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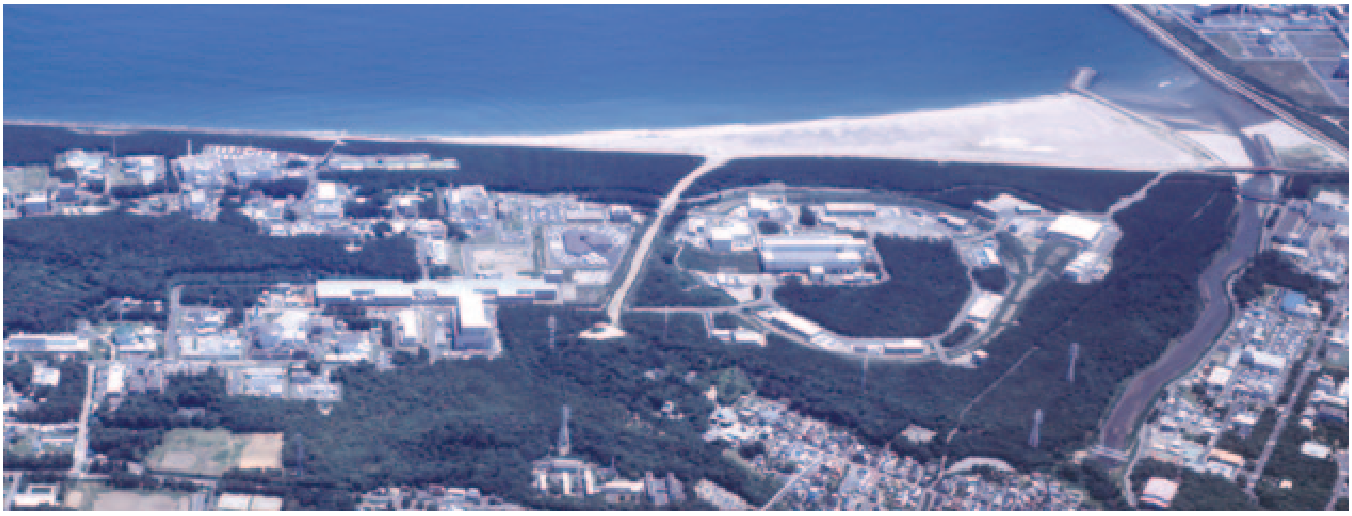
Japan Proton Accelerator Research Complex

J-PARC Annual Report 2013

Contents



Preface

If I need to select one word to define "Year 2013", it should be "the Hadron incident". On May 23, 2013, radioactive materials leaked from a primary beamline area to an experimental hall of the Hadron facility, and then were released the outside of the radiation-controlled area of the facility. This incident, regardless of the released amount, had a tremendous impact not only on the J-PARC's operation and users community, but also on the society at large: the residents and the local government of Tokai-mura, the neighboring municipalities, other accelerator user facilities, The Radiation Regulation Authority, and MEXT.

In order to develop preventive measures against recurrence of a similar accident, we investigated the cause(s) of the incident and reviewed J-PARC's safety management system. The measures included, but were not restricted to, taking every action to enhance the level of our safety caution, establishing a new safety review system, and reorganization of J-PARC Center's management structure.

In parallel to the investigation of incident's causes, we prepared a renovation plan for the Hadron facility to ensure workers' safety. I would like to appreciate all of the J-PARC staff members, in particular, those of the Hadron facility, for their sincere self-sacrificing contribution to the recovery work.

As a user facility, we have a mission to steadily deliver beam to users. Due to incredible work of the J-PARC staff members, it was concluded that the facilities, other than the Hadron, were safe enough to approve the restart of the operation, and finally, the Materials and Life Experimental Facility was able to resume its user operation in February 2014.

Beside the Hadron incident, another exciting outcome through the 2013 FY should be noted here. I am very proud of a remarkable accomplishment by the T2K collaboration to discover the electron neutrino appearance from muon neutrino, which has been one of their scientific goals. I also have to stress that we have successfully completed the energy upgrade to 400 MeV at Linac. This achievement gave a technological base for the 1 MW power goal of J-PARC.

The FY 2013 should be an unforgettable year for all people related to J-PARC. Here, I would like to thank again all of you for your faithful work, significant contributions and continuous support for the constant progress at J-PARC.

Yujiro Ikeda
Director of the J-PARC Center

Hadron Incident

Introduction

A radioactivity leak incident[1] occurred on May 23, 2013, in the Hadron (HD) Experimental Facility of J-PARC. Because of a malfunction of the slow extraction system of the main ring (MR: 50 GeV synchrotron), a proton beam with abnormally high instantaneous power density was delivered to the gold target for kaon production, and caused partial melting and evaporation of the target, and resulted in exposure of thirty-four workers in the experimental hall, and release of radioactive materials to outside of the controlled area of the HD hall. The incidence was, therefore, an event that should be notified to relevant authorities and local governments. The reporting, however, was delayed due to inappropriate emergency responses.

The issues of the incident were summarized as follows:

1) Release of radioactive material to the environment outside of the controlled area,
2) Delay in reporting the incident to relevant authorities and local governments, and
3) Exposure of workers in the HD hall.

A direct cause of the incident was a malfunction of the slow extraction system of MR. As described later, however, there were also failures in taking measures to prevent exposure of workers and diffusion of radioactive materials, although the exposure and the influence to the environment was not serious as noted in section 3. For these reasons, the incident was evaluated as Level 1 (incident) in the International Nuclear and Radiological Event Scale (INES), which means "Anomaly" with the words "lack of safety culture" by the Nuclear Regulation Authority of Japan (NRA).

[1] The term "incident" is employed in place of "accident" which has been used in the report from J-PARC Center, according to the criterion by INES described below.

For thoroughly reviewing the causes of the incident and the emergency responses in J-PARC, an external experts panel (EEP) was set-up by the two parent organizations of J-PARC, Japan Atomic Energy Agency (JAEA) and High Energy Accelerator Research Organization (KEK), in response to the request from the Minister of Education Culture, Sports, Science and Technology. A Working-group (WG) was formed under this EEP and analyzed possible causes of the incident and the safety management system in collaboration with J-PARC Center. The EEP examined also the soundness of the facilities other than the HD facility in J-PARC.

The present report describes an overview of the incident, i.e., the outline of the incident including influence of the incident, analysis of the causes of the incident, and preventive measures against recurrence of a similar incident on the basis of the EEP summary report [1] and the final (third) statutory report submitted from the J-PARC to the NRA on Aug 12, 2013 [2]. The information publicized from J-PARC Center after the submission of these reports was also included [3-6]. The third statutory report provided a detailed review on the incident and clarified what were the problems in emergency procedures, and also outlined possible measures to prevent similar incidents. It also described how the facilities other than the HD facility are maintained in terms of the radiation safety.

Outline of the Incident

On May 23, experiments were being carried out in the HD hall of J-PARC using kaon beams produced via spallation reactions of 30 GeV proton beam extracted from MR with the gold target. Figures 1 and 2 show, respectively, the layout of the HD hall and the gold target. The primary beamline was designated as the 1st class radiation controlled area where radioactive materials may exist, but user working areas in the HD hall was assigned to be 2nd class radiation controlled area where radioactive materials were not taken into management, owing to the air-tight design of the shielding wall of the primary beam line.

Proton beam to the HD hall was extracted from MR through a slow extraction system employing extraction quadruple (EQ) magnets to make even the proton beam intensity over two seconds. A gold square bar, 6 mm × 6 mm square in cross-section and 66 mm in length, was used as the target and mounted on a water-cooled copper block for heat removal. The container of the gold target was not hermetically sealed.

At around 11:55, a malfunction occurred in the power supply (PS) system of the EQ magnets of MR, and 2×10^{13} protons were delivered to the gold target in a very short period of five milliseconds, whereas in normal operation, 3 × 10^{13} protons should have been evenly extracted over two seconds. Although the beam was halted by the machine protection system (MPS), the instantaneous proton power far exceeded the design condition, and thereby a part of the gold target melted and evaporated along with the beam axis, as target melted and evaporated along with the beam axis, as presumed by the simulation calculation and was confirmed later in the inspection of the target with a fiberscope (Fig.3) [3]. Further, as shown in Fig.4, sprayed out gold was observed on the beryllium widow in the downstream side. This fact indicated that gold was pushed outward because of very rapid volume expansion resulted from vaporization of the melted gold. These observations match very well with the presumption based on the simulation shown in Fig.5.

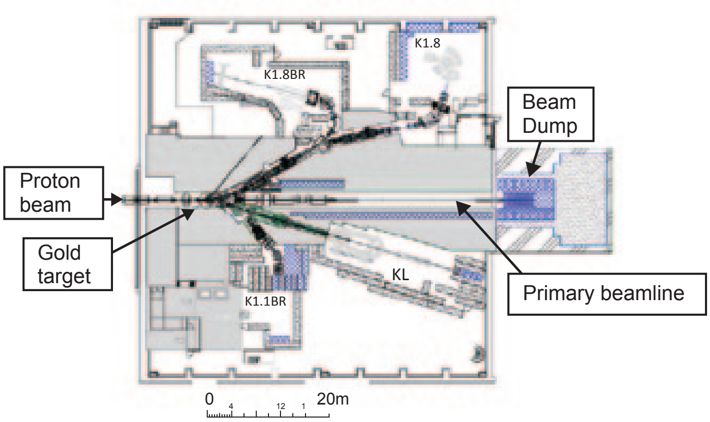


Fig. 1. Layout of the HD Hall.

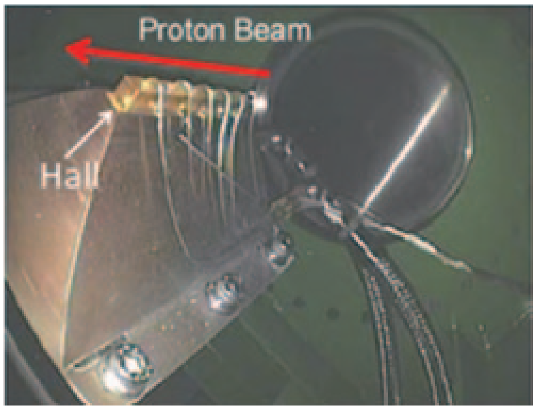


Fig. 3. Picture of gold target damaged.

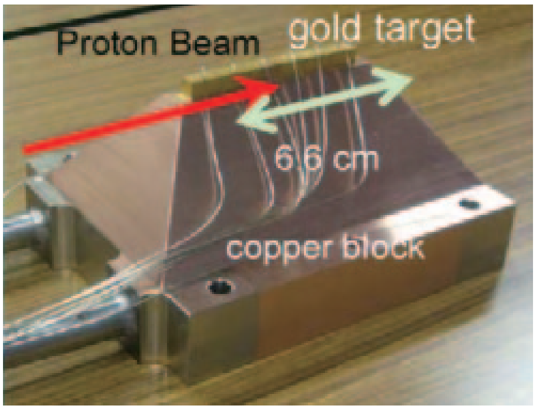


Fig. 2. Structure of gold target for HD facility.

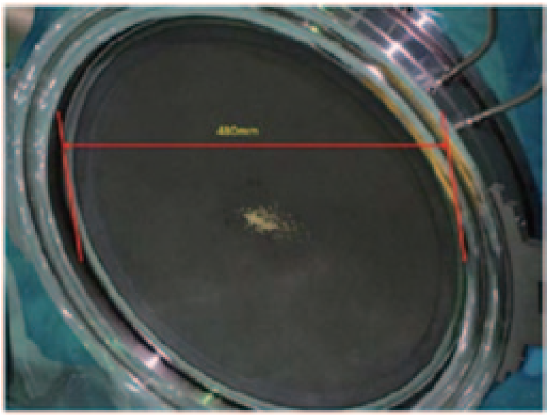


Fig. 4. Beryllium window for gold target.

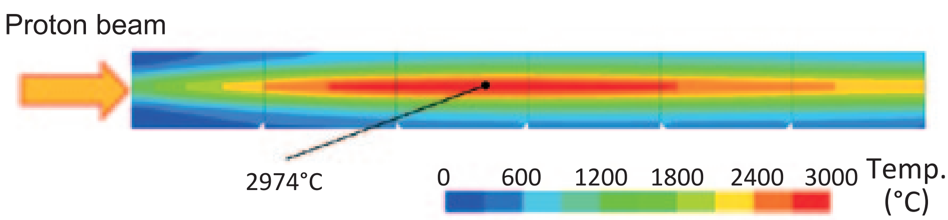


Fig. 5. Temperature distribution within gold target at the time of incident.

Consequently, radioactive materials which had been accumulated in the target via the spallation reactions were released into the primary beamline room because the target container was not hermetically sealed. Then the materials diffused to the HD hall because of insufficient airtightness of the beamline room, and caused exposure of workers (users and staff), in the HD hall. Even worse, the materials were released to the environment outside of the radiation controlled area of the HD facility by two-times inadvertent operations of ventilation fans in the HD hall: the first one was for checking radiation monitor's reliability and the second one was for reducing radiation does in the hall.

Because radioactive materials were released to the environment outside the radiation controlled area of the HD facility, the event should be notified to the relevant authorities in central and local governments as being obliged by the Japanese Radiation Regulation Law and the Agreement between local governments and JAEA. However, this fact was not recognized until receiving an inquiry from the Nuclear Fuel Engineering Laboratory (NFEL) of JAEA about small increases in the radiation level at monitoring posts placed at a boundary between J-PARC and NFEL, in the evening of the next day, May 24. Consequently, the notification was delayed by one and half days.

Major events and our actions after the abnormal beam shot on May 23, are summarized in the chronological order below:

May 23

11:55 Abnormally short proton beam was delivered to the target in the HD hall and halted by MPS. MPS indicated a tracking error which means too large deviation between the command and the response of the EQ system.

12:08 MPS was reset by the regular procedure, delivery of proton beam was restarted.

12:15 Decrease in secondary particle yields was observed, and beam course was adjusted.

12:55 High count rates in the safety counter and scintillation detector for experiment were recognized.

13:30 Increased radiation dose rate in five area monitors of the HD hall to 4 μSv/h maximum, which was about ten-times as high as the normal value.

15:15 Ventilation fans were turned on to check the monitor's validity. Radioactive materials were released to the outside the HD radiation controlled area.

17:00 Radiation survey of the HD hall indicated detectable contamination and high dose rate.

17:20 Sampling of air in the HD hall to check the radioactive material contamination.

17:30 Ventilation fans were turned on to reduce airborne radiation dose rate. Evacuation of workers from the HD hall began.

18:20 Radioactive nuclides other than activation products were recognized within the air sample taken in the HD hall.

23:30 Survey measurement and decontamination of workers were completed, and access to the HD hall was prohibited.

May 24

14:00 Started whole-body-counter (WBC) measurement for checking internal exposures.

17:30 Inquiry from NFEL about increases in radiation level at their monitoring posts. Inspection of the data log of area monitors indicated radioactive materials leak to outside the radiation controlled area of the HD facility.

21:10 The first report was faxed to the NRA, Ibaraki Prefecture, Tokai Village and other authorities.

May 25

0:46 Operation of all accelerators and experiments at Material and Life Science Experimental Facility (MLF) were stopped.

1:00 The results of first WBC measurement indicated that 4 workers in the HD hall were internally exposed in the range from 0.6 to 1.6 mSv.

Within the airborne sample taken in the HD hall, various nuclides attributable to a spallation reaction of gold were identified with a gamma-ray spectrum [5]. Most of them were short-lived, but some were relatively long-lived ones such as ^{125}I (Half-life is 59.5 d) and ^{75}Se (120 d). The species and relative abundance of these nuclides were in qualitative agreement with model calculations [5].

Hundred two persons who were in the HD hall during and/or after the incident were checked with a WBC measurement and a glass badge for their internal and external exposures, respectively [2]. All of them were registered as radiation workers. WBC measurements were carried out using a germanium detector and special database that were prepared for the airborne nuclides found in the HD hall. The highest contributors to internal dose were ^{197}Hg and ^{195m}Hg. Thirty-four workers received detectable radiation exposure. The internal dose (committed effective dose) and external dose (effective dose) were deduced from the measurements. The highest does of internal and external doses were 1.7 mSv and 0.1 mSv, respectively. The total exposure dose ranged from 0.1 to 1.7 mSv which is about 1/30 of the annual dose limit for radiation workers (50 mSv/yr). Medical examination was performed for all of the hundred-two persons, and no adverse effects due to the radiation exposure were confirmed.

The total amount of radioactive material that was released to outside of the HD hall was estimated with a diffusion simulation, on the basis of radioactive isotopes found in the airborne sample collected in the HD hall as well as the readings of the area monitors in the HD hall. It was found to be ~20 GBq. The radiation dose, which could be experienced if he/she were at the J-PARC site boundary closest to the HD facility, was estimated to be 0.17 μSv. This exposure dose was not so high but was unplanned one. From a fundamental view of radiation safety in a user facility, unplanned radiation exposure should not be validated regardless of the amount [2].

In addition, soil samples around the site boundary were also examined, but no contamination from incident- originated spallation product was detected.

Analysis of the Causes of the Incident

As described above, the direct causes of the incident were failures in the accelerator and equipment, i.e., a malfunction of EQ magnets for slow extraction system of MR, lack of a hermetic target container and insufficient air-tightness of the primary beamline room and the HD hall.

A systematic inspection to find out the cause of the malfunction of EQ magnets revealed that the malfunction was due to the degradation of the power supply that supplies a voltage to the interface circuit board of EQ magnet that converts an external input signal. The degradation was due to insufficient preventive measures against overheating in a three terminal positive output regulator [3]. At the same time, the following problems were also pointed out [1,2]:

a) The current limit setting of the EQ magnet was too high;
b) MPS was designed only to provide a warning but not to stop the EQ magnet power supply regardless of the seriousness, i.e., a tracking error;
c) A response time of the EQ magnet current supply was set up to ~5.5 ms and was not fast enough to prevent the incidence;
d) The radiation monitor system of the HD hall was not sufficient, i.e., no monitor displays were placed in the HD shift console and the central control room. Further, the monitor was not equipped with a function of multi-leveled warning. These problems were also the cases for the Neutrino Experimental Facility.

In addition to the hardware problems, the chronological sequence of events indicates that emergency actions against the incidence were so late, in spite of various information suggesting abnormality of the situation such as high dose rate and high background in counters, etc. The delay of emergency actions led to the exposure of workers and the release of radioactive materials to outside the radiation controlled area. In other words, information was not integrated and shared among relevant personnel. This resulted in the delay of proper recognition of the situation and emergency actions such as evacuation of workers.

Furthermore, it should be pointed out that misunderstanding of the status of radiation and the radiation regulation law led to the operation of ventilation fans. Therefore, the safety management system, a software aspect is also a very important point in the analysis of the incident.

For these reasons, the causes of the incident can be divided into two aspects: hardware and the software ones.

Preventive Measures

As noted in the previous section the deficiencies in the radiation safety management system of J-PARC Center were the background of the incident as well as those in the accelerator and radiation monitors. Therefore, the preventive measures that were proposed from J-PARC Center cover both the hardware and software (safety management system) aspects.

1. Accelerator and equipment (hardware) [1,2]

The preventive measures against recurrence of similar incidents consist of the following standpoints: (1) prevention of the radioactive material leak and (2) prevention of radioactive exposure. They are summarized in Table 1.

These preventive measures are developed based on the concept of "defense-in-depth", i.e., prevention of occurrence of incidents, prevention of expansion of the effect, and minimization of damage or effect by a combination of multilayered preventive measures. Furthermore, ensuring soundness of other facilities of J-PARC, the MLF, the Neutrino Experimental Facility, and the Accelerator Facility, was important in the preventive measures. These facilities were examined on their validity of a classification of radiation controlled areas, safety management equipment, and the soundness of instruments and devices. It turned out that the classification of radiation controlled areas and the radiation control were adequate, and also it was confirmed that, at these facilities, the instruments and devices were highly safe owing to multiple barriers for prevention of radioactive material leak to outside.

Table 1. Preventive measures relevant to accelerator and equipment.

Issues	Preventive measures
Anomalous beam extraction	- Revising current limit setting of the EQ magnet power supply (PS) - Shutdown of the magnet PS on detection of anomalous current deviation - Improving interlock system for faster shut down of the magnet PS on an anomalous operating condition
Damage to the target	- Improving target temperature monitoring system - Retracting the target off the beam orbit during accelerator studies
Leakage of radioactive material to outside the controlled area	- Employing a hermetically sealed target container - Monitoring radioactive material in a target container - Reinforcing airtightness in the primary beam-line room - Monitoring radioactive material in the primary beamline room - Exhausting the air of the HD hall through filters from a stack, after checking concentration of radioactive material
Insufficient radiation monitor	- Installing radiation monitors in an operation console - Reinforcing monitoring functions: alarm level setting, trend data, etc. - Sharing of radiation monitor information into accelerator operation system

2. Safety management system (software)

The preventive measures from the aspect of safety management are summarized in Table 2 and Fig.6. The following four points are the essence of the measures:

1) reinforcing safety management system,
2) clarifying the criterion for emergency response,
3) reinforcing the review system for radiation safety, and
4) fostering safety culture.

They are addressed from the study on the fact that quick and adequate responses could not be taken in the Hadron incident. A fundamental problem was the lack of imagination and/or understanding on possible risks, and actions to be taken in emergency because of the ambiguity in staff's responsibility and the command line in emergency. Underlying concept of the renewed safety organization is that the safety of the facility is of the responsibility of each own facility, not the safety division.

In the new safety management system, "Alert Status" is introduced to facilitate systematic actions in emergency. It is setup for a time when an anomalous situation occurs, such as turning-on of high-risk interlock or an anomalous radiation behavior, etc. In Alert Status, relevant personnel congregate to central control room or other appropriate place, and collect information to understand the situation and the necessary actions under the direction of the facility manager. This will enable quick griping of the situation at an early stage and making proper actions in timely manner.

In addition, Radiation Safety Review Committee was newly organized to enhance a risk review capability at J-PARC by inviting external experts (Fig.6). The committee is expected to provide detailed risk assessment and preventive measures for planned new apparatus and works. The risks include, but not limited to, a high radiation dose, a high contamination environment, works in a high place, etc.

Table 2. New measures in the safety management system (software).

Issues	Preventive measures
Unclear responsibility and command line	- Creating a new position of Deputy Director for safety management - Clarifying responsibilities of relevant personnel and a command line - Assigning a facility manager, a person-in-charge for a building, a radiation generator, and equipment for each facility, and assigning an alternate when they are absent
Insufficient radiation safety review capability	- Reorganizing "Radiation Safety Meeting" to J-PARC Radiation Safety Review Committee (RSRC) with new external experts - Setting up working groups under RSRC for thorough review of a specific item/issue
Unclear criterion for judgment and actions	- Clarifying criterions in operation manuals and relevant documents - Introducing "Alert Status" between existing "Normal Status", and "Emergency Status" to properly respond to an incident - Carrying out a drill for an emergency situation
Insufficient safety culture	- Creating safety slogans and safety card in J-PARC - Providing continual safety education and training for both staff and users - Employing bidirectional education process for safety education - Carrying out a periodical review and upgrade of contents and procedures of safety education

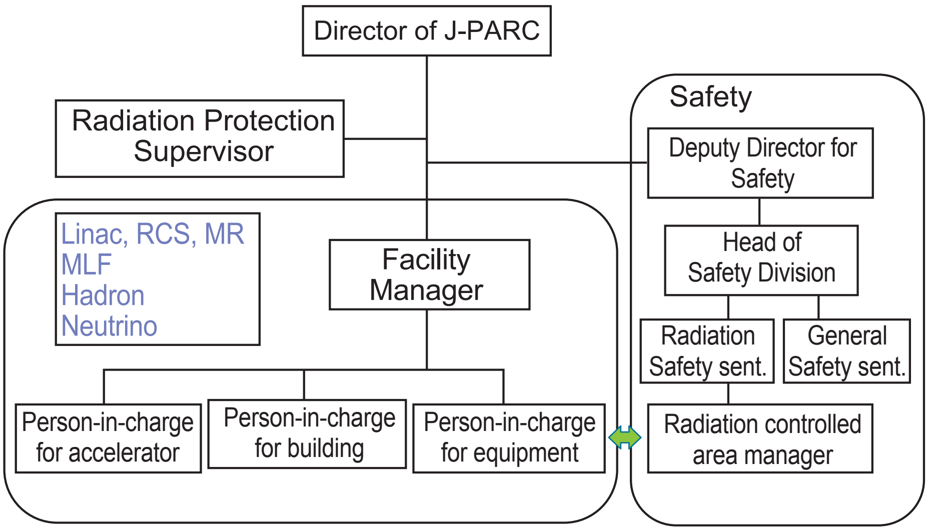


Fig. 6. New safety organization in J-PARC.

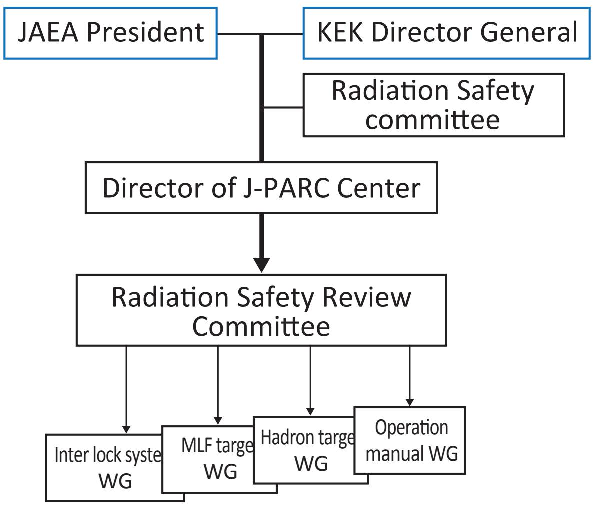


Fig. 7. Schematic of radiation safety review system in J-PARC.

Present Status and Outlook

The Hadron incident made us re-acknowledged that the safety is essential in the facility operation. Therefore, the reinforcement of soundness of facilities, equipment and the safety management system was of the first priority for J-PARC Center to make J-PARC a safer user facility. Along the above preventive measures, the EQ magnet system, target container, primary beamline room, HD hall, and radiation monitoring system have been improved, and the work is almost completed. In addition to the items listed in Table1, various upgrades have been undertaken toward higher reliability and safety of the J-PARC accelerator system. The new safety management system became effective on October1, 2013, and new rules for the safety management were put in enforcement on November1, 2013. Since then, education/training courses about the new safety management system and rules, and the safety culture were carried out several times. Drills for an emergency situation, including a case of "Alert Status", were conducted at various facilities in collaboration with Nuclear Science Research Institute of JAEA.

On February 17, 2014 user operation at MLF was resumed after about 9 months shut down [6]. Operation of MR for tuning started on March 24, 2014, and the neutrino collaboration experiment, T2K, started on April 26. The repair and improvement of the HD facility have been conducted steadily.

At the end of September 2014, the damaged gold target was safely replaced with a new target. The new target is placed in a new hermetically sealed chamber with improved structure for heat removal. The improvement of airtightness of the primary beamline will be completed in December, 2014. The HD facility is expected to resume its operation following the completion of the reformation and the approval from relevant authorities, local governments and residents.

References

[1] J-PARC Center: http://j-parc.jp/ HDAccident /HDAccident-e.html.

[2] http://j-parc.jp/en/topics/20130812Accident_Report.html

[3] http://j-parc.jp/en/topics/HDAccident 20131117.pdf

[4] http://j-parc.jp/en/topics/HDAccident20131211.pdf

[5] HAGIWARA Masayuki, Proceedings of 2nd J-PARC Symposium (July, 2014), Session S-15-PM1

[6] http://j-parc.jp/en/topics/20140221director_message.html

Accelerators

Overview

In the beginning of fiscal year 2013, the rapid cycling synchrotron (RCS) and the main ring synchrotron (MR) were delivering 300 kW proton beams to the material and life science experimental facility (MLF) users and 220 kW to the Tokai-to-Kamioka (T2K) experiment, respectively. On May 13, 2013, the operation mode of the MR was switched from fast extraction to slow extraction mode. The maximum beam power of the slow extraction mode until then was 15 kW. The beam power was gradually increased in the accelerators study in this period and reached to 30 kW in maximum. User operation with 24 kW beam power was started on May 18, 2013.

At around 11:55 on May 23, 2013, one of the spill feedback quadrupole magnets, Extraction Quadrupole (EQ), malfunctioned. A beam consisting of 2×10^{13} protons was extracted within a very short time of 5 ms and delivered to the gold target in the hadron experimental (HD) facility, whereas normally a total of 3×10^{13} protons were extracted for 2 s. The gold target was instantaneously heated up to an extraordinarily high temperature due to the short-pulse beam and partially damaged. As a result, the radioactive material dispersed from the gold target and leaked into the primary beamline room, because the target container was not hermetically sealed. Since the airtightness of the primary beamline room was not sufficient, the radioactive material leaked into the hadron experimental hall (HD hall) and workers were exposed to radiation. Additionally, due to operation of the ventilation fans in the HD hall, the radioactive material was released into the environment outside of the radiation controlled area of the HD facility.

Due to the incident, all of the J-PARC facilities stopped the beam operation for seven months. The operation of the linac was resumed in December, 2013, after the long work on introducing preventive measures against similar incidents.

During the shutdown period, we investigated the cause of the malfunction of the EQ magnets in cooperation with the manufacturer of the EQ power supply. As a result of the investigation, it was identified that a primary failure occurred in part of the data transmission system of the power supply. The setting value of the magnet current was not transferring correctly. This failure resulted from voltage drop in a circuit board of the voltage power supply that supplies a fixed voltage of 5 V to an interface board that converts an external input signal. The EQ power supply had been operated without a failure since 2009. However, the circuit board of the relevant power supply suffered aging degradation due to insufficient preventive measures against overheating in a three-terminal regulator on the board and, which led to the malfunction at the time of the incident. To avoid the recurrence of the aging degradation, we changed the configuration of the circuit board of the voltage power supply to increase its heat capacity.

For a safe and reliable operation with a high power beam, it is essential to adopt effective measures against malfunction of the system. For this purpose, the following improvements on the EQ system were made: 1) to stop the operation if anomalous current deviation is detected, 2) to shorten the shutdown time when occurrence of abnormality is detected, 3) to decrease the maximum setting of the current value of the power supply from 340 A (a maximum current of the power supply) to 120 A, which is sufficient for routine users operations.

On the other hand, various improvements of the accelerators have been performed during the long shutdown period. Most improvements were originally planned before the incident. The energy upgrade of the linac is one of the most important of them. We have installed a new accelerating structure system, the annular-ring coupled structure (ACS) linac, to increase the beam energy from 181 MeV to the full energy of 400 MeV. For the beam injection of the RCS at 400 MeV, all of the power supply of four shift-bump magnets was replaced with newly manufactured ones.

For the MR, upgrade of the ring collimator system and replacement of a part of the beam duct were the main improvements. Four additional collimator units and additional iron shield walls were installed just in the downstream area in the beam injection section of the MR to increase the beam loss capacity of the collimator system from 2 kW to 3.5 kW. A part of the quadruple and sextupole beam ducts made of stainless steel was replaced with new ones, made of titanium, to reduce the residual radiation dose.

The beam commissioning of the linac with the ACS system started in December, 2013. The designed beam energy of 400 MeV was achieved in January, 2014. The beam commissioning of the RCS with linac beam of 400 MeV started in the same month and the 400 MeV injection beam was accelerated to 3 GeV in February, 2014. The user operation of the MLF resumed on February 17, 2014 with beam intensity of 300 kW after the nine-month beam shutdown. For the MR, beam study restarted on March 24, 2014. The injection beam from the RCS was accelerated to 30 GeV and extracted by the fast extraction system to the abort beam dump on March 30 for the first time after the incident in the HD facility.

LINAC

The J-PARC linac power upgrade program is now in progress in parallel with the user operation. To realize the nominal performance of 1 MW at the RCS and 0.75 MW at the MR, we need to upgrade both the energy (400 MeV) and the peak beam current (50 mA) of the linac.

For the energy upgrade, we installed ACS cavities (Fig. 1) and 972 MHz klystron system (Fig. 2) during the summer shutdown in 2013. The installation work was completed on schedule in spite of only three months allotted to the installation because the upgrade of related systems such as a waveguides, cables, cooling water system and so on started in 2010 during the annual summer maintenance period. The beam commissioning of the linac started in December, 2013, and the designed beam energy of 400 MeV was achieved in January, 2014. Thereafter, we performed additional beam study to reduce the beam loss. The transverse beam profile at the ACS exit shows a significant beam halo which is supposed to come from the longitudinal mismatch at the ACS entrance. We think that this halo can be mitigated by a longitudinal matching. After the linac beam commissioning, the beam tuning of the RCS started. The tuning result showed that the beam loss at the beam injection area decreased significantly by increasing the incident energy from 181 MeV to 400 MeV. It was confirmed that the energy upgrade was quite effective to reach a beam power of 1 MW.

