A Preliminary Thermal Result for HRS

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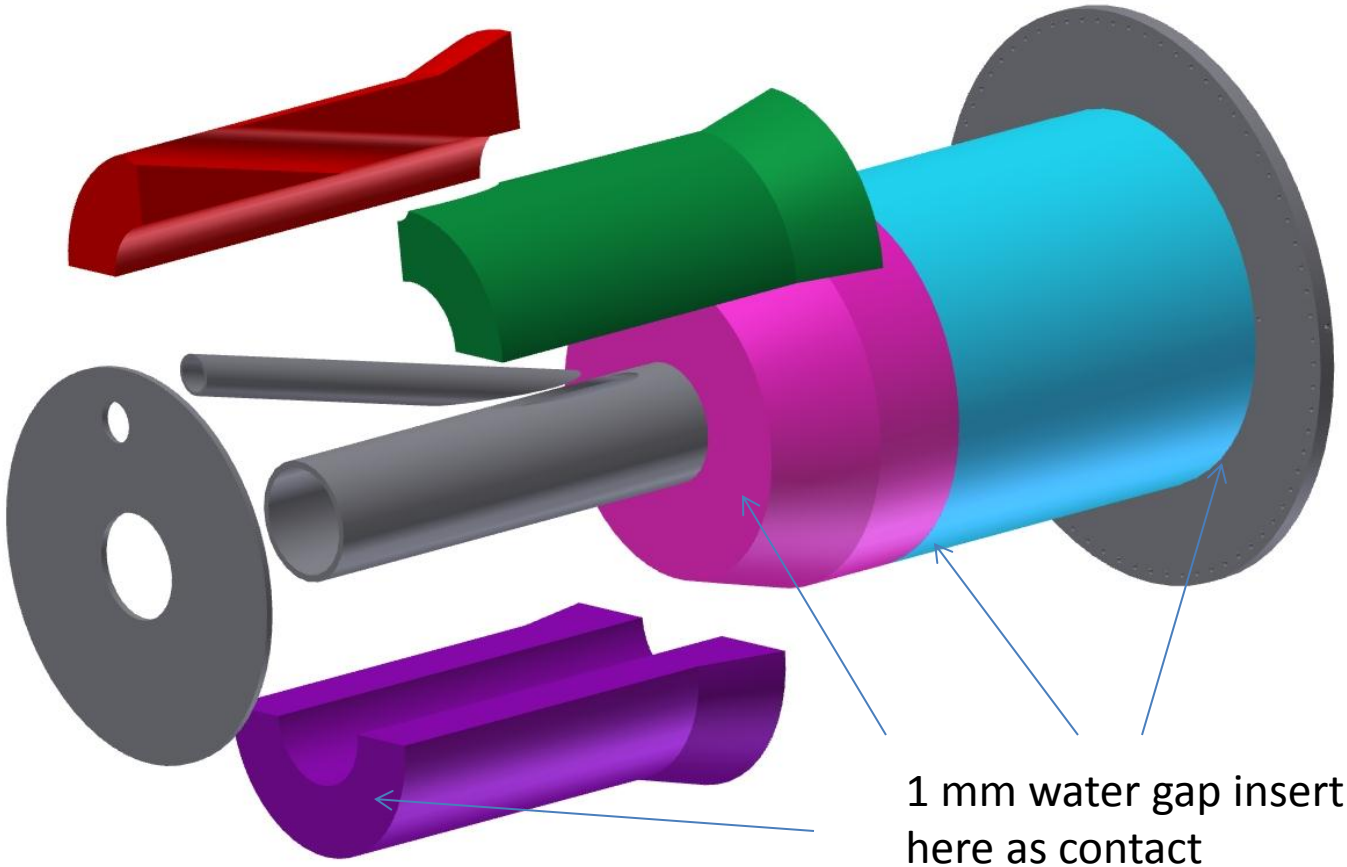
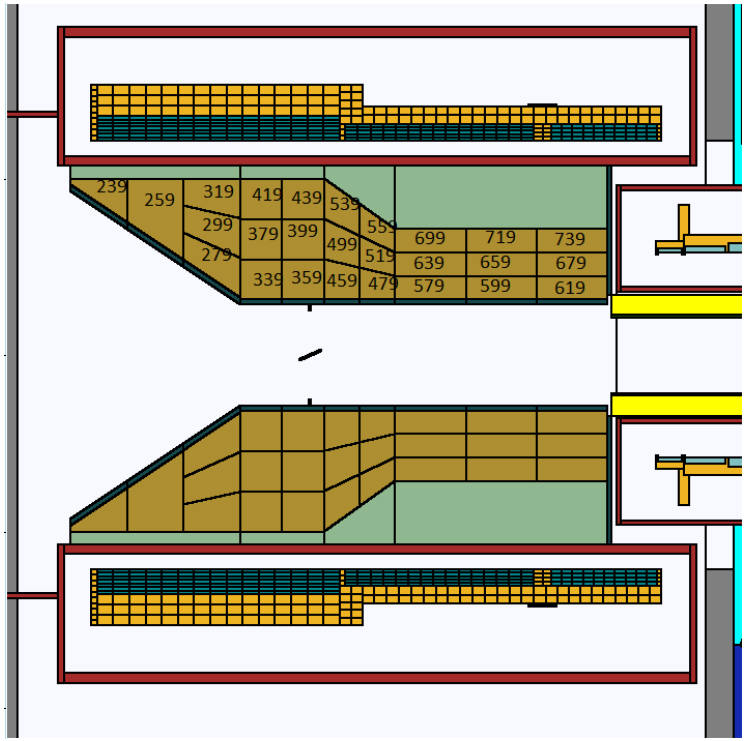
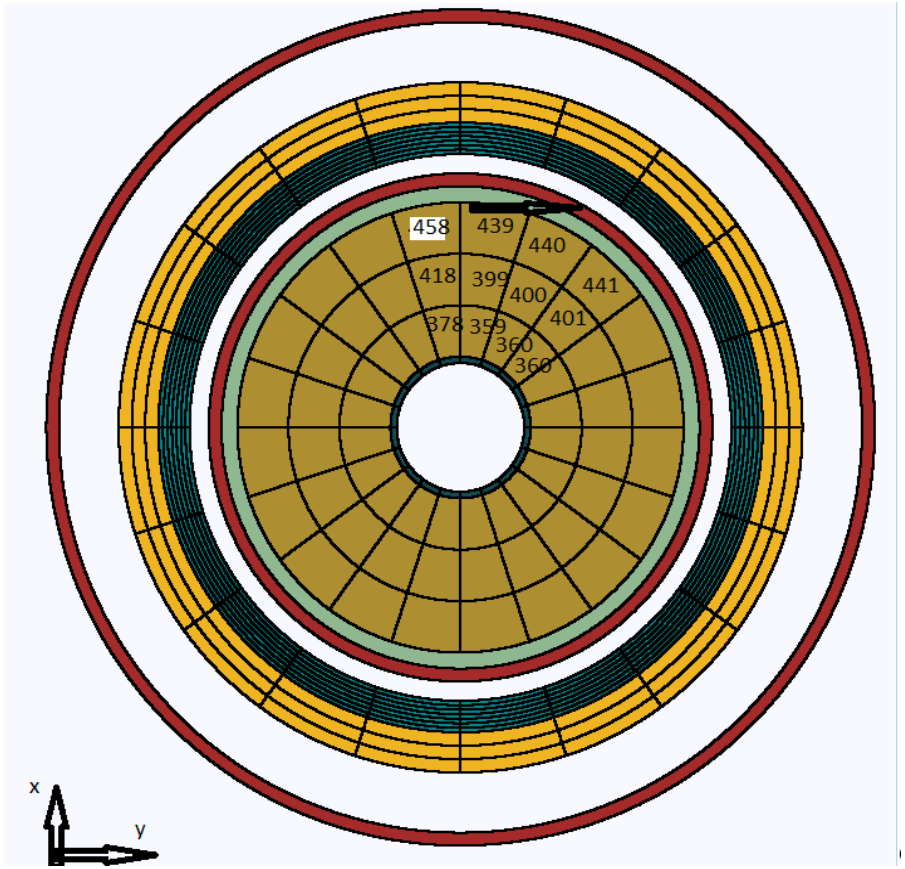
Geometry From Larry's CAD model



