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, vacuum systems and diagnostic devices in beamlines and experimental facilities. There are about 600 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. The group provides support to different labs and users in vacuum related problems.

3.1.1.1 Development Activities

Vacuum lab has been doing installation of accelerators at IUAC with support from different groups. A lot of components like vacuum chambers, device controllers and vacuum interlock systems are designed and developed for integration into the accelerator during installation. Major development work done are given below: -

1) Design, fabrication and installation of a mild steel platform to cover cooling water pipes, installed on the floor, and provide convenient height platform for working on HCI beamline components. It consists of 18 platforms of size 130 x 61 x 34 cm^3 and 2 step platforms at two ends installed along the beamline. Each platform is designed to withstands a load of about 600 kg.

2) To control and communicate with the beam line devices in beam Hall-3 (except HV deck) through remote console the details of required signals were documented and given to control system group.

3) Schematic and PCB Design of BPM signal (16 signals) distribution Panel is done and 02 No of panels have been fabricated. These panels can take input from 16 BPM and can give three outputs for each signal. One of them is designed to work for digital read back and display on computers. Other two signals would be read on CRO through BPM selector. One panel will be installed in the main control room and another one in the local control console.

4) Design, fabrication and installation of Vacuum Interlocking system for 6 nos. of DTL turbo pumping system. Three interlock boxes are assembled and installed in HCI and are working fine. Each interlock box is designed to control two DTL chamber Turbo Pumps.

A new PCB was designed and fabricated for this system. Signals from Turbo pump controller, gauge controller and backing valve have been used for this interlock system.

Figure 1: Vacuum Interlock Controller for DTL.

3.1.1.2 HCI Installation Work in beam hall 3

a) Installation of Device Controller Crate for HCI devices:

A new Faraday Cup (FC) and Beam line Valve (BLV) controller crate, fabricated and assembled last year, has been installed in beam hall 3. It houses three BLV controllers and five FC controllers and it can work both in local and remote mode. Each controller has LED out put on the front panel for easy diagnosis of problems in the device.

Figure 2: BLV and FC Controller Crate.

a) Cable for connecting devices, device controllers and VME control system were made and laid for remote and local operation of the beam line devices installed in Beam hall 3.

b) Re-organizing of electrical, grounding and signal cables in HCI deck was done. The cable which have now become un-necessary due to modification in the beamline components were removed, new cable was prepared and laid to replace bad ones and extra grounding connections were also provided for all the devices on the high voltage deck.

c) A new control console for remote control of HCI operation has been installed in the main control room (Pelletron control room). All required cables for BPM operation and Ethernet for other communication have been laid up to the console and shall be ready for operation within a month.

3.1.1.3 Modification of AMS Beamline for Proton Experiment

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The existing beamline components were dismantled for modification as per new optics suitable for proton experiments. The quadrupole doublet has been shifted from experimental area to vault-I area. The double slit is also vault-I area and installed with BPM-1 just before Wein filter. The turbo pumping station is also shifted from Wein Filter exit to Wein filter entrance. A Provision for additional turbo pumping port is kept in the beam line for probable future requirement. Alignment of all the optical beam line components (BPM, double slit, Wein Filter, quadrupole, experiment chamber, target ladder, etc.) was done with respect to switching magnet reference. All the components are aligned within 0.5 mm of beam axis.

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

1) INGA Beamline Vacuum Problem: BLV not opening due to interlock failure and Ion Pump not holding vacuum below 10^{-06} Torr range due to outgassing from samples in the chamber. Additional pumping set up was put there and Ion Pump baking done to resolve the issue.

2) The turbo pump of Super-Buncher, Diagnostic box I and Re-buncher in Phase-II had bearing failure last year and these systems were running on pumps borrowed from other systems. New pumps (800 lps) were procured and have been installed on the system. The interlock connections have been modified accordingly as per new pumps specification.

3) The turbo pump installed in the NAND chamber had stopped working, it has been replaced by another turbo pump. The interlock connections have been modified accordingly as per new pumps specification.

4) Re-buncher scroll pump had gone bad unable to maintain good vacuum in chamber. It has been removed and replaced with spare scroll pump replaced.

5) LINAC – III Turbo Pump Electronics Problem: Interlock signal problem from electronics (TC 1200). Replaced with Spare Electronics. Two bad electronics returned by company as not repairable. Spares TC 1200 needs to be procured. It appears the frequent failure in electronics could be due to x-rays under the LINACs during conditioning.

6) BLV-04-1 Interlock problem: Interlock signal not coming from Fast Closing valve. It was found that sensor selection signal for fast closing valve from rotary switch (which selects the fast valve sensor in the respective beamline) was not coming. Rotary Switch was repaired.

7) Vacuum Problem in Atomic Physics-II: Vacuum stuck at 10^{-05} Torr, leak detected in feedthrough.

8) GPSC: Problem in BLV L7-2 operation, Faraday cup working, chamber roughing valve position feedback switch problem and through leak in the system high vacuum valve were attended and have been rectified. The vacuum interlock controller is 30 year and its vacuum gauge (rough vacuum and back vacuum) modules were not working for quite some time. These old modules have been removed and interlock signals were traced in the controller and modified to work with new gauges. All the front panel switches have been changed and now are working fine.

9) New LEIBF: FC and Suppressor unit in zero-degree beam line had gone bad due to water condensation on these devices. FC head assembly signal connections were found shorted. The beamline had to be vented, and head assembly of the faraday cup was changed. The suppressor unit had also gone bad and replaced

with available spare. Edwards Turbo pump controller SCU-800 display was not working properly so it was replaced with spare controller. Pfeiffer Maglev Pump on the HV deck controller was having display problem so it was replaced with spare controller.

10) HCI (Beam hall III): The Turbo pump installed with DTL 3 had stopped working due to bearing failure. It was replaced with a new turbo pump. BPM (mounted on diagnostic box in high voltage deck) had stopped working and it was found that its magnetic bearing had failed and fiducials were not coming. After venting the beamline section, the BPM head assembly was changed. Double slit in the Diagnostic box (HV Deck) had signal problem in its top slit. It was repaired and installed back. Calibration of Double Slit (HV Deck) was done for position w.r.t. control voltage.

11) Phase Detector Removal from beamline (05 area): This Phase detector which wass installed in 05 area just before Super-buncher had a vacuum leak in 1 x 10^{-07} mbar l/s. Due to this vacuum leak ion pumps in the region were getting bad very frequently. After getting consent from LINAC group, it has been dismantled from the beam line and a drift tube of suitable size has been installed to connect the segment. The vacuum in the region is also improved to about 1 x 10^{-09} mbar.

3.1.1.5 Maintenance Work in Pelletron (with Pelletron group)

Venting / leak check and vacuum establishing activity was done multiple times in Pelletron tank terminal and high energy area during foil loading activity. Two ion pump (inside tank) IP T2 and IP D2 had gone bad and these have been replaced with spare pumps. Due to difference in outer dimensions of the spare pumps the installation orientation of these pumps had to be changed and their supports were modified accordingly. These are ruggedized ion pumps which can withstand high SF6 pressure inside the tank.

Leak testing of tank terminal section: Slow leak was detected from terminal section during post baking leak checking operation. The location of the leak could not be identified. The leak is very slow and small and it reached up to 2.0x 10^{-9} mbar l/s in 20 minutes. The leak path is very long due to which the response time is too high to detect the leak location. The leak might have been there for quite some time and should not affect the vacuum in the terminal. RGA (installed at tank bottom) readings may be taken at regular intervals to detect presence for SF6 gas that might enter the system through this leak, under SF6 pressure (~ 90 psi). The manual valves across the terminal are working fine and no through leak was detected during the operation.

3.1.2 CRYOGENICS LABORATORY

Anup Choudhury, Soumen Kar, Joby Antony, Suresh Babu, Manoj Kumar, Santosh Sahu, Rajesh Nirdoshi, Rajeev Mehta and P.N.Prakash

In this academic year, the cryogenic system consisting of beam-line cryostats, helium refrigerator, and its distribution network, and the nitrogen distribution network, was primarily operated for the beam acceleration through the RF-Superconducting LINAC. The helium refrigerator was also operated separately for off-line testing of cavities in the simple test cryostat and testing of few components of the 1.5T MRI magnet.

3.1.2.1 Cryogenic System for LINAC

I. Liquid helium refrigerator

The helium refrigerator was operated for approximately 1100 hours for beam acceleration, off-line testing of QWR in simple test cryostat, and testing of various components of the MRI magnet.

II. Liquid nitrogen network

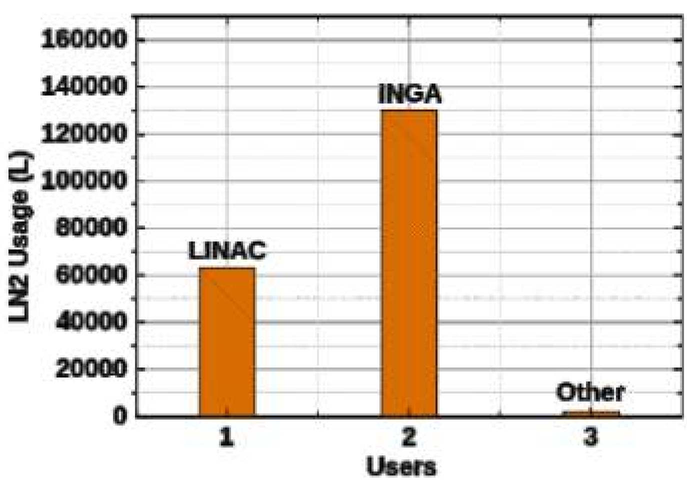


Fig. 3.1.2.1 Annual consumption of liquid nitrogen at IUAC.

The total amount of liquid nitrogen (LN_2) procured in the academic year was 2,13,000 L. Fig. 3.1.2.1 shows the distribution of the consumption of LN, which was primarily used for cooling the thermal shields of the beam-line cryostats, helium distribution network and detector cooling in the Indian National Gamma Array (INGA) facility.

Efforts were made to run the in-house LN_2 plant to produce liquid nitrogen in a challenging scenario like the COVID pandemic when it may be difficult to procure it commercially. A solenoid valve in the PSA module was found to be faulty. The plant was also found to trip which is suspected due to a failure in the control unit. The operation would be revived after replacing the valve and sorting out the problems related to the control unit.

III. Beam-line cryostats and Simple test cryostat

All the beam-line cryostats of the LINAC were operated for 500 hours for beam acceleration. All the cryostats performed well during the beam acceleration. The electronics controller of the turbo molecular pump of LC-III has been replaced with a new one due to repetitive failure during the continuous operation of the pump. In this academic year, the simple test cryostat was used for off-line testing of cavities. The base vacuum of the cryostat deteriorated due to a vacuum leak that appeared at the nitrogen vent line of the test cryostat. The base vacuum got improved to 5.0E-7 mbar from its initial value of 5.0 E-6 mbar after fixing the leak.

Fig. 3.1.2.2 Simple test cryostat at IUAC.

IV. CFMS-VTI Facility

Soumen Kar and R.N. Datt

The indigenously developed CFMC-VTI facility as shown in Fig. 3.1.2.4 was used for the characterization of 12 samples at the magnetic field and the low temperature. The Hall measurement using Labview-based program for material characterization is presently under development.

Fig. 3.1.2.4 CFMS-VTI facility

3.1.2.2 Activities on Applied Superconductivity

A. Development of a whole-body 1.5T Superconducting MRI magnet system (MeitY Project)

Soumen Kar, Navneet Suman, Sankar Ram Theketthil, Vijay Soni, Ajit Nandwadekar, Rajesh Kumar, S. K Saini, Santosh Sahu, Rajesh Nirdoshi, Manoj Kumar, 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 co-ordination of SAMEER-Mumbai (nodal agency). IUAC is primarily responsible for the development of 1.5T superconducting magnet and ever-cooled or zero-boil-off (ZBO) cryostat for the MRI scanner.

MRI magnet Bobbin and winding

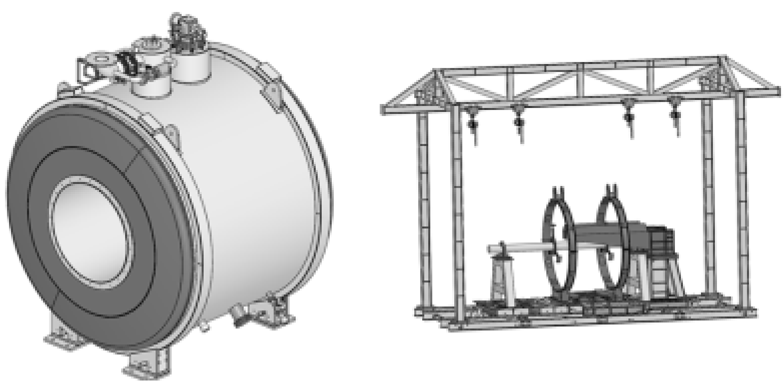
The bobbin for the multi-coil superconducting MRI magnet has been fabricated. The individual bobbins of the primary coils of the magnet have been integrated to a primary bobbin structure as shown in Fig. 3.1.2.5. The inner diameter and the length of the integrated bobbin are respectively 1m and 1.4m. The integrated bobbin structure is made. Similarly, the bobbins for two shield coils have also been fabricated.

Fig 3.1.2.5 The integrated primary bobbin structure of the MRI magnet.

The trial winding of the superconducting coil has been done to generate the parameters of the final winding for all the eight superconducting coils. Various amplitudes of the winding pretension have been applied during the trial winding. Based on the parameters of the trial winding, all the bobbins would be machined to its final dimension as per the EM design to achieve the central field with desired homogeneity.

Zero-Boil-Off MRI cryostat

The cryocooler based zero-boil-off MRI cryostat as shown in Fig. 3.1.2.6 is presently under fabrication at the vendor's site. The MRI magnet needs elaborate jigs and fixtures for its precise positioning and alignment during the assembly to the cryostat. The assembly sequence of the magnet along with the intermediate tasks, not limited to helium leak test, pressure test, MLI wrapping etc. has been finalized prior to designing of the final configuration of the assembly jigs and fixture. The assembly jigs and fixture is presently under fabrication.

