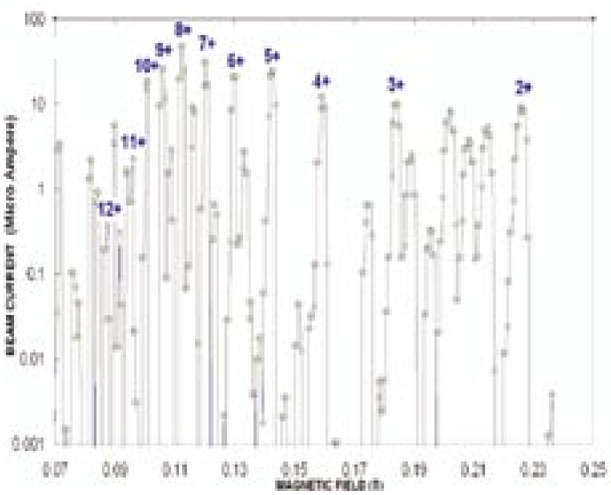


Fig.8: Charge state distribution optimised on Ar^{8+}

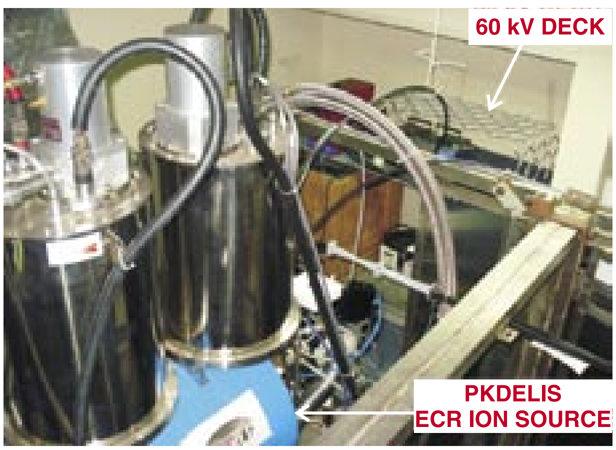


Fig.9: View of 60 kV Deck coupled to PKDELIS ECR Source

Indian National Gamma Array in Beam Hall II

The support structure of Indian National Gamma Array (INGA), which will house the 24 Suppressed Clover germanium detectors, has been installed in Beam hall II. The response to experimental proposals for using the INGA was overwhelming during the "Nuclear Physics with Beam hall II facilities workshop" (Aug 30, 31, 2007). With the arrival of Clover and ACS detectors from TIFR, UGC-DAE-CSR, and SINP the INGA will have all detectors in place to increase the photo peak efficiency to ~ 5%.

All the Clover Germanium detectors will be cooled by a dedicated automatic liquid nitrogen filling system developed in house. Custom made power supplies will be used to bias the Germanium detectors and the Anti-Compton shields. Clover modules developed in IUAC will help in processing signals from suppressed Clover Germanium detectors. The signals will be digitized by the 8 channel 13 bit CAMAC ADC-814 developed in house. Multi CAMAC crate based data acquisition CANDLE of IUAC will be used for collecting data from all the detectors. The detectors are arranged in two hemispherical structures (Figs. 10 and 11) each movable on precision rails by dedicated controlled motor. In the HYRA-INGA combination the forward structure will be removed and the back structure can be moved forward to HYRA target. The arrangement of detectors is shown in Figs. 10 & 11.

Fig.10: The side view of INGA during installation in Beam hall II

Fig.11: The inside view of INGA during installation in Beam hall II

Workshops /Acquaintance Programs (April – October, 2007)

A One Day **Acquaintance Programme** of IUAC was held at Pandit Ravishankar Shukla University, **Raipur** on 20th July 2007. It was well attended by sixty participants. Another IUAC Acquaintance Programme was held on 17th August, 2007, in the Department of Studies in Physics of Karnataka University, **Dharwad.** The programme was locally organised by Dr. N.M. Badiger and coordinated by Chairman of the Department, Prof. S.S. Kubkaddi. Approximately 90 participants comprising of students, faculty members of the university as well as others coming from different educational institutes, colleges and universities located on or around Dharwad, actively attended the day long programme. Both the programmes generated a lot of enthusiasm among the young faculty and students attending the programme.

