

Update on Island Suppression Effort

NCSX Physics Meeting

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Objective

- Try to suppress islands produced by a given coil set by varying the coil currents, targeting both $B \cdot n$ on boundary and calculated island width on resonant surfaces

but first

- Demonstrate that methods used to target island size correlate with islands observed

– Note: All data presented refers to Vacuum Configuration

Procedure Being Pursued

- Start with generating a coil set
 - Presently still targeting $B \cdot n = 0$. on plasma boundary
- Run VMEC free boundary
 - Extract VMEC surfaces to use as PIES background coordinates using vp code
- Run PIES
 - Extract PIES resonant surfaces (surface thru x and o points, in magnetic coordinates) and their associated iota, s, $d\Psi/ds$
- Run Curropt
 - Calculate Island Widths on Resonant Surfaces
 - Correlate with PIES field line plots
 - Try to suppress Islands by varying coil currents while preserving $B \cdot n = 0$. on plasma boundary using SVD

Island Width Evaluation

Using s , θ , ϕ as the magnetic coordinates, island width given by :

$$ds = 4 \left| \frac{C_{mn}(s)}{ml'(s)} \right|^{1/2}$$

where $C(s) \equiv \frac{B^s}{B^\phi} = \frac{B \bullet \nabla s}{B \bullet \nabla \phi}$

$\frac{B^s}{B^\phi}$ is evaluated by making use of

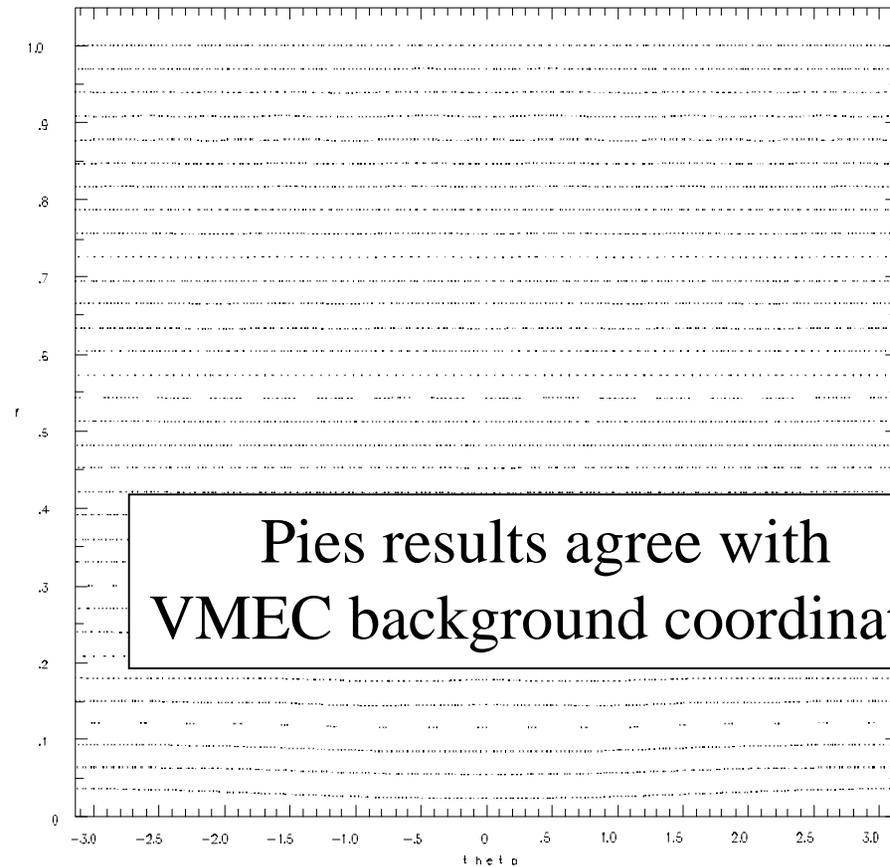
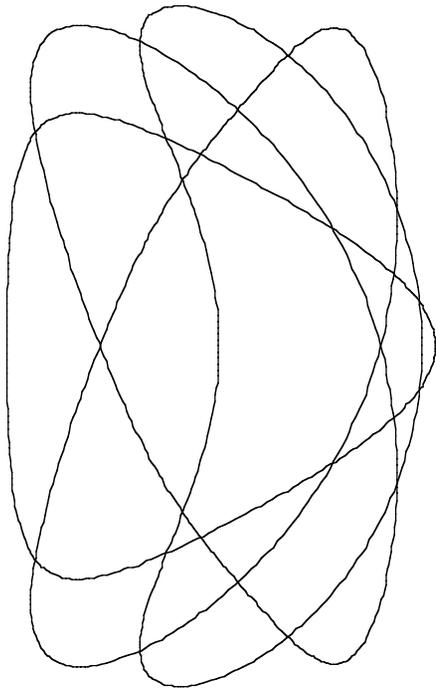
$$B^\phi = \frac{1}{J_{s,\theta,\phi}} \frac{d\Psi}{ds}$$

