

4. International Collaboration

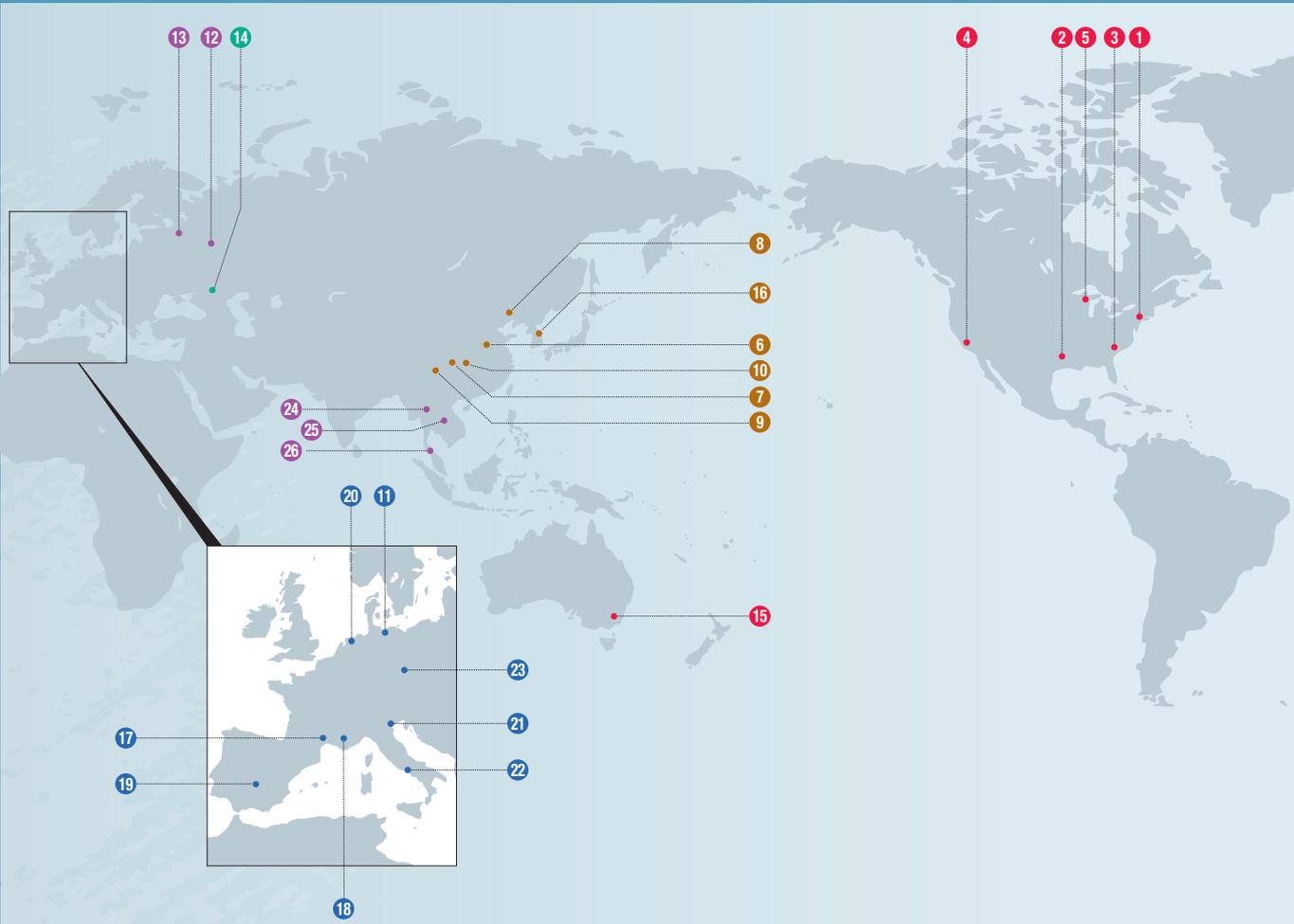
Many research activities in NIFS are strongly linked with international collaborations with institutes and universities around the world. These collaborations are carried out in various frameworks, as follows,

- 1) Multinational coordination in Fusion Power Coordinating Committee (FPCC) under International Energy Agency (IEA),
 - Stellarator-Heliotron Technology Cooperation Program (TCP)
 - Plasma-Wall Interactions TCP
 - Spherical Tori TCP
- 2) Binational coordination,
 - Japan-United States Collaborative Program
 - Japan-Korea Fusion Collaboration Programs
 - Japan-China Collaborative Program
 - Japan-EU Cooperation
- 3) Coordination with other institutions
 - 32 international academic exchange agreements

The geographical distribution of international collaborations and summary of each activity are shown in following pages.

