4. EXPERIMENTAL FACILITIES IN BEAM HALL

4.1 GENERAL PURPOSE SCATTERING CHAMBER (GPSC) & NEUTRON ARRAY FACILITY (NAND)

M. Archunan, A. Kothari, P. Barua, K. S. Golda, A. Jhingan and P. Sugathan

The GPSC facility is being used extensively for many user experiments in various fields of Physics viz. Nuclear reaction studies, material science and atomic physics. The nuclear reaction experiments involved the studies of heavy ion induced fusion-fission dynamics by measuring fission fragment angular distribution and mass distribution. The experimental facility consists of a time of flight setup using two large area multi-wire proportional counter (MWPC) for detection of complimentary fragments in coincidence, array of hybrid detector telescope (gas ionization & Silicon detector) for particle identification and angular distribution measurements.

Neutron array facility

The existing neutron array facility consisting of 24 liquid scintillators and two MWPC detectors for fission fragment setup has been used in user experiments measuring pre- & post scission neutron multiplicity from heavy ion induced fission. The neutrons were detected in coincidence with fission fragments. A series of experiments were performed in this year and the analysis of data from these experiments is currently in progress. This facility will soon be replaced by the large array of neutron detectors (DST project) being setup at IUAC.

4.1.1 DEVELOPMENT ACTIVITIES FOR LARGE ARRAY OF NEUTRON DETECTORS

V.V. Satyanarayana, S.K. Suman, T. Varughese, Rajesh Kumar, P. Barua, E.T. Subramaniam, J. Antony, S. Venkataramanan, J. Zacharias, Ruby Shanti, Kundan Singh, K.S. Golda, A. Jhingan & P. Sugathan

The DST supported project on large array of neutron detectors consisting of 100 liquid scintillators along with high efficiency fission fragment detector array will be used for neutron- fission coincidence measurements using heavy ion beams from LINAC accelerator facility at IUAC. Once completed this facility will be the largest neutron array in India. The project is being implemented in two phases, with the first phase consisting of 50 detectors and its pulse processing electronics. The detectors will be NE213 compatible liquid scintillator of type BC501A, 5”x5” cylindrical size coupled to 5” photomultiplier tube R4144 from Hamamatsu. Currently the work on development of readout electronics, high voltage power supplies, spherical target chamber and the detector mounting structure are progressing well and soon we will start installation of the first phase of the project.

Mechanical structure:

The mounting of 100 detectors in the array requires dedicated mechanical structure for the positioning and alignment of the detectors. For the mechanical structure, we considered the geometry of a 'Geodesic Dome' with detectors mounted at a radial distance of 175 cm from the reaction point. The targets and the fission detectors will be housed in a 100 cm dia spherical vacuum chamber at the center of dome. Detectors are to be mounted on suitable hubs fixed at the vertices of the geodesic. A total of 111 detectors can be accommodated in this geometry. Few of the detectors and its supporting struts will be removed for beam inlet & outlet and for access to the inside of the structure. Since the height of the beam line is ~ 1.5m above the floor level, no detectors will be placed below -15° due to back scattering from floor. Currently the mechanical structure and spherical vacuum chamber are being fabricated at J.J. Enterprise, Delhi and soon it will be delivered at IUAC.

Fission Detectors:

Since neutrons are always detected in coincidence with fission fragments, it is necessary to have a highly efficient fission detector system. We plan to put 4 large area multi-wire proportional counters (MWPC) as fission detectors covering maximum space around the target to capture the binary fragments with maximum efficiency. With reasonable flight path available in 1m chamber, these detectors can separate fission fragments from other reaction products in a Time of Flight (TOF) set up. We will be using indigenously developed MWPC delay line detectors and custom made electronics for the delay line readout and TOF measurement.

Pulse processing Instrumentation:

For pulse processing and readout of the detector signals for the first phase of 50 detectors, we will use our indigenously developed electronics and data acquisition system. The neutron gamma separation from liquid scintillator is achieved by zero cross method using homemade Pulse Shape Discriminator (PSD) modules. For this purpose, the existing design of PSD has been modified to incorporate some additional features such as gamma suppression. A few such modules have already been tested and work on further development of 50 channels of PSD has already started. Alternatively, we have also evaluated the performance of commercial high density PSD electronics versus our home made PSD module. Even though, the commercial module is more versatile with features such as remote control and low power dissipation, the performance of homemade electronic module is found to be far better and more customized to our specific application. For the full array consisting of 100 detectors, we may initially use a mix of commercial and homemade PSD electronics.

PMT Bases & High voltage power supply:

The detector array requires more than 100 voltage divider bases and channels of high voltage power supply to operate the photo multiplier tubes (PMTs). Each voltage divider base will have built in pre-amplifier for signal from dynode enclosed in the same aluminum housing. The prototype base has been built and tested with detectors. More than 100 of such bases will be made locally and work has already been started. The PMTs are to be operated typically at voltages less than -2000 volt to get a reasonable pulse height from anode and optimum timing performance. Instead of using conventional high voltage power supply, we tried to incorporate the requirement of high voltage by making a modular assembly of DC-DC high voltage converter chips (M/s Pico Electronics, USA). These chips can generate a maximum of 2000V with low ripple and high stability. Prototype board has been developed and performance evaluation showed good stability. At present 50 such boards are being assembled at IUAC.

High Voltage Control:

To control the voltages remotely, a compact, low cost Ethernet based high voltage power supply controller module has been developed and tested for distributed control of DC power supplies (0-2000V) over a Local Area Network. The analogue section contains one 12 bit Digital to analog converter and a read back mechanism. The controller connects to a specific power supply's remote control connector via a twisted pair cable which carries 0-5 Volt. The modules can be distributed over LAN using a network switch for interconnect. Each module has its own unique MAC and ip address with port number so that each can be specifically selected at a time for read write operations. A compact two layer board is made with the DC-DC HV converter. A network of 50 such

controllers have been made in the first phase of NAND. A user friendly GUI has been developed using Qt as the preferred language under linux/windows. The advantage of such a system is, it is easily expandable to a large number of power supplies, low cost, globally accessible, and multiple users in a network can set or read any power supply value simultaneously.

