VECC NEWSLETTER

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ACCELERATOR

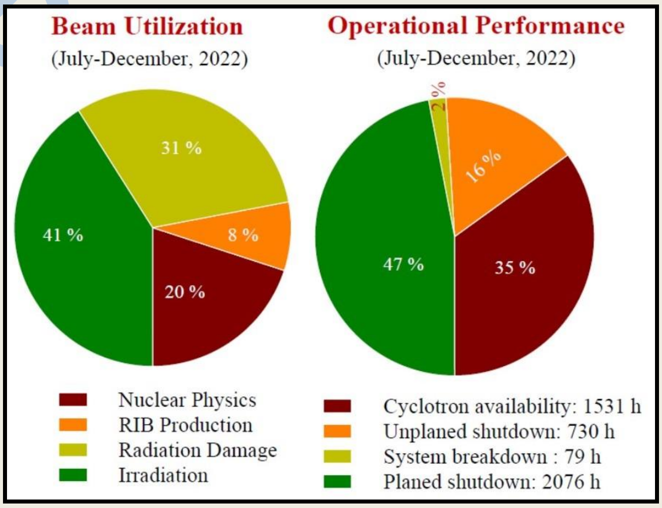
Operational Activities of K130 Room Temperature Cyclotron

The K130 room temperature cyclotron has been operating round the clock and delivering ion beams for various research programs during the period "July - December, 2022". In this period light ion beams have been used for the production of isotopes, radiation damage study, material science, nuclear physics and radioactive ion beam (RIB) experiments etc. The light ions like alpha and proton are produced from the internal PIG ion source. Cyclotron operation was suspended in the months of August to October due to planned shutdown. During this period six movable RF panels and eight gear box assemblies has been replaced to minimize the frequent LCW leak and air leak in the RF resonator. One diffusion pump and its Freon unit are connected to an UPS system to run the cyclotron main vacuum during small power fluctuations. Few faulty magnet flow swathes have been replaced and LCW cooling tower maintenance has been carried out. To avoid the load of thick filament cable on the PIG ion source shaft, it is now terminated near the shaft and connected with a short flexible cable. Apart from this, cyclotron operation was also interrupted due to problems in magnet power supplies, power dips and trips, diagnostics probe work, beam line alignment, electrical shutdown, cave shield door movement problem, electrical change over, safety interlock checking etc.

During the above mentioned period, K130 cyclotron has delivered alpha beam of the following beam energies (see table) @ 1.0 nA to 3 nA in channel# 3 and 125 nA -650 nA in channel#1 as per user requirement. Proton beam of following energies @ 150 nA – 3.5 μA in channel#1 have been delivered. Proton beam with energy 11 MeV and alpha beam with energy 28 MeV have also been transported in channel#4 with current in the range 2.5 μA and 300 nA respectively for performing RIB experiment.

Projectile	Beam Energy (MeV)
Alpha	26, 28, 29, 30, 32, 33, 34, 36, 38, 40, 42
Proton	7, 7.5, 10, 11, 12, 14

The facility has been utilized by the experimentalists of VECC, SINP, VECC/HPU, RCD/BARC, ACD/BARC, BHU-Varanasi and Viswa Bharati University-Santinekatan etc. The beam utilization chart for doing experiments (2504 hrs) 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.

Fabrication Of Resin Casted Steering Magnet Coils For K-500 Cyclotron Beamline In VECC

Steering Magnet consists of 4 resin casted coils to be assembled over 4 separate iron yokes as shown step by step in Fig1 to Fig 4. Each casted coil consists of a bunch of 7 nos. of double pancake coils made of hollow water cooled copper conductor of cross section 6 mm x 6 mm with a bore diameter (ID) of 3 mm. Each double pancake coils consists of total 18 turns in 2 layers.

Figure 1: 7 Pancake coils bunched together.

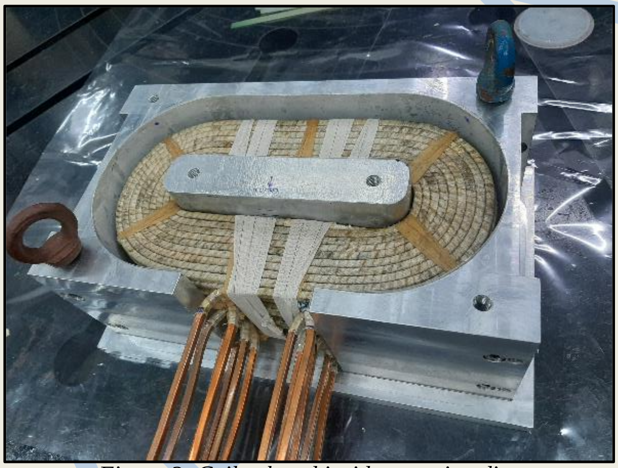


Figure 2: Coils placed inside a casting die.

Double pancake coil winding was done in the Coil Winding lab at VECC. The copper conductor was insulated by self-adhesive Fiber glass tape of insulation class “F”. After winding, the coils were dipped in Elmo luft air dry varnish to increase the turn to turn dielectric strength. Finally, a set of 7 double pancake coils were assembled and taped around to make a bunch and casted by Dr. Beck Resin Dobefil 60 & Hardner 758 for extra reinforcement to protect the coils from dust, moisture etc.

Figure 3: Coil casting is under process

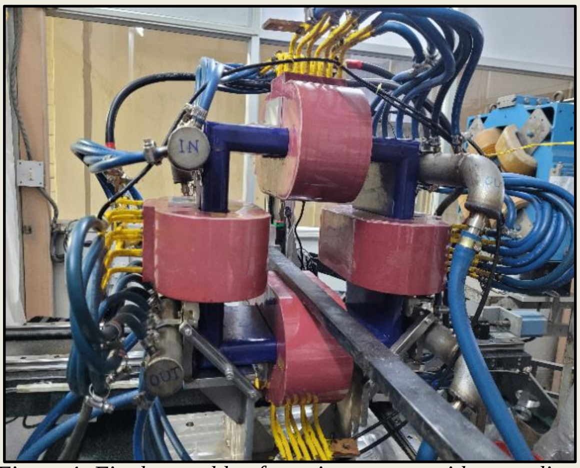


Figure 4: Final assembly of steering magnet with water line.

Status Report Medical Cyclotron Facility 30MeV at VECC Kolkata

A 30 MeV, 350 µA Medical cyclotron facility is a unique facility under the aegis of Department of Atomic Energy, India which facilitates production of various radioisotopes and basic research simultaneously.

The heart of this facility is a 30 MeV H-cyclotron called CYCLONE-30. This cyclotron is a fixed magnetic field, fixed RF frequency, variable energy and dual-beam cyclotron. There are two RF cavities, called dee, to accelerate the negative hydrogen ions. At the extraction radius, two carbon stripper foils are placed at diametrically opposite ports Three beamlines are dedicated for medical isotope production from liquid and solid targets and two beam lines for material science research and window study for Lead-Bismuth target assembly. There are nine hot cells in clean room area for production of the radioisotopes

During this period the machine availability was satisfactorily and it has delivered beam for irradiation of O^{18} to produce F^{18} and FDG (Fluorodeoxyglocose) produced by BRIT was delivered to various hospitals. Production was carried out everyday morning for 5 days a week without any major interruption. Two hotcells were used in automatic process for regular production FDG from medical cyclotron.

In addition to the regular production beams of different energies were developed and transferred to the target at beamline#1.1. Using this facility Ga^{68} was produced and supplied to local hospital by BRIT.

