IV. Department of Engineering and Technical Services

The Department of Engineering and Technical Services is involved in all kinds 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 educate excellent engineers with responsible administration.
3) To cultivate creative engineering abilities.
4) To improve the documentation of and the transfer of engineering knowledge to the next generation.
5) To perform tasks with a systematic responsibility.

The department consists of the following five divisions: the Fabrication Technology Division takes care of the construction of small devices and the quality control of parts for all Divisions. The Device Technology Division is responsible for LHD and LHD peripheral devices except for heating devices and diagnostic devices. The Plasma Heating Technology Division has responsibility for the ECH system, ICRF system and NBI system. The Diagnostic Technology Division develops, operates and maintains all diagnostic devices and the Control Technology Division has responsibility for the central control system, the cryogenic system, the current control system and the NIFS network. The number of staff is 45 engineers and 13 part-time workers. We take care of the development, the operation and the maintenance of LHD and the LHD peripheral devices with about 45 operators.

1. Fabrication Technology Division

The main work of this division is the fabrication of experimental equipment and the management of the LAN systems. We also take care of technical consultation and experimental parts supplies to persons concerned with the LHD experiment. In addition we handle the administrative procedures of the Department.

The total number of components completed in this FY by the central workshop was 149 by machining and 31 by electronic engineering. The details of some activities are as follows.

(1) 8ch latching scaler circuit

The final prototype of a latching scaler circuit for a neutral particle detector was manufactured as shown in Figure 1. The specifications of the circuit are: counting frequency maximum 150MHz, 8 channels, 16bit counter, latching frequency maximum 1MHz, data memory 32MB, and data readout through Ethernet LAN from PC. The results of the circuit testing that showed the specification was met. The real circuit will be designed in the next phase.

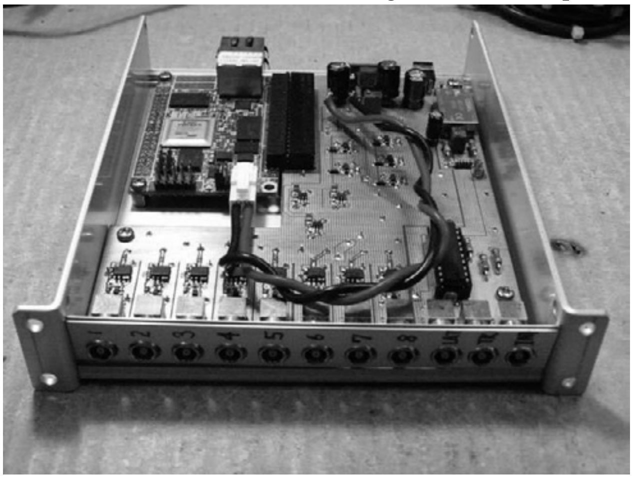

Fig. 1. Prototype 8ch Latching Scaler Circuit.

(2) 90MHz variable gain amplifiers (VGA)

10 small signal amplifiers were made for general purpose use in the ICRF system. The frequency bandwidth of the amplifier is 90MHz; the variable voltage gain is -11~31dB. AD603 of Analog Devices co is used as a VGA (as shown in Fig. 2).

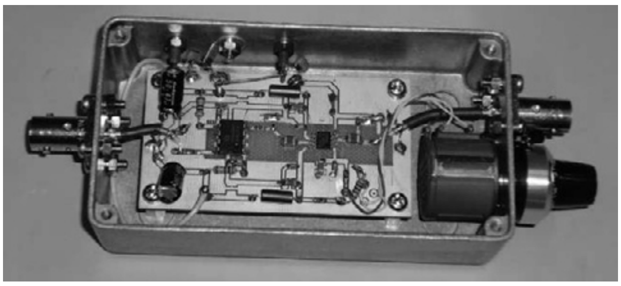

Fig. 2. 90MHz VGA.

(3) Feed-through

The feed-through is a component of the transmission line of the ICRF. The shape is complicated as shown in Figure 3. The inside shape is almost the same as the outside shape, nearly 6mm thickness. We had to divide it into four parts, because of the 417.4mm length. The specification of the maximum boring length is 140mm, using our NC lathes. Each connection was interference fit. It took four days to manufacture this.

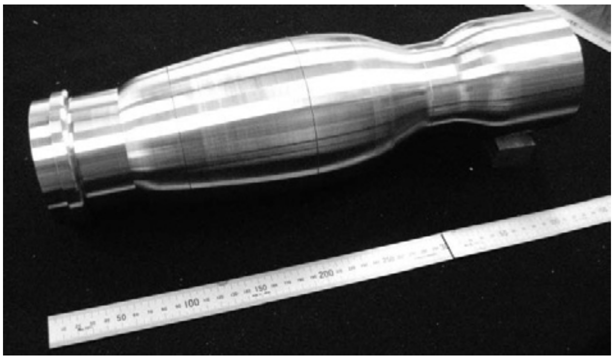

Fig. 3. Feed-through.

(4) Waveguide switch for Heliotron J

The waveguide switch is a device changing the injection of microwaves for diagnostics and heating devices. Corrugated miter bend is a component of the vacuum waveguide switch (Fig. 4). In order to improve the transmission efficiency of the 2.5inch-corrugated waveguide, it is necessary to cut 38 corrugated slots on the surface of the inside diameter of the miter bend. The depth of the corrugated slot is 1.41mm and the width is 0.565mm (Fig. 5). The wave guide system requires precise rectangular ridges.

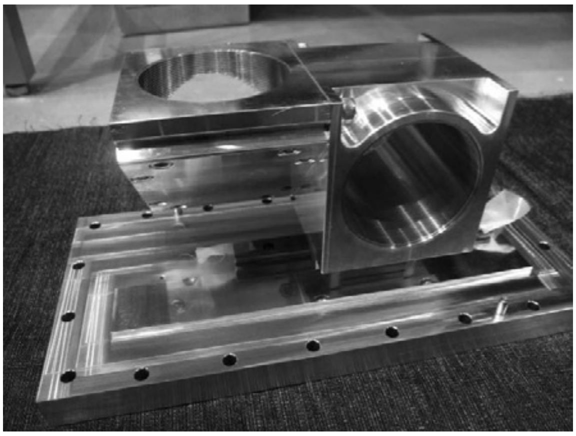

Fig. 4. The main parts of the waveguide switch.

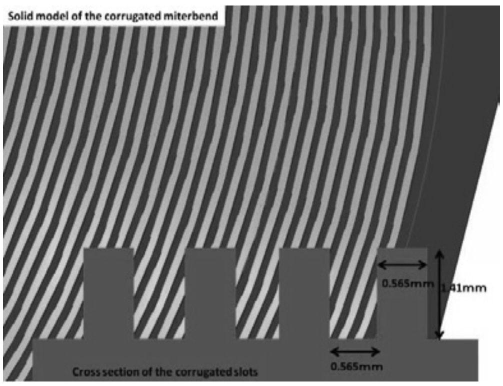

Fig. 5. Model of the corrugation.

