PIES applications to NCSX

D. Monticello, A. Reiman, A. Brooks,
L. Ku, and C. Jun

Princeton Plasma Physics Laboratory
Princeton, NJ

- PIES - Princeton Iterative Equilibrium Solver
  PIES does not assume the presence of good flux surfaces in solving for three dimensional MHD equilibria
- NCSX - National Compact Stellarator eXperiment
  Proposed to be built at Princeton - making use of PBX hardware.

Purpose of this Study

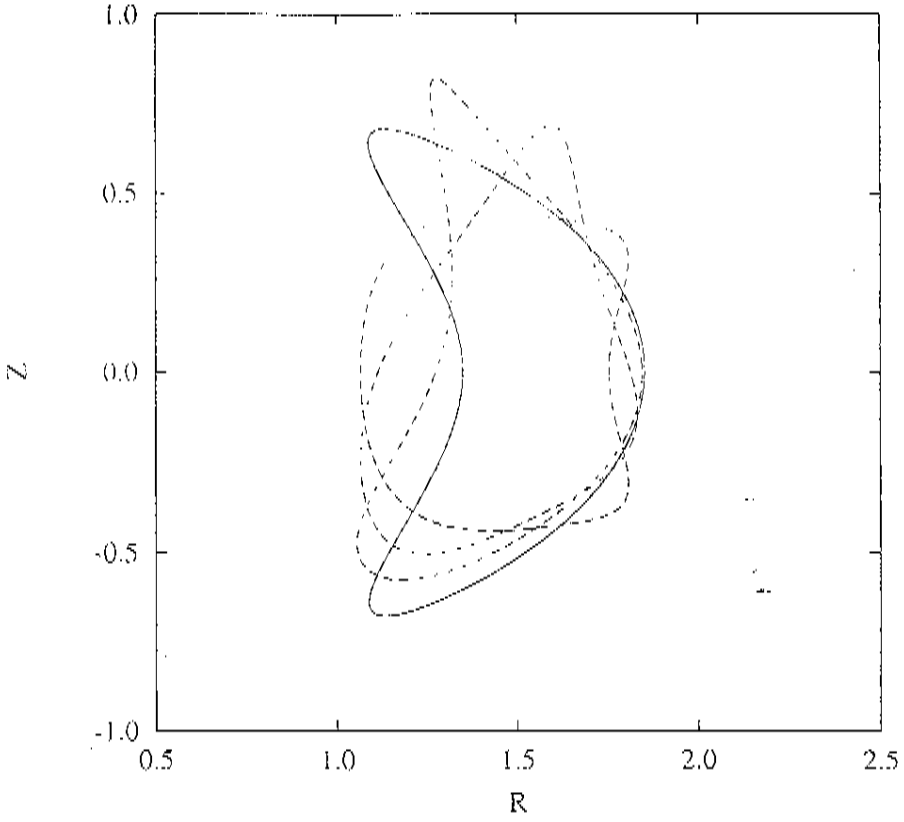
- Assessment of flux surface quality for NCSX plasma configurations
- Find remedies that can be used reduce island size

Outline

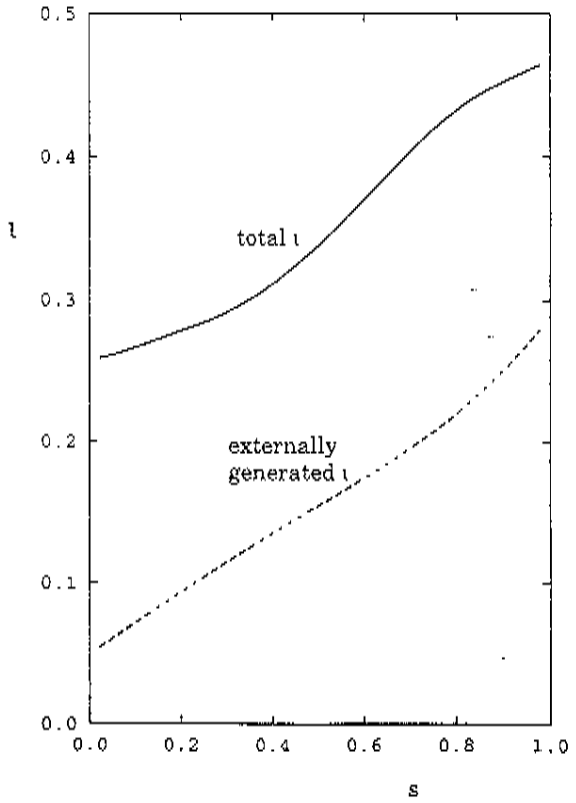
- C82 flux surface quality
  C82 was an earlier a QAS candidate configuration for the NCSX experiment.
- Surface quality issues for 383
  383 is our latest candidate configuration
  - Fixed boundary surface quality
  - Robustness to pressure and current profiles
  - Free boundary surface quality
  - Remedies for suppressing islands
    * Boundary perturbations
    * Coil perturbations
    * Trim coils

