VECC NEWSLETTER

June 2022 Volume 24 Number 1 VECC-NL-2406

Table of Contents

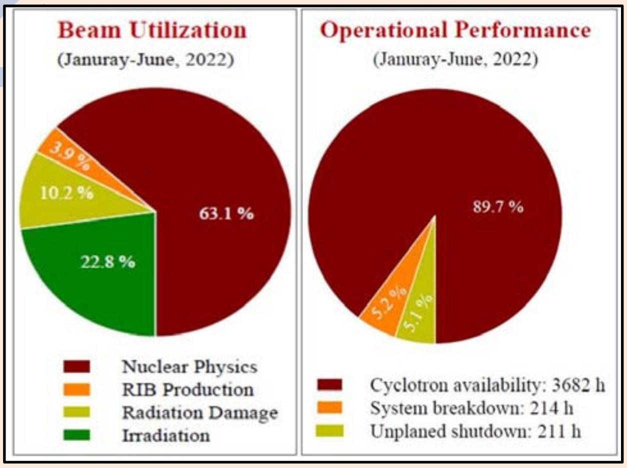
ACCELERATOR

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 "January to June, 2022". During 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 month of May and June due to unplanned shutdown. This was due to the ceramic break near the main RF amplifier feedthrough which consumes about eight days altogether to replace it. Planned shutdown has been taken in the month of April for six days and May for two days during which installation of screen power supply for RF system, Freon unit replacement and air handling unit (AHU) work etc. have been carried out. 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, cooling tower maintenance, cave shield door movement problem, electrical change over, safety interlock checking etc. During the above period, K130 cyclotron has delivered alpha beam of the following beam energies (see table) @ 1.0 nA to 8 nA in channel# 2 and 3 and 125 nA -600 nA in channel#1 as per user requirement. Proton beam of following energies @ 2.0 nA in channel#2 and 500 nA – 3.8 µA in channel#1 have been delivered. Proton beam with energy 9.5 MeV, 11 MeV and alpha beam with energy 28 MeV have also been transported in channel#4 with current in the range 1 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, 50
Proton	7, 8, 9.5, 9.8, 10, 10.5, 10.6, 11, 11.2, 12

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.

INTEGRATION OF INDIGENOUSLY DEVELOPED 1.5 KV, 2A VOLTAGE REGULATED RF SCREEN POWER SUPPLY WITH RF AMPLIFIER OF K130 ROOM TEMPERATURE CYCLOTRON

The RF System of K130 Room Temperature Cyclotron VECC consists of tetrode (Eimac 4CW150000E) based high power RF amplifier which operates in the range of 5.5MHz – 16.5MHz. Four nos. of power supplies are required to operate this amplifier – Filament power supply, Control Grid power supply, Screen power supply and Anode power supply. PE&MCDS of ATG, VECC has developed a solid state based screen power supply with required and achieved specifications given below. The power supply was tested with a resistive dummy load.

Parameters	Specifications	
	Required	Achieved
Output Voltage (V_o)	1-1.5 kV	0-1.5 kV
Output Current (I_o)	2 A	2A
Line & Load Regulation	0.06 %	<0.05 %
Peak to Peak Voltage Ripple Factor	0.1 %	<0.07 %
Voltage Stability	500 ppm/°C	<300 ppm/°C

The power supply also features in-built protection features against overcurrent, over-temperature, single-phasing along with integration with external crow-bar protection system. The power supply can be operated and monitored remotely from control room.

The developed power supply has been installed with the existing RF amplifier system and interfaced with existing Siemens PLC based supervisory control system that incorporates the operational logic and machine safety interlocks. It has been tested with actual RF system and after passing all acceptance tests, integrated with the running RF system of K130 Room Temperature Cyclotron.

Figure 1: Newly developed RF screen power supply in RTC vault.