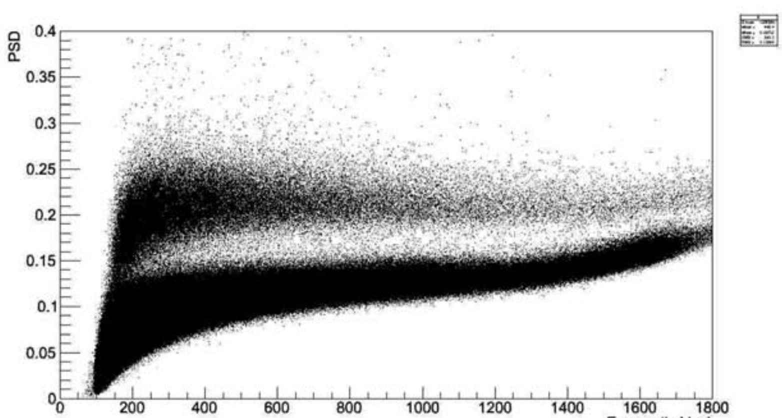
Data acquisition:

Our existing multi crate CAMAC data acquisition can be extended for collecting data from 50 detectors using standard CAMAC analog ADCs and TDCs. Alternately, we have initiated the work on VME based data acquisition using multi channel VME ADC/TDC read out. For this purpose, a VME based data acquisition system has been setup and tested by collecting data from multi channel detector signals. The system is based on VME-PCI optical link controller from CAEN. The conventional analog electronics using 32channel VME ADC and TDC are used for readout. The front-end is being implemented by modifying the existing Freedom software used in our CAMAC data acquisition. Other software such as MIDAS (midas.psi.ch) and LAMPS (from TIFR) were also tried to collect data from a single VME crate system.

4.1.2 NEUTRON - GAMMA DISCRIMINATION USING DIGITAL PULSE PROCESSING

Manik Aima*, & P. Sugathan
* Student trainee working at IUAC

Currently there is a growing interest in deploying digital techniques in processing pulses from nuclear detectors. Many fast waveform digitizers are now commercially available that can be used in digital processing of detector signals. We have demonstrated the application of such digital techniques in discriminating neutron and gamma from a liquid scintillator coupled to a PMT. In this work we used the DRS4 evaluation board (available from Stefan Ritt, PSI) to capture and digitize the the anode signal from PMT. A 5"x5" liquid scintillator coupled to 5" PMT tube was used in the test setup. The waveforms are digitized at 5 GHz sampling and stored on event by event basis. The algorithm for pulse shape discrimination (PSD) was implemented based on the method of charge comparison within two time windows. A C++ code was written to integrate the pulse waveform in two time window and calculate the ratio of them on event by event basis giving total light output and the PSD parameter. The figure below shows the two dimensional histogram of PSD plotted against total energy for neutrons and gammas from a fission source (Cf252). As seen in the figure, the neutrons and gammas are well separated.



4.2 GAMMA DETECTOR ARRAY (GDA)

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

The users of INGA and GDA facilities have published prolifically this year contributing over twelve contributions in DAE 2011 and thirteen communications in international journals. As Indian National

Gamma Array (INGA) experimental campaign is in TIFR, very few experiments were done in GDA beamline.

4.2.1 EXPERIMENTS AND DETECTOR MAINTENANCE

The experiments were done using GDA with CPDA for 'l' distribution experiment, and Perturbed angular distribution system.

As the HPGe and Clover detectors are damaged by neutrons in fusion evaporation reactions, over the years, they need periodic servicing cum annealing. Six detectors were evacuated and were annealed to restore the performance of the detectors. Efforts to fix the problems of the Clover detectors showing vacuum leaks or noisy preamplifier would be taken up this year as service order is placed with supplier Canberra.

4.3 HYBRID RECOIL MASS ANALYZER (HYRA) AND HEAVY ION REACTION ANALYZER (HIRA)

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

HYRA facility, with the first stage operated in gas-filled mode and coupled to TIFR 4π spin spectrometer, was used in few experiments involving measurements of fusion excitation function and spin distribution in heavy compound nuclei (CN). In addition, a couple of experiments were carried out using spin spectrometer and HIgh energy Gamma RAy SPectrometer (HIGRASP) to study GDR built on excited states, using the HYRA beam-line.

In most of these experiments, beams from Pelletron accelerator boosted by first two modules of superconducting LINAC accelerator were used and both the LINAC modules were found to work very well and in a stable manner. The experiments include (i) measurement of evaporation residue (ER) excitation function and spin distribution in $^{30}Si + ^{170}Er$ leading to $^{200}Pb^*$ CN which has already been studied using two more asymmetric combinations at IUAC earlier (IUAC/JNU student), (ii) measurement of ER excitation and spin distribution in $^{31}P + ^{170}Er$ to look for effects due to departure from Z=82 closed shell (IUAC/JNU student), (iii) ER excitation function in $^{19}F + ^{192, 194, 198}Pt$ systems to study the effect of N=126 closed shell in CN (Panjab University student), (iv) angular distribution of GDR decay from excited states in CN formed by $^{16}O + ^{180}Hf$ fusion-evaporation reaction (TIFR group), (v) GDR decay from excited states in CN formed by $^{28}Si + ^{116}Cd$ fusion-evaporation reaction (IUAC/JNU student), etc.

Measurements of time-of-flight, energy and angular momentum through gamma multiplicity have helped in separation of ERs from products arising due to other competing processes and have also given an idea of the origin of such processes. The higher gamma fold events normalised by the corresponding fold in singles spectrum helped in extracting the average transmission efficiency of the ERs through HYRA.

