QAS 3-D Equilibrium Studies

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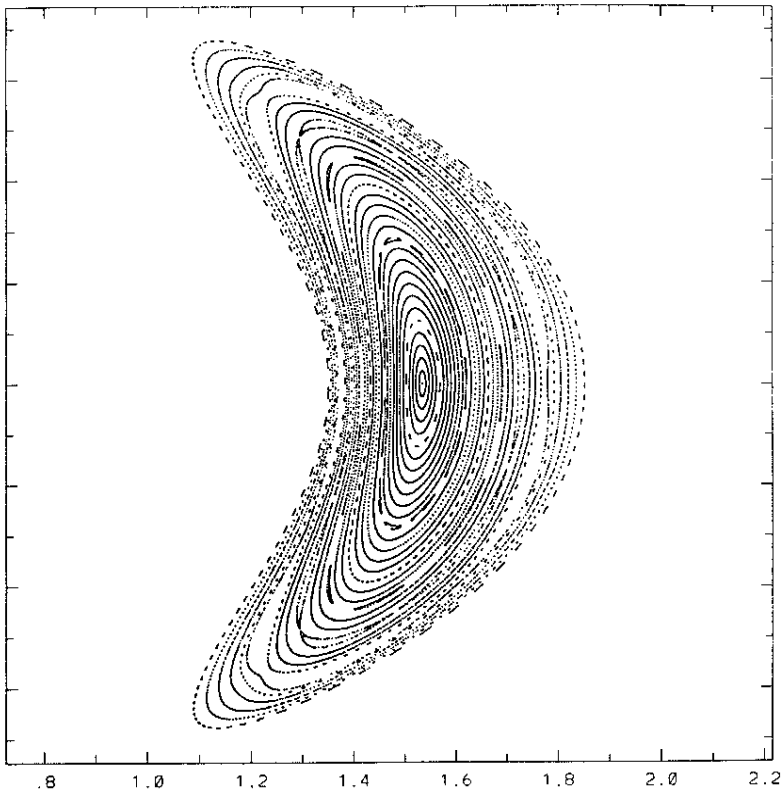
Purpose of this Study

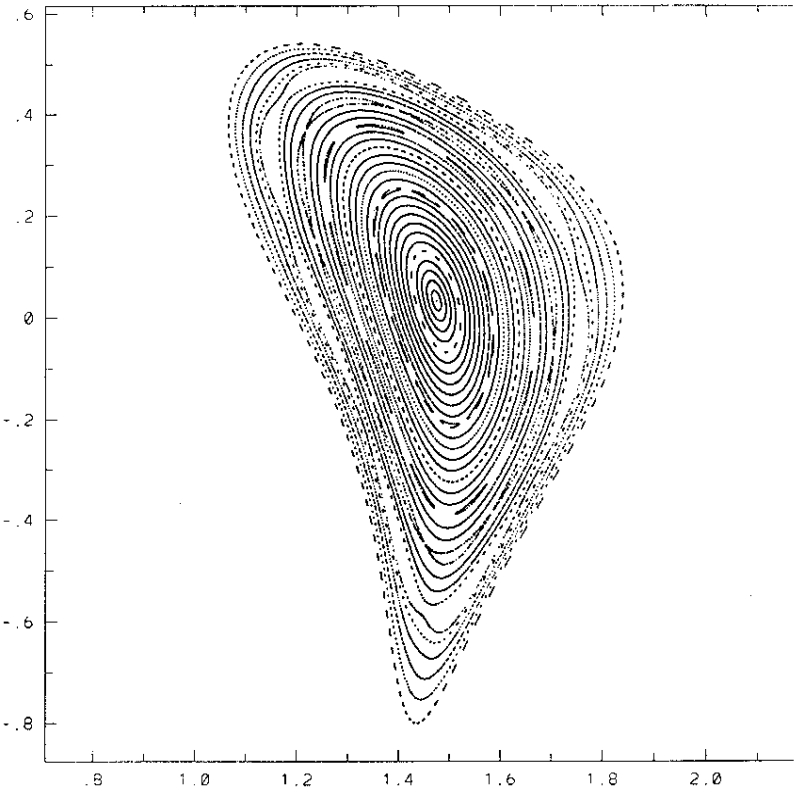
- **Assessment of NCSX plasma configurations**
- **Assessment of 3-D MHD tools (PIES and VMEC)**

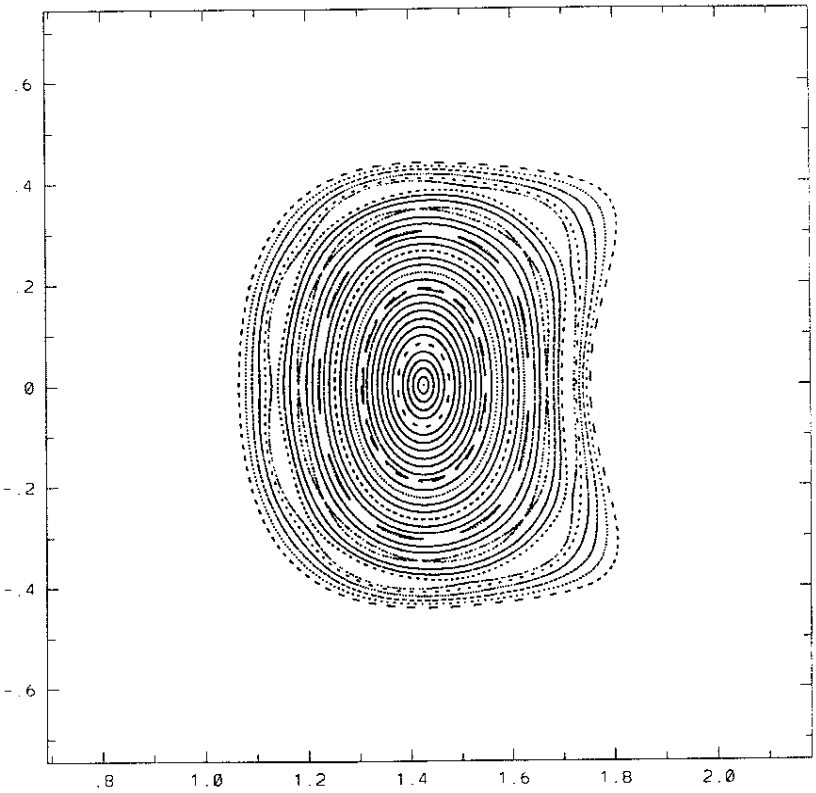
Outline

- **C82 flux surface quality for several snapshots in the evolution of the plasma from 0% β to 3.5% β**
  C82 is a QAS candidate configuration for the NCSX experiment.
- **W7-AS flux surface quality at finite current**
- **Evidence of the violation of the Hamada Condition in VMEC equilibria**

