MHD, Transport, and high performance - long pulse scenario development on NSTX

David A. Gates
Princeton Plasma Physics Laboratory, Princeton, NJ, USA
On behalf of the NSTX Team

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The National Spherical Torus Experiment has substantially broadened the boundaries of the available operating space. In particular plasmas with elevated elongation $\kappa < 2.6$ have achieved β_NH89 of ~12 for $17\tau_E$ and β_NH89 of ~10 for $25\tau_E$ as shown in Figure 1. This represents a factor of two increase in the normalized pulse length over previous best performance. Another important aspect of achieving these performance milestones is the triggering of H-mode during the plasma current ramp-up phase. The onset of early H-mode increases the bootstrap fraction and broadens the temperature profile early in the discharge thereby reducing flux consumption. Accurate shape control using real-time reconstruction of the plasma boundary, and important aspect of achieving true steady state, has been implemented using the rtEFIT algorithm. rtEFIT, originally developed for use on DIII-D, inverts the Grad-Shafranov equation and real-time and uses the calculated boundary for boundary control. Precise boundary control has been fundamental for many experiments including HHFW heating. Experiments at high normalized plasma current ($I_N = I/aB$) have achieved β_t ~39%, an increase which is also associated with elevated elongation. The scaling of $<\beta_N>$ is in accordance with ideal MHD calculations. These high current discharges are limited by a low frequency (~350Hz) n=1 mode that appears to be a global kink. The mode has tentatively been associated with a time varying error field resonance – a branch of the RWM dispersion relation. The locked mode threshold for onset of tearing modes was reduced using the new non-axisymmetric coil set. In addition, plasma breaking experiments have been performed and the error field amplification has been measured. Low density plasmas with strong heating during the current ramp, which are believed to be good candidates for having reverse magnetic shear in the core have exhibited improved electron confinement. Global scaling relations based on scans of plasma current heating power and toroidal field have been developed. The implications of future improvements to plasma shaping capability will be discussed.

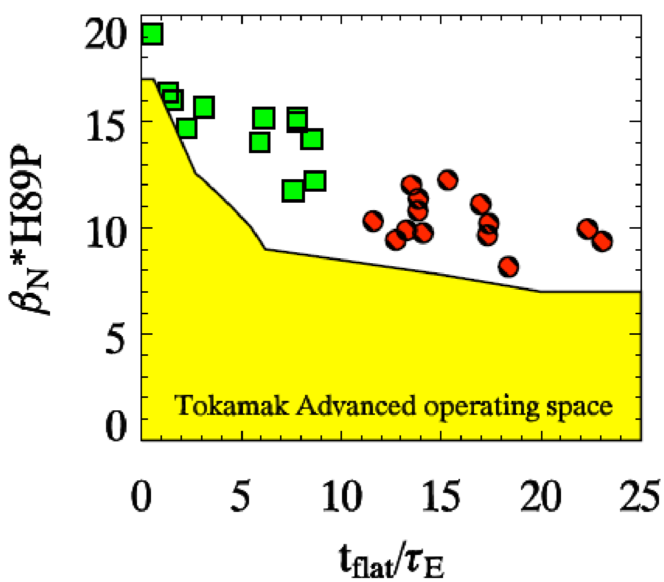

Figure 1 Normalized β ($=\beta_t aB/I_p$) times the ITER-89P confinement factor versus pulse length normalized to energy confinement time (red is 2004, green is 2002-2003)

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