- **C82 Flux Surface Quality**

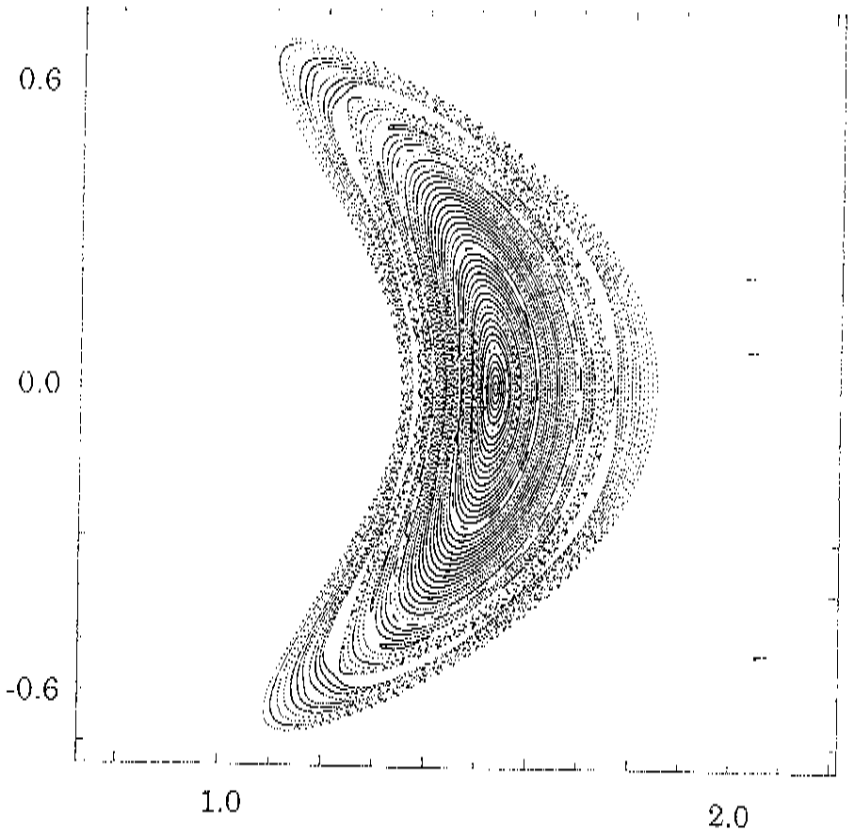
  - **Boundary of C82 as a function of toroidal angle**



