3. RESEARCH SUPPORT FACILITIES

3.1 SUPPORT LABORATORIES

3.1.1 High vacuum laboratory

Chandra Pal Maurya, A.Kothari, P.Barua, and S. Chopra

High vacuum laboratory is primarily responsible for maintaining vacuum and vacuum systems in beamlines and experimental facilities. It provides support to different labs and users in vacuum related problems. Vacuum lab is involved in maintenance of a large number of experimental facilities. Therefore, vacuum components like vacuum pumps, gauges and their control systems are monitored regularly.Vacuum lab is also involved in the installation and commissioning of various beamlines,experimental and accelerator facilities at IUAC. At present, installation of components of High Current Injector [HCI] is in progress. The high voltage platform with ECR source and other LEBT components have been installed along with onboard beamline components. Initial test beam has been successfully extracted, analyzed and diagnosed at the first BPM and Faraday cup.

3.1.1.1 Installation of the Low Energy Beam Transport (LEBT) section of High Current Injector (HCI)

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The ECR source of the HCI along with the low energy beam transport (LEBT) components and control system were installed last year. The two water chillers for ECR source cooling and water cooled Faraday cups were installed and made operational. This year beam was successfully extracted, analyzed and diagnosed in the BPM and Faraday cup just after the magnet. Some problems in the focusing and a lateral shift in the horizontal planewere observed. The following modifications were carried out after thorough discussion.

1. The Electrostatic Quadrupole Doublet (EQD) had been installed just before the magnet entry port at a distance of about 300mm from the magnet inlet. To improve the focusing of the beam, the EQD was required to be moved closer to the magnet. Since EDQ could not be shifted due to physical limitations, the EQD was replaced by an Electromagnetic Quadrupole (EMQ) with single coil for focusing in X-X plane, as shown in Fig. 3.1.1. It has been installed at a distance of about 165 mm from the magnet entry.
2. Initially, there were no beam diagnostics before magnet to optimize the beam from ECR source and the extraction system. Hence, Beam Profile Monitor (BPM) of 50 mm aperture and 1kW water cooled faraday have been installed just before the EMQ, (Fig. 3.1.1).
3. To correct the position of analyzedbeam in the horizontal plane, a C type magnetic steerer was designed, fabricated and installed immediately at the magnet exit port.
4. A new control console for remote operation of the HCI ECR source has been designed, fabricated and installed in the beam hall, as shown in Fig.3.1.2.

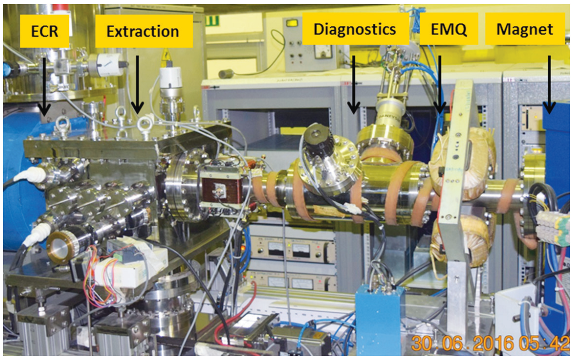


Figure 3.1.1:Diagnostics and EMQ in HCI LEBT

Figure 3.1.2: Control Console HCI LEBT section

5. An additional turbo pump of 300 lps has been installed to augment the vacuum pumping capacity inthe ECR source region. The vacuum in the ECR injection side improved from 4×10^{-6} mbar to 4×10^{-7} mbar after installation.

6. Design of components for HCI LEBTsection:Vacuum housing for Fast Faraday cup (FFC), Slit chambers and vacuum pumping stations have been designed and fabrication is under progress. The individual flange mountable modules of FFC,Slits, Faraday cup and pumps etc. will be installed on these housings with proper alignment and installation fixtures. Few of them are shown in Fig. 3.1.3 and 3.1.4.

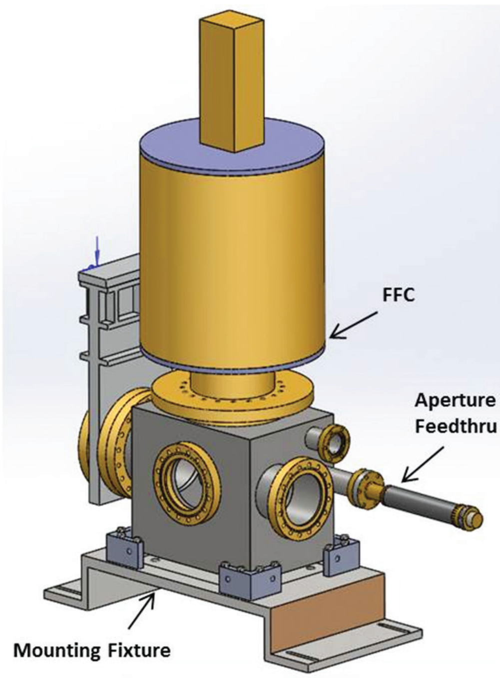


Fig. : 3.1.3: FFC Vacuum housing

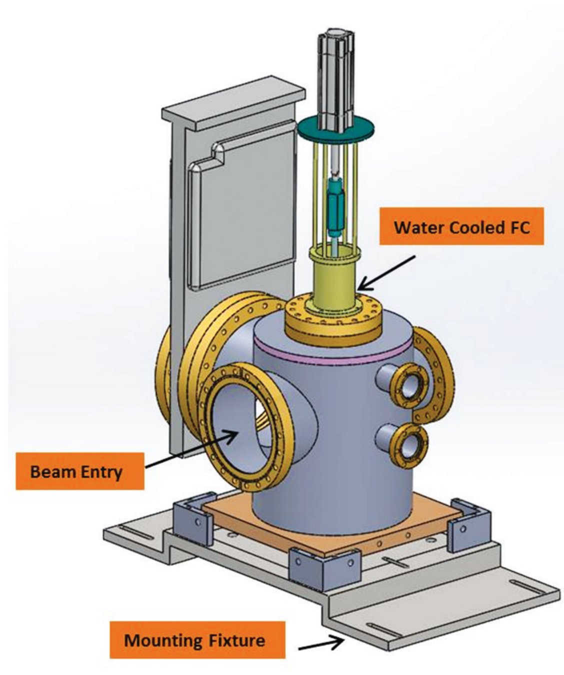


Fig. : 3.1.4: Pumping Chamber

7. Layout for the HCI LEBT section has been finalized with due discussion from concerned members.

3.1.1.2 GP Tube Replacement in the Ion Source Area

P. Barua, Ashok Kothari, Devarani Devi, Rajan Joshi, S. Gargari, Pranav Singh, Jagdish Prasad, Rakesh Kumar, N.S. Panwar and S. Chopra

The GP tubes of the Ion Source room got shorted due to dust accumulation over so many years and were unable to hold high voltage during experiments. To replace these tubes, all the components from ion source up to steerer had to be dismantled. Before dismantling the Einzel lens,theodolite, which is required for alignment of components, was set up at the Injector magnet side with references from the magnet viewport bracket and the Einzel lens aperture. All the five GP tubes, Ion Source, Einzel lens, gate valve and other adaptors were dismantled. New GP tubes were installed with proper alignment. All the other components were also installed and aligned again. Finally, the Ion source and the Einzel lens aperture were installed and aligned within 0.8 mm of the reference axis.

3.1.1.3 Maintenance Activities

Chandra Pal Maurya, A.Kothari, P.Barua, D. K. Munda and Kundan Singh

- **CAMAC Crate maintenance:** Due to frequent problems in the read back and control signals from CAMAC crate 5 and 6, these crates were taken up for maintenance. Few cards of the Spark Protection crate were found burnt, so these were repaired and put back. All the connectors were removed and cleaned. Read back and control signals from each channel were tested and problems were rectified. Testing and calibration of all the phase II Faraday cup log amplifiers were performed.

- **Fast closing valve Interface System maintenance:** The valve interface module of the fast closing valve control system had stopped working. The power supply module of the unit had got burnt. Therefore, a new similar rating power supply was procured and installed and the unit was made functional.

3.1.2 Cryogenics and Applied Superconductivity Laboratory

Anup Choudhury, Jacob Chacko, Joby Antony, Manoj Kumar, Suresh Babu, Soumen Kar, Santosh Sahu and T. S. Datta

3.1.2.1 LHe plant operation

(1) The Linde LHe plant was operated only once (run no 12) for the LINAC operation, which was the longest run for the plant since beam delivery to usersfrom LINAC had started. A total of 3250 hrs was clocked on the main compressor. A brief tabulated report on the total runs is shown below.

Run no	Date of operation	Hrs on compressor	Usage
12	09/03/15 – 25/07/15	5844 - 9100 (3250 hrs)	LINAC and Oxford cryostat

During the operation of the plant, some important points need a mention.

(i) Run no 12 has been the longest run in the history of LINAC operation at IUAC

(ii) During the operation there was no beam through LINAC for almost 5 weeks due to Pelletron tank opening for installation of carbon foils in the terminal. During the lean period, the cryogenics was operated in standby mode which used lesser power.

(iii) Oxford cryostat is filled up from the plant directly and it requires filling every 1.5-2 days. A number of experiments were conducted on this cryostat starting with temperature calibration measurement and other sample measurements for users.

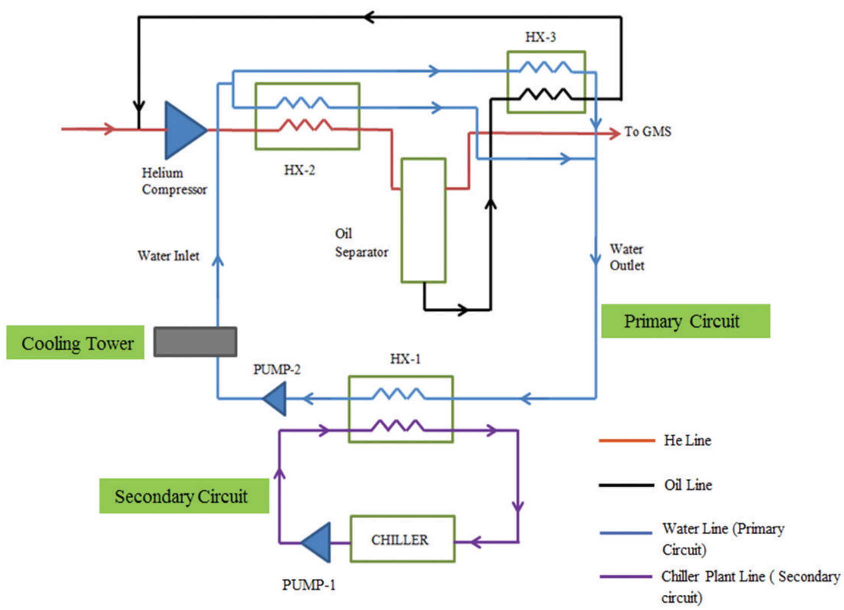


Fig. 3.1.5 : Diagram of the circuits used in the experiment to improve the compressor cooling mechanism during power failures

(iv) During the lean period, some system tests were conducted to improve the compressor cooling mechanism during power failures when the chiller stops. Two sets of experiments were carried out to see the effectiveness of the secondary pump running with (1) secondary pump running in UPS mode and (2) secondary pump off and 3rd phase cooling tower running(Fig. 3.1.5&3.1.6). It was seen that the compressor temperature cut off time can be increased almost 2-2.5 times using the secondary pumps. Based on the observations, generator power needs to be provided to these installations before commencement of the future LINAC runs.

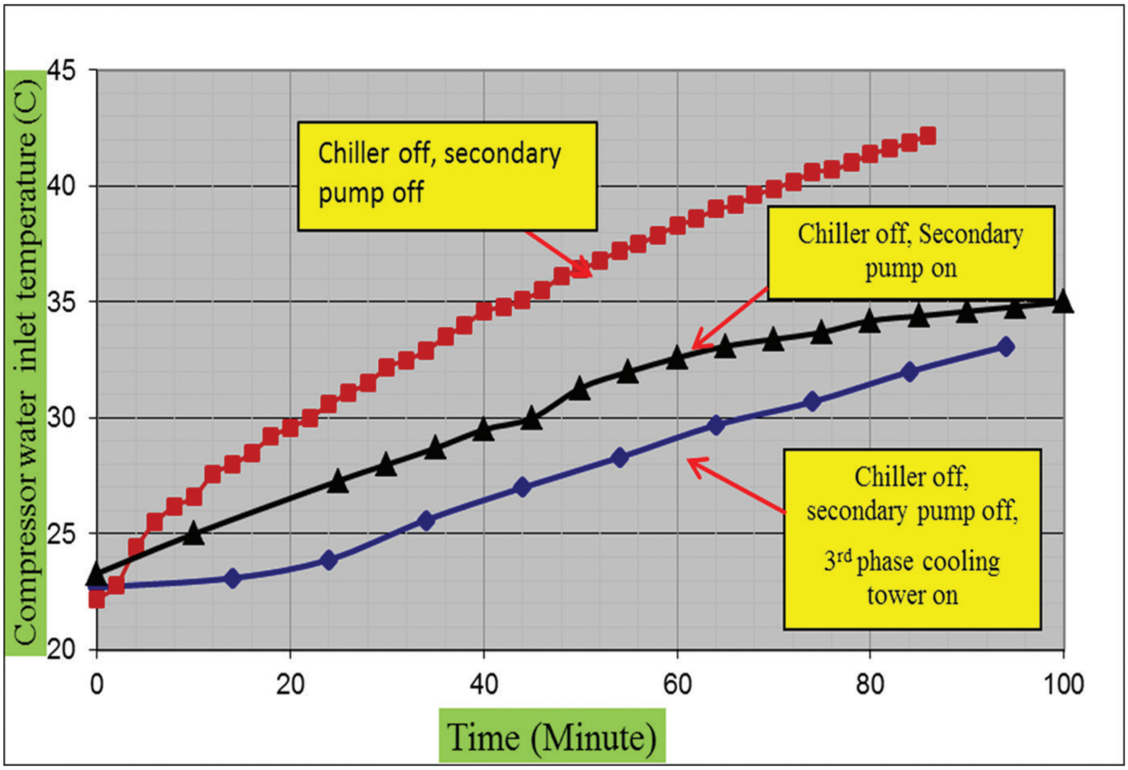


Fig. 3.1.6: Compressor water inlet temperature versus time

(v) Air compressor is another important item which needs attention whenever there is a power failure during such long LINAC runs. Till now only one compressor has been provided with emergency power. The other compressor is also being proposed to be put on generator.