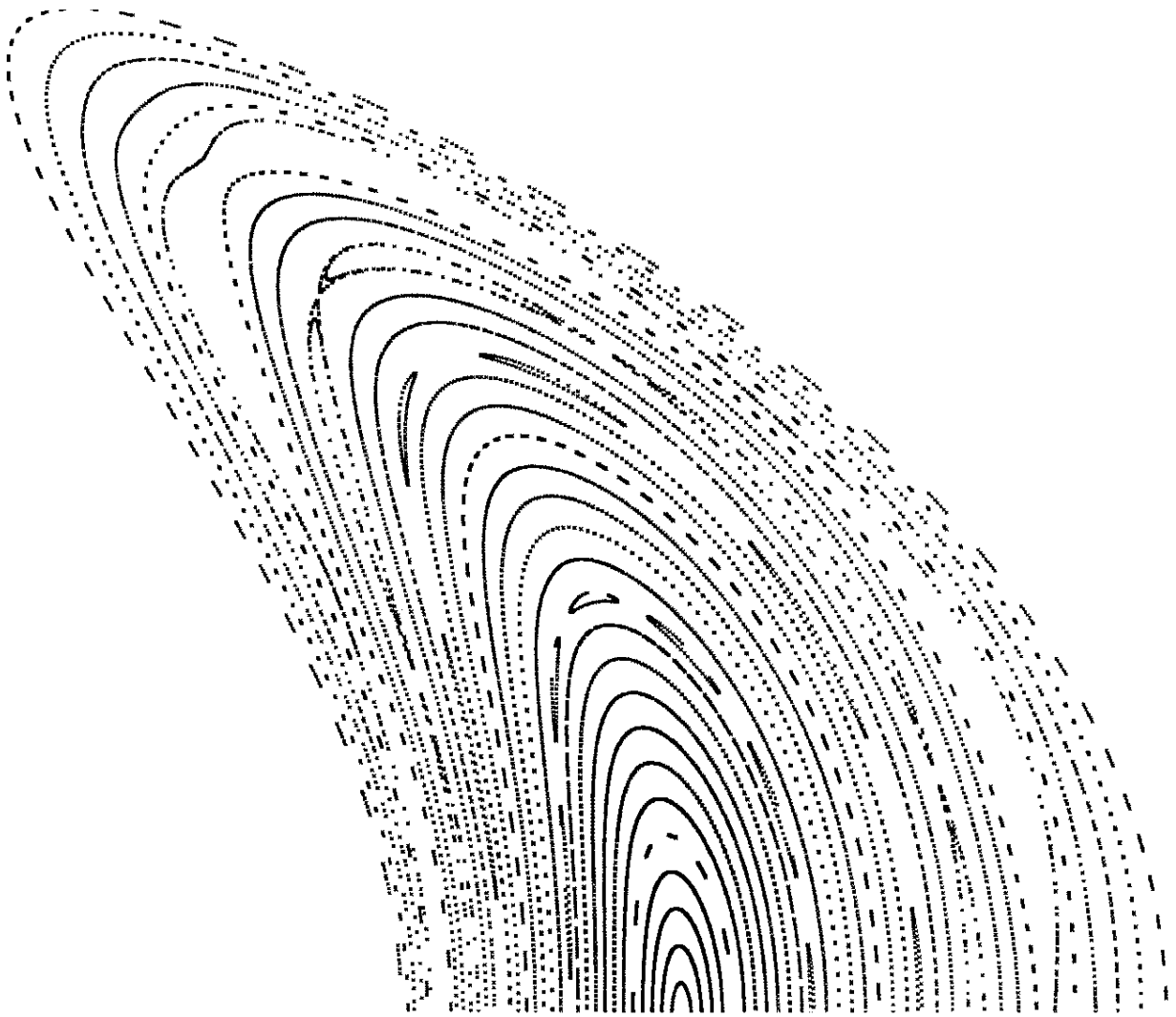
- **C82 at Full Current and 0% β**
  Various Cross-sections in Real Space





