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Global Ion Heating/Transport during Merging Spherical Tokamak Formation

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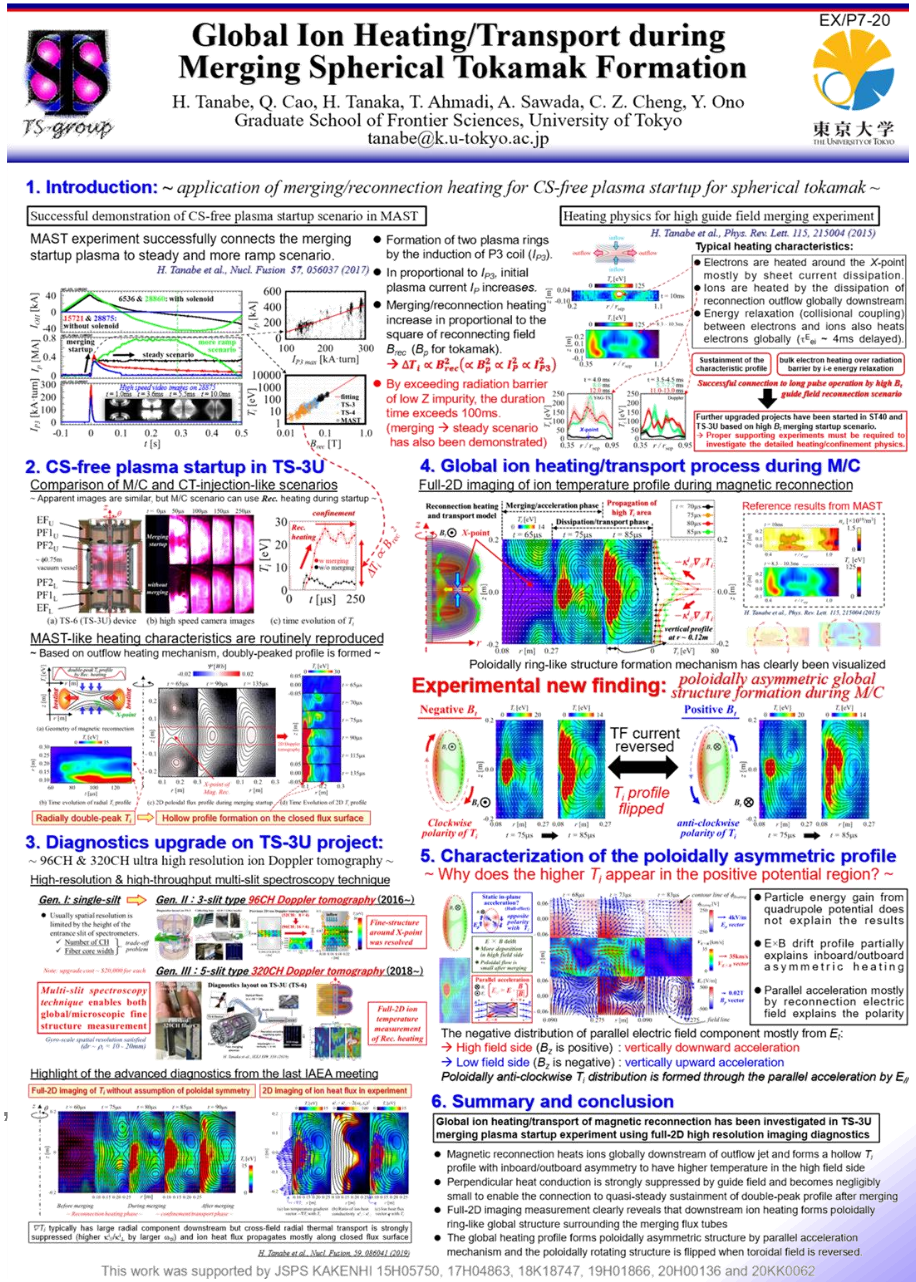
