

3. RESEARCH SUPPORT FACILITIES

3.1 SUPPORT LABORATORIES

3.1.1 High Vacuum Laboratory

Chandra Pal Maurya, M. Archunan, A.Kothari, P.Barua, A. Mandal

Negative Ion Implanter [NII] has been fully commissioned and is being tested with different beams. The facility with MC SNICS source mounted on high voltage platform [200 kV] can deliver particle beams from Li to Gold with beam energy varying from 30 to 200 keV. The installation of High Current Injector [HCI] components in the beam hall 3 has commenced with the installation of 200 kV high voltage platform and further installation is in progress.

3.1.1.1 Modifications in the Low Energy Ion Beam Facility

The shorting of few gaps in the GP tubes was observed. Last year all the tubes had got shorted and we had introduced two collimators in the tubes to prevent GP tube shorting in future. The shorting of the tubes is occurring due to sputtering of the inner electrodes due to beam, probably while tuning. To solve the issue it was decided that since the Electrostatic quadrupole doublet (EQD) is quite powerful lens and the beam is frequently hitting the inner electrode of the tube during tuning, so Einzel Lens should be installed in its place. The entire components on the deck were dismantled and all the GP tubes were removed for cleaning. EQD had a turbo pump mounting port, so to augment the pumping in the high voltage deck section, in the absence of EQD, a new vacuum TEE, as per available space, was designed and fabricated with 8" port for turbo pump. A 700 l/s Maglev turbo pump has been installed on this TEE (Figure 1). An additional turbo pump of 300 l/s has been installed on the pumping port available on the Einzel lens, taking the total pumping capacity of 1000 l/s in the Extraction area. All the components in the HV deck and GP tube were installed back with proper alignment. As the Einzel lens delivers a stable beam, the 2nd collimator earlier installed before the third GP tube was not installed this time. After this a stable beam, with better beam transmission and higher currents is being delivered by the facility.

To improve the vacuum in the GP tube area, a new pumping cross with larger mounting port for the turbo pump was designed, fabricated and installed. To improve the vacuum in the switching magnet area, an additional 500 l/s turbo pump has been installed near entry and vacuum has improved to 1.0×10^{-8} torr. A suitable pumping cross was fabricated for the purpose. To accommodate the pumping cross in the limited space NEC Faraday cup FC18 was replaced with a Danfysik Faraday cup 568. The vacuum in the area has improved considerably. An additional NEC make BPM80 has been installed after GP tube to diagnose the beam before delivering through electrostatic quadrupole triplet.

Installation of two experimental chambers in the 15 degree atomic physics beamline with fine alignment was completed in the beamhall of LEIBF.



Fig. 1 : HV Deck Components after modification

3.1.1.2 Installation of Negative Ion Implanter Facility

P. Barua, Ashok Kothari, M Archunan, Chandra Pal, Devarani Devi, Rajan Joshi, S. Gargari, Mukesh Sota, Pranav Singh, Vijay Patel, M.P. Singh, Jagdish Prasad, Rakesh Kumar, SurajKumar, N.S. Panwar, Raj Kumar, U.G. Naik, A.J. Malayadri, Kundan Singh, Deepak Kumar Munda, K.K. Soni, Rajeev Ahuja, S.K. Saini, B.B. Chaudhary, Sunder Rao

A new Negative Ion Implanter [NII] has been installed and commissioned at IUAC. The major components like MC SNICS source, High voltage platform and switching magnet were already available. The beam optics was calculated to finalize the position of critical beam controlling and diagnostic components. The facility can deliver wide variety of beams from Lithium to Gold having 30 keV to 200 keV energy.

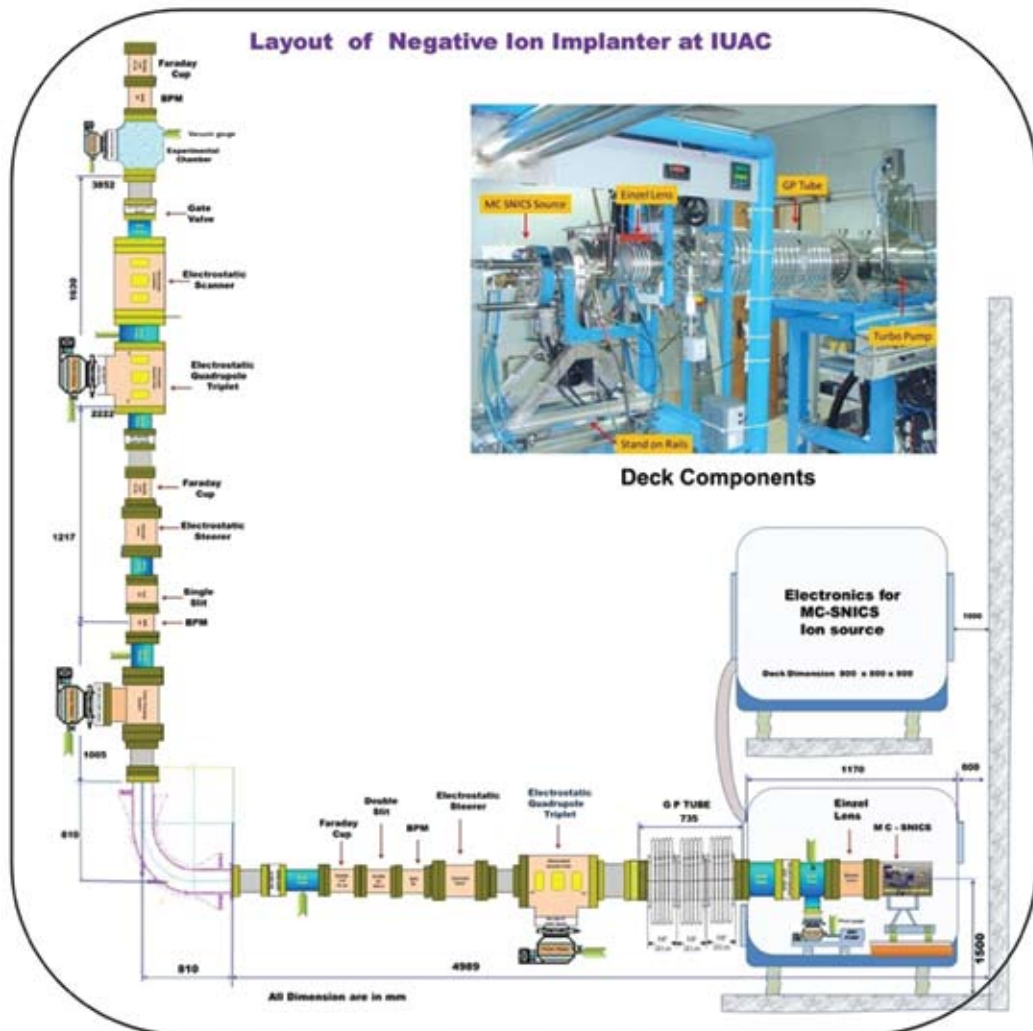


Fig. 2: Layout of Negative Ion Implanter

The complete layout of the facility is shown in Fig. 2. New beamline stands and brackets were designed and fabricated for the facility. The existing high voltage [HV] platform was modified to install components on deck. The HV platform sits on two stories of insulators and can be raised to a potential of 200 kV. A new guide rail based stand was designed and fabricated for the installation of MC SNICS. It facilitates easy, fast and accurate coupling and decoupling of the source with the beamline. Vacuum system for the facility is completely turbo pump based pumping system. A 1000

l/s capacity turbo pump maintains vacuum in the beamline between source and switching magnet. A provision for mounting an additional turbo pump near Einzel lens has been kept, to improve the vacuum in the region, if required. Two sets of vacuum interlocked turbo pumping station, each having 500 l/s capacity, are installed in the beamline, between magnet and experimental chamber, and maintain low 10^{-08} torr vacuum in the region. A fully interlocked turbo pump installed on the chamber maintains low 10^{-7} torr vacuum in the chamber. IMACS control system, which has been running satisfactorily in LEIBF, is used to control the facility. Two sets of Interfacing and IMACS crates were fabricated and installed, one for deck components and one for beamline devices. *PCLI* software is used to run the control system; it is the same software which is being used in Pelletron accelerator.

The critical components of the facility like Ion Source, Magnet, BPM, Quadrupoles, etc. are aligned within 0.5 mm. Reference points have been transferred on the floor and wall for future reference. A new sleek power distribution panel has been installed and cable trays are laid along the beamline stands for high finish. A new high finish control console has been installed in the facility. The facility has been tested with Si beam for 30 – 200 keV energy and up to 8 μ A current.

3.1.1.3 High Current Injector Installation

Beam hall 3 is ready for the installation of components. The 200 kV high voltage deck with the cage has been fabricated and installed in the beam hall. The average height of beamline in the beam hall is 1.8 m. The layout of the first phase up to RFQ is finalized and the installation of the components on the HV deck and up to RFQ is in progress. The picture in Fig. 3 shows the present status of the beam hall.



Fig. 3 : High Voltage Platform and Cage in Beam Hall

3.1.1.4 Maintenance Activities

- There was noise problem in BPM of all beamlines of phase II. The problem was minimized by installing an Isolation Transformer in the main input line of each BPM.
- An individual user control for Faraday cup FC 07-2 has been provided for NAND and INGA users in their respective electronics area, with master control in the control room. The respective controller gets the control from phase II Fast valve interface, depending on the beamline selection in the fast valve interface.
- Proper vacuum interlock controllers for LINAC II and III have been incorporated in the system.
- The 1200 l/s turbo pump installed in Material science high vacuum chamber developed some problem. So, the chamber is now pumped by a 1000 l/s Maglev turbo pump.

3.1.2 Beam Transport System

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

Beam transport system (BTS) laboratory is primarily responsible for regular upkeep and maintenance of beam transport system instruments of different accelerator facilities at IUAC. Power supplies and magnets of different accelerator facilities are maintained regularly to ensure proper beam dynamics and best performance in terms of stability during long term operations. Besides the maintenance, BTS laboratory also involved (in collaboration with other groups) in development of equipments for Accelerator augmentation and beam modification, high power RF amplifiers, low level RF electronics (LLRF) and superconducting magnets. Details of development and maintenance activities are summarized below

3.1.2.1 Power Supply for HCI Steerer and low power Quadrupole Magnets

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

Approximately 40 nos. of steerer magnets and low power quadrupole magnets will be installed on the High Current Injector (HCI). The power requirement for these magnets is upto 300W. Beam transport system group has taken the responsibility to design develop and supply these power supplies. A compact air cooled bipolar current (± 10 A) regulated power supply has been developed to power these magnets. Series pass transistor controlled linear mode circuit configuration is adopted for simplicity in design and to have clean and stable output. The power supply can be operated in unipolar as well as bipolar mode by selecting a jumper. It can be remotely operated through standard CAMAC and RS-232. After successful testing of first prototype which was assembled last year, 15 number of power supplies have been fabricated this year. Testing of these power supplies is going on.

