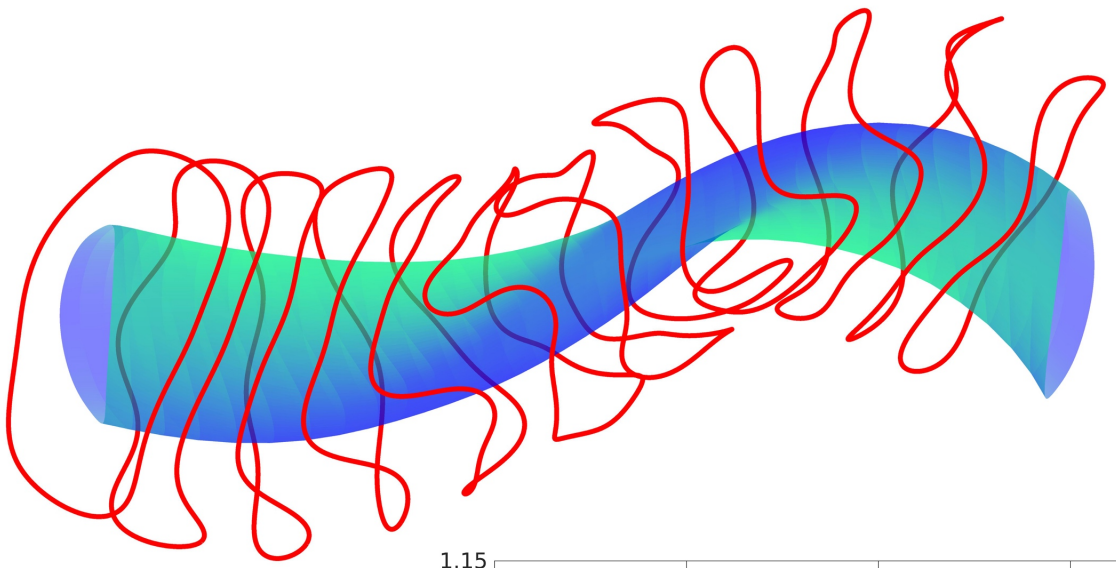
Coils for HSX using FOCUS

Thanks to Aaron Bader, Caoxiang Zhu, Luquant Singh, Joseph Talmadge, and David Anderson