(5) Update of the Firewall

We updated the Firewall on December 11 (Sun) 2011. The new Firewall model is PA-4020 by Paloalto Networks. The throughput of PA-4020 is 2Gbps and the number of concurrent sessions is 500,000. Moreover, it has sixteen 10/100/100 Mbps Ethernet interfaces and 8 SFP optical interfaces. We usually manage it through a web browser. However the firmware update to version 4.07 has been causing a problem in that its operation is very slow for a low-performance PC. We will change the PCs next FY. Figure 6 shows a photograph of PA-4020.

Fig. 6. Picture of PA-4020.

(6) Services around the network

We manage a TV conference system, servers such as FTP and PROXY, external networks mainly for visiting guests, wireless-LAN, UPS and the electrical outlets in our rooms or the Research Information Cluster. In this FY, we replaced the terminals of the TV conference system with new models that support HD. The contract for maintenance from this FY can provide more secure environments such as the most recent firmware to users. The number of TV conferences increases year by year, and the TV conference is believed to become one of the important services. The operation of the TV conference system was requested 52 times in FY 2011. The actual number of use is supposed to be more than 52, since some users control the TV conference system by themselves. The wireless-LAN operated as a part of an external network is increasingly used at conferences, etc. The major purposes are to browse e-mail and the web. Furthermore, we have been investigating backbone wires such as UTP and optical cables for preparing an update of the NIFS-LAN planned after next FY.

2. Device Technology Division

The Division supports the operation, the improvement and the maintenance of LHD.

(1) Operation of LHD

We started to evacuate the air from the cryostat vessel for cryogenic components on June 9 and the plasma vacuum vessel on June 10. Subsequently, we checked air leaks from maintained flanges of the plasma vacuum vessel and could confirm no leakage from there on June 23. The number of those checked flanges was 81. The pressure of the plasma vacuum vessel was achieved below 1x10-6 Pa on June 24 and the pressure of the cryostat vessel achieved the adiabatic condition (1x10-3 Pa) on June 28.

The LHD experiment of the 15th experimental campaign began on July 28 and ran until October 20. The number of days of the plasma experimental period was 49 days in total.

During this experimental campaign, our vacuum pumping systems were able to evacuate the air from both of the vessels without trouble. The LHD operation was completed on November 20.

(2) Closed Helical Divertor

In the LHD, for the purpose of peripheral plasma density control by efficient particle pumping, the helical divertor has been closed by a baffle structure and an in-vessel pumping system from the end of 2011. The Closed Helical Divertor (CHD) system consists of three components (slanted divertor plates, a dome structure and target plates), which are installed at six I-port sides (2, 4, 6, 7, 8, 10-I) in vacuum vessel. This system has been designed and developed by the members of the research staff and the Department of Engineering and Technical Service staff.

For further improvement of the thermal performance of the divertor tile, numerical analysis (ANSYS) was applied to some shape of the tile. From the results, the transfer of heat to the cooling pipe will become more effective due to changing the shape of the back of tile from a step shape to a sloped shape. The peak temperature during the heat load of around 1.0 MW/m2 was decreased by over 100 °C compared that of the normal type (open divertor).

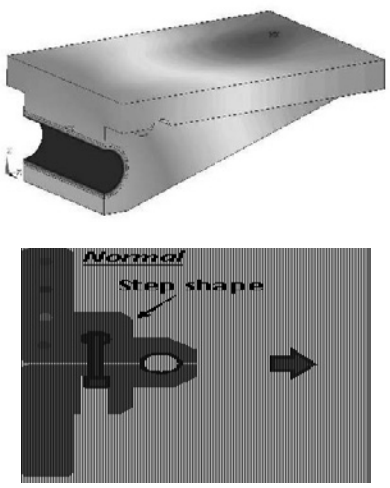

Fig. 7. Improved shape of the divertor tile by numerical analysis "ANSYS".

We chose the method of the cryo-sorption pump type to evacuate inside the CHD. Six pumping units per one section are installed under the dome structure. One pumping unit consists of a cryo-panel with active charcoals, an 80 K shield cooled by liquid nitrogen (LN2) and a thermal shield cooled by water. This cryo-panel is cooled by heat exchange with helium gas at about 10 K and surrounded by the above two shields. This ultracold gas, which is derived in a cryostat unit consisting of three cooling machines and some heat exchangers, is fed in to the vacuum vessel through a port on the U-port side using a helium transfer tube and is extracted from same port. LN2 and cooling water are fed in through the L-port side and extracted from the U-port side.

The feed ports had been selected by considering the length of the transfer tube and routes. About 60 ports are kept for the CHD system. And almost all existing measuring machines were replaced to other ports.

Three new stages for the CHD system had been designed and constructed on the B-stage, the D-stage and the LID-stage, and the cryostat unit was put into the south-stage on the LID-stage. Compressor units, a valve unit, a buffer tank of helium gas and control boards were put into the C-stage and floor, respectively. Almost all installation sites for these apparatus were also rearranged by the technical staffs.

(3) Installation of Water cooling system and Gas pumping system for LHD

The water cooling system consists of three systems called the middle stage cooling system, the basement cooling system and ICRF cooling system. This system had consisted of one system until last year. We decided to divide it into three systems in order to improve the cooling performance of LHD. The middle stage cooling system and ICRF cooling system were installed to cool devices in the LHD Room. Pumps of these systems were installed in the basement in order to avoid a magnetic field. Both systems adopted the pressurized circulation system to prevent the water hammer by the vertical interval (about 13m) from the floor in the LHD Room to the basement. We can operate and monitor all of these systems from the Control Room in the Control Building.

The gas pumping system consists of two systems called the middle stage pumping system, for assisting the vacuum pumping of gas from the diagnostic devices, and an outdoor exhausting system for evacuating the gas from the vacuum pump to the outdoors. The oil rotary vacuum pumps were used for the middle stage pumping system until last year. In the case that the middle stage pumping system had been operated for a long time, diagnostic devises were possibly contaminated with oil mist from the rotary vacuum pumps. Therefore, these oil rotary vacuum pumps had been removed and the dry pumps which do not use oil were installed. Since the number of installed dry pumps increased to more than twice the number of the oil rotary vacuum pumps, the control units were also newly installed. In an outdoor exhausting system, all exhausting gas was evacuated by only one pipe until last year. In order to construct a safer exhausting system, it is mandatory to divide systematically the fuel gas discharged from the devices in a plasma shot and the air discharged at the time of maintenance work. Therefore, we newly installed two exhaust pipes which were experiment gas exhaust pipe and the purging air exhaust pipe.

