Stability to the External kink

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http://w3.pppl.gov/ manickam/FIRE/talk.pdf

ABSTRACT

We investigate the underlying physics of the current driven external kink mode and its dependence on plasma parameters, such as *geometry, current density, safety-factor*

OUTLINE

- Physics model
- Stability Analysis
- Discussion

Physics Model

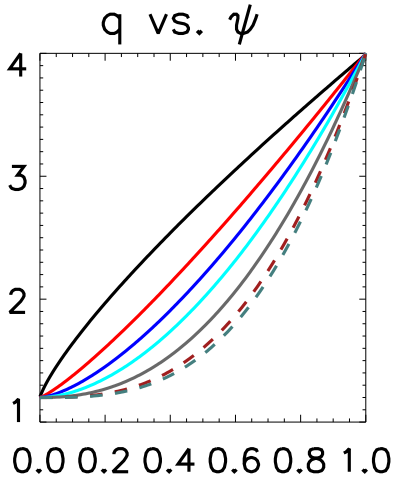
The stability of the kink depends on:

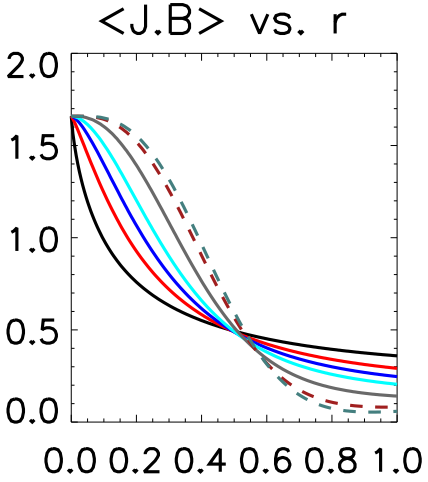
- The flux surface geometry
- q_{edge}
- q'
- $\mathrm{J}_{\mathrm{edge}}$

Study equilibria with:

- $\beta = 0$
- $< J \cdot B >= f(\Psi)$ - control details of edge current

  or
- $q = f(\Psi)$ - control details of q-profile
- Vary geometry - circle, low and high triangularity

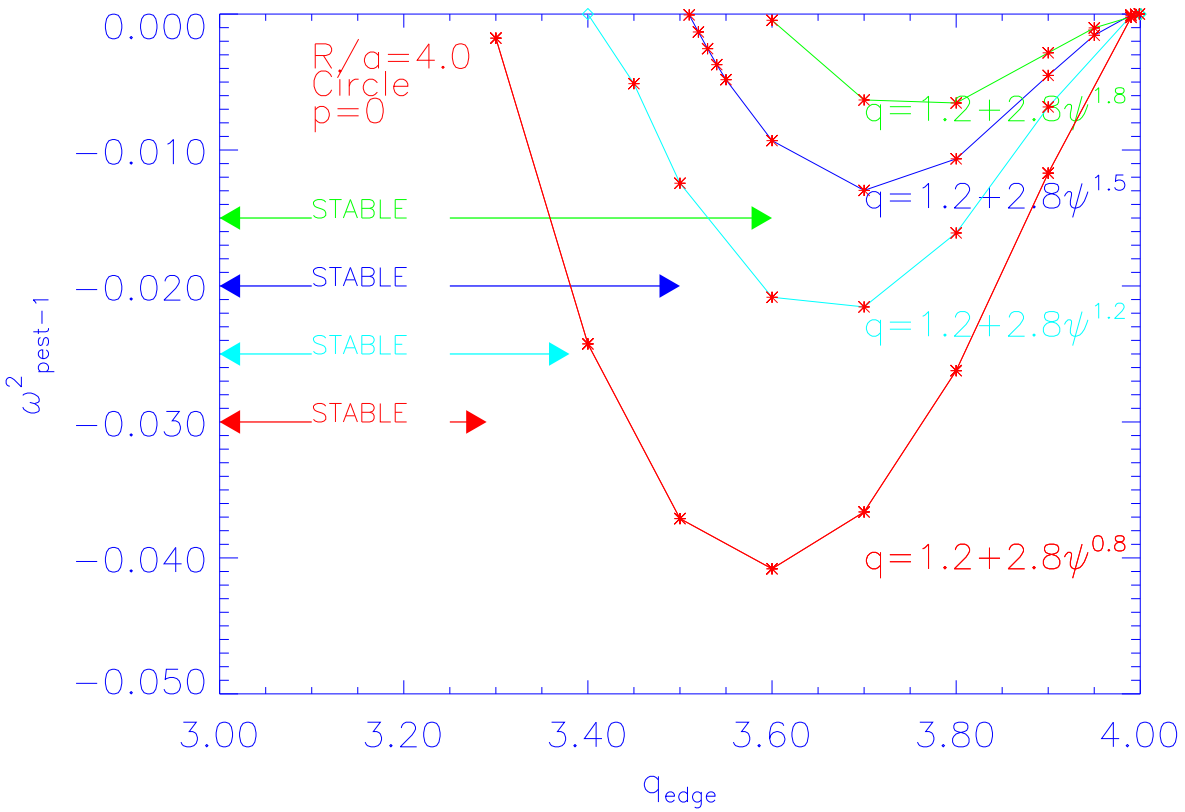




- Circular cross-section, R/a=4
- p=0

$q = 1.2 + 2.8\Psi^{\alpha}$

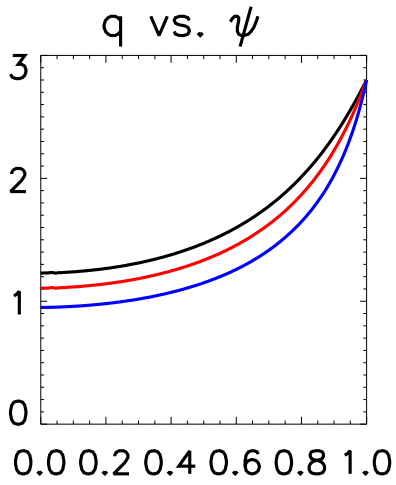
The edge current density varies inversely with q'