Eighteenth **International Conference on 'Ion Beam Analysis'** was jointly organized in Hyderabad from 23rd Oct. to 28th Oct. by Hyderabad university, Inter University Accelerator Centre and Institute of Physics, Bhubaneswar. Prof. A.P. Pathak of Hyderabad University was the chairman. Dr. D.K. Avasthi, IUAC and Dr. B.N. Dev, ICAS were co-chairs for the event. There were 270 participants from 34 countries who participated in this prestigious biennial event in Ion Beam Science, which was hosted in any Asian country for the first time since its inception over 35 years back. Theme of the conference was Ion Beams in nano- and bio-materials. There were 30 invited talks, 60 oral presentations and 240 posters. More than 200 papers were submitted for proceedings, which are under refereeing process for publication in Nuclear Instruments and Methods B. Another two day workshop on **"Materials Science with Swift Heavy Ions"** was organised on September 17-18, 2007 at IUAC. The topics covered included Electronic energy loss induced interface and surface modifications, ion beam induced epitaxial re-crystallization, fabrication of nano/micropores modification of oxide materials and creation and modification of nanoparticles by SHI. The workshop was attended by approximately 80 participants. The workshop included 16 invited talks and nearly 40 contributed papers (14 oral and 26 posters).

A one day workshop on **Accelerator Mass Spectrometry (AMS)** was organized at IUAC, New Delhi on October 05, 2007. The aim of the workshop was to inform the users about AMS facilities available at IUAC and to plan the future programs regarding utilization of AMS facility at IUAC. Around 80 participants from different universities and institutes participated in the workshop. Technical details of AMS facilities and the applications of ^{10}Be and ^{26}Al AMS measurements in different fields of basic sciences were discussed in the workshop.

To meet the growing interest in the study of radiation environment around accelerators and low level radiations, a conference was arranged on "**Accelerator and low level radiation safety"** on April 26-27 at IUAC. A number of eminent experts in this field were invited to exchange experiences and information on this topic. The sessions included several invited talks, contributory oral and poster presentations. Participation of research scholars and young researchers from academic institutions and universities was strongly encouraged.

Status of 15UD Pelletron (April 1 to October 31, 2007)

Operation of Pelletron was quite satisfactory from 1st April 2007 to 31st October 2007. An important landmark was achieved by IUAC Pelletron during this period. One of the charging chains of Pelletron completed 1,00,000 hours of operation. There were one scheduled and two unscheduled tank openings of the Pelletron. Scheduled maintenance took place in the month of October 2007. Routine maintenance jobs like, terminal foil stripper loading, column support post and accelerating tube resistors maintenance, charging system maintenance, in-tank ion pump maintenance and maintenance of rotating parts inside tank were carried out in this maintenance. Other major jobs done in this maintenance were replacement of ion pumps in lower terminal area (IP T-2) and in vault area (IP 04-1). Maintenance of the ion source along with Cesium loading and conditioning of deck high voltage power supply were also carried out during this scheduled maintenance.

Generated Voltmeter Motor (GVM) broke down during ^{197}Au, 7^{+}, 100 MeV beam run in materials science line. GVM motor broke down for the first time since the commissioning of IUAC Pelletron accelerator. The first unscheduled tank opening maintenance was in May 2007 for the replacement of this damaged GVM motor. After this maintenance, the stability of accelerator improved.

Failure of gas stripper and full consumption of foil strippers lead to another unscheduled tank opening maintenance. This maintenance was held in the month of July 2007. Problem of gas stripper was rectified by replacing gas valve control card. Fresh lot of foil strippers were also loaded in terminal.

Maximum terminal voltage achieved during high voltage conditioning was 14.57 MV. ^{12}C beam (91 MeV) was delivered to user at the maximum terminal potential of 13.91 MV and ^{28}Si beam (40 MeV) was delivered to user at the minimum terminal potential of 5.75 MV. Out of total beam time of 2258 hours, 449 hours were used for pulsed beam runs using multi harmonic buncher (MHB) along with low energy chopper and traveling wave deflector.

