VECC NEWSLETTER

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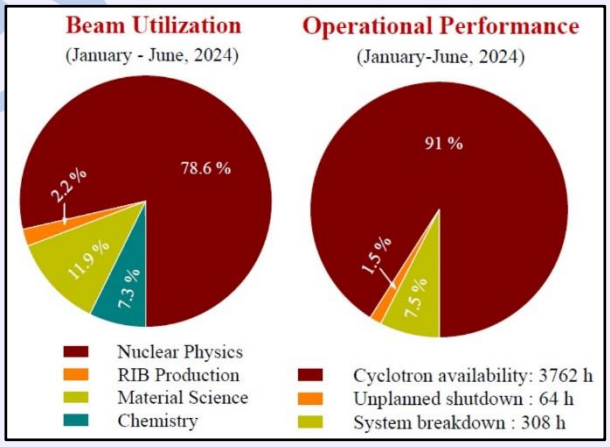
ACCELERATOR

OPERATIONAL ACTIVITIES OF K130 ROOM TEMPERATURE CYCLOTRON

The K130 variable energy cyclotron has been operating on a round the clock shift basis and has been delivering stable accelerated light ions beams like alpha, proton, deuteron and heavy ion beam like O6+ for nuclear physics, radiation damage, material sciences, isotope production and other experimental research programs throughout the year. Light ion beams (proton, deuteron and alpha) have been extensively used by the users during this period. During March, 2024 heavy ion beam (O6+) was produced, using external ECR ion source, for nuclear physics experiment. Experiment with 15 MeV deuteron beam in channel#1 and 3 has been performed. The beam current for deuteron beam at the target was 400 nA and 0.2 nA in channel#1 and 3 respectively as per the user requirement. In the period "January to June, 2024", apart from round the operation, maintenance and upgradation work has been carried out to improve the performance of the cyclotron. A water detection system comprising of around ten numbers of low cost water detectors has been developed and installed in RTC vault for detection of LCW leakage in beam line components (magnets). It generates alarm signal and local LED indication after either of the detectors comes in contact with water and subsequently helps to identify the area of water leakage. In this period, K130 cyclotron has delivered alpha beam with current 150 pA to 3 nA in channel#3 and 150 - 800 nA in channel#1 for performing experiment in nuclear physics and material science. Proton beam of following energies (see table) @ 2 – 3.5 µA in channel#1 have also been delivered.

Projectile	Beam Energy (MeV)
Alpha	28-46
Proton	7-10
Deuteron	15
Oxygen 6^{+}	125-142

The facility has been utilized by the experimentalists of VECC, SINP, VECC/HPU, RCD/BARC, University of Allahabad, IIEST-Shibpur, IIT Bombay, IIT-BHU, CSIR, AMPRI, Pedong General Govt. degree college etc. The beam utilization chart for doing experiments (2467 hrs beam on target) of K130 cyclotron and its overall performance during this period are shown below.



For further details please contact Dr. Animesh Goswami (animesh@vecc.gov.in), Head, Cyclotron Operation Section/ APG.

K500 SUPERCONDUCTING CYCLOTRON (SCC)

The K500 Superconducting Cyclotron (SCC) at VECC is in regular operation and provides much higher energy ion beams compared to other operating accelerators in our country. It is designed to deliver light ion beams of maximum energy 160*(Q/A) MeV/u and heavy ion beams of maximum energy 500*(Q/A)2 MeV/u. The cyclotron has been operational for the last few years, and currently, several ion beams (as listed in Table-1) are routinely provided to the users. Furthermore, recently the machine delivered Nitrogen beam (30 MeV/u) to the user, marking the highest energy beam to date in India. The beam current delivered to user for most of the ion species varies from 5-10 enA. However, there is scope to increase the beam current to the target as needed by the user.

The machine presently delivers extracted beam to the experimental hall through Zero degree beam line dedicated for charged particle detector array. Users are engaged in carrying out experiment with a large scattering chamber facility. Some of the experiments recently carried out are as follows: (i) Study of isoscaling property of emitted fragments in reaction with different isotopes of tin nuclei (ii) Study of fragment emission mechanism in ^{70,71}As at the intermediate energies (iii) Heavy ion irradiation of CR-39 samples (from ISRO) for dose mapping with 362 MeV Oxygen beam etc.