(T. Morisaki)

Academic Exchange Agreements



- U.S.A.** ① Princeton Plasma Physics Laboratory (PPPL)
- ② Institute for Studies, The University of Texas at Austin (IFS)
- ③ Oak Ridge National Laboratory (ORNL)
- ④ Center for Energy Science and Technology Advanced Research, University of California, Los Angeles (UCLA)
- ⑤ Letters & Science and College of Engineering, University of Wisconsin–Madison College (UWM)
- China** ⑥ Institute of Plasma Physics, Chinese Academy of Sciences (ASIPP)
- ⑦ Southwestern Institute of Physics (SWIP)
- ⑧ Peking University
- ⑨ Southwest Jiaotong University (SWJTU)
- ⑩ Huazhong University of Science and Technology
- Germany** ⑪ Max Planck Institute for Plasma Physics (IPP)
- Russia** ⑫ A. M. Prokhorov General Physics Institute, Russian Academy of Sciences (GPI)
- ⑬ Peter the Great St. Petersburg Polytechnic University
- Ukraine** ⑭ National Science Center of the Ukraine Khar'kov Institute of Physics and Technology Institute of Plasma Physics (KIPT)
- Australia** ⑮ Australian National University (ANU)
- South Korea** ⑯ National Fusion Research Institute (NFRI)
- France** ⑰ Aix-Marseille University (AMU)
- ⑱ Commissariat à l'énergie atomique et aux énergies alternatives (CEA)
- Spain** ⑲ National Research Center for Energy, Environment and Technology (CIEMAT)
- Netherlands** ⑳ Dutch Institute for Fundamental Energy Research (FOM)
- Italy** ㉑ CONSORZIO RFX
- ㉒ Institute of Ionized Gas (IGI)
- Czech** ㉓ HiLASE Center, Institute of Physics CAS (FZU)
- Thailand** ㉔ Chiang Mai University (CMU)
- ㉕ Mahasarakham University (MSU)
- ㉖ Thaksin University (TSU)

The ITER International Fusion Energy Organization (ITER)

Japan (Universities) – US Fusion Cooperation Program

In 1977, US President Carter and Japanese Prime Minister Fukuda discussed new bilateral cooperation on fusion. A governmental agreement on Japan and US joint activity in the field of fusion research and development was established, and the Japan-US Coordinating Committee for Fusion Energy (CCFE) was established in August 1979. This cooperation has been continuing for 45 years, producing many excellent results across a wide range of activities.

This joint planning program consists of three categories, each of whose main results in FY2024 are shown, as follows:

(1) Fusion Technology Planning Committee (FTPC)

The FTPC deals with collaborations on fusion technology, that is, superconducting magnets, plasma heating technologies, in-vessel/high heat flux materials and components, etc.

In 2024, Takumi Seto (DC2, Univ. Tsukuba) was dispatched to the University of California, San Diego (UCSD). In two separate visits, he installed two fast reciprocating probe systems in PISCES-RF in UCSD, which were fabricated in Tsukuba university, and performed an experiment to evaluate wave property in PISCES-RF helicon plasma. A data acquisition system was prepared by UCSD.



Fig. 1 (left) two fast reciprocating probe systems by U. Tsukuba, and (right) data acquisition systems by UCSD.

(2) Fusion Physics Planning Committee (FPPC)

The FPPC deals with collaborations in the experimental research of fusion plasma physics, consisting of steady-state operations, MHD and high beta, confinement, diagnostics, and high energy density science.

In 2024, Kunihiro Ogawa (Assoc. Prof., NIFS) was dispatched to General Atomics (GA) to study “the inter-



Fig. 2 Imaging neutral particle analyzer for (left) vertical and (right) tangential viewing in DIII-D.

action between energetic ions and energetic ion-excited waves in toroidal plasmas” for one week. During the stay at GA, with Drs. Michael Van Zeeland, Deyong Liu and Xiaodi Du he discussed neutron diagnostics and an imaging neutral particle analyzer for high-energy ion measurement in DIII-D (GA) and LHD (NIFS).

(3) Joint Institute for Fusion Theory (JIFT)

The JIFT deals with collaborations to advance theoretical understanding of plasmas and to develop fundamental theoretical and computational tools.

In FY2024, one workshop was successfully held, and one visiting professor and three visiting scientists made exchange visits. As for the workshop, the “US-Japan Joint Institute Fusion Theory (JIFT) Collaboration Meeting on Exascale Computing” was held at Princeton Plasma Physics Laboratory (PPPL), Princeton, NJ, USA, on February 27–28, 2025. There were 15 oral presentations (six from Japan and nine from US). The presentation topics covered: (1) Simulation code developments and applications, (2) Data science software for extreme scale computing, (3) US SciDAC projects for high-fidelity integrated simulations, and (4) The latest status of flagship high-performance computers in Japan and the US.

