A very thin MRPC developed for TOF-PET

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ABSTRACT: PET (Positron Emission Tomography) is a medical molecular imaging modality used in cancer diagnosis and monitoring. MRPC (Multi-gap Resistive Plate Chamber) is used for TOF (Time of Flight)-PET due to its superior time resolution. Our research group has developed a 4-chamber 32-gap MRPC prototype with 128 μm gap thickness. The measured time resolution for cosmic rays is 20 ps. The measured time resolution of the time difference between 0.511 MeV photon pairs is 239 ps FWHM. But the 23.6 mm thickness of MRPC will affect position precision. In this paper, in order to study the influence of the number and total thickness of gas gaps on the time resolution, Geant4 software is used to simulate the specific process of the interaction between particles (such as cosmic rays and photons) and MRPC detectors. The simulation results show that most of the gamma photons interact with the resistive plates in MRPCs. It is ejected mostly a Compton electron into one gas gap, causing the gas ionization. Therefore, an 8-gap MRPC detector with 128 μm gap thickness is designed to achieve a time resolution of about 20 ps and a detection efficiency of 1.5%. The performance of 8-gap MRPC detectors with 128 μm gap thickness is simulated. Besides, two 8-gap MRPC prototypes with 4.2 mm total thickness are fabricated and tested. The time resolution of 39 ps for cosmic rays and 166 ps FWHM for 0.511 MeV photons is obtained by using the fast front-end amplifier and waveform acquisition system. The experimental results are in good agreement with the simulation results. So a real time PET image can be obtained with a pair of MRPCs and the detection efficiency for gamma can be improved by increasing the number of thin MRPCs.

KEYWORDS: MRPC detectors; Time of Flight; Positron Emission Tomography; Time resolution

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