3. RESEARCH SUPPORT FACILITIES

3.1 SUPPORT LABORATORIES

3.1.1 HIGH VACUUM LABORATORY

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

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 places. Faulty instruments are replaced with available spares to reduce 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 groups care) during experiment runs are attended on urgent basis. It provides support to different labs and users in vacuum related problems.

3.1.1.1 Installation, Alignment of High Current Injector (HCI) High Energy Beam Transport (HEBT) section and Integration with (Phase I zero-degree beamline)

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Installation and alignment of HCI HEBT beamline components, [from Achromat I (ACH-I) exit to Achromat IV (ACH-IV)], was started by vacuum lab after getting the responsibility for the same in around September 2022.

HCI HEBT beamline components encompass beamline section from ACH –I in beamhall 3 up to ACH IV exit section in phase I zero-degree beamline. The installation was carried out in two phases. In first phase installation of components up to ACH- II exit was done and a 100% beam transmission through ACH-I and II confirmed the perfect alignment of the installed components. In second phase further installation of beamline components along with ACH-III and IV was completed and HCI beamline integrated by the installation of ACH-IV, which is aligned with both the HCI beamline and phase I zero-degree beamline in perpendicular configuration. All the critical components like Achromats, Faraday Cup, Foil stripper, BPM, Electrostatic Quadrupole Triplets, Singlets, Spiral Buncher, etc. are aligned within an accuracy of ±0.5 mm of beam axis. Vacuum system consisting of turbo pumps, scroll pumps, vacuum gauges, vacuum valves, Ion Pumps, etc. mounted on a pumping chamber with necessary interlock for preventing vacuum accidents are installed and evenly spaced to achieve vacuum better than 1.0 E-09 mbar.

The sequence of steps followed for installation and alignment of beamline components is briefly summarized below:

1. Preparing of 3D layout of beamline components based on the beam optics/magnet/diagnostics layout given to us so as to evaluate the feasibility of placement, installation of components within the available space and finalize the exact position of each component.
2. Design of pumping chamber, bellow assemblies, installation and alignment fixtures, drift tubes, beam line stands and finalizing the flange types for each component for proper assembly of components.
3. Design and fabrication of beam line valve controllers (2 nos.), faraday cup controllers (8 nos.), controller crate (2 nos.), an interfacing crate for these devices and vacuum interlock system for pumping systems.
4. Marking of reference points on the floor and walls for creating new references for beamline axis from existing references required for ongoing and future installations.
5. First in any straight beamline the magnets, here Achromat magnet, are aligned and grouted, thereby freezing the beam axis. Then other alignment crucial components like BPM, Faraday Cup, Quadrupoles, etc. are installed (aligned and grouted). After those pumping sections along with pumps, gauges, valves, etc. are installed.
6. After thorough leak testing the complete installed beamline, vacuum devices are switched on and vacuum is established in the system, followed by baking and post bake leak testing.
7. Beamline device (Faraday Cup, BLVs, Vacuum system controllers, etc.) installation and alignment is done and all the devices are connected with their device controllers. Cables with end connections and connection details are given to Remote Control group for the remote control of these devices.

Critical Points and Achievements:

1. **Installation and alignment of Achromat Magnets**: There are three achromats in this section namely ACH-II, ACH-III and ACH-IV. Each achromat, consisting of two dipole magnets, two quadrupole triplets and a singlet in between the dipoles, is responsible for bending the ion beam by 90 degrees. Alignment of these

magnets is very important for accurate beam transportation. There are three axes in each Achromat, which are required to be aligned for its installation. Each dipole has two axes for alignment, one axis of both the dipoles are required to be aligned along the two perpendicular beamline directions and their 2nd axis are aligned with each other for their mutual alignment of the two dipoles. Two theodolites had to be used simultaneously for its alignment so that correct distance between the two magnets, alignment of each dipole with their axis and alignment of the dipole with each other is achieved correctly.

2. **Zero-degree beamline modification for integration of HCI ACH-IV with Phase-I:** One dipole of ACH-IV installs and aligns with HCI beamline and the other dipole with zero-degree beamline. To place ACH-IV in zero-degree beamline the existing quadrupole had to be shifted upstream with concurrence from beam optics group. Zero-degree beamline components up to Super-buncher entry had to be dismantled and beamline modified for doing this work. One theodolite was set-up in the vault and the other one near ACH-III. Installation of ACH-IV with perfect alignment with the two beam axes was critical in this section because both the axes were fixed and the achromat had to be installed with respect to the two fixed axes. Ach-IV alignment with the beam axes was achieved successfully.

   GPSC, GDA mat science-made operational as many things dismantled for HCI installation GPSC controllers shifting and cable extension and testing, log amp testing.

3. **Floor Sinking Problem in Phase-1 beamhall near vault-1 side:** The phase-1 beamhall area adjacent to vault-1 wall has sunk down by about 40 mm. The HIRA beamline and GDA beamline have already been raised few years back to correct the alignment issue due to this issue. Exact height issue in the beamline components in the area was taken and required packing plates were inserted under Quadrupoles and Achromat-IV magnet stands to correct the same. Alignment of all the BPM of zero-degree beamline were corrected wherever required.

4. **Angular and beam line height matching of HCI beamline with Phase – I GDA, GPSC and Zero-degree beamline:** Height reference for starting the installation HCI was taken from phase-I vault Analyzer and Switching magnet and the directional axis was taken with reference to the beamhall-3 side wall. Now after installation the angular matching of HCI beamline with the phase-1 beamlines was perfect 60° with GDA, 75° with Mat. Sc. And 90° deg. with Zero-degree beamline. Height of the HCI beam axis also matches well within ±0.5 mm of height references from phase-1 vault.

   Status: Integration of HCI with phase-1 beamlines (GDA, Mat. Sc. And Zero degree) has been completed and all the open sections of phase-1 beamlines made ready prior to scheduled Pelletron beam run. All the Achromats, quadrupoles and diagnostic devices have been installed. Fabrication and installation of device controllers and installation of few components is under progress and shall be completed soon.

3.1.1.2 Maintenance of Vacuum System and Diagnostic Devices work in beamlines and experimental facilities

(a) **Maintenance Work in Pelletron (with Pelletron group):** Venting of high voltage terminal inside Pelletron tank for foil loading and leak check and vacuum restoration after foil loading was done.

(b) **Extended NAND beamline remote control provision for FC 09-2, BPM 09-2 and BLV 09-2:**

Long pending requirement for extended beamline regarding separate remote control for FC 09-2, BPM 09-2 and BLV09-2 has been implemented. For this a new fabrication and assembling of a new FC controller and BLV controller has been made and required cables from the respective device to spark protection crate is done and connected.

(c) **Replacement of Faulty Vacuum Devices in different beamlines and facilities:** Due to continuous and non-stop operation of vacuum devices, few 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:

1) xDS35i Scroll pump in LINAC II Turbo Pump backing.
2) xDS 35i in HCI Fast Faraday Cup Turbo Pump backing.
3) Re-installation of DTL 2 Turbo pump (1600 lps) to replace leaking rubber gasket.
4) 1600 lps turbo pump in Drift Tube LINAC 6 cavity to replace failed turbo pump.
5) HiPace 2300 lps turbo-Pump in LINAC III was frequently shutting down. It was replaced with TPU 2301-P turbo pump.
6) Rotary pump (20 m^3/h) as backing pump for Ion source turbo pumps TP 01_1.
7) Rotary pump (20 m^3/h) as backing pump for Ion source turbo pumps TP 01_2.
8) Rotary pump DUO 10 as backing pump for GPSC beamline turbo pump.
9) Rotary pump replacement in HIRA during experiment.
10) Penning Gauge IKR 251 in GDA experimental facility.

11) DCU 700 and TC 750 in target lab turbo pump.

12) DCU 300 in Test cryostat (STC) turbo pump TMU 521.

13) MKS gauge controller replacement in EQT in HCI high voltage platform.

14) Rotary pump (20 m^3/h) in HIRA.

15) Maxi gauge controller in HYRA.

16) Turbo pump 500 lps in test cryostat (STC).

17) Turbo Pump 300 lps in Spiral Buncher (HCI beamhall 3)

18) New Turbo pump 700 lps installation in NAND chamber.

19) Pirani Gauge in Negative Ion Implanter beamline vacuum system.

20) DCU 600 (turbo controller) in Ion Source room turbo pump TP 01_2.

21) MKS Gauge Controller in LINAC I.

22) MKS Gauge Controller in Diagnostic Box 1 at LINAC entry area.

(d) Testing, Repairing and Servicing of Vacuum equipment

1) Lubrication Oil Change in 1600 lps turbo pump in LINAC II.

2) Lubricant Oil change in 1600 lps Ions source turbo pump TP 01_2.

3) Lubrication oil Kit replacement in Pfeiffer Turbo Pumps located in INGA Chamber, Phase II Atomic physics chamber, Phase II Raman Chamber and High vacuum Chamber, NAND Beamline and Test Cryostat (STC) and Pumping Chamber at Achromat 4 (HCI) entry.

4) Repairing of 5 numbers of faulty Edwards rotary pumps through OEM service engineer (purchase order for servicing along with spares was placed to OEM).

5) Testing and Calibration of 16 nos. of faulty Pirani Gauges, now working.

6) Cleaning, repairing and testing of 10 Cold Cathode gauges.

7) 13 nos. of faulty MKS Gauge controller model PDR 900-1 were evaluated thoroughly. The working components from these faulty controllers were tested and useful modules were taken out from these and assembled to make three Gauge controllers working.

8) Getter Pump (GP) Overhaul and new cartridge installation in GP 03-2, GP 04, GP 05-1, GP L5-1 and GP L5-2.

9) Cleaning, seal kit replacement and testing of xDS35i Edwards make scroll pumps: 5 nos.

10) Cleaning, Oil change and testing of Alcatel rotary pump for HIRA facility.

11) Repairing of Beam line valve controller BLV09-3.

12) Five faulty Ion Pump controllers (Gamma Vacuum & Physical Electronics) repaired by changing high voltage module / microprocessor module / power supply module from available spares.

(e) Miscellaneous Vacuum Maintenance Problems attended and resolved

There were about 100 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 **c**ompressed air failure, problem in pneumatic drives, CAMAC problems, radiation interlock problems, solenoid valves problems, Reset not done, vacuum pump off / gauge problems, etc. We identify the cause and resolve the issue or convey to other groups if it's in their scope.

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 users request.

3.1.2 CRYOGENICS AND APPLIED SUPERCONDUCTIVITY

S R Nirdoshi, M Kumar, S Babu, J Antony, S Kar & A K Choudhury

3.1.2.1 Introduction

In this academic year, the LINAC cryogenic system consisting of beam-line cryostats, helium refrigerator, and liquid helium and liquid distribution network, was operated for the beam acceleration through the RF-Superconducting LINAC. The helium refrigerator was also operated for off-line testing of cavities in the simple test cryostat, and testing of a few components of the 1.5T MRI magnet system. A major maintenance work has been

3.1.2.2 Helium refrigerator

During this academic year, the helium refrigerator (*Model- LR280, LINDE Kryotecnik*) having a capacity of **750W@ 4.2** K was operated five times for the total duration of ~1322 hours. First LINAC cryomodule (LC-1) was cooled to 4.2K twice to verify the removal of the blockage in the valve box 1 (VB1). All the beam line cryomodules were cooled to 4.2 K and made them ready for the beam acceleration. Prior to the beam acceleration, there was a power blackout which resulted evaporation of a large quantity of the helium gas due to the non-functioning of the UPS backup. In this academic year, 10 number of cold tests were performed in simple test cryostat (STC) for testing of the superconducting cavities. In addition, there were 14 more cold tests for testing various components of the MRI magnet. The total usage of the LN_2 for the academic year was ~ 3.2 lakh liters.

3.1.2.3 Maintenance of the helium refrigerator

In this academic year, scheduled maintenance work was undertaken after 25000 hrs. of compressor operation (last scheduled maintenance was done after 16000 hrs. of operation in 2017). In this maintenance work main coupling of the motor of the helium compressor was changed. The oil filter and the three number of oil separator cartridge inside the compressor module was replaced. Various minor maintenance work has also been performed in the GMS unit of the helium refrigerator. Fresh activated charcoal of 300kg was filled into the GMS after taking out the old charcoal. The oil filters of the GMS have been replaced. The compressor has been operated successfully after the maintenance work of the compressor and GMS unit of the helium refrigerator. Fig.3.1.2.1 shows photographs of various components of the helium compressor and the GMS unit of the refrigerator during the scheduled maintenance period.

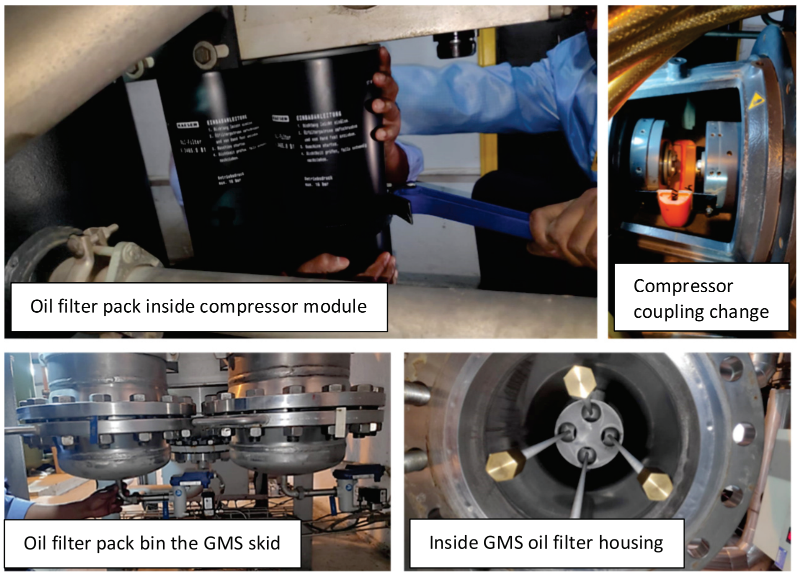


Fig. 3.1.2.1 Various components of the compressor and the GMS of the heliuum refrigerator .

3.1.2.4 WHOLE-BODY 1.5T SUPERCONDUCTING MRI MAGNET SYSTEM (MeitY Project)

Soumen Kar, Ajit Nandawadekar, Bhavana Avasthi, Farukh Khan, Rajesh Kumar, S. K Saini, Rajesh Nirdoshi, Manoj Kumar, Suresh Babu, Joby Antony, and R.G. Sharma

A multi-institutional project on the development of a whole-body 1.5T 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 and zero-boil-off (ZBO) cryostat for the MRI scanner.

The winding of all eight solenoidal coils and the external interference screening (EIS) coils of the 1.5T MRI magnet was completed as per the EM design of the magnet. After completion of the winding on a metallic bobbin structure, the superconducting wires of the magnet coils and EIS coils were routed onto the bobbin as per the predefined electrical scheme. A large number of the critical components including superconducting switches, cold diode assembly, current leads assembly, dump resistors, current limiting resistor, cryogenic temperature sensor, level sensor, etc. were mounted onto the magnet and made the necessary electrical connection through numerous resistive joining or superconducting joining. The fourteen inter-coil superconducting joining of the magnet coils and EIS coils were made in-situ onto the magnet using a versatile mobile joint-making station following the proprietary indigenous technology. Before making the inter-coils joining of the magnet, a low amplitude magnetic test was performed on each coil. The leads of the quench propagation heaters and the emergency run-down heaters fixed inside the winding of the respective coils were electrically connected. The electrical insulation test was performed on the various critical components at different stages during their integration with the magnet. The internal electrical scheme of the MRI magnet was verified at several stages of the final integration. The integrated bobbin structure was transported to a factory in Gujarat for its integration with the zero-boil-off MRI cryostat using a versatile rail-guided, spider-based assembly station.

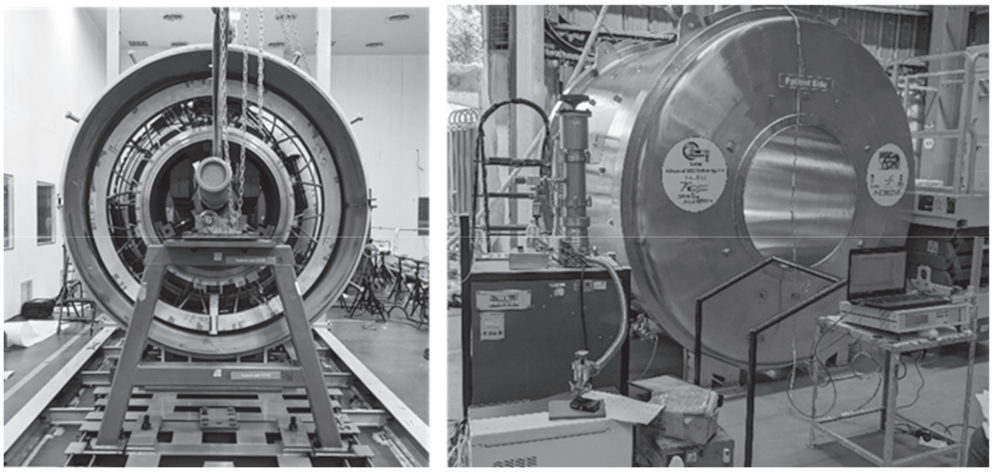


Fig. 3.1.2.2 The integration of the 1.5T superconducting MRI magnet.

