Chapter 3

RESEARCH SUPPORT FACILITIES

3.1 Support laboratories

3.1.1 High vacuum laboratory

Chandra Pal, A. Kothari and P. Barua

High vacuum laboratory is primarily responsible for maintaining vacuum and vacuum systems in beamlines and experimental facilities. There are about 800 instruments (pumps, gauges, valves, diagnostic BPM, Faraday cups, device controllers, etc.) installed and running in different beamlines and facilities. Faulty instruments are replaced with available spares to reduce machine downtime. Indigenously designed and fabricated instruments are repaired in house and others are maintained with available expertise in house and manufacturer's service support. Problems occurring in vacuum system and device (under our group's care) during experiment runs are attended on urgent basis. This lab provides support to different labs and users in vacuum related problems.

3.1.1.1 Status of vacuum systems, diagnostic devices and their instrumentation

There are about 950 equipment which includes vacuum system, diagnostic devices, and their instrumentation installed and under nonstop operation in different accelerators and experimental facilities. Of the 950 equipment, about 120 are designed, developed and fabricated in-house (mostly device controllers and vacuum interlock systems). This year we have added about 50 equipment to the accelerator systems and beamlines during the installation of the High Current Injector (HCI) facility. All equipment is operating in good condition.

3.1.1.2 New installations in the HCI beamline

HCI facility installation was commissioned successfully but due to the late delivery of few vacuum components, a stop-gap arrangement was performed with the available vacuum and diagnostic components. Ordered equipments like turbo pumps, ion pumps, valves, gauges, and backing pumps have been received, tested in laboratory, installed, and commissioned in the HCI beamline at required locations. The list of new vacuum and diagnostic components added to the HCI beamline is tabulated below:

3.1.1.3 Design and development of Faraday cup suppressor unit

There are about 20 Faraday cup units installed at different sections of High Current Injector beamline and LEIBF. To suppress secondary electrons in the FC a suppressor voltage of -380 V is required. Fabrication of 25 numbers of such suppressor units is needed. Communication between FC / Log Amp and FC controller will also be done through this unit. A custom -380 V PCB mountable power supply has been purchased, the design and fabrication of the main PCB has been completed and a compact housing unit has been designed and fabricated for this (see Fig. 3.1). Assembly of 25 such units is in progress.

Table 3.1: List of new additions to HCI beamline.

Equipment	Quantity	Location
Turbo pumps (with valves, backing pumps) and with vacuum interlock system	5 sets	Spiral Buncher 2 Pumping Chamber PCH-05-1 Pumping Chamber PCH-06-1 Pumping Chamber PCH-08-1 Spiral Buncher 3
Ion pumps with manual gate valve	4 sets	Pumping Chamber PCH-05-1 Pumping Chamber PCH-06-1 Pumping Chamber PCH-08-1 Achromat 3 Entry section
Motorized double slit	1	Achromat 4 Exit

3.1.1.4 New beamline valve controller for linac 3 exit valve

Linac 2 exit valve BLV 07-2 and linac 3 exit valve BLV 07-3 were being operated by a single beamline valve controller. A new separate valve controller has been assembled and installed for BLV 07-3. Spare channels in the CAMAC crate were located for the remote connection and new device controller was integrated with CAMAC control system. Data entry for its operation was updated in the control system with support from REC group. The controller was tested in local and remote mode and it is working fine.

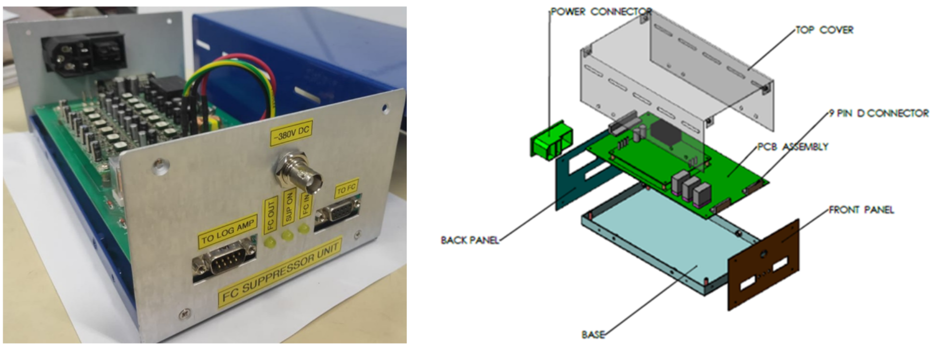

Figure 3.1: FC suppressor assembly (left) and 3D model of suppressor cabinet and inner components (right).

3.1.1.5 Maintenance of vacuum systems and diagnostic devices in experimental facilities

1. Maintenance work in the Pelletron (with the Pelletron group)
   - Venting of high voltage terminal inside Pelletron tank for foil loading and leak check and vacuum restoration after foil loading was done.
   - Faraday Cup shorted head assembly replacement in Ion source room: Faraday cup at FC01-1 location got shorted due breaking of insulating ceramics and was not able to read beam current. Related area was isolated and vented for head assembly replacement. Vacuum restored and Faraday cup working fine after that.
2. Replacement of faulty vacuum and diagnostic devices in different beamlines and facilities: Due to continuous and non-stop operation of vacuum devices, few devices get bad and after the fault is established faulty components are replaced from available spares for not stop operations. A list of replaced vacuum and diagnostic devices is given below:
   - Faulty turbo controller (SCU 800) replacement in phase 1 materials science 1st experimental chamber.
   - Faulty Maxi Gauge controller replacement in Phase 1 Material science first experiment chamber.
   - Installation of a new Maxi gauge controller in Radiation Biology beamline and interlocking with existing vacuum system.
   - Faulty scroll pump replacement in HCI RFQ.

- Faulty scroll pump replacement in LEIBF atomic physics beamline.
- Faulty scroll pump replacement in LEIBF high voltage platform.
- Faulty scroll pump replacement in LEIBF in TP-02 vacuum system.
- Faulty scroll pump replacement in Re-buncher vacuum system.
- Faulty scroll pump replacement in general purpose testing chamber in vacuum lab.
- Faulty vacuum gauge (full range gauge PBR 260) replacement in HCI DTL 3, 4 and 5.
- Faulty MKS hot cathode gauge replacement in Re-buncher vacuum system.
- Installation of serviced rotary pump ED-18 back in the Ion source room turbo pumping system TP01-1
- Faulty rotary pump replacement in GPSC and GDA beamline vacuum system,
- Log Amp replacement in Faraday cup at HCI 08-1 location.
- Log Amp replacement in Faraday cup at FC 05-3.
- Turbo controller (DCU 300) replacement in LEIBF 90 deg chamber vacuum system.

3.1.1.6 Testing, repairing and servicing of vacuum equipment

Many vacuum and diagnostic devices were diagnosed for faults and repaired in-house. A list of the same is given below:

1. Calibration and testing of 35 nos. of Log- amplifiers with a current source meter.
2. Repairing and servicing of bad Cold cathode gauges- 12 nos.
3. Calibration and testing of Pirani gauges – 10 nos.
4. Repair of NEC make BPM 80: Unusual noise observed in its motion and problem diagnosed in bearing of magnetically coupled motor. Faulty motor removed and replaced with a spare motor. BPM tested in vacuum with CRO, BPM selector and preamp and working ok.
5. Repair and servicing of Alcatel make rotary pump: Contaminated oil replaced and broken sight glass replaced to make the pump working.
6. Repairing of Scroll Pump: Bad scroll pumps dismantled and cleaned thoroughly. New tip seals and exhaust kit installed in the pump and assembled back. Tested and ultimate vacuum and bearing noise found ok – 12 nos.
7. Repairing of NEC make BPM selector – 4 nos.
8. 10-inch Vat make Gate valve repairing.

3.1.1.7 Miscellaneous vacuum maintenance activities

1. There were many calls related to vacuum problems that were attended in different beamlines and experimental facilities. Some common calls are listed below: -
   - BLV / FC are not closing - opening: caused by compressed air failure, problem in pneumatic drives, CAMAC problems, radiation interlock problems, solenoid valves problems, Reset not done, vacuum pump off / gauge problems, etc.
   - Vacuum Problems: Gauge problem, pump off due to power failure, huge outgassing due to target, leak from joints, pump electronics problem, pump failure, user mistake, vacuum accidents, etc. Problems are identified and resolved, user is advised for leak testing and proper sequence of operation to be followed.
   - Leak detective and resolving issues: helping others in resolving critical leak detection problems
   - Venting/ Vacuum Pumping: in beamlines / HCI area upon user's request.
2. Vacuum failures in beamlines: Three vacuum accidents happened in different beamlines causing pump shutdown in the following beamline.
   - Bio-science beamline: Vacuum failure happened in Bio science experimental chamber side due to aluminum foil rupture and due to sudden air inrush ion pumps of bio-science beamline (IP-L1-1) and that in switching magnet -I (IP-SW-1) got shut down due to high current. Both the ion pumps were revived back by baking after dismantling the magnets and portable pumping system was connected to take care of outgassing load. High vacuum was restored back for the experiment.
   - Phase I materials science beamline: Vacuum failure happened in the beamline from experimental chamber side probably due to accidental venting. Ion pumps of mat-science beamline (IP-L5-1) and that in switching magnet -I (IP-SW-1) got shut down due to high current. Both the ion pumps were revived back and vacuum was restored back for the experiment.

- Vacuum failure in LEIBF '0' degree and 90 degree beamline: A vacuum accident happened in 90-degree beamline of LEIBF and due to this the vacuum in zero-degree and 90-degree beamline got bad to about 2 mbar. While venting the user/operator did not close the 2^{nd} beamline valve (near experimental chamber) and vented the chamber. Due to this the Ion pumps of 90 degree and zero-degree beamline tripped and high vacuum gauges also got switched off. The vacuum in both the beamlines was restored in 2 days to 1.0×10^{-8} mbar levels.
- Vacuum Problem in LEIBF '0' degree beamline: A vacuum leak (1.0×10^{-5} mbar l/s) developed in the welding joint of a pumping chamber (TEE) installed 10 years back in LEIBF zero-degree beamline. The location of the leak on the chamber was detected and marked for re-welding. The beamline was vented and turbo and other connected components were dismantled to repair the vacuum chamber. Welding on the leaking chamber was done in IUAC Workshop, again leak tested found ok, installed back and vacuum re-established within two days.
- Through Leak Problem in BLV 05-2 at Superbuncher entry: This beamline valve was 30-year-old NEC valve and developed a through leak of the order of 1.0x 10^{-5} mbar l/s and its operational mechanism had also gone bad. This valve and another non-operational fast closing valve were removed form Superbuncher entry location during Pelletron schedule maintenance and a new all metal VAT valve was installed and commissioned.

3.1.2 Cryogenics

Poonam Meena, Rajesh Nirdoshi, Manoj Kumar, Suresh Babu, Joby Antony, Soumen Kar and Anup Kumar Choudhury

The cryogenic system of linac consists of five beam-line cryostats, liquid nitrogen (LN2) network and helium refrigerator, liquid helium (LHe) network, helium gas management system and associated cryo-instrumentation and data acquisition system shown in Fig. 3.2. In this academic year, the linac cryogenic system was operated for the beam acceleration through the RF-Superconducting linac. The helium refrigerator was also operated for testing a 1.5T superconducting MRI magnet for the IMRI project.

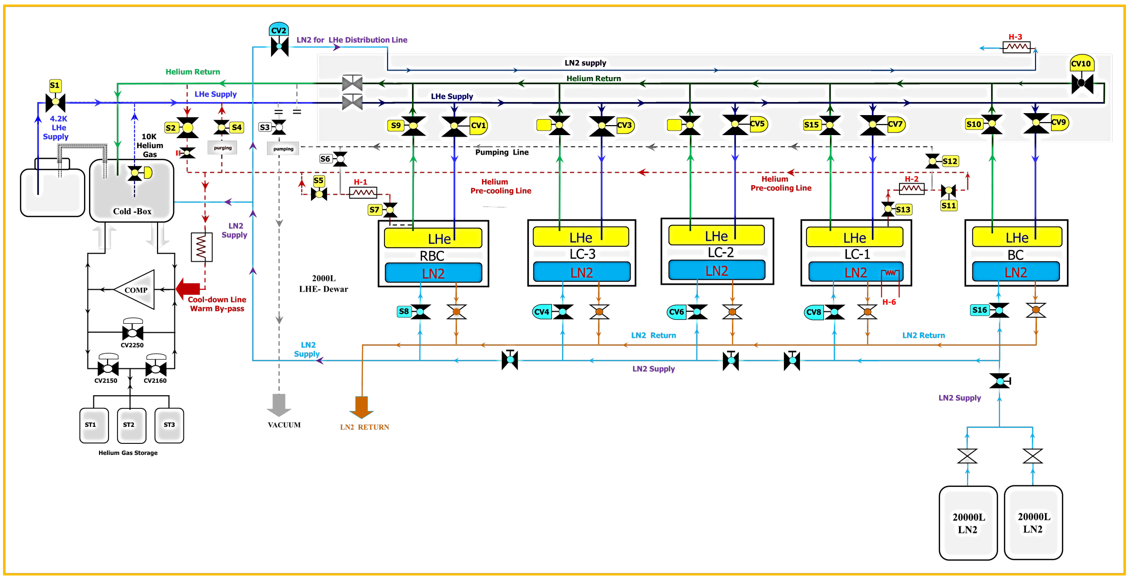

Figure 3.2: A schematic of the cryogenic system of the RF-superconducting linac.

3.1.2.1 Helium refrigerator

During this academic year, the helium refrigerator (Model-LR280, LINDE Kryotecnik) having a capacity of 750W@4.5 K was operated for $\sim$ 1500 hrs. and the compressor was operated for 30000 hrs which is shorter than the previous two academic years as shown in the left panel of Fig. 3.3. The plant was operated for the beam acceleration, cavity testing in test cryostat and the testing of MRI magnet.

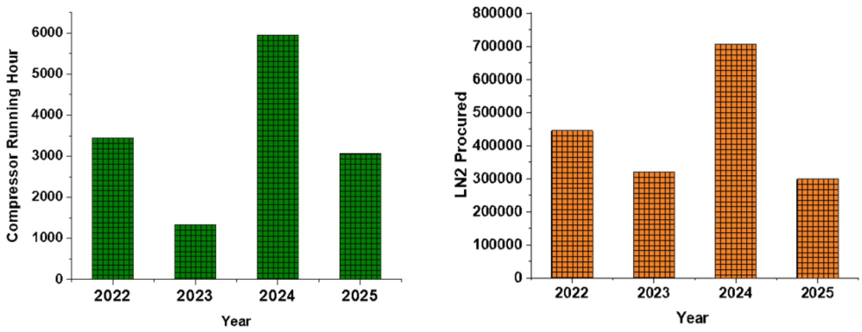

Figure 3.3: Year-wise running hours of the helium compressor (left) and year-wise consumption of the liquid nitrogen.

3.1.2.2 Liquid nitrogen network

During this academic year, the total consumption of liquid nitrogen was ∼3,00,000 litres primarily for the cooling of the thermal radiation shield of the beamline cryomodules during beam acceleration and cooling the germanium detectors of the INGA facility. A substantial amount liquid nitrogen was used to precool the MRI magnet from 300K to 80 K. The right panel of Fig. 3.3 shows the year-wise consumption of the liquid nitrogen.

3.1.2.3 Beamline cryostats of the linac

The beamline cryomodules, namely the super-buncher cryostat (SBC), three linac cryostats (LC1-LC3) and the rebuncher cryostat (RBC), were operated for the beam acceleration. The performance of all the cryomodules was satisfactory during the beam acceleration. After the completion of all the experiments of the beam accelerated through the linac, the cryomodules were warmed up to room temperature. In this academic year, the effect of the superconducting solenoid magnet on the beam transport was tested in LC1 with $^{12}C^{5+}$ beam accelerated through the Pelletron accelerator. A significant improvement in beam size was observed along with a steering effect, thereby signifying the need for proper alignment of the solenoid magnet for its use in tuning the beam through the linac.

