Modular Coil Optimization for Recent NCSX Plasma Configurations

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Plasma Configurations Analyzed

- II75 - A=4.8, high iota
- LI383 - A=4.4, medium iota
- II283 - A=3.3, 2 field periods

Coil Optimization Model

- 7 modular coils per period (11 for 2-FP case)
- Coils constrained to winding surface
- Winding law $\phi = \phi(\theta)$ given by Fourier series
- Variables include N_s coefficients of winding surface and N_ϕ coefficients of coil ϕ-variation for each unique modular

Target Functions in Optimization

- Error in normal component of magnetic field (BNORM) at plasma edge (VMEC)
- Minimum separation penalty for adjacent coils - Δcc
- Lengths of individual coils - L_c
- Minimum separation between coils and plasma - Δcp
- Minimum radius of curvature - ρ_c (future)

Summary of Results

Config	Seq.#	N_c/N_{fp}	N_ϕ	N_s	δB-rms (%)	δB-avg (%)	δB-max (%)	Δcc (cm)	Δcp (cm)	ρ_c (cm)	Re-con
II75	0613a5	7	5	22	0.95	0.67	3.68	11.59	21.91	2.9	Y
LI383	0705a1	7	9	21	0.71	0.55	2.54	15.02	21.73	4.2	Y
II283	0706a5	11	7	26	1.40	0.93	7.40	15.44	17.04		Y?

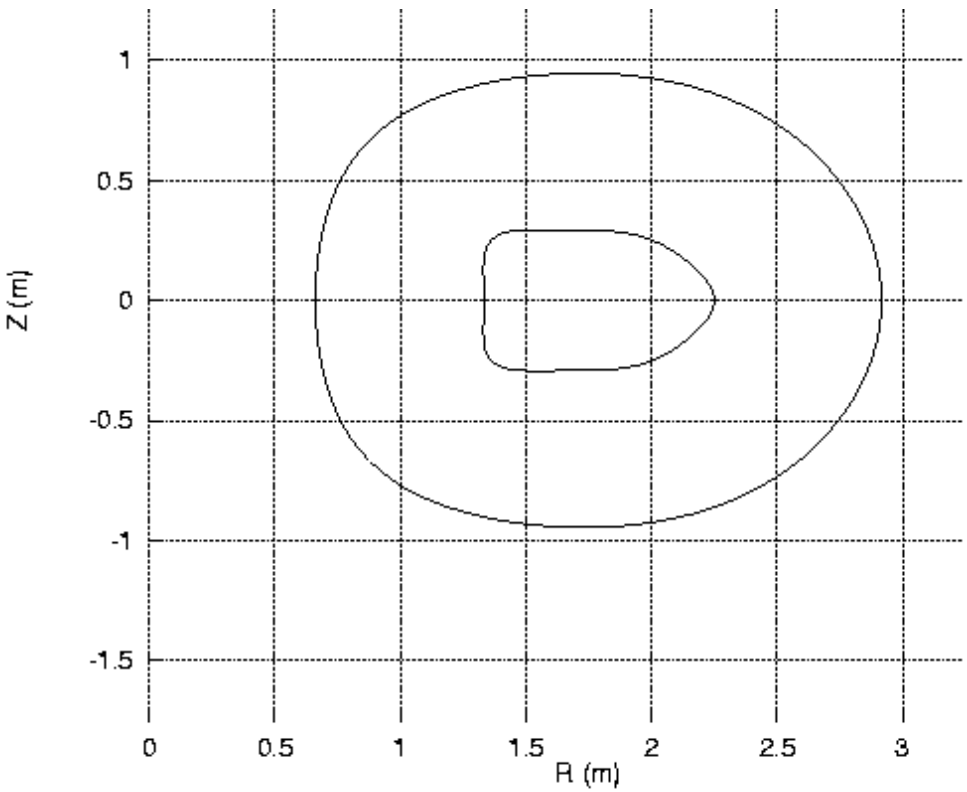
Modular Coil Optimization for II75

Run #	N_s	N_ϕ	δB_{rms} (%)	δB_{avg} (%)	δB_{max} (%)	Δcc (cm)	Δcp (cm)
0613a1	10	5	14.28	8.93	37.19	7.23	26.11
0613a2	10*	5	6.50	4.49	24.40	6.63	19.87
0613a3	16*	5	2.05	1.55	7.88	10.18	18.02
0613a4	16	7	1.72	1.24	5.95	11.76	17.89
0613a5	22*	9	0.96	0.66	2.88	11.59	21.90

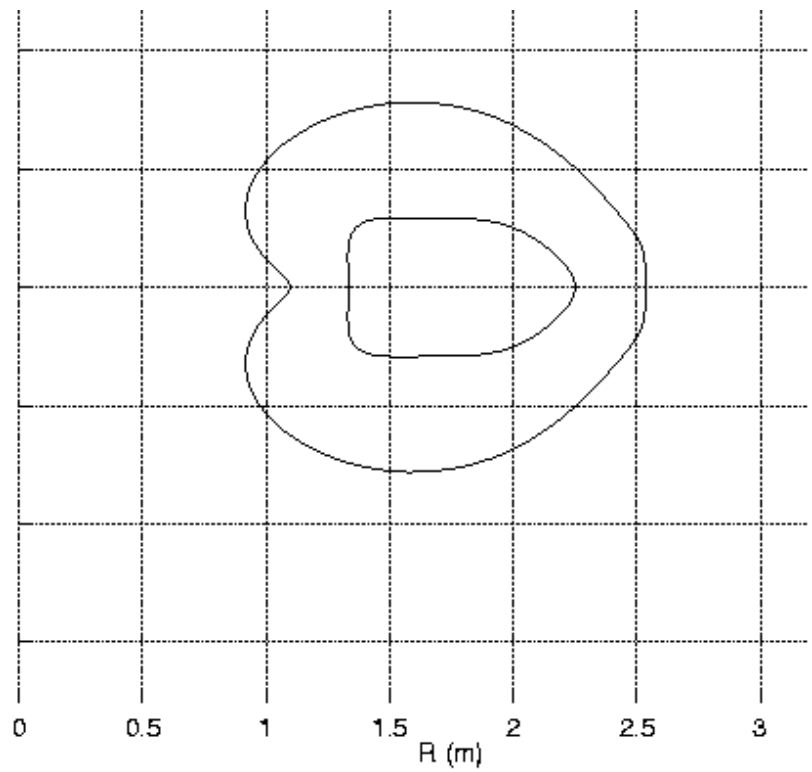
* Vary winding surface coefficients

Change in Winding Surface with Coil Optimization
(v = 1/2)