and $\nabla s = \frac{1}{J_{s,\theta,\phi}} \left(\frac{\partial R}{\partial \theta} \times \frac{\partial R}{\partial \phi} \right)$

leaving an expression which does not require explicit evaluation of the Jacobian and linear in B (and therefore coil currents)

$$\frac{B^s}{B^\phi} = \frac{B \bullet \left(\frac{\partial R}{\partial \theta} \times \frac{\partial R}{\partial \phi} \right)}{\frac{d\Psi}{ds}}$$

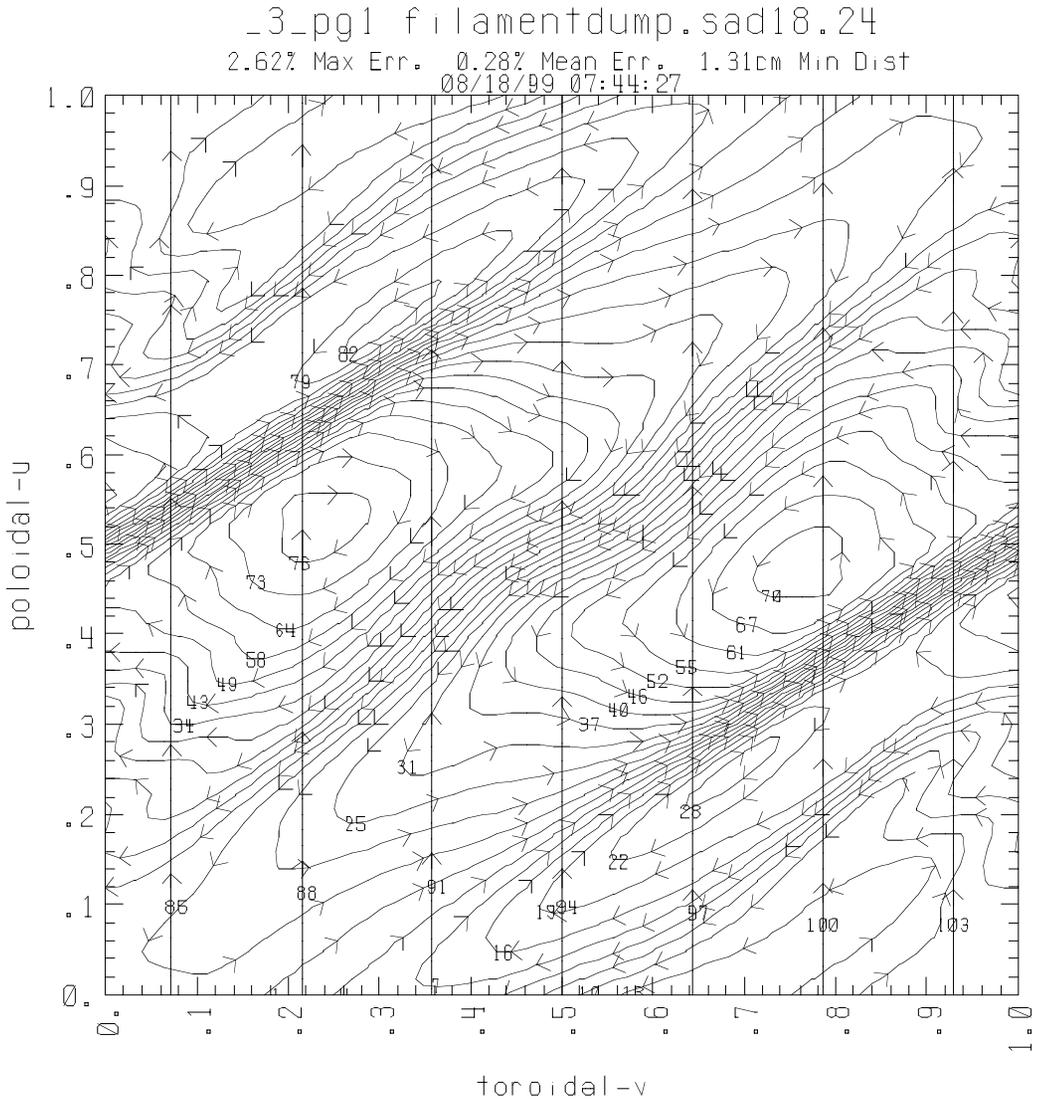
Test Plasma PG1 with Good Vacuum Fixed Boundary Surfaces



