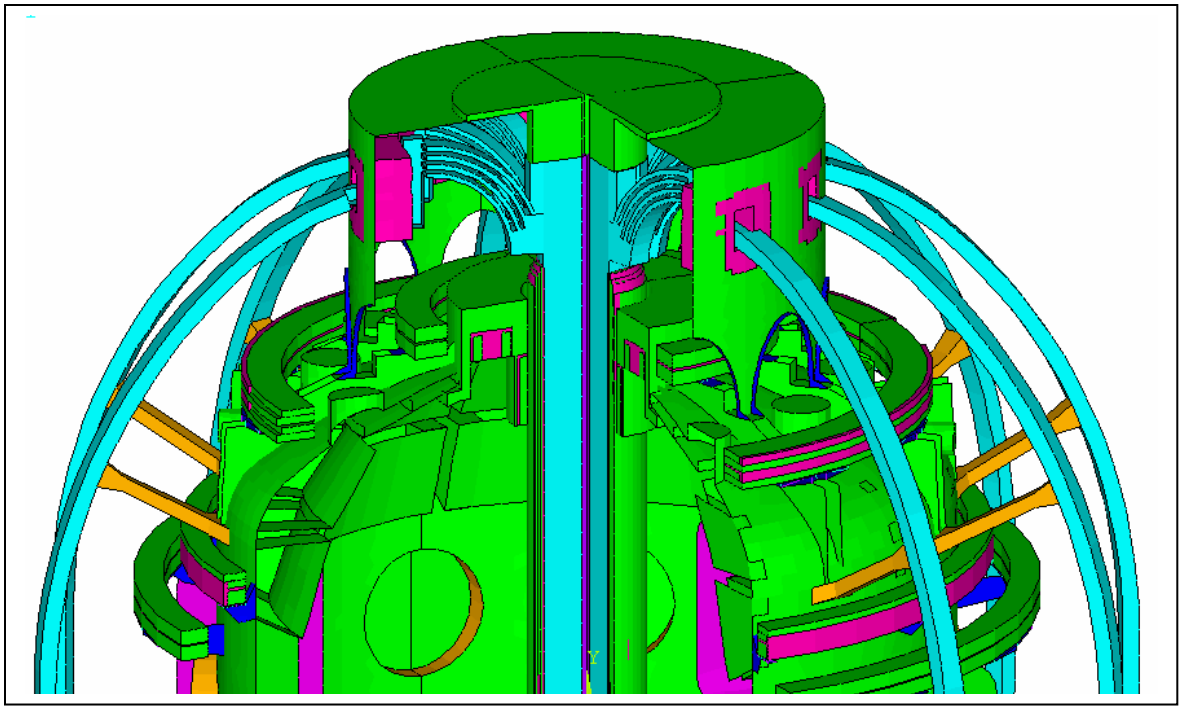
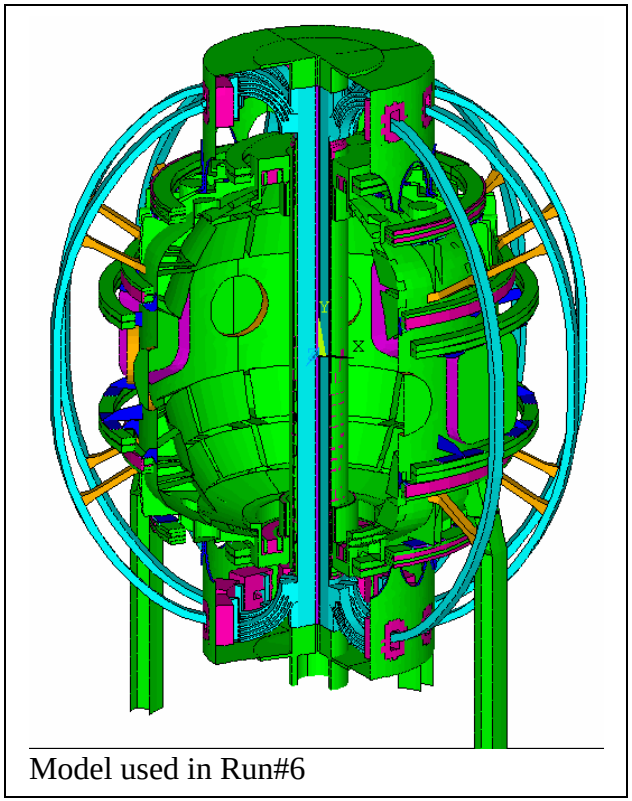
NSTX Upgrade Global Modeling

Peter H. Titus

Thursday January 22 2009





Model used in Run#6

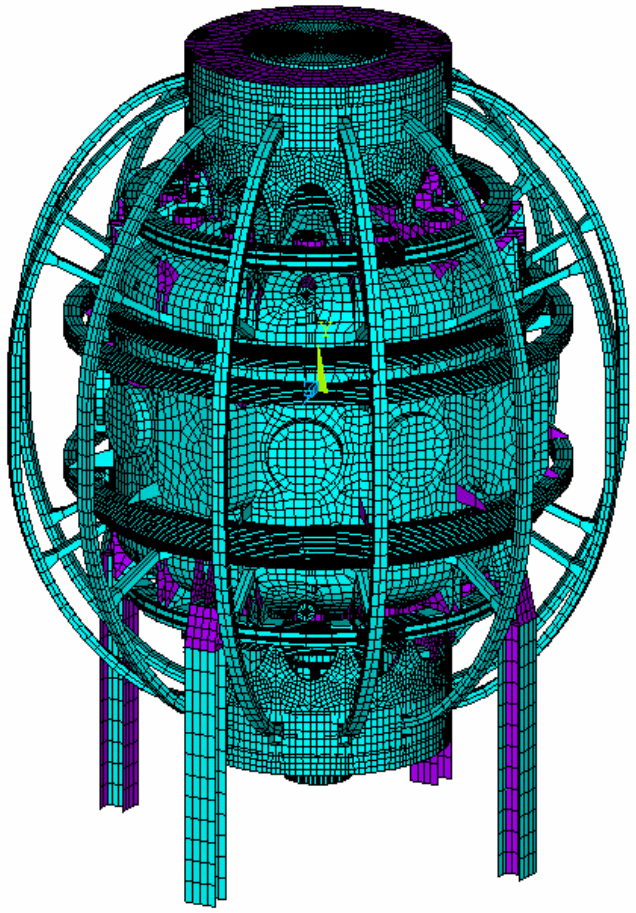
Global Modeling

- **Provides Overall Behavior**
- **Provides Boundary Conditions for Local Models – Sub Models , or Inclusion of the Detailed Model in the Global Model. Can be Built From Other Models – The Vessel Model i this Global Modeling comes from H.M. Fan**

- **Scenario Developement**
  Real Scenarios
  “Worst Case”
  Monte Carlo - Influence Coefficients with Multiple Permutation of Currents
  Provides Means for Qualification of Future Operational Scenarios

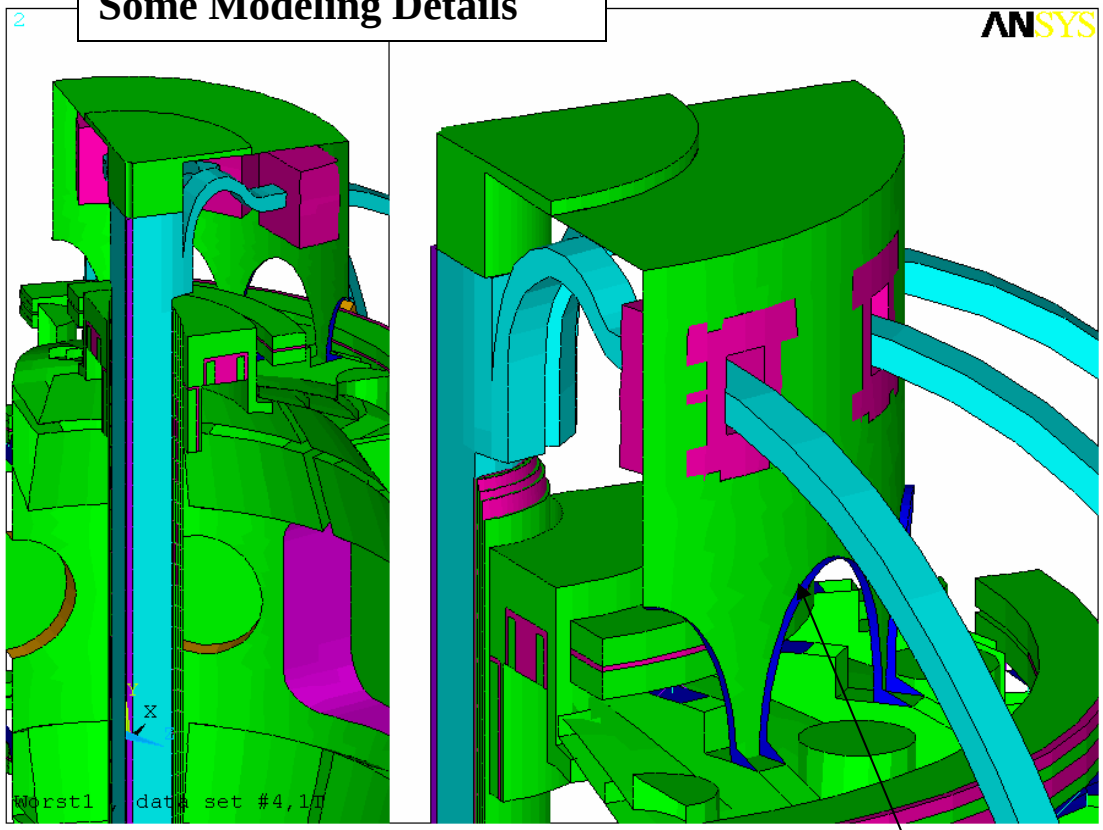
- **Thermal Extremes – Not yet in my Model But Need to Be**

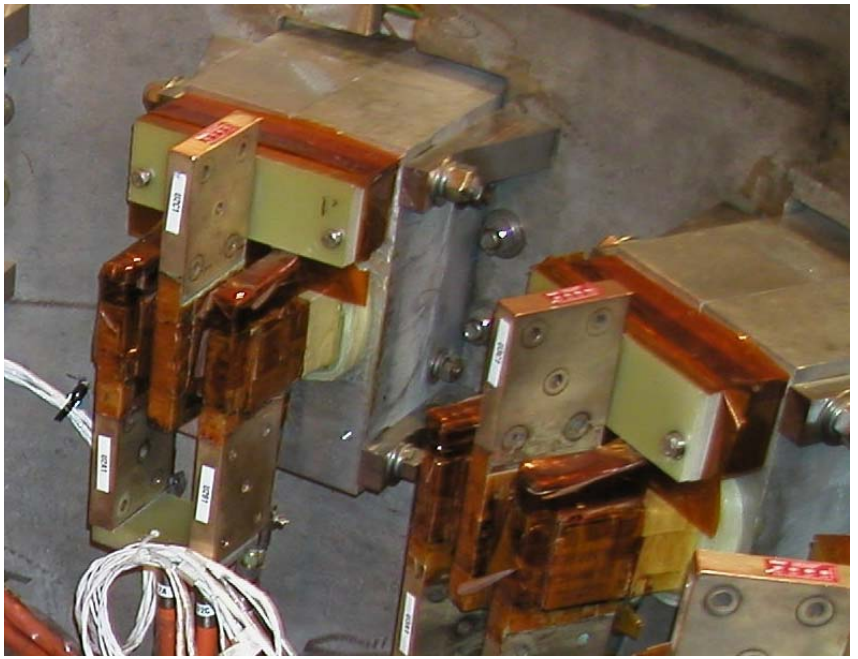
- **Vacuum Loads – Not Yet In My Model**



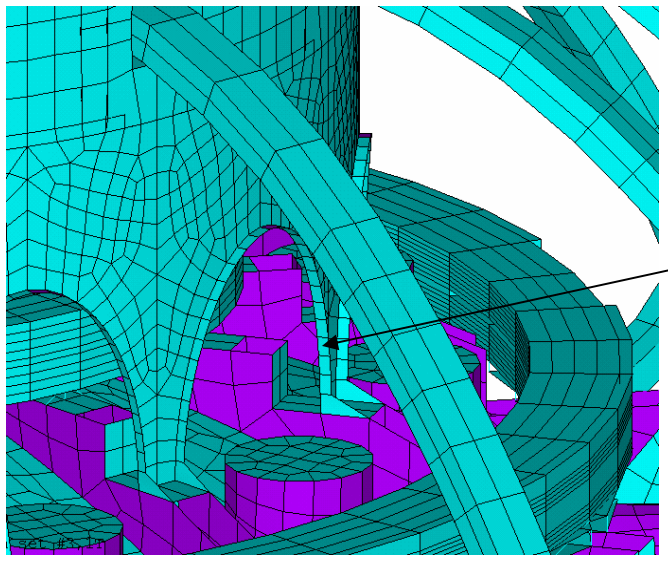
Four Fold Symmetry Expansion. HM Proc=vided the Vessel Model

Some Modeling Details

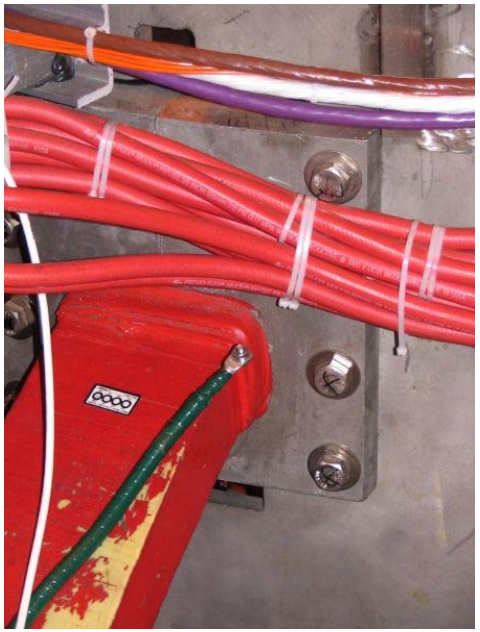




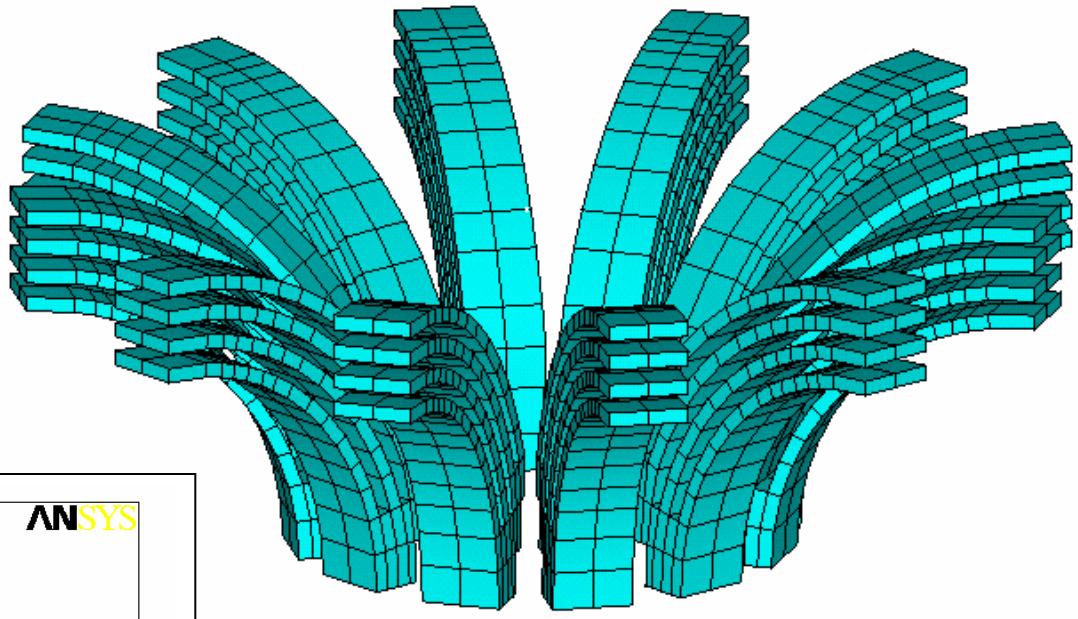
View Inside Umbrella Structure



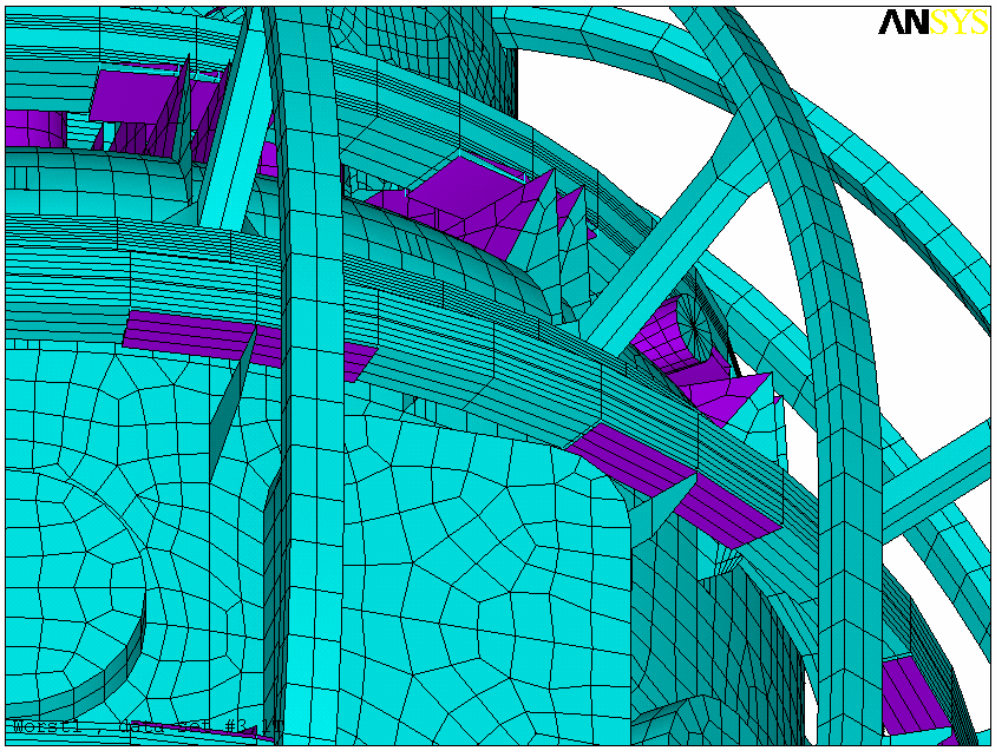
Arch Reinfocement "Guess"



