

CeCPoP low power beam dump thermal and stress analysis

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CeCPoP low power beam dump thermal and stress analysis

Beam energy: 2 Mev. Power: 1.0 Watt

Model: For 2 Mev beam, energy is absorbed in window and pipe. Steel beam dump is not included in the calculation. Due to symmetry, only half of the geometry was modeled using 3D solid element.

Thermal Condition: Total heat input is 1 watt; .9 Watt in window, .1 watt in pipe.

Conduction: Through full length to room temperature anchor, 25°C, at pipe after ceramic break.

Convection: Only parts outside the steel dump are included.

H: .0005 W/cm².C (still air), Tb: 30°C, total conv. area: 449 cm².

Materials 1. Break: Ceramic, K: .0146 W/cm.C

2. Seal Gasket: Copper (clamped tight metal to metal), K: 4.01 W/cm.C

3. Window, pipe and flange: SS304, K: .15 W/cm.C

Yield strength: 30,000 psi, allowable: 20,000 psi

Loading: Case 1. Cooling by both conduction and convection.

Case 2. For conservatism, conduction only, convection was not included.

Results: Case 1. Temperature distribution in window:

Max. T=56.80 °C at center, T= 45.90 °C at edge, ΔT= 10.9 °C

Max. Stress at window: 2,143.2 psi (allowable: 20,000 psi).

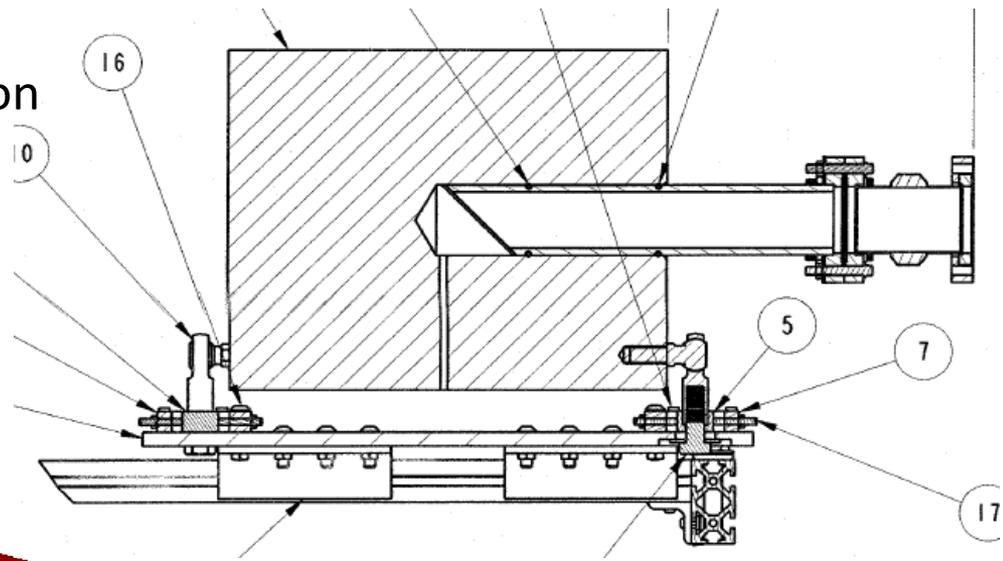
Case 2. Temperature distribution in window:

Max. T=103.92 °C at center, T= 92.81 °C at edge, ΔT= 11.1 °C

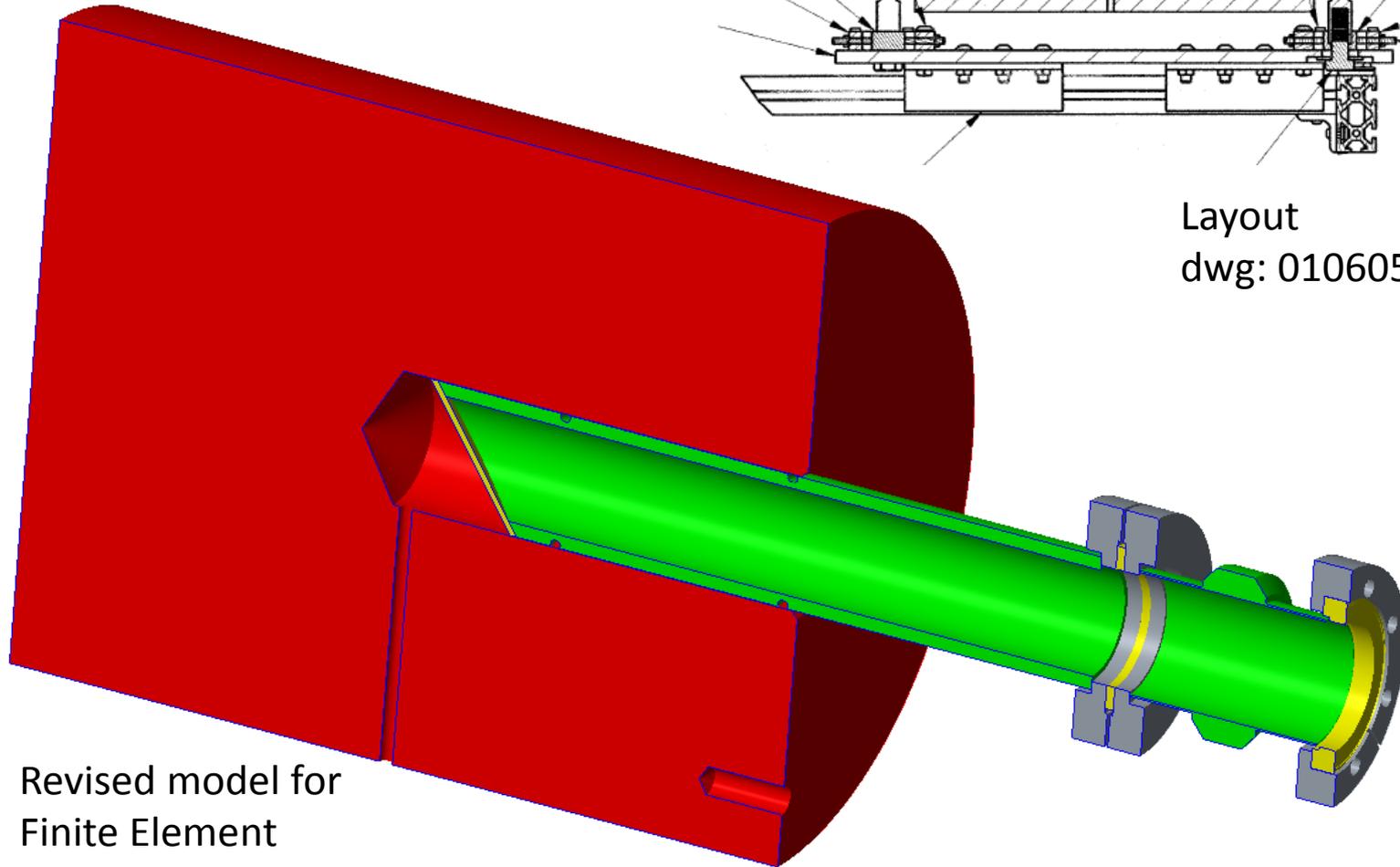
Max. Stress at window: 2,146.5 psi (allowable: 20,000 psi).

