4. EXPERIMENTAL FACILITIES IN BEAM HALL

4.1 GENERAL PURPOSE SCATTERING CHAMBER (GPSC)

M. Archunan, Golda K.S., A. Kothari, P. Barua, P. Sugathan, S.K. Datta and R.K. Bhowmik

During this year, a number of experiments both in Nuclear Physics as well as in Materials Science have been conducted using this facility.

As per the experimental requirements, necessary support was provided to the user community. Major support activities during the experiments include installation of different extra components such as reentrant Gamma detector port, gas handling system, special flanges, extended beam dump, etc. to the chamber. The requirement of detectors, electronics, data acquisition systems, etc. varies with experiment since a large variety of experiments are normally carried out in this beam line. The list of experiments carried out last year using this facility is given below.

Nuclear Physics Experiments

User	Experiment	Beam	No of shifts
IUAC	Study on performance of large area MWPC for fission fragment detection	^{16}O pulsed	6
Punjab University	Dynamics of heavy ion induced fission fusion process	^{16}O pulsed	8
Calcutta Univ.	Exp. Investigation of near barrier fusion & break up with loosely bound stable nuclei.	6,7Li	20
University of Delhi	Study of elastic scattering and fusion for $^{7}Be + ^{12}C$ system	Li	15
IUAC	Facility test for Neutron Detector array	O	9
Punjab University	Study of induced fusion-fission dynamics	0 / F Pulsed	15

Materials Science Experiments

User	Experiment	Beam	No of shifts
Bangalore Univ.	Study of radiation induced effects in semiconductor electronic devices	Li	3
DRDO	Exposure of polyester films with Si-28 ions beam for the development of nuclear track microfilters	Si	3
Bangalore Univ.	Study of radiation induced effects in semiconductor electronic devices	Si/O	3
Rajasthan Univ.	Development and characterization of etched polymeric membrane filters	Ag	3
Punjabi Univ.	Particle induced X-ray cross section measurements & PIXE analysis of forensic samples	Li	6
Tezpur University	Effect of SHI irradiation on intrinsic conducting polymers	Si	3
Bangalore Univ.	Study of semiconductor materials and devices using nuclear techniques	Li	3
Kurukshetra Univ	Energy loss straggling for MeV heavy ions in different absorber materials	Si Cl	2
ISRO	Heavy ion induced effects in VLSL Devices	Si, Ti, Ni/Fe, Ag/I	2

4.1.1 National Array of Neutron Detectors (NAND)

Golda K.S.[1], R.P. Singh[1], B. Behera[2], S. Mandal[3], Mihir Chatterjee[1], J. Zacharias[1], Hardev Singh[2], Venkataramanan[1], Arti Gupta[1], Rajesh Kumar[1], Ranjit[3], M. Archunan[1], A. Kothari[1], P. Barua[1], A Jhingan[1] P. Sugathan[1], S.K. Datta[1] and R.K. Bhowmik[1]

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[3]Delhi University, New Delhi.

National Array of Neutron Detectors (NAND) is a large array of neutron detectors being setup at Inter University Accelerator Centre. This will be one of the major nuclear physics experimental facilities using the booster LINAC beams at Phase II beam hall. The super-conducting Linear Accelerator can provide ion beams up to mass 80 above the Coulomb barrier. Considering the general interest of the user group it is decided to enhance the existing small array of neutron detectors into a larger array of neutron detectors. The array at present would consist of about 30 organic liquid scintillators of 5" diameter and 5" thick by pooling out detectors available at different institutions in the country. NAND will be a national collaborative effort of IUAC, TIFR, SINP, PU and DU. This array is planned particularly to study heavy ion fission reaction dynamics, but it can also be used as an auxiliary detector system in gamma ray spectroscopy.

The main detectors for light charged particles and fission detectors are placed inside a spherical chamber. A light weight mechanical structure is made to place the neutron detectors at a distance of 2m from the target position around this chamber. Beam will be dumped at a distance of 4.5m downstream from the target position in a borated paraffin shielded Faraday Cup.

A single width dual channel NIM based integrated electronics module is under fabrication to process neutron detector signals for each channel. The dynode & anode output from PMT are fed into the integrated electronics module which consist of pre-amplifier, shaper amplifier, CFD, PSD and TAC circuits built in it. A prototype module has been tested during off beam and on beam conditions and found satisfactory for pulse shape discrimination and timing performances. The final module will be made very soon.

Taking into account the large number of requirements of high voltage power supplies, it is decided to go for in-house development of power supplies rather than depending on commercially available ones. The fabrication of a 3KV, 5mA high voltage power supply for neutron detectors is under progress.

4.1.2 Scattering Chamber for NAND

Golda K.S., J. Zacharias, A. Kothari, P. Barua, R.P. Singh, S.K. Datta, R.K. Bhowmik

A 60cm diameter spherical chamber made of 3mm thick Stainless Steel is fabricated (Figure 1) as the target chamber of NAND. It has two asymmetric hemispherical parts for normal use. A flat lid is provided for using gamma detectors along with neutron array. The target ladder located at the center of the chamber can

Fig. 1. Spherical scattering chamber

accommodate 4 targets at the same time including beam viewing quartz. Linear as well as rotary movement of the ladder will be possible. There is provision for in vacuum transfer of target also. The chamber has an annular platform (Figure 2) with 1^0 graduation on which the detector arms can rest. Detectors arms have distance from the target position marked on it. Chamber has separate flanges to accommodate vacuum feedthroughs, gas feedthroughs, etc. Pumping of the chamber is done through the beam entrance and exit ports by turbo pumps of 300 l/s pumping capacity.

Fig. 2. Inside view of scattering chamber with detectors mounted.

4.1.3 Neutron Detector Stand

Golda K. S., J. Zacharias, R.P Singh, S.K. Datta, R.K. Bhowmik

Special stands (Figure 3) are made to keep neutron detectors around the spherical neutron chamber at a distance of 2m from the target position. The stands are designed such a way that the material around the detector is minimum to reduce the neutron scattering. Each individual stand can carry three detectors; one in the reaction plane and other two are out of plane at $\pm 15^0$ with respect to the reaction plane. The detectors can be mounted with the flexibility of adjusting the positions as well as their angles. Sixteen stands are made and mounted in a circular position to accommodate a detector array of 48 neutron detectors.

Fig. 3. Mechanical structure for neutron detectors

4.1.4 Detector Characterization

Golda K.S.[1], Hardev Singh[2], R.P. Singh[1], Mihir Chatterjee[1] and S.K. Datta[1]

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Eighteen neutron detectors (NE213 detectors coupled to Philips make XP4512B PMT) have been received from SINP for the array; 12 of them are 5" thick × 5" diameter and 6 of them are 3" thick × 5" diameter. These detectors have been tested with gamma as well as neutron source for timing, pulse height and pulse shape discrimination properties at different bias voltages and their bias voltage optimized for the best performance. Dynode signals of SINP detectors are modified by tapping it from different dynode to reduce the signal amplitude.

4.1.5 Facility test of NAND

Golda K.S.[1], R.P. Singh[1], Hardev Singh[2], A Jhingan[1] P. Sugathan[1], Pankaj Kumar[1], B. Behera[2], Ashok Kumar[2], G. Singh[2], Ranjit[3], S. Mandal[3] and S.K. Datta[1]

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A test run was carried out to see the performance of the NAND facility in beam hall II. Fourteen 5" × 5" neutron detectors were set up along with a large area MWPC and two silicon surface barrier detectors for fission detection and two silicon surface barrier detectors for beam normalization. 100 MeV ^{16}O pulsed beam from Pelletron accelerator was transmitted through LINAC to the new beam hall facility. The beam was tuned by viewing on the quartz and the Faraday cup current read out. The beam was then put on a 400μg/cm^2 thick evaporated ^{197}Au target. Proper beam tuning was ensured by looking at the elastic peaks (Figure 4) from the monitor detectors placed at ±16^o with respect to beam axis. To reduce the back ground radiation seen by the neutron detectors, beam was dumped in a paraffin shielded Faraday Cup 4.5 m down stream from the target position. Signals from 10 neutron detectors and all other charged particle detectors were collected. TOF, PSD (Figure 5) and pulse height spectra (Figure 6) from the neutron detectors, timing and fractional energy loss spectra from MWPC and energy spectra from SSBDs were collected in singles.

