and resulted in beam time loss of approximately 22 hrs. The major time loss was due to the breakdowns caused by leaks in water cooled heat sinks.

All the breakdowns were immediately attended by the BTS personnel, who work as a 24x7 on-call team, investigate the beam stoppage caused by the magnets and power supplies.The BTS systems are performing with required stability and do not need any immediate up-gradation.

5. Power supply installation area upkeep

All the power supply installation areas were cleaned and arranged. This has helped to reduce the dust levels inside the instruments and hence the H_2S and humidity related corrosions. While less technical in nature, house-keeping services are important pieces of preventive programme. An effective cleaning program improves indoor air quality and in turn slows down the corrosion effects.

6. Spare / redundant power supply fabrication

The cooling water related corrosion has resulted in increased failure in power section of magnet power supplies. In case the failure is in the power section, on-site component level repairing has to be done because power section is bulky and not modular. If the fault is major, to save time, the power supply is replaced with spare supply. To minimize the beam down-time, 03 numbers of discarded power supplies were refurbished using available spare parts to be used as redundant spare power supplies. These power supplies will be installed at appropriate locations to be used in case of major fault in any power supply. As the magnet power supplies are bulky, they cannot be shifted without proper planning and man power.

7. Power supply Electronic module repair activity

Component level repairs were performed at BTS Lab for the faulty electronics cards taken out during scheduled preventive maintenance and breakdown. No faulty electronic module is discarded. The following significant repairs are done this year; 10 nos. Auxiliary PS cards of Danfysik Sys 9100, for Sys 8000 the repairs of 03 control cards, 04 regulation modules, 03 IGOR interface modules and 02 Auxiliary power supply modules.

8. Fabrication of In-house designed magnet power supplies for HCI and FEL facility

BTS group has taken the responsibility to develop and fabricate in-house the low power (<500W) air-cooled magnet power supplies for High Current Injector facility (HCI) and Free Electron Laser (FEL) facilities.

These facilities need large numbers of such power supplies for steerer (±10A, bipolar type) & low power quadrupole (+20A, unipolar type) magnets. BTS group is fabricating 100 numbers of such power supplies out of which 80 numbers are for HCI and 20 numbers are for FEL.

So far, 50 units of such power supplies have been developed, installed and are in operation. The fabrication of 50 more units is going on, in which the fabrications of different sub-assemblies and control electronic modules have been completed last year. This year, 27 power supply units have been integrated using the last year assembled sub-assemblies. In the coming year, the integration and testing of all the units will be completed.

9. BTS Installation jobs

Beam transport system installation is a regular activity in the upcoming HCI & FEL accelerator facilities. The installation work consists of rack & rail installation, cable laying/routing for AC power, output DC power, remote control, safety interlocks, grounding, cooling water distribution, remote connections and testing at full power to verify the magnetic field and thermal performance.

Following are the significant BTS installation activities performed in this year. At HCI facility, 30 nos. of magnet power supplies were re-located to re-route and reduce the length of output DC current cables. Earlier the cables trays were very small in size with no perforation for cooling, resulting in heating of cables even at 50% of output current. At FEL facility, 02 nos. of in-house made steerer magnet power supplies were installed. In the newly developed Proton beam line in Beam Hall-I, the cabling work for all the magnets has been completed. Three numbers of RS232-based magnet power supply remote control server were installed at HCI & FEL.

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

Every year, BTS group performs the preventive maintenance of all types of Detector Bias -High Voltage Power Supplies (DB-HVPS) used in the **I**ndian **N**ational **G**amma **A**rray (INGA) and **N**ational **A**rray of **N**eutron **D**etectors (NAND) experimental facilities. All the DB-HVPS used in these two facilities were developed in-house by BTS group in 2007. Since then, every year all these are maintained by BTS group to ensure the required performance and trouble-free operation during operation.

