Effect of Central Pressure Gradient on the Stability of Advanced Tokamak Equilibria

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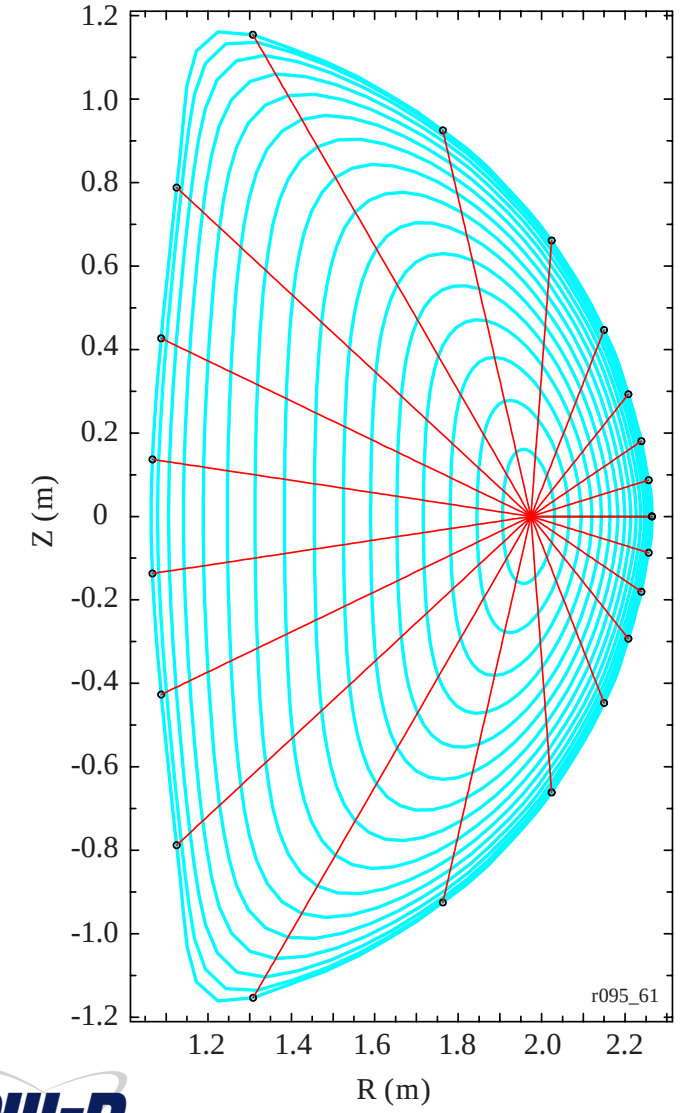
Goal is to Investigate the Role of P'(ψ=0) on Stability

- $P'(\psi=0) \sim q_0 \cdot d^2P(\rho=0)/d\rho^2$ and is related to the peakedness of the profile
- High peakedness is known to be destabilizing
- Corsica/TEQ used to generate equilibria based on model profiles
- Used both DCON (run under Corsica) and GATO to evaluate stability

Studied is Based on a Symmetric AT Equilibrium



- H-mode pedestal - pedestal pressure based on empirical scaling law
- High β_N
- $q_{min} > 2.0$, $q_0 \sim 2.5$
- High boot-strap fraction, typically > 0.7
- Weak negative central magnetic shear