The user operation of the MLF resumed in February, 2014 with a beam power of 300 kW using a linac output peak current of approximately 15 mA. During the operation, some failures such as discharge of a klystron, malfunction of high voltage power supply for the klystron and instability of cooling water flow level occurred.

In February, 2013, the klystron for DTL2 was replaced with a brand-new one because frequent discharges between the anode and the body occurred at the klystron. This was the first replacement with a spare since the operation started in November, 2006. Subsequently, the klystron for SDTL13 was replaced in February, 2014, because the klystron was incapable of sustaining the required voltage. We think the klystron may be approaching the end of its life because it has been in operation for over 30,000 hours as of March, 2014.

A high voltage transformer (HVTR) of the klystron power supply #2 was broken in December, 2013. The failure was caused by destruction of the diode module due to sudden voltage overload, which was the same situation as when the HVTR#1 was broken in March, 2012. As a countermeasure, we consider the installation of some surge absorbers at the input terminals of the HVTR.

For the beam current upgrade, we plan to replace the ion source and the Radio Frequency Quadrupole

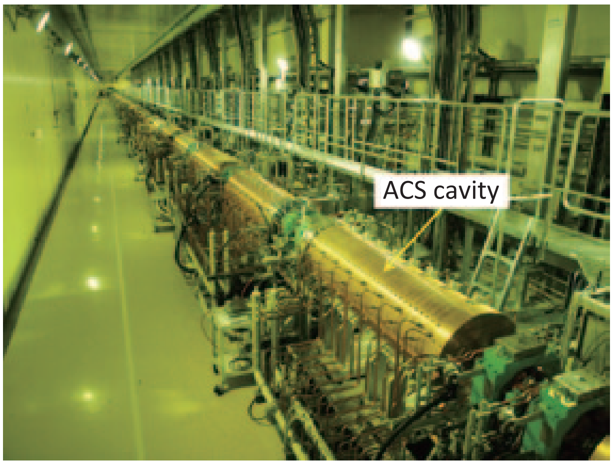


Fig. 1. ACS cavities installed in the accelerator tunnel.

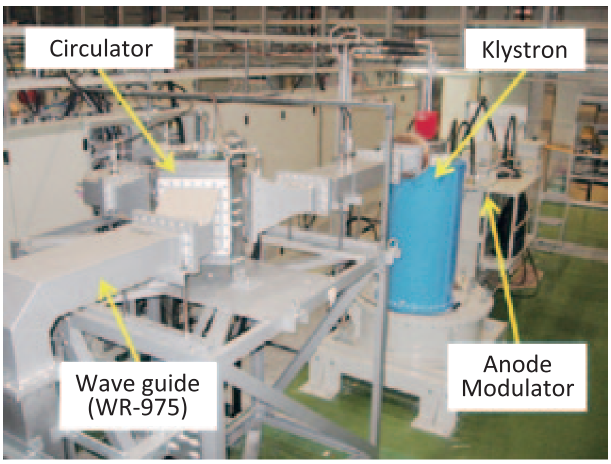


Fig. 2. 972 MHz klystron system for the ACS cavity.

linac (RFQ) during the summer shutdown in 2014.

The prototype cesiated RF-driven H^- ion source satisfied the upgrade requirements of an H^- ion beam current of 60 mA with a flat top beam duty factor of 1.25%. We need to replace an RF antenna, an end-flange, a plasma chamber and the plasma electrode periodically to prevent unscheduled beam stop due to their failure. To perform the replacement work efficiently, the replacement elements were unitized to allow dismount and mount in bulk. Moreover, in order to install the unitized source on the beam line by hand, a low-weight material was needed, so we adopted stainless steel (SS) for the plasma chamber instead of the nickel-plated OFC used in the prototype source. We confirmed that the SS plasma chamber source had the same beam performance as that of the prototype source.

A test stand has been constructed to perform the new RFQ beam test before installation. The conditioning of the RFQ was conducted, and after 20 h of conditioning, the RFQ became very stable with a nominal peak power and duty of 400 kW and 1.5%, respectively. The beam test was subsequently conducted, and the peak beam current of 50 mA with the pulse length of 50 μs and the repetition rate of 25 Hz from the RFQ was successfully demonstrated on February 6, 2014 (Fig. 3).

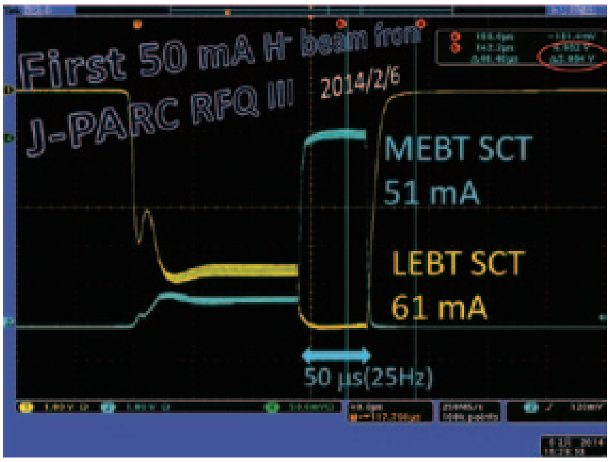


Fig. 3. Waveforms of the beam current measured at the ion source exit (LEBT) and the RFQ exit (MEBT).

RCS

The RCS was also severely damaged by the earthquake on March 11, 2011 and the beam operation was shut down. The main magnets and other components were displaced by the earthquake, but we didn't perform realignment of these components, because the rapid restart of the user operation had a priority over their realignment. Since this displacement caused a beam loss in the beam power of more than 400 kW, the realignment of those components was essential to realize higher beam power and stable operation. On the other hand, to achieve the nominal performance of 1 MW at the RCS and 0.75 MW at the MR, the full energy (400 MeV) and higher peak beam current of the linac is necessary for the J-PARC facility. The linac has upgraded its energy from 181 MeV to 400 MeV with the new ACS linac. These two heavy tasks, which were the realignment and the 400 MeV beam injection upgrade in the RCS, were done at same time (from July to December in 2013). At the same time, we had the challenge to achieve higher beam power operations with better stability. This paper deals with the RCS status and progress for this one year.

(1) OPERATION FOR THE USER PROGRAM

The RCS could deliver beam whose power was 300 kW to both the MLF and the MR for their user operation with an average availability of more than 95% before the linac energy upgrade. The user operation resumed from February 17, 2014, with a 110 kW beam only for the MLF after the linac beam energy upgrade (400 MeV injection). The beam power gradually increased, and then reached 300 kW for the MLF users on February 27, 2014. Since the MR started the user operation for the neutrino experiment from mid-May, the RCS also started to deliver beam with power of 300 kW to both the MLF and the MR. The availability of the beam delivery after 400 MeV injection was not so high at first because several kinds of devices, for example newly installed power supply, oil cooling system for power supply, and so on, stopped for one day and more, but this situation improved and the delivery reached more than 90% at present.

(2) MAINTENANCE AND IMPROVEMENTS

Realignment and preparation for the 400 MeV injection were the main task in this maintenance period. The details of those works and several progresses are described in this section.

1) Realignment of RCS

To minimize the amount of realignment work, we decided that not all components should move to designed regular positions. The components, which should be aligned, were chosen to be secured the design acceptance 486 π mm mrad. Almost all components, which were main magnets, RF cavities, and extraction magnets, had to be moved in the range of ~17 mm for horizontal, ~4 mm for vertical and ~10 mm for longitudinal, respectively. Ceramics chambers were also moved to the center of the magnet. It was not necessary for the components installed in injection straight line to move because the displacement of these components was less than +/-0.2 mm. The positions of the magnet, RF cavity and other components were measured by laser tracker and adjusted within +/-0.2 mm compared with the design value. This work was successfully completed on schedule by a total manpower of 2200 person-day.

2) Replacement of ceramics chambers and capacitors

The withstand voltage of the capacitor is 250 V, which is lower than the voltage induced by the shift bump magnet. That is why capacitors were broken down during the shift bump magnets operations. More than 90% capacitors cutoff in situ were to escape broken of the ceramics chamber due to discharge of the capacitors. Since this effect disturbed the balance in the configuration of the RF-shield, this condition caused kick field to the beam due to dipole field induced in the RF-shield by eddy current of the bump field. The reason why this work was conducted is that the symmetric configuration of the RF-shield was important to reduce the beam loss. Ceramics chamber was installed in each shift bump magnet, and there was a total of four ceramics chambers in this area. Two ceramics chambers were replaced with new ones and only capacitors were replaced with new high withstand voltage ones for another two ceramics chambers, because there were not enough spare ceramics chambers.

3) Improvement of charge exchanger #2 and #3

There were three charge exchangers in the injection area for H^- beam injection from linac. Since charge exchanger #1 was mainly used for charge exchange, its design was convenient to maintain, on the other hand, there were some issues with the maintenance of charge exchangers #2 and #3 because their configuration was very simple. These charge exchangers were replaced with new ones, in which those issues have been solved.

4) Vacuum condition improvement in the injection line

The inner periphery of the injection branch of the RCS had a high activation level which was a few mSv/h on the surface of the vacuum chamber measured 4 hours after of stopping the beam for the user operation. The user operation has been performed with a beam power of 300 kW for 3 weeks. This high activation was due to H^0 beam, whose electron was stripped by the molecules in the beam pipes during the beam transportation through the beam transport line from the linac to the RCS. They were not bent by the injection magnets and hit a wall in the vacuum chamber. To solve this issue, two vacuum pumps were additionally installed in this area.

5) Installation of new scrapers in the injection beam line

Small size beam injection by removing the beam halo is essential to reduce beam loss at the injection area, especially downstream of the charge exchange foil and the injection dump in the RCS. However, the previous scraper for halo reduction, which was installed in the beam transport line from the linac to the RCS, was not useful, because the scraper produced beam loss downstream of it due to large angle scattering caused by too thick scraper head. To solve this issue, we installed a new scraper with optimized head to mitigate the radiation around it.

6) Replacement of MA cores and new cavity installation

We have been replacing the old magnetic alloy (MA) cores with buckling-free type ones for 2 cavities during this maintenance period. Replacing MA core work was done for a total of 9 cavities. A new cavity was installed this year, which increased the number of the cavities to 12, the designed number for the RCS. At present all 12 cavities work well.

7) Preparation for correction Q-magnets

To correct an unwanted edge focusing effect due to the injection bump magnet and a tune during the beam acceleration period of 20 ms, correction quadrupole magnets (QDTs) have been developed. A total of 6 QDTs and their beam pipe made by alumina ceramics were installed in the RCS. The cabling between their magnets and power supply was also finished. The power supplies are under construction at present and this correction system will be operated from this autumn.

The corrective dose for each work operation is summarized in Table 1. Many people, max. ~100 persons per day, worked in the RCS tunnel on maintenance, however, the corrective dose was not so high. Our radiation protection and control for each worker worked well and the RCS tunnel was clean.

Table 1. Corrective dose for each work operation.

work	Corrective dose [μSv]	Personal maximum exposure dose [μSv]
Realignment	50	20
Replacement of ceramics chamber and capacitors	1467	300
Improvement of charge exchanger	234	60
Monitor maintenance in injection area	420	170

(3) 400 MeV BEAM INJECTION AND ITS EFFECTS

To achieve the nominal performance of 1 MW at the RCS and 0.75 MW at the MR, the full energy (400 MeV) and a higher peak beam current of the linac are necessary for the J-PARC facility. The linac has upgraded its energy from 181 MeV to 400 MeV with the new ACS linac. At the RCS preparation for 400 MeV injection, beam commissioning and user operations have been carried out.

The new power supply for injection shift bump magnet (SB) was designed to accept 400 MeV beam from the linac. The cause for beam loss of the RCS is the excitation of coherent beam oscillation due to the SB induced dipole ripple. Figure 4 shows the beam position change due to the SB induced dipole ripple both for the previous and the new power supply. In the previous power supply and original RF-shield with lack of capacitors, the beam position changed by more than +/- 2 mm. On the other hand, in the new power supply and modified RF-shield without the lack of capacitors, the beam position in the flat top was stable. The beam position changed +/- 1.5 mm for the horizontal only in starting ramping down of the field. This result shows that the new power supply works very well, however, a stable operation has not been achieved yet.

Beam commissioning with injection energy of 400 MeV was started from January 30, 2014 without acceleration to tune and adjust injection parameters at first. Adjustment, tuning and measurements for injection, acceleration and extraction have been performed during the beam commissioning operation for two weeks, and a high intensity beam trial was also carried out. An equivalent beam power of 560 kW with a beam loss of only 0.3% was achieved in a short time for this high intensity beam study.

By the commissioning after the shutdown, the 300 kW operation condition was established. In this condition, the doses of most areas were kept at the same level as the 181 MeV injection energy operation or decreased except to the injection foil chamber, with 100 degrees and H^0 dumps. The first results from the user operation with the new injection energy indicated that the residual dose on the vacuum chamber of the charge exchange foil became higher, the residual doses near the injection H^0 dump were increased by the halo of the injection beam, and the dose at the injection septum magnet was reduced due to improvement of the vacuum pressure in the beam transport line from the linac to the RCS and higher injection energy.

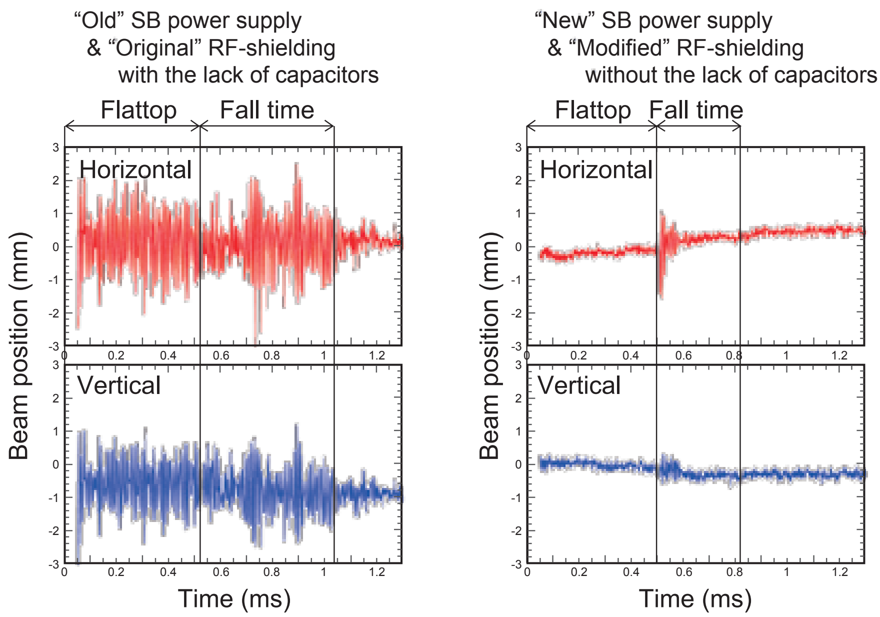


Fig. 4. Beam position change due to SB induced dipole ripple for both the previous and the new power supply.

MR

The operation of the MR was also upset by a radioactive material leak at the Hadron Experimental Facility. On May 23, 2013, the control of the EQ power supply malfunctioned, which led to the extraction of 2 × 10^{13} protons to the gold production target during a 5 ms long pulse. The very short pulse melted and evaporated the target material and caused radioactive contamination in the Hadron hall and its surroundings.

Prior to this incident, the MR had achieved the beam power of 240 kW for the fast extraction, and 24 kW for the slow extraction. In particular, the slow extraction provides a "duty factor" of 43% at 24 kW and 99.5% extraction efficiency. A study demonstrated as much as 30 kW slow extracted beam delivered to the target. However two serious problems occurred in the MR before the succession of the slow extraction of 30 kW beam. The first was an issue with the low-field septum magnet for the SX system. This was discovered on March 14, 2013, when the septum magnet showed a large, unexpected beam loss. It eventually became clear that a septum conductor was deformed and obstructed the beam. Its conductor was made of a 1 mm-thick copper plate. The cooling water pipe had torn off from the septum conductor, and the heat induced by the beam was not being removed, causing the thermal extension of the conductor to deform. This problem was fixed by replacing the conductor, and the beam operation restarted on April 27, 2013. Another issue was a water leak from the hollow conducting coil of the injection septum magnet. It was found on May 8, 2013, and the operation resumed on May 13, after repair.

Immediately after the incident, a number of proposals were presented to prevent the extraction of a short intense beam pulse to the target in the hadron hall, including limiting current excursions of the EQ power supply. These improvements would address not just a malfunction of the EQ power supply but also other possible scenarios such as a pre-fire of the beam abort kickers. For the EQ power supply, the following measures were taken with regard to other probable risks:

(1) Add items to stop output current;
  a. tracking error (5% of 340 A),
  b. error bit and abnormal strobe of digital signals
  c. external interlock
(2) Lower current trip limit
(3) Fast interlock system
(4) Check tracking Error between DSP Set Value and Output Current.

During the long shutdown after the hadron incident, the following jobs were completed to increase the beam power:

(1) The injection collimation system was modified by the installation of 4 additional short collimators resulting in a beam loss capacity of 3.5 kW, increased from 2 kW. The configuration of the collimators is shown in Fig. 5.
(2) The stainless-steel beam ducts were replaced with titanium ducts to reduce residual activation.
(3) The waveform of the injection kicker was improved by applying a matching resistor. It is shown in Fig. 6.
(4) The repetition period of the MR was 2.48 s for the FX mode just before the hadron incident. At present, a period of 2.40 s is being tested by modifications to the magnet power supplies.

As the almost jobs described above were completed before the end of JFY2013, the beam study of MR was resumed in April, 2013. In the near future, the MR must increase the power of the fast extracted beam to 750 kW from the present 240 kW. Thus, the immediate challenge lies in improving the beam loss handling in the MR. The followings are potential corrections for addressing this issue:

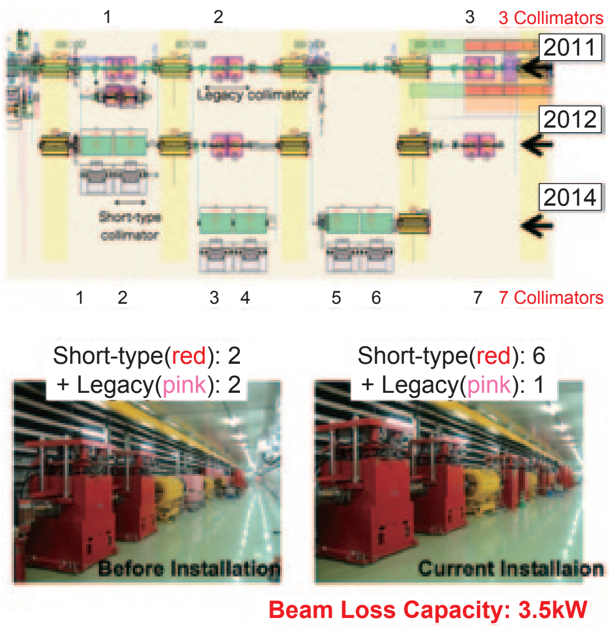


Fig. 5. Configuration of the MR injection collimators.
Top: The change of the collimator layout.
Bottom: Comparison of the injection area before and after the installation of the last collimators. The left picture corresponds to the layout in 2012. The legacy means the originally installed collimators.

(1) Shortening the repetition cycle to 1.3 s. To achieve this, the magnet power supplies and RF cavities will be replaced. Beam simulation of the MR operation at high beam power is ongoing.

(2) To generate a 1.3 s repetition cycle, new magnet power supplies utilizing capacitive energy storage are now in development. These provide all the required magnetic energy, around 1 MJ for one bending family, from the capacitors. Halving the load-per-supply and using three choppers in parallel addressed the requisite increase in ramp rate. Precise output current control, with a current ripple of less than 10^{-6} at the flat top and precise tracking, will be achieved by shifting the phase and low-noise digital control. An example of the measured result for the developed small power supply is shown in Fig. 7.

(3) New RF cavities with FT3L cores will allow for the necessary voltage for acceleration in the MR with a 1.3 s repetition period without building new RF amplifiers. The 9 cavities with 3 gaps each will ultimately be replaced by 7 cavities with 5 gaps and two cavities with 4 gaps.

(4) To reach the required intensity for the 750 kW operations, the anode power supplies of the cavities will need additional power units to bring their output from 840 kW to 1.2 MW.

(5) Mass production of the FT3L cores began commercially in May, 2013. The construction of two cavities with 4 gaps and two more with 5 gaps was launched during JFY 2013. The first one will be delivered on March 25 and checked in the test array before its installation into the ring during the summer shutdown. All remaining cavities will be installed during JFY 2016. Figure 8 shows the upgrade plan for the new FT3L cavities.

(6) A second harmonic cavity for relaxing the space charge effect of the bunch is in construction, using air-cooling and Finemet cut cores. It will be tested during the spring of 2014.

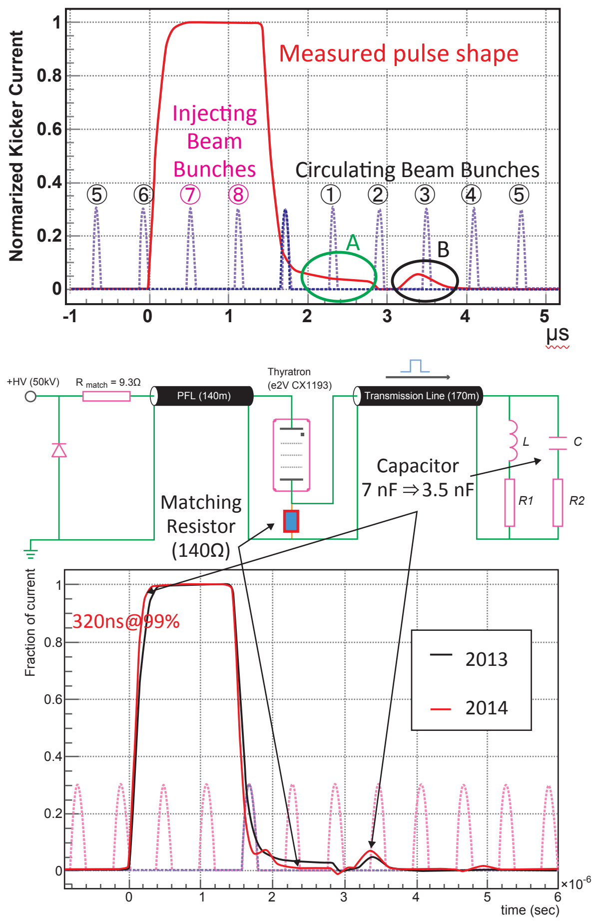


Fig. 6. Waveform of the injection kicker magnet.
Top: Measured original waveform. Tail shown as A and B makes the beam loss by kicking the circulating beam.
Bottom: Improved waveform by adding the matching resistor and changing the capacitor.

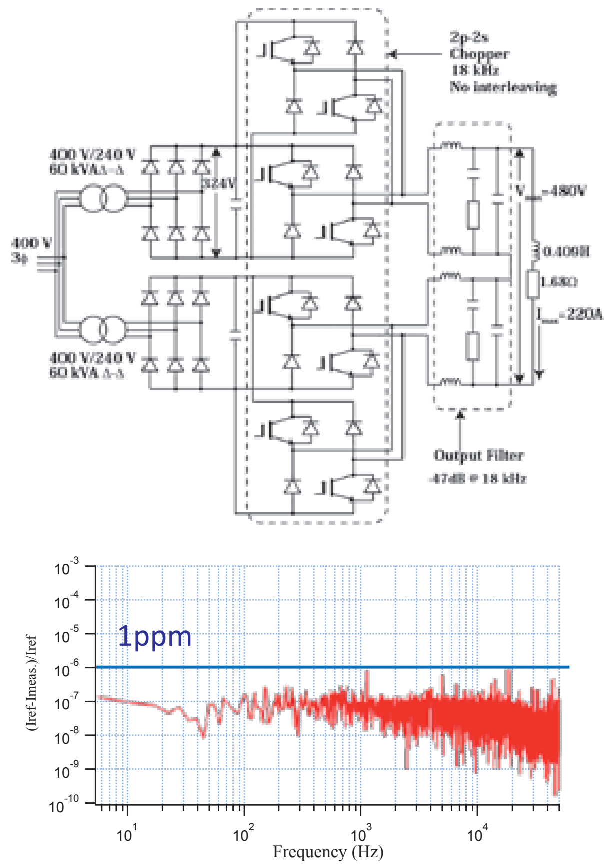


Fig. 7. Developed small power supply.
Top: Circuit diagram of the power supply for the sextupole magnet.
Bottom: Measured current deviation from the reference value.

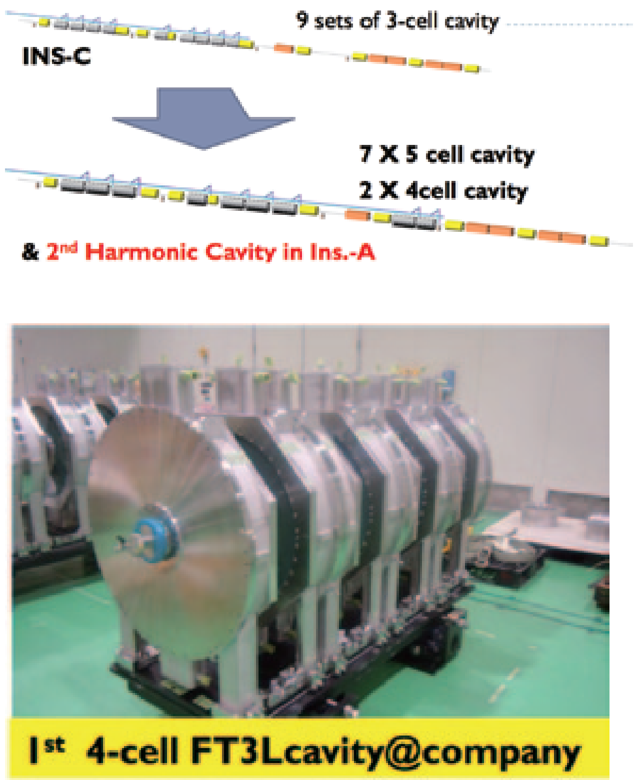
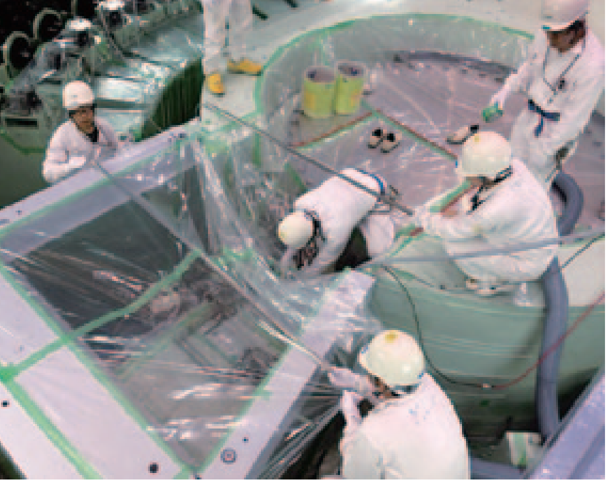
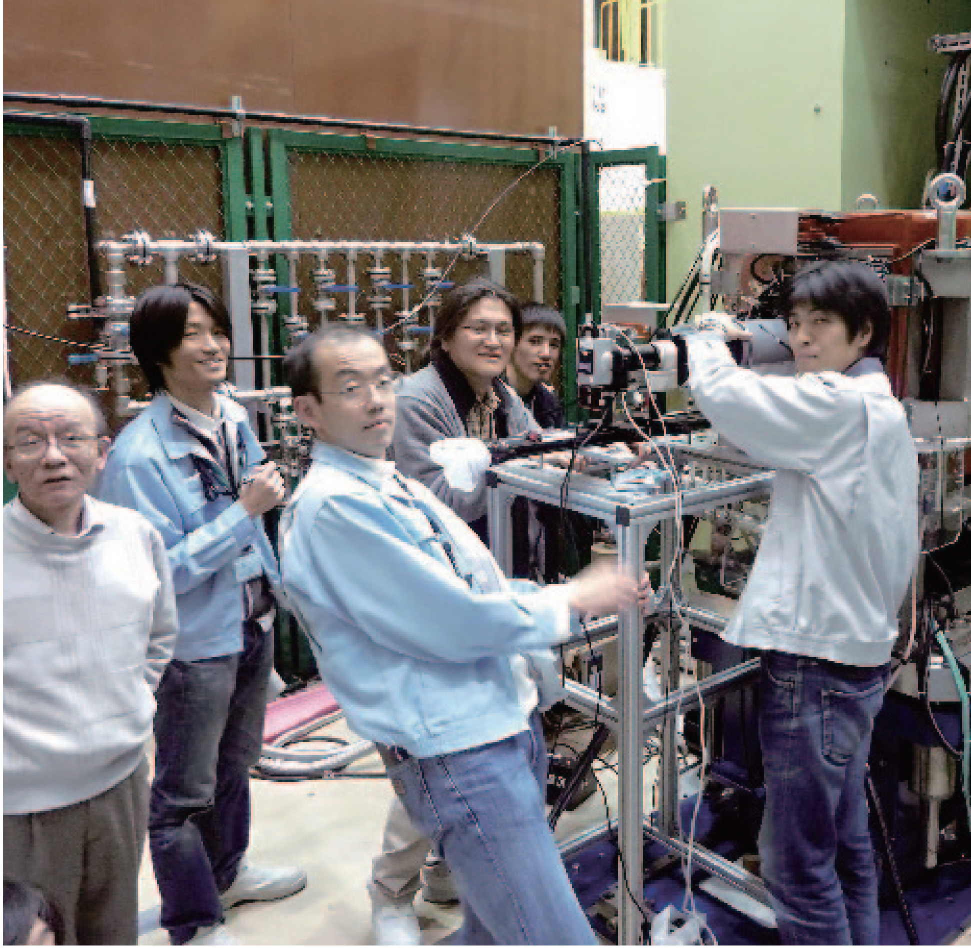


Fig. 8. FT3L cavities & upgrade scenario.
Top: RF cavity upgrade configuration.
Bottom: New FT3L cavity with 4 gaps.





Materials and Life Science Experimental Facility

Overview

In JFY2013, the beam operation at MLF started with a beam power of 300 kW. The scheduled time and availability are shown in Table 1. We had a good start with high availability in Run#48, and then the incident at the Hadron Facility occurred in Run#49. Due to this incident, all user programs in 2013A, including the on-beam training of AONSA neutron school that was scheduled for June 18-19, were cancelled without carrying over. After the installation of the 400-MeV superconducting LINAC and beam studies in Run#50 and #51, the user beam operation started with a beam power of 100 kW on February 18, 2014, and resumed with a power of 300 kW on February 28. The number of neutron users in JFY2013 decreased to 520 compared to that in JFY2012 (735) because the total beamtime allocated to users was reduced by the incident at the Hadron Facility, while the number of muon users slightly increased to 77 from that in JFY2012 (72).

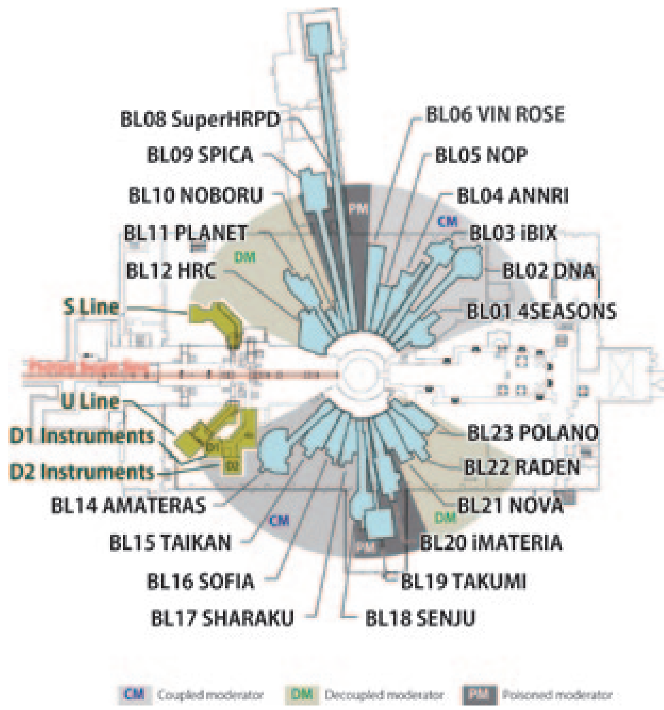
Regarding the status of beamlines, the user programs of neutron and muon science were carried out at 17 and 2 instruments, respectively, in JFY2013 (Fig. 1). BL09 (SPICA) is still in commissioning phase. BL11 (PLANET) was introduced as a public beamline to be used in the user program from 2013B, after completion of the commissioning work in 2013A. At the neutron facility, construction of three new neutron instruments, BL06 (VIN ROSE), BL22 (RADEN) and BL23 (POLANO), has progressed. VIN ROSE, which is installed by Kyoto University and KEK consists of a neutron resonance spin echo (NRSE) instrument and a modulated intensity by zero effort (MIEZE) one. The guide mirrors and downstream concrete shielding were installed in JFY2013. The installation of the shielding of BL22 was completed in this fiscal year. Other components, such as optical devices and a rotary collimator, were also installed. POLANO is constructed under the joint project between Tohoku University and KEK. Its construction started in JFY2013 when the supplemental budgets were approved for both institutes. The basic design and construction of the shielding were completed. The U-Line has been constructed since the last fiscal year, and is currently under commissioning. In JFY2013, the construction of the S-Line has started. The main beamline components to direct the muon beam toward the S1 experimental area, such as the quadrupole magnets and DC separator, have been manufactured.

