UPDATE ON β LIMITS FOR ARIES-CS

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ARIES-CS Project Meeting

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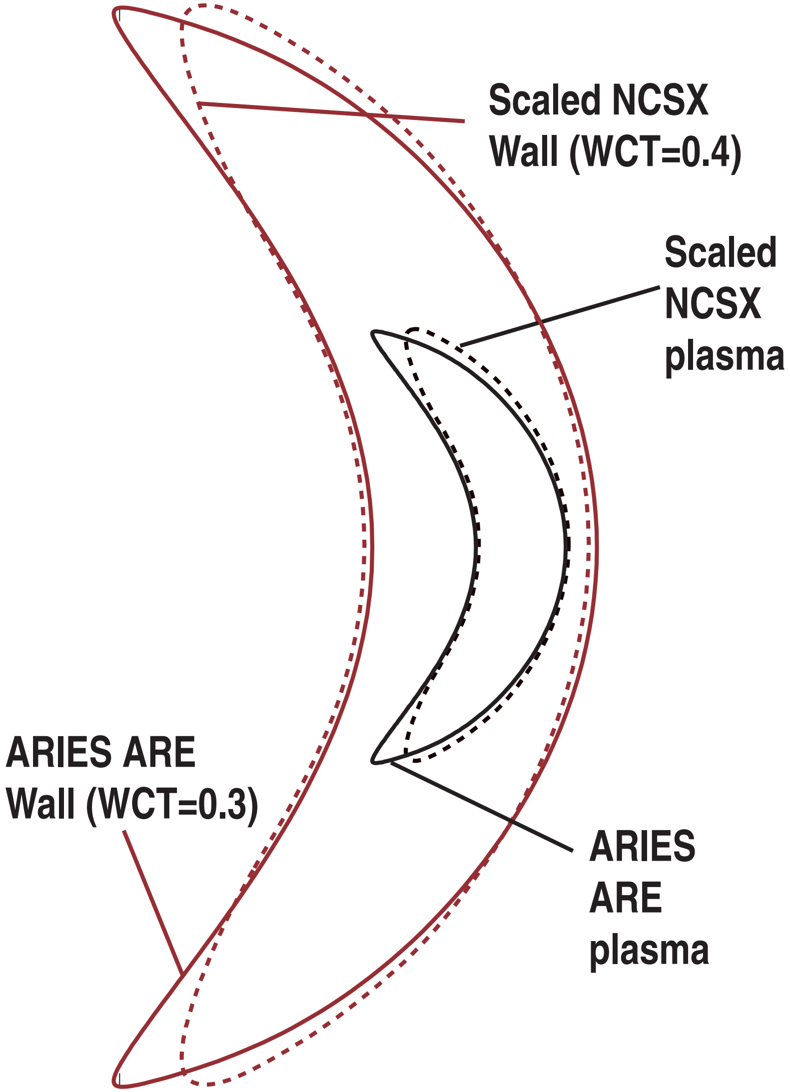
Wall Construction in Terpsichore Failed Due to Pointed Bean Cross Section



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 $((R_p - R_{0,0}),(Z_p - Z_{0,0}))$

