3. RESEARCH SUPPORT FACILITIES

3.1 SUPPORT LABORATORIES

3.1.1 HIGH VACUUM LABORATORY

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

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

3.1.1.1 Design and development of a Double Slit Assembly

Chandra Pal, Ashok Kothari, P. Barua, Kundan Singh, D. Munda, C. P. Safvan

A four jaw motorized slit has been designed and fabricated for defining ion beam in both X-X and Y-Y planes. Slit jaws are made of tantalum material and are mounted on motorized vacuum compatible linear drives. Each jaw can move linearly from 0 to15 mm from centre of the assembly with an accuracy of 50 microns. It is a UHV compatible slit and the four jaws are placed in staggered and non-colliding configuration. Slit housing is 200 mm long and 100 mm in diameter with DN 100 CF entry and exit flanges, four DN 40 CF ports for mounting slit jaws with motorized drives and four DN 16 CF ports for current feedthrough. Each jaw has a power rating of 50 watt and is connected to its corresponding feedthrough for reading slit current. It can be operated in local as well as in remote control mode.

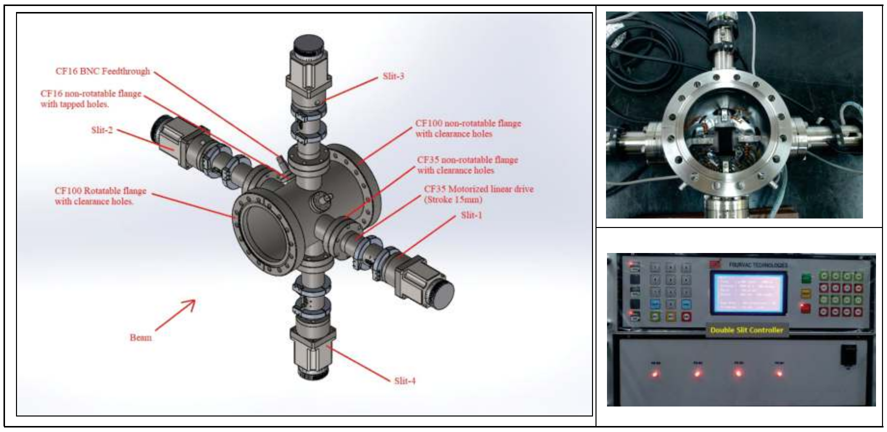


Figure 3.1: UHV Motorized Double Slit

Electronics for UHV Double slit consists of two numbers 3U, 19 inch instrument case. Power supply unit contains stepper motor drives and transformers for each channel and another unit consists of microcontroller based control circuitry with local control switch. Stepper motor is used for precise movement of slit jaws. Controller is having analogue voltage input for each of the four slits. Set positions and current positions are calculated with respect to voltage input of 0-5 DC voltage. Its fabrication is complete and final testing and few modifications in the controller are in process which will be completed shortly.

3.1.1.2 Development and Installation Work for High Current Injector (HCI)

a) **HCI remote control console in Pelletron control room** has been installed, and is now operational for HCI operation. Two CRO, two BPM selectors and a BPM digitizer computer are installed in the console. BPM signal distribution boxes are also installed, one in control room and one in beamhall-3 local console. Remote viewing camera (5 nos.) display and selection for monitoring different readings in beam hall 3 is provided.

b) **Design and Fabrication of BPM signal distribution box**

In high current injector (HCI) presently, 7 numbers of beam profile monitors (BPM) are installed and 7 more will be installed in the HCI high energy beam transport (HEBT) section. These were being operated from local control console in beamhall 3. In view of the radiation safety, a new remote control console has been installed in the main (Pelletron) control room.

All the BPMs need to be operated from beam hall-3 and as well as from Pelletron control room. Two units of BPM signal distribution box have been designed, fabricated & assembled. One unit each is installed in the main control room and in the beamhall 3 local control console. There are 4 parallel sets of 16 channels for BPM operation. One set of 16 channels is dedicated for BPM digitizer and output from these channels can be used to display beam profile on computer display. All the required cables have been installed & connection established. Both the units are in parallel and can be used to operate BPM.