Initial



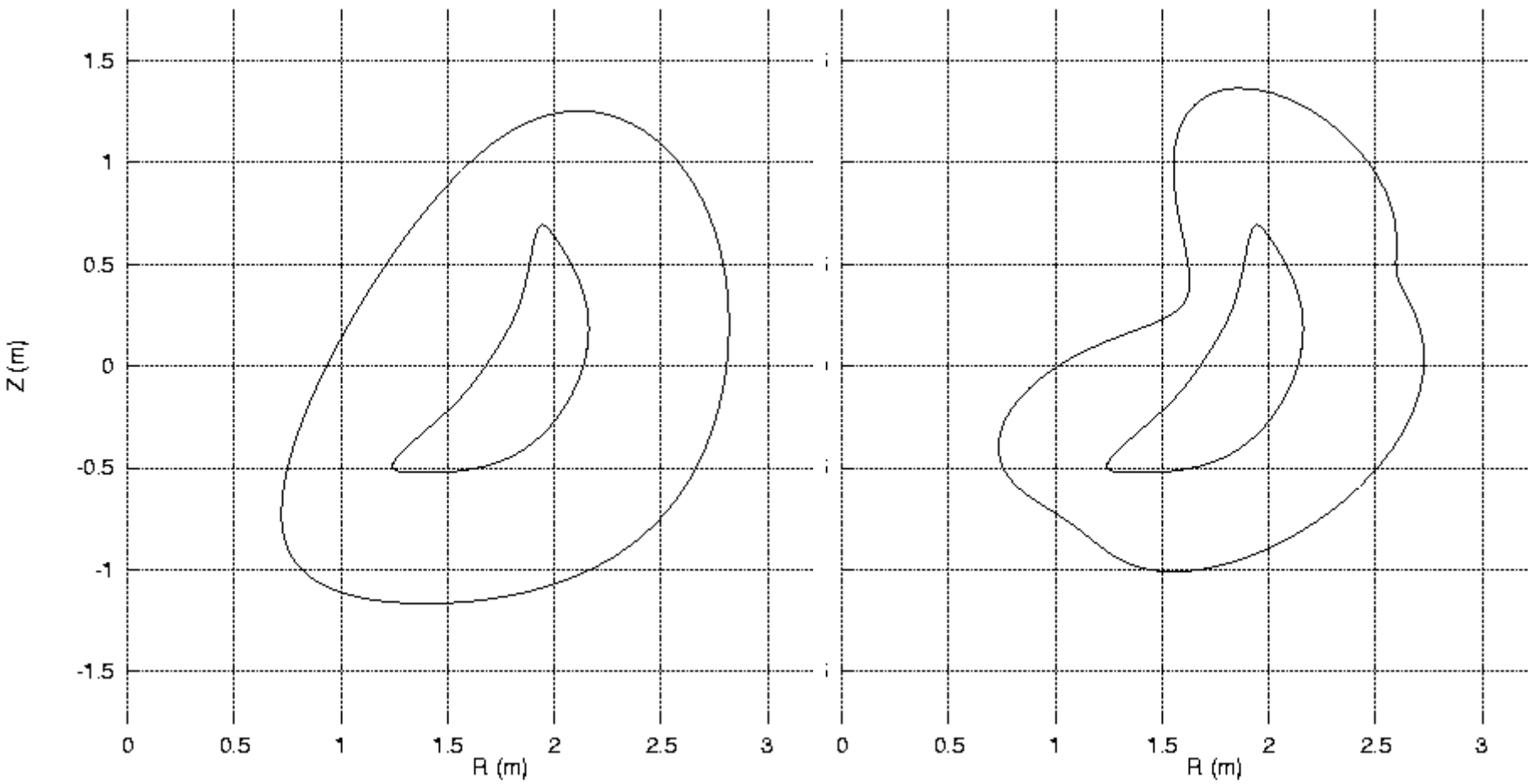
Final



Change in Winding Surface with Coil Optimization
(v = 3/4)

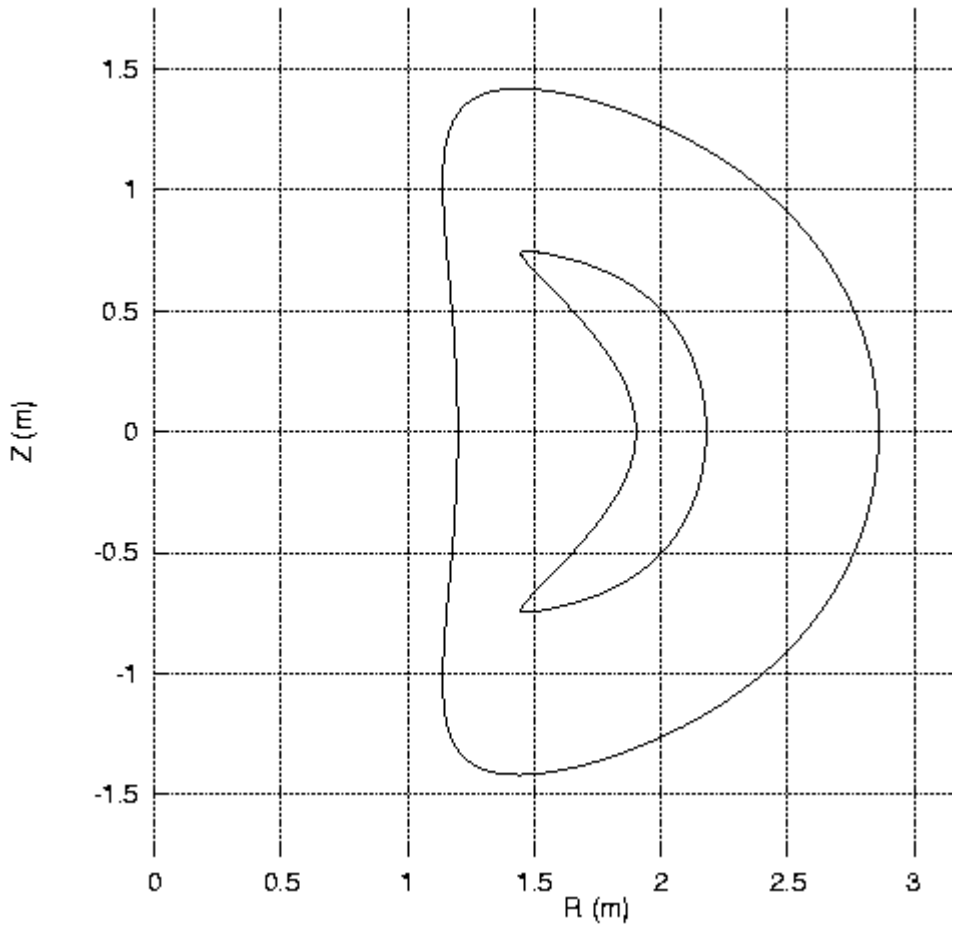
Initial

Final

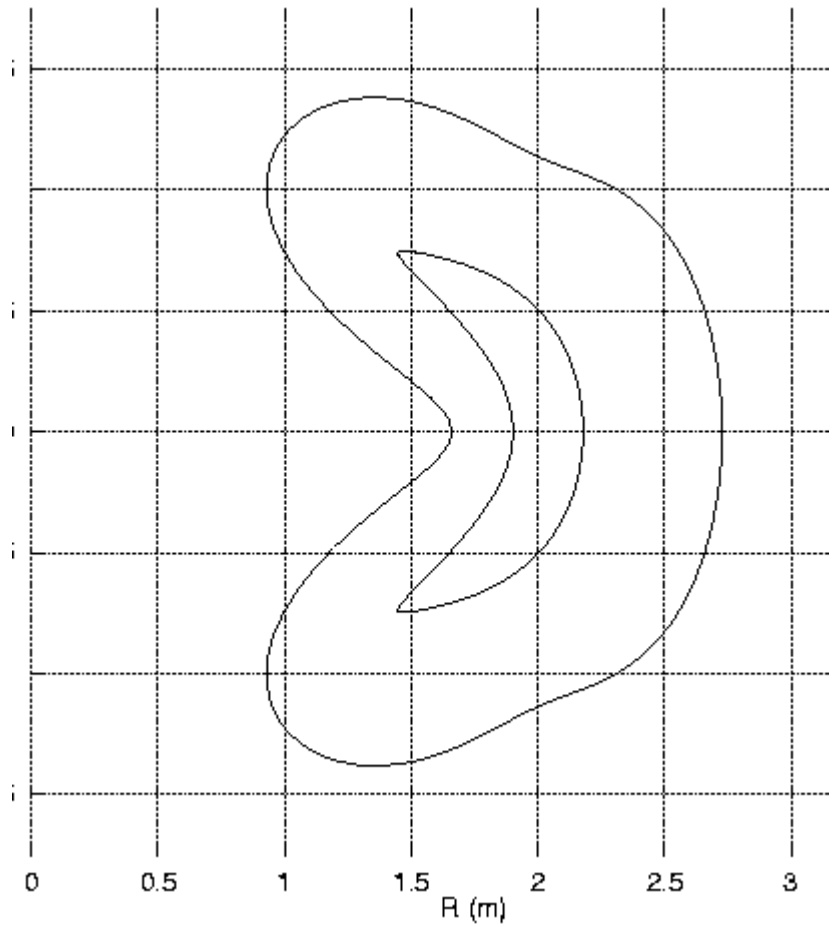


Change in Winding Surface with Coil Optimization
(v = 1)

