National Institute for Fusion Science (NIFS)

National Institutes of Natural Sciences (NINS)

External Peer Review Reports in FY2014

March, 2015

External Peer Review Committee, NIFS Advisory Committee

Contents

Chapter 1 Background

In order to advance fusion research in universities, the National Institute for Fusion Science (NIFS), as an Inter-University Research Institute, was established in 1989 with the Large Helical Device (LHD) as the main device. Planned to bear the collective opinion and expectations of the fusion community and with the special characteristic of generating a heliotron-type magnetic field using a superconductor, an idea developed in our country, the LHD, together with generating high-performance plasma by using the helical magnetic field configuration through high-power heating, is advancing experimental research that aims at clarifying physics and engineering issues in anticipation of the achievement of a toroidal magnetic field confinement fusion reactor.On the other hand, parallel with this, theoretical research utilizing large-scale simulations is essential in analysis of fusion plasmas of great complexity. At NIFS we have introduced the most advanced supercomputers, and having made these supercomputers available through joint-use with fusion theory scholars throughout Japan we thus have moved forward with pioneering research.

During this time, there have been changes in the domestic academic research system, and since 2004 NIFS, as an institute in the Inter-University Research Institute Corporation National Institutes of Natural Sciences, has advanced still further in countrywide joint use and joint research. Upon incorporation, we developed a six-year mid-term plan, and a system for receiving an annual evaluation regarding the state of our progress was introduced. This annual evaluation focuses primarily on management. Regarding research results, NIFS has determined that receiving an evaluation by external experts is important. Under the Advisory Committee, an external peer review committee is organized and each year an evaluation of research is conducted. The evaluation topics are decided by the Advisory Committee, and the evaluation **is** undertaken by the External Peer Review Committee, which is composed of the external Advisory Committee members and foreign experts appropriate for the evaluation topics. The External Peer Review Committee reports the results of its evaluation to the Advisory Committee, and NIFS respects those results, which become useful for improvement in the next fiscal year's research activities.

At NIFS, upon the start of the second mid-term goals period that began in 2010, in order to further strengthen the centripetal force of NIFS as a Center of Excellence (COE) in the field of plasma and fusion research we designed research projects in three areas: the LHD, the Numerical Simulation Reactor Research, and the Fusion Engineering Research. Looking toward the realization of the fusion reactor, we then initiated research planning that would unify the results of these projects. For this reason, in FY 2010 we revised the research structure of NIFS. Placing all research staff members in one research department, we introduced a structure by which each researcher would freely select the research project in which she/he would participate. Since then, coordination among the LHD Project, the Numerical Simulation Reactor Research Project, and the Fusion Engineering Research Project has become much closer, and we have become able to respond to new issues as occasion demands.

In the Advisory Committee meetings, in order to confirm results of the research project system, we conducted the external peer review on the LHD Project in 2011, the Numerical Simulation Reactor Research Project in 2012, and the Fusion Engineering Research Project in 2013. We then assigned the “Deuterium Experiment Implementation Plan” as the subject for external peer review in 2014. To serve as members of the external peer review, we selected ten members of the Advisory Committee who are outside of NIFS and four members from foreign countries. Furthermore, the Experts Committee on this topic was composed of the External Peer Review Committee and five specialists outside of NIFS. In this way, we composed the External Peer Review Committee and the Experts Committee and then conducted the evaluation.

At the first meetings of the External Peer Review Committee and the Experts Committee, which were held on September 12, 2014, we discussed how to move forward with this fiscal year’s external evaluation, and decided upon the perspectives and the specific issues for evaluation. We will introduce this information below. At the second meetings of the External Peer Review Committee and of the Experts Committee, which were convened on November 29, 2014, we received from each person in charge at NIFS a detailed explanation that used viewgraphs to treat the points for evaluation and materials regarding the reports of activities. A discussion session followed. Subsequently, on January 29, 2015, the third meetings of the External Peer Review Committee and the Experts Committee were held. Including further discussion with NIFS, these committees undertook evaluation duties that followed the points and items that had been determined at the committee meetings. With the draft version of the evaluation submitted, on February 24, 2015, the fourth External Peer Review Committee meeting and the Experts Committee meeting were held. The final report was compiled.

This report is composed of the following four parts: Part 1: The Particulars to Present; Part 2: Evaluations by Item; Part 3: Summary of the Evaluations, and Recommendations; and Part 4: Conclusion.

After this report is approved by the NIFS Advisory Committee, the Director General of NIFS will submit it to the President of the National Institutes of Natural Sciences (NINS). Subsequently, after approval by the Education and Research Council and the Administrative Council of NINS, this report is expected to be reference material in the reports “2014 Fiscal Year Report on Management and Achievements” and “National Institutes of Natural Sciences Annual Plan (2015)” to be submitted to the Ministry of Education, Culture, Sports, Science and Technology. This report will be made public as a printed text and on the NIFS homepage.

The points for evaluation in the “Deuterium Experiment Implementation Plan” are composed of requisite items for evaluation of the research plan and the safety management plan, and of the readiness of the plans for the LHD Deuterium Experiment, which will advance as an important NIFS plan in the third mid-term plan that the Inter-University Research Institute Corporation National Institutes of Natural Sciences will formulate. The appropriateness and the level of achievement will be the basis of the points for evaluation.

Further, referencing the “Recommendation” in the external peer review regarding safety management that was implemented in 2009, the following two points were considered in this evaluation.

1. Are the training and the education of the people who will be responsible at the time of the deuterium experiment being conducted appropriately?
2. Are the Safety Committee and the Safety Surveillance Committee for Radiation Safety Management, the organization of the Radiation Control Office, and the systems for responses to emergencies being constructed appropriately?

The topics in the “Deuterium Experiment Implementation Plan” for the fiscal year 2015 evaluation are as follows below.

[1] Research Plan

(1) Is the goal of the deuterium experiment appropriate? Further, do the research plan and the implementation system for ensuring safety achieve those goals?

(2) Does this plan contribute to the promotion of a comprehensive understanding of toroidal plasma and heighten its academic value with regard to the realization of fusion energy?

(3) Regarding implementation of the plan, will this achieve a system of joint use and joint research that enables participation by a wide range of researchers?

[2] Deuterium Experiment Preparation System

(1) Moving toward the initiation of the deuterium experiment in 2016, is the preparation of

equipment and facilities being planned appropriately?

(2) Is the preparation system for the initiation of the deuterium experiment appropriate? Is preparation of the facilities and devices, including safety equipment, being advanced appropriately?

[3] Safety Management Planning

(1) Is the fundamental concept regarding safety management appropriate at the time of the formulation of the deuterium experiment implementation plan as also based upon the opinions of local residents?

(2) Are safety management equipment, facilities, and experiment equipment being planned appropriately for the safe accomplishment of the deuterium experiment and to be managed for maintenance?

(3) In order to safely accomplish the deuterium experiment, are various types of regulations being formulated appropriately?

(4) Are the operation manual, the radiation management manual, and the emergency measures manual being formulated appropriately?

(5) Are the organization of and the system for safety management while the deuterium experiments are being conducted constructed appropriately?

(6) Are education and training for the safe execution of the deuterium experiments, and nurturing of those responsible for safety management being undertaken appropriately?

[4] Understanding by Society and Citizens

(1) Is enhanced understanding of the safety of the deuterium experiment being advanced appropriately to local residents?

(2) Is promotion of the deuterium experiment plan being designed in conjunction with local governments?

(3) Is the importance and the safety of fusion research being widely disseminated in society?

Chapter 2 Reviews and Proposals

Points for evaluation results are summarized based on discussions by the External Peer Review Committee and the Experts Committee, and several important recommendations are proposed to promote the "Deuterium Experiment Implementation Plan."

2.1 Summary of the External Peer Review

[1] Research Plan

(1) Is the goal of the deuterium experiment appropriate? Further, do the research plan and the implementation system for ensuring safety achieve those goals?

From the deuterium experiment, research in high-performativity through improvement of confinement, isotope effects, and confinement of high energy ions will advance, and contributions to the comprehensive understanding of toroidal plasmas are anticipated. Such goals as these are appropriate. This is a research plan, which together with expanding the plasma parameter regime through the improvement of confinement and the strengthening of heating devices, will expand toward new research realms through the maintenance of neutron diagnostics and high precision diagnostics, and maintenance of the closed divertor. And combined with the advances in the preparation of securing the safety of the deuterium experiments, we highly evaluate this plan.

Next, together with deepening further discussion regarding the formulation of concrete experimental planning, it is necessary to academically verify the isotope effect in improving confinement in helical devices and to contribute to a comprehensive understanding of toroidal plasma. The safety measures and the implementation system for advancing with this research are appropriate. In the future, while adding further examinations that include additional researchers, it will be desirable to advance while planning continuous revisions of the safety management system.

(2) Does this plan contribute to the promotion of a comprehensive understanding of toroidal plasma and heighten its academic value with regard to the realization of fusion energy?

Through confinement improvements and elucidation of physics, improvement of MHD stability and enlargement of the high beta region, confinement of high energy ions, optimization of the divertor, plasma wall interaction, and diversification of ICRF heating, this is a plan that heightens the academic value in achieving fusion, and is highly evaluated.

Through the closed divertor and by applying a perturbation magnetic field, the transport phenomenon in edge plasma will develop, and contributions to the control of particles in core plasma are expected. This is highly evaluated.

Considering cases in which improved confinement through the isotope effect are insufficient, it is hoped that there will be elucidation of various confinement improvement methods and that there will be predictions regarding modeling.

(3) Regarding implementation of the plan, will this achieve a system of joint use and joint research that enables participation by a wide range of researchers?

Establishing links with research institutions in Japan and abroad through joint research projects aiming toward the deuterium experiment, results have been achieved in neutron diagnostics, tritium recovery, plasma wall interaction, and other fields. We highly praise the formation of a countrywide research network.

That NIFS has held joint meetings for research planning for the deuterium experiment and for safety management planning with the Fusion Network as well as with the Experts Committee of The Japan Society of Plasma Science and Nuclear Fusion Research, and that NIFS has held discussions with a wide range of researchers at symposia and invited lectures in the case of academic society are also evaluated highly.

[2] Deuterium Experiment Preparation System

(1) Moving toward the initiation of the deuterium experiment in 2016, is the preparation of equipment and facilities being planned appropriately?

Aiming toward the deuterium experiment, NIFS is planning appropriately repairs and improvements to facilities for establishing the controlled area, reinforcement of the NBI, development and maintenance of neutron diagnostics, and planning and construction of a diagnostic for the tritium recovery. We highly evaluate this, and also evaluate that NIFS is advancing appropriately the maintenance execution plans by separating them into three stages.

(2) Is the preparation system for the initiation of the deuterium experiment appropriate? Is preparation of the facilities and devices, including safety equipment, being advanced appropriately?

Aiming toward the initiation of the deuterium experiment, we highly evaluate the establishment of the Division of Deuterium Experiments Management. Under its direction, preparation of manuals, preparation and improvement of facilities, and the preparation of safety facilities were implemented without delay.

[3] Safety Management Planning

(1) Is the fundamental concept regarding safety management appropriate at the time of the formulation of the deuterium experiment implementation plan as also based upon the opinions of local residents?

We judge the fundamental way of thinking regarding safety to be satisfactory. And implementing a system for monitoring the environment for very small amounts of tritium too can be praised from an academic perspective. Further, compliance is important, but because introducing excessive self-regulation together with hindering academic development will also affect the operation of other RI facilities, it is necessary to make NIFS regulations abundantly clear and to move forward so that these do not become standards.

(2) Are safety management equipment, facilities, and experiment equipment being planned appropriately for the safe accomplishment of the deuterium experiment and for their maintenance?

We judge and highly evaluate that the safety management instruments and facilities, and the experiment equipment will safely perform the deuterium experiment, and that operation and maintenance are being appropriately planned. Further, we would like the disposal of tritiated water to move forward in close cooperation with the Japan Radioisotope Association.

(3) In order to safely accomplish the deuterium experiment, are various types of regulations being formulated appropriately?

We highly evaluate that regulations have been sufficiently prepared for safe execution of the deuterium experiment. Further, regarding the handling of radioactivated materials, we seek sufficient study. Depending upon the material and the region in the LHD, radioactivated materials are subjects of research, and it is necessary to clarify that it is possible to transfer them according to law.

(4) Are the operation manual, the radiation management manual, and the emergency measures manual being formulated appropriately?

Manuals for the safe accomplishment of the deuterium experiments are being basically prepared, and these are highly evaluated. It may be stated that it is better for times of emergency to write the division/section and the telephone numbers to contact specifically. Further, as a more specific evaluation, in treating radioactivated materials, it is thought to be necessary to prepare a manual that includes concrete methods for measurement.

(5) Are the organization of and the system for safety management while the deuterium experiments are being performed being constructed appropriately?

The organization of safety management is highly evaluated for having been sufficiently prepared. However, so that inflexibilities due to bloated organization not occur, it likely will be necessary to operate while conducting appropriate reviews even after starting operation.

(6) Are education and training for the safe execution of the deuterium experiments and nurturing for those responsible for safety management being undertaken appropriately?

In addition to the lectures mandated by law, activities such as actually experiencing the handling of tritium conducted through cooperation with the Toyama University Hydrogen Isotope Research Center are highly evaluated. It is believed that training in communication in a time of emergency will be conducted and that cultivation of human resources for safely executing the deuterium experiment are being appropriately planned.

[4] Understanding by Society and Citizens

(1) Is enhanced understanding of the safety of the deuterium experiment being advanced appropriately to local residents?

In order to plan for enhancing understanding of safety, over nearly the past decade NIFS has held open meetings for local residents. These open meetings have been held each year at from 20 to 30 places and more than 4,000 people have attended. NIFS has explained the deuterium experiment and the results of research, and is advancing a shared understanding. And opinions raised at explanatory meetings are made available on the NIFS homepage. We very highly evaluate this. Further, NIFS is engaging in public relations such as through brochures and leaflets, and is participating in science fairs and local events. In particular, in 2013 NIFS held a Science Classroom and more than 1,000 people participated. That NIFS is actively engaged in these efforts is highly evaluated.

(2) Is promotion of the deuterium experiment plan being designed in conjunction with local governments?

From around 1997, while continuing to consult with the nearby cities of Toki, Tajimi, and Mizunami, NIFS has deepened their understanding of its research activities and position regarding safety. And in 2013, NIFS concluded agreements with Gifu Prefecture and these three cities. Further, as joint activities with the Toki City Plasma Research Committee, we can evaluate extremely highly that NIFS is continuing local radiation measurements together with elementary and junior high school teachers.

We also highly evaluate the continuation of regular explanation meetings and research report meetings after the conclusion of the agreement. Further, training in information delivery together with local communities and the establishment at NIFS of the Regional Coordination Office, which is a system for coordination.

(3) Is the importance of fusion research and its safety being widely disseminated in society?

An Open Campus is held each year at NIFS, and this is becoming a large event with from 2,000 to 4,000 people attending each time. Further, NIFS conducts outreach not only in this area but also in other areas, too. NIFS holds the Fusion Festa in Tokyo at the National Museum of Emerging Science and Innovation. In 2014, more than 2,000 people attended, and that this has become a large event where people can learn about fusion research can be highly evaluated. In addition, the holding of academic lectures for local residents, the production of a mail magazine and of mail news, and visitors to NIFS exceeding 4,000 people indicates that NIFS is pouring strength into public relations activities. Moreover, through cooperation with the SSH activities and cooperation with internships for junior high and high school students NIFS is actively engaged in public relations toward youths who will support the next generations. This can be highly evaluated.

2.2 Recommendations

In this evaluation we have listed our recommendations regarding the path forward based upon the discussion of the Deuterium Experiment Implementation Plan.

(1) Regarding the improvement of confinement that will be accompanied by the deuterium experiment as well as the maintenance of heating devices and diagnostics instruments, together with the further deepening of discussion toward a concrete experiment plan formulation, and through enhancement of modeling we anticipate contributions toward a comprehensive understanding of toroidal plasma. We anticipate further continuation and maintenance of the countrywide research networks for neutron diagnostics, tritium recovery, and plasma-wall interaction that have been formed through collaborative research toward the Deuterium Experiment.

(2) To start the Deuterium Experiment on schedule, and under the Division of Deuterium Experiments Management we anticipate completion without delay of the preparation and maintenance plan formulation as well as the maintenance of equipment, reinforcement of facilities, and establishment of a safety management system.

(3) NIFS also summarizes fusion research performed at universities, and in safely achieving success in the deuterium experiment, completion also is extremely important. In particular, while respecting the law, respecting the opinions of local residents, and maintaining a well-balanced sense regarding the development of scholarship, one must respond with flexibility. Further, it is hoped that regarding actual safety management, NIFS will proceed safety management in a polite and reliable manner by the overlap of appointment terms for supervisors and by rotating their appointments.

(4) That NIFS has over a long period of time explained matters to local residents and has cooperated in communication activities with local governments can be highly evaluated. From now, too, through results from safety management and continuous practice it is hoped that NIFS will work toward receiving understanding and support of fusion.

Chapter 3 In Closing

At the National Institute for Fusion Science, from the beginning of the second mid-term goals period in 2010, in order to strengthen further the centrifugal power of NIFS as a Center of Excellence in the plasma - fusion field, NIFS composed research projects in the following three fields: the LHD Project, the Numerical Simulation Reactor Research Project, and the Fusion Engineering Research Project. Aiming toward realization of the fusion reactor, we started research planning toward integrating these results. For this purpose, in 2010 NIFS undertook a revision of the research structure within the Institute. All of the research education staff were set in one research division, and each researcher could freely choose to participate in one of the three projects. These are the LHD Project, the Numerical Simulation Reactor Research Project, and the Fusion Engineering Research Project, and their coordination was promoted. It is anticipated that expedient responses will occur as occasions demand.

The NIFS Advisory Committee introduced external peer reviews for the LHD Project in 2011, for the Numerical Simulation Reactor Research Project in 2012, and for the Fusion Engineering Research Project in 2013. Then, in the fiscal year 2014 NIFS initiated an external peer review of the Deuterium Experiment Implementation Plan. The external peer review members include 10 Advisory Committee members from outside the Institute and four foreign researchers. The Experts Committee is composed of the External Peer Review Committee and five specialists for the topics. They have undertaken the evaluation.

At the First External Peer Review Committee and Experts Committee meetings held on September 12, 2014, there was discussion of how to proceed in conducting this year’s external evaluation. It was decided that the committees would evaluate the following points.

[1] Research Planning

(1) The appropriateness of the deuterium experiment’s goals; the implementation system for a research plan that will achieve its goals and an implementation system for safety protection
(2) Plans for raising the academic value
(3) Joint use; joint research system

[2] Deuterium Experiment Preparation System
(1) Maintenance planning for equipment and facilities
(2) The preparation system and facilities and equipment maintenance

[3] Safety Management Planning

(1) Fundamental ways of thinking about safety management

(2) Safety management equipment and facilities; planning regarding experiment equipment

(3) Appropriate formulation of regulations

(4) Appropriate formulation of manuals

(5) Formulation of organization and system

(6) Education and training as well as appropriate planning for the nurturing of the person in charge for safety management

[4] Understanding by Society and Citizens

(1) Enhancing the understanding of the safety of the deuterium experiment among local residents

(2) Coordination with local governments

(3) Informing society of the importance and the safety of fusion research

Subsequently, at the second External Peer Review Committee and Experts Committee meetings held on November 29, 2014, members received a detailed point-by-point explanation of the evaluation's perspective and the points for evaluation from the person in charge at NIFS, and a question-and-answer session was held subsequently. Moreover, on January 29, 2015, the third External Peer Review Committee and Experts Committee meetings were held. Including additional discussions with NIFS, there also was a point-by-point discussion that followed the topics of evaluation decided by the External Peer Review Committee, and a summation. When all of the texts for the evaluation had been gathered, on February 24, 2015, the fourth meetings of the External Peer Review Committee and the Experts Committee were held and the final report compiled.

A result of this external evaluation of the deuterium experiment plan is the conclusion that, regarding all of the items above, nearly all of the items may be highly evaluated. In particular, regarding the enhancement of the understanding of safety and cooperation with local governing bodies, we evaluate this extremely highly. This may be called a result of the Institute's continuous efforts. In the future, we look forward to continuing activities. We can highly evaluate the ongoing composition and preparation of appropriate regulations and manuals as well as the construction of organizations and systems, but we anticipate further effort.

Furthermore, at the third External Peer Review Committee and Experts Committee meetings held on January 29, 2015, there was further discussion regarding ways of thinking about safety management and the treatment of radioactivated materials. In addition to receiving explanations of the Institute's approaches to safety management, we received an explanation through additional materials regarding negotiations with local governments and citizens. In addition, we received several days later a report that summarized the fundamental way of thinking regarding the treatment of radioactivated materials, too. As a result of discussions that referenced these explanations and materials, we have concluded that the fundamental way of thinking regarding safety management and the treatment of radioactivated materials is appropriate.

Finally, we have summarized below recommendations regarding how to move forward from now with the deuterium experiment implementation planning.

(1) Referencing improvement of confinement that is accompanied by the deuterium experiment and the preparation of both heating devices and diagnostic equipment, through deepening further discussion of concrete experiment planning formulation together with enhancing modeling we anticipate that this will contribute to a comprehensive understanding of toroidal plasma. We anticipate further continuation and support of research networks throughout Japan that focus on neutron diagnostics, tritium recovery, and plasma-wall interaction constructed through joint research aimed at the deuterium experiment.

(2) To begin the deuterium experiment on schedule, and under the Division of Deuterium Experiments Management, we anticipate completion without delay of the formulation of preparation implementation planning, the preparation of equipment, the improvement of facilities, and the establishment of the safety management system, all of which are aimed at the deuterium experiment.

(3) NIFS has the standing as an inter-university research institute that summarizes research in fusion studies at universities, and succeeding safely in completing the deuterium experiment is extremely important. In particular, while respecting laws and regulations, respecting the opinions of local residents, and maintaining an awareness of a good balance of academic development, it is important to respond flexibly. Further, regarding the actual safety management, it is expected that the appointment period for supervisors will be overlapped and that new supervisors will be appointed appropriately, and that this will proceed politely and steadily.

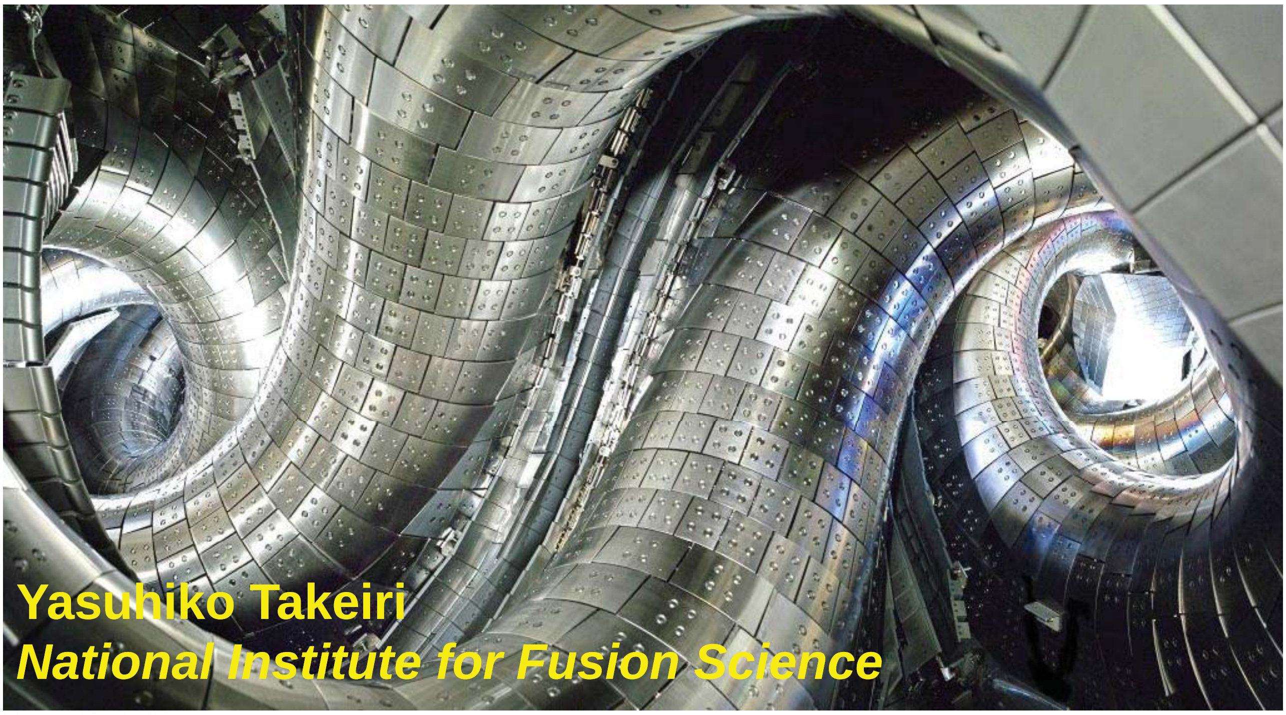
(4) We can highly evaluate NIFS' explanations for local residents and cooperation activities with local governing bodies over these many years. From now, through achieving safety

management and constant effort, it is hoped that this endeavor will gain understanding and support for fusion

Documents

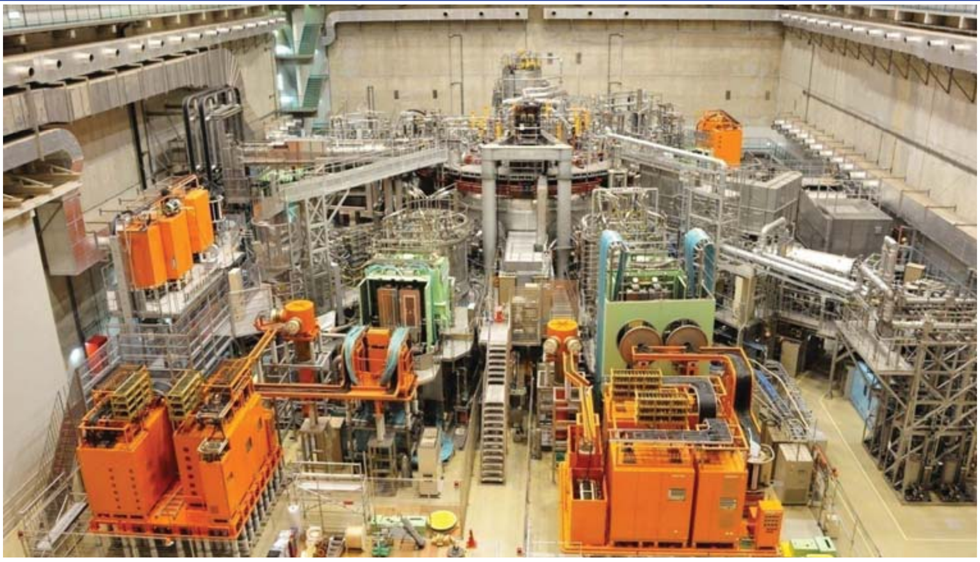
2014 External Peer Review Presentation Materials

The Deuterium Experiment Implementation Plan



2014 NIFS External Review (Nagoya, November 29, 2014)

Large Helical Device (LHD) Project



- The world-largest helical system, and the world-largest SC fusion machine
- Intrinsic advantage and engineering capability of steady-state operation
- Complementary/alternative role to tokamak approach

The goal of the Large Helical Device project

✓ **Establish scientific basement for a helical fusion reactor**

✓ **Comprehend physics of toroidal plasmas**

Objectives of Large Helical Device Project - defined in the basic plot in 1989 -

To clarify the physics and engineering problems important for helical fusion reactor plasmas by studying currentless plasmas in the next large-scale fusion experimental device of the university program.


Photo by J. Nishizawa from "Build the Future"

(1) Realize plasma with a high fusion triple product and conduct extensive confinement study requisite for a fusion reactor.

(2) Realize beta exceeding 5 % and explore related physics.

(3) Employ divertor, conduct long pulse experiment and accumulate basic data for steady state operation.

(4) Investigate high energy particles in helical fields and conduct simulation experiment of alpha particles in a reactor plasma.

(5) Conduct complementary study to tokamak and deepen comprehensive understanding of toroidal plasmas.

LHD has worked very well for 16 years.

✓ **Operation for 16 years**

➔ engineering base of a large-scale superconducting and cryogenic system for fusion reactor development

Heating capability

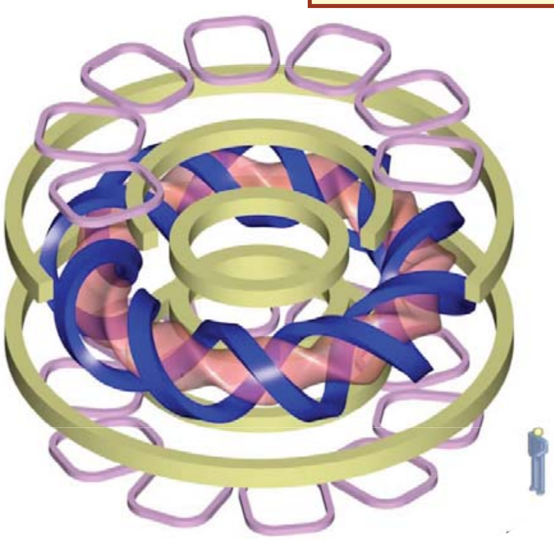
NBI	28	MW
ECH	4.6	MW
ICH	3.5	MW

< LHD basic dimension >

- Outer diameter 13.5 m
- Cold mass 820 ton
- Total weight 1500 ton
- Magnetic field 3 T
- Magnetic energy 0.77 GJ

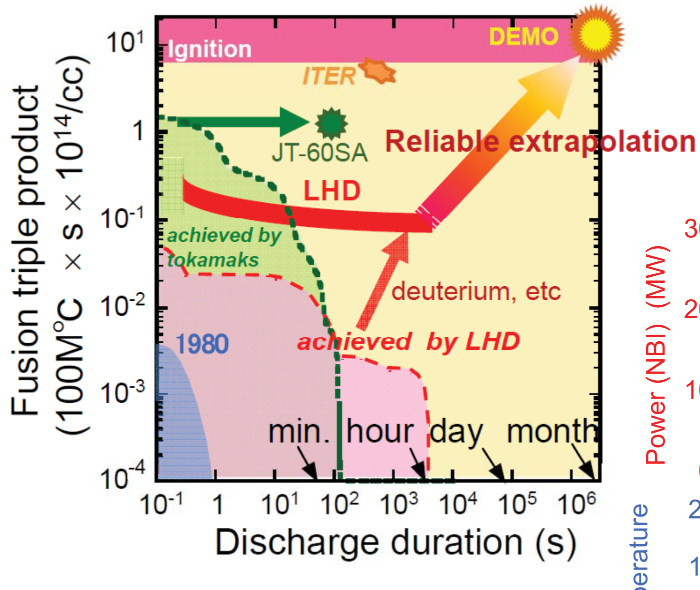
Several-month-long operation, 17 times since 1998

- Operational time of He compressor : 75,000 hours ➔ Duty > 99 %
- Coil excitation number : 1,545 times
- Plasma discharges : 122,000 shots (Plasma generation every 3 min)

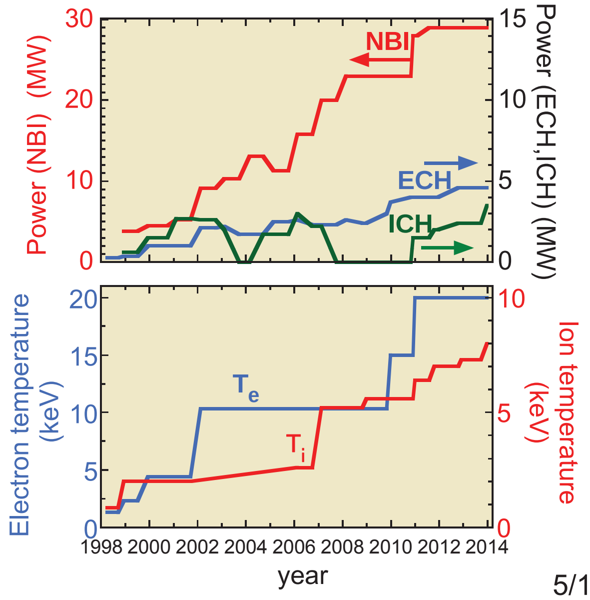


A large number of opportunities for diversified collaboration on physics

Demonstration of steady-state-operation of high-performance fusion plasma



LHD has shown steady and encouraging development of plasma performance in these 16 years since the initial operation.



Two major keys to realize fusion energy

1. Control of burning plasmas
   ➔ ITER
2. Steady-state operation
   ➔ LHD and JT-60SA

Achieved plasma parameters encourage the further next step.

Plasma parameters	Achieved	Target	Fusion condition
Ion temperature	8.1 keV at $1\times10^{19}m^{-3}$	10 keV at $2\times10^{19}m^{-3}$	> 10 keV > $1\times10^{20}m^{-3}$
Electron temperature	20 keV at $2\times10^{18}m^{-3}$ 13.5 keV at $1.4\times10^{19}m^{-3}$	10 keV at $2\times10^{19}m^{-3}$	
Denisty	$1.2\times10^{21}m^{-3}$ with T_e of 0.25 keV	$4\times10^{20}m^{-3}$ with T_e of 1.3 keV	
Beta	5.1% at 0.425 T 3.7% at 1 T	5% at 1-2 T	> 5% at > 5 T
Steady-state operation	54min. 28sec (500kW) (1keV、$4\times10^{18}m^{-3}$) 47min. 30sec. (1,200 kW) (2keV、$1\times10^{19}m^{-3}$)	1 hour (3,000 kW)	Steady-state (1 year)

Achieved in 2013

Innovative discovery to enable breakthrough ➔ acceleration of research

- ✓ Steady and stable high beta due to self-stabilization of instability
- ✓ Super-high density plasmas beyond 10 times the conventional fusion condition
- ✓ Impurity hole to pump out impurity automatically, etc.

Objectives of the LHD deuterium experiment

1. To realize high-performance plasmas by confinement improvement and to provide a wide range of plasma parameter space relevant to the reactor plasmas.

   As a consequence, scientific research area will be expanded with an increase in the variety of experiments.

2. To study the mass dependence (isotope effect) in the plasma confinement, leading to the establishment of a model for the burning experiment using deuterium and tritium.

3. To demonstrate that the confinement capability of high-energy ions is relevant to the burning plasmas in helical systems.

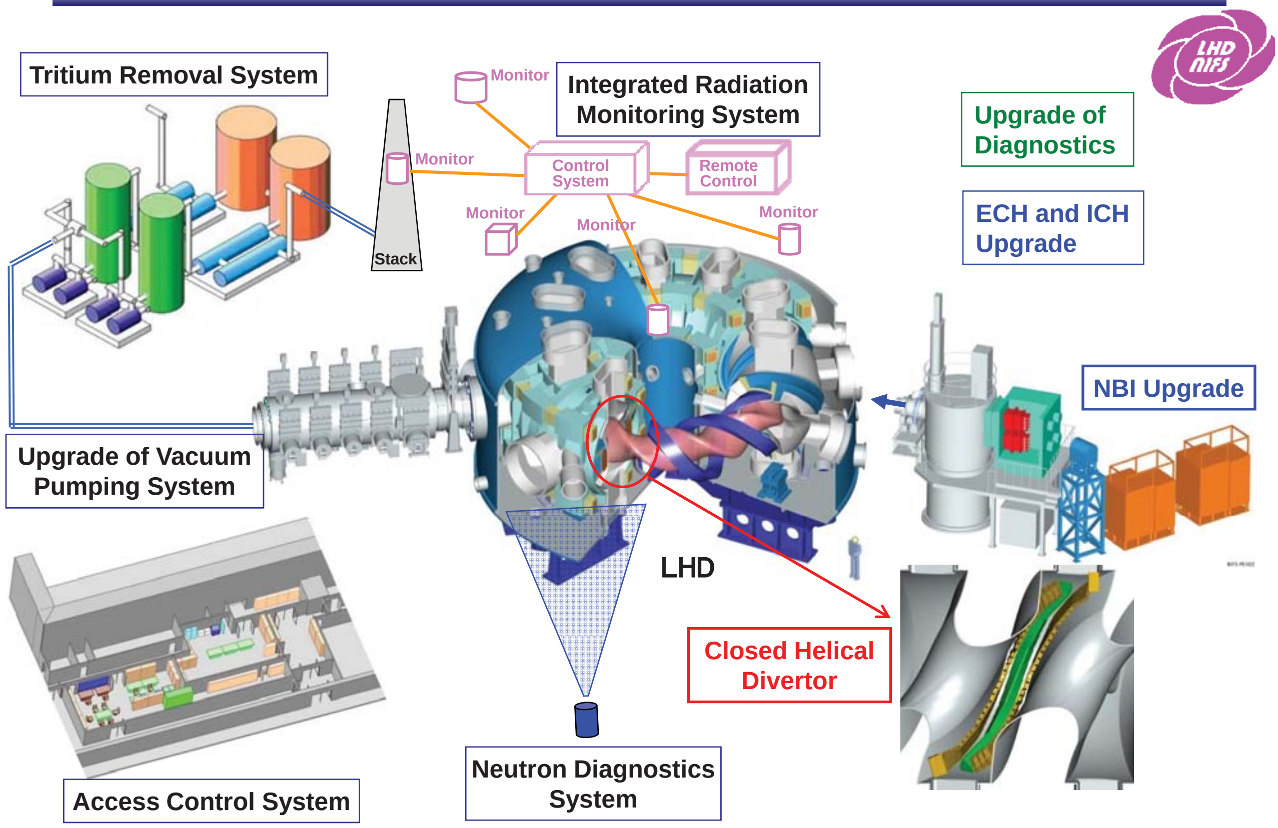
Annual Plan for LHD Deuterium Experiment

	First 6 years		Second 3 years	
FY	1st year	2nd – 6th year	7th – 9th year	After 10th year
Experiments	Preliminary Exp. (Commissioning)	Plasma Exp. For Target Parameters	Integrated High-Performance Exp.	Post-LHD Project
Maximum Annual Yield of Tritium	3.7×10^{10} Bq (1 Ci) (Integrated yield)		5.55×10^{10} Bq (1.5 Ci) (Integrated yield)	---
Maximum Annual Discharge of Tritium	3.7×10^{9} Bq (0.1 Ci) (Integrated yield)			---
Maximum Annual Yield of Neutron	2.1×10^{19} (Integrated yield)		3.2×10^{19} (Integrated yield)	---

LHD deuterium experiment will start after the supposed 3-years preparation.

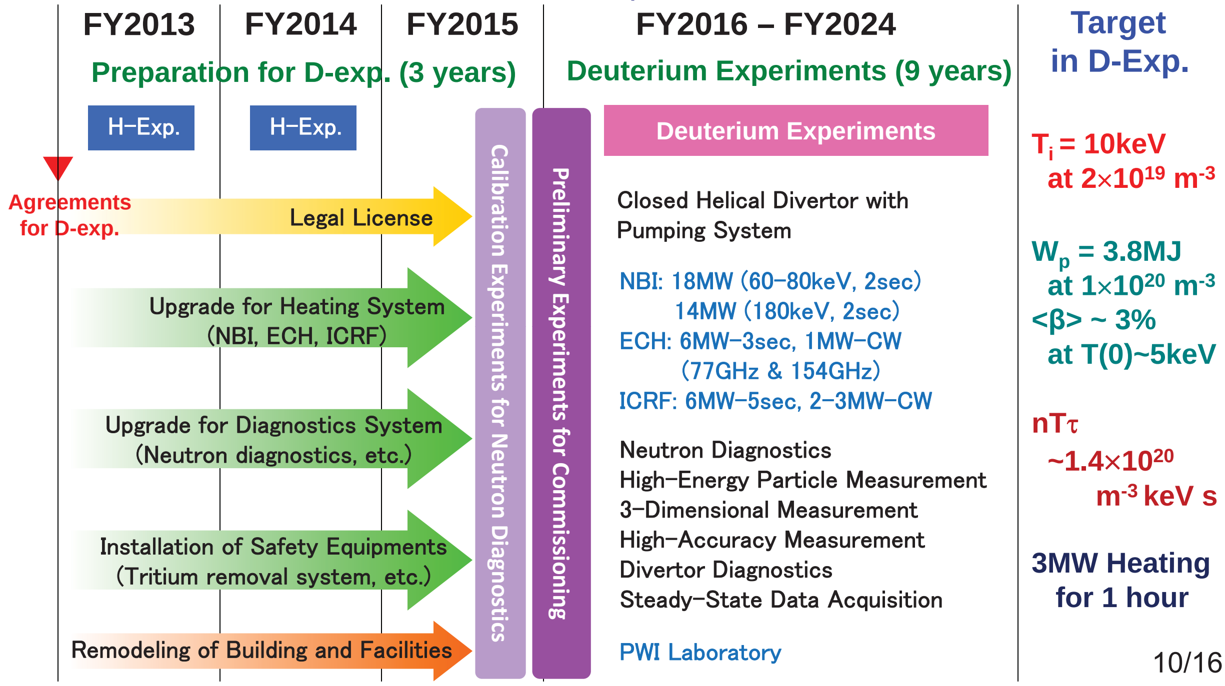
Post-LHD project will be directed to researches for the basic plasma science and the plasma application as well as the reactor design, with hydrogen plasma experiments.

Device Upgrade Plan for the LHD Deuterium Experiment

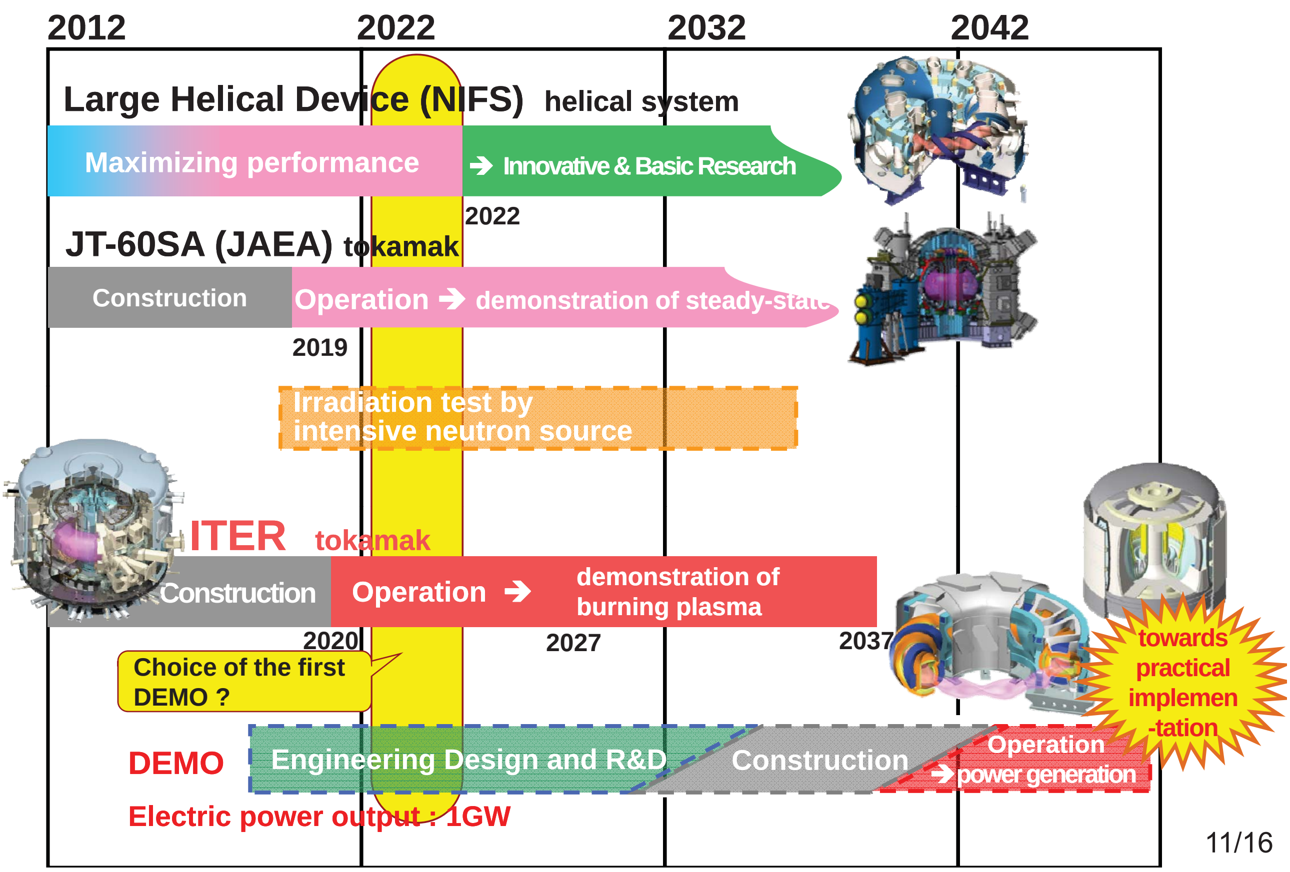


Schedule for LHD deuterium experiment (tentative)

- Concluding the Agreements for the LHD deuterium experiment with local government bodies on March 28, 2013.
- Deuterium experiment will start in 2016, and during the planned 9-years' experiments, 10keV of the T_i should be achieved.