(vi) During the long operation, the in-house liquid nitrogen plant needed maintenance and had to be put off. During this period, the entire LN_2 supply was managed from the outside storage tank and the existing infrastructure could handle this change successfully.

(2) After LINAC operation was over, the helium liquefier machine needed its 1st major service as it crossed the mandatory 9000 hrs of running. During the service period some major maintenance activities were taken up, like (i) complete charcoal change of GMS (338 kg) (ii) replacing of 8 nos. oil coalesce filter (iii) changing of O-ring seals in both turbine o-ring. After replacement of the charcoal, a special effort was needed to regenerate the charcoal bed with hot and dry nitrogen gas. For drying the bed, 99.999% purity nitrogen gas was required, so high purity nitrogen gas was obtained from liquid nitrogen tanker in liquid form and then it was heated through an 8 kW Watlow process gas heater. The complete drying took ~8 hrs of heating (outlet temperature was maintained at 100 ºC), then cooling the bed for next 2 days and subsequent pressure test of the vessel. During the inspection period it was found that the cold bypass valve seal had cracked and started to leak slowly, but due to non-availability of special tool the seal could not be changed.

(3) Two new helium vertical tanks of capacity 60 m^3 each have been ordered.With this addition, 2000 m^3 of extra gas storage capacity will be created. This extra gas buffer (in addition to the present capacity of 1400m^3) shall be used fully in case of accidental loss of gas during a long haul LINAC operation.

3.1.2.2 Electronics for Cryogenics and LINAC

Joby Antony and D.S.Mathuria

A. Cryogenic controls

1. CADS

The successful crate-less model of completely indigenous control hardware and software built out of in-house designed large number of different intelligent cryogenic instruments, interconnected over Ethernet(LAN) with http servers has been operational for last four years(24×7) continuously without problems. Hence it has proven to be a rugged design for Cryogenics distribution system. Some spares have also been built this year.

2. CRYO-DACS

The second system, CRYO-DACS, a VME system which was installed in 2002 for all LINAC temperature monitoring is still operational continuously without switching it off. This system failed only once in the last 14 years due to dust related issues and was restored within a week.

B. Other development activities

1. Field Mapping System

The project involved development of software and hardware for the automated three-dimensional movement and mapping of magnetic field of a magnet at precise points and intervals, A daisy chained ALST model of RS232 based Stepper motor based system for X-Y-Z has been bought from M/s Zaber Technologies. A Hall probe, paired with a Digital Tesla Meter, measured and displayed the accurate magnetic field. The Digital meter has an RS232 output which was tapped by us for remote read-back.

We tried out a PC based system and PC free system for evaluation purposes.

a) PC- free system

The method chosen was to use a Programmable Logic Controller (DELTA PLC) to control the three motors with the help of a Human Machine Interface (HMI). Software programs were needed to be developed to make a Graphic User Interface (GUI) on the HMI for precise remote control and read-back of the data and to plot the data in a graphical plot for further analysis. Though the system doesn't need a PC, it was decided that that the PC system may be more useful considering the support of EXCEL in windows for on-line & off-line analysis on screen.

b) PC based system

This is purely a PC based system which is developed using LabView®. The following Fig.3.1.7 shows the data taken from a real measurement.

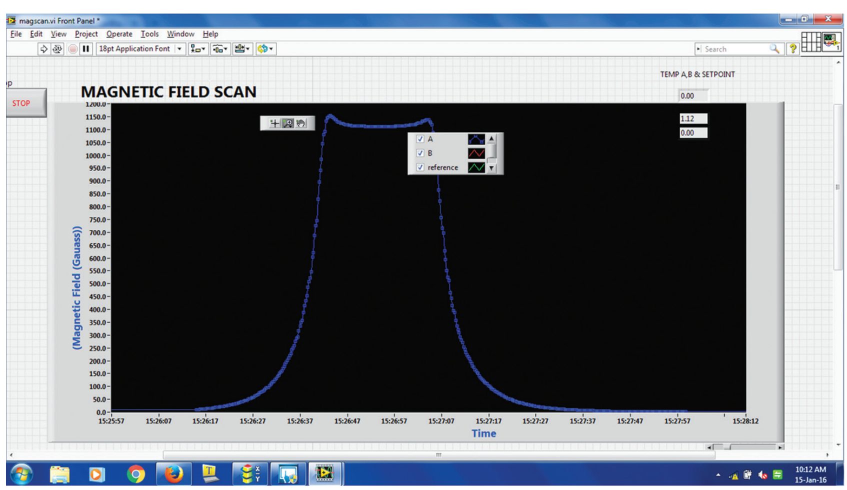


Fig. 3.1.7: A test field map captured in an experiment using the new system

2. An AUTOMATED CRYO-COOLER: HARDWARE & SOFTWARE

A hardware system was developed and tested for the PC based remote operation of Cryocooler. The hardware and software were developed in-house and tested with the Low-Temperature Laboratory. The Figure 3.1.8 and 3.1.9 show some test setup and results.

Fig. 3.1.8: Test setup

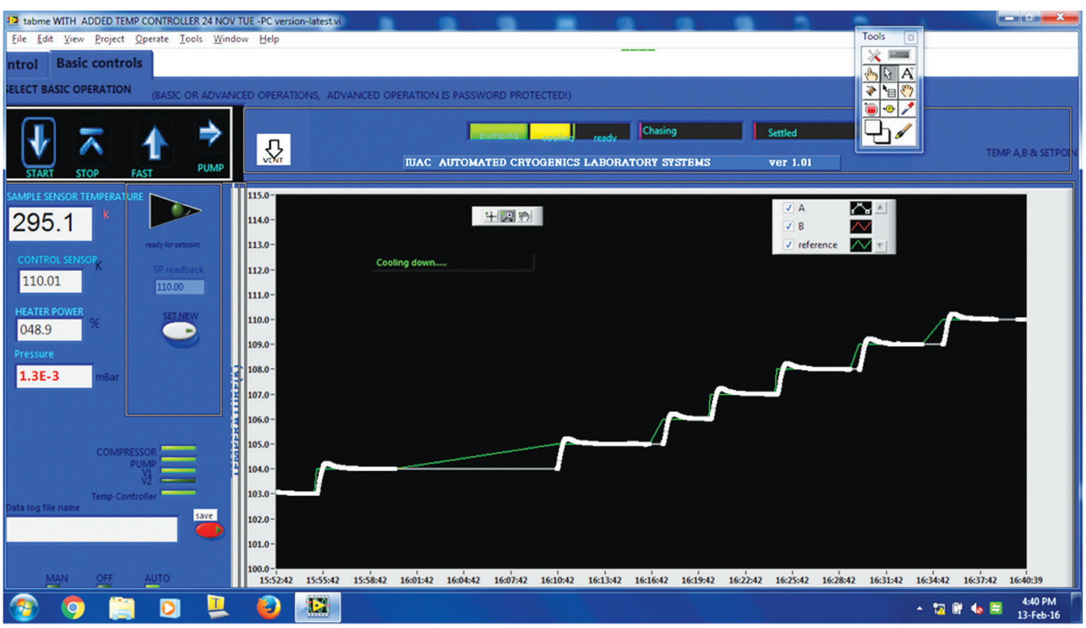


Fig. 3.1.9: Ramping control of temperature in PID mode

C. Other development activities

Patent formalities have been completed for the developed measurement device for the liquid nitrogen level with in-situ calibration features, known as LN_2 servers which can work with different geometry of capacitive sensors and different mounting arrangements of extended coaxial cables. It is a preamplifier free design.

D. Other activities: LINAC related in the last one year:

i) Upgraded EBW testing

The upgraded EBW system is operating without any issue.

ii) SPL

The automated surface preparation facility using Allen Bradley PLCs and Intouch Wonderware SCADA needed some minor modifications like software interlocks and user friendly interfaces and is operational.

3.1.2.3 Other developmental activities

3.1.2.3.1 Quadrupole Cryostat

(i) A superconducting quadrupole doublet cryostat with ever cooled magnet technology using two 4.2K cryocoolers was made (annual report 2013-2014). During one of the long operation test runs with both the magnets at peak field, one of the magnets quenched due to heating at one of the HTC to copper joint,which initiated quench in the bigger coil since both were thermally connected. During the quench of 300 coil, the stored energy got dissipated at one of the loose sharp corners through a spark and it killed the coil altogether. After identifying the possible failure sequence of the superconducting quadrupole cryostat, the cryostat was required to be cut open in order to look inside for the position of possible shortening of the 300 coil to the body. The entire cryostat had to be shifted to an open as cutting it inside the beam hall II would have generated fine metal dust which could create problems for the HYRA ED's. For cutting open the same, a very careful approach was adopted so that the inner vessel can be extracted from the outer shell unharmed. Similar precautions were adapted to take out the magnet assembly from inside of the helium vessel. On examination it was found that one of the coils has sparked at the pole corner touching the vessel body. The position of the spark suggests that there may have been some strain in the coil around that sharp corner during the room temperature assembly.

(ii) A fresh effort was initiated to make a new cryostat for the quadrupole magnet. Some salient design features in the new cryostat are: (1) The new design shall also have 2 cryocoolers as in the old design, but here the mode of operation will be different. One of the cryocoolers shall operate in the liquefier mode and the other in reliquefier mode, and both the cryocoolers shall be put in the helium process line (different from last time where they were in common cryostat vacuum). (2) The HTS current leads in the old design have been replaced with more reliable conventional 2 pairs of LTS current leads. The use of LTS leads necessitates use of liquid helium and the room temperature helium gas thus needs liquefaction through GM cryocooler. (3) The support system of the cryostat shall be much different from that of the old cryostat. Here, radial support system will be used which should help in making the magnetic alignment easier. (4) Overall footprint of the cryostat will be smaller than the previous one. (5) Heat transfer to the heat shield will be different from the earlier design. A successful test has been carried out in this direction whose details are given in the following.

3.1.2.3.2 Carbon link development

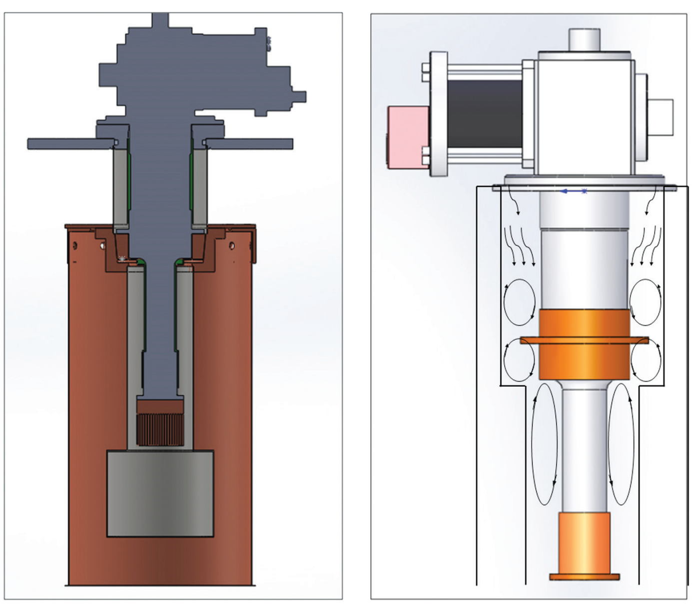
For supporting the helium vessel of the new magnet cryostat with higher strength and low thermal conductivity support links a technical program has been initiated. One carbon fiber link has been developed (using carbon fiber cloth of 15 mm width and 40 layers of it impregnated with resin) which can take a load of 10 ton.The link has been tested up to liquid nitrogen temperature. Efforts are underway to characterize it thermally between 300K-4K range. The links development assumes significance since these links are planned to be used for the radially symmetric loading of the quadrupole cryostat in the immediate future which are not possible with the G10 links used in the earlier design.

Fig. 3.1.10: Carbon fiber support with SS fixture

3.1.2.3.3 GM cryocooler based LHe liquefier

A helium liquefier using a GM cryocooler has been built in a user friendly coaxial configuration where the cryocooler and the cryostat are symmetrically positioned around the same axis. In a Sumitomo make GM cryocooler SRDK-415, extra cooling power is available at the inter stage regenerator region (50K-10K) due to periodic oscillation of helium gas in the labyrinth seal between regenerator holder and outer jacket (Fig 3.1.11). For liquefaction, this additional cold enthalpy has been utilized with two geometrical arrangements to cool the incoming helium gas at 50K namely, (i) natural convection between regenerator and the cryostat neck wall and (ii) laminar flow cooling between regenerator and another coaxial low thermal conductivity screen placed very near to the regenerator. Natural convection current in that annular region interacts with the incoming helium gas and cools it down further to ~10K, leading to an increase in the production rate of LHe to 17.4 lpd (liters per day) up from existing 16.6 lpd using same cryocooler.

Cryostat schematic



Gas dynamics

Fig. 3.1.11 : Liquefier cryostat with gas dynamics

3.1.2.3.4 Heat Transfer studies with cryocooler in refrigerator / liquefier mode:-

The design of the new cryostat demands that the shield covering the helium vessel in the cryostat be cooled from the 1st stage and the 1st stage is in the process gas. So the heat from the shield has to be transported to the 1st stage through mechanical contact. A setup was made to study and quantify the heat transfer through the tapered joint and the experiment was carried out using the Apiezon N grease between the two tapered copper flanges. Heat load up to 30 watts was put on the vacuum side of the flange in steps of 5 watt and temperature was measured at both the copper flanges. At maximum power of 30 W a temperature gradient of ~1.6K (Fig 3.1.12) was measured which is well within the expectation of the design goal.