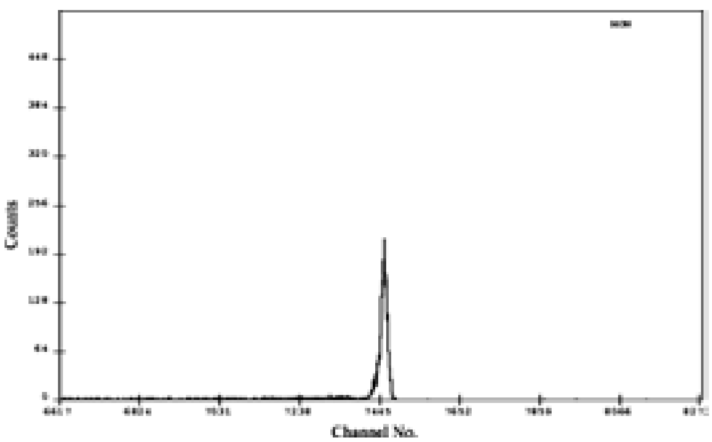


Fig. 4. Energy spectrum of one of the monitor detectors showing the clean elastic peak.

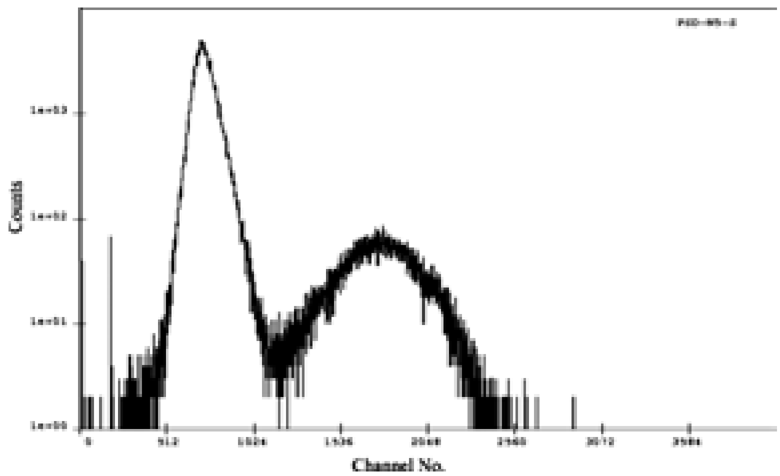


Fig. 5. Pulse shape discrimination (PSD) spectrum obtained from the homemade electronic module.

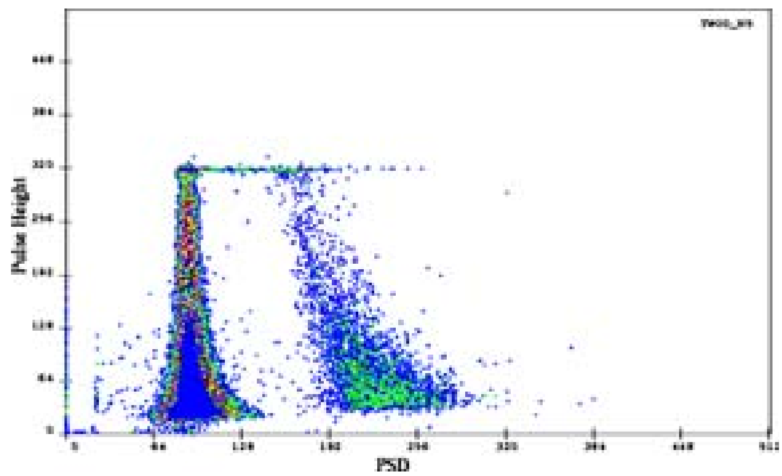


Fig. 6. PSD vs. Pulse height two dimensional spectrum clearly separating neutrons and gammas.

4.2 GAMMA DETECTOR ARRAY (GDA)

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

This year has seen a new beginning of International Collaboration in using GDA facilities by GSI group doing the lifetime measurements in A~50 region (refer the list of experiments carried out using GDA facilities) and in electronics development as GSI is using IUAC developed INGA clover electronics module for EXOGAM's Super Clover Germanium detector. The activity in the GDA laboratory in this year was devoted in the following areas:

4.2.1 Indian National Gamma Array (INGA)

The first installment of funds is received from Department and Science and Technology for this project and steps are initiated to realize this in Beamhall II. Order has been placed for five clover detectors along with anti-compton shields. The support structure is modified to accommodate LEPS detectors (6 nos) also along with 24 Clover Germanium detectors with Anti-Compton Shields. The drawings of all parts including movement mechanism have been finalized. The procurement of components for setting up of beamline components / detectors / electronics has started. The initiatives for making the required number of ADCs, Clover electronics INGA Modules, High Voltage power supplies of Anti Compton Shields and Clover Germanium detectors have been taken up by our in house personnel.

4.2.2 INGA at Calcutta

Twelve number of IUAC clover modules are used in INGA campaign at the ongoing VECC, Kolkata. This has helped in reducing considerably the power, NIM bin space and interconnecting cables requirement besides reducing the tuning time. Four INGA clover electronics modules were serviced and tested for stable and reliable performance and were loaned to INGA campaign at VECC / SINP / UGC-DAE-CSR, Kolkata. The present series of experiments is expected to come to an end in May 2006.

4.2.3 Clover in GDA

As the users wanted to have polarisation data in Nuclear structure experiments using the regular HPGe array one Clover Germanium detector without Anticompton shield (due to space limitation) has been added to the array. This has been used in five experiments this year by various users. The 'Autofill' program of liquid nitrogen filling system takes care of separate filling cycles of HPGe (once in 24 hours) and Clover Ge detectors (once in 8 hours) simultaneously during the days of experiments.

4.2.4 Home made Analogue to Digital Converters - ADC814

Mamta Jain, E. T. Subramanian

The home made Analogue to Digital converter (ADC814) 8 channel 14 bit CAMAC module has been successfully tested with Pileup reject enabled during inbeamexperiments and are regularly used in experiments, replacing the commercial ADC 413A which have gone bad. This (ADC814) module is much cheaper than the commercial ones and has excellent linearity (1 in 10^4).

4.2.5 LPCC Multicrate CAMAC - DAS

Kusum Rani, E. T. Subramanian

In order to collect more data during experiments the List Processing Crate Controller was installed in GDA with 2 CAMAC crates and the Data Acquisition system CANDLE with dedicated data network. The entire system has been successfully tested with event rates as high as 8 Kcps in singles mode for days together. This system is used in all experiments regularly giving as increased data rate (850 Kb/s per crate) compared to single crate with separate LPCC and Crate Controller systems (425 Kb/s).

4.2.6 NUSPE 05

An international workshop on “Nuclear Structure Physics at the Extremes: New Directions was organised in Himachal University, Shimla from 21 March to 24 March 2005. It was well attended and appreciated by Nuclear Physics community of the country and abroad. The proceedings of the workshop are to be published by Allied Publishers.

4.2.7 GDA Electronics Module

S.Venkataramanan, A.Gupta

Home made NIM double-width module, to cater for the Compton suppression cum shaper for two number of HPGe detectors, has been made and is being tested for reliability. This module reduces the number of electronic units used significantly as it replaces Timing Filter Amplifiers, Constant Fraction Discriminator, Delay, Coincidence Logic, Shaper, Gate stretcher of two HPGe along with their ACS to one single module. This step has been taken to increase reliability of our electronics, used in experiments, as the commercial shapers (Timing Filter Amplifier and Spectroscopy amplifiers) are behaving erratically (burning out of components / Gain drifting) after several years of use.

