MHD Stability limits in Lithium Tokamak eXperiment (LTX)

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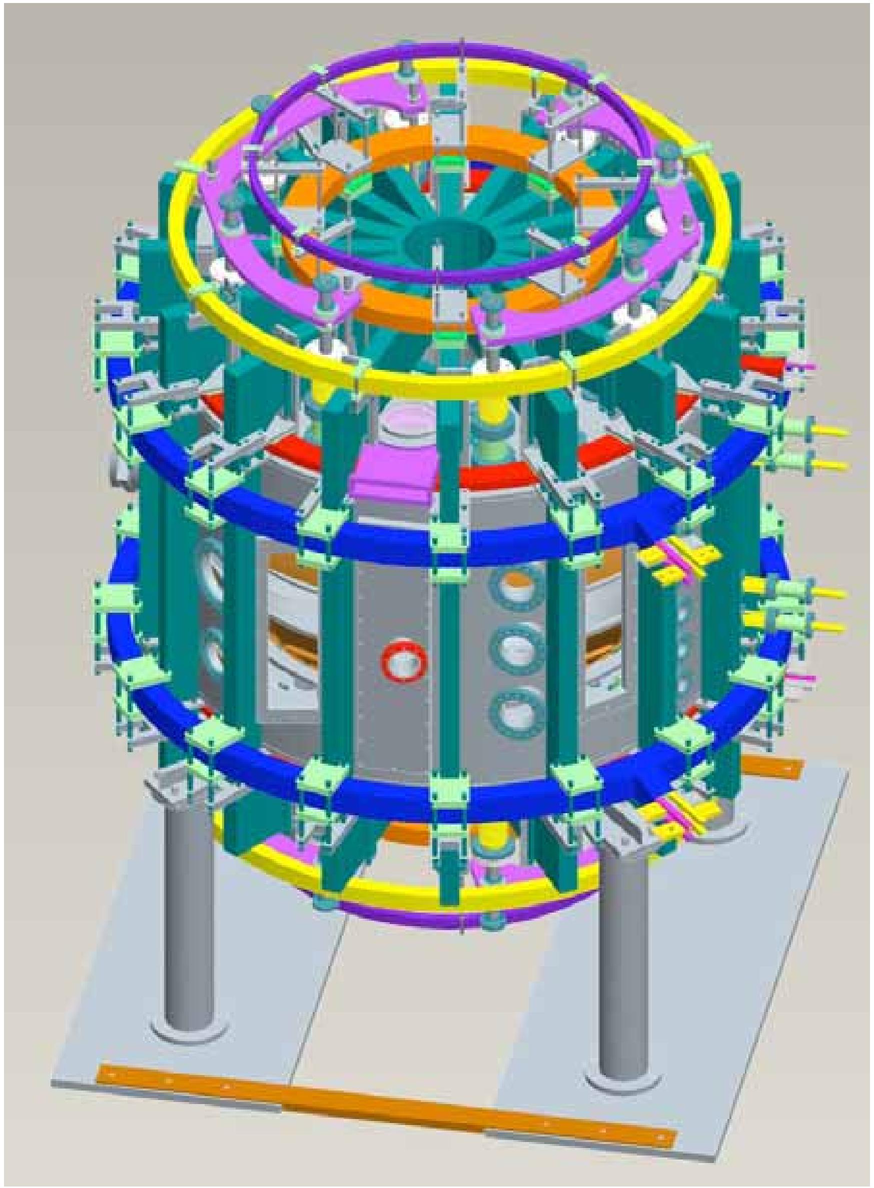
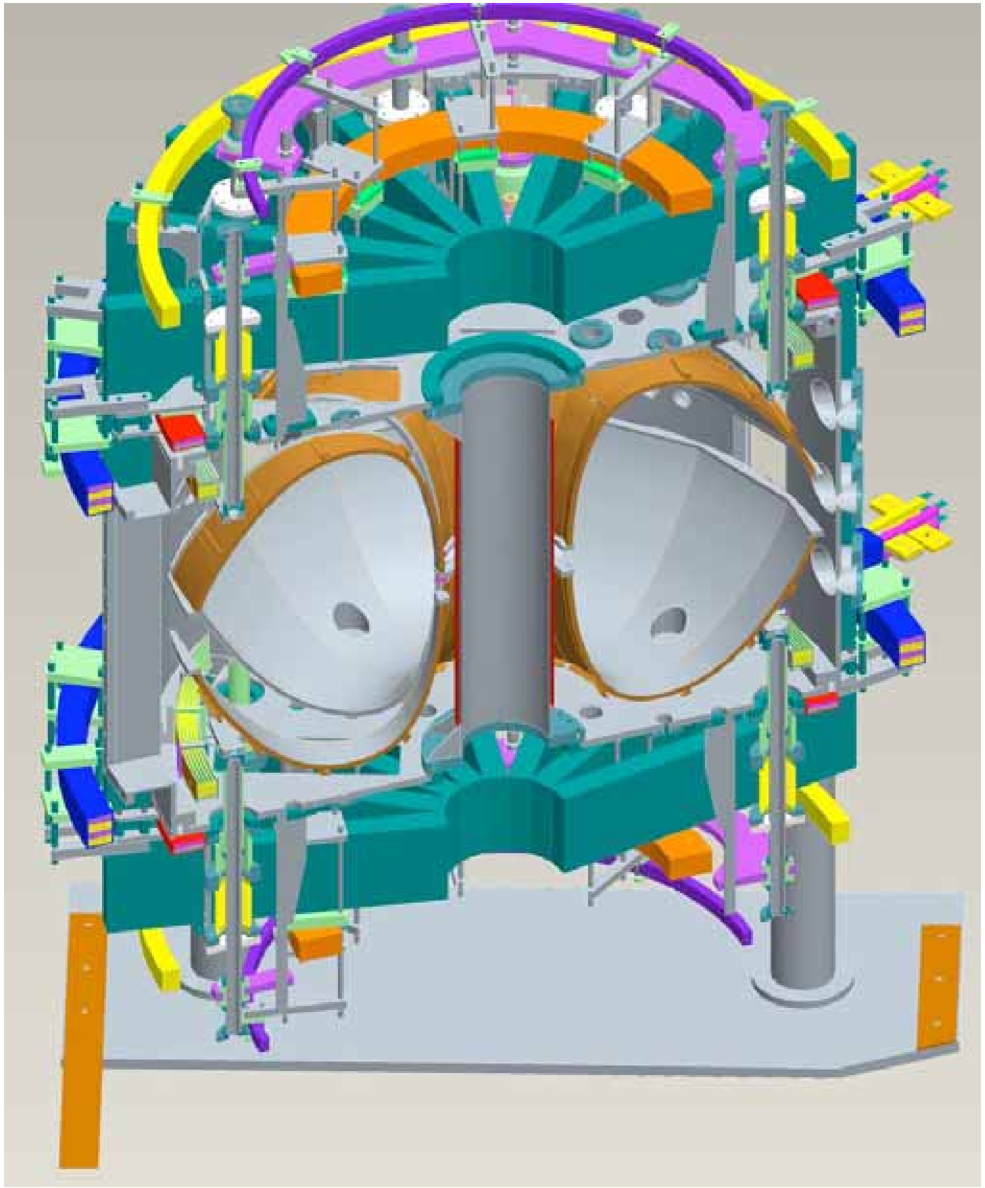
Abstract

