3. RESEARCH SUPPORT FACILITIES

3.1 HIGH VACUUM LABORATORY

M. Archunan, A.Kothari, P.Barua and A. Mandal

There was regular involvement with the Pelletron group in maintenance activities, scheduled and emergency, requiring vacuum operations, maintenance of vacuum pumps and installation of critical components. Beam line components of INGA beam line in phase II were dismantled and reinstalled with a few modifications for accommodating the INGA structure in the beam hall.

3.1.1 Design of Diagnostic Box

A Diagnostic box having a BPM, a Double slit, a Faraday cup and a pumping port has been designed as a single unit to accommodate all the diagnostic components in limited space. The individual components have already been bought from respective vendors. An eight inch CF port for mounting a turbo pump is also provided. The length of the housing is 600 mm.

3.1.2 Modifications in Material Science-I Experimental Chamber

The Diffusion pump installed in the Material Science Experimental Chamber was removed this year and a few modifications required were done for the Vacuum Interlocking System. The location of the venting setup was also changed for easy access. One vacuum switch has been installed in the system. It is used for indicating venting of the chamber. It is necessary because the compressed air is being used for venting the system and it causes over venting of the system. Because of this the gasket of the system was coming out very often. Now venting can be stopped after getting the indication.

3.1.3 Repairing and Periodic Maintenance Works

- Three numbers of Pfeiffer Gauge controllers (one Dual Gauge and 2 Maxi Gauge), being used in the experimental lines, were repaired. The power supplies of the controllers had gone bad and were irrepairable. So new power supplies were bought and faulty ones were replaced.
- The vacuum Gauges get contaminated by deposits. So these gauges are regularly cleaned, tested and calibrated with SRG and Capacitance gauges. Last year, we cleaned 25 gauges in our lab.
- Scroll pumps are dry pumps using teflon coated gaskets for sealing. These gaskets need to be replaced periodically after 12-15 months. Four numbers of Dry Scroll pumps (2 Varian and 2 Pfeiffer) were dismantled for replacing seal kit. After dismantling, it was noticed that

there was a lot of dust inside & the Tip seals had gone bad. The dusts were cleaned thoroughly and the tip seals have been replaced with the new tip seals. Finally the parts were reassembled and then tested. All these pumps are working fine.

- Maintenance work like Cleaning and Oil Changing of the Rotary Pumps was done for six rotary pumps.

3.1.4 Installation of Vacuum Interlocking System in High Current Injector Lab

The Vacuum interlocking system was installed in the High Current Injector Lab. Here only one vacuum interlocking system is used to control two turbo pumps since both the pumps are being used to create the vacuum for the same area.

3.1.5 Other Beam line Related Work

- The High Vacuum Gate valve of the Radiation Biology beam line has been replaced with another one.
- In ion source the Varian turbo (TP 01.1) controller went bad, and it was replaced. A few more modifications were done for the Interlocking system.
- In Ion-Source Test Bench a few modifications were carried out. The double slit at the injection side of the analyzer magnet was removed. It has been installed at the waist/image position of the magnet. A drift tube of same length was replaced at the double slit space. The alignment of injection side of the magnet from the source (einzel lens entrance aperture, BPM I and magnet entrance) was rechecked and fine adjustments were done.

For the installation of slit all the components (Electrostatic quadrapole triplet, steerer II, BPM II and Faraday Cup) were shifted towards the chamber. The existing PSTV was removed and a new slim Gate valve was installed to accommodate for the shifting of components towards chamber. The X -X and Y-Y plane slits were calibrated for zero position with respect to the beam axis. All the components were aligned with the beam axis. The target ladder was also aligned and placed. The whole beam line was checked for leak and required vacuum was established. Installation of all other electrical and pneumatic connections was completed.

3.1.6 Repair of UHV Sample Manipulator (Goniometer)

Ashok Kothari, Rajeev Ahuja, ET Subramaniyam, Mamta Jain and S A Khan

A Goniometer installed in the Materials Science experimental facility started malfunctioning. It is used for precise sample movements. It is mounted from the bottom of the chamber, central shaft protruding in y axis and at the end is a sample holder in a plane parallel to y axis and sample facing z axis. All the three additional motions are precisely controlled by stepper motor. The central shafts rotate with a step of .018 deg. up to 360 degrees.

The problem was detected in rotary motion of the central shaft. Its motion in vacuum was not smooth and was jerky, noisy and missing. It leads to the lack in precision and proper control. We dismantled the unit and rectified the problem and the jerks, noise and missing motion were completely removed. The accuracy of the motion was checked with the help of a laser reflection setup and the accuracy and repeatability of the motion was found less than .018 degree (the minimum motion possible). The system was installed back on the chamber. Goniometer is now fully operational.

3.1.7 HTS-ECR Beam line and Soft Landing Setup Alignment

The HTS-ECR beam line and the Soft Landing setup were not aligned properly. There was 6-7 mm misalignment. So the pumping unit, collimator, Collimator on LMFT and De-accelerating tube were dismantled and realigned properly.

3.1.8 Design and Fabrication of Detector Annealing System for GDA / INGA

In GDA different detectors are being used during experiments. These detectors have to be annealed regularly. While servicing/annealing the Detectors, vacuum is required for out gassing of the detectors. Earlier there was no proper vacuum system and it was managed on temporary basis. The new system consists of a custom made rack. In this rack four detectors can be mounted at a time, 2 detectors in horizontal and 2 in vertical. Also a turbo pump, one scroll pump, four Roughing valves, four Gate valves, one Backing valve and the associated electronic modules can be installed with the Vacuum chamber and the Vacuum Interlocking System.

Vacuum Interlocking System was designed and fabricated for the detector annealing system. This system is capable of pumping four different detectors/channels independently. It automates the sequence required for pumping the vacuum chamber from atmosphere to ultimate vacuum for all the 4 Detectors independently. This is a user friendly system. The system gives an error signal on wrong operation by the user and shows the indication where the actual problem occurs. It works as a failsafe system and prevents any vacuum accident due to manual error.

Fig. 1. Detector Annealing System

3.1.9 Installation of Compressed Air Sensor in Vault -I and Vault-II.

The remote display of both the sensors is installed in control room. Both the channels can be observed by selecting the sensor. Whenever there is compressed air failure, many devices in the accelerator and beam lines stop working and the experiment stops. By this indicator the operator can immediately check whether the system problem is due to compressed air failure or not. It would save lot of time while locating the cause of system problem.

Fig. 2a. Vault - I

Fig. 2b. Vault - II

Fig. 3. Control Room

3.2 MAINTENANCE OF MAGNETS AND POWER SUPPLIES

S.K.Suman, Rajesh Kumar, Mukesh Kumar, A.J.Malayadri and A.Mandal

Beam transport group has been performing regular maintenance of magnets, power supplies and its supporting instrument (CAMAC Modules, magnetic field measuring instruments, beamline selector switchgear etc.) to maximise uptime of beam transport system for operation of PH-I pelletron and PH-II Linac. There are different types of magnets in our systems which are powered by highly stable power supplies. The following major jobs have been carried out in this year.

3.2.1 Routine Maintenance

Routine maintenance of all magnets and their power supplies are done twice in a year during which the following scheduled tasks are carried out:

- Output ripple monitoring of all power supplies and rectification.
- Stability measurement and rectification of bending magnet power supplies.
- Testing of different interlocks of all magnet power supplies.
- Calibration of readbacks of all magnet power supplies.
- Thorough observation of all power devices like power contatctors, power transistors and water cooled heatsinks etc and changing the faulty ones.
- Dust cleaning of electronic cards of all magnet power supplies.
- Checking input and output power connections for loose contacts.
- Checking of water leakage in the cooling systems and changing damaged hose pipes.
- Temperature monitoring of all magnets at full load current to observe its cooling ficiency and cleaning the partially blocked coils.

3.2.2 Breakdown maintenance

All BTS instruments performed well without any major failure.

3.2.3 BTS Installation

This year following magnet power supplies were tested and installed:

The stability performance of the Analyser and Injector magnet power supplies were tested and it was found to be ~200PPM. Since these power supplies have been twenty years old, their stability has deteriorated because of sparks in the sliding mechanism of auto transformer in the pre-regulation section. We decided to change these power supplies as these are the critical components for the pelletron to analyse ion beams. Two new power supplies (ratings- 26kW and 32kW) have been procured from Danfysik. These new power supplies are thyristor controlled. The performance of the power supplies have been tested in the factory in the presence of IUAC personnel. The stability performance of these power supplies over 24 hrs is less than 10PPM. These power supplies have been installed by replacing old power supplies. They are working fine.

The large area scanning magnet and its power supplies developed in-house has been installed in the materials science beam line in beam hall-II. The on line performance of the scanner has been tested using silver beam. The system worked very well.

3.3 DETECTOR LABORATORY

A. Jhingan and P. Sugathan

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 for new experimental facilities. Apart from various developmental activities, the group is intensively involved in various user experiments in nuclear reaction dynamics in HIRA, GPSC and Neutron Array using heavy ion beams. Detector lab provided special training on experiential activities for Scientist Trainees, JRF students, and M.Sc orientation program students.