Poster and oral presentations in FUSION11 (organised by GANIL at St. Malo, France), oral presentation in TAN11 (organised by FLNR/JINR in Sochi, Russia) and presentations in DAE symposium of Nuclear Physics (organised by DAE/BRNS at Andhra University) covered the work carried out during the last couple of years.

The international advisory committee of FUSION conference has selected our bid to host the FUSION14 conference at Delhi in February 2014, during their meeting in FUSION11.

Several new experiments have been proposed using HIRA and HYRA facilities and have been sanctioned beam time in the July 2011 and December 2011 AUC workshops. A joint experimental proposal by FLNR, Dubna, IUAC, TIFR, etc. has been approved beam time recently using HYRA and spin spectrometer. We propose to expand this collaboration by using mutual expertise and equipment and efforts are underway in this direction between IUAC and FLNR. The scheduling of HIRA related experiments and HYRA related experiments will be done taking into account the LINAC operational schedule.

This year, the focal plane detection system of gas-filled mode of HYRA was modified. The smaller MWPC (57 mm x 57 mm) was replaced by a large area (150 mm x 50 mm) MWPC detector in order to collect most of the evaporation residues reaching the focal plane. The resistive two-dimensional (50 mm x 50 mm) energy detector was replaced by a 50 mm x 50 mm double-sided silicon strip detector in order to improve the energy resolution. Electronics available for 32-channel configuration requires shorting two adjacent strips, in X- and Y-directions. With the experience gained in the type of signal transmission connector/ cables and electronics, we will be finalizing the final configuration for individual strip read-out. The energy resolution achieved, so far, has been 55 keV and efforts are on to improve it further.

Modifications carried out in the target chamber include, incorporation of two silicon surface barrier monitor detectors at 23°, on either side, with respect to beam direction, close to the target. A new target ladder was incorporated to increase the number of targets that can be mounted.

The second stage installation has started with the positioning of the electrostatic deflector (ED) chamber and the marking of the layout of the components on the floor. The Faraday cage for the high voltage power supplies and feedthrough cables has been set up at ground level to create a dust-free space for installation of electrode assembly. The installation of the sliding door for radiation shielding has been carried out to increase the space around the final focal plane.

The superconducting, super-ferric quadrupole doublet being developed by the Cryogenics laboratory of IUAC has reached another milestone with the successful testing of all coils in liquid helium bath by passing 100 A current. The coils were then fixed around the poles and quadrupole field configuration was checked at room temperature by passing a very low current. The final welding of the cryostat will be taken up after the installation and alignment of the magnets inside the cryostat structures fabricated in parts.

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 106 user experiments in materials science with energetic ion beams. These were spread over 278 shifts and were performed without any major beam time loss due to facility break down. The swift heavy ion (SHI) irradiation and related experiments are mostly performed in the irradiation chamber in the materials science beamlines in beamhall I and 1 experiment was performed in materials science beamline in beamhall II. Low fluence irradiation experiments are performed in general purpose scattering chamber (GPSC) in beamhall I and this year there were 8 such experiments spread over 25 shifts. The experiments using on-line/in-situ facilities in materials science beam lines, which have unique features, are given emphasis. Besides that many experiments were carried out using low energy ion beams using LEIBF facility and atom beams using atom beam sputtering set up. Experiments are being done in different areas of SHI induced materials modification and characterization and the details of the research programmes are given in Section 5.2.

The materials synthesis techniques: RF sputtering system, ball milling system, box furnace and tubular furnaces are being extensively used by users for preparing samples. The microwave plasma based deposition system has also become operational. The off-line characterization facilities: XRD, FTIR, PL, UV-Vis SPM, micro-Raman and transport measurement facilities continue to be used by a large number of users.

4.4.1 IRRADIATION CHAMBER MAINTENANCE

A. Tripathi, S A Khan, P Barua, J. Zacharias

The irradiation chamber in materials science beamline was used in more than 250 shifts of irradiation experiments and ERD studies. It was observed that the vacuum was taking longer than usual and its performance with two existing sample ladders was tested. An O-ring used in the old sample ladder had developed a crack and was replaced. It was also decided to make new ladders for simple irradiation experiments. One such ladder is operational now and the second one is being made. This ladder has also been tested to reach the operating vacuum in less than an hour time. A new ladder for in-situ measurements and one for high temperature irradiation has also been made.

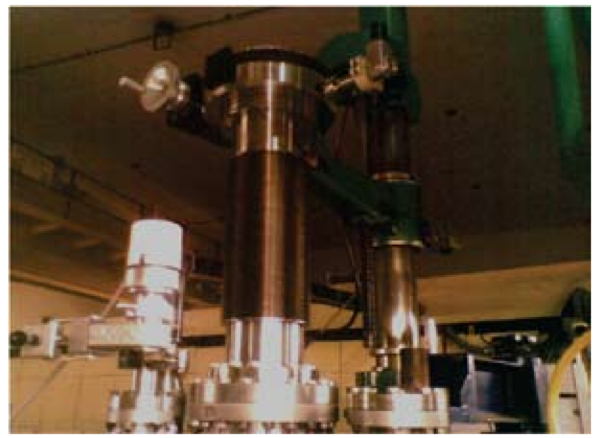


Fig. 1. Sample ladder manipulation system with new bellow

One major problem observed was a leak in the bellow used in sample ladder movement. A replacement bellow was ordered for the same and it was installed after making necessary modifications in its mounting arrangement (Fig.1). The chamber was tested alongwith new ladders to obtain an operating vacuum of better than $5x10^{-6}$ torr in less than one hour and an ultimate pressure of $7x10^{-7}$ torr was obtained.

4.4.2 SCANNING PROBE MICROSCOPE

A. Tripathi, I. Sulania

Multi Mode SPM with Nanoscope IIIa controller acquired from Digital/Veeco Instruments Inc. is extensively used in user experiments. Its controller developed a problem and a replacement for the same was acquired. The replacement controller sent by the company was found to be incompatible and a second replacement was acquired. The system is now operational again and more than 500 samples from 71 users were studied in AFM, MFM and C-AFM modes.