Beams of energies from 15.5 MeV to 30 MeV (up to 50 µA) were developed and transported to the end of beam line faraday cup in the low current and high current beamlines of the Materials Science Cave. In this period target facility for carrying out irradiation of solid targets in the low current beam line has been developed and tested at 16 MeV and 10 µA beam current. Beam is transported up to the target station and various interlocks have been integrated and tested. During the irradiation the required radiation data have also been recorded.

Estimation of Radioactive Inventory for The New Target Assembly in Materials Science Beam line at MCF, Kolkata

A new target assembly designed by VECC, Kolkata is being installed at 1.3 beam line at Medical Cyclotron Facility, Kolkata. Estimation of the radioactive inventory is mandatory as per regulatory guidelines of AERB. The identification and quantification of these radionuclides are required to safely handle the target materials after the irradiation is over. To meet this regulatory requirement, a comprehensive simulation study of proton induced activation products has been carried out using FLUKA, a Monte Carlo Code.

In the target assembly, different types of samples will be placed behind Aluminium degraders (degraders are metallic foils placed in front of the target by which incident beam energy is reduced and a desirable beam energy can be applied on the target) energy on the target. The thickness of the sample and the degrader has been chosen in such a way that the incident proton beam can be completely stopped in the sample. Five types of samples have been used for the irradiation study (Zircaloy, Ni, Nb alloy, V alloy and Ta). In this study, simulations have been carried out for two situations considering an irradiation by 16 MeV proton with an intensity of 10 μA for 330 hours:

Case 1: A degrader thickness of 1.23 mm and sample thickness 1 mm: induced activity produced in the degrader will be maximum.

Case 2: A sample thickness of 1 mm without any degrader: induced activity produced in the sample will be maximum.

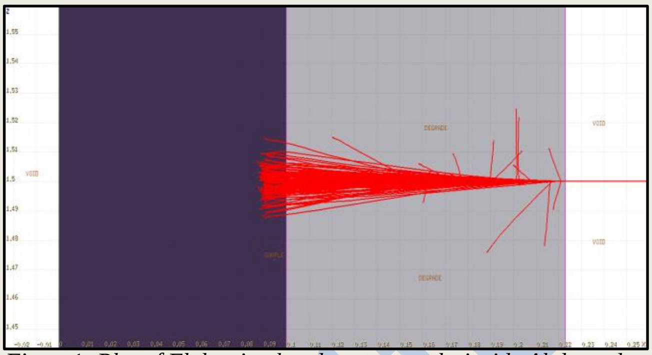


Figure1: Plot of Fluka simulated proton tracks inside Al degrader (1.23 mm) and Nb alloy sample (1 mm)

The FLUKA Monte Carlo code (latest CERN FLUKA code: FLUKA 4-2.2 and its graphical interface Flair) is used to model the irradiation geometry and to carry out activation study. In the present study, the sample and the degrader are attached to each other surrounded by a vacuum medium. A plot of FLUKA simulated proton tracks inside the Al degrader and Nb alloy sample has been shown in Fig. 1. The details of activity build up at the end of 330 hrs of proton irradiation and then the residual activity after 2.5 hours of cooling period in both cases are given in Table 1 and Table 2. For case 1, the activity is maximum for V alloy and main contributors to these activities are 51Cr (T1/2 = 27.70 d) and 48V (T1/2 =15.90 d). For case 2, the activity is maximum for Zircaloy and main contributors to these activities are 92mNb (T1/2 = 10.15 d) and 91mNb (T1/2 = 60.86 d). Hence, although the residual activity in mCi range after 2.5 hrs of cooling period, within few months, this activity will be reduced largely.

Table 1 Total activity (mCi) generated at the end of 330 hrs of proton irradiation with an intensity of 10 μA

Cases considered	Al degrader	Nb alloy	Zircaloy	Ni	Ta	V alloy
Degrader + sample	1E+03	1.24E+00	2.27E+00	1.60E+00	8.40E-01	1.14E+01
Sample without degrader	-	7.85E+02	2.82E+03	6.10E+02	1.22E+01	1.13E+03

Table 2; Total activity (mCi) after 2.5 hrs of cooling period

Cases considered	Al degrader	Nb alloy	Zircaloy	Ni	Ta	V alloy
Degrader + sample	3.94E-02	8.83E-01	4.52E-01	1.24E+00	1.67E-01	1.13E+01
Sample without degrader	-	5.88E+02	1.51E+03	9.07E+01	5.67E+00	1.07E+03

For further details, please contact Dr. R Ravishankar (rravi@vecc.gov.in), HPU, VECC, HPD, BARC.

BRIT, KOLKATA AND VECC JOINTLY PRODUCED GERMANIUM-68 FIRST TIME IN INDIA FOR ^{68}Ge/^{68}Ga GENERATOR PRODUCTION

Gallium-68 is an important positron emitting radionuclide with 68-minute physical half-life and decays by β^+ (89%) used in PET imaging for prostate cancer and neuroendocrine tumor. At present BRIT, Kolkata supplies ^{68}Ga radiopharmaceutical by direct production from enriched Zn-68 solid target using 30 MeV Medical Cyclotron to local hospitals. However due to a very short half-life of ^{68}Ga (68 min), the supply of cyclotron produced ^{68}Ga-radiopharmaceutical is limited in the Kolkata region only. Therefore, it is important to prepare Ge-68 ($t_{1/2}$ = 271 days) radiochemical for the manufacture of ^{68}Ge/^{68}Ga generator to cater to various nuclear medicine centers in India. This will also eliminate the import of exorbitantly expensive generator from abroad.

Figure 1: Irradiated Ga-Ni

BRIT, Kolkata and VECC have jointly produced Germanium-68 first time in India for ^{68}Ge/^{68}Ga generator from indigenously developed Ga-Ni alloy electroplated target using 30 MeV Medical Cyclotron. The target was preliminarily irradiated for 80 hours (4000 µAh) continuously with 28 MeV proton energy. The irradiated target was chemically processed after sufficient cooling, using indigenously developed automated module. Pure ^{68}Ge-chloride (radionuclidic purity of 98.5%) was successfully produced for preparation of ^{68}Ge/^{68}Ga generator. Therefore, approximately 250 mCi of pure ^{68}Ge-chloride can be produced in future by irradiating Ga-Ni target for 28 days.

