Plasma Configuration, Status and Plans

L. P. Ku, C. Kessel, M. Isaev

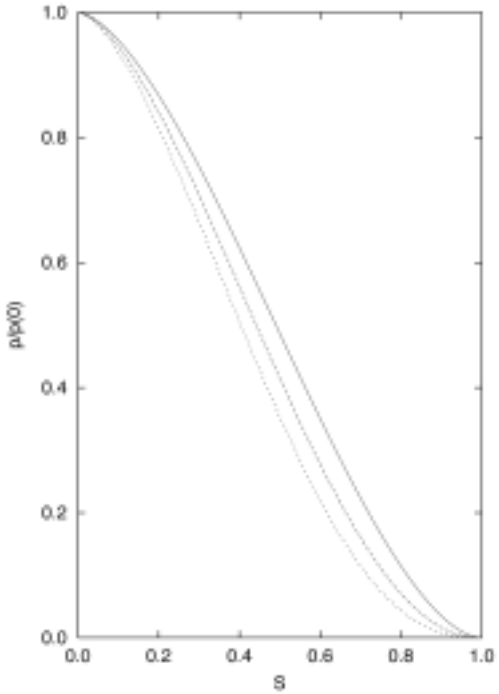
NCSX Project Meeting, September 2-3
Princeton Plasma Physics Laboratory

Primary Tasks Since Last Project Meeting

- Main focus has been to improve plasma performance by increasing C82 stability beta limit. We explored two avenues:
  - Pressure and current profile modification/optimization
  - Plasma shaping with higher elongation

Pressure and Current Profile Modification/Optimization
(pressure and current profiles decoupled)

- Kink/ballooning stability is improved with more peaked pressure profiles for a fixed current profile.



