National Institute for Fusion Science (NIFS)

National Institutes of Natural Sciences (NINS)

Peer Review Reports in FY2011

March, 2012

External Review Committee, NIFS Administrative Council

Contents

Chapter 1 Background

Large Helical Device, or LHD, was constructed as the leading device to advance universities' fusion research in conjunction with the establishment of the inter-university research institute, National Institute for Fusion Science, or NIFS and began operation in 1998. LHD was planned under the consensus and hopes of the whole fusion community and featured by the *heliotron* magnetic field configuration, which was originated in Japan, produced by superconducting coils. The device is able to generate high-performance helical plasmas by its powerful heating system and expected to solve physical and engineering issues towards realization of a magnetic-confinement fusion reactor. LHD has steadily increased plasma performance and enhanced uniqueness over the past 14 years. It has been state-of-the art in fusion research and been served as a device of collaboration for domestic as well as international activities.

During these years, there were changes in Japan's academic sector. In 2004, NIFS became a member of an Inter-University Research Cooperation named National Institutes of Natural Sciences, or NINS, to serve as an inter-university research institute. Along with the change, NIFS became exposed to annual review by Ministry of Education, Culture, Sports, Science and Technology (MEXT), which checks the progress of the 6-year-long mid-term plan towards the mid-term goal. Although this formal annual review is basically targeted to management works, NIFS believes its scientific performance should be also reviewed and put it under review by external eyes every year. The administrative council of NIFS defines what to be reviewed, and then an external review committee formed by the non-NIFS administrative council members as well as experts designated for the defined purpose. The reviewers give advice to the administrative council based on their review, and NIFS reflects the advice on its future activities. Looking through the review reports published during the first mid term, this system seems to work effectively.

NIFS embarked on a new plan for the second 6-year mid term in 2009. In order to increase the centripetal force of COE of fusion research, a newly-introduced framework of three research Projects – the LHD Project, Numerical Simulation Research Project and Fusion Engineering Research Project, was formulated and aims at integration of all the achievements from the three towards the realization of a fusion reactor. NIFS made the organizational change in 2009 to accommodate this strategy. NIFS's main activity of LHD research had already been conducted as a project since the beginning of the institute, where major staff of the Department of LHD Project and the Department of Engineering and Technical Services had made a commitment. In comparison, the newly-introduced system puts all the research staff in a unique department and removes all the barriers, enabling them to participate in any of the Projects. Therefore, the LHD Project will tie up

with the two other Projects more efficiently, and will be able to respond flexibly to new challenges.

The administrative council of NIFS conducted the external review of the LHD research in 2007 while the first six-year mid-term plan was in operation. It was recognized for the fact that it was managed to show an outstanding performance through the nationwide inter-university research system with intensive research investment and high motivation of participants. At the same time, some advice for improvement was also given as follows: (1) LHD should enhance its plasma performance during the next six-year mid-term by upgrading heating capability, installing closed divertors and implementing the deuterium experiment as planned, to attain a steady-state operation in the regime with higher density and higher temperatures. (2) More efforts should be made to enrich joint researches and human-resource-development activities including education. (3) Being aware of the role of a global COE, NIFS should have a strong will and courage to tackle new issues for developing the LHD research.

Four years have passed since then. It is meaningful to review the LHD work as compared to the previous advice, in terms of what has been produced with the new plan and new system, and whether the products deserve the name of a global COE as well as the device of Japan's inter-university research. This will be helpful in considering the future of NIFS as well. Besides, environements have been changing surrounding fusion research – the attempt to achieve a safe and "ultimate green innovation" – due to the nuclear accidents at the Fukushima Daiichi plant, which was caused by the Great East Earthquake on March11th. It is desired the efforts for academic systematization speed up more than ever, and LHD has to bear part of the responsibility. Reflecting these factors, LHD was chosen to be evaluated this year. Nine of non-NIFS from the administrative council and four of foreign members, as well as five Japanese experts appointed from outside of NIFS took charge of the review.

In their first meeting held on October 28th, 2011, the members discussed the way of review and determined perspectives and items. On December 10th, NIFS presented LHD activities in detail using view graphs and other materials, and answered the questions from the reviewers. On January 23rd, 2012, reviewers gathered in groups and rated the activities after making questions clear. The reviewers met on February 21st to finalize their review and document this report.

This report is constituted by "Chap.1 Background", "Chap.2 Reviews and Proposals" and "Chap.3 In Closing". The reports from the reviewers from abroad are described as they are by permission of them.

