Evaluating Coils for Recent Plasma Configurations

NCSX Physics Meeting

June 8, 2000

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Overview

- Screening of Plasma Candidates in 1/R Field
- Assessing Alternate Coil Topologies for most promising candidate
- Status of Ongoing efforts

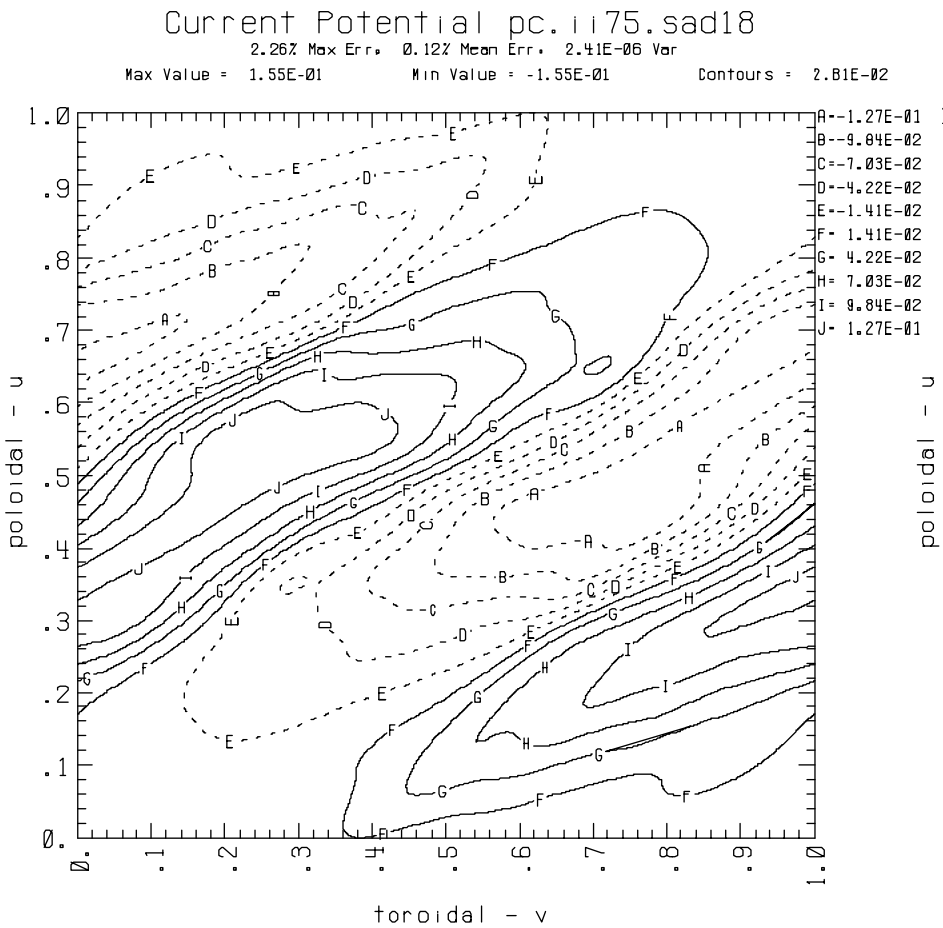
Screening Plasma Candidates

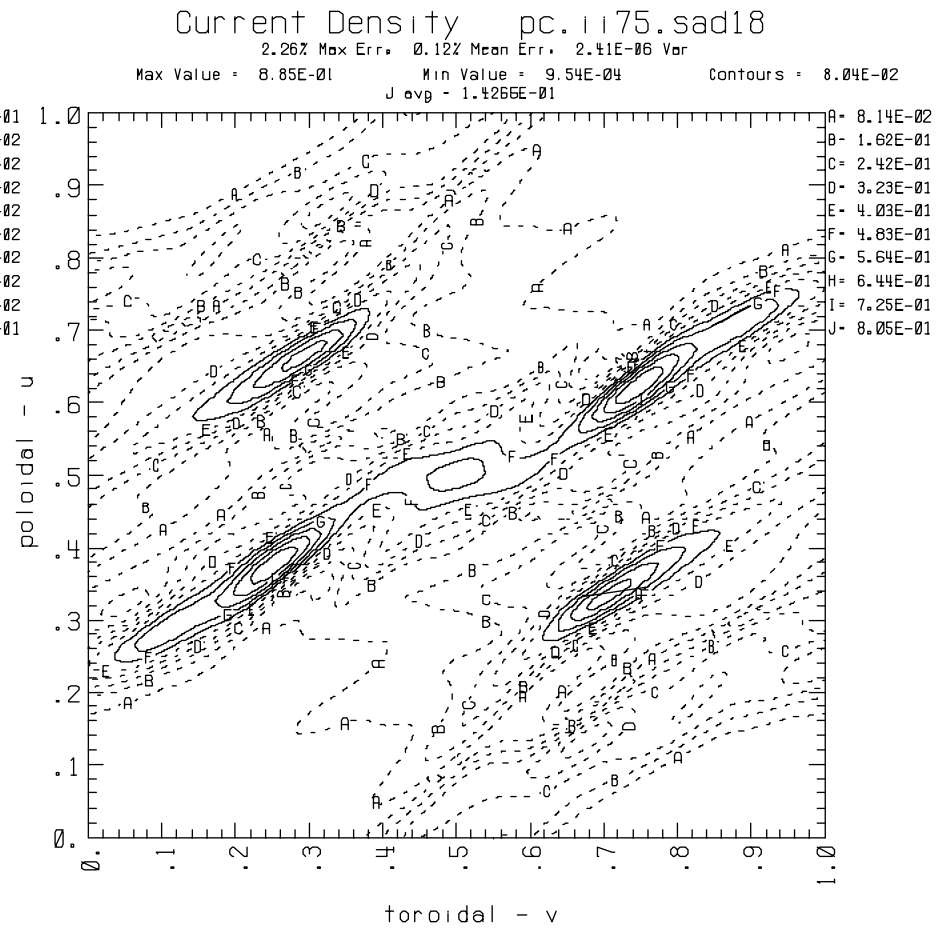
- Plasma Candidates
  - High Iota (ii75, Ku)
  - High Kappa (ka4.0_4a, ka4.0_b5.00a, Kessel)
- Coil Topology
  - 1/R Background Field with Conformal Coils
- Coil Surface
  - 18 cm Uniform Offset from DESCUR
- Current Sheet Solution
  - Standard NESCOIL
- Coil Cutting
  - Uniform Contours

