Plasma Reconstructions for Coil Topology Study

NCSX Project Meeting

May 16-17, 2000

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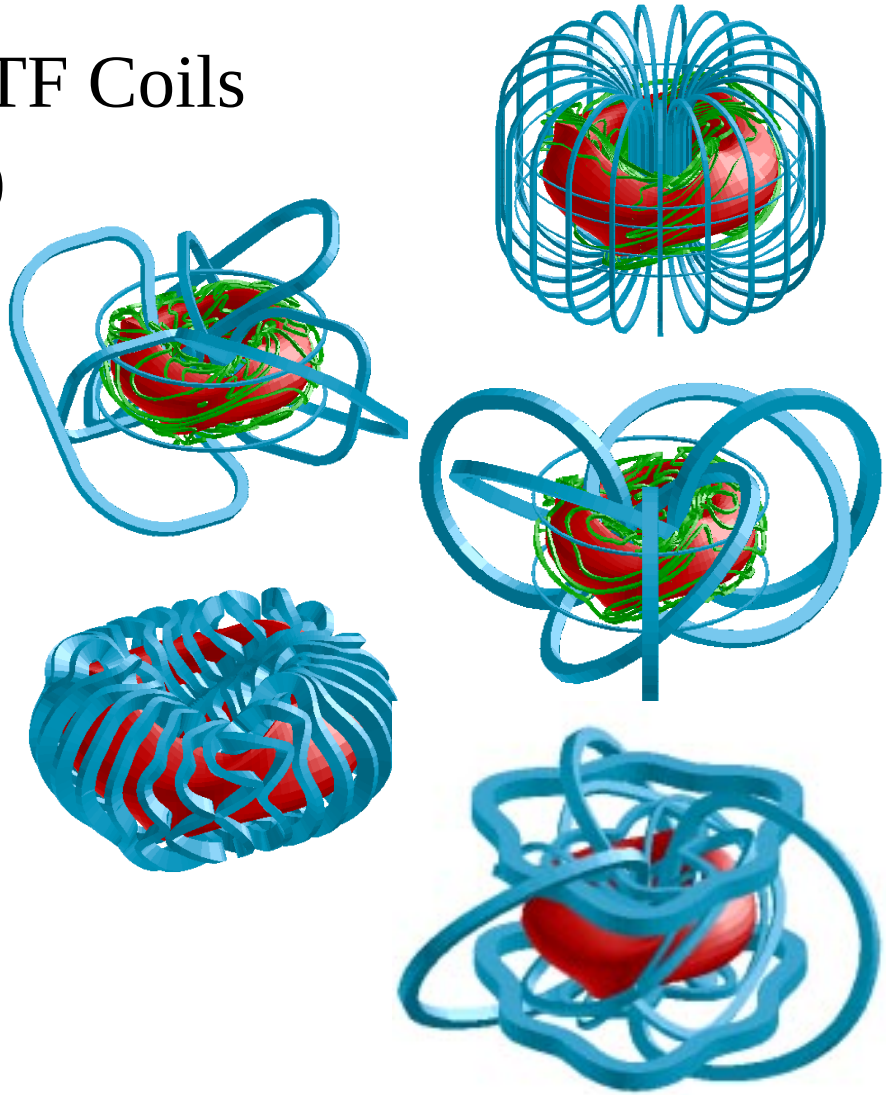
Introduction

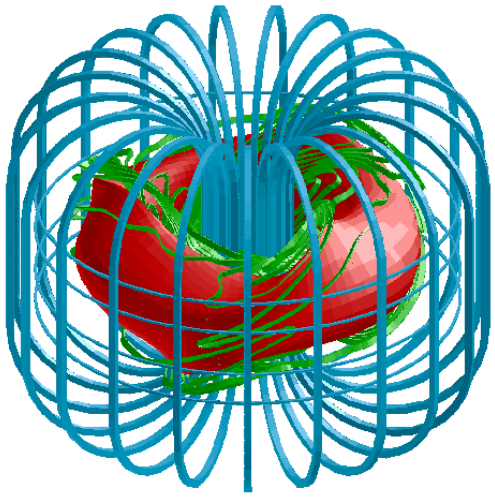
- The Coil Topology Study has produced a number of distinct Coil or Machine Options targeting the c82 fixed boundary plasma
- Coils were generated using various approaches discussed at previous meetings
  - Nescoil/SVD, GA
  - Coilopt
  - Background Coil Optimizer (tiltopt)
- Plasma Reconstructions compared here for each

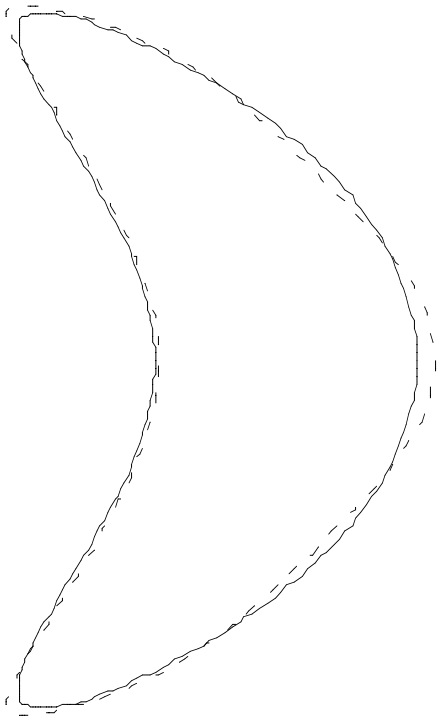
Coil Topology Study - Candidate Coils

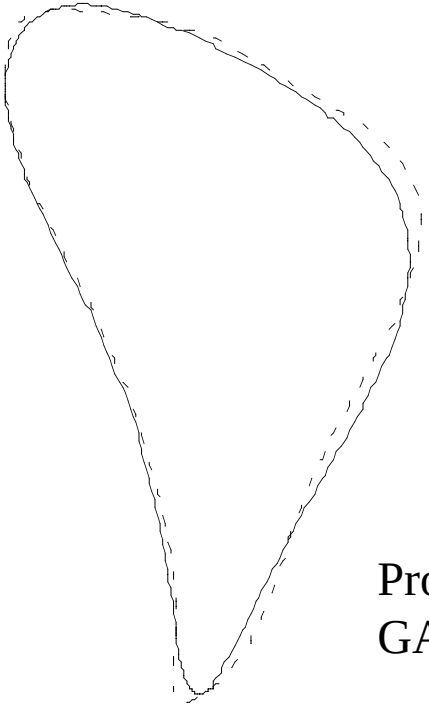
- Saddle coils with PBX TF Coils
  - 4064_rev6 (4064_rev7)
- Tilted TF Coils
  - Case536.3
- L = 3 Coils
  - Case619.4
- Modular Coils
  - Strickler's 0424a1
- No Conformal Coil
  - Case564