4.4.3 IN-SITU X-RAY DIFFRACTOMETER

P. K. Kulriya

The low temperature insitu x-ray diffraction system which is an internationally unique facility is equipped with parallel beam focusing device: gobble mirror and fast detector Vantec. It has been used to record diffraction spectrum of the nano-materials, thin films, polymers and powder samples. This year offline XRD system has been used to record spectrum of 780 samples out of which 675 are thin film/nanoparticle form characterized using our diffractometer system. The maintenance work related to (a) cleaning of x-ray tube water filter, (b) replacement of water flow controller (c) replacement of old x-ray tube with new one (d) replacement of rectifier (e) repair work in the high voltage knob (f)

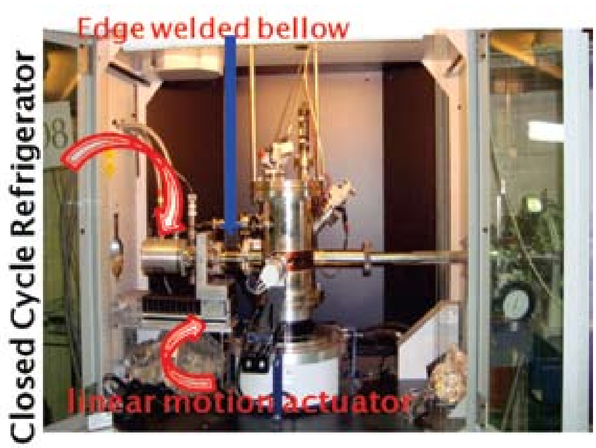


Fig. 2. CCR installed with in-situ XRD

water flow problem in the x-ray generator and (g) interfacing problem of Vantec detector, are performed this year. One insitu experiment on the "Ion beam synthesis of doped and un-doped ZnS nanocrystals in host matrices" is also performed. In up-gradation of XRD system, a GM based close cycle refrigerator which is able to cool the sample at 10K tested and installed with existing x-ray diffractometer. A custom built edge welded bellow is also installed between CCR and XRD vacuum chamber, as shown in Figure 2, to reduce vibration at the sample.

4.4.4 PLASMA BASED SYSTEMS FOR THIN FILM DEPOSITION.

V.V. Siva Kumar

The rf sputtering system was operational and used for thin film depositions of users. Thin films of TiO_2, nanocomposite CdS/Al_2O_3, Al_2O_3, $CoFe_2O_4$, Co doped TiO_2, ZnO and ZnMgO were prepared using the rf sputtering system for ion beam studies on these materials. Study on the growth of Ag and Ag-N doped ZnO was also carried out using the rf sputtering system. The microwave plasma system is being upgraded to ECR plasma based deposition system. A substrate heater (up to 900 °C) was procured from M/s Meivac Inc (USA) and a thin film thickness monitor was procured from M/s Lew Vac LLP (U. K.). Sector magnets were procured from M/s United Magnetics (China) which will be assembled into ring magnets.

The multi-cathode sputtering system was assembled by installing a manual gate valve, making water and gas flow connections, incorporating penning, pirani gauges and gauge controller, making ground connection of the system and connecting a rotary pump. The assembled system was tested for DC sputtering in rough vacuum using a 2 inch dia copper target and thin film was deposited on a glass substrate. A turbo pump is being procured for the system.

4.4.5 BALL MILLING SYSTEM.

The Ball milling system was set-up and was used for preparation of powders of Mica (GNDU, Amritsar) and sand and sediments (NIT, Hamirpur).

4.4.6 FIELD EMISSION SCANNING ELECTRON MICROSCOPE (FE-SEM)

A. Tripathi, D.K. Avasthi

The field emission scanning electron microscope (FE-SEM) from TESCAN, MIRA II LMH CS is regularly being used to boost research activities in nanomaterials. The recurring problems in automatic sample chamber venting and sample position calibration were solved. SEM interlink with EDS system developed a snag and was rectified after re-loading the software. SEM system computer was repaired by replacing its SMPS. Some of the problems were linked with the air-conditioning system and the problem was resolved with the help of MG group.

The system has been used for studying more than 400 samples from 70 users.

To improve the performance and applicability to different types of samples, Q150T-S High Vacuum Turbo pumped Sputter Coater system from Qoram Technologies is being used to coat samples with carbon and gold.

4.4.7 ONLINE ERDA SET UP

S.A. Khan

The modified ERDA system with MKS gas flow meter with controller and Baratron gauge was installed last year and is now operational.

4.4.8 STATUS REPORT ON SPECTROSCOPY FACILITIES

Fouran Singh, Vinod Kumar, I. Sulania, and S.A. Khan

Micro-Raman facilities being heavily ex situ by a large number of users and about 550 spectra were recorded on various kinds of samples; includes thin films, nanostructures and bulk. FOP is re-aligned for the better laser power output about 25 mW. Spectra are recorded, but not intense enough for in situ experiment. Custom design (Renishaw) FOP stage and objective with high numerical aperture is ordered for better alignment and better signal. A temperature stage from liquid nitrogen temperature (LNT) to 450 °C is ordered to enhance the utility of the setup by doing the temperature dependent measurements.

Photoluminescence (PL) setup was working and used by some user, but later it was decided to shift it to the lab for easy access to setup with better sensitivity. Systematic removal of laser case and shifting of laser along with its accessories was done and it was fixed/mounted on optical table and preliminary testing is done. After making some cubical for the safety of users and other detailed testing, it will be soon available to the users for regular experiments. A series of IL experiments were conducted on lanthanide doped silicates and other oxide hosts at 300 K and at LNT were also carried out using the same setup under excitations by ions beams.

FTIR spectrometer is working fine and being used by many users for their regular experiments. There was a breakdown of the system for about a month due to the life time of source; which is replaced with available spare source. System is re-aligned for better sensitivity and efficiency. Software is updated and card is installed in XP based computer, as previous one applicable for WINDOWS98 only.