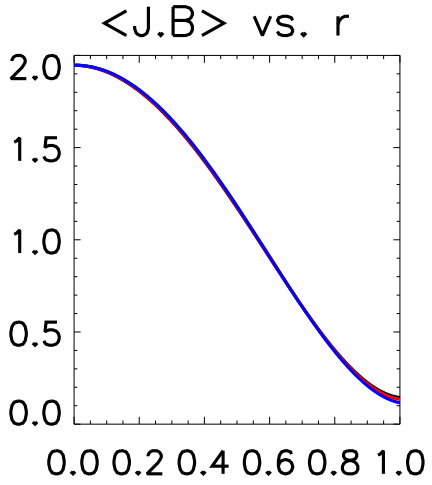


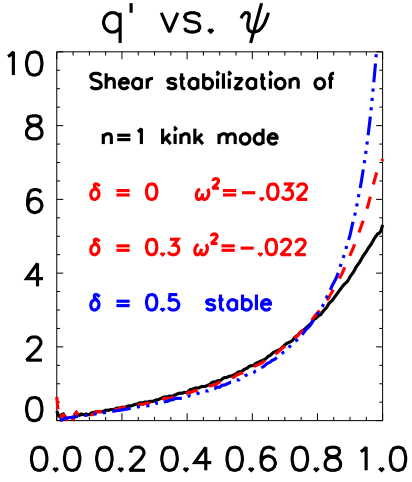
There is a stable window which increases as α and q' increases

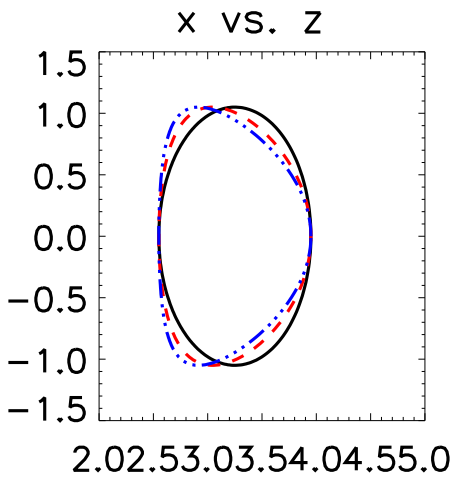
Increased q' is associated with reduced J_{edge}

We can use the plasma shape to change q' without changing J_{edge}









Stability is achieved by changing the plasma shape

Review

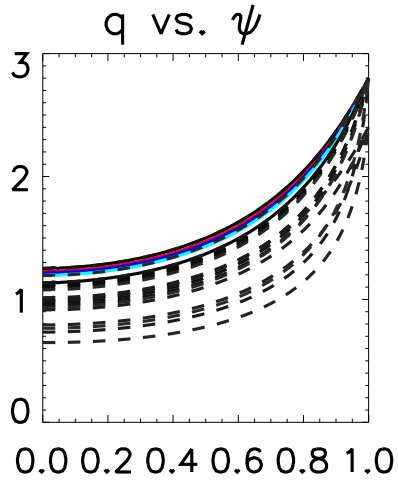
Kink stability depends on q_{edge} , J_{edge} , q' and shape

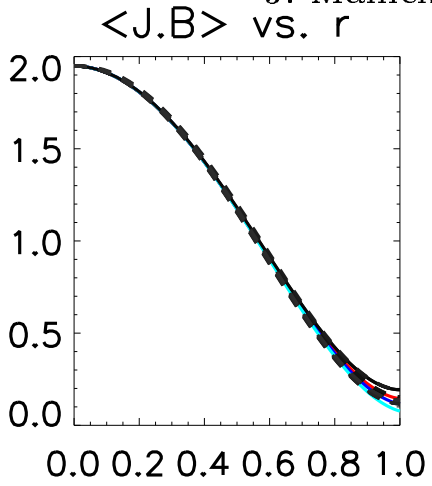
- J_{edge} destabilizes the external kink
- Shear stabilizes the external kink
- The shear can be changed by changing J_{edge}
- The shear can be changed by changing the plasma shape

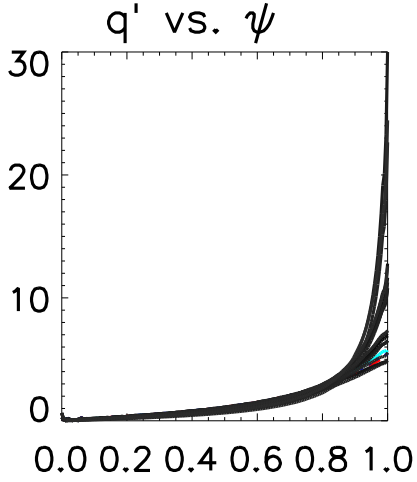
Can we form an integrated picture ?