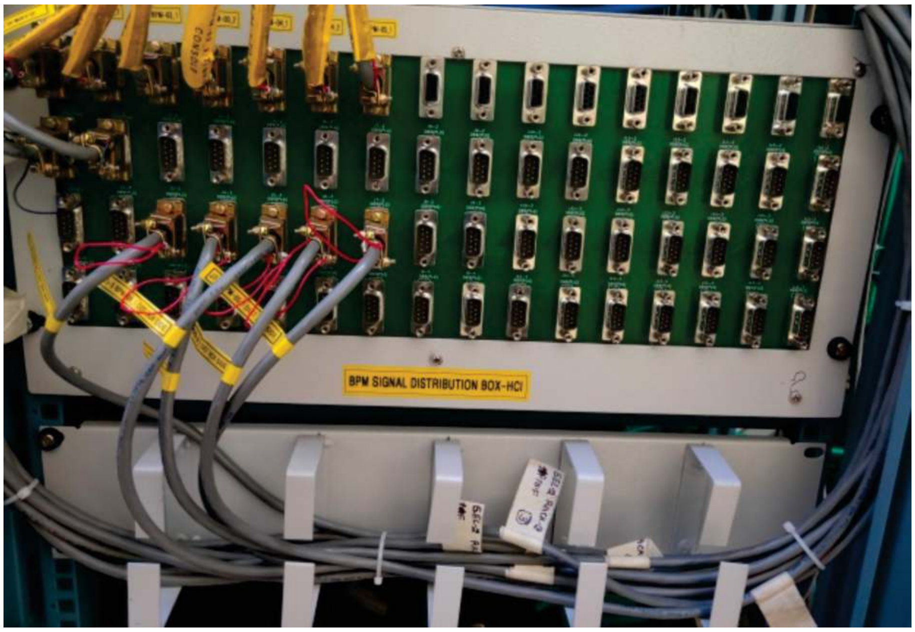


Figure 3.2: 16 - Channel BPM Signal Distribution Box

c) **HCI high voltage cage door Interlock**: An interlock unit for interlocking the doors of high voltage cage with the 200 kV HV power supply has been designed, fabricated and installed. High voltage (HV) power supply supplies power to the HV platform. Limit switches were installed on all the cage doors and connected with the interlock system. All the doors need to be closed in order to switch on the HV power supply. Interlock failure display for each door is provided on the interlock unit and output signal for the same is available for remote interface.

d) Fabrication of new communication cables for remote control of LLRF controllers of RFQ, spiral buncher and DTL cavities was done and laid through the cable trays as per controllers position. These cables were made as per signal requirement on controller side and terminated with 37/25 pin D connectors and terminated on the other side for connection with VME strips. A total of 8 sets of cables were made for remote operation.

3.1.1.3 Restoration of Vacuum system and Beamline diagnostic devices in AMS/Proton beamline

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

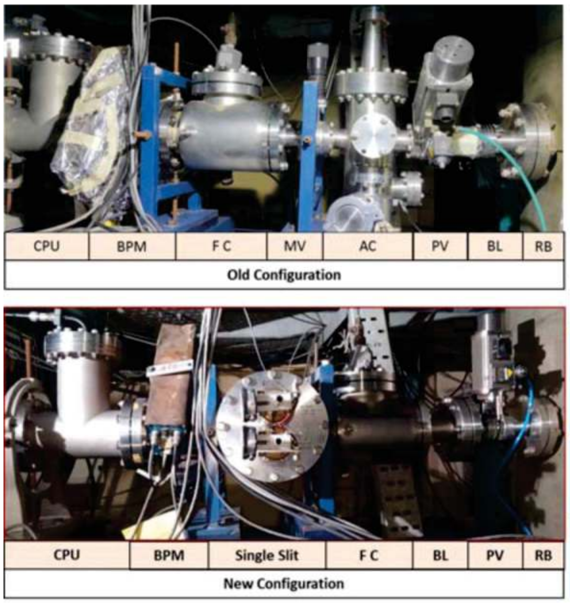
AMS beamline was modified last year as per new beam optics to make it compatible for proton beam experiments. The alignment and installation was completed last year. This year its vacuum system has been repaired and made functional and the high vacuum has been restored. All the control and read back connections to the BPM, faraday cup and beamline valves have been restored. All beamline devices were made operational in local as well as in remote mode. A beam test in the beamline was successfully carried out and operation of all the devices and alignment of the installed components were found ok.

3.1.1.4 New Vacuum Interlock system for mobile Pumping System

A new vacuum interlock system for existing mobile pumping system was fabricated by assembling component PCBs and required components. Its front panel has ON/OFF switches for roughing valve, backing valve, high vacuum valve, turbo pump and roughing pump. All the components are interlocked for fail safe operation of the system and status of all the devices are available on front panel. It is installed with the mobile pumping system, tested and is operational.