3.1.2.2 Development of Multi Harmonic Buncher (MHB) Control Electronics

Rajesh Kumar, Abhijit Sarkar, A.Mandal

A single gap MHB fed with 12.125 MHz sawtooth voltage will be used at the upcoming HCI facility. The control electronics for the MHB to generate a 12.125 MHz sawtooth voltage and to maintain its phase and amplitude over time has been developed. The fundamental (12.125 MHz) and three harmonic (24.25 MHz, 36.375 MHz, and 48.5 MHz) are mixed in fixed proportion to get a close approximation of the sawtooth voltage. The design has been successfully assembled and testing is going on. Individually each module tested successfully meeting all the design goals. While testing, problems were observed such as cross coupling, poor grounding, EMI shielding

and oscillation. All these problems were rectified successfully by improving the PCB designs and feedback loops dynamics. The Phase and amplitude correction loops were optimised to have $\pm 90^\circ$ and ± 3 dB dynamic range.

As MHB setup is a servo system and the MHB cavity is the part of the control loop. So for final testing and calibration of the control electronics, MHB cavity is required, which is under fabrication. The gain and bandwidth of cavity and pick-up signal will decide the further optimization and tuning of the circuit. The final integration to test the instrument as a whole has been completed.

3.1.2.3 Feedback Controller for Piezoelectric actuator based Phase locking of SCQWR

S.K.Suman, Rajesh Kumar, D.S.Mathuria, Mukesh Kumar, B.K.Sahu

In order to improve the dynamics of existing phase locking scheme of LINAC resonators and to improve the response time of the slow tuner control, piezoelectric actuators are used in close loop to deflect the bellow. A feedback controller has been developed to drive the piezoelectric actuator for correcting the slow drifts caused by external mechanical vibrations.

As the piezoelectric actuators are quite fast, there is no delay in acceleration. So the controllers for these don't need any damping and proportional gain. A controller having only integration is sufficient for this purpose. An integral (only I) type controller is developed having large gain at DC and gain roll-off at 20 dB/decade up to unity gain crossover frequency at 16 Hz. The gain is rolled off to unity at 16 Hz to prevent excitation of mechanical resonances in cavity starting from 20 Hz up to several kHz.

After successful testing of controllers during two months beam acceleration using Linac, 20 nos of such controller have been developed in this year. All assembled units have been first tested at lab for proper functionality and then installed with Linac cavities for final loop gain optimisation before using with beam.

3.1.2.4 Development of 20 kW, 97 MHz. RF amplifier by combining two 10 kW amplifiers

Rajesh Kumar, S. Venkataramanan

A high current injector (HCI) for Super-conducting LINAC is under development at IUAC. The HCI consists of Drift Tube LINAC (DTL), where high power RF amplifiers ranging between 6 kW to 30 kW at 97 MHz. would be needed to power DTL cavities. The plan is to generate higher RF power up to 30 kW by combining 10 kW amplifier units. Use of only one type of amplifiers (10 kW) to serve the complete power range up to 30 kW will help to minimize the inventory and manpower training.

The output of a 20 W solid state pre-driver is split using quadrature splitter to drive two intermediate 500 W solid state amplifiers which in turn drive 10 kW tube amplifiers in quadrature. The output of the two 10 kW amplifiers is combined using a four port quadrature 20 kW combiner. With best phase and impedance matching of the combined input 18 kW (9 kW+ 9 kW), output obtained is 16.2 kW. The result shows that the combining efficiency is poor, so to have 30 kW power combining 15 kW amplifiers is more suitable.

3.1.2.5 Development of 97 MHz, 10 kW vacuum tube based RF amplifier cavity

Rajesh Kumar, S. Venkataramanan

A program has been taken up for in-house development of 10 kW tube amplifiers. A tube assembly with input and output impedance matching network has been developed using a high amplification factor triode tube (YU148) used in grounded grid class-A configuration. All the components of the

impedance matching network, and tube assembly were developed in house. To test the developed tube assembly, required biasing power supplies (plate & filament) and control electronics are used from existing power amplifier. We could achieve only 7 kW from this assembly instead of 10 kW due to poor quality dielectric material and surface finish of plate tank circuit.

3.1.2.6 Beam Transport System Maintenance

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

Power supplies and magnets of all the facilities like Pelletron, LINAC, HIRA, HYRA and LEIBF are regularly maintained during “scheduled maintenance period” to avoid failures during beam time and to ensure stability of magnetic field within limit. Approximately 200 instruments of 16 types which includes, Magnet power supplies, CAMAC based control modules, magnetic field measuring instruments, beam line switchers are in round the clock operation and are being maintained by this group. The maintenance activities are described below:

3.1.2.6.1 Scheduled Preventive Maintenance

To avoid failures during beam time and also to ensure the best performance in terms of stability, schedule maintenance of magnets, power supplies and other instruments has been done carefully and thoroughly twice this year. Some routine tasks carried out during the maintenance are:

- ***Dirt cleaning while checking for loose connections, hot spots corrosion and water leak:*** Compressed air blows and dirt cleaning solvents are used to keep all the power supplies and magnets clean. This reduces leakage currents, improves heat dissipation and hence avoids the unpredictable drifts
- ***Cooling of cooling water paths of power supplies and magnets:*** To remove cuprous oxide from the inner walls of the magnet coils, water hoses, sulphamic acid (moderately strong acid) is circulated through water cooling paths once every year. This minimizes leakage currents to ground and also helps to maintain proper water flows by removing partial blockages due to scaling.
- ***Remote control operation:*** Data read write and on off commands are checked thoroughly for any malfunctioning.
- ***Safety interlocks:*** During scheduled maintenance safety interlock are falsely generated and tested to ensure the safety during abnormal conditions.
- ***Full power test:*** Full power test is conducted after finishing all servicing procedures to guarantee proper operation and to monitor temperature rise and hot-spots in power supply and magnet.

3.1.2.6.2 Breakdown Maintenance

Power supply failures during beam operations are considered as breakdowns. During this year, there were only few occasions when power supply problems caused the suspension of beam operation. The most frequent causes for power supply operation interruption were because of external factors such as over temperature because of low water flows, input mains power fluctuations and remote control failures. In most of the cases the power supplies were recovered immediately after rectifying the cause.

3.1.3 Detector Laboratory

A. Jhingan, P. Sugathan

Detector Laboratory at IUAC provides experimental support to various users in setting up charged

particle detectors and readout electronics. New detectors and electronics have been designed and developed for new experimental facilities. Apart from various developmental activities, the group is intensively involved in various user experiments in nuclear reaction dynamics in HIRA, HYRA, GPSC and Neutron Array using heavy ion beams. Detector lab provided training on experimental activities for Scientist Trainees, JRF students, and M.Sc orientation program students.

3.1.3.1 Detector system for Quasi-elastic scattering/ fission angular distribution studies in GPSC/ NAND

A. Jhingan, Gurpreet Kaur (PU), B. R. Behera (PU), P. Sugathan

Work was initiated for fabricating and development of detector set up for performing quasi-elastic scattering and fission angular distribution experiments in GPSC/ NAND. The detector system is proposed to have 16 hybrid telescopes. Each telescope will have an axial field ionization chamber, followed by a Silicon detector. Machining of SS cylindrical chambers was executed. Fabrication of wire frames was also carried out for ionization chamber. An Aluminum dome was also fabricated to mount detectors in a ring. An aluminum arc was also fabricated for mounting telescopes in forward angles for fission angular distributions/transfer reactions. Currently mounts are being designed to place few detectors out of plane so that angular distribution experiments can be carried out in NAND which does not have rotating arms. Work has also been initiated to have dedicated read out electronics. These will require 32 channels of front-end electronics.

3.1.3.2 Detector system for charge particle multiplicities in fission experiments

IUAC, Panjab University (Chandigarh), BARC

A sixteen channel CsI array was mounted in GPSC for performing pre/post-scission charged particle multiplicity experiments. The detectors were assembled in group of four (2x2). Four such quads were placed in an arc close to the target. Each crystal, with active area 20mm x 20mm x 3mm, is read by a 10 mm × 10 mm photo-diode. The detectors are mounted on a PCB. Preamplifiers are mounted on the other side of the PCB with bias network and test input. The output of the preamplifier (inside vacuum) is fed to a 2nd amplification stage with a differential driver output. This output is fed to two shaping amplifiers, long (3ms) and short shaping (0.5ms) time. Particle identification is realized using ballistic deficit pulse shape discrimination technique. The array was tested off-line with radioactive sources and in an in-beam experiment $^{16}\text{O}+^{194,198}\text{Pt}$. Energy resolution of about 250 keV for 5.48 MeV Alpha was observed. A good separation of particles was observed during the experiment. In experiment, particles in CsI were detected in coincidence with fission fragments (detected in MWPC).

3.1.3.3 MWPC in GPSC

New wire frames for the fission MWPC of GPSC were mounted in the old detector body. In the new configuration, the wire pitch was reduced to 0.63 mm as against 1.27 mm. The reduced wire pitch was expected to improve the timing resolution. Due to higher density of wires, the PCB was found to bend under the stress of stretched wires. This resulted in sagging of wires and frequent breakdown of MWPC during the in-beam experiments. The reduced wire pitch (0.63 mm) electrodes were replaced with 1.27 mm wire pitch electrodes. Thereafter the detectors have performed satisfactorily

3.1.3.4 Annular PPAC for Coulex

A. Jhingan, R. Ahuja, R. Kumar, M. Saxena (DU), A. Kothari, H. J. Wollersheim (GSI)

The annular PPAC setup developed for Coulex experiments in GDA was revived and installed in GDA. A Coulex experiment was performed with annular PPAC from GSI. A test experiment was carried out using annular PPAC fabricated at IUAC. A new Aluminum chamber to house the electrodes was designed and fabricated. This replaced the previous SS chamber. New electrodes were also fabricated. As compared to our previous design, the pitch of rings in theta electrode (anode) was reduced to 1.27 mm from 2.54 mm. Both GSI and IUAC PPAC gave identical performances. It is planned to perform ER gated neutron Multiplicity experiments in NAND with this set up.

