EXPECTED β PERFORMANCE LIMITS IN ARIES-CS

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With Acknowledgements to:

Lang Lao	General Atomics
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Long-Poe Ku	PPPL

ARIES-CS Project Meeting

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Princeton Plasma Physics Laboratory

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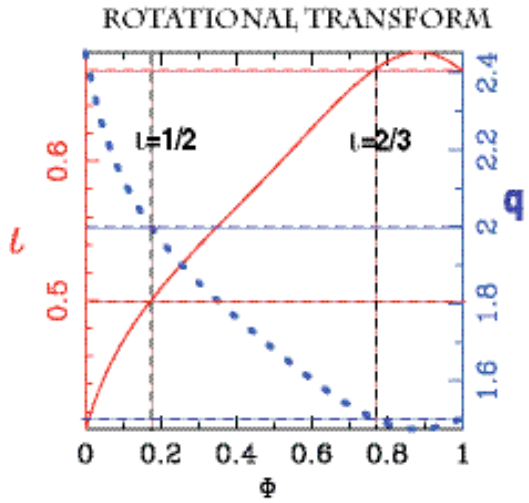
GENERAL ATOMICS

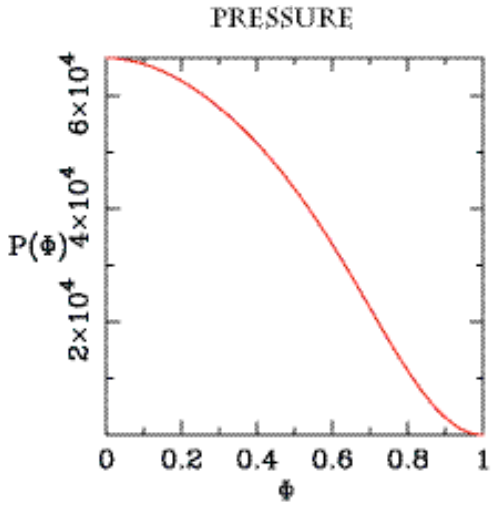
Stability for ARIES ARE Case is Likely Dependent on Profile Parameters As Well As Shape Parameters

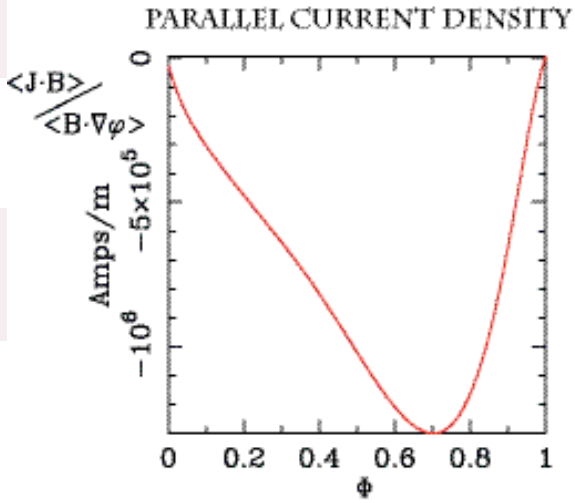
- **Lowest order rational ι = 0.5 is well inside core:**
  - Sole n=1 surface

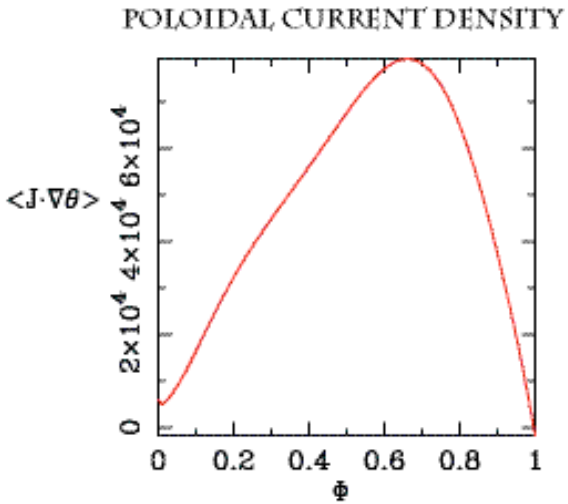
- **ι = 2/3 surface near edge:**
  - Sole n=2 surface (ignoring 4/2)
  - Near ι = 2/3 surface right near edge

