

3. Bilateral Collaboration Research

The purpose of the Bilateral Collaboration Research Program (BCRP) is to reinforce the activities of nuclear fusion research in universities by using their middle-size experimental facilities at specific university research centers as joint-use facilities for all university researchers in Japan. The current program involves five university research centers as follows:

Plasma Research Center, University of Tsukuba
Laboratory of Complex Energy Process, Institute of Advanced Energy, Kyoto University
Institute of Laser Engineering, Osaka University
Advanced Fusion Research Center, Research Institute for Applied Mechanics, Kyushu University
Hydrogen Isotope Research Center, University of Toyama

In the BCRP, each research center can have its own collaboration programs, using its main facility. Researchers at other universities can visit the research center and carry out their own collaboration research there, as if the facility belongs to NIFS. These collaboration research efforts are supported financially by NIFS as research subjects in the BCRP. These proposals are received from all over Japan every year. The collaboration research committee, which is organized under the administrative board of NIFS, examines and selects the subjects.

In FY2024, it was decided that Bilateral Collaboration Research be integrated with Network-type Research of General Collaboration Research and reformed into three categories: Fundamental Facility Type Collaboration Research, Subject Proposal Type Collaboration Research, and Research Core Proposal Type Collaboration Research. Bilateral Collaboration Research was closed in FY2024.

(Y. Todo)



University of Tsukuba



Fig. 1 Bird's eye view of GAMMA 10/PDX. The inserted pictures are a divertor simulation experimental module (D-module) and a 14 GHz CW gyrotron.

Highlight

Study of boundary plasmas by making use of open magnetic field configuration and development in high power gyrotrons towards the DEMO project

In the Plasma Research Center, University of Tsukuba, research on boundary plasma and the development of high-power gyrotrons has been conducted under a bilateral collaboration research program. Processes of plasma detachment have been studied by introducing hydrogen and impurity gases into the end-loss plasma in a divertor simulation experimental module (D-module) located at the west end of GAMMA 10/PDX (Fig. 1). In FY2024, we studied the influence of ion temperature on the process of detached plasma formation, and observed three-body and radiative electro-ion recombination (EIR) by increasing H_2 gas pressure. A new 1 MW 14 GHz CW gyrotron for low-field fusion devices was developed. In the first experimental test, an output power of 1.05 MW for 2 ms was achieved at a beam current of 42.6 A, which is a world record in the 14 GHz frequency range. In the superconducting mirror device, Pilot GAMMA PDX-SC (PGX-SC), an ion cyclotron range of frequencies (ICRF) wave with a frequency of 1.8 MHz and a power of 160 kW was applied, suggesting the ion temperature was increased.

A divertor simulation study has been carried out by using end-loss plasma in GAMMA 10/PDX (Fig.1). A divertor simulation experimental module (D-module) was installed in the end region of GAMMA 10/PDX, and a V-shaped tungsten target in the D-module was exposed to the end-loss plasma. The ion and electron temperatures of the end-loss plasma were several hundred eV and several tens of eV, respectively. Utilizing the fact that plasma is a high-temperature state of matter, we have examined how the processes of detached plasma formation depend on ion temperature by adjusting the radio-frequency (RF) heating power. In the experiment on detached plasma formation leading to hydrogen molecular activated recombination (H-MAR), we compared differences in the detached plasma across three different diamagnetism (DM) levels of the central cell, ranging from 0.1 to 0.5×10^{-4} Wb. The spatiotemporal distribution of the Balmer H_{α} and H_{β} emission intensity ratios, observed simultaneously with a high-speed camera, along with measurements from the electrostatic probe array on the target plate, indicated that the recombination region shifted downstream with higher DM plasmas.

The importance of hydrogen molecules in vibrationally excited states during recombination reactions has been highlighted, with the intensity ratio of Balmer α to β serving as a key indicator. Recently, we observed three-body and radiative electro-ion recombination (EIR) by increasing H_2 gas pressure. A detailed analysis shows that both EIR and the mutual neutralization between H_2^+ and H^- play significant roles in emissions from highly excited levels.

