UPDATE ON β LIMITS FOR ARIES-CS

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ARIES-CS Project Meeting

January 23 2006

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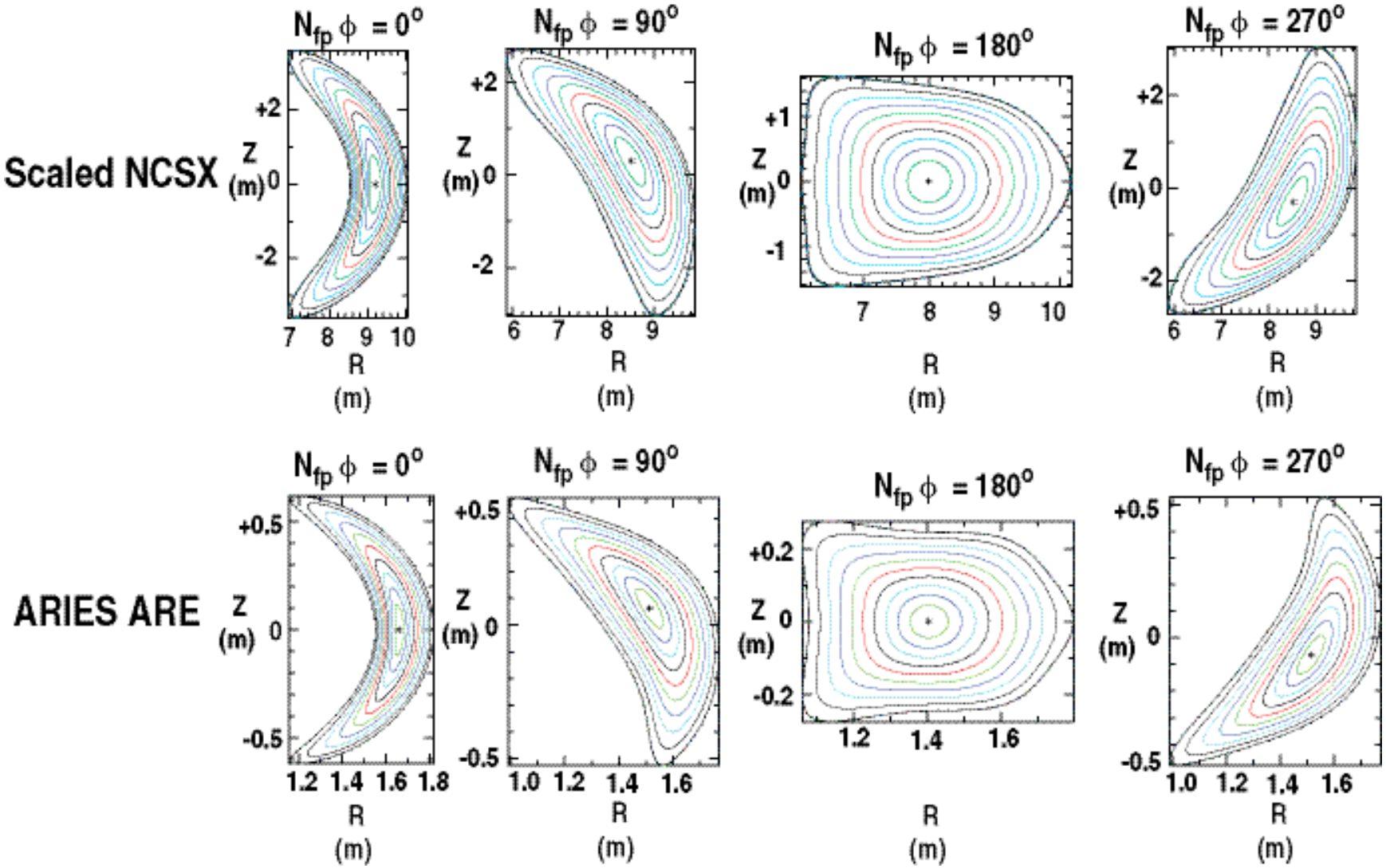
Proposed Stability Analysis For January 2006 To December 2006

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	***Initiated (January 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*

