IV. Department of Engineering and Technical Services

The Department of Engineering and Technical Services is involved in a wide range of work in the design, fabrication, construction, and operation of experimental devices in the fields of software and hardware.

This department is composed of engineers, and their tasks fall under the following five goals:

1) To develop advanced and systematic engineering capabilities on the basis of basic engineering results which have been obtained thus far.
2) To nourish excellent engineers.
3) To cultivate creative engineering abilities and skills.
4) To improve the documentation and the transfer of engineering knowledge to the next generation.
5) To perform tasks.

The department consists of the following five divisions. The Fabrication Technology Division oversees the construction of small devices and quality control of parts for all divisions. The Device Technology Division works on the Large Helical Device (LHD) and its peripheral devices except for heating devices and diagnostic devices. The Plasma Heating Technology Division supports the ECH system, the ICRF system, and the NBI system. The Diagnostic Technology Division develops, operates, and maintains all diagnostic devices. And the Control Technology Division concentrates on the central control system, the cryogenic system, the current control system, and the NIFS network. The total number of staff is 45 engineers and 12 part-time workers. We take care of the development, the operation, and the maintenance of the LHD and its peripheral devices with approximately 45 engineers.

1. Fabrication Technology Division

The main work of this division is the fabrication of experimental equipment. We also take care of technical consultation and experimental parts supplies related to the LHD experiment. In addition, we manage the administrative procedures of the department.

The number of machined requests was 122, and the total number of production parts was 507 in this fiscal year (FY). The total number of electronic engineering requests and articles were 11 and 31, respectively. The details of some of this division's activities follow below. In addition, we also support the LHD experiments through the servicing of devices.

(1) The trial manufacture of the high-speed AD conversion board

The prototype of the 12bit 500MHz sample/sec 2ch AD converter circuit for the Thomson-scattering diagnostics was made on an experimental basis, secondary to last year. Based on combination of the commercial evaluation boards, the first prototype of a 6-layered printed circuit board (Fig. 1) was designed. The functional test of this board was continued.

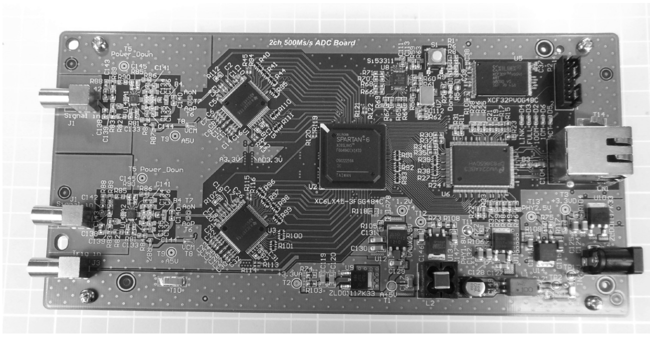

Fig. 1. The first prototype board of the high speed AD converter.

(2) The 1.25 inch corrugated miter bend for microwave at the frequency of 245 GHz

The corrugated miter bend (Fig. 2) is a component of the vacuum waveguide system that is installed in the part of the 90 degrees bend. In order to improve the transmission efficiency of the 1.25 inch-corrugated waveguide, it is necessary to cut corrugated slots on the surface of the inside diameter of the miter bend. Parameters of the rectangular corrugation are a width of 0.14mm and a depth 0.25mm, and the periodic length is 0.45mm.

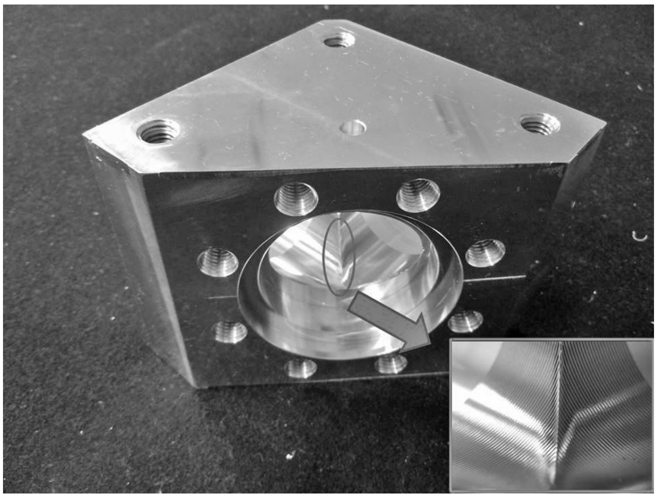

Fig. 2. The miter bend.

(3) A plural target of HIBP ion gun

The HIBP ion gun had to change the ion species according to the magnetic field condition of LHD and for the target for measurement. A period of several days was necessary for change in the incident ion kind with the atmosphere release work, up to now. By the changing of the ion species about 2 minutes became possible to use this improved ion target (Fig. 3) while maintaining the chamber's vacuum position.

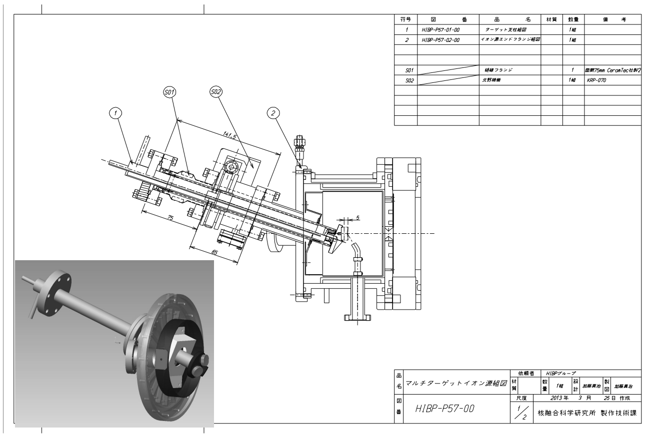

Fig. 3. A plan for multi-target.

2. Device Technology Division

The Device Technology Division supports the operation, the improvement, and the maintenance in LHD.

(1) Protection of the ECH launcher facing wall in LHD

The new ECH launcher system at the 2-O port has been installed. For ensuring the safety implementation of the ECH beam injection, the ECH-facing wall protection has been enhanced, as shown in Fig. 4.

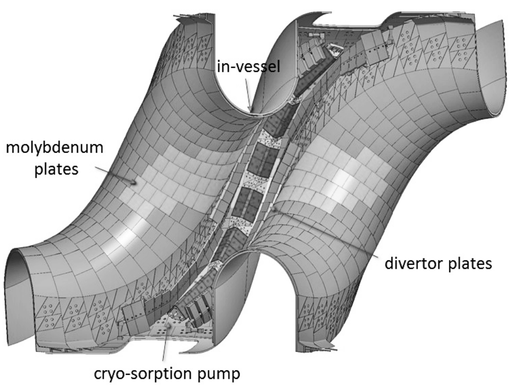

Fig. 4. A schematic view of inboard side of the vacuum vessel with the target area of the ECH beam irradiation.

The cross section view of the ECH launcher-facing area is shown in Fig. 5. A part of the first wall and the divertor are located in the target area of the ECH beam irradiation. In order to prevent damage to the first wall improving heat resistance, the stainless steel first wall plates have been replaced with the molybdenum plates. A gap between the first wall and the divertor at the torus is protected by the L-shaped molybdenum plates, which are fabricated under high temperature conditions at 500 - 600 degrees Celsius.

