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 and the network in NIFS. 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 LHD network. The number of staff is 45 engineers and 10 part-time workers. We take care of the development, the operation and the maintenance of LHD and the LHD peripheral devices with about 46 operators.

1. Fabrication Technology Division

The main works of this division are 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, too. In addition we handle the administrative procedures of the Department.

The total numbers of components completed in this FY by the central workshop are 218 by machining and 31 by electronic engineering. Some of the projects related to the management of the LAN systems are also described as follows.

(1) 100ch amplifier for the optical imaging camera

The amplifier is made for an optical imaging camera that is used to observe the path of the injecting fuel ice pellet in the plasma. The voltage gain of the amplifier is 100; the frequency bandwidth is 2MHz. To prevent crosstalk between channels, electromagnetic shielding is installed between each channel, as shown in Fig. 1.

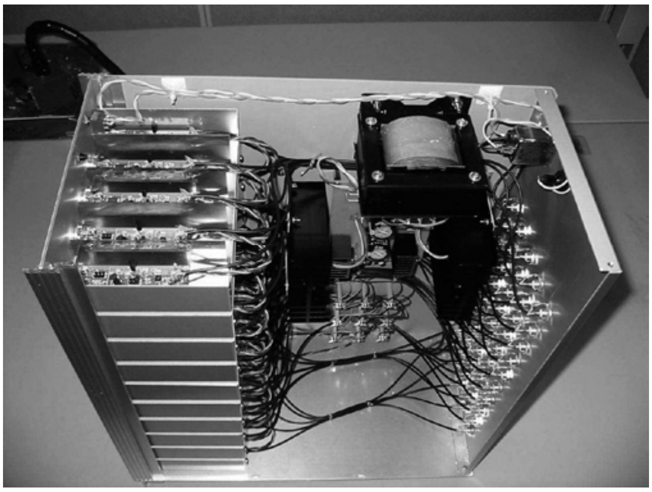

Fig.1. the 100ch amplifier for the optical imaging camera

(2) Latching scaler circuit

The prototype of a latching scaler circuit for a neutral particle detector was manufactured (as shown in Fig.2). The specifications of the circuit are: counting frequency max 150MHz, 4 channels, 16bit counter, latching frequency max 1MHz, data memory 32MB, and data readout through Ethernet LAN from PC. Since a large crosstalk affects the performance of the device and circuits, two prototype versions have been manufactured. A prototype circuit of 8 channels is currently being manufactured.

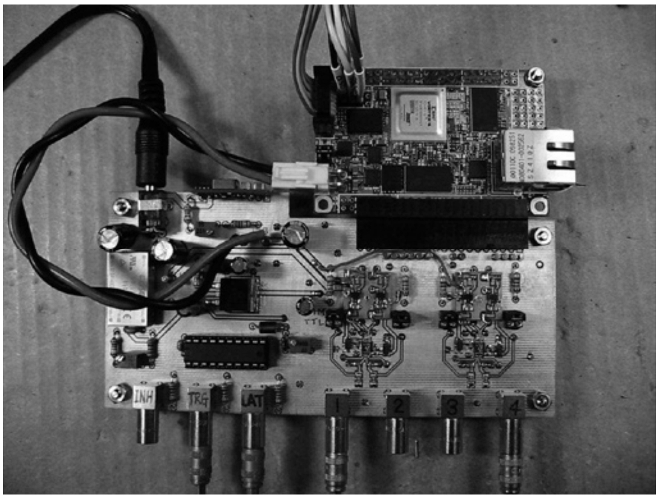

Fig.2. The prototype of the latching scaler

(3) A concave mirror for the Microwave Imaging Reflectometer (MIR)

An MIR is a device that was developed in order to visualize electron density fluctuations in LHD. In an MIR system, to focus the reflected microwave from the plasma to the detectors, it is necessary that we manufactured a large concave mirror (Fig. 3). The material of the mirror is an aluminum alloy; the size is 500mm in the major axis, 470mm in the minor axis and a thickness of 40mm. In order to manufacture the mirror, it takes about 26 hours to cut the material. Five years ago, about 192 hours were necessary to manufacture this type mirror of a same size. We use a machining center, in which a high-speed processing system is installed. The high-speed processing system of the machining center brings to us a large savings in the time that was necessary for manufacturing the mirror.

Fig.3. A concave mirror for MIR

(4) Protection pipes

These products (as shown in Fig. 4) are intended to be used in the examination of the deposition of impurities occurring during a plasma experiment on the mirrors fixed to the vacuum vessel. When impurities accumulate on the mirrors, the reflectivity decreases. So, we produced a protection pipe to suppress the deposition of impurities. The protection pipe's lengths above the test mirrors are 110, 75 and 30 mm and are 30 mm in width. The materials are anoxic copper and stainless steel. We produced the protection pipes in the machining center and the general-purpose milling machine.

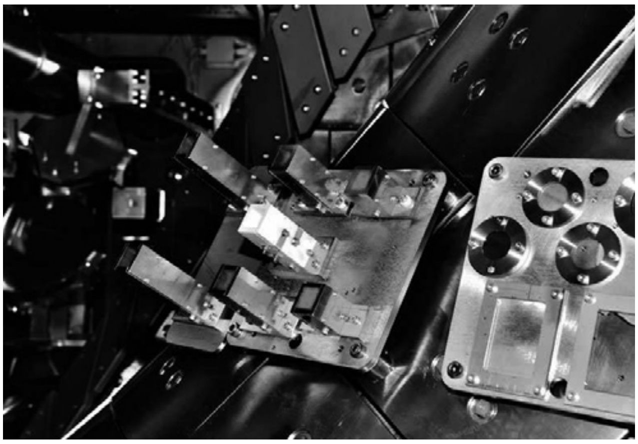

Fig. 4. Test sample with different length protection pipers

(5) 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 whose maximum throughputs are over 210 million packets per second. They are connected by two of 10 Gigabit Ethernet ports, based on a link aggregation protocol for load balancing and redundancy.

The schematic structure of the new LHD-LAN is shown in Fig. 5.