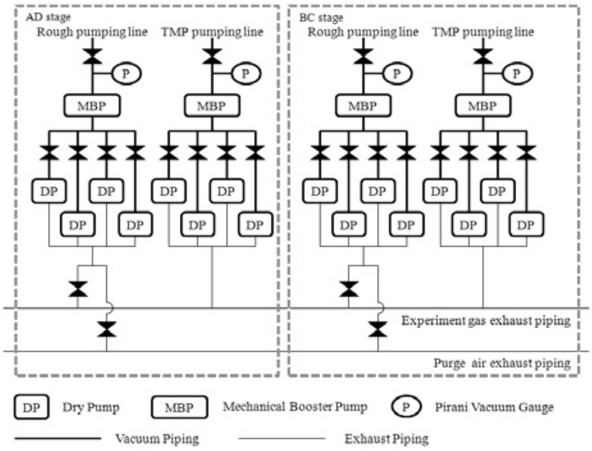

Fig. 8. Diagram of the middle stage pumping system.

(4) Preparation of the gaspuff device

A He-beam probe device was introduced in the 15th experimental campaign.

This device regains the inject ion of He-gas at high speed. So, we manufactured a new gas control system. A solenoid valve that had achieved results in the 14th cycle LHD experiment was used to inject gas, and these injection gases were controlled by a control PC with a built-in DA-board. Figure 9 shows the control PC and the waveform output unit. This waveform is made by a waveform editor, and is outputted by a waveform output software coincide with the plasma discharge (Fig. 10).

Fig. 9. The control PC and the waveform output unit.

This waveform is inputted to the solenoid valve via an amplifier. On the other hand, the waveform output software of the gaspuff device could have some bugs corrected. As a result, the CPU load became to be improved, and the incorrect operation of an interlock also could be cleared.

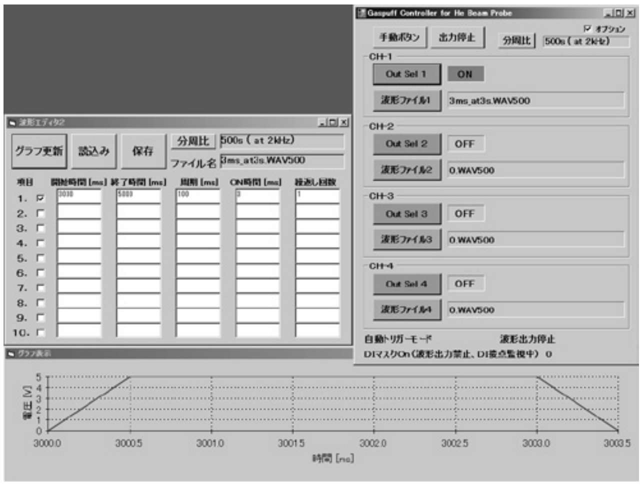

Fig. 10. The waveform editor and the waveform output software.

(5) Cooling tower renovating

The cooling tower, which is part of the Cooling Water Building-I, has reached 17 years since it was built. Though we clean up the tower every year, age-related degradation and adhesion of dirt become conspicuous in some complete parts because the tower is exposed to the elements. If things continue, it might affect not only the cooling performance degradation but also the operation of Cooling Water. Therefore, we completely replaced the calcification parts of the cooling tower. We replaced a half of them. The replacement was made during the winter season, antifreeze measures were particularly required. We could accomplish this replacement with careful planning and preparation.

Fig. 11. Cooling Tower under construction.

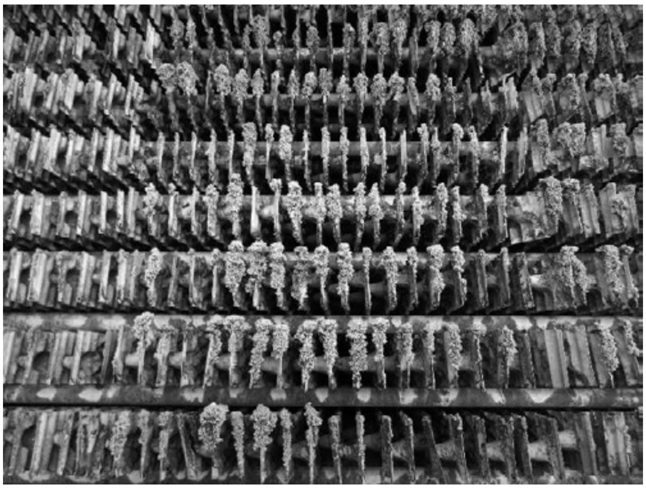

Fig. 12. Cu pipe and filler (before replacement).

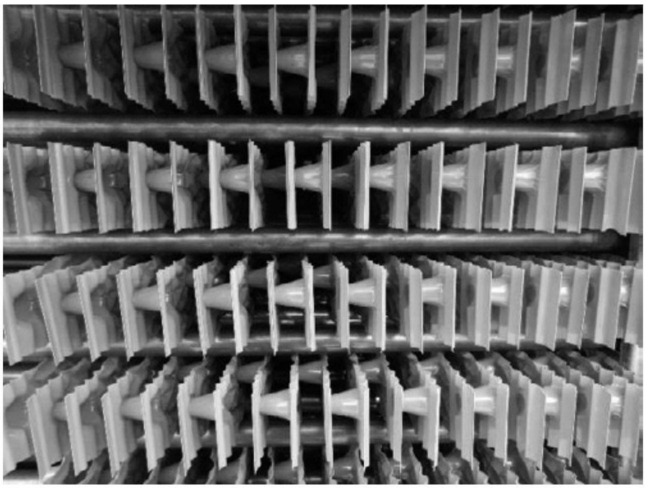

Fig. 13. Cu pipe and filler (after replacement).

(6) Operation of X-ray killer limiter

An X-ray killer limiter is the device to eliminate the runaway electrons X-ray generation when the excitation current of the coil is changed. We designed and assembled this limiter before starting the 15th experimental campaign. After the assembly, we conducted the operation test of the limiter and confirmed that there were not any problems. In the 15th experimental campaign, the trial operation of the limiter was performed. As a result, it was confirmed that the limiter restrained X-ray generation when the excitation current of the coils were changed. The limiter was used 58 times in changing the excitation current of the coil. Now, we have been preparing for the official start of operations since the 16th experimental campaign.

3. Plasma Heating Technology Division

The main tasks of this division are the operation and the maintenance of plasma heating devices and common facilities. We have also performed technical support for the improvement and the development of these devices, and the installation of new ones.

Two poloidal array antennas for ICRF were newly installed on the 7.5U and L ports of the LHD. As for the ECH, the 77GHz s/n3 gyrotron which had been introduced and operated successfully during the 14th experimental campaign suffered from a gas pressure rise after the campaign. This pressure rise itself was recovered shortly but the after effect that excess out gas inside the gyrotron occurs during high power operation remained. This out gassing was reduced by conditioning. The gyrotron systems showed the same performance as the last campaign. In the 15th experimental campaign, total NB injection power reached 27 MW. The highest ion temperature of 7 keV is achieved by NBI. The motor generator (MG) supplied electric power to ECH in additional to NBI in the 15th experimental campaign.

The details of these activities are as follows.