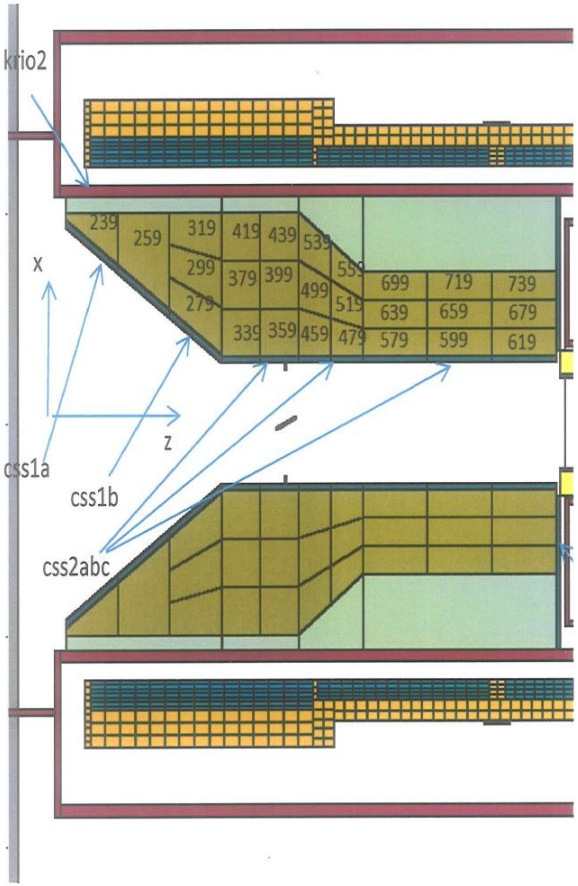
Vitaly's MARS result





More Vitaly's MARS result

NREG	VOLNAME	Material	RHO g/cm3	VOL cm3	Q W/cm3
5	krio2	S316	7.92E+00	8.55E+05	6.15E+01
33	cwtr1	Water	1.00E+00	2.73E+05	9.67E+00
34	cwtr2	Water	1.00E+00	1.34E+05	6.38E+00
35	cwtr3	Water	1.00E+00	3.13E+05	5.67E+00
36	cwtr4	Water	1.00E+00	1.47E+06	3.55E+00
39	css1a	S316	7.92E+00	1.99E+03	2.58E-01
40	css1a	S316	7.92E+00	2.00E+03	2.55E-01
41	css1a	S316	7.92E+00	1.98E+03	2.55E-01
42	css1a	S316	7.92E+00	1.99E+03	2.69E-01
43	css1a	S316	7.92E+00	2.00E+03	2.99E-01
44	css1a	S316	7.92E+00	1.98E+03	3.45E-01
45	css1a	S316	7.92E+00	1.98E+03	4.71E-01
46	css1a	S316	7.92E+00	1.94E+03	7.92E-01
47	css1a	S316	7.92E+00	2.00E+03	9.19E-01
48	css1a	S316	7.92E+00	2.02E+03	1.10E+00
49	css1a	S316	7.92E+00	2.00E+03	1.02E+00
50	css1a	S316	7.92E+00	2.02E+03	9.12E-01
51	css1a	S316	7.92E+00	2.02E+03	5.67E-01
52	css1a	S316	7.92E+00	1.99E+03	4.30E-01
53	css1a	S316	7.92E+00	2.02E+03	3.52E-01
54	css1a	S316	7.92E+00	2.01E+03	3.06E-01
55	css1a	S316	7.92E+00	1.97E+03	2.77E-01
56	css1a	S316	7.92E+00	1.98E+03	2.62E-01