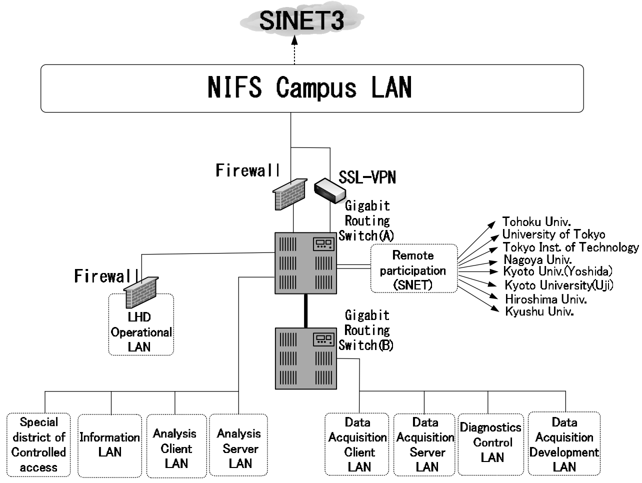

Fig. 5. The schematic structure of the new LHD-LAN

New contributions in FY 2010 are as follows:

Upgrade hardware configuration

A 10/100/1000-T module with 48 ports was installed into one of the Cisco Catalyst 4507R multi-layer switches for redundancy.

Security improvement in the LHD-LAN

1) In order to monitor the antivirus software for the recent version of the virus definition remotely, we adopted the

“Symantec System Center (SSC)” and “Symantec Endpoint Protection Manager (SEPM)” and started operation. In last fiscal year, all clients PC using antivirus software have been managed by either of these management systems.

A security check of PC using the Windows operating system has been done before the beginning of the 14th LHD experimental campaign.

In the security check, Windows XP SP2 or Vista PCs have been updated to a secure Service Pack. Windows 2000 PCs, reached the end of support in July 2010, and have been isolated into the special domain of controlled access.

Before reaching the end of support for Windows 2000 Server, a Windows 2000-based Active Directory server has been upgraded to Windows Server 2003 R2. Thus all of the servers were unified to Windows Server 2003 R2.

(6) Update of the Mailing List Server

The Mailing List Server was updated on Sunday, May 16, 2010.

The processing capacity of the Mailing List Server was improved by this update. In addition, the new Mailing List Server which made of dual 145GB hard disks came to resist trouble by the mirroring of the RAID1 system. The hardware trouble is not yet taking place after the Mailing List Server was updated.

Figure 6 is a photograph of the new Mailing List Server.

Fig. 6. New Mailing List Server SPARK Enterprise T5120

(7) Services around the network

We manage servers such as VPN, FTP and PROXY, external network mainly for visiting guests. And we also take care of wireless-LAN, UPS and the electrical outlets in our rooms to Research Information Cluster. In FY 2010, by integrating FTP and PROXY servers into one machine, we cut down the number of servers to manage. The number of VPN users is increasing, then it is required that VPN supports not only PCs but also mobile devices. One of the works which we took over in FY 2010 is the operation of the TV conference system. We updated the multipoint control unit and terminal to have it user-friendly. The number of TV conferences increases year by year. In addition, we have investigated UTP, optical cables, etc. for preparing an update of NIFS-LAN which is planned after the next FY.

2. Device Technology Division

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

(1) Operation of LHD

LHD operation started on August 20 in the fourteenth-experimental campaign, the cryostat was evacuated as usual. The evacuation of the plasma vacuum vessel began on August 20. The number of the maintained flanges was 130. We found eight vacuum leaks. The vacuum leaks were fixed on September 13.

The first energizing of LHD in the fourteenth - experimental campaign was on October 14. The number of days of the plasma experimental period was 106 days.

(2) Installation of the metallic meshes to cover the millimeter-wave that reaches the cryogenic-pumps

The vacuum pumping systems of LHD have ten cryogenic-pumps. In the ECH long-pulse discharges, a part of the millimeter waves from ECH reached the cryogenic-pumps and the temperature of cryogenic-panel came to rise. As a result, the pressure of the vacuum vessel came to rise. To shield these millimeter waves, we decided to install the metallic meshes in the inlet of the cryogenic-pumps. But we expected that installing the metallic meshes decreased the pumping speed of the vacuum pumping system. Therefore, we estimated the amount of the decrease of the pumping speed by to be calculation and experiment, and the amount was expected 14%.

After we actually installed the meshes in the cryogenic-pumps, we measured the pumping speed of the vacuum pumping system. The amount of the decrease was about 15 %. We could obtain the predicted results (Fig.7). Moreover, we could suppress the temperature rise of cryogenic-panel in the long-pulse discharges after the metallic mesh installation (Fig.8).

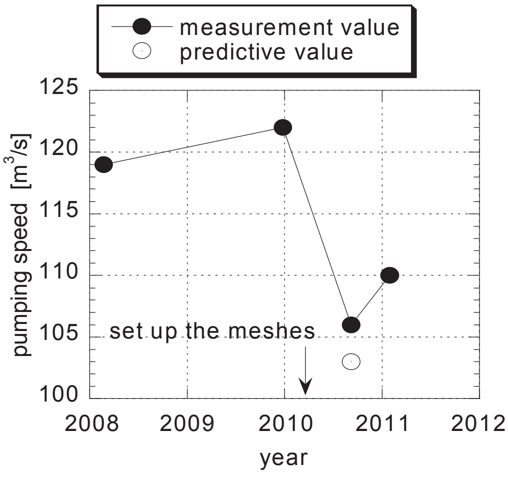

Fig. 7. Pumping speed after the metallic mesh installation

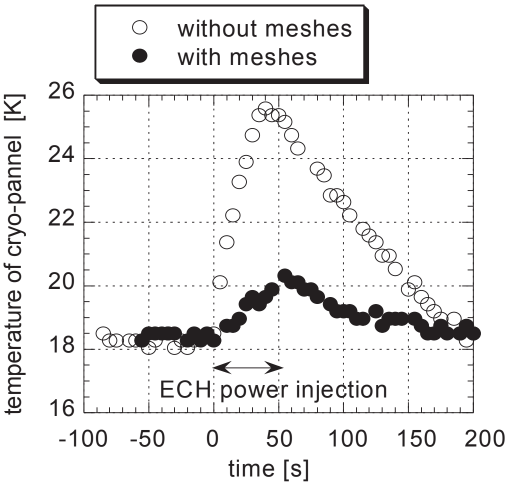

Fig. 8. Suppression of temperature rise by the metallic meshes installation in the ECH long-pulse discharge

(3) New stages for Closed Helical Divertor

The Closed Helical Divertors with ten cryogenic-sorption pump units are going to be designed for the purpose of peripheral plasma density control by efficient particle pumping. One unit of the cryogenic-sorption pump system consists of cryogenic panels with active charcoals and a cryostat unit which consists of refrigerators and heat exchangers. Ten cryostat units and those compressor units will be put into three new stages (east-stage, west-stage and south-stage) constructed on the B-stage, the D-stage and the LID-stage.

