4. EXPERIMENTAL FACILITIES IN BEAM HALL

4.1 GPSC & NEUTRON DETECTOR ARRAY FACILITY

The GPSC facility has been used extensively for many user experiments in nuclear physics and material science. For nuclear physics experiments, the facility has been used in a few time of flight experiments measuring fission fragment mass distribution and experiments which measured angular distribution of fission fragments and other emitted particles. This year, a new charged particle detector array, HYTAR (Hybrid Telescope Array) facility has been used in GPSC experiments to study the quasi-elastic scattering and fission fragment angular distribution measurements. Each telescope consists of an axial field gas ionization chamber followed by a Silicon detector forming the conventional ΔE-E telescope detector.

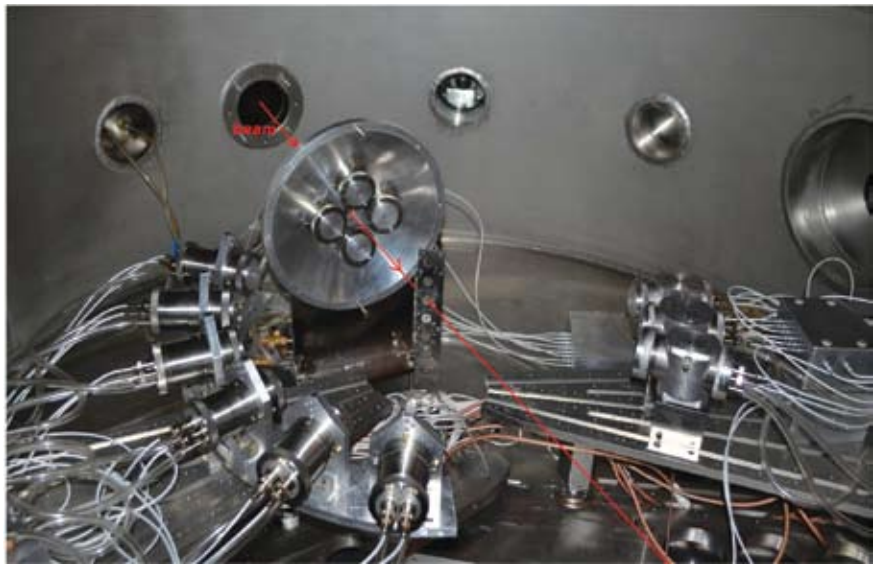

Fig. 4.1.1 HYTAR facility in GPSC for quasi -elastic scattering experiment

The neutron detector array facility installed in Beam Hall II at IUAC now consists of 100 neutron detectors and associated signal processing electronics. All the detectors have been mounted on the geodesic dome structure and signals routed to the data room through coaxial cables. Photo multiplier bases, high voltage supplies and pre - amplifiers for all the detectors have been installed in the beam hall setup. To process the neutron detector signals, 50 more channels of pulse shape discrimination electronics have been incorporated in the data room electronics setup. The VME based data acquisition system has been upgraded to collect data from the full detector array. All detector signals, electronics and data acquisition setup have been tested offline with radio-active

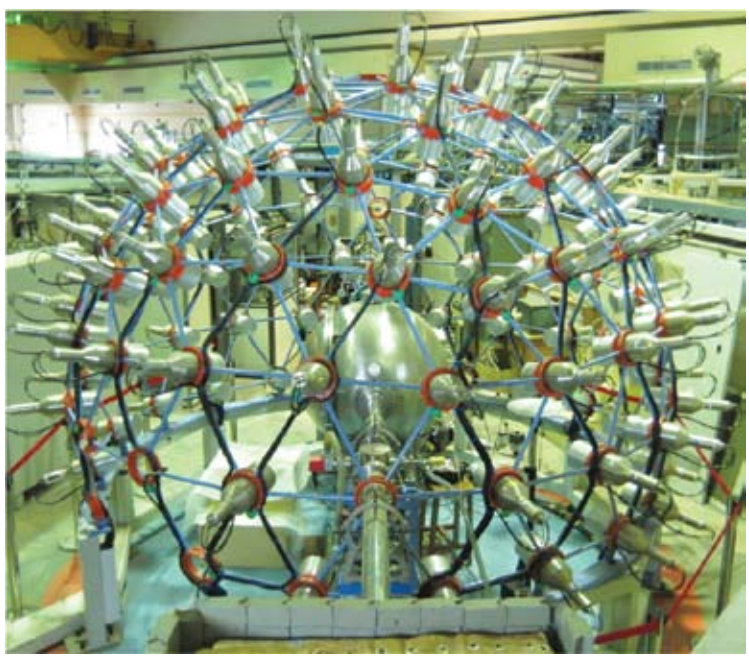

Fig. 4.1.2 Neutron Detector array facility installed in Beam Hall II at IUAC

source and tuned for online test and user experiments. Fission fragments are detected using multi wire proportional counters (MWPC). Two new detectors have been fabricated and tested with radioactive source.

4.1.1 Design, Fabrication and Testing of MWPC

N. Saneesh, A. Jhingan and P. Sugathan

A pair of Multi Wire Proportional Counters has been fabricated for the detection of fission fragments in nuclear physics experiments. The detectors have been built using four electrodes geometry based on the design of Breskin's [1] four electrode configuration. All electrode (Position, cathode and anode) frames were made by soldering stretched gold plated tungsten wires (20 micron diameter) on 3.2 mm thick printed circuit boards. The wires were stretched on each frame by adjusting the wire tension to ~ 50-60 cN. Commercial passive delay line chips (Rhombus TZB 12-5) were soldered on each position frame (X and Y) to extract position information [2]. The end-to-end delay in X and Y frames were 160 ns and 80 ns respectively. The electrical connectivity and continuity on each position wire frame was tested by injecting test pulses from a pulser. The electrodes were mounted inside aluminum housing and vacuum sealed using an entrance window foil. The entrance window foil was prepared using 1 micron thick mylar foil having an active area of 20 cm x 10 cm. The off line test of detector was performed using ^{252}Cf fission source. The detector was operated with isobutane gas at a pressure of 2 mbar and a bias voltage of +390 V and -180 V on anode and cathode respectively. The timing signal from the detector is shown in fig. 4.1.3. The 2D position spectrum with a rectangular mask (having 1 mm diameter holes at 5 mm separation) kept in front of the detector is shown in fig. 4.1.4. The position resolution estimated by this method is found to be 1.3 mm FWHM.