In MLF, whole operation manuals and accident response were revised and several kinds of safety drills were carried out after the incident at the Hadron Facility. Furthermore, most of the instrument scientists and engineers in MLF and CROSS were qualified to join the shift leader team as the sub-shift leader. This is a newly introduced position for assisting the shift leader, who is a person in charge of the MLF operation. The sub-shift leader has the same responsibility along with the shift leader.

Table 1. Beam statistics for the MLF user program in JFY2013.

Run#	Scheduled Time (h)	Availability
48	250	99.0%
49	993	58.6% *1
50	No time for users	
51	No time for users	
52	889	86.2%
Overall	2132	74.8%

(*1 Due to the incident at the Hadron Experimental Facility.)



Neutron Instruments

BL	Name of Instruments	Moderator	Status
BL01	**4SEASONS:** 4D-Space Access Neutron Spectrometer	Coupled	Available to users
BL02	**DNA:** Biomolecular Dynamics Spectrometer	Coupled	Available to users
BL03	**iBIX:** IBARAKI Biological Crystal Diffractometer	Coupled	Available to users
BL04	**ANNRI:** Accurate Neutron-Nucleus Reaction measurement Instrument	Coupled	Available to users
BL05	**NOP:** Neutron Optics and Fundamental Physics	Coupled	Available to users
BL06	**VIN ROSE:** VIllage of Neutron ResOnance Spin Echo spectrometers	Coupled	under construction
BL08	**SuperHRPD:** Super High Resolution Powder Diffractometer	Poisoned	Available to users
BL09	**SPICA:** Special Environment Neutron Powder Diffractometer	Poisoned	commissioning
BL10	**NOBORU:** NeutrOn Beam-line for Observation & Research Use	Decoupled	Available to users
BL11	**PLANET:** High Pressure Neutron Diffractometer	Decoupled	Available to users
BL12	**HRC:** High Resolution Chopper Spectrometer	Decoupled	Available to users
BL14	**AMATERAS:** Cold-Neutron Disk-Chopper Spectrometer	Coupled	Available to users
BL15	**TAIKAN:** Small and Wide Angle Neutron Scattering Instrument	Coupled	Available to users
BL16	**SOFIA:** Soft Interface Analyzer	Coupled	Available to users
BL17	**SHARAKU:** Polarized Neutron Reflectometer	Coupled	Available to users
BL18	**SENJU:** Extreme Environment Single Crystal Neutron Diffractometer	Poisoned	Available to users
BL19	**TAKUMI:** Engineering Materials Diffractometer	Poisoned	Available to users
BL20	**iMATERIA:** IBARAKI Materials Design Diffractometer	Poisoned	Available to users
BL21	**NOVA:** High Intensity Total Diffractometer	Decoupled	Available to users
BL22	**RADEN:** Energy Resolved Neutron Imaging System	Decoupled	under construction
BL23	**POLANO:** Polarization Analysis Neutron Spectrometer	Decoupled	under construction

Muon Instruments

BL	Name of Instruments	Status
D1	**D1 Instrument**	Available to users
D2	**D2 Instrument**	Available to users
U Line		under construction
S Line		under construction

Fig. 1. Status of the neutron and muon instruments at MLF.

Neutron Source

Progress of the Neutron Source Section (H. Takada)

In 2012, we started supplying helium gas micro-bubbles in the running mercury circulation loop, which mitigates pressure waves generated in the mercury target by injecting intense proton beam, and confirmed that the vibration velocity on the target vessel initiated by the pressure waves was decreased for the first time in the world. However, the flow rate of helium gas did not reach the rated value because mercury was unexpectedly intruded from a vent line to a helium supply line through a surge tank. During the maintenance period in JFY2013, we removed the mercury from the helium gas supply line by hands-on work and installed a gas-liquid separator as a counter measure. We also replaced the helium gas supply device with a new one with remote handling tools such as a master-slave manipulator and an in-cell crane. As a result, the flow rate of gas micro-bubbles in the mercury was successfully increased from 2.5 l/min to 7.5 l/min, suppressing the vibration velocity of the target vessel by 1/3 to 1/4.

Flattening the proton beam profile is another effective technique to suppress the pressure wave. Since the current proton beam profile has a Gaussian distribution, we have installed two octupole magnets to suppress the beam profile upstream of the muon production target in the 3 GeV proton beam transport line. We investigated the performance of the octuplole magnets during the accelerator study period in February, 2014, and obtained a promising result, confirming that the peak of the proton beam profile has been reduced by about 40%. At the 3 GeV proton beam transport line, we replaced the proton beam window installed to create the boundary between the high vacuum environment in the transport line and the helium environment in the helium vessel, in which the target-moderator-reflector system is placed.

We also replaced the accumulator of the cryogenic super-critical hydrogen circulation loop during the maintenance period. It has a bellows structure enclosing helium to make its volume variable up to 6.85 L so that it could control the pressure rise in the hydrogen loop induced by nuclear heating of 3.8 kW at the moderators when the 1-MW pulsed proton beam injects or stops. The new accumulator has a diameter of 300 mm and unrestricted length of 85 mm, the same specifications as for the current one. As the bellows consists of 5 blocks of welding bellows with 17 units in each of them, the plate thickness was increased from 0.4 mm to 0.8 mm in order to withstand a high pressure of 2.0 MPa. The consequently manufactured bellows can expand and contract smoothly without hysteresis. We also confirmed through actual operation with a 300 kW proton beam that the pressure rise in the cryogenic super-critical hydrogen loop was mitigated at 20 kPa and it could reach 60 kPa for the 1 MW operation, which satisfied the design requirement.

The neutron shutter system of J-PARC is driven by an electric servo motor. Since the operational beam power increased up to 200 kW in 2011, a failure indicating servo motor error occurred randomly several times. We found that it was caused by a single event effect at the semi-conductor part of the servo amplifier by neutrons produced at the target-moderator-reflector system. Therefore, all servo drives of the shutter system were replaced to the robust type, which does not include semi-conductors.

Modification of the MLF General Control System for Sustainable Long-Term Operation (K. Sakai et al.)

The outline of the General Control System (GCS) in MLF in 2013 is shown in Fig. 2. It consists of several subsystems such as an integral control system for controlling muon and neutron targets, interlock system, servers, networks, and timing distribution system. The interlock system consists of subsystems named MPS (Machine Protection System), TPS (Target Protection System) and PPS (Personnel Protection System). We have modified this system to match the device upgrade of the target systems to ramp up the proton beam power and increase the user apparatuses year after year.

The control and interlock system is operated by monitor and operation (MO) systems, which consist of administrative control PCs (ACP), PPS operating PC, interlock monitoring PC (IM-PC), and so on in Fig. 2. Since 2012, we have developed prototypes to upgrade the MO system both for the integral control system and PPS. After confirming that they work properly as designed, in 2013 we built two full-scale upgraded MO systems. One is the MO system, which controls the devices for the target stations by using more than 130 operation screens and acquires operation data about 7000 items every second. The other is the system, which administers the PPS devices by using 6 screens and acquires data about 1400 items. They have been operated in parallel with the current systems during beam operation and maintenance for over half a year, and debugged in comparison with the correct ones for replacement until 2014. The MO system for the PPS was already replaced completely by the upgraded one in the end of 2013.

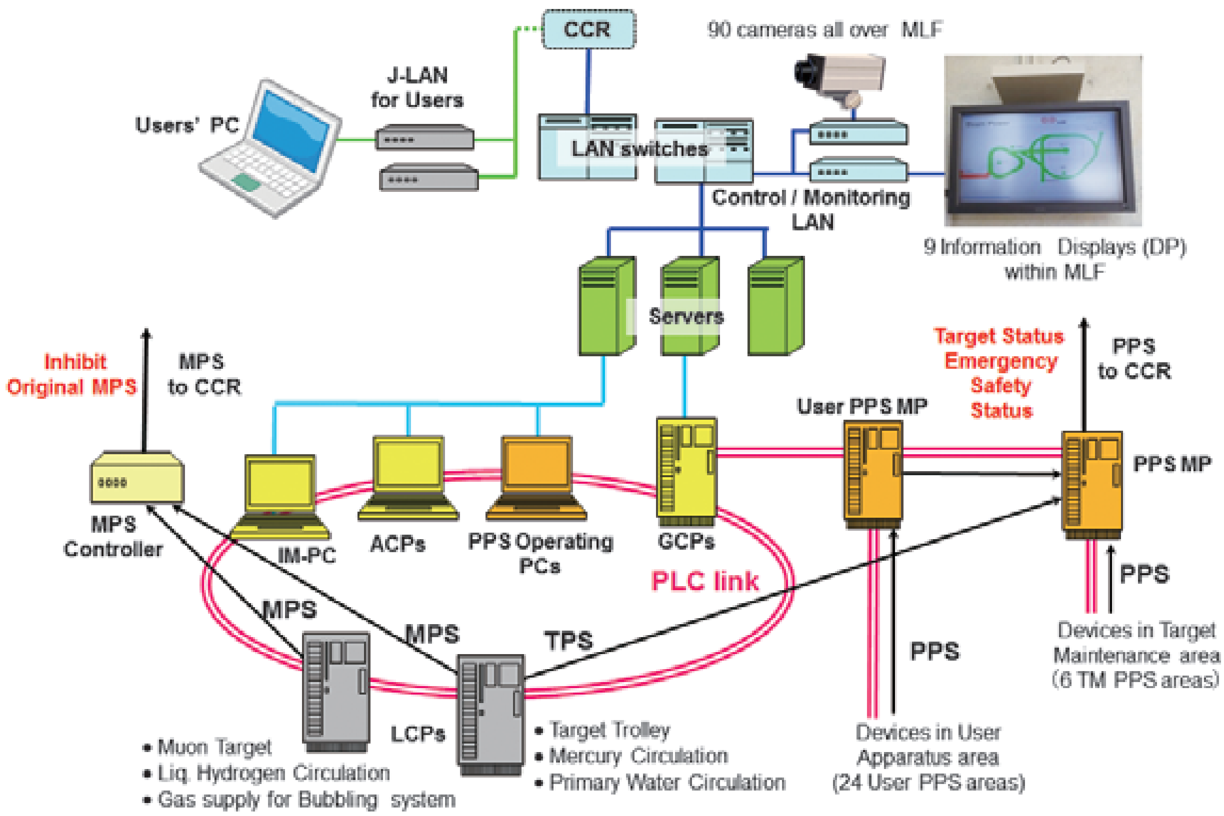


Fig. 2. Outline of the MLF-GCS in 2013.

Neutron Science

Doping-Evolution of High-Energy Spin Excitation in the Electron-Doped $Pr_{1.4-x}La_{0.6}Ce_xCuO_4$ (M. Fujita et al.)

In the research of high-transition-temperature superconductivity, the evolution of the spin excitation with doping is a fascinating and long-standing issue. A doping dependence of spin excitations separated by the energy region is one of keys to understanding the role of magnetism in the mechanism of superconductivity, as reported on Mott insulator La_2CuO_4 or $YBa_2Cu_3O_6$. In contrast to the progressive research in the hole-doped system, less is known about the entire spin excitation in the electron-doped cuprates. Fujita and Wilson separately observed the spin excitation up to ~ 200 meV in the superconducting (SC) sample and clarified a steeper excitation along the energy direction than in the undoped compound. This result suggests an increase of zone boundary energy by the electron-doping, unlike to the doping-independent high-energy dispersion in the hole-doped system. However, even in the parent compound, measurement of high-energy spin excitation up to the zone boundary is still missing. In order to confirm the electron-doping dependence of spin excitation and gain an insight into the electron-hole symmetry in the spin correlation, we performed neutron scattering measurement on a series of $Pr_{1.4-x}La_{0.6}Ce_xCuO_4$.

Inelastic neutron measurements were carried out on as-grown single crystals of $x = 0$, 0.08 and 0.18, which are non-SC, at BL01 (4SEASONS). As shown in Fig. 3, well-defined spin-wave excitation emerging from $h = 0.5$ was observed in the $x = 0$ sample. The zone boundary energy determined from the dispersion is ~320 meV. The intensity lying at ~100 meV in a wide momentum range corresponds to a crystal field excitation from Pr^{3+} ion. The high-energy excitation shows a drastic doping evolution, that is, the magnetic excitation gets steeper with

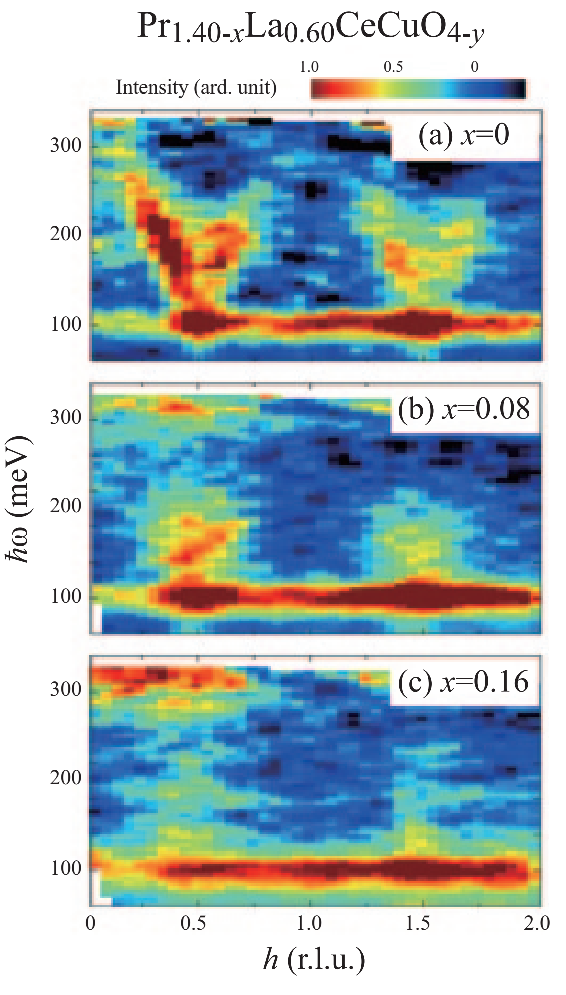


Fig. 3. Spin excitation spectrum in the $Pr_{1.4-x}La_{0.6}Ce_xCuO_4$ with (a) x=0, (b) 0.08 and (c) 0.18. To enhance the high energy excitation, the value of energy transfer was multiplied to the intensity after subtracting the background.

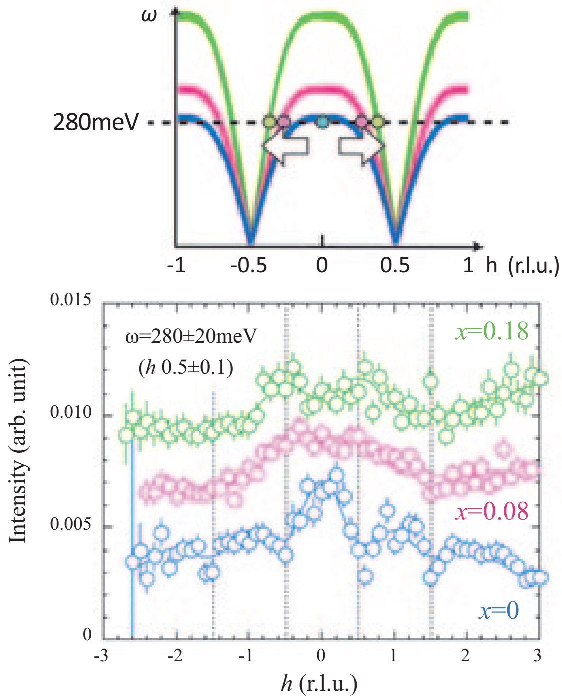


Fig. 4. (Upper) Image of the doping evolution of spin excitation suggested from the present study.
(Lower) Constant energy spectra sliced at 280 meV.

increasing the Ce concentration. Slicing the maps at 280 meV along *h*-direction through (0.5, 0.5) reciprocal position (Fig. 4), the magnetic intensity in $x = 0$ shows peaks at the $h = 0$ and ± 1 while the main peaks locate at $h = \pm 0.5$ in $x = 0.18$, indicating the elongation of the magnetic excitation toward the high-energy region. This trend is in stark contrast with a negligible doping dependence of high-energy spin excitation in the hole-doped LSCO. Thus, there exists electron-hole asymmetry in the spin excitation against doping.

Visualization of Magnetic Field Distribution by Polarized Pulsed Neutron Imaging Inside the Power Magnetic Instruments (T. Imagawa et al.)

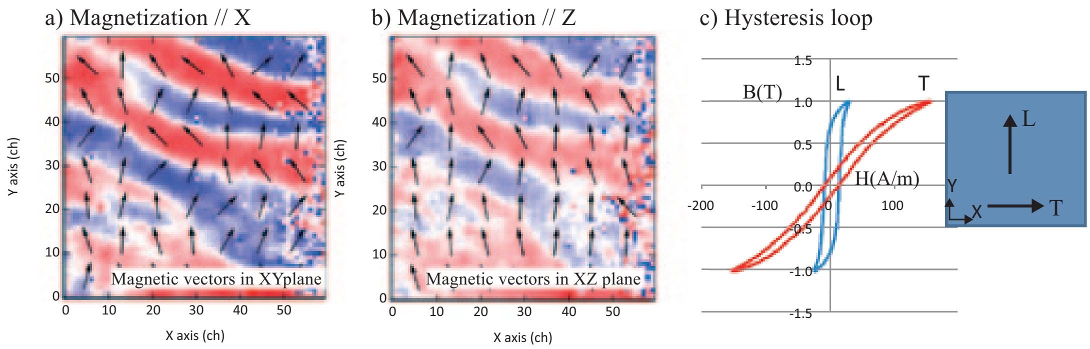


Fig. 5. Magnetic domain observation by polarized pulsed neutron imaging.

The loss reduction of power magnetic instruments, such as motors and transformers is the urgent problem for retardation of global warming because the loss produces heat increase. In order to reduce the loss we have to design these instruments properly, however, we have very few methods to inspect the design directly. In power magnetic instruments both the performances of magnetic materials and the magnetic field designs are important. The polarized pulsed neutron imaging developed in MLF should be able to visualize both the distribution of the material magnetization and the magnetic field, so it is a promising method for magnetization analysis. An expected application is the motor analysis, by measurement of both the motor gap magnetic field and the motor core magnetization. The polarized pulsed neutron imaging in MLF is carried out at BL10 (NOBORU). Among magnetic materials for the motor core, amorphous films are expected to reduce the core loss significantly because of their small coercive forces. But they also have extreme sensitivity to the stress produced in motor fabrication that degrades their performance. The degradation could be reduced if the magnetic moments motion inside the motor core be visualized.

Figure 5a) and 5b) show the magnetic moment distribution of the annealed amorphous foil of 25 μm in thickness measured by the polarized pulsed neutron imaging experiments. The results should reflect its residual magnetization state. Figure 5a) shows the distribution of magnetization components along the horizontal direction (parallel to the X axis), where red color means a positive sign and blue is a negative one. Also corresponding magnetization vectors in the XY plane, which lies in the foil plane and the X axis is along the horizontal direction, are indicated by arrows. All the vectors are almost oriented in +Y direction (upward in this figure), but they incline to the left/right in the red/blue area. These areas can be recognized as “magnetic domains”, and their shape change by applying magnetic field is connected directly with the magnetization process. Our results are consistent with that of the hysteresis loops, which suggests that the easy axis is oriented to the L (Y) direction (Fig. 5c)). On the other hand, Fig. 5b) shows the distribution of the magnetization component parallel to the beam propagation direction (Z axis), which is normal to the foil surface, and the arrows in this figure indicate magnetic vectors in the YZ plane. Similar magnetic domain structure as Fig. 5a) was observed. This indicates the presence of perpendicular magnetization due to the perpendicular magnetic anisotropy. While this magnetization component is known as the reason for the degradation of magnetic performance, the presence of such a magnetic component inside the foil was confirmed experimentally for the first time.

Figure 6 shows the result of the motor gap observation. Figure 6a) shows the model motor fabricated as frame-less type so that the motor gap is open and observable by the eye. On the rotor surface 4 crescent type magnets are stuck and the stator consists of 15 yoke teeth with coils wound by distributed type. Figure 6b) is the gap field in absolute value calculated without the coil current. At the center of the gap the maximum magnetic field intensity was 5 kOe. Figure 6c) shows the neutron transmission image of the motor sample. The opaque area at the center of this image corresponds to the rotor, and the surrounded ring-shaped bright area does the motor gap. The polarization image of the motor is shown in Fig. 6d). The neutron spin was along the Y axis. At both sides of the rotor, neutron polarization kept the initial value, but it turned to zero in the other area. This result indicates that neutron spin direction is parallel to the magnetic field at the both sides of the rotor that corresponds to the calculated field direction.

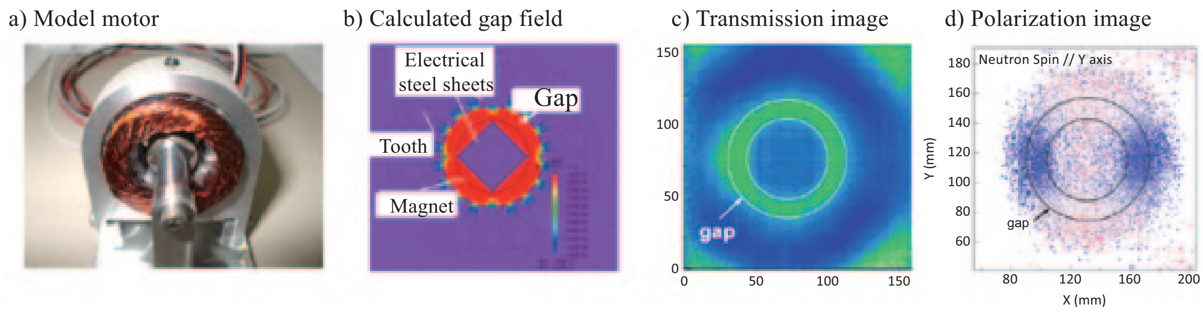


Fig. 6. Motor observation by polarized pulsed neutron imaging.

Multistep Thickening of Nafion Thin Films in Water Studied by Optical and Neutron Reflectivity (Y. Ogata et al.)

Known for its remarkable conductivity and durability, Nafion is widely used as a proton exchange film in polymer electrolyte fuel cells (PEFC). The excellent electrochemical and mechanical properties of Nafion are associated with the characteristic network structure of the hydrated water phase. One of the interesting developments in the near future is downsizing PEFC. The physical properties of a polymer film are generally altered with decreasing thickness for films and the effects of air and substrate interfaces on thin films are undoubtedly responsible for this thickness dependency, because the ratio of interfacial area to the total volume of the film increases markedly with decreasing film thickness. In this study, the thickness of thin Nafion films in water was characterized as a function of time by surface plasmon resonance (SPR) reflectivity in conjunction with neutron reflectivity (NR) measurements performed at BL16 (SOFIA).

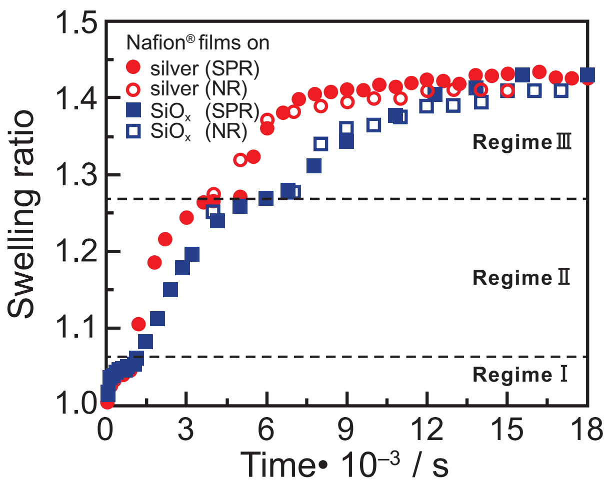


Fig. 7. Time dependence of swelling ratio for Nafion films on silver (red) and SiO_x (blue) substrates with an h0 of 47 nm and 49 nm, respectively, prior to coming in contact with water.

In the time dependence of the swelling ratio, which is the ratio of the film thickness in water (h_w) to that in the dried state (h_0), for Nafion films on silver and SiO_x substrates after coming in contact with water, the Nafion films thickened in three steps named here regimes I, II and III (Fig. 7). The films asymptotically reached a swelling ratio of 1.05 (regime I), resumed thickening asymptotically up to 1.26 (regime II), and then the swelling ratio reached 1.41 (regime III). While the characteristic swelling ratio at the border between different regimes was neither dependent on the substrate species nor the film thickness, the swelling kinetics depended on the type of the substrate.

To examine the aggregation structure of the Nafion films near the substrate interface, the NR curves were obtained for Nafion films with an h_0 of 53 nm supported on silver and quartz substrates in air and D_2O at various times. They were fitted with the calculated reflectivity based on the model (*b/V*) profiles normal for the interface. A model (*b/V*) profile with a moderately single hydrated interfacial layer was suitable for the Nafion film on the silver substrate. On the other hand, a model containing such an interfacial layer structure with a total thickness of ca. 15 nm gave a better fitting for the film on the quartz substrate. The result indicates that H_2O was sorbed in the interfacial region before soaking it into D_2O.

It has been accepted that the swelling of bulk Nafion by water sorption is accompanied by a structural change. In short, the water first binds to sulfonic acid groups of the side chain portion of Nafion. When the water content in Nafion increases further, sphere-like ionic clusters are formed. The clusters finally connect to one another forming bridges. Interestingly, the swelling ratio for the structural transition, was coincident with the asymptotic swelling ratios in regimes I, II and III. Thus, the three-step sorption behavior shown in Fig. 7 could be explained in terms of the structural evolution in the internal region of the film. Figure 8 shows a model for the swelling of a thin Nafion film. It is noteworthy that the hydrated layer is formed near the substrate.

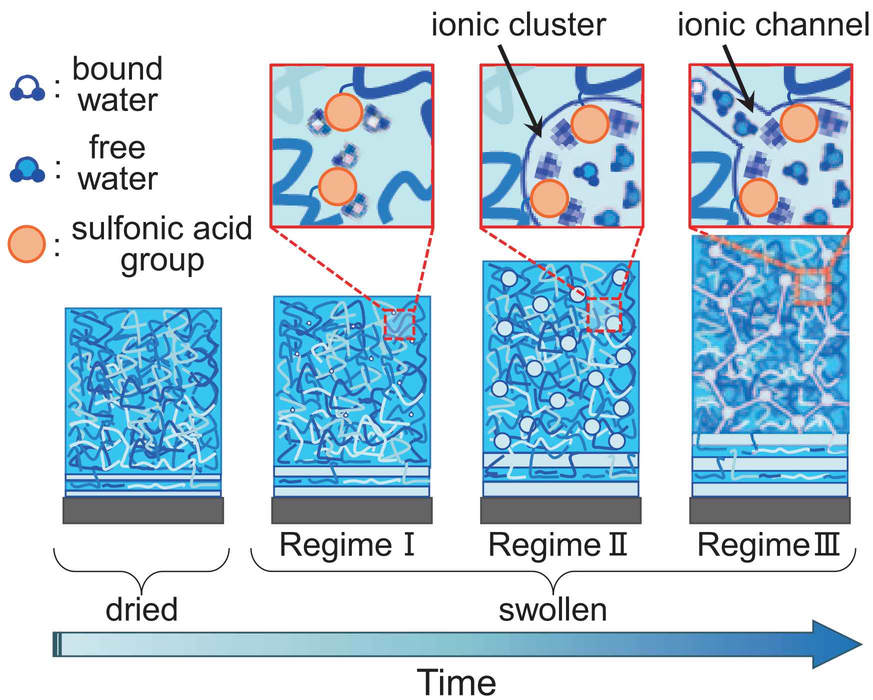


Fig. 8. A schematic representation of the structural evolution in a thin Nafion film contacting water.

Muon Science

Multiple-Probe Study of Highly Hydrogen Doped Fe-based Superconductor $LaFeAsO_{1-x}H_x$ (M. Hiraishi et al.)

The recent development of the hydrogenation technique in rare earth systems of Fe-based superconductors *RE*$FeAsO_{1-x}H_x$ (*RE*: rare earth) has succeeded in surpassing the limitation of the doping range available in fluorine doping. In the case of $LaFeAsO_{1-x}H_x$, the existence of a secondary superconducting dome (SC2) around $0.2 \le x \le 0.4$ has been revealed. Moreover, the maximum T_c of ~ 36 K in SC2 is higher than that of ~ 26 K in the first superconducting dome (SC1) around $0.05 \le x \le 0.2$, drawing broad attention regarding the difference in superconducting mechanism between SC1 and SC2. The relationship of SC2 with magnetism would be of particular interest in comparison to that of SC1. To investigate the origin of the two SC domes, we have performed a multiple probe study in the range $0.40 \le x \le 0.51$ using muon spin rotation/relaxation (μSR), powder neutron diffraction (ND), and X-ray diffraction (XRD).

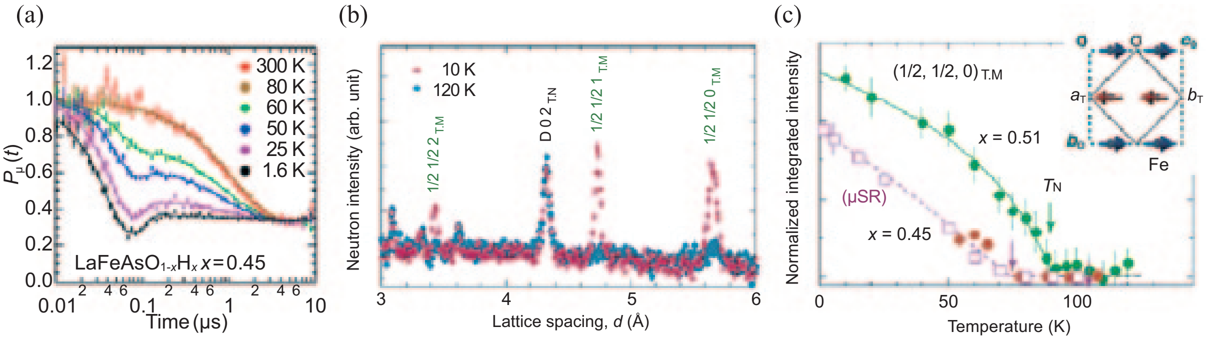


Fig. 9. (a) μSR time spectra of $LaFeAsO_{1-x}H_x$ for $x = 0.45$. Spectra below 80 K exhibit fast relaxation with precession signal.
(b) Neutron diffraction of $x = 0.51$ sample. At 10 K, there are additional Bragg peaks from magnetic order.
(c) Temperature dependence of muon magnetic signal intensity (volume fraction x precession frequency squared) and neutron Bragg peak intensity.