3.1.3.2 Power Supply development activity

The BTS group has initiated development of three types of power supplies for magnetic devices, electrostatic devices and to bias the detectors respectively. For magnetic and electrostatic beam line devices, a high bandwidth bipolar design is chosen so that the same unit can be used for unipolar and bipolar applications. For all types of detector bias HV power supplies (Ge, MCP, PMT, Si & Gas detectors), a common design and unit will be made to minimize the inventory. The first objective of the development is to develop versatile, multi-use power supplies to minimize the types of power supplies used at IUAC. This will simplify the manpower training and maintenance efforts and minimize the spare part inventory.

Design of the core amplifier circuits (without user interfaces) and magnetic components has been completed for all the three projects. PCB design and assembly of first prototype to test the design feasibility is in progress for each type. Once the feasibility test of the core amplifier design is completed, a complete instrument design will be taken up considering all the controllability and functionality.

3.1.3.3 Instrument repair support for other than BTS instruments

BTS group has been providing extensive instrument repair services in the field of power supplies and power electronics to other labs at IUAC as well as to the other institutes. This year, following instruments were repaired by BTS group members; High temperature Furnace of IUAC-Mat. Sc. facility, PWM-based slow tuner controller of IUAC LINAC facility. Repair of PPFM Power Supply, dipole magnet power supply (±6A/70V) and design/ assembly of 100ADC capacity Polarity reversal switch for Thin Film Laboratory (TFL) Department of Physics of IIT -Delhi

3.1.4 DETECTOR LABORATORY

Mohit Kumar, Akhil Jhingan

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

3.1.4.1 Transfer Induced Fission setup in NAND

A. Jhingan, M. Kumar, N. Saneesh, A. Punia*, K.S. Golda, B.R. Behera*, P. Sugathan.
* Panjab University, Chandigarh

A new detection system used for performing transfer induced fission experiments or surrogate reaction was prepared in NAND. The detection system has two silicon strip detector (SSD) telescopes, for detecting projectile like multi-nucleon transfer products, along with two MWPCs for coincident detection of transfer induced fission fragments. Each SSD telescope comprised of two SSDs in ΔE-E configuration having a thin 40 μm SSD at the entrance followed by a 300 μm SSD. All the four SSDs are model-W from Micron Semiconductor UK, having an active area of 5 x 5 cm^2 with 16 horizontally stacked strips on junction side and 16 vertically stacked strips on ohmic side. To reduce the requirement of electronics, 16 horizontal strips from ΔE and 16 vertical strips from E detector were processed so as to have 256 pixels (16 x 16) from each telescope. Remaining strips in each SSD were shorted and then processed as a unit signal (separately for each SSD) using a four channel home made preamplifier unit. The mounted detector system is shown in fig.3.9. The system was used to study the surrogate reactions for the system $^{28}Si + ^{232}Th$ @ 190 MeV with the Pelletron-LINAC system.

Fig.3.9: Detector system for transfer induced fission experiment.

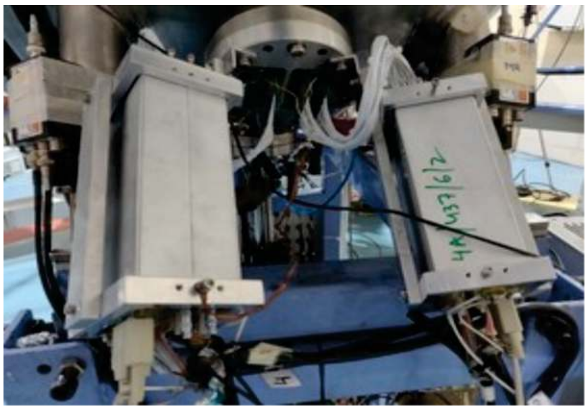


Fig. 3.10: Mesytec preamplifier units mounted on flange for SSD signal processing.

