U.S. DEPARTMENT OF ENERGY | Office of Science

NSTX-U

Progress in Resistive DCON Applications

Z.R. Wang[1]

J.-K. Park[1], A. Glasser[2], D. Brennan[3] ,Y.Q. Liu[4], J. Menard[1]

[1]Princeton Plasma Physics Laboratory
[2]Fusion Theory & Computation, Inc.
[3]Princeton University
[4]Culham Centre for Fusion Energy

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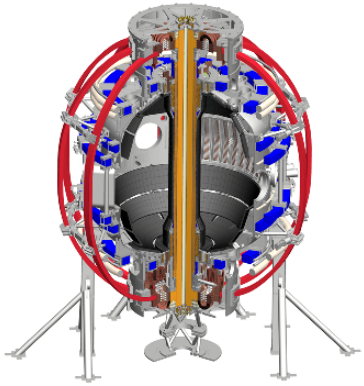
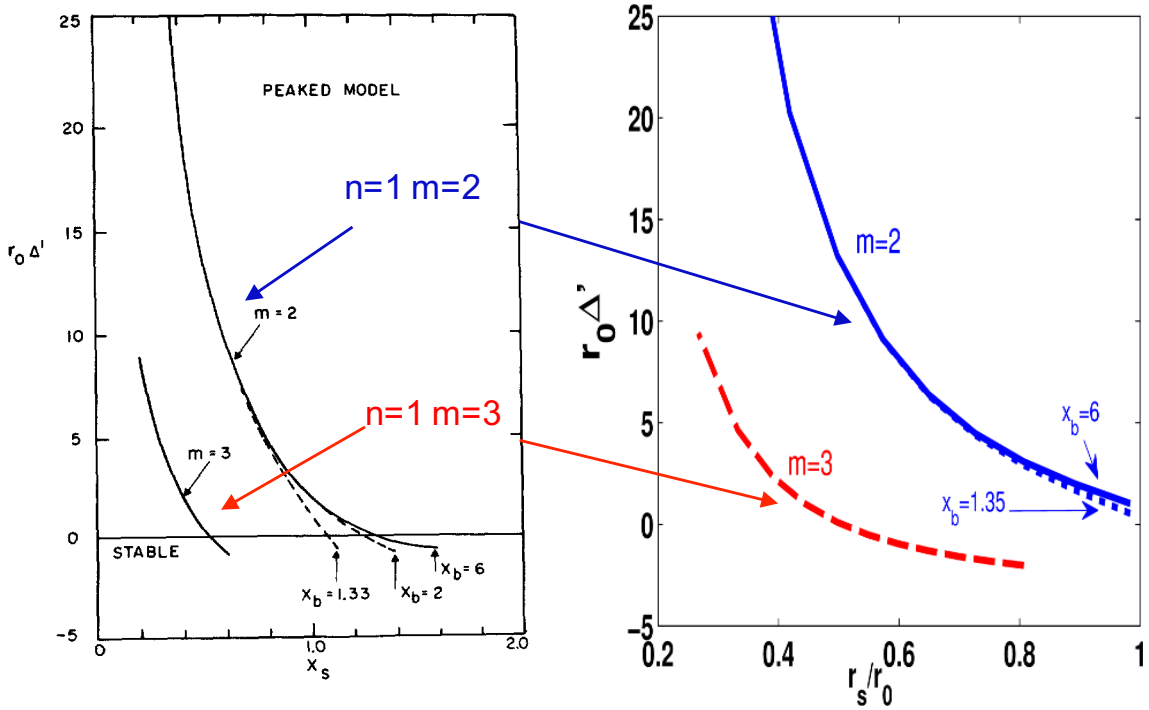
PPPL



Resistive DCON Solves Reliable Outer Region Δ' and Indicates Δ' is Destabilized by Plasma Pressure

