IUAC. The power generator is a forced air cooled unit and it has been thoroughly cleaned during this period for dust. Due to inconsistency in power delivery, the individual building blocks of the power generator was tested with a 40 GHz VNA at Special Centre for Nanoscience, Jawaharlal Nehru University. Routing of wave guides for delivering Klystron microwave power output to the ECR plasma chamber was done to have minimum possible transmission loss. It was tested and calibrated using the directional coupler and power meter to verify the power transmission.

Spiral Buncher #1 Power Amplifier

The solid state 48.5MHz, 2kW power amplifier of Spiral Buncher #1 of HCI was reported to be faulty with low gain. During troubleshooting it was found that, the power equalising resistor of 2-way Wilkinson power combiner was blown due to disconnection of one of the power amplifier leads. The power stages were individually checked, and faulty resistor was replaced. The RF connection from power sections were redone for reliable connection. On another, the partially damaged LDMOS was repaired and the power amplifier was restored into the system. The control card of spiral buncher power amplifier has been modified for remote control and remote status read back.

120kW RFQ Power Amplifier

The 48.5MHz, 600Watts pre-driver amplifier section of RFQ power amplifier was reported to be malfunctioning. During troubleshooting the power amplifier cooling fan was found to be faulty due to broken leads, in turn causing thermal reliability problem. The cooling fan leads were repaired and the power amplifier driver unit was restored into the system. This amplifiers has been secured firmly on the rack using customised bracket.

Power Amplifier of DTL 2 & 3

During this year the 97MHz, 20kW CW solid state power amplifier powering DTL-2, DTL-3 cavities respectively have been incorporated into the remote control scheme. The RS-232 control is used to remotely control the amplifier as well as to read the crucial operational parameters of these power amplifiers. A faulty SMPS (3kW) unit was replaced in one of the 6kW sub-units of power amplifier connected to DTL #2. One of the amplifier pallet was repaired by replacing a blown LDMOS transistor.

Power Amplifier of DTL 4 & 5

The 97MHz, 28kW CW solid state power amplifiers powering DTL cavities # 4 & 5 respectively were successfully incorporated into the remote control scheme through RS-232 control, wherein these power amplifiers can be remotely controlled, monitored for power amplifier parameters. One of the RF pallet amplifier in 8kW RF sub-unit was repaired for blown electrolytic capacitor.

Power Amplifier of DTL 6

The 97MHz, 30kW CW vacuum Triode power amplifier powering DTL #6 had developed cooling water leakage during normal operation. The plastic union connecting RF tube and water hose was found to have minor hole. The union was locally sourced and replaced successfully. The remote control and monitoring of various parameters of power amplifiers have been made accessible remotely through VME control scheme.

High Potting of Vacuum tubes

The spare power vacuum tubes of 120kW and 6kW power amplifiers are being subjected to hi-potting test periodically with homemade Hi-potting setup. The Hi-potting conditioning were done regularly to keep the power vacuum tubes in good health and avoid their vacuum degradation during storage.

Broadband Electronics

A faulty low noise, high gain wide band pre-amplifier used with Charge pick-off of TOF setup established with SC_Linac at IUAC was repaired, characterised during this year. The TOF signal processing using two channels of Ultra fast discriminator was altered for uniform low level discriminator settings for both start and stop channels. The front end ultra wide band pre-amplifier of an indigenous Fast Faraday Cup as a part of Vajra Project was characterised successfully for its gain, bandwidth (LF – 10GHz) using available test and measurement equipment.

RF Power amplifiers of SC_Linac

During this year some of the faulty 350W CW, 97MHz solid state power amplifiers of SC-Linac have been repaired and restored into the system. It is reported that, most of the faults in these power amplifiers have been occurring due to aging of control card. We have redesigned the control card which would be consealed in a die-cast aluminium box while retaining the original functionality intact. A prototype version has been installed and tested with existing power amplifier. We have initiated the process of implementing the new control card in atleast 12 IUAC built power amplifiers during this year.

