NCSX CDR Preparation
Physics Overview

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Timeline

- Finalize coil design ~ 1 Sept. 2001 → engineering for CDR
  - → Design new Modular coils, including using merged optimizer
  - → Evaluate properties of new coil designs
  - → Heal coils
  - → Design PF coils
  - → Final design of trim coils
  - → VV clearance needed for edge design and upgrades

- Other near term physics issues for CDR
  - – Edge design
  - – Develop diagnostics plan

FY'02: rest of CDR issues (full validation of final design, PVR issues)

Optimizer Progress

- PPPL Optimizer versions merged (MCZ, LPK, Hmynick)
  - Differential-Evolution and Genetic optimization algorithms
  - Direct targetting of effective ripple, orbit confinement,
  - Coil regularization & OH constraints
  - Bloating of VMEC equilibrium

  …

- Merged Coilopt/Stellopt (see D. Strickler's talk)
  - Being debugged and tested

- Merging Coilopt/Stellopt with PPPL Optimizer version
  - Merger started

Coil-Configuration Testing Since Last Project Meeting

L.-P. Ku

- Evaluate and optimize physics performance of newly developed coils.
- Improve further the MHD stability of the baseline LI383 by modestly modifying the boundary shape.

Nineteen modular coil designs have been evaluated. Optimization of coil currents has been carried out to further improve physics properties at the S3 state.

- Symmetry coil @ v=0, 7 coils/period:
  0907a2(M2), 1017a2(M3), 0105c2(M8), 0305a1(M11), 0123a1(M9), 0125a1(M10), 0227a1(M12).

- Symmetry coil @ v=1/2, 7 coils/period:
  1115b8(M4), 1219a6(M7), 0321a1(M15), 0321a4(M16), 0321a5(M17).

- Symmetry coils @ v=0 & v=1/2, 6 coils/period:
  1207a6(M5), 1215b4(M6), 0312a3(M13), 0312a4(M14).

- Coils on neither symmetry planes, 6 coils/period:
  0620a7(M18), 0628a1(M19), 0708a1(M20).

Observation and General Discussion

- M12 coil remains to be the one that best reproduces the physics properties of the baseline plasma.

- For 18 coil designs, the one with coils on both symmetry planes (M13) has better QA than the designs having coils on neither (M18-M20), but the difference is not large enough to favor one or the other. All have QA worse than M12 (Fig. 1).

- The best case of the off-symmetry plane, 18 coil design is the one optimized for M18 (M18.K24). It has a larger aspect ratio (4.53) and the effective ripple at r/a~0.5 is 50% larger than the best M12 case (Fig. 2).