Comment: The cooling capacity of the beam dump is sufficient for 1 Watt operation.

CeC low power beam dump configuration



Layout
dwg: 010605122



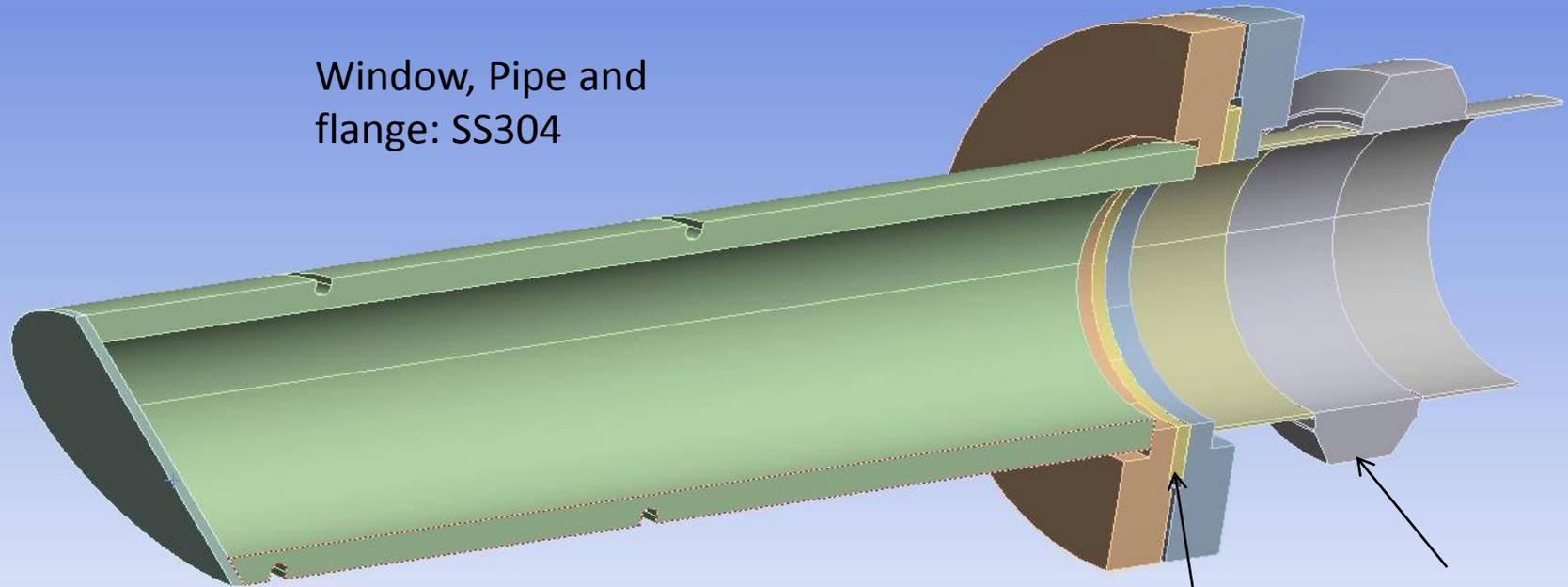
Revised model for
Finite Element

FE model, revised CeC low power beam dump

Geometry
9/9/2015 9:19 AM

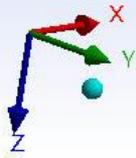
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Window, Pipe and
flange: SS304



Ceramic

Copper
gasket



Thermal Loads and boundary conditions

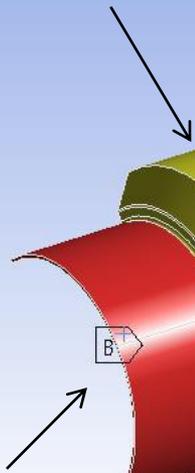
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R16.1

Heat Generation : 1 W total
.9W in window, .1W in beam pipe
case 1. Cooling by Conduction and Convection
case 2. Cooling by Conduction only

B: Steady-State Thermal-Cond+conv
Steady-State Thermal
Time: 1. s
9/11/2015 9:08 AM

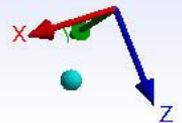
A Convection: 30. °C, 5.e-004 W/cm².°C
B Temperature 2: 25. °C