(4) Joint Project (FRONTIER)

The FRONTIER project started in April 2019 to provide the scientific foundations for reaction dynamics in interfaces of plasma facing components for DEMO reactors. This project consists of four tasks: irradiation effects on reaction dynamics at plasma-facing material/structural material interfaces (Task 1), tritium transport through interface and reaction dynamics in accidental conditions (Task 2), corrosion dynamics on liquid-solid interface under neutron irradiation for liquid divertor concepts (Task 3) and engineering modelling (Task 4).

The FRONTIER project successfully completed its sixth year in 2024. The experimental and theoretical studies being planned in the following year as follow-up research will address key issues for plasma-facing components of common interest to Japan and the U.S. The accomplishments of FRONTIER will provide important and essential elements toward realizing attractive fusion energy options. In October 2024, the final year of the project, a concluding workshop was held in Kyoto with 24 participants.



Fig. 3 Group photo at the workshop.

(T. Morisaki, S. Masuzaki, N. Yanagi, H. Sugama and Y. Hatano)

Plasma Wall Interaction (PWI) Collaboration

This collaboration is based on the IEA Technical Collaboration Programme (TCP) of the “Development and Research on Plasma Wall Interaction Facilities for Fusion Reactors” (PWI TCP) which involves Japan, Europe, the United States, Australia, and England. The objective of this program is to advance the physics and technologies of plasma-wall interaction research by strengthening cooperation among plasma-wall interaction facilities (in particular, by using dedicated linear plasma devices), to enhance the research and development effort related to a fusion reactor’s first wall materials and components, shown in the figure below.

NIFS collects proposals for international collaborative studies based on the PWI TCP, from domestic universities every year. The proposals are reviewed by the PWI technical committee whose members are domestic senior researchers in universities, QST, and NIFS, and some of the proposals are approved. Proponents of the approved collaborative research go to foreign institutes with support from NIFS and conduct the studies.

In the fiscal year of 2024, two collaborations on PWI experiments were conducted.

Comparison of deuterium desorption from tungsten fuzz between multiple plasma devices

A low-temperature deuterium (D) desorption around 350 K from a tungsten (W) surface with a fibrous nanostructure (fuzz, see Fig. 1) during thermal desorption spectroscopy (TDS) has been observed in the small RF plasma device APSEDAS at the University of Tsukuba and the small DC discharge plasma device Co-NAGDIS at Nagoya University. However, no such low-temperature D desorption has been reported in D plasma irradiation experiments on fuzz samples prepared by other plasma irradiation devices. The purpose of this study is to understand the mechanism of the low-temperature D desorption in detail by searching for conditions under which such desorption from the fuzzy layer occurs. In this study, APSEDAS, which has already confirmed the low-temperature D desorption, PISCES-A, a DC discharge plasma device at the University of California, San Diego (UCSD), which has many research achievements but has not observed low-temperature D desorption, and PISCES-RF, a new RF plasma system at UCSD, were used to obtain more experimental data.

First, helium (He) plasma was irradiated on two W specimens at APSEDAS to form fuzz on each surface. Then, the sample temperature was kept at 400 K, and D plasma was irradiated in APSEDAS. TDS was performed on one sample at the University of Tsukuba and the other sample at UCSD. The TDS results are consistent with each other, and low-temperature D desorption was observed in both cases at about 315 K.

In PISCES-A, W-fuzz samples prepared at APSEDAS were irradiated with D plasma (sample temperatures of 400 K and 600 K), and fuzz samples were prepared by He plasma irradiation and irradiated with D plasma (sample temperatures of 400 K and 600 K). Some of the fuzz samples prepared in PISCES-A were brought back to Japan and irradiated with D plasma (sample temperature: 400 K) at APSEDAS. In PISCES-RF, preparation of a fuzz sample and D plasma irradiation (sample temperature: 400 K, see Fig. 1) were performed.

No low-temperature D desorption was observed from the fuzz samples irradiated with D plasma at 600 K, while it was observed from the samples irradiated with D plasma at 400 K. These results indicate that the desorption characteristics of TDS may change depending on the sample temperature during D plasma irradiation. The trapping site that causes the low-temperature D desorption peak is considered to be less likely to trap D atoms when the sample temperature at the time of plasma irradiation is as high as about 600 K. The trapping site is also considered to be less likely to trap D atoms immediately after plasma irradiation. It is also possible that D atoms may have already been desorbed during the process of cooling the sample from a temperature of about 600 K immediately after plasma irradiation down to around 400 K.

Differences in the fuzz created in APSEDAS, PISCES-A, and PISCES-RF should be checked by using surface analysis methods such as scanning electron microscopy and X-ray photoelectron spectroscopy.