Signal processing of SSDs was realized with 32 channel model no. MPR-32 preamplifier units from MESYTEC followed by STM16+ spectroscopy amplifier units. Further processing was performed with the VME based data acquisition system in NAND. Special fixtures were prepared to mount the SSDs in NAND scattering chamber. Further to have noise free signal processing, special mechanical fixtures were prepared to mount the preamplifier units coupled to the scattering chamber feed-through port. A special feed-through flange compatible with CF100 port was prepared which has four FRC 34 pin connectors. These can transmit a total of 128 signals. In present case, 64 SSD signals were transferred to preamplifier units using this feed-through flange. Fig. 3.10 shows the two units of

MPR-32 mounted with the feed-through flange. For signal transmission, special multi-pin cables compatible with FRC34 connectors (in SSD and feed-through flange) and D-Connector (25 pin) for MPR-32 units were also fabricated. These cables were prepared using thin shielded coaxial cables. Fig.1 and fig.2 shows these cables inside the chamber (from detector to flange) and outside the chamber (from flange to MPR-32 input). The differential signals from the MPR-32 units are then transmitted through four 34 pin and 100 feet long round and shielded twisted pair cables to the NAND data acquisition room.

3.1.4.2 Repair of APPAC and Fission detectors for NAND/GPSC

The Annular Parallel Plate Avalanche Counter (APPAC) was found to be damaged. The cathode foil had developed wrinkles and cracks at many junction points of segmentation. The entrance window was also damaged. A new cathode foil (aluminised on one side) was prepared on the same frame and was segmented into 16 parts. The damaged foil was also replaced with a new one. The APPAC detector system was installed in the GDA beam line for performing Coulex experiment. The entire beam line had to be open and disconnected from GPSC. The detector system was carefully aligned along with installation of gas handling system. The detector was used to study the coulomb excitation of $^{32}S + ^{64,68,70}Zn$ system. The pair of multi-step proportional counters used for fission experiments in GPSC (2004-2013) were refurbished by replacing their electrodes (all wire frames), the performance of which had deteriorated due to sagging of wires and aging effects. Old wires were carefully removed and new wires were soldered on the same frame. The detectors will be tested in coming days for their performance.

3.1.4.3 CsI detector and MWPC setup in NAND

M. Kumar, A. Jhingan, H. Arora*, N. Saneesh, K. S. Golda, B. R. Behera*, P. Sugathan.
* Panjab University, Chandigarh

Two position sensitive MWPC developed earlier for GPSC were installed in NAND along with 16 CsI detectors (coupled to photo-diodes). The multi-step MWPCs were modified to conventional 3 electrode design with central cathode mylar foil (aluminized on both sides) sandwiched between position anodes. The X position wire frame was also modified by reducing the wire pitch from 1.27 mm to 0.63 mm for enhanced gains. The detectors were used to detect fusion ERs at angles from 4 to 15 degrees for the system $^{48}Ti + ^{48}Ti$. The ERs were detected in coincidence with neutrons and light charged particles. Neutrons were detected in 16 liquid scintillators of NAND setup, and light charge particles were detected in 16 CsI scintillators. Active area of the MWPC detector is 10 x 5 cm^2. At very forward angles, the detector was exposed to particle count rates as high as 10^5 pps along with high intensity delta rays (~ 10^6 pps). The survival and long term stability of the MWPC at such high rates was established. Fig. 3.11 shows the setup inside NAND scattering chamber. CsI detectors were also used to investigate fission gated light charge particle multiplicity for the system $^{12}C + ^{198}Pt$ with the setup shown in Fig. 3.12. In this case MWPCs with area 20 x 10 cm^2 were used for the detection of fission fragments.

Fig. 3.11: Setup for ER gated light charge particle and neutron experiment.

Fig. 3.12: Setup for fission gated light charge particle and neutron experiment.

