3. RESEARCH SUPPORT FACILITIES

3.1 SUPPORT LABORATORIES

3.1.1 High vacuum laboratory

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

High vacuum laboratory is primarily responsible for maintaining vacuum and vacuum systems in beamlines and experimental facilities. It provides support to different labs and users in vacuum related problems. Laboratory members are also involved in the installation and commissioning of various beamlines, experimental and accelerator facilities at IUAC. High Current Injector (HCI) installation is in progress and installation of all DTL cavities, Achromat 1 and a test set-up with pumping systems have been completed. Cable trays for power and signal cables have also been designed, fabricated, erected and installed.

3.1.1.1 Installation of High Current Injector (HCI) components in beam hall III

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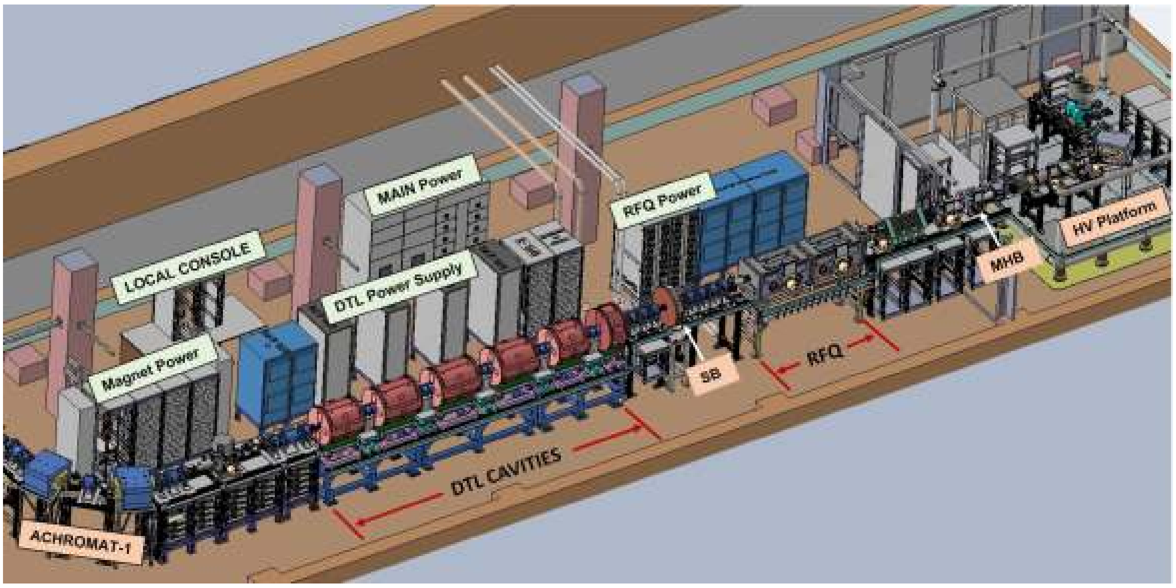


Figure 1: Layout of High Current Injector (HCI) (3-Dimensional Model

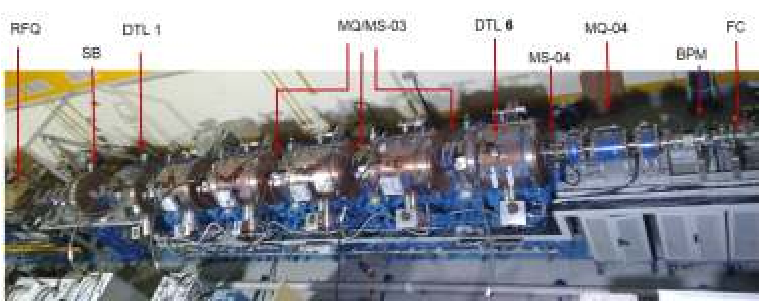


Figure 2: HCI Components installed in beam hall

Figure 3: RF Power Supplies

The existing beam energy measurement setup was installed up to DTL-1 with half achromat at testing position, as per the beam optics. To continue installation beyond that, the half achromat section along with the diagnostics and testing set up was dismantled from its temporary position. The remaining five DTL cavities (DTL-2 to DTL-6), along with five intermediate magnetic quadrupole cum steerer, have been installed in between DTL cavities and aligned with the beam axis. A compact vacuum tube with bellow had to be designed and fabricated for inter-DTL sections. For energy measurement of RFQ and DTL cavities, diagnostic components (BPM, slit and faraday cup) have been installed at object and image position of achromat-1 (ACH-1). The complete ACH-1 assembly has been installed at its final position in HCI. Installation of achromat is tricky as it does not have a single mounting frame and the two half achromats are to be installed independently with the two orthogonal beam directions, maintaining their mutual alignment and gap. The installation of all the components is complete up to ACH-1 image point. The alignment of all the optical and diagnostics components has been achieved within ±0.5 mm. All required RF power supplies and magnet power supply racks are installed. The entire section is leak tested and leak tightness maintained better than 5.0xE-10 mbar l/s. It is pumped by magnetically levitated turbo pumps installed at appropriate sections. All the devices are being interfaced and connected with VME control system for remote operation. An additional Faraday Cup (FC-03-0) has been installed at the exit of RFQ and interfaced with VME for remote operation.

New cable trays for cables have been fabricated and installed. Power, signal and grounding cable have been laid in the cable trays. The position of beamline after ACH-1 has been marked on the HCI beamhall, phase-I corridor and phase-I beamhall, as per final beam optics. References on the floor have been transferred at appropriate places for installation of components in these areas. The GPSC chamber which was interfering with the position of ACH-3 has been relocated to GDA experimental area and the GPSC beamline has been dismantled. The ACH-2 and ACH-3 have been approximately placed at their respective positions along with intermediate quadrupoles. A new control console has been designed, fabricated and installed in the Pelletron main control room. The design of vacuum chambers and procurement of diagnostic and vacuum components for the remaining part of HCI installation are in progress.

3.1.1.2 Relocation of GPSC experimental facility to 30° beam line

Chandra Pal, Ashok Kothari, P. Barua, G.O. Rodrigues, K.S. Golda, Akhil Jhingan, N. Saneesh & P. Sugathan

General Purpose Scattering Chamber (GPSC) is a versatile facility which has been extensively used for Nuclear Physics experiments as well as Atomic Physics and Material Science experiments using Pelletron beam. However with the upcoming High Current Injector (HCI), to accommodate the beam transport components of HCI in beam hall-I, it was decided to relocate the GPSC chamber to GDA beamline and place it after GDA experimental set-up. The beam optics parameters were re-evaluated to adjust the distances and positions of optical & diagnostics elements to suit GDA and GPSC experiments. The respective components were installed and placed as per the revised beam optics layout shown in figure 4.

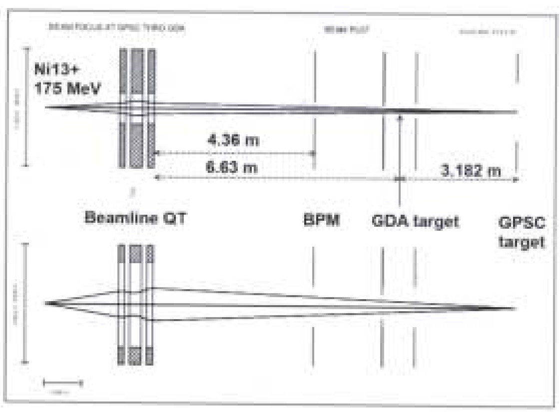


Figure 4: Beam Optics for GDA and GPSC beamline

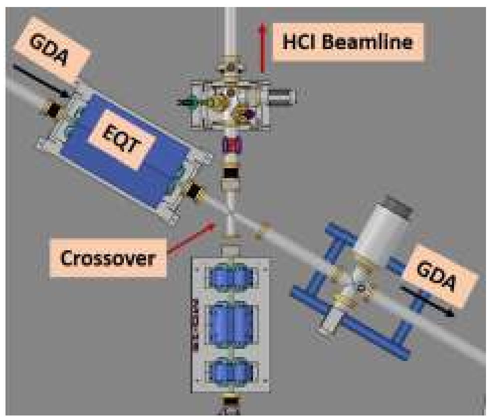


Figure 5: HCI – GDA beamline Crossover

The complete GDA & GPSC beamline components (quadruple triplet, magnetic steerer, BPM, faraday cup, beam line valves, GDA collimator system, turbo pumping station, all beam line stands, electrical /electronics) were dismantled from beam lines. The chamber has been installed 3 meters downstream the GDA target position and all beamline components re-aligned taking switching magnet-I as reference point. The GDA beamline components were reinstalled and aligned within ± 0.5 mm and GPSC chamber was positioned within 1 mm of beam axis. The GDA target position is kept unchanged and its earlier position restored. As shown in figure 5, the position of quadrupole and the pumping section had to be shifted away from HCI–GDA crossover point to accommodate nearby components. Dedicated beam diagnostic elements (Beam Profile Monitor, Faraday Cup) and Beam Line Valve are installed just before the entrance of the chamber. New reference points were marked on the floor and wall for future alignment work. The vacuum system with all interlocks have been installed for GDA and GPSC facility. The signal patch panel, water pipe line and pneumatic air pipe connections have been modified to extend up to new location of GPSC. Low flux experimental set up also has been restored on GPSC port with vacuum interlocks.

Entire installation was leak checked and required vacuum achieved in GDA experimental area (2.0E-07 mbar) and GPSC chamber (2.0E-06 mbar). A facility test was performed in GPSC line with beams of Oxygen (95 MeV, charge state 7^+), Lithium (50 MeV,3^+) and Silicon (80 MeV,6^+) focused to new target position. Beam position and spot size were measured on quartz and found to be satisfactory. Focused beam size of ~ 3 - 4 mm on target with good transmission has been achieved.

3.1.1.3 Maintenance and Support Activities

- Leak problem in phase-I material science beamline: Vacuum problem occurred in the beamline as the faraday cup (FC-05-2) bellow developed major leak and disrupted the ongoing beam run. An additional turbo pumping system was connected with the beamline to continue the experiment. Later on the head assembly of the faraday cup was replaced with available spares and made operational.

- Vacuum Interlock controller of LINAC II developed some problem and stopped working. It was diagnosed that its current transformer, IC and few other components got burnt, may be due to power surge. The faulty components were removed from the PCB and the system restored to working condition. It was installed back in the LINAC II and working fine.

- NAND Beamline: Log amp of FC-09-1 found faulty and it was replaced with available spares. The extended beamline was being pumped by two turbo pumps and the vacuum interlock was designed to control them together. One of the turbo pump was removed for other purpose and the vacuum interlock system was modified accordingly to run with single turbo system. The turbo pump installed after NAND chamber also stopped working due to bearing failure, it was removed and replaced by another turbo pump.

- Portable Annealing system for GDA Detectors: The multi-channel annealing system for detectors stopped working due to vacuum problem. It was found that its vacuum gauge had problems and many joints had vacuum leaks. The faulty gauge was replaced and multiple leaks were fixed. All other components were individually checked and found fit. The system has been restored to working condition and vacuum of 2.0E-06 mbar was achieved in each testing channel.

- Switching magnet-I ion pump got contaminated and stopped working. It failed the high voltage test and was diagnosed shorted. It had to be baked (without magnets) above 150 deg. for 2 days and normal working of the ion pump was restored.

- Pelletron support: Actively involved in the terminal venting and vacuum restoration during foil stripper changing activity.

3.1.2. Cryogenics laboratory

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

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 installed in the rebuncher cryostat and testing of a few components of 1.5T MRI magnet.

3.1.2.1 Cryogenic System for LINAC

I. Liquid helium refrigerator

The helium refrigerator was operated for approximately 3000 hours for beam acceleration through the superconducting LINAC and off-line testing of cavities of rebuncher cryostat.

II. Liquid nitrogen network

Fig. 3.1.2.1 shows the yearly consumption of liquid nitrogen (LN_2). The LN_2 is used for cooling the thermal shields of beam-line cryostats and helium distribution network, detector cooling in the INGA facility, and other off-line experiments conducted at low temperatures. In this academic year, there is an increase of almost 30% in the consumption of LN_2 in comparison to the previous year. This increment in consumption is primarily due to the ongoing LINAC run.

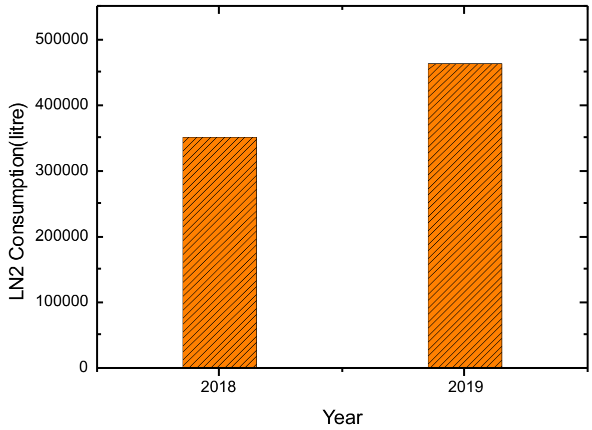
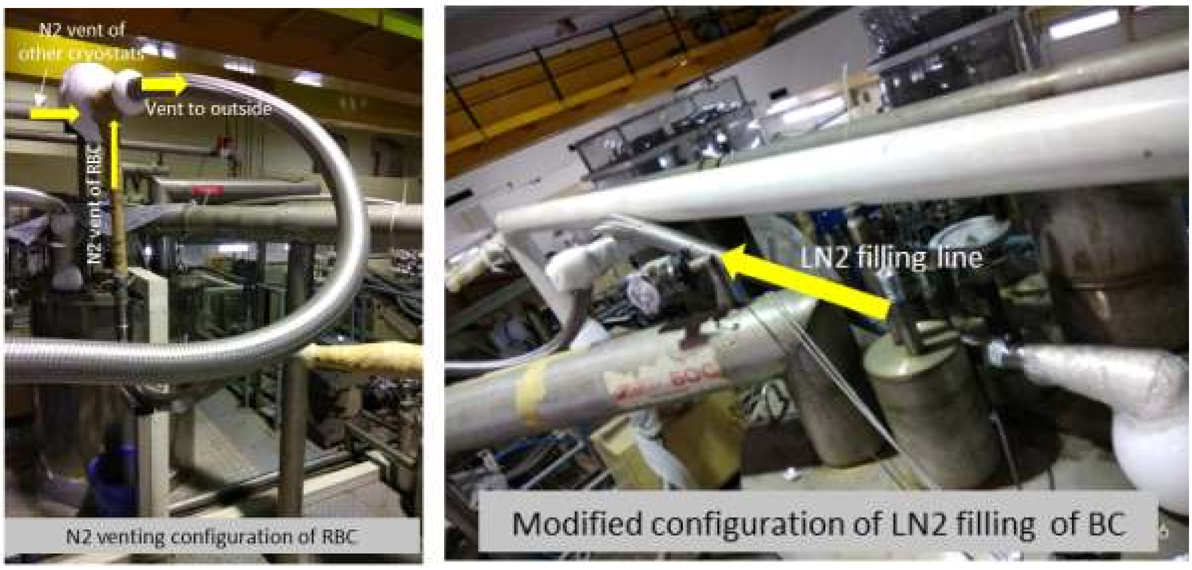


Fig. 3.1.2.1 Annual consumption of liquid nitrogen at IUAC.