Some More Modeling



Different but same as Bob's Flex Concept

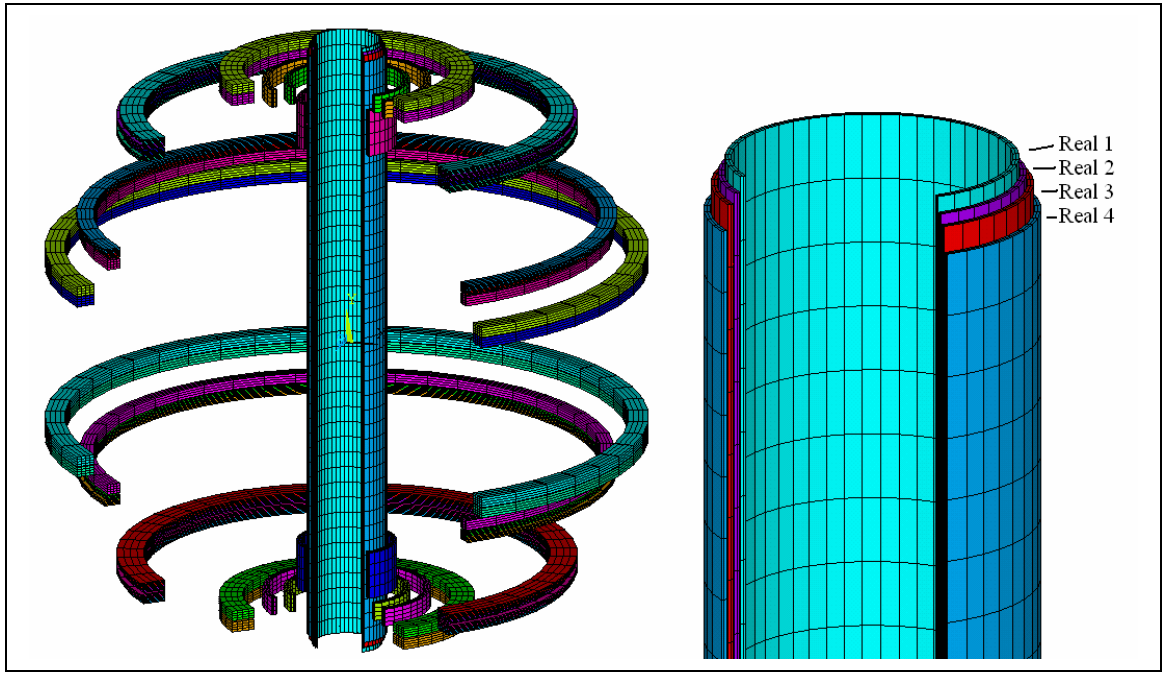


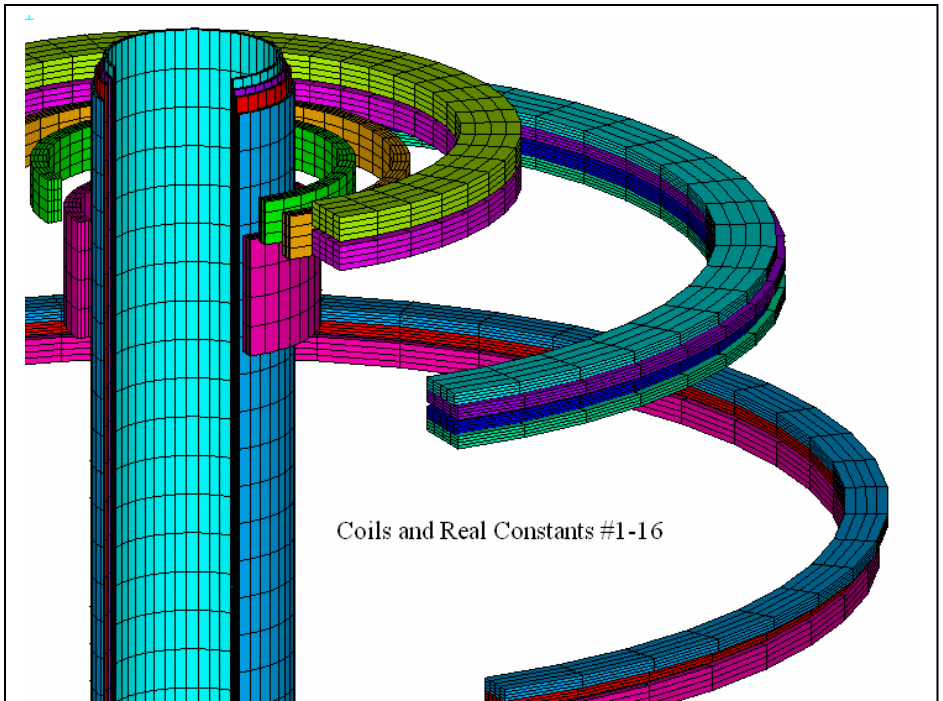
PF Supports. Vessel Shell is 5/8 inch thick

Coil Builds

Coil Builds
#33 is the Plasma

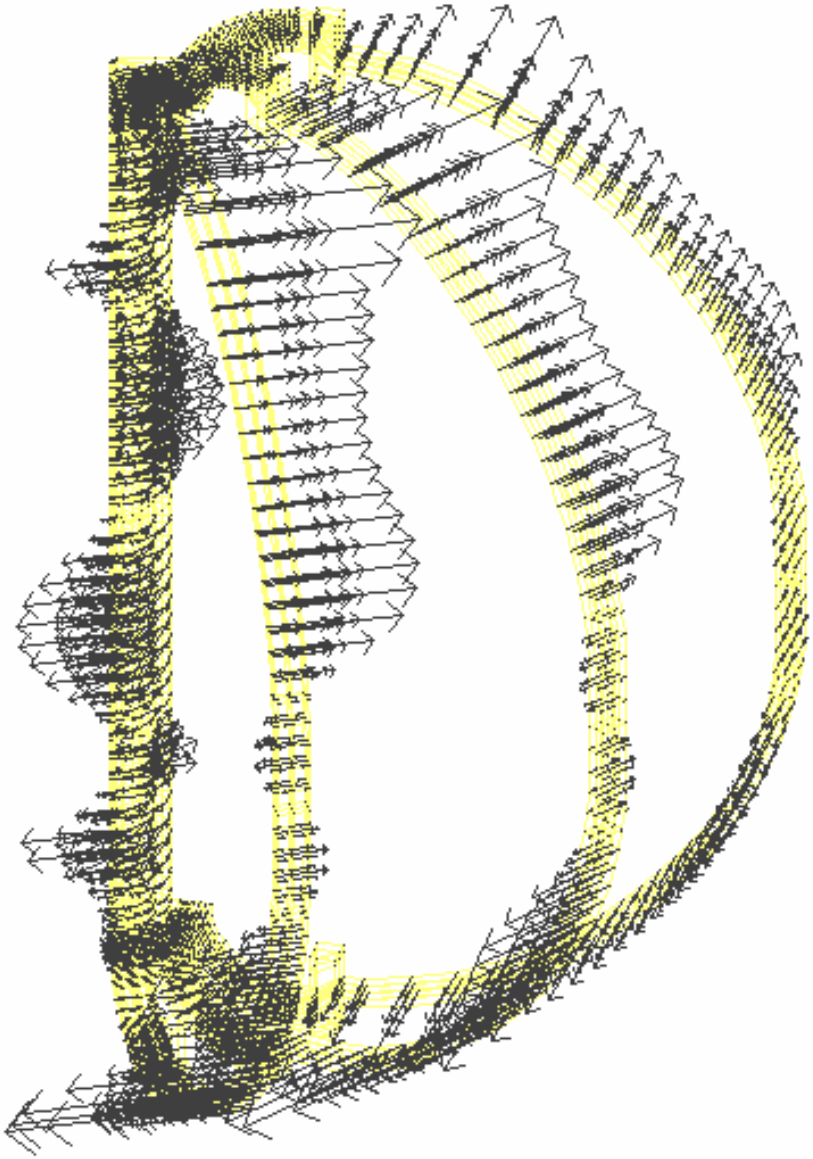
#	r	z	dr	dz	nx	nz
1	.2344	.0021	.01	4.3419	2	20
2	.2461	.0067	.01	4.2803	2	20
3	.2577	.0022	.01	4.2538	2	20
4	.2693	-.0021	.01	4.1745	2	20
5	.3239	1.5906	.0413	.3265	4	4
6	.4142	1.8252	.042	.1206	4	4
7	.56	1.8252	.042	.1206	4	4
8	.7992	1.8526	.1627	.068	4	4
9	.7992	1.9335	.1627	.068	4	4
10	1.4829	1.5696	.1631	.034	4	4
11	1.4945	1.5356	.1864	.034	4	4
12	1.4829	1.6505	.1631	.034	4	4
13	1.4945	1.6165	.1864	.034	4	4
14	1.795	.8711	.0922	.034	4	4
15	1.8065	.9051	.1153	.034	4	4
16	1.7946	.8072	.0915	.068	4	4
17	1.795	-.8711	.0922	.034	4	4
18	1.8065	-.9051	.1153	.034	4	4
19	1.7946	-.8072	.0915	.068	4	4
20	2.0118	.6489	.1359	.0685	4	4
21	2.0118	.5751	.1359	.0685	4	4
22	2.0118	-.6489	.1359	.0685	4	4
23	2.0118	-.5751	.1359	.0685	4	4
24	1.4829	-1.5696	.1631	.034	4	4
25	1.4945	-1.5356	.1864	.034	4	4
26	1.4829	-1.6505	.1631	.034	4	4
27	1.4945	-1.6165	.1864	.034	4	4
28	.7992	-1.8526	.1627	.068	4	4
29	.7992	-1.9335	.1627	.068	4	4
30	.56	-1.8252	.042	.1206	4	4
31	.4142	-1.8252	.042	.1206	4	4
32	.3239	-1.5906	.0413	.3265	4	4
33	.9344	0	.5696	1	6	8



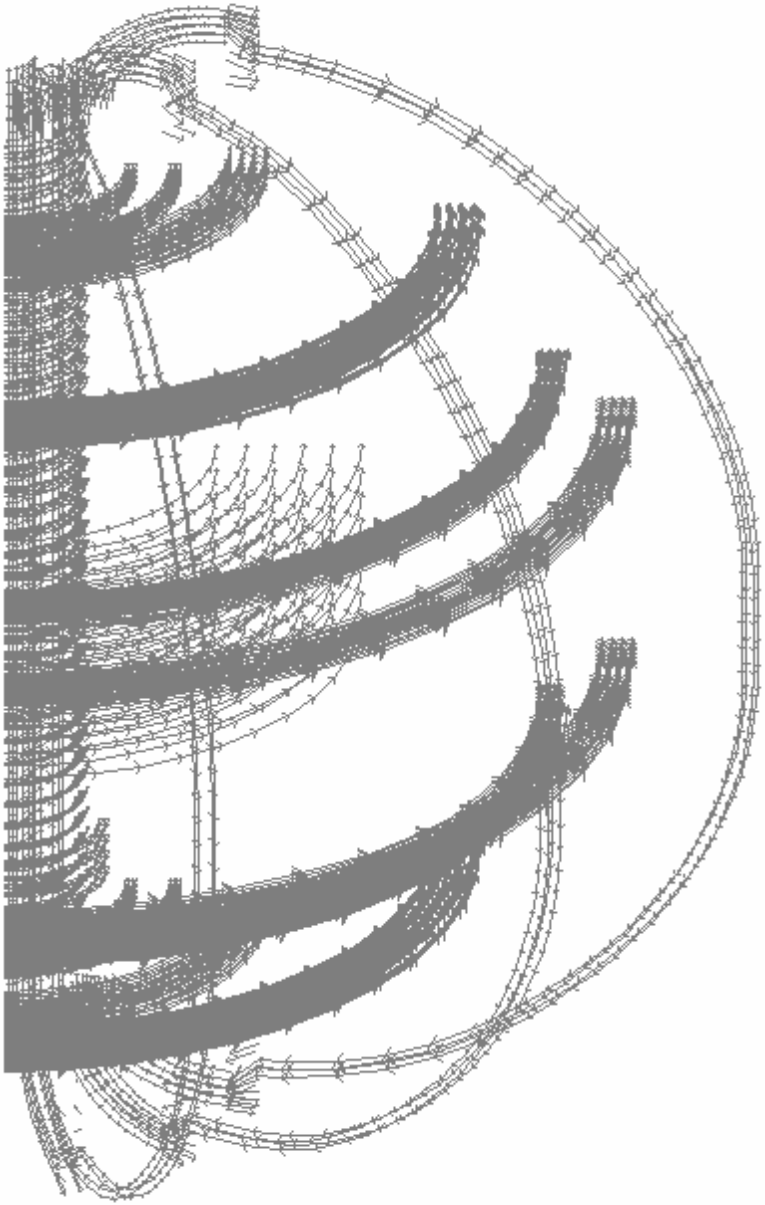


PF Scenario Currents In Mat

Coil #	TFON	IM	-0.1	-0.05	0	0.05	0.1	Worst 1	Worst 2	Worst3	Worst4	Worst5
Step	2	3	4	5	6	7	8	9	10	11	12	13
	Nst1	Nst2	Nst3	Nst4	Nst5	Nst6	Nst7	Nsw3	Nsw4	Nsw5	Nsw6	Nsw7
1	0	5.88	.000	.000	.000	.000	.000	-5.88	5.88	5.88	-1.47	-1.47
2	0	5.808	.000	.000	.000	.000	.000	-5.808	5.808	5.808	-5.808	-1.452
3	0	5.76	.000	.000	.000	.000	.000	-5.76	5.76	5.76	-5.76	-1.92
4	0	5.664	.000	.000	.000	.000	.000	-5.664	5.664	5.664	-5.664	-1.416
5	0	0	7.172	7.196	7.234	7.348	7.452	0.784	0.784	0.784	0.784	0.784
6	0	0	-5.650	-4.763	-3.628	-2.331	-.946	0.12	0.12	0.12	0.12	0.12
7	0	0	-4.922	-4.014	-2.936	-1.755	-.517	0.2	0.2	0.2	0.2	0.2
8	0	0	4.484	4.307	3.941	3.401	2.772	0.168	0.168	0.168	0.168	0.168
9	0	0	4.484	4.307	3.941	3.401	2.772	0.168	0.168	0.168	0.168	0.168
10	0	0	-1.058	-1.426	-1.655	-1.720	-1.690	-0.112	-0.112	-0.112	-0.112	-0.112
11	0	0	-1.058	-1.426	-1.655	-1.720	-1.690	-0.128	-0.128	-0.128	-0.128	-0.128
12	0	0	-1.058	-1.426	-1.655	-1.720	-1.690	-0.112	-0.112	-0.112	-0.112	-0.112
13	0	0	-1.058	-1.426	-1.655	-1.720	-1.690	-0.128	-0.128	-0.128	-0.128	-0.128
14	0	0	-2.388	-1.183	-.206	.488	.923	-0.08	-0.08	-0.08	-0.08	-0.08
15	0	0	-2.388	-1.183	-.206	.488	.923	-0.1	-0.1	-0.1	-0.1	-0.1
16	0	0	-2.388	-1.183	-.206	.488	.923	-0.16	-0.16	-0.16	-0.16	-0.16
17	0	0	-2.388	-1.183	-.206	.488	.923	-0.08	-0.08	-0.08	-0.08	-0.08
18	0	0	-2.388	-1.183	-.206	.488	.923	-0.1	-0.1	-0.1	-0.1	-0.1
19	0	0	-2.388	-1.183	-.206	.488	.923	-0.16	-0.16	-0.16	-0.16	-0.16
20	0	0	-3.374	-4.340	-5.139	-5.771	-6.210	-0.384	-0.384	-0.384	-0.384	-0.384
21	0	0	-3.374	-4.340	-5.139	-5.771	-6.210	-0.384	-0.384	-0.384	-0.384	-0.384
22	0	0	-3.374	-4.340	-5.139	-5.771	-6.210	-0.384	-0.384	-0.384	-0.384	-0.384
23	0	0	-3.374	-4.340	-5.139	-5.771	-6.210	-0.384	-0.384	-0.384	-0.384	-0.384
24	0	0	-1.058	-1.426	-1.655	-1.720	-1.690	-0.112	-0.112	-0.112	-0.112	-0.112
25	0	0	-1.058	-1.426	-1.655	-1.720	-1.690	-0.128	-0.128	-0.128	-0.128	-0.128
26	0	0	-1.058	-1.426	-1.655	-1.720	-1.690	-0.112	-0.112	-0.112	-0.112	-0.112
27	0	0	-1.058	-1.426	-1.655	-1.720	-1.690	-0.128	-0.032	-0.128	-0.128	-0.128
28	0	0	4.484	4.307	3.941	3.401	2.772	0.168	0.168	0.168	0.168	0.168
29	0	0	4.484	4.307	3.941	3.401	2.772	0.168	0.168	0.168	0.168	0.168
30	0	0	-4.922	-4.014	-2.936	-1.755	-.517	0.2	0.2	0.2	0.2	0.2
31	0	0	-5.650	-4.763	-3.628	-2.331	-.946	0.12	0.12	0.12	0.12	0.12
32	0	0	7.172	7.196	7.234	7.348	7.452	0.784	0.784	0.784	0.784	0.784
33	0	0	2.000	2.000	2.000	2.000	2.000	2	2	2	2	2

