National Institute of Natural Sciences
National Institute for Fusion Science

NIFS Peer Review Reports in FY2020

March, 2021

National Institute for Fusion Science
Advisory Committee External Peer Review Committee
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Chapter 1 Background

The National Institute for Fusion Science (below as NIFS) was established in 1989 as an inter-university research institute, and utilizes the Large Helical Device (below as LHD) as the principal device to advance fusion research in universities in Japan.

The LHD, which was planned by bearing the support and the expectations of the fusion community, has the special characteristic of producing the heliotron-type magnetic field, which is an idea unique to Japan. In addition to generating high-performance helical-type plasma through high-power heating, NIFS is advancing with experimental research that aims to clarify physical and technological issues for realizing the toroidal magnetic field confinement fusion reactor. On the other hand, parallel with this, in analyses of fusion plasmas having fundamental complexities, theoretical research that uses large-scale simulations are essential. For that reason, a supercomputer for exclusive use was introduced at NIFS. We are advancing with leading-edge research by making this supercomputer at NIFS available for use to fusion theory researchers in Japan through collaborative research. Moreover, since 2010, in order to further strengthen the centripetal power of NIFS as a Center of Excellence (below as COE) in the field of plasma and fusion research we have organized three research projects, these being LHD, theory and simulation, and reactor engineering. Looking forward toward achieving the fusion reactor, initiated research programs will integrate these research results.

In addition to having revised the research structure within NIFS and having placed all research staff in one research department, by establishing a research system that enables participation by free will in research projects and has enabled easier cooperation in the three projects of LHD, theory and simulation, and reactor engineering than in the past, we are increasingly able to respond resourcefully to new topics.

In this period, there have been changes to the structure of the domestic academic research system. Since 2004, NIFS has been a research institute under the Inter-University Research Institute Corporation National Institutes of Natural Sciences (below as NINS) for enhancing further the domestic research collaboration. Upon becoming an inter-university research corporation, a system for mid-term goals and mid-term planning spanning six years was introduced, and a system of annual evaluations regarding the progress, too, was introduced. This annual evaluation focuses primarily upon administrative management. However, at NIFS it has been determined that receiving external evaluations of research results is important. Under the NIFS Advisory Committee, each year an External Peer Review Committee is organized, and the members evaluate the research. The topics of evaluation are determined by the Advisory Committee. The evaluation is undertaken by the members of the External Peer Review Committee, which is composed of experts who are external members of the Advisory Committee and external experts who are appropriate for evaluating the topics. The External Evaluation Committee submits its evaluation results to the Advisory Committee. Then, NIFS,
together with making the results public by uploading that information to the NIFS homepage, utilizes this information to improve research activities in the following years.

The topics for evaluation for the External Peer Review Committee are discussed and decided upon by the Advisory Committee, and those topics for evaluation differ each year. Most recently, in 2017 the Reactor Engineering Research Project, in 2018 the Large Helical Device Project, and in 2019 the Numerical Simulation Reactor Research Project were topics evaluated by external reviewers. This year, 2020, the “Division of Health and Safety Promotion”, the “Division of Information and Communication Systems”, and the “Division of External Affairs” were selected and reviewed by the external examiners.

As external members of the External Peer Review Committee there were ten external members from the Advisory Committee and three members from foreign countries. Further, there were three experts from outside NIFS. Thus was the External Peer Review Committee composed, and thereby the evaluation was undertaken.

The first meeting of the External Peer Review Committee including the Experts’ Committee was convened on October 2, 2020. The Committee discussed the process for moving forward with this fiscal year’s external peer review, and decided upon the perspective of the evaluation. On November 24, 2020, the second meeting of the External Peer Review Committee and Experts’ Committee was held. From NIFS was provided a detailed explanation that utilized documents from the material of viewgraphs and reports based on the perspectives (see the documents section). A question-and-answer session also was held. Subsequently, the third meeting of the External Peer Review Committee and the Experts’ Committee was held on January 26, 2021. Together with holding another question and answer session with NIFS, evaluation work based on the topics of the evaluation and the coordination of the evaluation work were undertaken. We compiled the external peer review report (draft) based upon the discussions to this point, and further discussions were held by electronic mail. Upon confirmation and examination by the External Peer Review Committee and the Experts’ Committee, we compiled the final report on March 2021.

Moreover, in the external evaluation regarding NIFS’s “Division of Health and Safety Promotion”, the “Division of Information and Communication Systems”, and the “Division of External Affairs” which were implemented this fiscal year, the perspectives for the evaluation were determined as follows. The perspectives for the evaluation consist of all the aspects that are indispensable in evaluating the performance of NIFS's “Division of Health and Safety Promotion,” the “Division of Information and Communication Systems,” and the “Division of External Affairs.”
Evaluation items in FY2020 External Peer Review

1. Division of Health and Safety Promotion
   (1) Are the organizations and systems for safety and health management properly constructed and operated in compliance with relevant laws and regulations?
   (2) Are the safety management equipment / facilities, experimental equipment, etc., for maintaining and managing safety taken into account for the characteristics and circumstances peculiar to fusion research?
   (3) Are manuals and rules such as operation manuals, radiation control manuals, and emergency manuals properly formulated and operated?
   (4) As the Inter-University Research Institute, do you properly provide safety management and education to staff and collaborators?
   (5) Is the training of leaders to carry out safety management properly planned and implemented?

2. Division of Information and Communication Systems
   (1) Is the information and communication system as a research platform properly constructed and operated?
   (2) Is the division of information and communication systems properly responding to requests for information system development from inside and outside the institute?
   (3) Is the organization of the division of information and communication systems functionally constructed and operated?

3. Division of External Affairs
   (1) Do you provide information and have a dialogue on the importance and the safety of fusion research for the development of a sustainable society to a wide range of people?
   (2) Do you carry out community interaction activities appropriately to gain their trust and understanding of fusion research through communication with local residents?
   (3) Do you contribute to the science education of children, students, and society through various workshops and events?
Chapter 2 Summary of the Evaluation, and Recommendation

We summarize the key points of the evaluation, and report in writing the recommendation regarding promotion of NIFS’s “Division of Health and Safety Promotion”, the “Division of Information and Communication Systems”, and the “Division of External Affairs”.

[1] Summary of the Evaluation

1. Division of Health and Safety Promotion

(1) Are the organizations and systems for safety and health management properly constructed and operated in compliance with relevant laws and regulations?

➢ At the National Institute for Fusion Science, many large-scale equipment such as LHD, liquefied helium-related equipment, and high-power power supply equipment must be operated at the same time, and the radiation control system including tritium must be operated with an emphasis on safety. The Division of Health and Safety Promotion has 10 rooms consisting of administrative staff, technical staff, and research staff, and has created a close cooperation system in charge of specialized fields. You comply with many safety-related legal compliance operations and are working with a high level of awareness to create a safe environment.

➢ It is important to continue efforts such as collecting and disclosing cases of hiyari-hatto (near miss accident), preparing disaster prevention manuals, compiling and revising safety handbooks, safety seminars, and safety patrols. We hope that the current activities that maintain high motivation for health and safety will continue to be developed.

➢ Although the management and operation system has been properly established under the Division Director of health and Safety Promotion, we expect that we will strive for continuous safety and health management, such as taking measures such as strengthening support as necessary.

(2) Are the safety management equipment / facilities, experimental equipment, etc., for maintaining and managing safety taken into account for the characteristics and circumstances peculiar to fusion research?

➢ As a fusion research device, safety management and operation related to radiation handling are emphasized in LHD-related fields. After the deuterium experiment is started, management and operation at an extremely high level is required, such as activation of equipment due to neutron generation and prevention of environmental exposure of tritium. Under the Division
of Health and Safety Promotion, radiation level monitoring and necessary management equipment are being developed, and it can be judged that this is a sufficient response, including on-site gate management within the laboratory.

- Regarding radiation control, a third-party committee has been set up to measure radiation regularly. The transparency of information is guaranteed outside the laboratory. Environmental radiation in the surrounding area is measured regularly and reported to the area. In addition, the number of people who have acquired qualifications related to radiation control is increasing, and you are actively conducting educational activities within the facility. These things can be highly evaluated.

- In safety management of high power, high voltage, cryogenic temperature, high pressure gas, heavy objects, etc. required for fusion research as well as tritium and neutrons, the characteristics and circumstances are fully considered and appropriate measures are taken. It can be highly evaluated.

(3) Are manuals and rules such as operation manuals, radiation control manuals, and emergency manuals properly formulated and operated?

- Safety-related rules and response manuals for disasters have been properly formulated. It is operated with guarantee of continuity, such as not being able to participate in experiments and equipment installation without taking a seminar every year. Considering the actual use of the manuals, the minimum required items are summarized on pages 1-2, which can be referred to on the Web, etc. In addition, there are some ingenuities in terms of operation so that it is always checked in daily driving. From these things, it can be highly evaluated.

- As the Inter-University Research Institute, outside researchers including foreigners also have the opportunity to handle the equipment. The maintenance of these manuals is indispensable for building a safe experimental environment, and you are properly formulated and operated. From these things, it can be highly evaluated.

- Foreigners are also considered for the route display signs of emergency evacuation routes, and sufficient measures are taken against emergencies.

(4) As the Inter-University Research Institute, do you properly provide safety management and education to staff and collaborators?

- Not only faculty and staff inside the institute, but also many people such as collaborators outside the institute and employees of related companies are participating in the operation of the equipment managed by the National Institute for Fusion Science. In order to build a safe and secure working environment for the entire site, it is indispensable to build a safety and health management system and safety education. In addition to an appropriate health and
safety management system, you also give consideration to safety education not only for staff but also for collaborators and those who belong to companies involved in equipment installation and operation. From these things, it can be highly evaluated.

- We expect continuous improvement, such as reflecting the opinions of staff and collaborators and responding to the increase in foreign researchers. It is also worth considering imposing a simple test on the participants of the seminar.

(5) Is the training of leaders to carry out safety management properly planned and implemented?

- In order to properly comply with the law and operate the safety management system, it is necessary to train leaders who have qualifications in accordance with the law, such as radiation protection supervisor. Continued support to staff, encouraging the acquisition of national qualifications such as 27 first-class radiation protection supervisor’s license holders, 50 license holders related to high-pressure gas handling, and 25 first-class health officer’s license holders. The training of instructors who carry out safety management is systematically implemented and can be highly evaluated. We hope that you will continue to strive to develop human resources involved in health and safety management.

- Human resource development requires a long-term strategy, and we look forward to future measures such as conducting regular checks and reviews on scenarios for training and securing the necessary personnel in the future.

2. Division of Information and Communication Systems

(1) Is the information and communication system as a research platform properly constructed and operated?

- It is extremely commendable that the information and communication system and information network (NIFS-LAN), which form the basis of the institute’s activities, have been appropriately constructed and are being safely managed and operated. In particular, three types of networks (NIFS-LAN, LHD-LAN, and PS-LAN) have been constructed and are being operated with special attention to security, and appropriate responses to incidents have been taken. In addition, it is highly evaluated that the institute has established a system to support research activities as a major research institute in the field of fusion science in Japan, including the establishment of an information system for joint researchers and a teleconference system.

(2) Is the division of information and communication systems properly responding to requests for information system development from inside and outside the institute?
It is highly evaluated that the division of information and communication systems is responding appropriately to the development of information systems in response to requests from both inside and outside the institute, including support for the storage and management of large-scale experimental data, development of data transfer technology, software license management, and development and operation of various information processing systems such as the international conference participation registration system. On the other hand, this is a position that requires specialization, and organization needs to continue to take measures to ensure that the workload in not too unevenly distributed among some staff members.

(3) Is the organization of the division of information and communication systems functionally constructed and operated?

- Within the division of information and communication systems, task groups and operation teams have been organized and are operating appropriately. In addition to providing a single point of contact for system development, the task groups enable the exchange of technical information and cross-checking between tasks, which is highly evaluated as a way to enhance service response. On the other hand, considering the high level of expertise and responsibility in the business, it is expected that the institute will continue to manage labor appropriately by allocating personnel appropriately.

3. Division of External Affairs

(1) Do you provide information and have a dialogue on the importance and the safety of fusion research for the development of a sustainable society to a wide range of people?

- In addition to conducting facility tours, open campus, public academic lectures, Fusion Festa, public explanatory meetings, small group training sessions for SSH-designated schools, and other outreach activities for a wide range of people, the NIFS continues to disseminate information on the importance and safety of fusion research through the Web, newsletters, SNS, and press releases. This is highly commendable. Further continuation and development of online activities, which will become more important in the future, is expected.

(2) Do you carry out community interaction activities appropriately to gain their trust and understanding of fusion research through communication with local residents?

- Through the implementation of public explanatory meetings (341 times over 15 years), participation in local events, publication of PR magazines, etc., the Institute has maintained communication with local communities and residents, and has vigorously engaged in community exchange activities to gain the understanding of local residents. It is highly commendable that the NIFS has gained a better understanding of activities of the institute.
from the local community. Activities aimed at further building trust are expected while maintaining communication with citizens.

(3) Do you contribute to the science education of children, students, and society through various workshops and events?

- It is highly commendable that science education activities in a broad sense, not limited to nuclear fusion and plasma, are being conducted for a wide range of citizens, from preschoolers to elementary school students, junior high school students, high school students, and adults, utilizing various forms such as science handicraft workshops, delivery classes, work experience, internships, and public academic lectures according to age groups. In the future, it is expected to promote communication activities with an overseas perspective, while responding to the shift to online activities, such as the enhancement of video content.

[2] Recommendations

In the present evaluation, we discussed NIFS’s “Division of Health and Safety Promotion”, the “Division of Information and Communication Systems”, and the “Division of External Affairs”. Based upon the contents of the discussion, we describe the recommendations regarding the future plan of these three divisions below.

1. Division of Health and Safety Promotion

(1) You will continue to maintain a safety management system for operating a large number of large devices at the same time and an organizational system for safely operating radiation control including tritium, and establish a close cooperation system between departments in charge of specialized fields. While taking this, we hope that we will continue to strengthen the appropriate support system.

(2) We expect that the safety and disaster response manuals will be reviewed regularly, and that human resources involved in the safety and health system and management will be continuously developed.

(3) To carry out continuously safety education for not only staff but also collaborators including foreigners, those involved in research institute activities. To report to the community such as radiation measurement results. To consider measures for safety that are expected when nuclear fusion is implemented in society in the future. To study continuously safety and health in fusion research in general. We expect these things.
2. Division of Information and Communication Systems

(1) It is hoped that the institute will continue to maintain a system that supports various collaborative research activities as a major research institute in the field of fusion science in Japan, taking into consideration network security as well as the information and communication systems that form the basis of the institute's activities.

