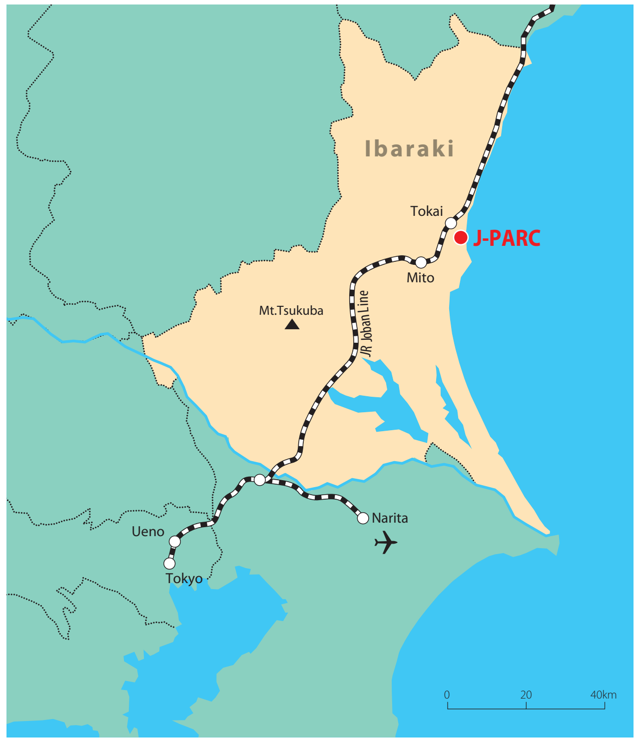
J-PARC

JAPAN PROTON ACCELERATOR RESEARCH COMPLEX

High Energy Accelerator Research Organization (KEK)
Japan Atomic Energy Agency (JAEA)



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J-PARC Center

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ANNUAL REPORT 2014

Vol.1: Highlight

J-PARC Annual Report 2014

Contents

Preface

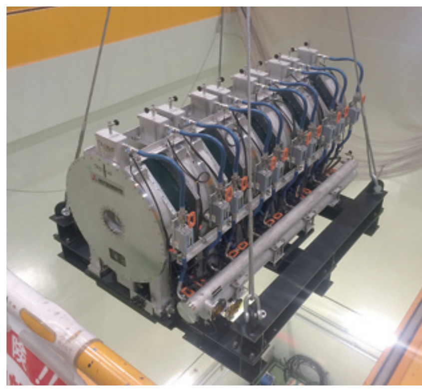
This volume describes the activities of the J-PARC Center from April, 2014, through March, 2015. As it was discussed in the previous volume, the entire organization of J-PARC was focused on the recovery of the facilities from the radioactive material leak incident at the hadron experimental facility (HEF) in May, 2013. Thanks to the deep understanding of the facility operation by many stakeholders and local communities, we were able to restart the Materials and Life Science Facility (MLF) and the Neutrino Experimental Facility in February and May, 2014, respectively. Since then, we have been producing more results out of the data taken before and after the incident. Typical examples of our achievements include: elucidation of the neutrino oscillation phenomenon and investigation of the strong interaction in the area of elementary-particle and nuclear physics research, discovery of new superconductivity phenomena, elucidation of functions in biological materials, and development of new materials in the area of materials and life sciences research. The results are described in this volume. We have high hopes to develop further these lines of research, and contribute to unlocking the mysteries surrounding the origin of the cosmos, matter and life.

Along the course of recovery from the incident, we worked hard to rebuild and strengthen our safety management system, and reformed our organization to ensure even better safety at J-PARC. We will continue with our unflagging efforts to advance and become a research facility with a total commitment to safety. Our activities to improve safety at J-PARC are also described in this volume.

I feel that my mission is to develop J-PARC, this international research center built up by my great predecessors, into a research facility which can contribute further to the progress of humankind. I plan to achieve this by promoting collaboration with research institutions inside and outside of Japan, expanding the facility use by various industries, promoting interdisciplinary research, which makes the most of J-PARC's unique characteristics as a multi-purpose facility, and broadly sharing the obtained research results with the public.

As we move forward, I would like to ask for your understanding, guidance and encouragement.

Naohito SAITO
Director of the J-PARC Center



Accelerators

Overview

After a 9-month shutdown due to the radioactive material leak incident in the hadron experimental facility, the user operation of the Materials and Life science experimental Facility (MLF) was resumed on February 17, 2014, with a beam intensity of 300 kW. For the Main Ring Synchrotron (MR), the 3-GeV injection beam from the Rapid-Cycling Synchrotron (RCS) was accelerated to 30 GeV and extracted by the fast extraction system to the abort beam dump on March 30, 2014, for the first time after the incident. After high power beam tuning, the beam delivery to the Tokai-to-Kamioka (T2K) experiment restarted on May 16. The delivered beam intensity before the summer of 2014 was 210-240 kW.

During the summer shutdown period, the replacement of the front-end part to increase the peak current from 30 mA to 50 mA was one of the most important improvements in the linac. The peak current of 50 mA is necessary to achieve the design beam intensities, 1 MW for the RCS and 750 kW for the MR. The new front-end system has an rf (radio-frequency)-driven ion source and RFQ optimized for accelerating the 50 mA beam. After a continuous one-month test run with 50 mA at the output of the RFQ in a test bench, the new front-end system was installed in the linac tunnel in August, 2014. The beam operation of the linac started on September 29, and a 50-mA beam acceleration was reached on October 15.

After the maintenance, the user operation for the T2K experiment and the MLF users was restarted on November 2 and 4, respectively. In November and December the delivered beam power in the operation for the T2K experiment was 220 - 260 kW and that for the MLF users 300 kW.

High power beam study of the RCS was performed in October, 2014, and during a short pause of the user operation in December, 2014 and January, 2015. In October, 2014, the RCS successfully demonstrated beam acceleration and extraction with an intensity of up to 773 kW-equivalent (6.44×10^{13} particles per pulse) in a single-shot operation mode. However, beam acceleration with an intensity larger than 800-kW-equivalent could not be achieved due to insufficient current capacity of the anode power supplies for the rf power amplifiers. In the study of December and January, the resonance frequencies of all twelve rf cavities were shifted from 1.7 MHz to 2.1 MHz to reduce the required current in the anode power supplies. As a result, on January 10 the RCS successfully accelerated and extracted a 1.01-MW-equivalent beam (8.41×10^{13}) in single shot mode. Although more studies are required to reduce the beam loss and it is also necessary to reinforce the anode power supplies of the rf power amplifiers, the achievement of 1-MW-equivalent beam acceleration is an important milestone for the J-PARC accelerator.

An incident with a burning transformer of the septum magnet power supply occurred in the MLF muon facility on January 16, 2015. All J-PARC facilities were shut down for a month due to the incident. The accelerators resumed beam delivery to the T2K experiment on February 25, 2015, and to the neutron users of the MLF on February 26, 2015. Before the user operation for the T2K experiment was restarted, beam studies for suppression of the transverse beam instability and correction of the betatron resonances were performed in the MR. To ensure beam instability suppression, the betatron tune, parameters of two types of bunch feedback systems, patterns of rf voltage and sextupole magnet field were optimized in the timings of beam injection and acceleration. To correct the resonance, parameters of four skew-quadrupole magnets were optimized for correction of the linear coupling resonance. As a result of the study, the beam loss of the MR was reduced and it became possible to increase the delivered beam intensity for users from 260 kW to 320 kW. The MR continued stable beam operation with 320 kW beam power for the T2K experiment until the end of March, 2015. On March 26, the delivered number of protons to the neutrino target since April, 2010, when physics data taking began, exceeded 1×10^{21}. For the MLF users, the RCS increased beam power from 300 kW to 400 kW on March 10, 2015.

Figure 1 shows statistics of the accelerator operation in Japanese Fiscal Year (JFY) 2014. The total operation time was 5495 hours. The availability of the user operation was 85.6% for the MLF and 82.8% for the T2K experiment excluding the one-month shutdown due to the fire incident. Figure 2 shows the causes of beam trips and down time in JFY2014. The beam stops exceeding 100 hours were due to troubles in the high voltage transformer of the klystron power supply of the linac and the bending magnet power supply of the RCS. Diode modules in the high voltage transformer of the klystron power supply were damaged by voltage surge. We took some countermeasures against the voltage surge in the 2014 summer shutdown period. Since then, we did not encounter the same problems. The problem with the RCS magnet power supply was caused by breakdown of choke transformer's oil circulating pump. The broken pump was replaced with a spare one and the user operation restarted after a week.

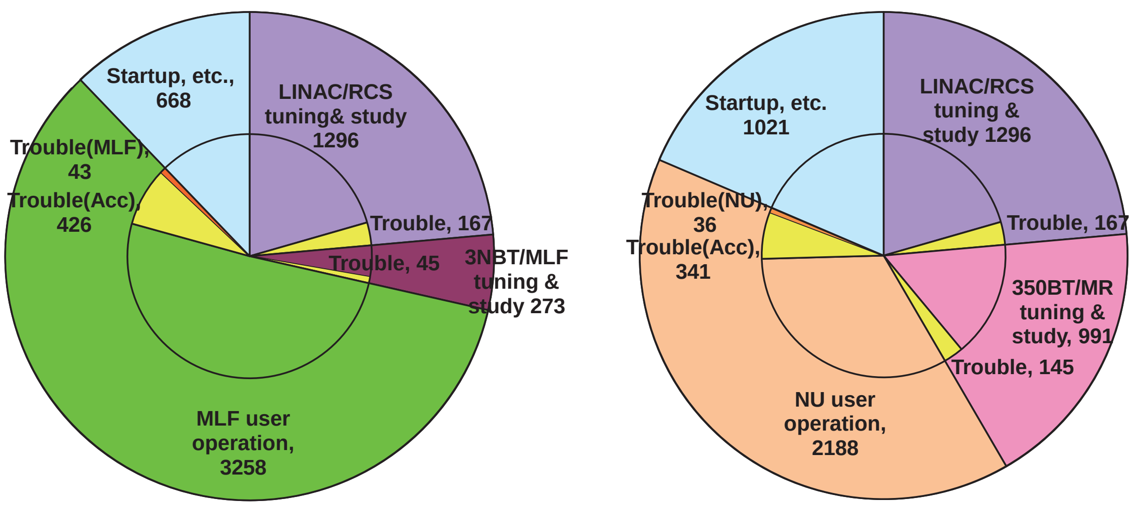


Fig. 1. Statistics of MLF and neutrino user operation in JFY2014.

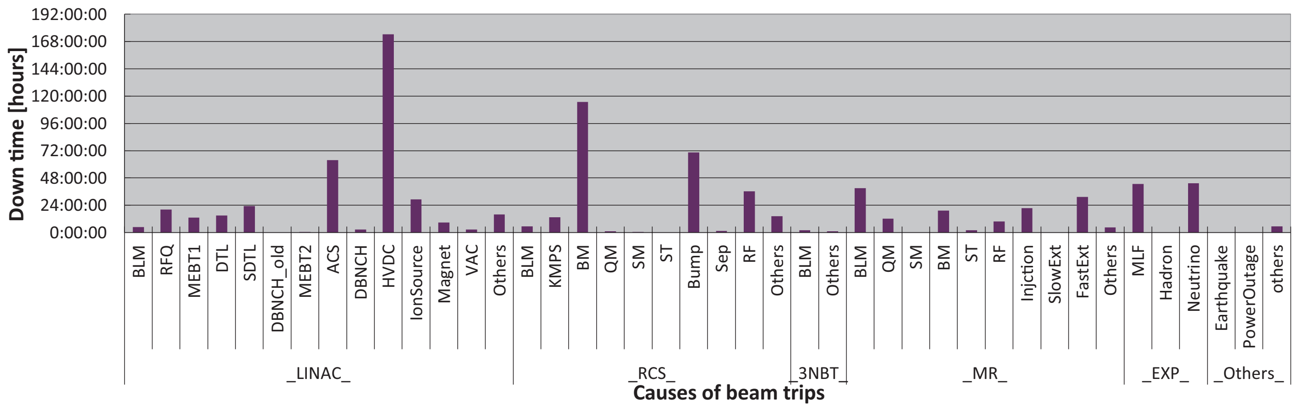


Fig. 2. Causes of beam trips and down time.

LINAC

To realize the nominal beam power of 1 MW at the RCS and 0.75 MW at the MR, the linac peak beam current had to increase from 30 to 50 mA. In order to facilitate the upgrade, we developed a new front-end system consisting of a negative hydrogen ion source and an RFQ for 50 mA operation. We developed a cesiated RF-driven ion source using an internal RF-antenna built at the Spallation Neutron Source (SNS) at Oak Ridge National Laboratory (ORNL) (Fig. 3). It successfully produced a peak beam current of more than 60 mA with a duty factor of more than 1.25% stably. A new RFQ was designed and fabricated (Fig. 4). There is a significant structural difference between the new and the previous RFQ. The RF cavity of the previous RFQ was installed in a large vacuum vessel. Because the surface area of this type is very large, it was difficult to obtain good vacuum quality. Therefore, a vacuum-tight cavity structure was adopted for the new RFQ.

After a one-month continuous test run with 50 mA at the output of the RFQ in the test stand, the front-end system was installed in the linac tunnel in August, 2014. In order to chop the 50 mA beam for making the intermediate time structure of the linac beam pulse, the RF chopper cavity was also replaced with a newly fabricated one with a larger aperture and longer gap length between electrodes to decrease unexpected beam loss in the cavity (Fig. 5). Two new scrapers were also installed to absorb the higher power of the deflected beam by the chopper cavity.

The beam operation of the linac was resumed on September 29. The ion source has been successfully providing the required beam to the accelerator with almost no serious problem, except for the RF antenna failure caused by the excess cesium due to a misoperation of

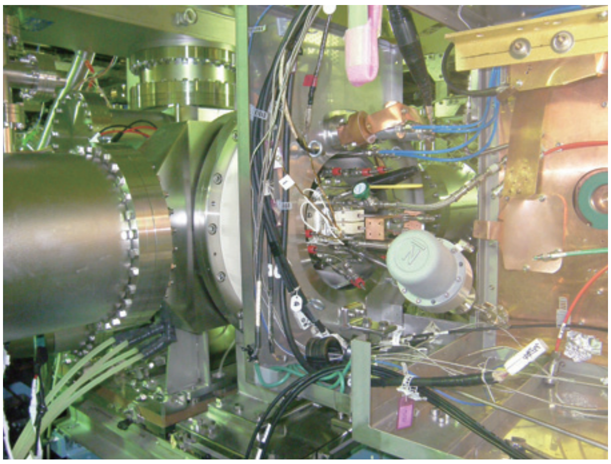


Fig. 3. Cesiated RF-driven negative hydrogen ion source.

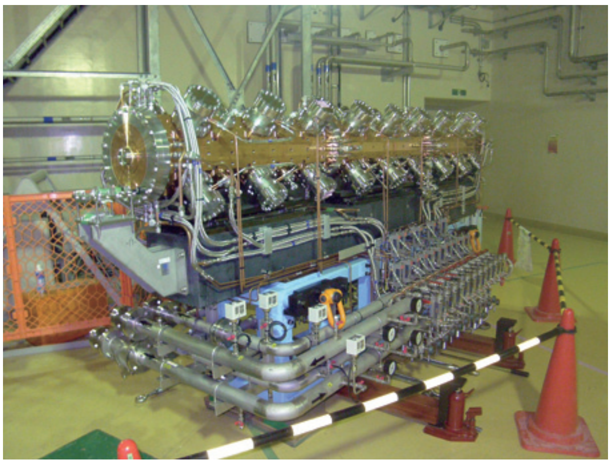


Fig. 4. RFQ for 50 mA operation.

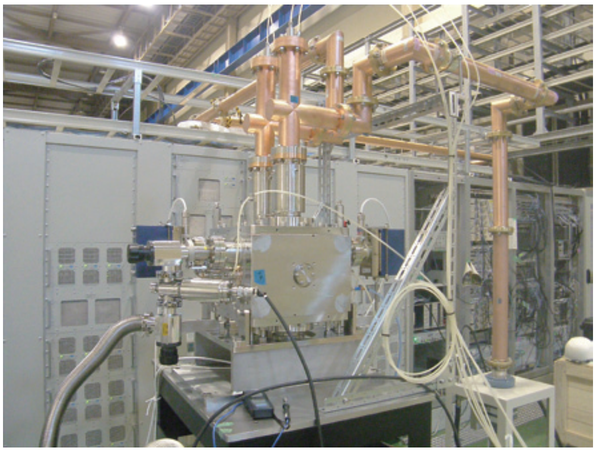


Fig. 5. New chopper cavity for 50 mA operation.

the cesium injection system once. We observe the RFQ RF-trip about 10 times daily during the user operation, which decreases the beam availability by about 1%. We attempt to reduce the trip rate by testing certain measures, like adding vacuum pumps to improve the vacuum in the cavity.

We challenged the first 50 mA beam acceleration test in the restart commissioning after the summer shutdown. After careful tunings, which took two weeks, we successfully demonstrated 50 mA beam acceleration to 400 MeV on October 15 (Fig. 6). The beam was transported to a dump for beam study just upstream of RCS without any reduction of the beam transmission quality. That was an important milestone toward a user operation with design beam power. We observed, however, beam loss at several spots along the beam line. Further beam study is needed to ensure a stable operation at design beam power. For the acceleration of the 50 mA beam, we introduced a new method for verification of cavity tuning. Since the increase of beam power results in stricter demands for preventing beam loss, the verification of operation points is essential to avoid unnecessary beam loss. The effectiveness of this method has already been proven. The RF of one DTL cavity was found to be 8% lower than the designed parameters.

The ACS (Annular-ring Coupled Structure) cavities, installed to increase the linac beam energy to 400 MeV

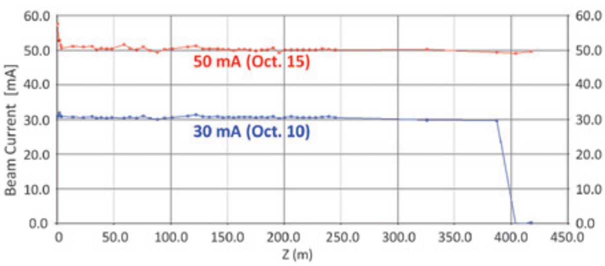


Fig. 6. Beam current along the linac beam line.

in the summer of 2013, are running stably. The vacuum pressure and the RF trip rate have been reduced through the beam operation. During this operation period, the aluminum chain clamp used in the ACS beam line suddenly broke down, which caused vacuum leakage problem (Fig. 7). To prevent the same from happening, we replaced all aluminum chain clamps in the ACS beam line with stainless steel ones. After the replacement, no vacuum problems were observed.

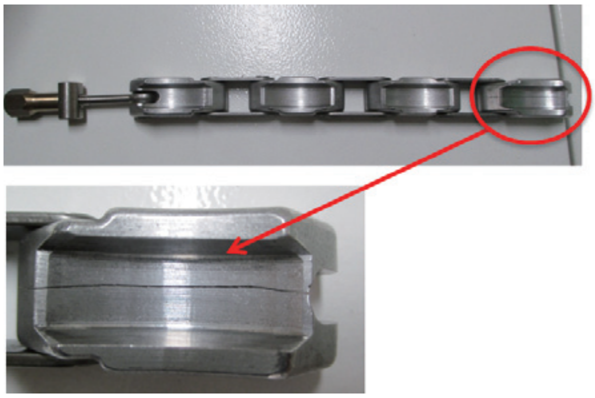


Fig. 7. Broken chain clamp (crack in the hooking part of the chain).

On June 30, 2014, a HVTR (high voltage transformer) of klystron power supply #5 broke down due to failure of capacitors in the HVTR assemblies. The same troubles occurred at the HVTR in the power supply of #1 and #2 in 2012 and 2013, respectively. The surface observation of the broken capacitors showed the failure was due to overvoltage to the capacitor. We refurbished the HVTR by replacing the old capacitor with a new one with better high voltage properties. After applying these countermeasures, we did not encounter any more HVTR problems in this period.

At some SDTL cavities, the multipactor region, where the VSWR become very high, has been observed after the earthquake in 2011. The region of the SDTL #05B spread significantly with the operation time. We applied various countermeasures (improvement of the vacuum condition, cavity baking, and so on), however, they did not provide sufficient improvement. Recently, we found that the upper boundary of the region can be shifted with detune condition, which is caused by a changing tuner position (Fig. 8). At present, SDTL #05B is operated with detune condition of - 1 kHz. We expect the upper boundary not to exceed the operation power condition for a few years with this condition. To solve this problem drastically, we will try some ideas and continue the simulation with various tuner parameters.

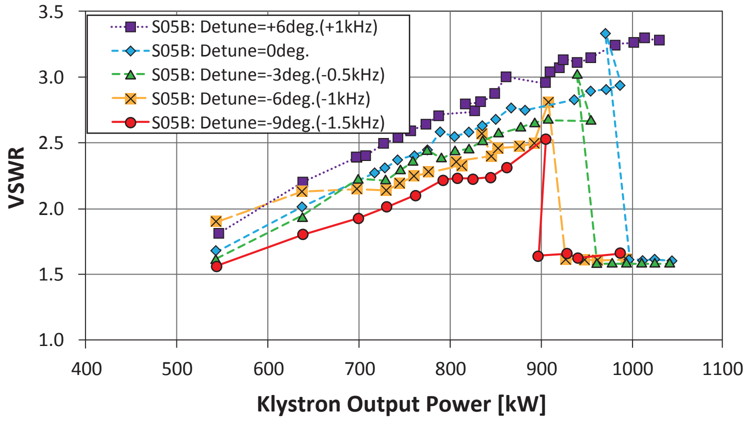


Fig. 8. VSWR of SDTL #5B as a function of klystron output power for various detune condition.

RCS

The beam power of the routine operation of the J-PARC RCS increased gradually for the MLF user operation, and a 400-kW user operation has been performed stably from March 10, 2015. Beam studies were also performed to demonstrate the capability of the RCS to operate at powers in excess of 1 MW. The study produced a beam intensity of 8.41×10^{13} protons within a short time, an intensity equivalent to a 1.01-MW operation, on January 10, 2015.

OPERATION FOR THE USER PROGRAM

The RCS could deliver beam with power of 300 kW to both the MLF and the MR for their user operation with an average availability of more than 95%. The duration of the summer maintenance period is usually three months (from July to September), but last summer it was four months to provide time for replacement of the front-end (ion source and RFQ) of LINAC. Beam studies were performed in spare moments from the routine operation in the end of June, end of December, and mid-January. A stable user operation for the MLF and MR could be continued with 300 kW beam power. The beam power had been limited 300 kW for the MLF due to government permission of radiation safety, but it became possible to increase the beam power to 1 MW for the routine operation at the RCS after December 2014 because we obtained the government permission. Beam power increased gradually for the MLF user operation and beam power of 400 kW was achieved on March 10.

The availability of the RCS was not that good before the summer maintenance. There were mainly two causes of machine malfunction, one was the failure of an oil cooling pump in the bending magnet choke transformer that caused down time of about 110 hours; the other was a newly-installed power supply for injection bump magnets. The total down time was about 171 hours during one year, and almost 95% of it occurred before the summer maintenance. After the restart of the user operation in November, the RCS could continue to maintain a stable user operation.

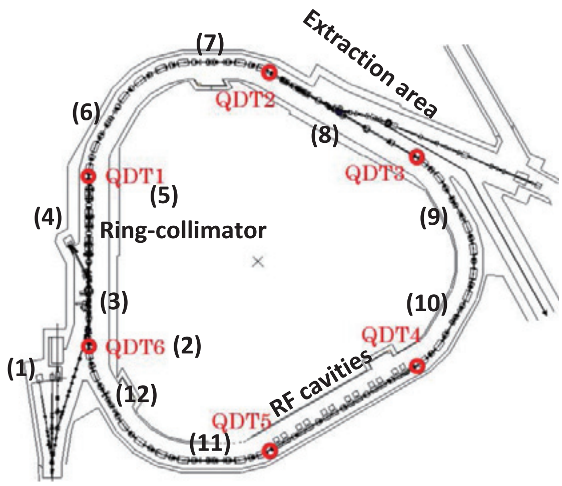


Fig. 9. Residual dose measurement points and new correction magnets installation points at RCS.
(1) 100-degree dump, (2) injection branch, (3) 1st charge exchange foil, (4) H0 dump, (5) entrance of 1st arc at downstream of the ring collimator, (6) Dispersion peak point, (7) Dispersion peak point, (8) Extraction septum magnet #3, (9) Dispersion peak point, (10) Dispersion peak point, (11) Dispersion peak point, (12) Dispersion peak point , and QDT1-6 : new correction magnets.

This year the residual dose distributions of the RCS were measured several times. The residual dose measurement points are shown in Fig. 9. The points shown in this figure were registered at a radiation level of more than 10 μSv/h. These values, typically measured on July 1, 2014, and April 1, 2015, were summarized in table 1. After three-week user operation with beam power of 300 kW, a two-day high-intensity beam study was conducted on July 1, 2014, and the residual dose was measured four hours after the beam stopped. Consequently, after a two-week user operation with beam power of 400 kW performed from March 18 to April 1, 2015, the residual dose was measured four hours after stopping the beam. All values described in table 1 were residual dose measured on contact with each device. The residual dose of beam dump (measurement point (1)) was very big in spite of the temporary use. The use of a high residual material (nickel with thickness of 10 mm) for the vacuum window was the reason for such a high activation. This window was replaced with low activation material (thin titanium with thickness of 0.3 mm). The residual dose of the vacuum chamber of the 1st charge exchange foil (measurement point (3)) was huge due to neutrons produced by interaction between the foil and the injection/circulation particles. Since this activation would limit the beam power of the RCS, the reduction of the number of particles passing through the foil becomes a key issue.