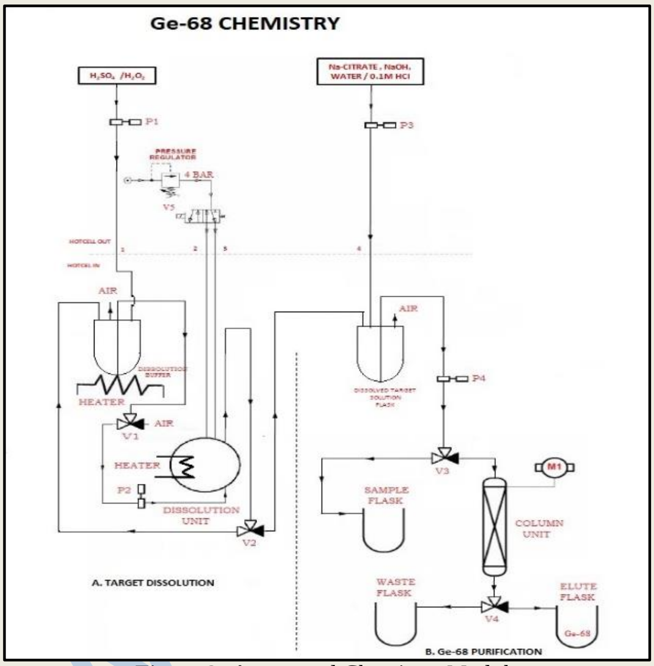


Figure 2: Automated Chemistry Module

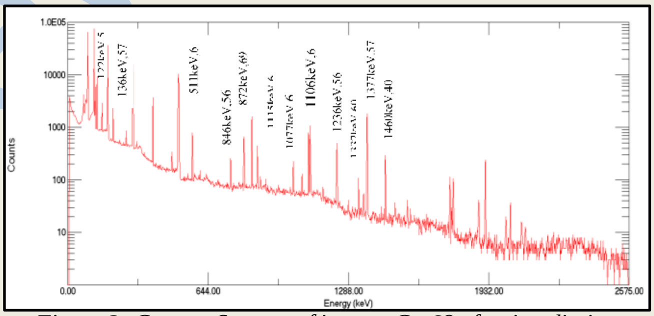


Figure 3: Gamma Spectra of impure Ge-68 after irradiation

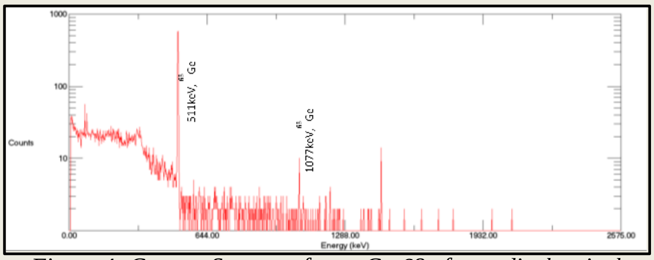


Figure 4: Gamma Spectra of pure Ge-68 after radiochemical separation

PHYSICS

LONG –TIME CONFINEMENT OF ELECTRON CLOUD IN VECC PENNING TRAP

A cloud of electrons trapped in a Penning trap was observed through a non-destructive technique. In the present work, a compact Penning trap was used, where permanent rare earth magnets provided the radial confinement to electron clouds. The quadrupolar electrostatic potential for axial confinement was generated by applying voltages to five closed ended cylindrical copper electrodes. The schematic drawing of Penning trap is shown in Fig. 1(a). The electrons were generated inside the trap by applying voltage to a Field Emission Point (FEP). A negative pulsed voltage of around 800 V was applied for a duration of 400 ms to generate pulses of electron beam which pass through the trap assembly and hit the lower endcap electrode. This primary electron beam collided with the background gases in the trap to generate low energy secondary electrons that were eventually trapped. The axial motions of the trapped electrons induced image current on the end-cap electrodes and were measured by an improved tank circuit resonance detection scheme.

The confinement time of the stored electron cloud is defined as the time upto which the trap signal was last observed after the primary beam is switched off. It was observed that the confinement time increased as the background pressure dropped. A long trapping time of 800s was measured at a vacuum of 5×10^{-10} mbar. The improvement of confinement time with decreased residual pressure indicates that there was no dominant contribution from any angular asymmetries in magnetic field or trapping potential and it qualifies the superiority of trap designing and fabrication.

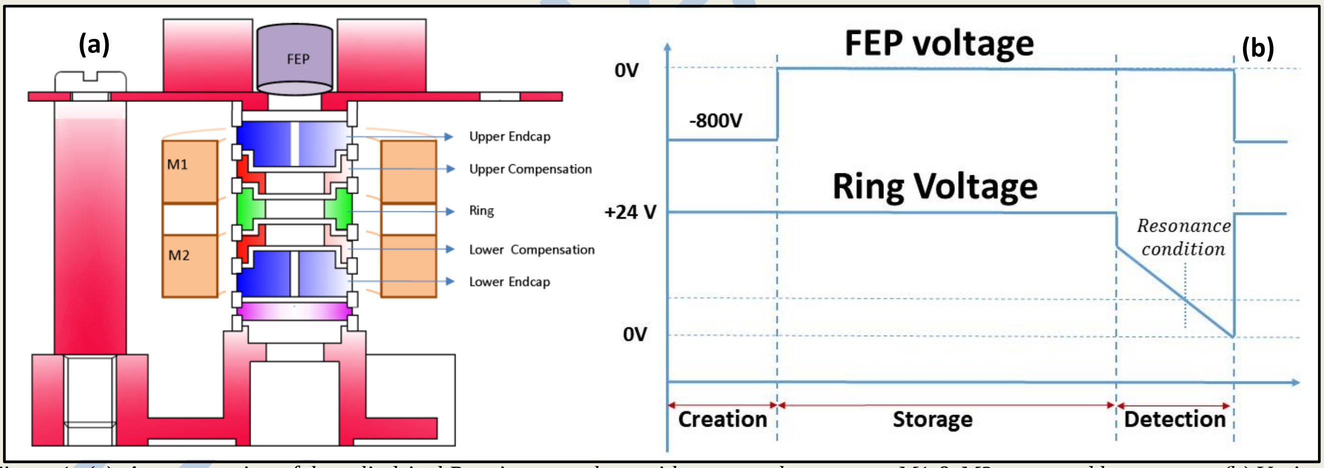


Figure 1: (a). A cross-section of the cylindrical Penning trap along with two annular magnets M1 & M2 separated by a spacer, (b) Various pulse sequences used to measure the confinement time of electron cloud in Penning trap.

For further details please contact Dr. Arindam Kumar Sikdar (aksikdar@vecc.gov.in), Cryogenic Trap Section / ENPD / PG.

TIME-WALK CHARACTERISTICS OF 1.5″X1.5″ $CeBr_3$ DETECTOR COUPLED WITH HAMAMATSU PMT R13089-100

The lifetime measurement of the nuclear excited states provides useful information of the nuclear structure. The direct measurement of lifetime in γ-γ electronic coincidence method depends on the time resolution and energy resolutions of the detector system. With the availability of new generation scintillator detectors with excellent time resolution as well as reasonably good energy resolution, the precise measurement of lifetime in sub nanosecond ranges have become possible.

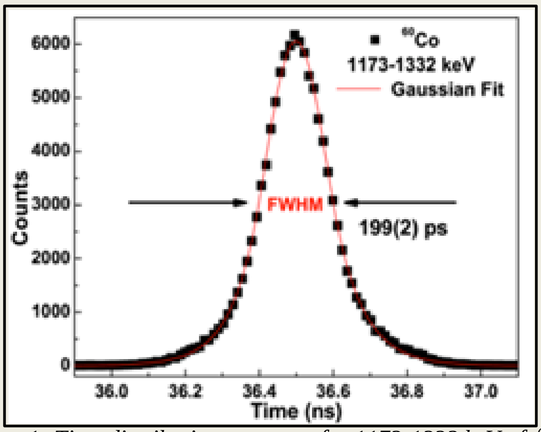


Figure 1: Time distribution spectrum for 1173-1332 keV of ^{60}Co

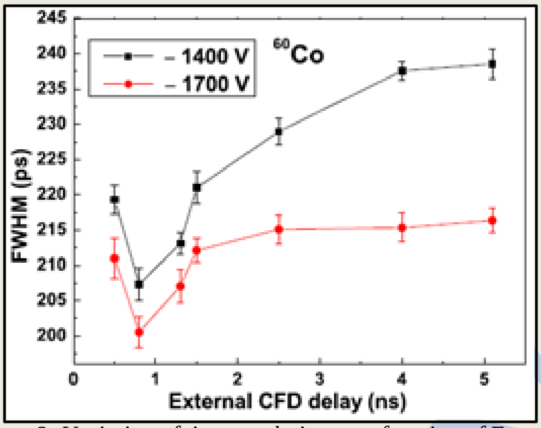


Figure 2: Variation of time resolution as a function of External CFD delay

At VECC, the energy and time resolutions of 1.5″x1.5″ $CeBr_3$ detectors coupled with a Hamamatsu PMT R13089-100 has been investigated. The typical energy and time resolution obtained with 1.5″x1.5″ $CeBr_3$ detectors are 4.1%, at 662 keV of ^{137}Cs source and 199(2) ps, for 1173-1332 keV cascade of ^{60}Co source. The systematic variation of the time-resolution for different PMT bias voltage and external CFD delays has also been studied. It was observed that the time resolution improves with shorter CFD delay and higher PMT bias voltage. The time distribution for 1173-1332 keV coincident gamma rays, obtained with two 1.5″x1.5″ $CeBr_3$ detectors, is shown in Fig.1. The variation time resolution (FWHM), obtained from this time distribution, is shown in Fig.2, as a function of the external CFD delay.

