High Energy Nuclear Physics Laboratory
Chief Scientist: Takehiko Saito (Ph.D.)

(0) Research field

CPR Subcommittee: Physics

Keywords: Nuclear physics, hadron physics, strangeness, detector technique, machine learning

(1) Long-term goal of laboratory and research background

We would like to reach the comprehensive understanding of the interactions among microscopic particles that is essential to understand the building block of the matter in our universe. We study the hadronic interactions by using energetic heavy ion beams at international large accelerator facilities in Germany and China in order to understand the hierarchy of the matter at nuclear and hadronic levels. Beside leading these large-scaled experimental projects with accelerators, we are developing techniques for particle detections and data analyses, especially for passive detectors such as nuclear emulsions at the best precision ever in the world to study structures of multi-strangeness nuclei. We are furthermore aiming to realize those techniques to industrial and medical applications.

(2) Current research activities (FY2019) and plan (until Mar. 2025)

The FY2019 is the first year for the High Energy Nuclear Physics (HENP) Laboratory at RIKEN, which was started in February 2019. During the year, we were mainly working for the experimental hypernuclear project at GSI in Germany, the WASA-FRS project, which has been led by the chief scientist of the HENP Laboratory before he moved to RIKEN. The main goals of project are to confirm the existence of the unprecedented neutral hypernuclei with two neutrons and a Lambda-hyperon and the unpredicted short life of hypertriton, that became very hot topics in the field of nuclear and hadron physics recently, as well as to search for eta'-mesic nuclei. Currently, we are leading and preparing the WASA-FRS experiments at GSI, which will be performed in 2022. Figure 1 shows the technical drawing of the WASA detector to be installed inside the fragment separator (FRS) at GSI. The WASA detector and its associated devices are currently located for the preparation at the dedicated area in the experimental hall at GSI, and we are leading and conducting all the preparation works. In FY 2019, we have completed 1) commission of the inner gaseous detector inside the superconducting magnet, 2) development and test of the prototype of scintillating fiber detectors, 3) preparation of the commissioning of the superconducting magnet, 4) test of the cryogenic system down to the liquid-N2 temperature, and 5) development of the basic framework of software packages for Monte Carlo simulation and data analyses. Figure 2 shows the current status of the preparation of the WASA detector at GSI; the top-view of the whole apparatus in the left panel and the cryogenic devices for the superconducting magnet in the right panel.

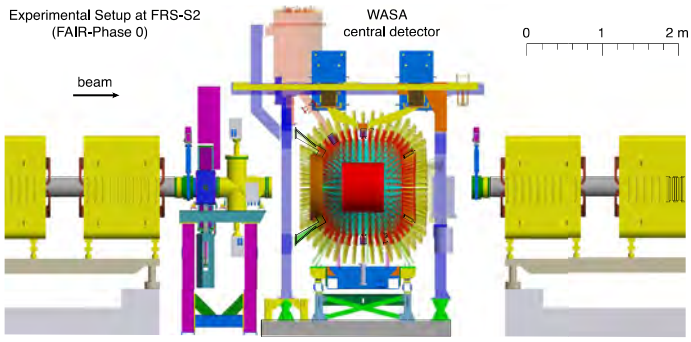

Figure 1: Technical drawing of the WASA-FRS setup which will be installed in the mid-focal plane of the fragment separator (FRS) at GSI in Germany.

We'll continue the preparation of the WASA-FRS experiment in FY2020. The superconducting

magnet will be cooled down to the liquid-He temperature by July 2020, and the construction of the holding structure will soon be started. Upgrading of the plastic scintillator barrel will be completed by the end of the year. All the scintillating fiber detectors will be built by summer 2020, and they will be tested at RIKEN prior to transport them to GSI for the experiment. We have built up a new laboratory at RIKEN, as shown in Figure 3, and the preparation of the test of all the fiber detectors is currently in progress. In the new laboratory, we are also preparing the facility to analyze the emulsion data from the J-PARC E07 experiment to study hypernuclei with double-strangeness, and we have started a new project for the data analyses by employing machine learning technique. We also built up our own computing facility, currently with approximately 1400 CPU cores, 67000 GPGPU CUDA cores and 200 T Byte storage for Monte Carlo simulation, data analyses and machine learning. In addition to the fundamental researches, we also started a new project to develop the super-precise imaging techniques with neutrons and gamma-rays, together with collaborators in/outside RIKEN.

Figure 2: Phots representing the current situation of the preparation of the WASA apparatus at GSI.

Figure 3: Newly constructed laboratory space in the HENP Laboratory at RIKEN.

The coming five years till 2025 are very important for the research activities of the HENP Laboratory. As mentioned above, the WASA-FRS experiment will be performed in 2022 at GSI, and we have to complete all the preparations at RIKEN and GSI in advance to the experiment. The data, information and accumulated experiences from the WASA-FRS experiment will be very important input to our future multi-strangeness hypernuclear experiments at FAIR in Germany and HIAF in China since the WASA-FRS experiment is a pilot project towards them.

After the WASA-FRS experiment, the design works on the detectors for the experiments at FAIR and HIAF should be completed by 2025 prior to the new FAIR and HIAF accelerator facilities being operational. The completeness of the emulsion data analyses on the J-PARC E07 experiment should also be met before 2025 since the physics program at HIAF depends on the result of the analyses with emulsions. To complete the analyses before 2025, the modern, fast and efficient analyses techniques should be developed, and we'll first develop techniques with machine learning. We are also aiming to realize the newly developing neutron and gamma-ray imaging techniques for the industrial and medical applications by 2025.

(3) Members as of March, 2020

(Chief Scientist)
Takehiko Saito

(Research scientist)
Yoshiki Tanaka

(Technical Staff)
Hiroyuki Ekawa, Manami Nakagawa

(International Program Associate)
Abdul Muneem, Enqiang Liu

(Assistant)
Yukiko Kurakata

(4) Representative research achievements

1. Take R. Saito, invited talk, "Update on the WASA-FRS Experiment", NuSTAR Annual Meeting 2020, GSI, Germany, March 2nd, 2020.
2. Take R. Saito, invited seminar, "New Research Activities at RIKEN: Hypernuclear Physics with Heavy Ion Beams and Beyond ", Special Seminar, Osaka University, Japan, December 25th, 2019.
3. Take R. Saito, invited talk, "Few-body strangeness nuclei and their puzzles", 24th European Conference on Few-Body Problems in Physics, University of Surrey, Guildford, UK, September 2nd-6th, 2019.
4. Take R. Saito, invited lecture, "New Frontier on the Hypernuclear Physics", NUclear physics School for Young Scientists (NUSYS-2019), Institute of Modern Physics, Lanzhou, China, August 12th-17th, 2019.
5. Take R. Saito, invited talk, "Hypernuclear experiments with Heavy Beams: HypHI and Beyond", 4th CBM-China Workshop, Yichang, China, April 12th-15th, 2019.

Group Photo

Figure 4: Bottom row, from left, Vasyl Drozd, Enqiang Liu, Manami Nakagawa and Abdul Muneem. In the top row, from left, Yukiko Kurakata, Yoshiki Tanaka, Takehiko Saito, Yue Ma and Hiroyuki Ekawa. Vasyl Drozd is a Ph.D. student of GSI and University of Groningnen working for the WASA-FRS experiment, and he stayed at RIKEN for a month in September and October in 2019.

Laboratory Homepage
https://www.riken.jp/en/research/labs/chief/high_ener_nucl_phys/index.html