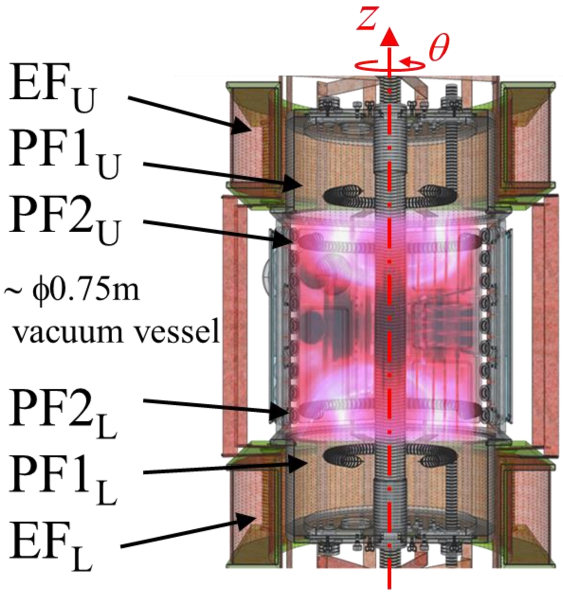
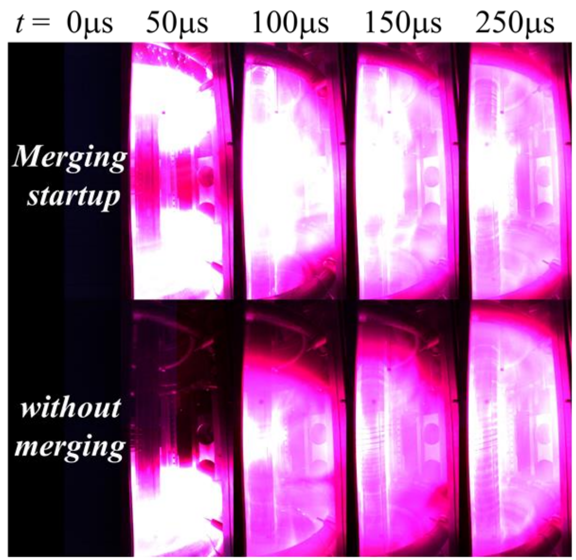
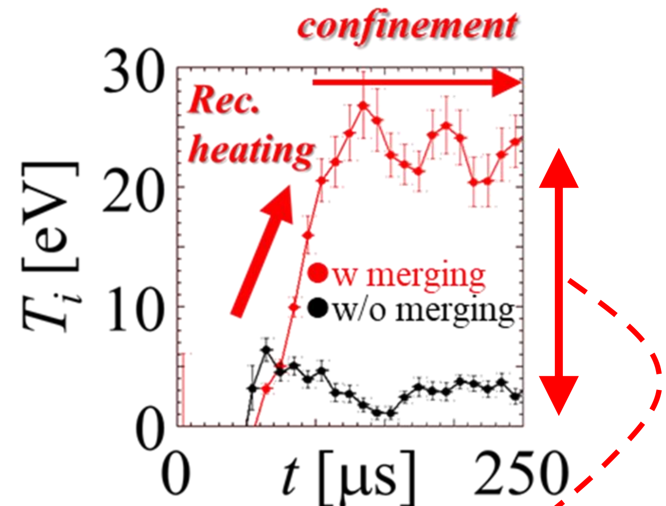
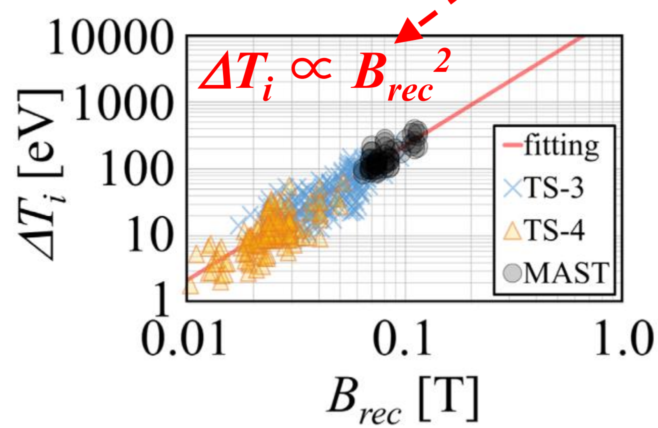