3.1.3.5 Strip detector set up in GPSC

A. Jhingan, T. Nandi, J. Gehlot, G. Kaur (PU), Dheeraj, Gaurav (DTU), Gajender (DTU)

A strip detector telescope was installed in GPSC to perform multi-nucleon transfer experiments. The telescope had 140 mm Silicon detector followed by a 300 mm Silicon detector. Both detectors are strip detectors (32 strips each), from Micron Semiconductors UK. The 64 signals were extracted using a custom made feed-through flange having 4 layer PCB sealed by Araldite epoxy resin. Two Mesytec preamplifier units (32 channels each) were plugged on outer side (outside GPSC chamber) of the flange. Signal output from preamplifiers were taken to data room via round and shielded twisted cables and fed to Mesytec amplifiers followed by Phillips ADC. Performance of the system was found to be reasonably good.

3.1.3.6 Instrumentation

For signal processing, a 16 channel differential driver module in a single width NIM unit was assembled and used for processing signals from CsI array. The drivers can drive 100 feet twisted pair cables without deterioration in the signals. Custom made charge sensitive preamplifiers have also been fabricated for the readout of charged particle detectors such as CsI, gas ionization chambers and Silicon detectors. Fast timing preamplifiers for MWPC were also fabricated. All the preamplifiers were tested and used in in-beam experiments by placing them inside vacuum chambers next to detectors. In one of the experiments a total of 30 preamplifiers were placed inside GPSC scattering chamber.

3.1.4 Target Development Laboratory

Abhilash S. R, D. Kabiraj, and D. K. Avasthi.

Target Development Laboratory at IUAC provides facilities to the users for the preparation of targets used for the experiments with IUAC Pelletron and other ion beam facilities. Most of the facilities in target lab were available for users in the last year with minimum down time. Man-machine utilization in target development laboratory is presented in the form of a bar chart in Figure 4. It indicates that one or more than one facility of target lab had been used every day in the last year. More than 340 attempts were performed for target fabrication in different systems. The targets were prepared for the experiments in Nuclear Physics [1-9], Materials Science [10-18], Atomic Physics [19], using facilities: (i) high vacuum evaporator (HV evaporator) (ii) evaporator with oil free pumping system with a base pressure of 6×10^{-9} mbar (UHV evaporator) (iii) rolling machine for the preparation of thin foils by cold rolling method (iv) atom beam source (ABS). More than 200 attempts were performed for target fabrication in different systems. In addition to IUAC Pelletron users, target lab provided target/thin film samples to IITs and VECC.

Tab.1-Utilization of facility

Facility	No of attempts
Diffusion pump based coating Unit	116
Cryo pump based coating Unit	74
Tubular furnace	49
Rolling Machine	99

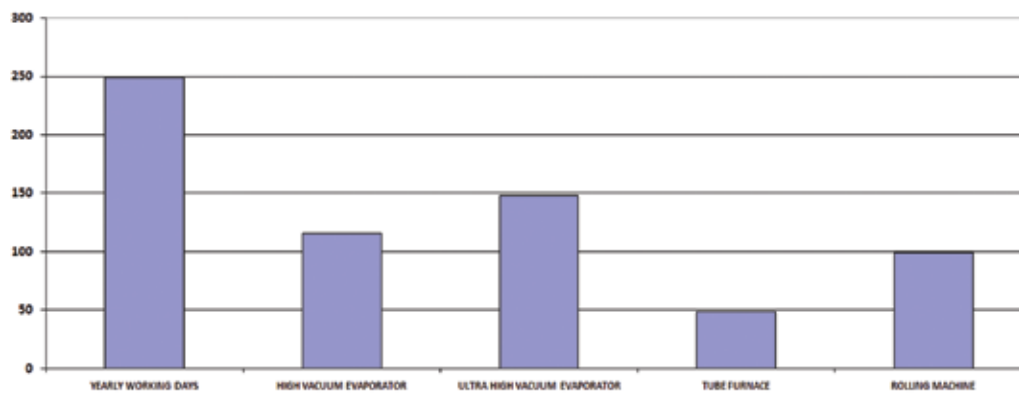


Fig.4- Utilization of time

Fabrication, Inspection and Loading of stripper foils

More than 150 imported carbon stripper foils and 100 IUAC foils were loaded in the last year. Foils are imported in the form of carbon films coated on glass slides. Floating of the foils, etching of the foils in the acid solution to remove the copper backing, mounting of the foils on stainless steel frame and loading of the foils in the terminal of the Pelletron are the major responsibilities in this work. In addition to regular stripper foil of $4\mu\text{g}/\text{cm}^2$, target lab also supplied stripper foils of $10\mu\text{g}/\text{cm}^2$ for dead section.

One of the major activities of this laboratory is to prepare targets of isotopically enriched elements. Approximately Rs 10 lakhs were spent for the procurement of isotopes in the last year. Details of some of the target fabrications of isotopes are as follows.

(1) Fabrication of $^{204,206,208}\text{Pb}$ Targets

Pb targets were prepared for the nuclear physics group of VECC and IUAC. Thermal heating set-up in HV evaporator was used for the preparation. Self-supporting targets and targets with thin carbon backing were prepared successfully. Self-supporting targets of $<400\mu\text{g}/\text{cm}^2$ found with less stability and life. These targets were successfully used in nuclear physics experiments.

(2) Fabrication of $^{142,150}\text{Nd}$ Targets

Nd targets were prepared for the nuclear physics experiment in IUAC. Nd target of $250\mu\text{g}/\text{cm}^2$ with a thin backing of carbon was the requirement of the experiment. Carbon foils were prepared in diffusion pump based coating unit. Nd was evaporated on carbon backing foil in the UHV evaporator by electron beam evaporation. Several attempts were done with natural material to perfect the parameters prior to the final evaporation. We had only limited success in this work. More attempts are required to perfect the method to fabricate more targets in a single evaporation [20].

(3) Fabrication of $^{92,94,96}\text{Zr}$ Targets

Isotopic Zr targets were prepared for the Nuclear Physics experiment of Delhi University. Targets with thick Ta backing and thin Carbon backing were fabricated. Electron beam evaporation technique in UHV evaporator was used for the target preparation. Targets with Ta backing with Au capping were successfully used for a beam time experiment in IUAC. However partial success was noticed with thin Carbon backing. Many targets with thin backing were not stable while preserving them for longer duration. More attempts and trials are required to minimize the failure of Zr targets.

Installation and testing of new evaporator for electron gun

Apart from preparation of thin films as user support this laboratory also takes up developmental work. At present we are in the process of installing a new evaporator where the electron beam gun is designed to operate the pressure of 1×10^{-3} mbar. This source will be useful to prepare oxide thin films in oxygen gas partial pressure. Installation and primary testing of electron gun (Figure 5) with leak testing is completed.

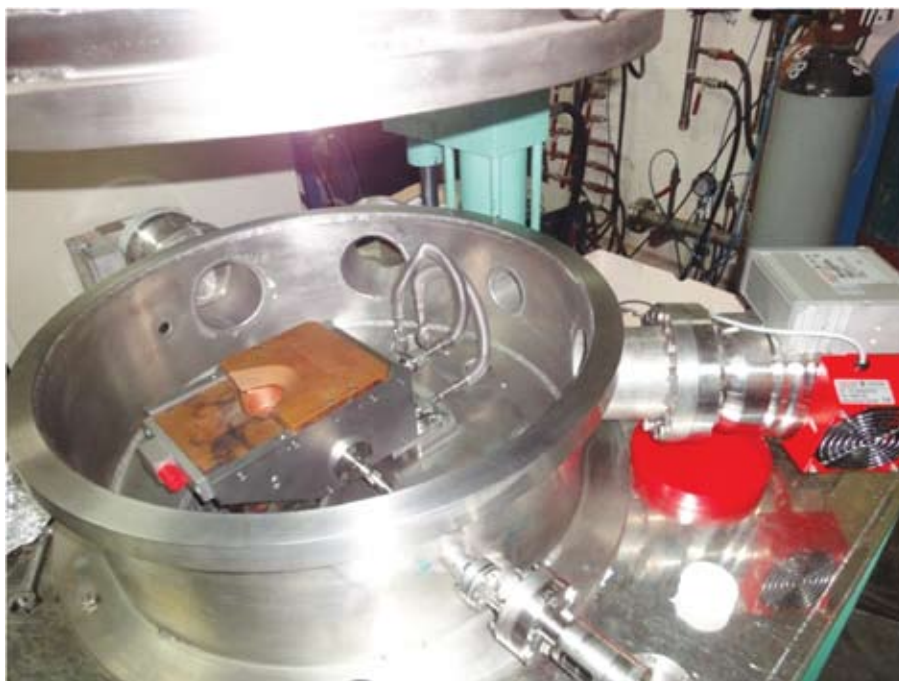


Fig. 5

References:

- [1] High spin structure in $^{130, 131}\text{Ba}$. N.Kaur, A.Kumar, G.Mukherjee, A.Singh, S.Kumar, R.Kaur, Singh, B.R.Behera, K.P.Singh, G.Singh, H.P.Sharma, S.Kumar, M.K.Raju, P.V.M.Rao, S.Muralithar, P.Singh, R.Kumar, N.Madhvan, R.K.Bhowmik. *Eur.Phys.J. A* 50, 5 (2014).
- [2] Influence of a one-neutron-excess projectile on low-energy incomplete fusion. Vijay R. Sharma, Abhishek Yadav, Pushpendra P. Singh, Devendra P. Singh, Sunita Gupta, M. K. Sharma, Indu Bala, R. Kumar, S. Murlithar, B. P. Singh, and R. Prasad. *Phys.Rev. C* 89, 024608 (2014).
- [3] Shape evolution in ^{123}Cs and ^{124}Ba nuclei. K.Selvakumar, A.K.Singh, S.Das, P.Singh, S.Nag, A.Gowsami, R.Raut, A.Mukherjee, U.Datta Pramanik, P.Dutta, S.Roy, G.Gangopadhyay, S.Bhowal, S.Muralithar, R.Kumar, R.P.Singh, M.K.Raju, T.Reddy. *Phys.Rev. C* 88, 024313 (2013)
- [4] g factors of $9/2^-$ and $23/2^+$ isomeric states in ^{129}Ba . J.Kaur, A.K.Bhati, N.Bansal, V.Kumar, V.R.Sharma, H.Kumar, R.Kumar, R.K.Bhowmik. *Phys.Rev. C* 87, 064312 (2013).
- [5] Low-energy incomplete fusion and its sensitivity to projectile structure. K.Kumar, T.Ahmad, S.Ali, I.A.Rizvi, A.Agarwal, R.Kumar, K.S.Golda, A.K.Chaubey. *Phys.Rev. C* 87, 044608 (2013).
- [6] Influence of projectile breakup on the $^{16}\text{O} + ^{115}\text{In}$ reaction at energies $\approx 4-7$ MeV/nucleon. K.Kumar, T.Ahmad, S.Ali, I.A.Rizvi, A.Agarwal, R.Kumar, A.K.Chaubey. *Phys.Rev. C* 88, 064613 (2013); *Pub.Note Phys.Rev. C* 89, 019901 (2014).
- [7] Effect of angular momentum on giant dipole resonance observables in the $^{28}\text{Si}+^{116}\text{Cd}$ reaction. Ish Mukul, A.Roy,

