CHAPTER 1

Introduction

From 1997 to 2010, the KEKB asymmetric electron positron collider at the High Energy Research Organization or KEK (Kō Enerugī Kasokuki Kenkyū Kikō), Tsukuba, Ibaraki prefecture, Japan, utilized 8 GeV electrons to collided with 3.5 GeV positrons in order to generate massive amount of B meson and $\bar{B}$ meson. A multilayer particle detector system of this collider, named “Belle”, was located at the collision point of the accelerator. By using the Belle detector, there were significant achievements in studying of B meson, charm hadron, Υ lepton decays and, especially, the experimentally confirmation of the CP-violation by Makoto Kobayashi and Toshihide Maskawa [1], which demonstrated that the CabibboKobayashi-Maskawa (CKM) mechanism is the dominant source of CP-violation in the standard model (SM). Due to the success of this experiment, Makoto Kobayashi and Toshihide Maskawa shared the 2008 Nobel Prize in Physics [1].

Although the SM theory was experimental demonstration successfully, it still has some clues which indicate the new physics beyond the model. For example, there are still many unknown parameters in the SM that must be determined experimentally. There is also a serious unresolved problem with the matter-antimatter asymmetry in the universe. While the CP-violation is a necessary condition for the evolution of a matter dominated universe, the observed CP-violation within the quark sector that originates from the complex phase of the CKM matrix is insufficient to explain the dominance of matter in the universe. Hence, there must exist undiscovered sources of the CP asymmetry responsible for the matter domination [2].

The future experiments in high energy physics are designed to to search for the new physics using complementary approaches. One approach fro the energy frontier can be reached with the ATLAS and CMS experiments at the Large Hadron Collider (LHC) of the European Organization for Nuclear Research or CERN (Conseil Européen pour la

Recherche Nucléaire) and the Tevatron experiment at the Fermi National Accelerator Laboratory (Fermilab). The second approach for the rare processes or the precision frontier which the observable signatures of new particles or processes can be obtained through measurements of flavor physics reactions at lower energies and an evidence of a deviation from the SM prediction. This approach is, for example, performed by the LHCb experiments at the LHC, the BESIII experiments at the BEPCII charm factory, the planned SuperB factory in Italy, and the Belle II experiments at SuperKEKB [2]. A detailed study of correlations among various observables, sensitivities and expected physics outputs of the Belle II experiment can be found in Ref.[3].

In order to explore physics beyond the SM via the rare processes, increase of accelerator luminosity can push the experiment to reach the detection sensitivity of the new physics effects. SuperKEKB collider (Fig. 1.1) is the next step of KEK on particle physics research with an unprecedented high luminosity of $8{\times}10^{35}\ cm^{-2}s^{-1}$ [1]. The experiment using this collider is expected to provide the physics event rate of 50 ab^{-1}, which if 50 times higher than the Belle experiment. The next generation of the Belle detector, called Belle II detector, is a general purpose spectrometer for next generation flavor physics experiment to search for the new physics beyond the CKM picture of the SM. Since the increased level of background from the 40 times higher luminosity, the Belle II detector has to deal with higher occupancy and radiation damage than the Belle detector. Furthermore, the increased event rate puts high demands on trigger, data acquisition, and computing process. To be able to operate at the conditions of the SuperKEKB collider, the components of the Belle detector are either upgraded or replaced by new ones. A detailed description of the detector can be found in Ref. [2]. Figure 1.2 shows the layout of the Belle II components, which will be operate with the 1.5 T super conducting solenoid magnet.

A Central Drift Chamber (CDC), a cylindrical multi-wire proportional chamber of the Belle detector, was working well along a decade for the KEKB operation without any serious problems [2]. The CDC provides significant roles of particle detection. Firstly, it provides the precise determination of charged particle trajectories and momenta. Figure 1.3 shows a reconstructed tracks of the charged particles from the Belle experiment [6].

