3. RESEARCH SUPPORT FACILITIES

3.1 SUPPORT LABORATORIES

3.1.1 High vacuum laboratory

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High vacuum laboratory is primarily responsible for maintaining vacuum and vacuum systems in beamlines and experimental facilities. It provides support to different labs and users in vacuum related problems. Vacuum lab is 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 Spiral Buncher and DTL-I along with testing set-up was completed. All the beamline devices in this experiment set up have been interfaced with VME control system and can be controlled remotely by control console.

3.1.1.1 Installation of High Current Injector (HCI) Components (Spiral Buncher, DTL, Quadrupoles, etc.) with Half-Achromat and Diagnostics in Beam Hall III:

Chandra Pal, Ashok Kothari, P. Barua, DK Munda, Kundan Singh, Prem Kumar Verma, Mukesh Kumar, S K Suman, Thomas Varughese, Rajeev Ahuja

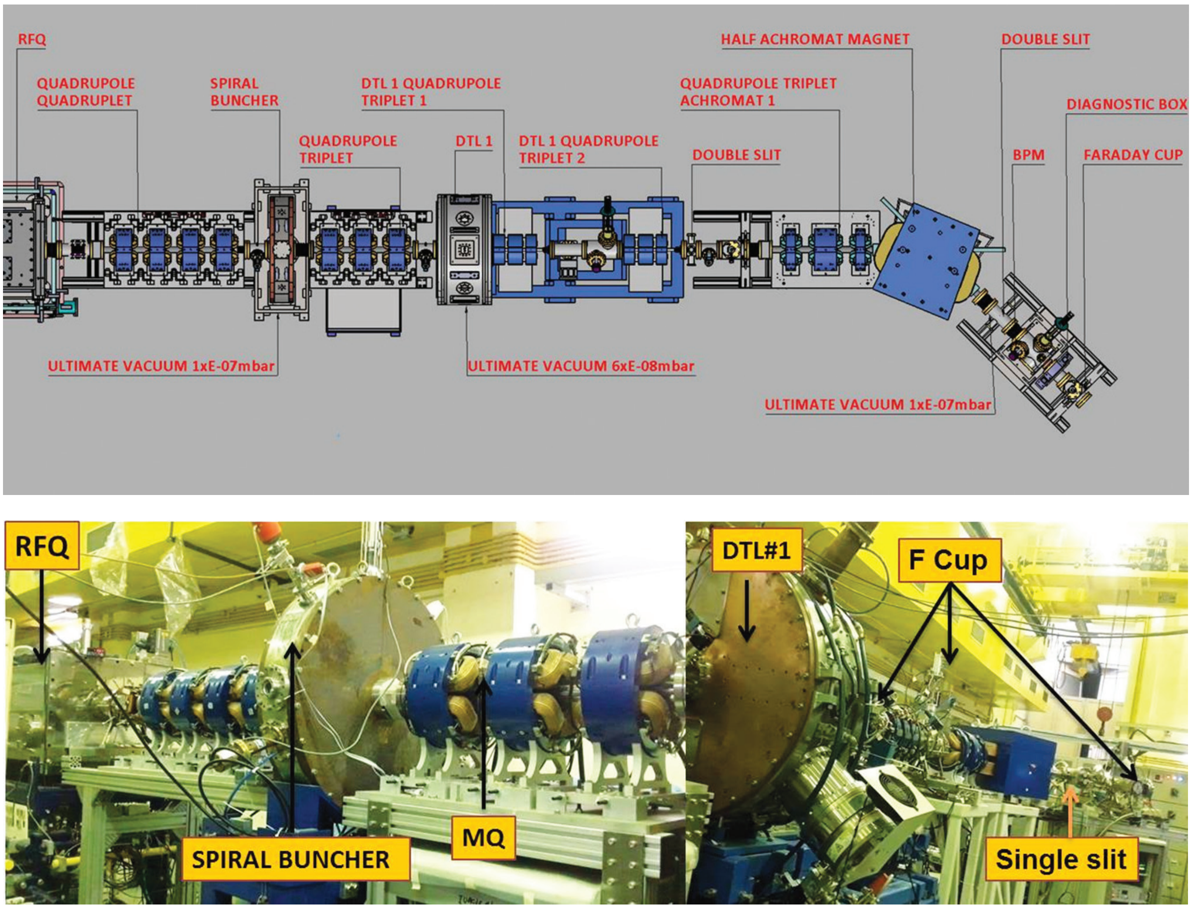


Figure 1: Layout and Installed Beamline for Testing Setup for HCI MEBT Components

The existing beam energy measurement setup was dismantled beyond four quadruplets section and Spiral Buncher -1 and DTL - 1 cavity have been installed in the HCI beamline as per final layout scheme of HCI. In the present configuration, DTL-2 cavity can be installed later without disturbing other installed components. The two DTL quadrupole triplets and beam diagnostics at required positions are also installed. The half Achromat section along with analyzed beam measurement set up have been shifted accordingly as per beam optics for this new configuration. Beam defining slits are also installed before and after the magnet. All the cavities and beam diagnostic elements are aligned within 50 microns of beam axis. All the beamline devices are interfaced with VME control crate for remote operation of devices. Four turbo based pumping stations with necessary interlocks are also installed and ~6 E-08 mbar of ultimate vacuum was achieved. The layout and the installed components are shown in figure 1.

3.1.1.2 LEIBF Maintenance and ECR Source re-Alignment

There was a major maintenance work in New LEIBF. The ECR source had some alignment problem. Dismantling of vacuum and other components like Einzel lens, vacuum pumps, vacuum valves and vacuum gauges etc. was done from the high voltage deck for maintenance purpose. Alignment of the source within 1 mm accuracy about the beam axis was done using theodolite with respect to available references and installed back all the components after completion of alignment work. Alignment of material science chamber and target ladder was checked and correction of both were done using available references. All log amps for diagnostic devices were tested for their proper operation and calibration was done for entire usable range using source meter. After completion of all the maintenance work, evacuation was done for ion source as well as beam line in proper phase and ultimate vacuum in the range of 5.10E-8 mbar was achieved.

3.1.1.3 Modification of GDA Beamline for DTL (Drift Tube Linac) Testing

To test DTL cavity with Pelletron beam in phase I, GDA beamline was modified, as per approved plan. Beam optics was carried out (by Dr. Rodrigues) and requirement of an additional quadrupole was seen as per optics. As per the new optics, layout of the beamline was modified with provision for additional quadrupole and DTL tank was position at the end. It was also ensured that regular GDA experiments would not be hampered due to this modification. The beamline was dismantled and fresh reference for beam axis was taken from switching magnet I. It was noticed that beamline quadrupole was off from beam axis and it required adjustment in alignment. We fabricated packing plates and realigned the quadrupole. The beam axis reference points were also transferred on the floor, wall and valves for future reference. The modification was completed and old position for GDA experiments was restored.

3.1.1.4 Design, Fabrication and Installation of Guide Rail Mechanism for Pelletron Ion Source.

Chandra Pal, A. Kothari, P. Barua, Rakesh Kumar, Jagdish Prasad

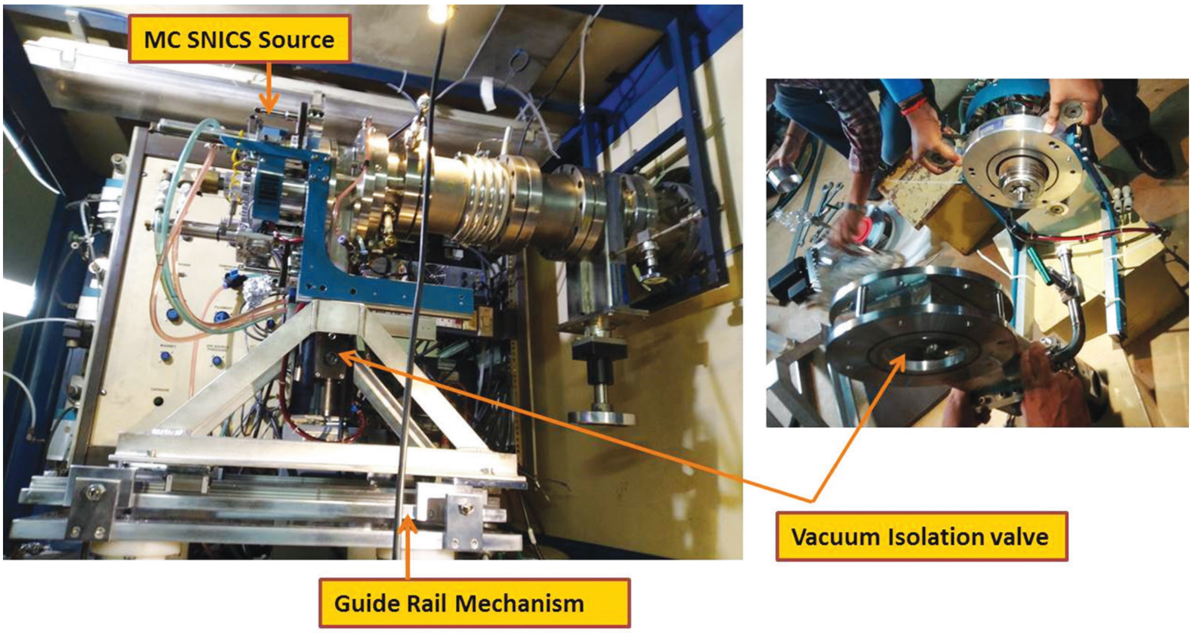


Figure 2: Ion Source with guide rail mechanism

Ion source of Pelletron is required to be opened for maintenance and in absence of proper fixtures rejoining it back with the system becomes very cumbersome. A guide rail mechanism for easy maintenance was designed, fabricated and installed for the same. The Ion source and other associated components were dismantled from the high voltage deck and the new guide rail mechanism was installed. After that the source and other components were installed and aligned within 0.2 mm of mating flange. The existing vacuum isolation valve was also replaced with a new one as the existing one was leaky. Tilting in Base plate of High voltage deck was observed during installation. After measurement nylon insulator was machined and installed on the deck plate. After installing the guide rail mechanism (as shown in figure 2), it is now quite easy to disengage the source for maintenance and can be easily connected back without any change in alignment.

3.1.1.5 Layout Design of FEL Beamline Test set up and Design of Components

Layout design of Initial part of FEL setup was done to finalize how the different components would assemble, their installation and holding fixture, alignment possibilities, etc. A 3-dimensional model of this beamline along with FEL components, brackets, stands, etc. was made. Photocathode chamber procured from vendor was vacuum tested for vacuum leak and ultimate vacuum. For this chamber new brackets were designed and fabricated for holding. Installation of vacuum pumps was done and thorough baking continued for few days to achieve 2×10^{-10} mbar vacuum. Design of mounting and alignment fixture for solenoid and cavity has been completed. Design of Laser Insertion chamber, Mirror mounting fixture and other necessary beam joining components was also completed.

3.1.1.6 Maintenance Activities

- Turbo Pumps failures and replacement work: The Turbo Pumps (5 nos.) installed on the Re-buncher, Super buncher, LEIBF switching magnet, HCI ECR source and spiral buncher were replaced due to bearing failure. A Varian make turbo pump (about 25 year old) installed on HIRA failed and stopped working. It was replaced with a turbo pump having pumping speed of 600 l/s. Turbo electronics failure happened in LINAC II and LINAC III so, alternate interlocks for operation of gate valve was made for normal operation. In due course of time these modules were procured and replaced.
- Vacuum problem due to Helium Leak in HYRA: Ion Pump 12-1 frequently tripped due to helium gas leak from experiment chamber side and Ion pump could not handle high helium load. So an additional turbo pumping station was connected to support the ion pump and beam run was completed.
- Thorough maintenance of GPSC Diffusion pump (2000 l/s) and rotary pump (175 m^3/hr) was done. Both the pumps were dismantled, necessary seals were replaced and all parts were properly cleaned. As existing pirani gauge (very old) had gone bad, so the interlocking logic in existing vacuum interlocking system for backing vacuum and gate valve was modified as per new gauge. After reassembly and integration of pump with the system, ultimate vacuum of 1.2 E-06 mbar was achieved.
- Getter Pump of 05 areas was cleaned and its cartridges were replaced. Ion pump of 05 areas got shorted, so new spare pump was installed. Ion Pump installed in material science beamline got shorted, so a new pump was installed, baked and then the magnet was installed after baking. During testing of the pump it was found that the controller of the Ion pump had also gone bad. It was replaced with a spare controller. Now the pump and controller are working fine.
- In Vault-1 area, through leak problem was observed in BLVL-02-1(AMS beam line). It was dismantled and repaired by changing the sealing sheet of internal bellow and installed back in the beam line and tested for through leak. No through leak observed.
- The existing beam line vacuum valve (30 yrs. old NEC make) of material science was not sealing properly. A series 48 all metal valve has been installed in its place and a PCB power box was fabricated and placed for its operation.
- IP 04 got contaminated. It was replaced with regenerated pump, followed by proper baking and leak testing procedures, required for vacuum.

3.1.2 Cryogenics Laboratory

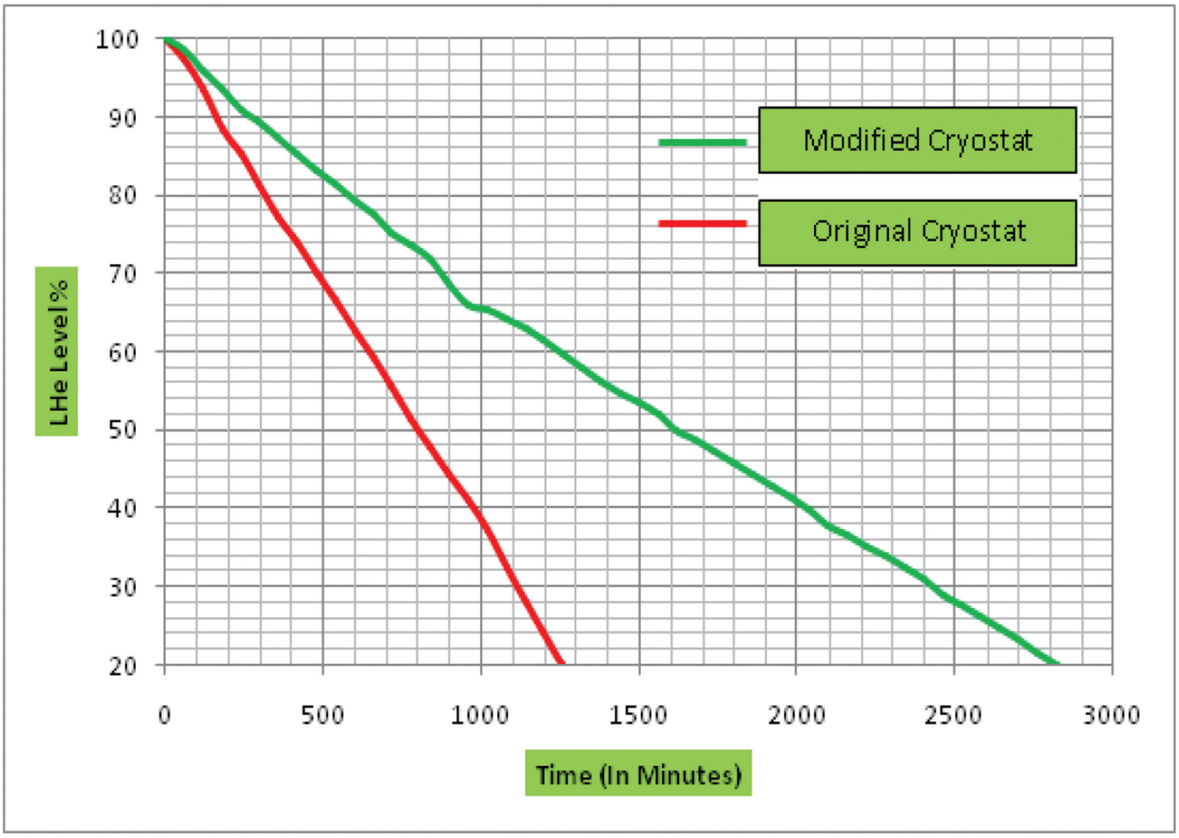
Anup Choudhury, Joby Antony, Suresh Babu, Manoj Kumar, Soumen Kar, Santosh Sahu, Rajesh Nirdoshi and T.S.Datta

3.1.2.1 Developemental Activities

Anup Choudhury, Santosh Sahu, Suresh Babu and Manoj Kumar

(1) Oxford cryostat modification:-

There is a PPMS system from Oxford Instuments at IUAC whose measured liquid helium evaporation load is ~14 litres per day(lpd). It is planned to incorporate a cryocooler liquefier (developed at IUAC) to run the system which can make the system to be a stand alone facility. To reduce the static heat load of the Oxford cryostat, a new modified helium vessel was designed and fabricated with an additional nitrogen vessel attached to it, which will be later be integrated to the indigenously developed helium liquefier with GM Cryocooler. The new cold vessel has been tested and the evaporation of the liquid helium has been found to be 8 lpd. The measured evaporation rate of liquid nitrogen vessel is ~20 liters per day.



(2) Cryocooler helium liquefier with thermo-siphon :-

A helium liquefier study setup using a 1.5 watt at 4.2K Gifford Mac Mohan (GM) cryocooler has been developed at IUAC for understanding the heat transfer mechanism between the gas and the cryocooler surface at all the four stages of cooling. A thermo-siphon loop is added to the liquefier bottom with a heater to know the precise liquefaction rate under various study conditions. Inclusion of thermo-siphon loop reduces the consumption of helium gas by utilizing the evaporated gas in a controlled manner. The study setup has other capabilities to measure the liquefaction rate under various conditions such as varied pressure, with or without heat exchanger at both cooling stages, and with or without nylon shroud in the regenerator regions etc. The experimental setup is successfully put in place and preliminary experimental results have started coming in. A liquefaction rate of 17.4 liters per day (lpd) has been measured with the basic configuration.

3.1.2.2 Activities on Applied Superconductivity

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

Soumen Kar, Navneet Suman, Vijay Soni, Sankar Ram Theketthil, Ajit Nandwadekar Rajesh Kumar, Santosh Sahu, Joby Antony, S. K Saini, Suresh Babu, Manoj Kumar, R.G. Sharma and T.S. Datta

Ministry of Electronics and Information Technology (MeitY), Govt. of India has initiated a multi-institutional project to develop a 1.5T superconducting MRI scanner in India. SAMEER, Mumbai is the nodal agency of the project. IUAC is one of the partner institutes for the project on indigenous development of the 1.5T superconducting MRI scanner. IUAC-MRI team 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 mechanical design of the bobbin for the optimized EM design of the multi-coil MRI magnet has been completed with desired tolerances and surface finish for the winding pack of each coil. The weight of the bobbin has been optimized to ~ 600kg considering the electro-mechanical forces on the magnet during its operation. Figure 3.1.2.2.1 shows the integrated bobbin structure which is under fabrication presently.

