# 704 MHz cavity folded tuner Thermal Analysis

C. Pai

4-20-2016

# Meeting Minutes 4/20/2016

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- Results look very good, we can live with the localized higher temperature. Assumption of 50% thread was very conservative and may cause the higher temperature rise in the model. It was agreed that no further thermal analysis is needed unless there is some other change in the RF design or results.
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- Cliff is going to look into modifying/manufacturing tuner from the cold model to be adaptable to the factory acceptance tests.
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- Binping will run the simulations to see if the reduction of the gap indeed significantly reduces the power dissipated in the tuner.
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- Do want to reduce the lateral gaps between the tuner elements from 3mm to 2 mm. This will allow the copper cup to be thicker which will reduce temperature, again unless something else changes, there is no need for further temperature analysis.
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- Question for Mike and Binping: Will changing from 3 mm to 2 mm gaps require further RF analysis?
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- Because of the reduced gap clearance, Cliff was requested to verify what the catalog accuracy of the Kurt Lesker drive means “2mm at 1 meter”. Requested Cliff to develop a simplified geometric representation of the possible tracking error in the drive system and verify that 1 mm and 2 mm clearance is okay. Hold a short review meeting.
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- Manny’s next priority is to do an ECN on the 704 cavity to extend the tuner flange. Overall design priorities in order for Manny:
- 1. ECN for 704 tuner flange location
- 2. Complete 2.1 GHz tuner assembly fabrication drawings after they have been checked (drawings have been submitted for checking).
- 3. Complete 704 MHz tuner assembly model with Kurt Lesker vacuum drive assembly and adapter flange (hold a design review and approval).
- 4. Complete 704 MHz tuner assembly fabrication drawings and submit for checking.
- 5. Complete 2.1 GHz support and stand assembly.
- 6. Complete 2.1 GHz vacuum transitions, ion pump support, and installation drawings.
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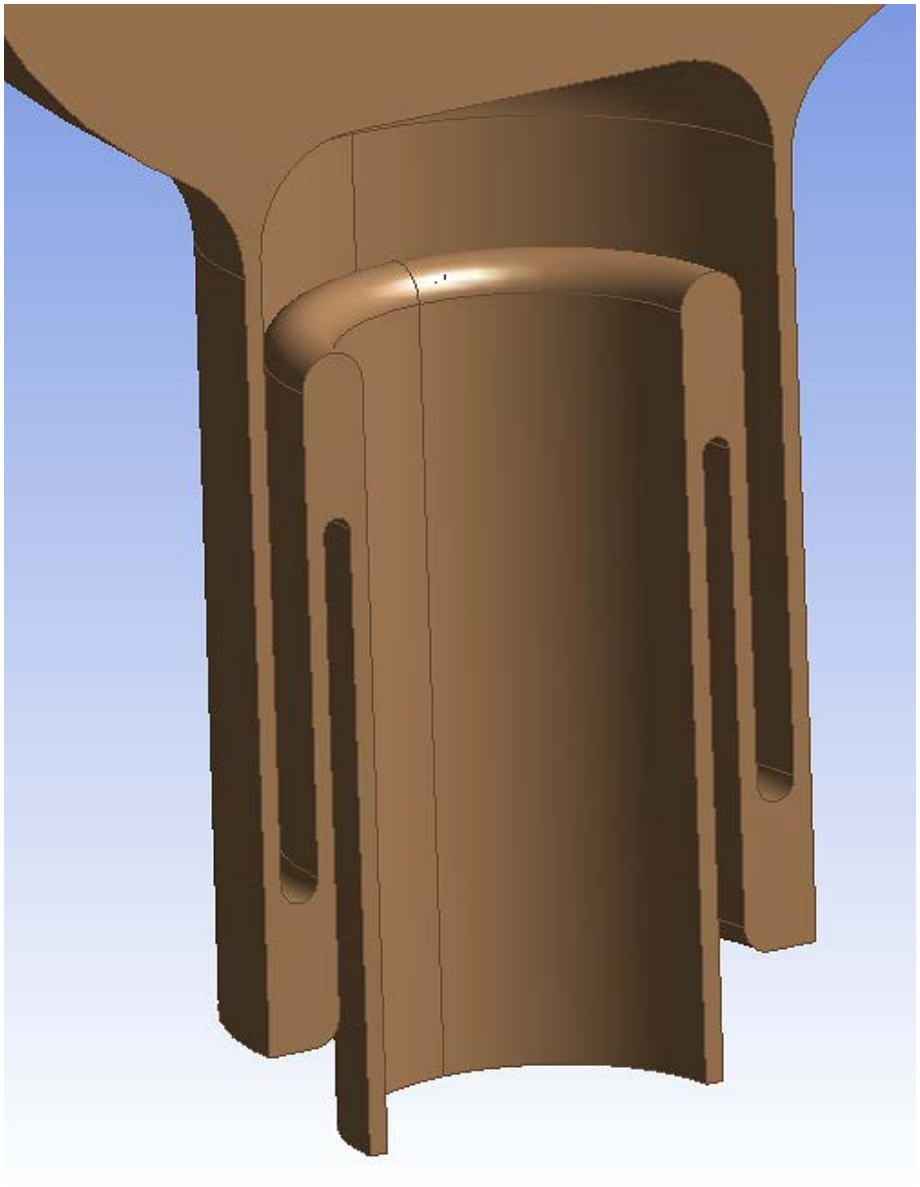
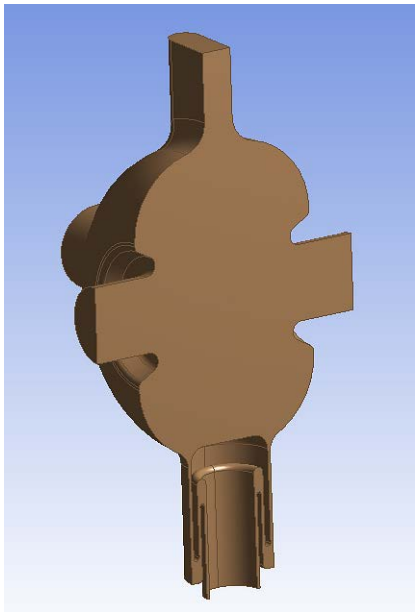
- By time item 5 is underway Sal Picataggio may be available to do items 5 and 6 for the 704 MHz cavity.

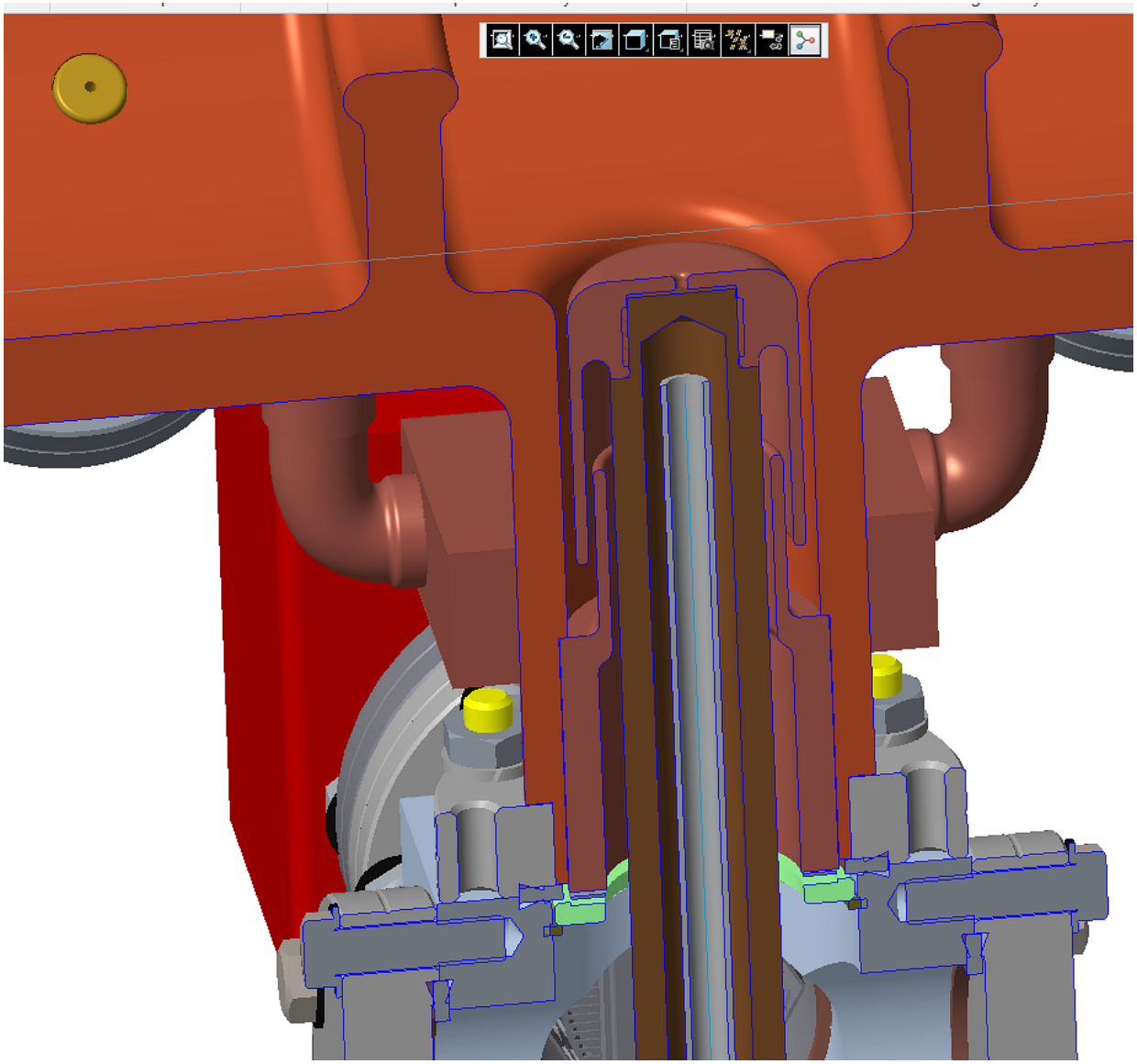
# 704 MHz Cavity with folded tuner,

Based on “704M_v7_704MHzv2_chokeTuner.stp”

