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:
To develop advanced and systematic engineering capabilities on the basis of basic engineering results which have been obtained thus far.

To educate excellent engineers with responsible administration.
To cultivate creative engineering abilities.
To improve the documentation of and the transfer of engineering knowledge to the next generation.
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 the heating devices and the 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 current control system and the LHD network. The number of staff is 46 engineers and several part-time workers. We take care of the development, the operation and the maintenance of LHD and the LHD peripheral devices with about 47 operators.

1. Fabrication Technology and Safety Health Management Division

The main tasks are the fabrication of the experimental equipment, technical consultation, research development of apparatus, technical cooperation and supply of experimental parts and materials. The division also administers all the office work and the Safety and Health of our department. The staff of our division is mainly working in the central workshop, and we received more than 420 jobs for the fabrication of devices in this fiscal year. 95% of them could be fabricated in our central workshop. We support the construction of devices and their control systems as requested from each research division.

(1)Safety and Health Education
"Hazard prediction training (KYT) was held as a part of Safety and Health Education. The lecture was held in cooperation with the Division for Health and Safety Promotion. Visiting lecturers were invited to execute the KYT in NIFS. 12 staff participated in the training.

(2) Production of Hemispherical Coil Bobbin
A hemispherical coil bobbin was produced. This hemispherical bobbin is to produce a coil that generates a uniform linear magnetic field with a radius of 50 mm. The coil is a double layer dual pancake winding. Each layer has 20 turns and the radius of the hemispherical bobbin is 58 mm. The diameter of the coil wire is 1 mm. The material of the hemispherical bobbin is a polyacetal resin. The hemispherical coil is shown in Fig. 1.

The hemispherical polyacetal bobbin has two types of grooves as follows: one is a latitude groove, which is a circular one for the coil; another is an azimuth groove for the leading wire. The latitude (circular) groove and the azimuth groove make a crossing, where the wire moves to the next latitude groove passing the azimuth groove. The latitude groove for the coil has the width of 1 mm and the depth of 2 mm. The azimuth groove for the leading wire has a width of 1 mm and a depth of 4 mm.
The bobbin was produced by the following procedure: (1) production of hemisphere; (2) production of circular grooves; (3) production of radial groove. The hemisphere with radius of 58 mm is made by using a numerical controlled (NC) lathe.

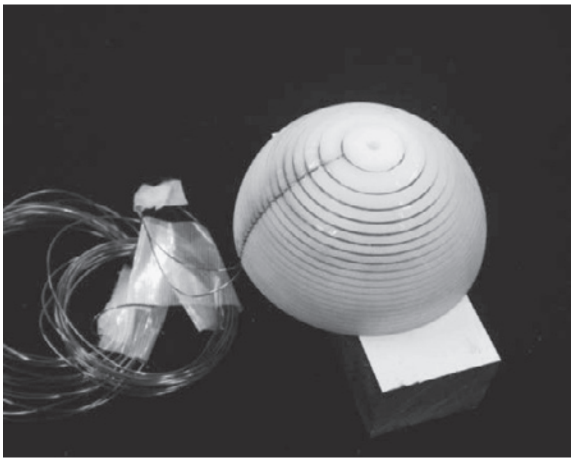


Fig.1 Spherical coil bobbin used to wind a hemispherical coil

The latitude (circular) grooves and azimuth groove are made by using a NC milling machine and a cutting tool with the edge radius of 0.5 mm. In this case the cutting tool should be perpendicular to the surface of the hemisphere. By using a usual rotation bed which has a single axis, these two types of grooves cannot be produced. Therefore, a dual axis rotation mechanism has been developed in order to produce these grooves. This mechanism has a rotation driver of the hemispherical bobbin on the usual single axis rotation bed, as shown in Fig. 2.

The rotation driver is controlled by a reversible motor and a

timing belt. The rotation speed is 20 turns/min. Each latitude groove is produced as the rotation driver rotates. Before the driver rotation, the rotation bed rotates as the cutting tool is perpendicular to the groove. Then the driver rotates. The driver often stops because the cutting of the polyacetal resin causes a resistive force while the torque of the motor is not so strong. Therefore, the cutting depth is 0.1 mm in every rotation in order to reduce the resistive force when cutting.
When producing the azimuth groove, the usual rotation bed rotates. In this case, the hemisphere may move because the timing belt is soft. Therefore, the rotation driver is locked by inserting a pin into the axis of the rotation driver.

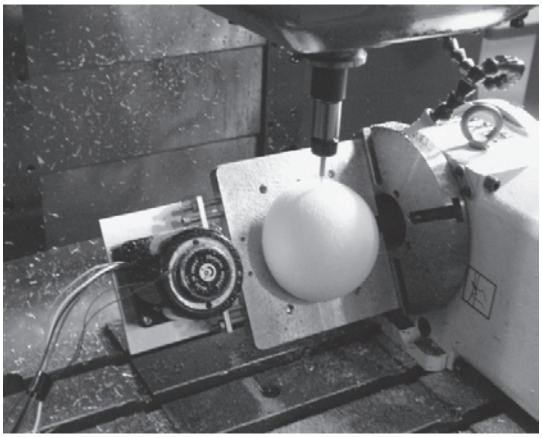


Fig.2. Dual axis rotation mechanism to produce the hemispherical coil bobbin

(3)Corrugated miter bend for waveguide switch
The vacuum waveguide switch is a device changing between a dummy road and a waveguide to LHD for microwave power. The corrugated miter bend is a component of the vacuum tight waveguide switch. In order to improve the transmission efficiency of 3.5inch-corrugated waveguide, it is necessary to cut 80 corrugated slots on the surface of the inside diameter of the miter bend. The size of the corrugated slot is 0.6mm depth and a 0.2mm tooth width. The wave guide system requires precise rectangular ridges.

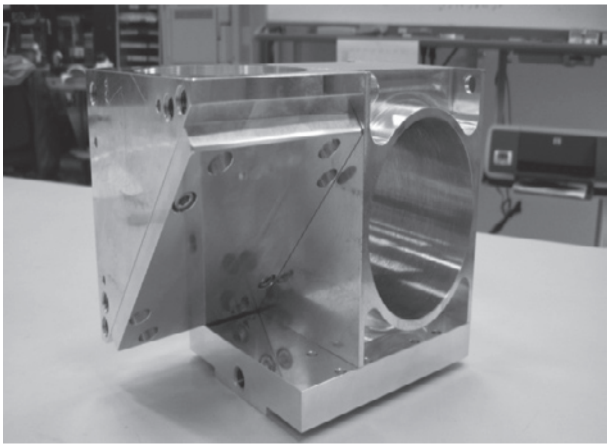


Fig.3 Corrugated miter bend for waveguide switch

(4) Remote operation circuit of the photo multipliers in Lost Ion Probe
There are20-channels of independent DC voltage sources in the circuit and these can be operated from a remote PC through a network. A part of both the communication and the logic circuit are installed in the FPGA (Field Programmable Gate Array) board. The hardware was made by our division and the software by the control technology division. Figure 4 shows the internal view of the circuit.