Table 1. Residual dose measured on 1st July 2014 and 1st April 2015.

Measurement point	Residual dose on contact [μSv/h]	
	1st July 2014	1st April 2015
(1)	8000	Not measured
(2)	2200	6000
(3)	3300	15000
(4)	900	2100
(5)	170	1100
(6)	220	110
(7)	60	300
(8)	<10	40
(9)	<10	150
(10)	<10	80
(11)	<10	70
(12)	<10	110

MAINTENANCE AND IMPROVEMENTS

Several kinds of maintenance and improvements were performed during the maintenance period. The details of the typical advancement and exposure dose at that time are described in this section.

1) Improvement of the beam transport line

There was enormous residual dose near the beam dump installed in the beam transport line, now used only for the linac beam tuning, as described in the previous section. Since this dump will be used not only for linac beam tuning but also for shaping the injection beam from the linac to the RCS, we improved the beam transport line near the beam dump, as shown in Fig. 10. The thick vacuum window was replaced with a new one made by thin titanium covered with radiation shield. A new rail was installed for moving and transporting this vacuum window for maintenance. Current transformer and wire scan monitor were installed to measure the beam current and shape with high resolution.

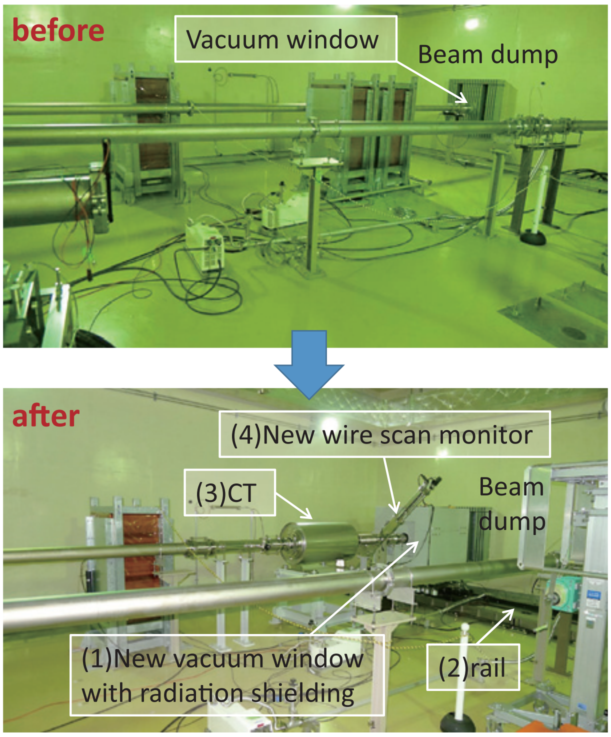


Fig. 10. Pictures of the beam transport line near the beam dump (we call it a 100-deg beam dump, shown in Fig. 9(1)) before and after the improvements in the 2014 summer shutdown.

2) Installation of correction quadrupole magnets

Reducing the number of particles which pass through the foil, as described in the previous section, is a key issue. The large transverse painting is one of the possible methods to fix the issue. It is difficult to perform the large transverse painting at present, the reason why the beta function beating excites various random betatron resonances through a distortion of the lattice super periodicity, which makes the extra beam loss. To correct the beta function beating caused by the edge focus of the injection bump magnets, six correction quadrupole magnets were newly installed in the tunnel.

3) Exposure dose during maintenance

The exposure dose during the summer maintenance in 2014 is summarized in table 2. An exposure dose of more than 0.01 mSv was detected in 53 workers. The corrective dose was 3.7 mSv, and the average exposure dose was 0.07 mSv. The maximum exposure dose was 0.31 mSv due to vacuum leakage test in the injection area. Our radiation protection and control for each worker was found to work well and the RCS tunnel was clean.

Table 2. Summary of the exposure dose during the summer maintenance in 2014.

Exposure dose [mSv]	Number of workers
0.01-0.05	31
0.06-0.1	10
0.11-0.2	8
>0.21	4

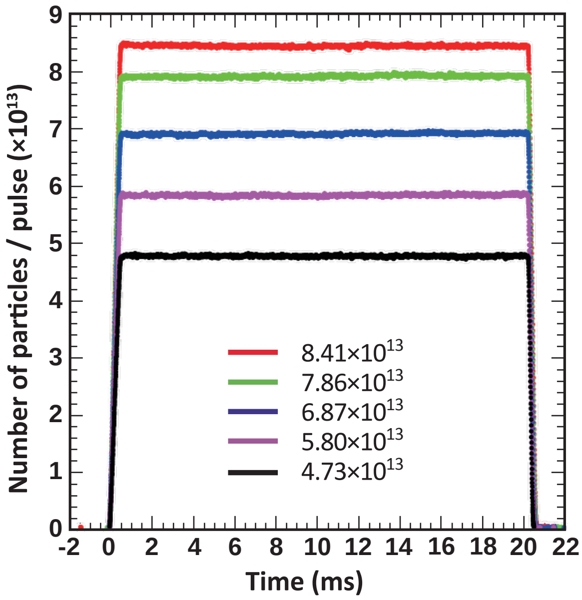


Fig. 11. Circulating beam intensity over 20 ms from injection to extraction measured by a current transformer (DCCT). The horizontal axis shows time and the vertical axis is the number of particles per pulse measured by the DCCT.

HIGH POWER BEAM STUDY

Beam studies were also performed to demonstrate the capability of the RCS to operate at powers in excess of 1 MW. On January 10, 2015, the study produced a beam intensity of 8.41×10^{13} protons within a short time, an intensity equivalent to a 1.01-MW operation. Figure 11 shows the circulating beam intensity over 20 ms from injection to extraction measured by current transformer. The 1 MW operation will require modification of the RF anode power supplies this summer. The 1 MW operation has been enabled by the linac upgrade to 400 MeV and the front-end upgrade to 50 mA. Studies were performed to demonstrate the capability of the RCS to operate at powers in excess of 1 MW. The study results are very promising and suggest that producing 1 MW is feasible, even without full amelioration of the RF issues.

SUMMARY

The beam power of the routine operation of the RCS increased gradually for the MLF user operation, with beam power of 400 kW user operation being utilized. The residual dose distributions of the RCS were measured several times after a routine operation. Beam studies were also performed to demonstrate the capability of the RCS to operate at powers in excess of 1 MW.

As a result of measurement of the residual dose after routine operation and high power beam studies, it was concluded that the requirements for a 1-MW stable routine operation are as follows:

(1) Modification of the RF anode power supplies to reduce longitudinal beam losses,

(2) Reduction of the number of particles passing through the 1st charge exchange foil to reduce the residual dose of the vacuum chamber of the foil.

We have to continue solving those issues and the beam power will be increased gradually with the goal to reach the design power of 1 MW.

MR

Operation status

The 30-GeV beam extracted from MR was fully used for the neutrino experiment in JFY2014 because the hadron beam line was still under reconstruction. Figure 12 shows the history of the MR beam power. Until the end of December, 2013, the 265 kW beam was accelerated stably for the practical operation. In January, 2014, the beam power of MR has reached approximately 310 kW on the neutrino production target. In March, 2014, the beam power for the practical operation increased to 330 kW. It was a high point for MR in JFY2014.

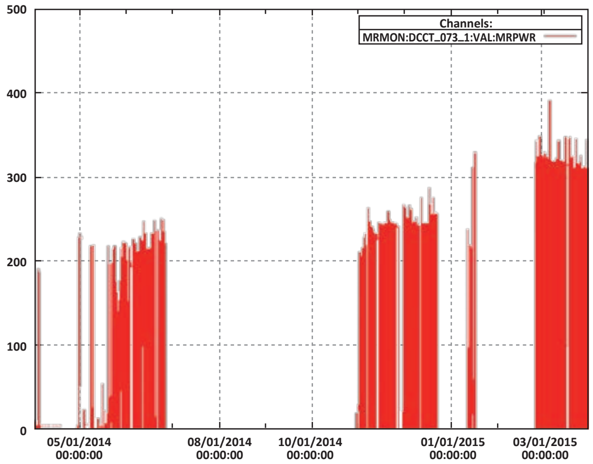


Fig. 12. History of MR beam power.
Abscissa: Date (Apr.1 '14 ~ Mar.31 '15)
Ordinate: Beam power (0~500 kW).

Future plans

The design beam power of MR is 750 kW for the neutrino experiment. It is expected to achieve a beam power of 750 kW by reducing the beam repetition period from 2.48 s to 1.3 s or less. Therefore, many pieces of the MR equipment must be modified or replaced to comply with the shorter repetition period of 1.3 s, as follows: (1) The power supply of the main magnets; (2) The RF cavity; (3) The injection magnet and its power supply; (4) The fast extraction magnets and their power supplies; (5) The injection collimators; (6) Beam ducts, etc. The production of almost all equipment, except for (1) magnet power supply, is in progress.

Furthermore, it has also been planned to increase the injection energy in the future in order to reduce the beam loss at the beam injection period.

Beam Injection system

The beam injection system of MR consists of injection septum magnets, an injection kicker and collimators. The modification of each of the components has started.

Injection septum magnet

MR has two injection septum magnets. A new first injection septum magnet with its own power supply has been developed because the present septum magnet cannot accept beams not only with higher repetition rate but also with higher energy. The power supply has been assembled and tested. However, it was found out that the vibration amplitude of the new septum magnet was bigger than the acceptable value. Thus, the magnet is being repaired. The system will be installed in the beam line in the summer shutdown period of 2015.

Injection kicker magnet

One of the biggest issues of MR is the pulse shape of the current for the injection kicker magnet, as shown in Figure 13. The following issues have been encountered:

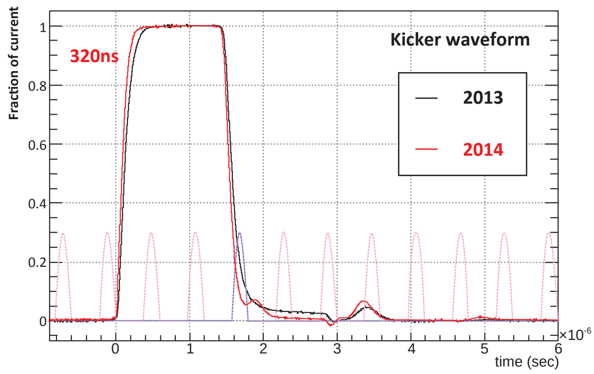


Fig. 13. History of the MR beam power

(1) There is a small peak in the tail of the pulse. It kicks the circulating beam previously injected.
(2) The pulse rise time (320 ns) is not fast enough. Although it is possible to speed up the rise time (200 ns), one more peak appears in the tail.

In order to compensate the peaks of the tail, a small correction kicker magnet was considered. As the correction magnet is being developed, it will be installed in the summer of 2015.

Injection collimator

Two new injection collimators were installed in the beam line in the summer of 2013. The new collimators increased the acceptable beam loss from 2 kW to 3.5 kW which is required for the operation with the design beam power of 750 kW. These have beam ducts made of titanium instead of ducts made of stainless steel because the residual radiation level of the titanium duct is smaller than that made from stainless steel. However, vacuum leakage occurred in the welding region between the duct for the collimator and the bellows. Thus, the new collimators and the leaky duct were removed and the layout of the collimators was restored to the original one, as shown in Fig.14. The reason for the vacuum leakage is now under investigation.

(a) Layout of the collimators (2011, 2014)

(b) Layout of the collimators (2013)

Fig. 14. Layout of the injection collimators.

Alignment

The magnet alignment was confirmed during the summer shutdown period of 2014. The results are summarized in Fig.15. A previous measurement was conducted in 2012. The result did not show significant differences. Thus, re-alignment of the magnet was not required.

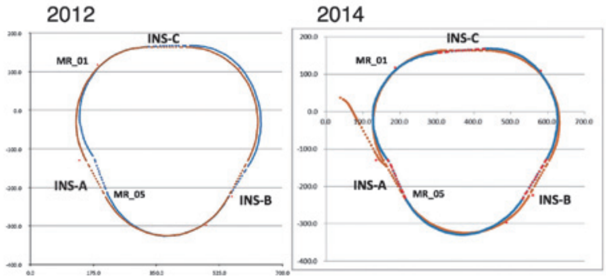


Fig. 15. Result of magnet survey in the horizontal plane Blue & red dots are measured data. Orange dots are design position.

RF cavity

The RF cavities, which accelerate the proton beam from 3 to 30 GeV, contain a core made of a magnetic alloy named Fine-Met FT3M. In order to increase the MR repetition rate, the accelerating voltage of the RF cavities must be approximately doubled because the accelerating period is reduced by half. The doubled accelerating voltage is achievable by the lower loss core made of Fine-Met FT3L which has been recently developed.

The first cavity with FT3L core has been installed in the tunnel as shown in Fig.16. It has been used for the practical operation without problems. Furthermore, the mass production of the new cavity is ongoing. Four more cavities with FT3L core will be installed in the tunnel in the summer of 2015.

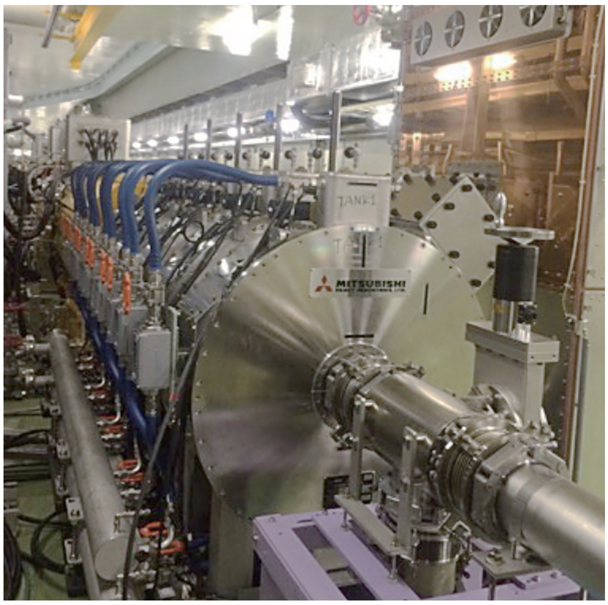
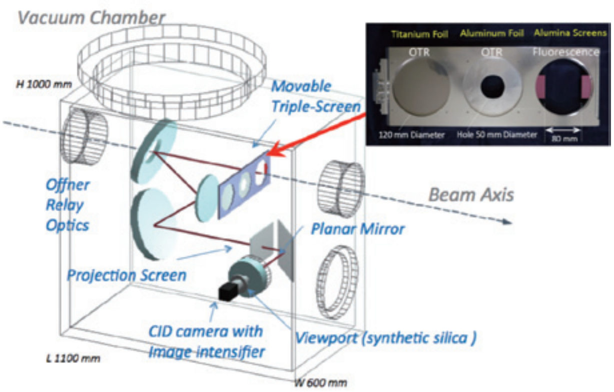


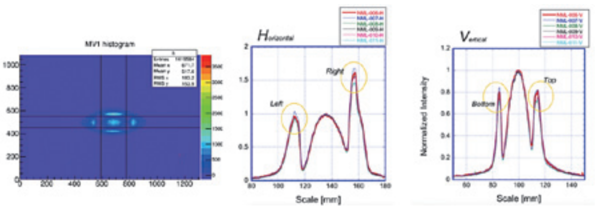
Fig. 16. Installed new FT3L cavity with 5 gaps.

Beam monitor

Topic of the monitor development is the installation of the Optical Transition Radiation (OTR) monitor in the beam line from RCS to MR. The monitor has not only OTR but also a fluorescence sheet for the beam hallo observation. The combination of both increases the dynamic range of the monitor to approximately 40dB. The schematic structure and test results of the monitor are shown in Fig.17. It is the very powerful tool to deal with the hallo of the beam coming from the RCS.



(a) Schematic view of the monitor



(b) Example of the output signal

Fig. 17. OTR monitor
(a) Inside structure of the monitor
(b) left: Observed profile, middle: Horizontal profile, right: Vertical profile.

Beam commissioning

As mentioned before, MR succeeded to accelerate a beam with power of over 300 kW. It was achieved by a number of efforts, as follows: (1) beta modulation correction with quadrupole trim coils, (2) third order resonance correction with sextupole trim coils, (3) a second harmonic RF cavity. These efforts have been applied at the original operation point (22.2, 20.5). In the view point of the beam loss reduction, new operating point around (21.4, 21.4) was studied very precisely. The study of new operating point would continue in JFY2015 because the new operation point is the candidate of the operation for the 750-kW beam.

Preventive measures for the hadron incident

On May 23, 2013, 2×10^{13} protons were extracted on the hadron target made of gold in 5 ms period. (In the normal operation 2×10^{13} protons are slowly extracted over 2 s.) It was caused by malfunction of the EQ-magnet system of the slow extraction mode for the hadron experiment. After the incident, counter measures to prevent the short-pulse extraction were proposed. In order to resume the slow extraction mode, the measures must be completed. Table 3 shows the results of the applied preventive measures. The following of the proposed measures will be sufficient to prevent the occurrence of phenomena that can extract a beam in a short period of time.

Table. 3. Preventive measures for short-pulse extraction

	System in May 2013	Preventive measures
Anomalous current deviation in the EQ-PS & feedback system	Only warning	Stop the beam operation & shutdown the power supply
Current limit	340A (Max. of the Ps)	< 120mA (< Max. for the user operation)
Response time of shutdown when an abnormal occurrence is detected	> 6ms	< 1ms

Summary

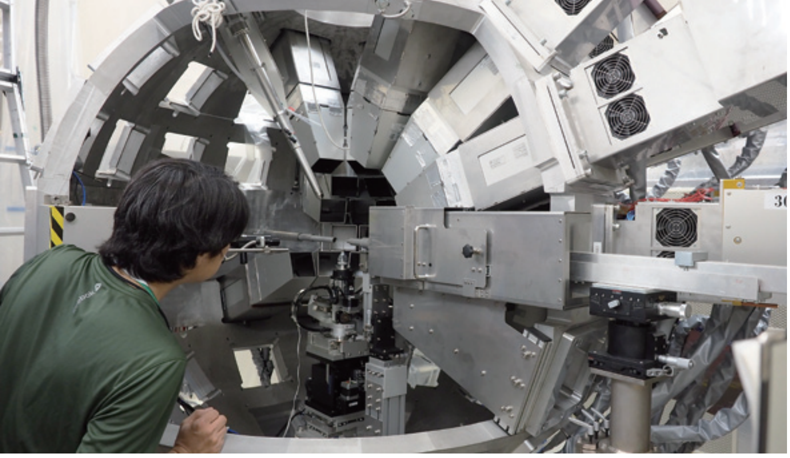
The main topics of the MR in JFY2014 are summarized below:

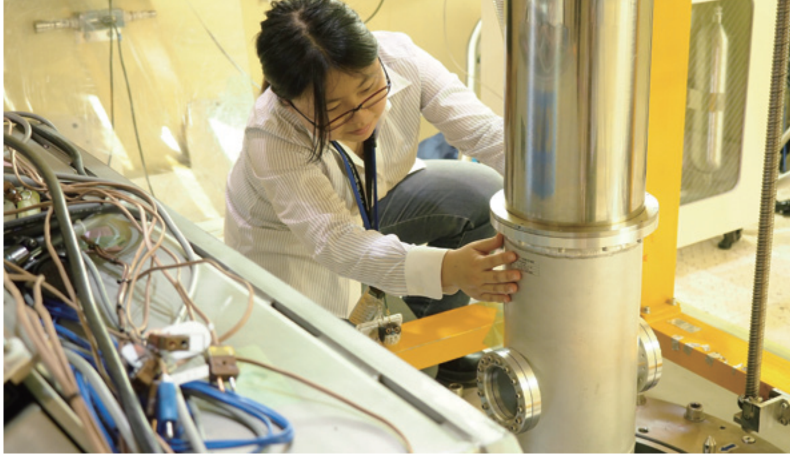
(1) MR delivers a stable 265-kW beam for users in 2014. The beam power increased to more than 300 kw from January 2014.

(2) The new collimator system was removed due to vacuum leakage of the titanium ducts.

(3) The first cavity with FT3L cores has been installed and used successfully in the ring.

(4) Counter measures to prevent the beam extraction in short period of time have been completed.





Materials and Life Science Experimental Facility

Overview

After the incident at the Hadron Facility on May 23^{rd}, 2013, J-PARC/MLF resumed the beam operation for the user program on February 17^{th}, 2014. In JFY2014, MLF maintained a steady 300-kW operation with gas micro-bubbles injection in the neutron target. The scheduled beam time in JFY2014 was 166 days with availability of 69%. The number of proposals was 780, and the number of unique users was 895.

In JFY2014, 18 instruments were under operation for neutron science. The construction of BL06 (VIN ROSE), BL22 (RADEN) and BL23 (POLANO) at the neutron facility advanced, and VIN ROSE and RADEN reached the commissioning phase. As for the muon beam lines, the D1 and D2 instruments were dedicated to the user programs and U-line and S-line were under commissioning.

We had a fire accident at the muon area on January 16^{th}, 2015, and the beam stopped until February 25^{th}, 2015. We decided to carry the user experiments canceled due to the accident over to 2015A. After the accident, we reconsidered our protocols related to safety issues. The operation manuals had been reviewed. We also introduced a new working standard protocol. According to the new protocol, all activities conducted at MLF will be checked by each section. Any suspected activities found by each section will be evaluated by MLF safety reviewing, which will be held at the regular MLF meetings.

Neutron Source

On January 12, 2015, for the first time ever proton beam pulses were accelerated to reach a power equivalent of 1 MW in the 3-GeV Rapid Cycling Synchrotron and successfully delivered to the neutron production mercury target through the 3-GeV proton beam transport facility. It was an exciting moment for the staff of the neutron source section and an important milestone for J-PARC towards steady operation with a 1-MW beam.

As for the user operation, until the summer shutdown period the neutron production mercury target has been operated steadily at a beam power of 300 kW with mitigating pressure waves successfully induced in it thanks to the gas micro-bubbles injection. The accumulated beam power on the target reached 2050 MWh at the end of June, 2015.

During the summer shutdown period, the mercury vessel was replaced with an advanced one with double-wall structure and a narrow width of 2 mm at the target front. Figure 1 shows the conceptual view of the double-wall structure. Part of the mercury flow is directed into the narrow channel with velocity of 4 m/s without passing through the bubbler, a gas micro-bubbles generator. The rest of the flow passes through the bubbler and advances to the inner wall with micro-bubbles. This structure enhances the cooling performance of the inner wall, making it possible to increase the wall thickness from 3 to 5 mm. This prolongs the life time of the target front preventing cavitation damage from operations with a higher beam power.

It was the second replacement operation since November, 2011, in the history of JSNS. We cut out a disk-shaped specimen from the target vessel front with a remote-handling cutting device. Unfortunately, the specimen fell into the target vessel. However, as shown in Fig.2, we could observe the mercury flow facing surface of the specimen and did not register any visible damages there. This proved the mitigation of mitigating pressure waves with the gas micro-bubbles injection. Based on this promising result, we upgraded the operational proton beam power from 300 to 400 kW from March, 2015.

An issue, sensitive from environmental point of view, emerged during the target vessel replacement operation that a certain amount of tritium could be released at the time when surrounding air came into the target vessel when it was removed from target trolley. The major mechanism of tritium release is the isotope exchange reaction between the air moisture and the tritium adhered in the target vessel. We introduced a process to evacuate the target system by an off-gas processing system when the surrounding air entered the target vessel, suppressing successfully the tritium release through the stack to an amount of about 12.5 GBq, which was about only 5.4% of the estimated value. It was a promising progress for us because the target is planned to be irradiated until it reaches the accumulated power of 5000 MWh or more in the future.

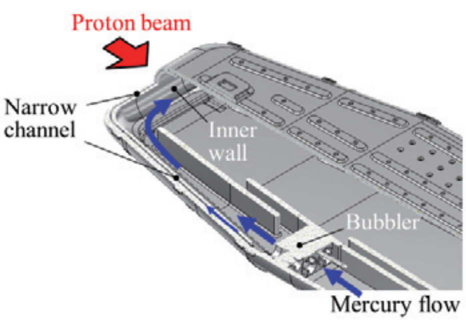


Fig. 1. Inner structure of the double-walled target vessel.

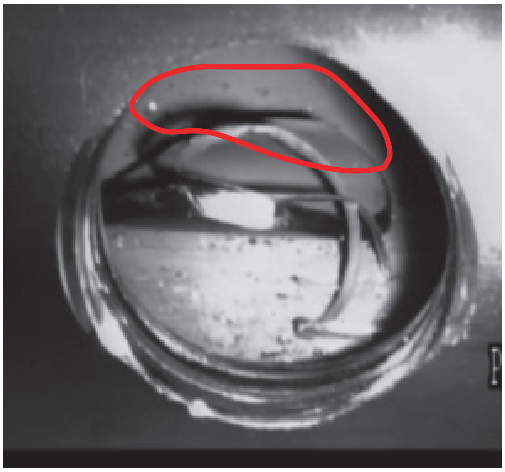


Fig. 2. Disk-shaped specimen cut out from the target vessel. The mercury flow facing surface of the specimen is outlined with red line.

Neutron Science

1. User Program

In 2014A and 2014B proposal rounds, 17 neutron instruments have been operating for users and 603 proposal applications were submitted for them. 345 proposals were approved. The reserved ones were 81. The beam operation scheduled for the period starting from January 17, 2015, was affected by the fire accident in the Muon area in MLF and the troubles at RCS and the neutron source, so a total of 33.5 days of user beamtime was lost. The experiments which could not be carried out in those terms from January to March were carried over into 2015 as exceptional measures.