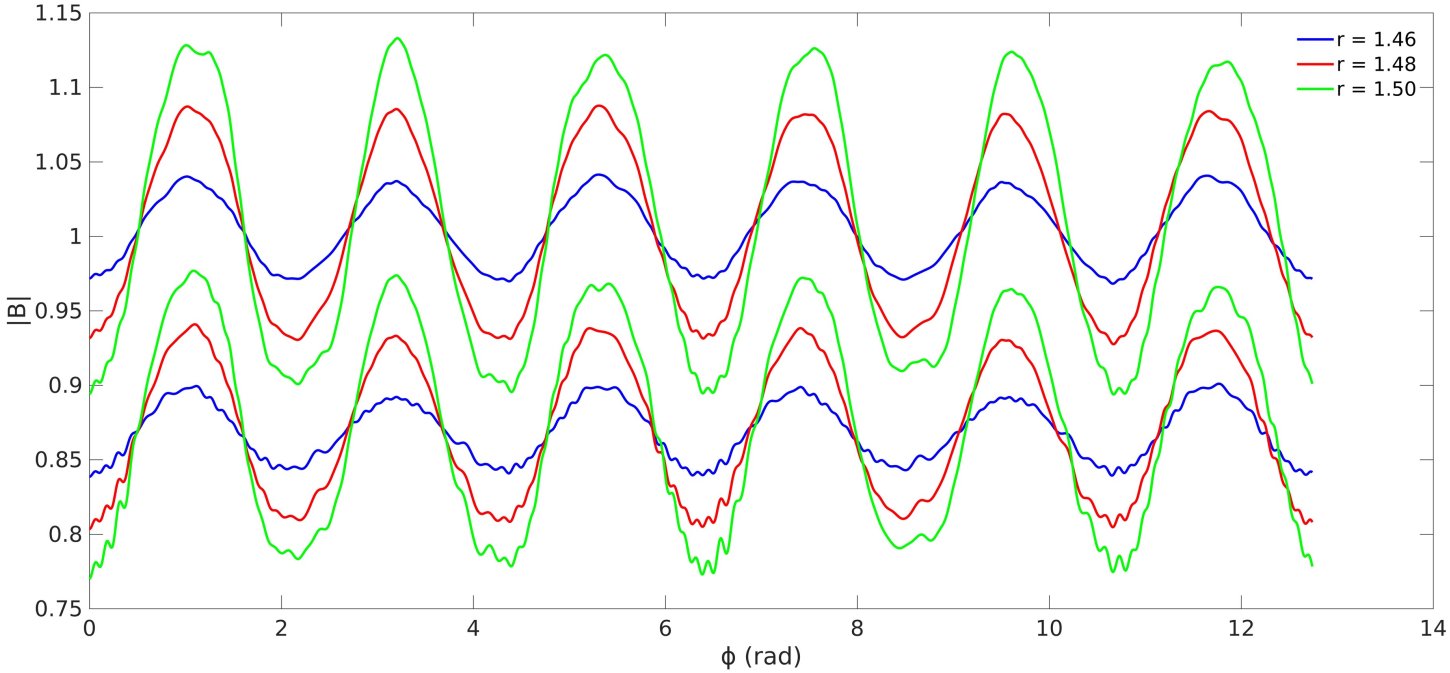
Overview

- Filamentary coils
- Targeting HSX vacuum fields
- $B_{normal} = \Sigma \frac{1}{2} \left(\frac{\boldsymbol{B} \cdot \boldsymbol{n}}{|B|} \right)^2$
- Goals
  - Decrease B_{normal}
  - Decrease coil ripple
  - Decrease coil complexity (compared to HSX coils)