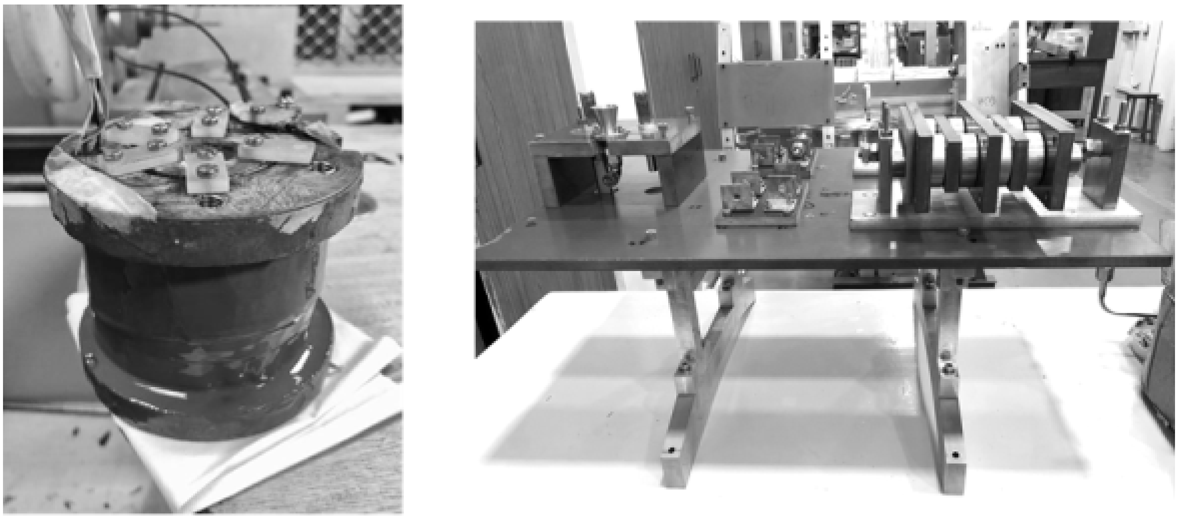


(a) (b)

Fig 3.1.2.6 (a) The zero-boil-off MRI cryostat, and (b) the magnet-cryostat assembly jigs and fixture.

Superconducting switches

The final set of superconducting switches for the main magnet and the EIS coil have been developed as per the test results of the prototype switches. The thermal and electrical performance of the both the switches have been characterized at 4.2K at their operating current. The main switch and the EIS switch have been respectively tested up to 450A and 10A. The switch of the main magnet is shown in the Fig. 3.1.2.7(a). Both the switches are now ready for installation into the MRI magnet.



(a) (b)

Fig 3.1.2.7 (a) The superconducting switch of the MRI magnet, and (b) one of the ancillary boards equipped with few ancillaries.

Ancillaries of the MRI magnet

The MRI magnet will have a large number of ancillaries for the quench protection system, the quench propagation system, superconducting switches, etc. which need to be fixed onto the integrated bobbin structure for their electrical connection. Most of the ancillaries need to be fixed at the region having low value of background field maintaining their structural rigidity during the operation so as to avoid any field dependent degradation in their performance. Most of the ancillaries have been fabricated and fixed to their corresponding ancillary boards. One such board equipped with various components is shown in Fig. 3.1.2.7(b).

3.1.3 BEAM TRANSPORT SYSTEM (BTS):

Prem Kumar Verma, Mukesh Kumar, S. K. Suman, Rajesh Kumar (Programme Leader: N. Madhavan)

3.1.3.1 Beam Transport System Upkeep and maintenance:

Beam Transport System (BTS) Group is an Accelerator Central Support Group (AcSCG), responsible for the design, fabrication, installation and maintenance of magnet power supplies and other BTS associated instruments. In order to achieve a high uptime of BTS, the group executes "Yearly Scheduled Preventive Maintenance" (YSPM) of BTS instruments of all the accelerator facilities at IUAC. As the beam transport system is a large subsystem of all the accelerator facilities, hence the BTS preventive maintenance cannot be completed during the one-month long Pelletron maintenance schedule. The BTS-YSPM is divided in time-slots, planned throughout the year in synchronization with the beam schedule. Additionally, the BTS group also performs preventive maintenance and repair of detector bias high voltage power supplies in use at different experimental facilities. Besides maintenance and repair activities, the group has also executed design and fabrication of BTS-magnet power supplies and remote-control instrumentation for the upcoming HCI and FEL facilities. The yearly activities related to maintenance, upkeep and development are summarized below.

3.1.3.1.1 Activities of Scheduled Preventive maintenance:

The planed YSPM schedule could not be followed during the three-month long lockdown period. In the initial phase of lockdown, the BTS system was kept in standby-mode, resulting in no-load on the cooling water system. This no-load condition has resulted in condensation in some of the water-cooled power supplies which has caused corrosion. Observing this, the cooling water of the BTS instruments was stopped and the mains power switched-off. After lockdown period, a new BTS-YSPM schedule was planned in tune with the beam time schedule and all the magnets and power supplies of all the facilities were serviced as per the set procedures. To pre-analyze the condition and to decide the preventive maintenance actions before servicing, the test point data of each BTS magnet power supply was recorded in the "Test Report Performa Pro-forma". To remove the scaling and sediments, all the water-cooled coils of the magnets were cleaned by circulating a dilute sulphamic acid solution using high pressure diaphragm pumps with the help of the water system group of IUAC.

3.1.3.1.2 BTS uptime and operational status:

During the beam time operations, there were 23 occasions when magnet power supplies stopped working and resulted in a total beam time loss of 12.5 hrs. These failures were not only due to the power supplies but also were contributed by the failures in remote control, electrical and cooling water systems. There was no significant or repetitive failure; most of the breakdowns were minor and random in nature. All the breakdown related calls were attended immediately by the BTS personnel, who work as a 24 X 7 on-call team, investigate the beam stoppage caused by the magnets and power supplies. The BTS is performing with required stability and functionality. The Physical condition of the BTS system is good. All the aging effects were overcome through refurbishment and rectification of the components. The system does not need any immediate up-gradation and development; there is enough overlap time to develop / change to future technology. Approximately 50 % of the total BTS instruments are in-house developed, resulting in minimum running cost in terms of spares.

3.1.3.1.3 Significant repair jobs:

Component level repairs were performed for the faulty electronics cards taken out during preventive maintenance; no faulty electronic module was discarded. The following significant repair works of magnet power supplies were executed during preventive maintenance:1) Refurbished the corroded power section and chassis of switching and scanning magnet power supplies of Low Energy Ion Beam Facility (LEIBF); 2) Eight numbers of Danfysik make sys 9100 power supplies of HCI magnets has been repaired for failures in auxiliary power supply modules; 3) Input inrush surge current limiter installed in one of the old Danfysik-make bending magnet power supply of Negative Ion Beam Facility (NIBF).

3.1.3.1.4 Steps taken to improve the BTS sustainability:

Following significant steps have been taken to improve the sustainability and uptime of the BTS system: 1) Installed silica gel / crystal pouch in magnet power supplies to reduce the humidity and hence the corrosion; 2) The external cabling of BTS devices has been arranged neatly to make the BTS system more organized; 3) BTS laboratory space reorganized to maximize the working space; 4) Operational and failure data logs were maintained to summarize the yearly operation data and to assess the condition of the BTS system.

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

Every year, 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 Detector (NAND) experimental facilities. All the DB-HVPS used in these two facilities were developed in-house by BTS group in 2007. Since then, all these are maintained by BTS group to ensure the required performance and trouble-free operation during experiments. A total of 60 power supplies (three types: 5 kV, 3 kV & pre-amp PS) along with NIM crates of INGA were cleaned, serviced and calibrated. Similarly, the neutron detector's bias power supplies of NAND experimental facility were also cleaned, calibrated and tested for remote operation.

3.1.3.2 Developmental Activities:

3.1.3.2.1 Remote Control Test Jig for Magnet Power Supply:

On many occasions, when a power supply stopped responding to the remote control, the first step is to fix the fault location, whether it is in power supply or in the remote-control instrumentation. So far, to do this task, a portable CAMAC control setup used to be transported to the faulty power supply location. This setup is quite heavy and takes quite a long time to setup and operate. To simplify and fasten this type of fault-finding, a standalone test jig has been developed, which substitutes the functionality of CAMAC system and manually generate all the remote-control commands of CAMAC-IGOR and the scanner power supply remote controllers. The test jig is designed using simple digital circuits and hard-wired switches; it doesn't need any computer and software support. Being handy and simple, it has certainly reduced the fault-finding time and has simplified the process.

3.1.3.2.2 Fabrication of In-house designed magnet power supplies for HCI and FEL facility:

The steerer (±10A, bipolar) and low power quadrupole (+20A, unipolar) are power supplies which are required in large quantities for the High Current Injector facility (HCI) and Free Electron Laser (FEL) facilities. BTS group has taken the responsibility to in-house develop such power supplies. BTS group is providing 100 nos. of such power supplies out of which 80 nos. are for HCI and 20 nos. are for FEL. So far, 50 units of such power supplies already have been assembled and installed in the respective facilities. The fabrication of 50 more units has been started this year; the fabrication of different sub-assemblies and control electronic modules have been completed and tested individually. In the academic year 2021-2022, all these sub-assemblies will be integrated as power supply units and then all the units will be tested for final performance and functionality.

3.1.3.2.3 In-house development and fabrication of RS-232 server and RS232-IGOR control card:

As a policy decision, the remote control of the magnet power supplies of HCI and FEL facilities will be provided using the in-house developed RS232 server and RS232–IGOR modules. These instruments were designed and fabricated last year in limited quantities and were installed with HCI facility magnet power supplies to verify the operation consistency data. After observing successful operation during last year, this year 15 nos. of RS232 servers (12 channels each) and 75 nos. of IGOR modules have been assembled. The testing and installation of the assembled servers and IGORs will be done in the coming academic year and will be installed for the remaining power supplies.

The RS232-IGOR developed last year was specifically for the in-house developed power supplies with limited functionality (that is, the minimum required). This year a prototype general purpose RS232-IGOR module has been developed having an 16-bit read-write and three on-off commands. This general-purpose RS232-IGOR will be installed in the Danfysik-make old power supplies of Pelletron and LINAC facility which are not using RS 232 remote control option. This will facilitate the upgradation of the remote control of magnet power supplies from the presently used CAMAC-based IGOR system to RS232 control using either VME server or the in-house developed RS232 server.

3.1.3.2.4 Power Supply Technology development initiative:

The BTS group has the moral obligation to maintain and repair every type of power supplies used at IUAC and specifically the magnet and detector bias HV power supplies. Considering this, the group has initiated three types of developments related to various high current and high voltage power supplies. The main objective of the development is to minimize the types of power supplies used at IUAC and in-turn to simplify the manpower training and maintenance. To achieve this, bipolar high bandwidth, high current and high voltage amplifiers will be developed, so that same unit can be used for unipolar, bipolar, DC and AC applications. Similarly, for detector bias high voltage power supplies, a common design will be adopted for 1kV/1mA, 2kV/5mA and 5kV/1mA power supplies which are commonly used at IUAC to bias different types of detectors.

To seek approvals for these developments, a project proposal for each type of development has been submitted to the Project Approval Committee (PAC). During this year following activities have been done for these developments; the tentative design topologies and block diagrams have been finalized, components required to prove the feasibility of the core-concept have been listed, designed and got fabricated a few magnetic components such as ferrite transformers, inductor and filters. The goal for the upcoming academic year is to demonstrate the required functionalities of the core-concepts using the proposed circuit topology.

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 Detector sytem for multi-nucleon transfer experiments in GPSC

Mohit Kumar, Akhil Jhingan, N. Saneesh, K. S. Golda, P. Sugathan

The detection system used for multi-nucleon transfer measurements in GPSC was modified for performing absolute TOF measurements in experiments performed above and near/below barrier. The old wire frames in multi-step configuration were replaced by new frames in three-electrode configuration. The central timing frame was prepared with 20 µm diameter Au-W wires at 0.3 mm pitch, while the position frames (X & Y) had 0.63 mm pitch. Start-stop detector configuration was used to extract TOF parameter along with gas ionization chamber for energy measurement. Combination of the two gives velocity-energy or *v-E* measurement system (fig.1). One standalone MWPC is used for detecting target recoils. Six new detectors were prepared for fast timing measurements, each of them having wires at 0.3 mm pitch while using 10 µm and 20 µm diameter wires for anodes and timing cathode respectively. It was planned to have three sets of start-stop (TOF) detector systems for measurements below barrier and one set of TOF system for measurements above barrier. Six new fast timing amplifier units were fabricated which were coupled to detector inside GPSC. Rise times ~ 2 ns were observed with fission fragments. Split anode ionization chamber, used for nuclear charge (*Z*) identification in measurements above barrier, was modified by placing newly developed charge sensitive pre-amplifier (CSPA) units (4 in number) inside the detector integrated with anodes (fig.2), thus eliminating cables between anodes and CSPA. This improved the energy resolution by a factor of 25%. For velocity-energy (*v-E*) measurements below barrier, HYTAR detectors were integrated with start MWPC. Due to mechanical constraints, only two sets of *v-E* detection system could be used in the experiments with Pelletron beam. The MWPC used for ER detection in MWPC was upgraded with new wire frames having 0.3 mm wire pitch for timing and 0.63 mm wire pitch for position electrodes, and placed at 8° (angular coverage 3° – 13°) with respect to the beam direction for the detection of target recoils at very forward direction. The entire setup is shown in fig.3. In total, 26 new wire frames were fabricated for TOF detector system, with 21 of them having 0.3 mm wire pitch and other 5 with 0.6 mm wire pitch. New mounts were also fabricated to prepare a new kind of hybrid detector comprising of a silicon PIPS detector and MWPC. System was tested off-line with radioactive sources, and used to perform in-beam multi-nucleon transfer measurements for the system $^{16}O + ^{144,154}Sm$ in GPSC. The in-beam measurements were carried out in two parts, one above and another below barrier. System requires further modifications for improved performance.

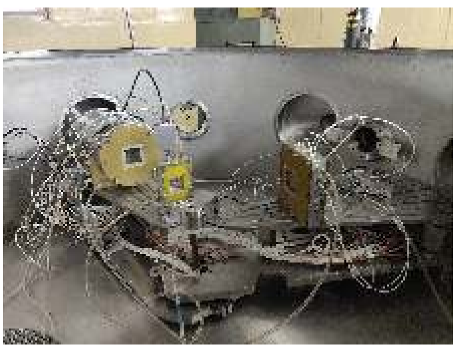


Fig.1: Detector system for multi-nucleon transfer measurements above Coulomb barrier.

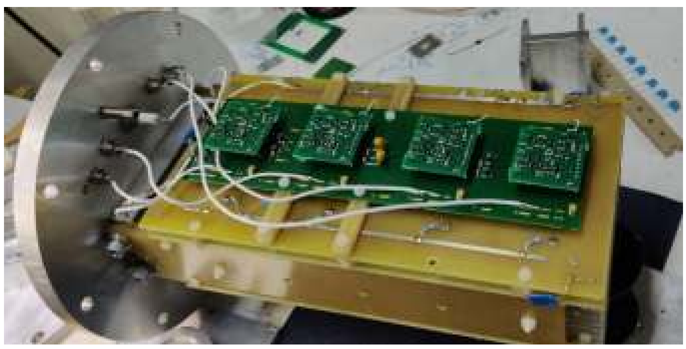


Fig.2: Split anode ionization chamber with integrated CSPA units for signal processing.

Fig.3: Detector system for multi-nucleon transfer measurements below Coulomb barrier.