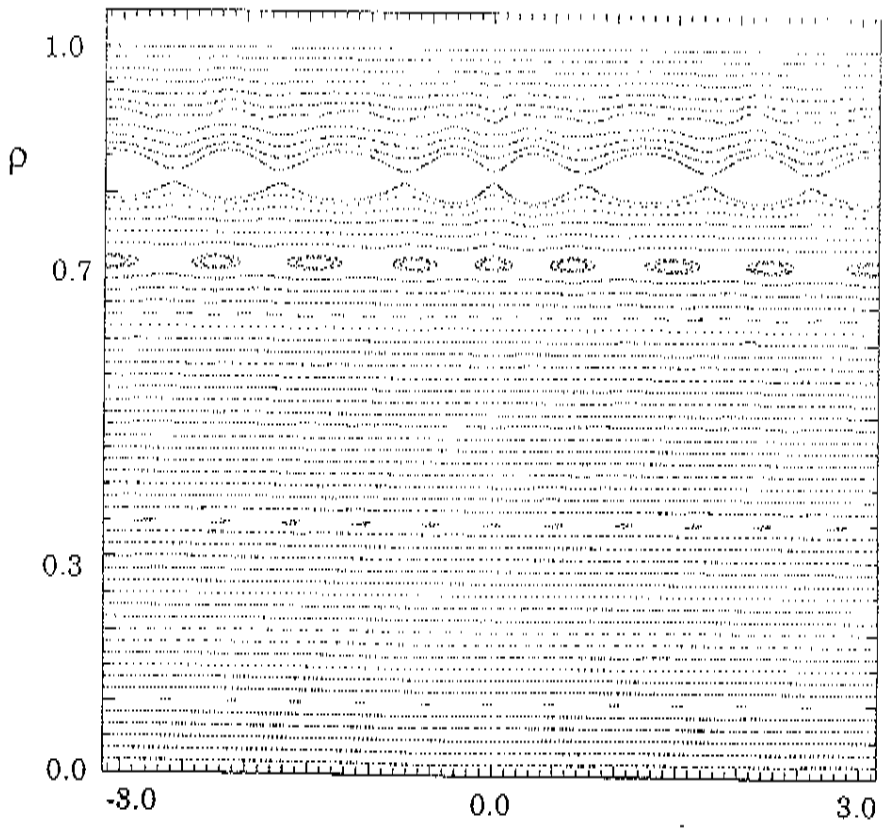
  - **Iota profile of C82**



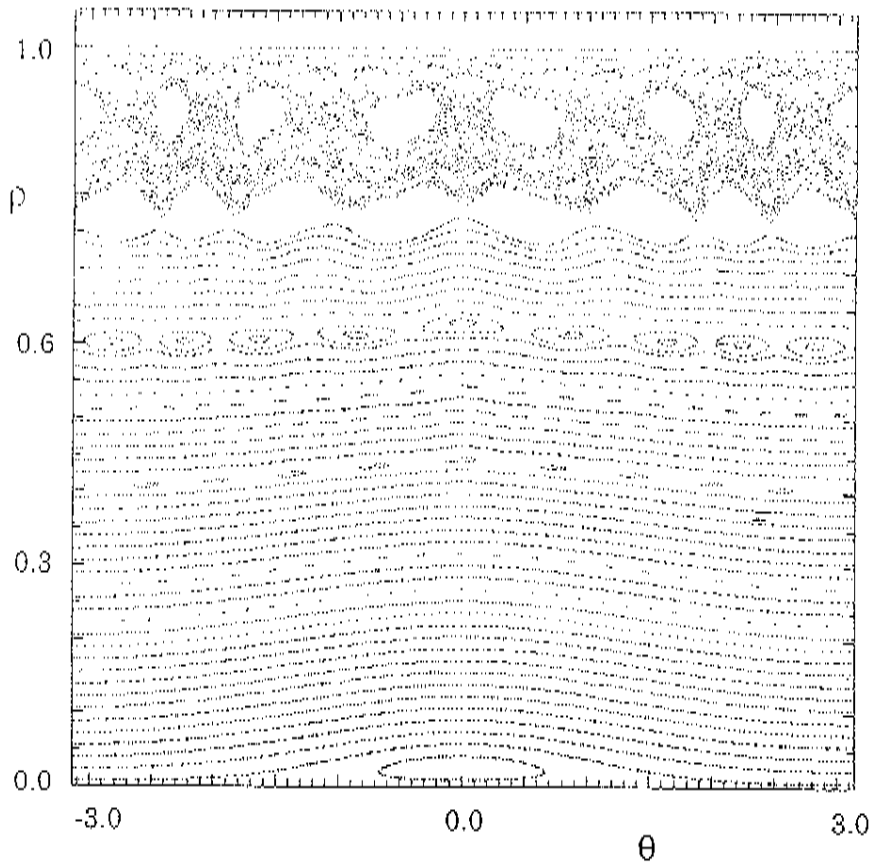
Poincare plot of C82 with boundary fixed
zero beta, full current
real space plot



– Poincare plot of C82 with boundary fixed
zero beta, full current
vmec coordinates

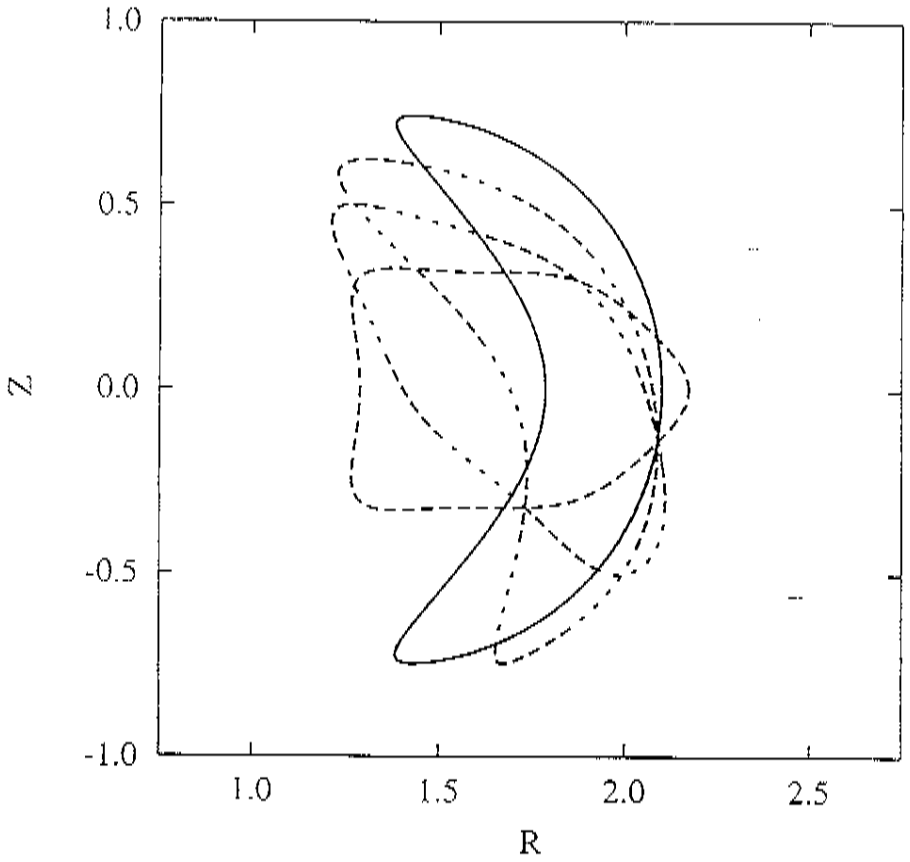


- **Poincare plot of C82 with boundary fixed full beta, full current vmec coordinates**

