Research Group for Hadron Nuclear Physics

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The research objectives of the Hadron Nuclear Physics Group are 1) experimental studies of exotic hadrons and nuclei with strange and charm quarks, hot and dense partonic/hadronic matter at J-PARC, BNL-RHIC, and Belle (II), and 2) theoretical studies of exotic hadrons, nuclear matter, and neutron stars at low and high densities, including strangeness and charm quarks. Through these topics, we investigate many-body problems of quarks and hadrons in relation to Quantum Chromo Dynamics (QCD).

Hadron experimental studies at J-PARC

We found 35 double hypernuclei from 85 % of emulsion in J-PARC E07 (studies of double Lambda hypernuclei) [1]. In particular, the multiple hypernuclei events ($\Xi^- + {}^{14}\mathrm{N} \rightarrow {}_{\Xi}{}^{15}\mathrm{C}$) that we identified will provide important information on the interaction between Ξ and nucleons as shown in Fig. 1.

The proposal of J-PARC E72 (search for a new Λ resonance) was officially approved by the Program Advisory Committee (PAC) of J-PARC in Dec. 2019 [2]. In preparation for the Hyperon Spectrometer for E42 (H-dibaryon search), E45 (baryon spectroscopy with $\pi \mathrm{N} \rightarrow \pi\pi \mathrm{N}$ reactions), and E72, a beam test of the water Cherenkov counter was performed at ELPH, Tohoku Univ. in Oct. 2019. As a result, the performance of the detector was confirmed to be consistent with the simulation. Then, the water Cherenkov counter prototype and the TPC of E42 were moved to the K1.8 experimental area in Nov. 2019 to test them during the E40 experiment in Feb. 2020. We also submitted a Letter-Of-Intent for a double K-nucleus K^-K^-pp to J-PARC PAC.

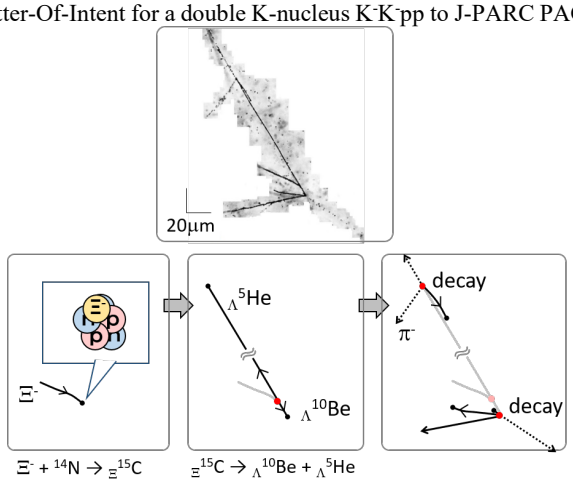

Fig.1: A hypernuclear event of $\Xi^- + {}^{14}\mathrm{N} \rightarrow {}_{\Xi}{}^{15}\mathrm{C}$.

J-PARC E16 aims at studying in-medium modification of ϕ spectrum which decays into e^+e^- inside the nucleus. The first beam time of E16 was scheduled in Feb. 2020, with the proton beam transported in the high-momentum beamline. We installed the lead glass calorimeter, Hadron Blind Detectors, and GEM (Gaseous Electron Multiplier) Trackers on the E16 spectrometer for electron measurements [3]. In addition, we developed and installed prototype detectors for charged hadron identification with the time-of-flight measurement: a high-timing resolution chamber (Multi-gap Resistive Plate Chamber), and start timing counters. For J-PARC E03 (Ξ atom X-ray spectroscopy) which will be performed late JFY2020, the maintenance work of Ge detectors was completed in June 2019 and the tuning of secondary kaon beamline was scheduled in Feb. 2020.

The beam time in Hadron Experimental Hall was postponed, and the test of the E42 water Cherenkov counter and TPC, the E16 experiment, and the E03 beamline tuning were rescheduled in June 2020.

Other research activities

We proposed the future heavy-ion beam program at J-PARC called J-PARC-HI to create dense baryonic matter to search for the first order phase boundary and the QCD critical point in the QCD phase diagram [4]. J-PARC-HI was selected as one of the large research projects in Master Plan 2020 of Science Council of Japan. We studied the beam transport of heavy-ion in the high-momentum beamline. and found that heavy-ion beam of 10 AGeV/c up to 10^8/spill can be transported in the current beamline and radiation shields.

We are participating in Belle and Belle II experiments for studies of hadrons with heavy quarks. Belle II is steadily taking data and is expected to exceed the highest luminosity of Belle in early JFY2020.

Reimei research programs

The Reimei research program “The Quark and Gluon Structure of Subatomic Particles” was proposed to advance research discoveries in unfolding the quark and gluon structure of hadrons, and develop plans for J-PARC-HI through an international collaboration with Ken Hicks (Ohio Univ.). We held the workshop “Synergies in Hadron Physics between J-PARC and JLab” in Nov. 2019 at Jefferson Lab., USA. Discussions in the workshop included advanced plans for a new proposal to J-PARC using the Drell-Yan method and the research preparations for the J-PARC experiments E42, E45 and E72.

References

[1] J. Yoshida, et al, JPS Conf. Proc. 26 (2019) 023005.
[2] K. Tanida, AIP conf. Proc. 2130 (2019) 040019.
[3] S. Ashikaga, et al, JPS Conf. Proc. 26 (2019) 024005.
[4] H. Sako, Nucl. Phys. A982 (2019) 959-962.