Understanding MARS DATA

NREG	VOLNAME	Material	RHO	VOL	Q
			g/cm3	cm3	W/cm3
5	krio2	S316	7.92E+00	8.55E+05	6.15E+01
33	cwtr1	Water	1.00E+00	2.73E+05	9.67E+00
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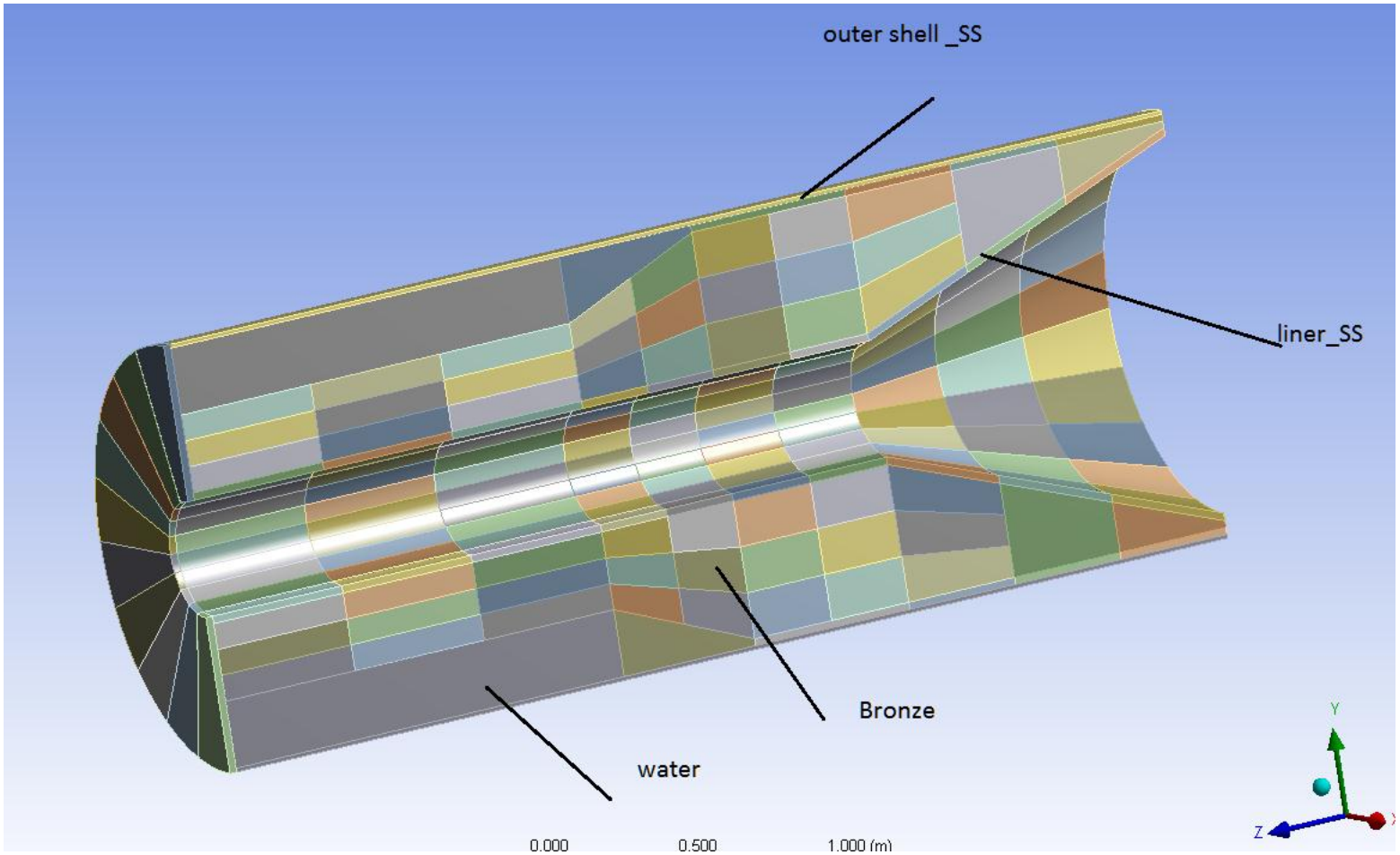
36	cwtr4	Water	1.00E+00	1.47E+06	3.55E+00
39	css1a	S316	7.92E+00	1.99E+03	2.58E-01
40	css1a	S316	7.92E+00	2.00E+03	2.55E-01
41	css1a	S316	7.92E+00	1.98E+03	2.55E-01
42	css1a	S316	7.92E+00	1.99E+03	2.69E-01
43	css1a	S316	7.92E+00	2.00E+03	2.99E-01
44	css1a	S316	7.92E+00	1.98E+03	3.45E-01
45	css1a	S316	7.92E+00	1.98E+03	4.71E-01
46	css1a	S316	7.92E+00	1.94E+03	7.92E-01
47	css1a	S316	7.92E+00	2.00E+03	9.19E-01
48	css1a	S316	7.92E+00	2.02E+03	1.10E+00
49	css1a	S316	7.92E+00	2.00E+03	1.02E+00
50	css1a	S316	7.92E+00	2.02E+03	9.12E-01
51	css1a	S316	7.92E+00	2.02E+03	5.67E-01
52	css1a	S316	7.92E+00	1.99E+03	4.30E-01
53	css1a	S316	7.92E+00	2.02E+03	3.52E-01
54	css1a	S316	7.92E+00	2.01E+03	3.06E-01
55	css1a	S316	7.92E+00	1.97E+03	2.77E-01
56	css1a	S316	7.92E+00	1.98E+03	2.62E-01