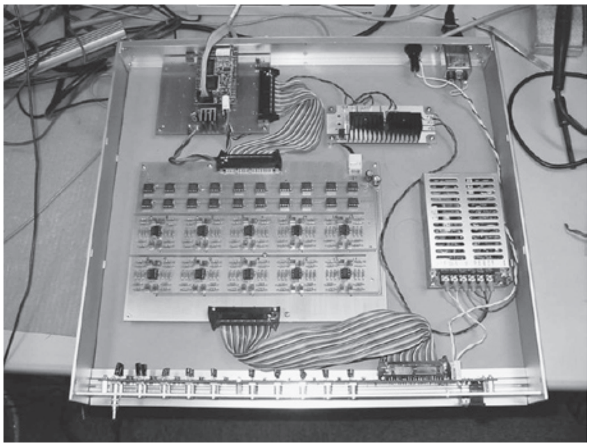


Fig.4 The 20 channel voltage source

2. Device Technology Division

The Division supports the operation, the improvement and the maintenance of LHD, the peripheral devices, the cryogenic system for LHD and the super conducting R&D devices at the SC magnet Laboratory.

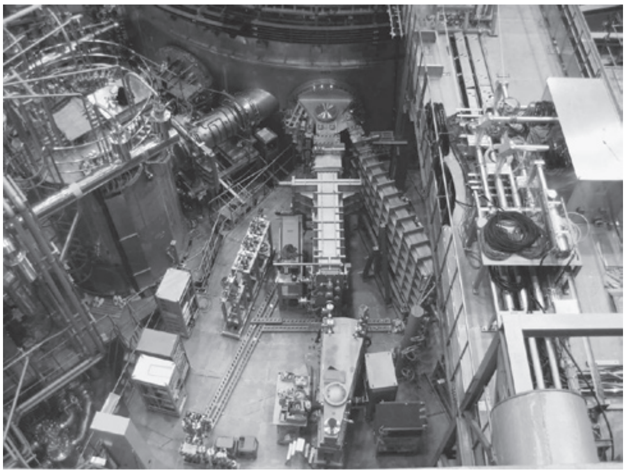
(1) Operation of LHD
LHD operation started on August 4 in the twelfth -experimental campaign, the cryostat was evacuated as usual. The evacuation of the plasma vacuum vessel began on August 5. The number of the maintained flanges was 88. We found two vacuum leaks. The vacuum leaks were fixed on Aug. 8, and the coil cool-down was started at Aug. 27. It was completed on September 22. The number of operation days of the S.C.-coils was 53 days. The warm-up of the S.C.-coils was started on December 26, and it was finished on January 30. The warm-up operation of the cryogenic system was interrupted for about one week in the cold state of around 80K from the year-end through the New Year holidays, and it was able to resume safely without trouble. The availability of the cryogenic system achieved 100%, and total operation time was 3,856 hours in this campaign.
The first energizing of LHD in the twelfth-campaign was on Sep. 24. The number of days of the plasma experimental period was 143 days.

(2) Maintenance of Diverter Plates

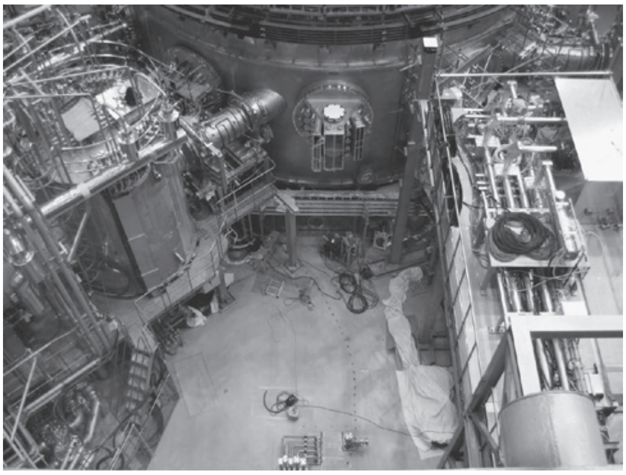
We checked impurity accumulation and damage to the screws on the helical diverter plates in LHD. We removed 450 plates. These plates were polished, and reset in LHD.

(3)Arrangement for New NBI at 1-O Port

First of all, equipment, pipes and cables that were set up above and below the stage must be moved. Next, half of the stage (about 73m^2) was dismantled (fig.5). These series of work had to be executed within 3 months. To do these smoothly and safety, it was very important to adjust the working process and area in the laboratory and among sub contractors.



(a) before



(b) after

Fig.5 Arrangement for a new NBI at 1-O port

(4) Fluid analysis of supersonic nozzle

We planned the introduction of the supersonic nozzle for the Gas-puff system to supply with more fuel gas to the center of the LHD plasma. Numerical analysis (ANSYS) was applied to the some nozzle design. As a result, mach volume of the injection gas (H2) was over 3 for the supersonic nozzle.

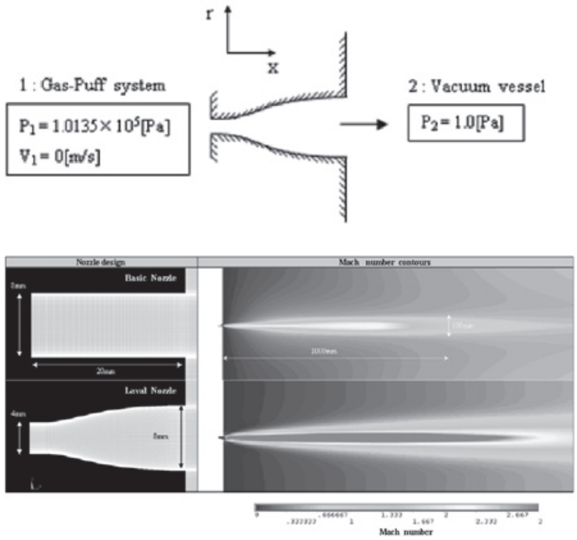


Fig. 6 Calculation result of supersonic gas flow

(5) Development of twenty-barrel hydrogen pellet injector

A twenty-barrel hydrogen pellet injector, which employed an in-situ pneumatic pipe gun concept, has been developed as a fundamental tool for the LHD. In order to reduce the development cost and to ensure the flexibility in the device operation, all the design of the pellet injector has been performed by ourselves. The pellet injector is composed of a pellet formation/injection system (1 and 2) and a differential pumping system (3, 4 and 5) as shown in Fig. 7. The development of this pellet injector mainly required vacuum technology and machine design technology. Control systems of the pellet injector are being set up by the Control Technology Division of our department. We will finish up these developments by the start of the LHD experimental campaign in 2009, and the pellet injector will be used in the LHD experiment.

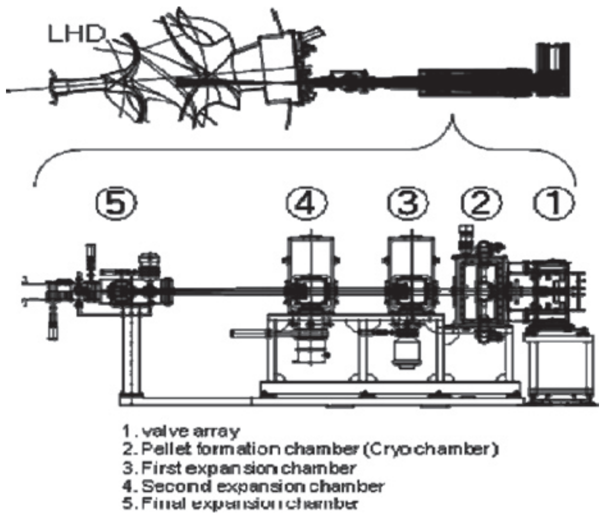


Fig.7 Twenty-barrel hydrogen pellet injector

(5) Technical Support for the SC magnet Laboratory
A cryogenic system with a capacity of 200 l/h (500 W at 4.2 K) and a high dc current supply of 75 kA at 21 V, including a cooling water system with an 800 kW heat exchanger, was installed at the SCL. Operation of these test facilities and daily inspection of them are carried out by the members of the Device Technology Division. In particular, we are responsible for the annual duty inspection of the cryogenic system, regular maintenance of the cooling water system and preparation for the experiments.

