Modular Coil Design

D. Strickler, S. Hirshman, B. Nelson, D. Williamson, M. Zarnstorff

NCSX Project Meeting

7/24/2001

- Recent Coilopt improvements
- Potential 18 modular coil design option
- Comparison of coil designs
- Stellopt/Coilopt progress

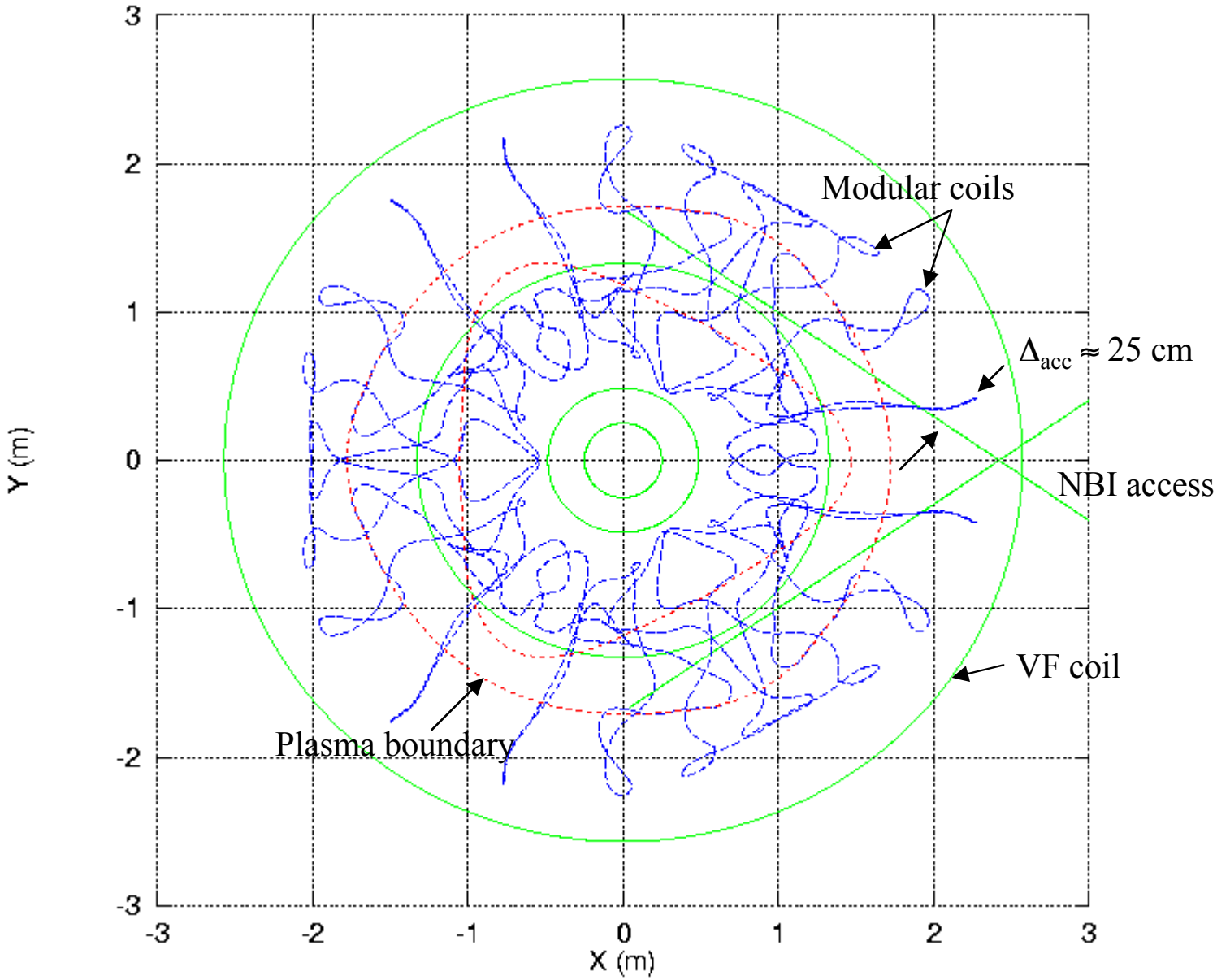
Coilopt Improvements

- Penalty functions for access zones (e.g., nbi)
- Penalty functions for integrated coil curvature
- VF coil current regularization penalty
- Improved interface with free-boundary vmec