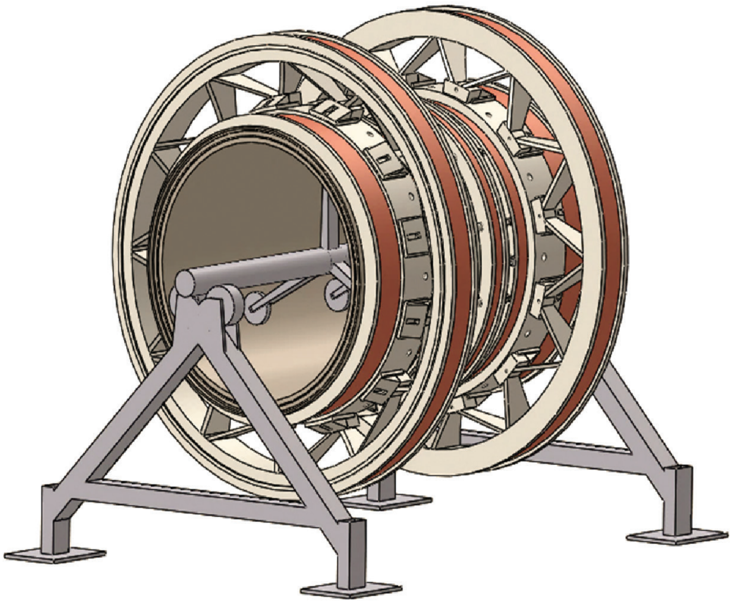
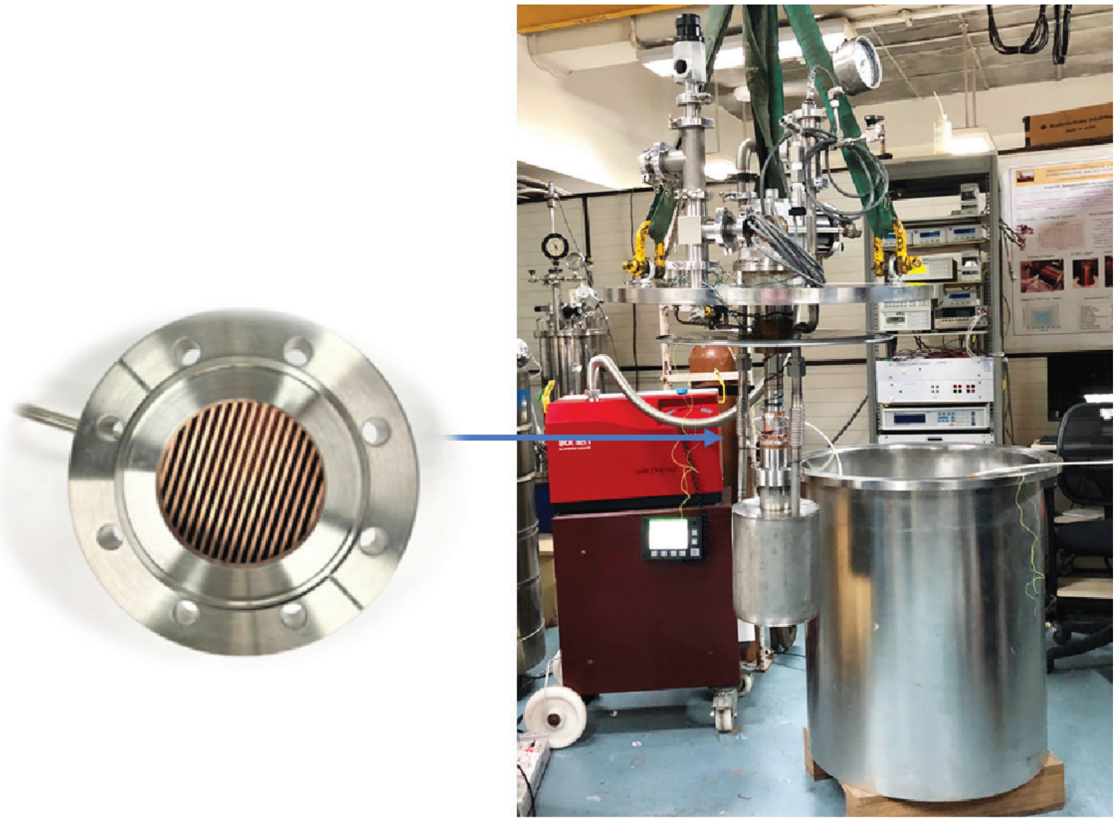


Figure 3.1.2.2.1 Integrated bobbin structure of 1.5T whole-body MRI magnet.

Helium Recondenser

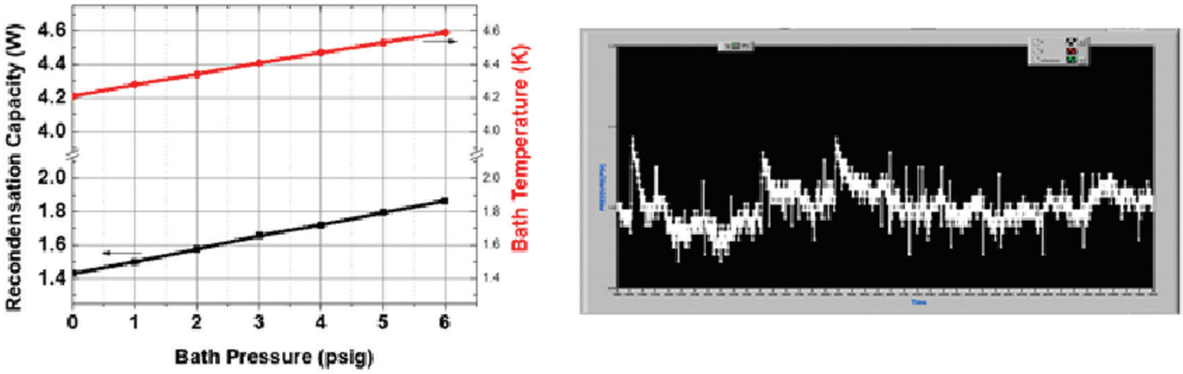
The MRI magnet to be housed in a cryocooler based Zero-Boil-Off (ZBO) helium cryostat. ZBO is achieved by recondensation of the evaporated helium inside the MRI cryostat using a fin-based heat exchanger (HX) integrated with 4.2K GM cryocooler. A fin-based heat exchanger has been developed for characterizing the zero-boil-off technique to be used in MRI cryostat. Figure 3.1.2.2.2 shows the helium recondenser and its associated test rig. The ZBO performance of the HX has been tested up to 6 psi of operating pressure as shown in Figure 3.1.2.2.2(a).



(a) (b)

Figure 3.1.2.2.1 (a) Fin based helium recondenser for Zero-boil-off MRI cryostat,
(b) helium recondenser integrated bobbin to the cryocooler based test rig.

The pressure inside the helium bath of the MRI cryostat needs to maintain around the operating pressure of the MRI magnet. A PID based helium bath pressure stabilization scheme has been developed and tested in the cryocooler based test rig. Fluctuation around the set pressure of 1psi has also been studied as shown in figure 3.1.2.2.2(b). The fluctuation is found to be of the order of ± 0.03psi.

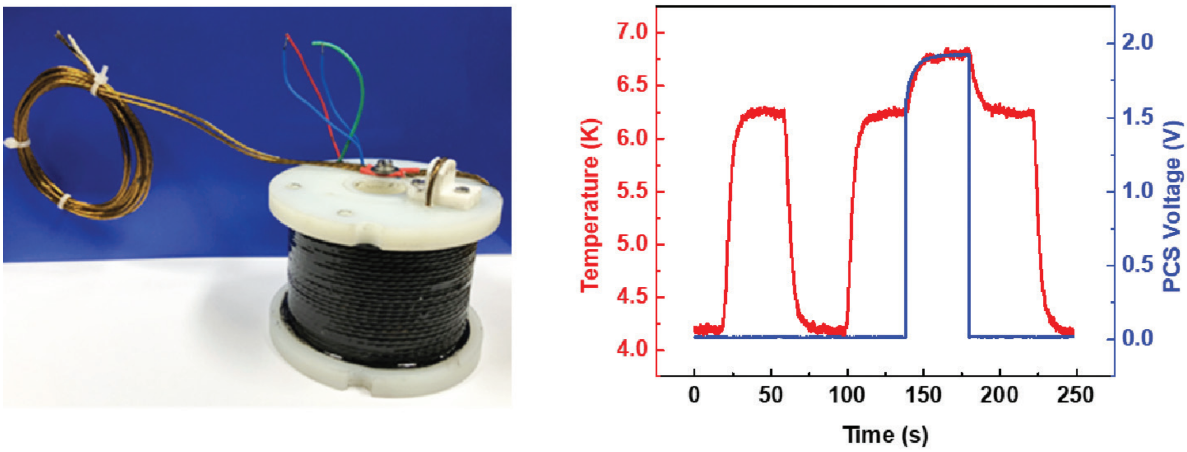


(a) (b)

Figure 3.1.2.2.2 (a) Recondensation capacity of the fin-based helium heat exchanger, (b) fluctuation of helium bath pressure at 1 psi set pressure using PID based pressure stabilization scheme.

Persistent Current Switch (PCS)

The Persistent current switch or superconducting switch plays a very crucial role in the persistent operation of the MRI magnet. A superconducting switch of capacity 500A has been developed using CuNi-NbTi conductor for the main MRI magnet. Figure 3.1.2.2.3(a) shows the superconducting switches developed for the MRI magnet. The current carrying capacity and the switching performance of the PCS have extensively been studied using an in-house developed 4K test rig. Figure 3.1.2.2.3(b) shows the switching performance of the PCS. The transition time for the PCS is measured to be less than 10s.

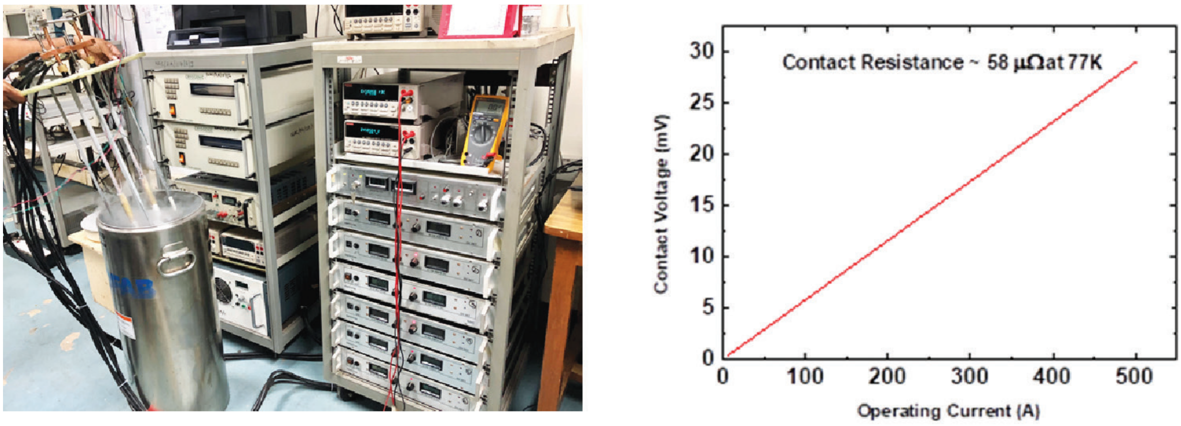


(a) (b)

Figure 3.1.2.2.3 (a) Superconducting persistent switch developed for MRI magnet, (b) switching performance of the PCS.

Retraceable Current Lead (RCL)

Vapour cooled retraceable current lead is a crucial component of the MRI magnet. In an MRI magnet, the current leads are taken out after energizing the magnet at its operating current and park the magnet in persistent mode. A pair of vapour cooled RCL of capacity 500A has been developed using multi-lam based current contacts as shown in Figure 3.1.2.2.4 (a). The retractable mechanism and the current carrying capacity of the RCL have been tested at 77K in liquid nitrogen using an indigenous DC power supply (600A/10V). The electrical joint resistance of each multi-lam contact is measured to be 55 at 77K which corresponds 23mV voltage drop across each lead at 420A of operating current of the MRI magnet.

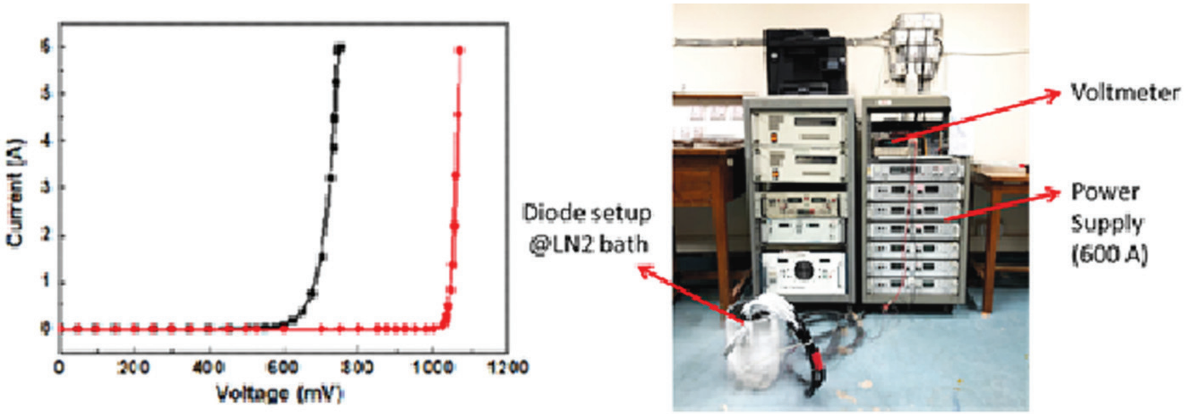


(a) (b)

Figure 3.1.2.2.4 (a) Multi-lam based retraceable current lead of capacity 500A,
(b) the I-V curve of the retraceable current contact (up to 500A current) at 77K .

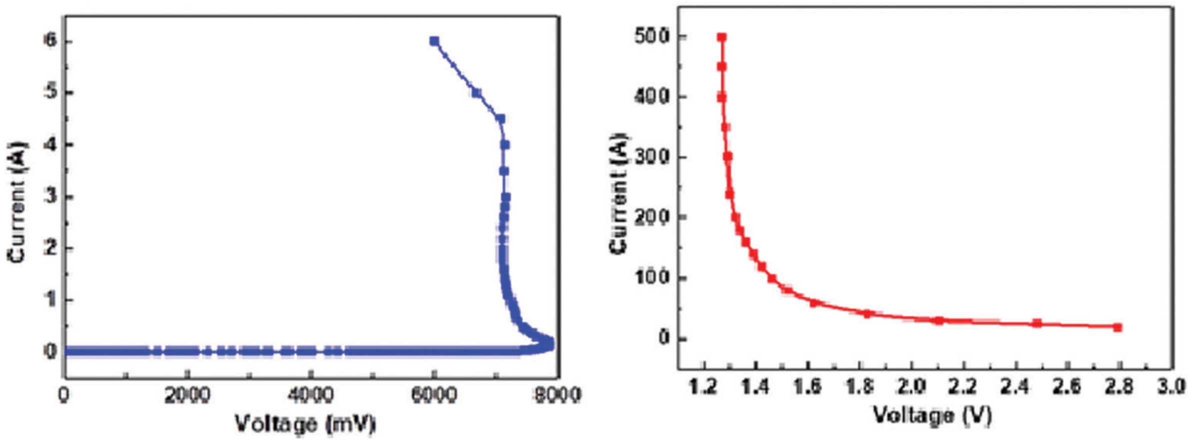
Quench Protection Diodes

High power cold diodes play an important role in the quench protection system and quench propagation circuit for the MRI magnet. Selection of proper diode having current (forward) carrying capacity more than 500A is a crucial task during designing of the quench protection system using finite element analysis based OPERA-QUENCH code. V-I characteristics have been done for various types of high power diodes at RT, 77K, and 4.2K. Figure 3.1.2.2.5 (a) shows the V-I characteristics at RT and 77K. Figure 3.1.2.2.6 shows the V-I characteristics of cold diode at 4.2K. The forward voltage is measured to be 7.9V at 4.2K as shown in figure 3.1.2.2.6.



(a) (b)

Figure 3.1.2.2.5 (a) V-I characteristics of the cold diode at RT and 77K,
(b) test rig for characterizing the diodes with 500A at 77K.



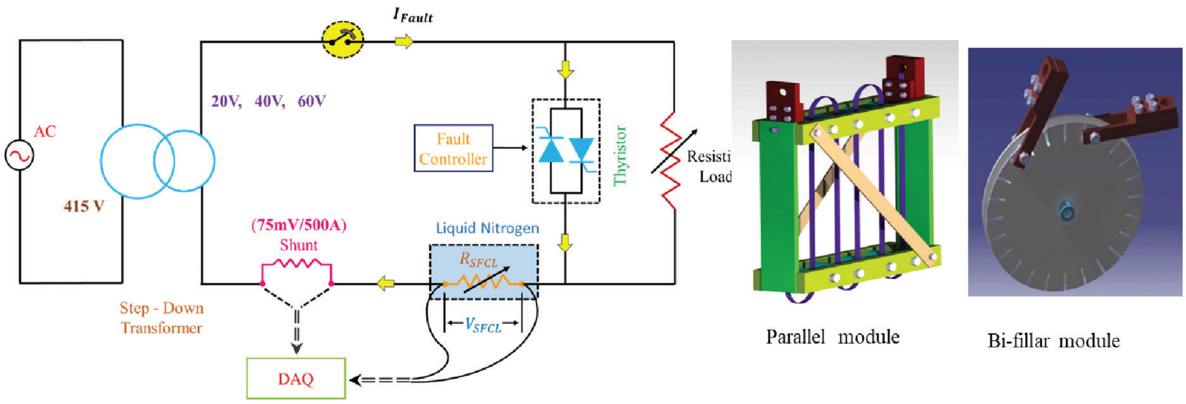
(a) (b)

Figure 3.1.2.2.6 (a) Forward voltage characteristics of high power cold diodes at 4.2K,
(b) the forward voltage characteristics of high power cold diode at higher operating current (up to 500A) at 4.2K.

