TEARING MODE ONSET AND EVOLUTION STUDIES ON DIII-D

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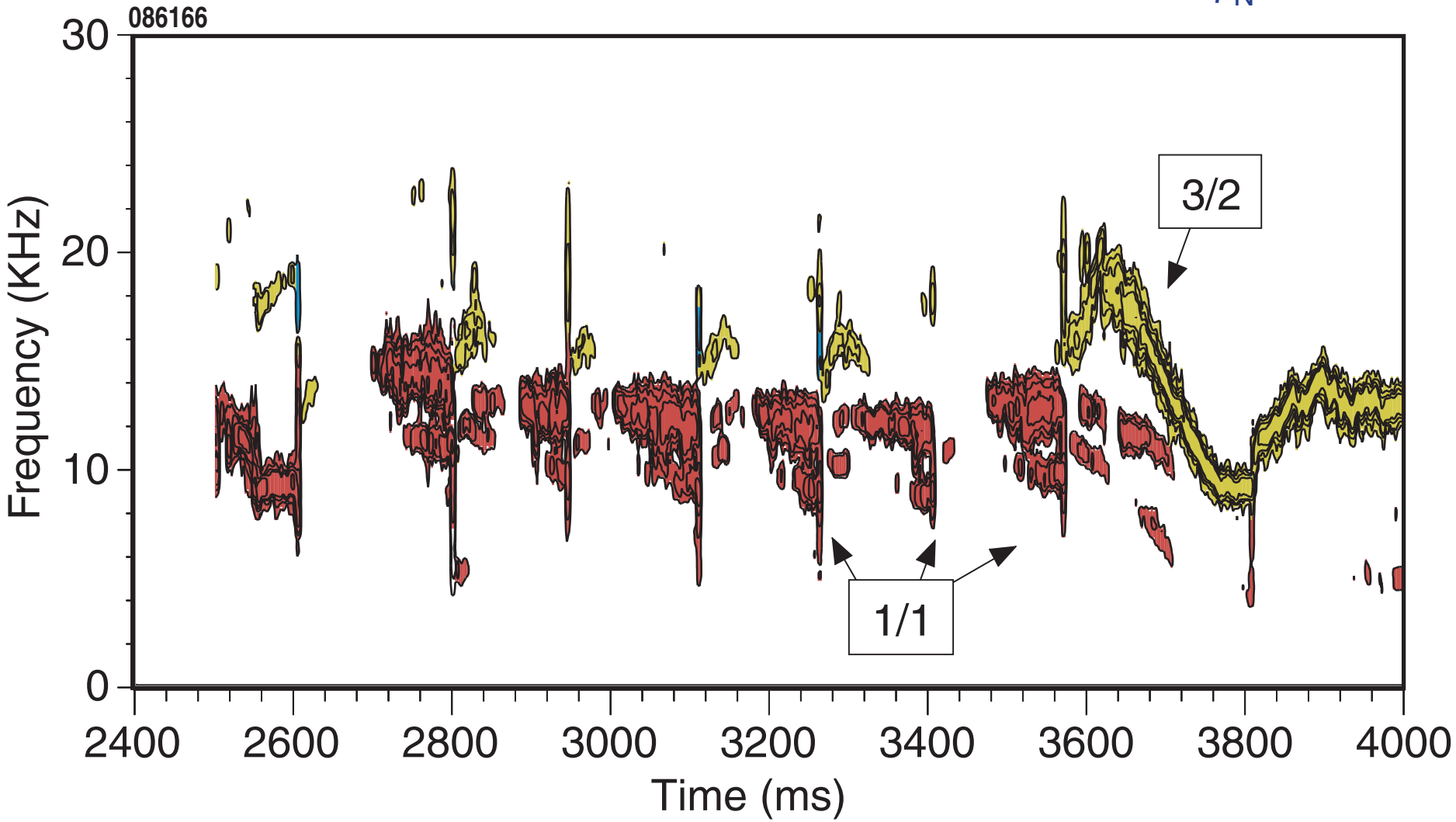
RESISTIVE STABILITY ANALYSES INDICATE A CLASSICAL ONSET MECHANISM FOR NTMs IN DIII-D

- Stability analyses of highly accurate MSE kinetic efits are compared to the experimental onset of tearing modes.
- Poles in Δ' are shown to exist in β space as the ideal stability boundary is approached.
- The standard deviation of Δ' in these equilibria are shown to support the occurrence of a pole in Δ'.
- The modified Rutherford equation is integrated for a time dependent Δ', and an experimental approach is proposed to determine if the poles are actually affecting island growth.
- Equilibria near the ideal stability boundary in β are also being used as initial values in NIMROD to model the non-linear evolution of the modes.

