NCSX
Coil Concepts and Tools

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Coil Design: Interface Between Physics and Engineering

- Responsibilities of Coil Group
  - Develop coils based on plasma boundaries supplied by physics optimization
  - Analyze “quality” of reconstructed plasma
  - Interact with engineering to ascertain construction feasibility of coils
  - Continue development of computational tools to support above goals

Coil Methodology Has Emerged

- Fast calculation of **current sheet** solution
  - Scoping analysis of current density and coil complexity (almost always reconstructs! therefore yields no recon info for finite coils)
  - Target B_{norm} or X_{norm} (displacement, island width for resonant perturbations…)

Coil Methodology (cont'd)

- Extraction of **finite coils**
  - Efficient, robust contouring algorithm using equi-spaced current potential levels
  - Improved contouring based on nonuniform, ('optimal') selection of levels: => promise of fewer coils, lower current density at fixed level of normal field (or displacement) error

Coil Methodology (cont'd)

- Plasma reconstruction
  - Use finite coils to reconstruct free boundary plasma
  - Correlate χ^2 physics error with surface reconstruction (quantifies "goodness" of fit)

Current Sheet Comparison for C10 Physics Genealogy

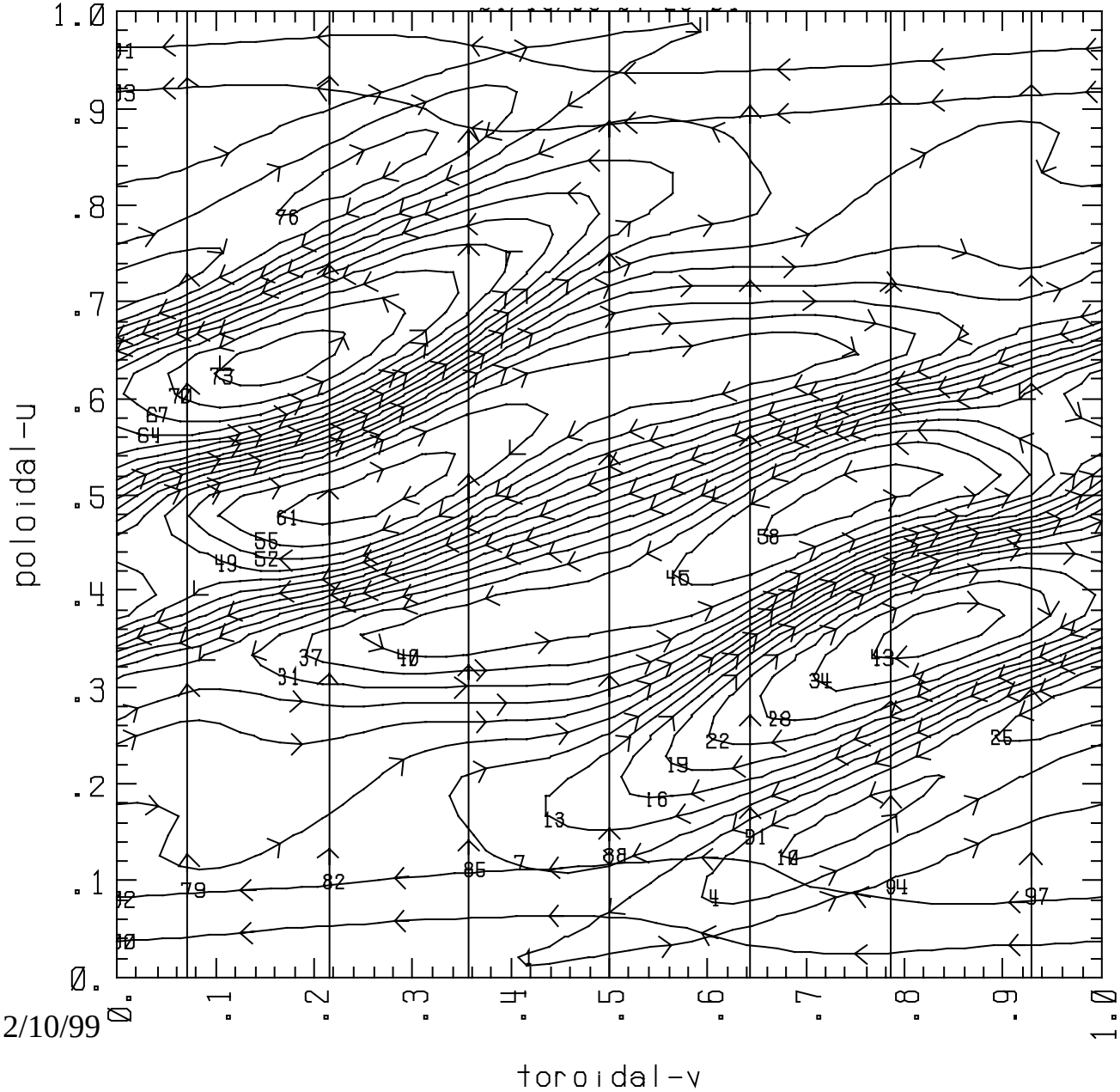
Comparison of Current Sheet Solution for Saddles on a 18 cm surface offset						
(Finite Beta with No Background Vertical Field)						
Plasma ID	cc1a	c10a	c76a	c86a	i55b	i63b
Description	c10a without edge shear	Fits in PBX (A=3.42)	kink stabilized c10a	QA Improved c76a	New Machine (A=2.75)	kink stabilized i55
Current Sheet						
Max Err, %	1.93	1.72	2.03	2.23	4.69	5.19
Mean Err, %	0.07	0.11	0.18	0.18	0.60	0.61
J max/Ipol	0.70	0.85	1.13	1.05	1.49	1.45
Ipol	2.73	2.75	2.76	2.76	2.82	2.92
J max, MA/m	**1.90**	**2.35**	**3.12**	**2.91**	**4.20**	**4.24**
Complexity	2.85	2.91	3.10	3.09	3.36	3.22