A vacuum insulated cryogenic venting line (~ 6 m long) for the cold nitrogen gas of the beam-line cryostats of the LINAC was indigenously built which has been erected outside beam hall-II to exhaust the nitrogen gas outside the newly built MRI hall. A few layers of MLI was also used for this cryogenic line to minimize the radiative heat flow. It had been made operational after rigorous vacuum and cryogenic testing. Presently it is in regular use for venting the nitrogen gas to the outside of the experimental area.

In this academic year, the nitrogen vent line configuration of the rebuncher cryostat was modified and connected to the common manifold of cold nitrogen gas to minimize the back-pressure of the return line for the smooth filling of liquid nitrogen in the cryostat. Fig. 3.1.2.2 (a) shows the new configuration of the nitrogen vent line.



(a) (b)

Fig. 3.1.2.2. (a) The new configuration of the nitrogen venting line for the rebuncher cryostat and,
(b) the modified scheme of the LN2 filling for the buncher cryostat.

Similarly, a new scheme of LN_2 filling has been incorporated for the buncher cryostat. The continuous (two-phase) flow coming from the vent of the thermal shield cooling line of the helium distribution network was used in place of batch filling for the buncher cryostat. A vacuum- jacketed new flexible line was integrated for the implementation of the scheme. A control valve was used to regulate the flow to maintain the desired level of LN_2 inside the cryostat. Fig.3.1.2.2(b) shows the modified configuration of the LN_2 filling line for Buncher cryostat.

III. Beam-line cryostats

All the beam-line cryostats of the LINAC were cooled down to 4.2K for beam acceleration through the quarter-wave resonators of the beam-line cryostats. Fig 3.1.2.3 shows the sequential cool-down of all the beam-line cryostats using liquid helium. The average cooldown time by liquid helium for Linac cryostats is 20 hours as shown in Fig. 3.1.2.3(a). The static refrigeration load for the five beam-line cryostats and helium distribution system is measured to be ~230W at 4.2K. The dynamic heat load during high-power pulse (HPP) conditioning of 2-QWRs at a time was measured for Linac cryostat-II (LC-II). Fig. 3.1.2.3(b) shows the variation in the refrigeration load at 4.2K during such HPP conditioning. The average dynamic heat load was measured to be 15W per cavity during HPP.

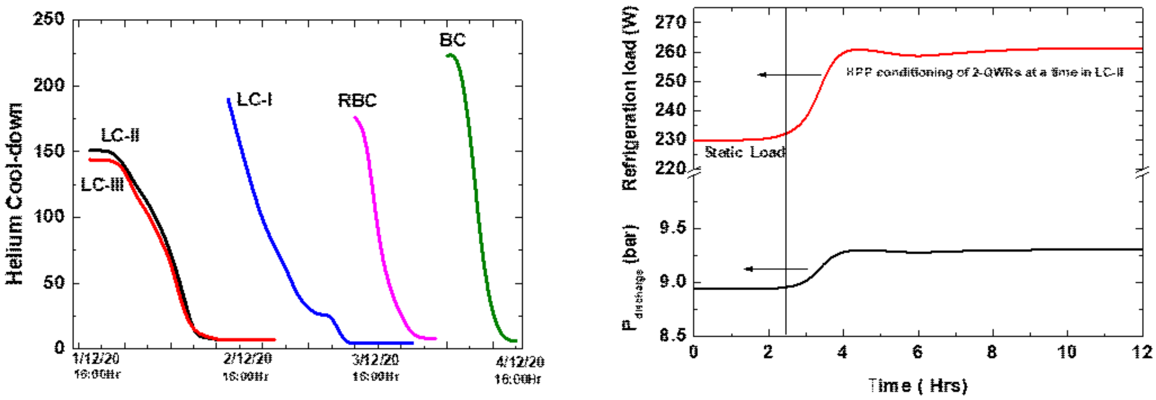


Fig. 3.1.2.3 (a) The helium cool-down profile of all the beam-line cryostats, (b) the variation in the refrigeration load during HPP of two QWRs at a time in Linac cryostat -II (LC-II).

3.1.2.2 Activities on Applied Superconductivity

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

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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

The indigenously designed integrated bobbin structure (shown in Fig.3.1.2.4) of the 1.5T superconducting MRI magnet is presently at the final stage of the fabrication. The winding of the eight superconducting coils on the machined bobbin is expected to be completed by June 2020. A large number of indigenous components like superconducting switches for the main magnet and EIS coil, superconducting joints, high power quench protection diodes, cryogenic instrumentations, etc. need to be fixed on the magnet at IUAC. Prior to the final integration of components, a one-twelfth section of the bobbin was fabricated for practicing the wire routing and placement of components and in-situ implementation of SC joints. Fig. 3.1.2.4 (b) shows the picture of the one-twelfth section of the bobbin.

Fig. 3.1.2.4 (a) The cut -view of the superconducting MRI magnet and, (b) the one-twelfth section of bobbin integrated on a prototype bobbin stand.

Superconducting Joint

MRI magnet needs a number of inter-coil superconducting joints for its persistent operation through the superconducting switches (PCS). In this academic year, the superconducting joint was characterized by long-term decay measurement using an indigenously developed joint testing rig. The SC-joints were also tested in the presence of the background magnetic field up to 1.7T. The electrical resistance achieved were: 2.4E-14 Ohm at 0T, 5.4E-14 Ohm at 0.85T, and 1.3E-12 Ohm at 1.27T background field as shown in Fig. 3.1.2.5.

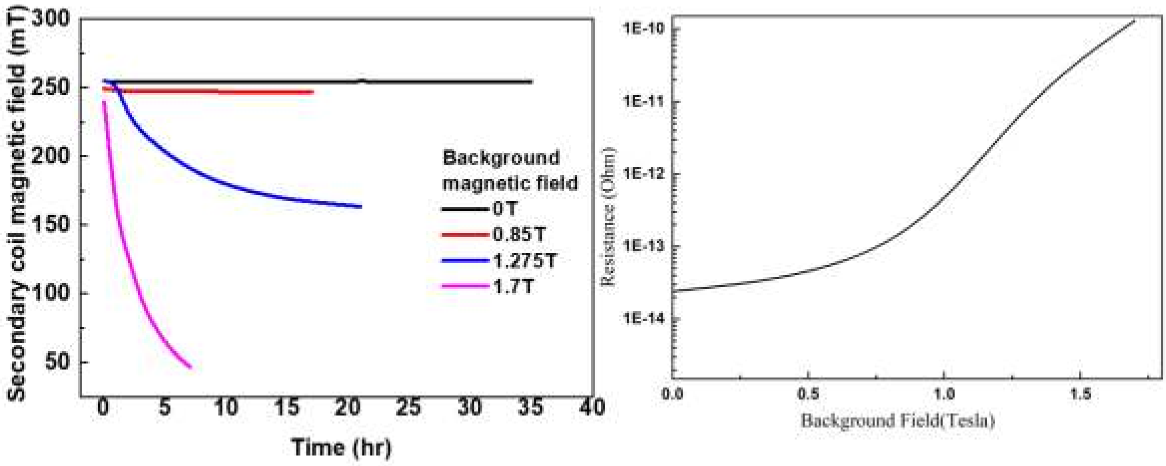
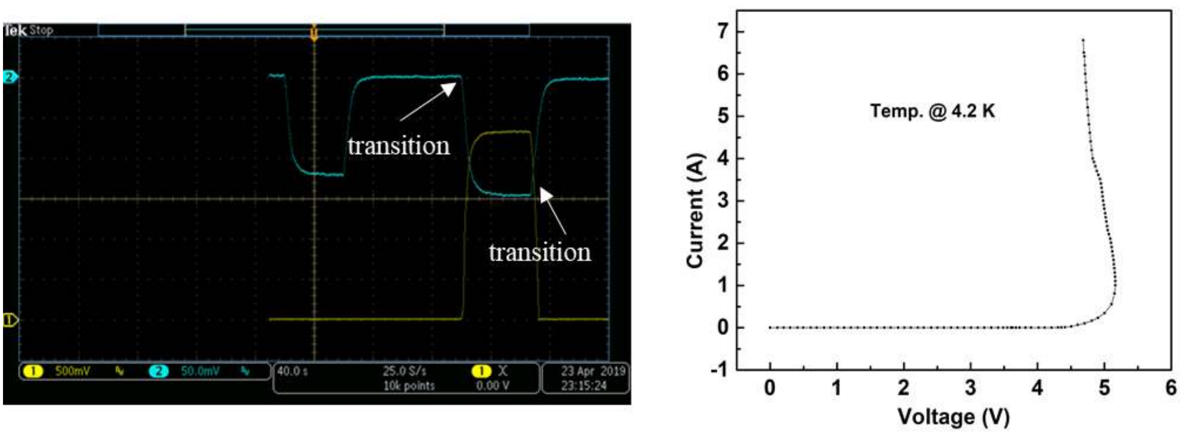


Fig. 3.1.2.5 (a) The field decay at various background field and, (b) the electrical resistance at various background field.

Superconducting switch and cold diodes for the EIS coil

Superconducting switch (PCS) for the EIS coil was developed and tested at 4.2K using a test rig. Switching behaviour (superconducting to normal and normal to superconducting) of the PCS was extensively studied and their transition period was measured as shown in Fig 3.1.2.6 (a). Various types of cold diodes for the superconducting EIS coil were characterized at 4.2K to find suitability for their usage. Fig. 3.1.2.6(b) shows the V-I characteristics of one type of cold diodes. The diodes were tested up to 7A of forward current.



(a) (b)

Fig. 3.1.2.6 (a)The transition curve of the superconducting switch and, (b) V-I characteristics of the cold diodes of EIS coil at 4.2K.

AC characterization of 2G high-temperature superconducting tape (HTS) for modular SFCL (CPRI project)

Soumen Kar, Reetu Bharti, Rajesh Kumar & T.S.Datta*

An R&D project on the characterization of 2G high temperature superconducting (HTS) tape for modular SFCL application was concluded in this academic year. Various types of modular configuration of the SFCL unit were developed. The electrical behaviour of the SFCL unit was characterized using two types of 2G HTS tapes up to the prospective fault current of 4 kA (peak) at 60Vrms input voltage. Fig.3.1.2.7 shows the experimental test rig and a bifilar modular SFCL unit.

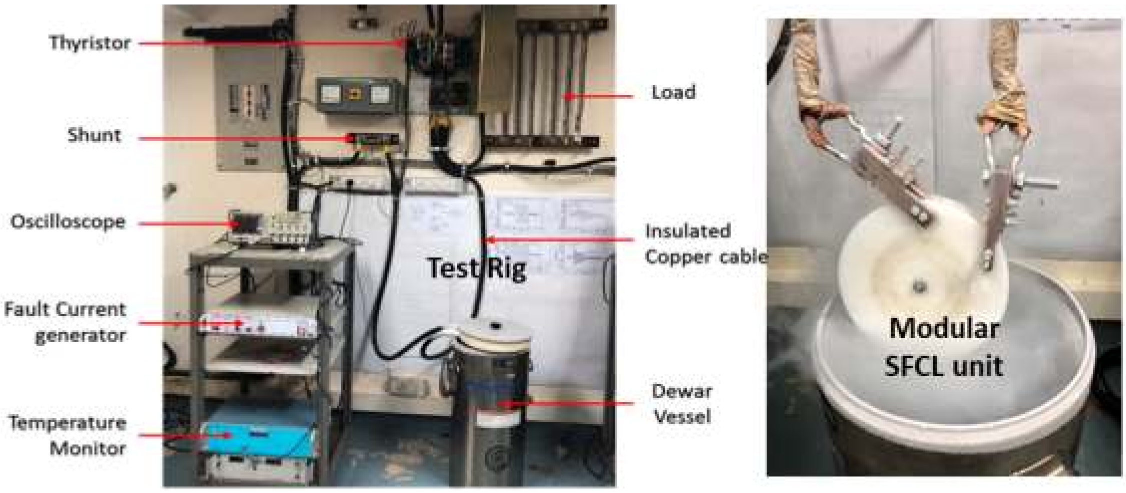
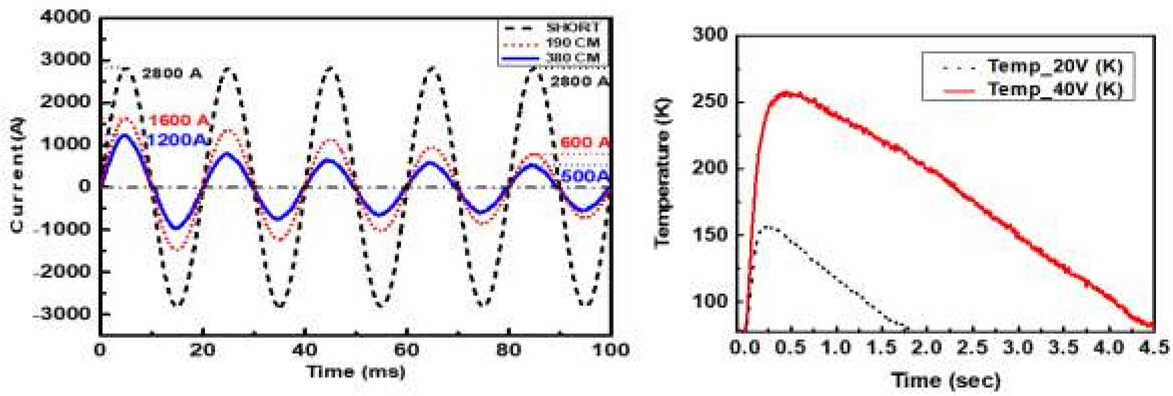


Fig. 3.1.2.7 (a) The experimental test rig for modular SFCL unit and, (b) an HTS based modular SFCL (bifilar) unit.

The fault limiting behaviour and successive recovery characteristics of the SFCL units were characterized by different lengths of the Cu-laminated 2G HTS tape. Fig. 3.1.2.8(a) shows the fault limiting behaviour of Cu-laminated 2G HTS tape at $40V_{rms}$ for two different lengths of tape for five cycles of fault. Fig. 3.1.2.8(b) shows the corresponding temperature behaviour of the HTS tapes at fault condition and their recovery. The peak temperatures on the HTS tape were measured to be 250K and 150K respectively during faults at $40V_{rms}$ and $20V_{rms}$.



(a) (b)

Fig. 3.1.2.8 (a) The fault limiting behaviour of the Cu-laminated 2G HTS tape and,
(b) the temperature profile on the HTS tape during fault and recovery.