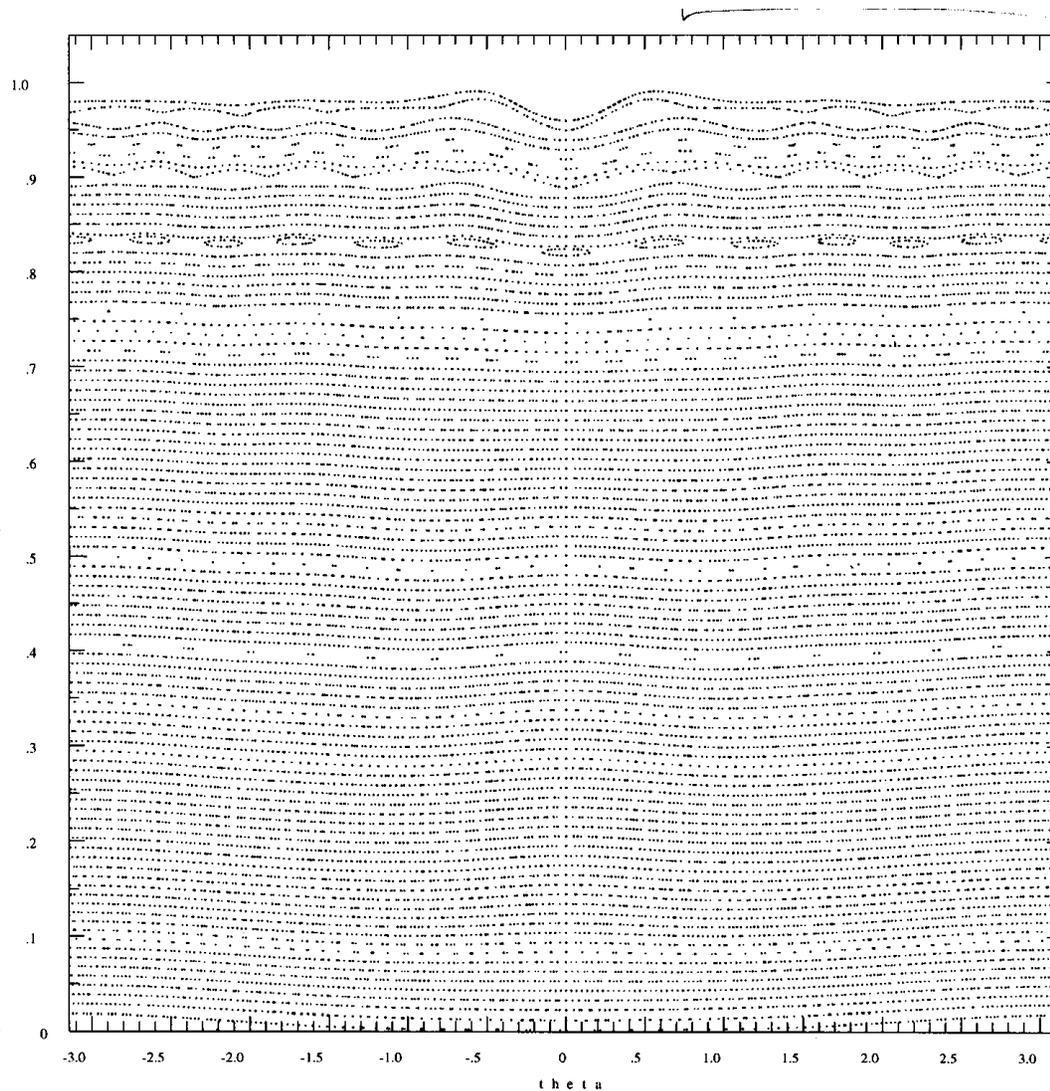
Pies results agree with
VMEC background coordinates