One of the important aspects of the γ-γ fast timing measurement is to calibrate the setup for the experimental time walk, i.e., the centroids of Prompt Response Functions (PRF), as a function of gamma ray energy, which is dependent on the timing properties of the crystal, the PMT and the time pick-off elements used in the setup. The time precision of the setup also depends on the statistics obtained for the coincident time distribution and thus demands higher efficiency of the detectors, keeping the time resolution of the setup within acceptable range.

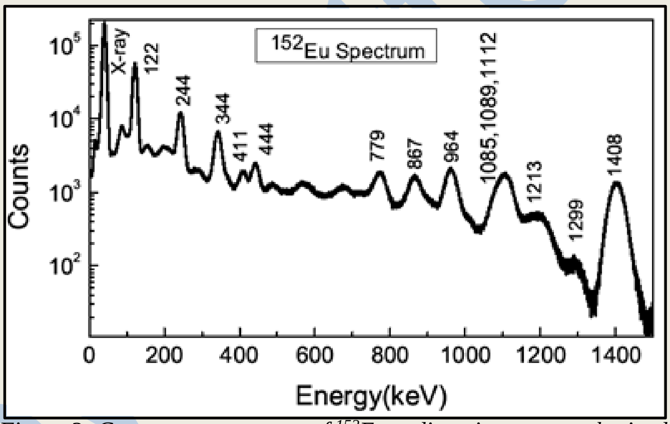


Figure 3: Gamma ray spectrum of ^{152}Eu radioactive source, obtained with 1.5"x1.5" $CeBr_3$ detectors

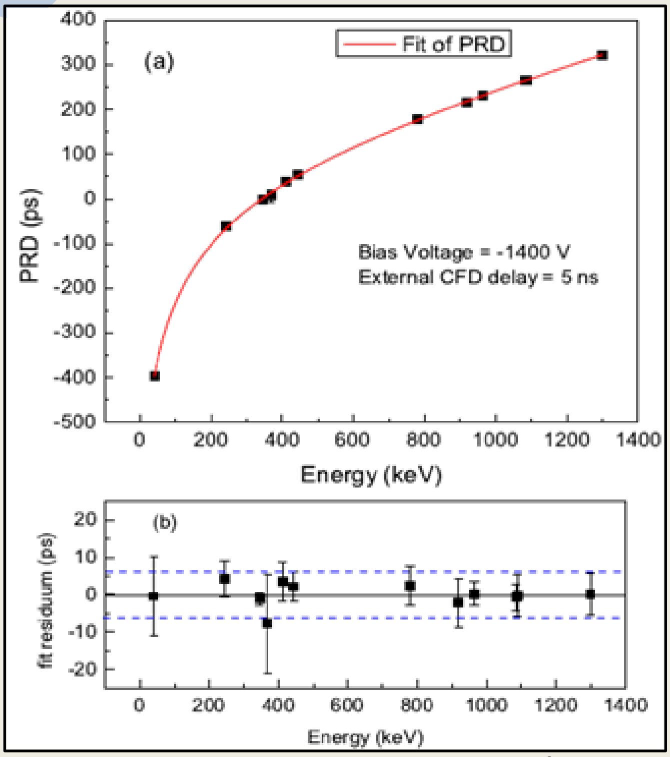


Figure 4: a) PRD calibration curve at -1400V. (b) The fit residuum for PRD calibration.

If the lifetime of the nuclear state $\tau < \sigma_{PRF}$, then the lifetime of the state is measured by Centroid Shift method. To eliminate the timing asymmetries of the start and the stop detector branches, Mirror Symmetric Centroid Difference (MSCD) method is used for a system of two detectors. In order to calibrate the prompt response of the experimental set-up within the energy range of interest, Prompt Response Difference (PRD) calibration curve has been determined for two 1.5″x1.5″ $CeBr_3$ detectors with ^{152}Eu radioactive source. The energy spectrum of ^{152}Eu source, obtained with the dynode pulse output of the PMT of one of the $CeBr_3$ detectors is shown in Fig.3. The PRD calibration curve for this particular detector+PMT assembly, at the PMT Bias voltage of -1400V and 5 ns CFD external delay, is shown in Fig. 4(a) and the corresponding fit residuum for the PRD calibration is shown in Fig. 4(b).

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

ESTIMATION OF AN EMPIRICAL FORMULA FOR EFFICIENCY OF A BEGe TYPE DETECTOR USING MACHINE LEARNING BASED ALGORITHM

High Purity Germanium (HPGe) detectors are extensively used in γ-ray spectrometry to identify and quantify radionuclides in environmental samples as well as wastes due to their high sensitivity and resolution. In recent years, a new series of Broad Energy High Purity Germanium (BEGe) detectors have shown spectral advantages over a Low Energy detector (LEGe) as well as a coaxial detector encompassing an energy range of 3 keV–10 MeV. Monte Carlo (MC) based detector simulations are now widely adopted in gamma-ray spectrometry enabling quick estimation of full-energy peak efficiency (FEPE) values which is one of the main parameters used in the calculation of radioactivity. The first step in such simulations is to prepare a computational detector model. The nominal values of geometrical specification of an HPGe detector provided by the manufacturer often suffer inaccuracy and are inadequate for realistic simulation. Apart from that, the thickness of the dead layers increases with the ageing of the detector leading to a reduction of the active volume which results in a decrease in the detector efficiency. The general practice followed globally is done by optimizing various parameters of the detector using multiple MC simulations till simulated FEPEs at various gamma energies match the experimental values. Often this optimization method requires numerous simulations and changing each parameter with small incremental values can lead to huge computational time. Hence, it is essential to build up a method to quickly identify the initial guess values to optimize these parameters.

