RCNP WORKSHOP

on

Towards Upgrade of the J-PARC Hadron Experimental Facility

「J-PARC ハドロン実験施設のビームライン整備拡充に向けて」

http://www.rcnp.osaka-u.ac.jp/Divisions/plan/kokusai/ws071111.html

11-12 November, 2007

RCNP, Osaka University

Workshop Summary

This workshop was held on 11-12 November, 2007 at RCNP, Osaka University, as an RCNP Workshop. In the workshop, with more than 60 participants, we intensively discussed future extension of beam lines and experimental apparatus in the Hadron experimental facility at J-PARC. Twenty two authors presented their ideas of experimental researches on 1) Hypernuclear Physics, 2) Hadron Spectroscopy, 3) Chiral Restoration of Hadrons in Nuclear Medium, 4) Quark-Gluon Distribution in Hadron and Hadron System, and 5) Physics beyond the Standard Model in Kaon Decays and Muon-Electron Conversion Process. Experimental overview of each presentation, including physics interest, necessary beam line, experimental setup, and so on, is briefly summarized, as is attached below. Many of them are expected to be proposed at J-PARC in near future.

At the beginning of the workshop, Professor Kazuhiro Tanaka, the leader of the J-PARC Hadron Beam Line Group, presented the status of the construction, showing that a separated secondary kaon beam line (K1.8/K1.8BR) from a primary target (T1) will be ready at the beginning of the beam commissioning, so-called DAY-1. On the other hand, a lot of research programs, not only the experiments approved for execution but also those to be proposed as discussed in the present workshop, are waiting. In order to push forward these research programs by accommodating more experiments in a timely manner, continuous construction of the other beam lines are strongly desired. In Table I, the presented experimental researches are listed in terms of beam lines.

At the end of the workshop, we discussed a strategy in order to fulfill the Hadron experimental hall as a high intensity hadron beam facility. Tanaka reviewed an original plan of the Hadron hall, where three primary beam lines with three thick production targets followed by three or more secondary beam lines, a thin target in a primary beam line followed by two or more secondary beam lines, and some beam lines for future extension were located. The area of the Hadron hall is decided to be shrunk into a half as is put a priority to the Phase I construction of J-PARC. It should be noted that the present Hadron hall is too small to locate the proposed beam lines. It is of essential importance to extend the Hadron hall.

This workshop should be connected to various movements toward planning of upgrade of the J-PARC facilities. Among these, the 4th international workshop on Nuclear and Particle Physics at J-PARC (NP08) will be held on 5-7 March, 2008. The present discussion will be carried on in NP08. It would be expected that the international collaborations are formed.

Workshop organizers

Hadron User's Association (HUA) executive committee

Table I : Summary of presented experimental researches in terms of beam lines. Hatched beam lines and apparatus are waiting to be prepared in the Hadron Hall. (The others are in modification or in preparation for approved experiments.) Experimental number, proposal status, and beam line status are those after the 3rd PAC.

Beam Line	p (GeV/c)	particle	Intensity $\times 10^6$ ppp	Apparatus	Physics (/+):related proposal/LOI with plans yet to be proposed
K1.8	1.5~2 1.2~1.5 ~2	K^- K^+ π	10 10 10	SKSplus, SKS, FEREST(γ detector) Neutron-Spec., γ detector	S=-2 Nuclear Spectroscopy(E05/+) Θ^+-Nucleus, K* in Nucleus ω-Nucleus Spectroscopy (could be done at High-P)
K1.8BR	1	K^-	1	KURAMA/CDC	K-Nucleus Spectroscopy (E15/E17/+, to be done at K1.1)
K1.1	1.1 0.78	K^- π	10 10	Hyperball-J, SKS or SKS-II π^0-Spec., Scifi-MPPC Neutron-Spec.	S=-1 γ-ray Nuclear Spectroscopy YN scattering η-Nucleus Spectroscopy (LoI)
K1.1BR	0.8	K^+ K^-	1	TROIDAL E949 spec. SPES-II	T-violation (E06) Θ^+ Spectroscopy (P09:LoI) Σ Hypernuclei in A=3
HIHR	1~2	$\pi^{+,-}$ pbar	1000 1	High Resolution Spec. K_S-Spec. ϕ(KK)-Spec., Neutron-Spec.	S=-1 Nuclear Spectroscopy (E10/+) Hypernuclear Weak Decay (E22/+) Θ^+ Spectroscopy ϕ-Nuclear Spectroscopy
High-P	30~50 ~2 5~10	p p/pol. p π K^-, pbar	10000 10 10 1~10	ϕ-spec HP-spec. (E906-spec.) Neutron-Spec., γ detector Emulsion	ϕ chiral restoration (E16) Q-G Distribution (P04/+) ω-Nucleus Spectroscopy (could be done at K1.8) Charmed Hypernuclei
KL KL 2nd Phase	<2.1> <5.4>	K_L	8 44	K_L-Spec., i.e. BL from Tx at 5 deg.	$K^0 \rightarrow \pi^0 \nu \bar{\nu}$ (E14/+)
Muon	<0.04>	μ^-	>100000	COMET	μ-e conversion(LoI)
Neutrino	~0.5	ν, $\bar{\nu}$		Dual Liq. Sci. Tracker	Δs in nucleon (could be parasitic on T2K)

Program List

11 Nov (Su)	Afternoon Session 1	Chair A. Tamii (RCNP)
13:00	RCNP director	Opening Address
13:05	K. Tanaka (KEK)	Construction Status of Hadron Experimental Facility of J-PARC
13:30	T. Takahashi (KEK)	Reaction Spectroscopy for S=-2 Hypernuclear Systems
13:55	K. Tanida (Kyoto)	Measurement of Θ^+ width via high resolution (π^-,K^-) reaction/ Search for Θ hypernuclei using (K^+,p) reaction
14:20	H. Ohnishi (RIKEN)	A new approach to study in-medium $\phi(1020)$-meson mass
14:45-15:00	Break	
11 Nov (Su)	Afternoon Session 1	Chair M. Yosoi (RCNP)
15:00	K. Itahashi (RIKEN)	In-medium N*(1535) Spectroscopy
15:25	K. Ozawa (Tokyo)	Combined measurements of nuclear ω bound state and ω mass modification in $p(\pi^-,n)\omega$ reaction
15:50	J. Imazato (KEK)	K1.1-BR beam optics optimized for K0.8 and E06 (TREK) experiment
16:15	N. Muramatsu (RCNP)	Θ^+ study with Low Energy K^+ Beam
16:40	T. Komatsubara (KEK)	K_L^0 rare-decay experiment and the beam line
17:30	Party	
12 Nov (Mo)	Morning Session 1	Chair T. Nakano (RCNP)
8:50	K. Miwa (Tohoku)	Hyperon nucleon scattering experiment using a Scifi and MPPC system
9:15	H. Outa (RIKEN)	Plan of kaonic nuclei and kaonic atom experiments at K1.1 beamline
9:40	K. Shirotori (Tohoku)	Hypernuclear gamma-ray spectroscopy via the (K-,pi0) reaction
10:05	H. Tamura (Tohoku)	Hypernuclear experiments at K1.1 in future
10:30-10:45	Break	

12 Nov (Mo)	Morning Session 2	Chair I. Tanihata (RCNP)
10:45	H. Noumi (RCNP)	Precision spectroscopy on Hypernuclear and Hadron Physics using High Intensity, High Resolution Beam Line
11:10	A. Sakaguchi	Experiments for Studies on Neutron-Rich Hypernuclei
11:35	S. Ajimura (RCNP)	Measurement of nonmesonic weak decay from 4-body Λ hypernuclei at the high intensity and high resolution beam line
12:00-13:00	Lunch Time	
12 Nov (Mo)	Afternoon Session 1	Chair K. Hatanaka (RCNP)
13:00	S. Sawada (KEK)	High Momentum Beam line at J-PARC
13:25	Y. Goto (RIKEN)	Polarized structure measurement of the nucleon with dimuon production at J-PARC
13:50	S. Yokkaichi (RIKEN)	Low mass dielectron measurement (E16) and the high momentum beam line
14:05-14:20	Break	
12 Nov (Mo)	Afternoon Session 2	Chair N. Saito (KEK)
14:20	T. Tsunemi (Kyoto)	Prospects of Searching for Charmed Nuclei
14:45	Y. Miyachi (TITech)	Measurement of strange quark spin component of the proton spin using neutrino-nucleon elastic scattering
15:10	A. Sato (Osaka)	An Experimental Search for Lepton Flavor Violating μ^--e^- Conversion at Sensitivity of 10-16 with a Slow-Extracted Bunched Proton Beam
*	M. Kaneta (Tohoku)	Rough Idea of $K^+ + A \rightarrow K^* + X$ Experiments
	Summary Session	Chair H. Noumi (RCNP)
15:45	K. H. Tanaka (KEK)	Phase-II Extension of Hadron Experimental Facility
16:00	Discussion Summary	

Hypernuclear Physics

Reaction Spectroscopy for S=-2 Hypernuclear Systems	KEK	Toshiyuki Takahashi
Search for Θ hypernuclei using (K^+,p) reaction	Kyoto Univ.	Kiyoshi Tanida
Hypernuclear experiments at K1.1 in future	Tohoku Univ.	Hirokazu Tamura
Hyperon nucleon scattering experiment using a Scifi and MPPC system	Tohoku Univ.	Koji Miwa
Hypernuclear g-ray spectroscopy via the (K^-,π^0) reaction	Tohoku Univ.	Kotarou Shirotori
Experiments for Studies on Neutron-Rich Hypernuclei	Osaka Univ.	Atsushi Sakaguchi
Measurement of nonmesonic weak decay from 4-body Λ hypernuclei at the high intensity and high resolution beam line	RCNP	Shuhei Ajimura
Precision spectroscopy on Hypernuclear and Hadron Physics using High Intensity, High Resolution Beam Line	RCNP	Hiroyuki Noumi
Prospects of Searching for Charmed Nuclei	Kyoto Univ.	Toshinao Tsunemi

Reaction Spectroscopy for S=–2 Hypernuclear Systems

T.Takahashi (KEK)

Physics Motivation

Motivations to study S=–2 system are

(1) Understanding of baryon-baryon interaction as a generalized nuclear force by extending to s quark world. From the viewpoint of flavor SU(3), baryon-baryon system with S=–2 is a new sector and gives an essential information. However a little is known so far; Only Λ-Λ interaction is known to be weakly attractive from Nagara-event which was recently discovered in the emulsion-counter hybrid experiment.

(2) S=–2 system is very dynamic system, since the mass difference between Ξ-N and Λ-Λ is only 28MeV, very smaller than ~80MeV for the difference between Σ and Λ at S=–1 system. Therefore a large mixing between Ξ-hypernuclear states and double-Λ hypernuclear states is expected.

(3) S=–2 system is a small but a significant step toward the multi-strangeness system which is expected to exist in the core of neutron stars. In such high-density nuclear matters, hadrons with strangeness play an important role. Negative charged baryons such as a Ξ^- expect to emerge in such matters, although depending on the interaction in detail.

Experiment Plan

Spectroscopy of Ξ-hypernuclei is one of the major experiments to explore S=–2 systems. Ξ-hypernculei, whose existence is not well established yet, give valuable information on ΞN and ΞN–>ΛΛ conversion interactions, Ξ potential in nuclear matter etc. As a first experiment, we will measure ${}^{12}_{\Xi}$Be hypernuclues produced by the ^{12}C(K^-, K^+) reaction with ~3 MeV (FWHM) resolution (J-PARC E05).

After E05 we are planning to perform following objects, although depending on the E05 results,

(1) The (K^-, K^+) spectroscopy on heavy targets up to ^{208}Pb or ^{209}Bi

Mass number dependence of Ξ potential is one of key to discriminate interaction models.