For further query please contact Shri Sabyasachi Pathak (spathak@vecc.gov.in), Power Electronics & Magnet Coil Development Section / ATG

PHYSICS

PROBING HIGH-ENERGY γ RAYS IN PROTON - AND ^{4}He-ION-INDUCED REACTIONS

When an atomic nucleus with sufficient energy collides with another nucleus, different particles such as neutron, proton, α, γ and other light nuclei are emitted. One can have an idea about the production mechanism and internal structure of the nucleus by detecting these particles. The γ rays produced during nuclear collision are less affected compared to other particles and therefore, they provide a clean probe to study reaction mechanism at early stages of the collision.

At VECC, an experiment was performed to probe the γ rays in proton and ^{4}He-ion-induced reactions on ^{115}In and ^{112}Sn nuclei, respectively. The aim of the experiment was two-fold, namely, to understand the mechanism of the production of the γ rays in these two reactions, and to probe reduction of nuclear level density (NLD) for nuclei away from β-stable nuclei as observed in neutron and charged particle emission. The proton and ^{4}He-ion beams were accelerated to 12 and 28 MeV respectively by the K-130 cyclotron at VECC. The high-energy γ rays were detected by using the in-house developed LAMBDA array. In Fig. 1, the high-energy γ-ray spectra for both the reactions are shown. It was observed that the yield of the γ rays in 10-20 MeV region was substantially large for proton-induced reaction, which points towards different production mechanism of γ rays in the two reactions studied. The statistical model calculations under-predict the yield for proton-induced reaction (pink dashed line, Fig. 1a). The extra yield could be explained by adding the contribution from the statistical process and the direct-semidirect process calculated within the exciton model formalism (green solid line, Fig. 1a). In proton-induced reaction there is a large overlap between the incoming channel and the 1priticle-1hole configurations in ^{116}Sn. This increases the yield of high-energy γ rays in 10-20 MeV region. The γ-ray spectrum for the ^{4}He-ion-induced reaction could be explained reasonably well

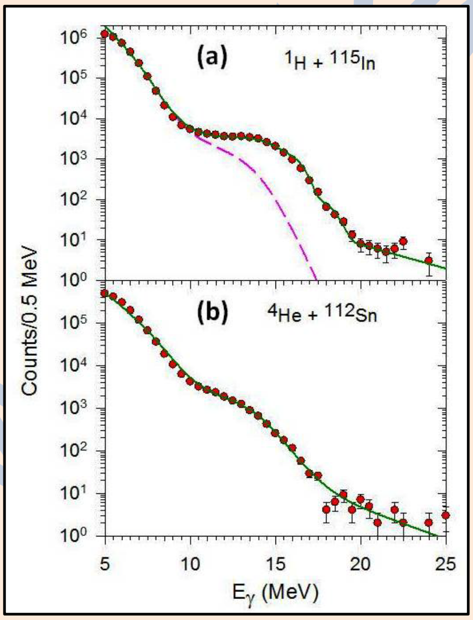


Figure 1: Experimental high-energy γ-ray spectra along with the statistical and exciton model calculations.

within the statistical model formalism which points towards the fact that the γ rays are emitted after equilibrium of the composite system. It was also observed that, in this case, the γ-ray spectrum could be better explained when a reduced level density was utilized, as compared to that used for the proton induced reaction, in the statistical model calculation. This study indicates that NLD for the nuclei away from the β-stability line decreases. This may have crucial implications for the model calculations of elemental abundances, where the level densities of the nuclei away from the stability lines are incorporated as input parameters.

For further details please contact Dr. Debasish Mondal (debasishm@vecc.gov.in), Nuclear Structure Section / ENPD / PG.

