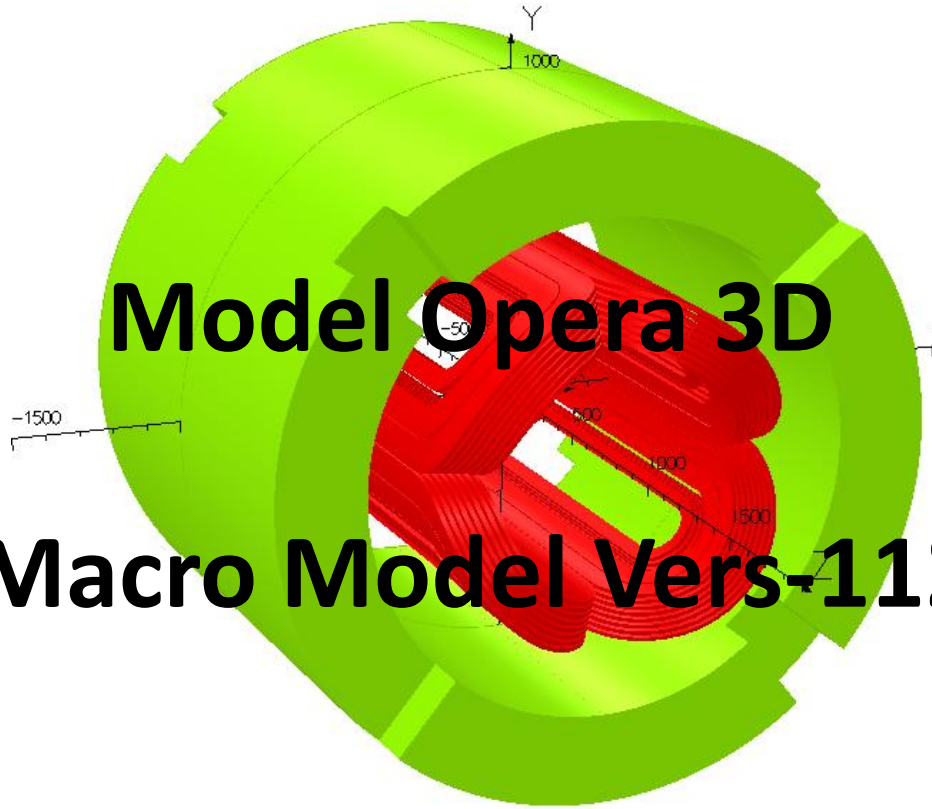


Model Opera 3D Analysis

Macro Model Vers-112 @ 4250 A

01 October 2013

Opera

Sylvain ANTOINE

Model OPERA-3D – Vers 112 @ 4250A

Revision and Abstract

Description	Revision	Date
Creation	A	01/10/2013-AS

ABSTRACT

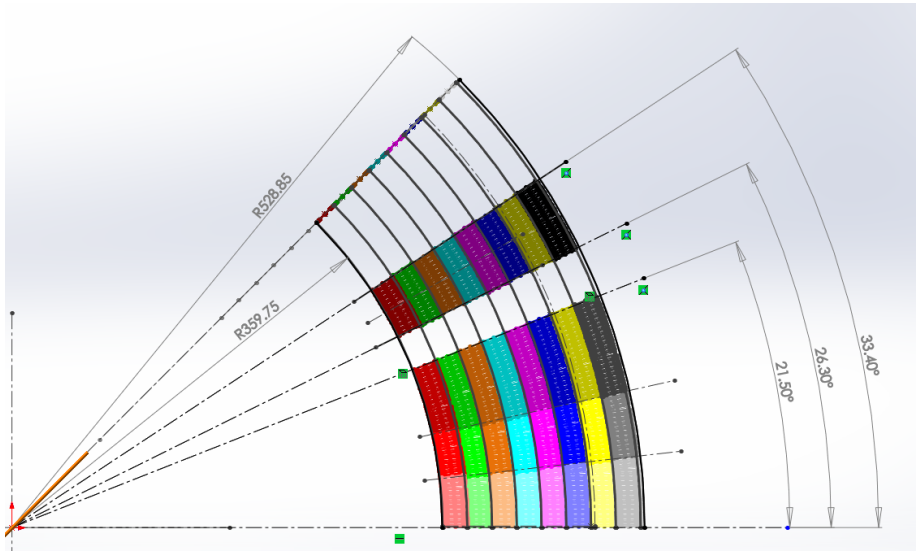
This report presents calculation made by Sigmaphi at 4250A

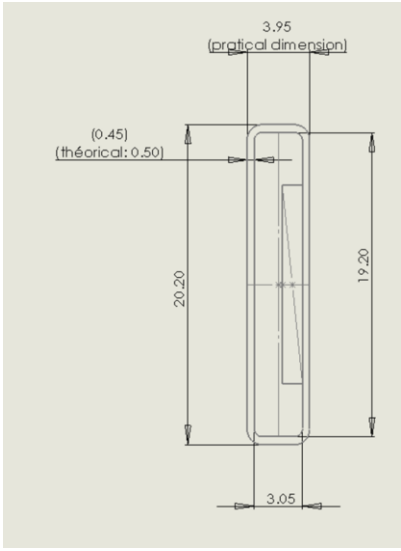
Opera files:

318711-JLAB-Qpole-V112-OP3 (simulation with shims)