(2) Study of p-n-Ξ^- (n-n-Ξ^0) system by the ^{3}He(K^-, K^+) reaction

The existence of this bound state depends on the spin-isopin structure of ΞN interaction. If it is bound, this system plays an important role in study of ΞN interaction like a deuteron in the NN interaction.

(3) Production of Ξ-hypernuclear states by the (K^-, K^0) reaction.

The (K^-, K^0) reaction can excite both ΔI=0 and 1 states, while the (K^-, K^+) can excite only ΔI=1 states. Therefore comparison of the both reactions is helpful to study isospin dependence of Ξ interaction.

Beam Requirement

To overcome small production cross section, high-intensity and high-purity K^- beam is required;

Beam momentum:	1.8 GeV/c.
Intensity:	Several x 10^7 /spill K^-
K^-/(charged particles)	>70% (as much as possible)
Δp/p(FWHM)	< 5 x 10^{-4}

Furthermore, since the allowable instantaneous intensity may be limited by the detector ability and accidental coincidence rate etc…, longer spill length is favorable; c.f. 2-3 sec. flat-top length.

Special beam transport such as large beam size at the tracking detectors may be needed so as to reduce counting-rate (per area) of the detectors.

Apparatus

SksPlus spectrometer which will be used in the E05 experiment for the (K^-, K^+) reaction.

Neutral kaon spectrometer in which K^0_s–>$\pi^+\pi^-$ decays are detected and reconstructed is needed for the (K^-, K^0) reaction. In this case, a large aperture detector system which measures weak decay is necessary in order to tag the production of the strangeness. The resolution of the spectrometer is key issue (2-3 MeV is necessary for spectroscopy)

Search for Θ hypernuclei using (K^+, p) reaction.

Kiyoshi Tanida, Kyoto University

Assuming the existence of Θ^+, one can easily guess that there may exist hypernuclei which contain Θ^+. Indeed, there are many theoretical works that predicted their binding energies. The potential of Θ^+ gives a hint on the nature of Θ^+ as it comes from selfenergy of Θ^+ in nuclei; for example, Ref. [1] pointed out a deeply attractive potential originates from the coupling of Θ^+ to $NK\pi$.

Production of Θ hypernuclei requires small momentum transfer as well as large cross-section for the elementary reaction. Also, backgrounds and mass resolution should be considered. In this point of view, meson induced reactions such as (π^-, K^-) and (K^+, π^+) are not suitable because of large momentum transfers and small cross sections. Here we propose (K^+, p) reaction for which the momentum transfer is smaller than Fermi momentum; it becomes nearly zero at around 600 MeV/c, and is as small as 120 MeV/c even at $p_{K^+} = 1$ GeV/c. Another merit for the reaction is that high resolution spectroscopy is possible.

As the first step, we will measure the cross section of the elementary reaction, $d(K^+, \pi^+)\Theta^+$. Such measurement is possible at K1.8 beamline with SKS-plus spectrometer and decay counters, but the sensitivity is rather low even though the missing mass resolution is as good as 2 MeV, because of the low intensity of K^+ beam at 1.2 GeV/c ($\sim 4 \times 105$ per cycle). For higher intensity, we either need K1.1 beamline or a high-momentum spectrometer which accomodates higher momentum K^+. π/K ratio is not very important, but one can expect it is better than 1. Assuming a cross section of 1 μb/sr and an intensity of 107 K^+ per cycle, we will be able to obtain enough yield (3600 counts per 100 hours). Main background sources are quasi-free reactions (elastic and charge-exchange), which can be largely suppressed by requiring sideway particles (p, K^+, and/or $K0_s$) in decay counters.

If the measurement of elementary reaction is successful, we will move to a measurement with a ^{4}He target, for which a yield similar to deuteron target case would be obtained. Heavier hypernuclei are more difficult to observe, but may still be feasible depending on the cross section and background level in the elementary reaction.

[1] D. Cabrera et al., nucl-th/0407007

Hypernuclear experiments at K1.1 in future

Hirokazu Tamura

Department of Physics, Tohoku University

1) Gamma-ray spectroscopy of hypernuclei at K1.1

For most of hypernuclear γ spectroscopy experiments, 1.1 or 1.5 GeV/c K^- beams are necessary to produce both spin-flip and spin-non-flip hypernuclear states by the (K^-,π^-) reaction. The first γ-ray spectroscopy experiment at J-PARC (E13), which has been approved as one of the Day-1 experiments, will be carried at the K1.8 beam line using 1.5 GeV/c K^- beam. However, the beam intensity is expected to be 0.5×10^6/spill at the full 30 GeV proton intensity. On the other hand, the planned K1.1 beam line provides 1.1 GeV/c K^- beam with an intensity of 2×10^6/spill and a purity of $\pi^-/K^- < 0.3$. In addition, the lower momentum transfer in the 1.1 GeV/c (K^-,π^-) reaction allows a better Doppler shift correction than in the 1.5 GeV/c case. Thus the planned K1.1 beam line is still an ideal apparatus for hypernuclear γ-ray spectroscopy, as we described in the Letter Of Intent in 2003.

Therefore, we request to construct the K1.1 beam line and use it for our future γ spectroscopy experiments, such as systematic studies of various hypernuclei in a wide mass region from *sd*-shell to heavy Λ hypernuclei ($^{20}_{\Lambda}$Ne, $^{28}_{\Lambda}$Si, ... , $^{208}_{\Lambda}$Pb, etc.), and measurement of g_Λ in a nucleus for various mass region by γ-weak coincidence method.

The final stage of K1.1 should be a magnetic spectrometer with a resolution better than 0.15% (FWHM). To analyze pion momentum, we need the SKS spectrometer, or a similar spectrometer with a large acceptance ($\sim$100 msr) and a good momentum resolution better than 0.15% (FWHM). Although we can use the SKS when not used at the K1.8 line, we will later request a fund to construct a similar new spectrometer for the K1.1 beam line. The Ge detector array Hyperball-J, which is under construction for the E13 experiment, will be moved from K1.8 to K1.1. It is tolerant to the full K^- beam intensity at K1.1.

2) Study of light Σ hypernuclei at K1.1BR

We plan to measure the spectrum of ^{3}He$(K^-,\pi^+)^3_\Sigma$n using 0.6 GeV/c K^- beam at the planned K1.1BR beam line. Although the $^3_\Sigma$H hypernucleus is expected to be barely bound or unbound, the behavior of the spectrum around the Σ binding threshold can be compared with three body exact calculations and used to derive the strengths of the ΣN interaction separately for different spin-isospin channels. In particular, determination of the strength of the $T = 3/2, S = 1$ channel, which is predicted to be strongly repulsive in the quark model due to Pauli blocking between quarks, is important to understand the short range part of the baryon-baryon force.

In the experiment, we use 0.6 GeV/c K^- beam from the K1.1BR beam line with the highest intensity and a moderate π^-/K^- ratio. We require a beam spectrometer at the end of the K1.1BR line, as well as the existing SPESII spectrometer for scattered particles. In the future, we also measure a ^{3}He$(K^-,\pi^0)^3_\Sigma$H spectrum using 0.6 GeV/c K^-, employing a π^0 spectrometer in order to further investigate the ΣN interaction strengths. In addition, we plan to measure the $\Sigma^0 \to \Lambda\gamma$ decay from $^4_\Sigma$He produced by the ^{4}He$(K^-,\pi^-)^4_\Sigma$He reaction using 0.6 GeV/c K^- to investigate baryon modification in nuclear matter.

Hyperon nucleon scattering experiment using a Scifi and MPPC system

Koji Miwa (Tohoku university)

In order to measure hyperon-nucleaon scattering events with high statistics, we propose an experiment to perform the scattering experiment using Scifi active target and MPPC for its readout. MPPC has characteristics which are suitable for the scattering experiment using a high intensity beam. By using 1.1GeV/c K^- beam whose intensity is more than 1MHz, we aim to detect 1000 Σp scattering events within one month beam time.

A hyperon-nucleon (YN) scattering experiment gives unique information in order to understand YN interaction. It is important to understand a nuclear force from the quark level by introducing a new degree of freedom, "strangeness". However, in reality, the YN scattering experiment is difficult due to the short life of hyperons. The realistic way to understand the YN interaction is to measure the structure of hypernuclei using a high resolution spectrometer or germanium detectors. However there are uncertainties to derive a two body YN interaction from the many body system. Therefore, the YN scattering experiment is the most fundamental way to investigate the YN interaction.

At KEK-PS E289 and E456 experiments, a scintillation fiber (Scifi) active target was used to detect both a production of hyperon and a scattering of hyperon and nucleon as an image. The feasibility of Scifi target was shown. However the statistics of the YN scattering data was still poor, because Image Intensifier Tube, the readout system of Scifi, was slow and could not operate at the high beam intensity.

Here I propose a new YN scattering experiment using Multi Pixel Photon Counters (MPPC) for the readout system of the Scifi. MPPC is a new Si photo-diode consisted of many pixels of Avalanche Photo Diode, each of that operates in a Geiger mode. The characteristics are followings.

- The time response is fast (< 10ns) and MPPC can operate at a high intensity beam.
- The Gain is large (10^5~10^6) and MPPC can detect 1 photon.
- MPPC can operate in the magnetic field.

Because MPPC can operate in the magnetic field, it is possible to surround the Scifi by a tracking chamber and a solenoid magnet. Using the tracking chamber, we can measure the momentum of particles which do not stop in the Scifi. This leads an increase of the acceptance for the charged particles in the final state. In this experiment, Scifi detector is focused to detect the scattered proton and hyperon as an image. The experimental setup is roughly shown in Fig. 1. By separating the roles of the Scifi and the tracking chamber, the size of Scifi can be small. The first target of YN scattering experiment is Σp scattering. The Σ hyperons are produced via the $(K^-,\pi^\pm)$ reactions. We need a beam of 1.1 GeV/c K^- beam because the production cross section of Σ becomes maximum. Moreover, in order to fix the production point of the hyperon, a pencil beam whose size is small is desirable.

In this experiment, with the advantages of both using a high intensity beam and a large acceptance for charged particle, we aim a high statistics YN scattering experiment.

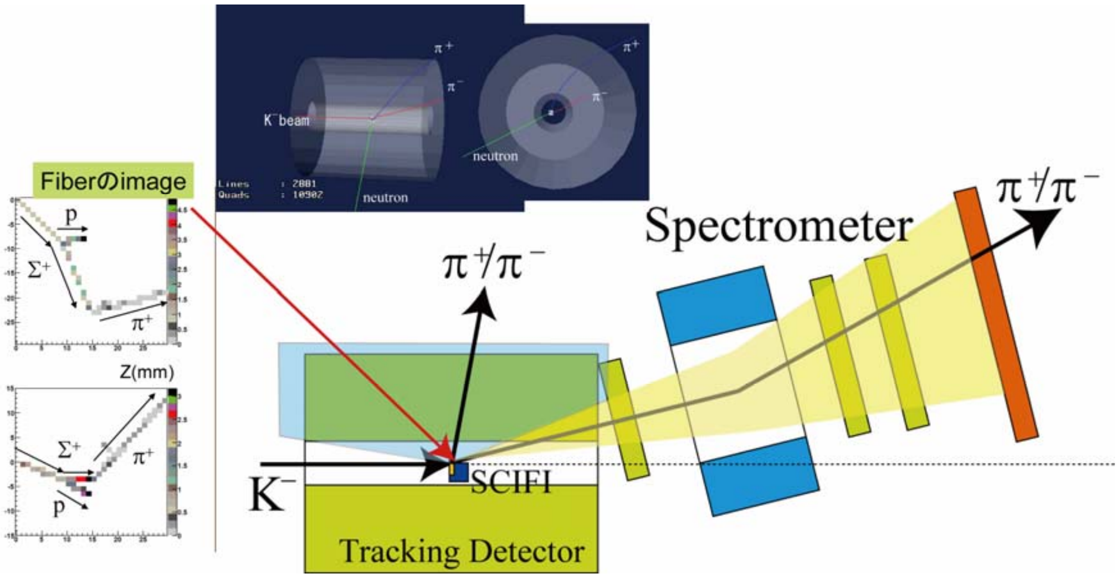

Fig 1. Experimental setup for the experiment. The left figure shows a typical image of Scifi for Σp scattering. The top figure shows a typical event for a tracking chamber. The π+, which does not stop in the Scifi, is detected by the tracking detector.