3.1.4.4 Developments for CPDA in INGA

Multi-channel charge sensitive preamplifier (CSPA) units were fabricated for CPDA in INGA. Different types of cards were prepared. One card has 4 CSPA units in 2x2 format and will hold 4 CsI detectors on the other side of the printed circuit board. Other design has 8 CSPA units on the same board for 8 CsI detectors. Size of these detectors is

2 x 2 cm^2. Another 4 channel card has been prepared for mounting four 1.5 x 1.5 cm^2 CsI detectors. For signal transmission of preamplifier signals, a differential receiver cum driver module has been developed. This 16-channel module will receive single ended preamplifier (mounted inside vacuum chamber) signals and convert them into differential signals which will driven to MESYTEC spectroscopy amplifiers. This 16-channel receiver-driver system is housed inside a double width NIM module. The earlier version of the same had LEMO inputs and FRC output. The new module has FRC input (differential) and FRC output (differential). This eliminates the need of LEMO connectors and cables which may not be desirable for large number of signals in the future. These instruments have been tested with the pulser. They will be integrated with detectors and tested with radioactive sources for performance evaluation in the second half of 2022.

3.1.4.5 Multi-channel FTA for MWPC and MCP detector system

Multi-channel fast timing amplifiers (FTA) units were fabricated for use with fast timing detectors such as MWPC and MCP. A pair of 5-channel FTA (one for master timing and four for positions signals) was fabricated for MWPC readout in NAND/GPSC. The earlier versions of FTA used in-vacuum in NAND were housed inside aluminum boxes which due to their volume was a source of scattering for neutrons and gamma rays, along with additional stress on cables and connectors. New FTA cards are covered with copper clad thin (1.6 mm thick) FR4 board for shielding. The RG316 cable is directly soldered on this card thus eliminating the use of bulky BNC connectors. These units have been used in-vacuum with MWPCs for fission experiments in the Pelletron LINAC experiments. Fig. 3.13 shows one of the assembled unit. Performance has been identical to the metal boxes with BNC connectors. An eight channel FTA box has been fabricated for HEXanode MCP detectors. This has six inverting channels for position (delay line) signals and two non-inverting channels for master timing output. It has been made using two 4-channel FTA cards which are housed inside a machined aluminum box having BNC connectors. The FTA has been tested with the pulser, and will be used with the MCP detector to perform molecular physics experiments using the LEIBF. Fig.3.14 shows the assembled 8-channel FTA unit.

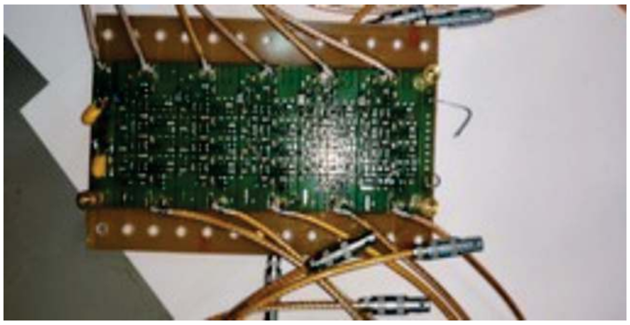


Fig. 3.13: FTA unit for MWPC readout.

Fig. 3.14: FTA unit for MCP detector.

3.1.4.6 MWPC setup for INGA

Two position sensitive MWPC are being developed for use with INGA. The detectors are intended to explore the feasibility of heavy-ion gamma coincidence experiments. The prototype detectors have an active area of 25 x 25 mm^2. They have 3 electrode design with central cathode mylar foil (aluminized on both sides) sandwiched between position anodes. The X-position wire frame has 0.63 mm wire pitch. Y-position frame is realized with etched strips on printed circuit board frame. To avoid material medium resulting in gamma attenuation, the housing of MWPC is prepared from low density plexi-glass material. It is proposed to test the system in first half of 2023.