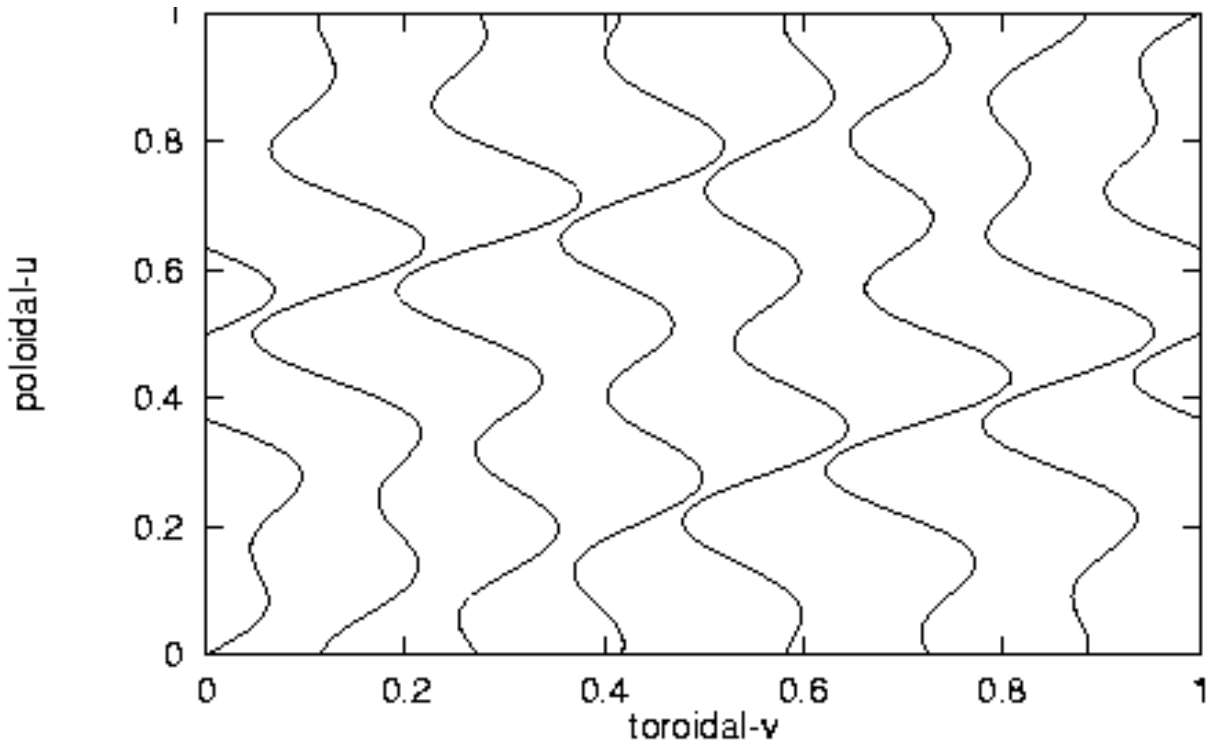
Initial



Final

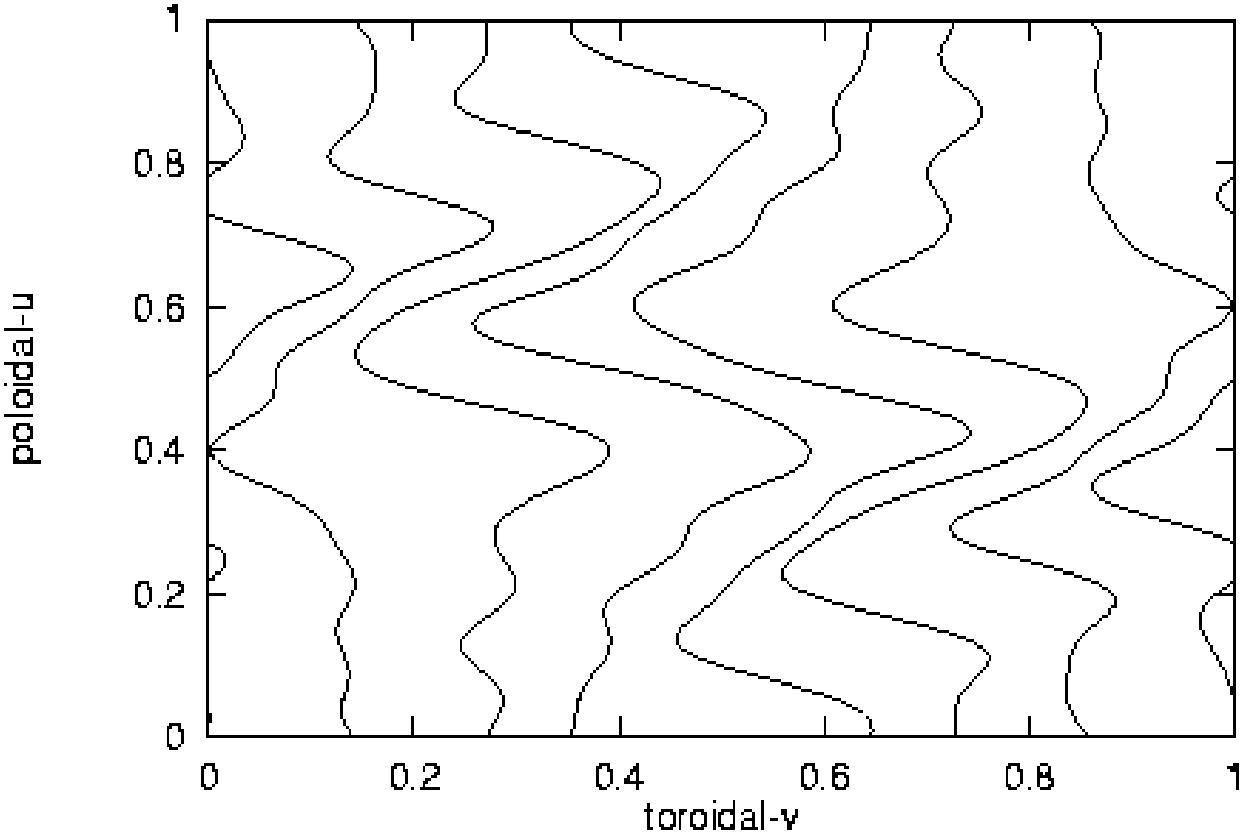


Modular Coils on Initial Winding Surface

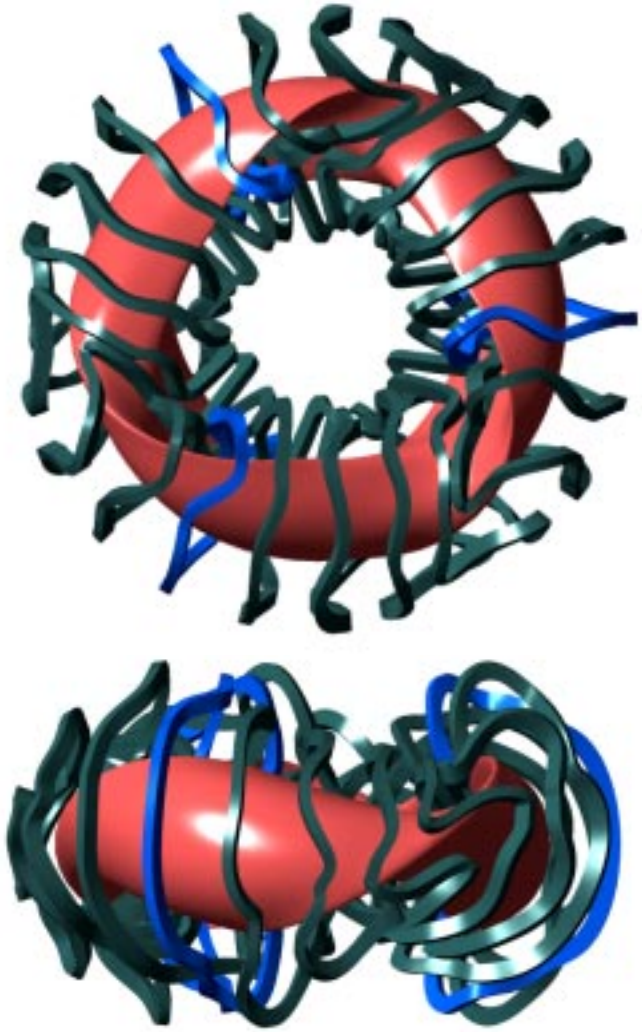