Progress has been made in modeling the kinetic effects of ion-conductive heat flux along magnetic field lines in the scrape-off layer (SOL) of a DEMO reactor. A transport equation derived from the Boltzmann equation has been implemented in a plasma fluid code and verified. Comparison with a first-principles particle-in-cell code shows that the heat flux is qualitatively and semi-quantitatively reproduced under a uniform magnetic field and high collisionality.

Regarding advanced diagnostic development, we upgraded the Dual-Path Thomson Scattering (DPTS) system to study non-invasive plasma structures in both the upstream core plasma and the end region D-module. In this system, the probe laser of the central-cell (CC) TS system is split into two paths: one directed to the central cell and the other transmitted about ten meters downstream to the end cell. Probe laser light is thus injected simultaneously into both the central and end cells.

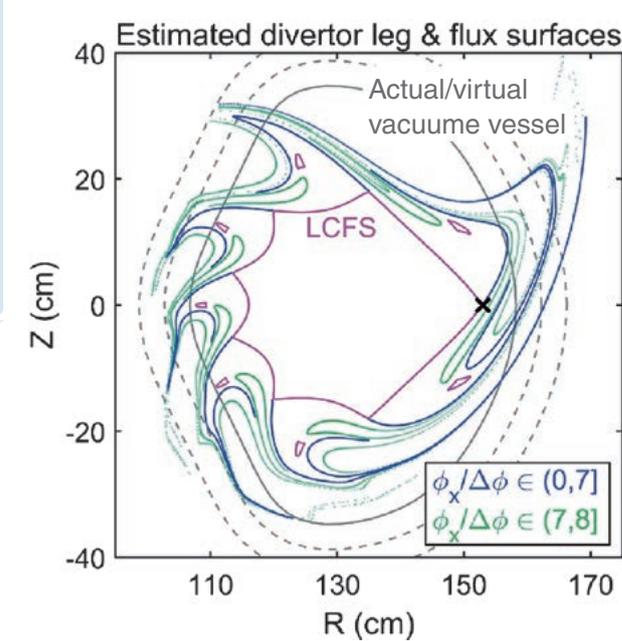
In the end region, the TS system uses a laser beam branched from the CC-TS system, which introduced beam alignment issues due to long-distance transmission. This made it difficult to obtain stable Thomson scattering signals. To resolve this, we introduced a laser beam alignment stabilization system (Aligner, TEM Messtechnik), which enabled precise stabilization of the beam position. By adjusting the beam alignment before plasma experiments, a stable probe beam path was successfully maintained.

The development of gyrotrons that are high-power microwave sources for electron cyclotron resonance heating (ECRH) is one of the most important areas of research at the plasma research center. Megawatt (MW) gyrotrons with a wide frequency range from 14 to 300 GHz are being developed for fusion devices in collaboration with fusion research institutes. A novel 1 MW 14 GHz CW gyrotron for low-field fusion devices has been developed. The design results showed that, despite a 14 GHz RF beam with high divergence, a transmission efficiency of 94% was obtained for the corrugated waveguide coupling position by employing a direct coupling design strategy using a built-in waveguide to minimize the RF transmission path. By installing a double-disk sapphire window, a 1 MW CW operation was possible at 14 GHz. In the first experimental test, the output power P_o increased with an increase in the beam current I_k , and 1.05 MW for 2 ms was obtained at $I_k = 42.6$ A, which is a world record in the 14 GHz frequency range. A maximum output efficiency η_o of 40.6% was obtained at $I_k = 25.3$ A. The successful development of this gyrotron will reduce the cost of gyrotron systems because it eliminates the need for a Matching Optics Unit (MOU) to connect the gyrotron and the waveguide. Furthermore, achieving a megawatt-class output at 14 GHz, which is the operating boundary frequency between gyrotrons and klystrons, can be useful in various fields, including nuclear fusion research, particularly in the development of compact fusion reactors.