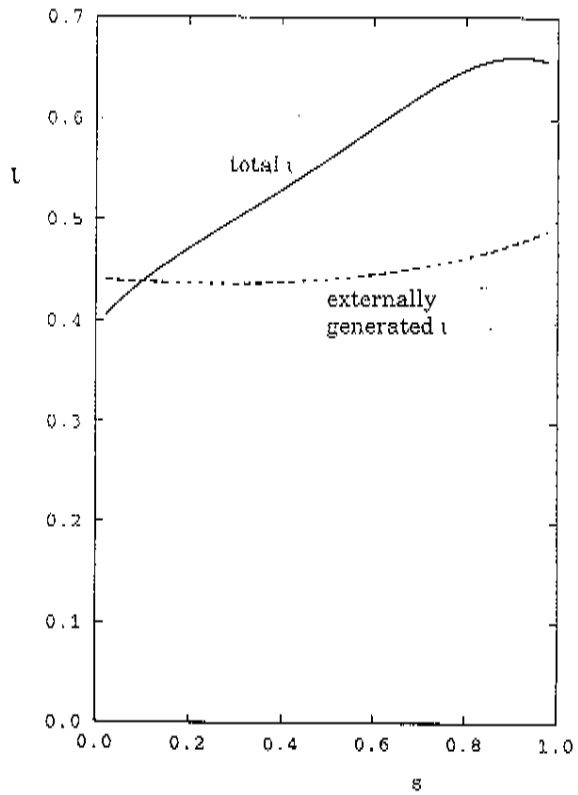


- **Poor surface quality is one reason we abandoned C82 and started a search for a new configuration. That search has settled on configuration 383**

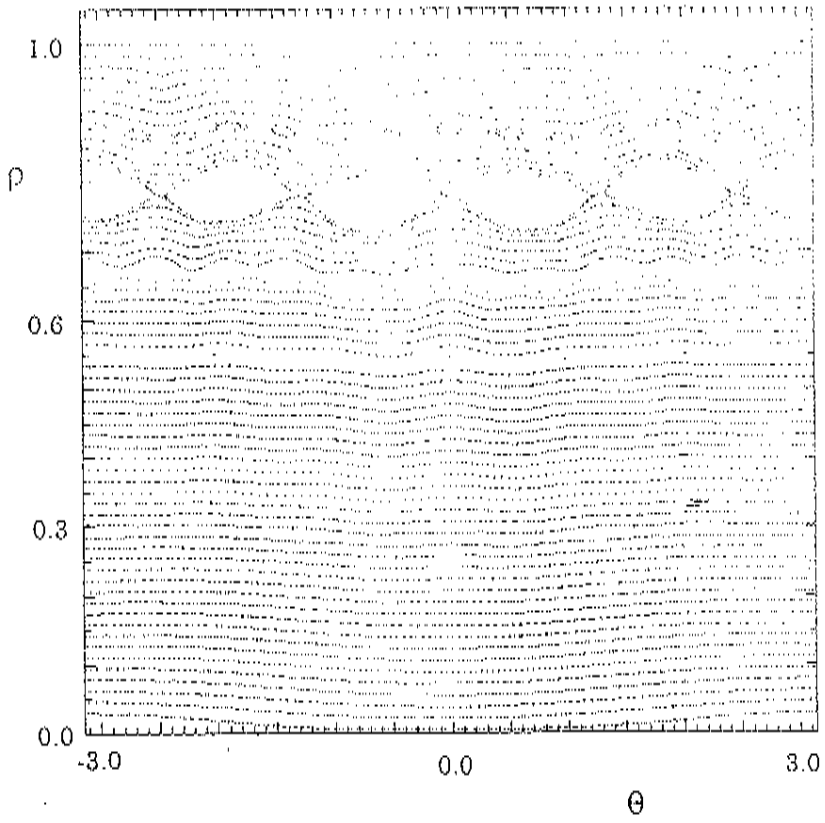
- **383 Flux Surface Quality**
  - **Boundary of 383 as a function of toroidal angle**



  - **Iota profile of 383**



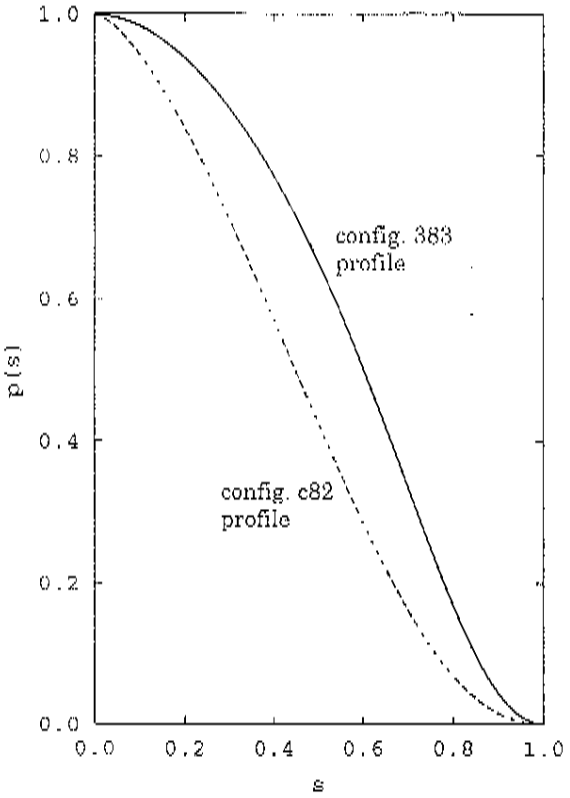
- **Poincare plot of 383 with boundary fixed full beta, full current vmec coordinates**