At the factory site, the magnet was precisely positioned inside the helium vessel using a laser-guided alignment system. The helium leak test, pressure test, and deformation tests were performed once the magnet was completely concealed by the helium vessel. The thermal radiation shield and the outer vacuum shell were sequentially integrated with the magnet vessel with precise alignment using the assembly station following the predefined assembly steps. The pre-tensioning of the magnet suspension system was performed using a complex mechanical process to make the system self-centering and to withstand the shock load during surface transportation. A large number of multi-layer insulation (MLI) was used on the thermal radiation shield and the helium vessel to minimize the radiation heat inleak. The cryocooler port and the service turret port were fixed at the top of the cryostat. Fig. 3.1.2.2 shows the integration of the 1.5T superconducting magnet system. The alignment of the current lead and the liquid filling port have been verified physically by engaging the removable current lead and the liquid transfer tube through the service turret. All the leads for the voltage taps, temperature sensors, and level sensors were taken out through the service turret using the hermetic connectors. The global leak testing of the helium vessel and the vacuum vessel have been performed for the entire MRI cryostat. After the successful completion of the factory acceptance test, the MRI cryostat was brought to IUAC for the testing of the magnet prior to its commissioning at SAMEER-Mumbai. A versatile fail-proof emergency rundown unit (ERDU) was indigenously developed to energize emergency rundown heaters. An eight-channel high-voltage signal isolator was developed to tap the high-voltage quench signals to the magnet data acquisition system (mDAS) for the analysis of the quench. The NI_CRIO based mDAS was developed in-house for the fast acquisition of the real-time data analysis

3.1.3 BEAM TRANSPORT SYSTEM (BTS)

Prem Kumar Verma, S. K. Suman, Rajesh Kumar, N. Madhavan

Beam Transport System (BTS) Group is an Accelerator Support Central Group (AcSCG), primarily responsible for the design, fabrication, installation and maintenance of magnet power supplies and other BTS-associated instruments for all the accelerators and experimental facilities at IUAC. Additionally, the group takes care of the design, development and repair of different types of detector bias HV power supplies. Besides, power supply-related activities, the group is actively involved in the development of some key technologies and equipment for non-BTS technology development projects at IUAC.

3.1.3.1 Beam Transport System maintenance and upkeep:

A large number of beam transport system-associated instruments which include magnets, magnet power supplies, remote control modules, magnetic field measuring instruments and beam-line selection systems are in round-the-clock operation. All these instruments are serviced and calibrated during the "Yearly Scheduled Preventive Maintenance (YSPM)" time-slot to ensure required performance specifications and to minimize the breakdowns and the aging effect.

1. Yearly Scheduled Preventive Maintenance (YSPM) activities:

The condition of every BTS instrument is assessed before implementing maintenance procedure; the condition of each instrument is recorded in the "Test Report Performa" to determine a maintenance plan, tailored for each individual instrument. The main steps of the preventive and predictive maintenance are cleaning, physical inspection, changing the corroded/degraded parts, stability and calibration tests, mock-test to certify safety interlocks and performance certification tests at full power.

To ensure the required current stability and current-setting resolution, specific tests are conducted only for the bending magnets (Injector, Analyser and Switcher). While current testing stability of the switching magnet-II, output current drifts were observed and the reason was the deposition of copper oxide in the cooling water supply hoses of the magnet, resulting in leakage current to the ground. The restored and measured stability of all the bending magnets are maintained and recorded within 3-4 ppm for 8hours.

2. Cooling water-related corrosions:

This year, an increase in cooling water-related corrosion is observed, resulting in more frequent failure of water-cooled heat sinks in magnet power supplies and partial blockage of magnet coils due to oxide deposition. Even some of the new heat sinks in power supplies have got punctured within a year's time. There are increased incidents of magnet coil heating due to reduced cooling water flow caused by oxide deposition. To restore the required cooling water flow rate the magnet coils are cleaned by circulating mild sulphamic acid.

3. Corrosion in magnet power supplies due to environmental parameters:

Frequent exposure of the beam-hall to the outside environment due to beam-line installations and up-gradation activities has resulted in uncontrolled humidity and temperature. This has caused condensation in the water-cooled magnet power supplies installed there. The dust and H_2S contamination along with the condensation resulted in corrosion of the transistors mounted on the water-cooled heat sinks. The corrosion of transistors result in poor heat dissipation and sometimes in inconsistent behaviour of the power supplies due to current leaks through corrosion tracks. Changing all these transistors is a huge exercise; the refurbishing will be taken up next year.

4. Redundant power supply installation:

In-situ repairing/changing of the punctured water-cooled heat sinks is time-consuming, resulting in a huge beam-time loss. In addition, even if the heat sink is changed, sometimes it is not possible to operate the power supply due to water spillage inside the power supply; it needs dry-up time. In such situations to reduce the downtime, it is decided to replace the power supplies where ever possible, but replacing the bulky power supply is a task involving time and manpower. Considering this, two power supplies with input/output cable extenders are kept ready on specially designed trolleys for fast transportation to and incorporation at the site.

5. Repair of faulty electronic modules of Magnet Power Supplies:

Broadly, there are three categories of magnet power supplies used for BTS magnets; 1) Danfysik-make system 8000; 2) Danfysik-make system 9100; 3) IUAC-make, in-house developed power supplies. In-house developed power supplies constitute 50 % of the total magnet power supplies. To reduce the import cost of spare parts, component-level repairs of the faulty electronic cards of all types of BTS magnet power supplies are carried out by BTS group members. Last year, the following electronic modules were repaired.

1) For the system 8000 type power supplies, 02nos. of regulation modules, 03 nos. of auxiliary power supplies, and 01 no. of the control board

2) For system 9100 type power supplies, 08 nos. of auxiliary power supply cards and 01 rectifier-filter module

The repairing skills for the system 9100 type are presently limited, the group is self-learning to improve the repair skills of such power supplies. The spares for the in-house made power supplies are also fabricated in-house and the repair skills are 100%.

6. BTS uptime and operational status:

There were 22 occasions when failures in BTS magnets and magnet power supplies disrupted the accelerator operation and resulted in a total beam time loss of approximately 24 hrs. Out of 24 hrs, the major loos of time of 19 hrs. was due to the breakdowns caused by leaks in water-cooled heat sinks of magnet power supplies. All the breakdowns are immediately attended to and rectified to minimize the BTS downtime. The BTS systems are performing with the required stability specifications, and do not need any immediate up-gradation.

7. Fabrication of the in-house designed Power supplies:

The fabrication and assembly of the in-house designed power supplies are done in-house only. This year 25 nos. of Low Current Power Supplies (LCPS) were assembled for the steerer and low-power quadrupole magnets of the HCI and FEL facility. The Low Current Power Supplies, are designed with flexible arrangements for output currents and voltages to power the entire load and function (unipolar or bipolar) variations within 500 W using a single type of power supply. The modular and configurable design is adopted to minimize the type of power supplies for easy manpower training and to minimize the inventory of spare parts.

8. Beam Transport System magnet power supply installation activities:

The installation of beam lines of the High Current Injector (HCI) facility and the Free Electron Laser (FEL) facility are going on. The BTS group installed the magnet power supplies for the beam transport magnets of these beam lines. At the HCI facility, 47 nos. of magnet power supplies are installed out of which 12 nos. are made in-house; at the FEL facility, 10 nos. of magnet power supplies are installed out of which 07 nos. are made in-house. The power supply installation activity involves installing power supplies in power supply racks, layout design of cable trays, cooling water distribution, low impedance ground distribution, AC / DC cable routing /termination, and cooling water connection. Six more LCPS are installed at LINAC and LEIBF facilities to replace the old power supplies of the same power rating and functionality.

9. Preventive maintenance of Detector Bias -High Voltage Power supplies (DB-HVPS):

Every year, the BTS group performs the preventive maintenance of all types of Detector Bias -High Voltage Power Supplies (DB-HVPS) used in the Indian National Gamma Array (INGA) and National Array of Neutron Detectors (NAND) experimental facilities. The types of DB-HVPS in use are as follows:

1) 35 nos. of 3 kV/10 mA /ACS Detector Bias HVPS of which 08 nos. are repaired to fix different functional and performance problems.

2) 45 nos. of 5 kV/0.1 mA Germanium Detector Bias HVPS of which 06 nos. are repaired.

3) 72 nos. of 2 kV/5 mA Neutron Detector Bias HVPS out of which 01 no. is repaired.

3.1.3.2 Support activities other than Beam Transport System:

1. Repair of instruments (non-BTS)

BTS group has been providing extensive instrument repair services for a different types of power supplies used at different labs of IUAC. A thyristor-based 500 A/10 Vac filament power supply of a vacuum deposition unit of the Target Development Laboratory (TDL) was repaired.

2. Fabrication of Frequency Tuner plate for HCI-Radio Frequency Quadrupole (HCI-RFQ):

A sliding tuner plate is installed between the vane posts of the HCI-RFQ to tune the resonance frequency. While fabricating such a plate the objective is to have a sliding contact with minimum thermal and electrical resistance to minimize the contact-heating at high power operation of RFQ. Beryllium-copper finger-stack connectors are used to fabricate the new tuner plate. Special solder paste and a high-temperature oven are used to solder the solder contacts onto the opposite surfaces of the 205x250x30 mm, 5 kg copper plate. The new plate is installed at the HCI-RFQ and is working satisfactorily. With the older plate, the RFQ was only able to take 25 kW power, and above 25 kW the previously used finger-stacks were burning due to excessive heating. However, with the new tuner plate, the HCI-RFQ is able to operate even above 40 kW.

3.1.3.3 Electronic Instrumentation Development activities:

In the available time after completing the maintenance, installation, repairs, fabrication, and operation related to the Beam transport system the group members were involved in the following electronic instrumentation activities.

1. High stability (10 ppm) power supplies for the dipole magnet of FEL Facility:

The DC current requirement for the FEL magnet is 10 A with 10 ppm stability. In general, the commercially available power supplies of the 10 ppm class are of 100 A rating, which is overrated for the requirement and is very costly. Hence, considering the high import cost, the design and fabrication of 03 nos. of 20 A /20 V, 10ppm power supplies have been started. In the year 2006, while developing power supplies for the HYbrid Recoil mass Analyser (HYRA) experimental facility magnet power supplies, common control electronics for all rating power supplies was designed with the goal to simplify maintenance, and personnel training and to reduce the types of spares. The same control electronics is used in these power supplies too. The power section is based on linear series pass technique.

2. Signal Conditioning, Isolation, and measurement (SCIM) instrumentation:

Indigenous MRI magnet is being developed at IUAC. The MRI magnet consists of eight coils connected in series; the diagnostics of the magnet's main coils are carried out using the coil voltage taps. Series- connected magnet coils makes a high voltage cascade network, generating very high voltages during the quench. To monitor the individual coil voltage during ramp-up/down and quench, eight channel front-end signal conditioning & isolation electronics have been designed to isolate magnet coils from the coil voltage monitor instrumentation. Each voltage tap will have an individual isolation amplifier, a low pass filter for noise filtering, and galvanic isolation to avoid grounding problems. The instrument provides 2.5kV isolation between channel to channel and to the ground.

3. The Emergency Run Down Unit (ERDU):

The ERDU facilitates the MRI operating staff to rapidly discharge the magnet inc case of an emergency. The equipment has been designed according to the medical safety standards. To achieve consistent and fail-safe operation, product engineering considerations have been emphasized in both the mechanical and electrical design. The instrument has been developed, tested in the laboratory and installed with the MRI magnet.

3.1.4 DETECTOR LABORATORY

Mohit Kumar, Akhil Jhingan

Detector Laboratory at IUAC provides experimental support to various users in setting up charged particle detectors and readout electronics. New detectors and electronics have been designed and developed, and are used in various user experiments in GPSC and NAND.

3.1.4.1 CsI – photo-diode based CPDA for INGA

Detector Lab, INGA group, Mechanical workshop group IUAC

The multi-detector array has been designed and developed for the detection of light charge particles such as *protons* and *-particles,* generated in a heavy ion induced reaction, in coincidence with *rays*. The array currently consists of 32 CsI(TI) detectors coupled to photo-diode and has been developed to serve as an ancillary detector system for Indian National Gamma Array (INGA)[1]. Each crystal has a thickness of 3 *mm* with an active area of 20 *mm* x 20 *mm*, coupled to a 10 *mm* x 10 *mm* photo-diode via a 7 *mm* thick plexi-glass light guide. The assembled detector has been procured from Scionix, Netherland. The entire detector system is housed inside a hollow spherical aluminum scattering chamber with an outer diameter of 230 *mm* and wall thickness 5 *mm*.

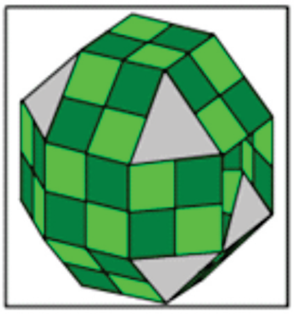


Fig.1: Rhombicuboctahedron structure with 4 detectors on each face.

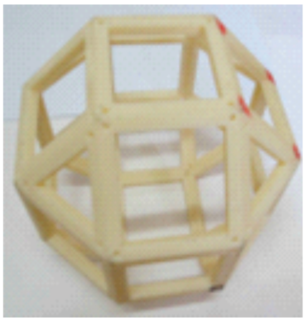


Fig.2: Plastic structure for mounting CsI detectors.

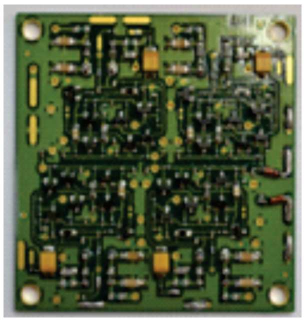


Fig.3: Four channel CSPA card. CsI detectors are plugged on the other side.

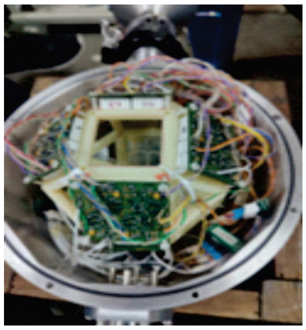


Fig.4: CsI detectors with CSPA units mounted inside scattering chamber.

The detectors are placed in a rhombicuboctahedron geometry (fig.1) around the target. The mounting frame is made out of plastic (fig.2). As shown, each face will have four CsI crystals. There is a provision to mount triangular crystal of each side 30 *mm* on the 8 corners of this structure. The target to detector distance is ~ 65 *mm*. The photo-diodes are read by conventional charge sensitive pre-amplifiers (CSPA). A preamp card developed in-house has four CSPA units arranged in a square 2x2 matrix compatible with the arrangement of CsI detectors. Each CSPA unit has a gain of 2 *V/pC* (*Si equi.*) with a power consumption of 30 *mW*. This preamp has been realized in the form of a hybrid (fig.3), with SMD components with a dimension of 55 *mm* x 55 *mm*. Photo-diodes with CsI crystals are plugged on the other side of the CSPA card. Fig.4 shows the detector structure mounted inside the scattering chamber. CSPA signals are extracted through a custom designed feed-through flange via 100 twisted pair cable. These signals are fed to an in-house designed 16-channel NIM module (fig.5) which has an active differential receiver followed by differential driver circuit. The differential analog signals are driven via shielded twisted pair cables (from Amphenol) to Mesytec spectroscopy amplifiers. Particle identification has been realized using ballistic deficit (BD) technique using short (0.5 μ*s*) and long shaping time (3 μ*s*).


Fig.5: Assembled differential receiver cum driver module.

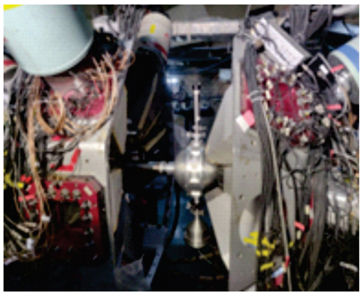


Fig.6: Scattering chamber with CPDA mounted inside INGA.

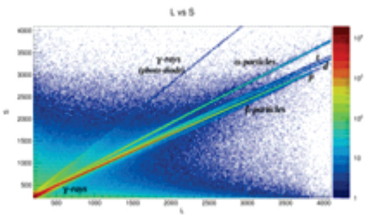


Fig.7: Particle identification plot of long (x-axis) against short (y-axis) shaping times.

The scattering chamber was mounted inside INGA array (fig.6) for experiments with Pelletron. It has linear motion target ladder on which 3 targets can be mounted. Off-line test of CsI detector was carried out using radioactive sources ^{137}Cs, ^{60}Co, ^{241}Am and ^{229}Th. Energy resolution of 250 *keV* (for 8.37 *MeV* -*particles*) and 70 *keV* (1332 *keV* - *rays*) were observed. The array was tested for light-charged particle – - *ray* coincidence for the systems $^{12}C + ^{28}Si$, $^{11}B + ^{165}Ho$, $^{12}C + ^{128}Te$, $^{16}O + ^{94}Zr$. Fig. 7 shows the plot between short and long shaping time for one of the crystals displaying separate contours of *protons*, -*particles* and - *rays*.