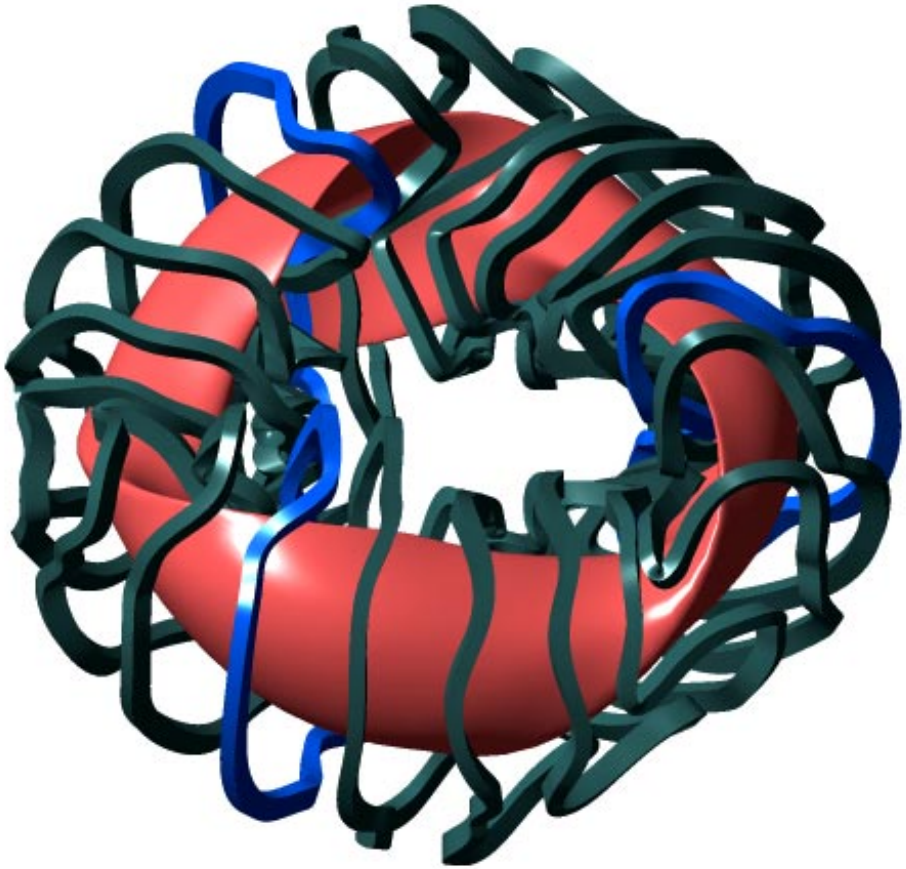
Modular Coils for II75

Final Solution



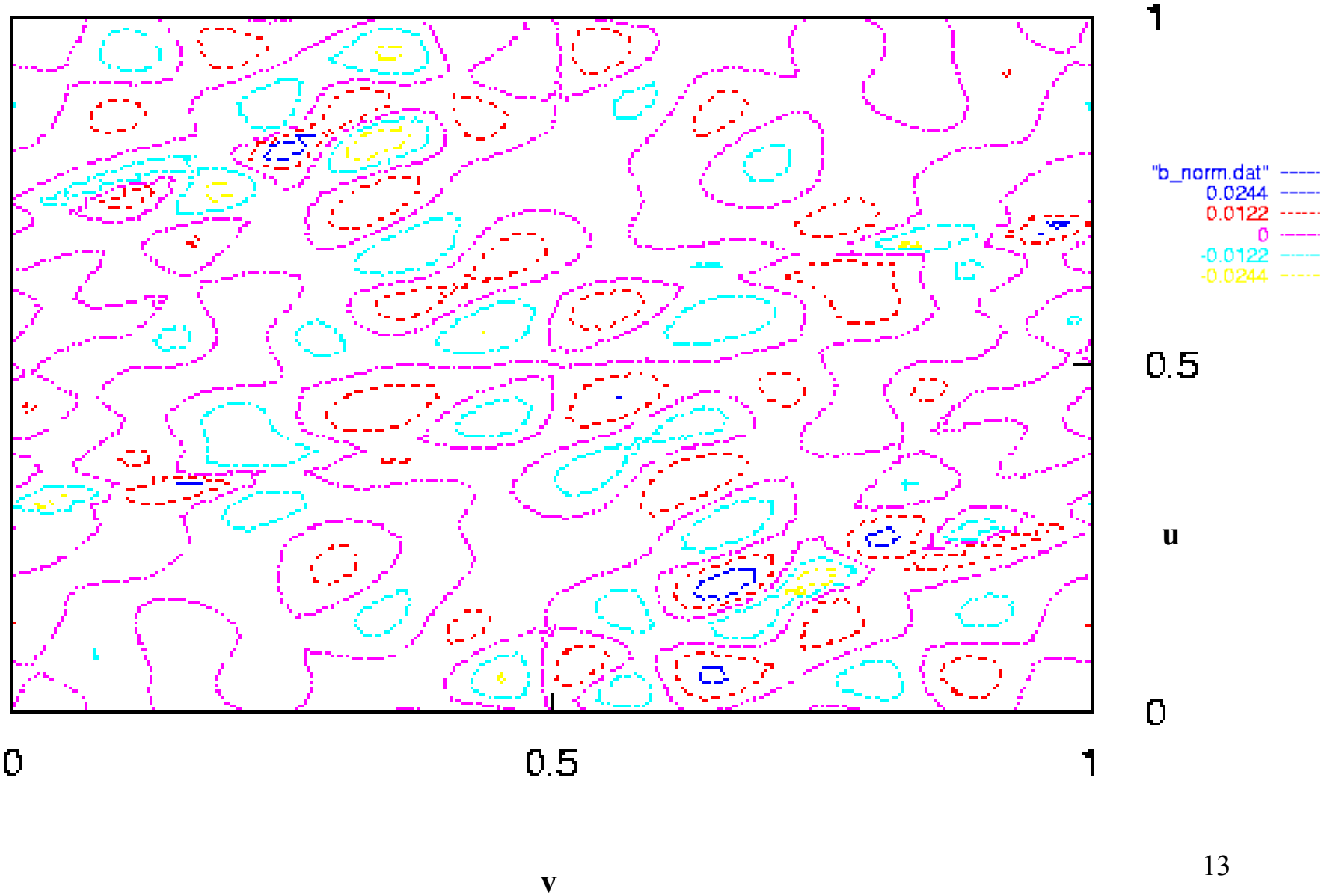
Modular Coils-II75