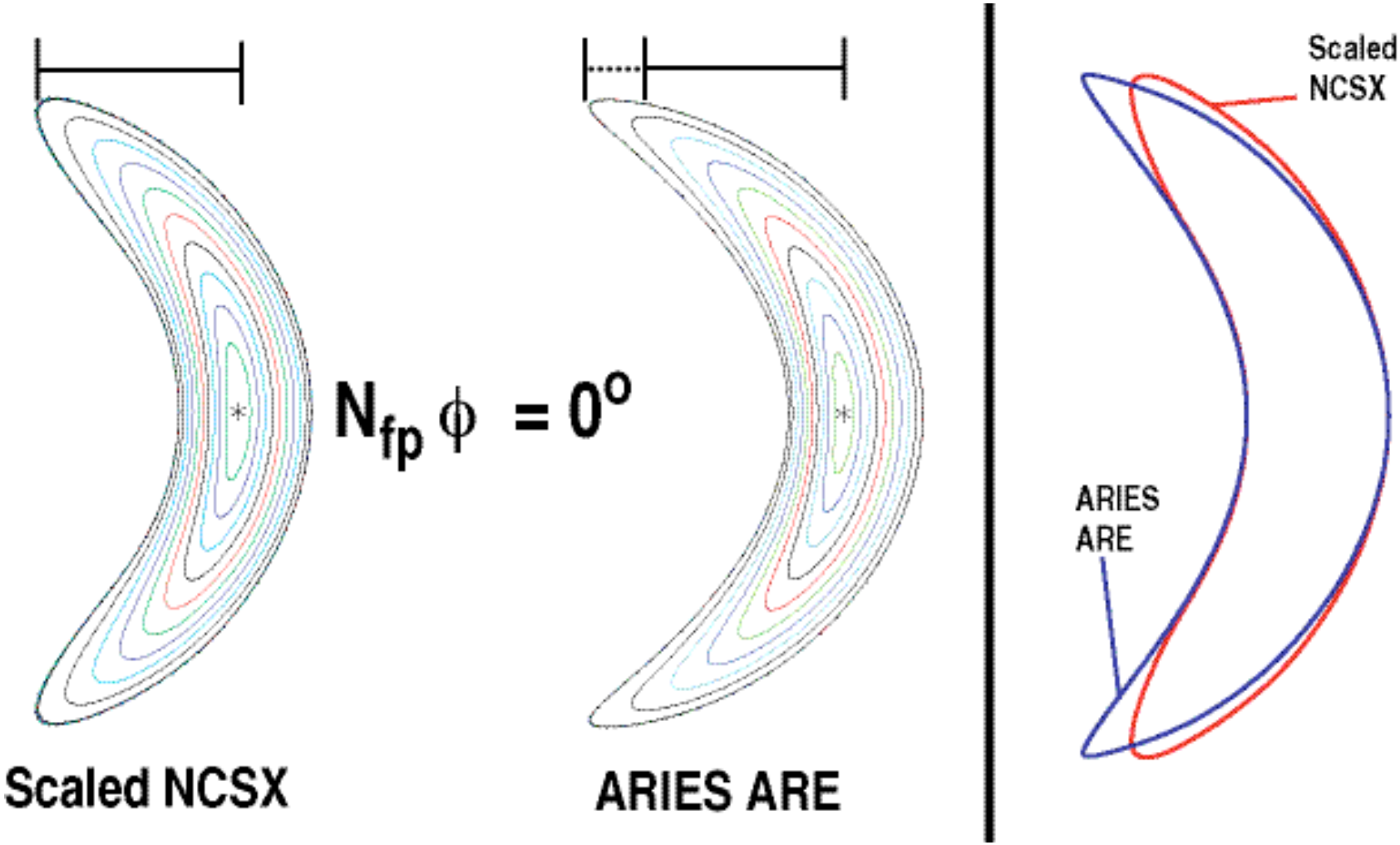
- **Check sensitivity of NCSX 'ARE' case to:**
  - Edge rationals by modifying ι profile
  - Edge pressure by flattening profile at edge
  - Boundary shape