- The Lithium Tokamak eXperiment, LTX, is expected to open access to new regimes in plasma-profile space. Of particular interest is the regime, characterized by nearly flat Te, a broad Ti, and a high edge current density. Another unique feature of LTX is the close fitting liquid Lithium wall, intended primarily for controlling the recycling; it would also affect the stability. This report addresses the ideal MHD stability of LTX. Target profiles are obtained from the ASTRA transport simulation code and the PEST stability code is used for stability analysis. Preliminary indications are that the n=1 mode, where n is the toroidal mode number, is stabilized by the close fitting shell, and a second stability regime for kink modes is accessed, as beta approaches β_N ~ 10. Results for n=1 and higher-n, will be presented.

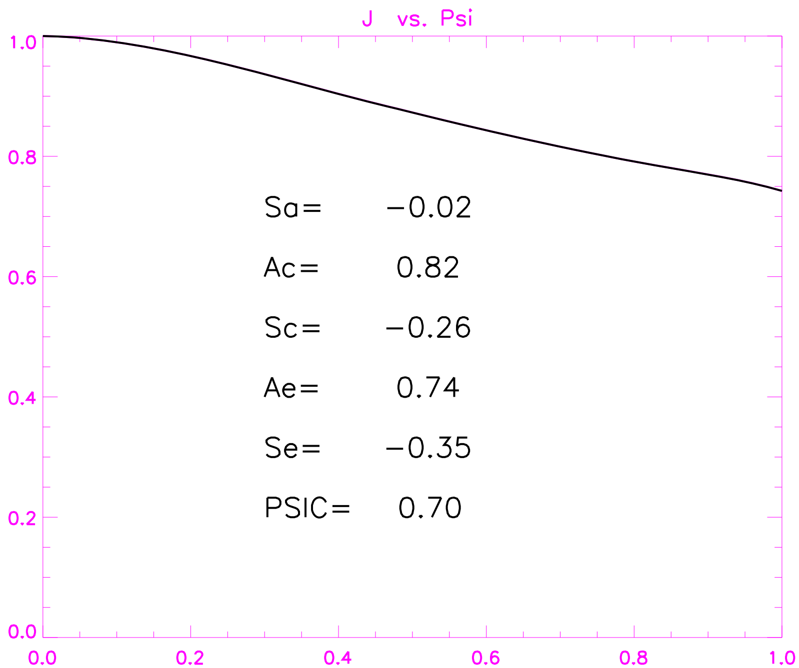
- This work was supported by DoE Contract No. DE-AC02-76-CH-3073



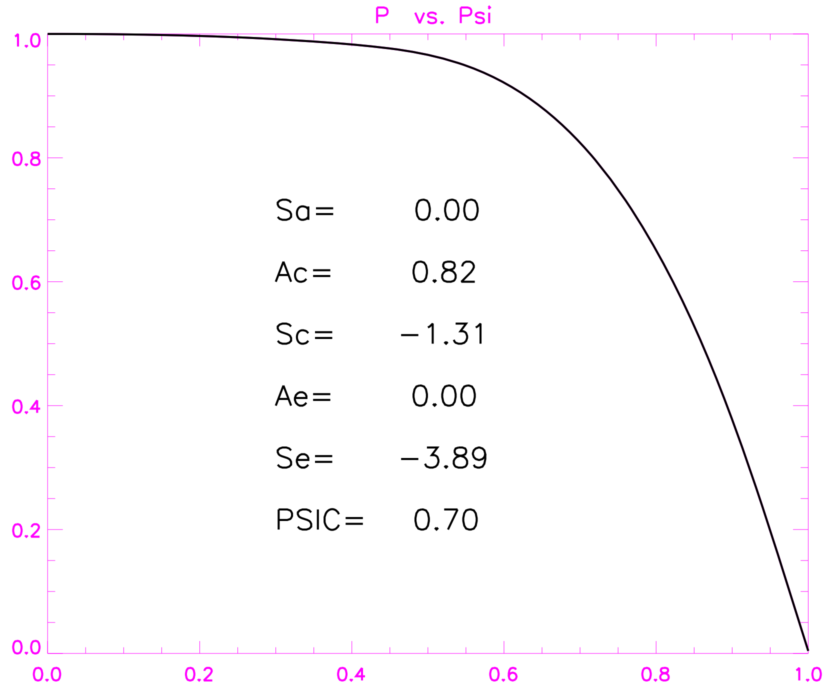


Two views of LTX are shown, which illustrate the essential features of the device.