Hypernucler γ-ray spectroscopy via the (K^-, π^0) reaction

Dept. of Phys. Tohoku Univ. K. Shirotori

Hypernuclear γ-ray spectroscopy via the single-charge exchange (K^-, π^0) reaction allows for studies that are not possible with the non-charge exchange (K^-, π^-) reaction.

One of the purposes of an experiment with this reaction is to measure energy spacings of mirror hypernuclei, such as ($^4_\Lambda$H, $^4_\Lambda$He) and ($^{12}_\Lambda$B, $^{12}_\Lambda$C). A large charge symmetry breaking is suspected from the data on $^4_\Lambda$H and $^4_\Lambda$He so far, whose origin, if exists, remains unknown until now. Another is to investigate neutron-rich hypernuclei. From theoretical calculations of excited states of $^7_\Lambda$He, a large shrinkage effect from a Λ bound in a nucleus is predicted. The core nucleus is a neutron-rich nuclei, ^{6}He. The excited state of ^{6}He is not a bound state, but it is in $^7_\Lambda$He and we can measure an energy of the E2 transition. This γ transition results from the disappearance of neutron-halo in the core ^{6}He and it can probe an origin of neutron-halo structure. Furthermore, we plan to study the *sd*-shell hypernuclei. From measurements of the cascade E2 transition energy and the reduced transition probability (B(E2)) of an even-even core which are known to be well deformed in the mid *sd*-shell, we can study hypernuclear deformation and collectivity as a function of a nucleon number. The single-charge exchange (K^-, π^0) reaction has an advantage of directly producing hypernuclei with the even-even core. However, this is difficult by the non-charge exchange (K^-, π^-) reaction since usage of an enriched less abundant isotopic target is not practical.

In the experiments, two γ rays from π^0 decay are measured by an electromagnetic calorimeter. Precise measurement of an opening angle of those γ rays is essential. But, it is difficult to determine the vertex position in the target, in particular along the beam axis. The calorimeter must have good position resolution and we may also segment the target to determine the precise vertex position. The size of the calorimeter is approximately 1 m $\times$ 1 m and placed at 1 m down stream of the target center. This dimension can be used for various beam momenta. Thus, both the K1.1 and K1.8 beam line can be used for the experiment. Sufficient thickness of the calorimeter to stop γ rays from π^0 (500$\sim$700 MeV) is $\sim$40 cm when CsI crystals are used. γ rays from the hypernuclei are measured and identified by the germanium detector array, Hyperball-J, placed around the target, through the coincidence with the calorimeter.

Experiments for Studies on Neutron-Rich Hypernuclei

Atsushi Sakaguchi
(Department of Physics, Osaka University)
for the J-PARC E10 Collaboration

We J-PARC E10 collaboration attempt to perform an experiment for the studies on properties of the neutron-rich hypernuclei those are not studied well yet [1]. The neutron-rich hypernuclei have many interesting features as follows:

- exotic structures with the large neutron/proton ratios
- possible large contributions of the ΛNN three-body interaction to the nuclear structures thorough the ΛN-ΣN mixing [2]
- links to the ordinary neutron-rich nuclei [3] and the matter properties in the core of neutron stars [4]

The studies require the copious production of the neutron-rich hypernuclei and the precise measurement of the hypernuclear structures. The requirements can be achieved at the same time by spectroscopic studies with the double charge-exchange (DCX) reaction, the (π^-, K^+) reaction, with a high-intensity pion beam line and a large acceptance magnetic spectrometer with a good energy resolution [5, 6]. The minimum requirements on the performances of the accelerator, the secondary meson beam line and the kaon spectrometer system are as follows:

1. flexibility of the beam spill length in the beam acceleration and the slow beam extraction
2. stability of the beam intensity during the slow beam extraction
3. beam intensity of 1.2 GeV/c pions higher than 10^7 particle/spill at the experimental target
4. spectrometer acceptance close to 100 msr for 0.8 GeV/c Kaons
5. spectrometer energy resolution close to 2 MeV (FWHM) for 0.8 GeV/c Kaons

The requirements from 1 to 4 relate on the yield of the production of the hypernuclei. The yield is considerably small due to the tiny cross section of the DCX reaction, roughly 10 nb/sr, which is about 1/1000 of that of the non charge-exchange reaction, so we need the high duty factor and the high beam intensity.

We believe such beam line and spectrometer will be available at the K1.8 beam line of the Nuclear and Particle Physics Facility at J-PARC within a few years. So, as the 1st step of the studies on the neutron-rich hypernuclei, we are planning to produce the ${}^{6}_{\Lambda}$H and ${}^{9}_{\Lambda}$He hypernuclei by the ^{6}Li$(\pi^-, K^+){}^{6}_{\Lambda}$H and the ^{9}Be$(\pi^-, K^+){}^{9}_{\Lambda}$He reactions, respectively. The measurements can be accomplished by minor modifications of the detector system in the K1.8 beam line with ordinary techniques.

For the future extension of the studies on the neutron-rich hypernuclei, we have to improve and develop the beam line and the spectrometer system. Current maximum pion beam intensity, roughly 10^7 pion/spill, is not limited by the primary proton beam intensity from the accelerator, but by the maximum count rates of the beam line tracking detectors. An update of the beam line tracking detectors with the GEM (Gas Electron Multiplier) technique may improve the maximum beam intensity over 10^7 pion/spill. The development of the GEM based tracking chamber is proceeding under the collaboration of Osaka University and Osaka Electro-Communication University.

A breakthrough may be possible by the High-Intensity and High-Resolution (HIHR) beam line and spectrometer system presented by Noumi in this workshop [7, 8]. Thanks to the dispersion matching technique, the HIHR beam line and spectrometer system has no tracking detectors in the beam line in keeping excelent energy resolution, and we can have the pion beam with the intensity close to 10^9 pion/spill. The HIHR beam line is ideal also for the study of the neutron-rich hypernuclei. So, we hope the HIHR beam line and spectrometer system will be developed and constructed as a part of the 2nd construction plan of J-PARC at the Nuclear and Particle Physics Facility.

References

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Measurement of the nonmesonic weak decay from 4-body Λ hypernuclei at the high intensity and high resolution beamline

Shuhei Ajimura
RCNP, Osaka University

The measurement of the nonmesonic weak decay from Λ hypernuclei gives us the opportunity to study the ΛN weak interaction. Since the weak interaction between nucleons cannot be studied experimentally due to the huge background from the strong interaction, the measurement of the nonmesonic weak decay is the first step to investigate the baryon-baryon weak interaction.

There are two important observables: partial decay rates and asymmetry parameter. Study of the partial decay rates ($\Lambda n \rightarrow nn$, $\Lambda p \rightarrow np$) constrains decay amplitudes in terms of final isospin. The asymmetry is due to interference between parity conserving and violating decay amplitudes. Therefore the asymmetry parameter is sensitive to the balance of decay amplitudes. Recent theoretical calculations agree with existing experimental values of brancing ratio, $\Gamma(\Lambda n \rightarrow nn)/\Gamma(\Lambda p \rightarrow np)$, fairly well. However, the theories based on various models cannot explain the asymmetry parameter.

We propose to measure the nonmesonic weak decay from 4-body Λ hypernuclei precisely in order to clarify above situation. The branching ratios, so-called np ratio, imply only the ratio of final isospin 0 and 1, since the experimental values come from ${}^{5}_{\Lambda}He$ and ${}^{12}_{\Lambda}C$ hypernuclei. The nonmesonic weak decay from 4-body Λ hypernuclei can give another information, because the initial states of $\Lambda n \rightarrow nn$ from ${}^{4}_{\Lambda}He$ and $\Lambda p \rightarrow np$ from ${}^{4}_{\Lambda}H$ are restricted to ${}^{1}S_{0}$ spin states. One can separate the initial ${}^{1}S_{0}$ decay amplitude from ${}^{3}S_{1}$ one. There is another interest in these decay modes. The ratio of these two decay mode can be used to verify the $\Delta I=1/2$ rule in baryon-baryon weak interaction.

The charge exchange reaction such as (π^-, Ks), (K^-, π^0) reaction needs to produce the ${}^{4}_{\Lambda}H$ hypernuclei. To achieve required missing mass resolution (1~2 MeV/c^2), the (π^-, Ks) reaction is suitable for this purpose. The spectrometer for the scattered Ks particle is necessary for the experiment. Generally, Ks spectrometer has small acceptance. Besides more, the branching ration of the interest decay mode is small as ~1%. Therefore we increase beam momentum up to 1.8 GeV/c, which larger than the normal momentum for (π, K) reaction at 1.1 GeV/c, and also we use the intense pion beam provided by 'high intensity and high resolution beam line' proposed by H. Noumi (2nd NPFC L08). Summary of the experiment is as following.

- beamline: high intensity and high resolution beam line (p=1~1.8 GeV/c, 10^9 p/spill)
- spectrometer: Ks spectrometer consists of two set of dipole magnet and tracking chambers for the negative and positive pion from Ks decay
- other apparatus: large acceptance decay counter systems which measure pion, proton and neutron with high efficiency

Precision Spectroscopy on Hypernuclear and Hadron Physics using High Intensity, High Resolution Beam Line.

Hiroyuki Noumi, Research Center for Nuclear Physics, Osaka University

1. Physics Interest

The nuclear force is not still understood very well. Particularly, origin of the short range force is unclear, where the quark degree of freedom may play a role. Hypernuclei provide opportunities to reveal baryon-baryon interactions through a framework of flavor SU(3). Hypernuclear studies give important impacts on physics of dense hadronic matter, i.e. a neutron (hyperon/quark) star. Precision spectroscopic studies on hypernuclei, employing SKS and Ge γ-ray spectrometers in particular, are successfully conducted with a strong Japanese leadership in this research field. At J-PARC, further precision investigations of hypernuclei must be performed. The following objects are of particular interest:

1) Neutron-rich Λ hypernuclei
2) Σ Nucleus Potential

These matters are not hither-to-explored very much. The lambda-nucleon interaction in a large isospin nucleus is interesting in terms of Λ–Σ coupling effect. Situation of Σ-nulceus potential is still unclear. A recent experiment measuring the inclusive (π^-,K^+) spectra claimed that the Σ-nucleus potential is repulsive. Precision spectroscopy of Σ bound state thus seems difficult. Coulomb assisted hybrid Σ-nuclear and/or a low-lying Σ-atomic states may be observed in heavy nucleus.

2. Beam Line and Spectrometer

We propose a high intensity, high resolution beam line (Fig. 1) in order to push forward above-mentioned precision spectroscopy. This beam line provides very high intensity pion and anti-proton beam, as shown in Fig. 2. The beam line produces a strong dispersion of η~10m at the experimental target. Combining a full momentum matched spectrometer, we can handle a pion beam of ~10^9 every second with expecting an energy resolution of ΔE~0.1 MeV in sigma at best. This performance is essential to study neutron-rich hypernuclei and Σ nucleus potential since the production cross sections are expected to be as small as a few tens of nb/sr.

This beam line can be very useful for studies of chiral restoration of hadrons in nuclear medium, such as ϕ-mesic[1] and η-mesic[2] nuclear spectroscopy.