3.3.1 Large area Position Sensitive annular PPAC

A. Jhingan, T. Varughese, P. Sugathan, R. Ahuja, S. Rao and B. B. Choudhary

A large area Annular PPAC has been developed. The detector setup will be used in Gamma Detector Array (GDA) for Coulomb excitation experiment. The detector has been designed and fabricated with two electrode geometry. Two sets of electrodes with different active areas were designed and fabricated using commercially available 2.4mm thick G-10 PCB. The cathode foil has been segmented into 16 parts to get azimuthal angles with a resolution of ~22 degrees. The anode is segmented into two parts and will give the polar angles using delay line technique. The detector will have 20 readouts.

A stainless steel chamber for housing the target has been fabricated. This will be followed by a stainless steel detector body housing the electrodes. The system will be very soon installed in the GDA beam line. Efforts are on to have custom made electronics for integrating charge from cathode foil to get energy loss information from PPAC active volume. Fig.1 shows the stainless steel target and detector chamber under vacuum test.

Fig.1 SS target(conical) and detector chamber (below) with Aluminum foil flange in between

3.3.2 MWPC for Neutron Array

A. Jhingan, T. Varughese, P. Sugathan, Hardev Singh, Rohit, Ranjeet, K.S. Golda and R. P. Singh

Two position sensitive multiwire proportional counters (MWPC) have been fabricated and installed in neutron array vacuum chamber. The detectors were used for detecting complementry fission fragments. The detectors have a three electrode geometry having a cathode frame, made up of 2 micron thick doubly aluminised mylar foil, sandwitched between two position frames giving X and Y positions. The electrodes are housed in vacuum tight rectangular aluminium chambers milled from solid aluminum block. Detectors have an active area of 125mm x 75mm. Positions are derived using delay line chips. The X position frame is made up of gold plated tungsten wires with a thickness of 10 micron for one detector, and 20 micron for the other detector. The wire pitch is 0.63mm. The Y position frame is made of 2.5mm thick tracks on a PCB. The detector was operated with isobutane gas. Fig.2 shows one of the assembled detectors.

The detector was tested offline with ^{241}Am alpha source at a gas pressure of 8 mbar and in beam using 120 MeV ^{16}O on ^{194}Pt from IUAC Tandem-Linac combination. For detecting fission fragments the gas pressure was kept at 4 mbar. Both the detectors were kept at folding angles to detect complimentary fission fragments at a distance of about 25cm from the target. Angular coverage at this distance in X plane is ~ ±14 degrees and that in Y plane is ±8 degrees. Rise times of about 3ns were observed from the preamp output. Fig. 3 shows the position spectrum taken during the experiment. Position resolution of ~1.1mm is observed from the detector.

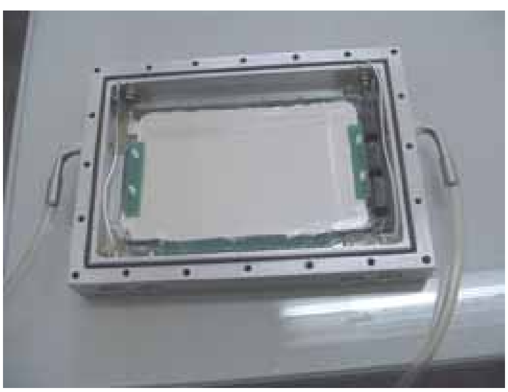

Fig. 2. Assembled MWPC

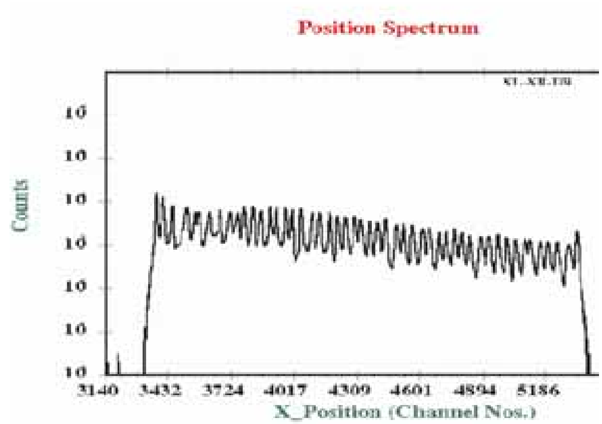

Fig. 3. X-Position spectrum from MWPC

3.3.3 Charge integration of MWPC anode pulse using QDC

The MWPC anode pulse, processed from a fast timing amplifier, was integrated using a QDC to get differential energy loss information in the active volume of MWPC. This information is useful in distinguishing between light and heavy particles such as light beam-like particles and fission fragments or heavy fusion products. Usually this is done either by time of flight technique, or integrating the charge using conventional charge sensitive preamplifier, followed by shaping amplifier and CAMAC ADC. In some experiments, both are required as 2D histogram plotting one against the other can be used for very clean separation. Charge sensitive pre-amplifiers – shaping amplifier (minimum shaping time 3μs) combination have count rate handling limitations beyond 10 kHz and also have saturation problems because of the high gain (large amount of charge generated in avalanche multiplication) of MWPC. A home made charge sensitive pre-amplifier with low gain

(~175 mV/pC Si equivalent) and shorter decay time constant of 50µs was used for MWPC. This eliminated saturation problem but count rate handling capability (due to large rise times and shaping times) is still a limitation. The fast timing pulse from the timing pre-amplifier (Fig.4) is split into two parts with one going to CFD and the other (delayed going to QDC). The fast pulse from timing preamp (input impedance 50 ohm) has a rise time <10ns and pulse width of about 60 ns. Count rates of about 100K can be easily handled without any pileup and saturation problem. Fig.5 shows the integrated anode pulse in QDC obtained by exposing the MWPC to a 12µC ^{252}Cf fission source. The detector was operated at 1.5mbar isobutane to keep it transparent to alphas which come at about 100K count rate. One can see a small bump on the left side due to alphas.

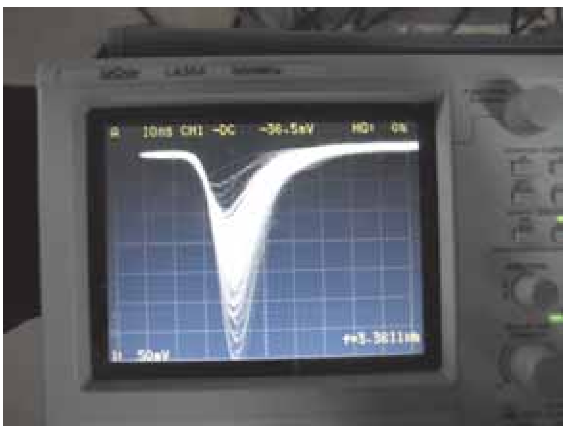

Fig. 4. Fast timing pulse from MWPC anode

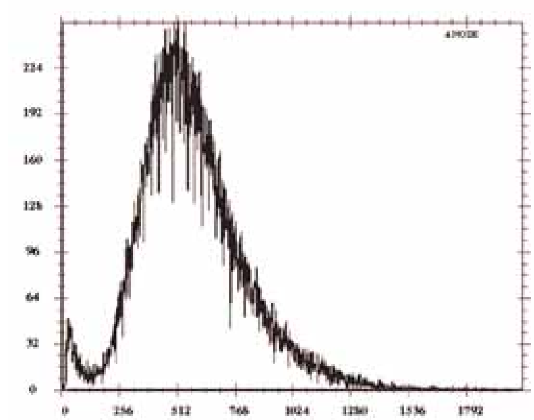

Fig. 5. Integrated anode pulse in QDC

3.3.4 Fast timing MWPC as master trigger for NAND

A fast timing MWPC of active area 1" x 1" has been designed and is currently under fabrication. The electrodes will be made of wire frames instead of aluminized mylar to avoid straggling of heavy fission fragments. The detector will be used as master trigger for NAND data acquisition providing a master start signal for time of flight measurements of fission detectors and neutron detectors in experiments to be performed with DC beams from pelletron. The detector is likely to be placed at about 5cm from the target at backward angle in lab frame.

3.3.5 Detector Telescope for transfer reaction studies

A simple detector telescope, comprising of silicon detector as stopping detector and an axial field geometry gas ionizer as delta E detector, was modified and used for identifying transfer products in a GPSC experiment ^{40}Ca + ^{70}Zn. The gas ionization part earlier used a grid (frisch grid material) or a aluminized mylar as anode. The entrance window used was also aluminised mylar (6µ), and aluminum side is grounded and acts as cathode. This configuration generally tends to have lot of straggling and non linearities due to improper field lines distribution owing to bulging of entrance window (convex shape) at high pressures. The electrode geometry was modified and the single anode grid or foil was replaced by a three electrode geometry made of stretched 20 micron gold plated tungsten wires placed 1mm apart. Central electrode acts as anode operating at 1-5V cm^{-1} $Torr^{-1}$. Cathodes are grounded. Entrance window is non-aluminised mylar of 1μ thickness. The detector was operated at about 100 mbar isobutane for offline alpha test in GPSC and around 70 mbar in the ^{40}Ca + ^{70}Zn experiment. The detector was placed at 45 degree in GPSC. The signals were processed using home made preamplifiers placed inside GPSC to minimize losses in coaxial cables. The detector showed separation between beam like and target like particles and various transfer channels.

3.3.6 Neutron-gamma discrimination using QDC

Neutron gamma discrimination was performed using digital charge comparison technique with commercially available Phillips CAMAC charge to digital converter. A custom made six channel active splitter NIM module was fabricated for the same. The module splits the PMT anode pulse into three parts, one going to CFD and other two delayed before being fed to QDC. The system was tested for its multichanel capability with four BC501 liquid scintillators using 65MeV pulsed ^{12}C on ^{204}Pb. The system showed good n-γ discrimination.