Comparison of Plasma and Coil Parameters

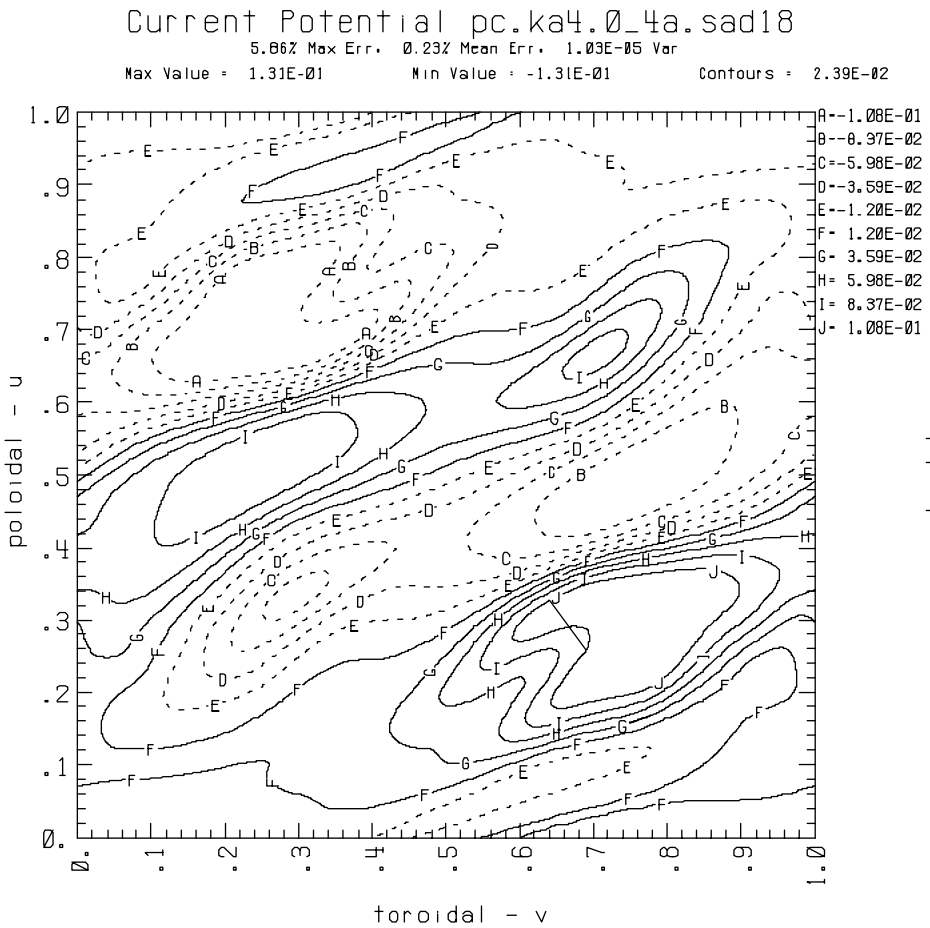
Parameters	Plasma Configuration			
	High Iota	High Kappa	High Kappa	Reference
Plasma	ii75	ka4.0_4a	ka4.0_b5.00a	c82
R(0,0)	1.758	1.600	1.600	1.433
Curpol, KA	3598	3210	3092	2763
Curtor, KA	120	207	244	201
iota(0)	0.464	0.280	0.308	0.260
iota(1)	0.748	0.479	0.484	0.468
beta	4.00	4.00	5.00	4.00
Current Sheet on 18 cm Surface				
Max Field Error, %	2.26	5.86	8.52	2.97
Mean Field Error, %	0.12	0.23	0.32	0.21
Max Current Density, A/m/Curpol	0.885	0.938	1.000	1.190
at Nominal Field				
Complexity	2.00	2.77	3.02	3.11
Coils from Uniform Contours				
Num Contours	12	12	12	12
Max Field Error, %	4.71	6.03	7.84	4.00
Mean Field Error, %	0.98	1.06	1.05	0.92
Max Current Density, KA/cm2	25.97	32.88	42.00	35.83
for 2T@R(0,0)				