Ceramic
break

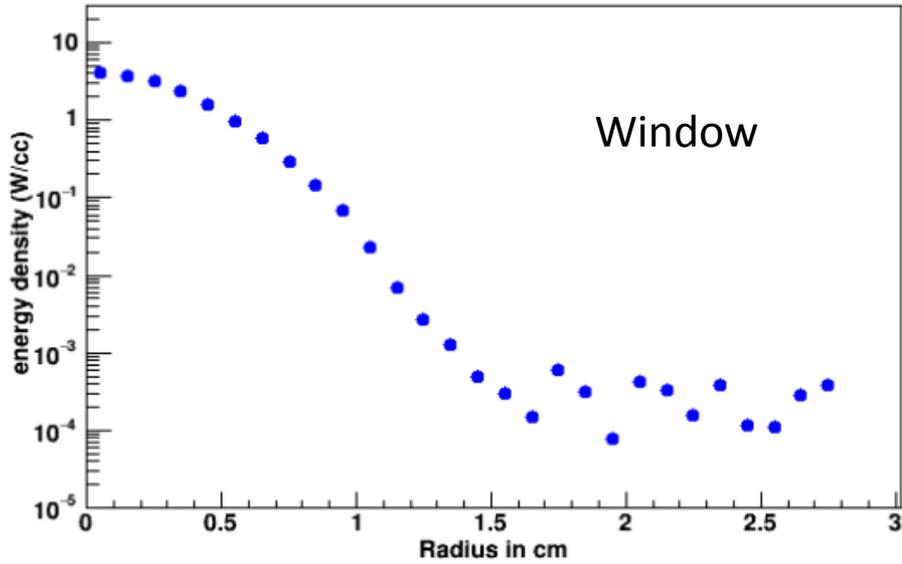


Room
T: 25°C

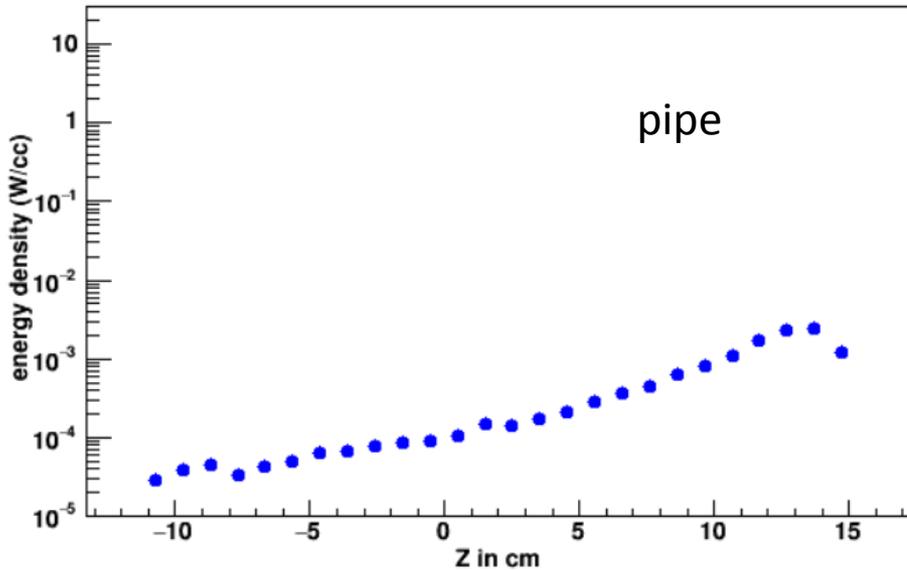
Convection only surfaces outside of dump.
Convection H for still air: .0005 W/cm².C
T_{bulk}: 30°C
Total Convection area: 449 cm²