Similarly, SS-laminated 2G HTS tape was also characterized in the modular SFCL unit having four parallel tapes for a various number of fault cycles. Fig 3.1.2.9 shows the fault limiting behaviour of SS-laminated HTS tapes for a various number of fault cycles.

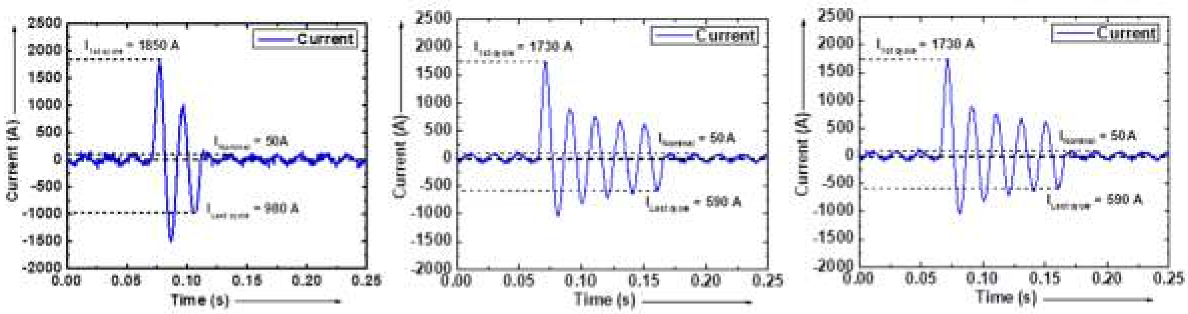


Fig. 3.1.2.9. The fault limiting behaviour of the SS-laminated 2G HTS tape at a various number of fault cycle.

*superannuated in June 2019

3.1.3 Beam Transport System (BTS) Group

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

The Beam Transport System (BTS) Group is an Accelerator Support Central Group (AcSCG), that takes care of the BTS instruments of all the accelerators and experimental facilities at IUAC. The group is responsible for the design, manufacturing, testing, calibration, operation and maintenance of magnet power supplies and other BTS associated instruments. In order to achieve the required throughput, the laboratory personnel work as a 24x7 on-call team, investigate beam-trips attributed to the power supplies and strive to minimise the overall down -time.

The group also performs the preventive maintenance and repair of Detector Bias HV power supplies used in experimental facilities. Besides maintenance and repair activities, the group is also involved in design and fabrication of BTS-magnet power supplies and LLRF-based control instrumentation for the upcoming High Current Injector (HCI) Facility. More significantly, almost 50% of the total magnet power supplies are developed in-house to have complete control on maintenance and repair. The yearly activities related to maintenance, upkeep & development are summarised below.

3.1.3.1 Beam Transport System Operation Status Report

During 2019-20 the overall up-time of the beam transport magnet power supplies was recorded to be more than 99% and all the power supplies met the required performance in terms of stability. There were no major breakdowns which would have resulted in considerable beam time loss. The failure log of BTS instruments has been maintained over the period to summarise the required action to be taken during scheduled preventive maintenance. Table-1 summarises the beam down-time (in hours) caused by BTS magnet power supply failures during beam operations.

Table-1: Facility wise Beam down time due to BTS breakdown

Cause of Breakdown	Pelletron	LINAC	HCI	Low Energy Accelerators (LIBF, NIBF)	HIRA/HYRA Spectrometer
Number of breakdowns	11	3	5	3	3
Power supply control electronics	0.50 Hr	2.00 Hr	2.00 Hrs	0.50 Hr	1.00 Hr
Remote Control-CAMAC	2.50 Hrs	1.00 Hr	0.50 Hr	0.50 Hr	0.00 Hr
Electrical-Low mains 3Ø input	0.50 Hr	0.00 Hr	0.00 Hr	0.00 Hr	0.50 Hr
Cooling water- Low Pressure	0.00 Hr	0.00 Hr	0.00 Hr	0.25 Hr	0.50 Hr
Facility Wise Breakdown	**3.50 Hrs**	**3.00 Hrs**	**2.50 Hrs**	**1.25 Hrs**	**2.00 Hrs**
Total BTS Breakdown during this year (Apr19-Feb20)				**12.25 Hrs**	

3.1.3.2 Preventive Maintenance

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

3.1.3.2.1 Preventive Maintenance Schedule of BTS Instruments

The Beam transport system at IUAC consists of large number of high performance, high current power supplies along with other BTS associated instruments. For the last few years, effect of corrosion has been observed on the stability and performance of power supplies. Because of this corrosion, preventive maintenance has become more intense and taking longer as compared to pre–corrosion time.

The maintenance activity has been spread throughout the year to allot enough time for each instrument to ensure service quality. The total BTS has been divided in zones, the Pelletron BTS is maintained in the same period when the Pelletron is under maintenance; the maintenance of other facilities (LINAC, HIRA, HYRA, LEIBF, HCI) are scheduled as per access available during any period of the year. Table-2 shows the schedule of facility-wise annual preventive BTS maintenance as well as the refurbishment of magnet power supplies performed this year.

Table-2: Facility-wise BTS Scheduled maintenance activity

	Pelletron	LINAC	HCI	Low Energy Accelerators (LIBF,NIBF)	HIRA/HYRA Spectrometer
BTS Schedule Maintenance & Refurbishment of Magnet Power Supplies	May & July'2019	June & Sept'2019	Feb & Oct'2019	Aug'2019	Sept & Dec'2019
Numbers of BTS Instruments is use	78	60	115	20	39

Preventive Maintenance Procedure:

Proven maintenance procedures finalized on the basis of maintenance experience are followed to standardise the activity and in turn, to ensure the service quality. The power supplies need high level of examination, monitoring and maintenance procedure and hence to make the preventive maintenance more planned and effective, following steps have been taken.

- Test Report Performa for each type of Power Supply and other BTS instrument is maintained.
- Laying out of Accelerator Beam Transport System for proper scheduling of maintenance activity.
- Keeping Magnet Power supply Installation areas neat and organised.

To finalize the corrective actions during preventive maintenance, the condition of each power supply has been assessed by doing the following.

- Visual Inspection
- AC / DC Voltage measurement of different test points
- Temperature measurement/ thermal analysis

The status assessment data has been recorded in Test Report Proforma. Data is analysed to assess the condition of the power supply and then to finalize the preventive repair actions.

a) Servicing Procedure to ensure output current stability

- Dust removal
- Cooling water flow and temperature
- Leakage resistance of the cooling water connections due to electrolysis
- Power supply output current ripple measurement
- Output current stability measurement and calibration

b) Servicing Procedures to ensure proper functionality

- Remote control operation
- Safety interlocks
- Full power test

Power supply Module repair:

The faulty electronic modules which are removed (replaced with spares) during preventive maintenance and breakdown repairs, are later on repaired at BTS lab to replenish the spare stock. The effort has reduced the running cost of the BTS system in terms of expenditure towards the purchase of spares. For the in-house developed instruments, the spare modules are also fabricated in-house. This year following electronic modules of power supplies (system 8500, Danfysik) were repaired in-house:

- Power supply control modules: 02 nos
- Auxiliary power supply modules: 06 nos
- Regulation Modules: 02 nos
- IGOR interface modules: 03 nos
- Refurbishment of Transistor Bank Emitter Boards: 206 nos.

3.1.3.2.2 Preventive Maintenance and Repair of Detector Bias HV Power Supplies:

Under the yearly maintenance activity, the detector bias HV power supplies of the following experimental facilities has been serviced and tested for performance and safe operation.

INGA facility Detector Bias HV power supplies

A total of 60 power supplies (three types: 5 kV, 3 kV & pre-amp PS) were cleaned, serviced and tested at BTS Lab. These power supplies were developed by BTS Group in 2006 and since then they are in operation in the Indian National Gamma Array (INGA) experimental facility. These power supplies were immersion cleaned in ultrasonic bath using LR grade alcohol and found to be very effective and does not cause any damage. The detector bias power supply installation racks at INGA facility have also been repositioned to have better access for maintenance & servicing.

NAND facility Detector bias power supplies:

The neutron detectors of National Array of Neutron Detector (NAND) experimental facility are biased using in-house (50 nos) and commercial (50 nos) power supplies. All in-house power supplies were also serviced and tested in BTS lab to ensure best performance and trouble free operation during experiments.

3.1.3.2.3 Academic Support Activities

This year the BTS group has provided / participated in the following academic support activities:

1. Repaired & calibrated 06 nos. of controllers of piezo-based Tuners of SC-QWR of LINAC.
2. Modified & installed an in-house developed (3 kV/100 mA) power supply for HCI-ECR Source
4. Repaired the Vacuum deposition unit e-gun power supply (6kV/1A) of Target Lab
5. Repaired the Super-conducting Magnet power supply of SQUID-Magnetometer (IIT, Delhi)
6. Participated in designing the low impedance grounding scheme for the HCI facility.
7. Participated in designing the cooling water layout for the HCI facility.

3.1.3.3 Development activities

3.1.3.3.1 In-house development and installation of power supplies:

If all the BTS magnet Power supplies were to be imported time to time, there will be large number of different design and make of power supplies. To maintain different designs of such power supplies, it requires large and varied spares inventory and trained manpower for each design, which is not possible with the available limited manpower and budget resources. In order to have control over the upkeep & maintenance activity of power supplies, the type and make of power supplies are minimised by doing in-house development. The single type of power supplies which are used in large quantity has been developed and assembled in-house. The steerer and scanner magnets power supplies are the ones most in use, constituting approximately 50 % of the total BTS magnet power supplies. The BTS Group has been designing and assembling such power supplies in-house and at present 100% power supplies for steerer and scanner magnets are made locally. This helped to minimise the spare part inventory and maintenance & manpower training efforts.

Power supply Fabrication for the upcoming HCI & FEL facility

The HCI Beam Transport System (HCI-BTS) and FEL Beam Transport System (FEL-BTS) use different types of magnets with different current ratings. The power supply requirement has been categorised in two: 1) High Current Power Supply (HCPS) of 100A /200A current rating for bending & quadrupole magnets and 2) Low Current bi-polar Power Supply (LCPS) of 10A for steerer magnets & 10A for air-cooled quadrupole magnets. The High Current Power Supply (HCPS) of single polarity are commercially procured. For the Low Current Power Supply (LCPS), it is decided to design and develop these in-house. The LCPS units are made as bipolar (unipolar configurable) current controlled linear power supplies, providing current stability of ±100 ppm or better. These power supplies are designed with flexible output arrangement to meet all the load requirements within ±10 A/±50 V.

Fig 1: In-house Developed Low Current bipolar Power Supply (LCPS)

Total number of LCPS required for HCI and FEL is 90 units, (70 units for HCI & 20 units for FEL). In last four years approximately 45 numbers of such power supplies were assembled in-house and installed. To complete the assembly /fabrication of remaining 45 units, the component procurement process has been completed this year.

Installation & commissioning of power supplies of the upcoming HCI & FEL facilities.

The beam line installation of High Energy Beam Transport (HEBT) section has been completed up to first achromat. This section includes magnetic steerers, quadrupoles & dipole magnets. To power these magnets, 33 HCPS and 11 LCPS units have been installed. All these power supplies are mounted in 19" instrument racks and all the racks are kept at one location to create a power supply hub so as to facilitate easy main power & remote control distribution. The heavy HCPS are mounted in the lower half of the rack using telescopic rails to have easy access for servicing, while the lightweight LCPS are mounted in the upper half of the rack without telescopic rails. The power supply mounting racks are specially designed to have wiring trays and distribution system for cooling water, mains power and safety ground. All the input/output cables are routed through cable trays with proper harnessing and identification tag. Ethernet based remote control has also been established through control console.

Fig 2: Installation of HCI-BTS magnet power supplies.

3.1.3.3.2 Low Level RF (LLRF) Controls for the HCI-RF cavities (RFQ, DTL & Spiral Buncher)

S. K. Suman, Rajesh Kumar, V. V. V. Satyanarayana

The LLRF control for HCI-RF cavities has been implemented using analog circuits. Generator Driven Resonator (GDR) based amplitude & phase control scheme has been chosen to control these room temperature cavities. The LLRF control requirements have been grouped into two units as follows; Amplitude and Phase Control Loop (APCL) and the Frequency Tuner Control Loop (FTCL). Final design of these controls is in operation with each type of cavity (RFQ, DTL & Spiral Buncher). Using these controls the amplitude stability of 0.002% and phase stability of 0.03° have been achieved with RFQ cavity at 25 kW power. The frequency tuner movement takes place at ±1° phase difference between pickup and forward power and stops at the phase difference of ±0.01°. The design & final product implementation of these controls has been done by BTS group and these designs have been handed over to LLRF Group for further production as required for the rest of DTL & Spiral Buncher cavities.

(a) (b)

Fig 3: (a) Amplitude and Phase Control Unit and (b) Frequency tuner control unit

3.1.3.3.3 RS232 Server Controller for Magnet Power supplies at IUAC.

Prem Kumar Verma, B.P. Ajith Kumar

So far the magnet power supplies were remotely controlled using either CAMAC based IGOR or VME based IGOR controls. To simplify the remote control hardware of magnet power supplies, an RS-232 server and control card have been developed. The RS-232 controller consists of a Micro-Controller board that multiplexes 12 numbers of RS232 Ports to an Ethernet port. This board is connected to a single board Computer running GNU/LINUX. A server program manages the communication to the Magnet Power Supplies in response to the commands received over a TCP/IP network. The system has been designed to make it compatible with the existing accelerator control system. Dedicated firmware has been developed and Orange-Pi single board Computer is used. Each power supply rack will have a RS-232 server and each power supply will have a RS-232 to IGOR convertor card. The system has been successfully installed and tested at High Current Injector (HCI) facility. More number of similar controllers are under development for other facilities at IUAC. These controllers are designed by LLRF group and being assembled by BTS group.

(a)

(b)

Fig 4: (a) RS-232 Server Controller (b) RS-232 to IGOR Convertor Card

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 HIRA, HYRA, GDA, GPSC and NAND. Detector lab provided training on experimental activities for Scientist Trainees, JRF, M. Tech, B. Sc and M. Sc students.

Multi Wire Proportional Counter (MWPC) for GPSC/NAND

Mohit Kumar, Akhil Jhingan, Honey Arora (PU), N. Saneesh, K. S. Golda, B. R. Behera (PU), P. Sugathan

A pair of new two-dimensional position sensitive MWPC were developed and installed in GPSC. The detectors were used to detect fusion evaporation residues (ERs) at angles from 2 to 10 degrees for the systems ^{16}O + ^{64}Zn and ^{32}S + ^{48}Ti. The ERs were detected in coincidence with neutrons and light charged particles. Neutrons were detected in 3 liquid scintillators and light charged particles were detected in 16 CsI scintillators coupled to photo-diodes. The MWPC has been prepared using four electrode geometry, but was operated with 3 electrode geometry having anode sandwiched between two position cathodes (X and Y). Active area of the detector is 10 x 5 cm^2. Off-line measurements were also performed using ^{241}Am alpha source and ^{252}Cf fission source. At very forward angles, the detector was exposed to particle count rates as high as 10^6 pps in including high intensity delta rays. The survival and long term stability of the MWPC at such high rates needs was established. It was observed that 3 electrode operation had higher count rate handling capability as compared to the 4 electrode as detector breakdowns were observed at high count rates.