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.

The NBI systems had been operated at high power levels with high reliability by introducing conditioning operations during the interval of shots throughout the 12th experimental campaign. As the result, many experimental subjects were executed successfully during the relatively short experimental term. In the ECH system, a new additional 1 MW output gyrotron at 77 GHz was installed and utilized for the experiment. ICRF heating devices were not used for the experiment, because their antenna systems had been removed from LHD. An overhaul of the Motor Generator (MG) was carried in this fiscal year out for the second time since its construction.

The details of these activities are as follows.

(1) ECH

(a) Gyrotron Operation during LHD experiment
At the beginning of the 12th experimental campaign, we could operate the eight gyrotrons that include newly installed 77GHz 1MW (#2) one. But toward the end of the first quarter of the campaign, one of the 82.7GHz gyrotrons (#12) suffered from a vacuum slow leak and could not be operated for the experiment any more. In turn, we have started the injection of another 77GHz (#1R) gyrotron which had been returned back from the repair of the broken output window but had been waiting for the injection window at the LHD. These two 77GHz gyrotrons were operated in parallel and contributed to high power injection. As a result, the total injection power into LHD reached 1.7MW for the pulsed operation as shown in Fig.8.
At the final stage of the campaign, where the CW/long pulse injections were tried, the vacuum leakage at the bellows of the injection antenna prevented further injection. The operation of two 168GHz gyrotrons was limited to only a few days due to the small need of the experiment.

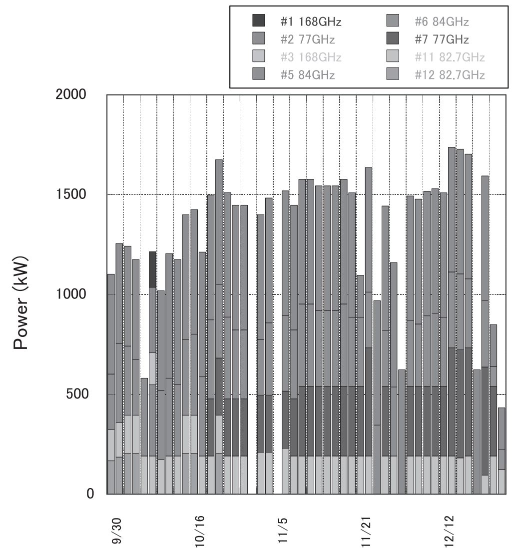


Fig.8 Historical result of ECH injection power during 12th experimental campaign

(b)Installation of new 77GHz (#2) gyrotron
As the 77GHz gyrotron was installed last year, the new gyrotron generated higher power at the same frequency compare with the former one. Fig.9. shows a new gyrotron on an oil tank directly connected to a dummy load for aging. It was installed and tested under a more strict interlock system than that for the last year before the beginning of the 12th experiment. Due to the needs of the experiment, we started injection to LHD before completely fulfilling the specification of the gyrotron.

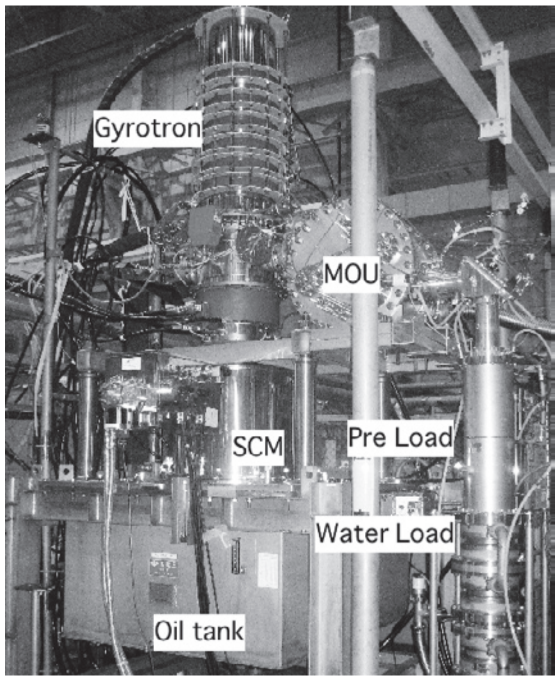


Fig.9. New gyrotron with dummy load

We transferred the 0.7MW injection power with pulsed (5seconds) operation and 0.2MW CW (2minutes) to LHD. During CW operation, the vacuum condition inside the gyrotron became worse indicating the need for more conditioning. We will improve them to achieve a longer duration by the next experimental campaign.

(c) Maintenance of the arc detector during a period between the experimental campaigns.

An arc detector is one of the important protection methods for safe gyrotron operation. The arc detector system for the ECH consists of one controller and 64 sensor units. Each sensor unit is linked to the controller by control lines and to a detection port on the transmission line by an optical fiber. During the experimental campaign, we perform a simple operation check of the sensor units using a self check function, every morning. We also adjust the threshold levels of sensitivity of all sensor units before every experimental campaign. All sensor units were once removed from transmission lines, adjusted and re-installed, in order to get the threshold of sensitivity of all sensor units adjusted, because the adjustment work needs a calibrated light source, special power supply and measurement apparatus. We had spent much time and efforts for these adjustments so far. Recently, we made a portable tool to confirm sensitivity. Fig.10.shows a handy checker in which a variable-resistance for light-intensity adjustment and a connector for an optical fiber are installed. Measurement and adjustment of the sensitivity became simple by using this handy instrument.

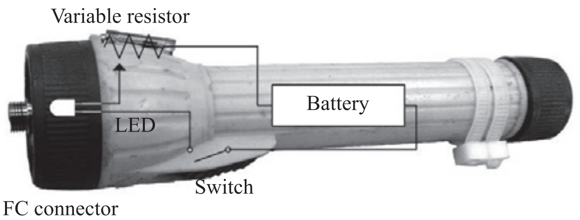


Fig.10. handy checker

(2) ICRF

(a) Data transfer and storage for operation of ICRF power generators

The control system for ICRF power generators has been renewed for the 14th experimental campaign on 2010 including the new generator system referred to as #3 and #4. It was requested that this system has the capability to control many generators from three places, i.e., the LHD device room, the RF control room and the RF device room. For that purpose these are required as follows:

1. Indicating the situation of interlocks for the reflection and the RF voltage, and the reset of the interlocks.
2. The voltage and the current of the plate, control grid, the screen grid and the cathode for each tetrode tube.
3. The time evolution of voltages and currents for each tetrode tube.
4. The forward and reflected RF power from the each ICRF heating antenna and the RF voltage at several points on the transmission lines.
5. The waveform of the injected RF power, the starting time of it and the RF power.

In this year, the interface was newly fabricated. This device is the detector and can reset for the interlock system.