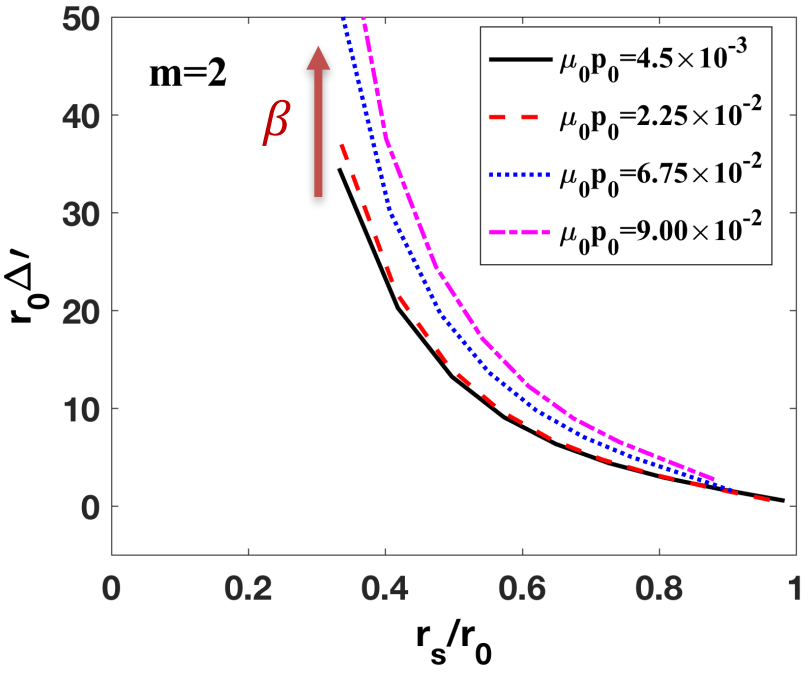
Resistive DCON reproduces Δ' behavior in Furth, Rutherford and Selberg, Phys. Fluids 16, 1054(1973).

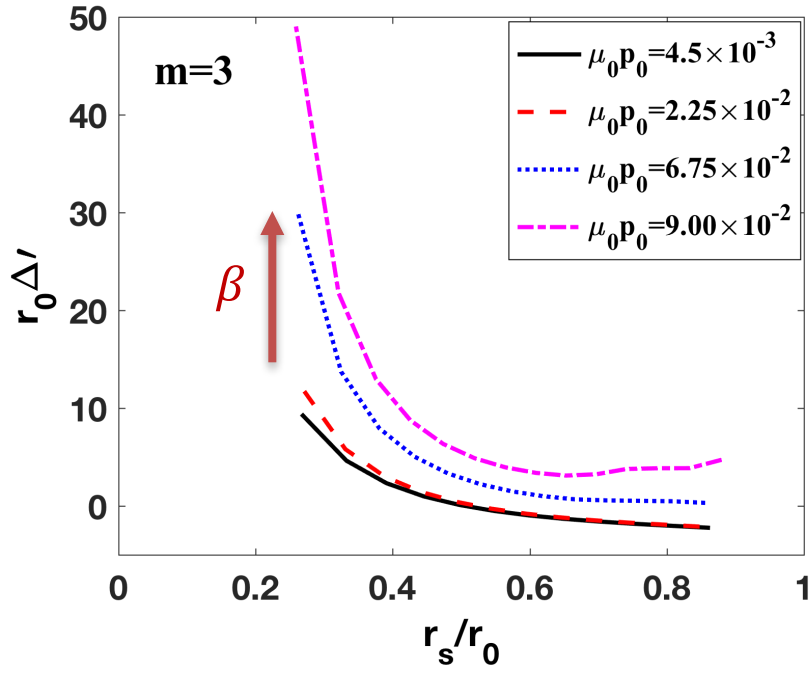


Resistive DCON solves Δ' in full toroidal geometry with $q_{max} > 8$.

