Physics Assessments of Recent Coil Designs

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Summary of Coils Evaluated

- Three new sets of coils released since last project meeting have been evaluated with respect to the physics reconstruction at the S3 state.
  - 0813a1 (M23), 0827a3(M24), 0918a17(M25)
  - All do not have coils at symmetry planes v=0, and v=1/2.
  - All have 6 coils/period.
  - M24 and M25 use “TF” (12 and 18, respectively) instead of 1/R field in coil optimization. They also satisfy better the engineering constraints.
  - M25 has been further improved upon by D. Williamson. The resulting design, 0918a17r1, has also been evaluated.

General Features of Plasmas Reconstructed from Coil Designs that Minimize B_{norm} Errors (CoilOpt)

- All reproduce well the ballooning characteristics of the baseline configuration.
- All configurations are unstable to the N=1 external kinks.
- All have degraded quasi-symmetry in the plasma core (ε-effective at r/a ~0.5 about twice as large compared to the baseline) . Many have significant mirror fields, $B_{0,1}$ $B_{0,2}$.

Strategies of Further Coil Optimization

- Coil currents are modified, without engineering constraints, to stabilize the external kinks to the extent that the Terpsichore code predicts stability using the reference mode tables.

- The ballooning characteristics of the baseline LI383 are maintained, and further improved if possible.

- The effective ripple at r/a~0.5 is minimized, also without changing coil geometry. As a secondary objective, $\chi 2$ of the non-axisymmetric components of magnetic field spectrum, is also minimized.

Strategies of Further Coil Optimization (cont.)

- Attempts to further improve plasma performance are then made by modifying coil geometry.
  - This is achieved by using the newly merged stellopt-coilopt. We have had only limited run experience, however.

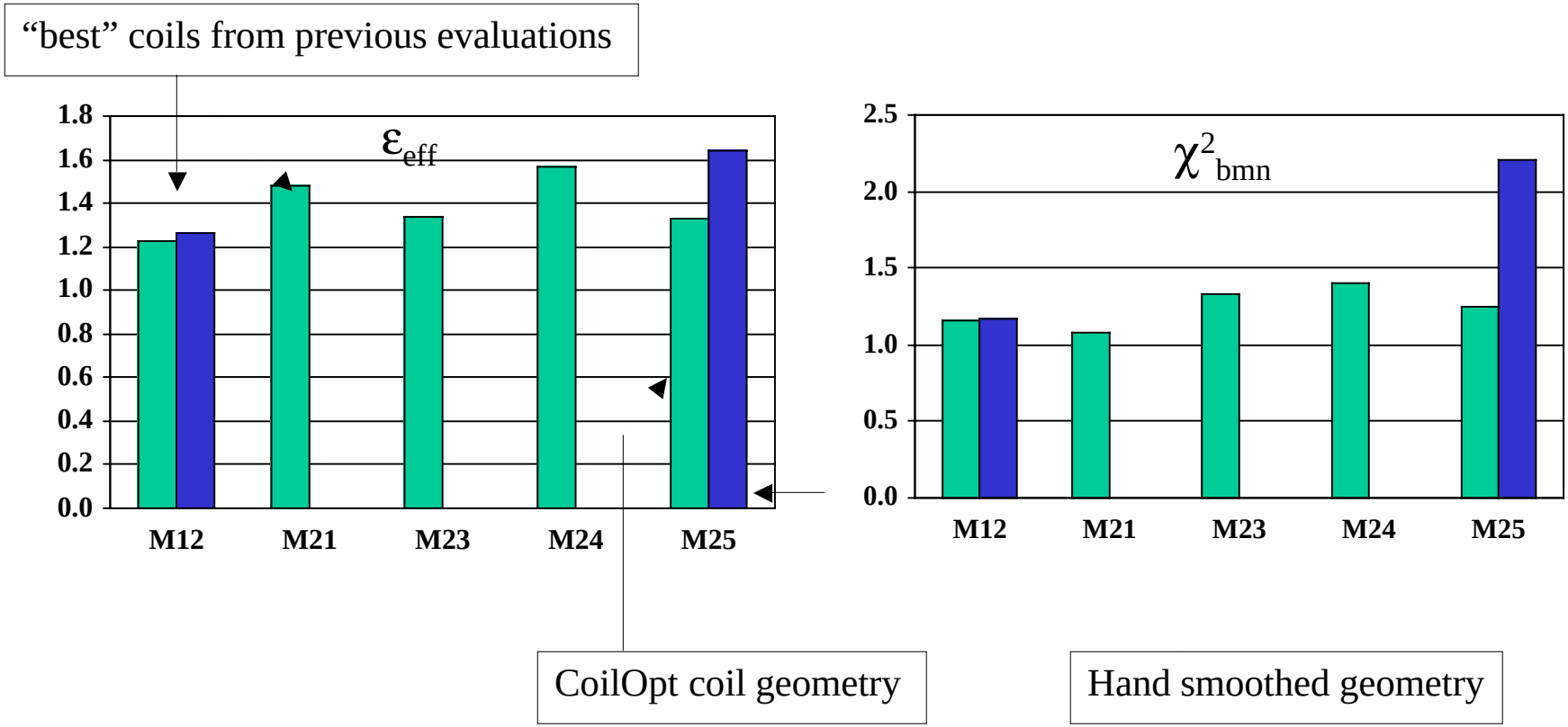
Results of Further Optimization

- In most coil designs, the kink stability may be attained with simultaneous improvement in QA by modifying coil currents alone.