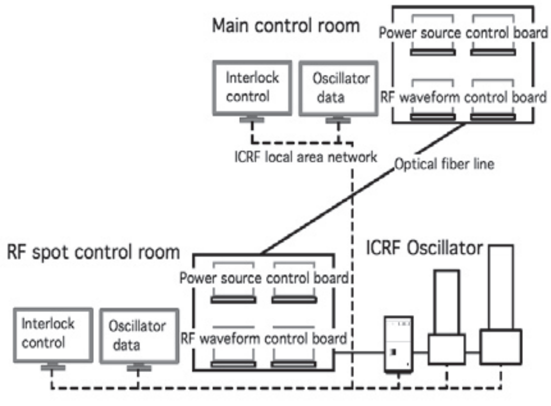


Fig.11 ICRF oscillator remote control system

The total system has an IO system consisting of the “Compact RIO”, which helps that the various data and the order for operation scenario are displayed on the screen at the center control room via LAN. The waveform of the injected RF power and the starting time for the equipped RF generators were already displayed on the screen, but these are newly installed for the new RF generators. In addition the remote attenuators are newly installed for the IO system, which have a compact RIO at the center, and screen various data and control panels via the LAN to fulfill the objective.

(b) New-type coaxial switches for ICRF heating

ICRF power is transmitted to an antenna from a final power amplifier during plasma experiment, however the power must be transmitted to a dummy load for adjustment of the amplifier. Therefore, a coaxial switch is an important component for the ICRF heating system. We installed three new-type coaxial switches (1390 mm in height) in the heating power equipment room. Each switch consists of a frame, two output ports and two input ports attached to the frame, a movable disk with two bended coaxial lines, and two air cylinders for the lift and turn of the disk. In the formerly installed coaxial switch (1920 mm in height), a large support for the turn-mechanism exists, which moves vertically by the lift-cylinder. However, the new-type coaxial switch does not have the support. The turn-cylinder is attached to the frame directly and the piston rod in the cylinder is connected to a small slide-shaft attached to a holder of the movable disk. By the removal of the large support, a compact coaxial switch was realized.

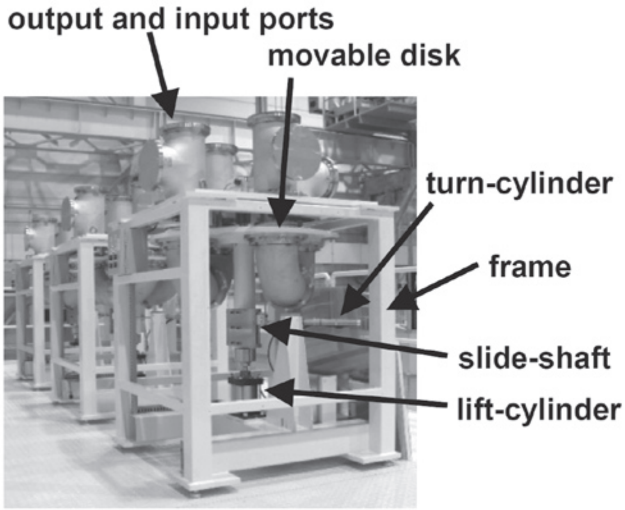


Fig.12 New-type coaxial switches

(3) NBI

(a) The Operation and the Maintenance of NBI Devices in the 12th experimental campaign of LHD.

The history of total injection beam power of N-NBI is shown in Fig. 13. About 6400-shots of beams were injected into LHD plasma in this campaign. The maximum total injection power of N-NBI marked 16.6MW, and the ratio of more than 15MW (Design value) increased clearly. BL-1 produced 5.5-6.5MW, BL-2 produced 4.5-5.5MW, and BL-3 produced 3.5-4.5MW for plasma heating. BL-4 produced 3.5-7MW and covered a broad range of injection power as a diagnostic-beam.

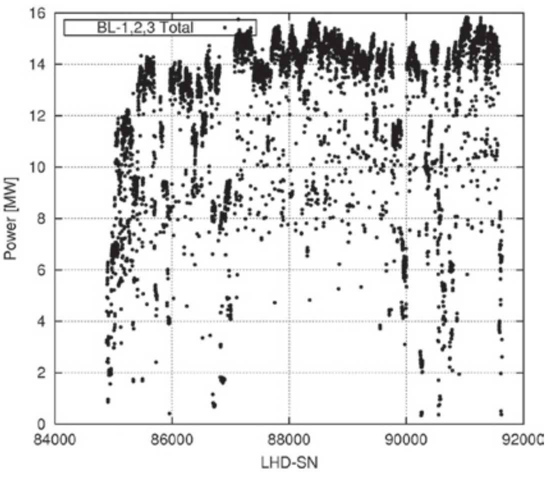


Fig. 13 The history of N-NBI injection beam power

In this campaign, none of the beam-lines had any big trouble, which stopped the LHD plasma experiment, but had several minor troubles. BL-1 experienced the burn out of the thyristor for the arc power supply, but it was replaced quickly. BL-2 had only the error by breakdown noise. BL-3 had a break of an insulation sleeve for the ion-sources screw bolt in this campaign too, which has no known cause yet. BL-4 had a break of the gas-controller for the ion-source, but it was replaced quickly.

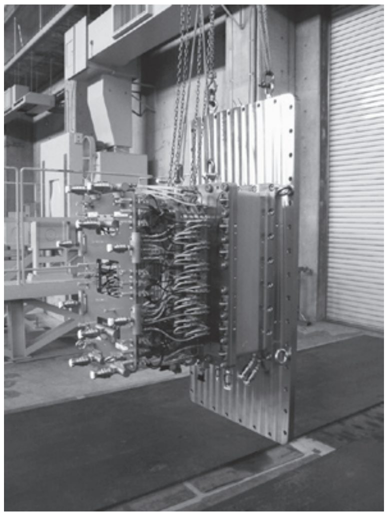


Fig. 14 R&D ion-source for BL-5

The BL-5 construction plan was begun as a 3-year plan. BL-5 will be P-NBI system of 80keV, 9MW (4 ion-sources). In this year, we procured several components, the transformer for the acceleration power supply, the arc power supply, the cryo-sorption panels, an ion-source for R&D (Fig.14) etc.

We will continue efforts to increase the injection power and to provide stable operation of the NBI.

(b) Improvement of Vacuum Pumping System for Beam-line

The previous vacuum pumping system is as follows. The beam-line vacuum vessel of which volume is about 39m^3 is connected to two pumping sets. One is the primary pumping equipment which is composed of an oil-sealed rotary pump and a Roots pump. It can evacuate the vessel from atmospheric pressure to the medium vacuum (~10^1 Pa). The other is the main pumping equipment which is composed of two turbo-molecular pumps connected to a Roots pump and an oil-sealed rotary pump. It can evacuate the vessel from medium vacuum to high vacuum (~10^{-2} Pa).