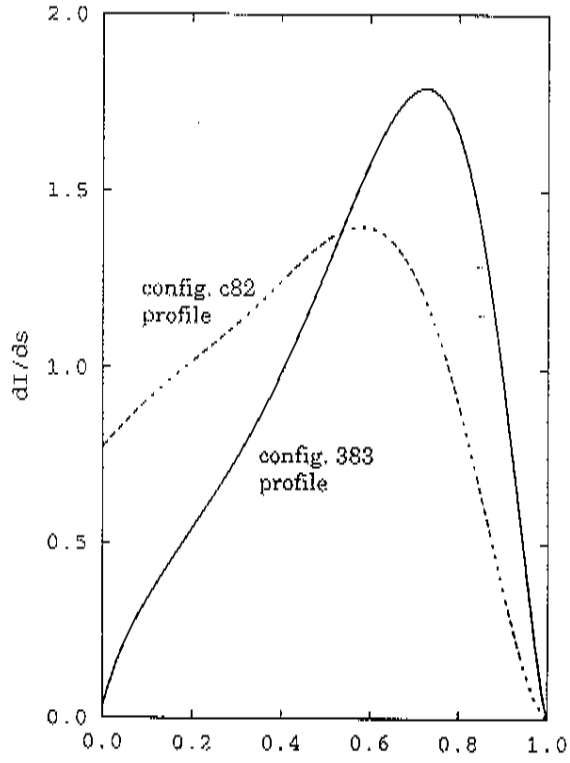
- **The flux surface quality, although not targeted in our optimizer, is a significant improvement over that of C82**

- **383 robustness study using C82 pressure and current profiles**

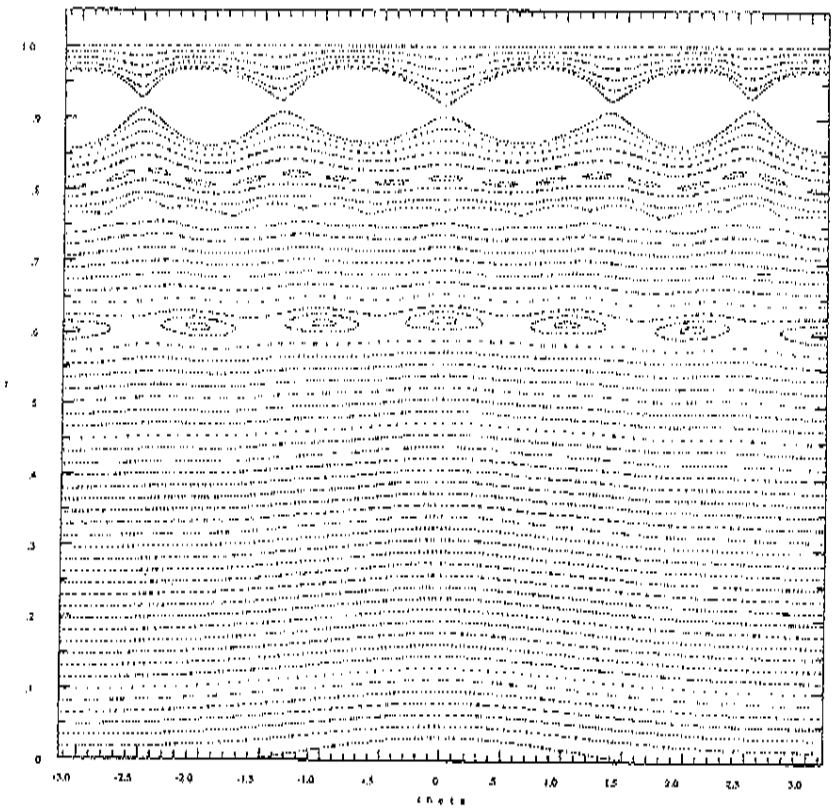
  - **Pressure profiles for C82 and 383**