Table 1: List of beams

Ion	RF Frequency (MHz)	Energy (MeV/u)	Total Energy (MeV)	Magnetic Field Bo (kG)
N^{4+}	14.00	18.0	252	31.91
N^{4+}	14.46	19.2	269	32.96
Ne^{6+}	14.00	18.0	360	30.37
Ne^{6+}	14.37	18.9	379	31.18
Ne^{6+}	14.70	19.8	397	31.89
Ne^{6+}	15.06	20.8	416	32.67
O^{5+}	15.20	21.3	341	31.67
N^{5+}	17.90	29.3	411	32.60
O^{5+}	15.72	22.8	362	32.74

OPERATIONAL ACTIVITIES OF MEDICAL CYCLOTRON FACILITY AT CHAKGARIA

The Medical Cyclotron-30 (MC-30) is a sophisticated facility designed for generating proton beams with a range of energies suitable for diverse applications in medical and material research. The MC-30 operates with a fixed magnetic field strength of 0.9 T and a fixed RF frequency of 65.5 MHz, which is essential for accelerating the negative hydrogen ions (H^-) in the cyclotron. It features two RF cavities, known as Dees, which are responsible for accelerating the negative hydrogen ions. The MC-30 is operational between 6:15 a.m. to 7:00 p.m., Monday through Friday. It has a high uptime, and is consistently providing proton beams without major interruptions. This facility has 5 beam lines among which one is specifically dedicated to the production of 18F-FDG, a short-lived PET radioisotope, essential in the diagnosis and monitoring of cancer due to its high sensitivity and imaging capabilities. Two of the beam lines are used for the production of SPECT radioisotopes. Among the other two research beam lines, one is dedicated to the study of radiation damage in nuclear structural materials. This research is vital for understanding how materials behave under radiation, which is crucial for various applications in nuclear technology and materials science. The other research beam line focuses on window studies for Lead-Bismuth target assemblies. This is important for optimizing the performance and safety of target assemblies used in various experimental setups.

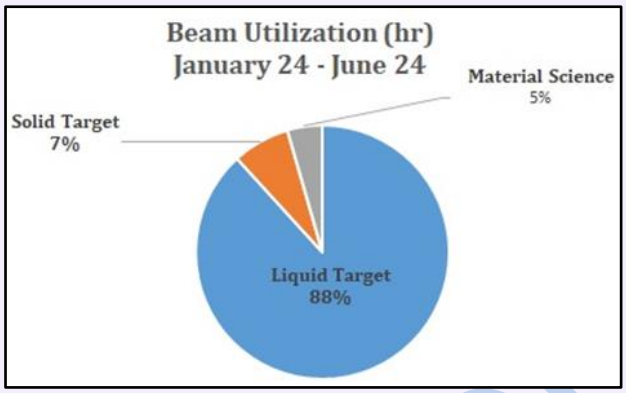
Period: January 01, 2024 to June 30, 2024

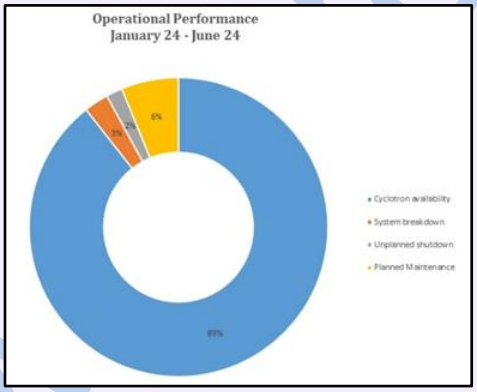
The Medical Cyclotron-30 (MC-30) has demonstrated a reliable performance record in producing the PET radioisotope 18F-FDG. The cyclotron regularly delivers an 18 MeV proton beam

for ~90 minutes each morning with beam current ranging from 33-35 μA for the production of 18F-FDG. During the above mentioned period, the cyclotron has been used for 101 days specifically for the production of 18F-FDG with a total production amounting to ~157 Ci of 18F-FDG. The total B.O.T. time was ~145 hours with cumulative integrated current of ~ 4763 μA-h. Production of 18F-FDG was suspended for 3 days during the period for vacuum problem in the liquid target cell side and 9 days due to the non-availability of chemicals from the user side.

MC-30 has also delivered 28 MeV proton beam for one whole day at the solid target line for production of 68Ge radiopharmaceuticals. The B.O.T time was ~ 4 hr with integrated current ~395.1 μAh.