An oil-sealed rotary pump has been widely used for many years. So, its performance is established, but a disadvantage is the need to maintain the oil. When it pumps out gases in the air from the atmospheric pressure, the oil absorbs water vapor contained in the air. If the amount of the absorbed water is large, the vapor pressure of the oil rises and the vacuum pumping ability is degraded. Then, we have to exchange the oil, and that actually costs much labor. So, we have just replaced the oil-sealed rotary pumps with oil-free dry pumps. A dry pump is used generally by semiconductor manufacturers who can not tolerate oil contamination. The pumping speed of the newly installed dry pumps is 9000 L/min for the rough pumping system and is 1600 L/min for the main pumping system. We selected the ones of which the pumping speed is the same as, or rather larger than that of the former oil-sealed rotary pumps (7500 L/min and 1200 L/min, respectively). In this fiscal year, only the pumping equipment in BL3 out of four beam-lines was replaced for the purpose of a performance and reliability test. Concretely, we checked the performance of the replaced dry pumps. The main subjects are whether the pumping ability is maintained during continuous operation throughout the year for the main dry

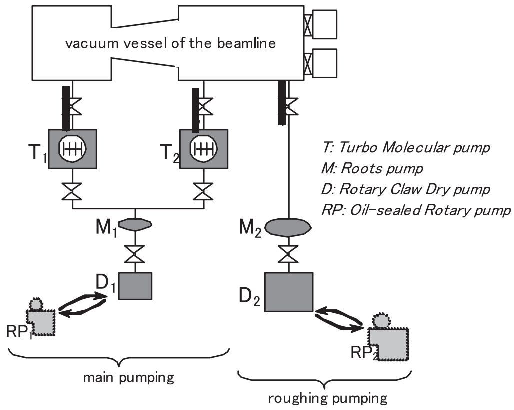


Fig. 15 Schematic diagram of the beam-line pumping system

pump, and whether there are detrimental effects by water vapor which is condensed in the evacuation from the atmospheric pressure, though that is only a few operations in a year, for the roughing dry pump.

(c) Development of the remote control system for high voltage power supply of E//B-NPA

On LHD, we are measuring fast-ions produced by a tangential Neutral Beam with E//B-NPA to evaluate their confinement properties. The device needs four High Voltage Power Supplies (HVPS). Before the 12th experimental campaign of LHD, we changed the control system of the power supplies to a system based on the Programmable Logic Controller (PLC) from the CAMAC (Computer Automated Measurement And Control standard) based one since the original power supplies were broken. The following are the reasons for choosing the PLC based system instead of the CAMAC-based one.

1. A substitute for the HVPS is difficult to find in the CAMAC modules, since the CAMAC modules are now old-fashioned and disappearing.
2. It is very easy to add the function of a real-time interlock of the HVPS if we use a PLC.

The schematic diagram of the HVPS-system is shown in Fig.16 In this system, a high voltage power supply unit containing four power supply modules is controlled by a PLC which is installed in the LHD hall. The voltages and the currents of these are monitored by this PLC. The PLC is remotely accessed through the LHD-LAN by a Personal Computer (PC) in the LHD control room using a GUI program. The system has a function of interlocks with the NPA-vacuum pressure to protect the micro channel plates installed in the NPA. If the pressure of the NPA exceeds the $4.0x10^{-4}$[Pa], the PLC automatically turns off the HVPS, immediately. The system was successfully operated without any troubles during the 12th campaign.

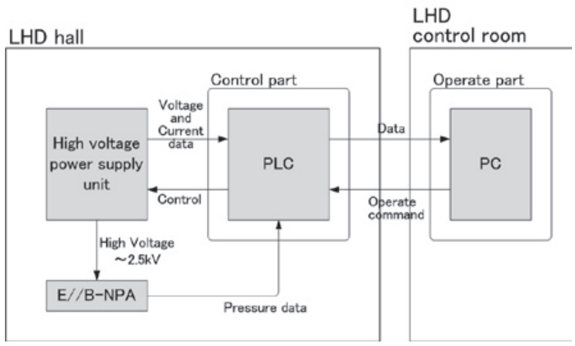


Fig.16 Diagram of remote control system for high voltage power supply

(d) Improvement of data acquisition systems in NBI

In the LHD experiments, it is important to monitor the injection parameters, such as beam energy, current and pulse length. Until FY 2007, the beam currents of some beam-lines were measured with the aid of oscilloscopes. It was difficult to obtain the correspondence of a shot number and its beam parameters, and to analyze the trend of the parameters immediately. We have installed the data acquisition systems based on a PC to all the beam-lines, since FY 2008. The system can display beam parameters visually making use of graphical user interfaces. The graphical data is also available for monitoring via the network. The visualization of the data provides the ion-source status at once, and we can operate the sources easier and with less error than previously.

(4) Motor-Generator (MG)

The MG is used to supply the pulsed power to the NBI for LHD. The MG had generated 20,802 shots in this fiscal year and 445,054 shots in total since its start of operation. The operation time counted 1,080 hours in this fiscal year and 20,285 hours in total. In the 12th campaign, the MG generated electric energy at 18 kV for NBI conditioning between shots in addition to the regular experimental shots. In this fiscal year, overhaul of the principal components were executed within a limited budget and period. The stator windings and support ring was fixed by inserting 2520 pieces of wedge. In a hammering test, which was performed by pulling up all the 16 pole-pieces, the wedges of most slots were found to be loosened. All the wedges would be changed in the next fiscal year. Fig. 17 shows a photograph under the hammering test of the wedges on the stator. The stand-off voltage test was carried out against the stator and the rotor. Three pairs of electrodes and a lot of parts in the liquid rheostat were exchanged to a new one. The air-cooling device was renewed too. The OS of the control system, the Human machine Interface (HMI) computer was changed from UNIX to Windows. The other items for inspection are a circuit breaker, two air-break switches and 14 vacuum circuit-breakers.

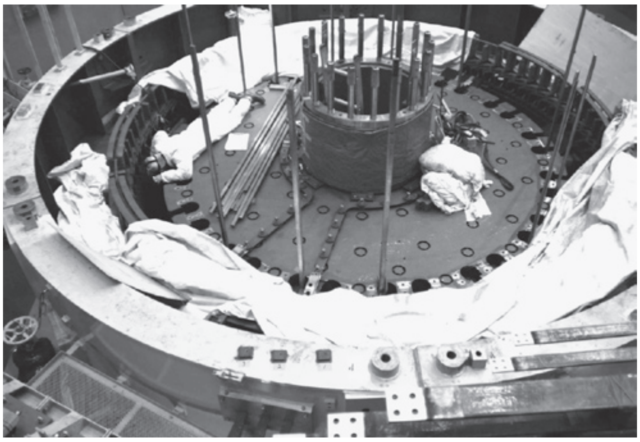


Fig.17 Photograph of hammering test on stator

3. 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 system for the LHD plasma experiments. For the twelfth experimental campaign, some of the diagnostics and the data acquisition system were improved. The Thomson Scattering Diagnostic was improved to derive accurate density data by adjusting the positions of the laser beam and the optical fiber. In the data acquisition systems, some cost reductions were performed by installations of a Box-PC, Linux system and etc. 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, five radiation monitoring posts around the experimental buildings and at the site boundary in the NIFS site were checked and calibrated with the standard checking radioactive sources. After this maintenance, two X(γ)-ray detectors in use since 1994 were repaired.

(2)Thomson Scattering Diagnostics

In the LHD Thomson scattering diagnostics, the gas scattering experiments are carried out every year to get calibration data for the electron density. In this fiscal year, we finely adjusted the laser beam and optical fiber holder position, while getting calibration data in the gas scattering experiment.