3.1.1.5 Installation of High Power Slit (1 kW) for Phase –II experiments

A high power water cooled slit (NEC make, 1 kW) has been installed in phase-II, 07 area just before Re-buncher. The space for the slit was created by removing the installed aperture cross (DN40 CF cross with aperture mounted on a linear motion feedthrough) as it was unable to serve the beam defining requirements for experiments in NAND and HYRA beamline. This slit is a single plane slit and it is installed at the exit flange of BPM 07-2 for defining the beam in X-X plane. Slit is positioned between BPM and faraday cup and beam enters from BPM and exits from faraday cup. After installation slit's exit flange position with respect to beam axis is about 2 mm down and 0.5 mm right (towards cryogenic room). Position of both slit jaws has been noted for beam axis position (centre) and is given in figure 3.3 below.



CPU- Capacity Pick-up
MV - Manual Valve
BPM- Beam Profile Monitor
BL- Bellow
PV- Pneumatic Valve
AC- Aperture cross
FC – Faraday Cup
RB- Re-Buncher

Readings at Beam center

Slit Name	Big Circular scale reading	Small Circular scale reading
Far Side	0	0
Near Side	50	Between 0 and 1

Figure 3.3: Single Slit Installation in Phase -II

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

(a) Vacuum problem in Phase-1 material science

Material Sc. Beamline got accidentally vented by user side in Phase -1 material science chamber. The beamline and switching magnet area got vented up to 10 mbar. Beam line ion pump and switching magnet ion pump got shorted, needed to be replaced. Pelletron 04 area vacuum was good and got protected because of fast closing valve protection system. Venting of the material science beamline and switching magnet area was done and vacuum disturbance in other beamlines was observed during venting to detect any through leak in the different vacuum beamline valves. No through leak was detected in any of the beamline valves located in phase -1 switching magnet area. Faulty ion pump was replaced, followed by baking, leak testing and vacuum pumping. High vacuum in the area was restored in 3-4 days.

(b) Vacuum Breakdown in zero degree section of low energy ion beam facility (LEIBF)

Vacuum failure happened in the zero degree section of LEIBF between high voltage platform and switching magnet. On investigation we detected two major vacuum leaks, one in the faraday cup (FC) assembly having leak of about 5 x 10^{-4} mbar l/s and another in the double slit assembly at the Y plane slit module having leak of about 2 x 10^{-6} mbar l/s. Both the faulty assembly i.e. FC assembly and Y plane slit assembly were removed and FC assembly has been replaced with a spare whereas the Y plane slit mounting port is blanked off due to unavailability of spare module. The beamline ion pump was also found shorted in high voltage test and it was removed and replaced with available spare pump. Post baking the beamline was leak tested ok and vacuum of about 2 x 10^{-8} mbar was achieved in the beamline.

The reason for these leaks appears to be due to interruption in the cooling water line that is connected to the faraday cup and double slit. To prevent this type of failure in future water flow switch connection has been provided for interlocking the high voltage platform power supply (400 kV) with cooling water flow. The flow switch display was not working so a new display switch was procure and installed with the switch. Minor leaks in the slit cooling connections were also rectified.

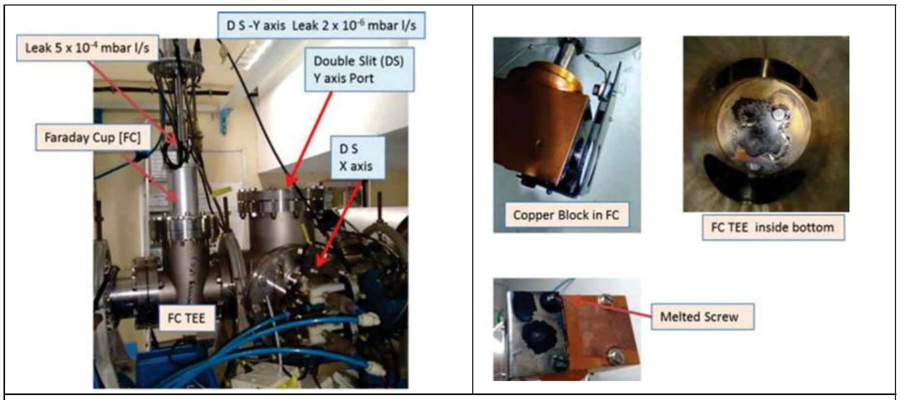


Figure 3.4 : FC and Double slit leak problem in LEIBF

(c) Electrostatic Quadrupole Triplet HV power problem in HCI

HCI Operation reported that EQT installed in the high voltage platform was having problem and –X power supply read back was not coming. After investigating it was found that –X power supply was not working and two others were loading above 4 kV. All the six HV feedthrough were insulation tested at 5 kV and were found OK. All the four power supplies were tested in manual mode and were found OK. During testing in remote connection it was detected that current control setting was at zero and due to this power was not getting delivered to the feedthrough. As this control option is not required for operation and to prevent this type of problem in future, remote current control program option in all the power supplies was shorted. The problem was resolved.