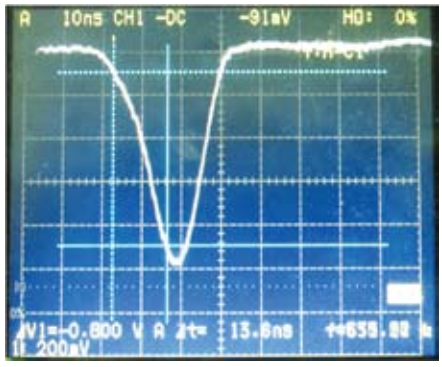

Fig. 4.1.3 Timing signal from MWPC

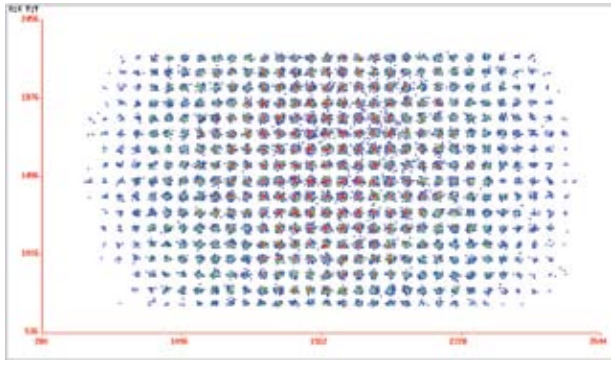

Fig. 4.1.4 2D spectrum of rectangular mask

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4.1.2 Measurement of Efficiency of Neutron detectors

N. Saneesh, A. Jhingan and P. Sugathan

The fast neutron detection efficiency of the NAND detectors as function of energy has been measured by Time Of Flight (TOF) method. Two fast timing detectors (BC501A and MWPC) were used for TOF measurement. A spontaneous fission source, ^{252}Cf, was placed at the target position

inside NAND reaction chamber (vacuum of $4x10^{-6}$ mbar) and a fission fragment detector, MWPC, was placed at 13 cm from the target. The MWPC was operated at 3 mbar pressure of isobutane gas, the neutron detectors were mounted on the geodesic dome structure with 175 cm flight path. The detection threshold for all the neutron detectors was kept at 1/4th of the Compton edge corresponding to ^{137}Cs. Data was collected using master trigger from MWPC,triggering on fission events and the corresponding neutrons detected in BC501A. Pulse shape Discrimination (PSD) modules were used for n-gamma separation and neutron TOF. Neutron energy spectrum was derived from the TOF spectrum in the laboratory frame. Theoretical neutron energy distribution from ^{252} Cf in the Center of Mass (CM) frame is best described by Maxwell-Boltzmann distribution equation,

$$f(E)dE = \frac{2*\sqrt{E}}{\sqrt{pi}*T^{3/2}} * e^{-E/T} dE$$

where E is the neutron energy and T is the source temperature (both in MeV).

For absolute efficiency calculation, the proper Jacobian matrix has been calculated for lab to CM conversion and the theoretical energy distribution in the lab frame was determined. Finally, the absolute efficiency as function of energy was extracted by comparing the theoretical and experimental energy spectrum in the lab frame and it is shown in fig. 4.1.5.

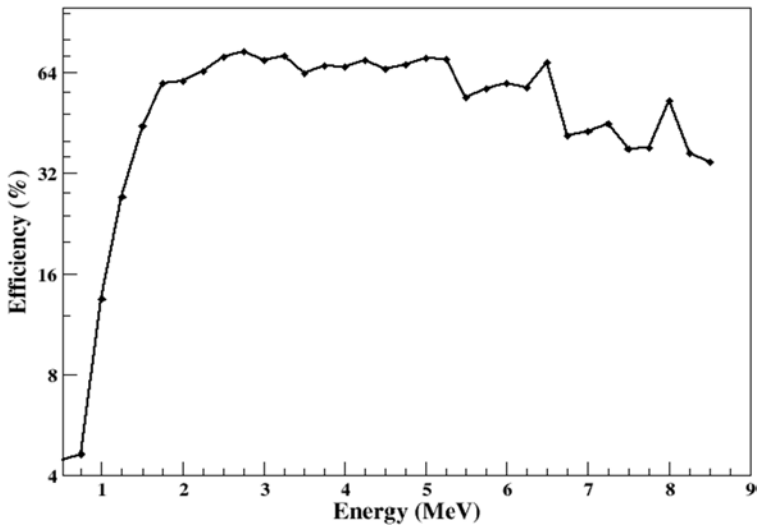

Fig. 4.1.5 Efficiency spectrum at 300 keV threshold

4.2 GAMMA DETECTOR ARRAYS (GDA AND INGA)

R.K. Gurjar, Indu Bala, Kusum Rani, R. Garg, R. Kumar, S. Muralithar and R. P. Singh

The Gamma Detector Array (GDA) setup was used for lifetime measurements in platinum and palladium nuclei using the plunger device. In these experiments six Compton suppressed HPGe detectors were employed along with 14 element BGO multiplicity filter. Experiments to study reaction dynamics in incomplete fusion reactions at 4-7 MeV per nucleon were also done using the GDA detectors in the last academic year. An experiment was carried out using the Perturbed Angular Distribution (PAD) setup. A number of short term student projects were also completed using the GDA setup.