To further advance the divertor simulation study, a new linear plasma device, Pilot GAMMA PDX-SC (PGX-SC), was constructed, and plasma production and heating experiments are in progress. A cascade arc plasma source and a helicon plasma source have been developed. Regarding plasma heating, ICRF and electron cyclotron heating (ECH) antennas are installed in the vacuum vessel. An ICRF wave with a frequency of 1.8 MHz and a power of 160 kW was applied to plasma sustained by a cascade arc plasma source. An ion-sensitive probe showed an increase in ion temperature due to ICRF heating.

(M. Sakamoto)

Kyoto University



Calculated divertor leg (blue, green), last closed flux surface and magnetic islands (magenta), and vacuum vessel (gray solid/dashed) in Heliotron J.

Highlight

Divertor Topological Structure Arising from Hidden Stochasticity in Heliotron J

Based on the stochasticity of the vacuum magnetic field, the divertor in helical devices is categorized into helical (or ergodic) and island divertors. The distinction between a helical and island divertor, however, is sometimes ambiguous. Therefore, it is useful to give a distinctive categorization of the divertors' topological structures based on distribution, in addition to field stochasticity. The stochastic feature of the magnetic field can be seen in an edge surface layer region outside the LCFS, which exhibits a “fold and stretch” effect on any topological structure in the region, as has been shown in Large Helical Device (LHD) [G. Kawamura *et al.*, Plasma Phys. Control. Fusion **60**, 084005 (2018)].

We have utilized an estimation method for the shape of divertor legs by tracing the field lines that originate from positions near an X-point, as indicated by the black “X” marker in the figure. Due to the stretch effect along the divertor leg and the divergence-free nature of the magnetic field, the distance between those field lines and the actual divertor leg reduces with the increasing tracing distance. This is also the reason why the edge surface layer can be observed in the Poincaré plot, where field line trajectories on a toroidal cross-section show some unique structures, regardless of their starting position. Hence, such field lines can be a reliable estimate of the shape of the divertor leg even if they are chaotically folded with massive details. A divertor leg in the Heliotron, calculated using this estimation method, is illustrated in the figure, where ϕ is the traced toroidal angle of a field line in the positive-toroidal direction from an estimated X-point. Note that the estimated divertor leg is discontinuous, owing to the limited calculation domain. Small regions with nested flux surfaces also exist at the O-points outside the LCFS. [F. Cai *et al.*, Contrib. Plasma Phys. **64**, e202300145 (2024)].

Electron Internal Transport Barrier (e-ITB) formation in NBI plasmas

It is important to control heat transport in order to achieve high performance in magnetic confinement fusion plasma. Methods for controlling heat transport in fusion-grade plasma confinement devices have not yet been fully established due to the complex heat deposition and profile formation. In this respect, clarifying the interactions between temperature gradients, turbulence, and flow is a crucial challenge for controlling heat transport. In this study, we have identified confinement conditions that improve heat transport in high-collisionality plasmas with a broad heating distribution by applying high-intensity gas puffs (HIGPs) to neutral beam injection (NBI) heating, [C. Wang *et al.*, 2024 Plasma Phys. Control. Fusion **66**, 022001]. Furthermore, we calculated the radial electric field via simulation and evaluated the differences between CERC and simulated plasmas from temperature and density profiles obtained from a Thomson scattering system and charge exchange recombination spectroscopy.

Figure 1 shows the time evolution of the electron temperature (T_e) profile for both conventional gas puffs and HIGPs. A plasma is heated by a balanced NBI with an injection pulse of 190–260 ms and an injection power of 280 kW. HIGP introduces a large amount of working gas (D_2) in the short time of 230–240 ms, followed by an abrupt stop to the gas puff. After an HIGP, the T_e profile initially shrinks and forms a centrally peaked one. Subsequently, the central region becomes steep at 260–270 ms, forming an e-ITB structure with $T_e(0) = 370$ eV. Compared to a gas puff (GP) experiment, the difference in central temperature is significant. At this point, the electron density rises to $6 \times 10^{19} \text{ m}^{-3}$ (although the central region is flat), and the collision frequency is higher than that of CERC plasma. After an HIGP, the ion temperature profile also sharpens with a similar time variation, but to a lesser extent. Using the DKES PENTA code to calculate the neoclassical bipolar electric field (see Figure 2), we found that (i) the sign is negative (ion root), and that (ii) there is no significant difference in the electric field profile between a conventional gas puff and an HIGP. Therefore, it is speculated that the electron transport barrier is formed by a different physical process during the HIGP than in CERC. Currently, in addition to measuring turbulence in the central region, we are investigating the effects of lower-order rational surfaces based on their relationship with electron transport barriers revealed in Heliotron J [N. Kenmochi *et al.*, Sci. Rep. **10**, 5 (2020)].