  - **Current profiles for C82 and 383**

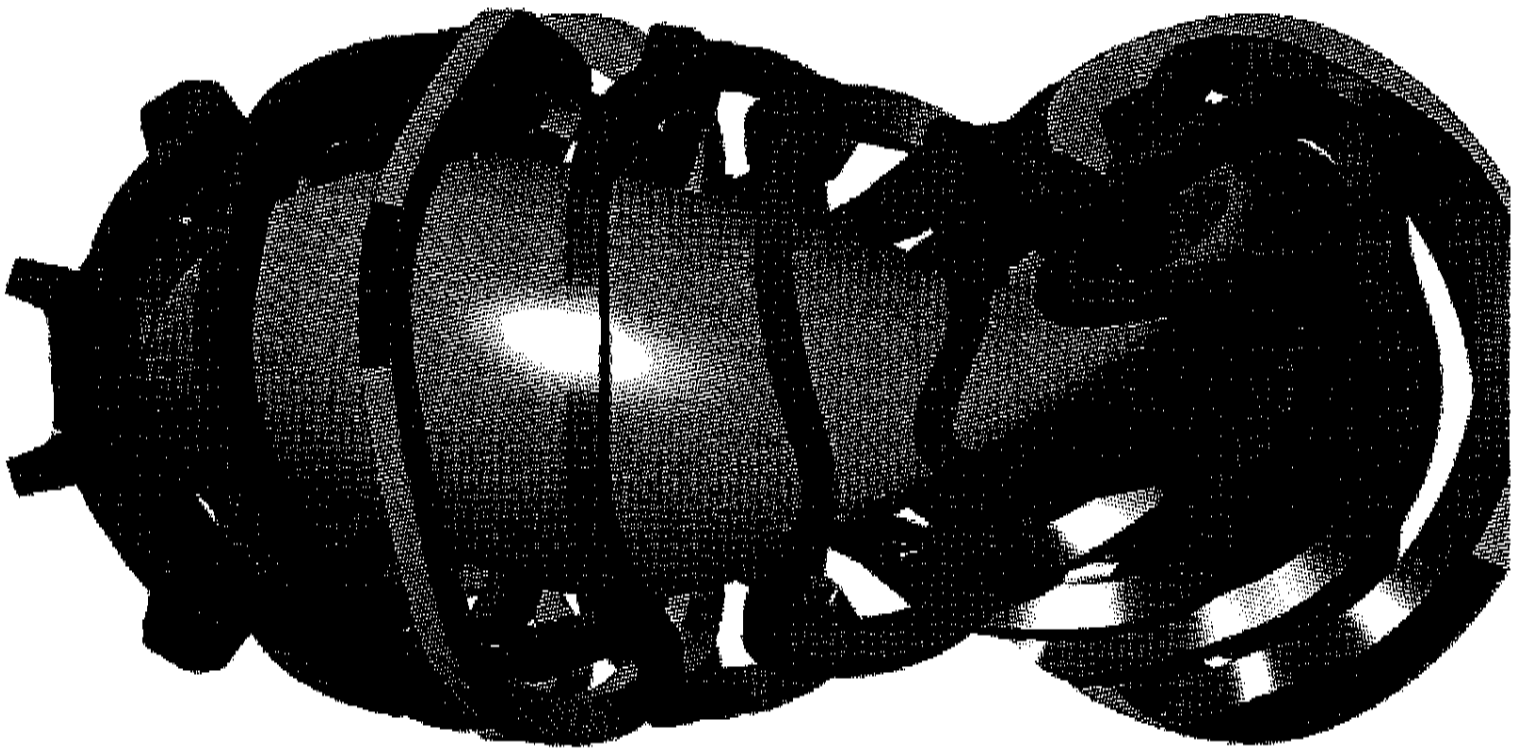


– Poincare plot of 383 with boundary fixed full beta, full current vmec coordinates