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[1] H. Ohnishi, this volume
[2] K. Itahashi, this volume

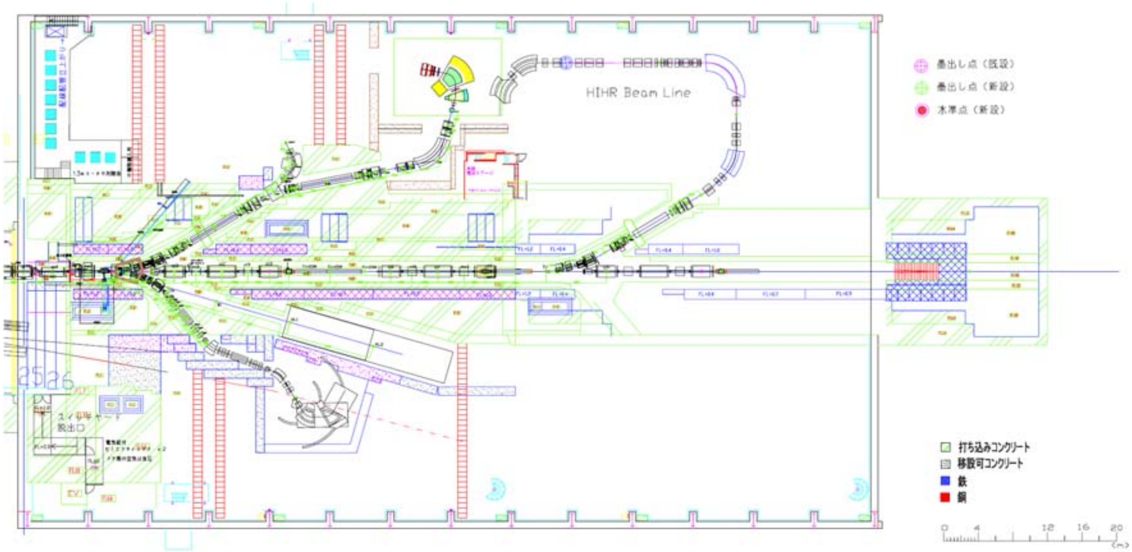

Fig. 1: An example of layout plan of High Intensity, High Resolution (HIHR) Beam Line connected to the T2 target in the extended Hadron Experimental Hall.

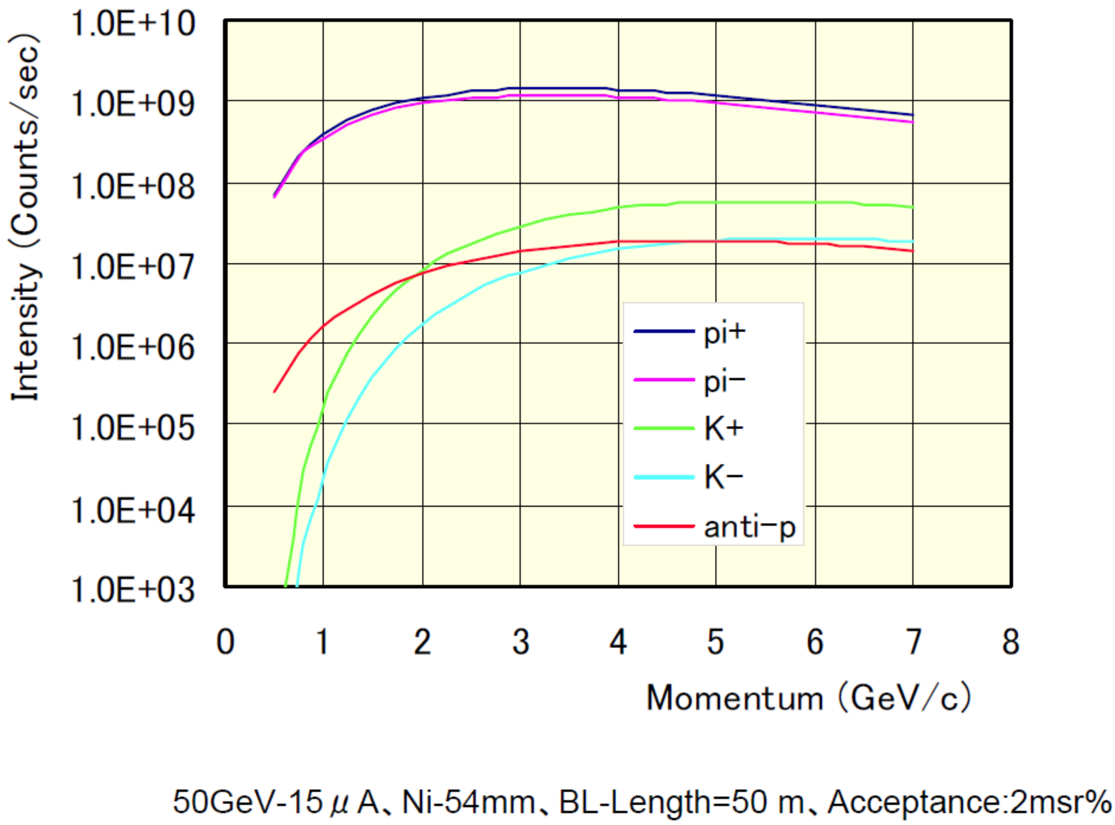

Fig. 1: Expected beam intensity

Prospects of Searching for Charmed Nuclei

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It is known that there are six quarks in the universe. An usual nuclei contains only up and down quarks. The nuclei containing a hyperon, whose part of quarks are strange quarks, are called hyper nuclei. A hyperon is a good prove to measure nuclear force in a nucleus because it is only affected by nuclear potential from nucleons while nucleons must obey Pauli exclusion principle. A strange quark has a partner in the generation. It is a charm quark. Λc (udc) must differs from Λ(uds) as a proton differs from a neutron because QCD does not predict that flavors are involved with nuclear interaction. If the binding energy of Λc is measured, we can compare the difference between protons and Λc. The result of measurement will provide strict constraints on nuclear theories, and open up a new world of knowledge on the universe.

Only the J-PARC can provide high-intensity and high-momentum proton beam. The beam allows us to produce heavy particles such as D^+. The binding energy is estimated to be same order as the binding energy of Λ[1]. Λc is produced at rest if D^+ collides at 0.6 GeV/c with proton in a nuclei[2]. It was pointed out that beam of anti-proton can produce slow Λc (about 0.5 GeV/c)[3]. We require a beam line of anti-proton (7 GeV/c), and the intensity is 10^7 anti-proton counts / sec.

A nuclear emulsion will be used as a key detector. It provides us the most precise measurement of positions of particles, and we can identify particles from charmed nuclei. While it provides good resolution of positions, it was difficult to process the data because the obtained data was a picture. A new method (general scan)[4] was established to process images automatically and massively. We can reconstruct tracks of particles from pictures. Because a charmed nuclei have large mass, all particles from charmed nuclei does not stop in the nuclear emulsion. In order to measure momentum and energy of the particles, spectrometer, TOF counters and Drift Chambers are required.

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[4] T.Tsunemi *et al.* Proceedings of HYP2006 P.127

Hadron Spectroscopy

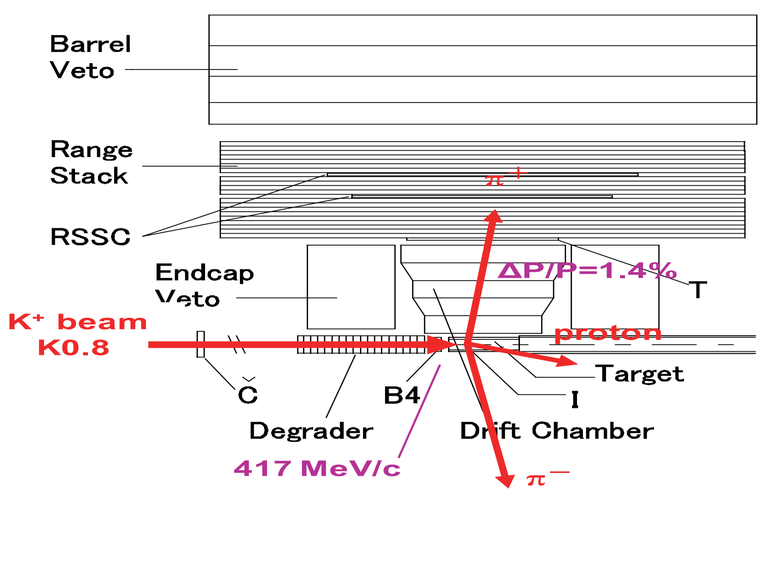
Θ^+ study with Low Energy K^+ Beam	RCNP	Norihito Muramatsu
Measurement of Θ^+ width via high resolution (π^-,K^-) reaction	Kyoto Univ.	Kiyoshi Tanida

低エネルギー K$^+$ ビームを用いた物理
Θ^+ Study with Low Energy K$^+$ Beam at J-PARC

Norihito Muramatsu
RCNP, Osaka University

Existence of pentaquark baryon Θ^+ has not been established yet, although further evidences have been obtained from photoproduction data collected by SPring-8 LEPS experiment with a liquid deuterium target. Comparisons of positive and null results indicate production angle dependence and target isospin asymmetry, which may be affected by reaction mechanisms. Width, spin and parity of the Θ^+ have not been determined.

In this situation, it is important to confirm the Θ^+ directly from K$^+$n resonance, which is independent from reaction mechanisms. There have been no experiments to search for Θ^+ by using high intensity K$^+$ beam and constructing a high resolution and large acceptance spectrometer. J-PARC must give a good opportunity for such an experiment. Width can be measured from cross section, which is calculated by 26.4Γ mb/MeV based on Breit-Wigner formula. Spin measurement will be possible from decay angular distribution, which is flat for spin 1/2 and $1+3cos^2\theta$ for spin 3/2.



Θ^+ is produced by 420 MeV/c K^+ beam and a neutron target if it exists at 1.53 GeV/c^2. K0.8 beamline is suitable to produce the low momentum K^+ beam by putting a degrader (ex. BeO). Thickness of the degrader may be decreased if the beamline momentum can be lowered. If K^- beam is also available even with lower intensity, there will be advantages for performing calibrations and checking data quality and analysis procedure by detecting $\Lambda(1520)$ with the same beamline and detector. The Θ^+ signal will be examined by calculating invariant mass of K^0_Sp with detection of $\pi^+\pi^-$p final state. A cylindrical drift chamber or a time projection chamber inside a large volume solenoidal magnet is under considerations to detect K^0_S. A proton tends to be emitted in forward direction, which will be covered by an active scintillating fiber target or a forward spectrometer. Θ^+ mass resolution is tentatively estimated to be 8 MeV by assuming momentum resolution of 1.4 % at the cylindrical drift chamber. Production yield is expected to be 200 events/mb/spill for K^+ intensity of 3×10^4/spill. Main background contribution comes from a charge exchange reaction, whose total cross section is 7 mb. The Θ^+ signal may be established at J-PARC, and its properties can be studied. In addition, the prepared beamline and detectors can be shared with other hadron physics programs and a rare kaon decay experiment.

Measurement of Θ^+ width via high resolution (π^-, K^-) reaction.

Kiyoshi Tanida, Kyoto University

The existence of the pentaquark, Θ^+, is still controversial. When we assumed it is real, there are many mysteries which need to be addressed. Among them, the width is known to be narrow, but there are only upper limits given by experiments. We propose to measure its width by very high resolution spectroscopy using the $p(\pi^-, K^-)\Theta^+$ reaction. This method gives direct measurement of the width, and is free from nuclear effects which may compromise the measurement proposed by Nakano et al. [1].

We have already proposed an experiment at J-PARC K1.8 beamline (J-PARC E19 [2]), which is approved as a Day-1 experiment. In this experiment, the missing mass resolution is about 2 MeV and the peak sensitivity is 100 nb/sr. For further improvement of mass resolution, here I propose to use dispersion matching technique at the high resolution beamline designed by Noumi [3]. A very good missing mass resolution of 200 keV, and hence the width sensitivity down to $\sim$ 100 keV, is possible. Details for beam requirements are to be determined based on the result of E19, but tentative numbers are 10^8 π^- per cycle at 2 GeV/c. Assuming a cross section of 1 μb/sr and a width of 0.5 MeV, we will be able to observe a 300 counts peak with a good signal-to-noise ratio in 100 hours.