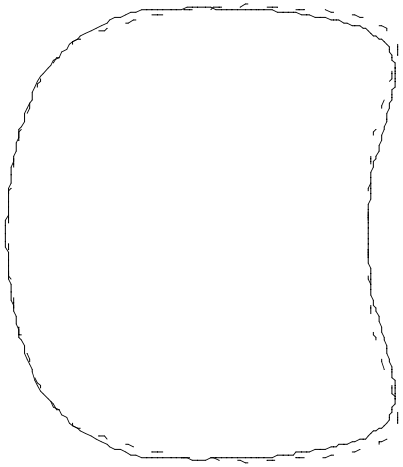


Reusing PBX TF Coils w/Saddles 4064_rev6



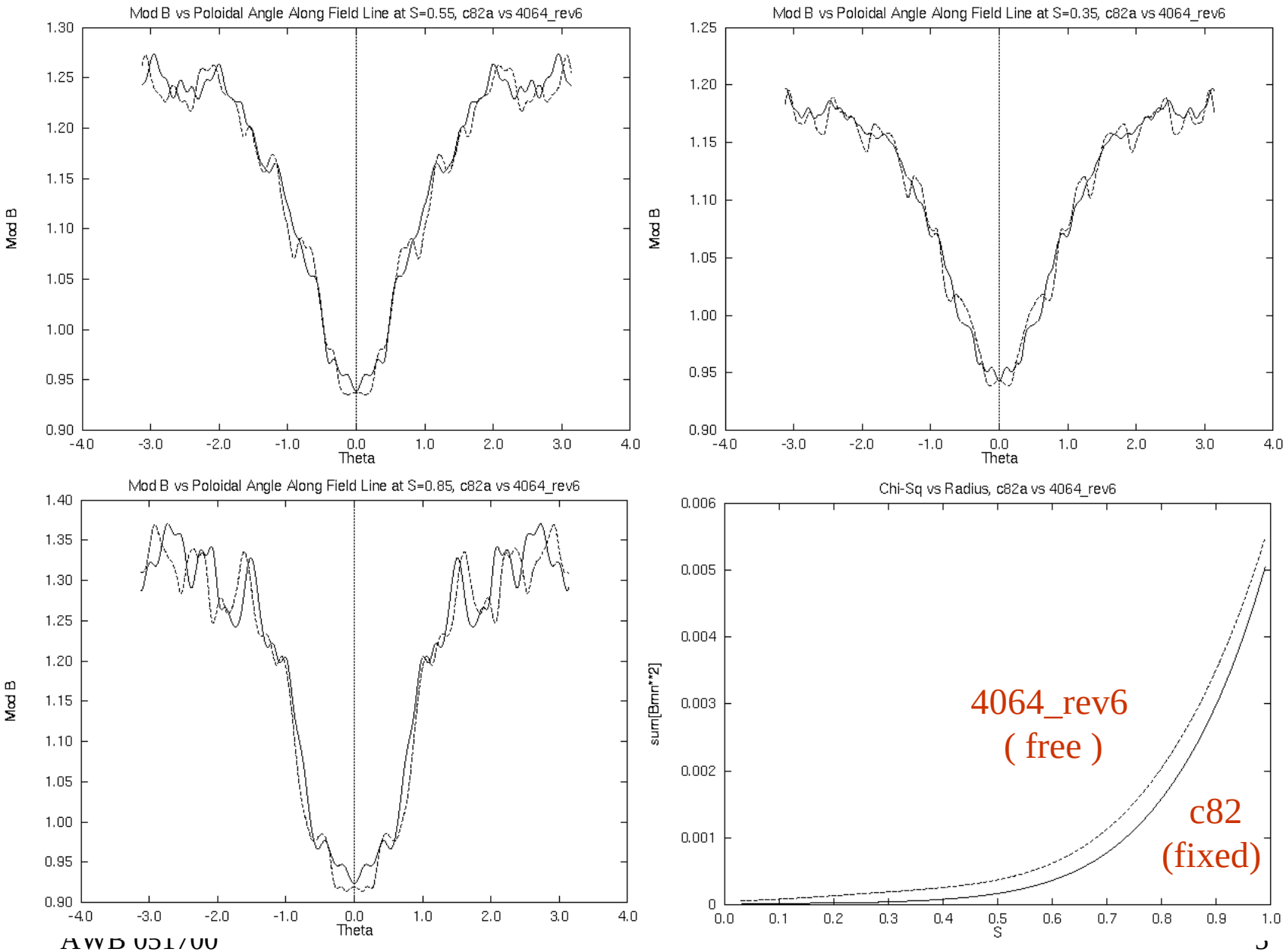




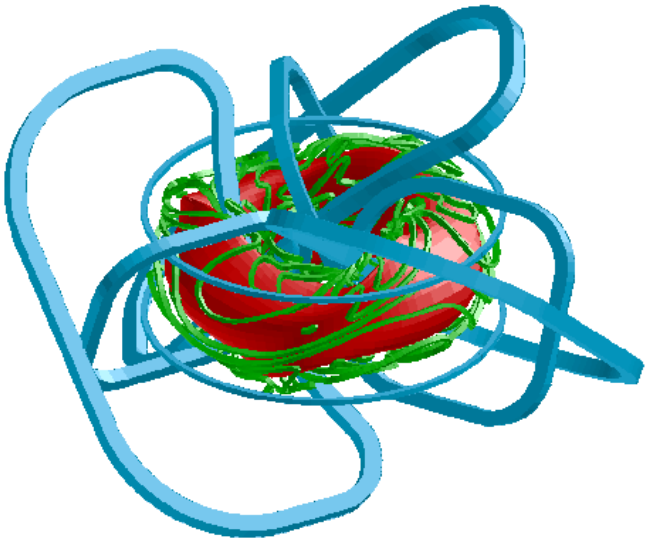


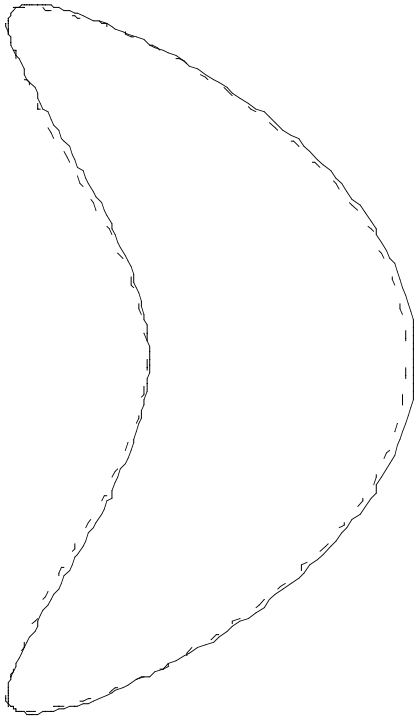
Produced by NESVD (Prashant) & GA (Buff)