The report will be submitted to the administrative council of NIFS. After gaining its approval, Director-General of NIFS will hand in it to the president of its parental body, NINS. It will go through NINS to be given in to the Administrative Council and the Education and Research Council in NINS. After the approval of these councils, this report will be used as an appendix of NINS's annual deliverables in "Annual Plan of NINS (JFY2012)" and "Report of Achievements of Business Work in JFY2011" to be submitted to the MEXT.. The report will be open to public on the web as well as in print.

The perspectives in review of "LHD Project" are shown below. All of them are indispensable in evaluating NIFS's activity of the LHD Project in the 6-year mid-term plan set by NINS. The rating is based on the extent of achievements and the scientific level of activities.

In particular, the following three perspectives are based on the recommendation in the last review in 2007 and noted in this year's review.

1. Does the LHD project strive for improvement in plasma performance as scheduled by means of upgrade of heating capability, installation of closed divertor and deuterium experiment? Is the approach towards steady-state experiments in the regime with higher density and high temperature appropriate?
2. Does the LHD project develop collaboration activities to enrich and stimulate the research and educational activities such as human resource development in universities?
3. Does the LHD project conduct new and original research as a global COE?

[1] Research achievements

Does the LHD project produce high-level achievements in accordance with international standards regarding the systemization of physics and engineering for a helical system and comprehensive understanding of toroidal plasmas directed towards controlled fusion?

(1) Are the achievements, which have been obtained by the approach to the realization of high performance plasmas extrapolative to a fusion reactor by a helical system, at a high level by international standards? (refer to the note from the last review)
(2) Does the LHD project advance scientific research towards a comprehensive understanding of toroidal plasmas?

[2] Development of research system and environment

Does the LHD project develop required the steps to execute the missions described in 1?

(1) Does the new LHD project system, which was introduced in 2010, contribute to efficient

execution of research and extension of opportunities for collaboration?

(2) Does the LHD project develop maintenance, upgrade and improvement of devices and facilities for the main device and heating systems appropriately?

(3) Does the LHD project develop diagnostics and theoretical/analytic models with high accuracy for comprehensive understanding of toroidal plasmas?

[3] Promotion of Collaboration

Does the LHD project promote collaboration as the major facility of the inter-university research institute to guide fusion science?

(1) Does the LHD project produce excellent research achievements by making use of the advantages of General Collaborations, LHD Project Collaborations and Bilateral Collaborations?

(2) Does the LHD project contribute to interdisciplinary development in cooperation with researchers from a wide range of fields as well as fusion science?

(3) Does the LHD project contribute to the development of research in universities?

[4] Promotion of international cooperation and collaboration

Does the LHD project make a sufficient contribution to the international community in the role of a global COE in fusion science?

(1) Does the LHD project produce achievement s as the center of activities international comprehensive agreements and academic exchange agreements between institutes?

(2) Does the LHD project promote cooperation with and contribution to ITER/BA?

[5] Human resource development

Does the LHD project contribute to human resource development of researchers with a global vision required for long-term fusion research?

[6] Future plan

Is the plan of the LHD project looking forward to the next decade appropriate in terms of the second mid-term plan, etc?

Chapter 2 Reviews and proposals

Here is a summary of evaluation based on the comments and arguments given by the reviewers. This is followed by proposals which will be important in advancing the LHD research.

2.1 Summary of reviews

[1] Research achievements

Does the LHD project produce high-level achievements in accordance with international standards regarding the systematization of physics and engineering for a helical system and comprehensive understanding of toroidal plasmas directed towards controlled fusion?

(1) Are the achievements, which have been obtained by the approach to the realization of high performance plasmas extrapolative to a fusion reactor by a helical system, at a high level by international standards ? (refer to the note from the last review)

LHD has made a significant progress in the work for the high-performance plasmas and reaches a high level by international standards. The longer sustainment of super high density plasmas (SDC), the ion temperatures attained by enhancing the NBI heating system and the power supply of the superconducting coils, and the electron temperatures obtained by strengthening the ECH system are a significant achievement that could pave the way to the future's reactor. Among them, achievements of the beta value of 5.1%, the plasma density of $1.2 \times 10^{21} \mathrm{m}^{-3}$, the ion temperature of 7keV and the electron temperature of 20keV are extremely important and progress in steady-state operation is also outstanding. Steady strides are made toward the realization of controlled fusion in a helical system, and hundreds of papers are published each year from there. They are extremely highly commended.

(2) Does the LHD project advance scientific research towards a comprehensive understanding of toroidal plasmas?