B. Characterization of 2G High-temperature Superconducting tape for Modular Superconducting FCL application (CPRI-Project)

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

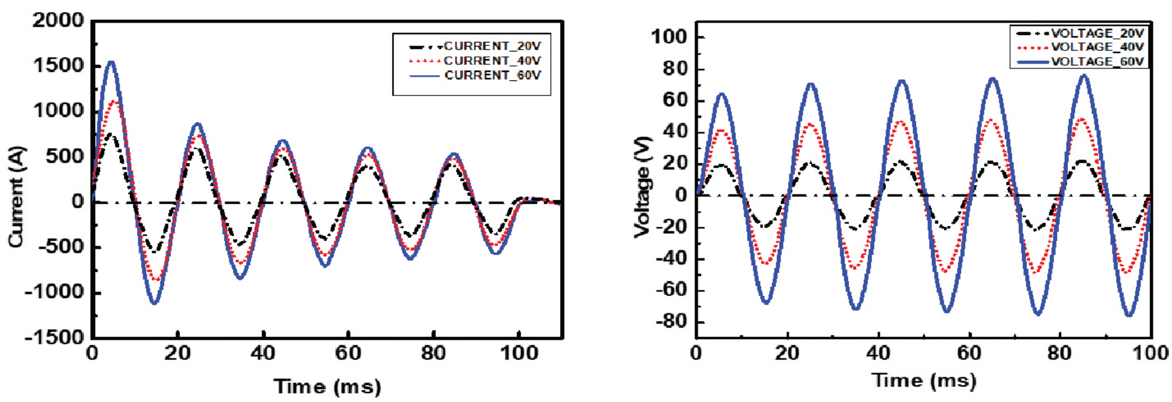
A R&D project on "Characterization of 2G high temperature superconducting (HTS) tape for modular superconducting fault current (SFCL) application" funded by CPRI, Bengaluru is at the final stage of completion. An electrical test rig has been developed using a 60V/300A transformer and an indigenously developed fault generator and controller. The schematic of the experimental set up is shown in figure 3.1.2.2.7(a). The fault generator is developed using high-power thyristor having capability of generating fault up to 12 cycles. The maximum fault current has been generated up to 4kA at 60V_{rms}. The resistive load of the circuit determines the nominal current through the SFCL during normal operation. Various configuration of modular unit has been developed, as shown in figure3.1.2.2.7(b), for their electrical characterization as modular unit.



(a) (b)

Figure 3.1.2.2.7 (a) The schematic of the test rig for characterizing modular SFCL units at 77K, (b) Various configuration of modular SFCL unit; parallel module and bi-filler module.

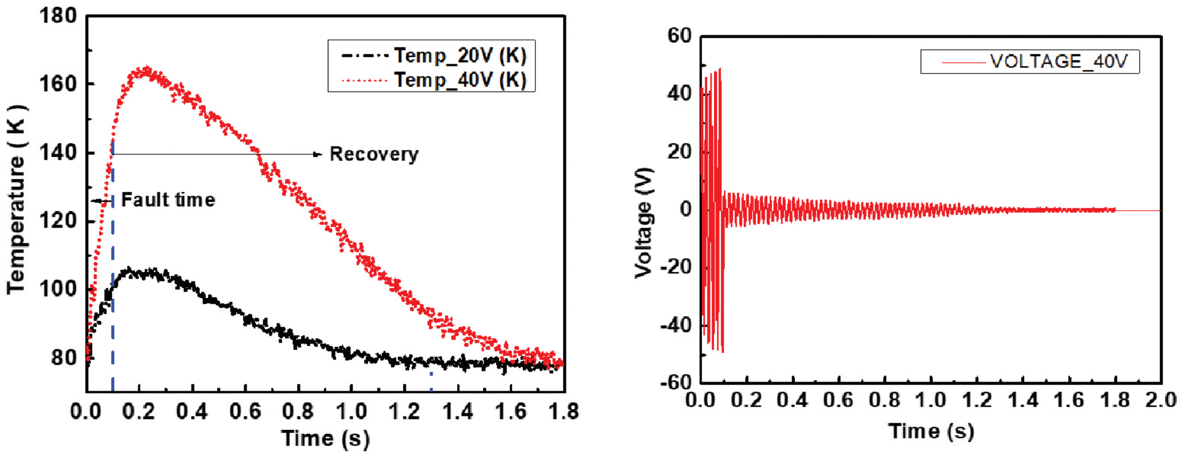
SFCL modular unit has been tested with two types of 2G HTS (YBCO) tapes: copper laminated HTS tape and SS-laminated HTS tape. Figure 3.1.2.2.8(a) shows the current limiting capability of the modular SFCL unit with copper laminated HTS tape at 20, 40 and 60V_{rms} for five cycles (100ms). The perspective peak fault currents (without SFCL) are 1.8kA, 2.8kA, and 4kA respectively for 20, 40 and 60V_{rms}. During fault, the voltage growth across the SFCL is shown in figure 3.1.2.2.8(b).



a e

Figure 3.1.2.2.8 (a) Fault limiting behavior of modular SFCL unit made of copper laminated 2G HTS tape, (b) the voltage growth across SFCL unit during fault at 20, 40 and 60V_{rms}.

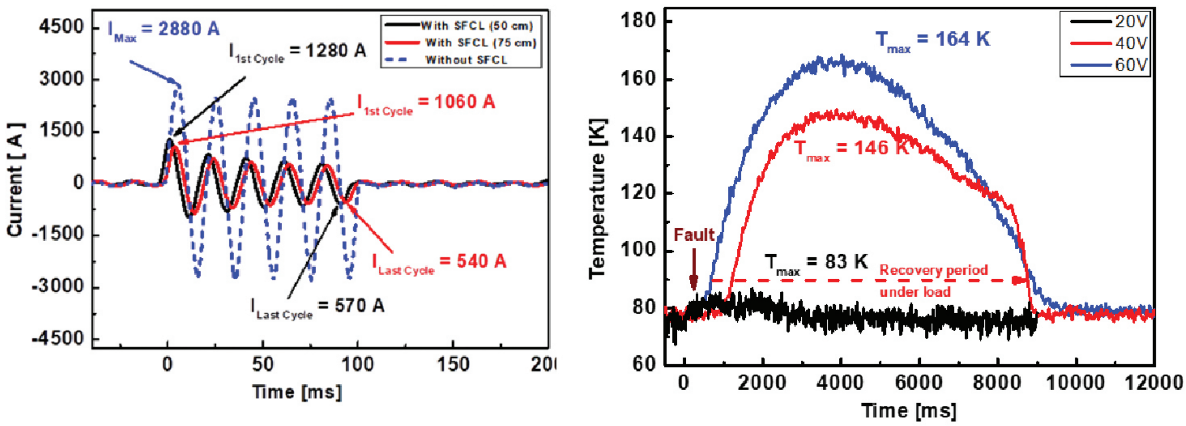
The perspective peak fault currents (without SFCL) are 1.8kA, 2.8kA, and 4kA respectively for 20, 40 and 60V_{rms}. During fault, the voltage growth across the SFCL is shown in Figure 3.1.2.2.8(b). The thermal profile of the HTS tapes has been studied during fault and recovery stage as shown in Figure 3.1.2.2.9(a). It takes ~ 1.8s to recover its normal operation after fault as shown in its thermal and voltage profile (figure 3.1.2.2.9).



(a) (b)

Figure 3.1.2.2.9 (a) The thermal profile of the copper laminated 2G HTS tape in a modular SFCL unit,
(b) The voltage recovery curve.

Similar characterization has also been done with SS-laminated 2G HTS tape in modular SFCL unit. Figure 3.1.2.2.10 (a) shows the fault limiting behavior of the SS-laminated 2G HTS tapes at $40V_{rms}$ for various length of the superconductor. Post-fault recovery is much longer (~ 8s) as shown in Figure 3.1.2.2.10 (b). This recover is under-load condition.



(a) (b)

Figure 3.1.2.2.10 (a) Fault limiting behavior of modular SFCL unit made of SS-laminated 2G HTS tape,
(b) thermal profile of SS-laminated 2G HTS tape in modular SFCL unit during fault and recovery.

3.1.2.3 Electronics for Cryogenics and LINAC: Lab activities

Joby Antony, Rajesh Nirdoshi, Anup Choudhury, Manoj Kumar, Suresh Babu, Soumen Kar and T.S.Datta

a) CRYOGENIC CONTROL SYSTEMS

The IUAC Cryogenics control room has been operational in continuous working mode. The control systems were used this year mainly for the off-line LINAC test runs. At present, the control room has the following computer control systems in place .

i) CADS

CADS is the Ethernet based Crate-less model of completely indigenous Cryogenic control system with indigenously built cryogenic meters and control hardware (together called device-servers) built for LINAC Cryogenic distribution systems. This system has in-house designed intelligent Cryogenic device-servers/ instruments (i.e. Cryogenic sensor nodes and actuator nodes) which is designed with a total of 72 embedded device-servers (on-chip HTTP servers), interconnected over Ethernet (LAN). The networked distributed control system survived to work for the closed loop control operations of Cryogenic distribution system components where the control loops run every second for PID & data logging and control operations. Based on the operational experience, in-situ modifications are planned for next year while considering the hardware redundancy.

i-a) FIRST PHASE UPGRADE OF CADS FOR REDUNDANCY

It has been decided to build a parallel low cost redundant commercial version of hardware, in additional to the indigenous ones, only for the critical LHe and LN_2 refill systems. This has 10 channels of PID controllers switched using PID Switcher Unit. The unit can select between any one of the indigenous IUAC make devices or commercial meters in case of emergency. This can save time due to hardware failures during an experimental run. Therefore the upgrade is planned in two steps. The first phase upgrade consisted of procuring ten such commercial PID controllers which completely suits to our linac refill needs and interconnect them to build remote control & DA software over Modbus protocol. Our team tried out two different low cost microprocessor based PID controllers from the market. The first one is Honeywell make DC1040CL30200BE model and the second one is Fuji make PXF9AEY2FVM00 model. Both these controllers were initially tested for the suitability with our off-line LINAC application which used our own home-built software specially made for this application. The control GUIs and back-end control programs were developed in-house using Labview. After thorough online and offline mode tests, Honeywell make DC1040CL30200BE model was rejected due to lack of remote changeover options from manual to auto in critical situations. Therefore Fuji PXF9AEY2FVM00 device has been chosen for 5 LN_2 and 5 LHe devices. This year we restricted the control GUI development for one single channel (figure 1). We will take up the 10 channels version with multi dropped RS485 via Modbus for control & DA GUI development next year. The basic functional block diagram is shown in figure 2.

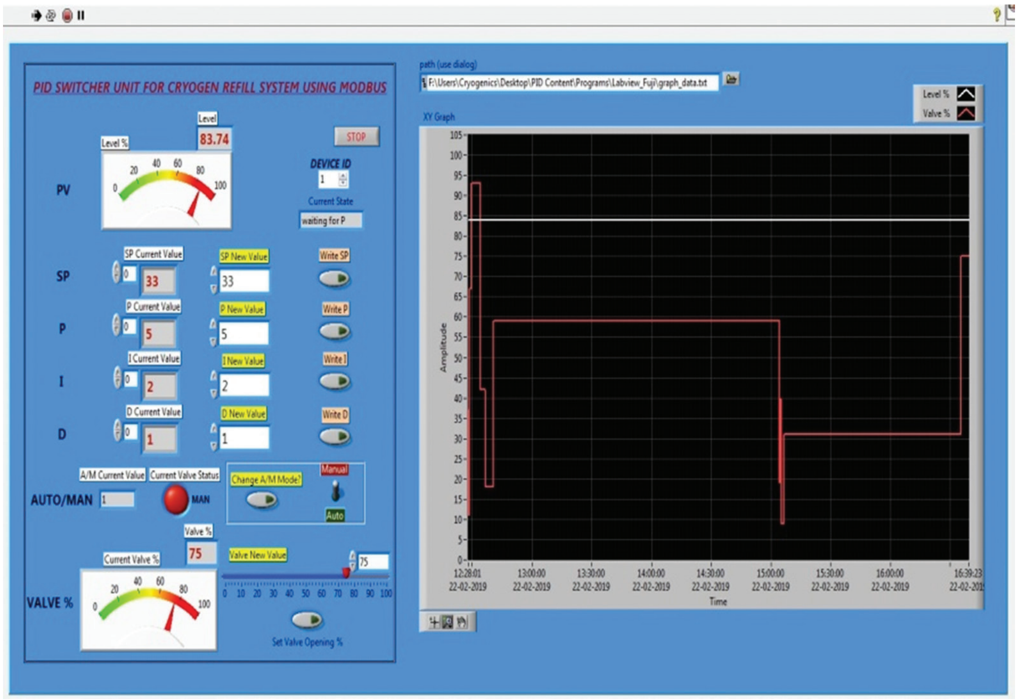


Fig 1: Single channel GUI system tried out using Modbus protocol of PID controllers

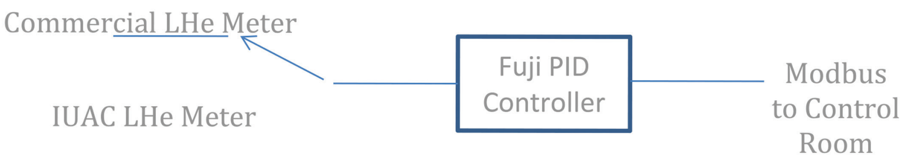


Fig 2: Block diagram of single channel switcher unit

ii) CRYO-DACS

The second control system, CRYO-DACS, is a VME system which was installed in the year 2002, currently running only for all the LINAC temperature monitoring and logging operations. Considering aging risk of this VME CPU and systems, a second phase upgrade is planned to replace VME system with low cost crate-less technology.

ii-a) SECOND PHASE UPGRADE OF CRYO-DACS

It has been decided to take up the second phase later this year to replace CRYO-DACS system (VME + software) by indigenous temperature meters with RS232 interface as well as commercial Lakeshore meters together (one to one replaceable with IUAC temperature meters) with compatible RS232 command set. This means that there is a requirement to newly design a large number of cryogenic monitors (up to 4.2K) which have the similar command set of RS232. So, hardware and firmware design process has been initiated and would need at least 10 new temperature monitors compatible to Lakeshore but each with 5 channels. This will help to interconnect these meters and eliminate expensive VME crate to control room. All the first and second phase upgrades would need a lot of firmware and software developments as we need to build our own devices compatible with commercial ones.

b) DEVELOPMENTAL ACTIVITIES

i) LV FPGA based Fast DAQ System for MRI Project

A fast RT FPGA based fast data acquisition system is developed this year for the undergoing MRI project. The work involved fast data acquisition and logging for MRI monitoring and controls. The control hardware includes fast differential ADC, DAC, Digital I/Os, RS232 modules etc. The first level version 1.0 of software development is completed. The system used NI cRIO backplane with Labview FPGA as the base development system. The RT scanning will be at the rate of 1 millisecond per channel and the data storage will account to huge GBs per day.

The block diagram of the system is shown in figure 3.

The following are some of the required features of the fast DA system that can capture and record various fast activities inside MRI.

Time resolution of each data monitored & recorded has to be 1 millisecond

- Analog inputs can go to 1mS high voltage spikes (+/- 2000 Volts inside)
- cRIO FPGA Platform (figure 4) is used, Programming language is Real Time Labview®
- cRIO (Compact RIO) has an FPGA which can be programmed to make a final bit file similar to other FPGA technologies.
- RT Labview with FPGA library can use VHDL inside. All Xilinx tools are inside.
- 24 bit fast ADCs can connect to Blank FPGA backplane but Blank FPGA has to be programmed to create a digitizer, similar to other languages.
- FPGA is programmed to create a program which runs on a remote target – for fast digitizers

MRI Fast Data Acquisition System has been developed for multichannel digitizers with 1 millisecond time resolution. Following are the specifications of the hardware used.

- ✓ NI cRIO-9035 (Embedded Compact RIO Controller with Real-Time Processor and Reconfigurable FPGA)
- ✓ C-Series Modules: NI 9229 (4 AI, ±60V, 24 Bit, 50 kS/s/ch Simultaneous), NI 9375 (16 DI/16 DO, 30VDC)

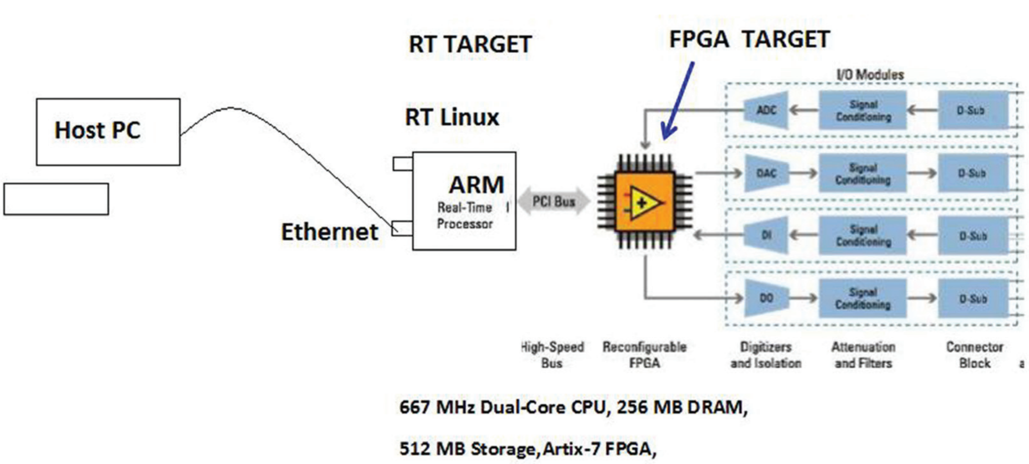


Fig 3: The internal architecture of cRIO based system

Fig 4: The FPGA based cRIO hardware for fast MRI DA system

The main signals of MRI system are:

a) Fast quench high voltages across coils (1 millisecond resolution)
b) Many low temperatures (> 4.2K)
c) Pressures
d) Cryogen Levels
e) Vacuum, fast interlocks

The GUI of MRI fast DA system is shown in figure 5.