3.4 TARGET DEVELOPMENT LABORATORY

D. Kabiraj, Abhilash S. R and D. K. Avasthi

Target Development Laboratory at IUAC provides facilities to the users for the preparation of targets used for the experiments with IUAC Pelletron. Several users (more than 70) have used the following facilities for the studies in Nuclear Physics, Atomic Physics, Materials Science and Bio Science. The facilities available are (i) a high vacuum evaporator, equipped with 2kW electron beam gun, evaporation setup by resistive heating, online thickness monitoring by quartz crystal thickness monitor. This evaporator is pumped by a diffusion pump with liquid nitrogen trap, with a base pressure of high $5x10^{-7}$ mbar. (ii) The oil free pumping system for the second evaporator includes a cryo-pump, a turbo molecular pump and a scroll pump, with a base pressure of $6x10^{-9}$ mbar. This evaporator is equipped with a 6 kW 4-pocket electron gun and evaporation setup by resistive heating method and a dual crystal thickness monitor and controller for online thickness monitoring and process control. (iii) A rolling machine for the preparation of thin foils by cold rolling method. Several thin films were prepared in this year which includes 600 carbon stripper foils of less than 5 mg/cm^2 thick used for IUAC Pelletron. Some of the interesting and important thin films prepared this year are mentioned here.

Targets of enriched isotope of ^{194}Pt, both self-supporting and 15 mg/cm^2 carbon foil as backing, have been prepared using only 90 mg material. $BaCl_2$ was used as parting agent for the preparation of self-supporting Pt films [1]. The evaporator equipped with 6 kW electron gun was used for this purpose. A crucible had to be designed specially to confine such a small amount of material which had to be directly bombarded with electron beam. High purity graphite was used for the fabrication of the crucible as Pt alloy with all the refractory metals. The melting point of Pt and the sublimation temperature of graphite being very close, much care had to be taken while designing the crucible so that the electron beam falls directly on the Pt, without localized heating of the crucible. The thickness of the targets was approximately 300 mg/cm^2 and these targets were used successfully in the first experiment using IUAC LINAC accelerator. In this experiment ^{16}O beam of 120 MeV energy obtained using both Pelletron and LINAC accelerators was used to measure the neutron multiplicity with the help of 16 neutron detectors.

Typically, ZnO nanostructures have been successfully synthesized by VLS process on an Au-coated silicon substrate by heating the mixture of ZnO with other material at high temperatures in the presence of carrier gas in horizontal tube furnace of alumina. In this case the substrates are placed at the different places of the tube furnace having the different temperature zones. The exact control of carrier gas partial pressure is non-trivial and the related thermodynamics needs careful optimization. In this laboratory the growth of ZnO nanorods on Si substrates using similar Vapor-Liquid-Solid (VLS) mechanism has been realized in an electron beam evaporation process, which is free of any carrier gas for the synthesis of ZnO nanorods. [2] Our process is compatible with the current high vacuum based semiconductor microelectronics processing schemes and the results on nanostructure growth are found to be highly reproducible. Moreover the required processing temperature is still lower as compared to other physical vapour deposition (PVD) techniques. Field emission scanning electron microscope (FESEM) images of ZnO nanorods (top view) are shown in Figure 1. The average diameter and length of the nanorods measured by AFM was found to be 25 nm and ≥ 350 nm respectively.

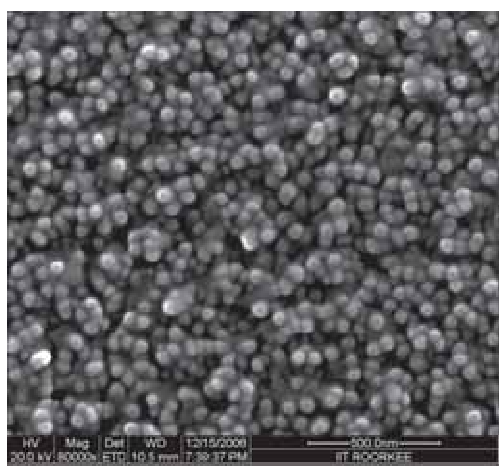

Fig. 1. FESEM images of ZnO nanorods (top view)

Au–ZnO nanocomposite films with metal fraction of ~10% were prepared by atom beam co-sputtering of Au and ZnO with fast neutral Ar atoms having energy of 1.5 keV [3]. Transmission electron microscopy (TEM) measurements were carried out using a JEOL 1200EX at 100 kV machine. The high-resolution TEM (HRTEM) images were obtained on Technai 300 kV system. TEM image of annealed samples showing formation of ZnO nanorods shown in Figure 2(a) – (c) after annealing. (d) shows the HRTEM image of the interface of ZnO nanorod and Au nanoparticles.

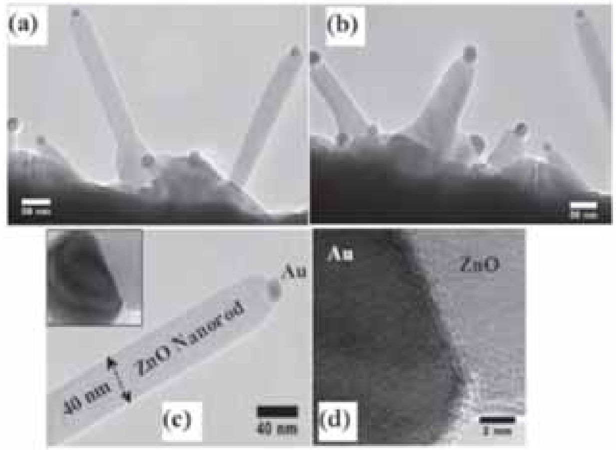

Fig. 2. TEM image of annealed samples showing formation of ZnO nanorods Figure 2(a) – (c) after annealing (d) shows the HRTEM image of the interface of ZnO nanorod and Au nanoparticles

Nanocomposite films containing Ag nanoparticles embedded in partially oxidized amorphous Si matrix were deposited on silica glass substrates by co-sputtering of Ag and Si with 1.5 keV neutral Ar atoms. [4] The Ag content and thickness of the nanocomposite films were determined by Rutherford backscattering spectrometry. Optical absorption studies revealed the presence of surface plasmon resonance (SPR) indicating the formation of Ag nanoparticles in the as-deposited films. The position, width and strength of SPR have been found to be strongly dependent on the Ag content of the films. For annealing in oxidizing atmosphere, a significant red shift in the SPR along with a drastic reduction in the resonant absorption has been observed. The amount of red shift has been found to be dependent on the Ag content of the films. Transmission electron microscopy was used to study the size distribution, shape and crystal structure of Ag nanoparticles in the nanocomposite films. TEM analysis of annealed sample revealed the formation of silver oxide nanoshells surrounding Ag nanoparticles shown in Figure 3.

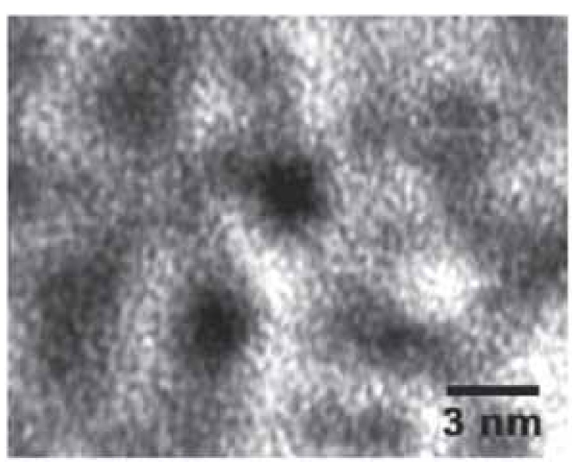

Fig. 3. Bright field TEM micrograph showing core–shell nanostructures in nanocomposite sample (7 at.% Ag) annealed in air at 500 ^{0}C

The effect of crystallinity of Ge nanocrystals on the charge storage properties of the metal oxide semiconductor (MOS) structure has been investigated. MOS structure with Ge nanocrystals embedded in the oxide has been fabricated by using atom beam sputtering technique. [5] After annealing at 600 °C in Ar+H_2 atmosphere, capacitance–voltage (C–V) measurements show flat band voltage shift of ~0.9 V. It is a clear indication of the memory effect of Ge nanocrystals, while unannealed structure does not show any hysteresis in the C–V curve (Figure 4). Micro Raman spectroscopy and X-ray diffraction (XRD) analysis show that crystalline content of Ge nanoparticles in the MOS structure has increased after annealing.

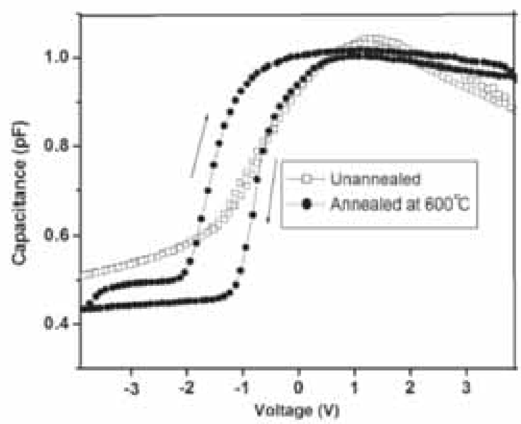

Fig. 4. C–V curves of annealed as well as unannealed MOS structure.

