BNL BLIP capsule design & analysis update

Beryllium and Graphite

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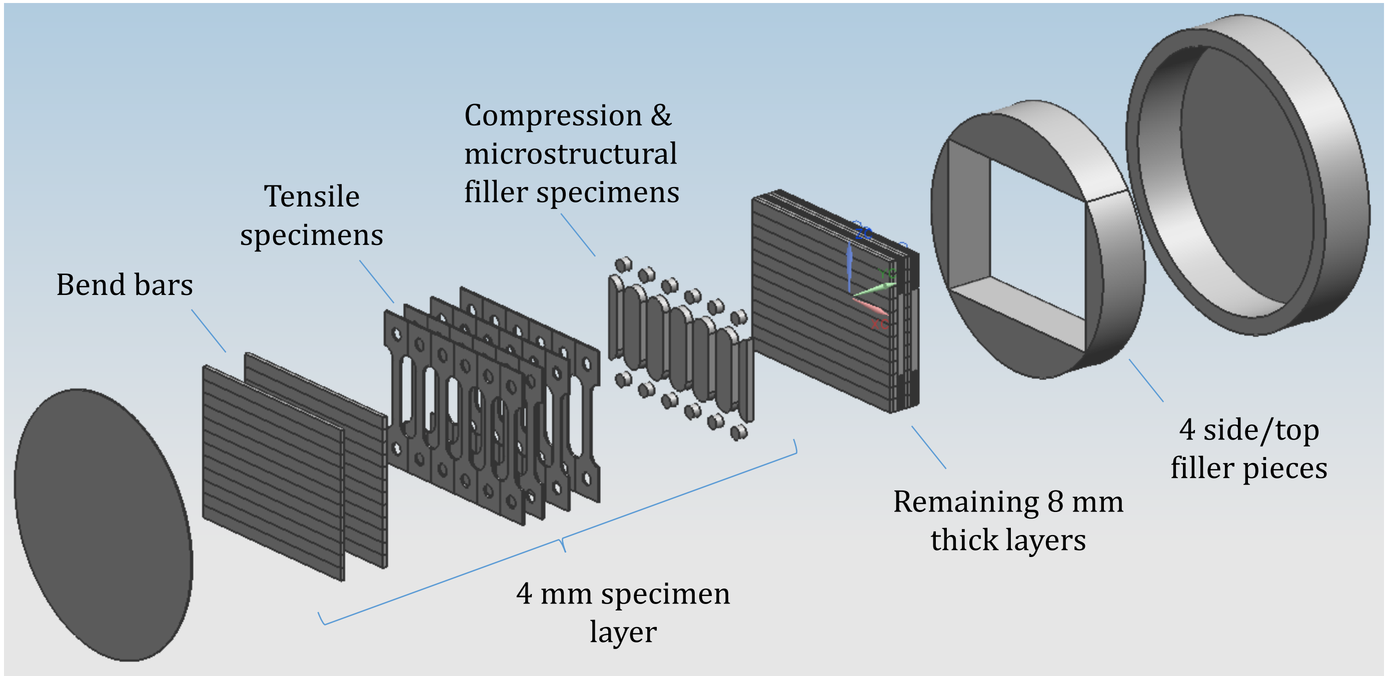
05.04.16

Beryllium capsule specimens

Be grade	Specimen type	Thickness (mm)	Layers	Total thickness (mm)
S-65F	Tensile	0.5	4	2
	Bend	1	2	2
	Compression	2	1	
	Microstructural analysis	2	1	
PF-60	Tensile	0.5	4	2
	Bend	1	2	2
	Compression	2	1	
	Microstructural analysis	2	1	
UHP	Tensile	0.5	4	2
	Bend	1	2	2
	Compression	2	1	
	Microstructural analysis	2	1	

- Atmosphere: **Argon**
- Specimens will be arranged within each layer to achieve all 3 grades at all temperature regimes