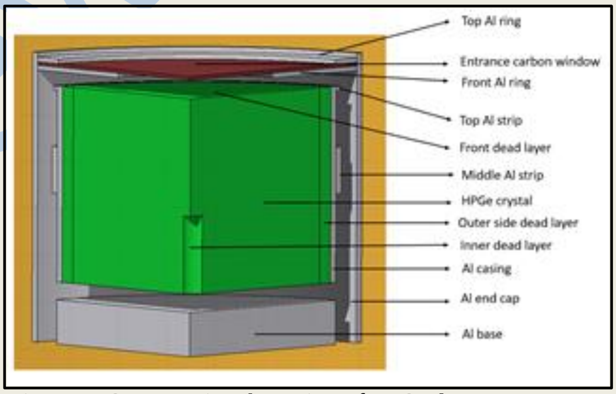


Figure 1: Cross sectional 3D view of BEGe detector geometry plotted in FLUKA

To achieve this goal, a machine learning algorithm-based non-linear regression method has been adopted to obtain an empirical formula for the FEPE of a Broad Energy Germanium (BEGe) detector. In that study, it has been explored that beyond 122 keV, the FEPE values mainly controlled by the geometry of the active region of the BEGe detector as well as on the incident gamma energy. FLUKA MC-based code has been used to model different detector geometries and corresponding FEPE values for various point sources have been obtained for various gamma energies. These simulated FEPE values along with the detector geometry parameters (detector active volume (V_{ac}) and diameter to length ratio $(D/L)_{ac}$ of the active region) and incident gamma energies (E) have been incorporated as input data set to machine learning-based non-linear regression models (GEEKO python code). Following this approach, a non-linear function having the following form has been obtained:

$$\ln(FEPE) = a * V_{ac}^{b} + c * \left[\left(\frac{D}{L}\right)_{ac}\right]^{d} + e * V_{ac}^{f} * \left[\left(\frac{D}{L}\right)_{ac}\right]^{g} * \ln(E) + h * \frac{E}{V_{ac}^{k}} + l * \left[\left(\frac{D}{L}\right)_{ac}\right]^{p} * \exp(E^{q})$$

where, a, b, c, d, e, f, g, h, k, l, p, q are constants (model parameters) and these values have been generated using the machine learning algorithm. It is to be noted that, in this empirical relation, V_{ac} is in cm^3 and E is in MeV.

Another python-based code (named as "Optimization python code) has been prepared implementing the above empirical formula to find out the optimised dimension of the BEGe detector present in the lab. The cross-sectional 3D view of detector geometry as modelled in FLUKA is shown in Fig. 1. The FEPE values obtained by these three techniques, namely, experimentally, empirically, and simulated using FLUKA, have been compared for the validation study. One validation example is shown in Fig. 2 for detector model GCD 50190X-LBG-LNM S/N 1851-16. This plot depicts a good agreement among experimental, simulated and empirically obtained FEPE values with a maximum relative deviation between experimental and simulated FEPE below 4% which could not be achieved earlier if nominal values were considered.

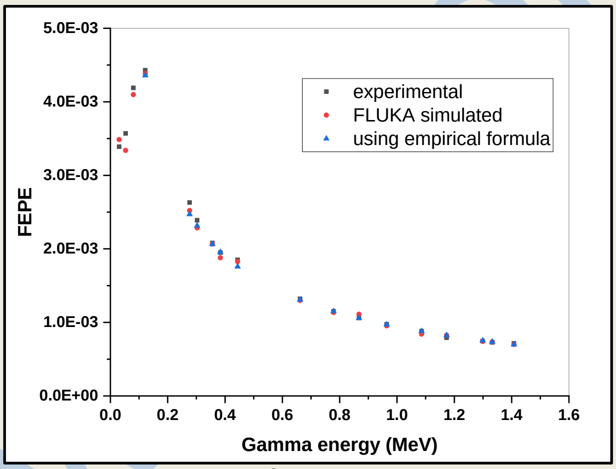


Figure 2: Comparison of experimental FEPE with FEPE obtained using empirical formula as well as from FLUKA simulation with optimized geometry

For further details, please contact Riya Dey (riyadey@barc.gov.in), HPU, VECC, HPD, BARC

CHEMISTRY

ADSORPTION BEHAVIOR OF DIATOMIC GASES WITH DEFECTED HEXAGONAL BORON NITRIDE NANOSHEET : A DFT STUDY

Unlike graphene, the hexagonal boron nitride nanosheet (h-BNNS) consists of hetero-atomic bonds between B and N. Thus, it is possible to generate different nature of vacancy sites unlike the case of iso-electronic graphene. One of the ways to create such asymmetry in h-BNNS is by creating B-vacancy or N-vacancy in h-BNNS sheets. The Lewis acid and Lewis base behavior of these vacancies play significant role towards the interaction with different diatomic gas molecules. The results have been analyzed by comparing the thermodynamical stability, geometrical parameters, charge distribution and the electronic density of state analysis. We have shown that, the interaction of the gases with pristine h–BNNS were weaker and that resulted in physi-sorption of gases. The results also revealed stronger adsorption of gas molecules on the vacancy defects in comparison to the pristine surface. Moreover, the interaction energy of dimer molecules is higher for nitrogen vacancy (N^V) than that of boron vacancy (B^V) defected sheet. A correlation between the interaction energy and electro-negativity difference has been established. The results show that during interaction, the H_2, Cl_2, O_2 undergo spontaneous dissociation whereas CO, NO and N_2 undergo bond elongation. The results in this study sheds new light in the application of adsorption, sensing and removal of toxic gases.

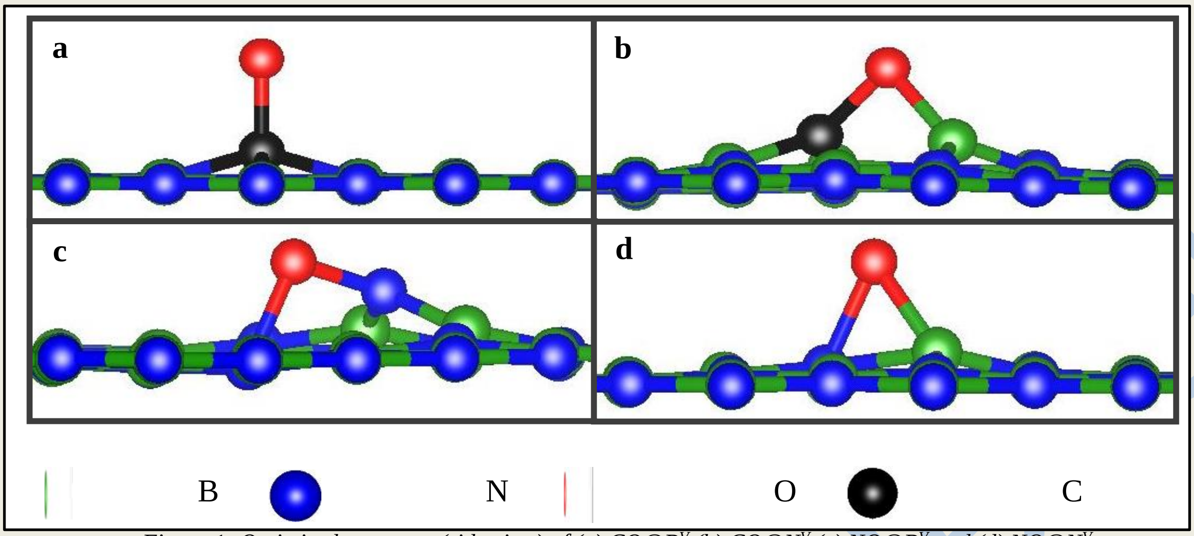


Figure 1: Optimized geometry (side view) of (a) CO@B^V (b) CO@N^V (c) NO@B^V and (d) NO@N^V.