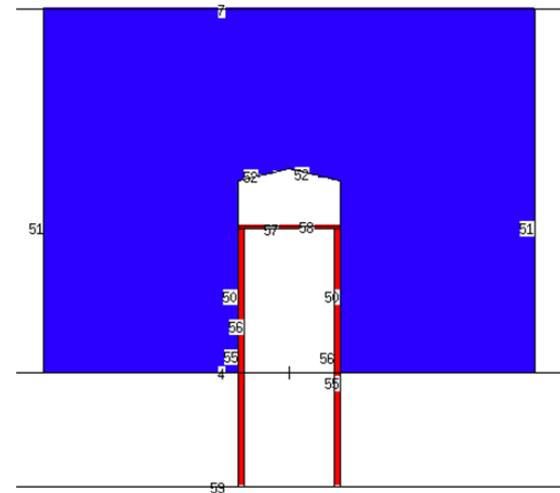
1W of 2.0 MeV electron



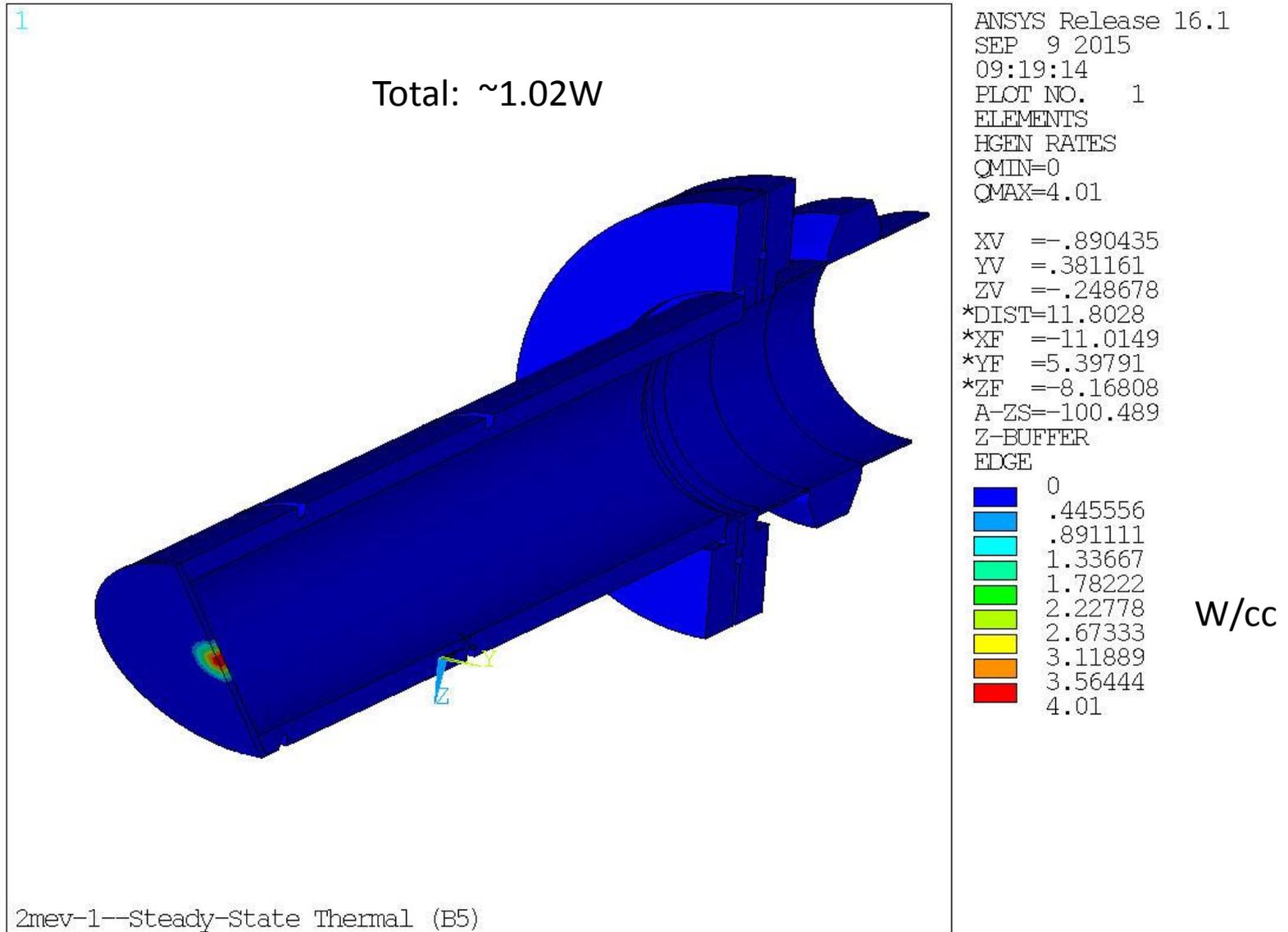
1W of 2.0 MeV electron



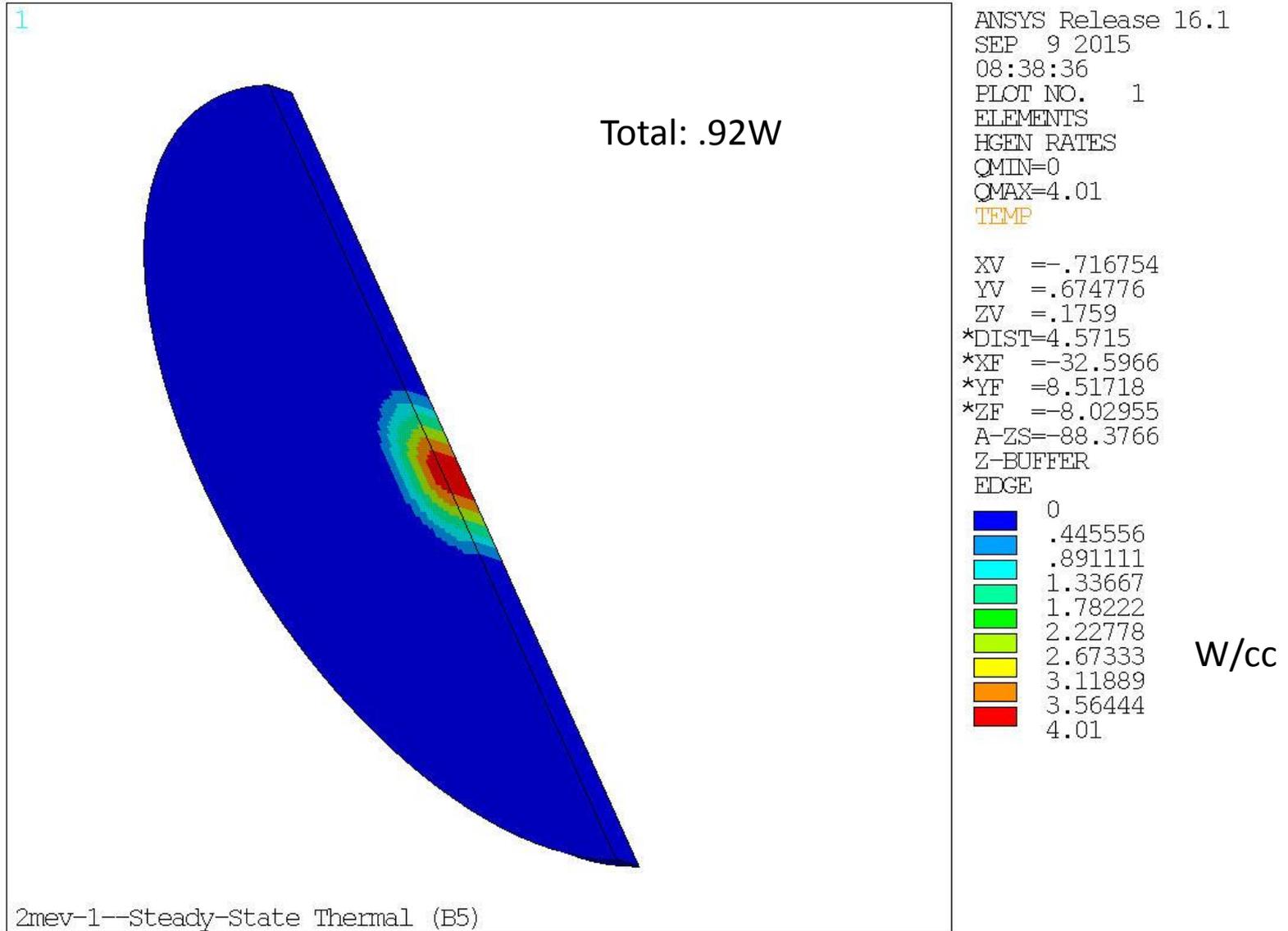
Heat load deposit in window and Pipe
Provided by D. Beavis