Merging/reconnection heating experiment in the TS-3U (TS-6) spherical tokamak









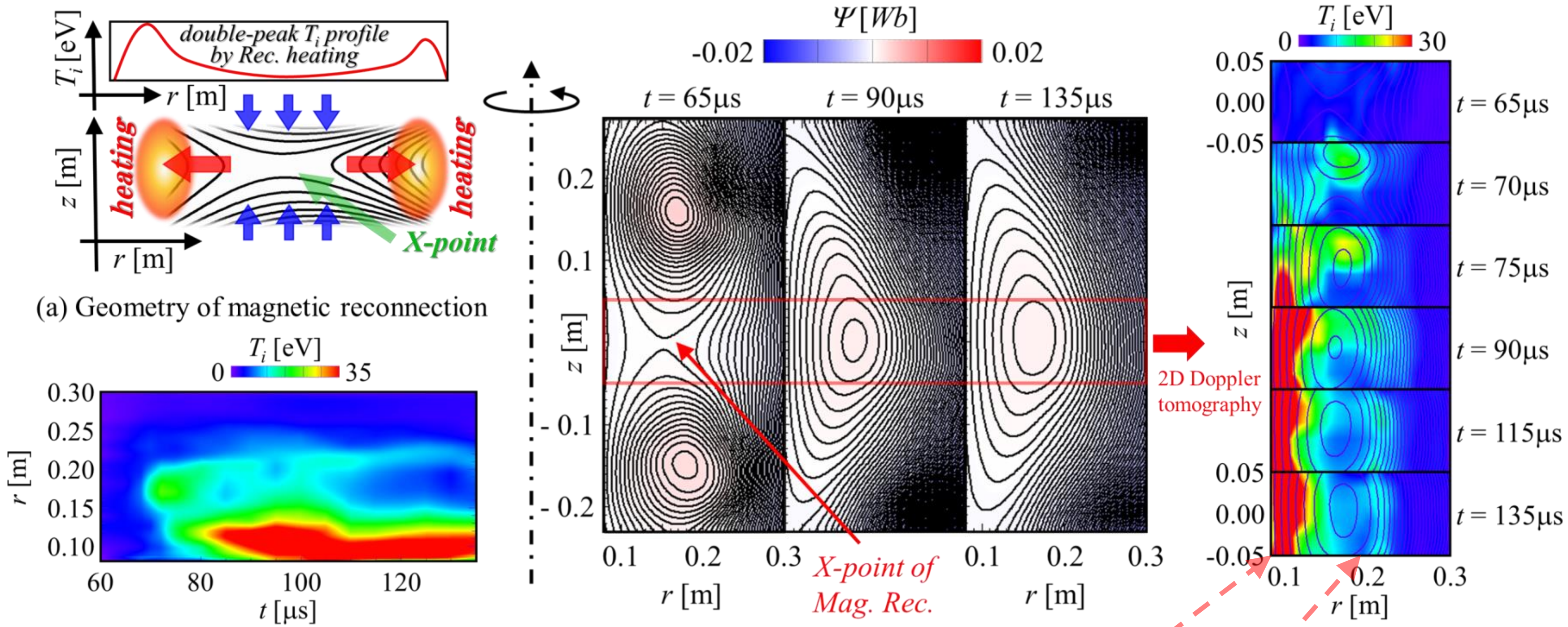
Merging spherical tokamak formation

- Central solenoid free (CS-free) plasma startup method
- In comparison with CT-injection startup scenario, MW-GW scale ion heating is also available through reconnection