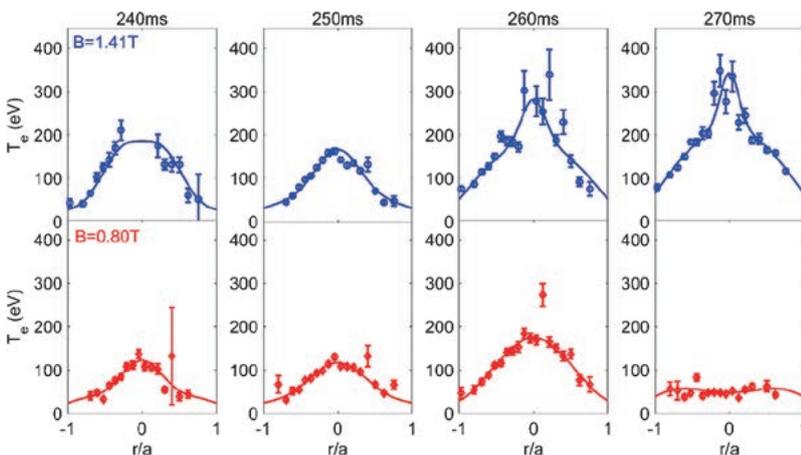


Fig. 1 Time variation of electron temperature profiles in upper (HIGP) and lower (Gas Puff) cases.

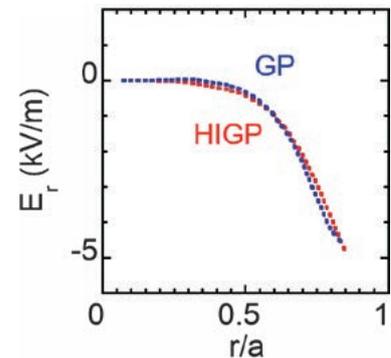


Fig. 2 Comparison of the radial electric field between HIGP and gas puff cases calculated by DKES PENTA code.

(Kazunobu Nagasaki)

Study on high-density core plasma formation and laser fusion with fast ignition scheme

The Institute of Laser Engineering (ILE) at The University of Osaka has been collaborating with NIFS and related universities to advance research on high-density plasma in laser fusion and to clarify the path to efficient fusion plasma through the FIREX-1 project. Starting in fiscal year 2021, ILE has launched the FIREX-NEO (Numerical Experiment Optimization) project, which aims to develop high-gain designs through numerical simulations. This project focuses on enhancing the accuracy of simulation codes for the three critical processes in high-energy laser fusion, i.e., implosion, heating, and burning, and conducting the necessary fundamental experiments to achieve this. Additionally, by incorporating research related to high-repetition laser technology development, plasma diagnostic development, and fusion reactor engineering, we are comprehensively advancing laser fusion research. By leveraging domestic and international researcher networks and collaborating with bilateral joint research projects, we are academically advancing high-energy-density science and striving to cultivate the next generation of researchers.

1. Improvement of compression ratio in high-density fusion fuel core formation

Laser fusion requires the generation of high-density core plasma that is more than 1,000 times denser than solid matter. In the central ignition scheme, the core plasma is generated by imploding a thin shell, but in the fast ignition scheme, there is no need to form a hot spot at the center. Therefore, we can adapt a solid ball and compress it using three shock waves. By introducing a random phase plate to improve the non-uniformity of laser irradiation, we have been able to achieve an implosion of the solid sphere, but the compression ratio has not been high enough. One possible cause was suspected to be an imbalance in energy conversion between the GEKKO-XII beams. This year we coated the solid sphere with aluminum to increase the Coulomb collision rate in the ablation plasma, thereby attempting to suppress cross-beam energy transfer between the beams. As a result, we successfully achieved a higher compression ratio than last year.