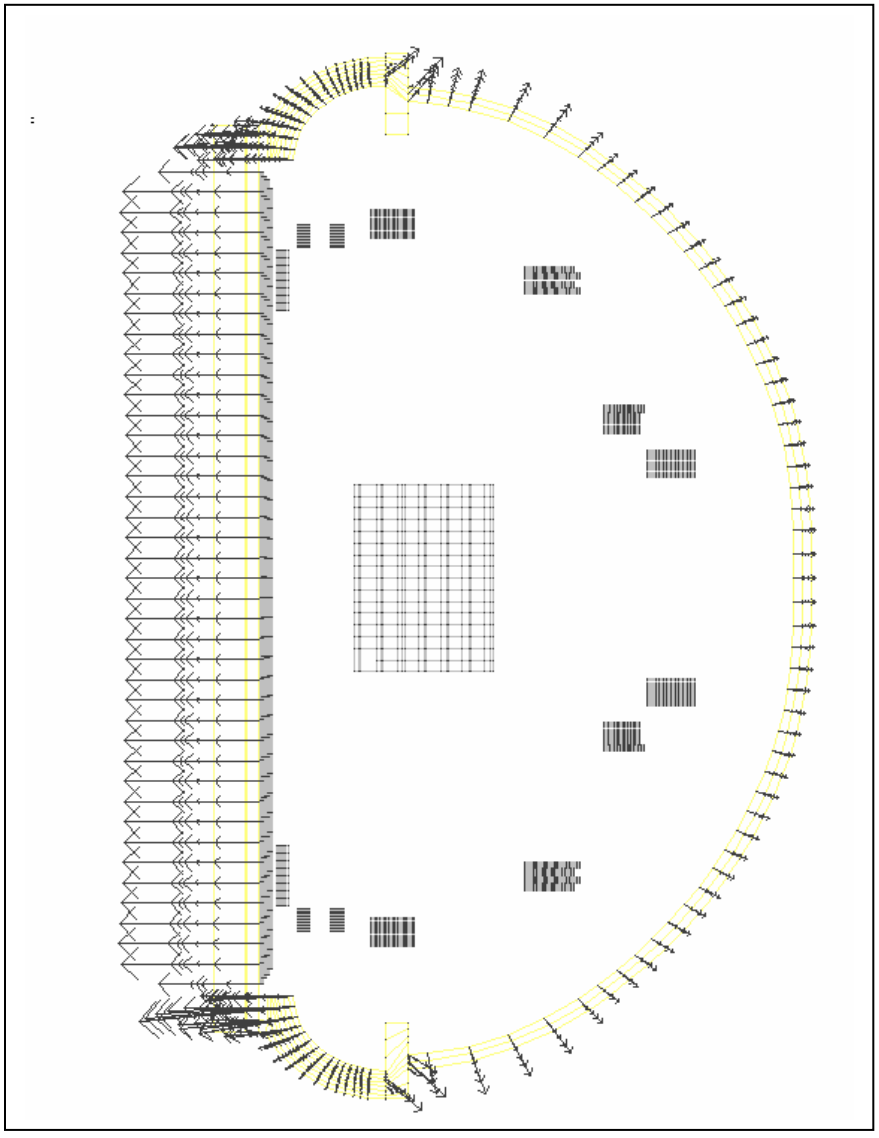


TF Out-of-Plane Forces

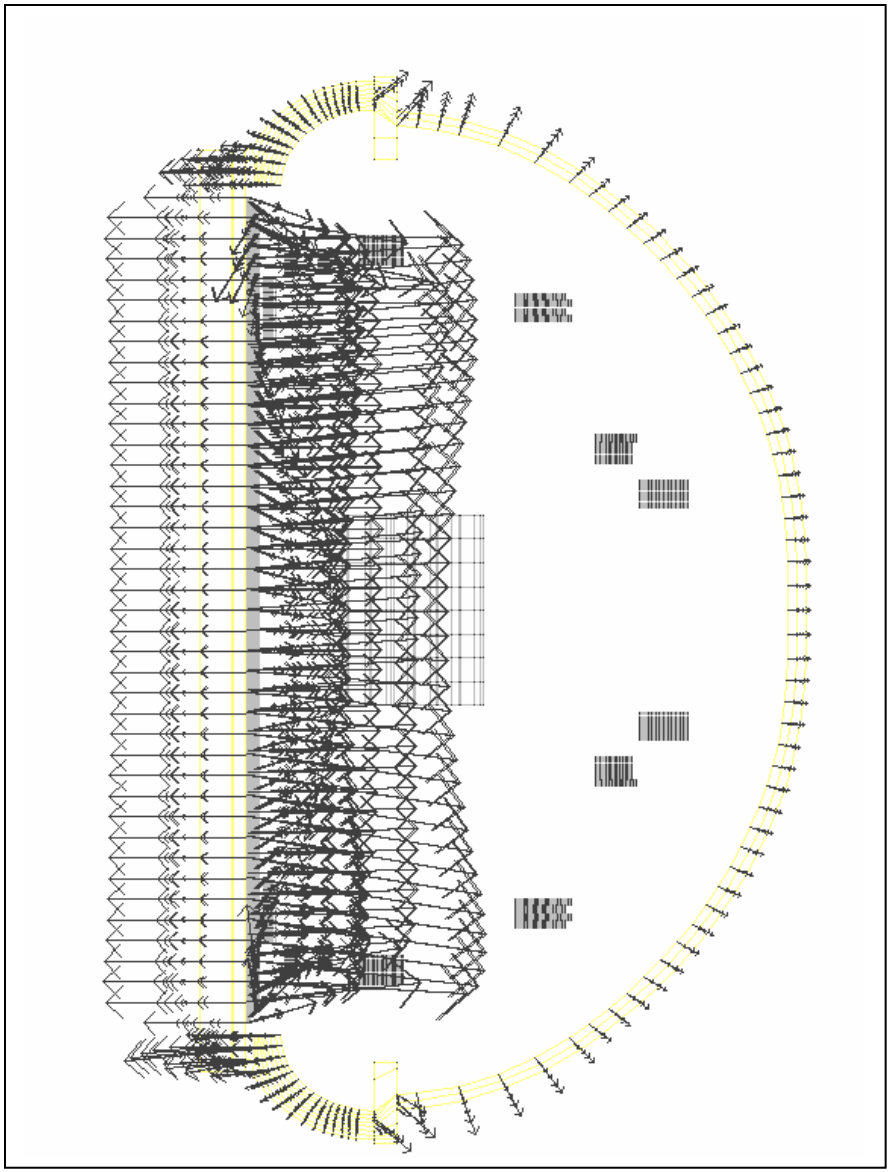


Current Sticks for Biot Savart Computation

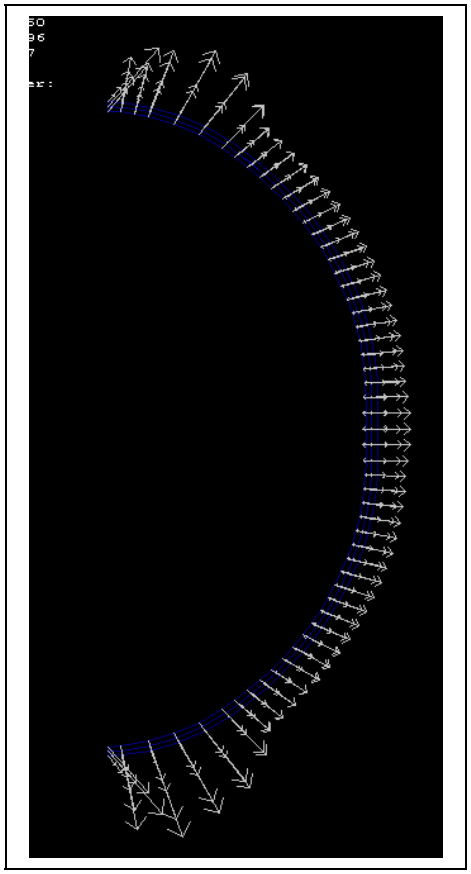
TFON - Flex Concept



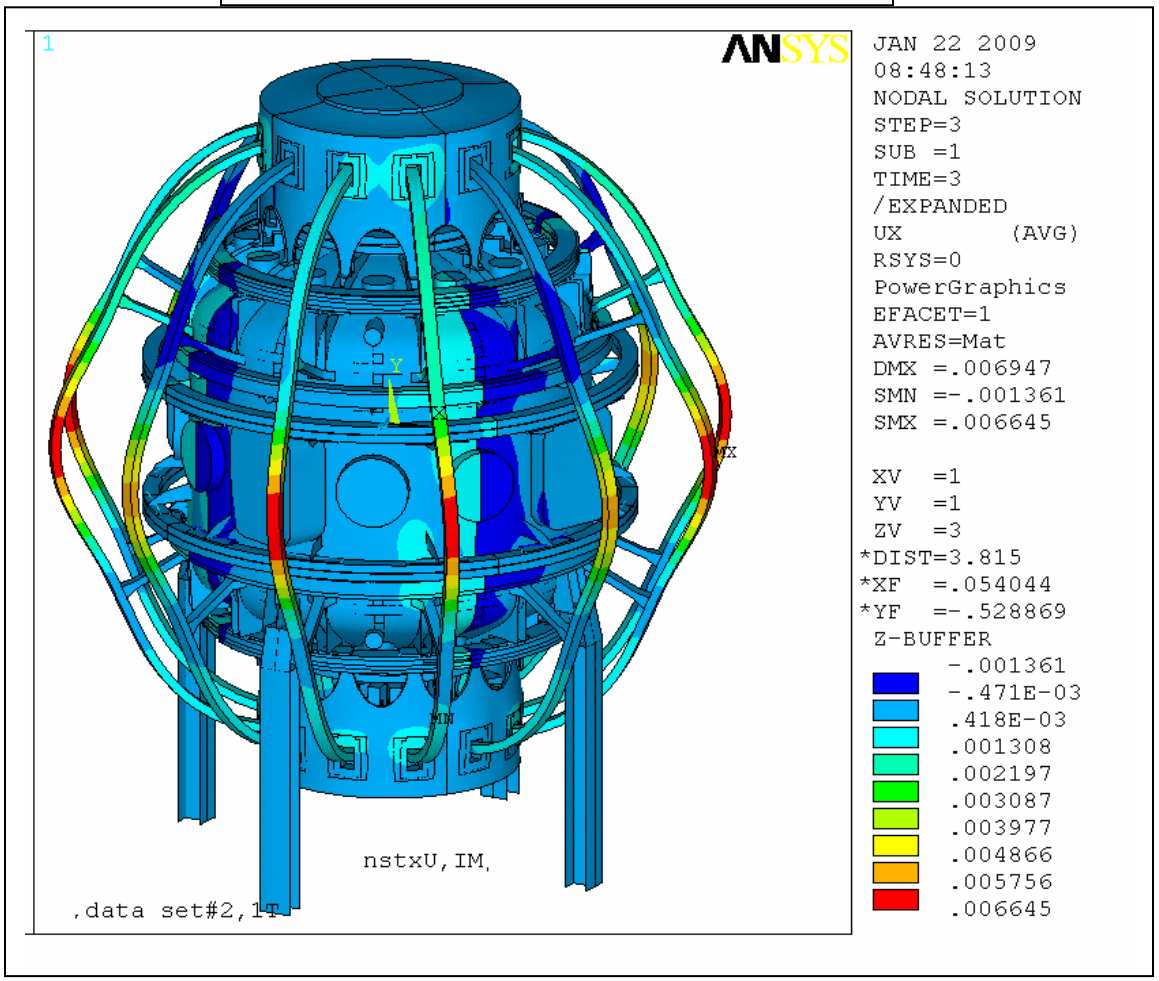
IM –Flex



Am I Ballpark?
Net Outward Force is 778KN
Compared with Han's 2*297 ~594kN

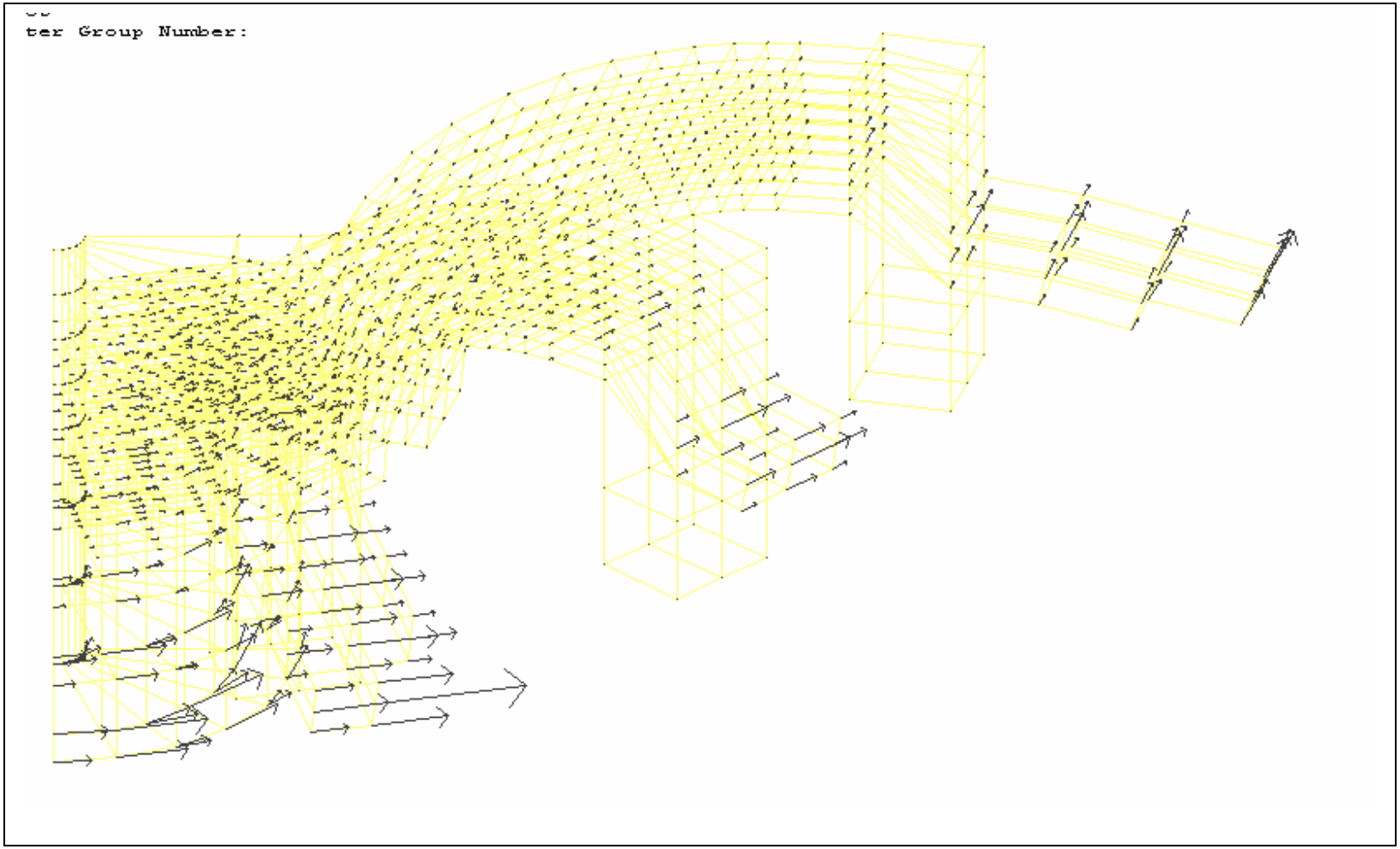


HM's Radial Displacement is .01m

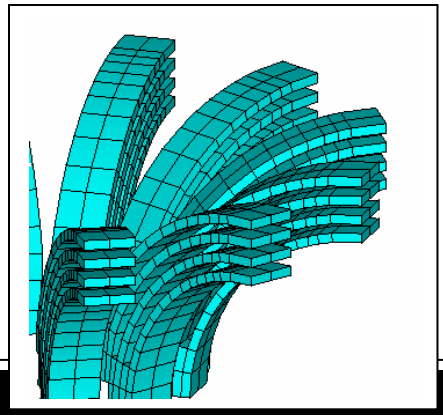


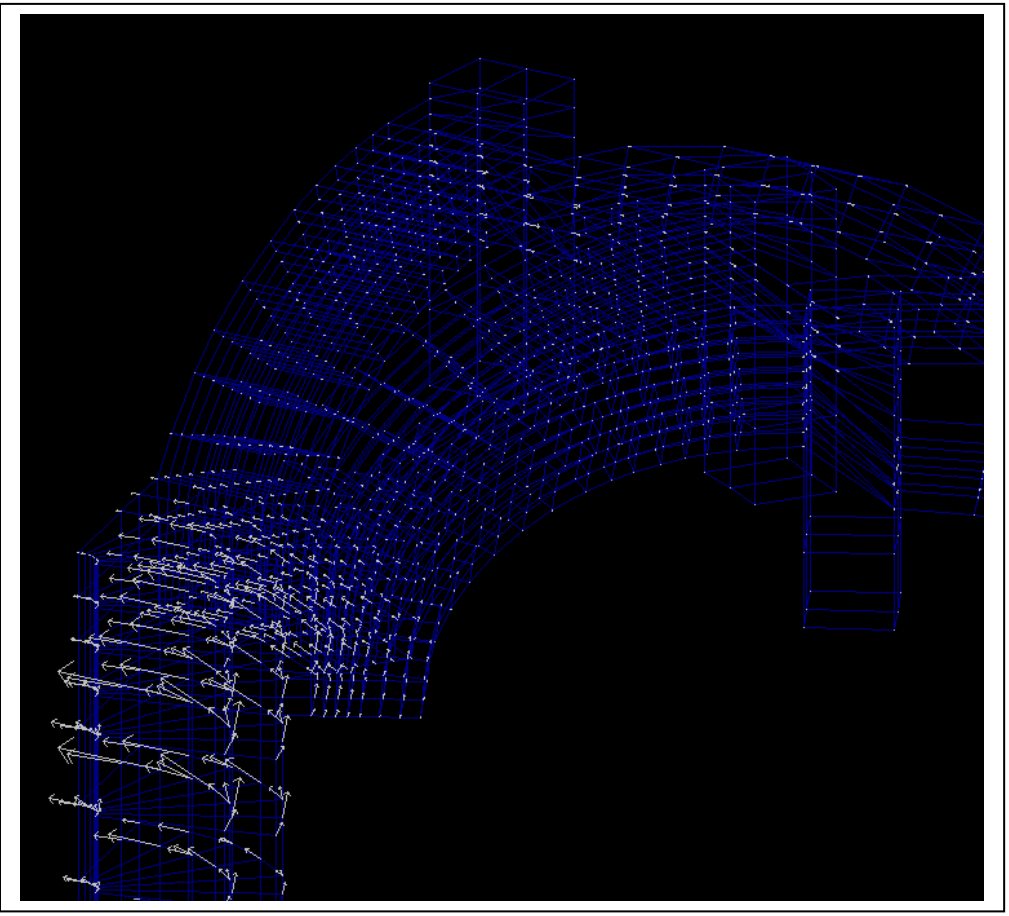
OOP Forces on Bob's Flex Region, Square -.05