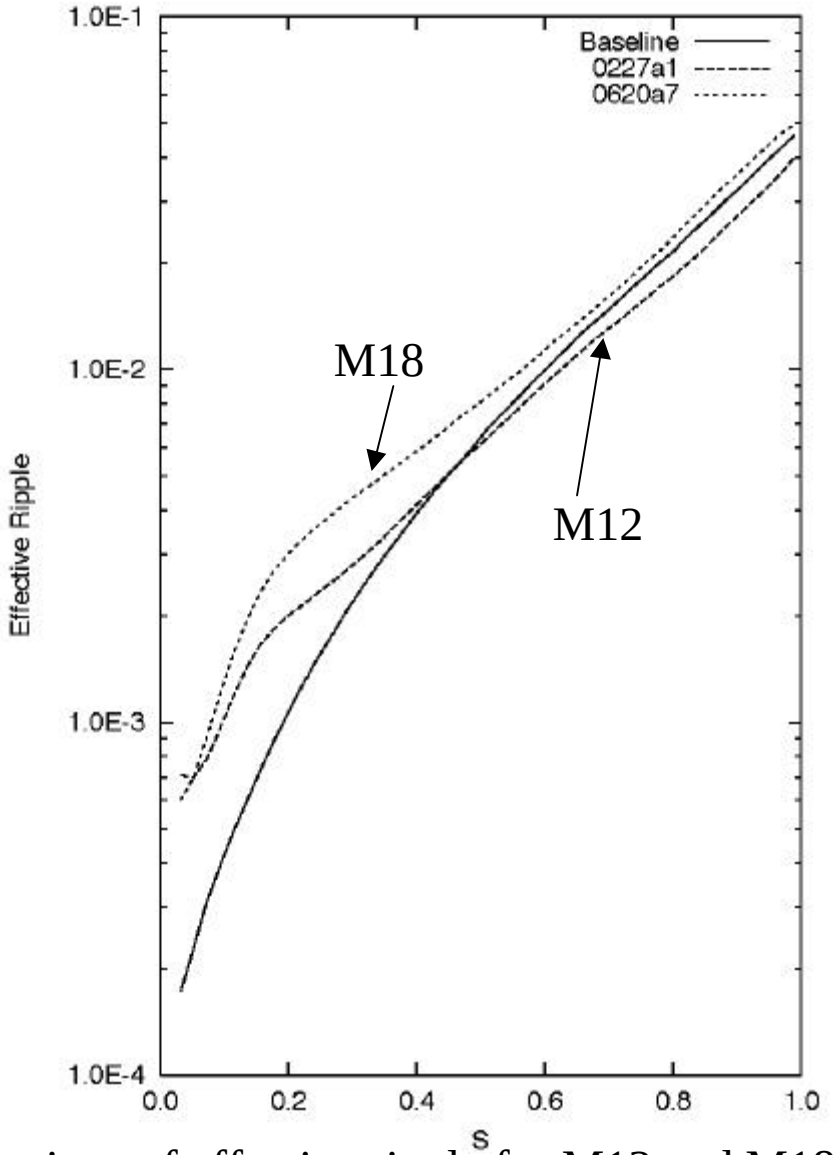


Fig. 1 Comparison of effective ripple for M12 and M18 at S3 state without modifying coil currents.

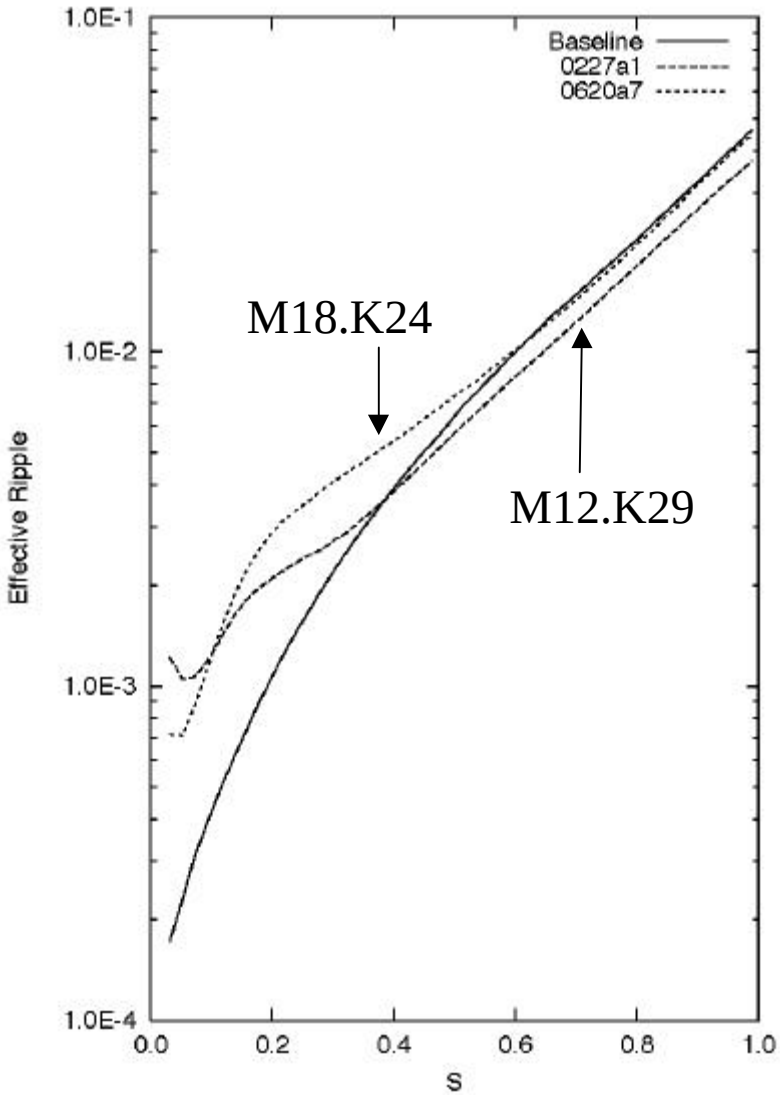


Fig. 2 Comparison of effective ripple for optimized M12 and M18 at S3 state.

