



## Overview of KSTAR results and Plan

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As a continuous effort for the development of steady-state high performance operation scenario, there has been significant progress in 2018 campaign including long-pulse extension, high ion temperature, and advanced scenario development in KSTAR. First of all, KSTAR extended the pulse length of H-mode upto 90 seconds [Fig 1] based on the previous high beta-poloidal discharges and issues for long-pulse operation is also addressed in terms of equilibrium reconstruction, effect of plasma shape and impurity accumulation. The essential role of Alfvén Eigenmodes is also verified on the fast ion confinement using TRANSP and MEGA simulations. The stable high ion temperature discharge using neutral beam injection was developed successfully using the internal transport barrier (ITB) and was demonstrated upto 20 second sustainment. In addition, the onset condition for ITB is also identified using on/off of additional electron cyclotron heating in double barrier discharge. Key issues on ELM physics was also investigated and a model for ELM suppression was applied to KSTAR and successfully validated with dynamic RMP condition. Using ECE 2-D imaging, changes of turbulent fluctuations and perpendicular flow were observed at the transition into and out of ELM-crash suppression. The RMP enhanced the turbulent fluctuations in the edge toward the ELM-crash suppression and at the same time, the rapid changes in perpendicular flow is synchronized with the onset of transition into and out of ELM-crash suppression. Using slow ramp-down of RMP, RMP-driven transport is clearly identified as the key to sustaining ELM suppressed states. The reduction of divertor heatload during ELM-crash suppression which is one of the ITER urgent issues was also investigated by intentionally misaligned RMP configuration and about 20% of reduction is confirmed without loss of ELM suppression. There has been significant progress for fundamental physics processes. 3-D characteristics of the turbulent transport and flow near magnetic island was measured with ECE imaging diagnostics and the measured fluctuation was localized near the magnetic island X-point with a finite poloidal shift and well reproduced with XGC1 and gKPSP gyrokinetic simulations. In addition, NTV offset toroidal rotation profile is measured

with high resolution charge exchange diagnostics and compared with intrinsic rotation, significantly greater co- $I_p$  direction at the plasma boundary region was revealed. Finally, in the coming campaigns with new NBI (6MW) and EC (4MW) powers, KSTAR will explore stationary high beta discharges ( $\beta_N > 3$ ,  $T_i \sim 10$  keV) sustained longer than hundred seconds. Major upgrade targeting for 2022 is already started for tungsten monoblock divertor sustaining 10 MW/m<sup>2</sup> of peak heat-flux and the RF off-axis current drive system (4MW) including helicon wave.

### References

- [1] S. W. Yoon, Nucl. Fusion 51 (2011) 113009 (9pp)  
[2] Y. K. Oh, S. W. Yoon, Journal of the Korean Physical Society 73(2018) 712

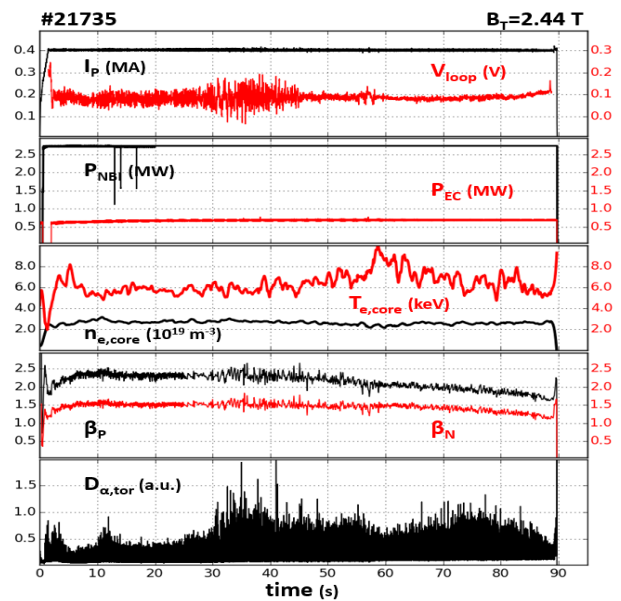


Figure 1. Long-pulse operation of NBI heated H-mode discharge