Klystron and Pulse Modulator of DLS

The RF Amplifier group is also actively involved in activities related to preventive maintenance, repair and assisting in operation of high power microwave pulsed power generator of Delhi Light Source (DLS). The Klystron based microwave pulsed power source is operated with microwave cavity at reduced power to accelerate generated photo electrons from photo cathode. The faulty IGBT switching unit (SU) which had failed during earlier operation was successfully repaired at IUAC with spare components sourced from the OEM.

Nuclear Instrumentation

RFA group is also fulfilling the responsibility of maintaining various customised front end and signal processing electronic units built by Electronics laboratory. These units under group care were mass produced by the group members and supplied to different nuclear physics experimental facilities of IUAC. During this year, we have done the preventive maintenance of the Clover Electronics Modules of of Indian National Gamma Array (INGA), wherein all the modules were tested for their functionalities, cleaned multiple cooling fan assemblies and NIM crates. The cooling assemblies installed with front end processing electronics of National Array of Neutron Detectors (NAND) were cleaned. All the NIM modules were subjected to standard test procedures, checked and documented with detailed check list before restoring them back into their original position.

Development of Time Enhancer Module

During this year, we have taken up a project to develop a Time Enhancer Module of INGA to use with INGA clover electronics modules of INGA at IUAC. In the existing INGA clover electronics module timing signal (TOF) for TDC is generated by logic sum of prompt CFD signal from individual crystals in anti-coincidence with ACS. As per new INGA experimental group requirement, TOF signal corresponding to each crystal needs to be generated. Since the new requirement cannot be implemented in the existing Clover electronics module, we have planned to implement these additional functions in a 2U height 19" cabinet. Each Time Enhancer Module is capable of processing the signals from 8 clover electronics modules as shown in the Fig. , wherein individual CFD prompt signals are received through rear panel LEMO connectors. After due processing, the TOF signals generated indifferential ECL levels are routed to TDC module (CAEN V775 – VME) through 34 pin FRC cable. Initial prototypes have been tested successfully with actual detector. After making suitable corrections required the final version is likely to delivered soon.