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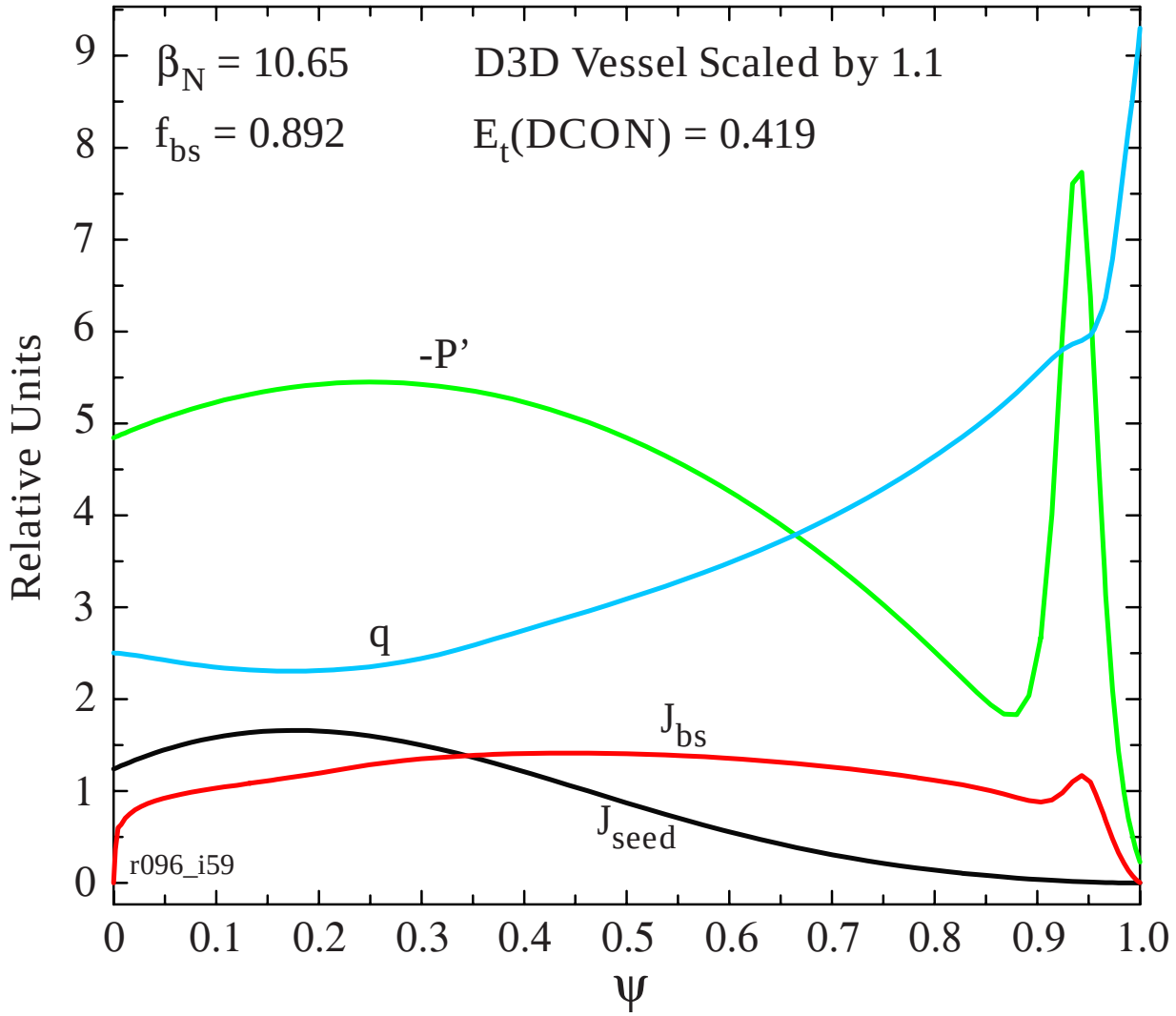
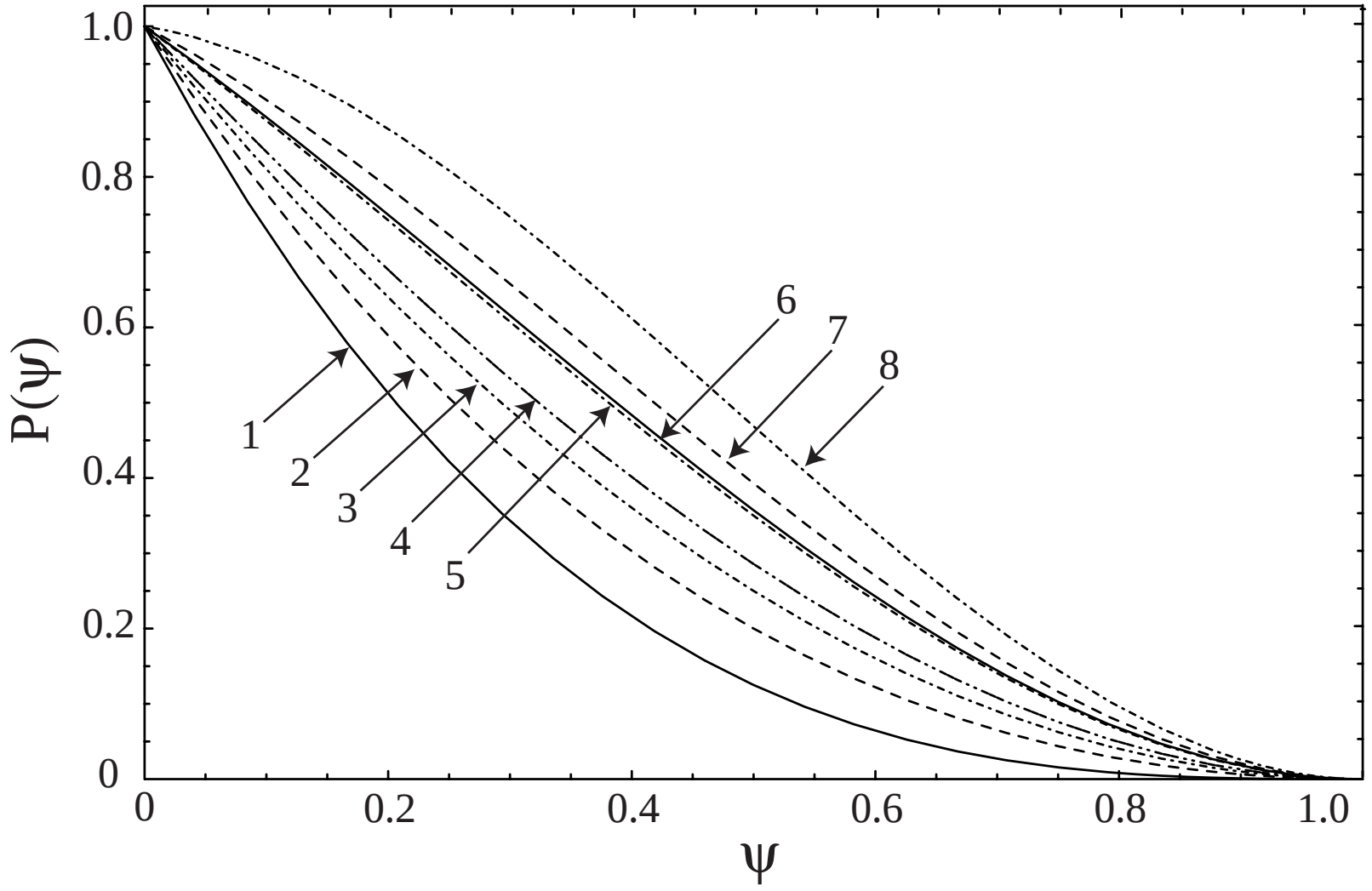
Seed Current Used to Maintain q_0