MC-30 also delivered 16.0 MeV proton beam in the 4th beam line for the irradiation studies on Ni-alloy. The beam line was operational for 8 days with B.O.T time ~30 hr, and having integrated current ~241.6 μA-h

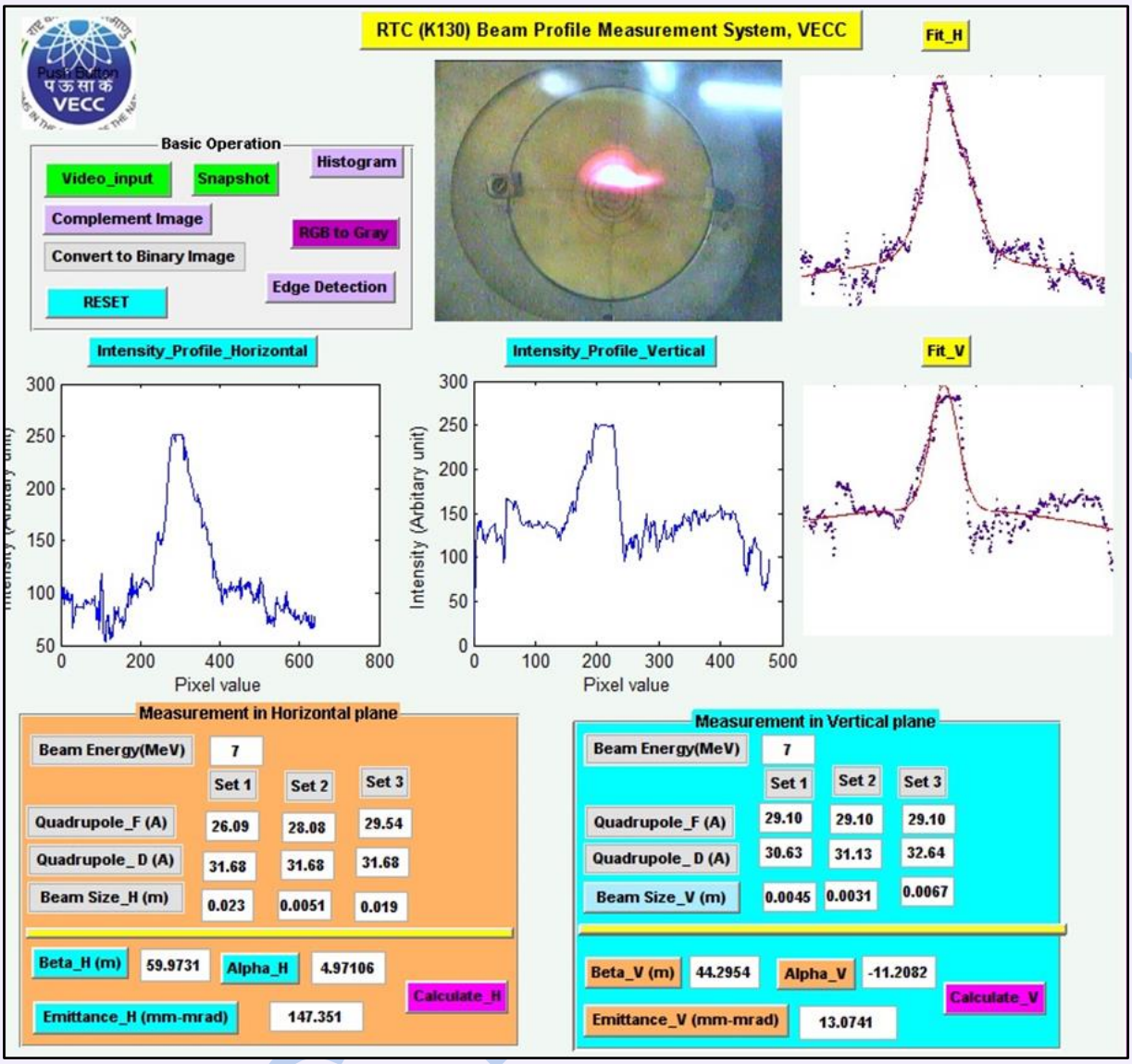




For further details please contact Shri. Aditya Mandal (aditya@vecc.gov.in), Head, Medical Cyclotron Facility Section/ATG.