- **Two n=3 surfaces present:**
  - 3/5 3/7 (ignoring 6/3)



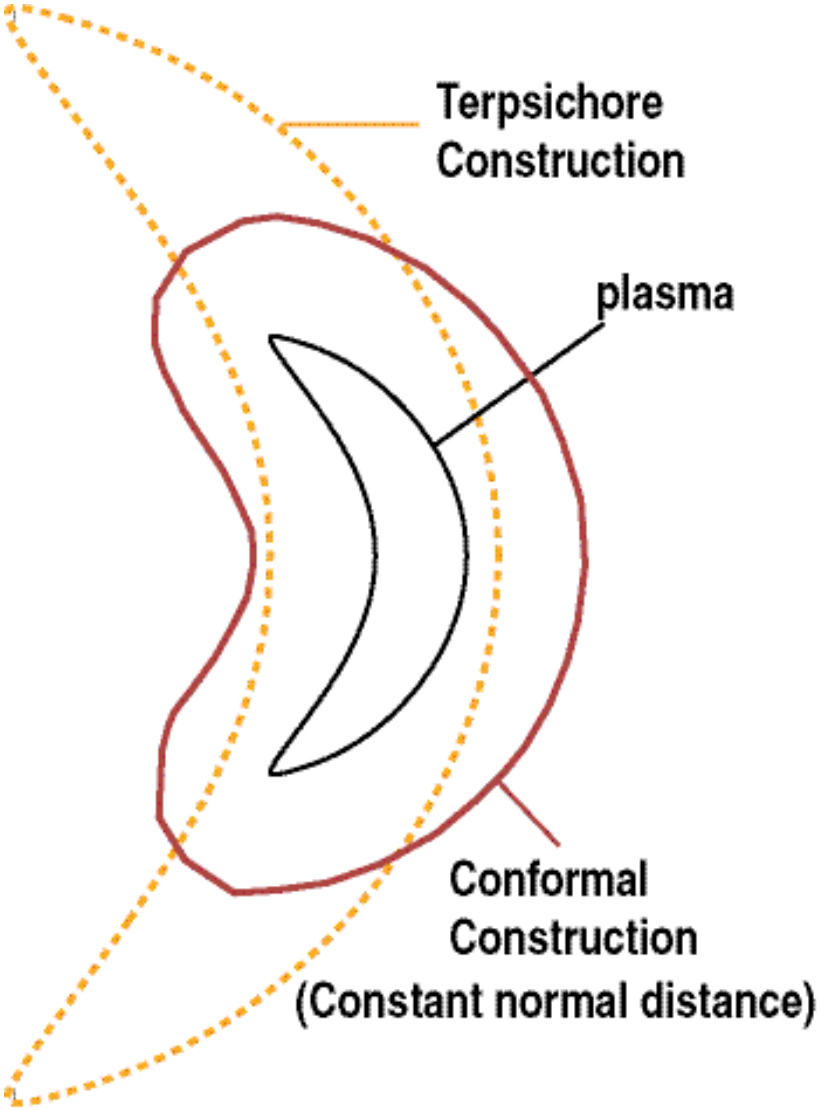




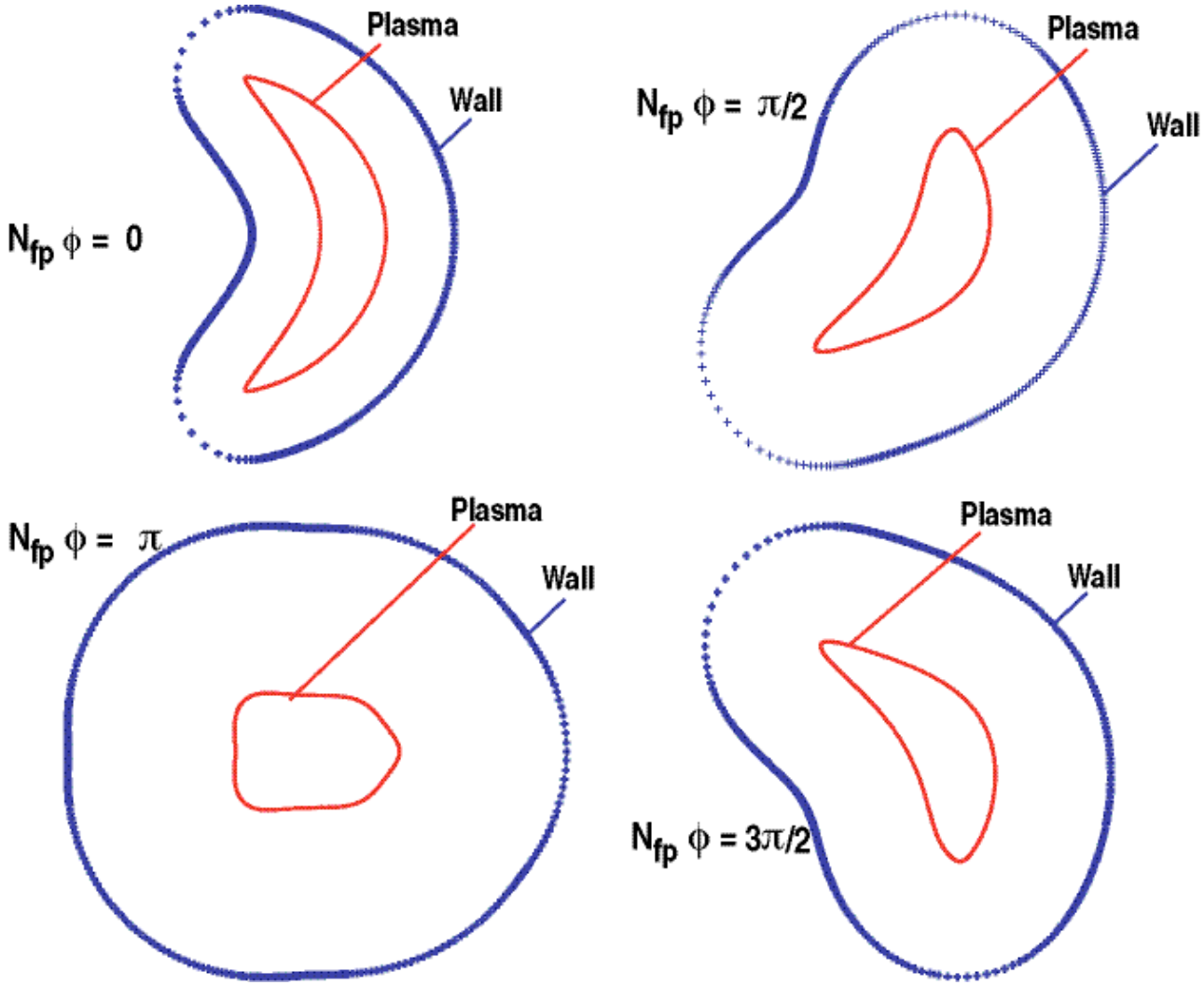


Wall Construction Requires More Conformal Wall with Constant Normal Distance

- **Wall is presently constructed as 'self-similar':**
  - Scaled plasma boundary Fourier harmonics excluding (m,n) = (0,0)
  - Modified with toroidal n = 1 variation to be closer to conformal



New Conformal Wall Construction with Constant Normal Distance Is Reasonable At All Toroidal Angles