Model OPERA-3D – Vers 112 @ 4250A

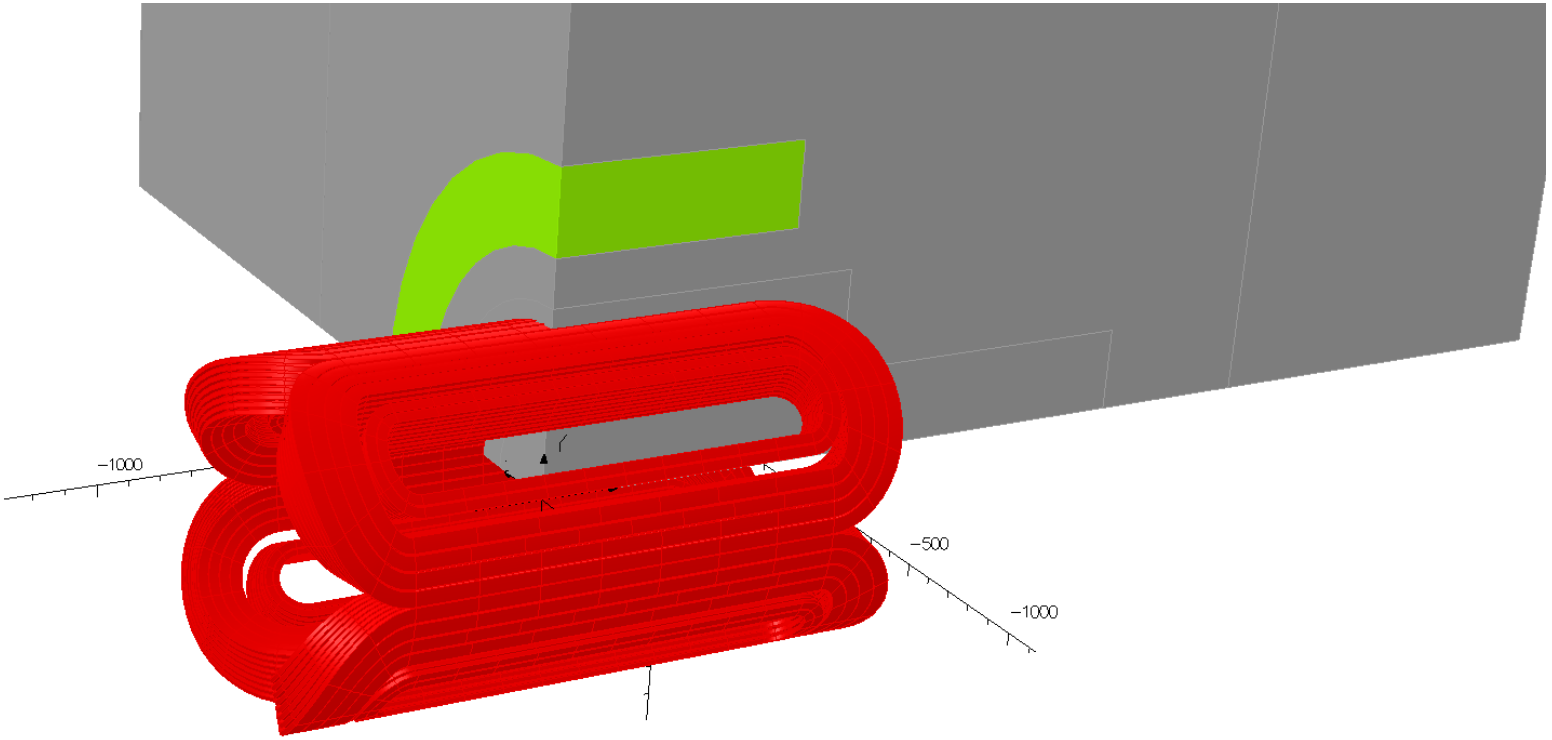
Solidworks geometry





Model OPERA-3D – Vers 112 @ 4250A

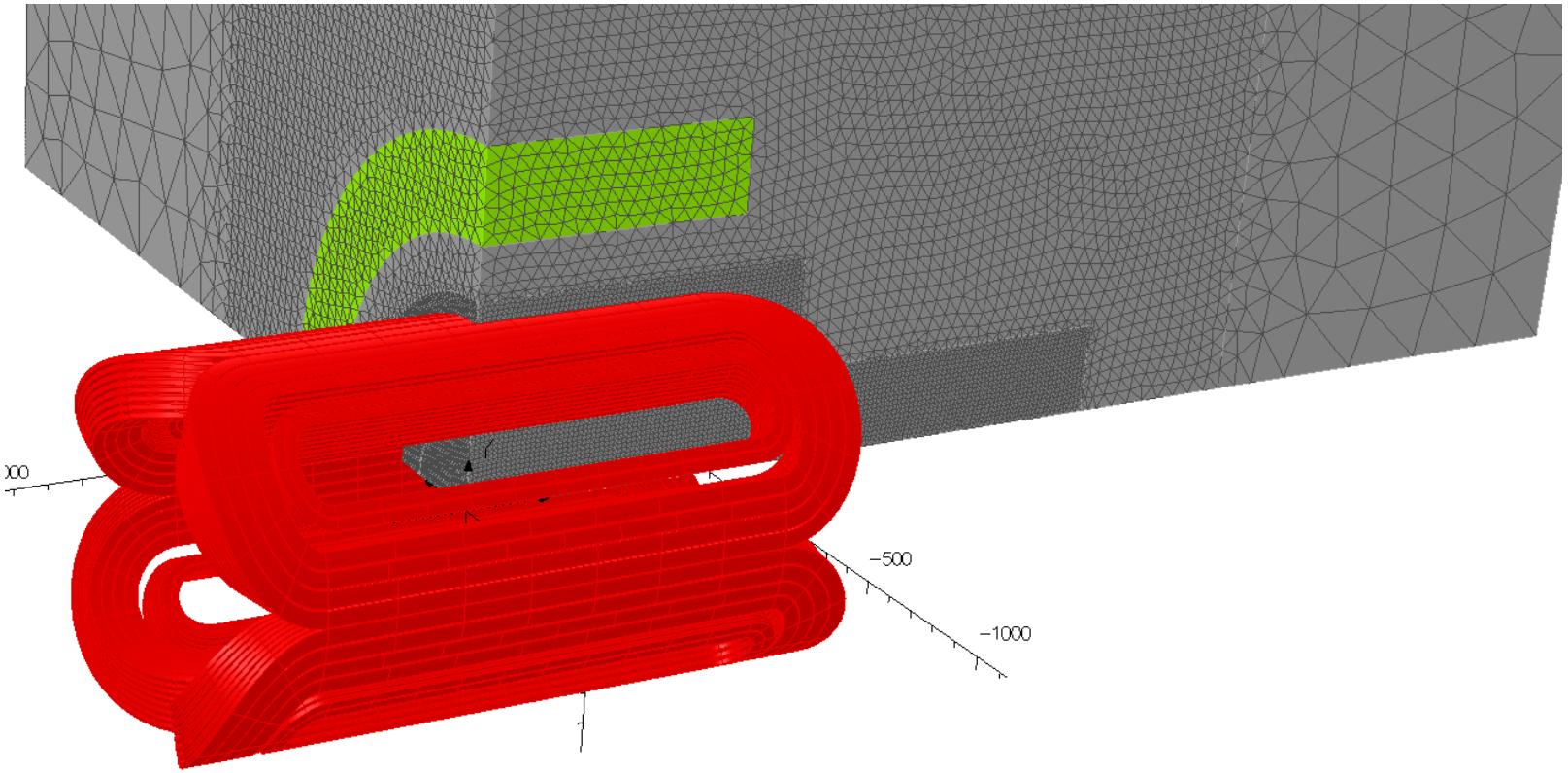
Opera Model



Opera

Model OPERA-3D – Vers 112 @ 4250A

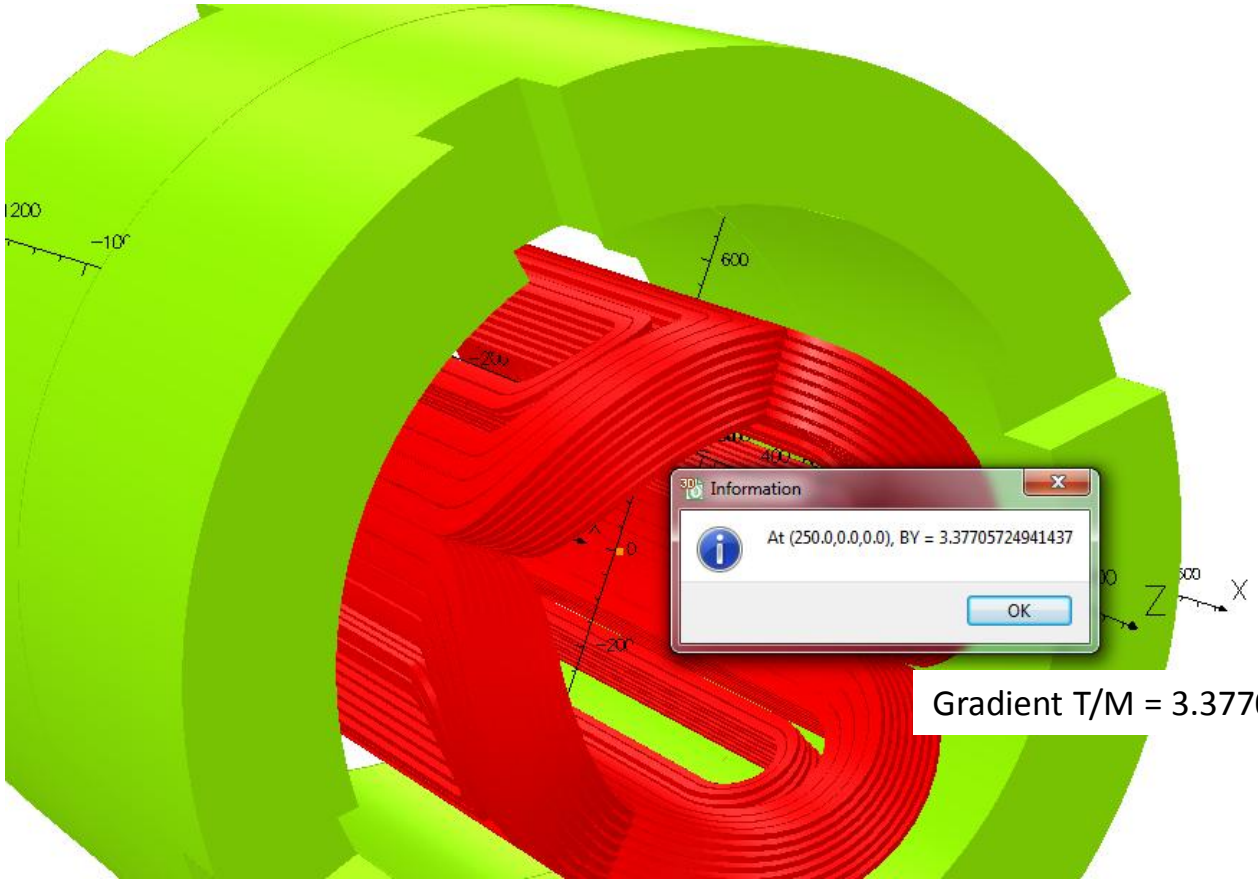
View of the mesh



Opera

Model OPERA-3D – Vers 112 @ 4250A

By at 250,0,0 (T) and gradient – Middle of the coil @ 4250A

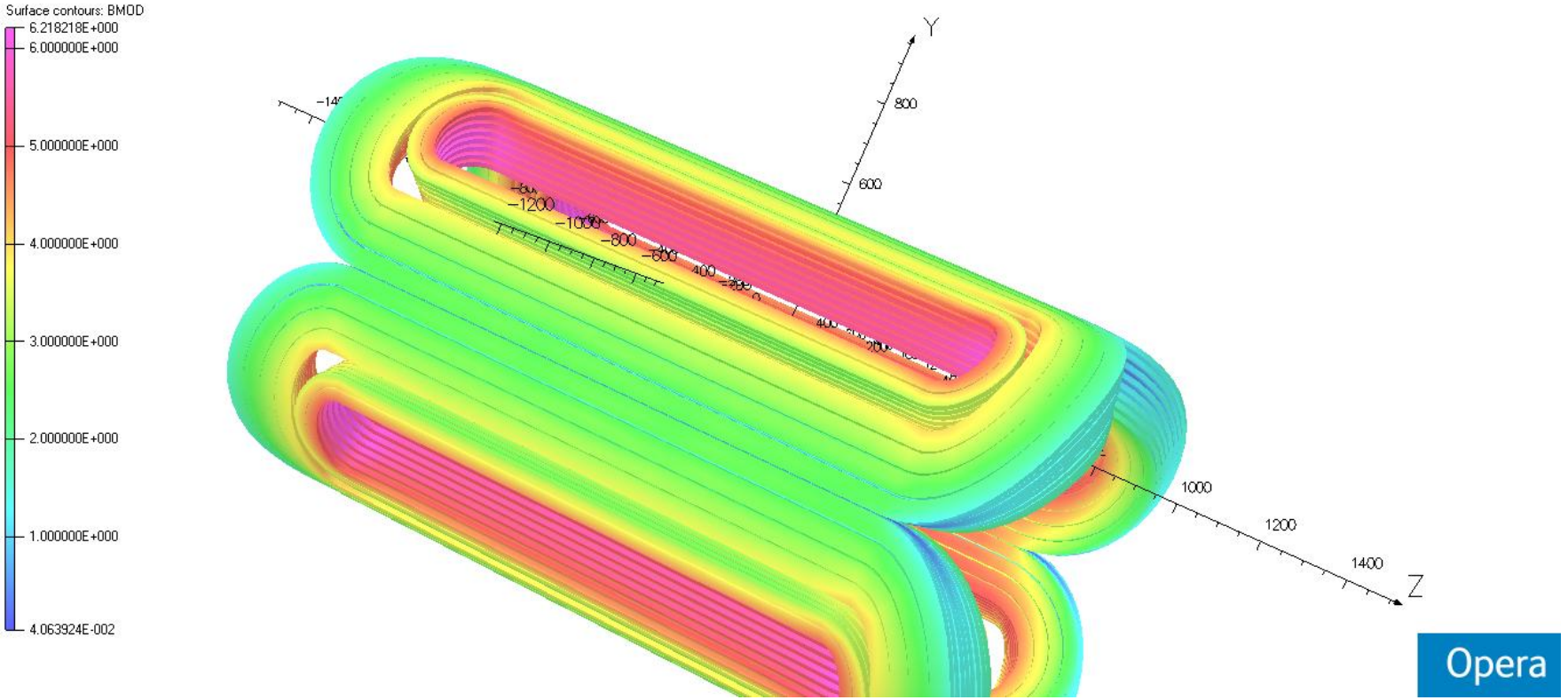


