Coil Design Status
Saddles in 1/R Field

NCSX Project Meeting

July 12-13, 2000

A Brooks and NCSX Coil Group

Overview

- Present Saddle Coil Configuration for Candidate Plasmas
  - Li383_328 (medium iota) - Prime Candidate
  - Ii75_286 (high iota) - Previous Contender
  - Ii283_16 (2 period) - Worth Mentioning

- Compare Free Boundary Plasma Reconstructions for Saddles and Modulars

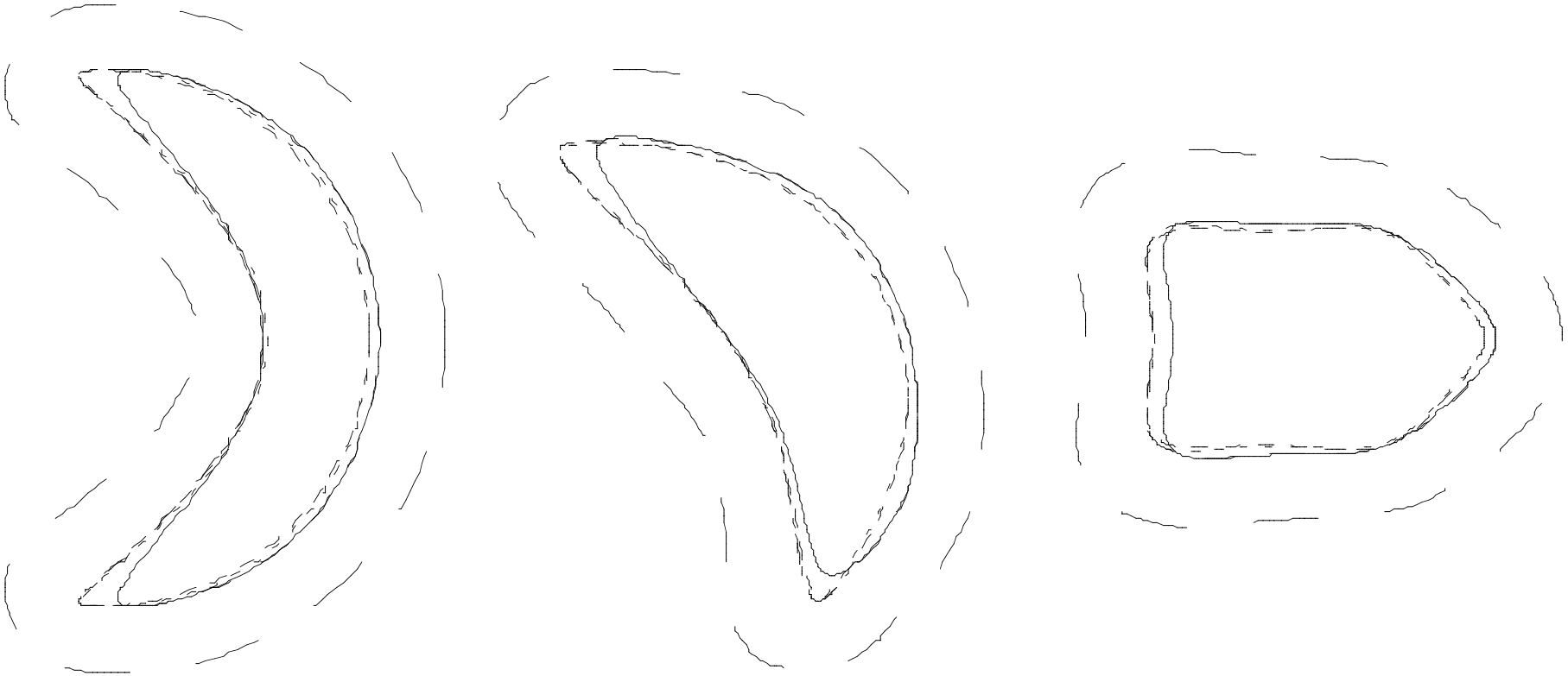
Coil Design Path

- Initially Screen all plasmas using saddle topology on conformal surface 18 cm offset from plasma
- Investigate (for ii75) supplemental background coils using background coil optimizer (tiltopt)to reduce coil current density
- Switch to li383 which already had low coil current density (< 20 kA/cm2) and focus on improving Physics and try to demonstrate flexibility using Free Boundary Optimizer (xstellopt)