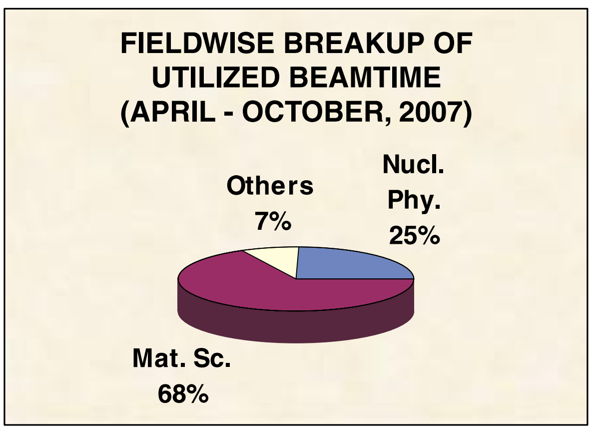
A chiller which was used inside accelerator tank to regulate the temperature inside tank environment around 25° C was quite old and prone to accident during operation. Therefore, a new chiller for this purpose was designed and fabricated. The fabrication was done by a local vendor

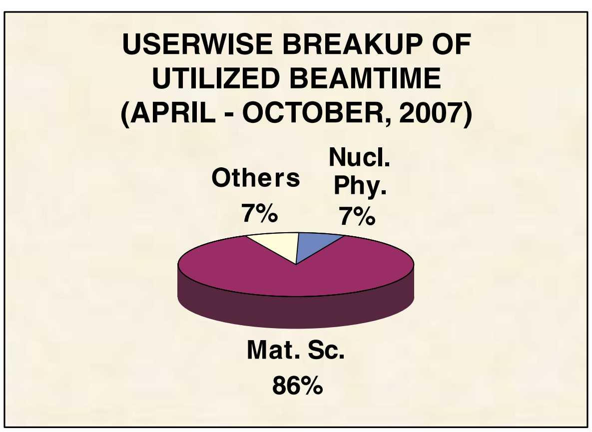
(Air Fridge). Proper inspection of this chiller was carried out during its fabrication. This newly fabricated chiller is now installed, outside the accelerator tank, to control the inside tank temperature. This new chiller regulates the temperature inside tank environment at around 25° C.

^{11}B, ^{12}C, ^{14}N, ^{16}O, ^{19}F, ^{28}Si and ^{58}Ni beams were bunched for different experiments. High energy sweeper was used, along with MHB for ^{28}Si, 130 MeV bunched beam for LINAC testing. All the pulsed beam runs were quite stable. The uptime of machine for this period was 93.93%. The beam utilization time was 55%.

Statistical Summary

Total Chain Hours	= 4105 Hrs.
Beam utilization time	= 2258 Hrs.
Beam change time	= 6 Hrs.
Machine Breakdown time	= 249 Hrs.
Machine scheduled maintenance	= 1011 Hrs.
Accelerator conditioning	= 1825 Hrs.





User List: April to October, 2007

University / Institute / College	Shifts utilized
Agra University	13
Allahabad University	03
AMU, Aligarh	18
Anna University, Chennai	04
Bangalore University	12
BARC, Mumbai	05
Bareilly College, UP	03
BH University, Varanasi	02
Calcutta University	02
Calicut University	15
Cochin University	03
CSNSM , France	03
Dayalbagh Institute, Agra	05
Dr. BAM University, Aurangabad	02
GB Pant University, Pant Nagar	03
GND University, Amritsar	07
Gujarat University	03
Hyderabad University	05
IIT, Delhi	11
IIT, Mumbai	03
ISRO, Bangalore	02
IUAC, New Delhi	45
IUC, Indore	04
Kiel University, Germany	03
Kongunadu College, Kerala	03
Kurukshetra University	03
Madras University	03
MMH College, Ghaziabad	03
MSU, Baroda	03
Mumbai University	04
NEHU, Shillong	02
NIT, Silchar	02
Orissa University	07
Punjab University	18
Rajasthan University	03
SPS, JNU	03
Tezpur University	03
Utkal University	06
VECC, Kolkata	18