(2) In the operation of information and communication systems, it is expected that the government strengthens its ability to respond to diverse services by training appropriate human resources and continuing flexible organizational management.

3. Division of External Affairs

(1) It is expected that information on the importance and safety of nuclear fusion research will continue to be disseminated to a wide age range, from children to adults.

(2) It is expected that implement activities to enhance trust with the local community and residents will continue to be conducted through various community exchange activities.

(3) It is expected to develop science education activities in a broad sense, not limited to nuclear fusion and plasma, and to promote communication activities with an overseas perspective, while adopting various PR methods such as web and video distribution.
Chapter 3 In Closing

Since 2010, in order to further strengthen the centripetal power of NIFS as a COE in the field of plasma and fusion research we have organized three research projects, these being LHD, theory and simulation, and reactor engineering. Looking forward toward achieving the fusion reactor, NIFS has initiated research programs that will integrate these research results. Moreover, the research structure at NIFS was reorganized and all academic researchers have now been placed in one research department. They may now participate in any or all of the three research projects by their choice. Due to this, we anticipate the promotion of links with LHD, theory and simulation, and fusion engineering, and we anticipate being able to respond resourcefully to new topics.

In the NIFS External Peer Review Committee review, in 2017 the Reactor Engineering Research Project, in 2018 the LHD Project, and in 2019 the Numerical Simulation Reactor Research Project were evaluated. Thus, in this current year of 2020 the Advisory Committee undertook an external evaluation that focused on NIFS’s “Division of Health and Safety Promotion”, the “Division of Information and Communication Systems”, and the “Division of External Affairs”. The External Peer Review Committee was composed of ten members of the Advisory Committee outside of NIFS and three members from abroad, and, as the experts, three members outside of NIFS.

Evaluation items in FY2020 External Peer Review

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(3) Do you contribute to the science education of children, students, and society through various workshops and events?

The External Peer Review Committee was convened four times from October 2020 through March 2021 including the e-mail discussion committee. Detailed explanations of the evaluation topics were provided from NIFS and active discussions were held. The External Peer Review Committee members summarize evaluation results based on discussion at the committee and submit this report.

As the result of the external evaluation of the NIFS’s “Division of Health and Safety Promotion”, the “Division of Information and Communication Systems”, and the “Division of External Affairs”, a recommendation of a high evaluation are received for the above evaluation points.

In conclusion, we suggest the following recommendations regarding the future plan of these three divisions.

Recommendations

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Documents

1. Presentation material: Recent Activities of NIFS

2. Presentation material: Division of Health and Safety Promotion

3. Presentation material: Division of Information and Communication Systems

4. Presentation material: Division of External Affairs
Recent Activities of NIFS

Takeo Muroga
Director, Department of Helical Plasma Research
STATUS OF NIFS IN 2020

• Organization structure
  ▫ 125 researchers, 46 engineers & technicians, 43 administration staff
  ▫ 68 graduate students
  ▫ about 100 of contract employees

• Research organization
  ▫ One department consisting of seven divisions
  ▫ Three research projects; LHD, Numerical Simulation Reactor Research, Fusion Engineering Research projects

• Budgetary condition
  ▫ 8,376million yen (1.0% less than that of FY2019) which includes salary, operational costs of LHD, Supercomputer and other facilities
  ▫ As for operation of LHD, it is 4,053million yen which is the same as the previous year.

• Collaboration programs
  ▫ 532 subjects have been approved as collaborative researches in four collaboration programs; General(395), LHD Project(25), Bidirectional Collaborations(105), and DEMO Reactor R&D(7)(started in 2019)
Fusion Research Activities in Japan for FY 2020

- JT-60SA Tokamak
- Kyushu Univ.
- QUEST ST
- National Institute for Quantum and Radiological Science and Technology (QST) Naka-site
- National Institute for Quantum and Radiological Science and Technology (QST) Rokkasho-site
- IFMIF-EVEDA, IFERC

Total numbers of universities and research institutes under collaboration with NIFS: 162
International collaborations

Agreements representing the Japanese government
- 6 bilateral agreements (with Australia, China, EU, Korea, Russia, USA)
- 3 multilateral agreements (IEA-Technology Collaboration Programmes)

Human exchange by leading programs in 2019

<table>
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<tr>
<th></th>
<th>J/US</th>
<th>J/China</th>
<th>J/Korea</th>
<th>Int. Base</th>
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<td>man</td>
<td>Day</td>
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<tr>
<td>to NIFS/Japan</td>
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<td>301</td>
<td>65</td>
<td>734</td>
</tr>
<tr>
<td>from NIFS/Japan</td>
<td>57</td>
<td>867</td>
<td>17</td>
<td>100</td>
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Academic exchange agreement with 32 institutes
- Promotion of collaboration and joint work
- Exchange of data and materials
- Human resource development/education

Lead standard database in fusion science
- Confinement physics database
- Atomic molecular database
NIFS carries out three projects by promoting collaboration with universities

• **Large Helical Device Project** pursues to achieve the high performance plasma in the 3rd deuterium experiment
  - Enhancement of plasma parameters toward reactor relevant regime
  - Confinement and transport study of energetic particles
  - Surface modifications on plasma facing components

• **Numerical Simulation Reactor Research Project** develops numerical simulation methods that will be the basis of numerical helical reactor
  - Understanding and systemizing physical mechanisms in fusion plasmas
  - Development of theoretical models for plasma behaviors and their validation
  - Integration of predictive models in a whole machine range

• **Fusion Engineering Research Project** proceeds fusion engineering research to solve key issues of the helical fusion reactor
  - Development of superconducting magnet, blanket, low activation materials, divertor / plasma facing components, and tritium control system
  - Design studies of helical fusion reactor
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  - Development of superconducting magnet, blanket, low activation materials, divertor / plasma facing components, and tritium control system
  - Design studies of helical fusion reactor
Extension of operational regime

Operational regime expands to higher $T_e$ regime

$T_e$ increased from 7.5 keV to 13 keV with relatively high $T_i$ of 7 keV, which is because

- ICH discharge cleaning by recently re-installed RF antennas
- ECH perpendicular injection to resonant surface
Improved confinement in EC heated D plasma

e-ITB could be formed with lower ECH power in D plasma than in H plasma

- Two discharges (H, D) with same ECH power (154 GHz, 2 MW)
- In D plasma, e-ITB was formed even in relatively high $n_e$ region ($n_e \text{bar} \sim 3.5 \times 10^{19} \text{m}^{-3}$)
- Not formed in H plasma (isotope effect)
Long sustainment of high performance plasma

High $T_e$ plasma (~ 6 keV) with e-ITB could be sustained for ~ 30 sec

- Two discharges (H, D) with same conditions
- Higher $T_e$ and lower energy transport coefficient were obtained in D
Simultaneous achievement of e-ITB and radiative divertor

Combination of Ne injection and RMP (m/n=1/1) application realized divertor flux mitigation during high performance discharge with e-ITB

- $P_{\text{rad}}$ increased 3 times by Ne, and 4 times by Ne + RMP
- $I_{\text{is}}$ decreased down to 60% with Ne, and to 24% with Ne + RMP
- e-ITB existed after Ne injection and RMP application
- low $T_e$ region increased by RMP.

![Graph showing $n_e$, $I_{\text{is}}$, and $P_{\text{rad}}$ over time with Ne and RMP effects.]

![Graph showing $I_{\text{is}}$ vs. Toroidal Section Num. with Ne and Ne + RMP effects.]
Transport study of energetic particles (EPs)

EPs lost by toroidal Alfven Eigenmode (TAE) induced MHD instability in D plasma was estimated to be about 5 %

- Low $B_t$ (~0.6T) plasma start-up was available by tentatively changing NB#3 injection with H
- From stored energy $W_p$ and neutron rate $S_n$ signals, it was found that ~ 5% of EPs were lost by single TAE burst

- In H/D mixture plasma, H and D EPs were simultaneously observed with E//B NPA
Boron powder drop experiment

Boron powder drop and discharges made clear effects on vacuum vessel wall and edge plasma properties (collaboration with PPPL)

- B or BN powder is dropped by piezo vibrator
  - B emissions from edge region
    - O drastically decreased after B-powder drop (blue => red)
    - B-power drop was effective even after conventional B$_2$O$_6$ coating (yellow)
  - Edge recycling was reduced by B-drop (ne: decrease, Te: increase)
Partial installation of W-coated divertor tiles

C deposition or flakes near W-coated tiles were drastically decreased

- A 10 µm W-layer was coated on C tiles of one of ten helical divertor sections
- Considerable W erosion was found at the striking point due to the sputtering with C

- No sputtering effect was found on NBI armor because ion energy is high
NIFS carries out three projects by promoting collaboration with universities

- **Large Helical Device Project** pursuits to achieve the high performance plasma in the 3rd deuterium experiment
  - Enhancement of plasma parameters toward reactor relevant regime
  - Confinement and transport study of energetic particles
  - Surface modifications on plasma facing components

- **Numerical Simulation Reactor Research Project** develops numerical simulation methods that will be the basis of numerical helical reactor
  - Understanding and systemizing physical mechanisms in fusion plasmas
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  - Integration of predictive models in a whole machine range

- **Fusion Engineering Research Project** proceeds fusion engineering research to solve key issues of the helical fusion reactor
  - Development of superconducting magnet, blanket, low activation materials, divertor / plasma facing components, and tritium control system
  - Design studies of helical fusion reactor
Extensive simulation code developments and comparisons between simulation and experiments towards numerical helical reactor.

- Turbulent transport (GKV-X)
- Non-linear MHD (MINOS, MIPS, NORM)
- Edge plasma (EMC3-EIRENE)
- Neoclassical transport (FORTEC-3D)
- High energy particle (MEGA)
- Plasma-wall interaction (MD-MC)
- Non-linear MHD (MINOS, MIPS, NORM)
- Integrated transport code (TASK3D)
- VR (virtual reality) visualization
**Recent research activities of NSRP (1)**

**MHD simulation** codes are extended to more accurately reproduce stability of LHD plasmas.

**Kinetic** effects of **thermal ions** are included.

Stabilization of **interchange modes** and sustainment of a **high beta** plasma in LHD are shown by **kinetic MHD** simulation in which thermal ions are treated kinetically.

Simulation studies of **high energy particle driven instabilities** are advanced.

- Efficiency of **ion heating** by **EGAM**
- Effects of **high energy electrons** on **Alfven Eigenmodes**
- Comparison of **MEGA simulation** and **FILD**

Direct comparison between simulation results of the **MEGA simulation** and measurements by **Fast Ion Loss Detector (FILD)** in LHD shows a reasonable agreement on energy and pitch angle distribution of lost fast ions.

Interchange modes and **trapped ion orbit**
Recent research activities of NSRP (2)

Global neoclassical transport simulations for multi-ion-species plasmas are performed to study impurity hole phenomena in LHD.

TEM/ITG instability analyses are made to investigate isotope mixture in LHD hydrogen-deuterium plasma experiments.

Electron and ion thermal transport models are constructed based on gyrokinetic simulation analyses.

Integrated transport code (TASK3D-a) is applied to analyses of LHD deuterium experiments.

Data Assimilation approach is implemented to TASK3D (collaboration with Kyoto U and The Institute of Statistical Mathematics).

Time evolution of $T_i$ at $\rho = 0.0$ and $0.6$ in LHD

$T_e$ and $T_i$ profiles in LHD are obtained by the integrated transport code (TASK3D) using the gyrokinetic transport model.

Thermal transport model optimized by Data Assimilation successfully reproduces $T_i$ in LHD.
Recent research activities of NSRP (3)

Simulation analysis of peripheral plasmas
- Impurity radiation in LHD
- JT-60SA with RMP fields
- MHD instability in the peripheral region of LHD induced by pellet injection

Nonlinear MHD simulation of pellet injection to LHD shows pellets with higher injection speed drive larger instabilities.

Simulation models and codes for core and peripheral regions and plasma-wall interaction are developed and extended.

Code integration of neutral transport code, charged particle code (EMC3-EIRENE) and the recycling model (MD) is successfully performed.

H₂ density distribution is calculated using Neutral-Transport code with H and H₂ data released from Divertor plate, which are simulated by MD-simulation.
Simulation studies of magnetized plasmas and **basic physics** are advanced.

- PIC simulation of radial transport dynamics in detached divertor plasma
- PIC simulation of heating mechanism of spherical tokamak (ST) plasmas

**Advanced visualization** techniques are applied to researches in **plasma physics** and fusion engineering.

Visualization of **magnetic field line structure** and plasma region

**PIC simulation of ST plasma merging**

Application of **VR and CAD** to examination of installing divertor plates in LHD
Supercomputer system for numerical simulation research at NIFS ("Plasma Simulator") was replaced from Fujitsu PRIMEHPC FX100 (peak performance about 2.62 PF, and the total main memory about 81TB) to NEC SX-Aurora TSUBASA (10.5 PF, 202 TB) in 2020.

Peak performances of plasma simulator and numbers of submitted jobs per month

Plasma Simulator Raijin (雷神)
NEC SX-Aurora TSUBASA
Peak performance: 10.5 PF
Total main memory: 202TB
From July 2020 to June 2025
The operation of Plasma Simulator ‘Raijin (雷神)’ started on July 1, 2020, and the celebration event was held on Aug. 29, 2020 with participation of guests including MEXT Deputy Minister, Diet members, Mayor of Toki City.

