Sustained High Beta Plasmas with Flat q-Profile in DIII-D*

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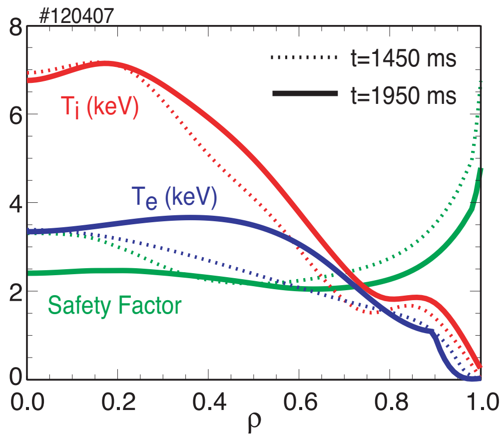
A first step to demonstration of ~100% bootstrap Advanced Tokamak (AT) is achieving and sustaining high normalized beta ($\beta_N > 5$) for at least one current relaxation time, in plasmas with a q-profile having high q_{min} (≥ 2) for high bootstrap current fraction, large radius of q_{min} [$\rho(q_{min}) \geq 0.8$] for good bootstrap alignment, and low q_{95} for high fusion gain. These q-profiles have been approached most closely in two types of discharges: a) "current-hole" discharges with $q_0 >> q_{min} \sim q_{95}$, b) "flat q-profile" discharges with $q_0 \sim q_{min} \sim q_{95}$. In the "current-hole" plasmas the maximum value of β_N has been limited to a low value (~2) by internal MHD instabilities. On the other hand, "flat q-profile" plasmas have achieved and sustained $\beta_N > 4$ for durations ≥600 ms in DIII-D.

Detailed stability studies [1] have shown the need to produce plasma discharges with a broad p-profile to raise ideal-wall instability thresholds and allow sustained operation at high β_N. The flat-q approach is motivated by the hypothesis that a broad pressure profile may be obtained more easily by creating a broad q-profile. To this end, the toroidal field (B_T) is ramped in DIII-D down while the plasma is sufficiently hot to behave ideally. In ideal MHD, the flux is conserved as B_T decreases and the flux surfaces expand. Both the current and the pressure profile are observed to follow the expansion of the core flux (see figure). With profile gradients closer to the plasma edge the calculated n=1 β_N limit with a conducting wall increases to 5.4, as needed for AT operation. Experimental results will be presented more fully.



[1] J.R. Ferron, et al., "Optimization of DIII-D Advanced Tokamak Discharges With Respect to the Beta Limit," to be published in Phys. Plasmas (2005).

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