1-2. Research and Development for LHD Upgrade

(1) Safety Management Research

The LHD upgrade is projected to explore the high-performance plasmas relevant to the fusion reactor, as well as achievement of the goal of the LHD project, i.e., the establishment of the physics basis for helical fusion reactor.

The research and development for the LHD upgrade is categorized as follows;
(1) Safety Management Research
(2) Diagnostic System
(3) Physics and Engineering of LHD Torus and Heating Systems

The agreement for the environmental conservation and the LHD deuterium experiment was concluded between NIFS and the local government bodies of Toki-city, Tajimi-city, Mizunami-city and Gifu-prefecture in March 2013. After that, the preparation for the deuterium experiment have been carried out including the program development.

The safety managements of experimental devices are major issues in the LHD research. Radiation management system and access-control system were well integrated for safety operation of the LHD and the related devices, and the results are intended to be applied to the LHD upgrade program. The radiation monitoring system (RMSAFE) has successfully worked. For the LHD deuterium experiment, the radiation safety management systems and the precise radiation monitors have been developed.

From a view point of the radiation safety for the deuterium experiment and for future fusion reactors, tritium is one of the key issues. The removing system from the exhaust gas of the LHD vacuum pumping system, the evaluation of the tritium monitoring system and that of the environmental radioactivity measurement have progressed. Especially, the commissioning of tritium removal system was completed in the Fiscal Year (FY) of 2015. It was confirmed that the removal system fulfilled its specification, i.e., it has an ability to remove more than 95% of hydrogen isotopes from the exhaust gas of LHD vacuum pumping systems.

Development of the diagnostics system has been performed for precise measurements of the plasma parameters and toward the LHD upgrade. For the deuterium experiment, the planning of the re-arrangement of the diagnostics in LHD has started. Neutron diagnostic is one of the key diagnostics at the deuterium experiment in the point of view of radiation safety control as well as that of plasma physics. A radial neutron profile monitor system based on stilbene-scintillator was installed in FY2015. The absolute calibration of neutron flux monitor and the radial profile monitor will be performed in FY 2016 by using a ^{252}Cf neutron source.

Development of heating system is inevitable for fusion relevant devices, such as ITER and DEMO, as well as the LHD experiments. Plasma heating and control by the high-energy Neutral Beam (NB) injection are most prospective to realize the burning fusion plasmas. The LHD is equipped with five NB Injectors (NBIs) as main heating devices. The NBIs consist of three negative-ion based NBIs and two positive-ion based NBIs. The total maximum injection power is 16MW for negative-ion based NBIs, and 12MW for positive-ion based NBIs when they are operated with Hydrogen. Upgrade of positive-ion based NBIs for Deuterium beam injection was already completed and its injection energy will be increased from 40keV(H) to 60/80keV(D). Consequently, their injection power will be increased to 18MW. On the other hand, the injection power of negative-ion based NBIs will be decreased to 11MW when they are operated with Deuterium since their injection energy will remain same to the Hydrogen operation and the optimum beam current is scaled with the inverse square root of the mass number of beam ion species. To overcome this degradation of the injection power, the research and development activities for the next-step negative ion based NBI system has been carried out. In the ECRH system, a new injection system from 9-O port is now under investigation to increase the injection power of ECH. For this system, The development of a new gyrotron which can operate at two frequencies (116/154GHz) is in progress under the collaboration with Tsukuba university. For further improvement in the injection efficiency of ECH microwaves, a new polarization system and a real-time polarization monitoring systems for the waves are also under development

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