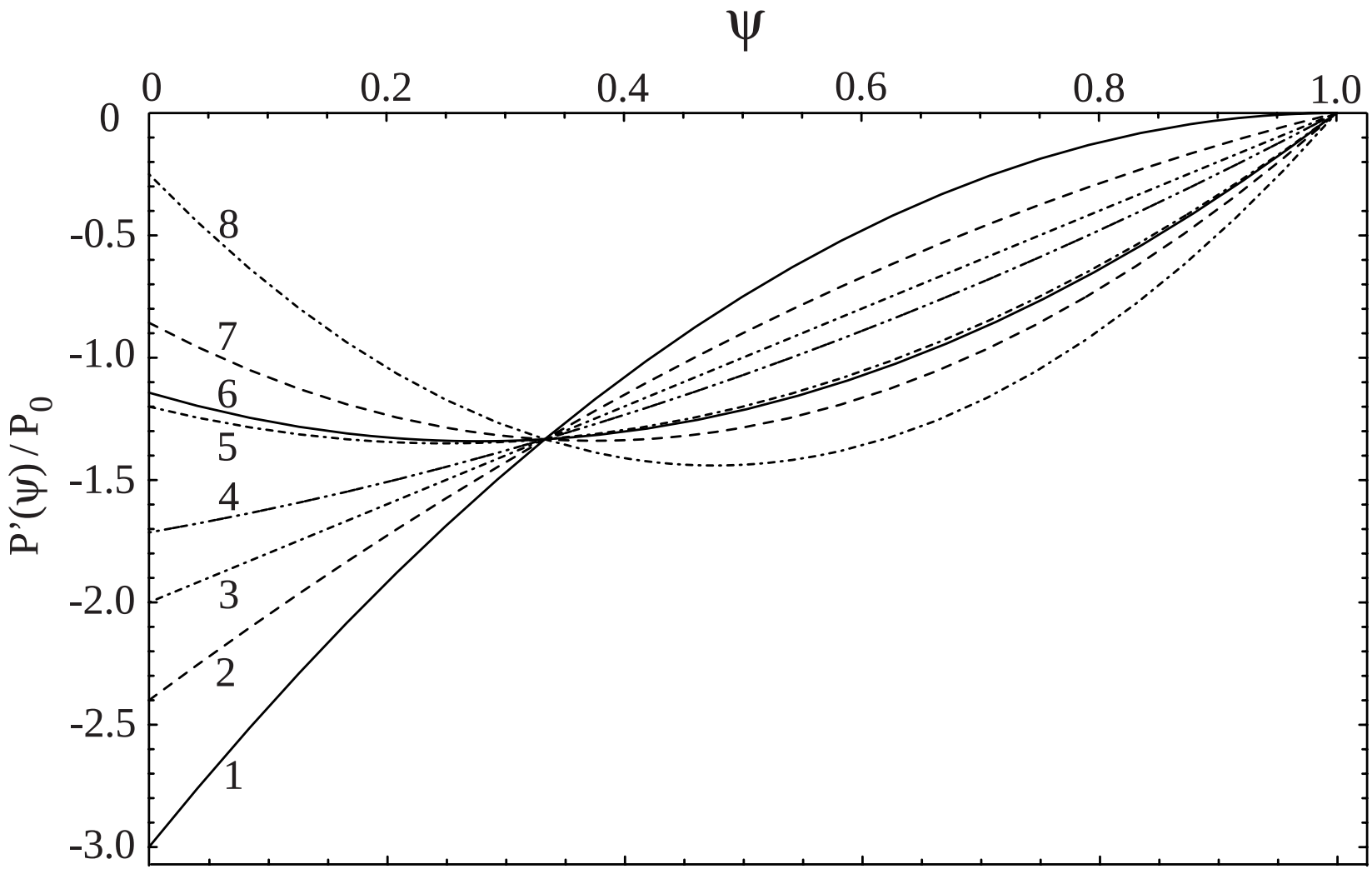
dP/dψ Varied Through a Family of Polynomials