The plasma physics brought by the 3-dimentional magnetic fields , such as transport, MHD and divertor physics, is important for taking a complementary approach between helical system and tokamak. There is a strong will in LHD activities to try to understand the whole world of toroidal plasmas, which is extremely highly commended. 3-dimentional effect intrinsic to helical plasmas has been a great help for the studies on transport of core and edge plasmas, plasma-wall interactions, MHD stability or divertor engineering, as it shed light on differences

or commonalties between helical and tokamak plasmas. It has not only advanced the studies drastically, but also helped better comprehensive understanding of toroidal plasmas. The Edge Localized Mode (ELM) and Plasma Wall Interaction (PWI) physics, the control of heat load by detached plasma using Resonant Magnetic Perturbation (RMP), and the physics in wave heating like Electron Bernstein Wave (EBW) and Ion Cyclotron Resonance Frequency (ICRF) were brought in by LHD and greatly contributed to the comprehensive understanding as well.

[2] Development of research system and environment

Does the LHD project develop the required steps to execute the missions described in [1]?

(1) Does the new LHD project system, which was introduced in 2010, contribute to efficient execution of research and extension of opportunities for collaboration?

Under the new system, theme groups are able to work agilely and flexibly. Preparation studies for deuterium discharges are ongoing and the number of research proposals grew from 220 in 2007 to 267 in 2011. It could prove the system helped efficient execution of research activities and expansion of collaboration opportunity, so it is highly commended. However, it has to be judged on a longer-term basis, and re-evaluation will be necessary in the next reviewing.

(2) Does the LHD project develop maintenance, upgrade and improvement of devices and facilities for the main device and heating systems appropriately? (refer to the note from the last review)

The measures to maximize LHD's capability have been appropriately taken, such as the improvement of the perpendicular NBI system to raise ion temperature; the extension of heating power and pulse length of the ECH system, the provisional installation of the baffle divertors needed for long pulse operation of the high performance plasma, and the enhancement of the DC power supply for the superconducting coils. It is extremely highly commended. In order to achieve steady-state operation, the installation of the full-torus closed divertor needs to be completed as early as possible, and research with high power, high density and high fast-ion density has to be planned in a strategic manner.

(3) Does the LHD project develop diagnostics and theoretical/analytic models with high accuracy for comprehensive understanding of toroidal plasmas?

Improvement of the quality of data on electron temperatures by the Thomson scattering system,

development of the heavy ion beam probe, measurement of the rotational transform of magnetic field by the motional Stark effect, availability of diagnostics of high-energy particles, improvement of the data acquisition system have progressed. As a result, not only very precise data is available, but also the data is working very effectively in an interactive manner with the development work of theoretical/analytic models, like a pair of wheels, to make a respectable consequences. It is highly commended.

[3] Promotion of Collaboration

Does the LHD project promote collaboration as the major facility of the inter-university research institute to guide fusion science?

(1) Does the LHD project produce excellent research achievements by making use of the advantages of General Collaborations, LHD Project Collaborations and Bilateral Collaborations?

The three Collaborations constitute a well-organized system which is capable of handling various types of joint work with universities. Fruits of research and development with universities are used in practice for the LHD experiment, and original results are coming out of there. They are very useful programs to the fusion community. The three are flexible enough to welcome a wide variety of studies from centers attached to universities to a level of small laboratories of universities. It is extremely highly commended.

(2) Does the LHD project contribute to interdisciplinary development in cooperation with researchers from a wide range of fields as well as fusion science?

As represented by the studies like the non-equilibrium plasma research using LHD and the solar observational satellite *Hinode* to clarify the heating mechanism of the corona, the search for common physics between the spontaneous rotation of laboratory plasmas and the differential rotation of the sun, and the investigation of the atomic and molecular process with use of an extensive parameter of LHD plasmas, interdisciplinary efforts are ongoing in coordination with basic studies of other fields including atomic physics, astrophysics, and light source development. It is highly commended.

What is desired now is to make an appeal to other research fields, telling about potential usage of LHD and related technologies, that is, the usability as a tool or as a study subject for various purposes, so as to develop the interdisciplinary participation more and explore a new research area.

(3) Does the LHD project contribute to the development of research in universities?

It is true a lot of universities in Japan take advantage of NIFS's Collaboration programs for their advanced research and highly-specialized graduate education. The programs' contribution is huge. The LHD joint experiment provides an educational effect on graduate students and young researchers of universities. What is highly rated in particular is that the place for joint activities using such a large-scale machine is continuously ready and open to university researchers. It is no other than the result of hard work of those in charge of LHD facility services, and the work deserves the extremely high praise as an outstanding contribution to universities. It is extremely highly commended.

The LHD Project also takes outward action, such as dispatching researchers to universities or lending diagnostics devices out to those participating in the programs. It helps conveying the advanced standard of NIFS's research to individual studies of research centers and laboratories of universities. This outward effort has to be encouraged continuously.

