Optimization of the safety factor profile for high noninductive current fraction discharges in DIII-D*

J.R. Ferron¹, C.T. Holcomb², T.C. Luce¹, P.A. Politzer¹, F. Turco³, A.E. White⁴, J.C. DeBoo¹, E.J. Doyle⁵, A.W. Hyatt¹, R.J. La Haye¹, M. Murakami⁶, T.W. Petrie¹, C.C. Petty¹, T.L. Rhodes⁵, and L. Zeng⁵

¹General Atomics, P.O. Box 85608, San Diego, California 92186-5608, USA
²Lawrence Livermore National Laboratory, 700 East Ave, Livermore, California 94550, USA
³Oak Ridge Institute for Science Education, Oak Ridge, Tennessee 37830-8050, USA
⁴Massachusetts Institute of Technology, 77 Massachusetts Ave, Cambridge, Massachusetts 02139, USA
⁵University of California-Los Angeles, PO Box 957099, Los Angeles, California 90095-7099, USA
⁶Oak Ridge National Laboratory, PO Box 2008, Oak Ridge, Tennessee 37831, USA

e-mail contact of main author: ferron@fusion.gat.com

Abstract. In order to assess the optimum q profile for discharges in DIII-D with 100% of the current driven noninductively (fNI = 1), the self-consistent response of the plasma profiles to changes in the q profile was studied in high fNI, high βN discharges through a scan of qmin and q95 at two values of βN. As expected, both the bootstrap current fraction, fBS, and fNI increased with q95. The temperature and density profiles were found to broaden as either qmin or βN is increased. A consequence is that fBS does not continue to increase at the highest values of qmin. A scaling function that depends on qmin, q95, and the peaking factor for the thermal pressure was found to represent well the fBS/βN inferred from the experimental profiles. The changes in the shapes of the density and temperature profiles as βn is increased modify the bootstrap current density (JBS) profile from peaked close to the axis to relatively flat in the region between the axis and the H-mode pedestal. Therefore, significant externally-driven current density in the region inside the H-mode pedestal is required in addition to JBS in order to match the profiles of the noninductive current density (JNI) to the desired total current density (J). In this experiment, the additional current density was provided mostly by neutral beam current drive with the neutral-beam-driven current fraction 40%-90% of fBS. The profiles of JNI and J were most similar at qmin ≈ 1.35-1.65, q95 ≈ 6.8, where fBS is also maximum, establishing this q profile as the optimal choice for fNI = 1 operation in DIII-D with the existing set of external current drive sources.

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