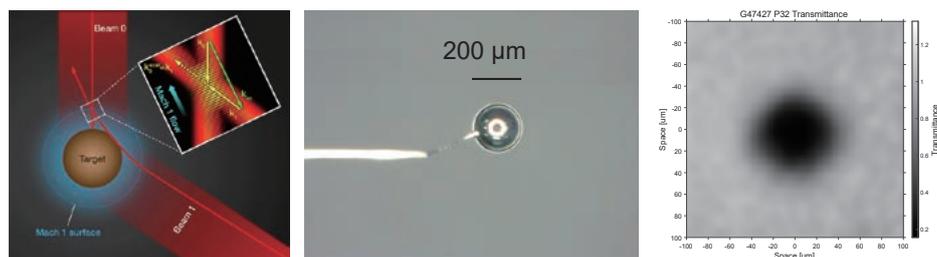


Fig. 1 (Left) Image of energy conversion between beams accompanying the overlap (beat) of implosion laser beams. (Center) Al-coated target used in the experiment. (Right) Improved compression performance (backlight image of implosion plasma).

2. Suppression of laser-plasma instability

In implosion, shock-wave ignition-laser fusion requires laser intensities exceeding 10^{15} W/cm². Even with the fast ignition scheme at the ignition scale, the final stage laser intensity can reach similarly high levels. In such high-intensity laser-plasma interactions, high-energy electrons with energies of several hundred keV, which are two orders of magnitude higher than the laser field's vibrational energy, have been observed. It is important to understand the physics of such high-energy electron generation. In this study, we achieved high-intensity blue (3w) lasers by simultaneously irradiating multiple beams using the GEKKO-XII laser. Additionally, by using green (2w) lasers as pre-pulses, we generated plasma with different scale lengths and investigated the

laser-plasma interactions of blue lasers. The time evolution of the scattered light observed at time intervals of 0.2 ns (short-scale plasma) and 0.8 ns (long-scale plasma) between the green laser and blue laser is summarized in Figure 2. Scattered light with a wavelength of approximately twice that of the blue laser (351 nm) is observed at the timing of the main pulse irradiation. The intensity of the scattered light is stronger than that observed for the short-scale plasma (0.2 ns). Additionally, the energy spectrum of the high-energy electrons observed simultaneously (Figure 2, right) confirms that the number of high-energy electrons generated in the long-scale (0.8 ns) experiment is nearly two orders of magnitude lower. From this, it can be inferred that the high-energy electrons were accelerated by plasma waves generated during the process of parametric decay. The above results suggest the possibility of suppressing parametric instability in implosion lasers by adjusting the plasma scale length.

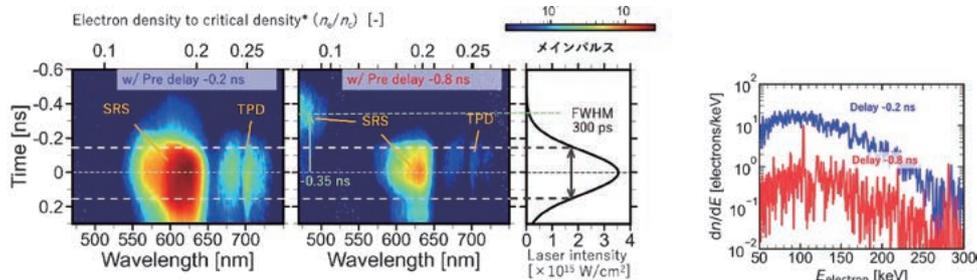


Fig. 2 (Left) Time evolution of the wavelength of scattered electromagnetic waves when the irradiation interval between the pre-pulse and main pulse is changed. (Right) Energy spectrum of high-speed electrons observed at that time.