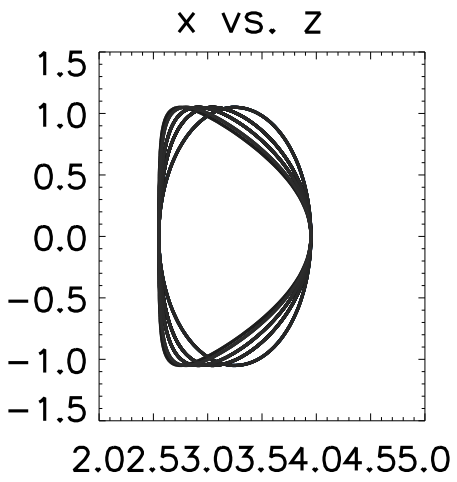
Look at I_{90} and q'

$$\text{I}_{90} \equiv \frac{\int_{0.90}^{1} < J \cdot B > d\Psi}{\int_{0}^{1} < J \cdot B > d\Psi}$$

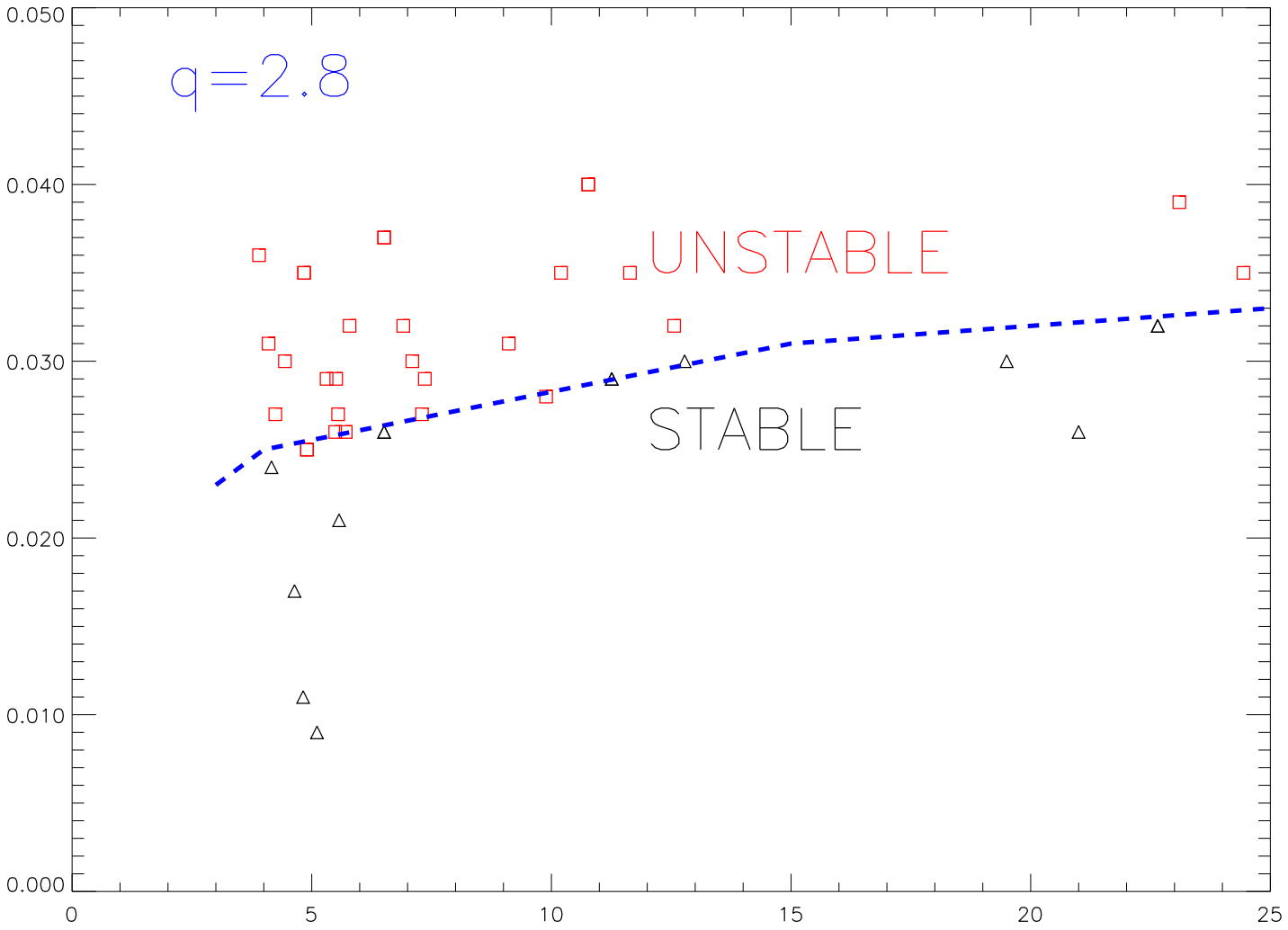




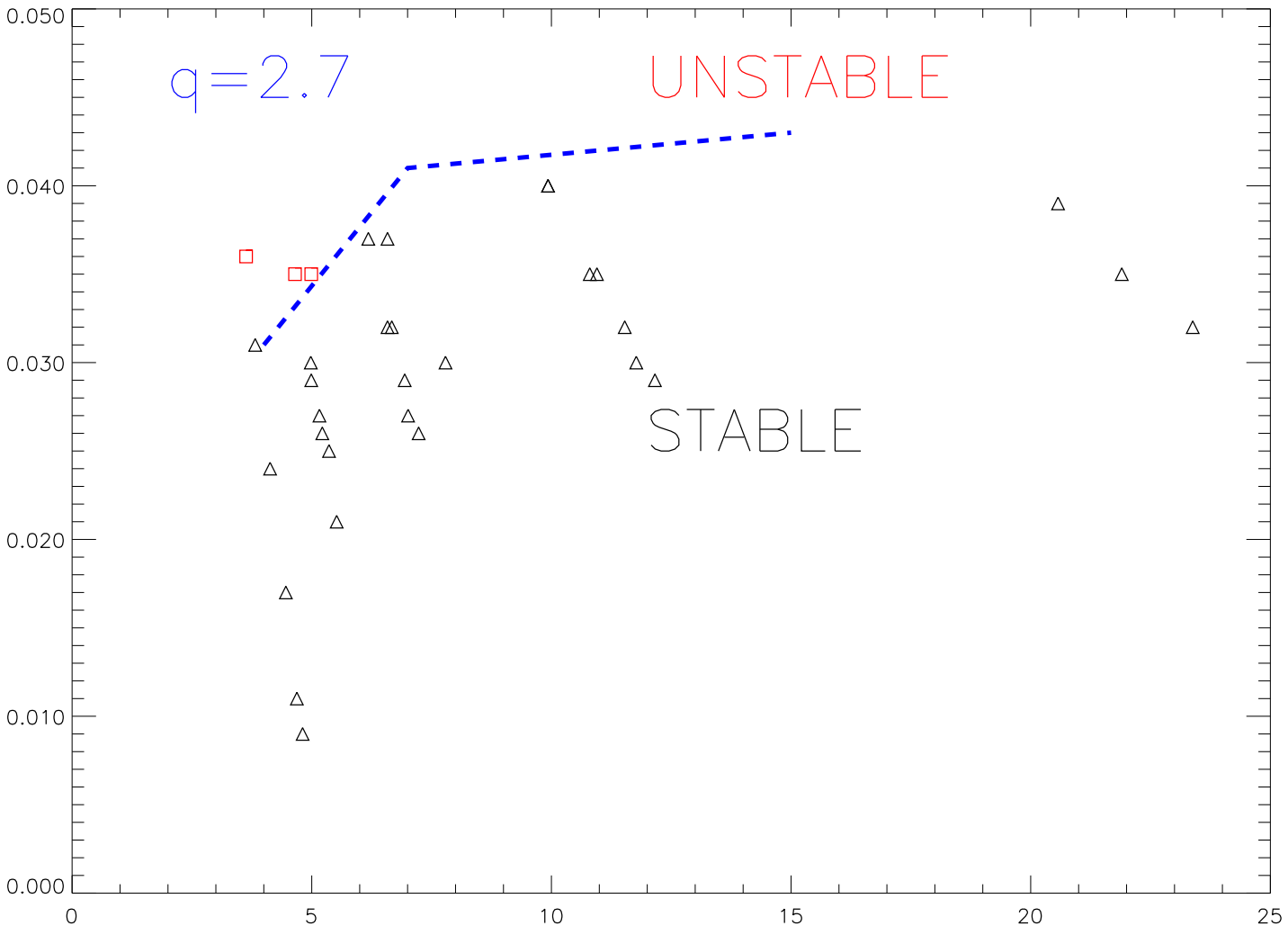




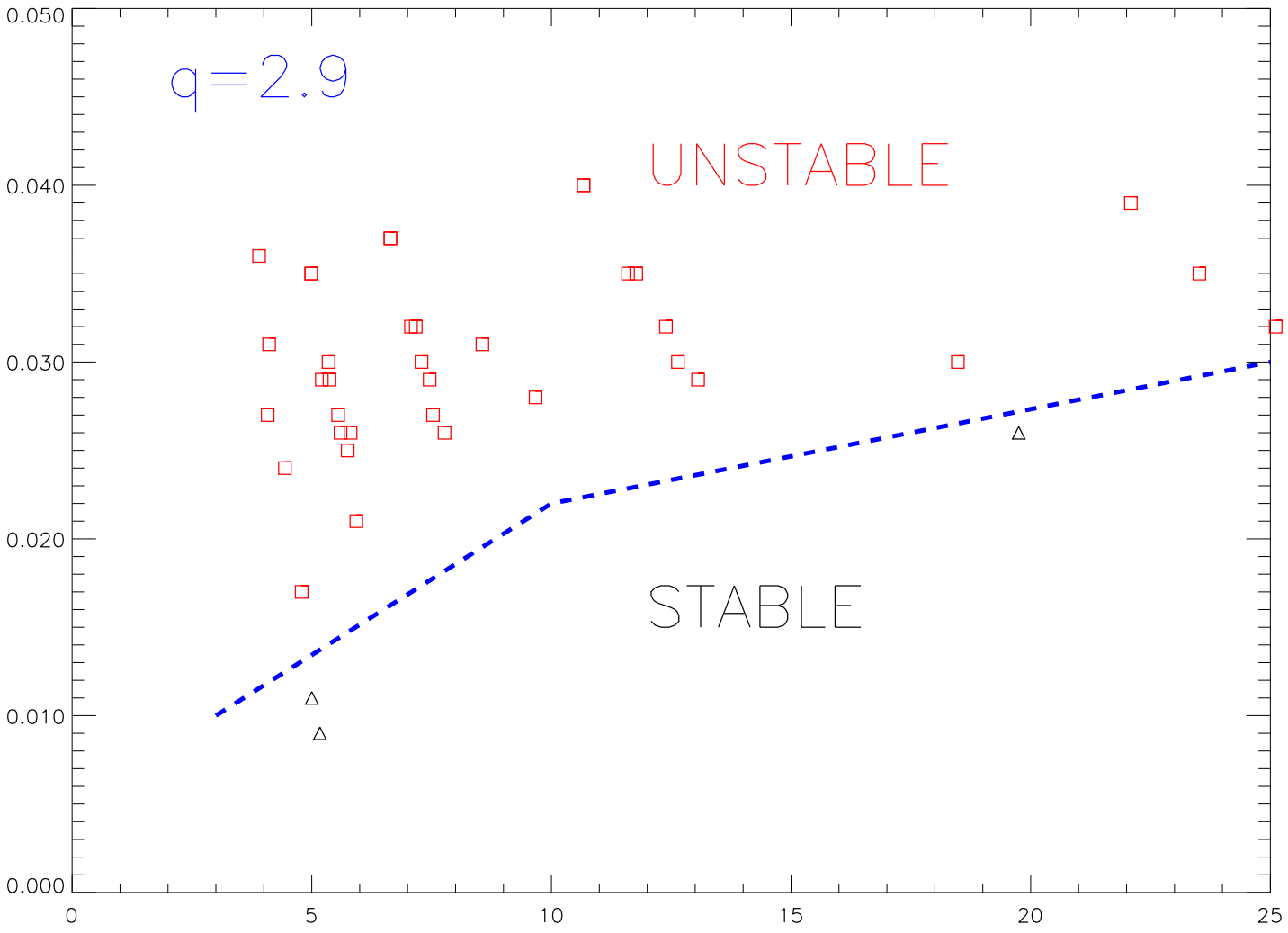
We examine a large set of configurations