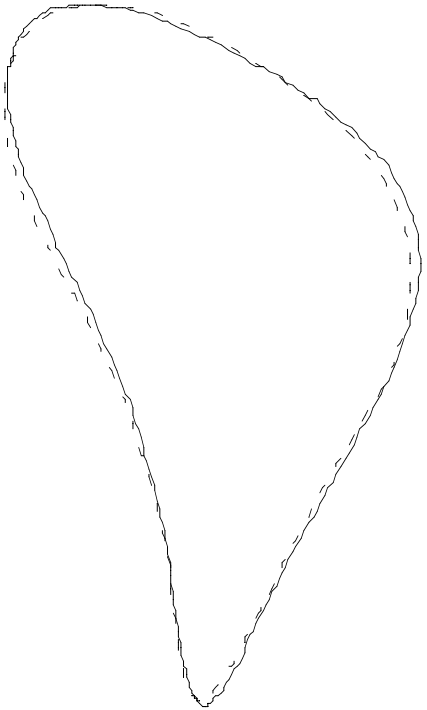
Coil Currents tweeked by Neil to improve physics

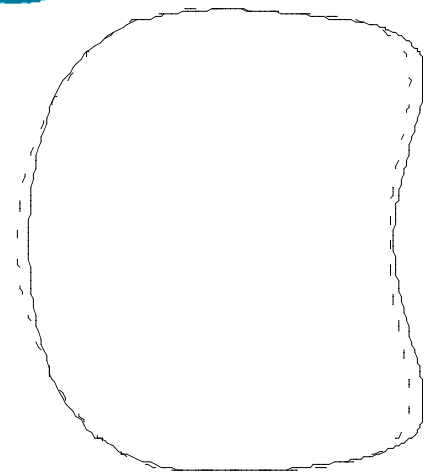

Mod B vs Poloidal Angle Along Field Line at S=0.55, c82a vs 4064_rev6
Mod B
Theta
Mod B vs Poloidal Angle Along Field Line at S=0.35, c82a vs 4064_rev6
Mod B
Theta
Mod B vs Poloidal Angle Along Field Line at S=0.85, c82a vs 4064_rev6
Mod B
Theta
Chi-Sq vs Radius, c82a vs 4064_rev6
sum[Bmn**2]
S
4064_rev6
(free)
c82
(fixed)