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

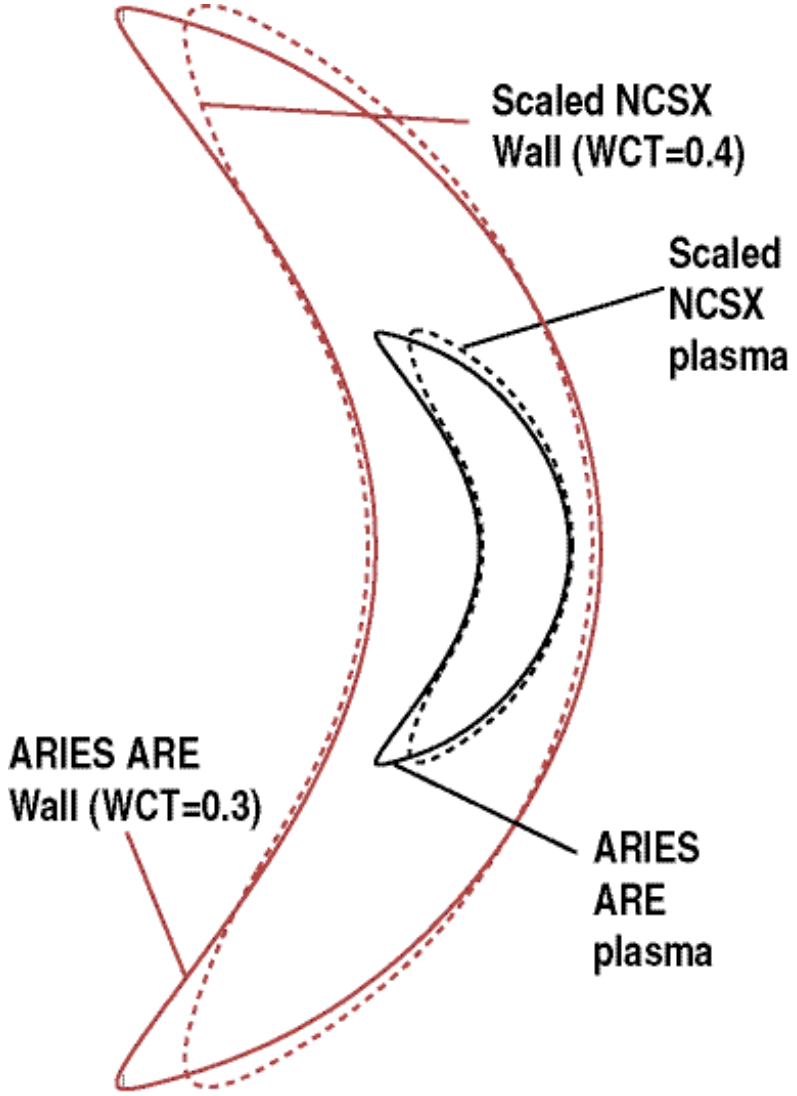
ARIES ARE Equilibrium Reconstruction Has Some Differences With Previous Scaled NCSX Equilibrium



ARIES ARE Equilibrium Has More Pointed Bean Cross Section then Earlier Scaled NCSX Cross Section



Wall Construction in Terpsichore Fails Due to Pointed Bean Cross Section



Wall for Scaled NCSX case follows plasma boundary reasonably well at bean cross section

Wall for ARE case does not follow plasma boundary well at bean cross section

All wall positions for ARE failed to run:
Wall either comes too close to bean tips or too close to outboard midplane

Previous Improved Wall Construction Used New Parameter WCT to Add Toroidal Modulation

- **Wall is constructed as an underlying 'self-similar' wall:**
  - Each fourier harmonic except (m,n) = (0,0) is scaled by the same factor k
  - Each wall point is then moved k times the distance of $((R_p-R_{0,0}),(Z_p-Z_{0,0}))$

$$R_p = R_{0,0} + \sum_{n,m} R_{n,m}\left[\cos(m\theta + n\phi)\right] \qquad R_w = R_{0,0} + k\sum_{n,m} R_{n,m}\left[\cos(m\theta + n\phi)\right]$$

$$Z_p = Z_{0,0} + \sum_{n,m} Z_{n,m}\left[\sin(m\theta + n\phi)\right] \qquad Z_w = Z_{0,0} + k\sum_{n,m} Z_{n,m}\left[\sin(m\theta + n\phi)\right]$$

