Government of India
Department of Atomic Energy

VECC Annual Progress Report

2021 - 22

Variable Energy Cyclotron Centre
Kolkata

The vibrant experimental group has carried out excellent research. They have measured the high energy gamma rays from spontaneous fission at the Jaduguda underground lab and provided a new upper limit. The group has performed noble work by measuring alpha decay rate under compression, Hoyle analogue state in ^{16}O, fusion suppression in complex fragment emission and isospin dependence of nuclear level density. On the development front, a signal from the cryogenic penning trap at 4°K has been obtained and ethernet interfaced remote control system has been developed for pulse shape discrimination.

In the low and intermediate energy domain, the isospin diffusion of the quasi-projectile formed in reactions around the Fermi energy domain is investigated using the Boltzmann equation. Fission trajectories are obtained within the density functional theory framework, allowing for a microscopic determination of the most probable fission prefragment configurations. Microscopic calculations of Isovector Giant Dipole Resonance at finite temperature were successfully done. In the higher energy domain, dilepton production from hot, dense and magnetized quark matter is studied using the 3-flavor Polyakov Nambu–Jona-Lasinio (PNJL) model considering the anomalous magnetic moment of the quarks. The ratio of photon anisotropic flow in relativistic heavy ion collisions was also studied. The impact of QCD critical point (CP) on the spin polarization of Lambda-hyperon in viscous quark gluon plasma (QGP) has been studied by using in-house developed computer code to solve (3+1) dimensional relativistic viscous causal hydrodynamics. The equation of state as well as structure of rotating hybrid stars was studied using color flavor locked quark matter.

The Experimental High Energy Physics and applications Group, VECC is engaged in exploring the strongly interacting matter under extreme temperature and density in the laboratory. For achieving such extreme conditions, heavy ions (e.g., Au, Pb) are accelerated at relativistic energies to collide with another heavy ion. Presently, VECC has been participating in two such major experiments i.e., ALICE at LHC-CERN and CBM at FAIR-Germany. VECC researchers have been working in analyzing data collected by the ALICE experiment for understanding the production of direct photons, particles with heavy flavors and particles at intermediate energies. Apart from that VECC is taking a lead role in development of p-type Si-pad detectors for the upgrade of ALICE detector in the form of installation of an electromagnetic calorimeter at the forward rapidity region. One such prototype p-type detector has been tested at VECC recently. For the CBM experiment at FAIR facility at Darmstadt, Germany, VECC is working on development of the dimuon system by employing an advanced gaseous detector called GEM. Two large size GEM chambers and a large size single-gap RPC have taken data at the SIS18 facility of GSI-Germany at very high beam intensity. VECC has made contributions in both physics analysis, simulation and in detector hardware activities. As a spin-off, a muon tomography setup using RPC has been setup and detailed performance analysis is ongoing.

Advancement in ASIC-based electronic developments continued with the developments of Neutron Flux Monitor (NFM), Multichannel Charge Sensitive Amplifier (MCSA-16), Multichannel shaper and discriminator for CPDA detectors etc. An EPICS based application has been developed for saving the operational setting of RTC in MySQL based database. Several developments related to IT services and IT security of VECC are carried out such as Meeting Room Booking Portal, Web-based video conferencing facility, SNORT-based Network Intrusion Detection System, Alert generation module in log management system, Network Access Control System etc. Activity on AI-based handshape recognition of Indian Sign Language is also reported here.

The academic activities of Homi Bhabha National Institute (HBNI) at VECC have continued as usual with its Ph.D programme. In spite of COVID-19 pandemic we managed to organize a few Symposia & other events.

Sumit Som
Director

1.1 Nuclear Experiment

PRECISION DETERMINATION OF ALPHA DECAY RATE FROM ^{211}At IMPLANTED IN DIFFERENT HOST MEDIA

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We have undertaken a precision study of α-decay rates of ^{211}At implanted in a small lattice (Pd), large lattice (Pb) and semiconductor material silicon (Si). Recent theoretical works [1] predict an observable change of α-decay rate under high compression and density functional calculations indicate that similar compressions could be achieved by implanting the α-emitting element in the interstitial spaces of a small lattice such as Pd. Moreover, a theoretical work [2] indicated the possibility of observable change of α-decay rate from an analysis of the quantum decoherence of the decay products by the interaction with the environment. The present study was undertaken because of these theoretical reasons.