Initial Screening led to li383

Configuration Description	c82 Reference	PG2	ii75_286 High Iota	ii378_21 High Iota	3k2.45b5. High Kapp	4k2.45b5. High Kapp	li65_136 med iota	li383_32 med iota	A3k2.45b high kappa	A4k2.45b high kappa	ii379_32 higher iota	ii283_16 2 period
Plasma												
R(0,0)	1.433	1.685	1.758	1.635	1.300	1.600	1.755	1.681	1.300	1.600	1.635	1.440
Curpol, KA	2763	3365	3598	3462	2497	3092	3535	3410	2500	3084	3461	4003
Curtor, KA	201	180	120	150	277	244	120	150	298	232	200	200
iota(0)	0.260	0.143	0.464	0.447	0.247	0.308	0.380	0.395	0.269	0.302	0.444	0.257
iota(1)	0.468	0.495	0.748	0.737	0.480	0.484	0.667	0.655	0.480	0.483	0.784	0.465
beta	4.00	4.00	4.00	4.56	5.17	5.00	4.00	4.25	5.72	4.72	5.11	4.00
Current Sheet on 18 cm Surface												
Max Field Error, %	2.97	0.45	2.26	3.3	5.77	8.52	1.82	1.19	7.21	5.58	3.64	6.87
Mean Field Error, %	0.21	0.05	0.12	0.14	0.03	0.32	0.09	0.13	0.26	0.26	0.17	0.15
Max Current Density, A/m/Curpol	1.190	0.880	0.885	1.120	1.550	1.000	0.740	0.760	1.360	0.820	1.190	0.708
js*r(0,0)	1.7	1.5	1.6	1.8	2.0	1.6	1.3	1.3	1.8	1.3	1.9	1.0
Complexity	3.11	2.02	2.00	2.12	3.06	3.02	1.98	2.05	3.04	2.84	2.19	1.75
Coils from Uniform Contours												
Num Contours	12	10	12	12	12	12	12	10	12	12	12	12
Max Field Error, %	4.00	4.35	4.71	5.88	7.16	7.84	4.68	5.41	6.88	6.02	6.33	6.61
Mean Field Error, %	0.92	0.99	0.98	1.07	1.42	1.05	0.87	1.08	1.30	1.11	1.13	1.69
Max Current Density, KA/cm2 for 2T@R(0,0)	35.83	27.20	25.97	40.50	54.10	42.00	18.00	17.80	34.90	25.50	51.70	19.30

Since li383 , ii379 and ii378 boundaries overlay, can one set of coils be found that works for all three?



Plasma boundaries with 18 cm Coil Surface
(li383_328, ii379_328 and ii378_218)

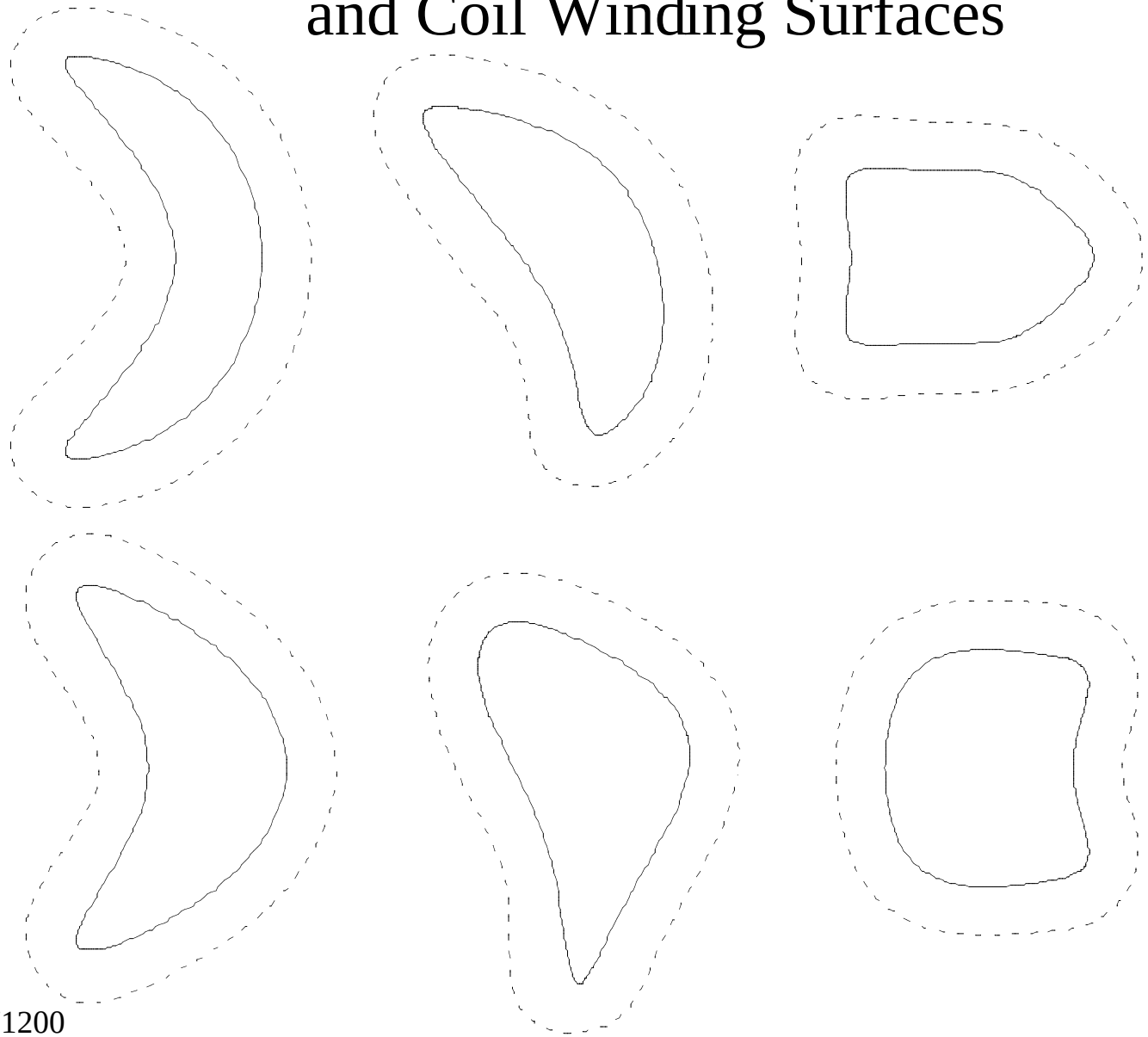
- Boundaries differ by ~ 10 cm. Current Sheet Solution for li383 using this surface resulted in current density increasing by a factor of 3