Zero-field μSR time spectra for the $x = 0.45$ sample measured at PSI shows an oscillation with increased amplitude below 80 K, indicating the development of the magnetically ordered phase (Fig. 9(a)). The temperature dependence of the magnetic volume fraction (MVF) was measured using the DΩ1 spectrometer at MLF, and it was found that the onset of the magnetic transition temperature T_N and the MVF at the lowest temperature decreases with decreasing the hydrogen content *x*. Magnetic structure analyses on the $x = 0.45$ and $x = 0.51$ samples were performed at BL08(SuperHRPD) and BL21(NOVA), and the magnetic Bragg beaks with $q = (1/2, 1/2, n)_{T,M}$ were observed in the low-temperature, where the subscripts T, M and N refer to the tetragonal cell, magnetic and nuclear peak, respectively (Fig. 9(b)). The temperature dependence of the Bragg peak intensity and the corresponding muon magnetic signal intensity are shown in Fig. 9(c). Intensities of magnetic peaks develop below $T_N = 89(1)$ K for $x = 0.51$ and $T_N = 76$ K for $x = 0.45$, which is perfectly in line with the μSR result. XRD of $x = 0.51$ performed at BL-8 in KEK-PF reveals that $(2, 2, 0)_T$ reflection exhibits peak splitting

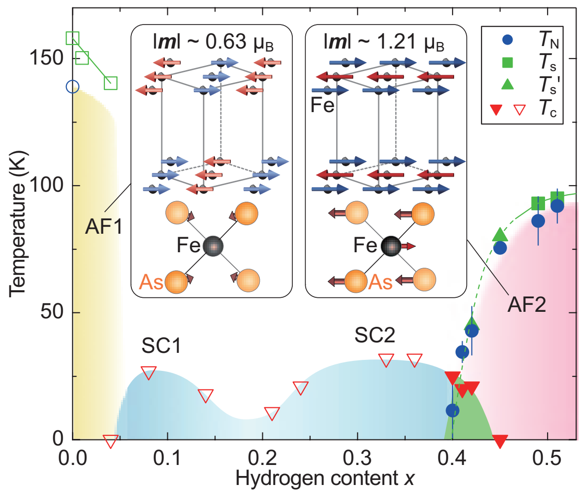


Fig. 10. Crystal and magnetic phase diagram of $LaFeAsO_{1-x}H_x$. Filled blue circles, green squares, triangles indicate antiferromagnetic transition temperature (T_N) determined by μSR, structural transition temperature (T_s), and c_T-axis upturn temperature (T_s') determined by XRD, respectively. Insets show the magnetic structures of AF1 (left) and AF2 (right) determined by neutron diffraction, and the structures of $FeAs_4$ tetrahedron.

on cooling, whereas, that reflection of $x = 0.45$ exhibits simply slight broadening. In $x = 0.51$, (0, 0, L) reflection does not exhibit peak broadening, indicating the occurrence of the tetragonal to orthorhombic (T-O) structural transition. T-O transition temperature $T_s \sim 95$ K is determined from the temperature dependence of the lattice constant. Interestingly, c_T axis length shows an upturn below T_s • In $x = 0.45$, although an apparent T-O transition does not exist, the c_T axis anomaly appears below $T_s' \sim 80$ K as in the case of $x = 0.51$, which may be attributed to the insufficient coherence of the splitting of a_T and b_T in the low-temperature phase.

These results are summarized in Fig. 10. The newly discovered antiferromagnetic phase (AF2) preceded by structural transition resembles the behavior of $x = 0$ (AF1). The two-dome SC phase diagram may be interpreted as the carrier doping starting from the left and right side of the parent compounds, where the valley of T_c around $x = 0.2$ may be a crossover region or the overdoping from both sides of the phase diagram.

Development on Non-Destructive Elemental Analysis for Extraterrestrial Materials using a Muon Beam (K. Terada et al.)

In 1971, Rosen proposed application of muon beam in the chemical analysis of tissues, as muon beam analysis would cause less damage to the host organism than neutron activation analyses. Muonic atom spectroscopy has been developed over the past four decades as a non-destructive analytical method. The stopping distances of both negative muons (~ tens of MeV/c) and muonic X-rays (more than several tens keV) are in the ranges of millimeters, which could potentially enable us to obtain the 3D elemental map from the near surface to the interior of rocky samples by changing the momentum of the muon beam.

At first, we tried the depth profile analysis of the four-layered sample which consists of SiO_2, C (graphite) BN and SiO_2 using the negative muon beam at the D2 beamline. Then the result successfully demonstrated a potential of the muon beam analysis to map non-destructively 3D elemental distributions of light elements such as B, N, C and O. Next we carried out X-ray fluorescence spectroscopy for carbonaceous chondrites, Murchison and Allende. As shown in fig. 11, significant counts of fluorescent X-rays of Mg, C, Si, Fe, Ca, and S from Murchison and those of Mg, Si, Fe, K, and Ca from Allende were detected. On the other hand, those of K from Murchison and C and S from Allende were not detected. This indicates that the detection limit of muonic fluorescent X-ray at the current analytical condition is about 1 weight percent in concentration.

Finally, we tried the measurement on powdered Murchison meteorite, weighting 610 mg, sealed in a glass tube as a simulant of Hayabusa 2 samples. Clear signals of Mg and marginally resolved signals of Fe were detected through the 1-mm thick glass wall (Fig. 12). Although O and Si are the major elements of rock samples, muonic X-rays of O and Si were emitted from the SiO_2 glass tube as well, which cannot be distinguished from the sample signals. Although further developments in analytical techniques are required, our first attempt for the non-destructive elemental analysis of an extraterrestrial sample inside a glass tube succeeded with the detection of Mg and Fe.

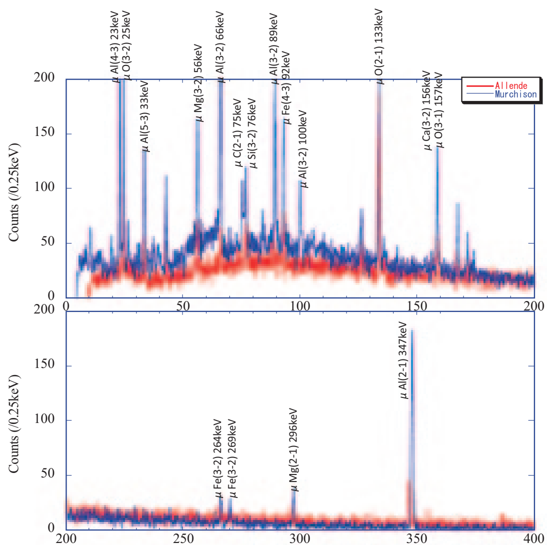


Fig. 11. Muonic X-ray energy spectra from carbonaceous chondrites: Allende (red) and Murchison (blue) meteorites.

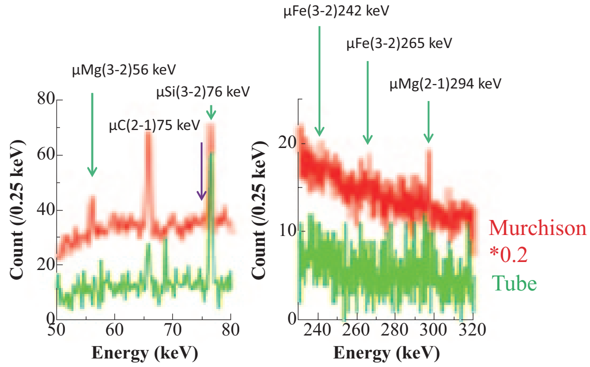


Fig. 12. Muonic X-ray spectra from the powdered Murchison meteorite in a SiO_2 glass tube.

Neutron Device

A Scintillator-Based Detector with Sub 100-μm Spatial Resolution for Time-of-Flight Neutron Imaging (T. Nakamura et al.)

Time-of-flight neutron radiography and neutron tomography are powerful non-destructive techniques for visualizing an object and quantifying the amount of elementals. However, the specifications required for neutron imaging place various challenges to the two-dimensional detectors; in general these include small pixels, a spatial resolution of less than 100 μm, a timing resolution of a few microseconds and a count rate capability of more than 10^5 cps. We have developed a new type of neutron-counting time-of-flight neutron imager that extensively employed the scintillator and wavelength-shifting (WLS) fiber technologies. The detector exhibits a high spatial resolution down to the sub-100-μm level with a low gamma-ray sensitivity of less than 10^{-7} at ~1 MeV.

The neutron-detecting head (Fig. 13) comprises a single scintillator screen, Fiber optic taper (FOT), crossed WLS-fibre arrays. The ZnS/^{6}LiF scintillator absorbs neutrons in a nuclear reaction of ^{6}Li(n,*a*)T, and the ZnS scintillator emits scintillation light. The scintillation light propagates through the FOT while magnifying the light image onto the WLS-fiber arrays. The scintillation image is magnified, in our case by a factor 3.1; in other words, the effective pixel size of the detector becomes about one-third of the fiber diameter. The WLS fiber reemits a shifted green light that is transmitted to the PMTs. The incident position of a neutron is calculated by the signal processing and encoder electronics according to the excitation pattern of the PMTs. In order to achieve the required spatial resolution the detector components were carefully selected or developed. Important R&D points were: The thin scintillator screen that has a thickness less than 100 μm, the FOT that can perform image magnification with good light transmission, and the crossed WLS-fiber arrays that were made with the dedicated 100-μm diameter fibers.

Figure 14 shows a photograph of the prototype detector. The scintillator thickness 100 ± 10 μm was made in house to match the range of the generated triton after the nuclear capture event. The pixel size of the detector is 34 μm × 34 μm, and the exhibited spatial FWHM resolution is 80 ± 7 μm and 61±6 μm in the *x* and *y* directions, respectively. The neutron images of a test piece, which was constructed from polycrystalline Cu and Fe, was measured at BL10, and clear signs of the Cu/Fe interface were successfully detected in the reconstructed neutron images. It was demonstrated that the prototype detector produced clear images with fine mesh and high contrast by reconstructing the image with the appropriate TOF window. It was also revealed that the detector has a superior ^{60}Co gamma-ray sensitivity of less than 10^{-7}.

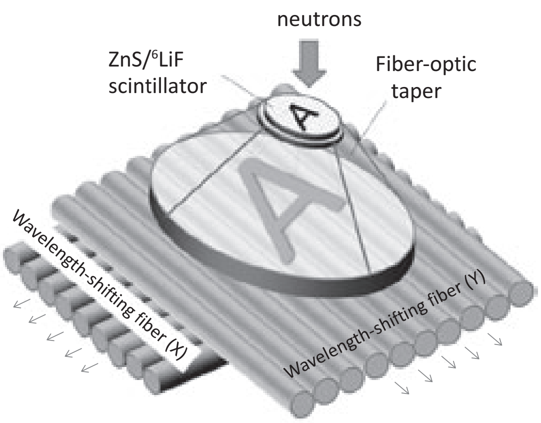


Fig. 13. A schematic view of a neutron-detecting head of the prototype detector.

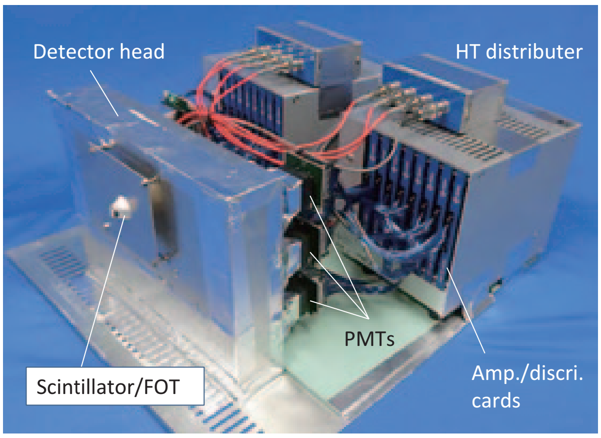
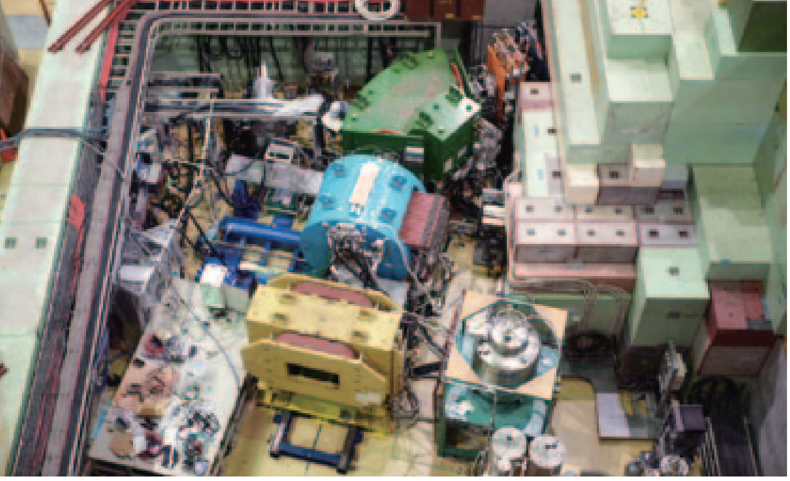
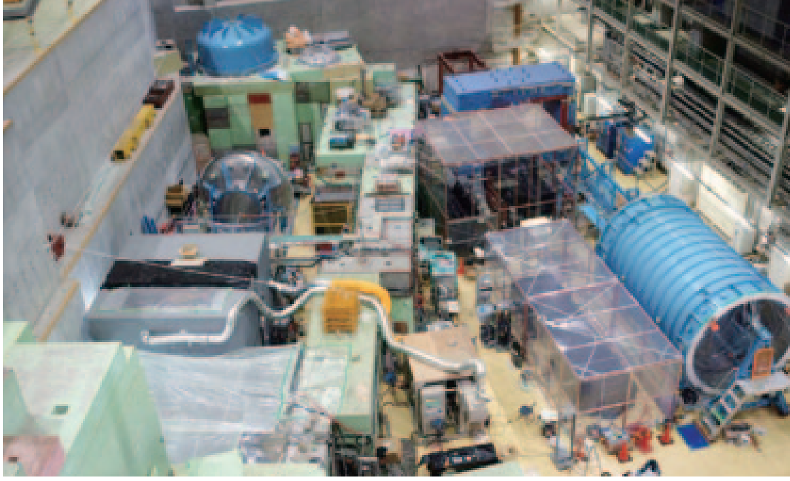
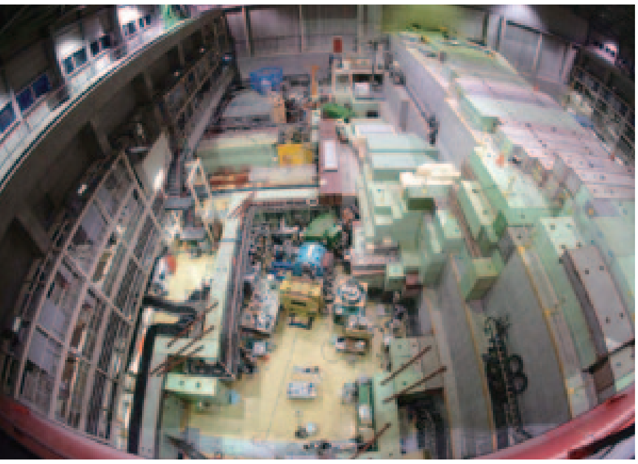
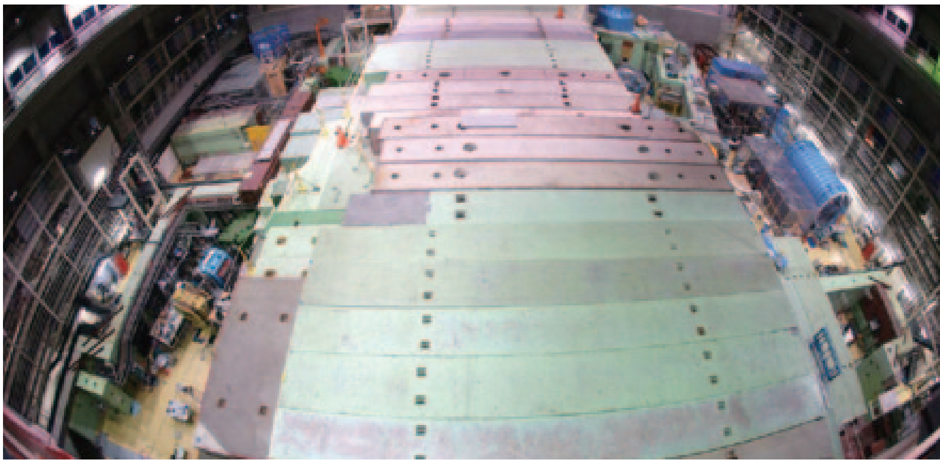


Fig. 14. A photograph of the prototype scintillator-based time-of-flight neutron imager.

Particle and Nuclear Physics

Muon Neutrinos Turn to Electron Neutrino (T2K)

On July 19, 2013, the international T2K collaboration announced that the transformation of muon neutrino to electron neutrino has been definitely observed [1]. In 2011, the collaboration reported the first indication of this process, a new type of *neutrino oscillation* [2]. Now with 3.5 times more data, this transformation has been firmly established.

Neutrinos are subatomic particles with no electric charge, and have the smallest mass of all known particles. Neutrinos come in three types (*generations* or *flavors*): electron, muon, and tau. As they travel, neutrinos transform from one flavor to another. This phenomenon is called *neutrino oscillation*, caused by the fact that neutrinos have mass and thus mix with each other.

The discovery of the neutrino oscillations was made by the Super-Kamiokande collaboration in 1998 [3]: They observed muon and electron neutrinos produced by primary cosmic rays interacting with the Earth's atmosphere. The number of upward muon neutrinos, generated on the other side of the Earth, was half of the number of downward ones, whereas the ratio for the electron neutrinos remained the same. The neutrino oscillation causes some of the muon neutrinos to change into tau neutrinos, which process cannot be observed. It was the first experimental indication of very tiny, but non-zero, mass differences between the neutrino generations.

Since then, for over a decade, many other experiments confirmed the phenomena of neutrino oscillations through various *disappearance* modes of flavor transformations. Meanwhile, the current observation by T2K is the first of its kind in the sense that an explicit appearance of a unique flavor of neutrino (electron neutrino) at a detection point is unequivocally observed from a different flavor of neutrino (muon neutrino) at its production point. The probability of such oscillation processes includes the *Charge-Parity (CP) violating* term in its mathematical representation. The CP violation provides a distinction in physical processes involving matter and antimatter, and so far this phenomenon has been observed only in quarks. According to a cosmological hypothesis named *leptogenesis* [4], the CP violation in neutrinos in the very early universe is the key to understanding why today's observable universe is dominated by matter.

T2K directs high-intensity neutrino beams produced at a neutrino experimental facility in J-PARC, located in Tokai Village, Ibaraki Prefecture, on the east coast of Japan. The neutrino beam is aimed at the gigantic underground detector, Super-Kamiokande, in Kamioka mine, near the west coast of Japan, 295 km (185 miles) away from Tokai (Fig.1). The neutrinos penetrate iron, concrete shields, and rocks effortlessly and reach Kamioka town within 0.001 second after they are produced. Although most of them continue through the atmosphere into outer space, very small number of traces is detected by the Super-Kamiokande.

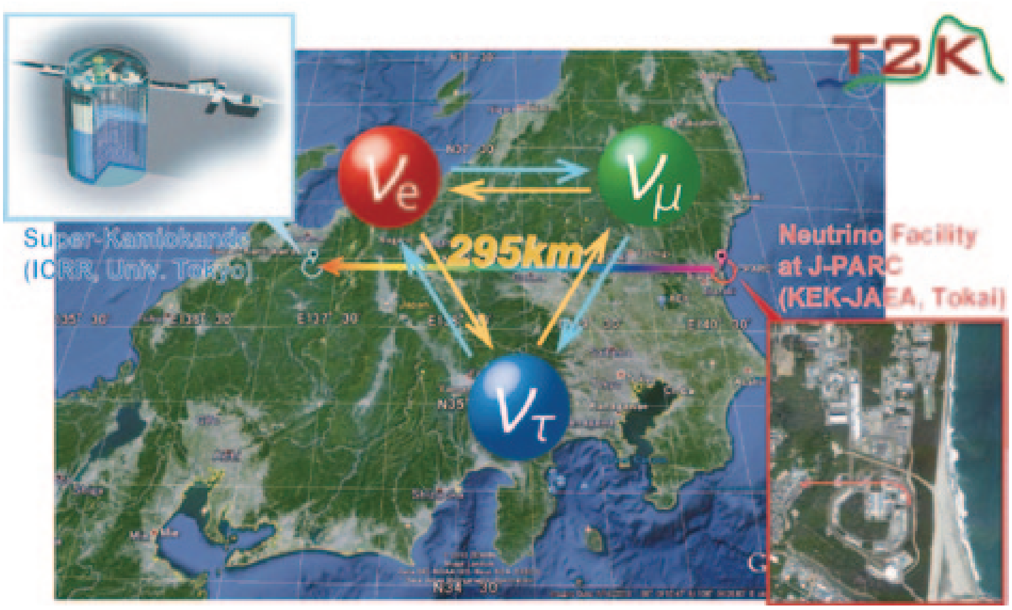


Fig. 1. Overview of the T2K experiment. Out of the neutrino oscillation between three generations, the primary objective of T2K is to discover ν_μ-to-ν_e oscillation.

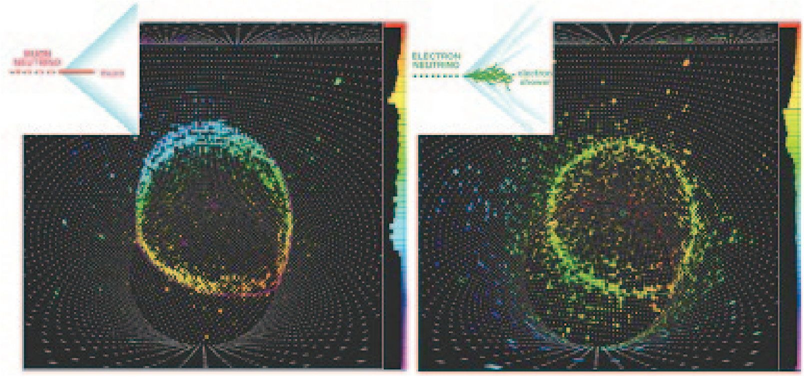


Fig. 2. A muon neutrino event (left) and an electron neutrino event (right) observed by Super-Kamiokande. The charged muon, produced by the muon neutrino interaction, goes straight into the water. Meanwhile, the electron, produced by the electron neutrino interaction, causes electro-magnetic shower. As a result, the edge of the ring image is blurred.

The Super-Kamiokande detector is cylindrical in shape. It contains 50,000 tons of ultra-purified water, and its inner surface is covered with approximately 11,000 highly sensitive photo-sensors, each of which is 50 cm in diameter. The interaction between neutrinos and nuclei in the water results in the formation of charged counterparts of the neutrinos, *i.e.*, muons and electrons. The muons and electrons emit weak conical wave fronts along their trajectories and produce ring images on the neighboring photo-sensors (Fig.2). The neutrino flavors (muon-like or electron-like) and energies can be determined by analyzing these images. The appearance of electron neutrino events denotes oscillation from muon neutrino to electron neutrino.

An analysis of the data from the Super-Kamiokande detector associated with the neutrino beam time from J-PARC reveals that there are many more electron neutrinos (a total of 28 events) than would be expected (4.9 events) without the electron neutrino appearance (Fig.3). The probability that random statistical fluctuations alone would produce the observed excess of electron neutrinos is less than one in a trillion, equivalently the new results exclude such possibility at 7.3 σ level of significance. Moreover, by a combination of this result to the others observing disappearance of antielectron neutrinos from nuclear reactors, the first-ever constraint has been obtained on a complex phase factor δCP, the parameter representing the CP violation phenomena. Although its level of significance is still limited, this observation has a strong impact on the forefront of the quest for the CP violation in neutrino sector.

It is to be noted that this discovery was made possible through the tireless efforts to deliver high intensity beam to T2K, especially after the devastating March 2011 earthquake in eastern Japan, which caused severe damage to the accelerator complex and facilities at J-PARC, and abruptly discontinued the data-taking of the T2K experiment.

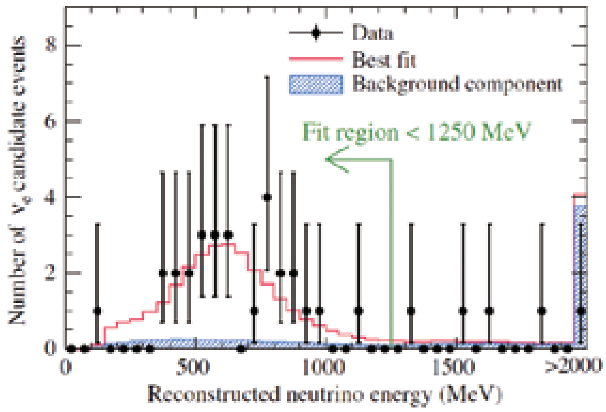


Fig. 3. Energy distribution of the electron neutrino appearance candidates. The data distribution (black dots with error bars) agrees well with the expectation (red histogram), which consists of background events (blue-hatched histogram) and electron neutrino appearance candidate events.

Now, after T2K firmly established the electron neutrino appearance, a search for the CP violation in neutrinos becomes one of the major scientific quests in the coming years, where T2K will continue to play a leading role. The T2K experiment expects to collect 10 times more data in the near future, including data with antineutrino beam for studies of the CP violation in neutrinos.

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(reprint from the KEK Annual Report (research highlights))

Hadron and Nuclear Physics

The results of the E10 experiment to search for a neutron-rich Λ hypernucleus, $^{6}_{\Lambda}H$, have been published [1]. Neutron-rich Λ hypernuclei are of interest because they provide valuable information about the strength of the ΛN interaction and its modification by the multi-body effect in a neutron-rich environment. This information is necessary to understand the properties of nuclear matter such as the equation of state (EOS), especially in the high-density regions like neutron stars. In the $^{6}_{\Lambda}H$ hypernucleus, unbound ^{5}H is bound because of the glue-like role of the Λ hyperon. Moreover, the coherent ΣN-ΛN mixing, which has a significant effect in neutron-rich nuclei present in neutron stars, may provide additional binding [2]. Therefore, the existence of $^{6}_{\Lambda}H$ and its ground-state energy need to be experimentally investigated.

Recently, the FINUDA group at DAΦNE reported on three candidate events of $^{6}_{\Lambda}H$ using simultaneous π^+ and π^- measurements of the production channel K^-_{stop} + ^{6}Li → $^{6}_{\Lambda}H$ + π^+ and the weak decay $^{6}_{\Lambda}H \rightarrow {}^{6}He + \pi^-$ [3]. The reported Λ binding energy of 4.0±1.1 MeV, with respect to ^{5}H+Λ threshold, was close to the value predicted without the coherent ΣN-ΛN mixing effect. Since this observation is still debated and the observed number of events is small, the confirmation of 6ΛH and measurement of the binding energy with different reactions using higher statistics are very important.

In the E10 experiment that was carried out in December, 2012 and January, 2013, the production of $^{6}_{\Lambda}H$ was searched for via the $^{6}Li(\pi^-,K^+)X$ reaction at p_π = 1.2 GeV/c using Beam and SKS spectrometers at the K1.8 beam line. The cross section of the double charge-exchange (π^-,K^+) reaction is very small in comparison with the non charge-exchange (p+,K+) reaction and was expected to be of the order of 10 nb/sr from the previous measurement of the $^{10}B(\pi^-,K^+)^{10}_{\Lambda}Li$ reaction [4]. Therefore, high-intensity beams of (12–14)×10^6 π^-/spill, where the beam spill length was 2.0 seconds in every 6.0 seconds, were used. In total, 1.4×10^{12} π^- were irradiated on the enriched ^{6}Li (99.54%) target with a density of 3.5 g/cm^2. The mass scale was calibrated using the $p(\pi^-,K^+)\Sigma^+$ reactions with an accuracy of ±1.26 MeV/c^2. The missing-mass resolution was found to be 3.2 MeV/c^2 (FWHM), as estimated from the $^{12}C\pi^+,K^+)^{12}_{\Lambda}C$ spectrum.

Figure 4 shows the missing-mass spectrum. No significant peak structure was observed around the

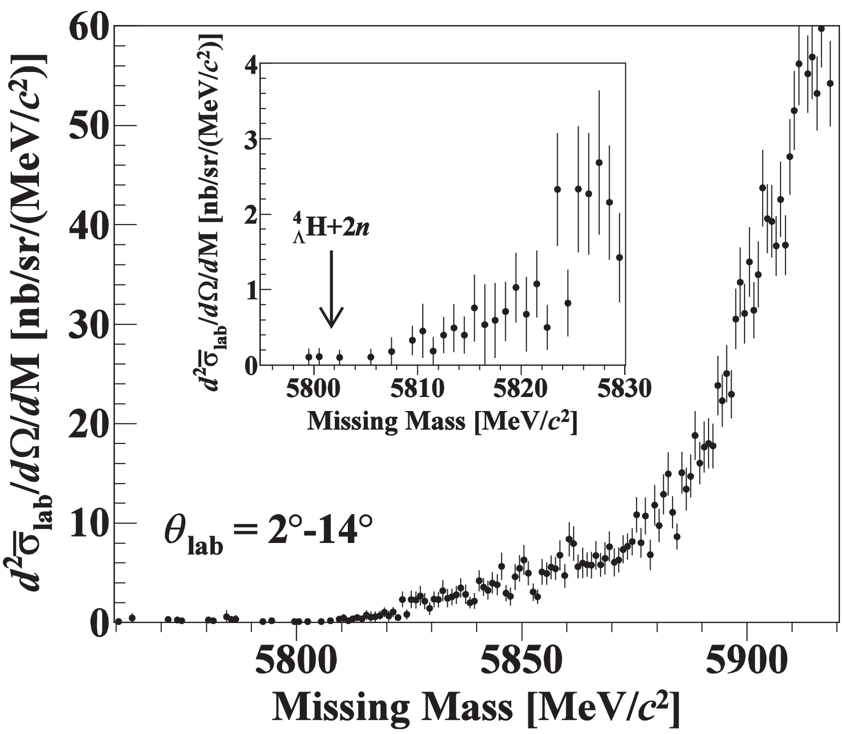

Fig. 4. Missing-mass spectrum of the $^{6}Li(p^-,K^+)$ reaction at 1.2 GeV/c. The vertical axis shows the double differential cross section averaged over the scattering angle from 2 to 14 degrees. A magnified view around the L bound region is shown in the inset.

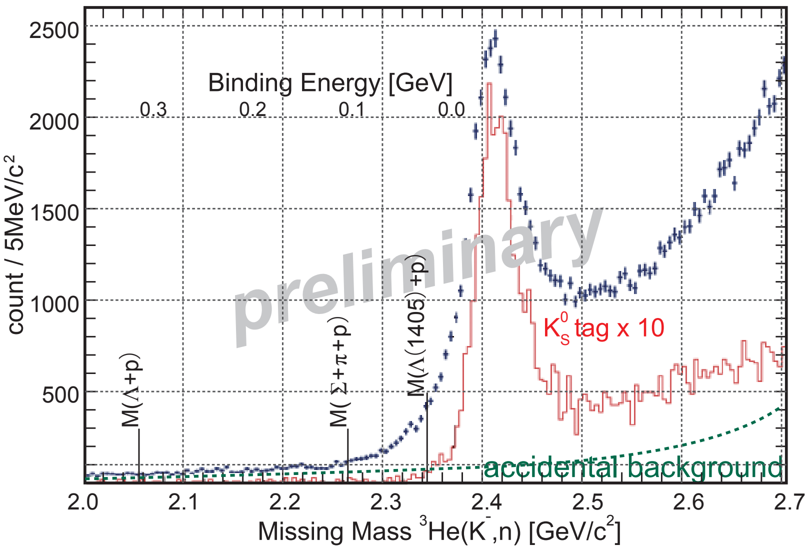

Fig. 5. Semi-inclusive spectrum of the ^{3}He(K$^-$,n) reaction at 1.0 GeV/c (black). Vertical lines indicate the various decay thresholds. The red histogram shows that K^0_s is detected with the CDS [5].

$^4{}_\Lambda$H+2n particle decay threshold of 5801.7 MeV/c^2. The number of events observed around the threshold is consistent with the background due to misidentification of π^+ particles and protons with K$^+$ particles. The upper limit of the differential cross section averaged over the scattering angle from 2 to 14 degrees was estimated to be 1.2 nb/sr at 90% confidence level. These results do not favor a simple interpretation of the FINUDA observation and suggest reconsideration of the structure of $^6{}_\Lambda$H.

Kaon bound nuclei are the other objects of interest in the context of the high-density region of the EOS. Two experiments at J-PARC aim to discover the simplest kaon bound nuclear system, K-pp. In 2013, E15 at the K1.8BR beam line started collecting data following E27 at the K1.8 beam line in 2012. In E15 K$^-$pp is searched for in both production and decay channels. The K$^-$pp is produced via the ^{3}He(K$^-$,n) reaction at 1.0 GeV/c as measured by beam spectrometer and neutron detector, and its decay, $K^-pp \to \Lambda p \to \pi^- pp$, is detected by the Cylindrical Detector System (CDS) surrounding the liquid ^{3}He target. Nearly 1% data was obtained before the incident at the Hadron facility in May. A semi-inclusive spectrum of the production is shown in Fig. 5. There were some yields below the K$^-$+p+p threshold that could not be explained by the experimental resolution or the known processes. This might be a contribution of the K$^-$pp bound system. Further data acquisition is planned.