3.1.2.4 Cryogenic instrumentation and machine learning

Rajesh Nirdoshi and Joby Antony

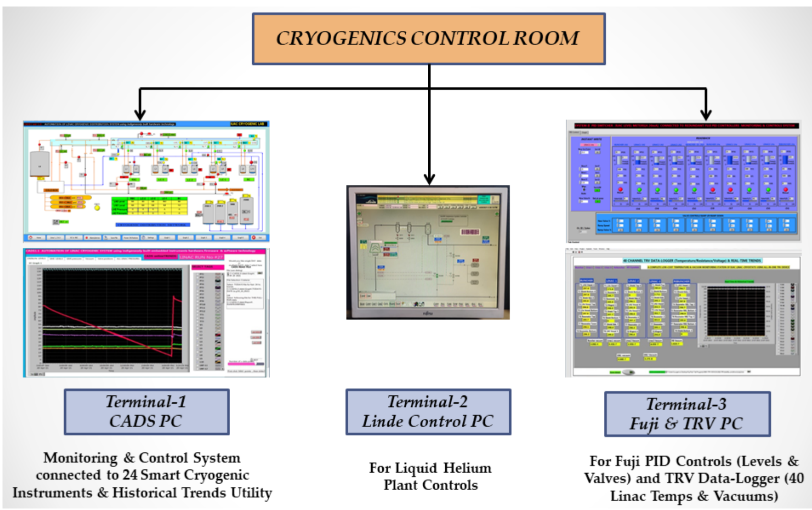

Figure 3.4: The cryogenic control room terminals.

The primary activity of the cryogenic instrumentation and machine learning group was to operate and maintain the cryogenic control and data acquisition system of the linac. The members are also involved in maintaining the electronics of the EBW machine and R & D in AI/ML-based technologies for cryogenics and other applications.

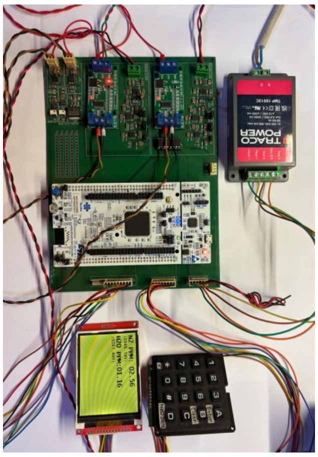

Figure 3.5: Dual channel impurity analyzer setup.

Cryogenics control system and associated electronics: Throughout this year, the IUAC Cryogenics Control System and its associated electronics have undergone preventive maintenance and have functioned reliably. The system was continuously operated during the linac run, which concluded in April 2024, As shown in Fig. 3.4, the cryogenic control room is equipped with three primary control terminals that facilitate remote control, data acquisition, trends monitoring, operator interface, and various other critical functions.

- **LINDE control terminal** : The Linde control terminal originally supplied by M/s Linde Kryotechnik, Switzerland in the year 2010, runs on Siemens software and serves as a vital standalone controller for the Liquid Helium Plant. In this academic year, the main control server (RMCS) encountered a motherboard failure, which was successfully repaired in-house and has since been operating reliably. However, the redundant PC located near the main plant has become completely non-functional. Plans are in place to upgrade both systems with modern PCs equipped with updated operating systems and compatible Siemens software.
- **Dual channel impurity analyzer for helium gas** A new dual-channel impurity analyzer as shown in Fig. 3.5 has been successfully developed in-house for real-time monitoring of impurity levels of nitrogen and moisture present in helium gas. The system utilizes a low-voltage raw signal from an arc cell, which is filtered, amplified, and further processed through an ADC and a microcontroller. Designed with user convenience in mind, the analyzer features a dedicated TFT display that provides a continuous readout of impurity levels (in PPM) along with corresponding voltage values. It also includes a 4x4 alphanumeric keypad for easy input of calibration parameters. One channel of the system, configured for nitrogen detection, was tested in conjunction with the arc-cell setup at the end of the last linac run and demonstrated reliable and satisfactory performance.
- **LSTM-based linac-cryogenics data forecaster system with advanced warning algorithm**: An LSTM-based linac-cryogenics data forecaster system with advanced warning algorithm was successfully developed to enhance predictive monitoring during cryostat warm-up. This initiative was carried out during the linac shutdown in April 2024, when the system's temperature rose from 4.2 K to room temperature. A Long Short-Term Memory (LSTM) neural network model was created and trained using time-stamped temperature and vacuum data collected in real-time from TRV data devices. The system utilized the latest 3 hours of data to continuously forecast the next 1 hour, enabling the identification of any potential anomalies during the warm-up process. This forecasting mechanism was set on an automated loop, running uninterrupted for several days until room temperature was reached. Additionally, a user-friendly LabVIEW-based linac data forecaster utility was developed, allowing easy visualization of the forecasted data, thereby equipping operators with timely insights and early warnings.

3.1.2.5 Whole-body 1.5T superconducting MRI magnet system

Neha Sharma, Arpan Kumar Goswami, Farukh Khan, Rajesh Nirdoshi, Manoj Kumar, Suresh Babu, S. K. Suman, Joby Antony, S. K. Saini, Rajesh Kumar, R. G. Sharma and Soumen Kar

A multi-institutional project on the development of a whole-body 1.5 T superconducting MRI scanner funded by the Ministry of Electronics and Information Technology (MeitY) is going on at IUAC under the coordination of SAMEER-Mumbai (nodal agency). IUAC is primarily responsible for the development of a 1.5T superconducting magnet system for the MRI scanner. In the last academic year, the indigenously developed MRI magnet system was successfully tested in the IUAC MRI laboratory. However, there were a few teething issues related to the cold leak and the instability in the PCS at the higher field, which were addressed in this academic year.

Figure 3.6: (a) MRI cryostat leak testing at 77K (b) gradient coil going into the cryostat warm bore.

The cryostat was taken to the factory of M/s. INOX in Gujarat for the repair of the cold leak. After the systematic disassembly of the cryostat, the leak was identified. The leaky joint of the cryostat was replaced with a new bi-metallic joint after a few trials of the vacuum brazing process. The PCS was also replaced with a new one. The cryostat was then reintegrated. At every step of the reintegration, extensive intermediate tests were performed in the helium vessel and the vacuum jacket to ensure no recurrence of the leak in future as shown in the Fig. 3.6 (a). The gradient coil having a capacity of 35mT/m gradient strength and slew rate of 120T/m/s was then mounted into the warm bore of the cryostat as shown in Fig. 3.6 (b). The cryostat was then transported and commissioned at IUAC. The magnet was precooled with liquid nitrogen after reaching a vacuum of 5×10^{-6} mbar. Liquid nitrogen precooling reduces the amount of liquid helium to be used to cool down the magnet to 4K. A GM cryocooler was installed in the CCR port, and shield cooling was started. After attaining a certain temperature of the shield, the magnet was cooled using liquid helium.

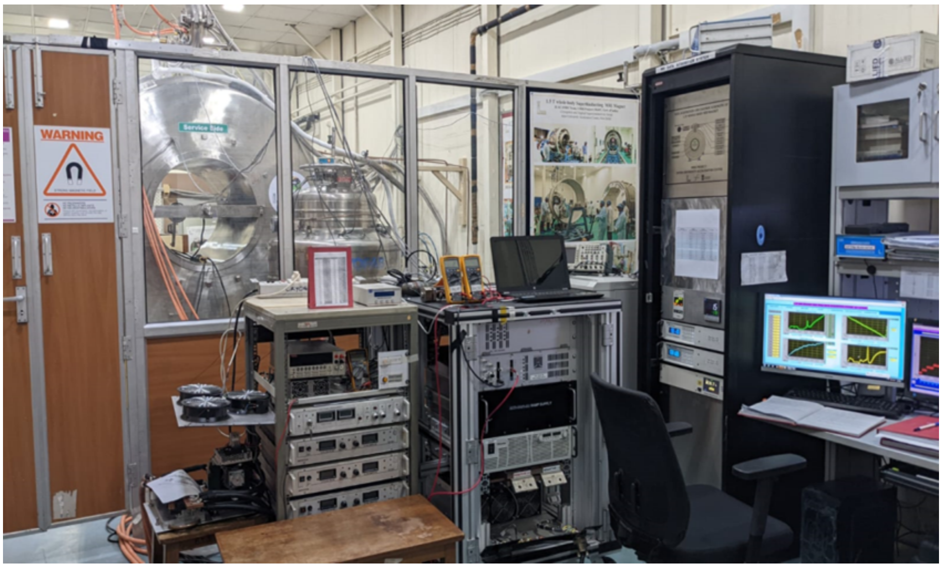

Figure 3.7: MRI magnet test in progress at IUAC.

The vacuum pump was isolated once the vacuum was improved to 8×10^{-8} mbar. The improvement of vacuum was observed, thereby the cold leak did not reoccur. The magnet was then ramped up to 1.5 T and put into persistent mode for the first time. Power supply was ramped down and disconnected. A temporal field stability of 0.07 ppm/hr was achieved. A spatial homogeneity test was also done using the NMR field camera, which exhibited a inhomogeneity of around 650 PPM, which is reasonably good for an unshimmed magnet. Fig. 3.7 shows the test set up of the MRI magnet at IUAC.

To overcome certain technical challenges, the MRI cryostat was refabricated and was integrated with additional critical components such as multiple temperature sensors and a high-sensitivity vacuum gauge. In tandem with this hardware upgrade, the MRI data acquisition (DAQ) software was comprehensively enhanced to seamlessly incorporate these new elements. Notably, the software update included the successful implementation of the transfer function for the vacuum gauge, ensuring accurate vacuum monitoring within the system. Following these upgrades, control and monitoring tests were carried out using the modified software setup, all of which were successfully commissioned. These advancements have significantly improved the system's diagnostic capabilities and operational reliability.

Figure 3.8: Magnet ramping unit.

3.1.2.6 Development of magnet ramping unit

S. K. Suman and Rajesh Kumar

A magnet ramping unit (MRU) was developed in this academic year for testing of MRI magnet. The MRU is equipped with the energy absorber unit, quench detection, and variable ramp rate was developed using Lambda-TDK-based DC power supply. All the functionalities of the MRU The MRU was extensively used for testing of the MRI magnet. The indigenously developed MRU is shown in Fig. 3.8.

3.1.3 Beam transport system

Ashish Chamoli, Prem Kumar Verma, S. K. Suman, Rajesh Kumar and B. K. Sahu

The beam transport system (BTS) plays a crucial role in ensuring high-quality ion beams for experiments. The real-time feedback system of the magnet power supplies (MPS), combined with high stability, establishes a steady magnetic flux that maintains a consistent beam profile and keeps the beam on the defined trajectory. The BTS group, prioritize preventive maintenance and troubleshooting to maximize uptime and performance. Additionally, the BTS group designs and manufactures power supplies as needed for upcoming new accelerator facilities and to replace outdated imported units. Furthermore, the group collaborates on development activities with other groups and contributes its expertise to various projects.

1. **BTS components:**
   There are currently 153 magnets and 193 magnet power supplies (MPS) operational at various accelerator facilities. Three major types of BTS magnet power supplies are used in the system. The first type is the model 8000 MPS from Danfysik, an older power supply installed at the Pelletron, linac, HIRA and HYRA facilities. The second type, model 9000 MPS, is a relatively new model from Danfysik, installed at the HCI and FEL facilities. The third type is the in-house manufactured MPS, which includes power supplies for the steerer, scanner, and superconducting solenoid magnet, totalling 98 units, installed across all the facilities.
2. **BTS operational status and breakdown handling:**
   During beam operations the magnet and power supplies worked well in terms of functionality and stability performance, which contributed greatly to the smooth beam tuning and beam quality. The BTS operation was majorly hampered by water leaks in transistor bank water cooled heat -sinks, and rarely by electronic and electrical failures in the power supplies. Such faults were immediately rectified, using spare parts and later-on the faulty modules were repaired in the lab.
   In cases where water-cooled heat sinks punctured inside power supplies during beam operations, immediate actions were taken to remove the water by dismantling the units and replacing them. For transportable power supplies, spare units were used as replacements while the faulty units were refurbished in the lab. However, repairs for the bending magnet MPS, which are not transportable, were conducted on-site.
3. **BTS structural integrity:**
   Most of the magnets and power supplies are either water-cooled, forced-air cooled, or both, making them more susceptible to oxidation from cooling water and corrosion caused by dust and humidity. Poor quality of cooling water causing oxidation and resulting in partial blockage of magnet coils and

punchers in the water cooled heat sinks of the power supplies. Some of the BTS areas are not fully enclosed, the dust levels are high and sometime the humidity also increased causing condensation inside water cooled power supplies. The dust together with condensation has resulted in corrosion of the water cooled components, have resulted in significant damage to the power supplies and magnets.

4. **Preventive maintenance of magnet and magnet power supplies:**
   The performance of the magnet power supplies relies significantly on their thermal performance and physical conditions. During preventive maintenance, the environmental damages are restored by cleaning off corrosion and dust. The degraded, underperforming components are identified by electrical data recording and analysis, and corrected either by repair or replacement.
   During the condition assessment conducted as part of preventive maintenance, two types of issues were identified with some of the magnets: overheating and current leakage to the ground through the cooling water hose. Both problems were caused by poor-quality cooling water, which led to the build up of copper oxide inside the coil, restricting the cooling water flow. The deposition of oxide in the return water hose resulted in earth leakage, causing instability. To resolve the thermal and magnetic field instability caused by leakage current, the coils were cleaned using sulphamic acid (H_3NSO_3), and the water hose were replaced.
5. **Corrective repairs and refurbishment:**
   Over time, we have understood the failure modes and identified the components that frequently fail in all type of the BTS magnet power supplies
6. **Power supply repair activities:**
   The primary cause of component failure is thermal stress, often resulting from dust accumulation on the components. We have developed significant skills in component-level repairs and have successfully repaired nearly every type of electronic and electrical sub-assembly, with no backlog in repairs. Repeated failures occurred on auxiliary power supply boards in system 9000 power supplies with similar effects. After implementation of a RC snubbers and replacement of an overloaded resistor the systems worked reliable over the whole operating period. To enhance diagnosis and enable component-level repairs for the Model 8000 and Model 9000 power supplies, we have created test jigs and PCB extenders
7. **Power supply refurbishment activities:**
   A total of nine magnet power supplies were refurbished and overhauled. Three of these experienced breakdowns due to leakage from the water-cooled heat sinks, which resulted in water spilling inside the power supplies. This led to damage to the control and power electronics. Additionally, the transistor banks of three HYRA quadrupole magnet power supplies and two high-field scanner power supplies were refurbished for corrosion. The transistors had corroded as a result of dust and condensation, resulting in unstable output currents. When these failures occurred, extensive refurbishment and repairs were needed, requiring a significant amount of man-hours and manpower

3.1.3.1 Developmental activities

1. **BTS magnet power supply development activities:**
   Currently, several linear, water-cooled power supplies are in use to power the beam transport magnets of these facilities. The cooling water corrosion has led to frequent failures of these power supplies. Some of these power supplies are over 35 years old, and the obsolescence of spare components has made repair and replacement increasingly difficult. Moreover, the use of imported MPS imposes several risks, such as high costs for spare parts and dependence on power supply manufacturers for repair support. Considering these, it has been decided to replace them with in-house developed, high-efficiency, forced air-cooled switch-mode power supplies
2. **Development of the first prototype of a 250 A / 50 V high-stability power supply:**
   In the design and fabrication of indigenous power supplies, a moderate approach has been adopted to minimize in-house fabrication work. This involves utilizing commercially available voltage-controlled AC-DC switch-mode converter modules as the DC power source. A prototype power supply rated at 250 A and 50 V, with a precision of ± 10 ppm, has been designed and assembled to validate the use of commercial SMPS voltage sources for creating current-regulated power supply. An in-house designed power supply controller unit and a current transducer have been added to the AC-DC switch-mode converter voltage modules to convert it into a high-precision, current-regulated power supply. The performance of this unit has been validated by measuring long-term stability, output ripple, and noise levels.

3.1.3.2 Participation with other groups in developmental projects

The BTS group collaborate with other groups in developmental projects and contribute in its area of expertise.

