High Voltage Stability Testing of CPC using MFC

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Introduction

The existing Cathode Pad Chamber (CPC) in the High energy Physics laboratory of SINP is a prototype of the quadrants of second tracking station of the Muon Spectrometer (MS) of ALICE at CERN. This CPC detector has inner and outer radii of 23.7 cm and 117 cm respectively. This detector has been configured as an anode wire plane is sandwitched between two segmented cathode planes maintaining each anode to cathode distance 2.5 mm. This CPC is a gaseous ionization detector and operates with a gas-mixture of Ar/CO_2 (80:20) in atmospheric pressure. The operating voltage of this CPC detector is 1650 Volt. The gain of the chamber is ~ 10^4 at these operating parameters. This large gain is desired for the track reconstruction of the Minimum Ionising Particles (MIP) through the chambers of the tracking stations of ALICE detector.

The second tracking station of MS is comprised of eight such CPC chambers. The second tracking station is being designed, fabricated, installed and commissioned by Indian collaborators (Saha Institute of Nuclear Physics and Aligarh Muslim University) during the period of June, 2005–September, 2009. The installation, commissioning along with the validation of High Voltage (HV) testing of these large area chambers had been described elaborately [1,2]. These CPC chambers were worked successfully for data taking in Run I. The data taking was done for p-p at $\sqrt{s}$ = 7 & 8 TeV, Pb-Pb at $\sqrt{s_{NN}}$ = 2.76 TeV and p-Pb, Pb-p at $\sqrt{s_{NN}}$ = 5.02 TeV during the period of November, 2010–February, 2013. The maximum LHC beam luminosity for p-Pb run was 32 nb^{-1}. The Large Hadron Collider (LHC) will operate in the unprecedented radiation environment of high energy $\sqrt{s}$ = 14 TeV and high luminosity after Long Shutdown 1 (the period of LS1 is March, 2013–December, 2014). In the Run II, the p-p collisions will take place for the luminosity in the order of 10^{34} cm^{-2} s^{-1} which is ten times higher than the beam luminosity of the p-Pb run of Run I. This will lead to very high particle fluxes and the consequences will be increased leakage current in the gaseous environment of the tracking detectors of MS.

The probability of leakage current will be increased by decreasing the proportion of quencher gas CO_2 in the laboratory environment. The high voltage stability test of a sectional part of the existing CPC prototype was tested with pre-mixed Ar/CO_2 (80:20) and also a gas-mixture of Ar/CO_2 (85:15) using a Mass Flow Controller (MFC). This study was done to observe a comparative leakage current study as a function of high voltage. The CPC detector was conditioned with N_2 gas for three hours before flushing with Ar/CO_2. This testing was done when ambient temperature and humidity were 25^0C and 70% respectively.

The Calibration of Mass Flow Controller for Ar and CO_2 gas

The calibration was done sending Ar and CO_2 gas inside MFC and a water column in the measuring cylinder from the calibration channel of MFC individually. Now, putting MFC gas flow reading to a fixed value in the range of 10-100 for Ar and 10-50 for CO_2, the requisite gas was flown in the inverted measuring cylinder of glass filled with water. The time was collected for water column changing from 100 Cubic Centimeter (CC) to 10 CC. So, the time was noted for 90 CC water volume for each fixed value of MFC reading. The Actual_SCCM is the amount of gas flow is to be required inside the MFC in Standard Cubic Centimeters per Minutes (SCCM). The rate of flow of gas in the water column is the MFC_SCCM which had been obtained using above calibration method. The pressure of each gas from the source i.e. from the cylinder was kept to a fixed value throughout the calibration. These fixed values of gas pressure of cylinder for Ar and CO_2 were also kept same for high voltage testing. The Actual_SCCM as a function of MFC_SCCM for Ar and CO_2 independently as shown in Figs. 1 and 2. Any percentage of Ar and CO_2 can be obtained from these plots.

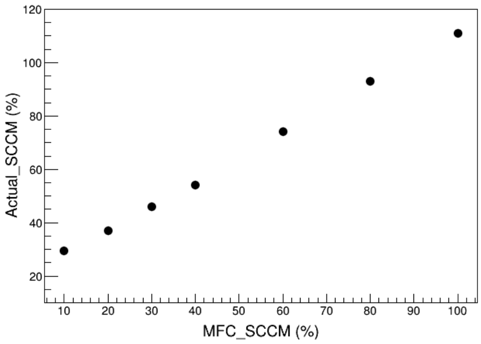

Fig. 1 The calibration plot for Ar

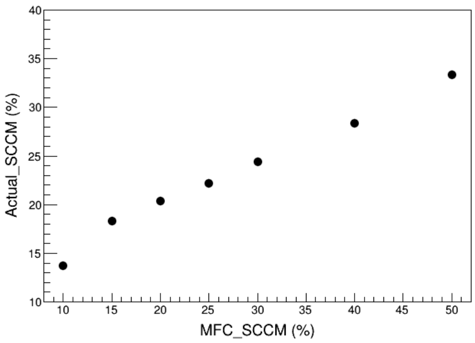

Fig. 2 The calibration plot for CO_2

The Results

The proportional plateau for MIP particles in this CPC chamber extends from 1575 V to 1700 V. The high voltage testing was done flushing the chamber with both the pre-mixed Ar/CO_2 (80:20) and Ar/CO_2 (85:15) gas-mixture using MFC.

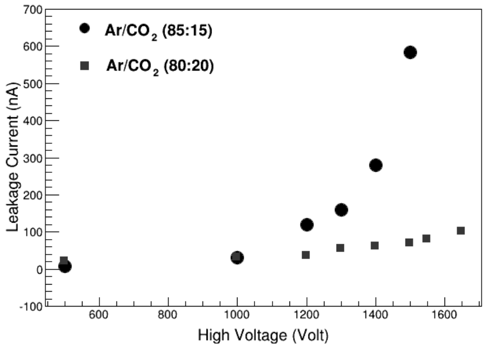

Fig. 3 The leakage Current as a function of HV

The leakage current as function HV for different proportion of quencher CO_2 with Ar is shown in Fig. 3. The increasing in percentage of quencher gas allows to stop discharges and also to absorb the photons to drain their energy into other channel. Hence, the high voltage operation could be done up to 1650 Volt when the higher percentage of quencher 20% CO_2 was used. The leakage current was increased by a factor of 10 at the high voltage 1500 V when proportion of quencher is decreased to 15% in comparison with the leakage current using Ar/CO_2 (80:20) gas-mixture.

Outlook

The knowledge which has been achieved from the high voltage testing study of CPC detector is that leakage current will be increased by a factor of 10 when the detector will be operated with a gas mixture decreasing the quencher by 5%. This study may be beneficial in the forthcoming RUN II of LHC where the beam luminosity will be increased by a factor 10 with respect to RUN I.

References

[1]. M. Danish Azmi et al.: Proceedings of the DAE Symp. On Nucl. Phys. 52, 587 (2007); 53, 685 (2008).

[2]. M. Danish Azmi et al.: Ind. Jour. Phys. 84, 1683 (2010).