LTX is predicted to access new regimes



$$\frac{< J \bullet B >}{< B \bullet \nabla \Phi >}$$



pressure

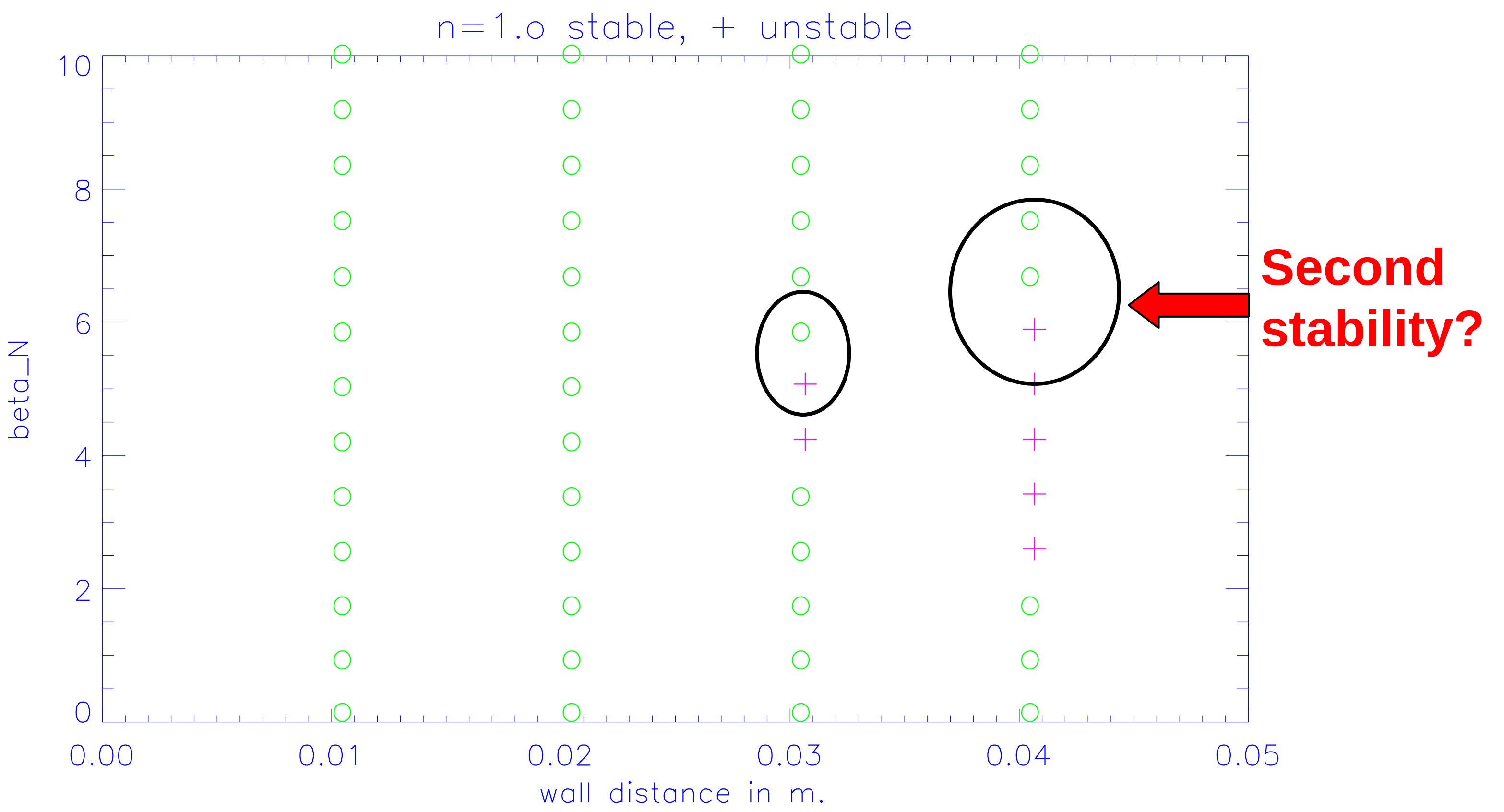
- nearly flat Te
- broad Ti ⇨ • Broad pressure
- high edge current density ⇨ • Peeling instability
- close fitting liquid Lithium wall ⇨ • Wall stabilization

Equilibrium sequence

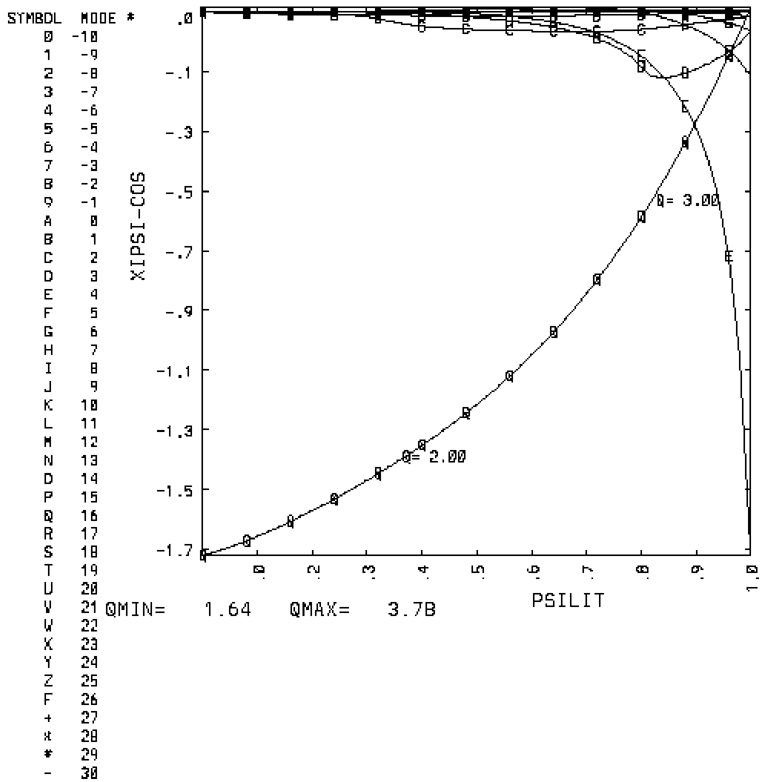
- Fixed boundary
- Specify Current $\frac{< J \bullet B >}{< B \bullet \nabla\Phi >}$
- Pressure profile
- Code: JSOLVER