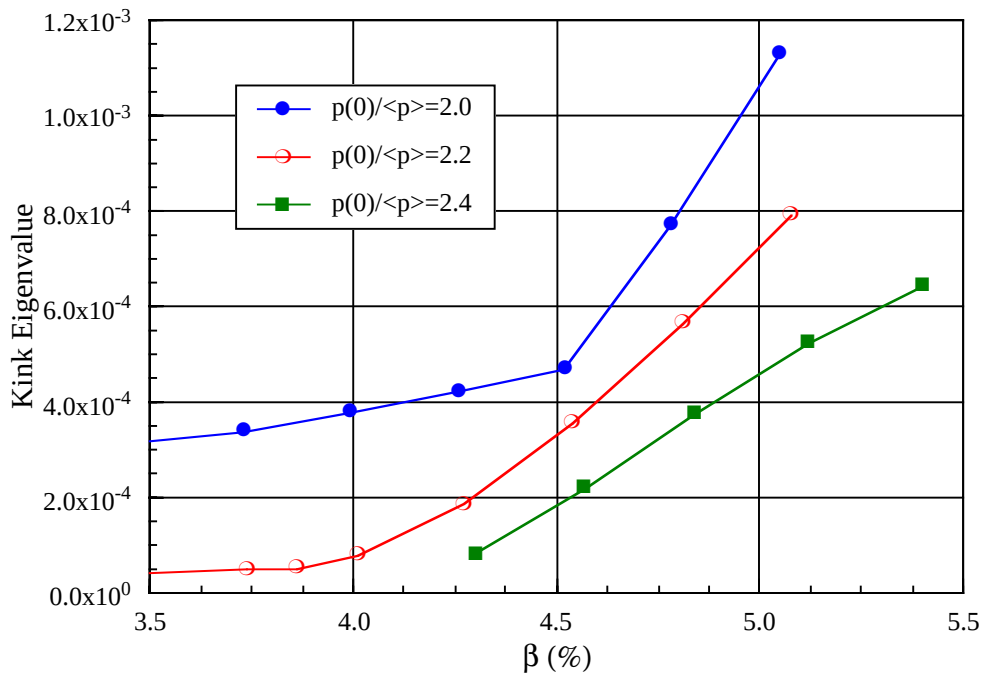
$p(s)/p(0)=(1-s^{\alpha})^{\beta}$

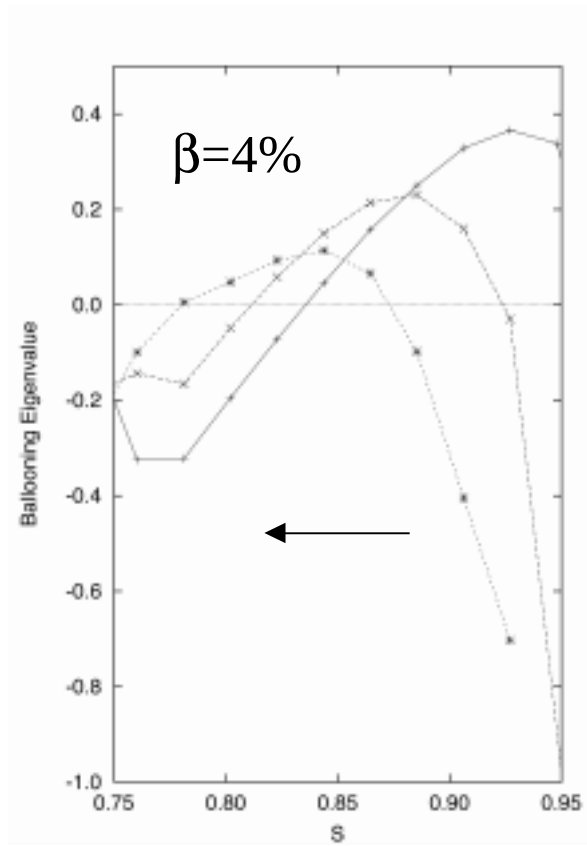
P1. $p(0)/\langle p\rangle=2.0$ for $\alpha=1.6$, $\beta=1.8$

P2. $p(0)/\langle p\rangle=2.2$ for $\alpha=1.6$, $\beta=2.2$

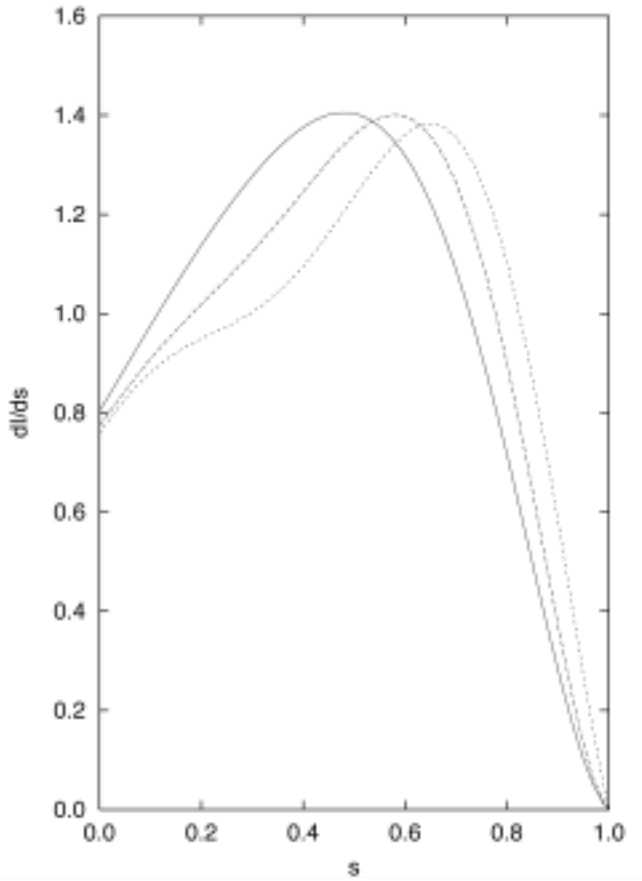
P3. $p(0)/\langle p\rangle=2.4$ for $\alpha=1.6$, $\beta=2.6$

Kink stability for β>4% may be achieved by using a more peaked pressure profile alone, but to achieve ballooning stability at the same time the pressure profile may have to be chosen to specifically minimize p' in 0.8<s<0.9.





- Kink/ballooning stability is improved with broader current profiles for a fixed pressure profile.