18 Modular Coil Designs

- Based on li383, R = 1.4m, B = 1.7T, β = 4%
- New coil representation (u(s), v(s))
- No coils on symmetry planes (three modular coil types)
- Variable currents in five pairs of VF coils (axisymmetric)
- Fixed toroidal (1/R) field
- NBI access

18 Modular Coil Optimization Model



Comparison of Coil Design Options

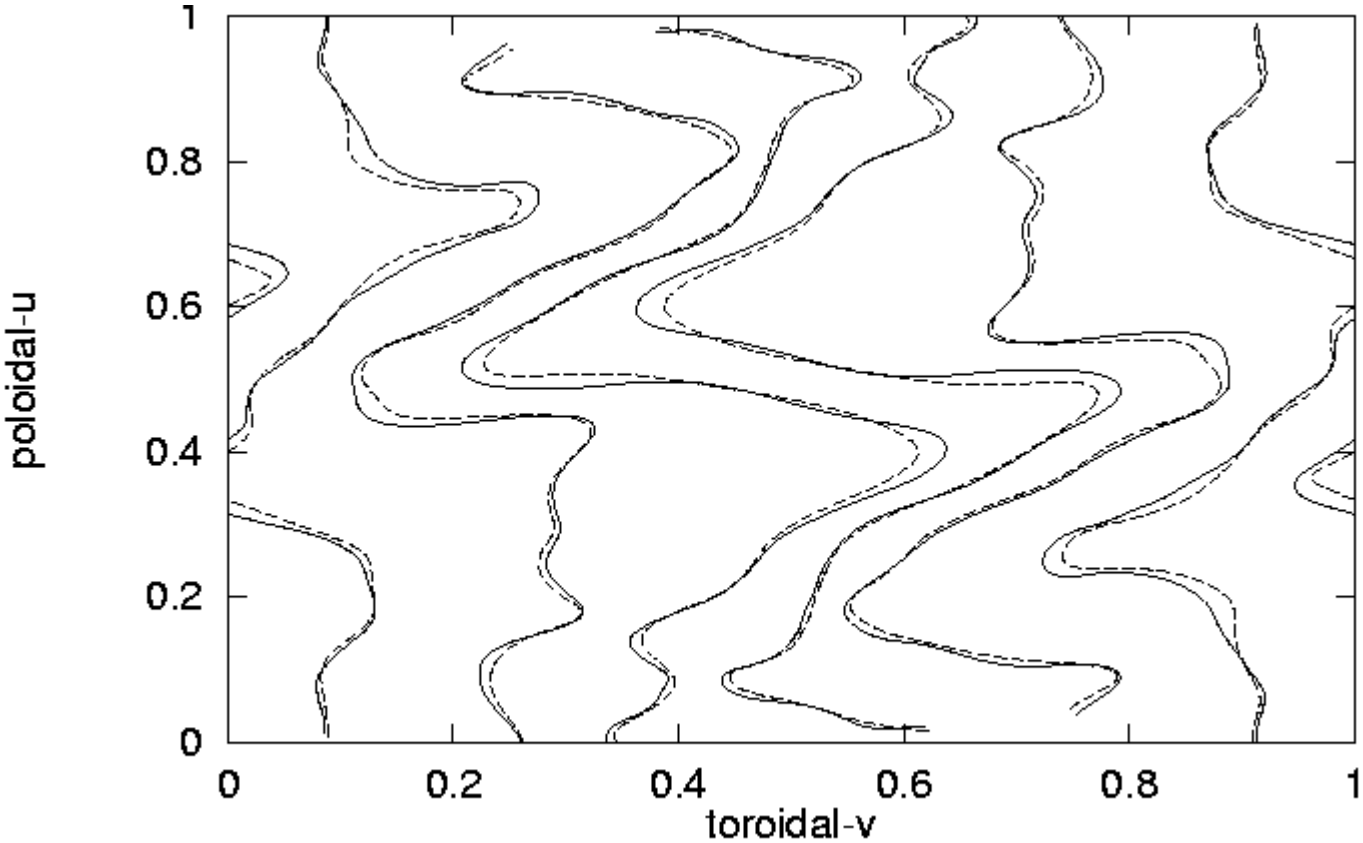
(Normalized to 1.4m, 1.7T)