1. **Development of superconducting magnet control (SMC) system for I-MRI magnet:**
   The Superconducting Magnet Control (SMC) is a comprehensive and customized system, specifically designed to power, control, and protect the 1.5T MRI magnet. The control algorithm, quenching protection circuit, and interlocking logic function are designed considering the operational requirements of this particular magnet. The architecture and construction of the SMC is modular, with particular attention given to maximizing both auto and manual operation options to handle various conditions during the excitation and demagnetization of the magnet.
   A commercial 12 V / 600 A DC voltage supply serves as the voltage source, to which an external current control feedback loop is implemented to convert it into a current regulator. Additionally, an energy absorber unit (EAU) is included to de-energize the magnet at 3.5 V. Two 0-500 mA adjustable current sources are provided for persistent current switches of the main coil and external interference screening (EIS) coil. The quench detection function, as one of the primary protections, features adjustable quench sensitivity; it detects a quench and promptly stops power from being delivered to the resistive magnet while simultaneously activating the EAU to safely discharge the magnet.
2. **Development and testing of super-conducting MRI magnet:**
   During the testing phase, the BTS group is specifically responsible for powering the magnet. To power the magnet, the in-house developed superconducting magnet control (SMC) system was employed, and the magnet was successfully ramped to 1.5 T, entering persistent mode, and was then ramped down without experiencing a quench. Throughout these modes of operation, the coil voltages were monitored to observe any loss of superconductivity or current decay within the passive quench protection circuits of the magnet. The SMC system's advanced current control feedback loop effectively managed the magnet during persistent mode activation, despite changes in the magnet's time constant due to the varying resistance of the main coil's persistent current switch, which can lead to instability in the current control loop. However, last year, an imported power supply failed during the activation of persistent mode and was unable to maintain the magnet's current stability.
3. **Design and development of high voltage pulse generator for ion-trap:**
   An Ion Trap is currently being developed at IUAC, which requires a bipolar High Voltage Pulse Generator (HVPG) for the switching of ion beams. The HVPG must meet the following functional and electrical specifications: it should produce square pulses with equal rise and fall times, a variable amplitude ranging from 100 V to 500 V DC, a variable frequency between 1k Hz and 200 kHz, and a variable duty cycle. Customized HVPGs with these specific functionalities are rarely available on the market and often come at a high cost. For the design of the HVPG, a MOSFET-based half-bridge topology has been selected, as it ensures equal rise and fall times. To prevent both the high-side and low-side MOSFETs from turning on simultaneously, incorporating a dead time is essential for safe and efficient operation, especially at high-frequency operation.
   In the first phase of development, a prototype dead time control circuit was built using programmable delay ICs and flip-flops. This circuit has been tested for the independent adjustability of rise and fall dead times, which can be set up to 50% of the duty cycle. It can also manage variable frequency and duty cycle functions. The circuit requires only an external trigger of the desired frequency for synchronization; both the duty cycle and dead time can be adjusted using accessible controls while observing the transition, while operating with the reactive load impedance.
   The design of the half-bridge section has also been completed. High-voltage MOSFETs equipped with necessary snubbers are utilized in a half-bridge push-pull configuration and are driven by isolated gate drivers. The half-bridge will be mounted on a forced-air cooled heat sink. Currently, the PCB designs, component procurement, and the high-voltage bias power supplies are in progress.
4. **Fabrication of plate tuner for the HCI-RFQ:**
   A 48.5 MHz Radio Frequency Quadrupole (RFQ) cavity is currently operational at the High Current Injector at IUAC. To achieve the desired frequency of 48.5 MHz, a plate tuner is inserted between the vane posts. The existing plate, made of pure copper, is ductile and prone to plastic deformation, which leads to poor electrical contact. As a result, the RFQ power is limited to 15 kW. In order to improve the electrical contact between the vane post and the tuner plate, spring finger contacts made of beryllium copper have been soldered to both sides of the tuner plate. Beryllium copper was selected for its excellent combination of electrical conductivity, mechanical strength, and spring properties. The

necessary processes and tools for soldering these spring finger contacts on to the 3 kg copper plate have been developed and successfully implemented. The same can be used with existing RFQ for high power testing.

3.1.4 Detector laboratory

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 nuclear physics experiments.

3.1.4.1 Development of hybrid telescope based on IC-CsI-photo-diode combination

R. Prajapati, M. Kumar, N. Saneesh, K. S. Golda and A. Jhingan

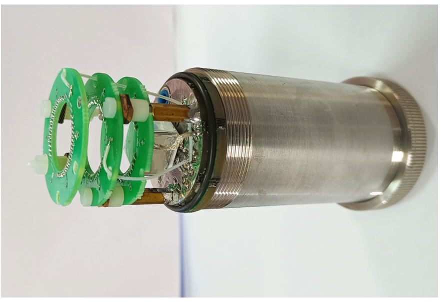

Figure 3.9: Assembled hybrid telescope.

Hybrid telescope, having combination of gas (ΔE) and CsI-photo-diode (stop), has been developed for heavy ion detection and particle identification in nuclear physics experiments with NAND / GPSC facility at IUAC. The detector telescope will be used for the detection of charged particles such as protons, α-particles and other heavy fragments (Li, C, etc.) emitted during the heavy ion induced fission process. Ability of the detector system to identify lighter fragments can make them useful in ternary fission experiments. The detector system can also be used to identify projectile like fragments along with lighter charged particles in low energy experiments of astrophysical importance. CsI-photo-diode detectors have been successfully used to study fission gated light charged particle multiplicity but these detector lack the ability to identify other lighter fragments (Li onward) which is required to study ternary fission. Since probability of ternary fission is very small, detectors are required to be placed close to target (for increased solid angle and statistics) thus exposing them to high flux of elastics. Hybrid combination of gas and CsI-photo-diode detectors are ideal since they are not prone to radiation damage.

Fig. 3.9 shows the assembled hybrid telescope. It consists of a gas ionization chamber, operating in axial field geometry mode, followed by a CsI-photo-diode. The ionization chamber (IC) is composed of three wire frames, a central anode sandwiched between two cathodes, of active diameter 25 mm. Inter-electrode separation is 10 mm. All wire frames are made from gold plated tungsten wires of 20 μm diameter stretched on a 1.6 mm thick printed circuit board. The wire pitch is 1 mm. The two cathodes are grounded whereas the anode operates in ionization region with a typical reduced field of about 0.5 - 1 V cm^{-1} mbar^{-1}.

The IC is followed by a 20 $\times$ 20 mm^2 CsI crystal of thickness 3 mm coupled to a 10 $\times$ 10 mm^2 photo-diode. The electrodes are housed inside a cylindrical SS tube. The detector is operated with isobutane gas at pressures 50 - 100 mbar. Entrance window is made from 0.9 μm mylar. Signals of both IC and photo-diode are processed using in-house fabricated charge sensitive preamplifier with charge sensitivity of 90 mV/MeV (Si equivalent). The detector was tested off-line with α-particle and ^{252}Cf fission source. The detector was operated at 60 - 80 mbar gas pressure with a bias voltage of +50 V. Fig. 3.10 shows the plot between energy loss in IC against CsI detector for fission fragments emitted from ^{252}Cf source. In future we plan to have an array of such telescopes covering more angles simultaneously for angular distribution studies. For ternary fission experiments, large area telescopes need to be fabricated by stacking more number of CsI detectors in 2 $\times$ 2 or 3 $\times$ 3 formation. PSD techniques will be incorporated for CsI detectors. Custom made high density electronics is currently under development for the same.

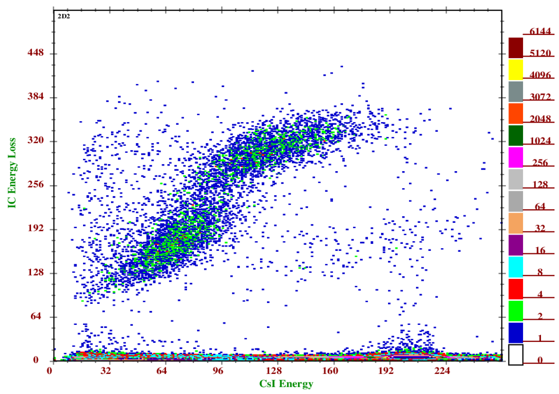

Figure 3.10: Plot of ΔE (y-axis) against E_{res} (x-axis) with ^{252}Cf fission source.

3.1.4.2 Electronics for BGO scintillator detectors in INGA

A. Jhingan and I. Bala

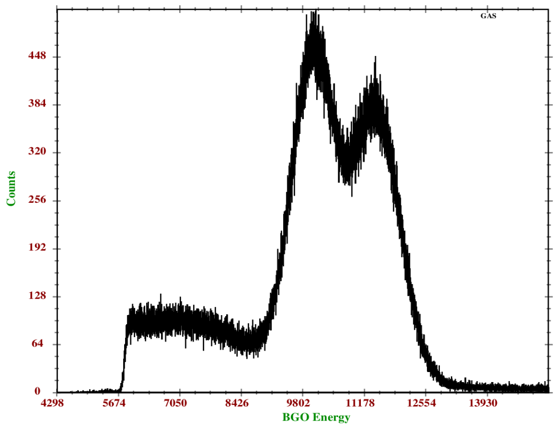

Figure 3.11: ^{60}Co γ-ray spectrum with BGO detector.

A custom designed charge sensitive preamplifier (CSPA) unit was fabricated to process signals from BGO scintillators coupled to photo-multiplier tube (PMT). The PMT base has only one signal output and it is required to extract both timing and energy information from the same. The CSPA has a high bandwidth and can provide both information. It has a sensitivity of 4.5 mV/pC (Si equi.) with a rise time of 10 ns. The CSPA facilitates signal transmission through long cables from INGA beam-line to the data room, and can drive into loads of timing amplifier (50 Ω) and spectroscopy amplifier (1 kΩ) simultaneously. Further processing of CSPA signals is performed using the earlier developed system for CsI detectors. The CSPA output is fed to a NIM differential driver unit which drives the differential energy signal to the 16 channel Mesytec (MSCF series) spectroscopy amplifier. An energy resolution of ~10 % (1.33 MeV γ-rays) with BGO using ^{60}Co source was observed (Fig. 3.11). Typical rise times with BGO detectors is ~ 250 ns. The modular CsI electronics developed earlier can be easily adapted to process signals from 14 BGO detectors. Timing characteristics are being evaluated using Mesytec amplifier as well as Canberra TFA with different shaping time plus CFD delay combinations to get optimum timing resolutions (~20 ns) for coincidence measurements.

3.1.4.3 Development of a reset charge sensitive preamplifier

A. Jhingan

In heavy-ion induced experiments, detectors are often exposed to different type of particles with energies ranging from few hundreds of keV to some times hundreds of MeV. The high gain CSPA units often get saturated due to injection of larger charges and the recovery times can be of the order of several milliseconds which can lead to loss of data from the subsequent events of interest with lower energies. The solution lies in using the standard technique of resetting the CSPA before it reaches saturation. A reset CSPA unit has been developed for processing signals of such detector systems. It uses a standard design of CSPA with FET as 1st stage followed by a trans-impedance amplifier made out of BJT. The output is split into two parts with one going to a spectroscopy amplifier while the other is fed to a voltage comparator. The comparator produces a voltage pulse which resets the input stage of FET once the output crosses preset threshold value. The CSPA unit was assembled using SMD components. It was tested using a silicon PIPS detector with a ^{252}Cf source which emits low energy alpha particles as well as high energy fission fragments. The reset function of the CSPA unit worked satisfactorily. The reset time was less than one microsecond. Resolutions were almost identical to a normal CSPA unit.

3.1.4.4 CsI detectors fabricated by crystal growth division, BARC

Shiv Govind Singh[1], G. D. Patra[1], Shashwati[1], M. Kumar and A. Jhingan

[1] *Crystal Growth Centre, TPD, BARC, Mumbai*

CsI (Tl) crystals have been developed by the crystal growth group, Technical Physics Division, BARC. The crystals have a thickness of 20 mm, and an area of 20 x 20 mm^2. The crystals are coupled to 18 x 18 mm^2 photo-diodes from Hamamatsu. The assembled units prepared by TPD-BARC were tested at IUAC with the charge sensitive preamplifier (CSPA) units fabricated by Detector Lab, IUAC. The crystals were tested offline with γ-emitters such as ^{137}Cs and ^{60}Co. The performance of the crystals were found to good. The energy resolution was found to be 6% for 1.33 MeV. It is proposed to develop more detectors with different sizes and geometry to meet the experimental as well as application oriented requirements.

3.1.4.5 Development of an Octal stretcher and delay generator

Kusum Thakur

An octal stretcher and delay generator has been developed as a single width NIM module. The module will also serve as a level translator and will provide delayed and stretched output in NIM as well as ECL format. This in particular will be very useful in cases where it is required to delay and stretch ECL signals. It can accept NIM and TTL inputs while providing NIM, TTL and ECL output. The width and delay can be varied from 50 nanoseconds to 12 microseconds. It is planned to modify the same into a 16 channel ECL gate and delay stretcher module.

3.1.4.6 Troubleshooting of faulty NIM modules

Kusum Thakur

NIM modules such as Timing Single Channel Analyzers (TSCA) and Spectroscopy Amplifier units were repaired and made operational for nuclear physics experiments. TSCA modules provide NIM and TTL signals at leading edge as well as zero crossing times. These are in particularly very useful for particle identification based on pulse shape discrimination. They are also used as window discriminators.

3.1.5 Target development laboratory

Sanjay Kumar Saini, D. K. Prabhakar, Amit Kumar and Debdulal Kabiraj

3.1.5.1 Target development for accelerator users

The primary responsibilities of the Target Development Laboratory (TDL) are the operation, upkeep and maintenance of instruments in the lab for developing, preserving, and delivering the nuclear targets and thin films for particle accelerator users. TDL is successful in delivering all the requested targets for accelerator experiments, and several research scholars have been trained in thin film deposition techniques this year. Most of the instruments in the target lab are well–utilized this year, except the UHV Evaporator with multi-pocket electron gun (e-gun). Target developments in IUAC were also reported in peer-reviewed journals and national symposiums.

3.1.5.2 Fabrication, inspection and loading of stripper foils

Target Lab fabricates the stripper foils twice a year according to the Pelletron maintenance schedule. Approximately 200 carbon foils of $4\mu g/cm^2$ for the terminal section and 200 foils of $8\mu g/cm^2$ thickness for the dead section. Target development laboratory develops carbon stripper foils by e-beam bombardment techniques. High-purity graphite is evaporated and condensed over the glass substrate coated with a releasing agent. To ensure the maximum uniformity in the thickness of the films, the glass substrates are rotated during the evaporation. A dedicated turbo pump-based e-beam facility is used for the stripper foil fabrication. The stripper foil fabrication process was upgraded through the integration of dip coating and spin coating techniques. The improved procedure involves a systematic sequence of steps, including the cleaning of glass slides, application of a releasing agent, drying via spin coater, and subsequent floating using the dip coater. This enhancement has led to a significant improvement in fabrication efficiency, increasing yield up to 90%, also reducing the time for setup preparation. Finally, the carbon films are mounted on the stripper foil holder.

3.1.5.3 Maintenance and up-gradation activities in TDL

In addition to the regular operation, the major maintenance activities are cleaning of the chamber, gauge cleaning, periodic maintenance of electrical systems, periodic maintenance of QCM, leak testing, cooling water supply, and performance testing. The Breakdown maintenance of the Rolling Machine was one of the major maintenance activities in TDL during this year. After the disassembly of the machine by TDL members, it was identified that the breakdown was due to the failure of the gears. A cost-effective yet robust custom gear train, which was manufactured indigenously by a vendor, was successfully replaced. The machine is back in operation after several tests with loads. A Python program was developed to communicate with the QCM through the RS-232 port. With a significant investment of time and hard work, we successfully achieved the ability to read from and write to the QCM using this program. After designing substrate heater, the job was manufactured with the help of the mechanical workshop.

3.1.5.4 Target library for users

The Target Library, TDL initiated in the year of 2019 for the systematic storage of the nuclear targets for future use and to avoid repeated fabrication of targets having the same specifications. Apart from saving money and manpower, this facility also helps users to plan experiments depending on the availability of the target. The Digital Inventory of the Target Library is maintained and updated periodically. A list of targets and their specifications is available in digital form. More than 1200 targets are already part of the library, and new targets are getting added after the completion of the experiments for those targets that were fabricated. The Target Library has issued more than 50 targets in 2024 for various experiments. The air-sensitive targets for longer durations are always a challenging job. The dedicated high vacuum storage facility for the target has not yet materialized. At present, the targets are stored in vacuum desiccators, which are filled with argon gas. A stock of 200 carbon stripper foils is maintained in the library to meet any unexpected requirement.

3.1.5.5 A few important target developments

During the deposition of erbium (Er) onto carbon foils, delamination of the Er layer is commonly observed due to its low sticking coefficient and high internal stress. To address this issue, a post-deposition annealing step is introduced. This thermal treatment facilitates stress relaxation within the foil, thereby enhancing its mechanical stability. Additionally, the annealing process may promote interlayer diffusion at the Er–carbon interface, potentially increasing the adhesion between the layers. By this method, long-lived ^{166}Er target has been developed.

