

Impact of Multi Filament Coil Representation on Field at Plasma

Preliminary Findings

Joint NCSX Engineering/Physics Meeting

April 26, 2001

Art Brooks

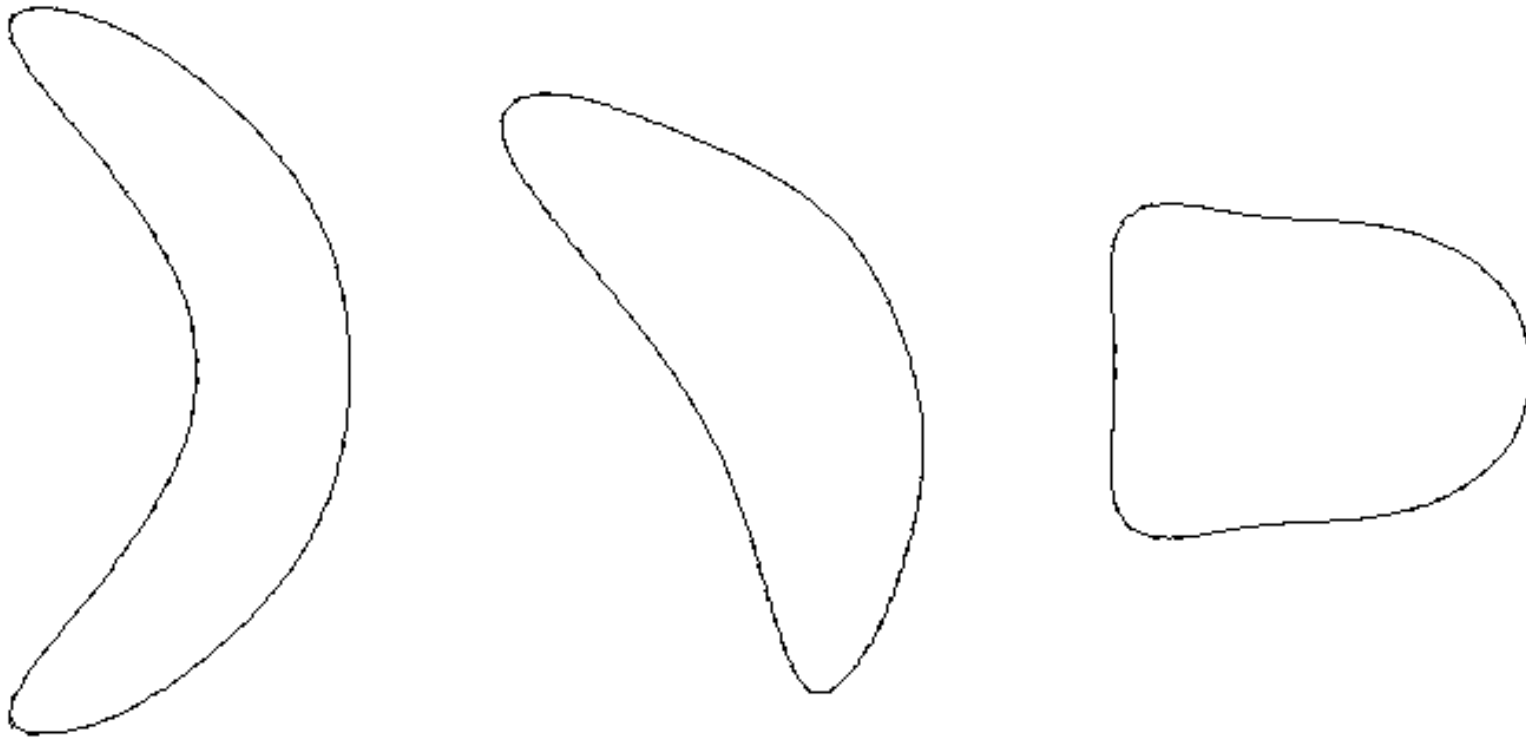
Overview

- Compare Multi filament representation to single filament for li383 using **0907 healed coils**
- Use coil bundle size of 127 mm radial build by 96.8 mm modeled with **16 filaments** (4x4)
- Assume Coil cross section orientation governed by coilopt winding surface. (Actual orientation set by Engineering to minimize interferences)
- Examine
 - Field Errors at Boundary
 - Resonant Field Errors
 - VMEC & PIES

Change in Normal Field Error at Plasma Boundary Not Significant

Field Error, % at Plasma Boundary		
Coil Set	Avg	Max
Single Filament, Unhealed	0.570	2.660
Single Filament, Healed	0.598	2.801
Multi Filament ,Healed	0.606	2.788

VMEC Sees Little Difference



Overlay of Single Filament and Multi Filament
Free Boundary VMEC Outer Boundaries

Separation: Average 1 mm, Max 4.8mm

Net Changes in Resonant Field Small, but are they negligible?