it= 1 rpoint: background coordinates

Coil Set Used to Explore PG1



Pies surfaces using un-optimized coil currents



10 Small Islands visible
11 on [10,3], [11,3], and
12 [12,3] surfaces

13

14

15

16

it = 1 isplit: background coordinates

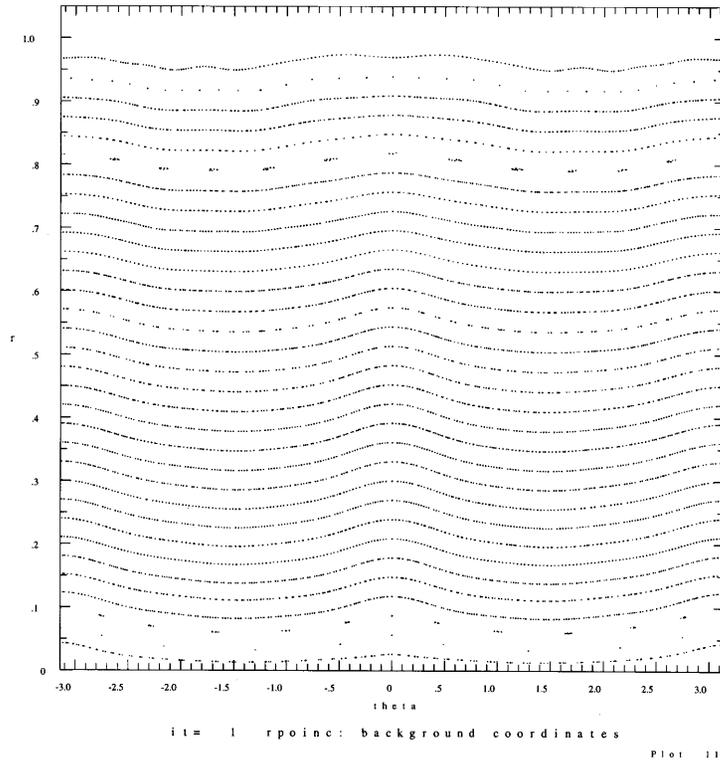
Plot 15

Comparison of Predicted and Observed Island Width

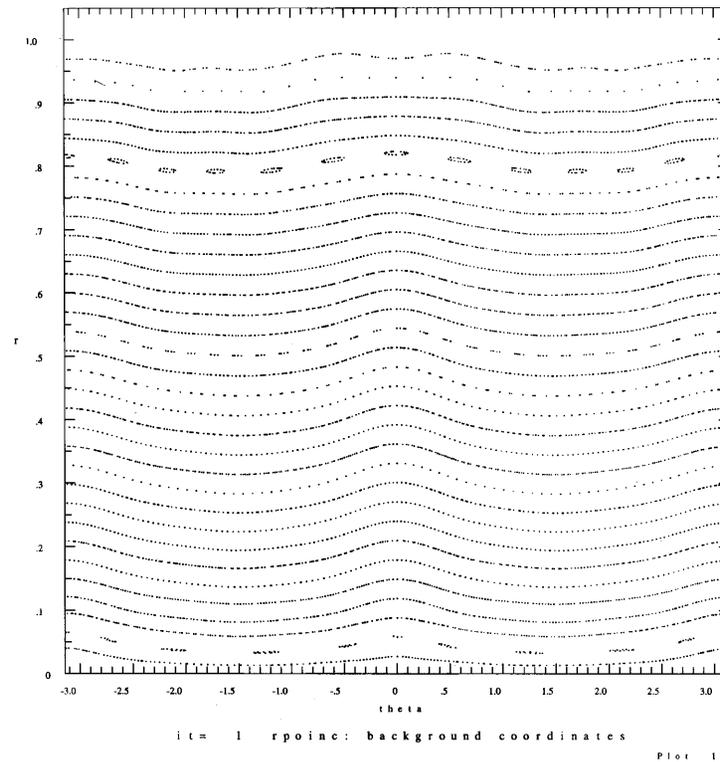