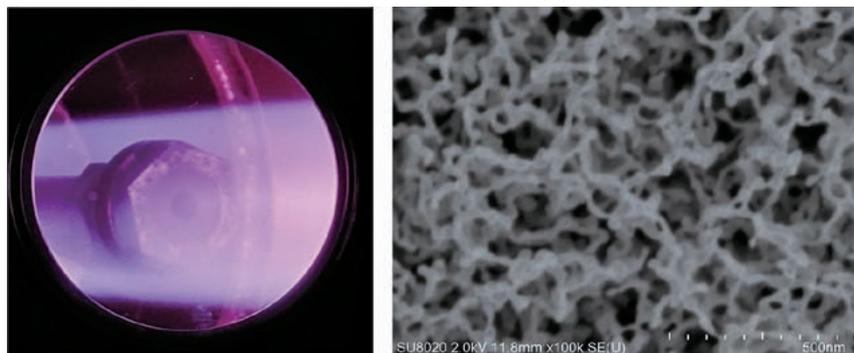


Fig. 1 A sample irradiated by D plasma in PISCES-RF, and a SEM image of fuzz

(K. Saito, University of Tsukuba)

Direct Measurements of the plasma potential and Electron Temperature using the Ball-pen Probe in VINETA

To investigate fluctuations in plasma space potential and electron temperature, a Ball-pen Probe method has been developed at Kyushu University. This collaborative research aims to test the Ball-pen probe on VINETA (see Fig. 2), the linear plasma device at the Institute for Physics at Greifswald University. VINETA has produced many excellent experimental results, primarily using electrostatic probe diagnostics. However, accurately measuring fluctuations in plasma space potential with conventional probes has proven difficult. Observing these fluctuations in space potential and electric field with high speed and accuracy is crucial for studying plasma instability.

By applying the Ball-pen probe, which is currently being developed for the linear plasma device PANTA at Kyushu University, to experiments on VINETA—similar in plasma generation method and device size to PANTA—the reliability and accuracy of the Ball-pen probe can be verified.

First, the plasma in VINETA needed to be characterized using a simpler Langmuir probe. A Langmuir probe was assembled to measure profiles of electron density, electron temperature, plasma potential, and floating potential. The probe was equipped with a compensating circuit to eliminate any RF signals. A 2D movable system was employed to position the probe, allowing for 2D profiling of the entire plasma column cross-section. To fit the probes onto the 2D system, a specific mounting arm was designed.

As VINETA has not yet demonstrated high-performance helicon plasma, it was decided not to install the Ball-pen probes at this time; however, this remains an option for future collaboration.

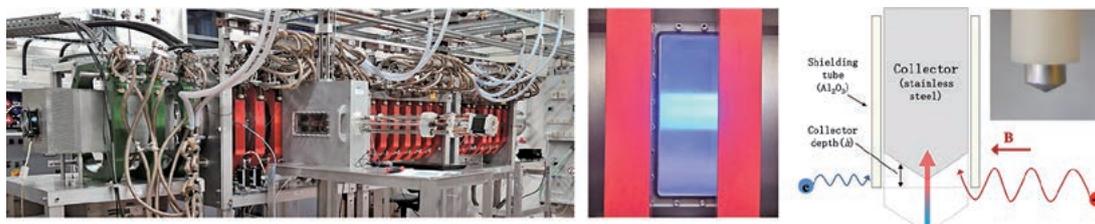


Fig. 2 VINETA and plasma generated in it, and a schematic view of a Ball-pen probe

(D.M. Donato, Kyushu University)

International Energy Agency (IEA) Technology Collaboration Programme (TCP) for Cooperation in Development of the Stellarator-Heliotron (SH) Concept (“IEA SH-TCP”)

The world Stellarator-Heliotron community has been promoting international collaborations under the auspices of the IEA TCP for Cooperation in Development of the Stellarator-Heliotron (SH) Concept. The participating countries and bodies in this program are Australia, China, EURATOM, Japan, Ukraine, and the United States. The Stellarator-Heliotron Executive Committee (ExCo) conducts arrangements of collaboration and endorses proposed activities. The 53rd ExCo meeting was held (on September 9, 2024) in Hiroshima in conjunction with the 24th International Stellarator-Heliotron Workshop. The Max-Planck Institute for Plasma Physics (Germany) hosts the web page of this activity at <http://www.ipp.mpg.de/sh-tcp>, and related content can be found on the webpage of the IEA, <https://www.iea.org/articles/new-milestones-in-magnetic-fusion-power>.

Highlights of recent activities

In FY2024, Hiroshima University successfully organized major meetings and workshops, with Prof. Yasuhiro Suzuki serving as the chair of the local organizing committee.