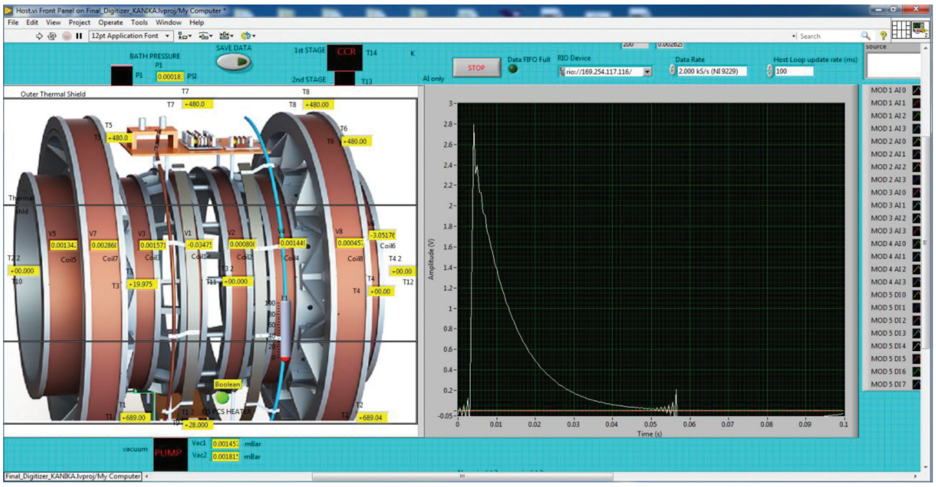


Fig 5: The GUI of MRI system

The simulated sampled/captured data of one of the 40 channels of MRI (One channel off-line test using a function generator) is shown below in figure 6.

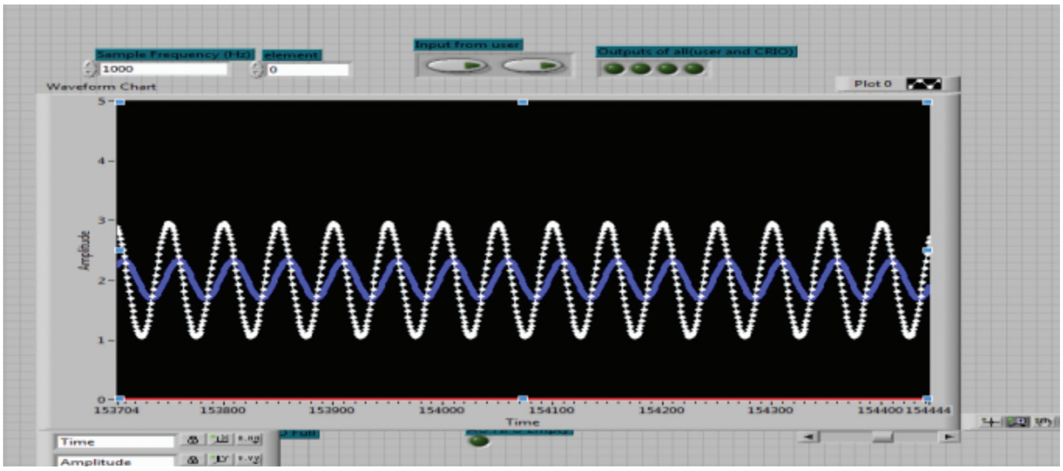


Fig 6: The fast sampled signals at the quench inputs reproduced on PC screens

ii) MRI Chamber-Constant Pressure PID Regulator using IUAC PID DEVICE

In order to maintain constant pressure within the MRI chamber, an indigenous device called "MRI PRESSURE REGULATOR with USB" has been designed (figure 7) and developed in-house to test and study the MRI pressure regulation in a simulated chamber. The USB data logger logged the data with respect to time. The following is the block diagram, data regulation test results at 1.5 PSI, 2.0 PSI and 3 PSI which achieved +/- 0.05 PSI stabilization. The figure 8 and 9 demonstrates some test results.

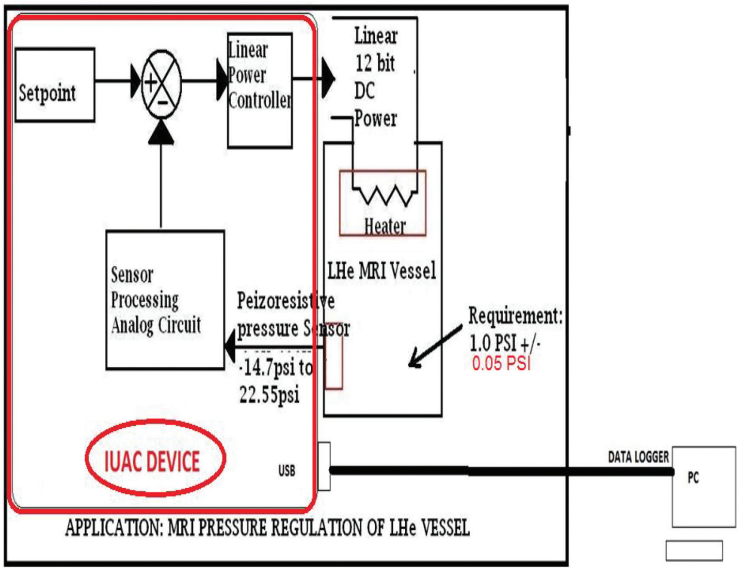


Fig 7: The indigenous MRI Pressure regulator meter system with interface

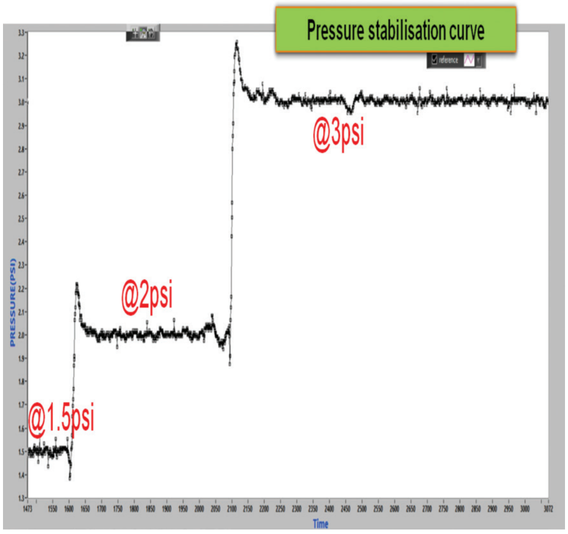


Fig 8: The indigenous MRI Pressure regulator regulated MRI chamber pressure in ramp up mode

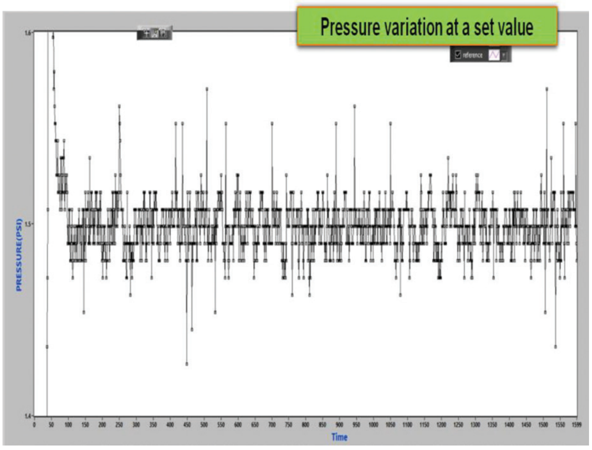


Fig 9: The PID regulation test results within +/-50mK

All the above hardware designs were based on an IUAC 32 bit MCU board (figure 10) which is designed indigenously using ARM processor.

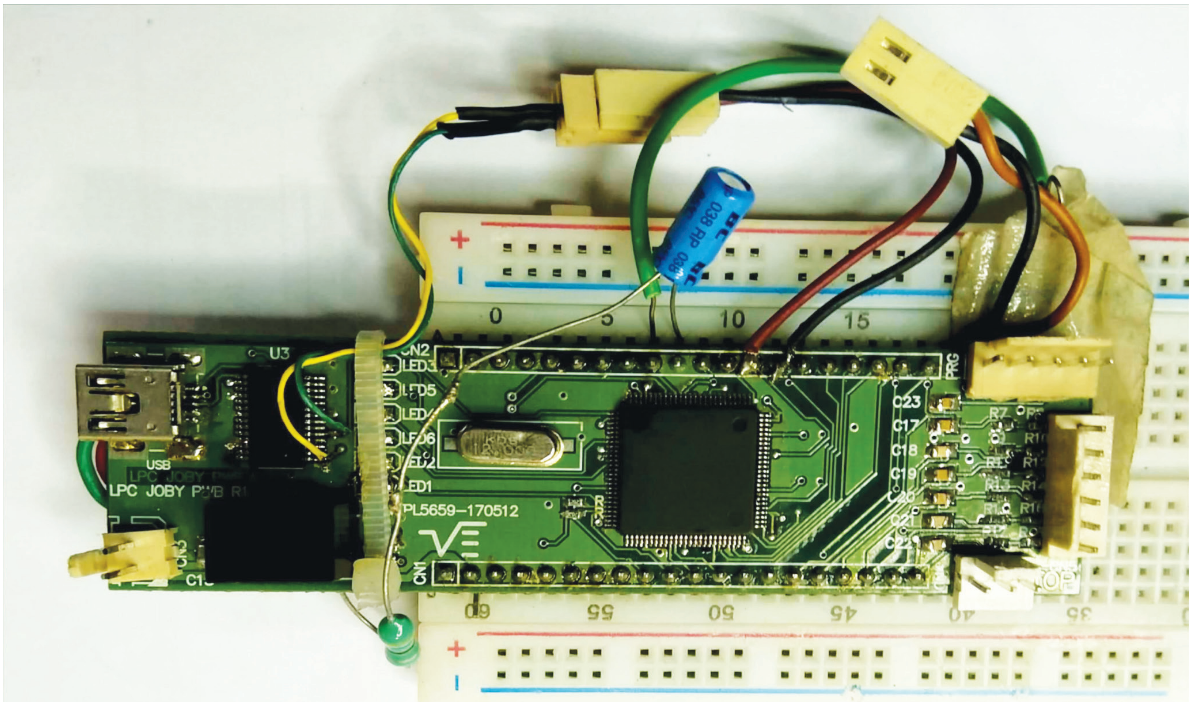


Fig 10: The IUAC MCU board designed for all developments using ARM processor

iii) PID based TEMPERATURE CONTROLLERS DEVELOPMENT

Device made for	Requirement	Range	sensor	Till now measured/achieved	Comment	Data logger in USB
MRI	+/- 0.1 Bar	+-1 Bar to +3 bar	peizo resistive	+/- 50 mBar	Full range measured	USB Yes
Low Temp Lab	+/- 0.1 K or better	40K to 350K	Pt100	+/- 1K	Partial range measured	USB Yes
Photoluminescence	+/- 1 K	77K to 350K	Si diode	+/- 1K	Partial range measured	Ethernet software needed extra, not yet done
NAND	+/- 1 millibar	1-100 mBar	inbuilt	+/- 1 millibar	Full range measured	USB(win) version done, Ethernet interface with linux Qt not yet done

Fig 11: Comparison of instrument calibrations

A number of low cost, low precision PID based temperature controllers with dc power outputs have been built to regulate Pressure, Temperature, Photoluminescence setup, NAND etc. where the requirements were different. However, since every device used PID for regulation, a comparison has been made based on test results of instrument-only-calibrations which are listed below. An online instrument calibration will be done in the future to verify the results in figure 11.

iv) An AC Susceptometer demonstrations on National Science day and at University

Joby Antony, A.K. Rastogi and K. Asokan

A prototype AC Susceptometer built at IUAC was demonstrated to various students at IUAC on National Science day and also at a conference at Cochin university of Science and Technology.

The AC susceptometer is used to study the magnetization induced in various magnetic materials in response to AC magnetic fields inside a driven solenoid. The indigenous list of parts for this experiment include LN_2, AC function generator, AC current source, two-phase lock-in amplifier, embedded Pt100 temperature sensor, computer data acquisition system with YBCO and Gadolinium samples. The major difficulty faced in the development of such a system is the noise contained in measurement, as the noise is approximately 1000 times more than the signal because of which we used digital DSP lock-in amplifier techniques to extract the AC signal.

In the second successfully tested experiment with our indigenous device, when YBCO sample is cooled to LN_2 temperature, the device gives negative diamagnetic signal and when temperature of the sample rises above 93 Kelvin, diamagnetic signal becomes zero.

v) An additional Gas Flow Processor hardware for NAND:

Joby Antony, Rajesh Nirdoshi, R. Saneesh, P. Sugathan

Regulated gas flow through a detector system (0.0 to 99.99 Torr) with an accuracy of the order of +/- 1 milliTorr was made last year and has been duplicated as a spare piece this year using this indigenous device. The remote control software development requirement using USB will be taken up next year.

c) IFR (INDIGENOUS FABRICATION OF RESONATORS) RELATED ACTIVITIES

Joby Antony, Rajesh Nirdoshi, Kishore Mistri and P. N. Prakash

This set of people are responsible for the complete maintenance of the electronics in the facilities used for fabricating SCRF resonators indigenously. This includes the Electron Beam Welding machine (EBW), Surface preparation lab automation and high vaccum furnace.

This year there were two issues related to EBW machine
i) Electrical cabinet FAN failure issue
ii) Pumping system valve sensor failure

The first issue was solved by replacing the failed FAN with a new one and second issue was solved by repairing the sensor contacts which got stuck.

d) OTHER ACTIVITIES

Other activities of the lab include the regular Electronics Apprentice training and management, conducting regular exams, evaluations (at present 3 electronic apprentices), B.Tech summer internship projects etc.

3.1.3 Beam Transport System (BTS) Group

The Beam Transport System (BTS) group is a central support group, which is responsible for the upkeep of the BTS Magnet Power Supplies (MPS) and associated instruments of all the accelerator facilities at IUAC. More than 100 numbers of current regulated high stability magnet power supplies are in round-the-clock operation. The group performs yearly scheduledpreventive maintenance of all the BTS instruments to ensure breakdown-free operation with optimum performance every year. During beam operations the group members are available 24x7 (on-call) to investigate the causes (if any) for beam trips due any BTS instrument. As an additional responsibility, the group also performs the preventive maintenance and repairs of Detector Bias HV power supplies, a large number of which are used in the experimental facilities. Besides maintenance and repair activities, the group is also involved in design and fabrication of BTS-MPS power supplies and LLRF based control instrumentation for the upcoming High Current Injector (HCI) Facility. The yearly activities related to BTS maintenance and development are summarised below.

OperationalStatus Report of Beam Transport System

The overall uptime of the beam transport system magnet power supplies has been recorded to be more than 99% this year. All the power supplieshave met the required expectation in terms of stability. There has been no major breakdown which may result in considerable loss of beam time. However, there were random trips of the power supplies due to corrosion in the fuse holders of the transistor banks. In some occasions the power supplies have failed or have been down due to problems in the associated systems such as water, electricity and remote control. Failure logs of the power supplies have been maintained over the period to decide upon the required actions to be taken during scheduled preventive maintenance. The beam line selection system (motorised electromechanical switches) has been out of operation due to corrosion since the last few years. Presently the beam line selection is done manually connecting the magnets of the selected beam line to the corresponding power supplies. Purchase of new motorised switches to replace the corroded ones has not been initiated until the problem of corrosion is completely resolved.

Preventive Maintenance

Maintenance Schedules: The BTS at IUAC consists of large number of high performance and high current power supplies along with other BTS associated instruments. It is not possible with the limited manpower to conclude preventive maintenance of such a large system in one month (annual schedule). The effects of corrosion on the stability and performance of power supplies has also been observed in the last few years. Because of corrosion, preventive maintenance has become more intense and time-consuming.

To allot enough time for each instrument for ensuringreliable service, maintenance activities have been spread throughout the year. The total BTS has been divided in zones. The Pelletron zone is maintained during scheduled maintenance of the Pelletron. Maintenance of other zones (Linac, HIRA-HYRA, Low Energy, RBS, HCI) are scheduled as per availability of access any time of the year. At present (till the HCI is operational), all the facilities are not working simultaneously. So it is possible to maintain all the facilities throughout the year.

Maintenance Activities: Proven maintenance procedures, which have been finalized on the basis of past experience, are followed to standardise the activity and in turn to ensure high quality of service. A few corrosive components in the power supplies have resulted in reduced reliability. The silver alloy coated fuse holders are the worst affected parts. These were replaced with the new silver alloy coated fuse holders in some of the power supplies two years ago. But the problem has resurfaced. It has now been decided to replace the silver alloy coated fuse holders with nickel coated fuse holders, as nickel is less reactive. The fuse holders of all the Pelletron-BTS power supplies have been replaced this year.

Repair of Faulty Power Supply Modules: The faulty electronic modules, which are identified and taken out during preventive and break-down maintenance schedules, are repaired at the BTS lab. Instead of importing spare power supplies, the faulty modules are repaired in-house to replenish the stock. The effort has reduced the running costs of the BTS system drastically. For the instruments developed in-house, the spares are also fabricated in-house. The following electronic modules have been repaired this year:

- Power supply control module: 04 nos.
- Auxiliary power supply module: 02 nos.
- Regulation module: 01 nos.
- IGOR interface module: 03 nos.

Procedures of Preventive Maintenance: The power supplies undergo high level of examination, monitoring and maintenance procedures. Test Report Proforma (TRP), containing the maintenance procedures, have been prepared for every type of power supplies to standardize the maintenance procedures. Before initiating the preventive maintenance, the condition of each power supply has been assessed by noting down the following in the TRP – visual inspection, AC/DC voltage measurement of different test points and measurement of temperature. Analysis of these data helps to conclude the required actions for preventive maintenance.

Preventive Maintenance and Repairs of Detector HV Bias Supplies

Under the yearly maintenance activity, the detector HV bias supplies of the following experimental facilities have been serviced and tested for optimum performance and safe operation:

Indian National Gamma Array (INGA): A total of 60 bias supplies of three types (5 kV, 3 kv and pre-amplifier) have been cleaned, serviced and tested at the BTS Lab. These power supplies were developed by the BTS Group in 2006 and have been in operation since then in the INGA experimental facility. These power supplies have been immersed in ultrasonic bath using LR grade alcohol which has been proved to be very effective. The racks housing the detector bias supplies in the beam hall have also been repositioned to have better access for monitoring and servicing.

National Array of Neutron Detectors (NAND): All the neutron detectors of the NAND experimental facility are biased using power supplies developed in-house. All these power supplies have also been serviced and tested in the lab to ensure optimum performance and trouble-free operation during experiments.