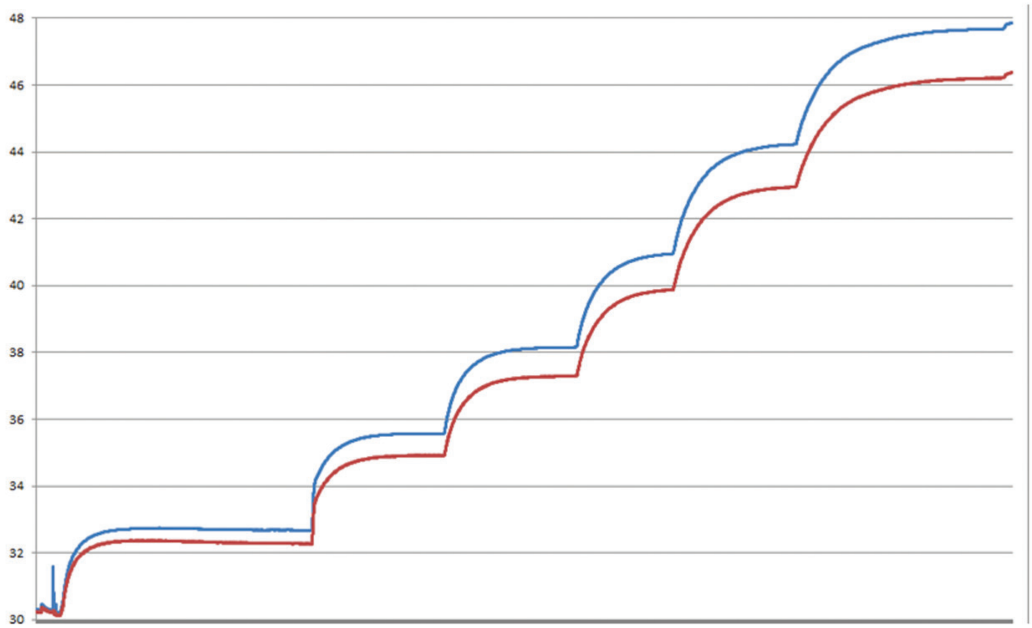


Fig. 3.1.12: Heat transfer studies with GM cryocooler in drop-in mode

3.1.3 Beam Transport System

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

Beam transport system (BTS) laboratory is primarily responsible for the design, construction and maintenance of beam transport magnet power supplies of accelerator systems. Besides the power supply development and maintenance, BTS laboratory is also involved in development of different type of control instrumentation for Travelling-Wave Chopper (TWC), Multi-Harmonic Buncher and RF cavities of the upcoming "High Current Injector" facility (see related section for development related to HCI). Activities related to beam transport system development and maintenance are summarized below.

3.1.3.1 Power Supplies for HCI Beam Transport Magnets

The installation of HCI beam transport system is in progress. The system will use approximately 84 magnets of different types which include 8 bending magnets, 46 quadrupole magnets and 35 steerer (corrector) magnets. The power supply requirement has been divided into two categories: high current (100 to 200A) of single polarity for bending and quadrupole magnets and low- current (± 10A) bi-polar for steerer magnets. The first category high current (100 to 200A) of single polarity are procured from DANFYSIK. For the low- current (± 10A) bi-polar power supply, it is decided to design and develop these in-house. Also to minimize the type within the same category whenever possible the same rating power supply shall be used. Activities related to these power supplies are described below

High Current Power Supplies (100 to 200A) of Single Polarity

DANFYSIK power supply model 9100 has been procured for bending and quadrupole magnets. For bending magnets 8 nos of 200A/60V power supplies and for quadrupole magnets 46 units of 100A/60V rating are procured and received in August 2015. After receiving, a few of these power supplies were tested under local conditions of mains power and cooling system and the stability and reproducibility specifications of the MPS were verified. These power supplies have RS 232 serial interface. Hence, to enable power supply control using VME a RS232 to VME interface module is under development at "Electronics Laboratory".

Low- Current Bipolar Power supplies (± 10A) for Steerer Magnets

This is the type of individual power supplies with the largest number i.e. nearly 50% of the total power supply requirement at HCI. The decision to design and fabrication of these power supplies is taken considering the in-house knowledge and capability to develop such power supplies. The developed units are bipolar current controlled linear power supplies, rated ±10A, ±50V and provide current stability of ±100 ppm or better. In the last two years approximately 30 numbers of such power supplies were assembled in-house in two lots. Fifteen units, which were assembled last year, were tested this year. Six power supplies are deployed for the first phase of HCI installation. The power supplies, as shown in Fig. 3.1.13, performed as per the given specifications. In the third phase of fabrication, 50 more power supplies will be assembled as per the projected requirement. Required material inventory list is being prepared; the material procurement process will start soon.

Fig. 3.1.13: Inside view of a power supply for steerer magnets

3.1.3.2 Bipolar Triangular-wave Current Regulated Supply Development for scanning magnets

Scanning magnet power supplies used with Phase-I materials science scanner magnets are more than 20 years old. To facilitate further maintenance and to meet the more demanding specifications a new power supply has been designed and assembled. To generate a raster scanning pattern, these magnets are fed with current regulated triangular wave having no cross over distortion and non-linearity. To accomplish the requirement, linear bipolar transconductance amplifier with "class-A" output stage has been designed and developed, delivering programmable current regulated triangular wave of 0 to ±10A for X-axis at 50Hz and at 0.5Hz for Y-axis. Required tests were done to check the linearity and crossover distortion. The power supply, as shown in Fig. 3.1.14, is ready for use and will be installed during scheduled maintenance time. More measurement related to bandwidth will be performed with the actual scanner magnet after installation in the beam line.

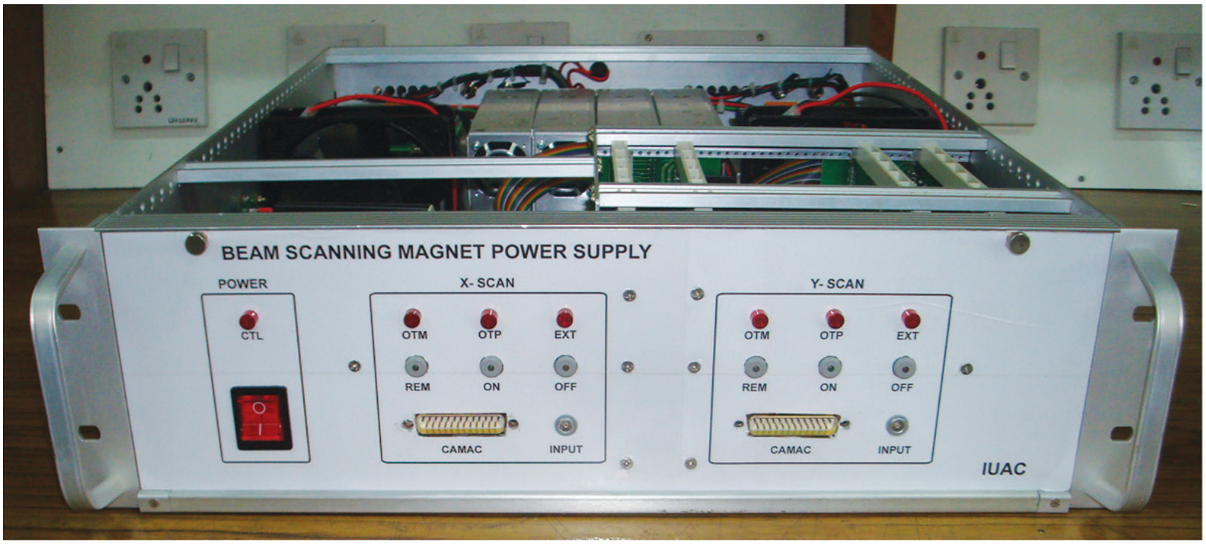


Fig. 3.1.14: Power supply unit for beam scanning magnets

3.1.3.3 Beam Transport System Maintenance

Magnet power supplies and related instruments are serviced during scheduled maintenance periods to avoid breakdown and to achieve best performance in terms of stability. The power supply breakdowns during normal beam operations are attended immediately as and when reported.

Scheduled Preventive Maintenance: Main tasks carried out during the maintenance period are listed below.

General Servicing: The power supplies and magnets were checked 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.

Safety interlocks: Safety interlock were falsely generated and tested to ensure their proper functioning during abnormal conditions.

Remote control operation: Data read-write and on-off commands were checked thoroughly for any malfunctioning.

Full power test: Full power test was conducted after finishing all servicing procedures to guarantee proper operation and performance.

Repairs: Some of the deteriorated control electronic modules and power section components were changed to improve the reliability of the power supplies.

Breakdown Maintenance:

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 external factors such as over temperature because of low water flow rates; input mains power fluctuations and remote control failures. In most of the cases, the power supplies were recovered immediately after rectifying the cause. One major power supply breakdown was encountered in DANFYSIK make 300A power suppliesin HYRA beam-line. Two power supplies broke down simultaneously because of a glitch in mains blew off the input filter capacitors. On-site repair has been carried out, and operation retrieved within minimum time.

3.1.3.4 Power Supply Installation

New indigenously made steerer magnet power supplies have been installed with MS-03 and MS-04 steerer magnet replacing the old power supplies. The performance and operational consistency of the old power supplies has deteriorated over time due to continuous operation since last 18 years. One of the LEIBF steerer magnet power supplies were also taken out of service and replaced with the latest version of new steerer power supplies.

An in-house made bipolar (± 10A /±50V) power supply has been sent to physics department of Cochin University to power the magnet of Magneto Optic Kerr Effect (MOKE) setup. The output ratings and feedback loops were modified as per their magnet specifications before sending. As per their feedback, the power supply is in use meeting all the performance and operational requirements.

3.1.4 Detector Laboratory

Mohit Kumar and Akhil Jhingan

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, and are used in various user experiments in HIRA, HYRA, GPSC and NAND. Detector lab provided training on experimental activities for Scientist Trainees, JRF, M.Tech, B.Sc and M.Sc students.

3.1.4.1 Hybrid telescope array (HYTAR) & MWPCs in NAND

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HYTAR with 16 hybrid telescopes was installed in NAND for performing quasi-elastic scattering experiment for the system ^{48}Ti + ^{232}Th. 4 telescopes were installed in a ring at an angle of 173º in contrast to 170º in GPSC earlier. The mounting structure of the ring is an Aluminium dome with an opening of 10 mm in the centre so as to enable passage of beam from the ion accelerator. Remaining telescopes were placed from 165º to 55º at 10º pitch. Opening aperture of detector was increased to 10 mm from 7 mm. For alignment of telescopes (at 173º), the exit beam tube of NAND scattering chamber had to be cut into two halves so as to enable mounting of the odolite for alignment. The preamplifiers were mounted inside vacuum and signals were driven by differential driver units through newly laid shielded twisted pair cables of 100 ft. length from beam hall to data room. Leaks were observed in foils of some of the telescopes so the array had to be operated at pressures below 60 mbar of isobutane.

A pair of position sensitive MWPC developed earlier, with active area 16 cm × 11 cm and delay line position readouts using discrete surface mount components, were put into operation in NAND experiments. The detectors have a three electrode geometry: cathode sandwiched between two position sensitive electrodes. Cathode is made from Mylar foil Aluminized on both sides. X-position frame has 10 µm diameter gold plated tungsten wires at 0.63 mm pitch whereas the Y-position frame has 1 mm thick tracks etched on a PCB. The delay line has a tap to tap delay of 1 ns and impedance 50 ohms. Entrance window is 0.9 µm mylar. The detectors were used to perform in-beam experiments with Pelletron-LINAC in NAND experiments. The 1 ns tap delay could be resolved in off-line tests with radioactive sources, which is an indication of charge collection faster than 1 ns.

3.1.4.2 Annular PPAC for Coulex

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

The annular PPAC fabricated for Coulex experiments was installed in GDA beam line. The 10 µm mylar window was replaced with a 2 um window so as to enable the target recoils, such as tin and barium, entry into active region of the gas counter. The detector was operated at 10 mbar of isobutane and provided pulse heights close to 4 V for target recoils and triggered on the delta electrons as well. The detector was operated for almost a month without any breakdown problems. The count rates were ~ 300 kHz. The detector was also placed inside GPSC for detecting particles around 3 degrees to 10 degrees such as elastic recoils and fusion ER. The count rates can exceed MHz in such cases. The delay line position readouts developed problems. Apart from troubleshooting, it is planned to further segment the detector for high count rate operations in the future.

3.1.4.3 Instrumentation

New designs of preamplifiers were fabricated for segmented and multi-detector systems. The main idea is to make them more compact and integrate them with detectors thus eliminating cables between detector and preamplifier. This is expected to reduce noise and improve time and energy resolutions. A 16 channel timing amplifier was fabricated for extracting timing information from silicon strip detectors. The preamplifier was assembled with SMD components having chip resistors and capacitors as small as 1 mm × 0.5 mm. The preamplifier board has a size of 8 × 5 cm^2 with option of plug in socket for FRC connector of strip detector. Total power consumption is ~ 1.5 W with a gain of about 4 mV/MeV and input impedance 50 Ω. Charge sensitive preamplifers have also been developed in identical fashion to be integrated directly to photo-diodes. Additional improvisations and miniaturization are being explored.

3.1.4.4 Activities in NUSTAR

IUAC-DU-PU-GSI (Germany)

Developmental activities were initiated for designing and fabrication of charged particle detection system for NUSTAR. This is being done in collaboration with the GSI group. A pair of transmission type MCP detectors and 40 um thick double sided silicon strip detector (DSSSD) were provided by GSI for evaluating timing performance. Offline TOF measurement with alphas was performed between two MCPs gated by silicon PIPS detector, MCP and DSSSD, MCP and large area MWPC. The time resolution of MCP was found to be ~ 180 ps for alphas. The strip detector yielded a resolution of ~ 600 ps for a pixel of 3 mm × 3 mm, and that for MWPC it was found to be ~ 500 ps (gated by position of 5×5 mm2). Measurements were carried out in GPSC with 28Si on 197Au at 120 MeV. TOF set up, between DSSSD and MWPC was placed at 60º. Timing signals for the front strips of DSSSD were provided by in-house developed 16 channel amplifier (3.3.3). A rise time of 4 ns was observed for alphas and 6.5 ns for scattered Si. The energy signals from the back side of DSSSD were extracted using Mesytec MPR-32 CSPA. A timing resolution of about ~ 200 ps is observed for a DSSSD pixel. A special flange was designed and fabricated with FRC connector feedthroughs to extract such large number of signals. Special multi-channel 50 ohm shielded cables were made for signal transmission. Some cables had FRC connector on both ends, FRC on one end and D pin on other end and in other case FRC on one side and lemo on the other side. To prevent degradation of signals in long length cables so as to preserve timing, a local data acquisition was set up in GPSC.