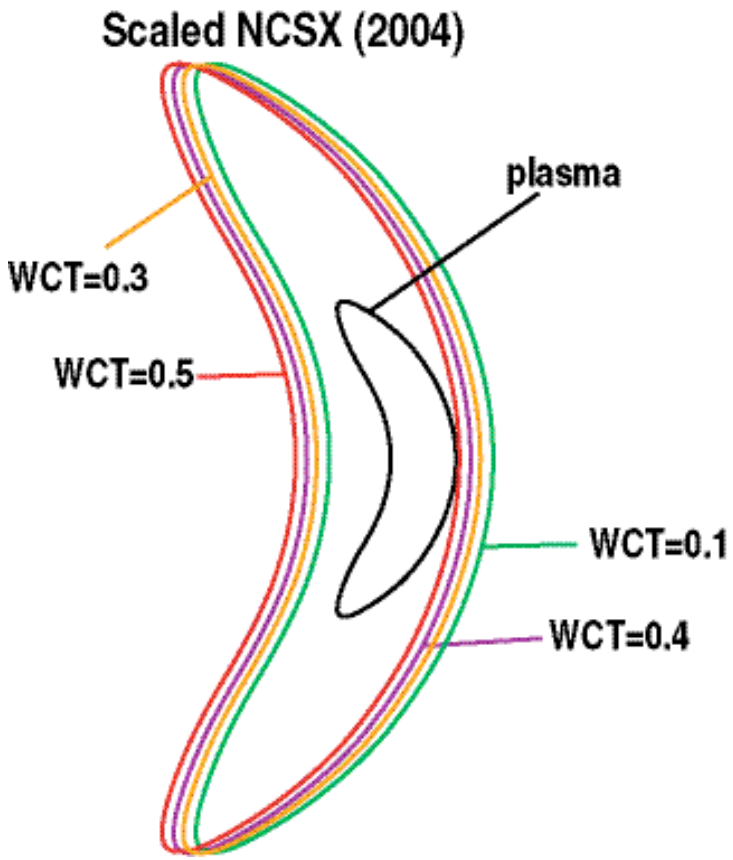
$$\left(R_w - R_{0,0}\right) = k\left(R_p - R_{0,0}\right) \qquad \left(Z_w - Z_{0,0}\right) = k\left(Z_p - Z_{0,0}\right)$$

Key point: plasma-wall distance proportional to local distance of R_p from $R_{0,0}$ i.e. to the local elongation

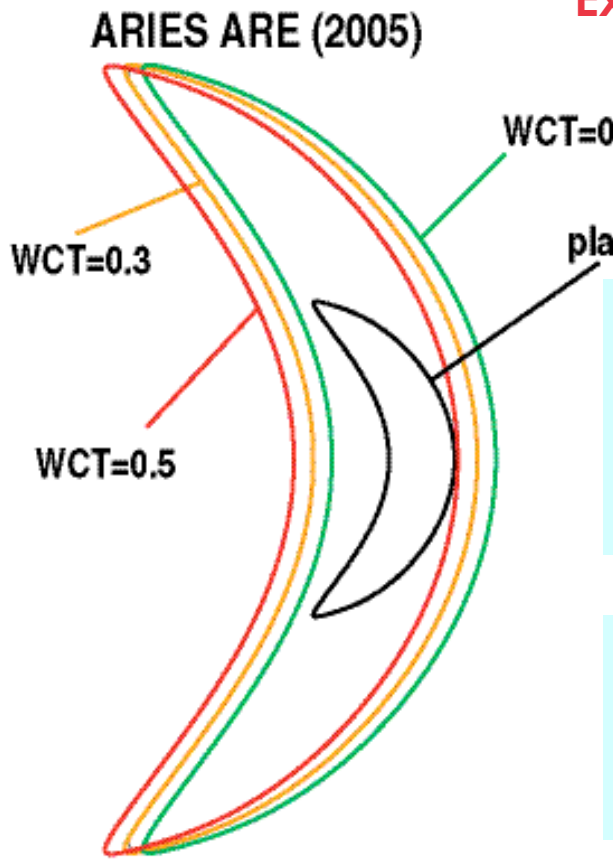
- **Additional toroidal modification is provided to reduce expanded $R_{0,m}$ and $R_{1,m}$ components by a fixed amount: $1/2(R_w-R_p)_{midplane} \times k^{\alpha}$ with default $\alpha = 1/2$**
  - **WCT parameter added to permit a to vary:**
    - **For closer walls WCT = $\alpha \sim 0$ which reduces the amount of the toroidal n = 1 modulation**