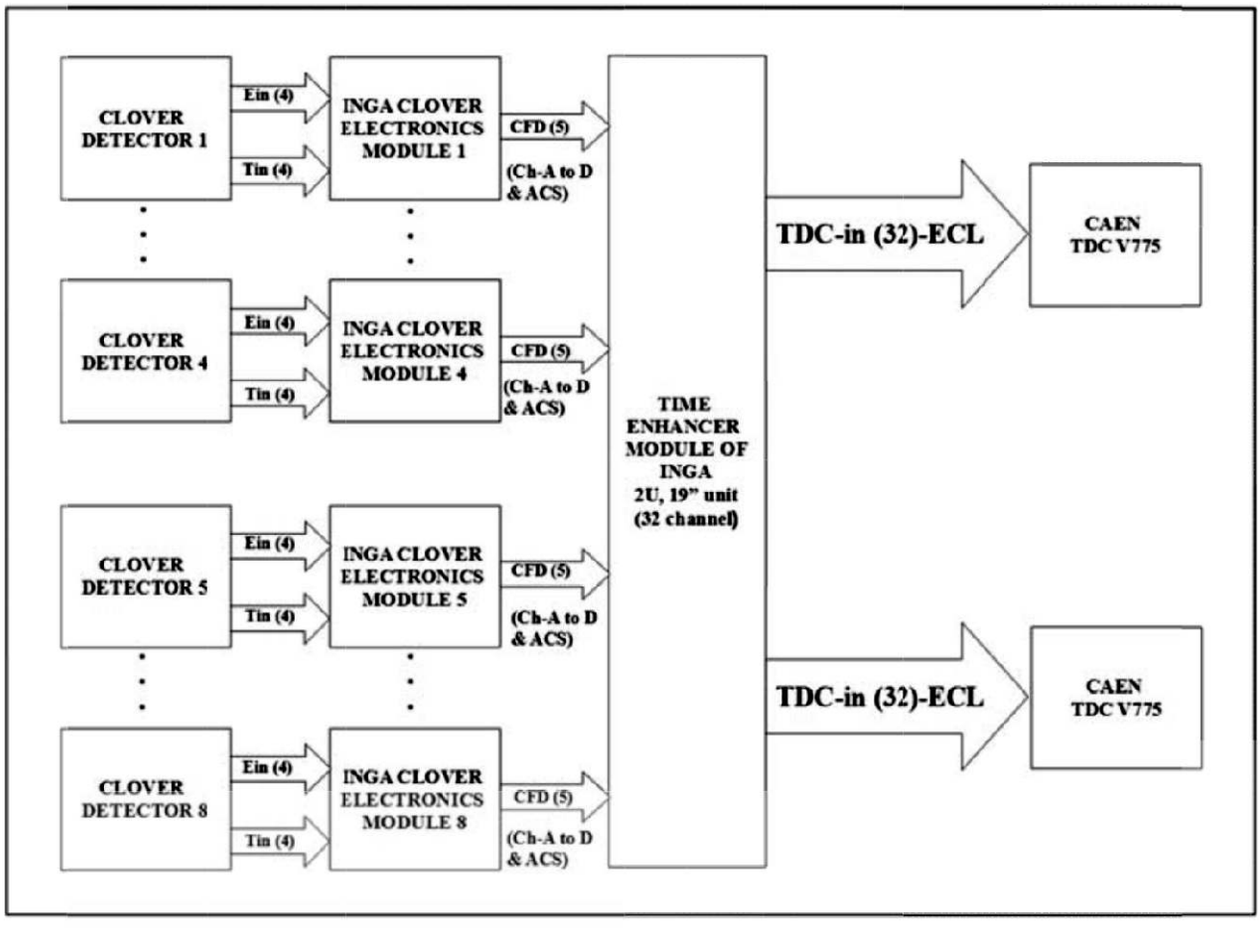

Fig: 3.18 Block diagram of Time Enhancer Module of INGA

3.1.7 HEALTH PHYSICS LABORATORY

Debashish Sen & Birendra Singh

The primary duty of the Health Physics group of the centre is to ensure the **radiation safety of the IUAC radiation workers**. The Health Physicists take care of the **personnel monitoring** system and the **area monitoring** set up of the different accelerator facilities at IUAC. To keep a vigil on the overall radiation safety, routine maintenance of the interlock system and the radiation monitors is also done regularly. To create **radiation safety awareness** among the radiation and non-radiation workers (by holding different orientation programmes) is another duty of the radiation safety officers. Apart from these, user support is provided to different radiation safety related research and development work conducted by different Universities & Institutes.

Radiation sources (with adequate shielding) are kept under strict vigil. Stock checking of all the radiation sources was carried out, and it was ensured that all of those were stored in safe custody. All radiation dose records (both gamma and neutron) of IUAC radiation workers are maintained regularly. As every year, few radiation monitors were replaced, and some new were installed in new strategic locations (as new facilities are coming up in the centre). Gamma/X ray monitors/ surveymeters/ pocket dosimeters get calibrated each year as per their calibration schedule. **Interlock systems, interlock doors**, **display boards**, which were malfunctioning, were repaired, and some of them were repositioned also, as per requirement. Some new **radiation shielding** was provided in different areas as per requirement.

A few university faculties and research scholars are using the existing Health Physics Lab. facilities (gamma irradiation chamber, TLD reader, electrochemical work station, furnace etc.) maintained and updated by this group. Many of the AUC approved projects require these off line facilities throughout the year. Some research scholars have completed their Ph.D. using these facilities and a few research scholars are continuing to do so. Users are from Punjabi University (Patiala), Delhi University, AM University, JMI University, HP University (Shimla), Indra Prastha University, Amity University (Noida & Gurgaon), NIT Jalandhar, NIT Kurukshetra, RTM Nagpur University, etc.

3.1.7.1 AERB regulatory inspection

The **regulatory AERB inspection** for **Gamma Irradiation Chamber** took place in November 2021. Two AERB officials visited the site to monitor the existing condition of the facility. The whole process was completed successfully to the satisfaction of the AERB officials. Few recommendations were made, which was incorporated immediately.