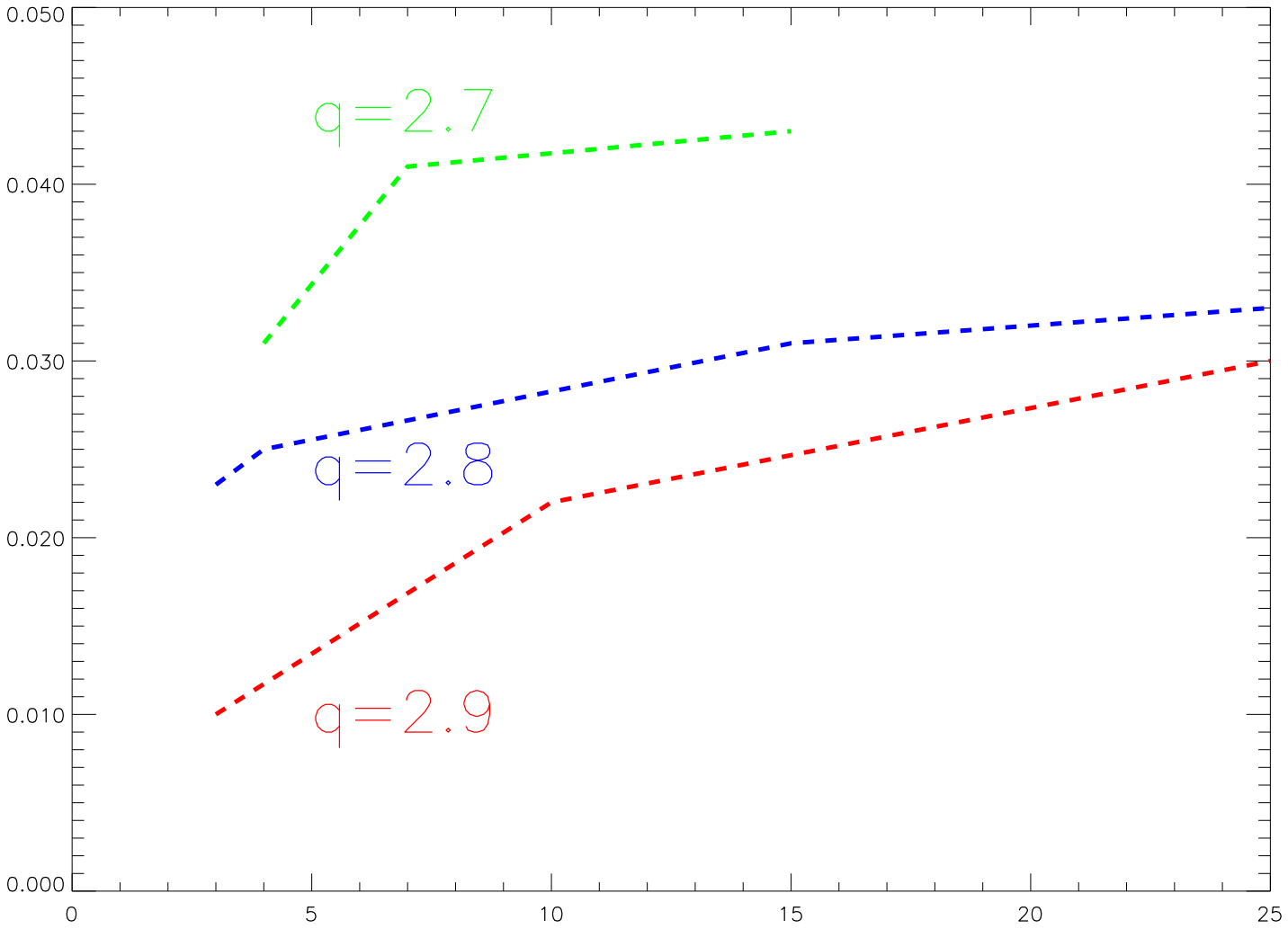
At large values of J_{edge} there is a weak dependence on q'



At lower values of q_{edge} the kink is stable for higher $\mathrm{J}_{\mathrm{edge}}$



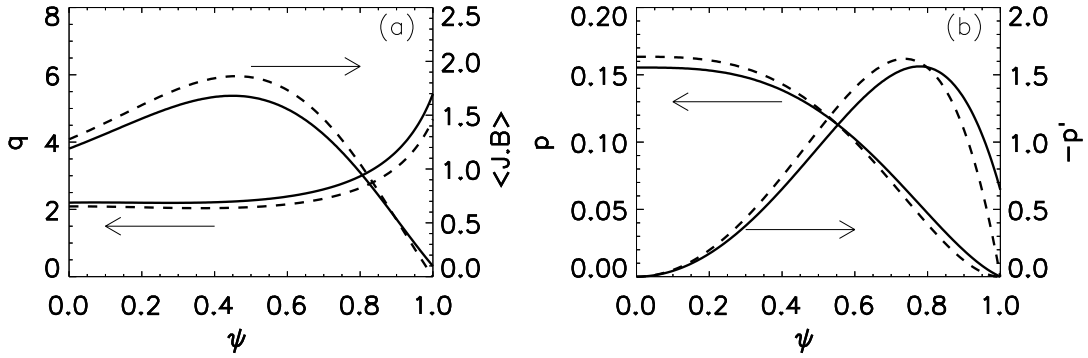
As q_{edge} approaches an integer value $\mathrm{J}_{\mathrm{edge}}$ threshold is reduced
If $\mathrm{J}_{\mathrm{edge}} > 0$ when q_{edge} is an integer, a peeling mode is unstable