(d) **Re-arranging and power distribution marking in HCI beam hall 3:** All the cables (power, signal and interlock) connected to pumping systems in HCI were re-routed and controllers placed properly for better space utilization. UPS power distribution from main distribution panel to all sub distribution boxes and different instrument racks for all the equipment was marked for easy identification and operation.

(e) LINAC Turbo Pumps Electronics Problem

Chandra Pal, A. Kothari, P. Barua, Abhishek Rai

IUAC has three big LINAC modules namely LINAC 1,2 and 3. These are big vacuum chambers are pumped by high capacity turbo pumps. LINAC 1 and 3 are pumped by Pfeiffer Make Turbo Pump HiPace 2300 with electronics TC 1200 (integrated electronics under the pump). These two pumps are running since 2012. In 10 years three nos. of its electronics [TC1200] have failed and these were replaced with available spares. Two TC1200 were to Pfeiffer service center and the company declared these units beyond repair. During LINAC tuning LINAC group informed that the pump HI Pace 2300 was getting off during the tuning and the observations affecting turbo pump operation are shown in table below. It is felt that the problem could be occurring due to exposure of the control electronics to high x-rays radiation.

Observation during LINAC tuning

S. No.	Duty Cycle Power On Time/Power Off Time	Voltage across electrode	Field	Observation
1	25% Pulse cycle ON time = 25% OFF = 75%	800 kV	8 MV/m	Turbo keeps getting off, showing error.
2	10%, Pulse Cycle ON time = 10% OFF = 90%	800 kV	8 MV/m	No problem observed in turbo pump
3	Continous powering cycle	250 kV	3 MV/m	No Problem observed turbo pump

(f) Replacement of Faulty Vacuum Devices in different beamlines and facilities

Due to continuous and non-stop operation of vacuum devices, few get bad and had to be replaced from available spares for not stop operations. A list of replaced vacuum and diagnostic devices is given below:-

1) MKS gauge controller replacement in HCI RFQ.
2) MKS gauge controller replacement is in Negative Ion Implanter facility, from their spares.
3) Scroll Pump (backing pump in Mat. Sc. Group pumping trolley) replaced with rotary pump.
4) Turbo Electronics DCU 200 replaced in NAND diagnostic box turbo pumping system.
5) MKS full range gauge head and MKS controller replaced in LINAC – II.
6) Ion Pump controller replaced in IP-06-1 ion pump.
7) Faraday cup controller in phase – II NAND beamline.
8) MKS full range gauge replaced in HCI high voltage platform diagnostic box.
9) Maxi Gauge controller gauge replaced in HCI high voltage platform.
10) PBR full range gauge replaced in HCI DTL- 6.
11) Penning gauge replaced in GPSC chamber and Pirani gauge in Low Flux chamber.
12) DCU 200 turbo controller electronics replaced in INGA beamline.

(g) Miscellaneous Vacuum Maintenance Problems attended

There were about 100 calls related to vacuum problems that were attended in different beamlines and experimental facilities. Some common calls are listed below:-

BLV / FC are not closing - opening: caused by **c**ompressed air failure, problem in pneumatic drives, camac problems, radiation interlock problems, solenoid valves problems, Reset not done, vacuum pump off / gauge problems, etc. We identify the cause and resolve the issue or convey to other groups if its in their scope. For easy diagnostic we have incorporated by pass system to immediately identify interlock problem from switching magnet/radiation interlock for phase 2.

Vacuum not OK**:** Gauge problem, pump off due to power failure, huge outgassing due to target, leak from joints, pump electronics problem, pump failure, user mistake, etc. problems are identified and resolved, user is advised for leak testing and proper sequence of operation to be followed.

Venting/ Vacuum Pumping: in beamlines / HCI area

Theodolite setting for Target ladder / Detector alignment for experiment

3.1.1.7 Maintenance Work in Pelletron (with Pelletron group)

Stripper foils of the foil stripper in tank terminal and high energy dead section were changed by the Pelletron group. Venting for foil loading and leak check and vacuum restoration after foil loading was done for both sections separately in two phases first in the terminal area and secondly in the high energy section of the tank. Ion gauge at tank bottom (IGC 03-1) was having problem so that area (03 area) was also vented along with the venting high energy section and the ion gauge was replaced with available spares. All the joints were leak tested after baking and found ok in both the vented areas. However, presence of slow leak of about 2.0x 10^{-9} mbar l/s was detected in the terminal section. *This leak was confirmed in Jan 2021 during schedule maintenance but it could not be located due to its slow response. As it was not creating problem in vacuum of terminal area, it was left as it is.*