[4] Promotion of international cooperation and collaboration

Does the LHD project make a sufficient contribution to the international community in the role of a global COE in fusion science?

(1) Does the LHD project produce achievements as the center of activities of international comprehensive agreements and academic exchange agreements between institutes?

Concluding numbers of international agreements on academic exchanges or comprehensive tie-ups, the project serves as the center of international joint activities sufficiently well. It is highly commended.

In particular, the project has recently enhanced hosting of many foreign researchers and installing high-performance diagnosing instruments developed in other countries. This preferable situation is expected to develop further. NIFS's collaboration programs allow foreigners to represent a collaborating subject. Therefore, it is expectable international activities will develop more and more, and that the project will continue to fulfill the role of the global Center of Excellence in fusion research.

(2) Does the LHD project promote cooperation with and contribution to ITER/BA?

In terms of the cooperation for the ITER project, the LHD Project actively participates in the ITPA activity and helps the development work of ITER facilities, such as heating devices and cryogenic systems. In terms of the BA activity, it helps the JT-60SA Research Plan and conducts a performance test on the superconducting conductors for JT-60SA. Its cooperation is extensive and varies, and highly commended.

Until JT-60SA starts operation, LHD will be only a large-scale device existing in Japan, so its data should be helpful for planning ITPA or JT-60SA. The cooperation with the ITER and the BA should be continued as it will be also useful to LHD itself in proceeding with the deuterium experiment. Meanwhile, alternative approach to ITER contribution – the support in a manner of taking outcome from unique studies of helical plasmas – will be also desired.

[5] Human resource development

Does the LHD project contribute to human resource development of researchers with a global vision required for long-term fusion research?

The LHD project is very active in training graduate students as well as post-doctoral researchers and promotion of assistant-professor-class young scientists to leaders and sub-leaders of the LHD experiments. In this sense, its contribution is significant for the development of human resources of fusion research. In particular, the strategic attempt that involves young members as a leader in promoting the project on the global stage is highly commended

It is hoped the LHD project will enhance the educational program to attract excellent students from across the world and bring out internationally-competitive and competent researchers to the world.

[6] Future plan

Is the plan of the LHD project looking forward to the next decade appropriate in terms of the second mid-term plan, etc?

Toward the goal of attaining plasmas which can be extrapolated to a fusion reactor, the plan predicts it will be accomplished around the end of the third 6-year mid-term plan and takes three measures to this end: the upgrade of the heating devices, the installation of closed divertor and the launch of deuterium experiments. The plan is adequate and highly commended. More effort is desired for gaining understanding from the locals on the deuterium experiment as early as possible.

It has to be made clear what role LHD will play after ITER starts operation and what will be the responsibility of LHD in the whole framework of Japan's fusion research in the ITER era . When considering the future of NIFS, the future plan should be discussed in order to to extend its academic contribution to plasma physics and fusion engineering. In addition, discussion will also have to be fully started over the next generation of the LHD project, which is run mainly by young and mid-ranked researchers.

2.2 Recommendations

In closing, recommendations for the future of LHD are summarized as follows:

(1) It is desirable that LHD as the leading device of joint activities continue to be the world's large-scale experiment platform for fusion research and development.

(2) It is hoped that the installation of closed divertor will be completed and deuterium experiment will be started earlier so as to get the LHD-maximization efforts accelerated.

(3) It is desirable that the LHD activities continuously encompass the work for ITER and BA as it does.

(4) It is hoped the project will lead the world's fusion research and create internationally-competitive human resources.

(5) It is desirable that discussion be started over a plan that looks to the future after the completion of deuterium experiment campaign.

To NIFS, which is a central body of the fusion community, it is hoped that it will work harder to obtain public understanding and support to the new energy of fusion power.

Chapter 3 In closing

The Large Helical Device, or LHD, has carried out collaborations actively to support universities' fusion research over the past 14 years while increasing its plasma performance. It was put under the evaluation in 2007, the fourth year of the first 6-year mid-term plan. It was recognized for the significant results it made through nationwide inter-university collaborations, but at the same time, some advice for improvement was also given. For the 2nd 6-years mid-term beginning from 2010, NIFS set up three new Projects of LHD, Numerical Simulation and Fusion Engineering, and commenced a plan to integrate outcomes of the three Projects, aimed for the goal of creating a fusion reactor. Following these changes, LHD was picked up again for external review.