Gradient T/M = 3.3770/0.250=13.508 T/M

Opera

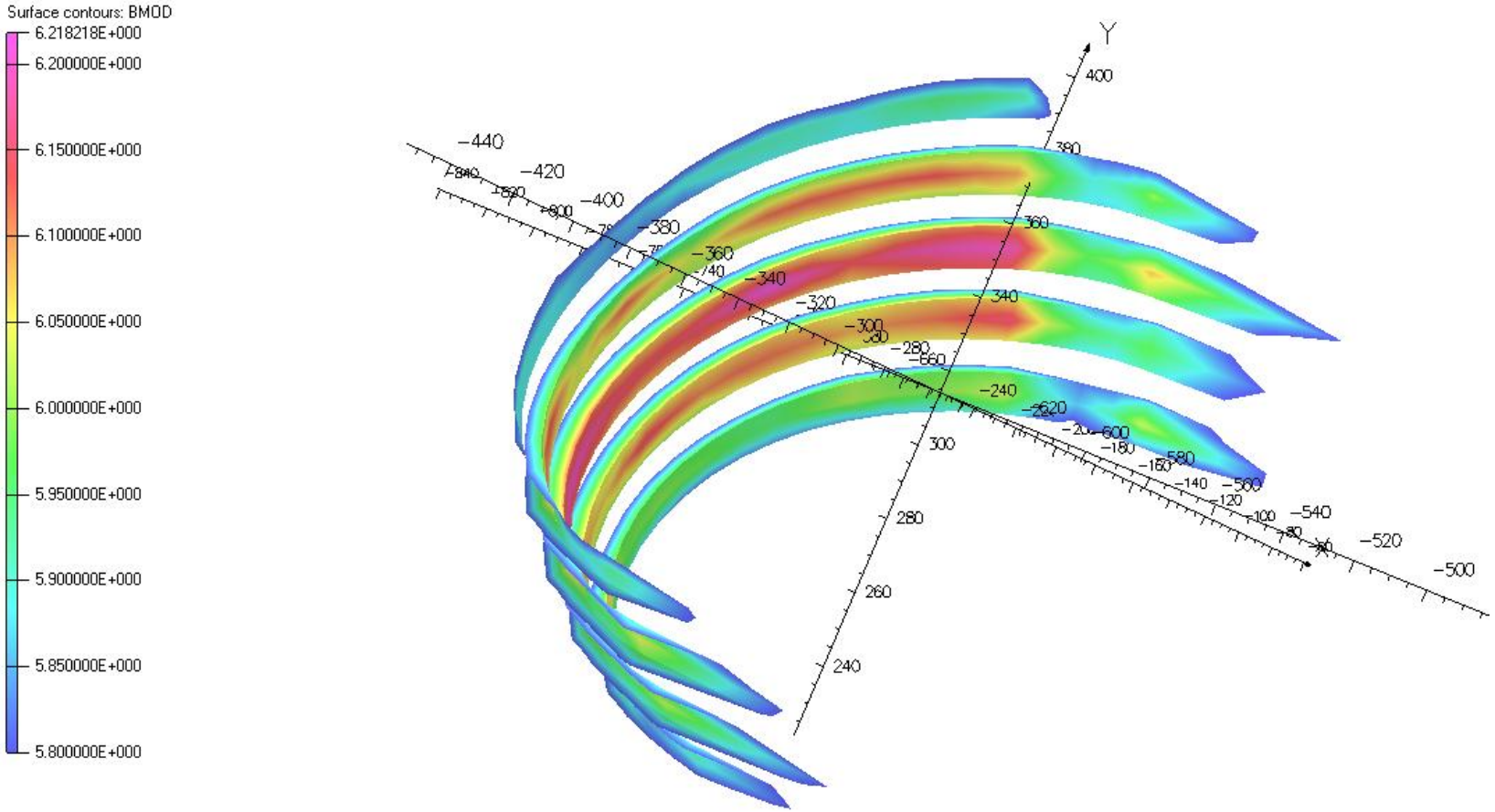
Model OPERA-3D – Vers 112 @ 4250A

Field map on the coil surface@ 4250A



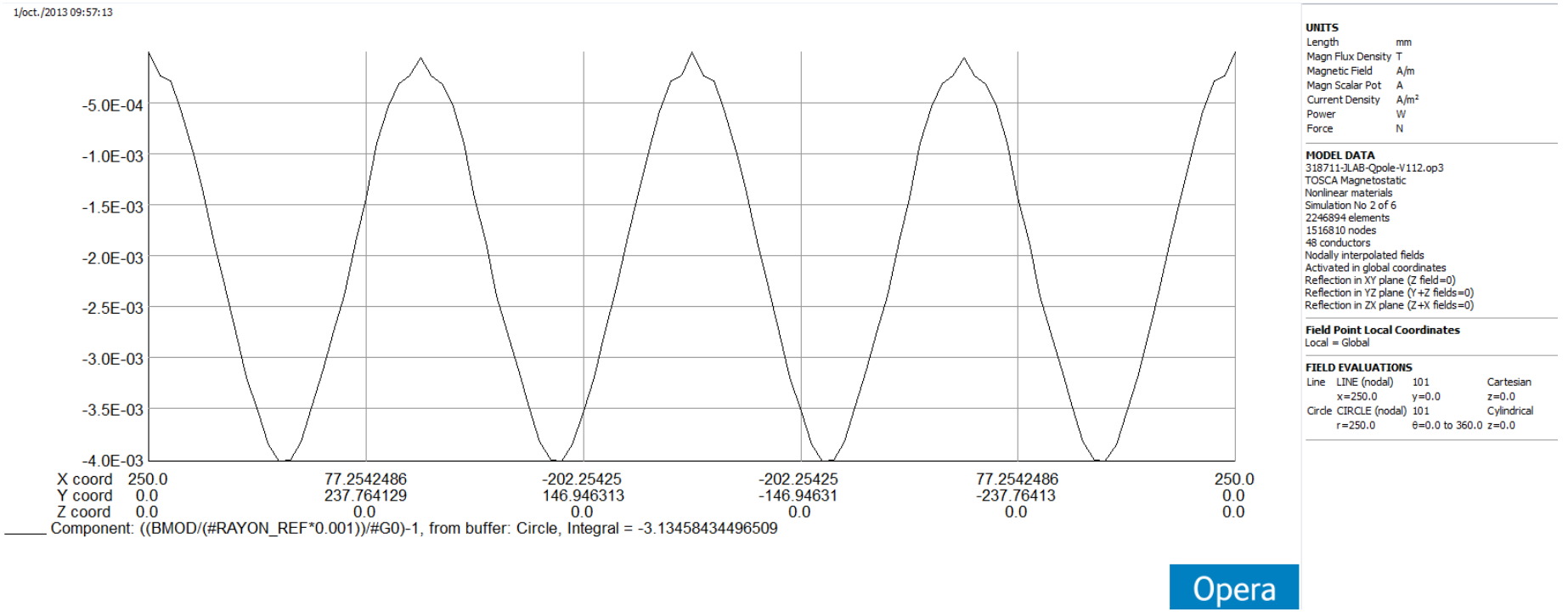
Model OPERA-3D – Vers 112 @ 4250A

Field map on the coil surface@ 4250A



Model OPERA-3D – Vers 112 @ 4250A

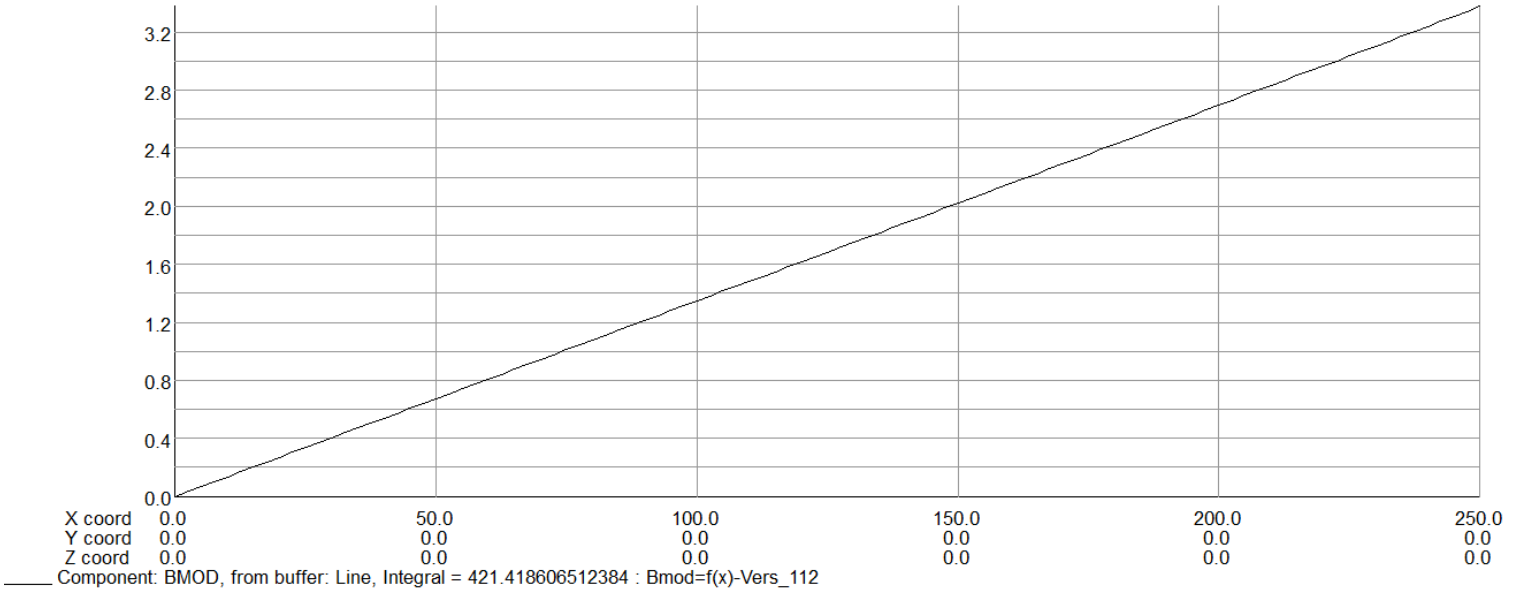
By field homogeneity on a circle Ø500 @ 4250A