3.1.2 CRYOGENICS AND APPLIED SUPERCONDUCTIVITY

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

3.1.2.1 Introduction

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

3.1.2.2 Helium refrigerator

During this academic year, the helium refrigerator (*Model- LR280, LINDE Kryotecnik*) having a capacity of 750W@4.5K was operated twice for the duration of ~3450 hours. In the first LINAC run, the refrigerator was operated for 938 hours. During this period, five beamline cryostats were cooled to 4.2K for the acceleration of the beam using all superconducting cavities. The LINAC run had to be abandoned midway without any beam acceleration or user experiments due to the sudden upsurge in Covid cases during the second wave of the pandemic. In the second LINAC run, the helium refrigerator was operated for ~ 2527 hours from Sept'21-Dec'21. Most of the planned beam experiments were performed during that period although 1st LINAC cryostat (LC-1) could not be operated due to a blockage in the LHe return line of the valve box 2 (VB-2) of the helium distribution network. The cool-down time of the helium refrigerator was ~ 20 hrs. and ~24 hrs. respectively for two LINAC runs. A different scheme was followed to cool down the helium refrigerator in the 2nd run which eventually took a longer time. The LN2 usage for the two runs were respectively 1.2 lakhs liters and 3.25 lakh liters.

During the first LINAC run, the LN2 valve controller (*make: SEIMENS*) in the inlet line of the LN2 for the cooling of the thermal shield of the LC-1 malfunctioned. Due to the non-availability of the same electro-pneumatic controller, a different controller (make: *SAMSON*) had been used for the same LN2 control valve with a necessary arrangement for proper mechanical fitment and new programming of the controller for the proper functioning.

3.1.2.3 Safety relief valve test of helium gas tanks

The safety test of high capacity relief valves of the helium gas storage tanks (5 Nos) was undertaken as per the recommendation of the IUAC safety council. Accordingly, a test bench was made for in-house testing of the safety relief valves in presence of the internal safety committee members. During the testing, the cracking pressure of the relief valves varied in the range of 250-260 psig, and the pop-off pressure was in the range of 270-290 psig. The nominal operating pressure of the system is in the range of 20-150 psi whereas, the maximum operating pressure of the helium compressor is 190 psig. The large pressure difference between the operating regime and the cracking pressure is due to the higher operating pressure of the helium storage tanks primarily designed according to the requirement of the old LHe plant (Make: CCI) which is not operational since 2012. Hence, all the relief valves have passed as per the annual safety audit. Similar testing will again be carried out in the next year as part of the annual preventive health check-up for the helium gas management system.

3.1.2.4 Development of an LHe level sensor as a temperature sensor

An existing helium level sensor having an active length of 30 cm was tested as a temperature sensor in the temperature range of 5K-300K, utilizing the basic principle of reduction of the electrical resistance of the superconducting level sensor due to the decrement of the surrounding temperature. As per the analytical calculation, a sensing current of 70 mA will result in a tolerable temperature rise of the wire, and the corresponding response time will be within one second. The resistance versus temperature (R-T) calibration of the level sensor was done inside a 100 using a silicon diode temperature sensor fixed to the body of the level sensor. The R-T calibration process was carried out using different excitation currents of 1mA, 10mA, and 70mA in a pulsed mode. The corresponding voltage response exhibited a linear response over the entire temperature range. The value of 70 mA current was finally chosen for its practical application as it enhances the sensitivity of the temperature measurement without compromising the requirement needed for the usual level measurement. Using a suitable transfer function, a cool down process for two different sensors having different active lengths installed in 2000 liter helium dewar and helium vessel of a LINAC cryostat were monitored with reasonable accuracy. Based on the experimental results, dual-purpose temperature-cum-level measuring electronics have been proposed, which can display both parameters in the same device depending on the thermal state of helium gas. The details of the experimental results can be found in reference [1].

References:

[1] A. Choudhury et.al. “Use of superconducting LHe level sensor as a temperature sensor and its applications”, Cryogenics, 121(2022)-103413.

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

Soumen Kar, Navneet Suman, Sankar Ram Theketthil, Ajit Nandwadekar Rajesh Kumar, S. K Saini, Rajesh Nirdoshi, Manoj Kumar, Joby Antony, and R.G. Sharma

A multi-institutional project on the development of a whole-body 1.5T superconducting MRI scanner funded by the Ministry of Electronics and Information Technology (MeitY) is going on at IUAC under the coordination of SAMEER-Mumbai (nodal agency). IUAC is primarily responsible for the development of a 1.5T superconducting magnet and zero-boil-off (ZBO) cryostat for the MRI scanner.