Regulatory Inspection is one of the types of inspections conducted by AERB through which it ensures that the nuclear and radiation facilities are in compliance with the legal & regulatory requirements and licensing conditions. A self-assessment checklist is created which helps the Employer/Licensee to verify that all the safety & regulatory requirements related to the licensed activities / practices are being met, and can be used as an audit tool or not. The self-assessment checklist has to be filled by the Employer / Licensee of the facility in consultation with the Radiological Safety Officer (RSO) while verifying the compliance through facility walk-downs, employee interactions, and/or document/record reviews.

3.1.7.2 e-LORA facility of AERB

Electronic **L**icensing **O**f **R**adiation **A**pplications (eLORA) System is basically a web-based application for automation of regulatory processes for various Radiation Facilities in India. An e-Governance initiative by AERB, the system is aimed at achieving paperless licensing of Radiation Facilities. The objective of the project is to enhance efficiency and transparency in the regulatory processes of AERB.

This facility was used regularly to update our radiation facilities and safety system. It includes

- Sending the **quarterly periodic safety status reports** of the running radiation facilities.
- **Renewal of license** of the running radiation facilities. In this period the Pelletron-LINAC and the RBS facility license got renewed on March, 2021 for the next 3 years.
- The two existing facilities **Low energy Negative Ion Implanter facility (NII) & Low energy (Positive) Ion Beam facility (LEIB)** was to be regularized under new online system, as they had been initiated at IUAC before eLORA online system was in place. The e-License for **Low energy Negative Ion Implanter facility (NII)** was given by AERB on Dec 4, 2020, and the e-license for **Low energy (Positive) Ion Beam facility (LEIB)** was also received this year on 16th September, 2021.
- For the two forthcoming facilities **A) High temperature superconducting electron cyclotron resonance ion source (HTS-ECRIS) for High current injector (HCI) facility** and **B) Free Electron Laser (FEL) based Light source facility,** site approval has already been procured. Design & Construction Application for the **Free Electron Laser (FEL) based Light source facility** has been submitted along with shielding requirements.

3.1.7.3 Audiovisual Lecture on Radiation safety at IUAC

Debashish Sen

Two **audiovisual lectures** on **radiation exposure and protection at IUAC** have been prepared for the orientation

programme of the new users, students, employees, and also for the refreshing programme for the existing employees, one of which has been uploaded in IUAC website. The basics of health physics, radiation benefits, effects & hazards, radiation safety rules & regulations, along with its relevance at IUAC, detailed user guidelines & instructions are all explained in the video. This is meant to be mandatorily shown to any user/new entrant before their entry in the radiation areas. **Health Physics related advice and safety guidance** has been provided regularly as per requirements to the new recruits, students and users of IUAC. The mandatory medical check up of the radiation workers have also been carried out.

3.1.7.4 Shielding modifications proposed

Debashish Sen

The proposal for making an additional manually operated entry into the NAND beam line area was proposed this year. The need for manual entry, i.e., a passage for personnel to enter the NAND beam line area in emergency situations, such as during power failure, was found to be essential. It has been observed that the radiation shielding sliding door which operates on motorised power cannot be opened when electrical and mechanical breakdown occurs. During any failure of backup power (UPS) to the sliding door motor, the users are unable to go inside the beam line to check the status of pumps, detectors and high voltages. In addition, when mechanical failure of motor occurs, there is no way to enter the hall. Also, any fire mishap may render the NAND beam hall not accessible.