3.1.4.2 Repair of Fission detectors for NAND/GPSC

Multi-wire proportional counters used for fission experiments were refurbished by replacing their electrodes, namely cathode foil and wire frames, the performance of which had deteriorated due to aging effects. Performance was restored after the replacement. Position frames have 10 μm diameter Au-W wires at 0.63 mmm pitch. Old wires were carefully de-soldered and new wires were soldered on the same frame so as to use the old delay line, which was prepared with discrete components. The detectors were used to perform fission mass distribution measurements for the system $^{16}O + ^{197}Au, ^{193}Ir$ in GPSC.

3.1.4.3 Development of new CSPA units for CPDA in INGA

Developmental activities were initiated for the development of a 16 element CsI – photo-diode array for INGA experiments. New designs of CSPA units were simulated and prototypes were fabricated. New designs are further miniaturized to a size of ~ 12 x 12 mm^2 and have a reduced power consumption of 15 mW. They can be adapted to smaller crystals of size 15 x 15 mm^2 in contrast to 20 x 20 mm^2 in the earlier design. The array is expected to be tested with INGA by middle of 2021.

3.1.4.4 TEGIC Detector for NUSTAR collaboration

IUAC – Delhi Univ. - Panjab Univ. (Chandigarh) – GSI (Germany)

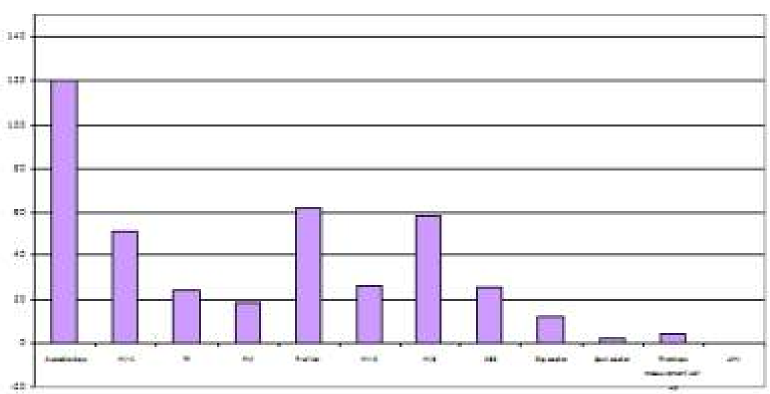
Fabrication work for the TEGIC detector was executed. The detector was shipped to GSI, Darmstadt in February/March 2020 for performing test measurements with UNILAC-SIS18 accelerator system. Due to Covid pandemic, test measurements were postponed to 2021. Some damage to thin electrode foils have been reported in transportation. Mounting rail assembly for TEGIC was prepared in the GSI mechanical workshop to install the detector at the FRS facility in GSI. Entrance and exit windows of the detector were prepared with 25 μm thick kapton foils by the detector development laboratory GSI and leak tested with P-10 gas at 1000 mbar. Troubleshooting of the damaged foils is planned in later half of 2021.

3.1.5 TARGET DEVELOPMENT LABORATORY

Abhilash S R, Ambuj Mishra and D Kabiraj

3.1.5.1 Target Development for Accelerator Users

The primary responsibilities of target lab are operation and maintenance of instruments in target lab for developing and delivering the nuclear targets and thin films for accelerator users. The disruptions brought in by *COVID-19* have affected the user related activities in target lab as well. However, target lab is successful in delivering several targets for accelerator experiments and several research scholars have been trained in thin film deposition techniques in this year. 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 2020-2021

The utilization of facilities indicates that more than one facility of target lab has been used in every working day. More than 100 evaporation attempts were performed for target fabrication in different systems for the completion of target requests of users of various streams viz., material science, nuclear physics and atomic physics. Target lab has successfully delivered more than 50 nuclear targets in this year. Target developments in IUAC were also reported in peer reviewed journals in this year [Section 6.7.G].

3.5.1.2 Target development of high vapour pressure metals

Target lab frequently receives the request for thin targets of high vapor pressure metals viz; bismuth, gallium, tin, indium, zinc, cadmium, tellurium, antimony, thallium, and lead. Vapor deposition technique like resistive heating technique is the ideal choice for evaporating the high vapor pressure metals. However, it involves high temperature process and effect of radiant heating from the source over the surface of substrate poses lots of challenges. High vapor pressure metals re-evaporate from the substrate surface even at moderate temperature. So, minimizing the heat load at substrate has more significance while dealing with high vapor pressure metals. In order to minimize the radiant heat at substrate surface and re-evaporation of metal vapor arriving at substrate, various methods are adopted in target lab.

Restricting the total duration of evaporation within few minutes has significantly reduced the re-evaporation and target lab is successful in producing several ^{64}Zn and ^{68}Zn thin film targets of 200µg/cm^2 thickness for a nuclear reaction experiment in IUAC.

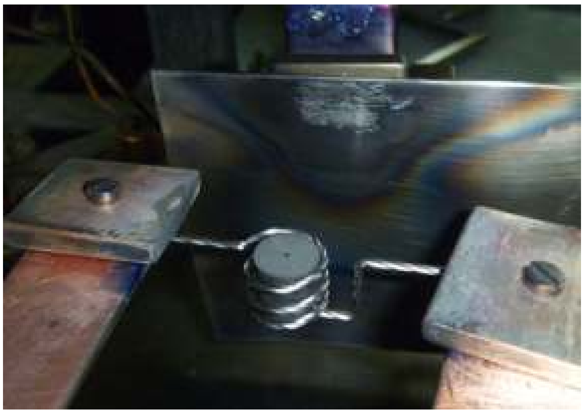


Figure.1: The indigenous graphite crucible source.

Thermal evaporation set-up in diffusion pump-based coating unit was used for the Zn target development. The indigenous graphite crucible source (Figure.1) with tungsten basket heater arrangement having narrow solid angle coverage plays important role in developing the targets with minimum consumption of material. The source to substrate distance is optimized by trial-and-error method. More distance results more material consumption and less distance results excessive heating of substrate by radiation from the source. The excess heat in the substrate causes re-evaporation of Zn vapor. Finally, it is decided to optimize the source to substrate distance at 8cm. Several evaporation attempts were done using the natural material of Zn to optimize the amount of material. It was experienced that evaporation duration of more than 15 minutes initiates re-evaporation of Zn from the substrate which is at 8cm from the tungsten basket source which is at high temperature. The thickness of finally deposited targets was in the range 200-270µg/cm^2**.**The carbon backing film was prepared by e-beam bombardment.

For further minimizing the material consumption especially during the evaporation of isotopic materials, the evaporation process needs to be done at a reduced source-to-substrate distance. In such cases, substrate holder with coolant circulation is widely used for the evaporation of high vapor pressure metals. The coolant circulation in the substrate maintains the substrate at low temperature during evaporation and it minimizes the re-evaporation of metal vapor. Target lab is in the process of developing a water-cooled substrate holder for the evaporation of Cd metal. At first, the chilled water will be used as the coolant. If more cooling will be required, other coolants with more refrigerating capacity will also be used.

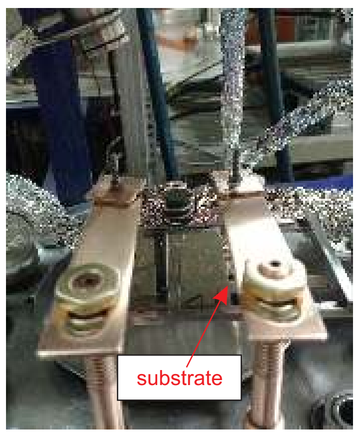


Figure.2: Inverted evaporation source.

The recent work in target lab shows that the inverted orientation of source (Figure.2) is more suitable for the evaporation of high vapor pressure metals like Cd with minimum source-to-substrate distance. In this orientation, the substrate is mounted just below the source which is placed in inverted orientation. It was also experienced that the re-evaporation of vapor from the substrate surface is minimized in inverted orientation of source.

3.1.5.3 Target library for users

Target lab had initiated the work for a target library in 2019 for systematic storing of nuclear target for future use and for avoiding repeated fabrication of targets having same specifications. Apart from saving the money and manpower, this facility will also provide lab access to more users in minimum time lag. More than 500 targets are already the part of library and more efforts are in progress to bring more targets under the library with a digital inventory.

Figure.3: Target Library in IUAC.

3.5.1.4 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 target lab. 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. In target development laboratory, carbon stripper foils are fabricated by e-beam bombardment techniques. A dedicated turbo pump-based e-beam facility is used for the stripper foil fabrication. Initially a thin layer of teepol solution is applied on the pre-cleaned glass substrate. The glass substrate is loaded on the substrate holder having planetary motion. The graphite is evaporated by e-beam and is condensed over the glass substrate. In order to ensure the maximum uniformity in the thickness of film, the glass substrate is rotated during the evaporation.

In addition to the IUAC stripper, imported Pulsed Laser Ablated (PLA) foils are also used in Pelletron. PLA foils exhibit superior life as stripper foils. In e-beam evaporation, carbon vapor is transported from the source to substrate in the form of clusters of different size and anisotropic films are grown with more lattice defect. In laser ablation, carbon atoms reach the substrate as single atoms and the atoms have high energies for the rearranging themselves across the substrate surface. So, PLA films are more in isotropic nature and thus show superior performance as stripper foil in comparison with e-beam foils. The PLA films are brought with the glass slides. The films are separated from the glass slide in target lab. The separated films are then put in the nitric acid solution for dissolving the copper backing. Finally, the carbon films are mounted on the stripper foil holder.

3.5.1.5 Activities in photo-cathode development

Target lab is taking important role in photo-cathode development for the compact Free Electron Laser facility known as Delhi Light Source (DLS) based on normal conducting photocathode (PC) RF gun which is under development at Inter University Accelerator Centre, New Delhi. Initially, the electron beam will be generated from copper photocathode and subsequently from semiconductor photocathode like Cs_2Te and other advanced photocathode materials. To deposit the thin film of photocathode material on metal substrate, a deposition system has been designed at IUAC (Figure.4). The system consists of four vacuum chambers which will be interconnected with vacuum manipulator with the option of isolating by gate valves. The system will have provision for cleaning of photocathode metal substrate (to be called subsequently as PC plug), deposition of photocathode film on the PC plug, storage of the PC plugs without residual gas poisoning and insertion of the PC plugs into the RF electron gun. The ultimate vacuum in all the chambers in the facility will be in the order of 10^{-11} mbar for ensuring minimum residual poisoning of photocathode thin film.

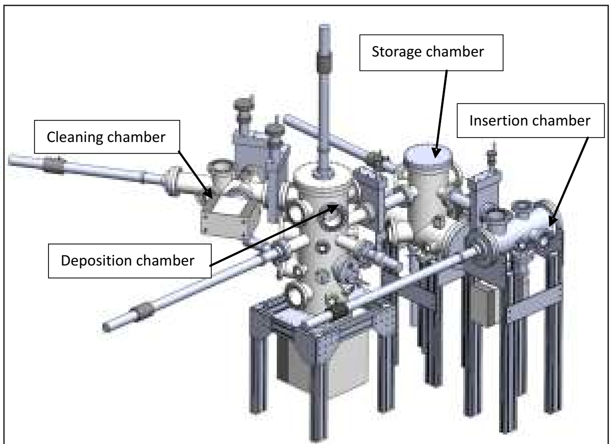


Figure 4: Assembly view of photocathode deposition and transfer facility.

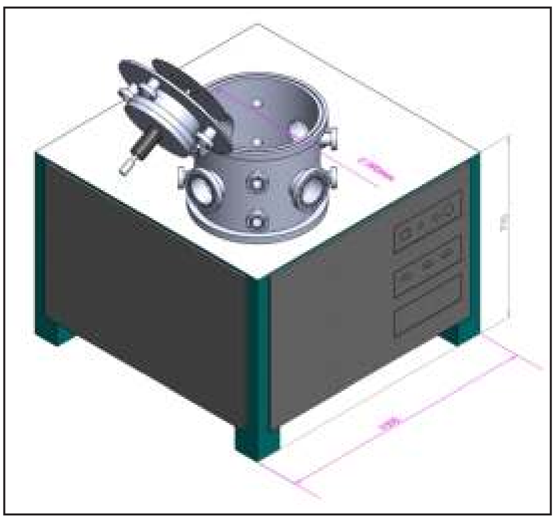
Since the semiconductor photocathodes like Cs_2Te has higher quantum efficiency (QE) of approximately three orders of magnitude in comparison with metal cathodes, the primary goal of photocathode preparation facility will be to develop Cs_2Te photocathodes. In addition to Cs_2Te, many investigators have reported the developments and performance of many other photocathode materials having improved QE. The main focus during the design of photocathode deposition facility was to include the features for developing such photocathodes too with more life time and QE. The development project of photo-cathode deposition facility is in the final stage at BNL under IUAC-BNL collaboration. Target lab member took part in the assembly, commissioning and testing of the deposition system. The deposition system is expected to be shipped to IUAC in the middle of 2021.

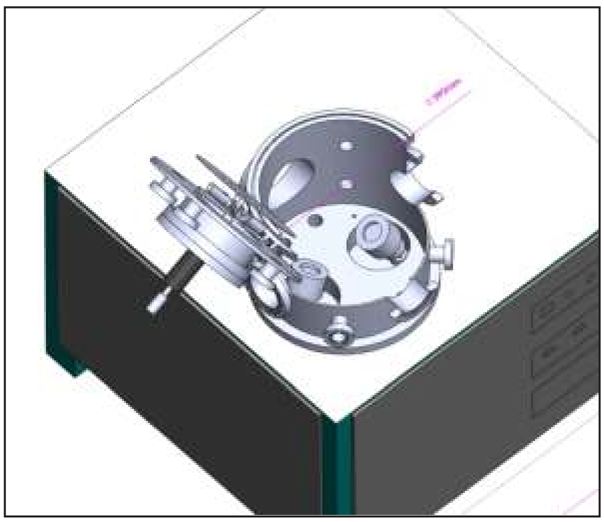
3.1.5.6 Maintenance and upgradation activities in Target Lab

Vacuum coating units and supporting systems in target lab are essentially the combination of several instruments viz; vacuum pumps, gauges, vacuum sealing components, cooling systems, power supplies, quartz crystal sensors and evaporation sources. The periodic and regular maintenance activities of instruments for ensuring the efficient functioning of the facilities are important. Cleaning of the vacuum chamber for minimizing the contamination, replacement of gaskets, replacement of quartz crystal in the QCM, cleaning of chilled water supply lines, cleaning of e-gun crucibles and oil replacement in rotary oil pump etc. are the few regular and periodic maintenance activities. In addition, e-gun sources in the lab are periodically disassembled for cleaning and replacement of ceramic parts. The replacement of 30 years old e-beam power supply in diffusion pump-based evaporator by a new power supply was the major upgradation activity in the lab in this year.