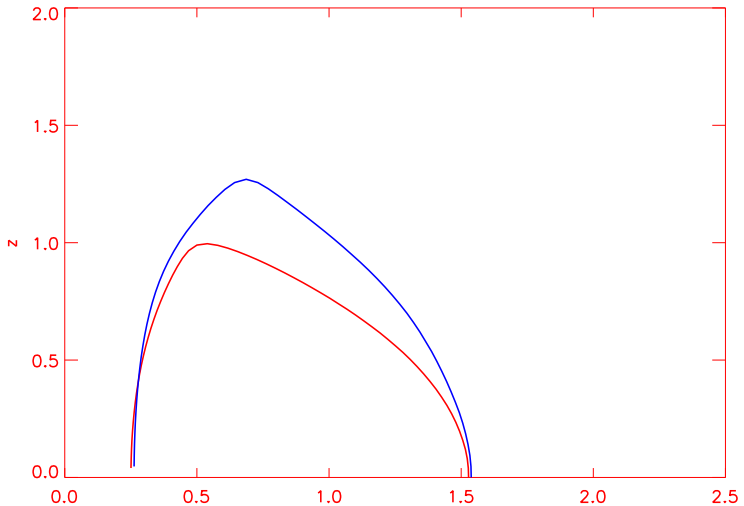
Note that these thresholds are approximate and specific to this class of J-profile and aspect-ratio

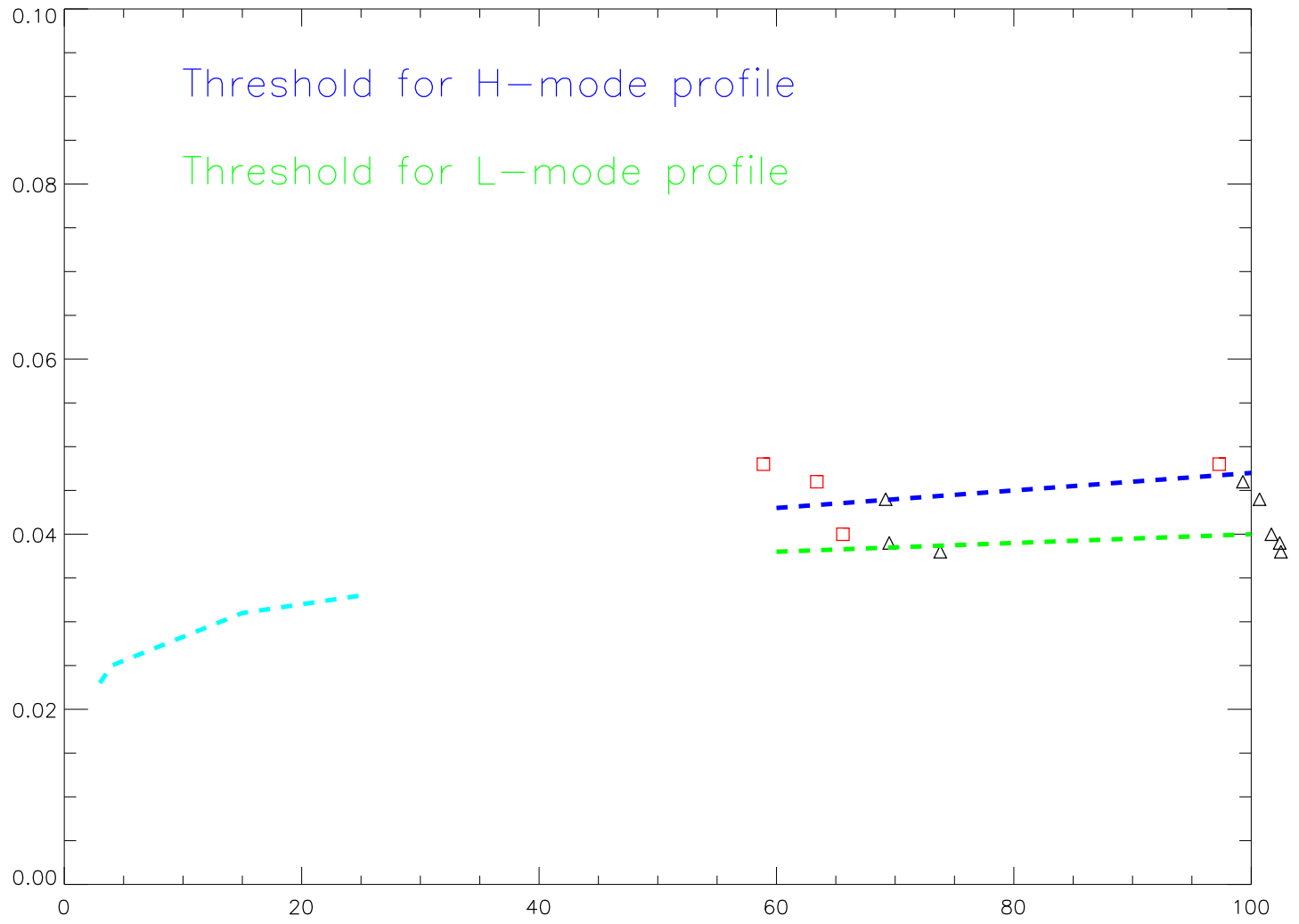
Can this model be extended to finite β ?