Tilted TF Coils
Case 536.3r1

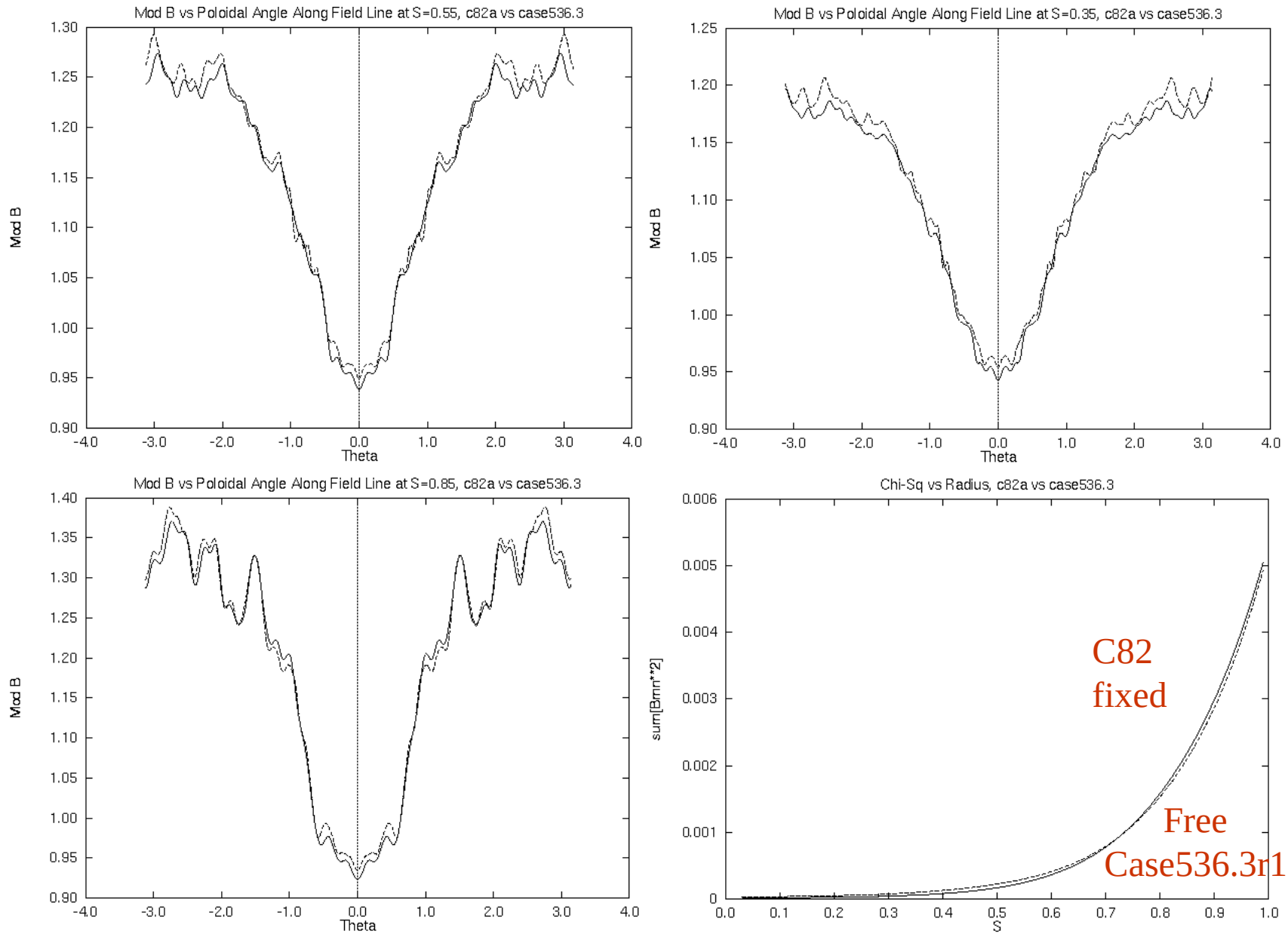




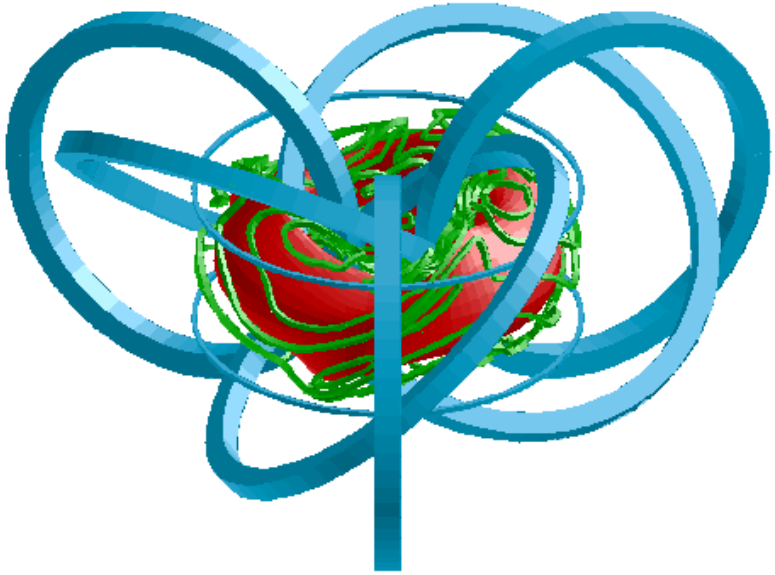


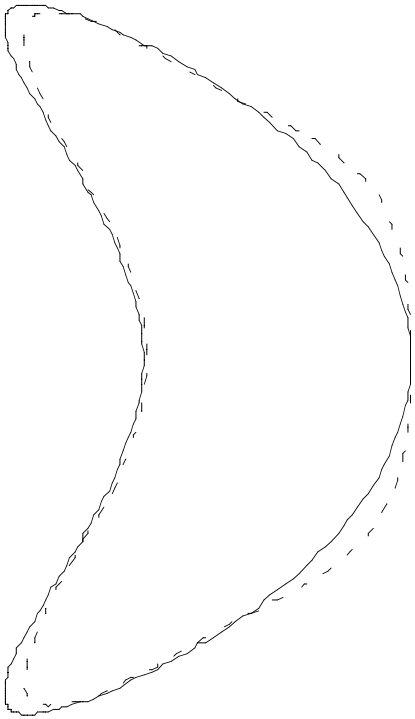


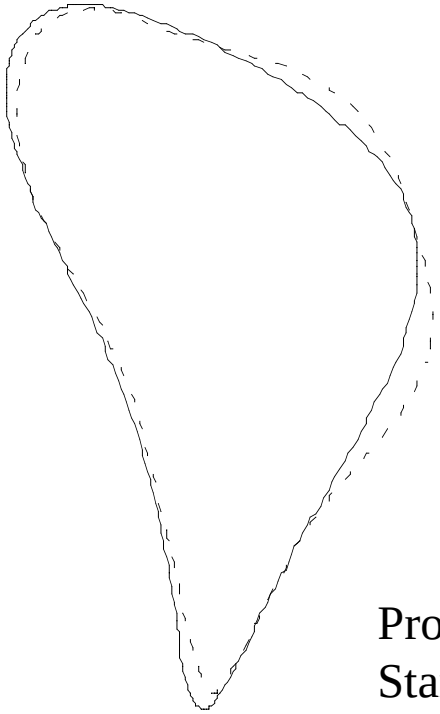
Produced by Tiltopt using Standard NESCOIL and uniform coil contours

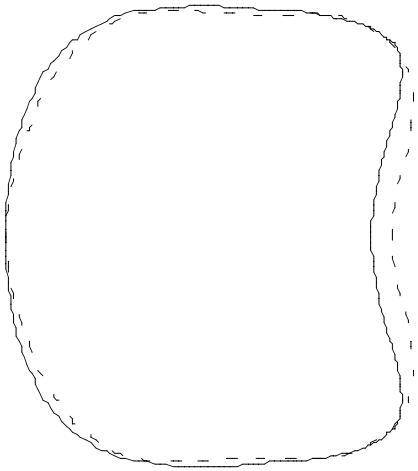

Mod B vs Poloidal Angle Along Field Line at S=0.55, c82a vs case536.3
Mod B
Theta
Mod B vs Poloidal Angle Along Field Line at S=0.35, c82a vs case536.3
Mod B
Theta
Mod B vs Poloidal Angle Along Field Line at S=0.85, c82a vs case536.3
Mod B
Theta
Chi-Sq vs Radius, c82a vs case536.3
sum[Bmn**2]
S
C82
fixed
Free
Case536.3r1