- Rather than try to reduce current density at this point (a time consuming process), the li383 screening coils were used to proceed with targeting Physics in free boundary optimizer

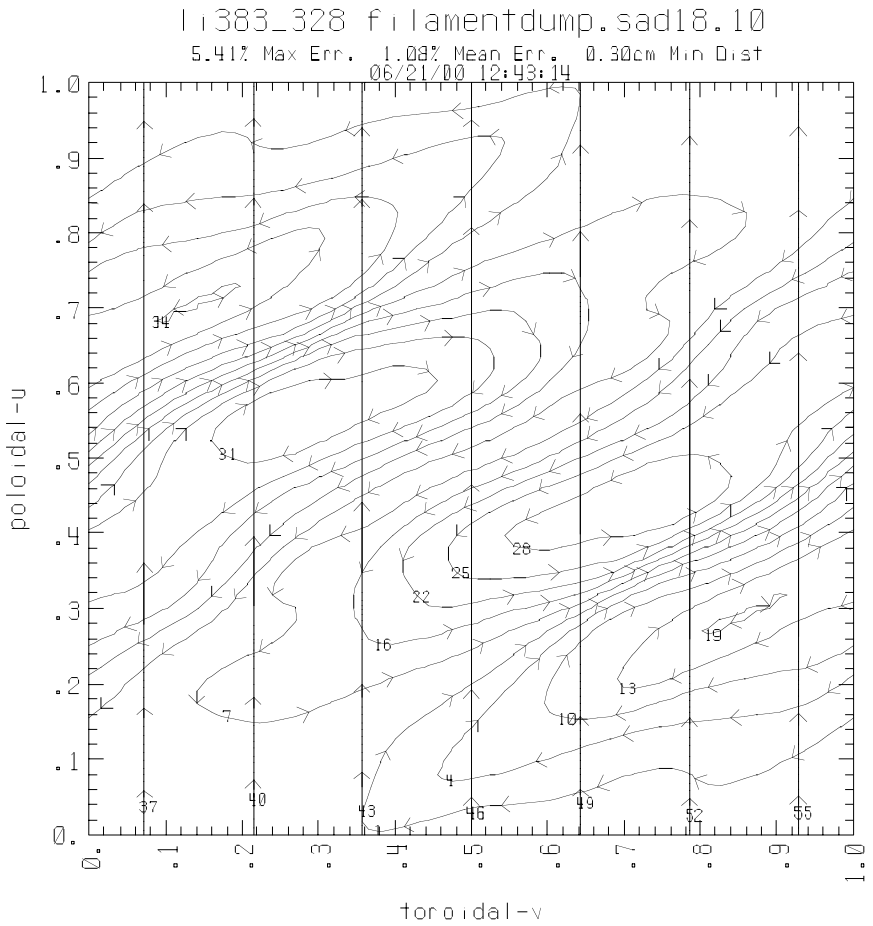
Comparison of Plasma Boundaries and Coil Winding Surfaces