Towards Realization of Fusion Energy by Magnetic Confinement



Issues of Evaluation (1)

1. Research Plan

(1) Is the goal of the deuterium experiment appropriate? Further, do the research plan and the implementation system for ensuring safety achieve those goals?

(2) Does this plan contribute to the promotion of a comprehensive understanding of toroidal plasma and heighten its academic merit with regard to the realization of fusion energy?

(3) Regarding implementation of the plan, will this achieve a system of collaborative use and collaborative research that enables participation by a wide range of researchers?

➔ Presentation by Y. Takeiri

Issues of Evaluation (2)

2. Deuterium Experiment Preparation System

(1) Moving toward the initiation of deuterium experiments in Heisei 28 [2016], is the preparation of equipment and facilities being planned appropriately?

(2) Is the preparation system for the initiation of deuterium experiments appropriate? Is preparation of the facilities, including safety equipment, and machinery being advanced appropriately?

➔ Presentation by Y. Takeiri

Issues of Evaluation (3)

3. Safety Management Planning

(1) Is the fundamental concept regarding safety management appropriate at the time of the formulation of the deuterium experiment execution plan as also based upon the opinions of local residents?

(2) Are safety management equipment, facilities, and experiment equipment being planned appropriately for the safe accomplishment of the deuterium experiment and to support management?

(3) In order to safely accomplish the deuterium experiment, are various types of regulations being formulated appropriately?

(4) Are the operation manual, the radiation management manual, and the emergency measures manual being formulated appropriately?

(5) Are the organization and the system for safety management when the deuterium experiments are being conducted being constructed appropriately?

(6) Are education and training for the safe execution of the deuterium experiments, and nurturing for those responsible for safety management being undertaken appropriately?

➔ Presentation by K. Nishimura

Issues of Evaluation (4)

4. Understanding by Society and Citizens

(1) Is enhanced understanding of the safety of the deuterium experiment being advanced appropriately to local residents?

(2) Is promotion of the deuterium experiment plan being designed in conjunction with local governments?

(3) Is the importance of fusion research and its safety being widely disseminated in society?

➔ Presentation by Y. Takeiri

Note from the review of the safety management in 2009

Referencing the "recommendation" regarding the safety management plan at the time of the deuterium experiment in the external review of the safety management undertaken in 2009, the two points below, too, are to be considered in this evaluation.

1) Has the cultivation and the education training of those responsible at the time of the deuterium experiment been conducted appropriately?

2) Are the organization of the safety committee for radiation safety management, the safety observation committee, the radiation management office, and others, and the structure at the time of an emergency being appropriately constructed?

➔ Reflect to "3. safety management planning"

1. Research Plan

(1) Is the goal of the deuterium experiment appropriate? Further, do the research plan and the implementation system for ensuring safety achieve those goals?

(2) Does this plan contribute to the promotion of a comprehensive understanding of toroidal plasma and heighten its academic merit with regard to the realization of fusion energy?

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1. Research Plan

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Objectives of the LHD deuterium experiment

1. To realize high-performance plasmas by confinement improvement and to provide a wide range of plasma parameter space relevant to the reactor plasmas.

   As a consequence, scientific research area will be expanded with an increase in the variety of experiments.

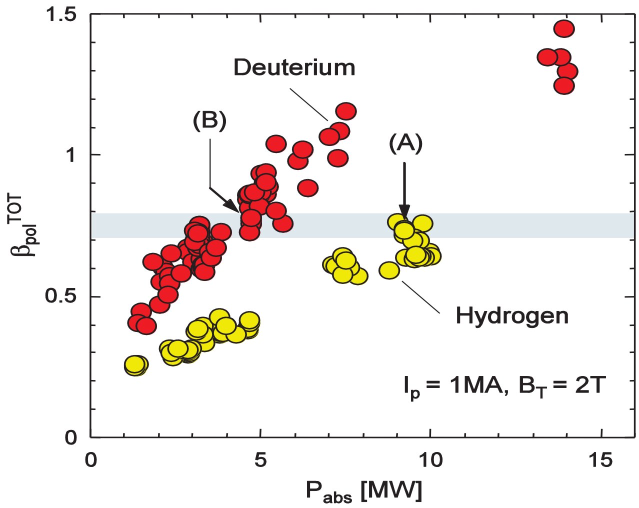
2. To study the mass dependence (isotope effect) in the plasma confinement, leading to the establishment of a model for the burning experiment using deuterium and tritium.
3. To demonstrate that the confinement capability of high-energy ions is relevant to the burning plasmas in helical systems.

Improvement of the plasma confinement (Isotope effect) is clearly observed in deuterium experiments in the world-major devices.

Device	Nation	Improvement factor in D-exp
JFT-2M	Japan	1.1～1.4
JT-60U	Japan	1.2～2
Alcator C	USA	1.5
DIII-D	USA	1.4～2
ISX-B	USA	1.4
TFTR	USA	1.2
ASDEX	Germany	1.3～2
ASDEX-U	Germany	1.5
TEXTOR	Germany	1.4
JET	UK	1.2～1.4
FTU	Italy	1.4

Isotope effect is a major issue to be identified for the burning plasmas.

Comparison between deuterium and hydrogen plasmas (JT-60U)



Main subjects in the LHD deuterium experiment (1)

(a) Confinement improvement and related physics

Research on the isotope effect in the plasma confinement and the related confinement improvement in the deuterium experiments, toward systematic understanding of the toroidal plasmas.

(b) Improvement of MHD stability and expansion of high-β regime

Research on the MHD equilibrium and stability in high-β regime of collisionless plasmas realized by the confinement improvement and the increase in the heating power in the deuterium experiment.

(c) Confinement of high-energy ions

Research on the confinement of high-energy ions, such as ICRF accelerated ions and 1-MeV triton with a high-accuracy diagnostic of neutrons (utilizing T+D --> n(14MeV)+α as the secondary reaction of D+D --> T(1.0MeV)+p).

Main subjects in the LHD deuterium experiment (2)

(d) Optimization of divertor

Research on the particle and heat control in the peripheral plasma region with the closed helical divertor and improvement of the steady state plasma performance.

(e) Plasma wall interaction (isotope effects)

Research on the isotope effects in the plasma wall interaction including the fuel recycling, to understand the behavior in the burning plasmas.

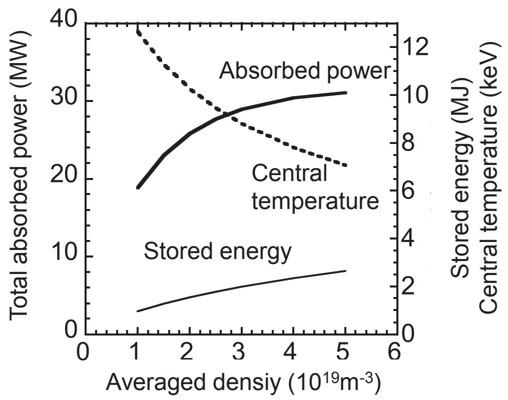
(f) Expansion of experimental approaches

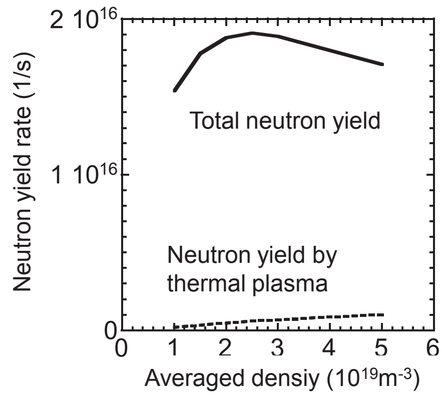
Ion heating experiments by the ICRF heating schemes of H-minority/D-majority and ^{3}He-minority/D-majority.

Expected plasma parameters and the resulted neutron and tritium yields

- Heating condition NBI 32MW (perp.: 80keV-18MW, tang.: 180keV-14MW)
  ICH+ECH 3MW
- Assumed energy conf. time 2 times ISS95 (Achievement: x1.6) ・Magnetic field 3T

➔ $T_i(0)$ = 10keV at $n_e = 2\times10^{19}$ m^{-3}
W_p = 3.8MJ at $n_e = 1\times10^{20}$ m^{-3} ➔ $\langle\beta\rangle$ ~3%, T(0)~5keV ➔ $nT\tau \sim 1.4\times10^{20}$ m^{-3} keV s
➔ if $\tau_E \sim 3\tau_E^{ISS95}$, Q~0.3





TCT effect is dominant

Maximum neutron and tritium yields

Line-averaged density	2.5×10^{19} m^{-3}	Total abs. heating power	27.7 MW
Central temperature	9.5 keV	Plasma stored energy	1.77 MJ
Neutron yield rate	1.91×10^{16} /s	(yield rate by thermal plasma 5.98×10^{14} /s)	

- Pulse length: 3sec ➔ Neutron yield: 5.7×10^{16}, Tritium yield: 1.0×10^{8} Bq (2.7×10^{-3}Ci)

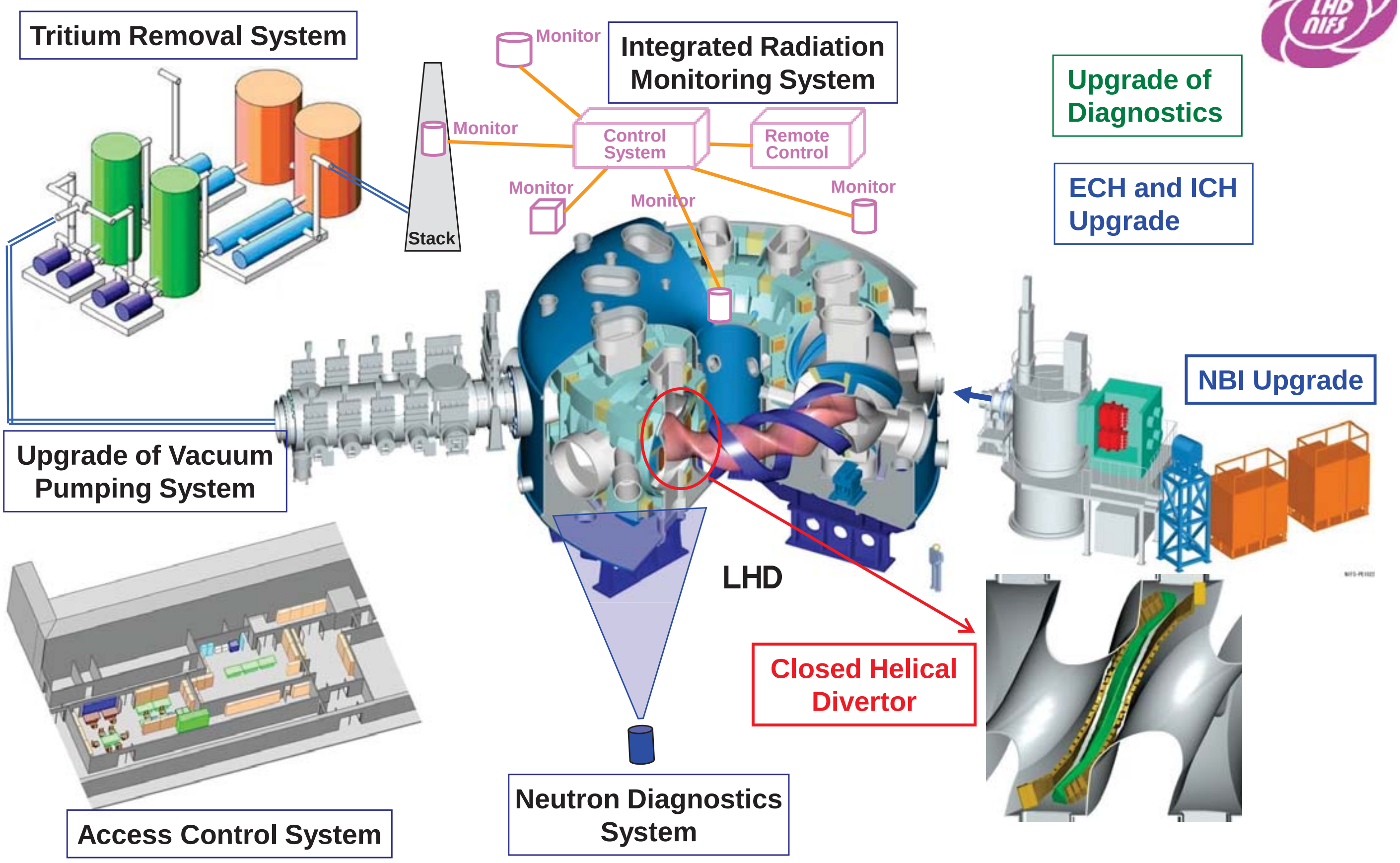
Annual Plan for LHD Deuterium Experiment

	First 6 years		Second 3 years	
FY	1st year	2nd – 6th year	7th – 9th year	After 10th year
Experiments	Preliminary Exp. (Commissioning)	Plasma Exp. For Target Parameters	Integrated High-Performance Exp.	Post-LHD Project
Maximum Annual Yield of Tritium	3.7×10^{10} Bq (1 Ci) (Integrated yield)		5.55×10^{10} Bq (1.5 Ci) (Integrated yield)	---
Maximum Annual Discharge of Tritium	3.7×10^{9} Bq (0.1 Ci) (Integrated yield)			---
Maximum Annual Yield of Neutron	2.1×10^{19} (Integrated yield)		3.2×10^{19} (Integrated yield)	---

LHD deuterium experiment will start after the supposed 3-years preparation.

Post-LHD project will be directed to researches for the basic plasma science and the plasma application as well as the reactor design, with hydrogen plasma experiments.

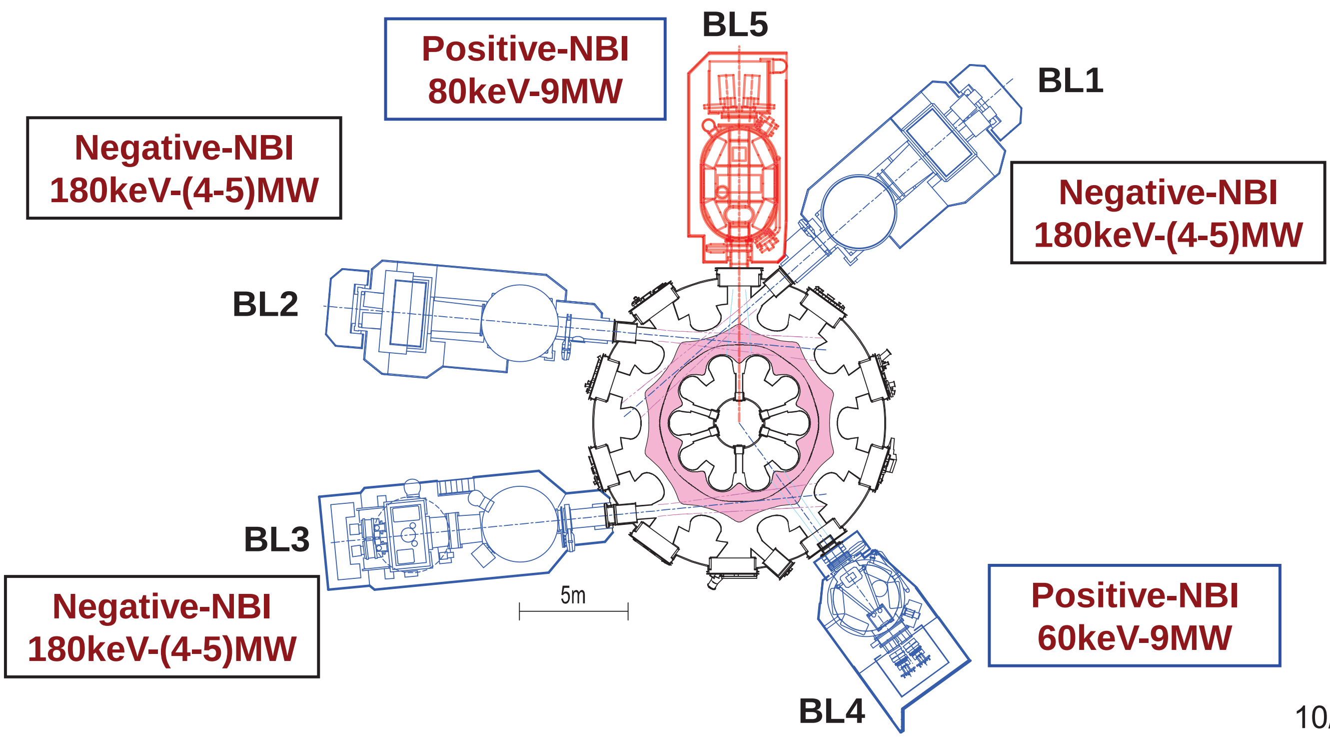
Device Upgrade Plan for the LHD Deuterium Experiment



NBI upgrade plan for deuterium experiment

Low-energy positive-NBIs: 2 (perp. inj.) 18MW
High-energy negative-NBIs: 3 (tang. inj.) 14MW

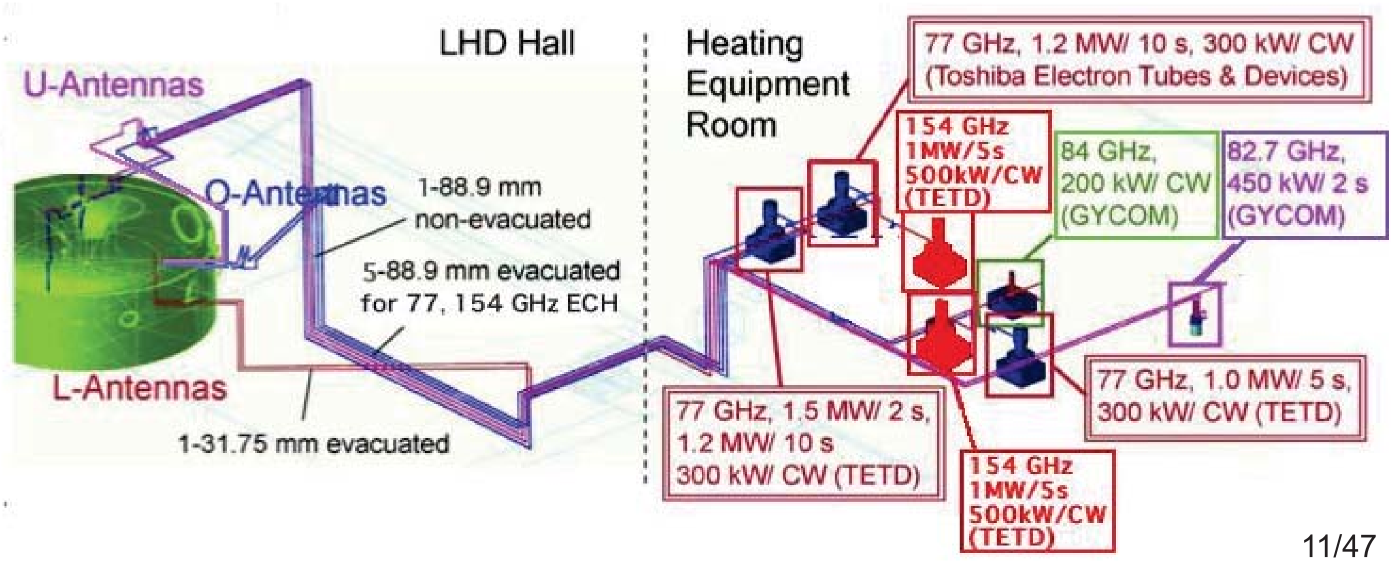
- NBI upgrade for raising the beam energy of positive-NBIs has been completed.



ECH upgrade plan for deuterium experiment

77GHz/154GHz 6 systems
6MW/3sec, 1MW/cw

- Three 77GHz- and two 154GHz-ECH systems, each of which injects >1MW for a short pulse and >300kW for CW, have been installed. (an 84GHz- and an 82.7GHz-ECH systems will not be available in the D-experiment.)
- One 154GHz-ECH system is planned to be installed after the start of the deuterium experiment.



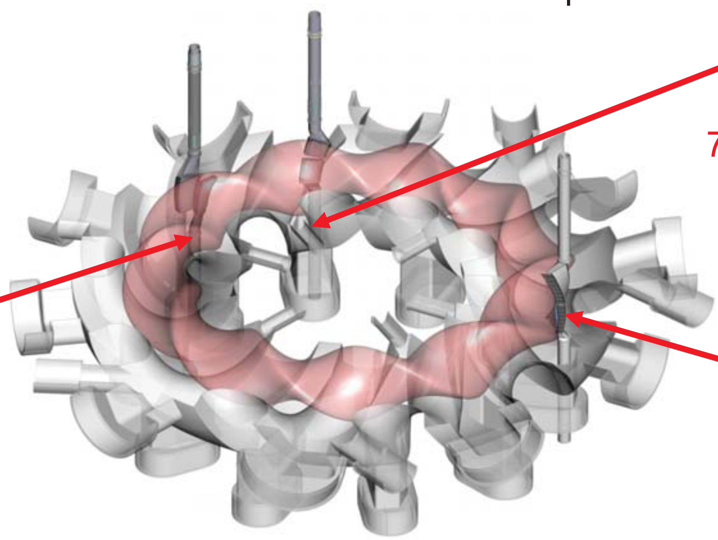
ICH upgrade plan for deuterium experiment

3 sets with 6 antennas 6MW/5sec, 2～3MW/cw

- Each antenna injects >1MW for pulse and >0.5MW for CW.
- 2 straps of HAS (HAsu-Seigyo) antenna
  2 straps of FAIT (Field-Aligned Impedance-Transforming) antenna
  2 straps of PA (Poloidal Array) antenna
- Frequency will be fixed at 38.5 MHz.
- PA antennas will be removed before the deuterium experiment.

4.5U/L FAIT antenna

3.5U/L HAS antenna

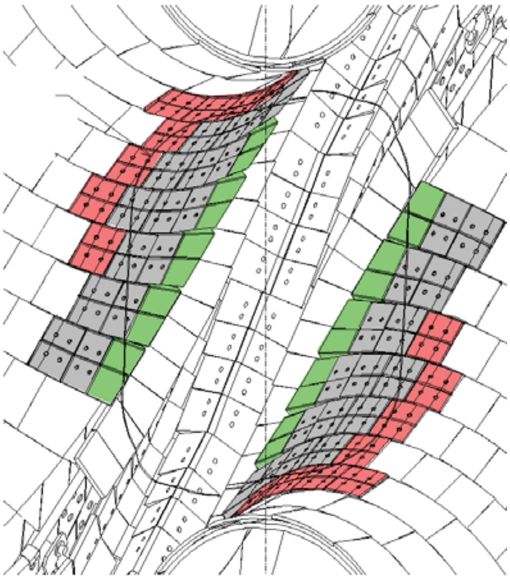


7.5U/L PA antenna

ICRF antennas in 2014 experiment

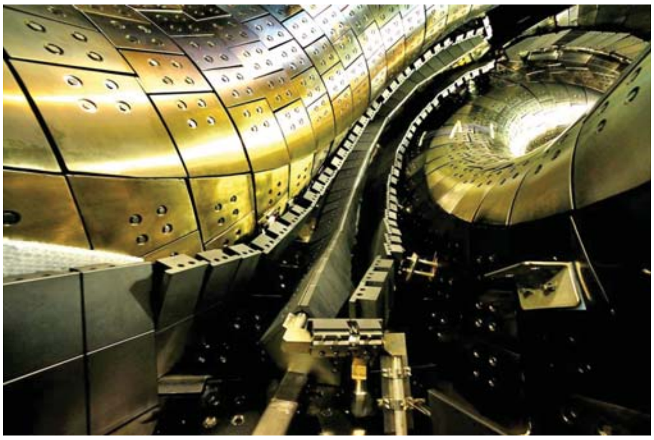
LHD in-vessel components

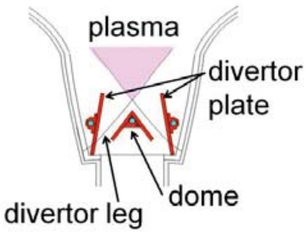
- **Armor** was installed to protect vessel wall from the increased NB power.



Tiles are made of tungsten or carbon fiber composite materials.

- Baffles to form **closed helical divertor** configuration have been installed (9 modules completed).

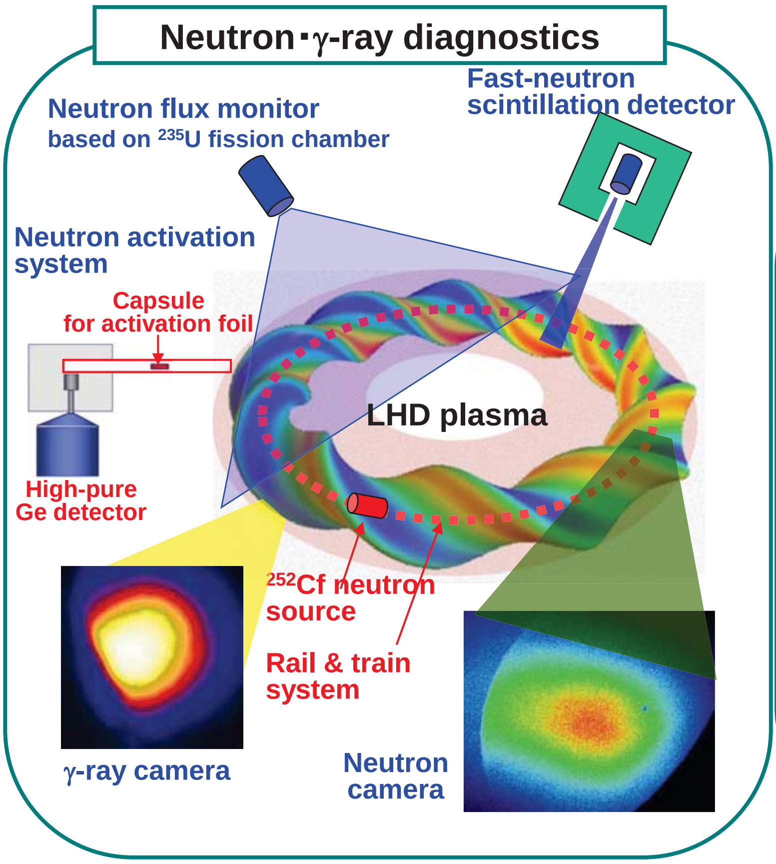


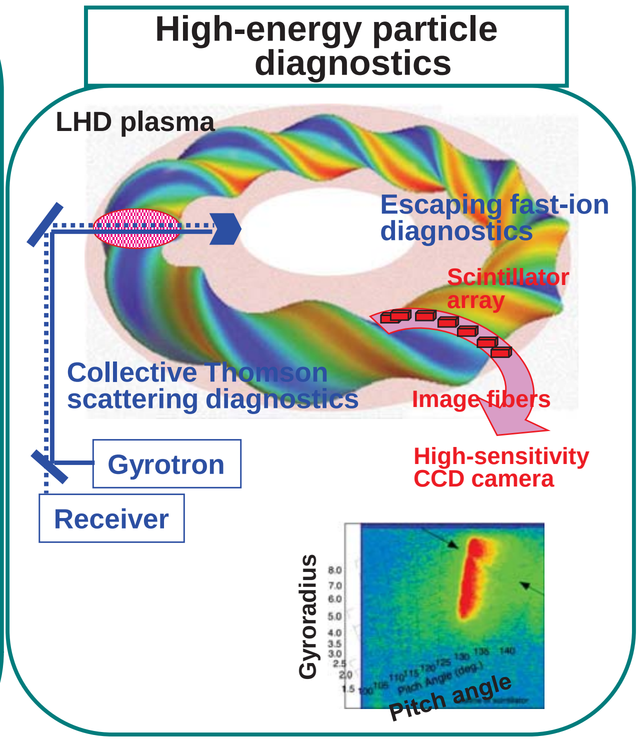


Cryopumps are being installed under the dome.

Upgrade plan for diagnostics (1)

Extension of confinement study for high-energy particles

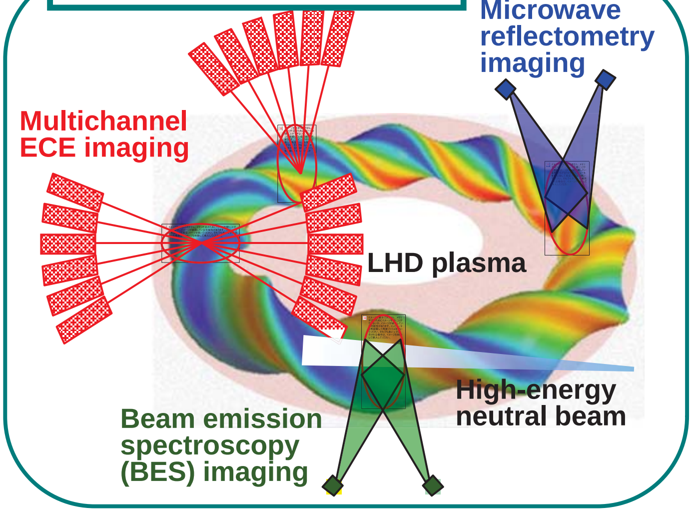




Upgrade plan for diagnostics (2)

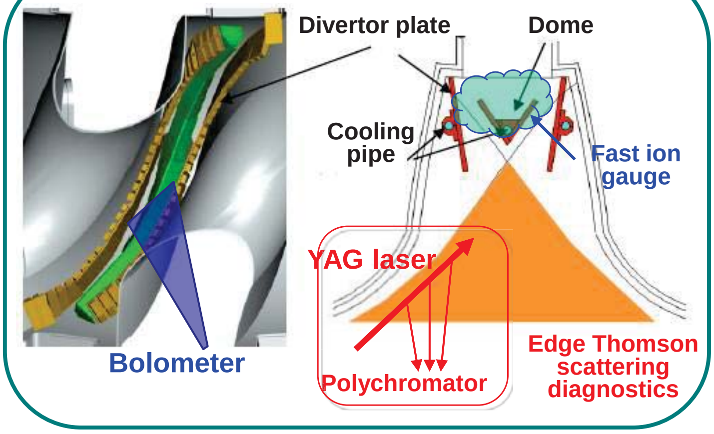
Enhancement of anomalous transport study

High precision transport diagnostics system



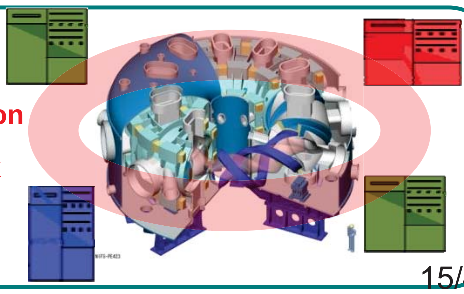
Toward deeper understanding of divertor physics

Upgrade of divertor, edge plasma diagnostics



Steady state, fast data acquisition and management system

- ✓ Fast DAQ for fluctuation measurements with high-time and space resolutions
- ✓ Data analysis computing cluster for real-time analysis and monitoring
- ✓ Real-time operability for steady-state plasma measurement and control



Schedule for LHD deuterium experiment (tentative)

- Concluding the Agreements for the LHD deuterium experiment with local government bodies on March 28, 2013.
- Deuterium experiment will start in 2016, and during the planned 9-years' experiments, 10keV of the T_i should be achieved.

FY2013	FY2014	FY2015	FY2016 – FY2024	Target in D-Exp.
Preparation for D-exp. (3 years)			Deuterium Experiments (9 years)	

H-Exp. (FY2013) · H-Exp. (FY2014)

Agreements for D-exp.

- Legal License
- Upgrade for Heating System (NBI, ECH, ICRF)
- Upgrade for Diagnostics System (Neutron diagnostics, etc.)
- Installation of Safety Equipments (Tritium removal system, etc.)
- Remodeling of Building and Facilities

Calibration Experiments for Neutron Diagnostics

Preliminary Experiments for Commissioning

Deuterium Experiments

Closed Helical Divertor with Pumping System

NBI: 18MW (60–80keV, 2sec)
14MW (180keV, 2sec)
ECH: 6MW–3sec, 1MW–CW
(77GHz & 154GHz)
ICRF: 6MW–5sec, 2–3MW–CW

Neutron Diagnostics
High–Energy Particle Measurement
3–Dimensional Measurement
High–Accuracy Measurement
Divertor Diagnostics
Steady–State Data Acquisition

PWI Laboratory

Target in D-Exp.

T_i = 10keV at 2×10^{19} m^{-3}

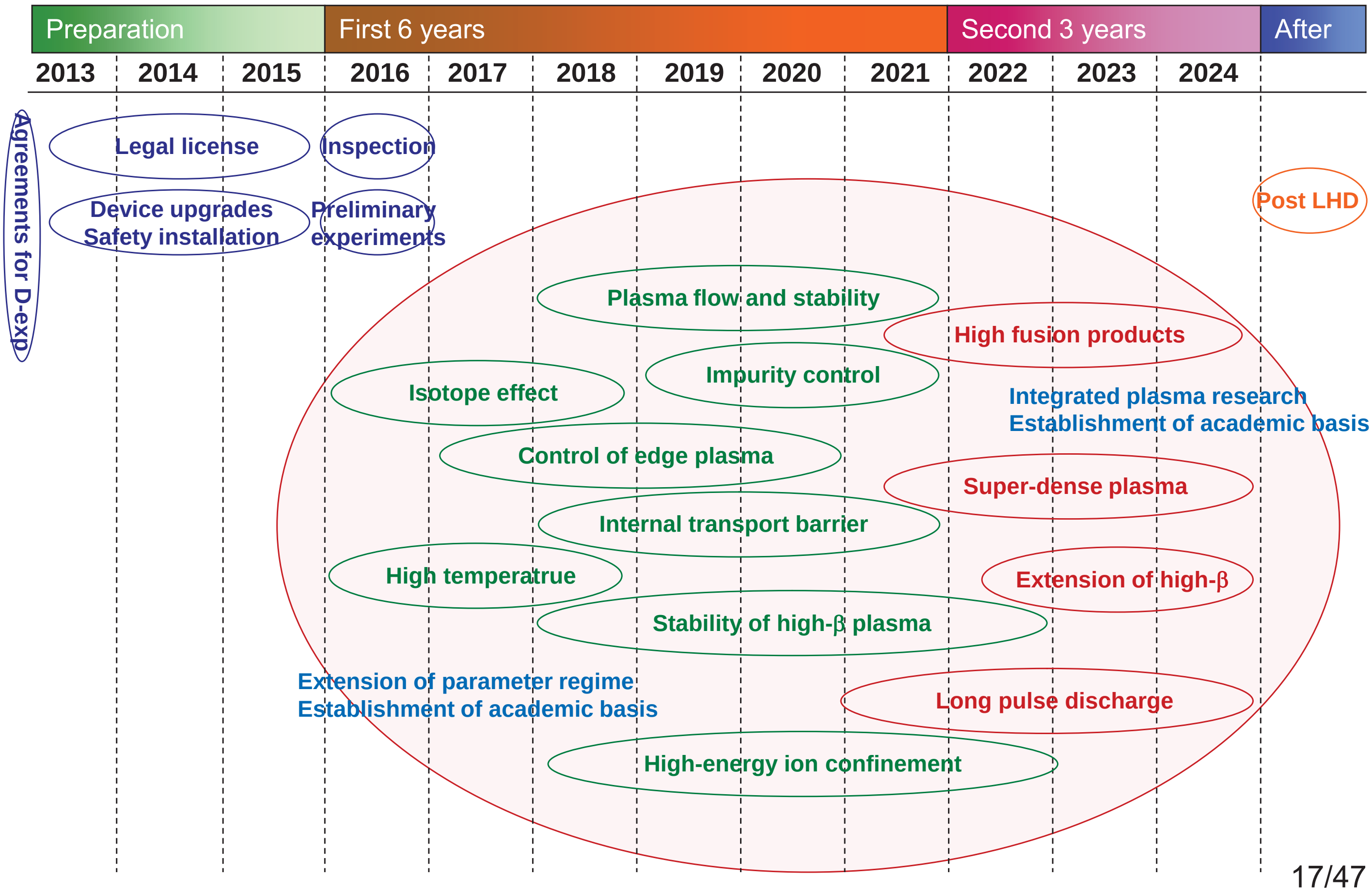
W_p = 3.8MJ at 1×10^{20} m^{-3}

<β> ~ 3% at T(0)~5keV

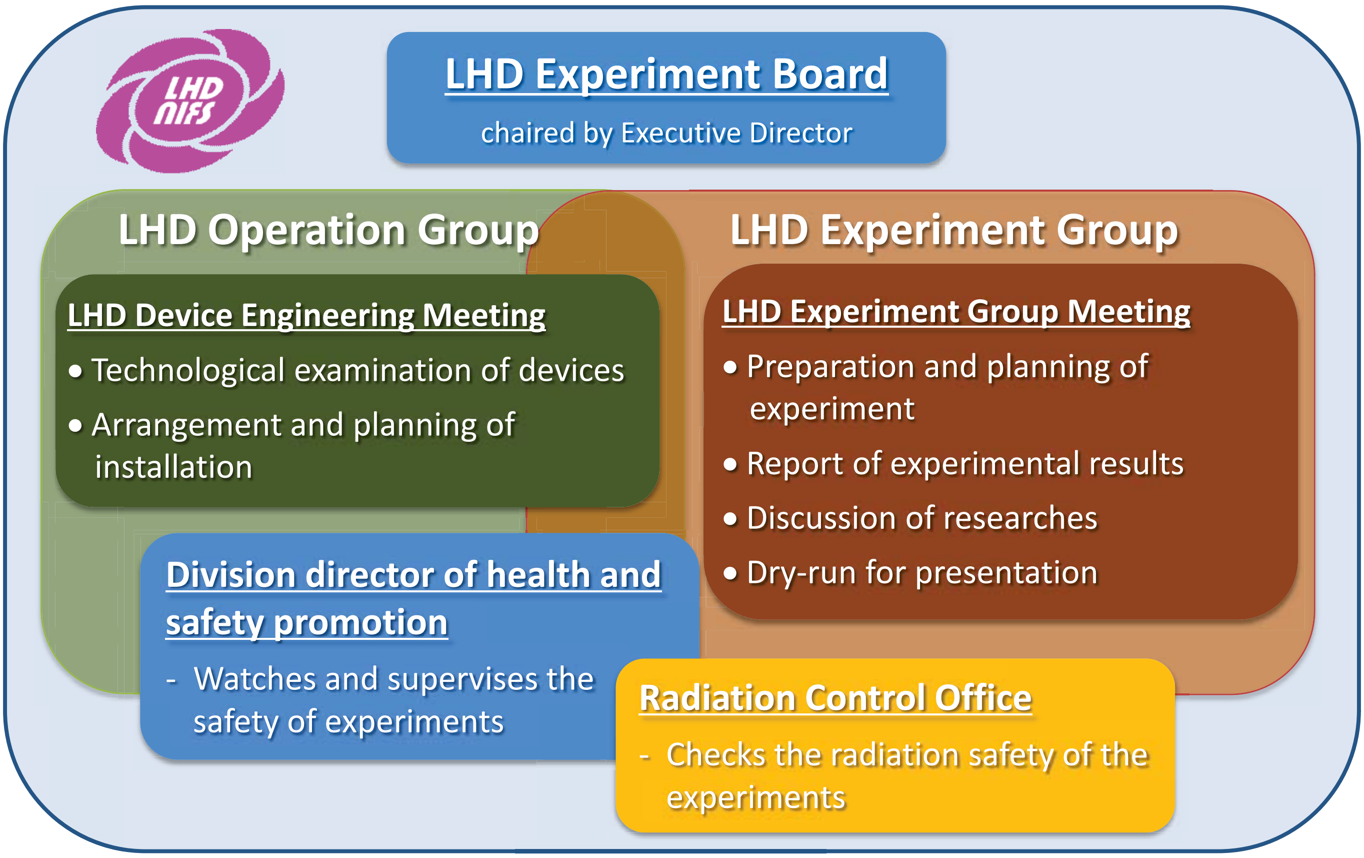
$nT\tau$ ~1.4×10^{20} m^{-3} keV s

3MW Heating for 1 hour

Research schedule plan for deuterium experiments

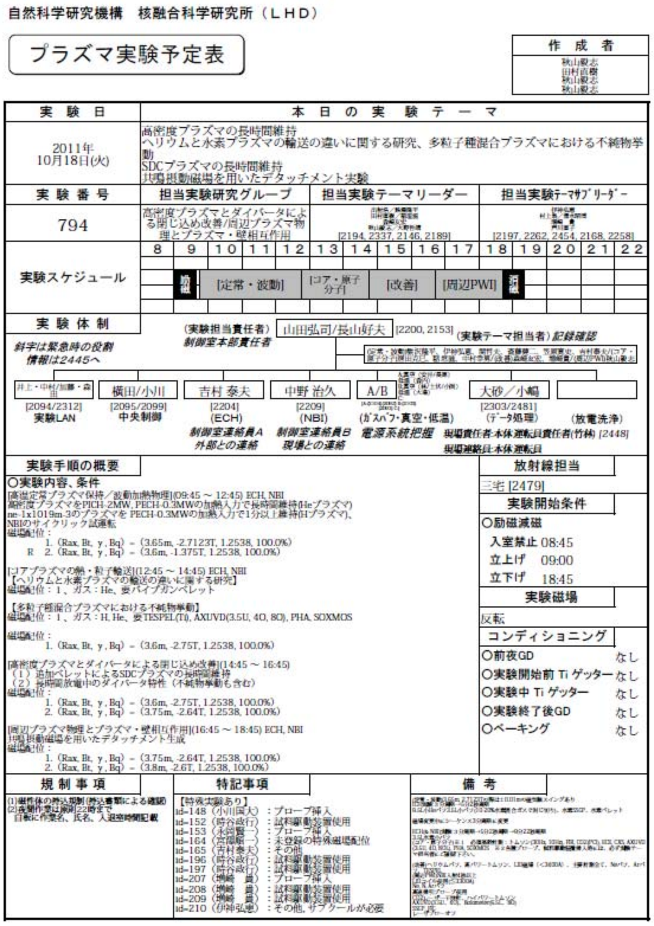


Implementation system for LHD deuterium experiment (1)



LHD team

Implementation system for LHD deuterium experiment (2)


自然科学研究機構　核融合科学研究所（ＬＨＤ）

プラズマ実験予定表

作成者
秋山毅志 田村直樹 秋山毅志 秋山毅志

実験日	本日の実験テーマ		
2011年 10月18日(火)	高密度プラズマの長時間維持 ヘリウムと水素プラズマの輸送の違いに関する研究、多粒子種混合プラズマにおける不純物挙動 SDCプラズマの長時間維持 共鳴摂動磁場を用いたデタッチメント実験		
実験番号	担当実験研究グループ	担当実験テーマリーダー	担当実験ﾃｰﾏｻﾌﾞﾘｰﾀﾞｰ
794	高密度プラズマとダイバータによる閉じ込め改善/周辺プラズマ物理とプラズマ・壁相互作用	[2194, 2337, 2146, 2189]	[2197, 2262, 2454, 2168, 2258]

実験スケジュール: 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
[定常・波動] [コア・原子分子] [改善] [周辺PWI]

実験体制
斜字は緊急時の役割 情報は2445へ
(実験担当責任者) 制御室本部責任者: 山田弘司/長山好夫 [2200, 2153]
(実験テーマ担当者) 記録確認
井上・中村/加藤・森田 [2094/2312] 実験LAN
横田/小川 [2095/2099] 中央制御
吉村 泰夫 [2204] (ECH) 制御室連絡員A 外部との連絡
中野 治久 [2209] (NBI) 制御室連絡員B 現場との連絡
A/B (ｶﾞｽﾊﾟﾌ・真空・低温) 電源系統把握
大砂／小嶋 [2303/2481] (ﾃﾞｰﾀ処理)
(放電洗浄)
現場責任者:本体運転員責任者(竹林) [2448]
現場連絡員:本体運転員

実験手順の概要
○実験内容、条件
[高温定常プラズマ保持／波動加熱物理](09:45 ~ 12:45) ECH, NBI
高密度プラズマをPICH-2MW, PECH-0.3MWの加熱入力で長時間維持(Heプラズマ)
ne-1x1019m-3のプラズマを PECH-0.3MWの加熱入力で1分以上維持(Hプラズマ)、
NBIのサイクリック試運転
磁場配位：
1. (Rax, Bt, γ, Bq) = (3.65m, -2.7123T, 1.2538, 100.0%)
R 2. (Rax, Bt, γ, Bq) = (3.6m, -1.375T, 1.2538, 100.0%)

[コアプラズマの熱・粒子輸送](12:45 ~ 14:45) ECH, NBI
【ヘリウムと水素プラズマの輸送の違いに関する研究】
磁場配位：1、ガス：He、要パイプガンペレット

【多粒子種混合プラズマにおける不純物挙動】
磁場配位：1、ガス：H, He、要TESPEL(Ti), AXUVD(3.5U, 4O, 8O), PHA, SOXMOS

磁場配位：
1. (Rax, Bt, γ, Bq) = (3.6m, -2.75T, 1.2538, 100.0%)

[高密度プラズマとダイバータによる閉じ込め改善](14:45 ~ 16:45)
（1）追加ペレットによるSDCプラズマの長時間維持
（2）長時間放電中のダイバータ特性（不純物挙動も含む）
磁場配位：
1. (Rax, Bt, γ, Bq) = (3.6m, -2.75T, 1.2538, 100.0%)
2. (Rax, Bt, γ, Bq) = (3.75m, -2.64T, 1.2538, 100.0%)

[周辺プラズマ物理とプラズマ・壁相互作用](16:45 ~ 18:45) ECH, NBI
共鳴摂動磁場を用いたデタッチメント生成
磁場配位：
1. (Rax, Bt, γ, Bq) = (3.75m, -2.64T, 1.2538, 100.0%)
2. (Rax, Bt, γ, Bq) = (3.8m, -2.6T, 1.2538, 100.0%)

放射線担当: 三宅 [2479]

実験開始条件
○励磁減磁
入室禁止 08:45
立上げ 09:00
立下げ 18:45

実験磁場: 反転

コンディショニング
○前夜GD なし
○実験開始前 Ti ゲッター なし
○実験中 Ti ゲッター なし
○実験終了後GD なし
○ベーキング なし

規制事項
(1)磁性体の持込規制（持込書類による確認）
(2)夜間作業は原則22時まで
日報に作業名、氏名、入退室時間記載

特記事項
【特殊実験あり】
id-148（小川国大）：プローブ挿入
id-152（時谷政行）：試料駆動装置使用
id-153（永岡賢一）：プローブ挿入
id-164（宮原昭一）：未登録の特殊磁場配位
id-165（吉村泰夫）：その他
id-196（時谷政行）：試料駆動装置使用
id-197（時谷政行）：試料駆動装置使用
id-207（増崎　貴）：プローブ挿入
id-208（増崎　貴）：試料駆動装置使用
id-209（増崎　貴）：試料駆動装置使用
id-210（伊神弘恵）：その他、サブクールが必要

備考

- LHD experiment board is responsible for management of the LHD experiment.
- Experiment plans are verified and finalized by the board including the safety management.
- Division director of health and safety promotion watches and supervises the safety for experiments as a board member.
- Head of radiation control office checks the radiation safety in the experiments.
- Safety regulation and roles in the emergency are confirmed at the morning meeting before the experiment.