- A single parameter is used to vary dP(ψ=0)/dψ
- Polynomial family used is
  - $P'_n(\psi) = -6\, P_0\, [1 + b_n\, \psi - (1 + b_n)\, \psi^2] / (4 + b_n)$
- Satisfies the boundary conditions
  - $P(0) = P_0,\ P'(0) = -6\, P_0 / (4 + b_n)$
  - $P(1) = P'(1) = 0$
- Eight cases considered with
  - $b_n = -2,\ -3/2,\ -1,\ -1/2,\ 1,\ 5/4,\ 3,\ 20$
  - $P'_0/P_0 = -3, -12/5, -2, -12/7, -6/5, -8/7, -6/7, -1/4$

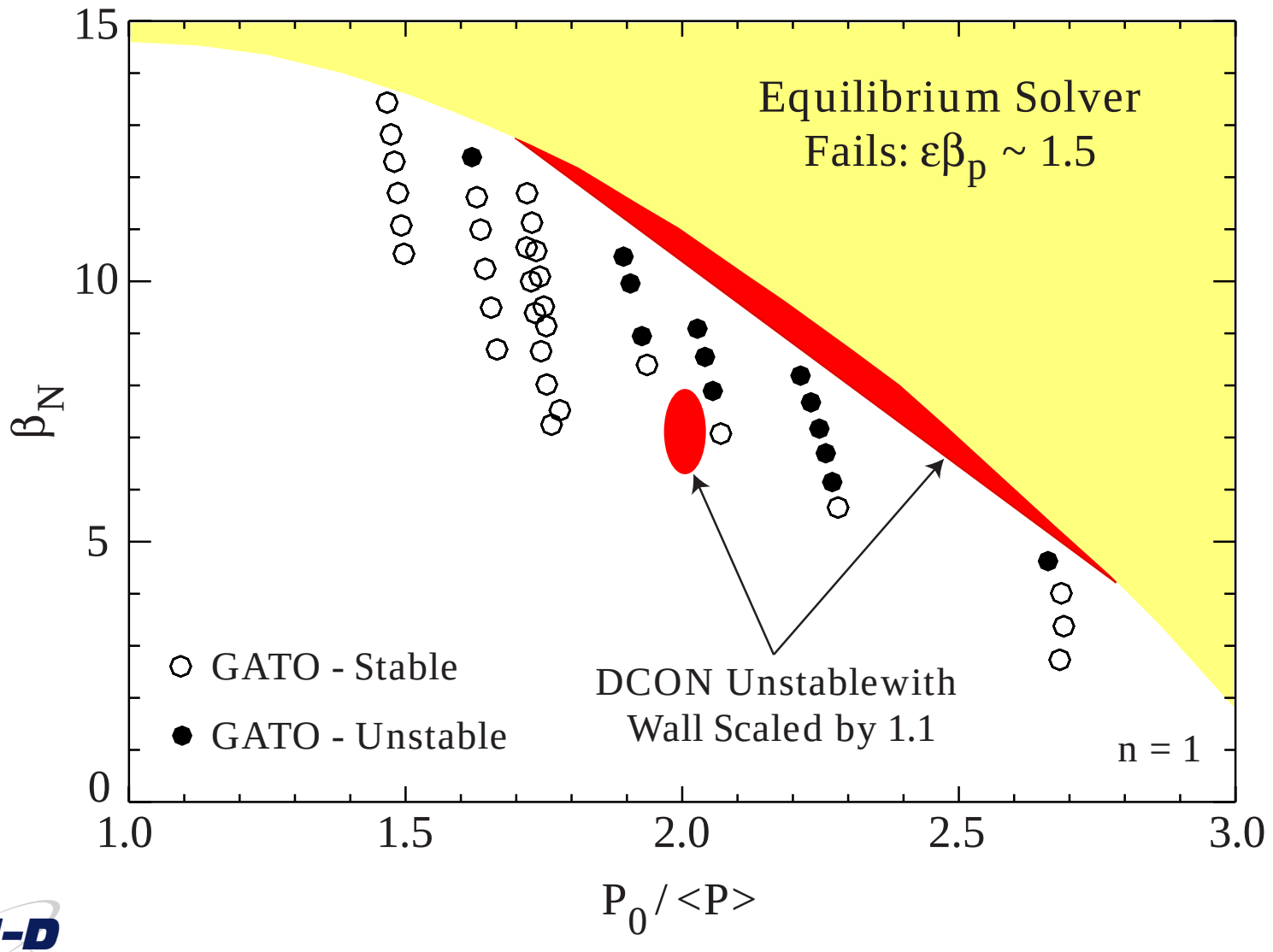
Wide Variety of Pressure Profiles Used



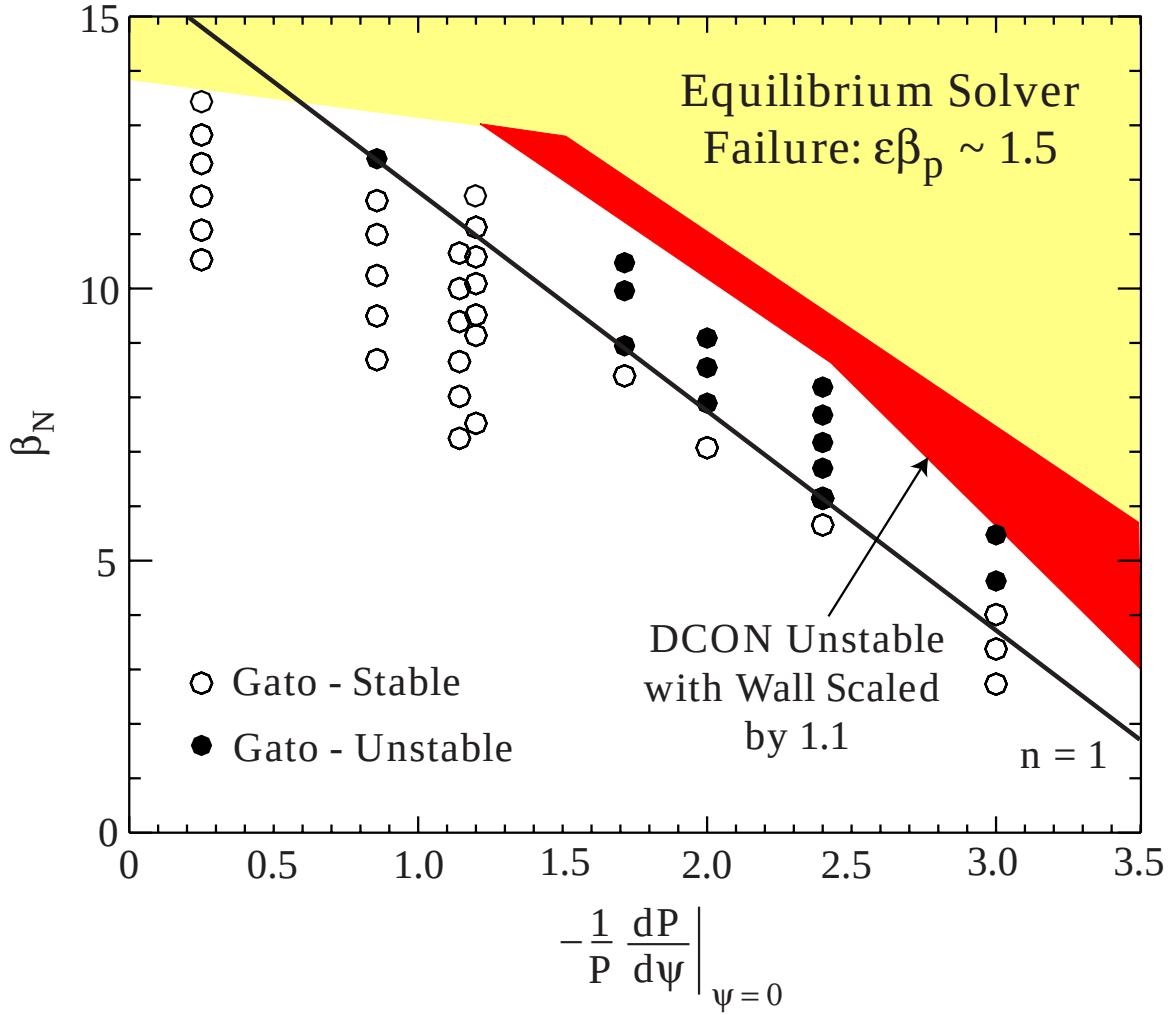
Polynomials Have a Wide Range in P'(0)



