Trim Coil Design Status

NCSX Project Meeting

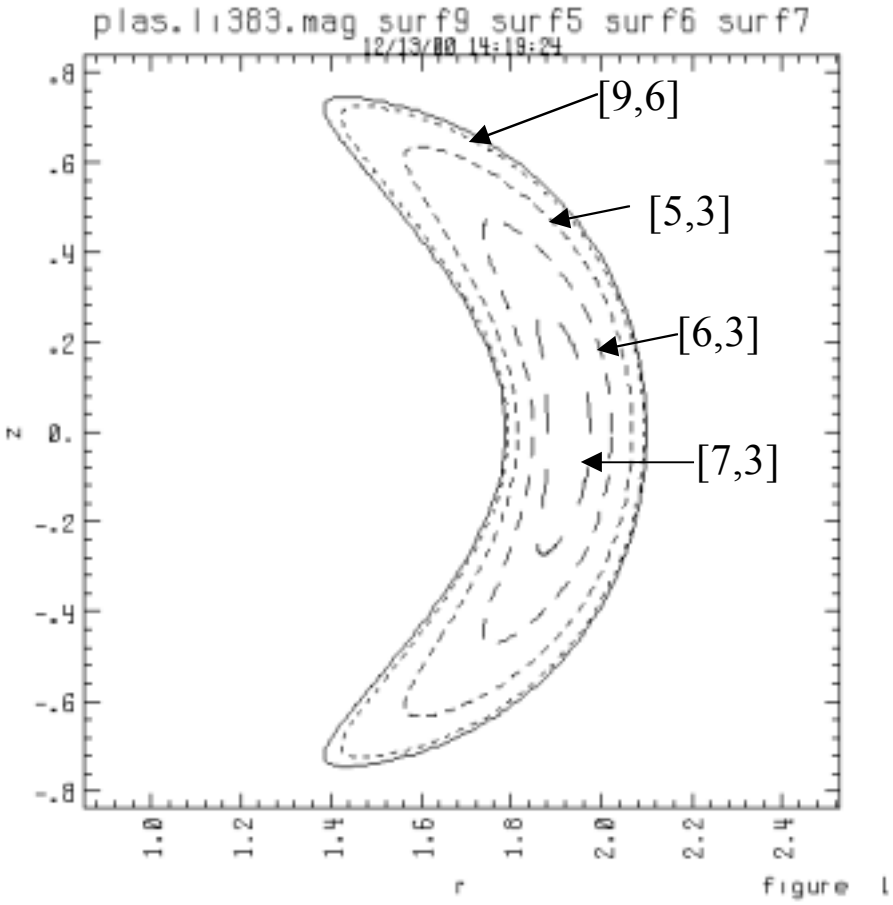
December 19-20, 2000

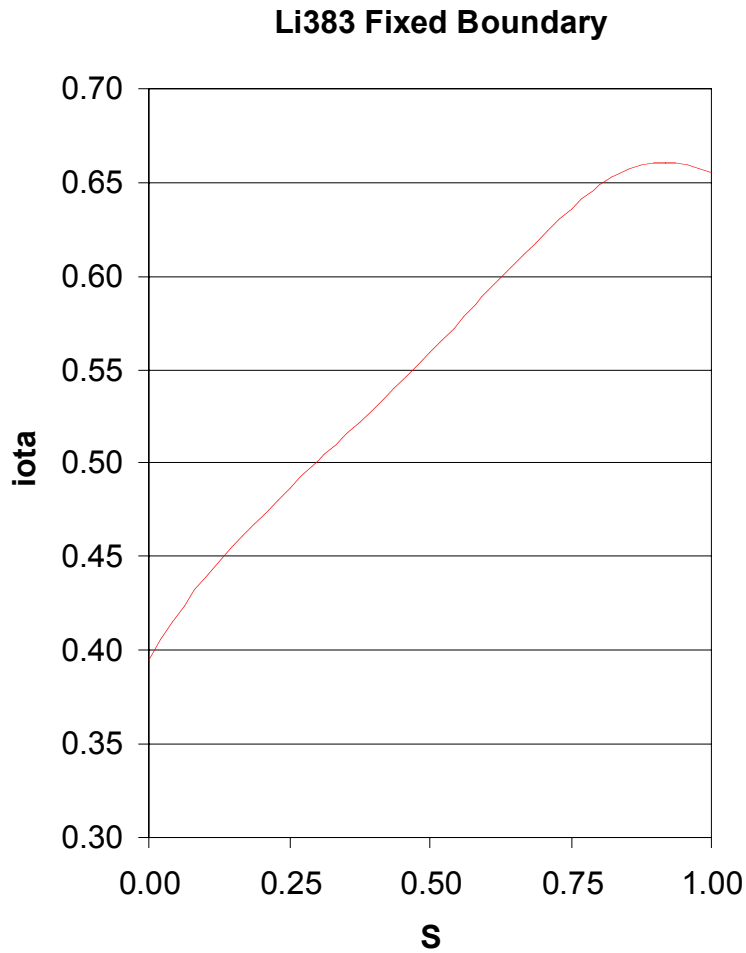
Art Brooks

Overview

- Status
  - Little progress since last project meeting
  - Effort just getting under way
- Plans
  - Begin to compare various options by evaluating
    - Coupling Matrix
    - Impact on Bn at plasma boundary
    - Current Requirements (Power Requirements?)
  - Focus on trim coils for Modular Coils (1017 design)
    - Locate trim coils where engineering feasible – inside or outside of modular coil/support structure
  - Strive for simplicity of coil design
    - Single layer of coils (multiple sets of helicals not attractive)

Li383 Targeted Resonances





What can we do with Existing Coils?

				Dennis Strickler's Modular coils li383_1017				Wayne Reiersen's 12/07/00 Design				
			1/R	Mod1	Mod2	Mod3	Mod4	PF1	PF2	PF4	PF6	PF7
B.n/Ic	s	iota'										
Boundary	1		2.60E-08	1.15E-07	9.71E-08	8.23E-08	5.87E-08	6.05E-09	3.61E-09	9.77E-09	1.60E-07	2.07E-07
ds^2/Ic												