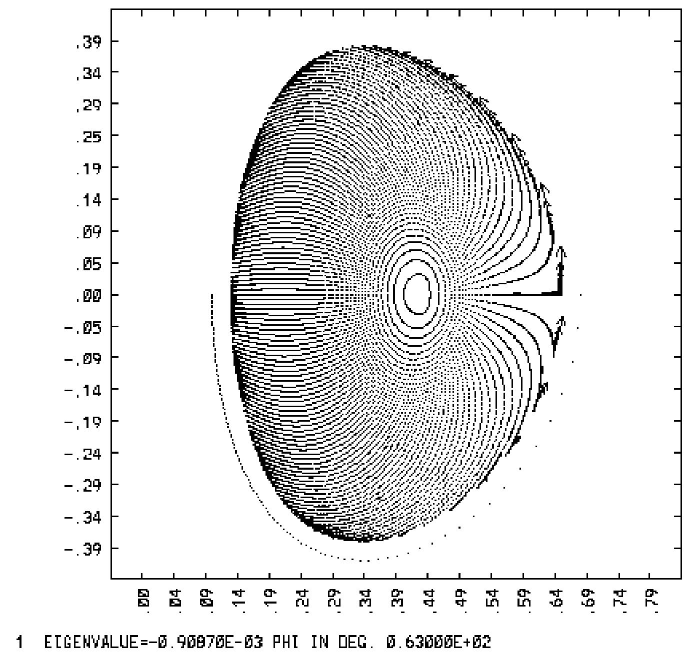
- Note that the figures show $\frac{< J \bullet B >}{< B^2 >}$

Stability to n=1 with an ideal wall



The instability is an edge 'peeling' mode





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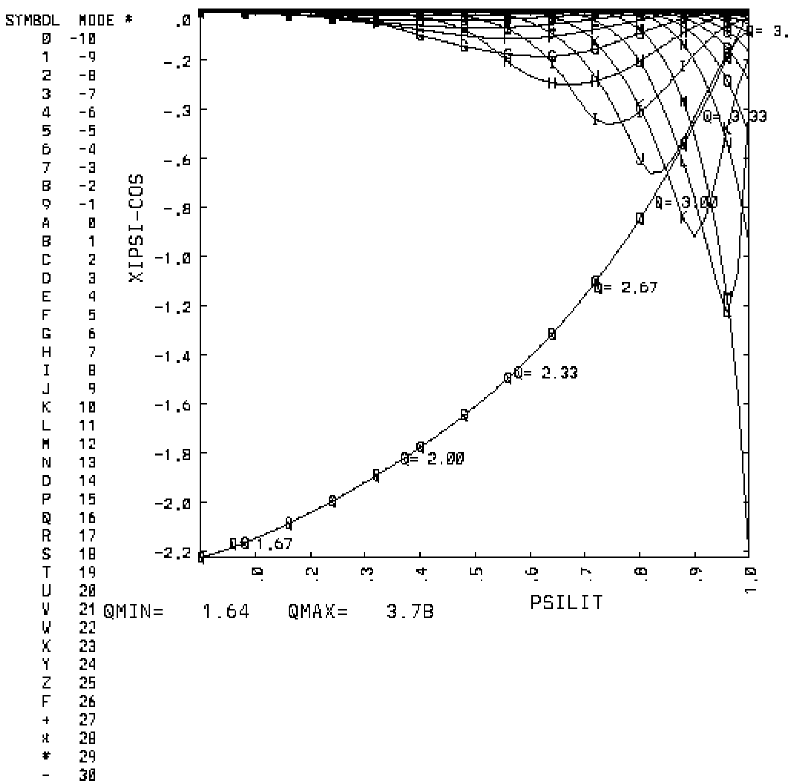
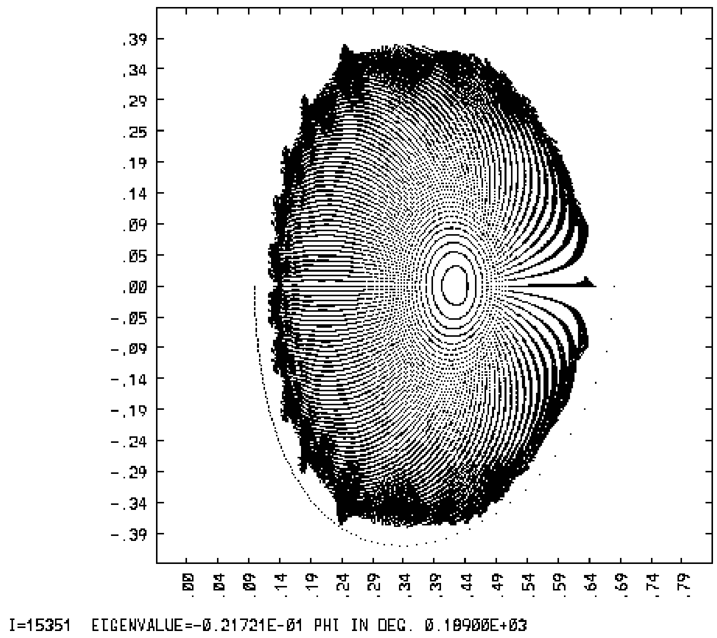
The mode is similar for higher n(=3)





