Modular Coil Design Improvements

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- Look at variations on present 0907, 1017 modular coils
- Impact of background 1/R field in modular optimization
- Goal is to improve $I_{mod}/?_{cc,min}$ ($\sim J_{mod,max}$), for comparable field error

Model

- Specify a set of I_{TF} values for fixed I_{pol}
  - maintain $I_{TF} + ? I_{mod} = 3I_{pol}$
- Vary winding surface, modular coils and currents I_{mod}
- Include penalty functions for $?_{cc} = ?_{cc,min} / I_{mod}$, and $?_{min}$, e.g.,

$$p(?_{cc}) = w\, e^{-? ?cc}$$

Reference modular coils

- Reference 1017 is a continuation of modular solution 0907 with coils 3 and 4 extended in R on the outboard side for NBI access
- For $I_{TF} = 0$, try varying modular coil currents in optimization

ID #	$N_?$	N_{WS}	I_{mod} (kA)	$?B_{avg}$ (%)	$?B_{max}$ (%)	$?_{cc,min}$ (cm)	$?_{min}$ (cm)	$?_{cp,min}$ (cm)
1017	10	30	-488	0.61	2.61	14.8	12.3	23.3
0105	10	40	I_1 = -469.7, I_2 = -485.2, I_3 = -494.5, I_4 = -517.8	0.55	2.85	14.3	11.1	23.0

Include fixed 1/R field in modular optimization

- Consider $I_{TF}/ I_{mod} < 0$
- Continue 0907 with modified penalty functions, variable modular currents
- Try to improve $J = ?_{cc,min}/I_{mod,max}$

ID #	I_{TF} (kA)	I_{mod} (kA)	$?B_{avg}$ (%)	$?B_{max}$ (%)	$?_{cc,min}$ (cm) J(kA/cm)	$?_{min}$ (cm)	$?_{cp,min}$ (cm)
0907	0	-488	0.57	2.55	13.4 (36.4)	11.0	23.2
0122a3	2400*	-600.3, -605.6, -602.8, -599.3	0.63	2.86	19.5 (31.1)	12.4	23.4
0122a2	1500**	-559.3, -563.4, -559.2, -552.8	0.54	2.28	19.4 (29.0)	12.7	22.8

* $I_{TF}/3I_{pol} = 0.23$, ** $I_{TF}/3I_{pol} = 0.15$

Include fixed 1/R field in modular optimization

•Consider $I_{TF}/ I_{mod} > 0$

ID #	I_{TF} (kA)	I_{mod} (kA)	$?B_{avg}$ (%)	$?B_{max}$ (%)	$?_{cc,min}$ (cm) J(kA/cm)	$?_{min}$ (cm)	$?_{cp,min}$ (cm)
0907	0	-488	0.57	2.55	13.4 (36.4)	11.0	23.2
0118b2	-2400	-383.1, -376.4, -379.2, -339.4	0.60	2.77	15.1 (25.3)	10.7	19.9
0124a1	-1500	-420.6, -421.7, -417.1, -397.8	0.51	2.33	15.9 (26.5)	10.2	21.4
0126a1	-1350	-425.3, -428.8, -425.9, -406.8	0.50	2.30	16.2 (26.5)	10.2	21.5
0126a2	-1650	-412.5, -414.3, -411.9, -389.5	0.51	2.30	15.5 (26.7)	9.8	21.3

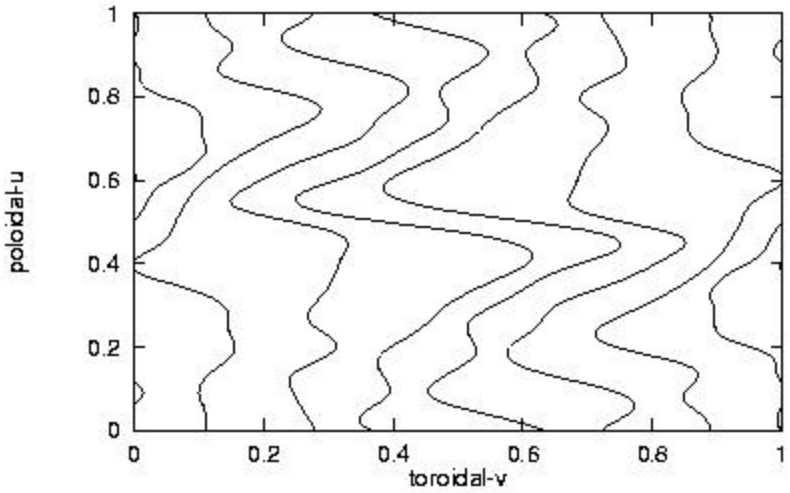
Extend modular coils 3 and 4 for NBI access

•Continue cases 0122a2 ($I_{TF}/I_{mod} < 0$) and 0124a1 ($I_{TF}/I_{mod} > 0$)

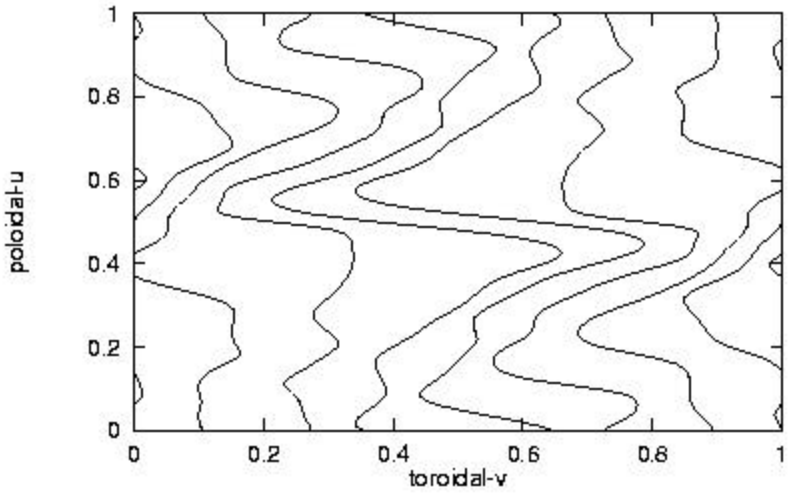
ID #	I_{TF} (kA)	I_{mod} (kA)	?B_{avg} (%)	?B_{max} (%)	? $_{cc,min}$ (cm) J(kA/cm)	L_1, L_{avg} (m)	? $_{min}$ (cm)	? $_{cp,min}$ (cm)
0105	0	-469.7, -485.2, -494.5, -517.8	0.55	2.85	14.3 (36.2)	7.38, 8.01	11.1	23.0
0123a1	1500	-546.1, -552.5, -567.6, -584.3	0.60	2.24	19.8 (29.5)	7.39, 8.03	12.4	22.5
0125a1	-1500	-407.0, -412.7, -432.3, -412.6	0.53	2.68	15.7 (27.5)	7.59, 8.10	9.3	21.4

Effect of background 1/R field on toroidal variation of modulars for cases with coils 3 and 4 extended in radius

0123a1 ($I_{TF}/I_{mod} < 0$)



0125a1 ($I_{TF}/I_{mod} > 0$)



Summary

- Improvements in modular coil current density and field errors are possible by prescribing a 1/R background field in modular optimization.
- Next – find the optimal 1/R field.