- P.Sugathan, J.Gehlot, G.Mohanto, N.Madhavan, S.Nath, R.Dubey, I.Mazumdar, D.A.Gothe, M.Kaur, A.K.R.Kumar, P.Arumugam. *Phys.Rev. C* 88, 024312 (2013).
- [8] Neutron multiplicity measurements for $^{19}\text{F}+^{194}\text{Pt}$ systems to investigate the effect of shell closure on nuclear dissipation. V.Singh, B.R.Behera, M.Kaur, A.Kumar, P.Sugathan, K.S.Golda, A.Jhingan, M.B.Chatterjee, R.K.Bhowmik, D.Siwal, S.Goyal, J.Sadhukhan, S.Pal, A.Saxena, S.Santra, S.Kailas. *Phys.Rev. C* 87, 064601 (2013)
- [9] Evaporation residue excitation function and spin distribution for $^{31}\text{P}+^{170}\text{Er}$. G.Mohanto, N.Madhavan, S.Nath, J.Gehlot, I. Mukul, A.Jhingan, T.Varughese, A.Roy, R.K.Bhowmik, I.Mazumdar, D.A.Gothe, P.B.Chavan, J.Sadhukhan, S.Pal, M.Kaur, V.Singh, A.K.Sinha, V.S.Ramamurthy. *Phys.Rev. C* 88, 034606 (2013).
- [10] Ion beam irradiation-induced tuning of SPR of Au nanoparticles in fullerene C70 matrix: dependence of energy loss. R. Singhal, J. C. Pivin and D. K. Avasthi.; *J Nanopart Res.* 15 (2013) 1641.
- [11] Formation of Self-organized Silver Nanocup-Type Structures and Their Plasmonic Absorption. Y. K. Mishra, R. Adelung, G. Kumar, M. Elbahri, S. Mohapatra, R. Singhal, A. Tripathi, D. K. Avasthi. *Plasmonics* 8 (2013) 811.
- [12] Synthesis of cobalt nanoparticles on Si(100) by swift heavy ion irradiation. A Attri, A Kumar, S Verma, S Ojha, K Asokan, L Nair. *Nanoscale Research Letters*, 8 (1) (2013) 1.
- [13] Effect of SHI irradiation on the morphology of SnO₂ thin film prepared by reactive thermal evaporation. Abhirami, K.M., Matheswaran, P., Gokul, B., Sathyamoorthy, R., Kanjilal, D., Asokan, K. *Vacuum*, 90 (1) (2013) 39.
- [14] Swift heavy-ions induced sputtering in BaF₂ thin films. R. K. Pandey, M. Kumar, U.B. Singh, S.A. Khan, D.K. Avasthi and A.C. Pandey. *Nucl. Instr. and Meth. B* 314 (2013) 21.
- [15] Blue-Shifted SPR of Au Nanoparticles with Ordering of Carbon by Dense Ionization and Thermal Treatment. R Singhal, D Kabiraj, P. K Kulriya, JC Pivin, R Chandra, DK Avasthi, *Plasmonics* 8 (2013) 295.
- [16] High-quality nanocrystalline ZnO films deposited by the atom beam sputtering. D C Agarwal, V V Sivakumar, D Kabiraj, P K Kulriya, I Sulania, D K Avasthi, *Journal of Nanoengineering and Nanomanufacturing* 3 (4) (2013) 331.
- [17] Investigation of ion beam mixing threshold value in Mn/Si system using swift heavy ions. Deepti Pratap, Vijay Kumar, Anshul Jain, A. Gupta, Sarvesh Kumar, I. Sulania, A. Tripathi, R. S. Chauhan. *Radiation Effects and Defects in Solids*: 168 (2013) 607.
- [18] Synthesis of carbon nanowires by SHI irradiation of fullerene C70 thin film. R. Singhal, A. Tripathi, D. K. Avasthi; *Adv. Mat. Lett.* 4(6) (2013) 413.
- [19] Fast Ion Surface Energy Loss and Straggling in the Surface Wake Fields. T. Nandi. K. Haris, Hala, G. Singh, P. Kumar, R. Kumar, S.K. Saini, S.A. Khan, A. Jhingan, P. Verma, A. Tauheed, D. Mehta and H.G. Berry, *Phys. Rev. Lett.* 110, 163203 (2013).
- [20] Enriched ^{148}Nd target on ultra low density backing. K Basu, et al., *Proceedings of the DAE symposium on Nuclear Physics* 57 (2012) 946.

3.1.5 RF and Electronics laboratory

A.Sarkar, S.Venkataramanan, K.Singh, B.K.Sahu, A.Gupta, M.Jain, P.Singh, D.K.Munda, Archunan, R.Joshi, R.Kumar, S.Kumar, U.Abhinav*, B.P.Jithin# and B.P. Ajith Kumar.

* IIT, Roorkee ; # IISER, Mohali

3.1.5.1 Front end and PSD electronics for NAND array at IUAC

The front end electronics earlier delivered to Phase-I NAND array (50 numbers) such as PMT voltage divider network along with charge sensitive preamplifier and pulse shape discriminator NIM modules (PSD) have been subjected to beam test during this period. All the modules performed as desired. Minor time delay (TOF) and width adjustments (STROBE) were carried out in all these modules for uniform performances. No failures of any front end electronics have been reported during this period, except for a failed TAC hybrid chip. The Phase-II analog front electronics for the NAND array has been initiated during this period. The front end electronics, namely PMT voltage divider network, Charge sensitive preamplifier, (50 numbers) required to power PMT have been integrated, successfully tested and commissioned in the array. At present, the dual channel PSD NIM modules (30 numbers) are being assembled for Phase-II array, and the testing and commissioning of these electronics modules will be completed by middle of 2014.

3.1.5.2 20 kilowatts VHF amplifier for DTL at IUAC

A high current injector (HCI) for Super-conducting LINAC is under development at IUAC. The HCI consists of Drift Tube LINAC (DTL), where high power RF amplifiers ranging between 6 kW to 30 kW at 97 MHz. would be needed to power DTL cavities. To use only 10 kW amplifier units to fulfill the RF power requirement up to 30 kW, an attempt has been made to combine such 10 kW

amplifiers to achieve higher power. The plan to use only one type of amplifier (10 kW) to serve the complete power range up to 30 kW will help to minimize the inventory and manpower training. Two 10 kW tube amplifiers were procured and power combined using a quadrature power combiner of 20 kW. The 10 kW amplifiers are based on Triode tube in grounded grid configuration. Before combining the power amplifiers were tested for power gain and power efficiency and measured to be +13 dB and 70% at about 8 kW respectively. The quadrature splitter, combiner were also tested for specifications such as insertion loss, isolation and are measured to be -3.2 dB and better than -20 dB respectively.

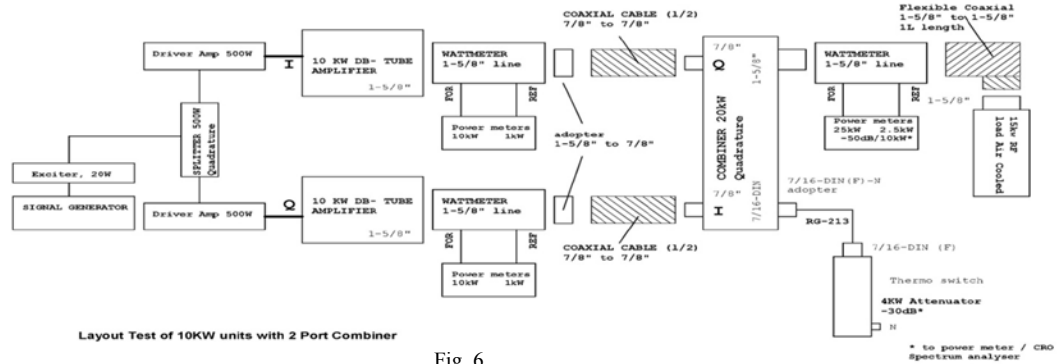


Fig. 6

A 20 W solid state pre-driver output is split using quadrature splitter to drive two intermediate 500 W solid state amplifiers which in turn drive 10 kW power amplifiers in quadrature as shown in fig. 6. The output of each 10 kW amplifier is combined using a four port quadrature combiner of 20 kW. The balanced and unbalanced ports of the power combiner are terminated in dummy loads of 15 kW and 2 kW respectively. With best phase and impedance matching the combined power achieved is ~13 kW, with power limited driver stages where combiner efficiency achieved is better than 83%. Simultaneously efforts have been made to develop a tube based 10 kW amplifier. Initially a tube assembly with input and output impedance matching network has been developed using a high amplification factor triode tube (YU148) used in grounded grid class-A configuration. To test the developed tube assembly, required biasing power supplies (plate & filament) and control electronics are used from existing power amplifier. We could achieve only 7 kW from this assembly instead of 10 kW due to poor quality dielectric material and surface finish of high power components of tank circuits.

3.1.5.3 Two kilowatts Solid state VHF amplifier module for DTL at IUAC

A prototype high power solid state radio frequency power amplifier designed to operate in the VHF-FM band has been successfully developed and demonstrated. The solid state amplifier is capable of delivering 2 kilowatts (CW) continuously. We plan to make use of these amplifier modules to build high power amplifier in the range of 5 kilowatts to 10 kilowatts along with commercially available or indigenous developed high power combiner structures to power the LINAC resonator cavities at IUAC.

3.1.5.4 Negative Ion Implanter Control System

The control system for Negative Ion Implanter has been implemented using indigenously developed IMACS (Indigenous Measurement and Control System) crates. Two no. of IMACS crates has been installed as servers, one in the high voltage deck section and other in the low voltage section. Appx. 50 signals are in use. Both the crates can provide 256 signals maximum. CentOS 5.0 LTS client.

3.1.5.5 VMEbus server for LINAC Module

Resonator control modules are controlled through CAMAC (computerized automated measurement

and control) supported servers in our existing Pelletron+LINAC control system. Now there is very limited support for CAMAC standard worldwide. We have decided to replace the CAMAC servers with VME servers. We did necessary changes in the control system software to accommodate VME standard. The hardware changes involve “Router *pcb*” design to route I/O signals from VME modules to the resonator controller modules to avoid any kind of wire mess. The data base file is written and server is tested with one resonator controller module in the lab. After thorough testing, server is installed in the zero degree beam line. Client (*pcli*) and server (*pserv*) programs will run on the same SBC. The control system is compiled with different Linux platforms and right now running with Ubuntu 12.10 and 12.04 LTS linux platforms with V7865 SBC.