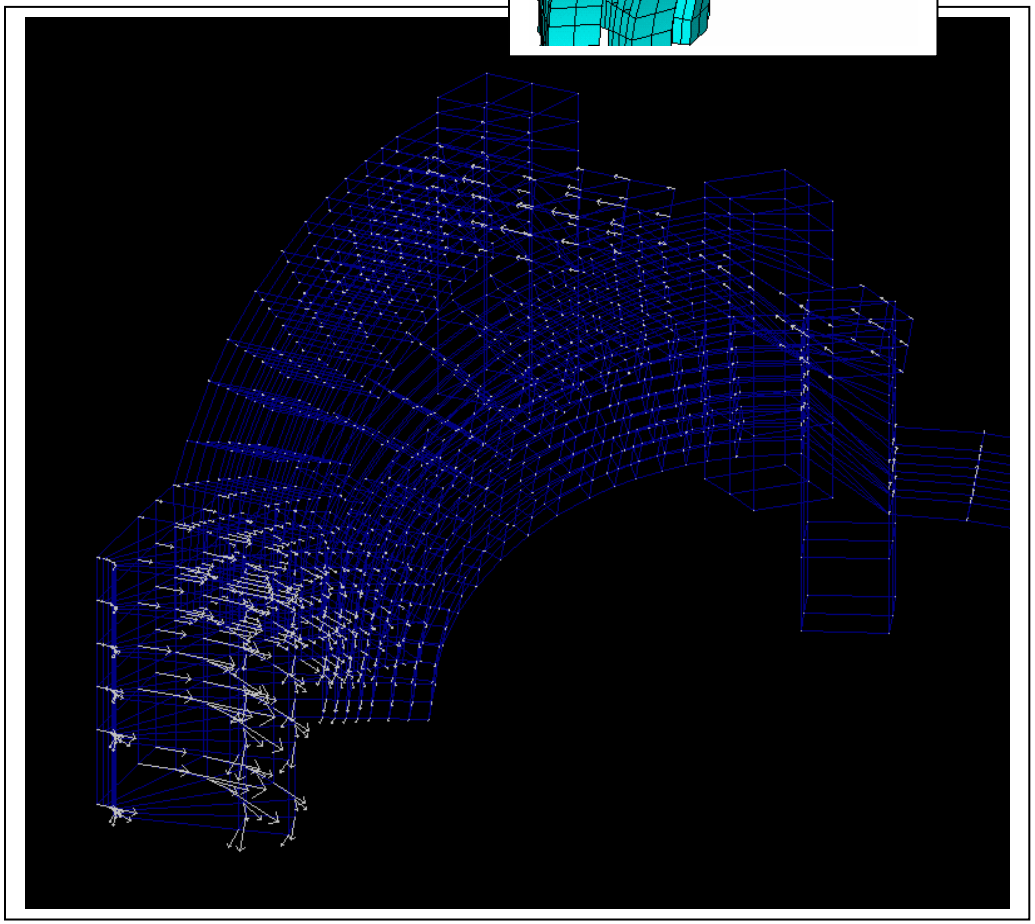
The TF motions impose displacements on the flexes as well as loads. Global model can model compliance and load carrying capacity.



OOP Forces on Bob's Flex Region, IM (Left) Worst1 (Right)

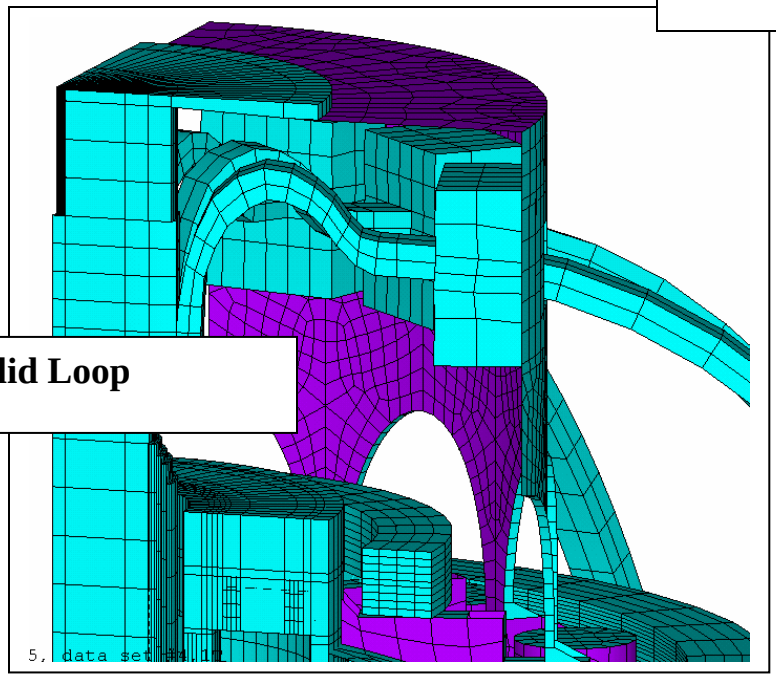


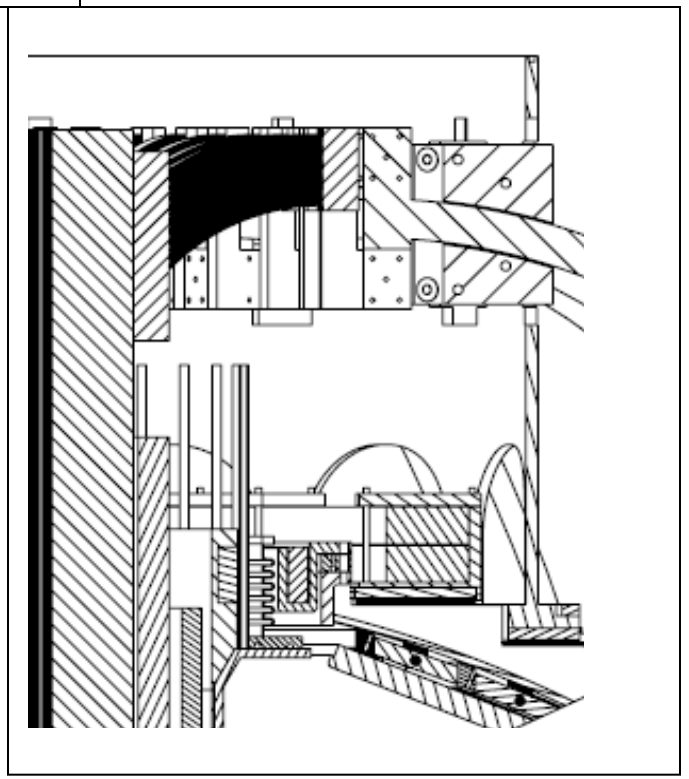




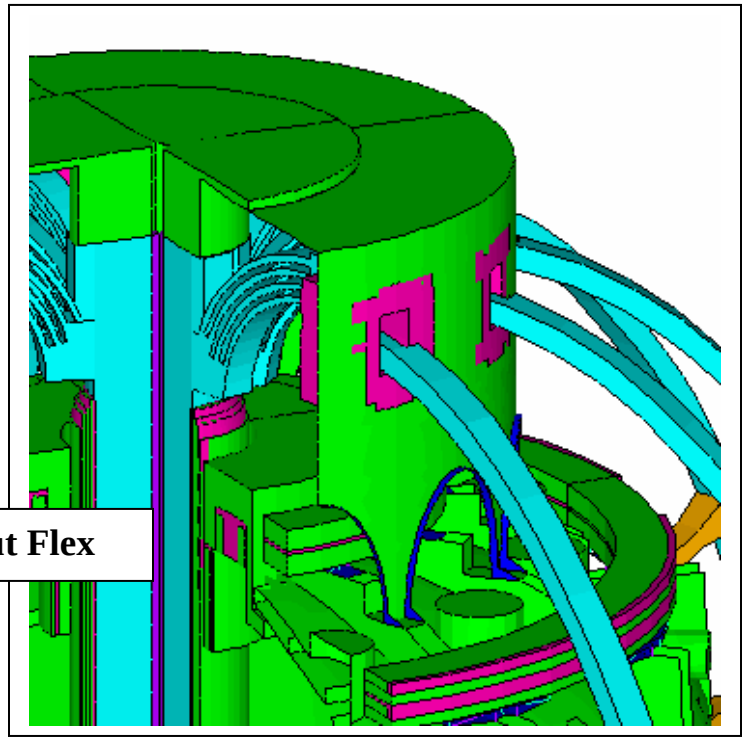
Upper Flex Modeling

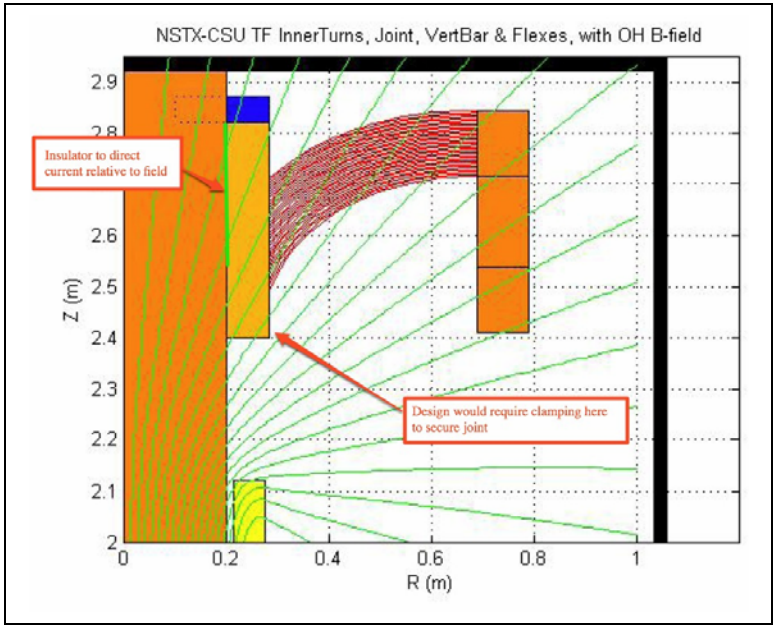
Solid Loop





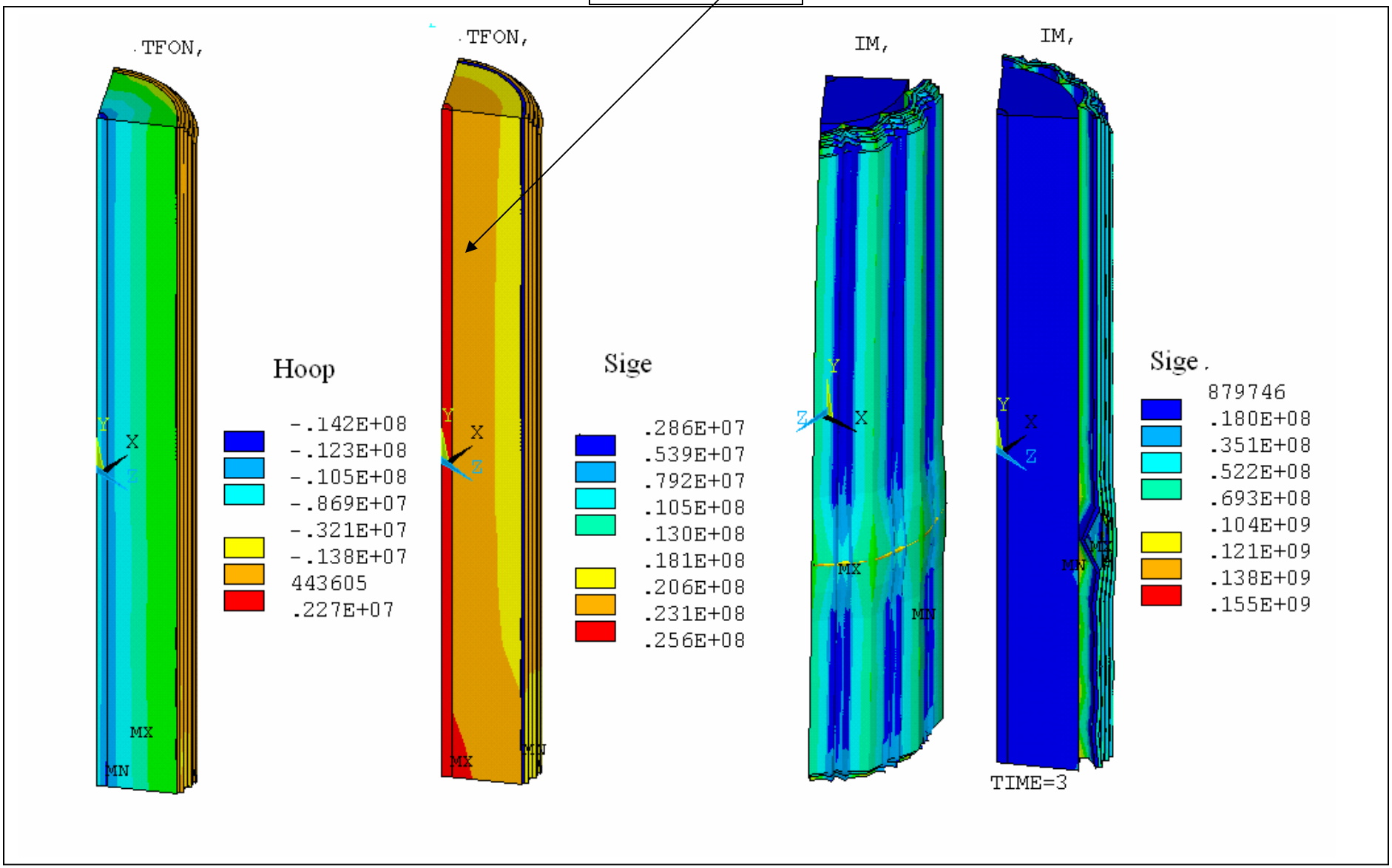
Cut Flex

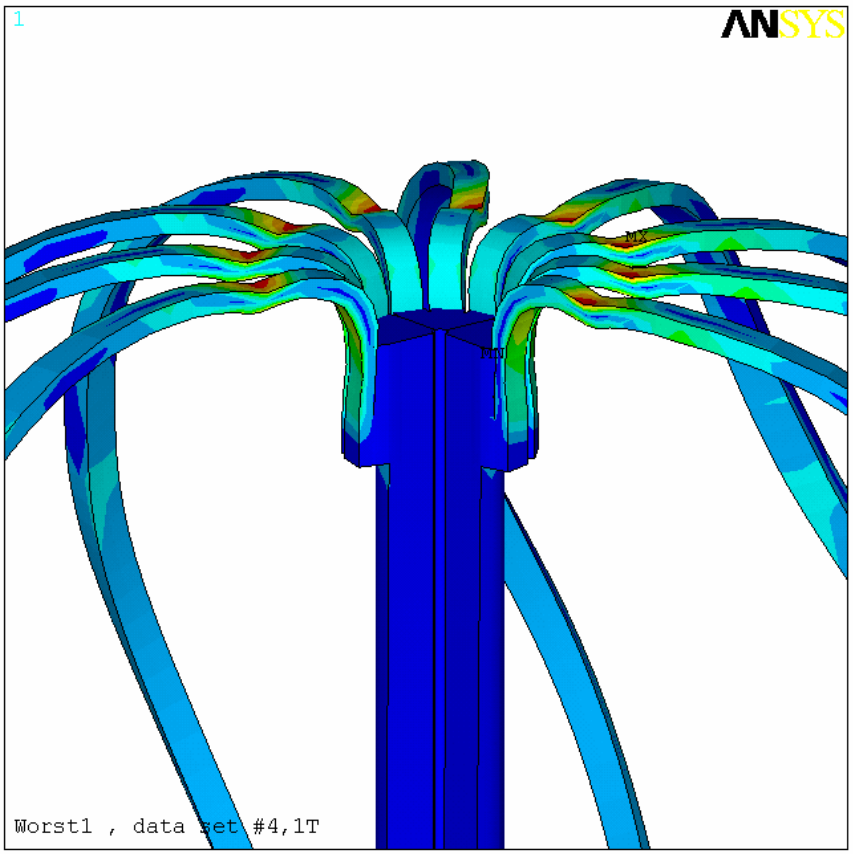




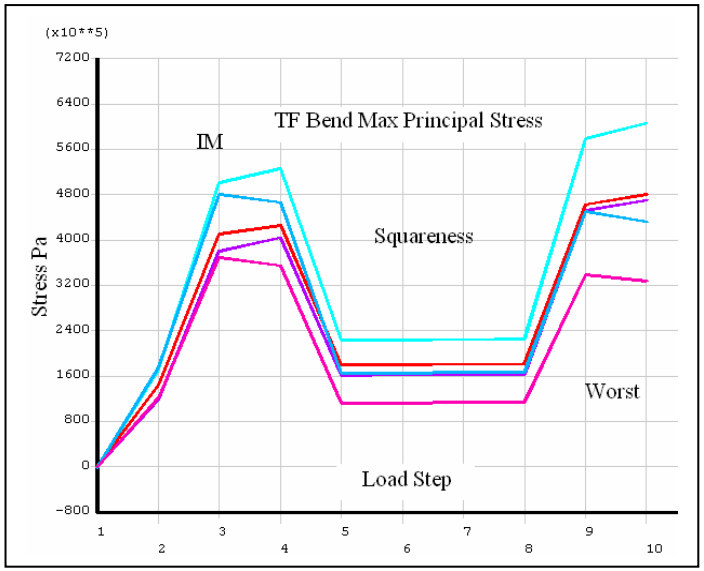
Basic Central Column Stresses
TF and CS are Bonded – Sort of..