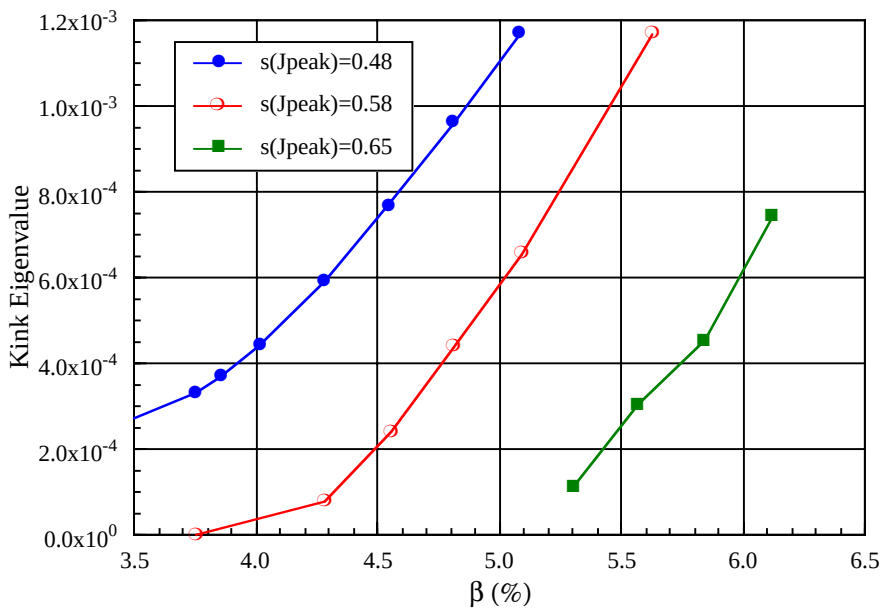


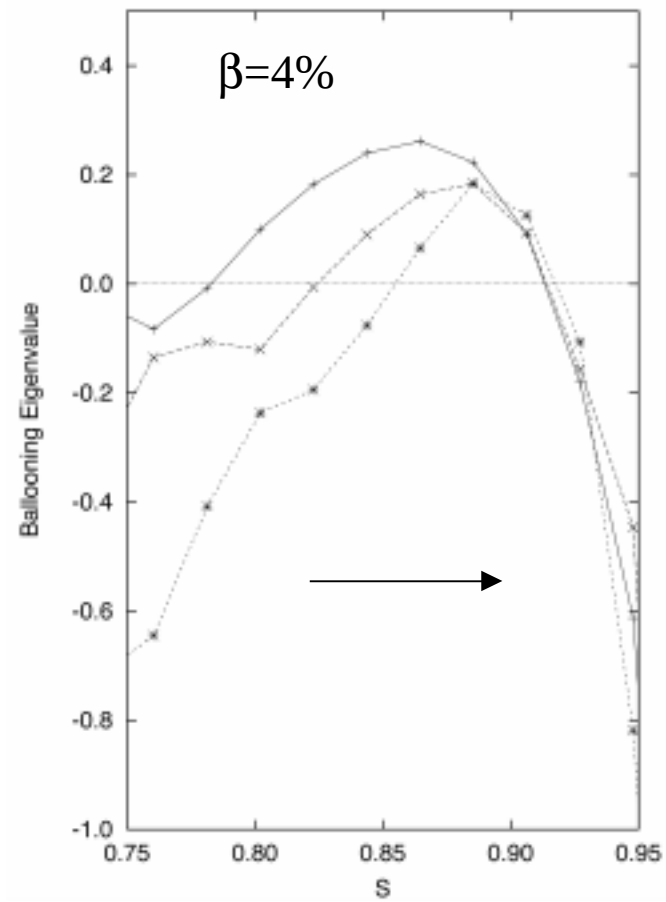
J1: S(Jpeak)=0.48

J2: S(Jpeak)=0.58

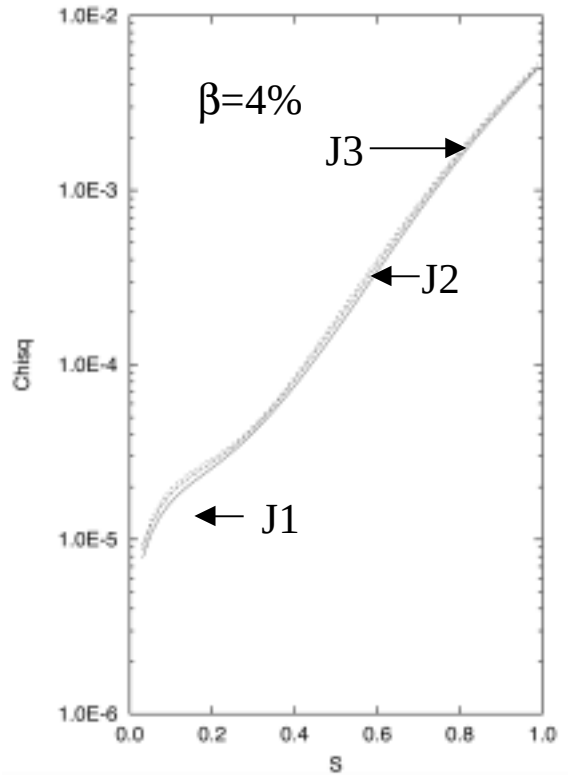
J3: S(Jpeak)=0.65

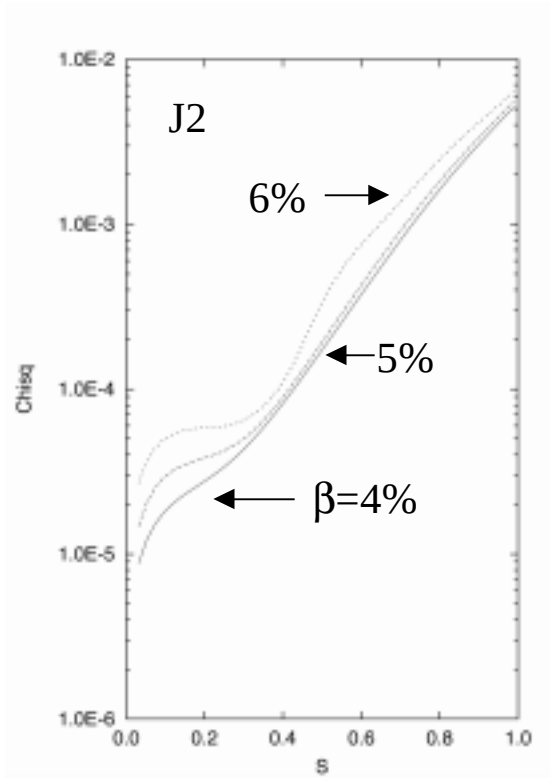
Kink stability for β>5% may be achieved by using a broader current profile alone, but to achieve ballooning stability at the same time