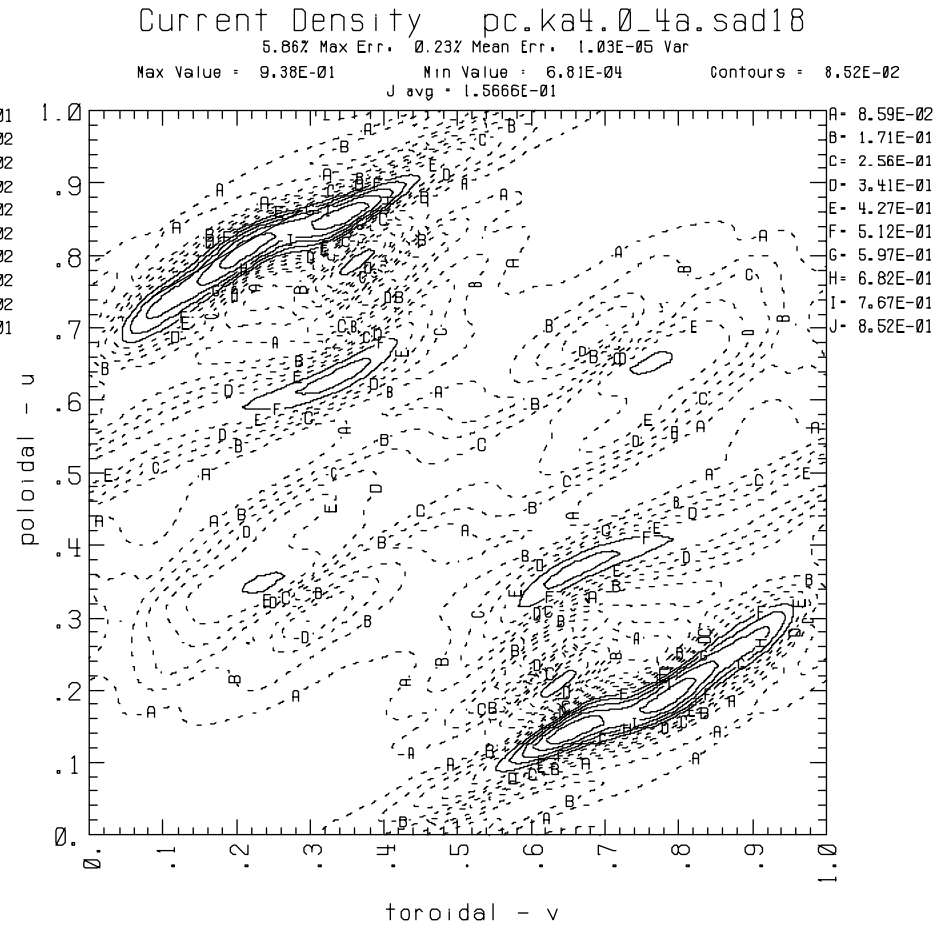
ii75 Current Sheet Solution



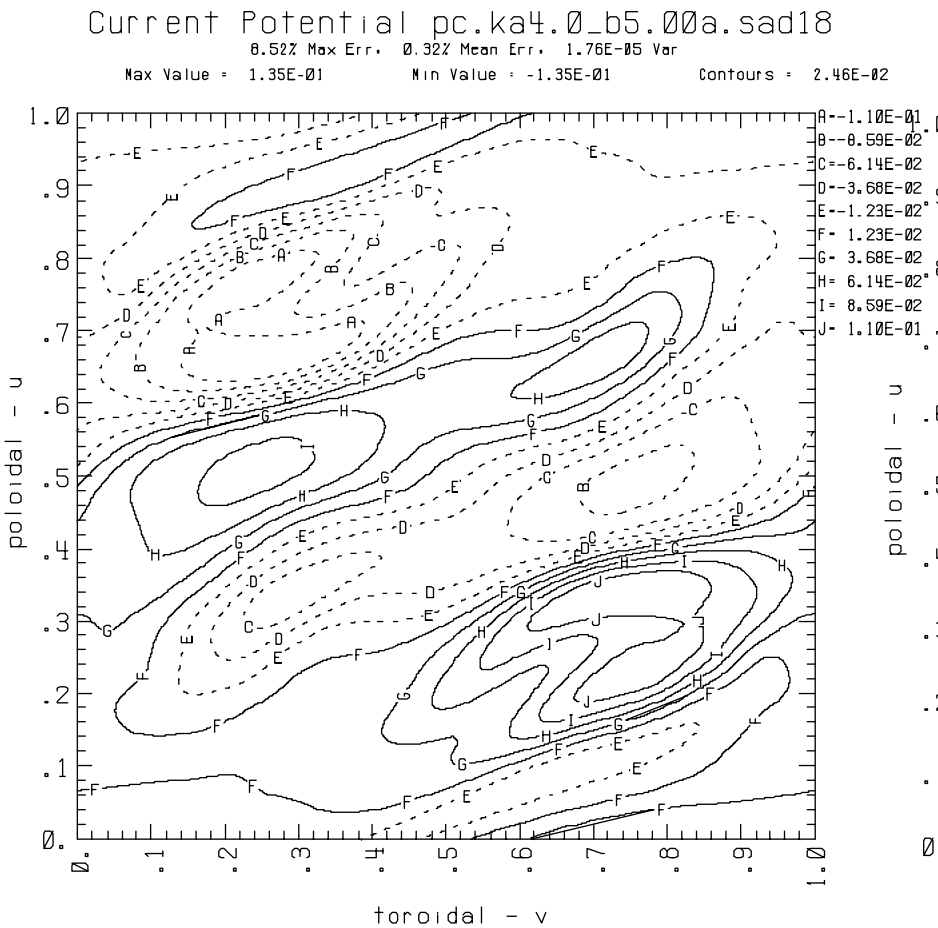


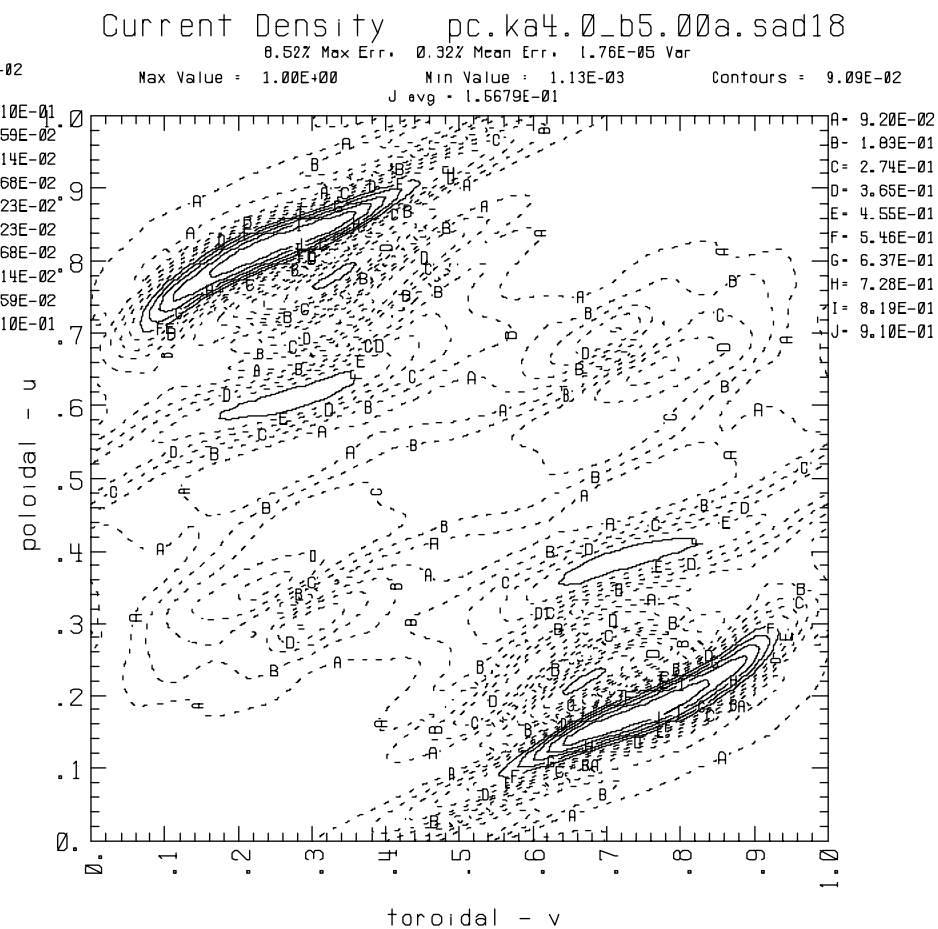
ka4.0_4a Current Sheet Solution



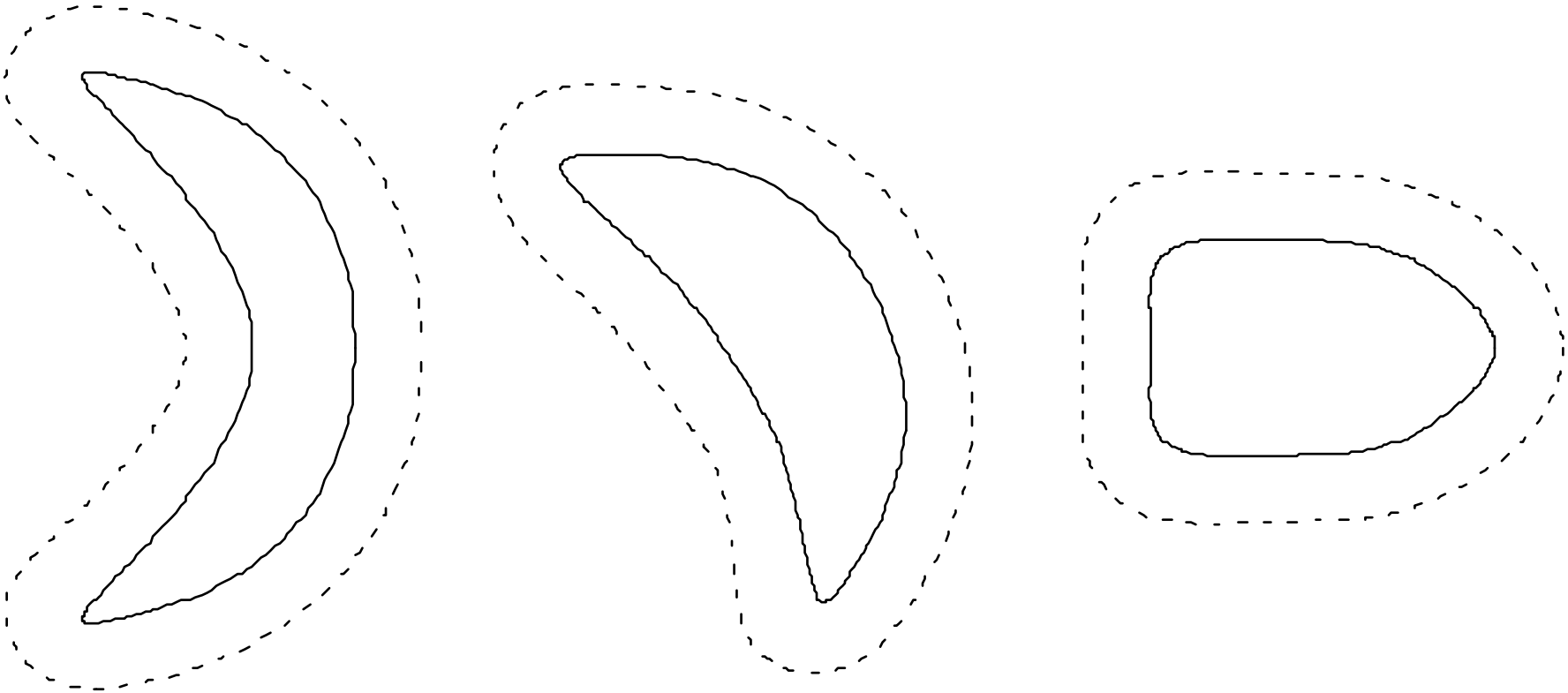


ka4.0_b5.00a Current Sheet Solution

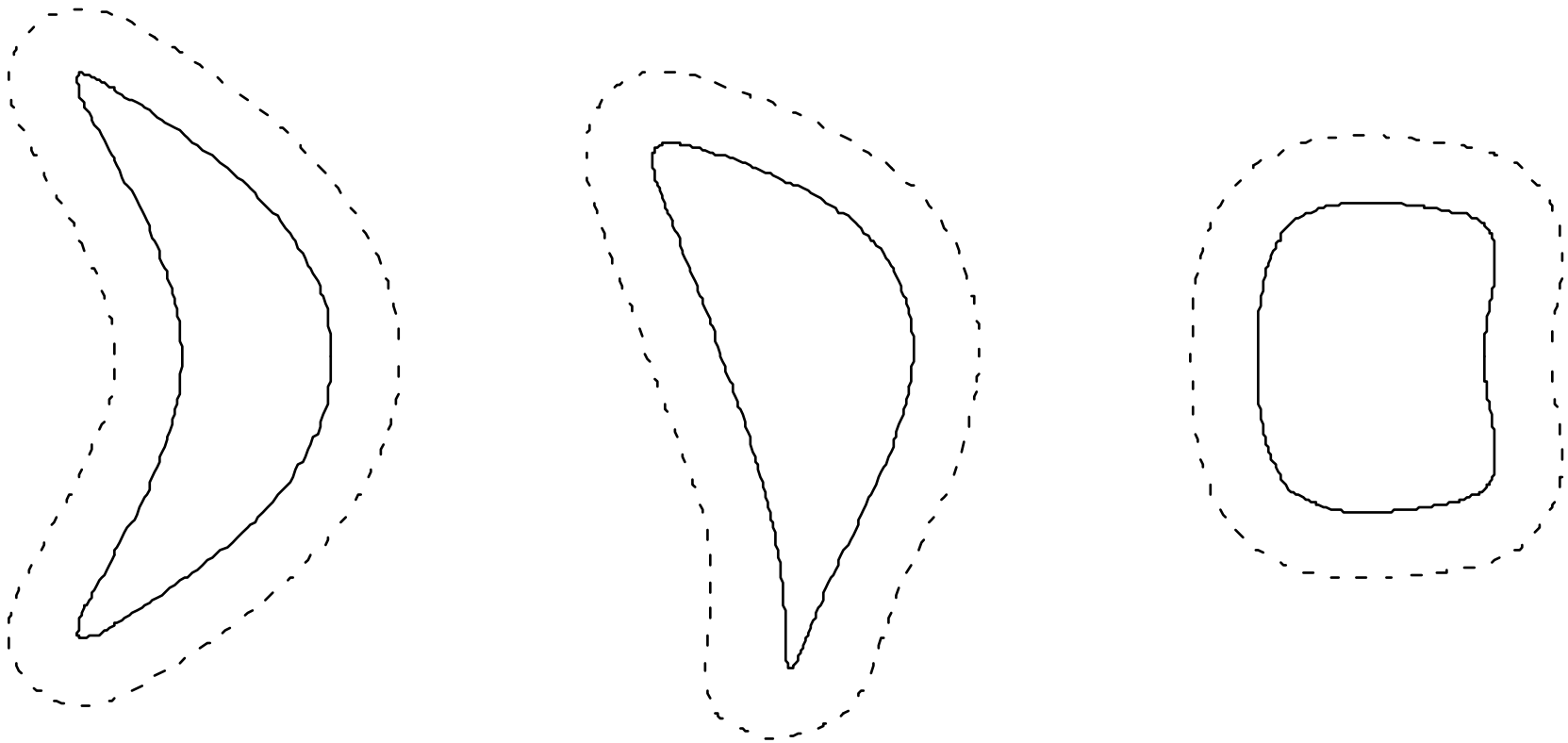