L = 3 Coils
Case 619.4









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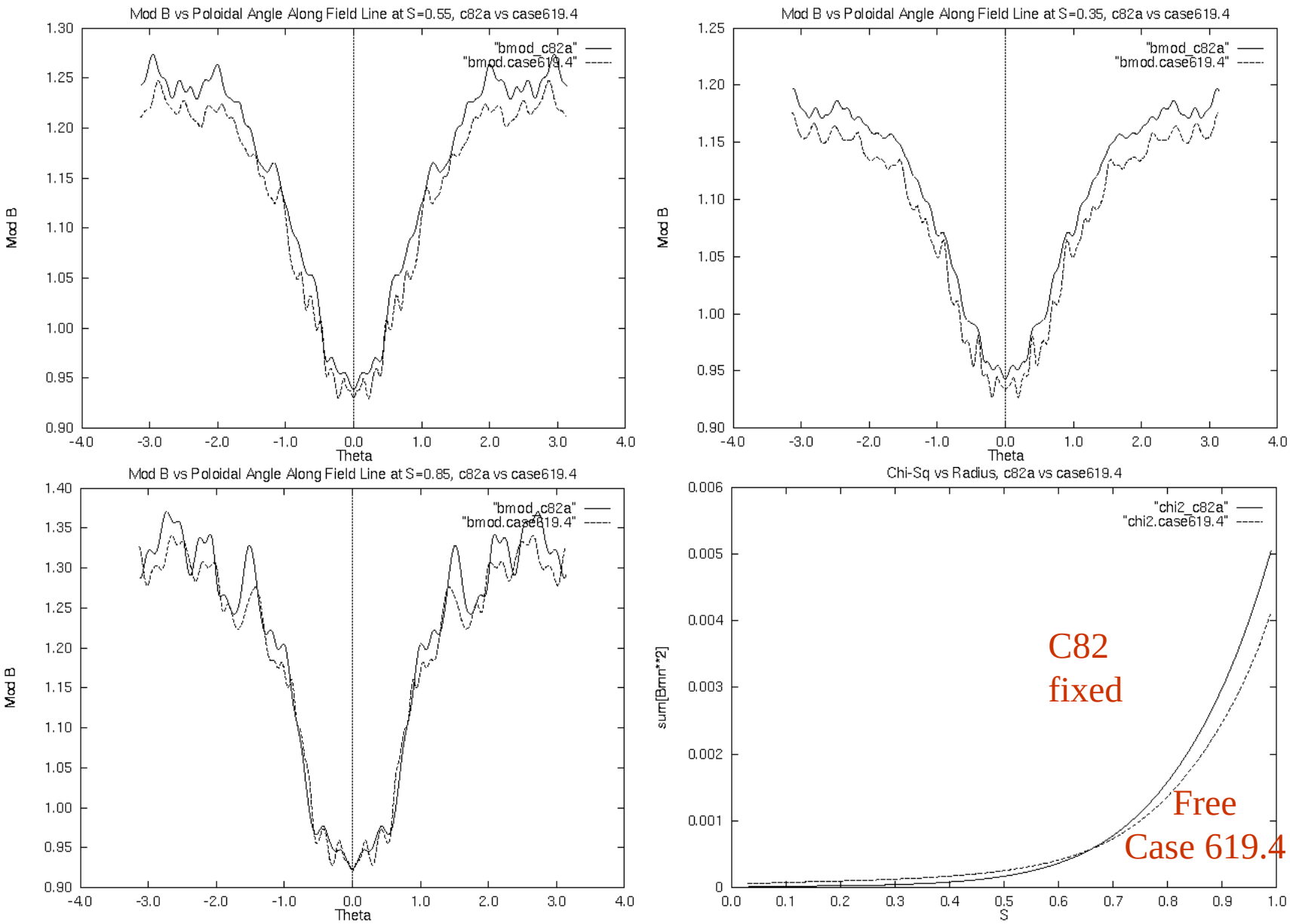
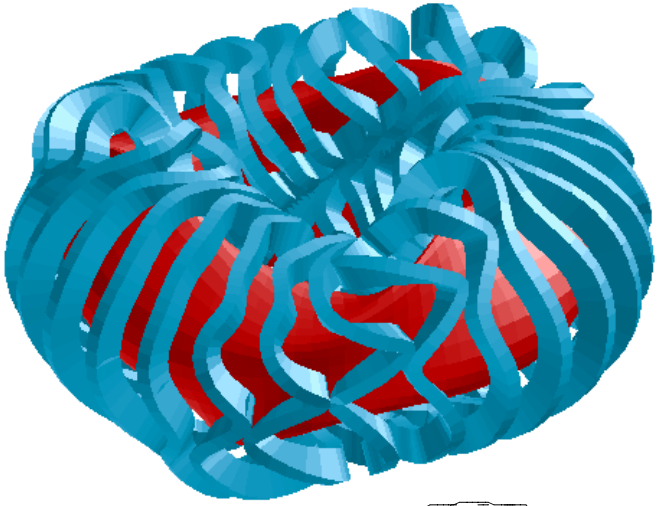
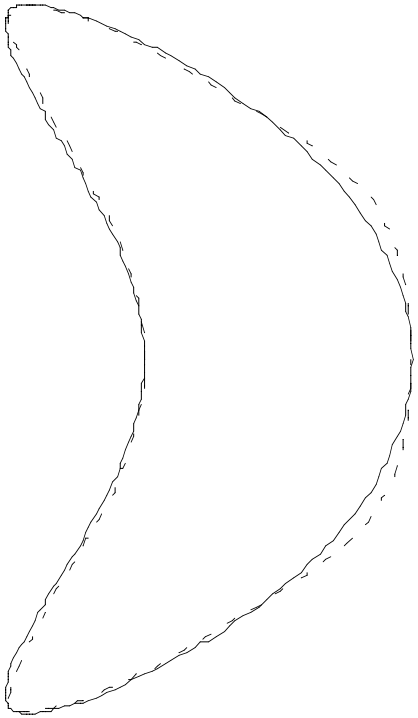
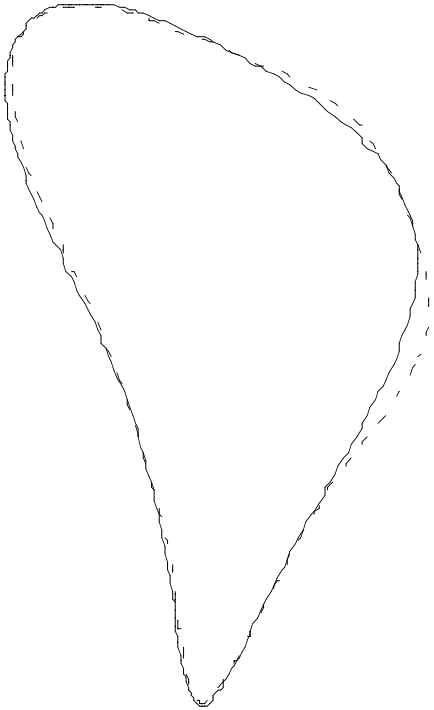
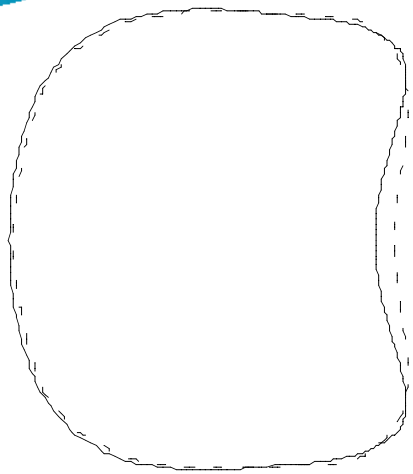

Mod B vs Poloidal Angle Along Field Line at S=0.55, c82a vs case619.4
"bmod_c82a"
"bmod.case619.4"
Mod B
Theta
Mod B vs Poloidal Angle Along Field Line at S=0.35, c82a vs case619.4
"bmod_c82a"
"bmod.case619.4"
Mod B
Theta
Mod B vs Poloidal Angle Along Field Line at S=0.85, c82a vs case619.4
"bmod_c82a"
"bmod.case619.4"
Mod B
Theta
Chi-Sq vs Radius, c82a vs case619.4
"chi2_c82a"
"chi2.case619.4"
sum[Bmn**2]
S
C82
fixed
Free
Case 619.4