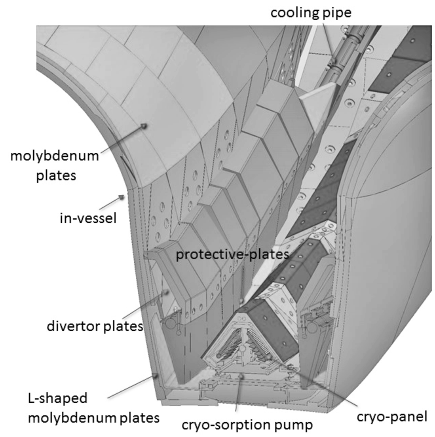

Fig. 5. A cross section of the ECH launcher facing wall.

The divertor plates and the newly-developed cryo-sorption pump are in the divertor region. The front surface of the cryo-sorption pump was covered with protective-plates made by Carbon Fiber Composite (CFC). The protective-plates of the cryo-sorption pump and the L-shaped first wall are overlapped so as to interrupt the line of a sight from the ECH launcher to the vacuum vessel. The configuration of the divertor plates were rearranged to protect the divertor-cooling pipes from the ECH beams.

In order to check interference among components, mockups of the divertor plates were made by using a 3D printer.

(2) Thermal analysis of the newly developed cryo-sorption pump in the closed helical divertor in LHD

For the effective divertor function, a strong pump (cryo-sorption pump) and an effective closed configuration are required.

The maximum surface temperature of the divertor plates is beyond 1000 degrees Celsius in long pulse discharges with high plasma heating power. Since the cryo-sorption pump is facing the divertor plates, it is exposed to the radiation from the high temperature area on the divertor plates. To protect the cryo-panel from the heat flux, the shield structure of the cryo-sorption pump, which consists of the water-cooled shield and the Liquid Nitrogen (LN2) cooled louver type shield, is installed, as shown in Fig. 6. The numerical analysis using the finite element method code (ANSYS) was carried out to evaluate the performance of the shield structure against the radiation heat flux. The simulation model is shown in Fig. 7. The inner surface temperature of the water-cooling pipes in the divertor plates and in the water-cooled shield are 20 degrees Celsius, and that in the LN2 shield is assumed to be

80 K. It takes a long time to calculate a large scale (~100,000 grid points) three-dimensional heat flow with the radiation. A high-performance computer using parallel processing is required. Figure 8 shows calculated temperature distributions of the divertor plate and the shield structure. The maximum temperature difference on the LN2 shield is less than 15 K, even though the maximum temperature of the water-cooled shield is approximately 190 degrees Celsius. Therefore, the thermal performance of the shield structure is adequate to protect the cryo-panel from the heat flux from the divertor plates.

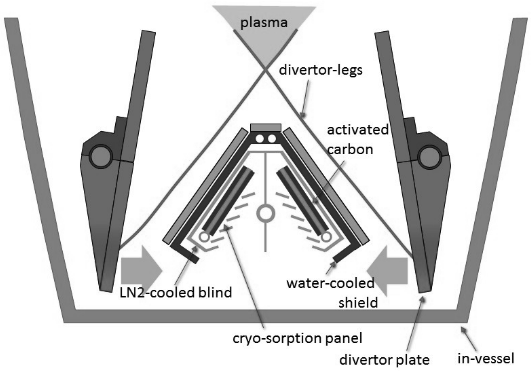

Fig.6. A cross section of the newly developed cryo-sorption pump and divertor plates.

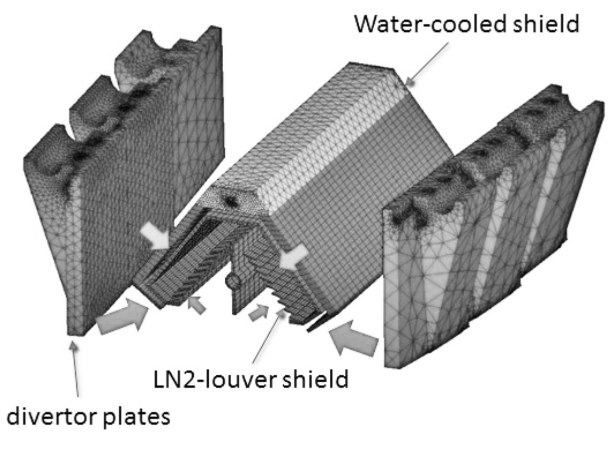

Fig. 7. Simulation model for evaluating the performance of the shield structure against the radiation heat flux from the divertor plates heated by the divertor plasma.

(3) The improvement of temperature data collection method in the CHD

We carried out real-time surveillance of the temperature of cryo-sorption pump installed in the Closed Helical Divertor (CHD), and this is shown as a trend graph at the LHD Control Room. This is very important for assessing what state CHD is in.

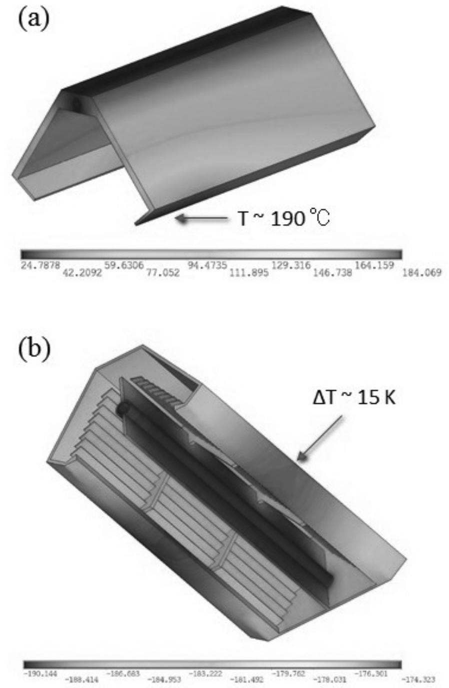

Fig. 8. Temperature distributions of (a) the water-cooled shield and (b) the LN2-cooled shield.

We had to conduct a review of the temperature measurement method this year, because of the increment of the number of the thermometric point (from 64ch to 110ch) and the modification of networks.

At the beginning, we exchanged the data logger which has a maximum of 200ch of the thermometric point. Then, by the data logger connected to the PC installed in the LHD Control Room by a dedicated line, these temperature data were shown as trend graph at the PC. This PC also has a function of storing these temperature data from the data logger. This made more detailed analysis possible regarding the status of CHD.

(4) Improvement of the gas supply system for the deuterium experiment in LHD

In 2014, the gas supply system was renewed for the deuterium experiment. Some improvements of this system were found in the 18th plasma experiment. The control system was improved as follows, and we could operate safer than before. Before improvement, the vacuum gauge alarm was issued even if the level of the vacuum gauge was less than the set point. The problem is that another important alarm might be hard to notice due to this alarm, not that the level of vacuum gauge becomes low. As a countermeasure for this, we stopped generating the alarm in case the level of the vacuum gauge becomes low (if the alarm is needed, the control system is able to generate the alarm by changing the set point).