(1) Is the goal of the deuterium experiment appropriate? Further, do the research plan and the implementation system for ensuring safety achieve those goals?

1. Deuterium experiment is expected to greatly extend the LHD plasma parameter regime to the reactor-relevant regime, which should lead to the firm design of a helical fusion reactor by establishment of an academic basis for toroidal plasmas.
2. Main subjects in the LHD deuterium experiment should contribute to achievement of the goal of the deuterium experiment through the confinement improvement due to the isotope effect, extension of high-β regime, intensive research on enhanced high-energy ions, optimization of divertor, and research on the isotope effects in the peripheral region and the plasma wall interaction, as well as expansion of ICRF heating schemes.
3. Machine upgrade is planned to maximize the heating capability in the deuterium experiments, to improve the diagnostic accuracy for precise physics research, and to install the closed helical divertors, and the research schedule is also planned along the main subjects.
4. LHD experiment board should conduct the deuterium experiment to achieve the goal, through well-organized research and safety management system.

1. Research Plan

(1) Is the goal of the deuterium experiment appropriate? Further, do the research plan and the implementation system for ensuring safety achieve those goals?

(2) Does this plan contribute to the promotion of a comprehensive understanding of toroidal plasma and heighten its academic merit with regard to the realization of fusion energy?

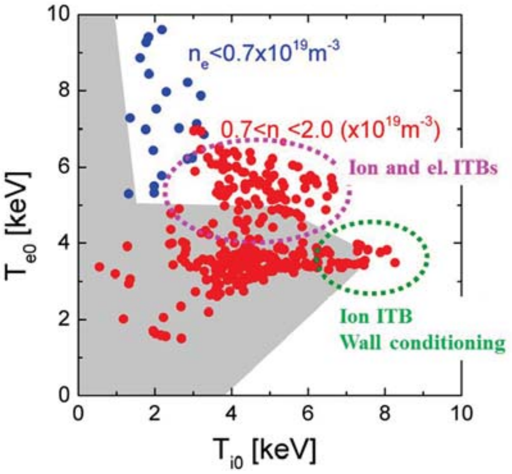
(3) Regarding implementation of the plan, will this achieve a system of collaborative use and collaborative research that enables participation by a wide range of researchers?

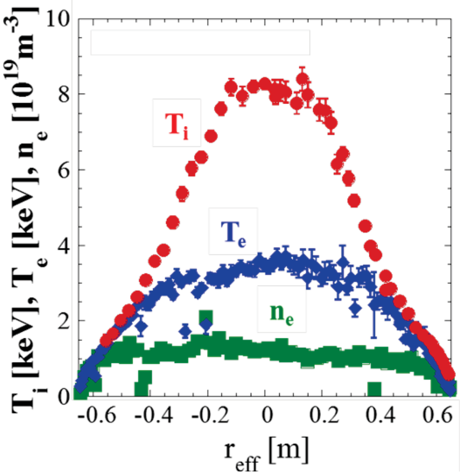
High-Temperature Plasmas with ITB formation

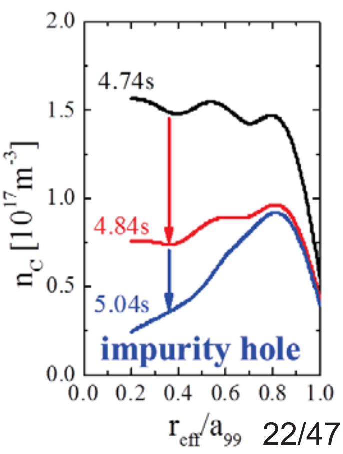
High electron temperature plasmas with Electron ITB/CERC
- → Upgrade of ECH power and fine control of deposition
- → Transport improvement due to the **bifurcation of E_r**

High ion temperature plasmas with ion ITB
- → Wall conditioning enhances the **transport improvement**
- → Impurity exhaust (**Impurity Hole formation**)

High temperature plasmas with comparable Ti and Te
- → **Integration of ion ITB and electron ITB**
- → Control of temperature profile







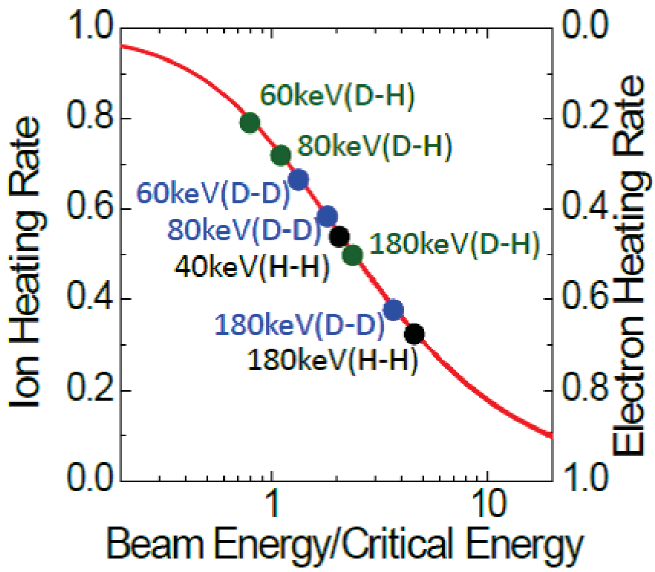
High-Temperature Regime in Deuterium Exp.

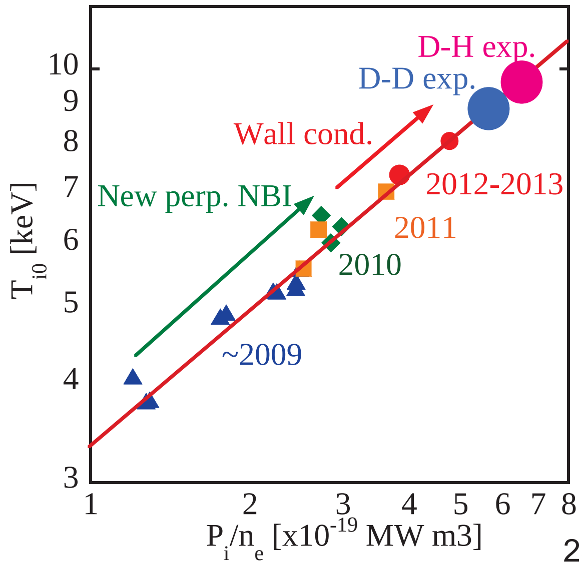
Neutral beam Injectors (NBIs) will be upgraded for deuterium beam injection, which have higher ion heating efficiency

Positive NBI (40kV, 6MW, H_0) + (40kV, 6MW, H_0) → (60kV, 9MW, D_0) + (80kV, 9MW, D_0)

Negative NBI (180kV, 5MW, H_0) x 3 → (180kV, ~3.5MW, D_0) x 3

In LHD deuterium experiment, T_{i0} = 10 keV will be achieved with deuterium beam injection and further improvement of confinement due to the isotope effect





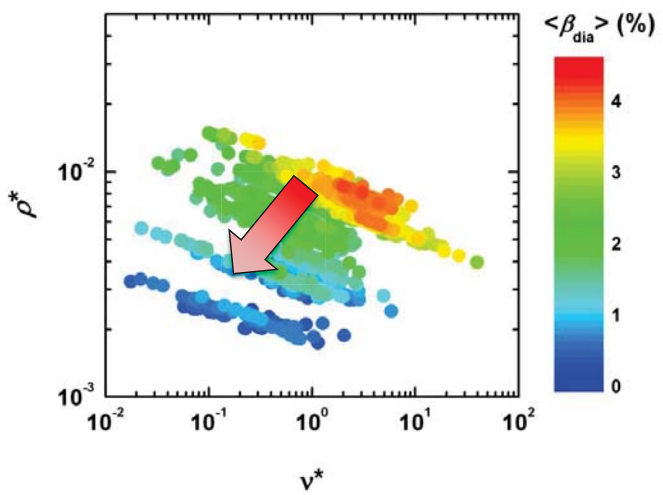
Extension of High Beta Regime

<β> > 5 % is required for realization of economical helical fusion reactor and was achieved in high collisional regime, which clarify the following characteristics of MHD equilibrium and stability:

- **Activities of resistive interchange modes are mitigated in collisionless regime with high magnetic Reynolds number**
- **Plasma is well confined in stochastic region**

Confinement improvement in DD experiments expects to

- **access to low-collisional high beta regime, which enable us to studies of equilibrium, stability and transport in new regime.**
- **clarify collisionality dependence of plasma confinement in the stochastic region**

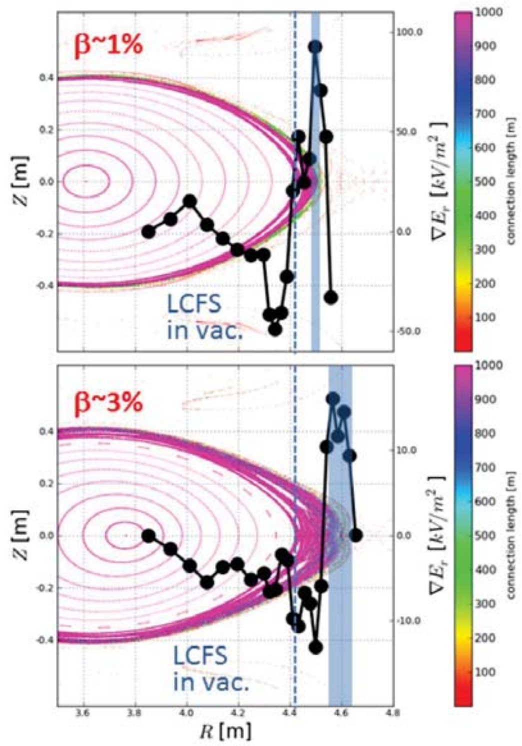


Subjects of MHD Studies

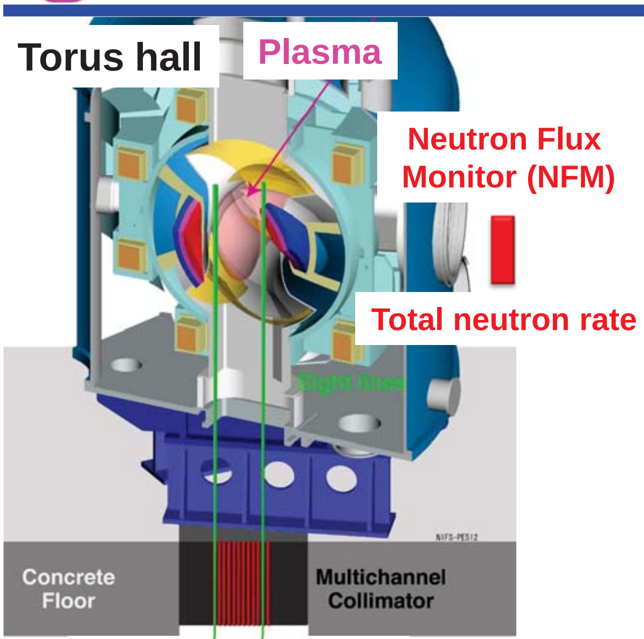
MHD studies are required for maintenance of stable plasma

The studies of the following subjects are ongoing:
- Beta limits due to equilibrium and stability
- Change of magnetic topology
- Equilibrium, stability and transport in stochastic region
- Response of 3D field to plasma
- Non-linear growth of MHD instabilities
- H mode physics and ELM control

Further understanding of MHD physics is expected through DD experiments



High-energy ions

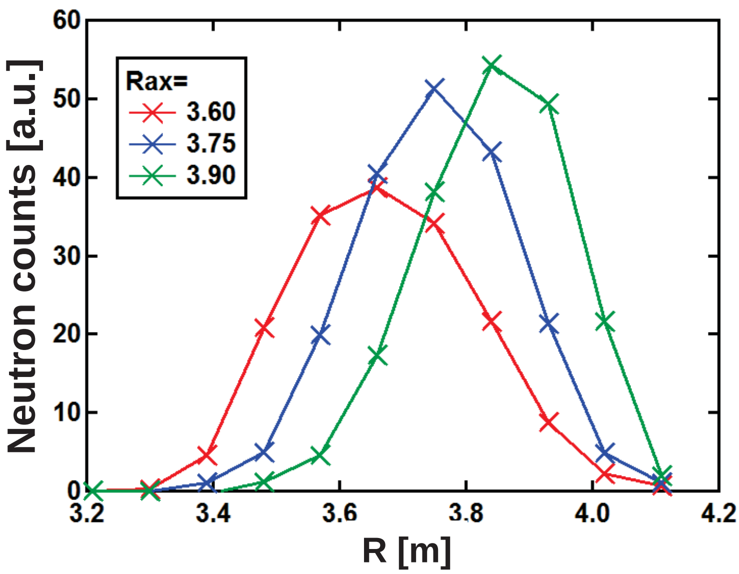


Neutron Profile Monitor(NPM)

Neutron profile

basement

Neutron profile based on FIT3D code



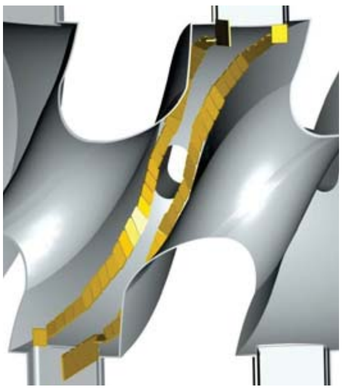
- Neutron is mainly due to fast-ion-plasma reaction.
- Neutron measurement expands the fast-ion study.
  - NFM reveals global confinement of fast ion.
  - NPM reveals radial profile of fast ion.
- Further progress of study on fast-ion confinement changing due to magnetic field configuration or MHD instability will be promising.

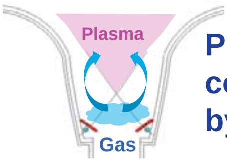
Closed Helical Divertor

Particle and impurity control by divertor pumping
- → **Suppression of plasma cooling due to gas and removal of impurity**
- → **Improvement of plasma performance**

Reduction of heat and particle load in divertor
- → **Achievement of high-power and long-pulse plasma**
- → **Divertor design of helical reactor**

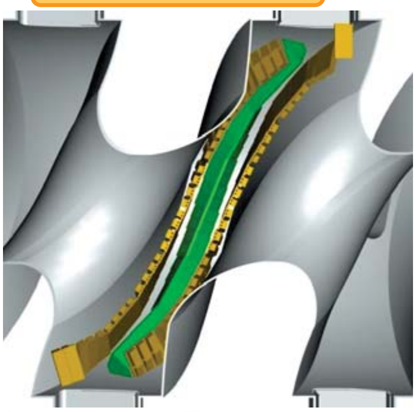
Open Divertor

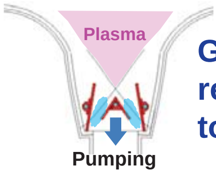




Plasma is cooled by gas.

Closed Divertor



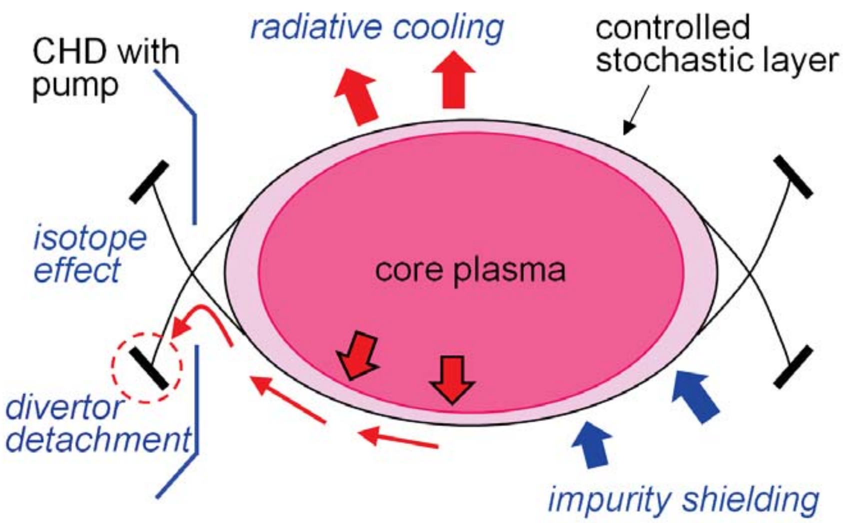


Gas is not returned to plasma.

- **Closed helical divertor with baffle structure and pumping system →Active particle control in high-heating power and long-pulse discharge**
- **Closed divertor in inboard side**
- **Step-by-step installation of closed divertor**

Divertor Studies

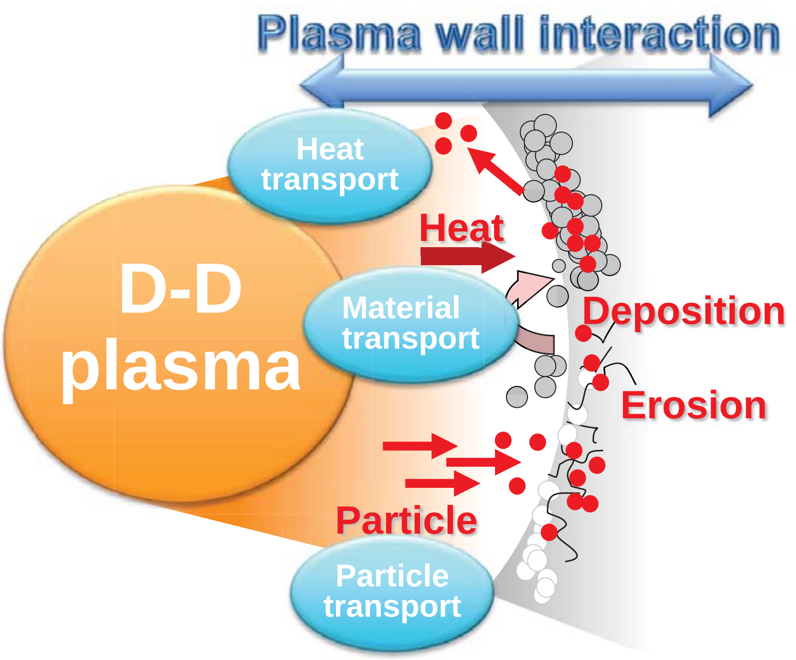
Strategy of edge plasma control: **combination of**
<u>Closed Helical Divertor (CHD) and Stochastization with RMP</u>



- Particle recycling is controlled with *closed helical divertor (CHD) with pump*
- RMP-controlled stochastic layer is utilized for *radiative cooling* and *impurity shielding*
- RMP-controlled stochastic layer is expected to enhance the *divertor detachment*
- Radiative cooling in stochastic layer mitigates heat load to divertor plates
- Isotope effect and neutral particle transport including He should be investigated

Plasma Wall Interaction

Three types of the transport study



Heat transport

- Distribution of the heat loading and its global balance towards the FFHR-d1 is estimated in the LHD D-D plasma with long pulse operation.

Particle transport

- Quantitative analysis of H isotopes on the entire wall surface is estimated by material probe experiment. Then, the data is applied to estimation of the total T inventory in the large fusion system.

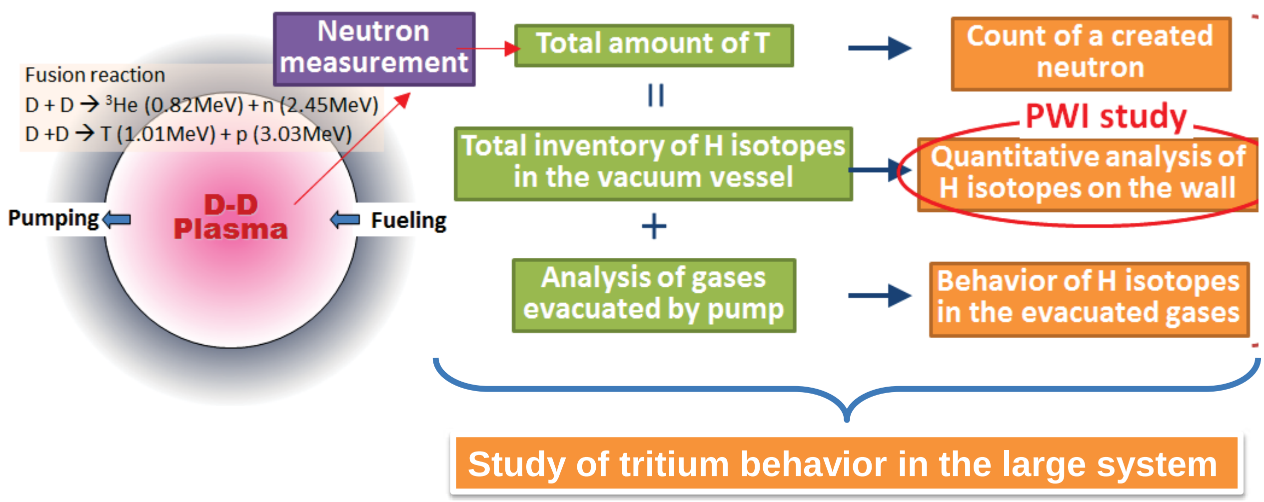
Material transport

- Erosion and deposition profile of the plasma facing components on entire wall surface in LHD is evaluated by material probe experiment.

Tritium Study

~ tritium mass balance and safety handling technology ~

- Application of tritium as a tracer
  - Study of tritium behavior in the large system
- Tritium mass balance in LHD
  - Total amount of tritium by neutron measurement
    = Tritium inventory in/on the first wall and the diverter tile [PWI study]
    + Tritium analysis in the vacuum exhaust gas
- Tritium safety handling technology
  - Validation of the tritium decontamination factor in the large scale tritium removal system



Heating & Steady State (Ion Cyclotron Heating)

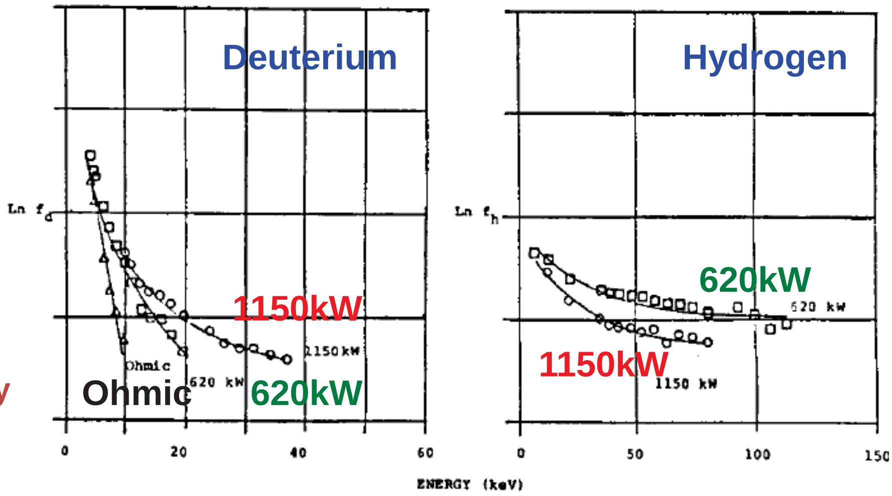
Helium will be replaced by deuterium in ICRF heating

Minority ion heating (D(H) plasma)
- Applicable to a variety of plasmas if deuterium is usually used
- Optimal minority ratio may differ from tokamak devices

Second harmonic heating of deuterium
- Effective with high temperature and/or high energy deuterium ions
- Simultaneous heating with minority heating in D(H) plasma

Other heating and physics experiment
- D(He3) heating
- Study about high energy ion and fusion products generated by ICRF heating

Steady state experiment
- Comparison with deuterium and helium plasmas
- Effect of actual fuel in steady state discharge on engineering and operation and so on



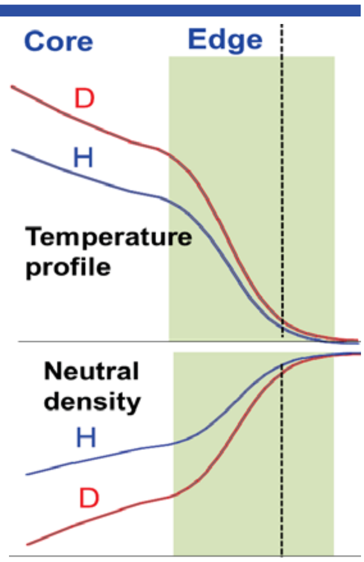
Comparison of charge-exchange spectra in D(H) plasma of PLT tokamak

Research on Isotope Effect

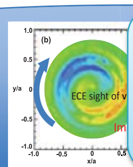
- Isotope effect is a long-standing mystery
- The one of missions of LHD deuterium experiment
  - ✓ key to realize confinement improvement
  - ✓ Academic base for physics towards burning plasmas

Previous experiments in tokamaks and helical systems have indicated the importance of low-recycling for improved confinement

→ **Hypothesis:**
recycling control and its impact on core confinement (through **core-edge coupling**)
→ Increased understandings through integrated view



Core neutral density profile (high dynamic-range Balmar α)



- Non-local phenomenon
- Multi-scale turbulence

Recycling control

Bulk ion temperature profile (bulk CXS)

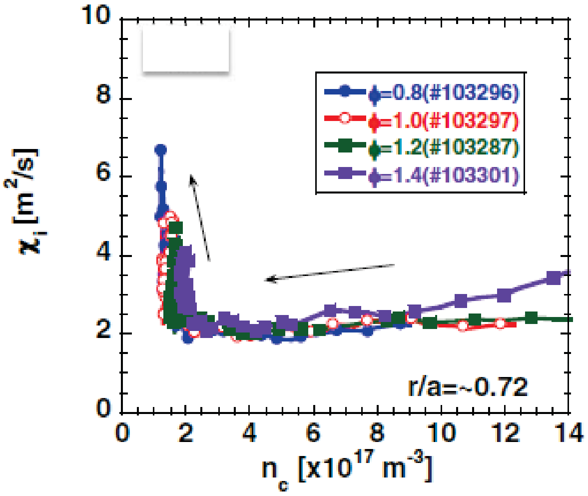
Isotope density ratio (GAM spectroscopy)

- Impacts of ion mass on poloidal flow → Mp
- Residual zonal flow level : D >H

Isotope Effect from the viewpoint of impurity

Isotope effect should be also considered from impurity

- **JET: ITER like wall experiment (Maddison NF2014)**
- **JT-60U Zeff is larger in D compared to H (T.Nakano)**
- **Impacts of wall material on H mode (Itoh, Itoh, PPCF1995) and so on**



Impact of impurity on ion heat confinement in LHD (Osakabe, PPCF2014)

- **4 different-size C pellets into in high-Ti plasmas**
- **Indicating the existence of threshold of C density for ion heat confinement improvement**

→ ***Isotope effect will be considered also from the viewpoint of impurity***

(2) Does this plan contribute to the promotion of a comprehensive understanding of toroidal plasma and heighten its academic merit with regard to the realization of fusion energy?

1. NBI upgrade for the deuterium beam injection effectively enhances the ion heating power, and should raise the ion temperature to T_{i0} = 10 keV with confinement improvement due to the isotope effect.
2. Confinement improvement in the deuterium experiments should extend high-β regime to low-collisional regime extrapolated to a reactor plasma, and clarify collisionality dependence of confinement in the stochastic region.
3. Precise measurement of neutrons should clarify the fast ion confinement and reveal the fast-ion induced MHD instability foreseen in a reactor plasma.
4. Particle control with closed helical divertor and control of stochastic region with RMP should lead to diverter optimization for a reactor.
5. Deuterium experiments greatly expand the PWI study with regard to the heat transport, the particle transport, and the material transport, contributing to the reactor design.
6. Deuterium experiments expand the heating scenario with ICH, leading to high-performance of long-pulse discharges, which extend the reactor relevant PWI study.
7. Research on the isotope effect contributes to establishment of academic basis for comprehensive understanding of toroidal plasmas.

1. Research Plan

(1) Is the goal of the deuterium experiment appropriate? Further, do the research plan and the implementation system for ensuring safety achieve those goals?

(2) Does this plan contribute to the promotion of a comprehensive understanding of toroidal plasma and heighten its academic merit with regard to the realization of fusion energy?

(3) Regarding implementation of the plan, will this achieve a system of collaborative use and collaborative research that enables participation by a wide range of researchers?

Research plan has been discussed by a wide range of researchers through collaboration.

- Research plan for the LHD deuterium experiment has been discussed and proposed in workshops organized in frameworks of the NIFS collaboration system. Eight workshops have been held, and various kinds of subjects have been discussed, such as device development, divertor study, PWI study, isotope effect, fast ion confinement, tritium study, and environmental radiation.
- Also, in academic meetings of the fusion community, such as meetings held by the Fusion Network and symposiums held in annual conference of The Japan Society of Plasma Science and Nuclear Fusion Research, the research plan related with the deuterium experiment has been proposed and discussed by a wide range of researchers.
- Through these discussions among the fusion community, the research plan for the LHD deuterium experiment has been established.

Workshops with collaborators toward deuterium experiment from 2010 to 2014

- Eight workshops have been held at NIFS to discuss on the deuterium experiment plan and the tritium safety.

No.	Framework	Date	Place	Workshop
1	Joint Sponsorship of NIFS General Collaboration &JSPF Expert Committe	August 31, 2010	NIFS	Tritium safety and handling 「LHDにおけるトリチウム安全研究の展望」 「LHD重水素実験における重水素吸気バランスとトリチウム回収・除去」 「核融合炉の運転制御の基礎となるトリチウム研究・技術の開発」
2	NIFS General Collaboration	December 13, 2011	NIFS	Tritium safety and handling 「LHD重水素実験における重水素吸気バランスとトリチウム回収・除去」
3	NIFS General Collaboration	March 22, 2012	NIFS	Deuterium experiment plan 「LHDにおける重水素実験計画の検討」
4	Joint Sponsorship of NIFS General Collaboration &JSPF Expert Committee	December 6, 2012	NIFS	Tritium safety and handling 「ヘリカル動力炉システムのトリチウム安全性」 「重水素吸排気バランスと関連研究」 「持続的燃料供給のためのトリチウム研究・技術開発」
5	NIFS General Collaboration	June 21, 2013	NIFS	Deuterium experiment plan 「LHDにおける重水素実験計画の検討」
6	Joint Sponsorship of NIFS General Collaboration &JSPF Expert Committee	August 8, 2013	NIFS	Tritium safety and handling 「核融合炉システムにおけるトリチウムの取り扱いと安全性」 「核融合炉燃料計量管理の基礎となるトリチウム研究・技術開発」
7	Joint Sponsorship of NIFS General Collaboration &Fusion Network	April 25, 2014	NIFS	Deuterium experiment plan 「LHD重水素実験研究計画の策定」 「重水素実験に関する核融合ネットワーク会合」
8	Joint Sponsorship of NIFS General Collaboration &JSPF Expert Committee	August 1, 2014	NIFS	Tritium safety and handling 「核融合炉システムにおけるトリチウムの取り扱いと安全性」 「核融合炉燃料計量管理の基礎となるトリチウム研究・技術開発」

Symposiums on deuterium experiment plan in academic meetings

- Deuterium experiment plan has been discussed with collaborators in symposiums of academic meetings.
- It has been also discussed in a question and answer time of plenary talk and invited talk.

No.	Classification	Date	Academic meeting and symposium	Place	Agenda and title
1	Symposium	November, 25 2011	Plasma Conference 2011 (PLASMA 2011) 「Symposium P4 : LHD重水素実験がもたらす学術研究の拡がり」	Kanazawa	0. はじめに(主旨説明) M. Sasao (Tohoku Univ.) 1. LHD重水素実験計画の概要 Y. Takeiri (NIFS) 2. 核燃焼プラズマにおける高エネルギー粒子閉じ込め T. Nishitani (JAEA) 3. 燃料リサイクリングにおける水素同位体効果 T. Tanabe (Kyusyu Univ.) 4. LHDプラズマ中の乱流輸送に生ずる同位体効果の物理 T.H. Watanabe (NIFS) 5. 総合討論 M. Sasao (Tohoku Univ.)
2	Symposium	December, 6 2013	JSPF 30th annual meeting 「Symposium IV : LHD重水素実験を通したプラズマ・核融合研究の拡がり」	Tokyo	1. 趣旨説明 M. Osakabe (NIFS) 2. LHD重水素実験による先進閉じ込め研究と計測の計画 K. Ida (NIFS) 3. LHDにおける精密科学を目指した計測 A. Ejiri (Tokyo Univ.) 4. ITER研究計画からのLHD重水素実験に対するコメント Y. Kusama (JAEA) 5. 理論的観点から見たプラズマ輸送に対する同位体効果 H. Sugama (NIFS) 6. 総合討論
3	Plenary talk	June, 19 2014	10th Joint Conference on Fusion Energy	Tsukuba	ヘリカル型定常核融合炉へ向けた大型ヘリカル装置の高性能化研究の進展 Y. Takeiri (NIFS)
4	Invited talk	November, 18 2014	Plasma Conference 2014 (PLASMA 2014)	Niigata	大型ヘリカル装置LHDでの重水素実験によるこれからの炉心プラズマ研究 Y. Takeiri (NIFS)
5	Symposium	November, 19 2014	Plasma Conference 2014 (PLASMA 2014) 「Symposium 7 : トーラスプラズマにおける質量比の閉じ込めへの効果」	Niigata	1. はじめに K. Ida (NIFS) 2. JT-60UのHモードにおける水素同位体効果 H. Urano (JAEA) 3. 改善コア閉じ込めプラズマにおける同位体効果 T. Fujita (Nagoya Univ.) 4. 乱流輸送における同位体効果の理論予想 T.S. Hahm(Seoul National Univ.) 5. 質量比・同位体効果の解明に向けた計測 M. Hasuo (Kyoto Univ.) 6. LHD重水素実験計画と閉じ込め特性に対するプラズマ核種の効果 M. Osakabe (NIFS)

All Japan fusion neutron diagnostics development team has been organized toward the LHD deuterium project.

NIFS
M. Isobe, K. Ogawa

Nagoya Univ./Prof. A. Uritani
・NFM design
- MCNP modeling

Nagoya Univ./Dr. H. Tomita, Prof.T. Iguchi
• Neutron spectrometer
• Nuclear emulsion

Hokkaido Univ./
Dr. J.H. Kaneko
• Triton burnup/NPA
- CVD diamond

ITER MFC

FNS collaboration

JAEA/Drs. T. Nishitani, K. Ochiai, M. Ishikawa, and K. Shinohara
• FNS
• Neutron camera on JT-60U
• ITER Micro FC

Kinki University/
Dr. H. Yamanishi
• Reactor UTR-KINKI

JT-60U collaboration

Kyoto University/
Prof. T. Misawa
• Reactor KUCA

Kyoto Univ./
Dr. S. Murakami
・Fast-ion modeling
・Prediction of fusion output

National Institute of Technol., Toyama College/
Prof. E. Takada
• Neutron camera detector

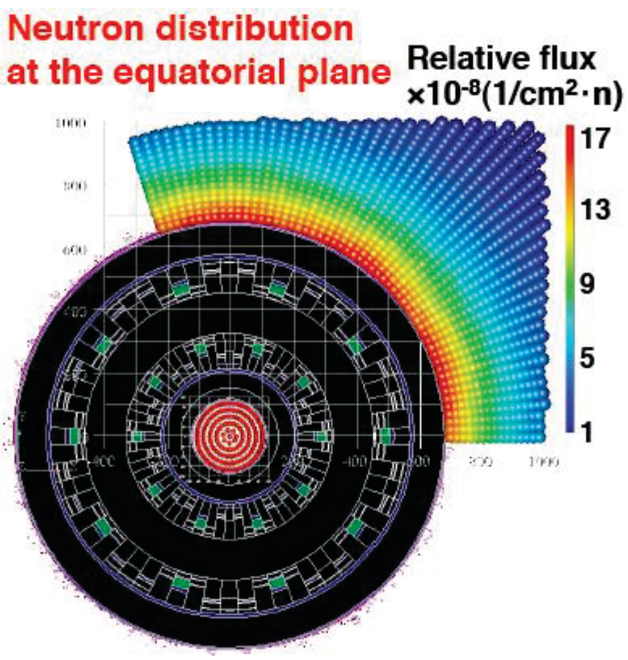
Fission reactor collaboration | **NIFS-Univ. collaboration** | **JAEA collaboration**

Collaboration with Nagoya University

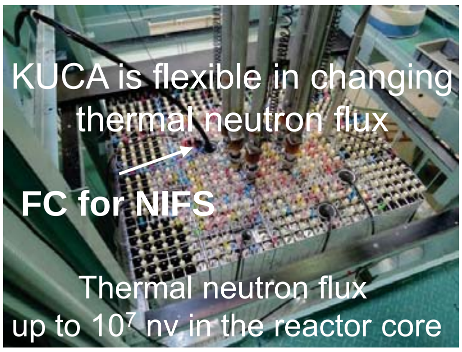
~ Joint work for neutron flux monitor development ~

Neutron transport study by MCNP

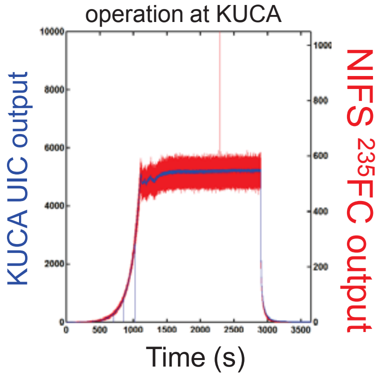
The LHD is fairly complicated.
→ A program generating an input file of 3D machine geometry for MCNP has been developed.



Test operation of wide dynamic range DSP unit prototype at KUCA



An example of test operation at KUCA



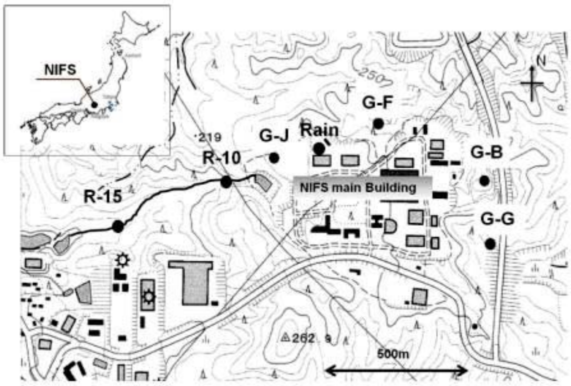
A satisfactory prospect was obtained toward manufacture of NFM-DSP unit for LHD

N. Nishio *et al*., Rev. Sci. Instrum. **81**(2010) 10D306.

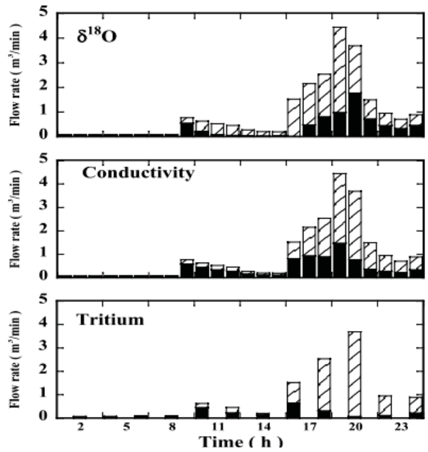
Research on environmental tritium

Collaborations with Kyushu Univ., Kumamoto Univ., JAEA, etc

- **Tritium behavior in ground water at the NIFS site**
  - To understand the background tritium level at the NIFS site and the tritium behavior released from the facility to the environment, two component separation analysis was carried out.
  - The tritium concentrations in rain was 0.09-0.78 Bq/L, and the tritium concentrations of stream water and ground water were almost constant, 0.34 Bq/L and 0.25 Bq/L, respectively.
  - The two component separation analysis gave good agreement between isotopic ratio and conductivity.