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[2] M. Naruki et al., J-PARC proposal E19.
[3] H. Noumi, J-PARC Letter of Intent.

Chiral Restoration of Hadrons in Nuclear Medium

Low mass dielectron measurement (E16) and the high momentum beam line	RIKEN	Satoshi Yokkaichi
A new approach to study in-medium $\phi(1020)$-meson mass	RIKEN	Hiroaki Ohnishi
In medium N*(1535) Spectroscopy	RIKEN	Kenta Itahashi
Combined measurements of nuclear ω bound state and ω mass modification in $p(\pi^-,n)\omega$ reaction	Univ. Tokyo	Kyoichiro Ozawa
Rough idea of $K^+ + A \rightarrow K^* + X$ experiments	Tohoku Univ.	Masashi Kaneta
Plan of kaonic nuclei and kaonic atom experiments at K1.1 beamline	RIKEN	Haruhiko Outa

Low mass dielectron measurement (E16) and the high momentum beam line

S.Yokkaichi, RIKEN Nishina Center

We intend to investigate the chiral symmetry restoration in a finite density environment. At J-PARC, we proposed the experiment E16, which perform a systematic study of the mass modification of vector mesons decaying in nuclei through the e^+e^- invariant mass spectra. To make vector mesons in target nuclei, we would use a high intensity proton beam, about 10^{10} protons per spill. The beam energy is required to be 10 GeV or more. Since secondary beams are unavailable to achieve such high intensity in these energies, we need to use the primary proton beam. Both of the 30 and 50 GeV primary beams are acceptable.

In five weeks of physics run with the intensity and energy, we can accumulate the 10^5 of phi mesons in the e^+e^- decay channel for each nuclear target. In addition, 10^6 of rho and omega mesons and 1000 of J/psi's can be accumulated simultaneously. Such statistics are required for the systematic study of the mass-number and momentum dependences of the mass-shape modification of phi mesons. With the data, we can establish the mass modification of vector mesons in nuclei, which was found by the KEK-PS E325 experiment for phi mesons in only the Cu nucleus. The comprehensive and decisive data are awaited to lead a progress of theoretical studies.

We need the 'high momentum beam line' in the J-PARC hadron facility. The cascade operation of the E16 and the dimuon experiment, both use the primary beam in the line, is discussed. The secondary-beam operation, which is performed for the measurements of omega-mesic nuclei proposed by Dr. Ozawa, and phi-mesic nuclei by Dr. Ohnishi, is also discussed.

Toward the stage-2 approval of the E16 experiment, the detector development is on going at U-Tokyo and RIKEN with some small grants including a Grant-in-Aid acquired in 2007 for this experiment.

A new approach to study the in-medium $\phi(1020)$-meson mass

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The vacuum expectation value of $\langle \overline{q}q \rangle$ is non zero due to the spontaneous chiral symmetry breaking of the vacuum, and this $\langle \overline{q}q \rangle$-condensation is the major source of masses of low lying hadrons such as protons, neutrons, pions, *etc.* The $\langle \overline{q}q \rangle$ expectation value (chiral order parameter) is a function of temperature and chemical potential (density), so that various experimental studies have been performed to detect the restoration of the chiral symmetry. Vector meson in medium is known to be a good laboratory to investigate chiral symmetry restoration in nuclear media.

A search for the ϕ-meson bound state itself is already quite interesting, although it seems to be natural that the ϕ forms a stable nuclear bound state. Compared to other vector-meson studies, the ϕ is quite interesting due to its narrow width. Since the ϕ barely interacts with surrounding nucleons, it is natural to have a narrow width even in nuclei. In fact, the width broadening in nuclear media is reported to be only 3.4 times that of free space [1]. This fact makes the discrete peak observation in the missing mass feasible and allows simple analysis of the mass shift from the systematic study of the binding energies over several nuclei.

The most interesting formation channel and could be ideal for the ϕ-meson bound state formation is $\overline{p} + p \rightarrow \phi + \phi$ channel. One striking result for this reaction is the rather large $\phi\phi$ production cross section near the production threshold (~ 0.9 GeV/c), namely incident $\overline{p}$ momentum at around $1.3 \sim 1.4$ GeV/c. The most distinguishable feature of this reaction channel is its *fully background-free* nature. The yield of the kaon-associated ϕ production channel, ϕK^+K^- and $K^+K^-K^+K^-$, is much smaller than the double ϕ production channel for the incident $\overline{p}$ momentum below 1.4 GeV/c[2], and those events can be discriminated by the invariant mass analysis so no background processes exist in the primary reaction. Another unique feature is that all the particles we shall observe, including forward $\phi \rightarrow K^+K^-$ decay, are labeled with strangeness so the discrimination from other processes is quite clear, which ensures that it is free from any accidental background formation.

We examined a new experimental approach to measure ϕ meson properties in nuclear media via formation of ϕ-meson bound state using the primary reaction channel $\overline{p}p \rightarrow \phi\phi$. We demonstrate that a completely background-free missing-mass spectrum can be obtained efficiently by $(\overline{p}, \phi)$ spectroscopy together with the $K^+\Lambda$ tagging for this reaction. From both missing mass and invariant mass study of the sub-threshold energy region, one can independently deduce the mass shift information. A systematic study over several nuclear targets will yield a unique, definitive and precise determination of the in-medium mass modification of the vector meson $\phi(s\overline{s})$.

To perform ideal completely background-free experiment, we propose to perform the experiment with the incident $\overline{p}$ momentum at 1.3 GeV/c. In spite of the lower cross section of $p(\overline{p},\phi)\phi$, we can expect an excellent ground-state formation event rate of 240 per month using the $\overline{p}$ beam of 2×10^6 per *spill* on a carbon target. Therefore this experiment requires at least the full capability of the J-PARC at 30 GeV operation. Even at this rate, we need a relatively long beam time for the systematic study of the ϕ meson properties in the nuclear medium over several nuclei.

We presented two different conceptual designs to achieve these experiment. To finalize the design, we need more detailed study including detector development. This experiment is feasible using present experimental techniques, however there are some difficulties to be resolved, namely the hardware trigger for these events etc.

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Spectroscopy of in-medium N(1535)
∼ Does mass of baryon change in nuclear medium?∼

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H. Fujioka, Department of Physics, The University of Tokyo, Japan

1. Physics Motivation

The goal of our study is to investigate the in-medium properties of the $N^*(1535)$ baryon resonance. $N^*(1535)$ is known to be strongly coupled to the nucleon$-\eta$ and its mass is located just above their threshold (~ 1485 MeV/c^2). This small difference between the masses of $N^*(1535)$ and the nucleon$-\eta$ system makes an unique opportunity to investigate the mass shift of the N^* resulting in a possible level crossing between the η and N^*-hole modes. One of the theories, namely chiral doublet model predicts the level crossing, and its signal may be observed through the in-medium N^* spectroscopy. According to the other theory, chiral unitary model, the N^* potential in the nucleus becomes attractive owing to the couplings to the $K\Sigma$ and $K\Lambda$.

For more than ten years, in-medium hadron properties have been studied by making spectroscopy of implanted mesons in nuclear matter. In-medium masses of the π, K, ω, ϕ mesons have been measured, and most of the results indicates that the chiral symmetry breaking plays an important role in the origin of the hadron masses. Changing our sights to the baryon sector, almost no data are available for the in-medium baryon properties. It should be noted that the $N^*(1535)$ has a $(J)^\pi$ of $(1/2)^-$ and is known as a candidate of the chiral partner of the nucleon, and thus its in-medium spectroscopy will place an important step toward understanding of the baryon properties.

2. Experimental Principles and Beam Properties

The spectroscopy utilizes (π^-, n) reaction to produce in-medium $N^*(1535)$ and to make its missing mass spectroscopy. Table 1 summarizes the experimental conditions. The target candidates for the production runs are ^{6}Li and ^{12}C. In order to optimize the formation cross section, the incident π^- beam momentum is 780 MeV/c. The emitted neutron momentum is measured by TOF in the 12 meter distance between the target and the neutron counter wall. The expected mass resolution is about 25 MeV/c^2 (FWHM). Figure 1 shows the theoretically calculated cross sections based on the above two theories for the ^{12}C(π^-, n) reaction.

3. Facilities

The experiment is to be carried out at the J-PARC K1.1 beamline. The experimental condition matches also with performance at the K1.8BR beamline in spite of the shorter TOF distance.

Beam	780 MeV/c π^-
Beam Intensity	1 MHz in average
Extraction	Slow
Reaction	(π^-, n)
Data taking hours	84 shifts
Shakedown hours	9 shifts
Targets	CH_2, ^{3}He, ^{4}He and (^{6}Li or ^{12}C)
Target thickness	~ 1 g/cm^2

Table 1: Summary of the experimental conditions. The target candidates includes those for calibration purposes. Numbers may change according to the specified experimental requirements.

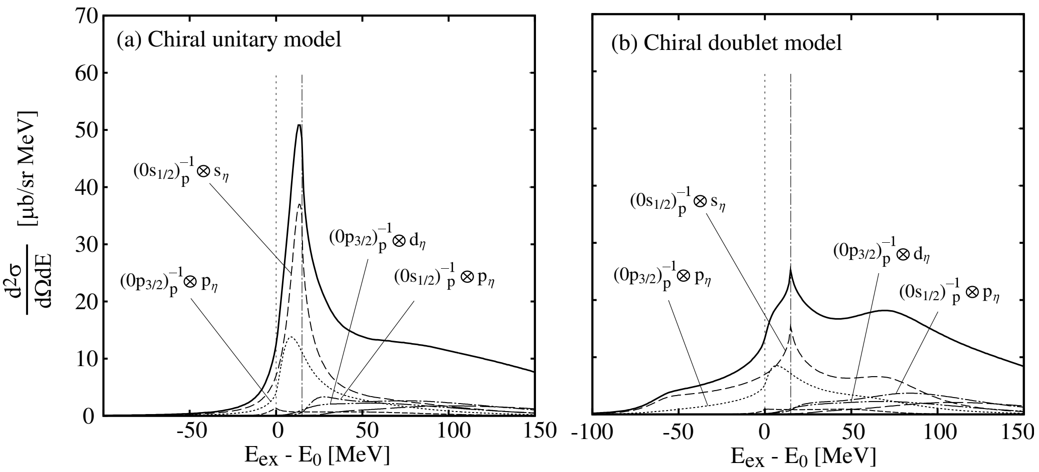

Figure 1: Calculated in-medium N^* formation cross sections for the chiral unitary model(left) and the chiral doublet model(right) by H. Nagahiro and D. Jido. The left side is the bound region.

Combined measurements of nuclear ω bound state and ω mass modification in p(π^-, n)ω reaction

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The origin of mass of hadrons has been drawing strong interest in nuclear and particle physicists. In QCD, mass of hadrons is composed of a sum of the effective mass of valence quarks, known as constituent quark mass, and their interaction term. The effective mass of valence quarks is determined by chiral property of QCD vacuum. This mechanism is understood as a consequence of the dynamical breaking of chiral symmetry. In hot and/or dense matter, this broken symmetry will be restored either partially or completely and, hence, properties of hadrons, such as mass, decay modes and life time, can be modified. Mass of ω meson at finite density, such as nucleus, has been studied in many theoretical methods. Hatsuda and Lee predicted 10$\sim$20% decreasing for ρ/ω mass at normal nuclear density using QCD sum rules [1]. H. Nagahiro *et al*. predict 50 MeV binding energy using an optical potential method [2].