THE ORIGINS OF 3/2 TEARING MODE IN A LOW q_{min} H MODE SHOTS IS THOUGHT TO BE NEOCLASSICAL

q_{min} ~ 1

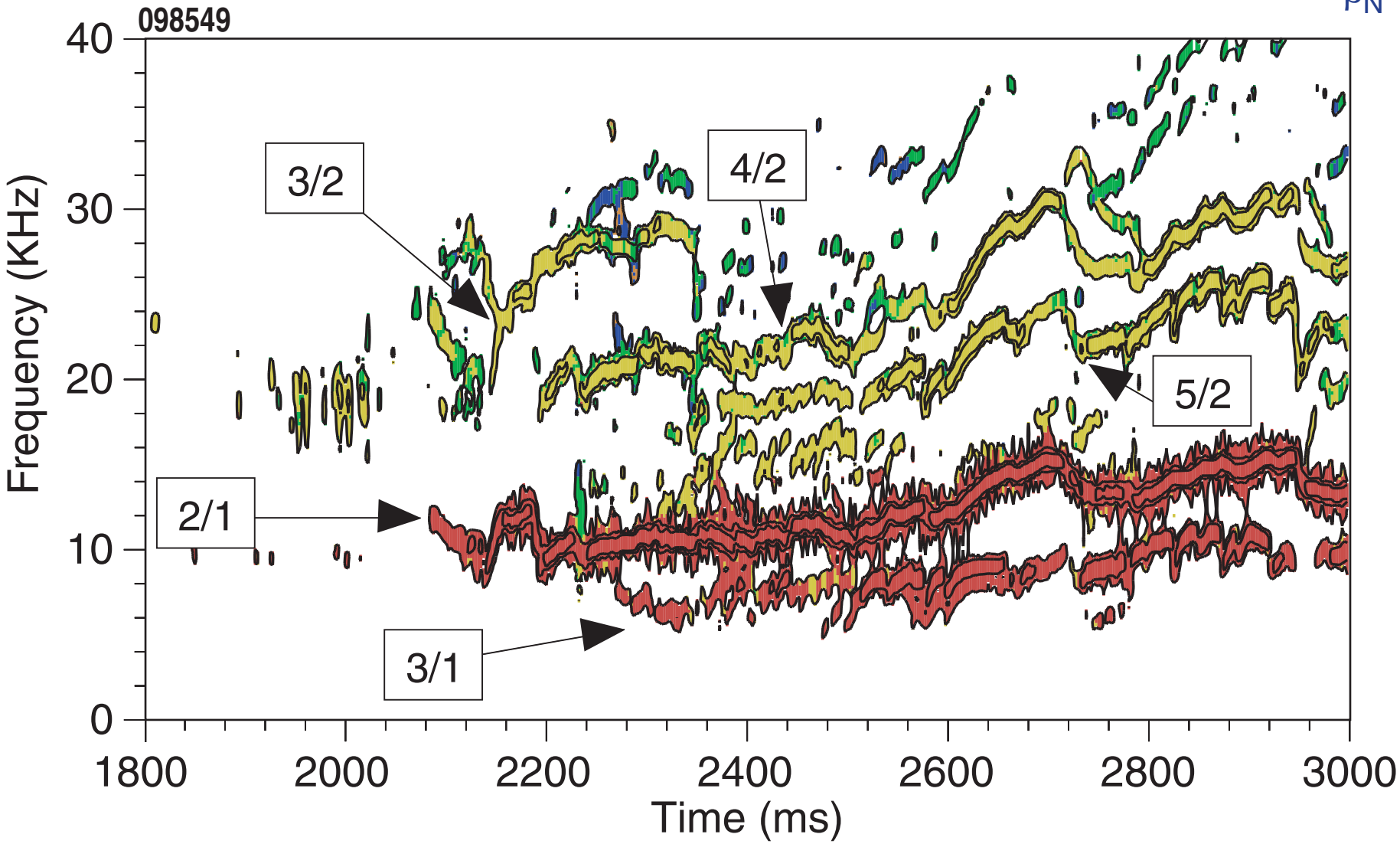
ELMing H-Mode
Sawteeth
Lower Single Null
β_N=3.1 constant