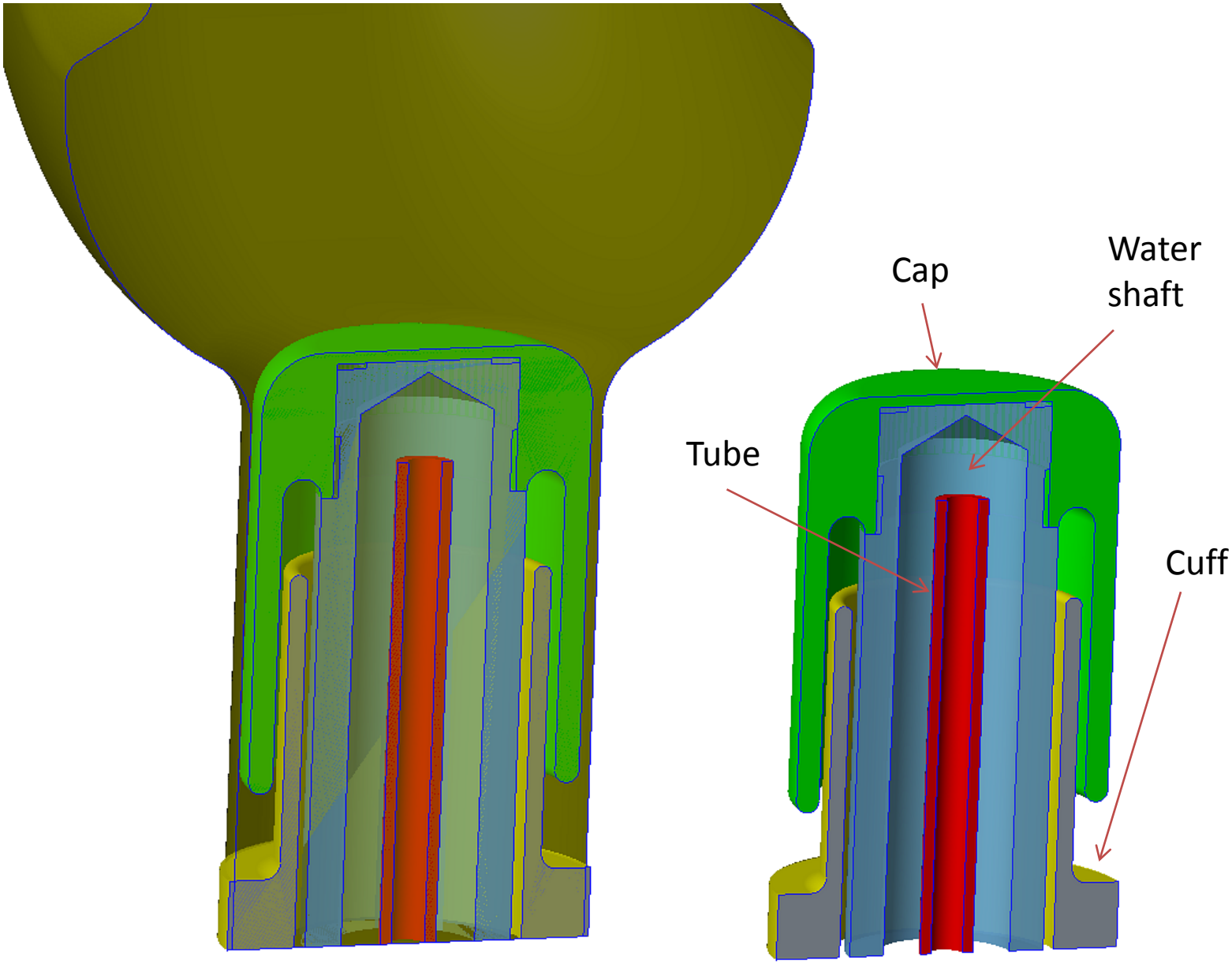




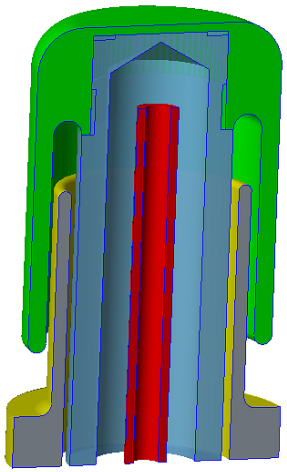
# 2.1 GHz cavity tuner

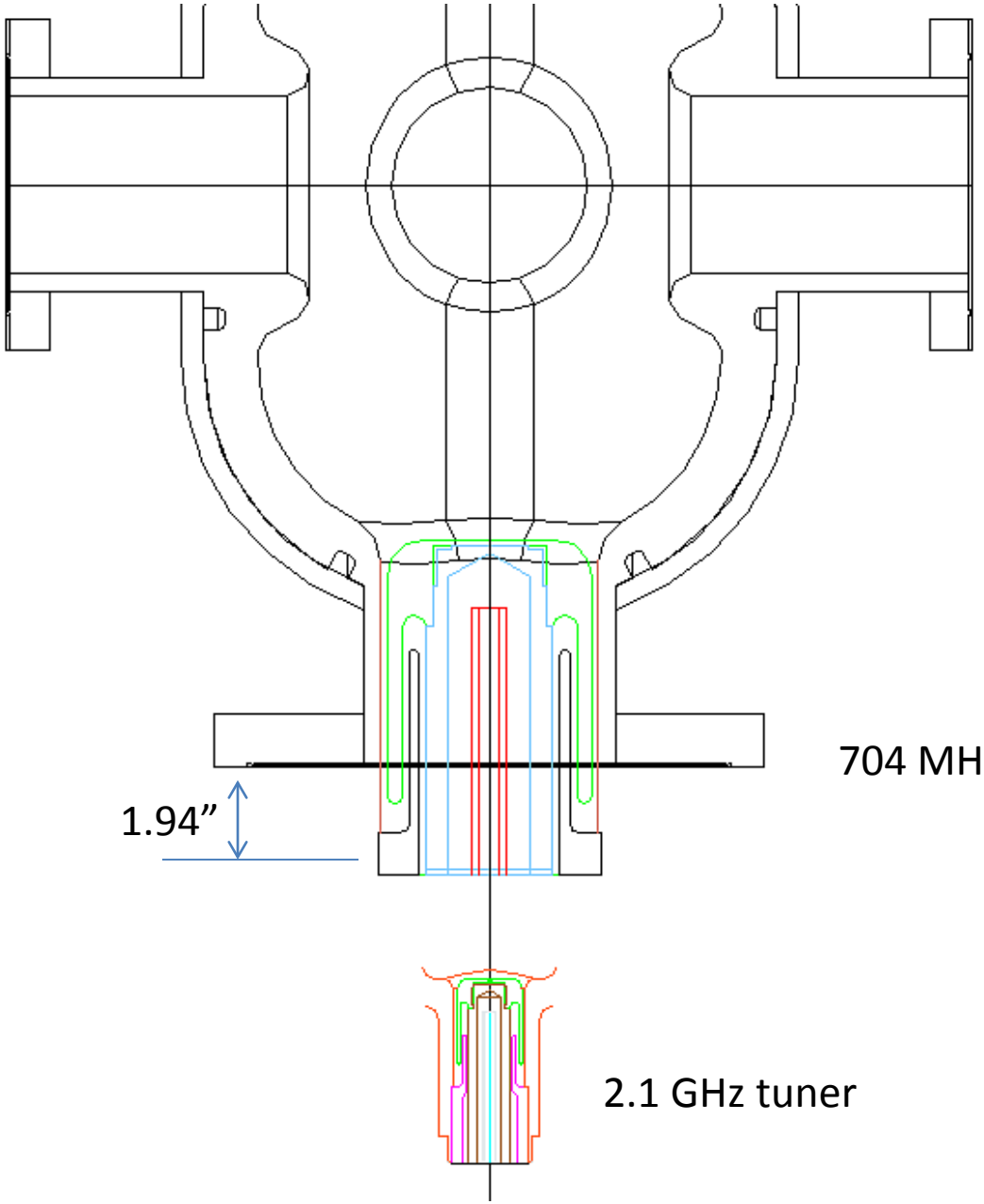


# 704 MHz Tuner conceptual design

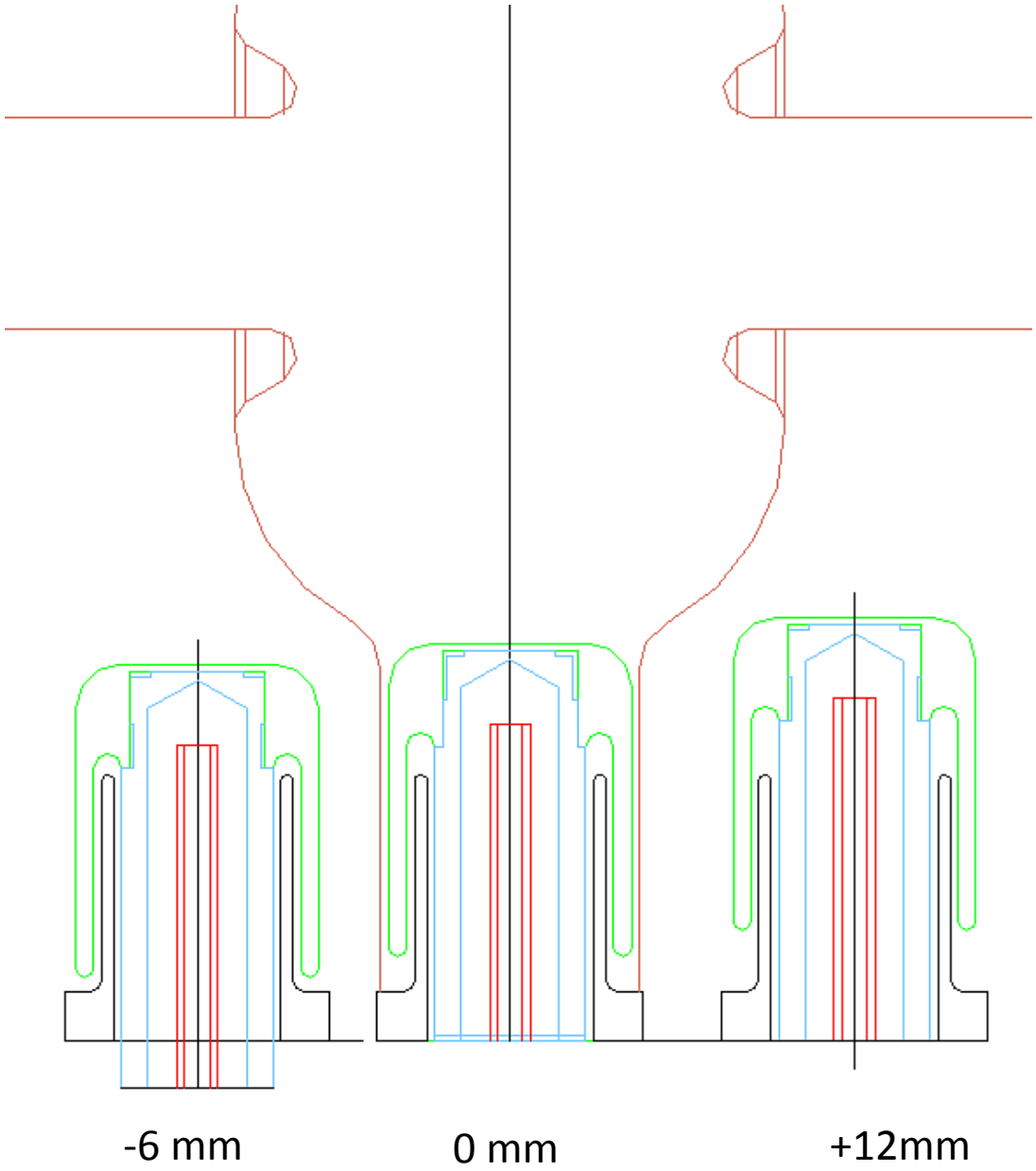