Fig.1: MWPCs for ER detection

Fission detectors for NAND

N. Saneesh, Mohit Kumar, Akhil Jhingan and P. Sugathan

Fission detectors for NAND were modified from 4 electrode geometry to 3 electrode geometry. Wire frame for Y position measurement was replaced by strip plane and central timing electrode (cathode) is made out of 2 um thick mylar foil aluminized on both sides, replacing the anode wire frame in the earlier design. The detector has been thoroughly tested with alpha emitters and fission source, and will be used for the fission experiments in NAND.

TEGIC Detector for NUSTAR collaboration

IUAC, Delhi University, Panjab University (Chandigarh) and GSI (Germany)

Fabrication work for the TEGIC detector was executed. Detector mechanical housing of cuboid shape was machined using aluminum sheets in the form of 5 frames and a base plate. These were then put together using bolts. Edges of each side were sealed using sealant to make it vacuum tight. The electrodes were prepared by pasting stretched 3μm thick mylar foils (aluminized on both sides) on the 3.2 mm thick FR4 printed circuit boards. There are 21 stacked electrodes (10 anodes, 11 cathodes). Inter-electrode gap is 2 cm and active area is 20x8cm^2. These electrodes are tilted at an angle of 30 degrees with respect to the normal to the beam direction. Ten charge sensitive preamplifier units, with differential readouts, were developed for anode readout and plugged directly next to the anodes inside the TEGIC chamber. Gains are 90 mV/MeV (Si equi.) with decay time constant of 10μs. The CSPA units have been tested with silicon PIPS detector as well as axial field gas ionization chamber (from HYTAR) with shaping time constants as low as 0.25μs for high count rate handling capability. Performance achieved is as per design goals. A custom designed gas distribution system for pressure uniformity inside TEGIC chamber was also fabricated and installed inside the detector. The gas will be distributed through three 0.5 mm holes in each electrode gap from the top, and will exit through 1 mm holes from the bottom. The detector has been assembled and leak tested with the new gas distribution. Currently the detector is being tested with alpha emitters. The detector is proposed to be commissioned, in first quarter of 2020, at the exit of FRS for initial phase of NUSTAR campaigns from 2020-2022. Fig. 2 shows the assembled detector system.

Fig.2: Assembled TEGIC detector.

Development of CSPA and FTA units

New charge sensitive preamplifier (CSPA) units are being developed for operation inside split anode gas ionization chambers in GPSC. Main idea is to integrate CSPA units with detector anode and eliminate cables between them so as to improve the signal to noise ratio and thus resolution. Efforts are also on to develop high gain versions for the detection of low energy heavy ions at LEIBF and table top accelerator facility. Two different designs are being developed. Fabrication work has been initiated and CSPA units will be assembled in coming days. Development activities were initiated to develop dedicated 8 channel FTA unit for the signal processing of position sensitive MCP signals. Two 4 channel cards for the same were designed and fabricated. Testing for the same will be carried out in near future.

3.1.5 Target Development Activities in IUAC

Abhilash S R, Ambuj Mishra and D Kabiraj

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. Several research scholars are trained in the operation of thin film deposition techniques during the target and thin film development. Most of the instruments in target lab are well–utilized in this year. Man-machine utilization in target development laboratory is shown in the table below.

Facility	No of attempts
High Vacuum Evaporator-I (HV-I)	41
Ultra- High Vacuum Evaporator (UHV)	40
Tubular furnace (TF)	40
Rolling Machine (RM)	61
Profilo Meter	61
High Vacuum Evaporator-II (HV-II)	43
High Vacuum Evaporator-III (HV-III)	21

Table.1-Utilizatation of facilities

The utilization of facilities indicates that more than one facility of target lab has been used every day in this year. More than 200 evaporation attempts were performed for target fabrication in different systems for the completion of target requests from more than 34 users of various streams viz., material science, nuclear physics and atomic physics. Target lab has successfully delivered more than 100 nuclear targets for various nuclear physics experiments in this year. Target developments in IUAC were reported in many national symposia and peer reviewed journals in this year [1-11].

Recent updates in Isotopic Target development

In target development, 80% of the time is being utilized for the fabrication of isotopic targets. List of isotopic targets developed in the last year is shown in Table.2 and few of them are first-time-development. Most of the targets are fabricated by physical vapor deposition method (thermal evaporation and e-beam method).

S. No.	Description of target	Thickness	No of targets
1	Zn-64	~200 μg/cm^2	17
2	Zn-64	~900 μg/cm^2	5
3	Nd-148	~900 μg/cm^2	3
4	Ti-48	~200 μg/cm^2	11
5	Re-187	~200 μg/cm^2	23
7	Ce-142	~200 μg/cm^2	23
8	Ce-140	~200 μg/cm^2	17
9	Pb-206	~225 μg/cm^2	14
11	Te-128	~750 μg/cm^2	3
12	Sm-144	~200 μg/cm^2	15
13	Sm-154	~200 μg/cm^2	17

Table.2: List of isotopic targets developed in 2019-20

Development of self-supporting targets

Development of self-supporting targets is the ideal choice for many nuclear physics experiments rather than backing targets. Fabrication of self-supporting targets involves more efforts and challenges. Target lab successfully developed many such self-supporting targets this year.

Development of ^{64}Zn target in self-supporting form was one of the challenging jobs performed in target lab this year [1]. The ideal requirement for a nuclear fusion evaporation experiment held at IUAC was ^{64}Zn target of thickness around 500μg/cm^2 in self-supporting form. Target lab has fabricated several Zn targets with backing in previous years. However, the success rate in fabrication of self-supporting films of Zn was low due to the difficulties in selection and optimization of parting agent. Only few literature were available for self-supporting targets of ^{64}Zn prepared by evaporation. The parting agent used in available literature was Betaine Monohydrate which was not suitable for humid environment. So, the fabrication of self-supporting targets of isotopic zinc with a very limited quantity (100 mg) was a challenging task. Various parting agent viz, Teepol, KCl and $BaCl_2$ have been initially tried and all the evaporation were unsuccessful. It was studied that the properties and crystal structure of the parting agent plays important role in the fabrication of self-supporting targets. Taking this into consideration, as Zn has hexagonal closed pack crystal structure, the parting agents having same crystal structure were shortlisted. On the basis of availability and cost, CaI_2, $MgCl_2$ and $ZnCl_2$ were chosen as parting agents. Finally, $ZnCl_2$ was selected as the parting agent for the isotpic Zn on the basis of trial evaporation. The $ZnCl_2$ was deposited by e-beam evaporation and Zn was deposited by using a tungsten basket source with graphite crucible in resistive heating method. Depositions of parting agent and Zn were done sequentially in a diffusion pump-based coating unit without disturbing the vacuum. More than 15 self-supporting targets of ^{64}Zn of various thickness (450 μg/cm^2 to 1.295 mg/cm^2) were fabricated and few of them were successfully used in nuclear fusion evaporation experiment held at IUAC.

Development of isotopic ^{48}Ti self-supporting target was another target which was developed in this year. The desirable specification of ^{48}Ti targets for the nuclear fusion evaporation experiment was 500μg/cm^2 thickness in self-supporting form. Methods adopted in the available literature for ^{48}Ti fabrication was not technically feasible in the evaporation facility of IUAC.

On the basis of available literature and trial attempts, it was decided to use a specially designed graphite crucible and to heat the crucible by e-beam bombardment. The turbo-based coating unit (UHV Evaporator) was used for the evaporation of materials on the pre-cleaned glass slides. CaI_2 was used as the parting agent in the evaporation. Due to internal stress developed during the film growth, the film was not stable in the form of self-supporting foil during initial attempts. In order to relieve the stress in the foil, the films were annealed in 200 Degree Celsius for an hour in tubular furnace in neutral environment. Target lab was successful in fabricating more than 6 self-supporting targets of ^{48}Ti of various thickness (318μg/cm^2 to 548μg/cm^2) with 100mg of material [2]. Targets were also characterized by various techniques such as Alpha particle energy loss technique and Energy Dispersive x-ray Spectroscopy (EDS) measurement along with SEM. The targets were successfully used in recent nuclear fusion evaporation experiment held at IUAC.

Preparation of targets of rare earth and oxidizing elements

Targets of lanthanides and other oxidizing materials were regularly fabricated in every year for accelerator users in IUAC. Many targets of lanthanides and other oxidizing metals were fabricated and successfully used in accelerator experiments in this year. Preservation of targets for longer duration involves lots of challenges as these materials are air-sensitive. Preparation of ^{144}Sm and ^{154}Sm targets were such kind of challenging work done in this year [3]. Various techniques to fabricate thin films of lanthanides are very well known. Two major techniques, electron gun deposition and thermal resistivity method have been employed for the fabrication of Samarium (Sm) targets for elastic cross-section measurements. The purity and thickness of the prepared targets has been verified and confirmed by using several characterization techniques. These targets have also been irradiated during one of the recent nuclear physics experiments performed to measure the quasi-elastic cross section. In an ideal case for such measurements, self-supporting thin targets were preferred. For the case of Sm, it was difficult to prepare self-supporting targets due to their highly oxidizing and chemically active nature. So, the sandwich thin films were prepared with carbon as backing and capping layer. Turbo based coating unit (high vacuum evaporator) was used for preparing the Sm targets with carbon capping. Due to high cost of the enriched isotopic material and having low abundance, number of trials has been carried out with the natural Samarium.

Initially the thin carbon backing foils were prepared in the high vacuum environment. KCl was used as the releasing agent for carbon. The stress relieved carbon foils were used as the substrate in Sm deposition. In order to relieve the stress in the carbon film, the films were annealed in 325 Degree Celsius for an hour in tubular furnace in neutral environment. The Sm deposition was done by thermal evaporation followed by the deposition of capping layer of carbon of 5μg/cm^2 by e-beam bombardment. The capping layer of carbon was very effective in protecting the Sm target surface. A number of trials were done before the final deposition of enriched material to optimize various parameters such as current, voltage, distances etc. Thermal evaporation using the Tantalum boat has proved to be better technique for preparing high purity Sm thin targets as compared to the e-beam evaporation. The characterization of the targets has been done using EDX and RBS technique. Approximately 15 targets of both the isotopes i.e. ^{144}Sm and ^{154}Sm were prepared. The above-mentioned procedure was also successfully used for the fabrication of targets of ^{142}Ce, ^{140}Ce and ^{206}Pb.

Preparation of targets of high melting point metals

^{187}Re targets of ~200μg/cm^2 thickness with thin carbon backing have been developed in this year [4]. Target lab had reported the development of thin Re targets of ~100μg/cm^2 in previous years. However, successful fabrication of ^{187}Re targets of ~200μg/cm^2 thickness is reported for the first time. Re is a metal with one of the highest melting points of all elements, exceeded by only tungsten and carbon. It also has one of the highest boiling points of all elements. Evaporation of high melting point metals poses lots of challenges. Requirement of more powerful e-gun source for melting the materials, difficulties in uniform heating due to poor thermal conductivity and limited amount of enriched material are the few challenges in fabrication of Re metals by physical vapor deposition.

Turbo based coating unit (UHV Evaporator) with 6kW e-beam was used for evaporating the Re. The available form of Re is in powder form. The powder was converted into a 3mm diameter pellet by using hydraulic press and die set. The pellet was placed in e-gun crucible with utmost care as the pellet was very fragile. Due to poor thermal conductivity of Re, the pellet is likely to be broken to small pieces during the bombardment of e-gun. Slow heating with proper focusing of the e-gun is essential for uniform heating and evaporation. Target lab has successfully fabricated 22 targets of ^{187}Re using 77mg of material. The thickness of the target has been further verified using profilometer. The targets have been characterized using EDAX, XRD and AFM and the result has indicated that the targets are uniform and are free from impurities which adversely affect the result of the experiment. The targets have been successfully used in Evaporation Residue Cross Section Measurement using HYRA facility at IUAC.

Studies in improving the collection efficiency of evaporation

Target development with minimum material consumption is very important as enriched isotopic materials are highly expensive and rarely available in India. Controlling the solid angle of evaporation plays significant role in increasing the efficiency of evaporation and thus minimizing the consumption of material. Target lab has already established several techniques and developed evaporation sources to minimize the material consumption. Isotopic Tellurium target development is a recent successful attempt with highest collection efficiency.

Isotopically enriched ^{130}Te targets of 1.2 mg/cm^2 thickness have been fabricated on 6 mg/cm^2 gold (Au) backing by using 10mg of material [5]. The vapor deposition method was employed using the resistive heating technique. An indigenously developed graphite crucible with 1 mm opening was used to deposit the Te metal powder at a minimum source to substrate distance of 2 cm. A heat shield was placed at 1 cm above the graphite crucible to partially isolate the target and to minimize the heat radiation effect on target surface. The purity, thickness and microstructure of the fabricated targets have been characterized using the XRF, EDS and SEM measurements. One of the fabricated targets has been successfully used in a ray spectroscopy experiment in IUAC.

Fabrication, Inspection and Loading of stripper foils

More than 300 stripper foils of carbon of ~4µg/cm^{2}and 200 stripper foils of carbon of ~10µg/cm^2 have been fabricated in this year. 19 evaporations of carbon were done in high vacuum chamber for the stripper foil. Target lab has already established a consistent method for the fabrication and loading of the stripper foils. We have also initiated the work for minimizing the human intervention in applying the releasing agent and in floating the foils. Application of machine will improve the uniformity of releasing agent and minimize the damage of films during floating.

Figure 1: Dip coating machine for stripper foil floating

Thin Film/ Target Thickness Measurement Facility

Alpha Energy Loss Target Thickness Measurement Setup

After preparing thin films, it is very important to measure their thickness. In case of free-standing thin films which are mostly used for experiments of Nuclear Physics, the thickness is measured by *Alpha Energy Loss Target Thickness Measurement Setup*. This year, thickness of around 61 free standing nuclear targets of 6 users from different Universities/ Institutes have been measured using this facility.

Stylus Profiler

In case of thin films deposited on thick substrates, alpha energy loss target thickness measurement method is not effective. For those cases, the step height is measured with *Stylus Surface Profiler*. This year, thickness of around 67 thin film samples of 16 users from different Universities/ Institutes have been measured using this facility.

Nuclear Target Library for Accelerator Users

Target lab has already initiated a target library for accelerator users. The main aim of this program is to systematically preserve the target for future use and to avoid 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. The library has already preserved more than 500 targets of various elements and more efforts are in progress to bring more targets under the library with proper documentation and tagging.