MEASUREMENT OF BEAM EMITTANCE AT K130 ROOM TEMPERATURE CYCLOTRON

The K130 room temperature cyclotron at VECC has been operating in round the clock mode and delivering light and heavy ion beams for carrying out various experiments. We have measured the beam emittance of 7 MeV proton at transport line of K-130 cyclotron at VECC, Kolkata using quadrupole scan method where quadrupole strengths are varied to get beam waist at beam viewer BV11 of channel-I beamline. A MATLAB based image processing graphical user interface (GUI) has been developed indigenously for measurement of beam size, transverse emittance and twiss parameters. Transfer matrix from switching magnet exit point to BV11 is calculated by measuring the quadrupole field gradient for different current settings of quadrupole. We have measured horizontal beam emittance of 147.35 mm-mrad, and vertical beam emittance of 13.07 mm-mrad for 7 MeV proton. These measurements will be used for proper optimization of the parameters of the beam line elements in order to avoid beam loss during transportation in the extraction line up to the target station. Presently we have measured beam size at BV11which is nearly 12m away from cyclotron exit point.



For further details, please contact Debasis Sinhamahapatra (debasis.sm@vecc.gov.in), Cyclotron Operation Section, APG

PHYSICS

FIRST OBSERVATION OF SHAPE-COEXISTENCE IN ^{115}Sb

A prolate-oblate shape-coexistence, has been observed for the first time in the nucleus ^{115}Sb, (which has 51 protons and 64 neutrons), using Alpha beam from K-130 cyclotron and Indian National Gamma Array (INGA) at VECC, Kolkata.

One of the noteworthy observations in the context of nuclear deformation is the dominance of prolate shapes over its oblate variety. In nature, oblate shapes are observed more frequently as compared to prolate shapes under rotational motion. For instance, the shape of the rotating planets, including Earth, Saturn, Jupiter and other celestial bodies like quickly spinning star Altair are found in an oblate ellipsoidal shape. The contradictory tendency of prolate dominance in nuclear shapes demands more experimental as well as theoretical investigations. This motivated to search for the shape coexistence in near spherical Antimony isotopes.

The excited states in ^{115}Sb were populated by bombarding α particles on Indium target. The gamma rays decaying from these excited states of ^{115}Sb were identified by the state-of-art Compton suppressed Clover detectors of INGA setup at VECC, Kolkata.

From this investigation, apart from the strongly populated prolate deformed band generated from a proton hole in $g_{9/2}$ proton orbital, a weakly populated oblate deformed band based on the similar quasi-particle configuration has also been identified. Earlier such observation of both prolate and oblate deformed bands was reported in a few Iodine and Cesium isotopes, but, in all of those cases the concern bands are associated with the quasi-proton configuration based on $h_{11/2}$ proton orbital. This work opens up a new avenue of research in weakly deformed nuclei in the vicinity of a shell closure. This research is published in Phys. Lett. B 851 (2024) 138565.

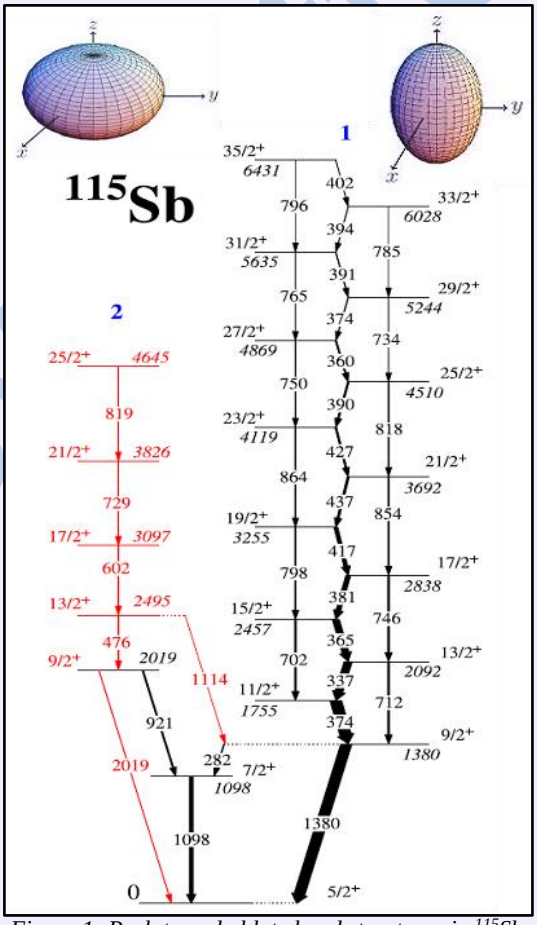


Figure 1: Prolate and oblate band structures in ^{115}Sb

For further details, please contact Dr. Sarmishtha Bhattacharyya (sarmi@vecc.gov.in), Head, Nuclear Structure Section / Experimental Nuclear Physics Division / Physics Group

CHEMISTRY

MEASUREMENT OF ALPHA INDUCED REACTION CROSS-SECTIONS ON ^{nat}Ag WITH DETAILED COVARIANCE ANALYSIS

In this study, natural silver (^{nat}Ag) was employed as the target material. Natural silver is highly versatile and finds various applications, including its use in dental alloys and in the production of silver paste for solar panel manufacturing. Upon interaction with natural silver (^{nat}Ag), alpha particles can induce the formation of several notable radioisotopes, including ^{111}In, ^{105}Ag, and ^{106m}Ag. Single Photon Emission Computed Tomography (SPECT) commonly utilizes ^{111}In, a radioisotope with a half-life of 2.8 days.