2. Instruments development and construction

The VIN-ROSE at BL06 (constructed by Kyoto University and KEK), which consists of a neutron resonance spin echo (NRSE) instrument and a modulated intensity by zero effort (MIEZE) instrument, and an energy-resolved neutron imaging system, RADEN, at BL22 (constructed by JAEA) received the first neutron beam on April 22 (Fig. 3) and November 4, 2014, respectively. Both beamlines proceeded to the commissioning phase.

The construction of the polarized neutron chopper spectrometer POLANO at BL23 (constructed by Tohoku University and KEK) continued.

Fig. 3. First beam of the VIN ROSE.

3. International Activities

MLF held the 2nd MLF School from December 16 to 19, 2014. The Neutron Science Section contributed to the neutron part of the school. 7 neutron instruments were provided for practical experiments.

The 14th Korea-Japan Meeting on Neutron Science was held from January 7 to 9, 2015, at the Ibaraki Quantum Beam Research Center. 50 Japanese and 29 Korean scientists participated.

4. Resultant outcomes

The research activities in neutron science at MLF resulted in more than 120 papers. The number includes articles in influential journals such as Nature Physics and Nature Communications.

Two staff members, Dr. H. Nakagawa and Dr. N. L. Yamada won the Encouraging Prize of the Japanese Society for Neutron Science. Prof. M. Hino of Kyoto University received the Technology Prize of the Japanese Society for Neutron Science for his work in developing neutron optical devices for VIN-ROSE.

We distributed 6 press releases on scientific outcomes and technical development from our beam lines.

- Combination of neutron and X-ray inelastic measurement reveals the whole scheme of electron excitation states: Electron doping effect on high-energy magnetic excitations in high-T_c cuprate. (Apr. 25, 2014)
- How does water define the shape of DNA? Local dynamics coupled to hydration water determines DNA-sequence-dependent deformability. (Aug. 29, 2014)
- Combination of neutron and X-ray inelastic measurement reveals the whole scheme of electron excitation states: Electron doping effect on high-energy magnetic excitations in high-T_c cuprate. (Apr. 25, 2014)
- Finding hydrogen in iron dissolved under high-pressure: Determination of site occupancy of interstitial deuterium atoms in face-centered cubic iron. (Sep. 26, 2014)
- New elemental analysis realized with J-PARC: Development of Time-of-flight prompt gamma-ray analysis (TOF-PGA) for multi-elemental analysis. (Dec. 22, 2014)
- New hydride with Cr: Predicted by the first principle calculation and confirmed by neutron scattering. (Mar. 24, 2015)

Neutron Device

Large Area One-dimensional Scintillator Neutron Detectors for TAKUMI at BL19

Neutron Detectors installed at TAKUMI, BL19, are large one-dimensional neutron detectors with a sensitive area of 1000 cm×20 cm and a position resolution of 3 mm, which have been developed under international collaboration with ISIS, Rutherford Appleton Laboratory. The detector has 360 pixels, each with size of 3 mm×20 mm. Determination of the incident neutron position was established introducing a $_2C_n$ coding method in the arrangement of fiber bundle to photomultiplier tubes (PMTs), and hence each of the 360 pixels can be specified by only 48 PMTs. Last year this type of detector was fabricated and delivered to BL19 and a total of 12 detectors will be operating at TAKUMI. These detectors have neutron sensitivity of 50% at 1 Å and gamma-ray sensitivity of less than 10^{-6} at energy of 1.3 MeV. Its performance met sufficiently the requirements for residual stress analysis in neutron scattering experiments at BL19.

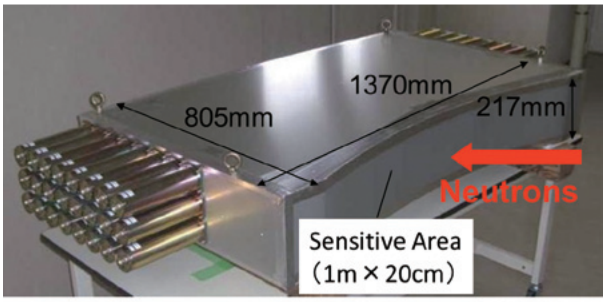


Fig. 4. A Photograph of the neutron detector developed for TAKUMI.

Development of Alternatives to ^{3}He Gas-based Neutron Detectors in Nuclear Security

The recent shortage of Helium-3 stockpiles had severely affected various fields such as neutron science and nuclear security. Thus, it is quite urgent to develop a technology, alternative to the conventional ^{3}He gas-based neutron detectors. On the other hand, we have developed a new neutron sensitive $ZnS/^{10}B_2O_3$ ceramic scintillator which has been adopted successfully in detectors of BL03, BL17, and BL18. Therefore, we have started to develop alternative detectors using the $ZnS/^{10}B_2O_3$ ceramic scintillators for nuclear safeguards application with support from the Japanese government, and consequently designed a new detector as shown in Fig. 5. The detector's design is simple, comprising of a scintillator strip, a light-reflecting case, and two photomultiplier tubes at both ends. The neutron detection efficiency and gamma-ray sensitivity of the detector were about 80% of that of a standard ^{3}He neutron detector and less than 10^{-7} under high gamma-ray field of 100 mSv/hr with a Co-60 source, respectively. These high performances were again confirmed by three evaluators from IAEA, LANL, and JRC (Joint Research Center) in a demonstration experiments conducted at the Facility of Radiation Standard, JAEA. The developed detector proved to be a promising alternative to the conventional ^{3}He detectors used in nuclear security by this experiment.

This work was partially supported by the Ministry of Education, Culture, Sports, Science and Technology.

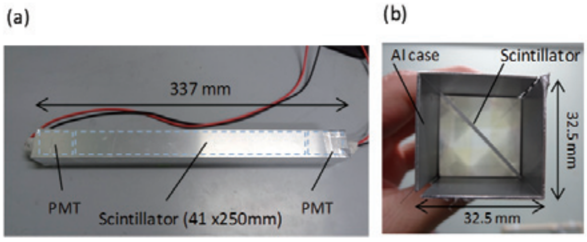


Fig. 5. Photographs showing (a) side and (b) internal views of the detector.

Muon Science

MUSE (Muon Science Establishment) returned to its normal operation after the proton beam delivery resumed in February, 2014, following the Hadron Hall incident in the preceding year. Since then, it was used in the Inter-University Research Program throughout the entire 2014A term and part of the 2014B term, and toward the end of the year on the muon D-line. Unfortunately, the scheduled restart after a short break, in the beginning of 2015, was deferred by a fire incident at the MUSE on January 16, 2015, that left the entire Material and Life Science Facility in limbo for a month. The fire incident was caused by faulty design of a renovated power supply for one of the D-line magnets (septupole) that led to overcurrent in a transformer that was newly added to the original system. Fortunately, the fire was immediately extinguished by the MUSE staff, and there were no casualties or any radiation hazards at the incident site. Although the hardware damage was limited to the burned transformer, it would take a few months to restore the D-line.

Meanwhile, MUSE witnessed steady progress in the facility infrastructure. After years of research and development, the rotating target was finally rolled into the primary proton beamline and used for pion/muon production at a beam power of 300 kW starting from November, 2014. In Experimental Hall No.1, the construction work for a part of the S-line and the adjacent S1 area reached its final stage. In November 2014, all components were integrated into the S-line, subjected to inspection for radiation safety by a third party organization, and deemed to be ready for beam operation. The construction of the μSR spectrometer (funded by the "Element Strategy Initiative", MEXT) was also nearly completed, waiting for installation to the S1 area.

Coming to the scientific activities, a new antiferromagnetic phase has been identified in a prototype iron-based superconductor, $LaFeAsO_{1-x}H_x$ (LFAO-H), over a range of unprecedentedly high carrier concentration ($x > 0.4$). A team of experts on muon, neutron, and SR-x-ray (working together for the "Element Strategy Initiative" project conducted at the Condensed Matter Research Center, CMRC) has made a concerted effort with a group from Tokyo Institute of Technology to shed light on the electronic properties of LFAO-H over the region of large H content. Here, the μSR technique served to map out the Néel temperature (T_N) vs. x in a timely fashion. Subsequent measurements by neutron and SR-x-ray inferred that the magnetic structure was different from that observed in the low x region, and that the magnetic transition accompanies structural change to a non-centrosymmetric structure (Aem2) at $x = 0.5$. These observations suggest that the new phase might be regarded as another "parent" for the secondary superconducting phase.

Technology Development

During the last year, the technology development section performed various kinds of technical support for common issues and maintenance of the neutron instruments. The first topic was the enhancement of the neutron shielding for the 1 MW operation of J-PARC. In the summer maintenance period, extra shielding was added to the main neutron shielding of BL02 and the beamstop of BL14 to comply with the surface dose criteria for the outer surface of instruments (Fig. 6). The second topic was the construction support for new instruments. The construction of BL22 (RADEN), which is the world's first imaging dedicated instrument at the pulsed-neutron source, and BL23 (POLANO) which is polarization analysis neutron spectrometer, proceeded successfully (Fig. 7). RADEN started the beam commissioning by the instrument group and the construction of POLANO will be completed in the next fiscal year. The third topic was the construction support for a new extension building for RADEN. It is located at the west part of MLF and connected to the second experimental hall on the first floor (Fig. 8). It is a two-story building and most of its parts are non-radioactive controlled area. The experimental controls of RADEN and sample preparations will be done in this building. The fourth topic was the maintenance of neutron instrument components. For example, in accordance with the annual maintenance plan, maintenance of the T0 chopper (BL01×1, BL11×1, BL18×1) and low-speed disk chopper (BL11×2, BL15×3) were carried out. As an enhancement of the infrastructure in the MLF experimental hall, common distribution boards for the operation and test of sample environment equipment, etc. were installed in the first and second experimental halls. The construction of the J-PARC Research building, the so-called User building, was completed. It is a four-story building. Various kinds of laboratories, such as sample environment equipment room, deuteration rooms for biomaterial and polymer samples, etc. are arranged on the first floor. The technology development section decided the specifications of the rooms based on the user requests and contributed to the design.

(a) (b)

Fig. 6. Enhancement of (a) neutron shielding of BL02 and (b) beamstop of BL14.

Fig. 7. Construction of BL22 (RADEN)

Fig. 8. Construction of the external building

Fig. 9. Maintenance of BL15 low-speed disk chopper.

Fig. 10. Maintenance of BL01 T0 chopper

Particle and Nuclear Physics

T2K experiment

The T2K (Tokai to Kamioka) long-baseline neutrino-oscillation experiment resumed data accumulation after about one year of shutdown caused by a problem in the hadron experimental facility.

Data acquisition commenced on May 26, 2014. The beam power was upgraded from 230 kW to 320 kW towards the end of March, 2015. The total number of protons on target (POT) in the fiscal year 2014 is 3.55×10^{20}, and the integrated number of protons on target since the beginning of the experiment is 10.12×10^{20}. The history of the beam power and data accumulation are shown in Fig. 1.

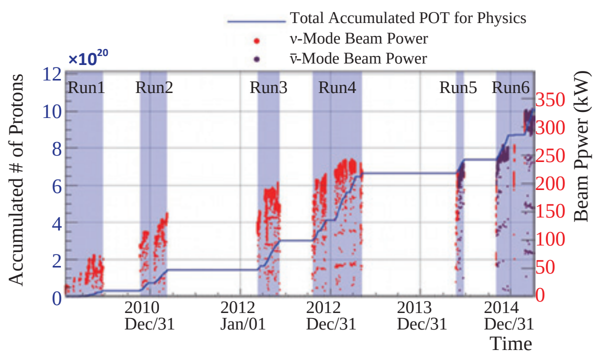


Fig. 1. Total accumulated POT (Protons on Target) and beam power (kW) of the neutrino beam since the beginning of the experiment in 2010.

1. Anti-neutrino run

In June, 2014, an anti-neutrino beam, as against a neutrino beam, was created for the first time by changing the polarity of the current of the magnetic horns. The first anti-neutrino beam event was recorded in the Super- Kamiokande detector on June 8, 2014. An exploded view of the event is shown in Fig. 2. The total number of protons on target in the anti-neutrino run is 3.12×10^{20}.

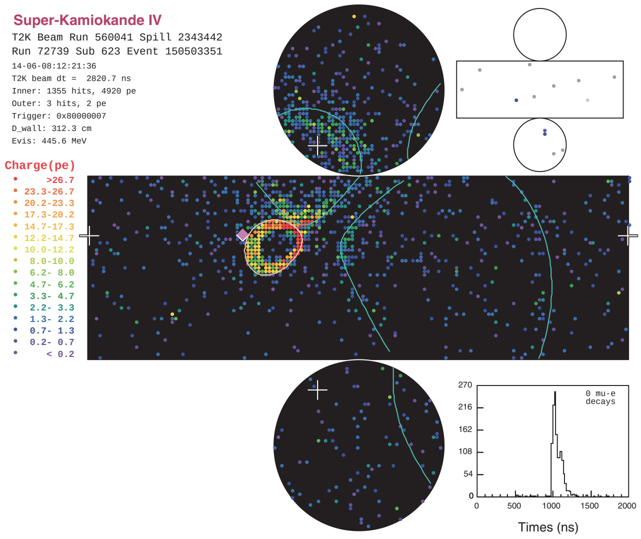


Fig. 2. Exploded view of the first anti-neutrino beam event observed in the Super-Kamiokande detector. The event was recorded on June 8, 2014.

2. Analyses

Constraints on the neutrino oscillation parameters were analyzed using the data recorded until summer 2013. Appearance studies for electron neutrinos and disappearance studies for muon neutrinos were combined, and more elaborate analyses were performed. The results shows hints towards normal mass hierarchy with a CP-violation phase $\delta_{CP}\sim-\pi/2$. Details are reported in the Research Highlights (see Vol. 1).

Other significant aspects of the study included measurements of neutrino cross-sections etc. Results for some interaction modes have been published in the fiscal year 2014. These are the inclusive ν_μ charged current cross section on iron and hydrocarbon [1], the neutral current interaction with oxygen [2], and the inclusive ν_e charged current cross section on carbon[3].

A search for sterile neutrinos was performed using the ND280 detector. No positive signal indicating sterile neutrinos were detected, and new constraints on the oscillation parameters were obtained [4].

3. Facility upgrade and maintenance

Replacements of all the three magnetic horns, initiated in November, 2013, were successfully completed in April, 2014, with the replacement of the most upstream magnetic horn. Since the replacements had to be conducted in a highly radioactive environment, all operations were executed using a remote control from a crane operation room isolated by a shield wall. The most upstream magnetic horn suspended by a crane is shown in Fig. 3. These new horns are expected to be functional for several years.

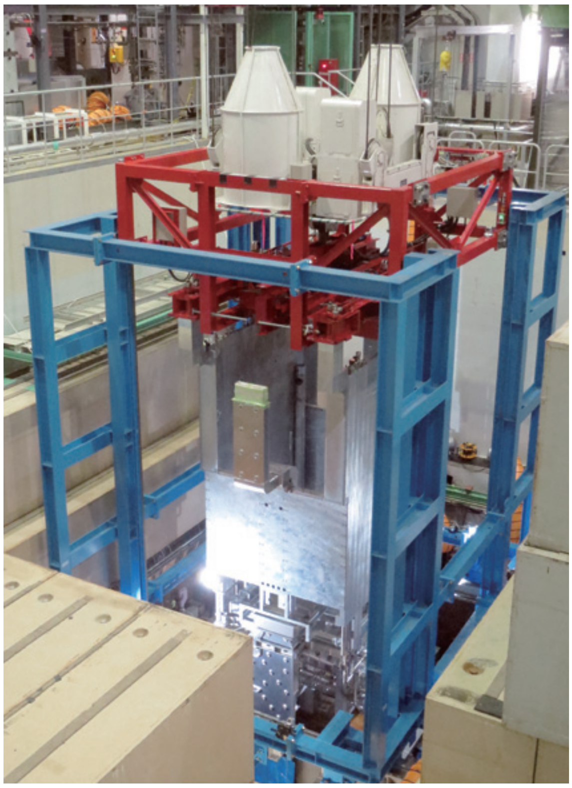


Fig. 3. The most upstream magnetic horn suspended by a crane, proceeding for a replacement.

Power supplies for the normal conducting magnets in the primary proton beam line were replaced with new ones. The old power supply system was mostly constructed in 1980's, requiring immense efforts for maintenance. The replacements were completed in September, 2014. The new system has been operating successfully since October, 2014. Normal conducting magnets and their new power supplies are shown in Fig. 4.

Fig. 4. (top) Normal conducting magnets of the primary proton beam line, and (bottom) their new power supplies.

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(reprint from KEK annual report)

Hadron and Nuclear Physics

In spite of there being no operations performed at the Hadron Experimental Facility (HEF) in JFY 2014 owing to the radiation incident that occurred in May 2013, some results of the experiments performed in 2012 were published [1,2,3]. Here, we present the results of the E27 experiment, which aims to find a K^-pp bound system [3].

Kaonic nuclei are exotic nuclei in which K-mesons are bound in nuclei by the strong interaction. Their existence is a key issue in developing an understanding of the $\bar{K}N$ interaction in vacuum, a nuclear medium, and high-density nuclear matter, such the core of neutron stars. Among them, the K^-pp bound state composed of K^- and two protons could be the simplest one, if it existed. However, the predicted binding energies and widths of the K^-pp state strongly depend on the $\bar{K}N$ interaction and calculation methods.

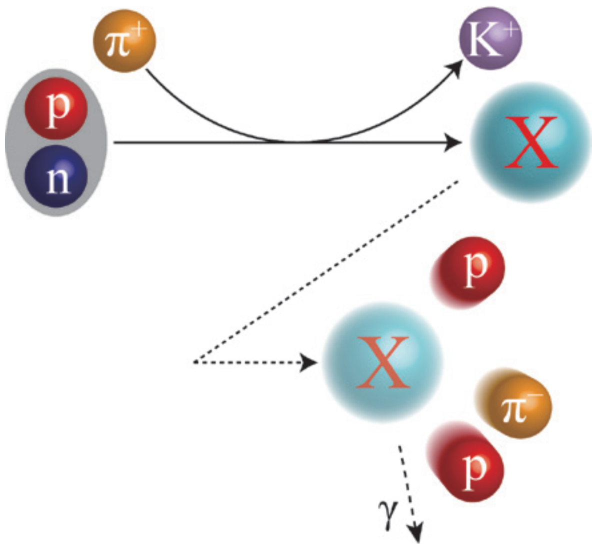

Fig. 1. Schematic of the production and decay reactions. K^-pp (denoted by X) is expected to be formed by the D ("p n") + $\pi^+ \rightarrow K^+$ + X reaction and is expected to decay to p + p + π^- + γ.

Experimental situation for the K^-pp bound state is not conclusive at present; the FINUDA experiment for the stopped K^- absorption on ^6Li, ^7Li, and ^{12}C [4] and the DISTO experiment for the exclusive reaction of $pp \rightarrow K^+ \Lambda p$ at 2.85 GeV [5] reported their observations of the K^-pp bound state. However, no signal was observed in the inclusive spectrum of the $\gamma d \rightarrow K^+ \pi^- X$ reaction at $E\gamma$ = 1.5–2.4 GeV at LEPS [6]. It is important to obtain new experimental information for different reactions.

The J-PARC E27 experiment was performed using the $d(\pi^+, K^+)$ reaction at 1.69 GeV/c with the Superconducting Kaon Spectrometer (SKS) at the K1.8 beamline of the HEF. In this reaction, K^-pp is expected to be formed through $\Lambda(1405)$ production and the produced K^-pp is expected to decay to $p+p+\pi^-+\gamma$ in the final state (Fig. 1). Thus, to improve the signal-to-background ratio, high-energy protons in the final state were also measured in coincidence with 6 sets of a range counter array (RCA), which were installed around a liquid D_2 target and cover the angular range from 39° to 122° in the laboratory frame.

In the detailed analysis, we distinguish the final states as follows: (i) Λp, $\Lambda \rightarrow p\pi^-$, (ii) $\Sigma^0 p$, $\Sigma^0 \rightarrow \Lambda g \rightarrow p\pi^-\gamma$, and (iii) YpN $\rightarrow pp\pi\pi$. Figure 2 shows a missing-mass distribution for two-proton coincidence events of the $\Sigma^0 p$ final state (ii) with the acceptance correction, which shows the K^-pp-like structure. By fitting the spectrum with a relativistic Breit–Wigner function, the obtained mass and width are

2275^{+17}_{-18} (stat.) $^{+21}_{-30}$ (syst.) MeV/c^2 and

162^{+87}_{-45} (stat.) $^{+66}_{-78}$ (syst.) MeV/c^2, respectively.

The corresponding binding energy of the K^-pp system is 95 $^{+18}_{-17}$ (stat.) $^{+30}_{-21}$ (syst.) MeV/c^2, ~10 times higher than the normal binding energy.

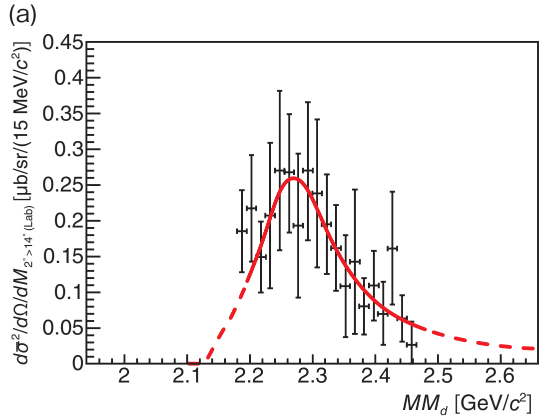

Fig. 2. Missing-mass spectrum of the $d(\pi^+,K^+)$ reaction for two-proton coincidence and the $\Sigma^0 p$ decay branch events with the acceptance correction. The red curve is a fitting with the relativistic Breit–Wigner function.

Another experimental investigation on the K^-pp system is underway at the HEF. The E15 experiment at the K1.8BR beamline aims to detect K^-pp in both production and decay channels. K^-pp is produced via the $^3He(K^-,n)$ reaction at 1.0 GeV/c, measured by a beam spectrometer and neutron detector wall, and its decay, $K^-pp \rightarrow \Lambda p \rightarrow \pi^- pp$, is detected by the cylindrical detector system surrounding a liquid ^3He target. As reported in the Annual Report in JFY 2013, no significant peak structure, but some yields below the $K^- + p + p$ threshold were observed in 1% of data obtained before the incident, which cannot be explained by the detector resolution or known processes [7]. Further collection of data is planned in 2015 after operations at the HEF are resumed.

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(reprint from KEK annual report)

Kaon Experiment

Experimental study of K-meson (kaon) has a long history since its discovery in 1947. The decay of long-lived neutral kaon (K_L) into a neutral pi meson (π^0) and a pair of neutrinos, represented as $K_L \to \pi^0 \nu\bar{\nu}$, is known to be a rare and precious decay mode in particle physics. The Standard Model (SM) predicts the branching fraction of this decay mode very precisely, once in forty billion K_L decays. New sources of symmetry breaking that can explain the matter-antimatter asymmetry in the universe may be revealed by examining this decay mode. On the other hand, for experimentalists, detecting this decay mode is a challenge because only two photons from the π^0 decay are observable.

The J-PARC E14 KOTO experiment was proposed in 2006 to study the $K_L \to \pi^0 \nu\bar{\nu}$ decay. In the Hall of the Hadron Experimental Facility (HEF) at J-PARC, a new neutral beamline was built for KOTO in 2009, and 2716 undoped CsI crystals were stacked for the KOTO calorimeter in 2010. The crystals and phototubes were the ones that had been used in the KTeV experiment at Fermilab, USA, in 1990's. For detecting extra particles from K_L decays, charged-particle and photon veto counters were built and were installed to the inside of the vacuum vessel of the KOTO detector. Veto counters were also placed downstream of the vessel in order to detect particles escaping along the beamline. A cross-sectional side view of the detector system is shown in Fig. 1.

After commissioning the trigger and data acquisition system, the first physics run was initiated in May, 2013; data for one hundred hours, corresponding to 1.6×10^{18} protons on target, were recorded before the radioactive material leakage at the HEF. Preliminary results of the analysis were reported [1] at the CKM2014 International Workshop. Figure 2 shows the scatter plot of the reconstructed transverse momentum (Rec. P_T) versus decay vertex position (Rec.z) of the observed π^0's after imposing all the selection criteria, including extra-particle vetoes. The $K_L \to \pi^0 \nu\bar{\nu}$ decay should appear as an event with a finite Rec.P_T, corresponding to the momentum taken away by two neutrinos, and with Rec.z in the decay volume. The dark box in the plot had been masked during the analysis; the inner box is the pre-determined signal region. The numbers of the events around the masked region (in black) were consistent with the numbers of expected background events (in red), based on Monte Carlo simulation studies. The background level in the signal region was expected to be 0.36±0.16, mainly due to interactions of neutrons with the calorimeter, and one event was observed. Detailed studies are being conducted to understand and suppress the background level further.

The KOTO collaboration is going to publish the results, resume the collection of physics data, and conduct beam-based background studies when the HEF restarts.

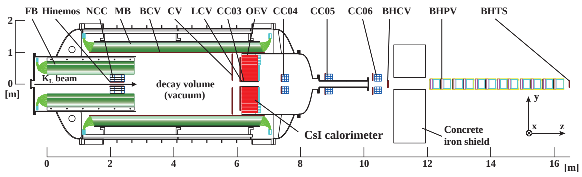


Fig. 1. KOTO detector system in 2013. The beam comes in from the left side.

