氏　　　　　名	岩田　修一（イワタ　シュウイチ）
所　　　　　属	理工学研究科　物理学専攻
学 位 の 種 類	博士（理学）
学 位 記 番 号	理工博　第 190 号
学位授与の日付	平成 28 年 3 月 25 日
課程・論文の別	学位規則第 4 条第 1 項該当
学 位 論 文 題 名	スーパーB ファクトリー実験用粒子識別装置 Aerogel RICH 検出器の開発（英文）
論 文 審 査 委 員	主査　准教授　角野　秀一
	委員　教　授　住吉　孝行
	委員　教　授　田沼　肇
	委員　准教授　足立　一郎（高エネルギー加速器研究機構　素核研）

【論文の内容の要旨】

本文

The framework to explain various phenomena in elementary particle physics known as the standard model (SM) had completely been established by the experimental discoveries, such as the *CP* violation in a *B* decay system and the existence of the Higgs boson expected in the SM. The next aim in elementary particle physics is a search for the physics beyond the standard model (BSM). As one of the approach of searching the physics BSM, now, the Belle II experiment, which is known as a super B-factory experiment, is being built at High Energy Accelerator Research Organization (KEK), Tsukuba, Japan. Belle II uses an asymmetric energy e^+e^- collider, which is named as the super KEKB accelerator, and the experiment consists of the Belle II spectrometer. That is the project upgraded from the Belle experiment that contributed to discover the *CP* violation in *B* system and achieved the world record of the highest peak luminosity.

The aim of super B-factory experiments is an indirect investigation of properties of the physics BSM through measurements of rare *B* decays, which were difficult to measure in the previous B-factory experiments. In particular, because the rare *B* decays are contaminated by similar decay modes in the SM, we have to exactly reject the contribution of mimic decays from the signal decay. For example,

$B \to \rho(\to \pi\pi)\gamma$ and $B \to K^{*}(\to K\pi)\gamma$ are known as the radiative penguin decays, and are strongly suppressed in the SM because these processes are the Flavor Changing Neutral Current (FCNC), that is prohibited from occurring through the tree diagram in the SM. Therefore, the precise measurement of a deviation from the SM predictions for the above decays is one of the good probe to verify the existence of the physics BSM. In order to discuss the effect of the physics BSM, we have to suppress the systematic uncertainty below a few % in a super B-factory experiment.

Due to this requirement, high energy physics experiments using accelerators including a super B-factory commonly uses the high precision particle identification (PID) device. Because $B \to \rho\gamma$ and $B \to K^{*}\gamma$ mostly decay into $\pi\pi$ and $K\pi$ respectively, the π/K separation with high precision is very important to collect only the signal decay mode efficiently. A Ring Imaging Cherenkov (RICH) counter is one of the methods providing the good charged particle identification. As a new PID device for the forward end-cap region of the Belle II spectrometer, a proximity-focusing type Ring Imaging Cherenkov counter with a silica aerogel as a radiator, which is named as Aerogel RICH (ARICH) counter, has been developed. The ARICH counter is designed to provide 4-sigma π/K separation in the wide momentum range up to 4 GeV/*c*. Especially, we aim at performing π identification as over 99% efficiency with a few % K fake probability at around 3.5 GeV/*c*, which is the expected momentum of a daughter particle decaying from the important B decay to search the physics BSM.

The ARICH counter consists of 144-ch multi-anode Hybrid Avalanche Photo-Detectors (HAPDs) as position sensitive photon detectors. One of the important concerns in the ARICH development is the radiation hardness of the HAPDs. We had studied and improved the HAPD to sustain the radiation damage during the 10-year Belle II operation of the expected fluence (<10^{12} one MeV-equivalent neutrons/cm^2) and the dose (<100 Gy for γ-ray).

As the final step of the development, we constructed a prototype ARICH counter using the designed HAPDs and large size aerogel tiles. We verified the performance of the prototype ARICH counter using a beam test at DESY, and succeeded to observe the Cherenkov ring images for 5 GeV/*c* electrons. As a result, we evaluated the number of the detected photoelectrons and Cherenkov angle resolution as 10.495 photoelectrons per a track and 14.03 mrad, respectively.

In order to estimate the PID performance of the ARICH counter, we performed an event-by-event analysis based on the likelihood method for the beam test data. We defined the probability density functions (PDFs) for distribution of the accumulated Cherenkov angle and the number of detected photoelectrons per a track.

In order to emulate π/K identification of the ARICH counter using the events obtained with the electron beam, we prepare the PDFs for signal and background assumption, and calculated likelihoods for an event of the beam test.

In this thesis, I present the development of the RICH counter using the silica aerogel tiles as the radiator for Belle II as a super B-factory experiment, especially the result of the study and improvement of the HAPD to enhance the radiation hardness for 10-year Belle II operation. We also present the PID performance of the prototype ARICH counter using the beam test. We estimated the π identification efficiency $\varepsilon(\pi)$ as 97.4% with the K fake probability as 4.9% at 3.5 GeV/c, and confirmed that these results were mostly acceptable to our target PID performance as the Belle II experiment.