Island Width		
resonance, m	dp, curropt calculated	dp, pies observed
10	0.02	~0.02
11	0.019	~0.02
12	0.014	0.01 - 0.015
13	0.0048	~0.0
14	0.0028	~0.0
15	0.0019	~0.0
16	0.0001	~0.0

Pies surfaces targeting Island size
Islands partially suppressed at Weight=0
(Improved $B \cdot n$ on boundary)

Weight=0

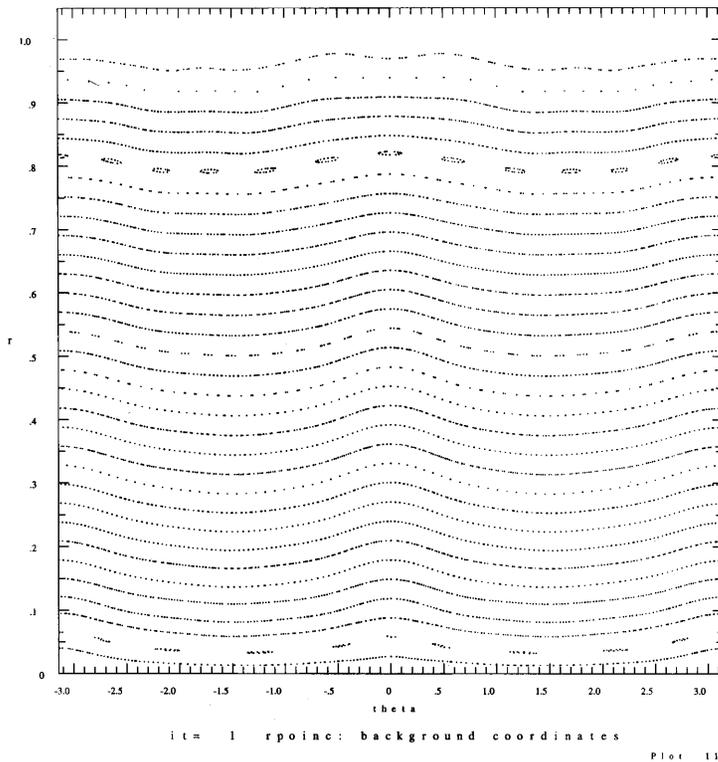


Weight=10?