3. Kinetic effects in DT fusion burning

In the ignition experiment conducted by the US National Ignition Facility (NIF), it has been reported that the observed neutrons contained non-thermal components. This indicates the presence of non-thermal high-energy ions in the fusion burning process. We evaluated how non-thermal ions with energies above several tens of keV are generated through Coulomb collision calculations between alpha particles and DT ions. In the calculations, we examined how the energy of α particles (3.5 MeV) initially present at a concentration of 1% in a DT plasma with an initial temperature of 3 keV and a density equivalent to 200 g/cc, was converted into plasma electrons and DT ions using a two-body collision model. First, we confirmed that the energy of the α particles decreases due to deceleration caused by electron heating. On the other hand, by considering large-angle scattering, it was found that non-thermal components of D ions are generated, and the time required for thermal relaxation of the α particles is boosted to one-third. The theoretical predictions also show good agreement with the reason why non-thermal components of D ions are generated first, compared to T ions.

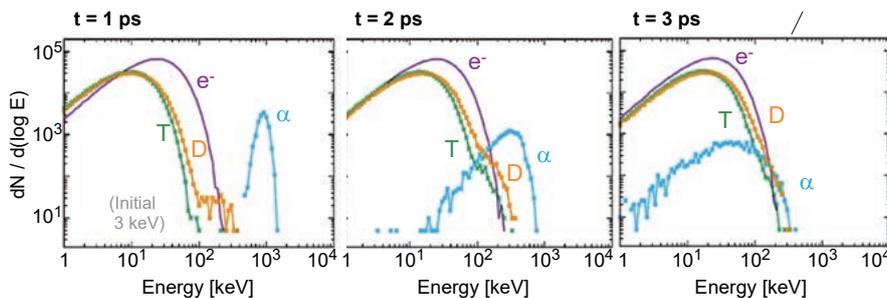


Fig. 3 Time evolution of the energy distribution in the energy relaxation process of alpha particles in a 3 keV DT plasma in the early stage.

(Y. Sentoku)

Research activities of QUEST in FY2024

Here we summarize the activities of the Advanced Fusion Research Center, Research Institute for Applied Mechanics at Kyushu University from April 2024–March 2025. QUEST experiments were executed from 5th Apr. – 22nd Aug. (2024 Spring/Summer, shot no. 53077-53571) and 11th Sep. – 16th Jan. (2024 Autumn/Winter, shot no. 53572-54445). The main topics of the QUEST experiments in FY2024 are listed below.

- 1) A non-inductive 28 GHz electron cyclotron plasma ramp-up with multiple fundamental and second harmonic resonances has been planned to achieve both a highly efficient plasma ramp-up and significant central bulk electron heating. A 100 kA DC power supply has been developed to double the toroidal magnetic field from 0.25 T to 0.5 T, enabling these goals to be met simultaneously. All the control systems for 125 modules of the power supply have been developed, and a 7.2 kA DC current was successfully attained by using 9 modules for a planned few seconds. Divertor plasmas with clear divertor legs were non-inductively ramped up with the 28-GHz electron cyclotron heating through the proper plasma equilibrium control.
- 2) Middle-scale W/ODS-Cu/SUS joint structure samples for the QUEST first wall was successfully fabricated. A middle-scale sample was installed at the first wall position of QUEST, and then, exposed to 4016s of tokamak discharges in total, while maintaining a temperature of around $\sim 350^{\circ}\text{C}$. There was no specific damage to the middle-scale sample, such as delamination or cracks, after the irradiation test in QUEST.
- 3) Using molecular dynamics simulations, we analyzed the energy distribution of hydrogen isotope (H, D, T) emissions and incorporated a machine learning model for hydrogen release into a neutral particle transport code in the case of protium. In addition, we developed a web-based VR system to visualize magnetic field lines in 3D within the QUEST device. These efforts are expected to contribute to the establishment of a technique for dynamically analyzing hydrogen release behavior from fusion reactor walls.
- 4) The ball-pen probe (BPP) is a new method for directly measuring space potential and electron temperature in magnetized plasmas. It has several advantages, such as a simple design, strong structure, and fast signal response. To test if it works well for the QUEST spherical tokamak, we built a new two-channel BPP and successfully tested it in the PANTA device.
- 5) The plasma shape reconstruction code using the Cauchy condition surface method (CCS) modified from the latest version for JT-60SA was applied to the QUEST plasma. A selected flux loop signal whose accuracy was confirmed by a coil energization test was applied and the drift of each signal was carefully compensated for. Fixing bugs in the code is continuing.
- 6) A new Permeation and Langmuir Probe (PALP) was developed and installed in QUEST to evaluate atomic and ionic hydrogen fluxes to plasma-facing components. Contamination effects were addressed using a dedicated calibration chamber, with lab studies showing that oxygen and tungsten alter the crystal structure and hydrogen permeation in Pd and Ni membranes.
- 7) Edge fluctuation measurements using the limiter-like electrode system were performed for Inboard Poloidal Null (IPN) configuration tokamaks produced by the 28 GHz gyrotron system.