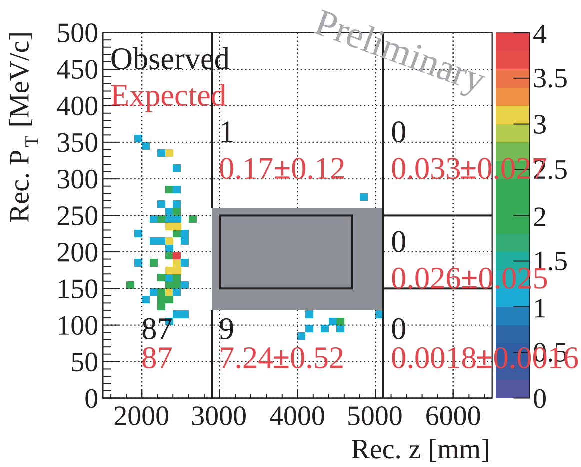


Fig. 2. Scatter plot before "opening the box", from the analysis of the 2013 data.

Reference

[1] K. Shiomi (for the KOTO collaboration), *arXiv:1411.4250,* to appear in the Proceedings of the 8th International Workshop on the CKM Unirarity Triangle (CKM 2014), Vienna, Austria, September 8-12.

(reprint from KEK annual report)

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 also violates the lepton-flavor conservation, using an intense pulsed-muon beam generated at J-PARC. In 2014 the COMET group has moved forward preparation of the experiment significantly. The COMET experiment uses a large solenoid magnet with a gradient magnetic field, called "capture solenoid", surrounding the primary target in order to collect produced secondary particles such as pions and muons. Then those particles are transported to the experiment area by a curved solenoid with a 90-degree bend, called "transport solenoid", in which momentum and charge of secondary particles are selected using a collimator located at the exit. Fabrication of these magnets was initiated in 2013 and continued in 2014. In March 2015 construction of the transport solenoid was completed. The magnet was then transported to J-PARC and installed to the position in the experiment area after assembling with an iron return yoke as shown in Fig. 7. R&D of the detector has also made significant progress in 2014. Prototype detectors for electron momentum and energy measurements to be used in beam background study and in physics measurement in future have been constructed and tested using cosmic-ray practical performance. In calorimeter R&D, LYSO (Cerium doped Lutetium Yttrium Orthosilicate) is selected as the crystal material for electron energy measurement owing to its better energy resolution. In addition to these R&D, fabrication of the main detector for COMET physics measurement in the 1st stage of the experiment, cylindrical drift chamber (CDC), has started at the initiative of Osaka university group with help of KEK [2]. Stringing of 20,000 wires will be continued for a half year in 2015 before detector commissioning. Construction of all these detectors is based on the technical design of the experiment summarized in 2014 [3]. The collaboration has grown in 2014. New members from Belarus and Korea have been approved to join the collaboration.

References

[1] New constraint on the existence of the $\mu^+ \rightarrow e^+ \gamma$ decay, J. Adam and others (MEG collaboration), Phys. Rev. Lett. 110, 201801, 2013.

[2] http://www2.kek.jp/ipns/news/comet-cdc-carry-in/index.html

[3] COMET Technical Design Report, COMET collaboration, submitted to the J-PARC PAC

(reprint from KEK annual report)

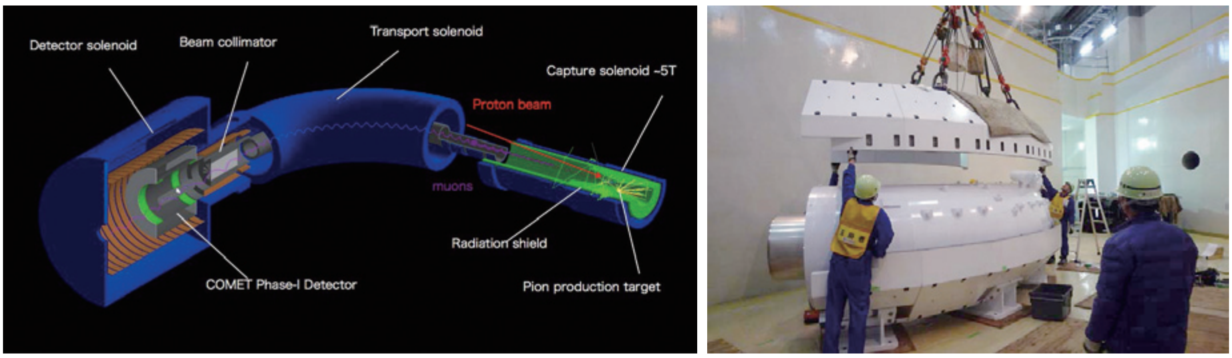


Fig. 1. Layout of the COMET Phase I and assembling of the COMET transport solenoid with the iron return yoke (right)

Muon *g*-2 / EDM

The experiment aims to measure 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 level. R&D is in progress to realize a novel experimental technique of ultra-slow muon source, muon acceleration, injection, storage magnet, and tracking detector. Major achievement on a large enhancement of the muonium emission was published in Ref. [1], and the results were confirmed by follow up experiment at J-PARC (more details are reported in the research highlights, see Vol.1).

Next milestone is a demonstration of muon acceleration. Simulation studies on the muon acceleration by a Radio Frequency Quadrupole (RFQ) linac confirmed that muons are accelerated with high efficiency. A test of muon acceleration using negative muonium ions was developed at MLF.

The experiment requires a novel three-dimensional beam injection to the muon storage magnet. Design of transport beamline to the storage magnet was developed. A demonstration of the spiral injection scheme by using low-energy electron beam is being prepared.

Precision magnetic-field measurement is one of the important technologies to achieve the required precision. Improvements were made to a system of the magnetic-field measurement by using nuclear magnetic resonance (NMR) to reach resolution of 0.017 ppm level.

Finally, positrons from stored muon decay are measured by a silicon-strip tracking detector. Test silicon-strip sensors were developed and evaluated with positron beam, confirming a good signal-to-noise ratio of 20. A full scale prototype of the frontend ASIC was developed.

A technical design to realize this experiment with the expected precision beyond the previous experiment was developed. The collaboration started preparation of a Technical Design Report.

Reference

[1] Prog. Theor. Exp. Phys. 091C01, 2014

(reprint from KEK annual report)

JSNS^2 (J-PARC E56) Experiment

JSNS^2 (J-PARC Sterile Neutrino Search at J-PARC Spallation Neutron Source) is a new stage-1-approved experiment, which aims to confirm or refute the existence of a sterile neutrino [1]. Sterile neutrinos do not have weak interactions, and their existence proves the physics beyond the standard model. They are predicted by some theories and are indicated by some past experiments, but their existence so far has never been confirmed by the experiments with small systematic uncertainties. Fig. 1 shows a bird's-eye view of the MLF building and a JSNS^2 detector location candidate , the third floor of the MLF.

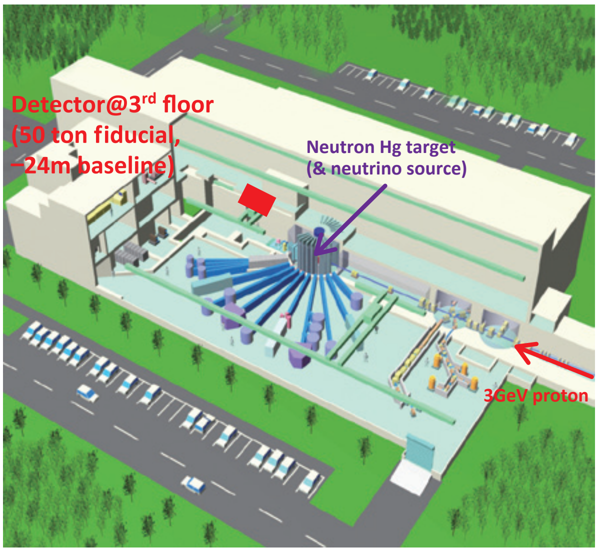


Fig. 1. A bird's-eye view of the MLF building and the detector location candidate (red box).

A large number of anti-muon neutrinos are created by the decay-at-rest process of muons at the mercury target at the MLF, and there could be oscillated signals from the anti-muon neutrinos to anti-electron neutrinos within the baseline of 24 m from the target to the detector, if neutrino oscillations with sterile neutrinos exist. The signals are detected by the 50 tons of liquid scintillator inside the detector using Inverse Beta Decay process.

In 2014, we measured the background rate and the energy spectra of the backgrounds at the candidate site to examine the feasibility of the experiment [2]. This measurement was performed using a 500 kg plastic scintillator borrowed from the LEPS2 experiment. Fig. 2 shows the result of the background measurement, with a 2D histogram of energy and the timing of the backgrounds.

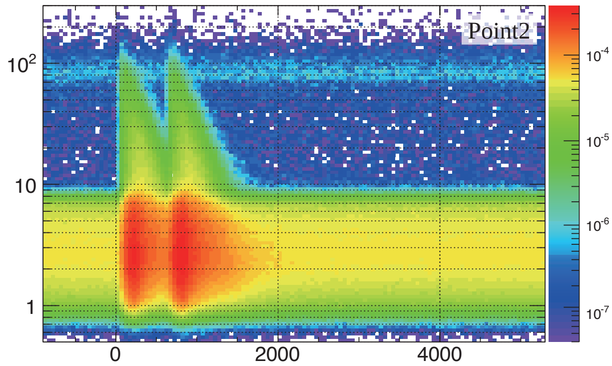


Fig. 2. Event timing (horizontal axis, ns) and energy (vertical axis, MeV) of the measured background at the detector candidate location. The rate is shown as number of background events / spill.

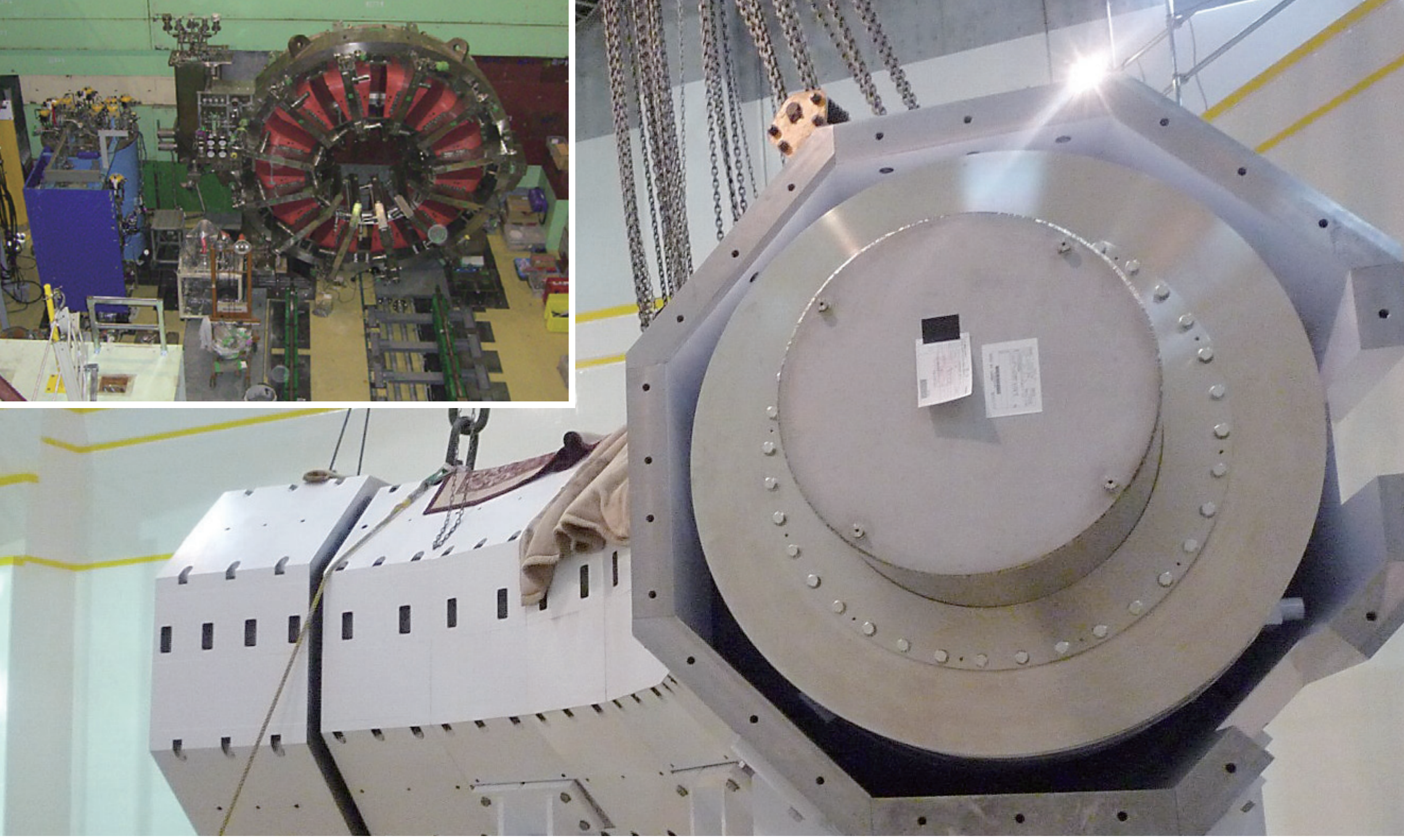
As shown in Fig. 2, there are a lot of background events around the proton bunch timing from 0 to 1000 ns, however, the number of the background is drastically reduced with the timing and energy window of $1<T<10\mu s$ from the beam time and $20<E<60$MeV, which JSNS^2 experiment uses to detect the anti-electron neutrinos because of the muon long lifetime and anti-neutrino energy from the muon decay-at-rest. The measurements proved that the backgrounds induced by the beam will not be an issue for the real experiment. The backgrounds from cosmic-rays could also be placed under control.

After obtaining the stage-1 approval, the JSNS^2 collaboration is intensively performing the R&D for the detector to write the Technical Design Report.

References

[1] M. Harada *et al*, arXiv:1310.1437

[2] S. Ajimura *et al*, Prog. Theor. Exp. Phys. 2015 6, 063C01 (2015)



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 superconducting magnet systems for the muon beamline at the Materials and Life Science Experimental Facility (MLF) and the magnets at the Hadron Experimental Facility. It also actively conducts R&D works for future projects at 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 2014 is summarized in Table 1. The refrigeration system operated steadily without any troubles, such as a compressor trip during the run time, observed in previous years and the operation in FY2014 records the longest operation time as shown in Fig. 1.

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

	2014									2015		
	April	May	June	July	Aug.	Sept.	Oct.	Nov	Dec.	Jan.	Feb.	Mar.
Operation	↔	4/1–4/29, 5/7–7/2	↔				↔	10/7–12/22	↔	←	1/9–4/13	—
Maintenance				↔	↔	↔						

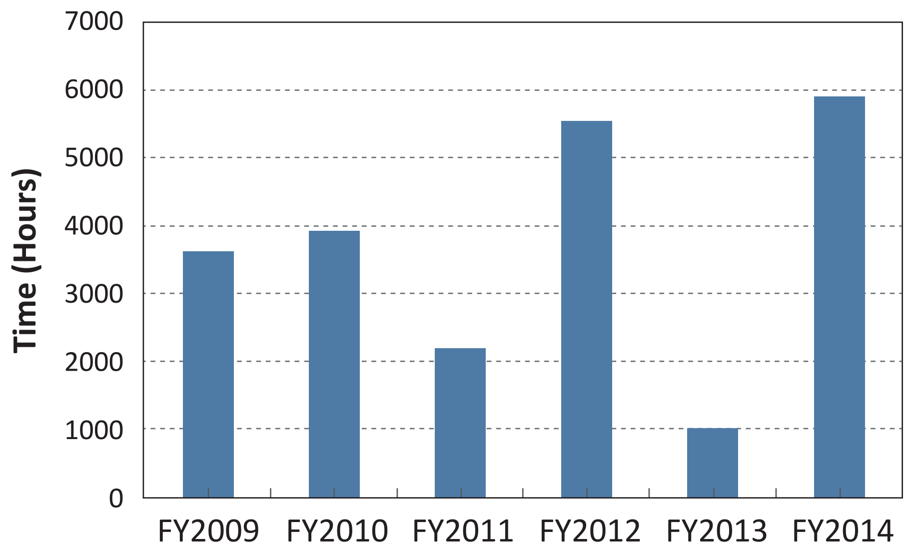


Fig. 1. Annual operation time of the cryogenic system for the J-PARC neutrino beamline

Superconducting magnet system for the muon U-line at MLF

The Cryogenics Section supports the maintenance of the intense ultra-slow muon beam line (U-line) at MLF. During the long shutdown in FY2013, it was found out that a radiation shield foil at the upstream end of the curved solenoid had disappeared for unknown reason, so the head of the curved solenoid was not cooled down enough for magnet excitation. In the summer of 2014, the problem has been fixed.

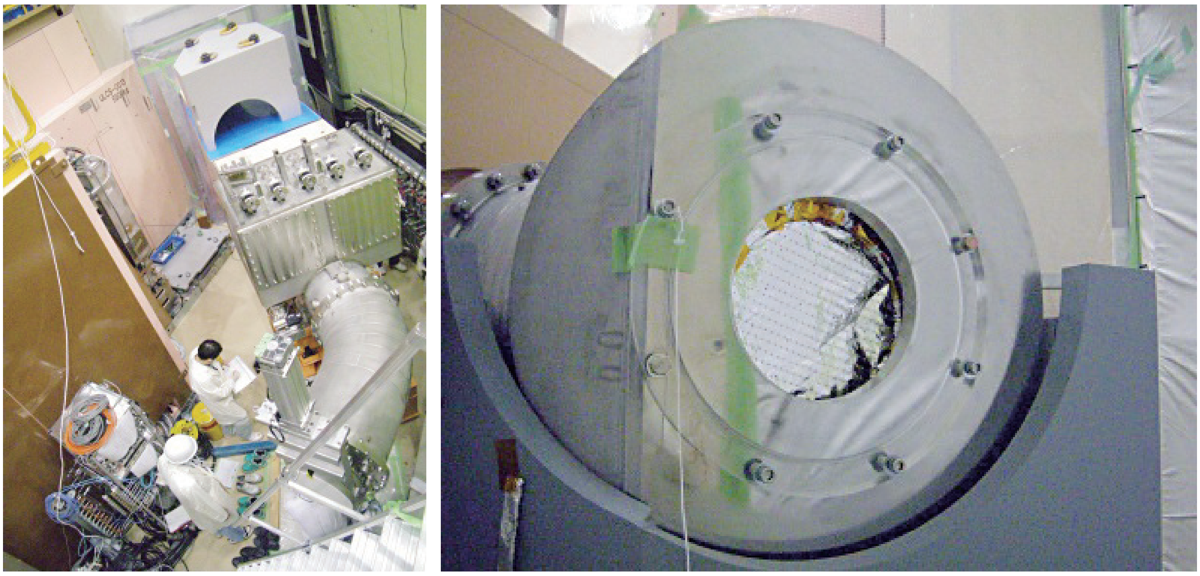


Fig. 2. Repair works on the radiation shield foil at the upstream end of the beam bore of the superconducting curved solenoid at the MLF U-line.

Superconducting magnet system for the muon D-line at MLF

One of the major contributions of the Cryogenics Section was 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 superconducting magnet and the helium compressor had to be replaced. The section contributed to the fabrication of the magnet and the reconstruction of the refrigeration system. The recovery of the refrigeration system, including the installation of a new helium compressor (Fig. 3), was successfully completed during the summer shutdown of 2014. The commissioning was finished in September, 2014, without any serious problems. The superconducting magnet was fabricated and delivered in March, 2015. The replacement of the superconducting magnet has been planned for the summer shutdown of 2015.

Fig. 3. New helium compressor for the MLF muon D-Line magnet system.

Superconducting Kaon Spectrometer (SKS)

The Cryogenics Section supports the Superconducting Kaon Spectrometer (SKS) operation at the Hadron Experimental Hall. The SKS suspended operation since the accident at the Hadron Experimental Hall in 2013. After investigation and reconstruction of the experimental hall, the SKS resumed operation in the fall of 2014 and the physics experiments using the SKS were performed safely.

Superconducting magnet system for COMET

The construction of the COMET Phase-I experiment started in 2013. The Cryogenics Section is involved in the COMET experiment with the task to construct the superconducting magnet system. Some of the solenoid coils for the Pion Capture Solenoid with radiation-hard resin and insulation were wound in FY2014. The Muon Transport Solenoid (Fig. 4) was delivered to the experimental hall at the Hadron Experimental Facility and installed on the cradle.

Fig. 4. Muon Transport Solenoid delivered to the J-PARC Hadron Experimental Facility.

Superconducting magnet system 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 Hadron Experimental Hall. The superconducting toroidal magnet and a helium cold box (TCF50) that had been used in the KEK E246 experiment in 1990, were used again in this project. The cryogenic system had several serious problems, which affected the control system and even caused leakage of the 4 K helium pipe. Along with the repair works to fix such issues, the Cryogenics Section also provides system construction for the Hadron Experimental Facility. Figure 5 shows the transportation and installation work of the superconducting toroidal magnet and the cold box. After finishing the construction, we confirmed that the cryogenic system did not have any problems by performing the cooling and excitation test.

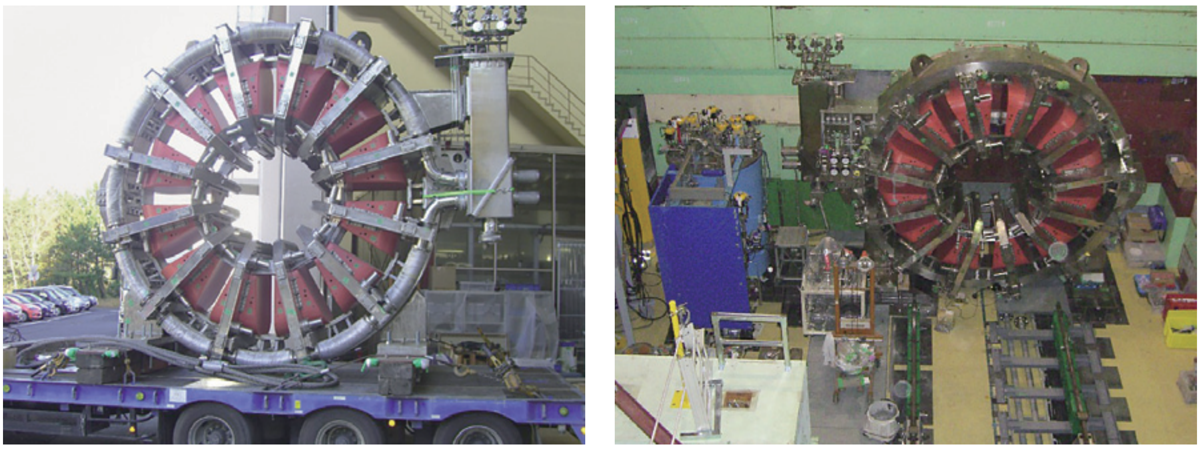


Fig. 5. Transportation of the superconducting toroidal magnet (left) and the system installation work (right).

Cryogen Supply and Technical Support

The Cryogenics Section provides liquid helium cryogen for physics experiments at J-PARC. The used helium is recovered by the helium gas recovery facility, which is provided and operated by the Cryogenics Section. Figure 6 summarizes the liquid helium supply in FY 2014. Until June, 2014, the helium gas was liquefied in collaboration with the Accelerator Division using the helium liquefier owned by the Accelerator Division. In the fall of 2014 the liquefier constructed and maintained by the Cryogenics Section started to provide liquid helium to the users.

Liquid nitrogen was also supplied to the users for their convenience and its amount during the FY2014 period is summarized in Fig. 7. Liquid nitrogen has been regularly provided to the Radiation Safety Section for operating a gas chromatograph. The commissioning of the refurbished refrigeration systems at MLF and Hadron Experimental Facility required liquid nitrogen in September and December. Liquid nitrogen was also supplied for the magnet R&D in February, 2015.

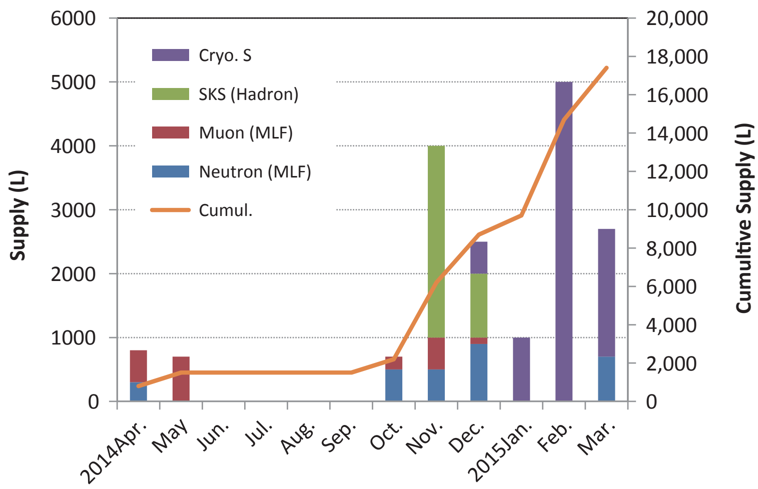


Fig. 6. Liquid helium supply at J-PARC from April, 2014, to March, 2015.