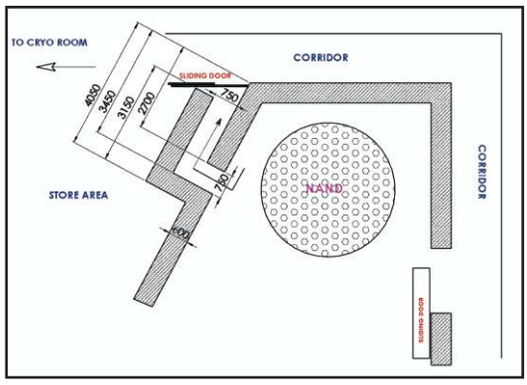

Fig 3.19. Proposed modification in NAND beam hall

Hence it was suggested, to avoid all these difficulties, to make an entry behind the NAND beam line leading to the triangular-shaped storage room. A portion of the triangle-sized room behind NAND beam line can be used, where an L-shaped radiation shielding wall can be constructed using concrete bricks, without major modifications or hindering already existing equipment of other facilities. This shielded entry behind the NAND beam line leading to the triangular-shaped storage room and opening into the corridor was found to be quite feasible (The drawing is shown, dimensions in mm). A normal sliding NLK door has to be provided, which will be interlocked with the beam, when beam is in NAND area. This requires minimum disturbance of the existing experimental set up of Beam Hall II. This wedge shaped entry was also found **to be fine from radiation safety point of view**. **Approval has been procured from AERB regarding this modification** (as shown in figure 3.19).

Reinstallation of LIBR beam dump (for reviving proton run) and a separation **shielding wall between ASPIRE and beam dump** has also been done. **(**Figure 3.20**)**