A 2/1 MODE APPEARS IN A HIGH q_{min} DISCHARGE WITHOUT AN OBVIOUS IDEAL MODE CAUSING A SEED ISLAND

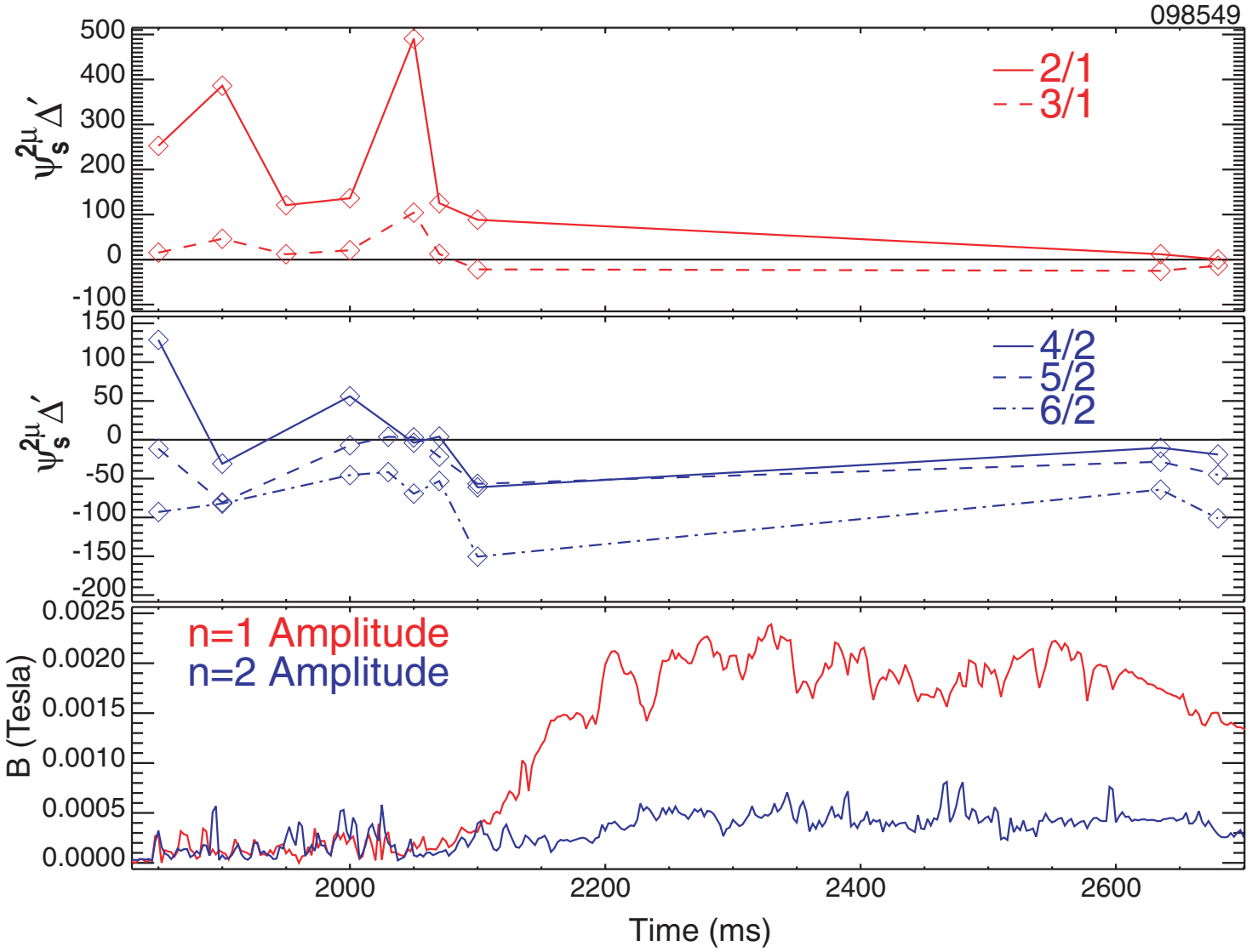
q_{min} ~ 1.5

ELMing H-Mode Advanced Tokamak
No Sawteeth
Double Null
β_N=3.4



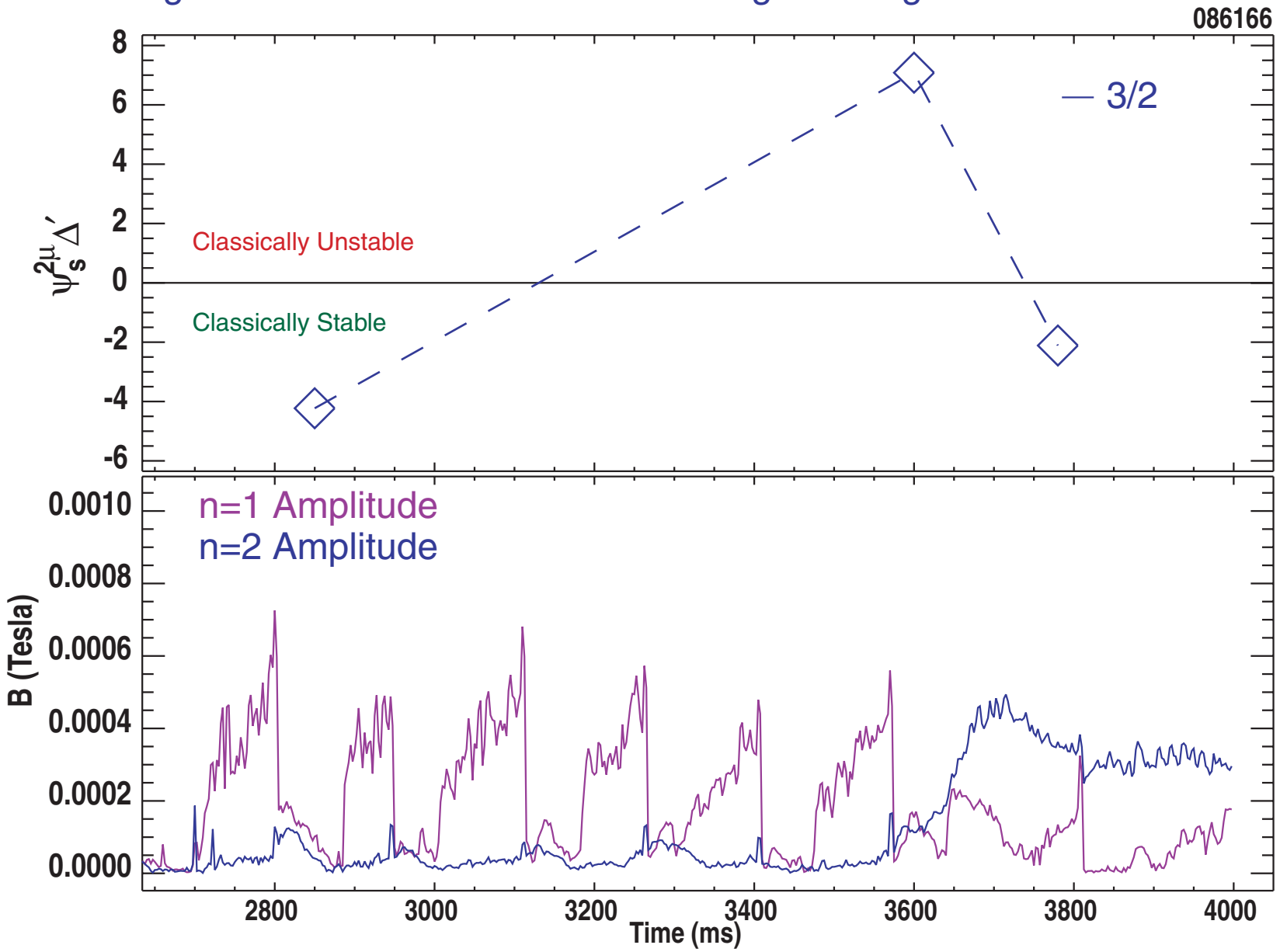
TEARING MODES IN A HIGH q_{min} PLASMA ARE DETERMINED TO BEGIN CLASSICALLY