3.1.4.2 Development of miniature low powered CSPA units

Miniaturized CSPA units with very low power consumption have developed for *PIN* diode readouts. The units have been developed as hybrids with a power consumption of 15 *mW* having a size of 15 x 13 mm^2 identical to Hamamatsu model S3590 series. They are intended to be used to extract signals from detector systems where array of pin diodes are involved. The *PIN* diodes can be directly plugged on these hybrids. Prototypes have been tested with windowless *PIN* diodes using ^{241}Am - *particle* source. It has also been tested with CsI scintillators coupled to photo-diodes of sizes 15 x 15 mm^2 and 20 x 20 mm^2. Performance identical to high power CSPA units developed earlier have been observed. For high capacitance detectors (large area), deterioration in performance has observed. Modifications in design are being explored to correct the observed deficiencies. These hybrids do have applications in the field of imaging. More tests, including in-beam tests are planned in the future. Fig. 8 shows the assembled CSPA unit with a PIN diode. The PIN diode has an active area of 10 x 10 mm^2 while the casing is 15 x 13 mm^2. The signals from CSPA adjacent to it is extracted with a 5 pin FRC header. Fig.6 shows the spectrum of Co^{60} gamma rays from a 15 x 15 mm^2 CsI crystal coupled to 10 x 10 mm^2 photo diode.

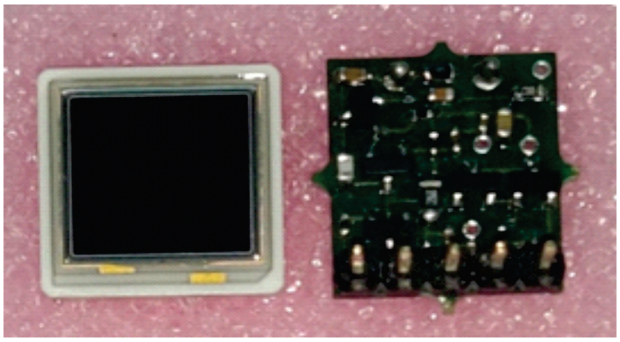


Fig.8: CSPA unit (right) with PIN diode (left)

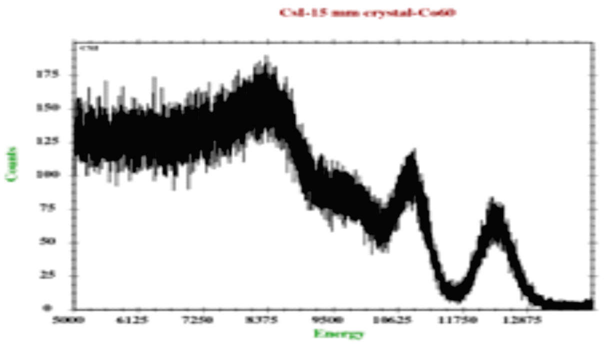
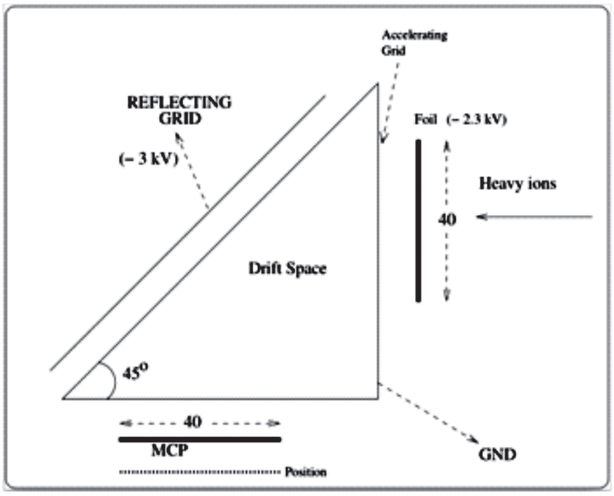


Fig.9: Co^{60} ?-rays from CsI-PIN diode combination.

3.1.4.3 MCP based TOF system for GPSC

Sunil Devi*, R. Yatoo*, M. Kumar, C. P. Safvan, A. Jhingan

* Thapar Institute of Engineering and Technology, Patiala



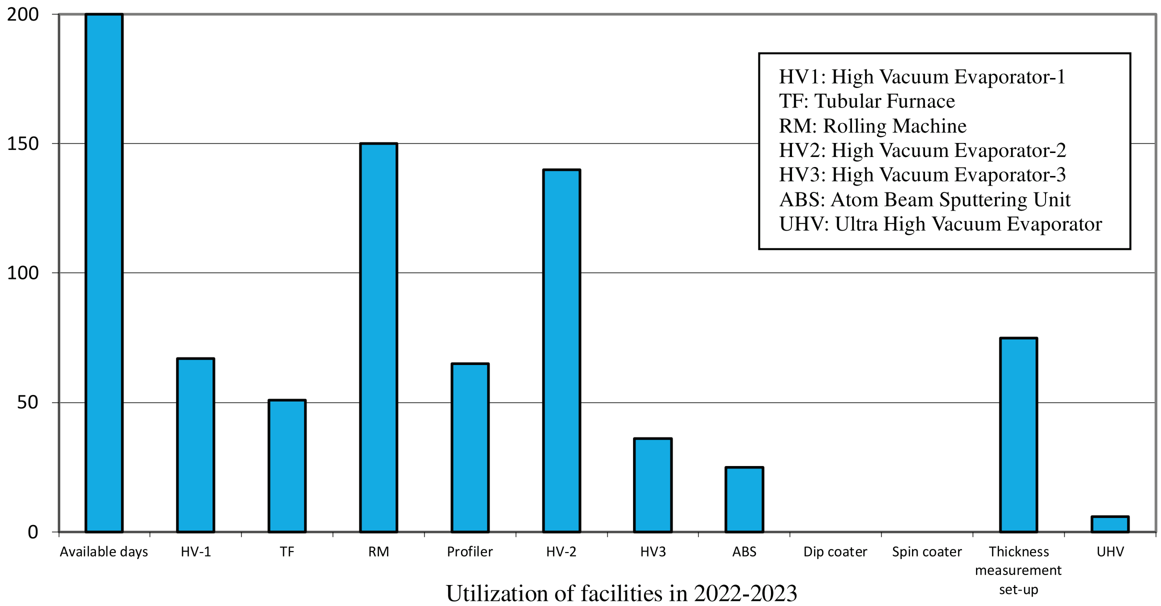
Developmental activities were initiated for the micro-channel plate (MCP) based TOF system. This involves fabrication of transmission type secondary electron detector (SED). This will require development of an assembly consisting of a conversion foil, electrostatic mirror and an electron detector. The conversion foil emits electrons whenever heavy ions traverse through it. These electrons are than accelerated and focused on MCP detector (in Chevron configuration) by bending these electrons, at an angle by 90 degrees with the help of an electrostatic mirror. Extensive simulations work has been performed to trace the path of secondary electrons from the emissive foil to the MCP. This is required to check the position linearity and efficiency of electron detection by the MCP. The same is required to freeze the relative position of MCP and emissive, and the electric fields to be applied to the respective elements in the detection system. The simulations are being performed using SIMION software. Fig.10 shows the basic layout of the proposed system. The active area of the MCP detector will be 60 x 40 mm^2. Position information will be extracted using the delay line technique. The fast timing amplifier circuits have also been designed. It is planned to fabricate the detector components in the coming months. MCP detectors have been procured. The electrostatic mirror will be prepared with stretched Cu-Be wires of diameter 50 m. Once the design parameters of the electrostatic mirror are frozen, the fabrication of the same will be taken. This project is funded by DST-SERB via sanction order no. CRG/2020/005552.

3.1.5 TARGET LABORATORY

Abhilash S R, Ambuj Mishra and D. Kabiraj

Target Development for Accelerator Users

The primary responsibilities of target development laboratory (TDL) are operation, up-keeping and maintenance of instruments in the lab for developing, preserving and delivering the nuclear targets and thin films for particle accelerator users. Target development activities in Inter-University Accelerator Centre (IUAC) are back on track after the disruptions brought in by *COVID-19.* TDL is successful in delivering several targets for accelerator experiments and several research scholars have been trained in thin film deposition techniques in this year. In addition, TDL is taking key role in the development of photocathode deposition facility for Delhi Light Source (DLS). Most of the instruments in target lab are well–utilized in this year. Man-machine utilization in target development laboratory is shown in the bar chart given below.



Utilization of facilities in 2022-2023

The utilization of facilities indicates that more than two facilities of TDDL have been used every working day. More than 125 evaporation attempts were performed for target fabrication in different systems for accomplishing the target requests of users of various streams viz., material science, nuclear physics, and atomic physics. TDL has successfully delivered more than 200 nuclear targets and 400 carbon stripper foil in this year. Target developments in IUAC were also reported in peer-reviewed journals and national symposiums in this year [1-5].

1. Maintenance and up-gradation activities in TDL

The Breakdown maintenance of Rolling Machine was one of the major maintenance activities in TDL during this year. The delay in the after-sales-support from the foreign supplier caused major interruption in the activities. After the disassembly of the machine by TDL members, it was identified that the breakdown was due to the failure of bearings. IUAC workshop took up the fabrication of the bearings on trial basis and four gunmetal bearings in place of carbon steel bearings were fabricated. The bearings were assembled and tested in TDL with the alignment of rolls. The machine is back in operation after several testing with loads.

Another important maintenance activity was the in-house repair of power supply of vacuum coating unit. TDL was unable to get the service support for the 25 years old high current power supply as the model was an obsolete item. The beam transport group of IUAC took the initiative to redesign the circuit diagram of the supply and the faulty components were replaced. The machine is back in operation after several testing and the coating units are available for the users.

2. Target development of metals with poor malleability

Target development of W, Re, Ta, Mo, Nb, Ir, and Hf poses lots of challenges by virtue of their high melting point and poor malleability. Targets of high melting point metals are frequently utilized for many accelerator-based nuclear physics experiments. Contrary to the low melting point metals, the involvement of a huge amount of heat brings in multiple complexities in target development by evaporation. According to the experimental need, both thick and thin targets in the form of either a self-supporting or with backing are used for experiments. In addition, highly enriched isotopic materials are the ideal choice for many nuclear physics experiments with ion beam. Most of the isotopes are highly expensive and rarely available. Target fabrication by evaporation techniques requires comparatively more quantity of material. So, the target development of isotopes having high melting point and poor malleability with limited quantity becomes more complicated. Over the last few years, an extensive amount of work has been done in IUAC in the target development poor malleable metals. The recent attempts to develop the self-supporting Hf targets by combining the vacuum annealing and rolling technique has more significance in this context [6]. Contrary to the evaporation technique, the rolling techniques ensure no-material wastage during the fabrication.

In addition to the problems associated with the high melting point, the tendency of Hf to react in air is also a major constraint during the target fabrication. The oxidization attributes porous texture over the metal surface and eventually pin holes are formed in the self-supporting targets. TDL is putting a substantial amount of effort to develop and standardize the procedure for fabricating stable self-supporting targets of such kind of metals. In the present procedure, initially, the surface of the Hf metal is cleaned with diluted hydrofluoric acid followed by storing the foil in an inert environment to minimize the oxygen contamination over the target surface. In the next step, Hf foil is annealed at 600^{0}C in high vacuum environment for improving the malleability of foil. The annealing and the cooling rate are 5^{0}C/minute and 3^{0}C/minute respectively. The annealing and the cooling rate were optimized by trial and error method and the optimization of the rate has crucial role in improving the malleable nature of the material. Finally, the annealed foil is rolled down slowly to 1mg/cm^2 by standard rolling procedure.

3. Target development of ^{107,109}Ag by combining the e-beam bombardment and rolling technique

The recent request for self-supporting and target with backing of ^{107,109}Ag with a thickness 1mg/cm^2 for a nuclear physics experiment involved various challenges. The powder form and limited amount of availability of enriched material were the major challenges in the target fabrication. The limited amount of material (less than 100mg) was not sufficient for fabricating targets of 1mg/cm^2 thickness by conventional evaporation technique. In this process, initially the powder was converted into a pellet by using the hydraulic press. The pellet is then melted into a single spherical piece in the vacuum environment by using the e-beam bombardment. The e-beam parameters are carefully optimized to ensure no loss of quantity and physical properties like ductility and malleability during melting. Several attempts were required to optimize the power of the e-beam, rate of heating and cooling. After the e-beam melting, the spherical piece is taken out of the vacuum chamber and gradually pressed into a disc form by the hydraulic press. Finally the disc is thinned down to the required thickness by the rolling technique. This unique method will be useful for fabricating the targets of expensive material without any significant loss of material. The post-fabrication characterization of the targets proved that the method of fabrication is free from major contaminations. The targets were developed jointly by TDL and Ms Bharti Rohila, Department of Physics, Panjab University, Chandigarh and one fabricated target has been successfully used in a recent nuclear physics experiment in IUAC.

4. Fabrication, Inspection, and Loading of stripper foils

Delivery of stripper foils as per the IUAC Pelletron maintenance schedule is one of the important activities in the TDL. More than 400 carbon foils of ~4μg/cm^2 for the terminal section and 200 foils of ~8μg/cm^2 thickness for the dead section are delivered every year. The PVD of carbon by e-beam heating is used to grow the thin films on detergent-coated highly polished glass slides. In addition to the IUAC stripper, Pulsed Laser Ablated (PLA) grown foils are also used which are sourced from Germany. These foils exhibit superior life under ion bombardment as stripper foils. These films are shipped in a sealed container filled with argon gas to avoid degradation of the parting agent. The films are separated from the glass slide by dissolving the parting agent followed by dissolving the protecting copper layer in the nitric acid solution. Finally, the carbon films are mounted on the stripper foil holder.

5. Development of substrate cooling set-up for the fabrication of targets with improved evaporation yield

For minimizing the material consumption, various orientations of source and substrate are explored in vacuum evaporation. It was recently experienced that the re-evaporation of isotopically enriched cadmium film can be minimized by placing the substrate below the source, oriented upside down, as represented schematically in Fig. 1 [1]. In the evaporation set-up, the optimum distance between the substrate and the source was found to be 3 cm. A few milligram of material (less than 10mg) was the material consumption during the evaporation.

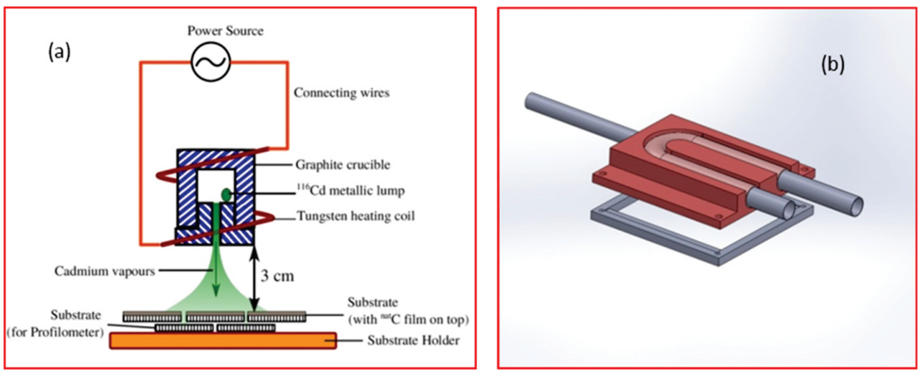
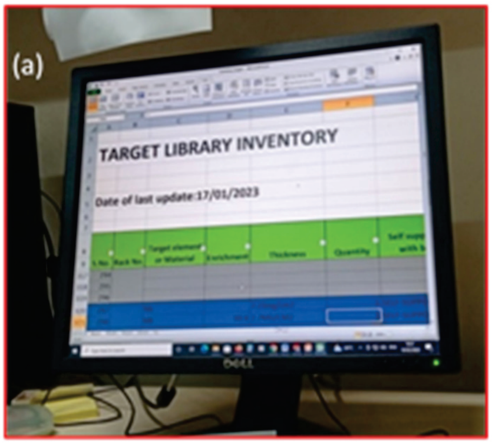


Figure 1: Schematic of (a) the Cd evaporation set-up and (b) substrate cooling set-up

If the substrate temperature can be maintained at room temperature during evaporation, the possibility of re-evaporation can be further reduced. So, TDL is planning to introduce a substrate cooling set-up in the vacuum coating unit to maintain the substrate temperature at room temperature. The room temperature at the substrate during the evaporation can further decrease the optimum distance between the source and substrate which will result the improved evaporation yield. The development of substrate cooling set-up is under the progress and the schematic of the set-up is shown in the Fig.1.

6. Target library for users



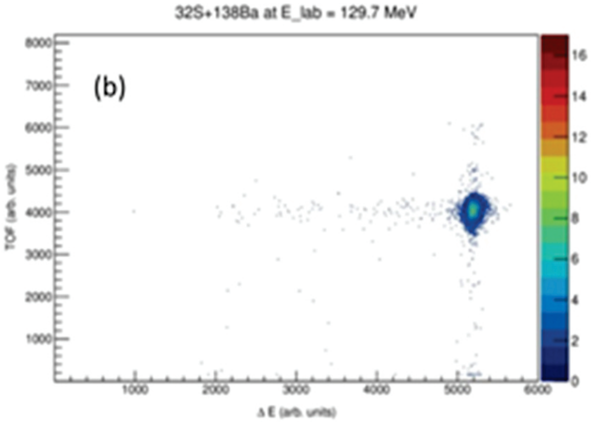


Figure 2: (a) Digital Inventory of Target Library and (b) the experimental spectrum of reaction 32S+138Ba, in HYRA facility

TDL had initiated the work for a target library in 2019 for systematic storing of the nuclear targets for future use and for avoiding repeated fabrication of targets having the same specifications. Apart from saving money and manpower, this facility will also provide lab access to more users with a minimum time lag.