‘Raijin (雷神)’ = a god of thunder
NIFS carries out three projects by promoting collaboration with universities

- Large Helical Device Project pursuits to achieve the high performance plasma in the 3rd deuterium experiment
  - Enhancement of plasma parameters toward reactor relevant regime
  - Confinement and transport study of energetic particles
  - Surface modifications on plasma facing components

- Numerical Simulation Reactor Research Project develops numerical simulation methods that will be the basis of numerical helical reactor
  - Understanding and systemizing physical mechanisms in fusion plasmas
  - Development of theoretical models for plasma behaviors and their validation
  - Integration of predictive models in a whole machine range

- Fusion Engineering Research Project proceeds fusion engineering research to solve key issues of the helical fusion reactor
  - Development of superconducting magnet, blanket, low activation materials, divertor / plasma facing components, and tritium control system
  - Design studies of helical fusion reactor
Research Roadmap of FERP

2010 2012 2014 2017 2019 2022

The 2nd mid-term

Step by step advancement of reactor design

Conceptual design → Basic design

Large Helical Device (LHD) → Maximization of LHD capacity

cooperation

Establishment of Engineering base → Full-scale, full-condition engineering validation

Establishment of engineering base requested by Fusion Research Working Group

(1) Reduced activation materials
(2) Large-scale, high-field superconducting magnet
(3) High heat flux plasma facing wall
(4) Long-life liquid breeder blanket
(5) Trace-tritium handling technology

Production of extremely high heat load plasma facing wall and validation study under simulated fusion conditions
Development of 100 kA-class conductor and test production of helical winding
Test production of blanket and validation study under simulated fusion conditions
Validation of separation/recovery apparatus of trace tritium

Advanced fundamental academic research

Engineering design of fusion reactors

Fusion reactor

Collaborative research with universities/institutes and human resource development

ITER / BA activity: DEMO R&D, conceptual design, JT-60SA, IFMIF/EVEDA
Optimization of helical coil configuration for better plasma performance

Pitch modulation parameter ($\alpha$) dependence of plasma parameters and fusion gain

Examination of enhanced maintainability by adopting advanced divertor and blanket concepts

Cartridge type blanket CARDISTRY-B2
Pebble divertor REVOLVER-D2
Remote-handling replacement of breeding blankets is examined

Topology optimization reduces weight of magnet supporting structure by > 25%
These devices are used to perform characterizations of specimens exposed to D-D plasmas of LHD.
Research Highlight  (1) High-Tc Superconductors

Superconductor Testing Facilities

Large-current High-Temp. Superconducting (HTS) conductors (3-types) are being development

STARS

Temperature variable refrigerator supplies 4-50 K liquid & gas helium

FAIR

Large-bore high-field magnet facility (φ700 mm, 13 T, 50 kA)

WISE

Critical current measurement

- in liquid nitrogen (77 K) and 0 T ➔ in progress
- in gas helium (20 K) and 9 T ➔ tested soon
Research Highlight (2) Blanket Loop Test

Blanket Testing Facility: FLiNaK / LiPb Twin-loop “Oroshhi-2”

Installed at the top of Oroshhi-2

Hydrogen recovery from Li-Pb (Collaboration with Kyoto U.)

Heat recovery from FLiNaK with pebble-packed pipes (Collaboration with Tohoku U.)

Experiment will be carried out soon
Divertor test sample fabricated by Advanced Multi-Step Brazing (AMSB) technique (for joining tungsten and ODS-copper) has shown >30 MW/m² of heat removal capability.

W (t=5mm)

GlidCop®

SUS

V-shaped staggered rib structure

Rectangular shape fluid flow path

Glidcop : Oxide-dispersion Strengthened Cu

Heat loading area (20 mm × 36 mm)

W/Glidcop/Steel divertor segments were fabricated. They are planned to be installed into LHD.
Task Force for Next Research Project

Under the Task Force, research is being enhanced targeting designing and proposing post-LHD project. The activity is guided by NIFS Next Project Planning Committee under NIFS Advisory Committee. The project plan has been presented as a proposal from NIFS for discussion in the plasma fusion community.

1. Supporting the inter-university liaison conference in which the foremost research themes to be addressed by academia is being discussed in the framework of the NIFS general collaboration research

2. Investigating the next research project for creating the next generation magnetic configuration with enhanced zonal flows and turbulence suppression, leading to a new discovery of innovative confinement

Physics and Conceptual Design Studies

- Explorations towards a ZF-activated plasma
  - Nonlinear gyrokinetics based modeling of turbulence & zonal flows towards a novel stellarator/heliotron optimizations
  - Showing much capabilities of establishing a 3-D magnetic configuration with turbulence transport suppressions by the activated zonal flows
  - Investigation for flexible controls of field structures: divertor configurations (leg type & island type)
  - The device feasibility is evaluated by preparatory studies on the engineering design of coils, VV, and support structures

Development of HTS Conductor

Three types of advanced High Temperature Superconductor are being fabricated and tested. After C&R, applicability to the next project will be assessed.

- STARS means “Stacked Tapes Assembled in Rigid Structure”
- Design of 18 kA conductor
- Current carrying tests of a 3-m-long prototype in liquid nitrogen
- Bending and thermal cycling effects were minimal

- FAIR means “Friction stir welding, an Aluminum alloy jacket, Indirect cooling, REBCO tapes”
- Current carrying tests of 1-m-long prototype conductors in liquid nitrogen
- Optimization of production methods

- WISE means “Wound and Impregnated Stacked Elastic tapes”
- Current carrying tests of Non-Insulation (NI) coils in liquid nitrogen

The first target of the submission of the proposal will be in early 2022 for “Master plan 2023”
SUMMARY

• D-D experiments of LHD successfully extended the high temperature domains for Ti and Te, and proved the confinement improvement. Studies on EC heated D plasma forming e-ITB, energetic particle confinement, and surface modifications of plasma facing components were enhanced.

• A series of simulation codes have been developed, improved and utilized. Operation of Plasma Simulator Raijin started to enhance the simulation research activity.

• Helical reactor design studies have progressed by adopting innovative concepts. R&Ds on basic technologies have proceeded using research facilities installed in NIFS including domestic and international collaborations.

• Technical investigation for the post-LHD project is progressing in NIFS and discussion by the community is being enhanced.
Evaluation viewpoint

the Division of Health and Safety Promotion

(1) Are the organizations and systems for safety and health management properly constructed and operated in compliance with relevant laws and regulations?

関連法令を遵守し、安全衛生管理のための組織、体制等を適切に構築し運用しているか。

(2) Are the safety management equipment / facilities, experimental equipment etc. for maintaining and managing safety taken into account for the characteristics and circumstances peculiar to fusion research?

安全を維持管理するための安全管理機器・設備、実験機器等は、核融合研究ならではの特徴・事情を考慮されたもとななるか。

(3) Are manuals and rules such as operation manuals, radiation control manuals, and emergency manuals properly formulated and operated?

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のマニュアル類や規則類は、適切に策定され、運用されているか。

(4) As the Inter-University Research Institute, do you properly provide safety management and education to staff and collaborators?

大学共同利用機関として、所員及び共同研究者に対する安全管理・教育を適切に行っているか。

(5) Is the training of leaders to carry out safety management properly planned and implemented?

安全管理を遂行するための指導者の養成は適切に計画・実行されているか。
(1) Are the organizations and systems for safety and health management properly constructed and operated in compliance with relevant laws and regulations?

関連法令を遵守し、安全衛生管理のための組織、体制等を適切に構築し運用しているか。
Positioning of safety and health management

The Constitution of Japan

Labor Standards Act
- Ordinance for Enforcement of the Labor Standards Act

Industrial Safety and Health Act
- Order for Enforcement of Industrial Safety and Health Act
- Ordinance on Industrial Safety and Health Act

Atomic Energy Basic Act
- Act on the Regulation of Radioactive Isotopes, etc.
- Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors

NIFS Regulations, Rules, Manuals
We establish internal rules and manuals before starting Deuterium experiment.
Applicable laws and regulations

- 労働基準法
  Labor Standards Act
- 労働基準法施行規則
  Ordinance for Enforcement of the Labor Standards Act
- 労働安全衛生法
  Industrial Safety and Health Act
- 労働安全衛生法施行令
  Order for Enforcement of Industrial Safety and Health Act
- 労働安全衛生規則
  Ordinance on Industrial Safety and Health
Applicable laws and regulations 2

- 原子力基本法
  Atomic Energy Basic Act
- 放射性同位元素等の規制に関する法律（R I 規制法）
  Act on the Regulation of Radioactive Isotopes, etc.
- 電離放射線障害防止規則（電離則）
  Regulation on Prevention of Ionizing Radiation Hazards
- 核原料物質, 核燃料物質及び原子炉の規制に関する法律
  Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors

- 消防法
  Fire Service Act
- 電気事業法
  Electricity Business Act
- クレーン等安全規則（クレーン則）
  Safety Ordinance for Cranes
- 高圧ガス保安法
  High Pressure Gas Safety Act
・特定設備検査規則
・ボイラー及び圧力容器安全規則（ボイラー則）
・ゴンドラ安全規則
・有機溶剤中毒予防規則（有機則）
・鉛中毒予防規則（鉛則）
・四アルキル鉛中毒予防規則
・特定化学物質障害予防規則（特化則）
・高気圧作業安全衛生規則
・酸素欠乏症等防止規則
・国際規制物資の使用等に関する規則
・一般高圧ガス保安規則
・特定設備検査規則
・冷凍保安規則
・危険物の規制に関する政令
Internal rules related to safety

○ NIFS Disaster Prevention Regulations
○ NIFS Electrical Safety Regulations
○ NIFS Safety and Health Regulation
○ NIFS Regulation on Prevention of Radiation Hazards
○ NIFS Detailed Regulation on the Ion Beam Analyzer
○ NIFS Detailed Regulation on the X-rays Device
○ NIFS Detailed Handling Regulation on very small amount Sealed Radioisotope
○ NIFS Accounting Provisions
○ NIFS Detailed rules for Radiation Education and Training
○核融合科学研究所高圧ガス（一般）危害予防規則
○核融合科学研究所高圧ガス（冷凍）危害予防規則
○核融合科学研究所高圧ガス（冷凍）製造施設運用基準（冷暖房設備）
○核融合科学研究所高圧ガス（冷凍）製造施設運用基準（大型ヘリカル装置低温設備）
Internal rules related to safety

- NIFS Hazardous Substance Management Regulation
- NIFS Regulation on Waste Liquid Handling
- NIFS Regulation on the Vacuum Maintenance on LHD
- NIFS Crane Usage Guidelines
- NIFS Detailed Regulation on the Vacuum Maintenance on LHD
- NIFS Detailed Regulation on LHD and other Experimental Devices
NIFS Safety Promoting Organization

- The National Institute for Fusion Science (NIFS) was re-established as a research institute of the National Institute of Natural Sciences (NINS) in April 2004.

- Director General organizes the Safety and Health Committee as a general safety and health manager based on the “Labor Standards Act” and the “Industrial Safety and Health Act”.

- Committee Meeting is held once in a month and things about safety and health are discussed.

- The “Division of Health and Safety Promotion ” was established as a department to solve various problems related to safety and health.
Purpose of activities of the Division of Health and Safety Promotion

- Prevention of occupational accidents
- Proper equipment operation and maintenance
- Ensuring the safety of staff and improving their health
- Creating a comfortable working environment

There are 10 offices under the division director. Each room is led by the chief.
Division for
Health and Safety Promotion
Division of Health and Safety Promotion

Division Director of Health and Safety Promotion

- Environmental Safety Control Office
- Health Control Office
- Fire and Disaster Prevention Office
- Radiation Control Office
- Electrical Equipment and Work Control Office
- Machinery and Equipment Control Office
- High pressure Gas Control Office
- Hazardous Materials Control Office
- New Experimental Safety Assessment Office
- Safety Handbook Publishing Office
Main Activities

Routine works:
- RI management,
- environmental radiation measurement,
- wastewater monitoring,
- safety education and seminars,
- issuance of safety handbooks,
- disaster prevention drills,
- safety patrols in working area.

Request from the Health and Safety Committee or individual experiment group:
- Improvement of the indicated matter.

Member:
The members of each room are selected from the Research Department, Engineering Department, and Administration Department, who are appropriate for the work in each office.
### 令和2年度 安全衛生管理計画

#### 委員会等
- 支持・安全衛生委員会（実）
- 安全衛生推進部会（実）

#### 定期検診
- 依頼先：株式会社春（実）
- 実施日：毎週金曜日13:30とする。

#### 防災対策
- 保険：保険会社（実）
- 対策：最大限の安全性を対策

#### 防災対策
- 自然災害：防災安全教育
- 他災害：高齢者安全教育

#### 事故調査
- 事故報告：KT株式会社
- 調査：KTリーダー（実）
- 安全検査：佐藤（実）

#### 教育
- 教育テーマ
  - 安全管理
  - 危険物管理
  - 事故対策

#### 健康診断
- 健康診断：株式会社春
- 実施回数：毎年

#### 保健管理
- 保健管理：株式会社春
- 実施回数：毎月
Roles

This office has the responsibility to maintain a safe work space and environment. Although the other nine offices of the division of health and safety promotion cover most of the risks that exist in the institute, some problems fall wide of them. The role of this office is to cope with such problems. Therefore, this office has a broad range of tasks.

Main roles of this office are as follows;

- Management to solve the problems pointed out by the safety and health committee.
- Maintenance of the card-key system for the gateways of controlled areas.
- Maintenance and management of the vehicle gate at the entrance of the experimental zone.
- Maintenance of the fluorescent signs of the evacuation routes and the caution marks.
- Management of sewage drainage from the NIFS.
- Accompany the inspections by the Safety Manager.
- Other matters related to general safety and health.
Examples of activities

Light charged Leading Plate

Caution marks

Component analysis table of sewage wastewater

- Nutrient content: Undetected
- BOD: 19.0
- Dissolved oxygen: 5.0

<table>
<thead>
<tr>
<th>Analysis Item</th>
<th>Unit</th>
<th>Measurement</th>
<th>Lower Limit</th>
<th>Standard Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspended solids</td>
<td>mg/l</td>
<td>57</td>
<td>0.5</td>
<td>600</td>
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<td>Dissolved solids</td>
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<td>1</td>
<td>600</td>
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<td>Phosphate</td>
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<td>1</td>
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<td>Fluorine</td>
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<tr>
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<td>0.01</td>
<td>3</td>
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<tr>
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<td>0.02</td>
<td>2</td>
</tr>
<tr>
<td>Total nitrogen</td>
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<td>0.01</td>
<td>1</td>
</tr>
<tr>
<td>COD</td>
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<td>0.04</td>
<td>2</td>
</tr>
<tr>
<td>Total KCl</td>
<td>mg/l</td>
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<td>1</td>
</tr>
<tr>
<td>Total iron</td>
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<td>0.005</td>
<td>0.005</td>
</tr>
<tr>
<td>Copper</td>
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<td>0.01</td>
<td>0.1</td>
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<tr>
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<td>0.02</td>
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<tr>
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<tr>
<td>Magnesium</td>
<td>mg/l</td>
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<td>0.005</td>
<td>0.003</td>
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<tr>
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<td>mg/l</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
</tr>
</tbody>
</table>

Data on sewage drainage

- Temperature: 2019/11/5 (Adjusted to room temperature)
- pH: 2019/2/5 (Adjusted to pH 7.0)

![Graph showing temperature and pH over time]
Hiyari-Hatto (near miss accident)
Report Page on WEB

<table>
<thead>
<tr>
<th>場所</th>
<th>どんな内容</th>
<th>考えられる対策</th>
</tr>
</thead>
<tbody>
<tr>
<td>本体室</td>
<td>フランジ作業 ヘルメットをぬいだ、LポールをLIDコイルサポートにぶつけた。</td>
<td>どんなときもヘルメット、つばの小さいヘルメットを買う</td>
</tr>
<tr>
<td>本体棟</td>
<td>Lポールでせまかったのでヘルメットを脱いだ、LIDコイルサポートに頭をぶつけた。けがはなかった。</td>
<td>ヘルメットをぬがない、つばの小さいヘルメットを買う</td>
</tr>
<tr>
<td>管理棟3Fから研究棟3Fへの廊下（管理部長室？の前）</td>
<td>コーナー部が2か所連続であり、対向者とぶつかりそうになったことがある。</td>
<td>カーブミラーの設置で、対向者を予測できるようにすることが効果的だと思います。</td>
</tr>
<tr>
<td>計測機器室（2）</td>
<td>本体棟1Fの計測機器室（2）への入出口のドアは、防火対策のため、常時、閉である。そのため、ドアの反対側にいる人にお気づくことができない。しばしば、両側から同時にドアにアクセスすることがあり、突き指しそうになる。</td>
<td>現在のドアに小窓をつけてもらいたい。見学者のルートであるため、東側（液化器室）と西側（本体棟）の両方に対策しでもらいたい。</td>
</tr>
</tbody>
</table>

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Roles

The main role of this office is to keep the workers in the institute healthy, including co-researchers and students.