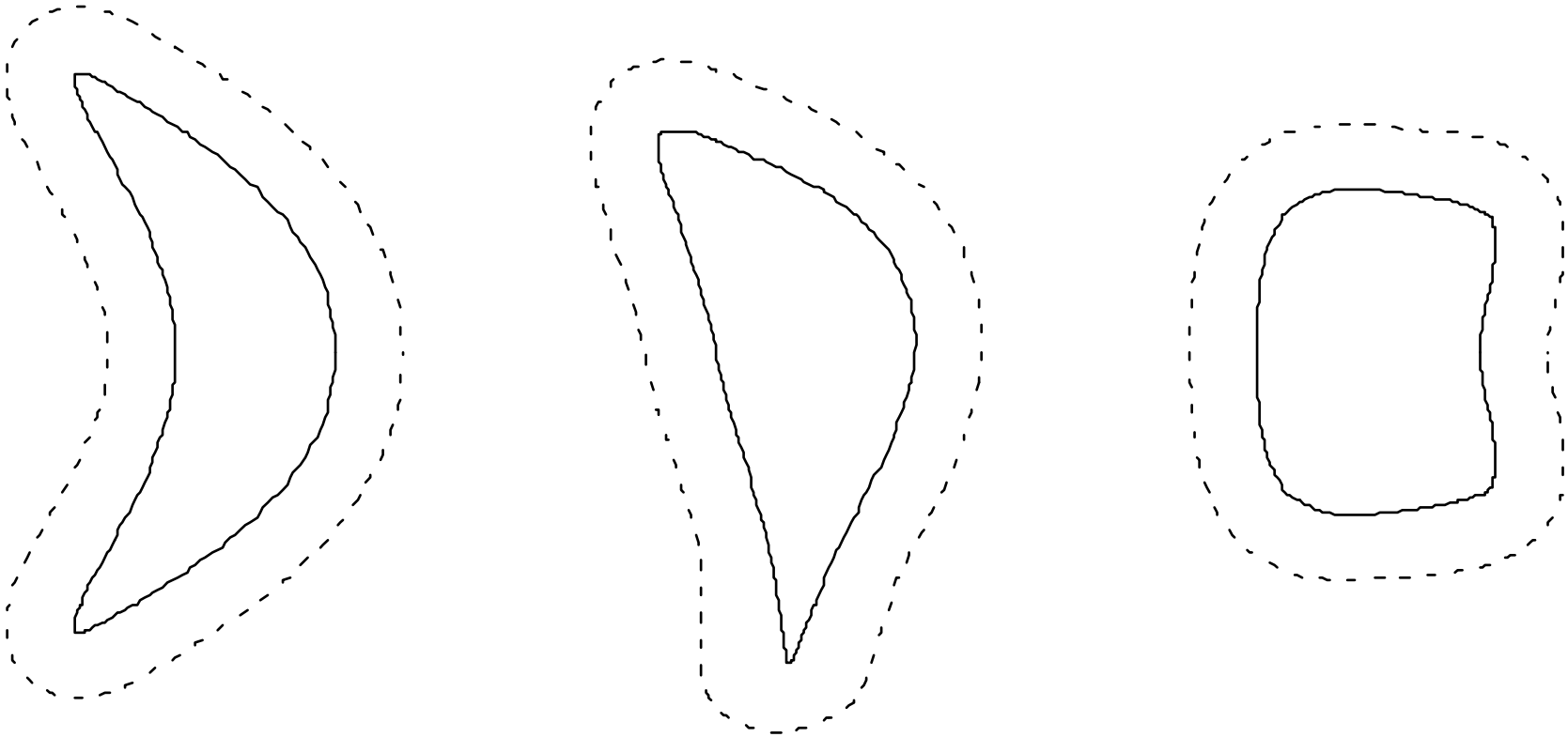
ii75 with 18 cm Surface

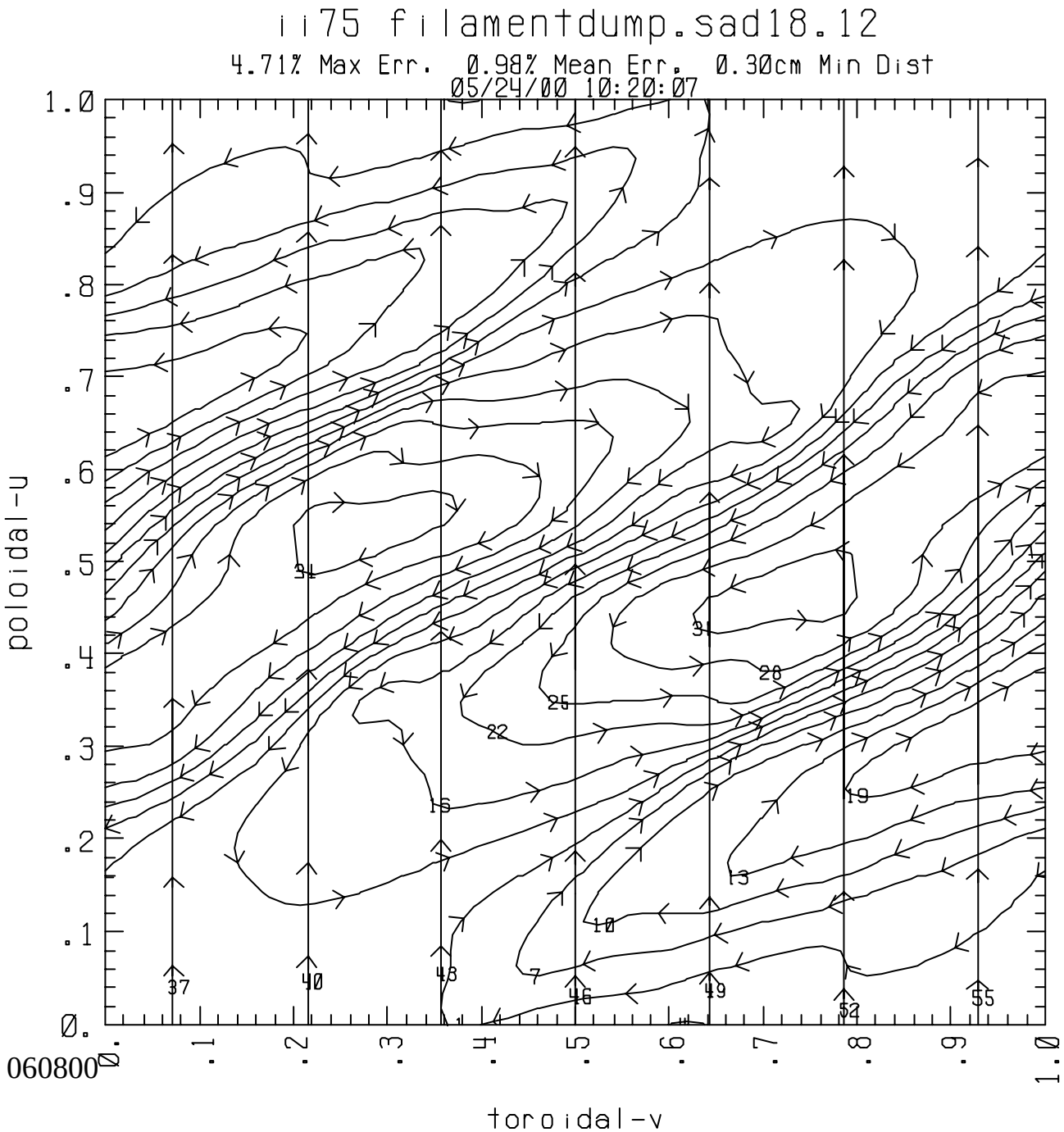


ka4.0_4a with 18 cm Surface



ka4.0_b5.00a with 18 cm Surface

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4.71% Max Err. 0.98% Mean Err. 0.30cm Min Dist
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poloidal-u