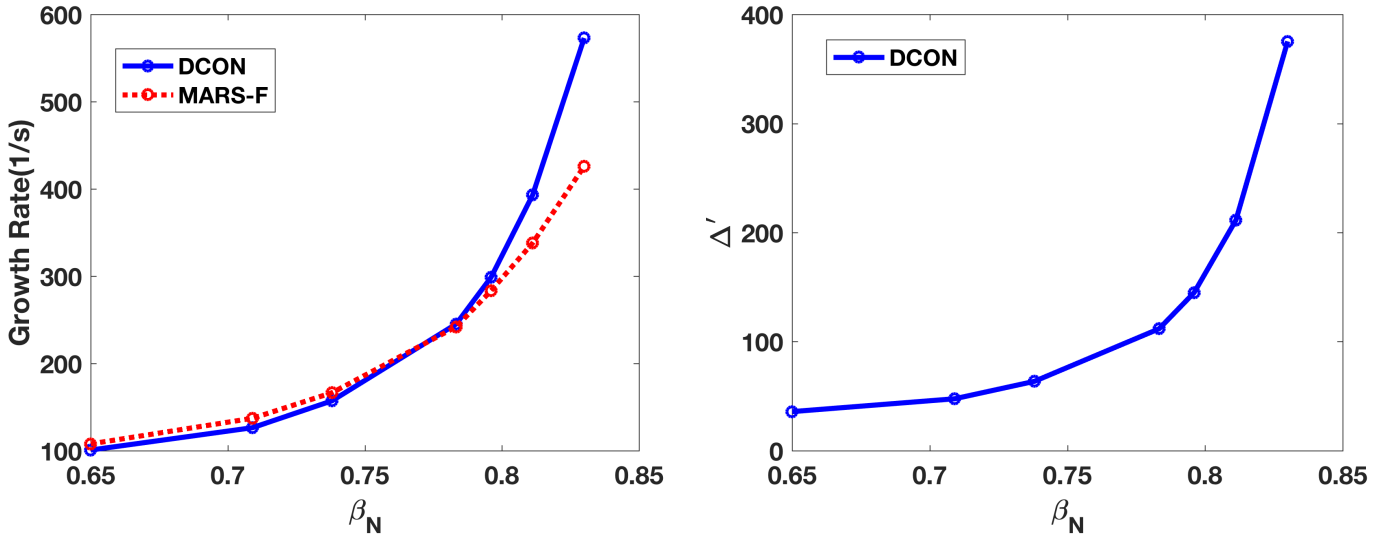
Finite β Effect on Outer Region Δ'

Higher β → Increase Δ' at q=2,3 → More unstable tearing mode



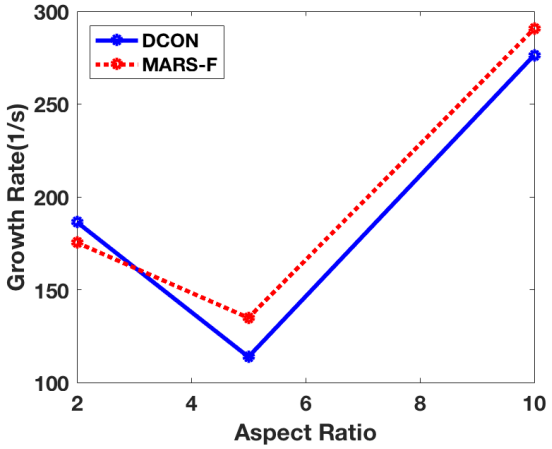


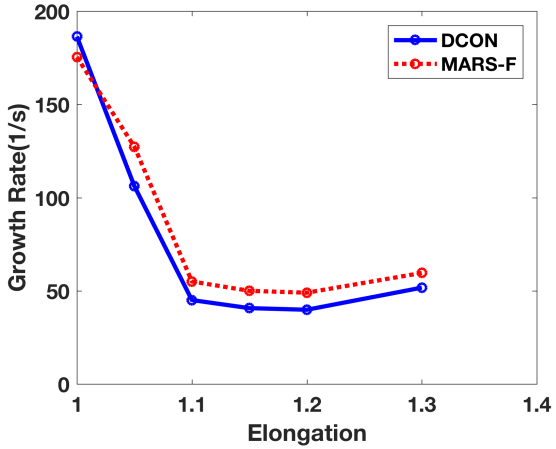
Finite β Effect on Outer Region Δ' and Tearing Growth Rates (q_a<3)

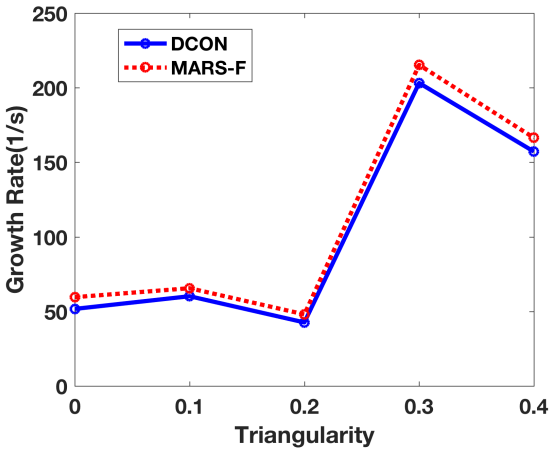


- n=1 tearing mode can be driven by plasma pressure.
- Δ' at q=2 surface is more positive while approaching no wall limit.