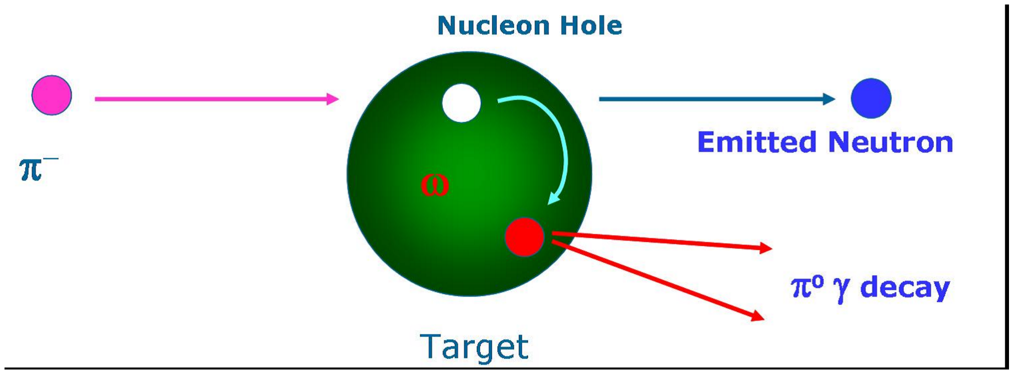

Figure 1: Schematic view of combined measurements

Table 1: Required beam and detectors

Species	$\pi-$
Intensity	10^7 per spill
Momentum	2 GeV/c^2
Beam area	20m (at least 7m) at 0 degree for flight path
Detectors	Neutron and Gamma detector

Two experimental approaches exist to study hadron properties in nucleus. One is focused on meson bound states in nucleus and another is a direct measurement of mass and decay width via meson decay. At the moment, two kinds of approaches are realized in independent experiments. One remarkable result on meson bound state is achieved by GSI-S236 group [3]. Their result indicates a reduction of the chiral order parameter, $f_\pi^*(\rho)^2/f_\pi^2 \approx 0.64$, at the normal nuclear density. Important results are also obtained in direct measurements of mass distribution in nucleus. Results of KEK-PS E325 suggests 9% decreasing of ρ and ω meson mass [4]. The mass spectral modification of ω meson was measured by the CBELSA/TAPS experiment in $\pi^0\gamma$ decay channel in γA reactions [5]. Their results show 14% decreasing of ω mass. It can be said that the existence of the hadron modification in medium has been established in these experiments. However, the origin of the modification is not clarified yet. There are also many explanations unrelated to the chiral symmetry restoration. To distinguish predicted effects experimentally, an exclusive measurement is needed.

Here we propose combined measurements of nuclear ω bound state and direct ω mass modification. Nuclear ω bound states are measured in p(π^-, n)ω reaction and decays of generated ω meson are also measured with $\omega \to \pi^0\gamma$ mode. Figure 1 shows a schematic view of combined measurements. Such exclusive measurement can supply essential information to establish partial restoration of the chiral symmetry in nucleus. When a binding energy of a ω bound state in nucleus is measured, it can be interpreted to optical potential and gives a phenomenological information about interactions between mesons and nuclei. If mass distribution of bounded ω meson is measured directly via decays, the relation between mass distribution and nuclear-meson interaction is established experimentally. Then, the amount of ω mass shift in direct mass spectrum and ω binding energy can be compared and such comparison gives information about effects beyond the meson nuclei interaction, such as chiral symmetry restoration.

Beam momentum of 2.0 GeV is required to generate ω meson at rest with expected 50MeV binding energy. Table 1 shows brief specifications of beam line and detectors. Thus, K1.8 beam line or high momentum beam line have to be used. The required beam intensity is 10^7 of π^- per spill. Also, emitted neutron should be detected at 0 degree to minimize momentum transfer of ω meson. Charged particles including π^- beam is swept by a magnet, such as SKS. To achieve good mass resolution in neutron detection using time of flight measuremnts, 20m flight path is needed. With the resolution of 80 ps and 20m flight path, 9 MeV/c^2 can be achieved. At K1.8 beam line, the maximum flight path is 7m and the mass resolution of 30 MeV/c^2 can be achieved.

In the measurements, two detectors are needed. One is neutron detector at the forward region and another is γ detectors for detecting 3 γ's at target region. The neutron counter has 4 layers of scintillation counter and will have 30% efficiency for neutron. The area of the counter is 30cm by 30 cm and the acceptance is $\delta\theta$ is 1° with 7m flight path. Tthe gamma counter consists of CsI crystal and is used at KEK E246 experiment. The nergy resolution of δE/E $= 3\%/\sqrt{E}$ is required. Mentioned gamma detecotr has δE/E = 2.8% at 200 MeV and it will be enough.

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Rough idea of K^+ + A $\rightarrow K^*$ + X experiments

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I. MOTIVATION

The KEK E325 experiment have studied a consequence of the partial restoration of the chiral symmetry in nuclear media via ϕ meson [1–3]. J-PARC E16 will focus dielectron measurement for studying the medium effect. I would like to propose a possibility of the study by the other vector meson, that is, K^*. This summary describes a rough idea of the experiment and no quantitative estimation in detail.

The full width of K^* mass is $\sim$50 MeV. That value is smaller than ρ ($\sim$149 MeV) and larger than ϕ ($\sim$4 MeV). A modification factor expected is naively larger than ϕ and smaller than ρ. So far, theoretical prediction from Walecka model is different from one of QCD sum rule [4]. Therefore, experimental results will make a limitation to the models.

There are several reactions to produce K^* at J-PARC. One of idea is to use primary proton beam and the other is to use K^+ beam. Before the primary beam will be ready, we may start kaon beam experiment.

$K^* \rightarrow K\pi$ decay branching ratio is almost 100%. We may not ignore an effect of rescattering effect of π with nuclei. The $K\gamma$ channel is better from view point of rescattering. The branching ratio to $K\gamma$ mode is about 0.1%. On the other hand, the $K^+ + p(n) \rightarrow K^{*+}(K^{*0}) + p$ cross-section is about 4 mb around the incident kaon momentum of 1.5 GeV/c. The order of $K\gamma$ mode cross section is about 1 μb. However, there is a merit which small mean free path of kaon is 5-6 fm/c and that value is same scale with atomic radius.

II. DETECTORS

The $K\pi$ channel measurement will be executed adding hadron PID detector to E16 experiment. The PID detector will be located in the magnetic field. A candidate is Multi-gap Resistive Plate Chamber (MRPC).

The SKS spectrometer is useful of K^+ measurement of $K\gamma$ channel. The gamma detector is needed to be cover large solid angle like FOREST at LNS-Tohoku.

III. REQUIREMENT

Kaon beam line (K1.1 or K1.8) with a space to be set the gamma detectors for K^+ + A experiment. The other requirement of beam, for example, rate, luminosity, purity (K/π ratio) are not estimated yet.

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Plan of kaonic nuclei and kaonic atom experiments at K1.1 beamline

Haruhiko Outa (RIKEN) for J-PARC E15/E17 collaborations

Recently possible existence of deeply bound kaonic nuclei has been extensively studied by many experiments. An observation of the large “repulsive” shift of the 1s-state of kaonic hydrogen in atomic x-ray measurement in KEK-PS E228 experiment[1] can be interpreted by the very attractive strong interaction between K^- and proton. The$\Lambda(1405)$ can be considered to be the bound state of K^-p and deeply kaon bound states may exist in kaon-nucleus systems. **It is indispensable to study both of kaonic atoms and kaonic nuclei with light nuclear targets** in order to understand the low energy kaon-nucleus interaction.

We carried out the series of experiments (E471/E549/E570) with ^{4}He(stopped K^-,N) reaction to search for narrow kaonic nuclei in the missing mass spectrum of protons/neutrons. We have not observed any “narrow”($\Gamma <$ 20MeV/c^2) signature of the deeply bound kaon formation[2,3], whereas the sensitivity of the formation of the “broad”structure is limited because of the ambiguity of the unknown background shape. In the hyperon—deutetron and hyperon—nucleon correlation analyses, we realized that the exclusive measurements on light nuclear system are crucial to scrutinize the difference of kaonic nuclear formation and kaon multi-nucleon absorption[4,5]. Also it is important to identify the same system both in formation and in decay stages. At J-PARC, we are aiming at the observation of the lightest kaonic nuclei —K^-pp system— formed in ^{3}He(In-flight K^-,n) K^-pp reaction by tagging its decay mode $K^-pp \rightarrow \Lambda p \rightarrow p\pi^-p$ by identifying all the charged particles in the final states by the cylindrical detector system(J-PARC E15)[6]. The experiment requires full intensity of 1GeV/c K^-beam (～1×10^6/spill) available at K1.8BR beam line with J-PARC full proton intensity.

When the kaon-nucleus potential is very attractive, there is a possibility to observe large anomalous shift of 2p state of K^{-4}He atom. We also carried out an precise measurement of the 3d→2p x-ray of kaonic atom with newly developed Silicon Drift Detectors (SDDs) and found that the shift is very small for K^{-4}He atom(E570)[7]. In the x-ray shift experiments, the sensitive region of potential depth is different in K^{-4}He and K^{-3}He atoms. By utilizing the target prepared for E15 experiment, we can measure the

K^{-3}He 3d→2p transition x-ray energy with the same precision as E570 ($|\Delta E|$<2eV) in one month physics run even when the J-PARC accelerator proton intensity is only 10% of its initial design value(30GeV/270KW)[8]. Because the monochromatic peaks ($K^+ \rightarrow \mu^+ \nu$ and $K^+ \rightarrow \pi^+\pi^0$) from the stopped K^+ events are the ideal calibration processes for the Cylindrical Drift Chamber (CDC) system tuning, we are now seriously considering to start the run from the E17 experiment.

Concerning the kaonic atom, the most important experiment at J-PARC must be the 2p→1s x-ray measurement of kaonic-deuteron atom. Whereas the K^-p interaction contains both of isospin T=0 and T=1 components, it is limited to only T=1 for K^-n interaction. Thus the comparison of the shift and width of 1s states of K^-p and K^-d

atoms must have vital importance. The intensity of the 2p→1s peak is expected to be much less than 1%/stopped K^-(about one-order lower than that of K^-p) even when we used the gaseous target to improve the x-ray yield. Since the peak intensity is low, the measurement usually suffers from the continuum background originated from the soft-compton scattering of high-energy γ-rays from $\pi^0 \rightarrow 2\gamma$. We can remove all of the π^0 backgrounds, when we tagged two pions with different charge $\pi^+ + \pi^-$, since only up to two pions can be emitted from the stopped K^- absorption (one in the hyperon formation stage and one in the hyperon decay)[9]. Rough event rate estimation tells that the experiment is feasible at J-PARC. When we prepare about 50 SDDs used in E570 and took data with full beam intensity at K1.8BR, we will obtain about 200-300 events of K^-d 2p→1s transition x-rays within 1―2 months running.

The total run-period for these series of experiments is rather long and we need full intensity runs. Since we can share primary proton beam with K1.8(SKS) experiments **only when the dedicated low-momentum kaon beam line K1.1 is realized in the early stage**. We must keep the distance of the target to the neutron counters to be longer than 10 meters in order to keep the sufficient energy resolution from the TOF measurement at E15, which is available only at K1.1 (not in K1.8BR).