The structure design of the new stages has been analyzed by the FET software "ANSYS" under the load condition of 500 kgm-2 and a quake of 0.3 G. In addition, the need of reconstruction or reinforcement for the B-stage, the D-stage and the LID-stage also has been studied. Figure 9 shows a schematic view of the west stage. Broken lines on the D-stage show a reinforcing bar. Figure 10 shows a distribution of the displacement magnitude for the west stage which has been analyzed by ANSYS. Therefore, the displacement magnitude of the new stages is suppressed within a few mm.

The fabrication of the new stages has been already put out to tender. Within 2011, construction of the new stages and reinforcement of the existing stages are going to be carried out.

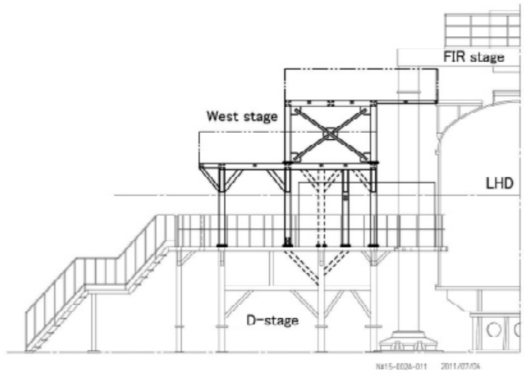

Fig. 9. Schematic view of west stage designed by FET software "ANSYS".

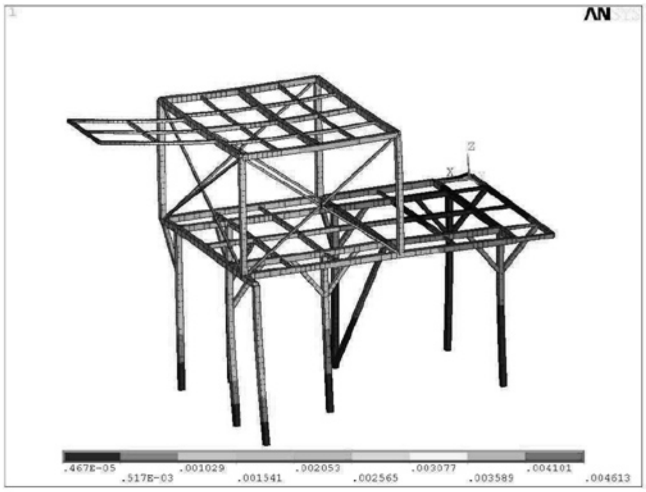

Fig. 10. Displacement magnitude distribution on the west stage.

(4) Design and assembly of X-ray killer limiter

An X-ray killer limiter, which consists of the stainless steel plate (600 mm × 1400 mm) and the linear-drive mechanism with a 1900 mm stroke as shown in Fig. 11, has been developed for LHD. The limiter is inserted into the center of the plasma vacuum vessel when changing the coil excitation current to eliminate the plasma current that causes X-ray generation. We performed all the design work and assembly operation before starting the LHD experimental campaign in 2011. Vacuum technology and machine design technology are required to develop the limiter. The drive control system has been also developed in NIFS. We could achieve the reduction of the development cost and ensure flexibility in the device operation.

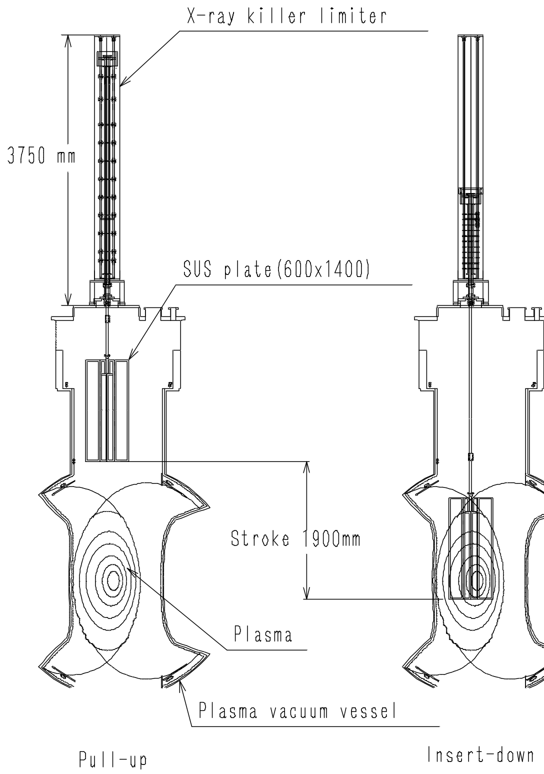

Fig. 11. Design and assembly of X-ray killer limiter

3. Plasma Heating Technology Division

The main works of this division are the operation and 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.

For the 14th experimental campaign, one of the high power 77 GHz gyrotrons that had been upgraded in FY2009 was re-installed in LHD ECH system. As the simultaneous injection power from the three 77GHz gyrotrons became about 3.36MW utilizing a two-step anode voltage application method the experiments aiming at high Te of more than 20keV were carried out successfully. As for the NBI, BL5 having a positive ion source was completed and performed injection of more than 6MW. The High Ti experiment updated a record of 6.4kV by reinforcing NBI and by improving the fueling and heating scenario. As for the ICRF devices, all antennas had been removed since 2008, but we attached one set of handshake form (HAS) antenna newly this time. The motor generator(MG) supplied an electric power to ECH in addition to NBI in the 14th experimental campaign.

The details of these activities are as follows.

(1) ECH

(a) Gyrotron Operation & LHD experiment

During the 14th experimental campaign, we could keep the total injection power level that is equal to the previous campaign. The power of the #5 gyrotron was decreased by aging, we stop #5 and set #6 gyrotron to recover the ECH power.

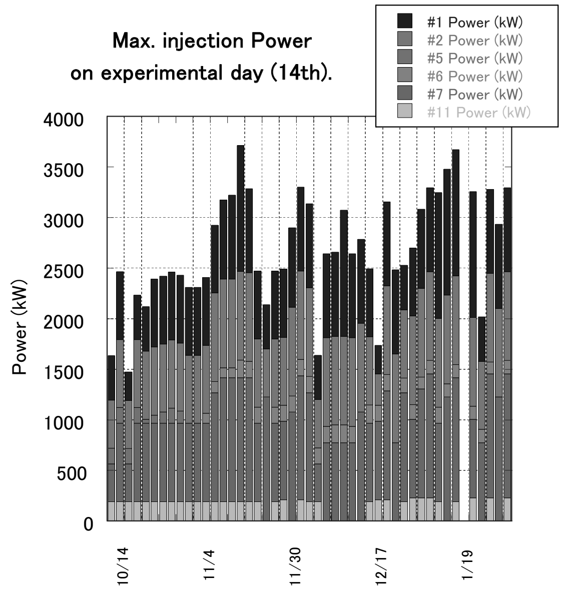

Fig.12. History of ECH injection power during the 14th experimental campaign

Alignment of the transmission line and re-estimation of the transmission efficiency were performed before the campaign. We injected ECH power stably during the whole campaign without any severe troubles that require a stop of operation for several days to restart. Fig. 12 shows the result of ECH injection to LHD in this campaign. Advanced operations of the gyrotron as will be described in (b) made the setting parameter of the gyrotron power supply complicated. The operation will be simplified and become easier by improvements of the control software before the next campaign.