Reviewers discussed the way of evaluation, perspectives and items to check at their first meeting. In the second meeting, a detail description was given by NIFS about the project and questions were answered. Then reviewers gathered by group to make the group's conclusion based on remarks made by individual members. In the third of the plenary meeting, evaluation was finalized and report was completed. The report will be handed in to the Administrative Council of NIFS, and then by the Director-General of NIFS it will be submitted to the president of its parental institution, NINS.

Following advice was given at the 2007 review:

1. Does the LHD project strive for improvement in plasma performance as scheduled by means of upgrade of heating capability, installation of closed divertor and deuterium experiment? Is the approach towards steady-state experiments in the regime with higher density and high temperature appropriate?
2. Does the LHD project develop collaboration activities to enrich and stimulate the research and educational activities such as human resource development in universities?
3. Does the LHD project conduct new and original research as a global COE?

The reviewers took note of these 2007 proposals in their review this year.

Here is a list of check points used in the review. Briefed results are shown in block letter.

[1] Research achievements

Does the LHD project produce high-level achievements in accordance with international standards regarding the systematization of physics and engineering for a helical system and comprehensive understanding of toroidal plasmas directed towards controlled fusion?

(1) Are the achievements, which have been obtained by the approach to the realization of high performance plasmas extrapolative to a fusion reactor by a helical system, at a high level by international standards?

LHD produces excellent results for achieving high-performance plasmas and reached a high level by international standard. It steadily moves forward to the goal of controlled fusion by a helical system, and produces hundreds of papers every year. It is extremely highly commended.

(2) Does the LHD project advance scientific research towards a comprehensive understanding of troidal plasmas?

The progress of studies on transport, magnetohydrodynamic behaviors and divertor physics, which are observed in the 3-dimentional magnetic field, is significant in terms of a complementary approach with tokamak. The LHD activities are willing to understand toroidal plasmas comprehensively and their findings are considerably helpful to the objective. It is extremely highly commended.

[2] Development of research system and environment

Does the LHD project develop the required steps to execute the missions described in 1?

(1) Does the new LHD project system, which was introduced in 2010, contribute to efficient execution of research and extension of opportunities for collaboration?

The new project system let experiment groups move agilely and flexibly. The number of proposals has increased from 220 in 2009 up to 267 in 2011. The both could prove the system increased research efficiency and expanded collaboration opportunities, so it is highly commended. However, the system will need another assessment from a longer-term standpoint.

(2) Does the LHD project develop maintenance, upgrade and improvement of devices and facilities for the main device and heating systems appropriately? (refer to the note from the last review)

Necessary measures have been given in an appropriate way, such as the improvement of the perpendicular NBI system, the upgrade of heating power and pulse lenght of the ECH system, the installation of the buffle divertor and the enhancement of the SC direct current power supply, which is extremely highly commended.

(3) Does the LHD project develop diagnostics and theoretical/analytic models with high accuracy for comprehensive understanding of toroidal plasmas?

The technique of measuring electric temperature has been made better, data analysis has been improved and various methods have been newly developed. It brings out highly precise

diagnostics and develops theoretical/analytic models in a good quality. It proves the work made a significant progress. It is highly commended.

[3] Promotion of Collaboration

Does the LHD project promote collaboration as the major facility of the inter-university research institute to guide fusion science?

(1) Does the LHD project produce excellent research achievements by making use of the advantages of General Collaborations, LHD Project Collaborations and Bilateral Collaborations?

The three Collaborations are well prepared enough to handle a various type of joint activities with universities. The coordinated work has raised the research standard of the participants and produced a number of research findings. The three Collaborations are an indispensable system for the prosperity of the fusion community. It is extremely highly commended.

(2) Does the LHD project contribute to interdisciplinary development in cooperation with researchers from a wide range of fields as well as fusion science?

Represented by the collaboration on non-equilibrium plasmas using the solar observational satellite *Hinode*, coordination with studies of other fields, such as atomic physics, astrophysics and light source development, is being promoted and showing a good record. It is highly commended.

(3) Does the LHD project contribute to the development of research in universities?

A lot of universities use the program to advance their research and provide highly specialized education, so it makes a considerable contribution. The LHD experiment greatly helps train young researchers. In particular, the fact that the large-scale device has been ready to use as the place of collaboration over the past 14 years is a great help in terms of advancing fusion research of universities. It is extremely highly commended.

[4] Promotion of international cooperation and collaboration

Does the LHD project make a sufficient contribution to the in international cooperation and collaboration?

(1) Does the LHD project produce achievements as the center of activities of international comprehensive agreements and academic exchange agreements between institutes?

The project is working for a lot of international agreements over comprehensive cooperation and academic exchanges. It fulfills the role of the center of international collaborations sufficiently well. It is highly commended.