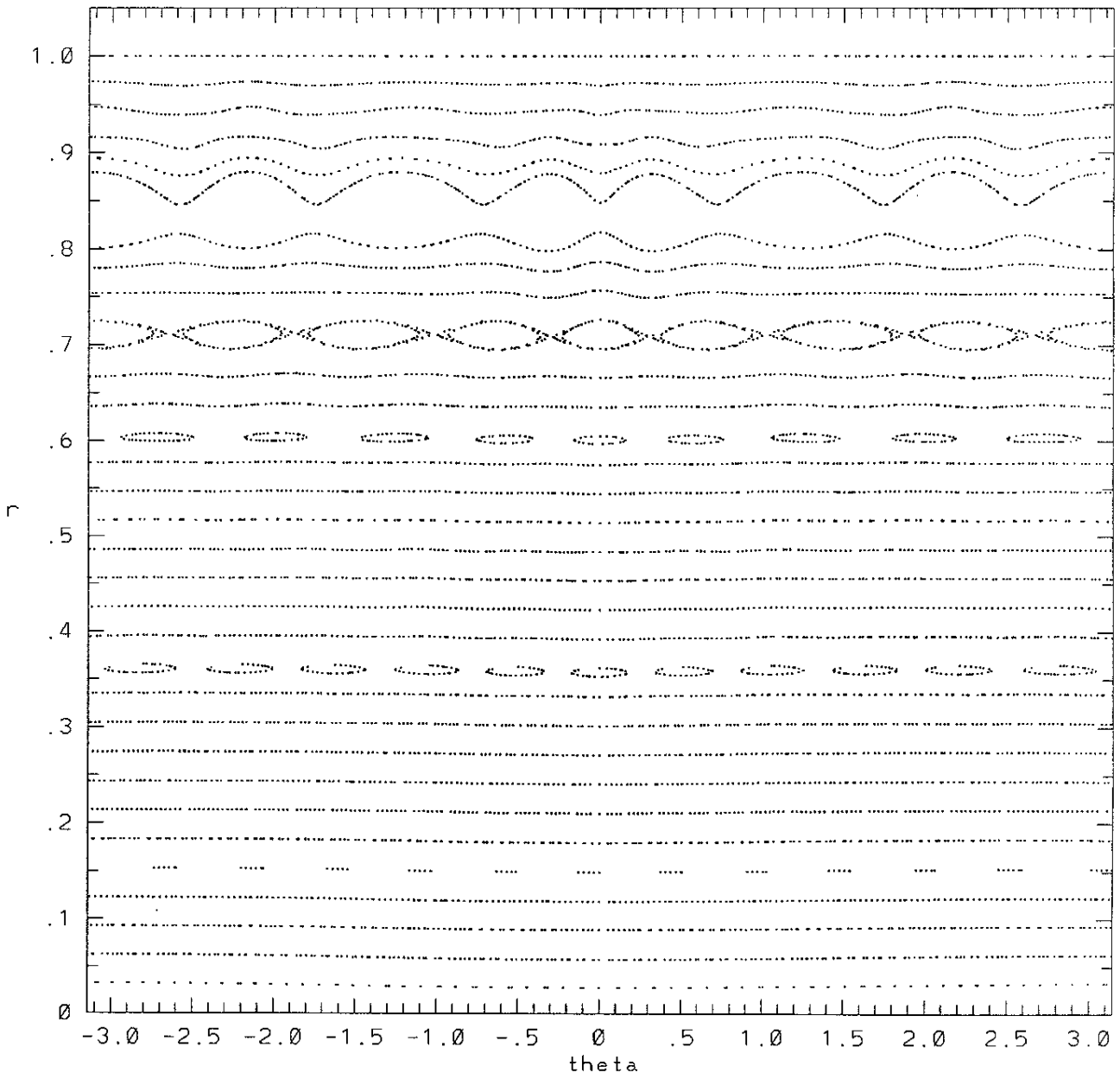


- **C82 at Full Current and 0% β**
  Enlarged $\phi = 0$ Cross-section in Real Space