(1) ECH

(a) Gyrotron Operation & LHD experiment

During the 15th experimental campaign, we have kept the same total injection power as that of the previous campaign. We injected ECH power stably during the whole campaign without any severe troubles that require several days' stop of operation. Figure 14 shows the trend of ECH injection to LHD from the first to the 15th plasma experimental campaign. Recently three 1MW class 77GHz gyrotrons have been installed and operated so that the major part of the injected power comes from them. In the next campaign, a new gyrotron which generates 1MW at 154GHz will be installed and operated for injection. It should support various and advanced plasma heating/production scenarios.

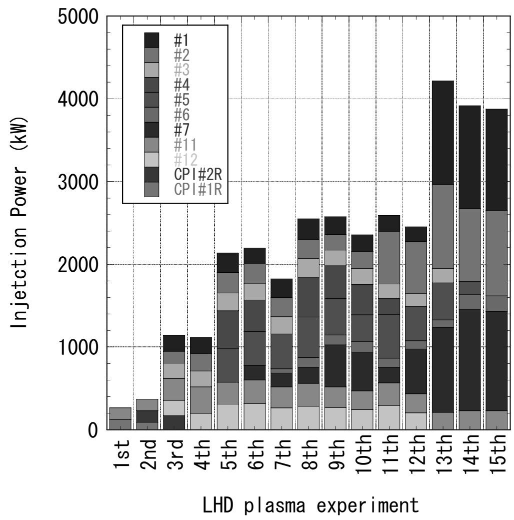

Fig. 14. ECH Injection Max Power during each Exp. Campaign.

(b) An improvement of the arc sensor.

After the 14th experimental campaign, the sensitivities of arc sensors are checked. A deficiency of the arc sensor at the injection window is found. A new arc sensor with a photomultiplier was developed (Fig12). During the 15th experimental campaign, this new arc sensor was tested. The minimum detectable threshold power was 10 nW, sufficiently low to protect an injection window. All arc sensors at the injection window should be replaced by the new arc sensor with a photomultiplier. So far, four of eight are already replaced by a new one.

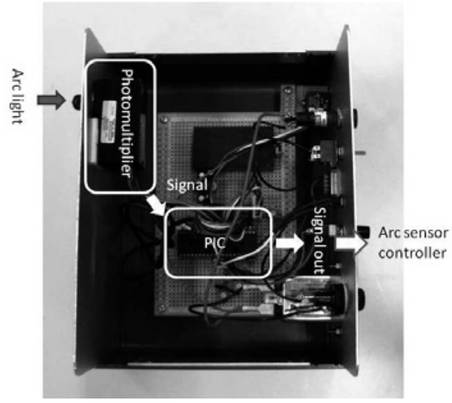

Fig. 12. Photomultiplier arc sensor.

(c) The new control system for the 1.5L antenna

The new control system for the 1.5L antenna has been installed on the LHD. The system can steer the direction of the beam faster than the previous one by using AC servo motors instead of ultrasonic motors. The maximum speed of the new antenna system is about 8[degree/s], which is 10 times faster than the previous one. This system is currently controlled by a PLC. We consider the use of an FPGA as a control device for quicker response of the antenna.

(2) ICH

In the 15th experimental campaign, two Poloidal Array Antennas were installed in the 7.5U&L port of the LHD, and we carried out the LHD experiment with one set of handshake form (HAS) antennas installed at the 3.5U&L port and in total four antennas. Furthermore, we used six oscillators for the first time in this experimental campaign. However, the oscillators of #1 - #4 were connected to the 3.5U&L antenna and we selected those oscillators by experiment frequency (28.4 MHz or 38.47 MHz). The total injection power with the four antennas into the plasma reached 2.2 MW in the short pulse of 10 seconds. Sparks occurred in the vicinity of the 7.5U&L antenna during a steady state discharge at the end of the experimental campaign. Therefore, we carried out a steady state discharge without the 7.5U&L antenna, and, as a result, the injection power into the plasma reached 0.76 MW / 320 seconds.

(a) Remote control of the magnetic ring for protecting a ceramic feedthrough

We install a magnetic ring which puts a permanent magnet in a ring-shaped case so that plasma does not hit the ceramic of the ceramic feedthrough when glow discharge is performed and remove it before the plasma experiment begins. We started the design and production of a new magnetic ring in order to perform this work remotely from the RF local control room. At first as a result of examining various methods, we chose the use of the air core coil in consideration of the simplicity of the apparatus and ease of control and maintenance. Figure 13 shows the cross-sectional view of a magnetic ring. Since the strength of the magnetic field at the feedthrough center at a present magnetic ring is 2.8x10-4 T, the magnetic field strength (B) that is required for one coil becomes 1.4 x10-4 T. The inner diameter of the coil (a) was decide in 250 mm in consideration of the outer diameter of the feedthrough, and the distance from the center of the feedthrough to the coil (x) was decided in 125 mm. From these conditions and eq. (1) the current required for one coil (I) becomes 75.77 A.

$$B = \frac{\mu_0 I a^2}{2\pi \left(x^2 + {a^2}/{4}\right) \sqrt{x^2 + {a^2}/{2}}} \qquad (1)$$

Next, we decided on polyester copper wire with a diameter of 0.5 mm for the coil and chose 6 V as the power supply voltage. In addition, the bobbin of the case of the coil is decided to be made from aluminum which served as alternating magnetic field cancellation to deal with the abnormal high voltage which occurs in the coil when a strong magnetic field changes suddenly during an experiment because the coil is installed in the vicinity of the top and bottom ports of LHD. We used the glass fiber crossing tape having an adhesive side for electric insulation between the bobbin and the copper wire. In this way, we surrounded the copper wire 1000 times, and it is confirmed that 80mA per copper wire flows at a power supply voltage of 6 V. We install this magnetic ring for the feedthrough and will test the performance in the next 16th experimental campaign.

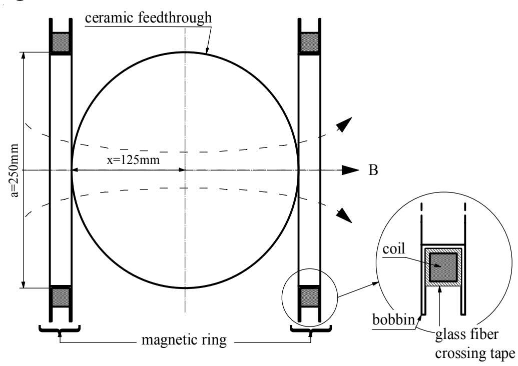

Fig. 13. Sectional view of a magnetic ring.

(3) NBI

(a) Replacement of the vacuum pumping systems in the NBI test-stand

Vacuum vessels of the beamline in the NBI test-stand are equipped with a vacuum pumping system. The vessels are exhausted to a high-vacuum level with two turbo-molecular pumps, and cryo-sorption pumps are also used for achieving an ultrahigh-vacuum in the beam production experiments.

The turbo-molecular pumping systems have been working for nearly 18 years since they were installed at the construction of the test-stand. Since the systems exceeded the nominal lifetime, we have renewed their components including the pumps in turn over several years. Figure 14 shows the vacuum pumping system of the beamline.