List of recent publications

[1] H. Arora, Abhilash S.R et al., Proceedings of the DAE Symp. on Nucl. Phys. 64 (2019)
[2] H. Arora, Abhilash S.R et al., Proceedings of the DAE Symp. on Nucl. Phys. 64 (2019)
[3] K.Rani, Abhilash S.R., G.R.Umapathy et al., NIM A963(2020)163736
[4] K. Hajara, M. M. Musthafa et al., Proceedings of the DAE Symp. on Nucl. Phys. 64 (2019)
[5] Neelam et al., Vacuum170(2019)108961
[6] A. Sood et al., Vacuum172(2020)109107
[7] S.S.Tiwary,et al., Vacuum 167 (2019) 336–339
[8] GIRI et al., INDIAN J PURE APPL PHYS, VOL. 57, SEPTEMBER 2019
[9] P. Sharma, B R Behera, Abhilash S.R., et al., NIM A935(2019) 65-68
[10] Anand Pandey, S. C. Chamoli et al., Proceedings of the DAE Symp. on Nucl. Phys. 64 (2019)
[11] A. Sharma, Abhilash S. R. et al., Proceedings of the DAE Symp. on Nucl. Phys. 64 (2019)

3.1.6 RF & ELECTRONICS LABORATORY

Arti Gupta, Bhuban Kumar Sahu, Deepak Kumar Munda, Kundan Singh, Mamta Jain, Parmanand Singh, Prem Kumar Verma, Yaduvansh Mathur, V.V.V. Satyanarayana, U. Koteshwar Rao, S.Venkataramanan, B.P. Ajith Kumar

RF Power amplifiers of HCI

We have been actively involved in installing, commissioning, repairing power amplifiers that are purchased for the purpose of powering various RF cavities of High Current Injector (HCI) during this year. The periodic maintenance of various RF power amplifiers installed in the systems such as Klystron based 2kW Ku band plasma generator, 250W TWT amplifier (8-18GHz) and 120kW, 48.5MHz RF amplifier of RFQ have been undertaken and restored them into the system successfully. We also restored the air cooled 6/10kW triode based power amplifier as a standby power amplifier for HCI along with its spare tubs. The air cooled driver amplifier and spare control cards were characterised during this time.

Two numbers of 20 kW, 97 MHz solid state power amplifiers corresponding to DTL tanks 2 & 3 in HCI have been installed and commissioned this year. The power amplifiers were initially tested with dummy load for their full specifications continuously. Minor problems related to plumbing, loose contact, failed PLC memory backup battery were identified during normal operation and restored. These amplifiers were connected to DTL tank 2 and 3 respectively and successfully RF conditioned the cavities for a nominal power.

For DTL tanks 4 & 5, we have installed and commissioned two numbers of 28kW, 97 MHz solid state power amplifiers. Numerous plumbing, interlock failure problems were encountered during dummy load test and they were all sorted out except for a major failure of DC power supply connected to one of these amplifiers. The DC power supply was repaired at local repair centre with in India and restored but problem persists. We planned to send the DC power supply back to manufacturer for repair or replacement. One of the 28kW power amplifier has been successfully integrated with DTL-4 cavity and subjected to RF conditioning for the required field. The standby air cooled 6/10kW triode based power amplifier has been used to power DTL-5 cavity and RF conditioned for a required power level.

We have installed and commissioned a Triode based 30kW, 97MHz power amplifier with DTL-6 RF cavity. The power amplifier was subjected to high voltage conditioning to recover from built up gas and the tube was subjected to hipoting with locally established setup at required voltage level continuously. The power amplifier was tested continuously to the specifications with RF dummy load before integrating with DTL-6 cavity.

All the power amplifiers and DTL cavities are now connected through flexible high power transmission lines with 3-1/8” terminations. We intend to add 6” flexible line sections to reduce stress between RF power coupler and transmission line in near future.

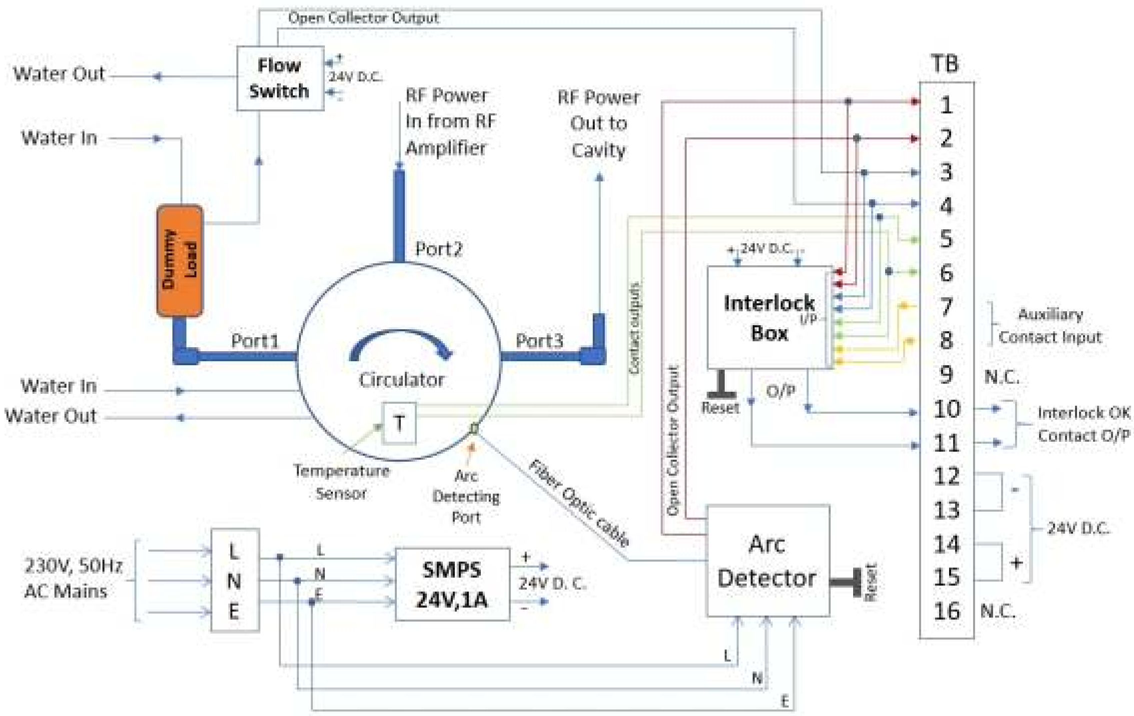
100Watts, 10-50MHz broad band solid state power amplifier has been developed locally and installed in the Multi Harmonic Buncher (MHB) of HCI and another locally developed 48.5Mhz, 1500Watts sold state RF power amplifier installed in the Spiral Buncher -1 of HCI. We plan to develop and assemble 3kW, 48.5MHz solid state power amplifier for powering Spiral buncher -2 & 3 of HCI for which various sub sections are under development. The control card for these amplifiers are being suitably modified for remote operation through VME control system.

This year around 6nos., of 350W, 97MHz solid state power amplifiers of SC-Linac have been repaired and successfully tested and restored into the system. The recalibration of 90 channels of RF to DC conversion electronics has been completed and documented. A hipotting set up has been made for high voltage conditioning various power vacuum tubes in use and spare. All spare tubes have been conditioned with this setup as per manufacturer's recommendation.

The RF group was also actively involved in various activities related to installation and commissioning of high power RF power generator of Delhi Light Source (DLS). Klystron, pulse modulator, vacuum type wave guides, vacuum pumps, ceiling mounted plates and other associated components were installed during this period. Initial conditioning of Klystron upto 12MW (pulsed power) was also carried out during this period.

High Power Circulator

A 30kW, 97MHz, 3-port, ferrite T-junction RF circulator (M/s. AFT-microwave) has been installed and commissioned for the purpose of RF conditioning various Drift Tube Linac (DTL) cavities. The circulator is integrated with manufacturer supplied arc sensor, water flow switch, external vacuum interlock switch, a 50kW water cooled RF dummy load and 3-1/8" line sections with accessories. The entire assembly is fitted on a trolley for easy portability along beam line during RF conditioning.



Modifications in the VME SDAC64 Module

Last year we have completed the in-house development of high density (64-channels) scanning ADC (analog-to-digital converter) module for VME bus architecture. One of the commercial scanning ADC module was replaced with indigenously developed module in HCI (high current injector) beam line for in-beam testing of the board. It was observed that for noisy input signal (e.g. Log Amplifier signal) there were fluctuations in the monitored values at the client GUI. It was decided to filter out the high frequency electronic noise by implementing low pass filter (LPF) at -3dB cutoff of ~40Hz. This resulted in an attenuation of the input signal which is compensated by introducing additional gain stage in the circuit design. The module is recalibrated with precision voltage source.

VME Input Gate/Output Register module (IGOR) Testing

In accelerator control system hardware we are migrating from CAMAC bus based servers to VME bus servers in a phased manner. The transition, especially in Pelletron, has put up a requirement of developing customized VME module to control magnet power supplies (Danfysik make). These magnet power supplies (e.g. analyzing magnet or switcher magnet) has customized remote control feature which need special boards to control remotely. In the continuation of our in-house control system instrumentation development we have designed two channels of IGOR module on a 6U single width VME board space, which can independently control two power supplies. The four-layer PCB has been designed using open source KiCAD PCB design software. The firmware for the board functionality is written in a hardware description language, VHDL. The module is thoroughly tested in the lab for functionality. Presently the module is under test at Low Energy Ion Beam Facility (LEIBF).

3.1.7 Health Physics

Debashish Sen & Birendra Singh

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

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. 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. Users are from Punjabi University (Patiala), Delhi University, AM University, JMI University, HP University (Shimla), IIT Delhi, Shiv Nadar University, Indra Prastha University, Amity University (Noida & Gurgaon), NIT Jalandhar, NIT Kurukshetra, DAV Amritsar, GNDU Amritsar, RTM Nagpur University, SUK Maharashtra, BU Tamilnadu etc.

Gamma/X ray monitors/ surveymeters/ pocket dosimeters get calibrated each year as per their calibration schedule. Few of the door interlock systems got extensive repaire work. Some monitors were replaced, and some were installed in new strategic locations (as new facilities are coming up in the centre). Some new shielding was added & modified as per requirements. Radiation sources (with adequate shielding), as usual, are kept under strict vigil. All dose records are maintained and are also available online

e-LORA facility of AERB

Debashish Sen & Birendra Singh

Electronic Licensing Of Radiation Applications (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 Informing safety status of radiation facilities at regular intervals.

2 Non compliance of any safety measures and its rectification.

3 Submission of siting, design & construction request of an upcoming radiation facility.

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.

6 Renewal of tenure of IUAC Radiation Safety Officers.

7 Providing details of radiation sources in custody of IUAC.

8 Procurement of new radiation sources if required.

AERB correspondence for different upcoming radiation facilities of IUAC (regarding radiation safety aspects)

Debashish Sen

Modification of HCI beam line shielding in beam Hall 1 & III (along with adjacent corridors)

The Site approval has been sanctioned. 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.

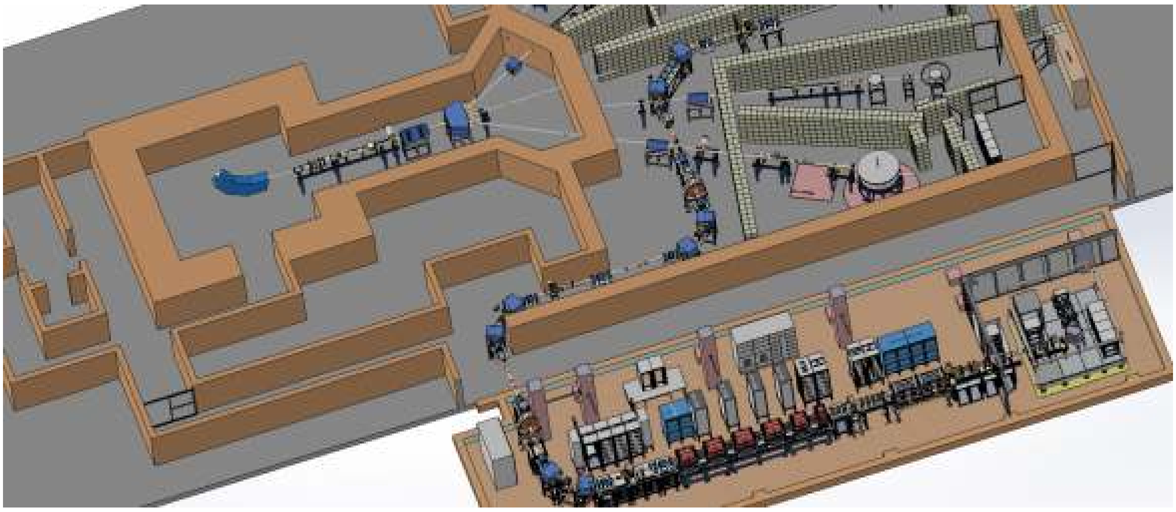
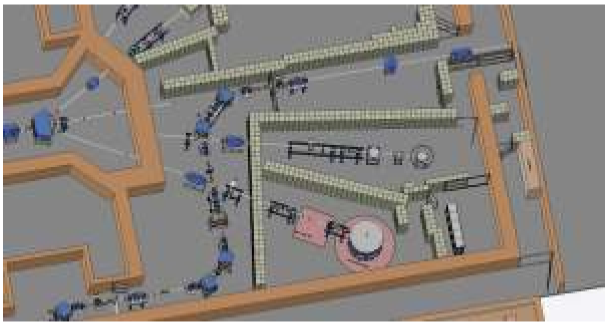


Fig 1. Beam line of HCI (beam hall I & III) and necessary shielding modifications in the corridor.

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. Two options are being considered

Option 1: (without cutting any existing wall) **Option 1: (without cutting any existing wall)**



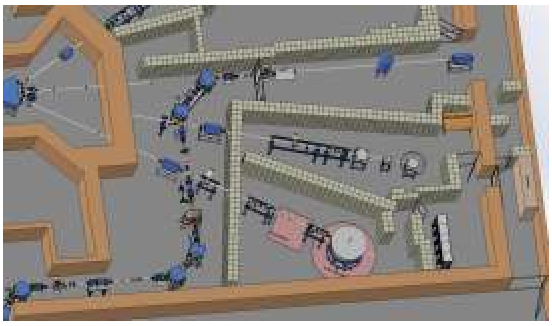


Fig 2: Beam line of HCI (in beam hall I) and proposed shielding modifications

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

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.

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.

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.

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.

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.

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.

Free Electron Laser (FEL) Facility

The Site approval has been sanctioned. Shielding calculations are also approved. The design & construction approval application needs some extra clarifications, which is under process.

