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

RESPONSE OF LARGE SIZE TRIPLE GEM DETECTORS DEVELOPED AT VECC TO VARYING INTENSITY IN mCBM EXPERIMENT

A. Agarwal, A. K. Dubey, C. Ghosh, A. Kumar, E. Nandy, G. Sikder[1], J. Saini, V. Singhal, V. Negi, S. Chatterjee[2], S. K. Prasad[2] and S. Chattopadhyay

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The CBM (Compressed baryonic matter) experiment is a major experiment at the upcoming FAIR (Facility of Anti-Proton and Ion Research) facility at Darmstadt, Germany. The aim of this experiment is to explore regions of the phase space diagram of strongly interacting matter where baryochemical potential is non zero. The experiment will be carried at an unprecedented collision rate of 10 MHz. This poses a major technical challenge of building detectors capable of handling high particle rates. The detector is designed to measure dimuonic signals in the heavy ion collisions at CBM, therefore it is also called MuCh (Muon chambers). Two of the large area modules of MuCh were tested in a precursor to actual CBM experiment called the mCBM (mini CBM) experiment. The data was acquired using STS/MuCh xyter, v2.1, in a self-triggered mode, for the data acquired in in mCBM 2020 campaign

The detectors, were subjected to intense particle flux from Pb beam colliding with p=1.06 AGeV on a 0.25 mm fixed Au target at varying intensities. The beam was incident in form of spills ~ 9 s long. Fig. 1 shows the spill structure as a function of time. Appropriate noise cleanup has been performed. The detectors were tested under various conditions like operating voltages (mainly 4500 V and 4600 V), coverages etc.

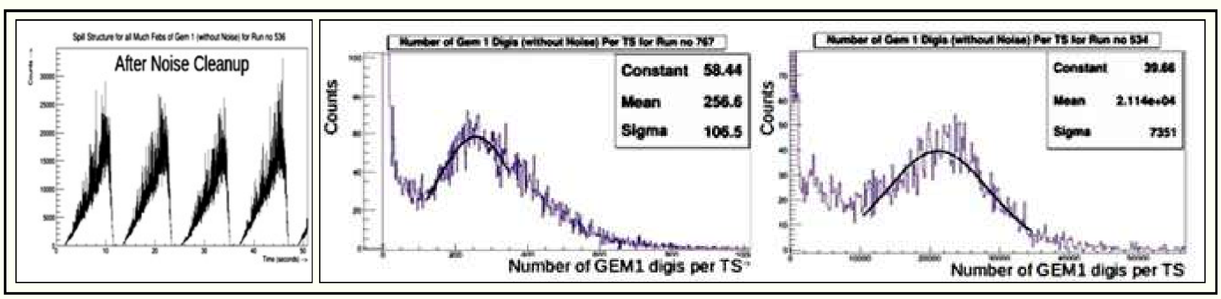

Figure 1: (Left) Spill structure from a high intensity run. (Right) Distribution of ndigis per Time Slice (TS).

The data was acquired in units of Time-slices(TS), each of ~12.8 ms. Fig 1(right) shows a distribution of number of digis per timeslice for GEM1 and GEM2. The average number of digis is obtained from the peak value after fitting this plot with a Gaussian distribution. This exercise has been performed at different intensities under identical conditions to investigate the detector response. It is observed from Fig. 2 that the detector response for both GEM1 and GEM2 is fairly linear and no saturation effects were observed in the range of intensity studied. Futher study is under progress.

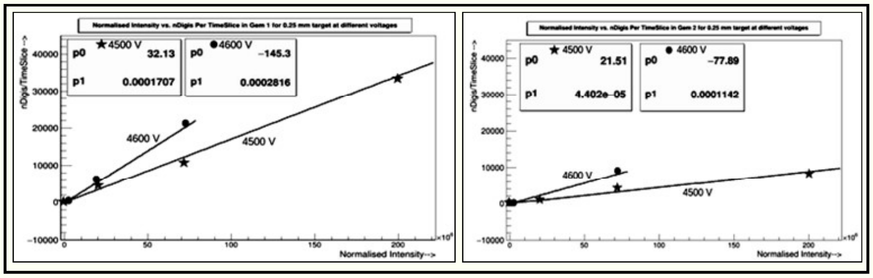

Figure 2: Variation of ndigis/TS for GEM1 (left) and GEM2(Right) with beam intensity.

CRI BASED mMUCH DAQ SETUP AND ONLINE MONITORING

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For last few years, Common Readout Interface (CRI) development work has been going on. After April 2020, mMUCH was uninstalled for debugging of link loss and other issues. During November 2021, mMUCH was re-installed on the beam table in mCBM cave. The readout chain of mMUCH was updated to CRI based DAQ as compared to AFCK in earlier mMUCH setups. Fig. 1 shows the present mMUCH setup connection to CRI Based readout chain in mCBM.