3.1.5.7 Proposal for Sputter Deposition Facility for Target Development Laboratory

Thin film development for the accelerator users of material science, nuclear physics, atomic physics and also the fabrication of stripper foil for the Pelletron are the responsibilities of Target Development Laboratory (TDL) in IUAC. In addition, TDL occasionally supplies targets for the accelerator users in DAE institutes. Development of thin targets and thin films in TDL are mainly accomplished by vacuum evaporation techniques i.e., resistive heating and e-beam evaporation. While evaporating the source material and condensing the same on an appropriate substrate, huge amount of heat is involved. So, target development (especially in the form of self-supporting target) of high melting point metals by evaporation involves lots of difficulties. TDL frequently receives the demand for targets of high melting point materials viz. W, Re, Mo and Ta. So, a comparatively cold thin film deposition process like sputtering will definitely have positive impact in user support activities in TDL





A proposal to build up a dedicated sputter deposition facility for TDL is submitted for the approval. TDL has already procured the sputtering sources, RF power supply and accessories. A dedicated stainless steel vacuum chamber, valves, pumping station, vacuum gauges, thickness measurement set-up and substrate heating arrangement to be either procured or developed availing the Indian industrial resources. The proposed Sputter Deposition Facility will be unique in nature and will be highly useful in developing high quality nuclear targets and thin film samples for material studies.

3.1.6 RADIO FREQUENCY AMPLIFIER LABORATORY

Arti Gupta, Parmanand Singh, S.Venkataramanan and Yaduvansh Mathur

RF Power Amplifiers of HCI

During this year we have been actively involved in installing, repairing, restoring and undertaking periodic preventive maintenance of various high-power microwave power sources and Radio Frequency power amplifiers that are installed with various RF cavities of High Current Injector (HCI) and other accelerator facilities at IUAC. All the power amplifiers of HCI were positioned in their respective places and RF interconnections were made with flexible high-power coaxial cables. Where ever required, suitable length rigid straight- and right-angle-line sections were added. The power amplifiers were frequently cleaned for dust and powered with RF dummy load or actual RF cavity due to various civil engineering work taken up at HCI beam hall during this period. Each power amplifier chassis is connected to a dedicated 220 sq.mm multistrand earth wire using specially made copper clamp.

Within HCI facility, a 120kW (CW), 48.5MHz RF amplifier of RFQ and various other vacuum tube based and solid-state power amplifiers ranging from 100Watt to 30kW are installed and in operation are under care of this group. There was no major failure of RF power amplifier except for a front-end burnout of 6kW RF power amplifier of DTL-1. Due to overdrive, the overdrive sensing circuit of this amplifier was chared, and eventually the burnt parts were locally sourced and repaired.

During this year, we have quickly developed a solid-state power amplifier and replaced an aging 4MHz, 100W Pentode based RF power amplifier installed with beam Chopper of Pelletron. The solid-state power amplifier is optimized for 4MHz operation with higher order low pass filter to reduce harmonics present at its input. The control card of the power amplifier has been modified for smooth integration with the existing control scheme.

In this duration, we have restored a 97MHz, 28kW solid state RF power amplifier with a broken 45kW, DC power supply after repairing the power supply by the manufacturer at their overseas factory. This power amplifier has been tested for its specifications with dummy load and successfully integrated with the HCI DTL cavity and is operational. Numerous tests were carried out in consultation with the supplier of the amplifier in order to get back this amplifier in working order. The remote monitoring and control of amplifier parameters can be done through a set of commands with RS-232 interface.

Some of the commercial solid-state driver power amplifiers (20W, 500W of 97 MHz and 600W, 48.5 MHz) have been repaired, redesigned for better performances. They have been characterized with dummy load and retained as spare units.

A hi-potting system developed for high voltage DC conditioning of power vacuum tube is in use and conditioned the high-power vacuum tubes periodically during this period. In order to maintain a prescribed water pressure to each power amplifier as suggested by the manufacturer, pressure reducing valve (PRV) have been installed in the water supply line. We intend to add water flow switch for interlock and water flow type solenoid valves with each amplifier in order to cut out the water flow in case of major water leakage.

RF Power Amplifiers of SC_Linac

During this time yearly preventive maintenance (YPM) of 38 Nos., of 350W CW, 97MHz solid state power amplifiers of SC-Linac have been taken up and completed. Thoroughly cleaned the interior of these amplifiers for dust and each amplifier was subjected to various essential DC and RF related tests, simulated various fault conditions to ensure the functioning of various interlocks incorporated in control card before restoring them in to system. The observations, repair carried out and test results are documented.

It is reported that, most of the faults in these power amplifiers have been occurring due to aging effect in the control card. We have redesigned the control card and prototype version has been tested. We intend to replace all the control cards in these power amplifiers at the earliest.

Microwave Power Generators

We have been taking care of the aging microwave power generator of ECR ion source (PKDELIS). The Klystron powered 17.7GHz, 2kW CW power generator has been thoroughly cleaned during this period, and faulty instrument cooling fans were replaced. Due to inconsistency in power delivery, the individual building blocks of the power generator was tested with signal generator and power meter. The faulty part of the power generator (an adjustable power Attenuator) was isolated. The re-calibration work of the power generator was carried out systematically and considerable increase in power output was measured while dumping the power across an air-cooled dummy load. The microwave power generator is being used for developing numerous beams. We have also procured and installed a DRO type microwave input power source. The remote operation of this power generator has been tested with newly laid pair of control cables.

The RFA group is also given the responsibility of implementing the RF tuner of PKDELIS ion source of HCI. The RF Tuner Controller is used for controlling the movement of Tuner for the PKDELIS ECR (Electron Cyclotron Resonance) ion source cavity of high current injector (HCI). By moving the tuner rod IN or OUT in plasma chamber with the help of a motor, we can tune cavity frequency and thereby we can impedance match the Klystron microwave power generator to the plasma chamber impedance. Position read-back of the tuner is also provided at the control console which helps in tuning of the beam and its analysis.

Another spare 250Watts CW Travelling Wave Tube (TWT) amplifier (8-18GHz) has been recovered and successfully tested with an air-cooled dummy load for operation with LEIBF at IUAC.

Klystron and Pulse Modulator of DLS

The RF Amplifier group is also actively involved in activities related to preventive maintenance, repair and assisting in operation of high-power microwave power generator of Delhi Light Source (DLS). The Klystron based microwave pulsed power source with full length of vacuum wave guide installed was initially tested with water cooled dummy load and later the RF cavity was connected and continued to be RF conditioned. The Klystron amplifier is powered with a state-of-the-art pulse modulator (M/s. Scandinova, Sweden) for generation of 25MW RF power with pulse duration of maximum 4 microsecond at 50 pulse per second. The faulty Capacitor Charger Power Supply (CCPS) and IGBT switching units which had failed during routine operation were successfully repaired locally with the help of OEM and reinstalled the CCPS for normal operation during this time.

Nuclear Instrumentation

RFA group is also fulfilling the responsibility of maintaining the various customized front end and signal processing electronic units. These units under group care were mass produced by the group members and supplied to different nuclear physics experimental facilities of IUAC. We have overhauled the analog signal processing electronics setup of Indian National Gamma Array (INGA) and National Array of Neutron Detectors (NAND), wherein all the cooling fan assemblies, NIM crates, individual modules and detector cells and PMT voltage dividers were thoroughly cleaned of accumulated dust and checked the functionality of individual units for performances with standard test equipment. The faulty units were pulled out and restored them after repair at our laboratory. In all the modules critical threshold settings (LLTH) were restored for user convenience. All the NIM modules were subjected to standard test procedures, checked and documented with detailed check list before restoring them back into their original position. In NAND all the modules were tested with detector set-up before handing over to user. The compiled list of equipment under our care are tabulated here.

List of Equipment >>	NIM Crates	Cooling Fan Assembly	No. of NIM Custom Modules	PMT Bases
NAND experimental facilty	11 Nos.	20 Nos.	54 Nos.	106 Nos.
	NIM Crates	**Cooling Fan Assembly**	**No of Custom NIM Modules**	**ACS Preamplifiers**
INGA experimental facility	6 Nos.	12 Nos.	42 Nos.	3 Nos.

List of Equipment >>	Multi-TAC	SSB Electronics	5 in 1 Pre-Amplifiers	Fission Detector electronics
HIRA/HYRA Group	2 Nos.	5 Nos.	5 Nos.	2 Nos.
General Purpose		5 Nos.		5 Nos.

3.1.7 HEALTH PHYSICS LABORATORY

Debashish Sen & Birendra Singh

To ensure 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 programs) 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.

All radiation dose records of IUAC radiation workers are maintained. Some 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. Purchasing of 2 X-ray survey meters for FEL facility, purchasing of 12 neutron area monitors, testing & installation of these 12 neutron area monitors, designing of 3 PCBs for Door Interlock system, assembling of 5 PCBs for Door Interlock system and installation in tower areas, with new LED display board were done during this period. Some of the door interlock systems underwent thorough repair. Some new shielding was added & modified as per requirements. Radiation sources (with adequate shielding), as usual, are kept under strict vigil.

A few university faculties and research scholars are using the existing Health Physics Lab. facilities (gamma irradiation chamber, TLD reader, electrochemical work station, furnace etc.) maintained and updated by this group. Users are from Punjabi University (Patiala), Delhi University, AM University, JMI University, HP University (Shimla), Indra Prastha University, Amity University (Noida & Gurgaon), NIT Jalandhar, NIT Kurukshetra, RTM Nagpur University, etc. Some research scholars have completed their Ph.D. using the facilities and a few research scholars are continuing to do so. Many of the AUC approved projects require these off line facilities throughout the year.

3.1.7.1 AERB online (remote) regulatory inspection (October 2020)

Online/Remote Regulatory Inspection (RRI) is one of the types of inspections conducted by AERB through which it ensures that the nuclear and radiation facilities are in compliance with 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.

In this inspection process, photocopy of duly filled & signed self-assessment checklist was sent to AERB by the facility through e-mail, which was reviewed at AERB. Based on the review, additional submissions were sought, followed by discussions through video-conference. Inspection findings, was communicated to IUAC during the video-conference, and was also sent to the facility for concurrence. Photocopy of the duly signed (Signature & Facility Seal) form was sent back to AERB through e-mail. Based on review and discussions, inspection report was generated through e-LORA. Response to the inspection findings (non compliances) was submitted through e-LORA within stipulated time to facilitate review and disposition. Finally, corrective actions, few of which arose from self-assessment was implemented without delay to the satisfaction of AERB officials.

3.1.7.2 e-LORA facility of AERB

Electronic Licensing Of Radiation **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.

As usual, following procedures are being carried out using this e-LORA facility:

1. Sent quarterly safety status of radiation facilities.

2. Non compliance of any safety measures and its rectification.

3. Permission/regularization request of an upcoming/existing radiation facility. (Negative ion implanter facility licence was procured)

4. Providing details of the radiation monitors used in the facility along with their calibration dates and other details.

5. Obtaining/Renewing license of a radiation facility. This year Pelletron-LINAC, RBS and Gamma Irradiation Facility licence was renewed.

6. Renewal of tenure of IUAC Radiation Safety Officers.

7. Providing details of radiation sources in custody of IUAC.

3.1.7.3 Audiovisual Lecture on Radiation safety at IUAC

Debashish Sen

An audiovisual lecture (duration 40 minutes) on **radiation safety** (meant for IUAC visitors/users/new entrants) was designed. The basics of health physics, radiation benefits, effects & hazards, radiation safety rules & regulations, along with its relevance at IUAC, detailed user guidelines & instructions are all explained in the video. This is meant to be mandatorily shown to any user/new entrant before their entry in the radiation areas. Also, it is supposed to be put in the official page of IUAC after its approval.

3.1.7.4 Shielding modifications proposed in Beam Hall I & III for augmenting HCI facility in future

Debashish Sen

Modification of HCI beam line shielding in beam Hall 1 & III (along with adjacent corridors): The facility site approval has been taken. The design and construction application is on hold. Shielding calculations are also in the final stages. The modification of the shielding layout of Beam Hall I is under consideration. The latter part of HCI beam line is to be built in Beam Hall I, which will merge into the Pelletron accelerator zero degree line. Hence, the original approved shielding layout has to be modified, so that the beam lines GPSC and Mat Sc. remains operational and accessible, even when the HCI beam is ON. The adjacent corridors also need new shielding set ups (to take care of the radiation safety when HCI is running). All these modifications are being planned at this stage, and will be implanted only after AERB approval is obtained.

Proposed addition/modification of shielding/interlock system for HCI beam line in BH III

1) The door from HCI to MRI room should be compatible to fire safety or emergency exit and must have the provision to get it opened only from HCI side without key. However, from MRI to HCI, it should be opened with Key and should maintain the radiation safety protocol. Radiation safety interlocking system will be provided on main door from HCI to MRI. The present door is to be replaced by a suitable new door.

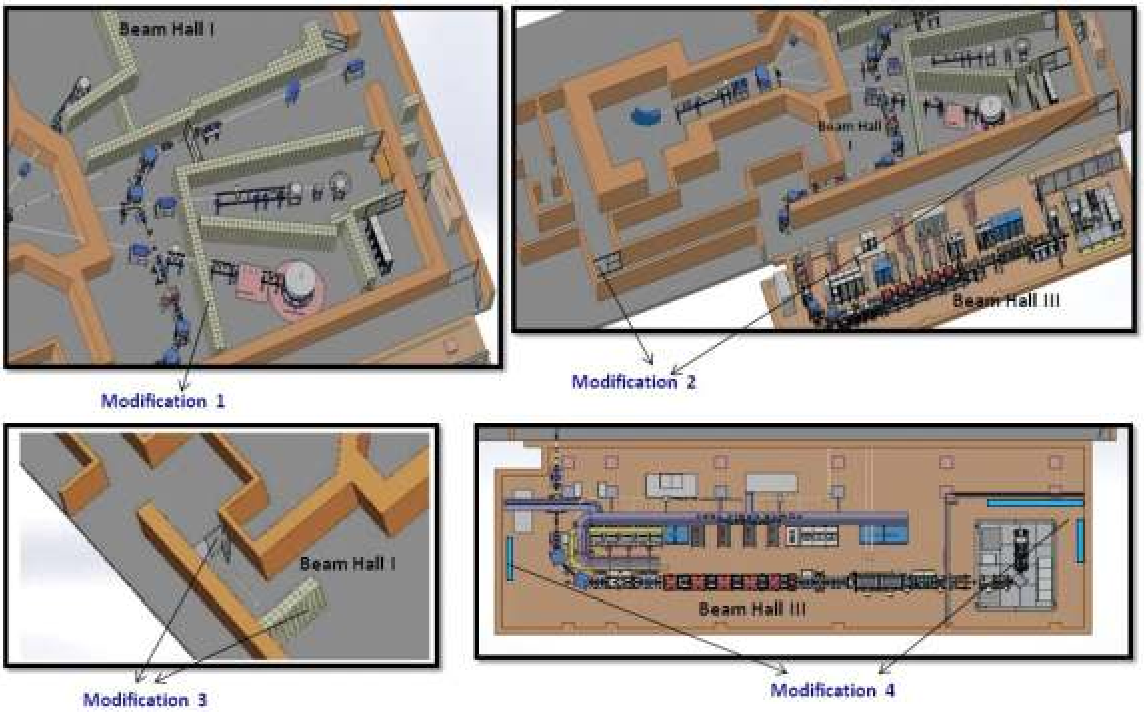
2) The existing Aluminium door from HCI towards east side external road will also have the same radiation safety provisions and hence the existing door to be replaced by new one.