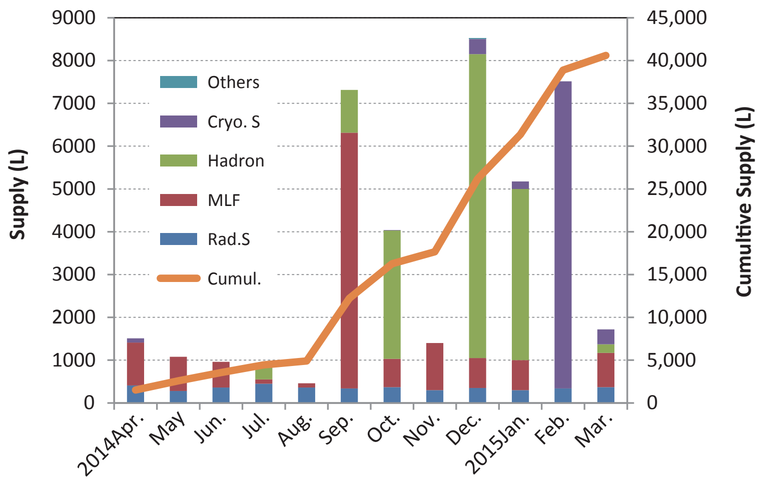


Fig. 7. Liquid nitrogen supply at J-PARC from April, 2014, to March, 2015.

R&D for the future J-PARC project: New muon *g*-2/EDM and muonium HFS

The *g*-2/EDM project aims for the precise measurement of the anomalous magnetic moment and the electric dipole moment of muons. This experiment is planned at the H-Line of the muon science facility (MUSE) in MLF. A superconducting solenoid with high field homogeneity, better than 1 ppm locally, plays a very important role as a muon storage ring. The design study of the magnet is proceeding in collaboration with IPNS and the Cryogenics Science Center. Technical design report, TDR, was being written to be submitted in May, 2015.

A muonium hyperfine structure measurement, called MuSEUM experiment, using the same beam line as the *g*-2/EDM project has also been proposed by a group of the Institute of Materials Structure Science of KEK. In the 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 an MRI system has been preliminary tested at the J-PARC Neutrino Utility Building No.1 from January to March, 2015, as shown in Fig. 8. After cooling down to 4.2 K from room temperature, the magnet was energized up to 1.5 T. In the magnetic field shimming test, the field homogeneity around within 30 cm DSV (diameter spherical volume) could be successfully improved from 860 ppm p-p to 3.88 ppm p-p. The next shimming test is planned for April, 2015, at 1.7 T required for the MuSEUM experiment.

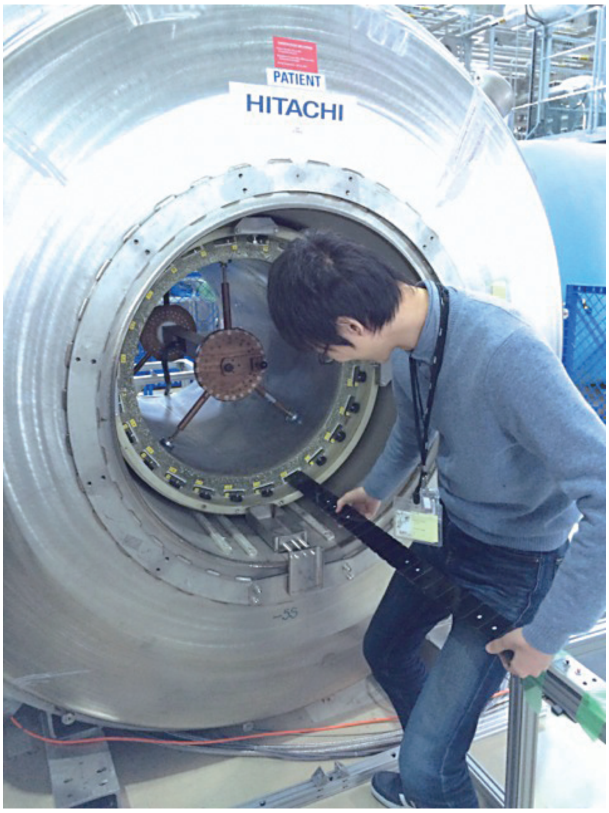
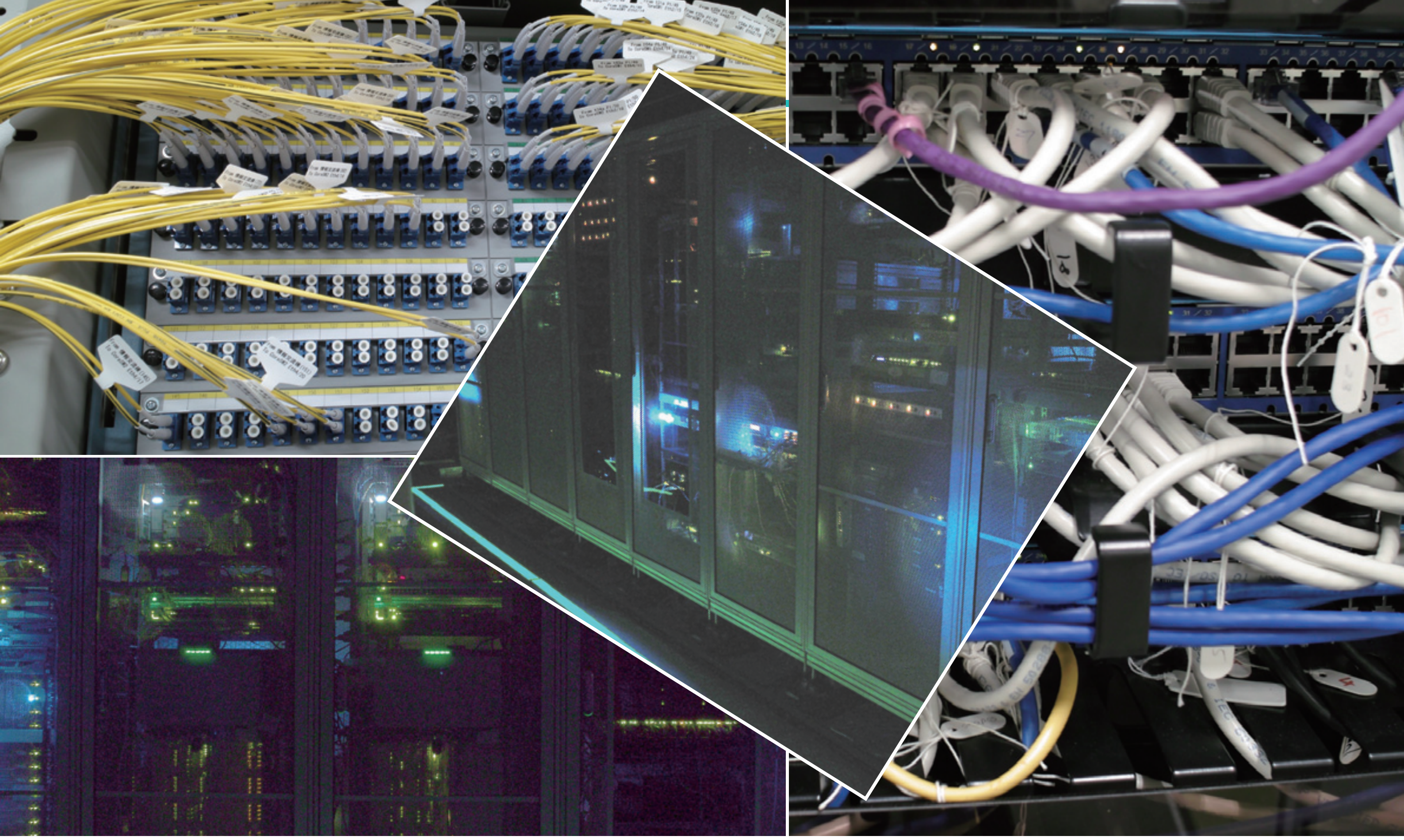


Fig. 8. Magnetic field shimming test at J-PARC.



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 2014, the total number of hosts on JLAN exceeded 4100, which was an increase of 106% compared to 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. Figures 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. Figures 4 and 5 show 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 half of the limit in 2 hours' average and two-thirds in 5 minutes' peak transfer rate, especially during the period when the Hadron facility was running in 2013 (Fig.6). The figure also shows that after that year 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.

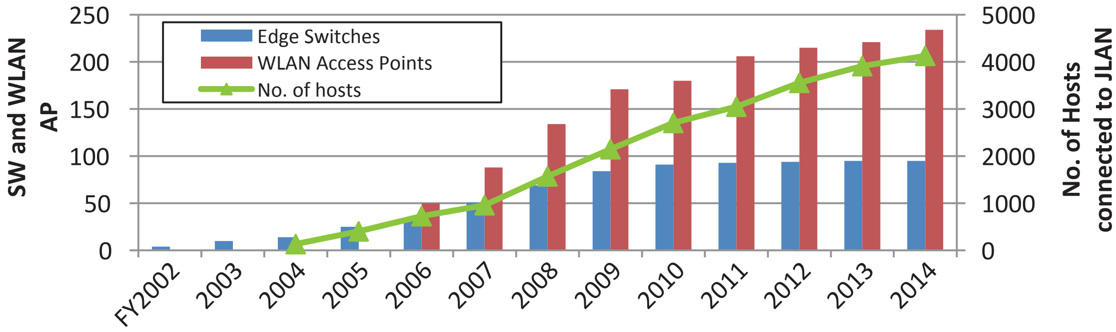


Fig. 1. Number of hosts, edge SW and wireless AP on JLAN.

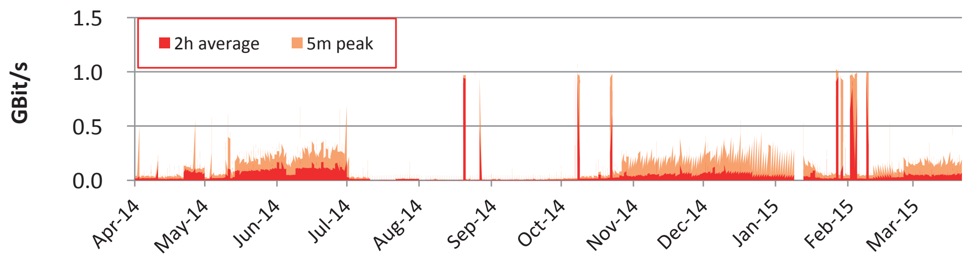


Fig. 2. Network traffic from JLAN to the internet.

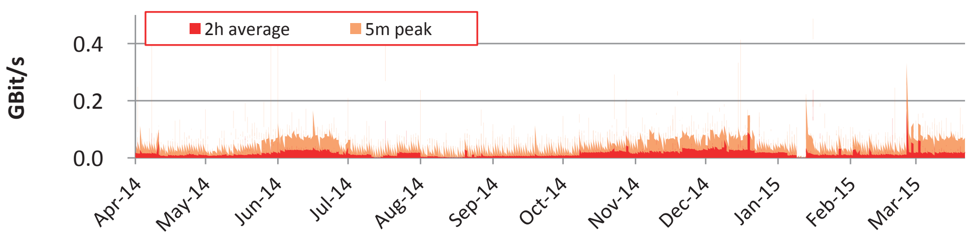


Fig. 3. Network traffic statistics from the internet to JLAN.

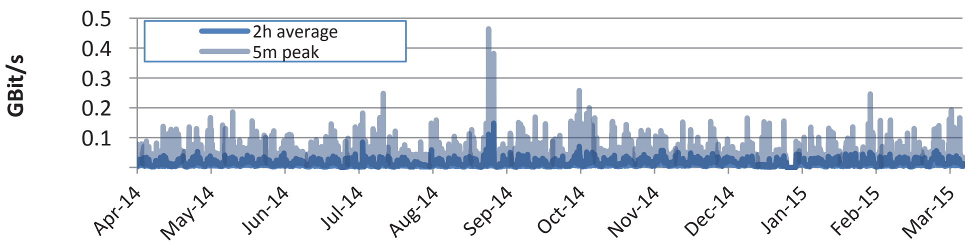


Fig. 4. Network traffic statistics from Tokai site to Tsukuba site.

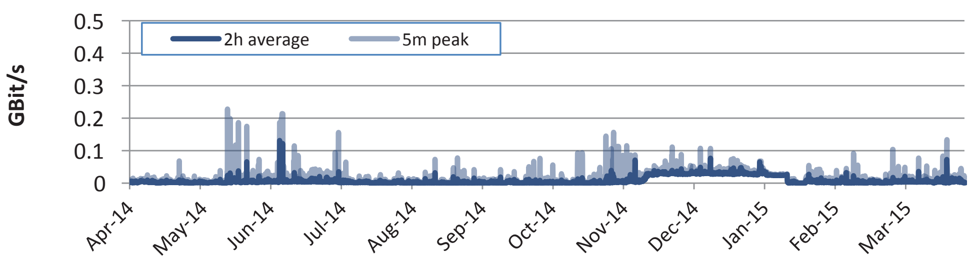


Fig. 5. Network traffic statistics from Tsukuba site to Tokai site.

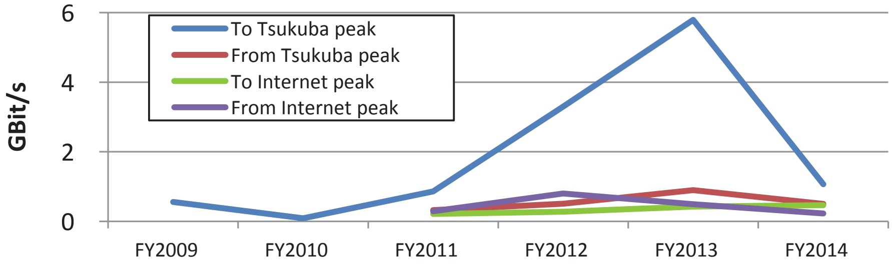


Fig. 6. Peak network traffic for the recent years.

New network service "User LAN" for public J-PARC users

Since 2009 J-PARC has offered a Guest network (GWLAN) service. The GWLAN is a wireless LAN internet connection service for short-term visitors available in almost all J-PARC buildings. In the end of 2014, an additional new network service called User LAN has started. In using the GWLAN users are required to receive beforehand a password from the J-PARC Users Office. In the new service the users are authenticated by the same ID and password of the User Support System, which is also used for dormitory reservation and so on. Figure 7 shows the usage statistics of GWLAN and User LAN.

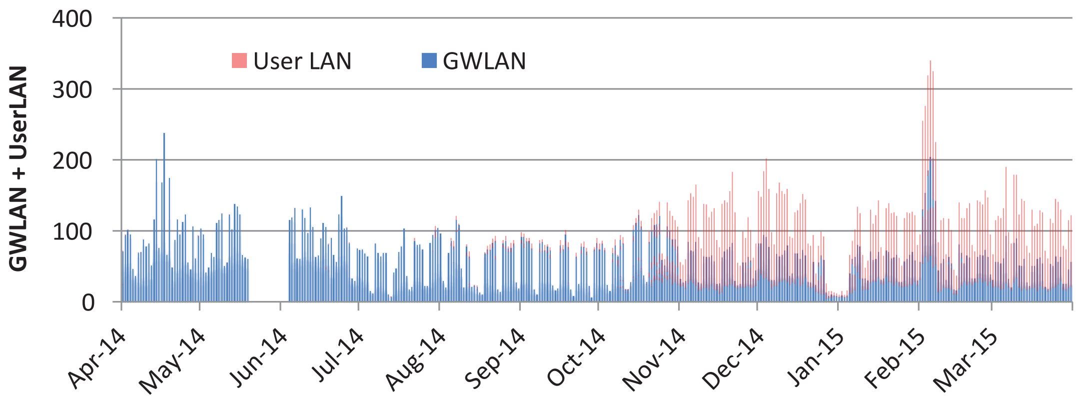


Fig. 7. Use trends of GWLAN and User LAN.

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 that purpose (the system was upgraded in 2012). Currently computer resources of 25,000 SPECint06 computing power, 1.2 PBytes disks and 5 PBytes tapes were assigned to J-PARC (Table 1).

At 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 8 to 12 show the utilization statistics of the computer resources in 2014. The main users who used the CPU and the storage constantly were from the Hadron experiment group (Koto). 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.

CPU	25,000 SPECint06
RAID Disk	1,200 TB
Tape	5.0 PB

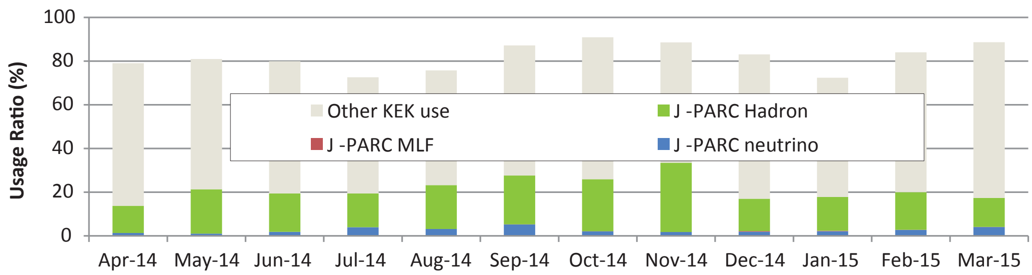


Fig. 8. CPU usage statistics.

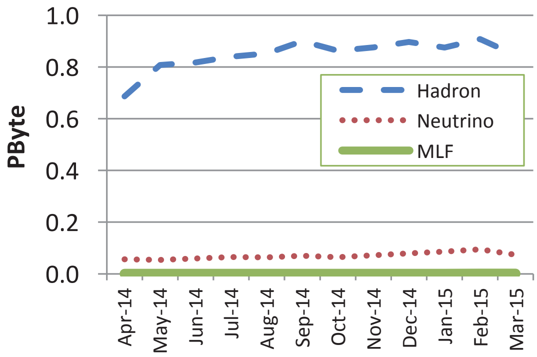


Fig. 9. Disk usage statistics.

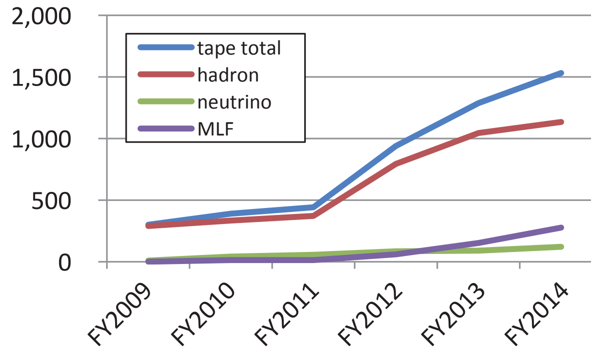


Fig. 10. Disk usage statistics.

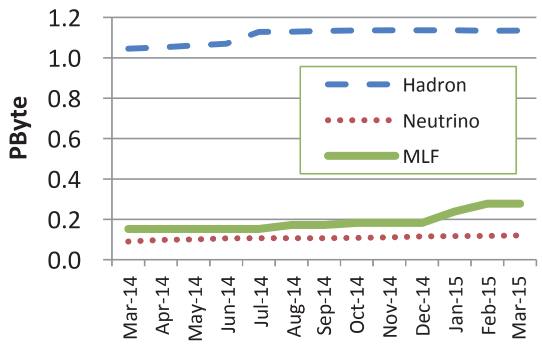


Fig. 11. Tape library usage statistics.

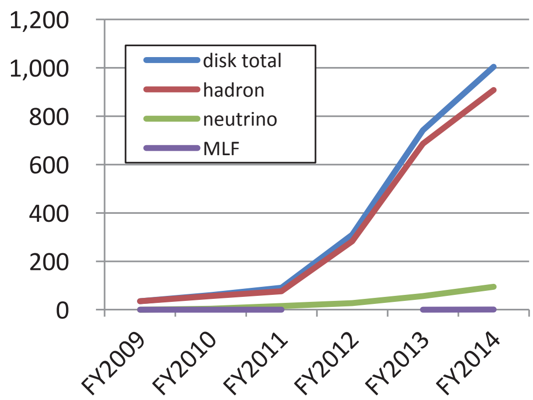


Fig. 12. Tape library usage statistics.


Transmutation Studies

Overview

The Transmutation Section has been working on developing the Transmutation Experimental Facility (TEF) in J-PARC for R&D on volume reduction and mitigation of harmfulness of high-level radioactive waste by using accelerator-driven systems (ADS). In April 2014, the Japanese Cabinet endorsed a "Strategic Energy Plan", the first Japanese comprehensive and systematic energy policy after the Great East Japan Earthquake in 2011. Promotion of nuclear transmutation technology development using accelerators was mentioned for the first time in the Japanese energy policy. The supportive message contained in this plan encouraged us to continue further with the construction of TEF. In response to the plan, the human resources involved in the TEF program were reinforced by increasing the numbers of the regular staff and staff concurrently work for the TEF program, from 7 and 6 as of April, 2014, to 12 and 9 one year later, respectively.

On July 10-11, 2014, the first TEF Technical Advisory Committee (T-TAC), which was one of technical advisory committees under the J-PARC International Advisory Committee, was launched. The discussed topics included: (1) strategy to realize transmutation technology, (2) readiness of the ADS Target Test Facility (TEF-T) construction and (3) validity of the Transmutation Physics Experimental Facility (TEF-P) concept from a technical point of view. The T-TAC endorsed our R&D activities for the TEF construction in general, and also gave us many valuable recommendations.

In July and August, the 6th and 7th meetings of the national review working party (WP) for partitioning and transmutation technologies using ADS were held following five meetings in 2013. The WP discussed the progress in solving the technical issues in the TEF construction, international cooperation and human resource development, and gave us some positive comments. But the WP did not recommend yet starting the TEF construction.

As a result of the increased funding for the TEF program, several new experimental devices were fabricated in FY2014, such as a TEF-T Target Mockup Loop, a High-temperature Material Corrosion Test Loop and an oxygen concentration measurement device to establish liquid lead-bismuth eutectic (LBE) handling technology for TEF-T, and mockup devices for minor actinide (MA) handling technology for TEF-P. Typical R&D results obtained by using these new devices as well as existing experimental devices will be introduced later. The conceptual design of various systems and buildings for TEF-T and TEF-P also progressed, and will be also introduced later.

Design of Transmutation Experimental Facility

Improvement of the nuclear safety regulations

The nuclear safety regulations specified by the Nuclear Regulation Authority (NRA) of Japan were re-examined fundamentally after the serious accident at the Fukushima-Daiichi Nuclear Power Plant in March, 2011. In the case of reactor facilities, the countermeasures against disaster, such as a big earthquake, a tsunami, a volcano eruption and so on, were enforced drastically. The nuclear security requirements for facilities using nuclear fuel materials were also enforced. These regulations for safety, security and the proper safeguards are fully applied not only at nuclear power plants but also at fuel cycle facilities and research reactors. Since TEF-P will be a new facility, which includes a critical assembly with highly enriched uranium, the regulations will be applied strictly.

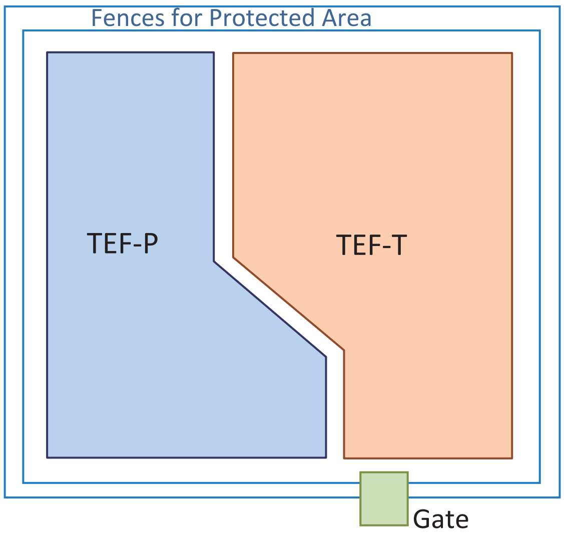


Fig. 1 Original TEF layout.

Rearrangement of the facility layout

The facility layout of TEF was re-arranged according to the new safety regulations. To comply with the nuclear security requirements, TEF-P has to be surrounded by a multi-layered barrier. The access to TEF-P will be controlled strictly and differ completely from that to the radiation facility TEF-T. In the previous facility design, the two TEF buildings were to be located nearly contiguous and tangled by a beam line for TEF-P as shown in Fig. 1. Because it is also required to protect the TEF-P building from flooding caused by a tsunami, the height of TEF-P site has to be at almost the same level as the J-PARC LINAC facility. In addition, since the earthquake energy for seismic analysis was also upwardly revised, the installation of man-made rock was proposed as a basis of the fundamental structure for TEF-P. Figure 2 shows a tentatively revised facility layout of TEF.

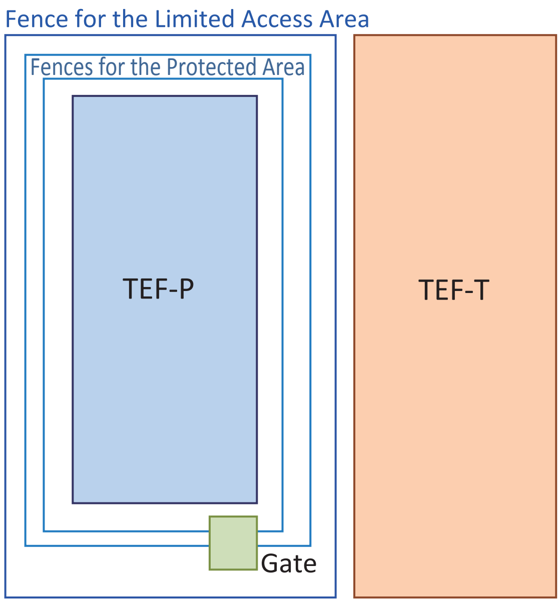


Fig. 2 Revised TEF layout.