3.1.4.7 TEGIC Detector for NUSTAR collaboration

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

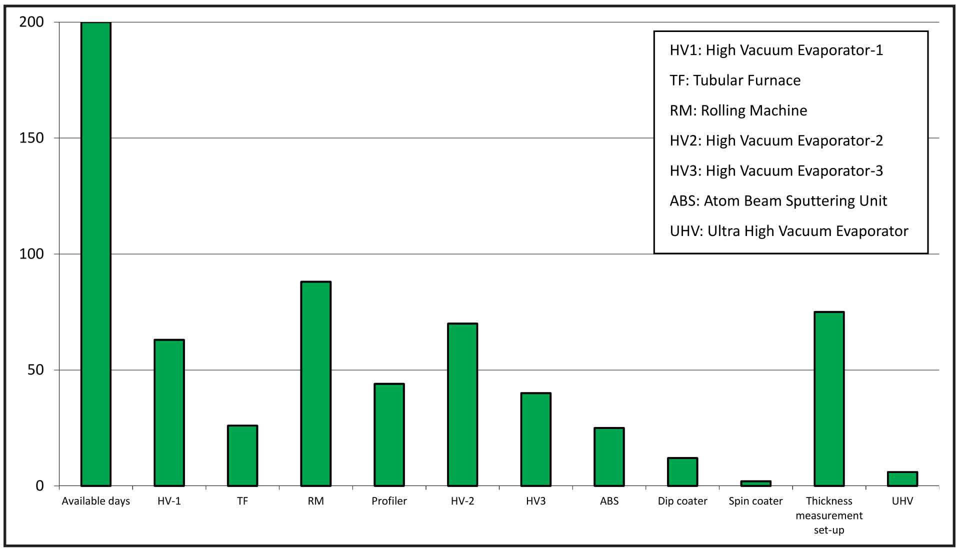
TEGIC detector was shipped to GSI, Darmstadt in February/March 2020 for performing test measurements with UNILAC-SIS18 accelerator system. Due to Covid pandemic, test measurements were postponed to 2021. Some damage to thin electrode foils and electrode mounting assembly were reported in transportation. The detector was repaired in the detector laboratory of FRS group at GSI. Mounting rail assembly for TEGIC was prepared in the GSI mechanical workshop. The detector was mounted in the CAVE experimental area after the FRS facility. Due to Covid restrictions and funding issues, travel to GSI for detector testing could not be organized. With the help of GSI personals, the detector was tested for a short time (parasitic beam time) with accelerated ions in mass A ~ 100 region at energies around 100 MeV/A. Severe noise issues have been observed with signals from the detector. Detector biasing issues have also been reported. Troubleshooting and further tests will be performed in future, subject to the availability of travel funds from IFCC and Covid situation.

3.1.5 TARGET LABORATORY

Abhilash S R, Ambuj Mishra and D Kabiraj

3.1.5.1 Introduction

The primary responsibilities of target development lab (TDL) are operation and maintenance of instruments in target development lab for developing and delivering the nuclear targets and thin films for accelerator users. The disruptions brought in by COVID-19 have affected the user related activities in target lab as well. However, target lab is successful in delivering several targets for accelerator experiments and several research scholars have been trained in thin film deposition techniques in this year. Most of the instruments in target lab are well–utilized in this year. Man-machine utilization in target development laboratory is shown in the bar chart given below.



Utilization of facilities in 2021-2022

The utilization of facilities indicates that more than two facilities of target lab have been used every working day. More than 100 evaporation attempts were performed for target fabrication in different systems for the completion of target requests of users of various streams viz., material science, nuclear physics, and atomic physics. Target lab has successfully delivered more than 275 nuclear targets this year. Target developments in Inter-University Accelerator Centre (IUAC) were also reported in peer-reviewed journals and national symposiums this year [1-6].