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

TECHNOLOGY DEVELOPMENT

DESIGN AND DEVELOPMENT OF HIGH POWER HORIZONTAL SLIT CUM COLLIMATOR FOR MC18 BEAMLINE

Extraction of proton beam from 18 MeV Medical Cyclotron will be obtained by stripping of H^- ions near the exit radius. The extracted beam will be placed in the beamline through a switching magnet which sits in the yoke of the main cyclotron. The extracted beam is required to be centered in position within 1 mm and angle with an accuracy of better than 1 mrad. To tune the beam with that accuracy a number of diagnostic elements are required. As future medical cyclotrons will be designed for higher current, a high power slit cum collimator has been designed and developed for MC18 beam line. The two slits are two water cooled vertical cylinders placed in a chamber and will horizontally cut the unwanted beam. The cylinders can be rotated with respect to the opening axis in the vacuum chamber without disturbing the vacuum inside the chamber. With the rotation of the cylinders the distance between the two cylindrical surfaces will change. By this method the gap between the cylinders can be changed from 40 mm to 60 mm for proper defining and tuning the beam.

Figure 1 shows the cross section of the slit cum collimator of MC18 beamline.

The cylinders are water cooled and can easily handle 500 watts of beam power. Water is forced to flow through a helical path on the cylindrical surface from bottom to top to increase heat transfer coefficient on the cylinder surface. A screw has been inserted inside the cylinder for that purpose. Table 1 shows maximum temperature of the cylinder surface for beam power 500 watts and different water flow rate @30 deg C. Figure 2 shows the temperature distribution on the cylinder and screw.

Both the cylinders are electrically isolated from the chamber so that during the beam tuning any beam current falls on the cylinder can be measured. The chamber, the cylinders including inside screws are made of Aluminium alloy. Figure 3 shows the actual picture of the slit cum collimator.

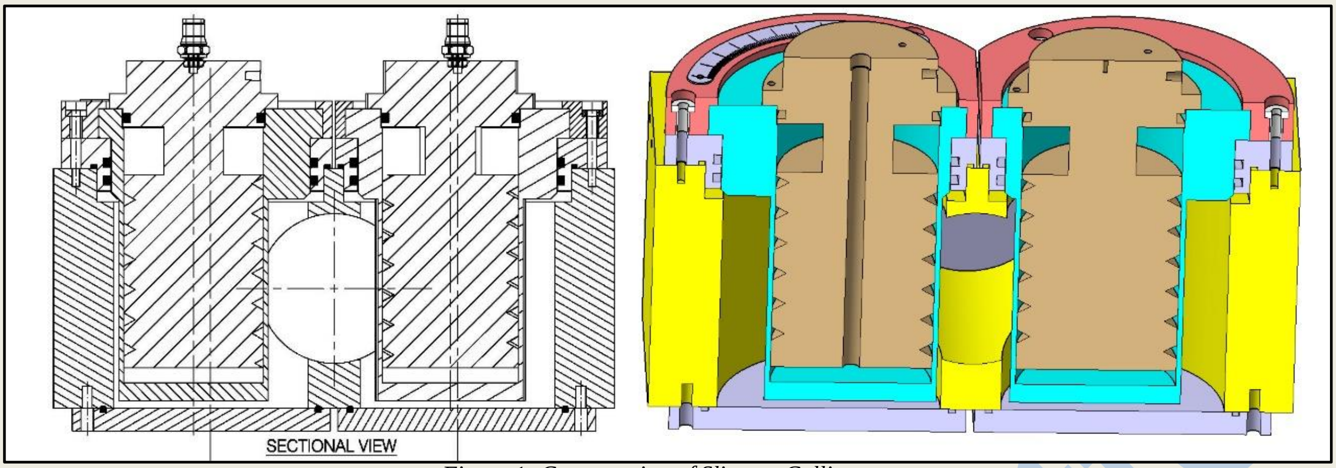


Figure 1: Cross section of Slit cum Collimator

Table 1: Maximum temperature of the cylinder surface for beam power 500 watts

Designed heat load	**500 W (for each cylinder)**			
Flow rate	5 lpm	10 lpm	15 lpm	20 lpm
Water Pressure drop	0.5 bar	1.3 bar	2.5 bar	3.5 bar
Max. Temp. (Deg. C)	54.9	51.3	49.7	48.7

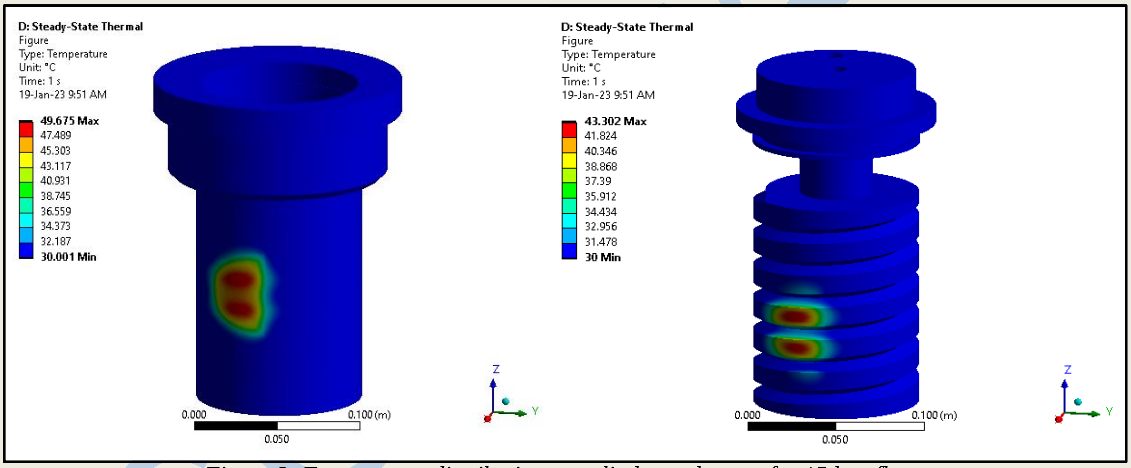


Figure 2: Temperature distribution on cylinder and screw for 15 lpm flow.

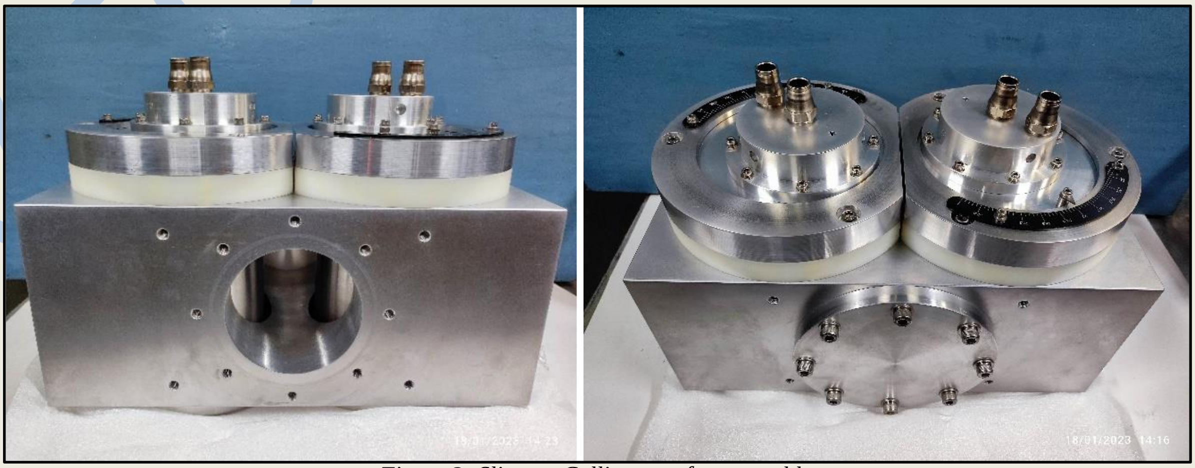


Figure 3: Slit cum Collimator after assembly

For further details, please contact Shri C Nandi (nandic@vecc.gov.in), Head, ATD(Mech) Section/MEG, VECC

DESIGN AND DEVELOPMENT OF QUADRUPOLE MAGNET FOR MC18 BEAMLINE

Quadrupole Magnets will be used in the beam line of 18 MeV medical cyclotron. The main function of the beam line is to transport 50 µA proton beam extracted from the cyclotron to the target area for irradiation and isotope production without significant loss. The extraction beam line is therefore designed in lossless principle and quadrupole magnets will play an important role in transportation of this beam through this line. The quadrupole magnets for MC 18 beamline is designed for focusing the beam. Maximum gradient requirement is 6.3 T/m. The pole radius is 55 mm. Field gradient uniformity is better than $4X10^{-3}$ in the usable diameter of the magnet. Figure 1 shows the magnetic field contour plot.