DCON vs. MARS Benchmark
One Singular Surface







κ = elongation = 1
τ = triangularity = 0
q_0 = 1.1, q_a < 3

R/a = aspect ratio = 2
τ = triangularity = 0
q_0 = 1.1, q_a < 3

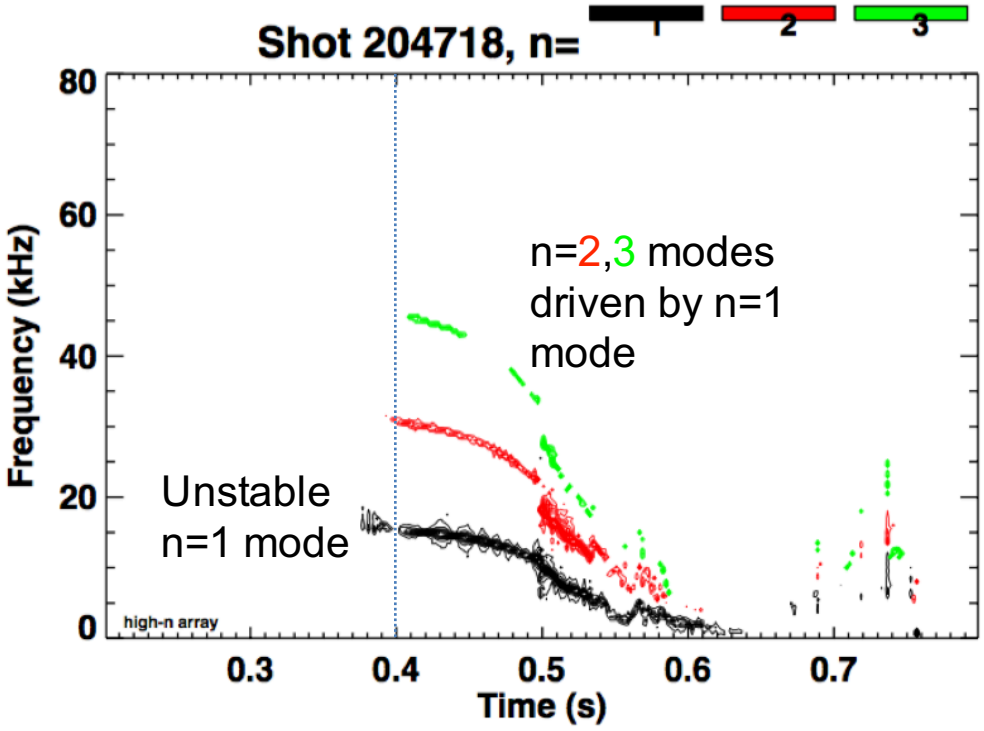
R/a = aspect ratio = 2
κ = elongation = 1.3
q_0 = 1.1, q_a < 3

First resistive DCON paper has been published.
Glasser, Wang and Park, Phys. Plasmas **23**, 112506 (2016)

Resistive DCON and MARS-F Predict Unstable n=1 Tearing Mode as Observed in NSTX-U Experiments

- Unstable n=1 tearing mode is observed in L mode NSTX-U discharge (204718).
- Resistive DCON and MARS-F predict unstable n=1 tearing modes at q≥3 singular surfaces.