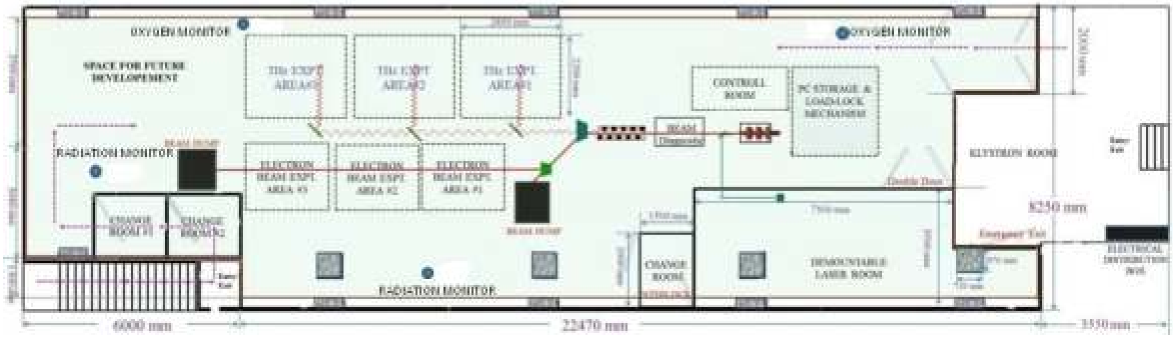


Fig 3: Proposed Beam line of FEL with beam dumps, radiation monitors & oxygen monitors

Accelerator Mass Spectroscopy (AMS) Facility

Final approval has been obtained after submission of the Quality assurance manual & detailed Acceptance test Report to AERB. Operation license has been received.

License to procure & operate one more X-ray diffractometer has been obtained.

Rutherford Backscattering (RBS) Facility & Pelletron LINAC Facility, licence was renewed for 2 more years.

3. 1.8 Data Support Laboratory

Mamta Jain, KuSum Rani, Ruby Shanthi, E.T. Subramaniam.

The primary objective of the group is the maintenance and upkeep of all the data acquisition systems, NIAS lab. The group also works towards the development of data acquisition system software, middle ware and hardware to cater to the ever growing needs of the modern day physics experiments.

ROSE - Readout Ordained Sequencer Engine for VME (NIAS-ROSE)

Mamta Jain, E.T. Subramaniam.

A controller for the versa modulo europa bus has been designed, developed to enhance the efficiency for multi parameter data acquisition systems. The basic building blocks of the developed module is depicted in Fig. 1. The controller also houses an Intel Atom based small box computer (SBC) running the server for data acquisition system, which has as well all the necessary drivers. The SBC has an inbuilt SD card which can boot the system or boot over a network in PXE environment. The VME crate controller has been successfully tested in the last neutron array experiments in Phase II of IUAC. It is very cost effective; the total cost including the SBC is less than $700.

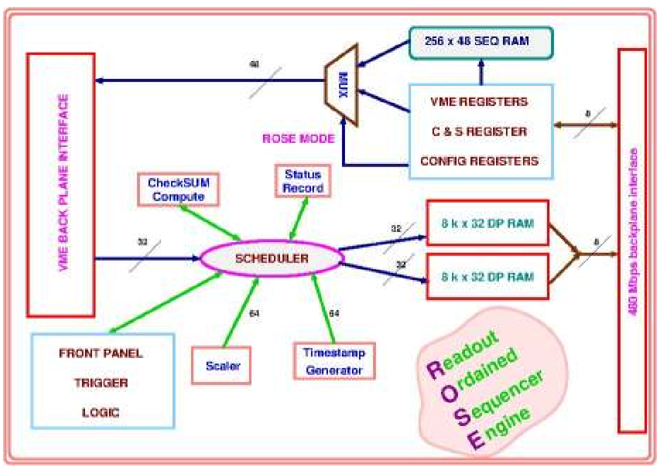


Fig. 1 : Basic building blocks of ROSE

The salient features of the developed module are

- A32/A24/A16 addressable.
- A32/A24 block transfer capable.
- D32/D16/D08 data width transfers.
- Built in separate scalers for triggers received and triggers accepted.
- Provides ADC and TDC strobes for accepted events, with programmable strobe delay and width.
- Ping pong buffer for maximizing through put. Reached up to 360 Mbps (or) 45 MiB/sec.
- With pulse generator and commercial ADC's / TDC's the event rate achieved is ~ 37 k Events / sec (strobe width 10μs + conversion delay 8μs)

MARS - Multi parameter Acquisition with ROOT based Storage (NIAS-MARS)

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

To overcome the problems of obsolescence, compatibility with the experimental community all over the world, a client-server model based data acquisition software package with 'ROOT' (CERN package) storage was envisaged. The graphical interface chosen was Qt/Qwt, for its enhanced signal based inter process communication capability and powerful graphical routines. Routines to display multiple one, two dimensional histograms with fit, gate and miscellaneous features are incorporated. Configuration module (Configurator, See Fig. 2) with graphical user interface, helps the user in configuring even the complex commercial acquisition modules with ease. The zero suppressed event information is decoded and stored as event files in 'ROOT' format. Miscellaneous information like triggers received, accepted, time stamp for every block are also digitally recorded. The information flow diagram is shown in Fig. 2. Data taken with source as well as the facility test run is shown in Fig. 3.

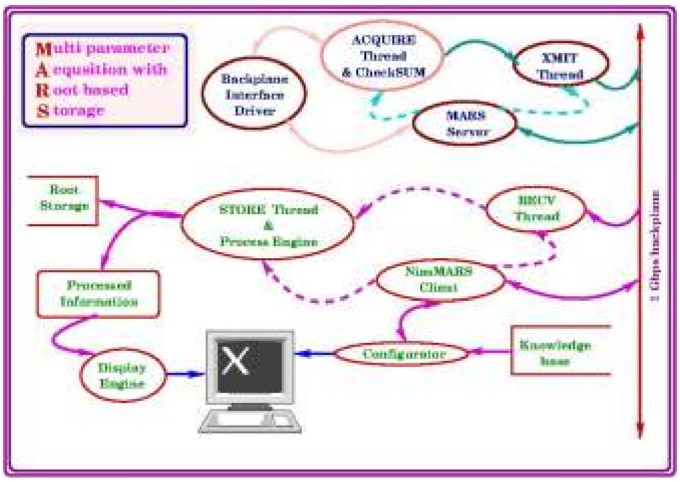


Fig. 2 : Information flow diagram of MARS

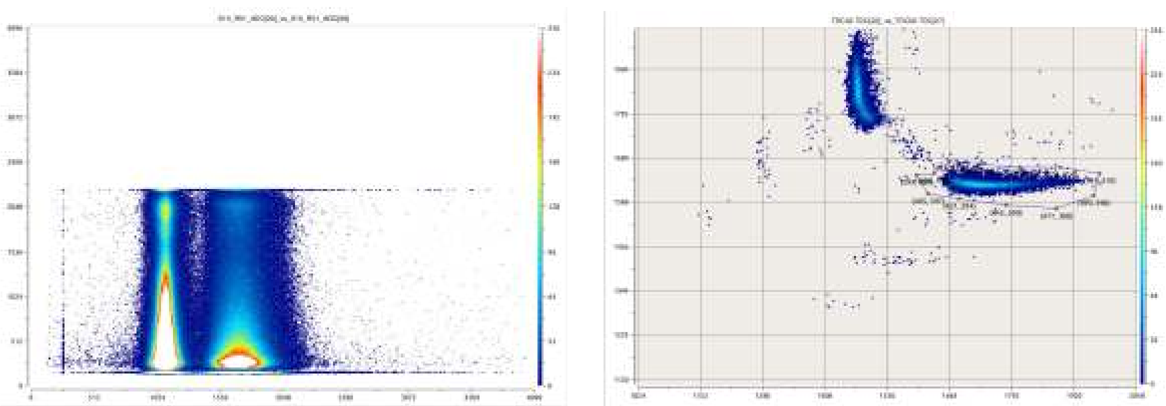


Fig. 3 (a) Light output vs. Pulse shape discrimination from AmBe source
(b) MWPC Anode1-Anode2 time correlation plot from in beam experiment

GEM - Global Event-identifier Module (NIAS-GEM)

KuSum Rani, E.T. Subramaniam.

A new Global Event Identifier module with VME back plane has been designed and developed. In house soldering of flip chip ball grid field programmable gate array was done. It can handle 32 inputs, with programmable stretch, delay and output width times. The module is capable of time stamping every event with a resolution of 10 ns and range greater than 32 days. It is also possible to cascade multiple GEMs. The prototype has been tested in NIAS lab and found to be working satisfactorily.

NIAS - Design and development of high speed back plane

E.T. Subramaniam.

To cater to the ever growing demand from the modern day physics experiments that require handling of voluminous data, a cost effective, futuristic yet simple back plane was selected after a thorough study of available back plane technologies: the super speed plus version of the universal serial bus (USB 3.1, Gen 1). This was accomplished with commercial USB interfacing chips. The necessary middle ware, communication library/driver were developed. The effective real world throughput is shown in Fig. 4.

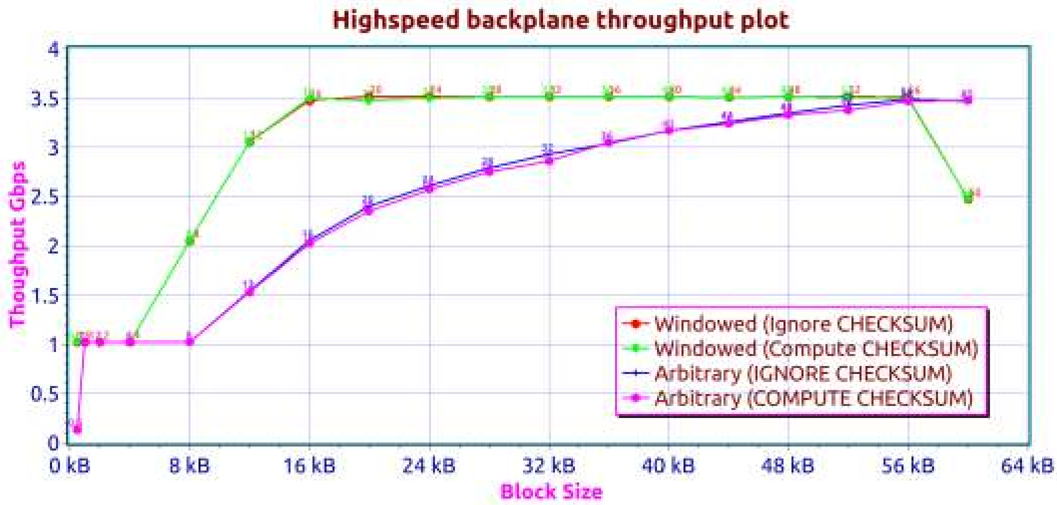


Fig. 4 : Throughput achieved in real world transfers

Maintenance of existing CAMAC based DAQ systems.

Ruby Shanti

In the data room, two CAMAC based on-line data acquisition systems are running with LINUX based FREEDOM software using CMC 100 controllers. During the current year, the system showed overall stable performance and many nuclear reaction experiments in GPSC and HIRA have been performed using this CAMAC based DAQ. Data Support Lab electronics modules maintenance and inventory are done.

Another commercial crate controller, Wiener CC-USB controller was tested with LAMPS On-line Data Acquisition system (with Dr. A Chatterjee) installed on a Ubuntu server. LIBUSB driver was compiled with Ubuntu 16.04 for VM-USB controller. For calibration purpose, we modified the DAQ software and tested with different radioactive sources. Testing of LAMPS DAQ software with the above VME controller is progressing.

3.1.9 COMPUTER AND COMMUNICATIONS

S.Mookerjee, S.Bhatnagar, A. Kumar

The major thrust this year was to complete expansion and migration works initiated last year, and also put in place efficient operation and maintenance processes to cover for increased usage and reduced manpower. Besides this, major issues with the mail system and the old high performance computing system were required to be tackled.

Networks and central services

Wireless network extension to auditorium: While the passive network components for connecting the auditorium to the internet and to the IUAC LAN were installed and tested in the preceding year, the active components for the network were installed and configured this year. This included installation and configuration of PoE and non-

PoE gigabit switches with 10G fibre uplinks, and wireless access points. The central wireless controller and the Sophos UTM were also configured to permit auditorium traffic.

Hardware firewall and UTM: The migration of the IUAC firewall and internet access setup to the Sophos XG310 UTM was completed this year, and all desktop and server systems were configured to send and receive internet data only through the UTM. The proxy server and software firewall, which had continued to operate after the installation of the UTM last year in order to provide a smooth transition, was shut down after all client systems were configured to use the UTM. The IUAC web server and mail server, which were earlier dual homed servers with direct connections to the internet and separate software firewalls, were placed behind the UTM with port forwarding. The UTM was configured to fall back automatically to the spare PowerGrid internet link on failure of the primary NKN link. While this provides agility and resilience to the IUAC security setup, the single UTM configuration also leads to a single point of failure. The existing manually configured software proxy server and firewall systems are being maintained as backup options to mitigate this situation.

Mail server issues: A major spam outbreak, caused by malware from infected systems on the trusted local network sending out large amounts of unsolicited bulk emails, brought down the mail system in May 2019. The solution consisted of backing up and completely reinstalling the mail server, migrating mail from backup after malware checks, configuring the server to ensure authenticated mail sending from the local network, and removal of the domain from spam blacklists. Scripts were then developed to help speed up checking of mail logs to ensure such outbreaks of outgoing spam did not recur, and regular manual log checking was instituted. A significant number of infected PCs in labs were identified, and mail services for these PCs blocked. Following these measures, the mail system has been stable.

High Performance Computing Facility:

The IUAC HPC facility was set up through a Department of Science and Technology grant, and was operational since 2009 as an inter-university super-computing facility. At the beginning of the academic year, it consisted of an Infiniband-based MPI cluster comprising 1700 Xeon cores across about a hundred working compute nodes, with a total of more than four hundred users from a hundred and forty groups. From 2013, when the project-based support from the DST ended, maintenance of compute, storage and interconnect hardware and software had been done in-house, while data centre power and cooling was maintained by the equipment manufacturers using IUAC funds.

However, major hardware problems, including with the master node and storage, started becoming more frequent from the beginning of the year. They were sought to be resolved for some time by cannibalizing and configuring compute nodes as master and metadata nodes, and using parts from nodes already down to repair other nodes. This did not prove workable for very long, as node and core counts kept reducing and reliability became a serious issue. After March 2019, no more new user requests could be entertained. Multiple hardware failures across nodes and storage continued. 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 has not been operational since May 2019, though some nodes were revived and a small HPC cluster configured for participants of the workshop on quantum modeling. A much larger cluster has now been sanctioned by the National Supercomputing Mission, and the IUAC facility should hopefully be back for its users in some time.

Modeling and simulations

A five-day workshop on “In Silico Quantum Modeling Studies” was organized at IUAC in November, with a focus on both theoretical and hands-on training on density functional theory methods. The workshop was facilitated by fourteen speakers from India and abroad, and forty research students and young faculty members from across the country participated. The lectures covered a range of topics in quantum modeling and its applications using DFT. The hands-on training was conducted using SIESTA as the density functional code of choice, implemented on a small MPI cluster set up for the workshop. The response of the participants was enthusiastic, and it is hoped to carry this exercise on more regularly in the future.

