# Research Group for Nuclear and Hadron Physics


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The research objectives of Research Group for Nuclear and Hadron Physics are 1) experimental study of exotic hadrons and nuclei with strangeness and charm at J-PARC and BNL-RHIC, 2) research and development of high rate particle detectors such as a time projection chamber, silicon strip detectors, and scintillation fiber trackers, 3) theoretical study of nuclear matter at low and high densities and the role of strangeness in nuclear matter and neutron stars. Through these topics, we study many-body problems of quarks and hadrons in relation with QCD.

### Hadron physics experiments at J-PARC

Due to the radiation accident at the hadron experimental hall in May 2013, the hadron beam has been postponed to April 2015, when E13 (gamma spectroscopy in ${}^{4}_{\Lambda}$H and ${}^{19}_{\Lambda}$F hypernuclei) will be resumed. Thus we did not have beam in 2014. We contributed to renovation of the hadron experimental hall for air tightness between the hadron beam line and the experimental hall, to improve readout rates for the interaction monitor of the secondary beam production target and the beam profile monitor in the hadron beam line.

We analyzed data of E27 experiment, to measure the smallest kaonic nucleus, a $K^-pp$ bound state in the d($\pi^+$,$K^+$) reactions. In inclusive analysis which measured only $\pi^+$ and $K^+$, we observed a ΣN cusp structure which is almost consistent with previous data [1]. We also observed a mass shift in the peak of Y* [Σ(1385) and Λ(1405)] by -32.4 MeV/$c^2$. This may be due to Y*N final state interactions. In order to investigate the origin, further experimental and theoretical studies are necessary [1]. In the exclusive analysis where two protons are required, we observed $K^-pp$-like structure in the $\Sigma^0$p spectrum for the first time as shown in Fig. 1 [2]. The $K^-pp$ binding energy and the width are estimated to be 95 MeV and 162 MeV, respectively.

We observed a deeply bound state of $\Xi^-$-nucleus bound state ($\Xi$-${}^{14}$N) for the first time in a new emulsion overall scan method for KEK-E373 experiment [3], from $\Xi^-$ produced in ${}^{12}$C($K^-$, $K^+$) reactions and captured in emulsion atoms.

### Research and development for high rate particle detectors

We have developed detectors for E03, E07, E42, and E45 experiments such as Beam Hodoscope (BH), Beam Aerogel Cherenkov counter (BAC), Proton Veto Aerogel Cherenkov counter (PVAC), and Charge Hodoscope (CH). We evaluated their performance in the test beam experiment at ELPH in Tohoku University. Time-Of-Flight counter (TOF) has been also constructed. The final TPC (HypTPC) with readout pads, GEMs, the gating grid, and a test field cage with a short drift length has been built and tested with radioactive sources. We design the final field cage and the target holder, based on electric field calculations which achieve electric field uniformity of $10^{-3}$ level. The test results of the prototype TPC and Silicon Strip Detectors (SSD) were published in Ref. [4, 5]. The readout electronic system based on GET (General Electronics for TPC) has been developed for HypTPC. We added new functions for fast clear in AD conversion and to send fast clear and second-level trigger signals, and event-tag information from the J-PARC DAQ system.

### High energy heavy-ion physics at RHIC and J-PARC

The RHIC-PHENIX experiment aims at studies of partonic matter called quark-gluon plasma. In 2014, we took Au+Au collision data at nucleon-nucleon center-of-mass energies of 15 and 200 GeV and ${}^{3}$He+Au data at 200 GeV. More than 80% of the vertex pixel detector was functional, which has been developed by JAEA and RIKEN to measure the secondary vertex of heavy-flavor hadrons.

A future heavy-ion program at J-PARC aims at exploring phase structures and hadron properties at the baryon density as high as neutron stars. We are developing a plan for the white paper. The acceleration scheme is being designed using existing 3-GeV Rapid-Cycling Synchrotron (RCS) and the Main Ring (MR). We have also designed a large acceptance spectrometer for hadron and lepton measurements in heavy-ion collisions [6].

### Theoretical study of nuclear matter

We have studied nuclear matter in compact stars. In particular, competition between hyperon mixture and kaon condensation has been studied within a relativistic mean field model. Depending on the kaon potential, Λ and kaon may coexist in uniform matter. However, Ξ vanishes when kaons appear in uniform matter. Currently, the case of inhomogeneous matter with pasta structures is studied.

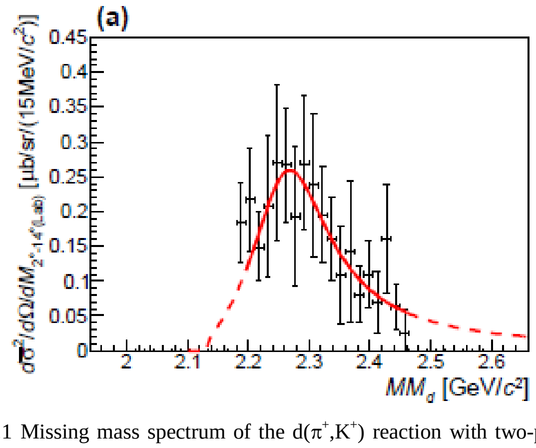


Fig.1 Missing mass spectrum of the d($\pi^+$,$K^+$) reaction with two-proton coincidence for Σp branch events.

### References


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