Design of the TEF-T spallation target

To accelerate the TEF construction, a conventional layout of the TEF-T spallation target system instead of the annular-tube type structure was selected. The trolley-mounted type primary circuit was also selected reflecting the experiences from the mercury target in J-PARC Materials and Life Science Experimental Facility (MLF). However, there are many differences between the MLF mercury target and the TEF-T LBE target. The biggest difference is between the operation temperatures of both targets. Because the main research objective of TEF-T is to prepare an irradiation database for future ADS design, the maximum LBE temperature exceeds 450°C even though there are no spallation targets operated above 500°C. To ensure the soundness of the LBE target loop, a TEF-T Target Mockup Loop to be operated without a proton beam was manufactured, and is ready for operation. Further details of the loop will be discussed in another section of this report.

Design of TEF-P

As mentioned in the previous section, the facility layout of TEF-P including the structure of the building and the beam transport line were revised to satisfy the regulations for nuclear security and the proper safeguards. A ground survey will be performed in fiscal year 2015 to obtain geological data needed to evaluate the strength of the TEF-P building.

The inner pressure of an MA bearing fuel pin to be installed to TEF-P will increase due to accumulation of helium gas coming from the alpha decay of MA nuclides. Hence the soundness of cladding of the fuel pin was evaluated. As a result, it was found that the MA bearing fuel pin could be used up to 600°C. Burst tests of the stainless steel cladding and simulation of conditions of a loss from a cooling accident will be performed.

Design of the TEF Beam Transport

The TEF beam transport (TEF-BT) was re-arranged according to the changes in the facility layout. In the beam transport line from TEF-BT to TEF-P, physical barriers for humans were introduced.

Because the output power of the TEF-P subcritical assembly is influenced by the injected proton beam power, the power has to be adjusted inside TEF-P. In the case of a reactor scram, the injected proton beam has to be also halted inside TEF-P. These functions are indispensable to separate the reactor components from the J-PARC accelerators. To satisfy these requirements, a beam power adjuster and a beam stopper were considered in the TEF-P area in the downstream from the physical barriers.

The height of TEF-BT which equals the LINAC beam line level (about 12 meters underground) and the height of the reactor level (about 1 meter up from the ground) are different. The re-arrangement of the TEF-BT especially for TEF-P is underway to connect the height difference together with the relocation of the TEF buildings.

R&D for TEF-T

Studies to Construct TEF-T

The experimental studies for LBE handling to construct TEF-T have been progressing. For the study of target materials, the High-temperature Material Corrosion Test Loop was installed in the end of March, 2015. The loop's purpose is the fundamental study of the future ADS development, such as corrosion data collection for post-irradiation examination (PIE) on TEF-T irradiated materials and development of a filtering system for LBE loops.

For the study of the components and operation, the TEF-T Target Mock-Up Loop was constructed. The loop is a demonstration test loop with the same configuration/components as of the primary cooling system of TEF-T. All components are in actual scales, except a temperature conditioner simulating heat generation by proton beam injection. The full-scale operation is scheduled to begin in 2015.

For the study of remote handling techniques and instruments, some tests have been performed by using a test-stand for fundamental LBE technology. An MLF-type remote handling flange with some necessary modifications was introduced as a joint to connect the TEF-T target and the primary LBE loop. For the high temperature operation, a package heater was adopted and its remote exchange tests have been advancing. The operation check of an induction type LBE level gauge and a diaphragm type LBE pressure gauge in static condition was completed without a problem.

The developments of oxygen sensors and an ultrasonic flow meter have been started as key instrumentation technologies for the LBE loop system. The results will be described in detail below.

Development of the oxygen sensor for LBE

An LBE target will be irradiated with a high-power (250 kW) proton beam in order to study the irradiation effects on structural materials. It is presumed that LBE is a promising candidate material as ADS's proton beam spallation target and core coolant because it has good neutron yield and is inactive chemically in comparison with other coolant materials (e.g., water, sodium). On the other hand, LBE is corrosive, so it is necessary to control the oxygen concentration in LBE adequately to protect the structural materials from corrosion. In order to control the oxygen concentration in LBE, it is required to develop an oxygen sensor to measure the oxygen concentration.

The oxygen sensors have previously been purchased through international cooperation with Europe and used to measure the oxygen concentration in LBE. In 2014, J-PARC tried to fabricate two-types of oxygen sensors (platinum type and bismuth type) based on the European ones. Figure 3 shows the fabricated Pt-type oxygen sensors. As a result, it was confirmed that the output voltage of the platinum type sensors was adequate in a wide temperature range, as shown in Fig. 4. For the platinum type sensor, it is known that there is a possibility of LBE leakage if the sensor fails. To prevent LBE leakage, a special structure was installed on the sensor itself. It was confirmed by experiments that

Fig. 3. Exterior of the oxygen sensors (Pt-type)

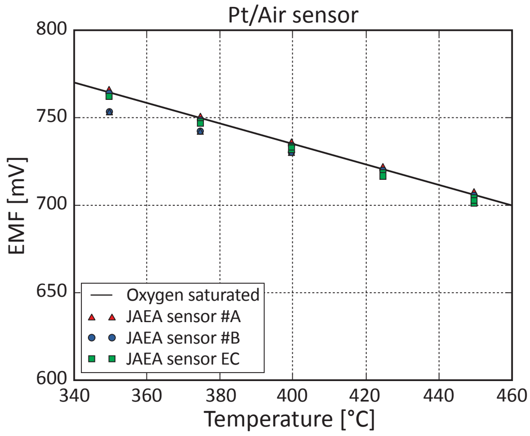


Fig. 4. Measurement results by Pt-type sensors. (EMF= Electromotive Force which corresponds to the oxygen concentration in LBE)

this special structure was functioning successfully to prevent the LBE leakage. This concept will be employed to measure the oxygen concentration of the LBE loop in TEF-T.

In the future, J-PARC will work in this field in collaboration with the JAEA's Nuclear Science and Engineering Center, universities, and other partners to carry out basic research to increase the precision of sensor outputs and to reduce the sensor failure rate, and perform demonstration tests in the LBE test loops.

Flow monitoring system for the LBE target

In TEF-T, LBE works as a coolant and spallation target material. The flow rate of LBE is one of most important parameters to secure the safety of the spallation target system and define the sample environment. Flow measurement of heavy liquid metal is very difficult in general because of its flowing condition and physical properties, i.e. high temperature, opaque fluid, and low *Pr* number. The poor wettability at solid-fluid boundaries is another reason to complicate the flow measurement. Electromagnetic flow meters (EMF) have been applied to measure the LBE flow rate. However, instability in its output was observed in JAEA's LBE loops. To overcome the difficulty in EMF, we have been developing an LBE flow monitoring system based on the ultrasonic method.

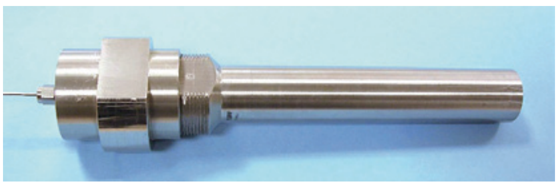


Fig. 5. Photo of the exterior of the ultrasonic sensor

We referred an ultrasonic monitoring system developed to measure sodium flow rate for fast reactors [1]. This system relies on the propagation time difference method showing the following advantages: the influence of change in the sound speed is low and a tracer medium is not necessary. Figure 6 shows the exterior of a semi-contactless type ultrasonic sensor. A $LiNbO_3$ element with a Curie point of 1140˚C is used in the sensor. A sensor plug is made of high Cr steel to improve wettability at solid-fluid boundaries.

The ultrasonic method was tested by using the JAEA Lead Bismuth Loop #4 (JLBL-4). Figure 6 compares flow velocity vs. flow rate. The temperature of LBE was 350˚C. The solid line shows velocity derived from EMF output, and the data points ((1), (2), (3)) show the mean velocity measured by the ultrasonic method over several different days. The good correlativity between the ultrasonic method and EMF was confirmed.

Figure 7 shows a result for a long-term operation test of the ultrasonic method. The flow rate of LBE was kept at 26.7 liter/min (velocity was about 0.36 m/s). The error bars indicate fluctuation of the measured velocity. It was confirmed that flow velocities measured by the ultrasonic method were rather stable within the error range of 3%, and the ultrasonic method was reliable enough for monitoring the LBE flow. In near future, we will continue the long-term operation test for up to 5,000 hours that corresponds to the maximum yearly operation period of TEF-T.

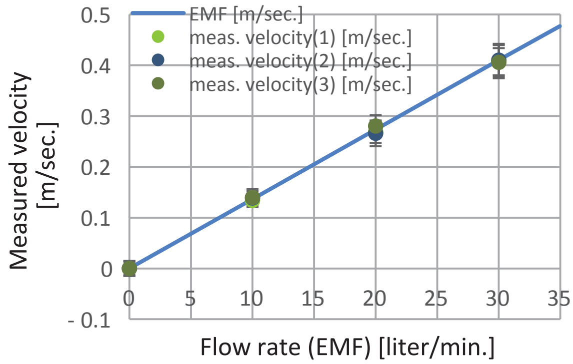


Fig. 6. Comparison of flow velocity vs. flow rate.

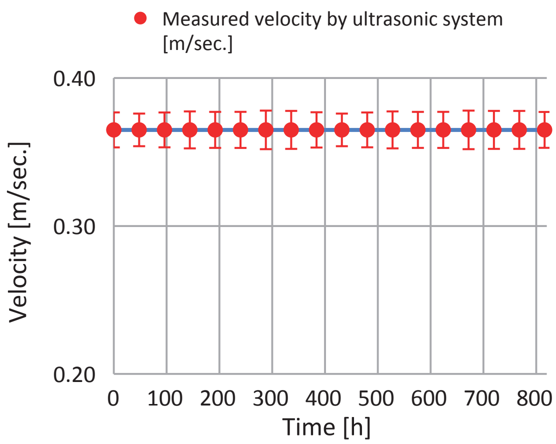


Fig. 7. Result for a long-term operation test.

Reference

[1] M.Hirabayashi, et al, Proc. of 13th ICON, 2005

R&D for TEF-P

Experiment related to the MA fuel treatment

In TEF-P, MA fuel will be used to perform reactor physics experiments for MA transmutation systems such as ADS or fast reactor. In order to handle the MA fuel with large decay heat and radioactivity, it is necessary to develop dedicated equipment, for instance remote handling or cooling for the MA fuel. To perform the basic experiments for the development of the MA fuel treatment methods, "MA fuel loading device", and some other devices were developed.

Figure 8 shows the basic concept of the MA fuel loading device. Six MA fuel pins will be stored in a cartridge and carried by a wagon. The MA fuel loading device holds the cartridge itself and the loading rod loads/takes one fuel pin to/from the core.

Figure 9 shows fabricated mockup equipment for the MA fuel loading device. It was confirmed that it was able to load or take a dummy fuel pin from the mock core without failure. A future task will be the improvement of the device to prevent it from dropping the fuel pin.

Laser Charge Exchange Technique

For the neutronics experiments using TEF-P, a low reactor power of less than 1 kW is feasible to ensure convenient experimental settings. To perform the experiments at TEF-P under such reactor power, with an effective neutron multiplication factor (k_{eff}) around 0.97, the incident proton beam power must be in the order of 10 W. It is also important to keep and reproduce the experimental condition especially for the injected proton

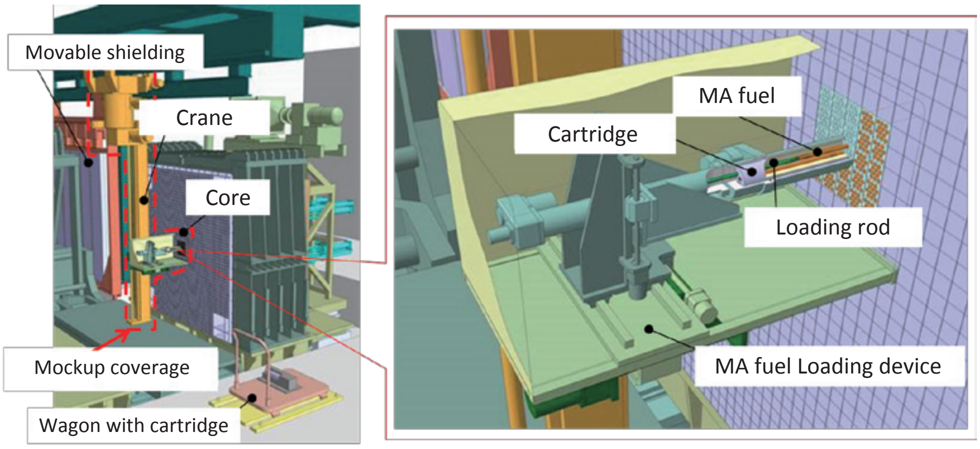


Fig. 8. Basic concept of the MA fuel loading device.

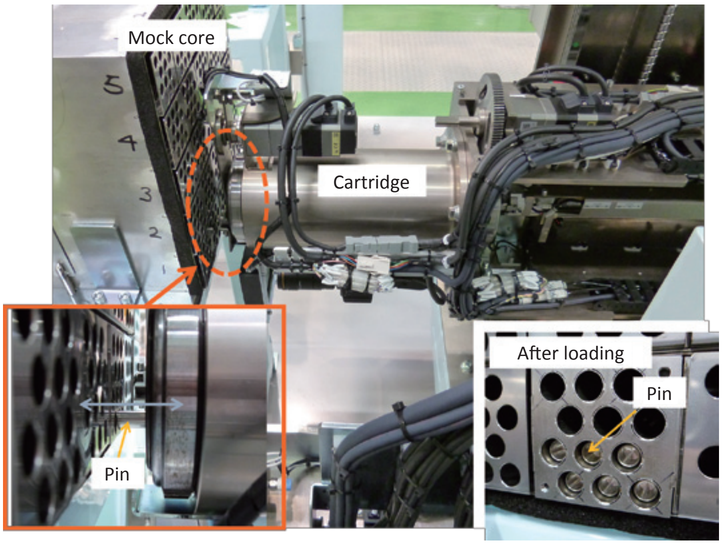


Fig. 9. Mockup for the MA fuel loading device.

beam. Because the J-PARC accelerators focus on much more higher beam power, the high-reliable low-power proton beam extraction device is indispensable. The development of a laser charge exchange technique for extraction of low power proton beam is now underway. The laser charge exchange technique is firstly used for beam profile monitoring and is applicable only for a H^- beam. When a laser beam is injected into a H^- beam, the charge of the H^- beam crossed with the laser beam changes into neutral. These neutral particles do not sense the magnetic field of a bending magnet, and are completely separated from the remaining H^- beam at the exit of the bending magnet.

However, it is well-known that pre-neutralized H_0 particles are produced by collision with the remaining gas in accelerator tubes and are transported with the main proton beam. When we apply the laser charge exchange technique to the H^- beam with the pre-neutralized protons, it becomes impossible to predict the total power of the extracted beam. To eliminate the pre-neutralized protons, we are trying to perform laser injection and beam bending simultaneously in one magnet. When the laser is injected in the magnetic field of the bending magnet, the pre-neutralized beam goes straight along the beam inlet direction and can be separated from the clean low power proton beam at the exit of the bending magnet.

A first demonstrative test of the laser charge exchange technique is to investigate the stability of the optical transport line and/or laser oscillator for obtaining a highly-reliable low-power proton beam. A Nd:YAG laser system with a pulse width of less than 9 nsec, beam energy of 1.6 J (repetition rate of 25 Hz) and an associated optical transport system have been prepared. Data of the stability for the laser system over a long period of time will be obtained.

Other activities and international collaboration

PIE of MEGAPIE samples

A series of post irradiation examination (PIE) works of the MEGAwatt Pilot Experiment (MEGAPIE) samples started at JAEA's hot-lab in March, 2014. The samples were cut from the beam window (BW, material: T91) and the flow guide tube (FGT, material: SS316L). The total number of JAEA samples was 67 and all of them were prepared without LBE.

Tensile tests were performed at the WAste Safety Technology Engineering Facility (WASTEF). Fracture surface observation after tensile tests and surface observation were performed at the Reactor Fuel Examination Facility (RFEF). By the end of May, 2014, the tensile tests on 23 samples were finished.

Results of tensile tests on T91 performed at room temperature (RT) are shown in Figure 10. The results indicate that the yield strength (YS) increased with the dose level by 10-30%. Total elongation (TE) did not change up to 0.82 dpa irradiation. After 1.44 dpa irradiation, TE decreased slightly. The YS values are almost at the same level as the literature value while the TE values are larger than the literature value. This may be attributed to the size effect of the specimen. Fracture surface observation was performed by SEM. Transgranular ductile surface was observed and brittle fracture surface was not.

Figure 11 shows the results of surface observation by SEM for inner surface of Spitze (T91) specimen cut from BW. Large number of pits was observed and their diameters were 10-30 μm.

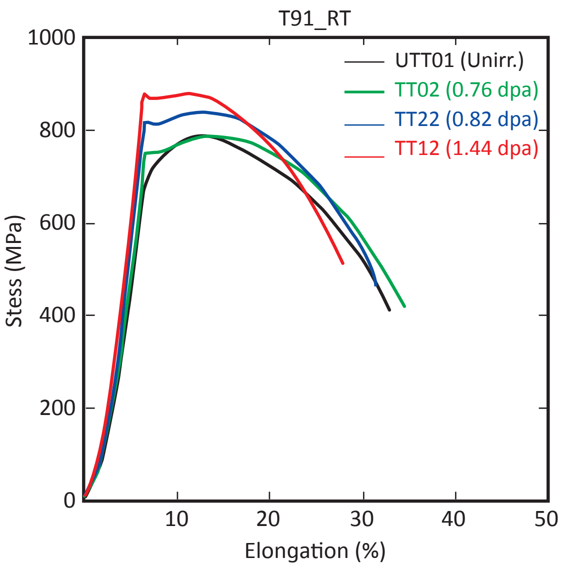


Fig. 10. The results of the tensile tests on T91 performed at RT.

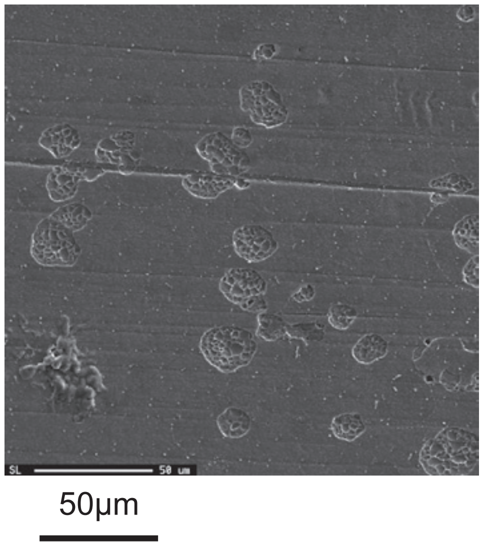


Fig. 11. The results of surface observation by SEM of the inner surface of BW.

Meeting and workshops

A MEGAPIE final Technical Review Meeting (TRM) was held at Bregenz (Austria) on October 23 and 24, 2014 subsequent to the 12th International Workshop on Spallation Materials Technology (IWSMT-12) at the same place on October 20-23, 2014. In the TRM, PIE results of each of the institutes including JAEA were reported and discussed. The workshop covered research fields related to the spallation target, ADS and related materials. The research activities in Japan, China, USA and Europe were presented and actively discussed.

The 12th International Workshop on Asian Network for ADS and Nuclear Transmutation Technology (NTT) was held at Hefei (China) on December 14-16t, 2014 In this workshop, JAEA's scientists presented and discussed the current status of the TEF project and the J-PARC linac, and the effect of the reactor physics experiments using TEF-P.

The SEARCH/MAXIMA 2014 International workshop was held at Karlsruhe (Germany) on October 7-10, 2014. The workshop's goal was to bring together international experts working in the field of the advanced heavy-liquid-metal cooling systems. In this workshop, the present status of the R&D for ADS in Japan and the TEF project were presented and actively discussed.

Safety

Radiation Safety

1. Overview

J-PARC is managed under the Law Concerning Prevention from Radiation Hazards Due to Radio-Isotopes, etc. under the Japanese legal system. A license for use is issued by the Nuclear Regulation Authority (NRA), and the related safety inspections are conducted by the Nuclear Safety Technology Center (NUSTEC).

The basic policy for radiation safety in J-PARC has been discussed by the J-PARC Radiation Safety Committee (RSC). We have discussed the specific rules for radiation safety in the J-PARC Radiation Safety Review Committee (RSRC) on the basis of this policy.

We applied the radiological license update twice to the NRA during the fiscal year covered in this report.

2. Meeting and committee on radiation matters

The RSC was held four times during the fiscal year. In the 19th and 20th Committee meetings, the safety margin in the J-PARC shielding design policy, related to the upgrade of the proton beam intensity of the Materials and Life Science Experimental Facility (MLF), was discussed. In the design stage, the design targets for the dose rates, which included the safety margin for design uncertainties, were defined. The committees approved the following items: (i) the safety margin for design uncertainty could be omitted based on actual operational experiences and measurements, and (ii) the concept of design targets would not be used in the future. In the 22th Committee on January 6, the installation of the new interlock related to exhaust and gate control of the accelerator tunnels was discussed.

The RSRC was held six times during the fiscal year and its discussions covered mainly issues of the radiological license upgrade.

3. Radiological license update and inspections

Table 1 shows lists of licenses for utilization of radiation generators and radioisotopes at J-PARC at the end of Japanese fiscal year (JFY) 2013 and application items for new licensing in JFY 2014.

Inspections of MLF were conducted twice by NUSTEC, on April 25 and November 10, 2014; the first inspection's item was to check the shielding performance, and during the second one the interlock system and the shielding performance were checked.

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 2014, 3942 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 records for individual exposure were undetectable, while the doses for 113 persons (2.8% of the workers) were detectable but less than 5.0 mSv.

Table 1. License at the end of fiscal year 2013 and application items for license in fiscal year 2014.

	License at the end of fiscal year 2013	Application items for license in fiscal year 2014
MLF	Power : 3 GeV/350 kW Secondary beam lines (neutron) : 19 Secondary beam lines (muon) : 3	Power : 3 GeV/1 MW Secondary beam lines (neutron) : 1
HD	Power : 30 GeV/50 kW Secondary beam lines (meson) : 4	
Neutrino facilities	Power : 30 GeV/450 kW	

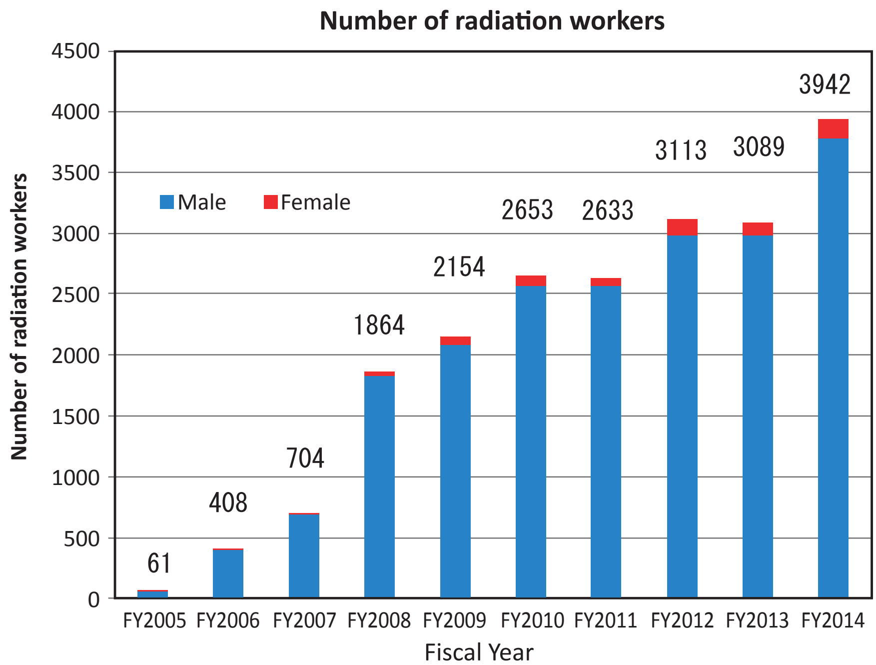


Fig. 1. Variation of the number of the radiation workers in J-PARC.

Table 2. Distribution of annual doses by the type of worker in fiscal year 2014.

