Off-axis neutral beam current drive for advanced scenario development in DIII-D

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Abstract. Modification of the two existing DIII-D neutral beam lines is planned to allow vertical steering to provide off-axis neutral beam current drive (NBCD) peaked as far off-axis as half the plasma minor radius. New calculations for a downward-steered beam indicate strong current drive with good localization off-axis so long as the toroidal magnetic field, B_T, and the plasma current, I_p, point in the same direction. This is due to good alignment of neutral beam injection (NBI) with the local pitch of the magnetic field lines. This model has been tested experimentally on DIII-D by an injecting equatorially-mounted NBs into reduced size plasmas that are vertically displaced with respect to the vessel midplane. The existence of off-axis NBCD is evident in the changes seen in sawtooth behavior in the internal inductance. By shifting the plasma upward or downward, or by changing the sign of the toroidal field, off-axis NBCD profiles measured with motional Stark effect data and internal loop voltage show a difference in amplitude (40%–45%) consistent with differences predicted by the changed NBI alignment with respect to the helicity of the magnetic field lines. The effects of NB injection direction relative to field line helicity can be large even in ITER: off-axis NBCD can be increased by more than 30% if the B_T direction is reversed. Modification of the DIII-D NB system will strongly support scenario development for ITER and future tokamaks as well as providing flexible scientific tools for understanding transport, energetic particles and heating and current drive.

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