Sampling locations at NIFS toki site (R-10, R-15: stream water, G-B, G-F, G-G, and G-J: groundwater, Rain: rain water)



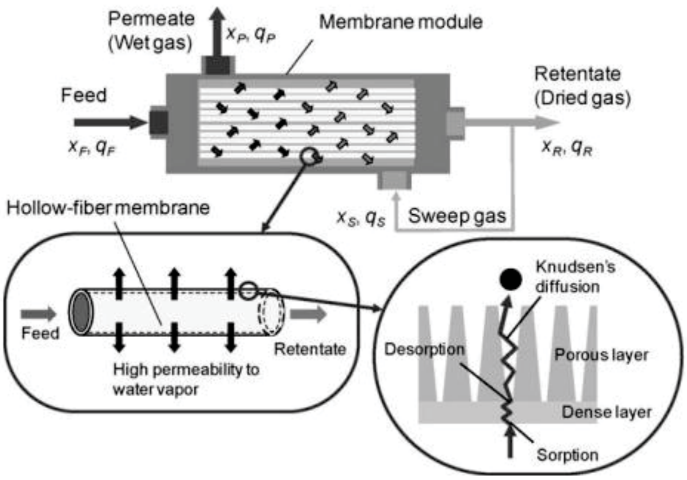
Two component separation of flow rate using $\delta^{18}O$, conductivity and tritium concentration at the rain event. The black bar represents the ground water component and the slash bar is the rain component.

S. Sugihara, et al., Fusion Science and Technology 60 (2011) 1300-1303

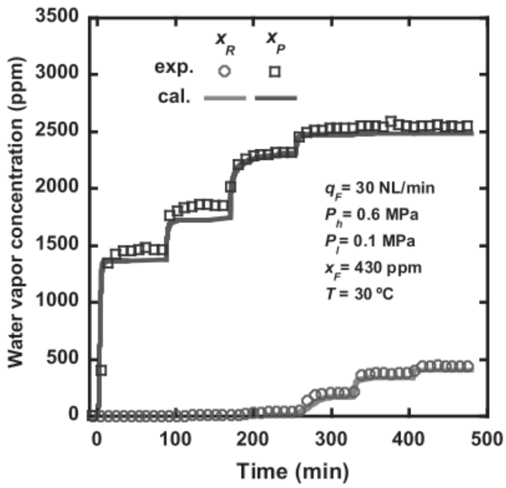
Research on polymer membrane

Collaboration with Nagoya Univ.

- **Simulation model of hollow fiber polymer membrane**
  - A simulation model was developed for transient response of a hollow fiber membrane for the tritium removal system.
  - The mass transfer processes such as sorption and desorption, diffusive transfer of gases are treated in the model.
  - This model represents well not only separation factors and recovery ratio at the steady state but also responses to the multi-step wise change in the sweep gas rate.



Water vapor separation model with the hollow fiber membrane module.

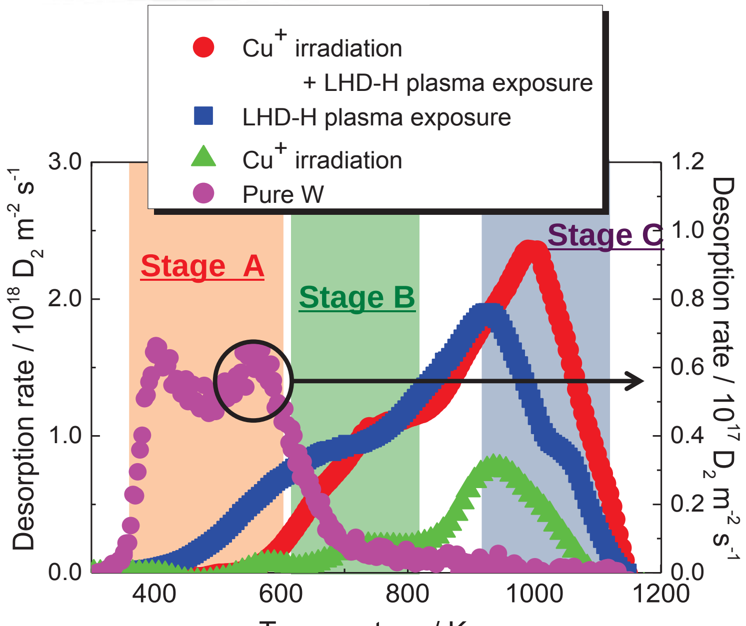


Transient response to the multi step-wise decrease in the reflux flow rate

T. Sugiyama, et al., Fusion Engineering and Design 86 (2011) 2743–2746

Desorption of deuterium from after exposed W

Shizuoka Univ.



TDS spectrum of D from various kind of the W samples

- **Post D^+ ion irradiation was carried out to the various kinds of W samples.**
- **Trapping sites are changed on each desorption stage**

Stage A
- Dislocations

Stage B
- W-O
- Point defects by irradiation

Stage C
- Void
- Carbon deposition layer

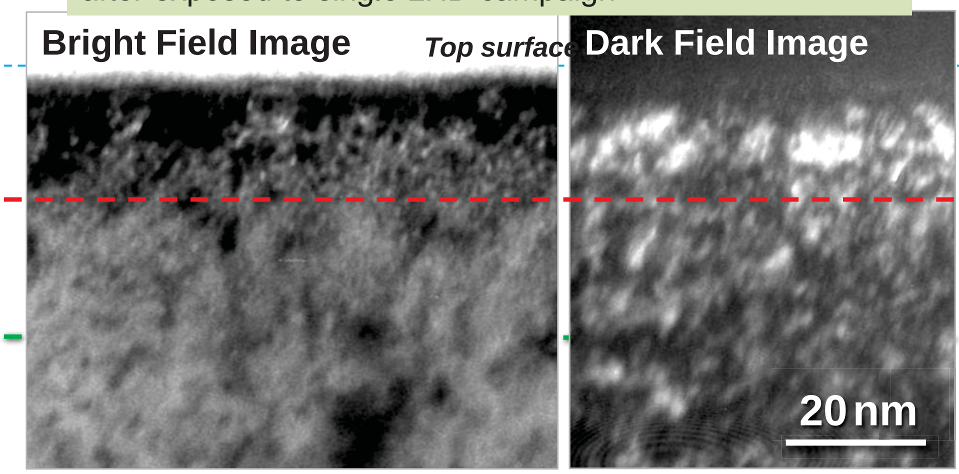
The surface morphologies such as formation of the point defects or impurity deposition make great affects for the retention properties of the deuterium

Characterization of surface morphologies of first wall

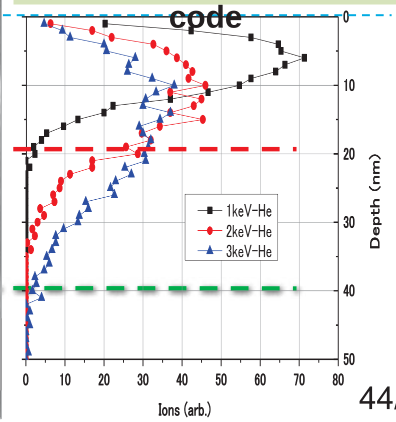
Kyushu Univ.

- Characterization of the surface morphologies were clarified by microstructural observation.
- Formation of the microscopic defects such as dislocation loops and helium bubbles were formed on the subsurface region. Impurity deposition was also observed on the top surface.
- These surface morphologies can act as the strong trapping site of the hydrogen isotopes.

Cross-sectional TEM images of stainless first wall sample after exposed to single LHD campaign

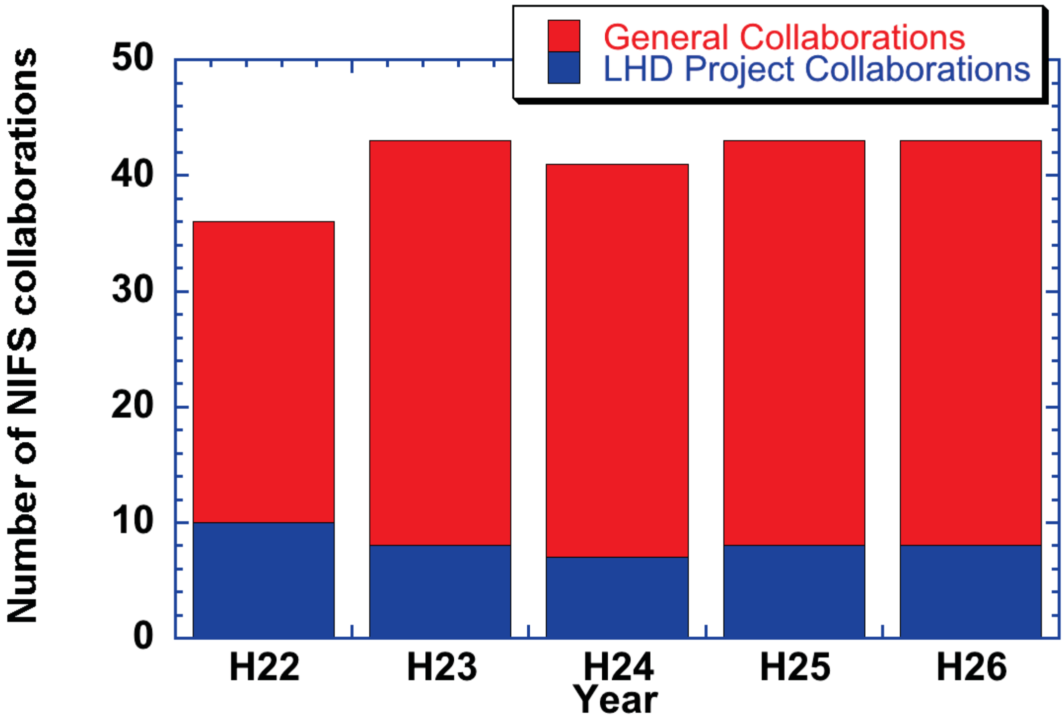


Depth profile of He calculated by TRIM code



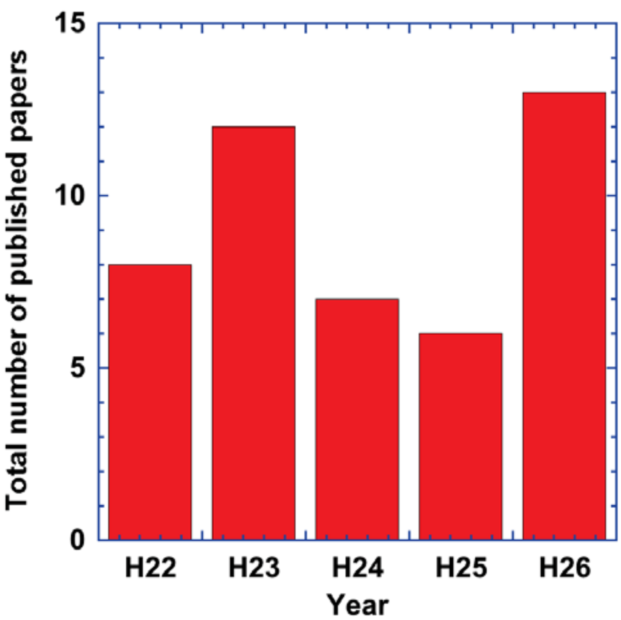
LHD deuterium experiment project promotes research activities in universities through the collaboration.

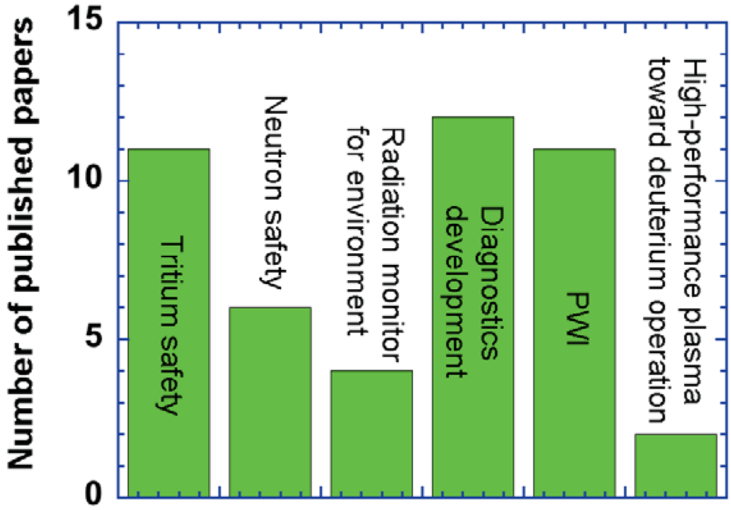
- Number of NIFS collaboration related with the deuterium experiment is counted to around 40 every year.



Statistics of published papers

- Through the NIFS collaboration, number of papers have been published related with the deuterium experiment project.





(3) Regarding implementation of the plan, will this achieve a system of collaborative use and collaborative research that enables participation by a wide range of researchers?

1. Research plan for the LHD deuterium experiment has been discussed and proposed by a wide range of researchers through the collaboration.
2. Toward the LHD deuterium experiment, all Japan fusion neutron diagnostics development team has been organized based on collaborative research.
3. Tritium-related studies important for the deuterium experiment, such as research on the environmental tritium and technology development for the tritium removal system, have been conducted in collaborative researches with universities.
4. PWI studies, such as the retention properties of hydrogen isotopes and the characterization of surface morphologies of the first wall, have been accelerated toward the LHD deuterium experiment, leading to establishment of a wide range of collaboration network.
5. Selected subjects related with the deuterium experiments are counted to around 40 every year in the NIFS collaboration system, and 47 papers have been published.

2. Deuterium Experiment Preparation System

(1) Moving toward the initiation of deuterium experiments in Heisei 28 [2016], is the preparation of equipment and facilities being planned appropriately?

(2) Is the preparation system for the initiation of deuterium experiments appropriate? Is preparation of the facilities, including safety equipment, and machinery being advanced appropriately?

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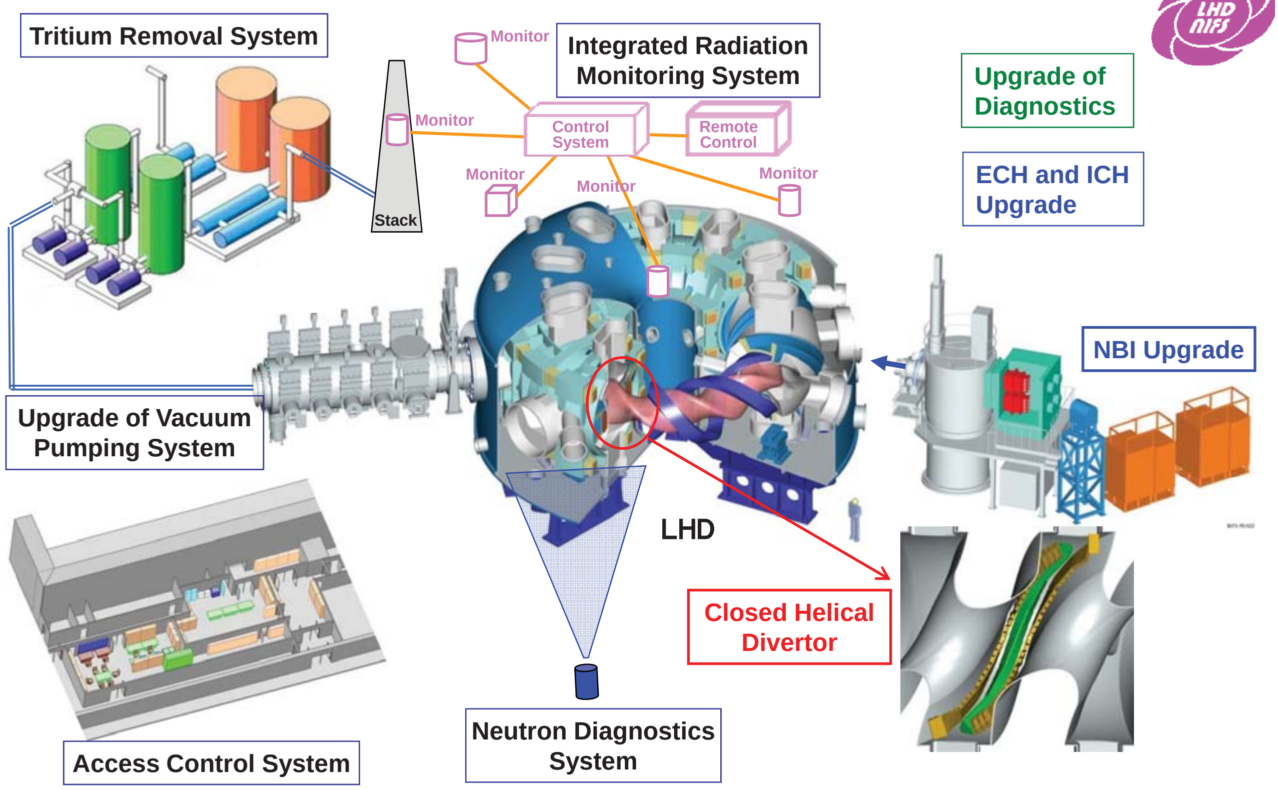
Device Upgrade Plan for the LHD Deuterium Experiment



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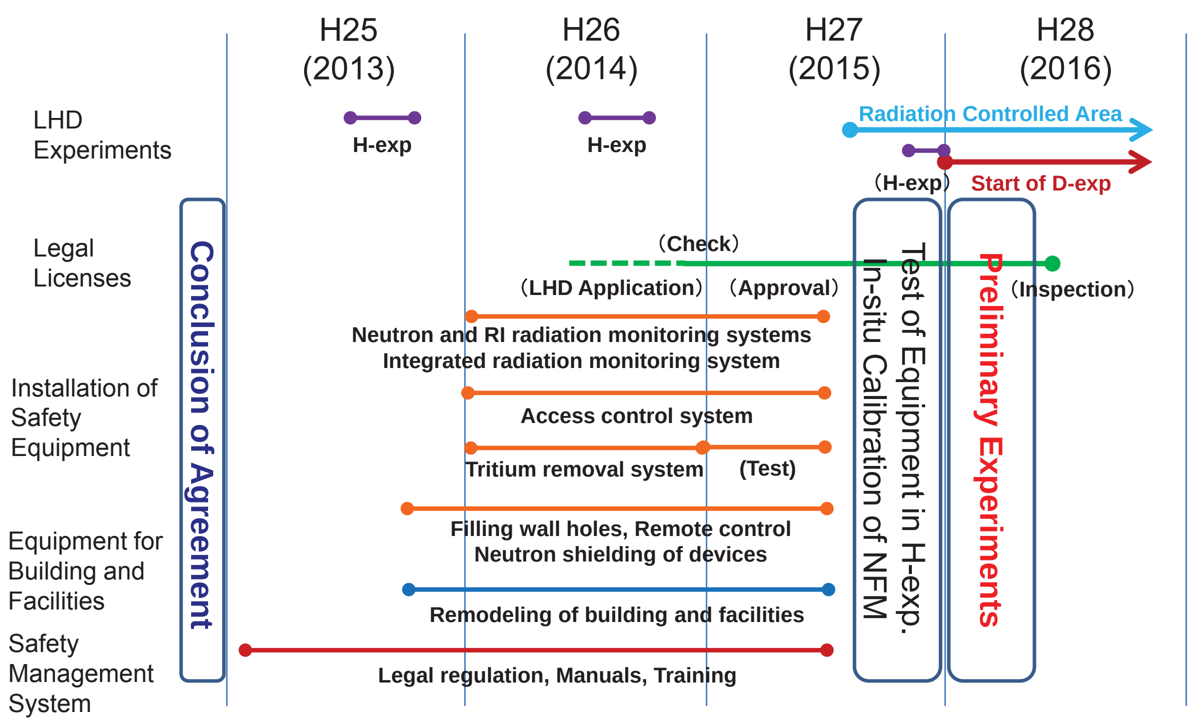
Preparation plan of equipment and facilities for safety for the start of deuterium experiment



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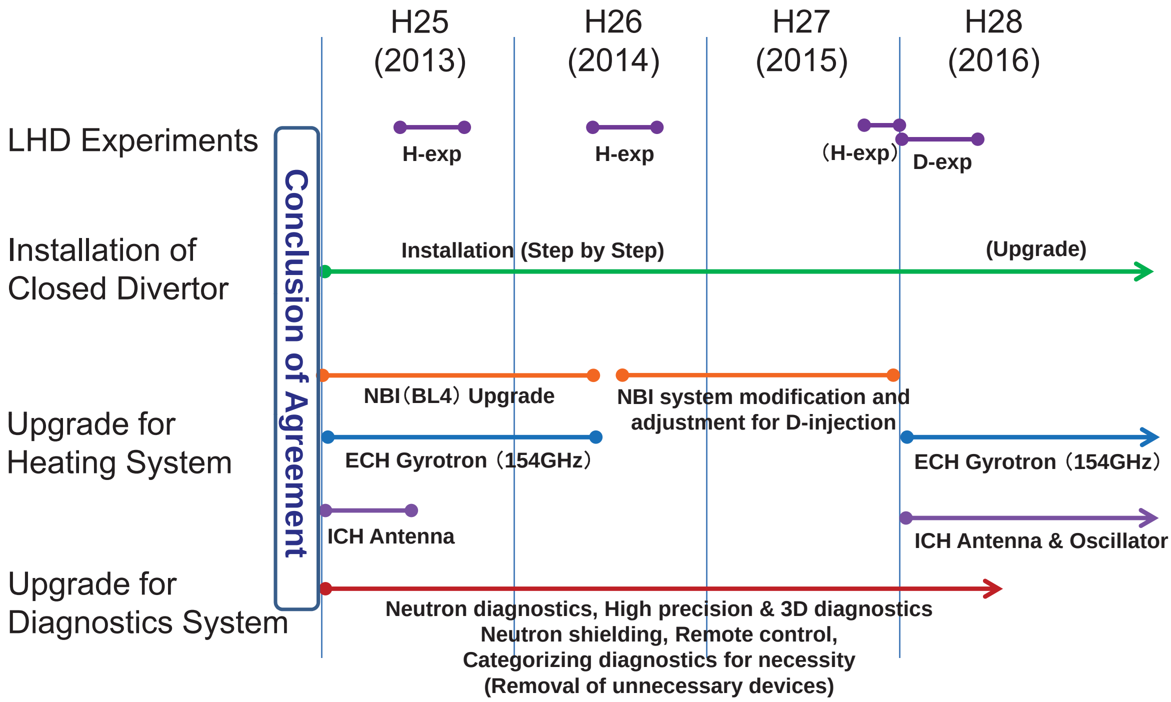
Preparation schedule of machine upgrade for the start of deuterium experiment



Upgrade of NBI for deuterium experiments

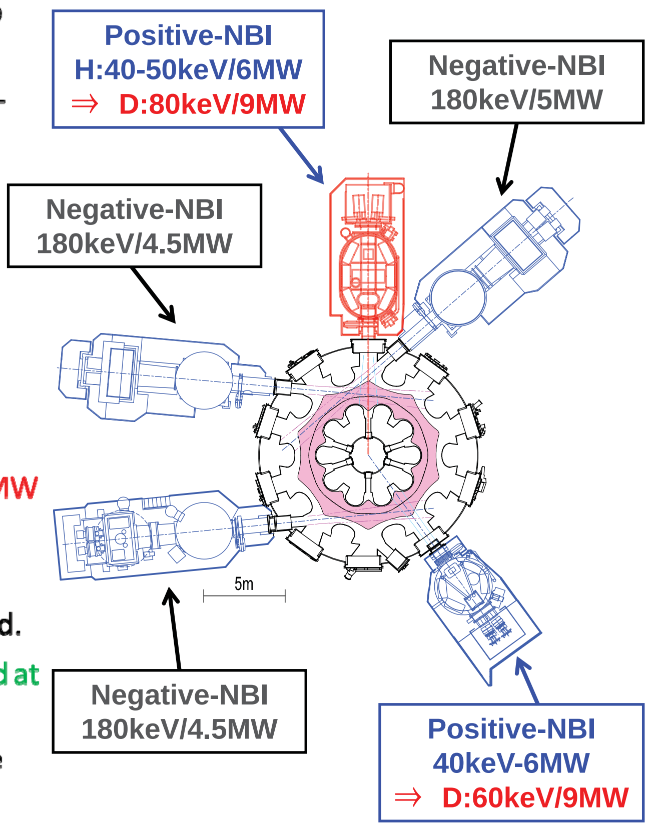
- Optimum beam current will be reduced to 70% by D-ion extraction:
  - Beam optics is governed by the Child-Langmuir law.

$$J_{si} = \frac{4\varepsilon_0}{9}\frac{V^{3/2}}{{d_s}^2}\sqrt{\frac{2Ze}{m_i}}$$

- Strategy of NBI for deuterium operation
  - ✓ Positive-ion based NBIs:
    - Beam energy will be increased from 40 to 60/80keV and their power will be increased from 6MW to 9MW.
  - ✓ Negative-ion based NBIs:
    - No significant upgrade is planned.

  ⇒ Beam power will be deteriorated at the initial phase of D-operation.

  The beam power will be recovered by the optimization of grids after D-operation.



Neutron Diagnostics

Fusion reaction producing neutrons in deuterium plasmas :

d + d → n (2.5 MeV) + ^{3}He (0.82 MeV)

→ p (3.0 MeV) + t (1.0 MeV)

Secondary reaction : d + t → n (14 MeV) + α (3.5 MeV)

DD neutron rate expected in LHD is >10^{16}n/s, comparable to JT-60U, TFTR, and JET.

Role of neutron diagnostics

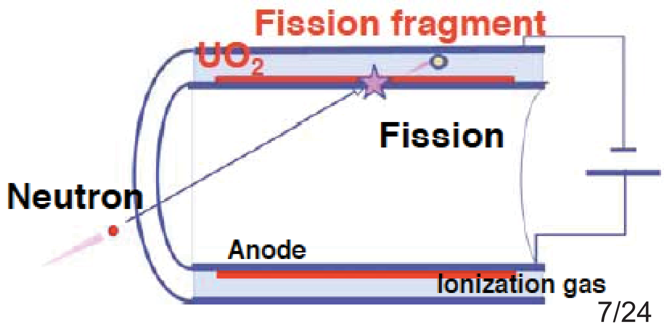
1. Measurement of fusion output, which estimates amount of tritium
2. Study on beam-ion behavior
   - Global confinement property and slowing down of beam ions
   - Radial profile of beam ions

   →Beam deposition

   →Effect of Alfvénic modes on radial transport of beam ions
3. Confinement study of MeV tritons isotropic in velocity space

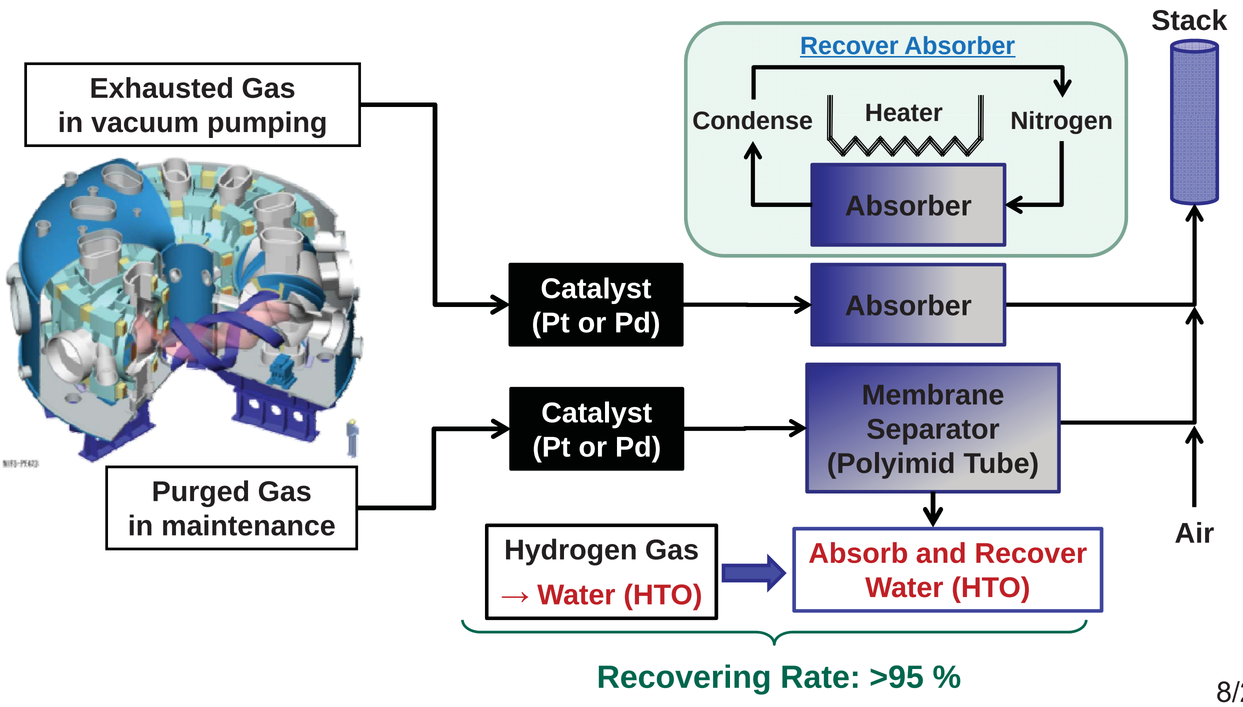
^{235}U fission chamber satisfies

1. Wide dynamic range
   -> Pulse counting mode
   + Campbelling mode
2. Fast time response (~1 ms)
3. Good n-γ discrimination capability
4. Long-term high reliability



Tritium Removal System

Two types of tritium recovery system are installed.
- Molecular sieve type for exhausted gas in the vacuum pumping
- Polyimide membrane type for purged gas in the maintenance



(1) Moving toward the initiation of deuterium experiments in Heisei 28 [2016], is the preparation of equipment and facilities being planned appropriately?

1. After the conclusion of the Agreement for the LHD deuterium experiment with local government bodies on March 28, 2013, the preparation schedule for the machine upgrade, the installation of safety equipment, and the equipment for building and facilities was defined, including the establishment of safety management system, toward the start of the deuterium experiment in 2016.
2. NBI systems has been upgraded for the deuterium beam injection with a high priority to enhance the ion heating power in the deuterium experiment.
3. Neutron flux monitor system development has firstly been started as the most important diagnostics for the deuterium experiment, and as a primary safety equipment, the tritium removal system has been designed and constructed.
4. Neutron shielding is designed for individual devices, and devices are listed, which should be removed due to weakness against neutrons and less necessity.
5. Building and facilities have been remodeled for the radiation controlled area.
6. Legal license procedure and preparation of various kinds of operation and safety manuals are scheduled.

2. Deuterium Experiment Preparation System

(1) Moving toward the initiation of deuterium experiments in Heisei 28 [2016], is the preparation of equipment and facilities being planned appropriately?

(2) Is the preparation system for the initiation of deuterium experiments appropriate? Is preparation of the facilities, including safety equipment, and machinery being advanced appropriately?

Preparation system for the initiation of the LHD deuterium experiment

- **Division for deuterium experiments management** is responsible for the preparation for the LHD deuterium experiment.
- D-exp management division mainly consists of division directors of NIFS including the safety-related divisions, which enables fast decision and top-down implementation.
- Under the D-exp management division, **LHD upgrade team** carries out the design and construction for individual items including the safety management, according to the planned preparation schedule for the initiation of the deuterium experiment.

○整備スケジュール策定（竹入、西村(清)、高性能化機器設計グループ）

○主要整備項目（竹入、西村(清)）
- 放射線総合監視システム（西村(清)、田中(将)）
  - システム整備
    - 放射線監視側（田中(将)、赤田、佐瀬、磯部、三宅、林浩）
    - 中央制御側（渡邉(清)、横田、前野）
  - 要素ハードウェア整備
    - トリチウム除去装置（田中(将)、西村(清)、鈴木(直)、近藤、加藤(ひ)）
    - 中性子計測（磯部、小川(国)、三宅、林浩、小渕、河合(将)）
    - 監視・管理用放射線計測（田中(将)、赤田、佐瀬、三宅、林浩）
    - 監視カメラシステム増強（庄司、成嶋、三宅、土伏、渋谷、施設・安全管理課）
    - 入退管理・インターロック（成嶋、赤田、三宅、林浩、横田）
- 貫通孔処理（今川、岡田(宏)）
  - 北側・東側南（加熱）：長壁、岡田(宏)
  - 東側北（低温）：今川、三宅
  - 南側（計測）：磯部、林浩
- 機器遠隔操作化、遮蔽・放射線対策（磯部、中西、庄司、小川(国)、向井、大砂、小渕、林浩、三宅）
- 配線、機器の更新撤去（磯部、中西、庄司、小川(国)、向井、大砂、小渕、林浩、三宅）
- ガス供給システム（宮澤、坂本、安井、長原）
- 真空排気系、排気ガス処理対策、試料加工工作室（坂本、本島、時谷、鈴木(直)、林浩己）
- 防塵室整備（森崎、本島、田中(宏)、林浩己）
- 冷却水系（森崎、坂本）
  - 本体冷却水系（坂本、本島、林浩己、土伏）
  - 加熱冷却水系（長壁、関哲夫、吉村(泰)、木崎、小林(策)）
  - 真空容器加熱冷却装置（森崎、田中(宏)、林浩己、土伏）
- 申請関係（西村(清)、磯部、三宅）
- 施設関連整備（西村(清)）
  - 防水改修（西村(清)、磯部、施設・安全管理課）
  - 空調・排水改修（西村(清)、赤田、佐瀬、施設・安全管理課）
  - 電気設備改修（関、施設・安全管理課）
  - 内装改修（磯部、時谷、駒田、施設・安全管理課）
  - 天井等耐震化（森崎、長壁、柳、横田、施設・安全管理課）

○重水素対応マニュアル整備（西村(清)、今川、森崎、磯部、三宅、林浩）
- 放射線管理マニュアル（別紙参照）
- 運転マニュアル（別紙参照）
- 異常時対応マニュアル（別紙参照）

○管理区域（西村(清)、成嶋、赤田、小川(国)、三宅、林浩、施設・安全管理課）
- 入退管理方法
- 管理区域の種別
- 管理区域への入室制限、機器・道具類の持ち込み・持ち出し制限
- 修繕、保守

○安全管理計画との整合性管理（竹入、西村(清)、高性能化機器設計グループ）

Preparation items executed by LHD upgrade team

Preparation items and schedule for the initiation of the LHD deuterium experiment

Conducted by LHD upgrade team

	区分		設備名	整備内容	2013年 平成25年度(2013) H25 (2013)	2014年 平成26年度(2014) H26 (2014)	2015年 平成27年度(2015) H27 (2015)	2016年 平成28年度(2016) H28 (2016)	2017年
Tritium removal system	重水素実験開始するために必要な整備	①	トリチウム除去装置（排気ガス処理システム）	大型ヘリカル装置で重水素実験により発生したトリチウムを、重水素とともに酸化して水にし、トリチウムを含む水として回収する装置。真空排気装置により排気された トリチウムの90%以上を除去したうえで、放出されるトリチウム総量を地域住民と約束・説明した値以下に抑える。	仕様策定	設置・調整	試験調整		
Neutron diagnostic system		②	中性子計測システム（1.トリチウム発生率監視装置 2.トリチウム総発生量絶対値監視装置）	重水素実験により発生する中性子及びトリチウムの発生量の正確に計測するシステムであり、放射線管理上必須の装置である。	仕様策定	設置・調整			
Integrated radiation monitoring system		③	放射線総合監視システム（モニタ・入退管理システム・監視カメラシステムを含む）	本体室を退室する作業者に付着した放射化物を測定すると共に、その処置（除染）を行うなど、入室、退室の管理を行うためのシステム、放射線管理区域となるエリア内の各種装置と入退出の状況の監視を行うための監視カメラシステムの更新、インターロックシステム等、放射線安全管理を総合的に行う。		仕様策定	設置・調整		
He gas tank	放射線管理区域の整備	④	ヘリウムガスタンクの改修・増強	ヘリウム供給が世界的に逼迫してきており、ヘリウムの消費を最小限に抑えるため、ヘリウムガスタンクのパッキンの交換及びマンホールの改修、放出弁を更新する必要がある。		He放出弁	Heガスタンク改修		
Filling holes		⑤	貫通孔処理	重水素実験により発生する放射線の遮へいを行うため、本体室地下の北・東・南壁に設けられている配線・配管のための貫通孔の穴仕舞い処理を行う必要がある。	NBI北側 SCバスライン トムソン, FIR 2.5L処理	計測南側 LHe東壁北側 ECHエリア天井部	NBI 東壁南側		
Neutron shielding & Remote control		⑥	機器遠隔操作化・放射線対策	重水素実験による本体室及び本体室地下の機器の遠隔操作化及び放射線対策を進めるため、耐放射線性ケーブルへの更新、機器の放射化低減のためのポリエチレン床処理、等を行う必要がある。	ポリエチレン購入	ケーブル更新（撤去・敷設） 遮へい材購入	ポリエチレン敷設		
Gas puffing system		⑦	ガス供給システムの遠隔操作化	重水素実験により、放射線管理区域内のガスボンベが放射化するため撤去する必要がある。そのため、ガス供給システムの移設及び制御系の改造とそれに伴う高圧ガス供給配管の敷設を行う必要がある。		ガス供給システム整備			
Vacuum pumping & Gas exhaust system		⑧	真空排気系・作業用排気ガス処理対策	重水素実験により、放射線管理区域内のガスボンベが放射化するため撤去する必要がある。そのため、ガス供給システムの移設及び制御系の改造とそれに伴う高圧ガス供給配管の敷設を行う必要がある。	真空排気装置ドライポンプ化 室外排気配管整備	室外排気配管	排気設備設置		
Cooling water system		⑨	冷却水系	重水素実験に先立ち純化系統のイオン交換樹脂を本体室、本体室地下から非放射化区域に移設しておく必要がある。	イオン交換樹脂等移設		熱交換器の増強等		
Device modification against radiation		⑩	放射化対策のための機器改造・移設	重水素実験により発生する放射線による機器の誤動作や損傷を避けるため、本体室に設置している加熱冷却装置、プラズマ放電用排気装置、真空排気装置等の制御盤を耐放射線用に改造を行い、必要なものを本体地下室に移設を行う必要がある。		計測機器退避エリア整備 盤改造移設	遠隔操作電源 盤改造移設		
Device removal		⑪	機器撤去	重水素実験により放射化される実験機器を最小限に留めるため、LHDに取り付けている古い機器を撤去する必要がある。		機器撤去	ICHアンテナ撤去 機器撤去		
Plasma monitoring camera system		⑫	プラズマ監視カメラシステム	真空容器内を見込むプラズマ監視カメラシステムを耐放射線性能の高いシステムに更新する。		仕様策定	設置・調整		
Access control room		⑬	管理出入口整備	重水素実験により真空容器内におけるメンテナンス作業の際に必要となる管理出入口の更新を行う必要がある。		仕様策定	整備		
Water-proof coating	施設・安全管理に係る整備	⑭	防水改修	建物保全のため、本体室屋上の防水改修及び南西外壁改修を行う必要がある。		屋上防水改修	外壁改修		
Air circulating system		⑮	空調改修	実験環境整備のため、大型ヘリカル実験棟の空調更新及び、管理区域内の排水管を更新する。また、重水素実験直前のフィルター交換、風量調整の実施は、適切な空調運転を行うため必要である。		本体棟空調更新	排気ﾌｨﾙﾀ取替		
Electric facilities		⑯	電気設備改修	安全性向上のため非常用自家発電機の設置、及び老朽化した本体室の火災報知器を取り替える必要がある。	自家発電機設置		火報取替		
Coating and painting		⑰	内装改修	管理区域内の粉じん対策として、保守作業室の鉄骨吹付の被覆、本体室等の塗床補修工事、本体室のダクト清掃を行う必要がある。	B2保管ｴﾘｱﾎﾟﾘｴﾁﾚﾝ壁	保守作業室粉じん対策	塗壁補修 ダクト清掃 塗床補修		
Reinforcement against earthquake		⑱	天井等耐震化	天井、照明、空調機等の非構造部材脱落防止のため天井の更新および照明機器等の固定を実施し、耐震化を図る必要がある。		本体室、加熱装置室、コイル電源室天井 制御室天井			

Strategy to select removed and/or reformed devices which are weak against radiation

Step 1: Check list submission for existing devices in the LHD torus hall and basement

- Status of existing devices and their robustness against radiation were checked.
- Diagnostics and/or control systems which are obviously weak against radiation were picked up, and were decided to be removed.
- Done in October, 2013.

Step 2: Manual preparation for operation and radiation safety

- Manuals for operation and radiation safety were prepared for each device and maintenance work.
- Device has to be removed if manual is not prepared.
- Done in May, 2014.

Step 3: Implementation plan submission

- Suitability and feasibility of the plan were checked.
- Done in June, 2014.

All devices are now being classified into three groups according to the implementation plan, for the judgement of removal or reformation.

Removal of devices that are weak against radiation is ongoing

List of devices that were and will be removed according to stages classified based on the check list

チェックリストに基づく撤去対象既設計測機器一覧

No	機器名称	設置位置	管理者	撤去実務担当	撤去作業予定時期	撤去済	撤去完了日
1	X線PHA	2.5L	武藤(貞)	小渕	2014.2中	済	14.03.31
2	X線PHA	2O	武藤(貞)	小渕	2014.5までに実施	済	14.05.20
3	ARMS	9O	尾崎	尾崎	第18サイクル終了後		
4	CsI(Tl)シンチレーション検出器	4.5L	磯部	磯部、小川(国)	第18サイクル終了後	済	14.5.27
5	Si-FNAアレイ	5.5L, 6O	長壁	長壁	15.03に実施		
6	AXUV	8O AD01-03(上部)	大舘	小渕	14.06 予定	済	14.06.11
7	AXUV	8O AD01-03(下部)	大舘	小渕		済	14.05.13
8	軟X線アレイ	3.5U, 3.5L, 6.5U	大舘	大舘	15.3-5に実施		
9	VUVカメラ	6T	大舘	大舘	15.3-5に実施		
10	VUVカメラ	10O	大舘	小渕	14.06 予定	済	14.07.17
11	軟X線アレイ	6O	武村	武村	15.3に実施		
12	軟X線カメラ(SXCCD)	6T	鈴木(千)	鈴木(千)	第18サイクル開始前	済	14.03.05
13	AXUVD	3.5U, 4O	田村(直)	田村(直)	第18サイクル終了後		
14	Dispersion干渉計	10O	秋山	秋山	15.02		
15	制御データ処理装置 山口盤&関ダイバータ熱電対	本体棟A.Cステージ～本体棟地下退避エリア	庄司	土伏、田中宏	14.09		
16	東井3次元磁気プローブ	8O	小川(国)	小川(国)	第18サイクル開始前	済	14.03.27
17	ペリスコープ	2.5U, 5.5U	原田、吉沼	吉沼	2014.04.18	済	14.04.18
18	SPRED	3-O	鈴木(千)	小渕	第18サイクル開始前	済	14.07.08
19	2.5U 損失高速イオンプローブ	2.5 U	小川(国)	小川(国)、小渕	14.06 予定	済	14.06.10
20	レーザーブローオフ	2.5 L	舟場	舟場	第18サイクル終了後		
21	CXS	2.5 UL	吉沼	吉沼	第18サイクル開始前	済	14.03
22	CXS	5.5 UL	吉沼	吉沼	第18サイクル開始前	済	14.03
23	CXS	7.5 UL	吉沼	吉沼	14.07に実施		
24	CXS	8O	吉沼	吉沼	15.05に実施		
25	CXS	10T	吉沼	吉沼	14.07に実施		
26	CXS	10.5UL	吉沼	吉沼	14.07に実施		
27	スニファープローブ	2O,5.5U,7O,9.5L	伊神	伊神	15.03に実施		
28	ECHアンテナ対向壁監視カメラ	2O	伊神	伊神	第18サイクル終了後	済	14.05
29	IRカメラ	2O	伊神	伊神	第18サイクル終了後	済	14.05
30	ディスコーンアンテナ	9.5L	伊神	伊神	第18サイクル終了後		
31	ICH-監視カメラ	3O,7O	斉藤(健)	斉藤(健)	第18サイクル終了後		
32	IRカメラ	10O	芦川	芦川	第18サイクル終了後		
33	電光表示盤及びパトライト	本体壁面	横田	横田	14.06.12	済	
34	IRボロメータ	6T, 6.5U, 6.5L, 8O, 10O	向井	向井	15.03に実施		
35	プラズマ監視カメラ	6T	庄司	庄司	第18サイクル終了後		
36	IRカメラ	9O,10.5U	増崎	増崎	第18サイクル終了後		

An example :
X-ray PHA based on Si detector

Reduce the neutron/gamma-ray streaming

- Effective dose outside the controlled area < 1.3mSv/3weeks
- We will have ~2,100 shots per year. -> effective dose < 0.6μSv/shot
- Some holes made for diagnostic/controlling at the basement level should be filled to satisfy the effective-dose limit.
- Now, filling holes at the northern side was completed.
- This work will be finished before the start of the deuterium experiment.