3.1.5.2 Developments of targets of high melting point metals

Due to the involvement of a huge amount of heat, the target development of high melting point metals by physical vapor deposition (PVD) remains a challenging task. Extensive works have been done this year to develop targets of high melting point metals. PVD by e-beam heating is one of the methods of choice for the thin target fabrication of high melting metals. An evaporator equipped with 6 kW e-gun is used for this purpose. Most of the cases the metals are deposited on carbon thin film used as backing or support. These films are grown on glass slides coated with a parting agent. The radiation heat produced during e-beam heating of the metal raises the carbon coated glass slides to high temperature which tend to degrade the parting layer. Target lab has successfully optimized a few parting agents which can withstand the high temperature. Thin foils of carbon film with KCl, NaCl, $BaCl_2$ of 100 nm as parting agent consistently withstand the substrate temperature during the e-beam evaporation. A standard procedure for stress relieving of the target film has also been developed in IUAC. The annealing of the targets in an argon or nitrogen environment at 200-325^{0}C significantly minimizes the stress in the film. The stress-relived targets exhibit remarkable stability during the experiments. The XRF spectrum of the target of ^{187}Re, the metal with the second highest melting point is shown in Figure. 3.15. Which indicate that the targets developed by this procedure are free from major contamination of high Z element. TDL has successfully developed and supplied several targets of high melting point metals with maximum evaporation yield, viz. W, Re, Ir, Ta, Hf, and Mo for the nuclear physics experiments in IUAC and other Accelerator labs in India [3, 4]

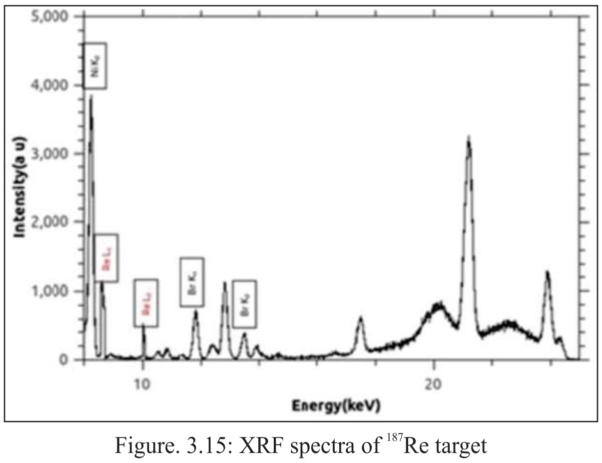


Figure. 3.15: XRF spectra of ^{187}Re target

3.1.5.3 Target library for users

Figure. 3.16: Target Library in IUAC

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

More than 1189 targets are already part of the library and more efforts are in progress to bring more targets under the library with a digital inventory. Target library has issued more than 79 targets in 2021 from this library. In order to meet the unexpected demand, 400 carbon stripper foils are also available in the library. A list of targets and their specifications are available in the digital form and users can access the same for planning their experiments.

3.1.5.4 Fabrication, Inspection, and Loading of stripper foils

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

3.1.5.5 Maintenance and up-gradation activities in Target Lab

Vacuum coating units and supporting systems in the target lab are essentially the combination of several instruments viz; vacuum pumps, gauges, vacuum sealing components, cooling systems, power supplies, quartz crystal sensors, and evaporation sources. The periodic and regular maintenance activities of instruments for ensuring the efficient functioning of the facilities are important. In the evaporator (having arc suppressed e-gun), precise positioning of the beam on the tiny target material was difficult due to lack of visibility through the viewport. The re-positioning of the e-beam source to remove this obstacle was the major facility up-gradation work in TDL this year. The disassembly of the e-beam source, modification in the e-beam source assembly, and leak-testing were done with the support of an in-house machine shop facility in IUAC.