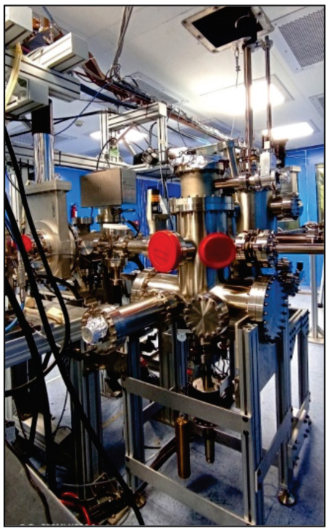
More than 1300 targets are already part of the library and more efforts are in progress to bring more targets under the library with a digital inventory. The Target library has issued more than 88 targets in 2022 for various experiments. In order to meet the unexpected demand, 200 carbon stripper foils are also available in the library. A list of targets and their specifications are available in the digital form and users can access the same for planning their experiments.

The air-sensitive targets for longer duration is always a challenging job. The dedicated high vacuum storage facility for the target is not yet materialized. At present, the targets are stored in vacuum desiccators which are filled with argon gas. This year, the library also issued ^{138}Ba targets, one of the most air-sensitive targets fabricated in 2015 for a recent HYRA experiment. The experimental spectrum (shared by Ms. Malvika, IIT Roorkee, BTR:66227) of reaction ^{32}S+^{138}Ba, in HYRA facility, shows that the 8-year-old targets remain stable throughout the experiment. The spectrum is showing the energy loss versus time of flight of the evaporation residues from the compound nucleus ^{170}Hf.

7. Activities in Photocathode development

A Photocathode deposition facility is in the final stage of commissioning at IUAC. The deposition facility will be capable of producing, preserving, and vacuum-transferring the photocathodes of Cs_2Te and advanced materials like Cs_3Sb and CsK_2Sb in ~10^{-11} mbar. The distinctive evaporation set-up in the facility with multiple sources and substrates with extensive temperature ranges will play a key role in the development of photocathodes with superior characteristics.

The geometry of the source and substrate plays a crucial role in growing uniform photocathode thin film with a minimal amount of time. The ***source***-substrate design of IUAC photocathode system will have provision of co-deposition and sequential evaporation with multiple sources. Seven sources are part of the deposition chamber of the system and all the sources are of retractable type with load lock system (Figure 3). The sources can be easily loaded and unloaded from the system without venting the UHV deposition chamber.



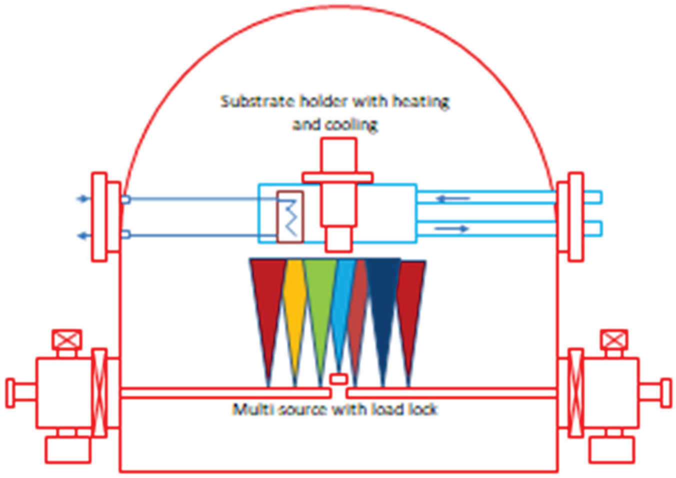


Figure 3: Photocathode deposition facility at IUAC and the schematic of source-substrate orientation

The Mo substrate holder is equipped with a pyrolytic boron nitride substrate heater and chilled water supply and this unique arrangement will provide a broad temperature range and temperature ramp rate which can enhance the quality of the film. A retractable quartz crystal monitor and quantum efficiency measurement set-up are also part of the system. The installation and testing of the source and substrate holder are in progress. The calibration of the substrate holder is complete and the calibration of the quartz crystal monitor is underway. The photocathode deposition facility is jointly developed by TDL and FEL group members. The plan is to start photocathode fabrication in the middle of 2023.

3.1.6 RF AMPLIFIERS AND LOW-LEVEL RF GROUP (RFA & LLRF - AcSCG)

Ashish Sharma, Parmanand Singh, Yaduvansh Mathur, V.V.V. Satyanarayana, Arti Gupta, S. Venkataramanan, Abhijit Sarkar

3.1.6.1 RF Power amplifiers of Pelletron, High Current Injector & Delhi Light Source

RFA group has been actively involved in operating, repairing, restoring, and undertaking periodic preventive maintenance of various high power microwave power sources and radio frequency (RF) power amplifiers that are under the group responsibility. These equipments are installed with Pelletron and various RF cavities of the High Current Injector (HCI), Super Conducting Linac (SC-LINAC), Delhi Light Source (FEL) and LEIB accelerator facilities. These power amplifiers and microwave power sources have wide range in both frequency of operation and operating power level ranging between 4 MHz and 17.9GHz. Throughout this year, all the power amplifiers and microwave power sources were in continuous operation at different power levels as per requirements. The power amplifiers installed are of both water-cooled and air-cooled types. The dust filters of these equipment are routinely cleaned and replaced. The cooling water quality to HCI, DLS installed equipment is also monitored and replenished whenever necessary. Regular logging of parameters in a day are part of the routine. Major preventive maintenance operation of all power amplifiers under care have been completed as per planned routine and documented. Purchase of required spare components, sub-units, spare power supplies, control cards and various consumables have been initiated and some purchases are completed for maintaining a stock of required spare components in order to ensure efficient operation of installed RF power amplifiers and microwave power sources.

Microwave Power Generators

The 1.7kW, 17.9 GHz Klystron Power Generator for ECR ion source (PKDELIS) of HCI at IUAC has been performing well and consistently operated upto 1000 Watts to develop various particle beams for HCI. This power generator is a forced air-cooled unit and it is routinely cleaned for dust and debris. Various WR-62 type waveguide components are being procured to maintain uniform transmission path as well as to minimize transmission line junction loss between microwave power generator and plasma chamber at 17.9GHz. A perennial problem due to an obsolete relay type in control and display (C&D) unit of this power generator was repaired and replaced during this period.

120kW, 48.5 MHz RFQ Power Amplifier

During this year the vacuum tube amplifier powering Radio Frequency Quadrupole (RFQ) was operated up to 40kW. During this period, the power amplifier had developed problem with power tube socket, wherein part of socket finger contacts welded with power vacuum tube electrode. This forced us to shut this amplifier for few months, to analyze the problem and to find replacement parts. Based on our fault analysis, due to poor water flow as the quick disconnect connector (QDC) in cooling water line was corroded and restricted the water flow in the tube and this could have caused the elevated tube temperature and socket. Alternate QDCs were sourced and replaced. The power amplifier was restored with spare socket and spare power vacuum tube from our stock. After conditioning the tube with filament and high voltage for 2 weeks, the RF power amplifier was restored to normalcy with minor tuning in output section. This year, in association with water supply group we have made efforts to commission a dedicated low conductivity water (LCW) plant to feed the tube amplifiers in use for liquid cooling as per the suggestion of the amplifier supplier. The remote control and monitoring of parameters of this power amplifier has been incorporated into the remote-control scheme of HCI. Meanwhile, the defective tube has been sent to the manufacturer for repair.

20 kW Solid State Power Amplifiers

During this year the 97 MHz, 20 kW CW solid state power amplifier powering DTL-2, DTL-3 cavities respectively have been incorporated into the remote-control scheme. The RS-232 control is used to remotely control the amplifier as well as to read the crucial operational parameters of these power amplifiers. A faulty SMPS (3kW) unit was replaced and a faulty amplifier pallet was repaired by replacing a blown LDMOS transistor. This year, we have procured driver amplifier, 6kW sub-units and a Control & Logic Unit (CLU) as spares for these two amplifiers and they have been tested for their specifications during this period.

28 kW Solid State Power Amplifiers

The 97 MHz, 28kW CW solid state power amplifiers powering DTL-4 & DTL-5 cavities were successfully incorporated into the remote-control scheme through RS-232 control, wherein these power amplifiers can be remotely controlled, monitored for power amplifier parameters. A spare 50kW dc power supply for this power amplifier was procured and tested on a dummy resistive load.

30 kW Vacuum tube Power Amplifier

The 97 MHz, 30kW CW vacuum Triode power amplifier powering DTL #6 through power circulator had developed cooling water leakage during normal operation. OEM supplied plastic union connecting RF tube and cooling water hose was found to have minor hole in the return line. The union was locally sourced in consultation with the OEM and replaced successfully. The remote control and monitoring of various parameters of power amplifiers have been made accessible remotely through VME control scheme. During this period, the failed vacuum tetrode tubes were successfully repaired at manufacturer's facility and returned to our stock.

Hi-Potting of Vacuum tubes

The spare power vacuum tubes of 120kW, 30kW and 6kW power amplifiers are being subjected to hi-potting test periodically with homemade Hi-potting setup. The hi-potting conditioning was done regularly to keep the power vacuum tubes in good health and avoid their vacuum degradation during storage.

400 Watts RF Power amplifiers

The SC-LINAC cavities are powered with ~35 numbers of homemade 400 Watts solid state RF power amplifiers. During this year some of the faulty 350W CW, 97MHz solid state power amplifiers of SC-LINAC have been repaired and restored into the system. It is reported that most of the faults in these power amplifiers have been occurring due to aging of control card. In this year, around 12 numbers of new control cards have been mass produced and some of the amplifiers have been installed with these control cards to study their performance. We have initiated the process of implementing the new control cards in remaining amplifiers in the coming year. During the preventive maintenance the power amplifiers are calibrated for Q point setting, gain, remote parameter read backs etc.

100 Watts Solid State Power Amplifiers

The in-house made 100 Watts RF solid state power amplifiers which are customized for Chopper, Multi harmonic Bunchers (MHB) of Pelletron and HCI are periodically maintained by this group.

3.1.6.2 Low-Level Radio Frequency (LLRF) Electronics

Low-Level RF & Beam Bunching Group (LLRF) is an Accelerator Support Central Group (AcSCG) that takes care of the operation, maintenance, upgrade, and development of different LLRF systems for all the accelerators. This includes the Beam Pulsing System of Pelletron-Linac (BPS) along with control electronics for Multi-Harmonic Buncher (MHB), Chopper, Travelling Wave Deflector (TWD), LLRF controls for Linac, High Current Injector (HCI) and Free Electron Laser (FEL). A brief description of the activities of the group during last academic year is listed in following sub-sections.

Operation and Maintenance of Beam Pulsing System for Pelletron

During this year, the Beam Pulsing System was extensively used for several pulsed beams runs for nuclear physic and Atomic Physics experiments with all the group members performing 24X7 on call operational duty. The operational efficiency of the Beam Pulsing System is more than 97% for the entire operational hours except for one breakdown maintenance during July 2022, due to TWD-related issues. During scheduled maintenance of the Pelletron, preventive maintenance of BPS electronics was also carried out with rearrangement of BPS electronics in control room and re-routing of interconnecting cables with proper labelling on both sides of the cables. A test bench for installed TWD Control Electronics has been assembled to understand the reasons for the frequent component failure in this installed system.

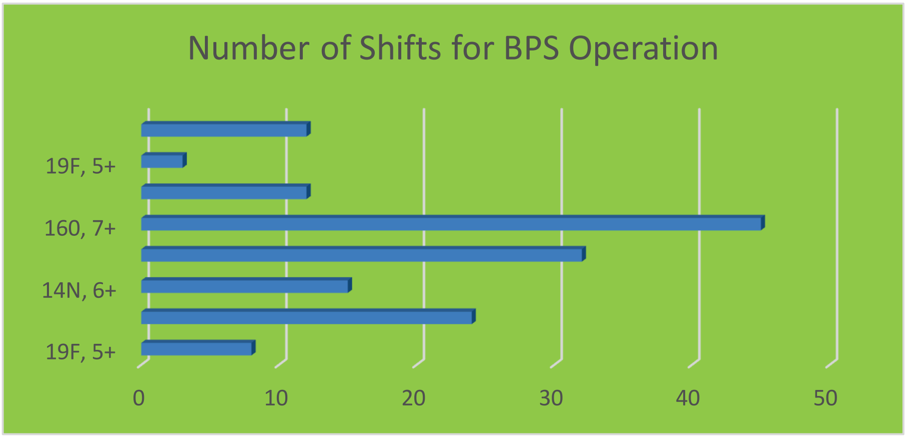


Figure 1: Beam Pulsing System operation summary

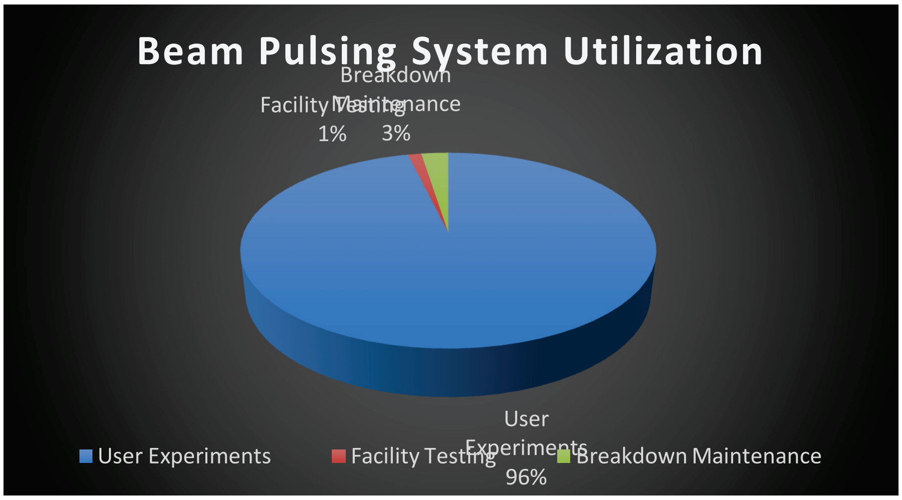


Figure 2: Beam Pulsing System Utilization

Apart from routine preventive maintenance, few repair jobs of TWD related electronics were also carried out. This activity included the in-situ replacement of faulty pre-driver transistors (2N3904) for channels #7, #8 and #9 and repair of clipper board of Bank-B of TWD electronics. During breakdown maintenance we have repaired a clipper board and replacing fused 33 Ohm resistor of channel #6.

Development of Test Bench for TWD Control Electronics

TWD Electronics Test Bench has been developed and tested to understand the functionality of various components and the reason for component failure. The external power supplies used are ±250V, +24V, -48V and 1kV variable DC power supply. TWD deflecting plates are simulated by a load consisting of a 5pF/1kV capacitor. The output HV pulses were measured using an oscilloscope and are comparable to the pulses (200V @ 20ns Rise and Fall timings) obtained from the actual TWD electronics. The trial of complete bypassing of any of the TWD channels without much up-time loss during user experiments can be tested on this before implementing with the actual system. It can also be used to condition the spare vacuum tubes used for this purpose. The basic version of the Test Bench needs to be modified by populating more control electronics channels. This test bench is very useful for conditioning of spare vacuum tubes so that the life time of those vacuum tubes can be enhanced.

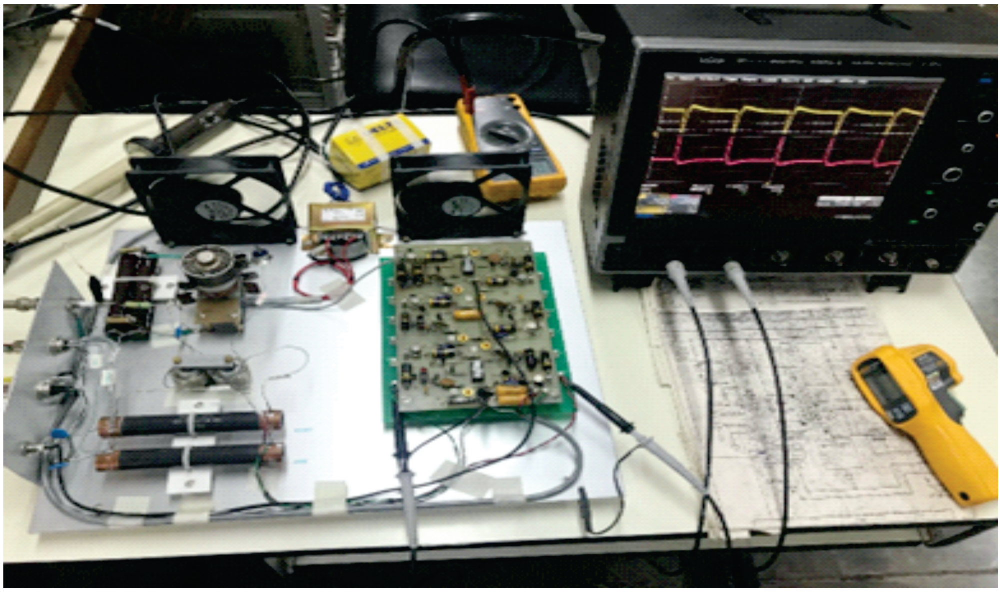


Figure 3: Test Bench for TWD Control Electronics

Preventive Maintenance of LLRF Systems for LINAC:

The linear accelerator (LINAC) at IUAC uses superconducting quarter wave resonator (SC-QWR) cavities for ion beam acceleration. The amplitude and phase stability of the cavity RF field of LINAC are very essential for stable operation and the desired acceleration of incoming beam packets. External mechanical vibrations can cause detuning of the resonance frequency of the superconducting cavities due to their narrow bandwidth of operation. This led to a disturbance of the amplitude and phase of the accelerating field. There is a set of RF control electronics in use for LINAC operation. A preventive maintenance activity is undertaken every year before the LINAC experimental run. This year's maintenance was done from October to December 2022.