Observation and General Discussion (Cont)

- For pressure and current profiles different from the reference, maintaining MHD stability by modifying coil currents results in substantial degradation in QA (Fig. 3).

- M7, for reasons yet to be understood, has poor NB particle confinement when optimization is performed to improve the kink stability, even though the overall measures of QA and ripple are not significantly changed.

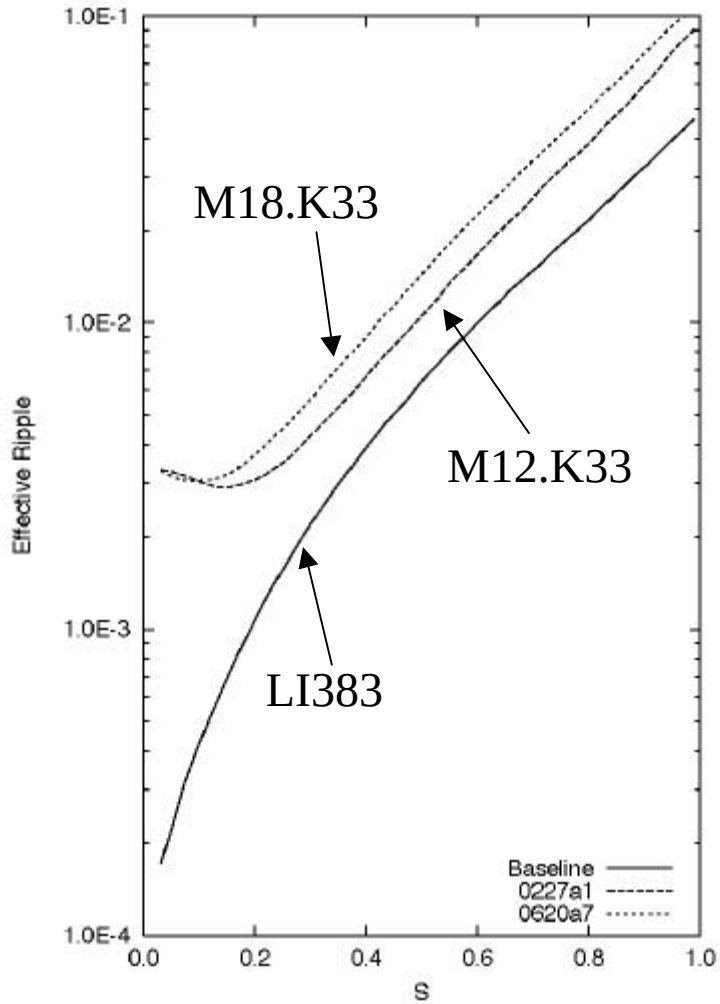


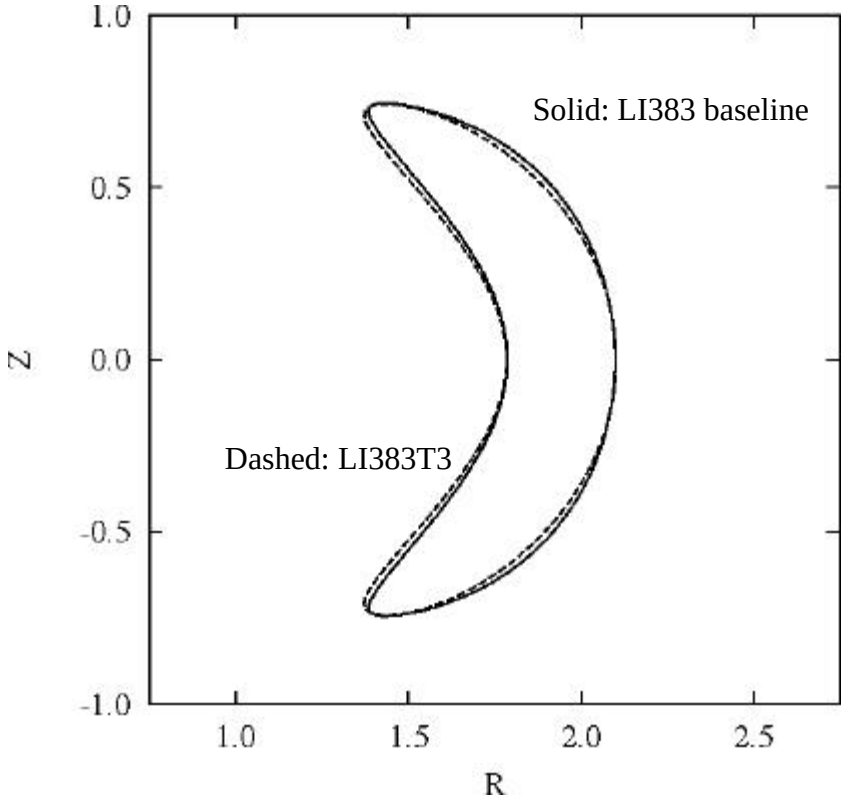
Fig. 3 Comparison of effective ripple for kink optimized M12 and M18 at S3 state with pressure and (bootstrap) current profiles from 1-D power balance (Mikkelsen- PVR).