One of these was the 24th Coordinated Working Group Meeting (CWGM) held on September 5–6, 2024 at Hiroshima University (Higashi-Hiroshima city), which was composed of regular sessions such as “Core transport and confinement in multi-ion plasmas (chaired by D. Carralero / M. Nunami)”, “Energy, particle and impurity transport in the SOL and divertor (chaired by V. Winters / A. Bader)”, and “Energetic Particles, MHD and high-beta (Chaired by A. Knieps / A. Wright)”, followed by a specially organized session with private companies (chaired by N. Pablant) reflecting emerging interactions between public and private sectors in overall fusion research worldwide. Six companies presented their activities, stressing their visions and short-term plans for the development of the SH concept. How public-private partnerships could be formulated in the CWGM activities, and furthermore in the entire SH activities, was discussed.

The other meeting was the 24th International Stellarator-Heliotron Workshop (ISHW), which was held on September 9–13, 2024, at the International Conference Center Hiroshima (Hiroshima city). A record number of participants (231) was counted, with a marked increase in participation from China (32) being particularly noteworthy. Moreover, alongside the special session in the CWGM, participation from the private sector, including companies involved in the supply chain, was also highlighted. A detailed report (in Japanese) by the chair of the local organizing committee can be found at https://www.jspf.or.jp/Journal/PDF_JSPF/jspf2025_03/jspf2025_03-139.pdf.

The next ISHW (25th in 2026) will be held in Spain, as agreed in the ExCo meeting.

Highlighting remarks from the ExCo report (summarized in late 2024.)

As for the CWGM framework, regarding the current status and future development of the Stellarator-Heliotron Databases, efforts should be made to enhance them, especially the profile and confinement database. There have been discussions about broadening the scope of databases reflecting evolving research needs. Thus, a joint action is ongoing. It was also reported on challenges in maintaining and expanding the databases, including reliance on individual institutes to archive and submit data, and the technical challenges of archiving data from older or decommissioned devices.

Status of domestic activities and international collaborations

China: Southwest Jiaotong University (SWJTU) has successfully achieved a precise quasi-axisymmetric magnetic configuration in the CFQS-T experiments with 0.1T operation. The University of South China (USC) reported significant progress on the H1 stellarator (shipped from Australia), now called CN-H1. Coil assembly is nearly complete and the device is close to entering operational status, with first plasma anticipated in 2025.

Japan: Hiroshima University is recommissioning a small Heliac (the former Tohoku University (TU) Heliac). First plasma is envisaged in 2025; Kyoto University continues operation and maintenance of Heliotron J, collaborating with both the Large Helical Device (LHD) and international partners. LHD is preparing for its 26th and final campaign.

Ukraine: Experimental tests on ion cyclotron frequency range (ICRF) plasma production in a hydrogen minority regime were conducted on the U-2M device and qualified at the Large Helical Device (LHD). Initial experiments were successful in creating plasma using a radio frequency discharge above the ion cyclotron frequency at low magnetic fields in LHD. The findings suggest new operational possibilities for the LHD, which are also relevant to W7-X. The concept of a stellarator-mirror hybrid reactor is pursued further.

United States: The US has four active stellarator experiments (located at University of Wisconsin-Madison, Auburn University, University of Illinois Champaign-Urbana, and PPPL) and three more devices under construction (at Hampton University, Columbia University, and another at University of Wisconsin-Madison). US researchers continue to play a significant role in international campaigns, including the LHD and the upcoming W7-X campaign. The stellarator theory community is preparing for some changes as the Simons Foundation grant approaches its conclusion in 2025.

Germany: W7-X is entering a new operational phase with ambitious goals: higher ion temperatures, advanced detachment at high heating power, and longer pulse scenarios. Strong international collaboration, particularly from Europe and the US, is supporting experimental campaigns. Technical upgrades are being made to improve the reliability of operation.

Spain: TJ-II was operated until June 2024. Now, maintenance is underway in the power generator building. A call for proposals for the next campaign will be launched in early 2025. Collaboration with W7-X remains a strong priority.

(M. Yokoyama, K. Nagaoka, Y. Suzuki (Hiroshima Univ.) and K. Nagasaki (Kyoto Univ.))

Japan–China Collaboration for Fusion Research

Japan-China collaboration on fusion research is motivated by (1) the joint working group (JWG) for implementing the arrangement between MEXT of Japan and MOST of China for cooperation in the area of magnetic fusion energy research and development and related fields. It is also, (2) a collaboration on fusion research with institutes and universities in China, including the Institute of Plasma Physics, the Chinese Academy of Sciences (ASIPP), the Southwestern Institute of Physics (SWIP), Peking University, Southwestern Jiaotong University (SWJTU), Huazhong University of Science and Technology (HUST) and other universities. The Japan-China collaboration is carried out both for studies on plasma physics and fusion engineering. Based on the following implementation system, the Japan-China collaboration for fusion research in FY 2024 was executed.

