Digital holographic interferometry method for tracking detector modules displacement

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Abstract

In high energy particle physics scattering experiments, the precision of the reconstructed particle tracks can be fundamental. For this reason, a method for detecting the displacement of tracking detector modules is developed. The modules are silicon planes mounted on a frame and used in the MUonE project, which aims at a precision measurement of the scattering angle of elastic muon-electron scattering. From the scattering angle, the hadronic contribution to the anomalous magnetic moment of the muon is extracted. To achieve the desired accuracy, the position of the tracking detector planes must be continuously monitored. The allowable relative displacements must be less than 10 µm. To meet the specifications and to monitor as large an area of the detector as possible, a digital holographic interferometer was developed. It is based on a novel lens-less design in off-axis holographic geometry. Light from a fiber-coupled laser source is split by a fiber beam splitter, with one output used to illuminate the detector plane and the other for the reference beam. The two beams produce an interference pattern on a CMOS image sensor. To obtain relative displacement information, successive images are superimposed on an initial reference image and reconstructed by solving the Rayleigh-Sommerfeld diffraction integral taking into account the spherical wavefronts of the beams. The interference fringes that appear in the reconstructed holographic image provide a measure of the relative displacement of the detector plane compared to the initial position. The performance of the reconstruction method used was verified with the proposed setup at a real tracking station.

Keywords: digital holography, interferometry, detector diagnostic, particle tracking, calibration, muon scattering