Charlie had 30 MPA?

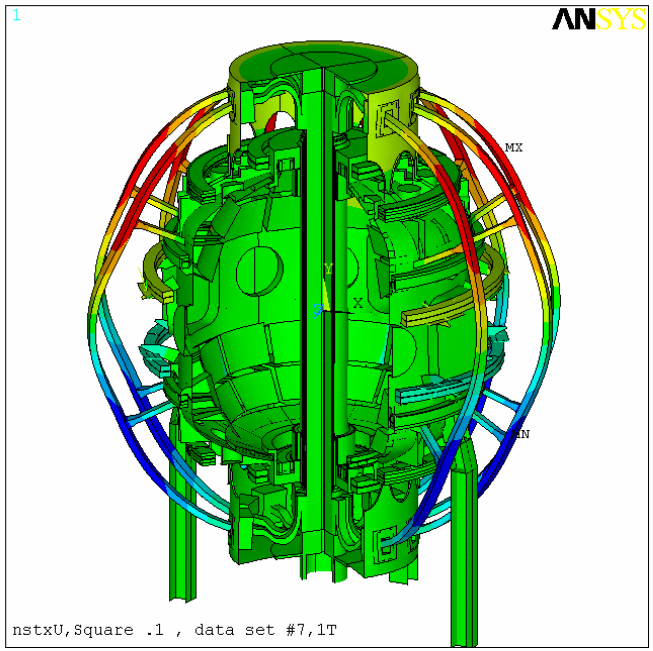


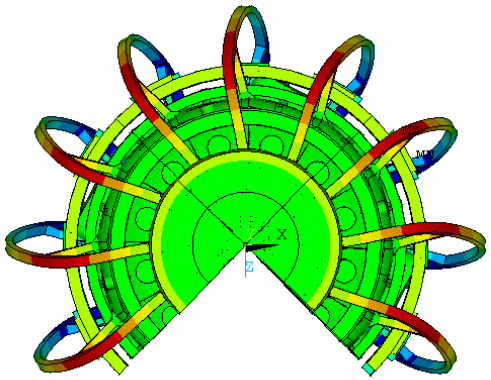


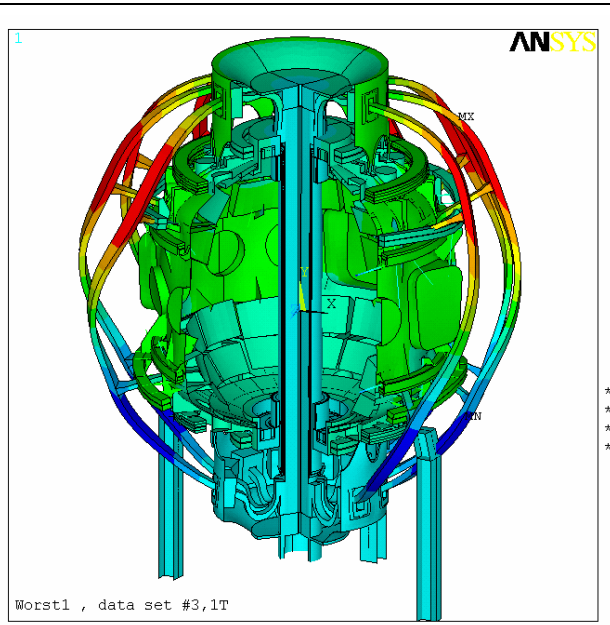
Upper Hub and Joint Stresses
Solid Loop Concept

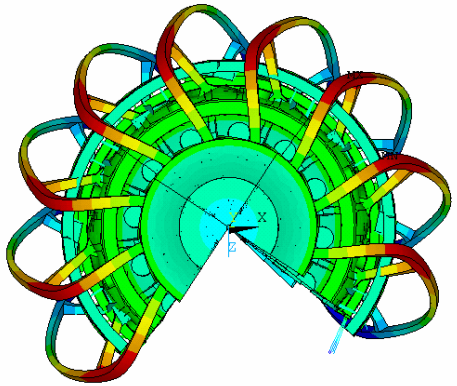


Out-Of-Plane Displacements, Solid Loop Concept

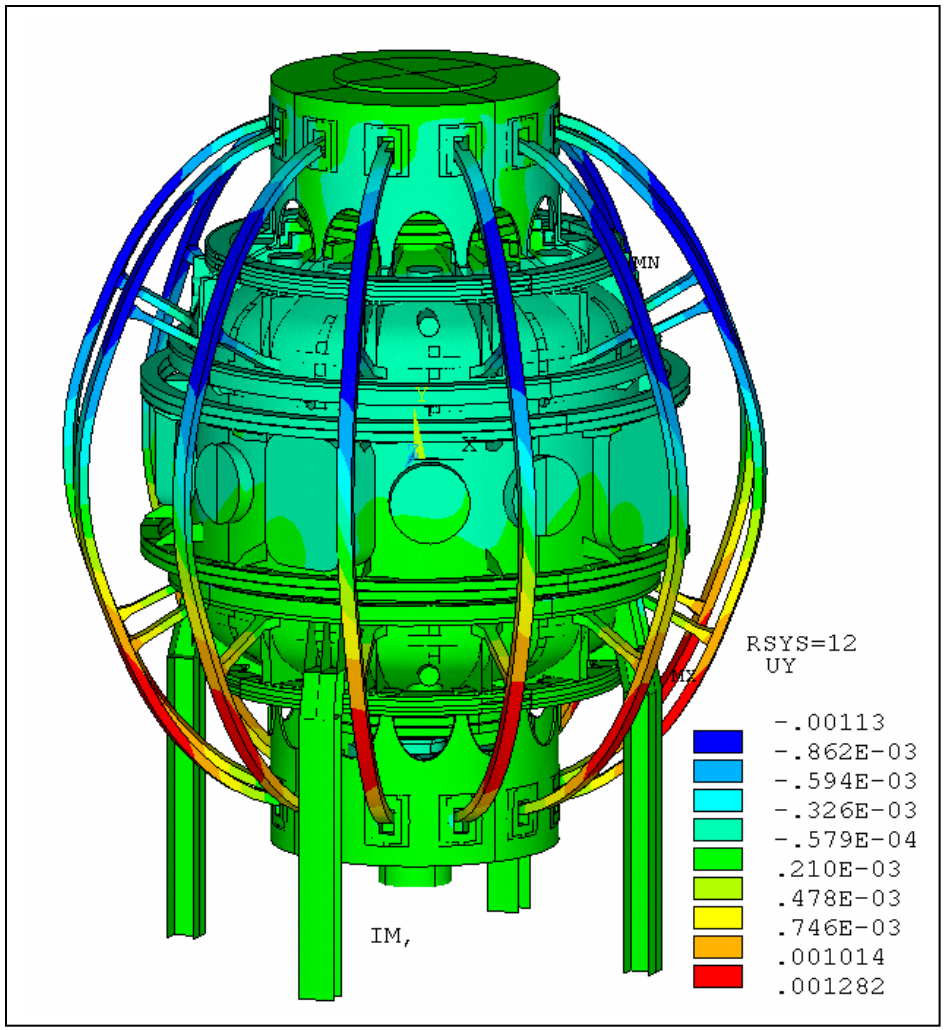


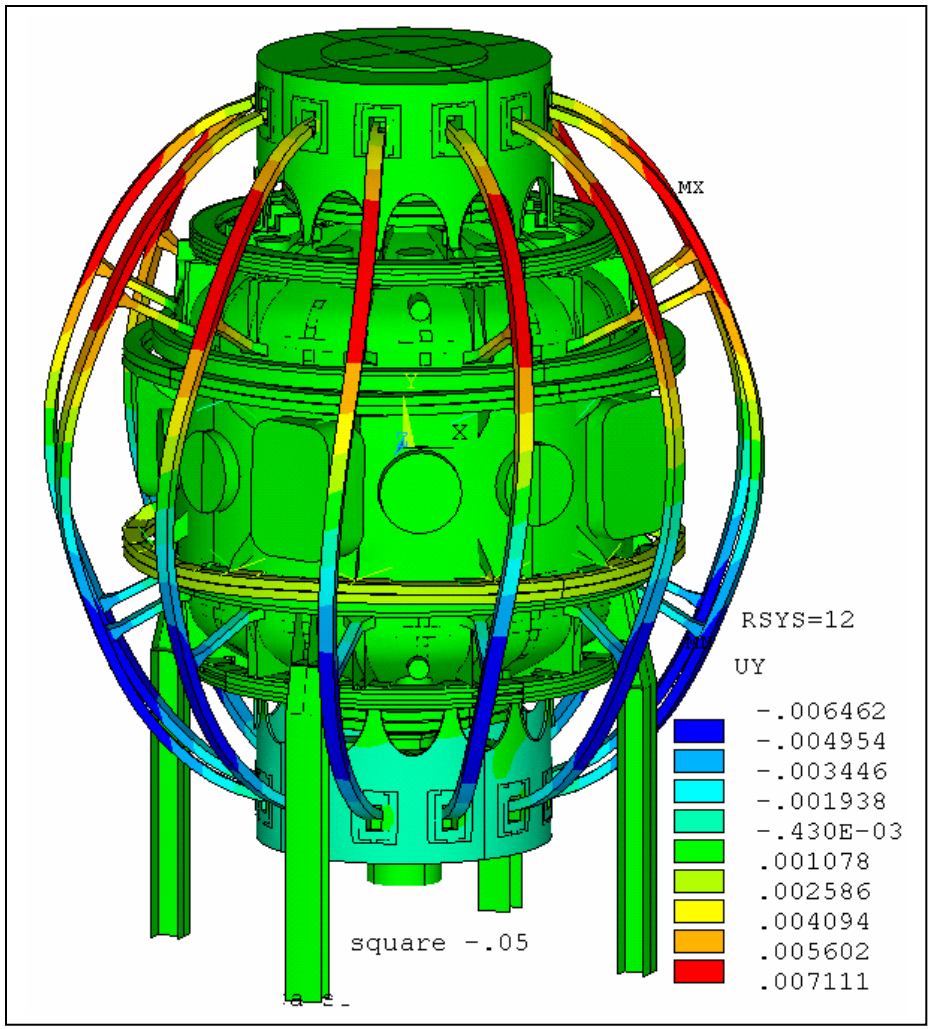




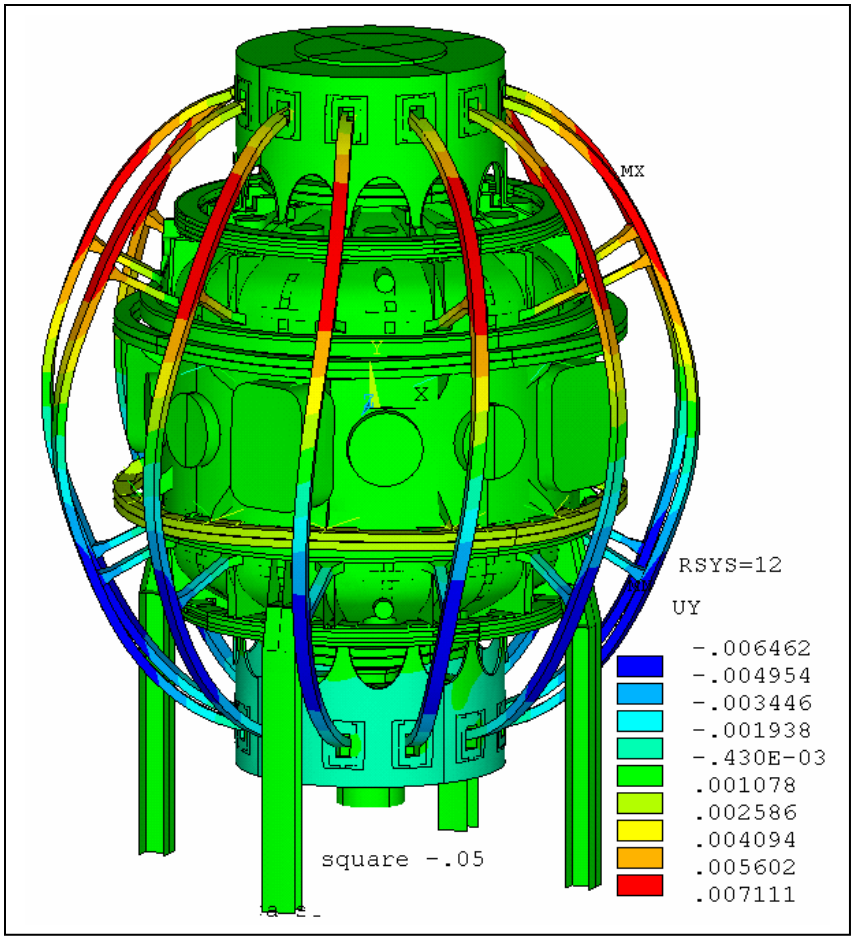


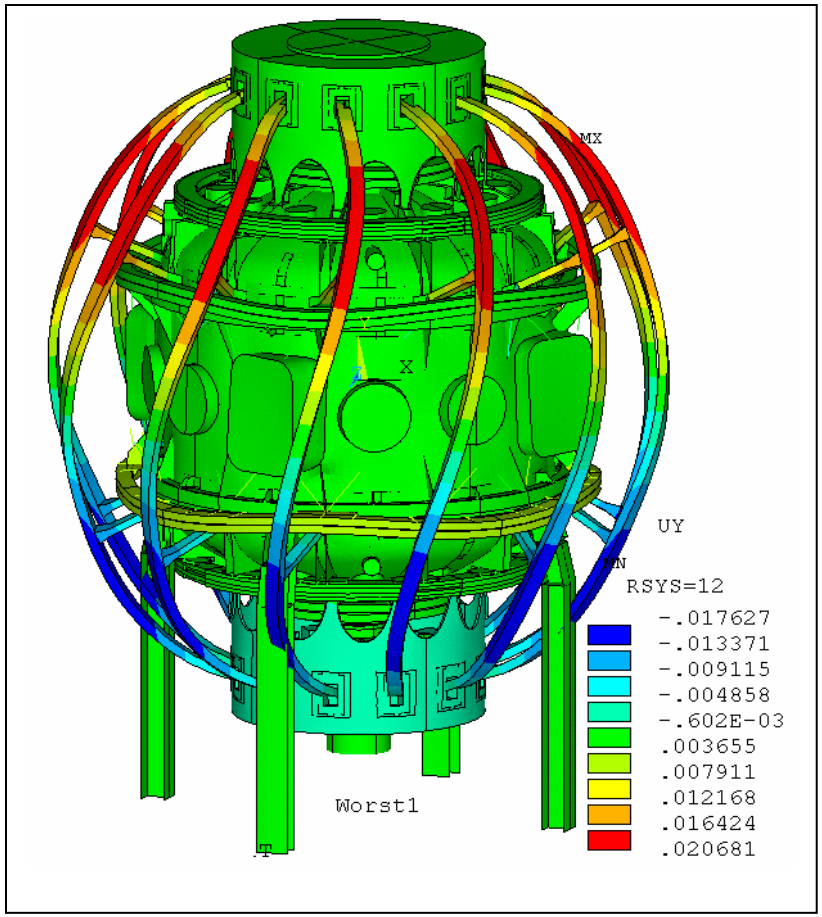
OOP Displacements, Flex Concept, /DSCALE,1,20