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Quark-Gluon Distribution in Hadron

and

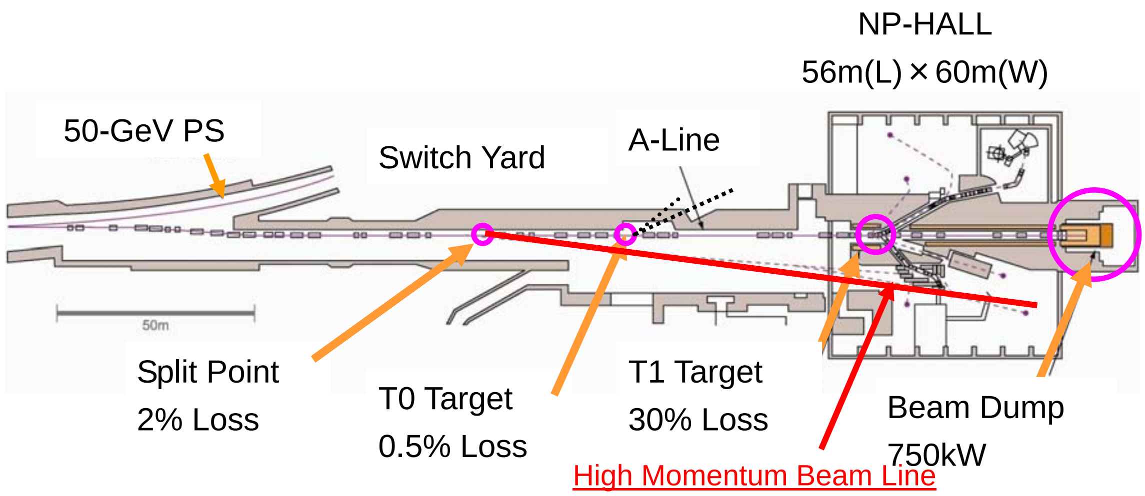
Hadron System

High Momentum Beam Line at J-PARC	KEK	Shinya Sawada
Polarized structure measurement of the nucleon with dimuon production at J-PARC	RIKEN BNL	Yuji Goto
Measurement of strange quark spin component of the proton spin using neutrino-nucleon elastic scattering	Tokyo I. Tech.	Yoshiyuki Miyachi

High Momentum Beam Line at J-PARC

Shinya Sawada (KEK)

The high momentum beam line branches off from the SM1 on the main primary beam line (A line) in the switch yard. It allows primary beams up to 50 GeV and also secondary beams, when one puts a thin target at the SM1 branching point. The radiation shielding there is designed so that 2% loss of the full proton beam (750kW) can be allowed.



The outline of the beam line has been designed so that a fraction of the primary proton beam can be used from about 10^9 particles per second (pps) up to around 10^{12} pps. Secondary beams can also be available, such as pions, kaons, and anti-protons. The intensity of the 5 GeV/c positive pions would be more than 2×10^7 pps, for example, even for the 30-GeV operation with 9 μA protons. Unseparated kaon beams would also be available with the intensity of the order of 10^5 pps (5 – 10 GeV/c, for example). The high radiation and heat deposit around the SM1 is the main issue for the beam line elements. We have started R&D studies to overcome the issue, which include the development of the new bending system with a silicon bent crystal, as well as R&D of a conventional method with electrostatic septum etc. Please note that our colleagues of the hadron beam group are heavily involved in the development of the slow extraction system of the 50-GeV synchrotron using an electrostatic septum and septum magnets. In addition, large dipole magnets have already been offered from Argonne to help construction of the high momentum beam line.

Experiments have been proposed to use 30-GeV and 50-GeV protons with this beam line. The title of the P04 proposal is "Measurement of High-Mass Dimuon Production at the 50-GeV Proton Synchrotron", which uses 10^{12} pps of protons. At the initial stage of the

J-PARC operation, only 30-GeV protons would be available from the accelerator and P04 utilizes even these protons to measure J/Psi, and then the Drell-Yan process with the 50-GeV protons (which would be available even during the Phase-1 era) is used to investigate flavor asymmetry of the sea quark (d-bar/u-bar) at large Bjorken x. The sea quark structure at large x has never been seen. This experiment will lead to the measurements of spin observables, as discussed by Dr. Goto in this workshop. The second example of an experiment at this beam line is the E16 experiment, "Electron pair spectrometer to explore the chiral symmetry in QCD". This experiment will use 30-GeV protons with 10^9 to 10^{10} pps. This experiment is discussed by Dr. Yokkaichi in detail in this workshop. Not only these examples, we know many other possibilities to use this beam line are under consideration. Early realization of the high momentum beam line is expected.

Polarized structure measurement of the nucleon with dimuon production at J-PARC

Y. Goto

RIKEN and *RIKEN BNL Research Center*

We propose to make the J-PARC facility allow acceleration of polarized proton beams to 30-50 GeV with some modifications for experiments using this primary beam.[1, 2] The modifications would consist of the addition of a polarized H^- source, an rf dipole in the 3 GeV Rapid Cycling Synchrotron (RCS) and two strong superconducting partial Siberian snakes in the 50 GeV Main Ring (MR). In addition, several external and internal polarimeters are needed for commissioning and operation of polarized proton acceleration. The proposed scheme for the acceleration of polarized protons is based on the successful experience of accelerating polarized protons to 25 GeV at the Brookhaven AGS [3], which is very similar to the J-PARC complex. To meet the requirements of spin physics program the MR should deliver about 10^{12} p/spill. The required beam bunch parameters that allow the acceleration of polarized protons to 50 GeV are a normalized 95% emittance of 10π mm mrad and 0.3 eVs longitudinal emittance. With the present available source intensity of 10^{12} H^- for a 0.5 ms pulse it is easily possible to produce a bunch intensity of 2×10^{11} protons for a single bunch in the RCS.

Polarized Drell-Yan measurement by the dimuon experiment which has been proposed [4] will provide us valuable new experimental data of the polarized nucleon structures, e.g. flavor structure of the sea-quark polarization, orbital angular momentum and transversity of quarks inside the nucleon. Since we know relatively well the contribution of the quark and gluon to the nucleon spin, and it is not enough to explain the entire contents, we want to measure the contribution of the orbital angular momentum of the quark and gluon to the nucleon spin as the final object. To restrict the quark and gluon contribution to the nucleon spin with high precision, it is also important to know the flavor-sorted sea-quark contribution to the nucleon spin directly. The polarized proton acceleration at J-PARC will provide a new and unique tool to study the nucleon structure and hadron interactions based on QCD.

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Measurement of strange quark spin component of the proton spin using neutrino-nucleon elastic scattering

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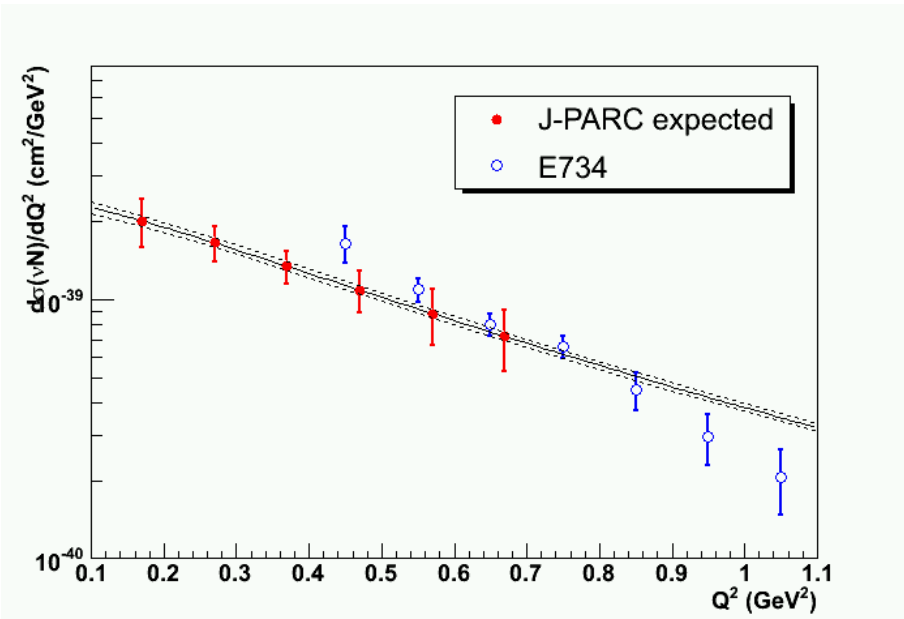
Strange quark spin is a key for understanding of *"Proton Spin Problem"* which was observed by the EMC collaboration. The extracted strange quark spin component Δs to the proton spin from the rst moment of the spin dependent structure function Γ_1^p indicated the negatively polarized strange sea. The recent results from the polarized deep inelastic scattering experiments con rmed with the improved precision, $\Delta s = -0.08 \pm 0.03$. However these results rely on the quark flavor SU(3) asymmetry. One of the cleanest probes to access Δs is neutrino-nucleon elastic scattering. Axial charge of the nucleon dominates di erential cross section of neutral current neutrino-nucleon elastic scattering (NCEL) at the small Q^2 region. The iso-vector component of the axial charge is known from β-decay, so that it is possible to determine the strange axial charge, which is related to Δs. The NCEL cross section was measured by the E734 experiment at BNL. The resulting constraint on Δs was rather weak.

J-PARC neutrino beam line provides intense neutrinos. With the o -axis con guration one can obtain neutrinos with the peak energy of less than 1 GeV and the energy spread of a few hundred MeV, which is ideal to perform the NCEL cross section measurement. Dual liquid scintillator active targets with di erent Hydrogen and Carbon mixture allows to separate neutrino-nucleon scattering from neutrino-nucleus scattering. Sensitivity study was performed based on the dual active target con guration, where each detector has 27 ton ducial volume, with 1E21 POT neutrino on the o -axis, 280 m away from the production target. The expected sensitivity on the NCEL cross section is given in the bottom gure. Δs can be determined with statistical precision $\delta(\Delta s) \sim 0.03$.



Physics beyond the Standard Model in Kaon Decays and Muon-Electron Conversion Process

K_L^0 rare-decay experiment and the beam line	KEK	Takeshi Komatsubara
K1.1-BR beam optics optimized for K0.8 and E06 (TREK) experiment	KEK	Jun Imazato
An Experimental Search for Lepton Flavor Violating μ^--e^- Conversion at Sensitivity of 10-16 with a Slow-Extracted Bunched Proton Beam	Osaka Univ.	Akira Sato

K_L^0 rare-decay experiment and the beam line

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Abstract

The prospects for the $K_L^0 \to \pi^0 \nu \bar{\nu}$ program at J-PARC are discussed.

The E14 collaboration at J-PARC is going to observe the rare decay $K_L^0 \to \pi^0 \nu \bar{\nu}$ and explore the flavor structure of New Physics beyond the Standard Model(SM) of particle physics. The theoretical uncertainty in the branching ratio, which is predicted to be 3×10^{-11} in the SM, is small and well controlled thanks to the continuous e orts by experts (e.g. [1]).

The experiment will be performed at the Hadron Hall of J-PARC with the neutral beam line (KL line), which is 20-meter long from the T1 target and whose extraction angle is 16°. With 30-GeV protons, the neutron momentum spectrum gets "softer" than the spectrum for the E391a experiment at KEK-PS and bene ts the new experiment because the π^0's and η's, produced by the interaction of halo neutrons to detector elements, are reduced. The KL line comprises two stages of narrow collimation ("pencil beam"), which starts at 6.5 meter from T1, and a sweeping magnet to remove charged particles. The γ absorber by Pb is located at the upstream of the collimators. The detector, based on the one used for E391a, is going to be upgraded with the CsI crystal blocks from KTeV, new photon-veto counters, and the electronics and DAQ system for waveform digitization. From recent simulation studies, it turns out that the "KL line alone" con guration is most preferable ($\times 1.7$ K_L^0 flux and $\times 0.52$ halo neutrons than the con guration with the K1.1 components in the upstream).

With the achievements in E14, we will proceed to the measurement of the $K_L^0 \to \pi^0 \nu \bar{\nu}$ branching ratio by using a new and optimized beam line (e.g. a dedicated neutral beam with the 5° angle from B-line, for higher K_L^0 momentum and larger kaon yield).

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K1.1-BR beam optics optimized for K0.8 and E06 (TREK) experiment

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The TREK experiment aims at a measurement of transverse muon polarization (P_T) in $K^+ \to \pi^0 \mu^+ \nu$ decay at J-PARC. P_T as a T-odd observable is a sensitive probe of CP violation from the origin of other than the Standard Model (SM), because the contribution from SM is very small. There are several theoretical models which allow sizable P_T without conflicting with other experimental constraints. The best limit of P_T which was consistent with zero was given by KEK-PS E246 with an accuracy of ~10^{-3} [1]. TREK at J-PARC intends to improve the limit down to 10^{-4} by using a K^+ beam of higher intensity as well as by suppressing systematic errors by a factor 10 and aims at a discovery of a positive effect. Since we know the performance and systematics of the E246 setup very well, we will use the E246 setup by upgrading each detector element [2], and the stopped K^+ method will be employed. The experiment has obtained a stage-1 approval in 2006.