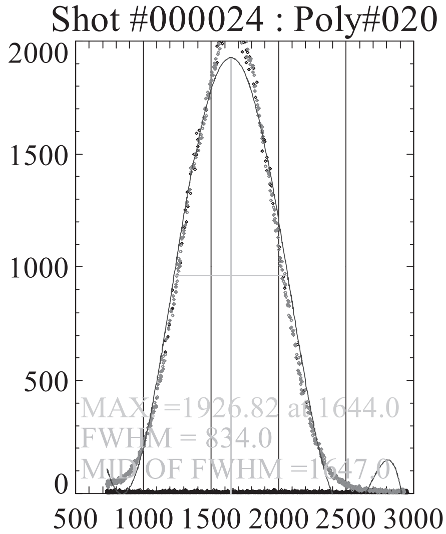


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Fig.18 Example data when the fiber holder is moved horizontally for fine adjustment.

(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 12th experimental campaign, in almost all shots, electron density data were taken completely. So it contributed greatly to the plasma experiments.

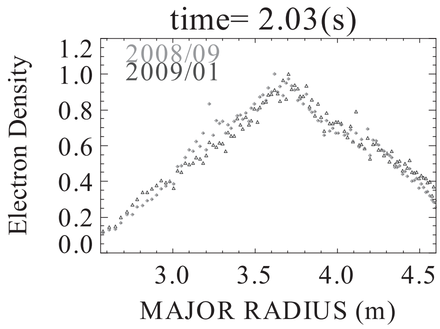

Fig.19 Electron density data derived from calibration data before and after the experimental campaign respectively.

(4) Improvement of the design of the HIBP components

a) New design of the stand to mount the ion source

Since the structure of the old stand was not adequate to support the ion source of the HIBP systems, we tried to design a new one. The new stand is not only sufficiently to mount the ion source but also such that we can remove the turbo pump without disconnection of all the beam lines from the stand. And the new stand has a jack useful for the maintenance of the ion source.

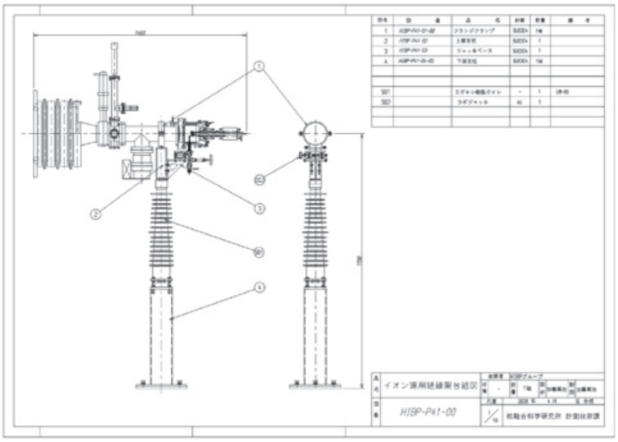

Fig.20 Design sheet of the new stand for setting ion source.

b) New design of the einzel lens

We designed a new einzel lens. In the new design, this lens was optimized for the size and positional precision between the three electrodes for an increase in the intensity of the signal.

(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.

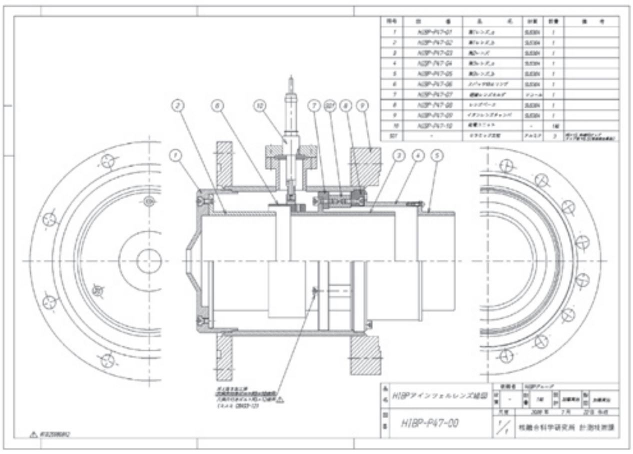

Fig.21. Drawing of the new stand einzel a lens of the HIBP

Before the twelfth plasma experiment campaign, some diagnostics elements were tested (for example, parts of the Thomson scattering diagnostics, Hα-spectroscopy diagnostics and Bolometer).

We carefully tested the vacuum components. Therefore, in this twelfth plasma experimental campaign, the plasma experiments were not stopped because of the diagnostics device vacuum leakage.

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

(6) Removal of Diagnostics from stage of LHD

After this plasma experimental campaign, some diagnostics were removed from the LHD 10-O port and 1-O port because of the preparation for a new plasma heating device installation after the 13th plasma experimental campaign. We supported the removal of diagnostics instruments (main panel, vacuum exhaust system and hundreds of various cables).

(7)Supporting of the construction of a Microwave Reflectometer system for measurement of the electron density of plasma

In the plasma experiment, the measurement of the electron temperature and the electron density with Thomson scattering diagnostic instrument is important as the absolute value measurement. The method of calibrating the electron temperature and the electron density with the gas scattering measurements has been used for a long time. It has enough important achievements as a calibration method, but it is difficult to calibrate them while operating the plasma experiment.

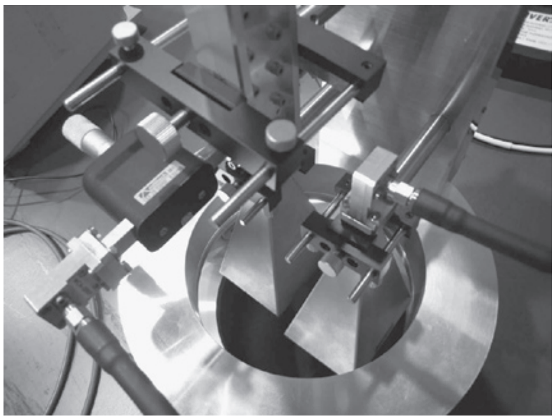

Fig.23 Example of layout of the Launching Antenna and Receiving Antenna by Microwave Reflectometer

Therefore, the method of calibrating the electron density while experimenting on the plasma with a microwave reflecto-meter is proposed, so the trial production of the device was started in practice in Fig.23. The injected wave frequency is swept from 26GHz to 40GHz.

Now, assembling the basic components is in progress.

(8) Development of a Data Acquisition System

In the LHD data acquisition system, some cost reductions were performed in this fiscal year. The rack mount servers were replaced by the Box-PCs for the hardware and maintenance cost reduction. Additionally, their OS has been changed to Linux for the software cost reduction. The data acquisition operation, turn on/off devices and start/stop processes, were scheduled and done automatically. The automatic operations reduced the man power cost and switching off devices at night reduced the electricity power cost.

For data storage, a GFS (Global File System) has been applied to manage data more flexibly. Using GFS and NFS simultaneously caused an unstable situation therefore FTP has been used to migrate data instead of NFS.