(2) Does the LHD project promote cooperation with and contribution to ITER/BA?

For ITER Project, it is actively involved in the ITPA activities and helps the technical advancement of heating devices or cryogenic system. For BA, it cooperates in a wide area including fusion materials, neutron sources, JT-60SA Research Plan and SC performance testing. It is highly commended.

[5] Human resource development

Does the LHD project contribute to human resource development of researchers with a global vision required for long-term fusion research?

LHD is very active in training COE researchers as well as young LHD experiment leaders and makes a significant contribution to the development of human resources. It is highly commended. It is desired the project continue to bring up young researchers to be international leaders.

[6]Future plan

Is the plan of the LHD project looking forward to the next decade appropriate in terms of the second mid-term plan, etc?

Toward the goal of attaining high-performance plasmas which can be extrapolated to a fusion reactor, the plan predicts it will be accomplished around the end of the third 6-year mid-term and takes three measures to this end: upgrade of heating devices, installation of closed divertors and launch of deuterium experiment campaign. It is an appropriate plan and highly commended. Discussion is desired to make plans of plasma research and fusion reactor engineering research that look to the future.

Extremely high marks are given to the achievements of LHD, the maintenance effort of research circumstances, the system of the three Collaborations as well as the contribution to the advancement of research in universities. The other items like the expansion of diagnostics and theoretic/analytic models, interdisciplinary coordination, international coordination, human resource development and future plan also receive high marks. All these results could be attributed to the high quality of academic and technological skills of LHD staff as well as the patiently continued effort of them.

The reviewers also discuss what it should do for further improvement. Here is a summary of the recommendations. It is hoped the advice will help future operation.

(1) It is desired that the LHD as the leading device of inter-university research activities continue to serve as a large-scale experiment platform of the world's fusion research.
(2) It is hoped that the installation of closed divertor will be completed and the deuterium

experiment will start as soon as possible to push the maximization of the LHD capability forward.

(3) It is desired that the LHD activity continuously encompass the work for the ITER project and the BA activities.

(4) It is hoped the LHD project will guide the world's fusion research and produce internationally-competitive human resources.

(5) It is desired a discussion start over a plan that looks to the future after the deuterium campaign is completed.

To NIFS, which is a central body of the fusion community, it is hoped that it will work harder to obtain public understanding and support to the new energy of fusion power.

FY2011 External Peer Review Result (Chart)