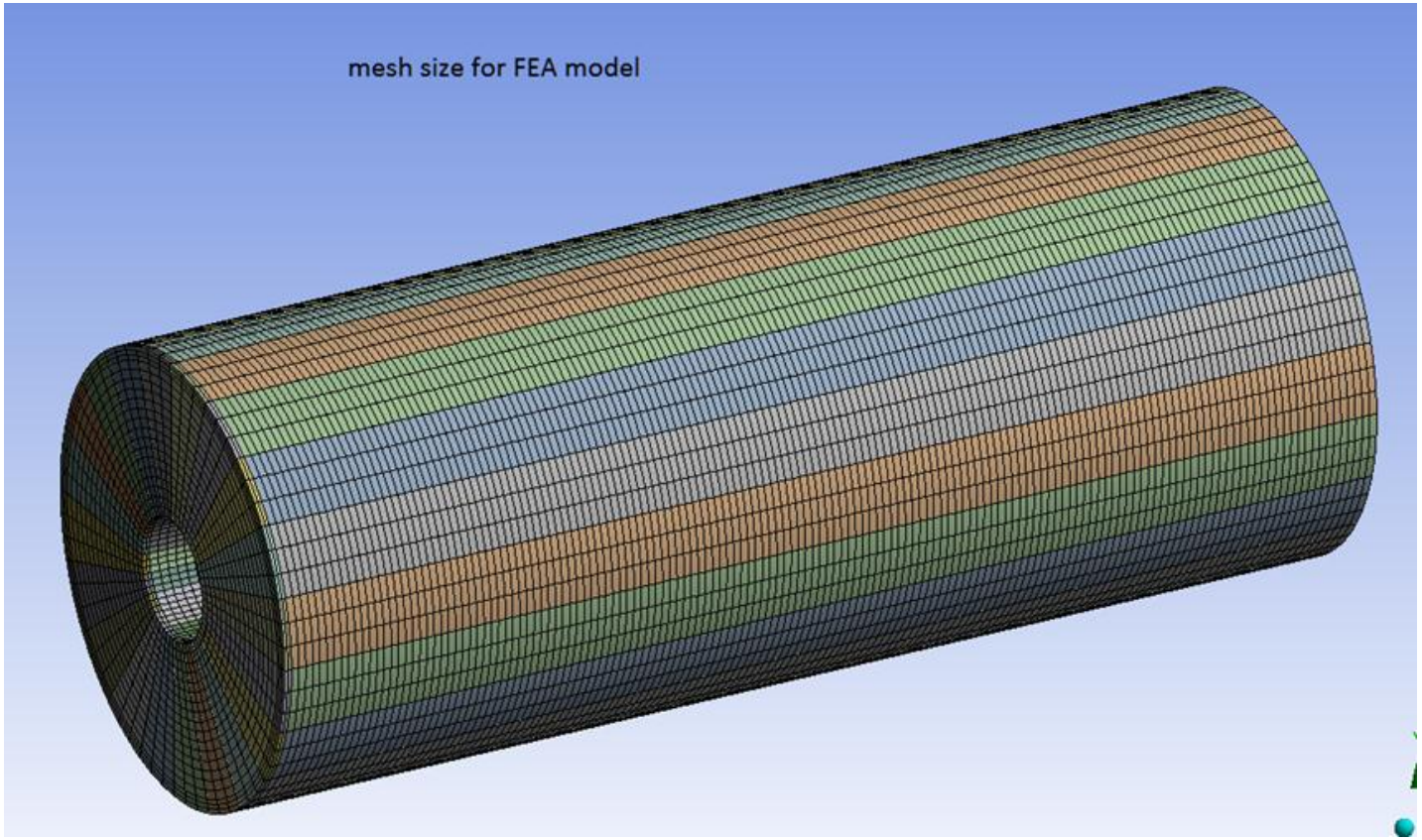
	Vol	W	%
outer	0.86	61.47	1.8608
water	2.19	25.26	0.7648
inner	1.58E-01	3.80E+02	11.4999
bronze	3.28E+00	2.84E+03	85.8687
flange	4.04E-02	1.91E-01	0.0058
total	6.52	3303.40	