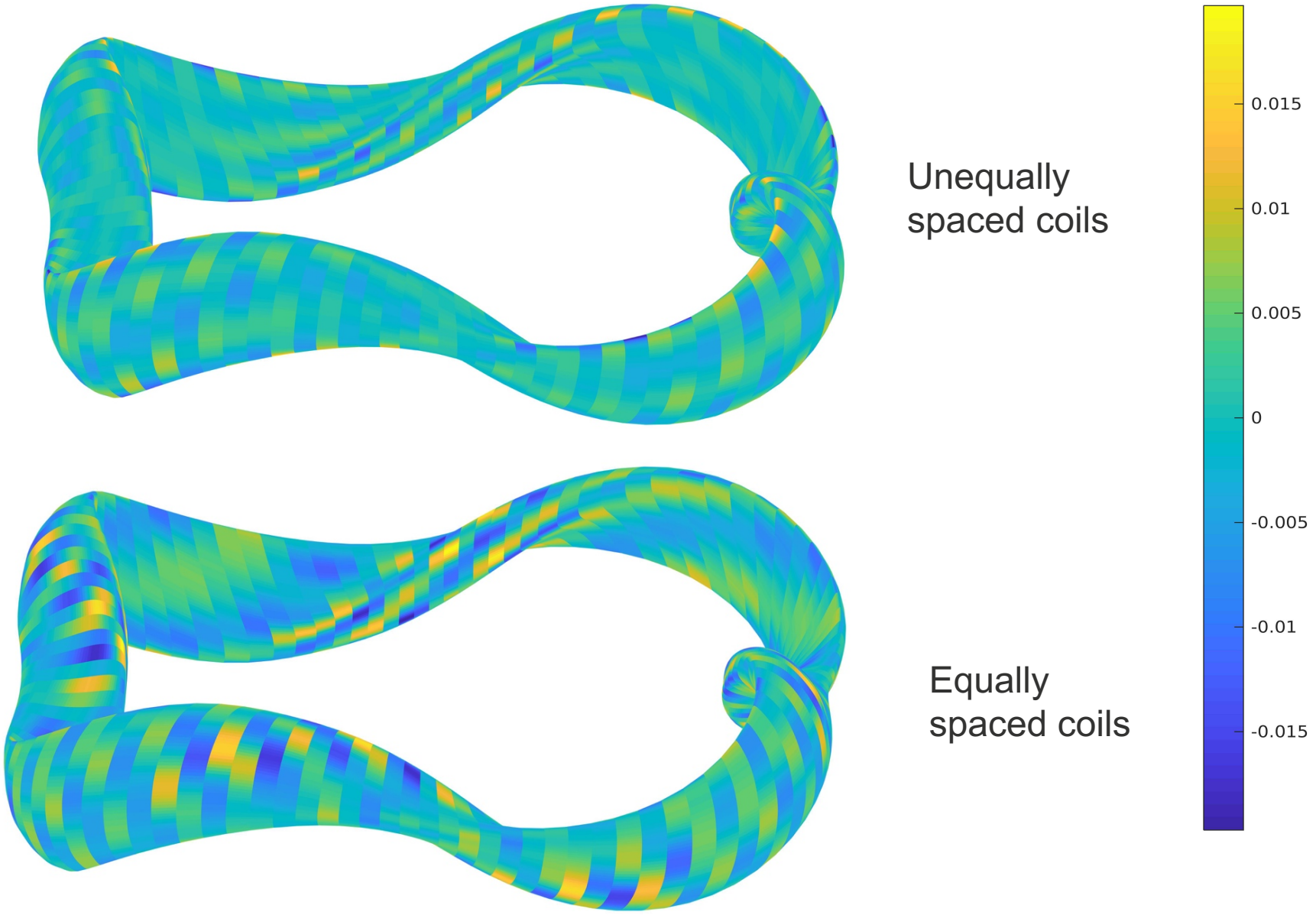
12 Modular



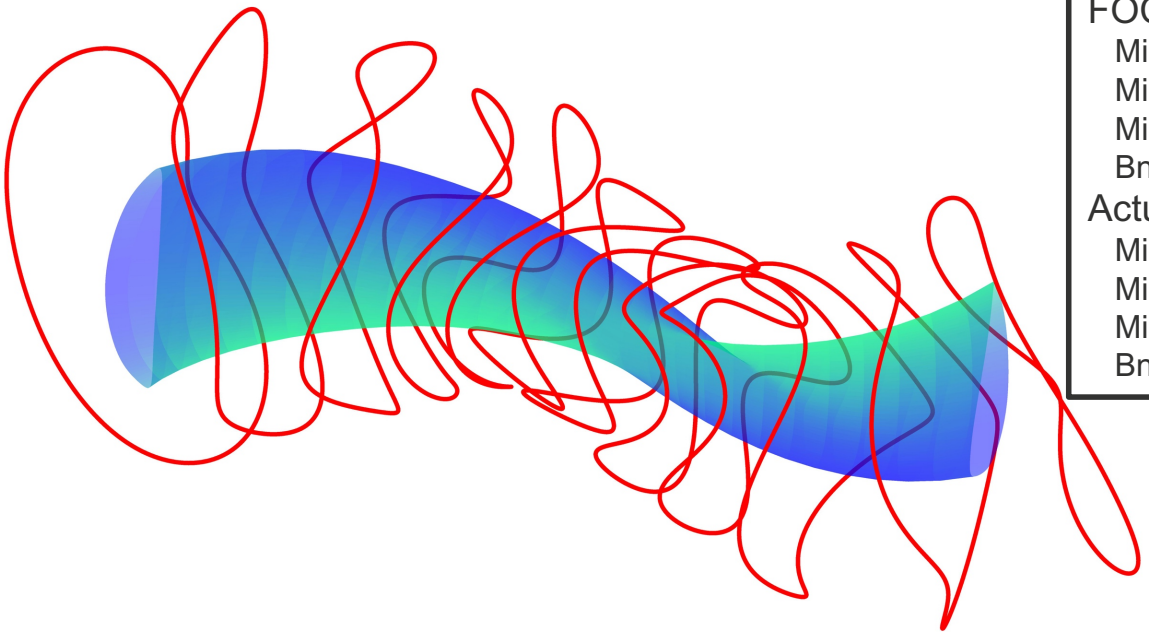
FOCUS Coils	
Minimum Coil to Plasma Distance	13.7 cm
Minimum Coil to Coil Distance	8.3 cm
Minimum Radius of Curvature	5.2 cm
Bnormal Error	2.30e-5
Actual Coils	
Minimum Coil to Plasma Distance	14.4 cm
Minimum Coil to Coil Distance	9.3 cm
Minimum Radius of Curvature	8.1 cm
Bnormal Error	1.37e-4