	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 Workers		
In-house staff	557	57	3	1	0	596	12.7	21.3
User	1052	1	0	0	0	1053	0.2	0.2
Contractor	2220	72	1	0	0	2293	15.3	6.7
Total	3829	108	4	1	0	3942	28.2	7.2

User Service

Users Office (UO)

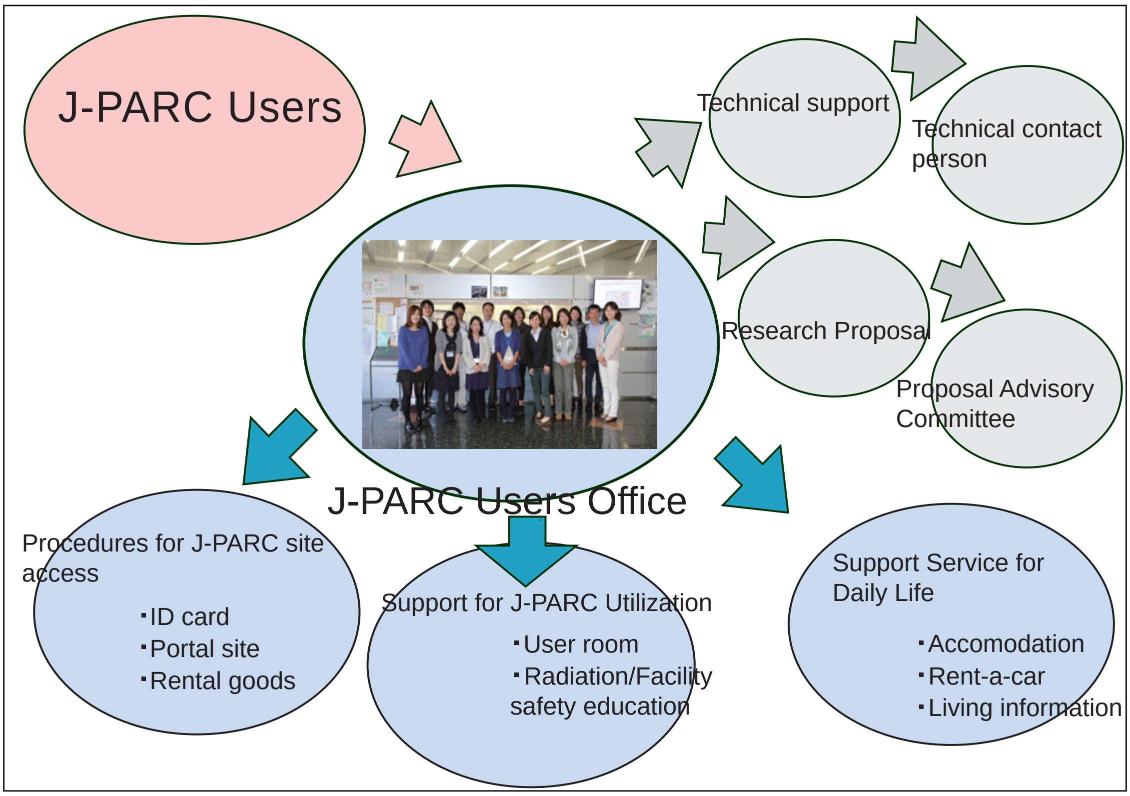
Outline

The J-PARC Users Office (UO) was established in 2007. Since December, 2008, it has been located on the 1st floor of the IBARAKI Quantum Beam Research Center (IQBRC) in Tokai-mura. UO operates the Tokai Dormitory for the users. In 2014, the Tokai Dormitory was added more 49 rooms, and had 100 rooms. UO provides on-site and WEB support with one-stop service for the utilization of the J-PARC with the cooperation of JAEA, KEK, Comprehensive Research Organization for Science and Society (CROSS), and the IBARAKI Prefecture Local Government. As of March 31, 2007, UO had 14 staffs and WEB SE – 4 staffs.

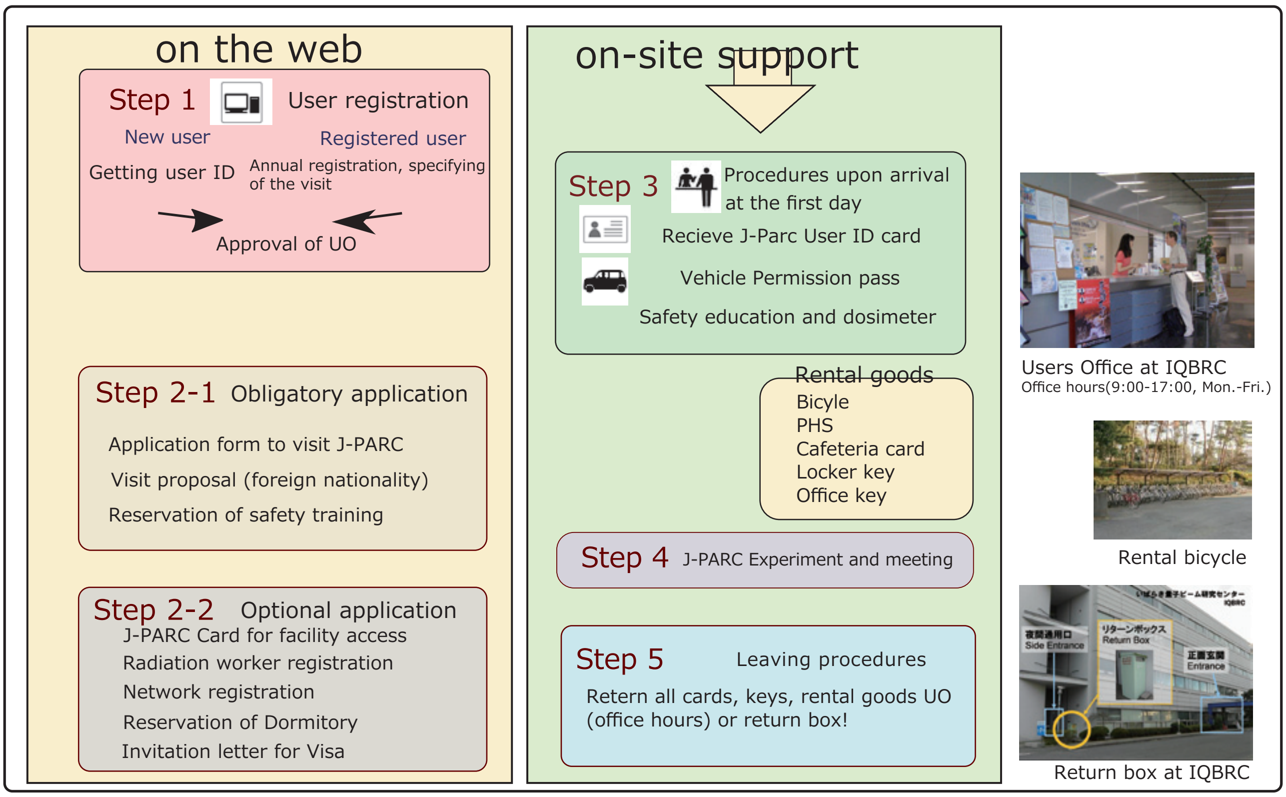
The J-PARC Users after approval of their experiment take administrative procedures on the Users Office (UO) WEB portal site, registration as a J-PARC User, radiation worker registration, safety education, accommodation, invitation letter for visa and other requirements. Then the UO staffs support them on e-mail base. After their arrival at the J-PARC, UO provides on-site support to the J-PARC Users and they receive the J-PARC ID, glass badge, and safety education.

写真の後列左から	Back(left to right)
磯崎　麻里（イソザキ　マリ）	Isozaki Mari
佐直　愛（サナオ　アイ）	SANAO Ai
荒川　正夫（アラカワ　マサオ）	ARAKAWA Masao
有賀　明日子（アリガ　アスコ）	ARIGA Asuko
山口　かおり（ヤマグチ　カオリ）	YAMAGUCHI Kaori
川上　めぐみ（カワカミ　メグミ）	KAWAKAMI Megumi
菊池　綾子（キクチ　アヤコ）	KIKUCHI Ayako
写真の前列左から	Front(left to right)
小林　さゆり（コバヤシ　サユリ）	KOBAYASHI Sayuri
木村　理恵（キムラ　リエ）	KIMURA Rie
國府田　一成（コクフダ　カズナリ）	KOKUFUDA Kazunari
鈴木　俊規（スズキ　トシノリ）	SUZUKI Toshinori
藤澤　貴子（フジサワ　タカコ）	FUJISAWA Takako
関　美幸（セキ　ミユキ）	SEKI Miyuki

Activities of UO

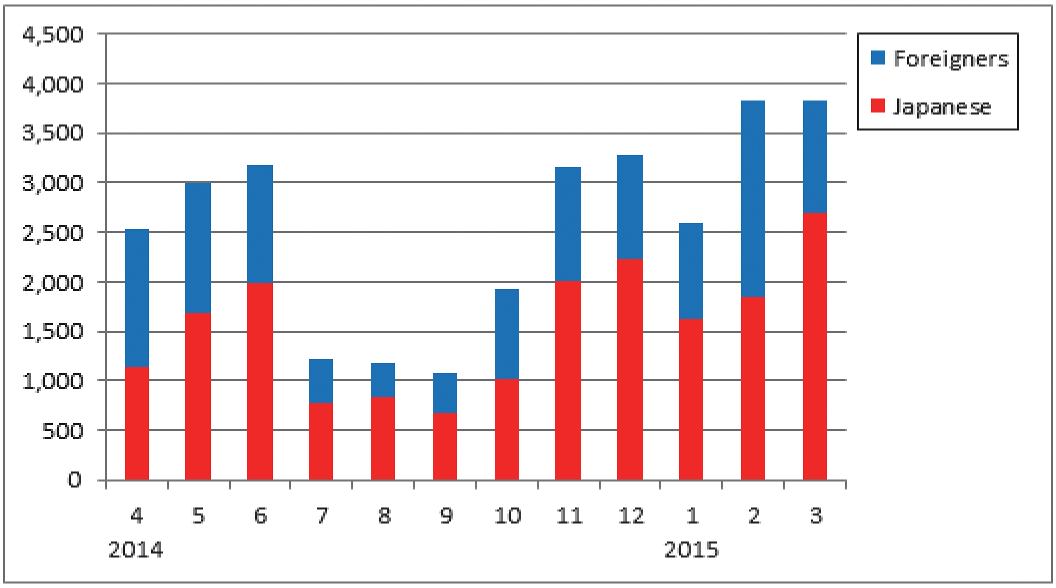


One-stop service for J-PARC users

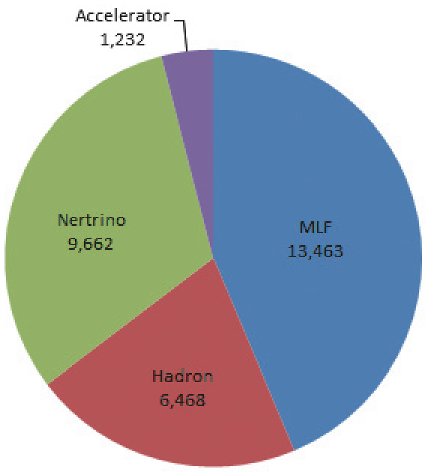


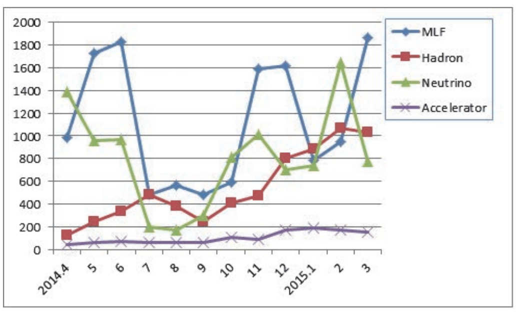
User Statistics

Users in 2014 (Japanese/Foreigners, person-days)

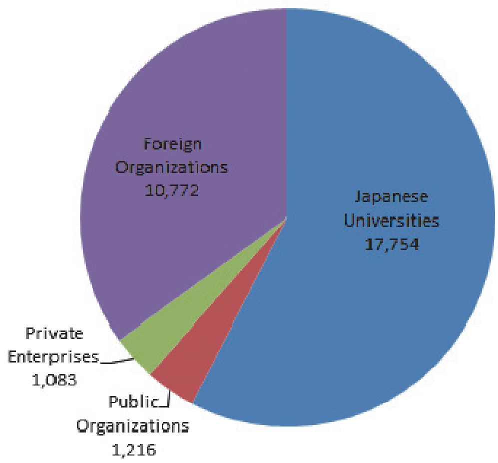


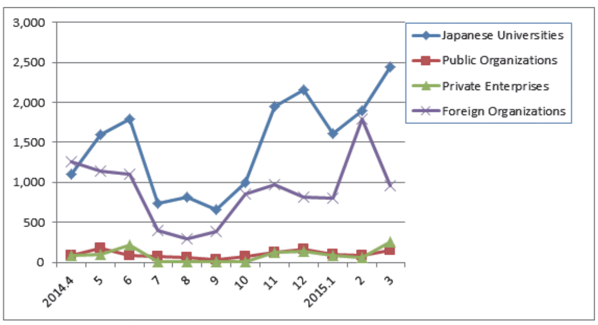
Users in 2014 (according to facilities, person-days)





Users in 2014 (according to organizations, person-days)





MLF Proposal Summary - FY2014

Table 1. Breakdown of Proposal Numbers for the 2014A & 2014B Rounds.

Beam-line	Instrument		2014A Submitted	2014A Approved	2014B Submitted	2014B Approved	Full Year Submitted			Full Year Approved		
			GU	GU	GU	GU	PU/S	IU	ES	PU/S	IU	ES
BL01	4D-Space Access Neutron Spectrometer - ***4SEASONS***		20(1)	14(1)	17(1)	13(1)	3	1	1	3	1	1
BL02	Biomolecular Dynamics Spectrometer - ***DNA***		18(1)	10(1)	23(1)	13(1)	3	2	0	3	2	0
BL03	Ibaraki Biological Crystal Diffractometer - ***iBIX***	(100-β)‡	6	2	8	2	0	0	0	0	0	0
		(β)†	0	0	0	0	15	0	0	9	0	0
BL04	Accurate Neutron-Nucleus Reaction Measurement Instrument - ***ANNRI***		6	6	12	10	1	1	0	1	1	0
BL05	Neutron Optics and Physics - ***NOP***		5	2	3	1	1	0	0	1	0	0
BL08	Super High Resolution Power Diffractometer - ***S-HRPD***		15	8	14	10	1	0	1	1	0	1
BL09	Special Environment Neutron Powder Diffractometer - ***SPICA***		0	0	0	0	1	0	0	1	0	0
BL10	Neutron Beamline for Observation and Research Use - ***NOBORU***		21	10	26	11	2	1	0	2	1	0
BL11	High-Pressure Neutron Diffractometer - ***PLANET***		14	11	9(1)	9(1)	0	1	0	0	1	0
BL12	High Resolution Chopper Spectrometer - ***HRC***		9	5	12(2)	8(2)	1	0	0	1	0	0
BL14	Cold-neutron Disk-chopper Spectrometer - ***AMATERAS***		21	7	29	9	2	1	2	2	1	2
BL15	Small and Wide Angle Neutron Scattering Instrument - ***TAIKAN***		37(2)	18(2)	40	15	5	1	3	5	1	3
BL16	High-Performance Neutron Reflectometer with a horizontal Sample Geometry - ***SOFIA***		11	10	7	7	1	0	0	1	0	0
BL17	Polarized Neutron Reflectometer - ***SHARAKU***		20	14	12(1)	12(1)	1	1	1	1	1	1
BL18	Extreme Environment Single Crystal Neutron Diffractometer - ***SENJU***		24	7	25(1)	10(1)	3	3	0	3	3	0
BL19	Engineering Diffractometer - ***TAKUMI***		25	15	28	13	3	1	2	3	1	2
BL20	Ibaraki Materials Design Diffractometer - ***iMATERIA***	(100-β)‡	16	7	9	9	0	0	0	0	0	0
		(β)†	14	14	7	7	14	0	0	13	0	0
BL21	High Intensity Total Diffractometer - ***NOVA***		21	13	14	8	1	0	1	1	0	1
D1	Muon D1		21(1)	16(1)	34(2)	16(2)	0	1	0	0	1	0
D2	Muon D2		11	10	13(1)	9(1)	0	1	0	0	1	0
U	Muon U		0	0	0	0	1	0	0	1	0	0
Total			**335**	**199**	**342**	**192**	**59**	**15**	**11**	**52**	**15**	**11**

GU : General Use **PU** : Project Use or Ibaraki Pref. Project Use **S** : S-type Proposals
IU : Instrument Group Use **ES** : Element Strategy
† : Ibaraki Pref. Exclusive Use Beamtime (β = 80% in FY2014)
‡ : J-PARC Center General Use Beamtime ((100-β = 20% in FY2014)
( ) : Proposal Numbers under Trial Use Access System or P-type proposals (D1, D2) in GU

J-PARC PAC Approval Summary after the 19th Meeting

	(Co-) Spokespersons	Affiliation	Title of the experiment	Approval status (PAC recommendation)	Slow line priority Day1?	Slow line priority Day1 Priority	Beamline
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 Higer priority than E31	Day1	1	K1.8
E06	J. Imazato	KEK	Measurement of T-violating Transverse Muon Polarization in $K^+ \to \pi^0 \mu^+ \nu$ Decays	Stage 1			K1.1BR
E07	K. Imai, K. Nakazawa, H. Tamura	JAEA, Gifu U, Tohoku U	Systematic Study of Double Strangeness System with an Emulsion-counter Hybrid Method	Stage 2 Highest priority for test			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 $K_L \to \pi^0 \nu \bar{\nu}$ 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 ^{3}He(K^-, n) reaction	Stage 2	Day1		K1.8BR

	(Co-) Spokespersons	Affiliation	Title of the experiment	Approval status (PAC recommendation)	Slow line priority		Beamline
					Day1?	Day1 Priority	
E16	S. Yokkaichi	RIKEN	Electron pair spectrometer at the J-PARC 50-GeV PS to explore the chiral symmetry in QCD	Stage 1 Stage 2 deffered			High p
E17	R. Hayano, H. Outa	U Tokyo, RIKEN	Precision spectroscopy of Kaonic ^{3}He 3d → 2p X-rays	Stage 2 Update the proposal	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
E19	M. Naruki	KEK	High-resolution Search for Θ^+ Pentaquark in $\pi^- p \to K^- X$ Reactions	Stage 2	Day1		K1.8
E21	Y. Kuno	Osaka U	An Experimental Search for μ - e Conversion at a Sensitivity of 10^{-16} with a Slow-Extracted Bunched Beam	Stage 1 Stage 2 deffered			COMET
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 (coord'ed by JPNC)			K1.8BR
E26	K. Ozawa	KEK	Search for ω-meson nuclear bound states in the $\pi^- + {}^AZ \to n + {}^{(A-1)}{}_{\omega}(Z-1)$ reaction, and for ω mass modification in the in-medium $\omega \to \pi^0 \gamma$ 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 $\bar{p} + {}^AZ \to \phi + {}^{(A-1)}(Z-1)$ 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 Pilot run approved with			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			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 $\Gamma(K+ \to e+ \nu)/\Gamma(K+ \to \mu+ \nu)$ 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 Stage 2 deffered			K1.8
P41	M. Aoki	Osaka U	An Experimental Search for μ - 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			K1.1BR
P50	H. Noumi	Osaka U	Charmed Baryon Spectroscopy via the (π,D*-) reaction	Stage 1 status			High p
T51	S. Mihara	KEK	Research Proposal for COMET(E21) Calorimeter Prototype Beam Test	Test Experiment			K1.1BR
T52	Y. Sugimoto	KEK	Test of fine pixel CCDs for ILC vertex detector	Test Experiment			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			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			K1.1BR
T55	A. Toyoda	KEK	Second Test of Aerogel Cherenkov counter for the J-PARC E36 experiment	Test Experiment			K1.1BR
P56	T. Maruyama	KEK	A Search for Sterile Neutrino at J-PARC Materials and Life Science Experimental Facility	Deferred			MLF
P57	J. Zmeskal	Stefan Meyer Institute for Subatomic Physics	Measurement of the strong interaction induced shift and width of the 1s state of kaonic deuterium at J-PARC	Deferred Update the proposal			K1.8BR
P58	M. Yokoyama	U. Tokyo	A Long Baseline Neutrino Oscillation Experiment Using J-PARC Neutrino Beam and Hyper-Kamiokande	Deferred			neutrino
T59	A. Minamino	Kyoto U	A test experiment to measure neutrino cross sections using a 3D grid-like neutrino detector with a water target at the near detector hall of J-PARC neutrino beam-line	To be arranged by IPNS and KEK-T2K			neutrino monitor bld
T60	T. Fukuda	Toho U	Proposal of an emulsion-based test experiment at J-PARC	To be arranged by IPNS and KEK-T2K			neutrino monitor bld

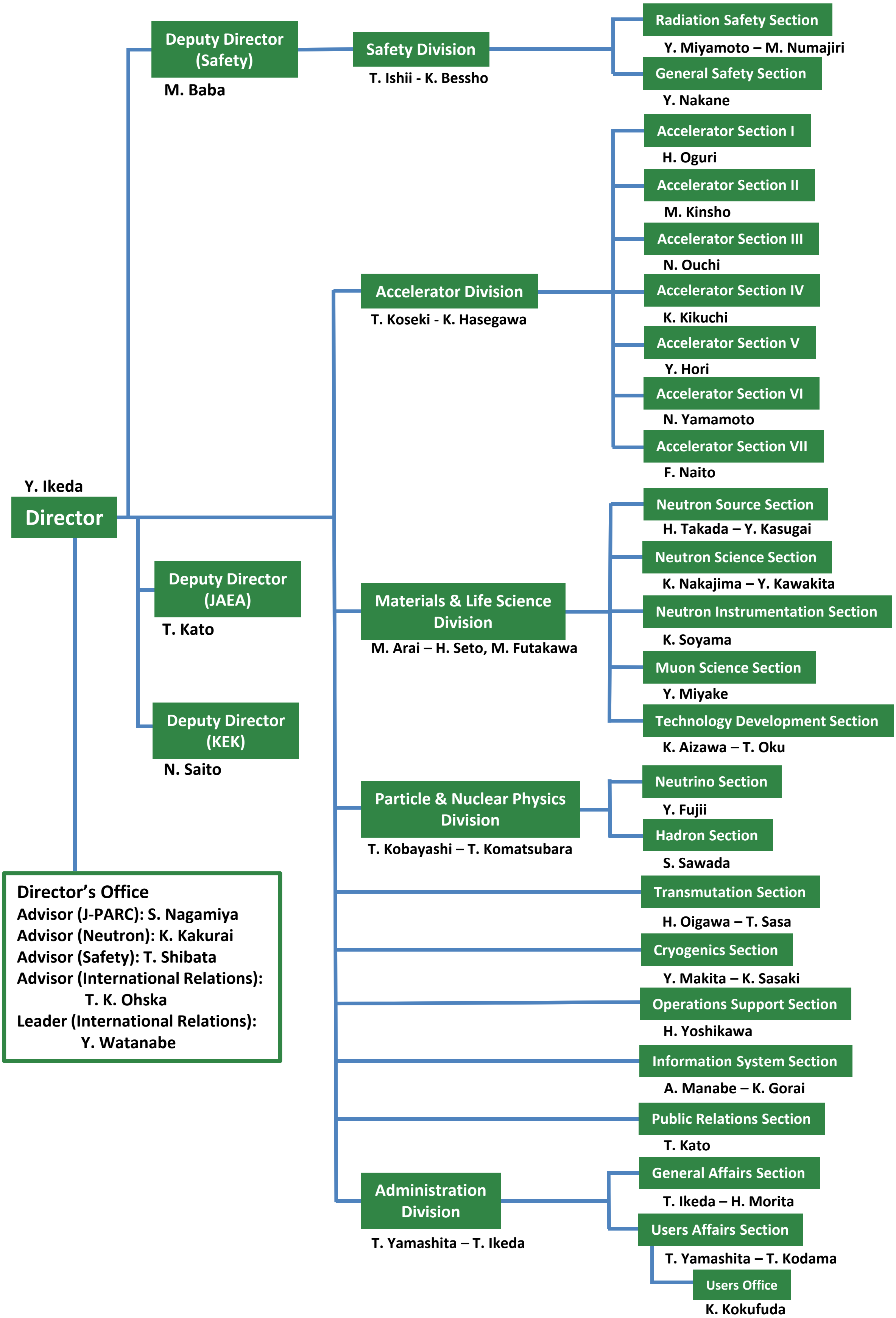
Organization and Committees

Organization Structure

J-PARC Center Management System Chart

as of April 1, 2014

When applicable: Head – Deputy Head / Leader – Sub Leader



Members of the Committees Organized for J-PARC

(as of March, 2015)

1) Steering Committee

Yuji Fujita	Japan Atomic Energy Agency, Japan
Yujiro Ikeda	J-PARC Center, Japan
Hisayoshi Ito	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
Yukio Oyama	Japan Atomic Energy Agency, Japan
Takayuki Sumiyoshi	High Energy Accelerator Research Organization, 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

Jean-Michel Poutissou	TRIUMF, Canada
Hiroshi Amitsuka	Graduate School of Science, Hokkaido University, Japan
Thomas Roser	Brookhaven National Laboratory, USA
Shinian Fu	Institute of High Energy Physics, China
Sergio Bertolucci	the European Organization for Nuclear Research(CERN), Switzerland
Robert Tschirhart	Fermi National Accelerator Laboratory, USA
Robert Tribble	Brookhaven National Laboratory, USA
Donald F. Geesaman	Argonne National Laboratory, USA
Horst Stoecker	GSI Helmholtzzentrum für Schwerionenforschung GmbH, Germany
Hajimu Yamana	Research Reactor Institute, Kyoto University, Japan
	Nuclear Damage Compensation and Decommissioning Facilitation Corporation, Japan
Hamid Aït Abderrahim	SCK • CEN, Belgium
Joël Mesot	Paul Scherrer Institute, Switzerland
Hidetoshi Fukuyama	Research Institute for Science & Technology, Tokyo University of Science, Japan
Robert Robinson	Bragg Institute, Australian Nuclear Science and Technology Organisation, Australia
Andrew Dawson Taylor	National Laboratories, Science and Technology Facilities Council, UK

3) User Consultative Committee for J-PARC

Masatoshi Arai	Japan Atomic Energy Agency, Japan
Yasuhiko Fujii	CROSS, 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
Yamada Yoshiyuki	Central Research Laboratory, Hitachi, Ltd., Japan
Taku Sato	Tohoku University, Japan
Tanaka Kazuhiro	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