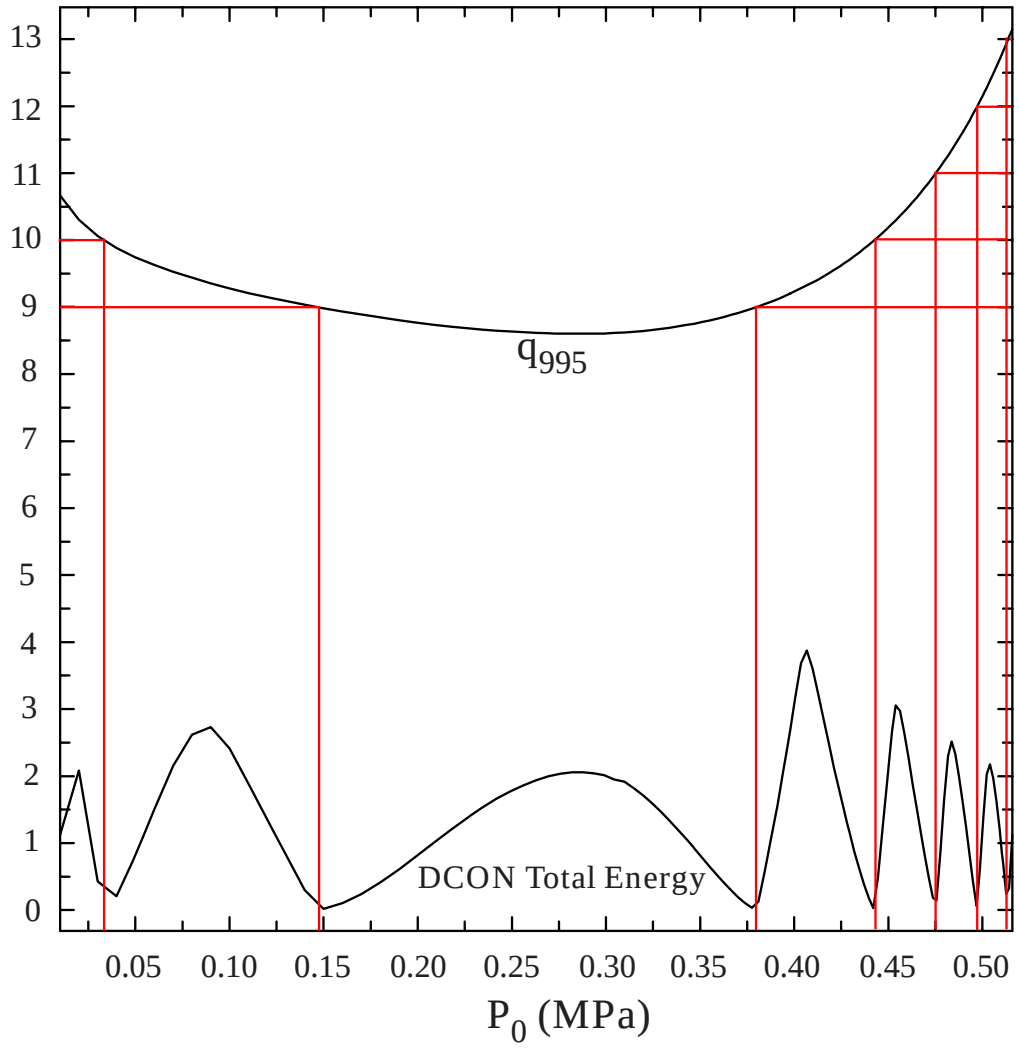
Large Stability Window for Flat Pressure Profiles