At the major radius of 1.1 m, intermittent low frequency kV order floating potential spikes and intermittent envelopes of MHz range floating potential fluctuations were observed during a single discharge. The spikes could be indicators of high energy electron flux, and the existence of the envelopes suggests wave excitation phenomena. Correlation between the spikes and the envelopes is suggested. Now the statistical significance

of the correlation is under investigation.

- 8) Improvements in hot wall heaters at the lower side were carried out to control the hot wall temperature locally. This improvement allowed for a more detailed investigation of the effect of wall temperature on particle balance. In addition, the modeling of hydrogen recycling, including trapped hydrogen into the plasma facing material, has been improved.
- 9) The injection port of the HIBP was modified to allow a wider sweep of the probe beam's incident angle, and the beamline installation was completed. A Cs⁺ beam has been successfully emitted from the ion source and accelerated. The next step is to compensate for the beam deflection caused by the toroidal magnetic field in order to inject the beam into QUEST.
- 10) To measure ion-scale turbulence and plasma poloidal rotation, a Doppler Backscattering (DBS) system was developed. The system used 10 GHz, 14 GHz, and 18 GHz microwaves, selected to match the plasma density range of QUEST. A successful benchtop experiment was first conducted using a simple metal reflector and a rotational scattering setup. The system was then installed in QUEST; however, no signal was detected. To address this, a focusing mirror system is being introduced for the next experimental campaign.
- 11) A transient heat-load test on GaInSn liquid metal has been proposed for development of advanced divertor concepts. The plasma irradiation will be conducted by using the CT injector of UH-CTI for fueling in QUEST. In the test for investigating the basic characteristics, in order to accommodate the fluidity of liquid metals, it is necessary to place the stationary liquid metal in a container in a horizontal position and irradiate it with a CT plasma from the vertical direction, passing through a curved drift tube. The drift tube equipped with observation ports has been designed and manufactured, and the stationary work platform has been modified to avoid interfering with the positioning of the drift tube in QUEST.
- 12) The Thomson scattering (TS) system has been upgraded. The number of simultaneous spatial measurement points has been increased from six to eight, by adding two polychromators and introducing new digitizers. Some related modifications have also been carried out. As a result, we can now measure eight spatial points simultaneously. Improvements in calibration and in the automatic alignment system were also carried out, leading to improved accuracy in temperature and density measurements.
- 13) The experimental result of the t-CHI current start-up in QUEST showed a definite current scaling relation, in which the driven toroidal current was proportional to the injector flux and the injector current was proportional to the square of the injector flux. In this study, the injector current profile was obtained by measuring the change in the toroidal field. The current and flux configuration during the flux evolution of the t-CHI discharge was estimated from the data of the scaled toroidal current and the injector current profile, which showed closed flux surfaces forming according to the trace of injector current.

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Fig. 1 Low energy X-ray spectrum measurement system.