Steps Taken to Improve the Functioning and Preparedness of the Laboratory

Breakdown repair is always accorded the highest priority (round the clock) to ensure minimum loss of beam time. The following steps have been taken to ensure quality of preventive maintenance and to improve the in-situ repair capabilities of the available manpower:

- All the service manuals of in-operation instruments have been kept updated and revised.
- A test proforma has been prepared for each type of BTS instrument to standardise the maintenance procedures.
- The laboratory has been rearranged to maximize the working area for maintenance activities.
- Critical maintenance processes and implicit knowledge has been identified and documented.
- Jigs and set-ups have been developed to repair faulty modules which are kept ready for future use.
- Limited quantities of spare cards have been stocked.
- Spare parts have been stored in designated places for easy and fast access.

Academic Support Activities

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

1. Developed a HV (3 kV / 100 mA) power supplyfor HCI-ECR source extractor.
2. Developed a HV (2 kV / 5 mA) power supply for HCI-fast Faraday cup biasing.
3. Participated in designing the low impedance grounding scheme for the HCI facility.
4. Participated in designing the cooling water layout for the instruments and RF cavities of the HCI facility.
5. Repaired power supplies for other labs of IUAC and other institutes:
   - Vacuum deposition unit e-gun power supply (6 kV / 1 A) of Target Development Lab. of IUAC.
   - Super-conducting magnet power supply of SQUID-Magnetometer of IIT Delhi.
   - Vacuum Tube based RF Amplifier of HCI-RF cavities of IUAC.
6. The BTS group is actively involved in the development of MRI magnet with the Applied Superconductivity Group and has participated in the following works:
   - Provided high current sources (500 A) and helped in setting-up test set-ups to characterise quench protection components, superconducting joints and persistent switches at 4.2 K.
   - Designed and delivered a controller for MRI-EIS coil persistent switch.
   - Participated in the design of MRI magnet quench protection schemes and magnet powering sequences and protections.

In-house Development of Power Supplies

If all the BTS magnet power supplies are imported, there will be large number of different types and makes of power supplies. To maintain different designs of power supplies, it needs different spares inventory and trained manpower for each type, which is not feasible. In order to streamline upkeep of the power supplies, the type and make are minimised by taking up in-house development. The single type of power supplies which is used in large quantity has been developed and assembled in-house whenever needed. The steerer and scanner magnets power supplies are the largest number of one type, constituting approximately 50% of the total BTS magnet power supplies. The BTS Group has been designing and assembling such power supplies since 1998. At present, 100% steerer and scanner magnets are being operated with power suppliesmade in-house.

This has helped to have complete control on maintenance / manpower training and resulted in approximately 100% uptime of the beam transport system at IUAC, though the variation in load values (current rating) is large. The power supplies for these magnets are true bipolar (class A output) current regulated power supplies with current rating up to ±10 A and wattage up to 500 W. To minimise the type of power supplies for different load values, the in-house made power supplies are designed with flexibility for output currents and voltages to meet all the load requirements within ±10 A. Linear transistorised design is adopted for simplicity and ease of maintenance. Common control electronics for power supplies with varying ratings is designed with the goal to simplify maintenance, personnel training and to reduce the types of spares. Presently the BTS group is assembling 70 such power supplies for the upcoming HCI facility. It has also agreed to supply approximately 20 such power supplies for the upcoming FEL facility.

Power Supplies for FEL- Beam Transport System Magnets

Approximately 20 power supplies will be needed for the FEL-BTS magnets. There will be 2 power supplies (10 A / 5 V / 25 ppm) for dipole magnets, 7 power supplies for quadrupole magnets (10 A / 5 V / 50 ppm) and 10 bipolar power supplies for steerer magnets (±4 A / 8 V / 100 ppm). For steerer and quadrupole magnets the existing design (same as in HCI facility) of power supplies will be modified to match the current and load ratings. This process has already been started. For the power supplies with stability of 25 ppm, the design will be modified with temperature compensation techniques and DCCT as the feedback element to achieve the required stability.

True Bipolar Power Supply Development Activity

To meet the technological needs for future power supplies, the BTS group has been making continuous efforts. Efforts are being made for developing bipolar power supplies which are used in large quantity in accelerators and other offline set-ups to generate bipolar magnetic fields. The development is aimed to have a simple technique of “class-AB” configuration which will give “class-A” output without any zero crossover distortion. In the presently used technique, additional feedback loops and accurately matched shunts are used to set-up a quiescent current in the push-pull stage in order have class AB bias. This technique has a major limitation, as it depends on the current gain of the BJTs, which decreases drastically at high output current.

A relatively simple technique was developed last year in which MOSFETs were used in place of BJTs and the quiescent currents were set by simply providing an offset voltage to MOSFET gates. As MOSFETs have high input impedance and constant current gain over a wide current range, no additional feedback loops are required to control the quiescent current. To validate the design of the new technique, a ±100 A / 50 Vtrue bipolar power supply was assembled. The group is presently working on different class AB bias schemes with an objective to increase the bandwidth and to provide a thermally stable bias point in passive biasing schemes.

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 facilities. Detector lab provided training on experimental activities for Scientist Trainees, JRF, M.Tech., B.Sc. and M.Sc. students.

MWPC for GPSC/NAND

A new two-dimensional position sensitive MWPC (fig.1), developed with the aim of detecting low energy heavy ions at angles ranging from 2 -10 degrees was installed in GPSC and tested in-beam using 90 MeV ^{16}O on ^{197}Au and ^{64}Zn. The detector was used to detect low energy fusion ERs, deep inelastic events, fission fragments, projectile-like elastics etc. These events were tagged with neutrons and light charged particles detected in liquid scintillator and CsI detector respectively. The MWPC has been prepared using a four electrode geometry, three wire frames and one PCB frames with strips for position information in vertical direction. Such a design will be useful in detecting low energy ERs. The active area of the detector is 10 × 5 cm^2. Off-line measurements were also performed using ^{241}Am

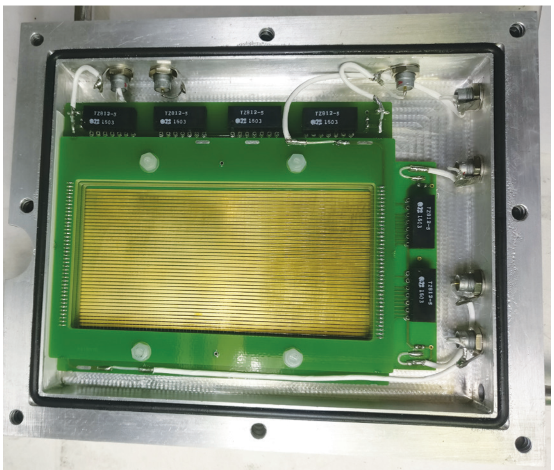


Fig.1: MWPC for ER detection

alpha source and ^{252}Cf fission source. At very forward angles, the detector is expected to be exposed to particle count rates as high as 10^6 pps. The survival and long term stability of the MWPC at such high rates needs is being 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.

HYTAR in GPSC

HYTAR detector system was used in GPSC for performing quasi-elastic scattering measurements using accelerated beams from the Pelletron. The detectors were placed in 3 groups of different angles. Three different gas handling systems were installed for the same so as to operate them at different pressures depending upon the energy of the reaction product to be detected. Experiments were performed with beams such as oxygen, silicon and lithium. For the detection of light ions, efforts were made to operate HYTAR at higher pressures (150-250 mbar). For the same, new foil flange were prepared with circular opening of 10 mm diameter and foil thickness of 2 μm. It was found that during prolonged operations, channels developed in the foil, resulting in leaks. For measurements with lithium beam, detector was operated at pressures as low as 20 mbar, and separation between low energy lithium isotopes was observed which may have been due to scattering from oxygen impurity in tin target.

TEGIC Detector for NUSTAR collaboration

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

Developmental activities for the fabrication of TEGIC detector were initiated. Detector mechanical housing of cuboid shape was designed and machined using aluminum sheets. The electrode material for the detector were procured. These are made out of FR4 printed circuit boards. There are 21 stacked electrodes (10 anodes, 11 cathodes) prepared by stretching aluminized mylar foil of 2 μm thickness. Inter-electrode gap is 2 cm and active area is 20 × 8 cm^2. These electrodes will be tilted at an angle of 30 degrees (fig.2) with respect to the normal to the beam direction. Ten charge sensitive preamplifier units, with differential readouts, were also developed for anode readout. Gains are 90 mV/MeV (Si equi.) with decay time constant of 10 μs. Shorter decay times will enhance high count rate handling capability. The CSPA units have been tested with silicon PIPS detector as well as axial field gas ionization chamber (from HYTAR) with 0.4 μs shaping time constants. Performance achieved is as per design goals. A custom designed gas distribution system for pressure uniformity inside TEGIC chamber is currently under development. The detector is proposed to be commissioned, in last quarter of 2019, at the exit of FRS for initial phase of NUSTAR campaigns from 2020-2022.

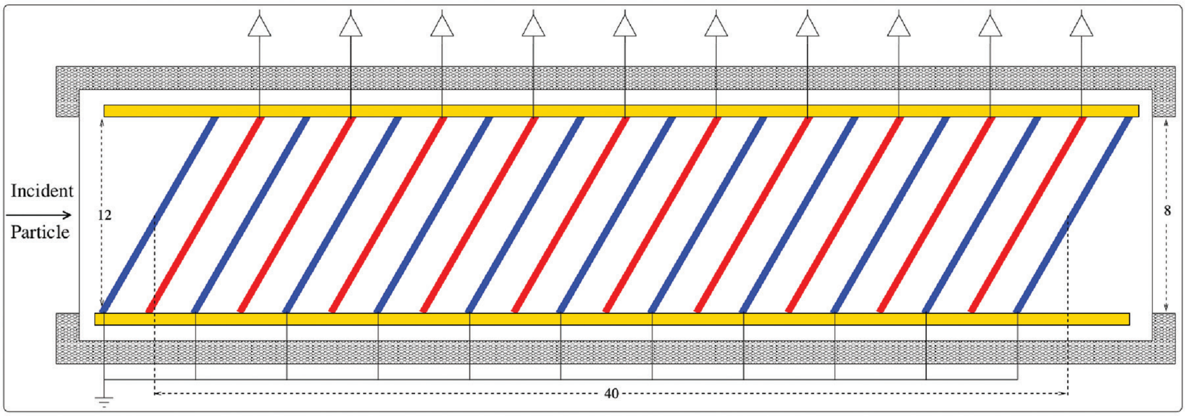


Fig.2: Schematic layout of TEGIC detector.

Development of CSPA and FTA units

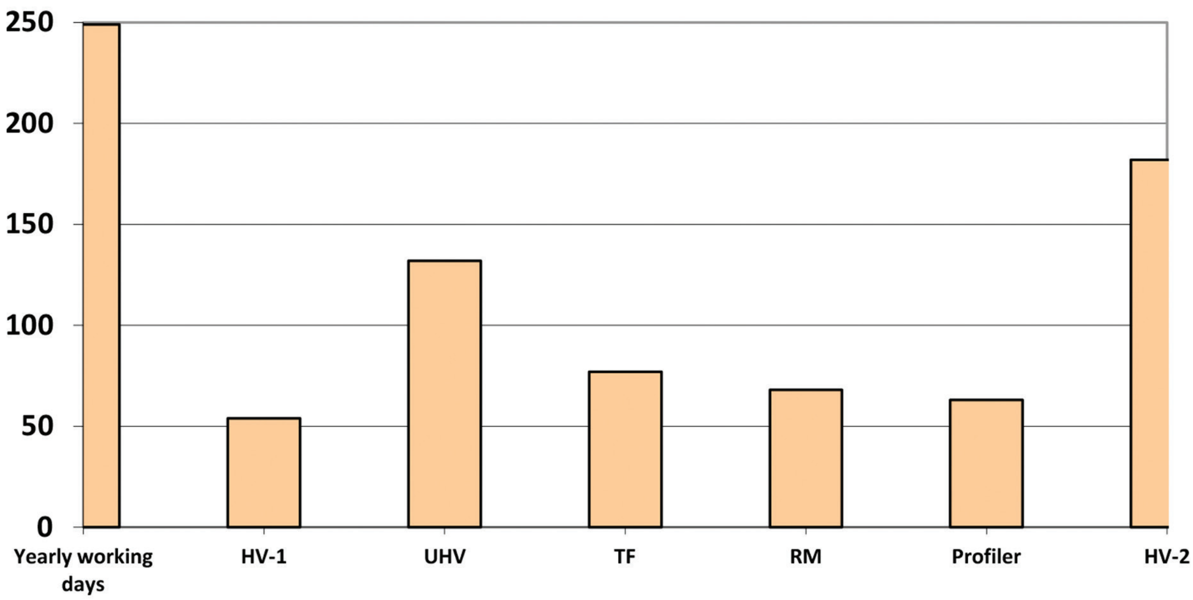
New charge sensitive preamplifier (CSPA) and fast timing amplifier (FTA) units were developed for detector signal processing as per requirements of the future experiments. 12 units of CSPA with gains 10 mV/MeV were developed for 6 silicon detector telescopes used to study the breakup effects in lithium induced reaction in molybdenum. Efforts are also on to develop high gain versions for the detection of low energy heavy ions at LEIBF and table top accelerator facility. Development has been initiated to develop dedicated 8 channel FTA unit for the signal processing of position sensitive MCP signals.

3.1.5 Target Development Activities

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 Development Laboratory (TDL) for developing and delivering the 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 TDL were well–utilized in this year. Man-machine utilization in target development laboratory is shown in the bar chart and table given below.



Caption ....

Facility	No of attempts
High Vacuum Evaporator-I (HV-1)	54
Ultra- High Vacuum Evaporator (UHV)	66
Tubular furnace (TF)	77
Rolling Machine (RM)	62
Profilo Meter	63
High Vacuum Evaporator-II (HV-2)	91

Table.1-Utilizatation of facilities

This indicates that more than two facilities of TDL have been used every day in this year. More than 250 attempts were made for target fabrication in different systems for the completion of target requests of more than 41 users of various streams viz., materials science, nuclear physics and atomic physics. TDL has successfully delivered more than 140 targets for various nuclear physics experiments in this year. Target development in IUAC is reported in many national symposia and peer reviewed journals in this year as listed below:

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Recent highlights in Isotopic Target development

Approximately 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. Few of them are first-time-development. Targets are fabricated by physical vapour deposition and cold rolling techniques.

Sl. No.	Description of target	No of targets	Thickness
1.	^{116}Sn	>12	~200-600 µg/cm^2
2.	^{118}Sn	>44	~200-600 µg/cm^2
3.	^{148}Nd	>25	~600 µg/cm^2
4.	^{146}Nd	>24	~600 µg/cm^2
5.	^{142}Nd	>25	~600 µg/cm^2
6.	^{122}Sn	2	~2000 µg/cm^2
7.	^{124}Sn	2	~2000 µg/cm^2
8.	^{61}Ni	>14	~150 µg/cm^2
9.	^{62}Ni	>18	~150 µg/cm^2
10.	^{144}Sm	>10	~200µg/cm^2
11.	^{154}Sm	>10	200µg/cm^2
12.	^{92}Mo	>8	150µg/cm^2
13.	^{100}Mo	>8	150µg/cm^2
14.	^{148}Nd	3	~900µg/cm^2

Table 2: List of few isotopic targets developed in 2018-19

Preparation of targets of oxidizing elements and its preservation

The TDL laboratory is continuously working on fabrication and preservation of oxidizing targets with minimum material consumption. In previous years, TDL has successfully delivered several targets of lanthanides and other oxidizing materials with various specifications. Minimizing the exposure of target surface to atmosphere plays the most significant role in target preparation of oxidizing elements. Protecting the target surface by sandwiching it between stable materials (e.g. C and Au) is more effective. Releasing agent also has crucial role in minimizing the contamination on target surface. The level of contamination with various releasing agents was also studied in detail during this year.

Fabrication of ^{150}Nd and ^{142}Nd targets of 150 µg/cm^2 with thin carbon backing is one of the targets developed recently. Neodymium, a rare-earth metal, one of the more reactive lanthanide rare-earth elements, quickly oxidizes in air. The oxide layer which peels off after the oxide layer formation exposes the metal to further oxidation. Neodymium metal tarnishes slowly in air and it reacts slowly with cold water. However it reacts quickly with hot water to form Neodymium (III) hydroxide. So the preservation of either Nd target material or Nd targets in metallic form is a difficult task.

The melting point and boiling point of Nd 1024 °C and 3074 °C respectively. Since the boiling point is very high, the Nd is usually evaporated by electron beam bombardment technique. However, to explore the possibility of Nd evaporation by thermal evaporation, initially few attempts were done in thermal evaporation set-up. As the results were not satisfactory, the Nd targets were finally fabricated by e-beam bombardment. To start with, the carbon backing foils for Nd targets were fabricated by e-gun bombardment. After annealing the carbon coated glass slides at 250 °C, it was again loaded in the vacuum chamber as backing foil. The isotopic Nd was evaporated on carbon foil by electron gun using the parameters which were optimized during the evaporation of natural Nd. A protective layer of carbon of 5 µg/cm^2 was then deposited for protecting the Nd surface from surrounding. After the deposition, the Nd film in carbon sandwich was again annealed at 250 °C for relieving the stress. Finally the film was floated in cold water and subsequently it was fixed on a stainless steel target frame. More than 15 targets of ~150 µg /cm^2 were successfully fabricated by this method using 30 mg of material. The targets were characterized by Energy Dispersive X-ray Spectroscopy technique and no unwanted impurities were traced in the analysis. The targets were successfully used for an experiment in IUAC Pelletron Accelerator.

In addition, few targets of ^{148}Nd of 900 µg/cm^2 thickness with thick gold backing were also developed in this year using the above mentioned method. For achieving 900 µg/cm^2, only 100 mg material was consumed. A tantalum crucible was used as the evaporation source to improve the collection efficiency of the evaporation [1].

Fabrication of ^{144}Sm and ^{154}Sm targets is another recent target development for a nuclear physics experiment in IUAC for measuring the quasi-elastic cross-section. The requirement of the user was for Isotopic Sm targets of ~200 µg/cm^2 thickness with a thin carbon backing. Thin

Sm target are generally fabricated by thermal evaporation and e-beam techniques. TDL has already reported fabrication of many Sm targets of various specifications.

Freshly prepared samarium film has a silvery luster. In air, it slowly oxidizes at room temperature. Samarium reacts slowly with cold water and quickly with hot water to form samarium hydroxide. Even when stored under mineral oil, samarium gradually oxidizes and develops a grayish-yellow powder of the oxide-hydroxide mixture at the surface. Minimizing the exposure to air and moisture is the most important challenging task during the fabrication of targets of materials like Sm. For longer life, after the fabrication the target surface is protected by sealing it under an inert gas such as argon.