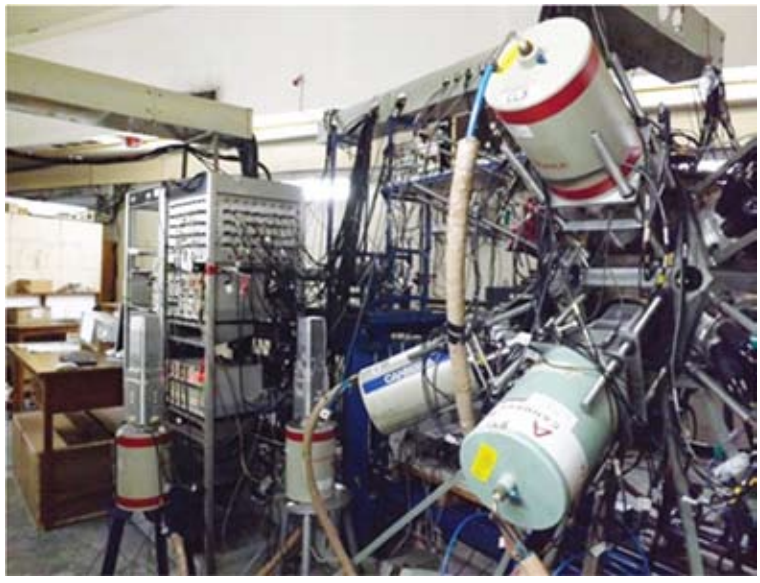

Fig. 4.2.1 Clover detectors being tested in GDA beam line area

We have diagnosed the problems in our old HPGe detectors and trying to get these detectors repaired.

The IUAC clover detectors which are part of Indian National Gamma Array (INGA) were brought back after the end of INGA campaign at TIFR. These detectors and the electronic modules, namely, clover modules, high voltage power supplies, ADCs are being tested in GDA beam line. In fig. 4.2.1 two clover detectors can be seen during the test.

The various sub-systems of the INGA setup are being tested for the up-coming INGA-HYRA campaign. The automatic liquid nitrogen (LN2) filling system was energized and it was checked with the 1000 litre storage dewar in beam hall 2. Some of the clover detectors were mounted in the INGA support structure and were filled with LN2 using the filling system. A few faulty LN2 sensors and the hoses are being replaced.

Fig. 4.2.2 (a) Clover and ACS detectors mounted in INGA support structure
(b) Control valves for LN2 filling using 1000 litre dewar

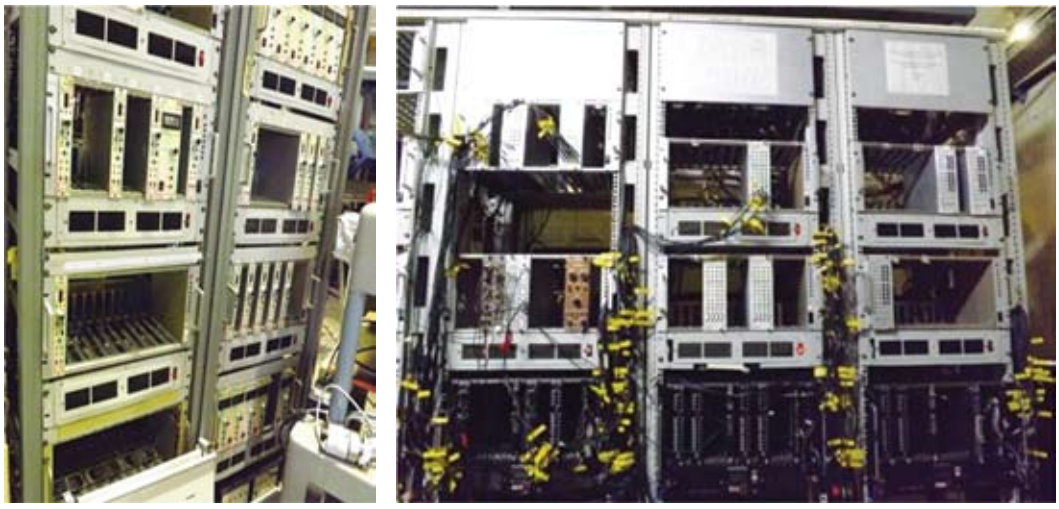

Fig. 4.2.3 (a) High voltage power supplies and (b) Clover modules and ADCs being tested

4.3 RECOIL MASS SPECTROMETERS AT IUAC

4.3.1 Heavy Ion Reaction Analyzer (HIRA)

S. Nath, J. Gehlot, T. Varughese, A. Jhingan, N. Madhavan

HIRA was used in four experiments, including three student thesis experiments, to select the evaporation residues (ERs) from excited, medium and heavy mass compound nuclei (CN), formed in $^{28}Si+^{92,96}Zr$ (Delhi University), $^{16,18}O+^{181}Ta$ (Calicut University), $^{16}O+^{174,176}Yb$ (Gauhati University) and $^{19}F+^{180}Hf,^{181}Ta,^{182}W$ (IUAC) systems. Channel coupling effects, role of CN shell closure on sub-barrier and near-barrier fusion and ER survival against fission were the main motivations behind these experiments. In the reaction 19F+181Ta, ER cross sections were measured up to the deep sub-barrier region (~27% below the Coulomb barrier).

The entrance window foil of the multi-wire proportional counter (MWPC) at the focal plane was changed to 0.5 μm thick mylar for the detection of very low energy heavy ERs. Routine maintenance of power supplies, water cooling channels in magnets and power supplies, re-filling of high purity helium gas in the cryo-compressor, high voltage conditioning of electrostatic dipoles (EDs), replacement of old surface barrier detectors (for normalisation of cross-sections) in the target chamber, etc. were carried out prior to these long experimental runs. The recent availability of uninterrupted power supply (UPS) for entire HIRA setup along with that of Pelletron accelerator systems made the experiments immune to power glitches and minor power failures.