# Tuner port length may need extension

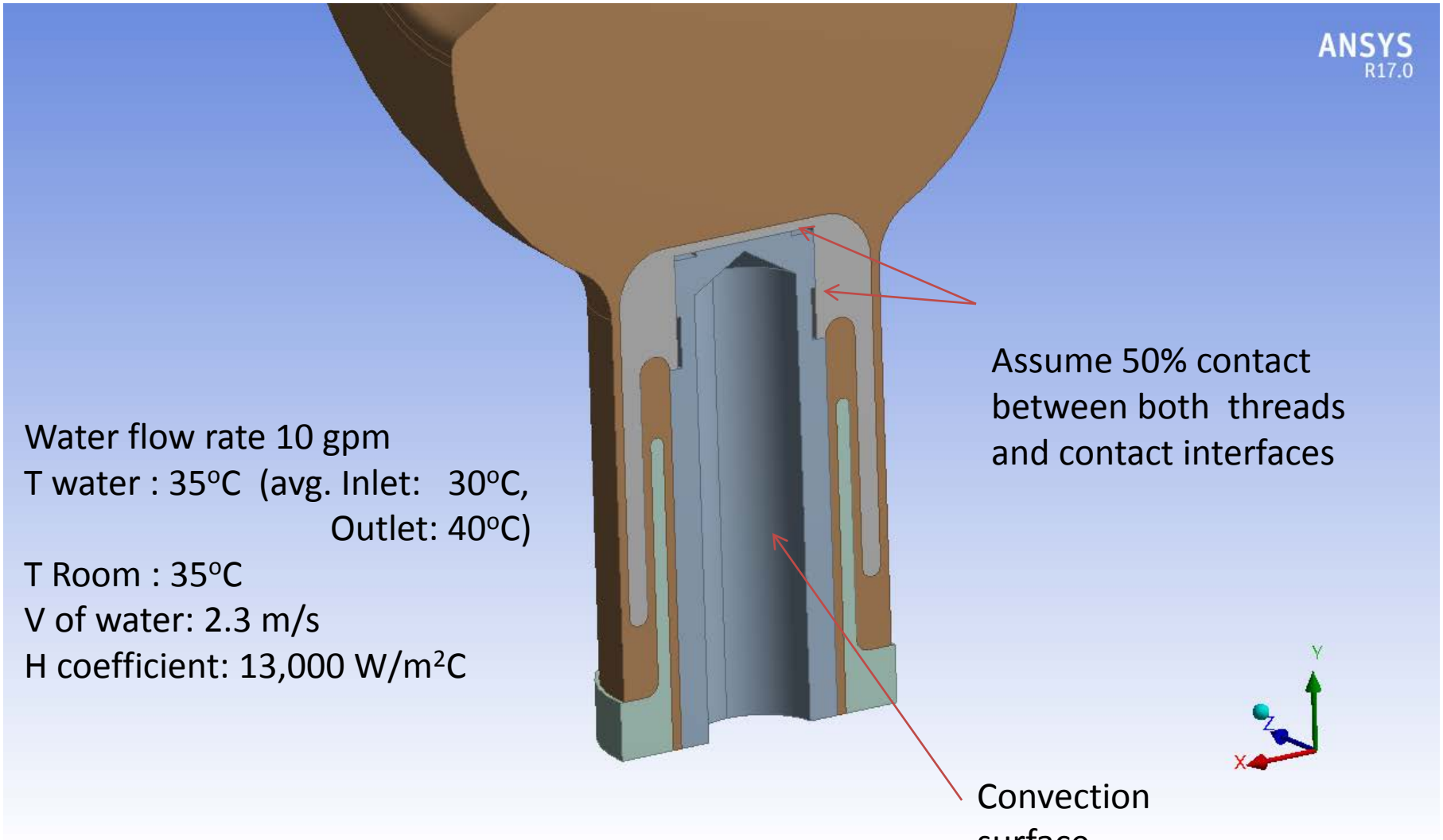




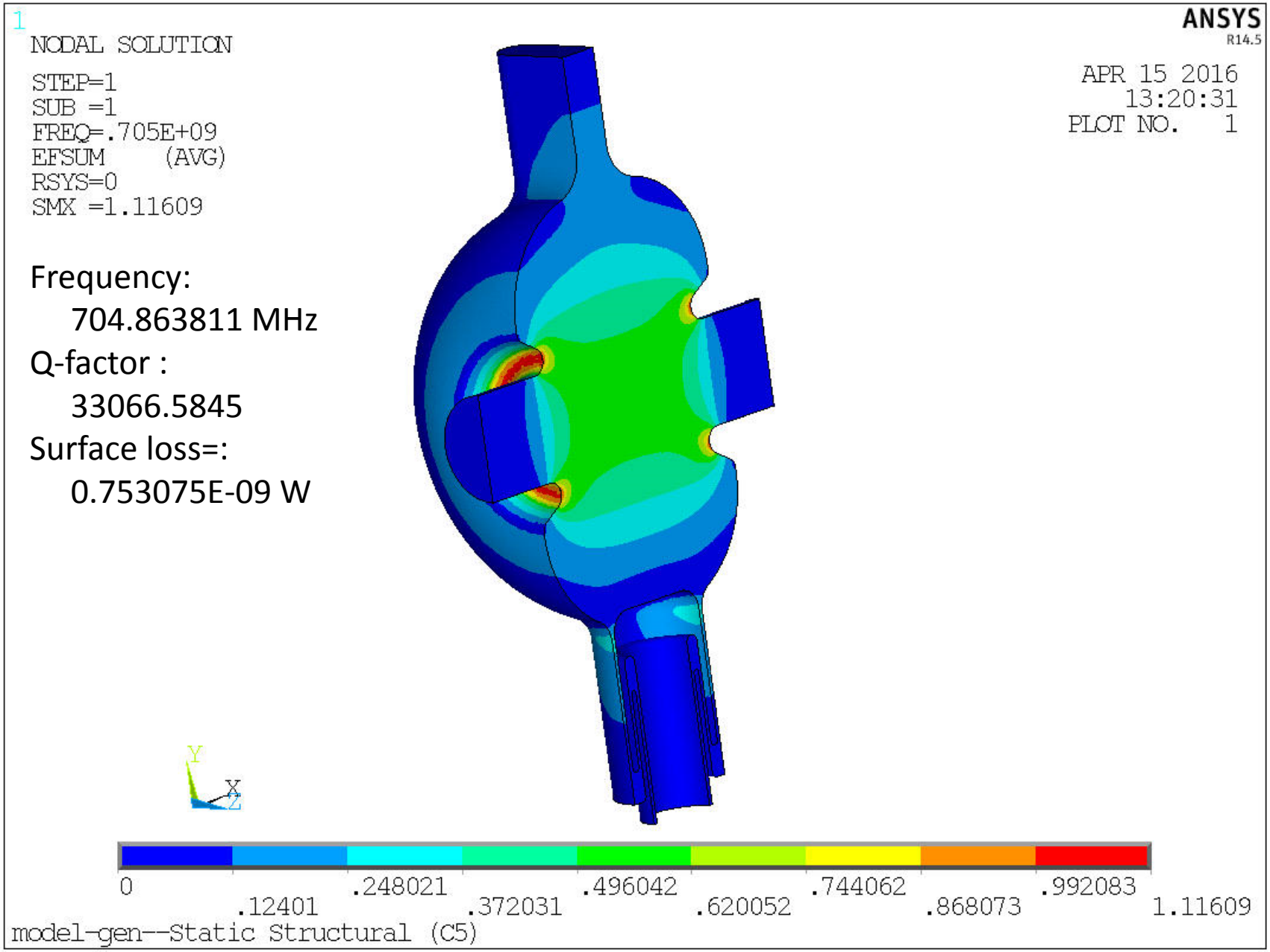
# Tuner position



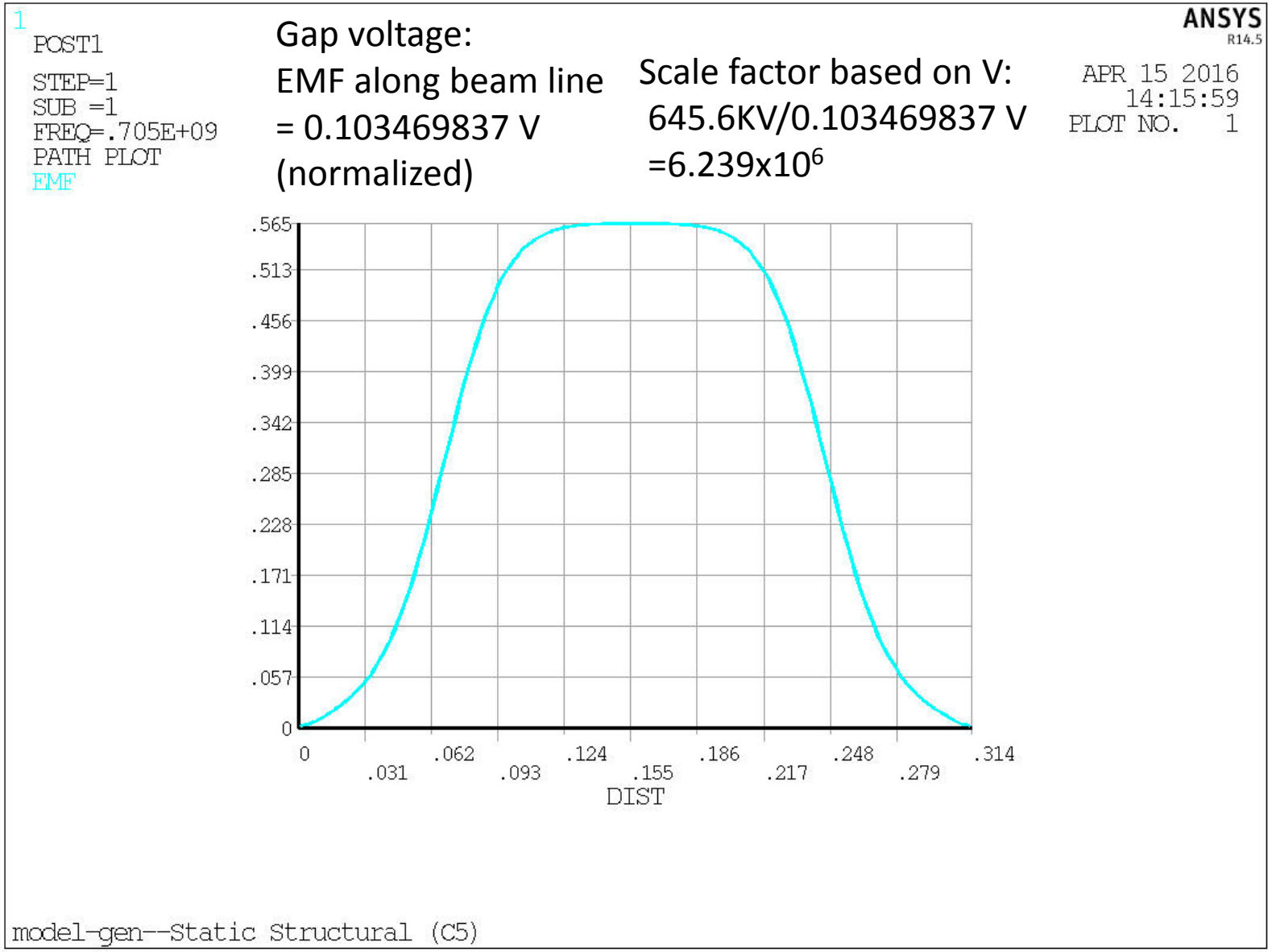
# Integral model for FE analysis



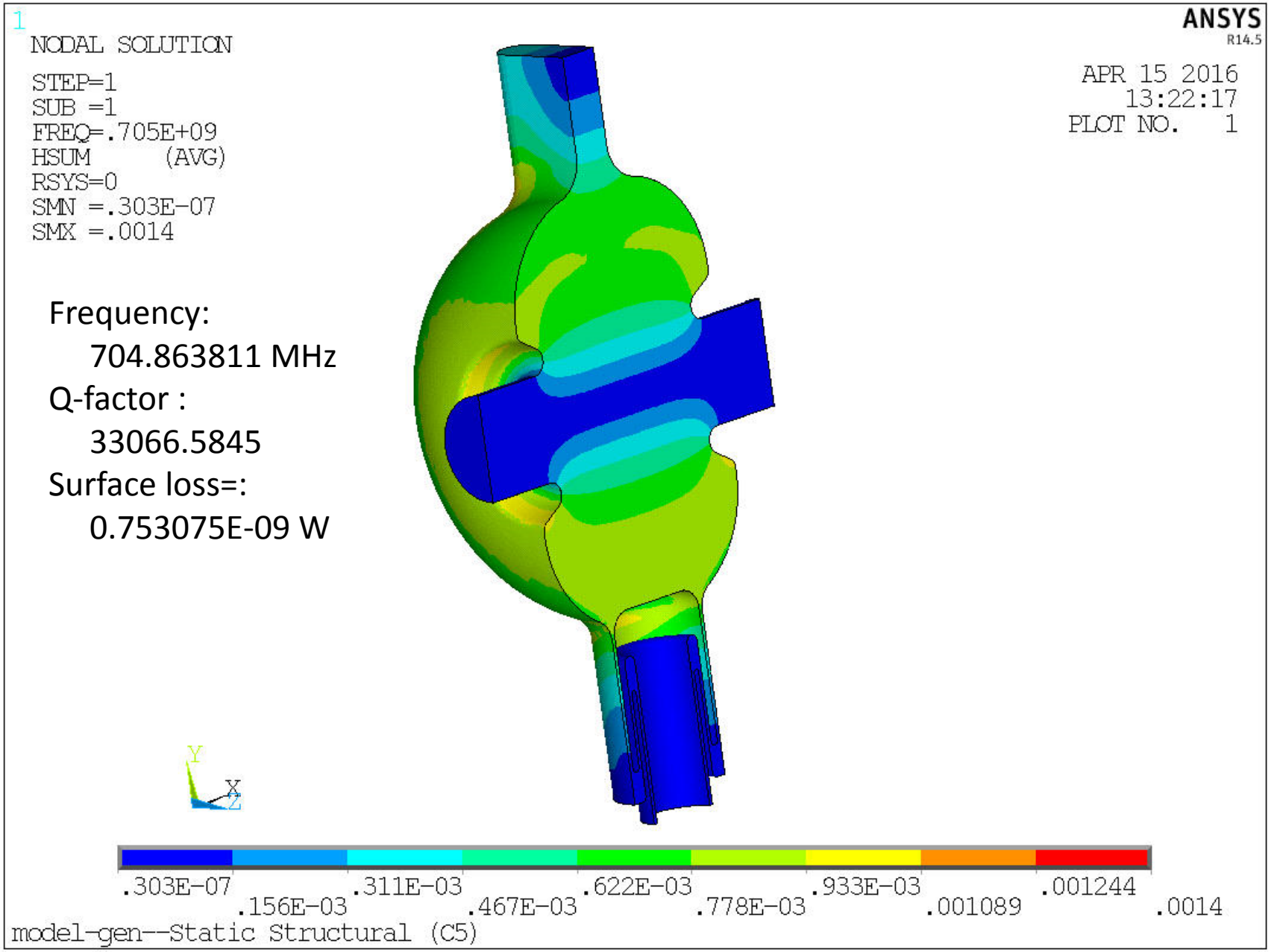