Example of shielding

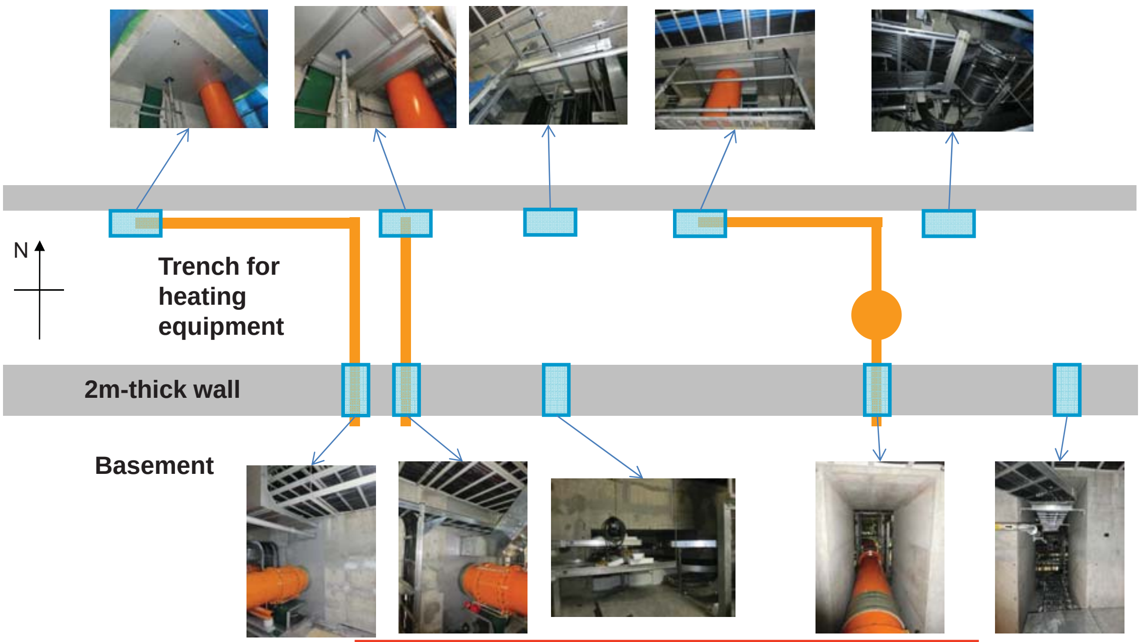
Effective dose at the basement level by calculation (after shielding)

Effective dose (μSv/shot)

- Northern side : 0.13
- Eastern side : 0.29
- Southern side : 0.16
- Western side : 0.06

Filling holes of northern wall in basement

Filling holes of the floor between the heating equipment room and the trench with polyethylene beads



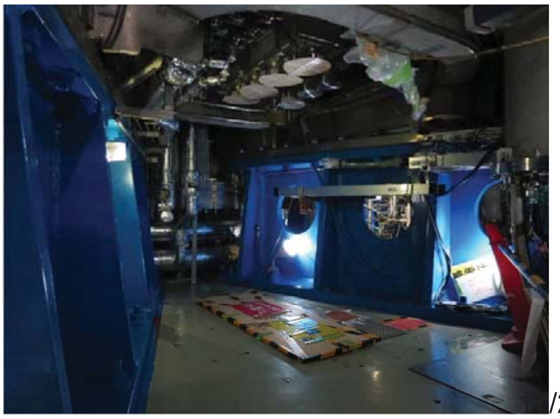
Filling holes of the wall between the basement and the trench with polyethylene plates and beads

Removed/reformed devices which are weak against radiation

- Last year, all systems equipped with LHD were classified into three groups based on the check list: “remove”, “reform”, and “satisfy”.
- Devices classified into “remove” are now antecedently removed.
- Implementation planning sheet is submitted and defined this year.
- Removing/reforming devices will be done according to the planning sheet.

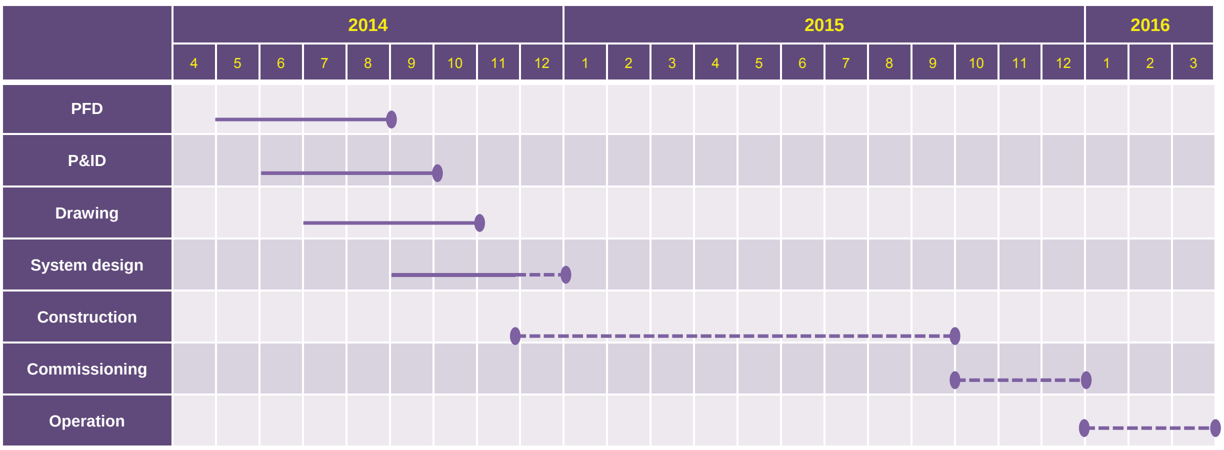
PHA diagnostics

After removing PHA diagnostics

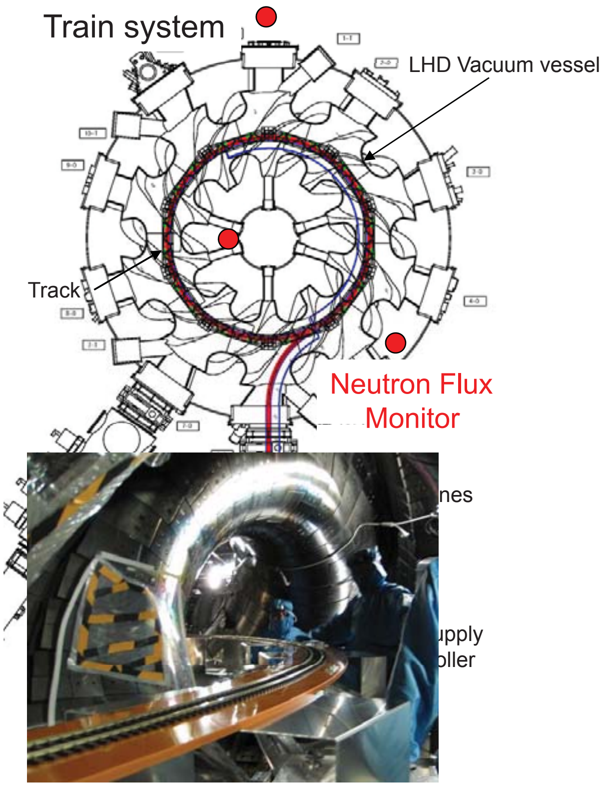


Exhaust gas processing system
~ Tritium removal systems ~

- Exhaust gas processing system
  - Two types of tritium removal system
    - Molecular Sieves [MS] type and Permeable Membrane [PM] type
- Schedule of construction and commissioning
  - Completion: PFD, P&ID, design of components and layout
  - Next step: Control system design, construction and commissioning



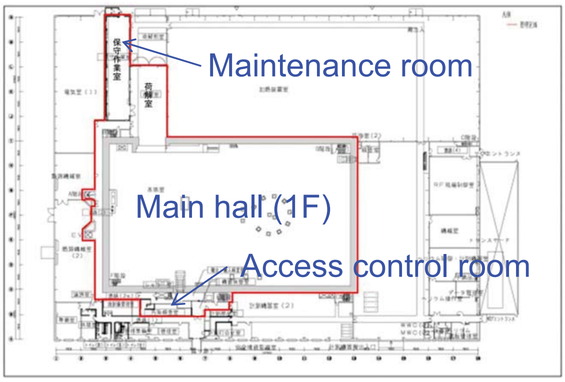
Absolute calibration of neutron flux monitor using ^{252}Cf neutron source



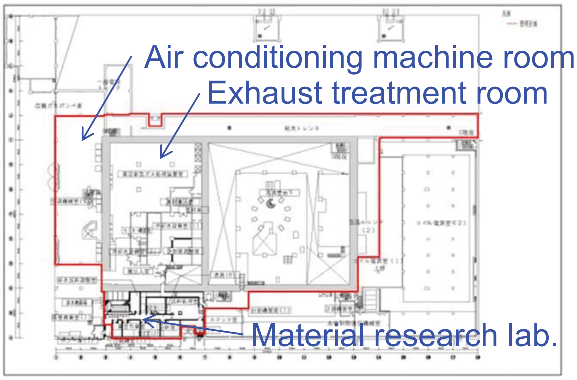
- To measure the total number of neutron, the neutron flux monitor system needs to be absolutely calibrated.
- Calibration will be carried out along the guide line decided in the WS on the neutron calibration*.
- To avoid rescue circumstance of the source, the train and track system should be reliable.
- We have developed a train that can run continuously at least for three days.
- Test installation of the track inside the vacuum vessel has already been performed twice to measure the time necessary to install, and to find points at issue for the installation.

*J.D. Strachan et al., Rev. Sci. Instrum. **61** (1990) 3501.

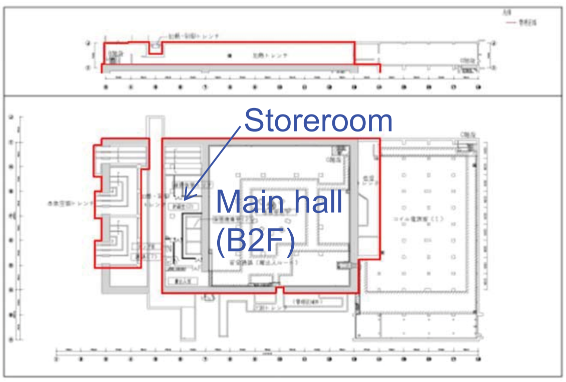
Refurbishment of LHD Building



1st Floor



1st Floor of basement



2nd Floor of basement

Controlled area is enclosed by red lines.

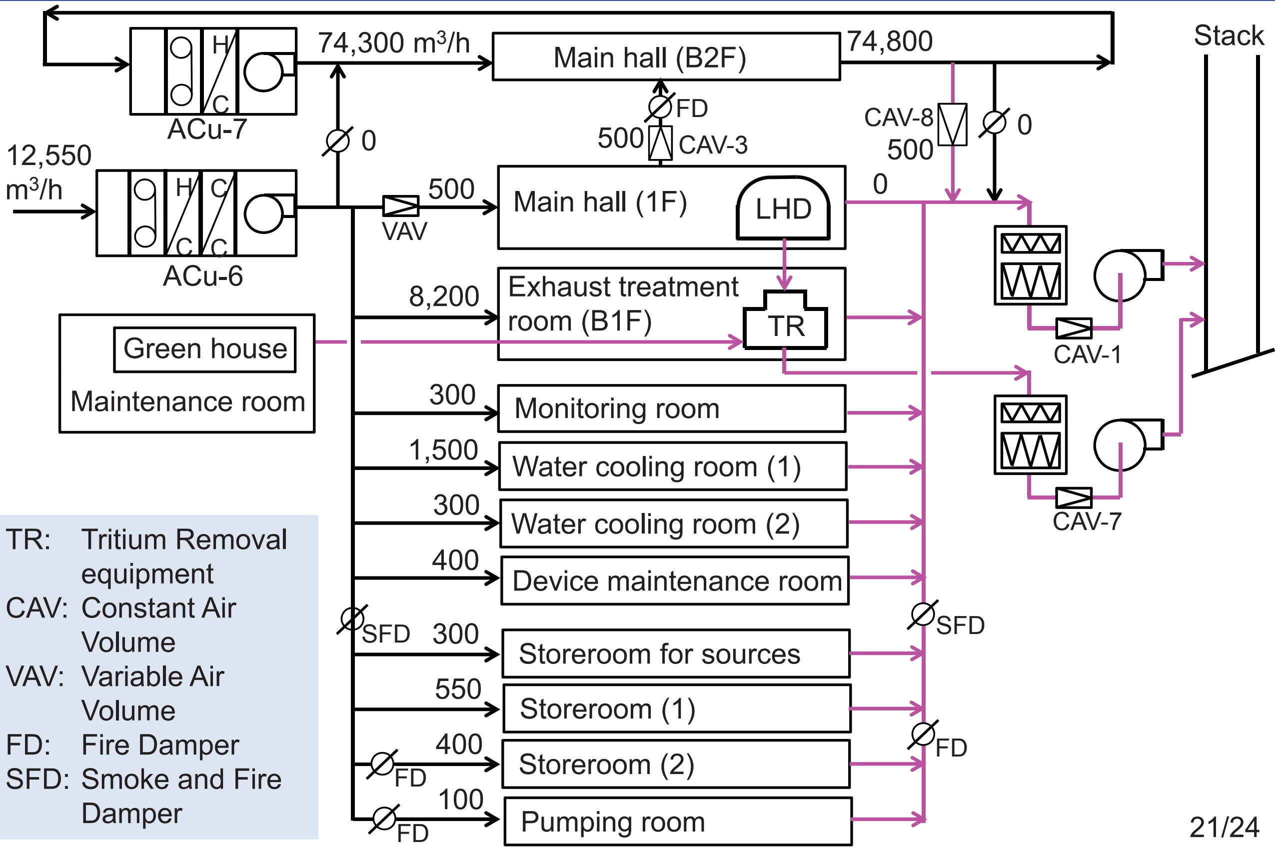
<Major items of refurbishments>

(1) Preparation of rooms in LHD building, such as access control room, material research labs., and maintenance room.

(2) Maintenance of air conditioning machine

(3) Installation of an emergency power generator of 100 kW providing for 10 days

Air Balance of LHD Building



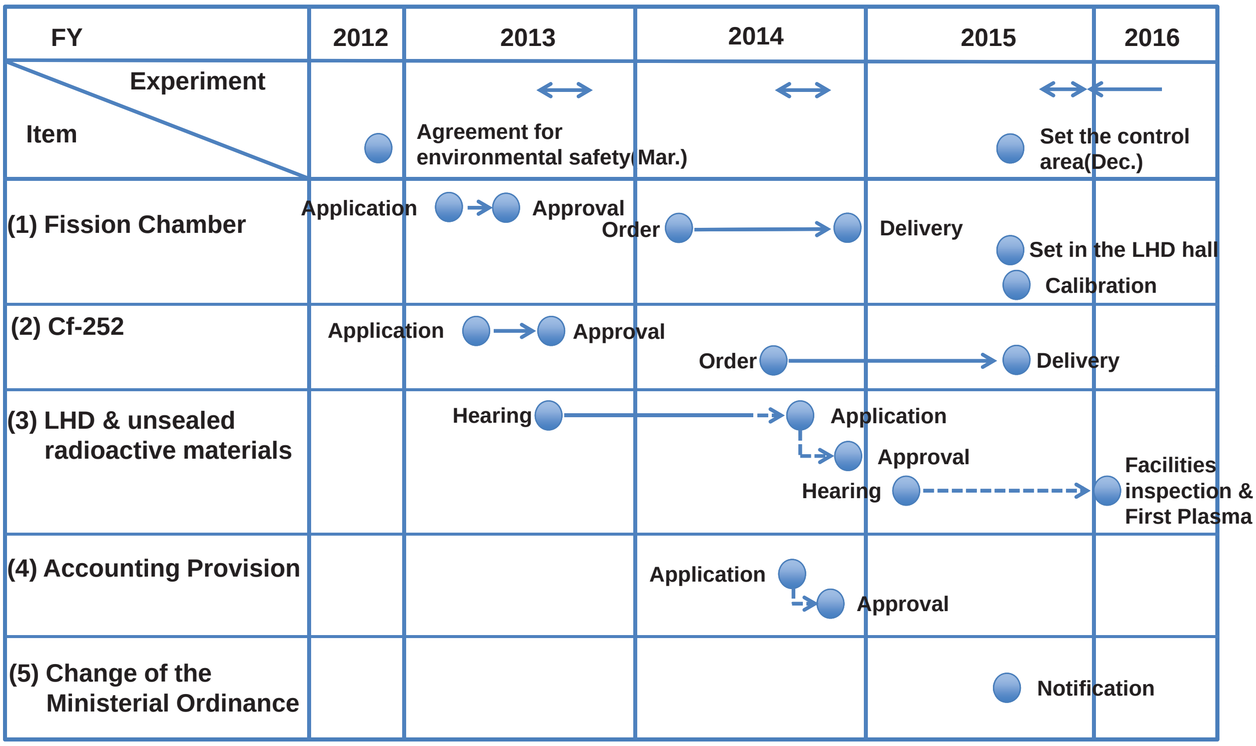
TR: Tritium Removal equipment
CAV: Constant Air Volume
VAV: Variable Air Volume
FD: Fire Damper
SFD: Smoke and Fire Damper

Application Procedure for the Licenses

Apparatus etc.	Act	Definition
Fission Chamber (U-235)	Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors (The Reactor Regulation Act)	Nuclear Fuel Material (enriched Uranium)
Cf-252 sealed source (800MBq)	Act on Concerning Prevention from Radiation Hazards due to Radioisotopes, etc. (Radiation Hazard Prevention Act)	Radio-isotope (sealed source)
LHD	Given above	Radiation Generating Device (Plasma Generator)
Material for the first wall and the plasma irradiation	Given above	Radio-isotope (unsealed source)

Some licenses have to be obtained before starting the LHD deuterium experiment.

Schedule for obtaining the Licenses



LHD deuterium experiment will start after the facilities inspection preparation.

(2) Is the preparation system for the initiation of deuterium experiments appropriate? Is preparation of the facilities, including safety equipment, and machinery being advanced appropriately?

1. Division for deuterium experiments management was established, which is responsible for the preparation for the initiation of deuterium experiments, and conducts and accelerates the preparation of the facilities and the establishment of the safety management.
2. LHD upgrade team for the deuterium experiment has carried out the design and construction of the safety equipment and the device upgrade required for the deuterium experiments.
3. Along the planned schedule, the device upgrade and the preparation of the safety equipment including the establishment of the safety management have progressed under the organized preparation system.
4. Filling holes of walls for reduction of the neutron streaming has been completed to 80%. Devices which are weak against the radiation are classified for the judgement of removing/ reforming based on the submitted implementation plan, and the removal has partly started.
5. Tritium removal systems and the neutron diagnostic system as the safety equipment are now under construction, and the preparation for the absolute calibration of neutron flux monitor has successfully progressed.
6. Refurbishment of the LHD building for setting the radiation controlled area has been completed, and the related facilities, such as the exhausted water and the air conditioning system, are under construction.
7. Procedure for the legal licenses proceeds without any problem, and the required licenses should be obtained before the start of LHD deuterium experiments.

[3] Safety management planning

(3-1) Is the fundamental concept regarding safety management appropriate at the time of the formulation of the deuterium experiment execution plan as also based upon the opinions of local residents?

重水素実験の目的は適切か、またその目的を達成する研究計画及び安全を確保する実施体制となっているか。

(3-2) Are safety management equipment, facilities, and experiment equipment being planned appropriately for the safe accomplishment of the deuterium experiment and to support management?

安全管理機器･設備、実験機器等は重水素実験を安全に遂行し、維持管理するために適切に計画されているか。

(3-3) In order to safely accomplish the deuterium experiment, are various types of regulations being formulated appropriately?

重水素実験を安全に遂行するために、規則類は適切に策定されているか。

(3-4) Are the operation manual, the radiation management manual, and the emergency manual being formulated appropriately?

運転マニュアル、放射線管理マニュアル、緊急時マニュアル等は適切に策定されているか。

(3-5) Are the organization and the system for safety management when the deuterium experiments are being conducted being constructed appropriately?

重水素実験を実施する際の安全管理のための組織、体制等を適切に構築しているか。

(3-6) Are education and training for the safe execution of the deuterium experiments, and nurturing for those responsible for safety management being undertaken appropriately?

重水素実験の安全な遂行に向けた教育･訓練及び安全管理責任者の養成は適切に計画され　ているか。

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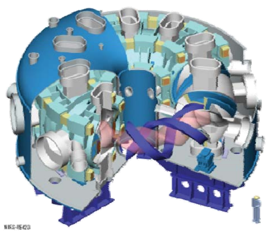
Fundamental Concept for Safety management

Deuterium Experiment

Neutron
Tritium
Radio-active Materials



LHD
Plasma
Generating
Device

Regulation for Safety Management

○Act Concerning Prevention from Radiation Hazards due to radioisotopes, etc. (Legal Level)
○Final report of the Deuterium Experiment Security Evaluation Committee (NIFS management Level)
○Arbitration proposal by the Environmental Dispute Coordination Commission(in deference)

Basic Concept

○**Minimize quantity of occurring tritium.**
⇒ Examination of the experiment parameter

○**Limit the quantity of tritium remaining in a VV which does not exceed a management level, even if a gross quantity is released.**
⇒ Examination of the experiment plan

○**Keep the management level of the radiological generations which have a possibility to give influence on the environment.**
⇒ Preparation of exhaust, drainage, the ventilation equipment

○**Pay attention severely about a leak of the tritium component water.**
⇒ Preparation of a safekeeping method, safekeeping facilities

the Safety Management Plan Evaluation Committee

Management of low level radiation
⇒ Develop and establish the measurement technique and is useful for the Fusion Reactor in Future

(3-1) Is the fundamental concept regarding safety management appropriate at the time of the formulation of the deuterium experiment execution plan as also based upon the opinions of local residents?

The basic concept for the safety management, such as the NIFS management level been set severer than laws and ordinances, is considered to be excessive as the standard for general facility treating with radiation. However, this was based on an Arbitration proposal by the Environmental Dispute Coordination Commission and on a local opinion. Furthermore, from the Safety Management Plan Evaluation Committee, "The NIFS management value is sufficiently low compare with that of laws and ordinances, but research of a such small amount radiation promotes the development of its measurement equipment and a research to establish its measurement technique." is evaluated to be appropriate.

(3-1) Is the fundamental concept regarding safety management appropriate at the time of the formulation of the deuterium experiment execution plan as also based upon the opinions of local residents?

重水素実験の目的は適切か、またその目的を達成する研究計画及び安全を確保する実施体制となっているか。

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(3-6) Are education and training for the safe execution of the deuterium experiments, and nurturing for those responsible for safety management being undertaken appropriately?

重水素実験の安全な遂行に向けた教育・訓練及び安全管理責任者の養成は適切に計画され　ているか。

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Neutron and tritium measure and control

D + D → (50%) T + p

D + D → (50%) ^{3}He + n

Number of Tritium = Number of Neutron

To manage these safely, it is necessary to grasp quantity of the neutron production precisely

The fission chamber detectors are used to grasp quantity of neutron precisely. (See §2.3.3.1)

1. N, γ-ray protection
2. Provision for tritium **(One of the most important issue)**
3. Management of Exhaust, drain water, RI and RA-waste
4. Radiation Controlled Area & Security
5. Integrated Radiation Monitoring System

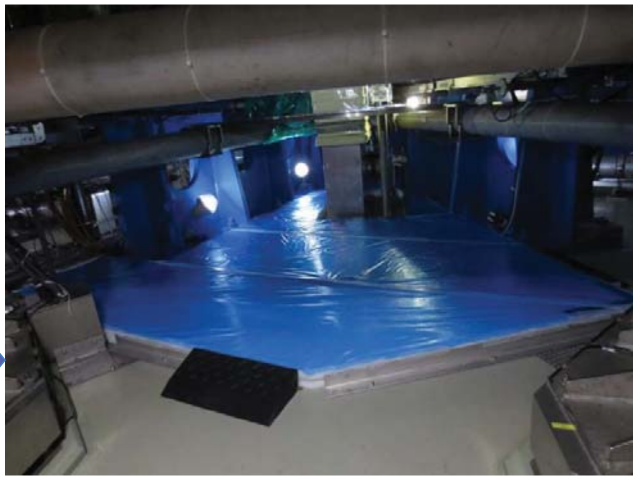
1. Neutron and γ-ray Protection

Reduction of radio-activation by neutron ⇨ **one of the important safety issue**

- **Concrete under the LHD machine will be strongly radio-activated.**
- **To reduce the radio-activation of concrete, we have a plan to cover the concrete with 5 cm thick borated polyethylene (PE).**

This year, covering concrete on one-torus section with PE was done.

- **We will finish covering concrete at the other torus sections before starting deuterium experiment.**



Covering concrete on one-torus section by Polyethylene blocks

2. Provision for tritium

- Exhaust gas processing system -

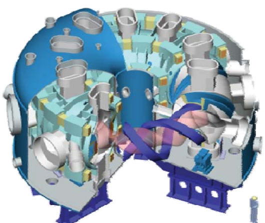
- Specifications of tritium removal systems
  - Type of tritium removal system:
    - Oxidation catalyst + absorbent [**MS type**]
    - Oxidation catalyst + polymer membrane [**PM type**]
  - Maximum flow rate :
    - MS type: 20 Nm^3/h
    - PM type: 300 Nm^3/h
  - Detritiation factor [DF] : > 20

Environmental monitoring

Stack

Tritium active sampler

Dilution by room air ($24610\ m^3/h$)



Large Helical Device (LHD)

Maximum tritium production: 55.5 GBq/y

Detritiation factor > 20

Tritium removal systems
MS type
PM type

Tritium removal system
Oxidation catalyst → Recovery of HTO

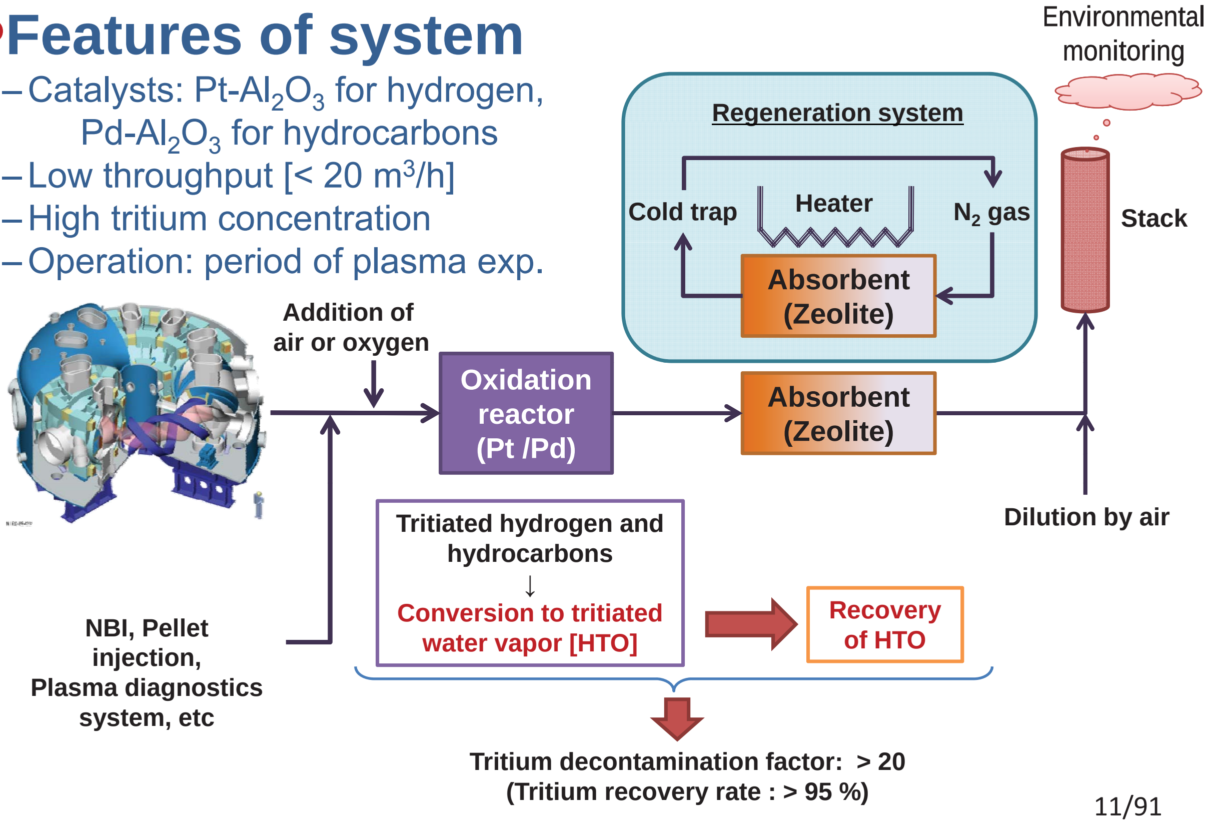
Chemical form of tritium
HTO

Collection and delivery to JRIA

- MS type tritium removal system -

•Features of system

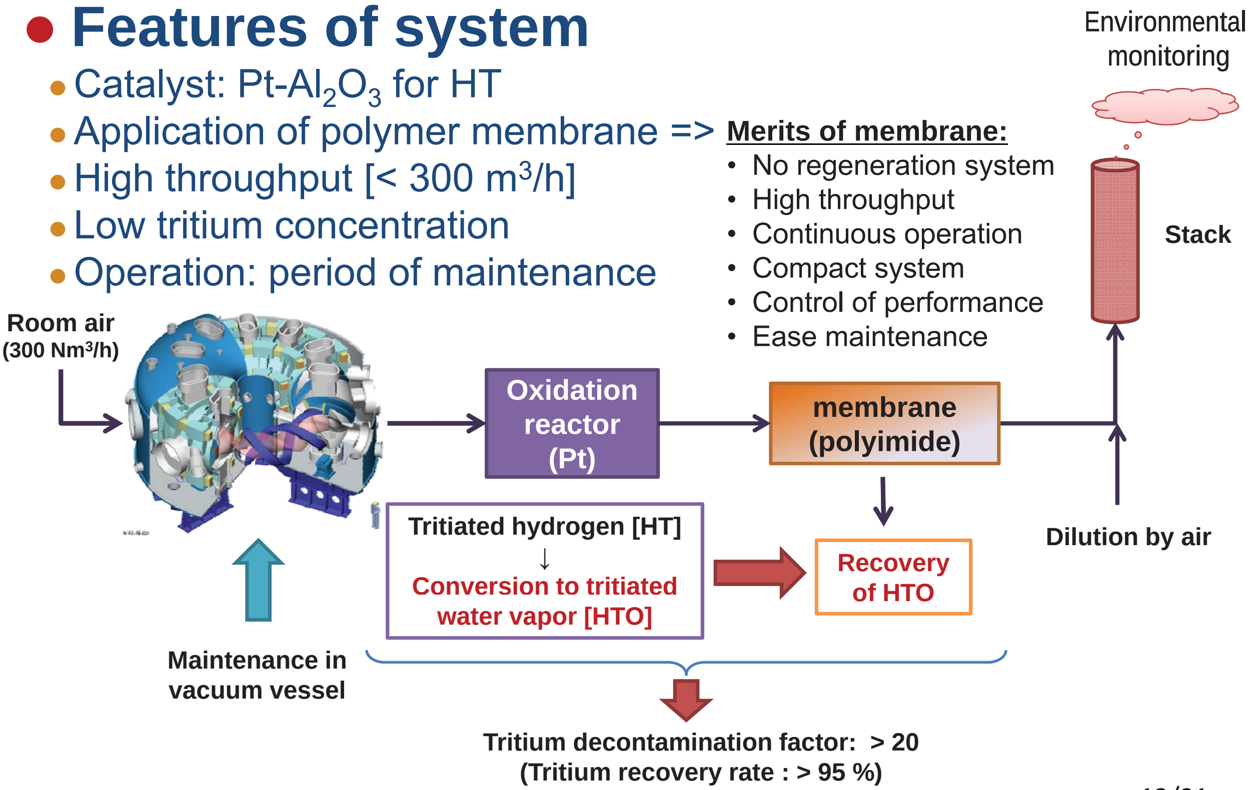
- Catalysts: $Pt\text{-}Al_2O_3$ for hydrogen, $Pd\text{-}Al_2O_3$ for hydrocarbons
- Low throughput [< 20 m^3/h]
- High tritium concentration
- Operation: period of plasma exp.



- PM type tritium removal system -

• Features of system

- Catalyst: $Pt\text{-}Al_2O_3$ for HT
- Application of polymer membrane => **Merits of membrane:**
  - No regeneration system
  - High throughput
  - Continuous operation
  - Compact system
  - Control of performance
  - Ease maintenance
- High throughput [< 300 m^3/h]
- Low tritium concentration
- Operation: period of maintenance



3. Management of Exhaust, drain water, RI and RA-waste 1

[Exhaust and Ventilation]

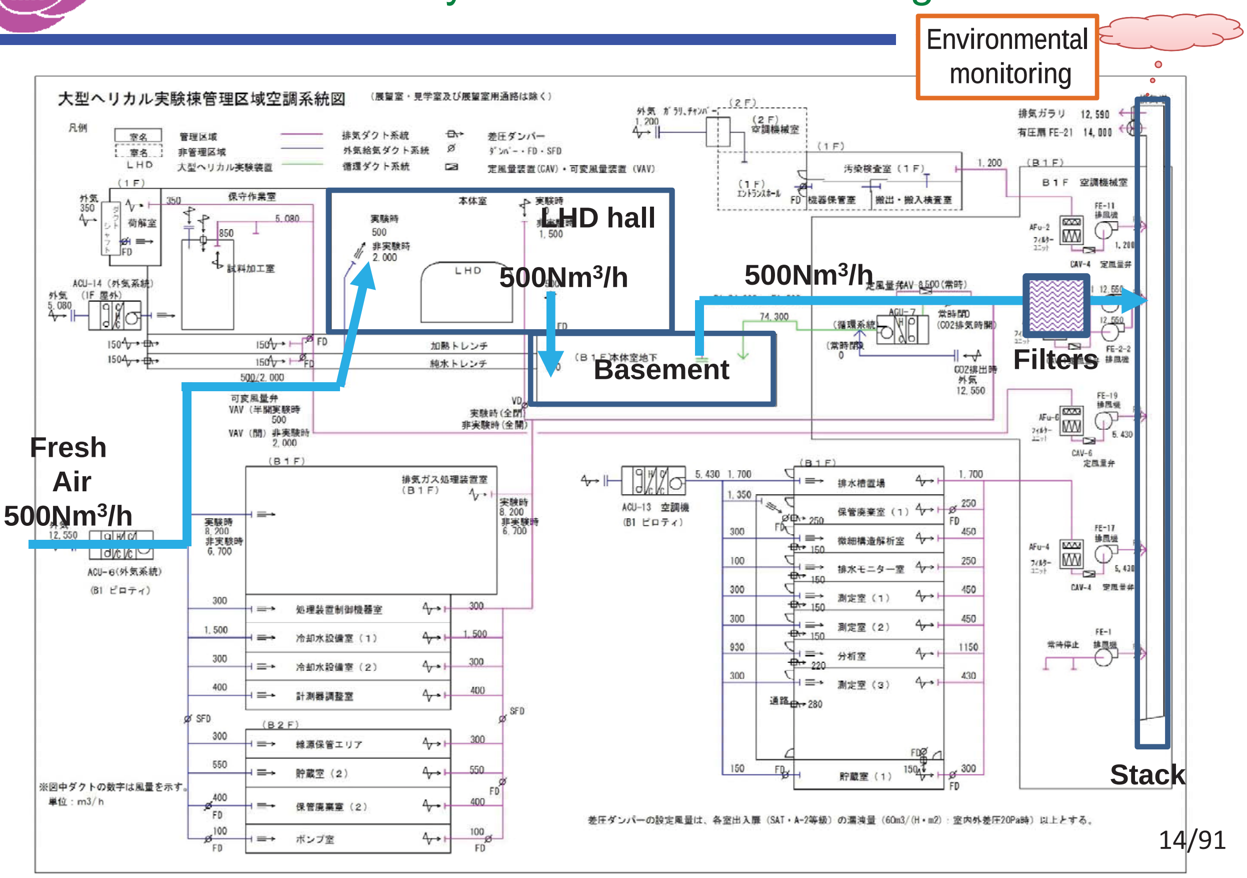
○ Since Ar in air is activated during Deuterium Experiment, we have to minimize the ventilation of the main experiment hall keeping negative pressure.

○ To keep the concentration of Ar-41 below the limit in law, we vent air with 500Nm^3/h.

○ A ventilation systems of ACU-6 and ACU-14 have ability to keep the pressure in the main hall and the maintenance workroom negative.

○ Radio-active dusts are removed by the pre-filter and hepa-filter before exhausting.

- Air ventilation system of the LHD building -



3. Management of Exhaust, drain water, RI and RA-waste 2

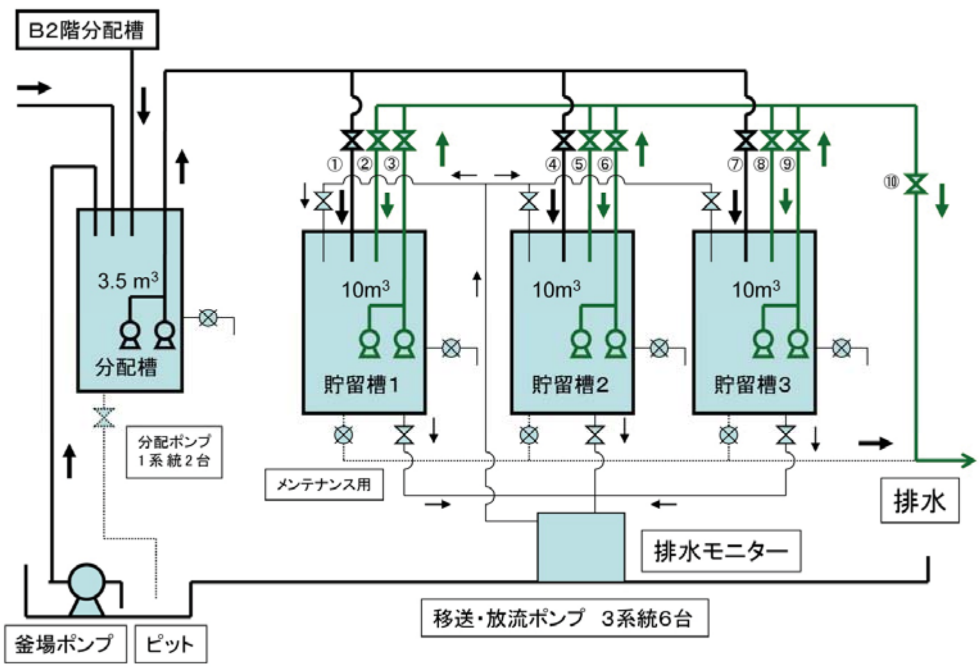
[Drain water and Recovered water]

○ All drainage that occurred in Controlled Area except the recovered water is kept in a retention tank temporarily and discharged after confirmation the radio-activity concentration below NIFS management level (tritium : 0.6 Bq/cm^3). (Legal level : 60 Bq/cm^3)

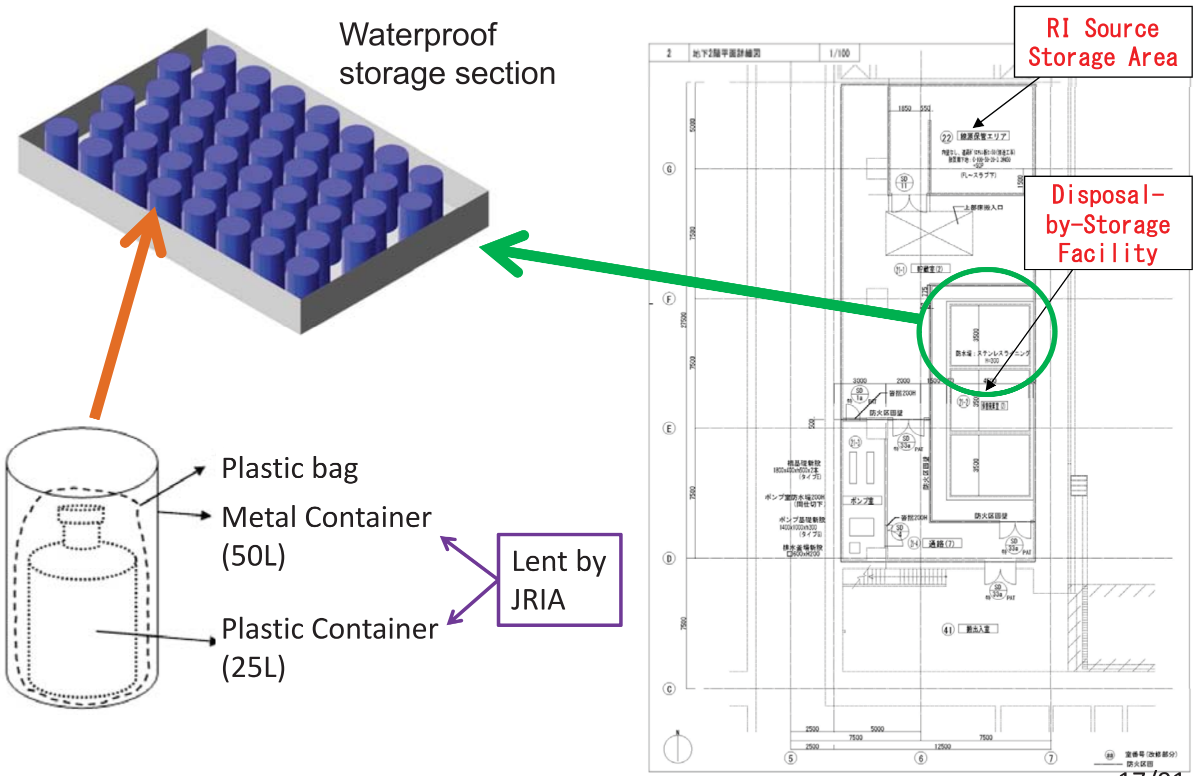
○ Drainage that exceeds NIFS management level (0.6 Bq/cm^3) is treated as same as recovered water described below.

○ Recovered water, which produces by the tritium removal system and contains the triated water (HTO), is contained in an exclusive safekeeping container and asks Japan Radio-Isotope Association (JRIA) for taking care of.

- Drainage Facility-



- Storage of Recovered Water -



3. Management of Exhaust, drain water, RI and RA-waste 3

[Radio-Active Waste]

Radio-Active wastes are classified into 8 categories as follows and put in the metal-container(50L) of the JRIA designation. These are kept at one time in a Disposal –by-Storage Facility and are asked JRIA for processing.

1) combustibles (type1)
2) incombustibles
3) incompressible incombustibles
4) combustibles* (type2)
5) filters
6) Ion-exchange resin (consultation required)
7) inorganic substances
8) organic substances

1) combustibles (type1)

- flammable waste such as work gloves, the mask, a paper towel, cloth Wes, etc.

2) incombustibles

- a glass vial, glassware vinyl chloride, silicon, china, aluminum foil, Teflon fit, etc.