Total heat =3303 W

FEA Model



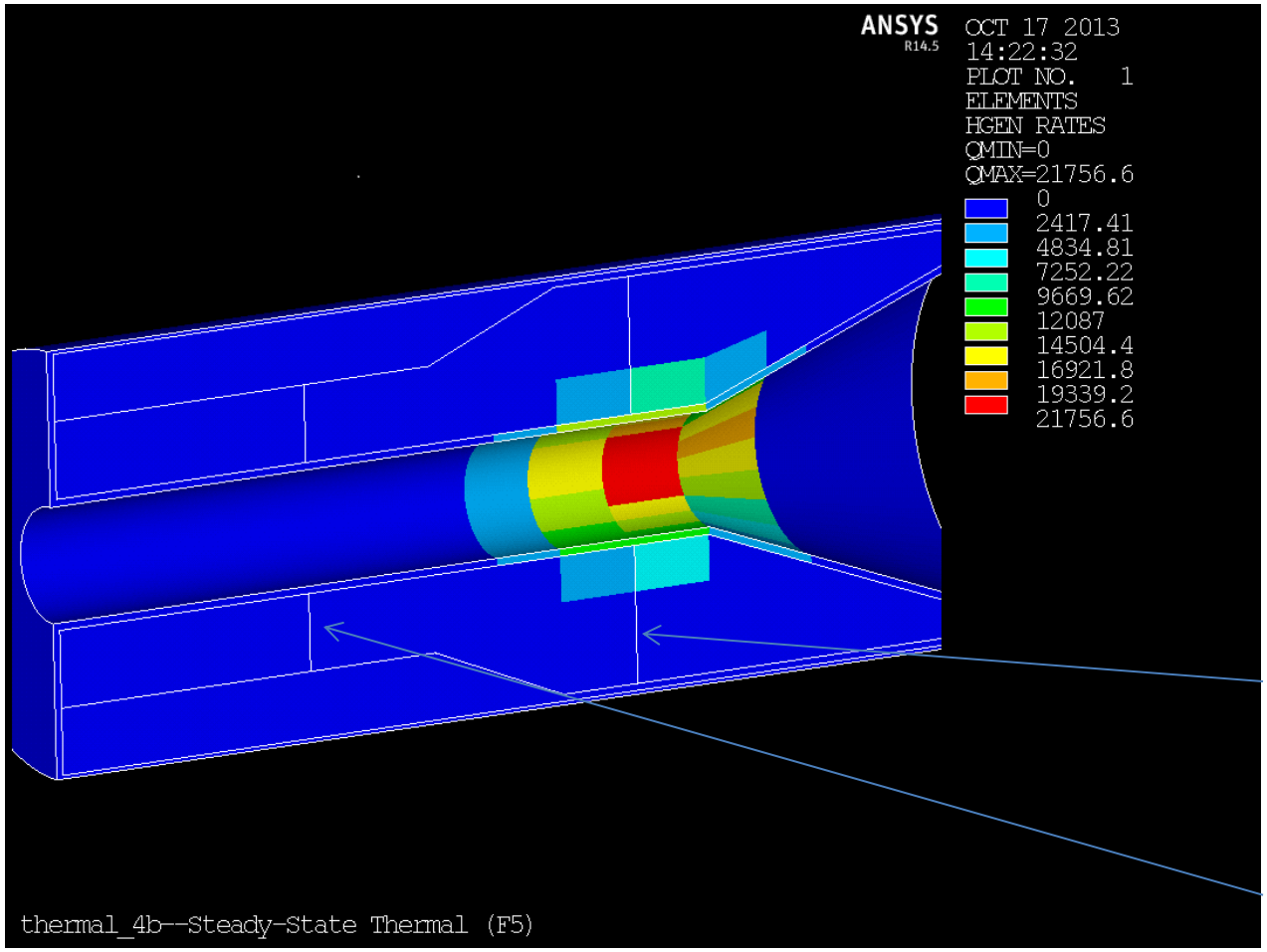
FEA model and mesh



FEA Loading and Boundary condition

- Map MARS data into FEA model as heat generation rate (W/m^3). It takes some time to work it out (since MARS data does not contain a x,y,z coordinate)
- Convective boundary for the water hc=20 (w/m^2 k) as a natural convection (normally hc=20~100 (W/m^2 K) for water).
- The water temperature is assumed to be 35 C
- The outer shell is considered to be insulated as a worst case.
- Total heat=3300 (W); Water flow rate=3 gpm; it gives a temperature rise ΔT =4.16 C. Not much!
- The contact resistance is assumed to be 1 mm water between inner liner and bronze; between pieces of the bronzes; as well as between the bronze and the end flange .
- MARS from Vitaly does not have an outer shell. Krio2 area=61 W. Instead of asking Vitaly to re-run it with the outer shell, we simply dump this 61 W into the 0.5 outer shell since it is away the beam interaction center (1.5% of total energy _ Secondary effect)

MARS data mapped in ANSYS



Conductivity(W/mK)