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3.5 RF & ELECTRONICS LABORATORY

A. Sarkar, S. Venkataramanan, B.K. Sahu, K. Singh, A. Gupta, A. Pandey, P. Singh and B.P. Ajith kumar

3.5.1 INGA Clover electronics module production [1]

The production of final batch of 24 nos. INGA clover electronics modules have been completed. The various sub-assemblies produced during last year have been integrated and subjected to various levels of tests for integrity. The assembled units have been used with recently commissioned

INGA at IUAC and any reported minor problems and required adjustments are completed. The INGA modules which were used in INGA campaign at VECC, Kolkata are also refurbished and being used.

Fig. 1. INGA Clover electronics modules

3.5.2 Pulse shape discrimination (PSD) electronics module for NAND array and Si-PAD [1]

At IUAC, we have developed a compact, high density Pulse Shape Discrimination (PSD) electronics module for National Array of Neutron Detectors (NAND). The single width NIM module contains two independent channels of all necessary front end circuits namely shaping amplifier (dynode-energy), CFD, pulse shape amplifier, zero cross discriminator, TAC and TOF Logics. Typical Figure of Merit (FOM) obtained is ~1.9 @ 1MeVee LLTH, and typical time resolution obtained is ~1.2 ns. The production of another set of 10 modules for NAND array with 30 detectors has been initiated.

The feasibility of using such compact electronics for proposed Si-PAD array at BARC-TIFR facility has been undertaken. The necessary minor modifications in choosing time constants and pulse processing were made in order to obtain the required particle separation as reported [2].

3.5.3 Quad Timing Filter Amplifier

In order to fulfill the requirement of generic Quad Timing Filter Amplifier (TFA), we have undertaken a project to develop a replacement for commercial module. The developed TFA module utilises the BARC developed [3] and BEL make Ultra fast amplifier hybrid microchips (HMC) and wide band operational amplifiers. The typical specifications suitable for use with HPGe or SSB Detectors are given here

Gain	:	upto 40 (INV, NINV)
Rise time	:	<5 nS for -2V @50 ohms

Noise	:	<10 uV rms
Optional	:	Tdifferentiation Tintegration jumpers selectable P/Z adjustments on Panel, BLR corrected

Fig. 2. Quad Timing Filter Amplifier module

3.5.4 Fabrication & testing of harmonic feedback control modules

The fabrication and testing of three harmonic feedback control modules for 12MHz, 24 MHz and 36 MHz were done in the Laboratory. These modules form a major part of the multi-harmonic buncher electronics. These modules take the feedback signal picked up from the buncher and use it to control and lock the amplitude and phase of the different harmonics used in the generation of the saw-tooth voltage of the multi-harmonic buncher. Presently these modules are kept as spares in the Laboratory.

3.5.5 Feasibility Study and Development of a piezo actuator based Control for Superconducting Resonators

A feasibility study is carried out to implement a piezo actuator based control for our existing 97 MHz Superconducting Resonators. The slow tuner bellow arrangement is tested with a known load to find out the tuning frequency range. Piezo Actuator specification is decided based upon this measurement results. Existing slow tuner bellow is attached to a piezo actuator from PI systems. The frequency tuning range with response time is being tested at room temp. and liquid Nitrogen temp using a piezo power supply and arbitrary wave form generator. It is found that in Liquid Nitrogen the response of piezo actuator is less than hundreds of milli seconds. A control Scheme is planned with our existing phase and amplitude control module to test the phase lock conditions using this piezo setup for the cavity operating in superconducting temp. This work will be carried out in future.

3.5.6 Design of a high-resolution programmable current source for coil magnet actuator

The design, implementation and testing of digitally programmable current source which permits the controlled current with a resolution of 2ppm was done. This is a bipolar current source with max. current +/- 30mA. It is basically voltage-to-current converter based design. Source has coarse and fine digital-to-analog converters (DACs) with local feedback provided by a 24-bit analog-to-digital converter (ADC). Current source has a single-chip micro-controller which has USB port to communicate with PC. The use of single-chip microcomputer to control two DACs and a precision 24-bit ADC is relatively straightforward. Serial ADC and DACs are used in the design and interfaced with micro-controller using serial peripheral interface (SPI). Digital control circuit is optically isolated from the analog section. At present it is a floating load type design and we expect the coil resistance to be very low. It will be more useful if the output stage can be converted in a grounded load type of design. The idea will be to measure the resistivity of a sample with four point probe method. Since ADC has 10 single ended and five fully differential channels.

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3.6 ELECTRICAL GROUP ACTIVITIES

U. G. Naik, Raj Kumar

Electrical group has the responsibility to maintain the existing electrical installation and take up the new projects required for the up gradation of the institute's expansion. It is a great pleasure to record that the uptime achieved for the systems was 100% with proper maintenance schedules and monitoring arrangements. This group has also successfully completed the projects and works envisaged and approved for the year F.Y.2007-2008.

MAINTENANCE

3.6.1 Captive Power Installations

Group has managed the emergency power requirements with the available power generating sets and has plans in next plan for bigger sets to meet the demand. One of the helium compressors has always been run on generator supply for every cycle of the plant operation. The group has shown ever readiness in running the systems round the clock and within short notices smoothly.

3.6.2 Power Stabilisers

The group has managed to have another year of 100% uptime without a single break in the supply through 1MVA and 500 KVA stabilisers catering to major loads such as A/C plant-II, Helium Compressors and the clean power to NSC pelletron cum experimental areas.

3.6.3 UPS Installations

Electrical group has maintained 50KVA, 3 phase, UPS dedicated to feed motor loads and some computer controls for High Current Injector systems besides a previous base of about 20 nos.of UPS rated from 2-10kVA. Only the 5KVA and above capacity UPS are put on AMC with manufacturer otherwise rest are all maintained by the group. During the present year all UPS were very healthy and had 100% uptime. Routine maintenance was carried out by the manufacturers authorised service centre and the faulty batteries were replaced.

3.6.4 Power Factor compensation

Electrical group is very happy to declare that average power factor has been maintained almost near to unity throughout the entire year. Our system power factor without correction is about 0.85 and by raising it to near unity we save around Rs.45 lakhs a year from energy billing.

3.6.5 Communication Equipments

Electrical group maintains the hand held radio stations (Walkie-talkie) and base station. Till now we have 14nos. of hand held stations and one base station. These are working fine. The group takes the responsibility of getting the revalidation of license periodically from the Ministry of telecommunications.

3.6.6 Maintenance of substation, power and Lighting installations of Office complex and Residential colony

The electrical Group is proud to declare here that during this year the installations have performed efficiently with uptime close to 100%. Few of the major yearly maintenance activities carried out are listed below.

- Dehydration of transformer oil.
- Periodic maintenance of LT panels, Distribution boards and other accessories, Lighting, Fixtures, lighting and power circuits.

- Servicing of DG sets 60kVAX 2nos, 2X 320 kVA, 1X 100 kVA-twice a year.
- Maintenance of street lighting and earthing.

3.6.7 Energy Saving

Energy savings measures taken earlier continued in the areas where we had installed the energy saving time switches and CFL lamps, T-5 lamps etc.

PROJECT WORKS

3.6.8 Installation for beam hall-II

UPS Power to the experimental areas and both electronics areas were made available properly with cables and distribution network.

3.6.9 UPS Systems

After making exhaustive study the group has procured and installed 2X60 KVA UPS systems to run in parallel redundant mode for the main lab block.

This group has also planned, procured and operated successfully 2x 300 KVA UPS systems to run in parallel redundant mode for liquid Helium systems having 2nos. of motors each of capacity 145 kW. This project was completed within the stipulated time.

3.6.10 LT Power Panels

Group has planned, designed, procured and operated successfully electrical power distribution panels, cables, cable trays and junction boxes at a total order value of more than 40 lakhs. This shall take care of the power input and output of the 2x 300 KVA UPS systems to run in parallel redundant mode.

3.6.11 Phase-II Part-II Installations:

Beam hall 3 (ECR) electrical works have been coordinated.

3.7 COMPUTER AND COMMUNICATIONS

S.Mookerjee, S.Bhatnagar, E.T Subramaniyam

The major thrust during the year was on upgrades of the central server facility, expansion of networking, the development and operationalization of data acquisition systems and software for the Indian National Gamma Array facility, and the development of and first results from software for simulation of ion beams in matter.

3.7.1 Central servers and network infrastructure

The central computer cluster was revamped, with the introduction of a new cluster comprising four dual quad-core Xeon servers with an Infiniband interconnect. This new 32-core system is in addition to the existing 20-CPU LAM-MPI cluster which serves atomic physics, materials science and nuclear physics users, and increases the peak throughput of the compute cluster to more than 300 gigaflop/s.

The Centre's Internet connectivity was improved, with a bandwidth upgrade on the Spectranet link to 2 Mbps. With the installation of more access points, wireless coverage was extended to the entire main building, and to the old Guest House and student hostel complex. The wired LAN was further expanded in the LEIB building and the new beam hall; the centre's fibre gigabit backbone with managed 100 Mb switched connections now serves more than 500 end nodes.

As part of the effort to stimulate the use of HPC clusters in modeling and simulation of ion beams in matter, a one-day workshop on "High Performance Computing in Physics Research: Applications and Computing Requirements" was held in March, 2007. The workshop was addressed by ten speakers from the JNCASR in Bangalore, the IACS in Kolkata, IIT Delhi, the University of Pune, the University of Hyderabad, the Jawaharlal Nehru University, the University of Kashmir and IUAC, and was attended by ninety participants from IUAC and other institutions in Delhi, including IIT Delhi, JNU, Delhi University and Jamia Milia Islamia. A consensus was evolved on the need for a 20 teraflop system accessible to the Centre's users and the larger university community in materials science, nuclear physics, radiation biology, and atomic and molecular physics.