The amplitude and phase locking closed loop electronics consist of a resonator controller (one for each cavity), an input module (one for a set of 4 cavities), and a reference splitter (one for a set of 4 cavities). These are operated by a self-excited loop mechanism. To cater for the operational needs of the whole LINAC, there are a total of 27 resonator controllers, 8 input modules, and 8 reference splitters. The RF group has a total of 38 resonator controllers, 12 input modules, and 10 reference splitters. As part of comprehensive preventive maintenance activities, all the electronic modules are serviced, repaired, and tested in a room-temperature test setup. In this year's maintenance activity, a total of 36 resonator controllers, 12 input modules, and 10 reference splitters were thoroughly repaired, tested, and made ready for usage in the LINAC experimental run. This ensures the availability of a sufficient number of ready-to- u s e spares to ensure seamless operation.

The resonator controller and allied electronics take care of all the fast amplitude and phase variations. However, due to some prominent mechanical disturbances called microphonics, there is a slow variation of phase as well. In this slow variation control scheme, there is a tuner bellow, which is deflected by using a piezoelectric actuator for fine adjustment of the frequency in place of helium gas. A feedback controller for piezoelectric actuators is used for dynamic phase correction. The phase of RF pickup from the cavity is taken as feedback, which is proportional to the deviation from the resonance. Currently, 16 cavities are equipped with piezoelectric actuators. The preventive maintenance is done to repair and test the control electronics. This year, a total of 19 piezoelectric tuner controllers were made ready for usage in the LINAC experimental run.

LLRF Systems for High Current Injectors (HCI)

High Current Injector (HCI) consists of at least ten numbers of phase-synchronised RF systems such as Multi-Harmonic Buncher (MHB), Radio Frequency Quadrupole (RFQ), six Drift Tube Linac (DTL) cavities, and three Spiral Bunchers (SB). To meet the requirements of these RF systems, low-level radio frequency (LLRF) controls of the analogue control-based generator-driven type were developed and installed. These controls were successfully used in the beam acceleration tests of HCI. LLRF-VME interface modules to enable the remote operation of RF systems were also developed and installed.

Presently, the controls for RFQ, Spiral Buncher #1, and DTL #1 to #6 are installed and used successfully. During the years 2022–23, the following major jobs have been carried out to address the requirements of HCI as planned; the details are given below.

Last year, LLRF controls were tested for a DTL cavity and found to be working as per the desired specification. This year, LLRF control modules were installed in all the DTL cavities of the HCI facility and made operational. Each RF cavity is connected with a set of amplitude and phase controls (APC) and frequency tuner controls (FTC) to control amplitude, phase, and frequency respectively.

Beam bunching system of HCI

During beam acceleration testing, N6+ beam having bunch width of approximately 3ns was effectively achieved, while Ag19+ metal beams having 8ns bunch width were observed for the first time when the metal beam was tuned. The beams are bunched by the MHB controller, which generates a pseudo saw-tooth wave by combining the frequencies of 12.125 MHz, 24.250 MHz, and 36.375 MHz in amplitude and phase proportion. A fast Faraday cup was used to detect the bunch width, and a 4 GHz oscilloscope was used to measure the beam bunch.

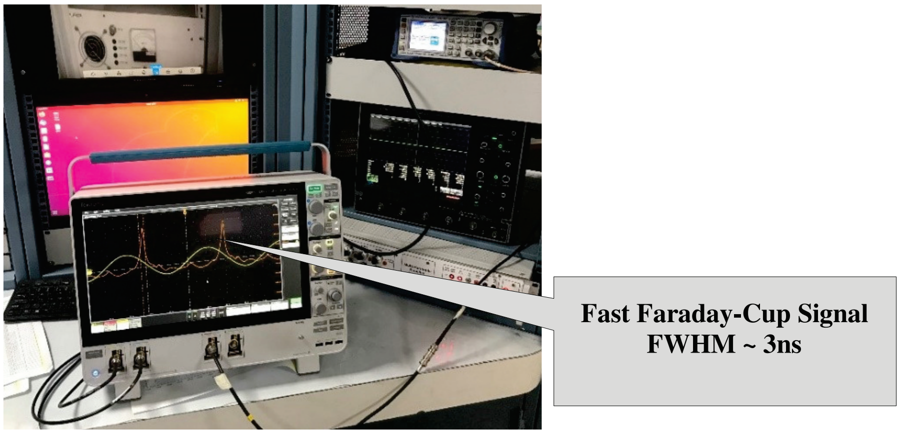


Figure 4: Bunched Beam Measurements in the IUAC main Control room.

Development of LLRF Systems for Spiral Bunchers

Two sets of amplitude, phase, and frequency tuner controls for spiral bunchers #2 and #3 have been developed, tested, and kept ready to install in the beam hall. These controls are similar to the ones installed with RF cavities in HCI. They are mainly operating at 48.5 MHz, like RFQ and Spiral Buncher #1, unlike the DTL cavities, which operate at 97 MHz. The controls mainly comprise two modules for one cavity, namely the Amplitude and Phase Control (APC) module and the Frequency Tuner Control (FTC) module. LLRF-VME modules to enable remote operation of spiral bunchers are also developed and ready to install. The development of FTC controllers to replace the existing FTC controllers for RFQ and SB#1, as well as spare controllers, is currently in progress.

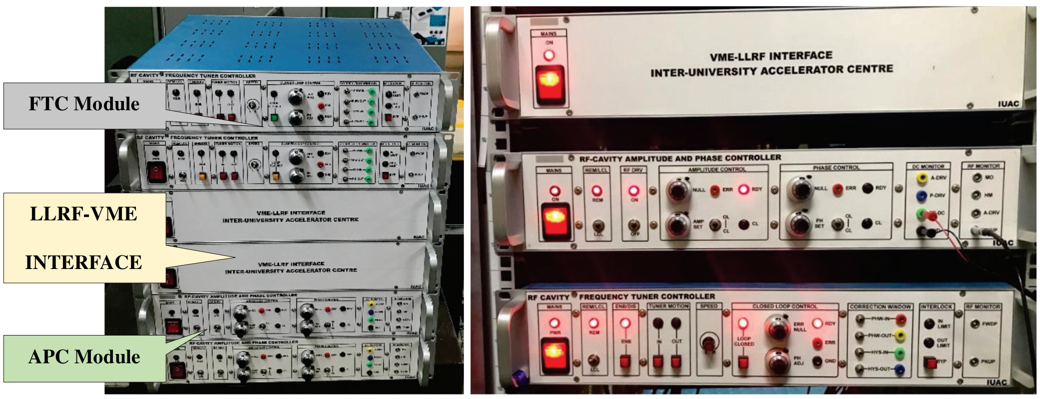


Figure. 5 LLRF-VME Interface during Testing and RFQ powered remotely using the Interface

Testing of Remote Operation of DTL Cavities

Although LLRF-VME Interface modules were developed and installed for RF systems in HCI, they have not yet been utilised in beam acceleration testing due to the shortage of VME hardware. Recently, the VME hardware resources were optimised to handle the crucial parameters needed for remote operation of the RF systems. As a result, all DTL cavities are checked for remote operation. Testing of other cavities will be done shortly.

Replacement of Interconnection Cables with Double-Shielded Cables for LLRF Controls as a precautionary measure to avoid cross-talk in the RF system, the interconnecting cables of LLRF systems have been replaced with double-shielded cables. The cables are labelled on both sides for documentation.

Preventive Maintenance of LLRF Controls for HCI

As a precautionary measure to avoid cross-talk in the RF system, the interconnecting cables of LLRF systems have been replaced with double-shielded cables. The cables are labelled on both sides for documentation.

LLRF Systems for Free Electron Laser (FEL)

The RF system of FEL consists of an LLRF system along with a Klystron-based 25 MW high-power RF source operating in pulsed mode for 4us pulse duration to power a 2.6 cell, 2860 MHz RF photo cathode gun. In order to control the amplitude and phase of the RF gun during 4us of operational time, commercial LLRF modules from Instrumentation Technologies were received along with the master distribution module. The modules are tested in open loop feed-forward mode and commissioned with high-power RF systems. An EPICS-based control scheme is developed and operationalized for testing. Feed-forward pulse ramping has been tried to reduce the problem of the initial high level of reflected power from the cavity.

Final Installation and Commissioning of High-Power RF Systems of IUAC-FEL

The final stage of installation and commissioning of the High-Power RF system of IUAC-FEL facility was carried out in the month of July 2022. The aim of this activity was to install a SF_6 based 4-port, high power Isolator consisting of a Ferrite Circulator, with a high power and a low power matched load. This installation was necessitated by the fact that in the absence of a circulator, the RF system consisting of a high-power klystron source was experiencing an increased reflected power from RF cavity side; so much that it was impossible to condition it beyond 1 MW as against rated power of 25 MW. Subsequently, the circulator and associated RF system comprising RF window, straight RF waveguide section, SF_6 filling and gauge kit was delivered by M/s Scandinova Systems AB, Sweden. In the presence of a service Engineer of M/s Scandinova, final installation was carried out between 03/07/2022 and 14/07/2022. Major goal of this activity was to remove few existing vacuum waveguide components and install the SF_6 based circulator.

The following components were removed from the beam line:

1. Double H-bend,
2. Waveguide Pumping Section,
3. Ion Pump and Ion Pump Controller

The following components were installed in the beam line:

1. Waveguide straight section
2. 4-port circulator with gas filling kit and water connection
3. ARC detector and associated interlock electronics
4. Ferrite load and dry load, along with water connection
5. RF Window

All the water connections were made and thoroughly checked. The SF_6 cylinder arranged by IUAC was connected through a gas filling kit comprising a regulator, a digital pressure switch, an analogue dial gauge, and a gas relief valve. High and low interlock limits were properly set and checked in the SMC-made digital pressure switch. An optical fibre-based arc detector was mounted, and interlock electronics were made, tested, and activated in the software. Similarly, interlocks from digital pressure switches (high and low levels) were made, tested, and activated in software.

Finally, high-power RF testing was done continuously for 4 days, and a maximum of 1.8 MW RF forward power with a 1ns pulse width could be reached. The problem of high reflected power from the cavity was solved, and currently the system has been conditioned to 8 MW. A photo-cathode-induced electron beam energised by the RF gun up to a field gradient of 65 MV/m has also been successfully demonstrated.

Upkeep and breakdown Maintenance of High-Power RF Systems at IUAC-FEL

The RF Group is responsible for the regular maintenance and upkeep of the high-power RF system at IUAC-FEL. It mainly consists of a high-power, solid-state, pulsed modulator of ScandiNova feeding a cathode of a Klystron tube of Toshiba and acting as an RF amplifier. The system requires the circulation of water at 24 degrees, which is done by a powerful 30 kW chiller from M/s. Schwamle. The pulsed modulator consists of high-voltag charging capacitor power supplies and high-voltage IGBT fast switches feeding multiple primary windings of a split-core transformer immersed in a high quality transformer oil of Shell Diala make. At the secondary of the pulse transformer, a peak voltage of 251 kV and a peak current of 255 A are generated to cause thermionic emission from a cathode towards the klystron. A low-power RF signal from an external signal generator is amplified through a solid-state river amplifier and klystron.

The above system has been continuously operational since its installation in July 2022. For the regular upkeep activity, klystron operation is halted once every 15 days, air filters are changed, humidity sensors are checked, and the modulator is cleaned for dust. The cleaning of filters inside the chiller room and the radiator of the chiller is also done thoroughly. A water top-up, if required, is also done at the same time.

Apart from that, there were two breakdown repair and maintenance activities performed. One in August 2022 and another in April 2023. In both instances, an IGBT and a protection diode became faulty and burned in a switching unit and a CCPS unit respectively. Due to the availability of spares from the manufacturer, faults on both occasions were repaired within a span of 2–3 days. After hardware repair, over-current trip limits are also adjusted on the repaired switching unit. Apart from hardware faults, a software issue was also experienced by the modulator, which prevented it from starting. The manufacturer, M/s. ScandiNova, was contacted to provide resolution in remote mode for this problem.

The RF system of FEL consists of an LLRF system along with a Klystron-based 25 MW high-power RF source operating in pulsed mode for 4μs pulse duration to power a 2.6 cell, 2860 MHz RF photo-cathode gun. In order to control the amplitude and phase of the RF gun during 4μs of operational time, commercial LLRF modules from M/s. Instrumentation Technologies were received along with the master distribution module. The modules are tested in open loop feed-forward mode and commissioned with high-power RF systems. An EPICS-based control scheme is developed and operationalized for testing. Feed-forward pulse ramping has been tried to reduce the problem of the initial high level of reflected power from the cavity.

3.1.7 Health Physics

Debashish Sen, Shaila Bahl & Birendra Singh

Ensuring the radiation safety of the IUAC radiation workers is the preliminary duty of the Health Physics group of the centre. The personnel monitoring system and the area monitoring set up are taken care of by Health Physicists. Routine maintenance of interlock system and radiation monitors is also done regularly to keep a vigil on the overall radiation safety. Creating awareness about radiation safety among the 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 & Institutes.

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. **Interlock systems, interlock doors**, **display boards**, which were malfunctioning, were repaired, and some of them were repositioned also, as per requirement. Some new **radiation shielding** was provided in different areas as per requirement.

3.1.7.1 AERB inspection & 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 & regulatory requirements and licensing conditions. A self-assessment checklist is created which helps the Employer/Licensee to verify that all the safety & regulatory requirements related to the licensed activities / practices are being met, and can be used as an audit tool or not. 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. A thorough **AERB inspection** by AERB officials took place in April 2022. AERB officials visited all the sites to monitor the existing condition of the facilities. The whole inspection process was completed successfully to the satisfaction of the AERB officials. Few recommendations were made, which are getting incorporated.

IUAC got 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 & 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 three years. Any reported deviation will lead to a reduction in eSPI value of the institute. IUAC got a 1.0 rating in all the categories.

3.1.7.2 e-LORA facility of AERB

Electronic **L**icensing **O**f **R**adiation **A**pplications (eLORA) System is basically a web-based application for automation of regulatory processes for various 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.

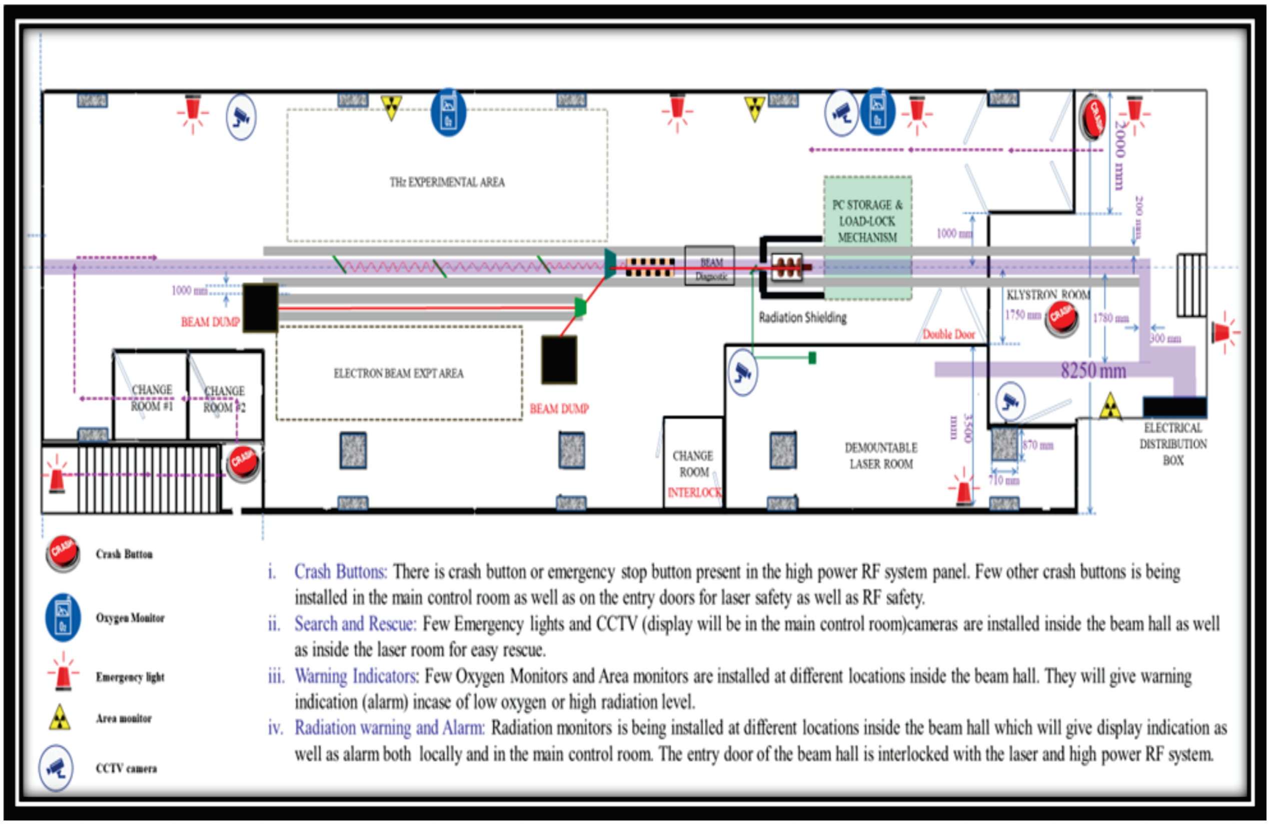
This facility was used regularly to update our radiation facilities and safety system. It includes