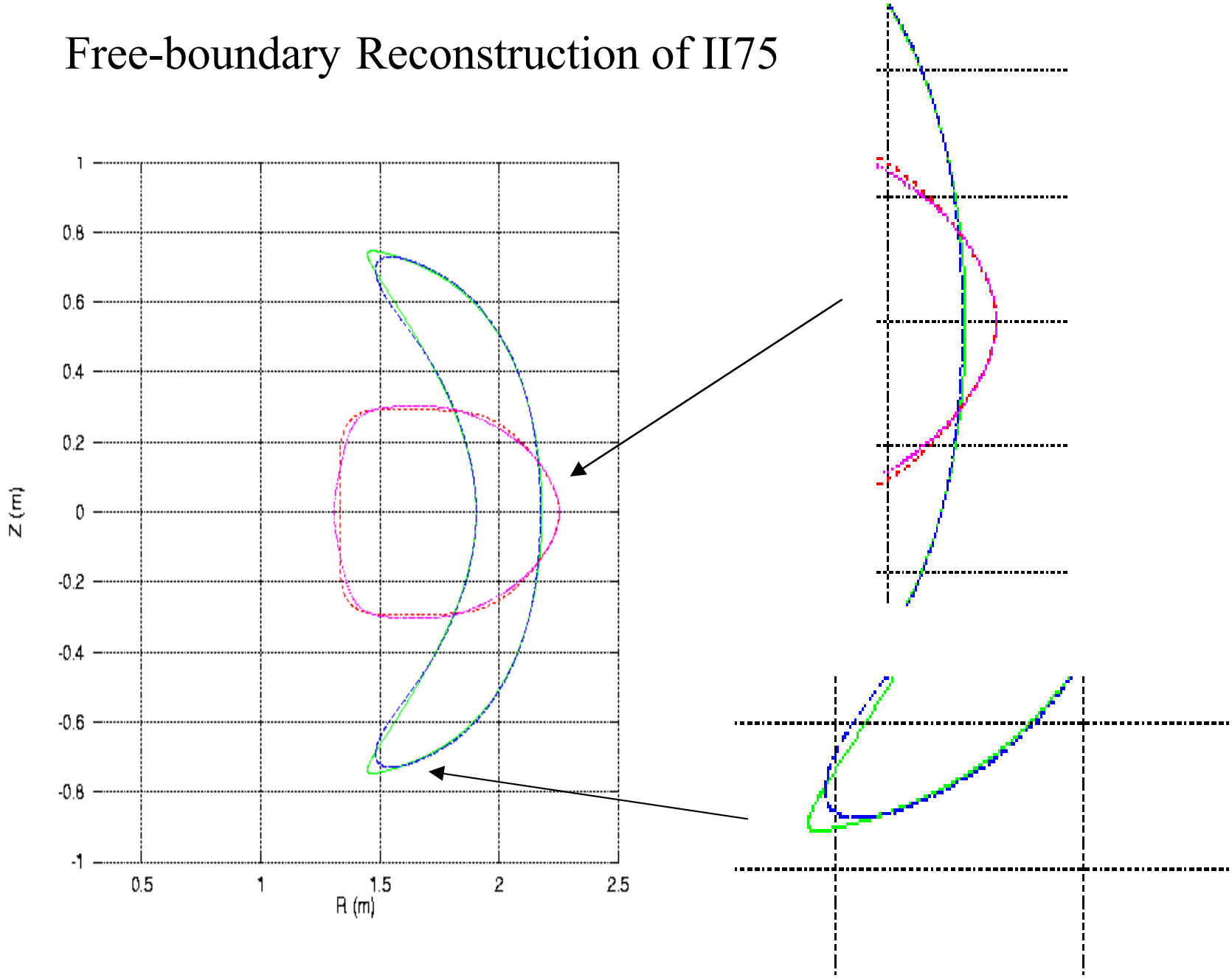


7 Coils / Period - 10 x 16-cm Xsec

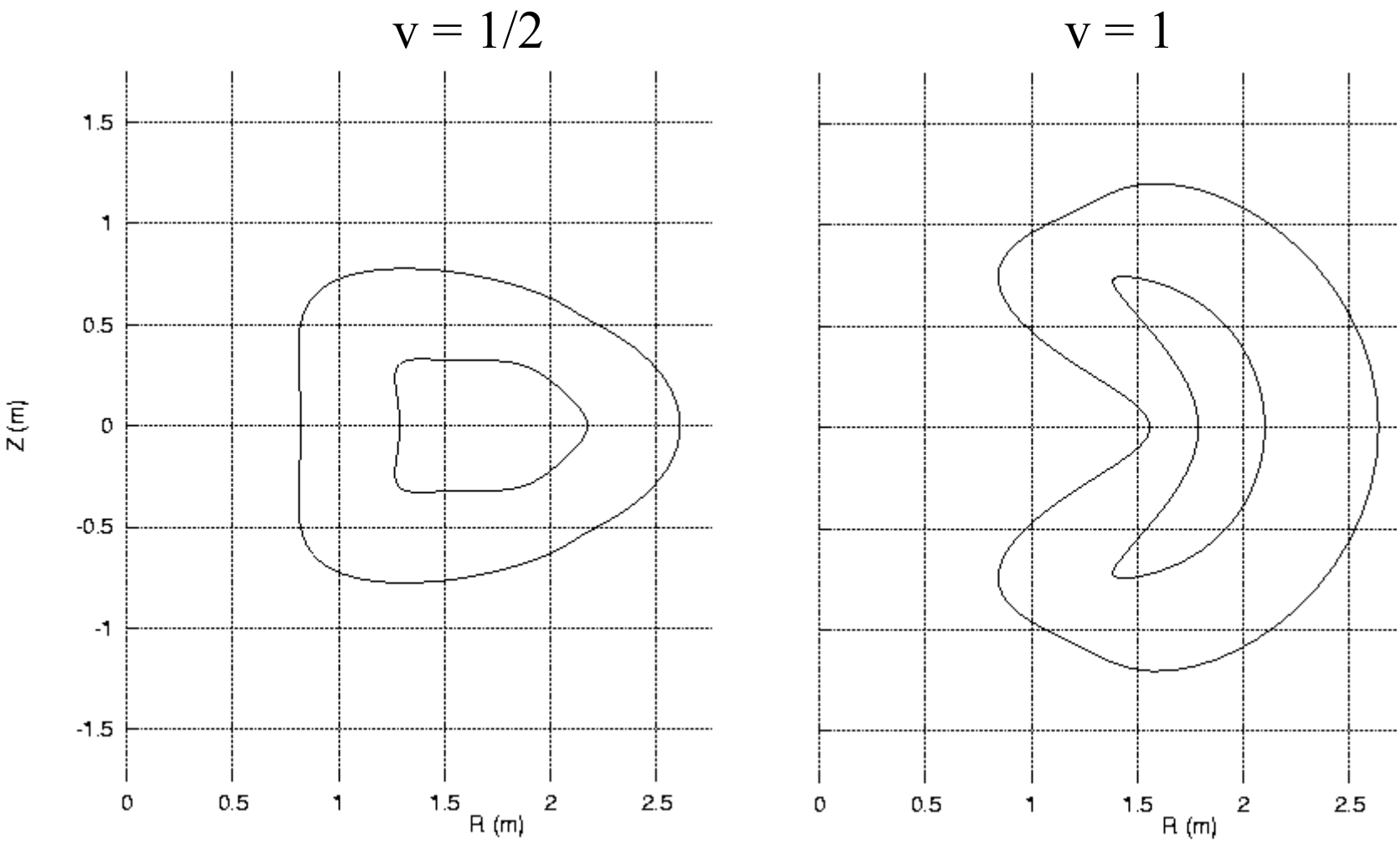
B-normal Error for II75