9,2	0.92	0.019	-1.39E-08	-2.20E-09	-4.87E-09	2.89E-08	-1.25E-08	4.37E-09	2.30E-09	-6.18E-10	-1.56E-07	-1.52E-07
5,1	0.63	0.318	1.04E-09	-3.91E-09	-1.02E-08	1.25E-09	-5.00E-09	1.12E-09	1.76E-10	-1.19E-09	-1.79E-08	-7.81E-09
6,1	0.29	0.286	5.07E-10	-1.01E-09	-1.63E-09	6.59E-10	1.68E-09	7.47E-11	1.91E-11	-2.10E-10	2.58E-10	2.31E-09
7,1	0.08	0.399	6.68E-12	-5.18E-12	5.24E-11	-1.62E-12	-3.93E-11	-2.49E-12	6.51E-14	7.79E-12	-4.40E-11	-1.13E-10
B.n(gauss) for ds=.05												
9,2	0.92	0.019	-46.9	-1311.4	-498.3	71.1	-117.7	34.6	39.3	-395.1	-25.6	-34.1
5,1	0.63	0.318	624.9	-738.2	-237.7	1642.7	-293.3	134.7	514.0	-204.7	-222.8	-663.1
6,1	0.29	0.286	1281.6	-2863.4	-1492.7	3121.3	873.6	2025.5	4734.8	-1161.2	15455.0	2241.3
7,1	0.08	0.399	97388.2	-557262.4	46343.1	-1269321.0	-37335.6	-60841.3	1388022.2	31326.3	-90856.9	-45669.5
Ic(KA) for ds=.05												
9,2	0.92	0.019	-180.3	-1136.8	-513.1	86.5	-200.5	571.9	1087.1	-4045.6	-16.0	-16.5
5,1	0.63	0.318	2402.2	-639.9	-244.8	1997.1	-499.7	2227.4	14229.6	-2096.4	-139.5	-320.0
6,1	0.29	0.286	4927.1	-2482.1	-1537.2	3794.8	1488.3	33486.5	131075.3	-11890.6	9675.7	1081.5

