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THE STUDY OF SILICON DRIFT DETECTORS FOR X-RAY PULSAR TIMING AND NAVIGATION

Abstract

Recently, there are some attempts of using the cylindrical Silicon Drift Detectors (SDDs) for X-ray pulsar timing and navigation on the International Space Station, due to its excellent energy resolution and operational simplicity. However, there exist some problems for the SDD to be used as timing sensor. The incoming photons generate short current pulses, with a certain rise time depending on the interaction location , and a certain amplitude depending on the energy of the incoming photon. So, the signals from the SDD have both rise time and amplitude floating effect, which is rather difficult to maintain the timing accuracy through the present constant-fraction discriminators (CFD).

In this paper, we will evaluate theoretically the timing parameters of the cylindrical Silicon Drift Detectors (SDDs) and suggest a general analog readout electronics for the use of SDDs in X-ray pulsar timing and navigation. The paper is organized as follows.

Section one gives an introduction of the cylindrical silicon drift detectors and the background of the X-ray pulsar timing and navigation.

Section two tries to state the working principle of the cylindrical SDD and get the potential distribution inner the detector after giving substantial parameters of the detector.

Section three studies the transport properties of the electron clouds along the potential valley. Because of more rapidly changed potential along the detector depth, the distribution of electron clouds will be a steady narrow Gaussian form in tens of nanoseconds. However, in the direction along the detector surface, the drift time will be hundreds of nanoseconds if the detectors radius is millimeters. If taking into the repulsion effect, we could also get the distribution of electron clouds along the detector surface by considering the electron clouds as flat disk geometry model and solving the continuity equation.

Section four suggests a general analog readout electronics for the use of SDDs in X-ray pulsar timing and navigation. The signal after pre-amplifier should be divided into two paths for both the time and energy determination. The signal for the timing and trigger should be fast shaping and reserve more primitive character of the signal rise time after the pre-amplifier, while the signal for the energy discriminating should be well Gaussian shaping to get better energy resolution.