- Sending the **quarterly periodic safety status reports** of the running radiation facilities.
- **Renewal of license** of the running radiation facilities.
- **Online Submission of necessary documents** to obtain the license of forthcoming facilities (FEL & HCI)
- **Calibration records** of the radiation monitors and the survey meters.
- **Amendment of issued licences.**
- **Any Adhoc requests** for some radiation related requirement.
- RSO assignment formalities has been initiated for the two newly joined ad-hoc employees of Health Physics. One of them will be deputed at GGSU, Bilaspur and will correspond with AERB on IUAC's behalf.
- Renewal of RSO licence.
- Initiation of the document communication/submission process through eLORA regarding the upcoming **Geo chronology facility of IUAC at NOIDA.**

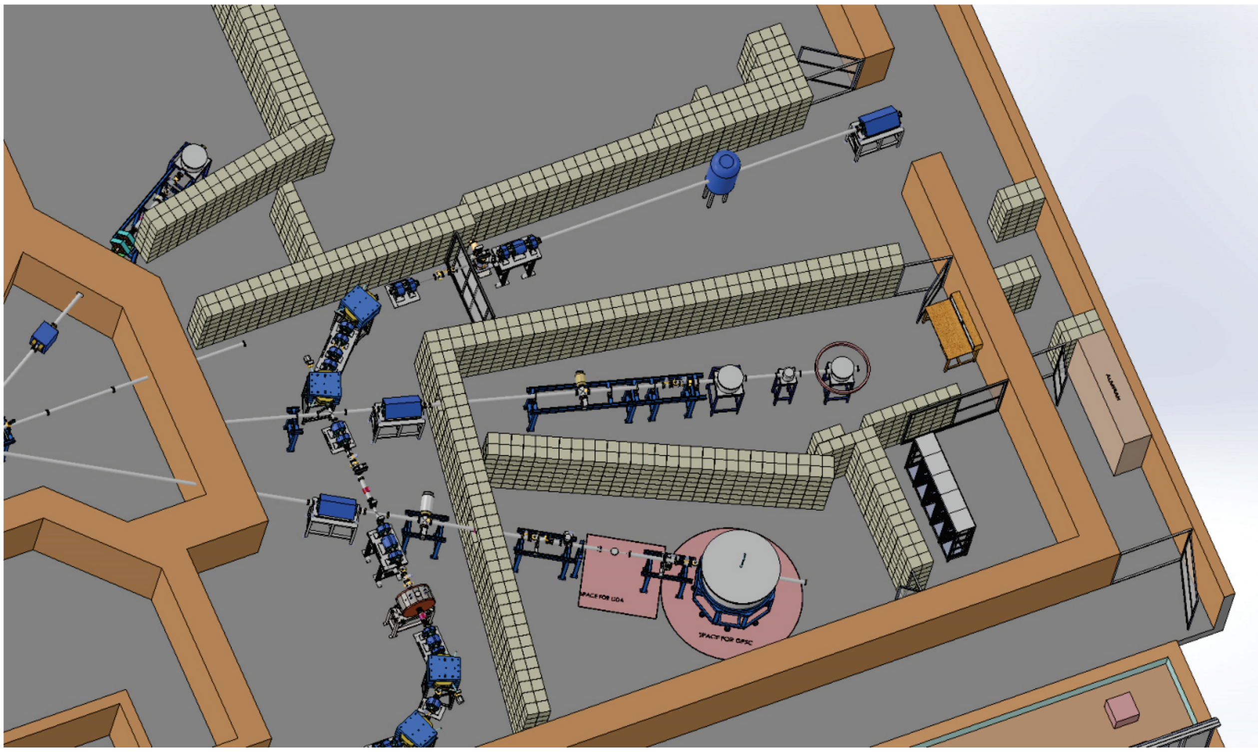
3.1.7.3 Upcoming facility requirements

A. Free Electron Laser (FEL) Facility

Safety features planned for FEL Facility are getting implemented.



B. **Shielding adjustments as per installation of HCI line in the corridor and Beam Hall 1 are getting implemented as per requirements**



C. Trial run of high current (1 μA) Proton of energy 25 MeV (along with other light and heavy ion beams) was carried out, and the detailed radiation survey report was submitted to AERB for amendment in beam parameters mentioned in the Pelletron license letter.

Inference: During proton run of 25 MeV and current < 100 nA, areas interlocked should be Tower, Vault I, Beam Hall I with all adjacent corridors, and only the Vault II area. Other areas may be kept accessible.

BUT during proton run of 25 MeV and current > 100 nA, areas interlocked should be Tower, Vault I, Beam Hall I with all adjacent corridors, the Vault II area, and also the Beam Hall II areas (to safeguard non-radiation workers). Other areas may be kept accessible. Special care has to be taken for reception area. * [In this case, No access in the office reception area. Restricted access in the staircase-way adjacent to tower]

As far as high current Proton Beam is concerned, it will be for translational research with special reference to Brachytherapy and radiation hardness tests of ISRO/DAE, henceforth, it will be only limited to such applications once in a while. These extreme conditions will be only when we plan to run proton at such high current otherwise historically up to 50 nA only (where the reception area may be kept as such accessible).

Survey reports for other beams (with maximum energy and maximum current) for below mentioned beams have also been carried out and submitted to AERB via eLORA.

Approved beam parameter list by AERB

Beam species	Maximum energy (MeV)	Maximum current
^{1}H	27	1 μA
^{7}Li	52	30 pnA
^{12}C	85	10 pnA
^{28}Si	130	10 pnA
^{58}Ni	180	5 pnA
^{197}Au	200	1 pnA

3.1.7.4 Status of AERB licence of running radiation facilities at IUAC:

Facility	Status	License valid till
Gamma Irradiation Chamber	Running	19/10/2023
Pelletron – LINAC facility	Running	03/03/2024
RBS Facility	Running	03/03/2024
NII Facility	Running	03/12/2025
LEIB Facility	Running	16/09/2026
AMS Facility	Running	30/09/2027

3.1.8 DATA SUPPORT LAB (NIAS-DAQ GROUP)

Mamta Jain, Kusum Rani, Subramaniam E. T, R. P. Singh

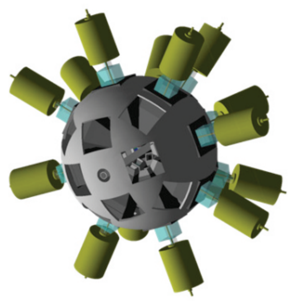
3.1.8.1 Introduction

Next-gen Instrumentation & Acquisition Systems group at IUAC maintains all the Nuclear Physics DAQ setups @ IUAC with 100% uptime. At the same time the group develops various modules and their control and analysis software indigenously, to fulfill the present and future needs of data acquisition systems & control systems applications.

This year **Installation, Testing and Commissioning** of all the prospective ROSE-MARS based DAQ have been completed, almost all the newly commissioned beam lines conducted in-beam experiments also. A brief description of NIAS-DAQ group's contribution for this year is listed below.

3.1.8.2 GEANT 4 Simulations for 24 clover array in INGA@IUAC

(Subramaniam E. T, Mamta Jain, R P Singh)



To study the different experimental conditions using the GEANT-4 simulations.
*The basic characteristics of the clover detectors along with zero/one/two non-working crystals and effect on the clover array efficiency and peak-to-total at different energies were simulated.
*The effect of variation of source position on the photo-peak efficiency and peak-to-total ratio of clover detectors for gamma rays from a 60Co radioactive source were also studied

The details of the study were reported in DAE symposium on Nuclear Physics -66 (2022) with following title
G82. Simulation study of clover detector performance in INGA at IUAC ***Pg 1238***

3.1.8.3 NiasMARS Upgradations

Subramaniam E. T., Mamta Jain

The NiasMARS has been upgraded for latest stable version Ubuntu-22.04 for the currently running VME controllers ROSE-II (USB3.0 based).

3.1.8.4 Mass Production of ROSE-II, the VME crate controller

(Mamta Jain, Subramaniam E. T.)

The mass production of the ROSE-II with USB3.0 has been completed for all the currently running DAQ setups at IUAC and the control system application, all are tested thoroughly for reliability, performance, and stability. The serial bus communication link performance tested for super speed standards in the lab.

✓ **a. *ROSE-II@DAQ (DATA Acquisition)***

4 ROSE-II modules were delivered to 4 different beam lines after doing step by step testing for full functionality.

✓ **b. *ROSE-II@CTRL (Control System)***

7 ROSE-II VME controllers has been tested and given to Remote Control Group. Following tasks were performed for ROSE-II in control system application

- Written serial port communication program for control systems requirements for tesla meter type applications.
- Installation of Ubuntu 20.04 based local boot setup in all the 7 SBCs of the controller and then tested with control system ADC and DAC in the lab.

This work has been published in RSI international journal

A VME: Versa Module Europa, crate controller for high speed data acquisition of heterogeneous, multidetector systems Review of Scientific Instruments, 94, 013304(2023)

3.1.8.5 BPM Digitizer

Kusum Rani, Subramaniam E. T.

Single channel BPM digitizer with USB 3.0 back plane along with a embedded PC has been packed in a 170*170*55 mm compact box which takes 24V DC supply as power input and has a RJ45 connector to operate the digitizer remotely.

Two has been made and deployed in HCI Deck area and eight more has been produced this year in which four are ready to use while rest of the five are in fabrication process.

3.1.8.6 Mass Production of Cable Adapter

(Kusum Rani, Subramaniam E. T.)

LEMO to FRC adaptor module has been deployed in INGA DAQ experimental setup last year as an interface between the lemo output based shaping amplifier and FRC input based ADC.

Eight more module has been produced and fabricated this year to cater the need of different beam line DAQ systems.

3.1.8.7 Mass Production of LVL Translator

(Mamta Jain, Subramaniam E. T.)

Last year 16 channel NIM to ECL level translator module has been designed and developed for ECL input based CAEN TDC and VME-GEM modules in the newly installed VME based DAQs @IUAC. Mass production and testing of the 9 module has been done for ROSE based VME DAQ setup in different beam lines.

3.1.8.8 Completion of Commissioning, Installation and Testing of New MARS-ROSE based VME-DAQ @ IUAC

All the CAMAC-DAQ @ IUAC have been upgraded with VME-DAQ using in-house developed the VME crate controller ROSE along with the acquisition and acquiring software MARS. This year GPSC, HYRA, LEIBF and GDA beam lines were commissioned with ROSE-MARS based VME-DAQ remaining beam lines were completed in the last academic year.

VME-DAQ @ HYRA

(Mamta Jain, Subramaniam E. T.)

To test the VME-DAQ @ HYRA a facility run was taken after the functionality test using pulser. During the facility run the DAQ fully was tested with Independent strobe option as per HIRA /HYRA setup requirement. And in continuation of the successful facility run, the in beam user experiment was performed.

VME-DAQ @ GPSC

(Mamta Jain, Subramaniam E. T.)

GPCS DAQ has been revamped, shifted from the data room to phase-I data acquisition room in beam hall - I. After the pulser test the DAQ has been tested with two different sources 22Na & 60 Co and two baF2 detectors to create in- beam experiment type situation with proper correlation between ADC and TDC data. A thorough testing of newly purchased VME QDC was done to resolve the issues, raised by user, related to smeared spectrum and missing peaks etc. Two options for QDC gateIN were tried, 1) gate input from ROSE and 2) gate input from GDG to check the required gate width with BaF2 detectors and termination conditions. Finally the QDC has been tested with 60Co source and correlation between the data has been found satisfactory so, now it can be used for in-beam experiments in future.

VME-DAQ @ LEIBF and GDA

(Mamta Jain, Subramaniam E. T.)

The LEIBF and GDA VME DAQ has been tested with pulser, later in LEIBF one in-beam experiment has been performed successfully. In GDA, source run data with one clover after the coulomb excitation experiment has been taken to compare The old AD814 data vs Mesytec MADC32 data.

This work has been reported in DAE symposium on Nuclear Physics -66 (2022)

G61. New VME based data acquisition systems for nuclear physics experiments at Inter University Accelerator Centre 1196

Schools on Data Acquisition Systems and Data Analysis

Gonika, Mamta Jain, Kusum Rani & Yash Raj, Subramaniam E. T, R. P. Singh

A three days schools was organized in offline mode to provide experimental insights related to DAQ and their DATA. During the school, participants were introduced with the fundamental and key features of DAQ systems along with practical sessions. In present scenario the data collection happens in ROOT format in all the laboratories like TIFR, IUAC etc. so the ROOT based Data Analysis was also discussed and taught. For futuristic view the digital signal processing was also taught by the experts. All the classes were taken by the exponents in field of nuclear physics and data acquisition to provide extensive details about DATA Acquisition, Acquire and Analysis. The school was found very helpful to all the users for their data analysis and a better understanding of the overall DAQ systems.

3.1.9 COMPUTER AND COMMUNICATIONS

B.K. Sahu, Abhishek Kumar, D. Munda

Post COVID-19 era, a lot of dependency on IT related infrastructure for the hosting of events and academic programs in online mode along with in person mode. The events and meetings were organized in the hybrid mode. The group had put up all the efforts to keep the 100 percent uptime of the network connectivity throughout the year. Necessary upgradation and arrangements took place for implementing a dedicated server for conducting schools, workshops and conferences. New servers were added for the access of subscribed journals of library from outside network. Apart from these, developments, the routine maintenance of packages, and servers were carried out. Highlights of these activities are mentioned below.

3.1.9.1 Status of servers

(a) Central servers

This year the email server of IUAC was attacked with malicious code due to exploitation of a critical vulnerability in the software suite. The entire data was recovered without loss and critical vulnerability was patched with the updated version of the software suite. The email server was enhanced with better security by the implementations of policies such as enforcement of strong user password and locking of accounts after failed login attempts to name a few. Changes at the firewall level were made to ensure the admin panel to be made available only in IUAC network. The performance of all other servers like Enterprise Resource Project Server (ERP), Web Server, LMS server were found to be satisfactory.

(b) Solid work licensing server status

The group used to maintain a solid works licensing server having 2016 solid works edition. A cloud-based solution of solid works (2023 edition) has been procured this year. The latest version of the solid work application was configured on 15 user accounts with active support being provided in case the user has difficulty in using the services.

(c) (Identity Provider) IDP server

Identity Provider server (IDP) has been installed with the help and support of the INFLIBNET, Gandhinagar. The IDP server has enabled the researchers to access the research articles and other e-resources from outside the IUAC. It also serves as the single sign-on for reference management services provided to IUAC by well-known reference management software. Along with it (Lightweight Directory Access Protocol) LDAP server was configured so that it can help in the user management of the IDP server users. Appropriate ports and policies were implemented on the firewall for the proper Network Address Translation of the incoming traffic to IDP and LDAP servers

3.1.9.2 Status of Network and Internet services

(a) Switch installation

This year one of the access switches went down in the Engineering lab building which resulted in network downtime for the Engineering lab and mechanical workshop. A new spare switch was configured and was deployed in place of the faulty switch. We are in the process of replacing ten years old switches installed at various locations, that has been showing signs of abrupt failing. The group has procured two switches which will be kept pre-configured in order to minimize network downtime.

(b) Wireless access point installation

As the demand for wireless connectivity keeps on increasing, new wireless access points were provided in new guest house and main building reception area. New wireless access points are provided near the Pelletron tank and entire experimental beam hall and MRI test area for better connectivity during operation and maintenance period. Additional access points were provided near Library and committee room for improving connectivity during meetings.

3.1.9.3 Communication systems

(a) Status of new IP based PABX System

Last academic year, we had upgraded the Siemens HICOM 330E EPABX system to a hybrid EPABX system from Matrix technologies. The new EPBAX system catered to nearly 290 analog extensions including connections to housing blocks, common areas, guest houses and hostels having limited network access along with IP based phones installed in the existing network. This year 30 more IP based phones are installed in addition to existing 20 Ip based phones and made operational. The freed analog extensions were provided to the rooms in the new guest house. Besides this, in order to provide full mobility in the lab complexes and experimental areas, 40 number of soft phone connections were being provided. The operational efficiency of the new EPABX system is found to be more than 99% without any breakdowns.

(b) status of Video conferencing systems and CCTV surveillance

This year also many of the events listed in the academic calendar were organized in hybrid mode using physical meeting halls and on-line video conferencing using Google Meet, Webex platforms. 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 expect failure of a Bose Audio Amplifier was reported. This year additional CCTV surveillance was provided in New Guest House and mechanical workshop area. CCTV surveillance systems was routinely maintained.

3.1.9.3 Developmental projects

(a) Computer Group Inventory Module and support for Workshop and conferences

The group has developed an inventory management module which can provide access to data related to assets of the data center and computer machines, printers being used in different buildings of the center. The same is being planned to be further modified for management of inventories by different groups of IUAC. Last academic year, a web-based application was developed by the group to create and publish forms for different application. In scenarios, where quick forms need to be created on standard templates, the application can be used. In the same line, this year another module was added to create standard conference, seminars and workshop websites using standard template. The website created can be managed by the creator through a user interface which is access protected. This year, twenty-one forms and five workshop websites have been created using the application.

(b) Development of Data storage solutions

Data storage solution was created using the already available data storage servers of the HPC. The data storage of 20 TB usable capacity was configured with RAID 10 with samba access for file transfer and retrieval. The samba client was installed on group members' computers so that official data like recordings, data backup of servers can be put on the data storage with access protection.