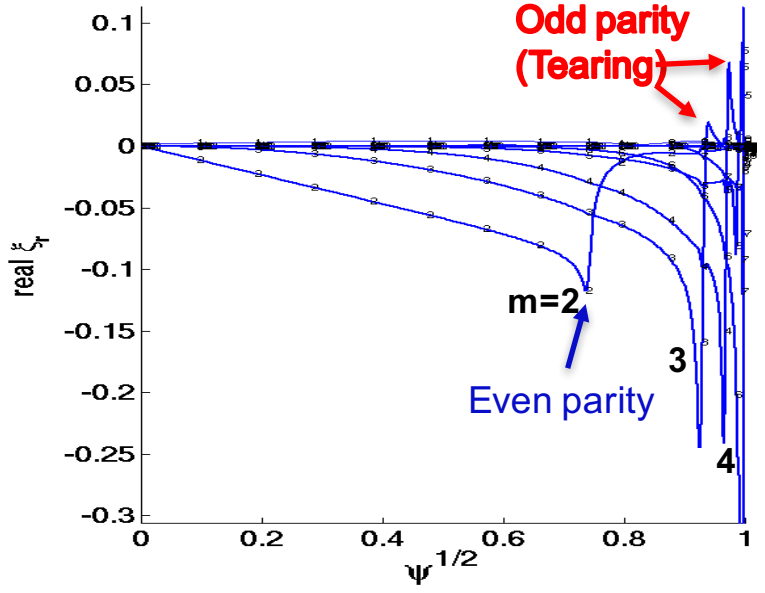
NSTX-U experiment observes n=1 unstable mode which drives n=2, 3 modes later



Diagonal terms of Δ' matrix solved by DCON (outer region) is positive at q=3 and 4 surfaces

Δ'(q=2)	-4.29
Δ'(q=3)	10.0
Δ'(q=4)	3.18

MARS-F finds unstable tearing mode at zero rotation, growth rate $\gamma = 1.7\times10^{-3}\omega_A$

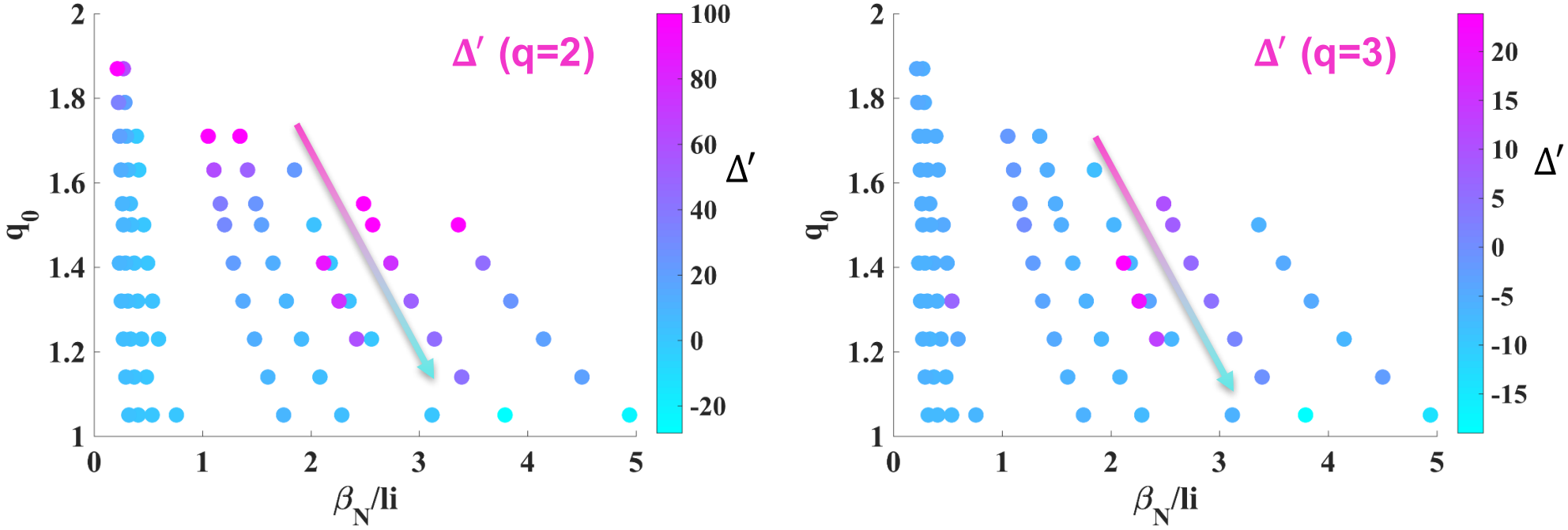


RDCON: Δ' Optimization of NSTX-U L-Mode Discharge to Stabilize n=1 Tearing Mode ($q_0 \downarrow$ and $\beta_N/l_i \uparrow \rightarrow \Delta' \downarrow$)

Resistive DCON is applied to optimize NSTX-U equilibrium to avoid tearing instability (varying equilibrium parameters to minimize Δ').