Several new experiments have been proposed and/or sanctioned beam-time in the last two AUC meetings for the utilization of HIRA in fusion and transfer reactions around barrier.

4.3.2 HYbrid Recoil mass Analyzer (HYRA)

N. Madhavan, S. Nath, J. Gehlot, T. Varughese, A. Jhingan and I. Mazumdar*

*Department of Nuclear and Atomic Physics, Tata Institute of Fundamental Research, Mumbai 400005, India

HYRA was used in gas-filled mode in five experiments, including four thesis experiments, to extract ER excitation function and/or spin distributions in heavy CN. The systems studied were $^{19}F+^{197}Au$, $^{16}O+^{203,205}Tl$ (ER excitation function and spin distributions), $^{28,30}Si+^{180}Hf$, $^{35,37}Cl+^{181}Ta$ and $^{48}Ti+^{142,150}Nd,^{144}Sm$. Data were taken for $^{30}Si+^{186}W$ and $^{48}Ti+^{122}Sn,^{154}Sm$ for calibration purposes and/or to extract the transmission efficiency of HYRA for ERs in appropriate kinematic regions. HYRA gas-filled mode is best suited for detection of heavy ERs as (i) it has higher efficiency due to charge state and velocity focusing, (ii) the selectivity of two large dipole magnets and (iii) continuous charge reset in the gas medium which overcomes the undesired problems of Auger processes (following internal conversion in long-lived isomers) which result in actual charge states of ERs being significantly higher than those predicted by empirical formulae. The ERs were selected using MWPC energy loss, timing and position signals and/or silicon strip detector energy, position and timing signals. The subsequent decay of ERs was also detected in silicon strip detector whenever the ER energy allowed the detection. Two of these experiments used only Pelletron beams and the rest were carried out with beams boosted by superconducting LINAC accelerator.

A new aluminium chamber (Fig. 4.3.1) with conical entrance and exit sections, which allows large angular acceptances (half angle of ~9.5° in θ and ϕ) and low γ-ray attenuation, was fabricated. The chamber has provision for monitor detector mounts machined from the bottom lid to maintain the angular accuracy, three-position target holder and a top lid, made of Perspex, to view the condition of targets. This new chamber was properly aligned and commissioned with HYRA and TIFR spin spectrometer combined facility and was used in all the above experiments.

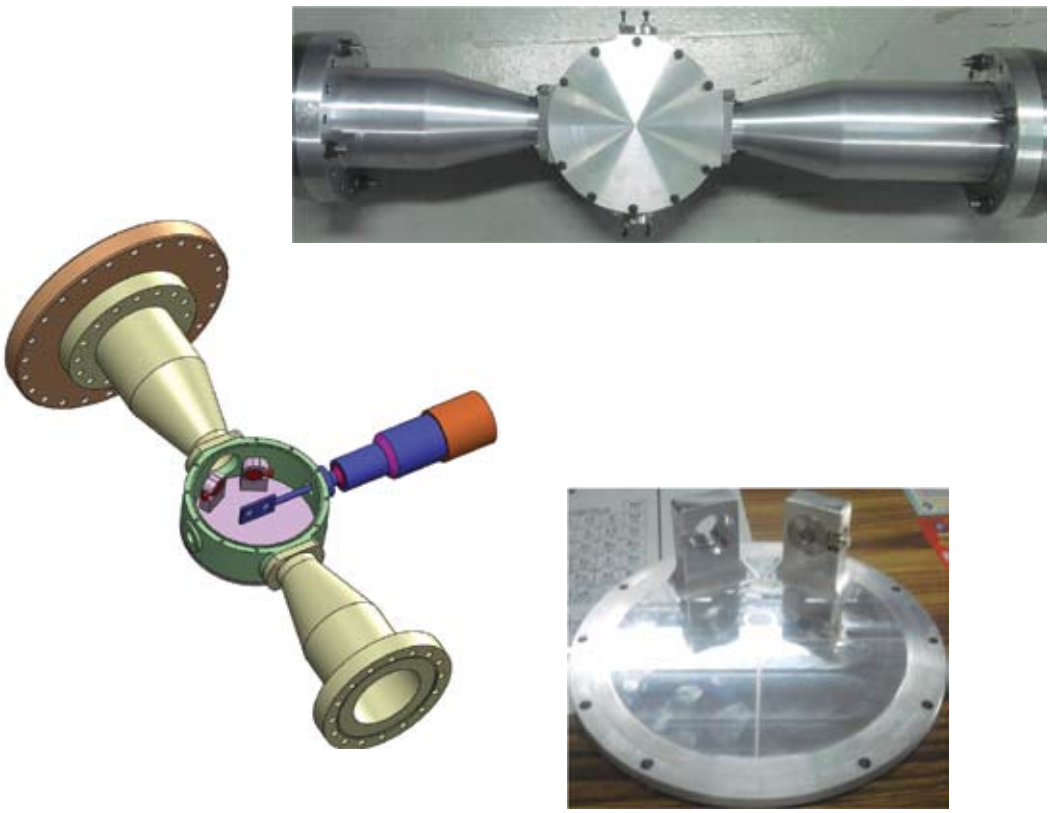

Fig. 4.3.1 The new target chamber of HYRA

All the electromagnetic components of HYRA (both stages), except the indigenously developed superconducting quadrupole doublet which is not yet fully ready for integrating with HYRA, have been set up (Fig. 4.3.2) and high vacuum has been achieved. ED conditioning, testing and use of second stage of HYRA will be initiated once the electrical connections, cooling water and compressed air supplies are provided.

Fig. 4.3.1 The new target chamber of HYRA

Several new experiments have been proposed and/or sanctioned beam-time in the last two AUC meetings for the utilization of HYRA and/or spin spectrometer (or 14-BGO detector array) in fusion reactions leading to heavy CN.