(b)Improvement of 77GHz #2 gyrotron

The pulse duration of this gyrotron could not be extended because of the temperature rise at the DC break that is set between the body and collector to isolate both potentials for collector potential depression (CPD) operation. Diffracted power from a mode converter inside the gyrotron heats a part of the DC break where cooling water cannot access. The absorbed power at this part made its temperature high during long pulse operation. This temperature rise limits the operable power and pulse length.

We decided to replace part of the DC break by a ceramic with lower microwave absorption and improve the cooling capability. After this and several related improvements, the gyrotron could be operated CW (250kW / 30min without interlocks, low vacuum condition and decreasing power).

(C) Improvement from the air to vacuum tight waveguide lines

The transmission line has to be evacuated and cooled by water for the high power microwaves. We have eight waveguide systems two with the inside diameter of 31.75mm and six with 88.9 mm. We changed two waveguide routes towards the 2-O port to accommodate a new NBI system installation. Figure 13 is the state of the waveguide setting before and after the change. These waveguides are evacuated. The level of vacuum was $3x10^{-2}$ Pa allowing a microwave transmission for 3sec of more than 1MW. Evacuation of two 31.75 mm and three 88.9 mm waveguides were completed before the 14th experimental campaign.

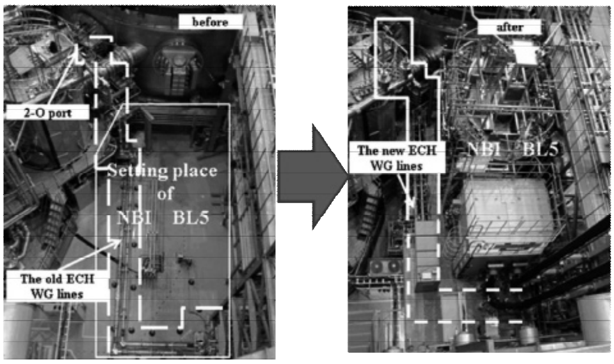

Fig.13. The transmission waveguides which we removed (shown by dotted lines in the left picture). Right picture shows them after a new NBI is installed. The new ECH waveguides run partly under the NBI stage (shown by dotted line).

(d) Trend of transmission line pressure during the 14th experimental campaign

As described in the last annual report, we have monitored and recorded the transmission line pressure during the 14th experimental campaign using a PC. Fig.14 is a history of the pressure of the L2 transmission line during the 14th experimental campaign. The points of over range indicate that the transmission line is filled by nitrogen gas for the maintenance. Pressure reached at 10^{-2} Pa within a few days from the start of evacuation. Pressure approached a TMP pressure level slowly thereafter. The breakdown in the transmission line can be avoided below the pressure of 1.0 Pa. But local pressure can become high when high power millimeter waves are transmitted due to the local temperature rise in the components. Local high pressure can cause a breakdown. After the break of the vacuum for around one week, we had to transmit a millimeter wave carefully. For a stable and reliable transmission at high power the number of vacuum breaks should be reduced.

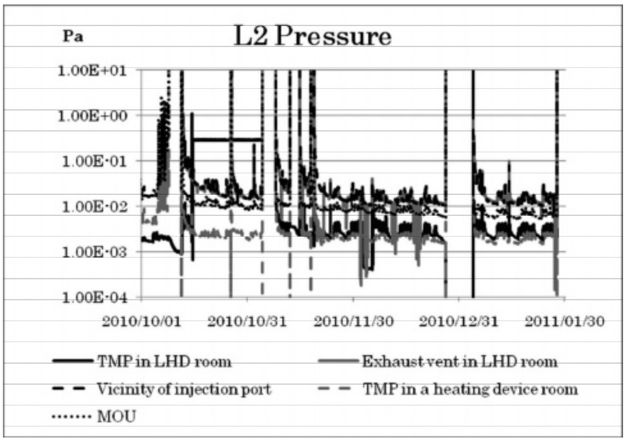

Fig.14. Trend of L2 transmission line pressure

(e) Antenna position measurement system

The existing ECH antenna control system obtains the antenna position by using an absolute or incremental type rotary encoder which is attached to the screw shaft. An incremental encoder sometimes suffers from large electromagnetic noise resulting in the miss count and indicates the wrong antenna position. For such cases, we have installed a reference point to reset the encoder, but no way to know when the miss count occurs. In order to overcome this problem, we have fabricated a laser sensor measurement system. This new system has a laser sensor which directly measures the movement of the shaft and activates a limit switch. The output of the sensor is transmitted to the existing antenna control unit via Ethernet. In cases when the difference between the outputs from the new and existing systems becomes larger than a certain level, an alarm event is triggered to notify the operator.

(2)ICH

(a) New remote pump/valve control system for liquid stub tuners

Impedance matching device for the ICRF heating is comprised of the liquid stub tuners. The liquid length in the tuner is adjusted utilizing a pump with the 5 valves or a cylinder. The former remote pump/valve control system was constituted of the multi-computer system (Cinos), UNIX sever in the RF local control room and a local control unit in the LHD experiment hall. We are planning to control the ICRF devices in the LHD main control room. For this purpose we installed the Compact Field-Point for the measurement and the control of the liquid stub tuners instead of Cinos and a new control panel was developed by using of LabVIEW. By these improvements the liquid stub tuners will be controlled not only in the RF local control room but also in the LHD main control room. Moreover the procedure of starting and shutdown of the remote control system was simplified. As a next step we are planning to acquire data of the reflection coefficient at the outlet of the final power amplifier and calculate the proper liquid heights in the stub tuners to close the feedback loop.

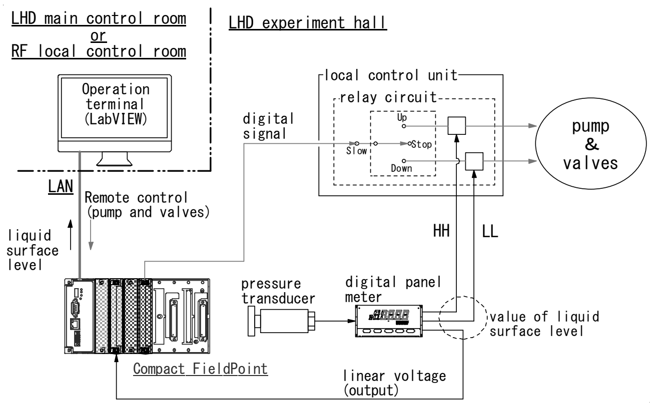

Fig.15. New remote pump/valve control system for liquid stub tuners.