3.1.5 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 in the experiments with Pelletron and other ion beam facilities in IUAC[1-13].In addition to IUAC users, the facilities are also extended to research groups in IITs, VECC and BARC. Most of the facilities in target lab were available with minimum down time as indicated in bar chart in Fig. 3.1.15. This man-machine utilization in target development laboratory indicates that one or more than one facility of target lab had been used every day. More than 200 fabrication attempts were performed againstall requests for target fabrication as indicated in Table 3.1.1.

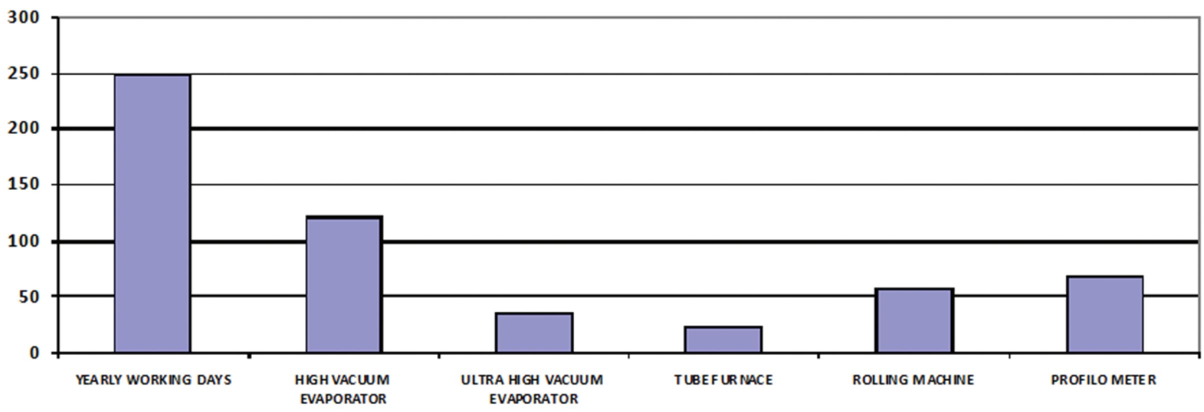

Figure 3.1.15: Utilization of time

Table 3.1.1: Utilizatation of facility

Facility	No of attempts
High Vacuum Evaporator	121
Ultra- High Vacuum Evaporator	35
Rolling Machine	57

Fabrication, Inspection and Loading of stripper foils

More than 200 imported carbon stripper foils and 200 IUAC foils were loaded in the last year. Pulsed Laser Deposited carbon foils are imported in the form of thin films grown on copper coated glass slides. Our work involves floating of the foils, etching of copper layer in the acid solution, mounting of the foils on stainless steel frame and loading of the foils in the terminal of the Pelletron. In addition to stripper foil of thickness $4\mu g/cm^2$ mounted at the terminal, target lab also supplied stripper foils of $10\mu g/cm^2$ for dead section.

Fabrication of targets for nuclear physics experiment

One of the major activities of this laboratory is to prepare targets for nuclear physics experiment. Target lab had successfully fabricated and delivered many isotopically enriched nucleartargets.Approximately Rs. 22 lakhs were spent for the procurement of isotopes in the last year. List of few recently fabricated nuclear targets is shown in Table 3.1.2

Table 3.1.2: List of recently fabricated targets

Sl.No	Description of target	Thickness	Method used
1.	^{208}Pb	$006 mg/cm^2$	Thermal heating
2.	^{208}Pb	$100\mu g/cm^2$	Thermal heating
3.	^{144}Sm	$150\ \mu g/cm^2$	Thermal heating
4.	^{154}Sm	$150\ \mu g/cm^2$	Thermal heating
5.	^{150}Nd	$150\ \mu g/cm^2$	Thermal heating
6.	^{142}Nd	$150\ \mu g/cm^2$	Thermal heating
7.	^{160}Gd	$200\ \mu g/cm^2$	Thermal heating

8.	^{122}Sn	150 µg/cm^2	Thermal heating
9.	^{138}Ba	200 µg/cm^2	Thermal heating
10.	^{124}Sn	300 µg/cm^2	Thermal heating
11.	^{54}Cr	800 µg/cm^2	E-Gun
12.	^{186}W	500 µg/cm^2	E-Gun
13.	^{92}Zr	300 µg/ cm^2	E-Gun
14.	^{174}Yb	763µg/cm^2	E-Gun

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3.1.6 RF & Electronics laboratory

A. Sarkar, S. Venkataramanan, B.K. Sahu, K. Singh, A. Gupta, M. Jain, P. Singh, D.K. Munda, A.Sharma and B.P. Ajith Kumar

3.1.6.1 Status of PSD electronics for NAND array at IUAC

At present, signals from 100 neutron array detectors and corresponding front end electronics are being processed in single width, dual channel home-made Pulse Shape Discriminator (PDS) modules. They were in continuous use during this year's campaign without any difficulty. No complaints related to failure of the PSD modules were received during this period.

In order to improve the data collection efficiency, multiplicity logic is being implemented with the NAND array. A prototype "16 channel Multiplicity & OR logic module" and a "Master Multiplicity Module" are assembled and tested with test pulser. In order to accommodate all 100 detectors, multiple modules are being fabricated for implementation.

3.1.6.2 Charge particle detector Array (CPDA) of INGA at IUAC

For a proposed CPDA with INGA, consisting of at least 72 CsI (size:10×10×10 mm^3) + Photo diode array, the electronics have been prototyped for evaluation. A polygon structure made up of printed circuit boards that will support all 72 detectors as well as charge sensitive pre-amplifier has been prototyped and evaluated with sample detectors available at IUAC. A charge sensitive preamplifier with minimum power dissipation (25mW per pre-amplifier) has been evaluated for this purpose.

3.1.6.3 Broad band amplifier, Ultra-fast discriminators for capacitive pick-off of LINAC

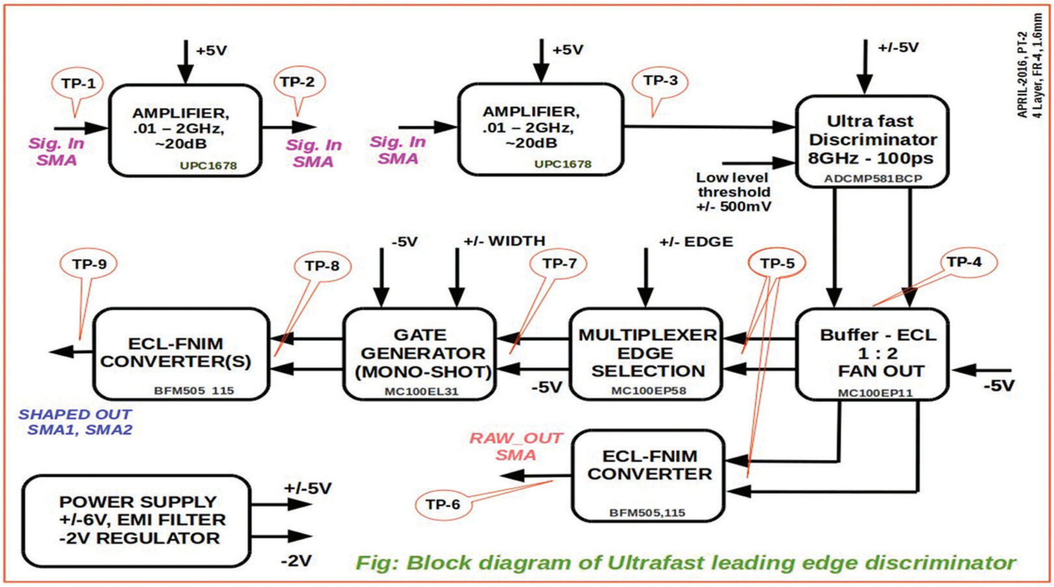

Fig. 3.1.16: Block diagram of ultrafast leading edge discriminator

In order to measure the pulsed beam properties (FWHM, centroid, etc.) in LINAC in a non-destructive manner, capacitive pick-off and time of flight technique are proposed and installed. Such techniques require consistent time marking of beam pulse from pick-off irrespective of intensity of the beam. Low level ultra-fast discriminators as well as CFD like, differential discriminators are proposed.

Prototype broad band amplifier(s) and ultra-fast discriminators in cascade have been tested with LINAC beam to evaluate the beam particle energy. Further, a dual channel, single width NIM module with functional blocks, shown in the Figure 3.1.16, is being fabricated for permanent installation with the LINAC control setup.

3.1.6.4 Solid state RF power amplifiers for High Current Injector (HCI)

Various RF resonance structures in HCI of IUAC require VHF power amplifiers of 2kW (CW). With rugged LDMOS power devices, we have designed and developed these amplifiers and demonstrated successfully on test bench. Two such amplifiers are developed with mid-band frequency of 48.5MHz and 97MHz. Sub-assemblies developed are

- Broad band 20W driver amplifier assembly consisting of RF pre-driver amplifier, LDMOS driver amplifier, 2 way Lumped Wilkinson power splitter
- Broadband VHF power amplifier (900W) unit
- Two port Wilkinson power combiner of 2kW (CW)
- Lumped low pass filter for harmonic reduction
- Control card with over drive limit etc.

Both power amplifiers have been tested on test bench with professional test equipments for all crucial parameters such as bandwidth, gain compression, phase change in power range of 200-2000 watts.

3.1.6.5 Status of the Multi-harmonic buncher (MHB) for High Current Injector (HCI)

The MHB vacuum chamber has been installed in the HCI beam line after thorough leak tests. The alignment of the chamber with the other components in the beam line is in progress. Once the alignment is done, the copper grid assembly along with the molybdenum grids will be re-assembled. The tank circuit assembly will be installed above the chamber. Proper RF connections will be made. Closed loop de-ionised water cooling system will be installed permanently. Earlier the tank circuit was tuned and tested off-line. The 12 MHz coil had some problem. New 12 MHz coils with modified water manifold have been made. Brazing of grids on spare copper cones is in progress. After the testing of the prototype controller with the Pelletron MHB, the final controller fabrication is in progress. The on line low power and high power tests of the MHB have been planned. This will be followed by beam tests.

3.1.6.6 Addition of Raspberry Pi based server with existing control system

IUAC Pelletron-tandem control system runs on network of servers compatible with standard CAMAC bus, VME bus and MOD bus based systems. Recently Raspberry Pi microcomputer has been tested and used as a control system server. The main network based server program (commonly known as *pserv*) was compiled for Raspberry Pi and it is placed in control network. Programming changes have been made in the structures and variables to take care of ARM based processor instead of generally used Intel based processors. This development has enabled us to use several measuring instruments like frequency counter, phase meter, and RF level meter from various vendors with different interfaces in the control scheme and they can be controlled over LAN through same clients (running *pcli*). Support has been added for all the devices provided with standard interfaces like RS232/485, USB and GPIB.

3.1.6.7 High density optically coupled status readout VME board for control system applications

A new Versa Module Europa (VME) module, VME_I64, featuring 64 optically coupled digital inputs, has been developed for control system applications at IUAC. The optically coupled digital inputs will provide isolation between field components and VME chassis. The inputs provide a sustained 1kV of system isolation to the VME backplane. The 64-bits can be configured as optically coupled voltage or contact sensing inputs. The complete input registers control logic and complexity of VMEbus 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, status register are implemented on same FPGA. The firmware is written as industrial standard HDL(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 VMEbus slave interface is written as a single component inside FPGA which will be used as a basic building block for any VMEbus interface project. This custom designed digital input VME module finds wide applications in the tandem and heavy ion linear accelerator (LINAC) control system. The design is implemented on Xilinx's Spartan3 FPGA.

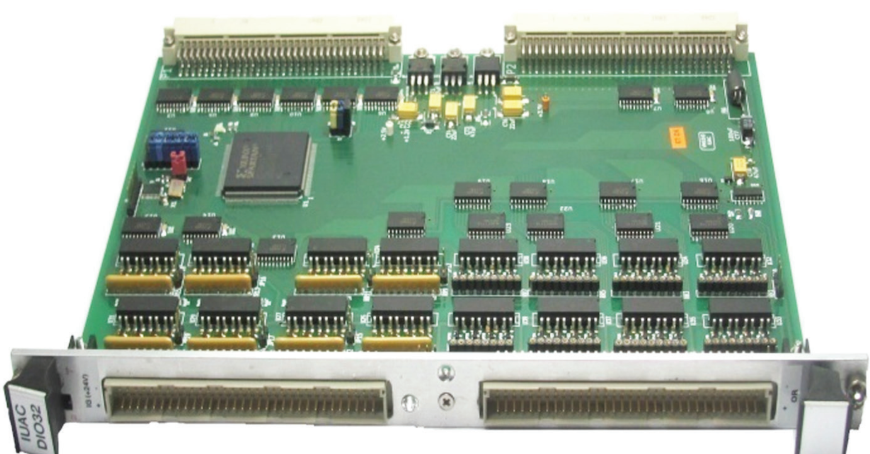

Figure 3.1.17:VME_I64, Digital Input VME board

3.1.7 Health Physics

Debashish Sen and Birendra Singh

Health physics group is involved in the field of radiation safety, research and development. Faculties and research scholars of many universities are using the facilities (gamma irradiation chamber, TLD reader, electrochemical work station etc.) developed and maintained by this group. A few of the research scholars have completed their Ph.D. using the facilities and a few research scholars are continuing to do so. Routine maintenance of door interlock and radiation monitors is done regularly to keep a vigil on the overall radiation safety.