The gas supply system needs to supply high purity gas to the other devices, because all gas cylinders have to be removed from the LHD experiment room.

This year, some gas pipes were laid from the gas supply system to major devices. The Helium gas pipe (up to 8M Pa) was laid to the Impurity Pellet Injection device and the He Beam Probe device. The Helium gas pipe (0.2M Pa) was laid to the E//B-NPA device and the Diborane device. The impurity density of Hydrogen, Helium, and Deuterium gas can be supplied below 100 ppb in the gas supply system.

After this, the pipes of He gas (up to 8M Pa) and Hydrogen and Deutreum gas (0.2M Pa) will be laid to the Ice Pellet Injection devices and the TESPEL / TECPEL injection devices.

(5) The installation of an exhaust fan system for LHD

An exhaust fan system was installed to emit the gas from the Exhaust Gas Processing System (EGPS) to outdoors. EGPS system diagram is shown Fig. 9. This system is composed of exhaust fans, vacuum pumps, filter units, valves, control devices and other devices. Since this system is aligned with the EGPS through the control device, it can make EGPS stop safely and automatically in case this system detects a failure. Additionally, it is possible to monitor and to operate this system with vacuum pumps. This exhaust fan system has been driven from January 2016, and any problems have never reported.

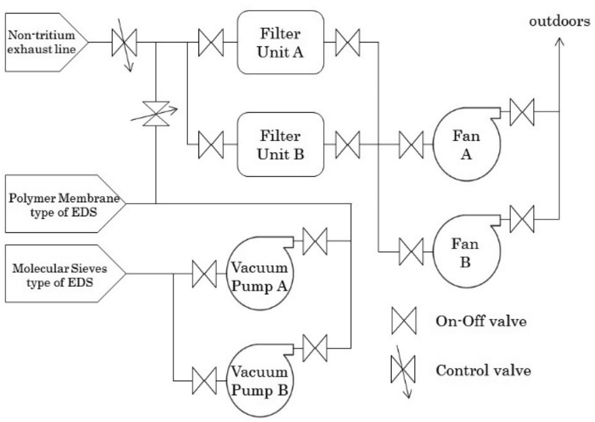

Fig. 9. System diagram of the exhaust fan system.

(6) Preparation for Deuterium Experiment

1) Defense of control panels from neutron

Some electronic devices which control equipment are installed in the LHD experiment room. It has been reported that the radiation (neutrons) generated in the deuterium experiment damage the electronic devices. Thus, we covered the control panels which housed the electronic devices with polyethylene blocks (t = 50 mm) (Fig. 10). It is expected that control panels installed near LHD would receive a significantly impact from neutrons, so we manufactured the control panels with a strong frame and covered these with polyethylene blocks (t = 100 mm).

Fig. 10. Control panel was covered by white polyethylene block (t = 50 mm).

2) Detection of cooling water leak

Much equipment used cooling water in the LHD experiment room. Nylon tube is used for those cooling water hoses. We mounted a water-leak sensor and a water pan (9 points), because those joint parts may leak, (Fig. 11). This can make it possible to detect water leakage rapidly.

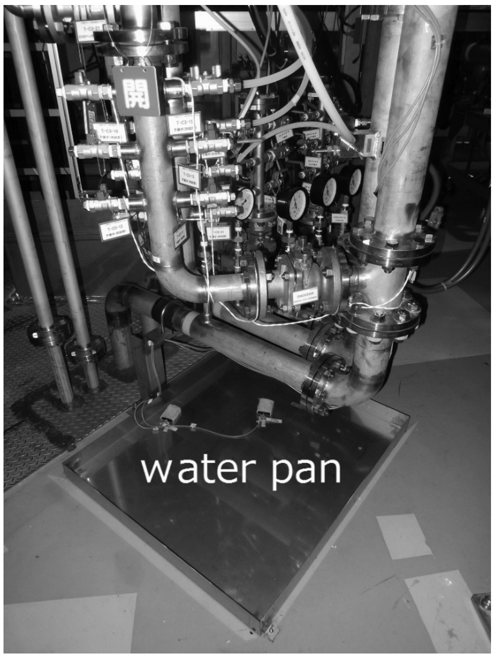

Fig. 11. Water pan.

3) LHD Vacuum Vessel Entrance

In order to work in the plasma vacuum vessel after Deuterium Experiment, it is necessary to further control and inspects radiation. Thus, the LHD Vacuum Vessel Entrance (Fig. 12) has been remodeled in order to expand the area (from 13 m^2 to 45 m^2) in March 2016. The new Radiation Control Entrance is a two-floor structure. The pressure of the rooms are adjusted in negative, (-30 Pa) and ventilated at 800 m^3/h or more by the exhaust fan.

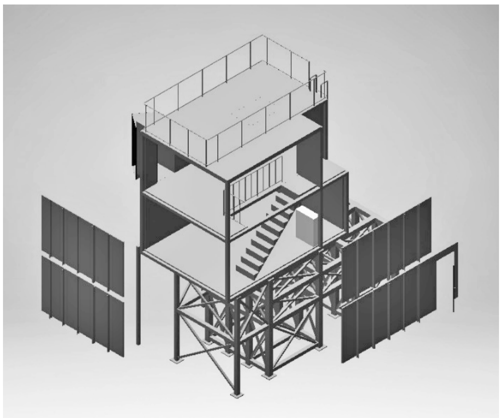

Fig. 12. View of LHD Vacuum Vessel Entrance by 3D CAD.

(7) Overhaul of dry scroll vacuum pumps

We have overhauled dry scroll vacuum pumps as part of the vacuum pumping system maintenance in LHD. Some pumps were found to have white dust on the inside (Fig. 13). We are planning to conduct the Deuterium Experiment in future years, It is considered that this dust generation is a safety hazard. At first, we investigated the cause of its generation. It was revealed that this dust was a solid from the residual material after the evaporation of moisture and abrasive substance of the scroll part (made from aluminum alloy) in pump. This shows that friction of the scroll part causes the generation of the dust. When this friction begins, the temperature of a dry scroll vacuum pump becomes higher than the rated state because of friction heat. For this reason, we can control the white dust from generating by monitoring the temperature of a pump, and improving safety maintenance.

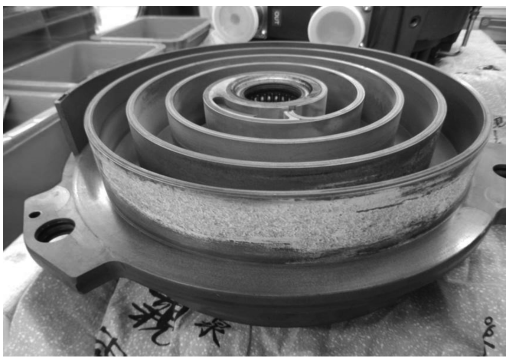

Fig. 13. White dust of the inner scroll.

3. Plasma Heating Technology Division

The main tasks of this division are the operation and the maintenance of individual (three different types of) plasma heating devices and their common facilities. We have also performed technical support for improving, developing, and newly installing these devices.