Table 1 Implementation system of Japan-China collaboration for fusion research at NIFS

Category	① Plasma experiment				② Theory and simulation	③ Fusion engineering research
Subcategory	①-1	①-2	①-3	①-4	—	—
Operator	A. Shimizu	H. Takahashi	M. Isobe	M. Goto	H. Wang	T. Tanaka

①-1: Configuration optimization, transport, and magnetohydrodynamics, ①-2: Plasma heating and steady-state physics, ①-3: Energetic particles, and plasma diagnostics, ①-4: Edge plasma and divertor physics, and atomic process

Primary joint research activities in FY 2024

The first plasma of CFQS-T was successfully achieved in July, 2024. Subsequently, the first CFQS-T workshop was held on Nov. 13th and 14th, 2024 at the SWJTU Jiuli campus, as shown in Fig. 1. The number of participants was 87 in total from both NIFS and SWJTU. Two primary topics, i.e., research progress on CFQS and scientific achievements at CFQS-T and the joint design and construction of CFQS, as well as its perspective in the future, were presented from both sides and discussed [1-4].



Fig. 1 The 1st CFQS-T workshop held on Nov. 13th and 14th, 2024 at SWJTU Jiuli campus.

In the research of energetic particles (EPs), NIFS and ASIPP conducted joint studies on energetic ion anisotropy in LHD using a compact neutron spectrometer [5], as well as triton burnup experiments in EAST using a scintillating fiber detector [6]. In addition, NIFS and ASIPP have collaborated on the development of neutron diagnostics [7] and lost energetic ion diagnostics [8] for EAST and BEST. NIFS and SWIP have been discussing neutron diagnostics, hard X-ray diagnostics, and E11B neutral particle analyzers. Furthermore, NIFS and SWIP carried out triton burnup and runaway electron experiments in HL-3. Five joint papers related to EP diagnostics and physics were published in FY2024 [5-8].

At EAST, preparations are underway for imaging observations of multiple impurity emission lines and for

measuring the spatial distribution of electron temperature and density using their intensity ratios. As a proof-of-concept for this measurement technique, we investigated the use of spectral data acquired by LHD. The LHD routinely measures spectra between approximately 30 nm and 300 nm with a time resolution of 5 ms. This allows the emission line intensity ratio to be correlated with the electron temperature and electron density obtained from Thomson scattering measurements. We plan to use the results from analyzing this LHD experimental data to validate the ADAS database and subsequently apply it to evaluate EAST experimental data.

Collaborations on theory and simulation have been carried out with several institutions to investigate key topics in plasma physics. With SWIP and ASIPP, a MEGA simulation was performed to investigate β -induced Alfvén eigenmode instabilities and mode transition in HL-3 and bursting core-localized ellipticity-induced Alfvén eigenmodes driven by energetic electrons in EAST. With the University of Science and Technology of China (USTC), analytical investigations were carried out on the electromagnetic perturbations of geodesic acoustic modes in tokamak plasmas. With the Dalian University of Technology (DLUT), a neoclassical tearing mode simulation was performed to investigate the enhancement of Electron Cyclotron Current Drive (ECCD) for controlling neoclassical tearing modes in tokamak plasmas [9-13].