3.7.2 Data Acquisition System and Hardware development

The new data acquisition system was installed in the Indian National Gamma Array facility, and used successfully in the first data runs. The system incorporates the 14-bit ADC module, the LPCC crate controller and the CANDLE data acquisition system, all developed in-house. Mass production of the ADC and LPCC modules was completed in time for the first INGA runs. Modifications were made this year to the LPCC modules and to the CANDLE data acquisition software to enable the use of bit patterns. A 3-crate system is now operational in the INGA facility. The data rate for random data is 10 K events/second with the bit pattern enabled, and 6.5 K without the bit pattern. Mass production of spare ADC and LPCC modules will now be undertaken.

The first prototype of the DSP-based data acquisition system, development of which started last year, was tested using a NaI/Tl detector system. A redesign incorporating feedback from these test runs is now under way.

3.7.3 Software development

The IMPACT molecular dynamics simulation code to explore target response to MeV ion beams, being developed as part of an IUAC-CIRIL-LIRIS collaborative effort, was extended to study the effect of details of the initial atomic energy distribution on the sputtering yield. The first results were presented at the 18th International Conference on Ion Beam Analysis held at Hyderabad. The order of magnitude differences in sputtering yields between different initial energy distribution models emphasize the importance of accurately simulating the electron-lattice energy transfer. They also indicate the use of the sputtering yield in swift ion-matter collisions as a signature of this femto-second transfer process.

The administration ERP package was extended with the modification and installation of the PF module.

3.8 AIR CONDITIONING, WATER SYSTEM AND COOLING EQUIPMENTS

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

Central AC Plant

IUAC's Central Air Conditioning / Low temperature Cooling System of Phase-1 consisting of 400 TR Central AC plant performed with 100% uptime. Proper maintenance ensured that the safety record of the plant was maintained at 100% and the power consumption kept at optimum levels. The reciprocating compressors (1,3&4) have logged in approximately 87,000 hours each and new compressor (Comp#2) 10250 hours. Other rotary equipments have logged in about 1,41,250 continuous run hours. The yearly maintenance costs have been maintained at approximately one-eighth the international standards of the installed project cost. The equipment being into their nineteenth year of sustained operations has far outlived their economic lives. In the current year, plenty of repair activities were carried out. This was essential to reset the reliability of the equipment.

The Phase-II, Central AC Plant with a Centrifugal Chiller and with its installed capacity of 250 TR performed to an uptime of 100%. The plant catered to the cryogenic activities and was used extensively for picking up the Phase-I heat loads. This affected a huge energy saving.

The highlight of the operation and maintenance of the above systems was the in-house responsibility and supervision provided to the contracts, thereby affecting substantial savings in the price paid for the operation and maintenance contracts.

The new A/C Plant, Phase-III, was provisionally taken over by IUAC on 03/04/2007.

CPWD/Blue Star are yet to carry out the plant load testing inspite of our repeated persuals. Also, CPWD has not attended to the "Engineering Building" Air-washer problems and have not yet handed over the same to IUAC.

Water Systems

IUAC's centralized water system of Phase-I feeding low temperature cooling water of a total heat removal capacity of 115 TR, potable water supply and the gardening water supply performed to an operational uptime of 100%. This was possible due to the stringent maintenance practices that were followed over the years. The mechanical systems have already overshot 93,000 hours beyond their expected life span. A strict monitoring on the water quality ensured that the flow paths are in healthy condition. Numerous replacement works were carried out. Several additional equipments were installed.

IUAC's centralized water system of Phase-II feeding low temperature cooling water of a total heat removal capacity of 80 TR, Liquid Helium Cooling water of approx. 350 TR, potable water supply performed to an uptime of 100%. This was possible due to the stringent maintenance practices that were followed over the years. Some replacement works were carried out.

IUAC's centralized water system of Phase-III feeding low temperature cooling water of a total heat removal capacity of 80 TR and potable water supply performed to an uptime of 100%.

Cooling Equipments

Availability of these equipments was recorded at around 99%. Several replacements are being done in a phased manner and several new equipments have been installed.

New Construction

The technical data after collation from users was given to CPWD for the purpose of design. The designs have been frozen in principle. CPWD has completed the engineering of cooling water system. The tender has been awarded and material supplies are underway.

3.9 MECHANICAL WORKSHOP

BB Choudhary, SK Saini, R Ahuja, Sunder Rao and Jimson Zacharias

The Mechanical Workshop is serving as an in house machining and welding facility for the 15 UD Pelletron accelerator laboratory, supporting various laboratories and large number of user community. Workshop has been involved in developmental activities of new systems as well as a large-scale production of beam line components right from the inception of IUAC. This year also most of the beam line components used for the new beam lines were fabricated in the IUAC Workshop. Workshop continues to assist the entire in house fabrication activities of LINAC, RFQ and DTL for HCI, INGA, HYRA, HIRA as well as the Cryogenic component developments.

The major facilities of the workshop are the Machine shop, Welding shop and the state of art Electron Beam Welding (EBW) machine facility.

The Machine shop is equipped with a five axis Vertical Machining Centre and a CNC lathe. A Renishaw probing system is installed on the VMC. Apart from these we have four conventional lathes, two milling machines and radial drilling machine to cater to the tool room jobs. Most of these machines are of HMT make, fitted with DRO's for achieving higher accuracy and better productivity. Apart from these, we have cylindrical grinder, tool and cutter grinder, horizontal and vertical band saw machines, sand blasting machine etc for general requirements. We also have the CAD facility, Solid Works for the design and the drafting purposes. We also have VISI CAM for the CAM support for the Vertical Machining Centre (5 axis).

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

The Electron Beam Welding facility is fully operational and fabrications of fifteen resonators are in full swing. Workshop personnel are involved in almost all the the major ongoing projects 1. Indigenous Fabrication of Resonators. 2. INGA detector platform fabrication (completed). 3. RFQ fabrication 4. Drift Tube Linac Fabrication. All these projects have made substantial progress.

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.

3.10 HEALTH PHYSICS

S.P.Lochab and R.G.Sonkawade

The activities of the health physics group in the centre are mainly related to radiation research and regulatory aspects. Over a decade, this group has produced excellent output in research and given excellent academic support towards radiation safety.

Presently there are around 20 universities, working with the health physics group on various interdisciplinary research activities and around 30 research scholars are presently associated with them. A few NGO's and some Government Agencies have also used these facilities. The universities associated with this group are from all over the country. Recently this group has got Atomic Energy Regulatory Board (AERB) accreditation for Low Background Counting System. Indian Environmental Radiation Monitoring network (IERMON) was installed with the help of BARC. We are putting our best efforts to make these activities par excellence in co-ordination with the Atomic Energy Regulatory Board (AERB) and the various universities involved with the health physics group.

There are two more research activities a) End Window Grab Sampling Method & b) Neutron dosimetry with CR-39 added in this year, with the existing facilities such as Radon/Thoron/Daughter products analysis. Evaluation, development of the conducting polymers, study and analysis of the soil samples with low background counting setup and the development of TLD phosphors for ion beam dosimetry purposes are carried out. Some of the important research activities are highlighted below.

3.10.1 Dosimetry for Neutrons from 0.25 to 15 MeV by the Measurement of LET Distributions for Secondary Charged Particles in CR-39 Plastic

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In the radiation fields of high energy accelerator facilities, high-altitude aircraft and space flights, high-energy neutron dosimetry of ~20 MeV or more is a significant issue for radiological protection. We studied the feasibility of experimental measurements of linear energy transfer (LET) distributions for secondary charged particles induced by fast neutrons using CR-39 plastic nuclear track detectors.

In order to investigate a method of analyzing the CR-39 detectors that is appropriate for fast neutron dosimetry, two-layer CR-39 stacks were exposed to monochromatic neutrons (0.25 MeV, 0.55 MeV, 5 MeV and 15 MeV) at the Fast Neutron Laboratory of Tohoku University in Japan. We also conducted Monte Carlo calculations to estimate the detection efficiency of the CR-39 detector for recoil protons. The CR-39 detectors treated by single-step chemical etching were used to obtain LET distributions for LET > 10 keV/μm-water. The results indicated that measurements of short-range particles are very important for obtaining the correct LET distributions. Using the measured LET distributions, we calculated neutron sensitivities, absorbed doses and dose equivalents based on the ICRP 60 Q-L relation and averaged quality factors. The dose equivalents were compared with the neutron fluence-to-dose equivalent conversion factors given by ICRP 74 and the averaged quality factors were compared with weighting factors given by ICRP 60 and ICRP 92.

3.10.2 Neutron dosimetry with LET concept for high energy particle accelerators

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The long-term stability of latent tracks and insensitivity to gamma-rays along with the high capacity for registering recoil-proton tracks are initiated using CR-39 as a neutron dosimetry material. Many types of neutron dosimeters based on CR-39 have been developed so far. Personnel neutron track detectors (PNTDs) are directly used to measure LET distributions of neutron-induced high-LET particle components, such kind of approach was initiated by space radiation dosimetry having a very long history, where different types of PNTDs are utilized for measuring the LET distributions of high-LET components in space radiation. Considering the high-LET components existing above several keV/mm is given a relative importance from the standpoint of radiation protection for astronauts and for high energy particle accelerators. The measurement of LET distributions of secondary heavy charged particles for ≥ 4 keV/mm-water induced by neutrons with CR-39 plastic nuclear track detectors is discussed. Neutron detection efficiencies and absorbed doses were calculated from the LET distributions. Dose equivalents were also calculated using the ICRP60 Q-L relation and were compared to those calculated from neutron fluences exposed and fluence-to-dose equivalent conversion factor given by ICRP 51.