A new primary beam line is under construction at the Hadron facility. This beam line will deliver a fraction of the main proton beam of 30 GeV for hadron physics experiments and a high-intensity 8 GeV proton beam for the muon-to-electron conversion experiment, COMET. The design of the beam line was reviewed by an international committee in January, 2014. The committee did not find any areas of serious concern. Detector developments for the first experiment, E16, are also underway. The technical design report of the E16 experiment will be submitted to the J-PARC PAC in April, 2014.

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Kaon Experiment

The quantum-mechanical transition of a heavy particle into lighter particles is called "decay" in particle physics. The decay of a specific particle proceeds via several paths or "decay modes." The branching fraction for a decay mode is, once experimentally determined, compared to theoretical predictions; any discrepancy between the experimental results and theoretical predictions can be regarded as a new evidence for physics beyond the Standard Model (SM).

The decay of a long-lived neutral K meson (K_L) into a neutral π meson (π^0) and a pair of neutrinos, $K_L \to \pi^0 \nu\nu$, is known to be a rare and precious process in particle physics. The SM predicts this decay occurs once in forty billion decays. New sources of symmetry breaking, which can explain the matter–antimatter asymmetry in the universe, may be revealed by examining this decay. On the other hand, for experimentalists, detecting this decay is a challenge because only two photons from π^0 are observable in the detector.

The J-PARC E14 KOTO experiment, proposed in 2006, is to study the $K_L \to \pi^0 \nu\nu$ decay. In the south side of Hall of the Hadron Experimental Facility (HEF) of J-PARC, a new neutral beamline for KOTO was built in 2009. A total of 2716 undoped CsI crystals were stacked for the KOTO calorimeter in 2010. The crystals and phototubes are those that have been used in the KTeV experiment at Fermilab, USA, in 1990's. The beamline components were realigned after the big earthquake in March, 2011, and the construction of the detector resumed. To detect extra particles from K_L decays, efficient charged-particle and photon veto counters were built and installed to the inside of the vacuum vessel of the KOTO detector. They surround the decay region hermetically. In 2013, more veto counters were placed to the downstream of the vessel (Fig. 6) in order to detect the charged particles and photons escaping along the beamline. After the commissioning of the trigger and data acquisition system, the first physics run started in May. The first KOTO data for one hundred hours, corresponding to 1.6×10^{18} protons on target, were recorded before the incident at the HEF.

The analysis of the data is in progress and will be reported in 2014. Figure 7 shows the distributions of the invariant mass and the momentum of K_L reconstructed from the selected events of $K_L \to \pi^0\pi^0\pi^0$ decay (one in five K_L decays) and the $K_L \to \pi^0\pi^0$ decay (one in a thousand). The distributions are reproduced by a Monte Carlo simulation, which demonstrates that the detector performance is well understood in the analysis.

Fig. 6. Extra-particle veto counters located at the downstream of the vacuum vessel of the KOTO detector.

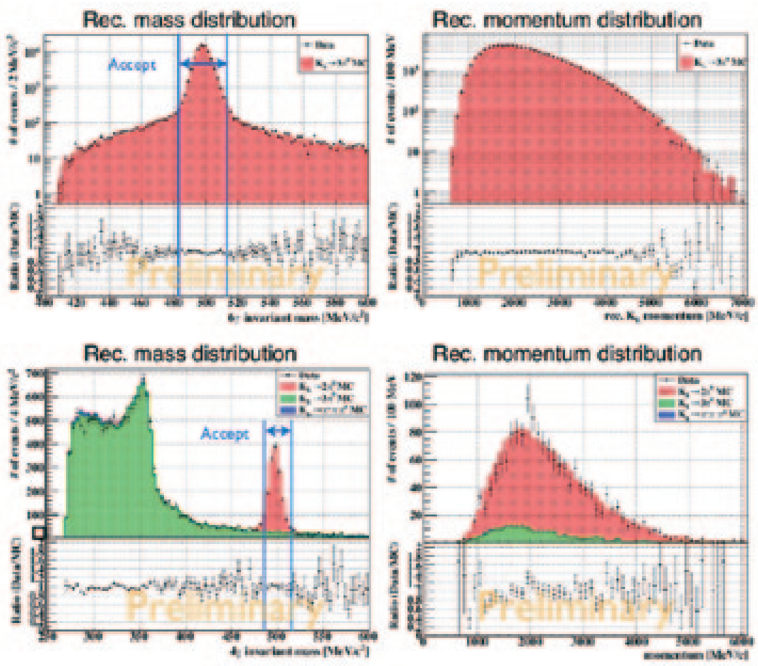

Fig. 7. Distributions of the invariant mass (left) and the momentum (right) of KL reconstructed from the $K_L \to \pi^0\pi^0\pi^0$ (top) and $K_L \to \pi^0\pi^0$ (bottom) decay events. Dots with error bars indicate the recorded data, and hatched histograms are the results of Monte Carlo (MC) simulation studies.

COMET

Coherent Muon to Electron Transition (COMET) is an experiment that aims to search for the muon-to-electron (μ-e) conversion in muonic atoms, which violates the lepton-flavor conservation, using an intense pulsed-muon beam generated at J-PARC. The μ-e conversion mode is thought to be sensitive to more physics cases compared to the $\mu \rightarrow e\gamma$ decay search [1]. Thus, success in the search has been expected since the previous experiment was completed [2]. In 2013, the COMET experiment started constructing facility components to achieve experimental conditions in a timely manner; fabrication of a superconducting wire with an aluminum stabilizer, which is indispensable for producing a strong magnetic field for generating a high-intensity muon beam in a high-radiation environment, has successfully started, and winding of magnet coils has also been initiated (Fig. 8). Construction of a new building containing a new beam line in the basement and control rooms for experimental facility operation upstairs began in early 2013. R&D of the detector has made significant progress; prototype detectors for electron momentum and energy measurements have been constructed in collaboration with Japanese and foreign institutes. Performance evaluation tests using prototype detectors were conducted with favorable results. This work will continue in 2014 toward construction of the innovative detector system, which is essential for the COMET experiment.

Fig. 8. Coil winding for the COMET experiment.

References

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g-2 / EDM

This experiment measures the muon anomalous magnetic moment (g-2) with 0.1-ppm precision and the electric dipole moment down to a sensitivity of 10-21 e·cm. R&D is in progress to realize a novel experimental technique to achieve an ultra-slow muon source, muon acceleration, injection, storage magnet, and tracking detector. One of the major achievements in FY2013 is the development of a muonium production target using silica aerogel [1]. A substructure was introduced on the surface of a silica aerogel to improve the efficiency of muonium emission to vacuum (Fig. 9). Systematic studies with these samples have started at TRIUMF and J-PARC [2]. There were also achievements in the following areas. Simulation studies on muon acceleration by an RFQ confirmed that muons are accelerated with high efficiency. Design of a transport beamline from the muon accelerator to the storage magnet was developed. The detailed design of the muon storage magnet was advanced, taking into account the assembly procedure. Improvements were made to a magnetic-field-measurement system using NMR to realize a resolution better than 0.1 ppm. Silicon strip sensors for a positron tracking detector were designed on the basis of simulation studies to optimize the performance. A prototype of the frontend ASIC was developed. Evaluation of the test sensors and the prototype ASIC confirmed that they meet the requirements for this experiment.

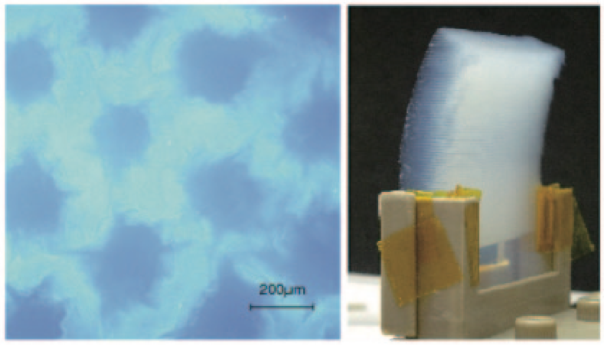

Fig. 9. Laser processed aerogel used in the muonium test.

References

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Cryogenics Section

Overview

The Cryogenics Section supports scientific activities in applied superconductivity and cryogenic engineering, carried out at J-PARC. It also supplies cryogen of liquid helium and liquid nitrogen. The support work includes the operation of the superconducting magnet system for the neutrino beamline, and support for the construction and operation of a superconducting solenoid magnet system for the muon beamline at the Materials and Life Science Experimental Facility (MLF) and the Hadron Hall. It also actively conducts R&D works for future projects in J-PARC.

Superconducting Magnet System

For the T2K Beamline

The Cryogenics Section operates the superconducting magnet system for the T2K neutrino beam line. The operation history in FY 2013 is summarized in Table 1. Due to a long shutdown period for a J-PARC machine upgrade, the number of operation hours in FY2013 was decreased. During the long shutdown period, the electric joints at all quench protection diodes in each magnet cryostat were refurbished, and an activated charcoal for a compressor oil adsorption was replaced.

Table 1. Operation history of the superconducting magnet system for the J-PARC neutrino beamline.

	2013									2014		
	April	May	June	July	Aug.	Sept.	Oct.	Nov	Dec.	Jan.	Feb.	Mar.
Operation	↔ 4/1–5/10	↔ 5/24–27		↔ 7/15–20*								
Annual Maintenance							←				→	
Cold Diode Consolidation							←					→
Commissioning												
Note	*1: Warm up											

For the Muon U-line at MLF

The Cryogenics Section supports the construction of the intense ultra-slow muon beam line (U-line) in the Muon Science MLF. After commissioning in FY2012, the superconducting curved solenoid and the superconducting focusing solenoids started their operations and successfully extracted muon beam into the experimental equipment. Unfortunately, a radiation shield foil at the upper end of the curved solenoid disappeared during the long shutdown period due to an unknown accident, so the upper end of the curved solenoid is not being cooled down enough for charging-up. In the summer of FY2014, it has been planned to repair the radiation shield.

For the Muon D-line at MLF

One of the major contributions of the cryogenics section has been the recovery of the superconducting magnet system of the MLF muon D-Line after the Great East-Japan Earthquake. The magnet and the refrigeration system were damaged due to the earthquake, and the SC magnet and the helium compressor had to be replaced. The section contributed to the fabrication of the magnet (Fig.1) and the reconstruction of the refrigeration system with the replaced He compressor. The commissioning of a refrigeration system with a new helium compressor is planned for September, 2014. The SC magnet will be fabricated by the end of FY2014, and will be installed during the shutdown in the summer of 2015.

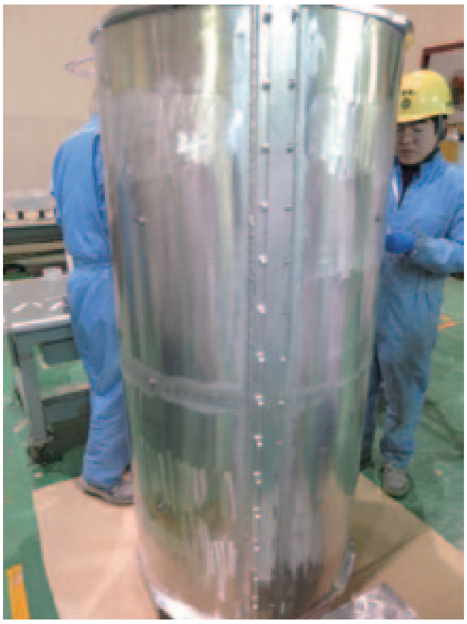

Fig. 1. SC Coil for the MLF muon D-Line magnet system.

Superconducting Kaon Spectrometer (SKS)

The Cryogenics Section supports the Superconducting Kaon Spectrometer (SKS) operation at the J-PARC Hadron Hall. Since the incident at the Hadron Hall, the operation of the SKS has been stopped. While the incident response and reconstruction of the Hadron Hall are advancing, maintenance for the SKS has been performed with the goal to resume the operation from the autumn of 2014.

For COMET

The construction of the COMET Phase-I experiment started in FY2013. The Cryogenics Section has been involved in the COMET experiment to develop the superconducting magnet system. The Pion Capture Solenoid magnet employs aluminum stabilized superconducting cable to reduce nuclear heating by severe radiation. The winding machine was newly developed for the cable with a cross section of 4.7 mm × 15 mm. One of the coils in the Pion Capture Solenoid, which consists of the SC cable and radiation hard insulation and resin, has been wound in FY2013 as shown in Fig.2.

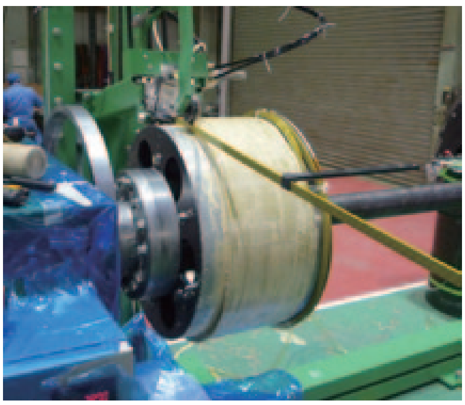

Fig. 2. Picture of a coil of the COMET Pion Capture Solenoid wound in FY2013.

For TREK

The TREK/E36 experiment for the measurement of lepton flavor universality violation is planned at the K1.1-BR experimental area in the J-PARC Hadron Hall. The superconducting toroidal magnet with a helium refrigerator that was used in the KEK E246 experiment performed in 1990 will be re-employed for this experiment. The Cryogenics Section conducts repair works on the magnet and the refrigeration system. Figure 3 shows the overview of the toroidal superconducting magnet and the internal assembly with cooling channels and superconducting bus bars at the magnet interface. Furthermore, a new control system for the cryo-plant was developed in collaboration with Taiyo Nippon Sanso Gas Co., Ltd.

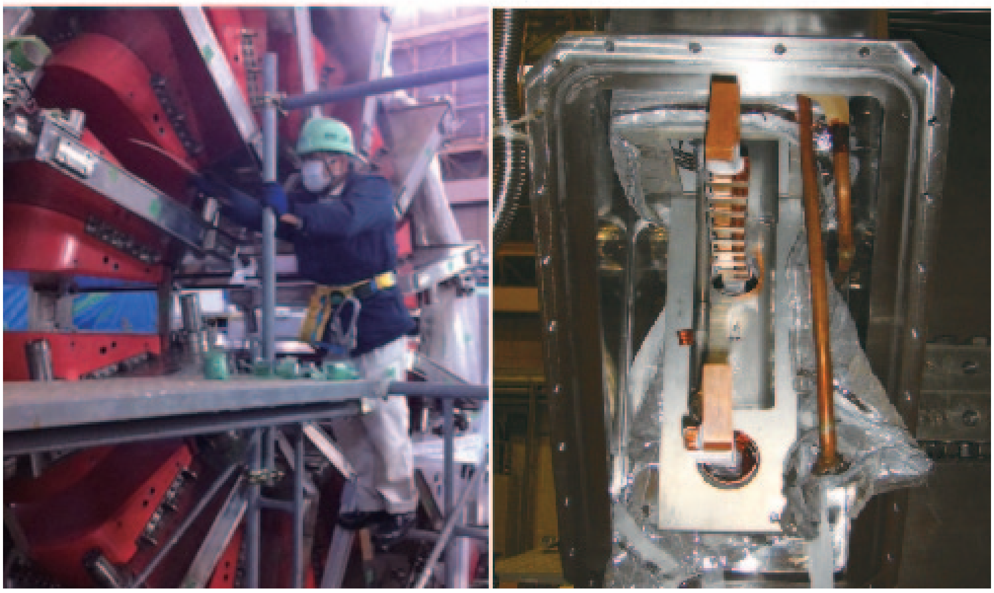

Fig. 3. Overview of the toroidal superconducting magnet (left) and the internal assembly (right).

Cryogen Supply and Technical Support

The Cryogenics Section provides liquid helium cryogen for physics experiments in J-PARC. The liquid helium is supplied to the users in collaboration with the Accelerator Division using the helium liquefier owned by the Accelerator Division. The used helium is recovered by the helium gas recovery facility, which is provided and operated by the Cryogenics Section. Figure 4 summarizes the liquid helium supply in FY 2013. The supply was stopped after the incident at the HD facility. The user operation was restarted at MLF in February, 2014, therefore, the helium supply also resumed at the same time.

Liquid nitrogen was also supplied to the users for their convenience and its amount during the period in FY2013 is summarized in Figure 5. After the incident at HD facility, the main user of liquid nitrogen was the Radiation Safety Section for operating a gas chromatograph. After the restart of the user operation at MLF, the nitrogen supply is also gradually increasing.

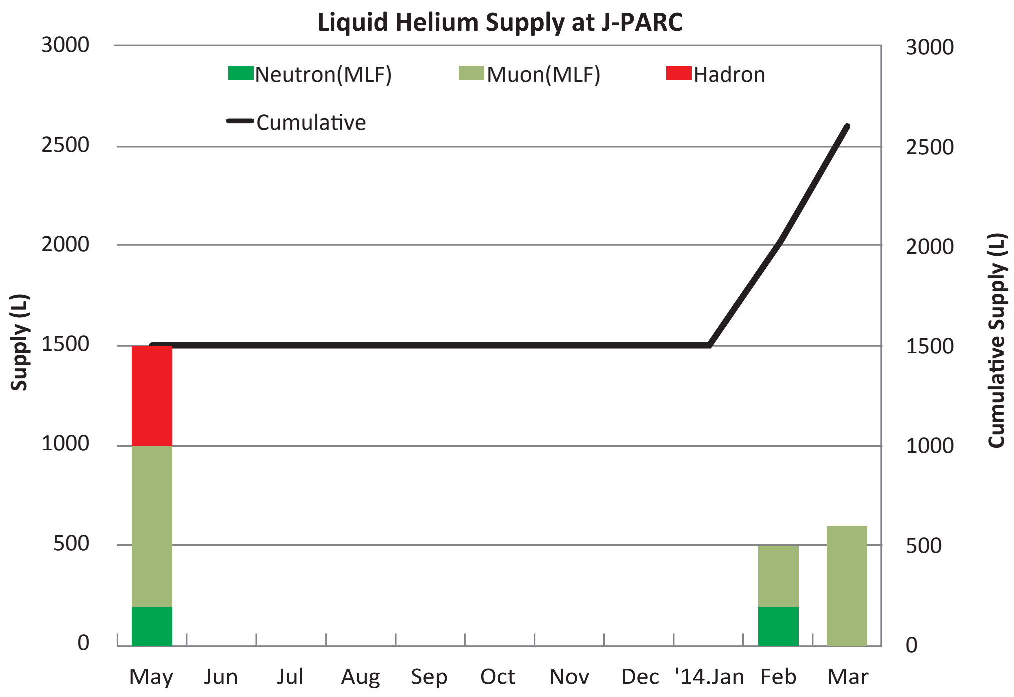

Fig. 4. Liquid helium supply at J-PARC from May, 2013, to March, 2014.

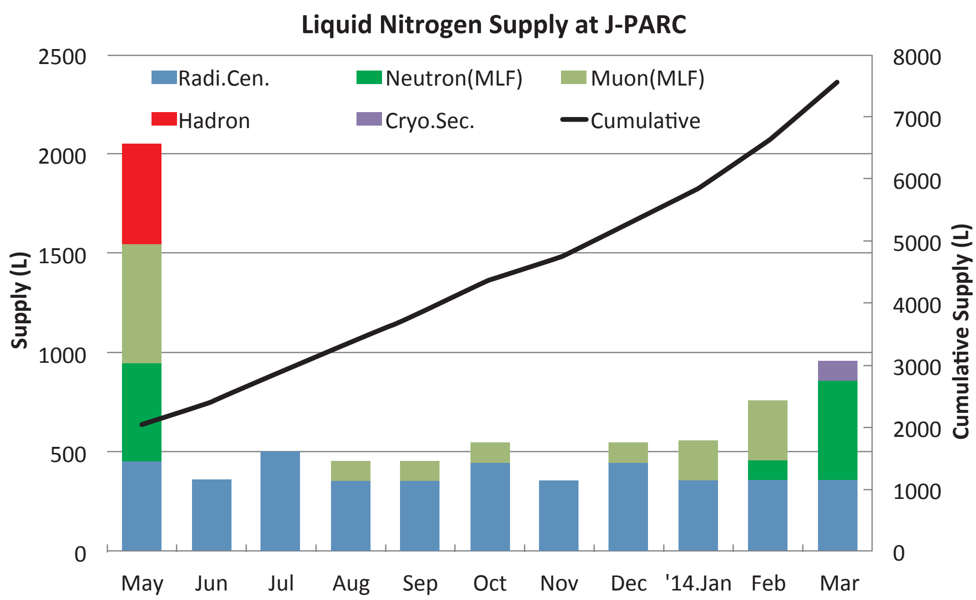

Fig. 5. Liquid nitrogen supply at J-PARC from May, 2013, to March, 2014.

R&D for the Future J-PARC Project: New Muon g-2/EDM and Muonium HFS

The g-2/EDM project using H-line of MUSE, which is the muon beam line in MLF, was proposed by a group of IPNS in 2009. The experiment aims for the precise measurement of the anomalous magnetic moment and the electric dipole moment of muons. In this experiment, a superconducting solenoid with high field homogeneity better than 1 ppm locally is a key component to store muons during the measurement of their precession frequency. Design study of the magnet is in progress in collaboration with IPNS and the Cryogenics Science Center. In parallel with the magnet design, the design of the experimental hall has also started.

A muonium hyperfine structure (MuHFS) measurement using the same beam line as the g-2/EDM project has been also proposed by a group of IMSS. In this experiment, the energy state transition in muonium will be observed under a static magnetic field with local homogeneity of 1 ppm. A superconducting magnet for a MRI system has been installed at the MLF for the experiment.

Information System

Statistics of Network Utilization

Since 2002 the J-PARC network infrastructure, called JLAN, has been operated independently from KEK LAN and JAEA LAN in terms of logical structure and operational policy. In 2013, the total number of hosts on JLAN exceeded 3900 and the number has increased by 108% from the last year. The growth curve of edge switches, wireless LAN access points and hosts (servers and PCs) connected to JLAN are shown in Fig. 1. Figure 2 and 3 show the network utilization of the internet from/to JLAN. The bandwidth capacity for the internet through the Japan Science Information Network (SINET) is 10 Gbit/sec, which allows enough extra activity. JLAN has not only been used for internal communication in the J-PARC and external networking through the internet but it also played an important role in the transfer of experiment data from the Tokai area, where the main J-PARC facilities were built, to the Tsukuba area, where the major computer resources for data analysis are located. Figure 4, 5 shows the statistics of data transfer between the two sites. The bandwidth capacity for the connection is currently 1 Gbit/s x 8 = 8 Gbit/s and the usage level has been approaching a half of it in 2 hours average and two-thirds in 5 minutes peak transfer rate, especially during the period when the Hadron facility was running. The figure also shows that after June the major network traffic output from J-PARC was suspended due to the J-PARC temporary shut-down following the incident at the Hadron Experimental Facility on May 23.

Independently of the JLAN, Guest wireless network service (GWLAN) for the internet connection is maintained to serve short-term visitors and is available in almost all J-PARC buildings, IBARAKI Quantum Beam Research Center and the Tokai Dormitory. Figure 6 shows the daily connections of visitors' hosts to the GWLAN.

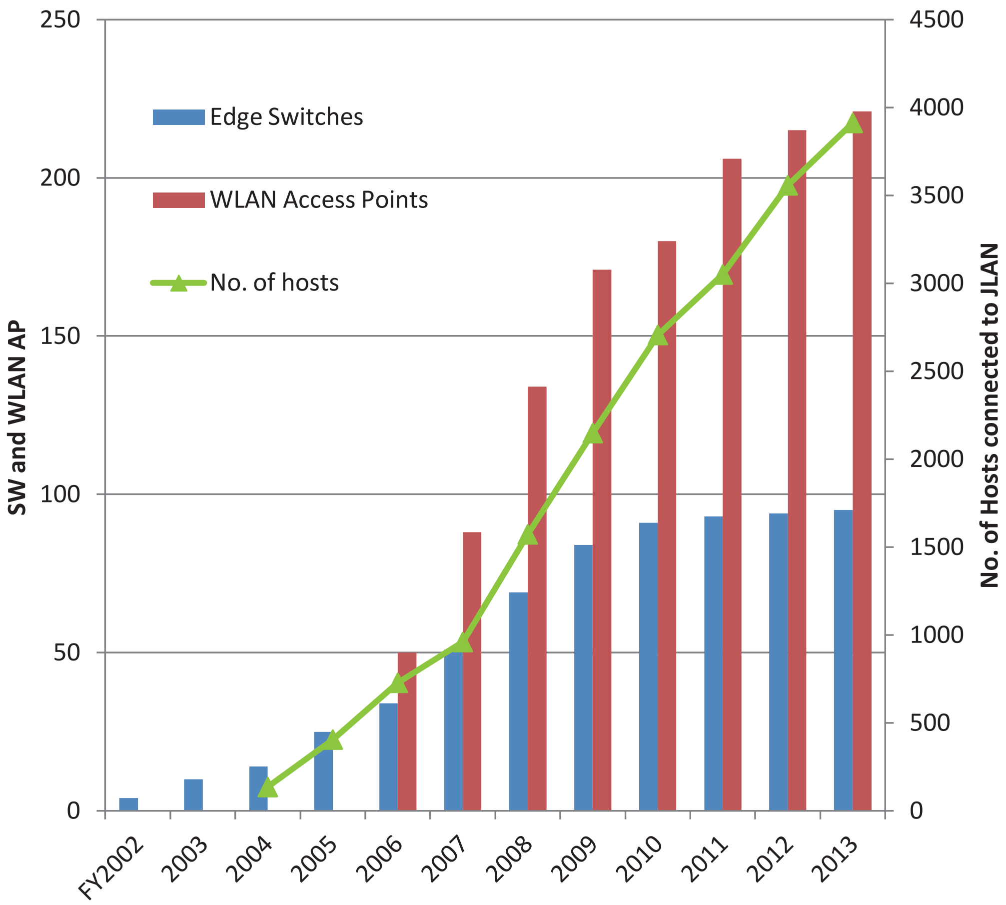

Fig. 1. Number of hosts, edge SW and wireless AP on JLAN.

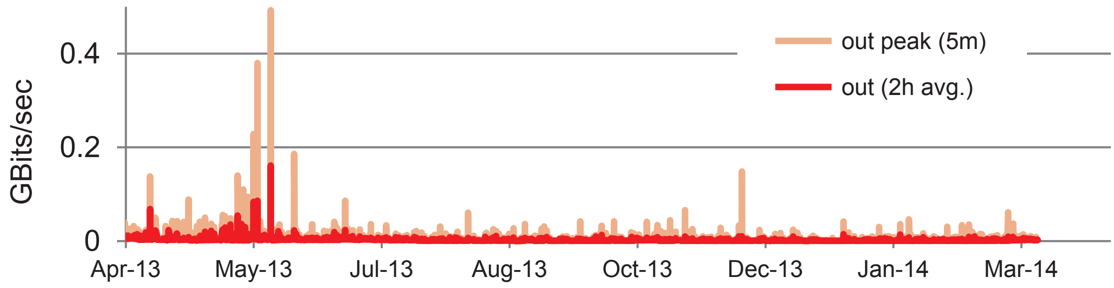

Fig. 2. Network traffic statistics from JLAN to the internet.

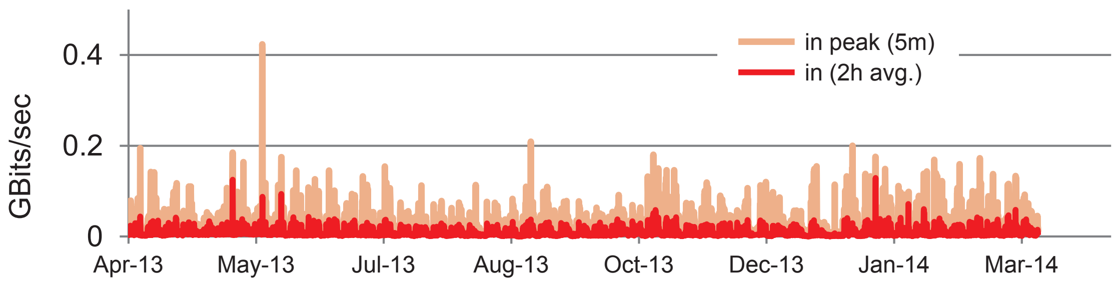

Fig. 3. Network traffic statistics from the internet to JLAN.

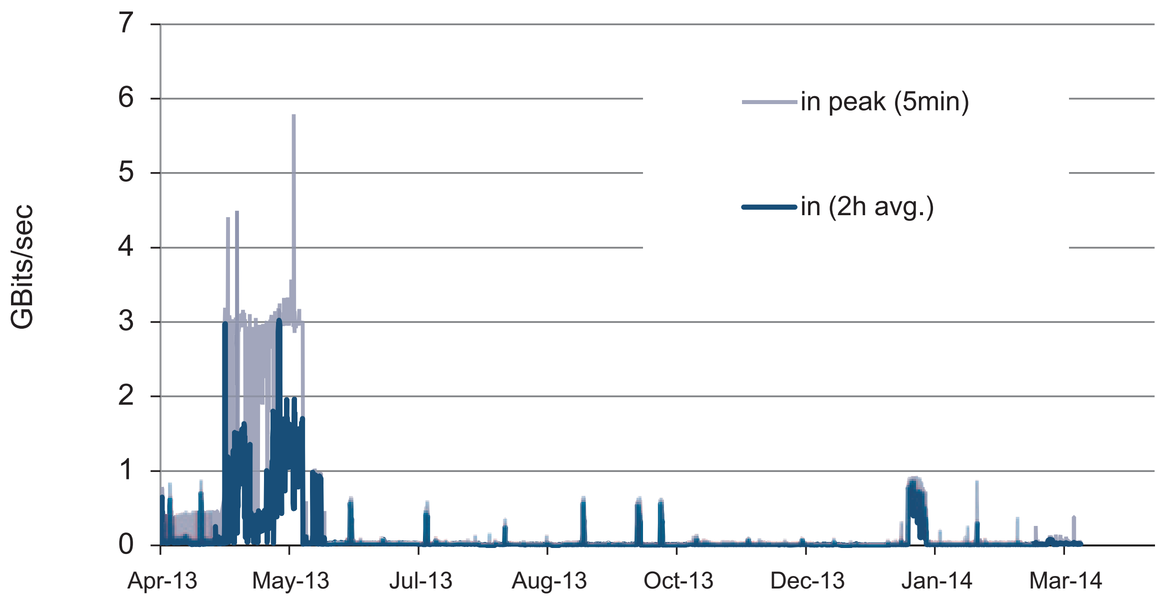

Fig. 4. Network traffic statistics from Tokai site to Tsukuba site.

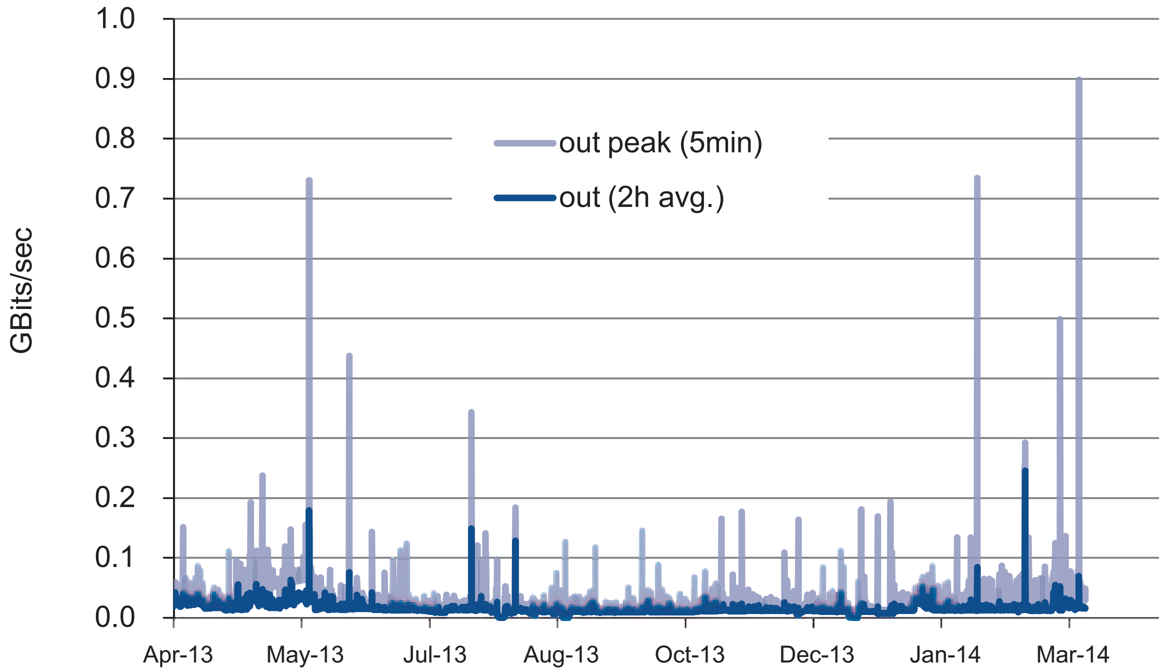

Fig. 5. Network traffic statistics from Tsukuba site to Tokai site.