H. Tanabe et al., Nucl. Fusion ***57**, 056037 (2017)*

Reconnection heating during Merging plasma startup typically forms double-peak hollow T_i profile

Based on outflow heating mechanism, ion temperature increases in the downstream region of outflow jet



(a) Geometry of magnetic reconnection

(b) Time evolution of radial T_i profile

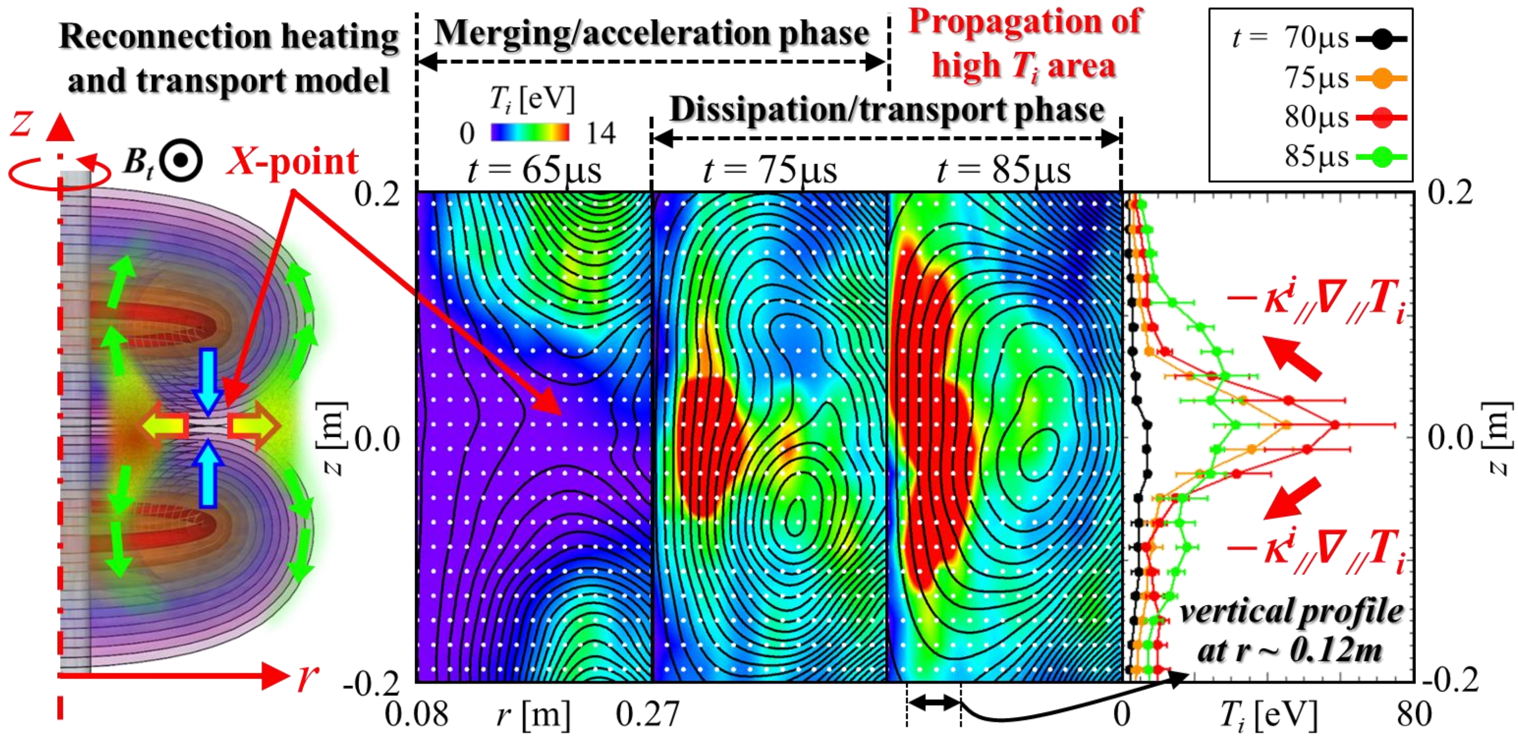
(c) 2D poloidal flux profile during merging startup

(d) Time Evolution of 2D T_i profile

After merging, the high T_i region is surrounded by closed flux surface and field-aligned feature appears both <u>inside and outside magnetic axis</u>.