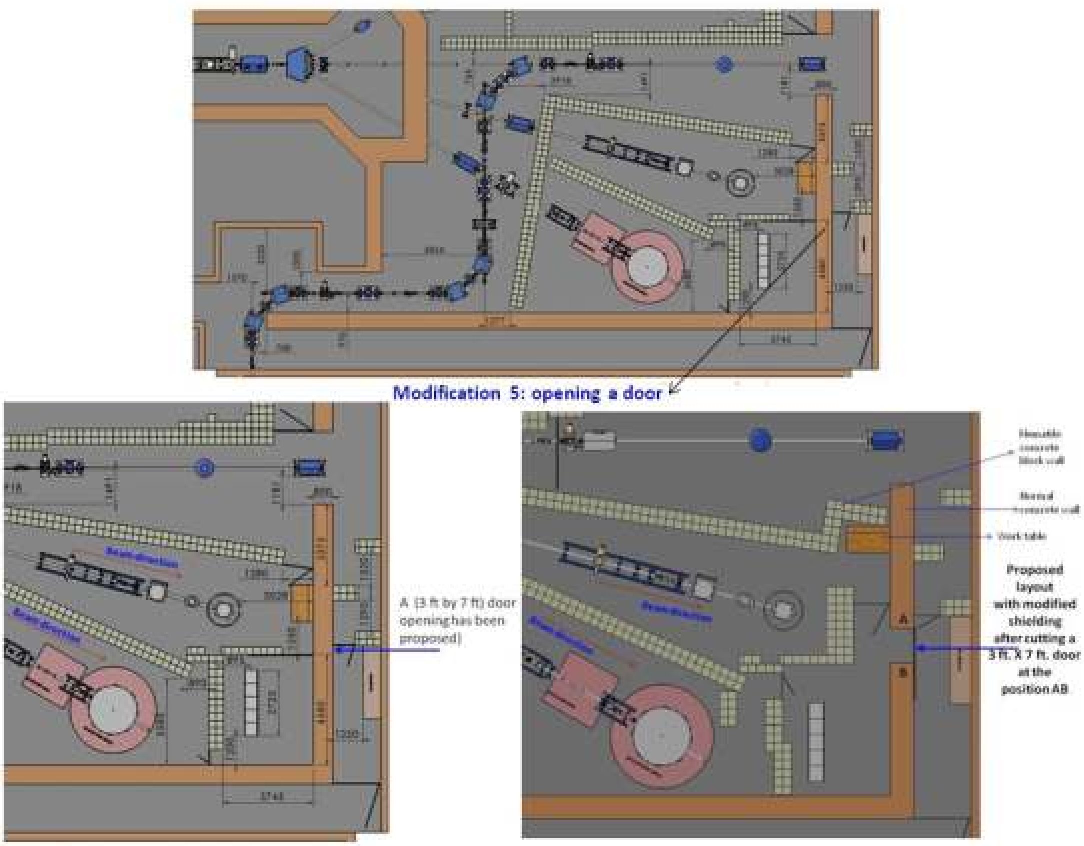
3) Lead blocks are to be provided (adjacent to achromat I) for radiation shielding to provide the access to the FEL area from outside of the building through the east door.

4) Another appropriate lead shielding is to be provided to stop the radiation from the HCI beam line through the door opening to the stairs going down to the Klystron area of FEL.

5) Near the glass door separating the corridor (going towards the MRI room) from the ECR ion source, a lead shielding is to be installed to ensure a radiation free passage from FEL to MRI area.

6) For HCI personnel, during normal and emergency situation, both the doors from HCI to MRI and the HCI to Data Room should be opened from HCI side and should be compatible with radiation safety.





The feasibility of opening a door in one of the existing shielding concrete walls (AB) is being looked into by architectural experts, from the load bearing point of view. Radiation safety, of course has to be maintained.

3.1.8 DATA SUPPORT LABORATORY

New-generation Instrumentation & Acquisition Systems (NIAS)

Mamta Jain, Kusum Rani, Subramaniam. E. T.

3.1.8.1 NiasOS-64

Mamta Jain, Subramaniam. E. T.

A 64 bit tiny linux, (around 1.7 MB compressed), with net boot ability, rootfs on memory disk along with GRand Unified Boot Loader (GRUB) was compiled. This contains the server (marsServ) and DAQ library (libnias) with user level Universal Serial Bus (USB) driver. All the in house developed Versa Modulo Europa (VME) controllers can boot over net from this tiny linux.

3.1.8.2 Beam Profile Digitizer (BPM Digitizer)

KuSum Rani, Subramaniam. E. T.

Printed Circuit Board for the new Beam Profile Monitor (BPM) digitizer has been designed, fabricated and populated. Alpha testing of analog board, digital board and power board has been done. It supports both USB 3.1 as well as USB 2.0 communication interfaces. Achieved through put is around 342 megabytes / sec. PXE based remote boot SBC has been used to make the the system uniform and easily up gradable.

3.1.8.3 Readout Ordained Sequencer Engine (ROSE) – II

Mamta Jain, Subramaniam. E. T.

The VME controller ROSE has been upgraded for future proof as well as to avoid obsolescence of USB 2.0 as USB 4.0 will be the new normal in all the computers from year 2022 onward this simultaneously reduces the latency from 2ms to 125us. This improves the number of VME cycles per second in Single Cycle Transaction (SCT) mode. In ROSE-I using USB 2.0 the maximum front end throughput was 48 Mbps, which has increased to 352 Mbps using USB 3.1 in ROSE-II. With VME cycle it could achieve throughput of 40 Mbps with zero delay clients and 27 Mbps with commercial VME clients. The in-situ testing with Eu152 source of VME crate controller ROSE-II is being carried out in the Indian National Gamma Array (INGA) experimental setup (Fig. 1) in Phase II beam hall of IUAC. This high throughput capable module designed and developed in house costs less than Rs. 75 K only, which is around an order of magnitude less than that of lesser capable (with respect to IUAC DAQ requirements) commercial controller module.

Fig 1: VME DAQ at INGA

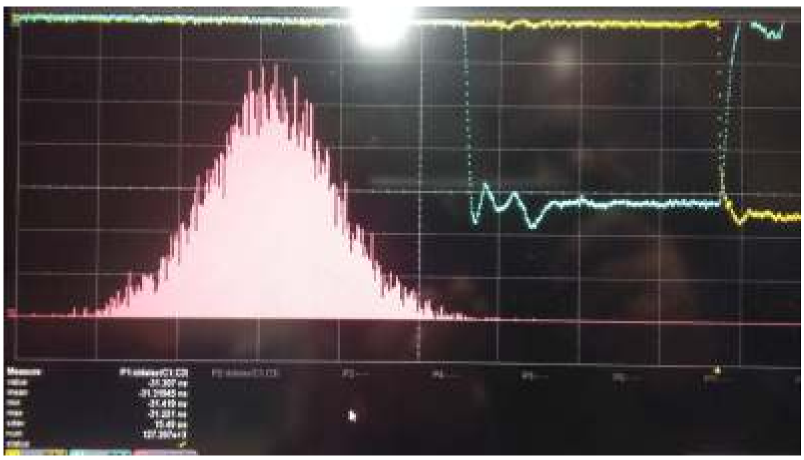


Fig 2 Delay and jitter of busy logic

Features :

1) 64-bit time stamping of every VME-IO in SCT mode and block of events in Block Transfer (BLT32) mode.
2) Supports A16 / A24 / A32 with SCT D08, D16 and D32.
3) BLT32 is supported in A24 / A32.
4) 64-bit scalar for counting the number of received triggers.
5) Two 4k x 32-bit ping and pong buffers for maximizing the through put.
6) 256 x 80-bit sequencer memory.
7) In-built busy and trigger logic with programmable strobe width and conversion delay up to 40 us.
8) The master strobe from the busy logic has σ (Fig. 2) of around 16 ps (much less than 1 LSB of the time to digital converter).
9) Being tested with pelletron control system.
10) In situ testing in INGA beam line.

3.1.8.4 ZEIT – Zap Event Identification and Time stamp module

Kusum Rani, Subramaniam. E. T.

A VME module was designed, developed for event identification, time stamping and hit pattern recording of the events of interest. The design is based on 45 nm FPGA Spartan 6, running at 100 MHz clock. Low Voltage Differential Signaling (LVDS) is chosen to achieve better noise immunity. Being tested in INGA beam line with gamma source.

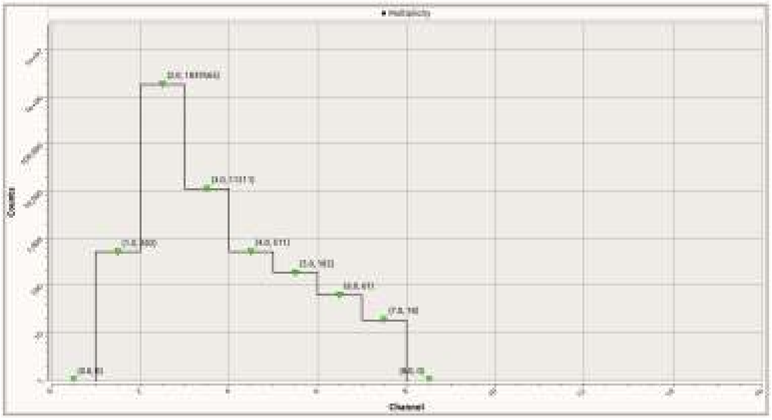


Fig 3: Coincidence (Doubles), veto (Singles)

- 32 INPUTS (Differential ECL)
- Event of Interest output for VME Controller. (NIM)
- Event selection efficiency > 99.97 % i.e., random singles with doubles coincidence is < 0.03 %. (Fig. 3)
- Latch Input for Event Time Stamping. (NIM) Delay between ECL (IN) to EOI (OUT) is ~ 22 ns.
- Multiplicity o/p width from 50 nS to 5 uS in steps of 10 ns.
- Configurable VETO selection, VETO width and VETO delay.
- Time Stamp with 10 ns resolution and 32.5 days range. Supports A32, D32 / D16, BLT32/Single cycle.
- In situ testing in INGA beam line.

3.1.8.5 NiasMARS – Multi-parameter Acquisition with Root based Storage

Subramaniam. E. T., Mamta Jain, Kusum Rani.

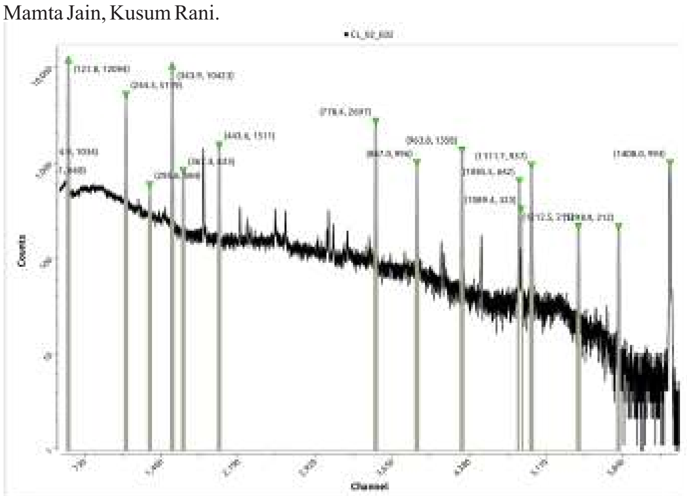


Fig 4: Histogram from Eu152 Source

The Qt, Qwt libraries based Graphical User Interface (GUI) client NiasMARS, was modified to adapt to global event identifier module (VME-GEM), scalar module (V830). Special configuration options for gamma multiplicity and individual detector rate computation logic were implemented. Supports 1024 signals, with simultaneous display of 32 two dimensional and 16 one dimensional spectra. Peak searching and automatic fitting (Fig. 4), calibrating after a match with radiation source information (e.g., Eu152, Co60 etc) are implemented. The log and the hardware configuration are also saved at the end of every list mode file. Example 'ROOT' (analysis library package from CERN lab) programs for display, manipulate, fit etc. has been developed and is distributed with GNU General Public License (GPL) as part of the NiasMARS DAQ package.

3.1.9 COMPUTER AND COMMUNICATIONS

B.K. Sahu, Abhishek Kumar, S. Bhatnagar, S. Mookherjee

In the year of pandemic, where physical distancing has become the new normal, the major thrust in this year was to sustain the load on network and internet requirements and also put in place efficient operation and maintenance processes to cover additional challenges of conducting various academic programs in online mode with necessary user support. The emphasis of the group is to ensure uninterrupted connectivity to outside world during the pandemic year.

3.1.9.1 Networks, Internet services & Central servers

Performance of the IUAC network in the pandemic year is found to be satisfactory without any major breakdown. Maintenance of wired and wireless network is carried out in house in absence of outside service personnel during restrictions. One core switch and two edge switched are replaced due to failure of operational switches. All the network switches, central wireless controller and the Sophos UTM were arranged in a dedicated rack and provisions kept for future expansions. Alternate internet link provided by Powergrid is replaced by a new link from Ishhan technologies. The UTM was configured to fall back automatically to this spare internet link on failure of the primary NKN link. The migration of the IUAC firewall and internet access setup to the Sophos XG310 UTM was completed last year has been functioning properly, and all the desktop and server systems are using the same to send and receive internet data only through the UTM. The security threats were being monitored and potential security threats from infected PCs in labs were identified and resolved.

Extension of IUAC Network to NAAC building: The passive network components for connecting the NAAC building to the internet using the IUAC LAN were installed and tested in this year. This included installation and configuration of a local router in the NAAC building premises configured in DHCP mode for addressing computers in the NAAC building. Wireless access is provided in FEL area for remote connection of operational devices for access outside.

Expansion of control network: Additional control network is added to take care of all radiation monitoring devices installed in various locations in main accelerator complex and beam line.

Status of Central Servers: All the servers are running efficiently without any major breakdown. A new LTS server that boots up thin clients using TFTP (Trivial File Transfer Protocol) with Ubuntu 20.04 operating system was installed and configured. The server successfully booted thin clients in the lab and is under further testing before finally getting deployed in the data centre to serve users of thin clients. A dummy ERP (Enterprise resource planning) server was installed with the existing database to speed up code development and testing of new functionalities without interrupting the services of the presently installed server. As the maintenance of the hard copy register has been suspended due to pandemic, the service complaints are registered online in the ERP system. Also, there is a provision of updating the status of the complaint by the respective group in-charges. Two HP servers for website and database were installed in the data centre with red hat enterprise linux 7. The servers have been made ready for installation of the software package in the coming year for implementation of Online APAR and BTS module along with the web server. Services of the Zimbra mail server has been extended for three more years and preventive steps are taken to prevent spam outbreak, caused by malware from infected systems.