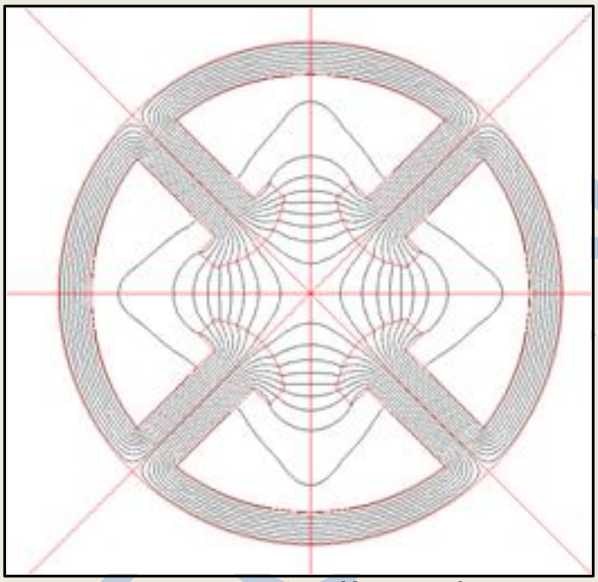


Figure 1: Magnetic Field contour plot

The magnet poles have been made from AISI 1010 steel and the yoke is from AISI 1020 steel. The yoke has been made in two halves. Position of poles and assembly symmetry is ensured using dowel pins. Pole position accuracy of within 150 micrometer has been achieved after assembly.

The coil for the quadrupole magnets are racetrack type. Flat copper wire 12.5 mm x 2 mm insulated with dual coated enamel has been used for winding the coils. Each coil has two pancakes and they are electrically connected in series. In-between two pancakes a water cooled copper plate has been placed to cool the coil.

The following parameters have been controlled during the fabrication of the quadrupole coils:

a. Number of turns
b. Dimension of the coils
c. Resistance
d. Inter turn insulation
e. Insulation between conductor to cooling plate
f. Insulation between coil to ground
g. Water flow rate
h. Water leak tightness

Load line data for quadrupole at different excitation is in Table-1

Table 1

Current in the coils I(A)	Magnetic Field gradient, G(T/m)	Magnetic field at pole tip, Bpole(T)	GxEffective magnetic length of the quadrupole (Leff) (T)
30	2.4	0.132	0.033
40	3.196	0.17578	0.043945
50	3.98	0.2189	0.054725
60	4.745	0.260975	0.065244
70	5.43	0.29865	0.074663
80	5.912	0.32516	0.08129
90	6.3	0.3465	0.086625

Fabrication and assembly of four quadrupole magnets have been completed recently. Figure 2 shows the actual picture of the magnet. Magnetic field measurement of the quadrupole magnets will be done very shortly.

Figure 2: Picture of quadrupole magnet after assembly

For further details, please contact Shri C Nandi (nandic@vecc.gov.in), Head, ATD(Mech) Section/MEG, VECC

HIGH PRESSURE WATER RINSING SYSTEM DEVELOPED FOR RIB E-LINAC PROJECT, VECC, KOLKATA

As a part of development of infrastructures for activities related to Superconducting Radio-frequency Cavity cleaning and conditioning, a High Pressure Water Rinsing System (HPRS) was developed and installed at RIB annex building inside the clean room (class: 1000) at VECC [Figure 1]. The ultrapure water system required for cleaning the cavity is now in the process of development.

Figure 1: High Pressure Rinsing System installed at the clean room

High Pressure Rinsing (HPR) system is a key process for the surface preparation of high field Superconducting Cavities. HPR is used to remove chemical residuals and contaminated particles from the resonator inner walls.

Figure 2: Cavity Handling Cart with rotation fixture

An Electric Lift Cart [Figure 2] along with specially developed maneuvering facility is being used for handling of Cavity along with housing structure during transfer of cavity during before and after the high pressure rinsing.

Demineralized water from Low conductivity water system will be available at the receiving tank of the separately installed water treatment unit after passing through the water treatment unit the ultra-pure water having less than 0.2 ppm suspended particle will be stored in a storage tank having Nitrogen blanketing. A high pressure low discharge pumping system will be used to spray this ultrapure water through spray nozzle at the Rinsing station for cleaning up and final conditioning of inside surface of the SRF cavities (9-cell cavity).

Spray nozzle with the rotational header has four spray points at same elevated position at different anglesfor uniform distribution of spray water at cavity inner wall.

The system had been tested with a dummy Superconducting Cavity which is housed in the support structure.

A dedicated control panel controls the total synchronized operation of High Pressure Water Rinsing System (HPRS) along with rotary motion of nozzle and linear motion of cavity through a dedicated control system supported by PLC.

For further details, please contact Shri B Manna (bmanna@vecc.gov.in), MEG, VECC

NIOBIUM DUMB-BELL DEVELOPMENT FOR 650MHZ LOW BETA SUPERCONDUCTING RADIO FREQUENCY (SCRF) CAVITY

VECC is developing five cell low beta 650 MHz Superconducting Radio frequency (SCRF) cavities under DAE-Fermilab Collaboration. In the initial stage, two niobium single cell cavities were developed and tested successfully at Fermilab, USA. VECC is presently working on the fabrication of the five cell cavities.

The forming, machining and inspection of the Niobium half cells have been completed. The Niobium half cells are Electron Beam Welded in collaboration with IUAC, New Delhi using their electron beam welding facility.

A prototype Niobium dumbbell with stiffener ring was developed to optimize the weld parameters to be used in actual components. Presently, actual components are being taken to IUAC for welding at iris joints to form the dumb-bells.

For further details, please contact Dr P Bhattacharyya (pbhatt@vecc.gov.in), Head, Mechanical Workshop Section/MEG, VECC.

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Figure 1: Developed prototype dumb-bell

AWARDS & HONOURS

Ms. Sneha Das, PhD student of Physics Group, VECC, HBNI, received one of the **Best Oral Presentation Award** in "Joint ICTP-IAEA Workshop on Nuclear Structure and Decay Data: Experiment, Theory and Evaluation", held at ICTP, Italy, during October 3-14, 2022. The presentation

was on "Single particle and collective excitations above Z = 82", based on the results of experimental studies of nuclei above Z=82 and below N=126 magic shell closures. The evolution of level structures from single particle to collective nature has been explored, using in-beam γ spectroscopy techniques and lifetime measurements.