toroidal-v
1.0
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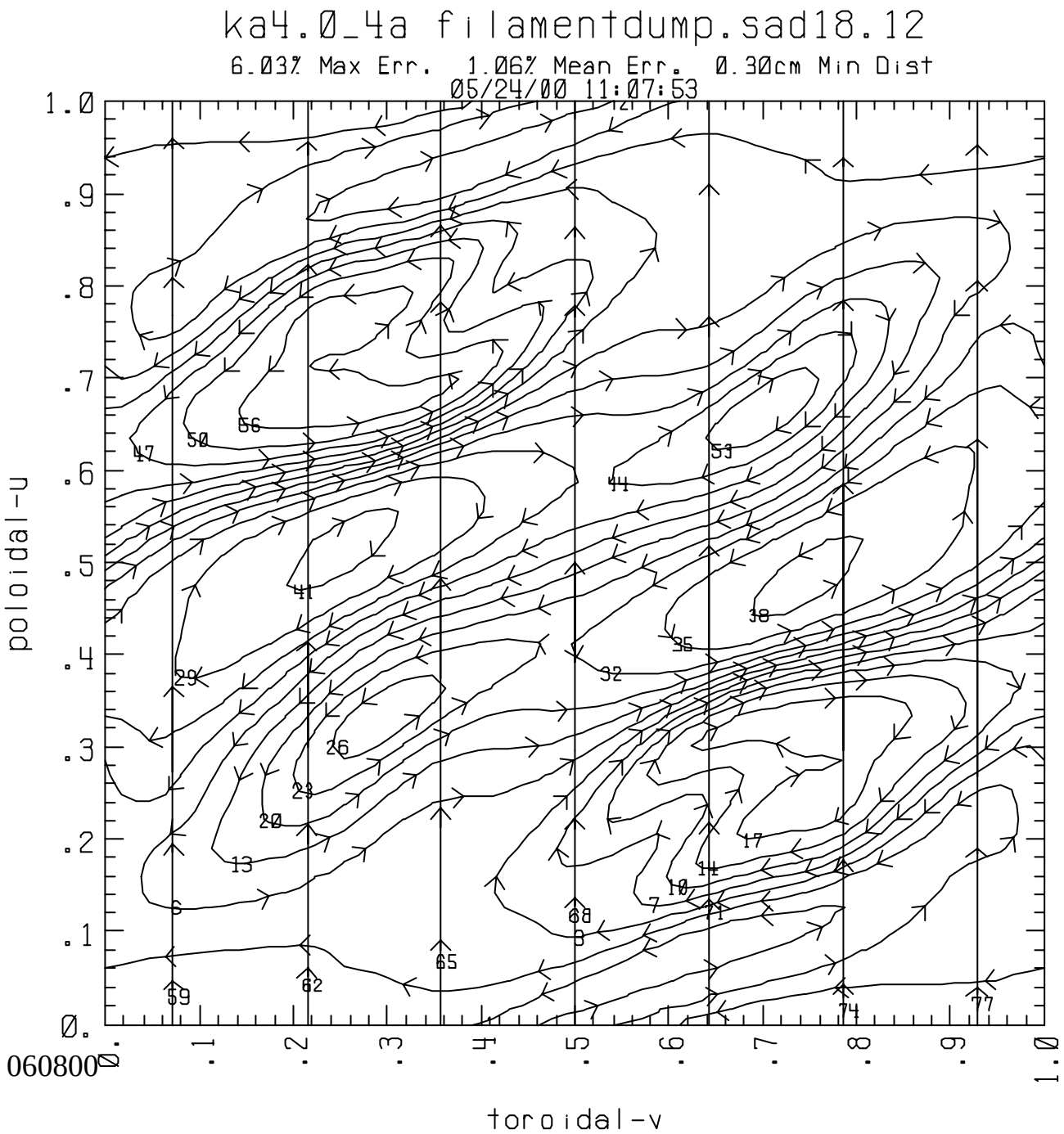
ka4.0_4a filamentdump.sad18.12
6.03% Max Err. 1.06% Mean Err. 0.30cm Min Dist
05/24/00 11:07:53
poloidal-u
toroidal-v
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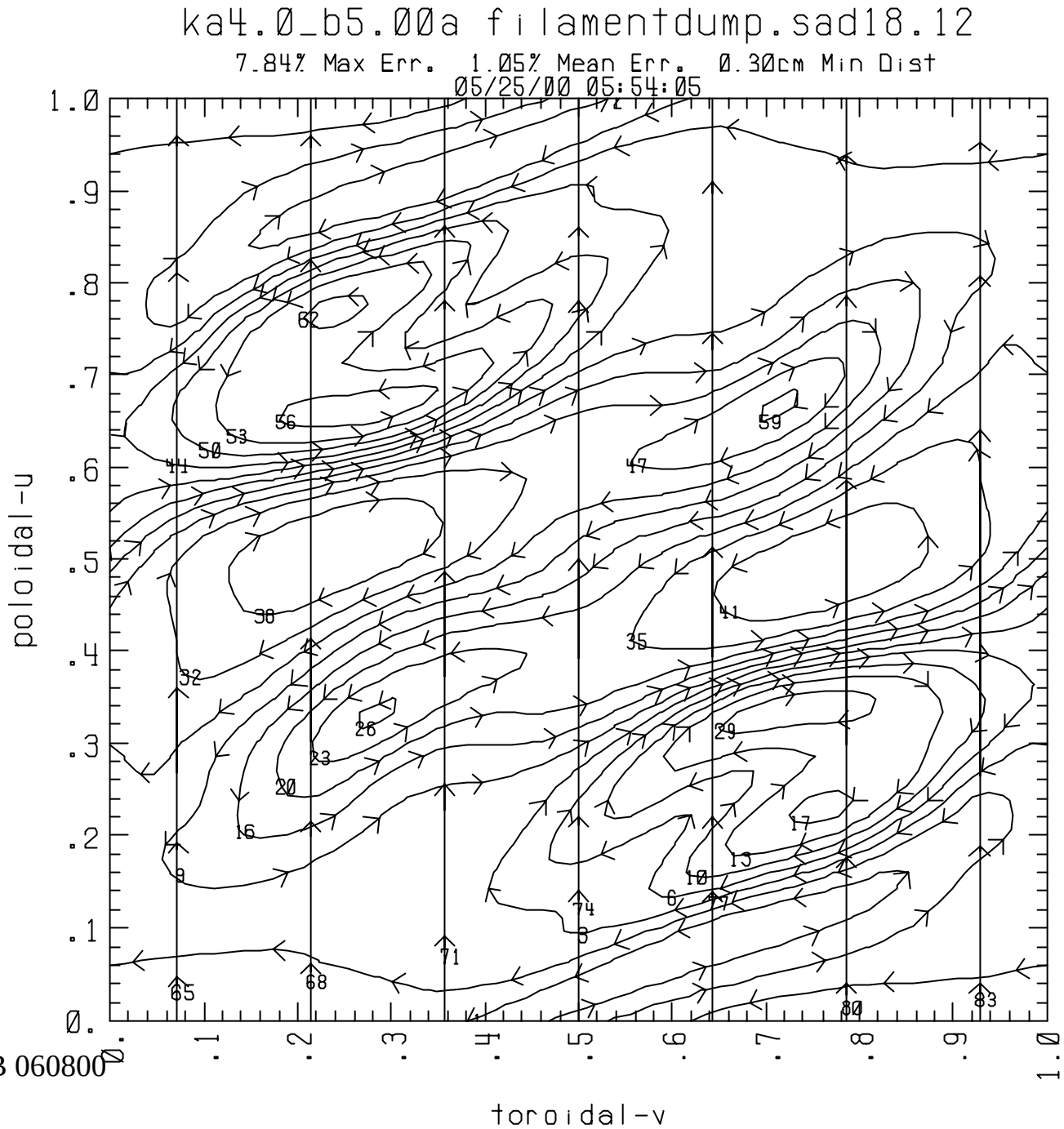

