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Development of Beam Diagnostic for 400 MeV Proton Beam Intensity Using Chromox-6 Scintillation Screen at Fermilab MuCool Test Area

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Abstract

Muon Colliders and Neutrino Factories need a low emittance muon beam which can be produced by a process called Ionization cooling. In this process, a muon beam is sent to a low-Z absorber (e.g. Hydrogen) to reduce all components of the momentum and only the longitudinal component is replaced by using RF cavities. These absorber and RF cavities are placed in a strong magnetic field to focus the muon beam in the absorber. MuCool Test Area (MTA) at Fermilab is actively involved to develop this technology. In this program, demonstrating various types of RF cavities in a high magnetic field environment with intense proton beam has been progressed. As a unique approach, we have tested a High Pressure RF (HPRF) cavity filled with hydrogen gas by using a 400 MeV proton beam in an external magnetic field (3 Tesla). The gas acts as a cooling material. When the energetic proton beam passes through the HPRF cavity, it ionizes the gas and produces the electron-ion pairs in the cavity. Such a beam-induced plasma consumes RF power and loads the cavity. The plasma dynamics was studied and was successfully controlled by doping an electronegative gas in the cavity. The measurement of beam position and profile are essential requirement in this analysis. When a dense hydrogen gas was contained in the cavity no energized beam monitor device could be used due to safety reason. Besides, the beam monitor should work in a strong magnetic field. We have developed a passive beam diagnostic system using the Chromox-6 scintillation screen. A CCD camera with a telescope lens was located outside the hazard zone to monitor the image. This paper shall present the system and the analysis of the beam position and beam profile. A neutral density filter was assembled to the CCD camera to reduce the intensity of scintillating light. The background pedestal was filtered out from the raw data and the image was fitted with Gaussian function to compute the beam size. The beam profile obtained from scintillation screen was compared with multi-wire beam profile. The beam transmission efficiency through a collimator with a 4 mm diameter hole was measured by the toroidal current monitor. The transmission efficiency estimated from the image was consistent with the toroid measurement. Consequently, the linearity of the system was quite good even the screen was exposed ~10^{12} protons per pulse.

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