Conclusion of Current Sheet Scan for C10

- Edge shear
  - **raises** J_{max} and increases coil complexity
- Lower *A* (i55a, i63b)
  - yields **largest** J_{max} and most complex coils
- Kink stabilization
  - **raises** J_{max} *and* coil complexity for $A = 3.42$ (c10a); not much change at lower *A* (which is already large and complex)

Discrete Saddle Coils for C10a: 16 contours

18 cm winding surface, 2.7% max error



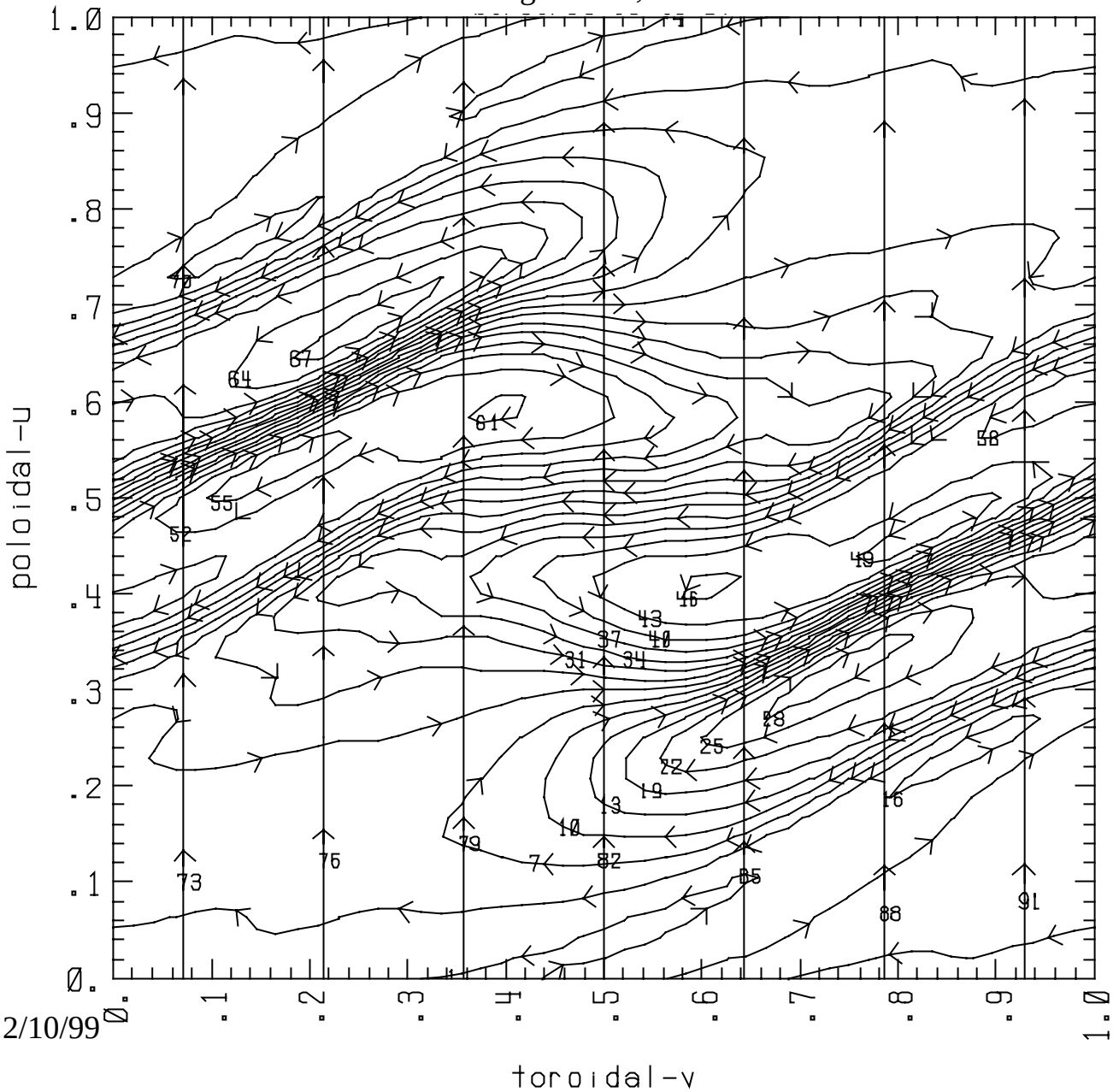
VF coils

Inboard

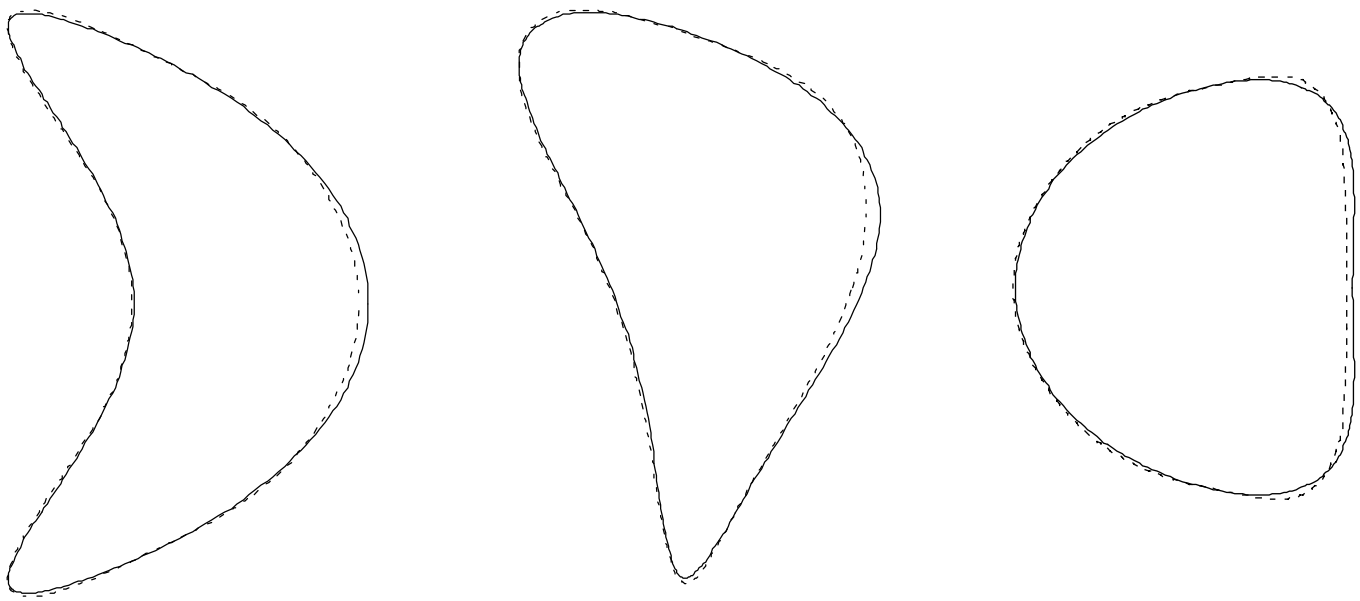
Outboard

Discrete Saddle Coils for I55b: 16 contours

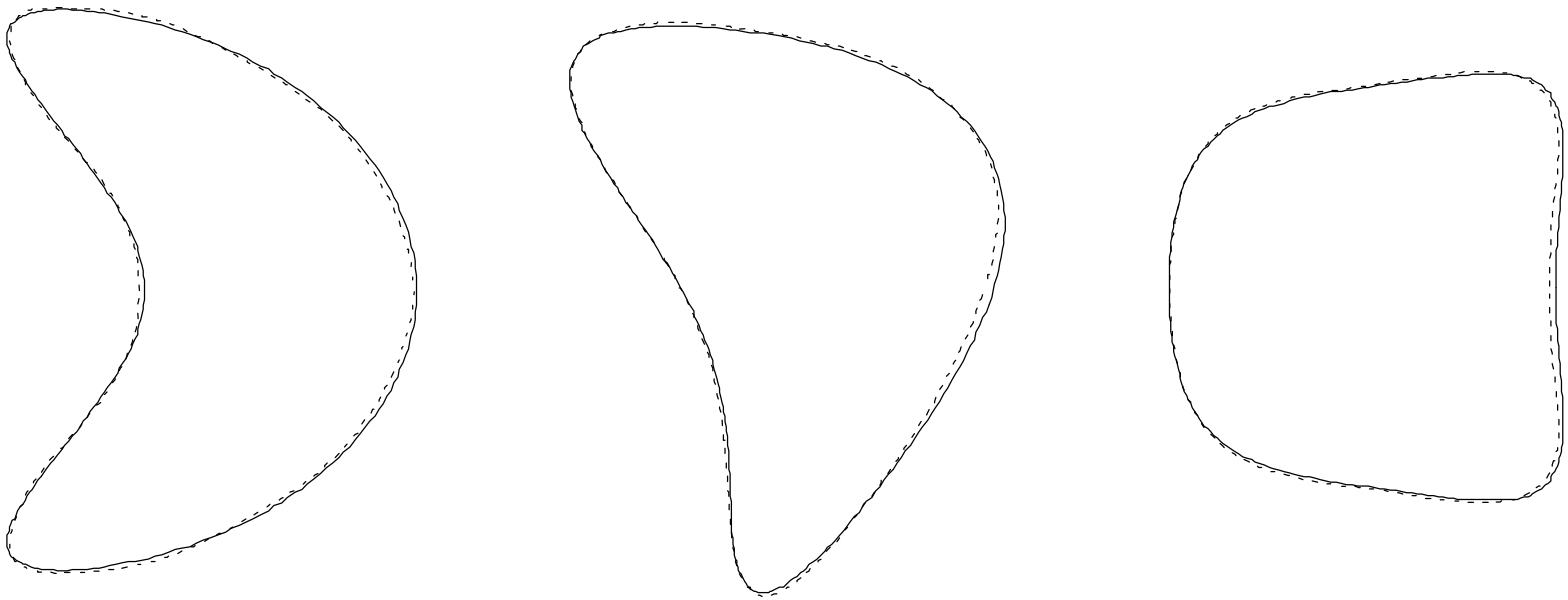
18 cm winding surface, 5.2% max error



Reconstruction of C10a
(N = 16 contours)



Reconstruction of i55
(N = 16 contours)