Coupling Of 0907 Modular Coils to li383 resonances						
Coil Set	m	ds^2 = 16*Cmn/m/iota' at 2T				Sum
		Mod 1	Mod 2	Mod 3	Mod 4	
Single Filament, Unhealed	5	4.15E-03	5.29E-03	-9.76E-04	4.19E-03	1.27E-02
	6	9.09E-04	1.56E-03	-1.89E-04	-1.01E-03	1.27E-03
	7	8.45E-06	-3.39E-05	-2.25E-06	1.24E-05	-1.54E-05
Single Filament, Healed	5	3.22E-03	2.88E-03	-4.92E-03	3.27E-03	4.44E-03
	6	9.10E-04	1.75E-03	3.26E-04	-9.42E-04	2.05E-03
	7	8.85E-06	-3.48E-05	-6.72E-06	1.21E-05	-2.05E-05
Multi Filament ,Healed	5	2.82E-03	2.56E-03	-5.04E-03	3.24E-03	3.58E-03
	6	9.14E-04	1.82E-03	4.30E-04	-9.09E-04	2.25E-03
	7	8.73E-06	-3.62E-05	-8.78E-06	1.15E-05	-2.48E-05

From Coils Only using CURROPT. Plasma Current Impact not Reflected

Based on Coupling, Changes in Islands would be Observable

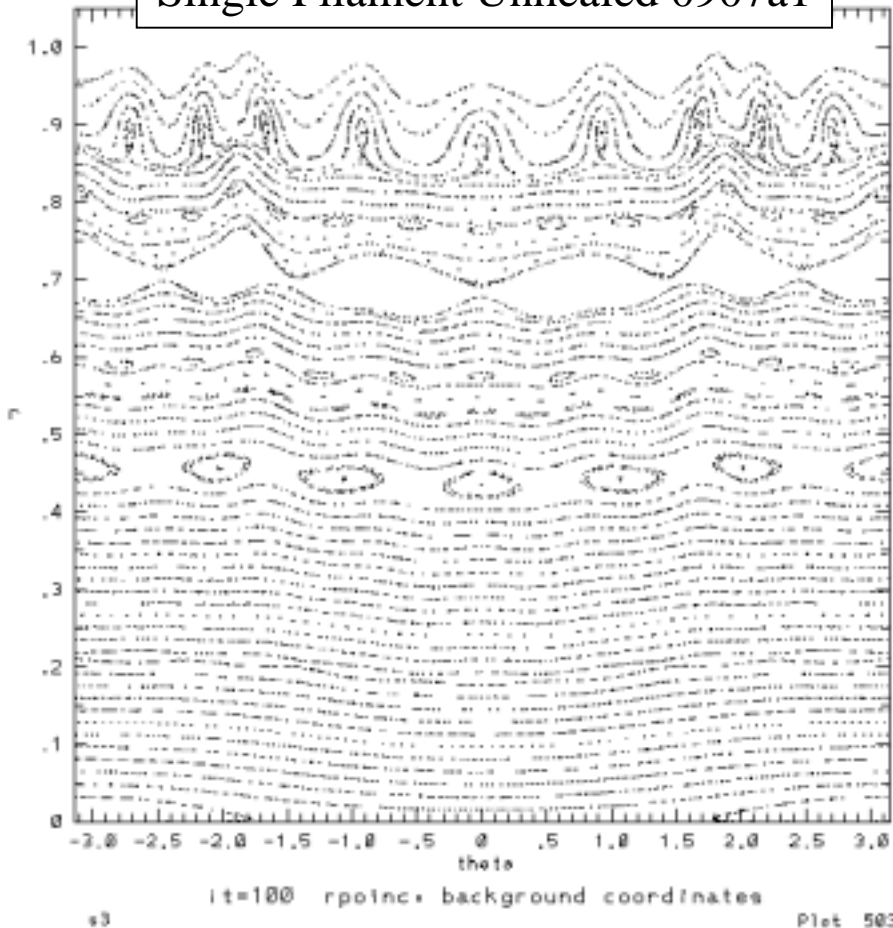
Relative Change in Coupling							Predicted Island Size		
	m	Mod 1	Mod 2	Mod 3	Mod 4	Sum	s	ds	dr
Single Filament, Healed/Unhealed	5	77.61%	54.33%	504.37%	77.90%	35.09%	0.63	0.0907	0.0573
	6	100.12%	112.46%	-172.41%	93.05%	161.59%	0.29	0.0279	0.0258
	7	104.78%	102.40%	298.97%	97.96%	133.37%	0.08	0.0023	0.0039
Multi/Single Filament, Healed	5	87.53%	88.98%	102.41%	99.19%	80.55%	0.63	0.0294	0.0186
	6	100.45%	103.59%	132.01%	96.44%	110.00%	0.29	0.0143	0.0132
	7	98.62%	104.26%	130.74%	94.80%	120.94%	0.08	0.0021	0.0036