Li383

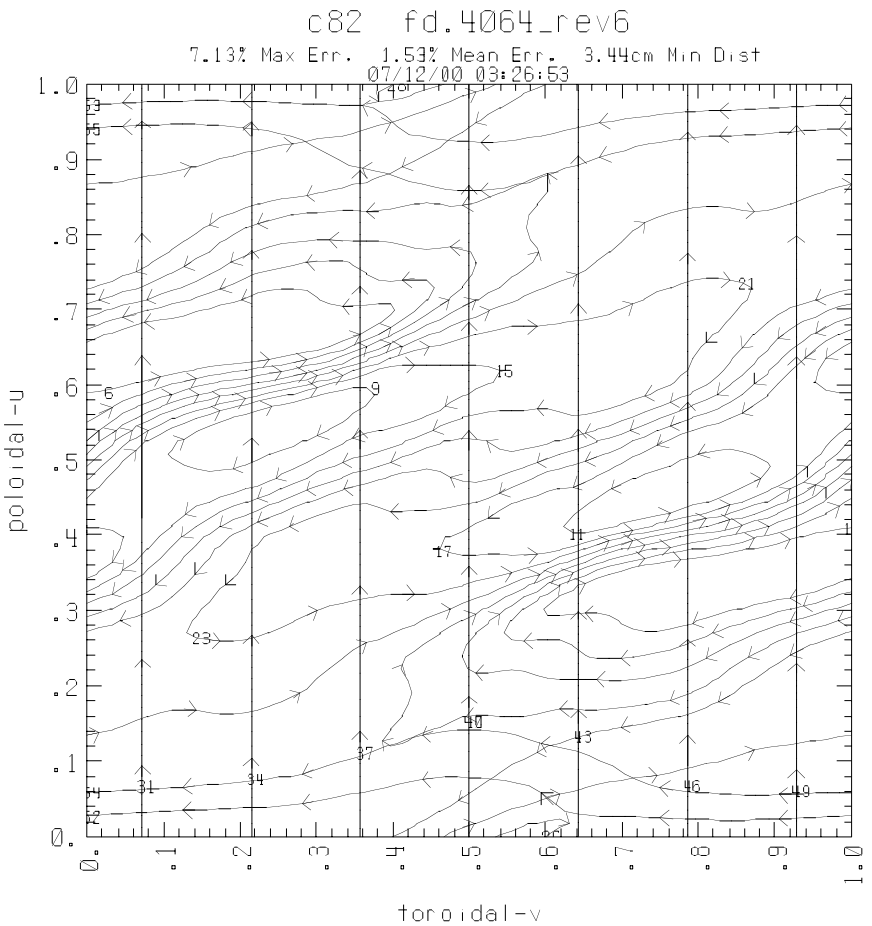
C82



Comparison of Coils in u-v space

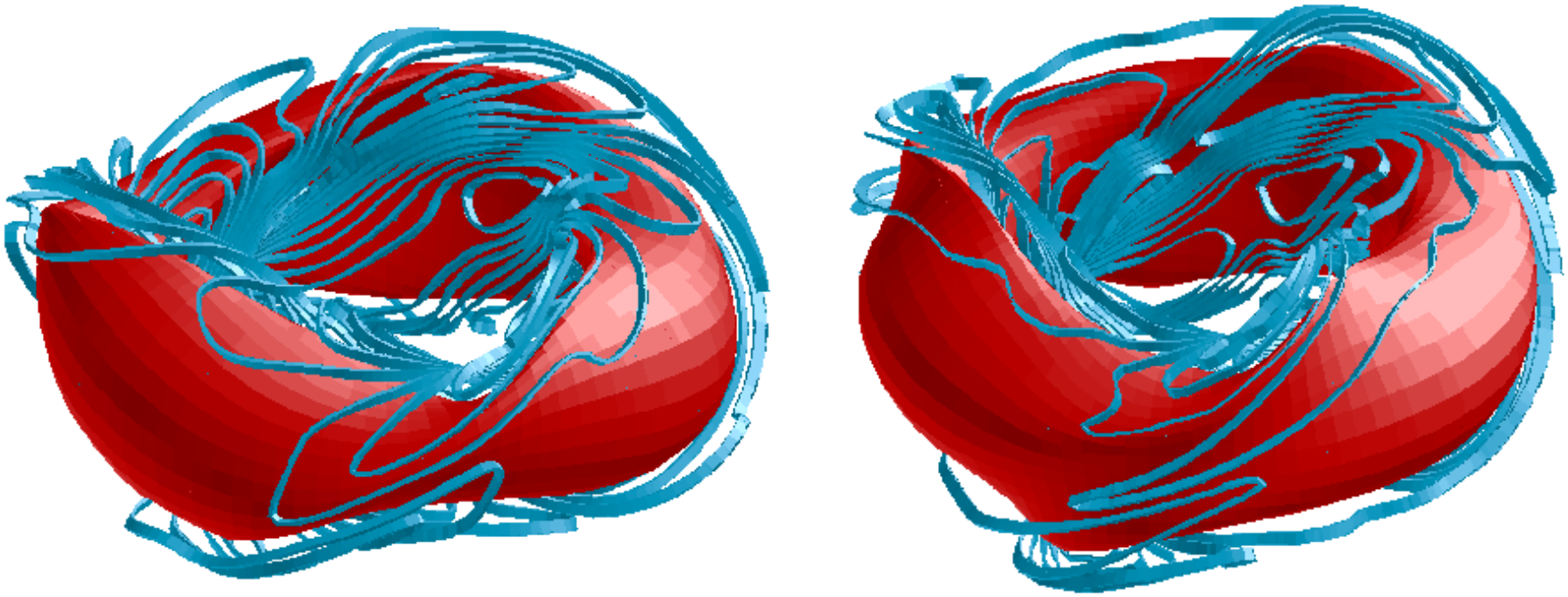