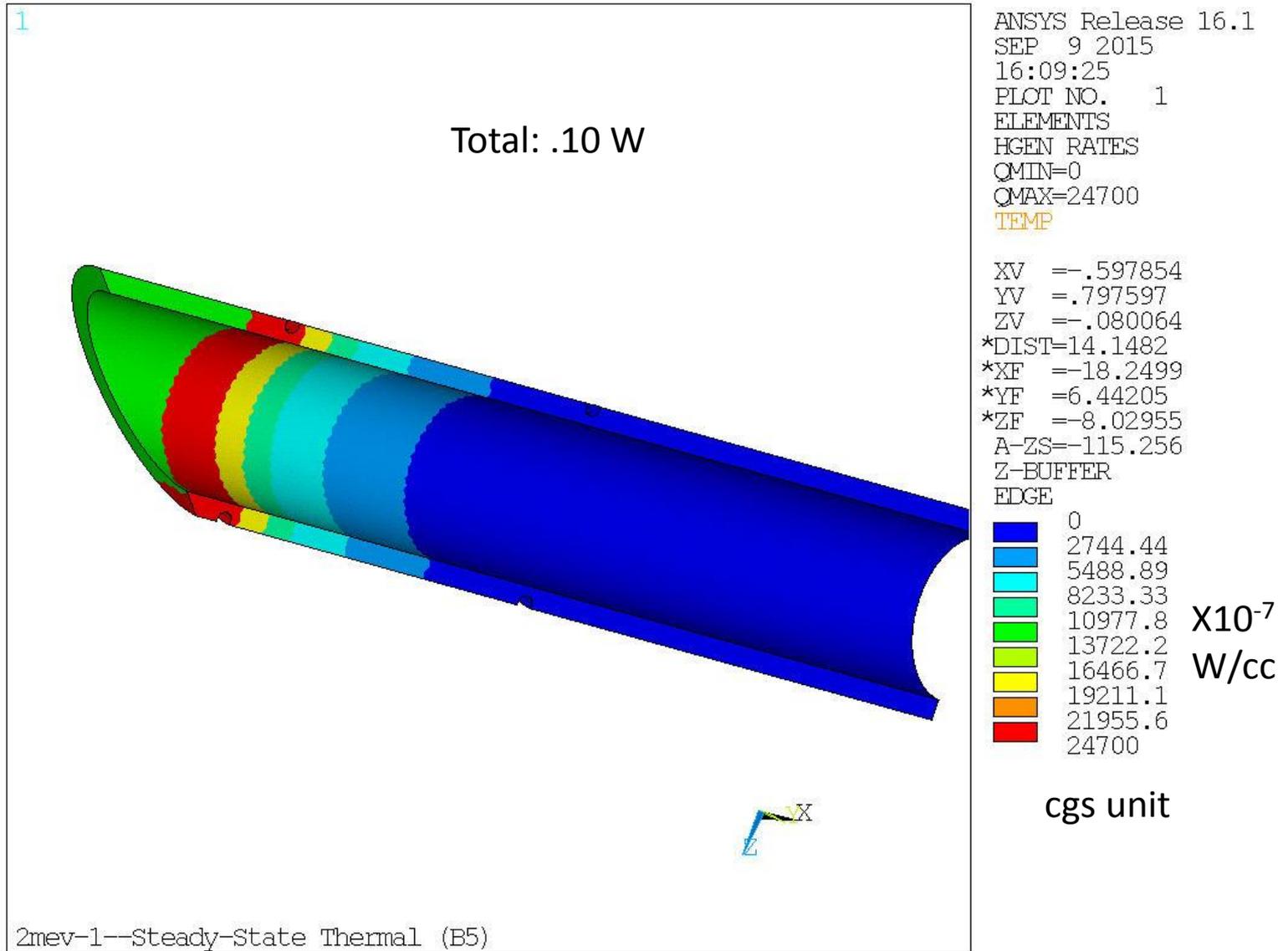
Heat Load as heat generation rate mapped to FE model



Heat Load as heat generation rate in window



Heat Load as heat generation rate in beam pipe



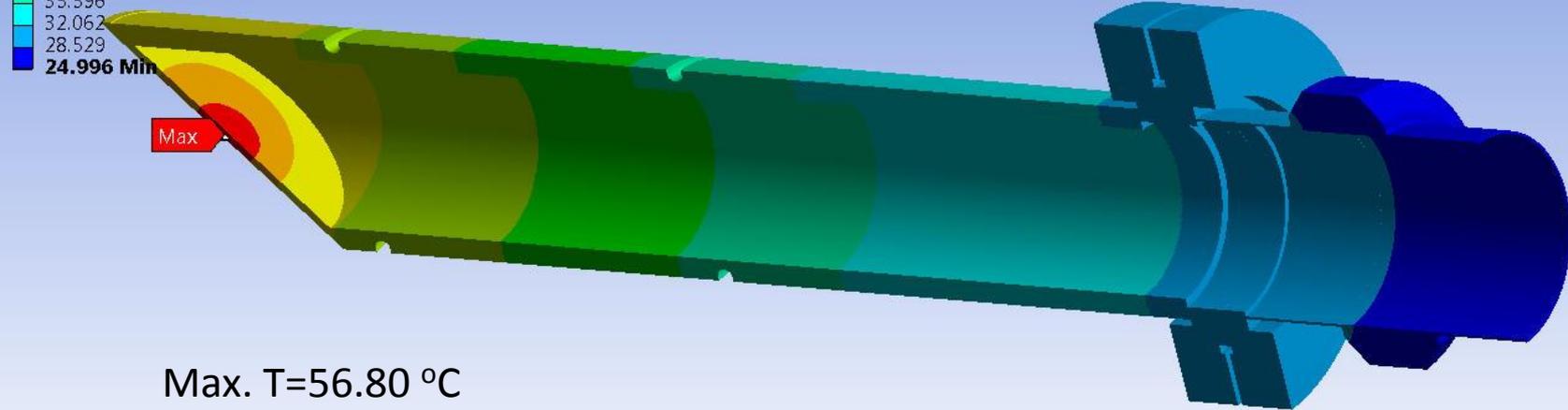
Case 1. Cooling by both conduction and convection. Temperature distribution