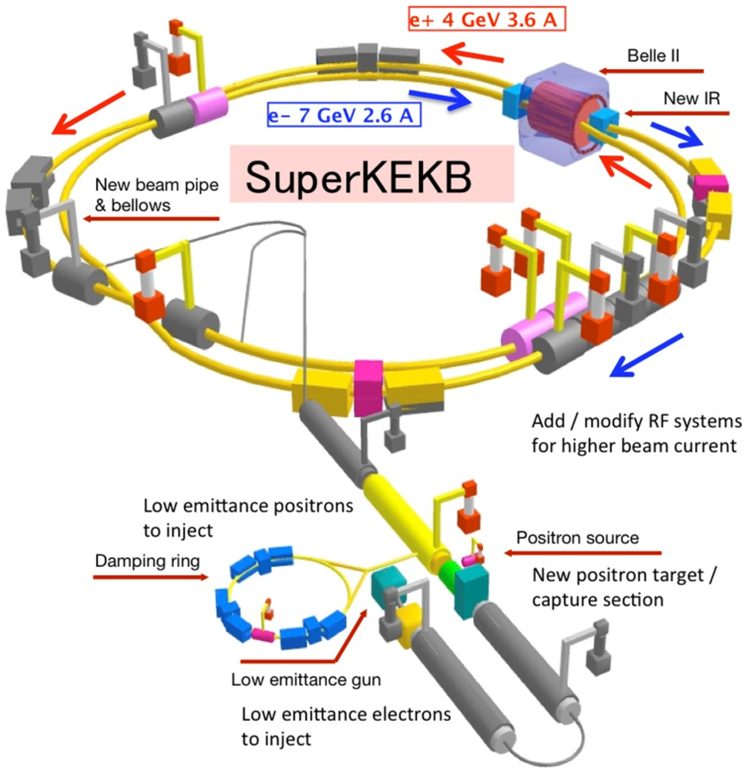

Figure 1.1: Schematic view of the SuperKEKB [4].

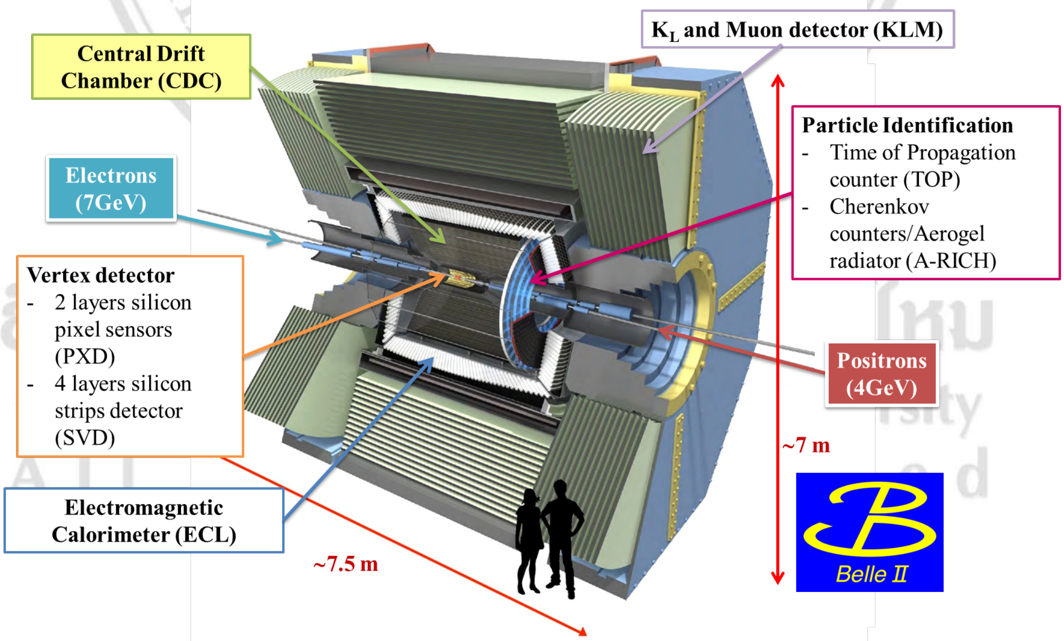

Figure 1.2: Layout of the Belle II detector components [5].

The momentum of each particle is calculated from its curved trajectory due to the 1.5 T magnetic field. Secondly, it provides the particle identification information using the energy loss within its gas volume, dE/dx. Lastly, it provides the signal of the incoming charged particle data, or the so-called “event”.