4.4 MATERIALS SCIENCE FACILITY

A. Tripathi, K. Asokan, V.V. Sivakumar, Fouran Singh, S.A. Khan, P. K. Kulriya, I. Sulania, P. Barua, A. Kothari and D.K. Avasthi

The materials science facilities continue to support the research programmes of a large number of users from different universities and institutions. This year there have been a total of 73 user experiments over 207 shifts and were performed without any major beam time loss due to facility break down in materials science beamline in beamhall I. These included 30 runs spread over 90 shifts which were BTA experiments associated with students' Ph.D. programmes. The swift heavy ion (SHI) irradiation and related experiments are mostly performed in the irradiation chamber in the materials science beamlines in beamhall-I, though one experiment running over 3 shifts was performed in materials science beamline in beamhall-II. Experiments are being done in areas of SHI induced materials modification and characterization and the details are given in Section 5.2.

Several synthesis techniques for preparing samples available for users such as RF sputtering system, microwave plasma system, ball milling system, box furnace and tubular furnace. Many off-line characterization facilities are also provided to users: XRD, UV-Vis, SPM, SEM, micro-Raman and transport measurement facilities.

4.4.1 Irradiation chamber maintenance

S A Khan, P Barua and A. Tripathi

The irradiation chamber in materials science beamline was used in more than 204 shifts of irradiation experiments from 72 users. The system has been running without any problem.

4.4.2 Scanning Probe Microscope

I.Sulania, Sunil Kumar and A. Tripathi

Last year about 372 samples have been scanned: 356 samples in AFM mode and 16 samples in MFM mode, from 48 and 3 users respectively.

There was a problem in AFM head mirror used for laser alignment. As the problem could not be solved by company engineer on site, the same was sent to company workshop for repair. The system was repaired in the company and was installed. Fig. 4.4.1 shows the parts repaired by the company. The AFM is now operational again.

Fig.4.4.1 The mirror head with its lever which was repaired

4.4.3 Field emission scanning electron microscope (FE-SEM)

S.A. Khan, Sunil Kumar and A. Tripathi,

The field emission scanning electron microscope (FE-SEM) from TESCAN, MIRA II LMH CS is widely being used to boost research activities in nanomaterials and other systems. This year the system has been used for studying surface morphology of nearly 577 samples from 117 users besides elemental analysis of 417 samples from 65 users in EDS mode.

The facility is supported by Q150TS Sputter Coater from Quorum Technologies, UK for measurements on insulating samples. The sputter coater was used to provide conductive coatings of gold and carbon for better imaging of nearly 373 insulating samples from 61 users. Many samples were also imaged in cross-sectional mode.

The FE source has run for more than five years and its tuning was also undertaken by company engineer.

4.4.4 *In-situ* X-ray Diffractometer

P K Kulriya, Renu Kumari, D K Avasthi

The XRD facility is used for structural characterization of samples in the two modes namely, (a) off-line XRD (temperature varying from 20 K to 300 K) of the pristine and post irradiated sample, and (b) *in-situ* XRD for the investigation of irradiation induced phase transformation.

This year offline XRD system has been used for characterization of around 425 and 110 samples in the GIXRD and Bragg-Brentano geometry, respectively. Two *in-situ* experiments related to irradiation induced structural phase transformation in the oxide materials for nuclear application are performed by (a) Dr. A.K. Tyagi, BARC, and (b) Dr. Shashank N. Kane Indore, using *in-situ* XRD setup. The results of the *in-situ* x-ray reflectivity test experiment performed during last academic year is analysized and published as "*In-situ* x-ray reflectivity study of swift heavy ion induced interface modification in a W/Si multilayer x-ray mirror, S Potdar et al J. Phys. D: Appl. Phys. 48(2015) 015305".

There is no major breakdown in the XRD system this year except the one related with high voltage switch which was replaced with new one. Some regular maintenance work carried out are (a) alignment of the x-ray diffractometer (b) cleaning of the x-ray tube water filter, (c) changing water of the chiller, (d) cleaning tank of chiller, and (e) cleaning the gobble mirror etc.

4.4.5 In-situ high temperature irradiation facility

P K Kulriya, Renu Kumari, D K Avasthi

The high temperature irradiation facility existing in the materials science beam line of LINAC can be used for irradiation of materials at elevated temperature to simulate reactor like condition. In one of the in-situ experiment, problem in the temperature controller was detected, which is rectified with help of resources available on internet. After that, a facility test experiment is performed on the irradiation studies of the pyrochlore materials. Another in-situ experiment on irradiation stability of the pyrochlore is performed in collaboration with Dr. A. K. Tyagi from BARC. A manuscript related to this facility is written, which is accepted for publication as "*In-situ* high temperature irradiation setup for temperature dependent structural studies of materials under swift heavy ion irradiation, *Kulriya et al*, Nucl. Instr. and Meth. B 342(2015)98. One more *in-situ* experiment to investigate the effect of microstructure on the radiation stability of the CeO_2 is performed and results are published as "Effect of grain size and microstructure on radiation stability of CeO_2: an extensive study, V Grover *et al*, Physical Chemistry Chemical Physics 16(2014) 27065-27073".

4.4.6 Installation and testing of RF sputtering setup

P K Kulriya, M. Archunan, Chandrapal, Sunaina Vashistha, D K Avasthi

The existing DC sputtering was upgraded to the RF sputtering system which can be used for preparation of thin films of the oxide materials. Figure 4.4.2 shows the photograph of the RF sputtering system. The RF generator (Advanced Energy Cesar 136, 13.56MHz, 600W), matching network and its accessories are procured. The pre-existing vacuum assembly such as rotary pump,

turbo molecular pump, and vacuum gauges etc, was reconnected with vacuum chamber after installing pnematic valve and roughing line. The leak testing of the vacuum chamber is done using He leak detector. After that, RF generator, and matching network are installed with vacuum chamber and plasma is generated. The system is tested by preparing thin films of the Ti, Pd, and TiO_2 at the room temperate as well as elevated temperature (300°C).