COLLABOTATIONS

MEASUREMENT OF REACTION CROSS-SECTIONS WITH DETAILED COVARIANCE ANALYSIS ON ^{nat}Mo USING ALPHA PARTICLE

Recently, many radio-isotopes have been synthesized due to their uses in the field of radiopharmaceutical and 3D SPECT imaging. The main goal of this investigation is to measure activation cross-section data for nuclear reactions natMo(α,x)97Ru, natMo(α,x)103Ru with respect to the production of medically important radioisotopes such as 97Ru, 103Ru. 97Ru (T1/2 2.79 days) is suitable for use in SPECT and 103mRh (T1/2 56.11 min), is useful for augur electron therapy. In this study the excitation functions for the nuclear reactions natMo (α,x)103Ru, natMo (α,x)97Ru, and also natMo(α,x)95Ru, natMo(α,x)96gTc, natMo(α,x)95gTc natMo (α,x)94gTc in the energy range 9–32 MeV have been measured. We have used the stacked foil activation technique followed by the offline gamma-ray spectroscopy using HPGe detector to measure the excitation functions. In this study we have also made detailed uncertainty analysis for these nuclear reactions. The excitation functions are compared with the available experimental data from EXFOR data library and the theoretical prediction from TALYS nuclear reaction code.

The experiments were performed in the K-130 cyclotron at Variable Energy Cyclotron Centre (VECC), Kolkata. In this experiment, α-particles were accelerated up to 32 ± 0.20 MeV and the average beam current used was ~ 170 nA. In this

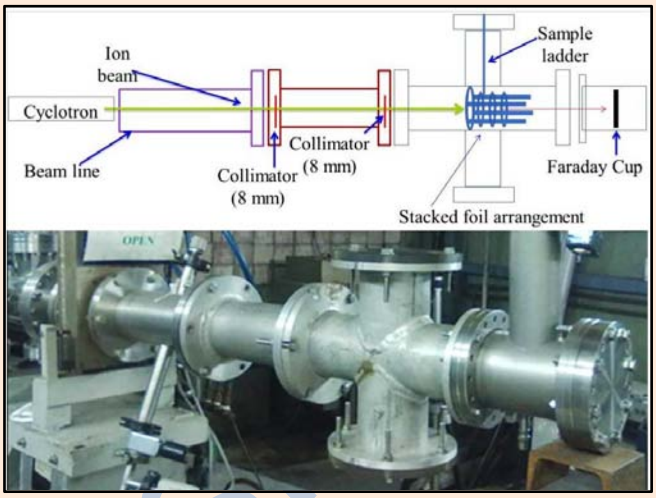


Figure 1: Schematic diagram and photograph of the experimental setup.

work, the nuclear reaction cross-sections (σ) were calculated using the standard activation formula. In this study, uncertainty in the factors contributing to the cross-section such as the efficiency of the detector $\varepsilon(E_\gamma)$, γ-ray intensity (I_γ), number density of atoms (N_t), decay constant, incident flux, γ-ray peak counts (C_γ) were taken into account to calculate the uncertainty of the obtained cross-sections.

The present measurements of molybdenum are important for astrophysics and nuclear medicine, so the accuracy and precision was the main objective of the present study as the earlier work were done by Tarkanyi et al. and Ditroi et al. have not taken care of different kind of corrections and covariance analysis associated with the experimental data.