# Electrical field plot (normalized) when tuner at +12 mm position



# E field along beam line



# Magnetic field plot (normalized) when tuner at +12 mm position




Frequency:

704.863811 MHz

Q-factor :

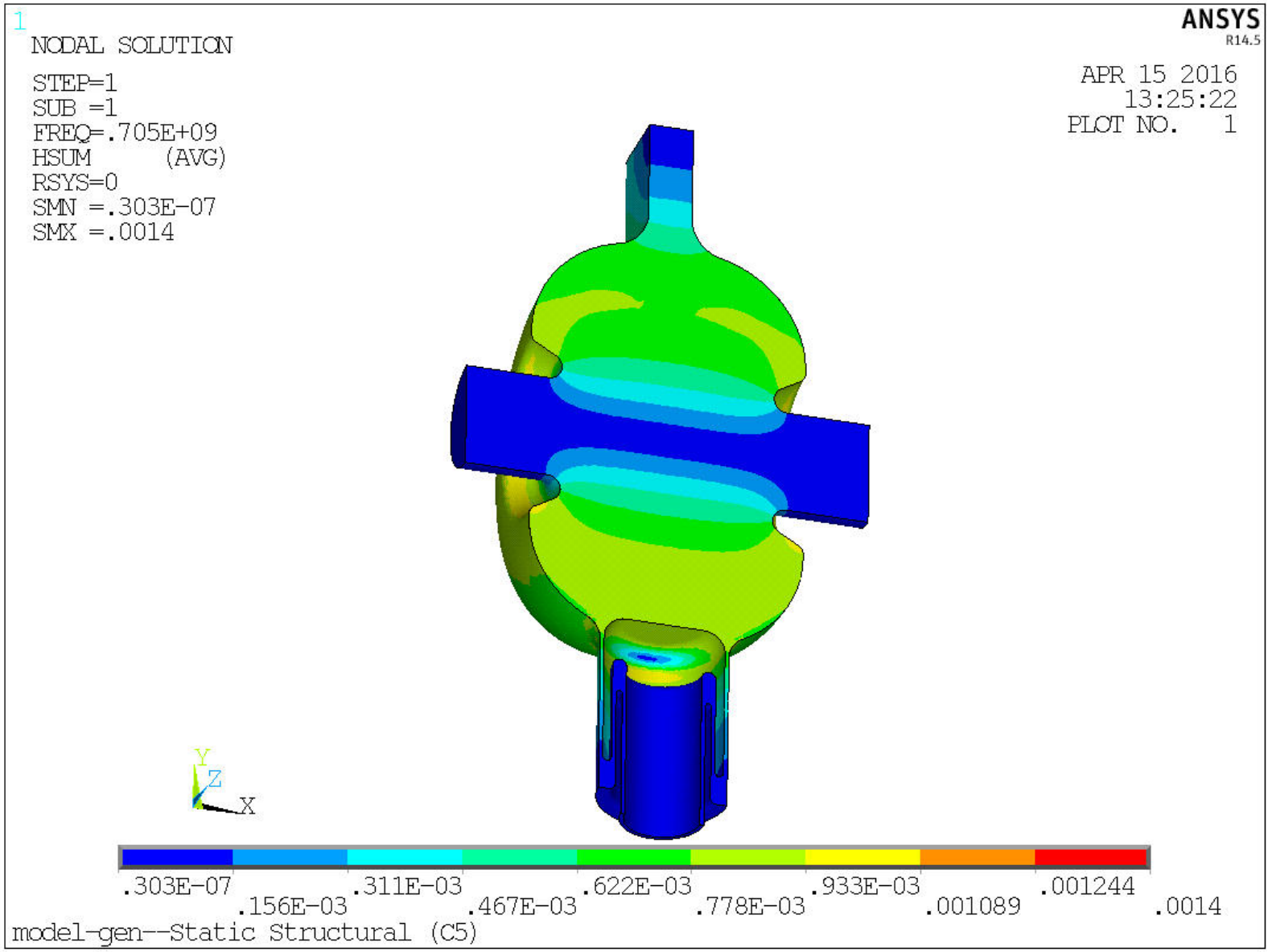
33066.5845

Surface loss=:

0.753075E-09 W

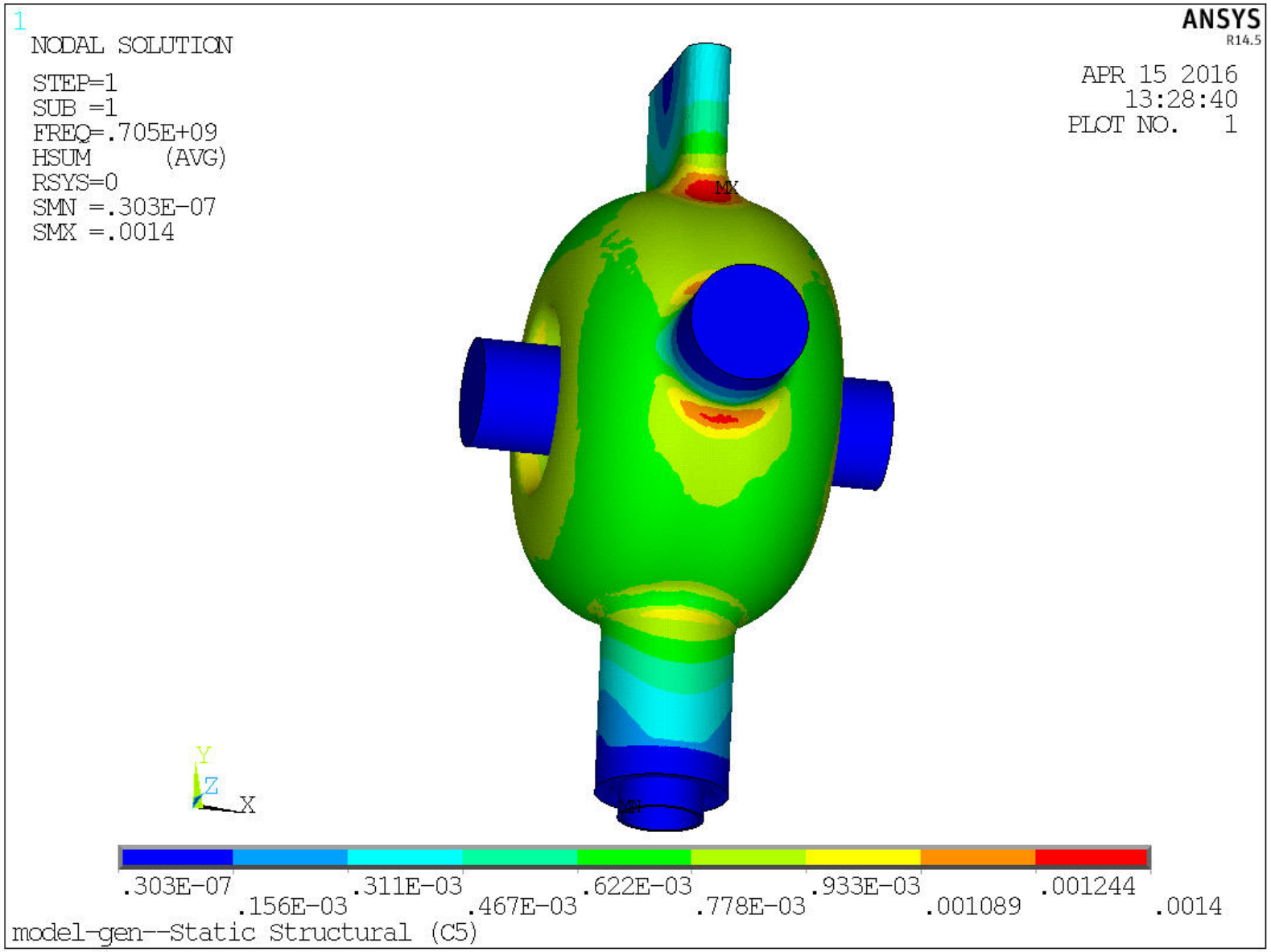
# Magnetic field plot (normalized) when tuner at +12 mm position

Viewed with tuner port



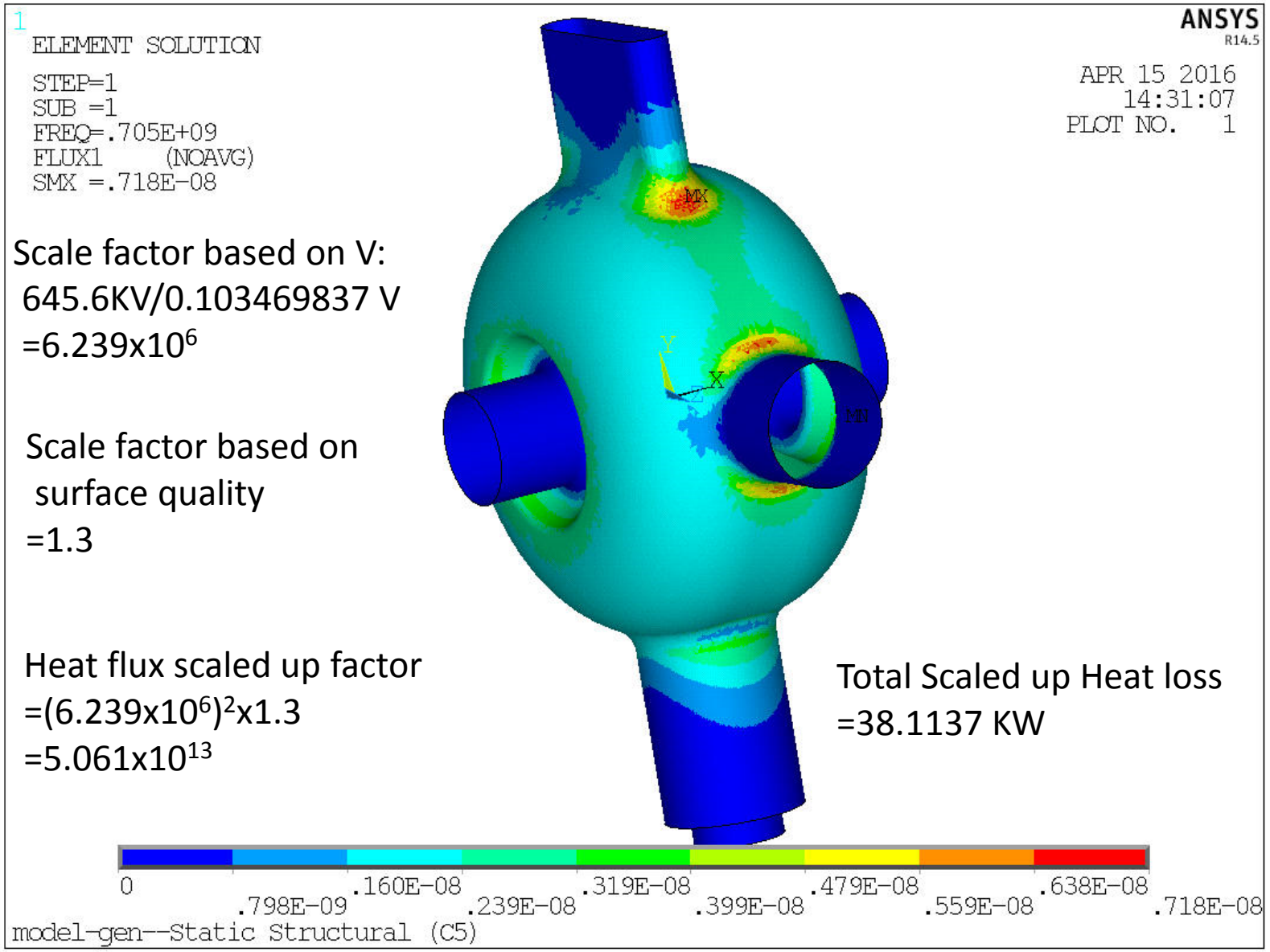
# Magnetic field plot (normalized) when tuner at +12 mm position

Viewed from port corner



# Heat Flux distribution on cavity surface loss (normalized RF calculation)

Surface loss from normalized model=0.753075E-09 W




Scale factor based on V:
645.6KV/0.103469837 V
$=6.239 \times 10^6$

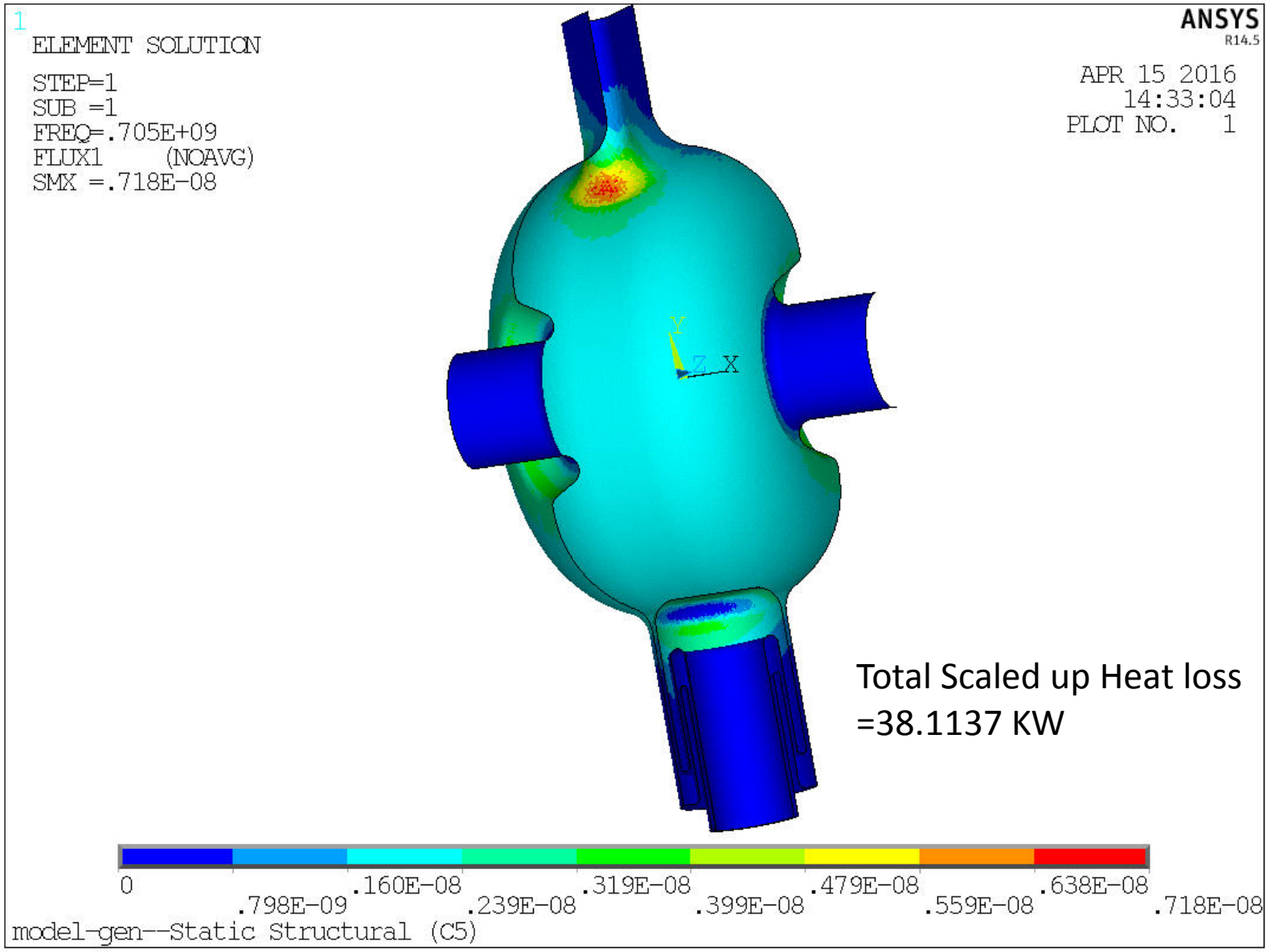
Scale factor based on surface quality
=1.3