The cross sections were calculated over the alpha energy range of 23-40 MeV for the alpha particle induced reactions ^{nat}Ag(α,x)^{111}In, ^{nat}Ag(α,x)^{105}Ag, and ^{nat}Ag(α,x)^{106m}Ag. Activation method was used after offline γ-ray spectrometry to achieve these measurements. The monitor reaction ^{nat}Cu(α,x)^{67}Ga was taken into consideration while calculating the reaction cross sections for the aforementioned nuclear reactions. Both the theoretical predictions generated using the TALYS nuclear code and the experimental results for the reactions ^{nat}Ag(α,x)^{111}In, ^{nat}Ag(α,x)^{105}Ag obtained in this study are consistent with the experimental data available in the EXFOR library. We also infer from this work that ldmodel-6 for nuclear reaction ^{nat}Ag(α,x)^{111}In, ldmodel-2 for ^{nat}Ag(α,x)^{105}Ag, and ldmodel-1 for ^{nat}Ag(α,x)^{106}mAg nuclear reaction yield the most correct theoretical findings. Moreover, correlation matrices and covariance analysis were used to compute the uncertainties in the measured experimental data. This gives us useful information for more general scientific applications, such nuclear physics and materials research, and aids in improving the accuracy of our measurements.

Table 1: Some characteristics of the radionuclides produced by the ^{nat}Ag(α,x) reaction

Radionuclide	Half-life ($t_{1/2}$)	Decay mode (%)	E_γ (keV)	I_γ (%)
^{111}In	2.8047 ± 0.0004 d	*ec* (100)	171.28	90.7 ± 0.9
^{105}Ag	41.29 ± 0.07 d	*ec* (100)	280.54	31.0 ± 3.0
^{106m}Ag	8.28 ± 0.02 d	*ec* (100)	511.85	88.0 ± 3.0

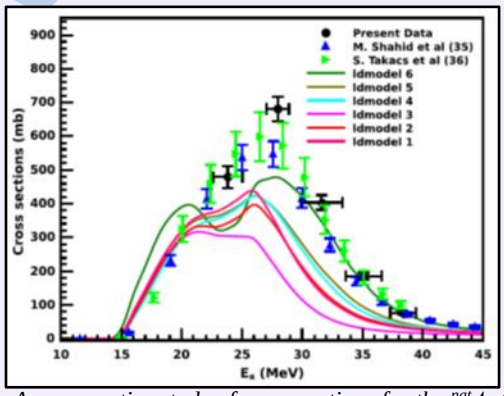


Figure 1: A comparative study of cross sections for the ^{nat}Ag(α,x)^{111}In reaction measured experimentally in contrast with previous experimental data from EXFOR and theoretical predictions.

For further details, please contact Dr. J. Datta (jdatta@vecc.gov.in), ACD, BARC, VECC

TECHNOLOGY DEVELOPMENT

DETECTING NEUTRONS USING GEM DETECTOR

A Gas Electron Multiplier (GEM) based detector prototype was built for neutron detection using Cf-252 source, at VECC. The drift cathode of the detector was coated with 90% enriched B10 powder, which was procured from Heavy Water Board (HWB), Mumbai. The B10 coating was carried out at VECC using doctor blade coating technique. The 10cm × 10cm triple GEM detector consisted of a 3cm × 3cm borated cathode region and a non-borated cathode also of the same area, beside it. The source was placed at a distance of about 15 cms from the detector with a High Density Polyethylene (HDPE) block of 10 cm thickness placed in between, for moderating the source neutrons. Signal was collected via 2D pad readout which was coupled to a self-triggered CBM-MuCh/XYTER electronics. AFCK based CBM DAQ was used for the free streaming data acquisition, where hits were recorded in a Time Slice (TS) of 10 ms. At appropriate voltage settings, a clear difference compared to non-borated case, was observed in the pulse height spectra (ADC spectra). The cumulative 2D hits spectra, shows good counts in borated region (bottom right quadrant) while it is insignificant in the non-borated cathode region (bottom left quadrant). The number of digits or pads hit per TS is much higher for the borated case as compared to that for non-borated cathode region. Further studies towards estimation of efficiency is under progress. This is first such attempt in the country towards exploring application of GEM detectors for neutron detection.