Gamma irradiation chamber is open for different users from universities and Institutions. The chamber has been successfully relocated to a different place within the office premises in the presence of BRIT officials. Required AERB approval has been taken. Permission for the trial run of the new **AMS** facility has been received. It is subjected to some particular safety measures which are in the process of getting implemented. The process of getting safety approval for the upcoming **FEL** (Free Electron Laser) & **HCI** (High Current Injector) facilities in IUAC has also been initiated. Regular status reports for the **Pelletron** and **RBS** facility is being sent to AERB. All dose records are maintained and are also available online.

Extra shielding for the **LINAC rebuncher** module has been provided to keep the existing radiation level below the permissible limit. Now the adjoining area is safe for access from radiation safety point of view. Also calibration of all the gamma monitors and survey meters installed/used in IUAC has been carried out this year.

3.1.7.1 Registration in E-LORA facility of AERB

Debashish Sen and Birendra Singh

Electronic **L**icensing **O**f **R**adiation **A**pplications (eLORA) System is an e-Governance initiative by AERB. It is a basically a web-based application for automation of regulatory processes for various Radiation Facilities in India. The system is aimed at achieving paperless licensing of Radiation Facilities. The objective of the project is to enhance efficiency and transparency in the regulatory processes of AERB.

Institute Registration facilitates registration of institute in the eLORA system. After successful registration, user account is created in eLORA. The Employer of the institute (in this case the Director of IUAC) gets USERNAME and PASSWORD for accessing eLORA system. **Radiation Professional Registration** enables Radiation Professionals in India to register themselves in eLORA for their inclusion as Radiation Facility personnel. Upon successful registration, they are provided with a unique RP ID. This RP ID is to be used by the RP in all further interactions with AERB.Both Institute registration and Radiation Professional registrations has been successfully done for IUAC. Also procedures like shifting of a radiation facility, providing details of the radiation monitors used in the facility along with their calibration dates, providing details of radiation sources in custody of IUAC, procurement of new radiation sources etc. are now done using this **E-LORA facility.**

3.1.7.2 Radiation safety aspects for AMS Facility

Debashish Sen

Any Accelerator can provide ionizing radiation by two basic mechanisms:

- X ray caused by accelerated electrons
- γ ray & neutrons from nuclear reactions caused by interaction of the ion beam with targets or other devices which intercept the beam.

As the energy of the ion beam is less than 1 MeV in the IUAC AMS facility, and the Coulomb barrier of any of the projectile target combinations in this case are much higher than the ion beam energy at any stage of the beam line, no nuclear reaction is possible.In case of X-rays, either we can suppress the acceleration of electrons or can shield against them.

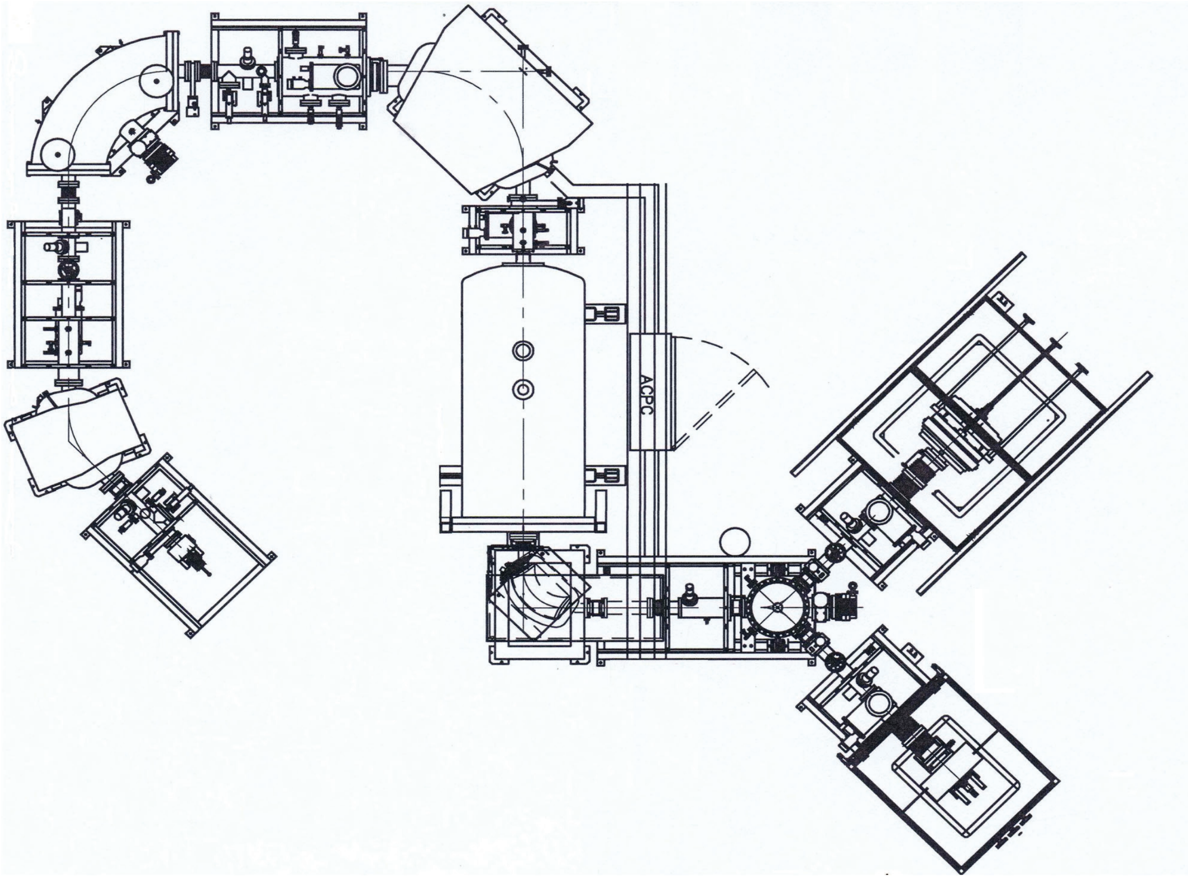

Fig. 3.1.18: IUAC AMS facility: beam hall layout

The injector produces ion beams of about 58 keV energy. Electrons which could produce X-rays at this low energy are strongly suppressed by surrounding magnetic fields in the vicinity of the ion source, and are therefore not accelerated to any significant degree. Thus radiation levels around the ion source are essentially background.

The accelerator has two acceleration tubes separated by a positive high voltage terminal containing a gas stripper (Argon) unit. Electrons produced by normal process within the acceleration tubes are accelerated towards the terminal, but are diverted from the tube axis by the inclined field geometry. The electrons travel few cms before they are captured by the tube apertures.

The maximum energy of electrons is of very low order, and the resulting X-rays are shielded by SF_6 gas, the steel tank and the in-built lead shielding, titanium and aluminium oxide within the acceleration tubes. X-ray Bremstruhlung yield depends strongly on Z of the target. The combination of careful choice of materials, electron suppression and inbuilt shielding results in low radiation level. The Bremsstrahlung radiation is more for high Z targets. Here the target is Argon in the stripper canal, which is not a high Z material. The Bremsstrahlung radiation also depends on the mass and energy of the projectile. The more the mass of the projectile, the less is the Bremsstrahlung radiation. The projectile carbon (or Be or Al) ions are of much higher mass than that of electron, and also in the keV energy range only.

To sum up, at the energies available with **1.5SDH AMS** (whose layout is shown in Fig. 3.1.18), Carbon Beryllium & Aluminium beams are not likely to produce nuclear reactions within the accelerator. **Post acceleration,** the current & energy is so low, that X-ray production will be very less, and generated low energy X-rays will be hugely attenuated by the beam pipe material. Hence, the radiation level in the adjoining area will be well below the prescribed safe limit.

3.1.7.3 Initiation of radiation shielding calculations for the upcoming FEL & HCI Facility

Debashish Sen

A project named as Delhi Light Source (DLS) (whose layout is shown in Figure 3.1.19) based on **Free Electron Laser** is under development at Inter University Accelerator Centre. The facility will consist of an electron accelerator which will produce energy of ~8 MeV with an average current of ~10 nA. The wiggling electron beam when injected in to the undulator beam will produce coherent radiation in the range of THz. The electron beam and the THz radiation will be used to do fundamental and applied research in the fields of Chemistry, Biology, Material Science, Physics, Medicine etc. The exact location, dimension and shielding materials to be used to build the beam dumps (so that the adjoining beam hall areas would be within safe radiation dose limits) are to be decided.

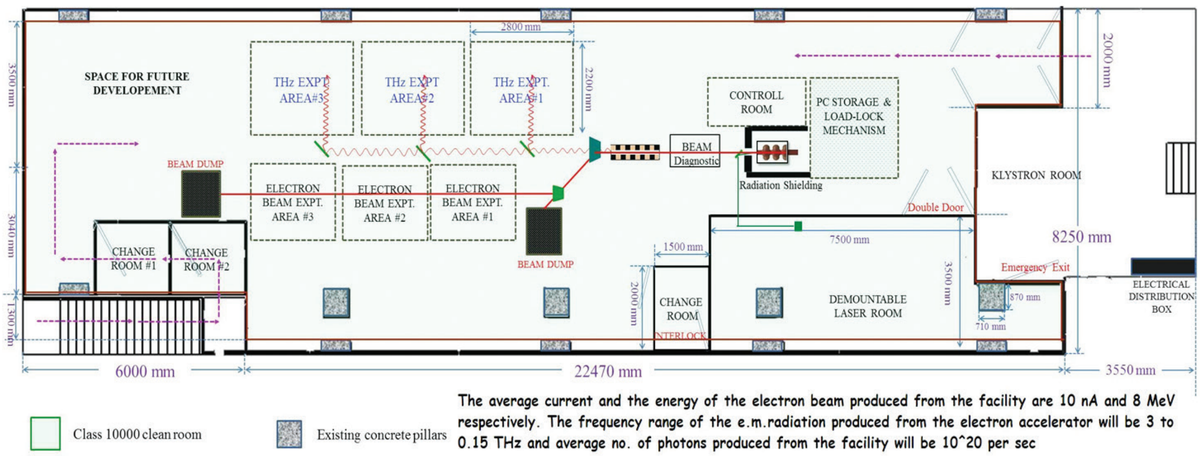

Fig. 3.1.19: IUAC FEL facility: beam hall layout

Another project under development, the **High Current Injector** (HCI) at Inter University Accelerator Centre would use a Radio Frequency Quadrupole (RFQ), Drift Tube Linac (DTL) and low beta superconducting cavities (Fig. 3.1.20) to accelerate heavy ions having $A/q \leq 6$, from the high temperature superconducting electron cyclotron resonance ion source (HTS-ECRIS called PKDELIS) to the existing superconducting linear accelerator (SC LINAC). The DTL has been designed to accelerate ions from 180 keV/u to 1.8 MeV/u, using six Inter digital-H (IH) type RF resonators operating at 97 MHz. The required output energy of the DTL is decided by the minimum input velocity ($\beta = 0.06$) required for the existing superconducting LINAC. The shielding calculations for this facility have also been initiated.

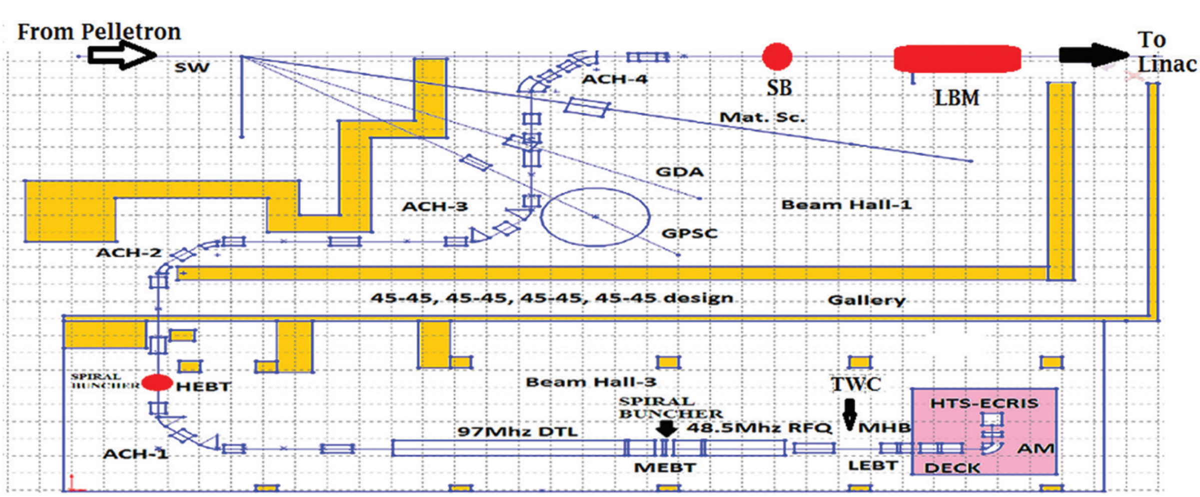

Fig. 3.1.20: IUAC HCI facility: beam hall layout

3.1.7.4 Luminescence study of Dy or Ce activated $LiCaBO_3$ phosphor for γ- ray and C5+ ion beam irradiation

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In this work, thermoluminescence characteristic of RE (Dy or Ce) activated $LiCaBO_3$ phosphors have been studied. Phosphors were synthesized by modified solid state synthesis. The thermoluminescence study was carried out for both γ-ray irradiation and carbon beam irradiation. All the samples were studied for 75 MeV C^{5+} ion beam exposure in the range of $3.75 \times 10^{12} – 7.5 \times 10^{13}$ ion cm^{-2} fluence, using the 15 UD Pelletron at IUAC. Fig.3.1.21 shows typical glow curves for the sample exposed to γ-rays (1.2 Rad) with a source of ^{137}Cs. TL glow curves were taken for different concentrations. The glow curve nature remains almost similar for different concentrations of Dy or Ce but the TL intensity is changed. The sensitivity of the main glow peak enhances with increase in Dy or Ce ion concentration in the $LiCaBO_3$ host and maximum for a concentration of 0.5 m% and 1.0 mol% respectively. From TL peaks, one can observe two resolved glow curves originating at lower and higher temperatures (160 °C and 211 °C, respectively) for both Dy^{3+} or Ce^{3+} doped $LiCaBO_3$.