4.2.8 Experiments using GDA related facilities

The GDA facilities were used in this year for collectivity studies of nuclei by lifetime measurements, incomplete fusion mechanism, Electromagnetic moment measurements by perturbed angular distribution, Fission hindrance and entrance channel effects in fusion reaction. The list of experiments is shown in the following table.

Description	**Beam**	**Energy MeV**	**Shifts**	**User**	**Facility**
Fission Hindrance	^{16}O	84-120	12	NMB/KU	HIRA + BGO Multiplicity filter
Incomplete Fusion	^{16}O	90	12	BPS/AMU	CPDA + GDA
Odd-Odd Iodine	^{10}B	70	15	PD/IITB	CPDA + GDA
MR in A=80 region	^{13}C	53	15	AKJ/IITR	GDA, BaF2, Pulsed Beamtime
Nucl. Str. in A = 130	^{19}F	80-84	18	NS/PU	GDA, CloverGe
Nucl. Str. in La region	^{32}S	125-140	24	UDP/SINP	GDA, CloverGe
Electromagnetic moments in rare-earth region	^{16}O	105‘	6	AKB/PU	PAD
Incomplete Fusion	^{16}O	100	12	AA/AMU	GDA/CPDA
New shell structure at N >> Z	^{7}Li	30	15	HJW/GSI	GDA/RDD
Nuclear structure-^{81}Rb	^{29}Si	95	15	RKS/BHU	GDA/DSAM

4.2.9 Polarisation Sensitivity of Clover

R.Abhilash

Two NaI crystals along with Clover Germanium detector have been used to measure the Polarisation Sensitivity of gammas emitted by radiation sources (^{60}Co, ^{152}Eu). The experimental setup is shown in Fig. 1 and the electronics block diagram is shown in Fig. 2.

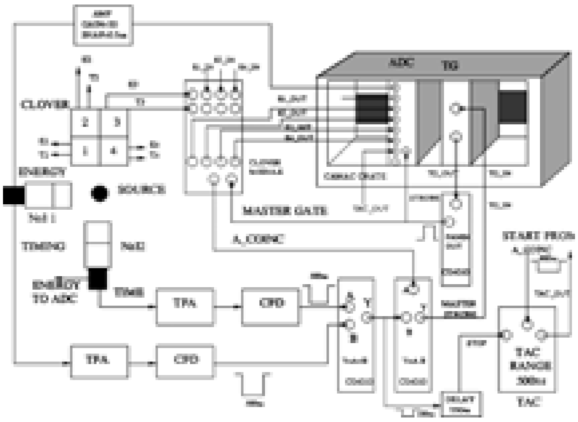
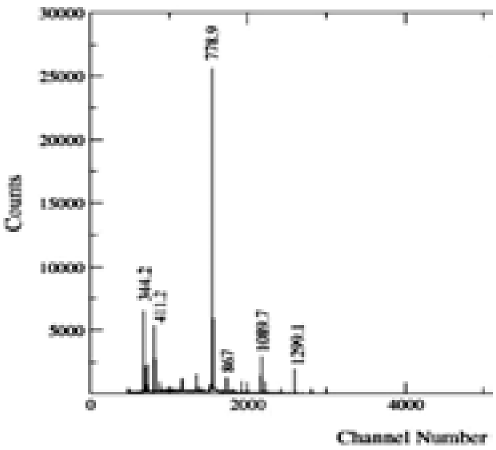


Fig. 1. **Fig. 2.**

The coincidence of any one of the NaI with Clover Germanium detector was used to start the list mode data collection. Energies of all the four crystals of Clover along with that of two NaI and the two TAC's of Clover with the NaI was recorded for each event. In the offline analysis the add-back spectrum of Clover (i.e. addition of all 4 crystals energy information) when two crystals of Clover are fired (either in parallel N_H or perpendicular N_V scattering plane) and the condition of Prompt time window from the relevant NaI-Clover TAC and the corresponding NaI energy condition (in the window of 1173 KeV to 1332 KeV in the case of ^{60}Co source, 344 KeV gate in the case of ^{152}Eu) was put (Fig. 3). By measuring the asymmetry parameter, and using calculated polarisation value, the values of polarisation sensitivity at various energies measured are shown in fig. 4. The values agree with those reported in /1,2.



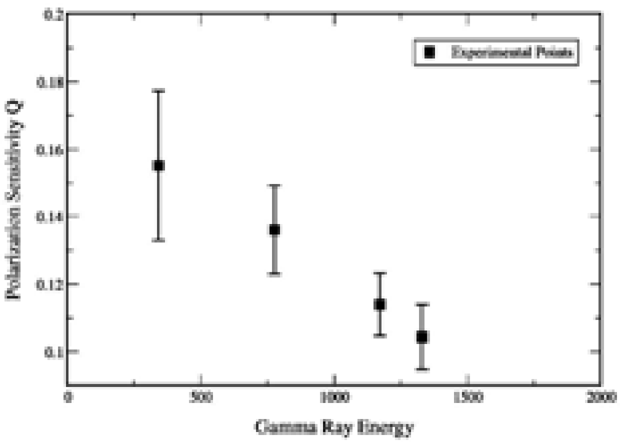


Fig. 3. **Fig. 4.**

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[1] R. Palit el al Pramana –J. Phys.,Vol. 54, No. 3, March 2000.

[2] P. M. Jones et al, Nucl. Instr. and Meth. A362(1995) 556-560.

4.2.10 IUAC's INGA Clover Modules in GSI

S. Venkataramanan, A. Gupta

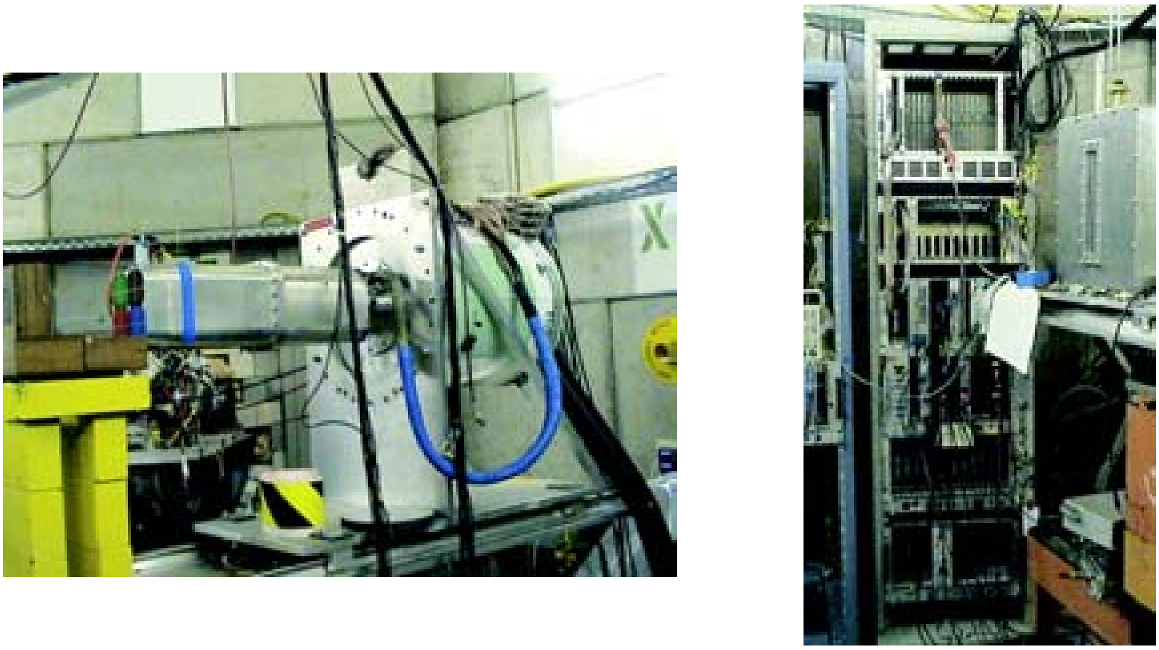


Fig. 5.