B: Steady-State Thermal-Cond+conv

Temperature
Type: Temperature
Unit: °C
Time: 1
9/10/2015 10:51 AM

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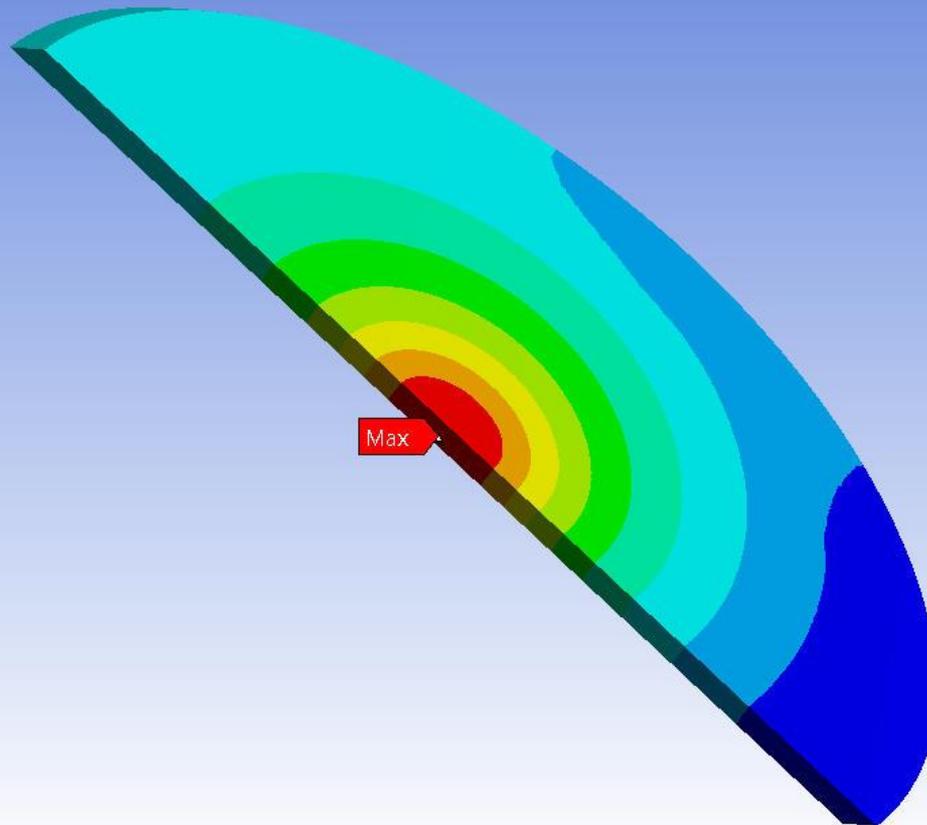
56.795 Max
53.262
49.729
46.195
42.662
39.129
35.596
32.062
28.529
24.996 Min



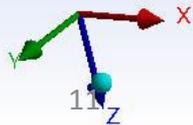
Max. T=56.80 °C
Edge:T= 45.90 °C
 $\Delta T= 10.9$ °C

Case 1. Cooling by both conduction and convection. Temperature distribution in window

B: Steady-State Thermal-Cond+conv
Temperature 2
Type: Temperature
Unit: °C
Time: 1
9/10/2015 10:50 AM



Max. T=56.80 °C
Edge:T= 45.90 °C
 $\Delta T= 10.9$ °C



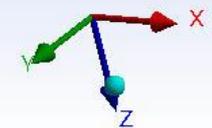
Case 1. Cooling by both conduction and convection. Thermal Expansion

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C: Static Structural
Total Deformation
Type: Total Deformation
Unit: cm
Time: 1
9/10/2015 10:59 AM

0.011072 Max
0.0098415
0.0086113
0.0073811
0.0061509
0.0049207
0.0036906
0.0024604
0.0012302
0 Min

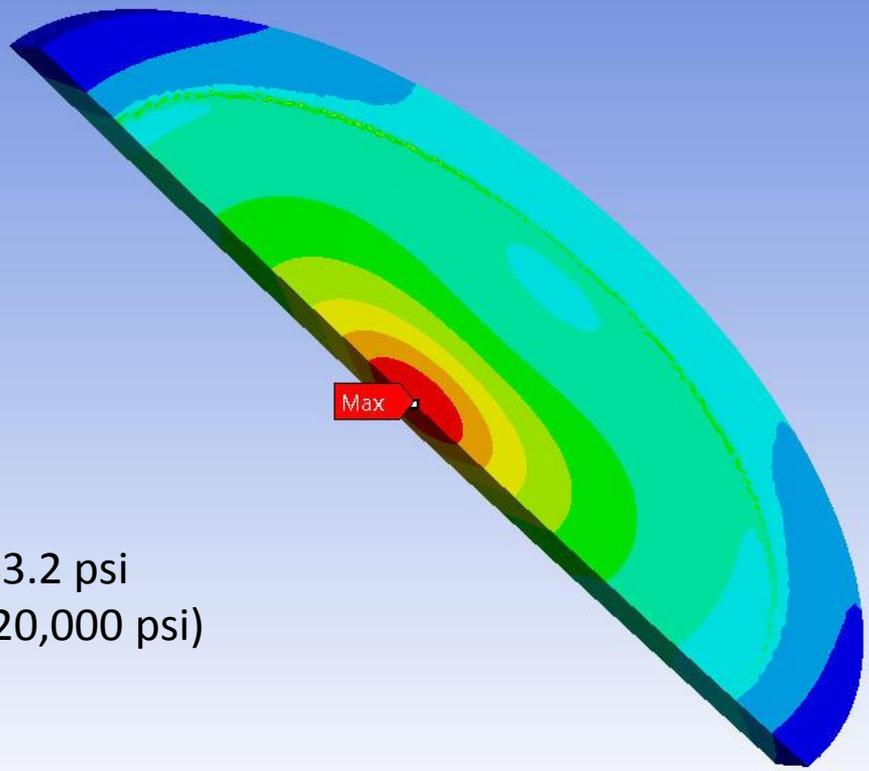
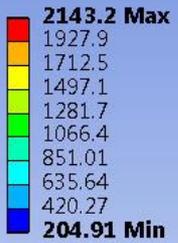
Max



Max. $\Delta L = .011$ cm

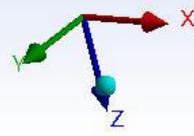
Case 1. Cooling by both conduction and convection. Stress in window

C: Static Structural
Equivalent Stress -window
Type: Equivalent (von-Mises) Stress
Unit: psi
Time: 1
9/10/2015 11:00 AM