3.1.9.2 Video Conferencing and Learning management system:

In order to follow social distancing protocol during the year of pandemic, Video-conferencing has provided the way forward in conducting meetings as well as providing support to academic programs. A dedicated webex and google cloud services are set up for conducting the online workshops, schools and conferences. All the events listed in the academic calendar are being organized in virtual mode using these platforms. This has enabled us for a wider range of participants across the nation and removed the constraints on the number of participants due constrain of physical space and long-distance travel to attend programs at IUAC. Ph.D. classroom programs are conducted in online mode. Support for online participation certificate in the events and admit card for tests has been provided by the group. A learning management system is also made with an open source package known as 'moodle'. This system can serve as the platform for delivering lectures, giving assignments and evaluating them, taking quizzes etc. for faculty members. This facility along with video conferencing can be utilised by university community in future to become the cornerstone in developing an online learning ecosystem for the university teaching system.

3.1.9.3 Status of Supercomputing Facility at IUAC

High Performance Computing system at IUAC established in 2009 with support from DST. Initially the computing facility named as Kalki with master+ 96 compute nodes, 768 cores, 9 TF computing capability with 5 TB PVFS2 was set up. Data Centre with 16 racks with 20 kW cooling system per rack was made to house the facility. In the year 2012 an upgraded cluster K2 consisting of Master+200 compute nodes, 3200 cores, 65 TF peak, 55 TB Lustre made operational. The computing facility was operational till 2019 with approximately 150 research groups and 500 users using the computing facility over these many years. At present Kalki facility is non-operational with all nodes down. K2 facility has also reached the end of life and more than 60 % of nodes are down. The fact that the systems were old and at the end of useful life, coupled with lack of hardware maintenance support, finally led to an unacceptable loss of nodes and reliability. The facility in its present form is not in operation as a national facility since May 2019. Now the facility is being used by internal students and staff of IUAC.

A project to set up high Performance Computing solution for universities got approved under National Supercomputing Mission (NSM) in the year 2020. The facility known as Virtual Inter University Computing Centre (IUC) with 3 PF computing facility will be installed at IUAC with support of technical team from CDAC. Initial meetings with CDAC was held for finalization of requirements. The computing facility is being planned under make in India super-computing facility by CDAC under phase 3 plan of NSM. As the installation of Phase 2 of NSM is delayed due to Pandemic, the Phase -3 projects will be taken up by CDAC after completion of Phase -2. In meantime infrastructure requirements at IUAC is being worked out. Approximately 4000 Sq. ft. place is needed for the facility setup with 2000 Sq.ft. for the Data Centre. in ground floor. Liquid Cooled servers will require 800-1100kW cooling power and ~ 2 Ton per Sq. m. physical load. Keeping in view of this, location for new data centre is finalized in ground floor (below the existing data centre). The Civil infrastructure will be made ready in consultation with CDAC.

3.1.9.4 Upgradation of EPABX System

The Centre has a Siemens HICOM 330E EPABX system operating at maximum installed capacity of 409 extension lines, 8 Junctor lines (MTNL), The EPABX is a TDM-PCM type of EPABX operational for last 21 years. This version of the EPABX is already announced as the end of support from the parent company. The system cannot be expanded as the licenses are not available. As the new facilities along with required building infrastructures are coming up in the Centre, the present EPABX system cannot cater to these future requirements. This year we have initiated plan for phasing out the TDM-PCM technology based EPABX with replacing the same by a futuristic IP based EPABX.

As our present EPBAX system also cater to nearly 200 extensions to housing blocks, guest houses and hostels. A full IP EPABX needs a network connection at every point where an extension is to be provided. This needs the upgradation/expansion of LAN switches along with LAN cabling to housing blocks. Also the cost and maintenance of IP phone is high as compared to the analog phone. As the existing analog phones are working in these extensions and support for copper cabling is available the new EPABX system needs to have the support for using existing analog phones. Besides this the IP EPABX is planned to provide full mobility in our lab complexes including experimental areas in the Beam Halls along with future ready technologies to connect with new age clients in lab complex such as PCs, smart phones, IP phones etc. along with VoIP and GSM input lines.

Based on these observations a Hybrid EPABX system supporting both TDM and IP extensions is going to be installed in the coming year. The Switching system of the EPABX is designed with IP at the core allowing fully distributed IP solutions across data networks. The system is going to be a digital and fully non-blocking switch, offering IP-PBX, enabled with Unified Communication and Collaboration Application.

3.1.10 ELECTRONICS FOR CRYOGENICS, SPL, EBW and MRI

Joby Antony, Rajesh Nirdoshi

3.1.10.1 Cryogenics Control System & Associated Electronics

The IUAC Cryogenics control system and associated electronics have been functional throughout this year. At present, the Cryogenics control room has four control terminals for control and data acquisition as shown in Fig. 1.

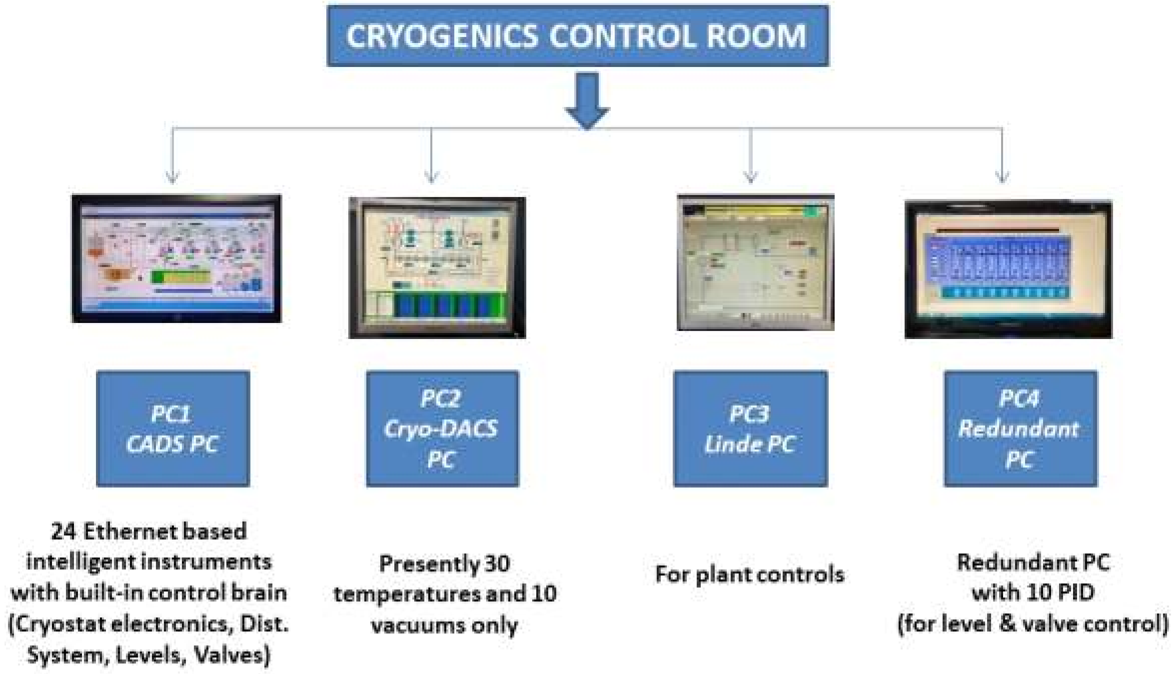


Fig. 1: The Cryogenic Control Room Terminals

1) CADS Terminal

CADS is the Ethernet-based crate-less IoT model of a completely indigenous Cryogenic control system built with 24 Cryogenic instrument nodes that work as autonomous controllers called device-servers, interconnected over Ethernet (LAN). This networked distributed control system has a total of 352 tags. It works for open and closed-loop control operations of the Cryogenic distribution system where the control loops run every second for sensor-actuator controls, monitoring & data logging. The system has a distributed sensor network at the back end for the measurement & control of Cryogen levels, pressures, ON/OFF systems, PID, etc. As part of the recalibration activity, all the instruments have been calibrated offline. To be updated with the development tools from time to time (revised MBED IoT ecosystem and cloud compiler), the firmware of each device has been updated first time since its inception in 2012. This also helped to incorporate the long-pending firmware modifications since the recent removal of many solenoids on/off valves from the initially planned Cryogenic system.

2) CRYO-DACS Terminal

CRYO-DACS is the oldest VME system of IUAC built in the year 2002. Most of the signals from this system have been ported to indigenous CADS systems already, except a few Cryostat temperatures (30 channels) and 10 vacuum signals of all 5 Cryostats. Considering the obsolete operating system (WIN2000) of the CRYO-DACS PC, we have immediate plans to upgrade the entire system with an indigenous system.

3) LINDE Control PC Server

This PC is a critical standalone system used for Cryogenic plant controls originally supplied by M/S Linde, Switzerland with Siemens software. This year, the main control server (RMCS) failed due to motherboard failure. Due to a lack of timely support from vendors, the faulty motherboard was repaired in-house and the control system was fully tested back to Linac operation successfully.

4) Redundant PC with 10 Fuji make PID controllers connected over RS-485

This PC is the outcome of the phase-I upgrade activities, as suggested by an earlier committee constituted for Cryogenics control system upgrade. This PID redundant system with a switch-over unit between indigenous IUAC soft-PID (10 channels) and commercial Fuji hard-PID meters (9 channels), is used in conjunction with 10 IUAC-make LHe & LN2 level meters from the back-end. This phase-I upgrade was tested for standalone proportional valve controls of all 5 cryostat levels. This system is presently used in the Linac runs and provided satisfactory redundancy.

5) New Historical Trends Utility

An additional GUI software utility has been added this year for the analysis of complete analog & digital parameters of every experimental run of long durations (i.e up to several months or years). It has a large number of historical trends to simultaneously view & analyze different parameters online & offline by operators. The parameters are levels, vacuum, valve positions, DIO, pressures, etc. of Linac as shown in Fig.

Fig. 2: Additional Historical Trends Utility

3.1.10.2 Prototype Development of a TRV Device

A special eight-channel device (called TRV device) has been prototyped and tested recently in our lab to use with some of the following future applications in mind.

i. A new cost-effective Cryogenic thermometry network using distributed TRV devices for Linac (remote without a VME crate) with multi-sensor support

ii. Import substitution for M/s Lakeshore meters for self-heat limited Cryogenic sensor calibration and various simple temperature monitoring applications.

iii. To populate it as a 5 channel Linac vacuum readout server.

As part of the phase-II upgrade plans, the obsolete VME system is to be replaced by an easily maintainable cost-effective distributed system of six interconnected devices for the measurement of a small number of temperature (30) and vacuum (5) signals from linac. Each single prototype device can measure and stream remote data to the distant control room. The devices can also be programmed to measure the sensor temperature, resistance, and voltages simultaneously and they come with an RS232/Ethernet data logger. Any particular type of sensor can be assigned to any one of the 8 channels through a menu-driven keypad (firmware). The model has eight programmable constant current sources (one for each input) that can be configured for a variety of sensor calibration curves (firmware). It supports DT470, DT670, old NSC diodes, CCS, custom, and PT100 RTD sensor curves. The 8 channel 12 bit-resolution A/D converter reads sensor inputs. One such prototype, fully built in-house is shown in Fig. 3. We are planning to build a 48 channel PC-based data acquisition system software dedicated to this TRV hardware for remote data monitoring and logging from the Cryogenic control room.

Fig. 3: A Prototype TRV Device

3.1.10.3 SPL Control System Activities

The in-house developed Surface Preparation Lab (SPL) control system has undergone the following issues this year:

a) The control system was giving communication error during electropolishing – Rectified at the Allen-Bradley PLC level.

3.1.10.4 EBW Control System Activities

There were the following two issues related to the Electron Beam Welding (EBW) machine this year:

a) A Gun temperature controller was malfunctioning as water leaked inside that – Repaired the controller.

b) Chamber vacuum gauge controller went faulty – Repaired

c) The diffusion pump pneumatic valve failure – sensor issues

3.1.10.5 MRI Related Activities

The majority of the cabling job of different components of the MRI instrumentation rack has been completed this year. This rack will work as a gateway between sensors & signals from MRI magnet and LabVIEW FPGA-based data acquisition system connected with cRIO crate. The work completed so far is shown in Fig. 4. The man-machine interfaces of MRI GUI software is being taken up separately and works are expected to be completed by next year.

Fig. 4: MRI Instrumentation Data Acquisition Rack Cabling

3.1.10.6 Other Activities of Lab

- Mentored a student in B.Sc Summer Programme &3 B.Tech Internship
- Operational duties of Linac
- Maintenance and upkeep of laboratory
- Documentation activities

3.1.11 LOW LEVEL RF & BEAM BUNCHING GROUP (LLRF)

V.V.V.Satyanarayana, Ashish Sharma, Sarvesh Kumar, B.K.Sahu and A.Sarkar

Low Level RF & Beam Bunching Group (LLRF) is an Accelerator Support Central Group (AcSCG) that takes care of the operation, maintenance, upgradation and development of different LLRF systems like the Beam Pulsing System of Pelletron-Linac (BPS) and associated control electronics for Multi-Harmonic Buncher (MHB), Chopper, Travelling Wave Deflector (TWD), LLRF for Linac, High Current Injector (HCI) and Free Electron Laser (FEL). Inspite of the COVID-19 restrictions laid down by the Govt. of India, this academic year (2020-21) was quite productive for the LLRF group activities. A brief description of the activities is given below.

3.1.11.1 Operation, Maintenance and Upgradation of Beam Pulsing System for Pelletron

During the year 2020-21 the operation of Beam Pulsing System of Pelleteron (BPS) includes several pulsed beams runs for internal users, few external users and facility test runs maintaining strictly the COVID-19 regulations as laid down by Govt. of India. All group members performed operational duties (On-Call mode) during Pulsing beam runs. BPS facility tests allowed us to test the spare Phase Control modules and initiated for development of Integrated Phase Controller and Receiver modules. Calibration of the existing MCA (0.055nS/Channel) and new MCA (0.034nS/Channel) was also completed during these facility tests.