* Early times show saturated low amplitude islands and positive Δ'
* As the shot progresses, q_{min} decreases, large 2/1 Δ' causes island growth
* The saturation may depend on the reduced Δ' and helically perturbed J_{bs}



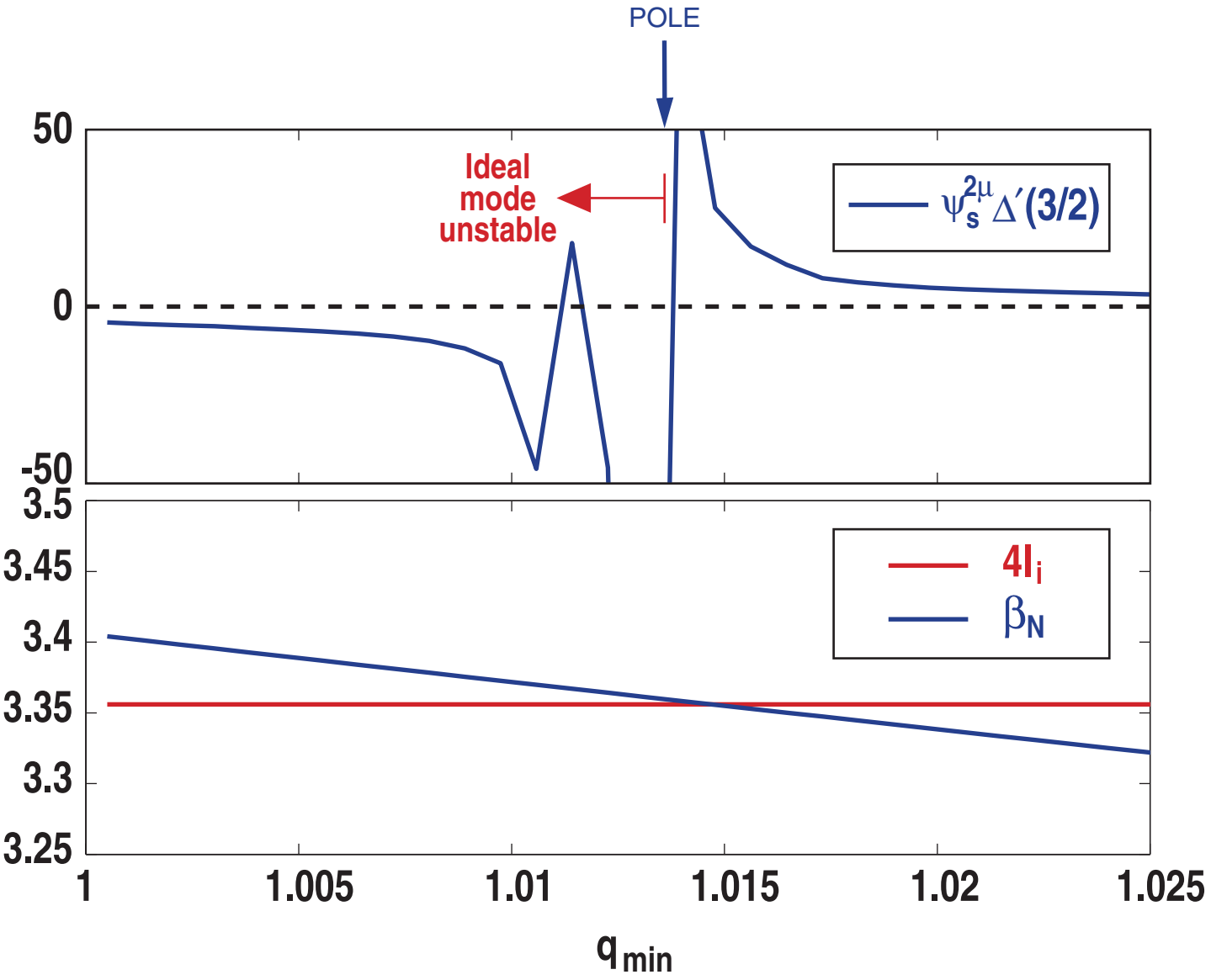
TEARING MODES IN A LOW q_{min} H-MODE PLASMA ARE CALCULATED AS BEING INITIALLY CLASSICALLY UNSTABLE