(3)NBI

Fig.16. The picture of BL-5

The history of the total injection beam power of N-NBI (BL-1, 2, 3) is shown in Fig.17 About 6,700-shots of beams were injected into the LHD plasma in this campaign. Non-power periods are during experiment for RF plasma heating only, and repair of the NBI bam-line. The maximum total injection power of N-NBI marked 15.7MW, and the power level of more than 15MW (Design value) was maintained while the experimental campaign without conditioning period. BL-1 output 5.5-6.5MW, BL-2 output 3.5-4.5MW, and BL-3 output 4.5-5.3MW for plasma heating. BL-4 output 3.5-7MW, BL-5 output 3.5-7MW, and covered a broad range of injection power as a plasma diagnostics-beam.

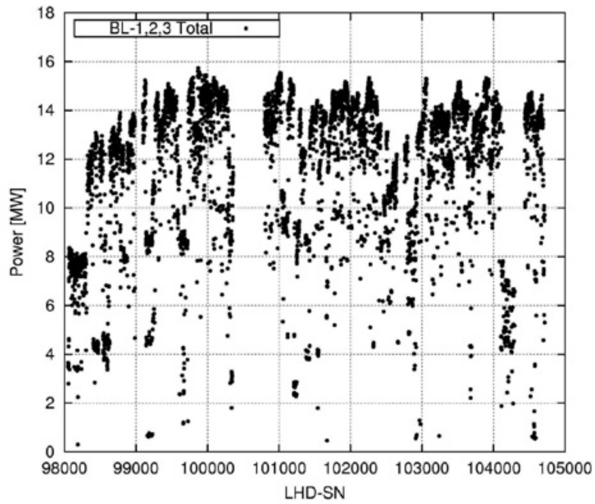

Fig.17. The history of N-NBI injection beam power

In this campaign, two big troubles occurred at BL-1 and BL-5. BL-1 stopped for three weeks due to a big water leak from the ion beam-dump. That causation was due to a pipe-rupture by a cooling water freeze-up by cold energy from a cryogenic-panel. BL-5's one was a small water leak from a movable-calorimeter, and did not worked for one week. The cause of this was poor silver soldering of copper cooling water pipes. A number of minor troubles (power supply error, air leak etc), which were quickly corrected, was the same level as every experimental campaign.

(b) Magnetic Field Analysis for Optimizing the Bending Magnet of NBI#4

The Neutral Beam Injector (NBI) #4 has a problem on residual beam dumps. Due to this problem, the pulse duration of the beam injection is limited to 0.5 sec at full power injection (6MW) for the injector. It is thought the problem is caused by a beam focusing at these dumps by fringe fields of the bending magnet of NBI#4. The upgrade of the injector is now under consideration to enhance the performance of LHD-plasmas. The beam injection power will be raised up to 9MW by increasing its acceleration voltage from 40kV to 60kV and the pulse duration of the beam is also expected to be increased. To expand the operational range of NBI#4, it is necessary to improve the performance of the residual ion-dumps. We think the improvement of the dump is possible by optimizing the configuration of the bending magnet. We are assigned to analyze the magnetic field structures for various configurations of the bending magnets by using the ANSYS-code. Fig. 18 shows an example of the results solved by ANSYS for the magnetic fields on the bending magnet. The results obtained from calculation of the magnetic fields are used to calculate the heat load patterns by the residual ions onto the dumps. The bending magnet will be optimized based on the results of these calculations.

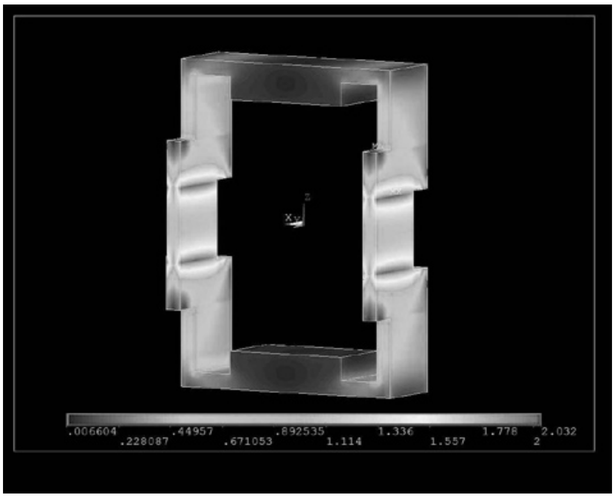

Fig.18. Calculation result of the magnetic field on the bending magnet

(c) Construction of a data acquisition system for a time-resolved Langmuir probe measurement

In order to investigate the dynamics of the charged particles in negative ion sources for NBI, we prepared a Langmuir probe for one of the diagnostics of an R&D ion source installed at a NIFS test facility. In the probe measurement, the most important issue was to observe the changes of the plasma parameters before and after the H^- beam extraction. A time-resolved data acquisition system for the Langmuir probe has been adopted to obtain the waveform of all the plasma parameters. Since an acceleration voltage of more the 50 kV is applied to the ion source, the entire probe system consisting of a voltage amplifier, a function generator, data-acquisition modules and PC is set on the high-voltage stage and the data is transferred via ether-light convertor and optical fiber. The frequency of the scanning voltage applied to the probe is 20 Hz, and the total sampling duration is 10 sec. The screen shot of the data-acquisition PC is shown in Fig. 19. Therefore, 200 scanned data, which includes about 5000 points of data, are saved in just a single shot. The data size is too large to analyze manually, and then an auto-fitting program is developed to quicken the processing time. By optimizing the program, 200 scanned data are processed within the shot interval of 2 min, and we can monitor the time changes of the plasma parameters shot by shot.