Due to oxidizing nature of Sm, possibility of forming self-supporting thin targets is completely ruled out. Therefore, very thin C-foil was chosen as the backing material. To facilitate the removal of C film from the glass slide KCl was used as the parting agent [2]. Prior to final deposition, many trials were performed with natural Sm to optimize different parameters of deposition such as current, thickness and evaporation geometry to evaporate the Sm from tantalum boat which is used as source. The Ta boat containing Sm material was placed at a distance of 12 cm below the carbon coated glass slides. Once the vacuum level reached to 2×10^{-6} mbar, Sm was deposited by thermal evaporation method. After the deposition of Sm, Sm coated glass slides were shifted to e-gun source for carbon evaporation. The shifting of substrate is done through a rotatable feed through which is capable of imparting rotary and linear motion to the substrate holder [3]. After placing the Sm coated glass slide over the e-beam source, capping of C of thickness 10-15 µg/cm^2 was deposited by e-beam bombardment. After this, the chamber was left for 7-8 hours to cool down to room temperature. Before proceeding to final deposition ofenriched Sm, thickness of natural Sm film which was prepared during trial run was verified with profilometer and was found to be 140-150µg/cm^2 and that of C capping was 20 µg/cm^2. Before floating, the Sm film under carbon sandwich was annealed in argon at 200oC temperature. The annealing is done for easy separation of films from glass slides during floating. Few Sm targets were also characterized by EDX measurement for studying the impurity level in the targets. The targets were successfully used in a recent nuclear physics experiment in IUAC.

Preparation of self-supporting Sn targets

This laboratory has delivered many self-supporting targets of isotopically enriched Sn in this year. The requirement of the experiment was for ^{116}Sn and ^{118}Sn self-supporting targets of thickness varying from 200µg/cm^2 to 800µg /cm^2. Since the number of targets required by the user was approximately 44, several trial evaporations were performed with natural Sn for optimizing the parameters of evaporation for maximum yield with minimum material consumption. Various releasing agents, viz; $BaCl_2$, NaCl and KCl were also tried using various evaporation sources for this purpose [1].

Finally, the Sn isotopes were evaporated by thermal evaporation technique using Ta tubular boat. About 50mg material was evaporated on KCl coated glass slide which was placed at 9 cm distance from the source. The KCl film of 100nm was deposited by e-beam bombardment technique prior to Sn evaporation. The Sn films were separated from glass slide by floating them in the warm water. After mounting the films on the target frame, the thickness of each targets were measured by alpha-transmission method. The films were also characterized by Rutherford Back Scattering (RBS) technique and no major contamination was observed in the analysis.

New Electron beam deposition facility

Carbon thin films of various thicknesses are regularly fabricated in this laboratory. Carbon thin films are used as a backing target in many reaction experiments in IUAC. In addition, we also fabricate more than 400 carbon films every year for use as stripper foils in the Pelletron accelerator. The new system is designed to have oil-free high vacuum environment with the provision for thermal heating source and electron gun. The salient features of the facility are vacuum chamber with leak rate of better than 1×10^{-10} mbar-liter/sec, substrate heater with radiant heating, quartz crystal thickness monitor, electron gun and two thermal evaporation heating sources. The facility was recently installed in target lab and it is available for users (Figure1).

Figure1: Electron beam deposition facility

Efficiency in evaporation technique

Target development with minimum material consumption is very important as isotopes are highly expensive. TDL has already established several techniques to minimize the material consumption. Controlling the solid angle of evaporation plays significant role in increasing the efficiency of evaporation. We have successfully fabricated 26 targets of 0.7 mg/cm2 of Sm using 100 mg of Sm in indigenously developed Ta crucible [1].

Fabrication, Inspection and Loading of stripper foils

More than 400 stripper foils of carbon of ~4 μg/cm^2 were fabricated in this year. 13 evaporations of carbon were done in high vacuum chamber for the stripper foil. TDL has already established a consistent method for the fabrication and loading of the stripper foils [4, 5]. 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.

Upgradation of Turbo based deposition facility

The turbo pump based deposition facility which was added in the last year is in regular use for e-beam evaporation. A thermal evaporation set-up was added recently to this facility. Since the solid angle of evaporation can be controlled effectively in thermal evaporation, expensive and rarely available materials having low melting points are evaporated by thermal evaporation to minimize the material consumption.

In the modified set-up, the thermal evaporation electrodes are fixed beside the electron gun source. This set-up will enable us to perform sequential evaporation and co-evaporation of materials using both the technique. Sm and Nd were evaporated successfully by thermal evaporation during the testing of the facility.

Thin Film/ Target Thickness Measurement Facility

(1) Alpha Energy Loss Target Thickness Measurement Setup

After preparing the thin films it is essential 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*. In this academic year, thickness of around 514 free standing nuclear targets of 8 users from different Universities/ Institutes have been measured using this facility.

In this setup at a time 5 targets can be loaded on a target ladder, which is mounted on a linear motion feedthrough. The alpha radiation source, generally Am^{241} is used, is mounted in bottom and SBD detector is mounted in top flange. In the side flanges, vacuum pumping and a view-port are installed. Alpha particles of the initial energy of

5.486 MeV are detected on the SBD detector after losing their energy through target. Alpha particle energy loss is measured using 4K MCA with Linux based MCA software. Then using SRIM calculated energy loss per unit thickness (in keV/Å or in keV/(mg/cm2)), actual thickness of the target can be calculated.

(2) Stylus Profiler

In case of thin films deposited on thick substrates, alpha energy loss target thickness measurement method is not effective. Thickness is measured using *Stylus Surface Profiler,* Model: Bruker DektakXT. For this a shadow mask is used to establish a step between substrate and the thin film. Following is the features of *Stylus Surface Profiler* at IUAC:

- Stylus Force: 1 – 15 mg, 0.3 – 15 mg (N-Lite)
- Scan Length: 55 mm.
- Vertical Range: 1 mm
- Vertical Resolution: 1 Å
- Max. Sample Thickness: 50 mm

During this academic year, thickness of around 132 thin film samples of 32 users from different Universities/ Institutes have been measured using this facility.

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3.1.6 RF and Electronics Laboratory

Arti Gupta, Bhuban Kumar Sahu, Deepak Kumar Munda, Kundan Singh, Mamta Jain, Parmanand Singh, Prem Kumar Verma, S.Venkataramanan, Ajith Kumar B.P

Pre-amplifiers for multi-wire proportional counters

We have developed a compact pre-amplifier unit to meet front end electronics requirement of multi-wire proportional counter (MWPC) detector. This unit accommodates different types of pre-amplifiers (up to 7 nos.), including two independent channels of charge sensitive pre-amplifier (CSPA) and five channels of wideband pre-amplifier to process the energy and fast timing signals originating from MWPC electrodes respectively.

The wideband pre-amplifier design is a transistorized (BJT) type, wherein multiple common emitter amplifier stages are cascaded depending upon polarity required, to achieve the required bandwidth and gain. There are 4 nos. of inverting type and 1 no. of non-inverting type wideband amplifiers are assembled with required gain of ~250. The bandwidth achieved by suitable component selection is measured to be ~350MHz (-3dB). These amplifiers are assembled on a common high quality RF type PCB with continuous ground plane, in turn flush mount on die-cast aluminium box top cover, which acts as a heat sink. To reduce cross talk, the pre-amplifiers are shielded with a thin copper sheet. SMA type connectors are used for input and output connections to preserve the rise time of the signal.

The charge-sensitive pre-amplifier design is a transistorised type with JFET front end along with optional front end protection circuit. The charge conversion gain is ~ -44 mV/MeV (Si equ.) with ~100 µS decay time. The preamplifier has two independent outputs (Energy & Timing) for energy and timing spectroscopy respectively. All the pre-amplifiers are mounted inside a die-cast aluminium box.

The wide band pre-amplifiers were tested for long term stability over a period of ~120 hrs and observed gain variation was < ±0.15%. They were tested with alpha source ^{241}Am at the focal plane of HIRA beam line. Position resolutions of ~2 mm and ~2.4 mm were obtained in X and Y positions, respectively which is comparable with the existing set up. Five such preamplifier boxes have been assembled, tested and delivered to the user.

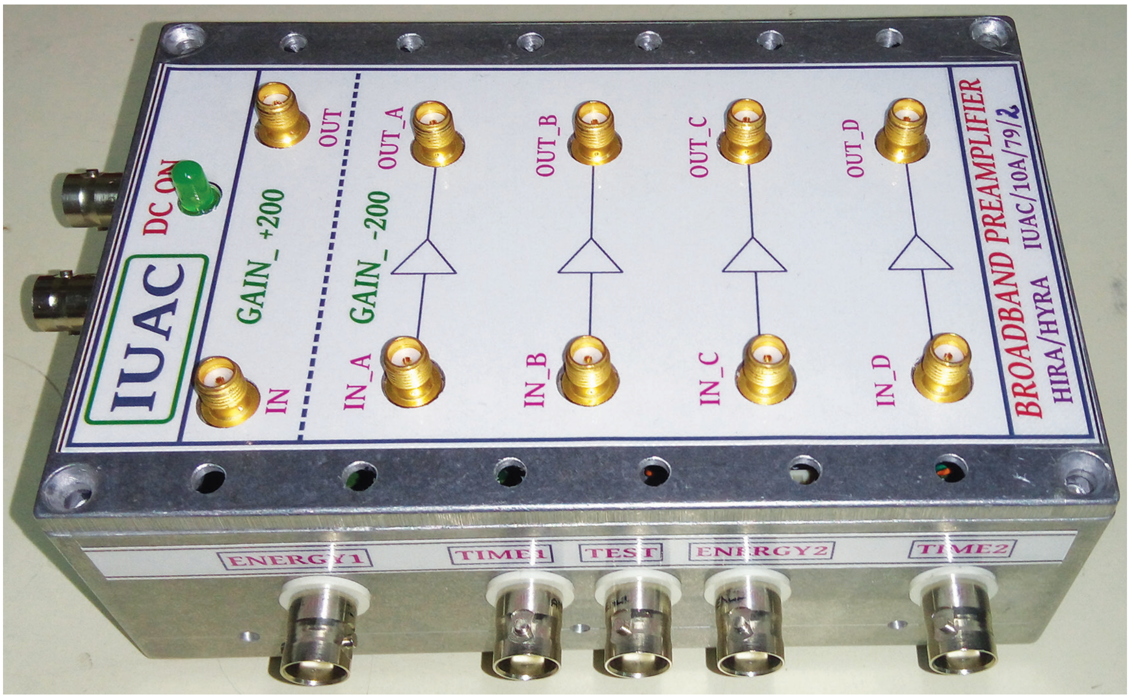


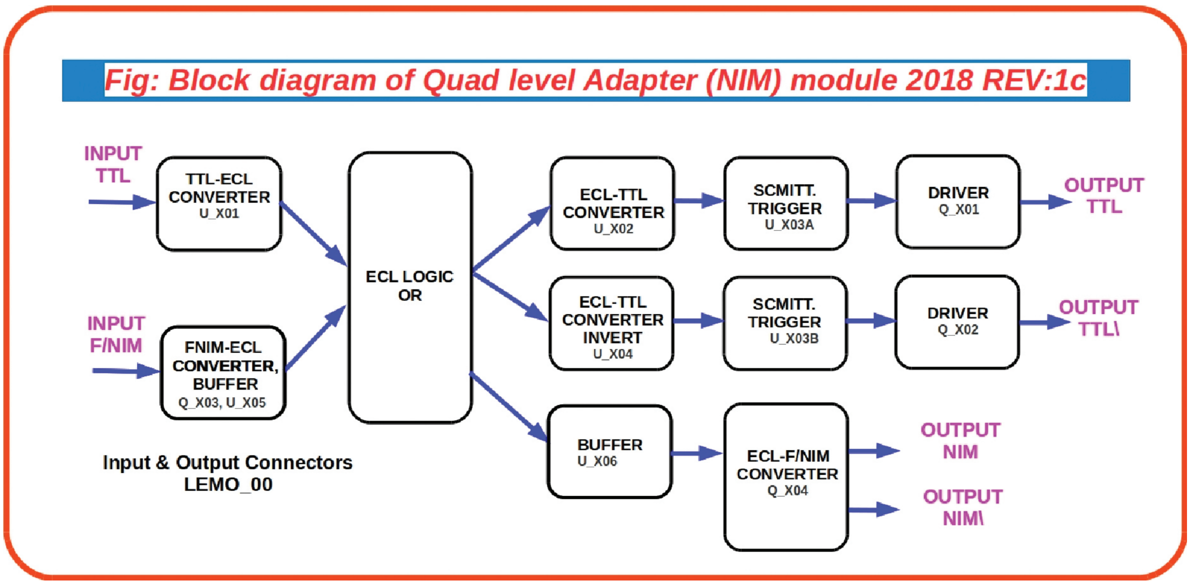
Figure: View of MWPC Pre-amplifier unit

MWPC Fission detector Electronics module

This front end electronics module processes Multi Wire Proportional Counter (MWPC) signals coming through pre-amplifier unit. The single width NIM module accommodates a Shaping amplifier for energy spectroscopy and Constant Fraction Discriminators (CFD) of MWPC of 5 electrode geometry. This year five modules were fabricated, assembled, tested and handed over to the user. The details of this module is discussed in earlier IUAC Annual report of year 2010, pg: 56-57.

Quad channel Level adapter module

A Quad Level Adapter is a general purpose single width NIM module to cater the need of logic translation from TTL to Fast NIM & vice-versa. This NIM module accommodates four identical and independent channels of level translators while each channel accepts either of the two inputs, Fast NIM or TTL and convert it into direct and complementary TTL and Fast NIM logic signals. The module has been developed successfully and duplicated (2 nos.) that are being used regularly with experimental facilities at IUAC.



Block diagram of Quad Level Adapter (NIM) module

Multi-TAC NIM module

As reported in the IUAC Annual Report 2017-18 page 66-67, the module was further refined as per the user requirements. The modifications made are in TAC Range: 100 / 200 / 300 nS corresponding to 0-10 V output. The performance tests were conducted to measure its resolution, linearity and long term stability to compare with commercially available Ortec 566 TAC module. We have used Ortec make Time calibrator module model: 462 for linearity and resolution measurements. The module was further subjected to live test with NAND type detector (STOP) and BaF_2 type detector (START) with Co-60 radiation source for duration of ~ 54 hours to study its long term stability. We have observed its resolution is about ±0.25% of full scale at 100nS range. The long term stability is measured to be ±0.03%, when tested with Co-60, which are comparable with Ortec 566 TAC. All the three channels of the module match within ±3.5% with respect to its TAC range.

VME SDAC64 Module Implementation

In this year we have completed the in-house development of high density (64-channels) scanning ADC (analog-to-digital converter) module for VME bus architecture. Last year, four layer printed circuit board (PCB) was designed in-house and populated with FPGA (Field programmable gate array) and discrete electronics components. The firmware (which contains the core functionality of the module) for FPGA device is written in industrial standard hardware description language, VHDL. The major components of firmware constitute, board selection, VME bus Slave interface, free running sequencer for analog circuitry and data steering logic. There are generic in-built registers which contains module information such as firmware revision, board ID, control and status register etc. The solid works design files are made and supplied to the vendor for front panel precision cutting (wire-cut) in local market. The full board assembly is completed in-house and FPGA is configured with newly developed firmware. The board is calibrated and rigorously tested for functionality and stability of the output of each independent channel. The firmware is implemented on Xilinx Spartan3 FPGA. One of the commercial scanning ADC module is replaced with indigenously developed module in HCI (high current injector) beam line for in-beam testing of the board. The module performance is at par with the commercial board.

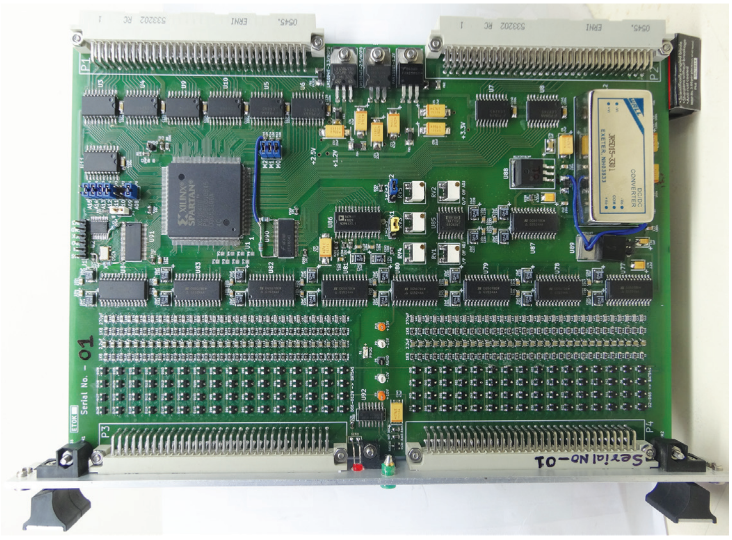


Fig: Top view of VME SDAC64 Module

VME Input Gate/Output Register module (IGOR)

In accelerator control system hardware we are slowly migrating from CAMAC bus based servers to VME bus servers in a phased manner in the older facilities, viz. Pelletron and LINAC accelerators. The transition, especially in Pelletron, has put up a requirement of developing customized VME module to control magnet power supplies. These older 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 (in 6U single width VME board space) which can control two power supplies independently. The four-layer PCB has been designed using open source KiCAD PCB design software. The firmware for board functionality will be written in hardware description language, VHDL.

3.1.7 Health Physics

Debashish Sen & Birendra Singh

The radiation safety aspect of IUAC is taken care of by the Health physics group. Besides this, radiation safety related research and development work is also carried out by users from different

Universities & Institutes. Routine maintenance of interlock system and radiation monitors is done regularly to keep a vigil on the overall radiation safety.

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 Delhi University, Jawaharlal Nehru University, IIT Delhi, Shiv Nadar University, Indra Prastha University, AIIMS, Amity University, NIT Jalandhar, Anna University, Nagpur University, Kolhapur University etc. Regular status reports for the Gamma irradiation chamber, Pelletron accelerator and RBS facility is being sent to AERB. Renewal of licence of existing radiation facilities has been taken from AERB. All dose records are maintained and are also available online. Facility wise RSO re-nomination and renewal of licence was also done using the eLORA facilty.

Few of the Gamma/X ray monitors/ surveymeters/ pocket dosimeters have been calibrated this year. Also some of the door interlock systems underwent thorough repair. Some monitors were replaced, and some were installed in new strategic locations (as new facilities are coming up in the centre).