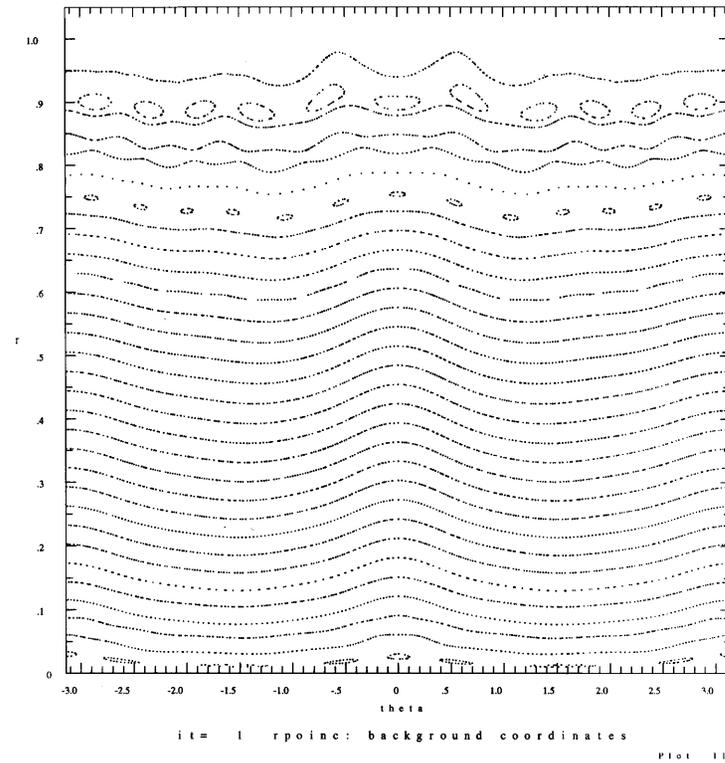


Heavy Weighing distorts boundary and introduces Islands

Weight=1e2



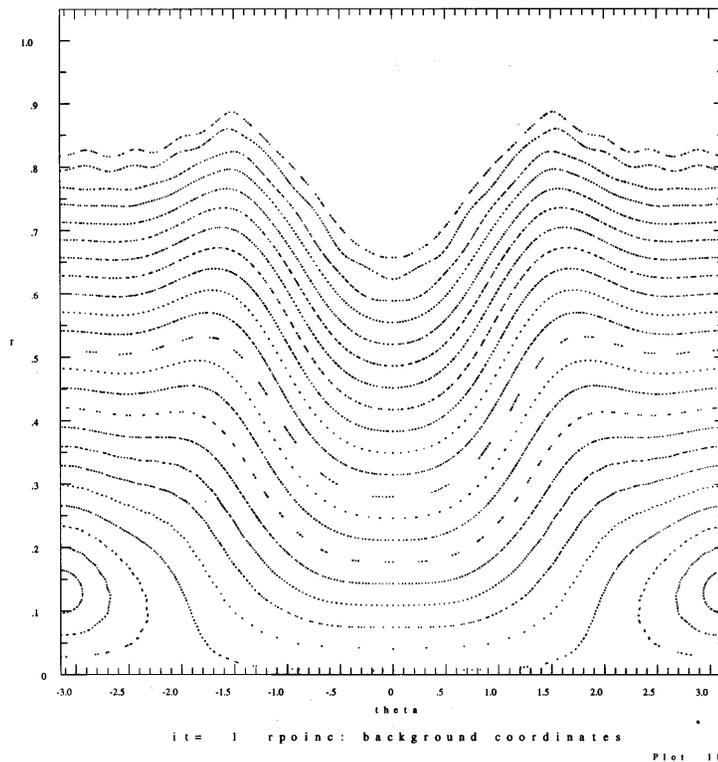
Weight=1e3



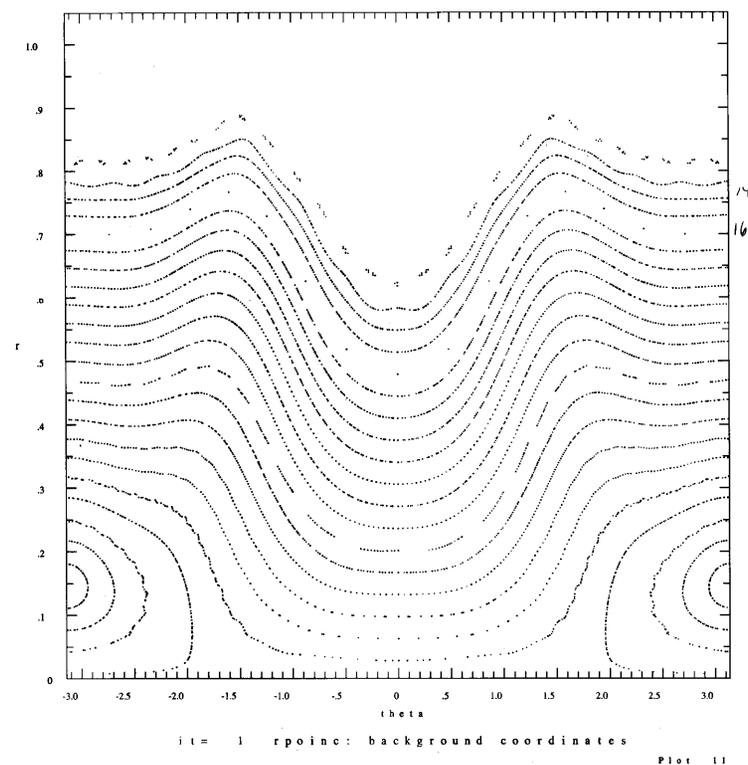
Using VMEC Fixed Boundary Surfaces as background coordinates