A sequence of equilibria are generated by scanning current and pressure profiles with CHEASE code, where plasma boundary of discharge 204718 is used.

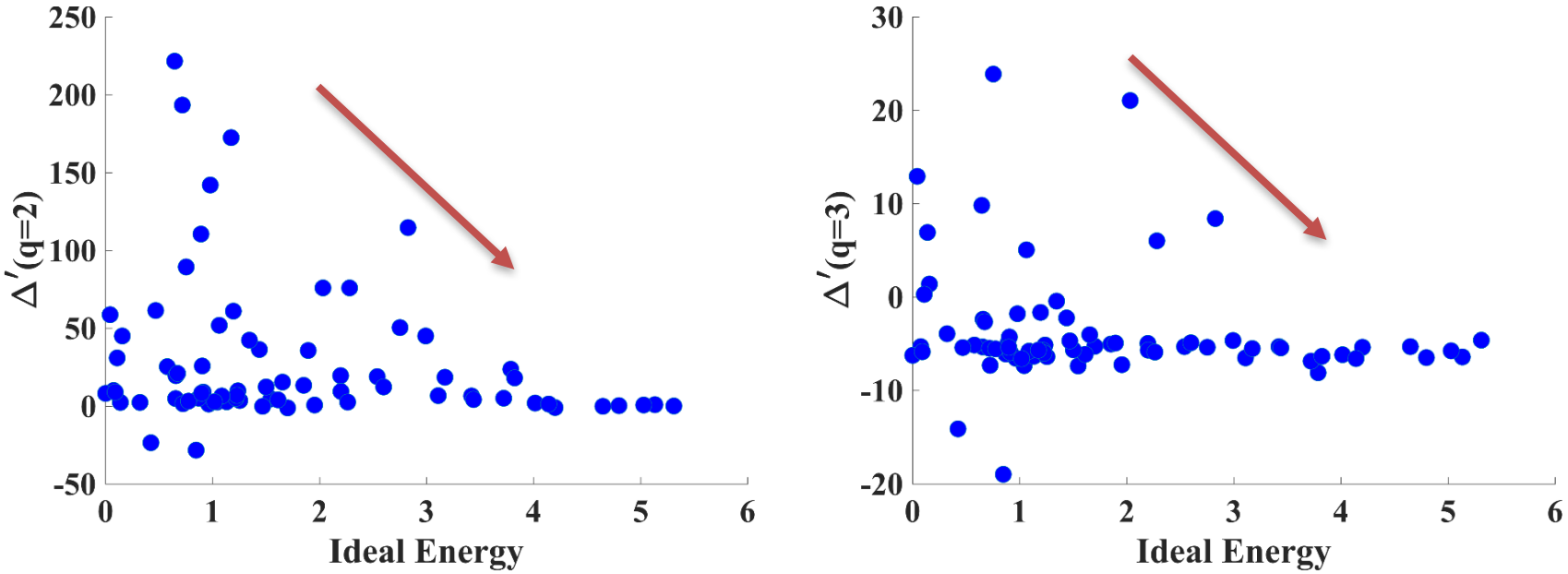
Reduce q_0 and increase β_N/l_i $\rightarrow$ Decrease Δ' at q=2,3



Outer Region Free Energy Decrease (More Positive Ideal Energy) → Δ′ Decrease

Δ’ behavior directly relates to the ideal energy (Outer region energy).

More stable idea MHD stability corresponds to smaller Δ′.



Real-time ideal DCON may important to both ideal and resistive MHD instabilities.

Future Plan of Resistive DCON Development and Application

- Complete the benchmarking between Resistive DCON and MARS in NSTX-U and DIII-D experimental equilibria (D-shape equilibrium with multiple surfaces).

- Develop the neoclassical inner region model to study the linear NTM stability with resistive DCON.

- Perform a systematic optimization of NSTX-U equilibrium (both L/H modes) to minimize Δ'.

- Investigate the small island opening near the pedestal due to RMP fields with resistive DCON and MARS code.