3.1.6 Radio frequency laboratory

Anupama, Ashish Sharma, Parmanand Singh, Yaduvansh Mathur, V. V. V. Satyanarayana and S. Venkataramanan

The RF Group is an Accelerator Support Central Group (AcSCG) and is responsible for the operation, maintenance, and development of various Radio Frequency Control Electronics (LLRF) and high power RF systems to power various accelerating structures for accelerating particle beam of different particle accelerators at IUAC. The group plays a key role in the operation of the Beam Pulsing System of the Pelletron during pulsed beam delivery with various nuclear physics experimental facilities. The RF Group manages a diverse array of high-power RF amplifiers, microwave power sources, and RF control systems. The radio frequency power sources under the group's care operate across a wide frequency range (4 MHz to 17.9 GHz) and at power levels ranging from milli watts to tens of megawatts. These systems are installed across major IUAC facilities, including the Pelletron, Superconducting linac, HCI, DLS, LEIB accelerator and a prototype table top Cyclotron. The group has been actively involved in periodic preventive and breakdown maintenance of these critical systems for successful operation, augmentation and development of new systems as per the system requirements. Beyond regular duties, the group members were actively involved in academic activities, including the training and mentoring of apprenticeship trainees, trainee scientists, students, and junior engineers during this academic year.

3.1.6.1 Operation of beam pulsing system for Pelletron-linac

During this academic year, the beam pulsing system was extensively used for delivering several pulsed beam runs supporting nuclear physics experiments. The operation summary of the beam pulsing system is presented in Table 3.2, detailing the variety of beams bunched, along with their corresponding energies, number of shifts, and the user facility. In total, the pulsing system was utilized for 212 shifts, amounting to 71 days or 1,696 hours of operation during the year. A total of 14 pulsing runs were carried out, including one for validating the in-house developed Beam Phase-locking electronics. The complex Travelling Wave Deflector (TWD) system was successfully operated in ten of these runs, demonstrating very good performance in terms of their reliability. One notable achievement this year was the successful development and testing of Beam Phase-locking electronics with the Pelletron beam. All group members were actively involved in the Beam

Table 3.2: Pulsed beam delivered on target during 2024-25.

Beam species	Energy (MeV)	TWD	Facility	No. of shifts
^{28}Si, 8^+	100	OFF	Facility test	2
^{16}O, 6^+	76.5	4 μs	HIRA	10
^{28}Si, 7^+	80	2 μs	HIRA	1
^{16}O, 6^+	79 - 85	4 μs	HIRA	10
^{16}O, 5^+	65 - 100	4 μs	HIRA	18
^{14}N, 6^+	65 - 80	OFF	NAND	21
^{28}Si, 9^+,12^+	120 - 145	OFF	NAND	12
^{11}B, 5^+	45 - 66	OFF	NAND	12
^{30}Si, 9^+	94 - 120	2 μs	HIRA	20
^{28}Si, 9^+	106 - 125	2 μs	HIRA	28
^{30}Si, 9^+	112 – 125.5	2 μs	HIRA	10
^{16}O, 6^+	65 - 80	4 μs	HIRA	23
^{28}Si, 6^+	55 - 85	2 μs	HIRA	30
^{35}Cl, 8^+	100 - 133	2 μs	HIRA	15

Pulsing System operations around the clock, in addition to handling their other group responsibilities, such as maintenance and development of various electronics systems.

3.1.6.2 Support to RF systems of Pelletron, SC-linac, HCI and DLS

Throughout the year, all RF power amplifiers and microwave sources are operated continuously, as per experimental requirements. Pre-scheduled preventive maintenance activities on RF systems under the care of RF group include a regular cleaning of surrounding, cleaning of systems, replacement of dust filters, monitoring and replenishing cooling water quality for equipment installed in HCI and FEL. Apart from this, daily logging of utility and equipment parameters for performance tracking is also documented. Proactively, RF group has undertaken and implemented fault detection systems, calibration procedures for calibrating the systems under care in order to reduce the system down time. Additionally, procurement of spare components, sub-units, control cards, spare power supplies, and various consumables are completed to maintain an adequate stock for ensuring uninterrupted operations.

3.1.6.3 Preventive and breakdown maintenance of Pelletron beam pulsing system

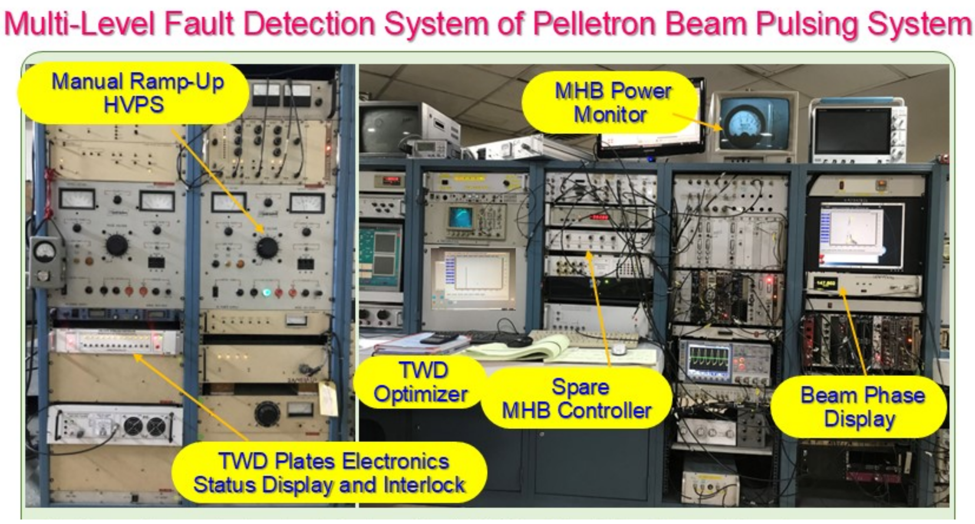

Figure 3.12: Pelletron BPS electronics implementation of multi-level fault detection system.

The Beam Pulsing System (BPS) of the IUAC Pelletron is a vital subsystem for delivering high-quality pulsed beams for various user experiments. In 2024, although Yearly Planned Maintenance (YPM) was originally planned for February as per the Technical Calendar, it was deferred due to ongoing linac runs. Consequently, the preventive maintenance was carried out in June 2024, aligned with the scheduled Pelletron maintenance, to take advantage of greater system accessibility during that period. As part of the preventive maintenance, standard servicing activities were carried out. Additionally, tuning of the MHB (Multi-Harmonic Buncher) tank circuit coils was performed. The entire team actively participated, ensuring confidence in both running and maintaining the system. There was only one instance of breakdown maintenance involving the TWD (Travelling Wave Deflector) electronics, which was swiftly resolved in situ without any loss of user beam time. Another round of YPM was successfully completed in February 2025, once again aligned with Pelletron maintenance activities for better coordination and efficiency.

3.1.6.4 SC-linear accelerator facility

Preventive maintenance for the LLRF electronics (with the linac Group): A total of around 10 Resonator Controller modules are thoroughly cleaned, recalibrated, serviced, repaired, and tested in a room-temperature test setup irrespective of their current status. Repair logs have been updated properly in the logbook as per the standard repair format.

3.1.6.5 High current injector

1. TWT amplifier for ECR ion source of HCI: During this year, the originally installed Klystron based 1.7 kW, 17.9 GHz microwave power generator of ECR ion source failed abruptly due to aging. In order to substitute the power source as a stand-by, we have installed a spare travelling wave tube (TWT) based microwave amplifier capable of delivering upto 250W, (CW 8 - 18 GHz) in ECR ion source of HCI in order to develop various particle beams.
2. 120kW, 48.5 MHz RFQ power amplifier: In order to ensure a consistent performance of this power amplifier, we have implemented the following modifications:
   (a) Installed a high power air blower for tube socket for better heat transfer.
   (b) Reduced the filament transformer tappings for reduced filament voltage as recommended.
   (c) Replaced the corroded QDC cooling water fittings of vacuum tube.
3. Other solid state high power amplifiers: Both indigenously manufactured and commercial high power solid state power amplifiers are routinely maintained for breakdown of power supplies, high power LDMOSFETs and repaired them and restored immediately to prevent any catastrophic failure of power amplifiers. Frequently these power amplifiers are cleaned for dust accumulated on the dust filters and internal sub systems as preventive measures.

3.1.6.6 Free electron laser facility

Multiple breakdown maintenance of the high-power Klystron modulator were performed during this year.

1. The 700 W pulsed, solid-state RF driver amplifier had failed due to failure of the main power module. It was replaced with a new power module sourced from the OEM of the amplifier, and suitable wiring modifications were carried out to operate the power amplifier.
2. The system was tripped due to the clogging of the oil filter preventing the oil flow through the pulsed transformer and system from going into STANDBY mode. The oil filter was subsequently changed following the manufacturer's guidelines and the system could be restarted.
3. The control card of the IGBT Switching Unit #1 had failed due to fault in the DC-DC converter module which prevented starting up of the switching unit. The card was changed from the spare unit and repaired.
4. A laser-to-RF Up-conversion module is used to generate a 2860 MHz low power RF signal for the Klystron Modulator based amplifier. This RF signal is generated as the sub-harmonic of 130 MHz photo-diode signal corresponding to the femtosecond laser output. The module consists of several packaged RF components like amplifiers, attenuators, splitters, directional couplers, and filters etc. An inter-digitated narrowband (50 MHz bandwidth) band pass filter with a center frequency of 2860 MHz has been especially designed for the output stage to reduce mixing effect of nearby frequency components. Amplitude and phase control is achieved through a voltage controlled attenuator and a voltage controlled phase shifter operational in the S-band of microwave regime.
5. Microcontroller controlled PLL multiplier-based synchronization electronics between laser-master and the TTL trigger generator with low jitter. The system is used to generate a 10 MHz input clock for

trigger generator in synchronization with the 130 MHz laser signal. It is currently operational while beam tuning in the FEL facility.

3.1.6.7 Developments for various RF systems

The development of electronics is a continuous process depends upon the requirements and in the process of up-gradation of the existing systems. Multiple system developments have been successfully carried out this year and they are briefly mentioned here.

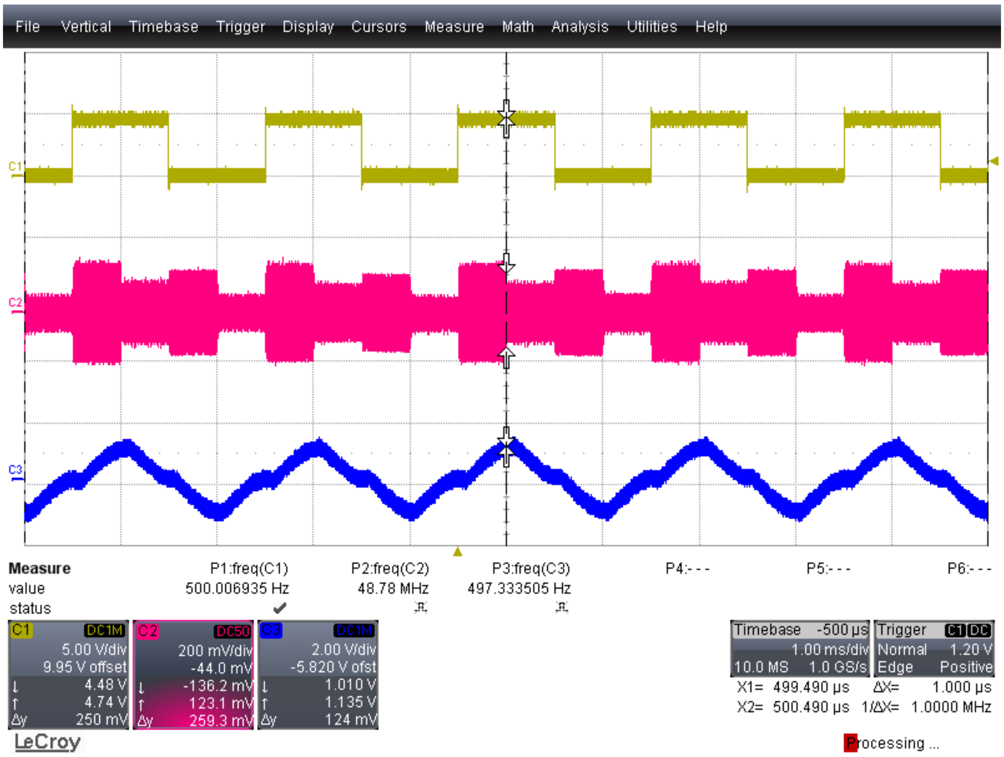

Figure 3.13: Pelletron beam phase-locking electronics testing and parameters validation.

1. **Pelletron beam phase-locking electronics testing and parameters validation**
   To enhance or replace the existing beam phase-locking electronics, a new set of electronics was developed and tested in the lab during the previous year. In April 2024, a dedicated facility test run was conducted to validate its performance with the Pelletron beam. The test was carried out using a $^{28}Si^{8+}$ beam at 100 MeV, with a beam current of 1 nA at FC_04. The validation process was consisting of the initial bench marking with the existing electronics, testing of new electronics, and dynamic range assessment. Beam bunching was first performed using the existing system. The measured Full Width at Half Maximum (FWHM) of bunch width 1.78 ns. The beam was then bunched using the newly developed electronics. An improved FWHM of bunch width 1.66 ns, was achieved indicating better temporal compression. The dynamic phase-locking range of the new system was successfully tested from 0.2 nA to over 30 nA. The upper limit of current was constrained only by the foil stripper used in the Pelletron accelerator, and not by the electronics.
2. **Chopper and deflecting system electronics of HCI**
   After successful testing of the electronics for two sets of deflecting plates of the HCI Chopper and Deflecting System (HCI-CAD), the electronics for the remaining two sets of deflecting plates have been procured this year, assembled, and successfully tested as per the required specifications. The electronics include fast square wave pulsers, a dielectric cooling system, high voltage and control voltage power supplies, and a pulse generator with four simultaneous outputs and the ability to adjust the delay between them. For initial testing, 10 pF ceramic capacitors were used in place of the deflecting plates and powered up to 1000 V at 2 MHz. Upon confirming that the high-voltage pulse rise / fall times were under 10 ns, as required, the deflecting plates were connected and powered under the same conditions.

The rise / fall times remained below 10 ns. A 48-hour continuous test was carried out successfully. At present, the design and development of the mechanical support structure are underway. Vacuum feedthroughs to interconnect the high-voltage pulses to the deflecting plates have been procured and are ready for installation with the HCI-CAD system. The system will be installed and tested with the HCI beamline in the near future.

Figure 3.14: HCI-CAD system electronics testing (left) and HCI-CAD system present status (right).

3. **Development of prototype of universal digital feedback RF controller**
   A Xilinx Zynq SoC-FPGA based digital feedback RF control has been designed in a hybrid mode with a wide band Analog Front-End (Up / Down conversion and signal conditioning) and a digital board implementing single and multiple frequency closed loop feedback control and signal processing algorithms in digital domain. A same set of hardware is used for a saw-tooth generator and an LLRF controller (both GDR and SEL) including a motorized frequency tuner controller. Remote control over LAN, and an EPICS-based control scheme has also been implemented and tested. Features of the module include loop ON / OFF switch with feed forward control, frequency re-configurable operation without need for FPGA reprogramming with a 47-bit programmable DDS and a synchronized operation with external reference signal. The system has been tested with lab-based test bench setup with a best steady state control response of 0.009 dB in amplitude and $\pm$ 0.15° in phase. It is currently under test with cyclotron and MHB of Pelletron.
4. **Development of RF system for table-top cyclotron**
   The RF group has undertaken the project for development of entire RF system for the table top cyclotron under development. The development includes a broadband solid state RF power amplifier up to 2 kW CW, Impedance matching network (IMN) and GDR based Digital LLRF Controller. The aim of the RF system is to generate and maintain high RF voltage across Dee-Dummy Dee to accelerate the particles from the ion source of Cyclotron. Frequency is fine tunes with vacuum variable capacitor. A capacitive pick-up built-in the Cyclotron chamber is used as feedback in order to control and maintain the RF voltage and frequency of the system using a digital LLRF controller and a motorized tuner. Pick-Up calibration has been performed using the Shunt impedance method, HV-HF Probe measurement. X-Ray Measurement via Bremsstrahlung radiation (done for HVDC) is currently in progress. Further testing of closed loop electronics, cooling system implementation, high power amplifier and modifications in the matching network are being currently being done.
5. **Development of solid state broadband RF power amplifiers**
   Multiple broadband solid state power amplifiers using LDMOS transistors have been developed for Beam Chopper of Beam Pulsing Ststem (BPS) of Pelletron, Multi-Harmonic Buncher (MHB) of Pelletron and HCI and Spiral Bunchers of the HCI. These amplifiers which are capable of delivering from 50 W to 3 kW (CW) in the frequency range of 10 MHz - 100 MHz as shown in the Table 3.3. At present, the chopper amplifier and MHB power amplifiers have been successfully characterised with

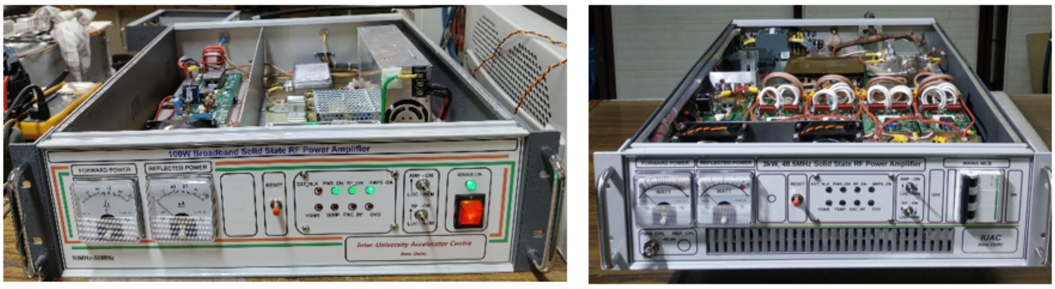

Figure 3.15: 100 W (10 MHz - 50 MHz) broadband solid state RF power amplifier for MHB (left) and 3kW solid state RF power amplifier for SB (HCI).