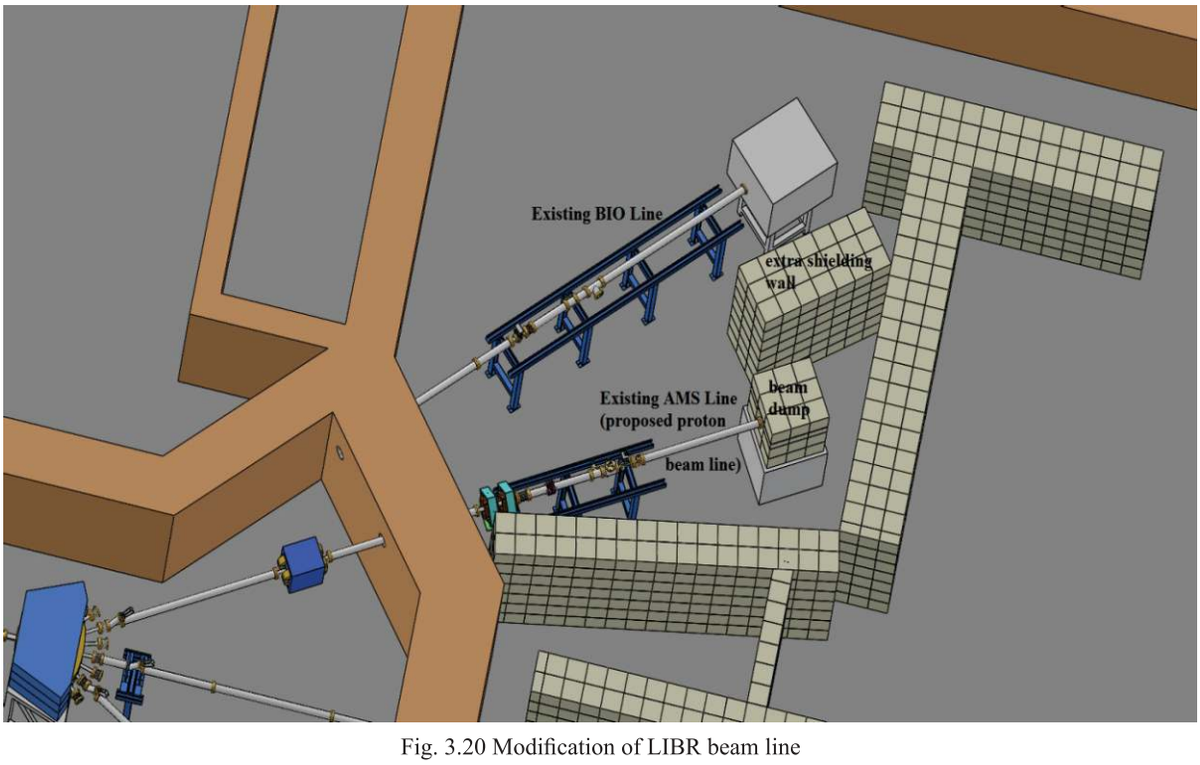

Fig. 3.20 Modification of LIBR beam line

Modification of HCI beam line shielding in beam Hall 1 & III (along with adjacent corridors): The facility site approval has been taken. The design and construction application are on hold. Shielding calculations are also in the final stages. The modification of the shielding layout of Beam Hall I is under consideration. The latter part of HCI beam line is to be built in Beam Hall I, which will merge into the Pelletron accelerator zero-degree line. Hence, the original approved shielding layout has to be modified, so that the beam lines GPSC and Mat Sc. remains operational and accessible, even when the HCI beam is ON. The adjacent corridors also need new shielding set ups (to take care of the radiation safety when HCI is running). All these modifications are being planned at this stage, and will be implanted only after AERB approval is obtained.

Proposed addition/modification of shielding/interlock system for HCI beam line in BH III

- The door from HCI to MRI room should be compatible to fire safety or emergency exit and must have the provision to get it opened only from HCI side without key. However, from MRI to HCI, it should be opened with Key and should maintain the radiation safety protocol. Radiation safety interlocking system will be provided on main door from HCI to MRI. The present door is to be replaced by a suitable new door.
- The existing Aluminium **door from HCI towards east side external road** will also have the same radiation safety provisions and hence the existing door to be replaced by new one.
- **Lead blocks** are to be provided (adjacent to achromat I) for radiation shielding to provide the access to the FEL area from outside of the building through the east door.
- **Another appropriate lead shielding** is to be provided to stop the radiation from the HCI beam **line through the door opening to the stairs going down to the Klystron area of FEL**.
- **Near the glass door separating the corridor (going towards the MRI room) from the ECR ion source, a lead shielding** is to be installed to ensure a radiation free passage from FEL to MRI area.
- For HCI personnel, during normal and emergency situation, both the doors from HCI to MRI and the HCI to Data Room should be opened from HCI side and should be compatible with radiation safety.

3.1.8 DATA SUPPORT LAB (NIAS-DAQ GROUP)

Mamta Jain, Kusum Rani, Subramaniam E. T

3.1.8.1 Introduction

Nxt-gen Instrumentation & Acquisition Systems group at IUAC maintains all the Nuclear Physics DAQ setups at IUAC with 100% uptime. At the same time the group develops various modules and their control and analysis software indigenously, to fulfill the present and future needs of data acquisition systems & control systems applications. A brief description of NIAS-DAQ group's contribution for this year is listed below.

3.1.8.2 NiasMARS Upgradations

Subramaniam E. T., Mamta Jain

The server (marsServ), the client (MARS) and the library (libniasvme.so) were completly revamped to maintain the uniformity for the currently running versions of the VME controllers ROSE-I (USB2.0 based) and ROSE-II (USB3.0 based), as ROSE-I and ROSE-II both will be in use until the completion of mass production of the ROSE-II. Apart from this, few new features have been incorporated as per the specific physics requirements of the different data acquisition systems.

- Display modified 1D split window upto 4 spectrum in the main 1D window.
- Implementation of independent strobe option for HIRA/HYRA DAQ setups.
- Integration of 12 bit VME QDC configuration in NiasMARS for NAND/GPSC facilities.
- Coincidence check option added for NAND application.
- Saving and loading of calibration constants for INGA to check the variations or gain drifts in spectra over the long period of the experiments.

3.1.8.3 ROSE-II, the VME controller development

Mamta Jain, Subramaniam E. T.

The first proto type of ROSE-II with USB3.0 daughter card was tested in INGA beam line and later the final version of ROSE-II PCB with inbuilt USB3.0 capability was designed and tested thoroughly for reliability, performance, and stability. The serial bus communication link performance tested for super speed standards, which works at clock

cycle of 200ps (5Gbps) where nominal jitter expected is less than 20ps in 8b/10b encoding mode.

a. ROSE-II @DAQ (DATA Acquisition)

Five ROSE-II modules were delivered to different beam lines and laboratories (HYRA, HIRA, At-Phy, NAND and LabDAS-2) after doing step by step testing for full functionality.