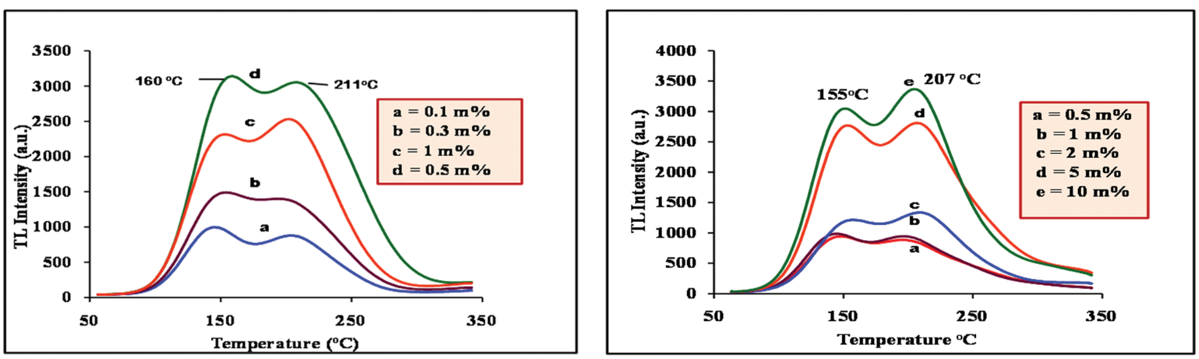

Fig. 3.1.21: TL glow curve of $LiCaBO_3$: Dy/Ce phosphor (at gamma ray dose of 1.2 Rad).

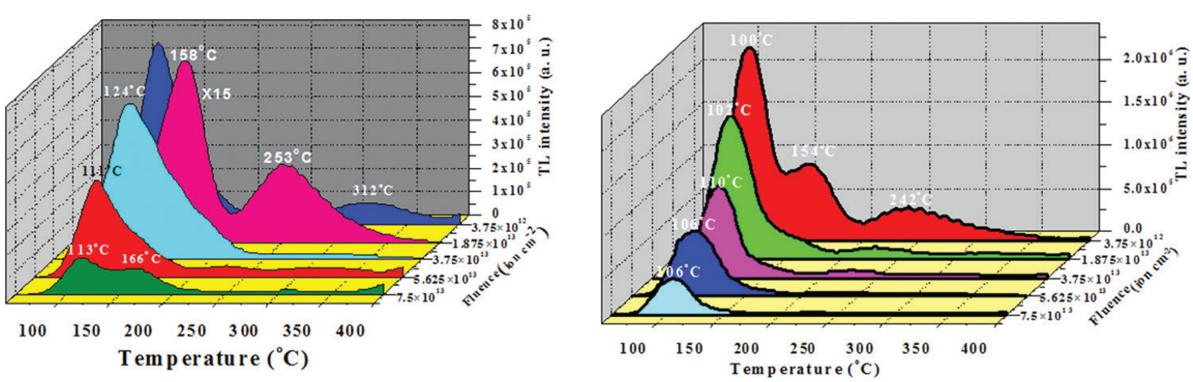

Fig. 3.1.22: TL glow curves of $LiCaBO_3$: Ce samples irradiated by the 75 MeV C^{5+} ion beam at different fluences

Fig.3.1.22 presents the TL glow curves of $LiCaBO_3$:Dy/Ce phosphors, irradiated for 1, 5, 10, 15 or 20 min C^{5+} ion beam exposures corresponding to 3.75×10^{12}, 1.875×10^{13}, 3.75×10^{13}, 5.625×10^{13} and 7.5×10^{13} ion cm^{-2} respectively. With increasing exposure time, TL output is reduced but the maximum TL output is noticed at 5 min (1.875×10^{13} ion cm^{-2}) and 1 min (3.75×10^{12} ion cm^{-2}) carbon exposure for Dy and Ce respectively.

With increasing exposure time, theTL glow peak temperature is shifted towards the higher temperature side.From

Fig. 3.1.22, it is seen that two well resolved glow peaks at 158 °C and 253 °C occur at a 5 min (1.9×10^{13} ion cm^{-2}) exposure time for Dy doped LCB, while the TL glow curve of 1 min (3.8×10^{12} ion cm^{-2}) carbon exposure of Ce^{3+} doped LCB shows three resolved glow peaks at 100 °C, 154 °C and 242 °C.

From both the Fig. 3.1.21& 3.1.22, it is clear that for the 75 MeV C^{5+} ion-irradiated samples, additional trapping levels are occurring, which exhibit more glow peaks as compared to γ-ray irradiated samples. The occurrence of additional glow peaks suggests the formation of intermediate trapping levels in-between the trapping levels responsible for the occurrence of glow peaks at their respective temperature positions[1]. Upon irradiation of the samples with C^{5+} ions, new trapping and luminescent centres may be formed that are responsible for this anomalous behaviour.

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3.1.7.5 Thermoluminescent characterestics of nanocrystalline $BaSO_4$:Eu

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The project had to begin with the preparation of TLD materials that have shown some traces of energy independence in the past. Initially, we started working on $BaSO_4$:Eu in its nanocrystalline form as *Bahl et al* [1] had recently reported that a TLD material (namely $BaSO_4$:Eu) showed invariability in its thermoluminescence (TL) response to doses of gamma radiation (of energy 1.25 MeV) and proton beam (of energy 150 MeV). The method used for the synthesis of nanocrystalline $BaSO_4$:Eu was the chemical co-precipitation method. Several batches of the sample were prepared and the sample was then optimised for its highest sensitivity using Co-60 gamma radiation. The optimised $BaSO_4$:Eunanophosphor was further, compared to commercially available standards like TLD-100 (LiF: Mg,Ti)and TLD-100H ($CaSO_4$:Dy) primarily for its sensitivity property. Further, the phosphor was irradiated by various energies (but same doses) of gamma radiation i.e. Co-60 (1.25 MeV) & Cs-137 (662 keV) and the response of all the variants of the phosphor were studied and analysed.

Preparation of the materials was followed by the study of their TL and other characteristics. A complete characterization of a material, which mainly focuses on the material's suitability as a dosimeter material for utility in the medical domain took about six months' time. During this time period, a material was prepared, optimized, irradiated to radiation (varied energies and species), its TL characteristics were studied, and its other features were also studies by techniques like XRD, TEM, SEM etc.

Finally, the target was to develop TL phosphors that will have a linear TL response over a wide range of radiation dose and measures the radiation dose irrespective of the energy of the source radiation (Energy Independent). In order to obtain such phosphors that are energy independent and thus are suitable for use as radiation dosimeter (in the medical domain) method of preparation, concentration and type of the dopants and various other factors are optimized to get samples with best characteristics.

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3.1.7.6 Theromluminescence studies of Gamma irradiated Ce doped MgO based nanophosphors

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[2]Health Physics Division, Inter University Accelerator Centre, New Delhi

Thermoluminescence (TL) [1-2] is the release of the energy in the form of light from materials which are previously exposed to ionizing radiations. Ce doped MgO nanophosphors were synthesized using solution combustion method at Health Physics Lab, IUAC, New Delhi. The phase formation of synthesized samples was investigated using x-ray diffraction (XRD), which revealed the single phase cubic MgO up to (0.1 mol%) of Ce in MgO as shown in Figure 3.1.23(a). The average crystallite size of samples was estimated to be in the range 30-40 nm using Debye Scherrer's relation. The samples were exposed to gamma radiations in the different dose range to investigate their thermoluminescence (TL) behavior. TL glow curve of Ce doped MgO nanophosphors comprises of a two peaks as shown in Figure 3.1.23(b). With the addition of Li^{3+} ions in MgO as charge compensator, TL response changes drastically as evident from Figure 3.1.23(c) and 3.1.23(d).

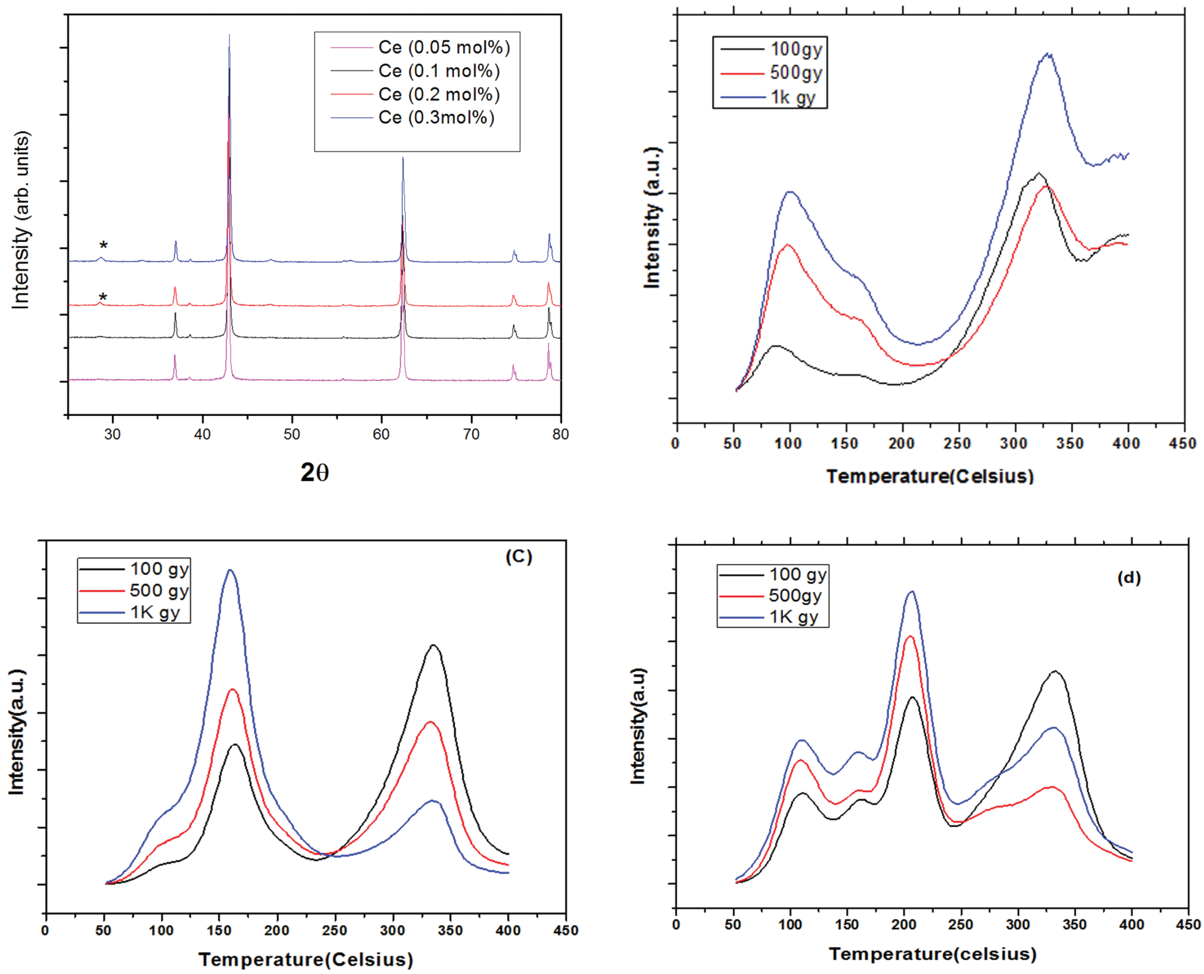

Fig. 3.1.23: (a) XRD, * represents the CeO_2 phase. (b) TL of MgO:Ce (0.1 mol%) (c) TL of MgO:Li (d) TL of MgO:Ce,Li nanophosphors

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3.1.8 Data Support Laboratory

Rajesh Nirdoshi, V. V. V. Satyanarayana, Ruby Santhi and P. Sugathan

Data Support Laboratory provides support to users for 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. 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 Modification of VME LAMPS for CAEN V785N Peak Sensing ADC

Ruby Santhi and Kundan Singh

LAMPS based VME data acquisition (TIFR LAMPS) has been tested for CBLT chain consisting 16 channel peak sensing ADC module V785N from CAEN. The LAMPS software was originally developed with default configuration for 32 channel ADC and TDC with flat ribbon FRC connector for signal input. With ADC model V785N, the readout part had to be modified for acquiring data. This was performed inside the software code and tested by acquiring data using Cs gamma ray source and plotting histograms. With modified version users from university who uses 16 channel version of ADC with LEMO connectors can now collect data using the CAEN modules. It currently supports CAEN V785, V785N, V775 TDCs and V862 QDC and V830 scalar modules.

3.1.8.2 Development of Electronic Modules

V. V. V. Satyanarayana

A few electronics modules such as Trigger module and Master Gate block Modulefor NAND Data Acquisition system, Pulse Generator for Atomic Physics experimental facility, Octal Gate and Delay Generators and, Quad Logic Fan In / Fan Out modules for NAND experimental facility have been developed at Data Support Laboratory.

3.1.8.3 Pulse Generator for Atomic Physics Experimental Facility

Ruby Santhi

This module generates exponential pulse and Logic pulse for pulse processing instrumentation used in Atomic Physics experimental facility at IUAC. The pulse frequency is 50-Hz with amplitude adjustable from 0 to +5V and 0 to -5V. This module generates exponential pulses (either polarity), with variable amplitude for each output pulse. The positive pulse output and negative pulse output are available independently at different LEMO output connectors. One logic pulse output also available in front panel through BNC connector. Two Modules have been developed and given to the user community. This is useful to simulate the detector pulse for longer time.