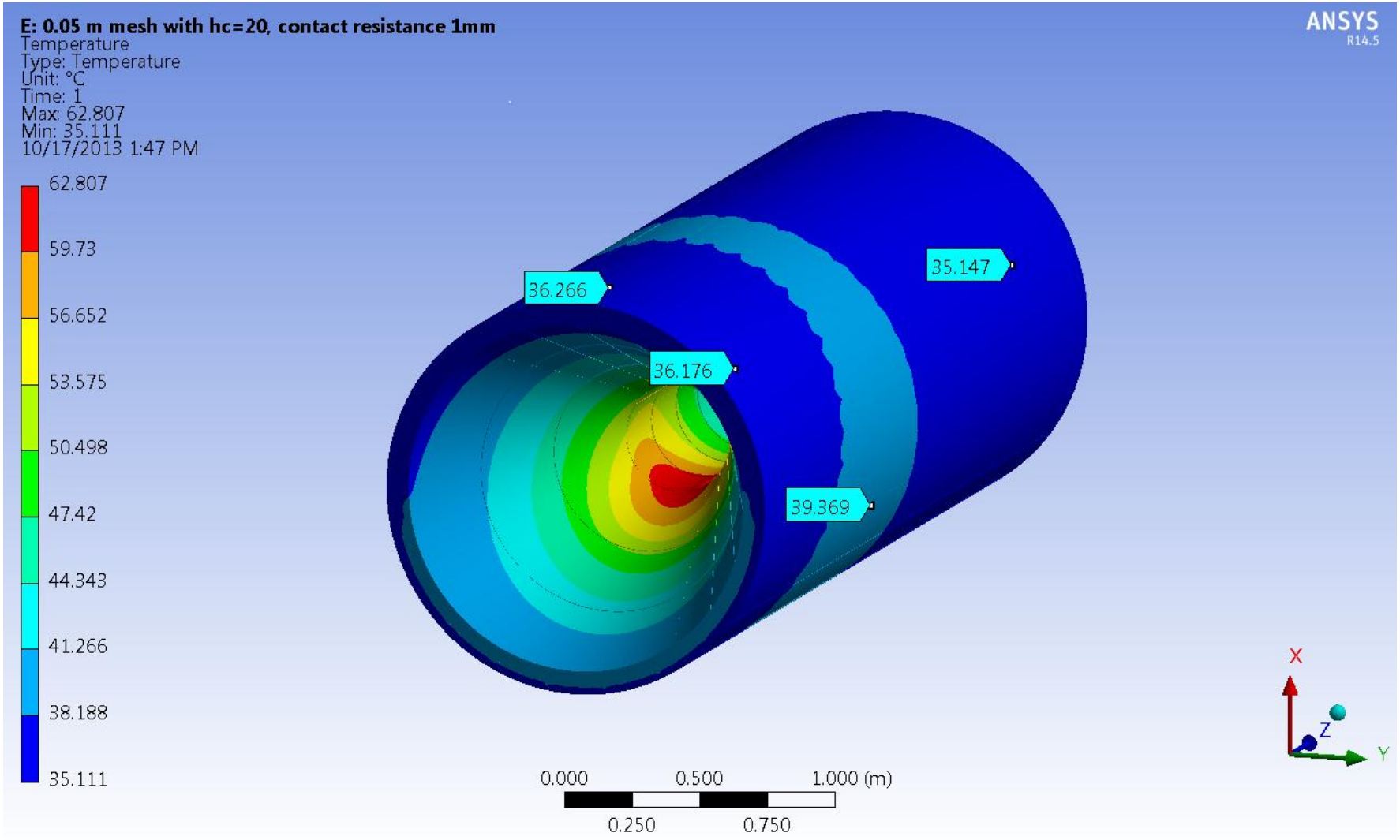
K(water)=0.604
K bronze=35
K ss=13.8

Where the contact resistance inserted

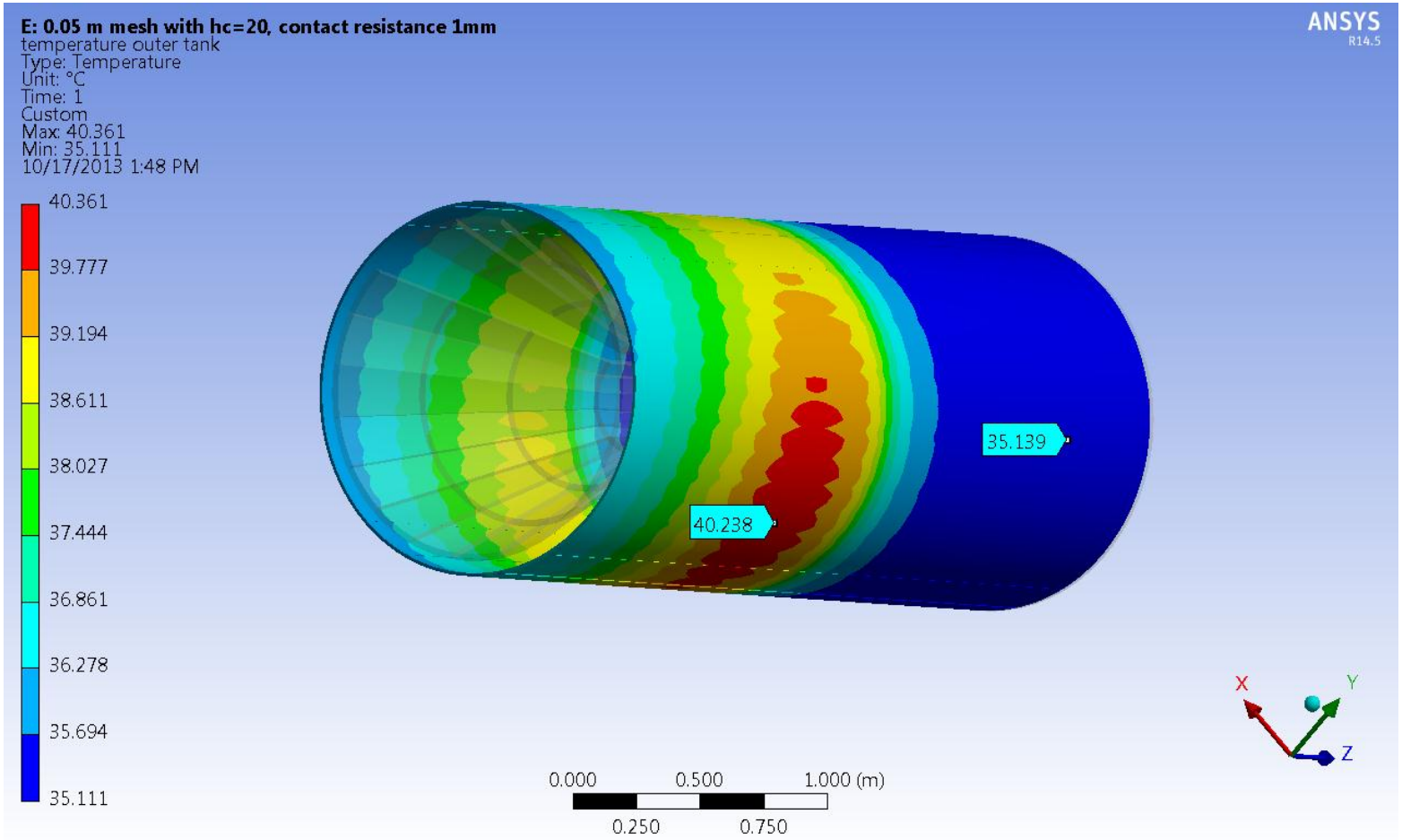
Case study

- 1) Leave the water section as is with a normal water conductivity _K, besides the convection effect. The reason for the case is to estimate the how much water conductance effect since water is very slow moving over this open section _ more like a “stationary”.
- 2) Similar as case 1, but just “ turn the water section off” such that the water section becomes complete “convective effect”
- 3) Temperature sensitivity vs convective film coefficient _hc as genetic study