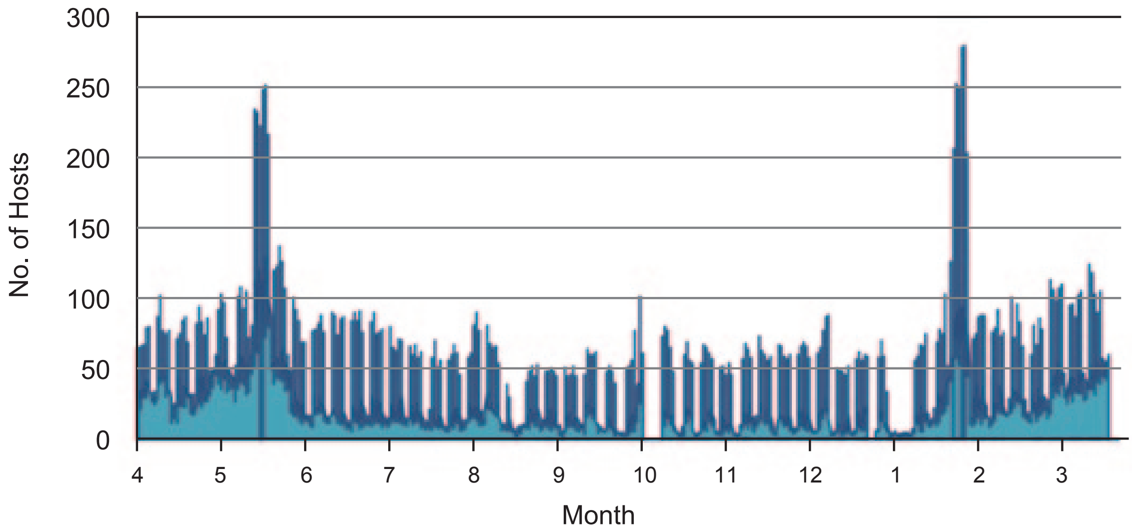

Fig. 6. Guest WLAN network service use statistics.

Statistics of Computer Resources Utilization

Though J-PARC does not have its own computing facility for physics analysis, since 2009 the KEK central computer system at the KEK Tsukuba site has been mainly used for the that purpose. In April 2012, the KEK central computer system was upgraded. Currently computer resources of 25,000 SPECint06 computing power, 1.2 PBytes disks and 5 PBytes tapes were assigned to J-PARC (Table 1).

In the Neutrino (T2K experiment) and Hadron experiments, the data taken in the J-PARC experimental hall will be temporarily saved at the Tokai site and then promptly transferred to, stored and analyzed at the system in Tsukuba. The storage of the system will also be utilized as a permanent data archive for the Neutrino, Hadron and MLF experiments. Figures 7, 8 and 9 show the utilization statistics of the computer resources in 2013. The main users who used the CPU and the storage constantly were a Hadron experiment group (Koto), and who continue their experiment in series from the KEK 12 GeV Proton synchrotron closed in 2005 to J-PARC. The MLF group also started to store data to tapes on the system.

Table 1. Assigned computing resources to J-PARC activities in the KEK central computing facility.

Assigned resources to J-PARC	New system
CPU	25,000 SPECint06
RAID Disk	1,200 TB
Tape	5.0 PB

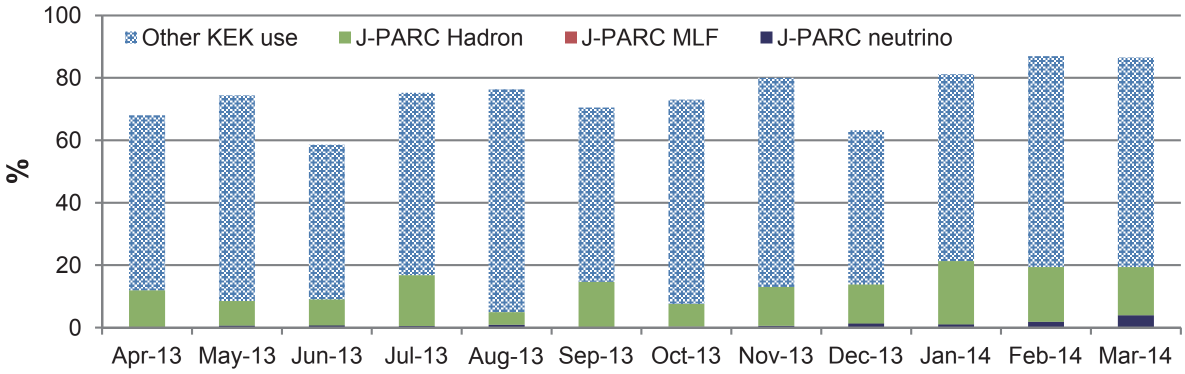

Fig. 7. CPU usage statistics.

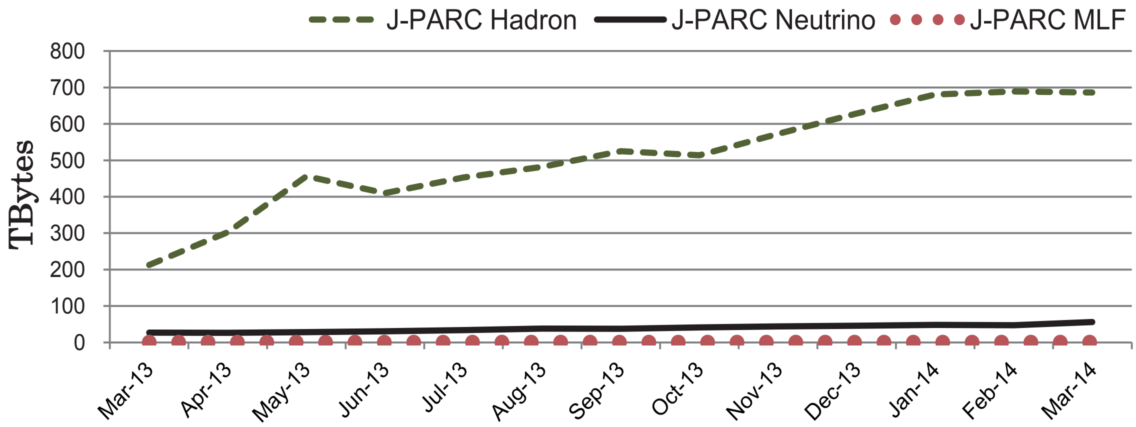

Fig. 8. Disk usage statistics.

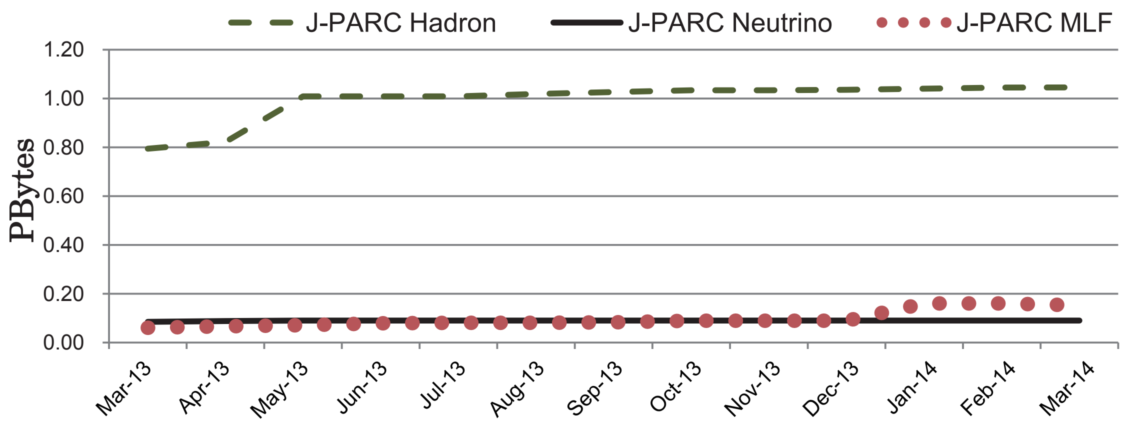

Fig. 9. Tape library usage statistics.


Transmutation Studies

Activities

National Review Working Party for Partitioning and Transmutation Technologies

In September, 2011, the Science Council of Japan summarized the recommendations for disposition of high-level radioactive waste to the Atomic Energy Commission of Japan. It recommended that the study for reducing radioactive waste such as partitioning and transmutation technology should be promoted. The public interest into spent fuel or radioactive waste also increased after the accident in the Fukushima-Daiichi nuclear power plant. To continue the nuclear power generation, the options to reduce the long-lived radioactive waste become one of the important issues for nuclear energy.

In 2013, national review working party for partitioning and transmutation (P&T) technologies using Accelerator-driven System (ADS) were launched by the Ministry of Education, Culture, Sports, Science and Technology in Japan (MEXT). The working party aims at reviewing the state-of-the-art P&T, feasibility for construction of J-PARC Transmutation Experimental Facility (TEF), and cost and benefit of cooperation with European MYRRHA project. Five meetings were held from August to October, 2013, and an interim report was issued in November, 2013, on the website of MEXT.

In the interim report, the working party specified a roadmap to realize ADS based P&T fuel cycle. The working party also recommended to promote P&T technology as an important alternative option for future nuclear waste management and agreed that it would be necessary to build facilities capable of handling certain amount of Minor Actinides (MAs) and the plan to establish such facilities should be continued. As for the construction of J-PARC TEF, a step up from the current basic study stage to the next stage is noted as “suitable”. It is also noted that a detailed technical review should be held before initiating construction. As for the participation in the MYRRHA project, it is proper to begin negotiations with Belgium in comprehensive cooperation not only with JAEA but also with universities and the commercial sector. The committee continues a review works of the P&T technology including the status of the TEF project and negotiation of the MYRRHA project.

Reflecting the recommendations, supplemental budget was allocated to the experimental studies for lead-bismuth eutectic (LBE) handling for ADS Target Test Facility (TEF-T) and remote operation of MA bearing fuel to be used in Transmutation Physics Experimental Facility (TEF-P). For the study for LBE handling, engineering examinations for loop equipment including electromagnetic pump will be performed. Mockup of spallation target for material irradiation will also be prepared. As for the remote operation tests for MA bearing fuel, confirmation of remote operation, which is designed to minimize the effect of experimental accuracy and to maximize the reproducibility of experiments simultaneously, will be performed. The experimental equipment will be completed in fiscal year 2014.

Studies to Construct Transmutation Experimental Facility

After the Fukushima Accident, the safety regulations for nuclear reactors, including critical assembly, became much stricter. The construction plan for TEF has been changed to start construction from TEF-T first, which was categorized as a radiation application facility, and design works and licensing procedure to build TEF-P, that was classified in the experimental nuclear reactor category will be performed simultaneously. Developments for the TEF-T equipment such as preliminary tests for off-beam target loop experiments and preparation for validation of target instruments are underway.

A prolonged operation of JAEA Lead-Bismuth Loop #2 (JLBL-2), which simulates sealed-annular tube type spallation target, has finished running 4,500 hours at the temperature of 300˚C. During the operation, the Electro-magnetic flow meter gives unstable values and we decided to perform simultaneous measurement of the LBE flow rate by the current Electro-magnetic method and the newly added Ultrasonic method with the experts of Fast Breeder Reactor development. The sensors and the measurement equipment are under preparation.

For the design study of TEF-T, design of the LBE spallation target components is in progress. Reflecting the experiences at the Material and Life Science Facility in J-PARC, trolley-mounted type primary circuit system for the LBE target was selected. There are two options for secondary coolant, helium gas and pressurized water and selection of secondary coolant material will be done based on the on-going cooling circuit configuration design. For the design study of the spallation target for TEF-T, reference operation condition was specified, and the soundness of the LBE target was evaluated. By the reference operation condition which is referring to the future ADS transmutor, the target casing made by T91 steel has enough strength for 4,500 hours operation of a 400 MeV proton injection.

MEGAPIE

The world's first megawatt-class lead-bismuth target, MEGAPIE (MEGAwatt Pilot Experiment), was dismantled and post irradiation examination (PIE) samples were prepared at the Paul Sherrer Institute (PSI) hot-lab. The samples were shipped to each institutions including JAEA. The JAEA samples were transported to JAEA's hot-lab WASTEF in May 2013 successfully. The samples were cut from the beam window (BW, T91) and the flow guide tube (FGT, SS316L). The total number of JAEA samples was 67 and all of them were prepared without LBE.

Before the PIE, some equipment in the WASTEF, manipulator arms, ventilation equipment and in-cell radiation monitors were replaced. As preparation for the PIE, tensile test jigs were newly designed and manufactured. TEM was repaired and some samples were prepared for microstructure observation.

After these works were finished, the PIE started in the beginning of March. Until the end of March, the tensile tests on 8 MEGAPIE samples were performed at RT. Microstructure observation by TEM was performed for 2 MEGAPIE samples.

Several meetings on MEGAPIE were held at PSI Switzerland in February, 2014. In the meetings, the PIE plan of each institutes including JAEA were presented and considered. Scheduling and test conditions were also discussed. It was decided to report the PIE results at TRM (Technical Review Meeting) to be held in October, 2014.

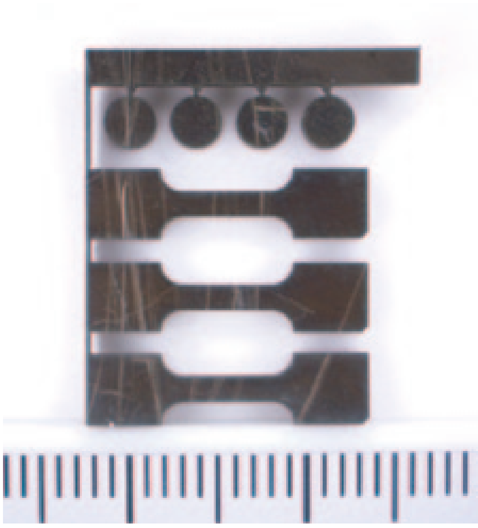

Fig. 1 MEGAPIE samples cut from the BW.

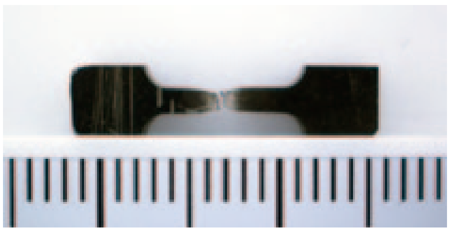

Fig. 2 The tensile specimen tested at RT (T91, 1.44 dpa).

BOP Analysis for LBE Target Beam Window

To deal with the similar phenomenon of the incident of Hadron Experimental Facility in J-PARC, an evaluation of the soundness of a present design beam window for TEF-T aiming at future realization was performed. Specifically, the transient thermal-fluid analysis was performed to estimate the temperature behavior of the beam window when an unexpected extreme beam was supplied to TEF-T. In TEF-T, the acceptance of the proton beam of peak current density of 20 μA/cm^2 with a Gaussian shape has been considered. Figure 3 shows the beam conditions in this analysis. The analysis was performed about two beam over power (BOP) conditions; (BOP case-1) a double peak current density for the normal condition, and (BOP case-2) a converged beam condition (two times as large as a 60 μA/cm^2 condition). The Inlet temperature of the coolant (Lead-Bismuth Eutectic alloy, LBE) was 350˚C, and its flow rate was 1 liter/sec. By the viewpoint of erosion/corrosion and structural strength of materials, the temperature criteria were set to 500˚C. The pulse repetition frequency of the proton beam was 50 Hz.

The analysis result is shown in Fig. 4. The horizontal axis represents time, and vertical axis represents the maximum temperature observed at the center of a beam window. When a beam window continued maintaining a soundness in steady state, the maximum temperature in case-1 reached 610˚C, and reached 963˚C in case-2.

In case-1, the arrival time to temperature criteria (500˚C) was about 300 msec, and it was equivalent to the beam incidence time for 16 pulses. In case-2, it was 60 msec and was equivalent to 4 pulses. These times were enough for a conventional beam stop sequence, and the countermeasure of BOP was to prove that the sequence will function normally.

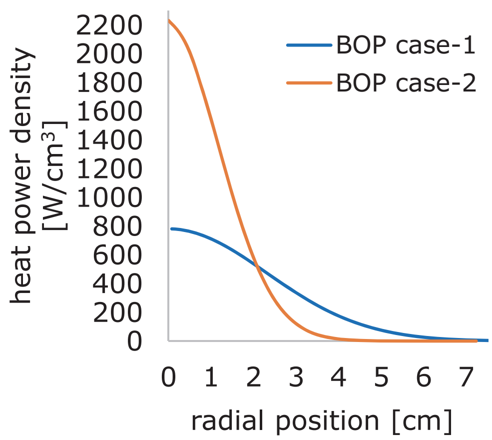

Fig. 3. Peak current density profile for BOP analysis.

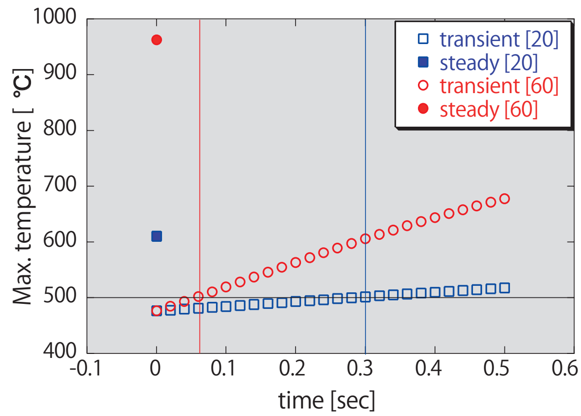

Fig. 4. Transient analysis result in BOP condition.

Safety

Radiation Safety

1. Contribution to the recovery from the Hadron incident

As described in the special section on "Hadron (HD) Incident", we had experienced an incident of radioactivity leak to the outside of the site boundary of J-PARC at the HD Experimental Facility. The radiation safety section, therefore, was heavily involved in the monitoring, decontamination, radiation safety management, and improvement of the radiation monitors in particular for the Hadron and Neutrino Facility, whose deficiency was one of the causes for the incident. In addition, the safety management system was reorganized to facilitate reliable safety management specifically in the case of emergency. As a part of the reorganization, the former Radiation Safety Meeting (RSM) was reformed to Radiation Safety Review Committee (RSRC) by inviting external experts and appointing a person-in-charge for each facility to reinforce the review capability of risks and measures. In parallel with those jobs relevant to the incident, regular tasks for radiation safety in J-PARC were conducted in the section.

2. Meeting and committee on radiation matter

Before the RSRC was created, the RSM was frequently held in the short period from August 30 to October 31[1] in order to discuss the urgent issues of the radiological license update, the revision of the operation rules[2] and so on.[3] The J-PARC license needed to be updated to accommodate the regulation revision concerned with the handling and storage of activated instruments and materials. In addition, we had to make the application for upgrading the highest acceleration energy of the linac from 181 MeV to 400 MeV. As for the operation rule, significant revision was needed because the J-PARC organization and the safety management system were largely modified after the HD incident. Drafts of the revised rules were prepared in a special-purpose working group organized under the RSM and proposed to the RSM. The meeting agreed with the proposed revision after it was discussed several times.

The newly organized RSRC held two sessions by the end of the fiscal year. In the 1st Committee meeting held on December 9, the new safety framework of J-PARC and the role of the RSRC were discussed. In the 2nd Committee meeting, held on January 15, the update of the radiological license, and other issues such as the installation of a new exhaust system at the HD hall, were discussed.

The J-PARC Radiation Safety Committee[4] met four times during the fiscal year. The 15th Committee meeting on July 31 discussed the statutory report on the HD incident. This report was submitted to the Nuclear Regulation Authority (NRA) on August 12, as the 3rd (and last) report on the incident. In the 16th Committee meeting held on October 3, the application for license update of J-PARC facilities was discussed. The main issue was the setup of storage and disposal facilities for activated materials, for which new rules were introduced in the radiation regulation law. These applications were submitted to NRA on October 25 and approved on December 6. The 17th Committee meeting held on October 24 discussed the new radiation safety system for the revision of local radiation protection rules. The 18th Committee meeting on January 22, 2014 discussed the application for the license update in which the main topic was renovation plans for the HD facility. The applications were submitted to NRA on February 19, 2014 and approved on March 19, 2014.

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[1] The year "2013" is omitted when dates are written in this report.

[2] According to the local radiation protection rule of J-PARC, the operation rule had been provided for each of the four facilities of the Accelerators, MLF, HD and Neutrino.

[3] The new members of non-J-PARC staff of KEK and JAEA were added to RSM after the HD incident. During that short period, the meeting was held nine times.

[4] The committee rules and the members of the Radiation Safety Committee were kept unchanged after the HD incident. The sequential number of the committee meetings start from the 15th in this fiscal year.

3. Radiological license update and inspections

During the fiscal year we applied twice to the NRA for a radiological license update .

Table 1 shows lists of licenses for utilization of radiation generators and radioisotopes at J-PARC at the end of Japanese fiscal year (JFY) 2012 and application items for new licensing in JFY 2013.

The inspection to confirm the status of the newly licensed linac facility was conducted successfully on December 13 by the Nuclear Safety Technology Center (NUSTEC): the items to be inspected were the interlock system and the structure and performance of the shielding.

The inspection of the Materials and Life Science Experimental Facility was conducted successfully on March 5, 2014 by NUSTEC: the items to be inspected were the interlock system and the shielding performance.

Table 1. Licenses at the end of fiscal year 2012 and application items for license for fiscal year 2013.

Facility	Status of license for each facility at the end of fiscal year 2012	Application items for new licensing for fiscal year 2013
MLF	Proton beam power : 3 GeV/350 kW Number of neutron beam lines: 18 Number of muon beam lines: 2	New neutron beam line : 1 New muon beam lines: 1
HD	Proton beam power: 30 GeV/50 kW Number of secondary beam lines (meson): 4	
Neutrino facilities	Proton beam power: 30 GeV/450 kW	

4. Radiation exposure of J-PARC radiation workers

Figure 1 shows the variation of the number of radiation workers in J-PARC since 2005. In JFY 2013, 3089 individuals were registered as radiation workers in J-PARC. Table 2 summarizes the distribution of annual doses for each category of workers. The radiation exposure of the workers has been monitored individually with glass dosimeters for photons and solid-state nuclear track detectors for neutrons. Almost all the records for individual exposure were undetectable, while the doses for 157 persons (5.1% of the workers) were detectable but less than 5.0 mSv.

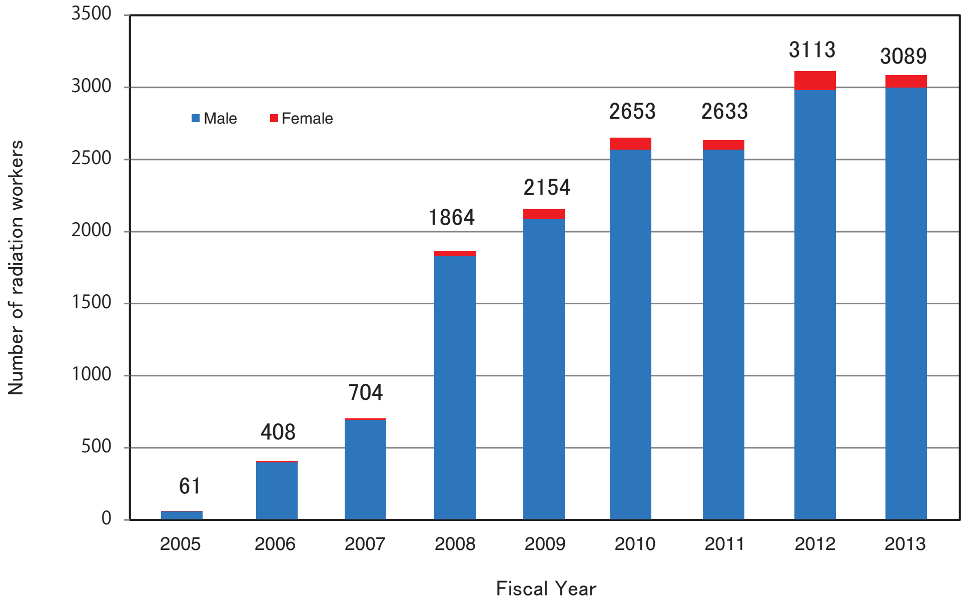


Fig. 1. Variation of the number of the radiation workers in J-PARC.

Table 2. Distribution of annual doses by the type of worker in fiscal year 2013.

	Dose range X (mSv)						Collective dose (person-mSv)	Average dose (μSv)
	UD	0.1≦X ≦0.5	0.5<X ≦1.0	1.0<X ≦5.0	X >5.0	Total worker		
In-house staff	554	37	7	1	0	599	19.4	32.4
User	966	14	2	4	0	616	10.3 (10.3*)	16.7
Contractor	1782	91	1	0	0	1874	27.5	14.7
Total	2932	142	10	5	0	3089	57.2 (18.3*)	18.5

* : The number in parentheses is the contribution of the HD incident.

Users Office

Users Office

That was a nightmare. On May 23, 2013, malfunction of the slow beam extraction system of the "50 GeV" synchrotron of J-PARC generated extremely dense protons which were delivered to the gold target of the Hadron Experimental Facility (HD Facility) damaging the target and dispersing radioactive material. It might not have developed into such a nightmare, if adequate responses had been applied. However, inadequate responses without grasping what was actually taking place exacerbated the situation. Consequently, thirty-four workers were exposed to radiation and radioactive material was released from the radiation controlled area. To make matters worse, there was a delay in reporting it to the relevant authorities and the local communities.

We deeply regretted the way we had responded. However, we must accept the "Arrow of time" which means "one-way direction" or "asymmetry" of time. Moreover, we must admit there was something wrong with our attitude toward safety. We should accept the experience as an opportunity to improve J-PARC. We needed to conduct thorough investigation to determine the causes, review the safety management system and procedures to follow in emergency situations and take measures to prevent similar incidents in the future.

To beef up the safety management system, the post of a Deputy Director of the J-PARC Center was created, combining the responsibilities for radiation safety of each facility and the procedures in emergency situations. Furthermore, the duties to supervise each facility in emergency situations were transferred from the deputy director of the J-PARC Center to the person responsible for the facility management, which allowed prompt action. In addition, "Alert Status" warning was created between "Normal Status" and "Emergency Status", under which those who were in J-PARC must be ready for adequate and prompt action.

In response to the improvement, the DVDs for the safety training were updated. Tests were adopted to ensure the users who took the safety training understood the contents. The safety training consisted of general safety training, specialized safety training for each facility and J-PARC radiation safety training. The J-PARC Center Users Office (UO) arranged the safety training and the tests, and executed them. The tests of general safety training and specialized safety training for each facility were executed online. Since prompt evacuation and prompt emergency call were specifically required in emergency situations, a paper card was adopted, on which the areas for evacuation and the phone numbers to dial were printed. The J-PARC users were handed the paper cards, which they must carry with them during their stay in J-PARC.

It was helpful not only to the J-PARC users but also to the J-PARC Center members to be informed about the current accelerator operation status. Screens to display the current accelerator operation status were installed at UO, the Tokai Dormitory, which is a main accommodation for the J-PARC users, the Central Control Building of J-PARC, etc.

Along with the above improvements, system engineers and UO members continuously developed web-based systems: proposal submission system, proposal review system, user support system and experimental report management system. Since many research proposals were submitted not only from Japan but also from foreign countries, adopting web-based systems was necessary to improve the UO operational efficiency. Proposal submission system and user support system were adopted in 2008, proposal review system in 2009 and experimental report management system in 2010. Those systems were improved every year including the Japanese fiscal year (JFY) 2013 to smoothly announce the call for proposals, forward the proposals to referees, notify the applicants of the results, execute procedures for conduct experiments, etc.

Other Achievements in JFY 2013

1. User registration and pre-visit procedures:

1)confirmed eligibility of the user registrations, conducted accurate procedures to comply with Foreign Exchange and Foreign Trade Control Law and approved the user registrations through the user support system; 2)arranged the Tokai Dormitory bookings in the case the automatic booking system did not function; 3)booked other accommodations when the Tokai Dormitory was fully booked; 4)checked applications for individual dosimeters; 5)issued temporary Shuttle Bus Passes;

6)checked eligibility of Foreign National Visit Proposals; 7)issued letters of guarantee for visa application; 8) applied for certificates of eligibility for visa application; 9)calculated the amount of travel expenses of inter-university research users whom KEK had accepted.

2. Procedures upon arrival:

1)issued J-PARC User ID Cards; 2)handed users individual dosimeters; 3)issued car driving permission passes; 4)issued J-PARC card keys to enter the J-PARC facilities during off-hours; 5)lent out bikes and handy phones for internal calls at J-PARC.

3. Post-visit Procedures:

1)checked MLF machine time completion forms or MLF experimental reports submitted by users and forwarded them to persons who had responsibilities for approving them.

4. User Statistics:

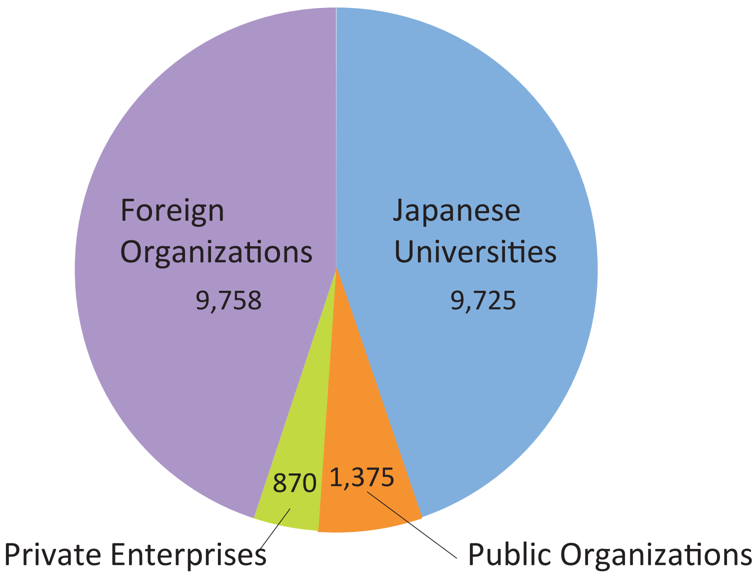
1)collected fundamental user statistics; 2)produced other user statistics when required.

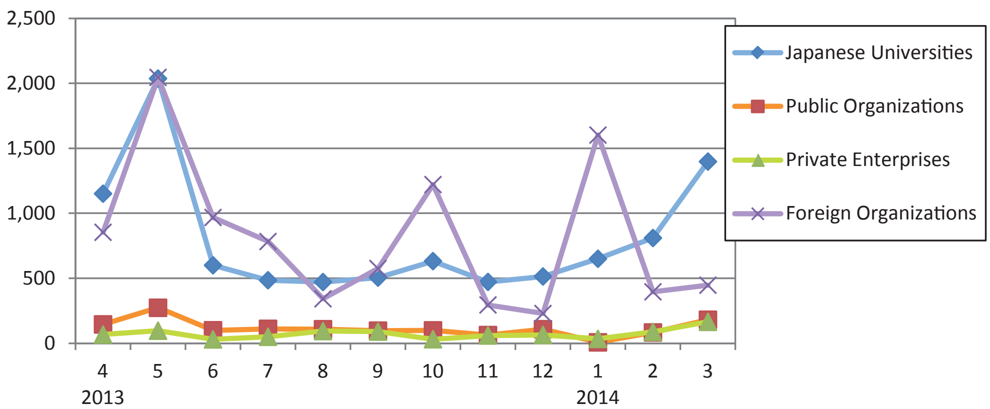
5. Others:

1)closed the Tokai dormitory's books every day; 2)took sick or injured users to hospitals; 3)booked taxis or airport limousines; 4)posted announcements about user support system shutdown, blackout, etc.