3.1.8.4 Octal Gate and Delay Generators for NAND experimental facility

V. V. V Satyanarayana

Eight of modules of Octal GDG have been assembled and tested in lab. Each module contains eight independent channels and each channel accepts NIM-standard, fast negative logic pulses and produces two NIM-standard, fast negative logic pulse outputs, and one positive TTL output. It serves as a convenient interface between logic pulse origin and its end use. Both pulse width and delay of each channel can be adjusted independently either from 70ns to 1000ns or 0.4μs to 10μs by selecting an internal jumper position. Overall dead time of the module is calculated by adding the pulse width plus pulse delay times and a 20 ns propagation delay of the module itself. Delay jitter was found to be $\leq$0.04% of selected delay.

3.1.8.5 Quad Logic Fan-In / Fan-Out modules for NAND Facility

V.V.V Satyanarayana

This module (Fig. 3.1.24) 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. Applications of this modules includes OR gate, coincidence experiments, master gate generation etc. The unit contains 16 negative fast-NIM inputs, that may be configured as a quad 4-input, 6-output OR gate; a dual 8-input, 12-output OR gate; or as a single 16-input, 24-output OR gate. A front-panel toggle switch allows the selection of any of the three matrices, 4×4, 2×8, or 1×16. Front-panel LEDs indicate when neighbouring channels are connected. For every 4 non-inverting outputs there are 2 inverting outputs. All inputs and outputs are negative fast-NIM compatible. Care has been taken to minimize the propagation time variation from one channel to another. One module has been developed and tested during last year and three more such modules have been made this year.

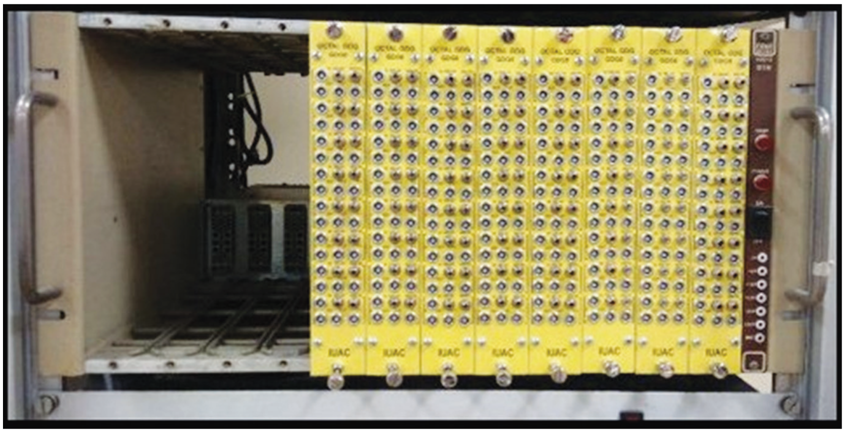

Fig. 3.1.24: Quad Logic Fan-In / Fan-Out modules for NAND Facility

3.1.8.6 Repair of Faulty Electronic Modules

V. V. V Satyanarayana

Apart from the indigenous development of electronics modules, few of the faulty electronic modules which were bought commercially, have been repaired at Data Support Laboratory. Repaired modules included Models 571, 572 Amplifiers, 142 IH Preamplifier, 416A Gate and Delay Generators from EG & G Ortec, USA.

3.1.9 Computer and Communications

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

The major activities this year include the consolidation 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.

3.1.9.1 High Performance Computing Facility

In 2008, the Department of Science and Technology sanctioned a grant of Rs. 13.54 crores to set up a high performance computing facility at the Inter University Accelerator Centre. The purpose of the grant was to provide a major computing facility not just for IUAC staff and users, but for all faculty and students of universities and colleges across the country for research in the areas of nuclear physics, materials science, atomic physics and radiation biology. With this grant, a new facility comprising a state-of-the-art data centre, two distributed memory compute clusters totaling more than 70 teraflops, a shared memory system with 256 GB of RAM, and parallel storage systems with a total capacity of 60 terabytes was set up. The data centre, the first of the two clusters, one storage system and the shared memory system were opened to public access in April 2010. A second cluster and storage system were added in 2013.

The facility now serves over three hundred and fifty faculty members and students drawn from a hundred and thirty colleges, universities and institutes. Most users are from less well endowed institutions, for whom the IUAC facility is often the only computing infrastructure available. More than forty software packages, both open source and commercial, have been installed on the clusters so far. User research areas include computational physics and chemistry, the study of biologically important systems, nuclear physics and atomic physics. Over forty publications have been reported to the facility by users so far. An estimated hundred research students are using the facility for their Ph.D. thesis work. The utilization of the cluster infrastructure has been exceptional, with a typical load of twenty jobs running and thirty in wait queue.

The high-density data centre consisting of sixteen cooled racks is the first large-scale deployment of chilled water based in-rack cooling in the country, a design that leads to large savings in power costs and space. However, the harsh environment and large temperature variations of Delhi cause major wear and tear of the cooling equipment, especially the outdoor water chillers; a major effort this year has had to be dedicated to keep the water cooling systems running. This has been achieved through rigorous monitoring and preventive care, and by incremental extensions to the SNMP and open source based data centre and cluster monitoring software developed in-house.

Of the two clusters, the older cluster Kalki is now at end of life and out of contract maintenance. This year, a major goal has been to progressively migrate users and applications from Kalki to the newer and more powerful cluster k2. Most active users have now been migrated, and all new users added this year were provided access to k2. With a large number of users with differing requirements, the cluster resource management system has also been considerably reconfigured to adapt to changing needs. The suite of shell scripts for system and resource monitoring has also been extensively added to and reworked. In anticipation of future needs, a GPU-based system with an Nvidia Tesla K40 was obtained on loan from Nvidia and made available to cluster users, in order to test and benchmark commonly used codes. The K40 comprises 2880 GPU cores on a single die, and a single node with a K40 GPU is rated at a peak Linpack Figure of 4.29 teraflops. A Xeon Phi based node with two standard 8-core Xeon CPUs and a 61-core Xeon Phi MIC was also loaned to the facility by Intel, and is now available for tests by users.

Research conducted by user groups using the facility has covered a wide range of basic and applied science, and this year has been no exception. Examples are a study of the effect of confinement on sodium nanoclusters (B. J. Nagare, Mumbai University), calculation of the phase transition of DNA under a periodic force (S. Kumar, BHU), relativistic configuration-interaction studies of the electron-nucleus interaction in the YbF molecule (M. Sikarwar, Govt. College, Tonk), large-scale Green's function Monte Carlo simulations of light nuclei (Q. N. Usmani, Jamia) and simulations of projectile fragmentation in intermediate energy nuclear collisions (Arun Bharti, Jammu).

However, after five years of continuous operation and a growing number of users, the infrastructure is showing signs of strain. The original facility was planned for about fifty users; more than six times that number now use the clusters. The usage pattern has also changed over the years, with more challenging problems being taken up, and users routinely request many times the number of cores they used to a few years ago. Contention for cluster resources has reached levels where users are dropping out of the system as they can no longer obtain significant results in reasonable lengths of time. A refresh of the compute infrastructure is required to ensure an uninterrupted HPC service to users, and the preliminary design of a proposed major upgrade was developed this year.

3.1.9.2 IUAC LAN and servers

All central servers (mail, web, proxy, database, firewall, LTS) were upgraded this year to Scientific Linux 6.5 from the earlier SL 6.2. The server pool was reorganized, and the NIS server which earlier served visiting students and as a backup system for IUAC staff was removed from the pool. All NIS users have been migrated to the LTS server. A hardware firewall and UTM system, now popularly used in most institutions as the first level defence, was installed on a trial basis for all the Centre's internet and mail users. While it provided administrative convenience, it did not provide the level of user authentication security that the current software firewall does, and it was decided to continue with the open source software firewall currently in use.

Additions to the local LAN were made, including expansion of the LAN to the newly constructed second floor of the main building. The gigabit network at IUAC now comprises a 48-port central switching system with 21 edge switches, more than seven hundred wired LAN ports, and twelve wireless access points across six buildings. With the second floor of the main building almost ready, backbone fiber cable was laid to the switching location for the floor, and network racks and new 48-port gigabit switches with 10-gigabit fiber uplinks procured. The local network for the floor is now ready to be connected at short notice when the premises are handed over.

The computer room in the main building, mainly used by visitors and students, was completely revamped. Besides reorganizing the work spaces to ensure a more conducive environment, the old computers were replaced by new desktop all-in-one systems. The old NIS server which served this area was decommissioned, and the new systems are now terminals to the central LTS server.

3.1.9.3 Ion beam simulations

Some progress was made in the coding of the new swift ion molecular dynamics simulation program being developed at IUAC. A two-day school on simulation of ion beams in matter was organized, to precede the 18th International Conference on Radiation Effects in Insulators. The school attracted lecturers from practically all the major ion beam simulation groups in the world, including speakers from GANIL, ANU, Helsinki, the University College London, ORNL and Vienna. More than forty Indian and foreign participants attended the lectures, which provided an exciting and detailed snapshot of the latest techniques in ion beam simulation. A third day was reserved for an in-depth hands-on demonstration of the thermal spike model, led by Dr. Marcel Toulemonde of GANIL.

3.1.9.4 New generation Instrumentation & Acquisition System

E.T. Subramaniam, Kusum Rani and Mamta Jain

Design and development of high precision ADC (16 channel 16 K)

A high density, peak sensing, analog to digital converter (ADC) double width module with CAMAC back plane has been developed for nuclear physics experiments with a large number of detectors. This module has sixteen independent channels in plug-in daughter card motherboard mode. The individual ADC daughter cards exhibit excellent integral non-linearity (≤ ±2 mV or ± 0.02 % full scale reading) and differential non-linearity (≤ ±1%).

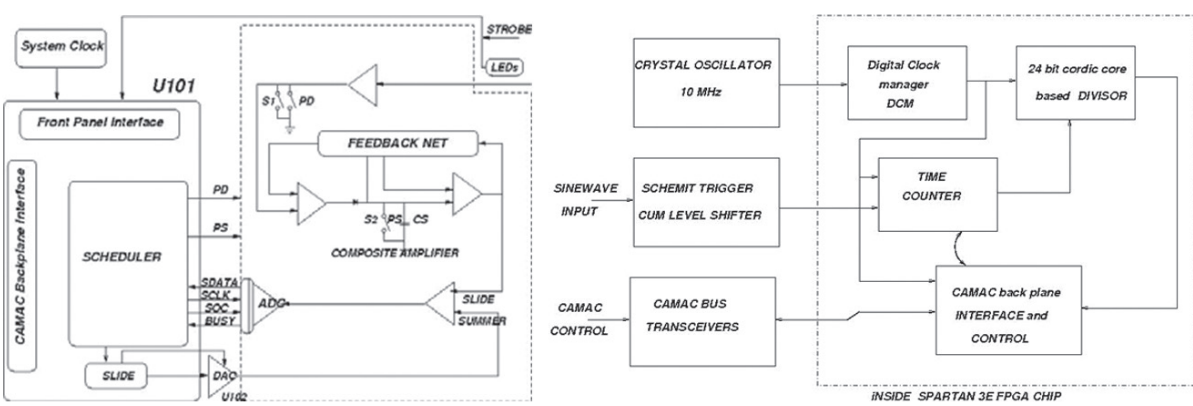

Fig. 3.1.25: (left) 16 channel ADC and (right) 8 channel FDC

8 channel frequency to digital converter module FDC

A frequency to digital converter CAMAC module (Fig. 3.1.25) has been designed and developed for the control scheme of superconducting linear accelerator. This module is used to measure the frequency difference of master clock and the resonator frequency digitally with a computer read out using CAMAC interface. This module has a range of 100 kHz with 1 Hz resolution and will enable us to monitor the tuning frequency for phase locking of the cavities using tuner control. This module has eight independent channels for the use of eight resonators housed in a single cryostat.

Beam Profile Digitizer

Mass production of the 12-bit, 12-channel digitizer has been completed and in-situ testing has been done. Two out of twelve BPMs can be selected and seen at a time.

Revamping of counting room

As in house development of data acquisition system modules is done in full swing and all most all the beam lines are using 'CANDLE' based data acquisition systems, the entire counting room was revamped to accommodate the basics.

Overhaul of networking of the data acquisition systems was undertaken by the newly formed group. The network diagram and electrical diagram (Figure 3.1.26) were modified to suit the new requirements. The entire process of providing a clean ground is undertaken and is being implemented. The false ceiling was repainted and the old lighting was replaced with energy efficient led lights.

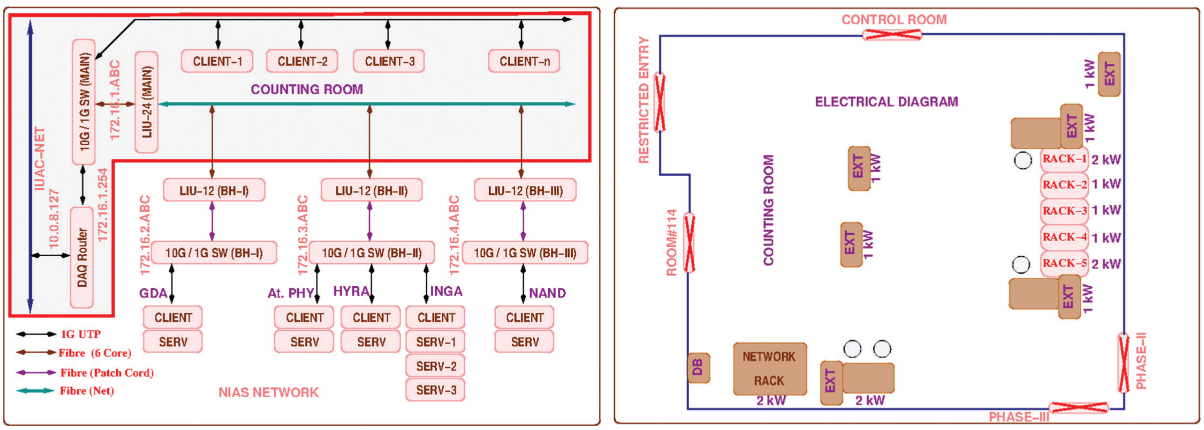

Fig. 3.1.26: (left) DAQ network and (right) Electrical diagram of counting room

A new data acquisition system was setup near the general purpose scattering chamber during a test run. This resulted in excellent timing resolution due to short cable distance between the detectors and the processing modules.