3) incompressible incombustibles

- the soil, a steel frame, a pipe, a concrete piece, a casting, etc.

4) combustibles* (type2)

- plastic, a poly-vial, a poly-seat, rubber gloves, Styrofoam, etc.

5) filter

- Pre-filter, hepa-filter to arrange to exhaust facilities

6) ion-exchange resin (consultation required)

- Ion-exchange resin such as primary cooling facilities

7) inorganic substances

- Be in 25L of poly-container, and it is held by 50L of metal-container

8) organic substances

- With liquid scintillation waste fluid, etc.
  Be in 25L of poly-container, and it is held by 50L of metal-container

[Radioisotope]

(1) The radioisotope which is used as a radiation detector and for the calibration

Enriched U-235 (fission chamber) : Neutron measurement
Cf-252 : Source for calibration of the neutron measurement

(2) The materials which are activated by a neutron or absorb Radioisotope

SUS sample, carbon sample, silicon sample : used for PWI studies

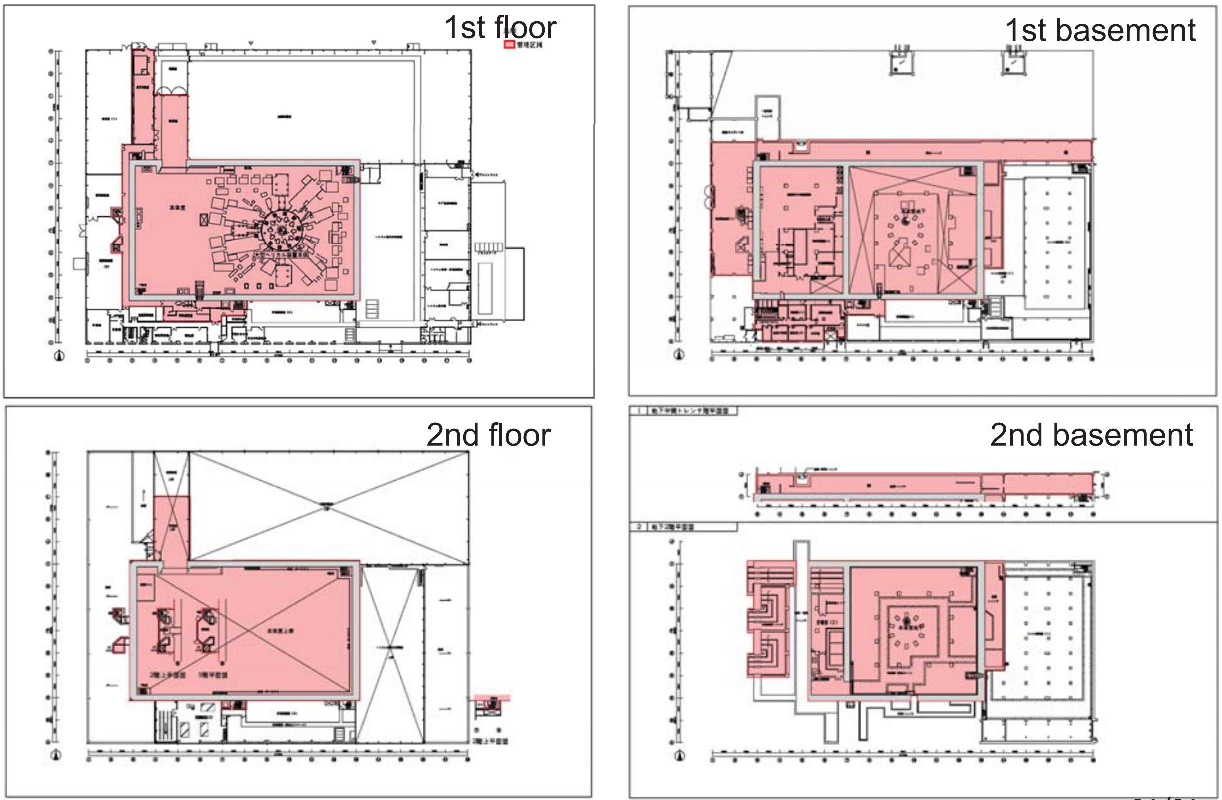
○ Main radionuclide

Graphite : T, C-14, Be-7
SUS316 : T, C-14, Cr-51, Mn-53, Mn-54, Fe-55, Fe-59, Co-56, Co-57, Co-58, Co-60, Ni-59, Ni-63, Zr-95, Nb-95m, Nb-94, Nb-95, Nb-93m, Mo-93, Tc-99

These materials are controlled in the Storage Facility.

4. Controlled Area & Security

- Controlled Area -



Controlled Area in the LHD Building for the Deuterium Experiments

Access Control

- Gates and Security Code (SQRC) -

Access Gates and SQRC (Security QR Code) for authentication

SQRC seal are affixed on personal dosimeters. Then, no one can enter the controlled area without personal dosimeter.

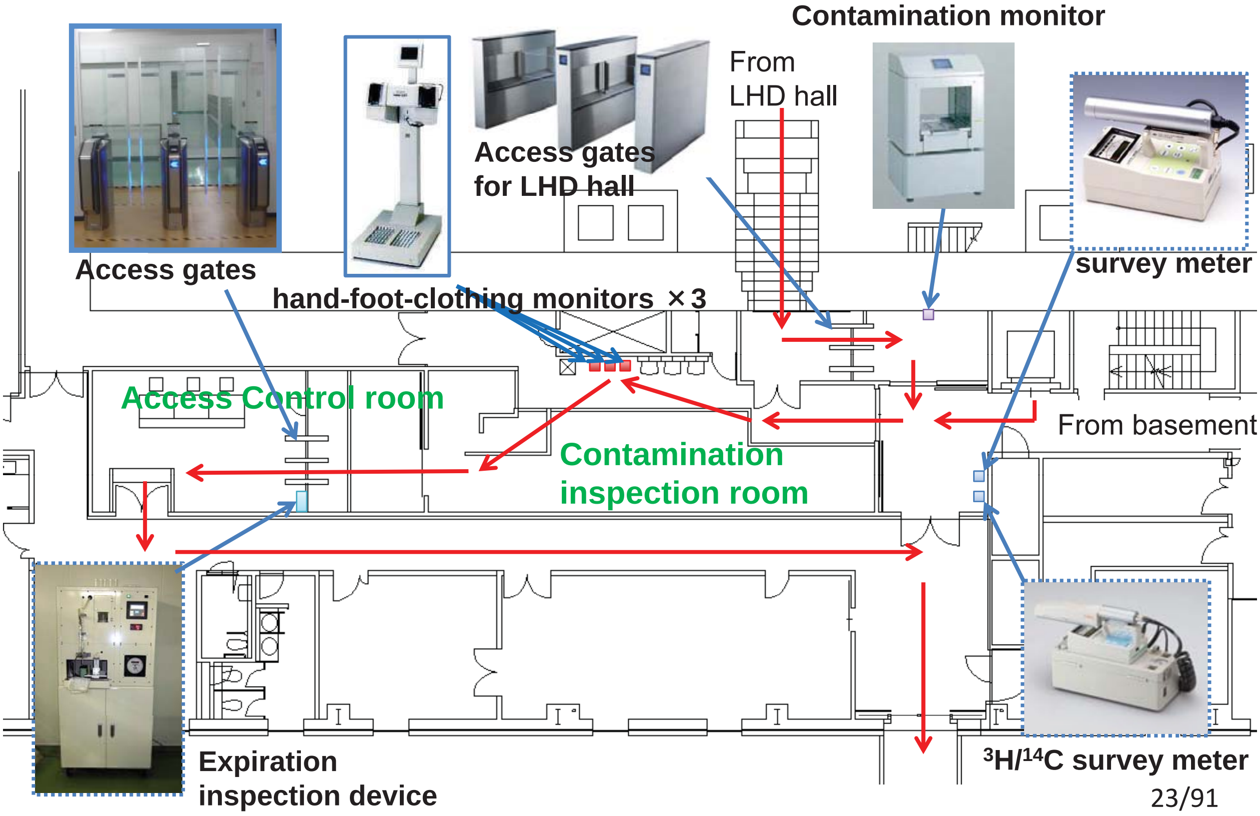
Personal dosimeter with SQRC

SQRC reader

Access gates

Access control room and rocker room

- Exit Flow and Contamination Test Apparatus -



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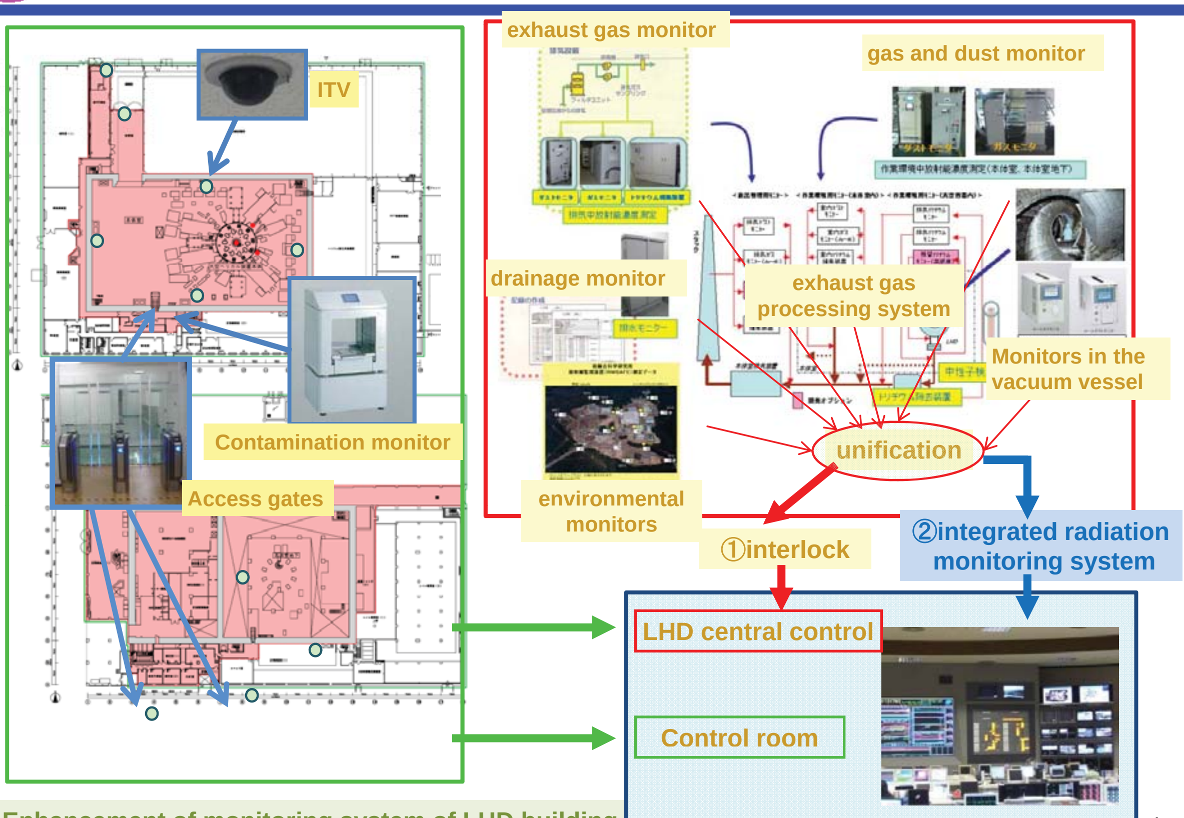
5. Integrated Radiation Monitoring System



③ Enhancement of monitoring system of LHD building

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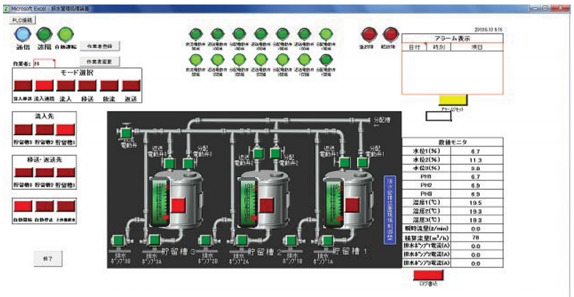
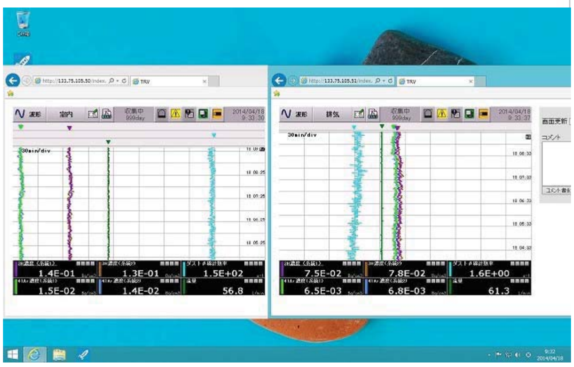
Example of Monitoring Displays

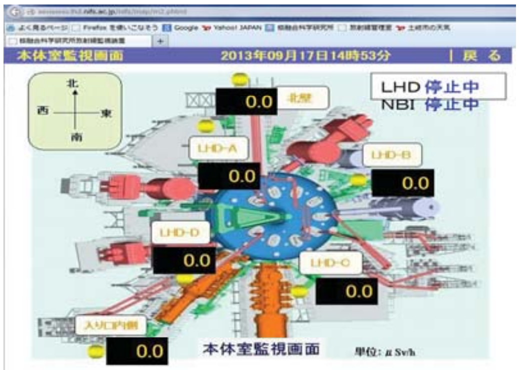
DRAINAGE CONTROL SYSTEM



RMSAFE (SITE BOUNDARY)



STACK and LHD HALL GAS MONITOR



RMSAFE(LHD HALL)

Measuring Instruments (1)

Measuring equipment

・prepared and started operations to get BG data

Stack gas monitors

^{3}H sampler for stack gas

Low background Liquid scintillation counters(LSC-LB7)

Drainage tanks

Drainage monitor

Ultra Low Level Liquid Scintillation Spectrometer (1220 QUANTULUS)

Auto Well Gamma System (AccuFLEX 7000)

Measuring Instruments (2)

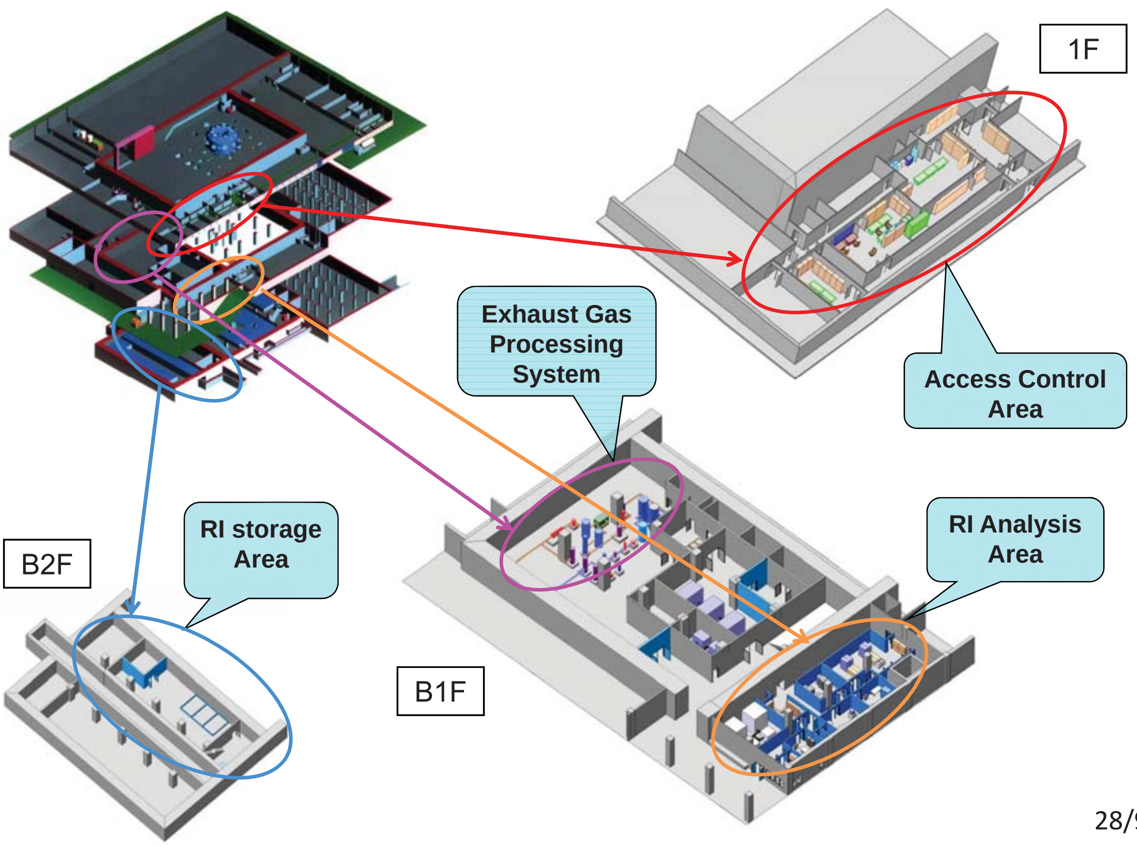
Air monitors for the LHD hall

Monitoring post of RMSAFE

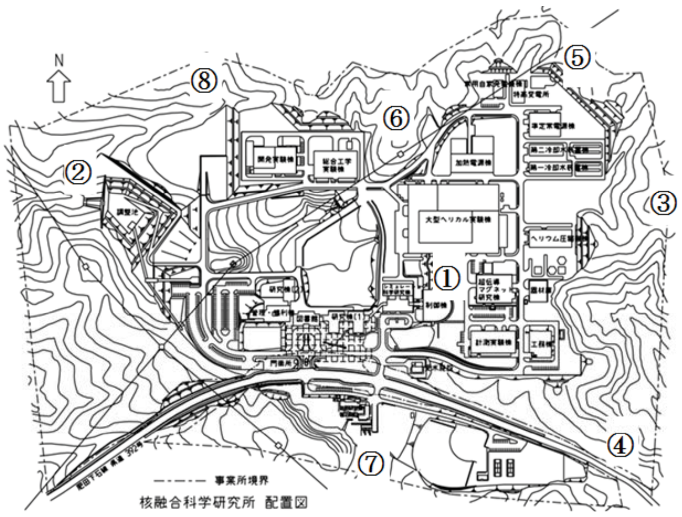
hand-foot-clothing monitors

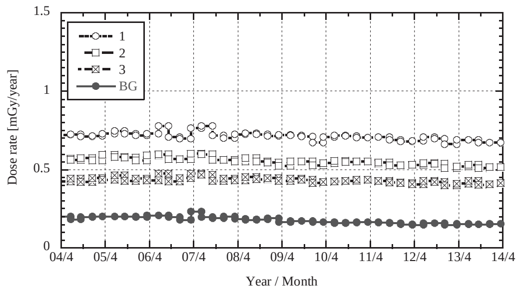
Survey meters

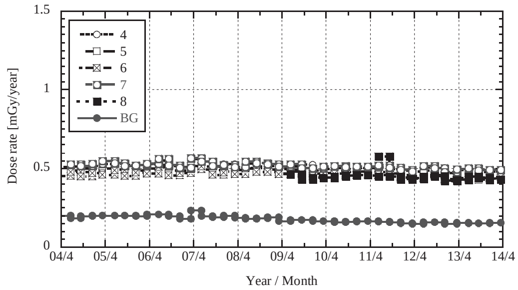
Renovated LHD Building to apply D-experiments



Environmental Radiation Monitoring







Cumulative dose were monitored by glass dosimeter installed in the site (1) and site boundary (2-8).

Data shows the flat background dose.

Environmental Radiation Monitoring
- Background of Radioactivity -

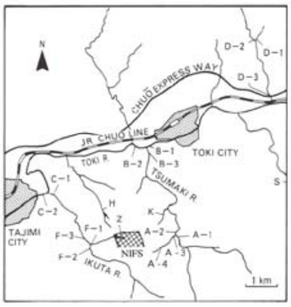
Environmental background of radioactivity	→	It is need to estimate the influence of the deuterium experiments

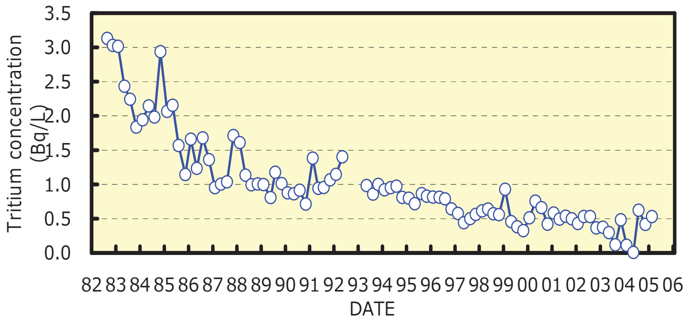
Following environmental background is being measured.

- **Radioactivity in the Stack Gas**
- **Atmospheric tritium**
  - **Three chemical type of tritium was measured separately**
    - **water vapor (HTO), molecular hydrogen (HT) and hydrocarbons (CH_3T)**
- **Tritium in the river water (HTO)**
  - **Recent date is under 0.5 Bq/L.**
- **Tritium in plant samples (FWT and OBT)**
  - **Pine needles at NIFS and Shiomi-park**
- **Environmental radionuclides**
  - **rain, atmospheric dust, atmospheric deposition and surface soil**

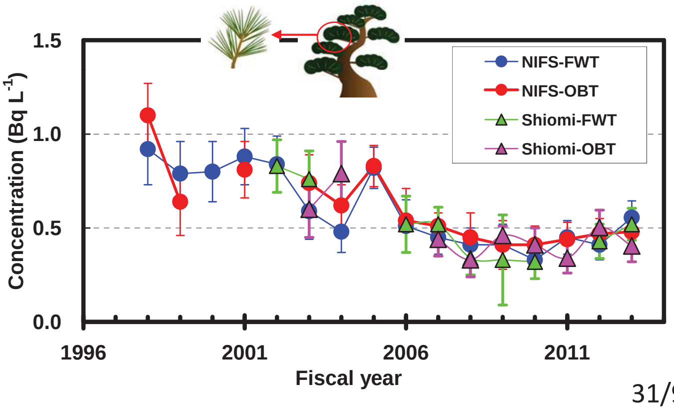
- Examples of Background of Radioactivity Data-

Tritium concentration in the river water





Tritium concentration in the plant

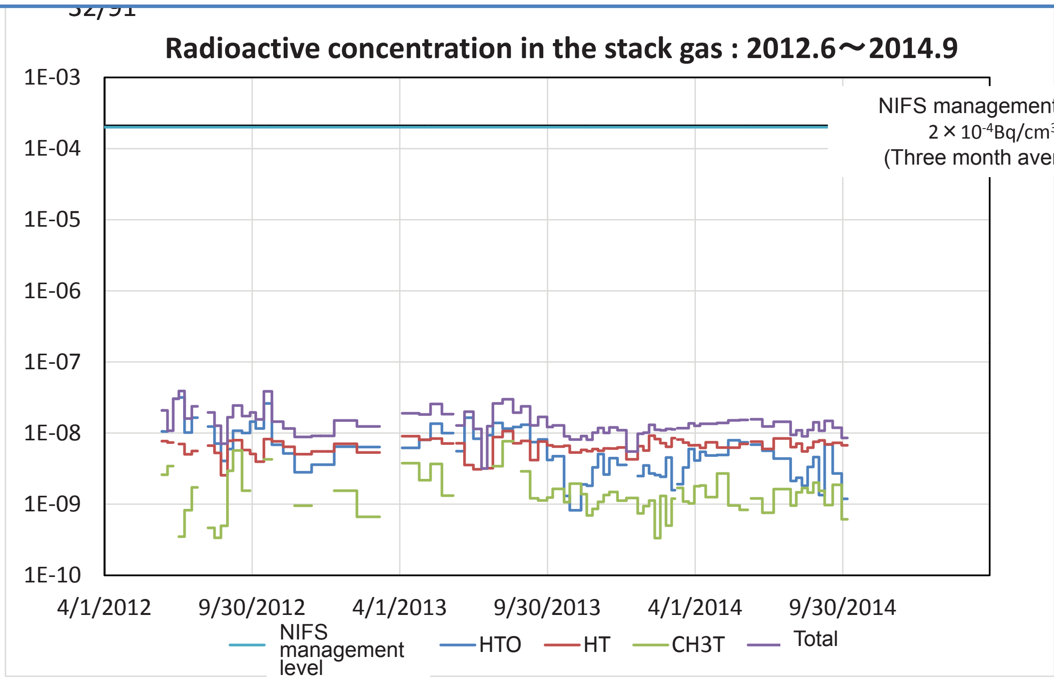


FWT: Free Water Tritium
OBT: Organically Bound Tritium

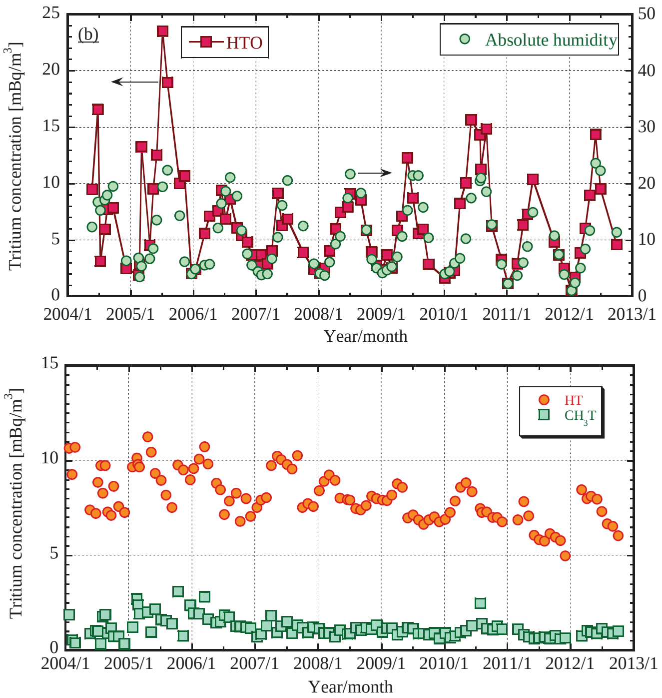
Background of Radioactivity

- Radioactivity in the Stack Gas -

Radioactivity in the stack gas is measured as background data in order to estimate the influence of the deuterium experiments.



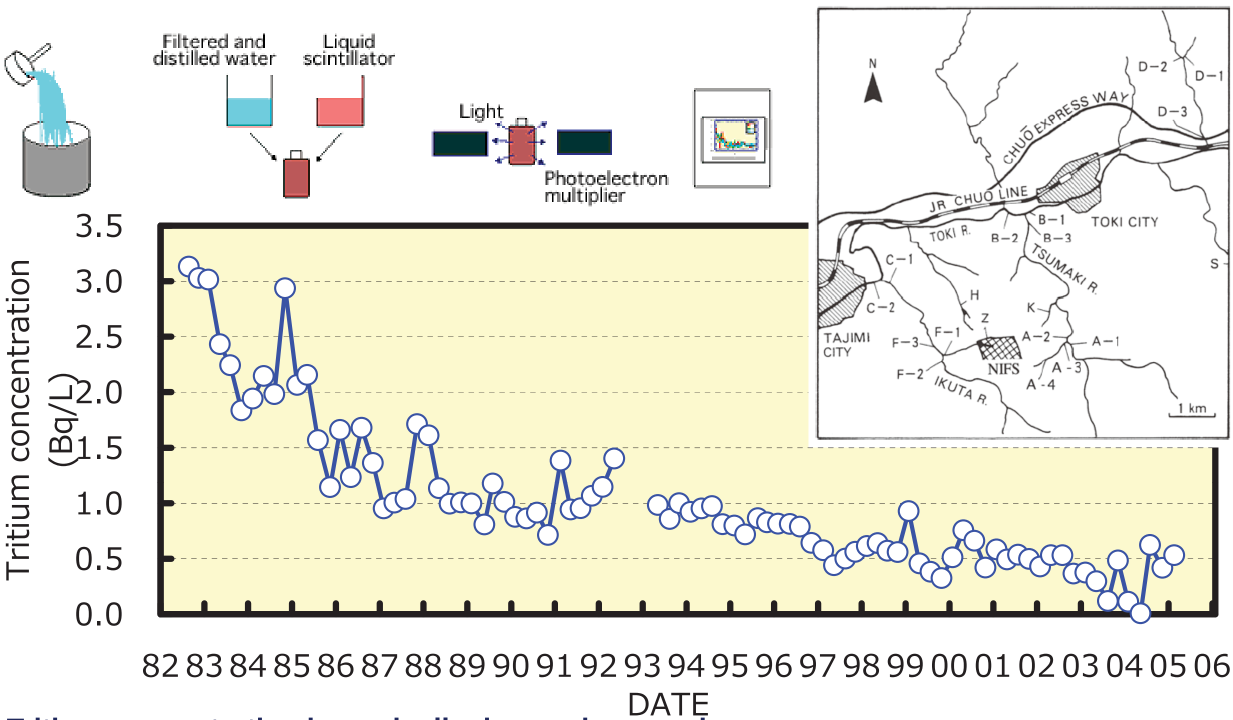
- Tritium monitoring in the atmosphere -



- ✓ Atmospheric tritium concentrations of three chemical forms such as <u>HTO</u>, <u>HT</u> and <u>CH_3T</u> had been measured since 2004.
- ✓ Tritium concentrations of HTO, HT and CH_3T were distributed around <u>**2-23 mBq/m^3**</u>, <u>**5-11 mBq/m^3**</u> and <u>**0.5-3 mBq/m^3**</u>.
- ✓ The HTO concentration depends on humidity in air.
- ✓ Recent <u>decreasing rate of HT concentration</u> to half was estimated <u>**19.4 years**</u>.

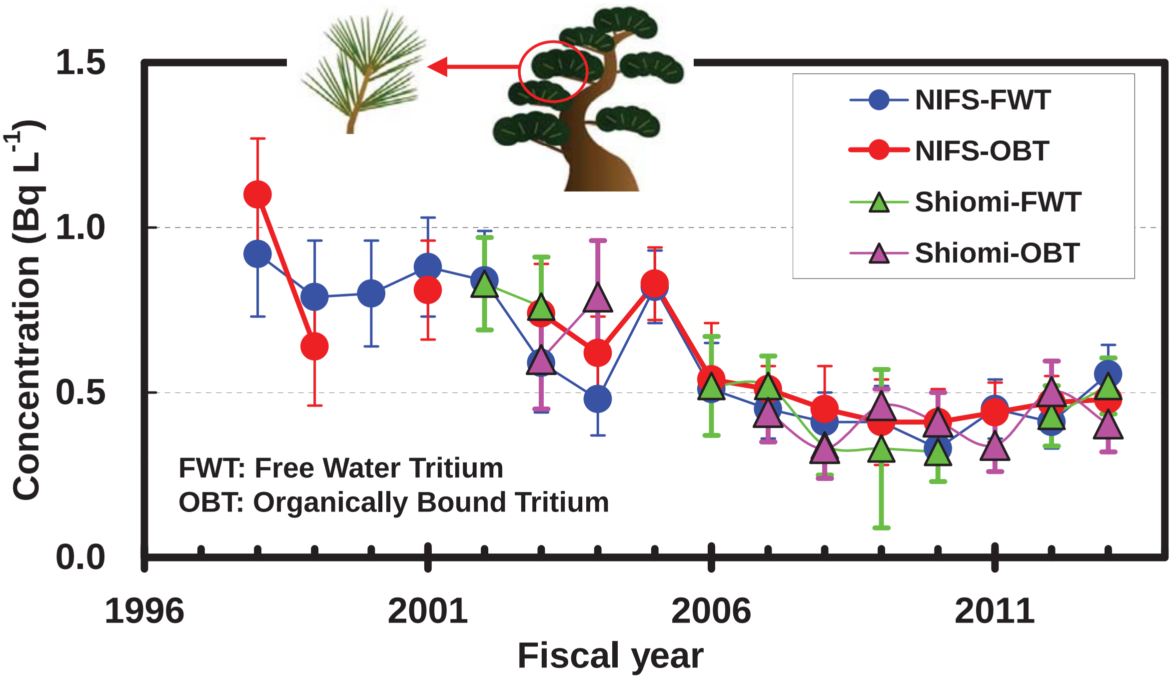
Atmospheric tritium was separately collected as water vapor (HTO), molecular hydrogen (HT) and hydrocarbons (CH_3T) by using this sampling system.

- Tritium monitoring in the river water -



Tritium concentration is gradually decreasing year by year.
Recent date is under 0.5 Bq/L.
This result is similar to background tritium concentration in Japan.

- Tritium monitoring in plant samples -



We monitored tritium concentration in pine needle samples.
Shiomi park is located about 5km south of NIFS.
FWT and OBT concentrations are gradually decreasing, and recent data is background level.

- Environmental monitoring of radionuclides -

Rain sampler

Air sampler

Atmospheric deposition sampler

Surface soil sampling

Passive type sampler (atmospheric water vapor)

In order to understand the background level of radionuclides, we stated the rain, atmospheric dust, atmospheric deposition and surface soil collection.

We also started the passive type sampling of HTO in atmospheric water vapor. A passive type sampler which does not require any power supply is more effective for the study on atmospheric HTO behavior around the LHD.

(3-2) Are safety management equipment, facilities, and experiment equipment being planned appropriately for the safe accomplishment of the deuterium experiment and to support management?

In the deuterium experiment, a neutron and tritium are produced, and this neutron activates the surrounding materials. Activated materials radiate the secondary Gamma-ray. To manage these safely, it is necessary to grasp quantity of the neutron production precisely. To measure the quantity of neutron precisely, the fission chamber detectors are used. To ensure this measurement, the calibration using 252-Cf will be carried out in LHD.

The deuterium experiment is limited by the quantity of the neutron production and the experiment is planed not to exceed the maximum neutron budget.

Protection against the neutron and gamma-ray are designed using the DORT-code and FISPACT-code. In this calculation, some shielding materials and some through holes are taking account. To reduce the radio-activation by the neutron, some holes are buried by the polyethylene and floor concrete under the LHD machine will be covered with the Borated Polyethylene brocks.

(3-2) Are safety management equipment, facilities, and experiment equipment being planned appropriately for the safe accomplishment of the deuterium experiment and to support management?

To minimize the influence of the radiation and tritium to the environment, NIFS management levels, which are lower than the levels in law, are set. Exhaust, ventilation, drainare and their monitoring system are equipped to keep the NIFS management level. The radiation monitoring system is also equipped.

Radio-Active wastes are classified into 8 categories and put in the container of the JRIA designation. These are kept at one time in a Disposal –by-Storage Facility and are asked JRIA for processing.

To reduce the tritium in the exhaust, 2 type of tritium removal systems are designed and equipped as the exhaust gas processing system. Tritium concentration is control 1/25 lower than that in law. Recovered water from the tritium removal systems is contained trebly in the JRIA container and is kept in the waterproof storage section. Some tritium monitors are set to get the background data.

(3-2) Are safety management equipment, facilities, and experiment equipment being planned appropriately for the safe accomplishment of the deuterium experiment and to support management?

Control area is set in the LHD building. To reduce unguarded expansion of the radiation contamination, entrance of this area is only one. Rocker room, contamination inspection room, decontamination room, etc. are set taking account the flow line. Key of each room is electric lock and controlled at the access control room.

Radiation related equipment is connected to the Integrated Radiation Monitoring System and be monitored their conditions on this system. Some date is connected to the LHD interlock system.

(3-1) Is the fundamental concept regarding safety management appropriate at the time of the formulation of the deuterium experiment execution plan as also based upon the opinions of local residents?

重水素実験の目的は適切か、またその目的を達成する研究計画及び安全を確保する実施体制となっているか。

(3-2) Are safety management equipment, facilities, and experiment equipment being planned appropriately for the safe accomplishment of the deuterium experiment and to support management?

安全管理機器・設備、実験機器等は重水素実験を安全に遂行し、維持管理するために適切に計画されているか。

(3-3) In order to safely accomplish the deuterium experiment, are various types of regulations being formulated appropriately?

重水素実験を安全に遂行するために、規則類は適切に策定されているか。

(3-4) Are the operation manual, the radiation management manual, and the emergency manual being formulated appropriately?

運転マニュアル、放射線管理マニュアル、緊急時マニュアル等は適切に策定されているか。

(3-5) Are the organization and the system for safety management when the deuterium experiments are being conducted being constructed appropriately?

重水素実験を実施する際の安全管理のための組織、体制等を適切に構築しているか。

(3-6) Are education and training for the safe execution of the deuterium experiments, and nurturing for those responsible for safety management being undertaken appropriately?

重水素実験の安全な遂行に向けた教育・訓練及び安全管理責任者の養成は適切に計画されているか。

Present NIFS Regulations for Experiment

Followings are present NIFS regulations for LHD experiment

※ [NIFS Regulation of Prevention of Radiation Hazards] is revising to fit the Deuterium Experiment now

NIFS Safety and Health Regulation
核融合科学研究所安全衛生管理規則

NIFS Regulation of Prevention of Radiation Hazards (revising for D-experiment)
核融合科学研究所放射線障害予防規程（案）

NIFS Detailed Regulation of the Vacuum Maintenance on LHD
核融合科学研究所大型ヘリカル装置真空維持管理細則

NIFS Detailed Regulation of the Heavy Ion Beam Probe
核融合科学研究所重イオンビームプローブ装置の維持管理細則

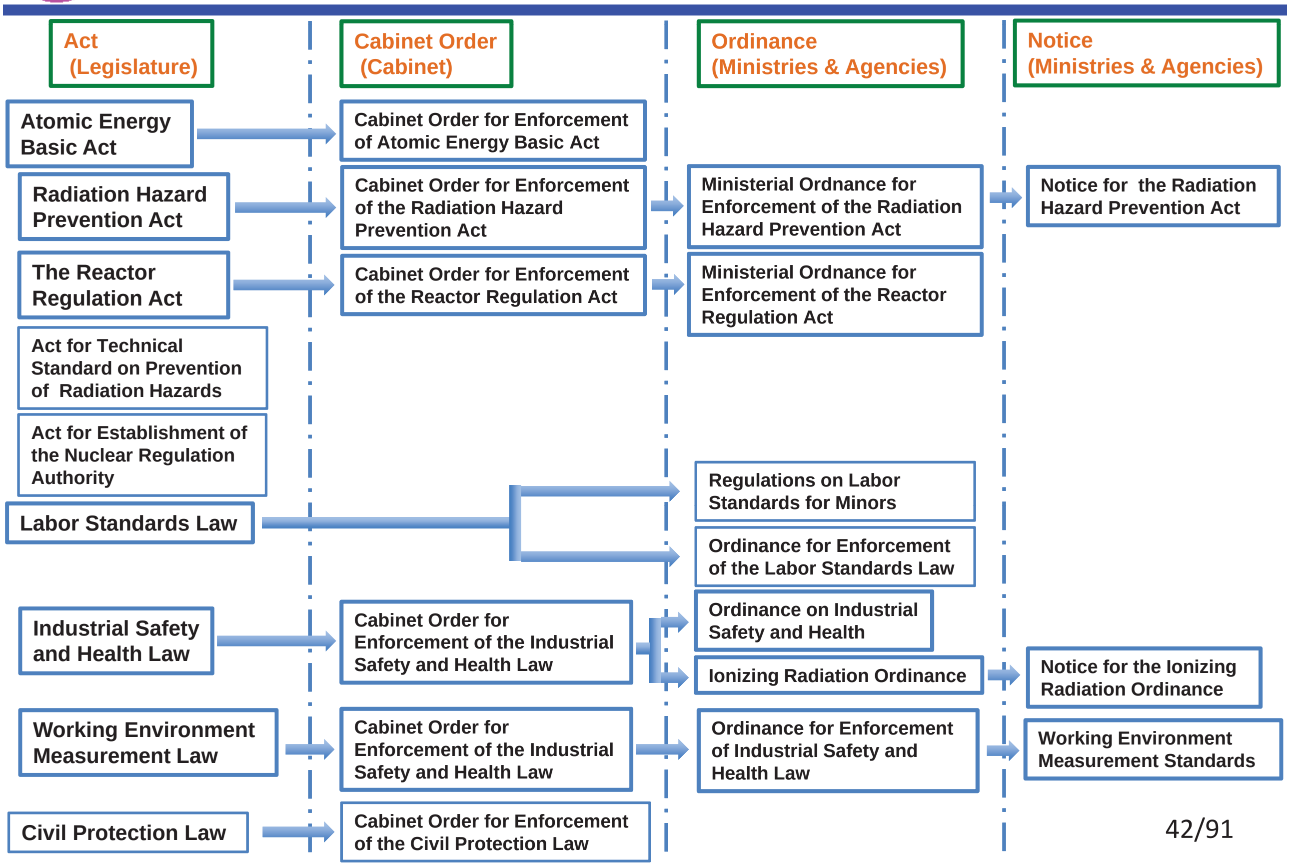
NIFS Detailed Regulation of Experimental Devices
核融合科学研究所における実験装置等の維持管理細則

NIFS Detailed Regulation of the X-rays Device
核融合科学研究所におけるエックス線装置の維持管理細則

NIFS Detailed Handling Regulation of very small amount Sealed Radioisotope
核融合科学研究所微量密封放射性同位元素等取扱細則

NIFS Detailed Regulation of the Ion Beam Analyzer
核融合科学研究所イオンビーム解析装置の維持管理細則

- General Hierarchy of Law related to Radiation -



- Rules for Deuterium Experiment -

Act → **Ordinance** → **NIFS Regulation** → **NIFS Internal Rules** → **Manual etc.**

原子力基本法 →

放射線障害防止法	放射線障害防止法施行規則		核融合科学研究所 放射線障害予防規程	装置維持管理細則	運転マニュアル他
第21条 放射線障害予防規程 許可届出使用者は放射線障害を防止するため文部科学省令ので定めるところにより放射性同位元素若しくは放射線発生装置の使用を開始する前に、放射線障害防止規程を作成し、文部科学大臣に届け出なければならない。		第21条 放射線障害予防規程 放射線障害予防規程は、次の事項について定める	第5条 所長は、法及びこの規程に定める事項の実施に関し、装置の維持・管理に関する取扱及び運用基準等を、維持管理細則として別に定めるものとする。	・大型ヘリカル装置係る通報連絡に関する細則 ・大型ヘリカル装置維持管理細則 ・重イオンビームプローブ維持管理細則 ・校正用(252-Cf) 密封線源維持管理細則 ・核分裂計数管維持管理細則 ・イオンビーム解析装置維持管理細則 ・核融合科学研究所における実験装置等の維持管理細則 ・エックス線装置の維持管理細則 ・微量密封放射性同位元素取扱細則	・通報・連絡マニュアル ・放射線管理マニュアル 1-1 運転監視マニュアル 1-2 入退管理マニュアル 1-3 真空容器内作業マニュアル 1-4 ポート作業マニュアル 1-5 真空系取扱マニュアル 1-6 本体室作業マニュアル 1-7 トリチウム回収マニュアル 1-8 加熱運転マニュアル 1-9 物品搬出入マニュアル 1-10 試料取扱マニュアル 1-11 分析エリア作業マニュアル
		(1)取扱に従事する者に関する職務及び組織に関すること	第7条～第18条		
放射線取扱主任者（第34条）	放射線取扱主任者の選任他（第30条～第32条）	(1)の2 放射線取扱主任者及び安全管理に従事する者の職務及び組織に関すること	第7条～第13条		・LHD運転マニュアル 2-1 本体運転マニュアル 2-2 本体冷却マニュアル 2-3 加熱機器運転マニュアル 2-4 計測機器運転マニュアル 2-5 入退管理装置運転マニュアル 2-6 放射線総合監視システム運転マニュアル 2-7 トリチウム除去装置運転マニュアル 2-8 分析機器運転マニュアル
放射線取扱主任者の代理者（第37条）	放射線取扱主任者の代理者（第33条）	(1)の3 放射線取扱主任者の代理者の選任に関すること	第14条		
使用の許可の基準（第6条）	使用施設の基準（第14条の7） 貯蔵施設の基準（第14条の9） 廃棄施設の基準（第14条の11）	(1)の4 放射線施設の維持及び管理に関すること	第21条～第23条		
		(1)の5 放射線施設の点検に関すること	第22条～第23条		
使用の基準（第15条）	使用の基準（第15条）	(2)放射性同位元素及び放射線発生装置の使用に関すること。	第24条、 第24－3条～第24－9条		
保管の基準（第16条） 運搬の基準（第17条） 廃棄の基準（第18条）	保管の基準（第17条） 運搬の基準（第18条） 廃棄の基準（第19条）	(3)放射性同位元素等の受入れ、払出し、保管、運搬又は廃棄に関すること	第24－1条、第24－2条、 第24－10条		
測定（第20条）	測定（第20条）	(4) 放射線の量及び放射性同位元素による汚染の状況の測定並びにその測定の結果について実施すべき措置に関すること	第27条～第30条		・放射線・装置管理区域関連マニュアル 3-1 重イオンビームプローブ運転マニュアル 3-2 252-Cf使用マニュアル 3-3 核分裂計数管使用マニュアル 3-4 イオンビーム解析装置運転マニュアル 3-5 ECH運転マニュアル 3-6 NBI運転マニュアル 3-7 校正用X線源運転マニュアル 3-8 ESCA・XRD運転マニュアル 3-9 微量密封線源取扱マニュアル
教育訓練（第22条）	教育訓練（第21条の2）	(5)放射線障害防止するために必要な教育及び訓練に関すること	第31条		
健康診断（第23条）	健康診断（第22条）	(6)健康診断に関すること	第32条		
放射線障害を受けた者又は受けたおそれのある者に対する措置（第24条）	放射線障害を受けた者又は受けたおそれのある者に対する措置（第23条）	(7)放射線障害を受けた者又は受けたおそれのある者に対する保健上必要な措置に関すること	第33条		
記帳義務（第25条）	記帳（第24条）	(8)法律第25条に規定する記帳及び保存に関すること	第34条～第41条		
事故届（第32条） 危険時の措置（第33条）	危険時の措置（第29条） 報告徴収（第39条第1項）	(9)地震、火災その他の災害が起こった時の措置に関すること	第42条～第43条		
		(10)危険時の措置に関すること	第44条		
報告徴収（第42条）	第39条第3項	(11)放射線管理の状況の報告に関すること	第45条		
		(12)省略			
		(13)その他放射線障害の防止に関し必要な事項	第47条		
原子炉等規制法 計量管理規定（第61条の八）	核燃料物質の使用等に関する規則		核融合科学研究所 計量管理規定	装置維持管理細則 ・核分裂計数管維持管理細則	運転マニュアル他 3-3 核分裂計数管使用マニュアル

We establish internal rules and manuals before starting Deuterium experiment.