In this fiscal year, we mainly carried out device improvement and modification which enable the deuterium experiment. The ECH system removed 1.25 inches diameter waveguides which had been used for 84GHz Gyrotron. A set of ICH antennas at 7.5UL port were removed. The driving sequence of NBI devices was updated and the vacuum pumping system for NBI was modified, and finally, adjustment and complete testing of the operation with deuterium were carried out. The motor generator (MG) supplied necessary electric power stably and reliably for ECH as well as for NBI.

The details of these activities are as follows.

(1) ECH

ECH system has improved, repaired, and replaced especially power supply and transmission control device in this year due to the cancelation of the LHD experiment. And we are preparing for deuterium experiments, needing some protection from the radiation, removal of unnessary objects and the remote detection system for leakage of cooling water at the LHD experimental hall, which is placed next to the heating device room. Below are details.

(a) Repair and replace – PLC in control system

ECH control system uses much PLC in the power supply and the transmission line. Our PLC was installed about 18 years ago and recently we have found some failure in these devices, and that made us introduce a new PLC this year in order to operate reliably. That also includes the speeding up of PLC processing and a new protection system for deuterium experiments.

(b) Transmission line development - New antenna system

A new ECH antenna for the 9-O port has been designed. This antenna consists of three mirrors, including a steering mirror, and has a water cooling system. Figure 14 shows the steering mirror which has a link mechanism to move the mirror direction. This new antenna will be installed in LHD before the next experimental campaign.

(c) Preparing for deuterium experiments - Cooling pure water leakage detection at LHD-ECH transmission lines

To prevent troubles by the heat of LHD-ECH power transmission lines, cooling jackets equipped with pure water flow channels were attached to the transmission lines. A monitoring system for water leakage from the cooling channels in the LHD hall and the basement was constructed.

The transmission lines were divided into six monitoring areas as shown in Fig. 15. Along the transmission lines, flame-resistant sheets or metal pans were set below the transmission lines to collect leaked water, and lines of sensors (OMRON F03-16SFC) were set on the sheets and pans to detect the leaked water. When a water leakage is detected, it is noticed in the RF control room by sound and light. Also, this sensor changes its color when it becomes wet in order to make the detection point visible.

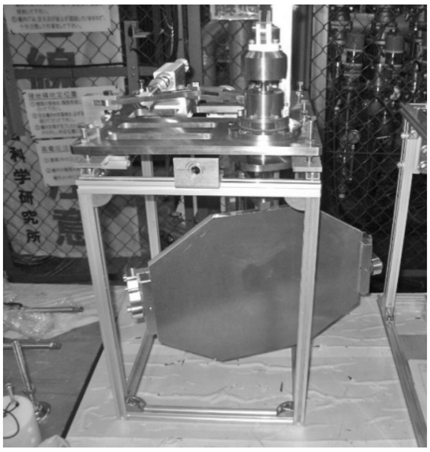

Fig. 14. Steering mirror with the link mechanism

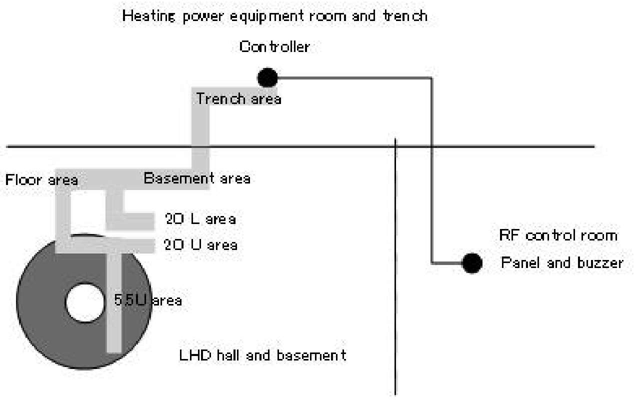

Fig. 15. Monitoring Areas

(2) ICH

(a) The water leak detection system

As a preparation for the deuterium experiment the system which detects a water leak in the radiation controlled area and it's required to monitor it for outside boundary of the controlled area. Water leaks detectors were put on pans which receive the leaked cooling water installed under the valves for the water supply and drainage in the LHD experiment hall, and the number of the sensors is fifteen. When the sensor absorbs approximately 1.5 ml of water, the AC resistance between the sensor electrodes drops to the preset value or below and the water leak is detected. This is changed into a signal by the water leak detector and the signal is sent to the RF local control room. We adopted the link terminal and coaxial cable (5D-FB) which have been used for signal transmission for the control system of the liquid stub tuner between the LHD experiment hall and the RF local control room. The connector type which was connectable with PLC was chosen as the link terminal in the RF local control room in order to use PLC. The system of water detector is not only intended to inform by the alert sound, to be detected the location, and also tells by the light for the warning. Figure 16 shows the outline of the water leak detection system. For more effective performance, we took the following measures for the water detector alert placed in the loud noise location.

(i) Covered all sensors with plain stitch tinned copper wire.

(ii) Made the program of PLC so that the alarm was raised when a detection signal was received continuously 5 seconds or longer.

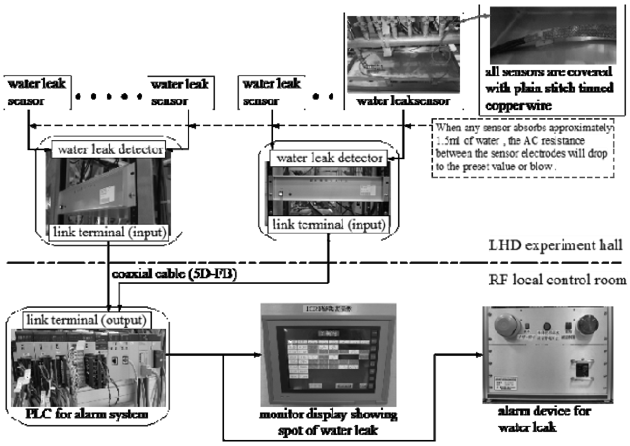

Fig. 16. Outline of the water leak detection system

(3) NBI

(a) Upgrade of the control system of negative-ion-based NBI (BL1, 2, and 3) for the deuterium experiment

Deuterium experiments are being prepared in the LHD. We upgraded the NBI control system for the deuterium beam operation. An interface programmable logic controller (PLC) was newly installed to construct the entire interlock system connecting integrated radiation monitoring system and each NBI control system. Major functional items added in this upgrade are summarized here.

1) Modification of the interlock system

We added four items in the interlock system for NBI operation. One is related to the operation mode, which is connected to interlock for NBI operation. The second is related to the gas species. The NBI operation with hydrogen gas and that with deuterium gas are separately controlled. The third is related to the exhaust gas processing system. There are two exhaust gas processing systems in the LHD and the situation is monitored by the interface PLC. The last one is related to the permission for the beam operation with the neutron radiation, which is under the control of the integrated radiation monitoring system. Figure 17 shows the interlock block diagram.