Heavier Weighing distorts boundary and introduces Islands (reduced plasma size)

Weight=1e4



Weight=1e5



Using VMEC Fixed Boundary Surfaces as background coordinates

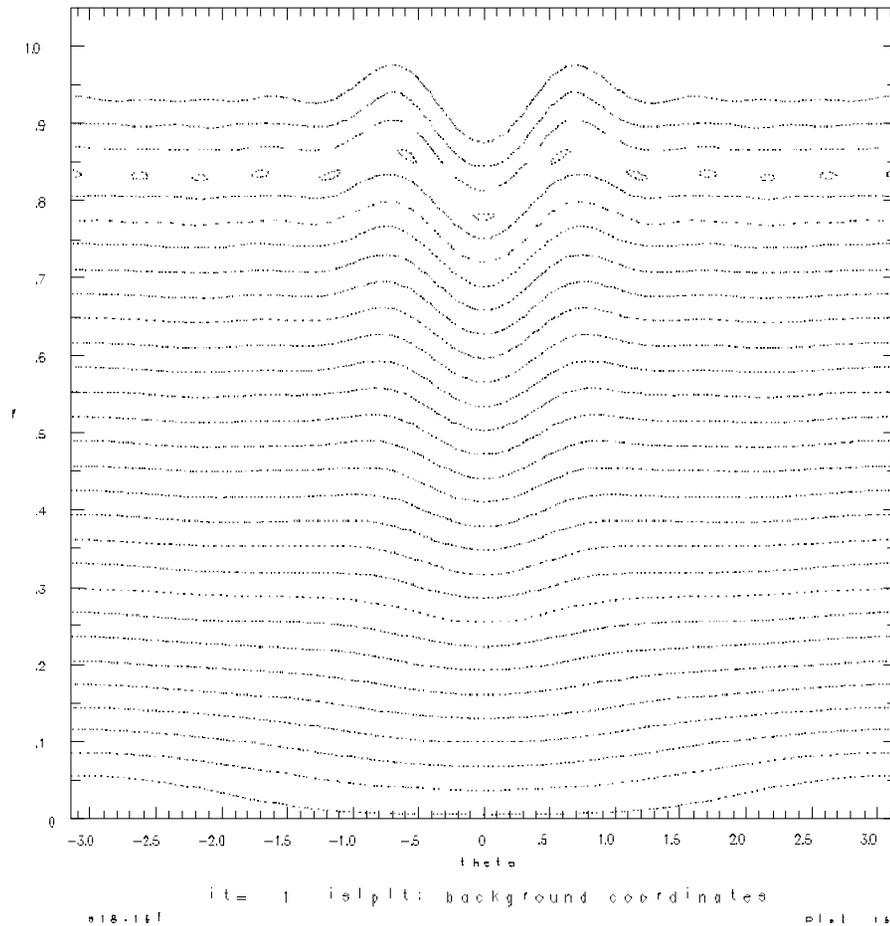
But Calculated Island size was forced down
while sacrificing Field Errors

Weight	Field Errors on Boundary		Calculated Island Size on Resonant Surface			
	Max Err	Mean Err	10,3	11,3	12,3	13,3
0.E+00	2.62	0.28	0.021	0.019	0.015	0.005
1.E+02	2.20	0.28	0.021	0.021	0.015	0.004
1.E+03	2.32	0.44	0.008	0.010	0.016	0.008
1.E+04	10.50	1.39	0.002	0.002	0.006	0.002
1.E+05	11.49	1.56	1.8E-04	2.2E-04	6.7E-04	2.5E-04