Comparison of Normal Magnetic Field



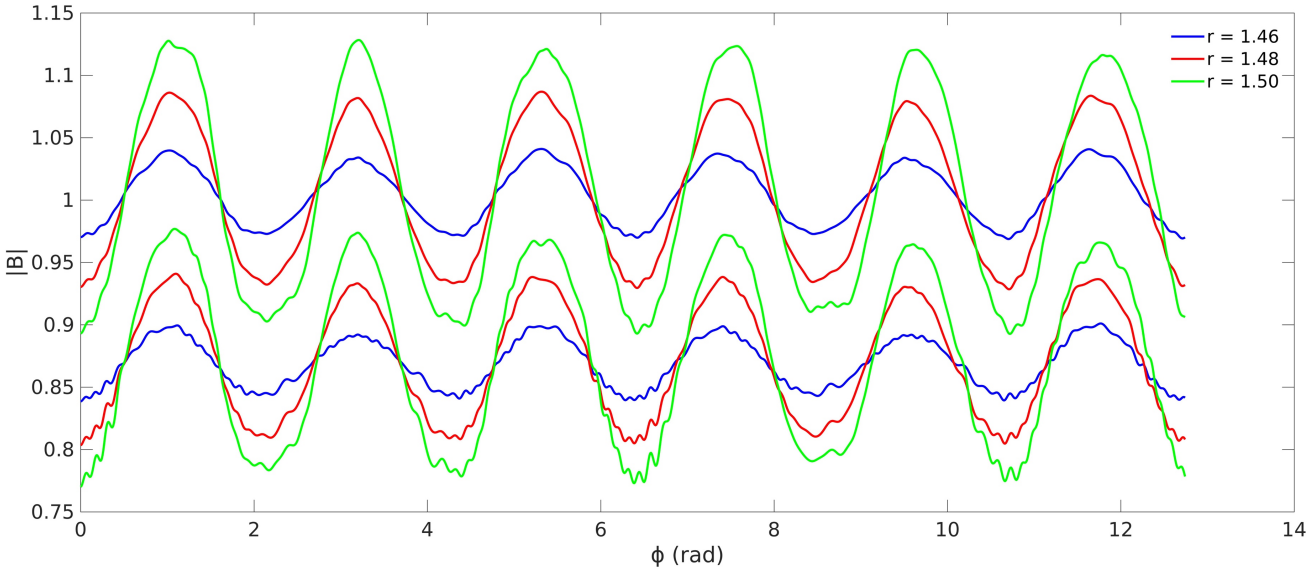
Unequally Spaced Coils



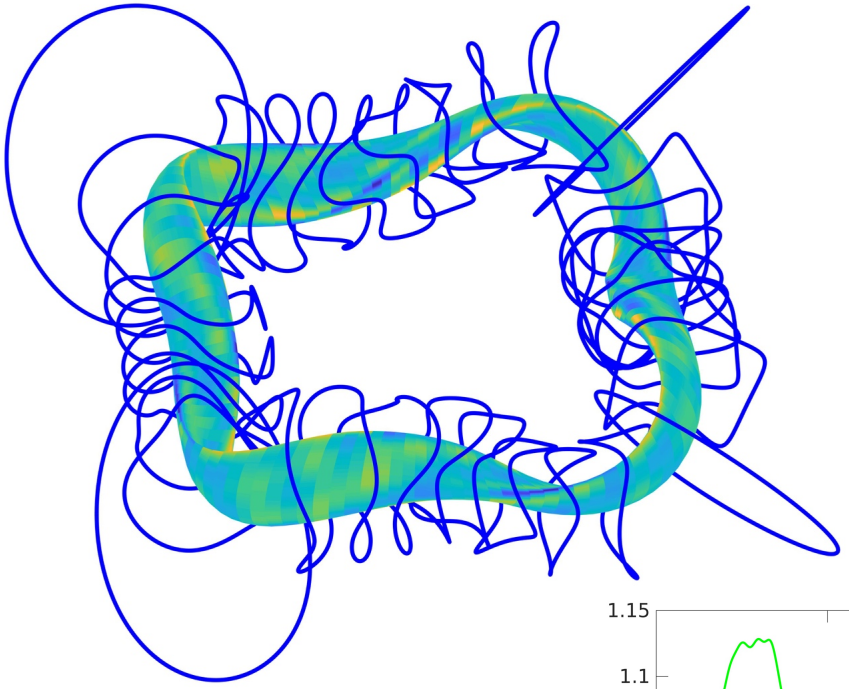
FOCUS Coils	
Minimum Coil to Plasma Distance	11.0 cm
Minimum Coil to Coil Distance	3.6 cm
Minimum Radius of Curvature	3.2 cm
Bnormal Error	2.51e-5
Actual Coils	
Minimum Coil to Plasma Distance	14.4 cm
Minimum Coil to Coil Distance	9.3 cm
Minimum Radius of Curvature	8.1 cm
Bnormal Error	1.37e-4