We have been carrying out the work step by step as follows:

(1) Renewal of the turbo-molecular pump in the beam-dump (BD) vessel

(2) Replacement of the rotary vane pump with a rough vacuum pumping

(3) Renewal of the turbo-molecular pump in the ion-source (IS) vessel

(4) Modification of the pumping control unit

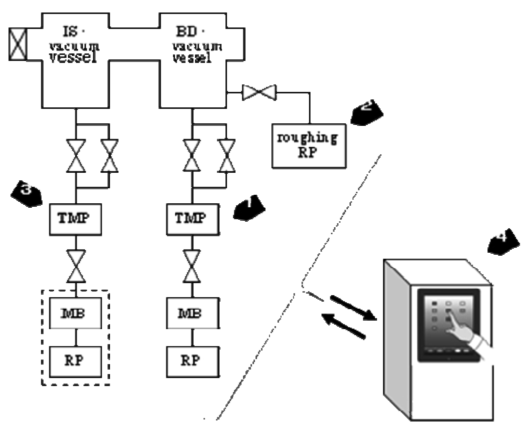

Fig. 14. The schematic of the beamline vacuum pumping system.

We did the following works of (4) in the period of the experiment break in this fiscal year, as a continuation from the last fiscal year; renewal of the programmable logic controller / exchange of the electric components / renewal of the operator control panel -- from the old style of illuminated pushbutton switch panel to the latest style of touch panel screen / integration of the operation control for both the turbo-pump system and the roughing pump system which were independently controlled / wiring reconnection / test run for debugging.

We completed the main part of the work by summer and the updated system can be employed now. At present, we manually operate each valve and the pumps one by one, watching a degree of vacuum. Now we are going to improve the operation control unit so that a series of the operational sequences could be automated.

(b) Development of image acquisition system for the RHD experiment

A new experimental study has been started to investigate self-generation of flow pattern in rotating turbulent fluids, named as the “Rotating Hydrodynamics (RHD) experiment”. For distinguished controllability, the turbulence is produced in a thin cell filled by liquid crystal fluid and turbulence can be controlled by applying electrical voltage.

In this experiment, two diagnostics are required. One is a monitor of the rotation of the stage. The other is a 2D image monitor, in which the turbulent state of the liquid crystal can be seen. Therefore, a unified system of these diagnostics is being developed. Figure 15 shows a configuration diagram of this system. Two pulsed signals are generated by a rotary encoder. The direction discrimination unit produces a digital signal and single pulsed signal corresponding to rotational polarity and speed, respectively. The pulsed signal is converted to an analog signal proportional to its frequency (F/V conversion). These two signals are saved to a PC with an USB data acquisition device. A video signal of a CCD camera mounted on the rotary stage has to be monitored in the laboratory frame. The video signal is connected to the PC with IEEE1394b protocol through a rotary terminal block, which connects electric signals (8ch/unit) between the rotating frame and the stationary frame. The video signal can be saved as a 2D image with the BMP format and as a movie with AVI format. The information of the rotation is also saved in the file name.

The unified monitoring system of the RHD experiment is now under preparation.

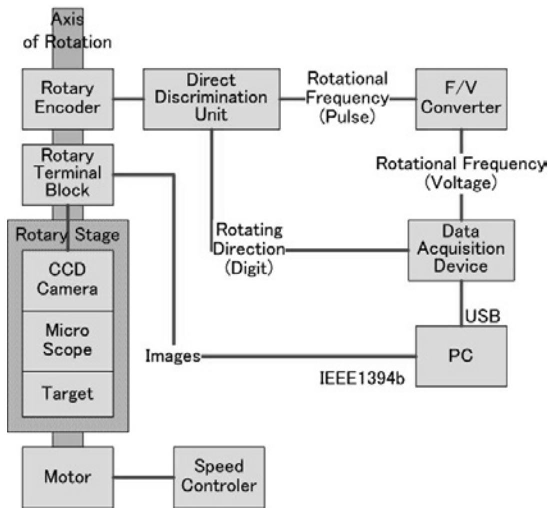

Fig. 15. Image acquisition system for RHD.

(c) Evaluation of neutral beam injection power

The Neutral Beam (NB) injected power is evaluated from the temperature rise of Calorie-Meter Arrays (CMA), which are installed in the armor tiles at the opposite wall of the NB injection-port. The temperatures of the calorie-meters are measured by 40 thermo-couples for NBI#1 and #2 and 27 thermo-couples for NBI#3. They are attached to molybdenum cylindrical chips and their signals are measured by isolation amplifiers using the WE data acquisition system. The measurement ranges of the amplifiers are mostly 0-500 degrees in Celsius. For some chips, the range of 0-1000 degrees is adopted.

The injection efficiency is estimated by normalizing the injection power by the power obtained from the beam voltage and current. Here, these monitor signals are acquired by the CAMAC data acquisition system. The typical injection efficiencies during the 15th experiment campaign were estimated to 0.35 for NBI#1, 0.33 for NBI#2 and 0.38 for NBI#3.

(4) Motor-Generator (MG)

The MG is used to supply the pulsed power to the NBI and the ECH for LHD. The MG had generated 22,633 shots in this fiscal year and 515,237 shots since its construction. The operation time was 1,153 hours in this fiscal year and 23,744 hours in total. Under the annual inspection in this fiscal year, the following components were checked: oil in the MG, AC voltage test for the stator of the 8,500 kV Motor, overhaul of the Scherbius control boards, UPS, the rectifier for excitation, the diesel engine generator.

After the inspection problem was found out during test operations. A leak of water occurred from the pipes that were changed three years ago. The pipes are located in the middle of the MG. To repair these, the MG was dismantled sequentially from the top so that these can be removed in this fiscal year.

4. Diagnostics Technology Division

This division supports utility construction and device installation work for the LHD diagnostics, and the development, operation and maintenance of the diagnostic devices and of the data acquisition systems for the LHD plasma experiments. For the 15th experimental campaign, some of the diagnostics and the data acquisition systems were improved. A new laser system was installed in the Thomson Scattering Diagnostic. This laser system can inject in various ways, for example three beams combined, depending on the LHD experiment. In the LHD data acquisition system, 9 new diagnostics have been added in 2011, then totally 95 diagnostics have worked. Consequently, the total amount of the acquired data grew up to 13.4GB (5.8GB after compression) for one short-pulse shot and the storage systems were also extended. For data storage, a new cloud storage system has been started. Our principal tasks in this fiscal year are described in the following.

(1) Development, Operation and Maintenance of the Radiation Monitoring System

In this fiscal year, we newly installed some radiation monitors in the NIFS radiation monitoring system; two radiation gas monitors in the LHD experimental floor, two gas monitors in the stack of the LHD building, and a radiation monitor for the drain water of this building. With these monitors, we collect the background data of radioactive concentration in the LHD environment.

Five radiation monitoring posts around the experimental buildings and on the site boundary in the NIFS site were checked and calibrated with the standard checking radioactive sources. During this maintenance, we had no problems with these radiation monitors.

Fig. 16. Snap shot of the room gas monitor on the LHD experimental floor.

