D-Alpha Measurements of the Fast-ion Distribution Function in DIII-D*

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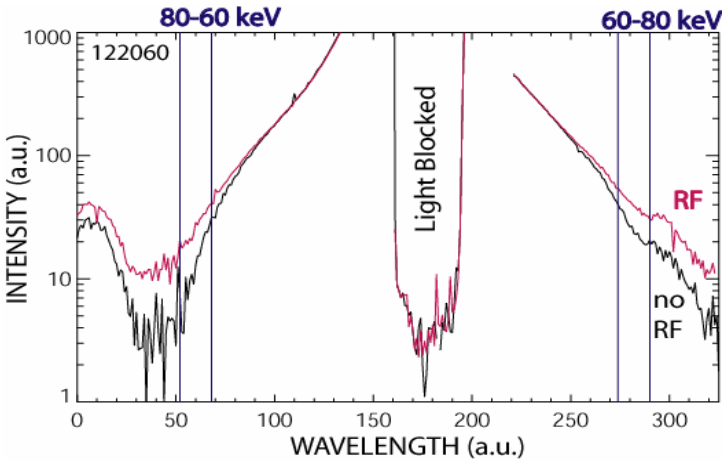
Using the Balmer-alpha light from deuterium ions that neutralize as they pass through a neutral beam,[1] we have measured[2] the fast-ion velocity distribution and spatial profile under a wide variety of operating conditions. Care is required to obtain fast-ion spectra that are free from pollution by injected, halo, and edge neutrals, impurity line radiation, bremsstrahlung, and sudden changes in background light associated with ELMs. The intrinsic spatial resolution of the diagnostic is ~ 5 cm for 40 keV/amu fast ions. Neutral particle, neutron, and beam-ion loss diagnostics corroborate the Balmer-alpha technique. Pitch-angle scattering and slowing down of beam ions are studied by varying the injection energy, beam angle, plasma density, and electron temperature in MHD-quiescent plasmas. The measured spatial profile is compared with TRANSP simulations. In plasmas with fast-wave heating at the fourth, fifth, and sixth harmonics, fast ions are accelerated above the injection energy (figure); the profile data show that the acceleration is greatest near the cyclotron harmonic resonance layer. In plasmas with strong fishbone and sawtooth instabilities, the spatial profile is much flatter than classically predicted. The spatial profiles in plasmas with internal transport barriers, with helical magnetic perturbations from a nonaxisymmetric coil, and with cascade, toroidicity-induced, and compressional Alfven eigenmode activity are also measured.



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[1] W.W. Heidbrink et al., Plasma Phys. Cont. Fusion 46 (2004) 1855.
[2] Y. Luo et al., Rev. Sci. Instrum. 75 (2004) 3468.