Table 3.3: Solid state RF amplifiers developed for various facilities.

Amplifier specifications	**Chopper amplifier**	**MHB amplifier**	**Spiral buncher**	**SC linac**
Operating frequency	4 MHz	10 MHz – 50 MHz	48.5 MHz	97 MHz
Power [CW]	50 Watts	100 Watts	3 kilo Watts	400 Watts
Form factor	19”×3U×31.5”			
Heat sinking	Copper heat spreader on aluminium block, water 22 °C, 5 LPM			
Protection	External, over temperature, Over RF drive, VSWR			
Biasing & harmonics	Class A, -40dBc	Class A, -40dBc	Class AB, -36dBc	Class AB, -36dBc
Combiner techniques	None	None	4 way-Wilkinson	None
Remote interface	Analog, contacts	Analog, Contacts	Analog, Contacts	RS-232

dummy load and these amplifiers will be integrated into the system very soon. The spiral buncher amplifiers have been already integrated with HCI. Two prototype VHF power amplifiers having specifications as in the Table 3.3 are being built for SC-linac applications. On successful trial, they will be mass produced in a phased manner in order to replace the aged power amplifiers.

6. **Development of 6 kW dual directional coupler** High power Dual Directional Coupler (DDC) is a valuable addition to power amplifier for truthfully reproducing the RF power levels in both forward and reverse directions. A DDC capable of handling >6 kW (12 MHz - 250 MHz) has been successfully developed with the help of workshop group and characterized for the following parameters as in the Table 3.4.

Table 3.4: Specifications of high power dual directional coupler.

Power rating CW	> 6 kW
Bandwidth	12 MHz – 250 MHz
Forward coupling	-60 to -68 dB (adjustable)
Isolation	-30 dB
Directivity	~ 25 dB
Insertion loss	~ 0.1 dB
Return loss	-35 dB
Main & ancillary connectors	7/16” – Female, SMA-Female

3.1.7 Health physics

Debashish Sen, Sejal Chandna and Birendra Singh

To ensure the radiation safety of the IUAC radiation workers and maintain AERB prescribed rules and regulations are the preliminary duties of the Health Physics group of this centre. All safety rules and regulations envisaged by AERB are followed in the beam lines. All beam lines are properly shielded, interlocked with the beam as and when required, locally and remotely area monitored, surveyed whenever required. Entry to any beam line with beam ON is strictly prohibited. Bypasses are permitted with HP permission only. Health physics has all sort of radiation survey data based on data collected in/experience of previous years, and accordingly safety instructions are properly displayed in the control room for a particular beam species and parameter.

Log books for issuing personal dosimeters and radiation sources are regularly maintained. All safety measures ought to be followed by beam time users and radiation source users are displayed in the log book, and shown to potential users and explained to them by health physicists on a regular basis. Lead shield cases, forceps are available for safe handling of radiation sources. Hot labs are properly maintained. Also, safety related orientation programmes are carried out every year for the new employees and students by the RSO.

The personnel monitoring system and the area monitoring set up are taken care of by this group. To keep a vigil on the overall radiation safety, routine maintenance of interlock system and radiation monitors is also carried out regularly. Creating awareness related to radiation safety among the radiation and non-radiation workers (by holding different orientation programmes) is another duty of the radiation safety officers. Apart from these, user support is provided to different radiation safety related research and development work conducted by different universities and institutes.

- **Personnel monitoring:** The TLD/neutron badge service went smoothly in 2024. The detailed dose reports of these quarters have been received in time. All the dose reports received in this period are within the permissible limit.
- **Area monitoring:** Monitors, which were due for calibration, were calibrated as per AERB norms. New monitors for upcoming facilities are in the process of procurement. As usual, stock checking of all the radiation sources was carried out, and it was ensured that all of these were stored in safe custody. No Radiation sources were procured in the last six months.
- **Interlock systems, interlock doors, display boards**, which were malfunctioning, were repaired, and some of them were repositioned also, as per requirement.
- **Radiation sources** (with adequate shielding) are kept under strict vigil. Stock checking of all the radiation sources has been carried out, and it was ensured that all of those were stored in safe custody. All radiation dose records (both gamma and neutron) of IUAC radiation workers are maintained regularly. As every year, few radiation monitors were replaced, and some new were installed in new strategic locations (as new facilities are coming up in the centre). Gamma / X-ray monitors / survey meters / pocket dosimeters get calibrated each year as per their calibration schedule. Some temporary radiation shielding was provided in different areas as per user requirement.
- **In a nutshell**, all the following jobs were carried out successfully throughout the year.
  - Upkeep / maintenance / repair and operation of all the systems /instruments / devices related to radiation safety irrespective of the facility / accelerator / upcoming facilities.
    - Radiation monitoring devices /badges / interlocks / shields /doors
    - Radiation survey and certification
    - Up keep of the installation areas
    - Maintaining log books for all sort of activities
    - Maintaining the inventory of the in-operation / stocked instruments/devices/modules.
    - Maintaining minimum required stock and inventory of the spares to ensure quick repairs.
    - Maintaining the updated operational and service manuals for each type of instruments.
  - Scheduled yearly preventive maintenance and calibration of every instrument/system.
  - Ensure best performance and breakdown free operation.
  - System up gradations as and when required in view of required performance.
  - Documentation of the carried out primary responsibilities, yearly activities, observance of maintenance schedules, functioning of laboratory, preparedness for emergency.
  - Daily activity briefing to define and monitor the daily activities. Maintaining the "Daily activity log book" for reporting to Programme leader during weekly meeting.

3.1.7.1 AERB inspection and monitoring

Regulatory Inspection is one of the types of inspections conducted by AERB through which it ensures that the nuclear and radiation facilities are following the legal and regulatory requirements and licensing conditions. A self-assessment checklist is created which helps the employer / licensee to verify that all the safety and regulatory requirements related to the licensed activities / practices are being met, and can be used as an audit tool. The self-assessment checklist has to be filled by the employer / licensee of the facility in consultation with the Radiological Safety Officer (RSO) while verifying the compliance through facility walk-downs, employee interactions, and / or document / record reviews. Such AERB inspections have been carried out successfully in the recent past.

IUAC is maintaining the highest safety rating of eSPI=1.0 (in a scale of 0.1 to 1.0) with respect to radiation safety related compliance matters from AERB. Electronic Safety Performance Indicator (eSPI) value refers to safety compliance of the institute derived using following parameters reported in eLORA for the last three years, *i.e.*, (a) Non-submission of Safety Status Report (SSR) for more than a year, (b) Excessive exposure cases reported, (c) Non-compliance (Grey, Orange and Red) raised and (d) Enforcement action taken. The maximum value eSPI is 1, which refers to no deviation, on the above parameters, is reported through eLORA for the last five years. Any reported deviation will lead to a reduction in eSPI value of the institute. IUAC maintains a 1.0 rating in all the categories

3.1.7.2 e-LORA facility of AERB

Correspondence with AERB through eLORA (e-Licensing of Radiation Applications, a web-based application by the Atomic Energy Regulatory Board (AERB) for automating regulatory processes related to radiation facilities in India. An e-Governance initiative by AERB, 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.

eLORA is a web-based I&CT (Information and Communication Technology) application establishing direct communication channel between AERB and its stakeholders for exchange of information and communication transaction for delivering its regulatory services as well as for achieving higher efficiency, reliability and transparency in dealings. The eLORA system is designed to automate the comprehensive business processes of radiological application regulations targeted to large number of facilities involved in use of ionising radiation as well as radiation workers working with them for safe service.

Purpose: eLORA aims to enhance efficiency and transparency in AERB's regulatory processes by automating the licensing of radiation facilities.

Functionality: It facilitates online submission of applications for various regulatory consents, including licenses for medical diagnostic x-ray equipment and other radiation facilities.

AERB initiative: eLORA is an e-governance initiative by the Atomic Energy Regulatory Board (AERB), which is responsible for ensuring the safe use of ionizing radiation and nuclear energy in India. Key Features:

- Paperless licensing of radiation facilities.
- Online submission of applications for regulatory consents.
- Detailed guidelines for stakeholders available on the eLORA homepage.

Online AERB communication jobs through eLORA in 2024-25:
In 2024

- Extension of licence received for Pelletron-linac and RBS facility.
- Design construction approval for HCI received in July.
- Renewal of RSO license.
- Re-registration for operation of X-RAY DIFFRACTOMETER.
- Re-registration for operation of X-RAY FLUORESCENCE DEVICE.
- Updating the regular status reports of accelerator facilities of IUAC and GIC.

In 2025

- Re-extension of licence received for Pelletron-linac facility.
- Re-registration for operation of second X-RAY DIFFRACTOMETER.
- Updating the regular status reports of accelerator facilities of IUAC and GIC.

3.1.7.3 Upcoming facility requirements

1. **Free Electron Laser (FEL) Facility** Thorough radiation surveys are being conducted in HCI and FEL areas, with high voltage conditioning ON in the FEL area. The purpose of the survey is to gather information about the increased radiation levels in the area and to decide about the limitation in access and duration of the working hours in these areas as per the regulatory limits and guidelines.
   In the previous year, extra lead shielding around the FEL electron gun was put to make above HCI area more access friendly. The survey results showed that the radiation levels in the HCI area were within the regulatory limits and guidelines set by AERB when the RF power does not exceed 3.0 MW.
   It was found from radiation survey that, while the FEL machine is powered to 3.0 MW (3.0 microsec

pulse width), radiation level of <0.1 mRem / hour is observed in the HCI beam hall, which is safe and permissible (max 0.1 mRem / hour) for all including non radiation workers. Hence, under these conditions, entry of both radiation and non radiation workers is allowed in HCI beam hall. However, radiation workers should use radiation badges, and non radiation workers pocket dosimeters.
Both the NLK doors are now operative. Above the cavity, this year, extra lead shield extension has been provided; total thickness is now 10 mm, total length 1 m, so as to further reduce the radiation level when higher power is used. Plans are there to shield it from side also to reduce the scattering.

2. Shielding adjustments as per installation of HCI line in the corridor and Beam Hall 1 are getting implemented (along with interlock doors) as per requirements, and also the proposed scram buttons.

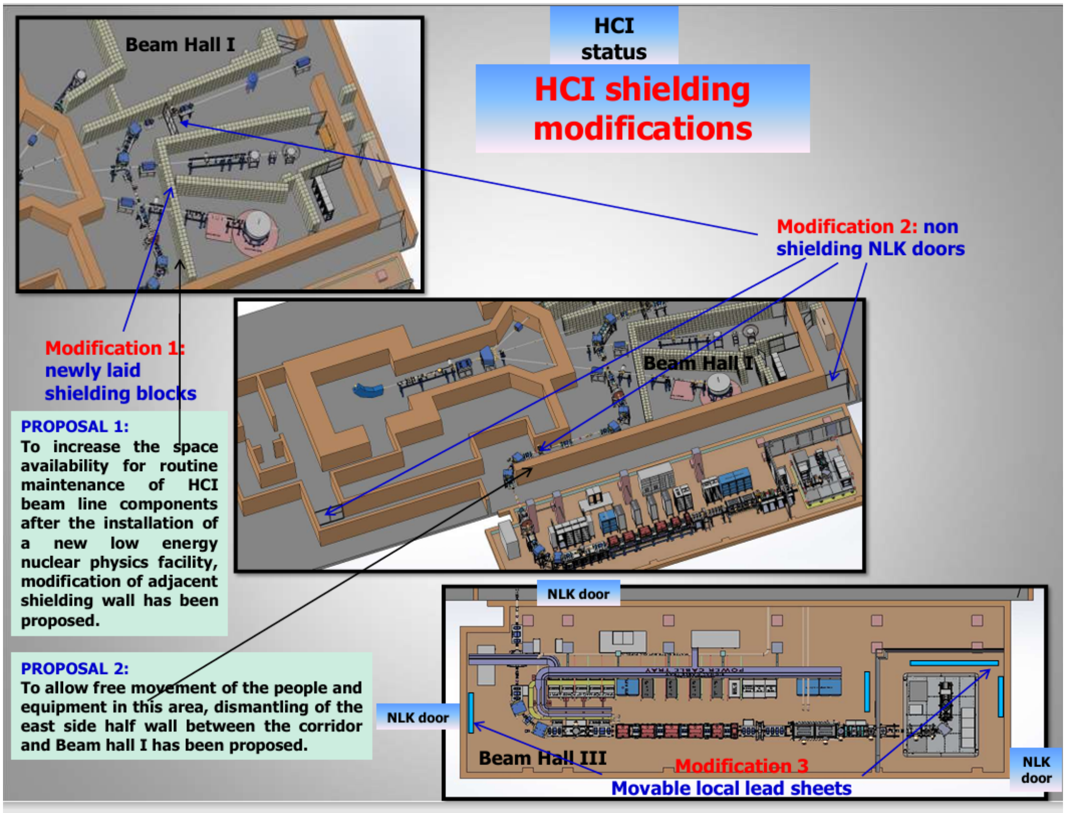

Figure 3.16: Shielding adjustments as per installation of HCI line.

3.1.7.4 Search and scram button safety system

The Search & Scram button safety logic is getting implemented as per AERB directives. Beamlines enclosures will be provided with search and scram switches which will be interlocked with the operation of the beamlines in BH-1 and BH-2. The same will be provided in BH-3 also.

3.1.7.5 Status of AERB licence of running radiation facilities at IUAC

Required radiation monitors have been re-calibrated in 2024. Renewal of RSO licences have been done till 2027. Electronic Safety Performance Indicator (eSPI) values are all perfect (at max value 1.0).

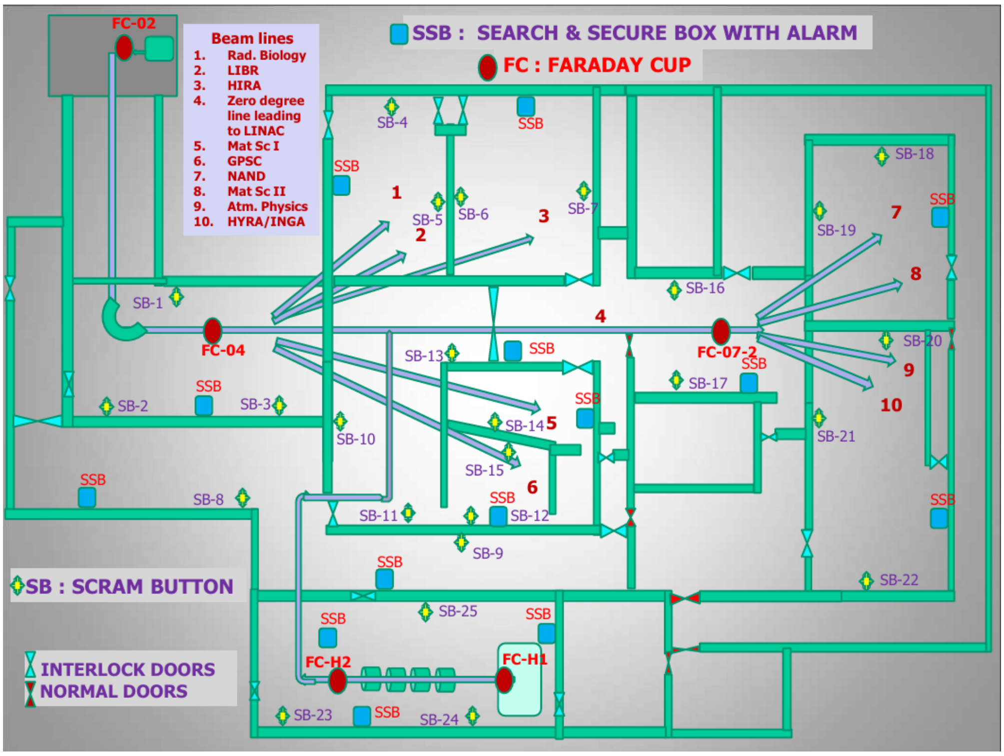

Figure 3.17: Search and Scram buttons

Table 3.5: Status of facilities.