Middle 6 coils carry 100 kA
First 3 and last 3 coils carry 200 kA

Corner coils have a 16% increase in coil to plasma separation as compared to HSX corner coils

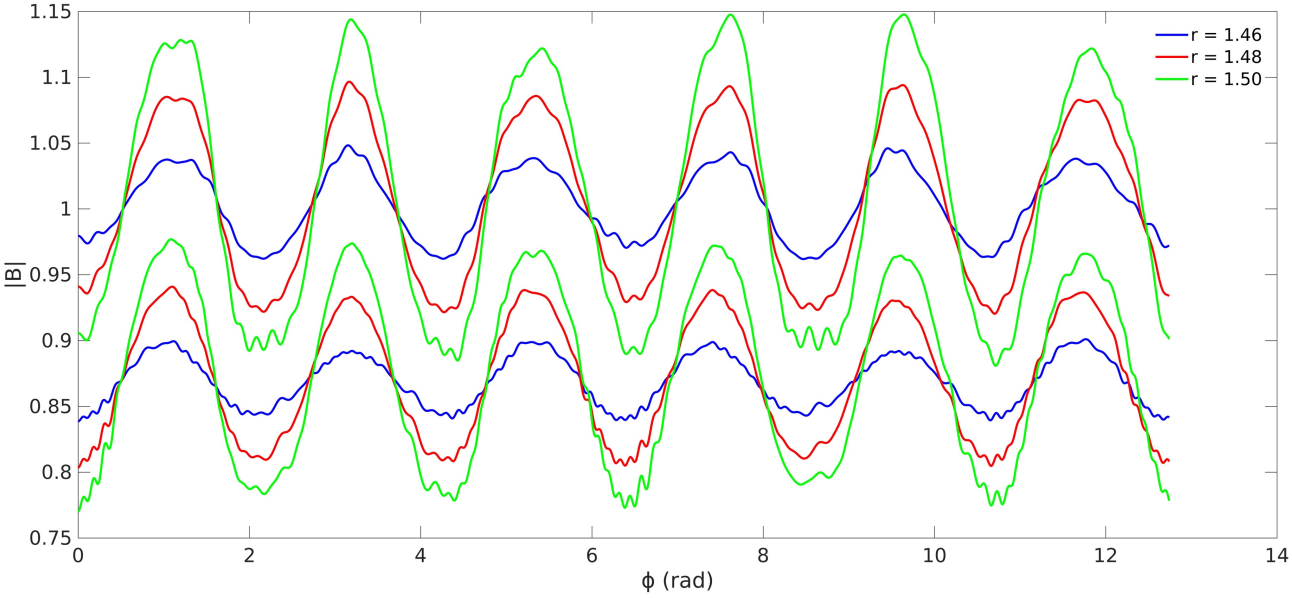


Larger Corner Coils

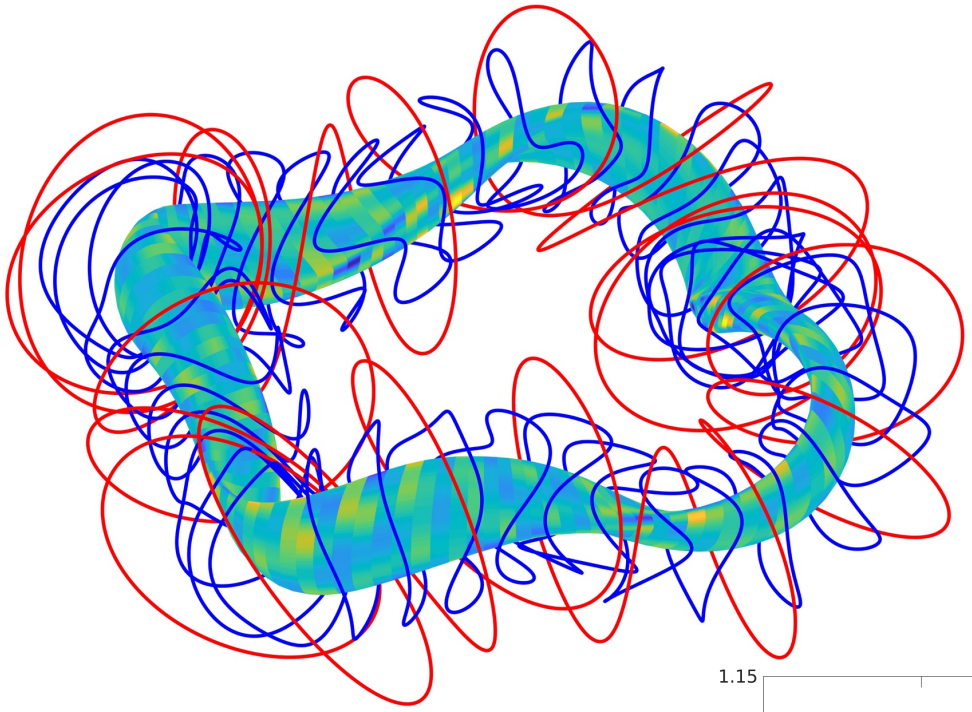


FOCUS Coils	
Minimum Coil to Plasma Distance	13.3 cm
Minimum Coil to Coil Distance	6.0 cm
Minimum Radius of Curvature	2.6 cm
Bnormal Error	1.76e-4
Actual Coils	
Minimum Coil to Plasma Distance	14.4 cm
Minimum Coil to Coil Distance	9.3 cm
Minimum Radius of Curvature	8.1 cm
Bnormal Error	1.37e-4