(2) Thomson Scattering Diagnostics

In this fiscal year, the laser system was improved and beams could be injected in various ways, for example three beams combined, depending on the LHD experiment. Because of this, the data processing system also was improved and information of the laser is added.

The improvement to deal with high electron temperature (~20keV) is also going on.

Additionally, since some equipment had troubled with age deterioration, we had to respond to the trouble; we had to replaced some aging devices gradually.

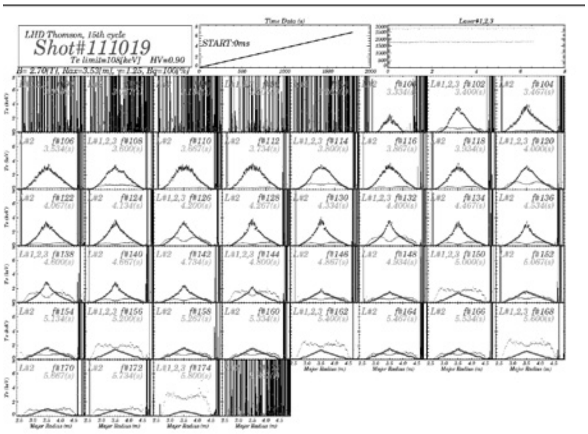

Fig. 17. Example of data graph with the laser information.

(3) Operation and Maintenance of FIR Diagnostics and Microwave Reflectometer

The operation and the maintenance (for example, high voltage power supply, vacuum pumping system, gas supply system, phase detection circuit, dehydrator, water cooling system etc.) were responsibly executed. Therefore in this 15th experimental campaign, in almost all shots, electron density data were taken completely. So it contributed greatly to the plasma experiment.

(4) Improvement of the negative ion source of the HIBP

The aperture (water-cooled beam stopper) was installed between the ion source and the accelerator. By the aperture insertion, the form of beam was arranged and unnecessary beam acceleration was stopped. Then, in order to extend the life time of the ion source, we investigated and optimized the quality of the material, diameter and current of the filament in the ion source. The tip of the target support improved last year was exchanged for a copper target, and the output of the copper ion beam was checked. But the copper target was not used in the LHD experiment because we need the long time for the target exchange.

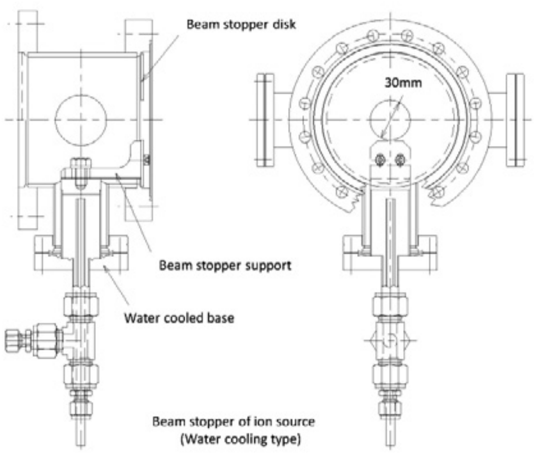

Fig. 18. Design of the beam stopper of the new ion source of the HIBP.

(5) Vacuum Leak Test with the Test Chamber in the Plasma Diagnostics Laboratories

Preliminary vacuum leak tests were carried out on the diagnostic devices to be used for the LHD plasma experiment and the parts to be used in these diagnostic devices by using the leak test chamber in the Plasma Diagnostic Laboratories. Before the 15th plasma experiment campaign, some diagnostics elements were tested, for example, some flanges of the laser blow-off system, feed through flange of the Soft X-ray spectroscopic system, the ZnSe windows of the FIR diagnostics, the some flanges of the penning vacuum gauge of the observation system for the closed divertor and crystal windows of the ECE system, etc. We carefully tested these vacuum components. Therefore in this 15th experimental campaign, the plasma experiment was not stopped because of the diagnostic device vacuum leakage.

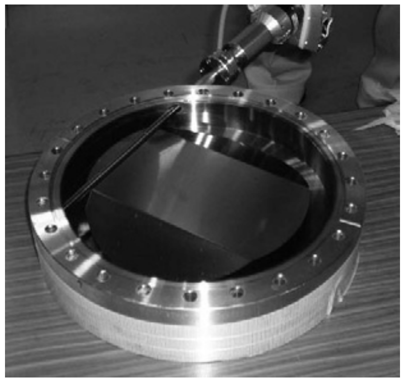

Fig. 19. Snap shot of the vacuum leak test in the Plasma Diagnostic Laboratories.

(6) Support work for the Lending System of various diagnostic apparatus through NIFS collaborative research

The lending system of various diagnostic apparatus managed by NIFS has been carried out for institutions with NIFS collaborative research programs since the 2011 fiscal year. We show the way of the usage as follows. The researchers who can use this system are limited to NIFS collaborative researchers. The period of the lending is by month and the longest is till the end of the fiscal year even if it is renewed. The application is required until the 15th of the previous month when the users want to use it.

We report the activity of this lending system of this year as follows. The high-speed video camera was lent 5 times a year and 3 universities used it. The lending of an analog-to-digital conversion device was 3 times a year and 2 universities used it. We check and calibrate each apparatus and then we do the necessary steps for sending them. After returning the apparatus, we perform the check and the calibration etc.

(7) Development of Data Acquisition Systems

In the LHD data acquisition (DAQ) system, 9 new personal computers for the DAQ system have been added in 2011, then totally 95 DAQ systems have worked. One of them acquires the very huge data from the high-rate sampling (12.5GS/s) digitizer. Consequently, the total amount of the acquired data grew up to 13.4 GB (5.8GB after compression) for one short-pulse shot and the storage systems were also extended. Additionally, in the QUEST and the GAMMA10 DAQ systems, 2 new personal computers for the DAQ system have been added and remote KVM devices have been installed to all active personal computers of the DAQ systems.

The data storage system for the 15th experimental campaign has changed from the Red Hat Global File System to the new cloud-based storage system called "InzaStore". The new storage system stored the amount of whole acquired raw data about 50TB during the 15th campaign.

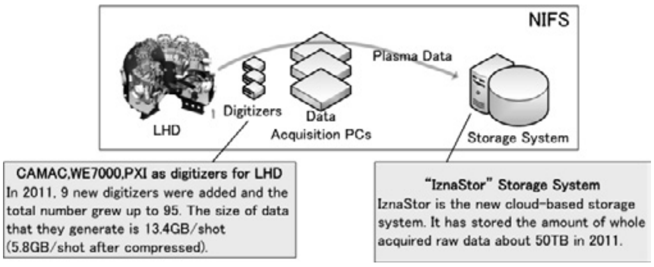

Fig. 20. Overview of the LHD Data Acquisition Systems for the 15th experimental campaign.

5. Control Technology Division

The Control Technology Division contributed to those important technological parts of the LHD, such as operation and management and development of the system. The work of the system operation and system management is as follows; the LHD central control system, the cryogenic system and the power supply system for the super conducting coils. The work of the system development in this year is as follows; updating the central control system and cryogenic control system, development of a new simulation algorithm for the cryogenic system, system development of the experimental parameter distribution and the network for LHD, and etc. Details of the activities in this division are described.