Stability Region Increases with Decreasing P'(0)

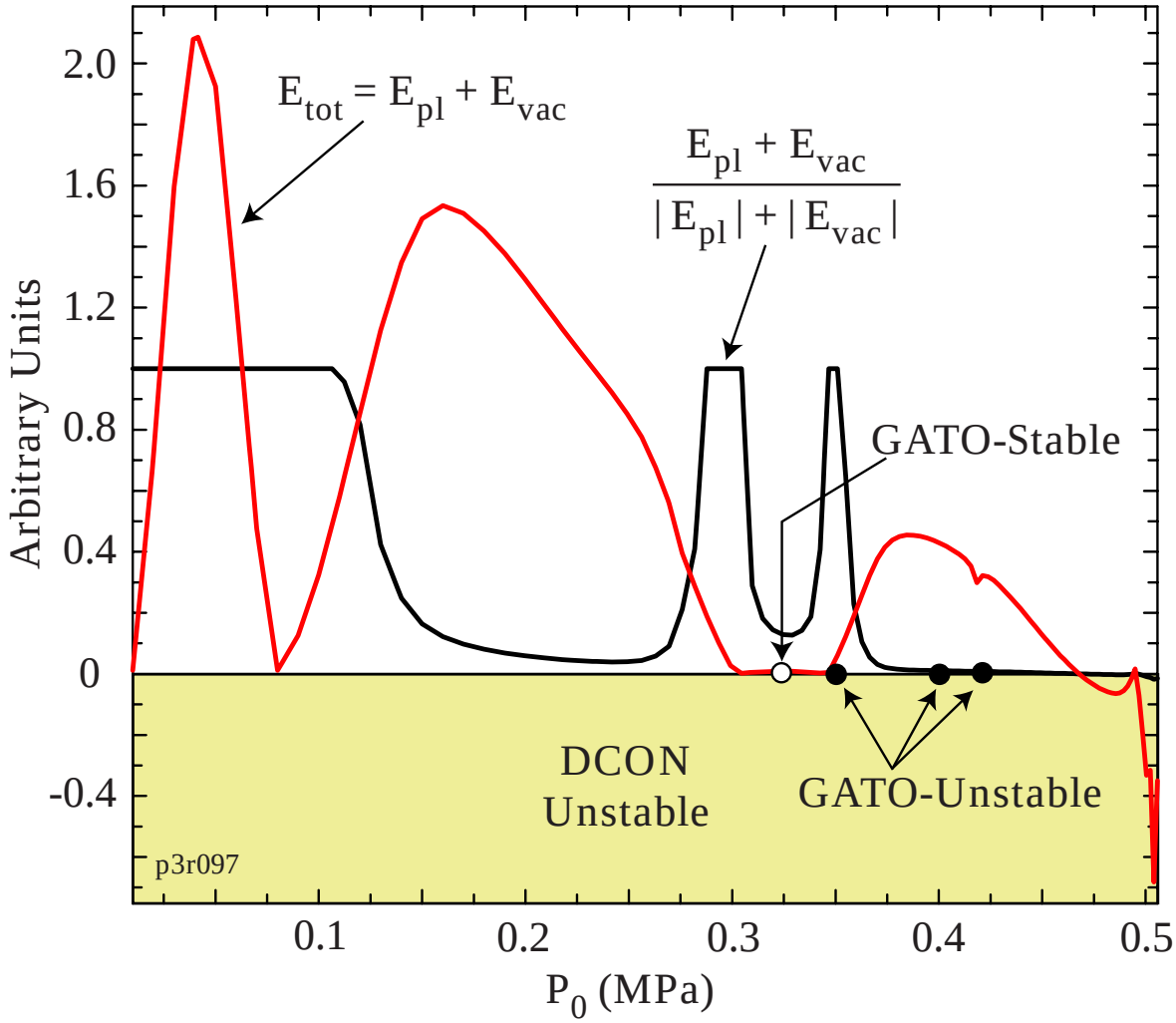


Marginally Stable Peeling Modes Occur at Rational q_{edge}



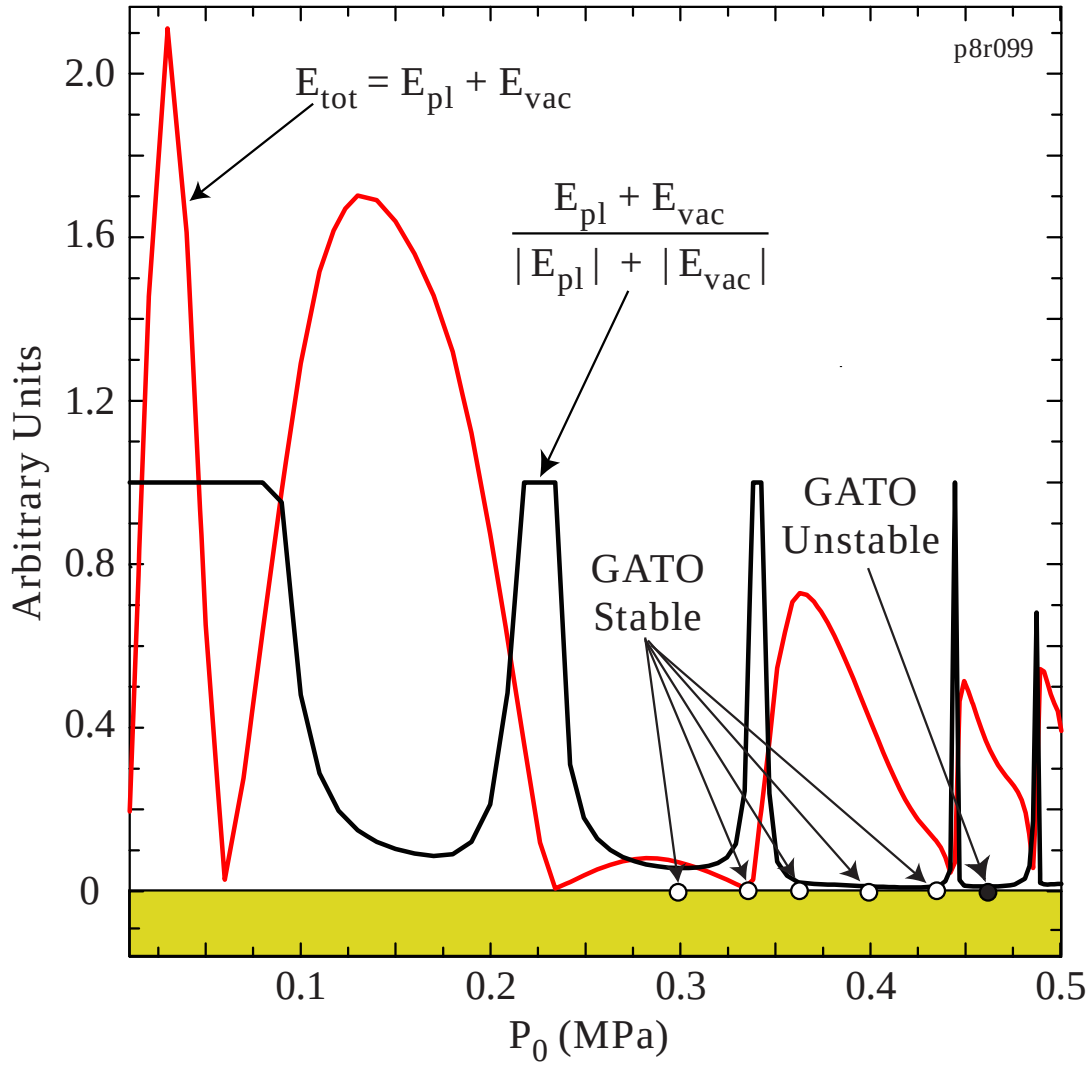
- Typical dependence of total energy and q_{edge} on central pressure
- Minima in energy correspond to mode rational surface at edge

DCON Predicts Regions of Marginal Stability



GATO and DCON are in general agreement on stability boundary when marginal stability is taken into account

Discrepancies exist, however


p8r099
$E_{tot} = E_{pl} + E_{vac}$
$\frac{E_{pl} + E_{vac}}{|E_{pl}| + |E_{vac}|}$
GATO Stable
GATO Unstable
Arbitrary Units
2.0
1.6
1.2
0.8
0.4
0
0.1
0.2
0.3
0.4
0.5
P_0 (MPa)

Results Appear to be Robust

- Several other polynomial forms were also used and gave analogous results
- Several parameters were varied without affecting the results
  - Pedestal pressure
  - Wall location
  - Edge current
- Have not found any “cliffs” in parameter space explored

Summary

- The value of $dP(\psi=0)/d\psi$ has a significant effect on stability
- Large region of (n = 1) stability for flat pressure profiles
- Stable high-β_N (> 12) AT equilibria have been found
- Generally, DCON and GATO yield similar predictions on stability. However, discrepancies exist.