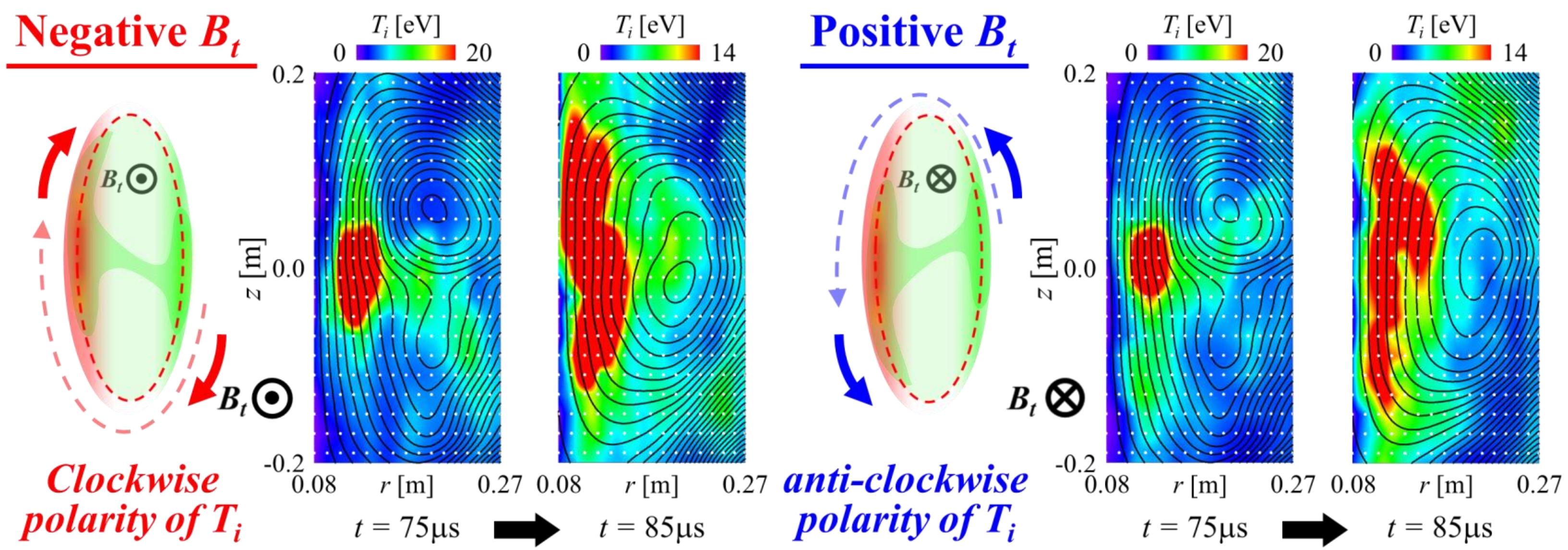
Full-2D visualization of ion temperature profile during merging/reconnection **in experiment**

- Ions are heated globally in downstream region of outflow jet
- The impulsively formed hot spots in the downstream region is then transported mostly by parallel heat conduction
- *Field-aligned* heat transport leads to poloidally-ring-like hollow T_i structure as shown in the model profile