3.1.7.1 e-LORA facility of AERB

Debashish Sen & Birendra Singh

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

- Submission of siting, design & construction request of a radiation facility
- Renewing license of a radiation facility
- Informing safety status of radiation facilities at regular intervals
- Providing details of the radiation monitors used in the facility along with their calibration dates and other details
- Providing details of radiation sources in custody of IUAC
- Procurement of new radiation sources
- Non-compliance of any safety measures and its rectification
- Renewal of tenure of IUAC Radiation Safety Officers.

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

Debashish Sen

A. Modification of HCI beam line in beam Hall 1

The Site approval has been sanctioned. The final design of the facility/beam line/ shielding layout need some modifications. Shielding calculations are also in the final stages.

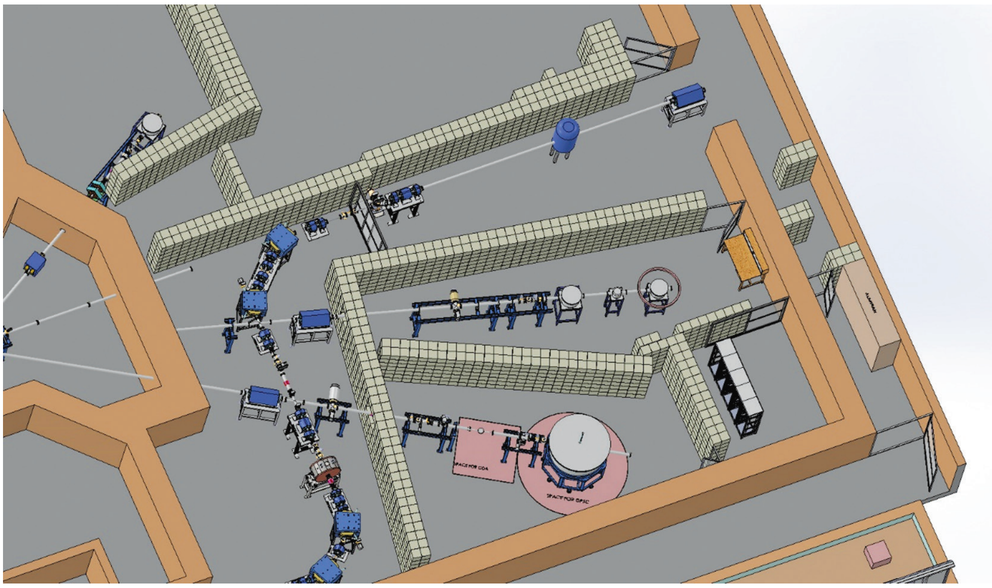


Fig 1: Proposed beam line of HCI (in beam hall I) and necessary shielding modifications (proposed)

The latter part of HCI beam line is to be built in Beam Hall I, which will merge into the zero degree beamline of the Pelletron accelerator. Hence, the original approved shielding layout has to be modified so that the beam lines of GPSC and Materials Science remains operational and accessible even when the HCI beam is ON. Fig. 1 shows the proposed beam line of HCI in beam hall I merging with zero degree line and the necessary shielding modifications required thereafter.

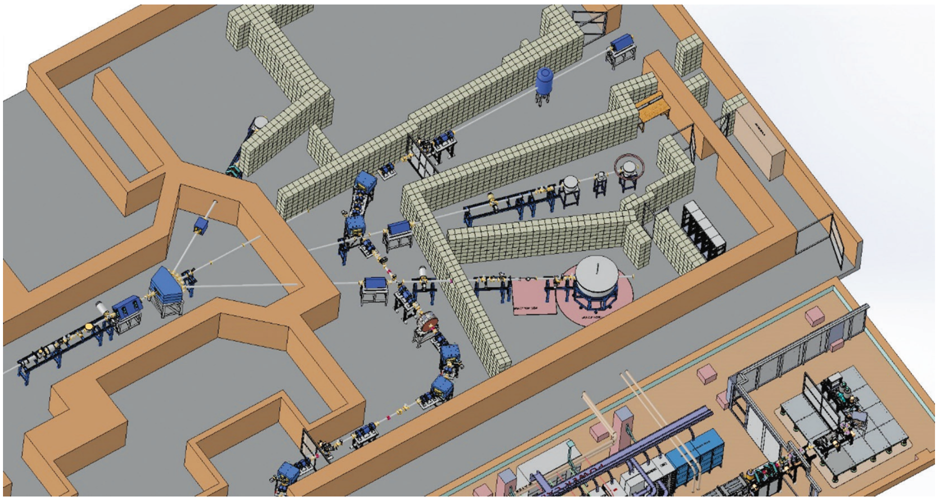
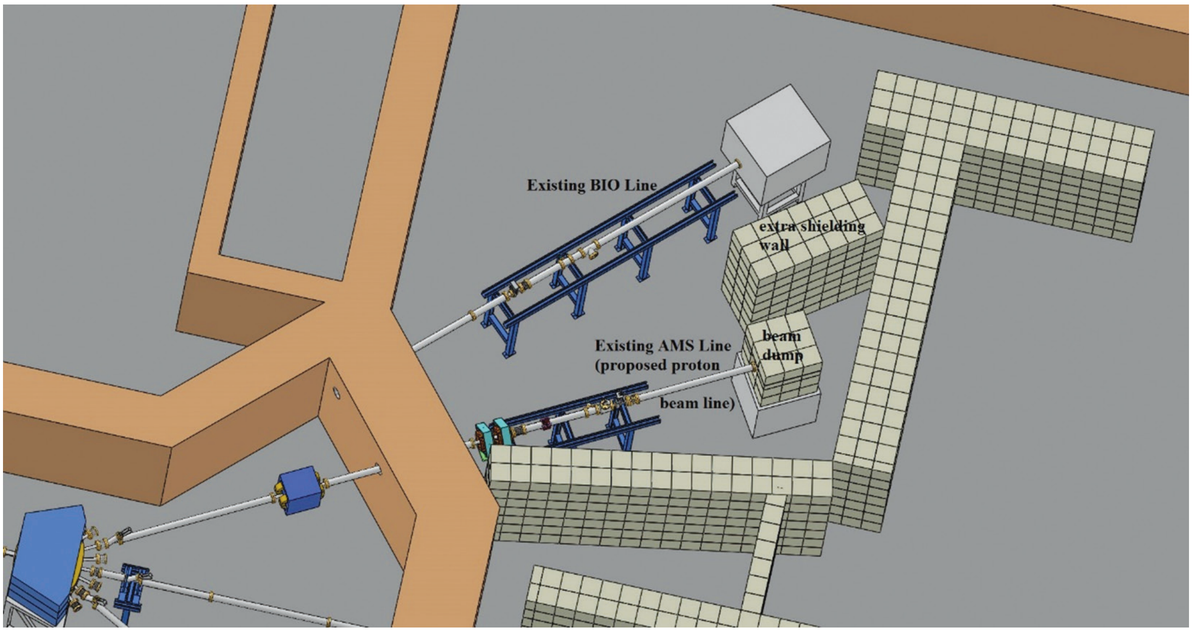


Fig 2: Proposed layout modifications of Beam Hall I with a new entrance (adjacent to the GDA cabin)

Under these circumstances, the entrance to the Materials Science beamline from the zero degree line has to be closed, and no access from that side will be allowed as per radiation safety rules. This requires a new door opening, from the corridor adjacent to GDA cabin area so as to access the GPSC and Materials Science beam line when HCI is ON. The feasibility of opening such a door (along with associated shielding lay out changes) is under consideration. 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 obtaining necessary approvals from AERB.

B. Revival of proton run facility in the original LIBR line

The existing AMS line in beam Hall I was originally used to deliver proton beams to the users. But later very light ion (e.g proton, deuteron) beam runs were suspended. The Centre is planning to revive this facility as demand for proton runs from the users is increasing. Hence, the beam line needs to be modified as per new requirements, and, most importantly, a beam dump has to be built at the end of this line to take care of the radiation safety. High neutron radiation level may damage the ASPIRE chamber components (at the end of adjacent BIO line). Hence an extra shielding wall has been proposed (between the ASPIRE chamber & Beam Dump) to protect it from any radiation damage). All these modifications are being planned at this stage and will be implanted only after AERB approval is obtained.



C. **Free Electron Laser (FEL) Facility**

The Site approval has been sanctioned. The design & construction approval application needs some extra clarifications. Shielding calculations are also in the final stages.

D. **Accelerator Mass Spectroscopy (AMS) Facility**

Final approval will be obtained after submission of the Quality assurance manual & detailed Acceptance test Report.

E. **License to procure & operate X-ray diffractometer & X-ray fluorescent device (cabinet type) was obtained.**

F. **Preliminary site layout information related to upcoming Geochronology facility (Ministry of Earth Sciences) and ISRO electron Accelerator Facility (Dept. of Space) has been conveyed to AERB.**

3.1.7.3 Investigating the Thermoluminescent Properties of Nano-crystalline $K_2Ca_2(SO_4)3$:Eu,Cu and CaF_2:Tm

Anant Pandey[1], Chirag Malik[1], Kanika Sharma[1], Pratik Kumar[2], Birendra Singh[3] and Debashish Sen[3]

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[2]Medical Physics Unit, IRCH, AIIMS, New Delhi
[3]Health Physics Lab, IUAC, New Delhi

The effect of co-doping and change in dopant concentration on thermoluminescence (TL) properties of $K_2Ca2(SO_4)_3$:Eu,Cu has been studied by varying the concentration of the two dopants europium and copper (0.05, 0.10, 0.20, 0.30 and 0.40 mol% equally divided between Eu and Cu). Chemical co-precipitation technique was used to prepare the co-doped phosphor $K_2Ca_2(SO_4)_3$:Eu,Cu. Using Williamson-Hall plot in the X-ray diffraction pattern of the phosphor, the size of the crystallites was estimated to be around 51.3–73.6 nm. Maximum TL sensitivity was obtained for 0.2 mol% concentration (0.1 mol% Eu and 0.1 mol% Cu). The co-doped phosphor was compared for its TL sensitivity with that of the singly doped phosphors $K_2Ca_2(SO_4)_3$:Eu, and $K_2Ca_2(SO_4)_3$:Cu and the standard TL dosimeter LiF:Mg,Ti (TLD-100). Higher TL peak intensity of co-doped phosphor compared to the singly doped phosphors $K_2Ca_2(SO_4)_3$:Eu and $K_2Ca_2(SO_4)_3$:Cu has been explained on the basis of energy transfer between the dopants. Photoluminescence studies of the co-doped and the singly doped samples confirm a positive energy transfer from Cu^{2+} to Eu^{2+}. A linear TL response curve over a wide range of doses (10 Gy to 1 kGy) is a key factor that makes the present phosphor quite capable for dosimetric purposes.

Further, chemical co-precipitation technique was used to initially prepare nano-particles of CaF_2 which were later activated by thulium (0.1 mol%) by the use of the combustion technique. X-Ray diffraction (XRD) and transmission electron microscopy (TEM) were used to characterize and confirm the preparation of the desired salt. 1.25 MeV of gamma radiation and 65 MeV of carbon (C^{6+}) ion beam were used to irradiate the samples. A major peak is evident at around 169 °C and two small humps at 223 °C and 295 °C in case of gamma radiation. Further, the salt at hand exhibited a linear TL response for the complete range of studied doses i.e. 10 Gy to 2000 Gy. Moreover, when the nanophosphor was exposed with 65 MeV of C6+ ion beam its glow curve exhibited a major TL peak at around 161 °C and a small shoulder at about 237 °C and the nanophosphor displayed a linear TL response for the entire range of studied fluences i.e. $5x10^{10}$ ions/cm^2 to $1x10^{12}$ ions/cm^2. Finally, a variety of tests like batch homogeneity and reproducibility were also performed in order to define the final product. Thus, co-precipitation method followed by combustion technique was successful in producing a dosimetric grade CaF_2:Tm for dosimetry of gamma radiation as well as carbon (C^{6+}) ion beam.

This work has been presented in the 22nd Asia-Australasia Conference of Radiological Technologists (AACRT 2019) in conjunction with the Australian Society of Medical Imaging and Radiation Therapy's 14th National Conference (ASMIRT 2019), held at Adelaide Convention Centre, from 28-31 March 2019 in Australia [2]. All of the above mentioned works have been performed at the Health Physics Lab, IUAC, New Delhi under the projects: BTR No. 57301, **BTR No. 63201 and BTR No. 63203.**

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[2] Pandey A, Sharma K, Singh B, and Kumar P, "CaF2:Tm nanophosphor as gamma radiation and carbon beam dosimeter for radiotherapy" 22nd Asia-Australasia Conference of Radiological Technologists (AACRT 2019) in conjunction with the Australian Society of Medical Imaging and Radiation Therapy's 14th National Conference (ASMIRT 2019), 28th-31st March 2019, Organized by the Australian Society of Medical Imaging and Radiation Therapy, held at Adelaide Convention Centre, Adelaide, Australia

3.1.7.4 Combustion synthesis and thermoluminescence response of near ultra-violet irradiated Mg2B2O5 nanophosphors

Jitender Kumar[1], Birendra Singh[2], Debashish Sen[2], Shalendra Kumar[3] and Ankush Vij[1]

1Nanophosphors Lab, Department of Applied Physics, Amity University Haryana, Gurgaon
2Health Physics Lab, Inter University Accelerator Centre, New Delhi
3Electronic Materials & Nanomagnetism Lab, Dept. of Applied Physics, Amity University Haryana, Gurgaon

Among the various kinds of metal borates, the magnesium borate has been considered to have promising luminescence properties. The synthesis techniques and conditions have a profound effect over the defect assisted luminescence properties of phosphors. We synthesized $Mg_2B_2O_5$ nanophosphors by combustion technique using urea as fuel. The formation of $Mg_2B_2O_5$ nanophosphors was investigated by X- Ray diffraction pattern, which clearly confirms the single phase triclinic structure. In order to investigate the thermoluminescence (TL) response of $Mg_2B_2O_5$ nanophosphors for near ultra-violet (UV) radiations, the samples were exposed with wavelength of 365 nm for different durations. The TL glow curve of the samples consists of two broad peaks around 425-430 K and 570-590 K, which signifies two kinds of trapping or defect sites present in the sample. With the increase in exposure time, we observed that higher temperature peak intensity increases at the expense of lower temperature peak. The analysis by using Chen's peak shape method confirms that TL glow curve comprises of complex glow peaks, thus not suitable from radiation dosimetric point of view. However the present TL results suggest that $Mg_2B_2O_5$ nanophosphors are sensitive to near-UV radiations and further synthesis optimization may be required to make $Mg_2B_2O_5$ usful for UV dosimetry.

3.1.7.5 Combustion Synthesis and Thermoluminescence Studies of Gamma Irradiated MgO Nanostructures

Savita[1,2], Birendra Singh[3] , Debashish Sen[3], Ankush Vij[4] and Anup Thakur[1]

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[2]Department of Physics, Punjabi University, Patiala-147 002, Punjab
[3]Health Physics Lab, Inter University Accelerator Centre, New Delhi
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Wide band gap metal oxide nanomaterials has attracted the researchers due to their excellent luminescence properties. Magnesium oxide (MgO), being a wide band gap (~7.8 eV) material, is explored for its application in radiation dosimetry. In this research, MgO nanostructures have been synthesized by solution combustion method using monoethanolamine as a fuel. A part of the sample is annealed at 950 °C to study the effect of annealing on crystallite size, and thermoluminescence behavior. The as-synthesized and annealed nanostructures are characterized by powder X-ray diffraction for phase confirmation. X-ray diffraction patterns of the nanostructures revealed the formation of single phase cubic structure in both the samples. Crystallite size of the as-synthesized and annealed samples is found to be ~20 nm and ~30 nm respectively. In order to study its thermoluminescence (TL) response, the annealed nanostrucutres were irradiated by 60 Co gamma-ray source at various radiation doses up to 10 kGy. A broad glow peak having two features at ~108 oC and ~165 0C is observed indicating the presence of various defect centers in MgO. TL glow curve intensity is found to increase with the increase in radiation dose upto 7 kGy and then saturates. Various trapping parameters viz. frequency factor, activation energy and order of kinetics were calculated from the TL glow curves.

3.1.8 Data Support Laboratory

Ruby Santhi and P. Sugathan

Data Support Laboratory at IUAC provides support to various users in setting up the required data acquisition & electronics during experiments. The lab also procures required electronic modules, co-axial connectors and cables required for user support. In data room, two CAMAC based on-line data acquisition systems are running with LINUX based FREEDOM software using CMC 100 controllers. Many nuclear reaction experiments in GPSC and HIRA facilities have been performed using the CMC100 Crate Controller based data acquisition system in data room.

3.1.8.1 VME based Data Acquisition test bench in INGA counting Room.

Ruby Santhi

A VME test bench was setup in INGA counting room for collecting signals from suppressed clover Ge detector using radio-active source. Spectrum from Europium source was collected after digitization using 32 channel VME ADC MADC-32, which is a fast, high quality 32 channel peak sensing ADC and provides 11 to 13 Bit (2 to 8 k) resolution with low differential non linearity due to sliding scale method. The ADC module also has a time stamp register. Scientific Linux software installation is no neing tried in all in one PC.

3.1.8.2 Testing of LAMPS Acquisition Software for Ethernet & USB CAMAC Controllers

Ruby Santhi and Ambar Chatterjee

Two new CAMAC controllers have been tested for data collection using LAMPS version of software. The driver parts of the controllers were modified to work for LAMPS software in Ubuntu and Scientific Linux operating systems. These are commercial controllers, Wiener CC-USB controller and CAEN Ethernet C111C controller. The Ethernet controller was procured by Dayalbagh University (Agra) user for setting up their muon measurement laboratory. After implementation of drivers and modification in LAMPS, the operating system and data acquisition software were installed in their setup at their university and sample data was collected. The setup will be used by students performing muon measurements.

3.1.9 Computer and Communications

S. Mookerjee, E.T. Subramaniam, S. Bhatnagar, A. Kumar

The major activities this year include a major overhaul of the Center's core network switching system, expansion and reorganization of the Center's local network, revamp of the internet access mechanism to a hardware firewall and UTM system, and operation and maintenance of the IUAC HPC facility. Work on swift heavy ion interaction simulations was also restarted after a hiatus of three years.

3.1.9.1. Local Area Networks

In a major upgrade, the core network switch stack, now more than ten years old and out of maintenance support, was augmented by a new single 48-port 10G switch. Five edge switches, also more than ten years old, were replaced by new gigabit Ethernet switches with 10G uplinks. The new core and edge switches were configured with full access control filters. The edge switches and associated old cabling were replaced with close to zero downtime. The new core switch is presently used as a passive standby, ready to replace the old core stack in case of failure.