li383



c82

Comparison of Coils in real space



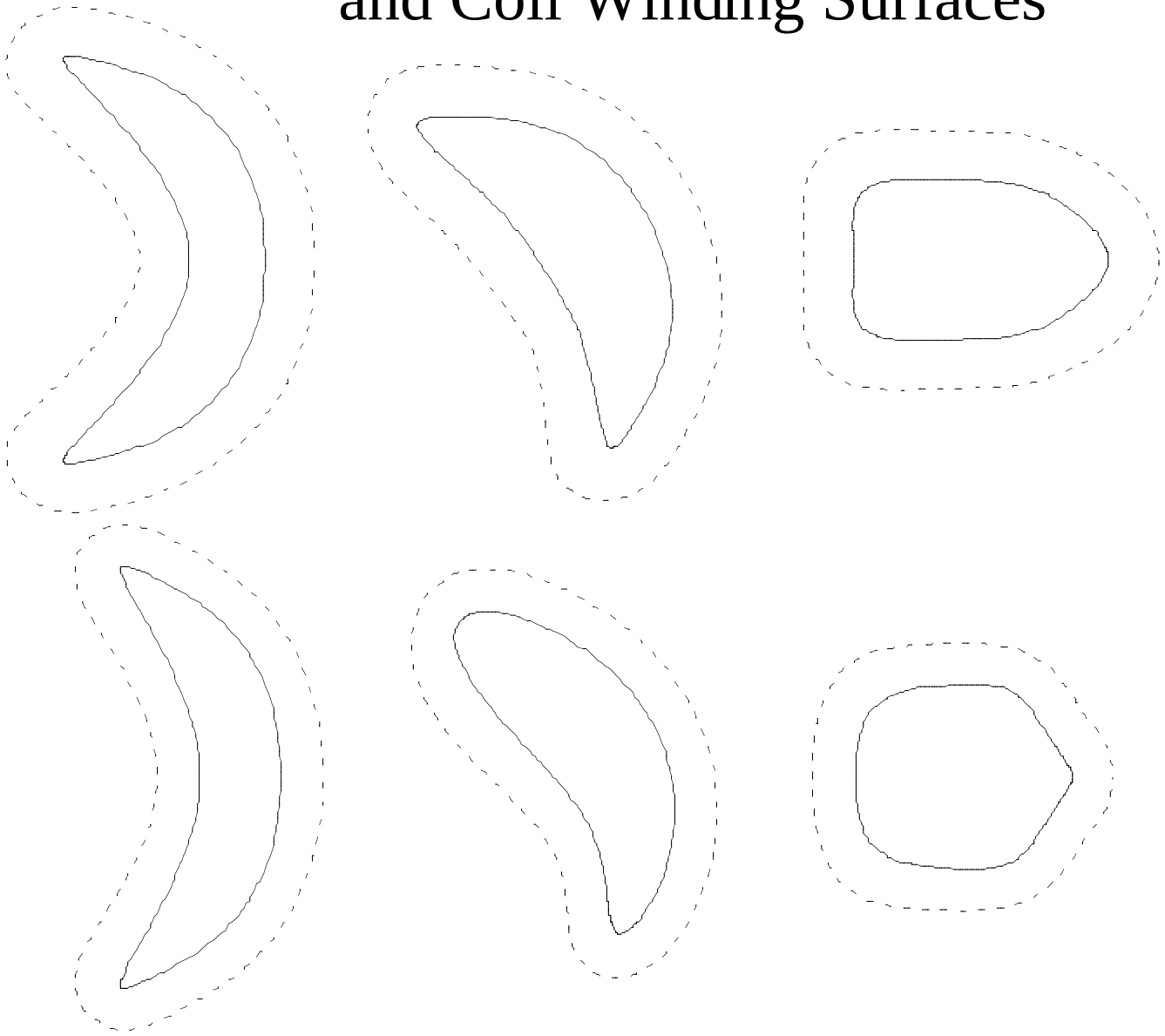
li383 c82