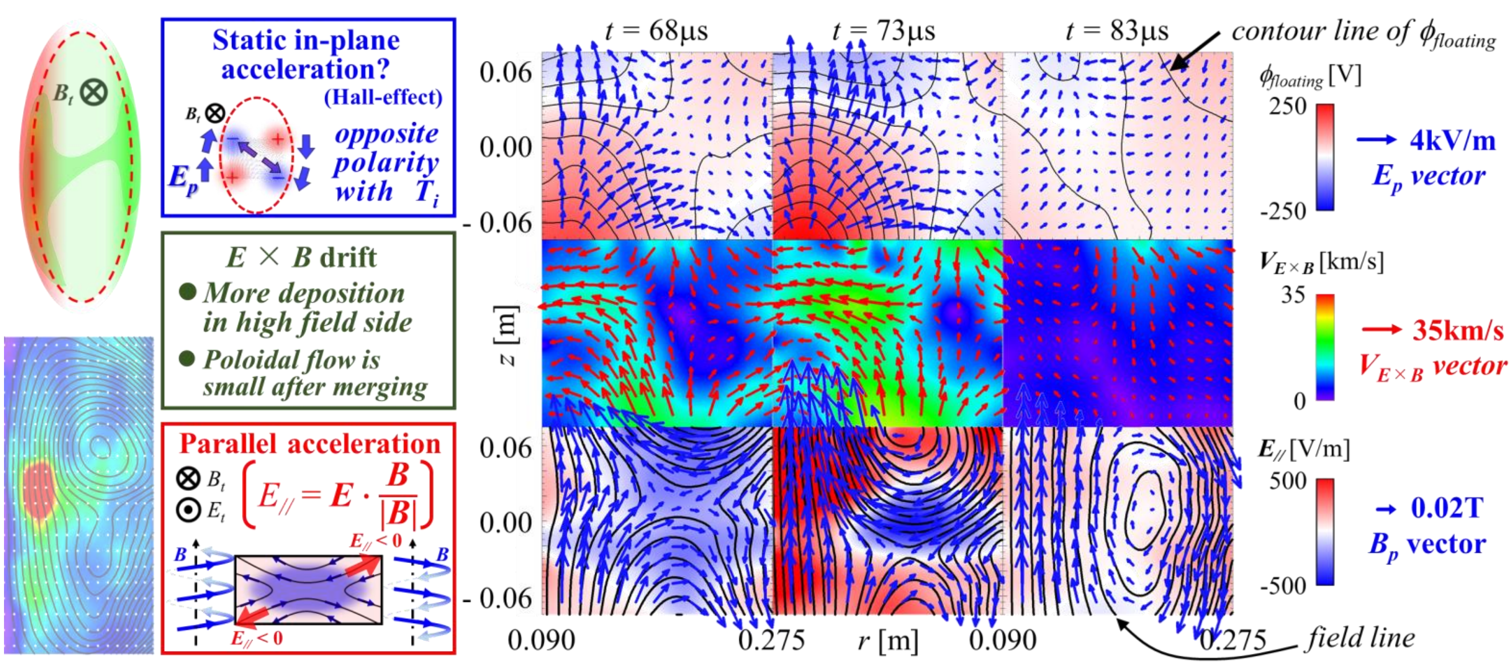
The full-2D imaging diagnostics experimentally reveals **poloidally asymmetric global structure**

- Through merging/reconnection process, the characteristic ion temperature profile shows poloidally rotating feature
- The polarity of the rotation of T_i profile is flipped when TF current is reversed (positive/negative B_t)



Characterization/interpretation of the measured poloidally asymmetric structure

- The rotating feature is not driven by quadrupole potential drop of guide field reconnection (opposite polarity with T_i)
- E × B drift distribution does not explain the poloidal rotation, while it has higher deposition of outflow heating in high field side
- Parallel acceleration by reconnection electric field E_t explains the measured ion heating/transport polarity around the X-point



Summary and conclusion

Global ion heating/transport of magnetic reconnection has been investigated in TS-3U (TS-6) merging plasma startup experiment using full-2D high resolution imaging diagnostics

- Magnetic reconnection heats ions globally in the downstream region of outflow jet
- The downstream ion heating forms poloidally ring like global structure surrounding the flux surface
- The global heating profile forms poloidally asymmetric structure by parallel acceleration
- The poloidally rotating structure is flipped when toroidal field direction is reversed.