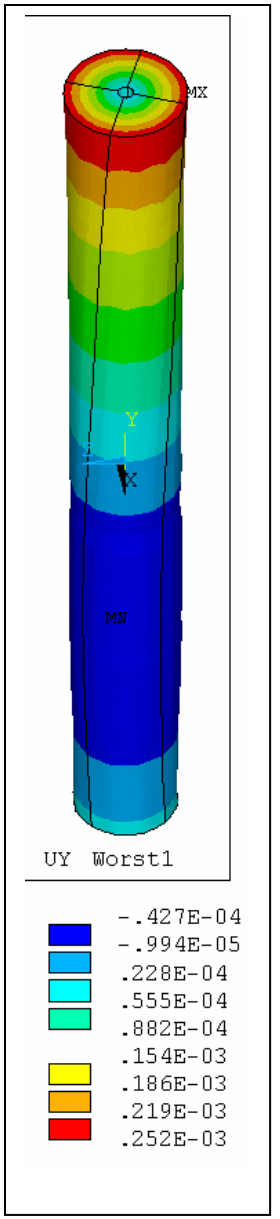


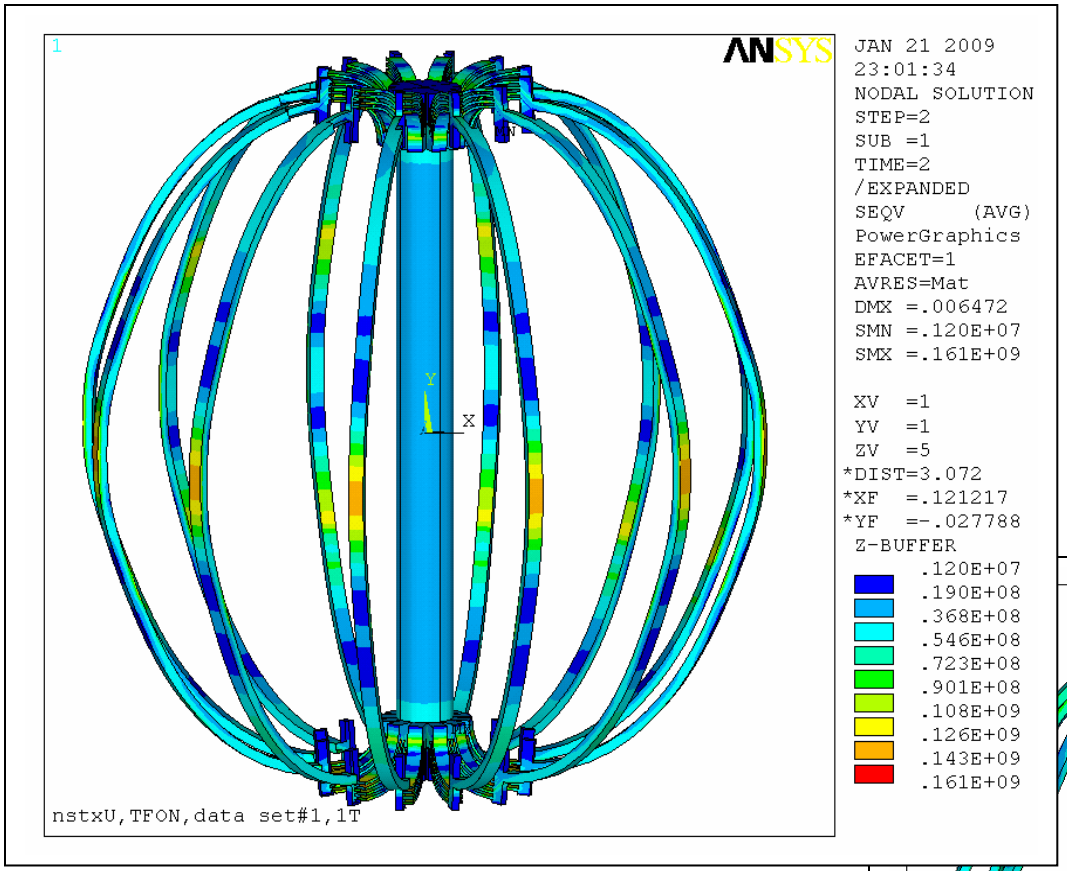


OOP Displacements, Flex Concept, /DSCALE,1,20

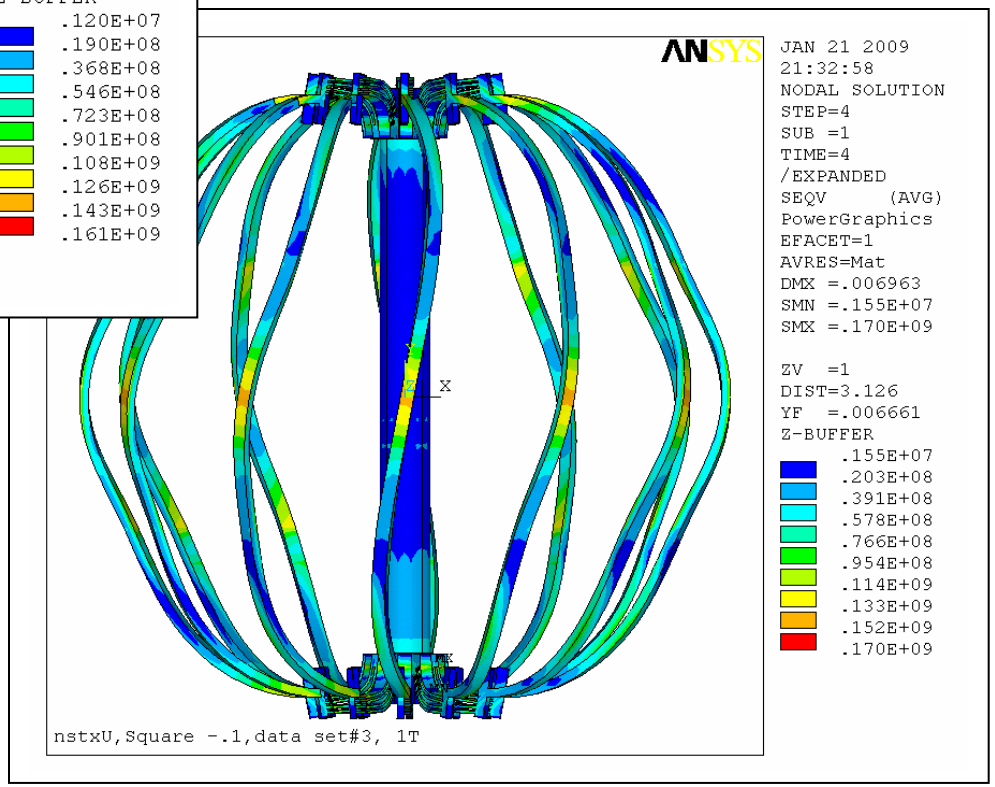




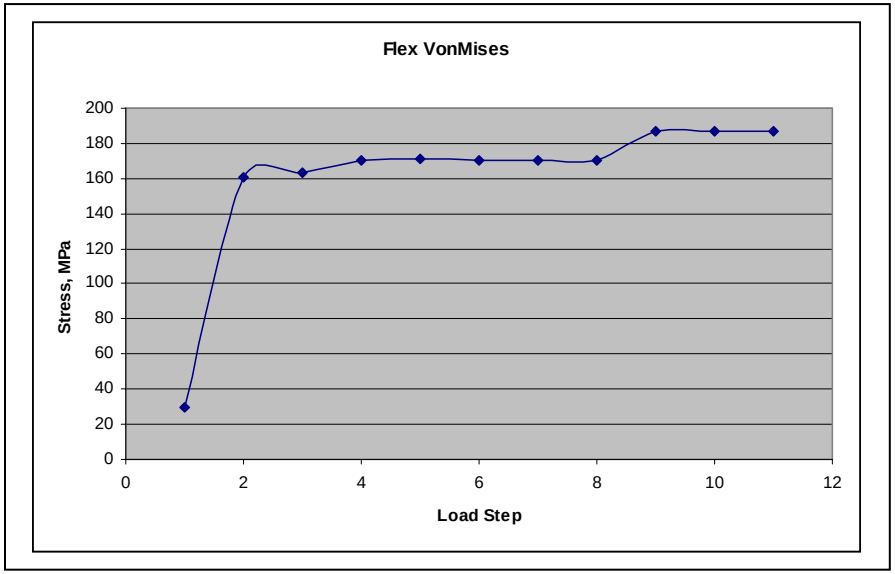


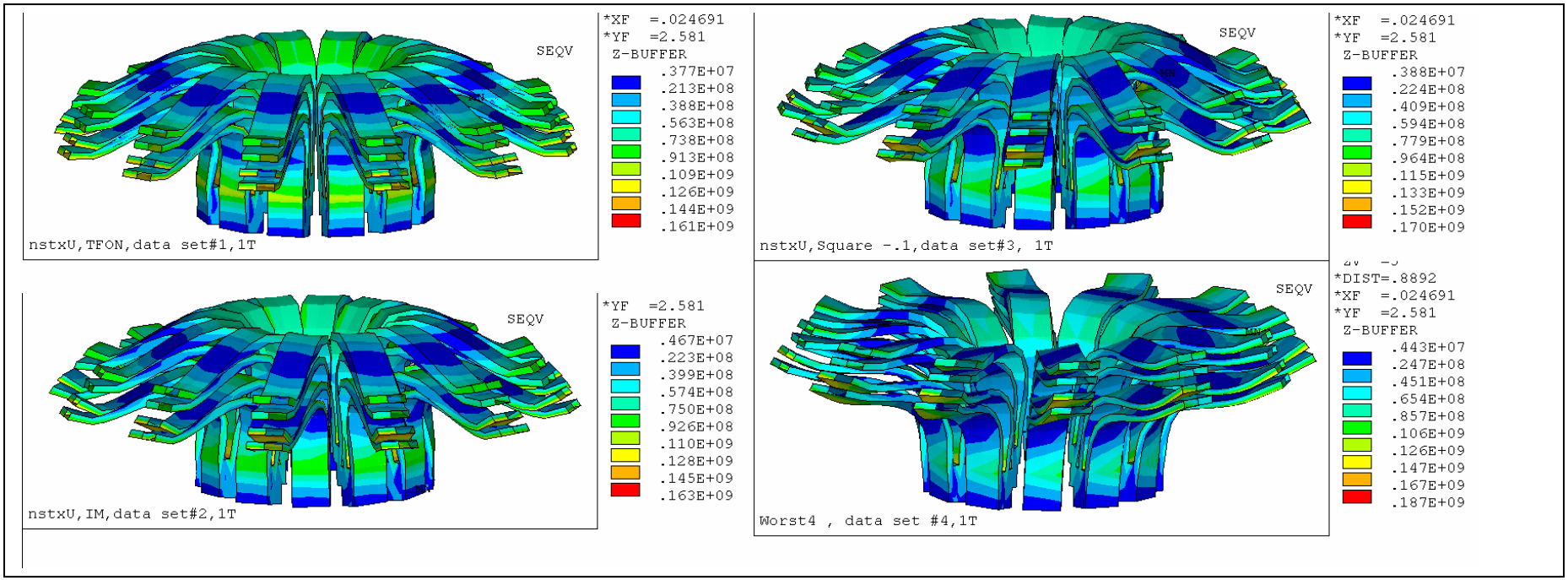


TF Von Mises Stress



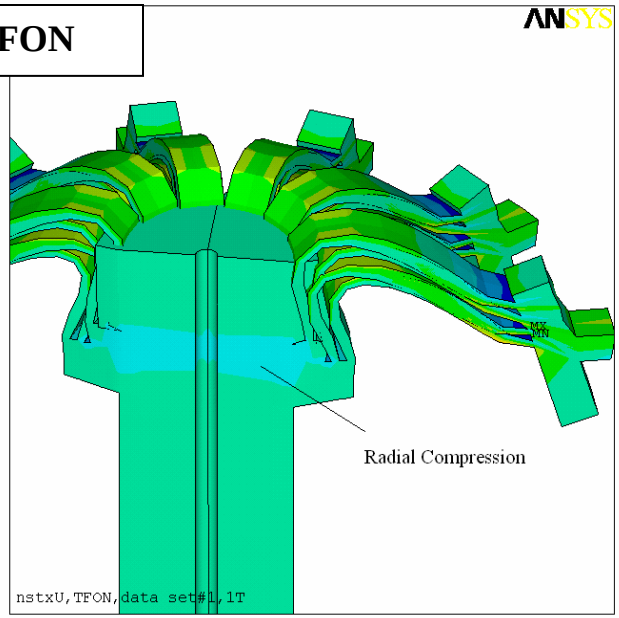
Flex Von Mises Stress



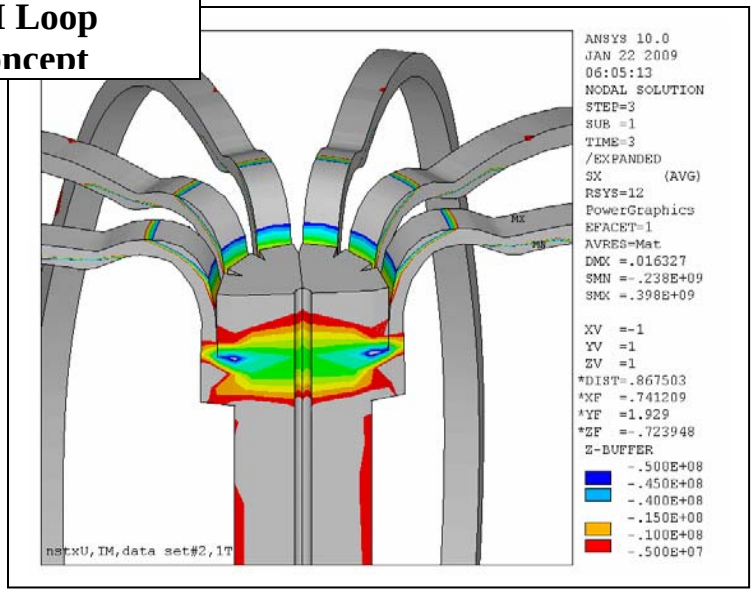


Radial Pressure at the Hub Is Compressive – Aiding Mechanical Connection

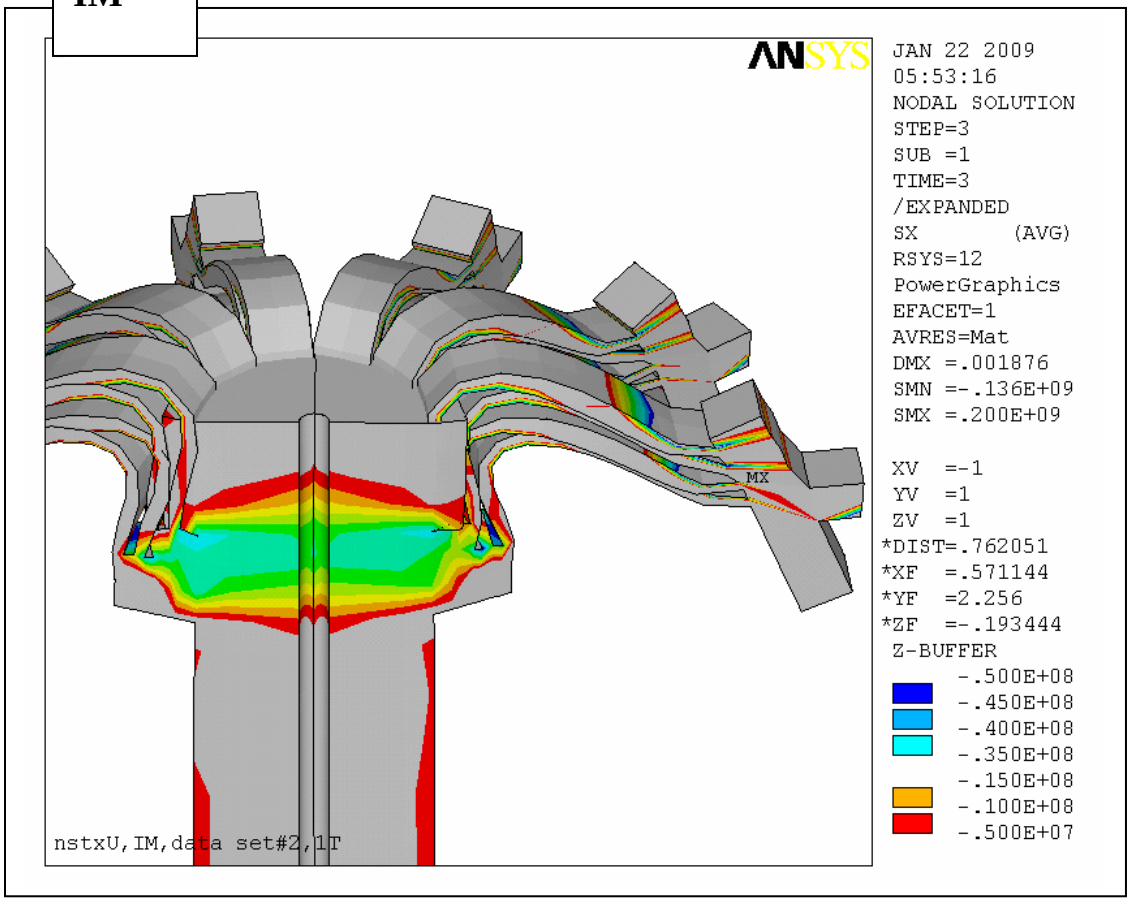
TFON



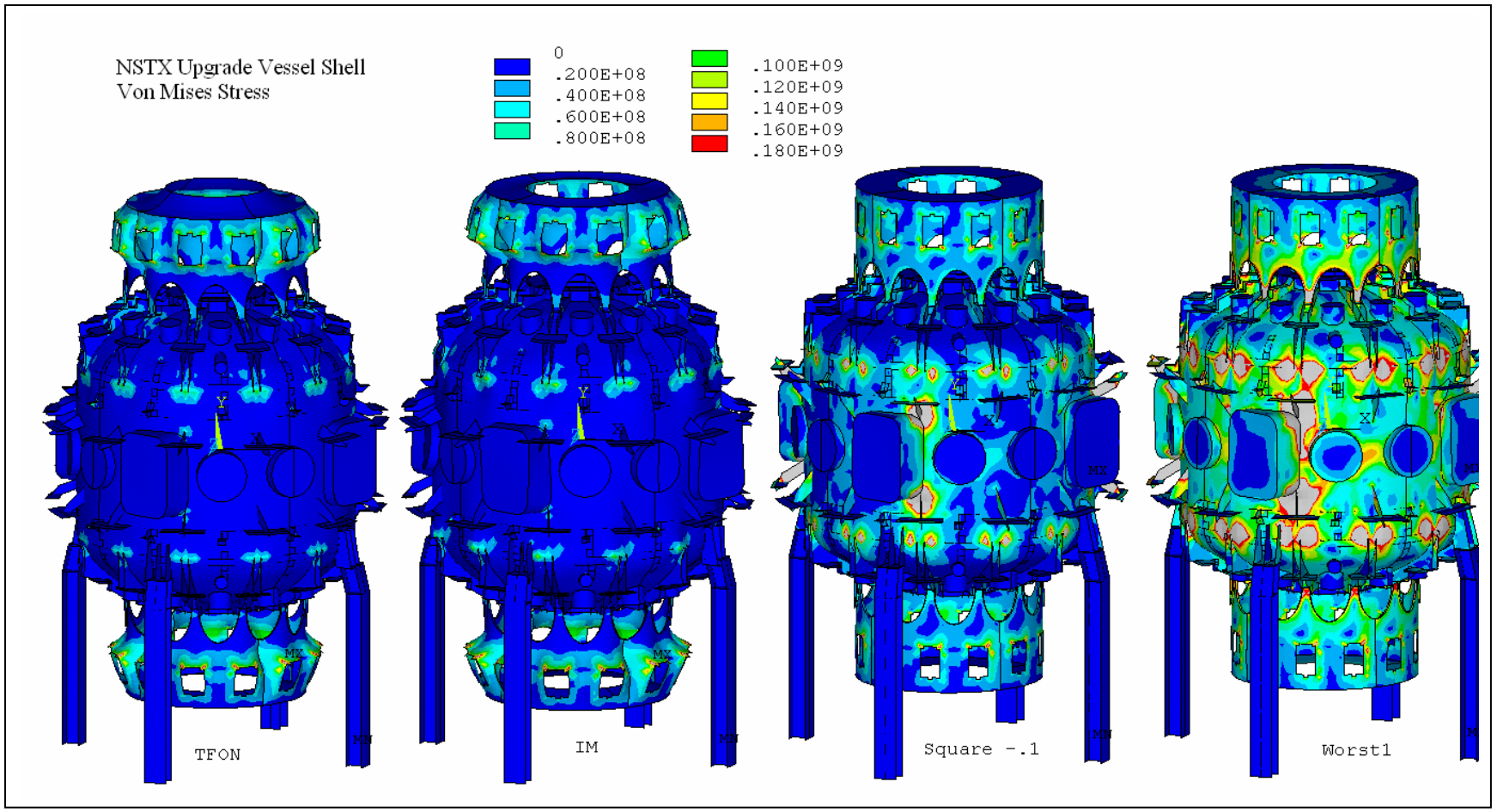
IM Loop Concept



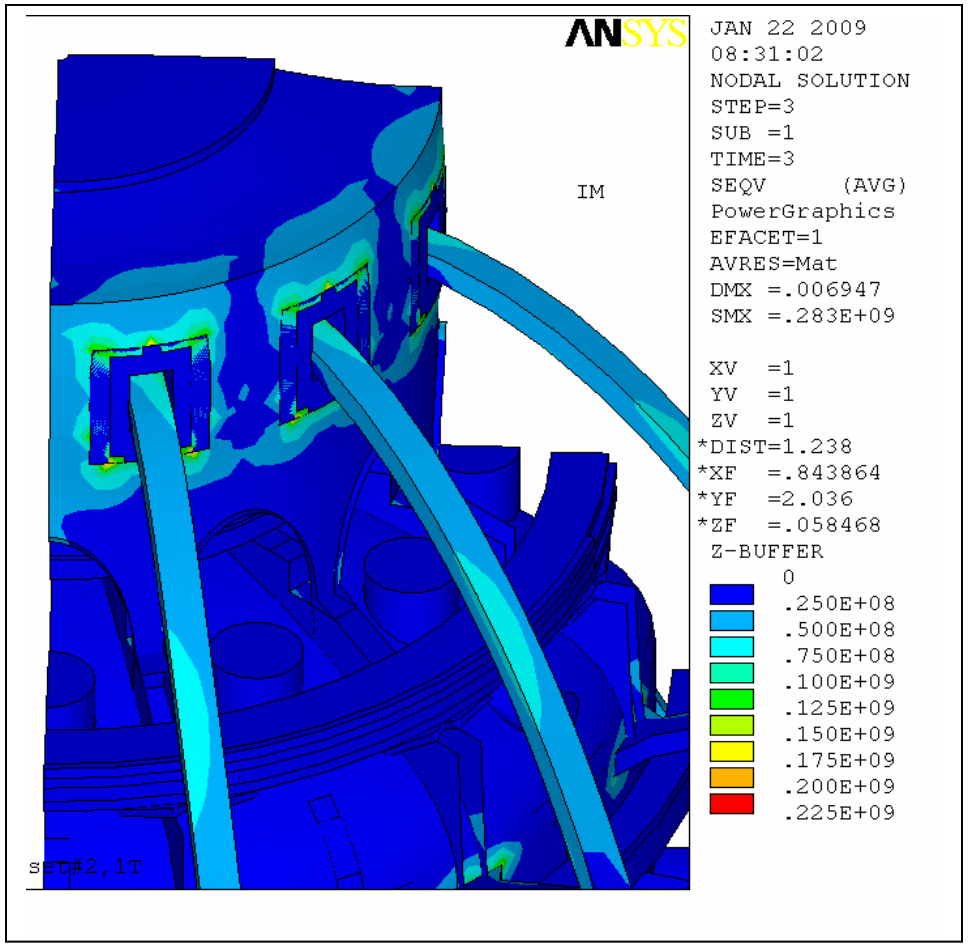