Table-1: BPS Operation Summary

	Energy (MeV)	TWD	Facility	No. Shifts
^{28}Si, 6^{+}, 11^{+}	125	OFF	NAND	9
^{16}O, 6^{+}	80	2uS	Stability Test Run	6
^{19}F, 6^{+} 9^{+}	160,155,145,135,125,115,105	4uS	HYRA	24
^{16}O, 6^{+}	76	4uS	HIRA	15
^{16}O, 6^{+}	84	OFF	GPSC	12
^{12}C, 5^{+}	73	OFF	GPSC	12
^{19}F, 6^{+}	84, 86, 64, 65, 68, 98	4uS, 1uS	HIRA	18
^{12}C, 5^{+}	74, 72, 70, 66, 54	4uS	HIRA	15
^{19}F, 4^{+}	52, 46, 41, 45,49, 51, 53	2uS	HIRA	18
^{19}F, 4^{+}	53	OFF	Facility Test Run	9

Apart from routine preventive maintenance, major repair of TWD was done. All 12 pair deflecting plate's control electronics were made operational and tested for more than 24 hours. Major jobs in this repair includes, making and testing of Pulse Transformers, replacing leaky Tetrode valves, driver transistors, and replacing control electronics PCBs of TWD, etc. This repair job was taken up mainly to utilize the time-slot available with Pelletron accelerator during Unlock 2.0 due to the Pandemic situation of COVID-19.

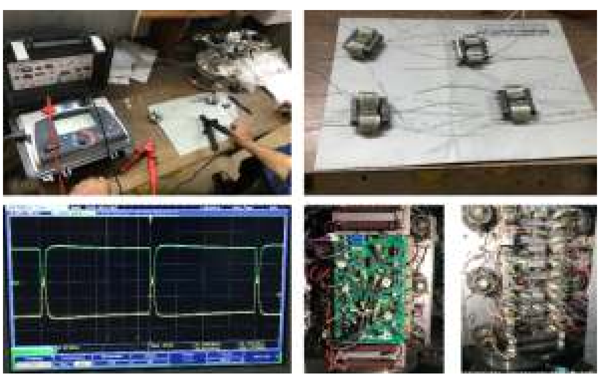


Fig. 1 TWD Repair and making of Pulse Transformers

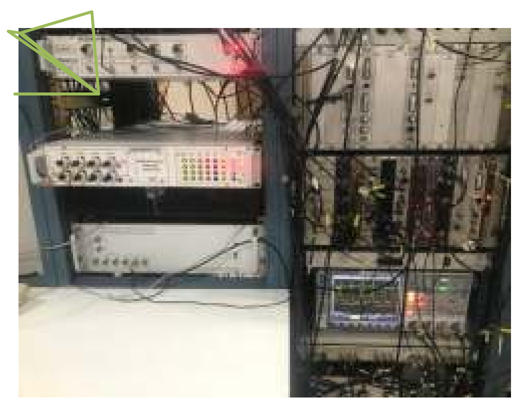


Fig. 2 Upgraded Pelletron MHB Controller

Upgradation of Beam Pulsing System includes Commissioning of new MHB Controller, Gated video Module, replacing chopper amplifier with water-cooled solid-state amplifier and testing of USB based 4k MCA to measure FWHM during Pulsed beam runs.

3.1.11.3 Preventive Maintenance of LLRF Systems for Linac

The operation and upkeep of all resonator controllers are done by the group members during the scheduled preventive maintenance. 27 resonator controllers, 8 Input modules, Reference splitters, 16 Piezo Tuner Controllers and their spares were tested and ready to use. A detailed report on the operation maintenance and upkeep of the Linac resonator controllers at IUAC is under preparation.

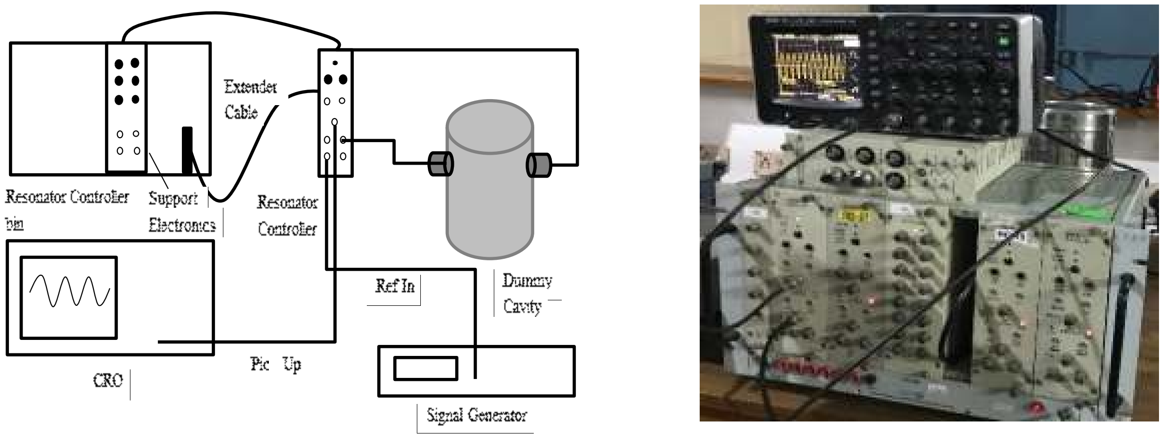


Fig. 3 Block Diagram and Test Setup of LLRF Controllers of Linac

3.1.11.4 LLRF Systems for High Current Injector (HCI)

The Multi Harmonic Buncher (MHB) and its LLRF Controller were restored after RF cables layout modification after a long break due to COVI-19 Pandemic. A time resolution of ~4nS as seen by FFC signal on 500 MHz CRO was measured for 8keV/u, N 5+ at beam current of 500nA.MHB amplifier was upgraded before this testing. Layout design and Installation of LLRF Controls electronics in two 19-inch racks was completed. Laying of RF and interlock cables between RF cavities and control electronics was completed. Development of LLRF Controls for DTL#3 to 6 was completed. Testing and Commissioning of LLRF controls for DTL#3 to 6 is under process. Design and development of VME and LLRF Interface modules for remote operation is under process. MHB chiller maintenance, Calibration of Master Clock distribution for HCI, restoring of LLRF controls for RFQ, Spiral Buncher and DTL#1-2 were completed during Preventive maintenance.

Fig. 4 LLRF Controls Racks and Inner view of Electronics

3.1.11.5 LLRF Systems for Free Electron Laser (FEL)

Installation and testing of Current Transformer was completed. Beam viewer camera was also installed VSWR, Vacuum and Temperature Interlock module is under testing. High power RF conditioning of the cavity is under process. Fabrication of additional fast analog interlock circuitry for High Reflected Power, poor cavity vacuum, and cavity temperature is under process. A 2T NIM module is being prepared which takes Reflected Power input from the Reflected Port of Directional Coupler after suitable attenuation and low pass filtering. Vacuum level signaling is done based on current output of the Ion Pump Controller and cavity temperature is taken from a PT100 sensor mounted on cavity's body. Based on the interlock situation, the Master Oscillator signal going into the driver amplifier is cut-off. This serves as an additional interlock mechanism over the existing interlock scheme of the klystron modulator.

3.2 UTILITY SYSTEMS

3.2.1 Electrical Group Activities

U. G. Naik, Raj Kumar

This group is primarily responsible for maintaining the electrical installations of IUAC and also to develop adequate electrical infrastructure for the new facilities. We are happy to put on record that in spite of COVID situation with support of skeletal maintenance staff the uptime achieved for electrical systems very good. This was possible with judicious maintenance schedules and monitoring arrangements

3.2.1.1 Maintenance of electrical installations of substation, office blocks and residential colony

Maintenance of electrical installations is managed through the AMC with external agency, however all the consumables required are supplied by IUAC. M/s KBS Electricals was engaged for AMC financial year 2020-2021 whose performance has been very good.

Besides the routine maintenance following works were carried out.

RMU service for the packaged substation, HT relay calibrations and settings

Dehydration of transformer oil for 7 Transformers- (4500ltrs)

Servicing of OCB and ACBs

Periodic maintenance of LT panels, Distribution boards and other accessories, lighting, fixtures, lighting and power circuits.

Maintenance of street lighting and earthing.

3.2.1.2 Captive power installations

Institute had a captive power base of 2500 kVA. Three DG Sets of 750 kVA are synchronized to power 15UD Pelletron, He Plant and HPC Data Centre. The group has shown ever readiness in running the systems round the clock O&M activities within short period if need arises.

These 3nos of 750KVA DG sets were procured in year 2012 and commissioned in year 2014. These are serviced once a year thru authorized Cummins engine service provider 'Cummins svam service'

3.2.1.3 Roof top solar system for IUAC

Roof top grid interactive CapEx model 2*50 kWp solar power generation plant is functioning successfully and is operational. Peak power generated in any particular day has reached 650 KVAH units. Average generation is 500units. Periodical cleaning is done to get maximum power out of it. 4years of units generation has almost recovered the capital investment cost. 2nd Roof top grid interactive plant in RESCO model of 100kW has been installed and put in to generation. Power is purchased at Rs.3.43/- per unit consumption.

3.2.1.4 UPS installations

IUAC has 10*60 kVA UPS, 3*300 kVA, 4*200 kVA, UPS systems maintained by electrical group. These are under supervision and control of this group. Day to day operations is carried out by electrical group by electrical O&M agency. All the UPS are covered under comprehensive AMC provided by OEM. Compulsorily quarterly routine preventive maintenance is carried out besides uncounted breakdown maintenance based on call. During the present period batteries of few UPS degraded and accordingly corrective actions have been taken for replacement. Battery banks of 4*200 KVA UPS have been replaced.

It is to report here that one of the batteries went in to thermal runway and developed a massive fire damaging all the battery banks and the UPS, Input power panel and output distribution panel. Battery manufacturing co replaced the entire battery banks worth of approximately 20 lakhs. Total damages are around 40 lakhs. UPS revival / replacement of ups is under way. This accident has occurred on 27/11/2020 since then the UPS power to pelletron and experimental areas is not available and only power with DG backup is arranged.

3.2.1.5 Power factor Compensation

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 and by raising it we saved > Rs.160 lakhs through the year from energy saving.

3.2.1.6 Fire detection and alarm system

Fire detection & alarm system covering whole lab complex, New guesthouse and auditorium are working well and under operation.

3.2.1.7 LED lighting

Group has initiated a step forward in the direction of energy efficient lighting. All the beam halls have been now fitted with LED lights and in the same manner many corridors are now have been fixed with LED battens. Experimentation is also done with sensor based led lights in beam hall corridor which lit up only when there is human movement. Campus compound lighting are gradually converted from HPMV/HPSV to retrofit LED

3.2.1.8 Renovation of housing colony

Renovation of housing blocks are in progress. Complete rewiring is being done in phase-1 housing blocks which were in use since 1990 all with exposed wood batten wiring. Rest phase-2 hosing only light fittings and fan fixtures are being replaced. Until now around 25 houses have been completed. Decision is taken to replace the electrical fittings of residential flats (104 no's) with energy efficient. Since the houses are occupied the works are accomplished at a very slow speed.

3.2.2 Utility services

A. J. Malyadri, Bishamber Kumar, S. Muralithar

3.2.2.1 AC SYSTEM

IUAC's central air conditioning / low temperature cooling system of Phase-1 consisting of 400 TR Central AC plant services are provided 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 35500 hours each. Other rotary equipment has logged 231000 **c**ontinuous run hours. It is relevant to note that the Indian industrial norms specify a life of ~25,000 run-hours for compressors and ~50000 hours for other rotating equipment. The Phase-II&III, screw chiller based central AC plants performed to an up time of 100%.

The highlight of the operation and maintenance of the above systems was the in-house supervision provided to the contracts, which affected significant savings. The hook-up of AC plants ensured optimum power consumption. The equipment being into their twenty-ninth year of sustained operations have far outlived their economic lives, yet have high operational reliability.

3.2.2.2 WATER SYSTEM

IUAC's centralized water system of Phase-I feeding low temperature cooling water having a total heat removal capacity of 115 TR performed to an operational up time of 100%. This is due to the stringent maintenance practices, which were followed over the years. The system has overshot 1,85700 hours from its expected life span. Centralized water system of Phase-II&III feeding low temperature cooling water also performed to an up time of 100%.

A strict monitoring on the water quality has ensured that the flow paths are in healthy condition. The maintenance costs were kept significantly low as compared to world class bench mark values. 150 KLD Sewage Treatment Plant (STP) performed satisfactorily.

3.2.2.3 COOLING SYSTEM

Availability of equipment was recorded at 99%.

3.2.2.4 COMPRESSED AIR SYSTEM

Compressed air plant (Ph-I&II) consisting of three nos. of screw compressors each of 150m^3/Hrs. 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 m^3 have been maintaining uninterrupted air supply to IUAC Lab campus round the clock throughout the year. Pneumatic connections are provided to different labs / area / instruments as and when required.

3.2.2.5 LABORATORY GASES:

Indigenous / imported Various industrial / Lab purity gases / cylinders / regulators have been made available as required in different labs from time to time. Since December 2020 the same is taken over by the MG-III.

3.2.2.6 ELEVATOR :

Preventive and break down maintenance is carried out so that elevator is operating safely with maximum up time. Since December 2020 the same is taken over by the MG-III.

3.2.2.7 MATERIAL HANDLING SYSTEM :

Preventive and break down maintenance of more than 14 Nos E.O.T cranes and electric hoists of various capacity up to 7.5 Tones are being carried out to ensure there smooth, uninterrupted and safe operation. Since December 2020 the same is taken over by the MG-III.

3.2.2.8 FIRE SAFETY:

Annual refilling and periodic maintenance of all the fire extinguishers were carried out. Demonstration for use of Fire extinguishers have been arranged and all the users and IUAC employees are trained to use the fire extinguishers. Since December 2020 the same is taken over by the MG-III. For Fire safety purpose pressurized 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:

1. Commissioning of SS Water Piping New work in Beam hall#III for HCI facility
2. Commissioning of SS Process Water System for HCI & FEL facilities
3. Re-routing of SS Pipes of Size 1-1/2" NB in Beam hall#II Cryogenic Area and leak repairing of SS Pipe of size 4" NB
4. Testing of Potable Water Samples and STP
5. Servicing of LEIBF De-Humidifier
6. Providing of 120 m of size- upto 1" S.S.Piping for Water, Air, N2 and He for MRI Room.
7. Providing of 12 nos of split air conditioner 1.5 Ton in First Floor Rooms of GH-II.
8. Quarterly PM / breakdown visits of 2 nos of 200 TR water chilling units.
9. Extension of AMC O&M AC PH-1, 200 TR water chilling unit, elevator, air compressors , dryers renewed.
10. License Approval : Lift Inspector's annual visit is arranged and license is got renewed.
11. Rescue the people if trapped inside lift in case of any fault / malfunction of lift & make it working by attending to the minor problems .
12. Providing of help in cylinder leak rectification, regulator leak / repair, connection etc.
13. Award Annual Rate Contract For High Purity Gases.
14. Annual check up and refilling of portable fire extinguishers are done.
15. Fire Pipe Leak repair.
16. Fire Drill / Demonstration

3.2.3 MECHANICAL WORKSHOP (MG-III Gr.)

S.K.Saini, T.Varughese, B.B.Choudhary, D.K.Prabhakar, Rajeev Ahuja , Santosh Sahu and P.N. Prakash

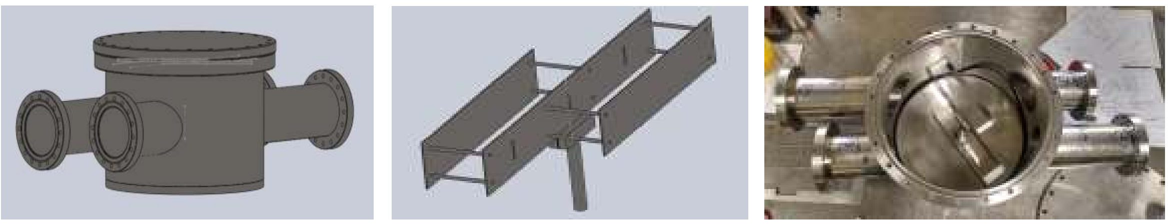
Mechanical workshop mainly designs and fabricates the mechanical components required for developing new facilities for IUAC's labs, beam lines and experimental facilities for users. IUAC workshop is well equipped with modern machines and welding facilities.