I. MRI magnet bobbin and winding

The fabrication of the integrated bobbin structure of the multi-coil 1.5T superconducting MRI magnet system is completed. The magnet has eight superconducting coils placed strategically in a mirror-symmetric manner to generate a field of 1.5T at the iso centre with ± 4ppm spatial homogeneity in a 45cm of the imaging volume. The solenoidal winding of the eight coils was done using Niobium-Titanium (NbTi) wire, having a critical temperature of 9.2K, at a predefined winding pre-tension. A high degree of packing factor was achieved during the winding of the coils with an optimized value of winding pretension. Various quench protection components were installed into the winding pack during its winding. Fig. 3.5 shows the solenoidal winding of the primary bobbin of the MRI magnet. The inner diameter and the length of the integrated bobbin are respectively ~1m and ~ 1.4m.

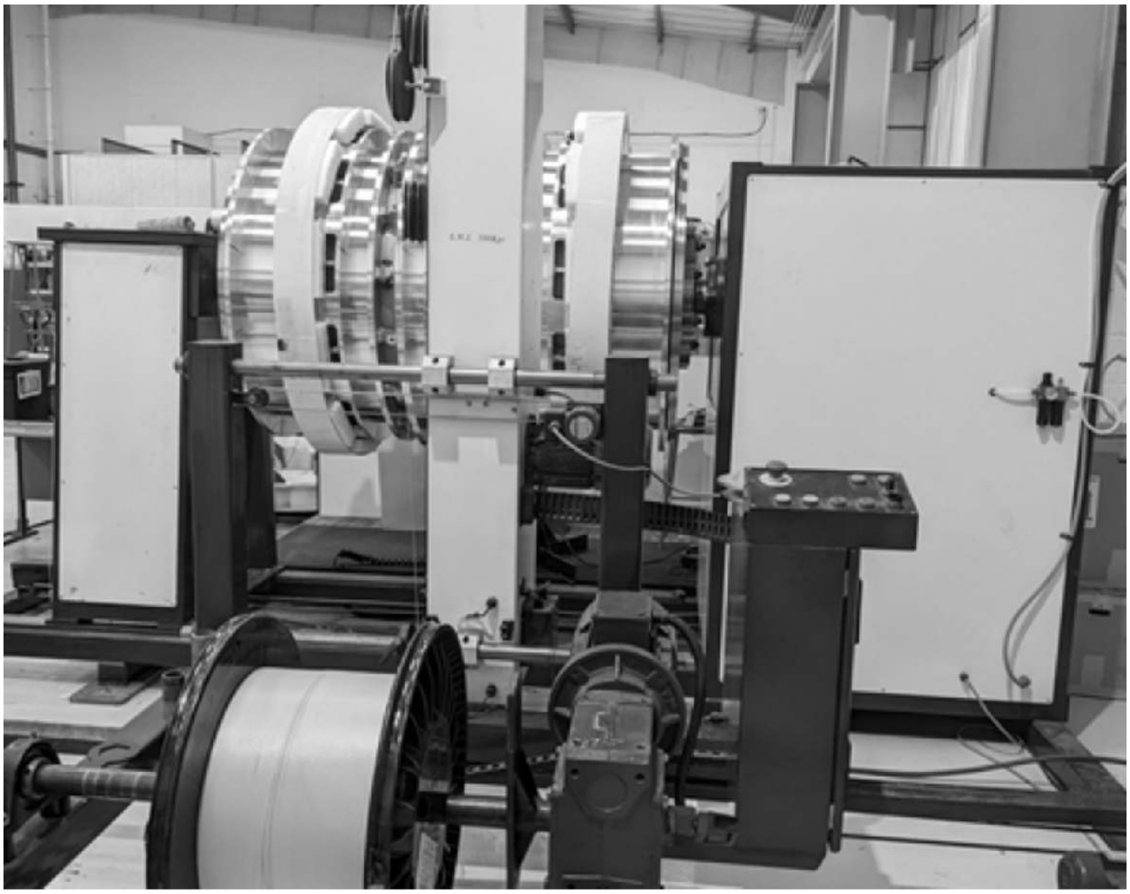
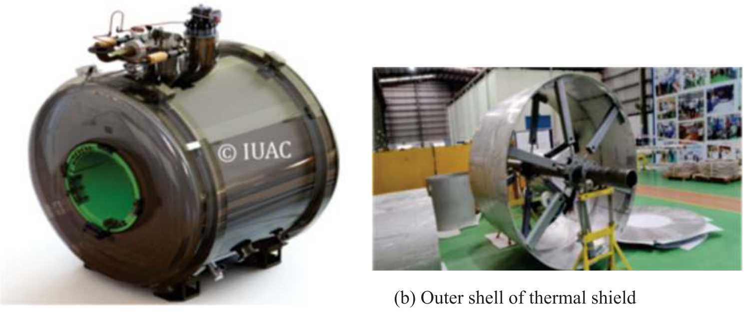


Fig. 3.5 The winding of the primary bobbin structure of the MRI magnet.