Shown without TF and PF Coils

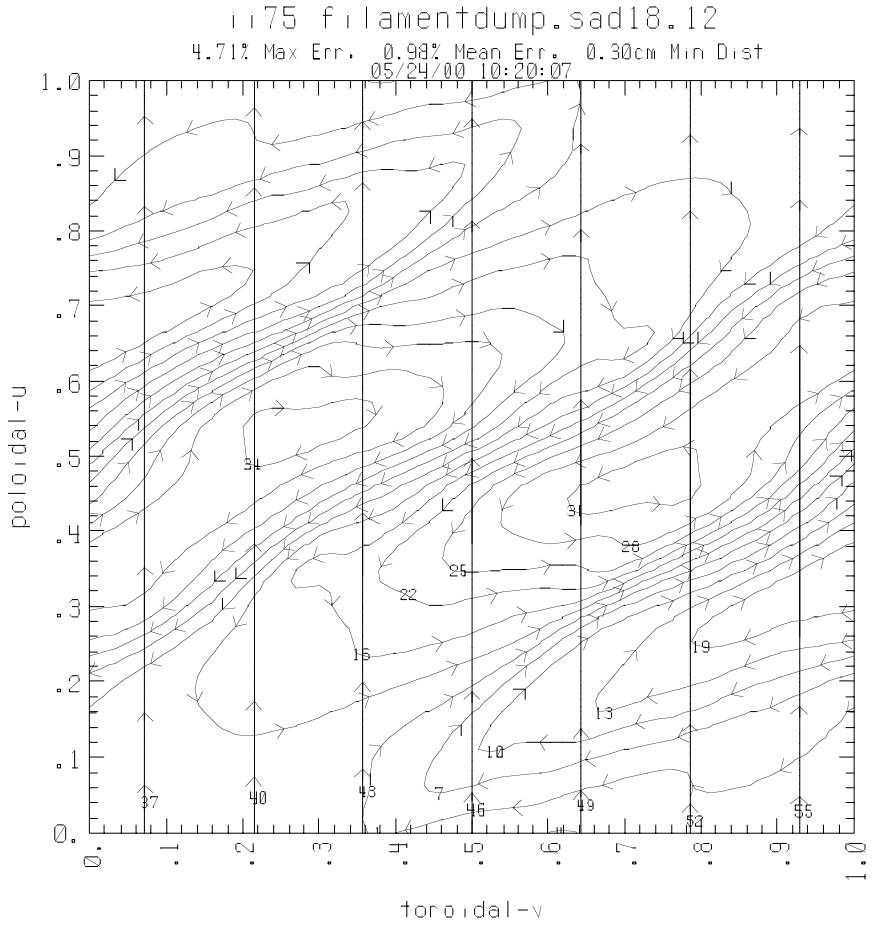
Comparison of Plasma Boundaries and Coil Winding Surfaces