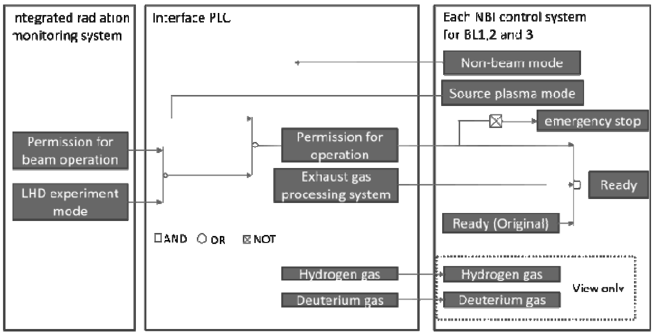

Fig. 17. Interlock block diagram

2) Addition of a new mode for beam operation

An interval of the plasma discharge in the deuterium experiments in LHD is not fixed and changes from 3 minutes to 15 minutes, depending on neutron emission rate. In order to keep the plasma grid (PG) temperature of the negative ion source, which is the most important parameter for the stable negative ion beam production, the additional sequential conditioning operations within the interval of the plasma discharge are required. However, it was necessary to operate a gate valve and a calorie meter to change the mode between “injection” and “conditioning” in the present system, and it is difficult to operate the gate valve and calorimeter during each interval. For the purpose of reducing these operations, we added "the non-beam mode" in the NBI operation system. Only arc discharge or only high voltage holding were permitted without any operation of the gate valve and the calorimeter.

After the upgrade, we tested the control system and it worked well without any problem.

(b) Development of the interlock system for NBI

Deuterium experiments are being prepared in the LHD, and new functions are required for the NBI vacuum system and for the NBI operation system. We developed a new logic control system using PLC. The system has two functions. One is an interlock logic system, which interfaces five NBI operation system. The permission from the integrated radiation monitoring system in LHD, the situation of valve in NBI vacuum system, the operation mode, etc., are connected to each NBI operation system through the developed system. The other is the control system of the NBI vacuum pump. The system controls the automatic regeneration procedure of cryo-pumps.

In the test operation we found a few points to be improved. Thus the system will be upgraded in 2016 and become operational in January 2017.

(c) The maintenance of NBI # 4 after the 18th experimental campaign of LHD

As one maintenance work job of NBI after the 18th LHD experimental campaign, the NBI group carried out the maintenance of the ion sources of the NBI # 4 by us on our site. This is also a part of the efforts toward the deuterium experiment starting from next year, for it will become difficult to take the ion sources out of the site after the beginning of the deuterium experiments. The contents of this maintenance work are removing plasma grids from the ion source accelerator, reassembling them (including the distance adjustment between the plasma grid and the deceleration grid (8mm) for the acceleration voltage at 60kV), vacuum leak tests using helium gas, insulation resistance tests of the ion sources, and related preparatory work. In the test operation after the maintenance, we could confirm each functions of ion sources such as voltage holding capability, beam optics, etc. and achieve our target values of the acceleration voltage of 60kV and the injection power of 9MW.

(4) Motor-Generator (MG)

The MG is used to supply the pulsed power to the NBI and the ECH for LHD. The MG generated 6,303 shots in this fiscal year, and 581,970 shots since its construction. The operation time was 319 hours in this fiscal year and 27,149 hours in total. Field discharge circuit breaker for generator has been used more than 20 years, and has been overhauled.

4. Diagnostics Technology Division

This division supports the radiation measurement and diagnostic devices. We mainly supported preparation for the deuterium experiments last fiscal year.

We support development and construction of the fusion products diagnostic system. The dry run for its calibration experiment has been carried out. We are installing the integrated radiation monitoring system, too. And several kinds of radiation measuring are continuing.

Also, we support the operation and maintenance of the diagnostic devices such as the FIR, Microwave Reflectometer, Thomson scattering diagnostic, and others. In order to store the extremely huge data from these diagnostics, the LHD data storage system was improved.

Our principal tasks in this fiscal year are described below.

(1) Fusion products diagnostics system

(a) Dry run for calibration experiment of fusion products diagnostics system

The Neutron flux monitor (NFM) has been installed on the LHD toward deuteron operation. Calibration using radiation source for NFM is needed and the calibration experiment is being planned before deuteron operation. This experiment consists of transport of a calibration source from the storage facility to the torus hall, and assembly and test of movable body setting the source in the vacuum vessel. The manuals of these processes have been drafted. In order to check and confirm the process following these manuals, the dry run without the calibration source has been carried out. The transport of the storage vessel of the calibration source is carried out by using a 30-ton crane, as shown in Fig. 18. This figure shows a process of the exchange of bell ropes. Figure 19 shows the moving test of the source using a hook-up tool with an electromagnetic catcher from the storage vessel to the movable body. This tool consists of an electromagnet and a dry cell battery of 9 V.

Fig. 18. Transport test of storage vessel.

Fig. 19. Moving test of the source using a hook-up tool from the storage vessel to the movable body.

(b) New stage for neutron flux monitor

A new stage has been designed for the purpose of inspection of the neutron flux monitor detectors installed above LHD. Figure 20 shows the constructed stage. The structure has been designed under a load condition of about 270 kg/m^2, which is considered with the sum weight of up to three adults. In order to carry out the detachment and attachment operations by hand from LHD, the stage consist of four floor panels and four beams, and are made of aluminum alloy of lightweight material. The radial size of the floor is about 2100 mm. The beams are fixed at the height of about 1100 mm of the guard rail by bolts. For the purpose of reinforcing, the existing guard rail has been reengineered by the enlarged poles of stainless steel.

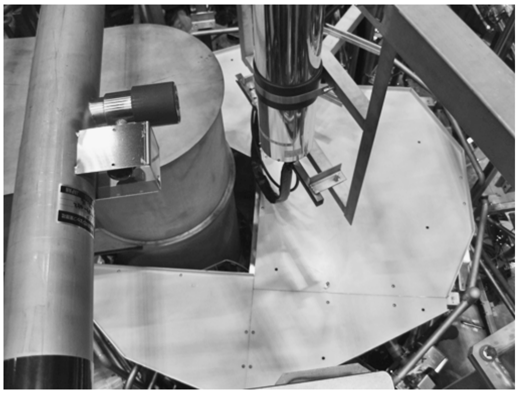

Fig. 20. New stage constructed on the top of LHD

(2) Integrated radiation monitoring system

In order to integrate information for radiation safety, the integrated radiation monitoring system is under construction.

(a) Interlock system

Interlock system is the main system of the integrated radiation monitoring system, which retrieves data from variety of radioactivity measurements and stops LHD experiment automatically when necessary. It has been installed in the LHD building as shown in Fig. 21, and it has been connected to the LHD central control system with signal lines.

(b) ITV

The ITV in the LHD building was installed about 20 years ago. Thus, the ITV was replaced in this fiscal year. All cameras and monitors have been replaced (Fig. 22).

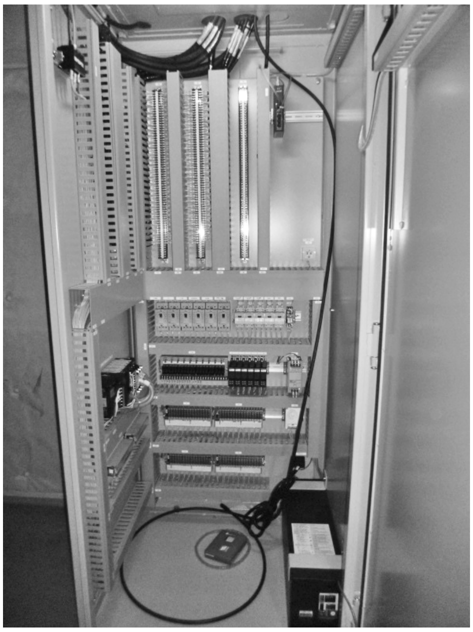

Fig. 21. One of the installed interlock control boards.