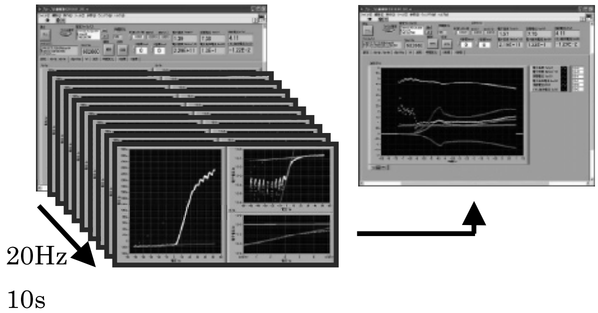

Fig.19. The screen shots of the data-acquisition PC for the Langmuir probe measurement

(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 25,970 shots in this fiscal year and 492,604 shots since its construction. The operation time was 1,214 hours in this fiscal year and 22,591 hours in total. Under the annual inspection in this fiscal year, the following components were checked: oil in the MG, a circuit breaker, two air-break switches, 6.6kV and 18kV switch-boards, 7 vacuum circuit-breakers for 6.6kV, 35 protective relays, a high speed DC circuit-breaker, control center, a diesel engine generator, condensers, harmonic filters, 4,050kV transformer for excitation, 5,600kV transformer for the Scherbius system, a rectifier-board, Scherbius system and a air-compressor. Batteries for the braking device were replaced with new ones.

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 14th experimental campaign, some of the diagnostics and the data acquisition systems were improved. We installed a new short wave-length channel each the 20 polychromators on a central channel for The Thomson Scattering Diagnostic. We can measure high electron temperature region for the LHD plasma with this new channel. In the LHD data acquisition system, 10 new diagnostics have been added in 2010, then totally 86 diagnostics have worked. Consequently, the total amount of the acquired data grew up to 11 GB (4.6GB after compression) for one short-pulse shot and the storage systems were also extended. For data storage, a new cloud storage system has been tested. 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, the 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. After this maintenance, two pulse counters and an ionization chamber detector were repaired.

(2) Thomson Scattering Diagnostics

In the LHD Thomson scattering diagnostics, we newly installed a new channel on the central 20 polychromators whose measuring points are from about 3.3m to 3.7m in major radius. The new channel can measure the short-wavelength region (620-720nm) as shown in Fig. 20. The leftmost curve shows the sensitivity of the new channel. And we improved the optical system and measured the reflectance and transmittance in the short-wavelength region.
Because Thomson scattering light is shifted to short-wavelength side as temperature increases, it enabled the detailed analysis of higher electron temperature (～20keV) data.

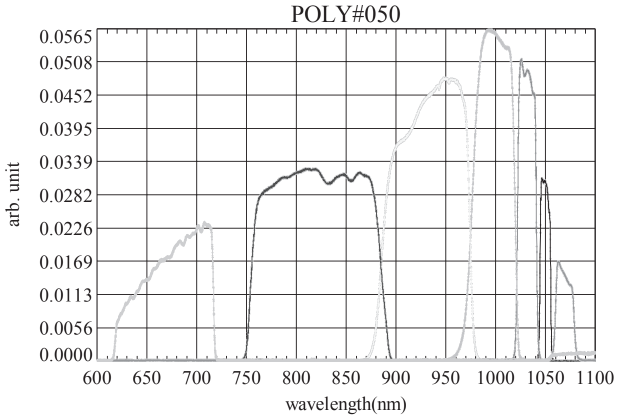

Fig. 20 Example of sensitivity of polychromators of the Thomson Scattering Diagnostics

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

Operation and 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 14th experimental campaign, in almost all shot, 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 structure of the target electrode of the negative ion source was improved. The target electrode is consumed during the operation of the ion source, and is often exchanged to extract other ion species. Thus, it was improved so as to be able to replace the target easily. In addition to that, the directly-cooled target was developed because lowering the temperature of the target was expected to increase the ionization efficiency.

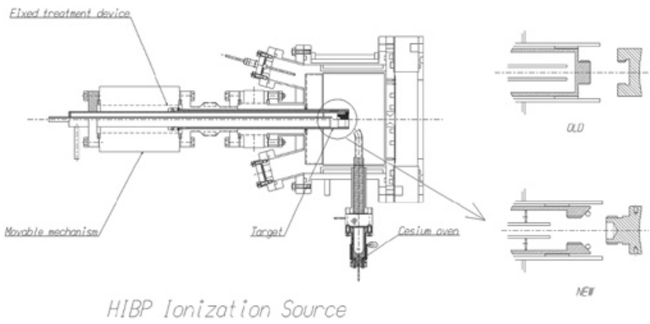

Fig. 21 Design of the new ion source of the HIBP

(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 14th plasma experiment campaign, some diagnostics elements were tested, for example, the feed through flange of the Soft X-ray spectroscopic system, the ZnSe windows of the FIR diagnostics, and the some flanges of the Penning vacuum gauge, of the Hα spectroscopy diagnostics, of the observation system for the closed divertor, and of the laser blow-off system, etc. We carefully tested vacuum components. Therefore, in this 14th experimental campaign, the plasma experiment was not stopped because of the diagnostic device vacuum leakage.

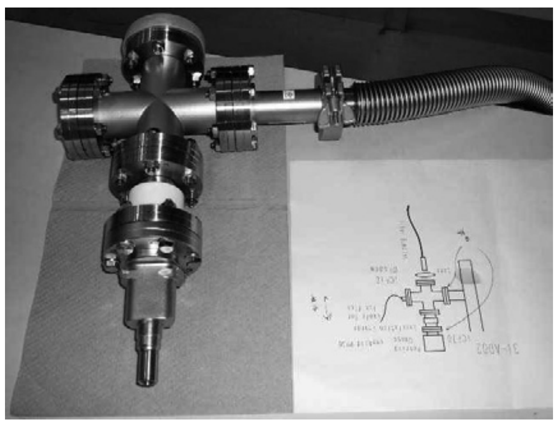

Fig. 22 Snap shot of the vacuum leak test in the Plasma

(6) Support work for the LHD diagnostics vacuum leak test before the plasma experiment

On the LHD plasma physics experiment, each diagnostic device is arranged in each port of the LHD vacuum vessel. Each device has its own shape, so it is difficult to connect without refine.

For example, we used a special treatment device considered the counter weight.

Next, we used the oxygen free copper gasket as a seal material for the connection of each vacuum device, the so-called vacuum flange. If the torque control of the bolt and the nut connecting the flange is not strictly carried out, unbalanced tightening occurs and causes a vacuum leak. And adhesion or jamming of foreign bodies in the oxygen free copper gasket also causes a big vacuum leak. The final decision on the quality of these operations is inspected by the following confirmations. The amount of leak is measured and it is decided whether a vacuum leak occurs or not by covering the whole flange with a hood including the surface of the flange and injecting helium gas into it as a detection test. A careful preparation is needed in order to finish this operation within the fixed date. Moreover, each object has a complex structure, so a special hood corresponding to each situation based on experience must be produced by hand. In this campaign, they are 60 points of various sizes only for the measurement devices. As a result of the leakage tests, there was no leak. It was a perfect preparation also in this campaign. Though these seem basic and easy operations, they are very important and cannot be missed.