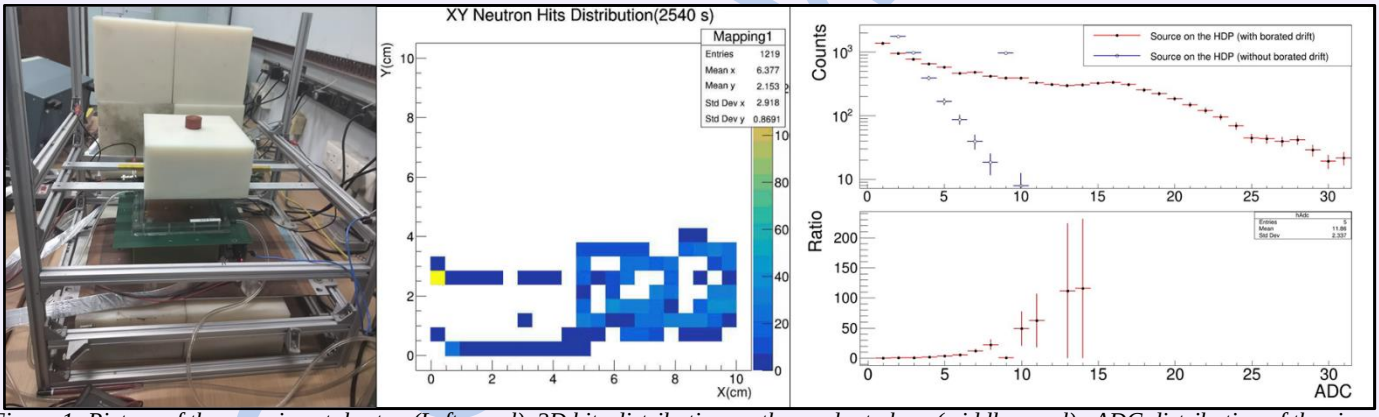


Figure 1: Picture of the experimental setup (Left panel). 2D hits distribution on the readout plane (middle panel). ADC distribution of the signal for both Borated and non-Borated cases (right panel).

For further details, please contact Dr. Anand Kumar Dubey (anand@vecc.gov.in), EHEP&A Group.

IN-HOUSE DEVELOPMENT OF SECURITY INFORMATION & EVENT MANAGEMENT (SIEM) SOLUTION FOR REAL-TIME NETWORK SECURITY MONITORING

In response to the evolving cybersecurity landscape, a Security Information and Event Management (SIEM) solution has been developed utilizing Graylog, Wazuh, Grafana, MISP and vetting IP reputation with different tools. This integrated solution enables real-time monitoring and analysis of logs from various network components such as firewalls located at different location including MCP as well as Rajarhat, mail exchangers, application servers, VPN server, DHCP server, NAC server, switches and routers as well as PCAP through network tapping at different important network points.

Figure 1 SIEM Dashboard for Internal Firewall (all IPs and Policies are masked due to security reasons)

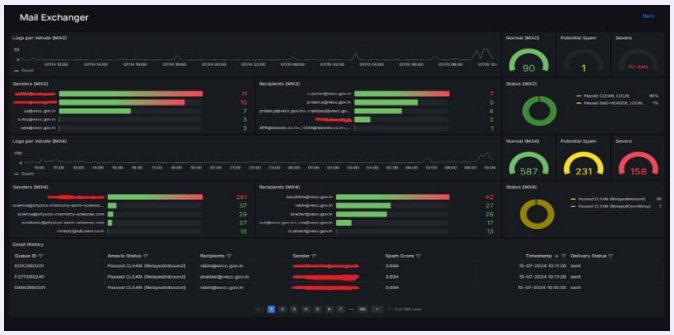


Figure 2: SIEM Dashboard for Mail Exchangers (GUI simply immune from cumbersome raw log views)

Graylog serves as the central hub for log aggregation and analysis, configured to efficiently parse and pipeline for incoming logs. Wazuh complements Graylog by providing scalable log storage and indexing capabilities to our SIEMsolution. The integration with Graylog enables centralized log management across our entire IT environment, facilitating correlation and in-depth analysis of logs to uncover hidden threats and anomalies. Additionally, MISP enhances our threat intelligence capabilities by integrating real-time feeds, enabling proactive detection and response to potential security threats. This setup provides intuitive visualizations of security analytics, offering comprehensive insights into our network's security posture within a unified interface.