Main roles of this office are as follows;

- Medical checkups both for general and special purposes and immunization for influenza.
- Accompany the inspections by the Industrial Physician.
- Maintenance of AEDs.
- Alerts and response to the COVID-19.
- Conduct the online stress check.
- Conduct various lectures for physical and mental health.

* Special medical checkups are provided to visiting co-researchers and graduate students when necessary.
3. Fire and Disaster Prevention Office

Roles
To prevent or minimize damages caused by various disasters including earthquakes, storms, fires and accidents, as well as of providing restoration work after such damages.

Main roles of this office are as follows;

- Making self-defense plans for fires and disasters, and implementation of various training.
- Promotion of first-aid workshops and the AED class.
- Maintenance of fire-defense facilities and attending on-site inspections by a local fire department.
- Review and update disaster prevention rules and disaster prevention manuals.
- Attending at on-site inspections by a local fire department once a year.
- Maintaining fire-defense facilities twice a year.
- Improvement of the surrounding environment such as weeds and fallen trees.
3. Fire and Disaster Prevention Office

Examples of activities

General emergency drill

Pivotal work at the disaster prevention center.

Fire extinguisher training.
3. Fire and Disaster Prevention Office

 Tight Connection (Emergency Contact)

- Disaster Control Center
  - Internal Line (Extension): 1111
  - External Line (Outside Call): 0572-58-2070

- Guard Station
  - Internal Line (Extension): 2071

- Control Room
  - Internal Line (Extension): 2445

- Fire Department
  - External Line (Outside Call): 119

Emergency Contact Information
Roles

The main role of this office is to maintain radiation safety for researchers and the environment. Legal procedures for radiation safety and regular education for the radiation area workers are also important roles of this office.

Main roles of this office are as follows:

- Maintain radiation safety for the workers.
- Registration and dose control of radiation area workers.
- Radiation monitoring in the radiation controlled area and the peripheral area.
- Maintenance of the radiation monitor.
- Applications for radiation equipment to the national agencies and the local governments.
- Always review existing rules and revise them if necessary.
- Held the educational lectures for all workers including the co-researchers and students.

* Non-Japanese workers can be educated and trained in English.
Educational lecture

The educational lecture was held on February 21, 2020.
* Until last year, three educational lectures in a year were held at the big meeting room.

For those who have not attended this lecture, it is possible to view the DVD of the lecture and submit a report.

Non-Japanese workers can be educated and trained in English.
NIFS Radiation Safety System

Radiation Control office was 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 Worker Registration

Number of NIFS Radiation Worker

<table>
<thead>
<tr>
<th>Fiscal year</th>
<th>NIFS</th>
<th>non-NIFS</th>
<th>Total (non-Japanese)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>166</td>
<td>84</td>
<td>250 (11)</td>
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<tr>
<td>2016</td>
<td>174</td>
<td>132</td>
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<td>177</td>
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<tr>
<td>2019</td>
<td>172</td>
<td>213</td>
<td>385 (13)</td>
</tr>
</tbody>
</table>

Registration Procedure

1. **Submit a registration form**
2. **Get a medical check**
   - From FY-2009 non-NIFS worker without registration as radiation worker in his university can get a medical check in NIFS.
3. **Education and Training**
   - For new non-Japanese worker can be educated and trained in English.
   - For renewal registration, worker can be educated with using the DVD-video source.
4. **Send a Permission**
5. **Receive a Lumines Badge**
Measurements of Environmental Radiation Dose

Environmental radiation dose have been measured by the Electrical Dosimeter and the Radio-photo Luminescence Dosimeter.

Example of the data sheet of radiation measurement points around the LHD. Measurement is done once a week.

Continuous measurement around the NIFS site by RMSAFE system

Every three months measurement in and around the NIFS site.
5. Electric Equipment and Work Control Office

Roles

The main role of this office is to maintain electrical safety for researchers, technical staff members and students.

Main roles of this office are as follows;

- Check and control the electrical facilities according to the technical standards.
- Accompany the inspections by the Safety Manager.
- Safety lecture for researchers and workers.
- Annual check of electrical equipment with blackout.
- Discussion with commercial electric power supplier.
6. Machinery and Equipment Control Office

Roles

The main role of this office is to maintain the safe operation of cranes. Main roles of this office are as follows;

- Inspection and maintenance of cranes.
- Management of the crane license holders and safety lectures for the crane users.
- Schedule management of crane operations.
- Safety lecture for researchers and workers.
Number of crane in NIFS  Total:34
  Cab operation type :8 (>3ton) → (Wireless operation :3)
  Floor operation type (>3ton) : 5
  Floor operation type (<3ton) : 20

Number of NIFS crane license holder
  Crane pilot      44
  Floor-operated crane pilot  59
  Slinger         100
Roles

This office has a very important role in NIFS, because the main experimental machine, LHD, is the superconducting machine which requires cooling by liquid helium. And many other machines have cryogenic pumping systems which require cooling down.

Main roles of this office are as follows;

- Safety operation and maintenance of high-pressure gas handling facilities (LHD cryogenic system, diborane gas supply facility, etc.) in NIFS.
- Daily operation, maintenance, system improvement, and safety education according to the law.
- Safety lectures for researchers and workers.

Safety training

The security staff must take the security staff training in accordance with the law. (Usually once every 5 years)
7. High Pressure Gas Control Office

- Cryogenic facilities for LHD superconducting system
- Diborane gas supply facility
- LN₂ storage/supply facility for LHD NBI system
- Cryogenic facility for superconducting magnet research laboratory
- LN₂ storage/supply facility for plasma diagnostic laboratory
- LN₂ storage/supply facility for fusion engineering research laboratory
- Refrigeration facility for fusion engineering research laboratory

High pressure gas safety Inspection

<table>
<thead>
<tr>
<th>Year</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
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<tbody>
<tr>
<td>Date</td>
<td>July-20</td>
<td>July-7/Nov.-10</td>
<td>July-20</td>
<td>July-20</td>
<td>Aug.-17</td>
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</table>
8. Hazard Materials Control Office

Roles

The main role of this office is the management of the safe treatment of hazardous materials and maintaining safety for researchers against hazardous events.

- Research the requests for hazardous materials and the storage status.
- Management to ensure safe storage of the waste.
- Monitoring of cooling drainage to prevent water pollution.
- Implementation of chemical substance risk assessment.
- Perform procedures to outsource the treatment of waste and waste liquid to a contractor.

<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>Number of Obtain Request</th>
<th>Number of Disposal Request</th>
<th>Number of Spent</th>
<th>Waste liquid treatment amount (kg)</th>
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<tbody>
<tr>
<td>2015</td>
<td>277</td>
<td>127</td>
<td>100</td>
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<td>2016</td>
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<td>2019</td>
<td>281</td>
<td>76</td>
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<td>1024.6</td>
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</table>
8. Hazard Materials Control Office

Hazardous substances storage area supervisor

Request to Obtain

Obtain

User

Disposal

Use

Available when the stored quantities are large
Available when there is concern over safety in storage

Move

Waste Oil & Waste Water

Storage

Hazardous materials storage

Request to Stock

(Waste Oil & Waste Water)

Tag

Request to Move

Waste management Special trader

Hazardous substances storage area
9. New Experimental Safety Assessment Office

Roles

The main role of this office is to check the safety of experimental devices other than LHD. For this purpose, researchers who want to setup new experimental apparatus must apply for the safety review. Two reviewers are assigned from members of this office and other specialists. They check the safety of these devices.

- Examine new experiments for safety problems and advise on safety measures.
  * New experiments in LHD are reviewed by the LHD Experiment Group.
- Improve safety in each experiment and reinforce the safety culture at NIFS by annual reviews by users. Therefore, each device needs to be applied for (updated) every year.
9. New Experimental Safety Assessment Office

**Inspection of New applications:**

- Researchers who want to setup new experimental apparatus apply for the safety review.
- Two reviewers are assigned from members of the Office and other specialists.
- The safety review is done with the applicant. Decisions are made in meetings of the Office.
- If the equipment is judged to be safe, a registration certificate is issued to the applicant and his division director.

*If he wishes to experiment with deuterium, dosimetry by the Radiation Control Office is required.*

**Update of applications:**

- The Office requests the researchers to check the safety of their existing experimental apparatus.
- The judgment is made at the Office meeting. If the check sheet does not pass the safety review, the applicant is notified and a new application will be required.
- If the update is approved, a registration certificate is issued to the applicant.
9. New Experimental Safety Assessment Office

<table>
<thead>
<tr>
<th>適番</th>
<th>審覧番号</th>
<th>実験装置名</th>
<th>実験場所</th>
<th>初回登録日</th>
<th>更新終了日</th>
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<td>9.1</td>
<td>開発-005</td>
<td>電子-イオン衝突実験装置（ACE-IT II）</td>
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<td>開発-006</td>
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<td>9.14</td>
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<td>(托盤)電気用水素ガス抽出装置</td>
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<td>9.20</td>
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<td>9.29</td>
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<td>20200325</td>
<td>20200617</td>
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## 9. New Experimental Safety Assessment Office

<table>
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<tr>
<th>製番</th>
<th>実験装置名</th>
<th>実験場所</th>
<th>初回登録日</th>
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<tr>
<td>2</td>
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<td>2020年6月11日</td>
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<tr>
<td>3</td>
<td>開発-006</td>
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<td>2020年6月11日</td>
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<td>17</td>
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<td>2004年10月9日</td>
<td>2020年6月12日</td>
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<td>18</td>
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<td>計測実験棟HIBP計測実験室</td>
<td>2004年10月9日</td>
<td>2020年6月12日</td>
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<tr>
<td>19</td>
<td>計測-007</td>
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<td>計測実験棟HIBP計測実験室</td>
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<td>2020年6月12日</td>
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<td>67</td>
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10. Safety Handbook Publishing Office

Roles

The tasks of this office are publication of the Safety Handbook in Japanese and in English and to update them as necessary.

Main roles of this office are as follows;

- Publication of the Safety Handbook in Japanese and in English and to update them as necessary.
- Held the safety lecture for all workers including the co-researchers and students.

Safety Lecture

The regular safety lectures were held on May 4, 2020.

As an alternative course for those who have not attended this lecture, we offer viewing the lecture DVD and submitting a report.
10. Safety Handbook Publishing Office

Safety Handbook

2011 Edition

In the event of fire, accident, or disaster, first call is to the Disaster Response Center!

Disaster Response Center (AED)
Inside line: 1 1 1 1
Outside line: 5 8 - 2 0 7 0

Gate Security Office
Inside line: 2 0 7 1
Outside line: 5 8 - 2 0 7 1

April 2011

Inter-University Research Institute Corporation
National Institutes of Natural Sciences

National Institute for Fusion Science

## Contents of Safety Handbook (English version)

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10. Safety Handbook Publishing Office

List of Safety Lectures

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<td>5/30</td>
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<td>6/7</td>
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<td>2008</td>
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<td>6/12</td>
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<td>2009</td>
<td>4/16</td>
<td>5/13</td>
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<td>2012</td>
<td>4/19</td>
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<td>2014</td>
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<td>4/22</td>
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<td>2016</td>
<td>4/27</td>
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<td>2017</td>
<td>5/12</td>
<td>△ 8/8</td>
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<td>2018</td>
<td>5/10</td>
<td>△ 5/22</td>
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<tr>
<td>2019</td>
<td>5/9</td>
<td>△ 5/22</td>
<td>△ 5/24</td>
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<tr>
<td>2020</td>
<td>▲ 5/14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- △: Watching DVD projection in the hall
- ▲: On WEB

Held the safety lecture for all workers including the co-researchers and students.

- The 2nd and 3rd lectures in 2017, 2018, and 2019 were projections of the 1st lecture.

- The lecture in 2020 was held on the WEB.

* For those who have not attended any of the lectures are asked to view the DVD of the lecture and submit a report.
(2) Are the safety management equipment / facilities, experimental equipment etc. for maintaining and managing safety taken into account for the characteristics and circumstances peculiar to fusion research?

安全を維持管理するための安全管理機器・設備、実験機器等は、核融合研究ならではの特徴・事情を考慮されたもとなっているか。
Characteristics and Circumstances Peculiar to Fusion Research

- **D Plasma (D-D reaction and D-T reaction)**
  - generation of X-ray, neutron, tritium and γ-ray
    - Management of neutron generation
      - Radiation shielding
      - Safe handling of tritium
      - Safe handling of radioactive substances
      - Management of Environmental Radiation

- **Large Experiment Machine (LHD)**
  - Installation/removal of measuring devices, heating devices, etc.
    - Safe Equipment handling work
    - Safe Crane work

- **Electromagnetic Waves, Magnetic Field**
  - shielding
Neutron and tritium measure and control

\[ D + D \rightarrow T + p \rightarrow 3He + n \]

\[ D + D \rightarrow \text{Number of Tritium} = \text{Number of Neutron} \]

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.