m	s	iota'
5	0.63	0.32
6	0.29	0.29
7	0.08	0.40

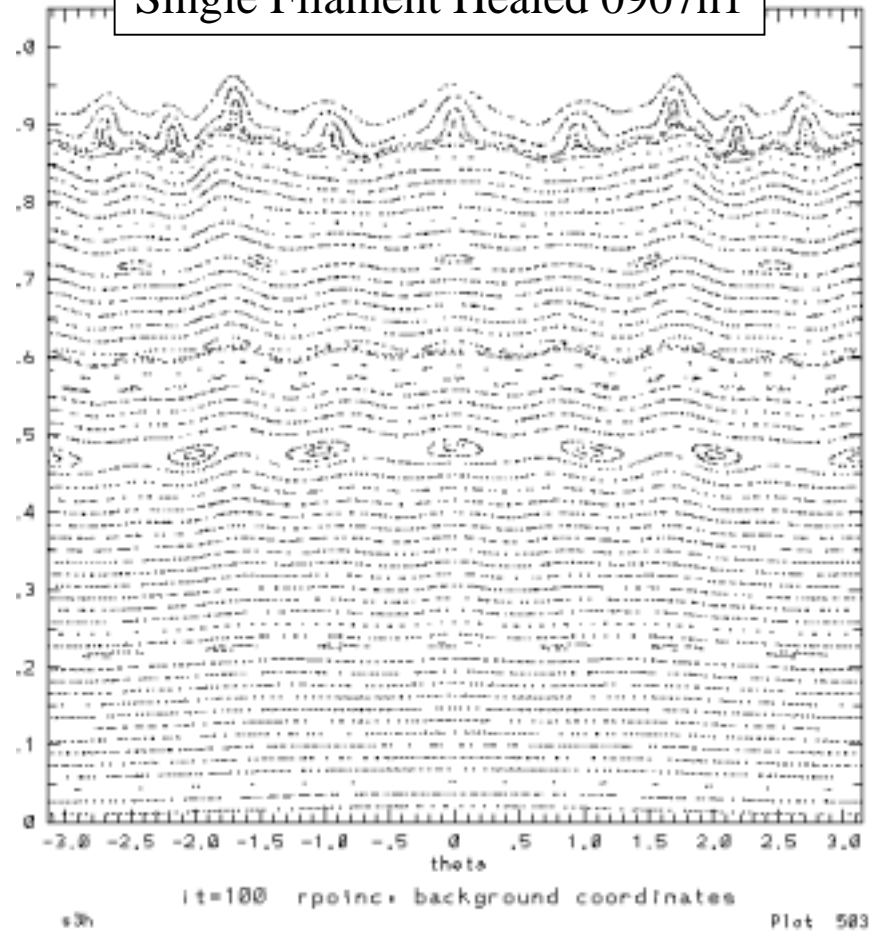
Predicted Island Size Assumes Single Filament Healed Coils are Island Free