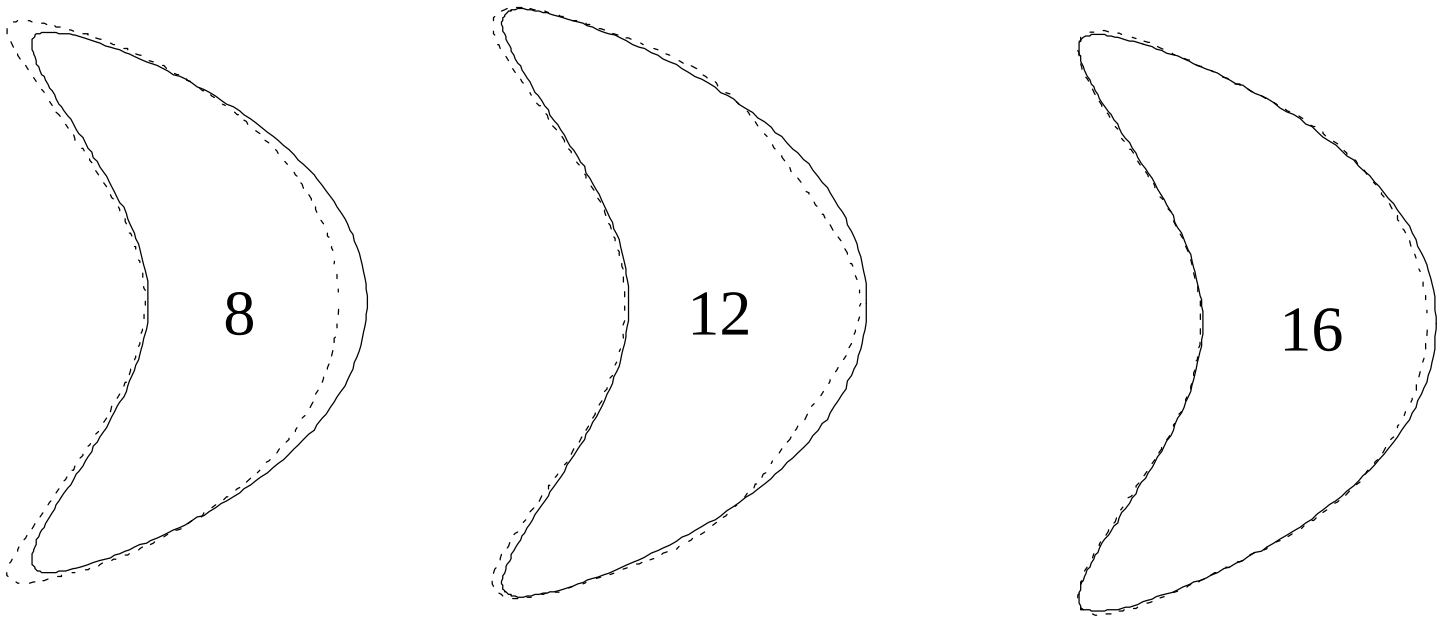


Number of Coils Scan for C10a: “Sweet Spot” at 13 coils/half period

Coils on 18 cm Coil Surface Offset						
#Contours	#Coils per	Max Err	Mean Err	Min Dist	Coil Current	<M>
	Half Period	%	%	cm	KA	surface complexity
current sheet	-	*1.70*	*0.11*	*jmax=2.963 MA/m*		*coil complexity=3.05*
8	7	4.38	1.10	4.24	91.22	2.548
10	9	4.02	0.90	3.35	72.97	2.860
12	10	3.69	0.77	2.74	60.81	3.192
14	12	3.09	0.70	2.29	52.12	2.483
16	**13**	**2.74**	**0.58**	**2.27**	**45.61**	**2.301**
18	15	2.50	0.50	1.87	40.54	2.317
20	17	2.25	0.49	1.57	36.49	2.349

C10a Reconstruction Status:

Transport Physics Targets are *Preserved* **only** when $N_{Contours} \geq 16$



Coil Code Developments

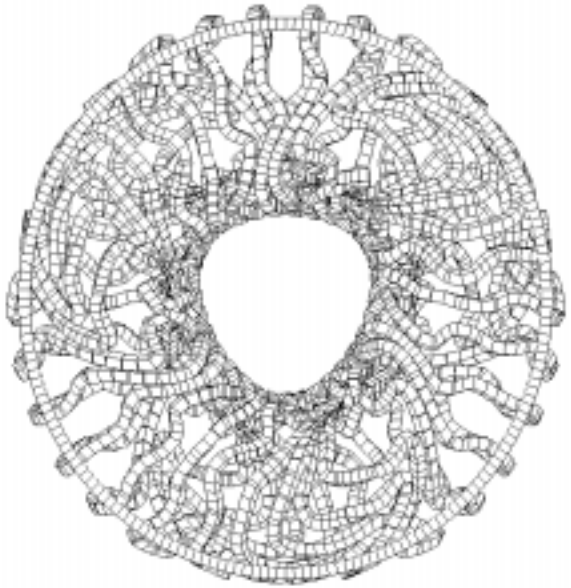
- Promising "research" work to improve coils
  - SVD smoothing produces reasonable coils at "reactor relevant" separations (40 cm.) However, j_{max} (and B_{coil}/B_0?) high
  - Targeting displacement has improved reconstruction at $N_{coils} = 8$. Inconsistent dependence of reconstruction with X_{error} needs to be understood

Code Developments (cont'd)

- Advanced coil extraction may reduce number coils and thereby j_{max}
- Extraction code useful for fixing coils, varying currents to study β, I_p start-up scenarios
- *PIES* "field-evaluation" mode runs useful in gaining insight into magnetic island, stochasticity mitigation (extend island suppression *into* plasma)
- *ONSET* - smoother coils, lower j_{max}

Onset Improvements to Modular C10a Case (M. Drevlak)

Original coils



Post-Onset coils

(same B-error)