Optimization of DIII-D Advanced Tokamak Discharges With Respect to the Beta Limit

J.R. Ferron, T.A. Casper,[a] E.J. Doyle,[b] A.M. Garofalo,[c] P. Gohil, C.M. Greenfield, A.W. Hyatt, R.J. Jayakumar,[a] C. Kessel,[d] J.Y. Kim,[e] T.C. Luce, M.A. Makowski,[a] J. Menard,[d] M. Murakami,[f] C.C. Petty, P.A. Politzer, T.S. Taylor, and M.R. Wade[f]

General Atomics, P.O. Box 85608, San Diego, California 92186-5608

[a] *Lawrence Livermore National Laboratory, Livermore, California.*

[b] *University of California – Los Angeles, Los Angeles, California.*

[c] *Columbia University, New York, New York.*

[d] *Princeton Plasma Physics Laboratory, Princeton, New Jersey.*

[e] *Korea Basic Sciences Institute.*

[f] *Oak Ridge National Laboratory, Oak Ridge, Tennesee.*

November 16, 2004

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 $q_{\min}\beta_{\mathrm{N}}$ to maximize the self-driven bootstrap current while maintaining high toroidal beta to increase fusion gain. Modeling shows that increases in the normalized beta (β_{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 $q_{\min}\beta_{\mathrm{N}}$ to increase with the minimum q value ($q_{\min}$) although β_{N} decreases as $q_{\min}$ increases. By broadening the pressure profile, $\beta_{\mathrm{N}} \approx 4$ is obtained with $q_{\min} \approx 2$. Modeling of equilibria with near 100% bootstrap current indicates that operation with $\beta_{\mathrm{N}} \approx 5$ should be possible with a sufficiently broad pressure profile.