Marc Schyns	SCK • CEN, Belgium
Eric Pitcher	European Spallation Source ESS AB, Sweden
Yacine Kadi	CERN, Switzerland
Yoshiaki Kiyanagi	Graduate School of Engineering, Nagoya University, Japan
Toshikazu Takeda	Reserch Instutute of Nuclear Engineering, University of Fukui, Japan
Juergen Konys	Institute for Applied Materials Materials Process Technology, Karlsruhe Institute of Technology, Japan
Minoru Takahashi	Research Laboratory for Nuclear Reactors, Tokyo Institute of Technology, Japan
Jie Wei	Michigan State Univ., USA
Robert Zwaska	Fermi National Accelerator Laboratory, USA
Simone Gilardoni	European Organization for Nuclear Research (CERN), Switzerland

5) Neutron Advisory Committee

Robert McGreevy	Rutherford Appleton Laboratory, UK
Bertrand Blau	Paul Scherrer Institut (PSI), Switzerland
John D Galambos	Oak Ridge National Laboratory, USA
Yoshiaki Kiyanagi	Nagoya University, Japan
Dan Alan Neumann	National Institute of Standards and Technology, USA
Jamie Schulz	Australian Nuclear Science and Technology Organization (ANSTO), Australia
Dimitri Argyriou	ESS AB, Sweden
Chang Hee Lee	Korea Atomic Energy Research Institute, Korea
Toshiji Kanaya	Institute for Chemical Research, Kyoto University, Japan
Mitsuhiro Shibayama	Institute for Solid State Physics, Tokyo University, Japan

6) Muon Science Advisory Committee

Hiroshi Amitsuka	Hokkaido University, Japan
Toshiyuki Azuma	RIKEN, Japan
Klaus P. Jungmann	University of Groningen, Netherlands
Elvezio Morenzoni	Paul Scherrer Institute, Switzerland
Yasuo Nozue	Osaka University, Japan
Francis Pratt	ISIS, UK
Jeff E. Sonier	Simon Fraser University, Canada
Jun Sugiyama	Toyota Centaral R & D Labs., Inc., Japan

7) Radiation Safety Committee

Seiichi Shibata	RIKEN, Japan
Yoshitomo Uwamino	RIKEN, Japan
Yoshihiro Asano	RIKEN, Japan
Tetsuo Noro	Kyushu University, Japan
Murakami Takeshi	National Institute of Radiological Science, Japan
Hitoshi Kobayashi	High Energy Accelerator Research Organization, Japan
Yoshihito Namito	High Energy Accelerator Research Organization, Japan
Shinichi Sasaki	High Energy Accelerator Research Organization, Japan
Kazuo Minato	Japan Atomic Energy Agency, Japan
Takeshi Maruo	Japan Atomic Energy Agency, Japan
Michio Yoshizawa	Japan Atomic Energy Agency, Japan

8) MLF Advisory Board

Jun AKIMITSU	Aoyama Gakuin University
Koichiro ASAHI	Tokyo Institute of Technology
Mikio KATAOKA	Nara Institute of Science and Technology
Toshiji KANAYA	Kyoto University
Taku SATO	Tohoku University
Mitsuhiro SHIBAYAMA	The University of Tokyo
Masaaki SUGIYAMA	Kyoto University
Makoto HAYASHI	IBARAKI Prefectural Government
Toshio YAMAGUCHI	Fukuoka University
Masahiko IWASAKI	RIKEN
Youji KOIKE	Tohoku University
Jun SUGIYAMA	Toyota Central R&D Labs., Inc.
Yasuhiko FUJII	Comprehensive Research Organization for Science and Society
Masatoshi ARAI	Japan Atomic Energy Agency
Takashi KATO	Japan Atomic Energy Agency
Masatoshi FUTAKAWA	Japan Atomic Energy Agency
Kazuya AIZAWA	Japan Atomic Energy Agency
Masayasu TAKEDA	Japan Atomic Energy Agency
Yukinobu KAWAKITA	Japan Atomic Energy Agency

Hideki SETO	High Energy Accelerator Research Organaization
Takashi KAMIYAMA	High Energy Accelerator Research Organaization
Toshiya OTOMO	High Energy Accelerator Research Organaization
Yasuhiro MIYAKE	High Energy Accelerator Research Organaization
Ryosuke KADONO	High Energy Accelerator Research Organaization
Shinichi ITOH	High Energy Accelerator Research Organaization
Toshio AKAI	MCHC R&D Synergy Center, Inc.
Shin-ichi KAMEI	Mitubishi Reserch Institute, Inc.
Naoki KISHIMOTO	National Institute for Material Science
Masaki TAKADA	RIKEN
Kiyoyuki TERAKURA	National Institute of Advanced Industrial Science and Technology
kazumi NISHIJIMA	Mochida Pharmaceutical co.,Ltd.
Hidetoshi FUKUYAMA	Tokyo University of Science
Kazuyoshi YAMADA	High Energy Accelerator Research Organaization
Yujiro IKEDA	Japan Atomic Energy Agency
Hideaki YOKOMIZO	Comprehensive Research Organization for Science and Society
Wataru Utsumi	Japan Atomic Energy Agency

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

Gino Isidori	Frascati National Laboratories, Italy
William A. Zajc	Columbia University, Columbia
Simon I. Eidelman	Budker Inst. of Nuclear Physics, Russia
Tetsuo Hatsuda	RIKEN, Japan
Kazunori Hanagaki	Osaka University, Japan
Edward C. Blucher	University of Chicago, USA
Thomas E. Browder	University of Hawaii, USA
William C. Louis	Los Alamos National Laboratory, USA
Wolfram Weise	European Center for Theoretical studies in Nuclear Physics and Related Areas, Italy
Ken-ichi Imai	Kyoto University, Japan
Kunnio Inoue	Tohoku University, Japan
Hiroyoshi Sakurai	University of Tokyo, Japan
Hajime Shimizu	Tohoku Univerisity, Japan
Akinobu Dote	High Energy Accelerator Research Organization, Japan
Junji Haba (Chairperson)	High Energy Accelerator Research Organization, Japan

Main Parameters

Present main parameters of Accelerator

Linac	
Acclerated Particles	Negative hydrogen
Energy	400 MeV
Peak Current	30 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*	
Open for User Program (General Use)	18
Under Commissioning/Construction	0/3
Muon Instruments*	
Open for User Program (General Use)	2

(* As of March, 2015)

Events

Events

2014 Workshop for Fostering Safety Culture at J-PARC (May 23)

In order to further improve the safety awareness and prevent the memories of the radioactive leak incident at the Hadron Experimental Facility in 2013 from fading away, J-PARC decided to hold a Workshop for Fostering Safety Culture every year in May. On May 23, the first workshop was held at the auditorium of the Nuclear Science Research Institute (JAEA-Tokai and broadcasted via TV to auditoriums at the Tsukuba and Tokai Campuses of the High Energy Accelerator Research Organization (KEK). At the workshop, J-PARC members reported on the safety progress in the year following the incident, the status of the renovation work at the Hadron Experimental Facility, plans for the future, and other topics. In addition, the journalist Naoyuki Uchimura, a member of the External Expert Panel for reviewing the incident, gave a talk entitled "Re-examining 'Research Facilities and Safety Culture'."

Mr. Uchimura interviewed participants after his talk

Operation of Neutrino Experimental Facility Resumes (May 26)

At the Neutrino Experimental Facility, tests to evaluate the performance started on May 16 and the user operation was resumed on May 26. Before that, on the 22nd at the Tokai Campus of KEK, an explanatory meeting prior to resumption of the neutrino experiment was held for the press.

24th Meeting of "Science Cafe at Ricotti" (June 21)

At the "Science Cafe", organized by the Japan Atomic Energy Agency (JAEA), J-PARC's public relations advisor Dr. Shinichi Sakamoto gave a talk for the general public incorporating unique experiments. The talk was entitled "The mysteries of Neutrinos and the Higgs Particle", and covered the latest discoveries in particle physics. There was a lively question-and-answer session afterward to wrap up this worthwhile meeting.

"Science Cafe" at Ricotti

The 2nd International Symposium on Science at J-PARC 2014 (July 12-16)

The J-PARC Center held this symposium at the Tsukuba International Congress Center, which started on July 12 with a public lecture entitled "Unveiling the Mysteries of the Universe" and continued for five days until the 16th. On the first day, a public lecture was held, for which as lecturers were invited Dr. Ulrich Walter, Professor at the Technical University of Munich, who became the first German astronaut after obtaining his doctorate for neutron research, and Dr. Masaru Tada who is involved in the neutrino oscillation experiment at J-PARC. The lecture was attended by 212 persons in total. The main symposium covered five fields: accelerators, particle and nuclear physics, materials and life science, nuclear transmutation, and safety and advanced technology for the intensity frontier. There was a total of 137 oral presentations, including 13 keynote lectures, and 245 poster presentations attracting 550 participants from 20 countries.

Participants in the symposium

Science Tour (July 12)

With support from the Tokai Village, the J-PARC Center organized a science tour for junior and senior high school students living in the Tokai Village to help develop their interest in science. During this tour, the students visited Japan Aerospace Exploration Agency (JAXA) and participated in a public lecture at the J-PARC International Symposium.

Participants at display space in JAXA

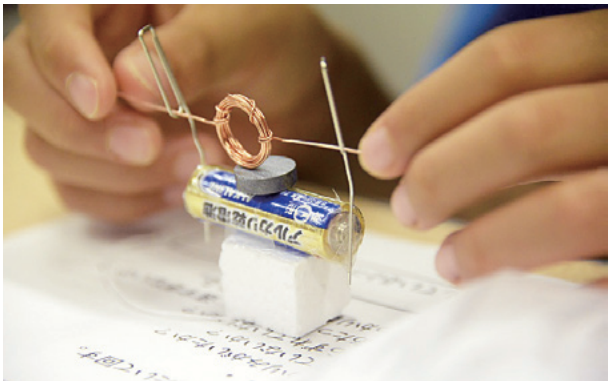
J-PARC Scientists Teach at the Tokai-mura Summer School (July 24)

In order to deepen the interest in science, the Tokai Village organized a "science summer school" for first-year students of two junior high schools in the village. Four lectures were given by young researchers who are active at J-PARC and JAEA. From J-PARC, Dr. Masaru Tada of the Neutrino Section and Dr. Seiko Kawamura of the Neutron Science Section gave a talk to 400 students in total.

Summer school at Ricotti

J-PARC Hello Science -"Feel the Power of Electricity and Magnetism!" Summer Workshop for Children- (August 6 and 9)

J-PARC held a science project workshop called "J-PARC Hello Science" for fifth and sixth-year students from elementary schools in the village. First, the J-PARC public relations advisor, Dr. Shinichi Sakamoto, explained the power of electricity to the children in an easy-to-understand way through quizzes and experiments in which static electricity was used to move and rotate familiar objects. Then the students worked to make a "pendulum bell" using static electricity, and a "clip motor" using enamel wire and a magnet. The participating children received support from the staff, and had fun working on their projects.



Clip motor: A coil rotates in a magnetic field

Ozora Marche at the Muramatsu-san Kokuzodo Temple (October 12)

This event was held by the Tokai Sightseeing Guide for passing the culture and history of the Tokai Village to the next generation. J-PARC participated in the event for the first time and set up a "Science Experiment Corner," where flowers, rubber balls and other items were frozen by liquid nitrogen, and a superconductor was cooled and ran along a rail made of magnets. Many people participated, ranging in age from children to adults, and experienced the unusual low-temperature world.

Rubber ball frozen by liquid N2

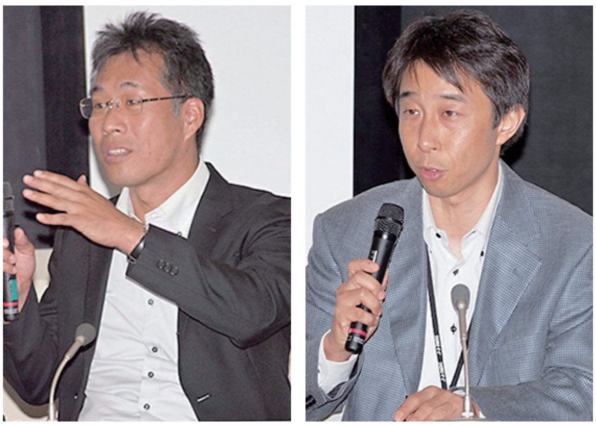
21st International Collaboration on Advanced Neutron Source ICANS-XXI (September 29 to October 3)

This event was held at the Ibaraki Prefectural Culture Center, and included about 220 researchers from major research institutions and facilities from eight countries, involved in nuclear spallation neutron sources. There were 210 presentations in 11 workshops for each area of research, and a “Blue Sky Session” for brainstorming where participants in the hall joined the discussion. On the final day, approximately 90 people participated in the J-PARC tour, in which they took a closer look at the experimental equipment.

Participants of the ICANS XXI

Takashi Kobayashi, jointly received the Nishina Memorial Prize 2014

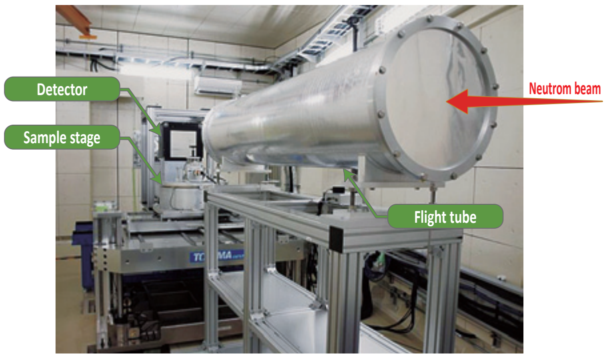
Professor Takashi Kobayashi, Head of the Particle and Nuclear Physics Division of J-PARC, received the Nishina Memorial Prize for 2014 jointly with Professor Tsuyoshi Nakaya of Kyoto University for their achievement in discovering the phenomenon in which electron neutrinos appear from a beam of muon neutrinos in the T2K Experiment. The Nishina Memorial Prize is awarded to researchers who have achieved outstanding research results related to atomic physics and its applications.



Prof. Kobayashi (left) and Prof. Nakaya (right)

Successful First Beam Extraction from the Pulsed Neutron Imaging Instrument (November 7)

On November 7, neutron beam extraction was successfully achieved for the first time at the world’s first Energy Resolved Neutron Imaging System (BL22: RADEN), which has been newly installed at the Materials and Life Science Experimental Facility. RADEN is a system which enables non-destructive observation inside matter using neutron beams.



The inside of the RADEN measuring room

Completion of the Tokai Dormitory II Building

The 51-room expansion of the Tokai Dormitory facilities for lodging of J-PARC users has been completed and the number of rooms doubled to 100.

Seventh Meeting of the External Expert Panel to Review the Incident at the Hadron Experimental Facility (October 29)

On October 29, the 7th External Expert Panel to review the radioactive material leak incident at the J-PARC Hadron Experimental Facility was held in Tokyo. The J-PARC Center reported on topics such as the safety management system review and the facility renovation work based on measures to prevent recurrence submitted by the panel in August last year. As a result of a general review, it was confirmed that the efforts are being properly carried out, and that the restarting of the facilities was justified. The panel proposed that we explain the matters to the local residents and obtain their understanding, and that we ensure continued awareness of crisis management.

The 7th external expert panel meeting

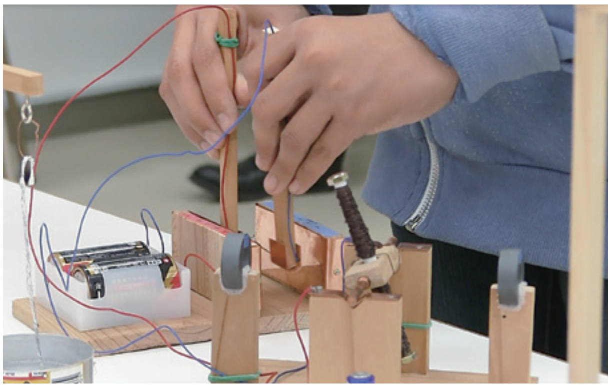
MLF School 2014 (December 16-19)

The 2nd MLF School for experiencing neutron and muon experiments was held at the MLF. It was for graduate students, young researchers and others who are new to the MLF and interested in its experiments. There were 22 participants including some from overseas.

Participants of the school and J-PARC staff

Hello Science School (December 15)

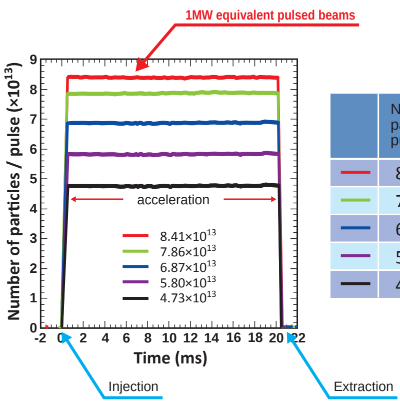
A science experiment school was held jointly with the Tokai Village for junior high school students from the local area. The participating students were given an easy-to-understand explanation of topics such as the principle of operation of the huge accelerator research instrument, while using experimental equipment constructed from familiar materials.



Basics of a motor were taught with handmade experimental equipment

Success in Transporting 1-MW Equivalent Beam to the MLF Target by 3-GeV Synchrotron (January 10)

The acceleration of pulsed proton beams to 1-MW equivalent, the designed value, was successfully demonstrated at the J-PARC's second accelerator, the 3-GeV synchrotron (Rapid Cycling Synchrotron: RCS). Extracting the beams without significant beam losses was also successful. Further beam studies would be carried out in order to increase the proton beam power in stages and eventually achieve a stable 1 MW beam supply to users.



	Number of particles per pulse	Corresponding power value in 25 Hz operation
— (red)	8.41×10^{13}	1010 kW
— (green)	7.86×10^{13}	944 kW
— (blue)	6.87×10^{13}	825 kW
— (purple)	5.80×10^{13}	696 kW
— (black)	4.73×10^{13}	568 kW

Values on RCS current monitor
Horizonral axis: time (ms)
Vertical axis: Number of particles per pulse ($\times10^{13}$)

SAT Technology Showcase 2015 (January 21)

This event was held at the Tsukuba International Congress Center by the Science Academy of Tsukuba (SAT) aiming to provide a venue for networking, exchange of information and other beneficial interaction among researchers and engineers in a wide range of fields. J-PARC Center showcased its facilities and covered related topics using models, panels, and PR DVDs.

At the J-PARC booth

Second Symposium on Safety in Accelerator Facilities (March 6)

The J-PARC Center held this symposium gathering approximately 120 participants, about half of whom were from outside of the organization, including persons in charge of accelerator safety at universities and accelerator facilities inside and outside of Japan. Information was exchanged about the recovery and the lessons learned from the J-PARC incident, and about the best approaches to ensure safety when using accelerator facilities.

The symposium at the auditorium of the Nuclear Science Research Institute

6th MLF Symposium (March 17-18)

This symposium was held jointly with other events such as the Science Festa of the Institute of Materials Structure Science of KEK and Photon Factory Symposium. Over 570 participants took part in the event. At the MLF symposium, there were reports on the efforts to increase beam intensity and related topics, and presentations on the results of user experiments.

Participants of three meetings

Science Cafe in Ricotti (March 14)

Dr. Shinichi Sakamoto, a J-PARC's public relations advisor, and Professor Toru Ishigaki of the Frontier Research Center for Applied Atomic Sciences, Ibaraki University, provided a general introduction to the types of research that can be done using neutrons, and how the results of that research are useful in our daily life and instruments.

Science cafe

Visitors

David MacFarlane and others, Committee member of the Japan/US Cooperation Program in the Field of High Energy Physics (April 26)

Genichiro Fukuchi and others, Members of Ibaraki Prefectural Assembly (May 21)

Yves Brèchet, Haut-commissaire à l'énergie atomique, France (May 27)

Delegation from the National Environment Agency of Singapore (May 27)

Mikito Kusuda, Vice Governor of Ibaraki Prefecture (May 28)

Hakubun Shimomura, Minister of Education, Culture, Sports, Science and Technology (July 7)

Tsutomu Tomioka, Parliamentary Vice-Minister, MEXT (August 6)

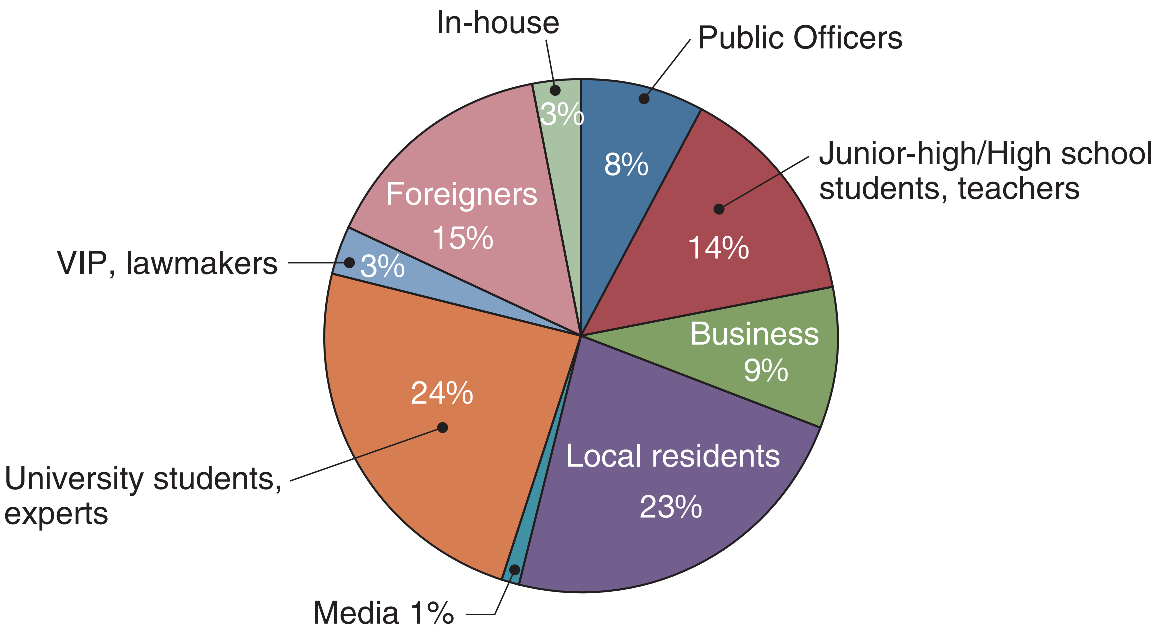
Harriet Kung, Associate Director of Science for Basic Energy Sciences, US Department of Energy, Chi-Chang Kao, Director, SLAC National Accelerator Laboratory, and others (October 21)

Kwadwo Osseo-Asare, Professor, Pennsylvania State University (November 7)

Bonnie Jenkins, Ambassador, Coordinator for Threat Reduction Programs in the Bureau of International Security and Nonproliferation, U.S. Department of State and Sugeng Sumbarjo, Acting Deputy Chairman for Licensing and Inspection, Indonesia Nuclear Energy Regulatory Agency (BAPETEN) (December 4)

There were 3,136 visitors to J-PARC for the period from April, 2014, to the end of March, 2015.

In FY2014, the number of visitors increased by 46% compared to the previous fiscal year.



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A-002
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Ohisa, S. *et al*.
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A-005
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Anal. Chem., Vol 86, 12030 (2014)

A-006
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A-007
Akutsu, K. *et al*.
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A-014
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A-050
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Synergistic Adsorption of MIBC/CTAB Mixture at the Air/Water Interface and Applicability of Gibbs Adsorption Equation
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Mater. Sci. Forum., Vol 778, p. 883

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Harada, H. *et al*.
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STABILIZATION OF BEAM INSTABILITIES BY INTRA-BUNCH FEEDBACK SYSTEM AT J-PARC MR
Proc. of 11th Annual Meeting of Particle Accelerator Society of Japan, p. 67

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THE PERFORMANCE OF A NEW FIRST EXTRACTION SEPTUM MAGNET FOR UPGRADE OF J-PARC MR
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Kamikubota, N. *et al*.
NEW SURVEILLANCE SYSTEM TO ENHANCE SAFETY OF J-PARC ACCELERATORS
Proc. of 11th Annual Meeting of Particle Accelerator Society of Japan, p. 224

C-125
Okada, M. *et al*.
DEVELOPMENT OF THE DLC COATED BEAM EXCITER
Proc. of 11th Annual Meeting of Particle Accelerator Society of Japan, p. 242

C-126
Sato, Y. *et al*.
HIGH POWER BEAM OPERATION OF THE J-PARC MAIN RING
Proc. of 11th Annual Meeting of Particle Accelerator Society of Japan, p. 245

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Ohmori, C. *et al*.
RADIATION DAMAGE MEASUREMENTS OF FET'S USING A RADIATION MONITOR, RADMON FOR LIU
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Proc. of 11th Annual Meeting of Particle Accelerator Society of Japan, p. 312

C-129
Oguri, H. *et al*.
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Proc. of 11th Annual Meeting of Particle Accelerator Society of Japan, p. 389

C-130
Liu, Y. *et al*.
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C-131
Igarashi, S. *et al*.
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C-132
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Satou, K. *et al*.
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C-139
Miyao, T. *et al*.
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Toyama, T. *et al*.
BEAM-BASED ALIGMNENT OF THE BPMS AT J-PARC MR
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C-141
Sawabe, Y. *et al*.
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Yamamoto, K. *et al*.
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Nomura, M. *et al*.
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C-152
Tamura, F. *et al*.
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C-163
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