Comparison of Unhealed and Healed Coils after 100 Pies iterations

Single Filament Unhealed 0907a1

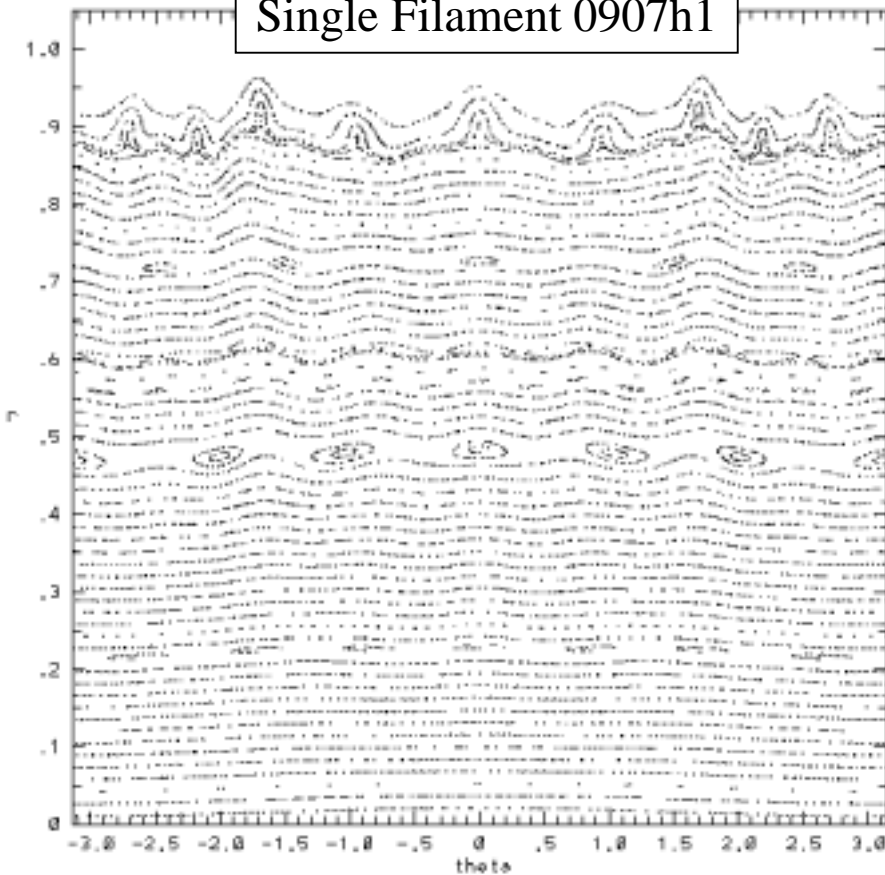


Single Filament Healed 0907h1

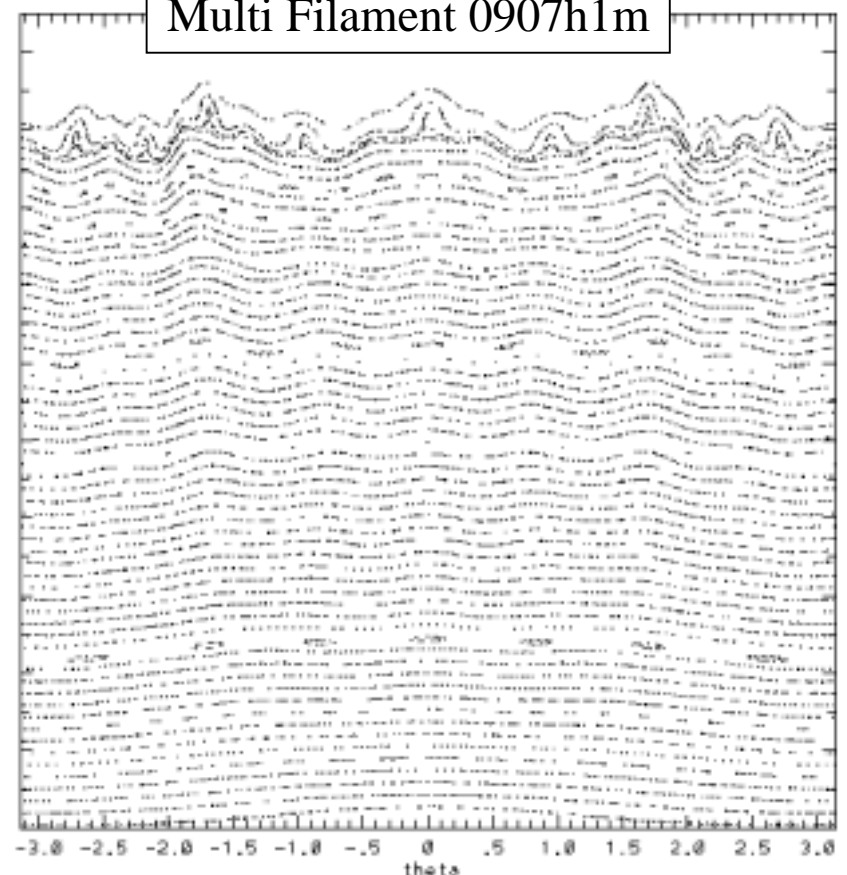


After 100 Pies iterations, Multi filament looks better

Single Filament 0907h1



Multi Filament 0907h1m



it=100 rpoint, background coordinates

it=100 rpoint, background coordinates

s3h

Plot 583

1f383a2.v3hm

Plot 583

Pies not yet converged.

Summary

- Impact of Multi filament representation of Modular Coils appears to be small.
- Need to resolve problem encountered converging pies in multi filament case to see full impact.
- Other Physics Measures not yet evaluated.

Island Width Evaluation

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

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

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)

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