Facility	Status	License valid till
Gamma Irradiation Chamber	Running	02/11/2026
Pelletron - linac facility	Running	24/02/2026
RBS Facility	Running	31/03/2027
NII Facility	Running	03/12/2025
LEIB Facility	Running	16/09/2026
AMS Facility	Running	30/09/2027
HCI Facility	Design construction approval received in July 24	Valid for 2 years
FEL Facility	Under process	NA
Table Top Cyclotron	Initiated	NA
Geochronology facility at NOIDA	Initiated	NA
Possessing /handling Radioactive sources	All properly stored/ shielded	Registration till 07.11.26
Empyrean XRD	Functional	Registration till 07.02.29
Axios max 4.0kW XRF	Functional	Registration till 07.02.29
D8 ADVANCE XRF	Functional	Registration till 01.01.30

3.1.8 Data support laboratory

Mamta Jain, Subramaniam E. T. and R. P. Singh

The group is responsible for maintaining Data Acquisition Systems (DAQ) round-the-clock with 100% uptime across all Nuclear and Atomic Physics experimental facilities. In addition to maintenance, the group actively develops custom hardware modules and software solutions for both DAQ and control applications, addressing the specific requirements of various experimental setups in beam hall 1, 2 and LEIBF at IUAC. Providing comprehensive user support for these facilities remains one of the group's core responsibilities.

3.1.8.1 Operation and user support

The group ensures seamless 24×7 operation and support of ROSE-MARS based Data Acquisition (DAQ) systems across all nuclear and atomic physics experimental facilities. The group also undertakes timely upgrades, preventive maintenance, and infrastructure enhancements to guarantee zero downtime during experiments.

1. **DAQ system updates and maintenance**
   All ROSE-MARS-based DAQ systems across various experimental facilities were upgraded to the latest Ubuntu 24.04 operating system, along with the latest release of the NiasMARS software. These systems operated with zero downtime during the experiments, ensuring smooth data collection and reliability. Facilities covered under this upgrade and maintenance include:
   - NAND, GDA, INGA, GPSC
   - HYRA, HIRA, Atomic Physics
   - LEIBF, 111 Lab

   To maintain uninterrupted operations, preventive maintenance was carried out as and when required throughout the academic year. This includes:
   - Upgradation / installation of operating systems.
   - Regular updates of DAQ software such as ROOT and NiasMARS.
   - Continuous monitoring of system health across different DAQ facilities and the central Data Room.
   - 5 Mesytec MADC were tested after repair from vendor.
2. **Data room and beam hall systems**
   All supporting systems located in the Data Room and Beam Halls I and II were effectively maintained, achieving 100% uptime during experiments. Key infrastructure and upgrades include:
   - DAQ server for remote booting of VME crate controller (ROSE).
   - Network router for the dedicated DAQ network in Beam Halls I, II and III.
   - NiasWebViewer for online remote monitoring.
   - Two new client PCs for online data acquisition and offline analysis has been put in data room.
   - Regular upkeep of monitors / TVs and DVR systems for monitoring.
   - Overhaul of Data Room racks and network infrastructure, completed without disrupting the ongoing experimental operations.

3.1.8.2 Development

- A new NiasBPM software has been developed for integrated view of multiple BPMs.
- The ROSE-MARS based DAQ system has been tested for higher data rates using a random pulser in the lab for upcoming HCI facility.

3.1.9 Scientific computing, communication and artificial intelligence group

B. K. Sahu, Joby Antony, Abhishek Kumar, Anand Prakash, Yatesh Dabas and Shweta Agarwal

Like previous years, this academic year the group had put up maximum efforts to keep the 100 percent uptime of the network connectivity and servers throughout the year. Preventive maintenance of various network equipment is carried out to avoid breakdown of network services. Continuous upgradation of desktop computers and licensed software are carried out throughout the year. This year paperless Human Resource management system has been implemented with fully functional leave management module. New web servers are added with additional security measure to prevent hacking of the website. Server and portal for online recruitment module is extensively used for recruitment of technical and administrative staff. During this academic year the group successfully completed the establishment of 3PF supercomputing facility at IUAC under NSM with the help of CDAC team. The same was dedicated to the nation by the Prime Minister on September 26, 2024. The facility is being used extensively by users from various institutes as well by industry.

3.1.9.1 Status of servers

This academic year, there were no hardware failures on any of the central servers. However, one hacking incident of the IUAC website server was reported. The server was reinstalled from scratch after recovering the data from the infected server. Effective steps were taken to avoid any incident in the future. The enterprise resource planning server (ERP), internal web server, and database server were found to be performing satisfactorily. Website server replication was conducted to test Azure Disaster Recovery, and several tasks were carried out for Tyrone storage management. A new Alma Linux server was deployed to support KVM requirements, along with auto-backup scripts for the existing setup.

3.1.9.2 Software support

Like previous years, this year also the group has been involved in the installation of licensed software and also upgradation of earlier packaged software like CST Microwave Studio, SolidWorks, MS Office, Windows, Quick Heal, etc. In this academic year the group has obtained licenses for the Vienna Ab-Initio Package (VASP) for carrying out Density Functional Theory calculations for corroborating the experiments done at IUAC with the theoretical predictions. The software is likely to help the researchers of IUAC in developing theoretical models for the prediction of ion beam effects in material science research. The group also has also procured COMSOL Multiphysics perpetual license software for performing finite element method-based electromagnetic field and heat transfer studies.

3.1.9.3 Status of network and internet services

The SOPHOS firewall system hardware installed at IUAC was upgraded from the XG310 to the XGS2300 series with minimal downtime. The firewalls were installed in a high-availability configuration for attaining hardware redundancy. All the installed network switches have been equipped with Access Control List (ACL) for better network security and monitoring purpose. The control network for Free Electron Laser facility has also been upgraded to include a 48-port managed switch with optical fiber backbone to handle high throughput of data for operation of network-based beam viewers.

3.1.9.4 Communication systems

1. **EPABX and IP Telephony:** The hybrid EPABX system performed without any major failure in this year. The group a managed the extension and renewal of the telephone AMC tender and ensured EPABX system maintenance through support from the OEM.
2. **Audio, video system, and CCTV-related:** In this academic year, the audio-video systems were upgraded with new video conferencing setups in the committee room and council room. All the installed Audio video systems in Auditorium, Seminar hall etc. are being used as per the need and kept functional. No major breakdown of the Audio Video system was reported except a few service related issues with microphones. Few of the microphones were replaced this year to improve the quality. The group has also ensured smooth operations of the audio-video equipment during seminars, conferences, workshops, etc. held in hybrid/online mode This year additional CCTV surveillance is provided as per the request. Presently CCTV surveillance systems having $\sim$150 Cameras are routinely maintained and faulty devices are replaced.

3.1.9.5 AI / ML related activities

This academic year documents are prepared for technology transfer of IUAC developed AI products and the technology transfer have been completed to a Pvt. Industry for production of these products. This will also be used for AI/ML training purpose. and IUAC in 2024. Four students of B.Sc Summer program worked on AI/ML rated projects under the supervision of group members.

3.1.9.6 Developmental activities

1. **Redmine project management system:** Open source based Redmine project management server was installed for management of academic projects along with the tracking of progress. Customization of the front end Redmine web server has been done based on the IUAC requirements. Beta testing of the same is being carried for implementation in future.
2. **Development of IRDC support application:** A web portal has been designed and developed for the registration of eligible academic staff of IUAC to be recognised as PhD supervisors as a part of the display of academic profile of researchers with available research opportunity for students on the basis the request of the research degree committee (IRDC). The application of the students interested to attend IUAC Ph.D, Course work program can also use a dedicated portal on IRDC to apply for the same.
3. **Improvements in IUAC recruitment portal:** Last academic year a portal for the online submission of applications and fee collection from the potential candidates for advertised vacant positions was designed, developed on the CodeIgniter framework and hosted on the IUAC server. This year an improved version of the recruitment portal was designed, developed, to facilitate the different requirements for academic and non-academic recruitment's online application process.
4. **Improvements in EPICS control scheme for FEL:** As reported earlier EPICS based control scheme is already implemented for the Free Electron Laser facility of IUAC. Features like data logging, auto start-up of the EPICS server, and GUI enhancements, along with other relevant tasks, were added to the EPICS server. A device driver for EPICS on SoC-FPGA is also developed along with a code-free GUI for this device driver. The approach followed can be implemented for control along with an efficient, compact, and reconfigurable design with minimal developmental effort while scaling up the design.
5. **HRMS and ERP-related developments:** Last academic year HRMS (Human Resource Management System) was implemented with operational leave module. In this academic year, the HRMS system's leave module was modified to include 'miscellaneous' leave types (paternity, maternity, study leave, etc.) for seamless flow of leave applications. LTC (Leave Travel Concession) leave encashment flow as per the leave rules are implemented. Note management module has been developed for e-file movement. Efforts are made to enhance the note management module for smoother e-file movement following the existing protocol of IUAC administration. SMS messages for instant notification to the users were integrated with the HRMS. In the ERP system, LaTeXwas used to generate well-structured PDFs, improving document presentation.

3.1.9.7 Installation of 3 petaflop supercomputing facility

Setting up of a 3 PF Super computing system under National Supercomputing mission was undertaken by IUAC with technical support of CDAC team. The installation along with the supporting infrastructure was completed at IUAC and the facility was dedicated to the nation by the Prime Minister (Fig. 3.18) on September 26, 2024 remotely. The supercomputing system having 70% CPU and 30% GPUs is based on Make in India PARAM Rudra servers. There are 650 compute nodes in total with the Dual Socket Intel Xeon 2nd Gen scalable processor having 24 cores each, 4 Peta Bytes of Storage units installed along with 200Gbps interconnect HPC software stack consisting of compilers, provisioning tools, etc. have been implemented based on Open Source Technologies. The open source-based user application software in various required domains such as Material Science, atomic and molecular physics, nuclear physics, fluid dynamics, artificial intelligence / Machine learning is being installed. The facility is being made available to all the universities and institutes in the country for running their HPC based applications.

3.1.10 Cryogenics instrumentation cum machine learning laboratory

Rajesh Nirdoshi and Joby Antony

The primary activity of the cryogenic instrumentation and machine learning group was to operate and maintain the cryogenic control and data acquisition system of the linac. The members are also involved in maintaining the electronics of the EBW machine, development & testing of IMRI Real-Time Data Acquisition system and R & D in IoT & AI/ML-based technologies for different applications.

Figure 3.18: Inaugration of 3 peta flop computing facility.

3.1.10.1 Cryogenics control system and associated electronics

Throughout this year, the IUAC cryogenics control system and its associated electronics have undergone preventive maintenance and have functioned reliably. The system has consistently supported the linac run, which concluded in April 2024, along with some MRI test runs. As shown in Fig. **??**, the cryogenics control room is equipped with three primary control terminals that facilitate remote control, data acquisition, trends monitoring, operator interface, and various other critical functions.

3.1.10.2 LINDE control terminal

The Linde control terminal originally supplied by M/s Linde Kryotechnik, Switzerland in the year 2010, runs on Siemens software and serves as a vital standalone controller for the Liquid Helium Plant. In this academic year, the main control server (RMCS) encountered a motherboard failure, which was successfully repaired in-house and has since been operating reliably. However, the redundant PC located near the main plant has become completely non-functional. Plans are in place to upgrade both systems with modern PCs equipped with updated operating systems and compatible Siemens software.

3.1.10.3 Developmental activities

1. **Modified MRI data acquisition software and its commissioning** To overcome certain technical challenges, the MRI cryostat was refabricated and was integrated with additional critical components such as multiple temperature sensors and a high-sensitivity vacuum gauge. In tandem with this hardware upgrade, the MRI data acquisition (DAQ) software was comprehensively enhanced to seamlessly incorporate these new elements. Notably, the software update included the successful implementation of the transfer function for the vacuum gauge, ensuring accurate vacuum monitoring within the system. Following these upgrades, control and monitoring tests were carried out using the modified software setup, all of which were successfully commissioned. These advancements have significantly improved the system's diagnostic capabilities and operational reliability.
2. **IoT-based smart interface device and real-time data monitor for HCI**

   Joby Antony, Sugam Kumar and Rajesh Nirdoshi

   As part of an intra-lab initiative for the HCI group, an IoT-Based Smart Interface Device & Real-Time Data Monitor was designed to enhance the monitoring capabilities of critical system parameters of HCI. After a detailed evaluation of all key signals within the HCI setup, the flow rate from the

SMC flow switch was identified as a top priority for interfacing and continuous monitoring. To meet this requirement, multiple PCBs were designed, culminating in the development of a 30-channel smart interface device capable of accommodating up to 30 flow switches. Complementing the hardware, a real-time data monitoring utility was developed using PHP, allowing users to remotely monitor flow rate data from any location within the IUAC network, thereby significantly improving operational awareness and system responsiveness. The hardware unit and its corresponding PHP utility are shown in Fig. 3.19.

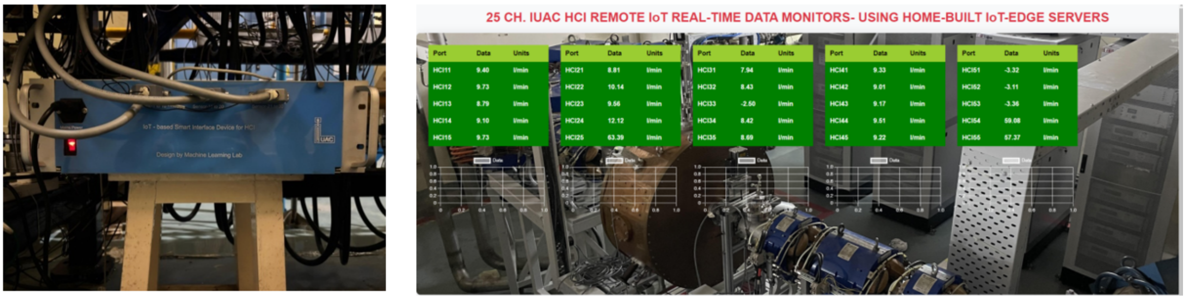

Figure 3.19: The hardware unit (left) and PHP-based utility for real-time data monitoring.

3.1.10.4 Electron beam welding machine related activities

Joby Antony, Rajesh Nirdoshi and Kishore Kumar Mistri

We have been maintaining EBW machine since its inception with almost 100% uptime. This year there was amajor spark occurred in the high-voltage cables of the EBW machine due to water leakage because of which the machine was shutting down. The issue was successfully resolved.

3.1.10.5 Technology transfer

The technology transfer of in-house developed AI products from IUAC was successfully completed to M/s Scientech Technologies Pvt. Ltd., Indore. The technology transfer fee has also been received by IUAC.

A patent filing process has been initiated for a system titled “A Real-time Data Acquisition System for Noise-free Capture of Superconducting Magnet Coil-Quenches and Associated MRI Cryostat Measurements”. This quench-trapper system wakes up only during a quench event in any of the eight magnet coils and efficiently records 24 magnet parameters with a timestamp resolution of 500 μs. It is specifically designed to operate with minimal storage requirements, enabling easy retrieval and post-event analysis.

3.1.11 Ion source group

Radhakishan Gurjar, Mukesh Kumar, Saif Ahmed Khan and Ambuj Tripathi

The Ion Source Group (ISG) is integral to the field of particle acceleration, focusing primarily on the operation and maintenance of Electron Cyclotron Resonance (ECR) Ion sources. The ISG’s managing the sophisticated electronics that control the high voltage platforms, ensuring the stability and efficiency of the High Voltage DC Power Supplies (HVPS), and overseeing the Light Link Interfaces and High-Temperature Superconducting (HTS) Coils. The work is not limited to maintenance; and also contributes significantly to the development and enhancement of these complex systems. The group also undertakes maintenance and test of the ECR ion source and GP (acceleration) tubes.