Model OPERA-3D – Vers 112 @ 4250A

By = f(x) @ 4250A

1/oct./2013 09:57:18



UNITS

Length	mm
Magn Flux Density	T
Magnetic Field	A/m
Magn Scalar Pot	A
Current Density	A/m²
Power	W
Force	N

MODEL DATA

318711-JLAB-Qpole-V112.op3
TOSCA Magnetostatic
Nonlinear materials
Simulation No 2 of 6
2246894 elements
1516810 nodes
48 conductors
Nodally interpolated fields
Activated in global coordinates
Reflection in XY plane (Z field=0)
Reflection in YZ plane (Y+Z fields=0)
Reflection in ZX plane (Z+X fields=0)

Field Point Local Coordinates

Local = Global

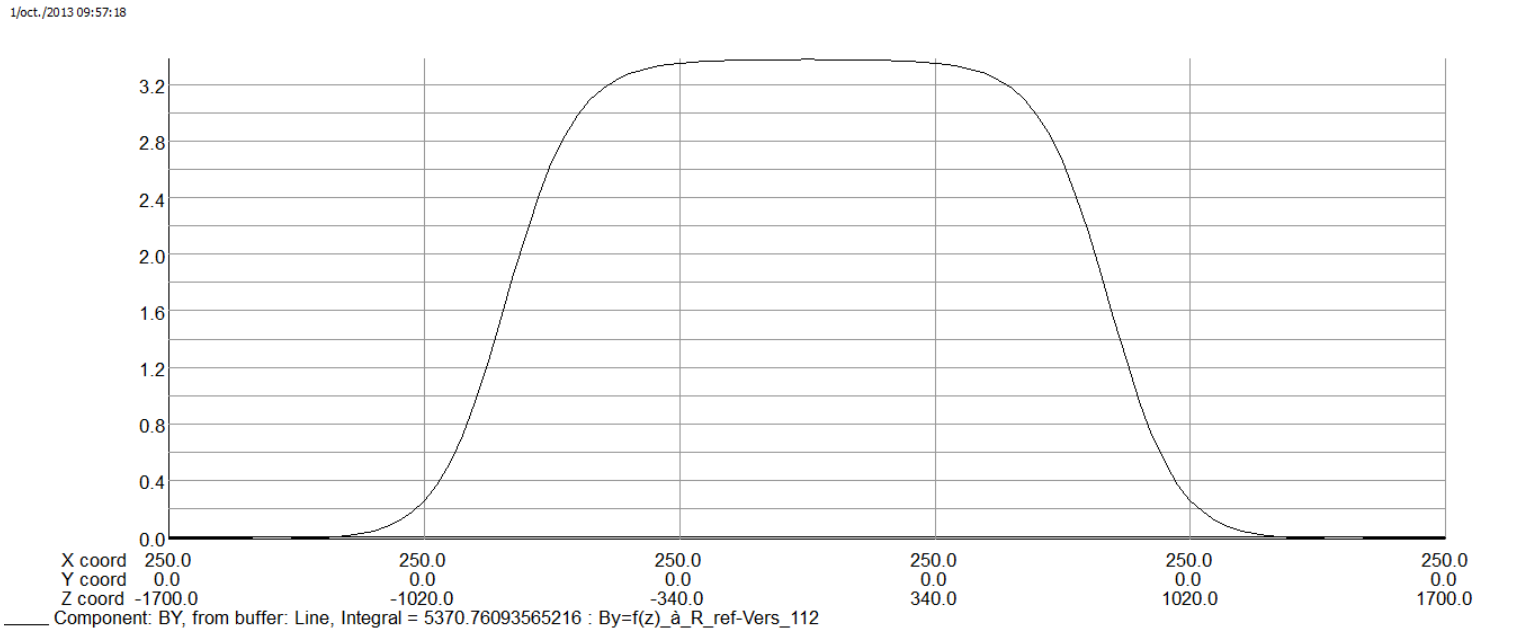
FIELD EVALUATIONS

Line	LINE (nodal)	101	Cartesian
	x=0.0 to 250.0	y=0.0	z=0.0
Circle	CIRCLE (nodal)	101	Cylindrical
	r=250.0	θ=0.0 to 360.0	z=0.0

Opera

Model OPERA-3D – Vers 112 @ 4250A

By = f(z) @ R=250mm @ 4250A



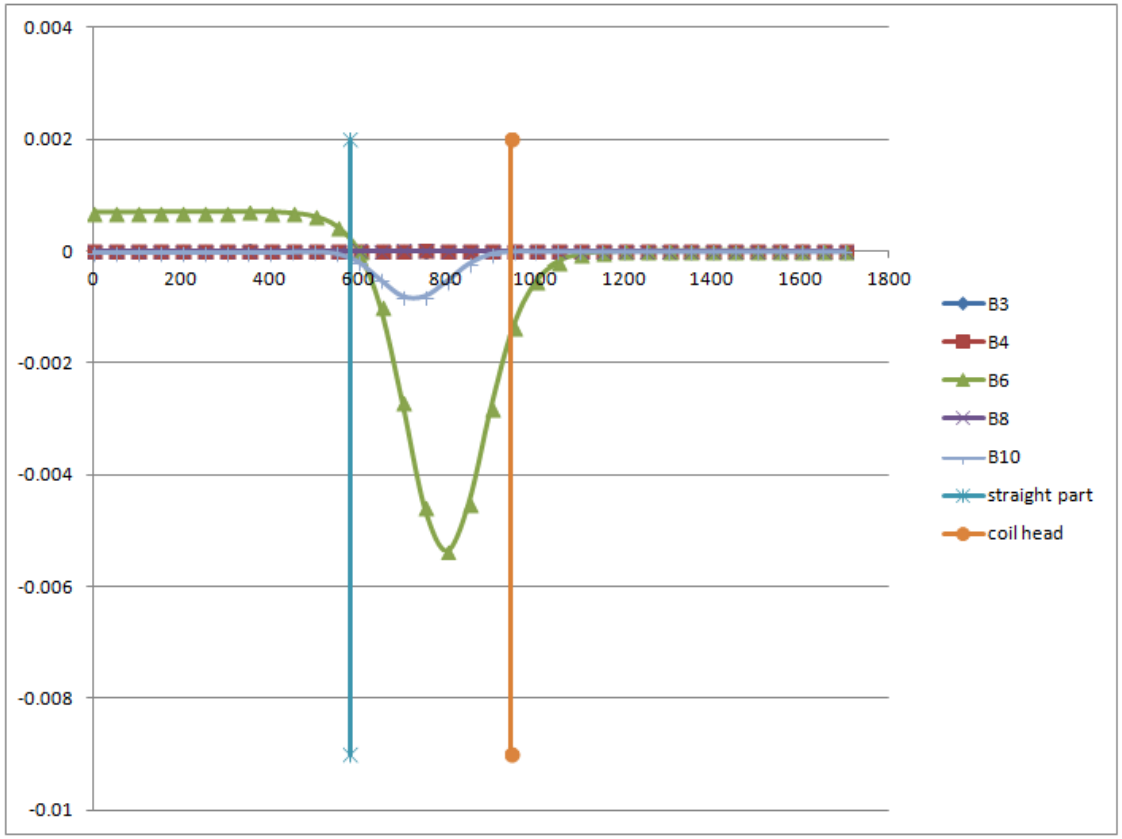
Model OPERA-3D – Vers 112 @ 4250A

Harmonics –

N°	An-Values @ In T.m	Bn-Values @ In T.m	an @ In unit (1.10^{-4})	bn @ In unit (1.10^{-4})	|cn| @ In unit (1.10-4)	
1	0	6.32E-07	0.00	0.00	0.00	
2	**0**	5.3890986	0.00	**10000.00**	10000.00	**100.00**
3	0	3.73E-07	0.00	0.00	0.00	6.92E-06
4	0	3.065E-05	0.00	0.06	0.06	5.69E-04
5	0	4.97E-07	0.00	0.00	0.00	
6	0	-0.014729	0.00	-27.33	27.33	-2.73E-01
7	0	2.1E-08	0.00	0.00	0.00	
8	0	1.816E-05	0.00	0.03	0.03	3.37E-04
9	0	2.37E-07	0.00	0.00	0.00	
10	0	-0.003287	0.00	-6.10	6.10	-6.10E-02
11	0	5.3E-08	0.00	0.00	0.00	
12	0	1.25E-05	0.00	0.02	0.02	
13	0	2.1E-07	0.00	0.00	0.00	
14	0	-0.000345	0.00	-0.64	0.64	
15	0	2.82E-07	0.00	0.00	0.00	
16	0	1.208E-05	0.00	0.02	0.02	
17	0	7.82E-07	0.00	0.00	0.00	
18	0	-0.000288	0.00	-0.53	0.53	
19	0	5.88E-07	0.00	0.00	0.00	
20	0	5.801E-06	0.00	0.01	0.01	
21	0	2.27E-07	0.00	0.00	0.00	
22	0	9.93E-05	0.00	0.18	0.18	
23	0	4.33E-07	0.00	0.00	0.00	
24	0	-2.59E-06	0.00	0.00	0.00	
25	0	3.92E-07	0.00	0.00	0.00	
26	0	2.374E-05	0.00	0.04	0.04	
27	0	7.12E-07	0.00	0.00	0.00	
28	0	2.619E-06	0.00	0.00	0.00	
29	0	6.55E-07	0.00	0.00	0.00	
30	0	8.774E-06	0.00	0.02	0.02	
31	0	4.84E-07	0.00	0.00	0.00	
Sum			**0.00**	**-34.20**	**35.02**	