Heat flux scaled up factor
$=(6.239 \times 10^6)^2 \times 1.3$
$=5.061 \times 10^{13}$

Total Scaled up Heat loss
=38.1137 KW

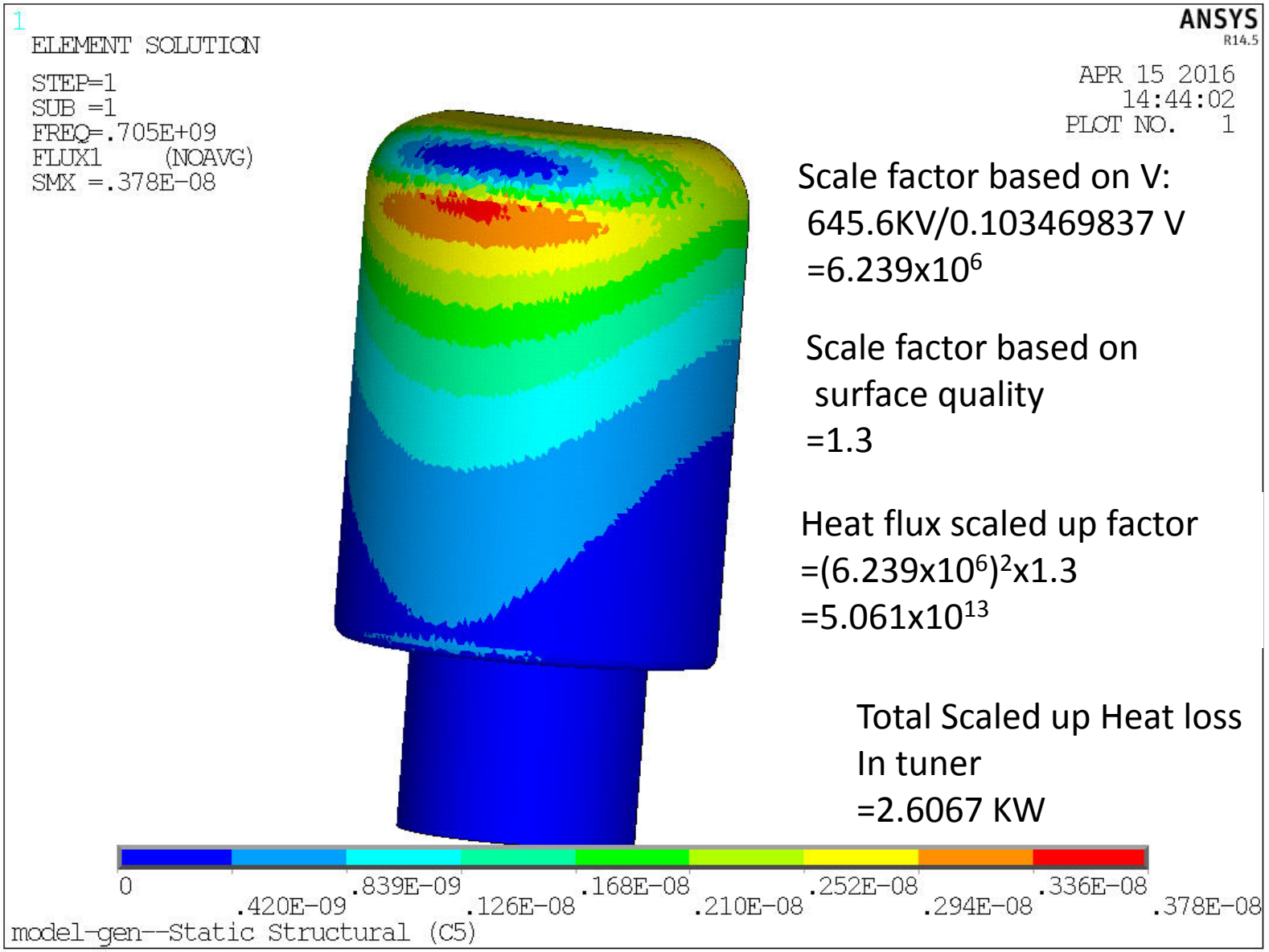
# Heat Flux distribution on cavity surface loss (normalized RF calculation)

View from inside



# Heat Flux distribution on tuner surface loss (normalized RF calculation)

Surface loss=0.515045E-10 W




Scale factor based on V:
645.6KV/0.103469837 V
$=6.239 \times 10^{6}$

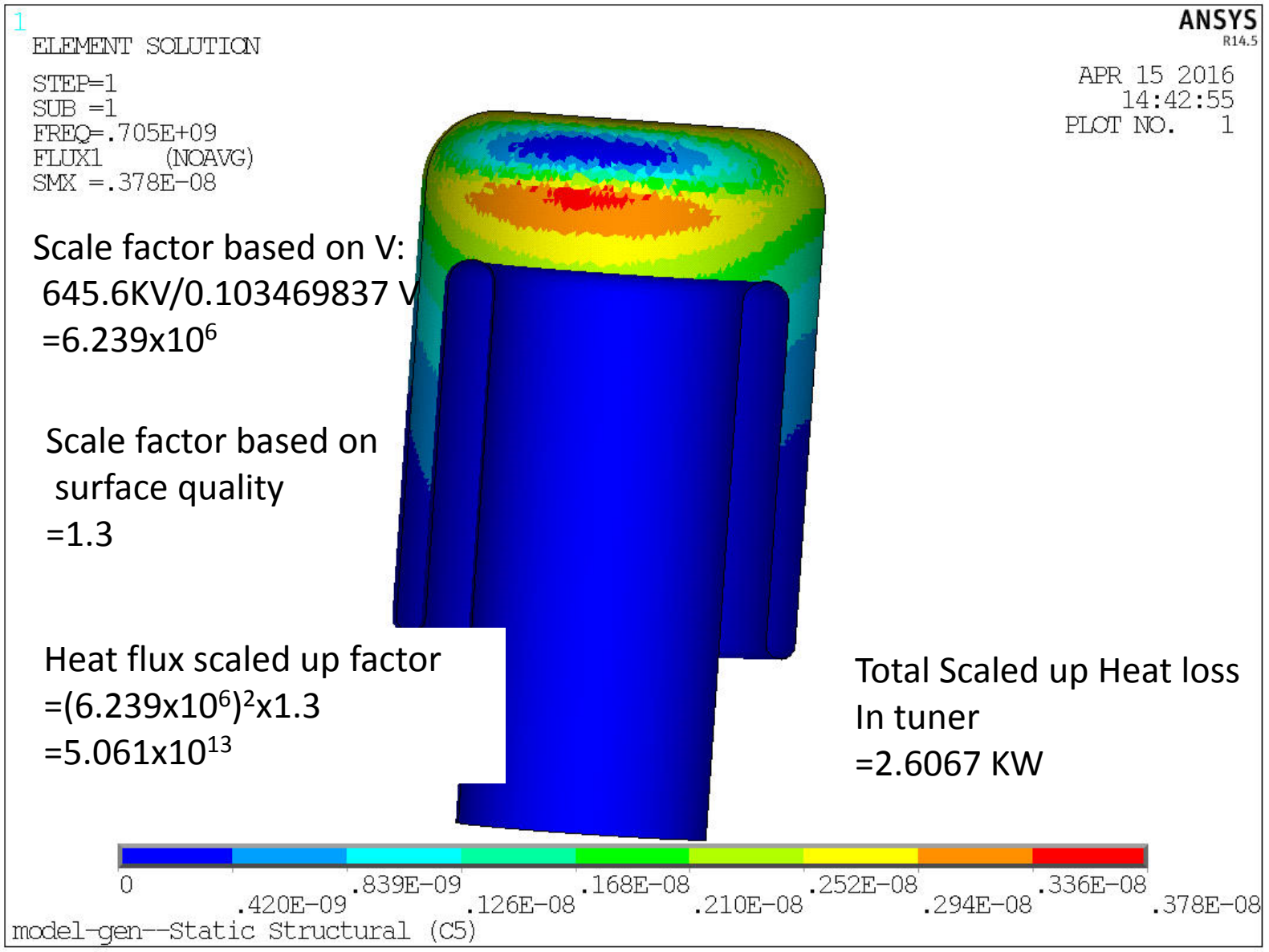
Scale factor based on surface quality
=1.3

Heat flux scaled up factor
$=(6.239 \times 10^{6})^{2} \times 1.3$
$=5.061 \times 10^{13}$