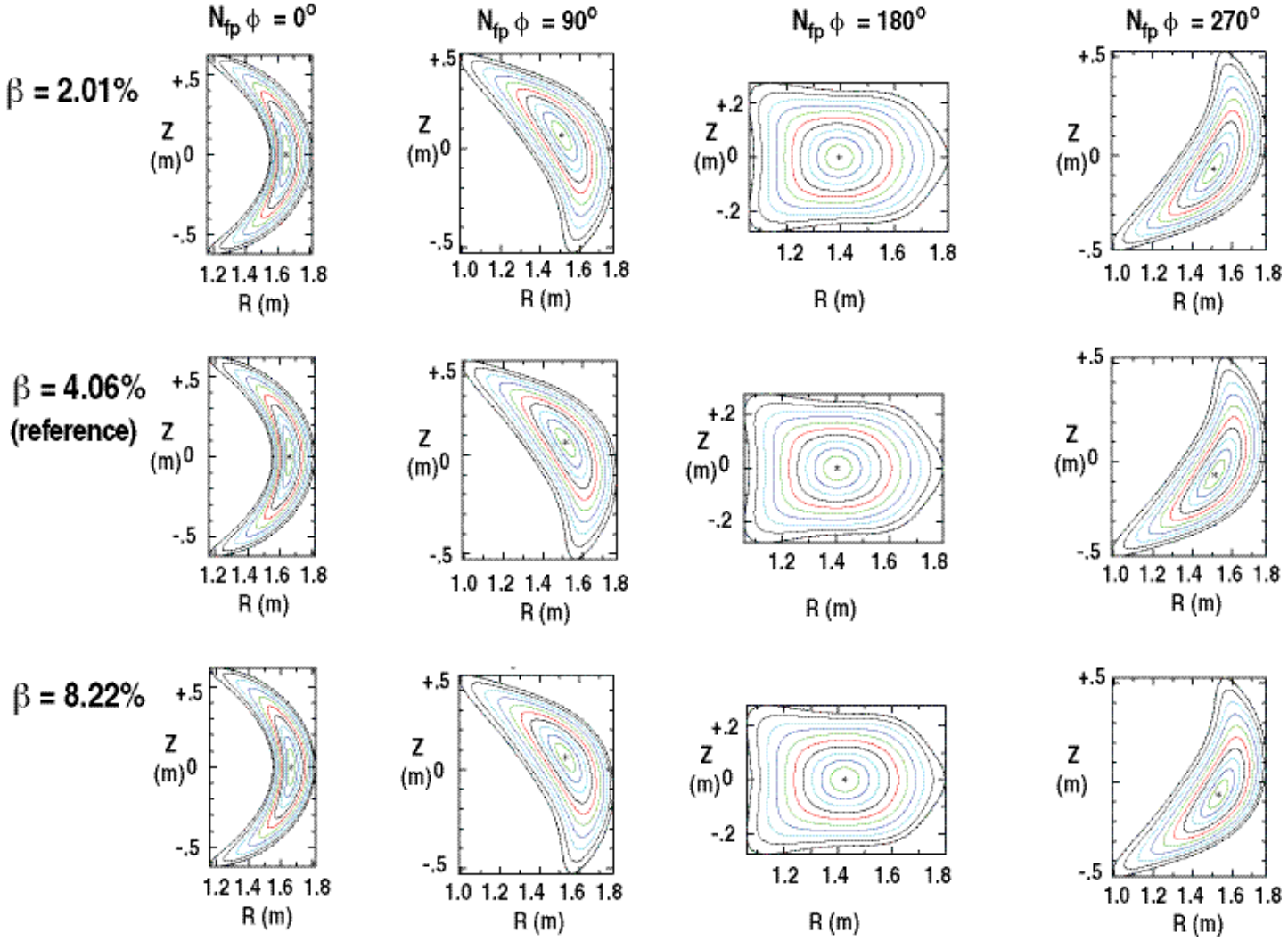
Proposed Variation in Profile and Shape Parameters

- **Vary ι profile by moderate amounts:**
  - Add in and delete lowest order rational surfaces:
    - ι = 2/3 inside edge
    - ι = 2/3 at very edge
    - Also ι = 3/4
  - Vary pressure profile:
    - Overall pressure peaking
    - Sensitivity to steepened edge pressure gradient (H-mode)
    - Sensitivity to flattened edge pressure gradient (ergodic edge)
    - Sensitivity to steepened internal local pressure gradients (ITBs)
- **Vary curvature around bean cross sections:**
  - Determine sensitivity to divertor modifications:
    - Sharpness of bean cross section
    - Other proposed divertor positions