3.1.5.6 64-channel optically coupled digital I/O VME board for control system

A new Versa Module Europa (VME) module, VME_IO32, features 64 optically coupled digital inputs and outputs, has been developed for control system applications at Inter University Accelerator centre (IUAC). The optically coupled digital I/Os will provide isolation between field components and VME chassis. Both inputs and outputs provide a sustained 1 kV of system isolation to the VME backplane. The complete input and output registers control logic and complexity of VME bus slave interface logic is designed and implemented on single FPGA (Field Programmable Gate Array) device to pack the density of 64 channels on a single width VME board. Other functions like firmware revisions, board ID, control and status register are implemented on same FPGA. The firmware is written as industrial standard HD (hardware description language), which can be ported to the latest commercially available FPGAs. The modular design of this VME board reduces the amount of time required to develop other custom modules for control system. The VME bus slave interface is written as a single component inside FPGA which will be used as a basic building block for any VME bus interface project. The design is implemented on Xilinx’s Spartan3 FPGA.

3.1.5.7 Development of the Multi-harmonic buncher (MHB) for High Current Injector (HCI)

The Mechanical Assembly:- The vacuum chamber which houses the buncher grids has been shifted to Beam Hall-3(High Current Injector location) after proper leak checks. The flanges and accessories required for the alignment of the grid assembly have been fabricated. The alignment of the grid assembly is done and the welding of the copper tubes to the RF feedthroughs has been completed. This will be followed by the mounting of the grids.

The tank circuits:- The tank circuit coils using OFHC copper tubes have been fabricated and mounted on the copper base plate. The vacuum variable capacitor holders are also mounted in place. The co-axial cooling arrangement in the coils including the manifold for water connection are made. An integrated closed loop de-ionised water cooling system which includes 2 pumps, a storage tank and a chiller with temperature control has been procured and tested.

The Electronics:- All the modules for the generation, control and locking of the saw-tooth voltage have been fabricated and tested successfully in the Laboratory. The phase locked loop and amplitude lock loop have been tested separately for each of 12 MHz, 24 MHz, 36 MHz and 48 MHz feedback control modules. All these loops have been found to work satisfactorily. The integration of the controller with the actual system is to be done shortly.

3.1.5.8 Web based monitoring of the Accelerator control scheme

Accelerator control scheme for Tandem and Linac runs on a network of PCs under the GNU/Linux operating system. The computers connected to the hardware runs a server program supporting the control/monitor of the signals over a TCP/IP connection. Only the unique signal identifier is known outside the server and used for accessing the signals from remote client computers running a specific client program. A web based interface has been developed for monitoring of the accelerator parameters, using Python and Javascript. The Python library is developed to access the accelerator

parameters using a message passing protocol, over a TCP connection, supporting functions like get-State, set-State, get-Value and set-Value. The web server is set up using python which acts as a client to the present accelerator control a server for other web based clients. User interface is developed using Javascript. The additional features of visual display using graphs and data logging are handled by user. Presently this monitoring is available in the IUAC intranet and has provision for real time monitoring from any outside network using standard www protocol.

3.1.6 Computer and Communications

S.Mookerjee, E.T Subramaniam, S.Bhatnagar and Ipsita Satpathy

The major activities this year include the expansion of the High Performance Computing facility at the Centre, expansion of the Centre's local area network, major enhancements to the Centre's enterprise computing and administration database package, and significant progress in the development of a DSP-based universal data acquisition system.

3.1.6.1 High Performance Computing Facility

The Centre's high performance computing facility, funds for which were sanctioned by the Department of Science and Technology in 2008, was inaugurated in April, 2010. The facility provides supercomputing access to university users across the country, and also provides a boost to the ion-solid, nuclear physics and atomic physics simulation programs at IUAC. The facility is targeted at computational chemists, physicists and biologists in the university system, working in the areas of materials science, atomic and molecular physics and chemistry, radiation biology and nuclear physics. The facility, currently one of the largest in the country, consists of three systems: a 200-node, 3200 core, 61 teraflop MPI cluster; a 96-node, 768 core, 9 teraflop cluster; and a 80-core shared memory Sun Enterprise server with 256 GB of RAM.

The 3200-core Xeon based cluster Vidya was made operational this year. The cluster consists of 200 compute nodes with dual 8-core Intel Xeon CPUs, 4 GB of RAM per compute core, and a 40 Gbps non-blocking Infiniband interconnect, providing a peak performance rating of 62 TF. In addition, the cluster has a 50 terabyte Lustre parallel file system attached through the Infiniband chassis, providing fast large storage accessible from all coimpute nodes. The software stack is mainly open source, with Rocks, CentOS and Lustre the building blocks. The cluster is expected to take much of the load off the old Kalki cluster, which has been operating on full loads and long wait queues for years.

As part of its training and outreach programs, the HPC facility conducted three training workshops on aspects of parallel computing and electronic structure calculations. One of these was a unique hands-on residential workshop directed at young researchers in the field of electronic structure calculations, held at Naukuchiatal. Leading experts gave lectures and followed it up by leading hands-on tutorials on a small cluster transported from IUAC for the workshop.

3.1.6.2 IUAC LAN and servers

The year saw a major overhaul of the local network and the administration software pool. The local area network at IUAC, which had reached a capacity of 900 ports across seven campus buildings through a process of incremental addition, was reorganized completely. The data centre for the central server pool was moved out to the state-of-the-art DC in the LEIB building, a new 5 km backbone cable laid to connect all buildings with the new DC in a star configuration, and the old campus fibre backbone was extended to serve as a redundant cabling option. The new network is now ready to cater to the Centre's expansion plans, including the auditorium and the new floor in the main building.

The administration ERP package was drastically enhanced this year, with the addition of major new

packages linking stores, purchase, accounts and personnel; a completely new and expanded set of user-accessible services, which moves the Centre a long way towards the goal of a paperless office; and a new user interface. The package was thoroughly tested and finally integrated formally in March. All operations in the financial year 2013-14 would use the new package. The new software is the result of a unique collaboration between the administrative staff and the computer group, and of a major effort put into many iterations of development and testing.

3.1.6.3 Enterprise Resource Planner

E. T. Subramaniam, Kusum Rani

The entire administration right from fund sources to write off almost all the modules required to make it a fully computerized system is implemented, tested. The accountancy module has been compared with a commercial software (used at IUAC) and found to be good as it is locally developed has more site specific options. Additional modules like complaint follow up, guest house allocation, employee dosimetry are being developed.

3.1.7 Health Physics Laboratory

S.P.Lochab, Debashish Sen, R G Sonkawade and Birendra Singh

Health physics group is involved in the field of radiation safety, research and development. Many university faculties and research scholars are using the facilities developed and maintained by this group. A few of the research scholars have completed their Ph.D. using the facilities and large numbers of research scholars are doing research available with this group. Routine maintenance of door interlocks and radiation monitors is being done regularly.

Newly developed TLD phosphors, more sensitive than commercially available TLDs, has been developed and applied for its patent. Gamma chamber is open for users from different universities and Institutions. Health physics lab provide help on radiation protection and radiation shielding calculations to universities which are in the process of installing particle accelerator facilities.

Our lab is actively participating in NDMA meets. The work associated with Health Physics lab is published in different journals.

3.1.7.1 Characterization and luminescence studies of Eu doped Barite nanophosphor

Shaila Bahl ^a, S.P. Lochab ^b, Anant Pandey ^c, Vipin Kumar ^d, V.E. Aleynikov ^e, A.G. Molokanov ^e, Pratik Kumar ^a

^a Medical Physics Unit, IRCH, AIIMS, New Delhi 110029, India

^b Inter-University Accelerator Center, Aruna Asaf Ali Marg, New Delhi 110067, India

^c Department of Physics, Sri Venkateswara College, University of Delhi, New Delhi 110021, India

^d Department of Physics and Astrophysics, University of Delhi, New Delhi 110007, India

^e Joint Institute for Nuclear Research, Dubna 141980, Russia

Barite (BaSO₄) nanophosphors were successfully prepared by the co-precipitation method. The structural analysis of the sample was carried out by analytical techniques such as X-ray diffraction (XRD), Transmission electron microscopy (TEM), Fourier transform infrared spectroscopy (FTIR) and Raman spectroscopy. XRD study reveals that the particles exhibit orthorhombic structure and are approximately 50 nm in size, while TEM study further confirms the particle size in the range 48–52 nm and depicts oval shape of the particles. The FTIR spectrum displays the bands centered at 1197 to 1077 cm⁻¹ and the shoulder at 982 cm⁻¹ corresponding to the symmetrical vibration of SO₄²⁻ ion. Moreover, S–O bending and stretching are the Raman signature of barite, which were proven by the

Raman spectra, unveiling the various vibrational modes of the compound. Samples were irradiated by gamma rays and proton beams and their thermoluminescent (TL) glow curves were plotted and studied. On applying two different types of irradiations in addition to large energy difference, the sample showed almost a similar TL glow curve structure, which is the remarkable feature of this phosphor. Analysis of the glow curve was also carried out by the glow curve deconvolution method. Photoluminescence (PL) study shows broad excitation spectra with the main peak at around 250 nm whereas the emission band excited by the wavelength 250 nm was observed at 374 nm which corresponds to the $4f^65d-4f^7$ ($^8S7/2$) transitions of Eu^{2+} ions. The sample was also examined for its PL response to different exposures of gamma irradiations where it showed an increase in the PL intensity up to a dose of 800 Gy for both excitation and emission spectra. The present sample shows good crystal quality along with high TL and PL sensitivity. Hence our results suggest possible potential applications of nanocrystalline $\text{BaSO}_4:\text{Eu}$ phosphor in dosimetric study of gamma and proton beams.