3.10.3 Analysis and Evaluation of Gamma And Neutron Dosimetry From 48MeV 7Li On Natural Cu And Its Dose Simulation With MCNP

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Neutron and gamma radiation dose as a function of angle was measured from 48MeV, 7Li3+ ion beam incident on thick natural copper target. The experiment is simulated keeping in view the health physics importance for monitoring the radiation environment in charged particle accelerator. The neutron dose observed in the forward direction is slightly higher compared to the lateral direction. Gamma energy of the same reaction is also monitored in the experimental setup with the HPGe-detector. The experimental results are compared with the calculated dose from empirical formulations. From the observed gamma spectrum, and PACE calculation, possible reactions were identified and correlated with the observed spectrum.

3.10.4 Radiological Risk Assessment of use of phosphate fertilizers in soil

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Concentration of the natural radionuclides namely ^{226}Ra, ^{232}Th and ^{40}K in the soil samples collected from the fields where a variety of phosphate fertilizers are being used by the farmers to enhance the crop yield are analyzed. LR-115 films (Solid State Nuclear Track Detectors) were used for the measurement of radon concentration and exhalation rates in soil samples. In order to evaluate the radiological impact of the use of phosphate fertilizers, the activity concentration of ^{226}Ra, ^{232}Th and ^{40}K, radon concentration and exhalation rates were also determined in soil sample collected from barren land in which no fertilizer was used. The concentration of Radium, Thorium and Potassium in the mixed soil sample from crop fields is 16.2 ± 0.22, 68.1±1.44 and 875.0±9.68 Bq/kg, whereas in barren soil sample it is 9.1±0.13, 59.4±1.45 and 668.4±8.01 Bq/kg respectively. The radium equivalent activity (Raeq) in the mixed soil sample from crop fields is 225.9 Bq/kg, where as in barren soil sample is 193.1 Bq/kg. The values of absorbed dose and annual effective dose (indoors and outdoors) are found to vary from 90.87 nGyh-1 to 119.71 nGyh-1, 0.45 mSv/y to 0.59 mSv/y and 0.11 mSv/y to 0.15 mSv/y respectively in soil sample from crop fields, whereas the value of absorbed dose and annual effective dose (indoors and outdoors) is 92.29 nGyh-1, 0.45 mSv/y, 0.11 respectively in soil sample collected from barren land. The activity concentration and exhalation rate was found to increase substantially with the use of phosphate fertilizers. The activity concentration of radium, thorium and potassium, radon concentration and exhalation rates were found to vary from sample to sample. The radium equivalent activities in all the soil samples were found to be lower than the limit (370 Bq/kg) set in the Organization for Economic Cooperation and Development (OECD) report. The absorbed dose and the indoor effective equivalent dose were found to vary from sample to sample and the dose equivalent is within the safe limit of $1 mSvY^{-1}$.

3.10.5 Natural Radioactivity and Radon Exhalation Rate in Rock Samples from Jaduguda Uranium mine Through Nuclear Track Detectors

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The activity concentration of the natural radionuclides namely U-238, Th-232 and K-40 is measured for the soil samples of Jadugoda uranium mines. The radioactivity concentration of natural uranium was found to vary from 123±7Bq/Kg to 40858±174Bq/kg, activity of thorium was not significant in the same, where as a few samples showed potassium activity from 162±11Bq/Kg to 9024±189Bq/kg. The concentration of natural uranium was found to vary from 5ppm to 1634ppm, which showed significant amount of uranium activity. Radon activities were found to vary from 11687.1 to 38061.4 Bqm^{-3} whereas the radon exhalation rate varied from 4.2 to 13.7 $Bqm^{-2} h^{-1}$. There was a positive correlation between the radon, radon exhalation rate and the uranium activity.

3.10.6 Natural radioactivity in common building construction and radiation shielding materials

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Commonly used building construction materials, radiation shielding bricks, hematite aggregate and other materials have been analyzed for the activity concentration of the natural radionuclides namely ^{238}U, ^{232}Th and ^{40}K, besides the radon exhalation rates. The activity concentration for ^{238}U, ^{232}Th and ^{40}K varies from 29 ± 1 Bq/kg to 98 ± 4 Bq/kg, 20 ± 2 Bq/kg to 112 ± 2.8 Bq/kg, and 200 ± 8 Bq/kg to 1908 ± 15.6 Bq/kg respectively in various materials studied in the present work. Radon concentrations in the various samples vary from 190 ± 11 to 313 ± 14 Bqm^{-3}, the mass exhalation rate for radon vary from 1.05 ± 0.07 to 1.92 ± 0.09 $mBqkg^{-1}h^{-1}$ and surface exhalation rate vary from 9.0 ± 0.30 to 19.8 ± 22 $mBqm^{-2}h^{-1}$ for materials under investigation. The activity concentration of uranium, thorium and potassium and radon exhalation rates vary from material to material. Thorium and Potassium activity in the granite materials is higher, followed by radiation shielding material compared to other common construction materials. Uranium activity concentration is higher in cement as compared to radiation shielding material and other common construction materials. The absorbed dose varies from 22 $nGyh^{-1}$ to 191 $nGyh^{-1}$ and the indoor effective equivalent dose varies from 0.10mSv/y to 0.93mSv/y. The outdoor effective equivalent dose varies from 0.02mSv/y to 0.23mSv/y. The absorbed dose and the effective dose equivalent are found to be higher in the granite, followed by radiation shielding material and other common construction materials. In all the samples, the activity concentration of ^{238}U, ^{232}Th and ^{40}K is found to be below the permissible levels. A strong correlation coefficient has been observed between radon concentration and surface exhalation rate (Correlation Coefficient = 0.899).

3.10.7 Effects of swift heavy ions irradiation on polypyrrole, Polyaniline and other non conducting polymers

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Conducting Polymers are suitable candidates for the rechargeable batteries, electrode materials for high performance supercapacitors, due to their high dc conductivity and the specific capacitance. High-energy ion beam irradiation of the polymers is a sensitive technique to modify the electrical conductivity, structural property and mechanical properties. Overall idea is to study effects of swift heavy ions on the structural, optical and surface properties of Polypyrrole (PPY), Polyaniniline, etc., Most of the conducting polymers are being prepared in the Health Physics lab, at the same time efforts are going on to use these polymers as a sensor for radiation dosimetry. The non conducting polymers are also studies and compared with the conducting polymers.

3.10.8 Nanocrystalline MgB_4O_7:Dy for high dose measurement of gamma radiation

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Magnesium borate activated by dysprosium (MgB_4O_7:Dy) is a low-Zeff, tissue-equivalent material that is commonly used for medical dosimetry of ionizing radiations such as gamma and X-rays using the thermoluminescence (TL) technique. Nanocrystals of the same material are produced and their TL characteristics are studied. It is found that the nanocrystalline MgB_4O_7:Dy with a dopant concentration of 1000 ppm is the most sensitive amongst varying dopant concentrations, with its sensitivity equal to 0.025 times that of the standard phosphor $CaSO_4$:Dy. The glow curve has two peaks at 154 °C and 221 °C. The nanophosphor has very poor sensitivity for low doses up to 10 Gy but beyond this dose the phosphor exhibits a linear response up to 5000 Gy. On increasing the dose further, the response first becomes supralinear and then sublinear, finally resulting into saturation. Considering also its low fading particularly under post-irradiation annealing and excellent reusability features, this nanophosphor may be used for high dose (10–5000 Gy) measurements of ionizing radiations.

3.10.9 Thermoluminescence and photoluminescence studies of nanocrystalline $Ba_{0.97}Ca_{0.03}SO_4$: Eu

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Nanocrystalline $Ba_{0.97}Ca_{0.03}SO_4$:Eu having a grain size of 58 nm has been prepared and a comparative study has been done with its corresponding microcrystalline form. The thermoluminescence (TL) glow curve of the nanophosphor has a prominent peak at 161 ^{0}C and a very small hump at 225 ^{0}C. The TL sensitivity of the nanophosphor is about 0.1 times that of the microphosphor. Kinetics parameters of the TL peaks of the nanophosphor are worked out and are compared with those of the microphosphor. The TL response of the nanophosphor is linear in the dose range 1 Gy–20 KGy, which is much wider than that of its corresponding microcrystalline form. The glow curve shape and structure also do not change in the linear dose range and since the TL response is linear at higher doses the nanophosphor is quite well suited for high dose measurements. Photoluminescence emission spectra of the nano- and the microphosphors are also studied and their results are correlated with other experimental findings.