Two number of INGA clover electronics modules made by IUAC's electronics laboratory are being used in Rare Isotope Spectroscopic Investigation at GSI (RISING), Germany setup, after modifications to take care of rise / decay time of Super clover Germanium detector and completing satisfactory tests with radiation sources. INGA clover electronics modules are processing both time and energy signals from all crystals and deliver results comparable to commercial modules considerably reducing setting up time. The test setup at GSI is shown in Fig. 5.

4.2.11 HPGe detector Service / Annealing

As the HPGe detectors are used continuously over the years they needed periodic service cum annealing. Six detectors were evacuated while eight detectors were annealed to restore the FWHM of the detectors.

4.2.12 LN2 Filling system Controller

One dedicated controller with embedded PC 104 (512 MB IDE compatible hard disc) under Linux operating system has been made. This can control upto 32

Valves with their respective sensors, so that the detectors can be periodically filled automatically. Fig. 6. shows the fabricated controller.

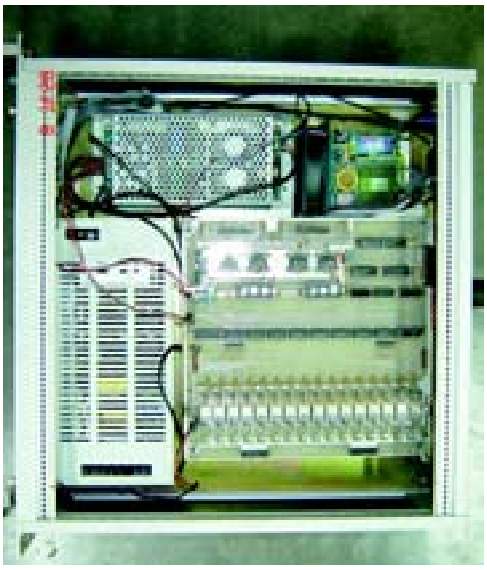


Fig. 6.

4.2.13 LPCC with local boot disc based DAS

Kusum Rani, E. T. Subramanian

A uni-crate system with local boot disc (32 MB) which contains both the servers “ms” (middle server) and data server (ds) has been made, installed and tested, for reliable and reproducable data collection, in GDA laboratory. This system was used to collect list mode data for Polarisation measurement of Clover detector. The setup is shown in the following fig. 7.

Fig. 7.

4.2.14 New Recoil Distance Device for lifetime measurements

R.P. Singh, Dinesh Negi and R.K. Bhowmik

With the installation of INGA in Beamhall II we need to develop new auxiliary systems which can be incorporated with the INGA set-up. Recoil distance device (RDD) is a very important device for lifetime measurements of excited nuclear states in the range of about a picosecond to few hundred picoseconds.

For this purpose we have procured three new linear actuators which are based on DC motors. These actuators allow for a minimal incremental motion of 50 nanometers at speeds up to 1.5mm/sec with a non-rotating tip. These actuators can provide linear motion up to 25 mm and are equipped with limit sensors. Each actuator includes a permanently connected 0.5 m cable with 15 pin sub-D connector. These DC-motor are also equipped with line drivers for cable legths up to 10 meters between the actuator and controller.

The control system for these motors works on a windows platform. The preliminary test of the motors have been carried. A new control system is being set-up for this system. The details of the mechanical housing is being worked out to fit in the INGA set-up.

4.2.15 Incomplete Fusion experiment with CPDA

The Incomplete Fusion experiments require the detection of gamma rays from nuclei produced with the charged particles emitted in the reaction. Till recently these experiments were done in GPSC without much success as the solid angle covered by Surface barrier detectors was less. Hence the AMU experiments were taken up in GDA with HPGe detectors and the CPDA as the efficiency of detecting both γ and charged particle (α) are more due to the number of detectors and the type of detectors. The spin distribution from side feeding pattern was attempted successfully in the first reaction ^{16}O on ^{169}Tm at ~ 6 MeV/A

4.3 RECOIL MASS SPECTROMETERS

4.3.1 Heavy Ion Reaction Analyzer (HIRA)

Jagdish Gehlot, Subir Nath, Akhil Jhingan, Thomas Varughese, J.J. Das, P. Sugathan, N. Madhavan, P.D. Shidling[1] and GDA Group of IUAC

[1]Department of Physics, Karnatak University, Dharwad, Karnataka

During this period, HIRA was used in a facility test and in an experiment involving stable beam and mass dispersive mode. Two more user proposals have been accepted in December 2005 AUC meeting for the use of HIRA in the mass dispersive mode, one for the study of state selected transfer and another for the study of contribution of deep inelastic processes in symmetric and light-heavy nuclear reactions above Coulomb barrier. These will be taken up after September 2006. There were nine published papers, four from experiments using HIRA-INGA facility, four from experiments using ^{7}Be RIB and one on the ^{7}Be production mechanism.

The second run of the experiment looking for fission hindrance in ^{16}O + ^{184}W $\rightarrow$ ^{200}Pb* was carried out with HIRA + 14 BGO detectors. Additional energy points were taken after repeating couple of earlier points. The measured cross-section and moments of spin are being compared with theoretical calculations. During part of this run, the top BGO detector array was removed and HPGe detector was used in its place to extract the HIRA efficiency taking the ratio of counts of gamma identified from an ER and in coincidence with that ER to that in singles gamma spectrum. This is the heaviest and most asymmetric system for which HIRA transport efficiency has been measured so far. The measured efficiency of ~ 1 % (see Fig. 1-2 and Table 1) agrees well with the simulation (1.1 % for ^{195}Pb and 1.3 % for ^{194}Pb, please refer to Table 1, section 4.3.3 of 2004-2005 Annual Report) carried out using the program developed here. The last run in this user experiment, to be taken up in July 2006, involves ^{19}F + ^{181}Ta leading to the same compound nucleus ^{200}Pb*.

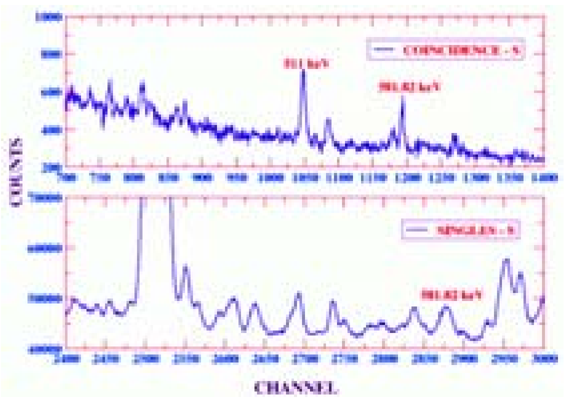


Fig. 1 γ-spectra of ^{194}Pb

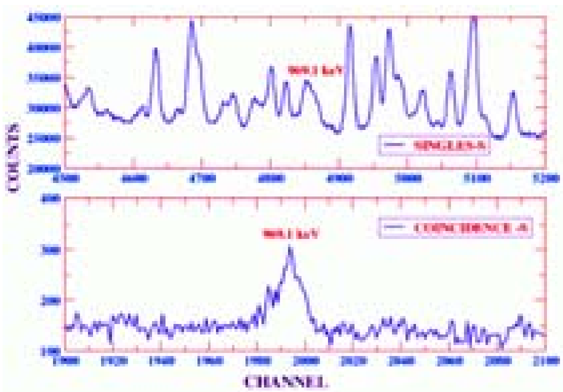


Fig. 2 γ-spectra of ^{195}Pb

Energy (keV)	Residual Nuclei	Efficiency
581.82	^{194}Pb	1.02 %
739.1	^{195}Pb	0.97 %
969.0	^{195}Pb	0.98 %

Table 1: η_{HIRA} extracted

A new MWPC detector has been made for the focal plane of HIRA and/or HYRA and this will be tested in the near future. Foil testing and dynamic pressure stabilization which are required for gas-filled operation of HYRA were initially carried out in the sliding seal chamber of HIRA.