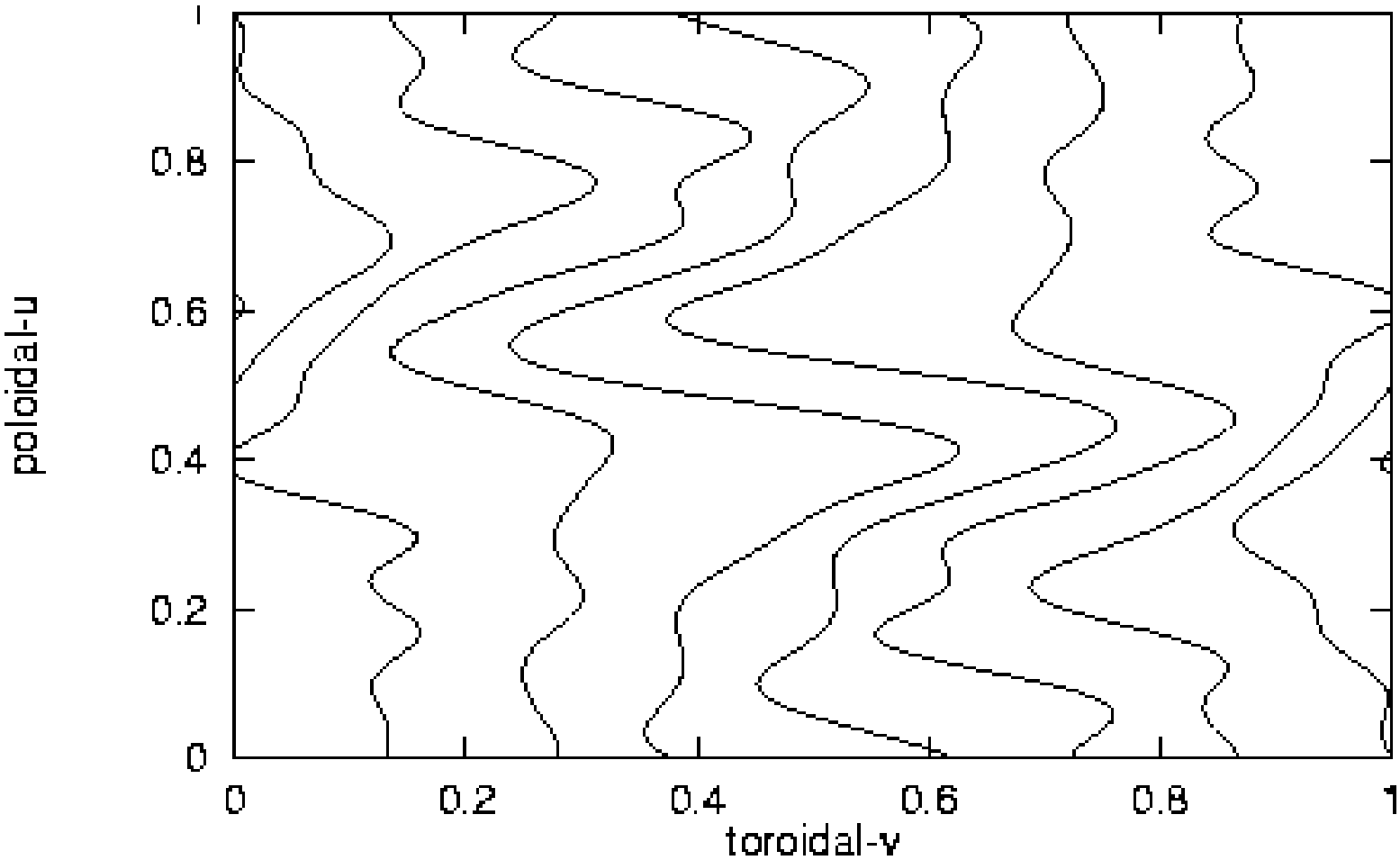
Free-boundary Reconstruction of II75



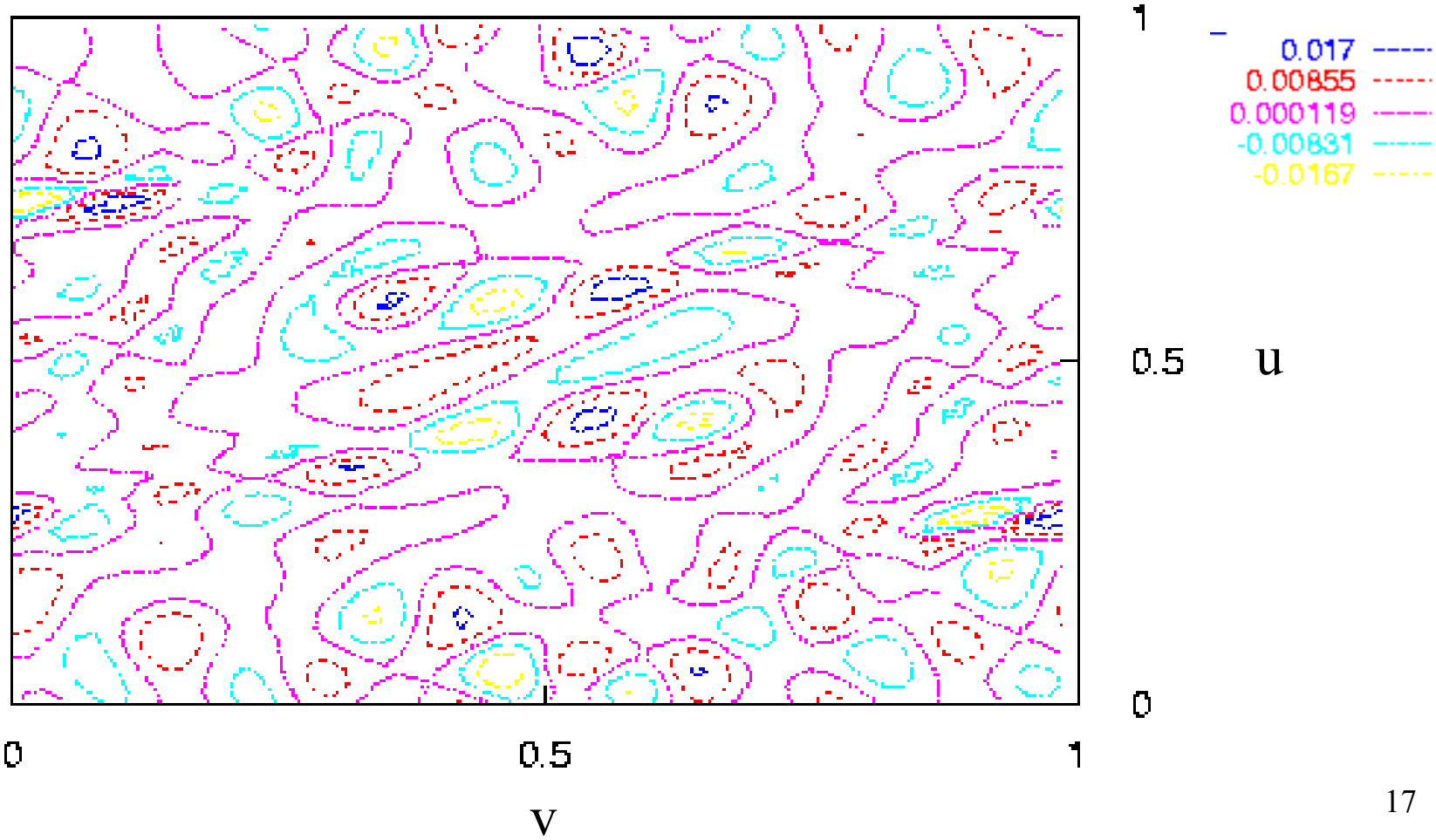
Modular Coil Optimization for LI383
Final Winding Surface