To understand the stability properties we examine the plasma profiles

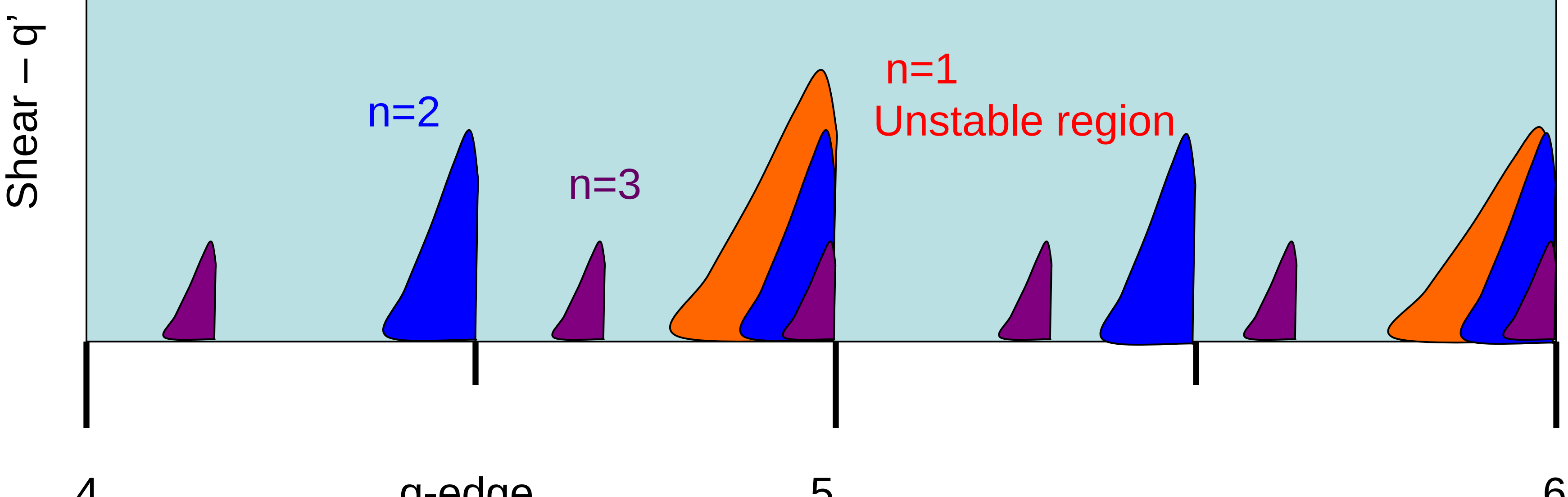
- Used fixed current profile
- Used fixed pressure profile function
  - $P = p0\ f_p(\psi)$
- Scaled p0 to increase β
- The edge q and shear q' change
  - Both increase with β
- The peeling mode is sensitive to both q,q'

Generic stability diagram for the peeling mode

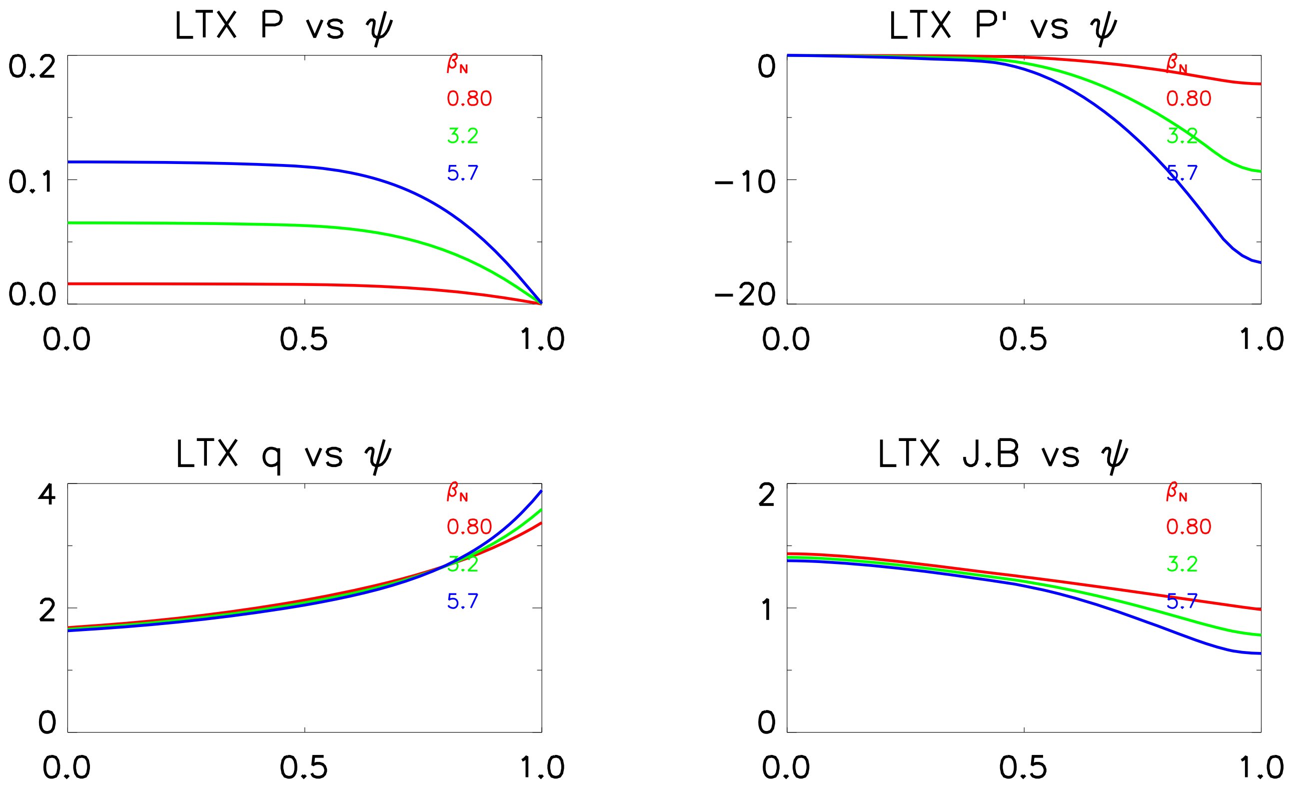
Instability is observed when nq (edge) is close to but less than an integer

Shear is stabilizing

Conducting wall is stabilizing



As β increases $\frac{<J \bullet B>}{<B^2>}$ decreases near the edge and the shear, q', increases