the pressure profile may have to be chosen to specifically minimize p' in 0.8<s<0.9.





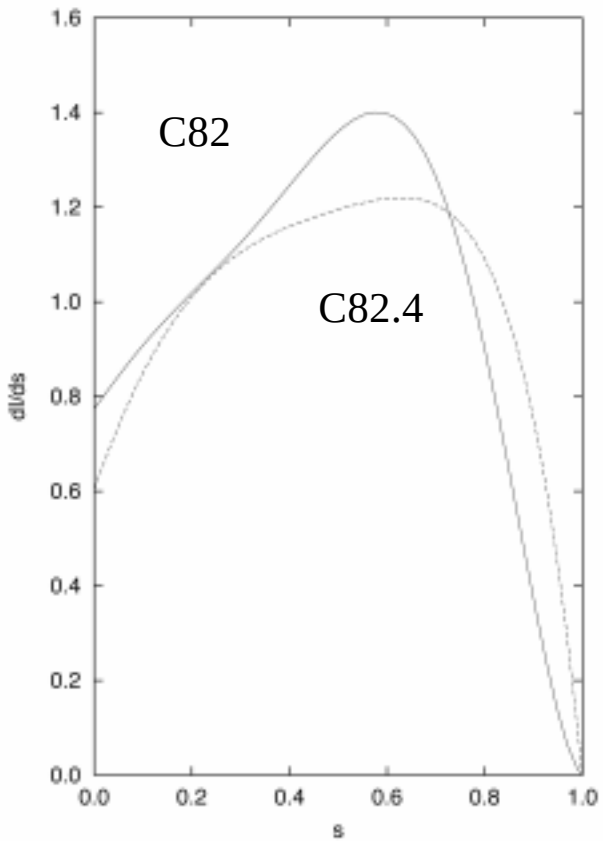
- Allowing the freedom to modify p and J profiles independently opens up an operating window of improved performance. However, this may also lead to degradation in confinement; the effects due to changes in β are more pronounced.