3.1.11.1 Operation activity

ISG instruments are constantly used with accelerators and their optimum performance is maintained with uninterruptible operation throughout the year. The operation of ISG instruments is taking place in LEIB, HCI, and NIB facilities at the moment. The acceleration tubes and ECR ion sources are functioning properly.

3.1.11.2 Scheduled maintenance activity

The ISG ensures that the instruments used with accelerators operate continuously, maintaining uninterrupted performance throughout the year. The group performs annual scheduled preventive maintenance of all instrument to extend their lifespan, optimize performance, and ensure reliable, breakdown-free operation throughout the year for long continuous use.

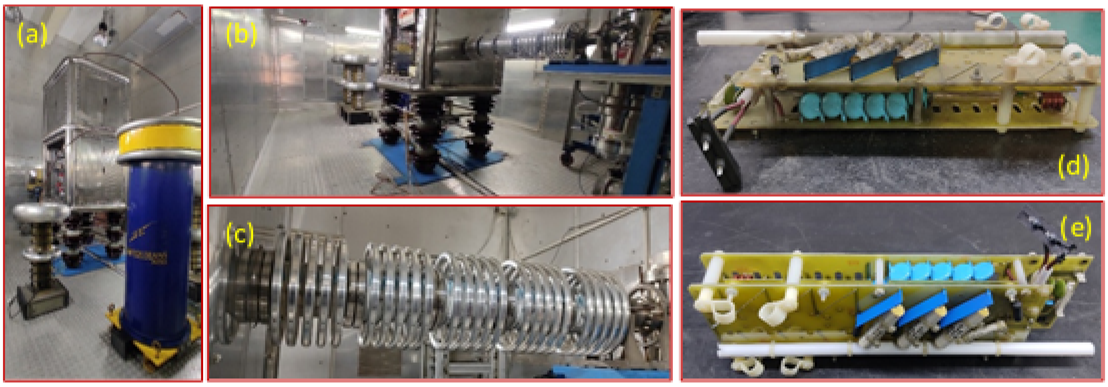

Figure 3.20: (a) Deck, Isolation Tx. and Deck HVPS. (b) Ion source room. (c) Acceleration tube. (d) Multiplier section before clean. (e) Multiplier section after cleaning.

1. **LEIBF ion source:** All Ion Source High Voltage Power Supplies (Deck, Extractor, Focus, and Bias HVPS) have been cleaned, and all loose connections have been checked for safety and stability. Both the inner and outer deck areas, including deck insulators, Isolation transformer, and GP (acceleration) tube rings, were thoroughly cleaned as well as ion source room was cleaned to remove any dust and debris. The multiplier sections were cleared of any loose dust or debris using dry compressed air. This is especially important for delicate electrical components, such as diodes, capacitors, and connectors. All types of wires, including fiber optic cables, fiber optic devices, bleeder resistors and high-voltage copper cables on the deck, were cleaned to eliminate accumulated dust and thoroughly checked. All high-voltage power supplies were tested both locally and remotely, with load. All high voltage DC power supplies performed as expected, confirming that all HVPS are in working order.
2. **HCI ion source:** Cleaning and maintenance of Second deck area, fiber optic devices, bleeder resistors and isolation transformer was taken up. Cleaning and inspection have been conducted on all Ion Source High Voltage DC Power Supplies (Deck, Extractor, Focus, and Bias HVDC PS). To ensure stable operation, the power supplies have been checked and secured for loose connections. Local and remote testing was conducted for all high-voltage power supplies, with and without load. All high-voltage DC power supplies are functioning properly.
   High temperature solenoid (HTS) magnet power supply: The power supplies were subjected to rigorous test in the laboratory under load conditions to simulate actual working environments. Once they passed these tests, the power supplies were reinstalled into their racks, with all connections securely reattached and tightened. Additionally, the wiring of the HTS magnet power supply rack was re-routed to optimize performance. The magnet interface unit, dump unit and heater power supply of HTS magnet power supply were thoroughly cleaned to remove any accumulated dust. All 16 electronic modules of magnet interface unit were carefully inspected and tested in conjunction with the HTS magnet to ensure they are functioning correctly.
3. **NIBF ion source:** The deck high voltage DC power supply (-300kV, 6mA) was cleaned and tested along with isolation transformer, high-voltage copper cables, fiber optics cables and ion source area. The deck high voltage DC power supply has been tested with load up to -200 kV remotely. The Deck HVDC power supply is now functioning properly.

3.1.11.3 Developmental activity

1. **Development of remote-control module for LEIBF deck HVPS (400 kV, 12 mA):** The development of a new remote-control module with new features for Deck HVDC power supply is necessary for maintaining smooth operations. The circuit design and PCB design of new remote-

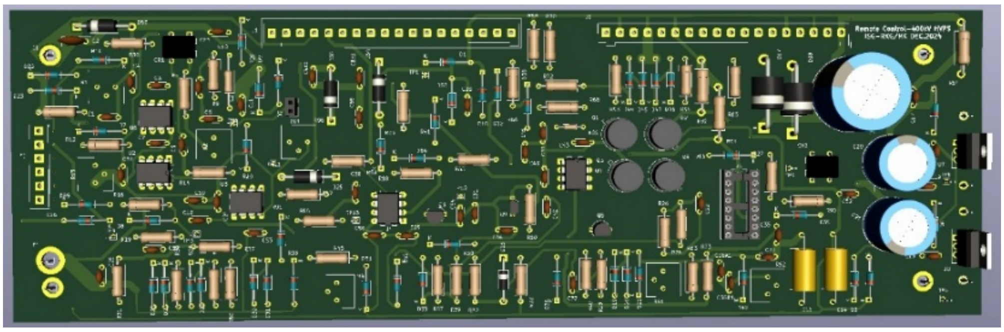

Figure 3.21: 3D rendered view using KiCAD software

control module have been completed using KiCAD software. The remote-control PCB is now in the process of being purchased. The remote-control PCB's components are being procured and processed is underway at the moment.

2. **Development of door interlock for HCI ion source HVPS and Klystron:** Integrating door interlocks with high voltage DC power supplies (HVPS) and the klystron generator is a critical safety measure for the HCI Ion Source operations. This ensures that all systems, including the deck, extractor, focus, and bias, are secured against unauthorized access while in operation. The development of such interlocks will prioritize safety, preventing the activation of HVPS and the klystron unless the deck door is properly closed, thereby safeguarding both the equipment and personnel. PCB procurement and assembly have been completed. The door interlock circuit is under testing mode.
3. **Development of 4-channels threshold detector module for HCI HTS magnet power supply:** A threshold detector module is being developed for HTS magnet power supplies. The circuit design is complete and the PCB design is currently under process using KiCAD software. The threshold

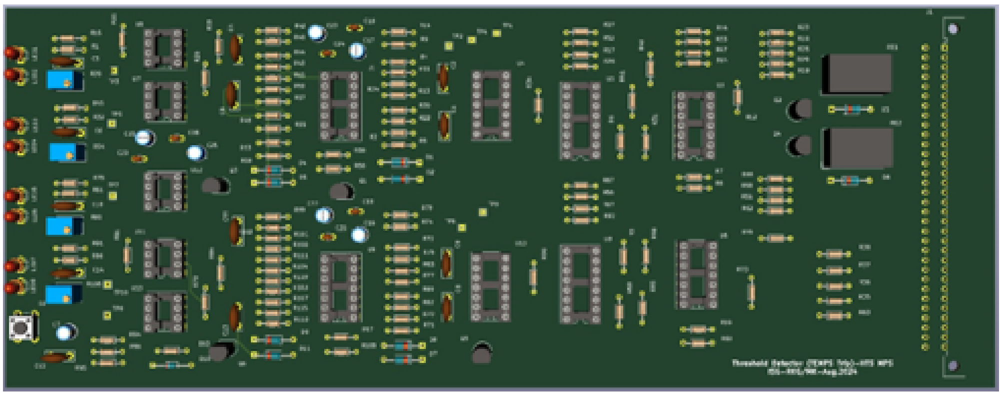

Figure 3.22: 3D rendered view using KiCAD software

detector module PCB's components are being procured and processed at the moment. The complete wiring diagram layout of the HTS magnet interface unit has been created in Ki Cad software using appropriate signal and block names.

4. **Development of spare modules for optical fiber interface:** We have made some modules of optical fiber interface as spares purpose. The spare modules are used during any system breakdown. We have constructed 10nos. optical fiber modules, consisting of 5nos. transmitter modules and 5nos. receiver modules.

3.1.12 Remote control laboratory

Rahul Ray, Deepak Kumar Munda, Ruby Santhi and Kundan Singh

RS232 servers for magnet power supply controls in FEL section: The FEL beam line has approximately 20 magnet power supplies to be controlled and monitored from Control room. Each unit

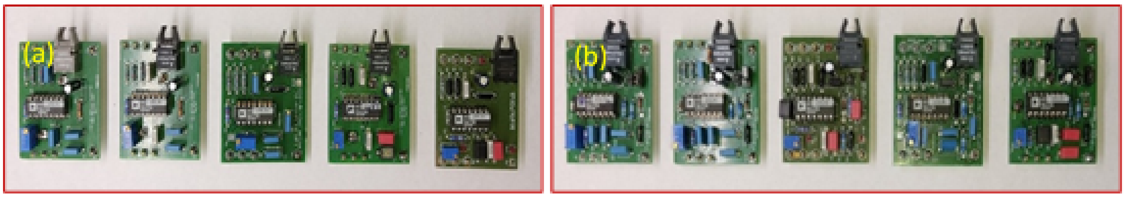

Figure 3.23: (a) Transmitter modules. (b) Receiver modules

of power supply is controlled through RS232 serial interface with BAUD rate 9600. We have indigenously designed and customized RS232 servers with each one can support 12 channels of RS232 interfaces. RS232 servers assembled and installed for the remote control of all Steerer and Quarterpole Bending magnet supplies in FEL beam line. OS Installation with server for TWTamplifier HCI beam Line.Implementation of a Standalone Server for TWT HCI beam line for Uninterrupted "pcli" controls.

Sycon deposition rate controller remote communication setup: Developing a remote control setup for the Sycon Deposition Rate Controller Instrument using orange pi server installed in the Target Lab at IUAC. This instrument is used to read the thickness and rate of deposition of target material on a quartz crystal and monitor these parameters. Additionally, a GUI was designed to send commands to the Sycon instrument, enhancing usability despite the display malfunction.

VME control system in FEL facility: VME Control system with ADC, DAC, Output register and Input Gate register installed in FEL beam line for beam line components for remote control.The application program "pserv" and "pcli" are compiled and tested on thisplatform in FEL beam line. (Abaco) VME controller installed with OS and other VME boards programs. VME DAC Module installation and setup for Phase Controller (0 -9 V) and integration with Pcli at FEL Facility and the VME ADC module for Ion pump readings.

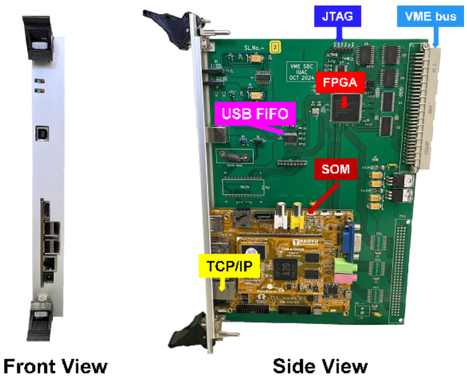

Figure 3.24: VME controller.

Vendor free VME master controller: Three number of MarsBoard-A20 are tested for three VME Master controllers (Fig. 3.24). Micro -5 another version of orangepi also tested with vme controller as 64 bit supported LinuxOS (Debian,Ubuntu etc.). All Three MarsBoard-A20 board installed with its dedicated OS and all the "PSERV" files compiled with supported files. MarsBoard based VME Master controller is tested successfully in vault area.

Salient features

- Single FPGA based design.
- Firmware written in Verilog and VHDL.
- Code portability tested on SPARTAN-3 and SPARTAN-6 FPGAs.
- On-board single board computer (SBC) for remote access.
- Data transfer rates of 1Mbytes /sec tested.
- Higher transfer rates with PCIe interface.
- Royalty-free VIRTUAL COM PORT (VCP) drivers support.
- Linux 2.4 and greater.

User support activities: Key upgrades also included the diagnosis and restoration of the HCI Magnets Power Supply Server, development of an automated I-V plotter for the Keithley 2601, and deployment of a real-time machine learning model on Raspberry Pi 5. Furthermore, legacy VME boards were evaluated for migration to FPGA-based replacements due to the obsolescence of SPARTAN-2/3 devices.

Another key highlight of the year was the design and functional testing of the HV Control System GUI tailored for the NAND Detector. Built using PyQt6 with real-time voltage readback, ramping safety features, and interactive visual feedback, the GUI supports 72-channel HV control across multiple boards. It allows both local and remote operation with voltage ramping protection, mutual exclusion for safe network/server communication, and graphical elements like radial spinners and status LEDs. The integration of this GUI into the experimental workflow significantly improved usability and operational reliability. In parallel, skills in Flask, socket programming, Linux, and GUI frameworks like Tkinter and PyQt were strengthened.

Double slit controller: In 2024, the Remote-Control Lab undertook several significant developments aimed at enhancing automation, precision control, and system scalability within IUAC's accelerator beamline infrastructure. A major achievement was the successful design and deployment of an indigenous Double Slit Control System, featuring both a remote-access Web GUI and a touch screen-based local interface. This plug-and-play system enabled simultaneous four-axis control (+X, -X, +Y, -Y) with micro-stepping precision (1.8° per step), and was tested for real-time operation via distributed server-client architecture.

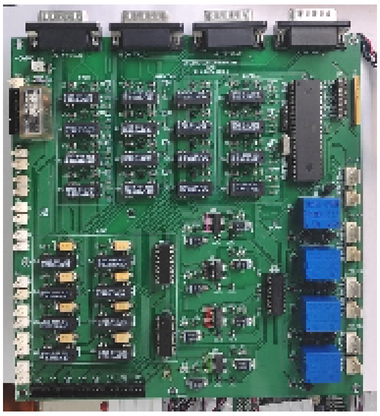

Figure 3.25: Four-layer PCB of the double slit controller.

The Double slit controller provides control to slit motor drives based on input from a computer- control system utilizing VME, or other equivalent data acquisition system (herein called computer control system). Indigenously designed Double slit controllers are intended to operate a beam defining slit (+X, -X, +Y, -Y) with up to four elements equipped with 24 VDC stepper motor drives. Desired slit position is input to the controller via the computer control system. A momentary status control is then input to the controller to enable drive motion to the new position. Based on a position read from the slit motor, the controller decides what direction the motor needs to turn.The controller have provision to interface with main accelerator control system, *i.e.*, pcli GUI. The future roadmap includes adding encoder feedback to motor controllers, expanding GUI functionality, integrating current sensing in the slit control system, and exploring EPICS for broader control system integration.

Figure 3.26: Front view of the double slit controller.

Salient features
- REMOTE and LOCAL operation.
- Microcontroller-based.
- Control from VME bus signals.
- Self-zero position.
- Status control, status read.
- Current read.
- Position read.
- Limit switch.

3.1.13 Analog and nuclear instrumentation

Arti Gupta and S. Venkataramanan

3.1.13.1 Maintenance of INGA and NAND electronics

There are nearly 100 customised front-end signal processing NIM standard modules developed at erstwhile Electronics Laboratory of IUAC for INGA type HPGe Clover detector and NAND liquid scintillation detector arrays, which are currently in active use. For reliable and smooth operation during experiments, Yearly Preventive Maintenance (YPM) activity is carried out regularly at determined intervals. All the above modules, NIM crates, cooling fan units and surrounding area are cleaned thoroughly with compressed air. All the modules are checked to find out for any damaged part / loose contacts and tested for their operability after repair.

3.1.13.2 Development of PMT active voltage divider

In order to demonstrate the PMT signal linearity at high count rate, an Active PMT voltage divider network, based on MOSFETs is developed and demonstrated in order to meet the future requirements due to high beam currents. The MOSFET based active PMT voltage divider networks have the ability to deliver PMT anode current spikes during high current rates than conventional resistor based divider networks, which suffer from non-linearity. Performance was compared with the existing resistive voltage divider network using ^{22}Na, ^{137}Cs, ^{60}Co and Am-Be sources with NAND experimental setup. System is stable with identical FOM (Figure-of-Merit, 1.7). We observed constant voltages at all the dynodes up to count rate 50k while the existing divider showing small variation in dynodes voltage. We need to conduct more trial tests in order to evaluate the effectiveness.