4.3.2 Hybrid Recoil mass Analyzer (HYRA)

N. Madhavan, S. Nath, P. Sugathan, J.J. Das, A. Jhingan, T. Varughese, J. Gehlot, A.K. Sinha[1], R. Singh[2], K.M. Varier[3], M.C. Radhakrishna[4], U.G. Naik, A . J . Malyadri, Cryogenics group, Beam transport group and GDA group of IUAC

[1]IUC-DAE Consortium for Scientific Research, Kolkata Centre, Kolkata
[2]Department of Physics and Astrophysics, University of Delhi, Delhi
[3]Department of Physics, Calicut University, Kerala
[4]Department of Physics, Bangalore University, Bangalore

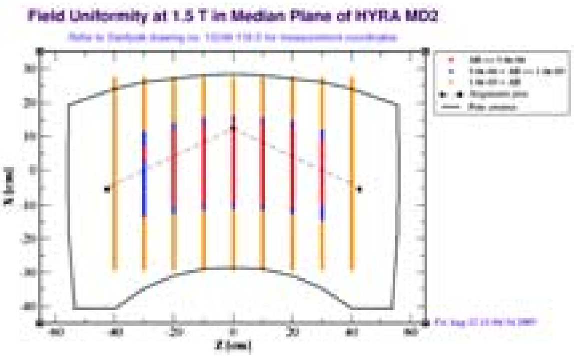
The first stage of HYRA QQ-MD-Q-MD, the components of which were received in June 2005, has been set up in beam hall II at IUAC (fig. 1 and 2). Cooling water and electrical connections are nearing completion. Beam-line laying is about to start and beam test is expected in the second half of May 2006. The work carried out in the period of April 2005 to March 2006 is summarized below.

Fig. 1. HYRA first stage magnets and power supplies

Fig. 2. Close-up view of HYRA first stage QQ–MD–Q–MD

The field mapping of the first stage magnets was carried out extensively in the presence of centre's personnel. All the relevant fringing field details were subsequently extracted. The field uniformity of MD2 at 1.5 T and the effective length measurement of Q4 at various excitation/radii are shown in figures 3 and 4, respectively.

The first stage magnets and power supplies, on acceptance, were received at IUAC in June 2005. Due to the upper limit of 7.5 tonnes lifting capability of beam hall II crane, the magnets came in parts which had to be put together at the centre. After a



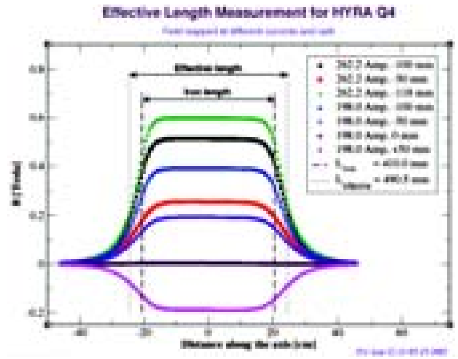


Fig. 3. Field uniformity in the median plane of MD2 at peak field of 1.5 T

Fig. 4. Effective length measurement in Q4 at various excitation and/or radii

mock assembly of the heavy dipole at ground level, the alignment process was started in July 2005.

The beam-line direction was transferred on metal sheets embedded on the floor and the height reference on the walls all around the space for HYRA facility and the mean trajectory was marked on the floor. As per the decision in the project investigator's meeting, while the superconducting Q1-Q2 is being developed, Q5-Q4 was installed at the beginning followed by MD1-Q3-MD2. Initially, after finalising the proper location and installation of the magnet stands, the magnets were set up except for the coils and chamber. This was done to look for any level difference with load and the final alignment was done with this configuration. The required alignment pins were made and with the help of two theodolites (telescopes) the entire alignment was done at beam level. The proper positioning and alignment of Q5-Q4 gave the entrance direction for MD1, MD1 on proper alignment and positioning gave the entrance direction for Q3 (and in turn MD2) which was the same as exit direction of MD1 and so on (fig. 5 and 6). All the

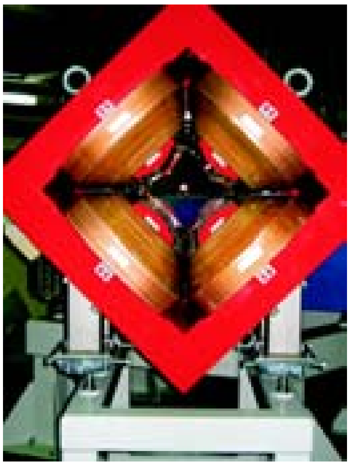


Fig. 5. Telescope aligned along beam direction for Q5Q4 and MD1 entrance direction

Fig. 6. MD1-Q3-MD2 with alignment pins (final alignment done with top yokes on) and sideways movement mechanism of Q3

quadrupoles were aligned to avoid rotation about any of the three axis from the required orientation with the magnetic axis passing through the proper direction and at beam level. The dipoles were aligned so that the bottom pole surface was horizontal and at 60 mm below the beam level. The entrance and exit directions of various components have also been transferred on the floor.

The sideways movement option of Q3 (fig. 6) was tested for reproducibility prior to the vacuum chamber installation. On the completion of alignment, the top yokes of the dipoles and quadrupoles were removed for the installation of coils (MD1 and MD2) and vacuum chambers. Jigs for proper compression of the welded bellows at the two ends of Q3 (required during insertion or removal of Q3) were made and tested. The vacuum chambers and the pumping system were subsequently installed. The first stage pumping system consists of two 550 l/s Turbo Molecular Pumps and the measuring system consists of Pirani and Penning gauges at suitable positions. In addition, for filling Helium gas during gas-filled mode operation, Baratron gauge, solenoid valve and controller are installed. A Baratron assembly has been tested separately in the sliding seal chamber of HIRA facility and found to control the gas pressure accurately. The entire vacuum system was checked with a Helium leak detector connected to the backing line of one of the turbo molecular pumps for better sensitivity. A few minor leaks found near welding joints and one on the body of MD2 chamber were sealed with Torr Seal and finally a vacuum of 7.5×10^{-8} Torr vacuum could be achieved. Hall probes were installed in the slots on top of MD1 and MD2 chambers and tested, prior to the connection of the top yokes. While the connection of the bottom coils in magnetic dipoles were relatively easier, special precautions had to be taken for the installation of top coils. The procedure adopted was to suspend the top yoke and pole assembly by crane and to gradually lift the coil on three jacks to the correct position. The assembly of first stage components was completed in the first half of February 2006.

The process for order/procurement of parts for the cooling water lines, cable trays and electrical cables had started during the installation of magnetic components. The main distribution panels for power (one each for the first and second stage of HYRA) had also been made ready as per the power requirement of various elements. On the completion of installation of magnetic components, the utility jobs were taken up. The welding and subsequent checks for leaks on the water-lines were carried out in-situ and a defective piece was immediately replaced. Three cooling water lines (one inlet and two outlets corresponding to two different pressure drops) have been laid from the southern, permanent wall to the HYRA facility and have been branched out to all the magnetic components and Tantalum linings below the stands and along the wall on the northern and eastern sides for power supplies. The sizes are chosen to provide required flow to each equipment. The magnets and power supply water-lines are individually provided with Y-strainers to prevent foreign particles from entering the equipments. The measurement of actual water flow in each equipment is being carried out. DC (high current) cables are laid from the power supplies to respective magnets and preparations are on for laying the AC cables to energise the power strips.

An existing chamber has been modified with re-entrant cups to allow easy mounting of window foil, either before or after the target, to separate the gas-filled region from the beam-line vacuum (fig. 7 and 8). Natural Ni foil, rolled to a thickness of about 2 mg/cm^2 and glued to ‘foil holding flange’ will be used upstream of the target in the initial tests. One such foil of active area of 9.6 cm^2 was tested in the sliding seal chamber of HIRA facility and found to rupture at ~ 10 Torr. As the operational pressure in HYRA will be 1 Torr or less, we plan to check another similar foil for a longer time. We plan to try out, in future, other foils such as Havar.

