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Access to high plasma current regime in KSTAR

Sang-hee Hahn[1], B. Na[1], M. Joung[1], J.G. Bak[1], J. Chung[1], H. Han[1], Y.M. Jeon[1], J.H. Jeong[1], J. Kang[1], Sunggug Kim[1], G.W. Shin[1], M.H. Woo[1], J.G. Kwak[1], W.C. Kim[1], and S.W. Yoon[1]

[1] Korea Institute of Fusion Energy (KFE)

e-mail (speaker): hahn76@kfe.re.kr

Advanced scenarios with high portion of noninductive current drive (NICD) have been assumed for the KSTAR project design [1], not only for the low-current long pulses but also for the high plasma current discharges, mainly due to the restrictions on the affordable inductive power bounded by the amount of allowed AC loss of the CICC superconducting PF coils.

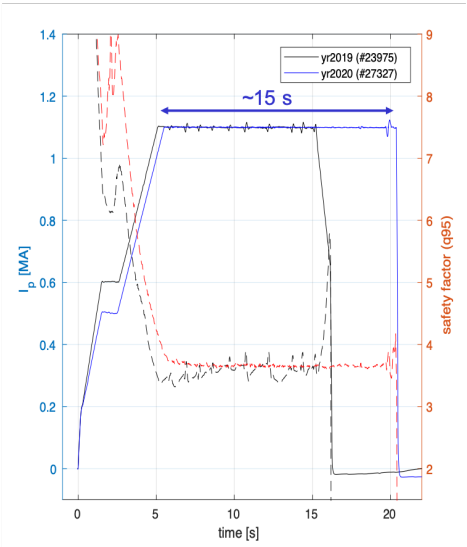

Figure 1. highest plasma current (Ip) achieved in year 2020/2021 in KSTAR: Achieved plasma current (Solid lines) and q95 measured from real-time reconstructions (Dashed lines).

In order to extend the operation space of the robustly sustained ELMy H- mode to the mega-ampere regime we developed a new control strategy on the plasma current rampup: 1) integration of the early diverting scenario [2] to guarantee a monotonic decrease of the q95 and internal inductance (li), 2) improvement of magnetic control for maintaining unbalanced DN shape [3,4] and 3) making intentional Ip flattop at the early stages of Ip rampup so that the first L-H transition can trigger the high-βp mode [5] to drive high noninductive current drive, utilizing real-time control of the fully steerable gyrotron mirrors [6].

The new strategy enabled us to sustain the H-mode at Ip = 1.1 MA, q95 = 3.3~3.7, for approximately 15 seconds at BT= 2.5-2.6T, with stored energy Wmhd ~ 0.8 MJ using total heating 6.3 MW, consisting of four neutral beam sources and two 140GHz gyrotrons. Introduction of the new off-axis beam ion source (NB2B) gives nontrivial current drive profile and other interesting physics; From a dedicated Ip scan to set the loop voltage ~ zero at the onset of high- βp, the amount of NICD was estimated as 460~480 kA in the similar beam source configuration, expecting more than 40% of NICD at the highest Ip discharges.

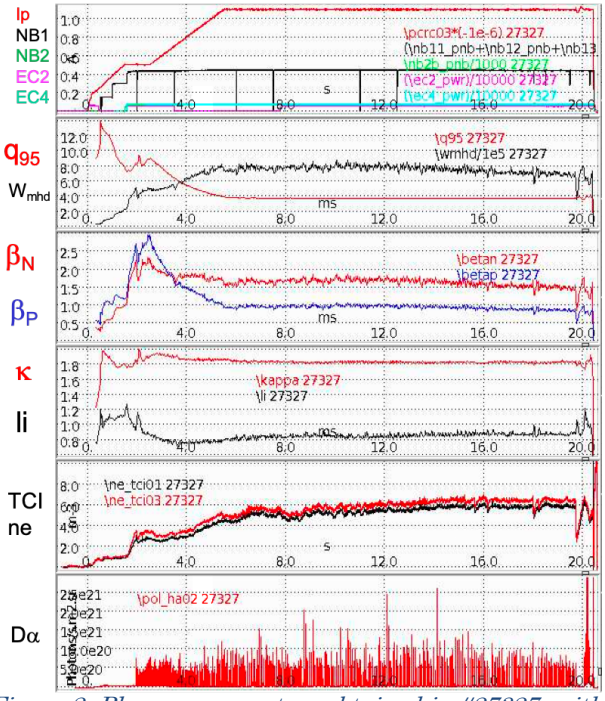

Figure 2. Plasma parameters obtained in #27327, with Ip=1.1 MA, ~15s of flattop. The line-averaged density, denoted as TCI ne, measured by two-colors interferometry [7].

References

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