Effect of Changes in Separatrix Magnetic Geometry on Divertor Behavior in DIII-D

T.W. Petrie¹, J.M. Canik², C.J. Lasnier³, A.W. Leonard¹, M.A. Mahdavi¹, J.G. Watkins⁴, M.E. Fenstermacher³, J.R. Ferron¹, R.J. Groebner¹, D.N. Hill³, A.W. Hyatt¹, C.T. Holcomb³, T.C. Luce¹, R.A. Moyer⁵, T.E. Osborne¹, and P.C. Stangeby⁶

¹General Atomics, P.O. Box 85608, San Diego, California 92186-5608, USA
²Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, Tennessee 37831, USA
³Lawrence Livermore National Laboratory, Livermore, California 94550, USA
⁴Sandia National Laboratories, P.O. Box 5800, Albuquerque, New Mexico 87185, USA
⁵University of California-San Diego, La Jolla, California 92093-0417, USA
⁶University of Toronto Institute of Aerospace Studies, Toronto, Canada

Abstract. Results and interpretation of recent experiments on DIII-D designed to evaluate divertor geometries favorable for radiative heat dispersal are presented. Two approaches examined here involved lengthening the parallel connection in the scrape-off layer, \( L_1 \), and increasing the radius of the outer divertor separatrix strike point, \( R_{OSP} \), with the goal of reducing target temperature, \( T_{TAR} \), and increasing target density, \( n_{TAR} \). From 1-D two-point modeling based on conducted parallel heat flux, it is expected that:

\[ n_{TAR} \propto R_{OSP}^2 L_1^{0.7} n_{SEP}^{-3} \]
\[ T_{TAR} \propto R_{OSP}^{-2} L_1^{-4/7} n_{SEP}^{-2} \]

where \( n_{SEP} \) is the midplane separatrix density. These scalings suggest that conditions conducive to a radiative divertor solution can be achieved at low \( n_{SEP} \) by increasing either \( R_{OSP} \) or \( L_1 \). Our data are consistent with the above scalings. On the other hand, the observed dependence of \( n_{TAR} \) and \( T_{TAR} \) on \( R_{OSP} \) displayed a more complex behavior, under certain conditions that can outweigh the expected dependencies. Our analysis indicates that deviations from the \( R_{OSP} \) scaling were due to the presence of convected heat flux, driven by escaping neutrals, in the more open configurations of the larger \( R_{OSP} \) cases. A comparison of “open” versus “closed” divertor configurations for the H-mode plasmas at the same density show that the “closed” case provides at least 30% reduction in the peaked heat flux in comparison with the “open” case and partial divertor detachment at lower plasma density.

PACS Numbers: 28.52.Cx, 52.25.Fi, 52.25.Xz, 52.25.Ya