Highlight

Research Activities in Hydrogen Isotope Research Center, Organization for Promotion of Research, University of Toyama

Measurement of tritium in solids is an important issue for the safe management of radioisotopes in fusion reactors. Tritium beta-ray induced X-ray spectrometry (BIXS) is one of the methods used for tritium analysis in solids, although it is currently a qualitative method. Since other methods for analyzing tritium in solids are destructive, non-destructive methods such as BIXS must be developed. We aim to develop a BIXS simulation system to upgrade the technique from qualitative to quantitative analysis for tritium in solids. The simulation program (GALET-BIXS) using the Geant4 toolkit has been created and optimized. The simulation program is designed to match the geometric configuration of the beta-ray induced X-ray (BIX) measurement system. GALET-BIXS can fully reproduce the low-energy X-ray spectrum observed by the measurement system. The spectrum shape of BIX generated from tritium in solids changes, depending on the tritium distribution within the solid. GALET-BIXS can calculate the spectrum shape changes as the tritium distribution in solids also changes, making it possible to quantify the tritium amount in the solid by measuring the BIX spectrum and its counting rate.

Development of Tritium Measurement System

In this study, we measured low-energy X-ray spectra using a sealed source and performed Monte Carlo simulations to reproduce the observed spectra. The refined simulation program is intended to be used for determining the depth profile of tritium via BIX spectrum analysis.

For the X-ray spectrum simulation, a Monte Carlo simulation program (GALET-BIXS) was developed using the Geant4 toolkit. The measurement device used in the actual experiments is shown in Figure 1. A silicon drift detector was used, and the radiation source was ^{57}Co . The geometric configuration of the sample and detector in the device was incorporated into GALET-BIXS.

Figure 2 shows both the measured X-ray spectrum and the spectrum calculated by GALET-BIXS. The intensity of the simulated spectrum was adjusted using a scaling factor to match that of the measured spectrum. The characteristic X-rays and gamma rays of iron emitted from the ^{57}Co source were successfully reproduced by our Monte Carlo simulation program (GALET-BIXS) for low-energy X-rays using the Geant4 toolkit.

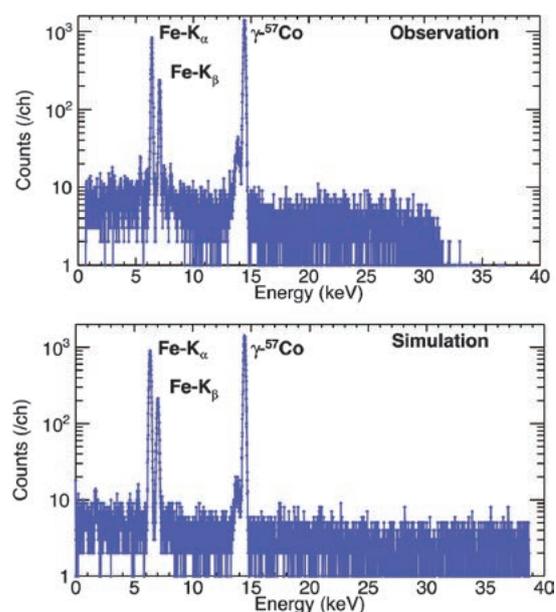


Fig. 2 Observed X-ray spectrum of ^{57}Co and simulated one.

Other experimental studies performed in the Hydrogen Isotope Research Center in the fiscal year 2024 are listed below.

- Release behaviors of hydrogen isotopes from tungsten materials exposed to hydrogen isotope plasma during oxidation (T. Otsuka, Kindai University)
- Understanding and optimization of tritium absorption into tritium target for 14 MeV neutron irradiation experiments (I. Murata, Osaka University)
- Effects of transmutation or irradiation damage on hydrogen isotope transport dynamics (Y. Oya, Shizuoka University)
- Depth Analysis of Co-deposited H, He and Impurity Atoms on Plasma Exposed W by Means of GDOES (N. Yoshida, Kyushu University)
- Development on liquid DT nuclear fusion fuel for high repetition laser fusion reactor (Y. Arikawa, Osaka University)
- Correlation between hydrogen isotopes trap density and vacancy concentration in tungsten (M. Kobayashi, NIFS)
- Effects of repeated short pulse hydrogen beam irradiation on hydrogen isotope retention in tungsten materials (K. Tokunaga, Kyushu University)
- Precise evaluation of tritium retention and permeation in solid/liquid tin exposed to tritium plasma (H. Toyoda, Nagoya University)
- Hydrogen isotope retention behavior in tungsten-rhenium layer created by pulse laser irradiation (Y. Nobuta, Hokkaido University)

(M. Hara)