4.4.9 MATERIALS SCIENCE: OFFLINE FACILITIES

K.Asokan

This facility provides the opportunities to the user community for various synthesis and characterizations techniques. Samples can be prepared from solid state reaction for bulk synthesis and sol gel technique for nanoparticles preparation. Pellets can be prepared with the help of Hydraulic Pellet Machine pellet to use these samples for various characterization techniques. Muffle furnace up to 1000 °C, Programmable furnace from Nabertherm up to 1400 °C and a tubular furnace up to 1400 °C are available for sample preparation and annealing. Recently sol - gel spin coater has been added for thin films fabrication.

The characterization techniques like dielectric measurement, resistivity measurement, Hall Effect measurement (room temperature) and 1/f noise measurements are routinely used by users. Dielectric measurements can be performed in the temperature range ~77 K – 450 K and in the frequency range from 20 Hz -1 MHz with the help of low frequency LCR meter 4284A Hewlett Packard and from 75 KHz – 30 MHz with the help of LCR meter 4285A Agilent. C-V measurements can also be performed with the help of these LCR meters. Room temperature as well as temperature dependent I-V measurements and temperature dependent resistivity measurements can be carried with 2612A dual channel Keithley source meter. All these experimental set up are interfaced with the computers through Lab view programming.

Hall Effect measurements can be carried out with HMS-3000 at room temperature and liquid nitrogen temperature. The set up is very good for metals and semiconductors.

Apart from these facilities, delta mode setup and Cryo head of Oxford instruments with high vacuum for resistivity and dielectric measurements are being added. Noise measurement experiments can also be performed from liquid nitrogen to room temperature with the help of dynamic signal analyzer (hp – 35665A). Attempts are being made to develop these characterizations available down to liquid helium temperature.

We are also having magneto transport setup with the field ~ 8T at 4 K. It has been tested. Once it is suitably placed close to He accessible location, it will be made available to users.

4.5 RADIATION BIOLOGY EXPERIMENTAL FACILITY

A. Sarma and D.K. Avasthi

The **ASPIRE** [Automated sample positioning and irradiation system for radiation biology experiments] system is updated to its automatic status where irradiations can now be done with a set of preset doses. It is being successfully utilized for irradiating biological samples. The characterization of the system has also been done. The uniformity as well as fluence verification has been done using irradiating SSNTD [CN 85] and subsequent etching. The tracks were counted using microscope over accurately measured areas across the entire irradiation field of 40 mm diameter.

The uniformity over a field of 40 mm diameter is having 2 % standard deviation. The mean fluence is within 1 % of the electronically measured value at the centre of the field.

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

- Two CO2 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 which also gives information about cell viability
- PCR machine, a crude gel documentation system, UV-Vis Spectrophotometer and a Fluorescence microscope.
- We are in the process of procuring a Multimode Plate Reader, Refrigerated Centrifuge and a micro-plate washer.

The laboratory section has been isolated from the central AC system. The air conditioning is done by split AC system resulting in a situation where no bacterial or mold contamination has been reported since. 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

Synthesis of Au nano-particle (AuNP) of different sizes

Functionalization with different agents like Glucose, Folic acid and PEG.

Internalization of such particles by cancer cells

Study of radiation interaction on them.

The basic aim of these studies on internationalization of AuNP in cancer cell is to "investigate the aspects of radiosesitization" so as to reduce the dose of radiation for killing the cancer cells.

4.6 ATOMIC & MOLECULAR PHYSICS FACILITY

4.6.1 A SETUP FOR ION ENERGY LOSS IN THE WAKE FIELD OF THIN SOLID FOILS

T. Nandi and K. Haris[1]

[1] Dept. of Physics, Aligarh Muslim University, Aligarh 20 2002

We used the 15 UD tandem Pelletron accelerator at the Inter-University Accelerator Center (IUAC), New

Delhi for this experiment. Ion beams of ^{58}Ni (111-160 MeV) and ^{56}Fe (115-139 MeV) were passed through a bi-layer target of polypropylene (PP) and aluminum and pure polypropylene targets. Since the energy loss in the wake potential is charge state dependent, the direct ion beam is to be projected on the target as well as on the detector. This means we need to reduce the beam current to avoid damage of detectors. The ion beam was collimated through a double slit device of size of 1mm x 1mm. This facilitates in keeping the beam optical parameters constant. In order to view and roughly monitor the beam intensity, the beam was tuned on a piece of quartz placed on the target ladder. The sputtered negative ion cesium source (SNICS) parameters such as oven temperature and cesium focus were reduced to a certain level so that the count rate reached about 50/s as detected by the monitor detector. The beam energy was measured with a Si- surface barrier detector. A schematic of the above mentioned experimental set up is shown in Fig.1. Apart from the bi-layer targets, single targets of aluminum and polypropylene were also mounted on the target manipulator system, which was able to move in the x and y directions (perpendicular to the z-axis beam direction). Travel along the x-axis allows the use of three target columns, whereas the y-axis motion allowed changes of target positions. One empty position was retained in every target column so that beam energy measurements can be repeated at least three times. In order to measure the individual layer thickness of the bi-layer PP/Al foil correctly, a weighing technique was used. The mass of the bi-layer foil of a fixed size was measured and then the aluminum layer was chemically removed with pure 1normal NaOH solution, allowing measurement of the mass of polypropylene only. Using this solvent method, the thicknesses of PP and Al were found to be 548±0.5 µg/cm^2 and 8.2±0.2 µg/cm^2, respectively. Dependence on the energy loss spectra on the ordering of the target (PP/Al or Al/PP) is shown in Fig.2. Results obtained in this experiment are displayed in Fig. 3.

