For the precise measurement of plasma parameters in a three dimensional helical plasma, an extensive set of diagnostics has been developed with national and international collaborators, and routinely operated in the Large Helical Device since 1998. The total number of diagnostics is over 60 owing to the continuous efforts for the development of new diagnostic instruments by researchers.

A new detection system for the Thomson scattering measurement, which enables us to detect the scattered light in both backward and forward configurations separately, has been developed. In order to avoid the delay time of forward scattering signal from backward scattering signal, a new system with a charge-integration type AD converter was installed in addition to the present FAST-BUS system. It has been confirmed that the electron temperature measured with the new system agrees with that measured with FAST-BUS system.

Basically, Thomson scattering system observes not only Thomson scattered light but also bremsstrahlung light that is usually subtracted as a background light. An estimation of Z_{eff} using "background light" was attempted. If the contribution from line spectrum is less than 10%, accurate measurements of Z_{eff} are expected to be possible. The plasma light profiles measured with a polychromator show hollow shapes similar to electron density profiles, and seem to have weak dependence on the electron temperature.

Thomson scattering system needs high energy probe lasers to increase the probability of the interaction between photons and electrons due to the small Thomson cross-section. However, repetition rate of the flash lamp pumped high energy laser is limited by the heat generation in the optical component of the laser system. The multi-laser system is valid for increasing the repetition rate, whereas thermos-optic effects exist in beam combiners where multi-laser pulses are combined. A coaxial laser beam combining device based on TGG ceramics has been developed to reduce the heat generation. The advantages of TGG ceramic material are large magneto-optic coefficient and good thermal property. The characteristics of thermally induced depolarization in TGG ceramics have been studied in the experiments, which suggest that five 1.6 J $\times$ 30Hz lasers are available coaxially if TGG ceramics are applied to the LHD Thomson scattering system.

The CO_2 dispersion interferometer was installed in 2012, and a good density resolution of 4×10^{17} has been obtained. One of advantages of the dispersion interferometer is that there is no fringe jump error even in the high density region. The temporal resolution was evaluated using atmospheric pressure plasmas, and it was found that there is a response delay of 80 μs and the response time constant is about 100 μs. These time responses are expected to be determined by characteristics of lock-in amplifiers, which are acceptable in LHD experiments.

The O-mode Microwave Imaging Reflectometry (O-MIR) has been newly developed to observe the ion-ITB plasma. The frequency generator and the imaging detector named Horn-antenna Mixer Array (HMA) have been developed and tested. The new HMA includes many technologies which improve sensitivity, such as fin-line transducer, RF amplifier, the double balanced mixer and adjustment of LO power. The optical imaging system of O-MIR is much simpler than that of X-MIR, and observed noise of O-MIR (4mV) is much smaller than that of X-MIR (800mV).

Radial profiles of density ratio of helium to hydrogen ions have been measured using charge exchange spectroscopy technique with two-wavelength spectrometer in the wide range of the density ratio of 0.05-5. The light from the plasma is divided into longer wavelength (> 495 nm) and shorter wavelength (< 495 nm) using dichroic mirror. In order to detect the HeII (468.6 nm) and Hα (656.3 nm), blue and red filters are applied to signals. The 8 channels of the optical fiber array from plasma are connected to the dichroic box system and 16 spectrum on the CCD detector gives a radial profile of the helium and hydrogen density ratio at 8 locations.

A Tracer-encapsulated Solid Pellet (TESPEL) has been extensively utilized as a plasma perturbation tool for various physics studies. The current TESPEL injection axis is set on the equatorial plane of LHD aiming the plasma center, while new TESPEL with an oblique injection was applied for avoiding large density perturbation. A successful injection of the TESPEL with new injector was confirmed.

The LHD data acquisition (DAQ) and archiving system continues growing in both number of DAQ nodes and the total data amount. The total storage capacity for the LHD and the related data reach about 1PB. One of the expected solution for protecting such huge data against a big natural calamity is to have data replication site which should be more than several hundred kilo-meters distant from the NIFS Toki site. It is generally known that TCP has a problem in transferring high-bandwidth data stream through a long distance connection (LFN problem). To make LFN tests by using real long distance network, the test platform has been prepared, and the test results suggest that it is technically possible to realize the real-time long-distance replication for the LHD data.

The python-based visualization tool (myView) have been developed for visitors who analyze the experiment data during their short stay in NIFS. In the last year, myView was significantly modified by the authors (myView2), which has 112 data loader modules. The most remarkable feature is that the three dimensional data plot is available. Also, myView2 has been improved to work in real-time mode, notify mode and sever mode, which permits the operation of myView2 by other programs.

The LHD project is going to start deuterium plasma experiments within two years, and new diagnostic systems have been considered and prepared.

The scintillator-based soft- X ray (SX) measurement system has been developed for avoiding the effects of neutrons and γ-rays. The detection system consists of a pinhole camera with scintillator screen. The SX emissions enter into the CsI:TI scintillator and are converted to visible light. The light are transferred to semiconductor detector array set in shielded box. The prototype of this measurement system was installed and applied to hydrogen experiments, and the basic function of the system was confirmed.

To execute the deuterium experiments as scheduled steadily and safely, a neutron monitoring system consisting of neutron flux monitor (NFM) and neutron activation foil system (NAS) have been developed. The neutron emission rate strongly depends on injection pattern of neutral beam (NB) and changes rapidly within a time scale of beam ion’s slowing down time after the NB turn-off. Therefore, a fast-response NFM with a wide dynamic range capability is required. The NFMs were fabricated in FY2014 and were installed in March, 2015. The NAS was also installed then. The NAS is expected to play an important role in assessing absolute DD neutron fluxes as well as NFM. These systems are useful for clarifying characteristics of MeV-ion confinement in the LHD.

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