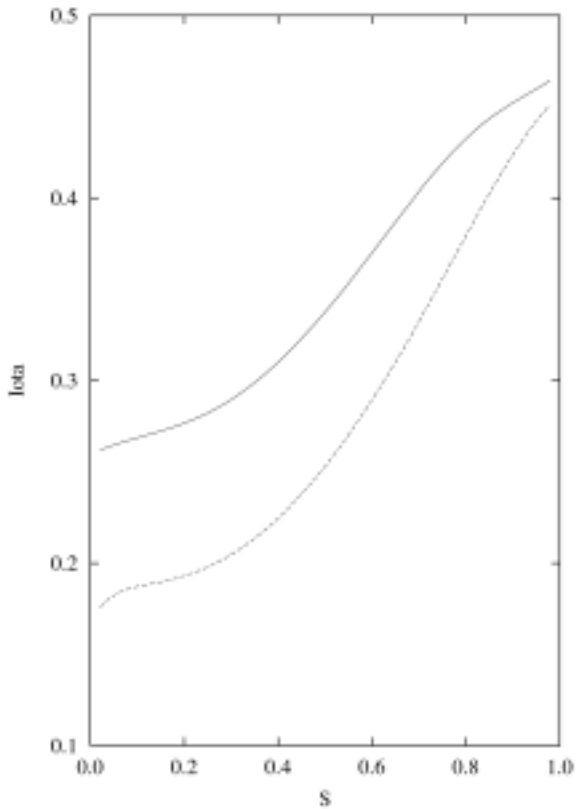




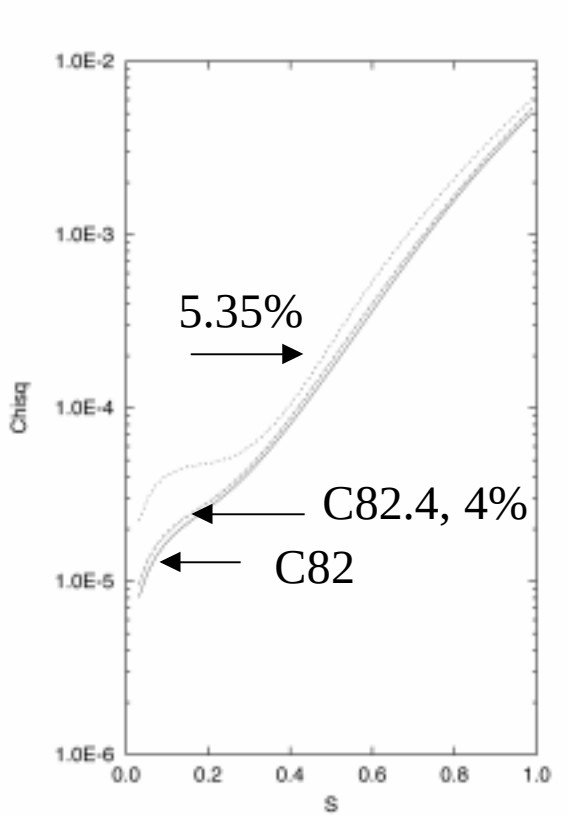
A Configuration C82.4 Stable to Kinks at β=5.35%

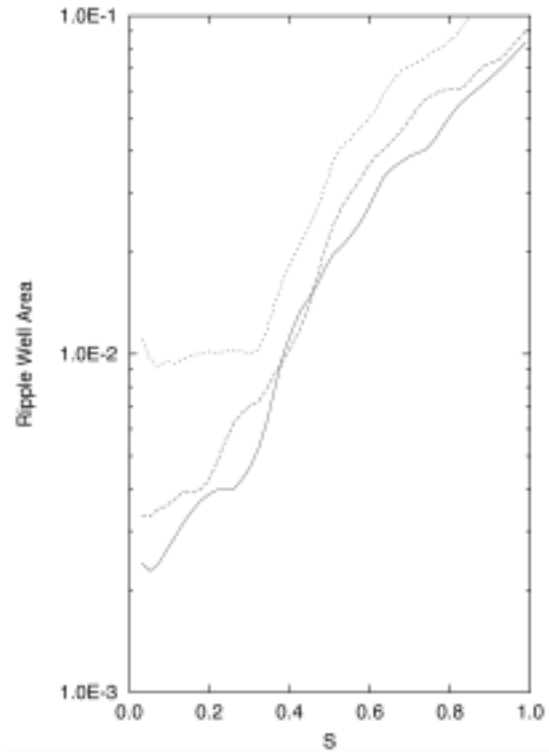
(Maxim Isaev)





C82.4 has degraded confinement.





τ^{nc}_{i} (C82) = 17.7 ms @ 4% β

τ^{nc}_{i} (C82.4)= 16.8 ms @ 4% β

= 13.4 ms @ 5.35% β

τ^{ISS95} = 7.6 ms @ 4% β

Issues To Be Addressed

- To increase the ballooning beta limit, it should be possible to modify p' to ride along p'_{crit} in the entire plasma, but the ballooning code needs to be made more robust.

- To study kink stability with high β and peaked p-profile, Terpsichore needs to be made less prone to the numerical mode problem.

- At which β and profile should we optimize QA?
  - Re-optimization at the new reference point.
  - Develop code capability to optimize QA and stability at different β and/or p, j-profiles.
- Establish performance boundary with respect to β_{kink}, $\beta_{ballooning}$ and confinement.