ii75

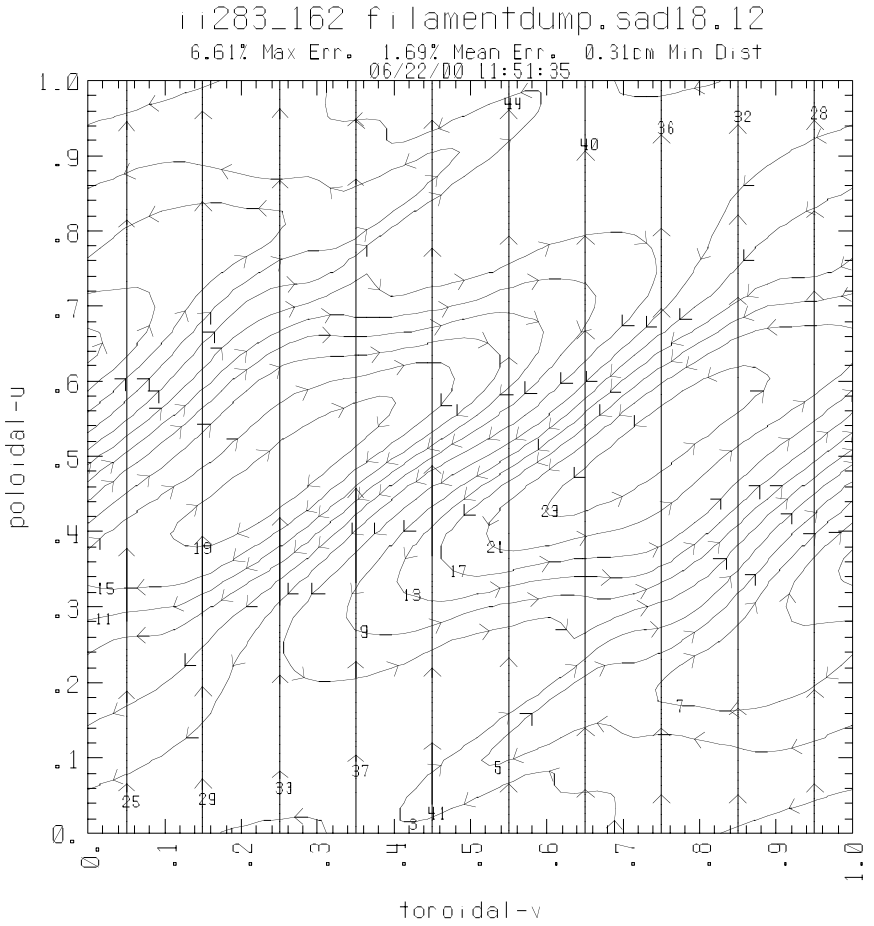
ii283



Comparison of Coils in u-v space



ii75



ii283

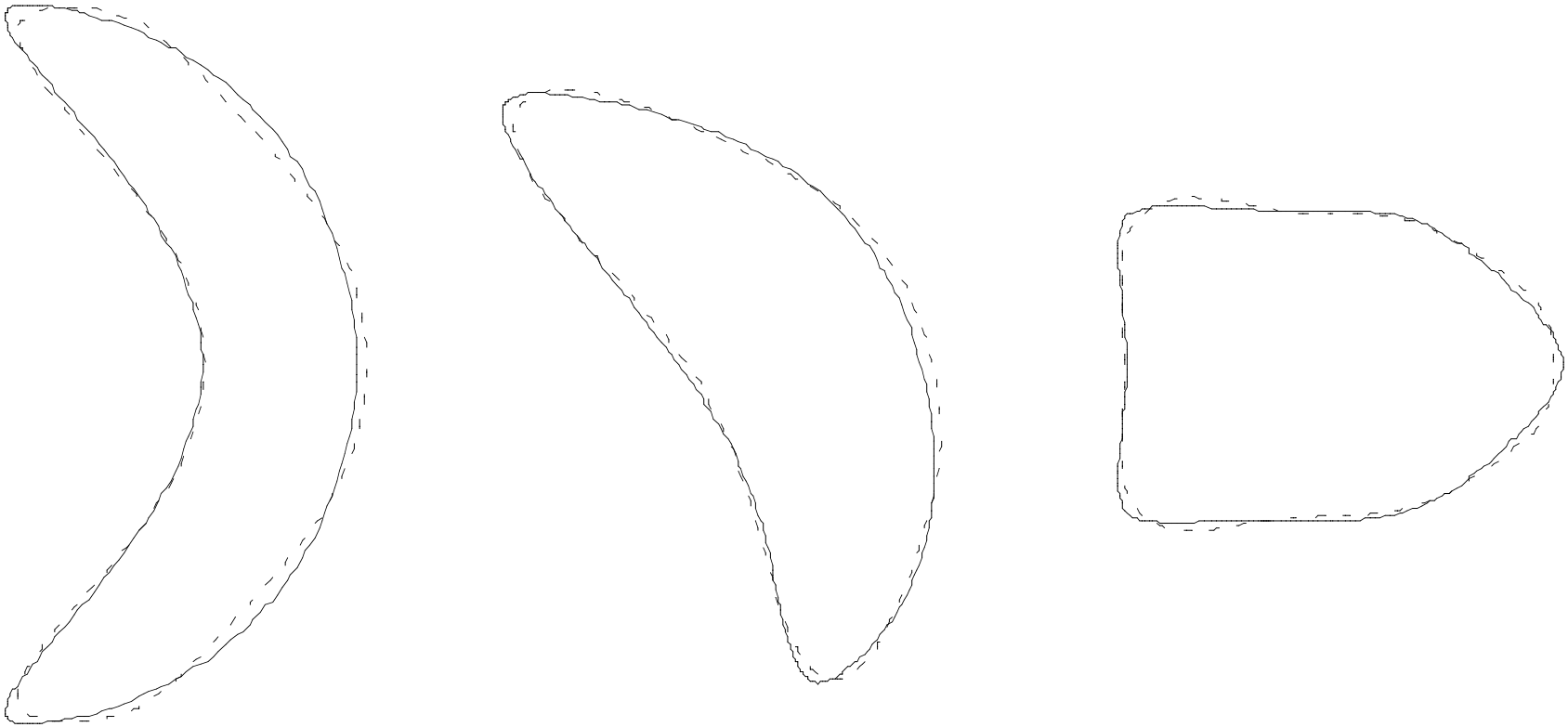
Free Boundary Reconstructions

- Reconstruction of Targeted Plasmas
- Improved reconstruction with Free boundary optimizer
  - Augment Coil Set with axisymmetric field from multipoles
- Target Higher Iota Plasmas with li383 coils