^{211}At ions were produced by bombarding a natural bismuth target with a 29 MeV $^{4}He^{2+}$ beam from VEC. The alpha beam loses ~ 2 MeV energy while passing through 25 µm bismuth foil. The energetic ^{211}At ions produced in the last few layers of bismuth foil came out with an average kinetic energy of 0.5 MeV and get implanted in lead, silicon and palladium catcher foils placed behind the bismuth target. It was expected that ^{211}At nucleus decaying to ^{207}Bi nucleus with 41.8 % probability would emit an alpha particle (E_α =5869.5 keV) with a half-life of 7.214 hrs. The emitted alpha particles would be detected using a silicon surface barrier detector and monitored continuously for ten half-lives. A standard pulse generator was used for pile-up rejection and dead time corrections. However, during the analysis it was observed that spectrum differed when ^{211}At was implanted in different lattices as shown in Figure 1.

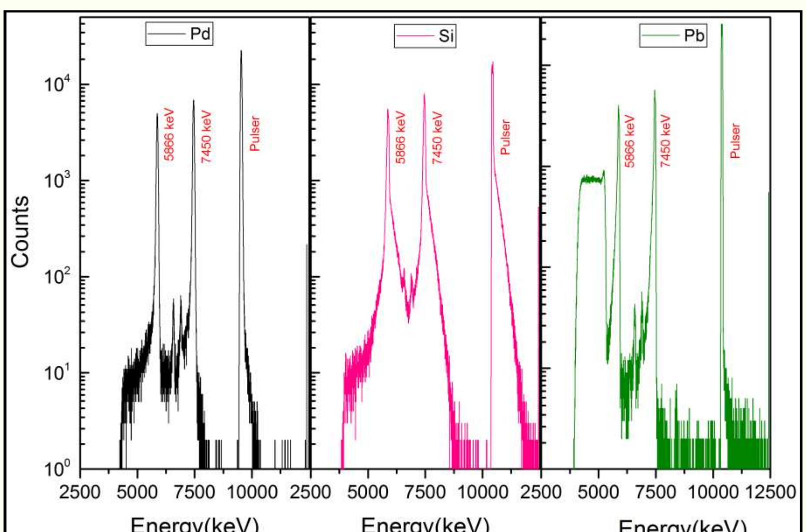

Figure 1: Alpha spectrum of ^{211}At implanted in different catcher foil

It is understood that alpha beam of 27 MeV while passing through the Pb-catcher produced ^{211}Po nuclei and it emitted 5.3 MeV alpha particles. A broad distribution was observed as 5.3 MeV alphas were getting emitted throughout the thick 25 µm lead foil. A background run was carried out where 27 MeV alpha beams from VEC were impinged directly on Pb and Pd foil to observe the presence of any unwanted lines in the alpha spectrum in our energy region of interest. The alpha spectrum for lead background run is shown in Figure 2.

TEST OF 300μm THICK p-TYPE SILICON DETECTOR AT VECC

Sanjib Muhuri, Jogender Saini, Subhasis Chattopadhyay

ALICE, A Large ion collider experiment, at CERN aims to address physics of evolution of early universe after Big Bang. ALICE in its present configuration has excellent coverage in mid-rapidity region with vertexing, tracking and measuring particle energy. As part of upgrade, a new detector called the forward calorimeter (FOCAL) will be installed in the forward rapidity to address gluon dominated regime of partonic matter. VECC is involved in fabricating the p-type silicon pad detectors for FOCAL with the help of BEL, Bengaluru.