1. Neutron, \(\gamma\)-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
NIFS management level 1 –

- Controlled Area (Working area)
  - 1 mSv/week (100 mSv/5 years)
  - 40 Bq/cm²

- Boundary of Controlled Area
  - 1.3 mSv/3 months
  - 4 Bq/cm²

- 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
### Tritium Concentration in Working Environment (Law)

<table>
<thead>
<tr>
<th>Types of Radioisotopes</th>
<th>Limit in Working environment (Bq/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isotope</td>
<td>Chemical form</td>
</tr>
<tr>
<td>³H</td>
<td>Gaseous tritium</td>
</tr>
<tr>
<td>³H</td>
<td>triated water or vapor</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>³H</td>
<td>1 × 10⁴</td>
</tr>
<tr>
<td>³H</td>
<td>8 × 10⁻¹</td>
</tr>
</tbody>
</table>

### Tritium Concentration in Exhaust (NIFS management level)

<table>
<thead>
<tr>
<th>Types of Radioisotopes</th>
<th>Limit in Air or Exhaust (Bq/cm³)</th>
<th>Limit in Drainage or Waste water (Bq/cm³)</th>
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</thead>
<tbody>
<tr>
<td>Isotope</td>
<td>Chemical form</td>
<td></td>
</tr>
<tr>
<td>³H</td>
<td>Gaseous tritium</td>
<td>7 × 10¹</td>
</tr>
<tr>
<td>³H</td>
<td>triated water or vapor</td>
<td>2 × 10⁻⁴</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(5 × 10⁻³)</td>
</tr>
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</table>

( ) : Concentration Limit in Law
## Radiation Monitoring Equipment

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<th>Installation location</th>
<th>Target</th>
<th>Frequency</th>
<th>Instrument</th>
<th>Detection method</th>
<th>Sampling time</th>
<th>Detection lower limit</th>
<th>NIFS management value</th>
<th>Remarks</th>
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<td>LHD building</td>
<td>neutron</td>
<td>linked to plasma experiment</td>
<td>fission chamber</td>
<td>Ionization chamber</td>
<td>real time</td>
<td>1-6y : 2.1E19/y 9- y : 3.2E19/y</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Exhaust measurement</strong></td>
<td>Exhaust stack</td>
<td>tritium</td>
<td>continuous</td>
<td>gas monitor</td>
<td>ventilated ionization chamber</td>
<td>5 ½ ~</td>
<td>5E-3 Bq/cm³</td>
<td>5E-3Bq/cm³</td>
<td>Outlier detected</td>
</tr>
<tr>
<td></td>
<td></td>
<td>tritium</td>
<td>accumulation</td>
<td>tritium collector</td>
<td>collect with molecular sieve after oxidation</td>
<td>1 week</td>
<td>&lt; 2E-5 Bq/cm³</td>
<td></td>
<td>Total amount &amp; concentration control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>radiated air (Ar-41)</td>
<td>continuous</td>
<td>gas monitor</td>
<td>ventilated ionization chamber</td>
<td></td>
<td>5E-4 Bq/cm³</td>
<td>5E-4 Bq/cm³</td>
<td>check with neutron generation rate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>dust (α,βray)</td>
<td>continuous</td>
<td>dust monitor</td>
<td>accumulated on filter paper</td>
<td></td>
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<tr>
<td><strong>Emission calculation</strong></td>
<td>Vacuum exhaust gas treatment system</td>
<td>tritium</td>
<td>continuous</td>
<td>gas monitor</td>
<td>ventilated ionization chamber</td>
<td>2 ~ 3 min.</td>
<td>0.1 Bq/cm³</td>
<td>35 Bq/cm³</td>
<td>(*1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>tritium</td>
<td>continuous</td>
<td>gas monitor</td>
<td>ventilated ionization chamber</td>
<td>2 ~ 3 min.</td>
<td>5E-3 Bq/cm³</td>
<td>5E-3 Bq/cm³</td>
<td>Below the exhaust control level</td>
</tr>
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<td><strong>Drainage measurement</strong></td>
<td>Water tank</td>
<td>tritium</td>
<td>continuous</td>
<td>β ray monitor</td>
<td>Liq.scintillation counter</td>
<td>10 min.</td>
<td>0.3 Bq/cm³ water</td>
<td>0.6 Bq/cm³ water</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>C-14</td>
<td>water sampling</td>
<td>LowB Liq.scintillation counter</td>
<td>Liq.scintillation counter</td>
<td>~ 3 hrs</td>
<td>1E-3 Bq/cm³ water</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Radiant</td>
<td>continuous</td>
<td>γ ray monitor</td>
<td>NaI detector</td>
<td>10 min.</td>
<td>1E-2Bq/cm³ water</td>
<td>legal regulation value for each RI</td>
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<td>Ge detector</td>
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<td>check nuclide</td>
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<td></td>
<td>Tritium treated water</td>
<td>tritium</td>
<td>water sampling</td>
<td>LowB Liq.scintillation counter</td>
<td>~ 3 hrs</td>
<td>1E-3 Bq/cm³ water</td>
<td>confirmation of delivery quantity</td>
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<td><strong>Radiation measurement</strong></td>
<td>Site boundary</td>
<td>X (γ) ray</td>
<td>continuous</td>
<td>Ionization chamber</td>
<td>Ar pressurized chaber</td>
<td>almost real time</td>
<td></td>
<td>50 μSv/y</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>accumulation</td>
<td>dosimeter</td>
<td>glass dosimeter</td>
<td>1 week/3 mon.</td>
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<td></td>
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<td>neutron</td>
<td>continuous</td>
<td>proportional counter</td>
<td>He-3 counter</td>
<td>almost real time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>accumulation</td>
<td>dosimeter</td>
<td>electronic dosimeter</td>
<td>1 week/3 mon.</td>
<td></td>
<td></td>
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</table>

*1 Maximum outlet concentration when tritium recovery rate is 95%

Monitoring of NIFS controlled values

Monitoring of Legal values
# Neutron measurements

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<tr>
<th>Purpose</th>
<th>NIFS control value</th>
<th>Installation Place</th>
<th>Measuring equipment</th>
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</thead>
</table>
| (1) Neutron Generation Management | 2.1x10^{19} n/y (former 6y) 3.2x10^{19} n/y (later 3y) | LHD hall (controlled area) | ○ LHD plasma  
  - Fission chamber: 3  
  - ³He counter: 2  
  - ¹⁰B counter: 1  
  ○ NBI (gas cell & beam dumper)  
  - ³He counter: 5 |
| (2) Working environment monitoring | | Out side the LHD hall (Peripheral restricted area) |  
  - Rem counter: 4  
  - ³He counter: 2 |
| (3) On site & at site boundaries monitoring | At site boundary: 50 μSv/y | On site & at site boundaries |  
  - Rem counter: 2  
  - ³He counter: 10 |

In addition to the above, as a research target, the indoor dose distribution is measured with a badge-type integrated neutron dosimeter.

: RMSAFE
Since the amount of neutrons generated and the amount of tritium generated are the same, the amount of tritium generated can be known.

The measurement is performed for 24 hours, and the total neutron integration amount is updated every 1/20 second.
Reduction of radio-activation by neutron

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

To reduce the effects of neutron irradiation, install PE block around the electronics.
Neutron monitoring on site and at site boundaries with RMSAFE

- $^3$He counter & REM counter
- $^3$He counter

With burst detection function
Continuous measurement
4. Controlled Area & Security

- Controlled Area -

1st floor

1st basement

2nd floor

2nd basement
LHD deuterium experiment will start after the supposed 3-year preparation.

- Exit Flow and Contamination Test Apparatus -

Access Control room

Contamination inspection room

From LHD hall

Access gates for LHD hall

Contamination monitor

jury meter

3H/14C survey meter

From basement

Access gates

hand-foot-clothing monitors x 3

Expiration inspection device
5. Integrated Radiation Monitoring System

Enhancement of monitoring system of LHD building

- Access gates
- Contamination monitor
- ITV
- Exhaust gas monitor
- Gas and dust monitor
- Drainage monitor
- Exhaust gas processing system
- Environmental monitors
- Monitors in the vacuum vessel

- Interlock
- Integrated radiation monitoring system

Rooting in the central control

Control room
Example of Monitoring Displays

DRAINAGE CONTROL SYSTEM

STACK and LHD HALL GAS MONITOR

RMSAFE (SITE BOUNDARY)

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
(3) Are manuals and rules such as operation manuals, radiation control manuals, and emergency manuals properly formulated and operated?

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のマニュアル類や規則類は、適切に策定され、運用されているか。
We establish internal rules and manuals before starting Deuterium experiment.
・労働安全衛生法
  Industrial Safety and Health Act

・消防法
  Fire Service Act

・電気事業法
  Electricity Business Act

・放射性同位元素等の規制に関する法律（R I 規制法）
  Act on the Regulation of Radioactive Isotopes, etc.

・核原料物質，核燃料物質及び原子炉の規制に関する法律
  Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors

・電離放射線障害防止規則（電離則）
  Regulation on Prevention of Ionizing Radiation Hazards

・クレーン等安全規則（クレーン則）
  Safety Ordinance for Cranes

・高圧ガス保安法
  High Pressure Gas Safety Act
・特定設備検査規則
・ボイラー及び圧力容器安全規則（ボイラー則）
・ゴンドラ安全規則
・有機溶剤中毒予防規則（有機則）
・鉛中毒予防規則（鉛則）
・四アルキル鉛中毒予防規則
・特定化学物質障害予防規則（特化則）
・高気圧作業安全衛生規則
・酸素欠乏症等防止規則
・国際規制物資の使用等に関する規則
・一般高圧ガス保安規則
・特定設備検査規則
・冷凍保安規則
・危険物の規制に関する政令
Internal rules related to safety

○核融合科学研究所防災規則
  NIFS Disaster Prevention Regulations
○核融合科学研究所電気保安規則
  NIFS Electrical Safety Regulations
○核融合科学研究所安全衛生管理規則
  NIFS Safety and Health Regulation
○核融合科学研究所放射線障害予防規程
  NIFS Regulation on Prevention of Radiation Hazards
○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
  NIFS Detailed Regulation on the Ion Beam Analyzer
○核融合科学研究所エックス線装置の維持管理細則
  NIFS Detailed Regulation on the X-rays Device
○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 Handling Regulation on very small amount Sealed Radioisotope
○核融合科学研究所計量管理規定
  NIFS Accounting Provisions
○核融合科学研究所放射線教育訓練実施細則
  NIFS Detailed rules for Radiation Education and Training
〇核融合科学研究所高圧ガス（一般）危害予防規則
〇核融合科学研究所高圧ガス（冷凍）危害予防規則
〇核融合科学研究所高圧ガス（冷凍）製造施設運用基準（冷暖房設備）
〇核融合科学研究所高圧ガス（冷凍）製造施設運用基準（大型ヘリカル装置低温設備）
○核融合科学研究所危険物質管理規則
NIFS Hazardous Substance Management Regulation

○核融合科学研究所における廃液取扱いに関する規則
NIFS Regulation on Waste Liquid Handling

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

○核融合科学研究所クレーン使用要項
NIFS Crane Usage Guidelines

○核融合科学研究所実験装置等の維持管理細則
NIFS Detailed Regulation on the Vacuum Maintenance on LHD

○核融合科学研究所大型ヘリカル装置等の維持管理細則
NIFS Detailed Regulation on LHD and other Experimental Devices
○防災マニュアル (重水素実験対応版)  
Disaster Prevention Manual (Deuterium experiment version)

○不法侵入・不審物・盗難等対応マニュアル  
Manual for dealing with trespassing, suspicious objects, theft, etc.

○通報・連絡マニュアル  
Report / contact manual

○衛星電話が不通の場合の職員の派遣マニュアル  
Staff dispatch manual when satellite phone is not available

○宿直マニュアル  
Night shift manual
Disaster and Abnormal Response Manuals 2

- Safety Handbook
- Radiation-related manual
- Leakage handling manual
- NBI Abnormal Response Manual
- LHD vacuum abnormality response manual
- Manual for dealing with abnormalities in the tritium removal device
- Manual for handling ECH cooling water leaks at night and on holidays
- Manuals for COVID-19
Examples of NIFS Regulation –
NIFS Regulation of Prevention of Radiation Hazards
Examples of NIFS Regulation –
NIFS Detailed Handling Regulation of very small amount Sealed Radioisotope
We are preparing the following three manuals.

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

* As a general rule, these manuals should contain the minimum necessary content on pages 1-2 so that even observers at night or on holidays can respond.