- The Rate test of ROSE-II for accepted events with different multiplicity using VME-GEM was done during the facility run in INGA.
- The ROSE firmware was changed for ADC strobe width as per DAQ requirements.
- ROSE-II firmware was changed to add the scalar functionality.

b. ROSE-II @CTRL (Control system)

Two ROSE-II VME controllers has been tested and given to Remote Control Group for deployment. Following tasks were performed for ROSE-II in control system application

- Implementation of VME16bit / VME8bit read / write operations.
- Written convenience routines for control systems requirements.
- Written a header file along with built-in library for control system.
- Ubuntu 20.04 based local boot setup for control system.
- Alpha testing in the lab using control system ADC and DAC (12K VME cycles per sec)

3.1.8.4 NiasWeb-Viewer

Subramaniam. E. T. , Mamta Jain

Web based online monitoring system for the data acquisition systems was envisaged, designed, developed and deployed. The web server establishes a link to the data acquisition system client and collects the 'ROOT' format data. The information is decoded using 'ROOT' s JSON and the list of configured spectra are populated to a combo box. The HTML, JS, DOM combination is used to display the user selected spectrum. With the present COVID scenario, the new normal, the users will be able to login to the system and see the experimental progress from their respective premises. The parameters and / or the spectrum visible can be chosen remotely, enabling one to study the required spectrum.

3.1.8.5 NiasOS-64 Upgradations.

Subramaniam E. T, Mamta Jain, Kusum Rani

NiasOS-64 was modified

- To adapt the new requirements by the marsServer, BPM server and RoseServer.
- For booting multiple systems with the same kernel image by modifying grub64.conf.
- To solve USB detection problem due to hibernation and / or sleep mode, the boot time script of 64 bit NiasOS was modified. Kernel tweaking was also done to disable CPU throttling (adjusting the clock speed of the CPU)

3.1.8.6 VME-GEM (Global Event identifier Module)

Kusum Rani, Subramaniam E. T.

The first prototype of VME GEM was tested with Eu152 source in INGA beam line last year. The final version of VME-GEM with few modifications was tested for reliability, stability and performance and then used in INGA on beam experiments. Three more modules are fabricated and tested for full functioning to serve the need of the DAQ setup at IUAC.

3.1.8.7 BPM Digitizer

Kusum Rani, Subramaniam E. T.

After testing of the first prototype single channel portable Beam Profile Digitizer module with USB 3.1 back plane, the final version of single channel BPM Digitizer has been developed and tested in lab. One BPM Digitizer has been deployed in HCI deck area and used continuously.

3.1.8.8 BPM Digitizer Viewer and Control Software

Subramaniam E. T. , Kusum Rani

Control software (server) has been developed to communicate with newly developed single channel BPM digitizer with USB 3.1 back plane, as ISA bus is becoming obsolete. The BPM viewer (the client) has been rewritten accordingly. An all in one PC, kept in control room for BPM viewer has been installed with Ubuntu 20.04 along with newly developed BPM viewer and control software.

3.1.8.9 Cable Adapter

Kusum Rani, Subramaniam E. T.

A PCB for LEMO to FRC adapter module has been designed and fabricated to fulfill the requirements of VME based data acquisition setup in various beam lines, as most of the old amplifiers gives output in LEMO connectors but the new ADCs needs input in a FRC form. Front panel for this module had been designed and fabricated, then two module were deployed in INGA.

3.1.8.10 ASPIRE and MAPS

Subramaniam E. T., Kusum Rani, Mamta Jain

During one of the experiments it was found that the ASPIRE system (Automated Sample Positioning and Irradiation system for Radiation biology Experiments) was not responding as per the requirements. After a lots of trials we found one of the opto-couplers was malfunctioning so it was replaced and tested thoroughly. And there was a response issue in the Farady cup so the delay in the software was changed. Noise related Issues were also addressed so grounding was redone.

3.1.8.11 ROOT based Analysis Support

Subramaniam E. T., Mamta Jain

To help the faculties/students for their analysis using ROOT based data, ROOT macros were written as per specific physics requirements during the experiment or the facility run. ROOT classes were taken almost for a month to teach the basics of ROOT based programming techniques for the benefit of young researchers.