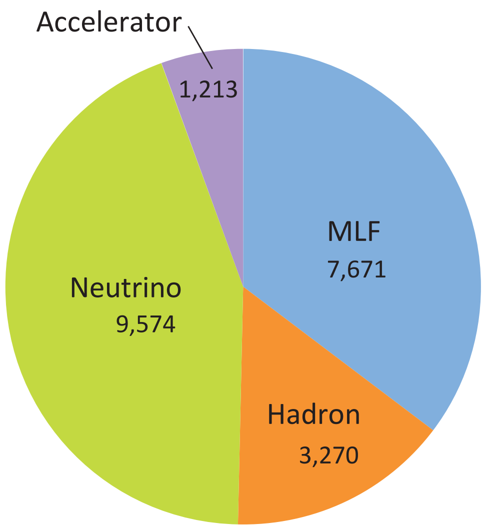
Although the radiation exposure and radiation leak occurred in May, 2013, some users came to J-PARC. However, their numbers plummeted on June and the low level continued during JFY 2013. Consequently the number counted by person-days in JFY 2013 was 21,728, down by about 33% from the previous year.

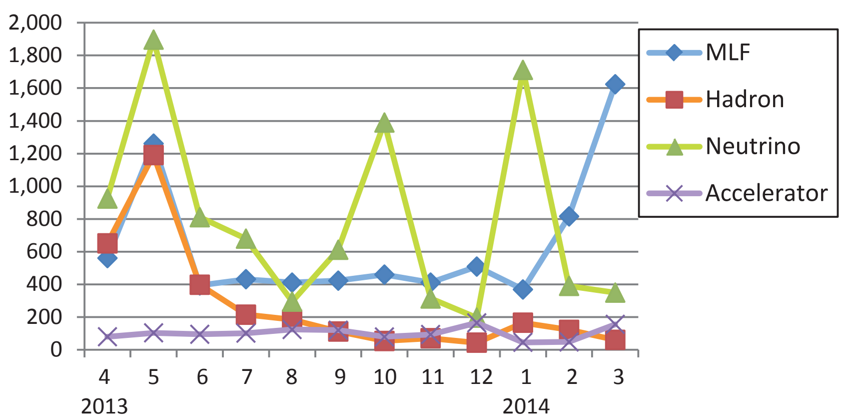
(1) Users in 2013 (according to organizations, person-days)



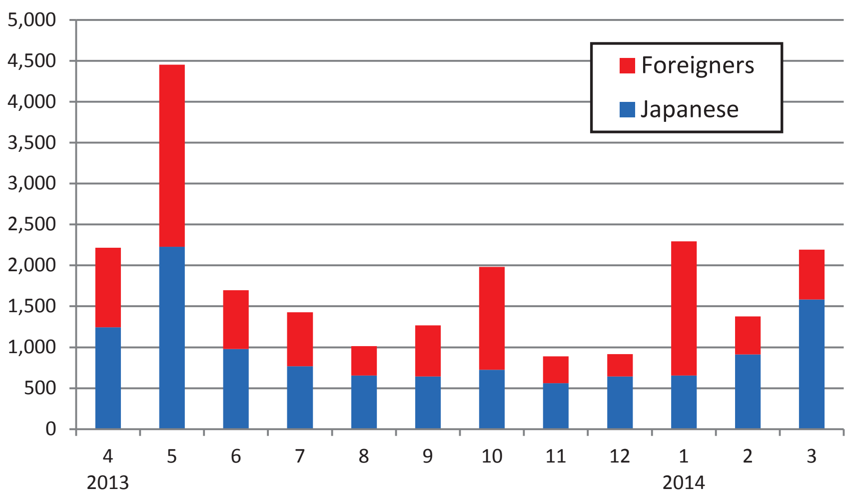


(2) Users in 2013 (according to facilities, person-days)





(3) Users in 2013 (Japanese・Foreigners, person-days)



User Program

Overview of MLF Use

(1) Basic policy of the MLF use

The Materials and Life Science Experimental Facility (MLF) is available to Japanese and overseas users for both academic research and industrial applications. The following peer review systems are introduced for fair, clear and user-oriented facility management: User Consultative Committee, Neutron/Muon Science Proposal Review Committee, and Neutron/Muon Science Instrument Review Committee. All nonproprietary proposals are reviewed and ranked by the Neutron/Muon Program Review Committee. The J-PARC Center is responsible for the beamtime allocation for approved proposals.

(2) Registered Institution for Facility Use Promotion (RIFUP)

Consistent with its longstanding policy of promoting open access to major publicly-funded research facilities, the Japanese Government in July 2009 designated the accelerators (linac and 3 GeV proton synchrotron) and some beamlines at J-PARC MLF as Public Neutron Beam Facility under the terms of the so-called "Public Use Promotion" legislation. The aim of the legislation is to advance science and technology through the effective promotion and operation of general user access program at designated large-scale research facilities. The legislation requires that the user program on the Public Beamlines be managed and supported by an independent, third-party organization. This organization is known as RIFUP.

Comprehensive Research Organization for Science and Society (CROSS) applied for RIFUP in February 2011 and was allowed by the Minister of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) to operate as RIFUP. Accordingly, CROSS commenced its operation on the 1st of April, 2011, at its Tokai office in the Ibaraki Quantum Beam Research Center (IQBRC) adjacent to the J-PARC site.

(3) MLF Instrument Use

There are 23 neutron beam extraction ports for the pulsed spallation neutron source and 4 muon extraction channels for the muon target at MLF.

Not only can JAEA or KEK, the parent organizations of J-PARC, construct instruments for conducting experiments using the neutron and the muon beams, but third parties can do it too. However, the manufacturers of the instruments at MLF are obliged to manage and maintain their beamline instruments.

Beamtime provided to the J-PARC users is classified into three categories: one managed by the J-PARC Center, one managed by a third-party, and one managed by CROSS-Tokai. The third-party must supply to the J-PARC Center a little portion of its full beamtime in exchange for having exclusive rights to use the beamline instruments.

Therefore, the J-PARC user program is carried out using all the beamtime for the instruments owned by JAEA or KEK and part of the beamtime for those owned by the third parties. The proposals for the MLF use program are reviewed uniformly and openly.

(4) MLF Access modes

(a) Beamtime managed by the J-PARC Center

There are three access modes to obtain outstanding scientific results or to meet the various needs of users: general use, project use and instrument group use. An applicant to general use must be an employee of or affiliated with a legal organization or entity that may be any of the following: a public or private college, university or other institute of higher education, a public or not-for-profit research organization, or a private company. A postdoctoral fellow is also eligible to submit proposals with the permission of his/her manager or supervisor at the home institute/organization to conduct research activities at MFL. Project use is the access mode in which JAEA or KEK conducts its mission-oriented programs such as inclusive scientific research projects or research programs proposed to fulfill plans to achieve midterm goals of JAEA, joint research programs and contract research programs with other institute(s)/organization(s). Experiment proposals requesting beamtime longer than one year may be acceptable for the project use. Only personnel belonging to either JAEA or KEK or a person approved by the director of the J-PARC Center can apply for project use. Instrument group use is the access mode in which the scientists responsible for the instruments maintain them in good condition and/or develop their performances to provide the J-PARC users with the most superior experimental environments.

(b) Beamtime managed by a third party-Ibaraki Prefecture

Ibaraki Prefecture constructed, for industrial application research, the Ibaraki Biological Crystal Diffractometer BL03(iBIX) and the Ibaraki Materials Design Diffractometer BL20(iMATERIA).

There are three access modes: Industrial Use Open Projects, Prefectural Projects and Urgent Use. Industrial Use Open Projects are classified into two types of uses: regular-interval use for which projects are accepted in either the first or the second half of the year and occasional use for which projects are accepted as late as about one month prior to the date the desired cycle starts. Prefectural Projects are for industry-academic-government collaboration research led by Ibaraki Prefecture or for promoting an advantage of neutron use to a certain industry. Urgent Use is for projects more urgent than the regular ones.

(c) Beamtime managed by CROSS-Tokai

CROSS-Tokai manages and supports the user program on the six neutron Public Beamlines (BL01, BL02, BL11, BL15, BL17, BL18). There are six kinds of access modes for these Beamlines.

1) General Use

General Use access works in exactly the same way for the Public Beamlines as it does for all other MLF instruments. This is the appropriate access mode for most researchers wishing to use the neutron Public Beamlines at J-PARC MLF.

To encourage and provide access to the widest possible range of users, General Use is, in principle, open to all local and international researchers, who wish to exploit the neutron beams and instruments in their research programs. Proposals are welcomed from researchers with academic, government or private research affiliations.

2) Elements Strategic Use

The government project to generate materials which serve as alternatives to rare materials, such as rare earth or rare elements, started in 2012. There are four categories in the project: magnet materials, catalytic or battery materials, electronic materials and construction materials. Elements Strategic Use is aimed at promoting that project.

3) Trial Use

Trial Use is aimed at assisting novice users of neutron-based experimental techniques to gain experience and expertise that will allow them to become independent General Use applicants in the future. It may also be used for first-time users of pulsed neutrons to determine the experimental feasibility.

The Trial Use framework offers a wide range of services to potential new users, including support and guidance provided by a CROSS-Tokai Science Coordinator.

4) Director's Discretion

A proportion of the total available beamtime is reserved for allocation at the discretion of the Director of CROSS-Tokai. This time may be allocated to urgent proposals that warrant expedited access or used for approved outreach or education activities of CROSS-Tokai.

5) CROSS-Tokai Research

In this access mode, members of the Neutron R&D Division of CROSS-Tokai can apply for beamtime to carry out research aimed at developing and advancing research activities on the Public Beamlines. Proposals with strong scientific objectives that expand the range of facility usage will be assessed and ranked together with General Use proposals.

6) Facility Use

To ensure that instruments with the highest possible performance and capability are available to users, this access mode allows members of the beamline group to carry out work associated with the maintenance, development and testing of the instruments. This access mode also facilitates the use of beamlines for approved research projects of the beamline owner organization (JAEA).

(5) Call for General Use Proposals to access the neutron and muon beamlines

The J-PARC Center and CROSS-Tokai announced the Call for General Use Proposals to access the neutron and muon beamlines in the 2013A and 2013B operations periods.

Call for proposals for the first half of 2013 (2013A term): October 17 - November 7, 2012

The review results were announced on March 25, 2013.

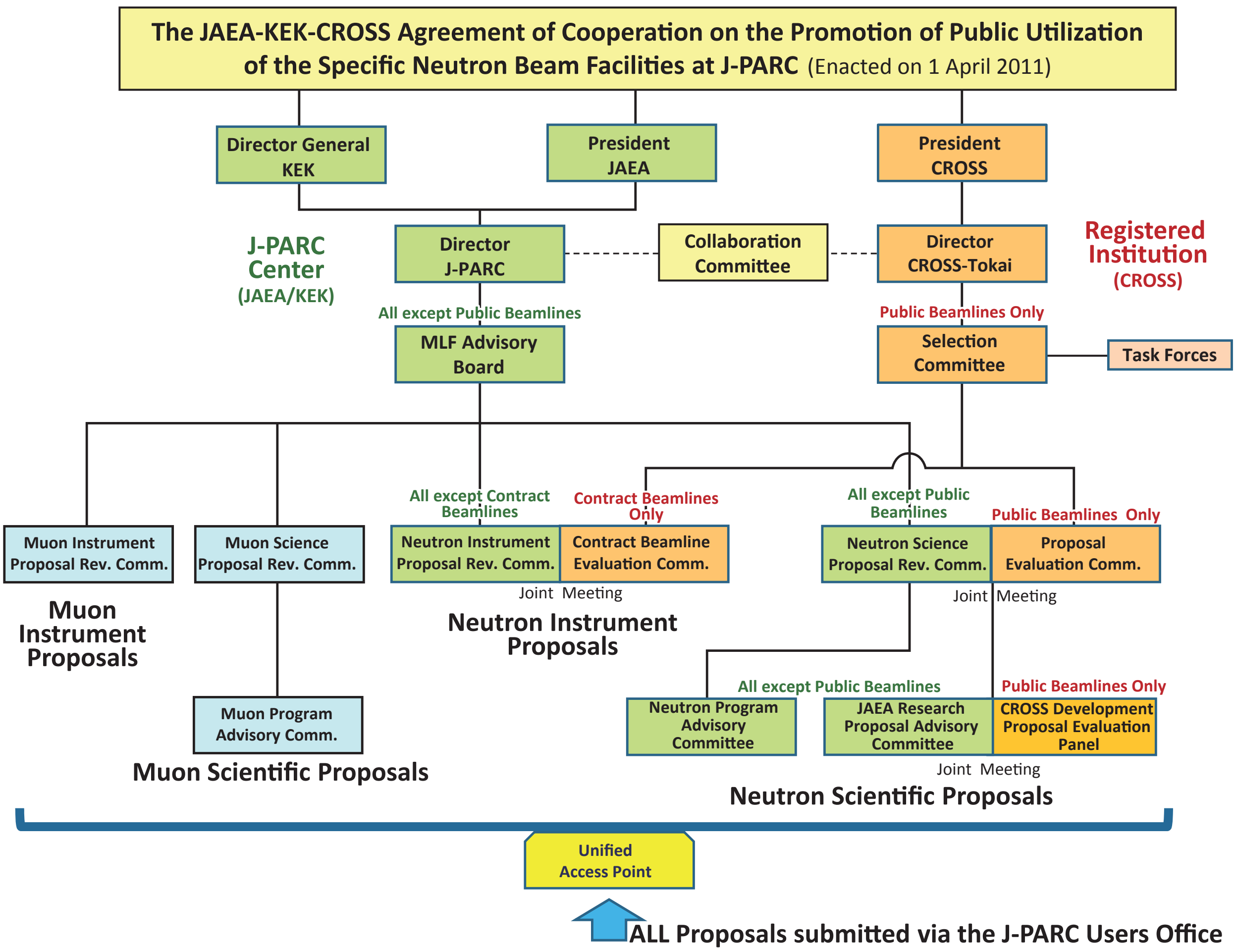
Call for proposals for the second half of 2013 (2013B term): May 17 - July 8, 2013

The review results were announced on December 6, 2013.

(6) Basic Concept of Nonproprietary Use

Research results obtained through J-PARC use should be shared widely by people all over the world, which enable us to step into the unknown world effectively and efficiently. Based on this idea, no beamtime fee is charged as long as the research results are published for public viewing.

Proposal Review System for MLF



MLF Proposal Summary - FY2013

Table 1. Breakdown of Proposal Numbers for the 2013A & 2013B Rounds.

Beam-line	Instrument	2013A						2013B					
		Submitted			Approved			Submitted			Approved		
		GU	PU/S	IU	GU	PU/S	IU	GU	PU/S	IU	GU	PU/S	IU
BL01	4D-Space Access Neutron Spectrometer - ***4SEASONS***	12(1^{+})	3	2	10(1^{+})	3	2	13(1$^{\#}$, 1^{+})	3	2	5(1$^{\#}$, 1^{+})	3	2
BL02	Biomolecular Dynamics Spectrometer - ***DNA***	13(1$^{\#}$)	3	2	7(1$^{\#}$)	3	2	10(1$^{\#}$)	3	2	3(1$^{\#}$)	3	2
BL03	Ibaraki Biological Crystal Diffractometer - iBIX (100-β)‡	6	0	0	4	0	0	4	0	0	1	0	0
	(β)†	0	14	0	0	9	0	0	14	0	0	9	0
BL04	Accurate Neutron-Nucleus Reaction Measurement Instrument - ***ANNRI***	6	1	1	6	1	1	6	1	1	4	1	1
BL05	Neutron Optics and Physics - ***NOP***	1	1	0	1	1	0	4	1	0	3	1	0
BL08	Super High Resolution Powder Diffractometer - ***S-HRPD***	12	1	0	9	1	0	13	1	0	3	1	0
BL09	Special Environment Neutron Powder Diffractometer - ***SPICA***	0	1	0	0	1	0	0	1	0	0	1	0
BL10	Neutron Beamline for Observation and Research Use - ***NOBORU***	8	2	1	7	2	1	18	2	1	5	2	1
BL11	High-Pressure Neutron Diffractometer - ***PLANET***	0	1	0	0	1	0	11	1	0	7	1	0
BL12	High Resolution Chopper Spectrometer - ***HRC***	2	1	0	2	1	0	11	1	0	2	1	0
BL14	Cold-neutron Disk-chopper Spectrometer - ***AMATERAS***	23	2	1	11	2	1	19	2	1	6	2	1
BL15	Small and Wide Angle Neutron Scattering Instrument - ***TAIKAN***	27(2$^{\#}$, 1^{+})	6	3	22(2$^{\#}$, 1^{+})	6	3	30(2$^{\#}$, 1^{+})	6	3	9(2$^{\#}$, 1^{+})	6	3

Beam-line	Instrument	2013A Submitted GU	2013A Submitted PU/S	2013A Submitted IU	2013A Approved GU	2013A Approved PU/S	2013A Approved IU	2013B Submitted GU	2013B Submitted PU/S	2013B Submitted IU	2013B Approved GU	2013B Approved PU/S	2013B Approved IU
BL16	High-Performance Neutron Reflectometer with a horizontal Sample Geometry - ***SOFIA***	16	1	0	15	1	0	12	1	0	7	1	0
BL17	Polarized Neutron Reflectometer - ***SHARAKU***	9(1#)	3	3	9(1#)	3	1	15(1#)	3	3	5(1#)	3	1
BL18	Extreme Environment Single Crystal Neutron Diffractometer - ***SENJU***	11	2	3	8	2	2	22	2	3	4	2	2
BL19	Engineering Diffractometer - ***TAKUMI***	31(1+)	3	1	16(1+)	3	1	25	3	1	5	3	1
BL20	Ibaraki Materials Design Diffractometer - ***iMATERIA*** (100-β)‡	14	0	0	6	0	0	12	0	0	3	0	0
BL20	Ibaraki Materials Design Diffractometer - ***iMATERIA*** (β)†	0	31	0	0	25	0	0	27	0	0	23	0
BL21	High Intensity Total Diffractometer - ***NOVA***	12	1	0	12	1	0	22	1	0	5	1	0
D1	Muon D1	20	1	1	19	1	1	19	1	1	5	1	1
D2	Muon D2	6	0	1	5	0	1	13	1	0	5	1	0
U	Muon U	0	1	0	0	1	0	0	1	0	0	1	0
Subtotal		229	79	19	169	68	16	279	76	18	87	67	15
Total		327			253			373			169		

GU : General Use **PU** : Project Use or Ibaraki Pref. Project Use **IU** : Instrument Group Use
S : S-type Proposals **†** : Ibaraki Pref. Exclusive Use Beamtime (β = 80% in FY2012)
‡ : J-PARC Center General Use Beamtime ((100-β = 20% in FY2012)
: Proposal Numbers under Trial Use Access System in GU
+ : Proposal numbers under Element Strategy in GU

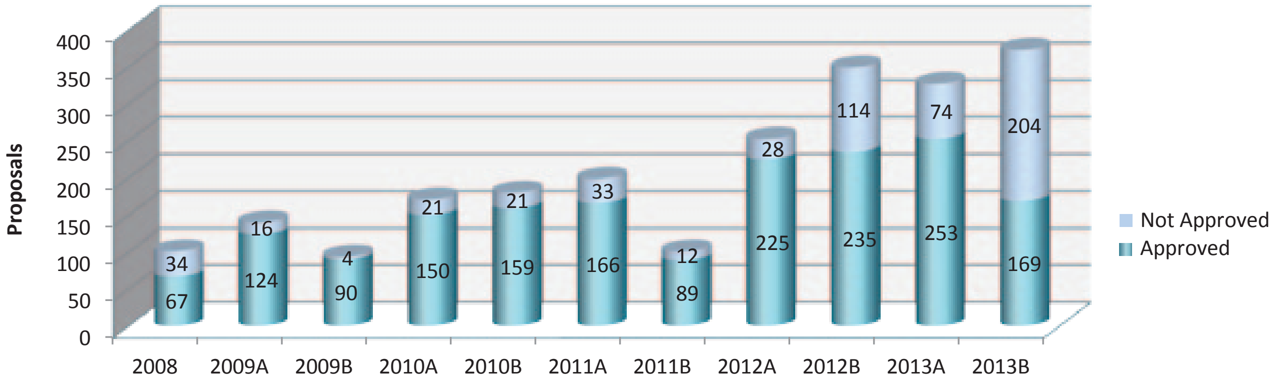


Figure 1. MLF Proposal Numbers over Time.

Table 2. Principal Investigator Affiliations in FY2013.

Universities (Japan)	JAEA	Companies (Japan)	KEK	Foreign Organizations	Research Institutes (Japan)
289	154	84	40	55	78

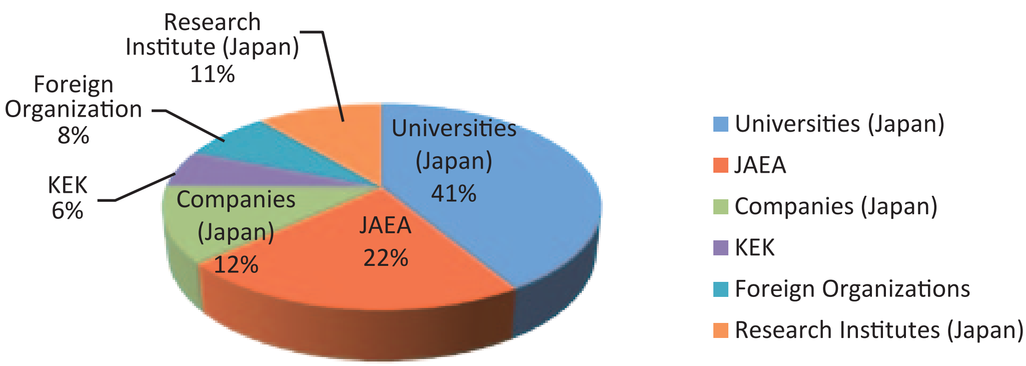


Figure 2. Origin of Proposals in FY2013.

Table 3. Proposals by Sub-committee/Expert Panel – FY2013A.

Sub-committee Expert Panel	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Q1	Q2	N/A
No. of Proposals	57	15	21	11	46	5	24	12	4	3	8	18	103

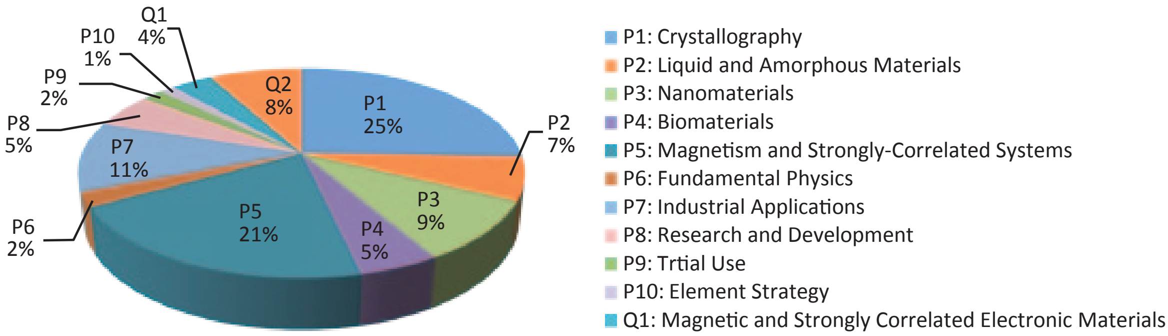


Figure 3. Submitted Proposals by Sub-committee/Expert Panel – FY2013A.

Table 4. Proposals by Sub-committee/Expert Panel – FY2013B.

Sub-committee Expert Panel	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Q1	Q2	N/A
No. of Proposals	66	16	35		70	24	27		5	2	11	21	96

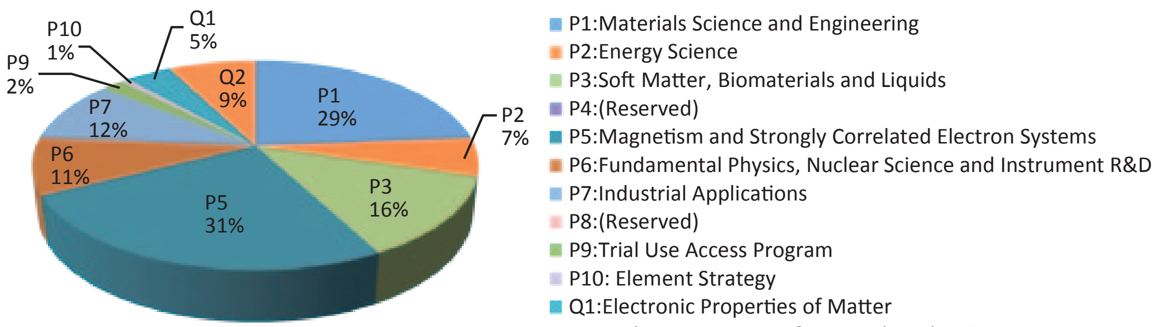
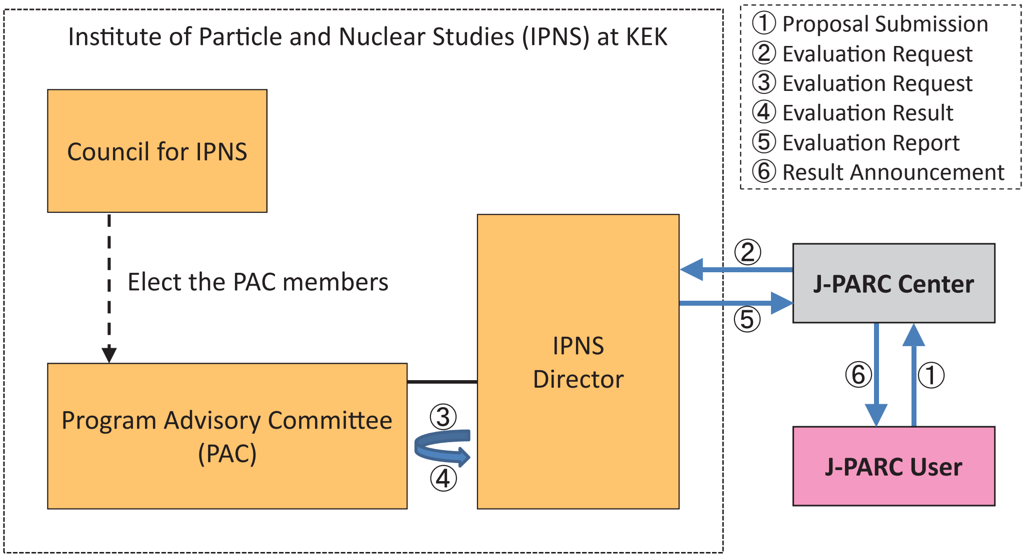


Figure 4. Submitted Proposals by Sub-committee/Expert Panel – FY2013B.

Proposal Review System for Nuclear and Particle Physics Experiments at the J-PARC "50 GeV" Proton Synchrotron



The 17h Program Advisory Committee (PAC) meeting was held on September 25 - 27, 2013.

Approval Summary of the Nuclear and Particle Physics Experiments after the 17th PAC Meeting (September 25, 2013)

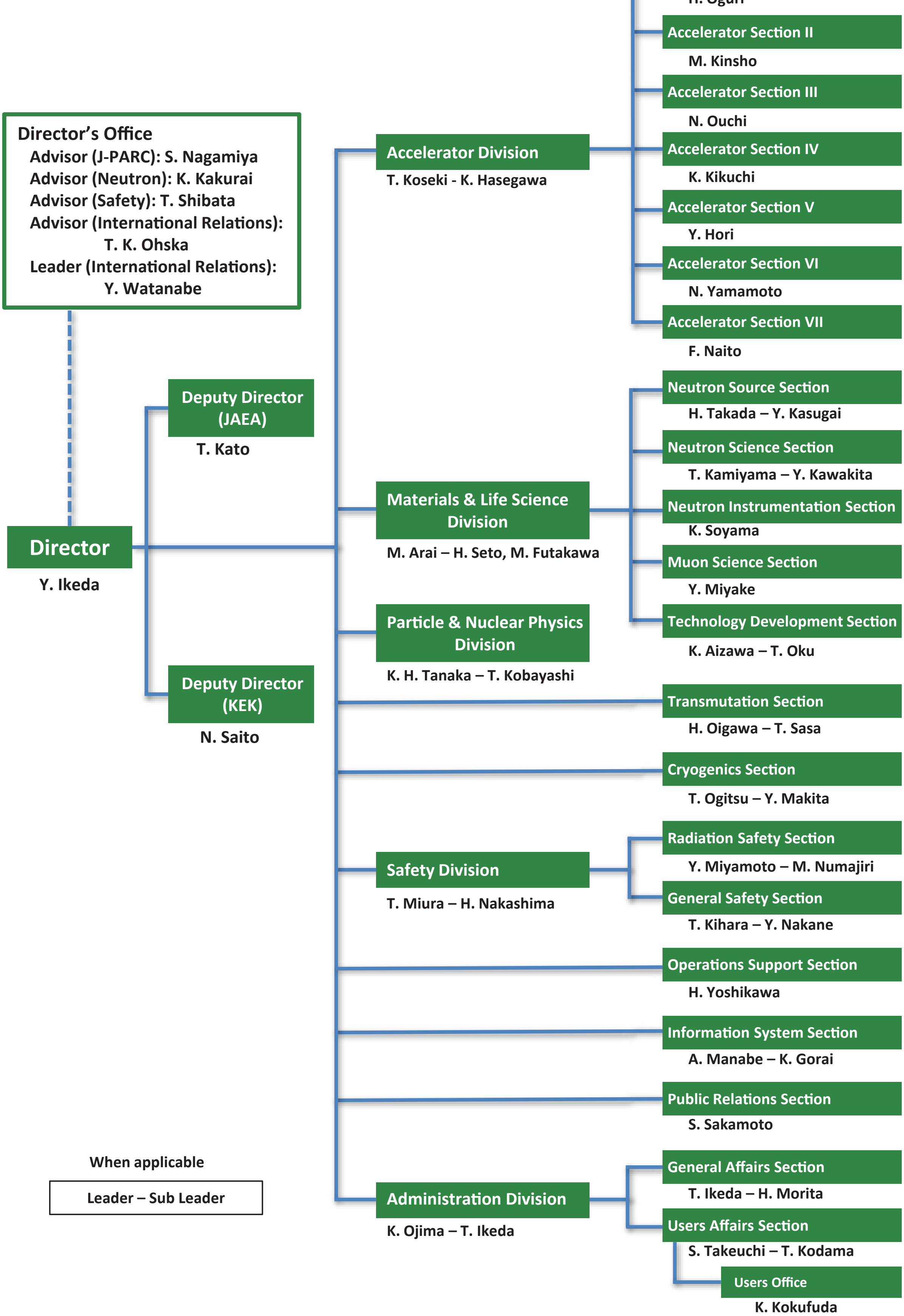
	(Co-) Spokespersons	Affiliation	Title of the experiment	Approval status (PAC recommendation)	Slow line priority		Beamline
					Day1?	Day1 Priority	
E03	K. Tanida	SNU	Measurement of X rays from Ξ^- Atom	Stage 2			K1.8
P04	J.C. Peng, S. Sawada	U of Illinois at Urbana-Champaign, KEK	Measurement of High-Mass Dimuon Production at the 50-GeV Proton Synchrotron	Deferred			Primary
E05	T. Nagae	Kyoto U	Spectroscopic Study of Ξ-Hypernucleus, ${}^{12}_{\Xi}Be$, via the ${}^{12}C(K^-, K^+)$ Reaction	Stage 2	Day1	1	K1.8
E06	J. Imazato	KEK	Measurement of T-violating Transverse Muon Polarization in K^+ -> π^0 μ^+ ν Decays	Stage 1			K1.1BR
E07	K. Imai, Nakazawa, H. Tamura	JAEA, Gifu U, Tohoku U	Systematic Study of Double Strangeness System with an Emulsion-counter Hybrid Method	Stage 2			K1.8
E08	A. Krutenkova	ITEP	Pion double charge exchange on oxygen at J-PARC	Stage 1			K1.8
E10	A. Sakaguchi, T. Fukuda	Osaka U, Osaka EC U	Production of Neutron-Rich Lambda-Hypernuclei with the Double Charge-Exchange Reaction (Revised from Initial P10)	Stage 2			K1.8
E11	T. Kobayashi	KEK	Tokai-to-Kamioka (T2K) Long Baseline Neutrino Oscillation Experimental Proposal	Stage 2			neutrino
E13	H. Tamura	Tohoku U	Gamma-ray spectroscopy of light hypernuclei	Stage 2	Day1	2	K1.8
E14	T. Yamanaka	Osaka U	Proposal for K_L -> π^0 ν ν-bar Experiment at J-PARC	Stage 2			KL
E15	M. Iwasaki, T. Nagae	RIKEN, Kyoto U	A Search for deeply-bound kaonic nuclear states by in-flight ${}^3He(K^-, n)$ reaction	Stage 2	Day1		K1.8BR
E16	S. Yokkaichi	RIKEN	Electron pair spectrometer at the J-PARC 50-GeV PS to explore the chiral symmetry in QCD	Stage 1			High p
E17	R. Hayano, H. Outa	U Tokyo, RIKEN	Precision spectroscopy of Kaonic ${}^3He$ 3d->2p X-rays	Stage 2	Day1		K1.8BR
E18	H. Bhang, H. Outa, H. Park	SNU, RIKEN, KRISS	Coincidence Measurement of the Weak Decay of ${}^{12}_{\Lambda}C$ and the three-body weak interaction process	Stage 2			K1.8