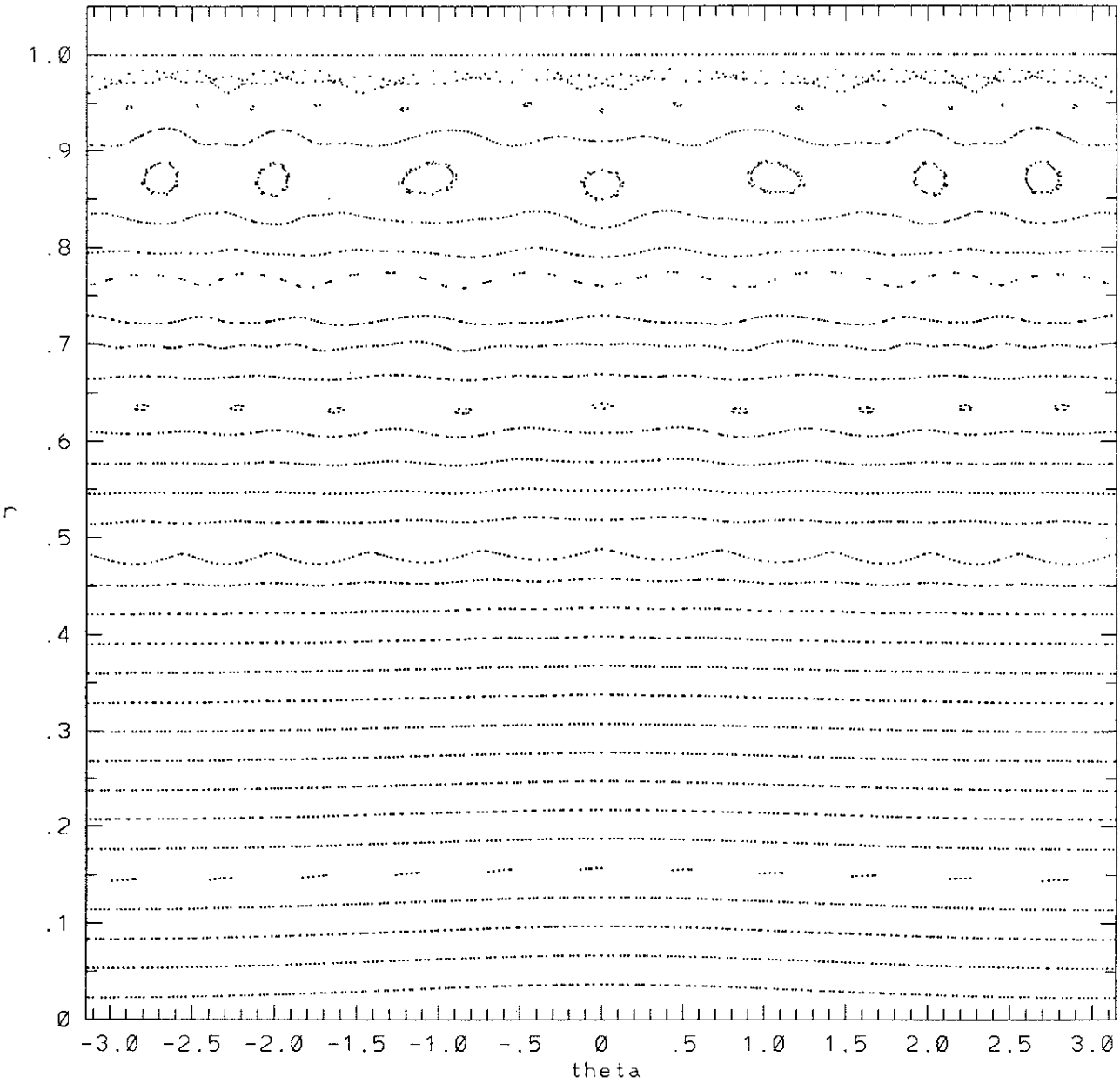


- **Flux surface quality appears reasonable**

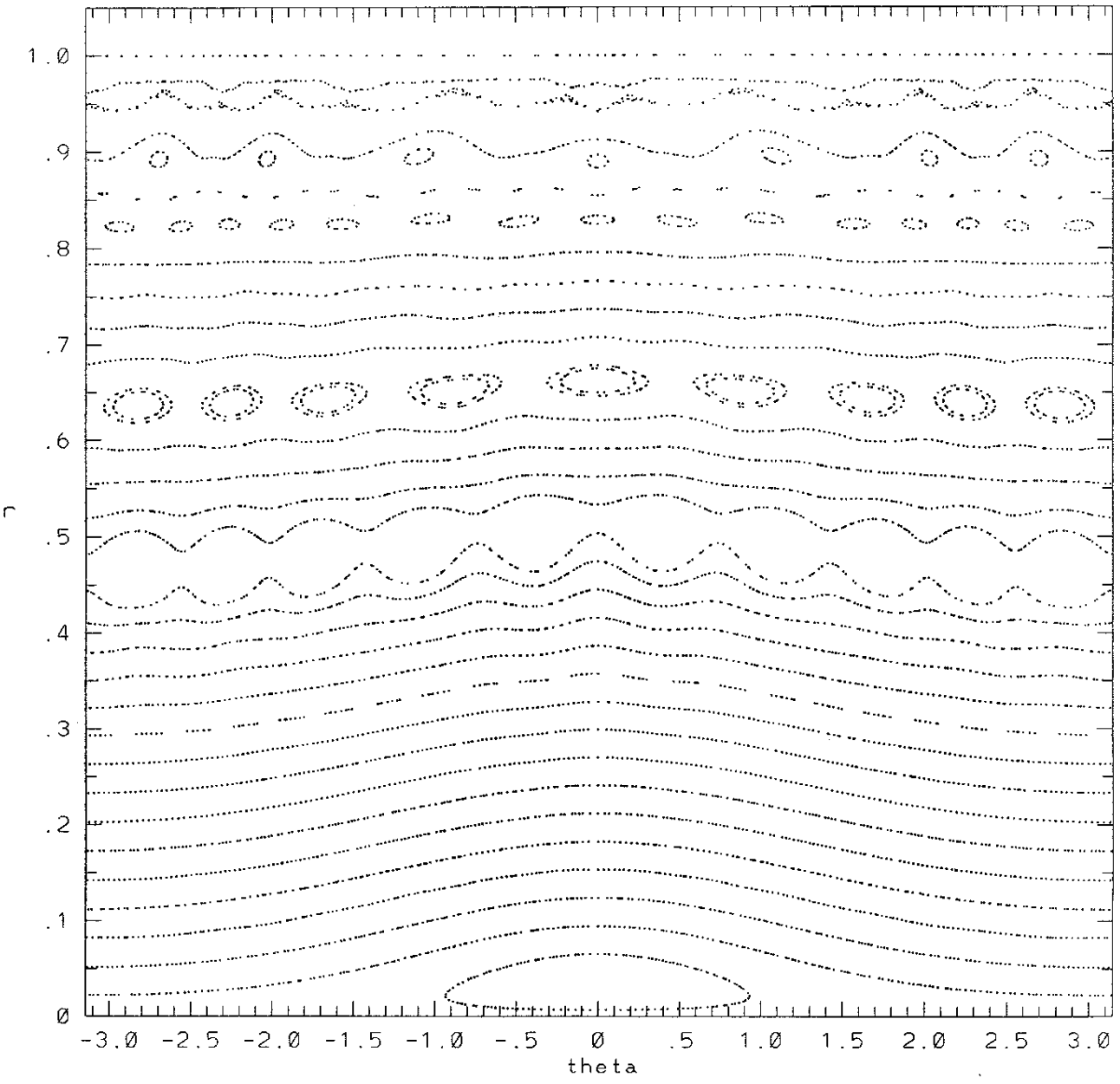
- **C82 at Full Current and 0% β $\phi = 0$ Cross-section in Background Coordinates**