Ms. Chandrani Sen, PhD student of Physics Group, VECC, HBNI, received one of the **Best Poster Award** at the DAE-BRNS Symposium on Nuclear Physics, held at Cotton University at Guwahati,

during December 1-5, 2022. The poster was presented on the topic: "Investigation of odd-even effect in giant dipole resonance width in medium mass nuclei". The collective dynamics associated with nuclear giant dipole resonance vibration is strongly correlated to the underlying nucleonic motions. In the poster, Chandrani investigated whether any odd-even effects influence the IVGDR width. For this purpose, IVGDR width of ^{63}Cu and ^{64}Ni have been calculated by employing the statistical thermal shape fluctuation model, where the associated driving potential is obtained self-consistently using the nuclear energy density functional formalism.

Mr. Devesh Kumar, Scientific Officer (D), Physics group, VECC received the **Best Poster Award** in "66th DAE-BRNS symposium on Nuclear Physics", held at Cotton University, Guwahati, during December 1-5, 2022. In the poster, entitled "Lifetime measurements in neutron rich ^{133,135}Xe", Devesh presented the results of lifetime

measurements in odd-A Xe isotopes around doubly magic ^{132}Sn. Measured lifetime values were used for obtaining transition probabilities in ^{133,135}Xe. The excited states of Xe isotopes were populated using Beta decay of Iodine isotopes, which were produced from radio-chemical separation of fission products of alpha, delivered from K-130 cyclotron, induced fission of ^{238}U. The experiment was performed using γ-γ fast timing array of $CeBr_3$ detectors at VECC, VENTURE, coupled with two HPGe Clover detectors.

Mr. Apar Agarwal, SRF HBNI-VECC, of EHEP&A group and working for the development of Muon

Chamber(MuCh) System for the Compressed Baryonic Matter Experiment at FAIR, achieved the **Best Poster Award** for his contribution entitled "Preliminary test results of real size GEM modules in nucleus-nucleus collisions at mCBM campaign 2022", in the 66th DAE

Nuclear Physics Symposium, held from 01-05 December, 2022 at Cotton University, Guwahati, India.

Dr. Sushant Kumar Singh, Scientific Officer (E) in the Physics Group, VECC, was awarded the C. V. K. Baba Award of Indian Physics Association (IPA) for the **Best PhD Thesis** on "Hydrodynamical Modeling of QCD Fluid with Critical Point in the Equation of State" at the recently concluded 66th

DAE-BRNS Symposium on Nuclear Physics 2022, held at Cotton University, Guwahati, during December 1-5, 2022. The award was instituted by IPA in the name of Prof. C. V. K. Baba, one of the most renowned nuclear physicist of India.

Dr. Pratap Roy of the Experimental Nuclear Physics Division, Physics Group, VECC, Kolkata has been awarded the **Young Achiever Award 2022** by the organizing committee of the DAE symposium on Nuclear Physics (**snp2022**) for his excellent contribution to the field of "Nuclear Level Density and Thermodynamics". Dr. Roy has been a key person in executing a detailed experimental program at VECC to understand the statistical and thermal properties of atomic nuclei. Some of the remarkable works of Dr. Roy in these areas include: providing experimental signatures of a pairing-phase transition, evidence for the reduction of nuclear level density (NLD) away from β-stability,

observation of collective enhancement and its fadeout in NLD etc. Some of these results have profound implications for nuclear structure and nuclear astrophysics. Dr. Roy has also played a significant role in the design, and development of fast neutron detectors for the time-of-flight (TOF) array at VECC and MONSTER (**Mo**dular **N**eutron **S**pectrome**ter**) array at FAIR.

Dr. Shreyasi Acharya, who completed her Ph.D. from the EHEP&A group of VECC (HBNI) in Dec 2021 under the supervision of Prof. Subhasis Chattopadhyay has been awarded with the **ALICE Thesis Award - 2022**, for her thesis entitled "Multiparticle production in proton-proton collisions at the LHC energies", by the international ALICE

collaboration at LHC-CERN for the year 2021-2022. In her thesis, Shreyasi has performed extensive analysis of ALICE data collected for pp collisions at LHC energy and extracted the yield of electrons, the decay products of heavy flavoured particles, which are the messengers of the reaction mechanism in such collisions. Her detailed and precise work led to some very interesting results enlightening the community in this field of research.

Dr. Zubayer Ahammed, SO/G, EHEP&A Group has been elected as the next **Spokesperson of the ALICE/STAR-India Collaboration** for a two- year period 2023-24. ALICE is one of the experiments at

the Large Hadron Collider at CERN. About 40 scientists and 60 research students from different Indian Institutes and Universities are working in this experiment.

EVENTS

Due to the COVID-19 pandemic, the VECC staff club could not conduct any activities. However, since we are moving towards normalcy at a great pace, the VECC staff club has been organising several activities during the period of July 2022 to December 2022.

A photography contest cum exhibition in two categories, nature and wildlife, was conducted on September 16, 2022, for the first time in the VECC. There was an enthusiastic and overwhelming response from VECC employees. The Judges selected best three photographs, and prizes were awarded to the participants.

Apart from that, the VECC staff club organized a Poetry Contest. Employees from different states and native language participated in the contest in order to maintain the harmony in diversity within our office. Staff club has distributed prizes among the winners of the poetry contest.

The VECC staff club also conducted several sports activities during this period. Afriendly football match was organised for employees of different age groups. The VECC staff club also conducted zonal selection trial for the Konark zone for the 36th DAE annual sports in the Chess and Table Tennis categories. Upgraded cricket kit facilities was provided to the VECC cricket team.

The VECC staff club acknowledges support and guidance from Director, VECC and other senior colleagues for successfully organizing all the events.

For Further information, please Contact: Shri Sanjay Bhakat (sanjaybhakat@vecc.gov.in)

Celebration of Bharatiya Bhasa Utsav at VECC was a different kind of celebration ceremony for the HBNI students and faculty members on December 12, 2022 when many of the scientists and employees of VECC joined them to celebrate the Bharatiya Bhasha Utsav. Dr. Sumit Som, Director, VECC inaugurated an exhibition where books of different languages (Tamil, Telugu, Malayalam, Saontali, Marathi, Bengali, Odia, English etc) and multilingual posters depicting VECC activities were exhibited. Lighting the lamp with the HBNI students, Dr Som in his address encouraged everyone to have awareness in different regional languages that helps to better understand the Indian culture and heritage.

The exhibition hall was beautifully decorated with flower rangoli and alpona, painted by the faculty members, students, other colleagues and in particular, VECC garden personnel.

(Hindi, Bengali & English) "We'll walk hand in hand, some day…Oh, deep in my heart, I do believe, We shall overcome, some day". The students recited poems in Kashmiri and Urdu. The full house lecture hall witnessed the programme consisting of Swaraswati vandana in Sanskrit, Tagore's songs in Bengali and song in Marathi written by Veer Savarkar apart from the songs in Odia, Malayalam, Hindi, Bengali and recitations, skits in multi languages. A brief account of the life of Subramania Bharati was depicted by a HBNI Professor who led a short Tamil program consisting of chorus songs written by the Mahakobi Bharati. The rich tradition and culture of Kerala was presented with a Malayalam boat song and a rhythmic folk song that even boosted energies among the spectators, many of whom participated in the event with their ethnic dresses! A beautiful Bengali poem ("Amalkanti" by Nirendranath Chakraborty) that reminds us of the eternal conflict between life's finest aspirations and the harsh reality of our earthly existence was presented by a senior Professor.

On the eve of Bharatiya Bhasha Utsav VECC indeed celebrated India's rich linguistic harmony among diversity.

Feedback may be sent to
newsletter@vecc.gov.in
Variable Energy Cyclotron Centre
1/AF, Bidhan Nagar, Kolkata 700064, India