IM

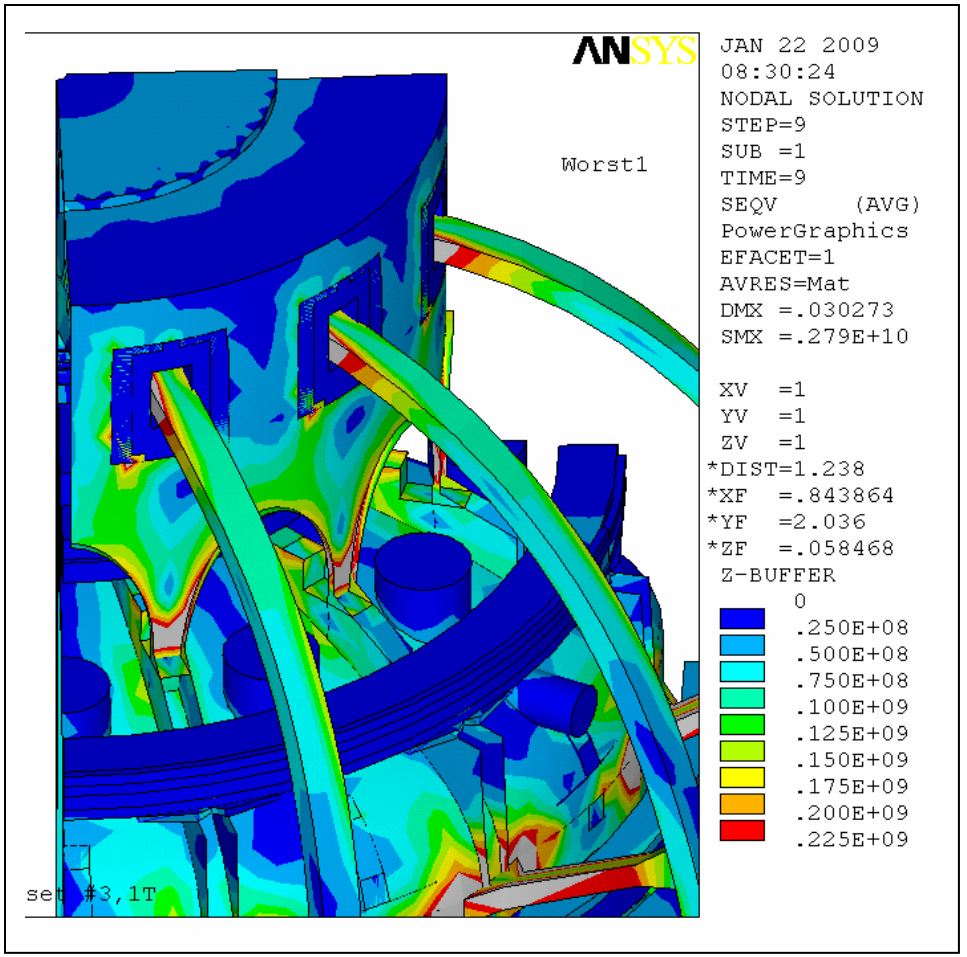


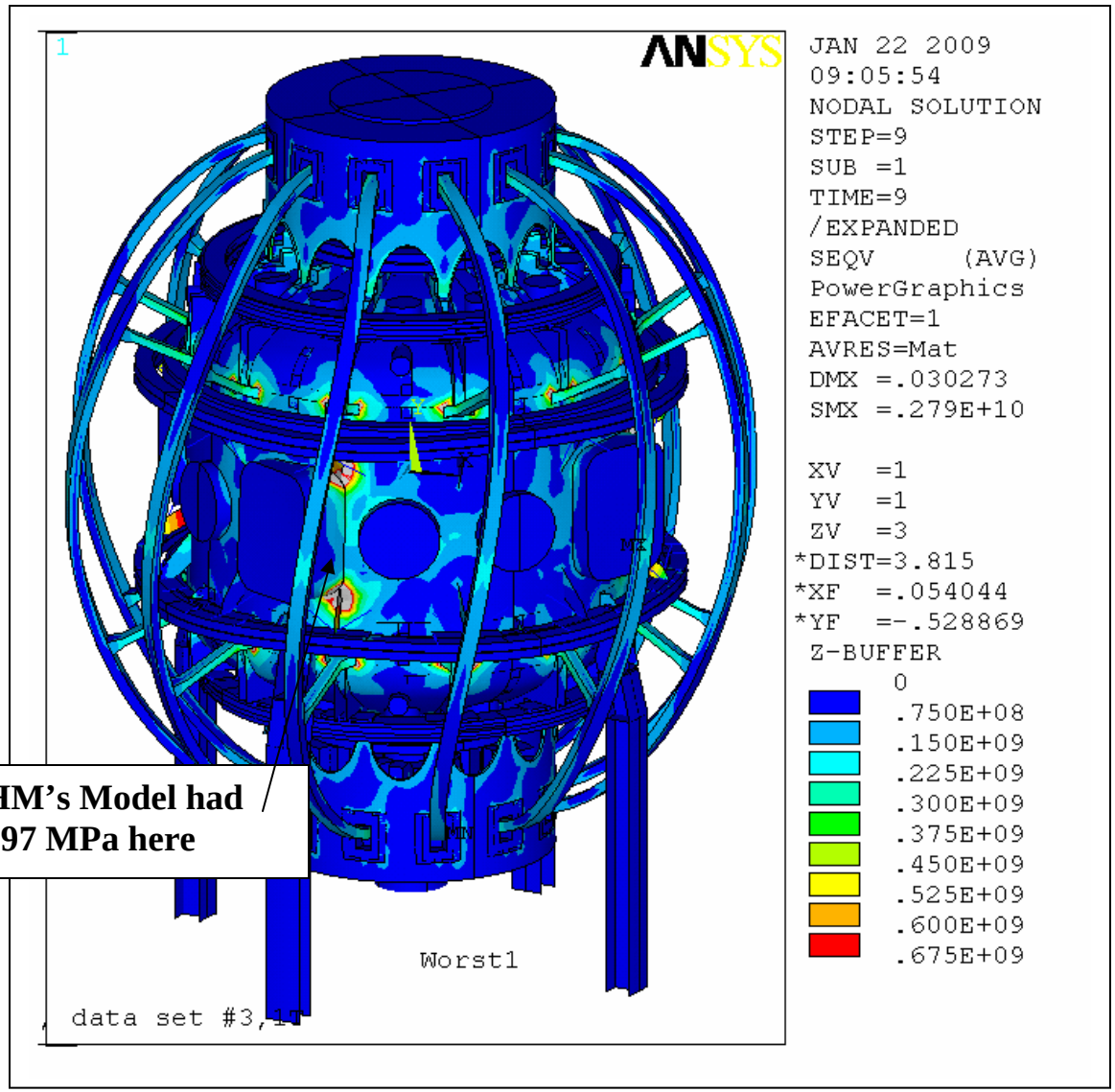
Vessel Shell Stresses

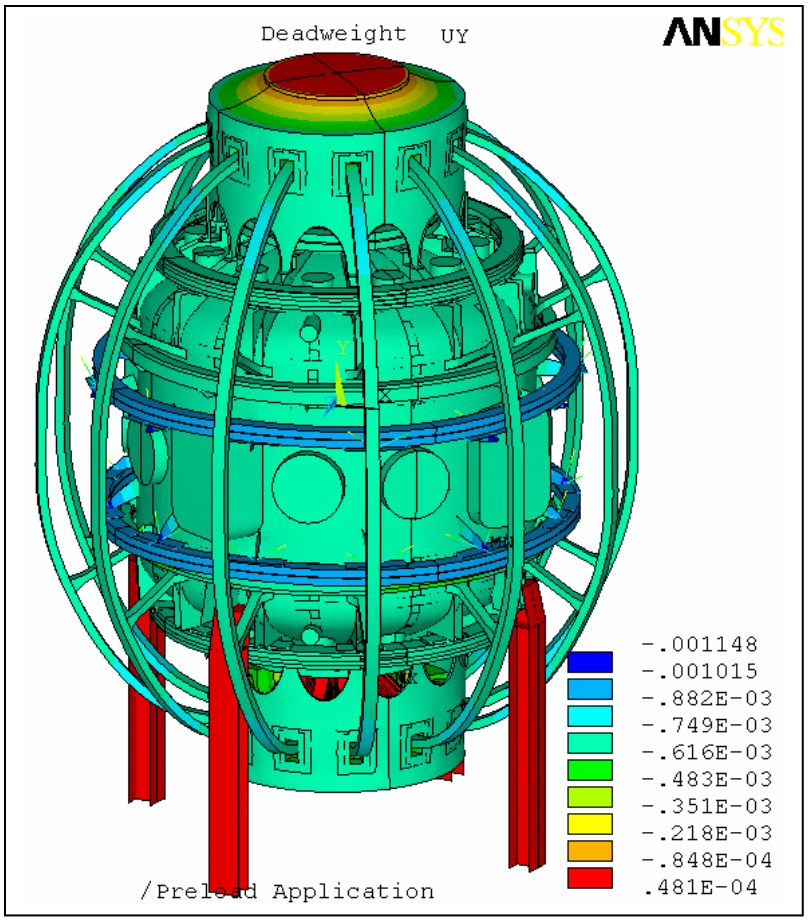


Vessel and TF Local Details

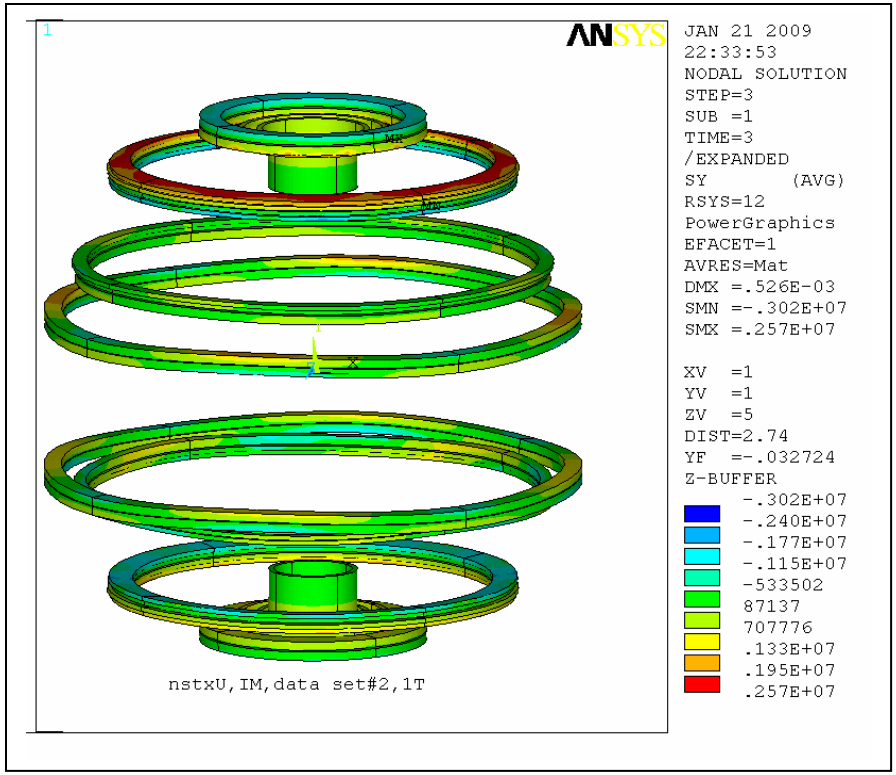


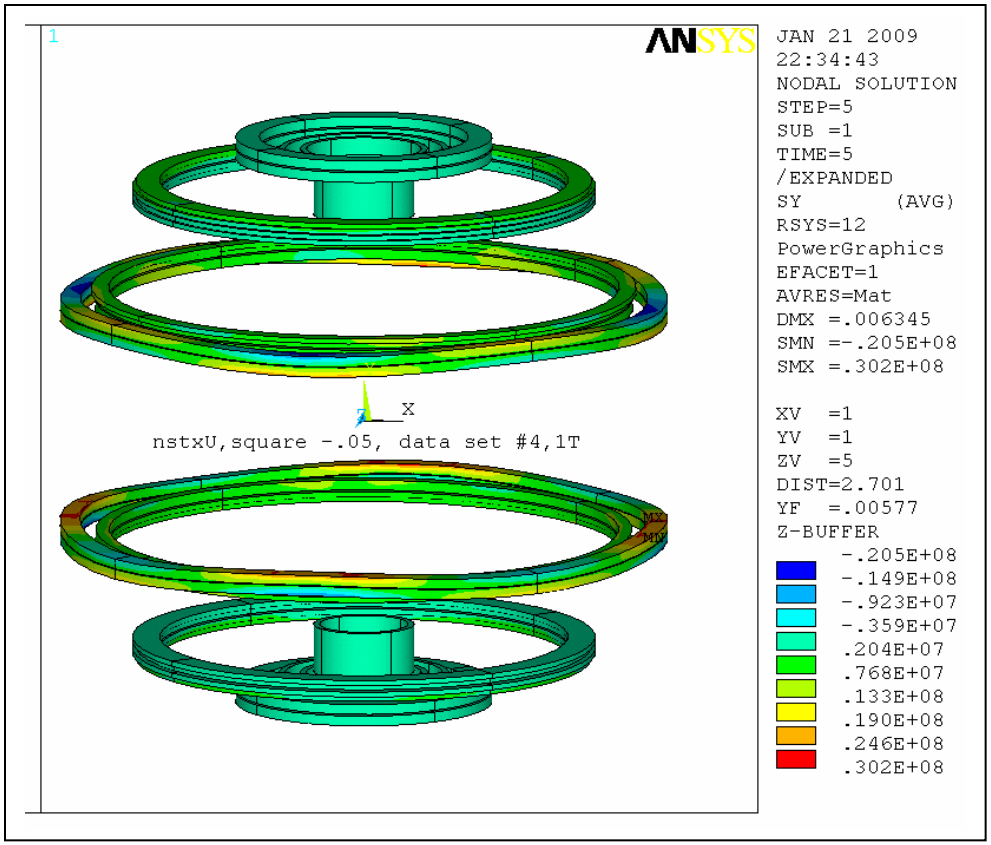



1
ANSYS
JAN 22 2009
09:05:54
NODAL SOLUTION
STEP=9
SUB =1
TIME=9
/EXPANDED
SEQV (AVG)
PowerGraphics
EFACET=1
AVRES=Mat
DMX =.030273
SMX =.279E+10
XV =1
YV =1
ZV =3
*DIST=3.815
*XF =.054044
*YF =-.528869
Z-BUFFER
0
.750E+08
.150E+09
.225E+09
.300E+09
.375E+09
.450E+09
.525E+09
.600E+09
.675E+09
Worst1
data set #3,1
HM's Model had
397 MPa here