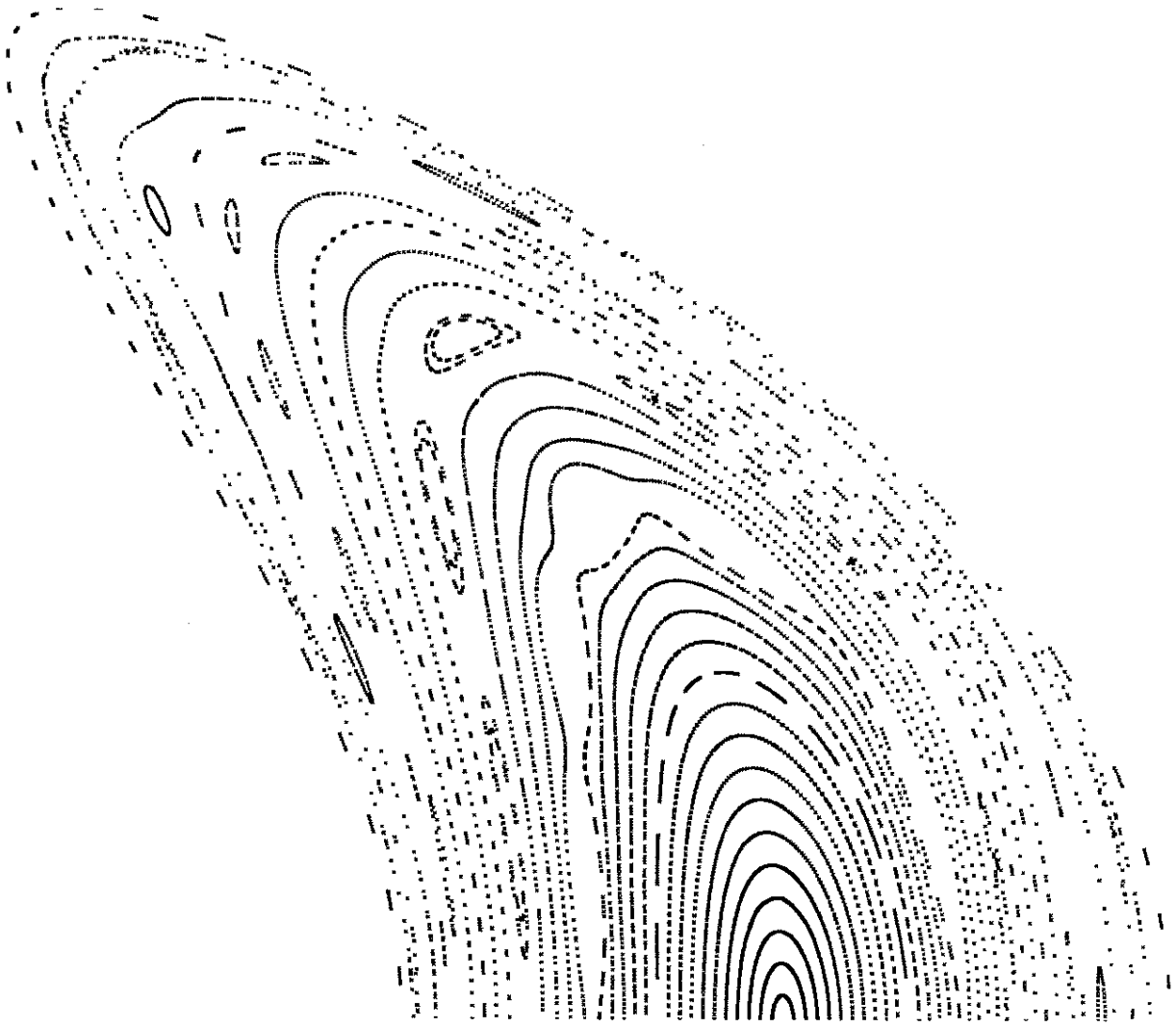
- **C82 at Full Current and 3% β $\phi = 0$ Cross-section in Background Coordinates**



- **C82 at Full Current and 3.5% β $\phi = 0$ Cross-section in Background Coordinates**



- **C82 at Full Current and 3.5% β**
  $\phi = 0$ Cross-section in Real Space



- **Flux surface quality becoming questionable**

- **W7-AS (Erckmann, et al, IAEA, 1996)**

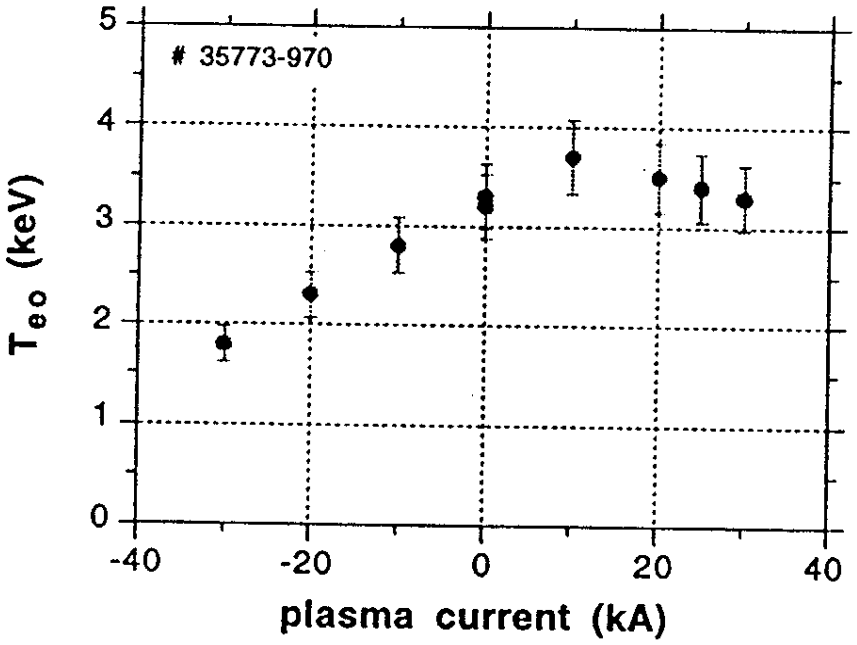
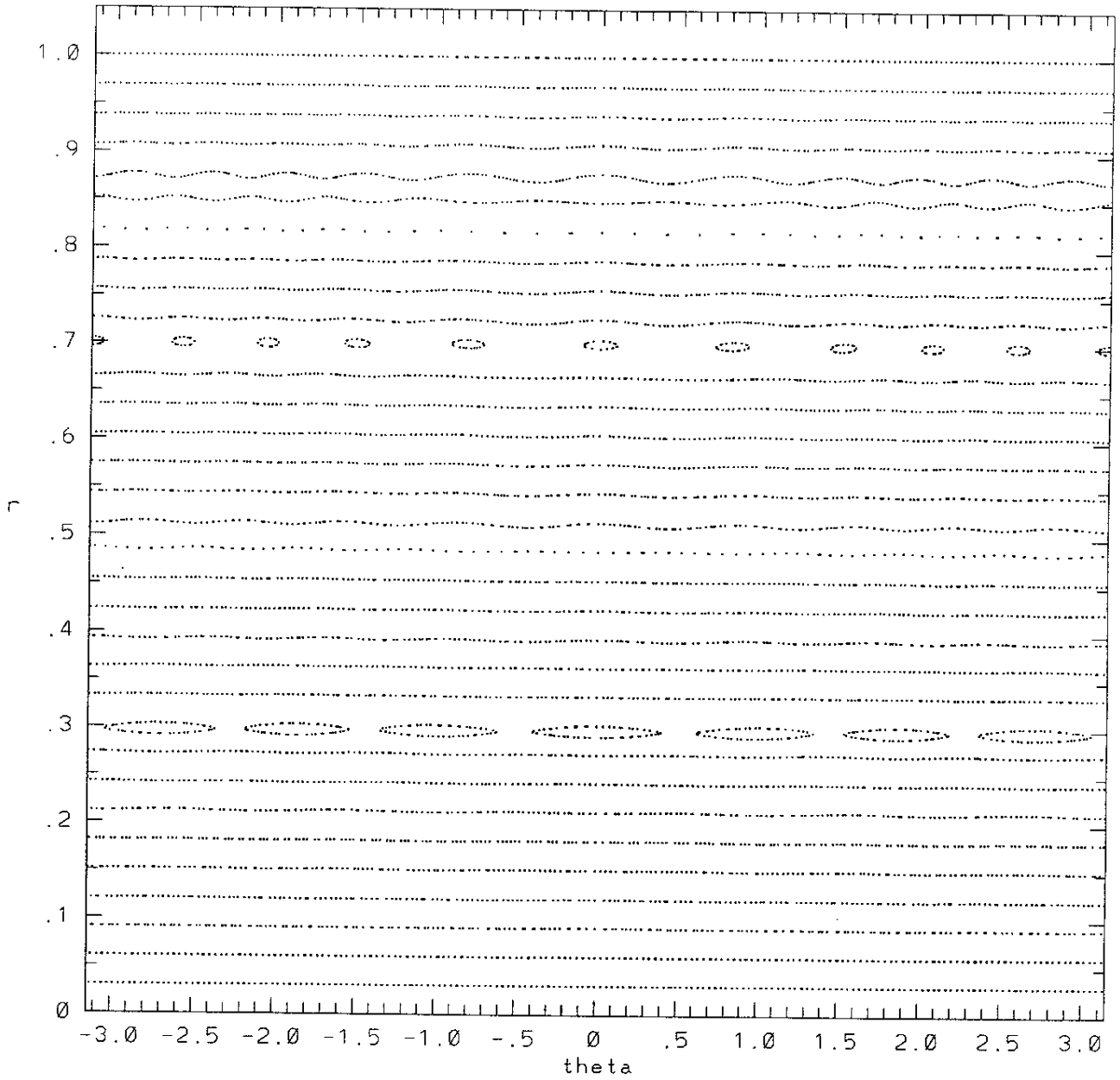