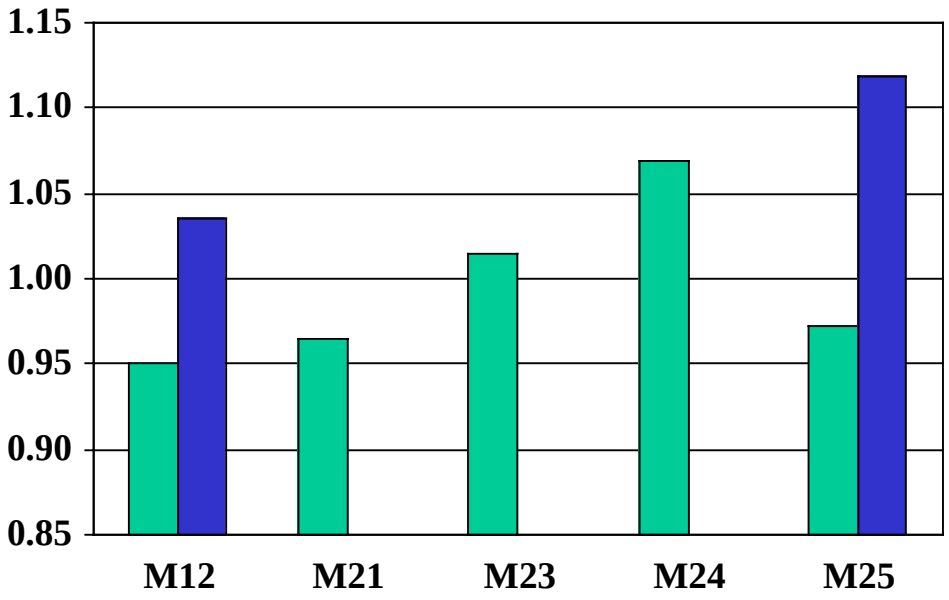
- The required change in coil currents is modest in most cases. The exception is 0918a17r1.

- The configurations obtained so far still have significantly degraded QA in the plasma core.

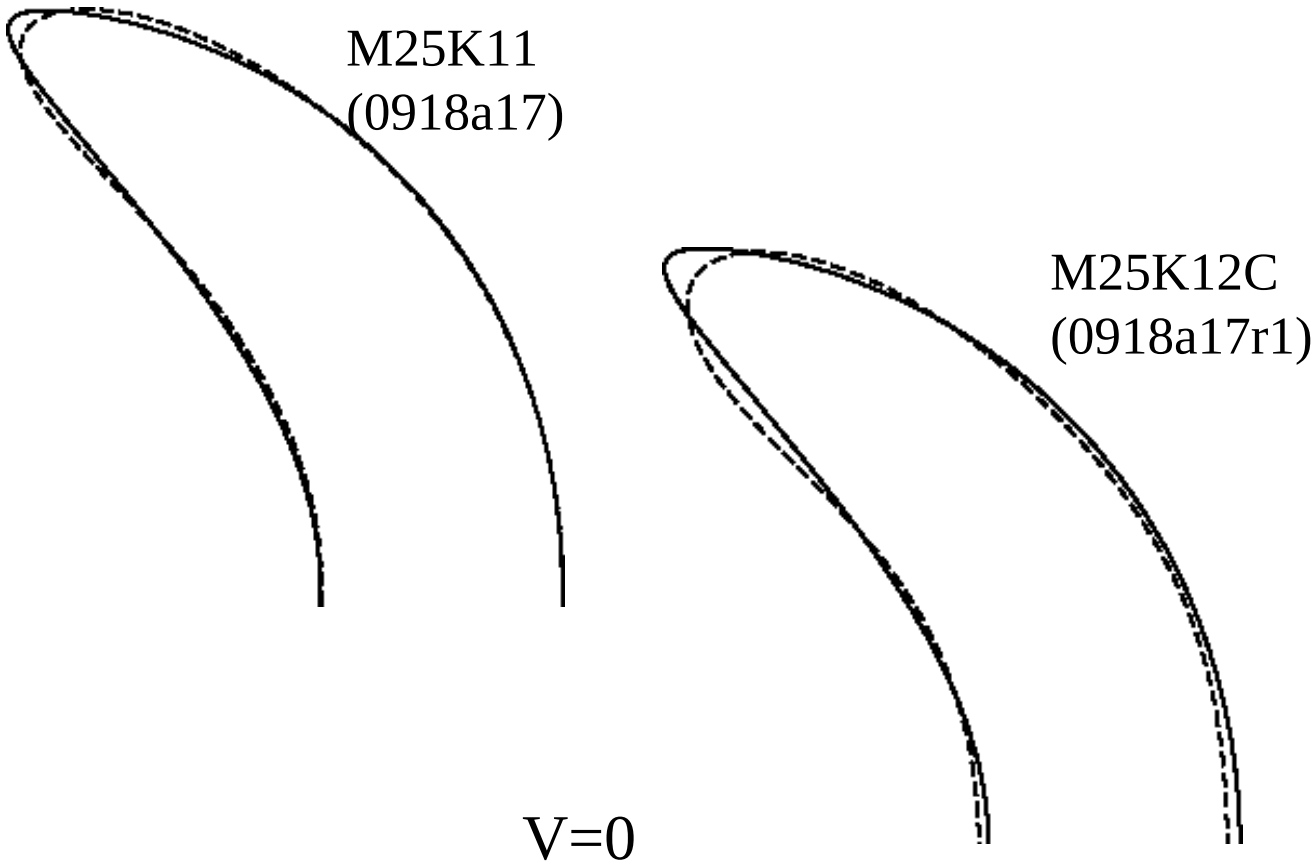
Ratio of ε_{eff} and χ^2_{Bmn} of presently optimized configurations to the baseline LI383 at r/a=0.5.