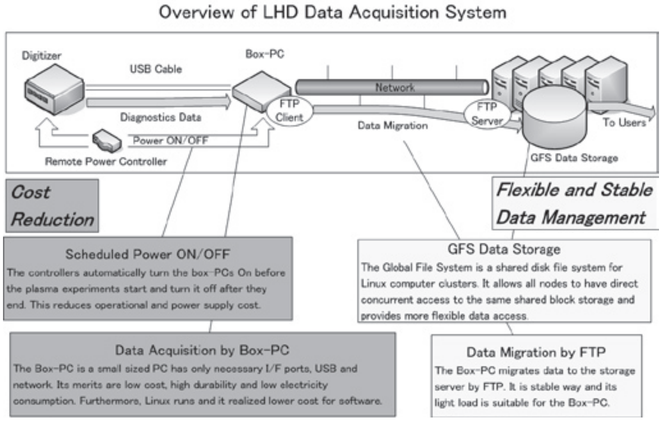

Fig. 24 Overview of the LHD data Acquisition System

5. Control Technology Division

The Control Technology Division contributed to those important technological parts of the LHD, such as management and development of the control system. The work of the system management is as follows; the control room utility, the central control system, the power supply system for the super conducting coils, the LHD-LAN system, the numerical analysis system and the campus LAN system. The work of the system development in this year is as follows; remodeling of the LHD protective interlock in the central control system, development of a new simulation algorithm for the Cryogenic, upgrading the network servers, recombination of the LHD-LAN switches, and etc. Details of the activities in this division are described.

(1) Modification of the Protective Interlock in the Central Control System

The protective interlock in hardware is one of the most important functions for the safe operation of LHD. Although the control system has been running without serious troubles from the beginning of the LHD experiments, we have made a small modification in the control logic to improve usability.

The interlock signal is watched by the control software every several seconds. Therefore, a momentary variation of the interlock signal shorter than this interval is occasionally missed. In order to catch all the signal variations by the control software, we have added a self-maintaining function in the signal detection. The modification will enhance the accuracy of the event analysis when the interlock works. Figure 25 is the LHD main control desk that is connected with a protective interlock unit.

Fig.25 LHD main control desk in control room

We have developed and operated the LHD man-machine interface system (LMS) in the plasma experiments, which is the core component of the LHD central control system. It covers the management of various experimental conditions, the acquisition of the operational data and their presentation on the terminal displays.

A high voltage power supply for pulsed excitation of the super conducting coils for LHD has been constructed. The following functions have been added to the preset program for the coil current.

1) Automatic preset function to match the plasma discharge.

2) Calculation of the coil parameters in the case when the pulsed power supply is operated.

In addition, we are reconsidering the conversion rule between the super-conducting coil current and four magnetic parameters, Bt, Axis, Bq and Gamma.

(2) Simulation Study of Advanced Control Algorithm for the Cryogenic Plant

The cold compressor model for simulating the LHD super conducting helical coil system, which is not a standard one, has been constructed this year. The new model was applied to the calculation of the operational range and performance of each cold compressor unit. Then the simulation in the case of combined operation of the two cold compressors was carried out with the conditions for the LIC and FIC control the same as the real machine and up to the rated speed. The result is compared with the real data of the LHD Cold Compressor control system. The computing model and operating method are under adjustment. Figure 26 is the screen of the simulation in the present model.

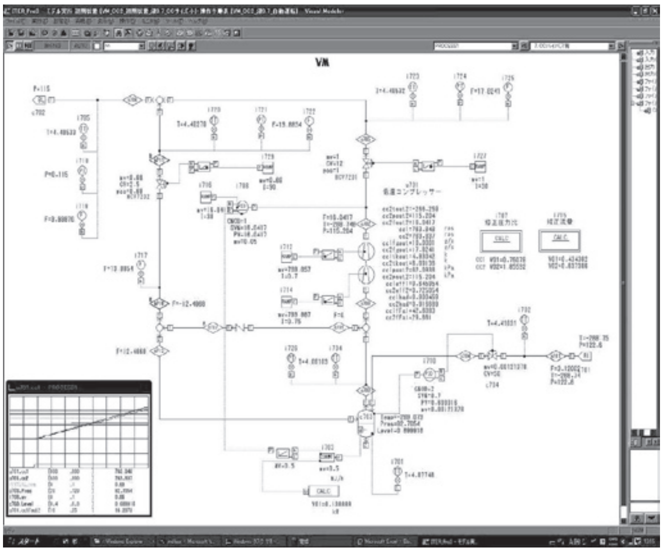

Fig.26 Cold Compressor Simulation Model Chart on PC.

(3) Upgrading the Mail Server

Mail files received in the last one week cannot be stored in the conventional mail server system. New mail servers were introduced in January 2009, which are the M600 of Mirapoint Company. The new system consists of two server computers that are synchronized electronically by hard wires, and the synchronizing signals are exchanged every 30 minutes between them. In this system, the mail files are stored in the two server computers in turn, that is, in one computer for 30 minutes and in another computer for the next 30 minutes. When a disk of one server computer is broken, another server computer can store mail files continuously. Then only the newest mail files within the last 30 minutes are lost in this system. The system is in constant operation since January. Figure 27 shows the running state of the two mail servers that are protected by the firewall system.

Fig.27 Two mail servers are set in network peripheral rack

(4) Development of Readout Electronics for Neutron Detector

The readout system for a neutron detector was developed, which is to be used in deuterium plasma experiments. In order to measure the bursting neutron emission accurately, a pulse count method is adopted in the signal processing system. The performance of the signal processing for the discrimination of the neutrons and the gamma rays has been checked. The neutron detector consists of a ZnS scintillator and a photo-multiplier tube (PMT). A prototype amplifier for the readout system has been designed and manufactured. The prototype set of the detector and the amplifier was introduced and tested in the nuclear fission reactor (UTR-KINKI) at the Atomic Energy Research Institute of Kinki University. Figure 28 shows a detector set (a scintillatoer and a PMT) placed on the top of the UTR-KINKI. Lead blocks were placed under the detector so that the direct gamma rays from the nuclear fission reactor are eliminated.

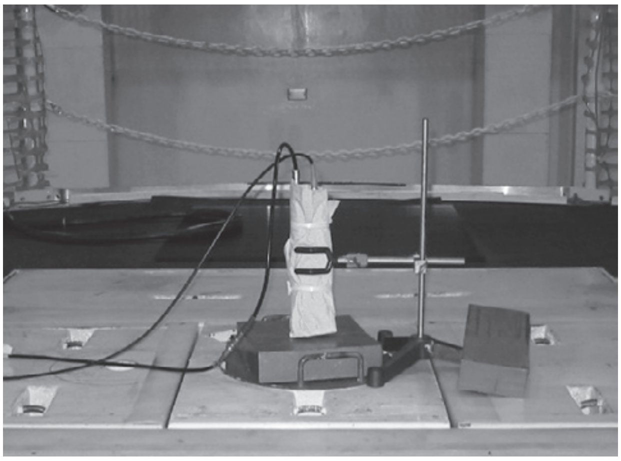

Fig. 28 Neutron detector set on the nuclear fission reactor

A multi-channel analyzer (MCA) was used for the data acquisition and analysis in this experiment. Various types of scintillators, which include luminescent materials such as lithium, fluorine, Zinc, sulfur and other mixtures were examined. In addition, a high-speed readout amplifier was developed and the neutron emissions were observed with the detector. Various types of lead shields (from QTAmp1 to QTAmp6) were examined. Figure 29 shows the MCA outputs for different types of lead shields in the case of the scintillator with Li+ZnS:Ag. In the case of QTAmp6, signal peak (at around channel 450) which comes from the neutron emission is clearer. Reduction of the background signals from gamma ray emission (at around channel 200) is also effective in this case. Distinction between signals from neutrons (signal peaks at around channel 450) and gamma rays (background signal below channel 400) is shown.