- Examples of NIFS Regulation –

NIFS Regulation of Prevention of Radiation Hazards

核融合科学研究所放射線障害予防規程（案）

目次

第１章　総則

（目的）

第１条　この規程は，核融合科学研究所（以下「研究所」という。）における放射線の発生を伴う装置並びに放射性物質等の取扱い及び管理に関する事項を定め，放射線障害の発生を防止し，あわせて公共の安全を確保することを目的とする。

２　放射線障害の防止に関しては，放射性同位元素等による放射線障害の防止に関する法律（昭和３２年法律第１６７号。以下「法」という。），及び労働安全衛生法（昭和４７年法律第５７号），電離放射線障害防止規則（昭和４７年労働省令第４１号。以下「電離則」という。）等の関係法令に定めるもののほか，この規程の定めるところによる。

（適用範囲）

第２条　本規程は，研究所の放射線施設に立ち入るすべての者に適用する。

（用語の定義）

第３条　この規程において，次の各号に掲げる用語の定義は，それぞれ当該各号に定めるところによる。

（1-1）「装置」とは次に掲げるものをいう。

イ　法第２条第４項に規定する放射線発生装置

ロ　イに掲げるもののほか，電離則第１５条第１項に規定する放射線を発生する装置又は機器及び所長の指定するものをいう。

（1-2）「放射性同位元素」とは，法第２条第２項に規定するものをいう。

（1-3）「放射化物」とは，放射線発生装置から発生した放射線により生じた放射線を放出する同位元素によって汚染された物をいう。

（1-4）「放射性物質等」とは，放射性同位元素，放射化物及び放射性同位元素又は放射化物で汚染された物をいう。

（1-5）「放射線施設」とは，法第３条第２項第５号から第７号までに規定する使用施設，貯蔵施設及び廃棄施設並びに附属設備をいう。

（1-6）「管理区域」とは，放射線管理の便のために設けられる区域であって，放射性同位元素等による放射線障害の防止に関する法律施行規則（昭和３５年総理府令第５６号。以下「法施行規則」という。）第１項第１号に規定する管理区域をいう。

（1-7）「放射性廃棄物」とは，放射性物質等であって廃棄しようとする物をいう。

（2）「放射線業務」とは装置並びに放射性物質等を取り扱う業務をいう。

（3）「業務従事者」とは装置又は放射性物質等の使用，管理並びにこれに付随する業務に従事するため，管理区域に立ち入る者で，所長が放射線業務従事者に指定した者をいう。

（4）「一時立入者」とは見学等の目的で，一時的に管理区域に立入るもので管理区域責任者の許可を得た者をいう。

1

（他の規程との関連）

第４条　装置又は放射性物質等の取扱いに係る保安については，本規程に定めるもののほか，次の各号に掲げる規則その他保安に関する規程等の定めによる。

（1）　核融合科学研究所安全衛生管理規則　（平成１６年規則第３号）

（2）　核融合科学研究所電気保安規則　（平成１６年規則第７号）

（3）　核融合科学研究所高圧ガス（一般）危害予防規則　（平成１６年規則第８号）

（4）　核融合科学研究所高圧ガス（冷凍）危害予防規則　（平成１６年規則第９号）

（5）　核融合科学研究所防災規則　（平成１７年規則第６号）

（細則等の制定）

第５条　所長は，法及びこの規程に定める事項の実施に関し，装置又は放射性物質等の維持・管理に関する取扱い及び運用基準等を，維持管理細則として別に定めるものとする。

（遵守等の義務）

第６条　業務従事者及び管理区域に一時的に立ち入る者は，放射線取扱主任者が放射線障害防止のために行う指示を遵守し，その指示に従わなければならない。

第２章　組織及び職務

（管理組織）

第７条　研究所における放射線業務に従事する者及びこれらの安全管理に従事する者の組織は，別表第１のとおりとする。

（安全衛生委員会）

第８条　研究所における放射線障害の防止に関する事項は，核融合科学研究所安全衛生委員会（以下「安全衛生委員会」という。）において審議する。

（放射線管理室）

第９条　研究所の安全衛生推進部長（以下「部長」という。）の下に放射線管理室を置く。

２　放射線管理室は，放射線施設における放射線安全管理に関する次に掲げる業務を行う。

（1）　装置の保守及び点検

（2）　装置及び管理区域に係る放射線の量の測定並びに放射性物質等による汚染の状況の測定

（3-1）　管理区域へ立ち入る者の入退域及び被ばく線量の管理及び汚染の状況の管理

（3-2）　放射性物質等の受入れ，譲渡，使用，保管，運搬及び廃棄に関する業務及び管理

（3-3）　放射性廃棄物の管理及び処理に関する業務

（3-4）　排気及び排水の管理

（4）　放射線業務従事者及び一時立入者に対する教育及び訓練の実施

（5）　放射線測定機器の保守管理

（6）　放射線業務従事者の登録に関する業務

（7）　前各号の業務に関する記帳及び記録並びにその管理

（8）　関連法令に基づく申請，届出及び報告に係る書類の作成業務

（9）　注意事項等の掲示

（10）放射線に関わる安全マニュアルの作成

（11）その他放射線障害の防止のための必要な技術的事項

３　放射線管理室に室長を置き，部長が放射線取扱主任者の意見を聴いて，選任する。

４　放射線管理室長（以下「室長」という。）は，第２項の放射線安全管理に関する業務を総括する。

2

- Examples of NIFS Regulation –

NIFS Detailed Regulation of Experimental Devices

核融合科学研究所における実験装置等の維持管理細則

制　　定　平成１６年７月１５日　所長裁定

（趣旨）

第１　核融合科学研究所放射線障害予防規程（平成１６年度規則第５号。以下「規程」という。）第５条の規定に基づく核融合科学研究所（以下「研究所」という。）の第２に定める実験装置等の維持及び管理に関し必要な事項は，この細則の定めるところによる。

（用語の定義）

第２　この維持管理細則の適用を受ける「実験装置等」は次の各号に定めるところによる。

(1)　大型ヘリカル実験棟に設置された大型ヘリカル装置本体，中性粒子入射加熱装置及び電子サイクロトロン共鳴加熱装置

(2)　総合工学実験棟に設置された中性粒子入射加熱法開発試験装置

（装置管理区域及び装置監視区域）

第３　規程第１９条第２項に基づいて指定する装置等に係る管理区域（以下「装置管理区域」という。）は別図１及び別図２のとおりとする。ただし，装置管理区域は，設備，機器等の保守点検，改装工事のためやむを得ない場合に限り，その指定を一定期間解除又は変更することができる。

２　装置管理区域の外側に近接する区域にあって，放射線の発生するおそれのある実験を行う期間（以下「マシンタイム」という。），業務従事者が装置等の運転監視や保守管理等を行うため常時又は随時立ち入る区域（以下「装置監視区域」という。）は，別図１及び別図２のとおりとする。

（装置管理区域範囲の一時解除又は変更の手続き）

第４　第３第１項ただし書きの規定に基づき，装置管理区域責任者は，装置管理区域の指定を一時的に解除又は変更しようとする場合は，変更の内容，期間，安全対策，理由等を記入した所定の申請書を所定の期日までに，放射線管理室長（以下「室長」という。）を経由して安全衛生推進部長（以下「部長」という。）に提出しなければならない。

２　部長は，前項の規定により装置管理区域解除又は変更の申請があったときは，室長及び放射線取扱主任者（「主任者」という。）と協議の上，解除又は変更の可否を決定し，その旨を装置管理区域責任者に通知するとともに所長に報告するものとする。

３　装置管理区域責任者は，装置管理区域解除又は変更が許可された場合はその内容を立ち入るものに周知しなければならない。

（放射線測定器の設置）

第５　規程第２７条に規定する放射線の量を測定するため，次に掲げる場所に放射線測定器（以下「測定器」という。）を設置する。

(1)　研究所の敷地境界に１箇所以上

(2)　敷地内にあって実験棟の近くに１箇所以上

(3)　装置監視区域内に１箇所以上

(4)　装置管理区域内に１箇所以上

（巡視）

第６　規程第２２条に規定する巡視は，次に掲げる事項について行うものとする。ただし，（３）は大型ヘリカル実験棟のみとする。

(1)　装置管理区域の区画，標識及びインターロック等の確認

(2)　出入管理システムの作動確認

(3)　自動表示装置の作動確認

(4)　各モニター設備の作動確認

(5)　放送設備の作動確認

(6)　その他管理状況の確認

２　前項の巡視の実施項目は，別表１－１及び別表１－２に定める。

３　装置管理区域責任者は，巡視結果を所定の期間ごとに，室長に提出しなければならない。

４　停電，断水，設備等の故障その他の事故及び地震，火災等の災害により，緊急に実験棟内の巡視を行う必要が生じたときは，その都度，実施するものとする。

（点検）

第７　規程第２３条に規定する点検は，次に掲げる事項について行うものとする。

(1)　実験棟の周囲の状況

(2)　実験棟の主要構造及び遮へいの異常の有無

(3)　装置管理区域区画等の異常の有無

(4)　各モニター設備の異常の有無

(5)　標識，注意事項表示等の状況

(6)　その他実験棟内の異常の有無

２　前項の点検の実施細目は，別表２－１及び別表２－２に定める。

３　装置管理区域責任者は，点検結果を所定の期間ごとに，室長に提出しなければならない。

（実験計画等の提出）

第８　装置管理区域責任者は，マシンタイム開始日までに，当該マシンタイム中における実験計画書を，室長に提出しなければならない。

２　装置管理区域責任者は，マシンタイムごとに測定された放射線量を１週間ごとにまとめ，その結果を所定の期間ごとに室長に提出しなければならない。

３　装置管理区域責任者は，装置を使用した運転記録を作成し，その結果を所定の期間ごとに，室長に提出しなければならない。

（実験の制限）

第９　マシンタイム中の実験は，装置監視区域内設置測定器の一週間当たり（月曜日を起算日とする。以下同じ。）の積算線量が 100 マイクロシーベルト以内となることを管理目標とし，管理区域の境界で三ヶ月間の積算線量が 1.3 ミリシーベルトを超えない範囲で行わなければならない。

２　装置管理区域責任者は，装置監視区域内設置測定器の一週間当たりの積算線量が 80 マイクロシーベルトを超えたときは，実験を停止し，次に掲げる項目について室長に報告しなければならない。

(1)　装置監視区域内設置測定器の当該週積算線量

(2)　発生箇所および原因

(3)　防止対策

３　装置管理区域責任者は前項の事態が発生したときは，室長の承認がなければ実験を継続して

- Examples of NIFS Regulation –

NIFS Detailed Handling Regulation of very small amount Sealed Radioisotope

核融合科学研究所微量密封放射性同位元素等取扱細則

制　　定　平成13年12月18日　所長裁定
最終改正　平成18年5月19日

（目的）

第1条　この細則は，核融合科学研究所放射線障害予防規程（平成16年度規則第５号）第46条の規定に基づき，核融合科学研究所における微量密封放射性同位元素等（以下「微量RI等」という。）に起因する障害等の予防及び安全な取扱い方法に関し，必要な事項を定めることを目的とする。

なお，ここでいう「微量RI等」は，放射性同位元素等による放射線障害の防止に関する法令に定められた諸条件に抵触しない数量のものを指す。

（定義）

第2条　この細則においては，次の各号に掲げる微量RI等について定めるものとする。

(1)　購入，譲受け又は一時的に所内に持ち込み使用するもの。

(2)　微量RI等が装着，混入されている機器，器具，試薬及び材料のうち，含まれる放射性同位元素の数量が明確であり，入手時に放射性同位元素についての記載事項と表示があるもの。

(3)　その他，放射線管理室長（以下「室長」という。）及び放射線取扱主任者（以下「主任者」という。）が管理の必要性を認めたもの。

（管理）

第3条　前条に規定する微量RI等は，放射線管理室が管理するものとする。ただし，室長及び主任者が特に指定した微量RI等については，その使用者が管理することができる。

2　放射線管理室は，微量 RI 等を保管し，出入庫管理を行う。

3　室長は，微量RI等の管理状況について主任者及び安全衛生推進部長（以下「部長」という）を経由して，少なくとも年1回は所長に報告しなければならない。

（使用者）

第4条　微量RI等を使用できるのは，放射線業務従事登録者又は室長が認めた者とする。

（使用願）

第5条　微量RI等を所内で使用する場合は，使用責任者は別に定める微量密封放射線同位元素使用願を室長に提出するものとする。

2　室長は，前項の使用願を許可したときは，別に定める微量密封放射性同位元素使用許可書を交付する。

3　所外から一時的に微量RI等を持ち込み使用する場合も同様とする。

（貸出と返却）

第6条　微量RI等の貸出を希望する者は，放射線管理室へ交付された微量密封放射性同位元素使用許可書を呈示するとともに，別に定める微量密封放射線同位元素借用書を提出し，微量RI等を借用する。

2　使用責任者は，微量RI等を返却する場合は，放射線管理室へ返却し，受領書の発行を受ける。

3　他の事業所へ貸し出す場合は，当該事業所の放射線安全管理責任者に貸し出すものとする。

（使用の中止）

第7条　使用責任者は，使用期間中であっても，室長又は主任者から使用の中止を求められたときは，使用を中止しなければならない。また，それが貸し出された微量RI等の場合，返却しなければならない。

（使用責任者の義務）

第8条　使用責任者は，次に掲げる諸事項を実施する義務を負う。

(1)　微量 RI 等の安全かつ確実な保管

(2)　微量 RI 等の安全かつ確実な使用のために必要な実験環境又は作業環境の整備

(3)　微量 RI 等を使用者が安全かつ確実に使用するために必要な指導と監督

(4)　使用中若しくは保管中の微量RI等に事故又は異常が発生した場合の応急措置の実施と放射線管理室への速やかな報告

(5)　その他の安全確保上必要な措置

（新規入手）

第9条　微量RI等を新規入手する場合は，室長及び主任者の承認を得なければならない。

2　微量RI等を新規入手した者は，入手後，速やかに入手した微量RI等に，検定書の写し及び別に定める微量密封放射性同位元素入手届を添えて室長に提出しなければならない。

（譲受け，譲渡し）

第10条　微量RI等の譲受け及び譲渡しは，室長及び主任者並びに譲受け又は譲渡す事業所の放射線安全管理責任者との間で事前に合意に達したときにのみ承認される。

2　譲受け又は譲渡す者は，その行為の完了後，速やかに内容を室長及び主任者に報告しなければならない。

（廃棄）

第11条　微量RI等の廃棄手続きは，室長及び主任者の承認を得て，放射線管理室が行う。

2　廃棄にあたっては，法令等を遵守し，手続きを進める。

（危険時等の措置）

第12条　地震，火災及びその他の災害等により，使用中若しくは保管中の微量RI等に所在不明，その他の異常が発生した場合又は発生するおそれのある場合は，これを発見した者は，直ちに使用責任者に通報しなければならない。

2　前項の通報を受けた使用責任者は，直ちに応急の措置を講ずるとともに，速やかに室長及び部長を経由して，主任者及び所長に報告しなければならない。

附　則

この細則は，平成13年12月18日から実施する。

附　則（平成14年11月25日）

この細則は，平成14年11月25日から実施する。

附　則（平成16年7月15日）

この細則は，平成16年7月15日から実施し，平成16年4月1日から適用する。

附　則（平成18年5月19日）

1　この細則は，平成18年5月19日から実施する。

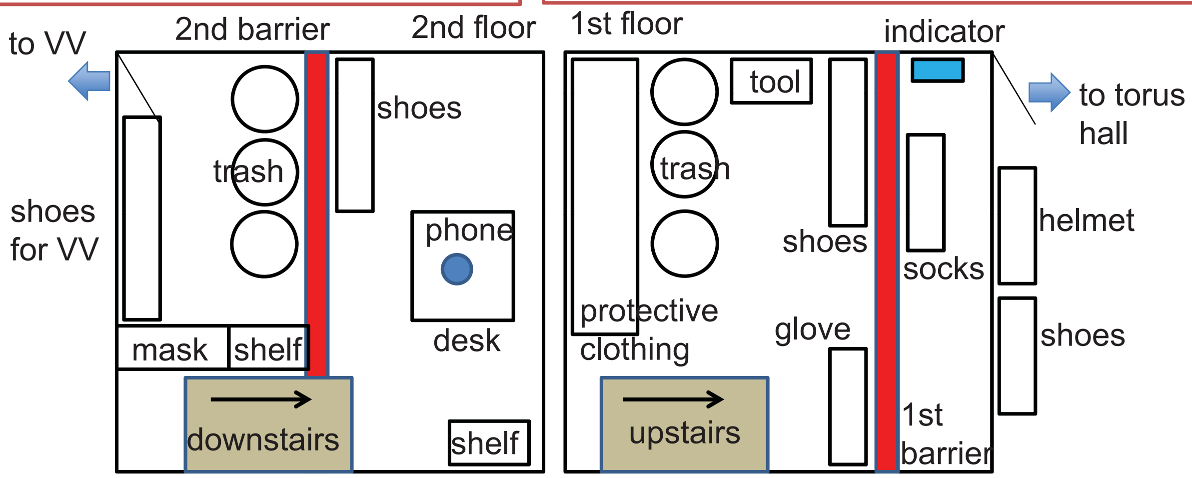
2　平成19年3月31日までに製造された3．7MBq 以下の密封された放射線同位元素のうち規制の下限値（数量と濃度）を超えるものは，本細則を適用するものとする。

- Procedure for in-Vessel Work –
* Prevent the tritium exposure

One should pass through anterior chamber to enter LHD vacuum vessel

Anterior chamber has
- isolated air conditioning system
- 2 level control areas divided by barriers
- survey system for fist check

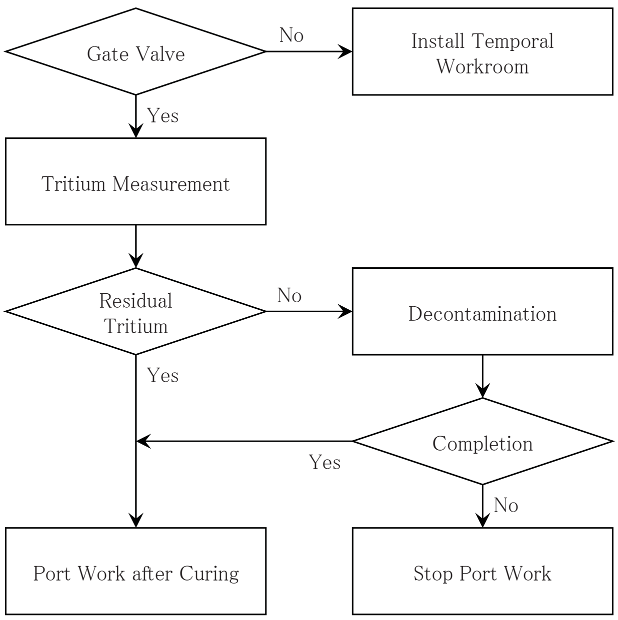
One should
- wear protective clothing depending on work level
- check radiation level, oxygen concentration before entering vacuum vessel



anterior chamber

- Procedure for port Work (Vacuum related) –
* To prevent the tritium exposure

- One should minimize tritium leak to LHD hall
- Staffs who completed the training of tritium handling in Toyama Univ. can conduct port work.



- LHD vacuum vessel is kept in a negative pressure during port work

with gate valve
- Measure residual tritium using a tritium monitor
- After confirming non-existence of residual tritium, port work is conducted with a proper curing
- If residual tritium cannot be decontaminated, port work is stopped

w/o gate valve
- Port work is conducted in a temporal work room with a ventilation equipment

- NIFS management level 1 –

○ Controlled Area (Working area)
  1 mSv/week (100 mSv/5years)
  40 Bq/cm^2

○ Boundary of Controlled Area
  1.3 mSv/3month
  4 Bq/cm^2

○ Site Boundary
  50 μSv/year

○ Tritium production
  37 GBq /year (former 6 years)
  55.5 GBq/year (later 3 years)

○ Maximum Tritium release into environment
  3.7 GBq/year

- NIFS management level 2 –

○ Tritium Concentration in Working Environment (Law)

Types of Radioisotopes		Limit in Working environment
Isotope	Chemical form	(Bq/cm^3)
^{3}H	Gaseous tritium	1×10^4
^{3}H	triated water or vapor	8×10^{-1}

○ Tritium Concentration in Exhaust (NIFS management level)

Types of Radioisotopes		Limit in Air or Exhaust	Limit in Drainare or Waste water
Isotope	Chemical form	(Bq/cm^3)	(Bq/cm^3)
^{3}H	Gaseous tritium	7×10^1	
^{3}H	triated water or vapor	2×10^{-4} (5×10^{-3})	6×10^{-1} (6×10^1)

( ) : Concentration Limit in Law

- Radiation Monitoring Equipment -

使用目的	使用場所	検出対象	頻度	測定器	検出方法	サンプリング時間	検出下限	研究所管理値	備考
中性子計測	本体室	中性子	プラズマ実験連動	フィッションチェンバー	電離箱	リアルタイム		1-6年：2.1E19/年 9- 年：3.2E19/年	別途、警報値を設定する
排気測定	排気塔	トリチウム	連続	ガスモニター	通気式電離箱	5分～	5E-3Bq/cm³	5E-3Bq/cm³ (法規制値)	異常値を検出
			積算	トリチウム捕集装置	貴金属触媒＋モレキュラーシーブにより捕集後液シン測定	1週間	2E-5Bq/cm³ 以下	総排出量、年間3.7E+9Bq (0.1Ci) 3ヶ月平均濃度 2E-4 Bq/cm³	総量及び濃度管理
		放射化空気(Ar-41)	連続	ガスモニター	通気式電離箱		5E-4Bq/cm³	5E-4Bq/cm³ (法規制値)	本体室の計測値及び中性子発生率と併せて確認
		ダスト（α線、β線）	連続	ダストモニター	濾紙上に集塵して検出				
排出量算出	真空排気ガス処理系	トリチウム	連続	ガスモニター	通気式電離箱	2～3分	0.1Bq/cm³	35 Bq/cm³ (注1)	
	真空容器換気処理系	トリチウム	連続	ガスモニター	通気式電離箱	2～3分	5E-3Bq/cm³	5E-3Bq/cm³	排気口管理レベルを下回ること
排水測定	貯留槽	トリチウム C-14	連続	β線水モニター	液シン	10分	0.3Bq/cm³水	0.6Bq/cm³水	
			採水	低BG液体シンチレーションカウンター	液シン	約3時間測定	1E-3Bq/cm³水		
		放射化物	連続	γ線水モニター	NaI検出器	10分	1E-2Bq/cm³水	核種毎の法規制値	
			採水	低BG半導体測定装置	ゲルマニウム検出器				核種確認
	除去装置処理水	トリチウム	採水	低BG液シン	液シン	約3時間測定	1E-3Bq/cm³水		引渡し数量の確認
放射線測定	敷地境界線量	X（γ）線	連続	電離箱	Ar加圧型電離箱	ほぼリアルタイム		50μSv/年	
			積算	線量計	ガラス線量計	1週間又は3ヶ月			
		中性子	連続	比例計数管	He-3計数管	ほぼリアルタイム			
			積算	線量計	電子線量計	1週間又は3ヶ月			

注1）トリチウム回収率95%時の最大出口濃度

[pink]：研究所管理値の監視　[orange]：法令値の監視

- Communication to the local government -

NIFS must report the emergency occurrence to the fire department, the police station and the hometown local government (Toki, Tajimi, Mizunami cities and Gifu Prefecture).
Following items are considered and discussed with the local governments.

○ Communication means
 ・satellite phone (facsimile), electric generator, bicycle, etc.

○ Working time of the communication system
 ・24 hours

○ Matters needing reports

○ the Important matter which should be reported without delay

○ the Matter which should be reported in advance or without delay

○ Report of the disaster occurrence which scale is less than that of former matter

- Communication to the local government 1 -

[Communication Means]
○ NIFS maintains satellite phones (facsimiles) which possessed battery.
In addition, these are connected to the non-common use generation facilities which is available for 7 days.
○ When a satellite phone (facsimile) is cut off, NIFS dispatches person in Toki city hall, Tajimi city hall, Mizunami city hall and the Tounou Promotion Bureau.

[the Communication System]
Because the monitoring system is operating all day, some person work as a responsible person by turns.
A responsible person communicates to the local government and to the other staff.

- Communication to the local government 2 -

[Matter Needing Reports]
○ When the accidents such as fires
○ When the recovered water containing tritium more than the limits of laws and ordinances leaked out in the facility by accidents
○ When the annual dose of radioactivity at the site boundary exceed the limit in law
○ When tritium or Argon-41 more than the limits of law and ordinances was exhausted
○ When the recovered water more than the limits in laws and ordinances was drained away
○ The earthquake that occurs after caution declaration based on a law, and earthquakes which level exceeds five minus
○ When the situation that might have an influence on the neighboring environment by the disasters and stopped deuterium experiment

- Communication to the local government 3 -

[the Important matter which should be reported without delay]

- Quantity of annual production of a neutron and tritium exceeds the NIFS management level
- When the keeping recovered water leaked out in an facility by accidents
- The annual dose of radioactivity of the site border is time beyond the NIFS management level
- When tritium or Argon-41 more than the NIFS management level was exhausted
- When the recovered water more than research institute management level was drained away
- When a deuterium experiment is stopped by the disasters such as earthquakes, and repair of the major equipment became the necessary for the experiment reopening

- Communication to the local government 4 -

[the Matter which should be reported in advance or without delay]

- The start time of the deuterium experiment in each fiscal year and end time (notify the assembly)
- When there are the maintenance plan of the research facility, a research plan and research contents and these changes (prior communication)
- Results of research (regularly)
- A certain matter of the publication duty
- After the deuterium experiment of each fiscal year, annual production quantity of a neutron and tritium, annual exhausted quantity of tritium to environment, the annual cumulative dose at the site boundary

- Communication to the local government 5 -

[Report of the disaster occurrence which scale is less than that of former matter]

NIFS reports the following cases to the local governments.

- ○ When the Meteorological Agency announces that there was rolling more than seismic intensity 4 caused by the earthquake in Toki-city, Tajimi-city and Mizunami-city
- ○ When, by a typhoon and/or a seasonal rain front, the disasters such as a landslide and the large-scale fallen tree may occur

In addition,

- ○ Publication to the homepage
  NIFS uploads on the homepage.
- ○ Reporting means, reporting time zone
  It is decided after local discussion with local government,.

(3-3) In order to safely accomplish the deuterium experiment, are various types of regulations being formulated appropriately?

On starting the deuterium experiment, NISF is pushing forward the change of the rule and the establishment according to the Industrial Safety and Health Law, the Atomic Energy Basic Act and the Civil Protection Law in addition to the present safety regulations.

"NIFS Regulation of Prevention of Radiation Hazards" was submitted to the Supervisory Authority as a regulation relating to the radiation generator due to the incorporation of 2004. Since the RI for the calibration and the radioactive materials for PWI research is used in the deuterium experiment, this regulation is revised.
This regulation is in the top priority, and the various manuals are maintained to push forward the deuterium experiment while checking the consistency with this regulation.

For the works which have a possibility to contact with tritium, such as in-vessel working and port working, work procedures are provided to keep a safety work. For the in-vessel work, the anterior chamber is provided as an entrance of the vacuum vessel and prevents spread of tritium contamination to the outside.

(3-3) In order to safely accomplish the deuterium experiment, are various types of regulations being formulated appropriately?

The NIFS management levels for the dose at the site boundary and the tritium concentration for the exhaust and the drainage are set to control the safety by NIFS. In addition, the management values of the neutron and tritium production and of the environmental dose are set, and their measuring methods and position to ensure these values are set. Measurement of the background level before the deuterium experiment is started about the possible measuring equipment.

In the event of an emergency, communication means, such as a satellite phone, to the local governments are secured, and the reporting matters and the announcement of their data are established.

(3-1) Is the fundamental concept regarding safety management appropriate at the time of the formulation of the deuterium experiment execution plan as also based upon the opinions of local residents?

重水素実験の目的は適切か、またその目的を達成する研究計画及び安全を確保する実施体制となっているか。

(3-2) Are safety management equipment, facilities, and experiment equipment being planned appropriately for the safe accomplishment of the deuterium experiment and to support management?

安全管理機器･設備、実験機器等は重水素実験を安全に遂行し、維持管理するために適切に計画されているか。

(3-3) In order to safely accomplish the deuterium experiment, are various types of regulations being formulated appropriately?

重水素実験を安全に遂行するために、規則類は適切に策定されているか。

(3-4) Are the operation manual, the radiation management manual, and the emergency manual being formulated appropriately?

運転マニュアル、放射線管理マニュアル、緊急時マニュアル等は適切に策定されているか。

(3-5) Are the organization and the system for safety management when the deuterium experiments are being conducted being constructed appropriately?

重水素実験を実施する際の安全管理のための組織、体制等を適切に構築しているか。

(3-6) Are education and training for the safe execution of the deuterium experiments, and nurturing for those responsible for safety management being undertaken appropriately?

重水素実験の安全な遂行に向けた教育･訓練及び安全管理責任者の養成は適切に計画されているか。

The operation manual, the radiation management manual, and the emergency

We are preparing the following three manuals.

- ○ Facility Operation Manual
- ○ Radiation Management Manual for Facility
- ○ Emergency Manual

These manuals stimulate revision to better things while using them.

- Facility Operation Manual -

○ Preparing the Operation Manual for the Facilities which will be used in the Deuterium Experiment.

○ This manual is prepared as one of materials which we decide whether this facility should remove before deuterium experiment or not.

○ Each facility is checked its rating, usefulness and the resistivity against neutron exposure.

○ Facility which is not submitted these materials and not cleared check is removed before the Deuterium Experiment.

- Model of the Facility Operation Manual -

○○○○運転マニュアル（案）

2014年4月16日

１．目的
　このマニュアルは、○○○○を安全に行うため、必要な事項を定めるものとする。

２．運転・監視体制について
　運転に拘わる責任体制を明確にしておくこと。

３．定期点検について
　別途定める項目に従い、定期点検を実施すること。

４．運転開始の手続きについて
　4-1.　始業前点検
　　4-1-1.　放射線総合監視システムが動作していることを確認する。
　　4-1-2.　始業点検表に基づき機器・設備の点検を実施する。
　　　（機器毎に、その必要性に応じて確認項目を設ける。）
　4-2.　機器の作動
　　（機器毎に記述する。）

5. 運転時について
・担当者あるいは運転員は、常に、機器の健全性の確認に努めること。
・作業時には、常時放射線モニタを監視し、異常のあった場合には、直ちに＊＊＊に連絡すること。
　（機器毎に、その必要性に応じて項目を設ける。）

6. 運転終了時の手続きについて
　6-1. 停止作業
　6-2. 運転後の点検
　　終了点検表に基づき機器・設備の点検を実施する。
　　終了を機器責任者（名称？）が確認を行うこと。

7. 異常時の対応について
　別途定める異常時対応マニュアルに従って、行うこと。

8. その他

以上

- Operation Manual for Vacuum Evacuation System

真空排気装置　運転マニュアル（案）

2014 年 5 月 20 日

1.　目的
このマニュアルは、真空排気装置を安全に運転するために、必要な事項を定めるものとする。

2.　装置構成
真空排気装置は主として以下の３系統で構成される。
　①　真空容器排気系
　②　ベルジャー排気系
　③　プラズマ放電排気系

3.　運転・監視体制について
研究教育職員を責任者として技術職員が運転・監視に当たる.
・大気圧からの排気運転、大気開放運転については、実験統括主幹の指示の下、装置担当者及び運転員が運転操作を行うこと。
・プラズマ実験時における運転は、実験責任者の指示の下、装置担当者及び運転員が運転操作を行うこと。
・その他の運転に関しては、装置担当者の判断の下、装置担当者及び運転員が運転操作を行うこと。

4.　定期点検について
定期点検は以下の様に分類される。
　①　週間点検
　②　月間点検
　③　年次点検
このうち①、②の項目については別途設ける点検リストに従って点検を行うものとする。
年次点検はポンプの運転時間やバルブの開閉回数等を考慮し、装置担当者の判断の下、行うものとする。

5.　運転開始前の点検について
運転開始前に以下の項目について点検、確認を行う。詳細は別途設ける点検リストに従うものとする。
　①　電源供給の確認
　②　停止状態における各機器の健全性確認
　③　排気ガス処理装置が正常運転していることの確認
　④　圧縮空気装置、GN2 供給装置から規定圧力のガスが供給されていることの確認
　⑤　規定流量の冷却水が流れていることの確認

6.　運転時について
・真空排気装置の運転モードは大きく以下の様に分類される。
　①　大気圧からの排気
　②　超高真空状態での定常排気
　③　大気開放
　④　クライオポンプ再生・冷却
　⑤　放電洗浄・ベーキング対応
　⑥　プラズマ実験時
　各モードにおける運転の詳細は別途設ける運転手順書に従うものとする。
・運転中は遠隔操作端末により本装置の真空ポンプ等各機器の運転状況の監視及び警報監視を行う。

7.　異常時の対応について
想定される異常時を以下に挙げる。
　①　冷却水停止
　②　故障等による真空ポンプの停止
　③　停電、地震
　④　中央制御装置による停止要請信号
別途定める異常時対応マニュアルに従って、行うこと。

8.　その他

以上

- Radiation Management Manual for Facility -

- Deuterium Experiment : We have to keep the NIFS management level for an exhaust, drainage and dose level at the site boundary.
- Port related Work : We have to minimize the tritium leakage into the environment.

In addition to the Facility Operation Manual, we push forward the preparation of the Radiation Management Manual in the viewpoint of the radiation management every apparatus.

- Model of the Radiation Management Manual -

○○○○放射線安全管理マニュアル（案）

2014 年 4 月 16 日

1. 概要

本マニュアルは、○○装置（以下略して装置という）を用いて実験を行う際の安全上の注意事項について記している。

装置使用者となる者は本マニュアルを必ず読んでおかなくてはならない。

本マニュアルの内容を変更する必要が生じた場合には、装置管理区域責任者を中心として変更案を作成し、放射線取扱主任者（以下略して主任者という）の承認を得るものとする。改定時には、装置使用者に再周知する。

2. 装置の主な仕様

・・・・・・・・・・・・・・・・・・・・・・・・・・・・・

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3. 使用者登録

装置の使用は、放射線業務従事者として登録された者で、装置使用の申請許可を得た者（以下、装置使用者という）に限る。

4. 実験計画書の提出

装置使用者は装置管理区域責任者に実験計画書を提出し、装置管理区域責任者は所長に装置使用許可申請書を提出する。

5. 管理区域への入退

装置管理区域を別図のように定める。管理区域への出入口は図中○○の○○及び○○の○ヵ所である。入退室に際しては以下の事項を遵守すること。

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・・・・・・・・・・・・・・・・・・・・・・・・・・・・・

6. 表示およびインターロック

○○への出入口に自動表示灯が設置されており、○○電源が入ると自動的に運転中と表示される。

○○には非常停止ボタンが設置されており、万が一、閉じ込められた場合にも非常停止ボタンを押せば自動的に装置は停止する。

・・・・・・・・・・・・・・・・・・・・・・・・・・・・・

7. 装置使用方法

装置使用者は、別に定める運転マニュアルにしたがって装置を運転すること。

「装置」でなく「作業」の場合は、以下の様に書き換える。

作業方法

「作業者は、別に定める「トリチウム拡散防止マニュアル」にしたがって作業を行うこと」

8. 巡視・点検

維持管理細則にしたがって巡視・点検を行うこと。実施結果は装置管理区域責任者を通して装置責任者及び安全管理室に提出すること。

9. 放射線量測定

実験に際して、装置使用者はルクセルバッジ等をつけておくこと。

装置管理区域責任者は、放射線線量をガラス線量計などを用いて定期的に測定し、装置使用者に周知する。

10. 緊急時の対応

万一事故が起こった場合には、装置使用者は直ちに守衛室及び装置管理区域責任者あるいは当該実験責任者を通じて放射線取扱主任者及び安全管理室に通報し、別途緊急時マニュアルに従って必要な処置をおこなうこと。また維持管理細則の定める報告の必要がある時は、装置管理区域責任者は速やかにこれを報告すること。

11. 責任体制

実験計画、装置運転に関する責任は当該実験責任者が負う。

放射線の測定、管理、報告に関する運用上の責任は装置管理区域責任者が負う。

12. その他

以上

- Radiation Management Manual for LHD Operation Monitoring System -

ＬＨＤ運転監視　放射線管理マニュアル（案）

2014 年 4 月 20 日

1.　概要

本マニュアルは大型ヘリカル装置（以下ＬＨＤ）を用いて実験を行う際の安全上の注意事項について記している。

ＬＨＤで実験を行う者、運転および点検・管理に従事する者（以下，実験関係者）は、本マニュアルを必ず読んでおかなければならない。

本マニュアルの内容を変更する必要が生じた場合には、装置管理区域責任者を中心に変更案を作成し、放射線取扱主任者（以下略して主任者という）の承認を得なければならない。改定後は実験関係者に周知しなければならない。

2.　実験の概要

ＬＨＤでは重水素を使用する実験を予定している。重水素実験では中性子およびトリチウムが発生し、わずかではあるが放射化物も生成されるため、全放射線量を研究所が管理し、すべての実験は例外なく許容値以下で遂行すること。

3.　使用者登録

実験関係者は「放射線業務従事者」として登録された者に限る。

4.　実験計画書の提出

実験遂行に係わる者は事前に実験責任者に実験計画書を提出しなければならない。特に重水素を用いた実験では中性子、トリチウムの発生量が研究所の管理値を超えないよう留意すること。

5.　実験時の監視体制

ＬＨＤと周辺設備、環境の安全を保障するために、機器の運転および放射線総合監視システムによる監視と異常時の対応を主な業務とする運転員を通年２４時間体制で置く。特に、重水素実験初期における実験期間中は、昼夜、休日を問わず研究所職員を含む実験関係者による６人以上の監視体制を維持する。

6.　実験時の対応

重水素実験ではプラズマ生成の起動を手動で行うこと。実験責任者は常に中性子発生量、トリチウムの排出量の積算値に留意し、これらのいずれかの値が研究所の管理値に近づいたところで実験を停止する。これらの量は放射線総合監視システムで常時監視され，管理値に近づいた場合に実験を自動停止するシステムとなっているが、常に手動停止できるよう実験を監視すること。

7.　放射線総合監視システムの異常時の対応

放射線総合監視システムが異常を感知した場合、その原因を究明するとともに直ちに適切な処置をとること。機器が故障した場合には、機器の修繕あるいは交換後、システム全体が正常に作動することを確認した上で、放射線取扱主任者の許可を得て重水素実験を再開すること。

8.　放射線量の測定

実験時は、放射線総合監視システムによるＬＨＤおよび周辺設備、環境の放射線量を常時監視するとともに、実験関係者の被曝の有無をクイクセルバッジで管理すること。

また、装置管理区域責任者は、実験室内の放射線線量をガラス線量計などを用いて定期的に測定し、装置使用者に周知すること。

9.　緊急時の対応

万一事故が起こった場合、装置使用者は直ちに守衛室及び装置管理区域責任者、あるいは当該実験責任者を通じて放射線取扱主任者及び放射線管理室に通報するとともに、別途定める緊急時マニュアルに従って必要な処置をおこなうこと。また維持管理細則の定める報告の必要がある場合は、装置管理区域責任者は速やかにこれを報告すること。

10.　責任体制

実験計画、装置運転に関する責任は当該実験責任者が負う。

放射線の測定、管理、報告に関する運用上の責任は装置管理区域責任者が負う。

11.　その他

以上

- Emergency Manual -

We are preparing the Emergency Manual during the Deuterium Experiment to keep the consistency with the conventional disaster prevention manual.

○ Basic way of thinking to an emergency and a disaster

We have to pay attention to a neutron and tritium which have a possibility to give influence to environment, when a disaster and/or an accident occurs.

Followings are basic way of thinking to the deuterium experiment safety at an emergency and a disaster.

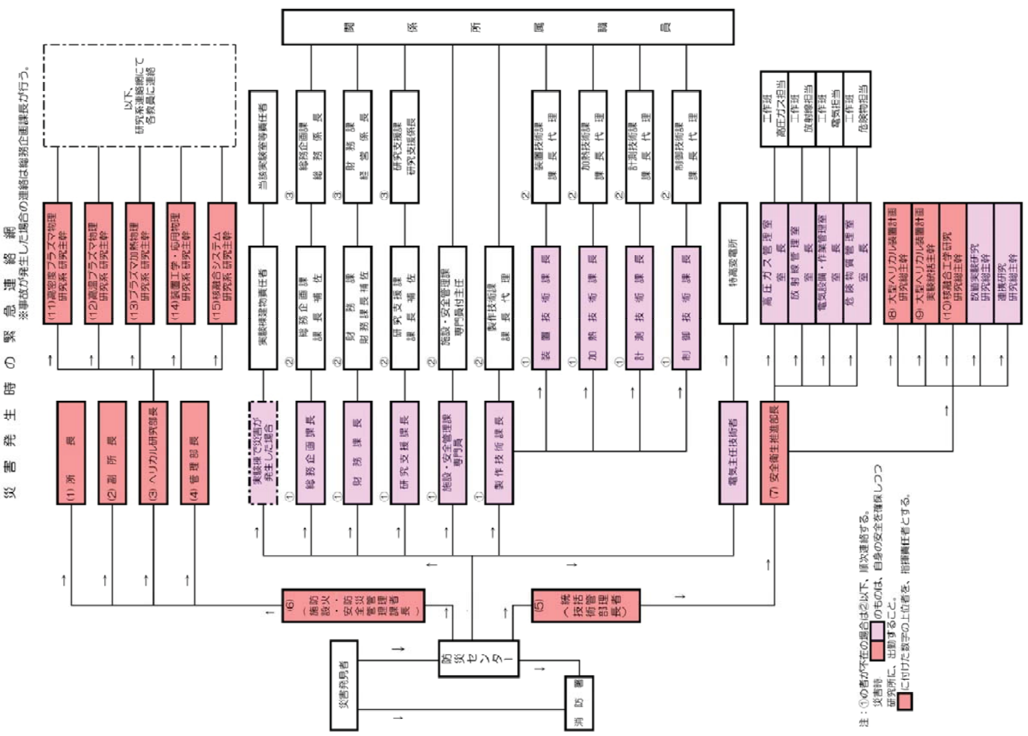
1) Minimize the quantity of occurring tritium,

2) Limit the quantity of tritium remaining in a VV which does not exceed the management level, even if a gross quantity is released,

3) Keep the management level of the radiological generations, such as Ar-41, which have a possibility to give influence on the environment

4) Pay attention severely to a leak of the recovered water.