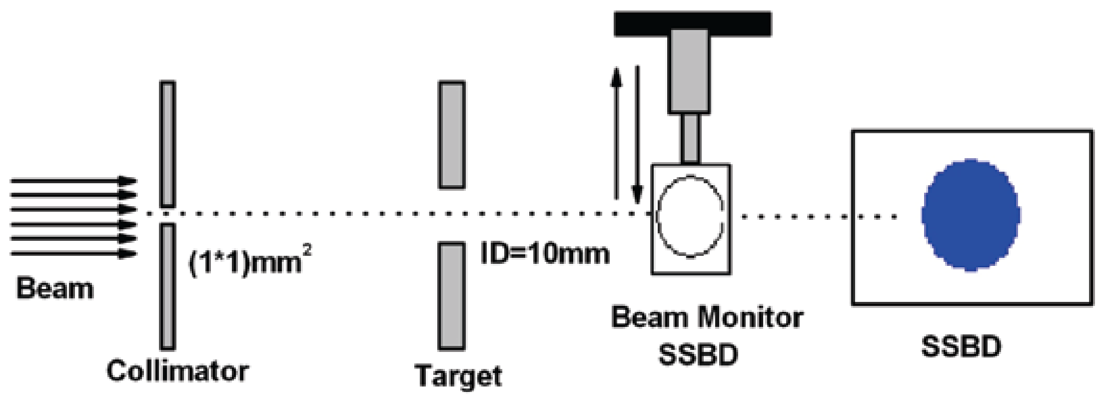


Fig. 1. Schematic diagram of experimental arrangement

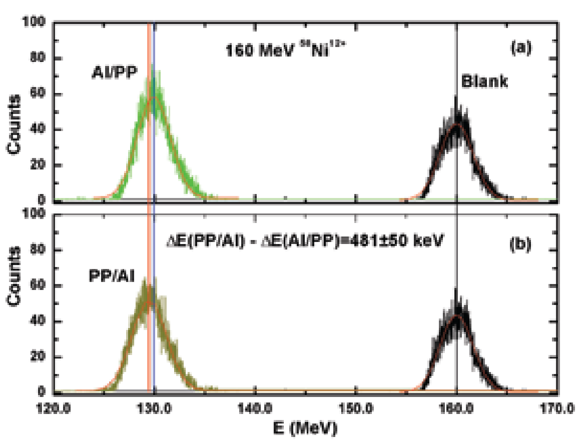


Fig. 2. Geometry dependent (forward/back) energy loss spectra of the bi-layer targets

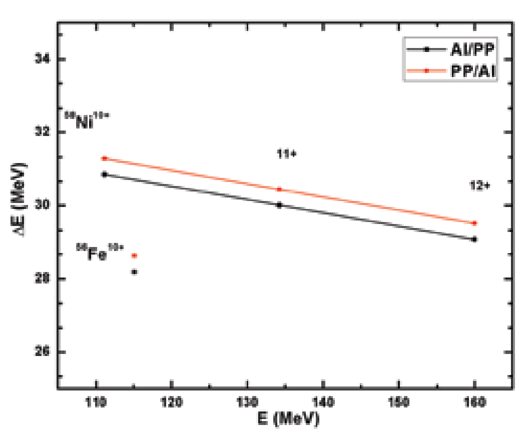


Fig. 3. Beam energy dependent energy loss in Al/PP and PP/Al bi-layer targets.

4.6.2 SETUP FOR STUDYING THE CROSS LINK BETWEEN ATOMIC AND NUCLEAR PHYSICS

T. Nandi, B.J.Roy[1], Biraja Mohanty[2], Mumtaz Oswal[2], Sunil Kumar[2], V. Jha[1], D.C. Biswas[1], and Akhil Jhingan

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[2] Department of Physics, Panjab University, Chandigarh - 160014

Our recent results obtained from the beam-foil experiments on highly charged ions in the form of projectile like ions (PLI) demands that we carry out atomic X-ray spectroscopy and nuclear transfer experiments simultaneously. In this view we made a set up in the general purpose scattering chamber GPSC as shown in Fig 1. We observed x ray spectra of PLI produced by α-transfer from ^{12}C target. Hence, possible reaction would be $^{58}Ni + {}^{12}C \rightarrow {}^{62}Zn + {}^{8}Be$ and ^{8}Be breaks in to 2α almost instantaneously. Thus, our aim was to measure 2α in coincidence to prove that ^{62}Zn indeed is produced from this reaction.

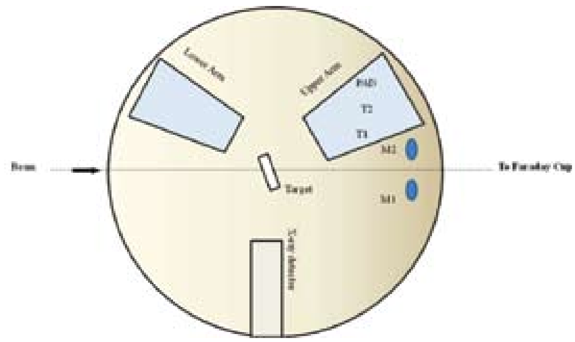

Fig.1. Schematic of Experimental set *up*

In the present experiment we have measured coincidence between the 2αs originating from ^{8}Be decay using two (ΔE -E) Telescope detectors and a silicon pad detector. A very good charge and mass separation has been achieved for projectile like ions and α-α coincidence spectrum as shown in Fig.2.