We apply this to NSTX



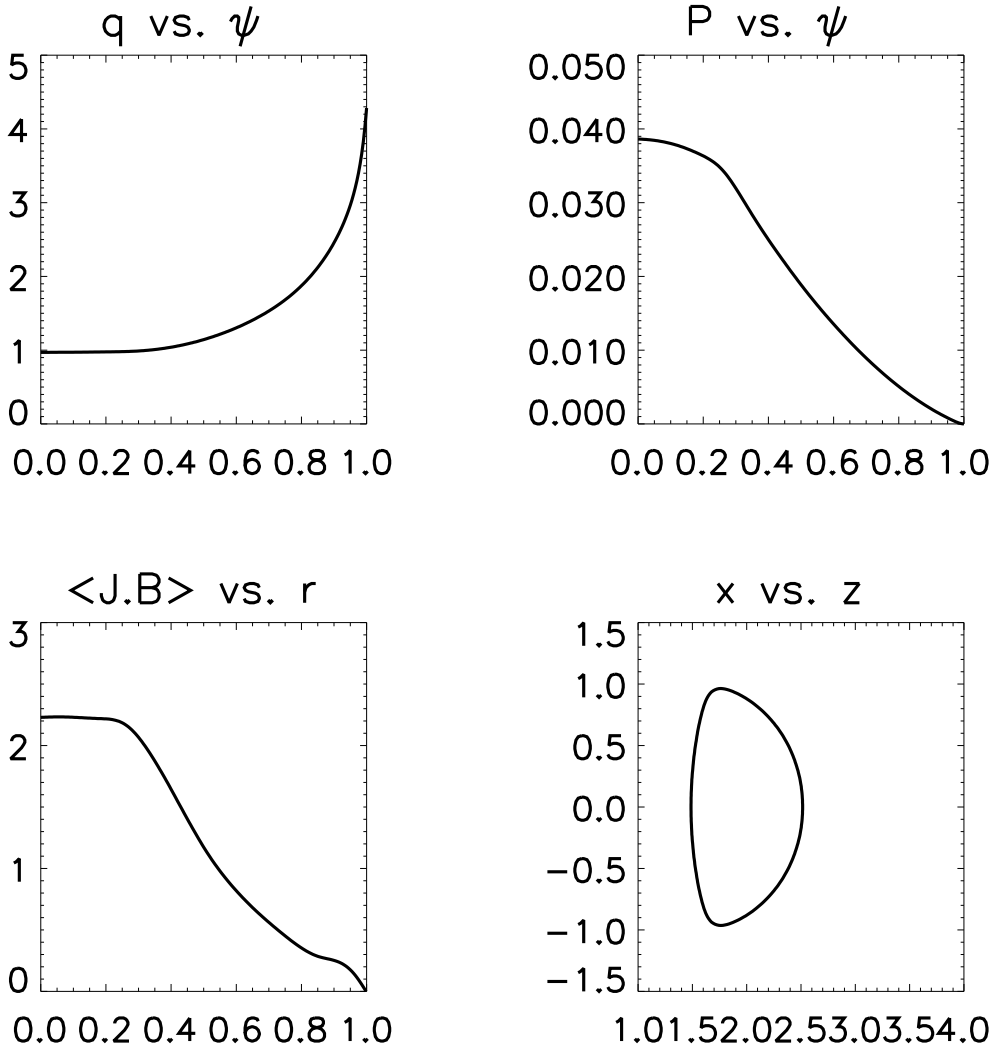
H-mode(solid) and L-mode(broken) profiles