* Although ideal modes are near marginal stability, they are stable for these calculations
* The tearing mode becomes neoclassical as it grows large



A q SCALING SHOWS A POLE IN Δ′ AT THE ONSET OF AN IDEAL MODE

This series of equilibria follow a similar progression to the high q_{min} case from right to left, with qmin dropping and a global ideal stability boundary being crossed.



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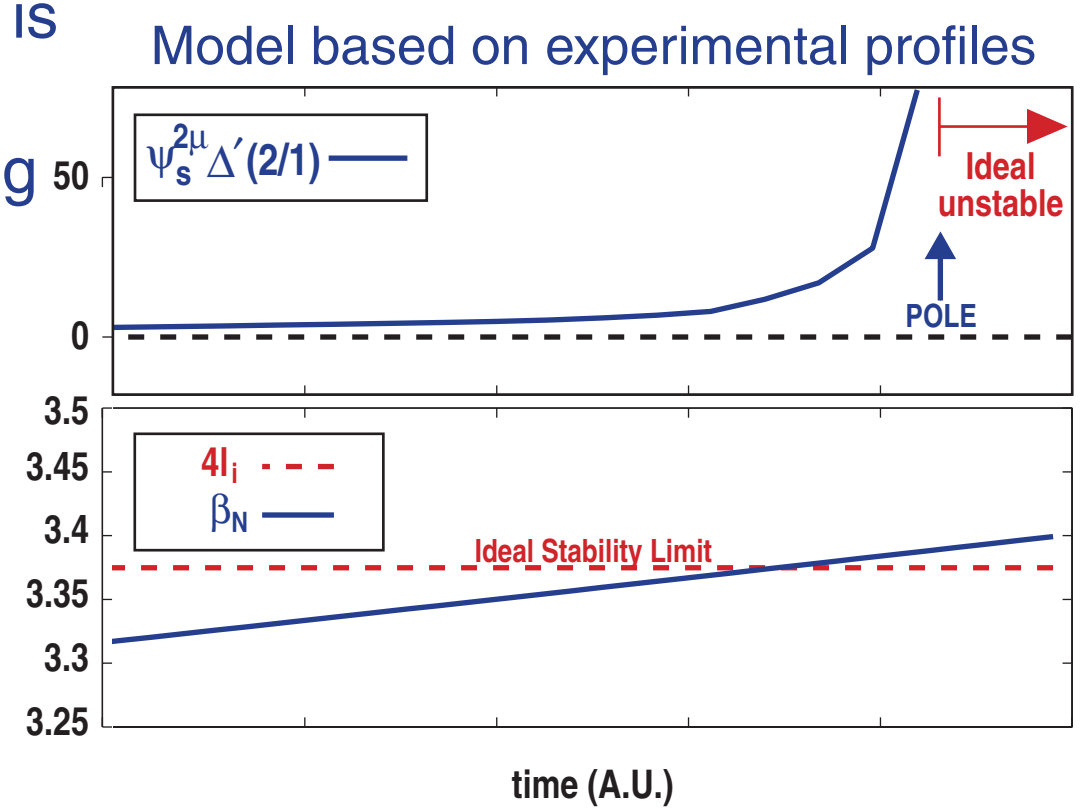
Δ' becomes large and positive on the stable side of the ideal boundary

As an ideal stability boundary is approached, a pole in Δ' can cause rapid growth of a tearing mode.