- Network at Emergency -



- Self Fire Brigade (Plan at D-experiment) -

- Emergency Manual -

防災マニュアル

2010年版

2011年1月

自然科学研究機構　核融合科学研究所

目　次

大学共同利用機関法人　自然科学研究機構
核融合科学研究所
安全衛生推進部　防火・防災管理室
平成２３年１月３１日　発行

(3-4) Are the operation manual, the radiation management manual, and the emergency manual being formulated appropriately?

Since the equipment was installed in the LHD hall and the LHD basement and these area is set as the Controlled Area after the start of the deuterium experiment, "Radiation Management Manual", "Facility Operation Manual" and "Radiation and equipment controlled area management Manual" are provided and revised for each equipment. Each manual has been written in a uniform format along the model that has been created by the Development Task Force Team for LHD Deuterium Program.

"Radiation and equipment controlled area management Manual " is written for the radiation source handling, radiation generating device, and the devices that generate radiation in operation even when LHD is not operating. This manual is developed to control the safety even during non-experimental period.

“Emergency Manual” is written about the communication system, the disaster prevention system, the responsibility at the time of the experiment, etc. taking into account the conventional disaster prevention manual. In particular, the security about a radiation and tritium is ensured by setting the top priority to check the RI safekeeping facilities and the tritium recovery system in the Emergency Manual for the deuterium experiment. For example, workers’ safety is ensured to set the time that worker can stay in the LHD hall, when worker enters into the LHD hall, in the view point of the radiation exposure.

(3-1) Is the fundamental concept regarding safety management appropriate at the time of the formulation of the deuterium experiment execution plan as also based upon the opinions of local residents?

重水素実験の目的は適切か、またその目的を達成する研究計画及び安全を確保する実施体制となっているか。

(3-2) Are safety management equipment, facilities, and experiment equipment being planned appropriately for the safe accomplishment of the deuterium experiment and to support management?

安全管理機器・設備、実験機器等は重水素実験を安全に遂行し、維持管理するために適切に計画されているか。

(3-3) In order to safely accomplish the deuterium experiment, are various types of regulations being formulated appropriately?

重水素実験を安全に遂行するために、規則類は適切に策定されているか。

(3-4) Are the operation manual, the radiation management manual, and the emergency manual being formulated appropriately?

運転マニュアル、放射線管理マニュアル、緊急時マニュアル等は適切に策定されているか。

(3-5) Are the organization and the system for safety management when the deuterium experiments are being conducted being constructed appropriately?

重水素実験を実施する際の安全管理のための組織、体制等を適切に構築しているか。

(3-6) Are education and training for the safe execution of the deuterium experiments, and nurturing for those responsible for safety management being undertaken appropriately?

重水素実験の安全な遂行に向けた教育・訓練及び安全管理責任者の養成は適切に計画されているか。

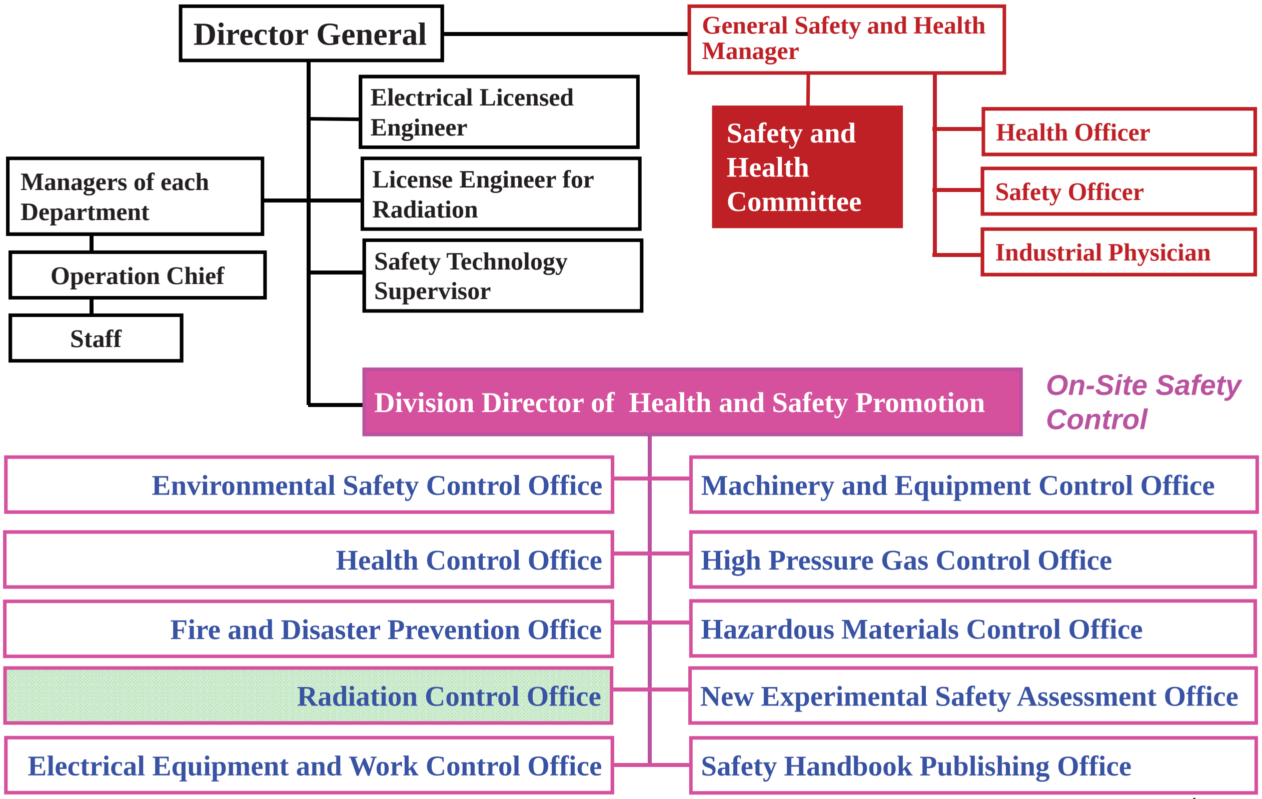
the organization and the system for safety management

NIFS Safety Promoting Organization

Director General organizes the Safety and Health Committee as a general safety and health manager based on the Industrial Safety and Health Law.
Member of the S&H Committee are the safety officer, the health officer, industrial physician and a few selected NIFS staff.
Meeting is held once in a month and things about safety and health are discussed.
Division of Health and Safety Promotion, which has 10 offices, carries out the safety and heath related matter pointed out by the above committee.

Radiation Control office is expanded and performs the administrative task in the deuterium experiment while getting support of the Radiation Safety Committee (plan).

- Structure of NIFS Safety Promoting Organization -



- Radiation Safety System -

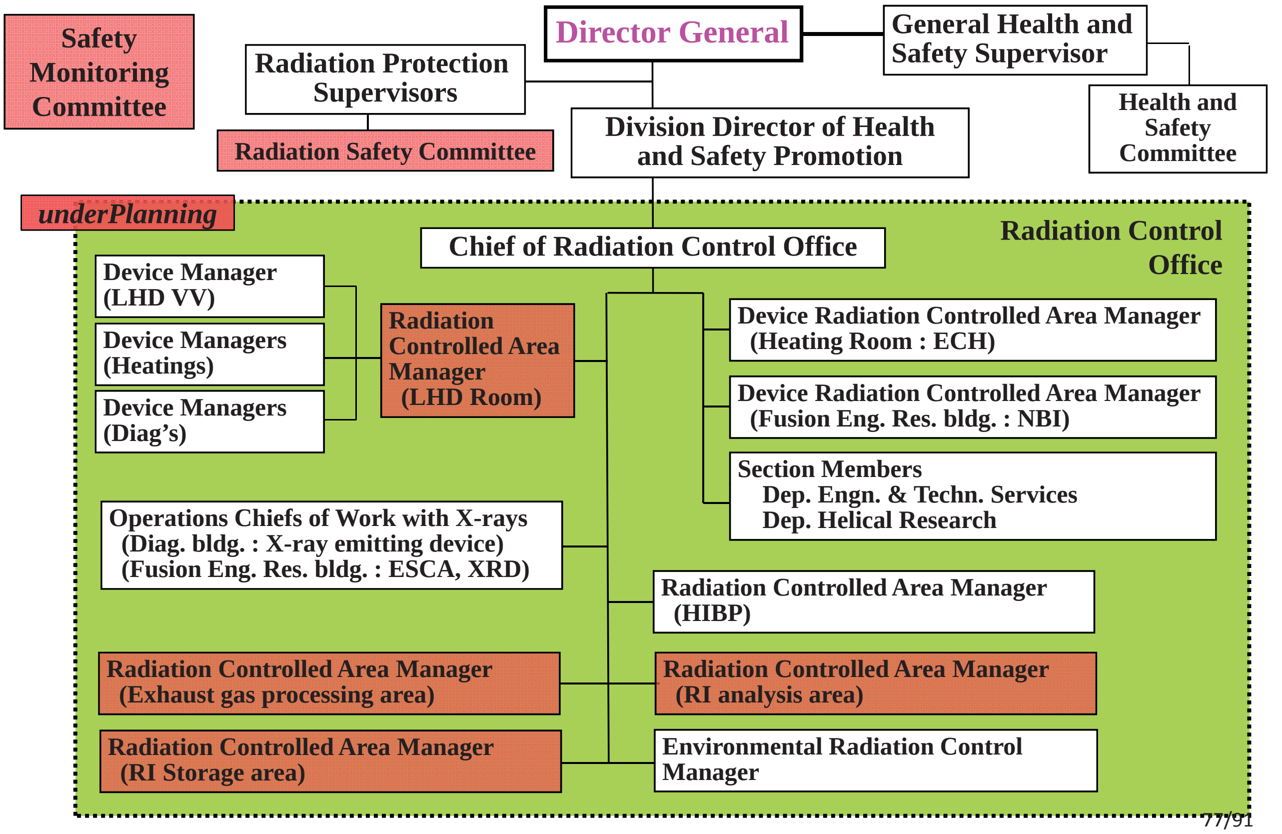
NIFS Radiation Safety System

Control office which will be expanded to deal with the deuterium experiment performs the administrative.

The Safety Monitoring Committee is organized by the local government as a third party organization independent of NIFS, and performs monitoring about the security of the deuterium experiment.

After the deuterium experiment begins, the Monitoring of various apparatuses, facilities is performed for 24 hours in a whole year.

- Radiation Control System -



(3-5) Are the organization and the system for safety management when the deuterium experiments are being conducted being constructed appropriately?

Safety management system of NIFS is established based on the Industrial Safety and Health Law and is consist of the General Safety and health manager, who is the Director General, the Health Officer, the Safety Officer and the Industrial Physician. The Safety and Health Committee is organized above member and a few additional members, and discuss the things related to health and safety on a meeting once a month. Furthermore, Division of Health and Safety Promotion with 10 offices is organized by the Director General. This division is carrying out matters pointed out by this committee and makes plan for improvement of the safety and prevention the work-related accident.

After the start of the deuterium experiment, the Radiation Control Office is expanded and deals with the safety management. In addition, the Radiation Safety Committee (tentative name) is established as a radiation management section other than the Radiation Control Office. And Safety Monitoring Committee (tentative name) is established by the local government and monitors the safety.

(3-5) Are the organization and the system for safety management when the deuterium experiments are being conducted being constructed appropriately?

Monitoring the equipment and management of the Disposal-by-Storage Facility are parts of the function of the Integrated Radiation Monitoring System, and these are carried out in 24-hours both experimental and non-experimental period. When there is an abnormality, necessary staff is assembled in accordance with emergency contact network and deals with correspondence.

(3-1) Is the fundamental concept regarding safety management appropriate at the time of the formulation of the deuterium experiment execution plan as also based upon the opinions of local residents?

重水素実験の目的は適切か、またその目的を達成する研究計画及び安全を確保する実施体制となっているか。

(3-2) Are safety management equipment, facilities, and experiment equipment being planned appropriately for the safe accomplishment of the deuterium experiment and to support management?

安全管理機器・設備、実験機器等は重水素実験を安全に遂行し、維持管理するために適切に計画されているか。

(3-3) In order to safely accomplish the deuterium experiment, are various types of regulations being formulated appropriately?

重水素実験を安全に遂行するために、規則類は適切に策定されているか。

(3-4) Are the operation manual, the radiation management manual, and the emergency manual being formulated appropriately?

運転マニュアル、放射線管理マニュアル、緊急時マニュアル等は適切に策定されているか。

(3-5) Are the organization and the system for safety management when the deuterium experiments are being conducted being constructed appropriately?

重水素実験を実施する際の安全管理のための組織、体制等を適切に構築しているか。

(3-6) Are education and training for the safe execution of the deuterium experiments, and nurturing for those responsible for safety management being undertaken appropriately?

重水素実験の安全な遂行に向けた教育・訓練及び安全管理責任者の養成は適切に計画されているか。

education and, and nurturing responsible person for the safety management

Education

- General Safety Lectures and Radiation Safety Lectures are held twice for each in the end of fiscal year for the workers including students to renew the permission of working in the next fiscal year.

- Radiation Safety Lectures after the deuterium experiment start are also held twice in a year. For a person who enters the radiation controlled area, new lecture of the non sealed RI treatment is opened.

Education for the visiting co-researchers

- Safety education
  - All the co-researchers are requested to take a safety lecture and a radiation safety lecture before they start the collaboration work.
  - A guide line is presented in the “NIFS Safety Handbook”
  - A covenant should be signed after the lecture.

- Radiation safety control
  - Co-researchers who want to engage in the controlled area (ex. LHD hall) should be registered as radiation worker before they start the research
    - Registration should be carried out at their own universities
    - If their university could not go through the registration procedure, NIFS would do it instead
  - A card key to access the controlled area is issued to the radiation worker

Education for the foreign co-researchers

- ○Safety education for the foreign co-researchers is carried out in English by their caretaker
  - All the co-researchers are requested to take a safety lecture before start of their collaboration work in the controlled area.
  - A guide line is presented in the "NIFS Safety Handbook"
  - A covenant should be signed after the lecture
- ○Warning signs are presented in English.
- ○English version of NIFS Safety Handbook is available.

Work Safety Check Sheet

October 2005

I am aware of my own responsibilities according to the laws and regulations to do work safely in accordance with the Safety Handbook published by the Safety and Health Promotion Department. In particular, I will observe the points listed below.

(1) Follow the training, cautions and directions received from the NIFS supervisors.
(2) Participate in the Tool Box Meetings (TBM) and danger anticipation (KY) activities.
(3) Willingly cooperate to keep the work site organized, orderly and clean (one task, one clean-up).
(4) Get permission in advance for the use of fire and give complete consideration to the prevention of fire accidents.
(5) Refrain from unsafe acts and strive to eliminate the causes of unsafe conditions. Furthermore, immediately act according to the safety-related cautions and instructions of the safety and health supervisor, the safety leader and other such persons.
(6) When accidents or disasters occur or are discovered, inform the NIFS Superintendent.
(7) Wear the proper clothing for safe working (long-sleeve shirt, long trousers and safety shoes) and wear a protective helmet properly.
(8) Use the designated safety routes and use ascending and descending facilities to go up to or down from places more than 1.5 m high. Do not engage in reckless behavior.
(9) Use proper mobile scaffolding, footstools and ladders for working at heights above 2 m; do not use them in incomplete stages of assembly.
(10) Abide by safety signs, such as "Do Not Enter".
(11) Always wear a safety harness when working in places more than 2 m high. Use them effectively to prevent falls.
(12) The scope of the day's work and the work procedures and methods are arranged in advance; so do not engage in any actions on your own according to your own judgment or desires.
(13) Do not throw things down from high places.
(14) In electrical work, take care to avoid electrical shock.
(15) Do not stand below loads suspended from a crane.
(16) Do not stand long objects and lean them against other objects.
(17) Do not remove safety devices (interlocks).

*If I am instructed to stop working because I was working in an unsafe manner or for failing to follow any of the 17 above listed points, I will do so immediately.

------------------------ Detachment line ------------------------

Receipt of the Worker Safety Check Sheet (This receipt is kept by the Safety Leader.)

Date

Health and Safety Promotion Department Manager

I have received the Worker Safety Checklist. I will abide by the items described herein.

Affiliation (section and department or company name)

Name (signature)

Safety Guidance Instructor's Name ( )

Training and Nurturing for Safety Responsible Manager

Training

For a person who want to work in LHD, it is necessary to take class not only for "a vacuum work in LHD“ but also for "the tritium safely handling course" which is held in the Hydrogen Isotope Research Center in Toyama University. In this class, students learn the actual tritium handling.
The contents of the training are as follows.

- knowledge about tritium
- the lecture about the radiation preventive rule
- the tritium measurement using the tritium detecting device
- tritium decontamination
- training of safe port work

Identification of completion is conferred on a person of completion by the center.

Safety Lecture

Tritium Safely Handling Course

- Training Program of Tritium Safely Handling Course -

トリチウム安全取扱い研修日程表

	9:00	9:15	10:30	10:45	11:30	12:00	13:30		15:00	15:15	16:00–16:45
（1日目）							共同利用控室（集合）	オリエンテーション （1）センター長挨拶（松山） （2）研修について（西村） （3）教育訓練（水素研予防規程）（阿部）	休憩	講義 （1）トリチウムの基礎。（松山） （2）計測器の取扱説明（阿部）	講義・実習 （1）研修概略・注意点について（林） （2）現場にて管理区域立入に関する説明（阿部） （3）荷解き、作業準備
（2日目）	共同利用控室（集合）	講義・実習 （1）真空装置作業説明(鈴木・林) （2）真空装置内トリチウム濃度測定（トリチウムモニタ取扱） （3）トリチウム除去（除去装置の取扱）	休憩	実習 （1）フランジ作業 （2）真空排気		昼食	実習 （1）QMASS確認 （2）リークチェック （3）チャンバー大気開放 （4）トリチウム濃度測定		休憩	実習 フランジ作業 （作業者を変えて）	
（3日目）	共同利用控室（集合）	実習 片づけ、廃棄物処理、汚染検査	休憩	実習 スミア・サーベイメータ・液体シンチレーション実習	修了式 修了証授与他	昼食					

Drills

Disaster Drill in NIFS

Disaster prevention drill in LHD is held once a year.
Toki south fire department participates this drill.
The training includes the report to the local governments.

The radiation control office which is incorporated in the self-defense disaster prevention team supports the radiation-related correspondence.

Fire Drill in LHD

Fire Drill in LHD during experiment period is performed some times in a year.

These Drills are opened to the governments and the media.

Disaster Drill in NIFS

Fire Drill in LHD

Nurturing for Safety Responsible Manager

Detailed knowledge about the radiation is necessary on pushing forward a deuterium experiment safely.

Therefore NIFS recommends to be qualified the license of "first class chief responsible for handling of radioactive substances" to several people every year.

Eight people passed it and were able to acquire a qualification so far.
Seven qualified people already exist.
Nine people passed a subject examination this year and they can get a qualification when they receive the technical training.
NIFS is going to increase qualified people in future.

(3-6) Are education and training for the safe execution of the deuterium experiments, and nurturing for those responsible for safety management being undertaken appropriately?

As same as before, education and training system is maintained after the start of the deuterium experiment, and the fresh training course and field education is conducted for new workers and update course for the continuators. However, the fresh training course are performed for two days incorporating the training using unsealed RI handling.

In NIFS, the disaster drill for the entire Institute is currently conducted once in a year combined with the report training to the local government, and has the participation of the Toki south fire department. Also, in LHD, the Fire Drill is conducted at least once a year assuming fire and earthquake during the experimental period.

The Radiation Control Office is incorporated in the work squad of the private disaster prevention brigade, and supports the radiation related step according to their duties. For the deuterium experiment, it is planned to increase the ripeness of the training by increasing the number of training and performing it regularly and to perform a necessary action as far as possible.

(3-6) Are education and training for the safe execution of the deuterium experiments, and nurturing for those responsible for safety management being undertaken appropriately?

In order to get a knowledge of radiation safety in many researchers and technical officers, NIFS encourages the qualification of "first-class radiation protection supervisor" to a few people every year, as an effort of nurturing the safety responsible reader. 8 person got this qualification by this effort. Including the existing qualified personnel, there are 9 researchers and 7 technical officers who have been qualified. Also, 9 person has passed the written test, and it is possible to qualify when receiving the technical training. In the future, It is planned to go to increase the qualified person in future.

Tritium is produced during the deuterium experiment same as a neutron. There is a possibility to contact with tritium in the works such as in-vessel working and port working. To accomplish such work safely, it is necessary a responsible person who has a knowledge and an experience to treat tritium safely. In order to nurture such a responsible person, "the tritium safely handling course" is held in the Hydrogen Isotope Research Center in Toyama University as a part of the research collaboration. The contents of the training are knowledge about tritium, the lecture about the radiation prevention regulations, the tritium measurement, tritium decontamination, and safely port work using the device which really handles tritium. An identification of completion is conferred on a completed person by the center. 17 people have completed the training so far.

4. Understanding by Society and Citizens

(1) Is enhanced understanding of the safety of the deuterium experiment being advanced appropriately to local residents?

(2) Is promotion of the deuterium experiment plan being designed in conjunction with local governments?

(3) Is the importance of fusion research and its safety being widely disseminated in society?

4. Understanding by Society and Citizens

(1) Is enhanced understanding of the safety of the deuterium experiment being advanced appropriately to local residents?

(2) Is promotion of the deuterium experiment plan being designed in conjunction with local governments?

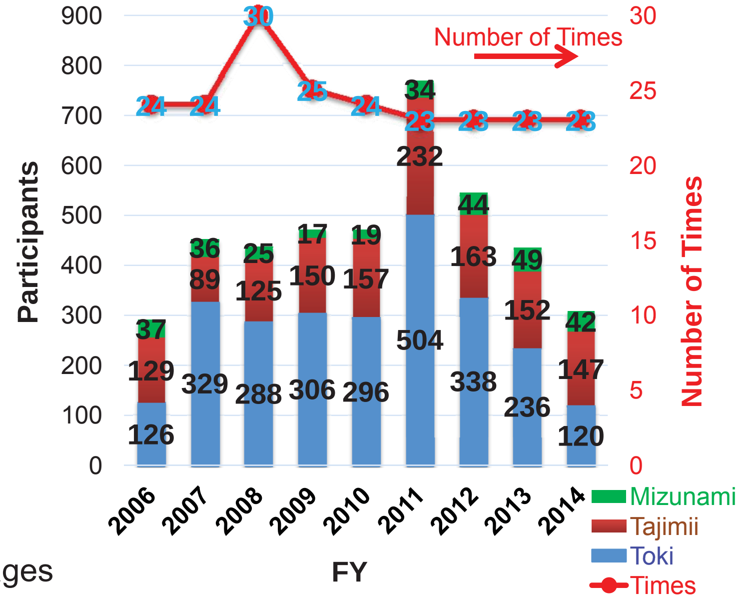
(3) Is the importance of fusion research and its safety being widely disseminated in society?

Outreach activities to increase social recognition (1)

NIFS has been focusing on the following activities with a view to increase social recognition of the necessity of fusion research and also NIFS's scientific achievements.

Public Forum

- Explanation about LHD and Deuterium Experiment to increase local citizen's recognition of NIFS's scientific achievements
- Forums take place at community centers at Toki City, Tajimi City, and Mizunami City, since 2006
- In FY 2014, 309 citizens joined the Forum
- Total: 4,190 (for 9 years)



Web

- Release of information by web pages
- Upgrading of Q&A web page
- Creation of special website featuring scientific events, symposia and conferences

Outreach activities to increase social recognition (2)

Publications

- Design and publication of the PR magazines and leaflets:
  "Plasma-kun Dayori" and "NIFS NEWS" issued every 2 months
  "Fusion – Energy to Pave the Way for Future",
  "NIFS Do Research Aimed at Extracting Energy from Sea Water",
  "Introduction to NIFS and the NIFS Tour",
  and "Welcome to NIFS"

Participation in the local events and festivals

- Science Fair in Mizunami City
- Toki Pottery Festival in Toki City
- Oroshi Pottery Festival in Toki City
- Tajimi Pottery Festival in Tajimi City
- Tajimi Festival in Tajimi City
- Children's Art Festival in Tajimi City etc.

・Achievement in FY 2013
- Scientific Handcraft: 29 times
- Scientific Experiments: 6 times
- Participants: about 1,100 children

(1) Is enhanced understanding of the safety of the deuterium experiment being advanced appropriately to local residents?

1. Public forum has been held at 23 – 30 places every year since 2006 to explain the LHD deuterium experiment, and the total participants were counted to 4,190 for 9 years, leading to increasing in the local citizen's recognition of the NIFS's scientific achievements and the safety of the deuterium experiment.
2. Safety information and the Q&A on the deuterium experiment are uploaded on the NIFS Web site.
3. PR magazines and leaflets are constantly published to the local residence, and public visitors are positively accepted to show LHD, counted to over 4,000 people per year.

4. Understanding by Society and Citizens

(1) Is enhanced understanding of the safety of the deuterium experiment being advanced appropriately to local residents?

(2) Is promotion of the deuterium experiment plan being designed in conjunction with local governments?

(3) Is the importance of fusion research and its safety being widely disseminated in society?

Cooperation with Local Autonomies

Agreement for the LHD Deuterium Experiment

- 1997: NIFS makes mention on tritium generation in D-D experiment
- 1998: Consultation on letter of agreement starts with local autonomies
- 2000: NIFS advances letter of agreement to councils and citizens
- 2001: Citizens take the case to council for common nuisance for abort of D-D experiment
- 2003: Adjustment of common nuisance unsuccessful
- 2006: Public forums start at local community centers
- 2007: Committee of Safety Evaluation of D-D experiment organized
- 2011: Great Higashi-Nihon earthquake
- 2012: NIFS asks conclusion of letter of agreement to local autonomies
- 2013: Concluded the Agreement for D-D experiment with local autonomies

Collaboration Research with "Toki City Plasma Research Committee"

- In 1979 move of IPP Nagoya Univ. to Toki City makes collaboration research start
- Mainly with elementary, junior-high and high school teachers at Toki City, and occasionally with science teachers at Tajimi City and Ena City
- Activity contents are as follows:
  - ･ holding of lecture meeting on energy and environment
  - ･ measurement of environmental radio-activities at 18 locations in Tono region

(2) Is promotion of the deuterium experiment plan being designed in conjunction with local governments?

1. Negotiation with local governments is fluently made to establish mutual understanding for the NIFS activities including the deuterium experiment.
2. Public forums held by NIFS have been supported by the residents' associations, as well as the local governments.
3. Agreement for the deuterium experiment was concluded with the local governments, and based on this agreement the safety monitoring committee is organized for the deuterium experiment by the local governments.
4. Collaboration research with "Toki-City plasma research committee" is carried out on measurement of environmental radio-activities, and promotes the understanding of the safety of the deuterium experiment.

4. Understanding by Society and Citizens

(1) Is enhanced understanding of the safety of the deuterium experiment being advanced appropriately to local residents?

(2) Is promotion of the deuterium experiment plan being designed in conjunction with local governments?

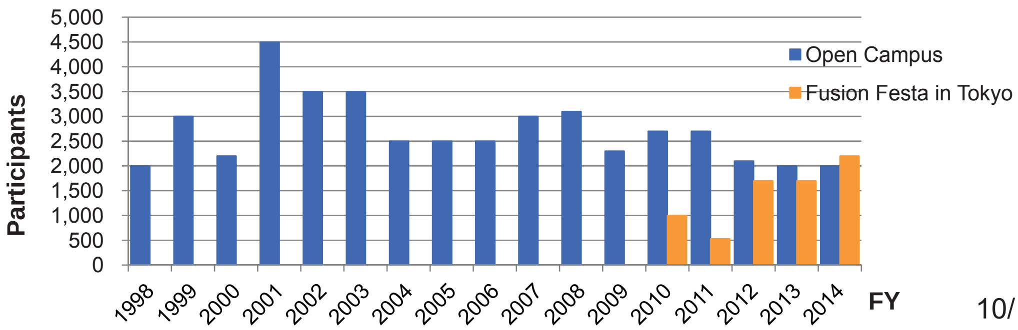
(3) Is the importance of fusion research and its safety being widely disseminated in society?

Release of Information to Public (1)

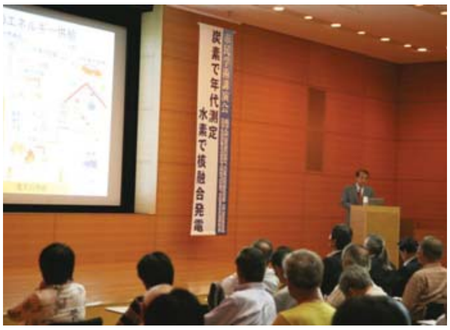
NIFS has been conducting various events and activities for the purpose of informing the public about our research activities.

Open Campus
- Once a year in autumn, since 1998
- More than 40 events such as NIFS introduction, science experiments, and open lecture

Fusion Festa in Tokyo
- Once a year in Tokyo as science event along the lines of Open Campus, since 2010
- Open lectures and experience-based event like scientific handcraft



Release of Information to Public (2)

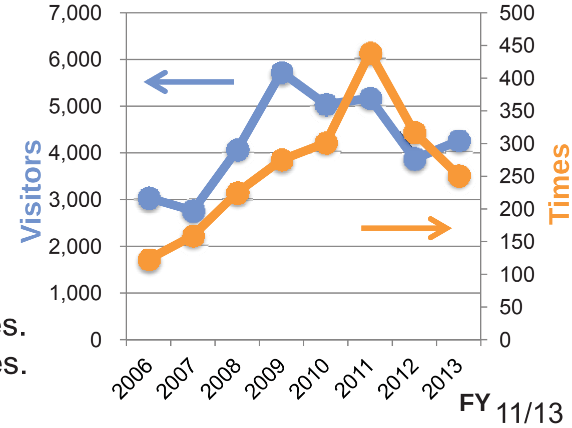


Open Lectures for Local Residents

- Every year in July and during the International Toki Conference, two academic lectures are given for city residents.
- Showing panels and LHD model at NINS Symposium

Release of information by Mailing Lists

- “Mail News”: release of event information in accordance with holding period (registered number: 1,157)
- “Mail Magazine”: research activities of NIFS disseminated twice a month (registered number: 361)



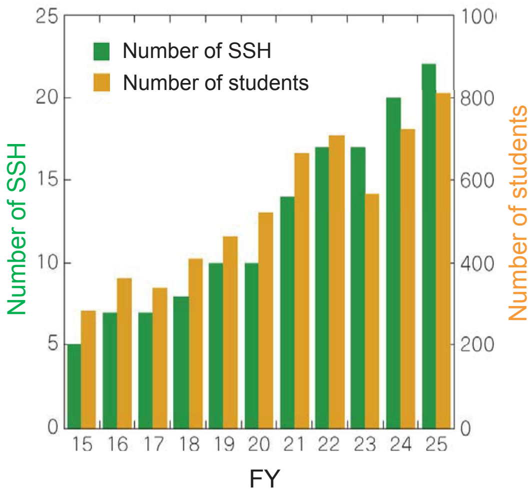
NIFS Tour

- Throughout the year, NIFS welcomes visitors for the facility tour.
- Visitors can see several experimental facilities and hear a summary of NIFS research activities.
- Tour is on weekday and takes about 90 minutes.
- Three staffed specializing in NIFS tour.

Release of Information to Public (3)

Educational contributions

- Educational partnership activities of Super Science High School (SSH) :
  22 high schools, 809 students participated.
- Visiting lectures: 7 high schools
- Internship programs for junior-high school, high school and technical college students:
  7 schools, 21 students



Press Release

- 10 times in FY2013
- Providing news to Japan Science and Technology Agency (JST) Science Portal, Science Media Center of Japan, The American Association for the Advancement of Science (AAAS) “Eurek Alert!” both at home and abroad.

(3) Is the importance of fusion research and its safety being widely disseminated in society?

1. Open campus has been held every year since 1998, showing the NIFS research activities, and the participant is over 2,000.
2. “Fusion Festa in Tokyo” has been held every year since 2010, for showing the importance of the fusion energy development widely to public people, and the participant is over 2,100.
3. Open academic lectures are given for city residents twice a year.
4. NIFS research activities are disseminated as a “Mail Magazine” twice a month.
5. Super Science High School (SSH) activities and the internship programs for students should contribute to public science education.
6. These activities, as well as the frequent press releases, contribute to wide dissemination of the importance of fusion research in society.

Results of the Evaluation through the 2014 External Evaluation of the "Deuterium Experiment Implementation Plan"

Number of persons

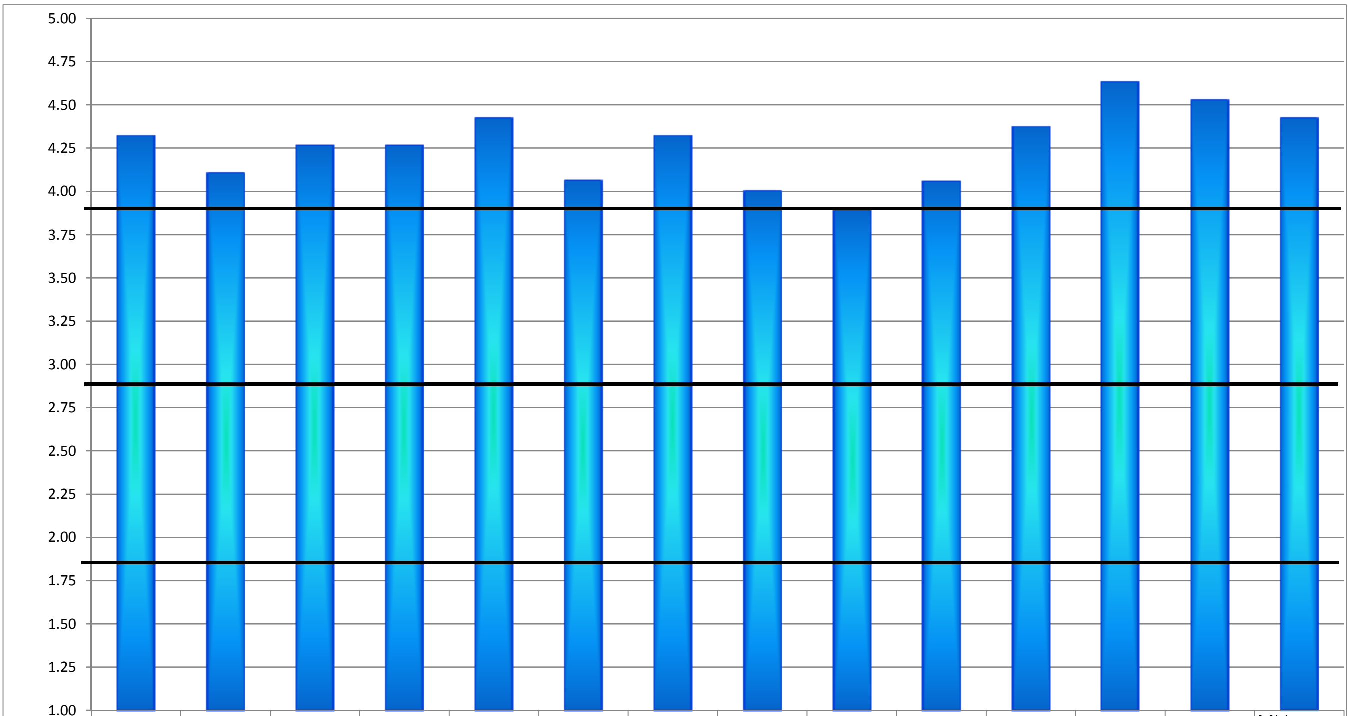
Items	[1](1)Implementation system to conduct research plan and to manage safety	[1](2)Research plan to heighten academic value	[1](3)System for joint research and joint use	[2](1)Maintenance of equipment and facilities	[2](2)Preparation system and maintenance system	[3](1)Fundamental way of thinking for safety management	[3](2)Plan of safety-related equipment and facilities	[3](3)Appropriate formulation of regulations	[3](4)Appropriate formulation of manuals	[3](5)Formulation of organization and system	[3](6)Education and training, and nurturing of persons in charge of safety	[4](1)Enhancement of understanding in safety	[4](2)Coordination with local governments	[4](3)Dissemination of the importance and the safety of fusion research toward
S	8	4	8	6	9	3	9	4	3	6	9	14	11	8
A	9	13	8	12	9	12	7	11	11	8	8	4	7	11
B	2	2	3	1	1	2	3	4	3	5	2	0	1	0
C	0	0	0	0	0	0	0	0	1	0	0	1	0	0
D	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg. points	4.32	4.11	4.26	4.26	4.42	4.06	4.32	4.00	3.89	4.05	4.37	4.63	4.53	4.42

Evaluation Response Table		
S	Evaluate extremely high	5
A	Evaluate highly	4
B	Praised	3
C	Satisfactory	2
D	Not satisfactory	1

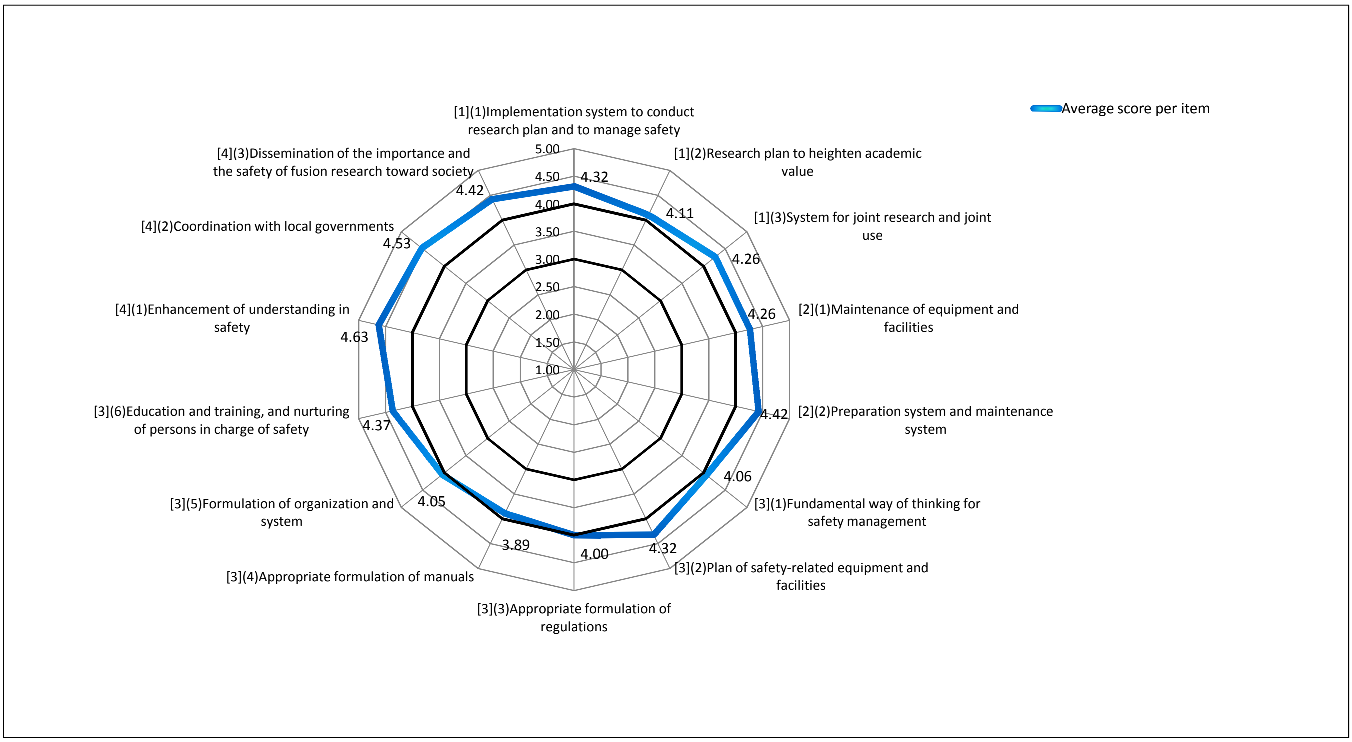
※ The evaluation results combine the results from the members based in Japan and the members based abroad. As there are committee members who did not respond to all items, the number of responses differs for each item.

Items	Points for Evaluation
[1]	(Research Plan)
[1](1)	Are the purposes of the deuterium experiment appropriate? Further, is this a research plan that will achieve its goals and an implementation system that will protect safety?
[1](2)	Is this a plan that will contribute to advancing our comprehensive understanding of toroidal plasmas and that will heighten the academic value toward achieving fusion?
[1](3)	Is this a plan that upon implementation will develop a system for joint use and joint research that enables the participation of a wide range of researchers?
[2]	(Deuterium Experiment Preparation System)
[2](1)	Aiming toward the start of the deuterium experiment in 2016, is this plan appropriate for the preparation of equipment and facilities?
[2](2)	Is the preparation system leading toward the start of the deuterium experiment appropriate? Is the preparation of facilities and instruments including safety equipment advancing appropriately?
[3]	(Safety Management Plan)
[3](1)	Is the fundamental way of thinking regarding safety management appropriate for the formulation of a deuterium experiment implementation plan that considers the opinions of local residents?
[3](2)	Will the safety management instruments and the equipment, and the experiment equipment be appropriately planned to safely perform the deuterium experiment and be appropriately planned for operation and maintenance?
[3](3)	In order to safely accomplish the deuterium experiment, are regulations being appropriately formulated?
[3](4)	Are the operation manual, the radiation management manual, and the emergency manual being appropriately formulated?
[3](5)	Are the organization of and the system for safety management upon the implementation of the deuterium experiment being appropriately constructed?
[3](6)	Are education and training for the safe performance of the deuterium experiment and the nurturing of the person in charge for safety management being appropriately planned?
[4]	(Society and Understanding)
[4](1)	Toward local residents, is enhancement of their understanding of the safety of the deuterium experiment being appropriately advanced?
[4](2)	Is communication with local governments being planned in promoting the deuterium experiment plan?
[4](3)	Is the importance and the safety of fusion research being spread widely throughout society?

Average Score by Evaluation Item



	[1](1)Implementation system to conduct research plan and to manage safety	[1](2)Research plan to heighten academic value	[1](3)System for joint research and joint use	[2](1)Maintenance of equipment and facilities	[2](2)Preparation system and maintenance system	[3](1)Fundamental way of thinking for safety management	[3](2)Plan of safety-related equipment and facilities	[3](3)Appropriate formulation of regulations	[3](4)Appropriate formulation of manuals	[3](5)Formulation of organization and system	[3](6)Education and training, and nurturing of persons in charge of safety	[4](1)Enhancement of understanding in safety	[4](2)Coordination with local governments	[4](3)Dissemination of the importance and the safety of fusion research toward society
Avg. points	4.32	4.11	4.26	4.26	4.42	4.06	4.32	4.00	3.89	4.05	4.37	4.63	4.53	4.42



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