ka4.0_b5.00a filamentdump.sad18.12
7.84% Max Err. 1.05% Mean Err. 0.30cm Min Dist
05/25/00 05:54:05
poloidal-u
toroidal-v

Impact of Surface Offset

		Surface Offset		
		18 cm	20 cm	22 cm
Current Sheet				
Max Field Error, %		2.26	2.39	2.5
Mean Field Error, %		0.12	0.13	0.14
Max Current Density, A/m/Curpol		0.885	1.15	1.58
at Nominal Field				
Complexity		2.00	2.11	2.38
Coils from Uniform Contours				
Num Contours		12	12	12
Max Field Error, %		4.71	4.61	4.62
Mean Field Error, %		0.98	0.97	0.97
Bundle Height, cm		7	11	15
Max Current Density, KA/cm2		25.97	33.41	119.23

Assessing Alternate Topologies for ii75

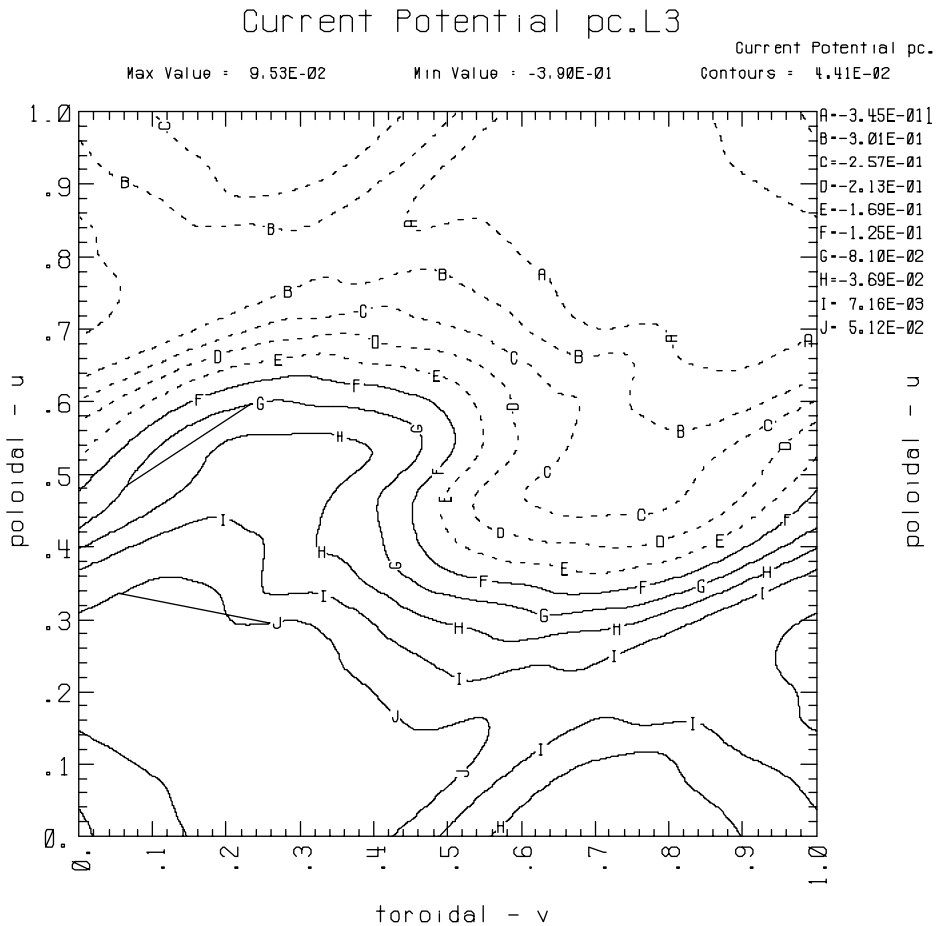
Current Sheet Solution

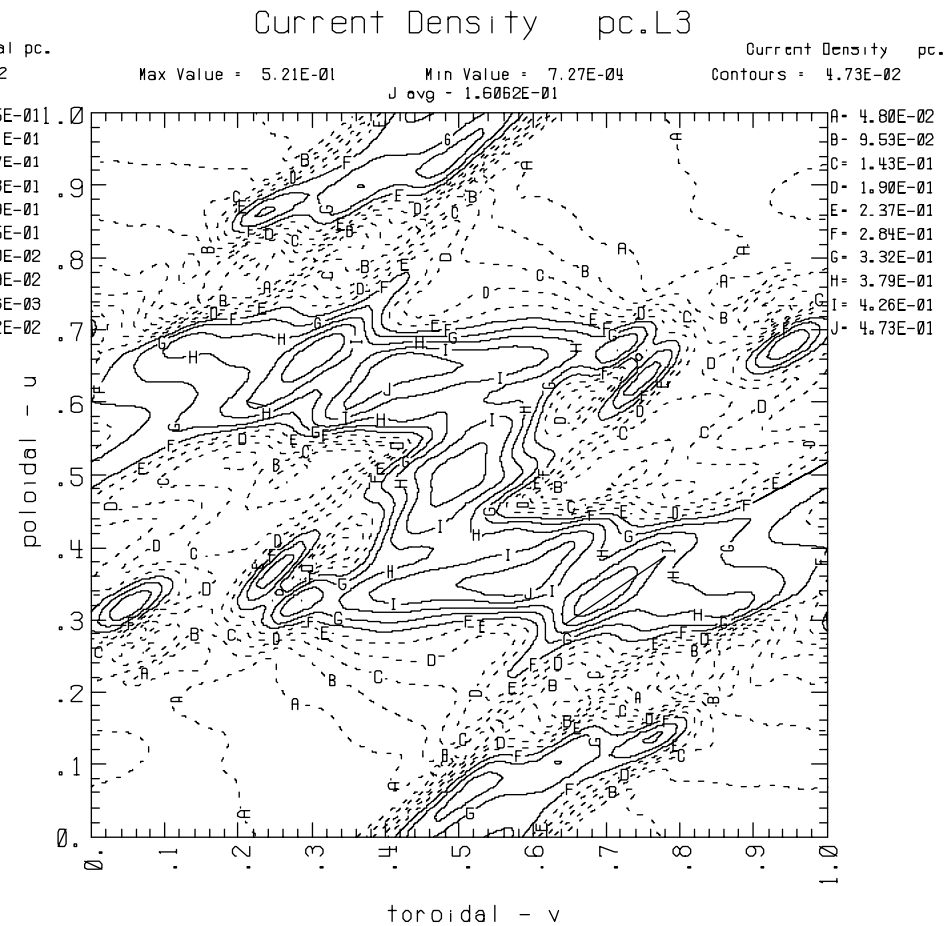
Topology		I_(1/r)	I_pol	I_tor	jmax	complexity	target
Saddle		1	0	0	0.885	1.97	2.855
Modular		0	1	0	0.739	2.05	2.789
WavyPF / Sawtooth		1	0	*-0.18*	0.800	1.96	2.760
Helical, No 1/R		0	1	*0.51*	0.718	1.91	2.628
		0	1	0.5	0.718	1.92	2.638
Helical w/1oR		0.044	*0.956*	*-0.62*	0.820	1.69	2.510
		0	1	-0.667	0.814	1.82	2.634
L=3 w/ 3 TF	TF	0.755	0	*-0.02*	0.469	1.73	2.199
	L=3	0.245					