II. MRI cryostat

Fig. 3.6(a) shows the 3D CAD model of the Zero-Boil-Off (ZBO) MRI cryostat. The fabrication of the various components of the cryostat was completed to make it ready for integration with the magnet. Figures 3.6. (b) - (e) show the various major and minor components of the MRI cryostat fabricated in this academic year. A two-stage GM cryocooler (CCR) will be used to provide the cooling of the intermediate thermal shield and the refrigeration to the 4K to achieve ZBO condition. The first stage of the CCR is thermally connected to the intermediate radiation shield to maintain the temperature range of 40-50K. The outer shell and the end plates of the thermal shield are shown in Figures 3.6. (b) and (e). The ZBO condition is achieved by the localized recondensation of the helium vapor using a fin-based HX attached to the 2^{nd} stage of the CCR. Fig 3.6(d) shows the CCR port of the cryostat.



(b) Outer shell of thermal shield

(a) 3D CAD Model of MRI cryostat

(c) based HX (d) CCR port (e) Endplate of the shield

Fig. 3.6 Various components fabricated for the zero-boil-off MRI cryostat.

III. MRI magnet-cryostat assembly station

The magnet needs to be positioned precisely into the MRI cryostat maintaining the co-axiality at the patient bore. A rail-guided, spider-based assembly station (length ~ 6 m, height ~ 5.6 m, width ~ 3m) was fabricated and erected at the vendor's site at Vadovara. Fig. 3.7 shows the 3D CAD model of the magnet-cryostat assembly station. The assembly station has various versatile features having spider supports, central support, axial and radial movement mechanism, and hoist support to position and align various cylindrical components of the cryostat.

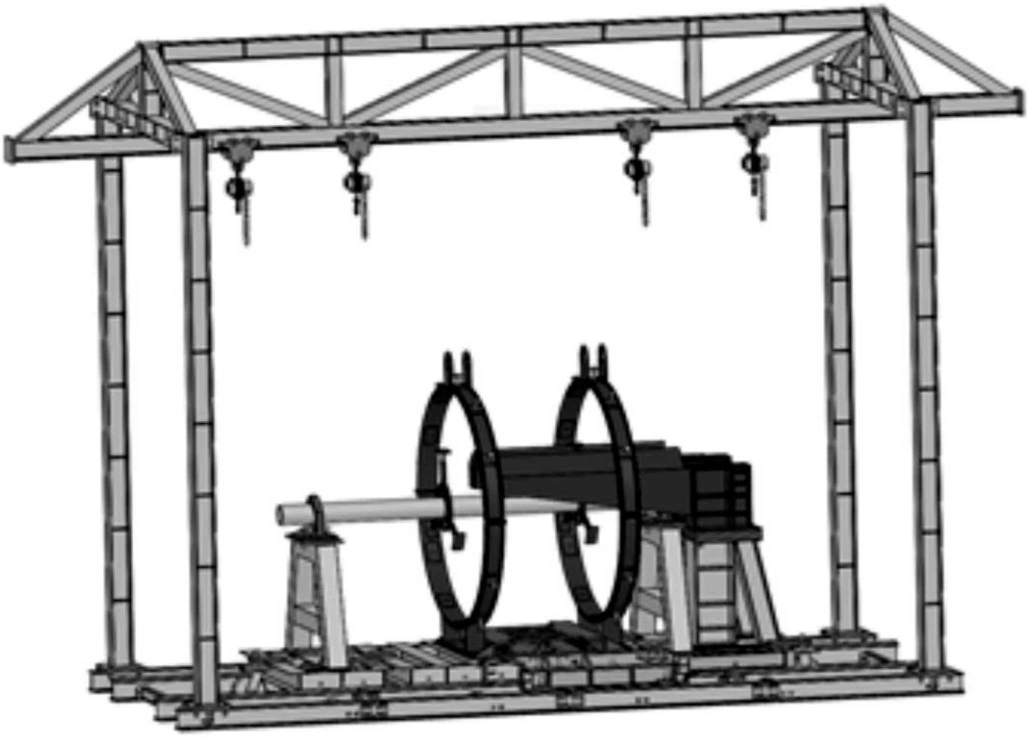


Fig. 3.7 The 3D CAD model of the magnet-cryostat assembly station.

Fig. 3.8 The magnet-cryostat assembly station of the whole-body MRI magnet system.