Achieving High β Through Plasma Shaping

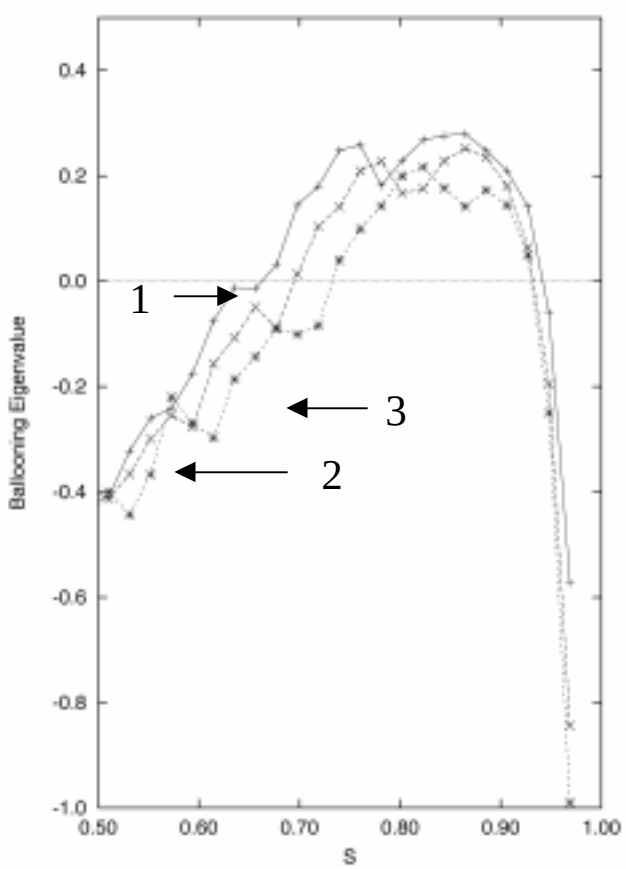
- Recap of report on 07/27/99:
  - At fixed J, B, kink/ballooning stability scales as $\sim\kappa$ (up to $\kappa=3$) for C82. Additional 3-D shaping is necessary. Configurations so obtained are not QA.
  - Configurations of excellent QA were obtained at higher elongation, but they are not kink stable.

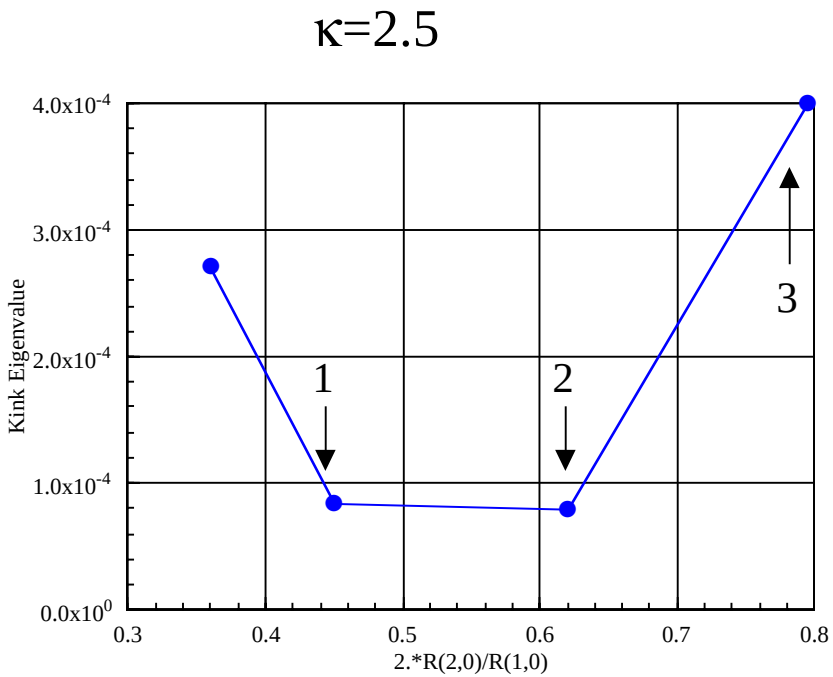
- Present status:
  - Reconciled QA and stability, but not adequate.
  - Carried out systematic studies of QA/kink with respect to κ.
  - Carried out systematic studies of kink/ballooning stability with respect to κ in 2-D (C. Kessel).