- nearly flat Te
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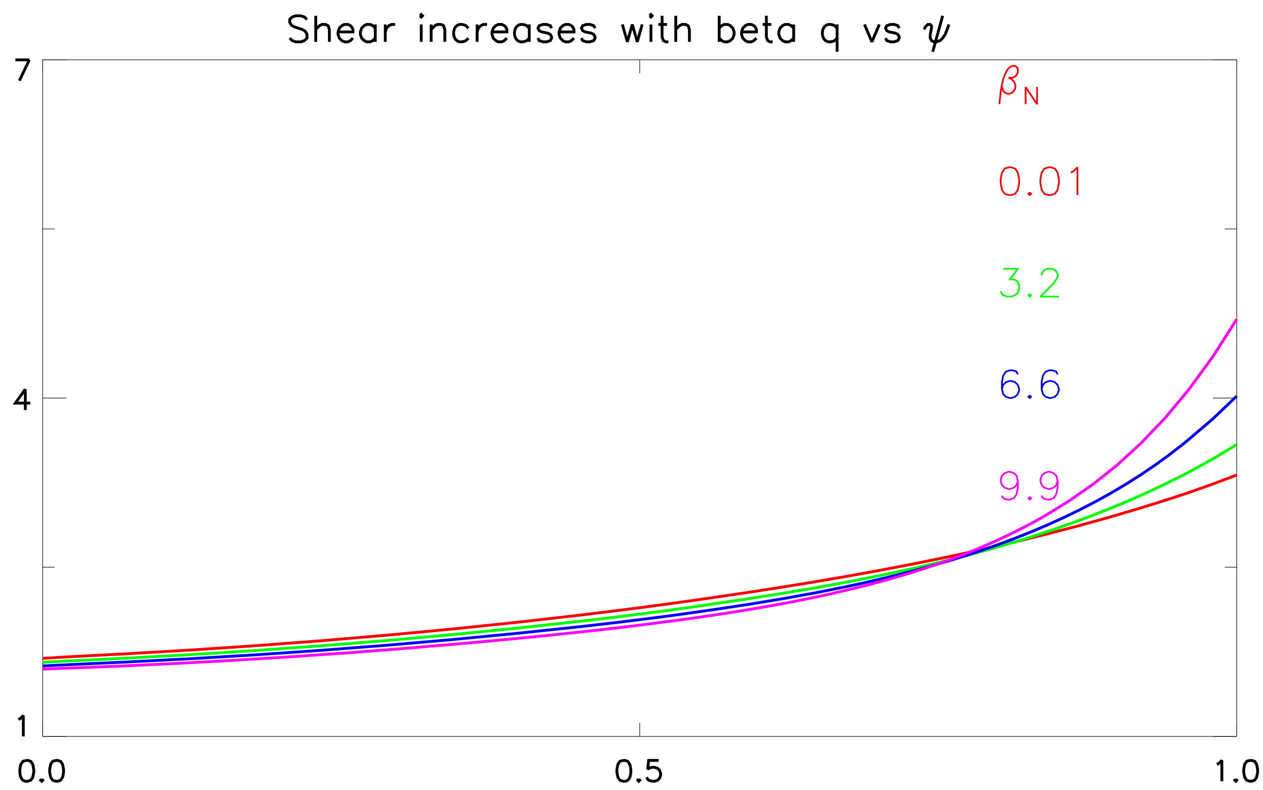