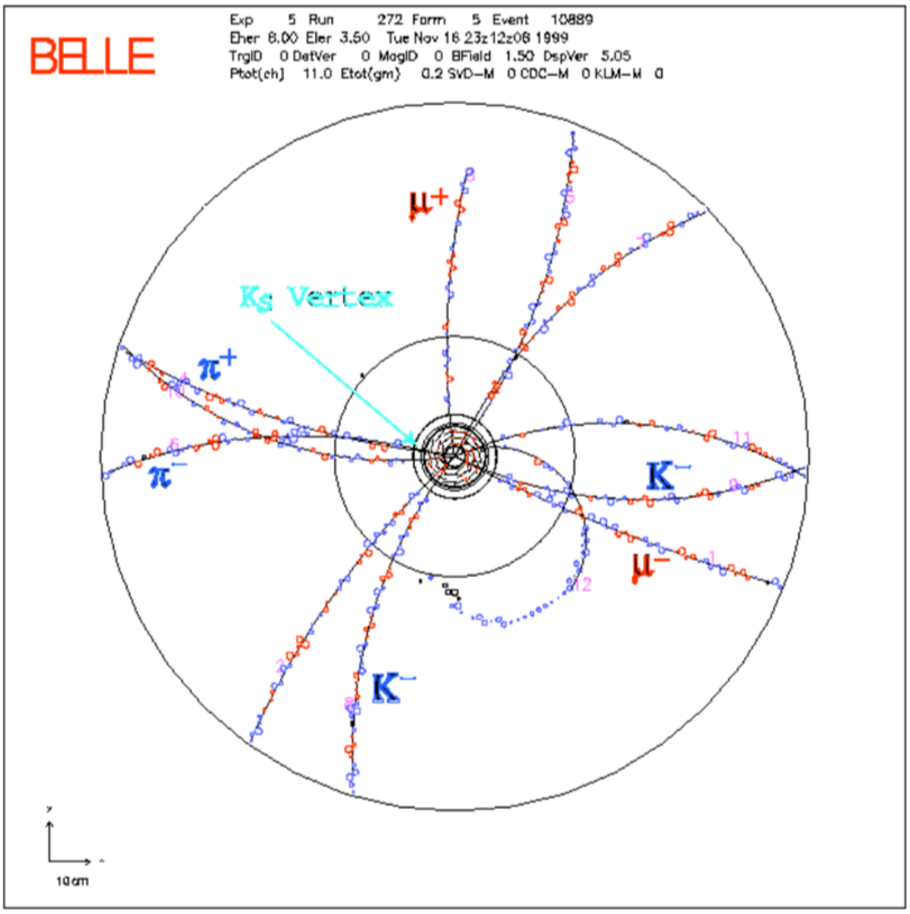

Figure 1.3: A reconstructed tracks of the charged particles from the Belle experiment

For the Belle II detector, the new CDC had been designed and constructed.The Belle II CDC is expected to face the 30 times larger beam background than the Belle detector at KEKB. This is due to the higher beam current and the luminosity [2]. Hence, the increase of the background tolerance and the improvement of the signal-to-noise ratio are significant [1]. In addition the two innermost layers with tiny cell size of 5 mm inner chamber, were installed to the Belle CDC in 2003 and achieved improved the ratio [2]. The smaller azimuthal cell size utilization provides, the better momentum resolution. In consequence of these mentioned reasons, the new design of smaller cell chamber for the Belle II CDC is required. Therefore, the eight layers of tightly space axial wires were constructed for the inner chamber of the Belle II CDC, which is called “the small cell chamber”. This research focused on the assemble of the small cell chamber and several significant tests. The test results demonstrated that the chamber was working well.

Since the inner part of the Belle II CDC is based on the multi-wire proportional chamber operation principle, the theoretical study of the principal will be described in Chapter 2. The characteristics, structure and wire configuration are discussed in Chapter 3.

The assembling of the inner part of the Belle II CDC begins with the construction of the core structure of the inner chamber including both aluminum endplates and the 0.52 mm carbon-fiber reinforced plastic (CFRP) inner cylinder. Then, the wires were strung and their tensions were tested. After that, the chamber was inserted to a temporary aluminum cover and the chamber was filled with helium gas for checking the gas leak. These assemble methods and all mechanical tests are explained in Chapter 4.

Chapter 5 describes and discusses the tests of the chamber with a prototype readout electronics board [7] by using the cosmic rays detection. The chamber was filled with 50 % He – 50 % C_2H_6 by volume. The high voltage was applied to the chamber and the leak current was checked. Then, the detection setup was arranged. The data events were accumulated by the prototype readout electronics board. The data analysis was performed by the using the ROOT program. The test results including the generated charge distribution, the drift time distribution, the fitting of XT function the cosmic ray track reconstruction and the calculation to approximate the spatial resolution will be discussed as well.