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## Preface

An accelerator complex which gives extremely high-intensity proton beams is being constructed in Tokai, Japan. The project is operated by JAEA (Japan Atomic Energy Agency) and KEK (High Energy Accelerator Research Organization) and called J-PARC (Japan Proton Accelerator Research Complex). J-PARC accelerator complex consists of 200 MeV linac, 3 GeV rapid cycling synchrotron, and 30 GeV main synchrotron. The energy of linac will be extended to 400 MeV and the energy of the main ring will be increased to 50 GeV in the near future.

J-PARC aims to perform various researches of life and material sciences by using neutron beams from the 3 GeV rapid cycling synchrotron. J-PARC also aims to perform various particle and nuclear physics experiments by using the 50 GeV main synchrotron. In this book we collected several proposals of particle and nuclear physics experiments to be performed by using 50 GeV main synchrotron.

Prof. Nagamiya gives a brief introduction of J-PARC. He describes the purpose of the project, the aims of the various facilities, and the researches to be done by using these facilities.

Prof. Ichikawa discusses about the long baseline neutrino oscillation experiment. This proposal is called T2K (Tokai to Kamioka) and it aims to measure mixing angles in the lepton sector. They try to perform a precise measurement of  $\theta_{23}$  by measuring the  $\nu_\mu$  disappearance. Then they go to determine  $\theta_{13}$  by measuring  $\nu_\mu \rightarrow \nu_e$  appearance signal. They also search for sterile components by measuring NC events.

Prof. Lim discusses about the experiment which searches a very rare decay of the neutral kaon:  $K_L^0 \rightarrow \pi^0 \nu \bar{\nu}$ . This decay occurs via a direct CP violation. He will search this decay mode with higher sensitivity than the standard model expectation level.

Prof. Imazato presents his plan to measure T-violation effect in  $K^+ \rightarrow \pi^0 \mu^+ \nu$  decay. He performed a precise measurement of this T-violation effect by measuring the transverse polarization of the decay muon using the TOROIDAL spectrometer system at KEK 12-GeV PS. He will use the same

detector system with some modifications at J-PARC. His goal is to measure the muon transverse polarization with an accuracy of  $10^{-4}$ .

Prof. Tamura describes the gamma-ray spectroscopy of  $\Lambda$ -hypernuclei. It aims to study hyperon–nucleon interactions, impurity effect in the nuclear structure, and medium effect in baryon properties through the precise measurements of the hypernuclear level structure using Ge detectors. With the development of a large-acceptance Ge detector array with fast readout electronics, he succeeded in the high-precision spectroscopy of  $\Lambda$ -hypernuclei of p-shell region. He will extend such studies in the wide range of hypernuclei from  ${}^4_\Lambda\text{He}$  to  ${}^{208}_\Lambda\text{Pb}$  at J-PARC.

Dr. Naruki reports their experiment to observe a pentaquark state  $\Theta^+$ . Since the LEPs collaboration observed a narrow resonance at 1540 MeV/ $c^2$  in 2003, many positive and negative results have been reported all over the world. They tried to observe this exotic state at KEK 12-GeV PS and obtained a hint to the possible existence of this exotic state. She is planning to search for this resonance by measuring  $\pi^- + p \rightarrow K^- + \Theta^+$  with much higher sensitivity.

Dr. Yokkaichi discusses about mass modification of vector mesons in nuclear medium. This subject is related to the spontaneous breaking of the chiral symmetry in QCD, which is considered to play the main role in the mass generation mechanism of light quarks and hadrons. He reports on the vector meson mass modification, in particular, on the  $\phi$  meson modification, observed in KEK-PS E325 experiment. At J-PARC he is going to collect 100 times statistics as that of the previous KEK experiment and investigate the in-medium meson properties in detail.

Prof. Iwasaki describes experimental mesonic bound states in nuclei. He reviews past experimental results which were not conclusive. These facts brought motivation for new experiments at J-PARC. He introduces three approaches: (1) study of kaonic atom, (2) search for the kaon bound states, and (3) search for the  $\phi$ -meson bound states. The first two use different modes from the previous experiments, i.e., (1)  ${}^3\text{He}$  instead of  ${}^4\text{He}$  and (2)  $K^-pp$  instead of  $K^-ppn$ . Both modes will provide decisive tests for the Akaishi–Yamazaki prediction of deeply bound kaonic nuclei. The third one is a new experimental approach to study vector meson in medium.

Prof. Kuno reviews nuclear and particle physics by using intense muon source produced at J-PARC MR. There are a variety of potential projects which could be realized with a high-intensity muon beam,  $10^{10}$ – $10^{12}$  muons/s. Among them, there are three important particle physics programs: (1) precision measurement of muon  $g - 2$  anomalous magnetic moment, (2) search for muon electric dipole moment (EDM), and (3) search for lepton flavor violation of charged leptons (LFV). All three are very important to search for new physics. Here he focuses mainly on one of LFV search projects, i.e., search for coherent muon electron conversion (COMET) and its future extension (PRISM).

In this book, eight representative experimental proposals are presented. Many more experiments are actually planned at J-PARC which will explore the high-intensity frontier of particle and nuclear physics.

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