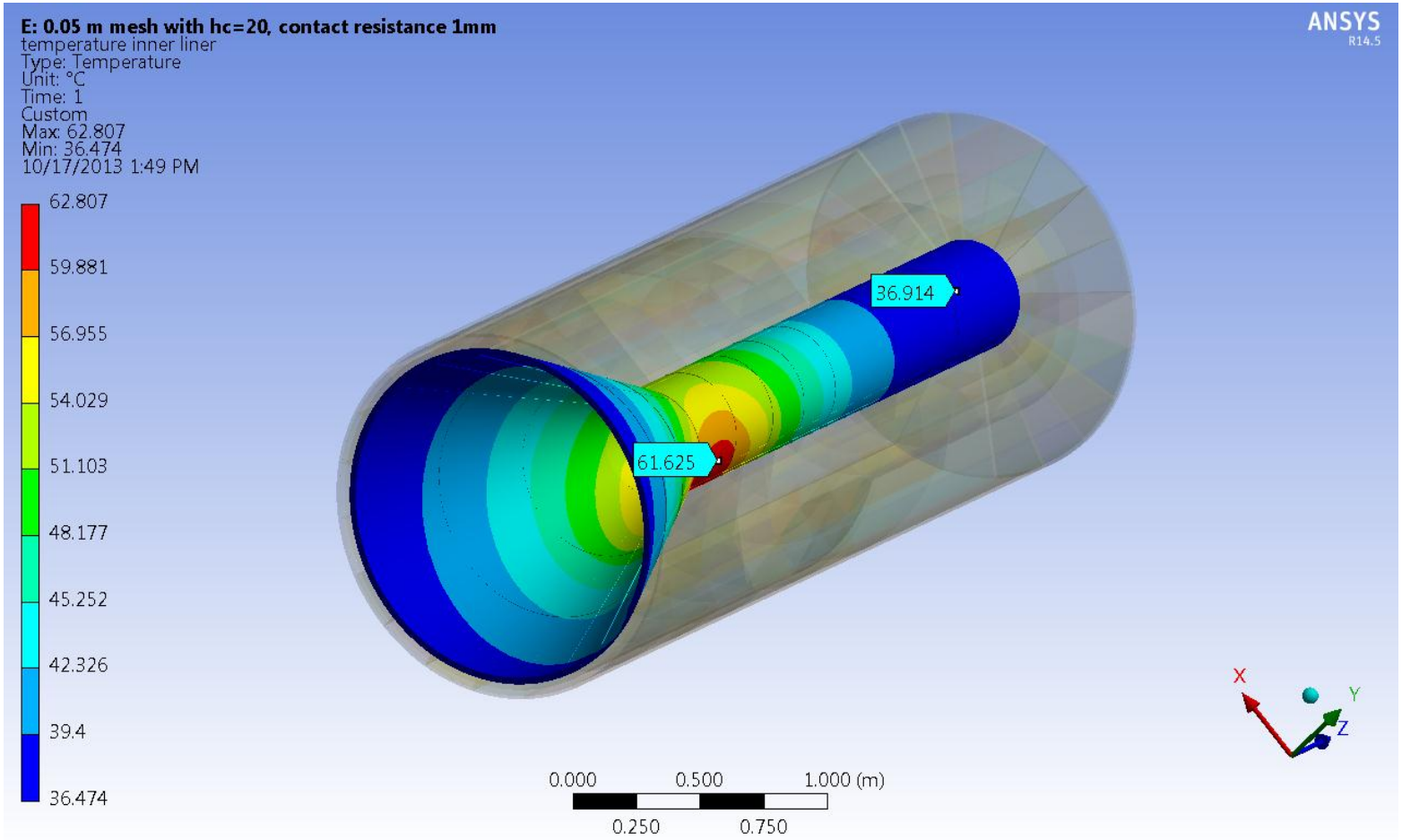
Case 1_Temperature



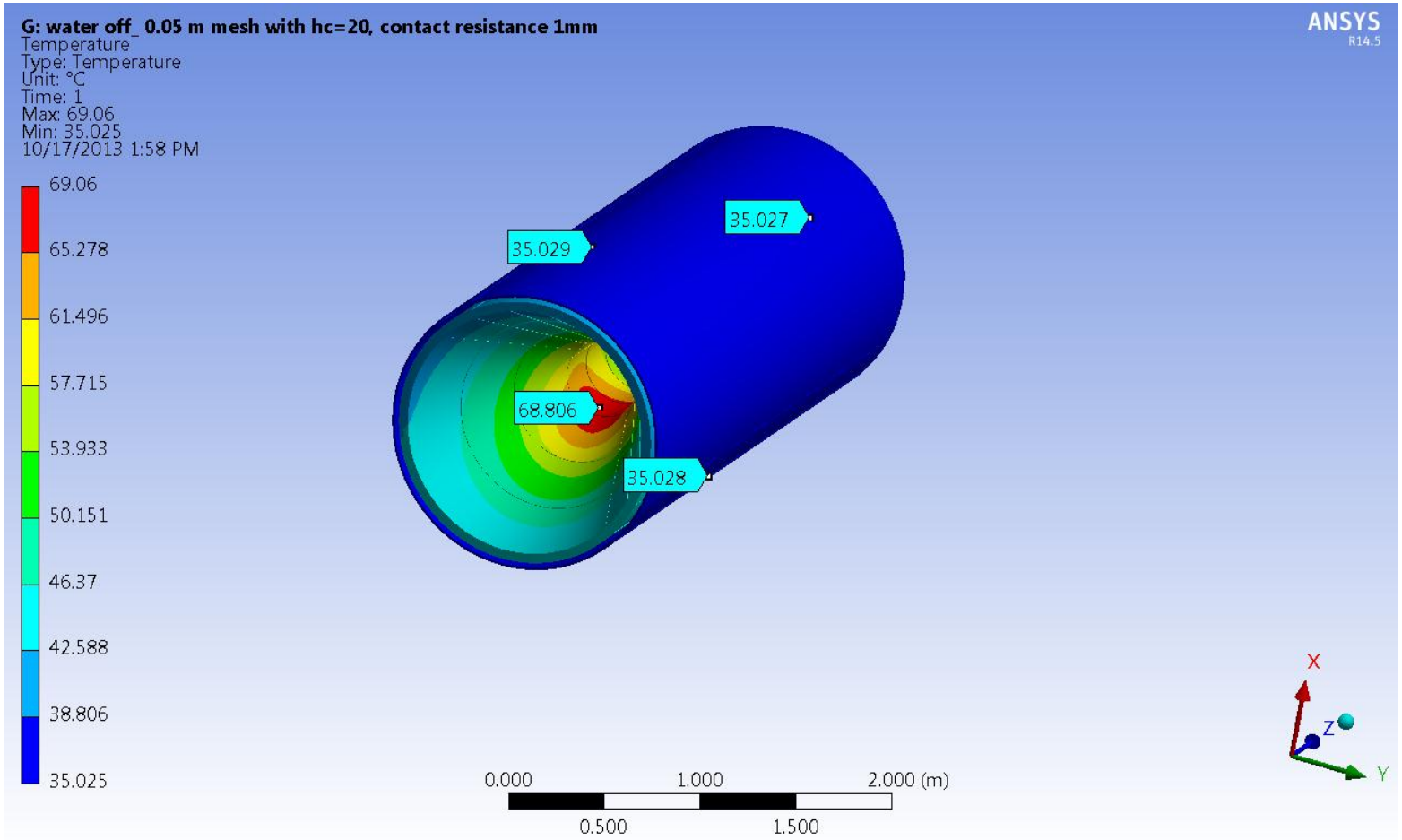
Case 1_outer shell



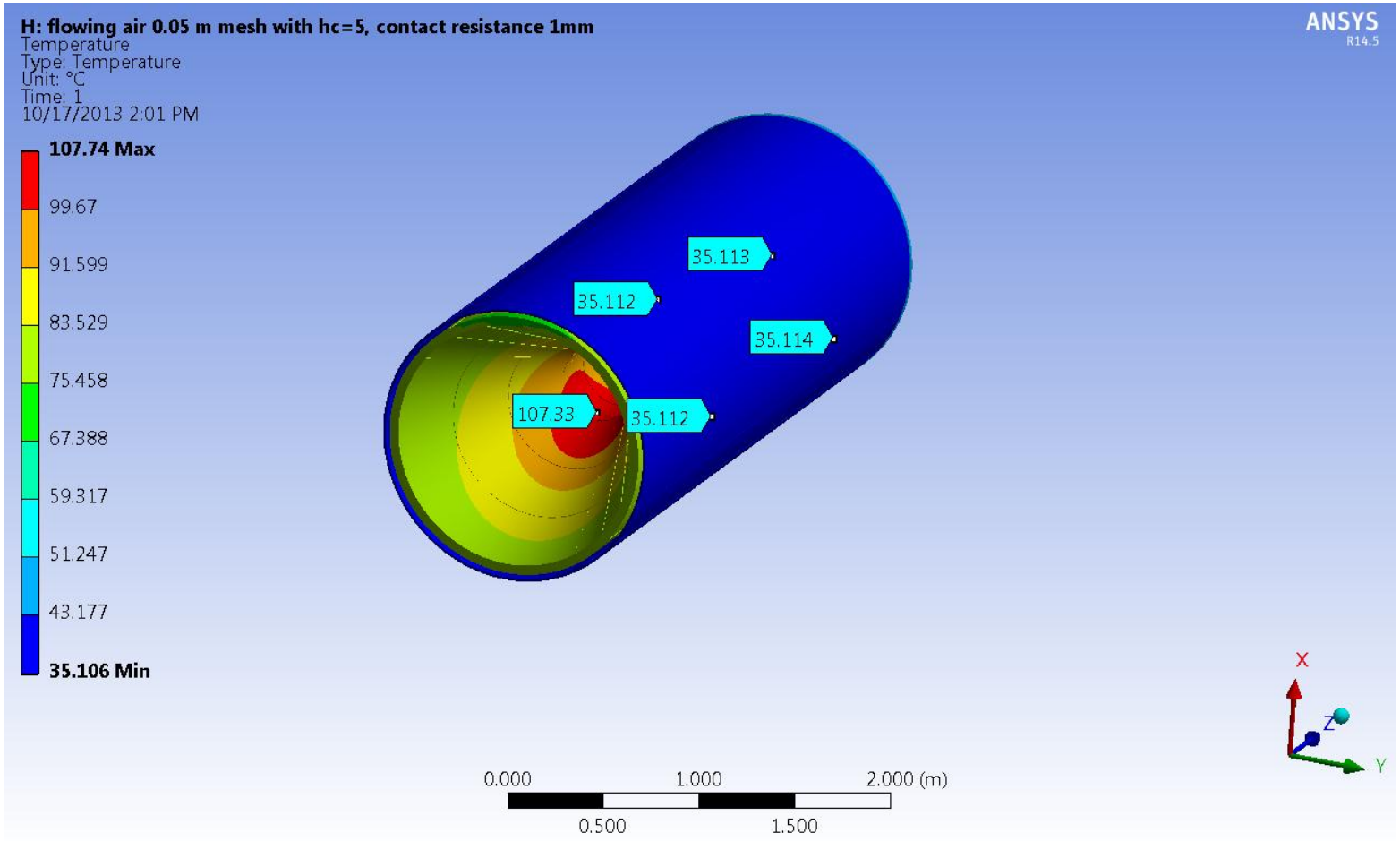
Case 1 inner liner



Case_2 Temperature (water conduction effect_off) just a natural convection hc=20



Case-3, hc=5, water off (similar as natural air cooling _ just a genetic study



Conclusion

- Case 1 (with considering water conduction effect) give a worst case for the outer shell temperature=41 c
- Case 2 (without considering water conduction effect) give a worst case for the inner liner Tinner=69C
- Total reaction (heat) from ANSYS=3335 W (matches MARS data 99.5%)
- Many thanks for Larry Bartoszek's CAD model and Vitaly Pronskikb's MARS data

Table 1 Summery of Result

	Outer Shell	Inner linner	Tmax
Case 1_T(c)	41	63	63
Case 2_T(c)	35.2	69	69