- These manuals will be revised in a timely manner when revisions are required.
- Manuals will be added as needed when necessary items arise.
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</table>

<table>
<thead>
<tr>
<th>4.9.1 LHD対応マニュアル</th>
<th>5.1.1 フレームワーク分析機関利用マニュアル</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.9.1 LHD対応マニュアル</td>
<td>4.10.1 フレームワーク分析機関利用マニュアル</td>
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<th>4.14.1 防災・防災マニュアル</th>
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<tbody>
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<td>4.15.1 防災・防災マニュアル</td>
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<td>4.15.1 防災・防災マニュアル</td>
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</tbody>
</table>
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.
LHD運転マニュアル／本体運転マニュアル／

真空排気装置運転マニュアル

2010年4月27日

1. 概要
このマニュアルは、真空排気装置を安全に運用するために必要な事項を定めたものである。真空排気装置の運用にあたっては以下の3箇所を確認すること。
① 真空排気装置
② 安全装置
③ フラズマ放電装置

2. 装置の使用について
装置の使用者は、指定の業務を委任者として業務を受託している者でなければならない。

3. 運転・監視体制について
運転監視者を監視責任者として指定職員が運転・監視に当たる。
① 大気圧力の状態
② 大気圧力の測定

4. 監視点検について
監視点検は以下の部位に分けてする。
① 運転点検
② 監視点検
③ 喪失対策

6. 運転開始の手順について
運転開始の手順については次の通り、確認を行う。
① 委託契約の確認
② 出力設定
③ 善状状態を確認
④ 運転モード下の機械の動作確認
⑤ 真空排気装置の確認

6. 運転時の注意について
真空排気装置の運転中に注意を欠くと危険が発生するため、以下の項目に注意を払うこと。
① 大気圧力の変動
② 機械の異常発生
③ 善状状態の確認
④ 運転モードの変更

7. 常時監視について
常に監視者及び監視責任者により監視を行うこと。

81/103
LHD運転マニュアル／本体運転マニュアル／

コイル電源運転マニュアル

2013年4月27日

1．概要
このマニュアルは、コイル電源を完全に無理するため、必要な手順を定めるものとする。

2．装置の使用について
装置の使用は、放棄者を第三者として加筆された者がなければならない。

3．運転・監視体制について
研究発表団体を設置者として技術員が運転・監視に当たる。装置の運転会議及び作業は放棄者

4．定期検査について
火炎による装置の運転管理規律に定める項目に関し、定期点検を実施すること。

5．運転開始の準備について
5-1．整備状態
1．装置が許可されていることを確認する。
2．装置の整備が終了していることを確認する。
3．コイルが電流条件を満たしていることを確認する。
5-2．電流の親し方
1．電流をもくと浸漬ガラス形に浸漬する。

6．運転時について
実験開始中は、装置の使用者は、整備で装置の健全性の確認を初めることは、装置の使用・分析

7．運転終了の手順について
1．流体冷却装置を止めて点検を施して塗装をするのである。
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.
- NIFS management level 1 –

- Controlled Area (Working area)
  - 1 mSv/week (100 mSv/5years)
  - 40 Bq/cm²

- Boundary of Controlled Area
  - 1.3 mSv/3month
  - 4 Bq/cm²

- 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)

<table>
<thead>
<tr>
<th>Types of Radioisotopes</th>
<th>Limit in Working environment (Bq/cm³)</th>
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<tbody>
<tr>
<td>Isotope</td>
<td>Chemical form</td>
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<tr>
<td>³H</td>
<td>Gaseous tritium</td>
</tr>
<tr>
<td>³H</td>
<td>triated water or vapor</td>
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<td></td>
<td>1 × 10⁴</td>
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<td>8 × 10⁻¹</td>
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</tbody>
</table>

○ Tritium Concentration in Exhaust (NIFS management level)

<table>
<thead>
<tr>
<th>Types of Radioisotopes</th>
<th>Limit in Air or Exhaust (Bq/cm³)</th>
<th>Limit in Drainare or Waste water (Bq/cm³)</th>
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</thead>
<tbody>
<tr>
<td>Isotope</td>
<td>Chemical form</td>
<td>(Bq/cm³)</td>
</tr>
<tr>
<td>³H</td>
<td>Gaseous tritium</td>
<td>7 × 10¹</td>
</tr>
<tr>
<td>³H</td>
<td>triated water or vapor</td>
<td>2 × 10⁻⁴</td>
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<td>(5 × 10⁻³)</td>
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( ) : Concentration Limit in Law
Radiation Management Manual for Entrance of Controlled Area

1. Introduction
   - This manual provides guidelines for managing radiation exposure at the entrance of a controlled area.

2. Procedure
   - Upon entering the controlled area, all personnel must pass through a detection portal equipped with a shower.
   - Any contaminated personnel will be directed to a decontamination area.

3. Staff Supervision
   - Staff members are responsible for monitoring personnel entering the area and ensuring adherence to the protocol.

4. Personal Protective Equipment
   - Personnel must wear appropriate PPE, including gloves and masks, when entering the controlled area.

5. Monitoring System
   - The monitoring system includes detection portals and showers that continuously monitor radiation levels.
   - Any deviation from normal levels will trigger an alert and immediate action.

6. Entrance Monitoring
   - Radiation levels at the entrance are monitored using detection portals.
   - Personnel are screened for any signs of contamination.

7. Enforcement
   - All personnel must comply with the procedures outlined in this manual.
   - Violations will result in disciplinary action.

8. Conclusion
   - The goal of this manual is to ensure the safety of personnel and the environment.
   - Continuous monitoring and adherence to protocols are crucial for preventing radiation exposure.

Diagram: Diagram illustrating the radiation management process at the entrance of a controlled area.
放射線管理マニュアル／ポート作業マニュアル

1. 概要

このマニュアルは、大型航路放射線管、大型航路放射線装置が存在する場合におけるポート作業を行う際の安全上の注意点に関するものです。ポート作業を行う者は、以下のدني after_instruction

2. ポート作業の流れ

ポート作業の流れは以下の通りです。ポート装置の設定、ポート作業の实施、ポート作業の終了の順に進めていきます。ポート作業終了後は、放射線管理マニュアルに従い、清掃を行うこと。

3. 責任者

ポート作業の責任者は、ポート作業の立会いを行う者です。立会いを行う者は、その他の作業者、製品、証明書等に関する運搬上の責任者を含む Pregnant Workers定義。

4. ポート作業の内容

ポート作業の内容は、大型航路放射線装置の操作、大型航路放射線装置に付帯する装置の操作、大型航路放射線装置の設置、清掃の順に進めていきます。

5. ポート作業の準備

ポート作業の準備は、大型航路放射線装置の設置と、大型航路放射線装置に付帯する装置の設置を行います。設置の後は、大型航路放射線装置の清掃を行い、清掃の後は、大型航路放射線装置の作業を行います。

6. ポート作業の実施

ポート作業の実施は、大型航路放射線装置の作業、大型航路放射線装置に付帯する装置の作業、大型航路放射線装置の清掃の順に進めていきます。作業の後は、清掃を行い、清掃の後は、大型航路放射線装置の作業を行います。

7. 適用法の対象

大型航路放射線装置の作業者、大型航路放射線装置の立会いを行う者、清掃を行う者、大型航路放射線装置の作業を行う者が対象となります。
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

In the event of a disaster or accident, we have to pay attention to neutrons and tritium, which can affect the environment.

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.
防災マニュアル
（重水素実験対応）

2020年版

災科学研究所 電気科学研究所
緊急連絡先（Emergency Contact）

■ 防災センター（Disaster Control Center）
  内線（Extension）：1111
  外線（Outside Call）：0572-58-2070

■ 門衛所（Guard Station）
  内線（Extension）：2071

■ 制御室（Control Room）
  内線（Extension）：2445

■ 消防署（Fire Department）
  外線（Outside Call）：119

Emergency Network

Emergency Contact Information
| 所長 (管理権原者) | 副所長 (管理部長 (統括管理者)) | 所長 (管理部長) | 総務班 | 総務企画課長 | 消防班 | 安全衛生推進部長 | 誘導班 | 管理部 財務課長 | 救護班 | 管理部 研究支援課長 | 工作班 | 管理部 施設・安全管理課長 |
|-----------------|------------------|---------------|--------|-------------|--------|-----------------|--------|-----------------|--------|-----------------|--------|-----------------|--------|
|                |                  |              | 総務班 | 総務企画課長 | 消防班 | 安全衛生推進部長 | 誘導班 | 管理部 財務課長 | 救護班 | 管理部 研究支援課長 | 工作班 | 管理部 施設・安全管理課長 |
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<table>
<thead>
<tr>
<th>高圧ガス</th>
<th>保安技術管理者</th>
<th>保安係員、保安監督者、保安係員代理、保安監督者代理</th>
</tr>
</thead>
<tbody>
<tr>
<td>放射線</td>
<td>放射線取扱責任者</td>
<td>管理区域責任者、環境放射線管理責任者、放射線管理室長</td>
</tr>
<tr>
<td>電気</td>
<td>電気責任者</td>
<td>電気装置責任者</td>
</tr>
<tr>
<td>危険物</td>
<td>危険物質管理者</td>
<td>危険物質保管庫責任者</td>
</tr>
</tbody>
</table>
(4) As the Inter-University Research Institute, do you properly provide safety management and education to staff and collaborators?

大学共同利用機関として、所員及び共同研究者に対する安全管理・教育を適切に行っているか。
Education and Nurturing responsible person for the safety management

Education

- General Safety Lecture and Radiation Safety Lecture are held for all workers, including students and collaborators. Workers are required to take lectures every year.

- Those who have possibility to contact with tritium during work, such as port work and work inside a vacuum vessel, require additional training for treatment of unsealed RI.
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 guideline 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 LHD building is issued to the co-researcher.
  – And a Lumines badge with QR code to access the controlled area are 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 guideline 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.
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.
Training and Nurturing for Safety Responsible Manager

Safety Lecture

Tritium Safely Handling Course
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<td>（2）真空排気</td>
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<td>片づけ、廃棄物処理、汚染検査</td>
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<td>修了証授与他</td>
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(5) Is the training of leaders to carry out safety management properly planned and implemented?

安全管理を遂行するための指導者の養成は適切に計画・実行されているか。
the first-class Radiation Protection Supervisor qualification

- Radiation control is essential to safely carry out the LHD experiments.

- To lead radiation control, knowledge of radiation law is required. For this purpose, it is desirable to obtain the qualification of the first-class Radiation Protection Supervisor.

- Every year, several people from the Research Department and the Engineering Technical Department are encouraged to acquire the qualifications of the 1st class Radiation Protection Supervisor.

- Specifically, it is a support for the cost of attending a pre-examination course, taking an examination, and practicing after passing the examination.

- In addition, it is recommended that the qualification of Working Environment Measurement Expert be acquired mainly by the Radiation Protection Supervisor.

Qualification holder

- Researcher : 18
- Engineers : 8
- Others : 1
- Radiation Protection supervisor : 5
- Working Environment Measurement Expert : 2
Qualifications related to the high-pressure gas

Production Safety Management Certificate

- Since the LHD is a device with a superconducting coil, liquid helium is used. Therefore, a qualification related to high-pressure gas is required for operation.

- The low temperature group consists of the Research Department and the Engineering Technical Department members, and each of them is required to obtain a qualification related to the high-pressure gas.

- In cooperation with the experiment group, we are promoting human resource development and qualification acquisition (several per year) with an eye on generational change.

Qualification holder

- Class B Mechanical Safety Management Certificates: 34
- Class 1 Refrigeration Safety Manager Certificates: 11
- Specific High-Pressure Gases Handling chief: 5
Qualifications of Health Manager and Safety Manager

- Health managers and safety managers are indispensable for workplace safety and health management.

- NIFS has selected one safety manager and five health managers.

- Health managers are selected from the Research Department, Administration Department, and Engineering Technical Department in order to deepen the awareness of safety and health among many staff members.

- The term of office is two years, and half of them change every year. Therefore, every year, several people are qualified as Class-1 Health Officer’s license.

**Qualification holder**

- Class-1 Health Officer’s license
  - Research Department : 12
  - Engineering Technical Department : 5
  - Administration Department : 8
Overview of the Division of Information and Communication Systems

Seiji Ishiguro and ICS members
Points for Evaluation

1. Is the information and communication system as a research platform properly constructed and operated?

2. Is the division of information and communication systems properly responding to requests for information system development from inside and outside the institute?

3. Is the organization of the division of information and communication systems functionally and operated?
Outline

0. Introduction
1. Information and communication systems as a research platform
2. Response to requests for information system from inside and outside the institute
3. Organization and functionality
Introduction

- Division of Information and Communication Systems (ICS) was established in April 2013 as an organization that builds and operates information systems and information networks by consolidating the information-related organizations of the institute that were operating independently.

- The organization has changed in response to changes in the external environment, etc.
Introduction (Cont.)

- Information security survey, education
- Network, mail service, security measures,
- LHD experiment support
- Development of backbone system, software distribution
- Atomic and Molecular database management and web publishing
1. Information and communication systems as a research platform

- Is the information and communication system as a research platform properly constructed and operated?
Network Operation Task Group supports research activities of NIFS by managing the network infrastructure, access-line, fiber and metal line, L2/L3 switch, firewall, SSL-VPN server, DNS, mail, and so on. The network of NIFS consists NIFS-LAN, LHD-LAN, PS-LAN, and Guest Network.
Progress of SINET and NIFS Campus network. SINET is an academic wide area network in Japan operated by National Institute for Informatics. The network of NIFS is connected to SINET with 10 Gbps lines via optical cables provided by Gifu information super-highway, a metro area network operated by Gifu Prefectural Gov. The internet connectivity is very important, the access line is contracted with a commercial provider that even if SINET data center is down, the internet connectivity is valid via commercial provide network.
Network connectivity map of NIFS campus network, NIFS-LAN. All of traffic of NIFS-LAN and the internet is controlled by a firewall. Network Operation TG provides the Guest Network, which is segmented by NIFS-LAN, for guest researchers to access the internet easily. Wi-Fi is serviced only on Guest Network.

Edge switches on the building are connected to Core switch with 2 10Gbeps lines for redundancy. The single-mode optical fibers are laid between buildings. Most of the metal cable in the building is replaced from Category 5 to Category 6 to ensure the connection with 1 Gbps.
Security measure

• AntiVirus
  • is provided to the staff of NIFS from 1999.
  • is ESET Endpoint Protection standard from June 2020.
    • Monitoring servers check the PC states on NIFS-LAN and LHD-LAN.
    • Symantec Endpoint Protection had used for a long time, but the product distribution was unstable since Symantec was buyout.

• Firewall
  • connects NIFS-LAN and the internet to control the inner and outer connections.
  • distincts Web sites which staff access and block some URL for security.
  • detects the application on the connection and disconnect some application for security.
Virtual infrastructure system

- Network Operation TG managed the virtual infrastructure system has built with servers, RAID-6 storage, and VMware ESXi to do the central management on several network services such as DNS, DHCP, Mail and so on.

- It is connected a power management system to avoid the damage by unplanned power outage.

- The virtual infrastructure system offer a common service for NIFS. For example, several public web servers managed by Division of Information and Communication Systems have moved to this system, recently. The number of servers operated in this system is 38 on Nov. 2020.

- This system will be upgraded in FY 2020.
NIFS-LAN has a unique function controlling the connection of PC to prevent the connect of unauthorized PC from 2014. The information about PC and user must be registrant to the authentication system.

The registrant should attend the information security course held by Information Security Office each year.

The PC is automatically checked the security requirements, OS and the virus definition file of anti-virus program is latest or not, when the user connected quarantine server and run the quarantine program. This procedure is required each 3 months to keep the online.
Quarantine and authentication system (2)

The PC with old OS, unsupported OS, cannot connect NIFS-LAN by the configure Quarantine System to deny the old OS.

The distribution of PC registered on NIFS-LAN. The hatch shows the percentage of expired PC. Multifunction copier is not set the expire term as it cannot run the quarantine program.

