Recent progress in advanced diagnostics for Thailand Tokamak-1

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Thailand has identified fusion energy as a strategic priority and is actively enhancing its national research capabilities, with the Thailand Tokamak-1 (TT-1) serving as a key platform for the development and validation of magnetic confinement fusion technologies. TT-1 is a compact tokamak, featuring a major radius of 0.65 m and a minor radius of 0.2 m, which was commissioned in early 2023 at the Thailand Institute of Nuclear Technology (TINT). It is designed to operate with plasma currents up to 100 kA, toroidal magnetic fields up to 1 T, and pulse durations of up to 100 ms. TT-1 successfully achieved its first plasma discharge, representing a major milestone in the advancement of Thailand's national fusion research program. Building upon these achievements, TT-1's development roadmap includes the integration of advanced diagnostic systems, which has significantly enhanced its research capabilities. By 2024, close collaboration with Japanese research institutions had enabled the implementation of sophisticated diagnostics, supporting comprehensive investigations into plasma transport, confinement, MHD activity, and energetic particle dynamics.

A hard X-ray (HXR) diagnostic system was developed to study runaway electron phenomena. Utilizing $LaBr_3$(Ce) scintillation detectors and plastic scintillators, the system captures high-energy photon emissions with good temporal and spatial resolution. Preliminary measurements successfully detected hard X-rays up to approximately 500 keV during plasma discharges [1], confirming the system's effectiveness for monitoring runaway electrons and contributing to the development of mitigation strategies. In addition, soft X-ray (SXR) diagnostics have been introduced to explore MHD activity, impurity transport, and core disruptions. Two complementary systems, a Soft X-ray Imaging (SXRI) system and a Si detector system, have been deployed. The SXRI system provides high-speed, two-dimensional imaging of plasma structures, while the Si detector system enables energy-resolved measurements of SXR. Moreover, electrode biasing experiments have been initiated to actively control the edge electric field, a technique known to improve plasma confinement by influencing plasma rotation and suppressing turbulence

Figure 1. The TT-1 as installed at TINT.

[2]. A biased electrode inserted into the plasma edge has demonstrated the ability to modify the radial electric field profile. In parallel, a Heavy Ion Beam Probe (HIBP) diagnostic is under development [3] to directly measure internal plasma potentials and fluctuations, offering high-resolution insights into transport phenomena and electric field structures within the plasma.

Together, these developments establish TT-1 as a capable and flexible platform for fusion plasma research. The progress in developing advanced diagnostics for TT-1 will be presented in this talk. Through the integration of advanced diagnostics, targeted experiments, and international collaboration, TT-1 is enhancing the understanding of plasma dynamics in compact tokamak environments and reinforcing Thailand's role in the global fusion research community.

References

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