Design and implementation of OFC based 10G network connectivity from IUAC core switch to auditorium network room, including all passive components and racks, was completed this year. New redundant OFC cables were laid from the network core in the IUAC data centre to the auditorium network room, with all terminations in LIU and jack panels completed in separate racks at both ends. The gigabit wired network inside the auditorium was also checked and fixed. The passive network has now been installed and tested, and is ready for active components for the auditorium network to go live.

The internet traffic load continued to increase this year, with much of the traffic being generated from the wireless LAN and mobile devices. The number of simultaneous sessions at peak times increased to about six hundred. Access to the internet by users on the local network was routed through a central Linux server running an authenticated Squid proxy server and an Iptables firewall. This server also served as a reverse proxy gateway for external access to the IUAC web page. The proxy server and firewall had to be manually configured for every change in rules, needed constant tweaking and policy changes, and had also reached performance limits. This was replaced by a hardware UTM providing firewall and web page forwarding functions, and allowing direct access to the Internet without mediation through a proxy server. The replacement involved the design of a zero-downtime migration plan, selection and purchase of a hardware firewall and UTM, reconfiguration of central servers, wireless controller and wired network switches to work through the new UTM, reconfiguration of DNS servers, migration of firewall rules, and configuration and implementation of new UTM-based internet access. Smooth migration to the new Sophos XG310 UTM was achieved with no downtime, by keeping parallel access to the old system available for a few weeks.

3.1.9.2. High Performance Computing Facility

In 2008, the Department of Science and Technology sanctioned a grant of Rs. 13.54 crores to set up a high performance computing facility at the Inter University Accelerator Centre. The purpose of the grant was to provide a major computing facility for faculty and students of universities and colleges across the country. The facility was operational since 2010, and served more than four hundred users from a hundred and fifty research groups in colleges, universities and institutes across the country.

The HPC facility consisted, at the beginning of the academic year, of a Infiniband-based MPI cluster comprising 2880 Xeon cores across 180 compute nodes. with a total of more than four hundred users from a hundred and forty groups. Maintenance of compute, storage and interconnect hardware and software, and addition and administration of the user pool, was done in-house.

While another fifty users in twenty groups were added during the year, and software problem resolution was speeded up, hardware problems multiplied and the number of usable cores came down to 1700 by January 2019. Hardware problems with master node and storage were resolved for some time by reconfiguring compute nodes as master and metadata nodes, and using parts from nodes already down to repair other nodes. However, the cluster was working with reduced node and core counts and reduced reliability. 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 six years 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. An attempt is now being made to revive a skeletal system to enable users to transfer data to their home institutions and enable a graceful shutdown.

3.1.9.3. New Generation Instrumentation and Acquisition System

E.T. Subramaniam, Kusum Rani, Mamta Jain

The defining direction of data acquisition system development work this year was towards the design and implementation of the next generation VME-based data acquisition system. Significant progress was made in putting together the associated hardware and software required for the development effort:

- The existing net boot 32 bit tiny LINUX OS was adapted to cater to the need of the VME SDK which would be required for the new data acquisition system.
- Feasibility study of VME based DAQ system was completed. The SDK and the driver available from the crate controller manufacturer appears to be incompatible with the recent 64 bit systems. So a user level driver was developed to communicate with the commercial VME crate controller through the built-in VME API of LINUX systems. The NiasOS (Tiny Linux) was modified to have provisions for the same. A text user interface (TUI) based client was also developed.
- Universal serial bus based interface was envisaged to cater to the needs of the upcoming DAQ requirements. The necessary middle ware and TUI based interface were designed and developed.
- Design, development and implementation of VME interface hardware and middleware was started.
- Design, development and implementation of unified event identification module with cascaded time stamp for multi strobe acquisition systems was completed.

3.2 UTILITY SYSTEMS

3.2.1 Electrical Group Activities

U. G. Naik and Raj Kumar

This group is primarily responsible for maintaining the electrical installations of IUAC and also to develop adequate electrical infrastructure for the new scientific projects. The uptime achieved for electrical systems was close to 100%. This was possible with judicious maintenance schedules and monitoring arrangements. The group has also successfully completed the projects and works envisaged for the year F.Y. 2018-2019.

PROJECT WORKS:

11 kVA Compact Substation

A Compact electrical substation with transformer of 11 kV/433 V, 1600 KVA has been Commissioned and put into operation after planning, designing, procurement, execution. Necessary approvals from the Electrical Inspectorate, CEA have also been obtained. Substation is in use since its commissioning on 28th march 2019.

Auditorium Works

All the works related to the auditorium have been completed and the auditorium is put into use. On completion of all works at Auditorium, application to Delhi Fire service was made by IUAC requesting for fire clearance. Fire inspector on his visit made observations and suggested certain changes to be made as per relevant BBL 1985. All the necessary modifications were carried out in record time of 30 days and NOC was obtained from Delhi Fire service to operate and use the Auditorium. In February IUAC organized the AFAD-2019 Workshop in the new auditorium.

UPS-SITC of 3 nos. of 60 KVA UPS

A 3x60 kVA On-line UPS System consisting of 3 units of 60 kVA UPS in load sharing N+1 configuration complete with AC, DC cabling etc. on turn-key basis was planned and procured after removal of existing 2x60 kVA UPS System. Five year Comprehensive AMC charges after expiry of warranty period are also part of the purchase order.

Maintenance Activities

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

Maintenance of electrical installations is managed through the AMC with external agency, however all the consumables required are supplied by IUAC. M/s KBS Electricals was engaged for AMC during financial year 2017-18, who have carried out the maintenance.

There was not even a single event occurred for the transformers or any switch gears related to transformer HT and LT.

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

- 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 are synchronized to power 15UD Pelletron, He Plant and HPC Data Centre. The group has shown ever readiness in running the systems round the clock O&M activities within short period if need arose.

Synchronisation panel and the PLC is subjected to the ambient temperature of >45 °C in summer on its successful service of 5 years it has failed for the first time and has been replaced. Fresh programming also has been done and put in to service.

Batteries are periodically changed once in 2 years or on failure whichever is earlier. Servicing (B-check) is carried out by Engine manufacturer once a year with Cummins genuine parts.

These 3nos of 750KVA DG sets were procured in year 2012 through M/s NCE Jaipur. Installation was completed by M/s H N Traders, New Delhi in 2014. However we were informed at that point of time that the approval of Electrical inspectorate was not mandatory. Now we have come to know that the approvals are needed and accordingly action initiated. On rigorous pursuation with Electrical inspectorate, CEA.

And on complying to their observation the installations stands approved by Electrical inspectorate, CEA.

Roof Top Solar System for IUAC

Roof top grid interactive 2×50 kWp solar power generation plant is functioning successfully and is operational. Peak power generated in any particular day has reached 650 KVAH units. Average generation is 500 units. Periodical cleaning of the panels is done to get maximum power output.

UPS Installations

IUAC has 10×60 kVA UPS, 3×300 kVA, 4×200 kVA, UPS systems maintained by electrical group. These are under supervision and control of this group. Although the day to day operations are carried out by electrical group, the comprehensive AMC order has been placed on the manufacturer for all the sets out of warrantee period. Under AMC, routine preventive maintenance is carried out by AMC agency once in every quarter.

Power Factor Compensation

Electrical group is pleased to state that yet again average power factor of >0.98 lag was achieved for the year. Our system power factor without correction was around 0.85, and by raising it we have saved > Rs.162 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 to Beam Hall-II stores areas. Renovation of fire detection system has been done in Beam Hall-III as this system was giving lots of troubles. All parts of the system were maintained in good health throughout the year. This year scope has increased due to addition of Lab Block 2nd floor and Auditorium Block.

3.2.2 Air Conditioning, Water System and Cooling Equipments

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

AC 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. 2×200 TR chillers installed in 2013 have run 28000 hours each. Other rotary equipment have logged 2,15,500 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 have been followed over the years. The system has overshot 1,70,000 hours from its expected life span.

IUAC's centralized water system of Phase-II & III feeding low temperature cooling water also performed to an uptime of 100%.

A strict monitoring on the water quality has ensured that the flow paths are in healthy condition. The maintenance costs were kept significantly low as compared to world class bench mark values.

150 KLD Sewage Treatment Plant (STP) performed satisfactorily.

COOLING SYSTEM

Availability of equipment was recorded at 99%.

WORKS CARRIED OUT DURING THE YEAR:

- Installation, Testing & Commissioning of 5 KW Process Chiller for FEL
- Installation of 30 KW Process Chiller for FEL
- Laying of SS Water Headers from Beam Hall#III Basement to Chiller Room for FEL
- Extension of SS Process Water Headers to MRI room from Beam Hall#III
- Replacement of leaking GI Pipes at various locations
- Provision of 6 nos. of process water tap-off connections from the main headers in Beam Hall#III for HCI
- Installation of RO Water Purifier in Parijat#1
- Replacement of 5 TR compressor in Beam Hall#II store extension ductable unit
- Overhauling of 3 nos. of Softeners of Ph-1, 2 & 3 AC Plants
- Planning & processing of renovation/repair of Workshop & LHe Compressor room Air-Washers
- Auditorium Air-Conditioning system was commissioned and taken over by IUAC in the month of July 2018.

3.2.3 Mechanical Workshop (MG-III Gr.)

Rajeev Ahuja, Sanjay Kumar Saini, Bipin Bihari Choudhary and Davinder Kumar Prabhakar

Machine Shop

Welding Shop

The prime responsibility of the workshop group is to take care of the machine shop activities. IUAC workshop is well equipped with *tool room type* modern machines and welding facilities.

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

Machine Shop is equipped with a five axis 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 one vertical Band Saw machine, catering to different types of jobs. Most of these machines are of renowned makes HMT, Batliboi, BFW.

Welding shop is having high quality TIG welding machine and other equipments. 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.

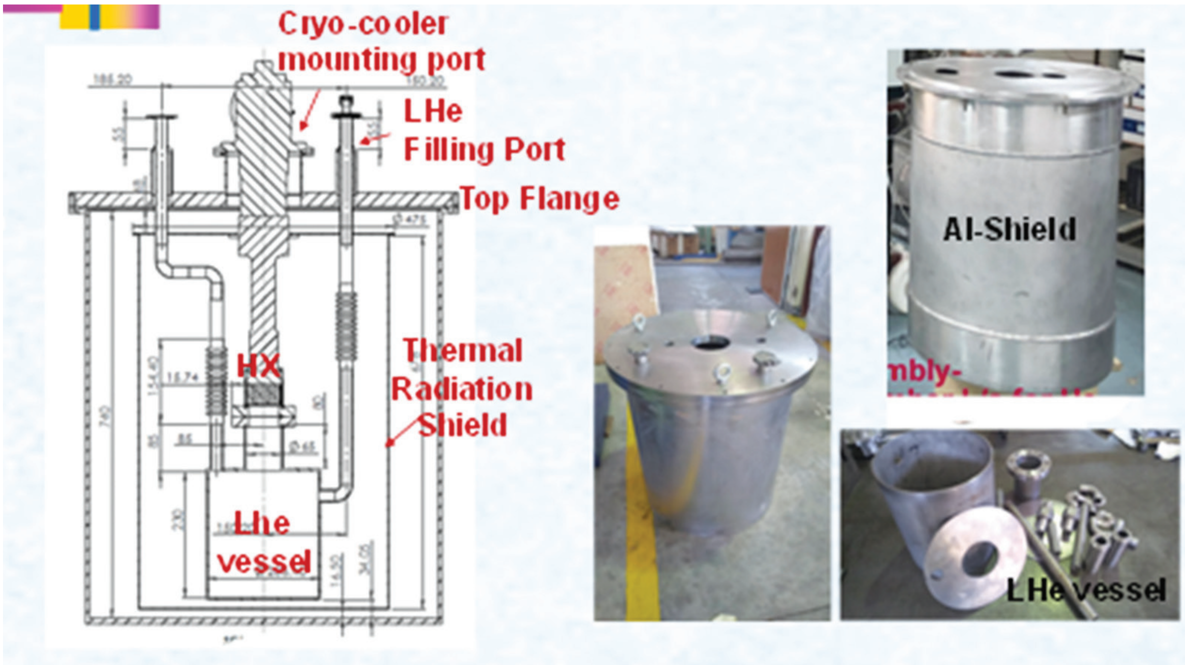
Workshop has Solid Works CAD facility for design and drafting purpose. It also has VISI CAM for the CAM support for the Vertical Machining Centre and CNC Lathe. A portable CMM, with 1.8 m inspection area with 40 µm accuracy is also part of Workshop for highly accurate measurement and assembly.

We cater to a large community of users and researchers from different labs of IUAC related with the 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 do in our workshop). Before delivering the job to the users or lab staff, the job is inspected to ensure that it is fabricated as per the required specifications. If required, we assemble and install it also at the site.

This year we had received and fabricated around 350 jobs of different nature in the workshop.

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 provided for the scientist trainees and Ph.D. students enrolled in IUAC.

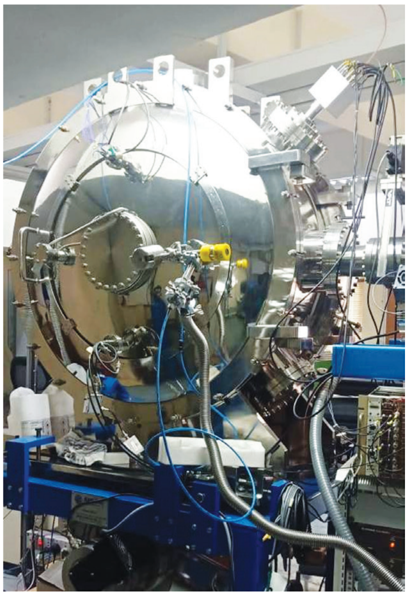
Apart from the above mentioned regular activities, MG-III group members were also involved in some of the on going major development projects and experiments related research and development activities. Some of them are mentioned below:



Cryo cooler based test cryostat for MRI development Project

- Radio Frequency Quadrupole, RFQ
- Drift tube Linac, DTL
- MEBT Spiral Buncher
- One meter diameter Vertical Scattering Chamber for LEIBF
- TEGIC related works
- MRI development program
- FEL related works
- Fabrication of Mezzanine platform for LINAC control room

Mezzanine platform for LINAC control room



Vertical Scattering Chamber for LEIBF

3.2.4 Civil Works

Harshwardhan, A.J Malyadri, M.K. Gupta

Works under Civil Section:

- Major Projects (right now under process /planning for renovation of housing and Lab Building Construction by CPWD under deposit mode)
- Minor Projects
- Minor works
- Civil Maintenance (from day to day basis under AMC (Civil)
- External cleaning of Campus
- Liaison with outside agencies for statutory approvals and various civic problems

Important Civil Activities undertaken during the year 2018-19

Following important civil works were undertaken during the year 2018-19 in addition to routine civil maintenance and minor works:

- P/F M.S Frame for vertical wall garden in front of Old Guest House's Entry wall.
- Supply of epoxy material for repair of floor in Room No. 308 in Engineering Building.
- Addition /alterations in waste pipes & rain water pipes on beam hall –I roof due to recent waterproofing.
- Cleaning of sewage effluent tank (1 no.) in housing area.
- Construction of room for water chiller for FEL project near south-side entrance of BH-III.
- Misc. civil works & wooden partitions in Spectroscopy, UV –Vis-NIR & FTIR lab (R. No. 348), 2nd floor, Main Lab Building.
- P/A External & Internal Painting of Parijat -1 (Director Residence) at IUAC.
- P/F new vinyl flooring (of 2 mm thickness) tough grade in R. No. 110 A, Main Lab Building.
- P/F EWC (European type water closet) in Parijat -1.
- Renovation of tea pantry near Room No. 212, 1st floor, Main Lab Building in IUAC.
- Misc. wooden work for Room No. 341 (Nuclear Target Lab), 2nd floor, Main Lab Building.

- P/F small glass partition for 3 nos. toilet in Auditorium & Main Lab Building.
- Waterproofing and re-sloping of Beam hall-I roof.
- Supply of painting related material for civil maintenance work at IUAC.
- Making enclosures outside Beam Hall –III on south-side for protection of BH-III Equipment.
- P/A painting of workshop area and corridor area in Engineering. Building.
- Waterproofing work on roof of canteen building, BH III Side terrace & Low Temp. Lab near BH-II.
- Construction of ramps at various places in phase –I housing area for facilitating elderly person for access to phase-I housing block.
- Civil work for making a central junk yard near AC plant III in IUAC.
- Misc. Civil works in IUAC Campus (I) Renovations of gent's toilet near Old Guest House & G.F Main Lab Bldg. (II) Renovations of visitor room near old guest house.
- P/F M.S Railing on existing parapet wall of 2nd floor, Main Lab Bldg.
- Misc. painting work in IUAC Campus (painting of material store, steel staircase & VIP Guest Dining hall etc.).
- P/A painting of 5 nos. flats in IUAC housing area.
- Misc. painting (under annual preventive maintenance) of outdoor location in IUAC.
- Civil works for TEM installation in Room No. 101, Main Lab Bldg., IUAC.
- Civil work for making vertical garden in front of flat let area in IUAC.

3.2.5 COMPRESSED AIR SYSTEM AND MATERIAL HANDLING EQUIPMENTS

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

Our Group is associated in the following activities:

i) **Compressed Air System:** Compressed air plant (Ph-I&II) consisting of three nos. of screw compressors each of 115M^3/hr capacity, 4 nos. of air dryers, pre/fine/oil removal filters with capacity of 3000 lpm @ 9.00 Kg/cm^2, Storage Tank of 25 cum have maintained uninterrupted air supply to various labs within IUAC round the clock throughout the year. Pneumatic connections are provided to different labs / area / instruments as and when required.

ii) **Laboratory Gases:** Indigenous / imported various industrial / lab purity gases / cylinders / regulators have been made available as per the requirement in different labs from time to time.

iii) **Elevator:** Proper maintenance is carried out so that elevator operates safely without fail.

iv) **Material Handling System :** Periodic maintenance / servicing of more than 14 nos. E.O.T cranes and electric hoists of various capacities varying from 1 Ton to 7.5 Tons are being carried out periodically to ensure there smooth, uninterrupted and safe operation.

v) **Fire Safety :** Annual refilling and periodic maintenance of all the fire extinguishers are carried out. Demonstration for use of Fire extinguishers have been arranged and all the users and IUAC employees are trained to use the fire extinguishers.

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