CHAPTER 1: INTRODUCTION

Experimental physics depends strongly on the capability to measure a variety of different physics observables in nature. Therefore, any recent progress in fields of experimental physics, such as nuclear and high-energy physics, depends largely on improvements in detector technology.

Most of the modern radiation detection methods rely on the interaction between the radiation and the detector medium. More specifically, charged particle detectors operate by measuring the ionization caused by the incident particle in detection mediums such as gas, scintillation crystal, or semiconductors. The released electrons are converted into an electric pulse that will provide information about the incident particle.

Semiconductor detectors, also known as solid-state detectors, were first developed in the early 1950's. Compared to other types of detectors, such as scintillation counters and gas chambers, semiconductor detectors have a much higher detection medium density. Consequently, an incident particle has a higher probability to interact with the medium therefore the total number of ionized electric carriers increases thus providing a better energy resolution, when compared to other types of detectors. Due to this high resolution, semiconductor detectors were quickly used in nuclear physics research for charged particle detection and gamma spectroscopy.

In more recent years, semiconductor devices have also gained attention in high-energy physics as high position resolution detectors for particle tracking. The relatively fast timing characteristics allow the use of these devices in high rate experiments. However, the disadvantages are the size limitation and the high susceptibility to performance degradation due to radiation-induced damage.

From the semiconductor materials such as Germanium, Gallium-Arsenide, Diamond, Cadmium-Telluride and Silicon, the latest is the most widely used. It has a band gap of *1.16 eV*, which is low enough to ensure the electron pair production by a charged particle, but high enough to avoid large dark current generation at room temperature (at room temperature $kT=0.026\ eV$). In addition to its applications in research areas such as nuclear and high-energy physics, semiconductor technology has grown widely into commercial areas such as integrated circuits for computers, infrared and CCD cameras. Due to the use of Silicon in integrated circuits, highly sophisticated processing and manufacturing technologies are available and presently Silicon crystals are produced in a variety of sizes and orientations with high levels of purity.

In the next chapter, a brief introduction of semiconductor physics and its basic concepts is presented followed by an overview of the main types of Silicon detectors. Further details of semiconductor physics can be found in the literature [ref. 1.1, 1.2].

The primary application of the Silicon Drift Detectors discussed in this thesis is in the Silicon Vertex Tracker (SVT) [ref. 1.3], one of the main components of the STAR (Solenoidal Tracker at RHIC) experiment at RHIC [ref. 1.4]. The SVT and the STAR projects are described briefly in chapter 3, followed by the main requirements imposed on a Silicon device in order to operate as a tracking detector in a heavy-ion collision environment. Also in this chapter, the final configuration of the Silicon Drift Detector developed for the SVT is described in detail.

In chapter 4, the detector operation and performance are characterized through the results of laboratory bench tests. Electric measurements performed on probe stations provide information of the detector quality, while drift curves measurements performed on a laser injection test station provide information of the operational characteristics of the detector. Based on these measurements, a testing procedure was developed to select the detector wafers that will be utilized for the SVT.

As will be discussed in chapter 4, the drift velocity varies with temperature. Since the SVT will perform at ambient temperature, with little temperature control, it is necessary to calibrate the drift velocity in order to maintain the high position resolution achievable with these detectors. Calibration is achieved through charge injection at localized drift distances. In chapter 5, different charge injection methods are discussed and compared. The reasons that lead to the choice of a MOS type injection methods for the final detector design are presented.

Previous applications of Silicon Drift Detectors in heavy-ion experiments are presented in chapter 6. Mainly two experiments, WA98 and NA45 at the SPS at CERN (Geneva) have used Silicon drift devices as vertex and multiplicity detectors. In both experiments the Silicon Drift Detector used were radial detectors with a circular configuration.

Recently, an array of linear STAR Silicon drift detectors was assembled in a relativistic heavy ion experiment at the BNL/AGS experiment 896. For the first time Silicon Drift Detectors were utilized as tracking devices and that STAR Silicon Drift Detectors were integrated with their corresponding front-end electronics and readout system. An overview of the experiment as well as details of the detector assembly is presented in chapter 7. Also in this chapter, the main steps of the E896 data analysis are described.

In chapter 8, the performance of the Silicon Drift Detectors is discussed based on results from data taken during the 1997 Gold beam time at the AGS. Hit occupancy and efficiency are compared to simulation results and the integrated charge distribution is compared to an energy spectrum calculated through energy-loss equations and statistical distributions.

The BNL/AGS-E896 superconducting magnet in which the Silicon Drift Detector were mounted provided a unique opportunity to study the effects of large magnetic fields on the dynamics of electron transport in semiconductors. In chapter 9, these magnetic field studies are presented.

Finally, in the last chapter, conclusions and future prospects are discussed.