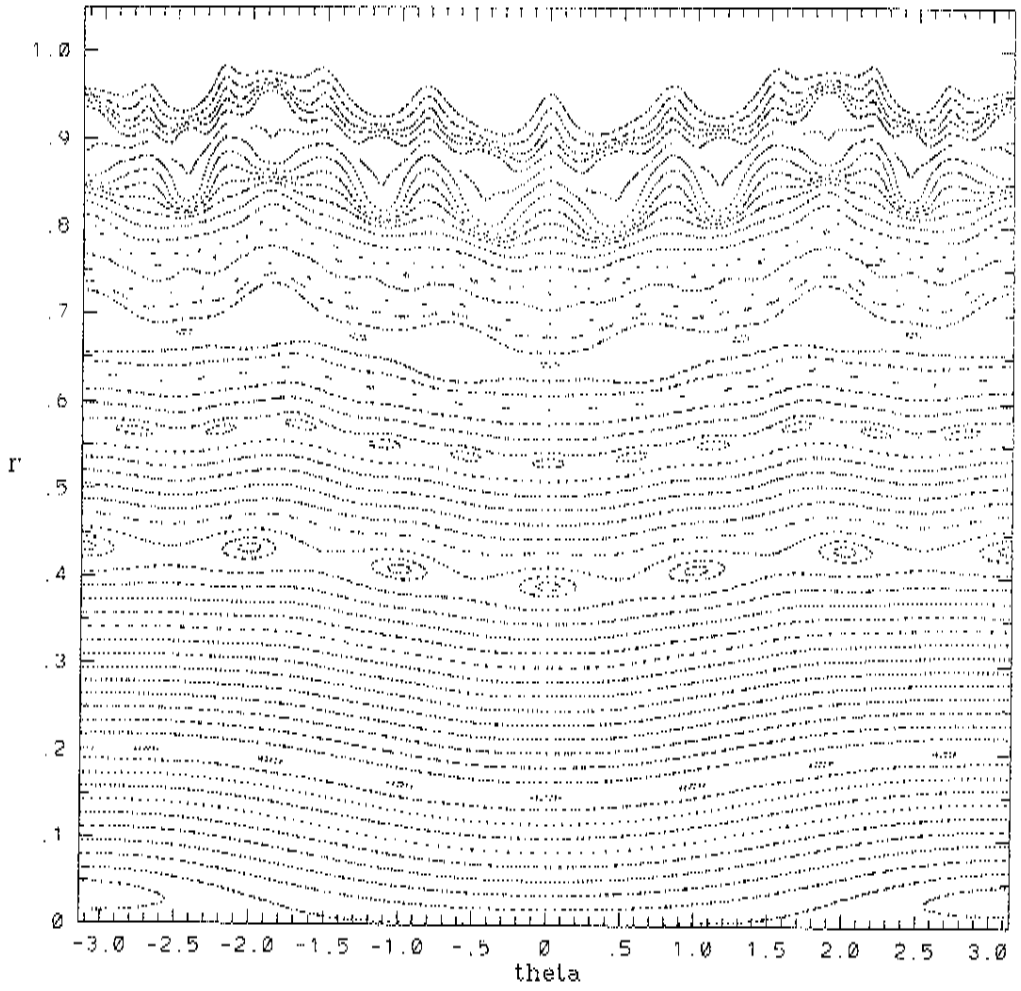


- **Free boundary flux surface quality for 383**

  - **Modular coils for 383**



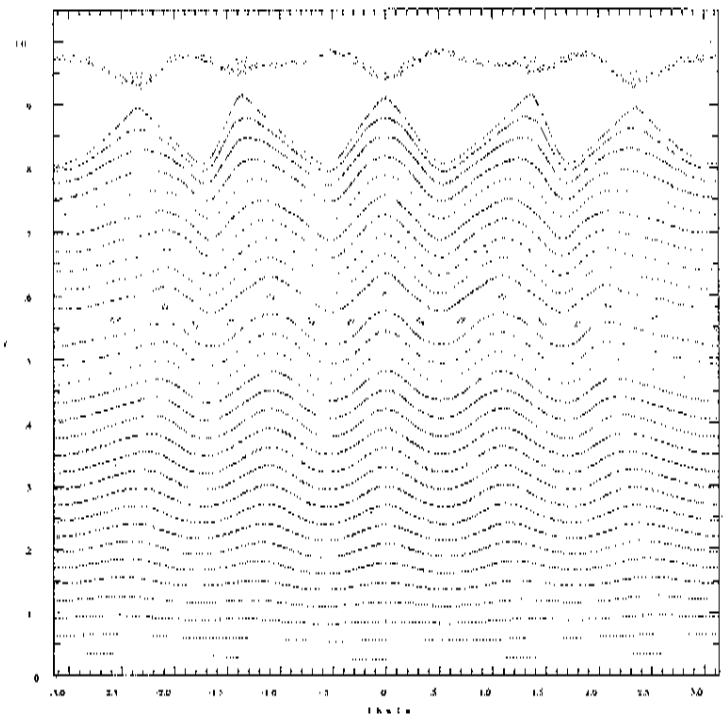
– **Poincare plot of 383 with boundary free**
using modular coils pictured above
full beta, full current
vmec coordinates
not converged