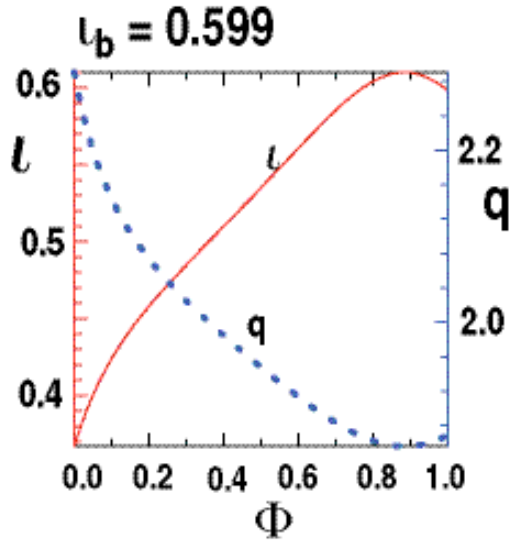
Completed First step:

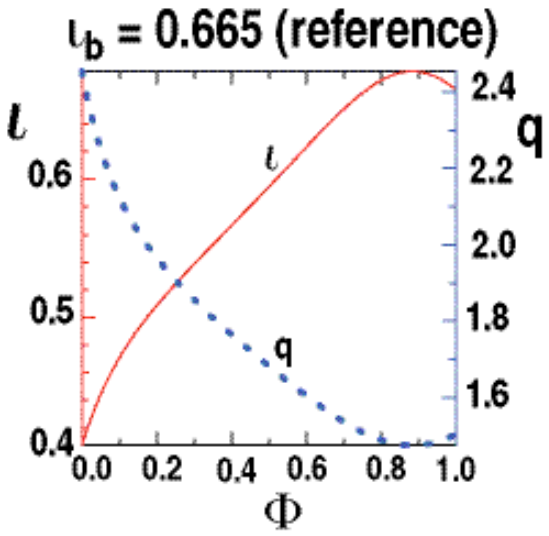
Remaining steps to follow in next few weeks

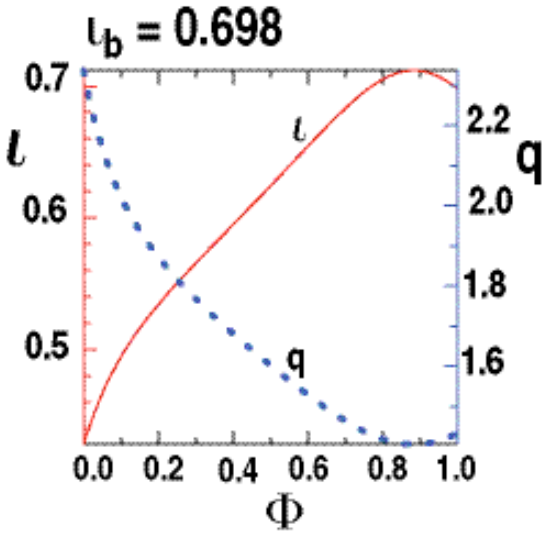
ARIES ARE Equilibria: β Sensitivity Scan At Constant ι Profile