Fig. 22 Monitors of new ITV in the control room

(c) Access control system

Several updates were carried out in the access control system.

Three hand-foot-clothing monitors have been incorporated in the access control system (Fig. 23). Only after measurement with the hand-foot-clothing monitor is one able to go out through the access control gate.

(3) Radiation monitoring

We are continually measuring and compiling data of environmental radioactivity in the LHD building and neighboring areas. We are using several radiation measuring devices to measure environmental radioactivity, as below.

Fig. 23. Three hand-foot-clothing monitors.

(a) High-Purity Germanium (HPGe) detector

Some samples of soil and pine needles from the NIFS site are measured with the HPGe to investigate the spectrum data and nuclides. And it is confirmed once a month whether this detector is operating correctly by using Co-60.

(b) The tritium monitoring measurement of the exhaust (The tritium sampler system II)

We are monitoring the tritium concentrations in the stack by the tritium sampler system, as shown in Fig. 24. This tritium sampler system was installed in order to perform the continual tritium concentration monitoring in the stack during the plasma experiment. It has been running without any problems.

Fig. 24. The tritium sampler system II.

(c) Gas and water monitor

The level of radioactive gas and dusts which are in the torus hall and in the stack of the LHD building are measured continually. And draining water is exhausted only after measurement with liquid scintillation counter. Draining water in the tanks become tainted, as shown in Fig. 25. Thus, cleaning of the inner side of the tanks was carried out.

Fig. 25. Drain water in the tank before cleaning.

(4) Operation and maintenance of diagnostics device

The operation and maintenance (for example, high voltage power supply, vacuum pumping system, supplied gas system, phase detection circuit, dehydrator, water cooling system, etc.) have been safely completed.

And we support the reform of the laser room of FIR and Thomson scattering diagnostic. The laser room was covered with light-shield boards completely, as shown in Fig. 26.

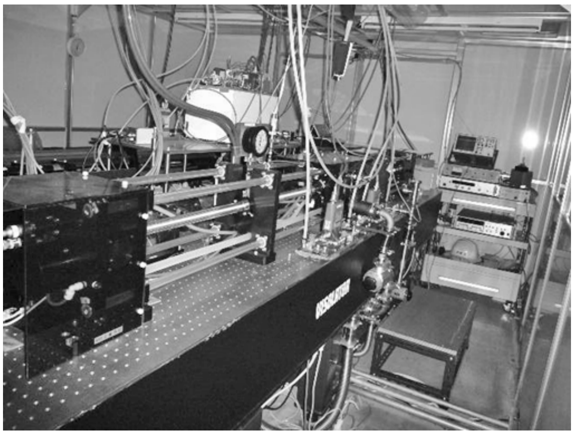

Fig. 26. Inside of the light-shield FIR laser room.

(5) Systems for data management and radiation monitoring

Using the VDI (Virtual Desktop Infrastructure) function of Windows Server, we have built the VDs to manage and maintain SNET terminals beyond firewalls. We have built the WWW server system that displays the neutron frequency data extracted from NFM (Neutron Flux Monitor) diagnostics (Fig. 27). Monitoring CVCF status by Network UPS Tools that is a freeware for the management of power devices, our servers will be shutdown safely and automatically when a sudden blackout occurs. In order to store the data of the next LHD plasma experiment campaign, we have installed two HDD-RAID PC and one BD Data Archiver additionally.

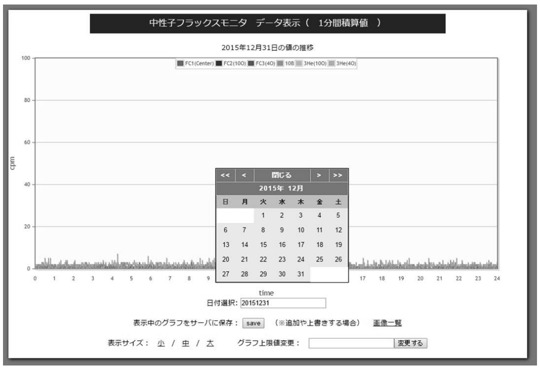

Fig. 27. NFM display system on the WWW.

5. Control Technology Division

The Control Technology Division contributed to important technological aspects of the LHD, such as operation and management, and development of the system. The division contributed also to management of the network system. The work in system operation and system management is as follows: operation of the cryogenic system and the power supply system for the superconducting coils, updating the central control system and cryogenic control system, and management of the network system. The work in system development this year is as follows: development of a new simulation algorithm for the cryogenic system, system development of the control system for LHD, and others. Details of the activities in this division are described below.

(1) Update of the LHD cryogenic control system

Regarding cryogenic control system, 16 problems were corrected. These were bugs and errors, but the system operated without any trouble for one year.

Total system operating time was 361 days (8627 hours). We responded to 8 of 16 points to be corrected. We are surveying the 8 remaining while recording then in the investigation logs.

Cryogenic control system was upgraded; a button to switch the screen by the alarm content was added to the driving operation computer. Since the screen switching becomes faster in the event of an emergency by this feature, it operates more stably.

(2) Update of the LHD central control system

The Integrated Radiation Monitoring System was installed in the LHD building, and changes were made to interlock with the signal line connecting this device to the central control system. And we installed the timing signal for NBI conditioning because of a request from NBI. Figure 28 shows control console of the central control system and PC for timing signal in the central control room.

Fig. 28. Control console of central control system and PC for timing signal.

(3) Replacing display switching system of Central Control Room large displays

One of two projectors in NIFS Central Control Room was replaced because there time for replacement. Also, the touch panel for switching input sources remotely for projectors was broken and display switchers are quite old, thus we built a new display switching system. We checked current input sources and removed cables which have been unconnected to any device. Nevertheless there are more than 15 input sources, thus we installed two new switchers and set them up in a multistage configuration with some long-standing switchers which are relatively recent (Fig. 29).

Fig. 29. Signal Switchers.

We also developed a web-based system for switching input signals. We selected a single board computer Beagle Bone Black as web and control server. This connects switchers and projectors using a USB to RS-232 serial hub. When an operator browses the web page (Fig. 30) and selects a button for each input source, the server sends RS-232C signals to switchers and each switcher changes status to show the selected input source to the projector. It is also able to switch power on and off for projectors. We developed this system with html, JavaScript and Python.

Fig. 30. Remote Control Web Page.

(4) Network management

The NIFS campus information networks consist of several clusters. We manage the Research Information Cluster (NIFS-LAN) and the LHD Experiment Cluster (LHD-LAN).

(4.1) NIFS-LAN

NIFS-LAN is the network of general use, and covers entire region of the campus. We have administrated the Routers, layer-2 / layer-3 switches, the quarantine authentication system, Mail server, SSL-VPN server, DNS server, and DHCP server.