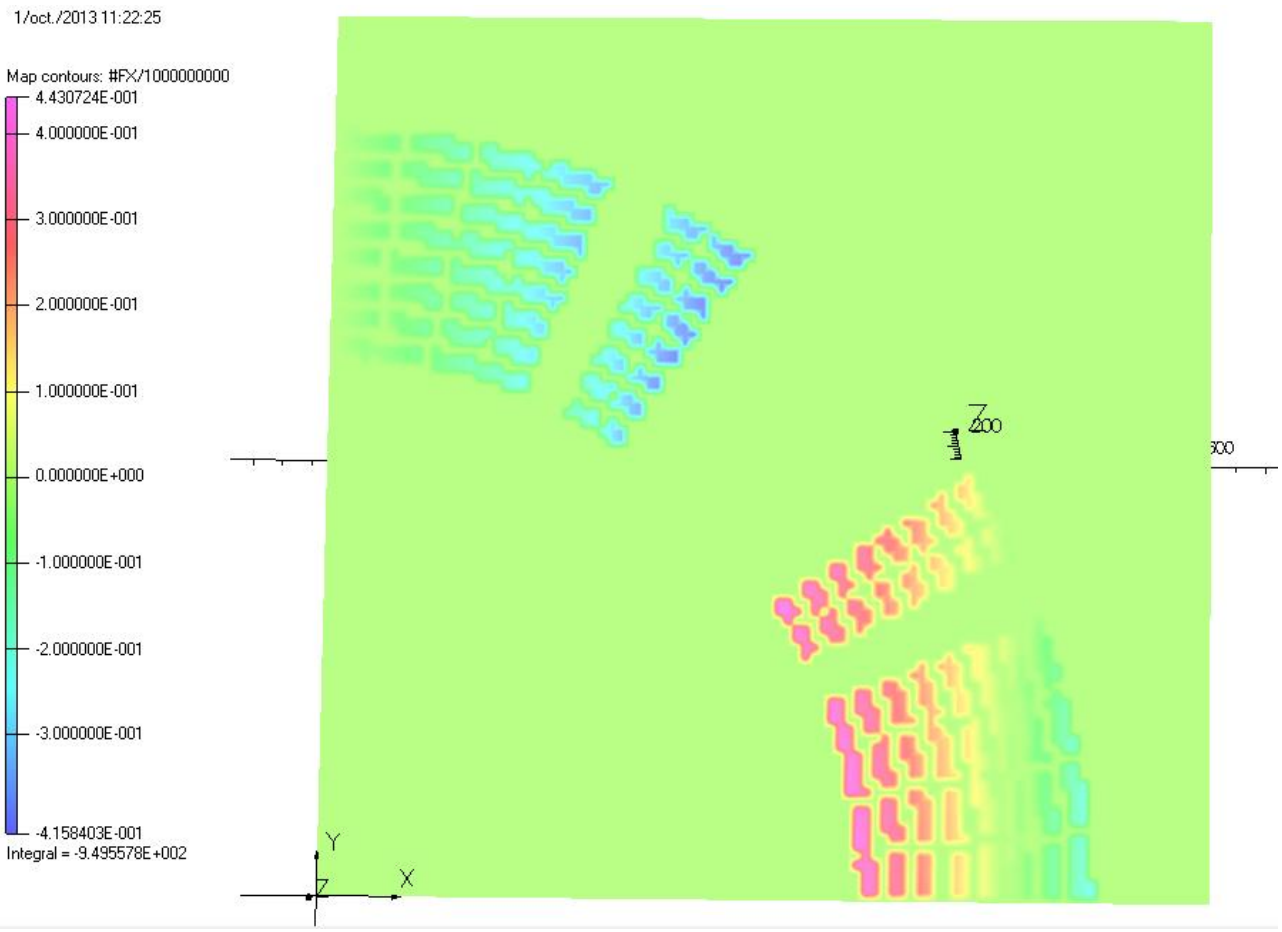
Model OPERA-3D – Vers 112 @ 4250A

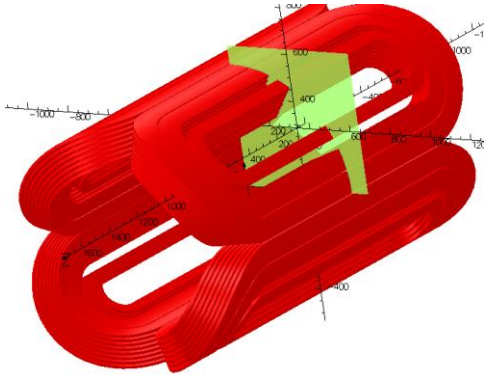
Harmonics –



Model OPERA-3D – Vers 112 @ 4250A

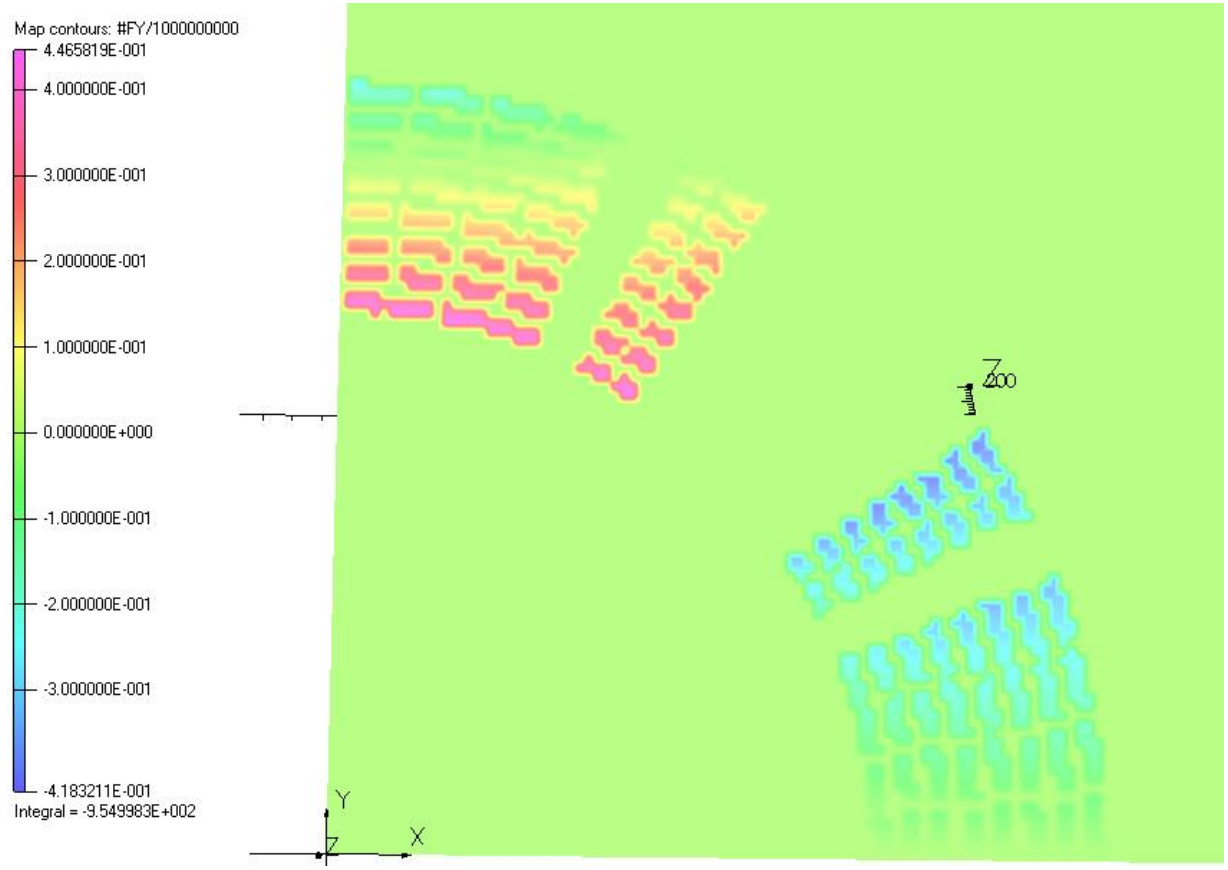
Fx force density in N/mm3 – 4250 A

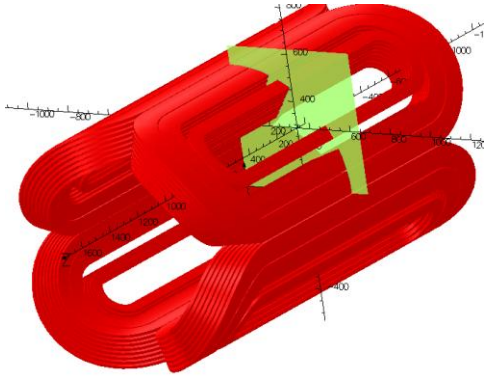




Model OPERA-3D – Vers 112 @ 4250A

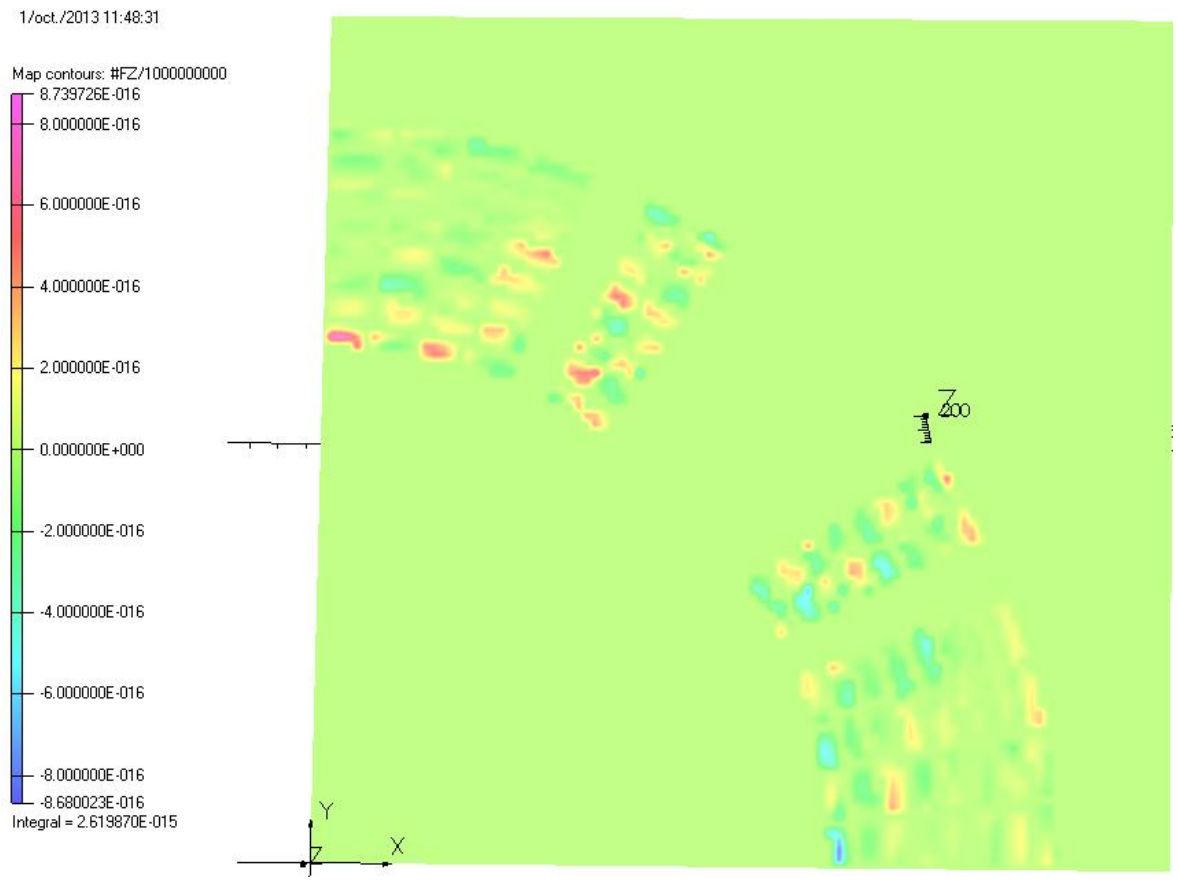
Fy force density in N/mm3 – 4250 A

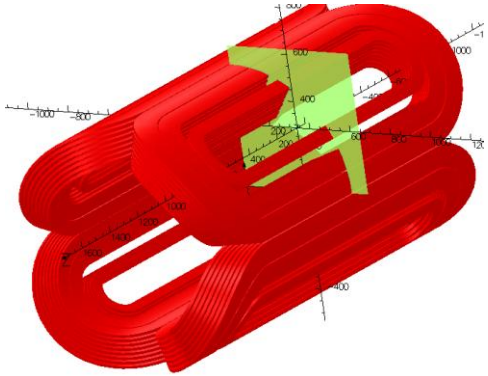




Model OPERA-3D – Vers 112 @ 4250A

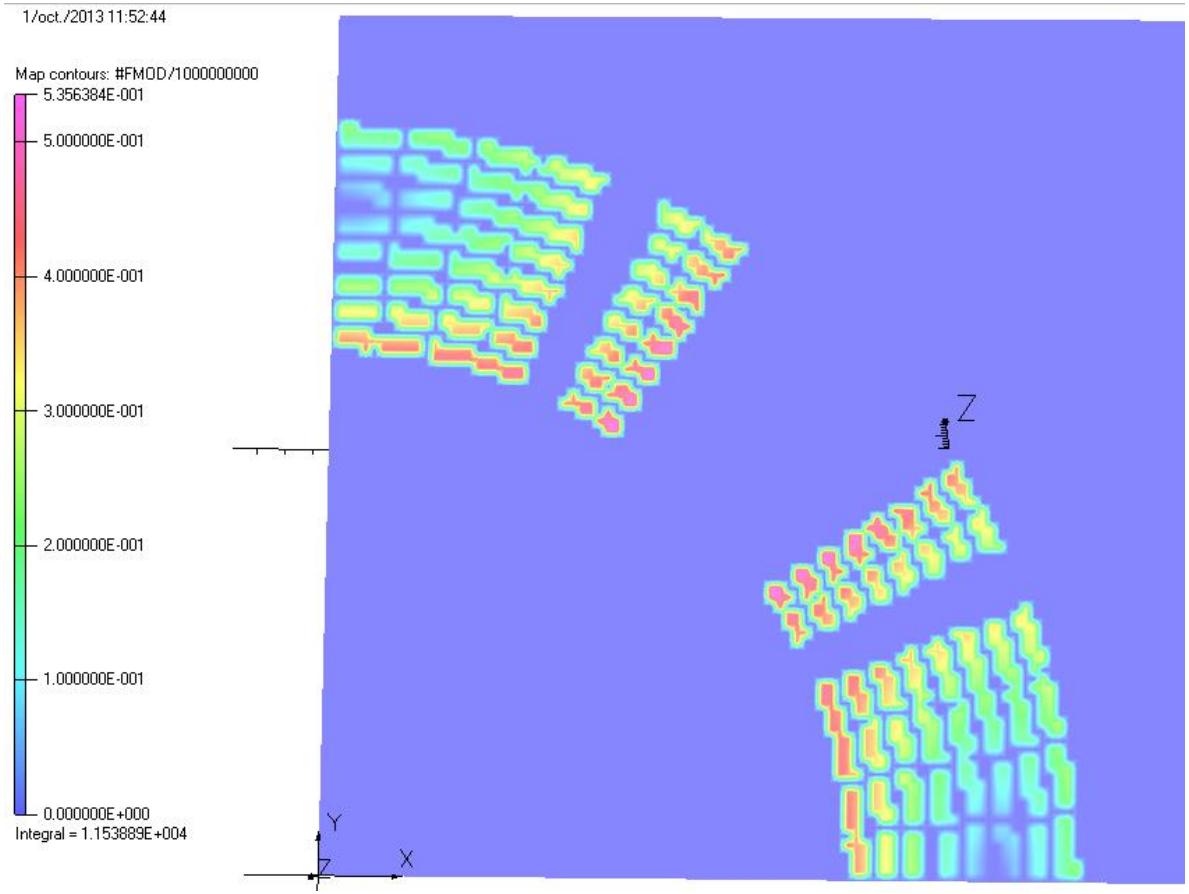
Fz force density in N/mm3 – 4250 A

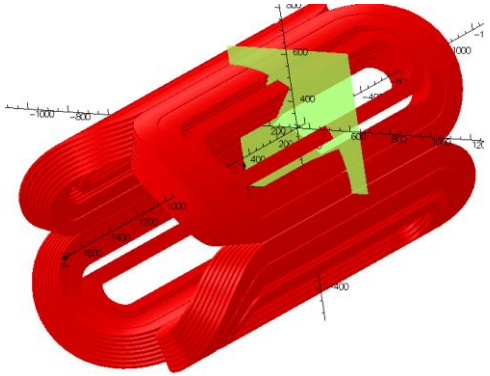




Model OPERA-3D – Vers 112 @ 4250A

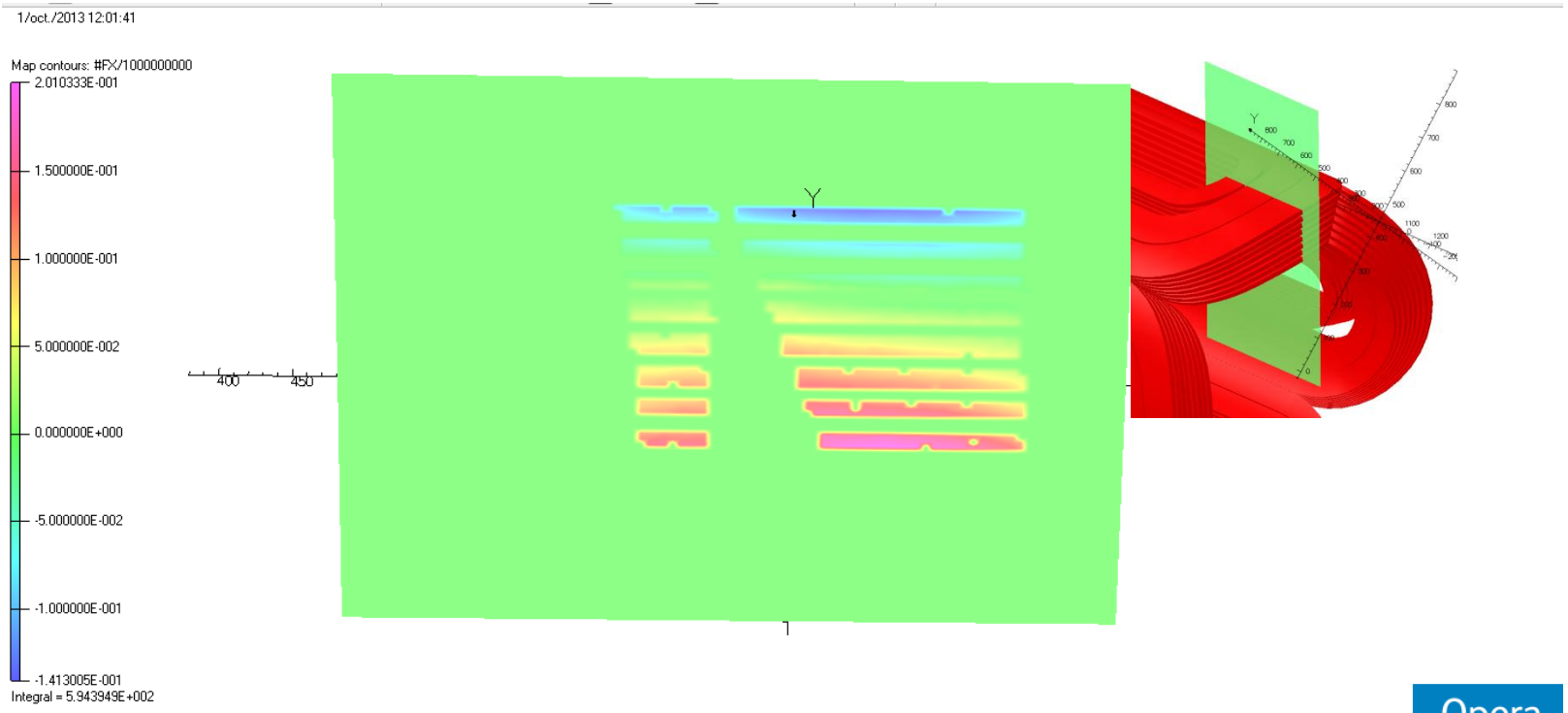
Fmod force density in N/mm3 – 4250 A





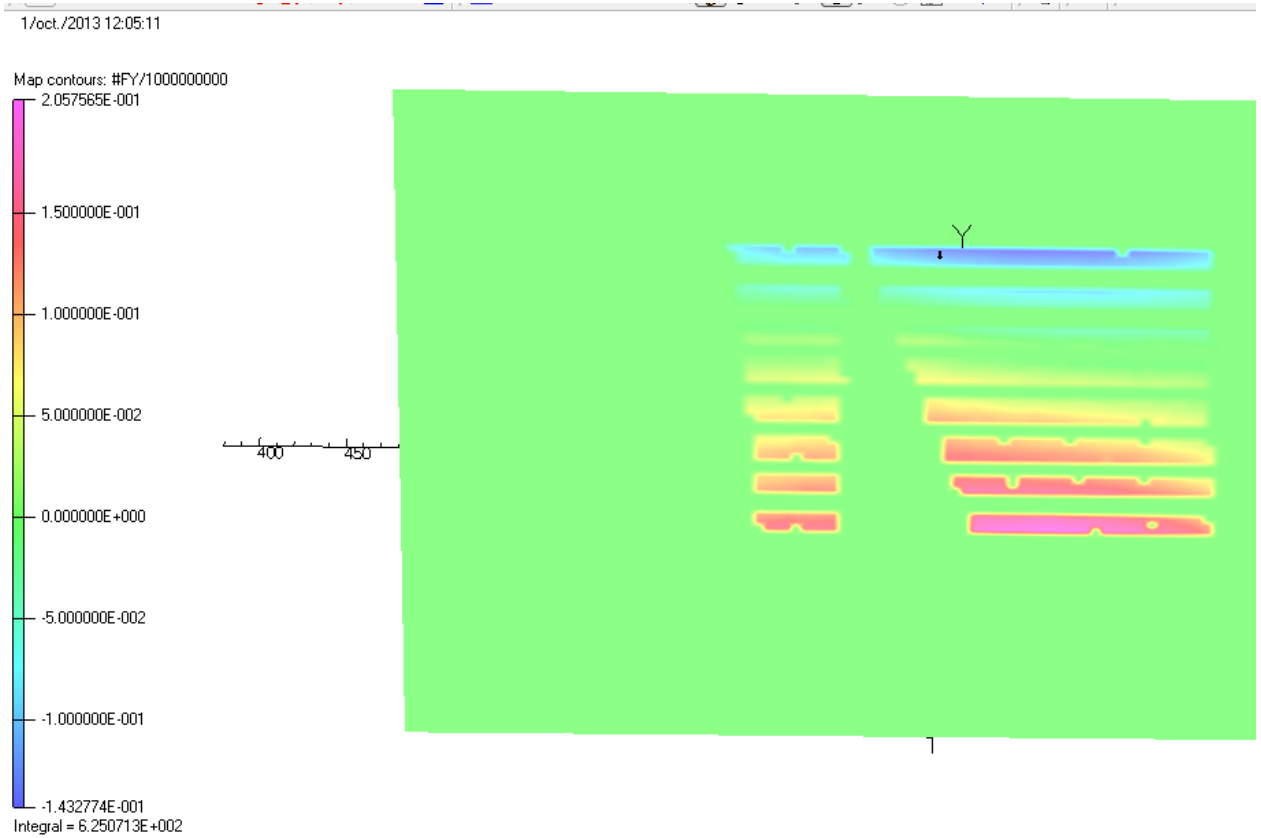
Model OPERA-3D – Vers 112 @ 4250A

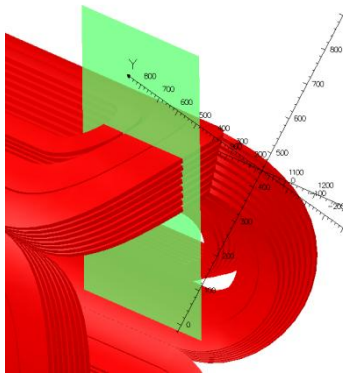