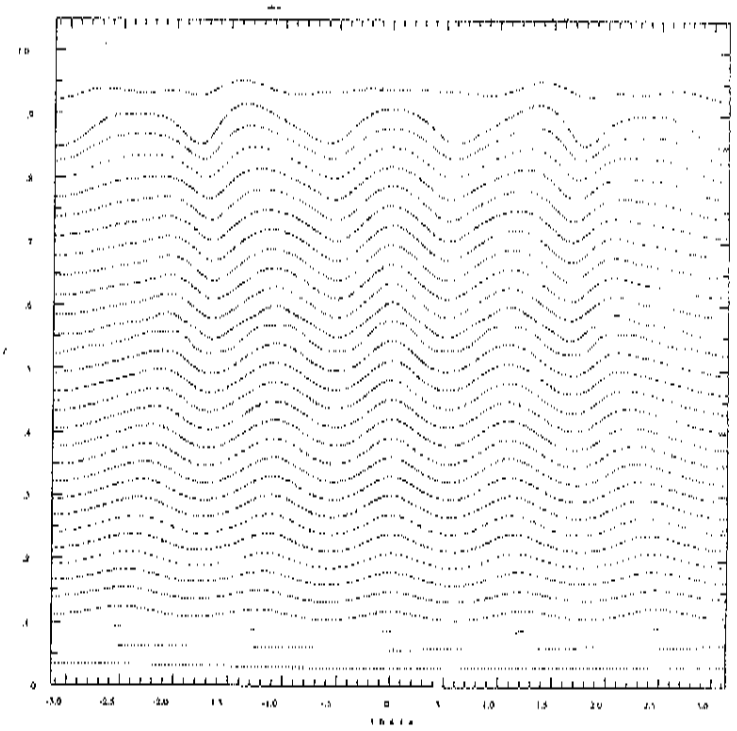


- Remedies for suppressing islands
  - Boundary perturbations
    - * The influence matrix of the boundary harmonics on island size is calculated using a series of PIES runs. SVD is used to solve for the boundary perturbations to minimize the islands. Coils are then cut to match the new boundary. See Stuart Hudson's poster in this session.
  - Coil perturbations
    - * A possible problem with the method described above is the that cutting the coils introduces errors and these errors might be large and cause islands. We have a possible work around this problem by targeting the important normal components of the magnetic field on the boundary and this procedure is being implemented. An alternative procedure is to work with the cut coils directly. Here, the parameters describing the coil are varied rather than the boundary harmonic as in procedure described above. This procedure is also being implemented.

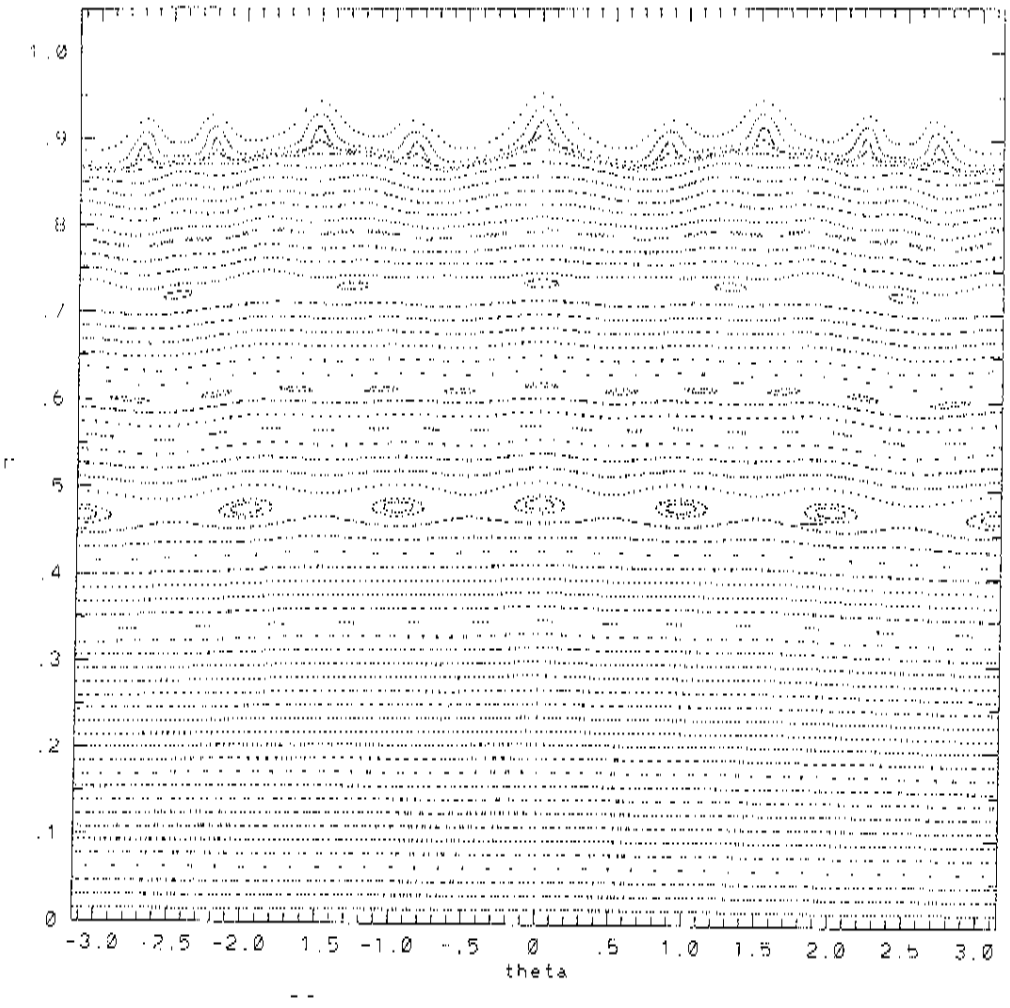
– Trim coils

* Since there are only a few large islands in the 383 plasma, it might be possible to use trim coils to reduce the size of targeted islands. We show two examples of this procedure, one for the vacuum state and one for the full current, full beta state.
* Vacuum state for 383 modular coils, plus m=5 trim coils. Without trim coils on the left and with trim coils on the right.





- Full beta, full current state for 585 modular coils, plus m=5 trim coils. This is not a converged PIES result, but the results thus far look encouraging.



- We are pursuing all the strategies above and may use them in concert to reduce islands occurring in the free boundary configuration.