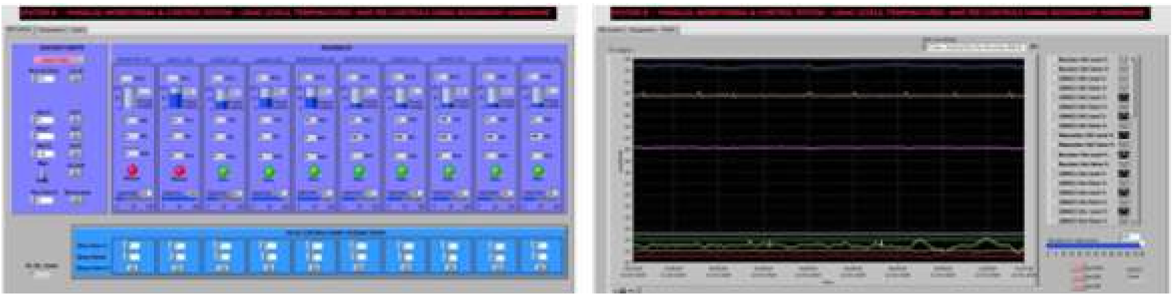
3.1.10 Electronics for Cryogenics of LINAC and IFR

Joby Antony, Rajesh Nirdoshi, Anup Choudhury, Soumen Kar, Manoj Kumar, Suresh Babu, R. Mehta, P. N. Prakash

Upgradation of Cryogenics Control System

In this academic year, an up-gradation of the existing CADs system, primarily used for automatic cryogenic valve control for the beam-line cryostats, was planned and implemented in a phased manner. The first phase of upgradation consists of planning, designing, prototyping, software design and installation at the cryogenic control room. The PID switch unit was upgraded with new system having ten channels of low-cost PID controllers connected with the Modbus interface and a PID Switcher Unit. The switcher unit and its control panel is shown in Fig. 1. The switcher unit can be used to select commercial cryogen level meters in place of indigenous devices in case of emergency using a manual switch mounted on the front panel. It can be selected at any time during an experiment without any interruption. Fuji make (PXF9AEY2FVM00) PID controller devices were chosen for LN_2 and LHe refill operations for five beam-line cryostats. The *control* GUI and *trend* GUI programs (as shown in Fig. 2) have been developed in-house using Labview® to operate in manual and auto modes .

Fig. 1 Newly installed PID switcher unit for the cryogenic control system.



(a) (b)

Fig. 2 (a) the control GUI and (b) the graphical trends of cryogen level and valve status.

We have started to develop 10 channels version of PID refill system with multi dropped RS485 via Modbus for control & DA GUI. The basic functional block diagram is shown in Fig. 3.

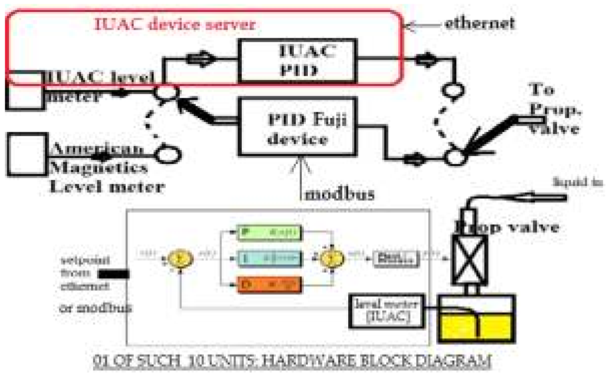


Fig. 3 The block diagram of single channel switcher unit.

Remote Display Unit of Temperature of Beam Line Cryostats

A thirty-channel temperature monitor has been designed and developed for remote display of essential temperature sensors of all beam line cryostats. The remote display unit shown in Fig.4a has been installed in the cryogenic plant room in beam hall-II . This device accept 0-10V inputs from the existing temperature monitors installed near each beam-line cryostat that is inaccessible during beam acceleration. It also has remote connectivity via built-in serial server to the cryogenics control room. Fig.4b shows the Labview® based GUI. The device is presently undergoing intensive test.

(a) (b)

Fig. 4 (a) The newly installed remote temperature monitor and its GUI at the cryogenic control room.

Cryogenic Control Room

A new PC for newly developed PID-based cryogenic valve controls has been added to the cryogenic control system in the control room as shown in the Fig.5. It has been tested during the LINAC run.

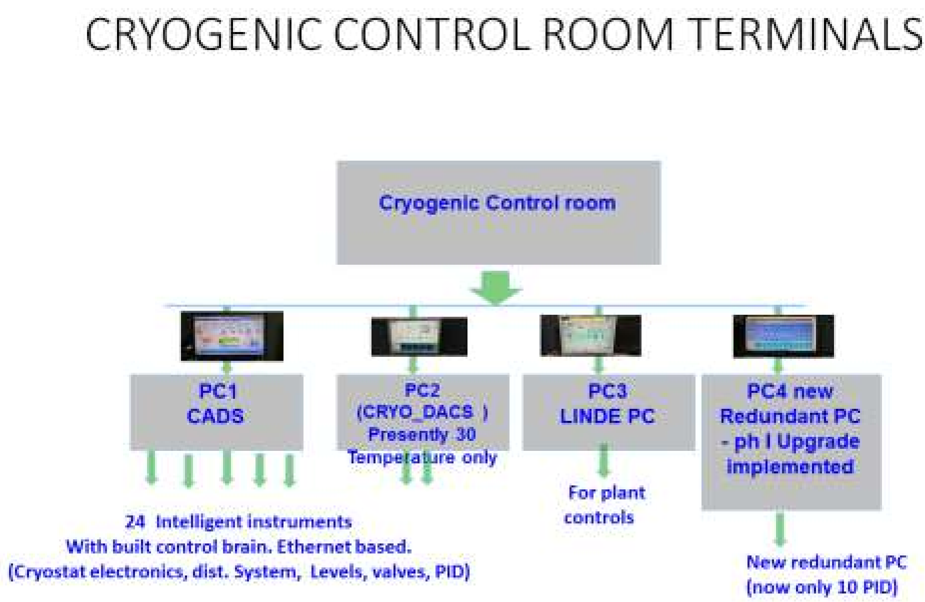


Fig. 5 The Cryogenic control room terminals

Ten numbers of web-server based spare instruments used in CADS for LHe and LN_2 levels have been developed and tested in this academic year. Most of the signals in the CRYO-DACs, a VME based system operational since 2002, have already been ported to the CADS system.

3.1.11 Low level RF & Beam bunching group (LLRF)

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

All the LLRF and related activities for the different accelerators (both operational as well as under development) at IUAC have been clubbed under this newly formed group. These mainly include the operation, maintenance, upgradation and development of different systems like the Beam Pulsing System of Pelletron-Linac, LLRF systems for Linac, High Current Injector (HCI) and Free Electron Laser (FEL). A brief summary of the activities in the different systems is given below.

Operation and Maintenance of Beam Pulsing System for Pelletron

The Multi-Harmonic Buncher (MHB), Low Energy Chopper (LEC) including the beam phase locking electronics are operated and maintained regularly by the group members during pulsed beam runs including Linac runs at IUAC. Any problem faced with beam-phase locking during these pulsed-beam operations is looked into and immediately corrections done by the members with minimum loss of beam to the users. The upkeep and upgradation of these systems are also taken care of. The control electronics panel in control room has been re-organised with proper labelled cabling, addition of new measuring instruments like beam phase meter and 4-channel digital oscilloscope has made phase-locking of the beam easier.

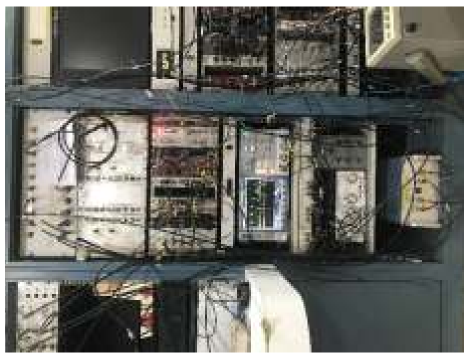


Fig. 1 Pulsing Electronics setup in Control room

The Travelling Wave Deflector (TWD) of Pelletron runs only on specific demands from users especially for experiments in HIRA/HYRA. The responsibilities of the TWD and Chopper related electronics are being transferred from Pelletron group to the newly formed LLRF and Beam Bunching group. Repair work of TWD electronics and Chopper amplifier has been performed by the group members along with the Pelletron group members during the breakdown maintenance. Other than the regular maintenance of the systems, as a preventive maintenance, the stability of the phase locking electronics was tested off-beam before the Linac run and the system was found to be quite stable over long time. Spare Pulsing electronics modules were also tested in RF Lab. These will be integrated to the system with proper calibration with beam in future. The upgradation of the different LLRF systems are also planned for future.

LLRF Systems for Linac

The operation and upkeep of all resonator controllers are performed by the group members. 27 resonator controllers are operational now. 6 spares are ready. During the scheduled maintenance before Linac-run all the controllers were tested, their problems noted and solved. A detailed report on the operation maintenance and upkeep of the Linac resonator controllers at IUAC has been made. During the present run no Linac downtime reported due to LLRF failure. A detailed report is given in the Electronics section of Linac.

LLRF Systems for High Current Injector (HCI)

The Multi Harmonic Buncher (MHB) for HCI has been operational since 2016. A spare electronics controller was assembled and is getting ready for testing. The LLRF controls viz. Amplitude Phase Control (APC) and Frequency Tuner Control (FTC) for RFQ, Spiral Buncher, DTL#1 and DTL#2 were installed and operational. The controllers for DTL#3 to DTL#6 and for Spiral buncher#2 are under development and will be ready before next beam test in HCI. Development of spare modules and replacing FTC modules with remote operation facility for RFQ, SB#1 and DTL#1 will be taken up in the next phase. The group members are also involved in the different jobs like cabling from control electronics to resonators, high power testing and solving associated problems of DTL cavities.

Fig. 2 LLRF Controls for HCI under development

LLRF Systems for Free Electron Laser (FEL)

Specification and procurement of LLRF system has been completed and commissioning will start soon after cavity installation. Development of frequency tracking mechanism for cavity conditioning is in progress. Installation of one beam viewer camera already completed. Several on-going developmental projects include: Design and development of strip-line fast faraday cup, Gigabyte camera integration into EPICS for beam viewing, FPGA based 4-channel digital trigger generator for high power RF, Characteristics Study of beam devices (BPM & FFC), etc.

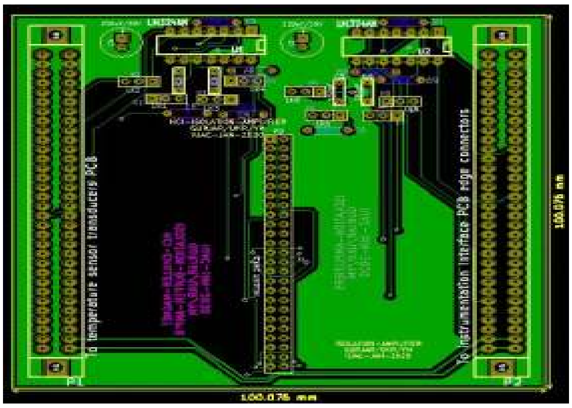
3.1.12 High Voltage Power Supply Activities (Ion Source Group)

U Koteswara Rao, Radhakishan Gurjar and A. Tripathi

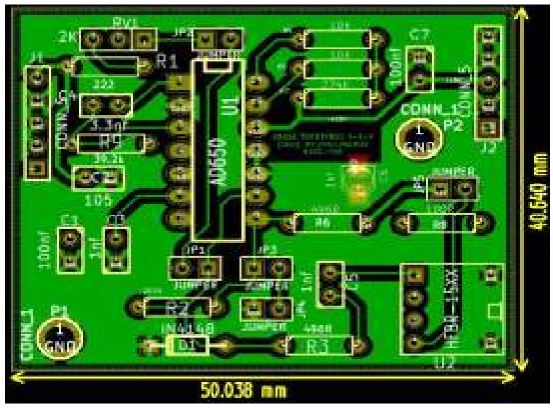
Ion Source Group(ISG) is an Accelerator Facility Central Support Group which takes care of the activities of ECR Ion sources on high voltage platform and associated electronics including High Voltage power supplies (HVS), Light Link Interfaces, HTS Coils related Electronics and System operation and maintenance.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

Developmental activities:

This year development of some of the electronic modules were undertaken to replace the obsolete parts for which spares are no longer available from he manufacturers. Some of these are: HTS interfacing buffer amplifier, Four Channel Temperature sensor, Four channel Threshold detector and Light Link Interface modules. PCB designs were completed and components procurement was undertaken for these.



Isolation Amplifier Module



Light Interface Module

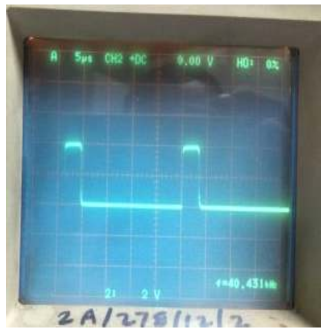
The group was also involved in installation and commissioning of Oven and Bias Power supplies and associated control Electronics in HCI area.

Maintenance activities:

Many important maintenance activities were undertaken this year making this a very productive year. An important breakthrough was achieved in repairing of 30kV, 1.0mA High Voltage Power supply of Table top Accelerator facility for which the schematic and IC details were not available. The trouble shooting was successfully done and its schematic was prepared for future repairs.

Control Module

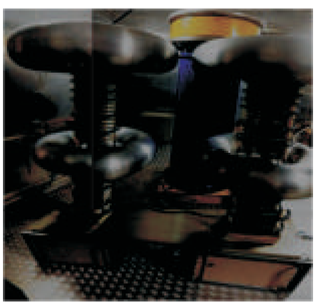
Power Board



PWM output wave form

The activities are described briefly as follows:

1). Repairing of LEIBF high voltage multiplier stack



300 kV High Voltage Power supply

Burned diode

Diode After Replacement

2). Repairing of RS232 to GPIB converters three in number
3). Troubleshooting and rectification of LEIBF door interlock system
4). HCI HTS Temperature Sensor noise problem was solved
5). Involved in HCI extraction power supply ground drifting problem.
6). Involved in HCI Cryostat maintenance work.

Support to other groups:

The group has provided support for the Nuclear Physics group for Detector annealing, replacing PT 100 sensors, replacement of faulty Clover FET and automatic LN2 filling system development work.

3.2 UTILITY SYSTEMS

3.2.1 Electrical Group Activities

U. G. Naik and Raj Kumar

Electrical group is primarily responsible for maintaining the electrical installations of IUAC and also to develop adequate electrical infrastructure for the new facilities. This year we could achieve near 100% uptime for all electrical systems. This was possible with judicious maintenance schedules and monitoring arrangements. The group has also successfully completed major works envisaged for the year 2019-20.