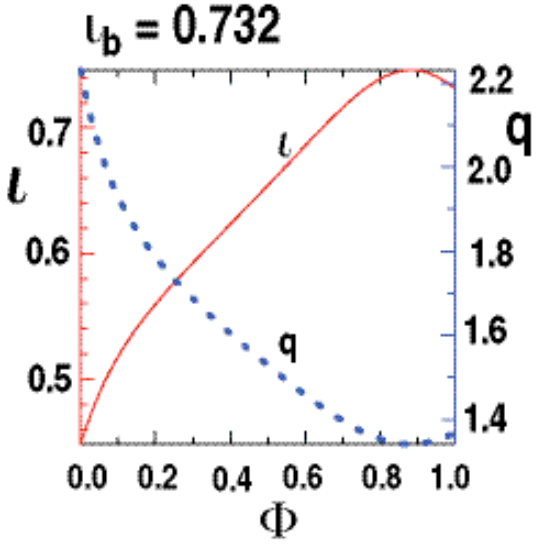


ARIES ARE Equilibria: ι Profile Sensitivity Scan At Constant β





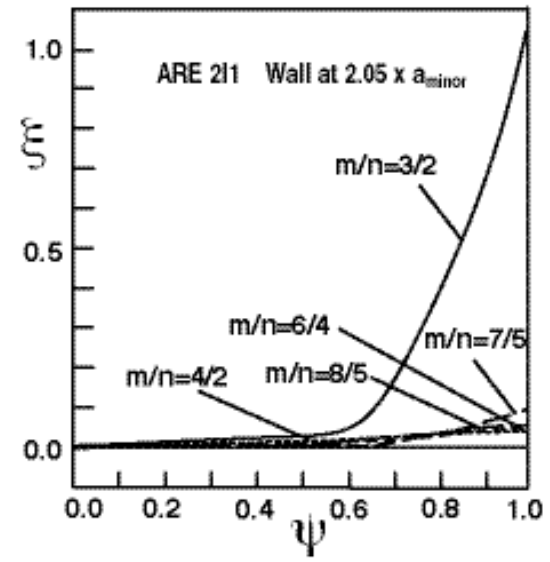


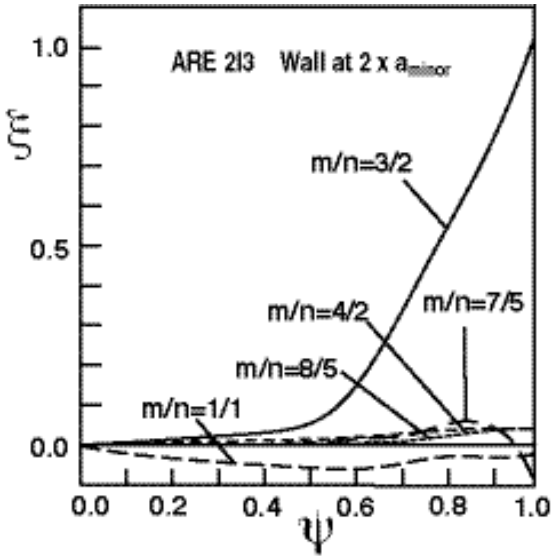


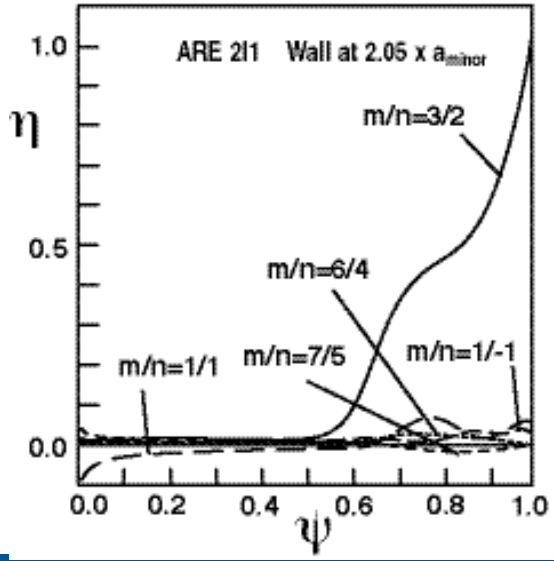
Sensitivity Scan Stability Summary

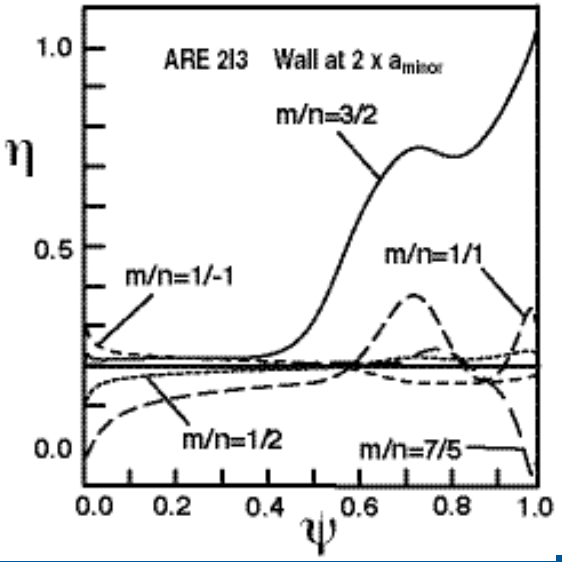
- **Terpsichore calculations with conformal wall at twice plasma radius:**
  - 197 radial flux surfaces
  - Up to 101 toroidal-poloidal mode combinations
- **Varying β at constant ι:**
  - Reference case β = 4.06%: Marginal unstable ($\gamma^2 \sim 10^{-7}$)
    - 9/6 (10/6 5/3) peaked at edge and
    - 6/4 3/2 7/4 2/1 10/7 peaked at edge
  - Decreasing β = 3.24%, 2.01% at constant ι is weakly destabilizing
  - Increasing β = 4.88%, 6.13%, 8.22% at constant ι is stabilizing:
    - Stable still at 8.22% for this ι profile
  - Interpreted as a weakly unstable current driven mode
  - Otherwise, robustly stable
- **Varying ι profile at constant β:**
  - ι_b = 0.698: Unstable 3/2 7/5 6/4 8/5 4/2 peaked at edge ($\gamma^2 \sim 10^{-3}$)
  - ι_b = 0.599: Marginal unstable 13/5 14/5 12/5 11/5 peaked in core ($\gamma^2 \sim 10^{-8}$)
  - ι_b = 0.732: Unstable 3/2 7/5 1/1 4/2 8/5 peaked at edge ($\gamma^2 \sim 10^{-3}$)