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

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

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

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

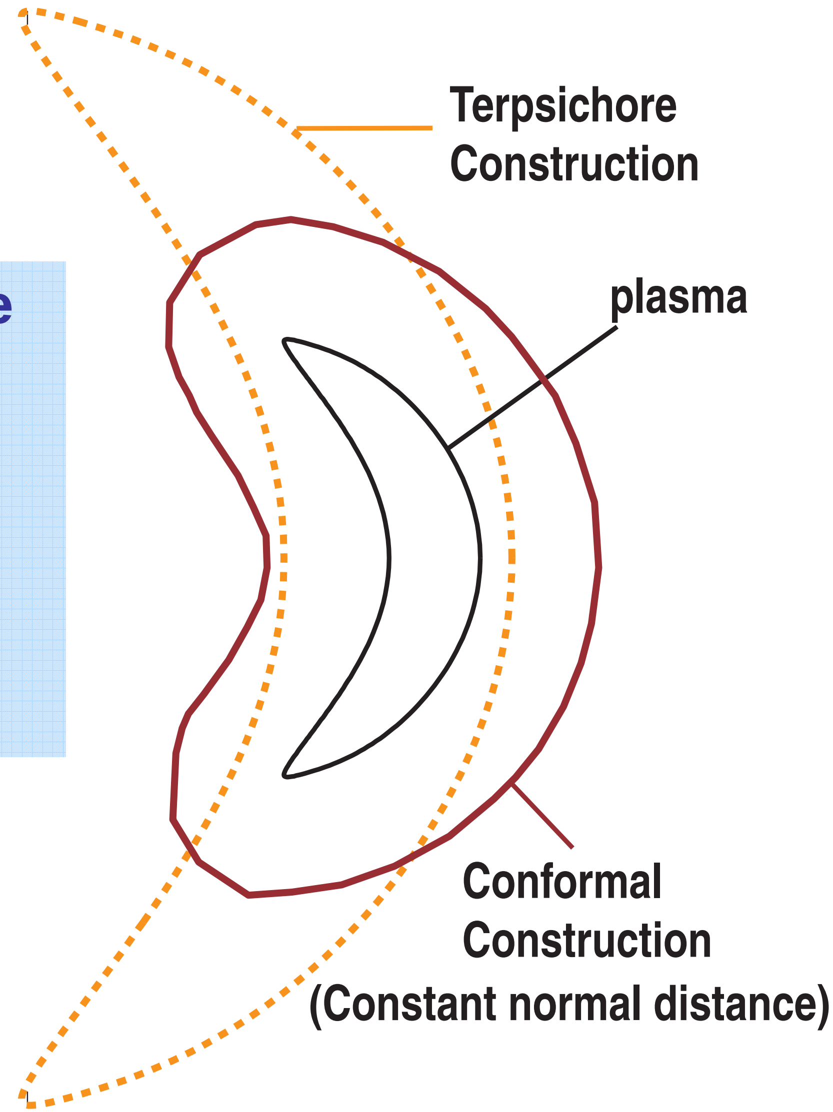
$$\left(R_w - R_{0,0}\right) = k\left(R_p - R_{0,0}\right) \qquad \left(Z_w - Z_{0,0}\right) = k\left(Z_p - Z_{0,0}\right)$$

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 both by a fixed amount: $1/2(R_w - R_p)_{midplane} \times k^{\alpha}$ with default $\alpha = 1/2$**
  - Effectively a radial shift at $\phi = 0$ and no shift at $\phi = \pi$
- **WCT parameter added to permit a to vary:**
  - **For closer walls WCT = α ~ 0 which reduces the amount of the toroidal n = 1 modulation**

Wall Construction Requires More Conformal Wall with Constant Normal Distance

- **Conformal means the wall should be at a constant distance from the plasma in the normal direction:**
  - This should avoid the numerical problems where vacuum surfaces approach too close to the plasma surface at some poloidal locations



Normal To the Plasma is Directly Obtained From Known Fourier Expansion of Plasma Boundary

- **Tangent to Plasma surface in each toroidal plane (i.e. fixed ϕ) is the vector :**

$$\Delta R_{\mathrm{T}} = \left.\frac{\partial R_p}{\partial \theta}\right|_{\phi} \Delta\theta \qquad \Delta Z_{\mathrm{T}} = \left.\frac{\partial Z_p}{\partial \theta}\right|_{\phi} \Delta\theta$$

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

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

$$\Rightarrow$$

$$\left.\frac{\partial R_p}{\partial \theta}\right|_{\phi} = -\sum_{n,m} m R_{n,m}\left[\sin(m\theta + n\phi)\right]$$

$$\left.\frac{\partial Z_p}{\partial \theta}\right|_{\phi} = +\sum_{n,m} m Z_{n,m}\left[\cos(m\theta + n\phi)\right]$$

- **Normal to Plasma surface is the vector:**

$$\Delta R_{\mathrm{N}} = +\left.\frac{\partial Z_p}{\partial \theta}\right|_{\phi} \Delta\theta \qquad \Delta Z_{\mathrm{N}} = -\left.\frac{\partial R_p}{\partial \theta}\right|_{\phi} \Delta\theta$$