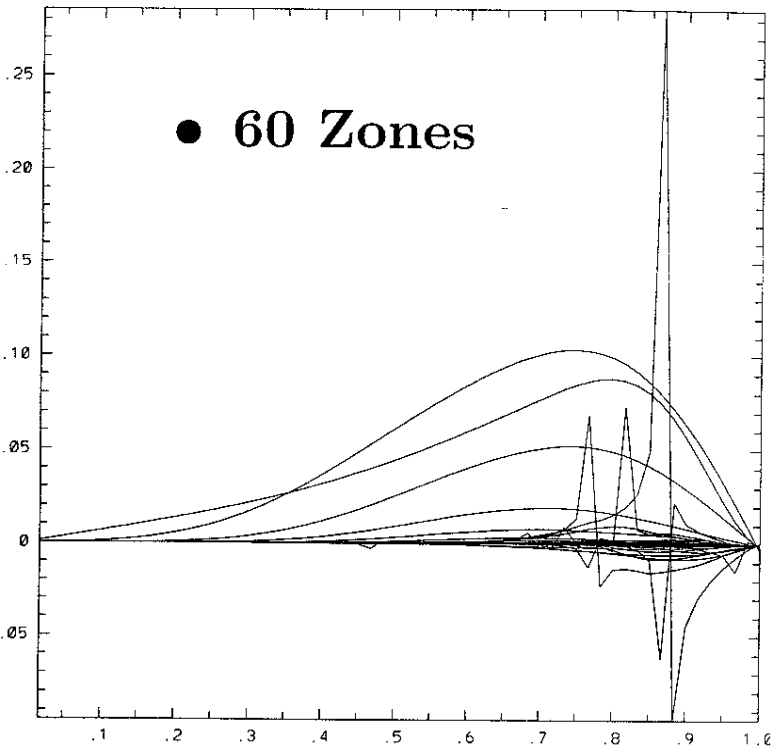
FIG. 6. Central electron temperature for discharges with different plasma current.

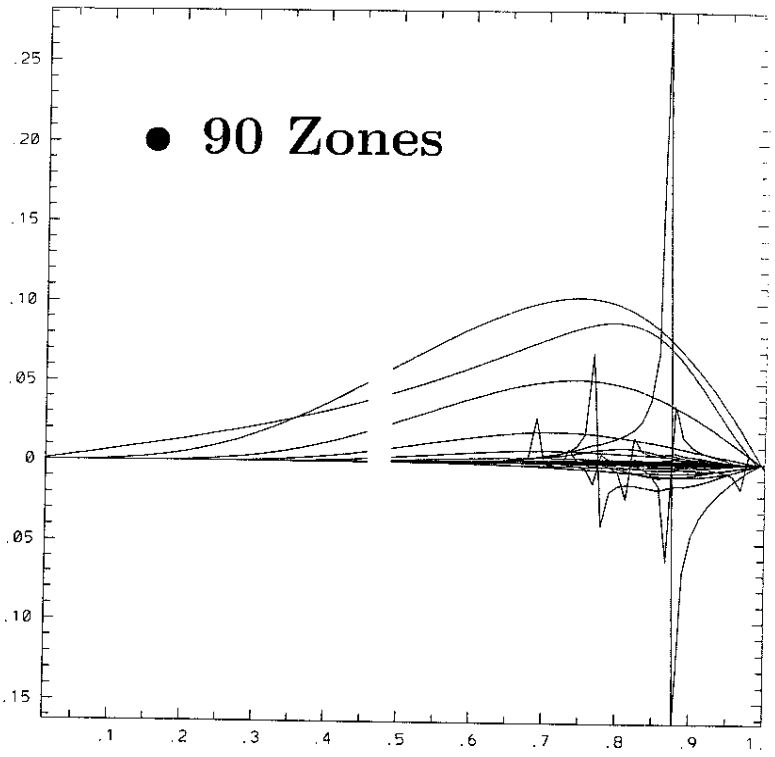
- **W7-AS +30KA Current and .1% β (Data from J. Geiger)**