Wall Construction in Terpsichore Fails For All Wall Positions Even with New Parameter

- **Wall does not follow plasma boundary well at bean cross section for any value of WCT parameter**



Extension k = 2.5

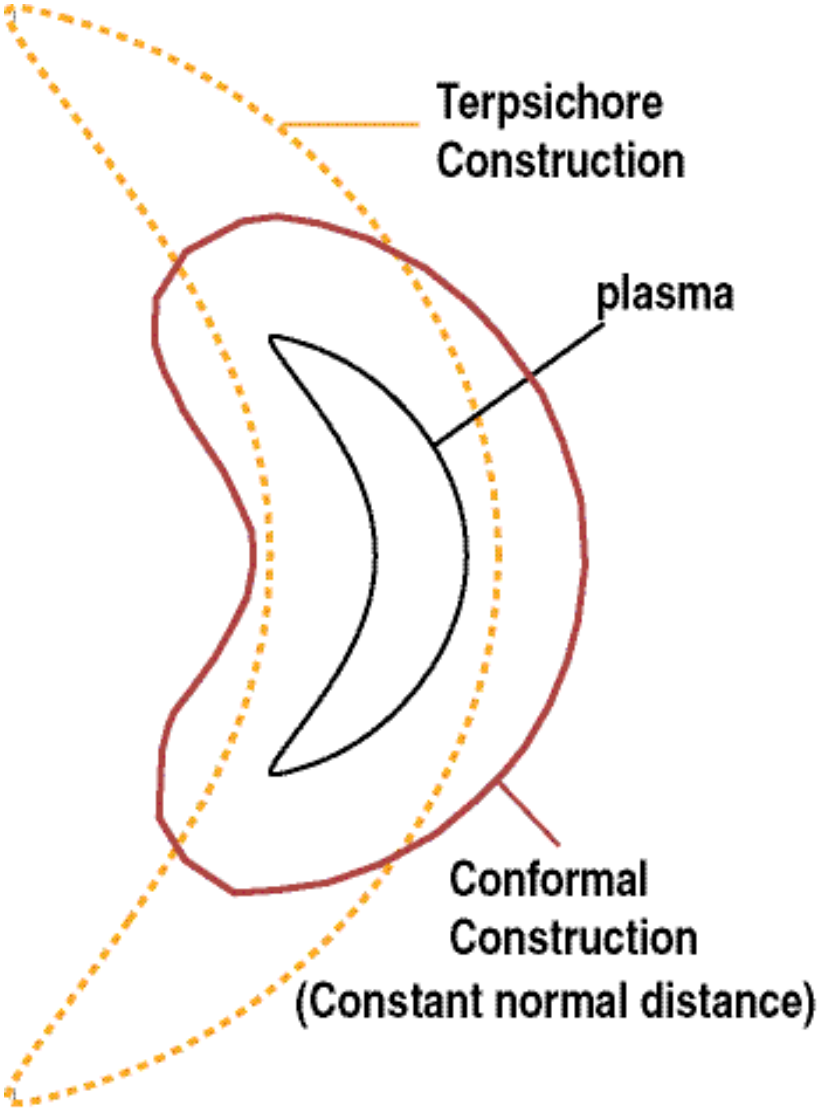


For WCT < 0.1 wall approaches plasma at inboard tips of the bean cross section

For WCT > 0.5 wall approaches plasma at outboard side of bean cross section

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

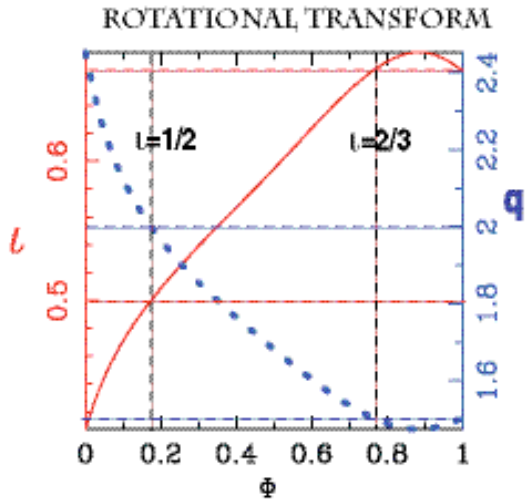


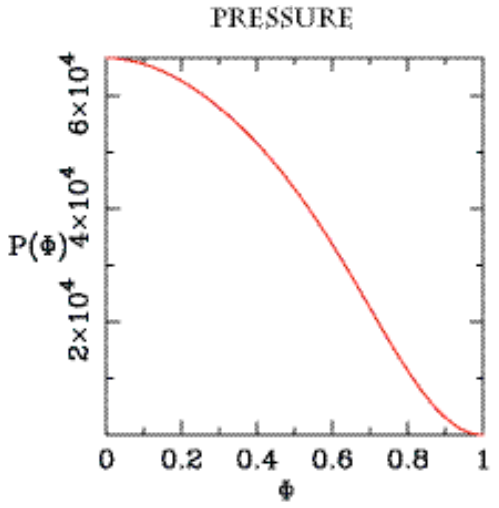
Stability for ARIES ARE Case is Likely Dependent on Profile Parameters As Well As Shape Parameters