QA is harder to achieve for higher κ with fixed 2-D triangularity when constrained by kink stability

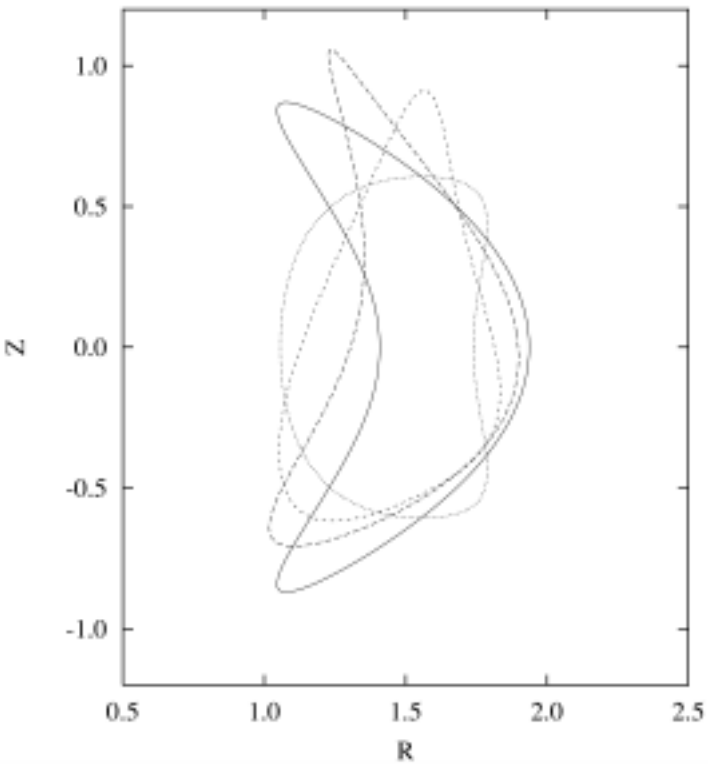
κ [z(1,0)/r(1,0)]	1.9	2.0	2.1	2.3	2.5	2.7
β	3.9	4.1	4.3	4.5	5.4	6.1
λ_{kink}	5.9e-5	4.5e-6	2.4e-5	7.7e-5	8.3e-5	1.0e-4
χ_{bmn}(s=0.5)	1.4e-2	1.8e-2	2.2e-2	2.8e-2	4.0e-2	5.0e-2
Area of secondary ripple wells (s=0.5)	2.4e-2	3.1e-2	4.3e-2	4.9e-2	9.9e-2	1.4e-1
$B_{1,1}$ (s=0.5)	3.5e-3	9.0e-3	1.5e-2	2.0e-2	2.3e-2	3.2e-2
ι(s=0)	0.26	0.24	0.22	0.19	0.16	0.14
ι(s=1)	0.47	0.45	0.44	0.49	0.42	0.34

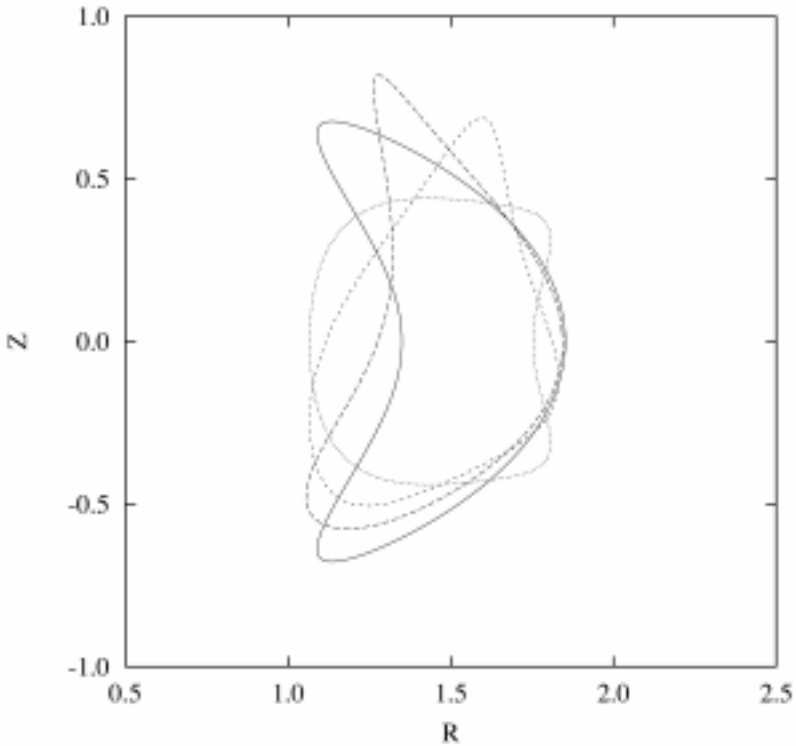
The above configurations optimized for QA/kink are not ballooning stable. Ballooning stability may be improved by pressure profile modification and/or by modifying 2-D triangularity





