8th Asia-Pacific Conference on Plasma Physics, 3-8 Nov, 2024 at Malacca

Development of Plasma Burn-through Simulation Code and validation in SUNIST-2 and EAST

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A full electromagnetic plasma burn-through simulation code has been developed to improve understanding of the plasma breakdown and initiation process in tokamaks, including spherical tokamak. A 0D plasma model is adopted in the model, with only operation signals as input, such as current waveforms of central solenoid coils and poloidal field coils, prefill gas pressure and parameters for wall conditioning, which are determined before discharge experiments. The output includes time evolution of plasma current, electron temperature, ion temperature and densities of gas compositions.

The simulation code mainly contains three parts: circuit equations, energy balances and particle balances. Eddy currents on toroidal passive conducting units of vacuum vessel and plasma current are calculated simultaneously by solving circuit equations. The using of eddy current waveforms and coil current waveforms enables calculation of 2D space distribution of time-evolving poloidal magnetic field and flux, and consequently the plasma volume evolution can be calculated by last closed flux surface. Energy balances and particle balances are used to solve temperature and density evolution of fuel gas and impurities. Main procedures in energy balances and particle balances are ionization, recombination, charge exchange, radiation and transport. Transport loss are estimated by perpendicular loss by Bohm diffusion and parallel loss along field lines, which is calculated using connection length and ion sound speed. Connection length is calculated using magnetic field line tracing with electromagnetic modelling.

The code has been used to reproduce the time evolution of plasma current, electron density, flux loop data and H/D-alpha data of plasma burn-through on SUNIST-2 spherical tokamak and EAST tokamak, and calculated results are in consistent with experimental measurements with a reasonable level.

References

[1] Hyun-Tae Kim *et al*, Nucl. Fusion 60 126049 (2020)
[2] Hyun-Tae Kim *et al*, Nucl. Fusion 62 126012 (2022)
[3] C. T. Hsu. Phys. Fluids B 4, 4023–4032 (1992)
[4] Hyun-Tae Kim, Doctor's Thesis "Physics and Computational Simulations of Plasma Burn-through for Tokamak Start-up"(2013)

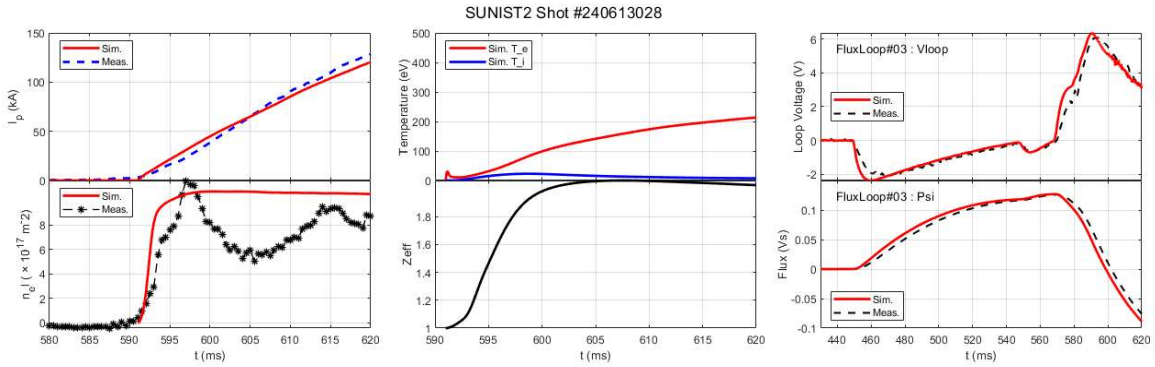

Figure 1. Simulation results of SUNIST2 discharge

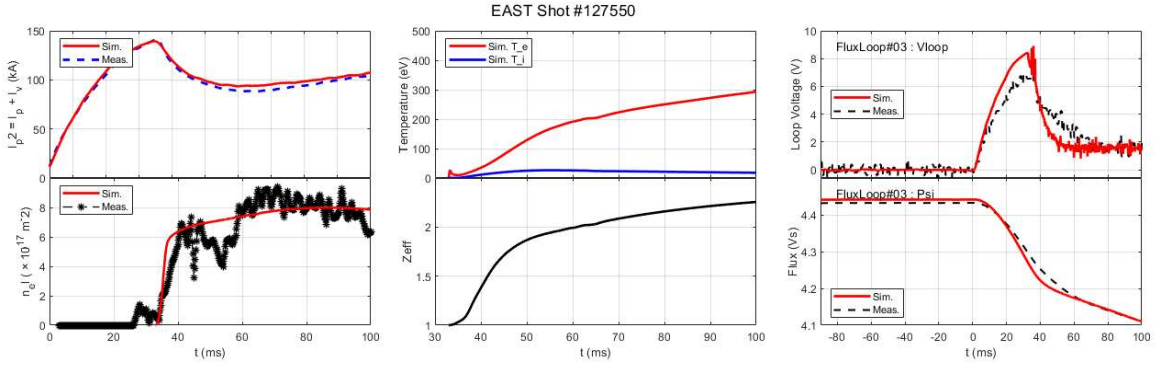

Figure 2. Simulation results of EAST discharge