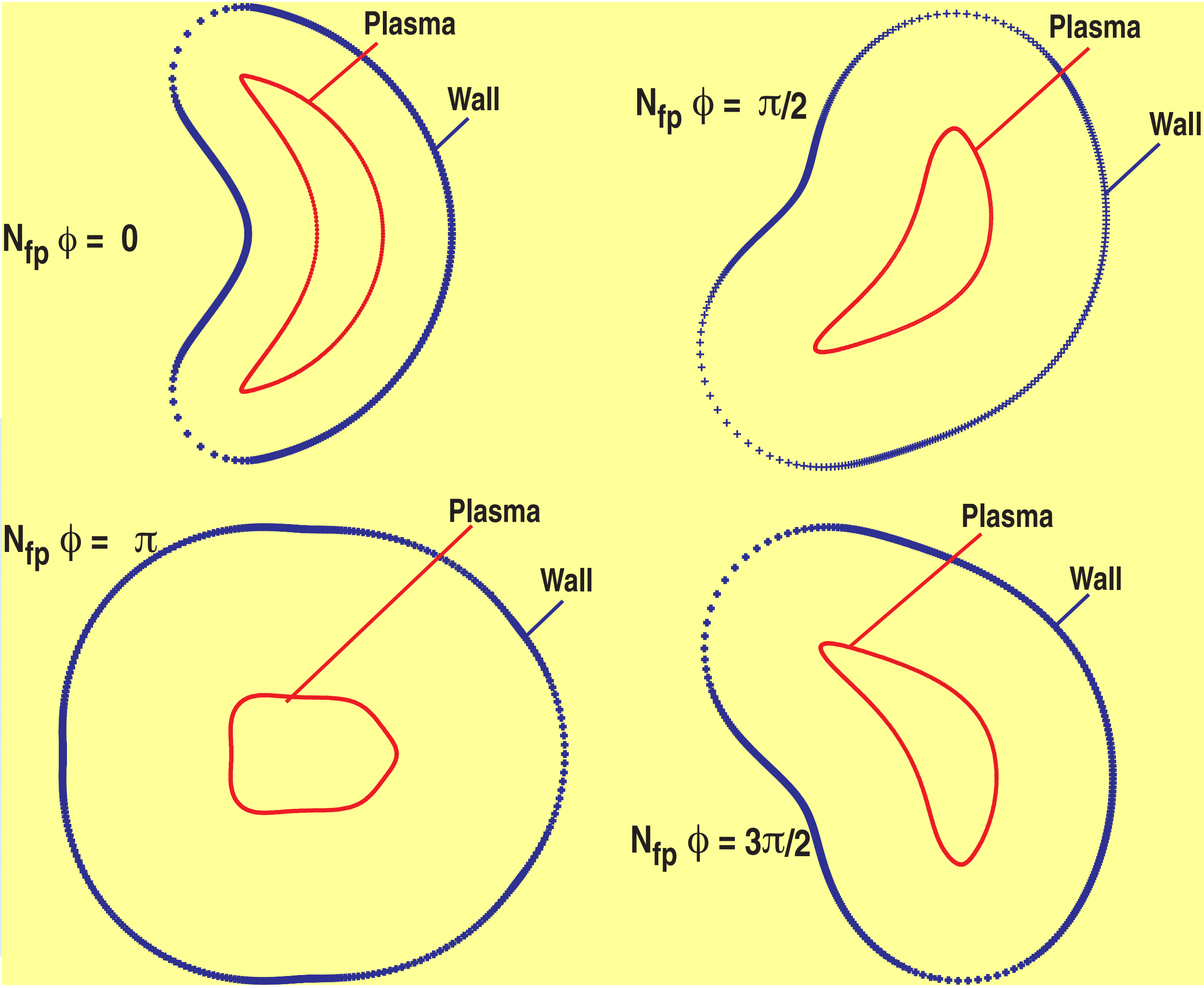
- **Choose $\Delta\theta$ so that:**

$$(\Delta R_{\mathrm{N}})^2 + (\Delta Z_{\mathrm{N}})^2 = \left[\left(\left.\frac{\partial Z_p}{\partial \theta}\right|_{\phi}\right)^2 + \left(\left.\frac{\partial Z_p}{\partial \theta}\right|_{\phi}\right)^2\right](\Delta\theta)^2$$

Conformal Wall Construction Yields a Reasonable Wall for Each Toroidal Plane

- **Wall construction works well for close walls**

- **Construction fails when wall extension factor exceeds ~ 2:**
  - Wall cuts itself on inboard side of indented cross sections
  - This can be corrected by eliminating points outside simply connected region



Status of Stability Analysis
January 2006 To December 2006

MAJOR TASK	SUBTASK	STATUS	COMMENTS
Monitor development of tools needed for ARIES-CS design	Continue monitoring progress of ideal and resistive MHD tool development	Continuing	This is ongoing from previous years
	Correct the wall construction in TERPSICHORE by implementing true conformal wall	Continuing	Required for further stability analysis of ARE configuration
Investigate impact of variations from the baseline configurations on system performance	Apply the equilibrium and stability tools to evaluate sensitivity to minor variations in the geometry	Initiated	Base NCSX and MHH2 configurations were evaluated previously
	Apply the equilibrium and stability tools to evaluate sensitivity to the ι and pressure profiles	Initiated	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

Investigation of the Impact of Variations From the Baseline Configurations on System Performance

Specifically, the investigation is expected to require testing of:

Sensitivity of the:

- 3-period NCSX 'ARE'
- 2-period MHH2 (16 coil case)
- 3-period SNS

configurations

Sensitivity to:

- Edge rationals by modifying ι profile
- Edge pressure by flattening profile
- Boundary shape