Modular Coils
Strickler's 0424a1

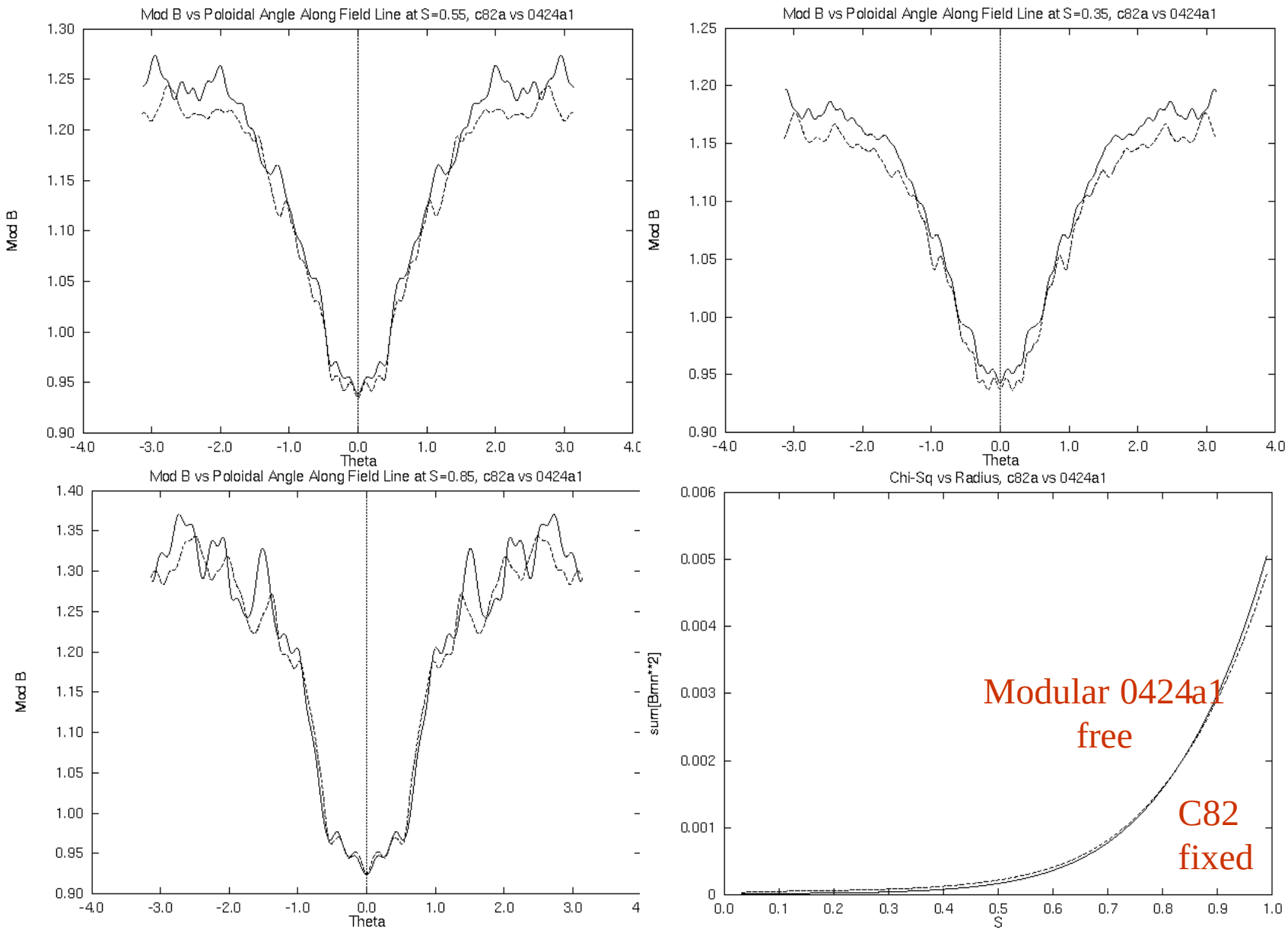




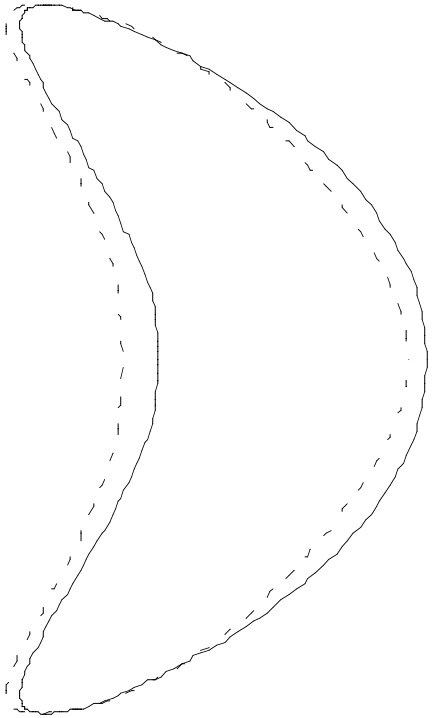


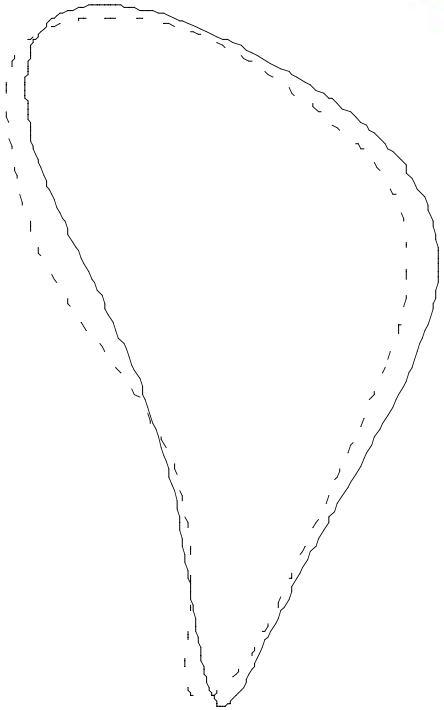


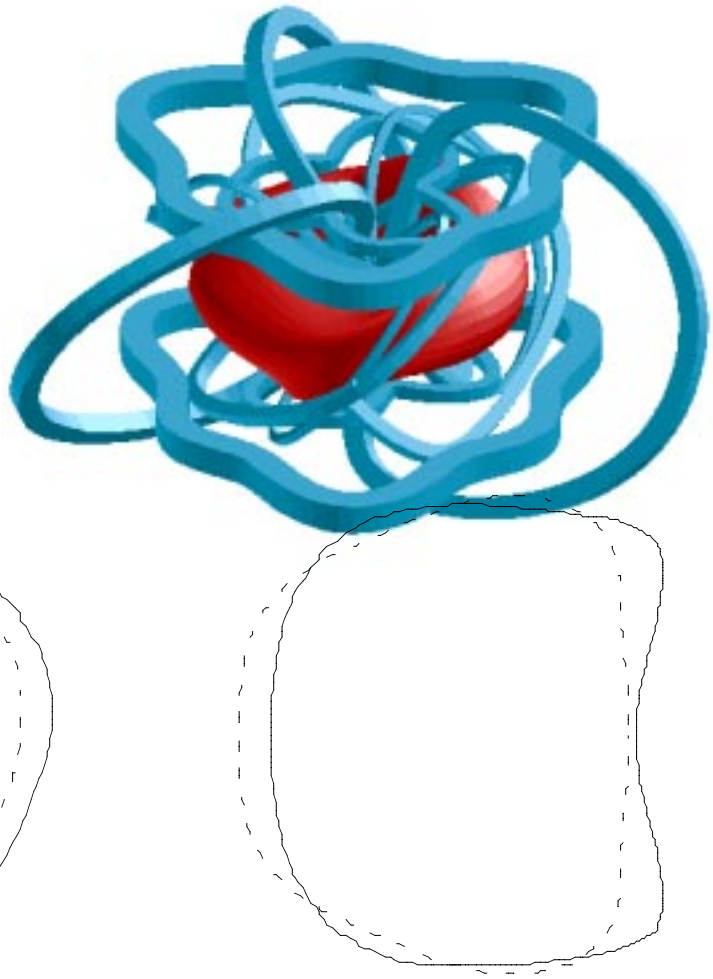
Produced by Coilopt


Mod B vs Poloidal Angle Along Field Line at S=0.55, c82a vs 0424a1
Mod B
Theta
Mod B vs Poloidal Angle Along Field Line at S=0.35, c82a vs 0424a1
Mod B
Theta
Mod B vs Poloidal Angle Along Field Line at S=0.85, c82a vs 0424a1
Mod B
Theta
Chi-Sq vs Radius, c82a vs 0424a1
sum[Bmn**2]
S
Modular 0424a1
free
C82
fixed