ROOT macros

1. Calibrate.cpp **2.** CheckMatrix.cpp **3.** CoincTest.cpp

ROOT procedures

- Mars Analyze. C
- Mars Matrix. C
- Mars Transitions. C
- Mars Auto Calibrate. C
- Mars Re Calibrate. C
- Mars Combined Efficiency. C
- Mars Nand Plot. C
- Mars Hira Tuning. C

3.1.8.12 School on Data Acquisition Systems (DAS) and ROOT based Data Analysis

Mamta Jain, Kusum Rani, Subramaniam E. T, R. P. Singh, S. Muralithar

Two schools were organized in hybrid mode (online and offline both) to make the users and young researchers fully conversant with the newly installed ROSE-MARS based VME data acquisition systems at IUAC. During the DAS school, participants were introduced with the fundamental and key features of DAQ systems. In present scenario the data collection happens in ROOT format using MARS software to support international standards. During the ROOT based Analysis school numerous classes were taken by the experts of nuclear physics, atomic physics and data acquisition to provide extensive details about ROOT structure and the required insights of analysis & programming techniques.

3.1.8.13 MARS-ROSE-GEM based VME DAQ @ INGA

Mamta Jain, Kusum Rani, Subramaniam E. T.

Installation, Testing and Commissioning of ROSE – GEM based DAQ involves multiple type of test runs and settings to achieve optimum data with available options.

- Tested TIFR MADC for its full functionality in the lab, and then put in INGA.
- Checked the calibration of the VME setup as compared to earlier CAMAC based DAQ system Co60 source run has been taken. Later Eu152 was placed to create real experiment type situation.
- The "FSR" range of the CAEN TDC was changed from 400 ns to 560 ns as the max delay of ACoinc and Tdc_In of clover amplifier module was found more than 500ns.
- Revamping of VME based DAQ setup @ INGA with 16 clover detectors.
- Successful INGA facility run taken with ROSE based VME data acquisition setup.

3.1.8.14 Level Translator

Mamta Jain, Subramaniam E. T.

Designed and developed a 16 channel NIM to ECL level translator module for ECL input based CAEN TDC and VME-GEM modules in the newly installed VME based DAQs @IUAC. One module has been assembled, tested and used in HIRA during first experiment with ROSE based VME DAQ setup.

3.1.8.15 MARS-ROSE based VME-DAQ@ NAND

Subramaniam E. T., Mamta Jain

Before this year's NAND run some problems of missing coincidence was reported in ROSE-I-based NAND DAQ which has been already used in last NAND run successfully.

- During the testing a ROOT based macro was written to check the coincidence in offline mode
- The NiasMARS modified to check the coincidence condition between two particular signals using NAND debug conditions during online mode.
- ROSE firmware was cross checked and rewritten to cross check possibility of missing coincidence due to firmware.
- After a thorough testing one of the ADC was changed.

Recently final version of VME Controller ROSE-II has been installed and tested along with the latest version of NiasMARS-1.5 in newly installed DAQ PC.

The CAEN 12 bit QDC has been implemented in present DAQ and tested first with pulser and then with source 137Cs and BC501A liquid scintillator detector.

3.1.8.16 MARS-ROSE based VME-DAQ @ ATPHY

Mamta Jain, Subramaniam E. T.

Installation, Testing and Commissioning of ROSE based DAQ in atomic physics beam line has been done. it involves

- Testing of all the CAEN VME modules like V785 ADCs, V775 TDCs and the CEN VME crates with pulser.
- Source run before in beam experiment.
- A facility test run was taken to test the recently purchased electrostatic analyzer along with the recently deployed ROSE based VME DAQ.

3.1.8.17 MARS-ROSE based VME-DAQ @ HIRA

Mamta Jain, Subramaniam E. T.

To test the VME-DAQ @ HIRA a facility run was taken after the functionality test using alpha source(241 Am). During the facility run few steps were taken to make the DAQ fully functional for the upcoming experiment

- ROOT subroutines was written to cater the need of beam tuning during online experiment using a offline data manipulation ROOT macro which shows results very fast.