Coils carry 152 kA of current except corner coils which carry 575 kA

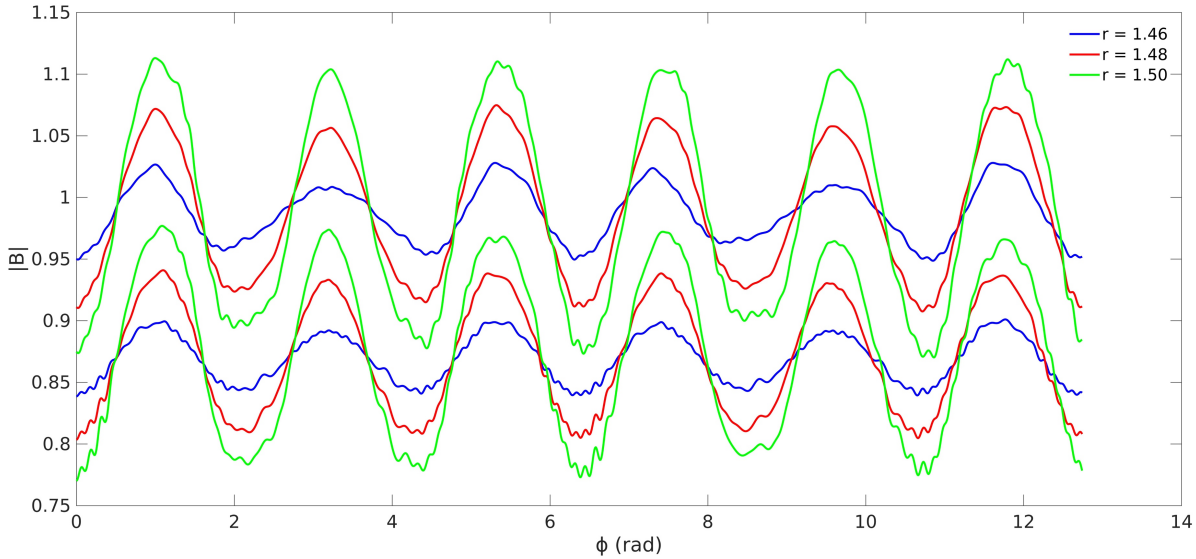


Hybrid: Helical L=1 m=5, 10 Modular

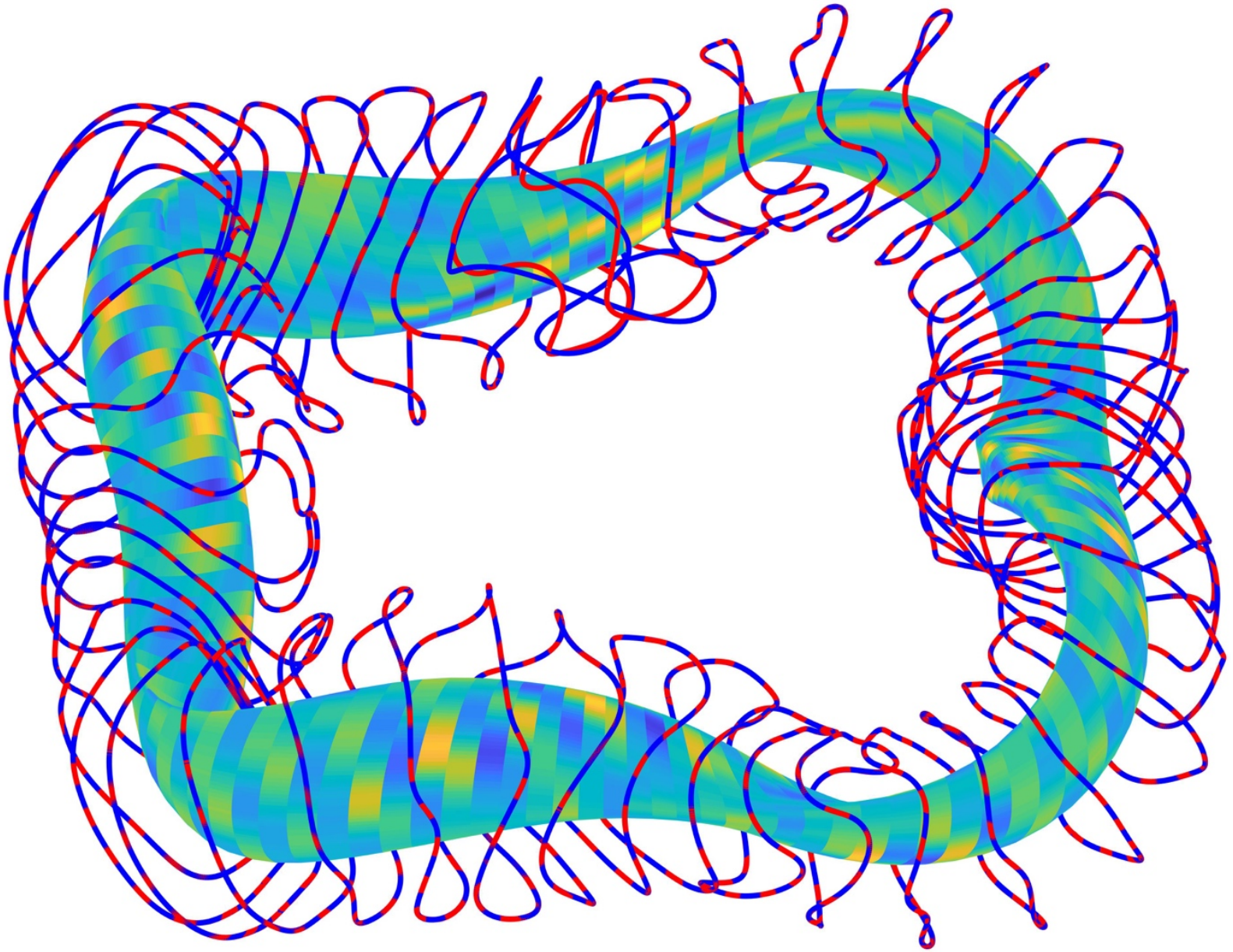


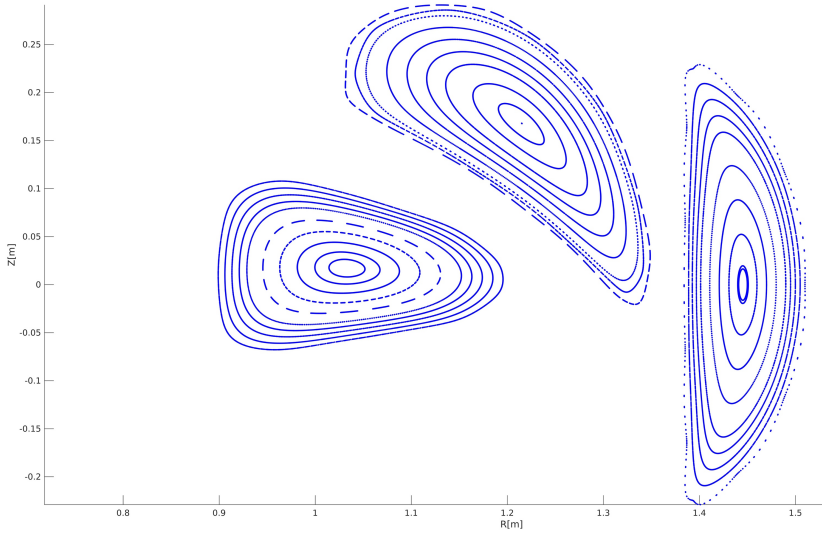
FOCUS Coils	
Minimum Coil to Plasma Distance	12.5 cm
Minimum Coil to Coil Distance	5.9 cm
Minimum Radius of Curvature	1.0 cm
Second Min Radius of Curvature	3.4 cm
Bnormal Error	7.89e-5