Fig.4.4.2 Photograph of the RF sputtering system for preparation of oxide thin films

4.4.7 Online-Elastic Recoil Detection Analysis Facility

S. A. Khan, A. Tripathi and D. K. Avasthi

The system is running fine. This year there was only one experiment utilizing this facility and it was in the beam-time of Mr. V. Singh (IIT Delhi). In this experiment, the hydrogen content was measured in Pd and Pd-C core-shell nanoparticulate thin film on silicon. The analysis showed the dependence of hydrogenation properties of the films on the carbon-shell thickness.

4.4.8 Insitu-Residual Gas Analysis Setup

S. A. Khan and A. Tripathi

The system showed no problem but it was not used in any user beamtime this academic year.

4.4.9 RF sputtering and ECR CVD systems

V. V. Siva Kumar

The RF sputtering system was operational during the year and thin film depositions of users were performed using the system. Thin films deposition using different targets such as $YBiO_3$ (IITD), ZnO , TiO_2 and Ag-TiO_2 (MNIT), TiO_2 , ZnO and Sm doped ZnO (GNDU) were carried out with different deposition conditions. The system is now changed to Thermal evaporation system.

In the Electron Cyclotron Resonance chemical vapor deposition (ECR CVD) work, thin films of

nanocomposite diamond-amorphous carbon were grown using methane and argon gases. An ECR argon plasma was first generated by using 200 watts microwave power with argon gas fed into the ECR plasma chamber in a controlled way. Prior to the deposition of thin films, the substrates were bombarded by argon ions from the ECR plasma to remove the SiO2 layer present on it. For the deposition of thin films, Methane gas was fed in a controlled way into the ECR argon plasma present in the ECR plasma chamber. The Thin films were deposited grown with different conditions obtained by varying the total pressure and methane partial pressure. Thin films were grown with 200 watts microwave power on Si substrates maintained at a substrate temperature of 150 °C with a dc bias of -400 V applied to the substrate holder.

The formation of nanodiamond and amorphous carbon phases in the deposited thin films was identified using X-Ray diffraction and Raman spectroscopy measurements and confirmed using High Resolution Transmission Electron Microscopy (HRTEM) measurements.

4.4.10 Status report on spectroscopy facilities

Fouran Singh, Subodh K. Gautam, I. Sulania, S K Saini, S. Rao, Archunan, and P. Barua

Spectroscopy facilities such as micro-Raman (MR), Photoluminescence (PL), and ionoluminescence (IL) are in operation for regular experiments. MR remains heavily utilized facility and have been exploited by large number users from various universities and institutes. Numbers of successful experiments were conducted on as-prepared and ion irradiated oxide semiconductors, graphene, ferrites and other pervoskites including multiferroic materials and thin films. The facility is in operation. This facility can also be used as in-situ characterization of materials during the swift heavy ion (SHI) irradiation in beam hall-II. However, the scattering intensity from such materials should be enough to collect the signal using fibre optic probe. PL facility is fully operational and being used regularly under blue (441.6 nm) and UV (325nm) excitations with the help of newly procured HeCd laser. A series of successful IL experiments were also performed. FTIR is down and planning of new FTIR spectrometer is in process. However, UV-Vis-NIR spectrometer has been ordered and this facility will be available soon.

4.4.11 Reinstallation of Low temperature magneto-transport set up using 8 T Oxford cryostat

R. Meena, A. Choudhary, J. Anthony, S. Sahu, K. Phaneendra, K. Asokan

Inter University Accelerator Centre, New Delhi-110067

Recently, we have reinstalled a magneto-transport measurement set up at IUAC to study the magneto transport properties of different materials in the temperature range from 1.5 K- 300 K in presence of magnetic field of 8 Tesla. The accuracy in the temperature range is 10 mK while the accuracy in the Magnetic field is 1 Gauss. Temperature below 4.2K was achieved by the evaporation method. The flow of He is controlled by the needle valve of size 10 micrometer in the bottom. The temperature is read by the Cernox 1050 SD model using the Lakeshore335 temperature controller. The resistance measurement is done by the Keithely 2612A in the four wire mode. We have interfaced all these instruments by using the lab view program such that it can measure two samples at a time. Measurements of both the samples can be controlled independently. Using this setup many measurements are done like – Calibration of the Allen-Bradley resistors, Diodes, Cernox resistors. We have also done the Characterization of some samples like- YBCO, V_2O_3 in magnetic field. The liquid He level was measured by the AMI 135 level meter. The liquid He level sensor

operates by measuring the resistance of a superconductive filament contained within a protective tube. The current through the sensor maintains the portion of the filament in He gas in the normal (resistive) state, while the portion in liquid remains in the superconducting state (zero resistance). The resulting voltage along the sensor is proportional to the length of filament above the liquid helium and provides a continuous measure of the He depth. The total length of the level sensor is 630 mm while active length is 610mm. It also consists mercury ips-20 power supply to charge the magnet. The oxford cryostat contains 26 litre liquid helium and normal evaporation rate is 2% per hour.

4.4.12 Magnetoresistance study of YBCO/Ag composites

Bilal A. Malik[1], Manzoor A. Malik[1], R. Meena[2] and K. Asokan[2]

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The study of vortex state of high temperature superconductors is important not only for technological application but also for theoretical understanding of high temperature superconductors [1, 2]. Vortex dynamics of high temperature superconductors provides vital information about the motion of vortices and their interaction with structural defects and about non-superconducting secondary phase which is usually added for tuning the superconducting parameters. Further, vortex dynamics received prominence in revealing the properties such as critical current density, upper critical field, vortex creep, activation energy etc. of superconducting state. To improve the physical parameters of superconducting state in general and critical current density in particular by the concept of flux pinning has received recently lot of attention from scientific community. Flux pinning can be achieved by number of ways; however, one of the simple methods of achieving flux pinning is to add the non-superconducting nano inclusions over the dimensions of coherence length. In order to improve the pining efficiency many researchers have found the nature of this non-superconducting nano inclusion can be magnetic, non -magnetic or ferroelectric material [3, 4]. In recent years, many efforts have been made in order to increase pinning efficiency of vortex lines of high temperature superconductors in general and YBCO in particular [5,6].