Improvement of S/N ratio at INGA setup (Grounding)

For the upcoming high resolution high density data acquisition systems, the acceptable ground noise is around 2mV. To achieve this standard, the first most important requirement is to retain isolated ground for the data acquisition system. In an already existing system it is very difficult to achieve fully isolated ground without dismantling the existing setup. Therefore, it has been decided to put an isolation transformer between the data acquisition ground and the beam line components. This modification is being implemented in the INGA setup. Keeping in mind the isolation of the detector signal, it has been decided to connect all racks of high voltage power supply units and data acquisition on the same ground. The calculated load is around 20 kVA. An isolation transformer of 25 kVA has been purchased and placed physically at a suitable and accessible position. A 10 mm^2 zinc plated drilled copper rod was fixed at the back of every rack and connected to extended earth connector of ground pit through an insulated multicore 10 gauge copper wire. All the instruments placed in the rack are connected individually to the copper rod through flat braided copper wire.

Zero delay time stamp for multi strobe DAQ System using GEM

GEM is a single width CAMAC module, developed for event identification and hit pattern recording. An individual module can accept up to 12 NIM signals and provides 3 bits wide event fragment identifier. If configured in multiple crate systems, the master can handle event identifier fragments received from four slave (including self), three via Unsheilded Twisted Pair (UTP) cables and the fourth is routed internally using look-up table delay. Master module provides 4 different event identifier outputs which can be selected via CAMAC commands.

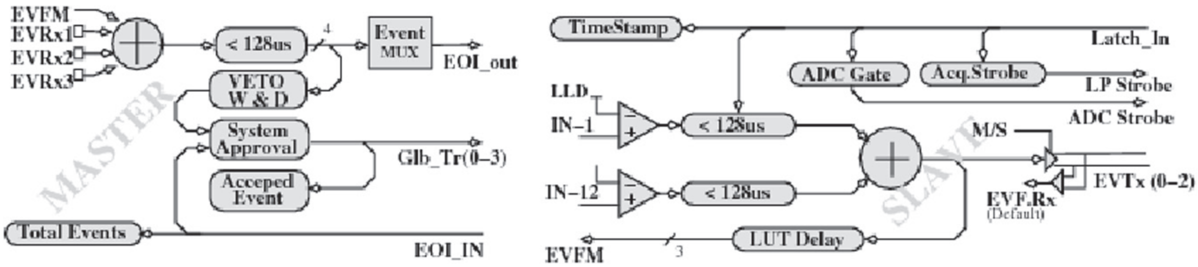

Fig. 3.1.27:Logic diagram for Event Assembly and Strobe generation

Encoded time stamp technique has been incorporated using a 48 bit counter and an encoder encoding the most significant 47 bits to 2 bits. Along with a 100 MHz clock, these encoded two bits travel through three pairs of a UTP cable. The fourth pair is used for the round trip calculation, needed to calibrate the system for zero-delay time stamp. The slave end de-serializes the received encoded information into a synchronized 48 bits time stamp. The possibility of errors is taken care of by ensuring that the difference between two consecutively retrieved decoded values is always one, else an ERROR flag is set and the decoded value is frozen by disabling the slave end counter.

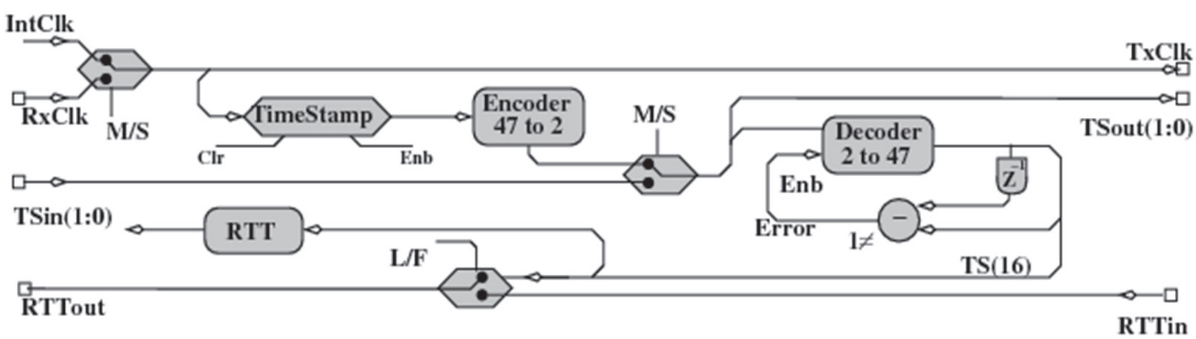

Fig. 3.1.28:Depiction of encodeddaisy chained zero delay time stamp

This zero delay time stamp technique (Fig. 3.1.28) can be used to synchronize the multiple strobe data acquisition system, where all the systems are connected through daisy chaining and decode the timing information coming through master. Round trip time for each module with respect to the last module can be calculated by scaling the difference between the locally decoded value and the received decoded value from the last module in the daisy chain.

3.2 UTILITY SYSTEMS

3.2.1 ELECTRICAL GROUP ACTIVITIES

U. G. Naik and Raj Kumar

This group is primarily responsible for maintaining the electrical installations of IUAC and also to develop adequate electrical infrastructure for the upcoming scientific projects. 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 financial year 2015-2016.

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. Fresh tenders were invited by open advt. and have issued an AMC order to M/s KBS Electricals for complete financial year 2015-16.

During the year, one of the 1MVA transformer tap changer failed due to which the HT 11kV along with LT windings on two core limbs had burnt. The oil had totally deteriorated. The transformer was sent to workshop and all windings were replaced with new windings and also the oil was replaced with fresh transformer oil. This did not interrupt the supply to any of the loads as immediately another transformer in the loop took over. This year, the installations have been maintained efficiently with uptime close to 100%. There are many maintenance activities which are routinely carried out. However, few major activities are listed below.

- Dehydration of transformer oil for 7 Transformers- (4500l)
- Periodic maintenance of LT panels, Distribution boards and other accessories, Lighting, Fixtures, lighting and power circuits.
- Servicing of DG sets 60kVA×2nos,1*750 kVA, 2× 320 kVA, 1× 100 kVA-twice a year.
- Maintenance of street lighting and earthing.

3.2.1.2 Captive power installations

Institute had a captive power base of 2500 kVA. Three DG Sets of 750 kVA are synchronized and take care of 15UD Pelletron, He Plant and HPC Data Centre. The group has shown ever readiness in running the systems round the clock O&M activities within short period if need arises. Not even a single failure has been observed during the year. Yearly maintenance is being carried out through service from the manufacturer.

3.2.1.3 Voltage stabilisers

Voltage stabilizers supporting the installations having capacities from 30 kVA to 1000kVA 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 warranty period. Batteries worth Rs. 3.22 lakhs were replaced for UPS during the FY 2014-15.

3.2.1.5 Power Factor Compensation

Average power factor of 0.98 lag was achieved throughout the year. Our system power factor without correction is about 0.85 and by raising it we saved around Rs.120 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 25000/- 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. On the same measure this year we have replaced 26 years old 80 watt fluorescent fittings to 32 watt LED and also reduced the number of fittings from 10 to 6 ratio for same lumens output. We have changed to LED lighting in Control, DATA room, Main lab lounge, discussion area, Directors office and few other rooms.

PROJECT WORKS:

3.2.1.8 Electrical Worksfor Fel Lab

Electrical group has successfully installed electrical earthing using chemical earthing for RF equipments, electronics and power in the beam hall-III basement for FEL laboratory. Specialized design was adopted for earth conductor with double copper foil shielding for RF activity. Cable trays were laid and cables are all installed in the clean room. A special care is taken to get the cables out of the trays by using dustproof PG glands.

3.2.1.9 Lighting Works For High Vac Furnace

Electrical group had taken up electrical works for this and provided the energy efficient LED lights along with fresh wiring for lighting and power.

3.2.2 Air Conditioning, Water System And Cooling Equipments

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

AC SYSTEM

IUAC's central air conditioning / low temperature cooling system of Phase-I consisting of 400 TR Central AC plant performed with 100% uptime. Maintenance ensured that the safety record of the plant was maintained at 100% and the power consumption was kept at optimum level. 200 TR chillers installed in 2013 have run 13000 hours each. Other rotary equipments have logged 1,95,250 continuous run hours. It is relevant to note that the Indian industrial norms specify a life of ~25,000 run-hours for compressors and ~50000 hours for other rotating equipment.

The Phase-II&III, screw chiller based central AC plants 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, which affected significant savings.The hook-up of AC plants ensured optimum power consumption.The yearly maintenance costs were 11.07% of ARV (Asset Replacement Value). The MTBF (Mean Time between Failures) for all the equipment were within acceptable norms.

The equipment being into their twenty-seventh year of sustained operations has far outlived their economic lives, yet has high operational reliability.

WATER SYSTEM

IUAC's centralized water system of Phase-I feeding low temperature cooling water having a total heat removal capacity of 115 TR performed to an operational uptime of 100%. This is due to the stringent maintenance practices, which were followed over the years. The system has overshot 1,49,000 hours from its expected life span. IUAC's centralized water system of Phase-II&III feeding low temperature cooling water also performed to an uptime of 100%.A strict monitoring on the water quality has ensured that the flow paths are in healthy condition. The maintenance costs were kept significantly low as compared to world class bench mark values.150 KLD Sewage Treatment Plant (STP) performed satisfactorily.

COOLING SYSTEM

Availability of equipment was recorded at 99%.

PLANNED WORKS CARRIED OUT DURING THE YEAR:

- Air-Conditioning of High Vacuum Furnace (HVF) lab
- Extension of Process Water SS Pipes was done in Beam Hall#II for HYRA line
- Provision of RO Water was made at inlet to DI (De-Ionized) water plant used for super conducting resonator cleaning facility
- Stand-by air-conditioning of UPS Room
- Air-Conditioning of Cryogenic Control room
- Water Cooler & RO Water Purifier were installed for the Lab Building
- Installation of Class-10000 Clean Room for FEL (Free Electron Laser) project is in progress and is expected to be completed by May 2016
- The works for replacement of Ph-2 AHU#1, M S Piping, Thermal Insulation etc. are in progress.
- Work order has been awarded for replacement of Room No. 408 AHU, M S Piping etc. and is expected to be completed in 2 months
- Work order has been awarded for the new auditorium air-conditioning works and is expected to be completed in 6 months

RESEARCH : Communicated 3 nos. papers to International Journals, which are under peer-review.

3.2.3 Mechanical Workshop (MG-III)

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

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

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

Machine Shop (Figure 3.2.1) is equipped with a five axis Vertical Machining Centre and a CNC lathe. Apart from these, there are 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. Also, there are cylindrical grinder, tool and cutter grinder, horizontal and vertical band saw machines, etc. for general requirements. In addition, there is a Wax molding facility for melting the wax and shaping it into required shape & size. It can handle 100 kg of wax at a time.

Fig. 3.2.1: (left) Machine Shop, (centre) Portable CMM and (right) CNC Vertical Machining Centre

The Machine Shop also has CAD facility, Solid Works for the design and drafting purpose. Also, there is a VISI CAM for the CAM support for the Vertical Machining Centre and CNC lathe. A portable CMM, with 1.8 m inspection area with 40µm accuracy, is also added 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 were fabricated in the IUAC Workshop. Workshop continues to assist the entire in-house fabrication activities.

Welding shop (Figure 3.2.2) 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.

Fig. 3.2.2:Welding Shop

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.

Apart from the regular workshop activities, Workshop group is involved in the following major projects/activities:

- High Current Injector Development Program
- RFQ
- DTL
- Multi harmonic Buncher for HCI
- 48.5 MHz Spiral Buncher
- Electrostatic Quadrupoles
- Multi Electrode Extraction System
- 50 keV Ion Source Development program
- Cryogenic component developments etc.

3.2.4 Civil Works

M.K.Gupta and Harshwardhan

Works under Civil Section

- Major Projects –on-going construction of (i)Auditorium Building (ii) Addition of one floor in Main Lab. Building (iii) Planning for new AMS building
- Minor Projects

- Minor Works (additions, alterations, upgradation, modification in the existing Civil works)
- Civil Maintenance
- External Cleaning of the Campus
- Liasion with various Govt. and external agencies for miscellaneous interactions
- Key management of the Centre

Important Civil Activities during the Year 2015-16

Following important civil works were undertaken & completed during the year 2015-16 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). Civil works almost complete in Lab. Block Extn. and 75% complete in Auditorium building
- Civil works for renovation and up gradation of HVF Lab. In UB-I
- P/F Concertina coil fencing over IUAC boundary walls on all four sides
- Construction of room for Gamma chamber on E-side of Main building
- Internal painting of phase I Housing complex(including Flatlets)
- P/F PVC flooring in Data & Control room, Council room & Committee room
- P/F Net fencing around Two sides of IUAC playground including making steps for sitting on S-side
- Civil works for modification in existing Cryogenic control room
- Wooden flooring in sitting area of Lounge in Main building
- Miscellaneous civil works in Beam Hall-III basement for setting up Clean room
- Covering of open cable trenches with MS cheqd. plates near HPC chiller area
- Repair & renovation of Toilet for Canteen staff in Canteen

3.2.5 Compressed Air System And Material Handling Equipments

K.K. Soni and Bishamber Kumar (MG I)

The 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 115 m^3/Hr capacity, along with air dryers & filters with capacity of 3000 lpm @ 9.00 kg/cm^2 have been maintained uninterrupted for 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 m^3 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 m^3/hr capacity is added in PH I plant in order to meet any eventuality of breakdown of the existing compressor. A storage tank of 1 kL 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 borosilicate 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.

Reciprocating compressors, which are more power consuming and source of excess oil contamination in the compressed air, have been phased out. Compressed air piping has been extended to Lab I, Lab II and New Workshop building.

ii) Industrial Gases: Various industrial gases, which are 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 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 Tones 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 have been added. Two heavy duty radiation protection sliding doors of experimental area are also added under AMC. 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. Few additional sign-boards including the "Escape route" is 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 pressurised 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 the Reception of Lab I which is attended round the clock by an operator.