(1) Operation of LHD

The LHD cryogenic system operation started on June 17 in the fifteenth-experimental campaign, the helium gas was purified as usual. The coil cool-down was started on June 29, and it was completed on July 25. The number of steady-state operation days of the super conducting coils was 88 days. Although the increase of the heat load occurred by a rise of cooling water temperature in summer, it was able to operate safely without serious trouble. The coil warm-up was started on October 21 and it was finished on November 11. The availability of the cryogenic system achieved 100 %, and total operation time was 3,527 hours in this campaign.

The power supply system excited the super conducting coils 66 times and total operation time was 482 hours. In these operations, the high voltage power supply for pulsed excitation was used 5 times and the polarity switch device was used 22 times. A problem of the DC 5V power supply unit occurred during these operations. We exchanged to the spare power supply. The cause of the trouble was due to age-related deterioration by using more than 10 years. Therefore, all of the DC power supply units used in this system will be exchanged for the new units by the next experimental campaign.

(2) Update of the LHD central control system

The central control system requires high reliability. Since starting 16 years have passed, and it became difficult to obtain maintenance parts. So we began an update of the main components (client PC, server and Programmable Logic Controller). The closed divertor, X-ray limiter and a new coolant device were installed in LHD. We had to instal the interlock signal lines connecting these devices to the central control system.

The delivery PLC delivers 1Q signal to the four PLCs which are set in the four stages in LHD hall through a private network.

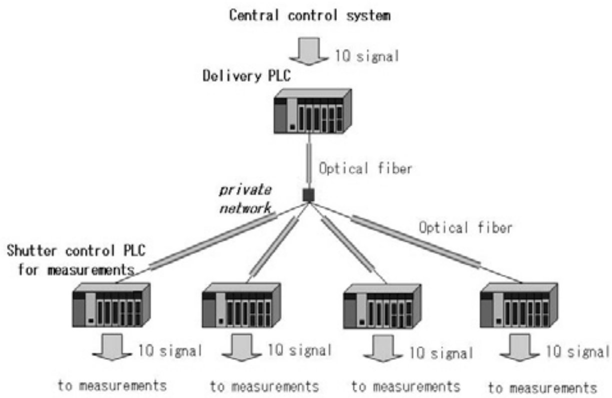

Fig. 21. Block diagram of the 1Q signal delivery system.

(3) Update of the LHD cryogenic control system

There was updating work of a LHD Cryogenics control system this year. The control system was changed into Compact PCI from VME.

An operation screen was created using Java, it enabled operation surveillance from the control room by PC and the remote surveillance by tablet PC. The data logger which can perform data collection for 100 ms was also connected.

The new CPCI control system operation will be performed on middle of the warm-up phase in the 16th experimental campaign .

Fig. 22. Tablet PC for remote monitoring.

(4) Malfunction of helical coil quench detector and investigation to determine the cause

The LHD helical coil used a quench detector for protection. Last year we constructed the noise measurement system. Thereby we discovered that the quench detector malfunctioned simultaneously with the breakdown of the NBI. (Fig.23 breakdown at 4.3s / malfunction signal at same time)

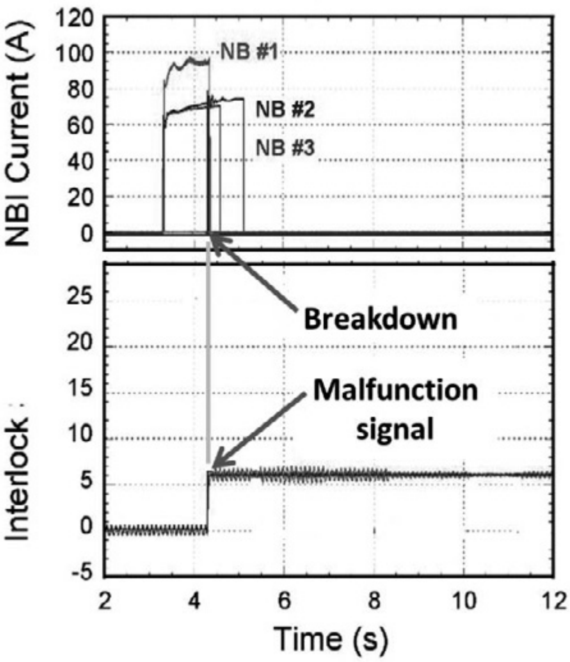

Fig. 23. Breakdown at 4.3s/ malfunction signal at same time.

As a result of the investigation we found that the signal cable of the central control system was not using a twisted pair cable but 70m loop wiring. There is some possibility of receiving noise because loop wiring plays the role of a noise antenna. We added a relay to the loop wiring because noise cannot invade the quench detector directly. After this improvement, the noise was decreased dramatically.

But last year we found some malfunction signal that is unrelated to the breakdown of NBI. (Fig.24 breakdown at 3.6s / malfunction signal at 3.8s) We keep on investigating.

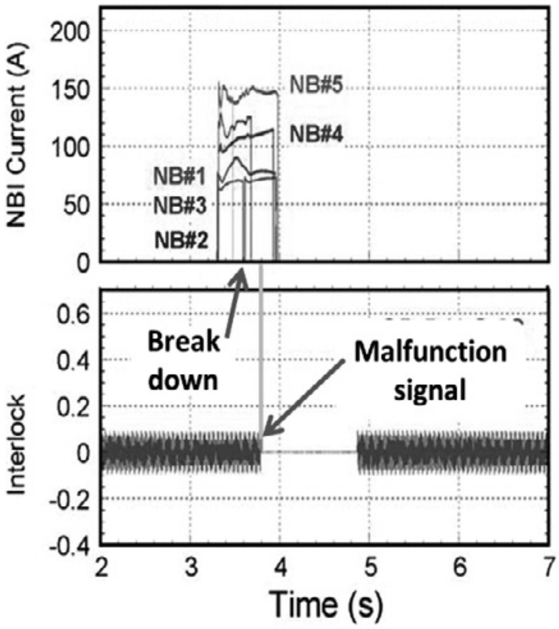

Fig. 24. Breakdown at 3.6s/ malfunction signal at 3.8s.

(5) Modification of experimental parameter distribution system

The experimental parameter distribution system is a core component of the central control system to distribute experimental parameters updated according to the progress of the plasma experiment in real time, such as shot number, experimental sequence status, magnetic condition and so on. Since we have developed this system in 2002, we have been in charge of the system modification, user management and technical support. At this time, approximately 130 applications, mainly in data-acquisition-systems, are using this system and the operating ratio has been kept high, around 99.98%, since the 10^{th} experimental campaign.