M12 M13 ← 18 Coil Designs →

		0907a1	1017a1	0227a1	0312a3	0628a1	0708a1	0711a1	0717a1
Modular Coils per FP		7	7	7	6	6	6	6	6
Symmetry coil, v=0		Y	Y	Y	Y	N	N	N	N
Symmetry coil, v=1/2		N	N	N	Y	N	N	N	N
NBI access		N	Y	Y	Y	Y	Y	Y	Y
Fourier modes-Modular coils		10	10	12	12	20	20	20	20
Fourier modes-Winding surf.		30	30	45	45	25	25	25	25
Avg. Field Error	%	0.57	0.61	0.48	0.59	0.61	0.6	0.59	0.6
Max. Field Error	%	2.55	2.61	1.95	3.06	2.57	2.25	2.17	2.33
Min. Coil-Coil Separation	cm	11.04	12.19	12.85	13.51	11.7	11.9	11.5	11.3
Min. Plasma-Coil Separation	cm	19.19	19.19	17.46	17.21	20.7	20.2	18.8	20.5
Min. Radius of Curvature	cm	9.06	10.29	7.74	7.66	9.1	9.4	8.7	7.9
Min. NBI Access	cm					26	25	24.6	26.2
I-mod,1	kA	-569.45	-569.45	-482.18	-644.35	-520	-505.6	-556.3	-648.5
I-mod,2	kA	-569.45	-569.45	-497.23	-549.85	-720.1	-700.1	-586.5	-719.1
I-mod,3	kA	-569.45	-569.45	-512.17	-587.53	-743.3	-677.6	-640.5	-815.7
I-mod,4	kA	-569.45	-569.45	-464.33	-600.48	0	0	0	0
I-TF	kA			-1615.25	-1400.00	0	-600	-1200	1200
I-VF,1	kA				95.20	-321.5	-190.7	-412	-436.2
I-VF,2	kA				-43.87	-686.1	-273.5	-448.8	-876.5
I-VF,3	kA				-48.88	30.8	78.2	211.6	95.2
I-VF,4	kA					37.4	17.3	33.4	53.8
I-VF,5	kA					10.5	3.3	4.2	8.9
I-mod,max/C-C,min	kA/cm	51.57	46.75	39.95	47.88	63.5	58.8	55.7	72.2

Effect of 1/R Field on Modular Optimization

0711a1 (solid), 0717a1 (dashed)



Stellopt/Coilopt Status

- Coil_geom ("coil-geometry-only" version of coilopt) computes the values of coil geometry targets and produces the coil filament file with coil group numbers
- Based on the most recent coil filament file, Stellopt calls xgrid to produce mgrid file for free-boundary vmec
- Tested for QPS problem (gb5) through several function evaluations
- Presently testing the components of the code for an li383 problem

Summary/Plans

- Based on recent Coilopt improvements, 18 modular coil design options show desirable engineering properties.
  - Need to improve physics reconstruction
- Continue to give priority to Stellopt/Coilopt merger