(c) Status of 3PF supercomputing facility

A 3 PF Supercomputing computing facility under National Supercomputing Mission (NSM) has been approved for installation at IUAC with support of technical team from CDAC. Appropriate data center for housing this facility was worked out in consultation with CDAC. Approximately 1800 Sq. ft. place was identified in the existing building of IUAC for the setting up the server room along with another 2000 Sq. ft. for supporting infrastructure. The design specification of the upcoming data center of the computing facility was finalized and the foundation stone for the upgraded data center was laid by Prof. M. Jagdesh Kumar, Chairman UGC. The contracts for the data center, racks and servers were awarded this year by CDAC through open tender and preliminary work started. As the Computing facility will serve as virtual inter university computing center and provide high performance computing access to all the researchers in the university system, IUAC has started interacting with various computing user community for creating potential user base from interdisciplinary branches within the university community.

Figure.1. Laying Foundation of upgraded Computing facility of IUAC

3.1.10 ELECTRONICS FOR CRYOGENICS

S R Nirdoshi, M Kumar, S Babu, J Antony

3.1.10.1 CRYO-DACS TRV-GUI software

A 48-channel temperature cum vacuum GUI data viewer, logger and trend monitor software was developed to replace the old VME system. This utilized six home-built cryogenic TRV instruments to replace the old VME crate system with an indigenous distributed crate-less system for measuring all vacuum and temperatures signals from LINAC. Each channel-display of this device can be separately configured as a Temperature/Resistance /Volt (TRV) meter using a front-panel keypad. Flash storage, multiple calibration curves, a VFD display, eight fast voltage outputs, and distributed connectivity directly to the Cryogenics control room are some of the additional features it offers. There are 3 current sources for each channel (10μA - 2mA). The low-temperature measurement (4.2K- 350K) can be done for a variety of sensor like silicon diodes (DT470 & DT670), pt-100, carbon ceramic sensors (CCS), and custom sensor. Sensor inputs are read by a 12-bit A/D converter. The data logger software has unlimited historical trends and a real-time viewer. In order to facilitate quick access due to radiation restrictions, these new TRV devices are stationed away from the radiation zones. In addition to being inexpensive, these instruments can be used as import replacements. One of the pages of software front-end at Cryogenic control room is shown in figure 3.1.10.1.1.

Fig. 3.1.10.1.1: One of the pages of TRV software installed in cryogenic control room

3.1.10.2 Dual meter for LHe level and temperature measurement

A new device (figure 3.1.10.2.1) is developed that uses a Super Conducting LHe Level Gauge as a sensor for measuring both liquid helium level and a temperature inside. This device measures LHe level (0-100%) and temperature (4.2K-300K) with auto switching facility for either mode of measurement. A switched HV current source is used to produce constant current of 70 mA, 5 W power with a voltage compliance of ~50 volts. At present it runs in pulse mode with a default frequency of 0.02 Hz and sample-interval of 10 seconds. ADC reads 100 times during the sampling interval and averages data to reduce noise. These pulsing parameters are web programmable. The system utilises a static IP address and has an embedded http server to work as an IoT device. A mobile app has been designed for the remote view of real time data on any Android mobile. A test run for this unit was conducted during the last LHe plant cooldown and data analysis is currently underway.

Fig. 3.1.10.2.1 An auto-switching 1000-L Dewar cool-down device

3.1.10.3 Pressure display server

LINAC cryostats have pressure sensor in LHe and LN_2 dewar and the existing standalone displays were malfunctioning due to ageing. These faulty units have been replaced with 2 numbers of homebuilt electronics each having 5 pressure inputs. Each of the device can be read in real time though the existing data acquisition system and the pressure unit can be read in multiple units (bar/psi) as shown in figure 3.1.10.3.1.

Fig. 3.1.10.2.1 An auto-switching 1000-L Dewar cool-down device

3.1.10.4 PT1000-based electronics & fast data logger

A Pt-1000 sensor-based electronics device has been prototyped and tested for high sensitivity low temperature (~78K) measurements. The sensor has 1000-ohm resistance at 0-degree C and is activated by using a constant current source of ~1 mA. A fast temperature recorder (-10 ms) with high sensitivity and Ethernet connectivity (figure 3.1.10.4.1) has also been developed and tested. The measured sensitivity of the device is ten times higher than that of a standard Pt-100 sensor. The system is planned to be used for automation of LN_2 filling system of an experimental facility at IUAC.

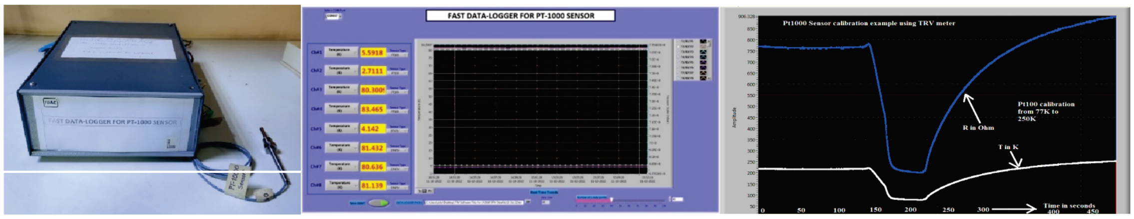


Fig 3.1.10.4.1 Pt-1000 sensor electronics, data-logger utility & calibration results

3.1.10.5 Gas pressure controller for NAND detector facility

An improved version of indigenously developed pressure controller electronics for MWPC detector in NAND facility has been successfully tested. It uses a flow transducer for pressure and a proportional control valve for PID control of the detector chamber pressure in the range of 0 to 100 mbar. The pressure control is required to have both fast and slow time setting to achieve diverse experimental requirements and also satisfy the failsafe mode of operation. This is achieved by using dynamically varied multi-PID settings for different operations. During control operation there is the stringent need for minimum pressure overshoot and hence such electronics can also be suitable for thin foil-based detectors. For safe operation during power failures, the gas inlet valve is instantaneously put off. The LLT and ULT alarm limits are web programmable from a PC or a mobile and alarms can be viewed remotely. The device has a built-in http server over Ethernet and hence is monitored / controlled through an Android App or IoT real-time analytics platform.

This PID device has been tested at different control pressure (2mbar-100 mbar) with diverse operational scenarios and has been found to be stable at all set point between 0 and 100 mbar. During the testing the steady state error is measured to be within $\pm$ 0.2 mbar. This development has successfully replaced an imported controller (MKS make gas flow controller model no-250E) and is found to have better remote control and monitoring facilities.

Fig. 3.1.10.5.1 A special low-overshoot Gas Pressure and flow controller under test in NAND

3.1.10.6 IMRI-magnet DAQ software

The following are some MRI data acquisition activities that have taken place this year:

a) During the IMRI TRAC meeting-2022, the completed MRI software was remotely demonstrated to the team using simulated signals. A group of SAMEER engineers were also trained on this software.
b) The design of a quick MRI data acquisition system employing FPGA has been documented in a technical cum operation manual.
c) With the aid of the Curve Handler utility, resistance vs. temperature curves for CCS and Cernox sensors have been successfully transferred to the Lakeshore temperature monitor.
d) A Windows installer of the developed IMRI software has been created to enable simple application transfer between computers.

3.1.11 ION SOURCE GROUP

Radhakishan Gurjar, Mukesh Kumar and A. Tripathi

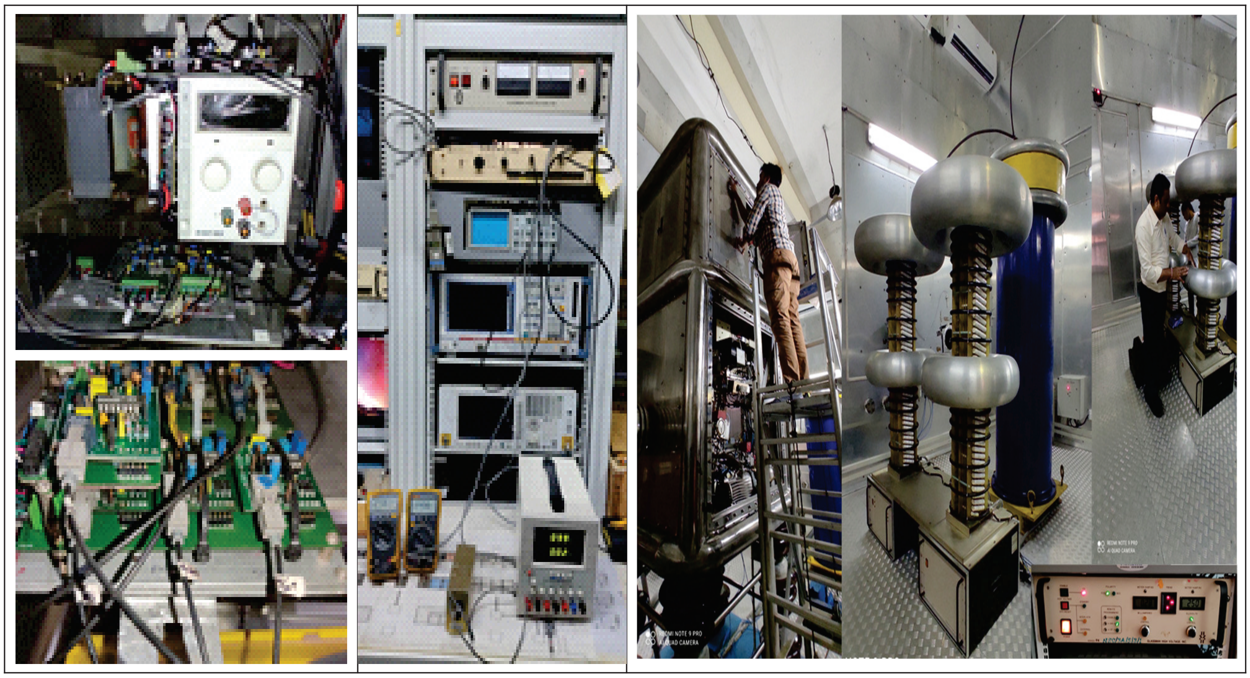
The Ion Source Group (ISG) is an Accelerator Facility Central Support Group (AcSCG) which takes care of the activities of ECR Ion sources on high voltage platform and associated electronics including High Voltage power supplies (HVPS), Light Link Interfaces, HTS Coils related Electronics and System operation and maintenance. The group also provides technical support to other groups regarding HVPS and development activities.

The yearly activities related to maintenance, upkeep and development are summarized below:

Preventive Maintenance Schedule of ISG Instruments:

The group performs yearly scheduled preventive maintenance of every instrument to preserve its life, performance and to ensure breakdown-free operation during the year long continuous operation.

- In HCI ion source: High Voltage Power Supplies (HVPS), the Deck HVPS (200kV), Extractor and Focus HVPS were cleaned. All the loose connections were checked and operated by remote control. Besides this bleeder were cleaned and covered with acrylic sheet.
- In LEIBF ion source: all High Voltage Power Supplies (HVPS), Ex. Deck HVPS (400kV/12mA), Extractor and Einzel HVPS were cleaned. All the loose connections were checked and operated by remote control. Besides this, bleeders were cleaned and covered with acrylic sheet.
- All Fiber Optics instruments were cleaned and checked the all loose connections.
- All power supplies were operated in local mode and remotely with and without load. Finally, all high voltage power supplies are in working order.



Installation and repaired work of ISG Instruments:

- Installation of oven power supply (60V/5A) and the changed the signals in the fiber optical communication system as per oven power supply.
- Repair of HCI deck HVPS (200kV/5mA): Deck HVPS was not working due to faulty remote module. This power supply was checked in the lab with extension cable. The cable was made in our lab. Some signals were not coming from PWM and op-amp ICs. So, changed the faulty ICs. The deck HVPS is working fine.

Repair power supply of Electron Gun (2kV): This power supply used for ionizing atoms in the ion trap. In this power supply, 24V was not coming from power section. This problem was occurring by burn transformer and 24V regulator IC. So, we used new SMPS for generate 24V DC and change the faulty 24V regulator IC. Now, electron gun power supply is working fine.

3.1.12 Remote Control Lab (REC Lab)

Deepak Kumar Munda, Ruby Santhi, Kundan Singh

3.1.12.1 Control electronics for HEBT section of HCI beam line

The HCI beam line is progressing into the final phase of installation and is being coupled with the existing zero degree beam line at the entrance of linear accelerator (LINAC) modules. The Remote Control (REC) lab is involved in developing the hardware and software for remote control / monitoring of beam line components, viz. Faraday cup (FC) controls, beam line valve (BLV) controls, beam line pressure monitoring, magnet power supply controls, controls of RF cavities (DTL), quadrupole (RFQ) and spiral buncher etc. We have adopted high density VME bus based control hardware and indigenously developed almost all kinds of control modules, Input/Output (IO), and bus controller, which are required to run the facility. To protect these high density VME I/O modules, spike suppressing circuitry is developed indigenously in a modular form and housed in a 4U height chassis.

Figure 1: VME Crate system with bus controller and I/O modules

Figure 2: Spike Suppressor modular circuitry: To VME modules

Figure 3: Spike Suppressor modular circuitry: To beam line Devices

3.1.12.2 CAMAC-to-VME system migration with Pelletron Accelerator at Ion Source

After successfully completing the control electronics i.e. CAMAC server to VME server, migration at 255-Level of Pelletron machine, we have partially completed the system migration at Pelletron Ion source. The migration from CAMAC system to VME system was started, in phased manner, without disturbing the experiments schedule of accelerator users. With the help of Pelletron group, the control of all the beam line devices, controlled or monitor from ion source CAMAC server, was fully migrated to VME server. Special router chassis was made to interface VME modules to Spark protection modules. Due to high density of VME modules, 11 CAMAC modules have been accommodated in 4 VME modules. So, it is a ~ 66% reduction in module count with this new system. The machine ran with this new control hardware at 255-Level and ion source for more than a year now without any problem. The new VME server is integrated with the existing main control console at control room. The hardware changes are taken care in the server software and are not visible to the operation personnel. The "Pcli" GUI is kept same.

CAMAC		VME	
N	Module	N	Module
5	ADC 16 CH 3512	8	VMEADC64 IUAC
6	ADC 16 CH 3512		
7	ADC 16 CH 3512		
8	ADC 16 CH 3512		
9	ADC 16 CH 3512	6	VMEADC64 IUAC
10	ADC 16 CH 3512		
2	DAC 10 BIT 3110	12	VME DAC64 IUAC
3	DAC 10 BIT 3110		
4	DAC 10 BIT 3110		
16	DAC 10 BIT 3110		
21	IGOR IUAC	15	VME IGOR IUAC

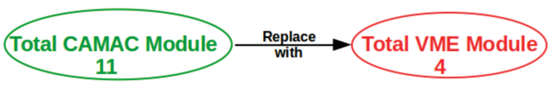


Figure 4 : VME Server at Pelletron Ion Source

3.1.12.3 RS232 Servers for Magnet power supply and RF power amplifiers

The HCI beam line in the HEBT section has approximately 40 magnet power supplies to be controlled and monitored. Each unit of power supply is controlled through RS232 serial interface with BAUD rate 9600. We have indigenously designed and manufactured customized RS232 servers where each can support 12 channels of RS232 interfaces. The BAUD rate for device communication can be programmed at the manufacturing stage of the unit. These are very low power, cost effective and light weight and occupy 1U, 19 inch wide rack space. It runs with linux operating system (OS) and have Ethernet connectivity with console client machine. RS232 servers are also setup for RF power amplifiers status monitoring. These RS232 servers for different power amplifiers and magnet power supplies are programmed with following parameters:

1) Remote control of Magnet Power Supply Controller with RS232 Server. This control requires Baud rate 9600, Data bits 8,1 Stop Bit.
2) Remote Control of QEI make 28kW RF Amplifiers with RS232 for (DTL: #4, DTL: #5) Control requires 19200 Baud Rate, 8 Bit,1 Stop Bit, No Parity, No handshake/flow control
3) DB Science 20 kW CW Solid State Amplifier for (DTL: #2, DTL: #3) Control requires Baud rate 115200, Data bits 8, Parity ODD, STOP Bit 1.
4) Remote Control of DTL #1 6kW RF amplifier (RS485 based RF power amplifier) Remote control and monitoring of RF power amplifier controls require Baud rate 19200, Data bits 8, Parity EVEN, STOP Bit 1

3.1.13 Analog Nuclear Instruments (ANI)

Arti Gupta, S. Venkataramanan, P. Sugathan

Nuclear Instrumentation

Analog Nuclear Instruments (ANI) group is having expertise in design, prototype development, characterization and mass production of various high quality analog front nuclear instruments such as pre-amplifiers, signal processing electronic functional blocks and functional blocks which are in regular use during various nuclear physics experiments. In the past, the group have delivered a large number of electronic units for GDA, INGA & NAND array for processing the signals.

Development of Timing Enhancer Module for INGA:

A high density Timing Enhancer module has been developed to fulfill individual crystal Anti-Compton timing signal requirement of INGA Clover detectors for the newly installed VME based DAS at IUAC. The unit houses electronics required to process individual crystal and ACS prompt timing signals, corresponding to 8 detectors coming from existing INGA Clover detector electronics, in one 2U height 19" Aluminum cabinet and provides differential ECL signals for TDC. The module was tested with INGA Clover setup using ^{60}Co radioactive source and identical performance was observed in terms of timing resolution for self-triggered peak and Peak-to-Total (P/T) ratio of energy spectrum with and without Timing Enhancer module. We also observed gain of ~2% in P/T ratio at count rate in the range of 7k to 8k counts per second in each crystal. More improvement is expected in the crystals during in-beam experiments. To test its stability data collected for ~120 hours which showed peak shift of <+/-200ps (<+/-0.025%) in 800ns TDC range.