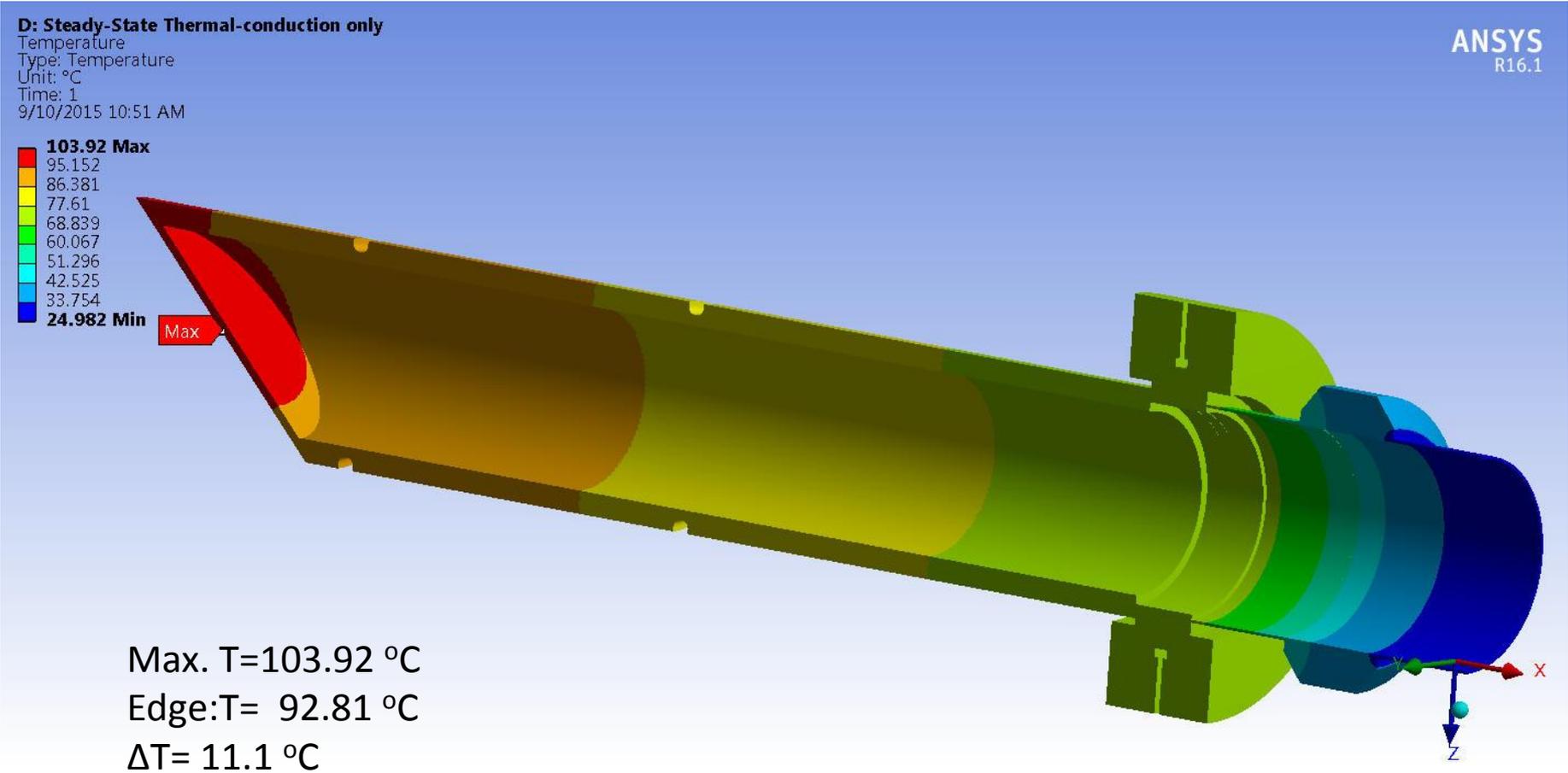


Max

Max. S: 2,143.2 psi
(allowable: 20,000 psi)



Case 2. For conservatism, conduction only, convection was not included.
Temperature distribution



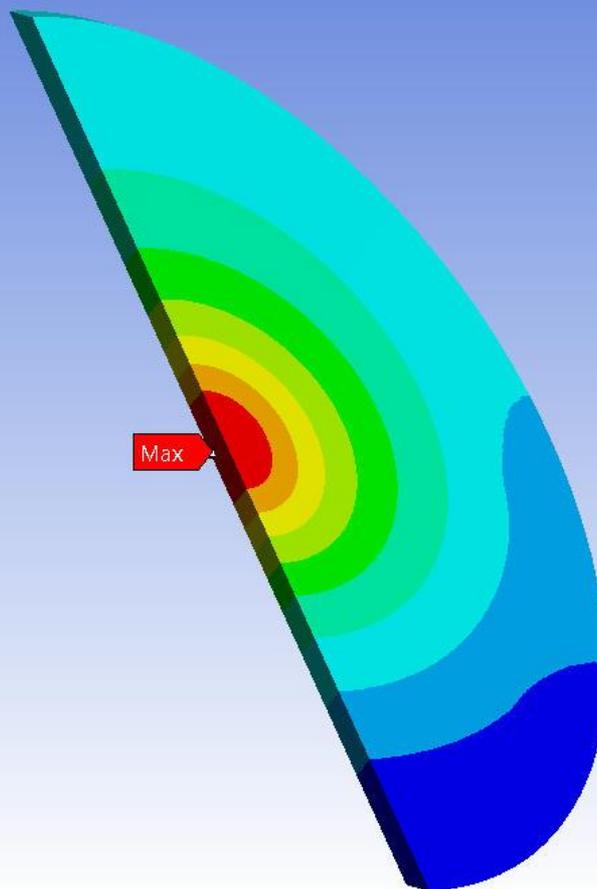
Case 2. For conservatism, conduction only, convection was not included.
Temperature distribution in window

D: Steady-State Thermal-conduction only

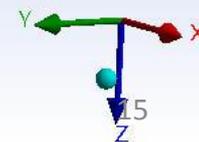
Temperature -window
Type: Temperature
Unit: °C
Time: 1
9/10/2015 10:46 AM