Total Scaled up Heat loss In tuner
=2.6067 KW

# Heat Flux distribution on tuner surface loss (normalized RF calculation)

Surface loss=0.515045E-10 W




Scale factor based on V:
645.6KV/0.103469837 V
$=6.239 \times 10^{6}$

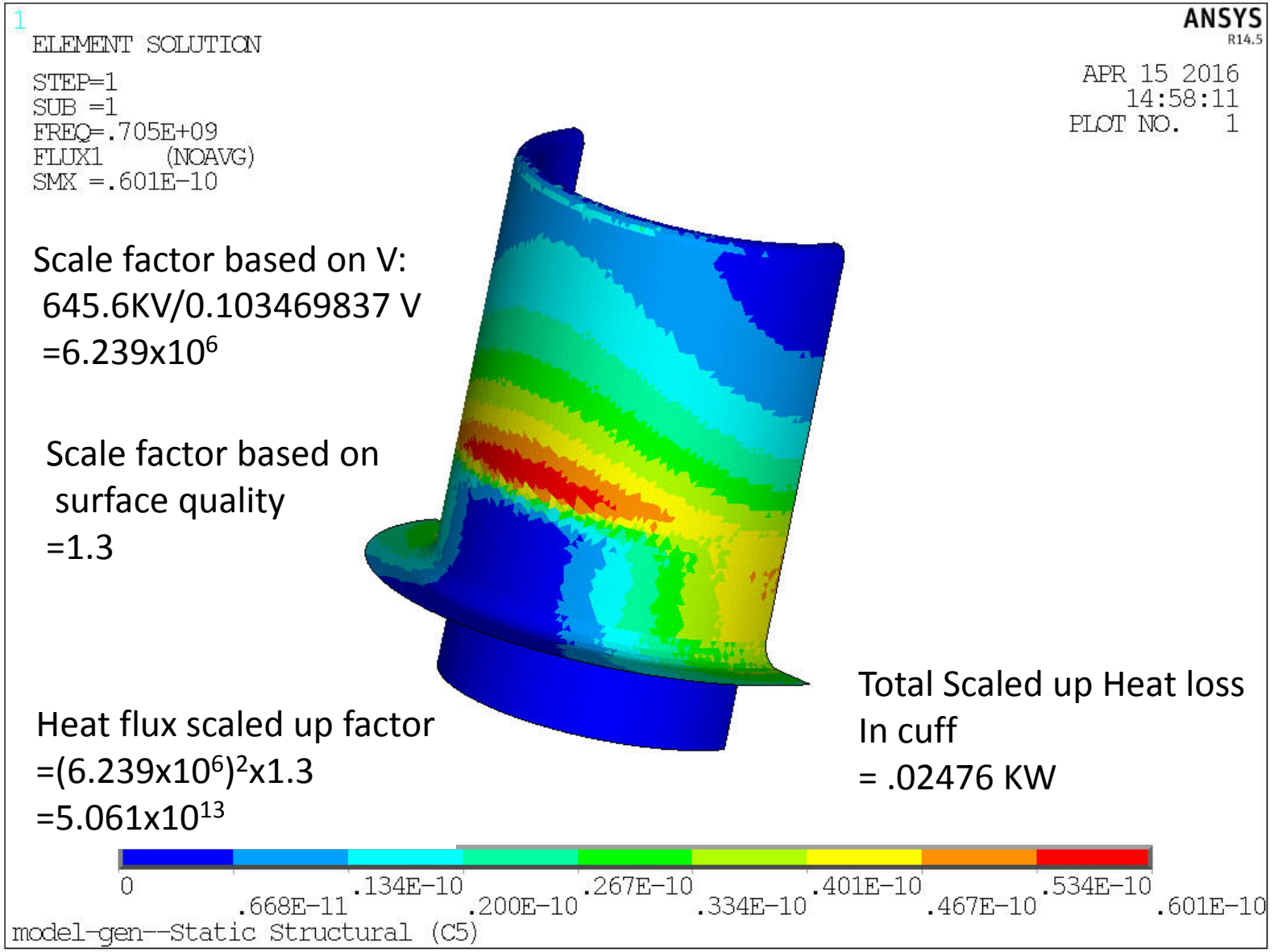
Scale factor based on surface quality
=1.3

Heat flux scaled up factor
$=(6.239 \times 10^{6})^{2} \times 1.3$
$=5.061 \times 10^{13}$

Total Scaled up Heat loss In tuner
=2.6067 KW

# Heat Flux distribution on cuff surface loss (normalized RF calculation)

Surface loss=0.489222E-12 W




Scale factor based on V:
645.6KV/0.103469837 V
$=6.239 \times 10^6$

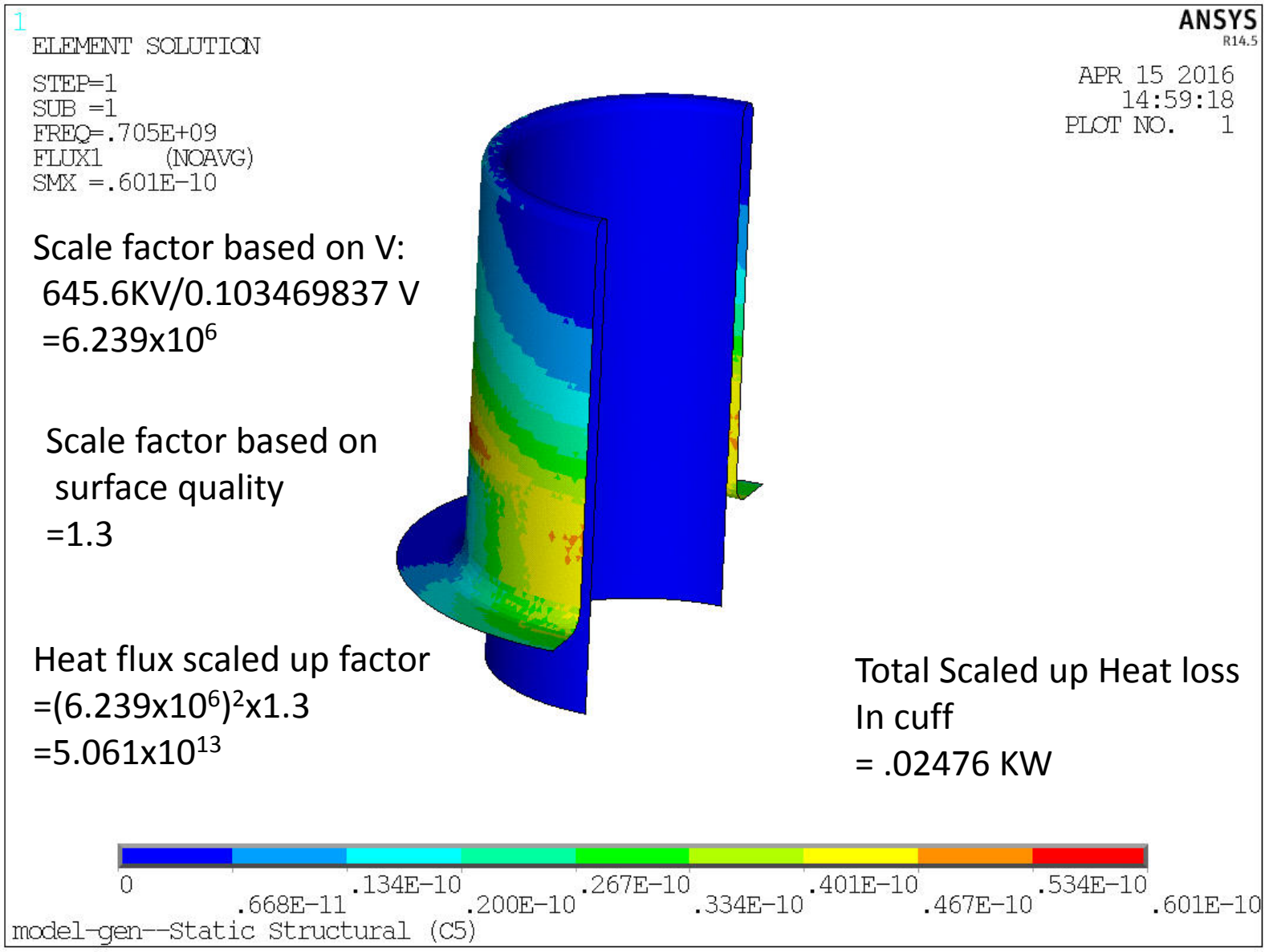
Scale factor based on surface quality
=1.3

Heat flux scaled up factor
$=(6.239 \times 10^6)^2 \times 1.3$
$=5.061 \times 10^{13}$

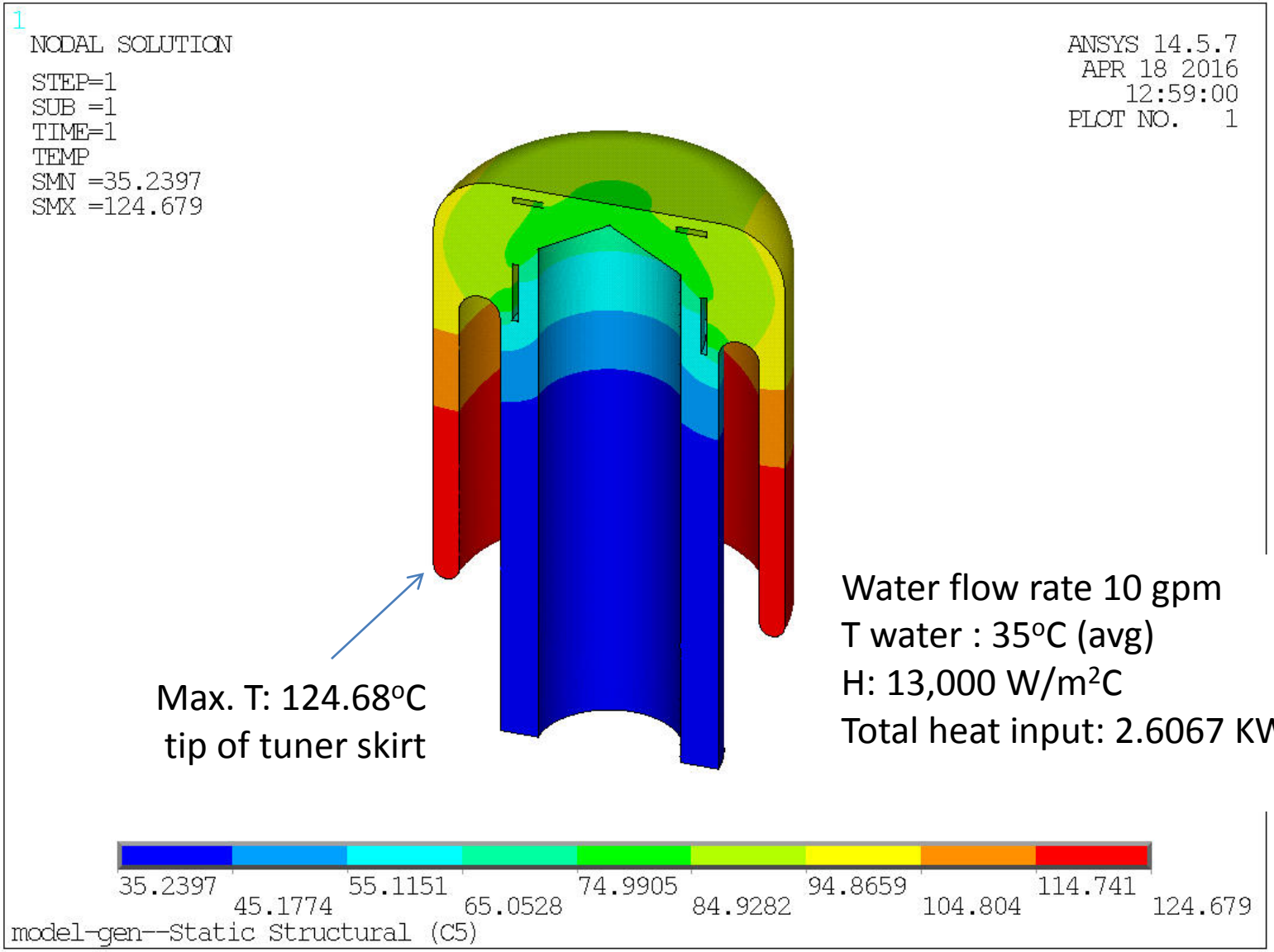
Total Scaled up Heat loss In cuff
= .02476 KW