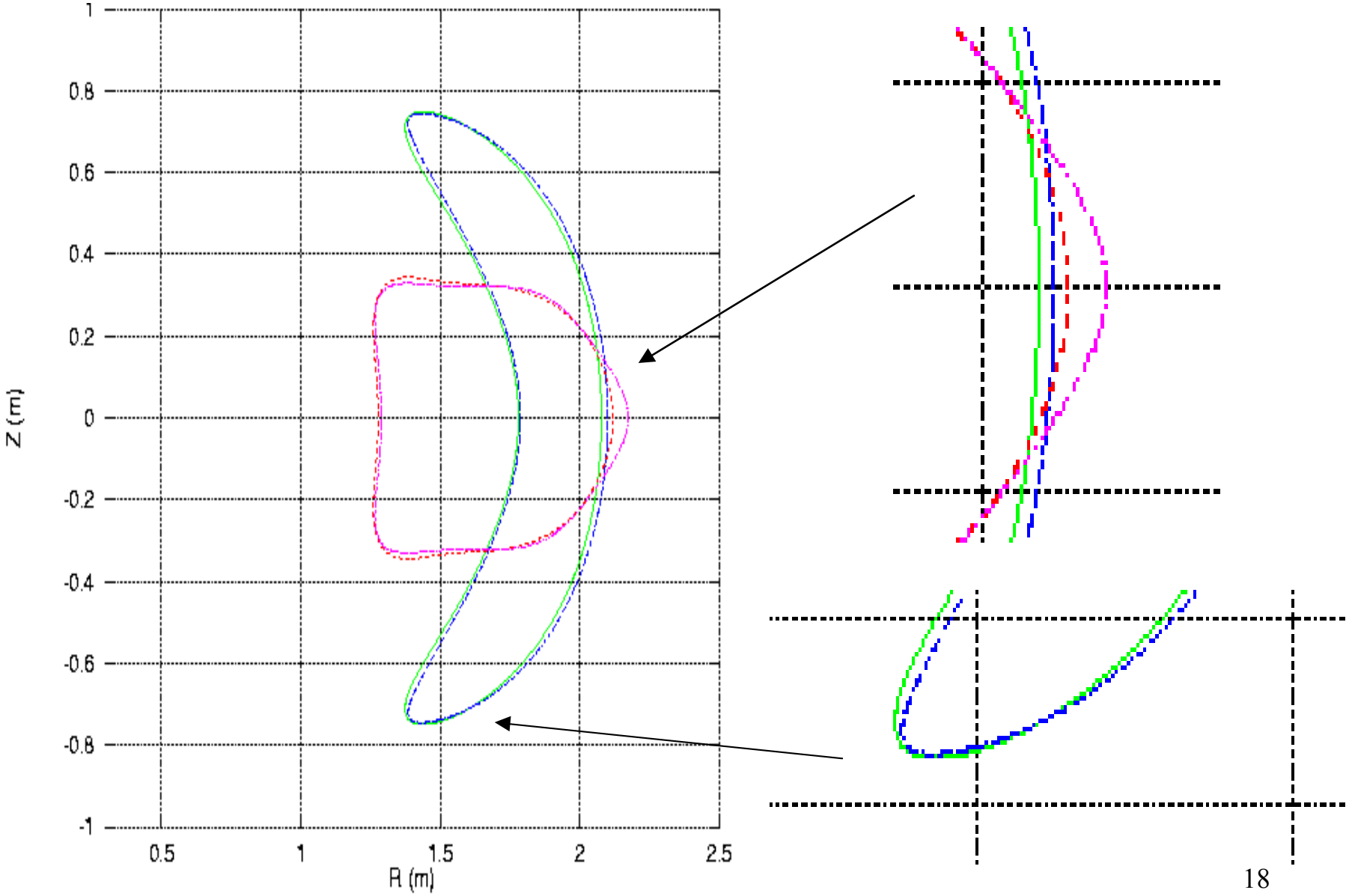
Modular Coils for LI383



B-normal Error for LI383



Free-boundary Reconstruction of LI383



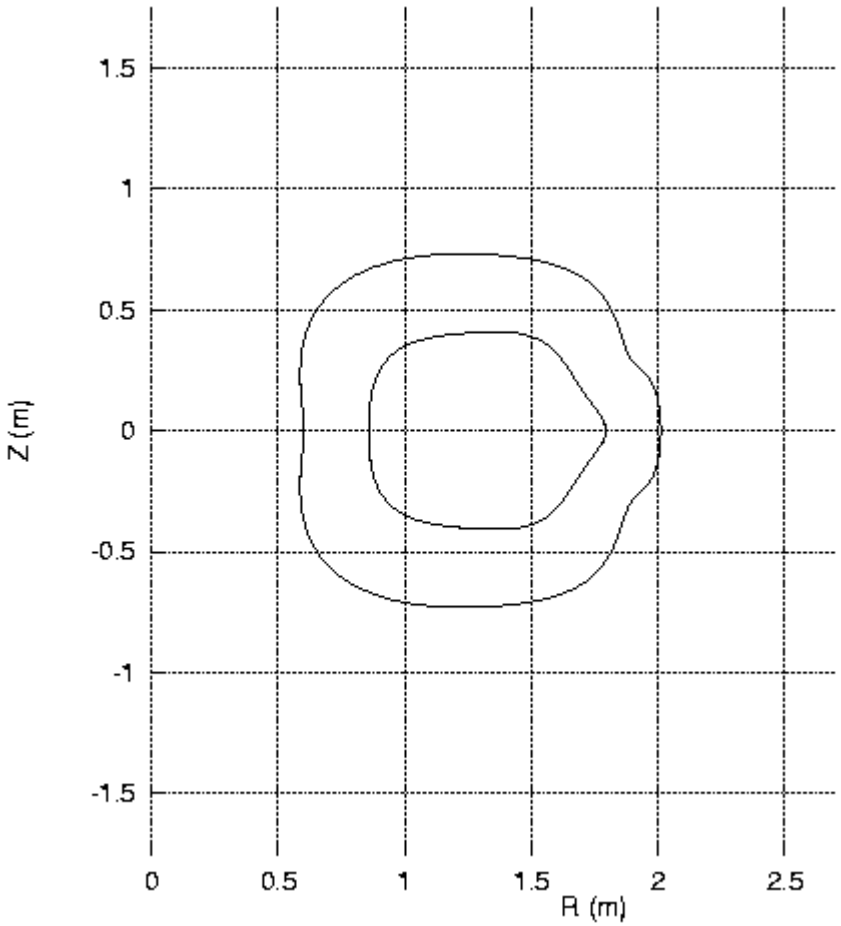
Modular Coil Optimization for II283

Run # 0706a	N_ϕ	N_s	N_v	δBrms (%)	δBavg (%)	δBmax (%)	Δcc (cm)	Δcp (cm)
0	5	18	0	14.86	9.46	38.10	16.57	19.06
1	5	18	49	2.59	2.07	7.95	6.10	19.11
2	5	18*	85	1.86	1.34	8.48	13.19	19.05
3	7	18	71	1.56	1.13	7.44	13.78	19.27
4	7	18*	107	1.53	1.03	8.23	11.87	15.62
5	7	26*	123	1.40	0.93	7.40	15.44	17.04