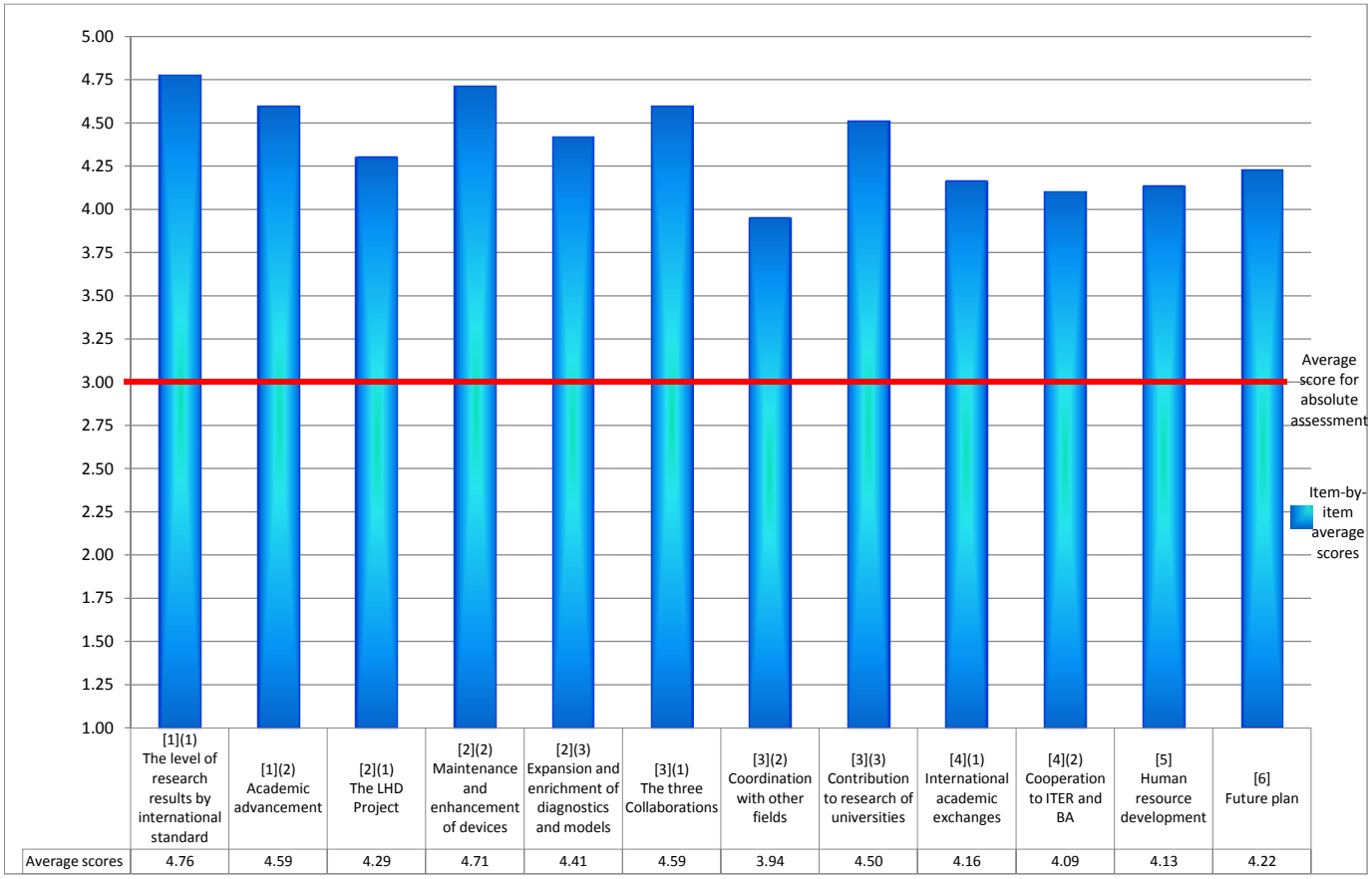
Number of persons

Items	[1](1) The level of research results by international standard	[1](2) Academic advancement	[2](1) The LHD Project	[2](2) Maintenance and enhancement of devices	[2](3) Expansion and enrichment of diagnostics and models	[3](1) The three Collaborations	[3](2) Coordination with other fields	[3](3) Contribution to research of universities	[4](1) International academic exchanges	[4](2) Cooperation to ITER and BA	[5] Human resource development	[6] Future plan
S	13	9	5	12	6	10	4	8	3	2	4	5
A	4	8	11	5	11	7	7	9	13	14	10	9
B	0	0	1	0	0	0	6	0	1	1	3	3
Average scores	4.76	4.59	4.29	4.71	4.41	4.59	3.94	4.50	4.16	4.09	4.13	4.22

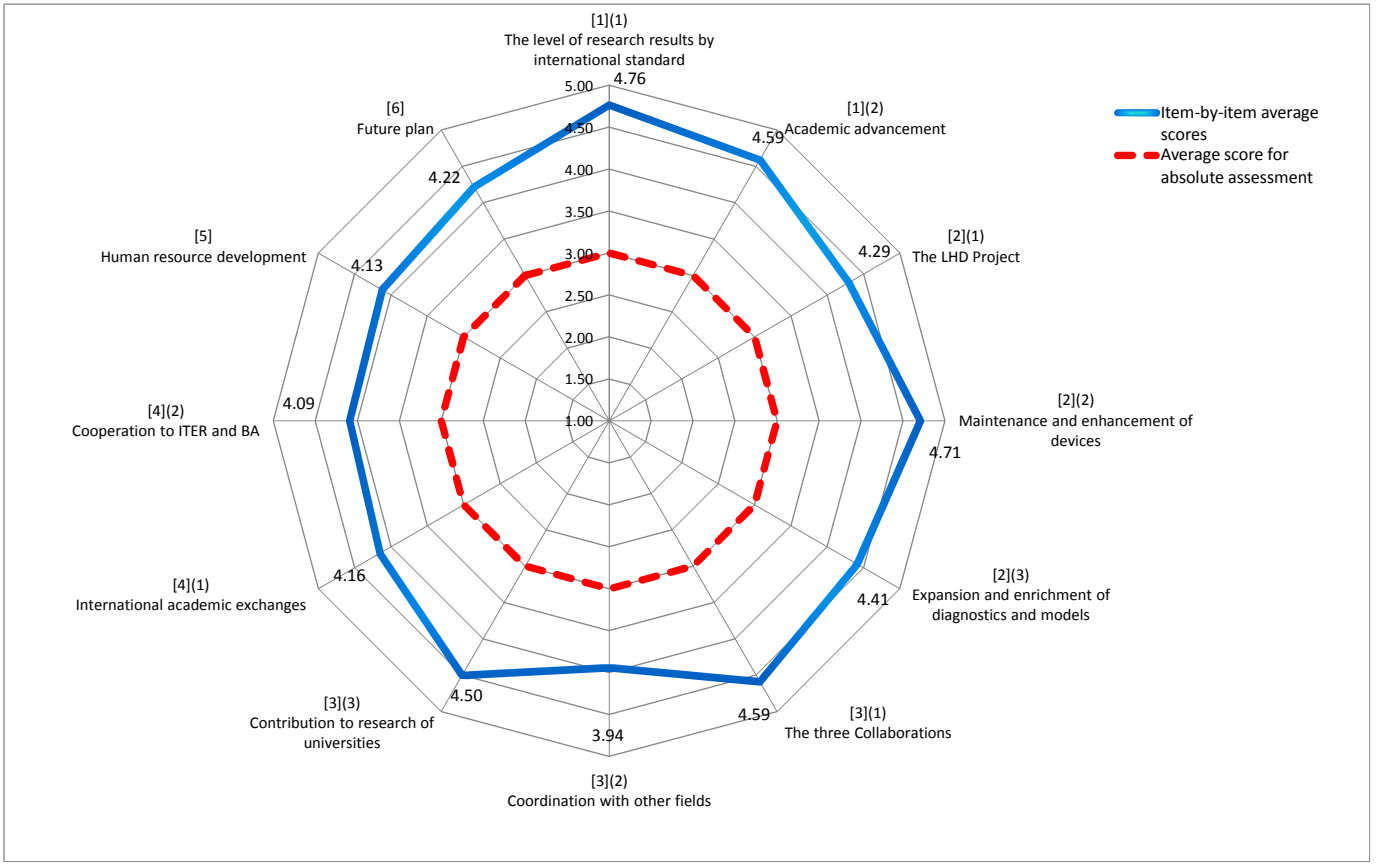
Evaluation scoring		
S	Extremely highly commendable	5
A	Highly commendable	4
B	Commendable	3
C	Adequate	2
D	Inadequate	1