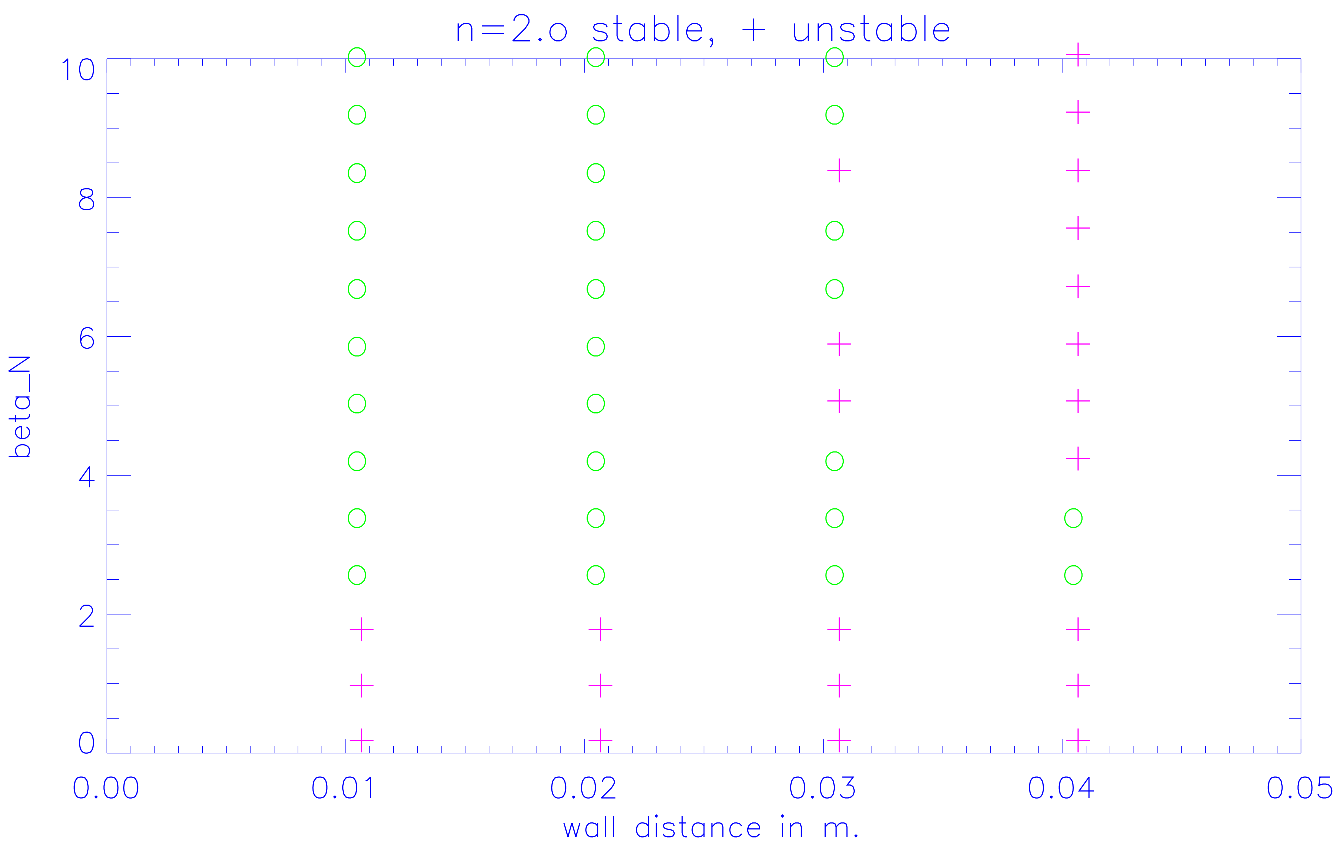
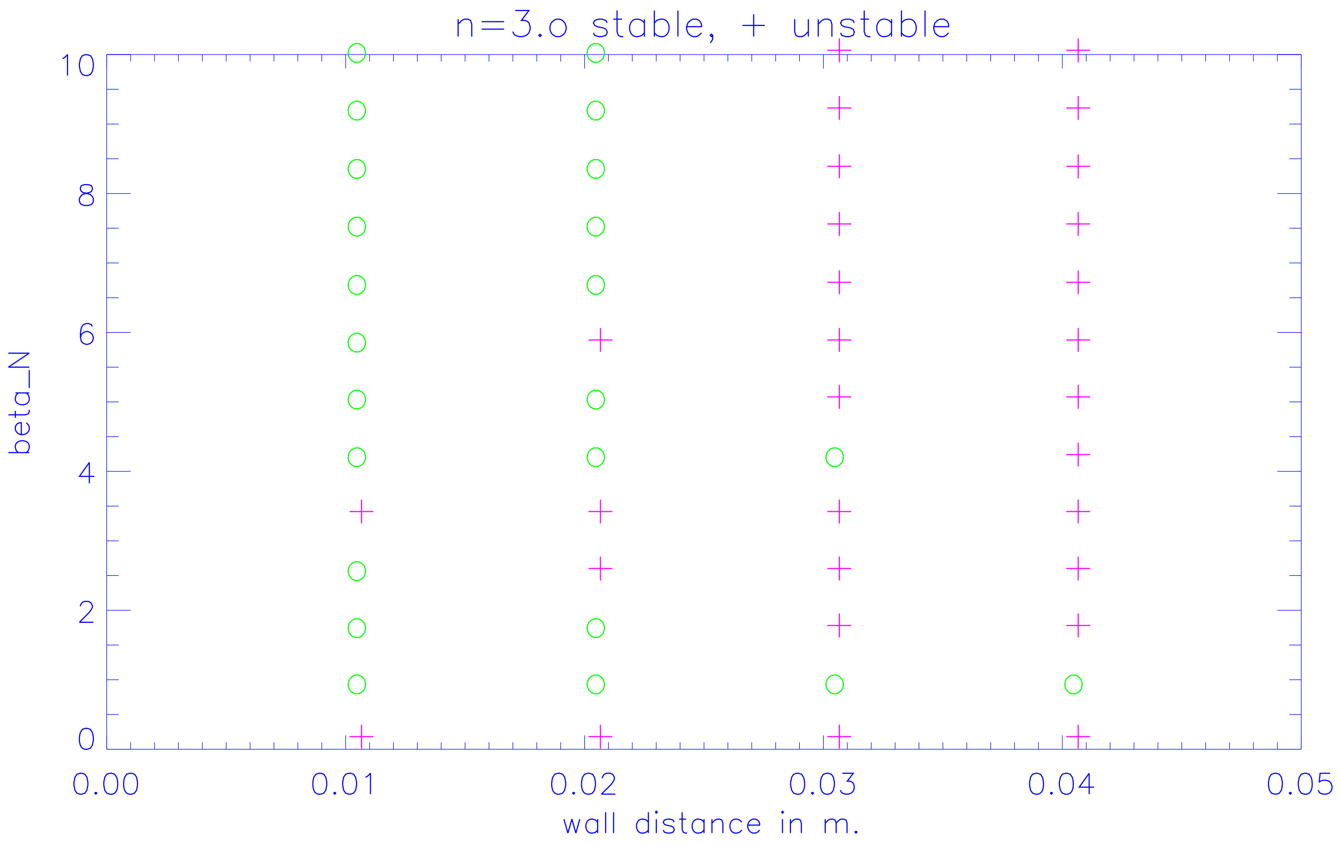