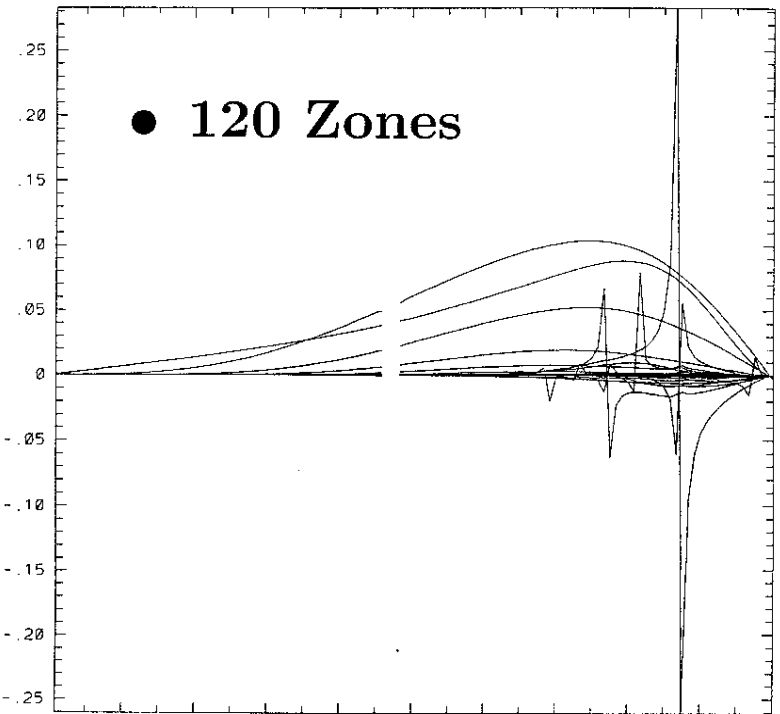


- **PIES result consistent with experimental result**

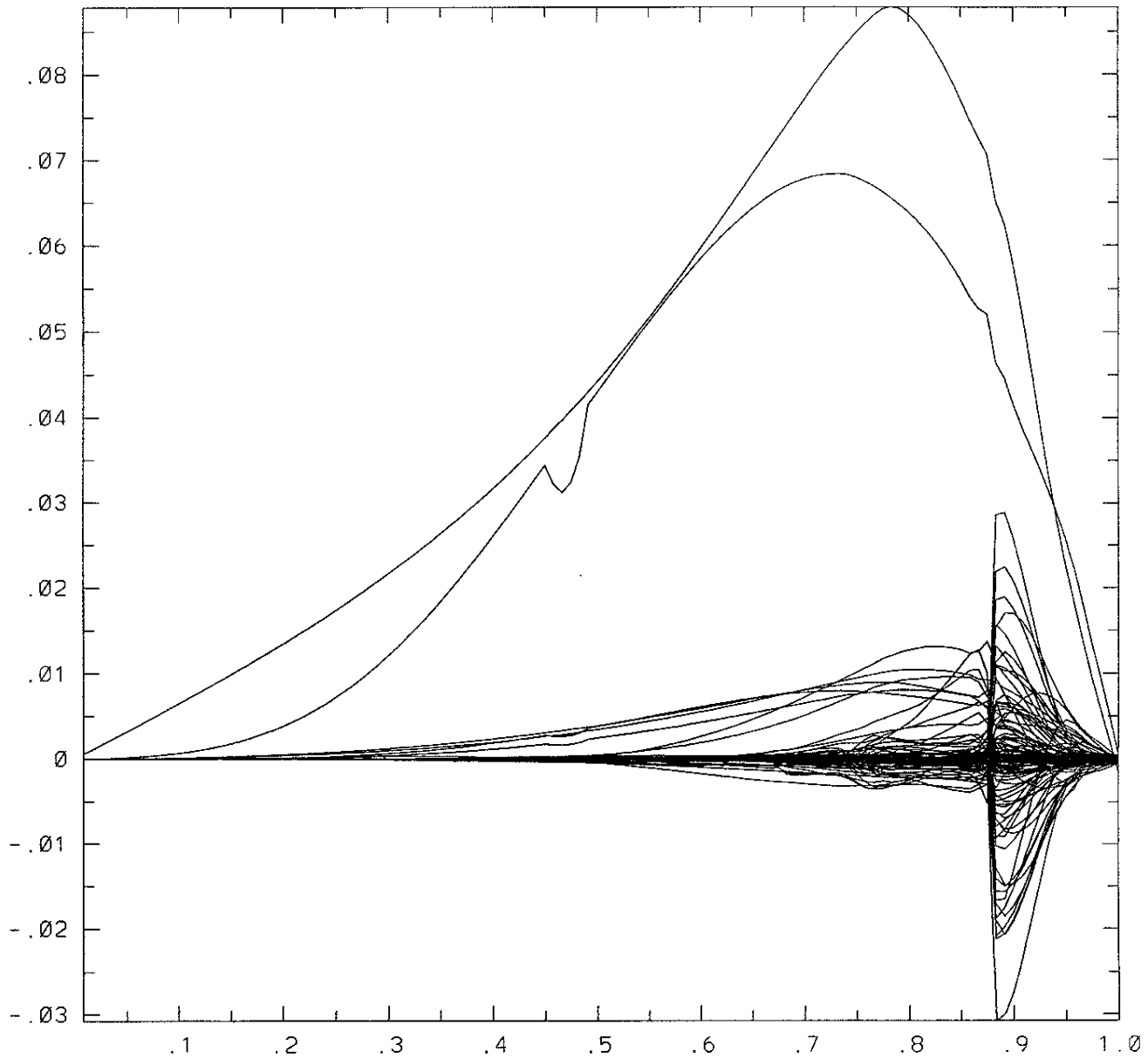
- Harmonic amplitude of $Jacobian * J^{\phi}$ vs radius for the C10 Plasma in Magnetic Coordinates at Full Current and Full β for Various Radial Resolutions Showing Evidence of Resonant Pfirsch-Schulter Currents