Summary of Plasma Reconstructions

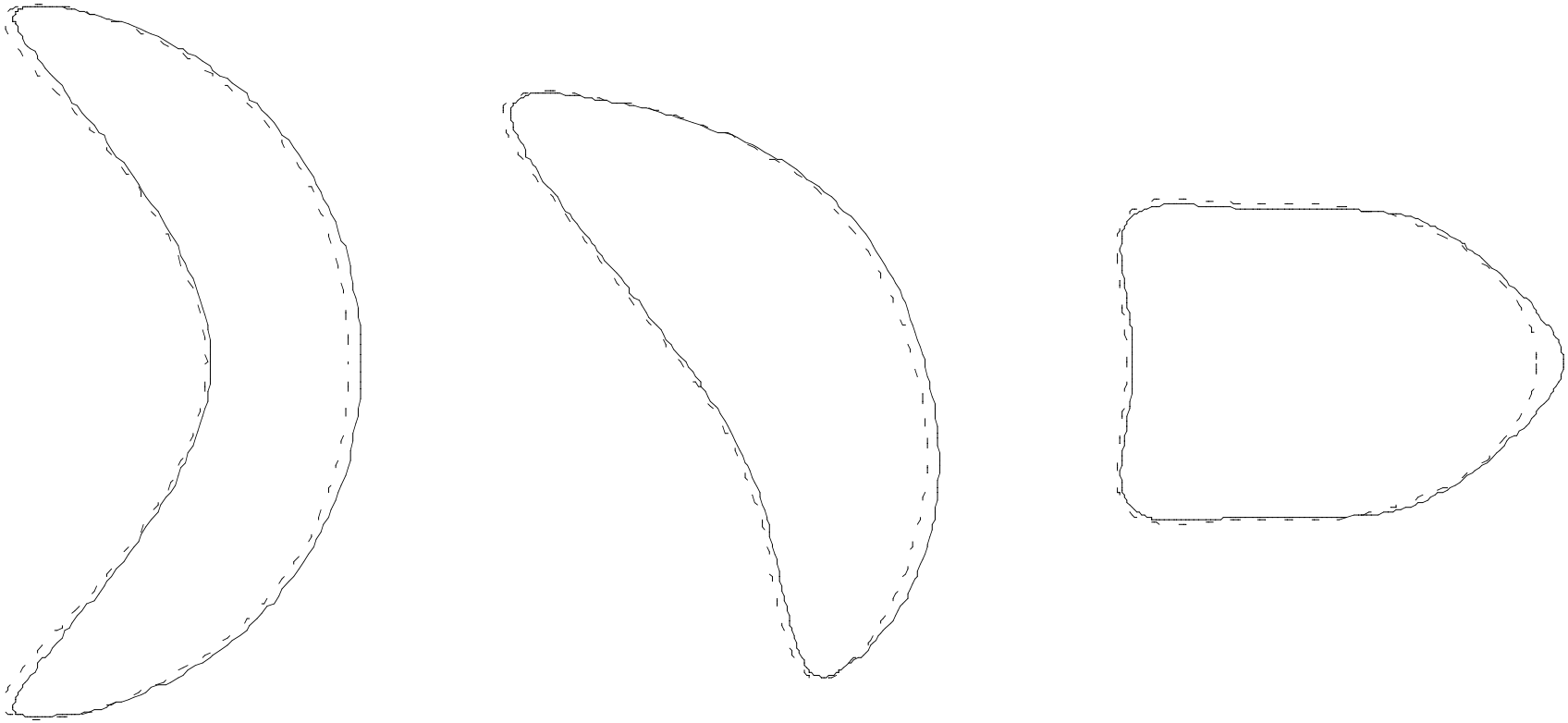
	iota			Kink	Bmn, Chi-Sq	Ballooning	Fix Boundary Overlay		Field Errors on Bndry		Coil Cur Dens
	s(0)	s(.5)	s(1)	Eigenvalue	free/fix	Unstable Range(s)	dmax, cm	dmean, cm	Bmax, %	Bmean, %	kA/cm2 @ 2T
li383_328											
Fixed Boundary	0.395	0.559	0.655	6.18E-06	1.00	<.94-.96>					
Saddles CS	0.405	0.560	0.656	7.56E-06	1.05	<.94-.96>	1.70	0.20	1.90	0.13	
Modulars	0.409	0.550	0.640	-2.17E-04	1.94	<.90-.96>	5.46	1.20	3.58	0.85	11.5
Modulars w/PF Opt	0.409	0.547	0.650	6.81E-06	1.56	<.94-.96>	3.02	0.79			
Saddles	0.355	0.557	0.636	-2.23E-04	1.84	<.75-.88,.94-.96>	3.65	1.03	5.41	1.08	17.8
Saddles w/PF Opt	0.370	0.557	0.640	-2.16E-04	1.84	<.75-.88,.94-.96>	3.50	1.00			17.8
Saddles at High Iota	0.448	0.642	0.748	5.26E-06	1.91	<.94-.98>	6.50	1.93			19.6
ii75_286											
Fixed Boundary	0.460	0.609	0.750	2.81E-06	1.00	Stable					
Modulars				Stable	1.21	<.65-.90>			3.68	0.67	20.6
Saddles	0.445	0.608	0.728	-1.22E-04	2.32	<.96>	4.57	0.73	4.71	0.98	26.0
ii283_162											
Fixed Boundary	0.257	0.389	0.465								
Modulars									7.40	0.93	
Saddles									6.61	1.69	19.3
c82											
Fixed Boundary	0.260	0.338	0.468								
Modulars	0.263	0.327	0.452	-1.06E-03	-82.89		3.98	0.90	6.44	1.13	14.6
Saddles	0.253	0.347	0.489				4.37	1.16	7.13	1.53	27.0

Saddles for Li383_328



Overlay of Fix and Free Boundary Reconstructions

Modulars for Li383_328



Overlay of Fix and Free Boundary Reconstructions

Summary

- Coil Designs for li383 (both Saddles and Modulars) are simpler and require lower current densities than comparable c82 designs.
- Coils show promise of reaching higher iota profiles without large increases in current density or large changes to winding surface.
  - Demonstrated with saddles
  - Probably true of modulars with additional TF. Need to verify
- More effort required to show configurations can be stabilized (particularly saddles at medium iota)
- Need to evaluate surface quality with PIES