3.1.7.2 Thermoluminescence response of gamma irradiated $\text{SrAl}_2\text{O}_4:\text{Eu}^{2+}/\text{Dy}^{3+}$ nanophosphor

A.K. Bedyal ^a, Vinay Kumar ^a, V.K. Singh ^a, S.P. Lochab ^c, Fouran Singh ^c, O.M. Ntwaeaborwa ^b, H.C. Swart ^b

^a School of Physics, Shri Mata Vaishno Devi University, Katra-182320, Jammu and Kashmir, India;

^b Department of Physics, University of the Free State, P.O. Box 339, Bloemfontein 9300, South Africa;

^c Inter-University Accelerator Centre, Aruna Asaf Ali Marg, New Delhi 110067, India

In this paper, we report on the thermoluminescence response of nanocrystalline co-doped alkaline earth aluminates synthesized by combustion method using metal nitrate as precursor and urea as fuel. A broad TL glow peak was observed at 367 K with a shoulder at 400K. TL Anal program has been used for GCD curve fitting. The Kinetic parameters like, the activation energy (E_a), the frequency factor (s) and the order of kinetics were calculated for the $\text{SrAl}_2\text{O}_4:\text{Eu}^{2+}, \text{Dy}^{3+}$ nanophosphors. The best dopants combination was Eu (1 mol%) and Dy (2 mol%). The samples were irradiated with γ -dose in the range 20Gy–800Gy, at room temperature. A shift from 367 K to 376 K was also observed in the main peak with an increase in irradiation dose which suggest that the irradiation doses affect the distributions of traps produced by the gamma-ray irradiations. Kinetic parameters also suggest that TL glow curve in $\text{SrAl}_2\text{O}_4:\text{Eu}^{2+}, \text{Dy}^{3+}$ nanophosphors is obeying second order kinetics. The nanophosphors show linear response with dose.

3.1.7.3 TL response of nanocrystalline $\text{MgB}_4\text{O}_7:\text{Dy}$ irradiated by 3 MeV proton beam, 50 MeV Li^3 and 120 MeV Ag^9 ion beams

Numan Salah ^a, Sami Habib ^a, Saeed S. Babkair ^b, S.P.Lochab ^c, Vibha Chopra ^c

^a Center of Nanotechnology, King Abdulaziz University, Jeddah 21589, Saudi Arabia

^b Center of Nanotechnology, Dept.of Physics, King Abdulaziz Univ., Jeddah 21589, Saudi Arabia

^c Inter-University Accelerator Centre, Aruna Asaf Ali Marg, New Delhi-110067, India

Magnesiumborate (MgB_4O_7) is a highly sensitive phosphor commonly used in a thermoluminescence (TL) dosimeter. In this work TL response of nanocrystalline $\text{MgB}_4\text{O}_7:\text{Dy}$ irradiated by 3 MeV proton beam as well as 50 MeV Li^3 and 120 MeV Ag^9 ion beams in the fluence range of 1×10^{11} – 1×10^{15} ions/cm² were reported. The induced TL glow curves were compared with that of gamma rays irradiation. A single glow peak is observed at around 430 K in the samples irradiated by Li^3 and Ag^9 ions, while that exposed to proton beam has an extra one at 525 K. This nanomaterial has maximum sensitivity to Li^3 , then Ag^9 ions and finally protons. The TL response curves of the samples exposed

to these radiations are linear/sub-linear at the lower fluencies, while at higher values they saturate. These variations in the glow curve structure and TL response could be attributed to the modifications created in the traps/luminescent centres. TRIM code was also used to calculate the absorbed doses, penetration depths and main energy loss. These results show that this nano material might be useful for the dosimetry of heavy charged particles such as Li^{3+} and Ag^{9+} particularly at low fluencies, while in case of proton beam the TL glow curve is greatly altered and shows poor sensitivity.

3.1.7.4 Thermo-luminescence kinetic parameters of γ -irradiated $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}, \text{Dy}^{3+}$ phosphors

A.K. Bedyal ^a, Vinay Kumar ^a, V.K. Singh ^a, S.P. Lochab ^c, Fouran Singh ^c, O.M. Ntwaeaborwa ^b, H.C. Swart ^b

^a School of Physics, Shri Mata Vaishno Devi University, Katra-182320, Jammu and Kashmir, India

^b Department of Physics, University of the Free State, P.O. Box 339, Bloemfontein 9300, South Africa

^c Inter-University Accelerator Centre, Aruna Asaf Ali Marg, New Delhi 110067, India

In this paper, we present a detailed investigation of the thermo-luminescence (TL) kinetics of the long afterglow phosphor, $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}, \text{Dy}^{3+}$, synthesized by the combustion method. Kinetic parameters such as the activation energy (E_a), the frequency factor (s) and the order of kinetics (b) were calculated using Chen's formalism. The crystalline structure of the phosphor was examined using X-ray powder diffraction and transmission electron microscopy. The average particle size was found to be in the range of 45–52 nm. The optimum dopant concentrations were Eu (1 mol%) and that of Dy (2 mol%). The TL response of the phosphor was monitored after the samples were irradiated with a γ -dose using a ^{60}Co source in the 20–800 Gy range. A broad TL peak, (stretching from 328 to 410 K) with a maximum at 368 K was observed. With increasing irradiation dose, the main peak shifts toward higher temperatures. Symmetry factor calculations show that the main TL glowpeak obeys second-order kinetics, which could be attributed to the creation of deep level traps. This means that γ -ray irradiation greatly affects the distribution of traps in the $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}^{2+}, \text{Dy}^{3+}$ phosphor. The phosphor showed a linear response with γ -dose.

3.1.7.5 Swift heavy ion induced structural and luminescence characterization of $\text{Y}_2\text{O}_3:\text{Eu}^{3+}$ phosphor: A comparative study

S Som ^a, S K Sharma ^a, * and S P Lochab ^b

^a Department of Applied Physics, Indian School of Mines, Dhanbad 826 004, India

^b Inter University Accelerator Centre, New Delhi 110 067, India

This paper reports a comparative study on structural and thermoluminescence modifications of $\text{Y}_2\text{O}_3:\text{Eu}^{3+}$ phosphor induced by 150 MeV Ni^{7+} , 120 MeV Ag^{9+} and 110 MeV Au^{8+} swift heavy ions (SHI) in the fluence range 1×10^{11} – 1×10^{13} ions/cm². XRD and TEM studies confirm the loss of crystallinity of the phosphors after ion irradiation which is more in case of Au ion irradiation. Structural refinement by Rietveld method yields the various structural parameters of ion irradiated phosphors. Thermoluminescence glow curves of ion irradiated phosphors show a small shift in the position of peaks along with an increase in intensity with ion fluence. SRIM calculations were performed in order to correlate the change in thermoluminescence properties of various ion irradiated phosphors. It shows that the defects created by 110 MeV Au^{8+} ions are greater in number. Trapping parameters of ion irradiated phosphors were calculated from thermoluminescence data using various glow curve analysis methods.

3.1.7.6 Effect of gamma irradiation on opto-structural, dielectric, and thermoluminescence properties of natural phlogopite mica

Sukhnandan Kaur¹, Surinder Singh¹, Lakhwant Singh¹ and S. P. Lochab²

¹Department of Physics, Guru Nanak Dev University, Amritsar 143005, Punjab, India

²Inter University Accelerator Centre, New Delhi 110067, India

Gamma ray induced modifications in natural phlogopite mica have been studied in the dose range of 1–2000 kGy. These modifications were monitored using different techniques viz: ultraviolet-visible spectroscopy, Fourier Transform Infrared spectroscopy, dielectric measurements, X-ray diffraction, and thermoluminescence dosimeter. The analysis of the results reveals that the dose of 100 kGy produces significant change in the natural phlogopite mica as compared to pristine and other exposed samples. Ultraviolet-visible analysis provides the value of optical indirect, direct band gap, and Urbach energy. Cody model was used to calculate structural disorder from Urbach energy. Different dielectric parameters such as dielectric constant, dielectric loss, ac conductivity, and real and imaginary parts of electric modulus were calculated for pristine and irradiated samples at room temperature. Williamson Hall analysis was employed to calculate crystallite size and micro-strain of pristine and irradiated sheets. No appreciable changes in characteristic bands were observed

3.1.7.7 Photoluminescence and thermoluminescence study of KCaSO_4Cl doped with Dy and Ce synthesized by acid distillation method

Bhushan P. Kore^a, N.S. Dhoble^b, S.P. Lochab^c, S.J. Dhoble^a

^a Department of Physics, RTM Nagpur University, Nagpur440033, India

^b Department of Chemistry, Sevadal Mahila Mahavidyalaya, Nagpur440009, India

^c Inter-University Accelerator Center, Aruna Asaf Ali Marg, New Delhi 110067, India

Photoluminescence and thermoluminescence properties of KCaSO_4Cl doped with dysprosium and cerium have been studied. Dy/Ce doped KCaSO_4Cl phosphors were synthesized by the acid distillation method. The samples were characterized by XRD, SEM, PL and TL for structural, morphological and luminescence studies. The SEM image analysis of KCaSO_4Cl phosphor shows nearly spherical particles with diameter varying between 3–10 μm . In the present host Dy³⁺ emission at 482 and 573 nm is observed due to $4F9/2-6H15/2$ and $4F9/2-6H13/2$ transition, respectively, whereas the PL emission spectra of $\text{KCaSO}_4\text{Cl}:\text{Ce}$ phosphor shows two luminescence band at 307nm and 326nm and area attributed to the allowed inter configurational transitions from the 5d-level to the $2F5/2$ and $2F7/2$ levels of Ce³⁺ ion. Effect of annealing on the structure of the glow curve is investigated for $\text{KCaSO}_4\text{Cl}:\text{Dy}$ phosphors. Thermoluminescence linearity has been studied for 0.1–9000Gy dose of gamma rays. Linear behavior over a large dose range between 0.1Gy and 170Gy was found. In addition to this trap parameters of $\text{KCaSO}_4\text{Cl}:\text{Dy}$ were studied using computerized glow curve deconvolution.

3.1.8 Data Support Laboratory

Data Support Laboratory provides support to users on data acquisition & nuclear electronics setup during experiments. In the data room, two on-line data acquisition based on CAMAC systems are maintained for data collection during in beam experiments and two desktop workstations for off-line analysis. The lab maintains the data acquisition computers & private LAN for data network. The lab also provides support to the local Data Acquisition systems that uses indigenously made List Processor Crate controllers and Candle Data Acquisition software. Apart from providing regular user support and maintenance of the setup, few electronic modules have been developed and some

existing modules serviced. The lab also procures required electronic modules, co-axial connectors and cables required for user support.

3.1.8.1 On-line Data Acquisition Systems upgrade in Data Room

Ruby Santi, Kundan Singh and P. Sugathan

The existing on-line data acquisition systems in the data room have been upgraded to new versions of software that support commercial USB based CAMAC crate controller CMC100. The CMC100 controller is a USB2.0 compliant list processing crate controller having its own internal buffer memory. To support this controller, "Freedom" data acquisition software has been modified to incorporate the new readout libraries and support of CMC100 driver under Linux 2.6 kernel. In the software, the list processor commands are executed by LAM trigger and the readout is done by polling. Option for normal as well as Q-stop mode readout has been implemented in the new versions. Commercial 16 channel Phillips ADCs and TDCs are supported by the system.