This work has been reported in DAE symposium on Nuclear Physics -66 (2022)
G17. Development of Timing Enhancer Module for INGA.

Maintenance and modification and of PSD module for NAND:

During this year more than 50 nos of PSD electronics modules which are part of NAND array were taken up for preventive maintenance. They were thoroughly cleaned for dust and clogged filters. The NIM crates as well as air cooling units were also taken up for preventive maintenance. The problem related to time jitter in "TOF signal" was rectified and verified with the experimental set-up.

Maintenance of INGA Clover electronics modules:

During this year more than 12 nos of Clover electronics modules which are part of INGA array were taken up for preventive maintenance. They were thoroughly cleaned for dust and clogged filters. The NIM crates as well as air cooling units were also taken up for preventive maintenance. All the modules were restored and tested with nuclear pulser in laboratory and any minor problems observed were rectified.

3.2 UTILITY SYSTEMS

3.2.1 ELECTRICAL GROUP ACTIVITIES

U. G. Naik, Raj Kumar

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:
- 3x750 kVA DG Dets synchronized and controlled through PLC.

UPS Systems:
- 3x300 kVA true online UPS System – 1 Set
- 3x60 kVA true online UPS system – 3 Sets
- 2x60 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 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.

MAINTENANCE ACTIVITIES:

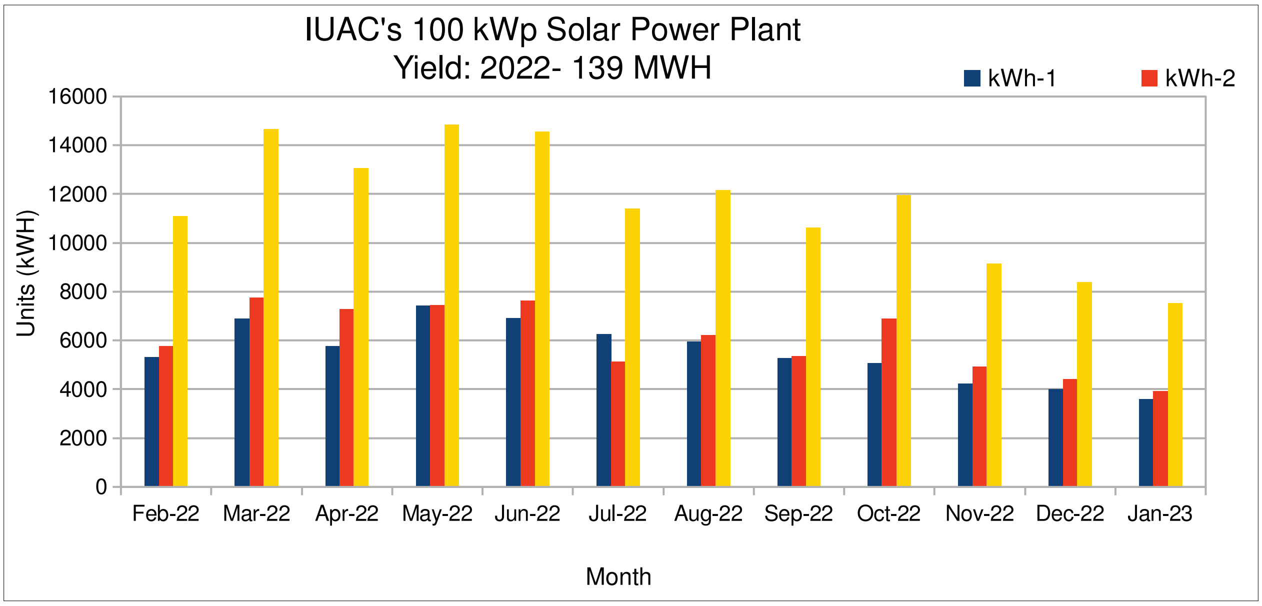
MAINTENANCE OF ELECTRICAL INSTALLATIONS OF SUBSTATION, OFFICE BLOCKS AND RESIDENTIAL COLONY

Maintenance of all above electrical installations has been carried out as per schedule during the year. All UPS systems are being maintained through AMC contract by their respective manufacturer.

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 6 Transformers.
- Servicing of all OCB and ACBs.
- Annual servicing of DG Sets.

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 2022 has been 1,39,337 kWH. Maximum monthly power generation during the year has been 14,884 kWH in the month of May 2022. 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. Monthly generation chart of the plant is as shown below.



POWER FACTOR COMPENSATION

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

- 350 kVAr, 7 stage power factor correction panel – 2 Nos.
- 300 kVAr, 7 stage power factor correction panel – 1 No.

Electrical group is very happy to declare that yet again we achieved 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.

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 2^{nd} floor lab complex.
- Conventional fire detection systems at main lab building, LEIBF building, new guesthouse, Beam Hall-3, engineering building, Beam Hall-2 stores.

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

3.2.2 AIR CONDITIONING, WATER SYSTEM, COOLING EQUIPMENTS, COMPRESSED AIR SYSTEM, FIRE HYDRANT SYSTEM.

Bishamber Kumar, S.S.K.Sonti

AC SYSTEM

IUAC's central air conditioning / low temperature cooling system of Phase-1 consisting of 400 TR Central AC plant performed with 100% up time. Maintenance ensured that the safety record of the plant was maintained at 100% and the power consumption kept at optimum level. 2x200 TR chillers installed in 2013, have run 43000 hours each.

2x 250 TR screw type water chilling units, 5 nos. of Condenser Pumps, 2 nos. chiller pumps, 2 nos. of cooling towers, electrical panel, control desk and Automatic power factor correction panel were installed, tested and commissioned under the upgradation of HVAC Ph-I to cater the additional cooling requirements of HCI and auditorium.

The Phase-II&III screw chiller based central AC plants performed to an up time of 100%. Ph-III cooling tower was overhauled. Ph-II cooling tower rusted pipes were replaced with new.

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 electricals led to least breakdown time and significant savings in operation and replacement costs.

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 100%. This is due to the stringent maintenance practices, which were followed over the years. The system has overshot 202700 hours from its expected life span.

IUAC's centralized water system of Phase-II&III feeding low temperature cooling water also performed to an uptime of 100%. Pumping system for supply of process water to HCI beam hall-III is in operation.

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.

Potable water pipe line from UG tank to Flatlet -II were rerouted and replaced with new pipe line to replace the rusted leaking pipe lines.

Potable water pipe line from flatlet-II to flatlet-I, canteen and hostel were rerouted and replaced with GI piping to replace the rusted leaking pipe

Potable water pipe line from Borewell-6 to Kamdhenu new block were rerouted and replaced with GI piping to replace the rusted leaking pipe

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

COOLING AND HEATING SYSTEM

Availability 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.

COMPRESSED AIR SYSTEM:

Compressed air plant (Ph-I&II) consisting of three 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.

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., Material Science building, Engineering Building, New Guest house and auditorium.

WORKS CARRIED OUT DURING THE YEAR:

- Servicing of LEIBF De-Humidifier
- Quarterly / PM / breakdown visits of 2 nos. of 200 TR, 2 nos. of 250 TR water chilling units.
- Procurement of spares for the system i.e., pumps, electric starters, desert coolers, window air conditioners, water coolers, geysers, v-belts, bearings, piping etc. as per requirement.
- Rewind of electric motors of HVAC system, WAC, desert coolers etc.
- PM / breakdown maintenance of desert coolers, geysers, air washer, canteen exhaust system etc.
- Descaling work of condensers and evaporators of 200 /250 TR water chilling units.
- Cooling tower Ph-III parts replacement and Ph-I electric motor bearing replacement.
- Dehumidifier heaters & Micro switch replacement.
- Attended to break down complaints (250) of window/ split air conditioners, water coolers, desert coolers, geysers etc.
- Drinking water pipe line leak search, repair and piping replacement work.
- BH-III water seepage pumping to drain out the water on regular continuous basis.
- Testing of Potable Water Samples and STP
- Records: Maintaining records of spares, consumables, maintenance works & Assets etc. on computer and different registers.

3.2.3 MECHANICAL WORKSHOP (MG-III Group)

G. K. Chaudhari, S. K. Saini, T. Verughese, K. K. Mistri, B. B. Choudhary, D. K. Prabhakar, and S. Ghosh.

The Mechanical workshop consists of the machine shop, the welding shop, the electron beam welding machine and Mechanical design department. The primary responsibility of the Mechanical Workshop is to fabricate, assemble and commission various mechanical devices related to accelerator, beam line and experimental projects of IUAC. The mandate of the mechanical workshop is to design, fabricate, assemble and sometimes commission the various mechanical devices so that a smooth functioning of all the accelerators of IUAC is ensured and the scheduled experiments are successfully conducted. To accomplish this, a few teams are formed from the group personnel of MG-III to take the responsibilities of each task.

The job requests for the mechanical components/devices are received through e-mail. Then the jobs are diverted to design department for preparation of engineering drawing, if needed or sent directly to the shop-floor for machining and fabrication. Entire process is designed in such a way that anybody who wants to fabricate a device can walk in with his idea and the workshop team helps the user to give a shape of his idea and to deliver the final product. Prior to delivery of the final components, they are sent to quality control Laboratory to inspect and check the dimensional tolerances and quality of the fabricated component. Only after the final inspection is over, the final product is handed over to the users.

Besides executing these routine jobs of design, fabrication, assembly and commissioning of the various mechanical devices by using the workshop, conventional welding shops and Electron Beam Welding facility, the MG-III Group members are also responsible to take care of the Elevator, Overhead Cranes, Management of the Fire Extinguisher and various types of Industrial Gas cylinders, and Shifting of various heavy items inside the laboratory.

There are total five operators are working in the workshop and the welding shops and they are ITI machinist, and welder.

MECHANICAL WORKSHOP

S.K.Saini, B.B.Choudhary, G. K. Chaudhari

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

Machine Shop is equipped with four conventional Lathe machines, two Milling machines, a Radial Drilling machine, a cylindrical grinder, a tool and cutter grinder, a horizontal and a vertical Band Saw machines. In addition, IUAC workshop has a five axis Vertical Machining Centre and a CNC Lathe machine. Most of these machines are of renowned brands like HMT, Batliboi, BFW.

Welding shop is having high quality TIG and MIG welding machine. Some of the TIG welding machines have pulsed arc feature for welding of thin sections. A sophisticated Air plasma cutter machine is also available to cut Stainless steel material of thickness up to 40 mm. Conventional Oxy-acetylene cutting and brazing set-ups are available for cutting and brazing related jobs.

In order to accomplish various types of mechanical jobs in a time bound fashion and to utilize resources in effective manner, a centralized tool/spares stores has been formed to issues tools and spares for workshop and welding shop operators.

This year about 234number of job requests were received but the actual number of components machined and fabricated could well passed 2000numbers. Several vacuum chambers, beam line components, drift tubes and other miscellaneous components were machined/fabricated from SS304/316L, including the parts and accessories of MRI project. The other components were also fabricated by using Aluminium, Mild Steel, Copper, brass, G-10, Hylum, plastics and many other types of materials.

As of today, the entire requirement of machining and fabrication is fully carried out by the IUAC workshop without any outsourcing. As per commercial costing of the components, the components of an estimated amount of ~84 lakhs are produced per last year in the workshop.

Design Department: T. Varughese and D. K. Prabhakar

This department has designed various components and prepared drawings of various parts and systems. Among them, the design and drawings of the beam line of Free Electron Laser is noteworthy. The design and drawings of a number of components of the beam line of High Current Injector are also carried out by the Design Department. Drawings are prepared as per IS-2102 medium class appropriate tolerance standards.

Quality Control laboratory: D. K. Prabhakar

Quality control lab is established by MG-III. Measuring instruments such as vernier calliper, micrometre, height gauge, CMM are being used for inspection of components.

Electron beam welding machine: K. K. Mistry and G. K. Chaudhari, P. N. Prakash.

- Electron beam welding machine is used for welding of the Niobium parts of Quarter Wave Resonators, mechanical tuners which are needed for the Superconducting Linear Accelerator of IUAC. This year most of the Niobium welding of spare resonators and their slow tuners were accomplished.
- EBW of Multi cell Niobium cavity of VECC was also carried out at IUAC as a part of inter institution collaboration and remaining work of the same project is also being done at regular intervals.
- In addition to this we have chalked out a plan to weld other dissimilar metals once current program of spare resonators is over.

Auxiliary Support Activities (elevator and cranes): S. K. Saini, B. B. Choudhary, G. K. Chaudhari

- Kone Lift: Regular servicing is being done by authorized service person of KONE, and license of KONE lift was renewed.
- Faulty and nonfunctional motor of Kone Lift was replaced.
- EOT Cranes/ Hoist: All EOT cranes are repaired and serviced regularly, all the breakdowns were attended and the maintenance was carried out.
- Hydraulic Trolleys/ pallet trolley are being maintained.
- Shifting of Heavy Scientific Machinery is being done as and when required. The equipment such as research instruments of Materials science, MRI machine, Liquid Nitrogen Dewar, Radiation shielding concrete blocks, etc. were loaded/unloaded/transported.
- Issue and upkeep, distribution and maintenance of industrial and specialty gas cylinders, maintenance of regulators, etc. were performed periodically.

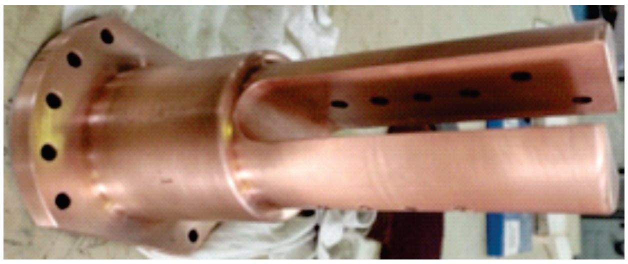
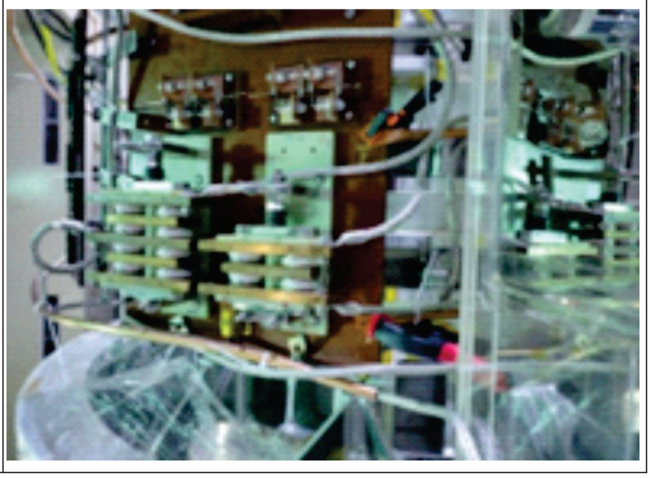
Auxiliary Support Activities (fire fighting equipment): (T. Varughese and D. K. Prabhakar

- Renewal of license of fire safety for IUAC main building, the annexure buildings and the auditorium was done.
- Refilling of 320nos. of portable fire extinguishers is being carried out.
- Audits of fire extinguishers of auditorium were performed. Accordingly, a list is prepared and after estimation, procurement process has been started.

Apprentice training to the ITI students and Graduate Engineers:

IUAC workshop is also providing Apprentice Training to the ITI trained manpower, graduate engineers students both in machine shop and in welding shop. Basic workshop training is also provided for the scientist trainees and Ph.D. students enrolled in IUAC.

Glimpse of activities of IUAC workshop

EBW set up Spare QWR of IUAC 	EBW set up of multi cell cavity of VECC 
HCI Beam line Vacuum Chambers 	View of IMRI machine showing contribution of workshop 
HCI spiral Buncher Stem 	View of IMRI machine showing contribution of workshop 

3.2.4 CIVIL ENGINEERING DEPARTMENT

Harshwardhan, Raj Kumar, U. G. Naik, 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. Centre has an academic or laboratory complex, utility buildings, auditorium, housing complex, hostel and guesthouse complexes. The civil engineering department takes care of day-to-day maintenance of all buildings, roads, sewerage system in campus including modifications, up-gradation, new construction activities and liaising with external agencies such as DDA, SDMC, Delhi Fire Service, Forest Department, RMB etc. for various statutory requirements such as building plan and construction approvals, fire safety approvals, property tax related issues etc.

The following are some of the important civil works undertaken through CPWD under deposit work mode.

- Up-gradation / renovation of Hostel complex, Main Gate House: The renovation work is in progress.
- Up-gradation / renovation of library has been taken up with introduction of digital reading stations, compactor for keeping old books, conference proceedings and records etc. to save on floor space.
- Renovation work of UPS room & toilets has been taken up and is in progress.
- Construction of 16 Nos. Type-III (Sumeru II type) flats (proposal under process).

Following works has been carried out and completed directly by IUAC:

- Upgradation/Construction of Garbage Bins, Construction of Plant waste bins and Extension of UPS room wall in IUAC
- Civil work for setting up of MCMC, FF, LEIBF Building and recovery compressor room
- Setting up of Chemistry lab above Beam Hall-II roof
- Fabrication, supply, installation and commissioning of LED light boards at Main Gate & Director Residence
- Replacement of all roof sheets of car parking (4 nos.) and electric sub-station area.
- Replacement of defective cisterns and glass door in auditorium.
- External painting work in IUAC Campus: Painting of Helium Gas tank (5nos.), SF 6 gas storage (6 nos.), Liquid Nitrogen (2nos.), MS Structure such as pipe bridge, cable tray supports, MS stair, MS railing etc. around Main Lab Building, UB-I, Helium Building