3.1.13.3 CFD and TAC units for Pelletron beam pulsing electronics

Customised 3-channel Constant Fraction Discriminators (CFD) and 2-channel Time to Amplitude Converter (TAC) daughter cards for Pelletron Beam Pulsing Timing electronics module were assembled and tested. These daughter cards will be used for processing signals in the beam pulsing system of the Pelletron.

3.2 Utility Systems

3.2.1 Electrical group

Raj Kumar, Gaurav Singhal and Mohd. Arif Waqar

Electrical system of IUAC is having following power source installations:

- Electrical sub-stations:
  - 11/0.433 kV Main sub-station of 4.5 MVA capacity having two HT supply – 1 No.
  - 11/0.433 kV Packaged compact sub-station of 1.6 MVA – 1No.
  - 11/0.433 kV Packaged compact sub-station of 1.0 MVA – 1No.
- DG sets and UPS systems:
  - 3x750 kVA DG Dets synchronized and controlled through PLC.
  - 3x300 kVA true online UPS System – 1 Set
  - 3x60 kVA true online UPS system – 3 Sets
  - 2x60 kVA true online UPS system – 1 Set
  - 3x200 kVA true online UPS system – 1 Set
- Solar power plants:
  - Grid interactive solar power plant of 100 kWp capacity- 1 No. (Owned and maintained by IUAC)
  - Grid interactive solar power plant of 120 kWp capacity- 1 No. (Owned and maintained by external agency)
- Servo voltage stabilizers:
  - 415 V, 3 Phase, 1000 kVA – 1 No.
  - 415 V, 3 Phase, 500 kVA – 1 No.

- Apart from the above power sources we have following electrical power & lighting systems:
  - Normal power distribution panels
  - DG power distribution panels
  - UPS power distribution panels
  - Lighting distribution panels
  - Light fittings and fixtures
  - Street and Compound Lighting
  - General earthing and dedicated clean earthing systems
  - Power factor compensation panels

All the above electrical installations have been working satisfactorily during the year with 100% up-time.

3.2.1.1 Maintenance activities

1. Maintenance of electrical installations of substation, office blocks and residential colony
   Maintenance of all the above electrical installations has been carried out as per schedule during the year.
   Besides the day-to-day routine maintenance following major schedule maintenance works are carried out annually.
   - RMU service for the packaged substations.
   - Servicing and calibration of all protective relays of HT & LT Panels.
   - Dehydration of transformer oil for 8 Transformers.
   - Servicing all OCB and ACBs.
   - Annual service of DG Sets.

3.2.1.2 Maximum demand and power consumption during 2024

The maximum demand during the year has been at 1800 kVA in July 2024 and minimum demand observed was 1470 kVA in November 2024. The monthly demand chart is as shown below.

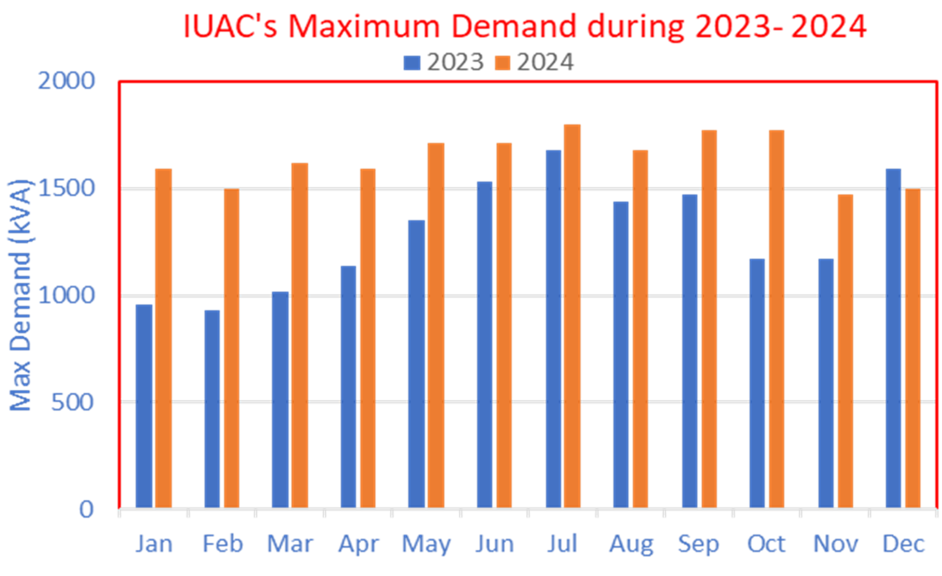

Figure 3.27: Maximum electrical load

3.2.1.3 Replacement of HPSV street and compound lighting into LED lighting system

This year we have replaced all streetlights and compound light system from HPSV light to LED light fittings. This will offer 50% power saving in the coming years.

3.2.1.4 Roof top solar system for IUAC

IUAC owned roof top grid interactive 100 kWp (2×50 kWp) solar power generation plant is operational and maintained in healthy condition. Total power generation of year 2024 has been 1,46,135 kWH. Maximum monthly power generation during the year has been 15,920 kWH in the month of May 2024. Periodical maintenance and cleaning of solar PV panels is carried out throughout the year to get maximum power out of it. We have already recovered capital investment on this plant within 4 years of generation. The monthly generation chart of the plant is as shown in Fig. 3.28

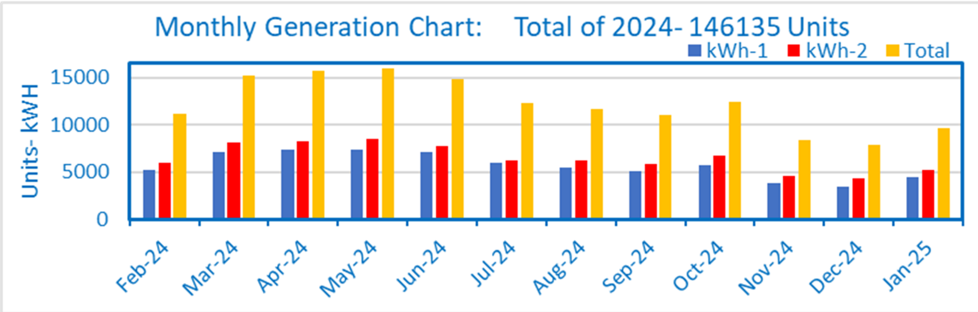

Figure 3.28: Solar power generation

3.2.1.5 Power factor compensation

There are following power factor correction panels in our distribution system.

- 350 kVAr, 7 stage power factor correction panel - 2 No's.
- 300 kVAr, 7 stage power factor correction panel - 1 No's.

Electrical group is very happy to declare that yet again we achieved an average power factor of >0.99 lag for the year. Our system power factor without correction is about 0.85 lag. This has been possible due to regular upkeep of power factor correction capacitors, contactors and other switchgears of the panels.

3.2.1.6 Fire detection and alarm systems

There are following fire detection and alarm systems installed in IUAC.

- Addressable fire detection system at Auditorium
- Addressable fire detection system at 2nd floor lab complex.
- Conventional fire detection systems at main lab building, LEIB building, new guesthouse, Beam Hall-3, engineering building, Beam Hall-2 stores.

All above fire detection and alarm systems are in healthy condition and are being maintained regularly through AMC.

3.2.2 Air conditioning, water system, cooling equipments, compressed air and fire hydrant systems

Bishamber Kumar, S. S. K. Sonti and Anup Choudhury

3.2.2.1 AC systems

IUAC's central air conditioning / low temperature cooling system of Phase-1, AC plant performed with >99% up time. Maintenance ensured that the safety record of the plant was maintained at 100% and the power consumption kept at optimum level. 2×200 TR chillers installed in 2013 have run 47000 hours each. 2×250 TR chillers installed in 2023 have run 5900 hours each.

AC Ph-I, Ion Source Room dehumidifier had operated for > 35 years has been replaced with new one. LCW System newly installed in HCI area is running satisfactory.

The Phase-II -250TR chiller installed in 2014 have run 60000 hrs. The Phase-III -250TR chiller installed in 2005 have run 20000 hrs. AC plants performed an up time of >99

Phase-II AC Plant, piping from the chiller condenser to Cooling tower have been replaced with new. AC Ph-II and III, Piping minor leaks were rectified / repaired in a major way.

The highlight of the operation and maintenance of the above systems is the in-house supervision, optimisation of operation parameters, timely maintenance of rotating machinery and elctricals led to least breakdown time and significant savings in operation and replacement costs.

3.2.2.2 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 up time of >99%. This is due to the stringent maintenance practices, which were followed over the years. The system has overshot 218500 hours from its expected life span.

IUAC's centralized water system of phase-II and III feeding low temperature cooling water also performed to an up time of >99%.

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. This has led to saving in water cost upto 10% of the billed cost.

Uninterrupted potable water has been made available to IUAC campus through the MCD supply and in house borewells.

Gardening water has been provided for campus horticulture work by supplying the reprocessed water conserving the potable water.

3.2.2.3 Cooling and heating system

Availabilty of portable water chillers, water coolers, window / split / package air conditioners, electric water geysers etc. was recorded at 99%. With in-house maintenance, there is significant saving the cost. Annual / routine / breakdown maintenance works of small air conditioners, geysers, desert coolers, indigenous / imported portable water chilling units in different labs is done as per requirement.

3.2.2.4 Compressed air system

Compressed air plant (Ph-I and II) consisting of 3 nos. of screw compressors each of 150m^3/Hr capacity, 4 nos of air dryers, pre/fine/oil removal filters with capacity of 2500 lpm @ 9.00 Kg/cm^2, Storage Tank of 25 cum have been maintaining uninterrupted air supply to IUAC Lab campus round the clock throughout the year. Pneumatic connections are provided to different labs / area / instruments as and when required.

3.2.2.5 Fire hydrant system

For Fire safety purpose pressurised water hydrant system including underground Water tank, electric / diesel engine water pumps have been installed. With this continuous water pressure is maintained in the water hydrant line. Wet risers, down comers, hose reels, hose pipes, boxes, hydrant branches have been provided in and around different buildings, *i.e.*, materials science building, engineering building, new guest house and the auditorium.

3.2.3 Machanical workshop

K. K. Mistri, B. B. Choudhary, Naresh Kumar, Rahul Kumar, G. K. Chaudhari and A Rai

This year the IUAC mechanical workshop has completed more than 200 jobs requests which involved fabrication of more than 1200 components. All the components were fabricated and installed in the various accelerator and experimental facilities in the centre. Some of the major in-house jobs that were successfully completed are; the low energy nuclear physics chamber for the High Current Injector, SS jacketing work of the spare Niobium Resonators for linac, two chambers for the Table Top Cyclotron project and several RF components like a prototype high power directional coupler, heat sinks for RF power amplifiers etc. Besides the in-house work, the workshop has also fabricated experimental chambers for Bilaspur University and

Cotton University. As of today, the entire requirement of machining, welding and assembly is fully carried out by the IUAC workshop without any outsourcing which is one of its mandates.

Besides fabrication, the workshop also ∼50 job requests where the components/assemblies had to be designed before construction. These include the designs of all the major in-house and outside jobs listed above.

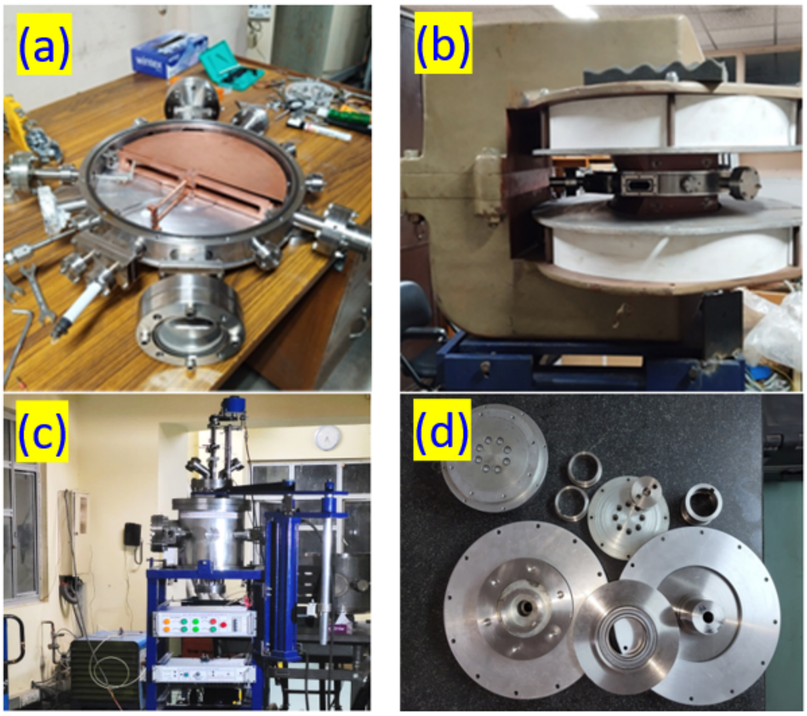

Figure 3.29: (a) and (b) Parts of the table top cyclotron, (c) Vacuum chamber for Guru Ghasidas University, Bilaspur and (d) Import substitution for Pelletron couplings.

Electron beam welding (EBW) facility and other auxiliary support activities: The responsibility of the operation and maintenance of the EBW facility also lies with the mechanical workshop. The facility was used for the fabrication of six spare niobium resonators and fourteen niobium tuner bellows for the superconducting linac in this academic year. Besides this it is also being used in the construction of two 650 MHz five cell elliptical cavities in collaboration with VECC, Kolkata. The workshop is also responsible for the purchase of industrial and speciality gas cylinders, their maintenance and distribution in the centre. This work is being performed on a regular basis as per the requirements. The maintenance and refilling of 320 nos. of fire extinguishers is also being carried out periodically by the workshop personnel. The group also provides apprentice training to ITI manpower and presently, one such person is undergoing training at the IUAC workshop.

In addition to regular jobs, IUAC workshop has made Efforts for Aatma-Nirbhar Bharat Mission and provided support for external accelerator laboratories (see Fig. 3.29).

3.2.4 Civil engineering department

Harshwardhan, Raj Kumar, Sourabh and D. S. Gangwar*

** Consultant*

IUAC campus is situated on a total plot area of 25 acre with built-up area (or ground coverage) of approximately 15000 m^2. The total covered area of all floors is around 25000 m^2. The centre has an academic or laboratory complex, utility buildings, auditorium, housing complexs, hostel and guesthouse complexes. The civil engineering department takes care of day-to-day maintenance of all buildings, roads, sewerage system in the campus including modifications, up-gradation, new construction activities and liaising with external agencies such as the Delhi Development Authority, the South Delhi Municipal Corporation, Delhi

Fire Service, the Forest Department, the Ridge Management Board etc. for various statutory requirements such as building plan and construction approvals, fire safety approvals, property tax related matters etc.

The following are some of the important civil works undertaken through the Central Public Works Department:

- Up-gradation / renovation of 28 residential flats: The renovation work is in progress.
- Renovation works of UPS room, hostel rooms, main IUAC gate and toilets have been completed.
- Construction of 8 Type-V (Kalptaru-type) residential flats: The proposal is under process.
- Construction of new laboratory complex: The proposal is under process.
- Repair of road leading from the main laboratory building (south-east corner) to Beam Hall II.

The following works have been carried out and completed directly by IUAC:

- Annual contract for day-to-day up-keep and maintenance of civil works at IUAC.
- Civil work for setting up of the cyclotron development laboratory and storage racks.
- Civil work for setting up high-pressure gas cylinder storage area.
- Internal painting of vacant residential flats, office spaces at IUAC.
- Construction of check-dam and pumping station in natural drain passing through the campus to avoid stagnation of sewage water.
- Setting up of automatic pumping station for dewatering FEL basement seepage water.
- Water proofing of the roofs of Beam Hall II and other rooms to avoid water seepage.
- Re-painting of various residential flats after 5 years maintenance period.
- Replacement of Indian-type toilet seat (IWC) by European-type toilet seat (EWC) including floor tiles at Flatlet-II/3.
- Renewal of fire safety clearance certificate (valid up to December 22, 2027), from the Delhi Fire Service.
- Miscellaneous civil works in IUAC campus.
- Construction of a new badminton court and partial covering of GI chain link of the existing badminton court.