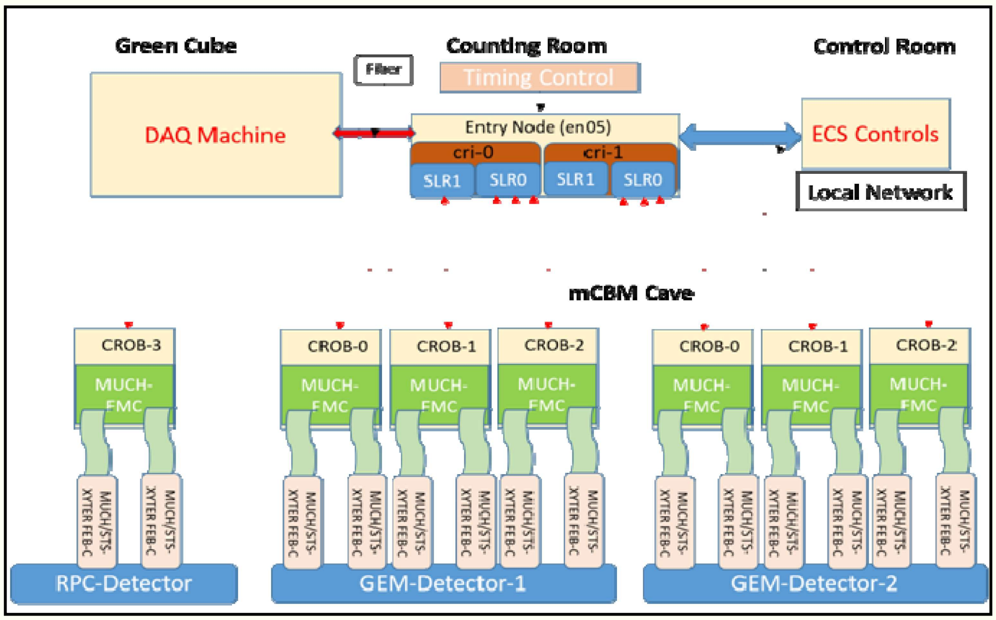

Figure 1: CRI based mMUCH DAQ Setup at mCBM.

Two real sized GEM detectors and one real sized RPC detector were installed in the cave. mMUCH detector front end boards (FEBs) were readout via Common Readout Boards (CROB). CRI card is mounted on *PCIe GEN3 16x* data bus on motherboard of the DAQ server. Number of CRI connected in a particular DAQ server depends on available PCIe slots. In mMUCH setup two CRIs were used which were installed in *en05* entry node placed in the mCBM counting room.

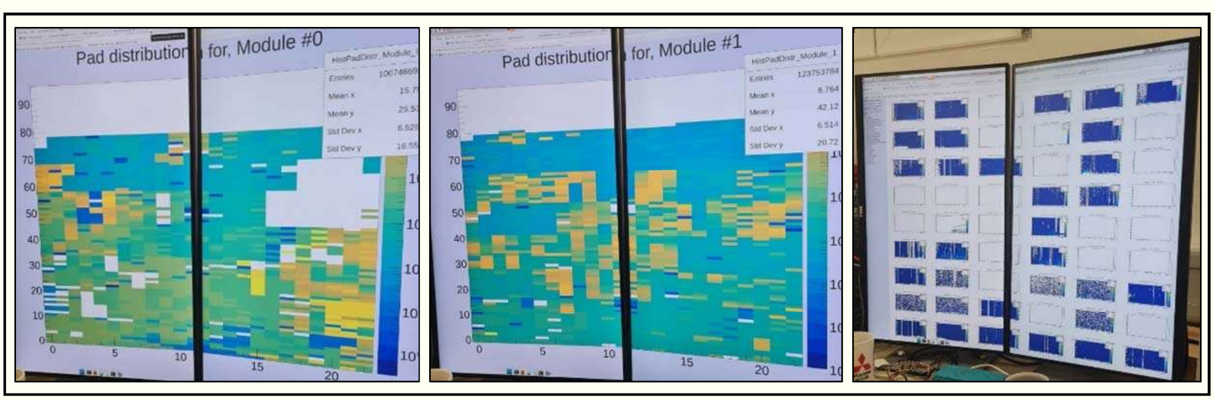

Figure 2: Pictures of online monitoring, (a) GEM1 and (b) GEM2 sector channel map during DAQ running in publisher mode. (c) Picture of online monitoring canvas for FEB by FEB electronics channel plots. Maximum of 54 FEBs can be connected under 6 CROBs. Blank space shows that particular FEB is not connected.