Items	Evaluation points
[1]	(Research achievements) Does the LHD project produce high-level achievements in accordance with international standards regarding the systematization of physics and engineering for a helical system and comprehensive understanding of toroidal plasmas directed towards controlled fusion ?
[1](1)	Are the achievements, which have been obtained by the approach to the realization of high performance plasmas extrapolatable to a fusion reactor by a helical system ,at a high level by international standards ? (refer to the note from the last review)
[1](2)	Does the LHD project advance scientific research towards a comprehensive understanding of toroidal plasmas?
[2]	(Development of research system and environment) Does the LHD project develop required the steps to execute the missions described in 1.
[2](1)	Does the new LHD project system, which was introduced in 2010, contribute to efficient execution of research and extension of opportunities for collaboration?
[2](2)	Does the LHD project develop maintenance, upgrade and improvement of devices and facilities for the main device and heating systems appropriately? (refer to the note from the last review)
[2](3)	Does the LHD project develop diagnostics and thoretical/analytic models with high accuracy for comprehensive understanding of toroidal plasmas?
[3]	(Promotion of Collaboration) Does the LHD project promote collaboration as the major facility of the inter-university research institute to guide fusion science?
[3](1)	Does the LHD project produce excellent research achievements by making use of the advantages of General Collaborations, LHD Project Collaborations and Bilateral Collaborations?
[3](2)	Does the LHD project contribute to interdisciplinary development in cooperation with researchers from a wide range of fields as well as fusion science?
[3](3)	Does the LHD project contribute to the development of research in universities?
[4]	(Promotion of international cooperation and collaboration) Does the LHD project make a sufficient contribution to the international community in the role of a global COE in fusion science?
[4](1)	Does the LHD project produce achievements as the center of activities of international comprehensive agreements and academic exchange agreements between institutes?
[4](2)	Does the LHD project promote cooperation with and contribution to ITER/BA?
[5]	(Human resource development) Does the LHD project contribute to human resource development of researchers with a global vision required for long-term fusion research?
[6]	(Future plan) Is the plan of the LHD project looking forward to the next decade appropriate in terms of the second mid-term plan, etc?

Item-by-item average scores



	[1](1) The level of research results by international standard	[1](2) Academic advancement	[2](1) The LHD Project	[2](2) Maintenance and enhancement of devices	[2](3) Expansion and enrichment of diagnostics and models	[3](1) The three Collaborations	[3](2) Coordination with other fields	[3](3) Contribution to research of universities	[4](1) International academic exchanges	[4](2) Cooperation to ITER and BA	[5] Human resource development	[6] Future plan
Average scores	4.76	4.59	4.29	4.71	4.41	4.59	3.94	4.50	4.16	4.09	4.13	4.22



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