Deadweight UY
ANSYS
-.001148
-.001015
-.882E-03
-.749E-03
-.616E-03
-.483E-03
-.351E-03
-.218E-03
-.848E-04
.481E-04
/Preload Application

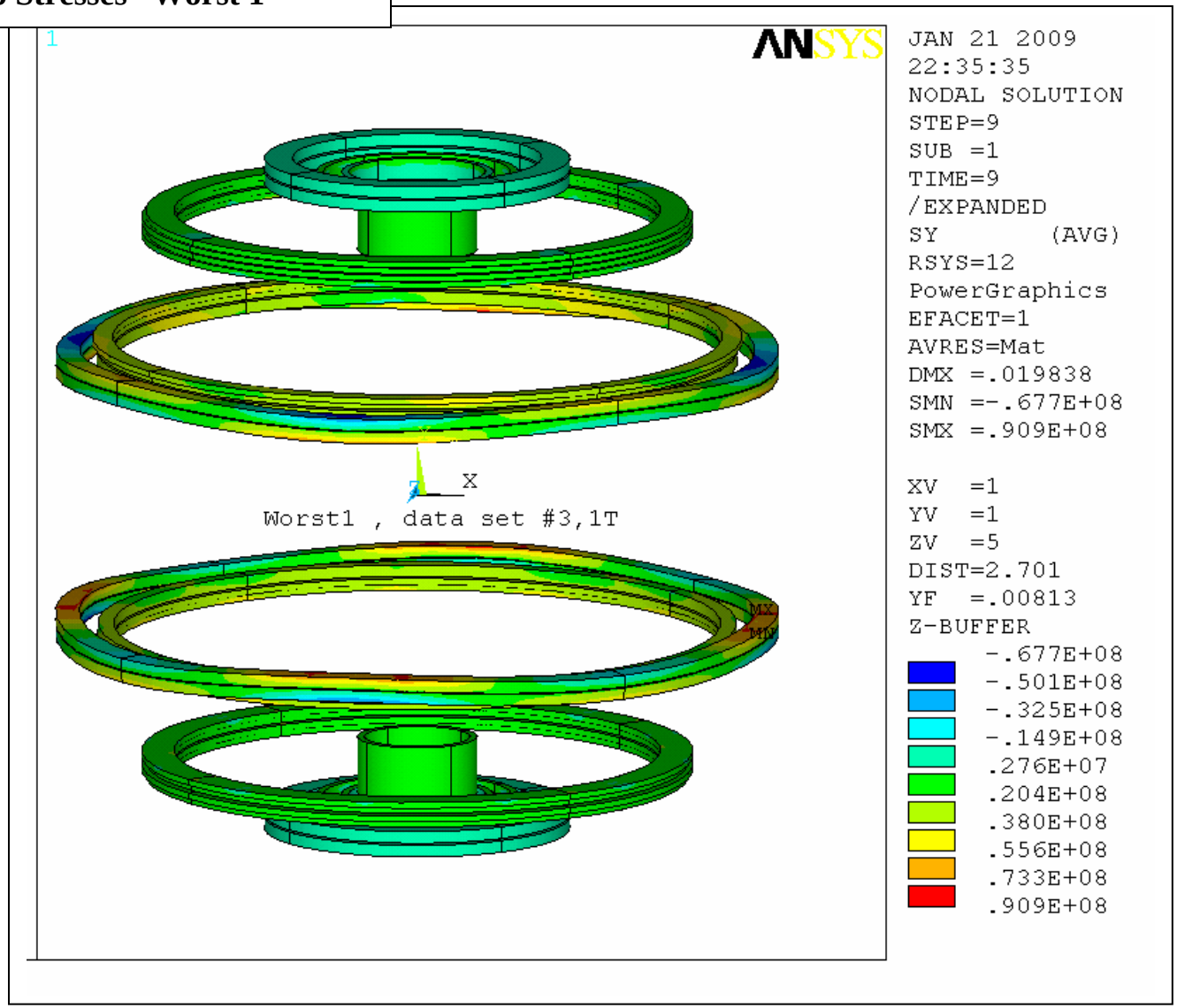
PF Coil Hoop Stresses





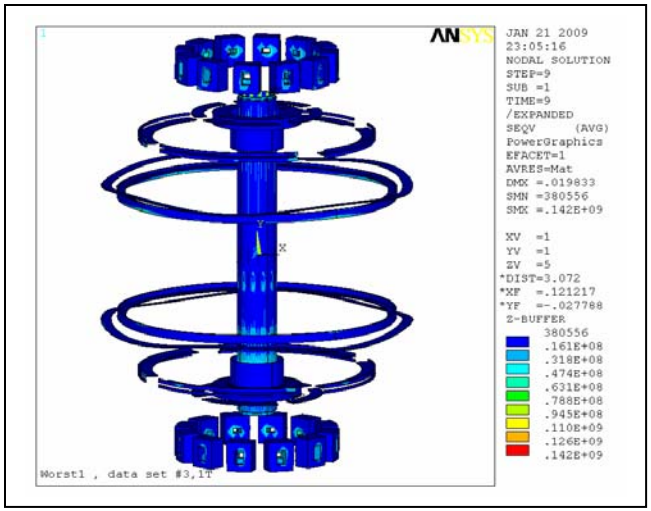
Normal Operation Looks Benign

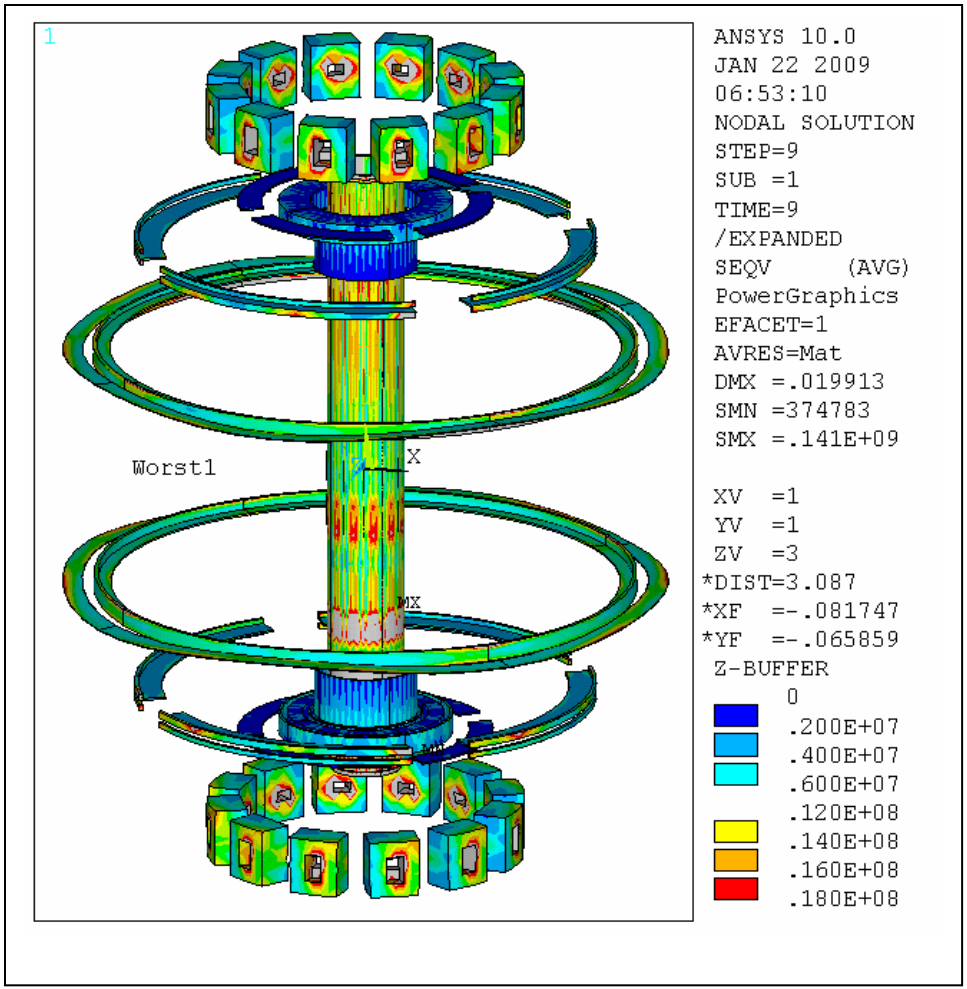
PF Coil Hoop Stresses “Worst 1”

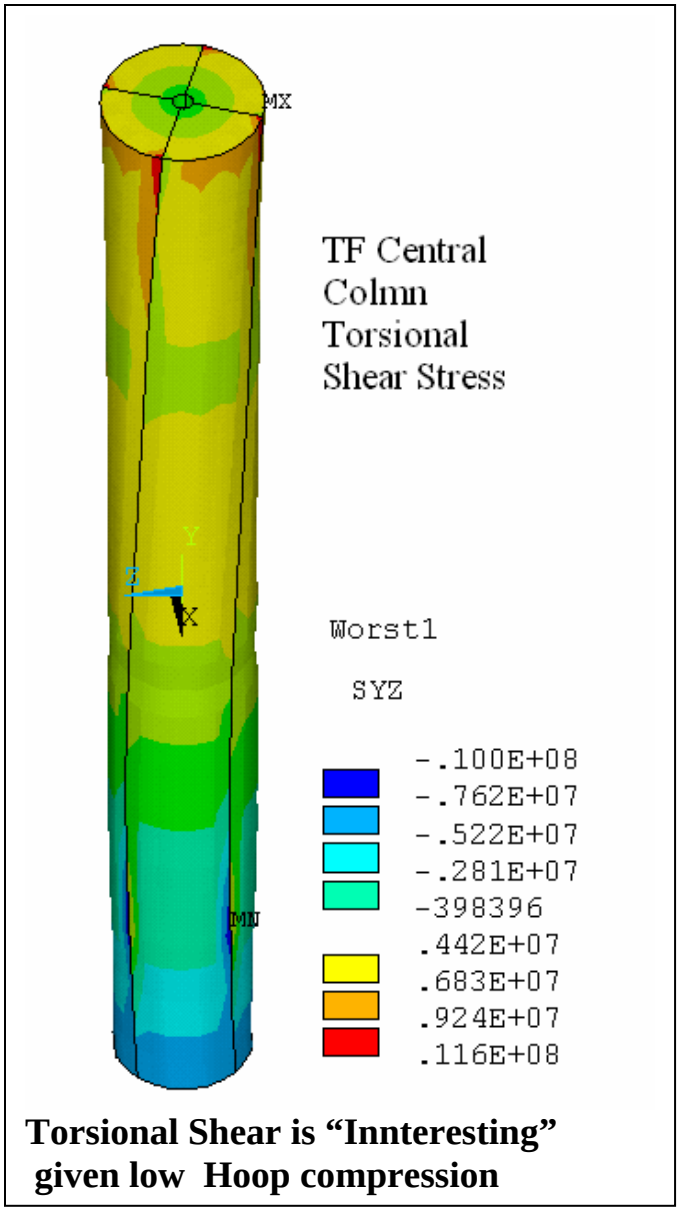


“Worst” Currents Interesting”

Insulation Stress

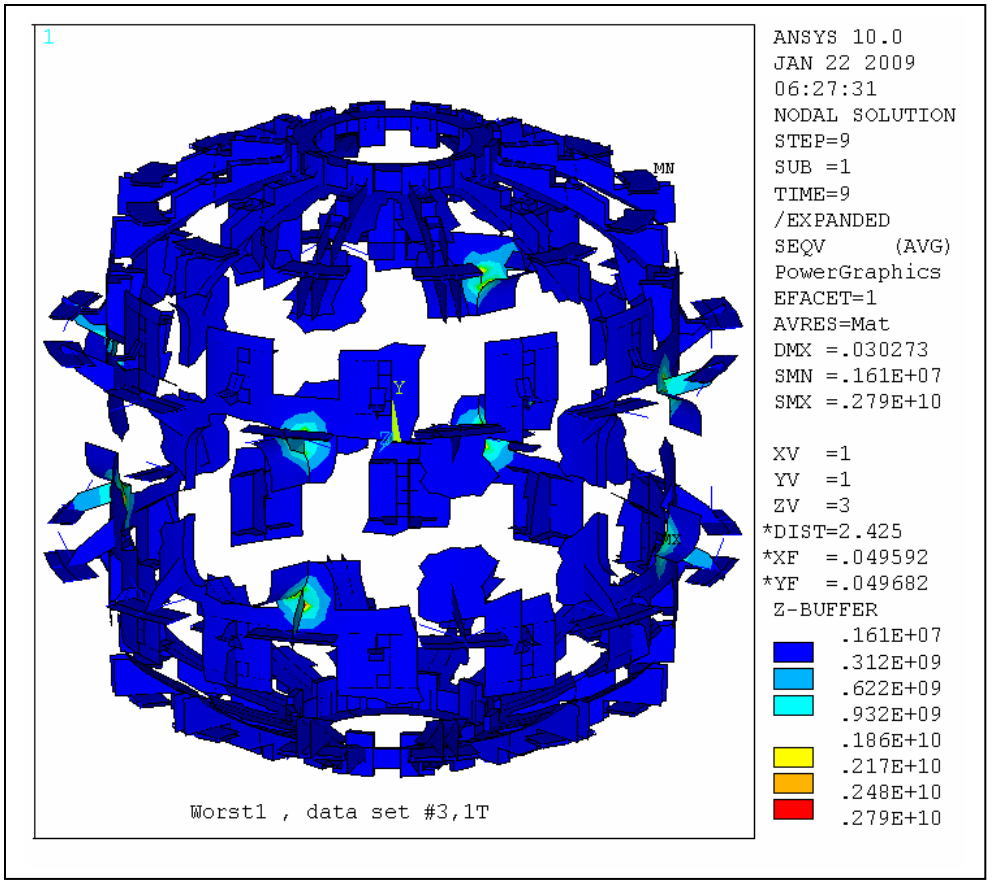


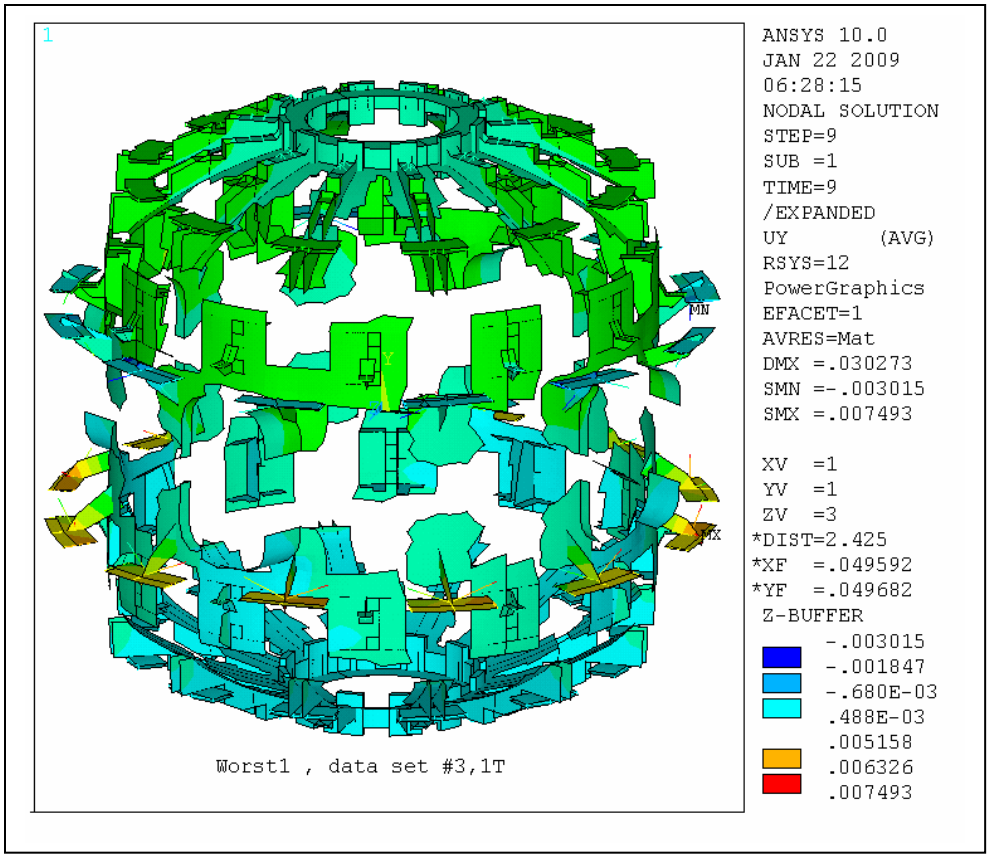




Torsional Shear is "Innteresting" given low Hoop compression

PF Supports


1
MN
Y
Z
MX
Worst1 , data set #3,1T
ANSYS 10.0
JAN 22 2009
06:27:31
NODAL SOLUTION
STEP=9
SUB =1
TIME=9
/EXPANDED
SEQV (AVG)
PowerGraphics
EFACET=1
AVRES=Mat
DMX =.030273
SMN =.161E+07
SMX =.279E+10
XV =1
YV =1
ZV =3
*DIST=2.425
*XF =.049592
*YF =.049682
Z-BUFFER
.161E+07
.312E+09
.622E+09
.932E+09
.186E+10
.217E+10
.248E+10
.279E+10


1
MN
Y
MX
Worst1 , data set #3,1T
ANSYS 10.0
JAN 22 2009
06:28:15
NODAL SOLUTION
STEP=9
SUB =1
TIME=9
/EXPANDED
UY (AVG)
RSYS=12
PowerGraphics
EFACET=1
AVRES=Mat
DMX =.030273
SMN =-.003015
SMX =.007493
XV =1
YV =1
ZV =3
*DIST=2.425
*XF =.049592
*YF =.049682
Z-BUFFER
-.003015
-.001847
-.680E-03
.488E-03
.005158
.006326
.007493