Actual Coils	
Minimum Coil to Plasma Distance	14.4 cm
Minimum Coil to Coil Distance	9.3 cm
Minimum Radius of Curvature	8.1 cm
Bnormal Error	1.37e-4

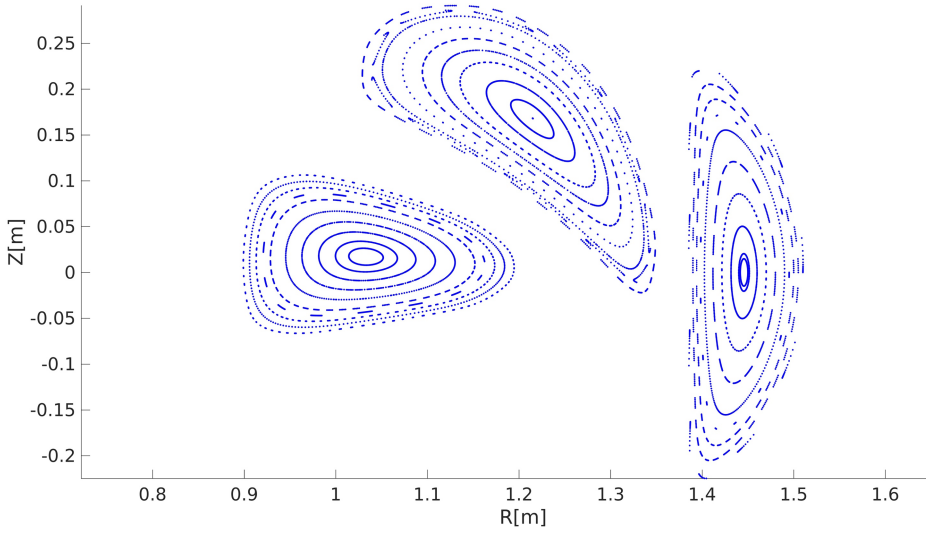
All coils carry 120 kA of current, HSX coils carry 150 kA



Extra Slides




Z[m]
R[m]
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5


Z[m]
R[m]
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6