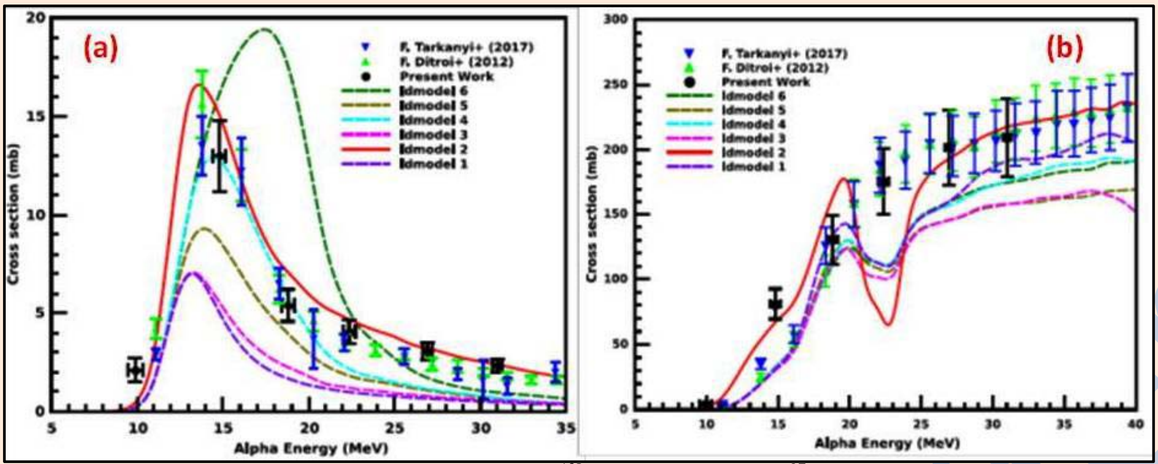


Figure 2: The excitation function of reaction (a) $^{nat}Mo(\alpha,x)^{103}Ru$ and (b) $^{nat}Mo(\alpha,x)^{97}Ru$ along with available experimental data from EXFOR and theoretical results from TALYS.

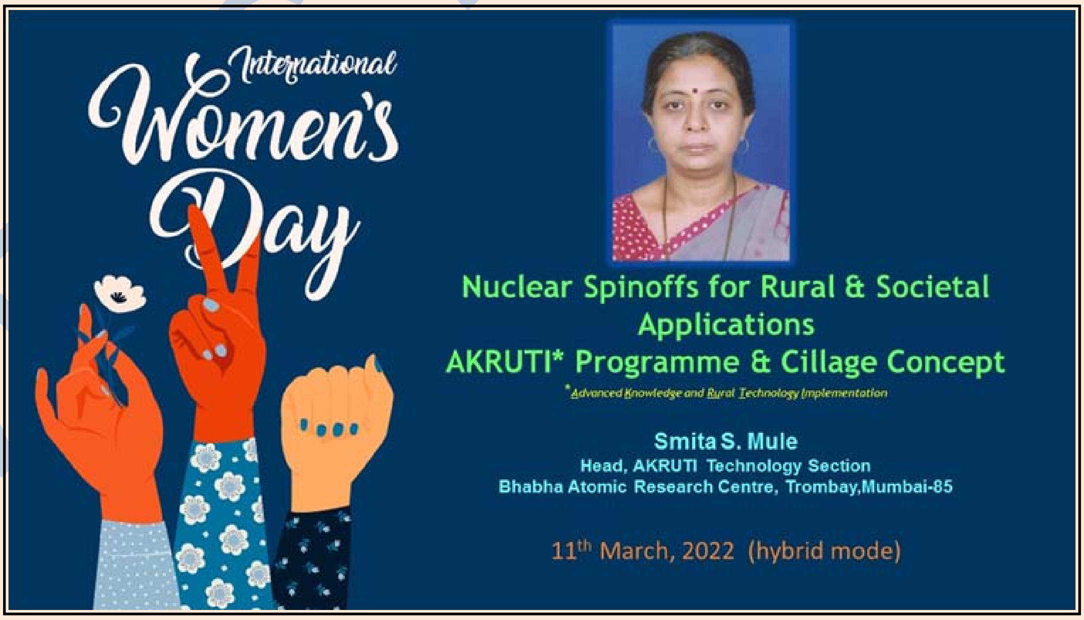
For further details please contact Dr. J Datta (jdatta@vecc.gov.in), ACD, BARC.

EVENTS

VECC CELEBRATES INTERNATIONAL WOMEN'S DAY

As part of the celebration of Women's Day 2022, VECC organized a special colloquium by Smt. Smita S. Mule, Head, AKRUTI Technology Section, Bhabha Atomic Research Centre, Trombay, Mumbai-85 on the topic: ***"Nuclear Spinoffs for Societal and Rural Applications: AKRUTI Programme & Cillage Concept"***.