In the present work, we have studied the addition of Ag in YBCO which acts as pinning centers as probed by magnetoresistance measurement. The experiment was done at IUAC New Delhi using Oxford superconducting 8T magnet. We have found that transition temperature ($\mathbf{T_c^{on}}$) as well as the onset of global superconductivity ($\mathbf{T_c^0}$) increases with the addition of Ag in YBCO due to better intergrain connectivity. However, with the application of magnetic field the $\mathbf{T_c^{on}}$ remains almost constant but $\mathbf{T_c^0}$ shifts to lower temperature as field is increased. This shift is more in case of pure as compared to YBCO+10%Ag sample. Quantitatively for pure $\mathbf{T_c^0}$ shifts from 91K to 65K and for YBCO+10%Ag,$\mathbf{T_c^0}$ shifts from 93K to 78. This is understandable since $\mathbf{T_c^0}$ is determined by the weak links between grains as well as by vortex flow of magnetic flux lines, while as Tcon controlled by upper critical field of individual grain. The resistive broadening below $\mathbf{T_c^{on}}$ under applied magnetic fields up to 8T has been analyzed by thermally activated flux flow (TAFF) model ($\mathbf{p}=\mathbf{p}_0\exp(-U/T)$) and activation energy has been obtained from Arrhenius plot. It is found that activation energy for pure YBCO varies from 37972K to 2757K and for YBCO +10%Ag vary from 21266K to 2123K under the application of magnetic field from 0T to 8T. In conclusion we have observed the transport properties are significantly improved by the inclusion of Ag in YBCO.

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4.5 RADIATION BIOLOGY EXPERIMENTAL FACILITY

A. Sarma

Different radiation biology experiments are being carried out in the dedicated Radiation Biology Beam line of IUAC utilizing the **ASPIRE** [Automated sample positioning and irradiation system for radiation biology experiments] system where irradiations of cells can be done with a set of preset doses. The system is characterized by the dose uniformity over a field of 40 mm diameter within 2 % standard deviation. The mean fluence is within 1 % of the electronically measured value at the centre of the field. The characterization of the system has also been done using irradiating SSNTD [CN 85].

The radiation biology laboratory is having the following equipment to facilitate the sample preparation and post irradiation treatments.

- Two CO_2 incubators, Two biosafety cabinets, one small laminar flow bench for cell culture
- Field Inversion Gel electrophoresis, Normal gel electrophoresis, protein gel electrophoresis set up
- Image based cell counter Countess [Invitrogen] which also gives information about cell viability and Beckman-Coulter Z2 cell counter
- PCR machine, a crude gel documentation system, UV-Vis Spectrophotometer and a Fluorescence microscope.
- Perkin Elmer Multimode Plate Reader, Eppendorf and Plastocraft Refrigerated Centrifuge and a Biotek micro-plate washer.

The laboratory section has independent Split AC supply isolated from the central AC system. The CO_2 supply to the twin incubators is done from outside the lab area, which facilitates the replacement of empty cylinder without disturbing the laboratory environment.

Regular work is going on in the laboratory on

- Analytical procedures involving gene expression studies using PCR, Western Blot, Flurescence Immunostaining studies etc by the University Users
- Studies on Radiomodification of cancer cell lines using small doses of NaF
- High LET Radiation interaction on cancer cell lines treated with Anti EGFR conjugated Au nano particles

4.6 ATOMIC PHYSICS FACILITY

4.6.1 A setup for studying the charge state fraction of post collisional Ions

D. Swami, S.K. Saini and T. Nandi

Knowledge of post foil charge state distributions is always useful in selecting the beam energy

for a particular charge state of interest with maximum yield[1]. For studying the charge state fraction in post foil, we are in the process of developing a new technique involving an Inclined and Straight Plate Electrostatic Analyzer (ISESA) [2] in which one plate is held parallel and the other kept inclined at a certain angle relative to the beam axis in beam hall-2. Therefore an ISESA is asymmetric about the beam axis. It is essential to apply the voltages to the plates in such a manner that the beam is deflected towards the inclined one. A small gap (10mm) between the plates at the entry causes large deflections due to a high field. As the ions move forward, the gap increases (causing a lower field) so that the ions can escape without hitting the plate. This inclination of one deflecting plate allows better resolution of charge states and increases the number of charge states escaping without hitting the plate also [2].

The setup has been installed at the back of the General Purpose Vacuum Chamber for atomic physics experiment in the beam line as shown in figure 4.6.1. A gate valve placed in between the chamber and ISESA allows us to isolate the chamber and ISESA during the experiment. Two beam collimating slit systems are placed to align the beam with the axis of in the ISESA. ISESA is being used to deflect the post foil charge state so that deflected ions in the field region do not hit the plate at the exit. A trapper drift tube chamber of 1.5 m long is used so as to transfer ions tangentially after passing the ISESA. Trapper drift tube chamber provides opportunity to place a 220 mm long Position Sensitive Proportional Counter (PSPC). A P-10 gas filled Position Sensitive Proportional Counter is used to measure the position of different charge states simultaneously. There is one view port at the end of the beam line and the insertable Faraday cup placed at the end of vacuum chamber is used to monitor the beam current throughout the experiment. A vacuum control system has been designed to create high vacuum inside the trapper drift chamber and ISESA. To achieve the desired vacuum, one turbo pump (300 l/sec) is employed on the trapper drift tube chamber. To measure the vacuum inside the ISESA, a Pirani gauge and a full range cold cathode gauge are used.