	(Co-) Spokespersons	Affiliation	Title of the experiment	Approval status (PAC recommendation)	Slow line priority		Beamline
					Day1?	Day1 Priority	
E19	M. Naruki	KEK	High-resolution Search for Θ^+ Pentaquark in $\pi^- p$ -> $K^- X$ Reactions	Stage 2	Day1		K1.8
E21	Y. Kuno	Osaka U	An Experimental Search for $\mu - e$ Conversion at a Sensitivity of 10^{-16} with a Slow-Extracted Bunched Beam	Stage 1			New beamline
E22	S. Ajimura, A. Sakaguchi	Osaka U	Exclusive Study on the Lambda-N Weak Interaction in A=4 Lambda-Hypernuclei (Revised from Initial P10)	Stage 1			K1.8
T25	S. Mihara	KEK	Extinction Measurement of J-PARC Proton Beam at K1.8BR	Test Experiment	will be coordinated by JPNC		K1.8BR
E26	K. Ozawa	KEK	Search for ω-meson nuclear bound states in the $\pi^-+{}^AZ$ -> $n+{}^{(A-1)}\omega(Z-1)$ reaction, and for ω mass modification in the in-medium ω->$\pi^0\gamma$ decay	Stage 1			K1.8
E27	T. Nagae	Kyoto U	Search for a nuclear Kbar bound state K^-pp in the $d(\pi^+, K^+)$ reaction	Stage 2			K1.8
E29	H. Ohnishi	RIKEN	Search for ϕ-meson nuclear bound states in the pbar + AZ -> ϕ + (A–1)ϕ(Z–1) reaction	Stage 1			K1.1
E31	H. Noumi	Osaka U	Spectroscopic study of hyperon resonances below KN threshold via the (K^-,n) reaction on Deuteron	Stage 2			K1.8BR
T32	A. Rubbia	ETH, Zurich	Towards a Long Baseline Neutrino and Nucleon Decay Experiment with a next-generation 100 kton Liquid Argon TPC detector at Okinoshima and an intensity upgraded J-PARC Neutrino beam	Test Experiment	schedule and beam time will be coordinated by JPNC		K1.1BR
P33	H.M. Shimizu	Nagoya U	Measurement of Neutron Electric Dipole Moment	Deferred			Linac
E34	N. Saito, M. Iwasaki	KEK, RIKEN	An Experimental Proposal on a New Measurement of the Muon Anomalous Magnetic Moment g-2 and Electric Dipole Moment at J-PARC	Stage 1			MLF
E36	M. Kohl, S. Shimizu	Hampton U, Osaka U	Measurement of $\Gamma(K^+ \to \varepsilon^+ \nu)/\Gamma(K^+ \to \mu^+ \nu)$ and Search for heavy sterile neutrinos using the TREK detector system	Stage 2			K1.1BR
E40	K. Miwa	Tohoku U	Measurement of the cross sections of Σp scatterings	Stage 1			K1.8
P41	M. Aoki	Osaka U	An Experimental Search for $\mu - e$ Conversion in Nuclear Field at a Sensitivity of 10^{-14} with Pulsed Proton Beam from RCS	Deferred			MLF
E42	J. K. Ahn	Pusan National U	Search for H-Dibaryon with a Large Acceptance Hyperon Spectrometer	Stage 1			K1.8
E45	K.H. Hicks, H. Sako	Ohio U, JAEA	3-Body Hadronic Reactions for New Aspects of Baryon Spectroscopy	Stage 1			K1.8
T46	K. Ozawa	KEK	EDIT2013 beam test program	Test Experiment			K1.1BR
T49	T. Maruyama	KEK	Test for 250L Liquid Argon TPC	Test Experiment	(not performed yet)		K1.1BR
P50	H. Noumi	Osaka U	Charmed Baryon Spectroscopy via the (π, D*-) reaction	Deferred			High p
T51	S. Mihara	KEK	Research Proposal for COMET(E21) Calorimeter Prototype Beam Test	Test Experiment	(had to be stopped)		K1.1BR
T52	Y. Sugimoto	KEK	Test of fine pixel CCDs for ILC vertex detector	Test Experiment	(not performed yet)		K1.1BR
T53	D. Kawama	RIKEN	Test of GEM Tracker, Hadron Blind Detector and Lead-glass EMC for the J-PARC E16 experiment	Test Experiment	(not performed yet)		K1.1BR
T54	K. Miwa	Tohoku U	Test experiment for a performance evaluation of a scattered proton detector system for the Σp scattering experiment E40	Test Experiment	(not performed yet)		K1.1BR
T55	A. Toyoda	KEK	Second Test of Aerogel Cherenkov counter for the J-PARC E36 experiment	Test Experiment	(had to be stopped)		K1.1BR
P56	T. Maruyama	KEK	A Search for Sterile Neutrino at J-PARC Materials and Life Science Experimental Facility	Deferred			MLF

Organization and Committees

Organization Structure

J-PARC Center Organization Chart
as of April 1, 2013



Members of the Committees Organized for J-PARC

(as of March, 2013)

1) Steering Committee

Yujiro Ikeda	J-PARC Center, Japan
Kazuhisa Kakurai	Japan Atomic Energy Agency, Japan
Satoru Kondo	Japan Atomic Energy Agency, Japan
Hideki Namba	Japan Atomic Energy Agency, Japan
Masaharu Nomura	High Energy Accelerator Research Organization, Japan
Katsunobu Oide	High Energy Accelerator Research Organization, Japan
Takayuki Sumiyoshi	High Energy Accelerator Research Organization, Japan
Yasuhide Tajima	Japan Atomic Energy Agency, Japan
Hiroshi Uetsuka	Japan Atomic Energy Agency, Japan
Kazuyoshi Yamada	High Energy Accelerator Research Organization, Japan
Masanori Yamauchi	High Energy Accelerator Research Organization, Japan

2) International Advisory Committee

Hamid Aït Abderrahim	Belgian Nuclear Research Center, Belgium
Hiroshi Amitsuka	Hokkaido University, Japan
Kelly Beierschmitt	Oak Ridge National Laboratory, USA
Sergio Bertolucci	European Organization for Nuclear Research, Switzerland
Shinian Fu	Institute of High Energy Physics, Chinese Academy of Science, China
Hidetoshi Fukuyama	Tokyo University of Science, Japan
Donald Geesaman	Argonne National Laboratory, USA
Hugh Montgomery	Thomas Jefferson National Accelerator Facility, USA
Jean-Michel Poutissou	Canada's National Laboratory for Particle and Nuclear Physics, Canada (chair)
Robert Robinson	Australian Nuclear Science and Technology Organization, Australia
Thomas Roser	Brookhaven National Laboratory, USA
Hoerst Stoecker	GSI Helmholtz Centre for Heavy Ion Research, Germany
Andrew Taylor	Science and Technology Facilities Council, UK
Robert Tschirhart	Fermi National Accelerator Laboratory, USA
Hajimu Yamana	Kyoto University. Japan

3) User Consultative Committee for J-PARC

Masatoshi Arai	Japan Atomic Energy Agency, Japan
Yasuhiko Fujii	Comprehensive Research Organization for Science and Society, Japan
Makoto Hayashi	Ibaraki Prefecture, Japan
Tomohiko Iwasaki	Tohoku University, Japan
Toshiji Kanaya	Kyoto University, Japan
Yoshiyuki Kawakami	Eisai Co., Ltd., Japan
Yoshiaki Kiyanagi	Nagoya University, Japan
Takashi Kobayashi	High Energy Accelerator Research Organization, Japan
Yoji Koike	Tohoku University, Japan
Sachio Komamiya	University of Tokyo, Japan
Yasuhiro Miyake	High Energy Accelerator Research Organization, Japan
Junichirou Mizuki	Kwansei Gakuin University, Japan
Tomofumi Nagae	Kyoto University, Japan
Takashi Nakano	Osaka University, Japan
Tsuyoshi Nakaya	Kyoto University, Japan
Nobuyuki Osakabe	Central Research Laboratory, Hitachi, Ltd., Japan
Taku Sato	Tohoku University, Japan
Shinya Sawada	High Energy Accelerator Research Organization, Japan
Masaaki Sugiyama	Kyoto University, Japan
Jun Sugiyama	Toyota Central R&D Labs., Inc., Japan
Hirokazu Tamura	Tohoku University, Japan
Kazuhiro Tanaka	High Energy Accelerator Research Organization, Japan
Eiko Torikai	Yamanashi University, Japan
Taku Yamanaka	Osaka University, Japan
Satoru Yamashita	University of Tokyo, Japan

4) Accelerator Technical Advisory Committee

Alberto Facco	National Institute of Nuclear Physics, Italy
Roland Garoby	European Organization for Nuclear Research, Switzerland
Alan Letchford	Rutherford Appleton Laboratory, UK
Subrata Nath	Los Alamos National Laboratory
Akira Noda	National Institute of Radiological Sciences, Japan
Michael Plum	Oak Ridge National Laboratory, USA
Thomas Roser	Brookhaven National laboratory, USA (chair)
Jie Wei	Michigan State University, USA
Robert Zwaska	Fermi National Accelerator Laboratory, USA

5) Neutron Advisory Committee

Kurt Clausen	Paul Scherrer Institut, Switzerland
Phillip Ferguson	Oak Ridge National Laboratory, USA
Toshiji Kanaya	Kyoto University, Japan
Mahn Won Kim	Korea Advanced Institute of Scienee and Technology, Korea
Yoshiaki Kiyanagi	Nagoya University, Japan
Dan Neumann	National Institute of Standards and Technology, USA
Robert Robinson	Australian Nuclear Science and Technology Organization, Australia
Uschi Steigenberger	ISIS, Rutherford Appleton Laboratory, UK (Chair)
Werner Wagner	Paul Scherrer Institute, Switzerland

6) Muon Science Advisory Committee

Hiroshi Amitsuka	Hokkaido University, Japan
Toshiyuki Azuma	Institute of Physical and Chemical Reserch, Japan
Klauss Jungmann	University of Groningen, Netherland
Elvezio Morenzoni	Paul Scherrer Institute, Switzerland (chair)
Yasuo Nozue	Osaka University, Japan
Francis Pratt	ISIS, Rutherford Appleton Laboratory, UK
Jeff E. Sonier	Simon Fraser University, Canada
Jun Sugiyama	Toyota Central R&D Labs., Inc., Japan

7) Radiation Safety Committee

Yoshihiro Asano	Institute of Physical and Chemical Reserch, Japan
Shuichi Ban	High Energy Accelerator Research Organization, Japan
Yukihide Kamiya	High Energy Accelerator Research Organization, Japan
Satoru Kondo	Japan Atomic Energy Agency, Japan
Takeshi Murakami	National Institute of Radiological Science, Japan
Tetsuo Noro	Kyushu University, Japan
Shinichi Sasaki	High Energy Accelerator Research Organization, Japan
Seiichi Shibata	Kyoto University, Japan (chair)
Yoshitomo Uwamino	Institute of Physical and Chemical Reserch, Japan (Deputy Chair)
Takenori Yamaguchi	Japan Atomic Energy Agency, Japan
Yoshihiro Yamaguchi	Japan Atomic Energy Agency, Japan

8) MLF Advisory Board

Jun Akimitsu	Aoyama Gakuin University, Japan
Masatoshi Arai	Japan Atomic Energy Agency, Japan
Koichiro Asahi	Tokyo Institute of Technology, Japan
Yasuhiko Fujii	Comprehensive Research Organization for Science Society, Japan
Masatoshi Futakawa	Japan Atomic Energy Agency, Japan
Makoto Hayashi	Ibaraki Prefecture, Japan
Shinichi Ito	High Energy Accelerator Research Organization, Japan
Ryosuke Kadono	High Energy Accelerator Research Organization, Japan
Takashi Kamiyama	High Energy Accelerator Research Organization, Japan
Toshiji Kanaya	Kyoto University, Japan
Mikio Kataoka	Nara Institute of Science and Technology, Japan
Takashi Kato	Japan Atomic Energy Agency, Japan
Yukinobu Kawakita	Japan Atomic Energy Agency, Japan
Kazuya Aizawa	Japan Atomic Energy Agency, Japan
Yoji Koike	Tohoku University, Japan
Yasuhiro Miyake	High Energy Accelerator Research Organization, Japan
Toshiya Ohtomo	High Energy Accelerator Research Organization, Japan
Taku Sato	Tohoku University, Japan
Hideki Seto	High Energy Accelerator Research Organization, Japan
Mitsuhiro Shibayama	University of Tokyo, Japan (Chair)
Masaaki Sugiyama	Kyoto University, Japan
Jun Sugiyama	Toyota Central R&D Labs., Inc., Japan
Wataru Utusmi	Japan Atomic Energy Agency, Japan
Toshio Yamaguchi	Fukuoka University, Japan (Deputy Chair)

9) Program Advisory Committee (PAC) for Nuclear and Particle Physics Experiments at the J-PARC 50 GeV Proton Synchrotron

Edward Blucher	University of Chicago, USA
Thomas Browder	University of Hawaii, USA
Akinobu Dote	High Energy Accelerator Research Organization, Japan
Junji Haba	High Energy Accelerator Research Organization, Japan (Chair)
Kenichi Imai	Japan Atomic Energy Agency, Japan
Kunio Inoue	Tohoku University, Japan
Gino Isidori	Frascati National Laboratories, Italy
Tadafumi Kishimoto	Osaka University, Japan
Konrad Kleinknecht	Mainz University, Germany
William C. Louis III	Los Alamos National Laboratory, USA
Tomofumi Nagae	Kyoto University, Japan
Matthias Gross Perdekamp	University of Illinois, USA
Hiroyoshi Sakurai	University of Tokyo, Japan
Hajime Shimizu	Tohoku University, Japan
Wolfram Weise	European Center for Theoretical Studies in Nuclear Physics and Related Areas, Ukraine

Main Parameters

Present main parameters of Accelerator

Linac	
Acclerated. Particles	Negative hydrogen
Energy	400 MeV
Peak Current	15 mA
Pulse Width	0.5 ms
Repetition Rate	25 Hz
Freq. of RFQ, DTL, and SDTL	324 MHz
Freq. of ACS	972 MHz
RCS	
Circumference	348.333 m
Injection Energy	400 MeV
Extraction Energy	3 GeV
Repetition Rate	25 Hz
RF Frequency	0.938 MHz → 1.67 MHz
Harmonic Number	2
Number of RF cavities	12
Number of Bending Magnet	24
Main Ring	
Circumference	1567.5 m
Injection Energy	3 GeV
Extraction Energy	30 GeV
Repetition Rate	~0.4 Hz
RF Frequency	1.67 MHz → 1.72 MHz
Harmonic Number	9
Number of RF cavities	8
Number of Bending Magnet	96

Key parameters of Materials and Life Science Experimental Facility

Injection Energy	3 GeV
Repetition Rate	25 Hz
Neutron Source	
Target Material	Mercury
Number of Moderators	3
Moderator Material	Supercritical hydrogen
Moderator Temperature/Pressure	20 K / 1.5 MPa
Number of Neutron Beam Ports	23
Muon Production Target	
Target Material	Graphite
Number of Muon Beam Extraction Ports	4
Neutron Instruments*	
Available for User Program (General Use)	17
Under Commissioning/Construction	1/3
Muon Instruments*	
Available for User Program (General Use)	2

(* As of March, 2014)

Events

Events

The Incident at the J-PARC Hadron Experimental Facility (May 23)

Due to a malfunction of the beam extraction system of the 50 GeV synchrotron, a proton beam was delivered to the gold target of the Hadron facility within a very short time. As a result, the gold target had momentarily reached an extremely high temperature and part of it was damaged. Radioactive material then leaked into the hadron experimental hall and some workers were exposed to radiation externally and/or internally. Operation of the ventilation fans of the hall resulted in the leak of radioactive material out of the radiation controlled area of the Hadron Experimental Facility.

The meeting on June 15

Meetings for Local Residents Held in Tokai Village to Explain the Recent Incident (June 13-15)

Over the three days from June 13 to 15, meetings were held in Tokai Village to explain the radioactive material leak incident at the Hadron Experimental Facility. The J-PARC Center apologized for causing the incident, and provided a basic overview of what happened. The executives of the Center listened carefully to what every single person had to say.

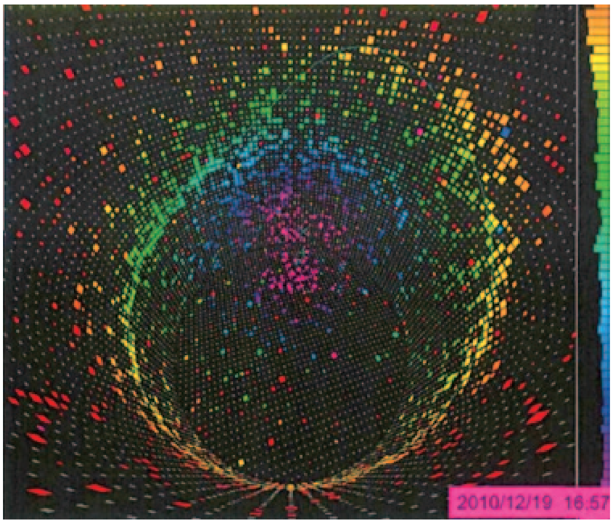
Meetings of External Experts Panel to Verify the Radioactive Material Leak Incident (June 21, July 5, 20, 29, August 9, 22)

In response to the request by the Minister of Education, Culture, Sports, Science and Technology (MEXT), High Energy Accelerator Research Organization (KEK) and Japan Atomic Energy Agency (JAEA) set up the External Experts Panel on June 18. Six experts from a wide range of fields were appointed as members to be asked to review the radioactive material leak at the Hadron Experimental Facility, and to recheck items such as J-PARC's safety management system and procedures to be followed in case of emergency. The meetings were held six times from June to August, then on August 27, the Chairperson of the Panel hand-delivered the inquiry report to the Director General of KEK and the Executive Director of JAEA.

1st External Experts Panel Meeting in Tokai Village

T2K Experiment Reveals Clear Indications of the Existence of the "Electron Neutron Appearance Phenomenon" (July 19)

At a meeting of the European Physical Society held in Stockholm, the International T2K Collaboration announced on July 19, for the first time in the world, the definite existence of the "Electron Neutrino Appearance Phenomenon" in which a muon neutrino transforms during flight into an electron neutrino. To announce this development, a press conference was held in Tokai Village by KEK, Institute for Cosmic Ray, University of Tokyo and J-PARC Center. This achievement was selected as one of the "top 100 science stories in 2013" by the Discover Magazine.



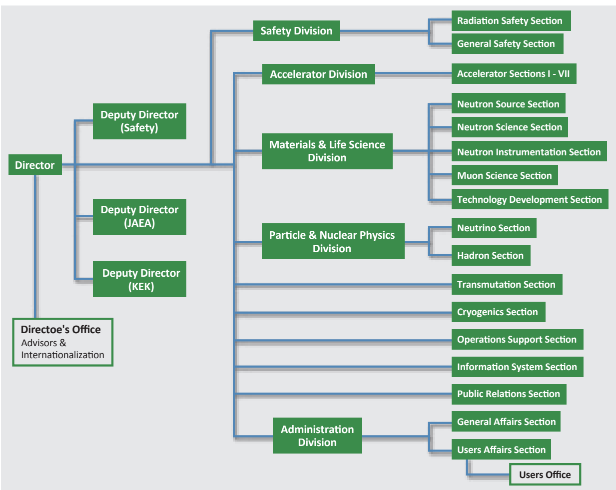
Electron Neutrino Event (Dec.19, 2010)

Submission of Third Incident Report (August 12)

Following the first report on May 31 and the second report on June 18, in accordance with Prevention of Radiation Health Impairment Due to Radioisotope, etc. and its enforcement ordinance, KEK and JAEA submitted the third report to the Nuclear Regulation Authority on August 12. On the same day, the third "incident report" on the same incident was also submitted to Ibaraki Prefecture, Tokai Village, and other relevant local governments based on the agreement on safety and environmental protection near nuclear facilities.

Submission of Report on Improvement Measures for the J-PARC Incident to MEXT (September 26)

Based on the developed improvement measures and other steps to prevent incident recurrence, which had been reviewed by the External Experts Panel, KEK and JAEA submitted a report on measures to be taken to MEXT.



J-PARC Center Organizational Chart as of October 1, 2013

Reorganized J-PARC Center to reinforce safety (October 1)

KEK and JAEA examined and reviewed the safety management system, and on October 1, implemented a reorganization of J-PARC. For the new organization, independency of the Safety Division was enforced, and a new Deputy Director position was created. In addition, two sections, the Neutrino and the Hadron Sections, have been newly established under the Particle and Nuclear Physics Division.

Held Explanatory Meetings for Residents on Efforts after the J-PARC Incident (October 31 – November 2)

Three explanatory meetings for residents were held in Tokai Village to present the efforts, including the results of the investigation of the gold target of the J-PARC Center made after the radioactive material leak incident at the Hadron Experimental Facility. The meetings were attended by a total of 85 people. After the presentation, the executives of the Center were able to respond to many questions from the participants, and hear their valuable comments.

The meetings in Tokai Village on November 2

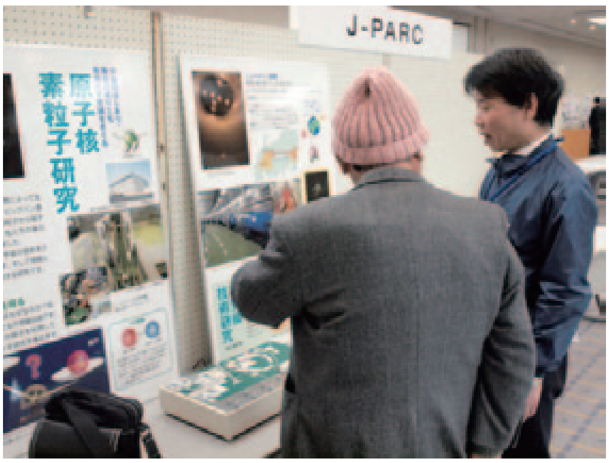
Japan-Australia Neutron Science Workshop: "Sharing Science with Neutrons" (November 5-6)

The attendees of the Japan-Australia bilateral Neutron Science Workshop

The Japan-Australian bilateral Neutron Science Workshop "Sharing Science with Neutrons" was organized by the Australian Academy of Science (AAS) and the Australian Nuclear Science and Technology Organization (ANSTO), and was held with the cooperation of J-PARC at ANSTO's OPAL reactor facility in the suburbs of Sidney. In the workshop, there were reports of the latest information regarding the facilities and equipment of both countries, as well as talks and exchanges of views on state-of-the-art research results in each specialized field. Many researchers participated there from Australian side, and 17 participants from Japanese institutes including J-PARC, JAEA, KEK and CROSS (Comprehensive Research Organization for Science and Society), took part in the event.

SAT Technology Showcase 2014 in Tsukuba (January 24)

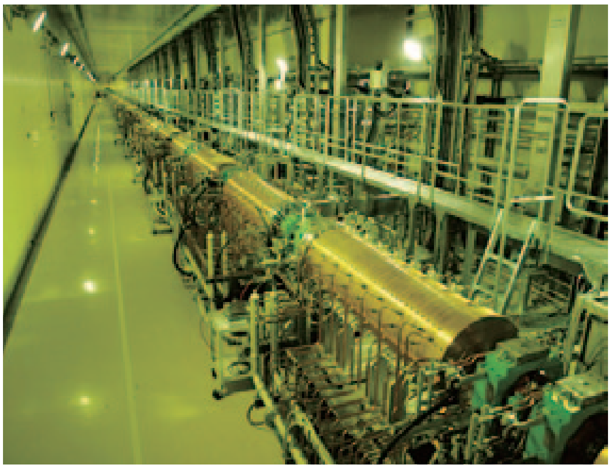
To enhance exchanges among researchers, Science Academy of Tsukuba (SAT) organized SAT Technology Showcase 2014 at Tsukuba International Congress Center. A total of 118 posters were presented there. In the indexing presentation, four presentations from J-PARC were featured. The corporate exhibition showcased facilities, research contents and topics of J-PARC using models, panels and publicity pictures.



J-PARC at the SAT Technology Showcase

Studies to Confirm Performance of the Linac and 3 GeV Synchrotron (Mid-December 2013 to Mid-February 2014)

During the period when J-PARC operation was halted, the accelerator team installed new ACS (Annular Coupled Structure) accelerating cavities to raise the beam energy to the design value of 400 MeV. Performance study using a proton beam began on December 16, 2013. In mid-January, the acceleration of a beam with current of 5 mA was verified, and thereafter acceleration studies were conducted with an increased beam current. From the end of January, performance testing was conducted at the 3 GeV synchrotron. At the test, the capability to accelerate the injected proton beam from 400 MeV to 3 GeV and that to extract the accelerated beam to the Materials and Life Science Experimental Facilty (MLF) were confirmed.



ACS accelerating cavities

Executive Directors of KEK and JAEA gave instructions for safe operation (MLF control room)

Operation for user programs resumed at MLF (February 17)

Since the radioactive material leak incident occurred at the Hadron Experimental Facility in May, 2013, the J-PARC Center reconstructed the safety management system and promoted measures against recurrence of similar incidents. Those actions were reviewed extensively by the External Expert Panel and the walk-through surveys were completed by the authorities of Ibaraki Prefecture and the regional municipalities by the end of 2013. MLF was confirmed to be safe for beam operation and the user programs were resumed on February 17.

Third International School for Strangeness Nuclear Physics 2014 (February 13-19)

The International School for Strangeness Nuclear Physics 2014 was held by the JAEA and other organizations for students and young researchers from both inside and outside of Japan. The first half was held at J-PARC, and the second half was held at Tohoku University. There were about 50 participants. At the opening session, Yujiro Ikeda, Director of the J-PARC Center, provided a basic overview of J-PARC. In a tour of the J-PARC facilities, the participants visited the MLF, the Central Control Room and the Neutrino Experimental Facility.

Participants and staff of the School

Collaborative Symposium of Elements Strategy Initiative and Large Research Institutions 2014 (February 28-March 1)

In 2012, MEXT launched the Elements Strategy Initiative for promoting research in the four domains of magnetic materials, catalyst/battery materials, electronic materials, and structural materials. This is to be achieved by forming research centers, using four large research facilities in Japan, including J-PARC. A meeting bringing together key persons was held at the Kashiwa Campus of the University of Tokyo, and over 200 participants attended. From J-PARC, Masatoshi Arai, Head of the Materials and Life Science Division presented how J-PARC reviewed and strengthened the facility safety system before the neutron and muon experiments resumed on February 17, and introduced the researches at MLF.

Symposium at the University of Tokyo, Kashiwa

Symposium at the Tsukuba International Congress Center

5th MLF Symposium 2014 (March 18-19)

The 5th MLF Symposium was held at the Tsukuba International Congreaa Center. The symposium was held jointly with the 2nd Science Festa of Institute of Materials Structure Science of KEK and the 31st PF Symposium. In total, about 300 posters and 50 talks were presented, and approximately 450 researchers participated.

Visitors (2013)

Venkatarama Venugopal, Vice-president of the Indian Nuclear Society (September 4)

Heri Widyawati, State Ministry of Research and Technology, Indonesia (December 16)

Fan, Mingwu, Professor, Huazhong University of Science & Technology (October 21)

Ai Aoki, member of the House of Representatives (February 7)

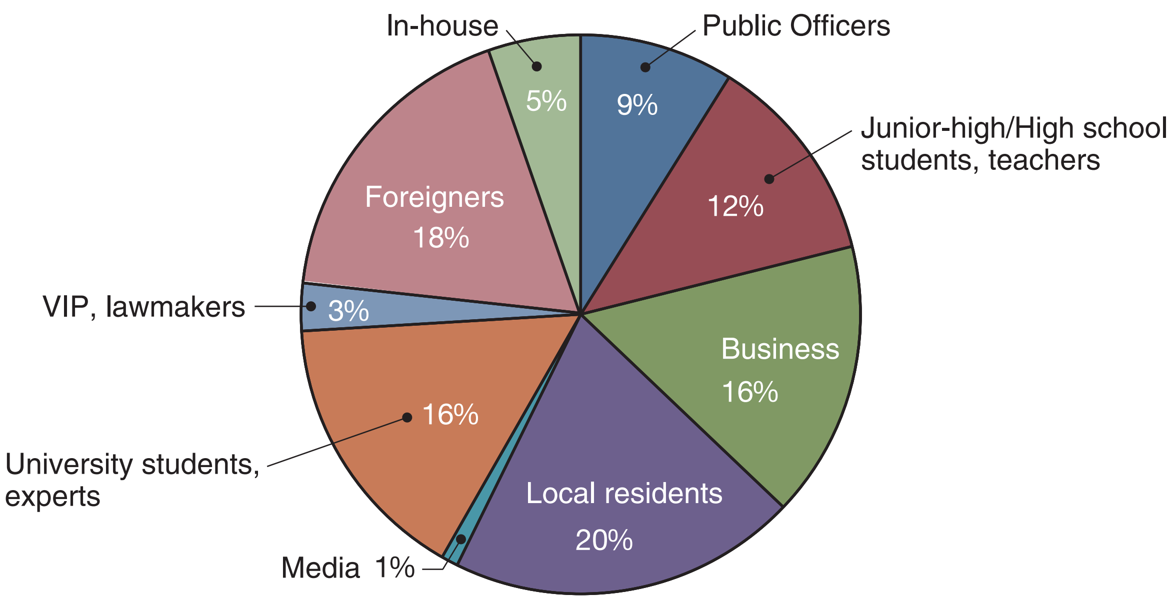
Nigel Rhodes, Detector Group Leader, ISIS, Rutherford Appleton Laboratory (October 24)

Akihisa Nagashima, member of the House of Representatives (February 10)

Akimasa Ishikawa, member of the House of Representatives, **Ryousuke Kouzuki**, member of the House of Councillors, and others (February 17)

There were 2,154 visitors to J-PARC for the period from April, 2013, to the end of March, 2014.

In FY2013, the number of visitors decreased 45% compared to the previous fiscal year since we had to stop receiving visitors due to the Hadron Incident.



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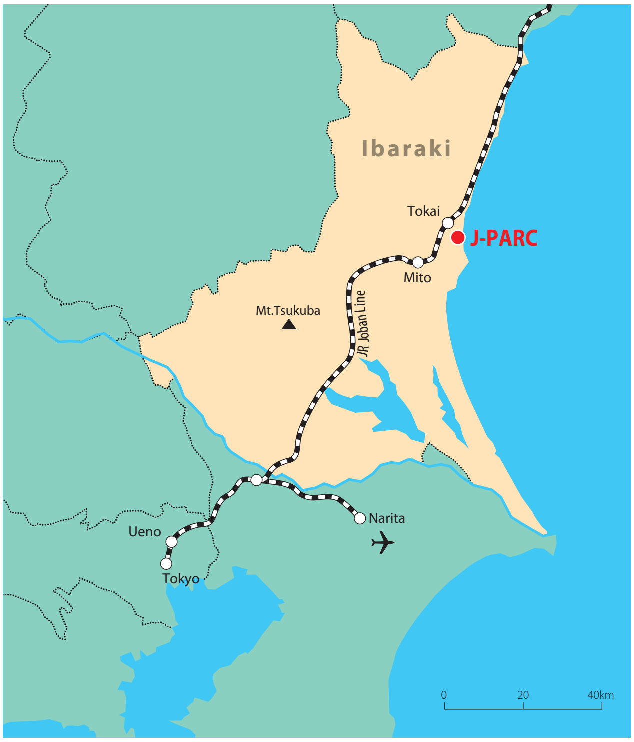

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