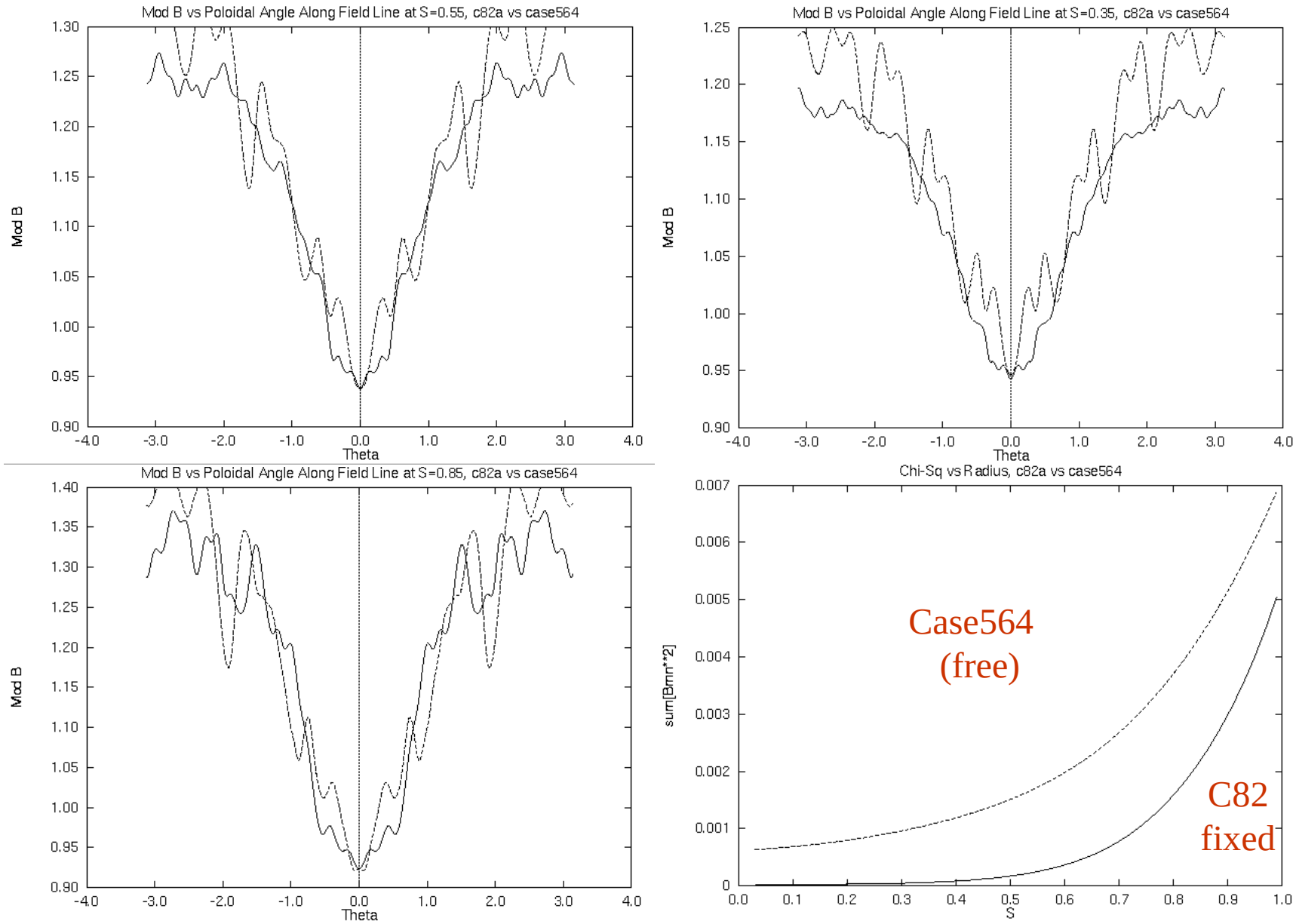
No Conformal Coils
Case 564







Produced by Tiltopt


Mod B vs Poloidal Angle Along Field Line at S=0.55, c82a vs case564
Mod B
Theta
Mod B vs Poloidal Angle Along Field Line at S=0.35, c82a vs case564
Mod B
Theta
Mod B vs Poloidal Angle Along Field Line at S=0.85, c82a vs case564
Mod B
Theta
Chi-Sq vs Radius, c82a vs case564
sum[Bmn**2]
S
Case564
(free)
C82
fixed