Data examines only how each coil impacts each resonance

20 gauss = 0.1 % Avg Field Error at 2 T

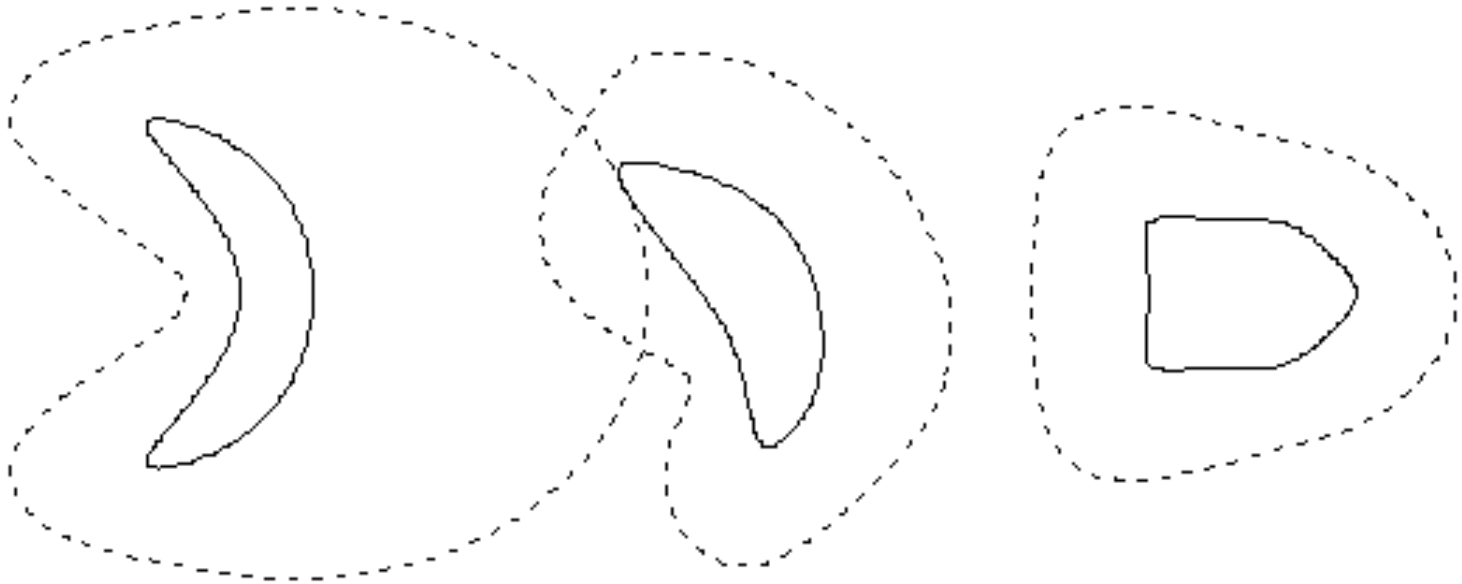
Earlier Helical Windings
Demand less current if located close to plasma, but impact boundary less if located further away

			Stellarator Like Windings 5 cm offset plasma				30 cm offset from plasma			
			m 9n2	m 5n1	m 6n1	m 7n1	m 9n2	m 5n1	m 6n1	m 7n1
B.n/Ic	s	iota'								
Boundary	1		2.0009E-06	1.7986E-06	1.9992E-06	1.9953E-06	1.0785E-07	2.3484E-07	2.0911E-07	1.6246E-07
ds^2/Ic										
9,2	0.92	0.019	0.00011146	2.9264E-06	3.9664E-06	1.2569E-05	6.9095E-06	2.0833E-06	2.3832E-06	3.3619E-06
5,1	0.63	0.318	3.292E-06	3.6881E-06	1.3115E-06	3.5772E-06	4.559E-07	6.9211E-07	5.6317E-07	5.6836E-07
6,1	0.29	0.286	3.3806E-08	5.6878E-08	4.2023E-07	4.6446E-08	6.4807E-08	1.956E-08	5.1685E-08	3.7801E-08
7,1	0.08	0.399	1.4875E-08	1.5454E-08	1.4573E-09	6.3322E-09	5.8222E-11	1.2565E-10	1.6534E-10	5.4377E-11
B.n(gauss) for ds=.05										
9,2	0.92	0.019	0.4	15.4	12.6	4.0	0.4	2.8	2.2	1.2
5,1	0.63	0.318	15.2	12.2	38.1	13.9	5.9	8.5	9.3	7.1
6,1	0.29	0.286	1479.7	790.6	118.9	1074.0	41.6	300.2	101.1	107.4
7,1	0.08	0.399	3362.9	2909.6	34296.3	7877.6	46309.8	46725.0	31618.2	74691.5
Ic(KA) for ds=.05										
9,2	0.92	0.019	0.02	0.9	0.6	0.2	0.4	1.2	1.0	0.7
5,1	0.63	0.318	0.8	0.7	1.9	0.7	5.5	3.6	4.4	4.4
6,1	0.29	0.286	74.0	44.0	5.9	53.8	38.6	127.8	48.4	66.1