3.1.5.6 Activities in photo-cathode development

The Photo-cathode Deposition Facility is in the final stage of installation at IUAC. The facility was fabricated under the strategic partnership between IUAC and Brookhaven National Laboratory (BNL), USA. The facility is designed to fabricate and transfer the photo cathode into an RF gun along with the provision of preserving the photo cathode in the range of ~10^{-11} m bar [5]. The initial plan is to prepare the thin film of Cs_2Te on the Molybdenum substrate. However, the facility is designed to develop the photo cathodes of advanced materials like CsK_2Sb also [6]. The photo cathode preparation and in-vacuum-transfer facility has got the following set-up (i) laser cleaning of the photo cathode substrate, (ii) evaporation sources with load-lock mechanism, (iii) quantum efficiency measurement system, and (iv) provision for long time storage of cathodes with minimal residual gas poisoning. All the vacuum chambers are interconnected where magnetically coupled vacuum manipulators are used to transfer the cathodes under a vacuum environment of ~10^{-11} m bar [7]. Designing of the facility within the available space, material specifications of each component for ensuring minimal out-gassing load to the pumping station, designing the pumping station, in-vacuum transfer of cathodes, and the source design are the major constraints during the development. After the fabrication at BNL, the setup was assembled and tested prior to shipment to IUAC in the middle of the year. The installation of the setup is in progress at IUAC and testing is expected in the middle of 2022.

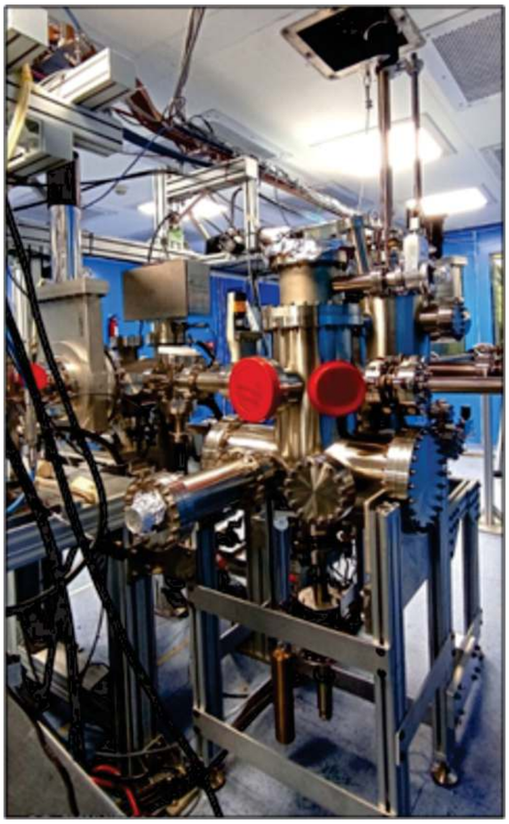


Figure 3.17: Photocathode deposition facility under installation stage at IUAC

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3.1.6 Radio Frequency Amplifier Group (RFA-AcSCG)

Arti Gupta, Parmanand Singh, Yaduvansh Mathur, S.Venkataramanan, Rajeev Mehta

RF Power amplifiers of Pelletron, HCI

During this year RFA group has been actively involved in repairing, restoring and undertaking periodic preventive maintenance of various high power microwave power sources and Radio Frequency power amplifiers that are installed with various RF cavities of High Current Injector (HCI) and other accelerator facilities at IUAC. Throughout this year all power amplifiers and power sources were in continuous operation at different power levels. The power amplifiers installed are of both water and air cooled types. The water flow to the power amplifiers have been normalized and water pressure has been optimized and set with pressure reduction valves (PRV). The cooling water quality to HCI installed equipment is also monitored and replenished whenever necessary. The remote control and monitoring for remote operations have been completed with majority of the power amplifiers. Major preventive maintenance operation of all power amplifiers under care have been completed and documented in this period. The power amplifiers are frequently cleaned for accumulated dust on air filters and water filters are cleaned to prevent any debris choking the filters and reducing the water flow. Purchase of required spare components, repair kits, sub-units, spare power supplies and various consumables have been initiated for maintaining a stock of required spare components in order to ensure efficient operation of power amplifiers.

Microwave Power Generators

We have been taking care of the aging 1.7kW, 17.9GHz Klystron Power Generator for ECR ion source of HCI at