# Heat Flux distribution on cuff surface loss (normalized RF calculation)

Surface loss=0.489222E-12 W



# Temperature distribution of water cooled tuner

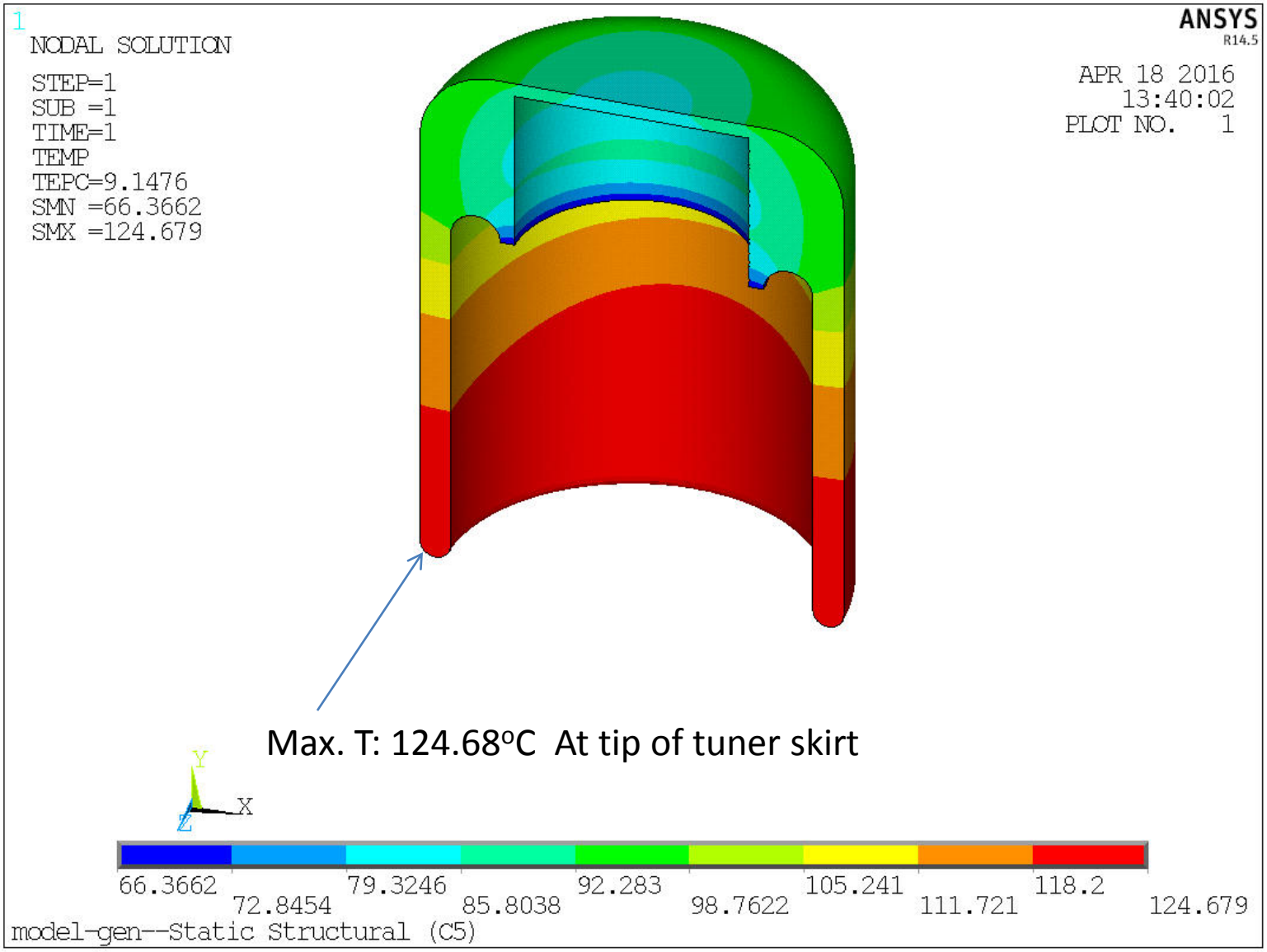



Max. T: 124.68°C
tip of tuner skirt

Water flow rate 10 gpm
T water : 35°C (avg)
H: 13,000 W/m²C
Total heat input: 2.6067 KW

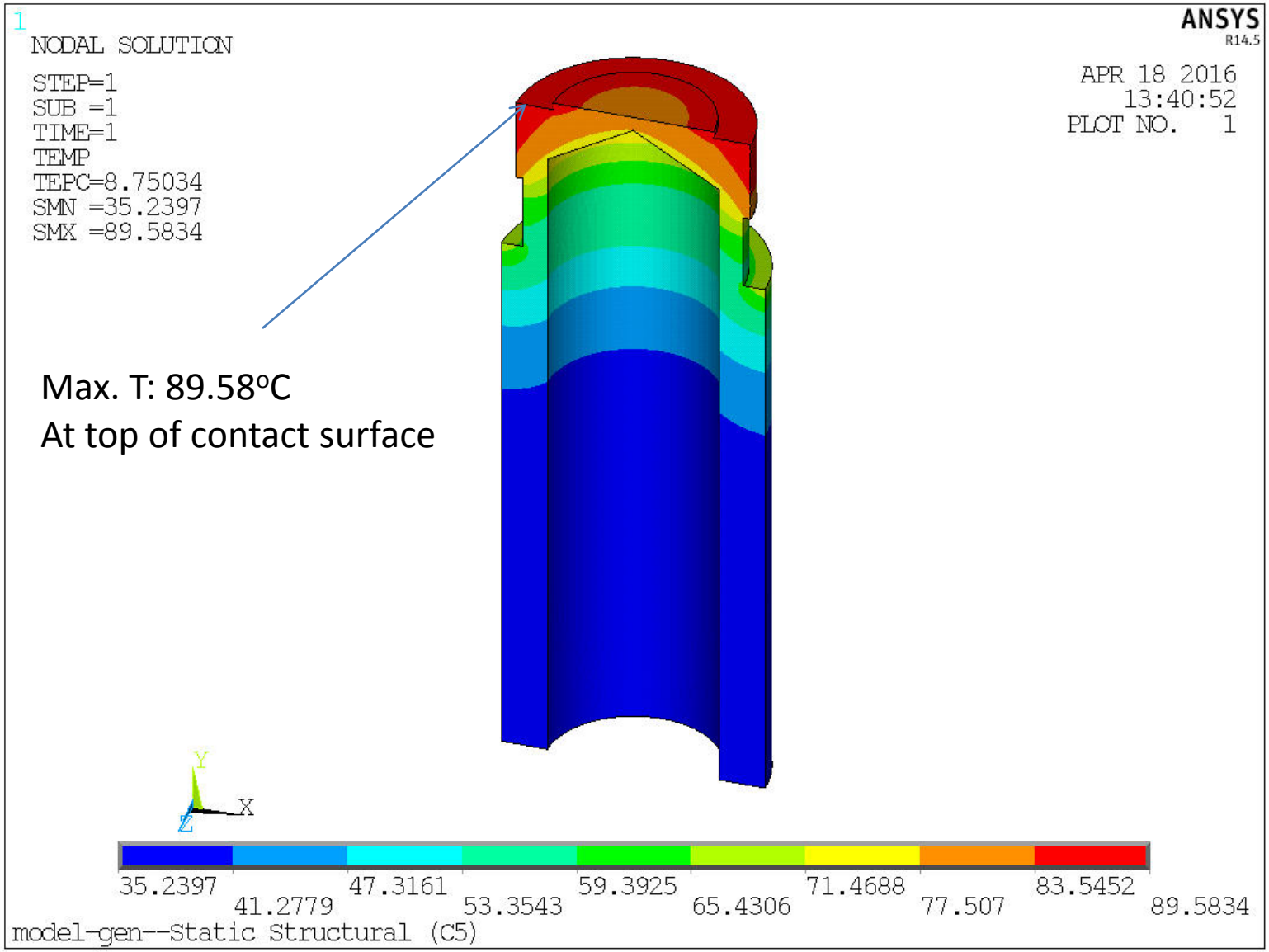
°C

# Temperature distribution of tuner cap




°C

# Temperature distribution of water shaft




°C

# Summaries: (Tuner at +12 mm)

RF results: (normalized value)

Frequency: 704.863811 MHz

Q-factor = 33066.5845

Surface loss=0.753075E-09 W

Gap voltage along beam line

= 0.103469837 V (normalized)

Scale factor from E field:

645.6KV/0.103469837V

$=6.239 \times 10^6$

Scale factor due to surface quality

=1.3

Total Scaled up factor for heat loss

$(6.239 \times 10^6)^2 \times 1.3$

$=5.061 \times 10^{13}$

Total Heat Loss= 38.1137 KW

# Summaries (cont.):

Thermal Results:

Total Scaled up Heat in whole cavity

= 38.1137 KW

Heat loss in body: 35.4823 KW

Heat loss in tuner: 2.6067 KW

Heat loss in cuff: .0247 KW

Water flow rate in tuner: 10 gpm

T water : 35$^{o}$C (avg. of inlet: 30$^{o}$C, outlet: 40$^{o}$C)

T Room : 35$^{o}$C

V of water: 2.3 m/s

H coefficient: 13,000 W/m$^{2}$C

Max. T in the tuner

: 124.68$^{o}$C At tip of tuner skirt (cap)

: 89.58$^{o}$C At top of contact surface (water shaft)