Note: Red indicates optimized quantity using tiltopt

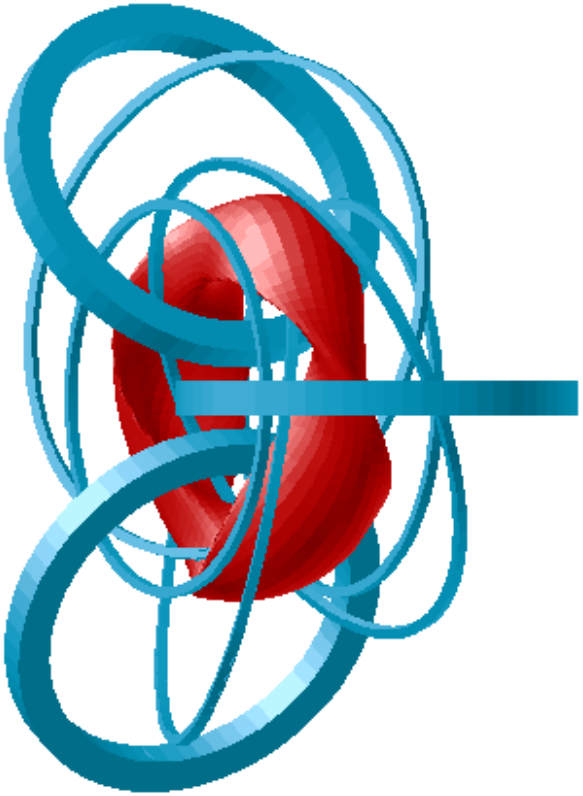
Using L=3 Background Coils

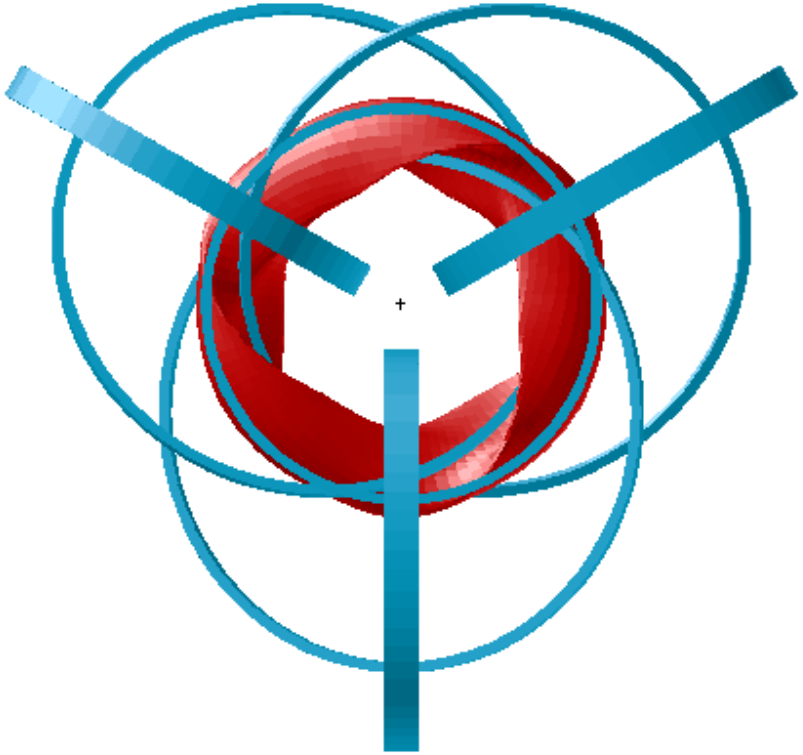
ii75

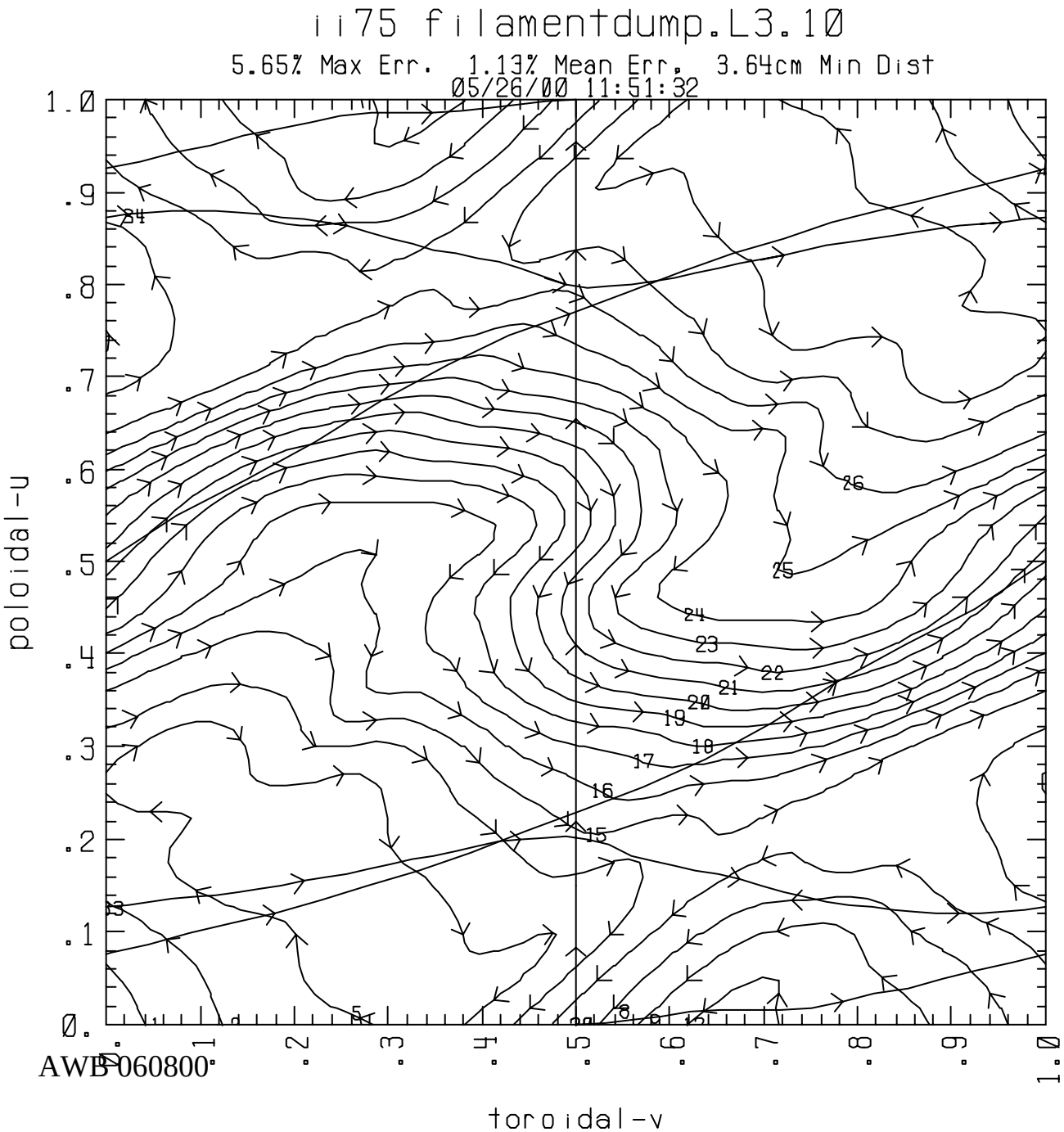




L=3 Background Coils







Max Conductor
Current Density
At 2T and R(0,0)
Is 10.15 KA/cm2

Shows promise,
But access still
questionable

What Next?