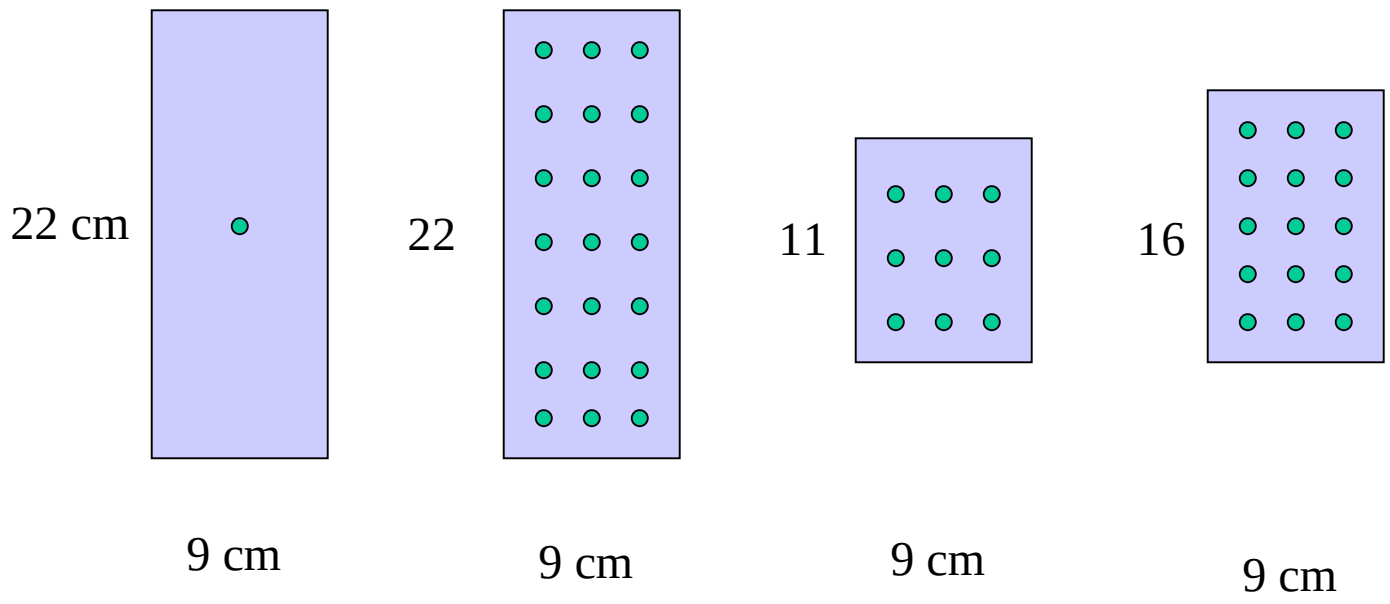
Summary of Reconstruction Parameters

Parameter	Reference c82 Fixed Boundary	Coil Option: Reuse TF 4064_rev6	Tilted TF case536.3	L=3 case619.4	Modular 0424a1	No Conforma case564
Field Errors targeting c82						
Max, %		7.13	4.78	6.67	6.44	7.77
Mean, %		1.53	1.09	1.20	1.13	2.47
Free/Fix Boundary Overlay						
Max Offset, cm		4.37	2.58	5.56	3.98	9.09
Mean Offset, cm		1.16	0.75	1.47	0.90	2.82
Bmn chi^2 (QA-ness) *1e-4						
s=.35	0.55	2.17	0.94	1.41	0.98	10.48
s=.55	2.50	4.77	3.05	3.22	3.01	17.27
s=.85	21.09	26.08	20.23	17.81	21.00	42.79
Kink Eigenvalue * 1e-4	Acceptable	Stable	Stable	?	Stable	Unstable
ceoc=ceop=1.05	-11.00	-5.12	-8.62 ?		-10.93	-24.00
ceoc=ceop=1.00	-0.49					
Iota Profile						
s=0	0.26	0.25	0.28	0.27	0.26	0.28
s=.5	0.34	0.35	0.35	0.34	0.33	0.38
s=1.	0.47	0.49	0.47	0.45	0.45	0.47
Shear						
iota(1)-iota(0)	0.21	0.24	0.19	0.19	0.19	0.19

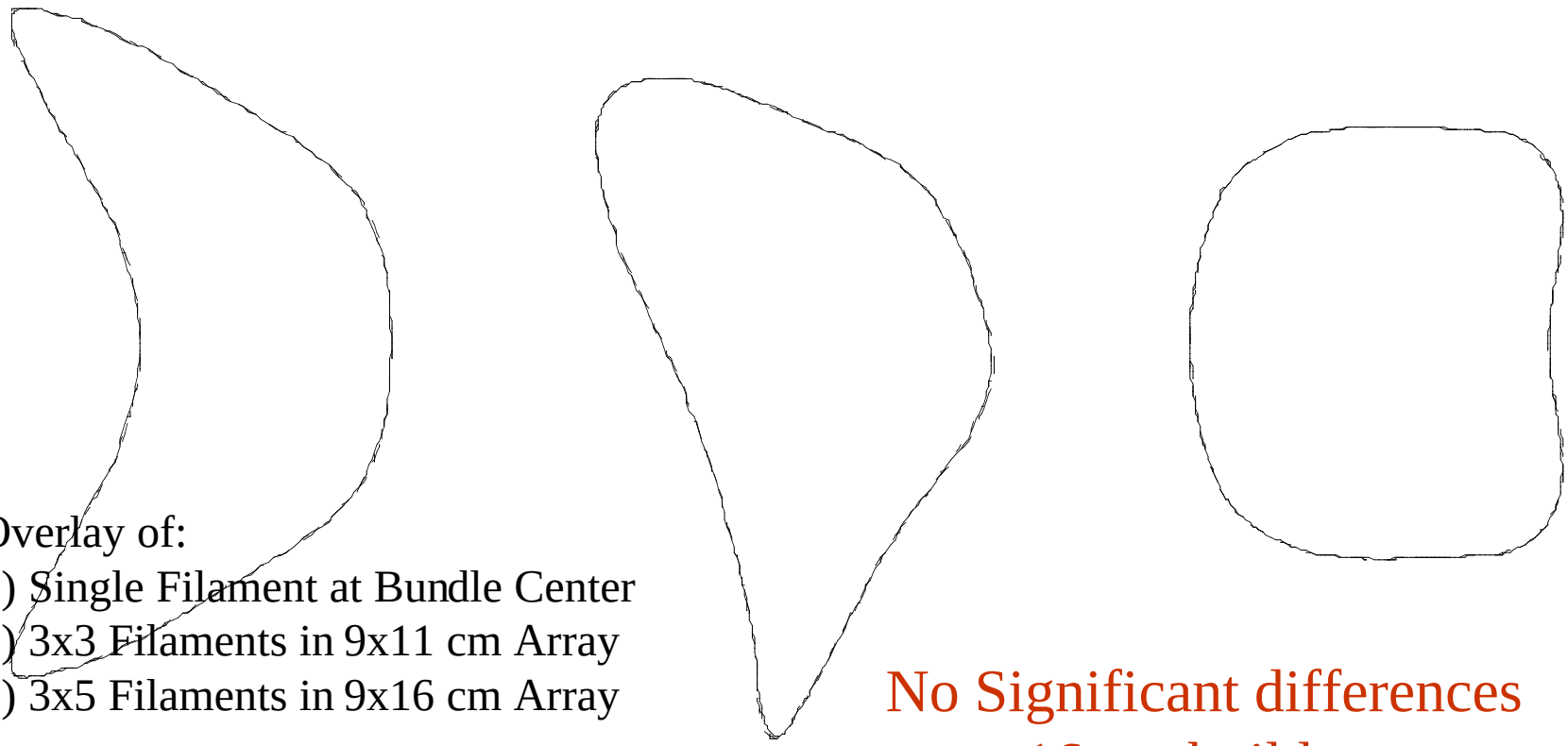
Impact of finite build coils on Reconstruction

- Modular Coils 0424a1 Investigated
  - Coil bundle centroid 21.5 cm from plasma at closest point potentially allowing for much larger radial build than other conformal coils presented
  - Results promising
- Other Coil Configurations not yet examined
  - Large Alternate Background Coils are further from plasma so may be less of a concern - **TBD**.

Single vs Multi-Filament Models for Reconstructing Modular Coils 0424a1



VMEC Free boundary Reconstruction
Modular Coils 0424a1 - Single vs Multi Filament



Overlay of:
1) Single Filament at Bundle Center
2) 3x3 Filaments in 9x11 cm Array
3) 3x5 Filaments in 9x16 cm Array

VMEC did not converge for
4) 3x7 Filaments in 9x22 cm Array

No Significant differences up to 16 cm build

Closing the Loop with Physics

Start with Fixed boundary Optimized Plasma at Full Current, Full Beta

Develop Coils targeting Fixed Boundary Plasma

Verify Plasma Reconstruction with VMEC

Original Path

Use Coils in Curropt to target Fix boundary Plasma
- in Vacuum
- at Zero Beta, Full Current

Verify Plasma Reconstruction at all States with VMEC & PIES

New Path

Use Coils in Free Boundary Optimizer to
- Improve Physics at Full Current, Full Beta
- Develop Plasmas for Vacuum and Zero Beta,Full Current

Verify Surfaces with PIES