New contributions in FY 2015 are as follows:

(a) Introduced the one-time password authentication for the mail system

The two-factor authentication using one time passwords has been introduced to the mail system for security improvement. Once a day via a web browser, it is necessary to enter the one-time password to use the mail system.

(b) Improved the quarantine authentication system

Improvements of the quarantine authentication system in FY 2015 are as follows:

- Adding to the MAC address registrant transfer function.

- Elimination of logical remove function.
- Modifying the expiry notification to two times from one time.

(c) Distributed the SEP version 12.1.6

Distribution of the Symantec Endpoint Protection (SEP) version 12.1.6, which covers Windows 10 and MacOS X 10.11 was started

(d) Renewed the video conference system

We offer video conference systems to connect to domestic and international ports: HDX-7000 (Polycom), HDX-6000 (Polycom), Lifesize Express (Lifesize), and RMX-1000 (Polycom), which is a multipoint connection unit and is able to connect up to 12 points. Real Presence Group 500 (Polycom) was newly introduced as an alternative system because maintenance service by the manufacturers of Lifesize Express (LifeSize) had expired.

(4.2) LHD-LAN

The LHD-LAN has been contributing to the LHD experiments since 1996. The new “LHD-LAN Core Switch System” was renewed in the 2007-2008 fiscal years. The main part consists of two Cisco Catalyst 4507R multi-layer switches connected by 10 Gbps Ethernet, whose maximum throughput exceed 210 million packets per second.

(a) LHD Access Gateway

A Firewall is installed to limit the connection between NIFS-LAN and LHD-LAN, and MAG4610 (Juniper Network) is operated as the authentication server.

We dealt with user account management (22 initial registrations and 19 deregistrations in FY2015), inquiries from users, updating web site, etc.

We upgraded ESAP from ver.2.6.0 to ver.2.9.1 in order to correspond to MacOS X 10.11.

(b) Renewal of the domain controller server

We manage the LHD domain in LHD-LAN.

Because the support for Windows Server 2003 was ended, we updated the domain controller server.

The model is “PRIMERGY RX1330 M1” (CPU: Xeon E3-1231 v3 @3.40GHz, Memory: 32GB) of Fujitsu Ltd. (The photograph is Fig. 31.)

Fig. 31. PRIMERGY RX1330 M1.

The operating system is Windows Server 2012 Standard. Fault tolerance of the new domain controller server was advanced by the RAID1 system and the duplication of the power supply.

Also, we unified the domain controller server with the file server.

(5) Modification of control systems for the deuterium experiment

We have modified the plant operation and monitoring system of repetitive pellet injector (Fig. 32). This involves adding optimized conditions of deuterium pellet generation, and enables selection of an operational mode according to the gas type, i.e., hydrogen or deuterium.

Lately, renewal requests of the aging control systems are increasing because the work inside the LHD room and the neighboring area will be strictly managed after the next experimental campaign starts. Under this circumstance, rebuilding the control systems of HIBP's tandem accelerator and bolonization are currently in progress.

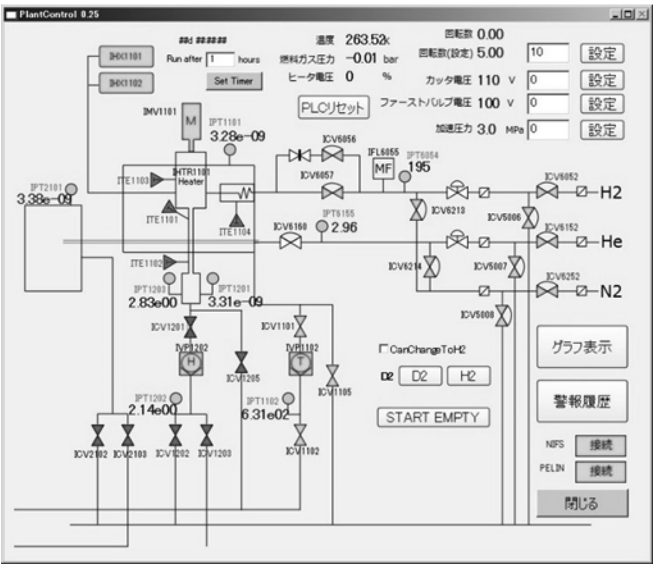

Fig. 32. Repetitive pellet injector controller.

(6) Modeling and simulation of the supercritical helium (SHe) loop of the Toroidal Field coils (TF) in ITER cryogenic system by C-PREST

In the past, we implemented the model and conducted the dynamic simulation of SHe loop of the TF-ST and the CS to investigate the impact of large pulsed heat load.

In 2015, we carried out modeling of a forced-flow SHe cooling loop of the TF coils and simulated its thermal-hydraulic behavior. Figure 33 shows a schematic of the SHe cooling loop of the 18 TF coils, which consists of two heat exchangers (HXs) immersed in liquid helium (LHe) reservoir, a circulation pump (CP), and control valves for flow distribution. The simulation model has been developed for one TF coil, assuming comparable characteristics. Accordingly, the characteristics of HXs, CP, and valves were scaled down for one TF coil. Figure 34 shows a simulation result of the SHe loop of the TF under 15 MA baseline scenario. The amplitude of heat load is about 1 kW, which is one-tenth of that of TF-ST or CS. The TF coil operation can be considered as quasi-static state under 15 MA baseline scenario.

In the future, we will implement the modeling and simulation of the SHe loop of the Poloidal Field coils and Correction Coils.

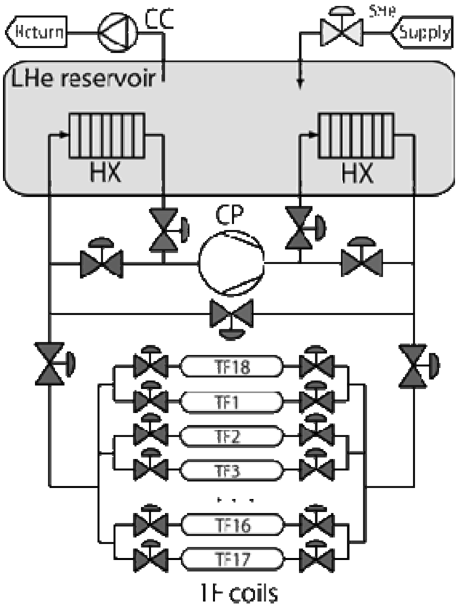

Fig. 33. Schematic of the forced-flow SHe cooling loop of the TF coils.

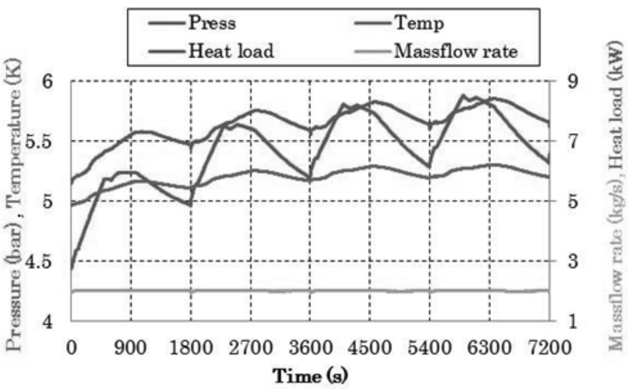

Fig. 34. Simulation result at the outlet of the SHe pump.