3.10.10 Thermoluminescence of $Ba_{0.97}Ca_{0.03}SO_4$:Eu irradiated with 48 MeV ^{7}Li ion beam

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Thermoluminescence (TL) of $Ba_{0.97}Ca_{0.03}SO_4$:Eu phosphor, irradiated with 48 MeV ^{7}Li ions at different fluences in the range 1×10^9–1×10^{12} ions/cm^2, has been studied. The phosphor was prepared by the chemical co-precipitation technique. Its pellets were irradiated using a 16MV Pelletron Accelerator. The samples from the same batch were also irradiated with γ-rays from a Cs^{137} source for comparative studies. It has been found that the TL glow peak at 460 K, seen prominently in c-irradiated sample, appeared as a small shoulder at around 465 K in $^7Li^{3+}$ ion irradiated sample, while that observed as a shoulder in the former at 430 K, dominantly appeared in the latter at around 435 K. Trapping parameters of both, ion beam and γ-irradiated materials, were also obtained after the deconvolution of the glow curves. The TL response curve of the ion beam irradiated samples has a linear ion beam fluence response over the range 1×10^9–1×10^{10} ions/cm^2. This property along with its low fading and simple glow curve structure makes $Ba_{0.97}Ca_{0.03}SO_4$:Eu phosphor, a suitable dosimeter for heavy charged particles (HCP).

3.10.11 $K_3Na(SO_4)_2$:Eu nanoparticles for high dose of ionizing radiation

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$K_3Na(SO_4)_2$:Eu nanocrystalline powder was synthesized by the chemical co-precipitation method. The x-ray diffraction pattern of the nanomaterials shows a hexagonal structure for its crystals having grain size of 28 nm. Transmission electron microscopy revealed that the $K_3Na(SO_4)_2$:Eu nanoparticles are single crystals with almost a uniform shape and size. Thermoluminescence (TL) was taken after irradiating the samples at various exposures of γ-rays from a ^{60}Co source. A prominent TL glow peak is observed at 423K along with three small peaks/ shoulders at around 382, 460 and 509 K. The observed TL sensitivity of the prepared nanocrystalline powder is around 4 times more than that of LiF : Mg,Ti (TLD-100) phosphor. The 423K peak of the nanomaterial phosphor eventually shows a near linear response with exposures increasing up to very high values (as high as 70 kGy), where all the other TLD phosphors saturate. This property along with its other desired properties such as high sensitivity, relatively simple glow curve structure and low fading makes the nanocrystalline phosphor a suitable dosimeter to estimate low as well as high exposures of γ-rays. TL analysis using the glow curve deconvolution technique was also done for determining different trapping parameters.

3.10.12 Effect of swift heavy ion irradiation on nanocrystalline CaS:Bi phosphors: Structural, optical and Luminescence studies

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Luminescence studies of CaS:Bi nanocrystalline phosphors synthesized by wet chemical co-precipitation method and irradiated with swift heavy ions (i.e. 100MeV O^{+7} ions and 200 MeV Ag^{+15} ions) have been carried out. The samples have been irradiated at different ion fluences in the range $1x10^{12}$-$1x10^{13}$ ions/cm^2. The average grain size of the samples before irradiation was estimated as 35 nm using line broadening of XRD (X-ray diffraction) peaks and TEM (transmission electron microscope) studies. The blue emission band of nanosized $CaS:Bi^{3+}$ at 401nm is from the transition of $^3P_1$ to $^1S_0$ of the Bi^{3+}. After ion irradiation the lattice constant decreases and optical energy band gap increases which may be due to irradiation induced grain fragmentation. We have studied the optical and luminescent behavior of the samples by changing the ion energy. It has been observed that ion irradiation enhanced the luminescence properties of samples.

3.10.13 Swift heavy ion induced structural modification and photo-luminescence in CaS: Bi nanophosphors

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CaS:Bi nanocrystalline powder of average grain size 35 nm was prepared by wet chemical co-precipitation method and irradiated with 100 MeV oxygen ions at fluences between 1×10^{12}–1×10^{13} ions/cm^2. The irradiation induced damage and modifications were studied using X-ray Diffraction (XRD), transmission electron microscopy (TEM) and photoluminescence (PL) spectroscopy. With the increase in ion fluences, the crystallinity of CaS was destroyed upto 25.9 % for the reflection (200) and 21.1 % for the reflection (220) and the peaks broadens at a much faster rate due to grain breaking process. Structural parameters such as grain size, strain and dislocation density have shown a significant change after ion irradiation. The effects of different dopant concentrations on PL emission intensity after irradiation were also investigated. A blue shift of the photoluminescence peak with increasing ion fluence was noticed and was also ascribed to a decrease in the CaS grain size.

3.10.14 Effect of high-energy $^7Li^{2+}$ ions on the TL behavior of LiF:Mg,Cu,P detectors

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Thermoluminescence (TL) of LiF:Mg,Cu,P (TLD-700H) phosphor irradiated with 24 MeV ^7Li ions at different fluences in the range $5x10^9$-$1x10^{12}$ ions/cm^2 (with corresponding doses in the range 620 Gy – 123.96 kGy) has been studied. The samples from the same batch were also exposed to ^{3}-rays from a Co60 source for comparative studies. It has been found that, at low fluences ($5x10^9$-$1x10^{10}$ ions/cm2) the TL glow curves of the samples irradiated with ^7Li ions have similar structures to that of ^{3}-irradiated sample, while at higher fluences ($5x10^{10}$ - $1x10^{12}$ ions/cm^2) the relative intensities and fluence responses of the TL glow peaks were observed to vary with fluences increasing. The TL intensity of the dosimetric peak at 481 K saturates at the fluence $5x10^{11}$ ions/cm^2, while that of the peak at 524 K increases till the maximum fluence $1x10^{12}$ ions/

cm^2. All the TL glow peaks are shown nearly sublinear behavior except the peak at 524 K, which exhibits supralinear. This has been attributed to the formation of more defects (Trapping Centers (TC)/Luminescence Centers (LC)) due to ^{7}Li ions implantation, during ion beam irradiation. Moreover, on ion beam irradiation, a shift in the peak positions towards lower temperature side by around 10 K was observed, comparing with those induced by Co^{60} γ-rays. The TL efficiency of LiF:Mg,Cu,P to 24 MeV ^{7}Li ion beam has been measured relative to γ-rays of Co^{60}. Further, theoretical analysis of the glow curves of the ion beam and γ-irradiated samples was done by Glow Curve Deconvolution (GCD) method to determine trapping parameters of various peaks. As LiF:Mg,Cu,P is highly sensitive and tissue equivalent TLD material and its peak at 524 K does not saturate even at high fluences. Therefore, this peak may be used for the dosimetry of ion beams in medical and other applications.

3.10.15 Nanoparticles of $K_2Ca_2(SO_4)_3$:Eu as effective detectors for swift heavy ions

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The modification of thermoluminescence (TL) and photoluminescence (PL) properties of $K_2Ca_2(SO_4)_3$:Eu nanoparticles by swift heavy ions (SHI), irradiation is studied. Pellets form of the nanomaterials were irradiated by 48 MeV Li^{3+}, 75 MeV C^{6+}, and 90 MeV O^{7+} ion beams. The fluence range is 1×10^{9} to 1×10^{13} ions/cm^2. The modification in TL glow curves of the nanomaterials irradiated by Li^{3+}, C^{6+}, and O^{7+} ion beams are essentially similar to those induced by γ-ray irradiation. These glow curves have single peaks at around 427 K with a small variation in their positions by around ±3 K. The TL intensity of the ion beams irradiated nanomaterials is found to decease, while going from low to high atomic number (*Z*) ions (i.e., $Li^{3+}$to O^{7+}). The TL response curve of the pellets irradiated by Li^{3+} ions is linear in the whole range of studied fluences. The curves for C^{6+} and O^{7+} irradiated samples are linear at lower fluences 1×10^{9}"1×10^{12} ions/cm^2 and then saturate at higher fluence. These results for the nanomaterials are much better than that of the corresponding microcrystalline samples irradiated with a Li^{3+} ion. The curves were linear up to the fluence 1×10^{11} ion/cm^2 and then become sublinear at higher fluences. The TL efficiency values of $K_2Ca_2(SO_4)_3$:Eu nanoparticles irradiated by 48 MeV Li^{3+}, 75 MeV C^{6+}, and 90 MeV O^{7+} ion beams have been measured relative to γ-rays of ^{60}Co and are found to be 0.515, 0.069, and 0.019, respectively. This value for the Li^{3+} ion (0.515) is much higher than that of the corresponding microcrystalline material (0.0014). These superiorities for the nanomaterials make $K_2Ca_2(SO_4)_3$:Eu nanophosphor a suitable candidate for detecting the doses of swift heavy ions. PL studies on the ion beam irradiated and unirradiated $K_2Ca_2(SO_4)_3$:Eu nanoparticles show a single band at 384 nm, which could be assigned to Eu^{2+} emission, while the microcrystalline form of this material shows emission at 436 nm. This wide blueshift in PL of the nanomaterial could be attributed to the extension of the band gap of Eu^{2+} due to the absence of crystal field effects.

3.11 CIVIL WORKS

M.K.Gupta

Civil section is associated with the following activities:

- Major expansion Project (right now Phase II – Part II expansion by CPWD)
- Minor Projects
- Minor Works (additions, alterations, renovation in the existing Civil works)
- Civil Maintenance
- External Cleaning of the Campus
- Liaison with various Govt. and outside agencies for statutory approvals and various civic problems

Important Civil Activities during the Year 2007-08

Following important civil works were undertaken during the year 2007-08 in addition to routine civil maintenance and minor works:

(i) Completion of Beam Hall-III Civil works by CPWD.
(ii) Construction of ATM room (for SBI) near Main gate.
(iii) Addition/alterations of toilet & bedroom doors in Flatlets.
(iv) External painting of Main Laboratory Building.
(v) Extension of Phase-II housing playground by leveling and dressing.
(vi) Fabrication/erection of Aluminium glazed partition and door at reception of New Guesthouse.
(vii) Fabrication/erection of PVC security booth at post “G”(near boundary wall between IUAC & ICGEB).
(viii) Construction of speed breaker at road crossing near Flatelets.
(ix) Extension of Phase-I housing drainage upto Septic tank.
(x) Fabrication/erection of PVC cabin for housing Raman set-up in Beam Hall-II.
(xi) Replacement of damaged RCC covers over storm water drains in the campus.
(xii) Installation of roadside convex mirror (of Polycarbonate) near Flatelets.