- [1] T. Fu, X.Q. Wang, X. Su, Y. Xu, S. Okamura, A. Shimizu, M. Isobe, J. Cheng, H.F. Liu, J. Huang, X. Zhang, H. Liu, and C.J. Tang, “*Suppression of equilibrium magnetic islands by density profile effect in quasi-axisymmetric stellarator plasmas*”, *Plasma Physics and Controlled Fusion* **66**, 065026 (8pp) (2024).
- [2] X. Su, X.Q. Wang, Y. Xu, S. Okamura, A. Shimizu, M. Isobe, J. Cheng, H.F. Liu, J. Huang, X. Zhang, H. Liu, Y. Luo, J.F. Shen, J. Hu, and C.J. Tang, “*Controlling three-dimensional magnetic island appearance with external current drive in the Chinese first quasi-axisymmetric stellarator*”, *Nuclear Fusion* **64**, 076023 (12pp) (2024).
- [3] Xin Zhang, Akihiro Shimizu, Sho Nakagawa, Yuhong Xu, Takanori Murase, Hiroyuki Tanoue, Kazuki Nagahara, Mamoru Shoji, Zilin Cui, Hiromi Hayashi, Kunihiro Ogawa, Hiromi Takahashi, Mitsutaka Isobe, Shoichi Okamura, Haifeng Liu, Xianqu Wang, Hai Liu, Jun Hu, Jun Cheng, and Changjian Tang, “*Investigation of modular coil misalignment on magnetic flux surface in the CFQS quasi-axisymmetric stellarator*”, *Fusion Engineering and Design* **211**, 114820 (2025).
- [4] Hiroyuki Tanoue, Sho Nakagawa, Kazuki Nagahara, Takanori Murase, Akihiro Shimizu, Kunihiro Ogawa, Hiromi Takahashi, Mamoru Shoji, Shoichi Okamura, Mitsutaka Isobe, Masaki Osakabe, Dapeng Yin, Haifeng Liu, and Yuhong Xu, “*Engineering design and manufacturing of the modular coil system for the quasi-axisymmetric stellarator CFQS-T*”, *Fusion Engineering and Design* **212**, 114853 (2025).
- [5] K. Ogawa, M. Isobe, S. Sangaroon, L. Liao, G. Q. Zhong, R. Seki, H. Nuga, and M. Osakabe, “*Observation of Energetic Ion Anisotropy Using Neutron Diagnostics in The Large Helical Device*”, *Nuclear Fusion*, **64**, 076010 (2024).
- [6] Kunihiro Ogawa, Guoqiang Zhong, L. Y. Liao, Weikun Chen, Ruijie Zhou, Kai Li, Eiji Takada, Siriyaporn Sangaroon, Liqun Hu, and Mitsutaka Isobe, “*Time-resolved deuterium-deuterium fusion born 1 MeV triton confinement study in EAST deuterium plasma*”, *Plasma Physics and Controlled Fusion* **67**, 025001 (2025).
- [7] Yubo ZHANG, Guoqiang ZHONG, Liangsheng HUANG, Mingyuan Xu, Liqun Hu, Juan Huang, Kun Xu, Ruixue Zhang, Li Yang, Chaowei Mai, Yongqiang Zhang, Weikun Chen, K. Ogawa, M. Isobe, Tieshuan Fan, and Mengjie Zhou, “*Study on the contribution matrix for the EAST radial neutron camera system*”, *Fusion Engineering and Design* **206**, 114602 (2024).
- [8] Mingyuan Xu, Guoqiang Zhong, Yubo Zhang, Liangsheng Huang, Liqun Hu, Ruixue Zhang, Li Yang, Yongqiang Zhang, Weikun Chen, S. Sangaroon, K. Ogawa, M. Isobe, and Tieshuan Fan, “*Investigation of Cs27LiYCl6:Ce scintillator energy response for D-D fusion neutron spectrometer*”, *Fusion Engineering and Design* **204**, 114490 (2024).
- [9] Yunpeng Zou, Vincent S Chan, Yasushi Todo, Ruirui Ma, Miao Xue, Xiaoran Zhang, Yiren Zhu, and Wei Chen, “*Simulation of β -induced Alfvén eigenmode instabilities and mode transition for HL-3 hybrid scenario*”, *Nucl. Fusion* **65**, 026034 (2025).
- [10] P. Su, H. Lan, C. Zhou, J. Bao, A. Liu, X. Zhu, M. Wu, C. Luo, J. Han, J. Wang, H. Liu, T. Zhang, R. Zhou, S. Lin, H. Zhao, Y. Sun, Z. Qiu, N. Chu, T. Tang, Y. Tan, L. Zeng, and Z. Gao, “*Bursting core-localized ellipticity-induced Alfvén eigenmodes driven by energetic electrons during EAST ohmic discharges*”, *Nuclear Fusion* **64**, 036019 (2024).
- [11] Zhe Chen, Yixiang Li, Haijun Ren, and Hao Wang, “*MHD analysis of electromagnetic GAMs in up-down asymmetric tokamaks*”, *Nuclear Fusion* **65**, 044001 (2025).
- [12] Zhe Chen, Haijun Ren, Hao Wang, and Colin M. Roach, “*On electromagnetic perturbations of geodesic acoustic modes in anisotropic tokamak plasmas*”, *Plasma Physics and Controlled Fusion* **67**, 045008 (2025).
- [13] Tong Liu, Zheng-Xiong Wang, Lai Wei, Jialei Wang, and Allan Reiman, “*Enhancement of ECCD by the current condensation effect for stabilizing large magnetic islands caused by neoclassical tearing modes in tokamak plasmas*”, *Nuclear Fusion* **64**, 036001 (2024).

(M. Isobe, K. Ogawa, M. Goto and H. Wang)

Japan-Korea Fusion Collaboration Programs

I. KSTAR Collaboration in FY 2024

Workshop on Physics and Technology of Heating and Current Drive

This workshop was held from 17th to 18th February 2025, at the National Institute for Fusion Science (NIFS) in Toki as a hybrid of face-to face and remote participation. There were 19 oral presentations (JA: 10, KO:9) including three by students (JA:1, KO:2). Three people including one student traveled to NIFS from their affiliated institutions for on-site participation. There were 29 participants (JA:17, KO:15) in total. The topics were electron cyclotron resonance heating/current drive, helicon wave heating/current drive, neutral beam heating/current drive, theoretical study for wave heating/current drive, and diagnostics related to heating.