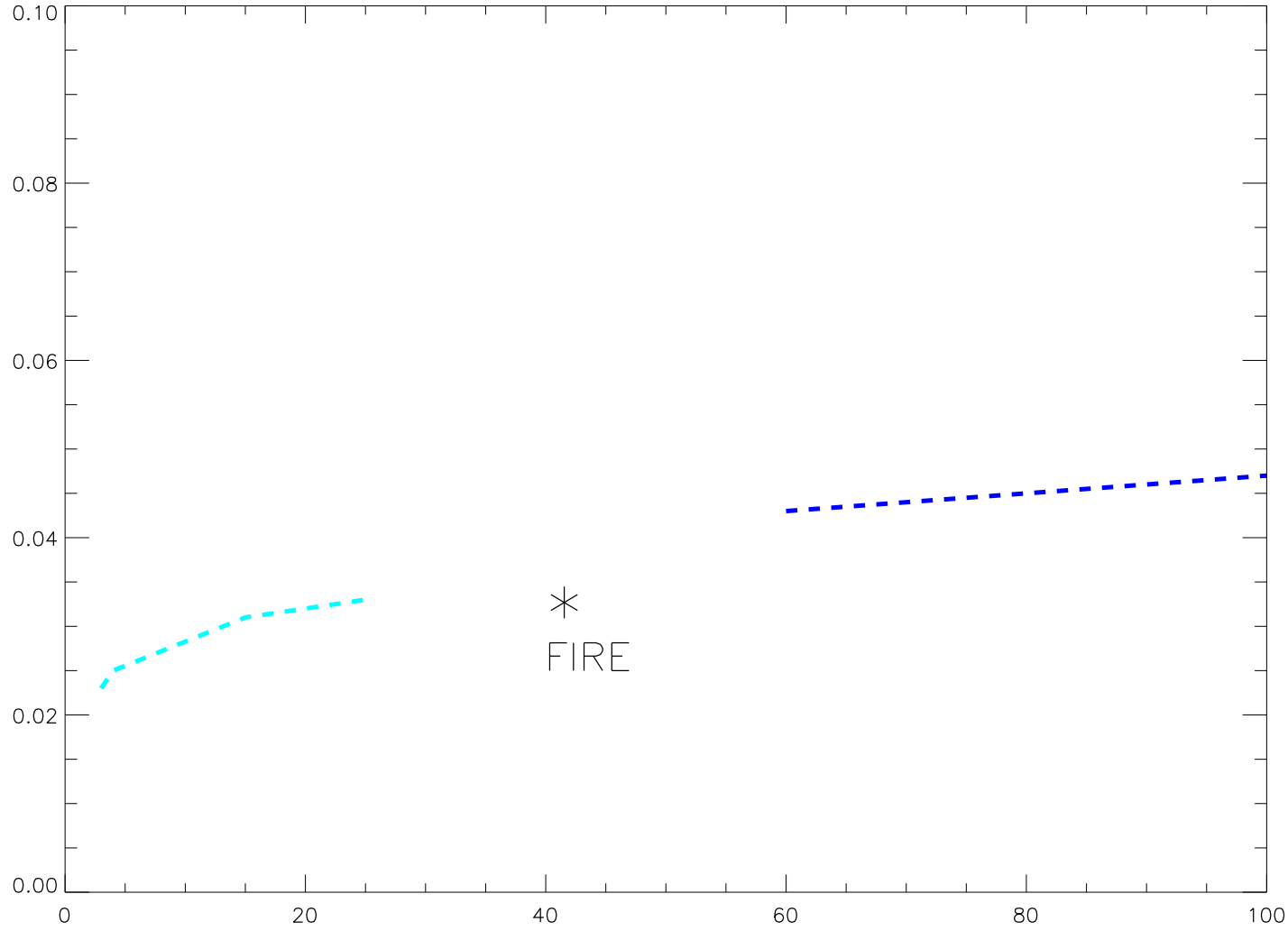


NSTX stability threshold with q_{edge} =5.5

The curve on the left is for the zero beta case with q_{edge} =2.8



FIRE profiles for β =3.3 and β_N =2.64



FIRE is below the stability threshold

DISCUSSION

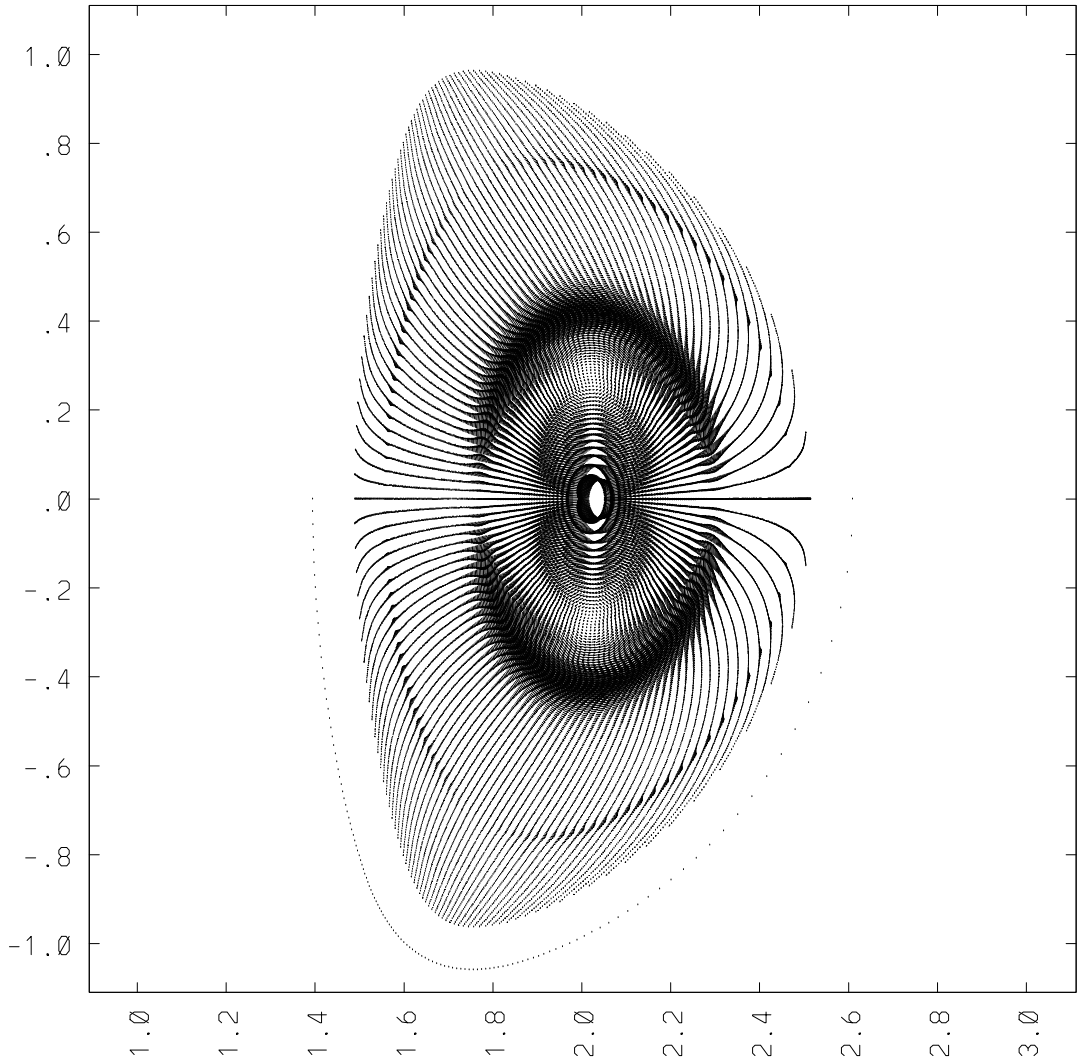
Kink stability depends on q_{edge} , J_{edge} , and the β
q' and J_{edge} are strongly coupled
The plasma shape can independently affect q'

- J_{edge} destabilizes the external kink
- Shear stabilizes the external kink
- The shear can be changed by changing J_{edge}
- The shear can be changed by changing the plasma shape

We can form an integrated picture of the external kink
by looking at I_{90} and q'

FIRE design point is stable to external kinks and
marginal for internal kink stability

Displacement vector showing an internal kink like structure



I=24641 EIGENVALUE=-Ø.83568E-Ø3 PHI IN DEG. Ø.ØØØØØE+ØØ