The "shot number", which is a unique identifier assigned to the experimental result data in every data-acquisition-system, is one of the most important parameters. If some trouble occurs in the system, it will seriously affect the entire LHD experiment. For the purpose of further improvement in an operating ratio, we reviewed a part of the system design in this fiscal year. Specifically, the software structure and components from the shot number generation function to the distribution function are integrated or simplified to achieve a longer MTBF (Mean Time Between Failures) and the automatic error monitoring function is enhanced to improve the error detection performance. In addition, all the components developed by Visual Basic6.0 are transported to Visual Basic.Net or C++ to Linux to enable maintenance in the next 10 years. New system will be officially operated in the 17th experimental campaign after a trial operation next fiscal year.

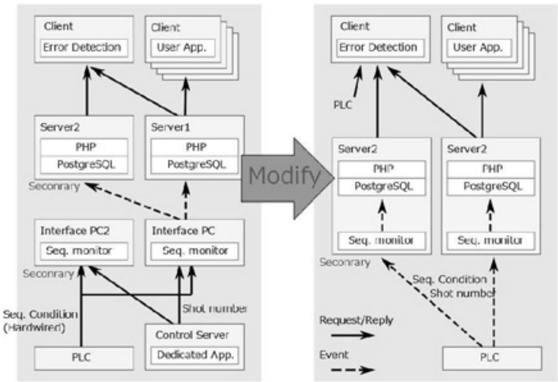

Fig. 25. Block diagram of experimental parameter distribution system.

(6) Validation of CEA test loop experiment to study ITER relevant supercritical helium loop

The dynamic simulation of the CEA (Commissariat a l'energie atomique et aux energies alternatives) test loop experiment to study ITER relevant supercritical helium (SHe) loop was carried out.

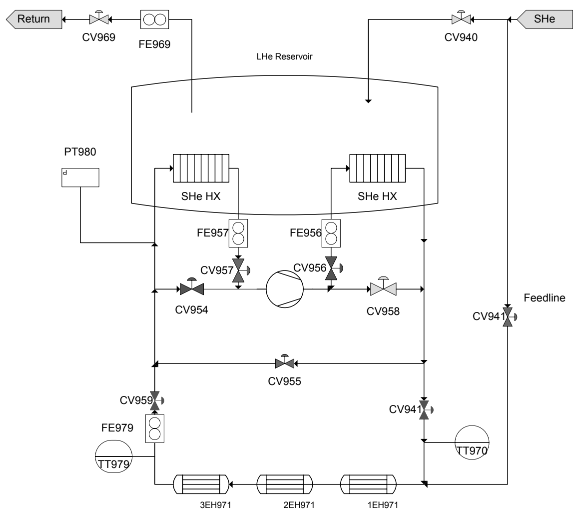

Fig. 26. Schematic of the CEA test loop experiment.

The dynamic simulation system, C-PREST, has been utilized to study the thermal-hydraulic behavior of a forced-flow SHe loop. Figure 26 shows a schematic of the CEA test loop experiment, which consists of a LHe reservoir, two immersed heat exchangers, three independent heated sections along the loop and bypass valves for the flow distribution. To simulate the thermal-hydraulic behavior of the SHe in the 200m long test loop, a new piping model has been developed taking into account the time rate change of the fluid internal energy. The heat pulse operation of the CEA test loop was simulated by using the piping model and the result of the simulation was in good agreement with the experimental result. We successfully validated the simulation model in C-PREST. The study will be extended to analyze the mitigation technique and the control of the heat load to the LHe reservoir.

(7) LHD-LAN

The LHD-LAN has been contributing to the LHD experiments since 1996. The new “LHD-LAN Core Switch System” has been 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 is over 210 million packets per second.

New contributions in FY 2011 are as follows:

(a) Upgrade hardware configuration

The LHD operational LAN switches which remained without being updated have been replaced with Cisco Catalyst 2960 layer-2 switches.

(b) Reconstruction of the LHD-LAN classification

The LHD-LAN classification has been reconstructed as follows in consideration of the convenience of the both sides of a user and an administrator.

- Integration of “Analysis/Diagnostics Client LAN” and “Analysis Server LAN”
- Integration of “Data Acquisition LAN”

The new schematic structure of the LHD-LAN is shown in Figure 27.

(c) Security improvement in the LHD-LAN

Upgrade to Symantec Endpoint Protection is planned for all PCs, before reaching the end of support for Symantec Antivirus Corporate Edition 10.x.

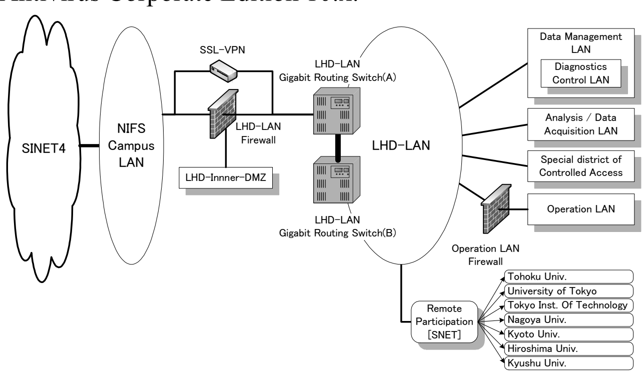

Fig. 27. The new schematic structure of the LHD-LAN.

6. Symposium on Technology, Technical

Exchange and Dual System

(1) The Symposium on Technology

The Symposium on Technology was held on March 8 and 9, 2012 at the Institute for Molecular Science. There were 252 participants from many Japanese universities, national laboratories, technical colleges and some industries. In this symposium 95 papers were presented in 5 oral sessions and poster sessions. Technical experience and new techniques were reported and discussed. Six papers were presented from our department.

Fig. 28. Snapshot of a lecture meeting.

(2) Technical Exchanges

The technical exchanges between our department and other institutes or universities were held in order to improve the technical skills of the staff. In this fiscal year, we invited Mr. Mizutani. He is technician belong to National Institute for Basic Biology. He gave us a lecture on "Presentation techniques". And the meeting "Symposium on Safety and Health Management in a Laboratory "was held from February 9 and 10 with 50 participants from 15 universities and 4 institutes. Figure 29 shows the scene of the LHD tour in the meeting.

Fig. 29. A snap shot of the members of the meeting "Symposium on Safety and Health Management in a Laboratory ".

(3) Educational coordinated activity on "A Dual system in Japanese version"

A dual system in Japanese version aiming to developed independent skilled workers by concretely combining an education by lectures in school with practice in enterprises. NIFS had accepted students from the Tajimi Technical High School since fiscal year 2005 for training from the point view of a researcher and an engineer.

Fig. 30. A snap shot of the presentation in the NIFS open campus.

7. The FY2011 Tokai and Hokuriku Area Technical Staff Joint Training

The FY 2011 joint training (the special composite course) for Technical Staff working in the Tokai・Hokuriku area was carried out for 3 days from November 9^{th} to 11^{th} . The purpose of this training is that Technical Staff acquire general and professional knowledge and techniques for the job. This training is carried out by taking turns among the organizations in the area. NIFS took charge of planning and hosting this time. 32 persons participated from 17 organizations.

Fig. 31. A snapshot of the training.