The detail OS information is obtained by the quarantine program. Windows 10 is widely used on NIFS-LAN and Red Hat included CentOS and Fedora is dominant on Linux distribution.
Mail Service

• Mail service on NIFS has migrated from MailSuite, an integrated mail software, to Google Gmail on September 1st, 2020.

• Motivations of the migration:
  • Maintenance term of MailSuite will be end at this financial year.
  • Request from staff that mail service should be up 24x7 is hard.
    • It needs to overcome the power outage due to legal inspection.
  • IP reputation of mail server is so low that sometimes the mail is not accepted as our mail server might seemed to be used by spammer.

• On the migration term, the forward configuration was setup to the mail could be received on both MailSuite and Gmail, the staff of NIFS could migrate to Gmail on the term.

• No major problem was occurred on the migration term.
• 2-Step authentication is mandatory because of the security trend.
  • MailSuite had customized to use 2-Step authentication. Onetime passwd (OTP) cards were used.
  • YubiKey, small USB-connect authentication device, have distributed to all the staff of NIFS.
  • SMS or authentication app on smartphone is permitted to use.

• All the migration process are done by the administrator, not user.
  • Account setting
  • Mail Spool on MailSuite
    • It takes more than a week. Number of account is about 400, and number of mail to migrate is about 4 million.
  • ML
    • ML, members of ML, and the detail configurations.
    • More than 40 configuration is there on Google Group.
    • Setting tools for Group configuration is not provided by Google, so small handmade programs written by Google Apps Script to call Admin API was used.
LHD-LAN

• LHD experimental LAN, LHD-LAN is dedicated to carry out the LHD experiment. It is separated from NIFS-LAN by FW.

• The PC on NIFS-LAN cannot directly reach LHD-LAN, an access-gateway server, which checks the security condition of PC and password authentication of user, controls whether PC can reach the LHD-LAN or not.

• LHD-LAN consists several segments, control sub cluster is separated by FW.

• Wifi is prohibit on LHD-LAN for security, Wifi on Guest Network is prepared in the control room.
Supervision Post LAN is used to connect the PCs whose OS is unsupported and needed to the experimental. The connection to other PC is limited by LHD-FW.

LHD-DMZ is used to inform the LHD experimental. The servers on LHD-DMZ send general information.

Outside research collaborator can access LHD-LAN via Remote access server on NIFS-FW, SSL-VPN server, which requests 2-Step authentication and checks the terminal's security condition.
Network infrastructure development for guests/collaborators

• User authentication system for remote access service
  • NIFS information network is protected from external accesses by a firewall system. In order to conduct collaborative works, we provides a remote access service by use of an SSL-VPN device. For better security, we impose multi-factor authentication.
  • The SSL-VPN device providing a remote access service was replaced in 2015. The prior system employed the RSA SecurID®. In FY 2014, the NIFS mail system has been replaced, which also impose multi-factor authentication using a one-time password (OTP) card by DAOU corp. In order to reduce the total cost of ownership, we developed an authentication system coupled with DAOU OTP authentication based on free-radius and mysql.

• Eduroam based wireless LAN service
  • A wireless LAN service for guests under Eduroam was deployed in FY 2018. The system is supported by inner and outer radius servers coupled with mysql user database, and we have distributed access points (Aps) covering common area such as a meeting room and accommodation facility. APs are managed by the centralized controller.
Institutional information systems supporting NIFS and the fusion research community

• NIFS Collaboration Database System: Nicollas
  • “Nicollas” was newly designed and developed in 2013 to be used for the online submission and judgment of the NIFS collaboration applications for FY. 2014, and had been continuously bug-fixed and functionally improved. In Nov. of 2017, this system was renewed as the NINS open use system (NOUS) in which most of the Nicollas codes have been ported with the original functionalities.

• NIFS-Repository
  • Institutional Repository (IR) is recognized as one of the most important infrastructures for universities and institutes. The first system for NIFS Repository based on “DSpace” started its operation in Mar. of 2009 by RIO. It was transferred to the institutional information systems task group (IIS-TG) in Apr. 2013 and ported into the “JAIRO Cloud” operated by National Institutes for Informatics (NII).
• NIFS Article Information System: NAIS
  • “NAIS” accumulates information of research achievements made by NIFS staffs and the collaborators for more than ten years. This system had been operated under Research Information Office (RIO) since April of 2006. In Apr. of 2013, it has been transferred to the institutional information systems task group (IIS-TG).
  • This system has been continuously improved under a collaboration with the Research Enhancement Strategy Office (RESO). This system is used not only for accumulating research products, but for an internal approval for publication / presentation. It becomes one of essential information systems supporting research activities in NIFS. The total number of registered records in Nov. of 2020 is about 17,000.
Distributed Data Storage System

• Many advanced diagnostics are installed on LHD. Huge amount of data should be stored safely.

• GlusterFS is selected for the distributed storage system by its scalability and by the fact that recovery of the file system is much easier than the previous system.

H. Nakanishi et. al., Fusion Engineering and Design 89 (2014) 707–711
• To obtain physical parameters, the AD converted binary data should be processed to the physical parameters.

• The dependence of the physical parameters is quite complicated. “AutoAna” system automatically resolves the dependency and generating analyzed data representing physical parameters.

• After developing the AutoAna system (2016), registered analyzed data increased drastically.
Transfer of the experimental data

- In the next generation fusion experiments, remote participance is the key developments. Technology of the high-speed transferring of the huge amount of the data has been developed.

Operation and Maintenance of NIFS Atomic and Molecular Database

- NIFS Atomic and Molecular (AM) Numerical Databases provide AM data on elementary processes important in fusion plasmas and other various plasmas for users via internet for free.
- Data are updated regularly.
- The server has moved to DMZ from NIFS internal network for security reason in 2016.
- The database system was reconstructed in a new replaced server with using PostgreSQL and Ruby on Rails in FY2016 to be more secure system.

Table: List of sub-databases in NIFS Atomic and Molecular Numerical Databases (http://dbshino.nifs.ac.jp) * As of Aug 11, 2020

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Number of data sets*</th>
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<tbody>
<tr>
<td>AMDIS</td>
<td>Electron-impact ionization cross sections and rate coefficients for atoms</td>
<td>806,493</td>
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<tr>
<td>EXC</td>
<td>Electron-impact excitation cross sections and rate coefficients for atoms</td>
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<tr>
<td>REC</td>
<td>Electron recombination rate coefficients for atoms</td>
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<tr>
<td>DIO</td>
<td>Dissociation cross sections for molecules</td>
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<tr>
<td>CHART</td>
<td>Charge exchange and ionization cross sections for ion-atom collisions</td>
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<tr>
<td>MOL</td>
<td>Cross sections and rate coefficients of electron-molecule collision processes</td>
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<td>AMOL</td>
<td>Cross sections and rate coefficients of electron-molecule collision processes</td>
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<tr>
<td>CMOL</td>
<td>Cross sections and rate coefficients of atom-molecule collision processes</td>
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<td>SPUTY</td>
<td>Sputtering yields by atomic ions for solid surface</td>
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<tr>
<td>BACKS</td>
<td>Energy and particle back-scattering coefficients of light ions from solid surface</td>
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</table>
New “simple search” query system for AM database

• “Simple search” system is developed for easier use in 2016. It allows users to find target processes and data more easily than before. Other problems in the older system were fixed as well.
Implementation to VAMDC

• Virtual Atomic and Molecular Data Center (VAMDC) is operated by international consortium and provides web portal to access various AM database at once and to present data according to XSAMS (XML Schema for AM data). AMDIS-ION is now implemented to VAMDC since 2018. We have developed additional system and new tables to connect to VAMDC.
2. Response to requests for information system from inside and outside the institute

・Is the division of information and communication systems properly responding to requests for information system development from inside and outside the institute?
License investigation for Microsoft products

• NIFS was asked to conduct license investigation by Microsoft Corp. in Feb. of 2015. Since the number of targeted devices is about 3000, we developed a web app for inquiry and counting.

• Using the app, NIFS reported the result of license investigation to Microsoft Corp. in Jun. of 2015.

• It took about 1 month to develop the app and 2 weeks for inquiry. Total man-hour cost was 3.5 MM, which consists of 1 MM for app developing, 1.5 MM for inquiry, 1 MM for hearing investigation and reporting. NIFS recognized such an investigation as a heavy burden and decided to contract Microsoft campus license in Oct. of 2016.
Since the license investigation asked by Microsoft Corp. was relatively high cost, NIFS contracted Microsoft campus license in May of 2017. As our main needs was a desktop office application and NIFS was a small institution, we chose OVS-ES plan.

In order to conduct an adequate license management, we installed a MKS server and distribute a customized installer package for Microsoft office product via an internal web site with a user authentication.

In May of 2020, NIFS changed the license plan from OVS-ES to EES. To adapt the EES, we established a regime for user administration under Azure Active Directory. On the ramp-up period, existing user account was exported from the email system operated by the NetTG and imported into Azure AD via a web interface and customized with use of PowerShell script.

Now we provides a cloud-based applications such as Microsoft Teams as well as a desktop office product. A large number of NIFS members are satisfied with the situation.
Infrastructure for information disclosure to research collaborators

• ID provider for research collaborators: Colid
  • Disclosure of information required for collaborative research is important task. In order to keep proper confidentiality, an Identity and access management (IAM) is required. The NIFS Collaboration Database System “Nicollas” had provided IAM functionality. Since Nicollas stopped its operation in 2017, we became to need an alternative IAM system.
  • The Integrated ID management and Authentication System Task Group (IDMAS) built a new IAM system for research collaborators in FY 2017. We launched the identity provider for NIFS collaborators Colid in Apr. of 2018. As a base software we employed shibboleth IdP, which is widely used in the Academic Access Management Federation in Japan (GakuNin).
  • Since collaborative research is adopted and updated every year, user account information in Colid is initialized and newly adopted research collaborators are exported from NOUS and imported into Colid. In order to establish a proper segregation of duties, this user import/export procedure is performed by the Research Support Division in the Department of Administration.

• Functional enhancement on LHD web site for collaborators
Support system for conferences/workshops

• Icarus
  • “Icarus”, deployed in July of 2013, is a web-based online service for assisting various host operation to hold international conferences, which is developed on Ruby-on-Rails. It provides general functionalities required for organizing international conference, such as online registration; abstract submission, review, selection, and notification; electronic account settlement via credit card for registration fees and other optional ones; online subscription for related event participation; and so on.
  • This system is utilized in international conferences hosted by NIFS, which are held once or twice in each year. The detailed workflow may differ for each conference, we made a customization in response to the need of a conference organizer.

• Workshop
  • The “Workshop” hosting support service, deployed in June of 2015, has been developed by intensive requests from the NIFS collaboration caretakers. Answering some configuration inquiries, the workshop caretakers can automatically build their own websites with necessary online functionalities, such as participant registration. This system has been constantly used by about 10 workshops every year.
Other services operated by BIS-TG

• Providing infrastructure for internal/external web site

• Support service for internal web site
  • RMSAFE, Division of Health and Safety Promotion, the Graduate University for Advanced Studies (SOKENDAI) Library, public offering information of research promotion, public offering information of collaborative research

• Development and operation of various web application site
  • Fitness facility, facility tour, accommodation facility, procurement information
  • (Under construction) Joint use of measuring equipment, researcher information database, Zoom meeting

• Administration and operation of video conference system

• Administration and operation of group-ware (Cyboze)

• Attendance management system for dept. of administration

• Activities toward sophisticated/integrated ID management service
Support for LHD experiment

• Full-remote control of the equipment is required for the Large Helical Device experiments. Many advanced diagnostics are developed with the support of System Task Group. The number of the supported system is increasing.

• Web services to establish very large-scale experiments (~100 researchers are involved) are being developed.

• Planning, operation, and summary graphs of the experiments are well organized with our web service.

• It is quite helpful for the domestic / international collaborators.
Information Security Office

- controls the issues of information security of NIFS.
- provides the information about security to staff and gathers the information about a current security status of staffs and servers.
- handles the security incident as Computer Security Incident Response Team, NIFS-CSIRT.

The security management diagram defined by the security policy of NIFS.

NIFS-CSIRT is a part of NINS-CSIRT and cooperate with other CSIRT. Administrative Bureau-CSIRT is a coordinating CSIRT to facilitate and coordinate the activities of institute CSIRTs.
Incident response

This handling procedure is defined by the security policy of NIFS. **NIFS-CSIRT is permitted to disconnect the network** of the system to mitigate the impact of the incident.

---

**Incident**

- **Discoverer**
- **Information Asset**
- **(6) Response**

---

**Incident**

- **(1) Report**
- **Point of Contact**
- **(3) Response**
- **(2) Report**

---

**NIFS-CSIRT**

- **(3) Report**
- **Info. Security Manager**

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**Info. System Admin.** is charged for the technical issues of the server.

**Info. System Admin.** is charged for the contents of the server.

**NIFS-CSIRT** is charged for the incident response.

**Info. Security Manager** controls the incident response.

**Inst. CISO** decides how to respond the critical issue of the incident.
NIFS-CSIRT receives many events from various sources and confirms that one by one.

FireEye is a network security appliance that detects web exploits and multi-protocol callbacks.

NII-SOC is the Security Operation Center of the National Institute for Informatics. We have made an agreement to notify information about incidents.

JPCERT/CC notifies indicator information based on the agreement.

Number of events handled by NIFS-CSIRT in 2020.
NIFS-CSIRT confirms each event because a few of those might be minor, medium, or major incident.

Number of incidents handled by NIFS-CSIRT. FY 2020 is limited to April to September.

<table>
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<tr>
<th></th>
<th>FY 2018</th>
<th>FY 2019</th>
<th>FY 2020</th>
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<tr>
<td>Minor incident</td>
<td>6</td>
<td>6</td>
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<tr>
<td>Medium incident</td>
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<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Major incident</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Event is an attack not to effect the system prevented by FW, Anti-Virus, and so on.

Minor incident is an attack which is an unwanted program starts up but not to compromise the system and not to effect the other system. It should be report to Inst. CISO. Ex. adware.

Medium incident is (a) an attack, an unwanted program starts up but not to effect the other system. (b) a status prevented the leaking the information from its possibility on the system. It should be reported to CEO of NINS.

Major incident on FY 2019:
- A staff had unintentionally entered the account information to phishing site through the link on the phishing mail. More than 200 staff had received such a malicious mails at that time.
- An attacker had tried to login the mail server of NIFS and to send the mail, however, failed thanking for OTP authentication on the mail system.
- NIFS-CISRT confirmed the attacker's activity by checking the system logs and interviewing the involved people.

