# Recent progress in improvement of ICRF coupling and power absorption with new antennas on EAST

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Ion cyclotron range of frequencies (ICRF) wave heating is particularly suitable for magnetic confinement fusion devices with large dimensions or magnetic fields [1, 2]. It is considered a promising heating method for future fusion reactors. This study reviewed recent progress in improving the ICRF wave coupling and power absorption of EAST, which has tungsten divertors and limiters. Various methods were investigated using a combination of experiments and simulations, and their effects on ICRF heating were quantified.

To improve the wave coupling from the antenna to the plasma, two new two-strap antennas with a low parallel wave number ($k_{||}$) were designed and installed on EAST in 2021 [3, 4]. Compared to the old antenna, the new antenna decreased $k_{||}$ from 13 $m^{-1}$ to 7 $m^{-1}$ and increased the ICRF coupling resistance by a factor of 2–4. Local midplane gas puffing close to the antenna increased the coupling resistance by a factor of two with a moderate gas puff rate of 12e22 el/s. In addition, increasing the global SOL density significantly increased ICRF coupling. In particular, decreasing the antenna–separatrix distance, increasing the core density, moving the strike point at the divertor targets, and optimizing the strap phasing were demonstrated to be effective methods for increasing ICRF coupling. For instance, by shifting the strike point position on the outer targets of the lower divertor from R=177 to 173 cm, the coupling resistance can be increased from 4 to 6.7 Ω.

Parametric scans of the resonance layer position and minority ion concentration were performed to increase the core wave power absorption by thermal plasmas. It was shown that when the resonance position overlaps the magnetic axis (i.e., on-axis heating) or when the hydrogen minority ion concentration in the plasma core is approximately 5%, the absorbed ICRF power density was maximized. Furthermore, three-ion heating schemes were numerically studied for future experiments. To achieve significant RF power absorption, the D-($^3$He)-H three-ion heating scheme should use plasma compositions of X[H]=[80%, 88%] and X[$^3$He]=[0.1%, 1.4%], and the D-($D_{NBI}$)-$^3$He heating scheme should use plasma compositions of X[$^3$He]=[25%, 29%] and X[$D_{NBI}$]=[0.5%,10%] (see Figure 1).

Quantitative characterization of these methods and the conclusions drawn from this study can provide important insights for achieving more efficient ICRF heating in current and future fusion machines.

References
[1] Lamalle P. et al 2015 AIP Conference Proceedings **1689** 030007
[2] Lin Y. et al 2020 Journal of Plasma Physics **86** 865860506
[3] Zhang X. J. et al 2022 Nuclear Fusion **62** 086038
[4] Liu L. N. et al 2022 Review of Scientific Instruments **93** 043506

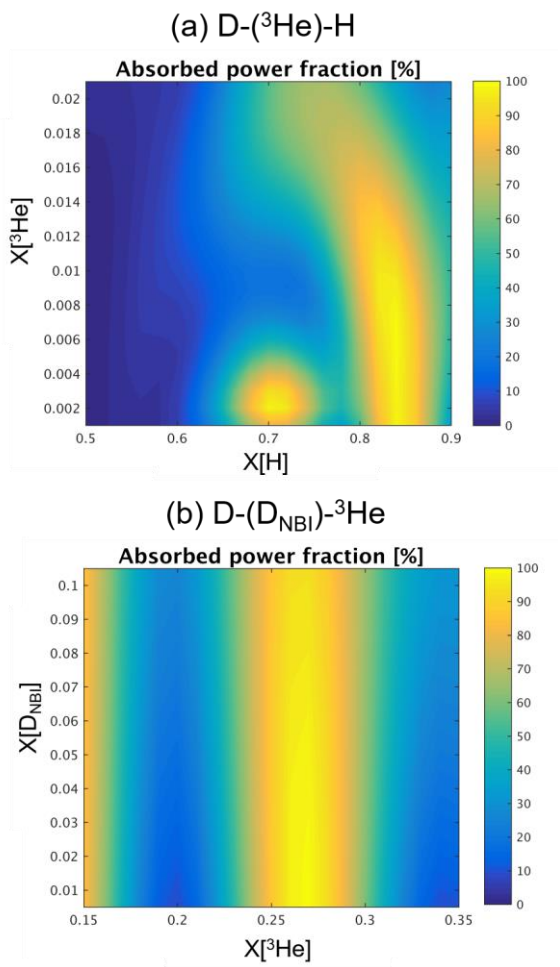


**Figure 1**. Dependence of first-pass ICRF power absorption on (a) X[H] and X[$^3$He] for D-($^3$He)-H heating scheme and (b) on X[$^3$He] and X[$D_{NBI}$] for D-($D_{NBI}$)-$^3$He heating scheme.