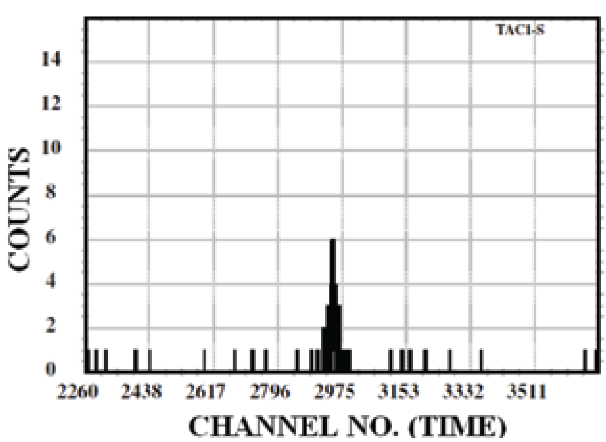

Fig.2. A typical α-α coincidence spectrum in 12C (58Ni, αα) at E(^{12}C)= 60 MeV

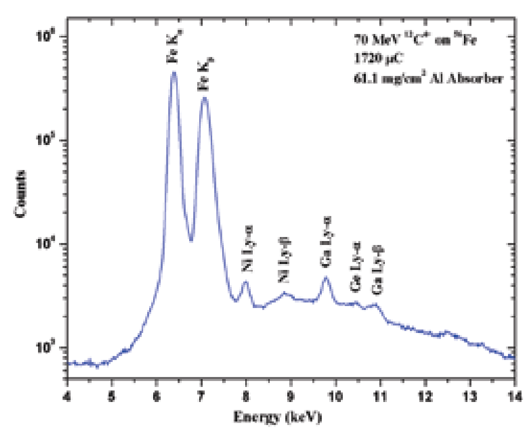

Fig.3. X-ray spectrum as obtained from 70 MeV ^{12}C bombarding on ^{56}Fe target.

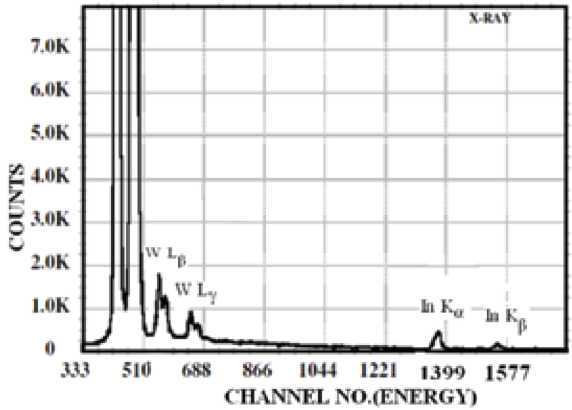

Fig.4. X-ray spectrum as obtained from 60 MeV ^{12}C bombarding on ^{58}Ni target.

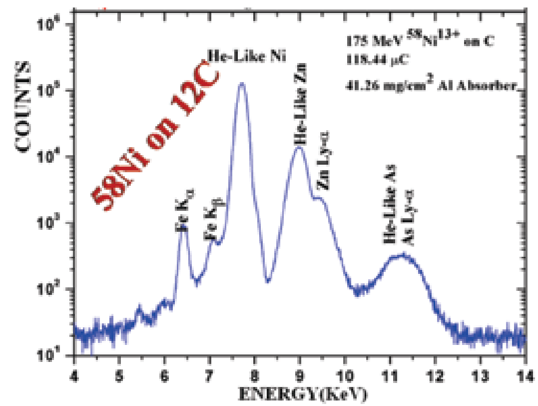

Fig.5. The observed X-ray spectra as obtained in inverse kinematics.

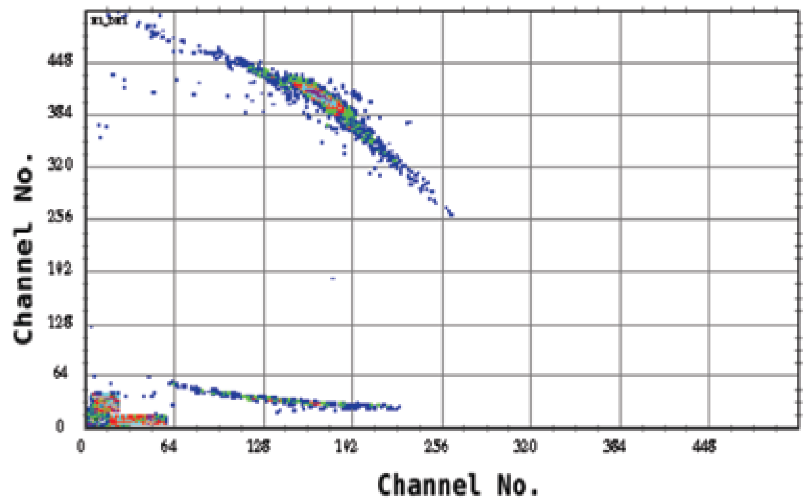

Fig.6. Two-D spectrum ($\Delta E - E$) for ^{58}Ni on ^{12}C @ 175 MeV at 30° forward angle

Table: Determination of α transfer cross sections for ^{12}C (^{58}Ni, α) ^{8}Be reaction at 175MeV.

File Name	Yield	Charge State	Faraday Cup	Projectile No. Np (p)	Target Density Nt (p/cm^2)	Solid Angle (sr)	Cross Section cm^2
Nic175r081.all	454	13	118440	5.69E+13	2.68E+018	1.80E-4	1.65E-26
Nic175r083.all	456	13	127350	6.12E+13	2.68E+018	1.80E-4	1.54E-26
Nic175r087.all	456	13	111960	5.38E+13	2.68E+018	1.80E-4	1.76E-26

Next objective was to measure α and X-ray in coincidence. In order to do that firstly we recorded the X-ray spectra in direct kinematic conditions, i.e. ^{12}C on enriched ^{56}Fe and ^{58}Ni as shown in Fig.3 and 4. One can notice that ^{56}Fe target indeed was pure but ^{58}Ni was contaminated from W and In, and hence, the region of x-ray spectra expected from PLI ^{62}Zn was getting obscured. To circumvent this impurity problem we opted for the experiment in inverse kinematic condition. Beams of 173 and 175MeV $^{58}Ni^{13+}$ were bombarded on ^{12}C. The X-ray spectrum is shown in Fig.5 and ($\Delta E - E$) spectrum is shown in Fig.6. The α-α coincidence (fig. 2) gives a clear indication of α transfer reactions. In the inverse kinematics 175MeV $^{58}Ni^{13+}$ can hardly produce any α-evaporation. Hence, the α-band in Fig.6 is taken as outcome of α-transfer reaction and accordingly α transfer cross sections are found out within an uncertainty of 10% as given in Table. 1