(xiii) Making heavy concrete block walls (including fixing door) near rolling shutter on E-side of Beam Hall-II for HYRA beam line.

3.12 COMPRESSED AIR SYSTEM AND MATERIAL HANDLING EQUIPMENTS

K.K. Soni and Bishamber Kumar

This section is associated with the following activities:

(i) Compressed Air System: Compressed air plant (Ph-I & PH-II) consisting of two nos. reciprocating compressors each of 60 M^3/Hr and two nos. screw compressors each of 115 M^3/Hr capacity, air dryers & filters with capacity of 3000 lpm @ 9.00 Kg/cm^2 have been maintaining uninterrupted air supply to tower, Beam Hall- I, Beam Hall -II buildings, round the clock. In order to further increase the reliability of the Compressed air supply at constant pressure, a 25 M^3 Storage tank is designed, fabricated and installed. It is installed in the Compressed air line on the roof of UB II .Pneumatic connections have been extended to all the labs.

Further to ensure proper dew point of the air, the compressed air is passed through two refrigerated type air dryers of 4300 LPM capacity. Ultra high filters of boro- silicate and carbon are provided in different location of the compressed air to provide clean air free from dust and oil particles.

Since Reciprocating compressors are more power consuming and source of excess oil contamination in the compressed air, two reciprocating compressors are replaced by one Screw Air Compressor of 2208 lpm capacity. Compressed air piping has been extended to Lab I, Lab II and New Workshop building. An additional GA-15 air compressor is being added to the system to meet the increased requirement of compressed air and also to make the system more reliable.

(ii) Industrial Gases: Various industrial gases required in different labs have been made available from time to time. Special gases like Iso Butane and mixture gases are also procured for labs.

(iii) Elevator: Elevator has been running smoothly and monthly preventive maintenance of the same is carried out to minimise the operational break down.

(iv) Material Handling System : Periodic maintenance / servicing of more then 10 E.O.T cranes and electric hoists of various capacity varying from 1 Tonne to 7.5 Tones are being carried out periodically and the same have been working smoothly. Two more cranes of 2 Tone capacities are installed in EBWM room and Material Storage area. A 2 Tones EOT Crane has been installed in new workshop building to handle the heavy items during machining of parts and also during maintenance of Machines. All the cranes are put on remote control operation for safe handling of machines. A crane of 7.5 Tonnes capacity is proposed and fabrication is under progress for BH III.

(v) Fire Extinguishers: Annual refilling and periodic maintenance of all the fire extinguishers have been carried out. New fire extinguishers have been installed in newly constructed BH II store area , Lab I and Lab II area, Workshop building. Some more signal including the "Escape route" in emergency is added in the building with GLOW LIGHT which shines even in darkness. Demonstration for use of Fire extinguishers has been arranged and all the users and IUAC employees are trained to use the fire extinguishers.

3.13 DATA SUPPORT LABORATORY

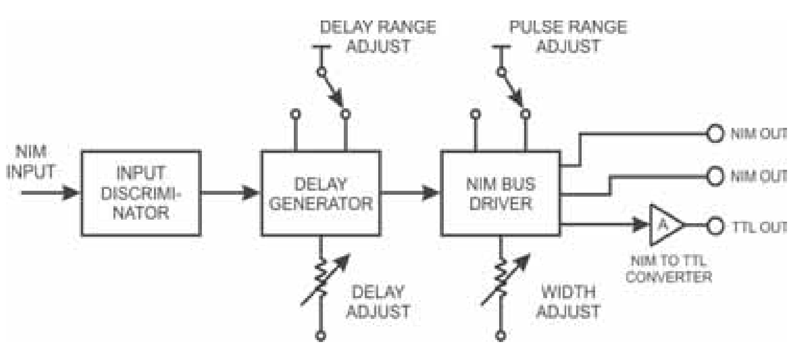
V.V.V.Satyanarayana, R.Ruby Santhi and P.Sugathan

Data Support Laboratory provides technical support to users in setting up their data acquisition system and readout electronics in data room. There are two independent On-line data acquisition systems based on CAMAC and NIM electronics system. This year, we have revamped the layout of the setup by adding two more PC based off-line data analysis system in the data room. Apart from providing regular user support & maintenance of the setup, we have developed few electronic modules and serviced a number of NIM & CAMAC modules. The lab had procured new modules, cables & connectors for data acquisition purpose.

3.13.1 Octal Gate & Delay Generator

This module provides a compact and versatile solution for gating and coincidence logic requirements, or in measurements requiring multiple delays and pulse widths. It contains eight independent channels of gate and delay generators in a single-width NIM module.

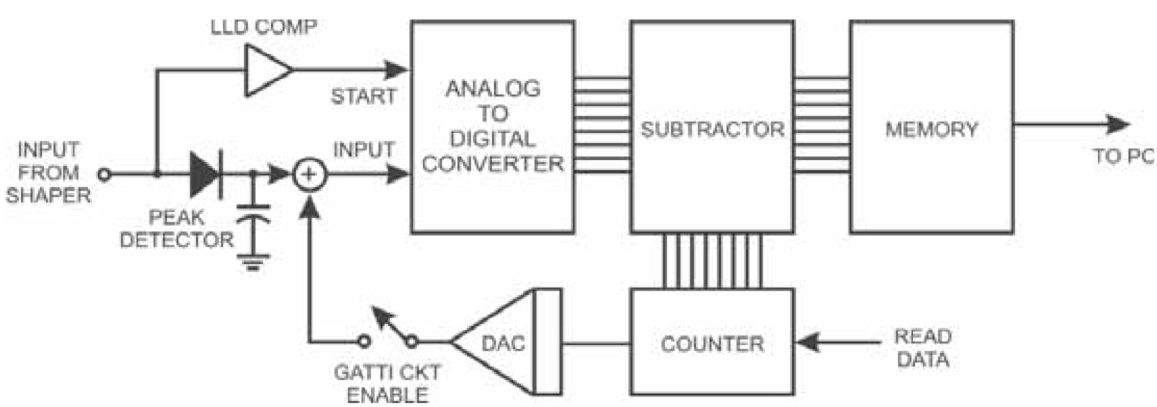
Each channel accepts NIM-standard, fast negative logic pulses at its input. The leading edge of the input signal triggers a delay period that can be adjusted separately for each channel. Delay ranges from 70 to 1000 ns or from 0.4 to 10 µs which can be selected separately for each channel by one of the eight jumpers on the printed circuit board. A second set of eight jumpers independently select ranges from 70 to 1000ns, or 0,4 to 10 µs for the output pulse widths.



Each channel produces two NIM-standard, fast negative logic pulse outputs, and one positive TTL output. The fast negative outputs provide fan-out capability, and are particularly useful for driving overlap coincidence modules that require NIM-standard, fast negative logic levels. They can also be used as delayed inputs to timing instruments, or as gating signals on modules that require fast negative inputs. The TTL output is compatible with modules requiring either TTL inputs, or NIM-standard, slow positive logic pulses. The TTL output is ideal for gating ADCs and Multichannel analyzers. This module has been used very successfully in one of the recent experiments using neutron detector arrays at IUAC.

3.13.2 Fabrication of FPGA based 8K ADC with Histogram

This year we have fabricated 4 numbers of FPGA based Histogram generator with built in ADC. The peak sensing circuit detects the height of the input and is given to an analog to digital converter based on the integrated chip AD676 from Analog Devices. A threshold comparator sitting at the input initiates the conversion process and after the conversion complete data will be given to the histogram generator implemented using Xilinx XC4010EPQ160 FPGA using VHDL design. The circuit is wired on a single width CAMAC modul



3.13.3 Fabrication of FPGA based Histogram generator CAMAC module

Six more Histogram generator module has been made this year. This is a single width CAMAC module which contains 8K, 24-bit memory and communicates through the CAMAC bus to the Data acquisition computer. Logic part of the circuit is integrated into a single XC4010 Xilinx integrated chip using VHDL design.

3.13.4 Fabrication of Current Integrators

Two more Current Integrator modules have been fabricated this year. The current integrator is used by the experimentalists for measuring the beam current in their experiments. This current integrator module includes the important features like input current polarity indication, pre-selection of dose and overload protection. It is regularly being used for measuring dc current or average pulsed beam current at IUAC.

3.13.5 Drive-probe Controller for LINAC

This is a single width CAMAC module which controls eight stepper motors connected to the Drive-probe in LINAC cryostat. By changing the position of this probe, cavity impedance can be adjusted to 50 ohms for injecting the maximum power.

3.13.6 Servicing and Maintenance

A few numbers of NIM and CAMAC modules were serviced and repaired. The following items are serviced during the year

1) Pre-amplifier, EG&G Ortec model 142A
2) Timing Filter Amplifier, EG&G Ortec model 474
3) 8K Analog to digital converters (2nos), Canberra model AD8075
4) Time to digital converters (5nos), Philips Scientific model 7186