Fx force density in N/mm3 – 4250 A



Model OPERA-3D – Vers 112 @ 4250A

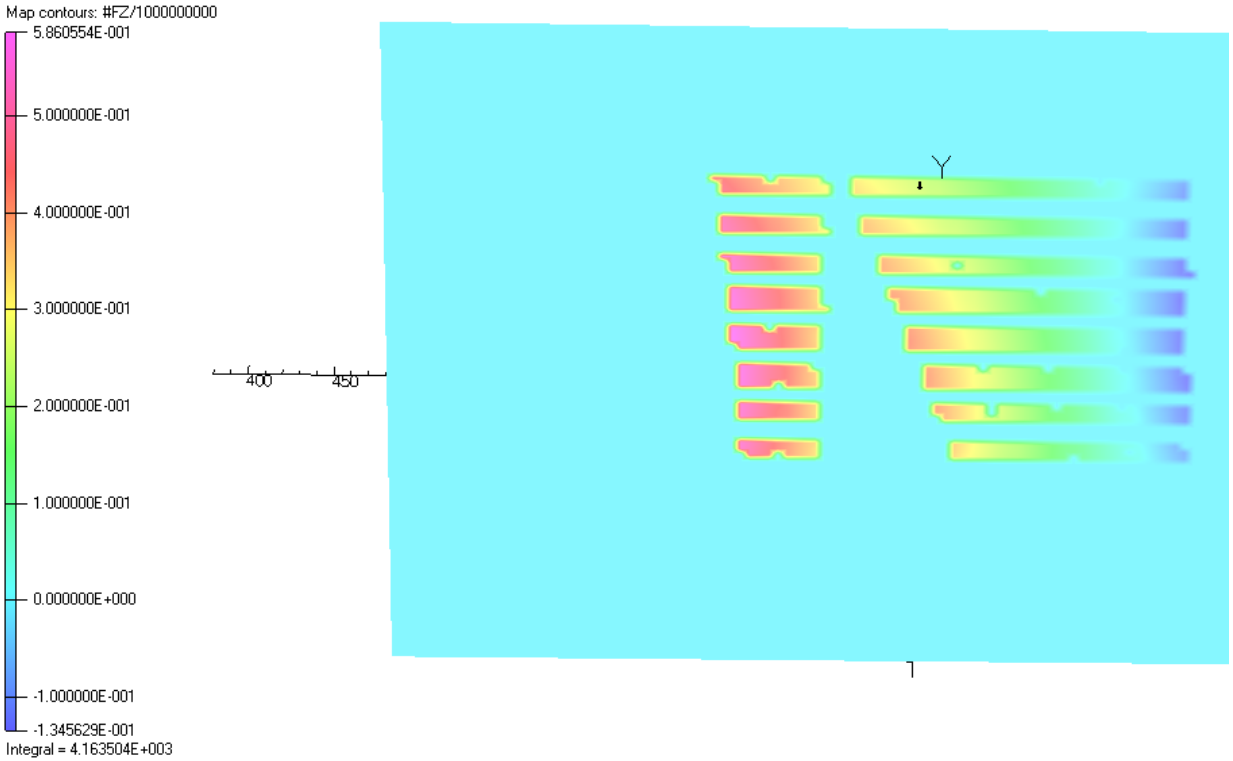
FY force density in N/mm3 – 4250 A

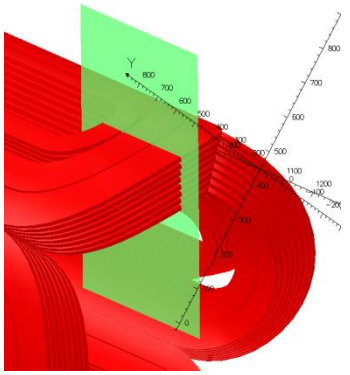




Model OPERA-3D – Vers 112 @ 4250A

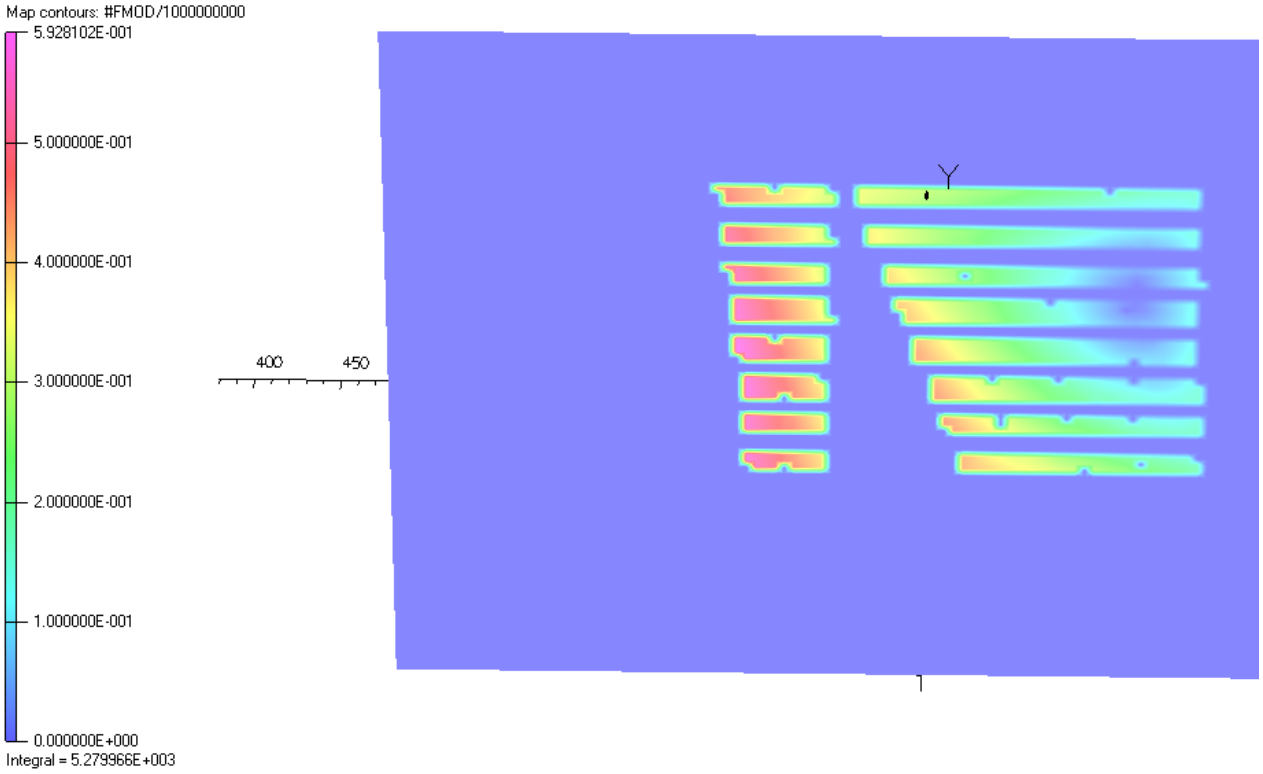
Fz force density in N/mm3 – 4250 A

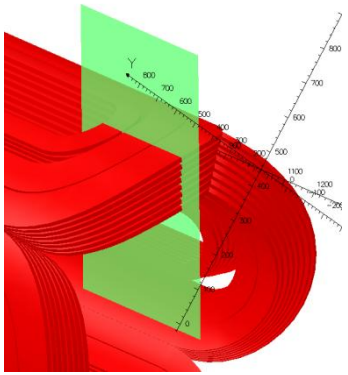




Model OPERA-3D – Vers 112 @ 4250A

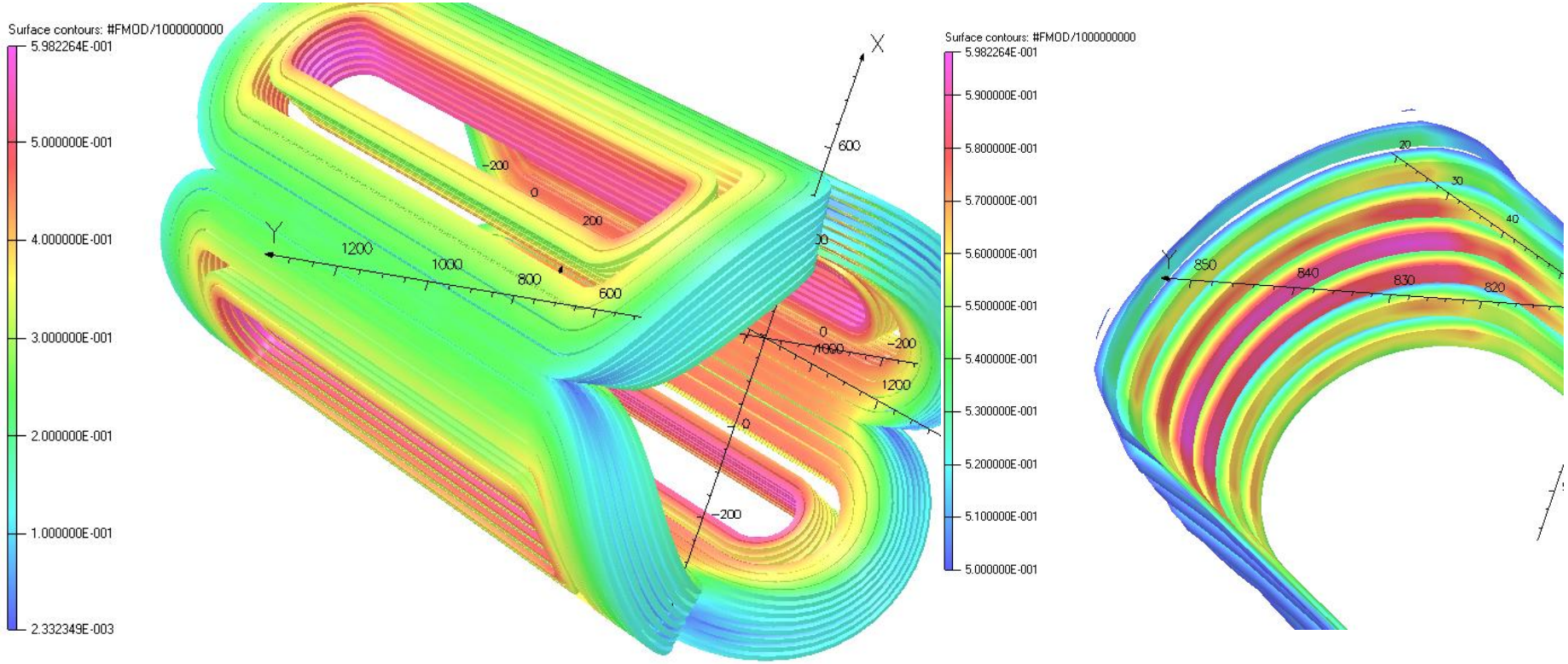
Fmod force density in N/mm3 – 4250 A





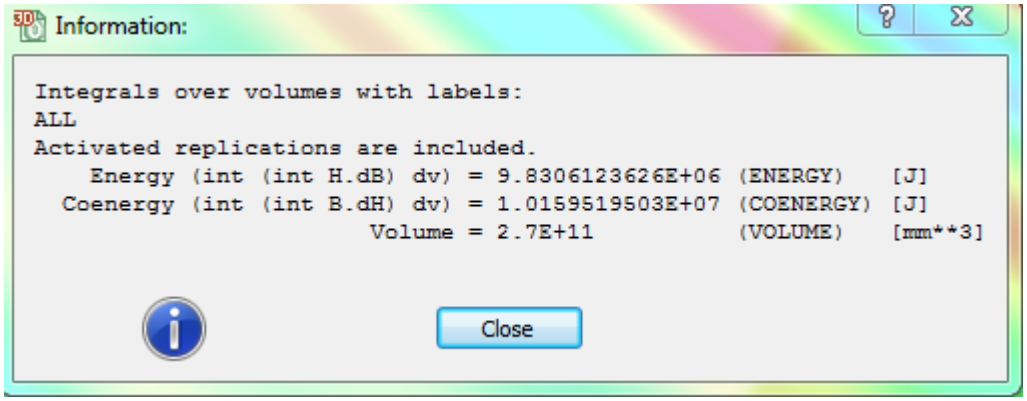
Model OPERA-3D – Vers 112 @ 4250A

The peak lorenz force density in the coil N/mm3 – 4250 A



Model OPERA-3D – Vers 112 @ 4250A

Energy– 4250 A

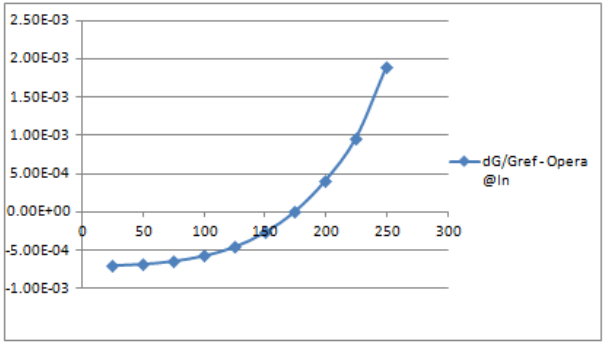


Inductance: (2*energy/Current²)=2*1.01/4250²=1.12H

Model OPERA-3D – Vers 112 @ 4250A

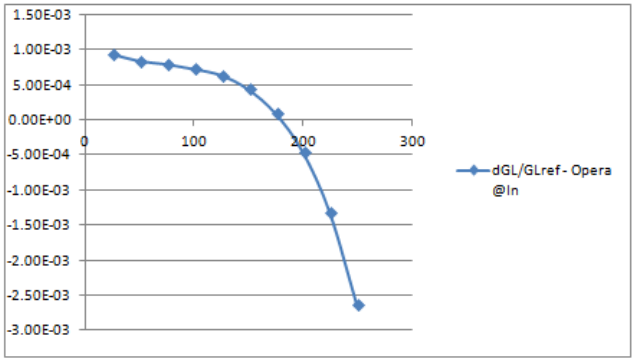