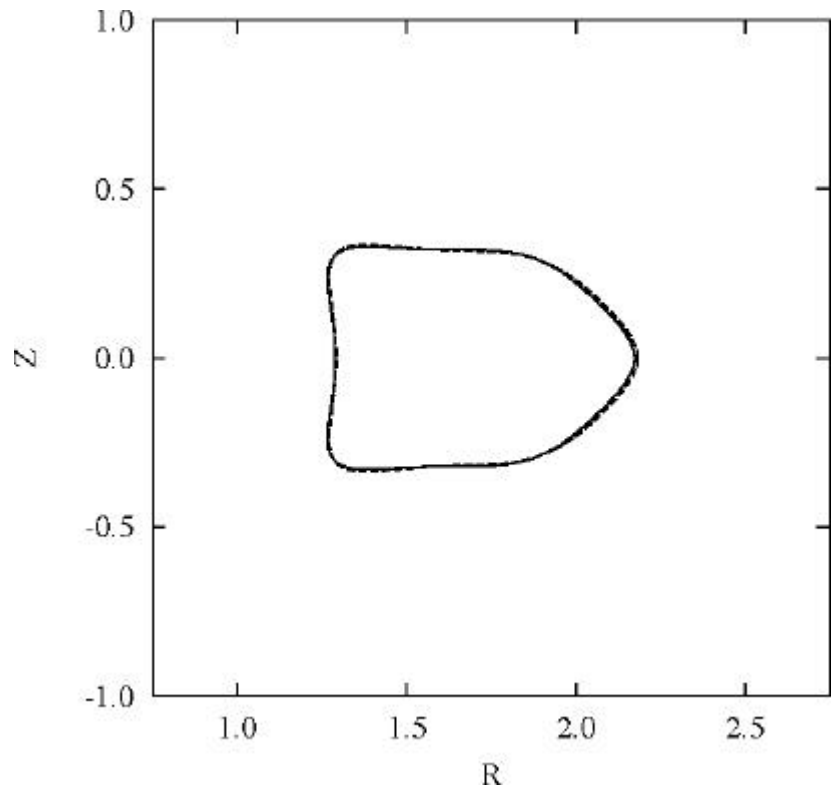
Modification of Baseline LI383

- Motivation:
  - Modifying coil currents, while able to stabilize MHD modes for alternate profiles, degrades the quasi-symmetry substantially.
  - Wouldn't it be better to modify the plasma shape to accommodate a desired range of profiles that are realistic?

- Approach:
  - Look for fixed-boundary shape with good characteristics for both reference profiles and Mikkelsen's profiles.
  - Minimize modification to lessen the impact on the present hardware design.

Configuration **LI383T3**: stable to kinks and ballooning at 4.3% beta for both the reference profile and the profile consistent with the 1d power balance*. It is slightly kink unstable ($\lambda \sim 10^{-4}$) to the profiles used in C82 (without core seed current). QA and NBI confinement are similar to the baseline LI383.





* 91 perturbation modes and 49 flux surfaces used in Terpsichore calculations. It is slightly unstable when 201 modes are used, but the eigenvalue is x2 smaller than the corresponding value of the baseline LI383.