Major incident is (a) an attack to effect the other system. (b) an occurrence of the successor attacks used the leaked information. It should be report to MEXT.
Education: Information Security Course

• is held every year from FY 2004.
  • Course for beginner is also held from FY 2018.

• is mandatory for all the staff of NIFS.
  • Attendance rate is more than 99%.

Main Contents are
• security trends
• the incident occurred on NIFS / NINS
• security instructions on NIFS

Greetings from the Director General and Inst. CISO.

Results of the questionnaire of the info. security course ever years. Most of the attendee are satisfied with these courses.
User support and registration work

Log of user support and registration work are analyzed.

The number of question about Mail service was raised rapidly on the first half of FY 2020 because of the migration to Gmail.

Number of questions for each area. Network Operation TG accepts more than 500 questions every year.
Resolve time for questions. Most of the questions (88%, average for Apr. 2018 to Sep. 2020) are resolved in a day, this is reflection of one of Network Operation TG's efforts.
User support and registration work (3)

Number of registration request for each device and service. It concludes removal and modify request. Network Operation TG accepts more than 600 request every year.

The number of request about SSL-VPN server, remote access server, was pulsed on the first half of FY 2020 because of the increment of the staff who works at home for COVID-19 prevention.

FireEye is a network security appliance detects web exploits and multi-protocol callbacks. The number shown in the graph is a count of event, not a count of alert. An event usually make multi alerts.

UPKI is an SSL certification issue service operated by National Institute for Informatics. TG is a point of contact of UPKI for NIFS.
2. Organization and functionality

- Is the organization of the division of information and communication systems functionally constructed and operated?
Organization and Functionality

Leader Meeting
- Division Director
- Deputy Division Directors
- Task leaders, sub leaders
- Operation Team Leader

All the specialists belong to the technical service sections and arranged dynamically in task and information security office.

Staff
- Full-time 1
- Dual appointment: Researchers 9, Engineers & Technicians 11, Administration staff 1
- Contact Employees 4
Preliminary Examination (including budget)

Submission of request form

Leader meeting:
1. Judgment of urgency/priority
2. Determine the task group and person to be in charge
3. Coordination with other jobs
4. Coordination of content and delivery date with the client
Effects of establishment

(a) Efficient collection and provision of experimental data
(b) Efficient response to control system development request
(c) Strengthening support for general services
(d) Development of a new system utilizing the knowledge
(e) Efficiency of new system introduction check
(f) Improving security through centralized management of information systems
Outline of Questionnaire

• The questionnaire had taken to confirm the opinion of staff of NIFS to Division of Information and Communication Systems.

Respondent: Staff of NIFS include students, LHD operators, and emeritus professors.

Period: October 20 to October 26, 2020.

Method: Google Form

Type: Selective answer format and free answer format

Response Rate: 47% (N = 439)
The numbers in parentheses are the number of total member.
Experimental Data Systems Task Group

- Response at the time of request
  - Excellent: 20%
  - Good: 30%
  - Average: 30%
  - Fair: 10%
  - Poor: 5%
  - N.A.: 5%

- Addressing the development
  - Excellent: 20%
  - Good: 30%
  - Average: 30%
  - Fair: 10%
  - Poor: 5%
  - N.A.: 5%

- Keeping the deadline
  - Excellent: 20%
  - Good: 30%
  - Average: 30%
  - Fair: 10%
  - Poor: 5%
  - N.A.: 5%

- Satisfaction with the system
  - Excellent: 20%
  - Good: 30%
  - Average: 30%
  - Fair: 10%
  - Poor: 5%
  - N.A.: 5%

N = 49
Backbone Information Systems Task Group

Satisfaction with the system:
- Response at the time of request
- Addressing the development
- Keeping the deadline
- Satisfaction with the system

N = 54

Response at the time of request:
- Excellent
- Good
- Average
- Fair
- Poor
- N.A.

Addressing the development:
- Excellent
- Good
- Average
- Fair
- Poor
- N.A.

Keeping the deadline:
- Excellent
- Good
- Average
- Fair
- Poor
- N.A.

Satisfaction with the system:
- Excellent
- Good
- Average
- Fair
- Poor
- N.A.
Information Security Office

Incident handling

Inquiry response

Provision of information

N = 208

Excellent  Good  Average  Fair  Poor  N.A.
Microsoft 365

- Function of Microsoft 365
- Migration to Microsoft 365
- Inquiry response
- Provision of information

N = 208

- Excellent
- Good
- Average
- Fair
- Poor
- N.A.
Google Gmail

Function of Gmail and G Suite

Migration to Gmail

2-Step authentication

Inquiry response

Provision of information

Excellent: 40%
Good: 40%
Average: 20%
Fair: 6%
Poor: 4%
N.A.: 0%

N = 208
Q. Is the Division of Information and Communication Systems doing business properly?

N = 208
Overview of Division of External Affairs

Kazuya Takahata
National Institute for Fusion Science
Organization of the Division of External Affairs

Official affiliation

<table>
<thead>
<tr>
<th>Department of Administration</th>
<th>Dedicated staff</th>
<th>Dual appointment staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Engineering and Technical Services</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Department of Helical Plasma Research</td>
<td>0</td>
<td>36</td>
</tr>
<tr>
<td>Other (Specially Appointed Expert, etc.)</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

Total: 57 staffs

Budget: 12 million ¥ (including a staff cost, 3 million ¥)
Perspective 1

Do you provide information and have a dialogue on the importance and the safety of fusion research for the development of a sustainable society to a wide range of people?

Activities
1. Website, Newsletter, Social media, Press release
2. Open Campus, Fusion Festa in Tokyo, Public explanatory meetings, Facility tours
Spread of the Division of External Affair’s activities

- **Regional Spread**
  - Overseas
  - EurekAlert! by AAAS

- **Local**
  - Children
  - Students
  - Domestic
  - Adults

- **Open campus (once a year)**
- **Scientific events held across the country (e.g. Fusion Festa in Tokyo)**
- **Research training, Internship**
- **Visiting lecture**
- **Facility tour**

- **Science handicraft workshops**
- **Science classroom**
- **Public explanatory meeting**
- **Public academic lecture**

- **Spread of Ages**
Website to inform the importance and safety of fusion research

Introduction to Nuclear Fusion
https://www.nifs.ac.jp/ene/index.html

- Uses only the Chinese characters learned in elementary school.
- Plenty of images
- Smartphone compatibility
- Higher rankings in search engines

Keywords that show up in the top 3 Google searches

Importance

-Safety

This website has become an important medium for first contact with the word “nuclear fusion.”
Website to inform the importance and safety of fusion research (cont.)

This website gets a higher CTR than commercial-based sites. Click-through rate (CTR) is the ratio of users who click on a specific link to the number of total users who view a page.

Average Click-Through Rate in Google Ads by Industry

<table>
<thead>
<tr>
<th>Industry</th>
<th>Average CTR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel</td>
<td>4.68</td>
</tr>
<tr>
<td>Auto</td>
<td>4.00</td>
</tr>
<tr>
<td>Health</td>
<td>3.27</td>
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<tr>
<td>E-Commerce</td>
<td>2.69</td>
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<tr>
<td>Finance</td>
<td>2.91</td>
</tr>
<tr>
<td>Technology</td>
<td>2.09</td>
</tr>
</tbody>
</table>

From WorldStream Website
https://www.wordstream.com/blog/ws/2016/02/29/google-adwords-industry-benchmarks

Performance on Google Search results

In particular, the CTR of users who searched for “fusion” and “radiation” was 55%. We also provide information on safety without hesitating.
We use a variety of internet services to provide information

**Monthly Newsletter**

372 subscribers

**Social Media**

Twitter: 1,134 followers
Facebook: 451 followers

**YouTube**

Starting in June 2020
12 videos

“New Plasma Simulator RAIJIN” 686 views
We distribute many press releases and spread information to the public in the form of press articles.

24 press conferences since 2015
43 press releases via websites, etc.
That resulted in 230 media reports (newspapers, online news)
We have an open dialogue on fusion research with nearly 8,000 people each year.

“Fusion Festa in Tokyo”  
(at Miraikan)

Open campus  
(at NIFS)

We also have a display booth at about 10 exhibitions each year.

Public explanatory meetings  
(In the neighborhood)

Facility tour
Many families with children visit the science events

Open Campus 
Fusion Festa in Tokyo

in 2019

- Below elementary school
- Junior high school student
- Senior high school student
- University student
- Community people
According to the results of the questionnaire at the Fusion Festa, more than half of the participants expect fusion energy.
At the Open Campus, we explain the importance of fusion research and have many exhibits to help children become familiar with science.

- Children's craft class
- Plastic bottle rockets
- Visiting the supercomputer
- Superconducting maglev train
- Plasma globe
- Visiting the control room
In 2020, the Open Campus was held entirely online!

Facility tour by live streaming (3 times, Total of 400 participants)

The ability to broadcast from places that are not usually open to visitors is one of the strengths of live streaming.

Filming of the online lecture (Two lectures, Total of 180 participants)

Eight video contents have also been released.

“New Plasma Simulator RAIJIN”
“Fusion Research in one minute!” etc.
Many community people come to visit the facility tour. Half of the visitors come from near and far.

Typical comments from visitors:
• I thought nuclear fusion was a dream, but when I saw the magnificent facility, I felt it was within our reach.
Do you carry out community interaction activities appropriately to gain their trust and understanding of fusion research through communication with local residents?

Community interaction activities
1. Public explanatory meetings in the community
2. Events at the request of local communities
3. Newspaper flyers to the community
In 15 years, we have held 341 public explanatory meetings

Total 5,761 participants

Explanatory Contents:
- Importance of fusion research
- Purpose of the deuterium experiment
- Radiation risk and safety management
  (Worst case scenario)
- Schedule

Participants' opinions gradually changed to trust in the Institute's safety management.

An example of an opinion:
“Fusion research is necessary for our children and grandchildren, so I hope that you will continue to proceed with safety and security in mind.” (September 2020)

All questions and answers can be found on the website.
We have participated in about ten community events each year at the request of local communities. This confirms the trust we have with the community. In addition, it is an opportunity for useful dialogue.
Publishing a bi-monthly newsletter to the community

6,000 newspaper flyers are distributed in the vicinity of the institute.

Contents:
- Latest Event Information
- Status of LHD preparations and experiments
- Commentary on fusion research
- Commentary on global environmental issues
- Nature in the Institute
- Quiz

An example of feedback:
“It was interesting to learn about the necessity of fusion power by combining it with current news. I would like to read every issue from now on because I can learn about recent activities and research at the Institute.” (June 2020)
Perspective 3

Do you contribute to the science education of children, students, and society through various workshops and events?

Activities
1. Acceptance of senior high school students for a lecture, facility tour, and group training
2. Acceptance of junior and senior high school students for a few days of work experience
3. Acceptance of interns from technical colleges and universities
4. Providing craft classes for children in the community
5. Public academic lectures in the community
Contributions to science education for high school students

- Students select one of the 13 training items (e.g. plasma, vacuum, superconductivity, simulation, electron microscope) and conduct a small group training session.
- Lecture and facility tour
- Researchers travel to their hometowns to lecture

Number of high schools participating in the research training

Experiments on superconductivity

Facility tour
Contributions to science education for various students

Acceptance of junior and senior high school students for a few days of work experience
(Four schools, 22 students in 2019)

Acceptance of interns from technical colleges and universities
(21 students in 2019)
Contributions to science education for children

We provide science handicraft workshops to over 1,000 children every year.

Completed robots. The vibration by the motors drives them forward.
Contributions to science education for society

We have biannual public academic lectures in the community.

Previous Themes:
• New mobility society
• HAYABUSA spacecraft
• Pyramids in Egypt
• Rocket development
• Biological clock
• Chimpanzees

We organize the lectures on a wide range of scientific topics.

Lecture on the HAYABUSA spacecraft
(July 2019, 660 participants)
Summary

We have provided information and had a dialogue on the importance and the safety of fusion research to a wide range of people through:

1. Website, Newsletter, Social media, Press release
2. Open Campus, Fusion Festa in Tokyo, Public explanatory meetings, Facility tours

We have carried out community interaction activities appropriately to gain their trust and understanding of fusion research through communication with local residents through:

1. Public explanatory meetings in the community
2. Events at the request of local communities
3. Newspaper flyers to the community

We have contributed to the science education of children, students, and society through:

1. Acceptance of senior high school students for a lecture, facility tour, and group training
2. Acceptance of junior and senior high school students for a few days of work experience
3. Acceptance of interns from technical colleges and universities
4. Providing craft classes for children in the community
5. Public academic lectures in the community
References

Table of Evaluation Results for the 2020 External Peer Review
Table of Evaluation Results for the 2020 External Peer Review
the “Division of Health and Safety Promotion,” the “Division of Information and Communication Systems,” and the “Division of External Affairs”

I. Points for Evaluation

1. Division of Health and Safety Promotion
   (1) Are the organizations and systems for safety and health management properly constructed and operated in compliance with relevant laws and regulations?
   (2) Are the safety management equipment / facilities, experimental equipment, etc., for maintaining and managing safety taken into account for the characteristics and circumstances peculiar to fusion research?
   (3) Are manuals and rules such as operation manuals, radiation control manuals, and emergency manuals properly formulated and operated?
   (4) As the Inter–University Research Institute, do you properly provide safety management and education to staff and collaborators?
   (5) Is the training of leaders to carry out safety management properly planned and implemented?

2. Division of Information and Communication Systems
   (1) Is the information and communication system as a research platform properly constructed and operated?
   (2) Is the division of information and communication systems properly responding to requests for information system development from inside and outside the institute?
   (3) Is the organization of the division of information and communication systems functionally constructed and operated?

3. Division of External Affairs
   (1) Do you provide information and have a dialogue on the importance and the safety of fusion research for the development of a sustainable society to a wide range of people?
   (2) Do you carry out community interaction activities appropriately to gain their trust and understanding of fusion research through communication with local residents?
   (3) Do you contribute to the science education of children, students, and society through various workshops and events?

II. Table of Evaluation

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<tbody>
<tr>
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<tr>
<td>5</td>
<td>14</td>
<td>11</td>
<td>12</td>
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<tr>
<td>(Extremely highly commendable)</td>
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<tr>
<td>Average Score</td>
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<td>4.69</td>
<td>4.75</td>
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</table>

※The evaluation result is a combination of the results of domestic committee members (13 persons) and foreign committee members (3 persons).