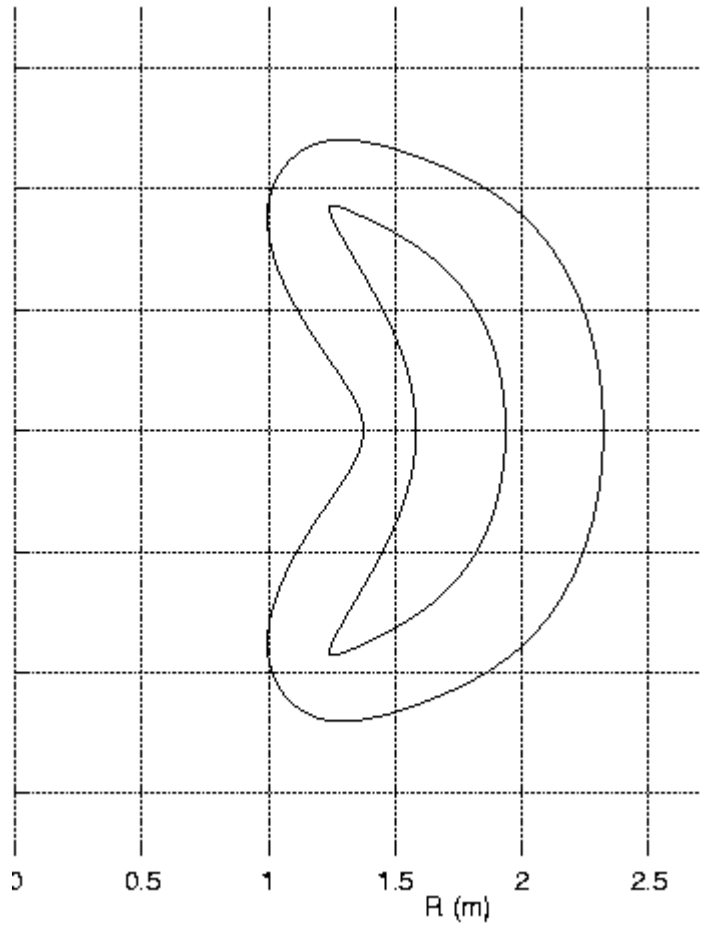
Modular Coil Optimization for II283

Final Winding Surface

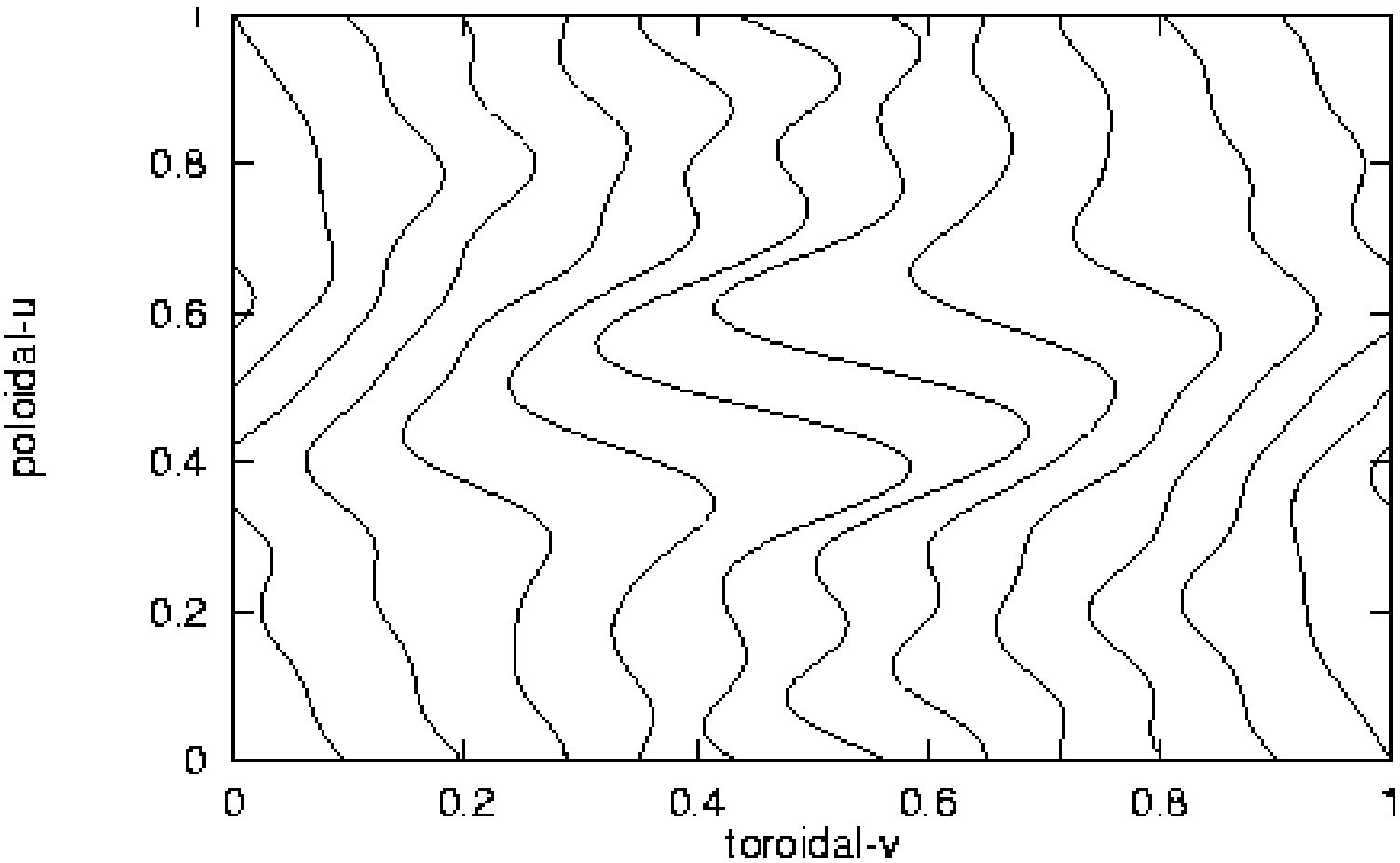
v = 1/2



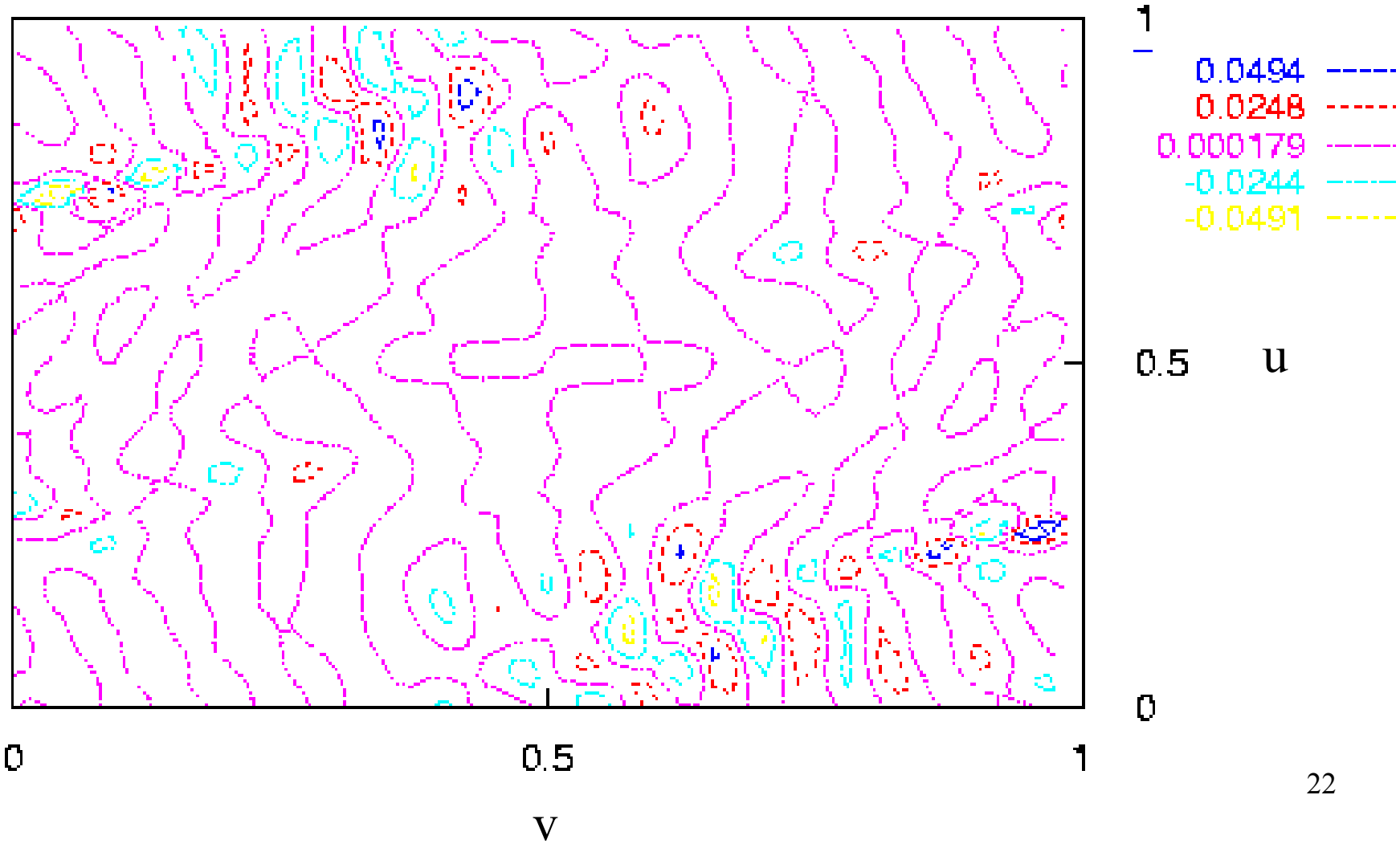
v = 1



Modular Coils for II283



B-normal Error for II283



Modular Coils for NCSX Configurations

- Solutions have been found for II75 and LI383 with 7 coils per period that reconstruct reasonably well.
- Two field period case II283 is still under investigation.
- Need to target minimum radius of curvature and consider multi-filament optimization.