Fig.4.6.1 ISESA setup of atomic physics beam line

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4.7 ACCELERATOR MASS SPECTROMETRY

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Accelerator Mass Spectrometry (AMS) facility for ^{10}Be and ^{26}Al measurement is in operation using 15UD Pelletron Accelerator. The clean chemistry laboratory is extensively utilized by various users for the chemical treatment and extraction of ^{10}Be and ^{26}Al from their samples.

In addition to the existing AMS facility, a new 500kV ion accelerator based AMS facility for ^{14}C measurements was installed last year. Graphitization laboratory was also developed. A brief of the activities performed in last year are explained below:

4.7.1 ^{14}C AMS facility

A new **XCAMS** system, the Compact Accelerator Mass Spectrometer eXtended for ^{10}Be and ^{26}Al, based on 500kV ion accelerator, was installed last year at IUAC [Fig. 4.7.1]. In addition to the ^{14}C measurements, the proposed system can perform ^{10}Be and ^{26}Al measurements also with better precision than using existing 15UD Pelletron accelerator. Installation of XCAMS system was carried out in the month of March 2015, followed by acceptance tests.

XCAMS system at IUAC has two ion sources, having 134 cathodes wheel and 40 cathodes wheel in each one. The 40 cathodes wheel ion source also has the option to accept gas cathodes.

The main components of XCAMS system are two MC-SNICS ion sources, an electrostatic analyzer at the low energy side, a 90°double focusing injector magnet with isolated vacuum chamber, 500kV Pelletron accelerator with re-circulating Ar gas stripper, a 90°double focusing analyzer magnet, a chamber with off-axis Faraday cups for stable isotopes measurements, a retractable SiN foil for ^{10}Be-^{10}B separation, a double focusing 90° electrostatic analyzer at the high energy side, a 45° analyzing magnet and a two anodes gas ionization detector.

The XCAMS system is remotely controlled by AccelNET user interface application program running on a PC under scientific Linux.

Fig. 4.7.1 XCAMS system installed at IUAC

For ^{14}C AMS measurements by XCAMS system, samples need to be converted into graphite form. Samples are first cleaned physically and then chemical pretreatment is carried out. The purified samples are combusted and CO_2 is extracted and converted into elemental carbon by graphitization. In a room adjacent to the XCAMS system a graphitization laboratory has been developed [Fig. 4.7.2] for pre-treatment and graphitization of carbon containing sample.

This laboratory is equipped with Automated Graphitization Equipment (AGE) and various other equipments, like soxhlet extraction unit, micro-balance, stereozoom microscope with transmitted and incident light, Freeze dryer, ultrasonic and centrifuge machine, fume hood, 100 class laminar air flow (LAF) units etc., required for pretreatment of carbon containing samples.

Automated graphitization equipment (AGE), developed in collaboration with ETH, Zurich is used for graphitization process [Fig. 4.7.2].

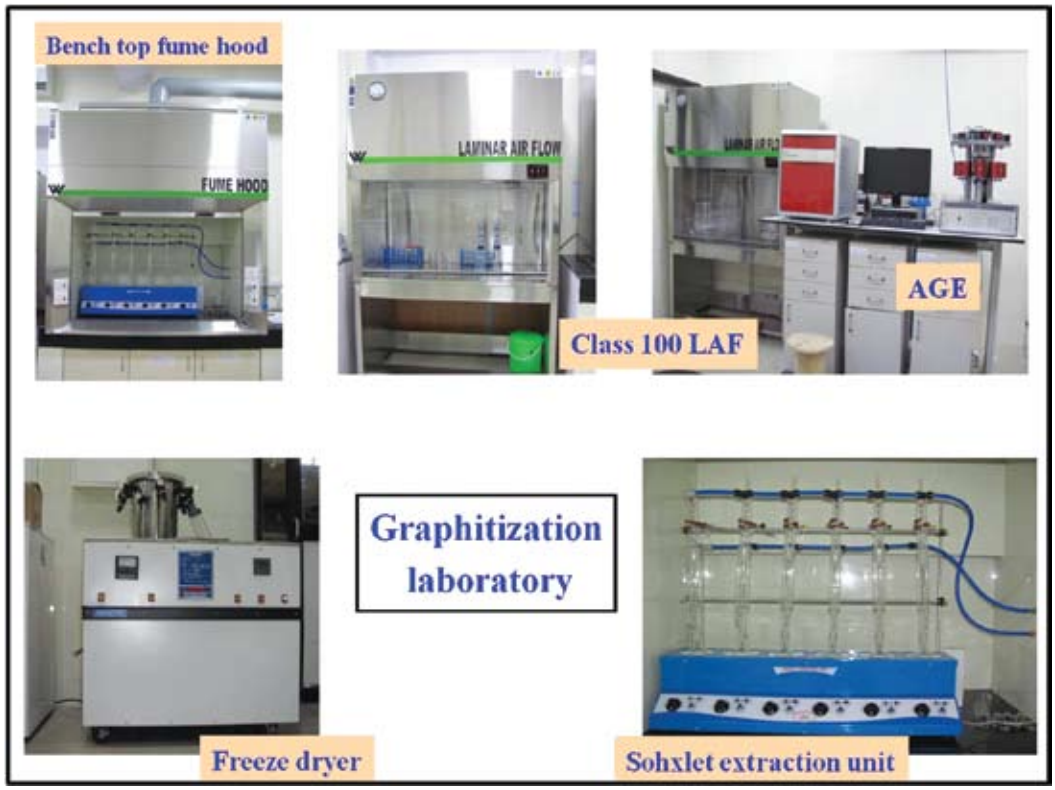

Fig. 4.7.2 Equipments in the Graphitization laboratory at IUAC