

## Disruptions in the High- $\beta$ Spherical Torus NSTX

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Disruptions in next-step tokamak devices, whether at conventional or low aspect ratio, must be rare, predictable, and have minimal consequences for the plant. This paper addresses these issues using data from the National Spherical Torus Experiment (NSTX). The disruptivity increases rapidly for  $q_{95} < 6$ , but does not show a strong dependence on  $\beta_N$ ; more complicated physics such as kinetic stabilization plays a role in determining the disruptive  $\beta_N$  limit. The lowest disruptivity is at higher- $\beta_N$ , where the large bootstrap current prevents the current profile from evolving to a kink/tearing unstable state. Many disruption precursors have been investigated from a database of  $>2000$  disruptions, including direct measurement of MHD signals, confinement indicators, and parameters of the equilibrium evolution. Disruptive thresholds on these quantities have been defined, often using physics based 0-D models of the plasma behavior. Compound disruption warnings are then formed from weighted sum of binary threshold tests. These compound tests can be used to detect  $\sim 99\%$  of disruptions with at least 10 ms warning time, with a false-positive rate of  $\sim 4\%$ . Most disruptions that evade detection within 10 ms are high- $\beta_N$  disruptions driven by resistive wall modes.

Once a disruption begins, the NSTX plasma typically becomes vertically unstable, and halo currents are observed to flow. Halo current fractions  $>30\%$  have been observed, with the largest currents typically in Ohmic and L-mode plasmas; large halo currents often occur in cases with the largest current quench rates. Both the final disruption onset and the growth of large halo currents typically correspond to the edge  $q$  dropping to 2, although some currents are observed during the phase of the VDE with higher edge- $q$ . The halo current patterns are not toroidally symmetric, and the non-axisymmetry is observed to rotate toroidally up to 7 times, with typical rotation frequencies of 0.5-2 kHz, although the rotation is often non-steady. The rotation frequency is anti-correlated with the halo current amplitude. The non-axisymmetric part of the halo current typically decays before the  $n=0$  part, and filament modeling of the plasma indicates that the loss of the  $n \neq 0$  current corresponds to the time when the last closed magnetic surface vanishes.

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