3.1.8.2 Trigger Logic implementation using V1495 module for VME Data Acquisition system

Ruby Santi , Kundan Singh and P. Sugathan

VME based data acquisition system requires a common dead time master trigger. This is usually generated using NIM electronics circuit that generate fast trigger signal from detectors and inhibited by common BUSY signal shared with all front-end modules. In order to implement the common BUSY and VETO circuit, we have used the general purpose VME module V1495 which is a user programmable FPGA module commercially available from CAEN. This module can be programmed for custom built digital logic circuit replacing many conventional NIM modules. V1495 which is a VME 6U board, 1U wide is suitable for various digital Gate/Trigger/Translator/Buffer/Test applications. It has two FPGAs, one used for VME interface and the other for user programming. The user FPGA manages the front panel I/O channels and is substantially an empty FPGA. It is available to be programmed by the User according to the desired logic function. It can be programmed "on the fly" via VME, without any external hardware tools and without disconnecting the board from the set up. A flash memory on the board stores the programming file. For FPGA programming, the QUARTUS software which is compatible with LINUX OS has been installed in the VME DAQ host computer itself. The gate and delay for the live master trigger is generated by the firmware loaded inside the module and necessary Tools are available to change the gate width and delay of the Master Gate.

3.1.8.3 Development of NIM modules for NAND experimental facility

V.V.V Satyanarayana and P. Sugathan

Few electronics modules, such as 16 channel NIM- ECL- NIM level translators (figure 7), Logic FIFO (figure 8) and LEMO to flat ribbon header adapter module have been developed and tested in the upcoming Neutron detector array facility in Phase II beam hall. To meet the requirement for signal readout from 100 Neutron detectors, more number of these modules have been fabricated and installed in the experimental setup.

16-Channel NIM to ECL level translators

This module is used to convert the fast NIM signals to ECL signal that are fed to the VME time to digital converters. The fast NIM signals are the CFD output from pulse shape discrimination modules and they are used as time of flight STOP signals for TDCs. The 32 channel TDCs used in VME setup receives ECL signals as its input and the level adapter is used here to make signal conversion. A prototype module has been built and tested for its performance. Based on this, eight more modules have been fabricated and installed in the experimental setup.



Fig. 7 : 16 channel NIM- ECL translator module

32-Channel Logic Fan-In / Fan-Out

This module provides a way to interconnect large number of logic modules with minimum additional delay time. The unit contains 32 negative fast-NIM inputs and these inputs generate 4 outputs which are the logical OR of all inputs. An adjustable gate-window (17ns to 400ns) is provided to generate a master gate for an event by taking care of delay in the output responses of detectors due to their position. Applications of this modules includes OR gate, coincidence experiments, master gate generation etc.

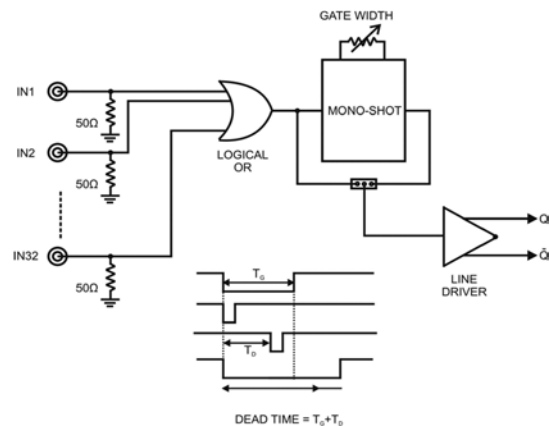


Fig. 8 : Functional block diagram

32 Channel Lemo to Header adapters

Our existing home made pulse shape discriminator modules used in neutron detector array facility have Lemo connectors at its outputs whereas all the ADCs/TDCs modules in VME setup have 34 pin header connectors at its input. In order to make them compatible with our existing setup, LEMO to header adapters are fabricated and used in the system. Module having 32 channels of adapters are implemented in a single width (NIM form factor) board and eight such modules have been fabricated and installed in the experimental setup.

3.2 UTILITY SYSTEMS

3.2.1 Electrical Group Activities

U. G. Naik, Raj Kumar

This group is primarily responsible for maintaining the electrical installations of IUAC and also to provide adequate electrical infrastructure for the scientific projects. I am happy to put on record that the uptime achieved for electrical systems was close to 100%. This was possible with judicious maintenance schedules and monitoring arrangements. This group has also successfully completed the projects and works envisaged for the year F.Y. 2013-2014.

MAINTENANCE:

3.2.1.1 Maintenance of Electrical Installations of Substation, Office Blocks and Residential Colony

Maintenance of electrical installations is managed through the AMC with external agency, however all the consumables required are supplied by us. This year we extended the AMC contract that we had with M/s KBS Electrical for the second year. Electrical Group is proud to declare here that during this year the installations have performed efficiently with uptime close to 100%. One of the major maintenance activities was replacement of 111 kV HT VC Breaker through M/s ABB as it had developed a flash. Although few of the major yearly maintenance activities are carried out every year, few of them are specific.

- Dehydration of transformer oil for 7 Transformers- (4500ltrs)
- Periodic maintenance of LT panels, Distribution boards and other accessories, Lighting, Fixtures, lighting and power circuits.
- Servicing of DG sets 60 kVAX2nos, 1*750KVA, 2X 320 kVA, 1X 100 kVA-twice a year.
- Maintenance of street lighting and earthing.
- LT Bush replacement for 1000 kVA Transformer#5

3.2.1.2 Captive Power Installations

Institute had a captive power base of 1560 kVA, having DG capacities from 100-750 kVA. In the financial year 2013-14 the group has successfully managed to upgrade it to 2500 kVA. The scheme worked out has a capability to synchronize 3*750 kVA DG sets making a total capacity of 2250 kVA that provides total redundancy to the critical loads. The group has shown ever readiness in running the systems round the clock O&M activities within short period if need arises.

3.2.1.3 Voltage Stabilisers

Voltage stabilizers supporting the installations having capacities from 30 kVA to 1000 kVA are working in healthy conditions with practice of periodic maintenance and have kept 100% up time. No failure occurred during the financial year.

3.2.1.4 UPS Installations

The institute has 5sets of 2*60 kVA UPS, 3*300 kVA, 4*200 kVA, 1*50 kVA and around 20 nos. of 2-10 kVA UPS systems maintained by electrical group. These are under supervision and control of this group. Although the day to day operations is carried out by electrical group the comprehensive AMC order have been placed on the manufacturer for all the sets out of warrantee period. Batteries worth 10 lakhs were replaced for UPS during the FY 2013-14.

3.2.1.5 Power Factor Compensation

Electrical group is very happy to declare that yet again we achieved average power factor of 0.98 lag throughout the year. Our system power factor without correction is about 0.85 and by raising it we saved around Rs. 68 lakhs through the year from energy billing.

3.2.1.6 Communication Equipments:

Electrical group maintains the 14 hand held radio stations (Walkie-talkie) and one base station. The routine maintenance such as replacement of batteries, antennas, switches etc is managed by this group. This year we have given AMC for service to the authorized agency of MOTOROLA @ cost of 35000/- per annum. The group takes the responsibility of getting the revalidation of license periodically from the Ministry of telecommunications.

3.2.1.7 Energy Saving

Energy savings measures taken earlier continued in the areas where we had installed the energy saving time switches and CFL lamps, T-5 lamps etc. This financial year we have added motion sensors in few toilets and committee rooms on experimental basis. On the same measure this year we have tried LED lights in few laboratories developed this FY. We are expecting save 70 % energy in these installations over the conventional T-8 Fl. Tube fittings.

PROJECT WORKS:

3.2.1.8 UPS Systems for 15UD Pelletron and LHe Plant

4*200 kVA on line UPS power system installed for 15UD Pelletron during end of last FY year has running smoothly and given a boost in the operation of the Pelletron and no failure due electrical disturbance was observed or reported during the FY 2013-14.

Similarly after adding a 300 kVA UPS to the existing 2*300 kVA UPS for He plant the operation of the He plant has been very smooth and no breakdown observed for the period of entire 12 months. We have also added a few water circulation pumps on to these UPS so that the water circulation to the He plant remains uninterrupted.

3.2.1.9 Power DG Backup to 15UD Pelletron, LHE Plant and HPC Centre

Group has planned, designed DG power backup of capacity 2*750 kVA to backup 15UD Pelletron and HPC Centre and all have been installed. This project was delayed and this year we have completed and put in to operation. One additional arrangement is done by shifting the 750 kVA DG set earlier installed for LHe plant to this new location and synchronizing all three of them. Now the installed capacity stands at 2250 kVA and programming is done in such a way that DG operation is being optimized by introducing load management through PLC programming.

3.2.10 Electrical Energy Management Network

Electrical group has maintained the MIS software successfully and managed the load and power factor control efficiently.

3.2.11 Electrical Earthing:

Electrical group has successfully executed 8nos. of electrical earthing using chemical earthing near BH-III to meet the requirements of earthing for electronics and power in the beam hall-III.

3.2.12 Works for Beam Hall-III:

Electrical group had taken up electrical works partially for the first part of HCI in BH-III involving

RFQ, DTL and few magnets besides 50 kVA of UPS power to the High voltage deck equipment's etc are now been completed.

3.2.13 Works For Graphitisation Laboratory (14 C):

Electrical group had taken up electrical works for this and provided the energy efficient LED lights. PVC cable trays have been introduced for wires and cabling so that they can remain rust free in the chemical environment. Power distribution is done in very efficient manner economical based exact need and sufficient provision of future needs. Graphitization table has been provided with UPS power. In the same manner IIFR and DTL lab has been developed and provided with energy efficient LED lights

3.2.2 Air Conditioning, Water System and Cooling Equipments

P. Gupta, A. J. Malyadri & Bishamber Kumar

AC SYSTEM

IUAC's central air conditioning / low temperature cooling system of Phase-1 consisting of 400 TR Central AC plant performed with 100% uptime. Proper maintenance ensured that the safety record of the plant was maintained at 100% and the power consumption kept at optimum levels. Installation of 2 nos. of 200 TR Screw Chillers in Ph-1 A/C Plant was completed and commissioned in March 2013. Each new chiller has run around 4000 hours. Other rotary equipment except AHU#1-7 have logged in about 1,81,750 continuous run hours. It is relevant to note that the Indian industrial norms specify ~25,000 run-hours for the life of compressors and ~50000 hours for other rotating equipment.

The Phase-II, centrifugal central AC plant with its installed capacity of 250 TR, catered to EBW, UPS, Beamhall#II and cryogenic activities. 19XL Chiller broke down again and most of the rotating components were severely damaged. Though the Ph-2 Chiller was down, the ph-2 loads were diverted on Ph-3 chiller and the breakdown did not affect the research activities. OEM (Carrier) advised on replacing the chiller in view of non-availability of critical spares, as this chiller model has become obsolete. Accordingly, it was decided to replace the chiller. Subsequently tendering exercise was initiated and order placed for SITC of 250 TR Chiller. It is expected to be installed by the end of April 2014.