We aim to evolve our SIEM into a Security Orchestration, Automation, and Response (SOAR) framework, empowering the envisioned VECC Security Operations Centre (SOC).

Figure 3: SIEM Dashboard for NAC and NMS data source presentation (Few details are masked due to security reasons)

For further details, please contact Shri Subhasish Pahari (s.pahari@vecc.gov.in), General Computing & Networking Infrastructure Section/CD/C&IG

FACILITIES

TRANSFORMER AND MAGNET COIL WINDING FACILITY REPORT

The PE&MCD Section, ATG has played a significant role in facilitating the production of transformers, inductors and magnet coils for various sections of the Centre over the years. These include design, development as well as in providing assistance to winding of various coils for diverse applications. The facility developed several types of coil systems during the years and is still being utilized for the purpose in DC, power line frequency and high frequency applications.

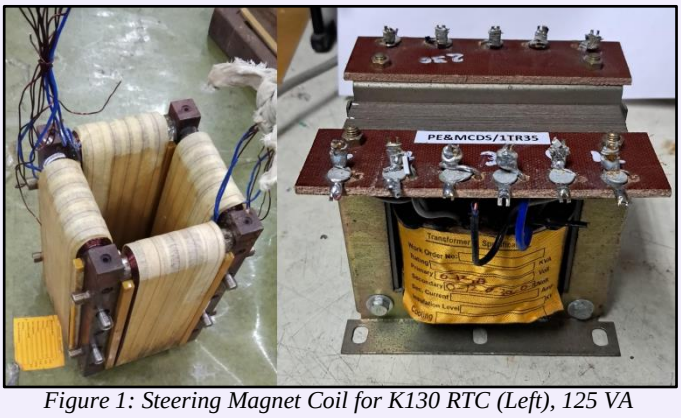


Figure 1: Steering Magnet Coil for K130 RTC (Left), 125 VA Transformer for BRIT (Right).

Figure 2: Set of 8 ferrite core inductors for Power Supply applications

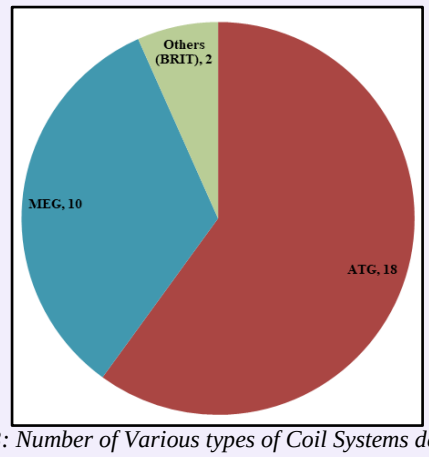


Figure 3: Number of Various types of Coil Systems developed for Groups and Units

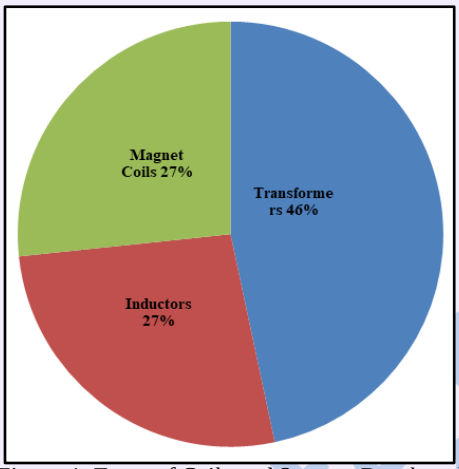


Figure 4: Types of Coils and Systems Developed

The winding facility has been put to use specifically during January to June 2024 for producing 14 nos. of 1-ϕ transformers, 8 inductors and 8 coils for magnets. The charts in Figure 3 & 4 highlight the products developed according to the requirements of different groups and unit for the respective systems.

For further details, please contact Dr Anirban De (ade@vecc.gov.in), PE&MCDS/ATG

EVENTS

National Fire Safety Week Observation-2024

Variable Energy Cyclotron Centre (VECC) observed Fire Safety week celebration programme from April 14 – 20, 2024. This year's theme was "Fire safety in Radiation Facilities".