This may be another mechanism for the onset of NTMs



As the pole is approached at varying rates, the island should first appear on the diagnostics at lower values of β for slower increases in β.This should be a distinctly different dependence than for forced reconnection.

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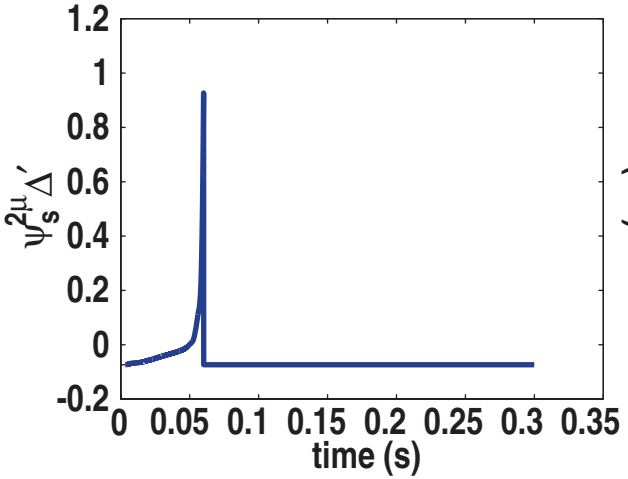
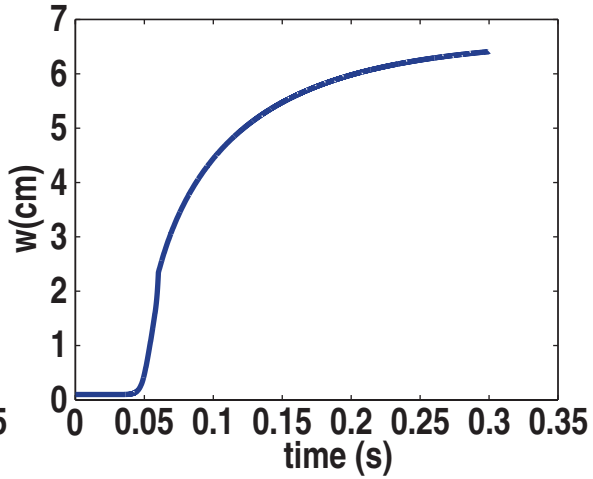
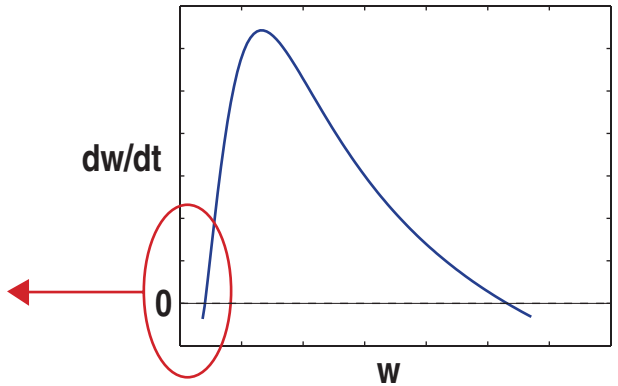
The Modified Rutherford Equation is Integrated to Determine Island Evolution on Approach to a Pole

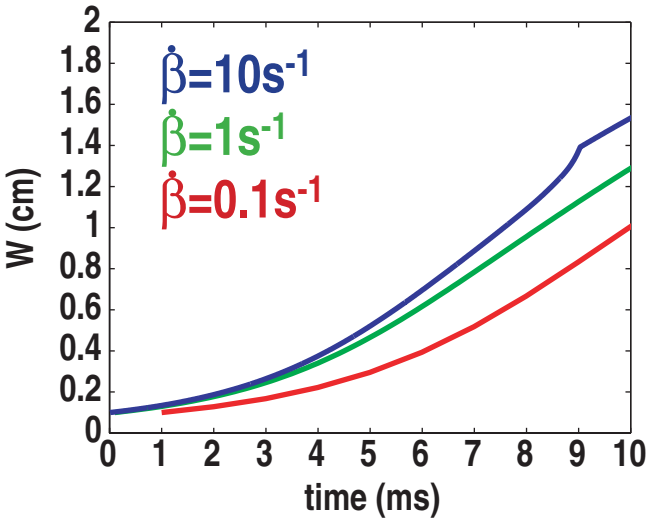
$$\frac{dw}{dt} = \frac{\eta^*}{k_0}(\triangle^* + \frac{k_1}{w}(D_{nc} + \frac{D_R}{\alpha_s - H}) + D_{pol}(w^{-3}))$$