The Phase-III, screw chiller based central AC plant with its installed capacity of 250 TR performed to an uptime of 100%.

The highlight of the operation and maintenance of the above systems was the in-house supervision provided to the contracts, thereby affecting substantial savings in the price paid for these.

Another very important feature of the above systems is the huge power savings achieved by making modifications in the systems, which has enabled us to run the plants optimally during winter months.

The yearly maintenance costs have been maintained at approximately one-eighth of the national standards and one third of the world class industrial bench marks. Though, the plants have aged, yet the MTBF for all the equipment is within acceptable norms.

The equipment being into their twenty-fifth year of sustained operations has **far outlived their economic lives**. Maintenance ensured that the equipment still possessed high operational reliability. Lot of repair / overhauling works initiated to improve the systems efficiency.

WATER SYSTEM

IUAC's centralized water system of Phase-I feeding low temperature cooling water of a total heat removal capacity of 115 TR, potable water supply and the gardening water supply performed to an operational uptime of 100%. This was possible due to the stringent maintenance practices, which were followed over the years. The system has already overshoot 1,35,000 hours beyond its expected life span.

IUAC's centralized water system of Phase-II feeding low temperature cooling water of a total heat removal capacity of 80 TR, liquid helium cooling water of approx. 350 TR heat removal capacity and potable water supply also performed to an uptime of 100%.

Further, centralized water system of Phase-III feeding low temperature cooling water of a total heat removal capacity of 80 TR and potable water supply performed to an uptime of 100%.

A strict monitoring on the water quality ensured that the flow paths are in healthy condition. The maintenance costs were kept significantly as compared to world class bench mark values.

Addition of System: New 150 KLD Sewage Treatment Plant (STP) was handed over to MG#2 and included in Water System from December 2013 onwards.

COOLING SYSTEM

Availability of equipment was recorded at 99%.

PLANNED BUDGET WORKS:

Tendering exercise completed for replacement of 1 No. 250 TR Screw Chiller in Ph-2 A/C Plant and order placed. It is expected to be commissioned by the end of April 2014.

Installation of Ultra-Pure Analytical Type-I DI Water Plant for super conducting resonator cleaning facility in Beamhall#II is in progress and is expected to be commissioned by 15th April 2014.

Tendering exercise completed for Clean Room of Class-100 for LINAC module servicing and order placed. It is expected to be commissioned by June 2014.

Tendering exercise completed for Dust Free Room for RFQ assembly work in Beam Hall#III and order placed. It is expected to be commissioned by the end of March 2014.

Clean Room of Class-100 commissioned in Room No. 240 for GDA detector servicing.

Provided Closed-loop Water Cooling System for HCI-MHB.

¹⁴C AMS sample preparation laboratory Air-Conditioning was done by providing 3 Nos. of 2.5 TR capacity Split A/C's.

IFR lab (Room No. 413) Air-Conditioning was done by providing 3 Nos. of 3.0 TR capacity Split A/C's. Process Water SS Pipe headers extended in Beam Hall#II for NII facility.

Involved in the the planning and finalisation of Lab#2 Air-Conditioning Works with PMC i.e., RITES. Tender for the subjected works is in the final stage and order will be placed soon.

Replacements:

Two nos. of Sewage Pumps along with control panel was replaced

Aqua guards (13 Nos.) were replaced by RO Water Purifiers

Kitchen Fume Hood Exhaust System replacement work is in progress and is expected to be commissioned soon

Additional cooling equipment were installed as per the requirement

3.2.3 Mechanical Workshop (MG-III)

B.B.Choudhary, S.K.Saini, R.Ahuja, S.Rao and J.Zacharias

IUAC workshop is an ideal workshop equipped with modern machining and welding facilities to support Pelletron Accelerator, various laboratories and large number of user community.

The major facilities of the workshop are Machine shop and Welding shop.

The machine shop is equipped with a five axis Vertical Machining Centre and a CNC lathe. Apart from these, we have four conventional lathes, two milling machines and a Radial drilling machine catering to the tool room jobs. Most of these machines are of HMT make, fitted with DROs for achieving higher accuracy and better productivity. Apart from these, we have cylindrical grinder, tool and cutter grinder, horizontal and vertical band saw machines, etc. for general requirements. We have also added one Wax moulding facility for melting the wax and shaping it into required shape & size. It can handle 100 kgs of wax at a time. Molded wax ingots were used for making NAND beam dump. We also have the CAD facility, Solid Works for the design and drafting purpose. We also have VISI CAM for the CAM support for the Vertical Machining Centre and CNC lathe. A portable CMM is also installed in the workshop metrology section.

Workshop has been involved in development activities of new system as well as a large-scale production of beam line components right from the inception of IUAC. Most of the beam line components used for the new beam lines was fabricated in the IUAC Workshop. Workshop continues to assist the entire in-house fabrication activities of LINAC, RFQ and DTL for HCI, INGA, HYRA, 1.7 MeV Pelletron as well as the Cryogenic component developments.

Welding shop is having high quality TIG welding machine and equipment. Some of the TIG machines can give pulsed arc for the thin section welding. Air plasma cutter with a capacity to cut up to 40mm thickness of stainless steel is used extensively. Aluminum welding and Oxy-acetylene cutting and brazing set ups are also available. We have a micro plasma machine from Air Liquide, France for very thin section welding.

IUAC workshop is providing Apprentice training for the ITI passed students in both welding shop as well as in machine shop. Basic workshop training is also provided for the scientist trainees and Ph.D. students enrolled in IUAC.

Some of the major completed/ongoing projects:

- Beam Dump for NAND
- Magnetic Quadrupoles for HCI
- Radio frequency Quadrupole
- Drift Tube LINAC
- High current proton source for 2.45 GHz source development program
- 48.5 MHz Buncher for HCI
- LEIBF -II Beam line components

- 25 kW-97MHz RF Amplifier Machine Housing
- Slow Tuner for LINAC

3.2.4 Civil Works

M.K.Gupta & Harshwardhan

Works under Civil Section

- Major expansion Projects (right now construction of (i) Auditorium (ii) Addition of one floor in Main Lab. Building (iii) FEL & AMS Lab. building (iv) Two new blocks of Housing (one Kalpataru and one Kamdhenu)
- Minor Projects
- Minor Works (additions, alterations, renovation in the existing Civil works)
- Civil Maintenance
- External Cleaning of the Campus
- Liaison with various Govt. and external agencies for statutory approvals and various civic problems
- Key management of the Centre

Important Civil Activities during the Year 2013-14

Following important Civil works were undertaken during the year 2013-14 in addition to routine Civil maintenance and minor works:

- Work for construction of Auditorium & Lab. block Extn. in progress in association with M/S RITES (our Project management consultant)
- Planning of two new projects namely Construction of FEL and AMS building and construction of two no. Housing blocks (one Kalpataru and one Kamdhenu block)
- P/F vitrified tiles in Parijat-1
- P/F new Aluminium doors in Beam Hall-III
- Replacement of broke & damaged drain covers in the entire campus
- Construction of MS platform for servicing Linac Cryostat in BH-II vault area
- Civil works for setting up C-14 Lab. in R.N.307 of Engg. Building
- Civil works for upgradation of IFR Lab. located in UB-II building
- P/F glazed tiles on walls of toilets in Parijat-1.
- MS platform in BH-II vault area for placing 500 litres water tank
- P/L Interlocking concrete paver blocks in front of Engg. Building
- Construction of Furnace room on W-side of LEIB building
- Renovation of Ladies toilet in Lounge area of Main building
- Sound insulation between R.N. 405 & 406 and UB-1 plant area
- Construction of 2 no. Stores near Civil maint. office
- Major maintenance works in Parijat 3 for conversion from Club to residential allotment

- Woodwork in C-14 Lab. below Granite counter slab in Engg. Building

3.2.5 Compressed Air System And Material Handling Equipments (MG-I)

K.K. Soni and Bishamber Kumar

Group is associated with the following activities:

- i) Compressed Air System: Compressed air plant (Ph-I & PH-II) consisting of three nos. screw compressors each of 115M³/Hr capacity, along with air dryers & filters with capacity of 3000 lpm @ 9.00 kg/cm² have been maintaining uninterrupted air supply to tower, Beam Hall- I, Beam Hall -II and other associated lab areas round the clock. In order to further increase the reliability of the Compressed air supply at constant pressure, a 25 M³ Storage tank is added in the system. It is installed in the Compressed air line on the roof of UB II . Pneumatic connections have been extended to all the labs.

A stand by screw compressor of 115 M³/Hr capacity is added in PH I plant in order to meet any eventuality of breakdown of existing compressor. A storage tank of 1KL is added between compressor and Air dryer for smooth flow of compressed Air.

Further to ensure low dew point of the air, the compressed air is passed through two refrigerated type air dryers of 4300 LPM capacity. Ultra high filters of boro silicate and carbon filters are provided in different location of the compressed air to provide clean air free from dust and oil particles. The filter cartridges of Ultra high filters are changed once a year to maintain the quality of supply air.

Since Reciprocating compressors which are more power consuming and source of excess oil contamination in the compressed air, therefore, generally we do not operate the reciprocating compressors. Compressed air piping has been extended to Lab I, Lab II and New Workshop building.

- ii) Industrial Gases: Various industrial gases required in different labs have been made available from time to time. Special gases like Iso Butane and mixture gases are also procured for labs.
- iii) Elevator: The Elevator has been replaced of similar capacity with modern features. The new Elevator is put in to use.
- iv) Material Handling System : Periodic maintenance / servicing of more than 14 Nos E.O.T cranes and electric hoists of various capacity varying from 1 Tonne to 7.5 Tonnes are being carried out periodically and the same have been working smoothly. Two more cranes of 7.5 T capacity in BH III and 2 T Electrical Hoist in BH III has been added. All the important area cranes are put on remote control operation for safe handling of machines.
- v) Fire Extinguishers: Annual refilling and periodic maintenance of all the fire extinguishers have been carried out. New fire extinguishers have been installed in newly constructed BH III, store area , Lab I and Lab II area, Workshop building. Some more sign boards including the "Escape route" are added in the building which shines even in darkness. .Demonstration for use of Fire extinguishers has been arranged and all the users and IUAC employees are trained to use the fire extinguishers.

New buildings under PH II part II have the newly added Fire safety norms which includes pressurized water hydrant system. It includes centralized pressurised water system connected to underground Water tank and water pumps which maintain continuous water pressure in the water hydrant line. This system is available in PH II Part II buildings. All the Labs and experimental areas have smoke detectors having display unit and sound alarm at Reception of Lab I which is attended round the clock by operator.