A single element p-type silicon detector has been fabricated at BEL and tested at VECC. The aim was to check the performance of the detector and feed to the foundry for next step of silicon detector array development. The effort to fabricate the p-type silicon detector of its type is first time in India. The successful R&D will lead to volume production for the real calorimeter detector layers. The single p-type silicon pad detector has dimension 1 cm x 1 cm with active area 0.7*0.7 cm^2. Shown in Fig.1(Left) is the photograph of the packaged detector with wire bonding for readout/biasing. The right panel shows the response of the detector to Sr^{90} beta source with MCA and oscilloscope.

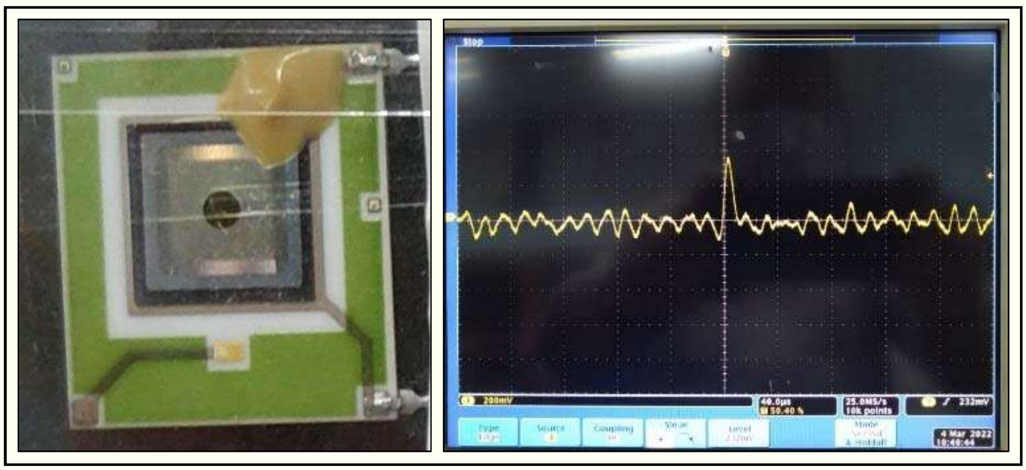

Figure 1: (Left): Photograph of the detector. (Right): Raw pulse from the detector

Several tests have been perfomed like I-V characteristics of the detector, performance of the detector as a function of the coupling capacitance and resistance, response to the beta source and etc.

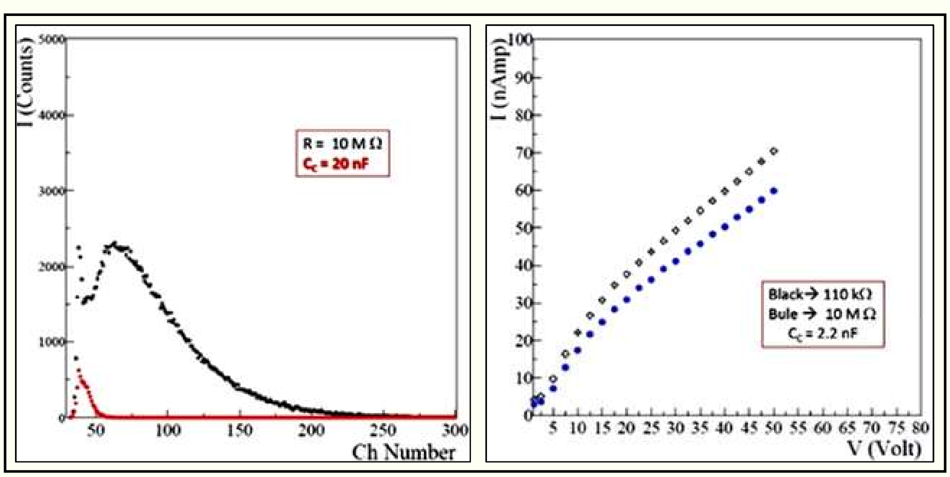

Figure 2: (Left) Signal with and without Beta-source. (Right) I-V characteristics for different coupling resistance.

Fig.2(Left) shows the signal from the p-type silicon detector with (blue) and without (red) beta source. It can be ssen that the signal is well picked compare to the noise floor. On the other hand the I-V