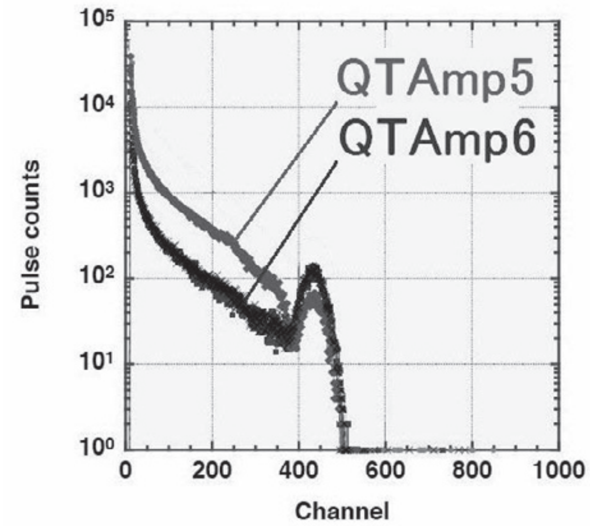

Fig. 29 The MCA outputs of the neutron detector for different types of lead shield (QTAmp5 and QTAmp6).

(5) LHD-LAN

The LHD-LAN has been provided for the LHD operation since 1996. The number of computers connected to the LHD-LAN has been increased as the LHD experiments have progressed. In order to process a large amount of data, a high-performance data transfer basis is inevitable. In the FY 2001, a Gigabit Ethernet-based network was introduced, which consists of three sets of multi-layer backbone switches and many other switching hubs.

Those switches were replaced with the new “LHD-LAN Core Switch System” in FY 2007 before the end of life came. The core part consists of two sets of Cisco Catalyst 4507R multi-layer switches connected to the 10 Gbps Ethernet, which enables high performance data transfer over 210 million packets per second. These additionally have 48 unit 1Gbps SFP and 48 unit 10/100/1000 Mbps UTP ports, respectively.

New contributions in FY 2008 are as follows:

(a) Redundancy of LHD-LAN Core Switch System

A supervisor engine and power supply modules were added to the core switch system to improve the redundancy of the system. 48 SFP and 48 UTP modules were added to both core switch systems. The 10 Gbps backbone was also doubled.

As a result of these improvements, the system reliability has been much increased for 24 hours and 365 days continuous operation. The block diagram of the new LHD-LAN is shown in Figure 30.

(b) Upgrade of Network Servers

1) A new file server has started in operation so that the LHD-domain users can exchange their data through the firewall between the LHD-LAN and the NIFS-LAN.

2) Turbo-Linux operating systems in some of DNS servers have been replaced with the CentOS 5.2 for better maintenance.

3) An Active Directory server has been added with the use of Windows Server 2003 R2. Some of old Active Directory servers in the LHD domain are Windows 2000 servers at the moment. Unification to Windows Server 2003 R2 is planned in the near future.

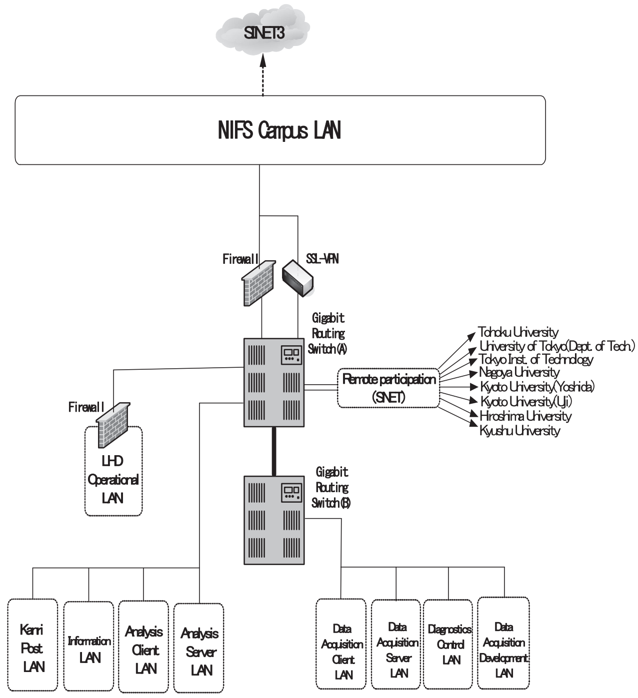

Fig. 30 Block diagram of LHD-LAN

6. Symposium on Technology, Technical Exchange and dual system

(1)The Symposium on Technology

The Symposium on Technology was held on March 9 and 10, 2009 at the Yoshida Campus of Kyoto University. There were 931 participants from many Japanese universities, national laboratories, technical colleges, and some industries. In this symposium 413 papers were presented in 11 oral sessions and poster sessions. Technical experience and new techniques were reported and discussed. Nine papers were presented from our department.

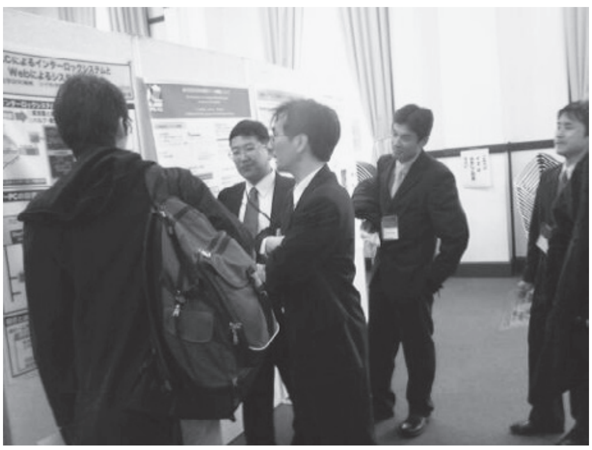

Fig 31 A snapshot of the poster session

(1) 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. Six technical officials of other laboratories participated in our five exchange programs in this fiscal year. The program names and participants were as follows; “Structure analytic simulation technology” from Nagoya University and the High Energy Accelerator Research Organization, “Application of a multitasking machining center” from Nagoya Institute of Technology, “Measurement and control technique using a PC” from Kyushu University, “Electronic publishing technology” from Tsukuba University. Figure 32 shows a scene of the technical exchange.

Fig.32. A snap shot of the technical exchange

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

A dual system in Japanese version aims to develop 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 of view of a researcher and engineer. In this fiscal year, we took over the theme “Design and production of a camera for the inside of LHD” from the last fiscal year.

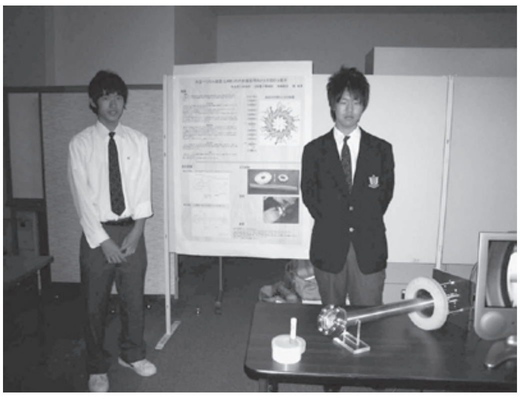

Fig. 33 A snap shot of the NIFS open campus

The main technical point is the design and manufacturing of a vacuum vessel for installation of the camera in LHD. In this trial, we installed the vacuum vessel in the vacuum leak test chamber in the plasma diagnostics laboratories. We could show the inside of the vacuum chamber by the camera set in the vessel. The results of the test were showed at the NIFS open campus by the students.