dG/G0 homogeneity an dGL/GL0 homogeneity– 4250 A

Radius(mm)	By(T) @ In	G (T/m) @ In	dG/Gref - Opera @In
25	0.336834	13.473371	-6.91E-04
50	0.67368	13.473605	-6.74E-04
75	1.010558	13.474111	-6.37E-04
100	1.347503	13.475033	-5.68E-04
125	1.684573	13.476581	-4.53E-04
150	2.021867	13.479112	-2.66E-04
175	2.359499	13.482854	1.19E-05
200	2.697658	13.488288	4.15E-04
225	3.036544	13.495751	9.68E-04
250	3.377057	13.508229	1.89E-03
Gref (average)	13.4826935		



dG/G

Radius(mm)	Integral (T.mm) @ In	GL (T) @ In	dGL/GLref - Opera @In
25	538.997109	21.559884	9.29E-04
50	1077.889185	21.557784	8.32E-04
75	1616.760237	21.556803	7.86E-04
100	2155.532011	21.55532	7.18E-04
125	2694.178318	21.553427	6.30E-04
150	3232.367455	21.549116	4.30E-04
175	3769.808547	21.541763	8.81E-05
200	4306.014557	21.530073	-4.55E-04
225	4840.071867	21.511431	-1.32E-03
250	5370.760936	21.483044	-2.64E-03
GLref (average)	21.5398645		



dGL/GL

Model OPERA-3D – Vers 112 @ 4250A

Opera calculation-Summary

	Jlab Specification 7 December 2009	Sigmaphi 3D calculation 318711-jlab-3D-vers112 @ 4250A
Amp-Turns Nb Turns	$6.818*10^6$ 423 Turns	$7.225*10^6$ 427 Turns
Gradient	13.03 T/m	13.50 T/m
Integrated Gradient	21.4 T.m	21.48 T.m
Lorenz force density –peak value at the coil (Vertical middle plan)	Not specified	Max fx density = 0.443 N/mm3 Max Fy density = 0.446 N/mm3
Lorenz force density –peak value at the coil (head)	Not specified	Max Fmod density = 0.592 N/mm3
Stored Energy	9.21 MJ	10.1 MJ
Field in the coil	Not specified	6.218 Tesla
Integrated harmonics coefficients B3/B2 B4/B2 B6/B2 B8/B2 B10/B2	 0.1% -0.05% -0.3% -0.1% -0.1%	 6.92E-06 % 5.69E-04% -0.273 % 3.37E-04% -6.10E-02 %