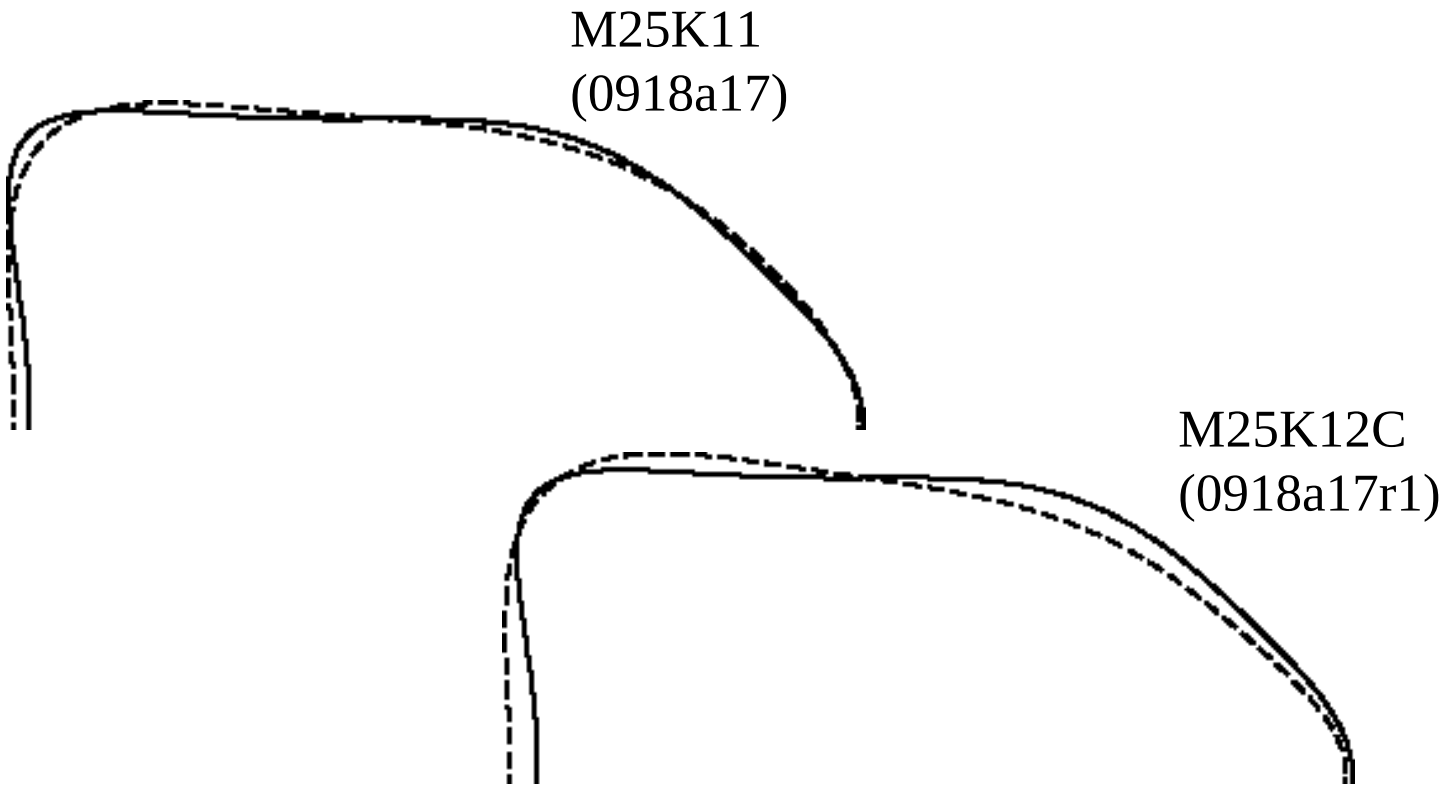


Ratio of average energy loss fraction of NB particles, presently optimized configurations to the baseline LI383. Calculations are for 1.7 m, 2T device, H species, and injection energy 40 keV.



The plasma boundary of the optimized configuration calculated by VMEC for hand smoothed M25 differs significantly from the baseline Li383.

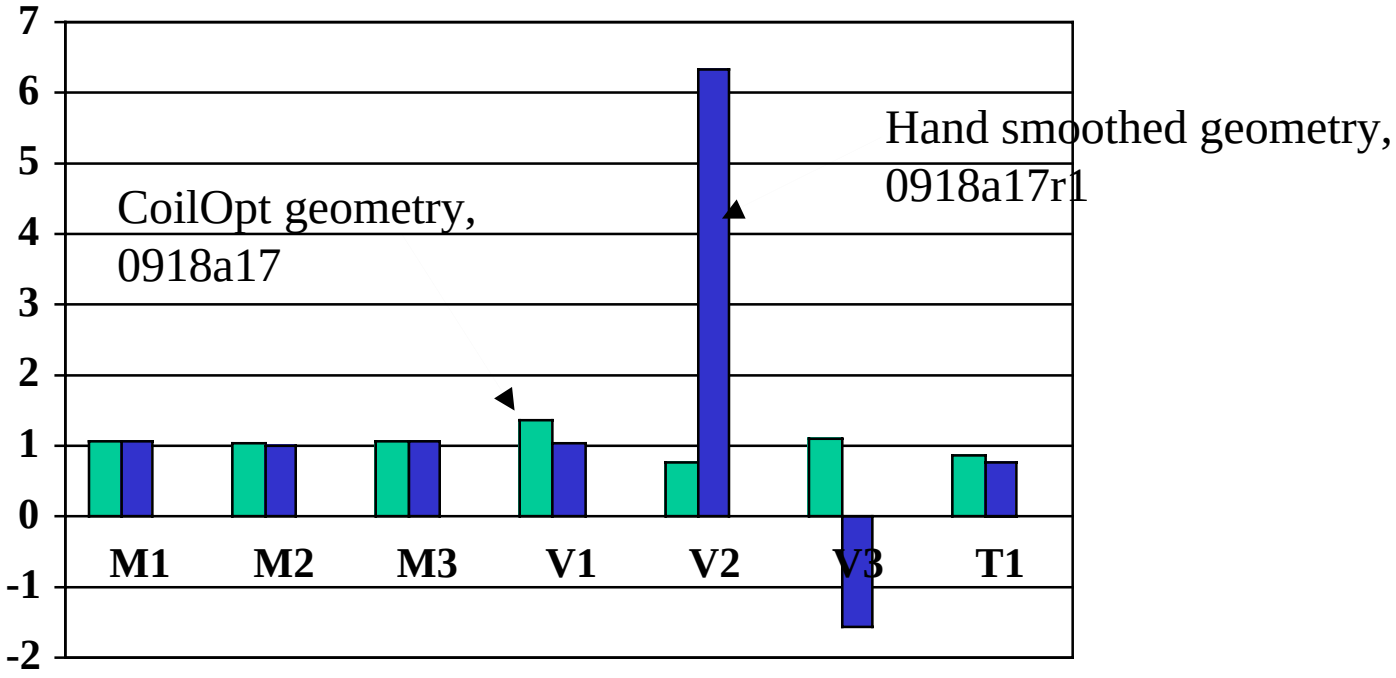




V=1/2

The optimized configuration for the hand smoothed M25 coils has significantly different currents in the VF system.

Ratio of coil currents, current optimized to CoilOpt direct.



Summary and Conclusions

- Recent coil development aimed at improving engineering features results in plasmas with degraded performance at the S3 state, but the lost MHD stability and some QA can be recovered by re-optimizing the coil currents.

- The 6 coil/period design (with coils located neither at the v=0 nor v=1/2 planes) is now able to provide plasmas with qualities approaching those by the best M12 coils.

- It is hopeful that further improvement in the coil design can be made by modifying the coil geometry with the newly developed optimization tool.