Shear increases with beta q vs ψ
7
4
1
0.0
0.5
1.0
βN
0.01
3.2
6.6
9.9

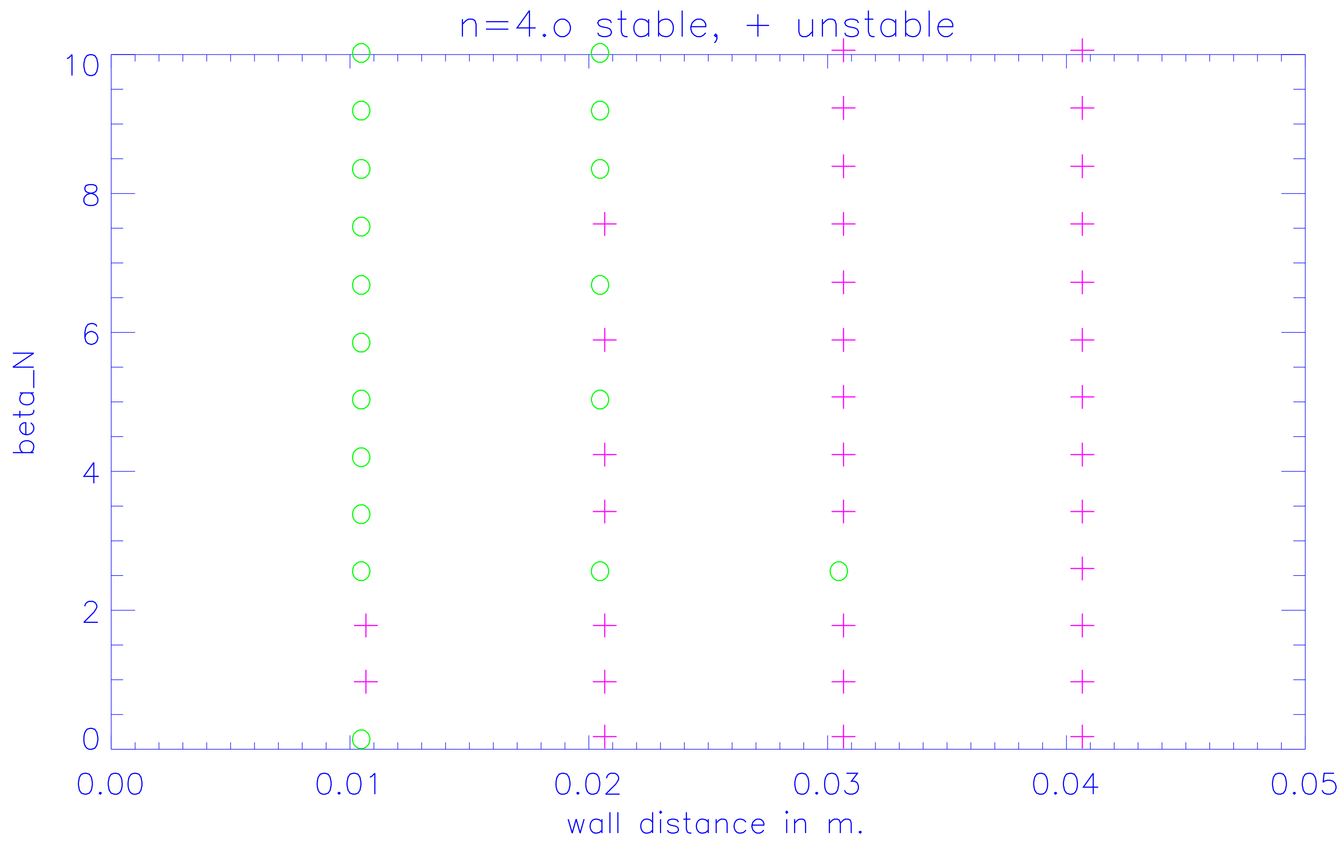
Stability to n=2 with an ideal wall



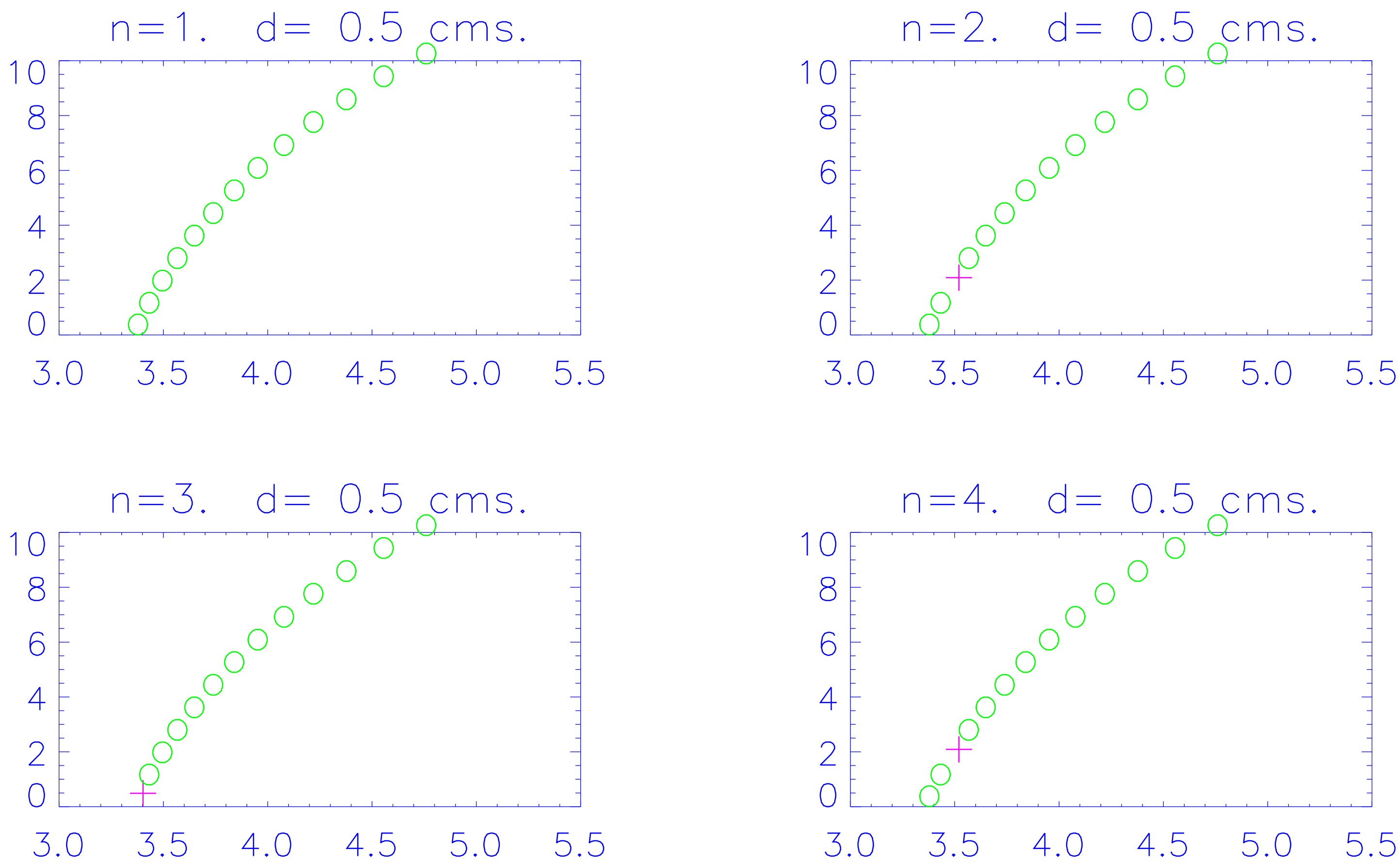
Stability to n=3 with an ideal wall



Stability to n=4 with an ideal wall



LTX wall distance will be less than 0.5 cm. instabilities are restricted to narrow bands of q_edge



Summary

- Examined the low-*n* ideal MHD stability
- Equilbrium based on ASTRA modeling
- Profiles are characterized by
  - High edge current-density
  - Broad pressure profiles
- Stability depends on
  - q_edge, beta, wall-distance
- LTX is stable upto beta_N ~ 10
  - Isolated regimes of instability when nq_edge < integer