Configuration Assessment Summary

29 June 2000

On 26 June we met to consider the new candidate configurations for NCSX and on 27 June there was a further discussion with R.Goldston and R.Hawryluk. The configuration characteristics are summarized in a spreadsheet, which was distributed, and will continue to be filled in. Both this summary and the spreadsheet will be posted on the NCSX web-site.

The goal of the meetings was to select one or more new configurations to focus our attention on for the PAC meeting and preparations for the PVR. In particular, the engineering tasks need a new configuration designated for evaluating coil topologies and machine designs. The goal of the recent configuration design phase was to improve on c82 with respect to flux-surface quality, confinement, and coils; and if possible to increase the beta-limit. Towards this end, a number of configurations were developed by L-P. Ku and C. Kessel, each of which showed improved characteristics relative to c82 in one or more regards. In the course of the analysis and discussions, it was also found that each of the configurations had one or more aspects that were not completely satisfactory and which would require further work.

The general conclusion of the meetings was to focus on II283_16 and LI383_328. As discussed below, additional work is needed on these configurations to remove islands and see if they can be further refined. Due to LI383_328 having iota=0.5 in the plasma, it was decided that it must (at least) have a flexibility requirement to be able to start up with a vacuum configuration everywhere above iota=0.5 (so that the edge does not have to pass thru it).

Significant interest was also expressed for II75_286/LI65_136 (but they have too-high aspect ratios), A4k2.45b4.75 (but it has stochastic flux surfaces outside r/a~0.6), and II379_328 /II378_218 (but they have too high coil-currents).

One of the goals of the analysis between now and the PAC meeting in August is to attempt to decide which configuration to develop for the PVR in December.

General Issues and observations

1. Some of the configurations have aspect ratios of ~4.7, which many thought was uncomfortably high for a "compact" program, given CHS (A=5) and LHD (A=6). It was felt that it would be better to stay within our previously advertised range of 3-4.
2. Different pressure profiles were used in the different configurations. In particular, the A3k- and A4k- configurations used the same pressure profile as C82 and ARIES-RS. The II- and LI- configurations used a broader profile, which tended to push the peak of the bootstrap profile further out, generally making MHD stabilization easier. Both profiles are within the range of the experimental data, with the broader profile looking similar to CHS and LHD.
3. Different strategies were used for determining the current profile and relating it to the bootstrap current for the different configuraitons. The A3k- and A4k- configurations

used a current profile that is broader than the calculated bootstrap current (much as in ARIES-RS and C82), but have the total current set to match the total bootstrap current. In addition, these configurations assume a small seed current (as with C82) The II- and LI- configurations have total current profile matching the bootstrap profile, but the magnitude of the current is slightly different from the calculated bootstrap. For most cases, I_P is taken as larger than I_{boot} (e.g. LI383 by 12%). We wondered if case II379 would have optimized better (e.g. lower coil currents) if its I_P/I_{boot} was reduced from the assumed 1.33.

4. Coil current densities: The coil current densities were assessed both via the NESCOIL current-sheet density and by looking at uniformly separated discrete saddle coils (in a 1/R background field). The maximum current density, by these measures, was a strong discriminator between configurations in the discussion. However, there was concern whether the discrete saddle-coil current-densities were indicative for other coil topologies. Also, the configuration designs had targeted coil complexity not current density (per previous discussions), so it is suspected that significant headway could be made on peak current densities in further configuration development.
5. The medium iota cases, including LI383, cross iota=0.5 in the outer region of the plasma. In addition, these configurations have their vacuum iota below 0.5 everywhere. This is a problem due to the observations of disruptions in W7-AS when they have iota=0.5 in the plasma, and the difficulty of operating tokamaks with edge iota=0.5 (even transiently). These configurations should be examined for tearing-mode stability, and a startup scenario would be required where the edge-iota was maintained above iota=0.5 throughout the discharge.
6. There is a significant interest in increasing the beta-limit, at least back to ~ 5% to be similar to ARIES-RS. II283's beta limit is slightly lower than 4%. Further work should investigate whether this (and II383's) can be increased.
7. Many of the new configurations have a small horizontal width in the elongated cross-section. How small is allowable due to CX losses? Can the neutral sources be localized away from the midplane at the elongated cross-section?
8. The spreadsheet should have a row for reconstructability of equilibrium and physics characteristics from coils. Which coil topology should be used?
9. Flux surface quality: All configurations need attention on cleaning up surface quality. Many have a few isolated islands which should be amenable to the resonant boundary perturbation techniques.

<u>Next Step Activities for these configurations</u>

These are in addition to the planned flexibility and robustness studies, the following tasks were identified (in approximate order, though many are in parallel):

1. Attempt to remove the PIES-calculated islands in II283 and LI383, e.g. by perturbing resonant boundary harmonics. Complete any further optimization needed, particularly of II283.

2. Attempt modular coil designs for II283, LI383, and II378 in addition to c82 and II75 which are already completed. Test whether their current density scales as in the saddle coil study reported in the spread-sheet. Assess the physics reconstructability of the new configurations with these coils. Assess islands introduced by discrete saddle coils, using PIES. Re-optimize coils after (1).
3. Complete the alpha-confinement calculations in the spreadsheet
4. Complete the A_Δ scan, particularly for II283 and LI383, in addition to II75, A3k2.45b5.0 and A4k2.45b5.00 which are under study.
5. Calculate the electron energy confinement times for all the configurations.
6. Test whether a single set of coils can produce LI383 and a II378-like configuration, at least for a low-beta target.
7. Attempt further optimization of II283 attempting to raise its beta-limit above 4%. E.g. by raising $\langle\kappa\rangle$?
8. Calculate tearing-mode stability for LI383 and II378, at least in high-aspect ratio approximation.
9. Attempt further optimization of the configurations targeting current-sheet J_{max} and max-error. Particularly, see if II378 can be made acceptable.
10. Attempt to fix the flux surfaces in A4k2.45b4.75
11. Estimate neutral penetration and CX losses for II283 and LI383 for varying assumptions of neutral source locations.