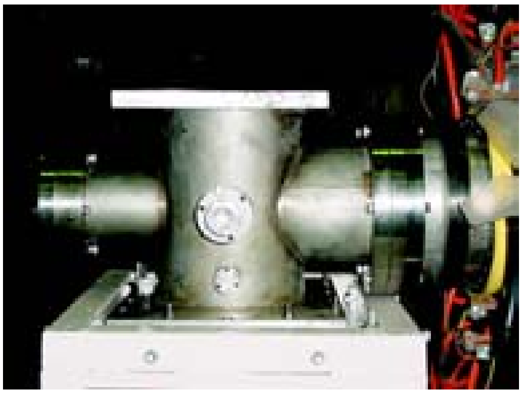


Fig. 7. Target chamber with re-entrant cups for mounting window foil

Fig. 8. Inside view - Provision for window foil at entrance and exit side

The beam-line components will be installed shortly and we plan to test the vacuum mode operation of first stage of HYRA with beam in the latter half of May and subsequently the gas-filled mode too.

The pole and yoke of the superconducting Q1-Q2 doublet are getting ready and will arrive in the beginning of May. The superconducting wire has been procured and the formers for coil winding are getting ready. The wire winding machine has been designed and efforts are on to get it fabricated. The design of the cryostat will be taken up shortly.

The second stage quadrupoles and dipole (MD3) and the power supply for MD3 are getting ready. They are expected at the centre this July after acceptance tests are carried out. The power supplies for the second stage quadrupole magnets to be made indigenously are in the design stage and some components have been fabricated.

4.4 MATERIALS SCIENCE FACILITY

A. Tripathi, Ravi Kumar, V.V. Shivkumar, F. Singh, S.A. Khan, P.K. Kulriya, I. Sulania, T. Mohanty, R.N. Dutt, 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 from India and abroad.

The swift heavy ion irradiation related experiments are performed in the three chambers in the beamline as well as in the general purpose scattering chamber. Besides this the off-line facilities are also being used by many users for preparing and characterizing samples. A total of 69 user experiments comprising more than 158 shifts were performed this year, without any beam time loss due to major facility break down. Experiments are being done in different areas of swift heavy ion induced materials modification and characterization and the details of the research programmes are given in Section 5.2.

The high vacuum chamber in materials science beam line is used in most of the experiments for irradiation and ERD studies. The goniometer chamber mounted on UHV chamber for channeling studies developed a problem this year and is being repaired.

FTIR system Nexus 670 from Nicolet is being actively used for vibrational analysis of thin films as well as bulk materials by users with analysis of more than 400 samples completed. The PL/IL study of more than 400 samples from nearly 30 users was also done this year.

4.4.1 Irradiation Chamber in BH II

A. Tripathi, R. Ahuja, R.N. Dutt, P.K. Kulriya, P. Barua, A. Kothari, S.A. Khan and D.K. Avasthi

The new target ladder for irradiation chamber in Beam Hall II was installed this year. This ladder was used in the first test experiment in the new beamline in beamhall II. Plans for computer controlled remote operation of linear motion and rotary table for

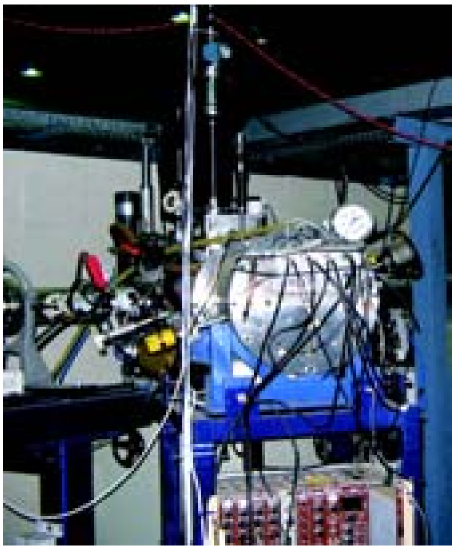


Fig. 1. The irradiation chamber with target ladder mounted on top of Z column and rotational table

the sample ladder were completed. The indexer/controller system, which had a minor manufacturing defect, was received after repair and mounted. Two adapters were made for integrating the linear and rotational motion set up. The Z column for mounting the ladder was modified in workshop to make it compatible with the rotational motion. A zero length insulating teflon flange was designed to insulate the target ladder from chamber and has since been installed. The irradiation chamber with the target ladder mounted on its top is shown in figure 1. The beam line was aligned and the alignment was tested with the beam in both the chambers. The scanning of the ion beam was tested and was used in in-situ XRD test experiment. The scanner is at present taken from GPSC beamline and the dedicated scanner for this beamline will be installed soon.

4.4.2 Swift Heavy Ions in Materials Engineering and Characterization (SHIMEC)

D.K. Avasthi, A. Tripathi, Ravi Kumar, F. Singh, S.A. Khan, P.K. Kulriya, I. Sulania

All the facilities planned under the SHIMEC programme funded by DST under its Intensifying Research in High Priority Areas (IRPHA) programme have been installed and tested. The thrust areas identified under the project are the study of Phase transformation, Electronic/ Potential Sputtering, Surface/Interface modification, Ion beam induced epitaxial crystallization, Nano phase modification and synthesis and Transient-enhanced diffusion. The beamline in the new beamhall with two of the facilities: in-situ XRD set up and LAPSDT detector is shown in figure 2. The first test experiment using in-situ XRD set up was conducted this year and details are discussed in section 5.2. The LAPSDT detector was tested with ion beam in the test experiment.

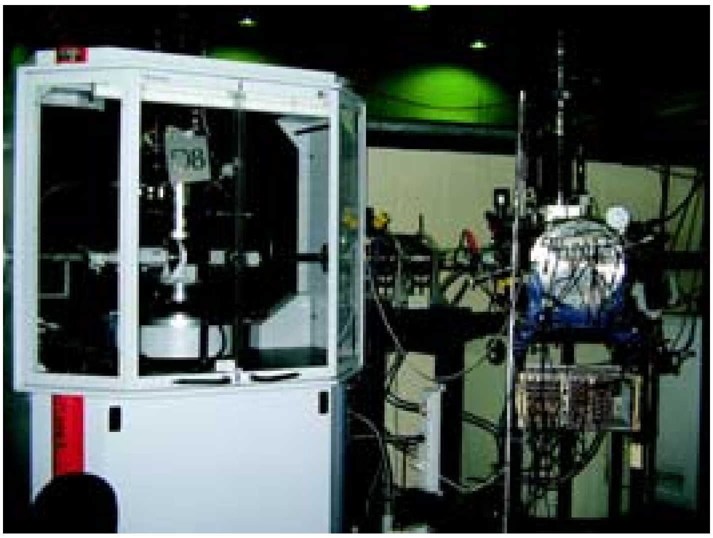


Fig. 2. The beamline in the new beamhall with in-situ XRD set up and LAPSDT detector connected to irradiation chamber.

4.4.2.1 Scanning Probe Microscope

A. Tripathi, I. Sulania

Multi Mode SPM with Nanoscope IIIa controller acquired from Digital/Veeco Instruments Inc. was extensively used in all the modes in user experiments. The areas of research include: Ion induced surface morphology, SHI induced changes in size and its distribution of nanoparticles, SHI induced modification in magnetic domains, SHI induced plastic flow of material and characterization of ion tracks in terms of size and number density.

The AFM was shifted to the new materials science building this year and re-installed there. The new laboratory has special provision for ground vibration protection as the complete floor has been isolated from the rest of the building. Besides that a special sand filled pit with a concrete block on top was designed to place the SPM table for further vibration isolation. The shifting to the new building was achieved without disturbing the routine operation of SPM and this year more than 650 samples from 56 users have been studied. The AFM facility in the new laboratory is shown in Figure 3.