For different values of dβ/dt, the pole in Δ′ will occur at different points in the island evolution, thus separating out the points in β space where the island reaches ~ 1cm and is detected



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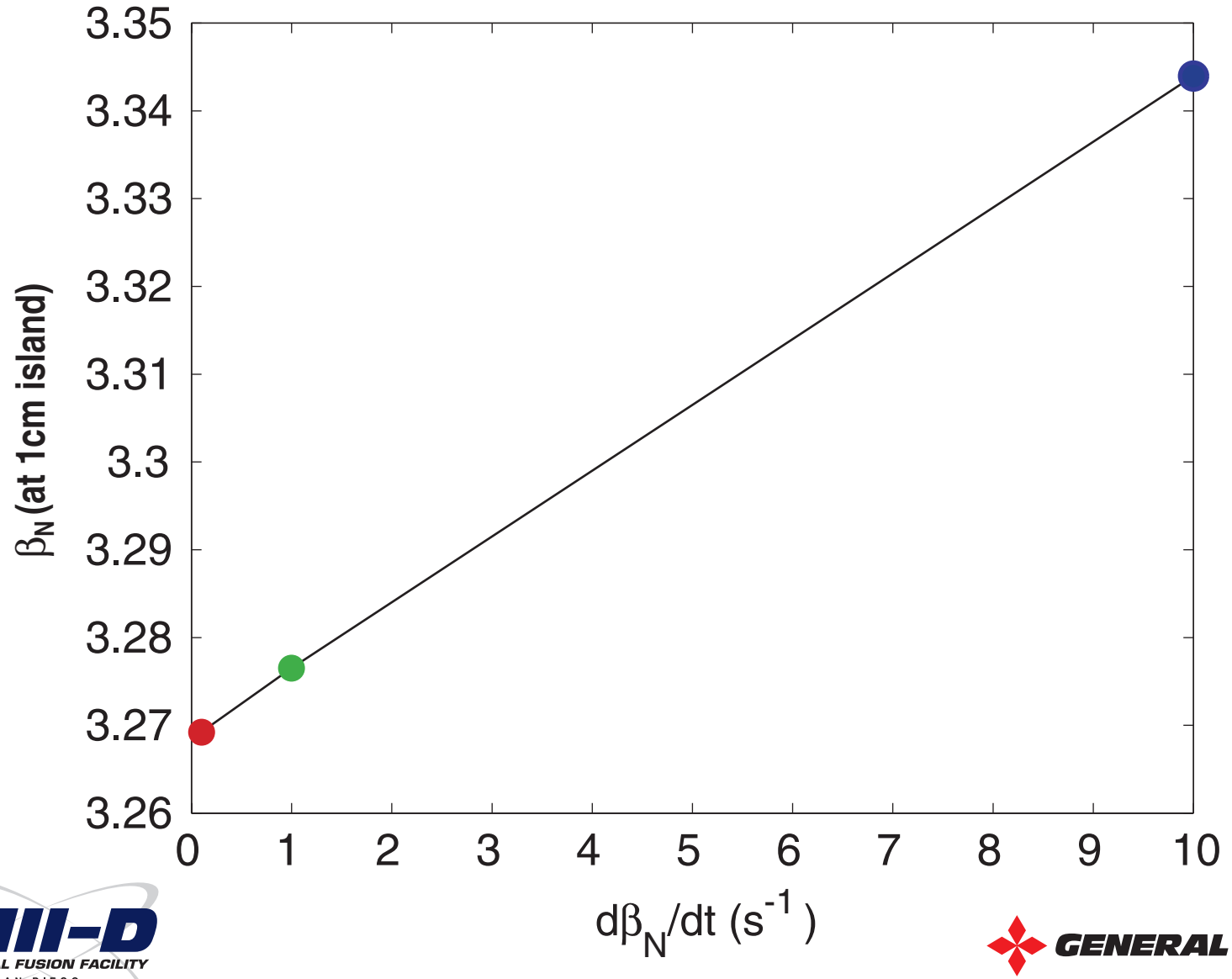
The dependence of the β at which the island reaches 1cm width should then monotonically increase with dβ/dt



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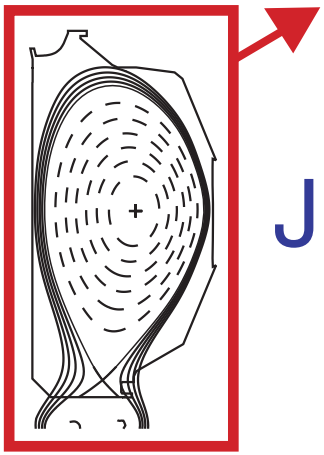
THE MODE STRUCTURE EVOLUTION ON APPROACH TO A POLE IS BEING STUDIED WITH NIMROD

The nonlinear evolution of tearing modes near ideal stability boundaries are be studied with NIMROD in two ways:

1. A series of equilibrium reconstructions on the approach to the onset of a mode are being used as initial conditions, and the Δ' and saturated island widths will be compared to the linear results.