Predominantly 3/2 Modes Unstable When ι = 2/3 Surface Enters Edge Plasma

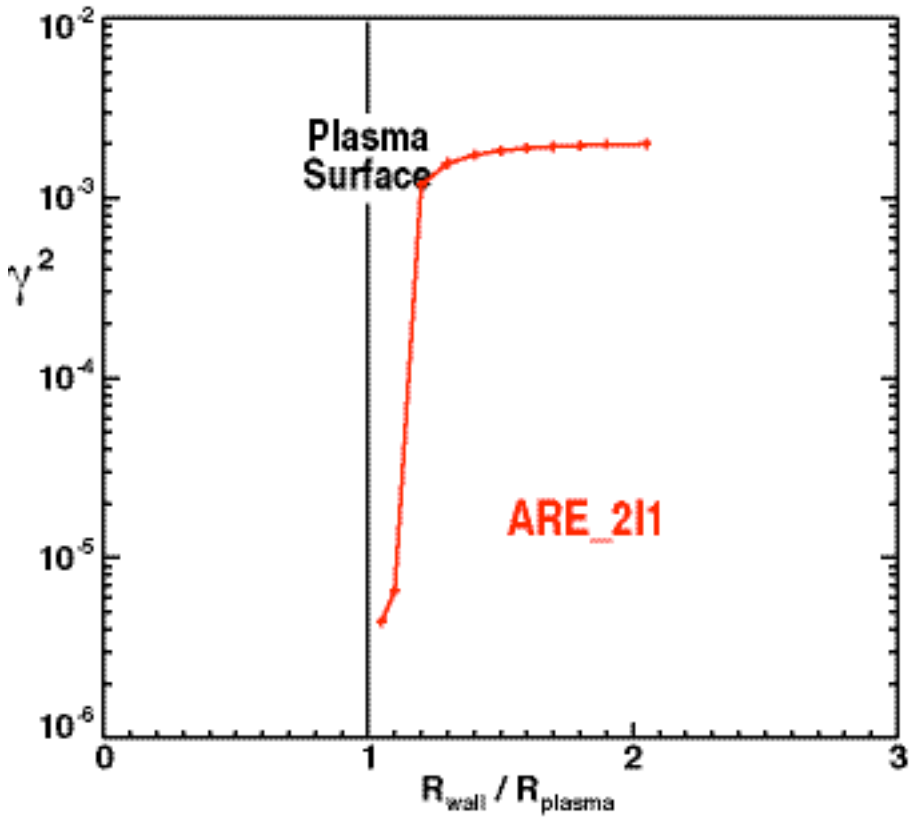


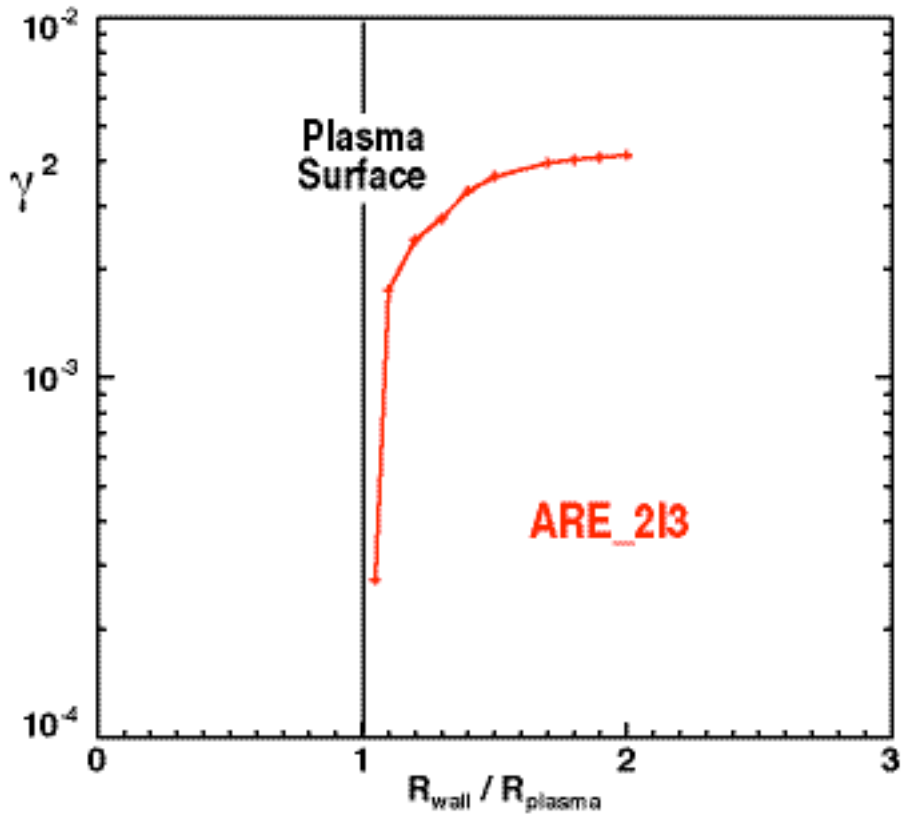






Unstable 3/2 Modes Appear to Be Stabilized Only By Close Fitting Conformal Wall





Key is to keep 2/3 surface outside plasma

Status of Proposed Stability Analysis For January 2006 To December 2006: As of October 1 2006

MAJOR TASK	SUBTASK	STATUS	COMMENTS
Investigate impact of variations from the baseline Scaled NCSX and MHH2 configurations on system performance	Apply the equilibrium and stability tools to evaluate sensitivity to minor variations in the geometry	***Initiated (January 04)***	*Base NCSX and MHH2 configurations were evaluated previously*
	Apply the equilibrium and stability tools to evaluate sensitivity to the ι and pressure profiles	***In Progress (October 06)***	*Required tools are set up to perform more systematic studies*
	Identify the key issues that affect the β limit	***Proposed***	*Expectation from tokamak experience is that ι and pressure will be key parameters*

- **Check sensitivity of NCSX 'ARE' case to:**
  - Edge rationals by modifying ι profile
  - Edge pressure by flattening profile at edge
  - Boundary shape

- **Check sensitivity of MHH2 16 coil case**
- **Check sensitivity of SNS configuration**