Fig. 3. The AFM facility in the new LEIB (Low energy ion beam) building

Three of the illustrative images taken in Tapping mode AFM (Fig 4A), and MFM (Fig 4B and 4C) are shown and results obtained are discussed in materials science research section 5.2.

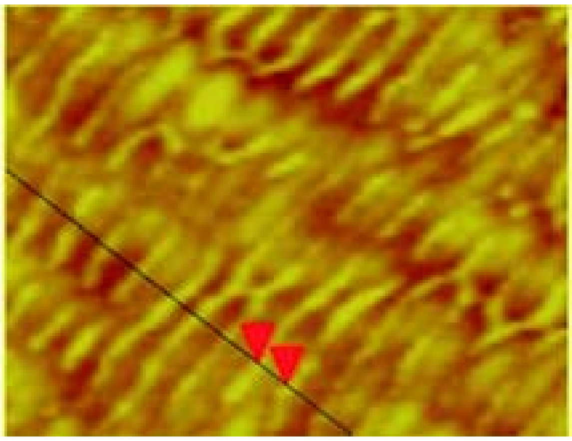


Fig. 4A. Ripple formation on Si(100) surfaces after irradiation with 1.5keV Ar^{+} beam at $5.1x10^{17}$ ions/cm^2 fluence at 45^0 incidence (P.K.Kulriya et al).

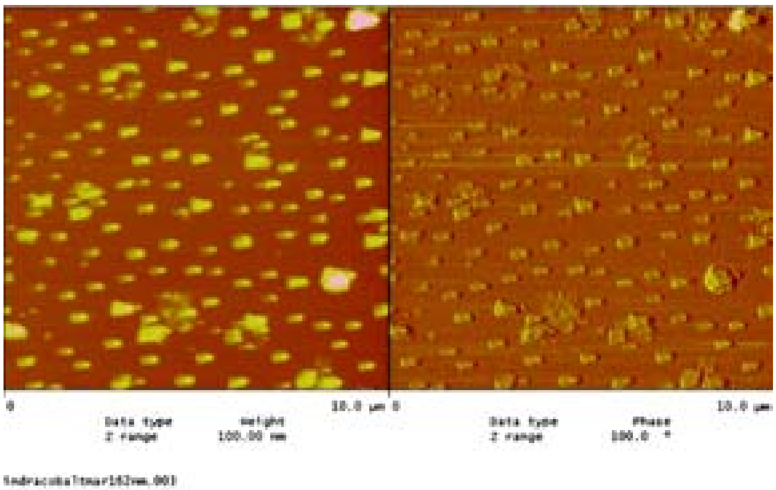


Fig. 4B. AFM and MFM image of Co film (2 nm) showing formation of nano-islands

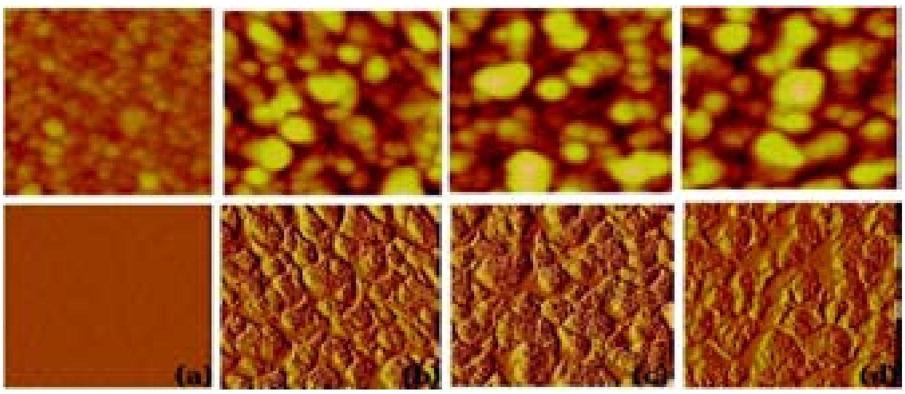


Fig. 4C. MFM image of C_{60} film before and after irradiation with 120 Mev Au ions (a)Unirradiated, (b) $1x10^{13}$ions/cm^2 , (c) $3x10^{13}$ions/cm^2, (d) $5x10^{13}$ions/cm^2 (Amit Pawar et al)

4.4.2.2 In-situ XRD set up

P.K. Kulriya, F. Singh, A. Kothari, R. Ahuja, A. Tripathi and D.K. Avasthi

XRD (Model D8 Advance) was acquired from Bruker AXS Germany, and offline testing was completed last year. This year the system was integrated to the beamline and in-situ testing of the system was completed.

The in situ XRD chamber was fabricated at work shop of the IUAC this year. This XRD chamber consists of two windows, one for incident X-ray and other for reflected X-ray. These two windows are sealed with the Kapton foil. This chamber has total nine ports: two KF50, four KF 2.75" and three KF25. Out of the two KF50 ports, one is used to connect the XRD chamber to the beam line and another one will be used for the planned low temperature attachment. The electropolished chamber is pumped by a turbo molecular pump and a vacuum of $5x10^{-5}$ torr was obtained. Two beam pipes were fabricated and electropolished and the XRD chamber was connected to the beam line using two gate valves and a bellow. The alignment of the sample holder to the beam line was done using a theodolite. Schematic of beam line with irradiation chamber and XRD chamber is shown below (Fig. 5). An arrangement is made to carry out the XRD measurement in a controlled gas environment, which has been used for the XRD of H loaded thin films of rare earth materials.

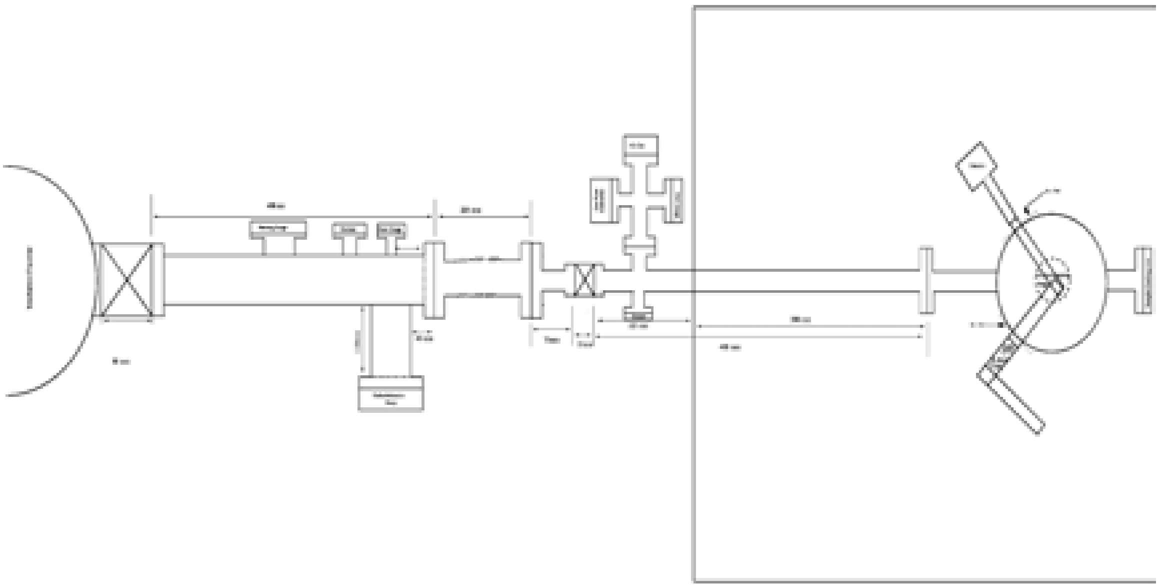


Fig. 5. Schematic of beam line between irradiation chamber and XRD.

To mount the sample, a lifting mechanism system that can lift the vacuum chamber up to a height of 200mm was fabricated. Two limit switches are also mounted to constrain the upwards and downwards motion of the chamber. To avoid any damage of the x-ray tube and detector, two SS guide rods are provided. Figure 6 shows the in-situ XRD facility integrated to the new materials science beamline in Phase -II beam hall.