Inaugural session of National Fire Safety Week Observation 2024

To enhance fire safety awareness and foster a culture of fire safety among VECC employees, a range of activities were organised, including a fire safety quiz, slogan and poster competitions, an essay contest, and a debate on the topic *"Proactive Fire Safety vs. Reactive Fire Safety"* Employees of VECC, contractors' employees, and the families of VECC employees who are involved with VECC participated in the events.

Fire Safety Training Programme at VECC -2024

Training on fire safety was provided to departmental officers, supervisors, technicians, and VECC contractors' workers at the centre. Additionally, family members residing at Anushakti Abasan received fire safety training, with a focus to

continuously improve fire safety culture of this centre.

Fire Safety Training Programme at MCF - 2024

The inaugural session began with Director's address to VECC employees for Fire safety awareness, requested every employee to continue to raise the issues for Fire Safety lapses, Fire safety improvement and suggestions etc.

Meeting on Physics of ALICE, CBM and STAR (MPACS)

A two day meeting titled *"Meeting on Physics of ALICE, CBM and STAR (MPACS)"* was held on January 29-30, 2024 to discuss on the unprecedented developments in the field of Quark Gluon Plasma

(QGP) in last three decades.

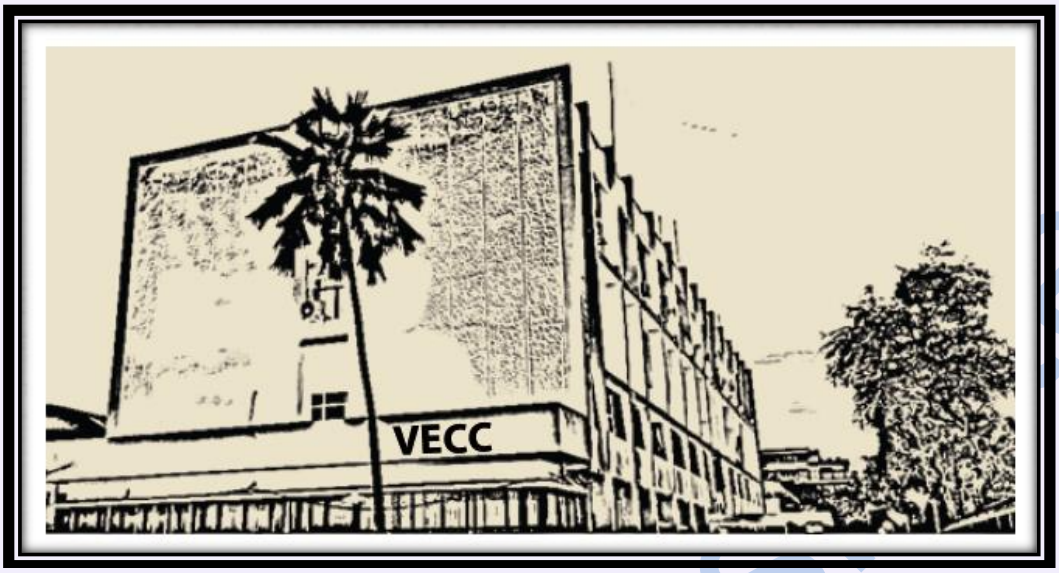
The meeting was inaugurated by Director VECC, Dr. Sumit Som. Prof. Paolo Guebellino, the scientific director of FAIR, Darmstadt, Germany presented a talk titled *"FAIR and India, a success story"*. A large number of participants that included students, young researchers, collaborators, and experts from within the country and abroad from both theoretical and experimental fronts presented their results on the present status and future developments and perspectives in the field of heavy ion physics.

AWARDS & HONOURS

CBM Best Thesis Award 2022/2023

Dr. Vikas Singhal of EHEP&AG has been selected as one of the winners of the CBM Best Thesis Award for the year 2022 and 2023 for his PhD Thesis entitled "Development and implementation of first level event selection process on heterogeneous systems for high energy heavy ion collision experiments", under aegis of the HBNI, India. His contribution on the development of a realistic time-based simulation framework for the Muon Chamber System (MuCh) of the CBM experiment is significant for the development of a trigger algorithm for MuCh and the evaluation of its performance in various heterogeneous computing platforms including CPU, GPU and hybrid platform. He is the first Indian student to receive the CBM best thesis award.

The award ceremony took place during 43rd CBM Collaboration Meeting, March 4-8, 2024 at GSI Darmstadt, Germany and Dr. Singhal received the award at Alice Centre, VECC from Dr. Arup Bandyopadhyay, Head EHEP&AG, VECC during online session of the CBM Thesis Award 2022/23.



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