2. Equilibria will be evolved with β increasing in time, approaching the ideal stability boundary and the Δ' pole.

The effects of profiles and shaping on the nonlinear evolution of tearing modes can be accurately studied.



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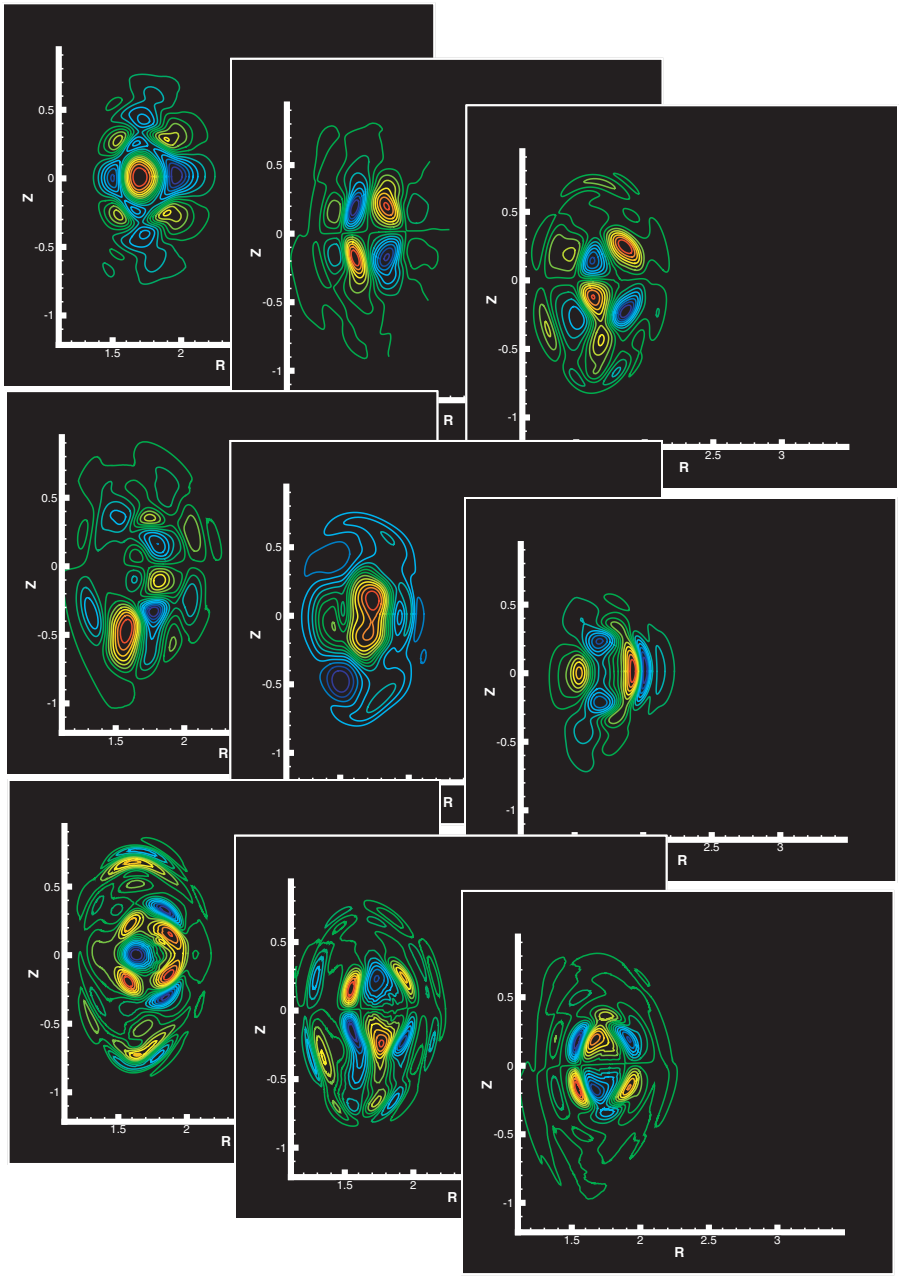

CONCLUSIONS

- Δ' calculations suggest that tearing modes may begin classically unstable.
- Theoretical analysis suggests that poles due to ideal stability boundaries may be responsible for the onset of tearing modes in some discharges.
- An experimental test for the occurrence of this onset mechanism is to vary $d\beta/dt$ near the onset point of an NTM.
- This problem would undoubtedly be best modelled by the non-linear initial value code NIMROD.

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