After this operation finished without incident, the plasma experiment was started.

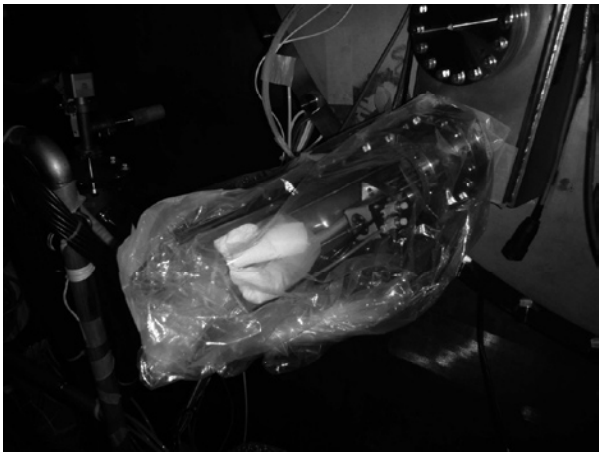

Fig. 23 Photograph of preparation of the LHD vacuum leak test.

(7) Development of Data Acquisition Systems

In the LHD data acquisition system, 10 new diagnostics have been added in 2010, then totally 86 diagnostics have worked. Consequently, the total amount of the acquired data grew up to 11 GB (4.6GB after compressed) for one short-pulse shot and the storage systems were also extended. For data storage, a new cloud storage system has been tested, but the system was unstable. As a result, the iSCSI + GFS2 storage system has been applied and it has worked stably in 2010. However, the cloud storage system has a lot of merits and its running test has been continued until now.

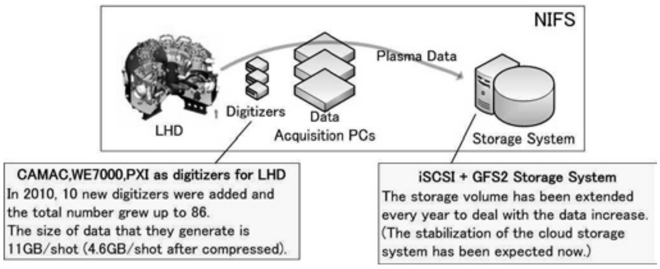

Fig. 24 Overview of the LHD Data Acquisition Systems

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; upgrading the central control system, development of a new simulation algorithm for the cryogenic system and a control system for a vacuum vessel heating-cooling device, and etc. Details of the activities in this division are described.

(5) Operation of LHD

The LHD cryogenic system operation started on August 27 in the fourteenth-experimental campaign, the helium gas was purified as usual. However, we stopped operation, and checked urgently because we had found an unusual enhanced vibration in the helium compressor. We found the cause of this trouble to be due to the deterioration of the bearing. The helium compressor for the LHD cryogenic system was maintained for 11 days, and then it was able to resume operation safely without trouble. The coil cool-down was started at September 17, and it was completed on September 27. The number of steady-state operation days of the S.C.-coils was 108 days. The coil warm-up was started on January 28, and it was finished on February 25. The availability of the cryogenic system achieved 94.8%, and total operation time was 4,128 hours in this campaign.

The first energizing of LHD in the fourteenth-experimental campaign was on October 12, and it was finished on January 27. The number of energizing times of LHD was 70 times, and total operation time was 463 hours 52 minutes in this campaign.

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

The LHD helical coil uses quench detectors for protection. Last year quench detectors malfunctioned three times. The emergency current breaker system of the LHD power supplies operated two times.

We started noise measurement for investigation to determine the cause.

The measuring method was isolated (using a clamp sensor) because there was a possibility that the measurement system was a noise source. In addition a measurement system was set near the quench detector and controlled through the network for the purpose of avoiding the influence of noise.

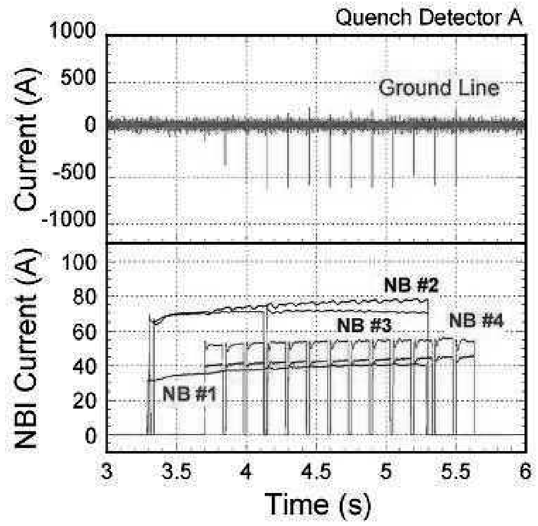

Fig.25 Time evolution of the noise and NBI pulses

Thereby we discovered noise on the ground line and it was synchronized with NBI#4 Beam current .(Fig.25 pulse noise current : max 15μs 600A)

It is still uncertainty whether the ground line noise for NBI#4 was the cause. But the quench detector malfunctioned simultaneously with the breakdown of the NBI. Next year we will continue the noise measurement and clarify the relation with the NBI.

(7)Operation of the polarity switch device for the power supply for the super-conducting coils

The magnetic field for the plasma confinement is generated by three pair of super-conducting helical coils and three pair of super-conducting poloidal coils. The power supply system for these coils consists of six thyristor rectifier units, which are controlled by computers. The change of the polarity of the current is needed according to the condition of the plasma experiment. The direction of the polarity had been changed by changing a mechanical switch by human power.

In FY 2009, a remote polarity switch device has been constructed, that enables operating from a distance in a short time. And this device has been operating from the 14^{th} experimental campaign. The polarity was switched 16 times in this campaign. The GUI for the polarity switch is shown in Fig.26. The experiment efficiency has improved because of shortening of the polarity switching time.

Fig.26 GUI for polarity switch

(6) The central control system for LHD

NBI#5 was established from the north side of the LHD room, and changes are made to interlock with the signal line connecting this device to the central control system.

The central control system requires high reliability. This system has been checked before the experiment. Since the beginning 15 years have passed; and it became difficult to obtain maintenance parts. So we began an examination of the main components upgrade.

In this experiment several false alarms of the superconducting coil quench detectors have been issued. Because of this, this affected some of the instrumentation also. To overcome this, we began to distribute the examination of the 1Q signals from the central control system to the instrument.