Fig. 3.8 shows the assembly station fabricated for the integration of the magnet with the cryostat. The entire assembly sequence is divided into fifty major assembly steps having various intermediate tasks not limited to helium leak testing, pressure testing, MLI wrapping, sensor mounting, etc. The integration of the magnet and the cryostat will soon be started at the vendor's site at Vadodara.

3.1.3 BEAM TRANSPORT SYSTEM (BTS):

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

Beam Transport System (BTS) Group is an Accelerator Central Support Group (AcSCG), responsible for the design, fabrication, installation and maintenance of magnet power supplies and other BTS associated instruments of all the accelerators and experimental facilities at IUAC.

Besides maintenance and repair activities, the group is actively involved in the design and development of BTS-magnet power supplies for the upcoming HCI and FEL facilities. The yearly activities related to upkeep, maintenance and developments are summarized below.

3.1.3.1 Beam Transport System upkeep and maintenance:

The equipments under beam transport system of all the accelerators at IUAC together with experimental facilities which include Pelletron, LINAC, HCI, LEIBF, NIBF, HIRA and HYRA is wide spread and very large in number. A large number of beam transport system-associated instruments which includes, magnets, magnet power supplies, remote control modules, magnetic field measuring instruments, beam line selection systems, etc. are in round-the-clock operation. All these instruments are serviced during the "Yearly Scheduled Preventive Maintenance (YSPM)" to keep the disruption of operation to a minimum and also to conserve the life span of the power supplies.

1. Yearly Scheduled Preventive Maintenance (YSPM) activities:

The BTS-YSPM is executed in time slots throughout the year in synchronization with the operation schedule of different accelerators and experimental facilities. To decide the preventive maintenance actions, the condition of every power supply is pre-analyzed. The systematic inspection and test procedure are followed to identify the potential problems before they lead to major failure. The main steps of preventive maintenance are: cleaning, physical inspection, changing the corroded/degraded parts, functional and safety interlock tests and performance tests at full power.

The BTS magnets are operated at 35-40°C maximum temperature to keep the impedance within range and also to minimize the corrosions related to cooling water. To certify proper cooling, the temperature of all the magnets is recorded at full power-and if found to be more than the specified safe range, the magnet coils are cleaned to remove the copper oxide scaling and sediments by circulating diluted sulphamic acid.

2. Cooling water related corrosions:

Early this year, symptoms of cooling water related corrosion was observed in the water-cooled copper components such as power supply heat-sinks and magnets. The rate and intensity of leaks in water-cooled heat sinks has increased, even some of the new heat sinks has developed leaks. The incidence of magnet heating due to oxide deposition and even complete blockage of water-cooled coils has increased.

Over the years, much has been analyzed and we learned about the factors affecting the corrosion rate and shared with cooling water system group. The dissolved oxygen concentration and the pH of low-conductivity water (LCW) is of critical importance at accelerator facilities and are not always maintained specifically at low conductivity cooling water plant at IUAC. An imbalance of water chemistry can have a direct impact on the water-cooled components.

3. Hydrogen Sulphide (H_2S) initiated corrosions and Power supply refurbishment:

Surface corrosions of power supply components and magnet coils are observed in the past few years. Silver-coated fuse holders, heat sinks of the transistor banks, high current copper bus bars and magnet coil joints are the most affected parts. In the first impression, the corrosion seems to be due to Hydrogen Sulphide (H_2S). In the neighborhood of the Laboratory complex, we have a waste water treatment plant and in the last few years a stagnant water pool has accumulated just near the experimental areas. The lab is in between these two probable H_2S sources. These air pollutants are reaching the indoor accelerator and experimental facilities. Small quantities of H_2S in the presence of humidity and dust form acidic coatings resulting in formation of an insulating layer. Several difficulties were encountered to ensure a consistent operation of power supplies due to the formation of insulating layers at many interconnections. To analyze~~,~~ why the power supplies are most affected, literature was surveyed and we found that the temperature played a significant role in the corrosion rate and is maximum at 35°C-40°C. Power supplies, being power handling devices, mostly operate at elevated temperatures. Silver-coated fuse holders of many power supplies were replaced with nickel-coated fuse holders. Nickel is less reactive with H_2S.This year, we refurbished and assembled the following; 17 numbers of transistor bank of model-853 power supplies; 02 numbers of leaked water-cooled rectifier module heat-sinks of HIRA quadrupole magnet power supplies; 03 numbers of transistor bank with emitter PCBs & cooing plate assembled as a spare or Danfysik system-858 quadrupole magnet power supplies.

4. BTS uptime and operational status:

The BTS power supplies are power handling devices, the resulting thermal stresses cause degradations; hence even after careful preventive maintenance breakdown in different section can't be ruled out completely. This year, there were 35 occasions when failures in BTS magnets and magnet power supplies disrupted the accelerator operation