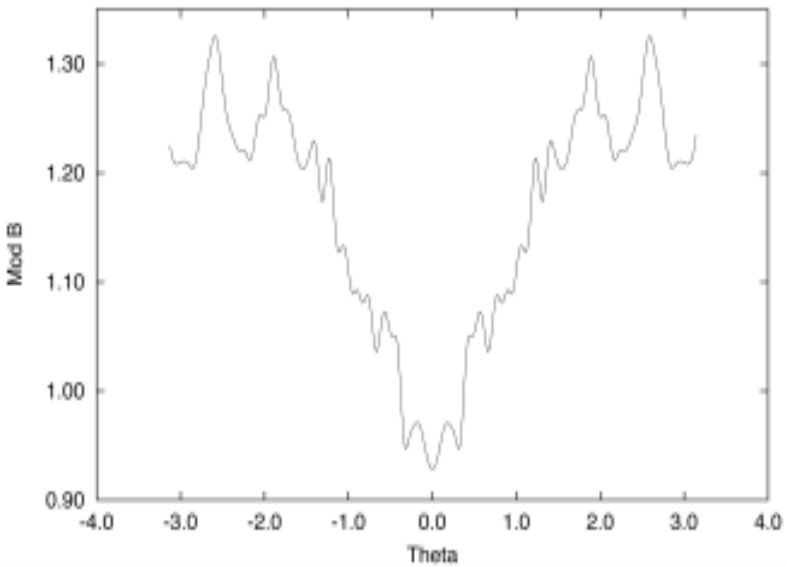
QAS3_ES3: A Configuration with κ=2.5, δ=0.7, and stability β ~5%



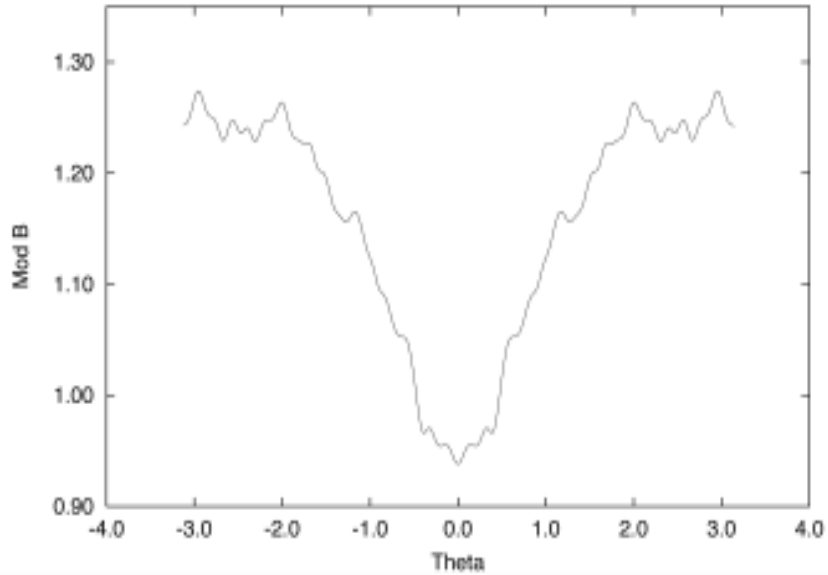


Plots of Mod(B) along field lines indicate QA is not adequate

ES3, s=0.5



C82, s=0.5



τ^{NC}_{i} = 14.6 ms @ 4% β

τ^{ISS95} = 9.3 ms

τ^{NC}_{i} = 17.7 ms @ 4% β

τ^{ISS95} = 7.6 ms

Issues To Be Addressed

- Can confinement be further improved by optimizing measures other than χ-Bmns?
  - Water target
  - Individual components
  - Stripped-down orbit code/DKES
- Can QA be further improved with
  - More optimal profiles?
  - Relaxed kink constraint?
  - Not demanding more poloidal flux?

- Need to ensure ballooning is not deteriorating too rapidly in the QA/kink optimization.
  - Speed and robustness of the ballooning code
- Need to improve the quality of calculations.