The colloquium was held in hybrid mode and attended by staff and students of VECC. Also, Dr. Sarmishtha Bhattacharya, Head, Nuclear Structure Section, VECC delivered a lecture titled, ***"Awareness Programme on the role and activities of VECC Internal Complaints Committee"***.



THEME MEETING ON NUCLEAR LIFETIMES, TRANSITIONS AND MOMENTS (NLTM2022)

A theme meeting, dedicated to the past, present and future of nuclear structure studies with lifetimes, transitions, moments and beta decays, was organized at VECC, Kolkata during February 1-3, 2022. The meeting started with the welcome address by Director, VECC and showing the glimpses of research and development being carried out at VECC.

The three-day meeting was held online and included a total of 27 invited presentations, out of which, 10 speakers were from reputed international laboratories. Eminent speakers from national laboratories and universities also shared their ideas related to the theme of the meeting. Junior faculties, post doctorates and senior students in the field, who are practicing the subjected research, were given the opportunity to present their works through 8 short presentations. A session was also dedicated for the PhD students to present their works and engage in discussion. Figure 1 shows the captured screenshots during the programme.

A panel discussion, open to all the participants, was co-ordinated to discuss about the future research in the country on Nuclear Lifetimes, Transitions and Moments. The discussions in the meeting also provided important inputs towards the development & up-gradation of large facilities of contemporary interest at VECC, viz.., VENTURE (VECC array for Nuclear fast Timing and angUlar CorRElation studies), VEBGYOR (VECC array for Beta-Gamma spectroscopY of Radio-nuclei), GMDA (Granular charged particle Multiplicity filter Detector Array) which will be used in standalone mode and/or coupled mode with high resolution Clover HPGe array like VENUS (VECC array for NUclear Spectroscopy) at VECC.

The meeting was a major step forward after the successful development and utilization of the VENTURE array, first of its kind in the country, at VECC. The theme meeting NLTM2022, with 196 registered participants, was a grand success with vibrant discussions and ideas exchange. Summary of the programme and other details can be found at https://events.vecc.gov.in/e/NLTM2022.

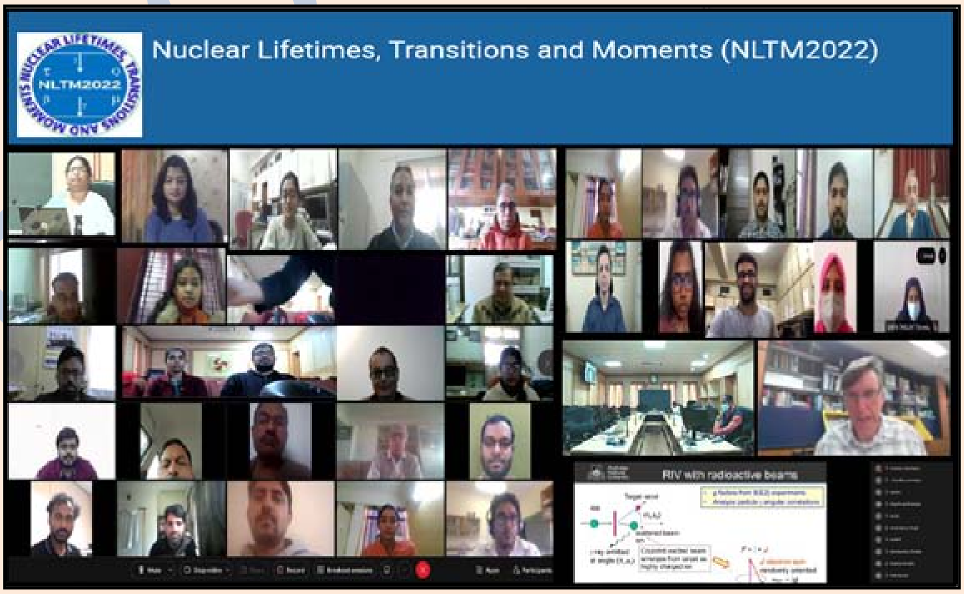


Figure 1: Screenshot captured during the programme.

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