KSTAR collaboration on plasma diagnostics

1st Asian School on Advanced Plasma Diagnostics for Magnetic Fusion Experiments: As a successor to



Fig. 1 Image of 1st APDS

the *Korea-Japan Seminar on Advanced Diagnostics for Steady-State Fusion Plasmas*, which had been held biennially in Japan and Korea, the *1st Asian School on Advanced Plasma Diagnostics for Magnetic Fusion Experiments (APDS)* was held from 19th to 21st February 2025 at NIFS. The school consisted of 20 lectures by scientists from Japan (7), Korea (7) and the China (6), two poster sessions for students and a tour of NIFS including LHD. Young researchers in attendance

totaled 38 including from Japan (12), the Republic of Korea (9), China (10), Taiwan (5) and Thailand (2).

Thomson scattering diagnostics: Two participants from Japan attended the *3rd International Fusion Plasma Conference (iFPC 2024)* held in Seoul, Korea, in June 2024, and delivered single oral and poster presentations. In addition, discussions on Thomson scattering diagnostics were held with three participants from the Korea Institute of Fusion Energy (KFE), who also attended the conference. Information exchange and discussion regarding polychromators were conducted.

RF Spectrometer: In May 2024, an LHD experiment was conducted as a joint project with Korea. By changing the helium neutral beam penetration region, energy, and particle number, systematic data were obtained to investigate whether variations appeared in the frequency range and intensity of non-thermal emissions in the ion cyclotron higher harmonic range, as well as in the burst-like enhancement of emission intensity.

SXCCD Camera: One person visited KFE to discuss with the person in charge of SXCCD measurements, aiming to explore the possibility of a new research collaboration on the measurement of tungsten multicharged ions using the existing visible spectroscopy system.

Japan-Korea KSTAR Diagnostics Collaboration Meeting: This meeting was held on February 13, 2025, at KFE. Two people from NIFS traveled to Korea to take part on-site and eight engaged remotely from NIFS. Thirteen participated from Korea. The status of each diagnostics collaboration was reported and discussion on Japan-Korea diagnostic collaboration was conducted.

Collaboration of RF plasma heating in KSTAR

In December 2024, one person visited KFE and the Ulsan National Institute of Science (UNIST) to carry out research collaboration on propagation mode identification analysis in the KSTAR electron cyclotron heating

(ECH) system. In the same month, another visited KFE to conduct a joint Japan–Korea research experiment on the observation of non-thermal electron emissions during electron cyclotron heating/current drive. In March 2025, one person visited KFE to carry out research collaboration on the Compact ICRF Antenna (CIA), the Helical Loop Antenna (HLA), and the Solid-State Power Amplifier (SSPA). An HLA was subsequently installed in KSTAR and utilized in plasma experiments.

II. Human Resource Development in FY 2023

Studies on multi-scale and multi-species transport in fusion plasma



Fig. 2 Image of 2024 Japan–Korea Workshop on Fusion Theory

studies using the MEGA code. A keynote lecture from the Korean side was delivered on DEMO reactor design activities in Korea.

There were 26 oral presentations (JA: 15, KO:11). There were 29 participants (JA:17, KO:12) in total including online participation (JA:2 KO:1).

Evaluation of Tritium behavior for reactor design in fusion (VI)

The 2024 Japan-Korea Tritium Workshop was held from 15th to 16th January 2025 at Paradise Hotel in Busan as a hybrid of face-to face and remote participation. There were 27 on-site participants (JA:6, KO:22) and one



Fig. 3 As part of the program of 2024 Japan-Korea Tritium Workshop, a visit was made to a Korean tritium start-up company

The Japan–Korea Workshop on Fusion Theory was held at Nagoya University from July 29th to 30th, 2024 as a hybrid of face-to face and remote participation. The workshop addressed theoretical issues of magnetically confined fusion plasmas, with a particular focus on transport phenomena involving multiple spatiotemporal scales and multiple particle species, while also covering broader themes including DEMO reactor design. At the opening of the workshop, a review was presented on the latest progress in kinetic magnetohydrodynamic (MHD) simulation

including students and members from a Korean start-up company. As ITER procurement-related technology development, Korea presented the status of the development of the tritium storage and supply system (SDS), while Japan reported on the status of the development of the detritiation system (DS). In recent years, design activities have also been advanced using 3D printing technology, including the optimization of the SDS glovebox and the design optimization of uranium beds. In addition, reports were presented on fundamental studies of hydrogen behavior in metals containing tritium, simulations of microstructural changes on tungsten surfaces under helium irradiation, and efforts to establish a database on hydrogen behavior.

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