As a stopped K^+ beam, the branch of K1.1 will be used as K0.8 taking the beam from the upstream of K1.1. Just as the K1.8-BR concept a considerably good K/π ratio can be anticipated in spite of single stage ESS thanks to the presence of a vertical intermediate focus IFY. Details of the beam optics were calculated by J.Doonbos [3] for the updated magnet configuration of the upstream of K1.1. Some details of the beam optics and beam performance were shown in the talk. It was found that the wedge-focusing by B3 forming a horizontal focus HFOC enables the suppression of slit-scattered pions and background decay muons substantially. A good K/π ration larger than 1.0 will be obtained. As for the acceptance, however, it is 4.5 mst%$\Delta p/p$ which is much smaller than in the case of the optimum K1.1-BR configuration.

Quite recently it was confirmed that the adoption of a combined-function magnet for B1 can drastically increase the acceptance to 8 msr%$\Delta p/p$. We want to pursue this possibility. It is urgent to check the K1.1 main stream beam optics at the adoption of a combined magnet. Regarding the installation of K1.1-BR we are requesting to put at least the front-end magnets not missing timing before the start of T1 high-intensity operation. This is a serious question not only for TREK but also for all the future K1.1 users. We hope that PAC and the IPNS/J-PARC managements select correct beamline installation policy.

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An Experimental Search for Lepton Flavor Violating $\mu^- - e^-$ Conversion at Sensitivity of 10^{-16} with a Slow-Extracted Bunched Proton Beam

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We have submitted a proposal to J-PARC for a new experiment (COMET) of searching for coherent neutrino-less conversion of a muon to an electron, $\mu^- + N(A,Z) \rightarrow e^- + N(A,Z)$, in muonic atoms ($\mu^- - e^-$ conversion) at a 90 % con dence-level sensitivity of $B(\mu^- N \rightarrow e^- N) < 10^{-16}$. The target sensitivity is a factor of about 10,000 better than the present published limit of $B(\mu^-\mathrm{Au} \rightarrow e^-\mathrm{Au}) < 7 \times 10^{-13}$. This experiment would provide a very large window on new physics beyond the Standard Model.

To achieve the target sensitivity of 10^{-16}, the total number of muons needed is of the order of 10^{18}. Therefore, a highly intense muon beam line has to be constructed. To increase the muon beam intensity, two methods are adopted in this experiment. One is to use a proton beam of high beam power. The other is to use a system of collecting pions using superconducting solenoid magnets which, produce a high magnetic eld surrounding. With the pion capture solenoid system, about 8×10^{20} protons of 8 GeV are necessary to achieve the number of muons of the order of 10^{18}.

The experiment is planned to be carry out at the J-PARC Nuclear and Particle Experimental (NP) Hall by using a bunched proton beam that is slow-extracted from the J-PARC main ring, where beam bunching is needed to eliminate beam-related background events and keep an experimental sensitivity as high as possible. Since muons in muonic atoms have lifetimes of the order of 1 μsec, a pulsed beam with beam buckets that are short compared with these lifetimes would allow removal of prompt beam background events by allowing measurements to be performed in a delayed time window. There are also stringent requirements on the *beam extinction* during the measuring interval. Tuning of a proton beam in the accelerator ring as well as extra extinction devices should be installed to achieve the required level of beam extinction. Required parameters on the pulsed proton beam are summarized in Table 1.

Table 1: Pulsed Proton Beam for $\mu^- - e^-$ experiment.

Beam Power	56 kW
Energy	8 GeV
Average Current	7 μA
Beam Emittance	10π mm·mrad
Protons per Bunch	$< 10^{11}$
Extinction	10^{-9}
Bunch Separation	1 μsec
Bunch Length	100 nsec

Figure 1 illustrates a schematic layout of the COMET experiment. The muon beam line considered in the experiment consists of a section of large solid-angle pion capture by surrounding high- eld superconducting solenoid magnets, a section of superconducting curved solenoid magnets for transporting muons and selecting their momenta, and a detector section of curved solenoid spectrometer to detect $\mu^-{-}e^-$ conversion signals with low counting rate environment.

This new initiative has been taken recently to achieve an early and timely start of a series of searches and is regarded as the rst step of our staging approach. This would evolve smoothly toward the ultimate search and the discovery of $\mu^-{-}e^-$ conversion by an experiment with a muon storage ring (PRISM) with a 10^{-18} sensitivity.

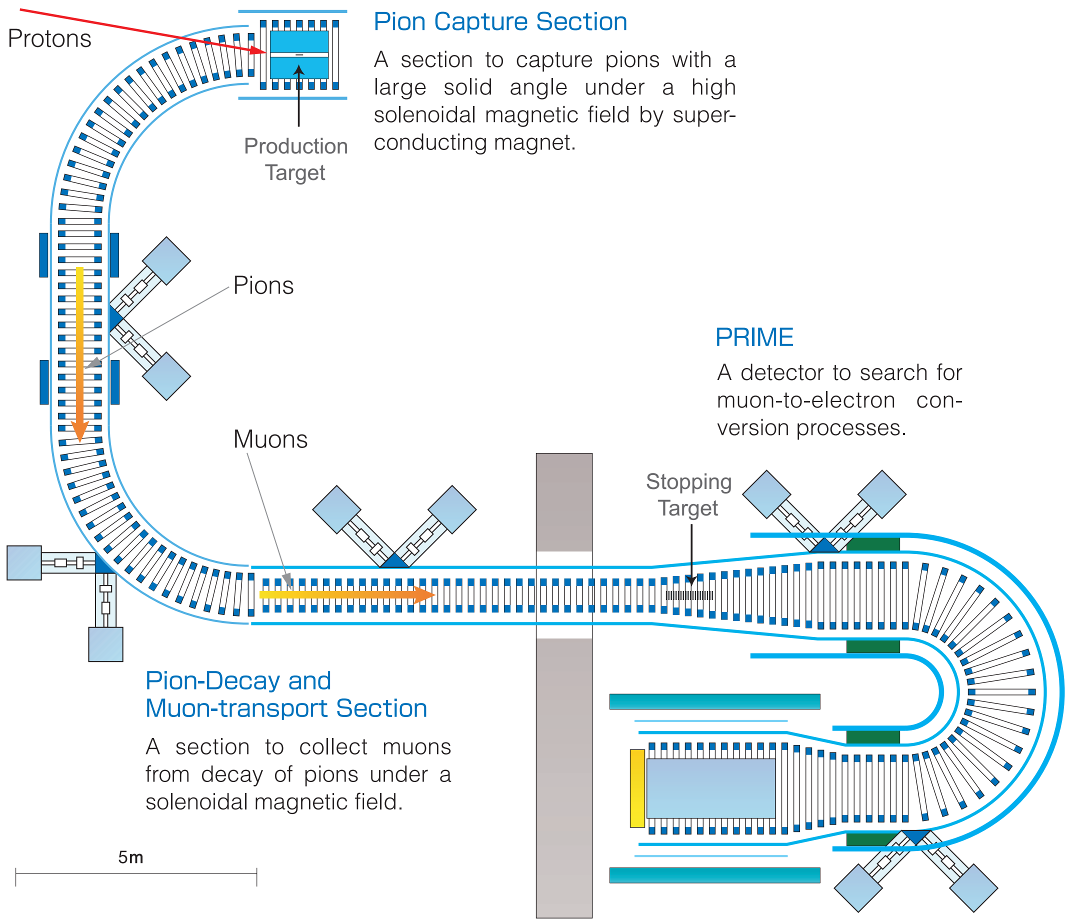

Figure 1: Schematic layout of the muon beamline and detector for the proposed search for $\mu^-{-}e^-$ conversion, the COMET experiment.

Construction Status and Phase II of the Hadron Experimental Facility

Construction Status of Hadron Experimental Facility of J-PARC	KEK	Kazuhiro Tanaka
Phase-II Extension of Hadron Experimental Facility	KEK	Kazuhiro Tanaka

Construction Status of Hadron Experimental Facility of J-PARC

Kazuhiro Tanaka
for
Hadron Experimental Facility Construction Team

The construction of Japan proton Accelerator Research Complex (J-PARC) started in 2001 as the new state-of-the-art research facility of experimental nuclear and particle physics of the 21st century. The construction site is the Tokai campus of the Japan Atomic Energy Agency (JAEA) since J-PARC is a joint project of the High Energy Accelerator Research Organization (KEK) and JAEA. The high intensity 50 GeV proton synchrotron (50 GeV-PS) is the main accelerator of J-PARC. The designed beam intensity of the 50 GeV-PS is 15 □A, i.e. a beam power of 750 kW, which is approximately 10 times more powerful than the existing 10-100 GeV energy accelerators in the world. The main application for this high-power 50 GeV proton beam is the intense production of kaons, pions, and many other rare secondary particles in order to promote significant progress in both nuclear and particle physics. Therefore the J-PARC 50 GeV-PS is the first real KAON Factory accelerator in the world.

Two extractions are under construction from the J-PARC 50 GeV-PS. One is the resonant slow extraction for the fixed-target counter experiments and the other is single-turn fast extraction for the neutrino beam production for the long baseline neutrino oscillation experiment, T2K. As injectors for the 50 GeV-PS, a rapid cycle 3 GeV proton synchrotron (RCS) and a 181 MeV linear proton accelerator (LINAC) are under construction. Extracted 3 GeV proton beam from RCS will be used solely for material and life science studies by producing intense pulsed neutrons and pulsed muons. The beam power of the RCS will reach approximately 1MW. Now most of construction works of injectors have been completed and the beam has already been accelerated by RCS up to its full energy of 3 GeV. The first beam from the 50 GeV-PS will be extracted to the slow beam line in December 2008. The beam to the fast beam line is scheduled in April 2009.

The Hadron Experimental Facility is prepared for the fixed target experiments using slow extracted beam from J-PARC 50GeV-PS. Civil engineering works and building construction works of the hadron experimental facility were almost completed and now the facilities construction such as a primary proton beam line, the secondary beam lines, a target device, the beam dump is in progress. After the beam line tuning using the first beam from the 50 GeV-PS (December 2008), physics experiments will start immediately. Some experiments have already been approved as Day1 experiments (the first experiments), and the preparation works of the Day 1 experiments have already been started.

At the Day 1, unfortunately, only one production (secondary particle) target, T1, will be available. The number of the secondary beam lines from the T1 target will be only one, i.e. K1.8BR. However several secondary beam lines such as K1.1, KL and High-p lines will be constructed year by year. Please take note the construction of the secondary beam lines and experimental facilities depends very much on the requirements of experimenters. Many GOOD proposals of NICE physics experiments are essential to fill up the Hadron Beam Facility!!!!

Phase-II Extension of Hadron Experimental Facility

Kazuhiro Tanaka
for
Hadron Experimental Facility Construction Team

At the first stage of designing of the hadron experimental facility, the Phase-II extension was included naturally. At the Phase-I construction, only one production (secondary particle) target, T1, will be available and the number of the secondary beam lines connecting to the T1 target is just 3, i.e. K1.8, K1.1 and KL. This is the miserable situation. Experimenters require more numbers of beams with unique performances. Small experimental area can not accept new GOOD proposals of NICE physics experiments.

At the initial design of the hadron experimental facility, the second target, T2, was considered naturally at the downstream of T1 and several secondary beam lines can be connected to T2. High momentum beam line "High-p", which can be constructed even at the Phase-I, was extended to more downstream direction in order to enjoy wider experimental area. Budget situation forced us to postpone the T2 and wider experimental area to the Phase-II. Now the Phase-I construction will be completed soon. It is the time to start the Phase-II!!!

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