Abstract:
Results are presented from comparisons of modeling and experiment in studies to assess the best choices of safety factor ($q$) profile, pressure profile and discharge shape for
high beta, steady-state, noninductive advanced tokamak operation in the DIII-D device [J. L. Luxon, Nucl. Fusion 42, 614 (2002)]. These studies are motivated by the need for high $q_{\text{min}}\beta_N$ to maximize the self-driven bootstrap current while maintaining high toroidal beta to increase fusion gain. Modeling shows that increases in the normalized beta ($\beta_N$) stable to ideal, low toroidal mode number ($n = 1, 2$) instabilities can be obtained through broadening of the pressure profile and use of a symmetric double-null divertor shape. Experimental results are in agreement with this prediction. The general trend is for $q_{\text{min}}\beta_N$ to increase with the minimum $q$ value ($q_{\text{min}}$) although $\beta_N$ decreases as $q_{\text{min}}$ increases. By broadening the pressure profile, $\beta_N \approx 4$ is obtained with $q_{\text{min}} \approx 2$. Modeling of equilibria with near 100% bootstrap current indicates that operation with $\beta_N \approx 5$ should be possible with a sufficiently broad pressure profile.