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103.92 Max
102.69
101.45
100.22
98.986
97.751
96.517
95.282
94.048
92.813 Min

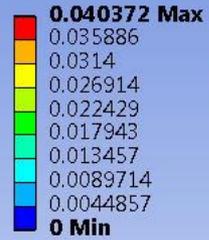


Max. T=103.92 °C
Edge:T= 92.81 °C
 $\Delta T= 11.1$ °C

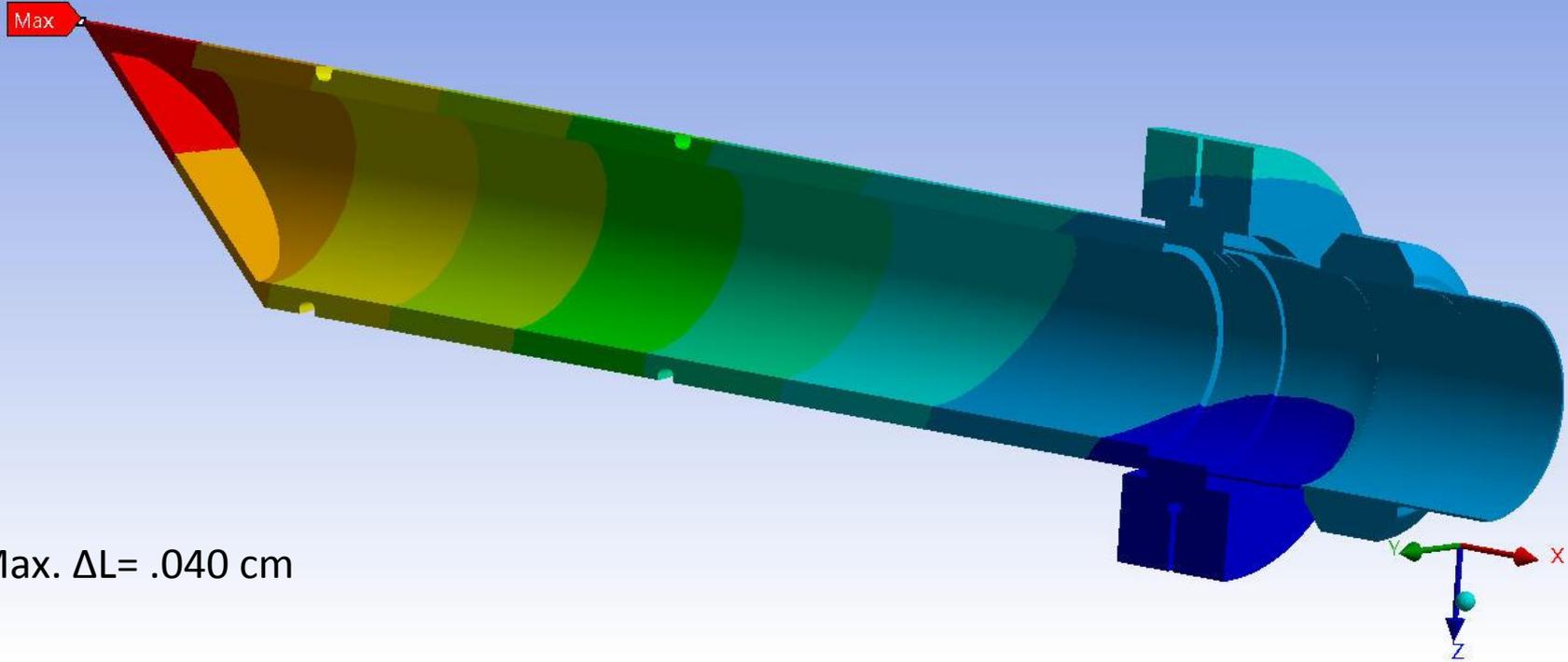


Case 2. For conservatism, conduction only, convection was not included.
Thermal expansion

E: Static Structural
Total Deformation
Type: Total Deformation
Unit: cm
Time: 1
9/10/2015 11:00 AM



Max

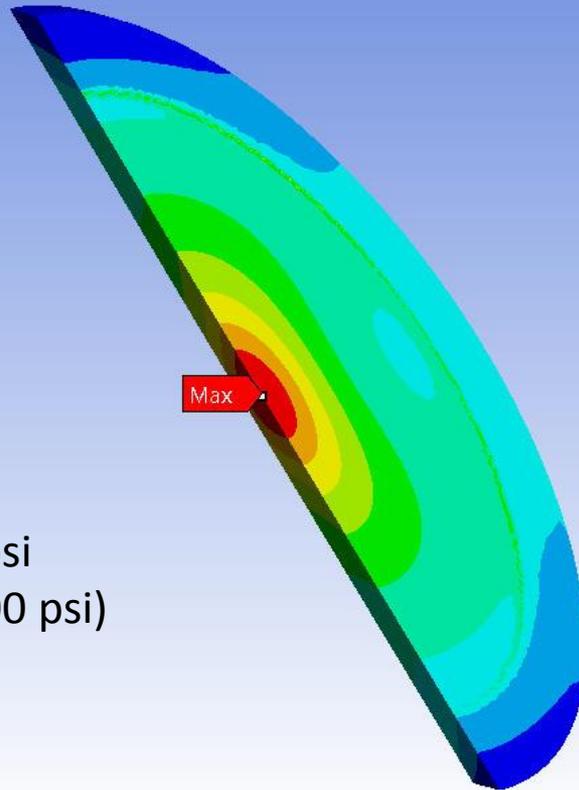
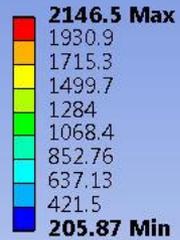


Max. $\Delta L = .040$ cm

Case 2. For conservatism, conduction only, convection was not included.
Stress in window

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E: Static Structural
Equivalent Stress window
Type: Equivalent (von-Mises) Stress
Unit: psi
Time: 1
9/10/2015 11:02 AM



Max. S: 2,146.5 psi
(allowable: 20,000 psi)