(7) Prototype visualization device of stainless steel corrugated tube

LHD uses super conducting Bus-Line (Fig. 35). The structure of super conducting Bus-Line is about 55m and the flexible stainless steel corrugated tube. This is necessary to investigate because there is a possibility that extreme transformation leads to performance degradation. We cannot watch the shape of stainless steel corrugated tube directly because it is covered by plastics of thickness 5mm. Therefore, we use X-ray photograph mainly. This time, we made a prototype visualization device using eddy current sensor.

Fig. 35. Super conducting Bus-Line (model).

The specification of prototype visualization device (Fig. 36), as follows.

- Eddy current sensor is moved straight along slide rail.
- The distance between the stainless steel corrugated tube under cover and the sensor is Y axis.
- The displacement of the eddy current sensor that is counted by linear encoder is X axis.
- The data of Y axis (0-10mm) = (0-10V) and X axis (25pulse=1mm) is shown in a chart (Fig. 37).

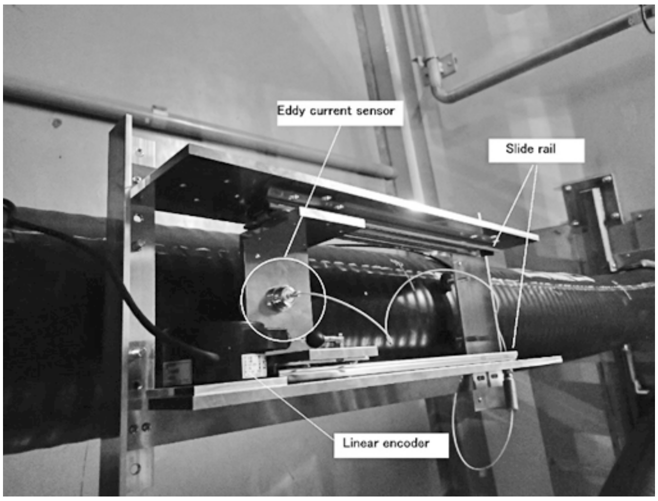

Fig. 36. Prototype visualization device.

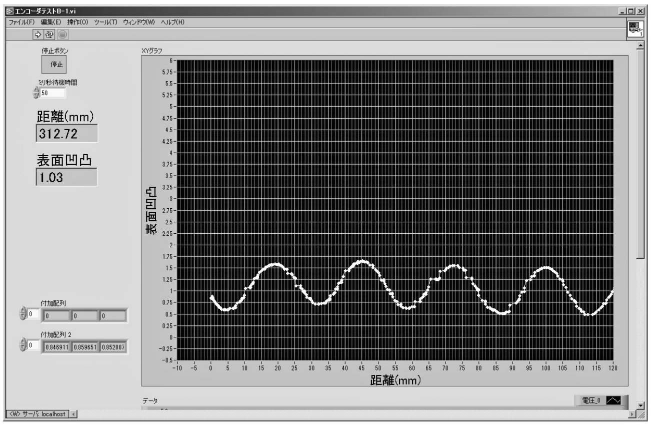

Fig. 37. Indication chart.

(8) Temperature rise test of polyethylene radiation protection box

Now we are preparing a deuterium experiment reaction and radiation protection for it. We sometimes enclose devices by polyethylene for radiation protection. In this case, we worry about temperature rise inside the box. This time we tested the temperature rise of the polyethylene box.

Iron box (270mm×170mm×95mm) with a film heater (power 5W) has the role of a device (Fig. 38). We enclosed this box by a polyethylene board of thickness 50mm and measured the temperature rise inside this box. Figure 39 shows the state of measuring.

In this case, the result was good. At atmosphere temperature 22°C～23°C, temperature inside this box reached saturation point in 10 hours and the temperature rise was about 6°C (Fig. 40).

Fig. 38. Inside the box.

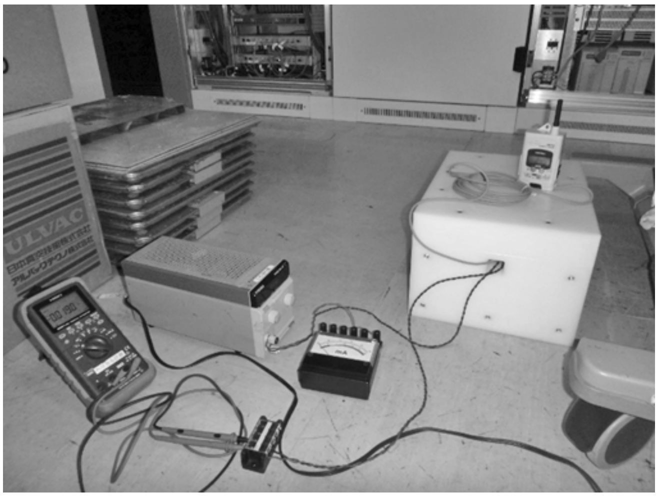

Fig. 39. State of measuring.

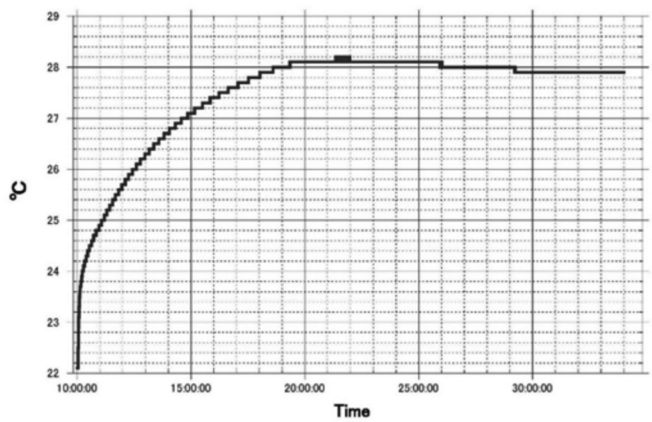

Fig. 40. Temperature rise chart.

6. Symposium on Technology, Technical Exchange and Dual System

(1) The Symposium on Technology
The Symposium on Technology was held on March 17-18 2016, at High Energy Accelerator Research Organization. There were 208 participants from many Japanese universities, national laboratories, technical colleges, and industries.
At this symposium 71 papers were presented in 5 oral sessions and poster sessions. Technical experience and new techniques were reported and discussed. Five papers were presented from our department. Figure 41 shows one of them.

Fig. 41. A snapshot of the oral presentation.

(2) Technical Exchanges
Technical exchanges between our department and other institutes or universities were held in order to improve the technical skills of the staff. In this FY, we invited Mr. Ohmine (Okinawa National College of Technology) September 7-11, 2015 (Fig. 42), and Mr. Sakamoto (Kyoto University) March 10-11, 2016 (Fig. 43). And the meeting "Symposium on Safety and Health Management in a Laboratory" was held February 4-5, 2016, with 60 participants from 20 universities and four institutes.

Fig. 42. A snapshot on September 10, 2015.

Fig. 43. A snapshot on March 10, 2016.

1) Murase, T. : Ann. Rep. NIFS (2014-2015) 601-603.