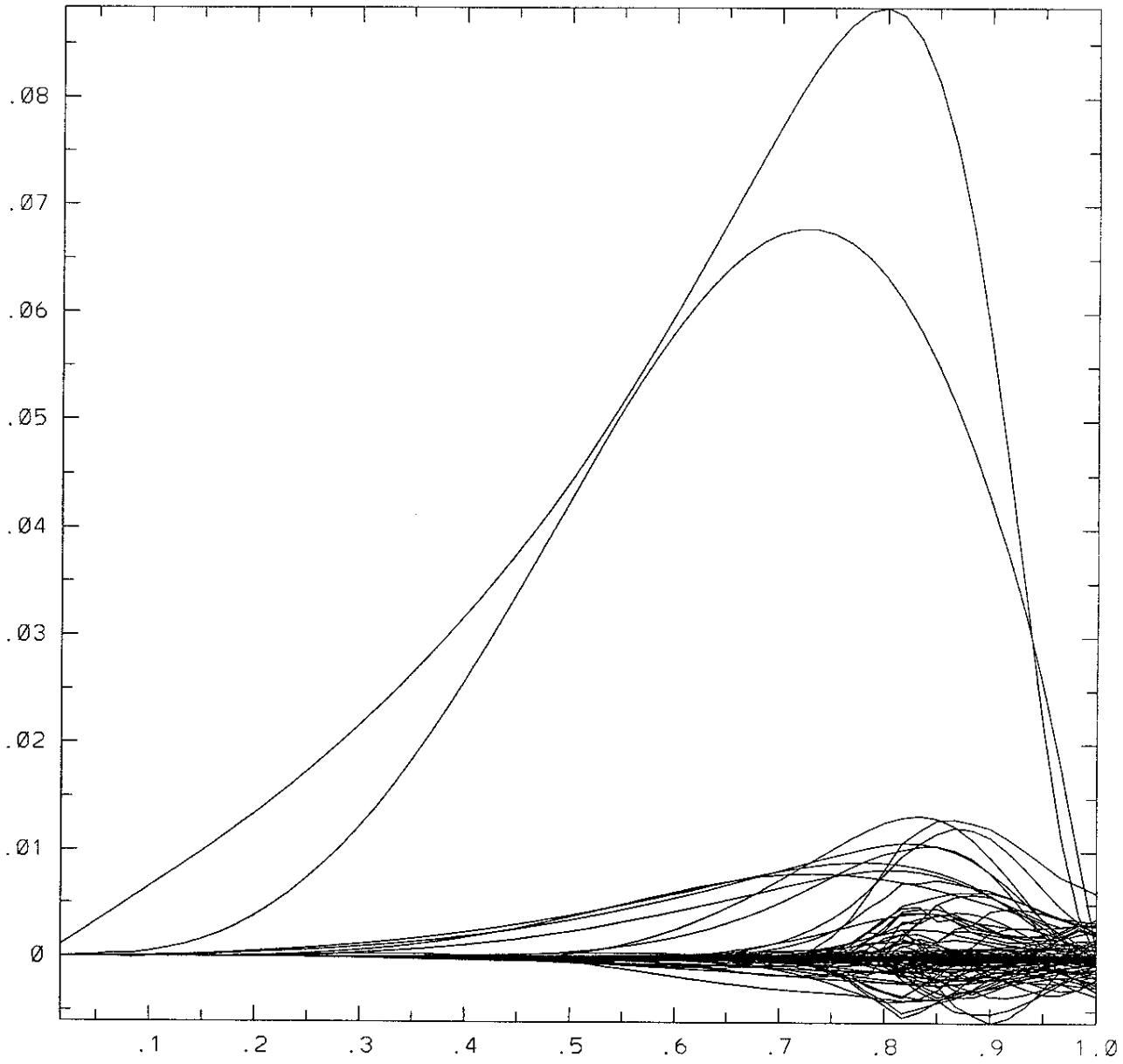




- Harmonic amplitude of $Jacobian * J^{\phi}$ vs radius for the C10 Plasma in Background Coordinates at Full Current and Full β Showing Evidence of Resonant Pfirsch-Schulter Currents (120 radial zones in PIES)



- Harmonic amplitude of $Jacobian * J^{\phi}$ vs radius for the C10 Plasma in Background Coordinates at Full Current and Full β Showing
  No Evidence of Resonant Pfirsch-Schulter Currents
  (400 radial zones in VMEC)



Summary and Remarks

- We have used the PIES code to examined the equilibrium of the C82 plasma for various snapshots without the constraint of simply nested flux surfaces used in the VMEC evaluation of these equilibria.
- At 3.5% β, the C82 plasma shows significant island structure. Before we begin studies to assess the effect these island would have on transport, convergence studies of the PIES results will be performed. Also, we are enlisting two other MHD equilibrium codes, M3D and HINT, to confirm these PIES results.

- In order to validate the PIES results, we have begun to look at experimental results of stellarator equilibria. We presented here a low beta, high current discharge from W7-AS. We plan to examine higher beta cases from W7-AS and other stellarators equilibria such as LHD and CHS.
- We have presented evidence that the VMEC equilibria are not converging to the weak solution. We are searching for the source of the discrepancy between the PIES code and the VMEC code by doing convergence studies with both codes. However, we point out that it has been noted by Gardner and Blackwell (Nuclear Fusion, Vol.32, No.11 (1992)) that VMEC solutions do not show resonant behavior.