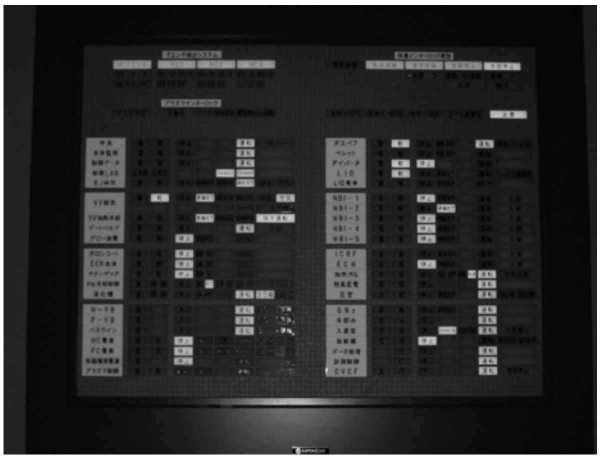

Fig. 27 Display of the central control system for LHD

(7) Development of control systems for various devices attached to the LHD

We have routinely received development requests about control systems from researchers, and carried out everything from consultation to implementation and maintenance. The requests are involved in a software/hardware renewal in aging control systems, modification of existing systems, development of new control systems and so on. In recent years, requests for a replacement of control software, especially a human-machine interface (HMI), are increased rather than a hardware replacement.

In these circumstances, we have established a new system which enables more efficient development and maintenance by clarifying common functions from HMIs we have ever developed and by optimizing the source codes as a template. Only a GUI design and minimum coding is necessary to complete the desired HMIs if the template is used.

We have successfully developed reliable HMIs for the vacuum vessel heating-cooling device, the ICRF alarm notification system and the repetitive pellet injector in an extremely short period by applying the HMI template this fiscal year.

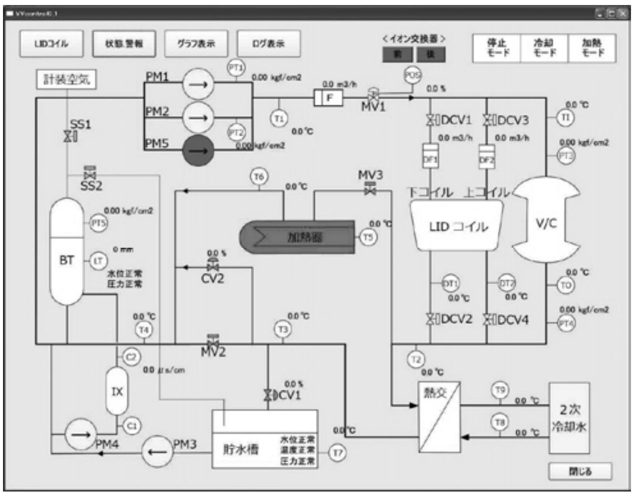

Fig.28 HMI for vacuum vessel heating-cooling device

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

The dynamic simulation system, C-PREST, has been utilized to study the thermal-hydraulic behaviour of a forced-flow supercritical helium loop. Figure 29 shows a schematic of the CEA test loop experiment, which consists of LHe reservoir, two immersed heat exchangers, three independent heated sections along the loop and bypass valves for the flow distribution. A supercritical helium circulation pump model has been developed based on dimensional analyses. Other components are implemented based on the existing module in C-PREST.

The experiments are being conducted to benchmark the dynamic behaviour of SHe circuit based on the numerical simulation results by the VINCENTA code. The experiment successfully reproduced the data and further experiments will be conducted to study the mitigation of the heat load to the LHe reservoir. Preliminary simulation results represent the experimental data very well and the model validation has been completed. The process study will take place after further confirmation with different experimental conditions.

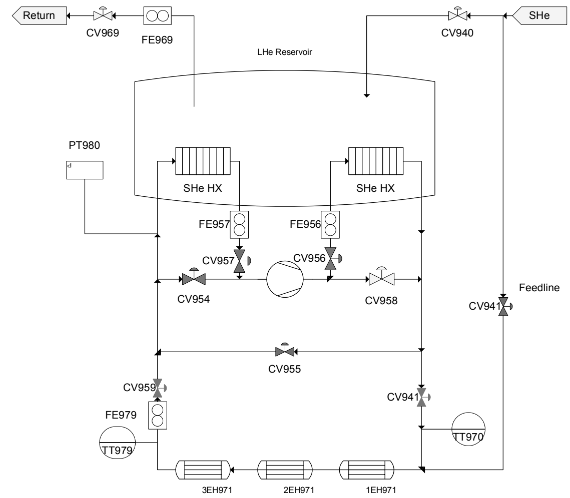

Fig.29 Schematic of CEA test loop experiment

6. Symposium on Technology, Technical Exchange and Dual System

(1)The Symposium on Technology

The Symposium on Technology was held on March 17 and 18, 2011 at Kumamoto University. There were 870 participants from many Japanese universities, national laboratories, technical colleges, and some industries. In this symposium 521 papers were presented in 11 oral sessions and poster sessions. Technical experience and new techniques were reported and discussed. Eight papers were presented from our department.

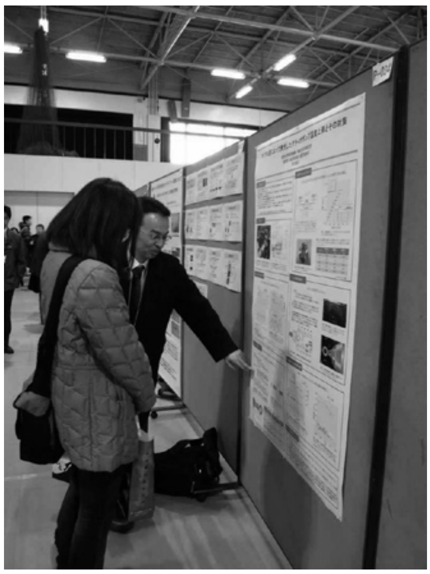

Fig. 30 A snapshot of the poster session

(2) Technical Exchanges

The technical exchanges between our department and other institutes or universities were held in order to improve the technical skill of the staff. In this fiscal year, four technical officials from Tohoku University and the High Energy Accelerator Research Organization participated in the exchange program "Measurement and control technique using a PC". The meeting "Symposium on Safety and Health Management in a Laboratory" was held from February 9 through 10 with fifties participants from nine universities and four institutes. Figure 31 shows the scene of the LHD tour during the meeting.

Fig. 31 A snap shot of the LHD tour during 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 is aimed at developing independent skilled workers by concretely combining 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 research and engineering.

Fig. 32 The members of the Tajimi Technical High School in this fiscal year.

In this fiscal year, we took over the theme "Design and production of a two-wheeled, self-balancing electric vehicle as well as the Segway PT" from the last fiscal year.

The main technical point is the design and manufacture of a two-wheeled, self-balancing electric vehicle. The results of the test run of were shown at the NIFS open campus by the students.