Options to be evaluated

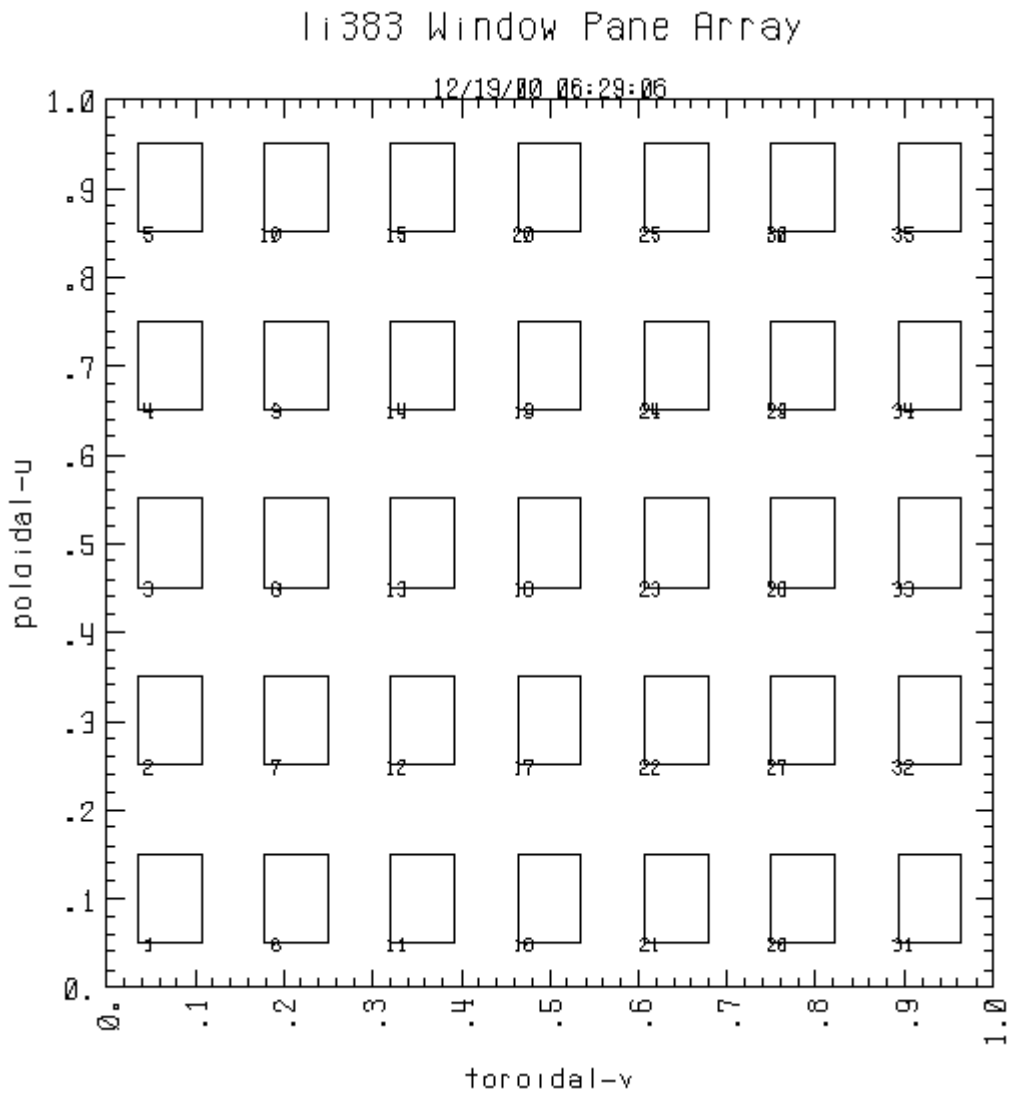
- Array of simple window pane coils (saddles)
  - Offset from coil winding surface
  - Where do they want to be on winding surface?
  - Can one set provided needed flexibility?
- Reverse Engineered coils targeting individual resonances on individual surfaces
  - Use existing codes (NESCOIL, etc)
  - Vary topology – Wavy PF, Modular, Saddle
  - Potentially more complicated and numerous
- May need to develop new tools to optimize above

Modular Coils 1017 Winding Surface



Coils on phi=0. plane
moved out for NB access

Sample Window Pane Array



5 x 7 Array

Summary

- Work in progress
- Parallel effort by Ron Hatcher also getting underway
  - Need to agree on common basis for comparison of options
- In practice, will need to extract from PIES values of ds to target for each resonance
  - Used with coupling matrix to set trim currents for each plasma state