Ultra fast timing MMRPC: a versatile detector for basic and applied science

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Introduction: Three decades ago the Resistive Plate Chamber (RPC) [1,2] was invented to overcome several problems of parallel plate chambers. Unlike parallel plate chambers, electrodes of RPCs are made of resistive material like Bakelite or float glass. This has the effect that only a limited part of the electrode is discharged during the passage of an ionizing particle with subsequent avalanches or streamers, while the rest of the electrode remains unchanged. Wide and/or single gap RPC detectors are used in many large scale experiments to explore various directions os science. This includes fundamental research in particle physics [3,4], in astrophysics [5], in cosmology etc,. In India, RPC detectors array [INO] will play a vital role in the measurement of mass hierarchy of three flavors of neutrino mass [6]. To improve timing resolution, Multi-gap Resistive Plate Chamber [7,8] (MRPC) is an intelligent modification of an RPC by increasing the electric field across the gap and creating thinner layers of gas gap by inserting (electro-statically) floating glasses between anode and cathode. It can be shown that a resolution in the range of 50–100 ps is achievable with gaps of 200–300 mm. Moreover, RPCs are insensitive to the magnetic field. Finally timing RPCs have already proved in the last years to be a reliable and stable detector with sensitive larger and regularly used in a large number of experiments[9].

The response of such detector under irradiation by the γ-rays and neutrons has not been studied in details [10]. In order to explore in this direction a prototype of Multi-strip Multi-gap Resistive Plate Chamber (MMRPC) has been developed at SINP, Kolkata. In first stage of development, the design was focused on the feasibility study of the MRPC as an active part of high energy, high efficiency neutron TOF. The response of the developed MMRPC detector using γ-rays from radioactive sources and cosmic muons was extensively studied at SINP laboratory [11]. Later, the detector was taken to the electron linac ELBE at Helmholtz-Zentrum Dresden-Rossendorf, Germany to study its electron response. The optimum operating condition (w.r.t efficiency, time resolution, position resolution, etc.) was studied . Time resolution of our newly developed MMRPC detector for detecting electrons is better than 91 ps and this can be achieved by operating a MRPC detector in avalanche mode [12]. Further, segmented structure in readout strips design makes the position resolution of MRPC as good as 2 cm. Measurements of time difference along the strip provides the information of position. The image reconstruction of pulsed electron beam, irradiating our developed detector, provides unique opportunity for imaging [13]. MRPCs are, thus, high granularity, high-resolution inexpensive TOF system (compared to standard scintillator with PMTs) appropriate for applied research in medical imaging (cost effective Positron Emission Tomography) [14], security purpose like cosmic muon tomography, climate change[15] etc. On-line verification of the delivered dose during proton and carbon ion radiotherapy is currently a very desirable goal for quality assurance of hadrons therapy treatment plans. Utilization of MMRPC for this purpose, may solve the problem [16]. Cosmic ray muon tomography is a novel technology to detect high-Z material and complex system imaging using MRPC[17,18].

In this presentation, I shall discuss the details of the development, response of the detector for various types of particles. I shall also highlight the utility of the detector in various applied science which are being explored in the worldwide scenario. A future plan in this direction will also be discussed.

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