4.6.3 A BEAM LINE AND AN EXPERIMENTAL SETUP IN NEW LEIBF DEDICATED TO ION-MOLECULE INTERACTION STUDY

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The highly charged ion beams of energy ranging from few tens of keV to few MeV, extracted from the ECR source placed on a high voltage platform in new LEIBF, are charge and mass analyzed by a dipole magnet and injected into one of the three available beam lines (75, 90 and 105 degrees). Out of these three beam lines the 105 degree beam line is dedicated to atomic & molecular (ATMOL) physics experiments. The injected ions are transported to the experimental chamber for surface science studies using a beam transport system comprising drift tubes, pumping stations, together with isolation valves and flexible bellows, electrostatic quadruple triplet for beam focussing, magnetic steerer for beam steering, double slit, beam profile monitor (BPM) and Faraday cup for beam diagnostics. We have developed our setup for probing molecular dissociation dynamics at the end of this surface science experimental chamber. The ion beam taken out from the chamber is further passed through a 4-jaw slit for cutting down the high beam current, a long drift tube along with pumping station and isolation valves for maintaining vacuum in the beam line and a deflector assembly for pulsing purpose. Finally before entering the ATMOL chamber, the beam is collimated by an aperture of 1 mm diameter.

In the experimental chamber the ion beam is made to interact with a molecular gas jet effusing from a grounded hypodermic needle (outer diameter of 0.25 mm) at right angles. The gas flow is controlled by a fine-control all-metal needle valve. The inside pressure of the chamber is maintained at 4×10^{-7} Torr without any target gas by using a dedicated turbo molecular pump which raises upto 8×10^{-7} Torr with gas load. In the interaction multiply charged molecular ions are produced and dissociate into various ions and neutrals. The fragment ions are then electrostatically deflected into a linear time-of-flight mass spectrometer (TOFMS) using an extraction field applied in a direction mutually perpendicular to both the ion beam and effusive gas jet and finally detected by Micro Channel Plate (MCP) detector equipped with delay line anode (DLD) which gives the time of flight (TOF) as well as position information of the detected ions. A channel electron multiplier (CEM or Channeltron) mounted opposite to fragment TOFMS is used to detect electrons emitted by the projectile or target. The fast output pulses obtained from the CEM serve as starting trigger for data acquisition. Post-collision projectiles are further studied using a parallel plate electrostatic analyzer. Typical TOF spectra obtained from the present set up are shown in Figure 1.

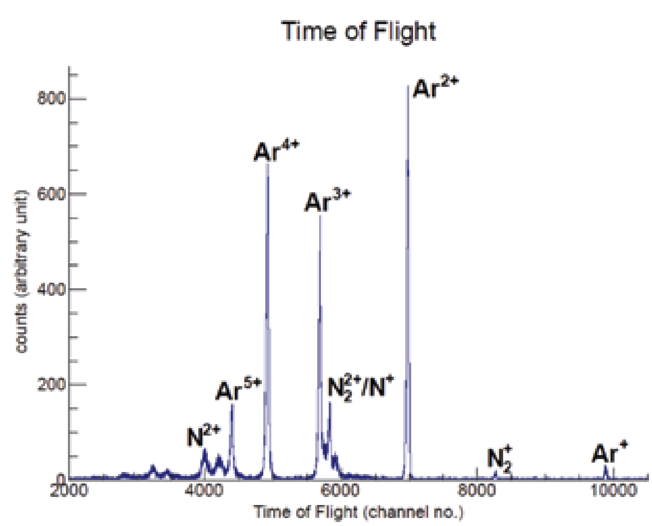

Fig. 1. TOF spectra

4.7 ACCELERATOR MASS SPECTROMETRY

Pankaj Kumar, Archna Bohra, Sunil Ojha, S. Gargari, R. Joshi, G.S. Roonwal and S.Chopra

Accelerator Mass Spectrometry (AMS) facility for ^{10}Be and ^{26}Al radio-isotopes measurement is in operation. Clean chemistry lab has been utilized by various users for the chemical treatment and extraction of ^{10}Be from their samples. Followings were the samples processed during last year.

a) **Chemical processing of samples from Central Indian Ocean:** Sediment samples from a 5 meter long core collected from central Indian Ocean basin were processed. The aim is to date the core using ^{10}Be radioisotope to correlate it with the climatic conditions in past millions of years. The digestion of samples was done in two ways. First was to extract ^{10}Be from organic and oxide phases (using HCl and H_2O_2) and other was the complete digestion using HF, HCl, H_2O_2 and HNO_3. The idea was to check the ^{10}Be input of terrestrial origin (if any) in the marine sediments. Total 14 samples (7 each method) and two blanks were processed. (User: Dr. J.N. Pattan, NIO Goa)

b) **Chemical processing of sulfide samples from Lau and woodlark basin:** 5 nos. Sulfide and Barite sample, collected from Lau and Woodlark basin (south west pacific) were processed. The digestion of these samples was done using HF, HCl and HNO_3 acid. After digestion samples were passed through the columns to extract ^{10}Be. The objective was to build geological history and period of hydrothermal activity by investigating measurements of cosmogenic radioisotope ^{10}Be ($T_{1/2}$ = 1.387Ma) present the samples. (User: Prof. G. S. Roonwal, IUAC)

c) **Chemical processing of samples from Teesta river (Sikkam) and Satluj River (Himachal Pradesh):** These samples contained quartz and the digestion was done using HF. The objective of the study was to study the erosion and tectonic rates across the Teesta and Satluj River using in-situ produced ^{10}Be (by the interaction of secondary cosmic rays on Si present in the quartz). Total 7 samples were processed. (User: Prof. C.S. Dubey, Delhi University)