Electrical Works for Accelerator Facilities

We have completed the procurement and installation of AC input and DC output cables for the magnets, AC input cables for all other HCI components, copper cables for dedicated clean and separate earthing to RFQ /DTL, Magnets in the Beam Hall-III area. Installation of LT DB in beam hall-I corridor and energization of same for catering power to the HCI beam line components in the Beam Hall-I side is completed.

All power requirements such as 3-phase and single phase UPS power for critical loads, air conditioning load power, LED lighting, grounding etc have been provided to PARAS, HR SIMS, XRD, TEM LABS, FEL facility and the Welding shop extension have been completed .

Renovation of Housing Colony

It has been decided to replace the electrical fittings of all residential flats (104 nos) with energy efficient fittings. Wood batten surface wiring in all phase-I houses constructed in the year 1990 will be replaced with concealed conduit wiring to the extent possible. This work is being carried out by CPWD through deposit work methodology. Work order has been issued to the contractor with stipulated completion time of 12 months.

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

Maintenance of electrical installations is managed through the AMC with external agency, M/s KBS Electricals. However all the consumables required are supplied by IUAC. During the year no failures occurred for the transformers or any switch gears related to transformer HT and LT.

Besides the routine maintenance following works were carried out.

2V stationary cells for battery charger in 11Kv/433v sub station
RMU service for the packaged sub station, HT relay calibrations and settings
Dehydration of transformer oil for 7 Transformers- (4500ltrs)
Servicing of OCB and ACBs
Repairing of 100kVA Transformer No-5
Periodic maintenance of LT panels, Distribution boards and other accessories, lighting, fixtures, lighting and power circuits.
Maintenance of street lighting and earthing.

Captive Power Installations

IUAC had a captive power base of 2500 kVA. Three DG Sets of 750 kVA capacity are synchronized to power the 15UD Pelletron, Helium Plant and HPC Data Centre. The group has been involved in running the systems round the clock O&M activities and attending the services within short period if need arises.

Synchronisation panel and the PLC are subjected to the ambient temperature of more than 45 °C in the summer and on after successful service of five years it has failed for the first time. The PLC has been replaced with fresh programming put in to service.

During this year batteries for self start were replaced for one DG along with a magnetic pick up unit.

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

Roof Top Solar System for IUAC

Roof top grid interactive 2 x 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 500 units. Periodical cleaning is done to get maximum power output.

UPS Installations

IUAC has 10x60 kVA UPS, 3x300 kVA, 4x200 kVA, UPS systems maintained by electrical group. These are under supervision and control of this group. Day to day operations are carried out by electrical group through by electrical O&M agency. All the UPS are under comprehensive AMC by the manufacturer and provide quarterly preventive maintenance besides on call break down maintenance. During the present period batteries of few UPS degraded and accordingly corrective actions have been taken for replacement. Battery banks of 2x300 KVA UPS have been replaced and battery banks of 4x200 KVA, 4x60KVA UPS are in replacement process.

Power Factor Compensation

Electrical group is pleased to state that yet again average power factor of >0.99 lag was achieved for the year. Our system power factor without correction is about 0.85 and by raising it we have saved >Rs.160 lakhs through the year from energy saving.

Fire Detection and Alarm System

Electrical group has been maintaining fire detection & alarm system covering whole lab complex and new guesthouse. This system has been extended in Beam Hall-II stores areas. All parts of the system were maintained in good health throughout the year. This year the scope has increased due to addition of Lab Block 2nd floor and Auditorium Block.

LED Lighting

Group has initiated steps towards energy efficient lighting. Henceforth only LED light fittings are procured and replaced. Electrical group has taken up the task of conversion of all fluorescent lamps light fittings to LED light fittings. All 70 watts HPSV lamp compound light fittings are being converted into 45/45 watt LED bulb fittings by replacing the retro-fit LED lamps. Similarly all fluorescent light fittings of 40 watts are being converted into 20 watts retro-fit T8 LED light tubes. Initially lights which are 24x7 in operation have been converted to LED lights and other fittings are also being taken up in phased manner.

3.2.2 Air conditioning, water system, cooling equipments, compressed air system, elevator, fire fighting system, supply of high purity gases to laboratories, cranes etc.

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

Air-Conditioning system

IUAC's central air conditioning / low temperature cooling system of Phase-1 consisting of 400 TR Central AC plant performed with 100% uptime. Maintenance ensured that the safety record of the plant was maintained at 100% and the power consumption kept at optimum level. 2x200 TR chillers installed in 2013 have run 28000 hours each. Other rotary equipment have logged 2,22,250 continuous run hours. It is relevant to note that the Indian industrial norms specify a life of ~25,000 run-hours for compressors and ~50000 hours for other rotating equipment.

The Phase-II & III, screw chiller based central AC plants performed to an uptime of 100%. The highlight of the operation and maintenance of the above systems was the in-house supervision provided to the contracts, which affected significant savings. The hook-up of AC plants ensured optimum power consumption. The equipment being into their twenty-ninth year of sustained operations have far outlived their economic lives, yet have high operational reliability.

Water system

IUAC's centralized water system of Phase-I feeding low temperature cooling water having a total heat removal capacity of 115 TR performed to an operational uptime of 100%. This is due to the stringent maintenance practices, which were followed over the years. The system has overshot 1,77,000 hours from its expected life span. Centralized water system of Phase-II & III feeding low temperature cooling water also performed to an uptime of 100%. A strict monitoring on the water quality has ensured that the flow paths are in healthy condition. The maintenance costs were kept significantly low as compared to world class bench mark values.

150 KLD Sewage Treatment Plant (STP) performed satisfactorily.

Cooling equipments

Availability of equipment was recorded at 99%.

Compressed air system

Compressed air system (Ph-I&II) consisting of three nos. of screw compressors each of 150M^3/Hr capacity, 4 nos of air dryers, pre/fine/oil removal filters with capacity of 2500 lpm @ 9.0 Kg/cm^2, Storage Tank of 25 cub.met. have maintained uninterrupted air supply to various laboratories round the clock throughout the year. Pneumatic connections were provided to different labs / area / instruments as and when required.

Laboratory gases

Indigenous / imported various industrial / Lab purity gases / cylinders / regulators have been made available as required in different labs from time to time.

Elevator

Preventive and break down maintenance carried out so that elevator is operating safely with maximum / high up time.

Material handling system

Preventive and break down maintenance of more than 14 Nos. of E.O.T cranes and electric hoists of various capacity up to 7.5 Tones are being carried out to ensure the smooth, uninterrupted and safe operation.

Fire safety

Annual refilling and periodic maintenance of all the fire extinguishers were carried out. Demonstration for use of fire extinguishers was arranged and all the users and IUAC employees are trained to use the fire extinguishers.

Fire extinguishers have been installed in the newly built second floor of Lab Building. For Fire safety purpose pressurised water hydrant system including underground Water tank, electric / diesel engine water pumps have been installed. With this, continuous water pressure is maintained in the water hydrant line. Wet risers, down comers, hose reels, hose pipes, boxes, hydrant branches have been provided in and around different buildings i.e. Material Science building, Engineering Building, New Guest house and Auditorium.

Works carried out during the year:

- Planning, Tendering & Finalisation of SS Water Piping New work in Beam hall#III for HCI facility
- Planning & Tendering of SS Process Water System for HCI & FEL facilities
- Provision of Cooling Water Connections in Beam hall#III for HCI facility Testing & Beam run
- Repair & Overhauling of Workshop & LHe Compressor Room Air-Washers
- Exhaust Air Ducting in FEL Chiller Room
- 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
- Repairing of Kiroskar Make Centrifugal Pumps and replacement of gland packing by Mechanical Seal
- Testing of Potable Water Samples and STP
- SS Headers for Magnets & Power supplies for HCI Project
- Provision of additional Cooling Water Supply/Return points in Beam hall#III for HCI
- Re-winding of 10 HP Motor and machining job
- Replacement of Compressor in 3 TR Split A/C of Beam hall#II UPS
- Replacement of 5TR Compressor in HCI 10 KW Process water Chiller
- Replacement of Digital Humidistat in LEIBF Ion Source Room De-Humidifier
- Replacement of Submersible Sewage Pump in STP
- Servicing of LEIBF De-Humidifier
- Resolving of 30 KW FEL Process Water Chiller High Pressure issues. OEM, Supplier and the local HVAC Vendors couldn't able to diagnose the problem. However, IUAC was successful in resolving the teething problems.
- Commissioning of 30 KW & 5 KW FEL Process Cooling Chillers
- Providing of 120 mts.. of size- upto 1” SS Piping for Water, Air, N2 and He for MRI Room.
- Providing of 1 no. of Split Air Conditioner 1.5 Ton in visitor room
- Providing of 3 nos. of Window Air Conditioners 1.5 Ton each in Parijat#3
- Providing of 9 nos. of Window Air Conditioners replacement in Flatlet-1

- Providing of 1 no. of Split Air Conditioner in Parijat -3
- Providing of 3 nos. of Split Air conditioners in HR SIMS (Room 103) lab
- Overhaul work of 2 nos. of cooling Towers Ph-I
- Overhaul work of 3 nos. of Softeners
- Quarterly PM / breakdown visits of 2 nos. of 200 TR water chilling units
- Procurement of spares for the system i.e. pumps, electric starters, desert coolers, window air conditioners, water coolers, geysers, v-belts, bearings, piping etc. as per requirement
- Rewind of electric motors HVAC system, WAC, desert coolers etc.,
- PM of desert coolers, geysers, air washer, canteen exhaust system etc.,
- Descaling work of condensers and evaporators of 200 TR Water Chilling units
- Replacement of 400 kgs. of Silica Gel in De-humidifier
- Replacement of Cooling tower 1&2 electric Motor Bearings
- Replacement of Dehumidifier Heater
- Replacement of Dehumidifier Timer
- Replacement of Dehumidifier Micro Switch
- Replacement of Cellulose Pads and blower bearing for canteen air washer
- Replacement of Canteen air washer pillow replacement.
- Extension of AMC of O&M of AC Ph-1
- Replacement of MCCB in CHWP -3 starter panel
- Attended to break down complaints (331 nos.) of window/ split air conditioners, water coolers, desert coolers, geysers etc.
- Renewal of AMC of 200 TR water chilling unit
- Records: Maintaining records of spares, consumables, maintenance works & Assets etc. on computer and different registers
- Replaced bearing P208-NA208-40mm FYH, pulley side for canteen exhaust system
- Replaced motor bearings and pillow blocks for AHU-2
- Replaced motor bearings for AHU-1

Instrument Air System:

- Daily check for oil level, condensate drain etc.,
- Weekly cleaning of the heat exchangers of air compressors and air dryers, air filter, room filters etc.
- To provide pneumatic connections to new instruments as and when required
- Procurement and Replacement of pre / fine / oil filters, regulators etc
- AMC renewal for air compressors, dryers

Elevator

- License Approval: Lift Inspector's Annual visit was arranged and license got renewed
- Supervision of Monthly maintenance and follow up for breakdown maintenance
- Annual renewal of AMC
- To attend to minor problems and making it to work
- Rescuing the people if trapped inside lift in case of any fault / malfunction of lift & make it working by attending to the minor problems

Gases:

- Providing of help in cylinder leak rectification, regulator leak / repair, connection etc
- Awarding Annual Rate Contract for High Purity Gases
- Portable Fire Extinguishers and Fire Hydrant System
- Annual check-up and refilling of portable fire extinguishers was done
- Procurement of new fire extinguishers for new systems
- Repairing of Fire Pipe Leak
- Fixing of Signage Glow in Dark for Clean Rooms - DLS, LINAC – 2 Nos.

- Demonstration of Fire Drill
- Fixing of LED Exit Signage for Auditorium
- Fixing of Floor Photo luminescent Signage for Auditorium
- Material Handling System:
- Providing operation of EOT cranes etc. as per requirement
- Preventive / Break down maintenance of EOT cranes, electric hoists, hydraulic pallet trucks, jib crane, material trolleys etc
- Procured spares for "JET-Make" Pallet Truck
- Repair of EM brake of Electric hoist at 286 level (Outsource)
- Repair of EOT, 7.5 Ton in BH-III. (Outsource)
- Repair of Electric Hoist in BH-III. Took help from the Mr. Rajesh for remote wiring re- connection
- Replacement of wheels of trolleys as and when required
- Providing help in unloading, shifting and lifting of heavy items by co-ordinating with the external agency as per requirement.

3.2.3 Mechanical workshop (MG-III Gr.)

R. Ahuja, S.K.Saini, T.Varughese, S.K.Sahu, B.B.Choudhary, D.K.Prabhakar 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.

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 the required specifications. If required, we assemble and install it also at the site.

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.

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

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. A portable CMM with 1.8 m inspection area with 40 µm accuracy is also part of Workshop for highly accurate measurement and assembly.

Assembly of six nos of DTL

Compact Diagnostics System for HCI

DTL Slow Tuner

DTL Assembly

MRI prototypingcomponents

Assembly of FEL components

Compact Diagnostics System components

DTL Coupler

PSPC Chamber

Figure – 1

This year we had received and fabricated around 400 nos. of jobs of different nature in the workshop. Figure 1 shows some of the components fabricated by or assembled with help from the Workshop.

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 and Ph.D. students enrolled in 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:

1 Drift tube Linac - DTL
2 MRI magnet development program
3 Free Electron Laser (FEL) related works

3.2.4 Civil Engineering Group

Harsh Wardhan, A. J. Malyadri, D. S. Gangwar*, N. Madhavan

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 m2. The campus include a laboratory complex, an auditorium, hostels, guest houses and housing complex. 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.

Following are some of the important civil works undertaken during the year 2019-20 in addition to routine civil maintenance and minor works:

- Up-gradation / Renovation of 88 Nos. of IUAC Flats through CPWD under deposit mode - Work has started in vacant sample flats after item finalization
- P/F Shed with polycarbonate sheet on the roof of Beam Hall – I (BH-I)

- Internal painting of walls/ceiling, Epoxy coating of BH-I, BH-II and adjoining corridor floors in the basement
- Construction of Ladies toilet in the basement and conversion of existing toilet to Differently-abled type on the ground Floor of the main laboratory building
- Civil and wood-work for Library, MS racks for storage in the Store room near BH-II & BH III
- Support in civil work related to Access Control System in IUAC
- Conversion from Indian WC to European WC and Temporary Partition in Beam Hall
- P/F shed for Trane chiller set up near western side of LEIB Building & near Room No. 307
- Providing PVC flooring for new LINAC control room
- Aluminium partition, wooden storage rack, etc. in Room Nos. 318 and 326
- Canteen roof repair
- Painting of 4 vacant flats in IUAC housing complex
- G.I. sheet for rain water drainage of AAS Laboratory
- P/F Steel wire fabric fencing on eastern side boundary wall (from Main Gate to CEC end) to prevent entry of stray dogs
- Internal painting of walls/ceiling, Epoxy coating on the floor of Room No. 103 (temporarily allotted for HR SIMS Lab).

(*Consultant)