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

Machine Shop is equipped with a Vertical Machining Centre and a CNC Lathe machine, four conventional Lathe machines, two Milling machines and a Radial Drilling machine, one cylindrical grinder, one tool and cutter grinder, one horizontal and a vertical Band Saw machines, catering to different types of jobs. Most of these machines are of renowned brands like HMT, Batliboi, BFW etc

We cater to a large community of users and researchers from different labs of IUAC related with the accelerator development and experimental activities, right from inception of an idea till final fabrication and even installation. For most of the jobs, the users discuss with workshop personnel regarding their requirements. Then it is designed, drawings are prepared and the job gets done under our supervision either in-house or from outside eligible vendors (if it is not possible to fabricate in our workshop). Before delivering the job to the users or lab staff, the job is inspected to ensure that they meet the required specifications. If required, we assemble and install it also at the site. Workshop has Solid Works CAD facility for the design and drafting purpose. It also has VISI CAM for the CAM support for the Vertical Machining Centre and CNC Lathe.

Welding shop is having high quality TIG welding machines and equipments. Some of the TIG welding machines can give pulsed arc for the welding thin sections. Air plasma cutter with a capacity to cut up to 40 mm thickness of stainless steel is extensively used. Oxy-acetylene cutting & brazing setups, Arc welding and MIG welding setups are also available.

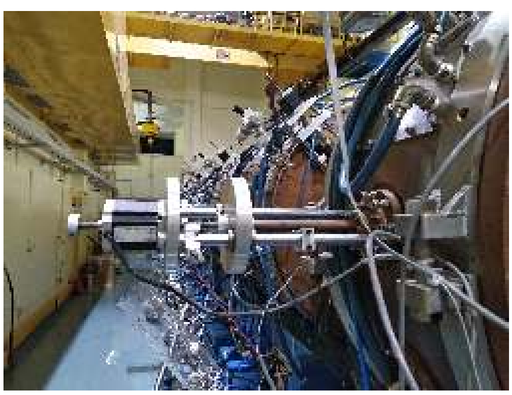


Electrostatic Analyzer Vacuum Chamber

PSPC Chamber

GPSC Target Ladder

DTL water line



HIRA- FP

Slow Tuners for DTL

MRI related components

Shifting of FEL Undulator Magnet into Beam Hall

This year we had received and fabricated around 230 nos. of jobs of different nature in the workshop. Some of the components fabricated by or assembled with help from the Workshop are shown in the pictures above.

In addition, IUAC workshop is providing Apprentice Training for the ITI passed students in both welding shop as well as in machine shop. Basic workshop training is also provided to the scientist trainees of IUAC.

MG-III group members were also involved in some of the ongoing major development projects and experiments related research and development activities. Some of them are mentioned below:

- MRI magnet development program
- Free Electron Laser (FEL) related works
- GPSC Vacuum Chamber refurbishment
- Spiral Buncher for HCI
- New target ladder and load lock for GPSC chamber
- Detector development for ISOMER Decay set up
- Design and development of Slow Tuners for DTL tanks in HCI
- Modification of existing AMS beam line to make a Proton beam facility in IUAC

Development Work:

New target ladder and load lock for GPSC chamber

T.Varughese, R.Ahuja ,S.Saneesh & K.S.Golda

There was some error in the Target ladder position reproducibility in GPSC chamber. We have measured a center out problem of about 3mm with the old target ladder. To solve this problem, two new target ladders with bigger holes (12mm to 15mm) with eight-hole positions were made and delivered. A new nylon insulator with close sliding fit was also made. We have aligned and checked this assembly in beam line with theodolite and it was found that the reproducibility is within ±0.5mm from top to bottom position. The users have satisfactorily used this target assembly in the last two experiments.

Last year we had also addressed the problems like lack of coplanarity in the detector platforms and rotating arms reproducibility and accuracy.

New Target ladder assembly

Work done in DTL facility

T.Varughese, A.J.Malyadri & R.V.Hariwal

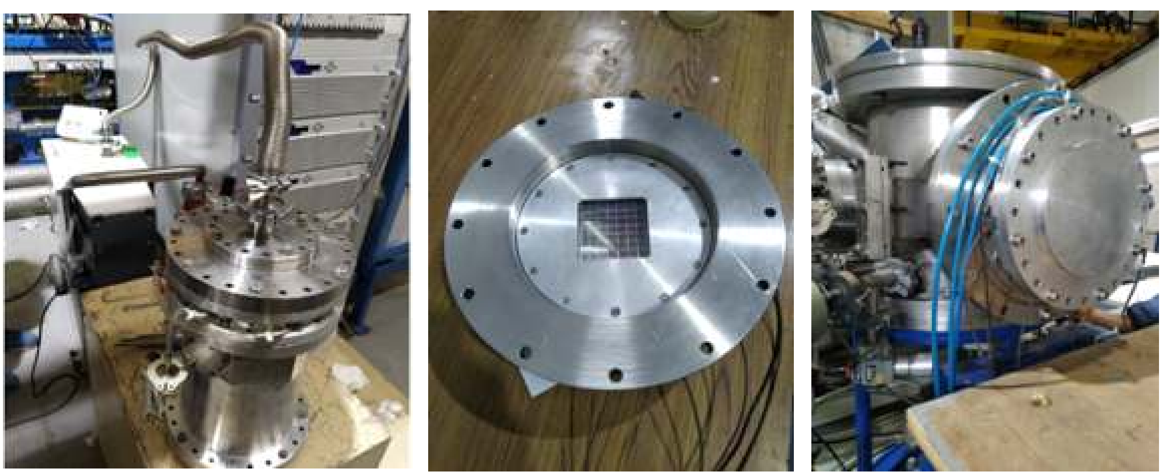
Cold water supply to DTL tanks and Quadrupoles were given through a temporary 3/4" flexible hose. This year permanent S.S pipes (3") were laid for this. During this process we had to do some corrections to properly position the already installed water headers on the structure. An I-section - 6" long and 3" in diameter was made and inserted in between two pipe sections to achieve this. We also standardized the naming of water branch pipes in all tanks and incorporated it in the control program. Flow rates of all flow meters were checked and found acceptable. There was a water leak from Tank-1 lid fittings. These fittings were modified and replacement structure rails were cleaned and anti-rust coating was applied.

DTL Water pipe connection

Detector development for ISOMER Decay set up

Jagdish Gehlot, T.Varughese & Gonika

Following activities were caried out to assemble and test the 3" x 3" MWPC for the proposed Isomer decay setup. The assembly was leak tested (<10^{-9} Torr.l/s) and a zero length adapter (HIRA focal plane (FP) exit flange to 10 inch flange) was made to mount the detector at HIRA FP for test purpose.



Taking over the responsibility of Portable fire Extinguishers.

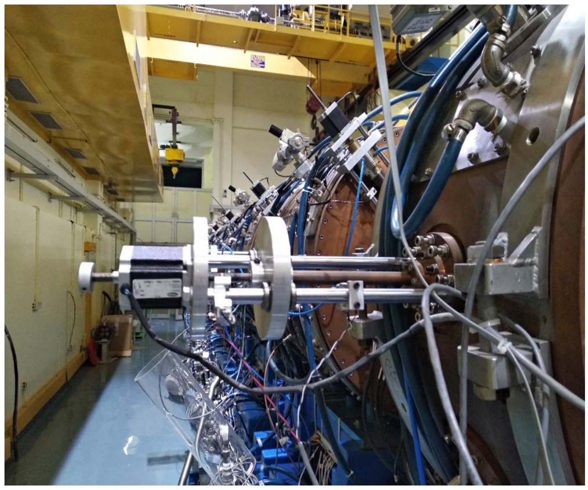
T.Varughese, Santosh Sahu & R.Ahuja

Recently the procurement, upkeep and maintenance of portable fire extinguishers have been assigned to MG-3 group. We have started the auditing of its quantity, location, present condition, inspection due date etc.

Design and development of Slow Tuners for DTL tanks in HCI

T.Varughese, R.V.Hariwal & B.P.Ajith Kumar

All DTL tanks except tank-1 have bellows based Slow tuners for frequency control. So, there was a requirement to make one bellow-based tuner for Tank-1 also. Apart from this, one spare tuner for the tanks was also made and kept ready in stock.

Slow Tuners for DTL

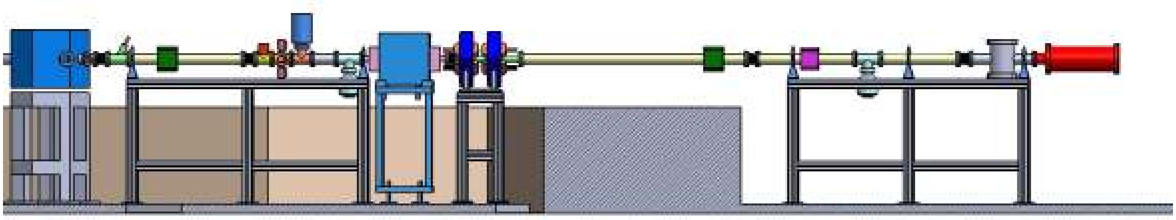
Modification of existing AMS beam line to make a Proton beam facility in IUAC.

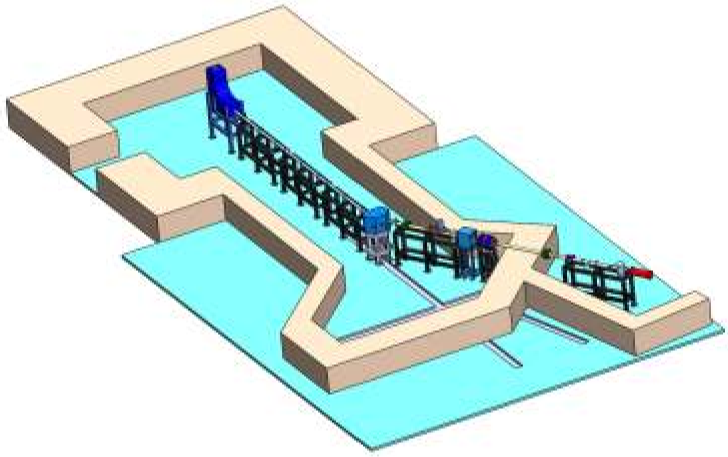
T.Varughese, Dr.Saif A.Khan, Mr.Rajiv Ahuja, Pradeep Barua, Rodrigues, Pankaj Kumar, Harsh Vardhan, Sandeep Chopra & P N Prakash

The project started with making a 'to the scale' drawing of the existing vault and beam hall-1. Over this the 3D model of the existing AMS beam line was drawn. The motivation for the project was:

- To make 3D drawing of the beam line.
- To check whether existing Quadrupole can be positioned in the vault area.
- To see the footprint of the existing quadrupole structure in vault area.
- To modify the support structure of quadrupole, if required.
- To see the possibility of swapping turbo pump with drift tube about Wein Filter (WF).
- Install an Electromagnetic Scanner two meters upstream from the target position in the beam line.
- To have a clear understanding before initiating the dismantling and modification of beam line.

After making the detailed drawings and subsequent group discussions we have concluded to move the existing quadrupole inside the vault, keep the same position for the WF at 2770mm from switching magnet (SM) flange, keep the same position for the beam profile monitor (1662mm) in the vault area, keep the same position for the target in beam hall (9415mm), swap turbo to the other side of WF, provide a steerer and slit in vault area after SM, provide one more turbo pump in beam hall side of the beamline, add a scanner 2000 mm upstream of target position, move the existing steerer 1000mm upstream of the above scanner, provide a gauge port in the quadrupole beam pipe & modify the quadrupole stand.





Schematic of the Beam Line

Technical Reports:

Design, fabrication and commissioning of mechanical support structure, water cooling system, diagnostic boxes, fix tuner and slow tuner for Drift Tube Linac (DTL) at IUAC.

T.Varughese*, V.V.V Satyanarayana, R.Hariwal, C.P.Safvan, Rajeev Ahuja & B.P.Ajith Kumar

Design and fabrication of an Isomer decay setup at HYRA focal plane.

T.Varughese*, J.Gehlot, Gonika, S.Nath and N.Madhavan

Road Sanitation Vehicle (RSV)

T.Varughese*, S.S.K Sonti, S.K Saini, Rajesh Kumar, Raj Kumar & Pankaj Baghel

3.2.4 Civil Engineering Group

Harshwardhan, A. J. Malyadri

(Programme leader: N. Madhavan; Civil Consultant: D. S. Gangwar)

IUAC has a total plot area of 25 acres out of which built-up area (or ground coverage) is about 15000 m^2. The total covered area of all floors is around 25,000 m^2. Centre has an Academic or laboratory complex, an Auditorium, a housing campus, hostel and guest house complexes. The civil wing covers day-to-day maintenance of entire campus, new construction activities under minor/major projects, minor works, regular supervision of contractual staff and liaison activities with outside agencies.

The following are some of the important civil works undertaken during the year 2020-21 in addition to routine civil maintenance and minor works; (* - through CPWD under deposit mode):

- Up-gradation / Renovation of 88 Nos. of IUAC Flats*; Work is completed in more than 30 flats and rest are under progress. The work was initially started in vacant sample flats after item finalization
- Up-gradation / Renovation of Canteen*
- Renovation of New Guest House & Hostels*
- Renovation of Director's Room & Council Room*
- IUAC Tower Painting*
- Construction of Type-III (Sumeru type) Flats* (Proposal under process)
- P/F signage /Name Boards for Auditorium & IUAC Tower
- Civil work related to Access Control System in IUAC
- Internal painting & Epoxy Flooring in HCI, BH III, Workshop area and Old Guest House in IUAC
- Aluminum partition & granite work in R. No. 103 (HR –SIMS Lab, Main Lab Building)
- Replacement of doors (3 Nos.) for incorporating Fire Exit/Safety in BH-III
- P/F wall mounted storage racks in personnel section (R. No. 207), Main Lab Building.