- Expand Topology Exploration
  - Modular (coilopt)
  - L=2, L=1 (strong components in current sheet) (tiltopt)
- Coil Surface
  - Conformality
  - Offset
  - Representation
- Current Sheet Smoothing
  - Mode Truncation
  - SVD
  - Regularization

- Coil Cutting
  - Uniform Contours
  - GA
- Reconstructions
- Berr vs Xerr Targeting

Lessons Learned from c82

- Remote Field at Neutral Beams from large “open” coils systems (ie L=3 with 3 TF) are very high and presumed unacceptable

- Coils designed for single plasma state not very flexible. Will need some supplementary coils for any configuration.

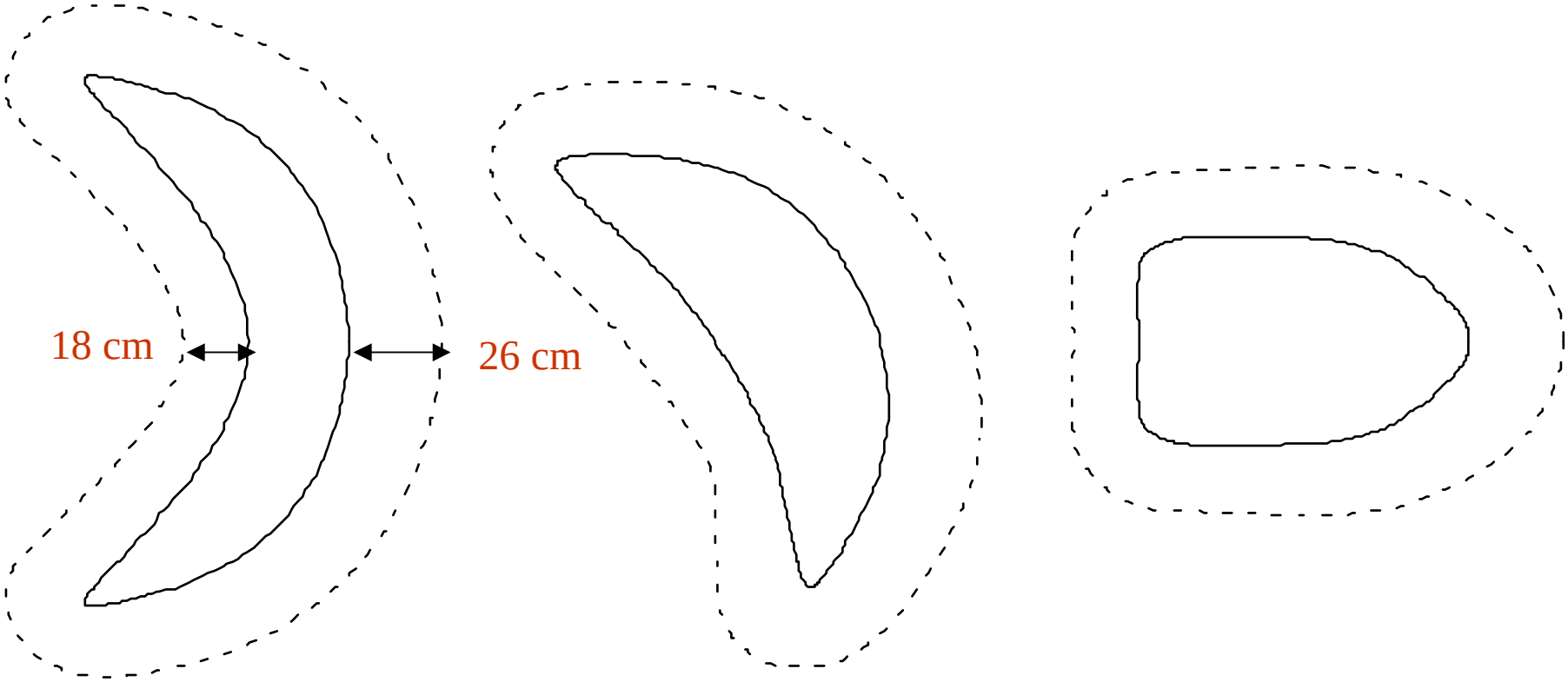
- Closely conformal winding surface too limiting for flexibility. Need to provide some wiggle room.

- Access issues need to be addressed early on

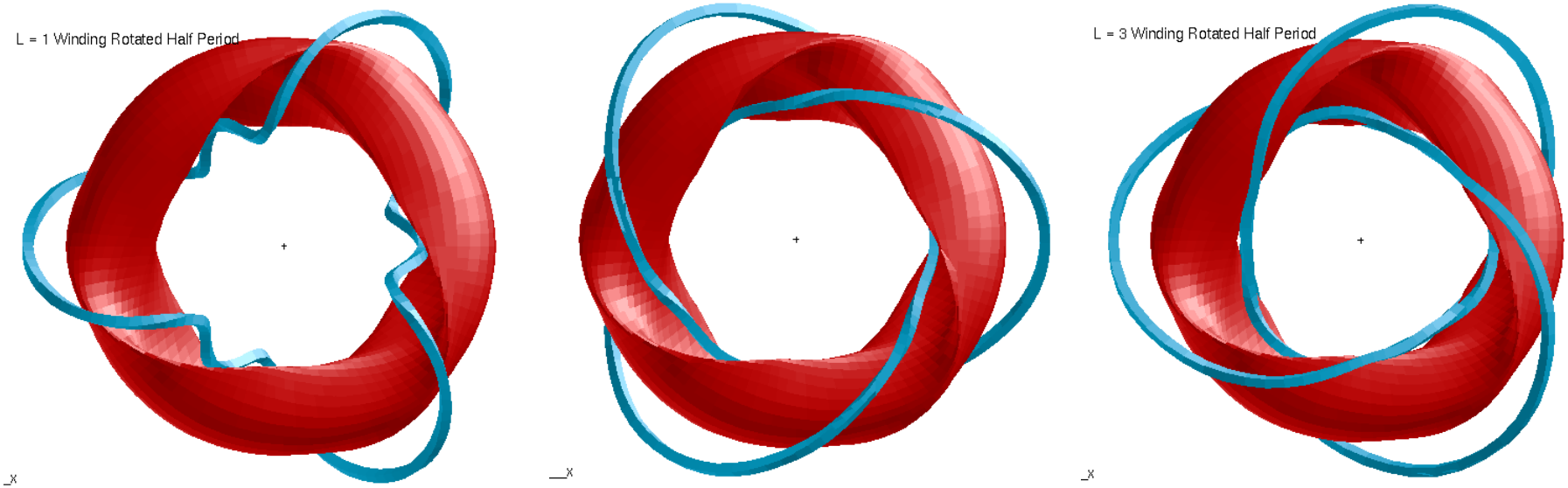
Alternate/Supplementary Background Coil Design

- Explore use of more traditional Helical Windings in both Torsatron and “Classical” Stellarator Configurations **in 1/R field** to
  - Try and reduce demand (ie current density) on conformal coils
  - Provide a (better?) knob for flexibility
- Increase Conformal Coil Surface Separation on outboard side of Plasma from 18 to 26 cm to increase plasma scrapeoff from 2 to 10 cm
- Target Average Current density in outboard region of CS

Variable Offset Coil Surface around ii75



Illustrative Sample of Possible Helical Windings



Shown wound on 40 cm Conformal Surface

L = 1	L = 2	L = 3
1 Coil	1 Coil	3 Coils

Summary

- Coil group consensus was the ii75 High Iota Plasma is the preferred candidate at this point for further study. Current Sheet Field Errors for High Kappa Plasma need to be reduced.

- ii75 appears to offer potential for coil improvement over c82

- Lessons learned from c82 need to be folded into design

- Work still in progress