*Weight=1 for B•n on boundary

Suspect targeted resonant surfaces no longer valid

Trying different coil set pg1.sad18.16 (fewer coils, poorer reconstruction)

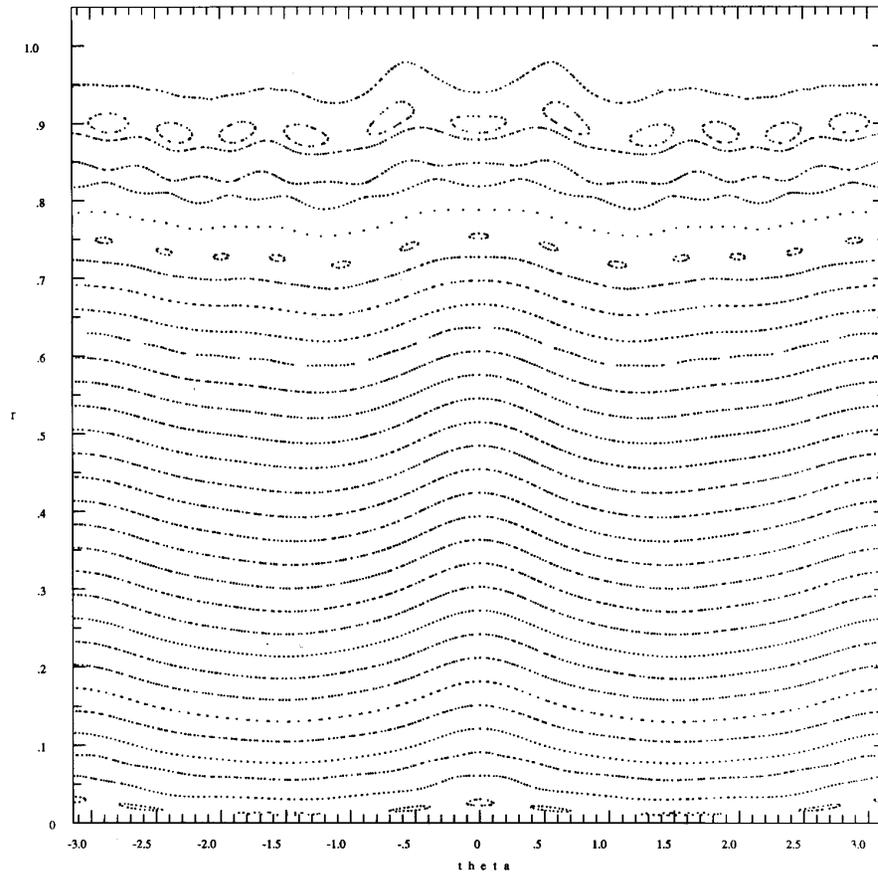


Predicted width
for [12,3] Island,
 $drho = .023$
close to observed

Need to rerun with
higher resolution in pies
for better validation

Weight island target
TBD

Reevaluation of Weight= 1e3 Case using updated surfaces from PIES



m,n	Predicted Island Sizes
10,3	0.005
11,3	0.028
12,3	0.028
13,3	0.017
14,3	0.0099

it= 1 rpoint: background coordinates

Plot 11

Summary

- Calculated Island width appears to correlate with islands observed in PIES field line plots when proper surface is targeted (for coil sets presented)
 - Further verification on larger islands desired (ie plasmas with larger iota profiles) and with plasma current
- Targeting of Islands in cases presented required large sacrifice in $B \cdot n$ on boundary to drive calculated island size down.
 - This distorts the initial boundary and resonant surface as well.
 - Targeted surfaces may need to be recalculated to be effective.
- Targeting of Islands within CURROPT may require different coils with stronger resonant coupling to minimize surface distortion.
 - Additional trim coils designed for resonance.
 - Produce different coils with NESCOIL by including island target
 - Add island target to background coil optimization