Fig. 6. Schematic of the in-situ XRD at Phase -II beam line with chamber lifting and planned sample cooling arrangement.

4.4.2.2.1 Facility test of the In-situ X-ray Diffractometer

The corundum was used for off line testing and a scan from a range of 2-theta between 20 to 80 degree is shown below. It was observed that the intensity of X-ray was reduced by 20 % when the spectrum of corundum was taken with XRD chamber. This reduction, however, improved to 10% after the chamber was evacuated using a turbomolecular pump to 1 x 10^{-5} torr vacuum.

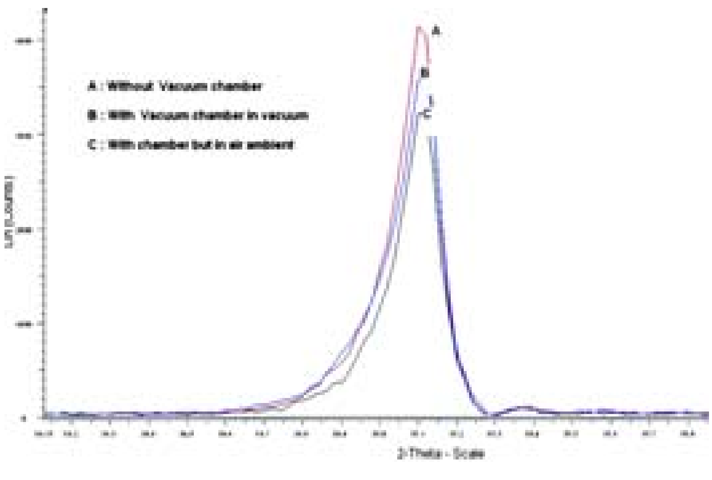


Fig. 7. XRD spectrum of the correndum sample with and without vacuum chamber

After the offline testing 93Mev Ni beam was used for in-situ testing. The in-situ monitoring of the amorphization in the Zircon phase of ThGeO4 was undertaken. It was observed that the amorphization increases as the fluence increases from $1x10^{12}$ to $8x10^{12}$ ion/cm^2 (M. Patel et al). The detailed results are discussed in section 5.2.

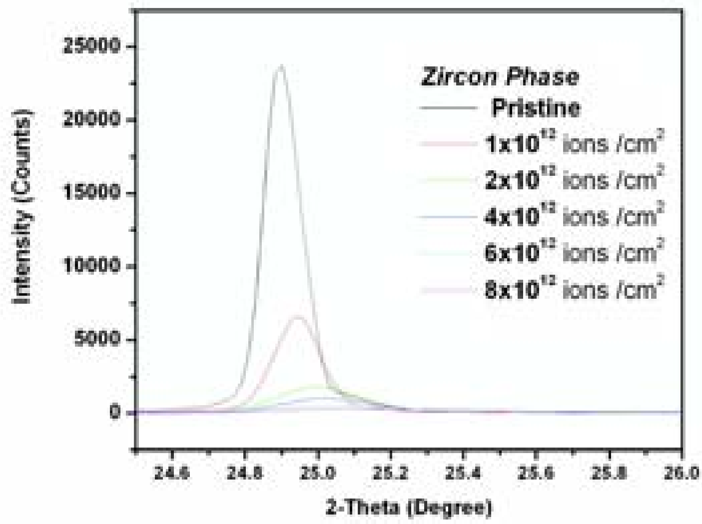


Fig. 8. XRD spectra of $ThGeO_4$ sample irradiated with fluence from $1x10^{12}$ to $8x10^{12}$ ion/cm^2(M. Patel et al).

4.4.3 Systems for synthesis of materials.

V. V. Siva Kumar, Ravi Kumar and D.K. Avasthi.

An rf sputtering and a ball milling system are present to synthesize materials for the users and development of a microwave/ECR plasma system is underway for the deposition of thin films in future. These works were affected upon shifting to new lab where time was consumed in making provisions of electrical connections, gas flow connections and water supply. Work on the provisions for compressed air and gas exhaust for the mechanical pumps is being done.

(a) RF sputtering system.

This year rf sputtering system was used to study the growth of CdS, ZnS and CdSe nanocrystals in silica matrix. A leak in the wilson seal of shutter was detected and solved. An LN2 trap was installed in the roughing line to prevent oil vapors of the rotary pump from entering into the deposition chamber. The RF sputtering system was disconnected and shifted to the new lab and assembled there. Water supply, gas flow and electrical connections are made to the system.

For the multilayers deposition set-up a rotatable substrate holder is fabricated and the matching network with provision to connect the output to two target holders is being procured.

(b) Ball Milling system.

The ball milling system was used to synthesize nanocrystalline powders of Mg-Mn ferrite from MgO, MnO and Fe_2O_3 powders and SiC from Si and C powders. Nanopowders of $Y_3Fe_5O_{12}$ and $Mn_{0.4}Zn_{0.6}Fe_2O_4$ were also synthesized for university users.

(c) Development of microwave/ERC plasma system for thin film deposition.

In this work, the gas flow control and process pressure control systems were tested. The microwave plasma chamber was designed and fabricated in in-house workshop. The adapter between mode converter and microwave plasma chamber was also fabricated. It is planned to install the microwave plasma system this year and take up the ECR plasma work in next 5 year plan.

4.5 RADIATION BIOLOGY BEAM LINE

4.5.1 Status of the Radiation Biology Beam line

A. Sarma, P. Barua, A. Kothari, E.T. Subramaniyam and M. Archunan

The specially designed beam line can deliver beams of proton, ^{7}Li, ^{11}B, ^{12}C, ^{14}N and ^{16}O. The flux can be controlled from 10^2 particles/sec/cm^2 to 10^6 particles/sec/cm^2. The radiation field is having 30 mm diameter with better than 97% uniformity. The flux control is done by adjusting a double slit through CAMAC from control room. A preset controller for faraday cup ensures the exposure repetition as per user requirement.

A major redesigning of the irradiation system is currently going on, which would take care of the remote handling of petri dishes in an enclosed sanitised environment during irradiation, multiple irradiations of one sample after another without losing time and keeping the petri dishes in the medium when they are not being irradiated. The dosimetry system would also be improvised along with that. The renovation would facilitate better experimental condition from the biological point of view. The exit window would behaving 40mm diameter. The beam line is also being modified at the same time

4.5.2 Status of the Molecular Radiation Biology Laboratory

A. Sarma

The laboratory is designed to extend user support to the best possible way during experiments. The experiments that are undertaken recently require suitable inhouse facilities for relevant protocols. Apart from the equipments of the Cell Culture facility like autoclave, biosafety cabinet, CO_2 incubator, and other normal equipment like microbalance, oven, refrigerated centrifuge, PCR machine, Gel Doc, AFIGE system and Semi dry transblotter etc., we have installed a -80 C Ultra Freezer [Heto] and a -20 C Deep Freezer [Vest Frost].

In addition a fluorescent microscope [Carl Zeiss] has been installed to facilitate the experiments based on FISH and immunofluorescent assays.

This year, a Coulter Cell Counter [Beckman Coulter] is installed in the laboratory. This equipment would drastically enhance the speed and accuracy of post irradiation cell plating during the beam time and thus save a lot of time.

4.6 ATOMIC PHYICS BEAM LINE

4.6.1 Status of Atomic Physics Beam Line

T. Nandi, P. Barua, A. Kothari, Rewa Ram and R.K. Karn

Last year atomic physics beam line was shifted from LIBR beam hall to beam hall II. The beam line up to the vacuum chamber has been installed in the beam line at 10^o east and the alignment has been checked with the beam also. Further extension of the beam line for charge state fraction analysis of the beam on passage of the solid foil using electrostatic analyzer is in progress.

Besides the activity in the atomic physics line a Doppler Tuned Spectrometer has been developed indigenously from the scratch and tested successfully with the beam recently.