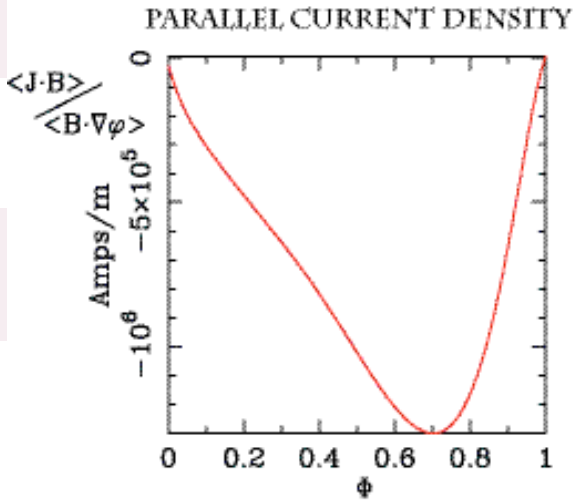
- **Lowest order rational ι = 0.5 is well inside core:**
  - Sole n=1 surface

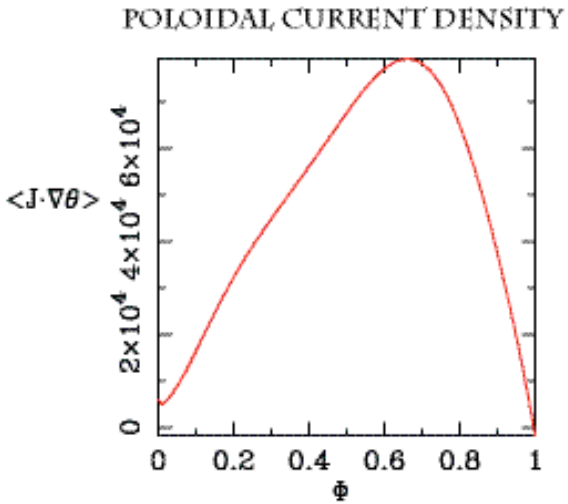
- **ι = 2/3 surface near edge:**
  - Sole n=2 surface (ignoring 4/2)
  - Near ι = 2/3 surface right near edge

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









Propose To Try To Fix Wall Construction And Then Vary Profile and Shape Parameters

- **Modify wall construction to utilize more conformal wall in each toroidal plane**
- **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