Beryllium capsule layout

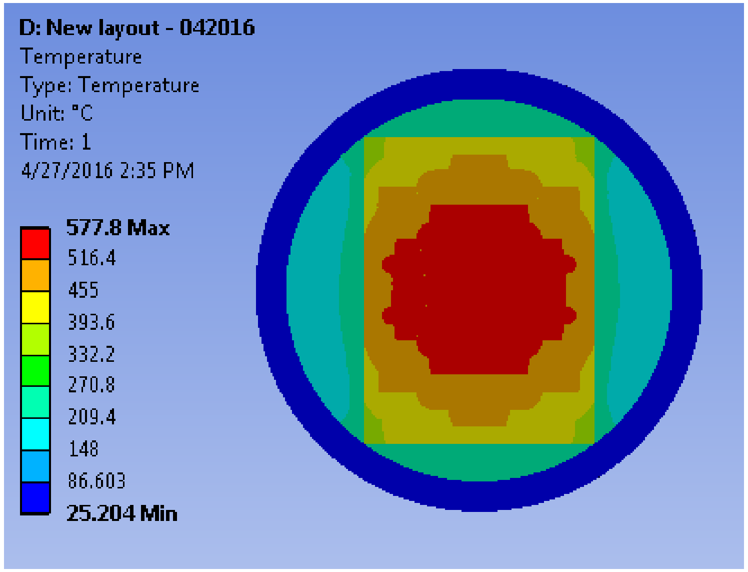


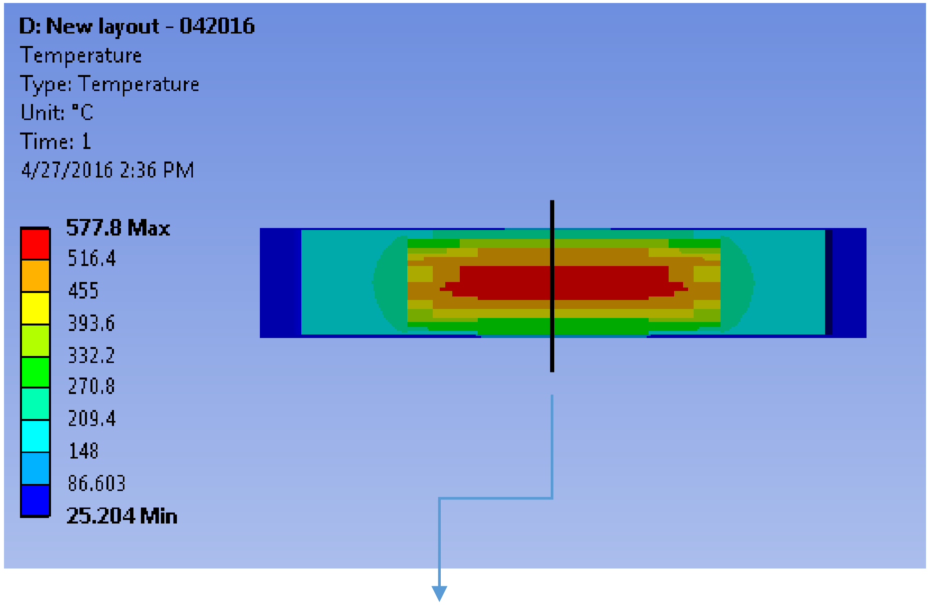
		Number of specimens	
Be grade	**Specimen type**	**In capsule**	**In peak ED area**
S-65F	Tensile	24	16
	Bend	24	16
	Compression	12	4
	Microstructural analysis	5	3
PF-60	Tensile	24	16
	Bend	24	16
	Compression	12	4
	Microstructural analysis	5	3
UHP	Tensile	24	16
	Bend	24	16
	Compression	12	4
	Microstructural analysis	5	3

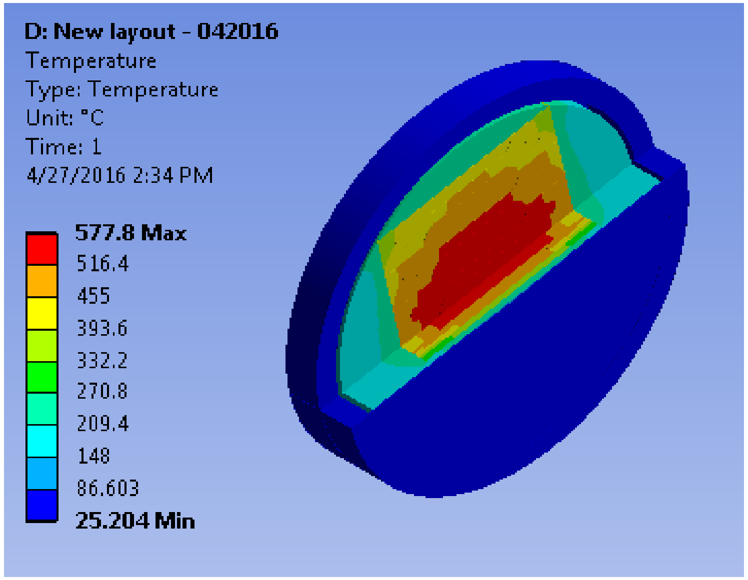
Beryllium capsule thermal analysis

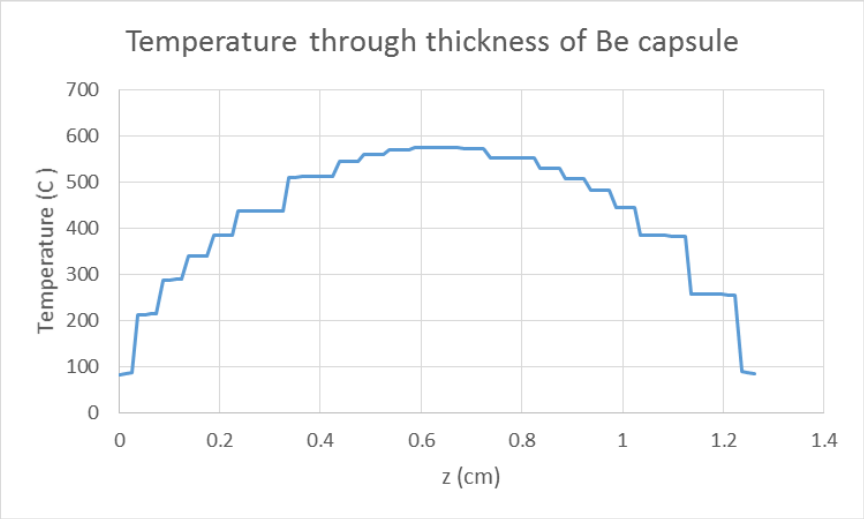
- Temperature dependent thermal conductivity for Beryllium
- Thermal contact conductance ~ **1750 W/m^2K**
  - Calculated for **Argon** atmosphere
  - Song and Yovanovich, J. Heat Transfer, Vol. 115, p. 533 (1993)
- Heat transfer coefficient on SS windows ~ **6000 W/m^2K**
  - Based on 22 GPM water flow through target box
  - Analytical calculation (Gnielinski Equation for Nu number)
- Assumed no heat transfer at radial edge of capsule
- Beam current: **150 μA**
- Total energy loss: ~ **10.41 MeV** (including SS windows)
- Total heat deposition in capsule: **1560 W**

Beryllium capsule temperature distribution



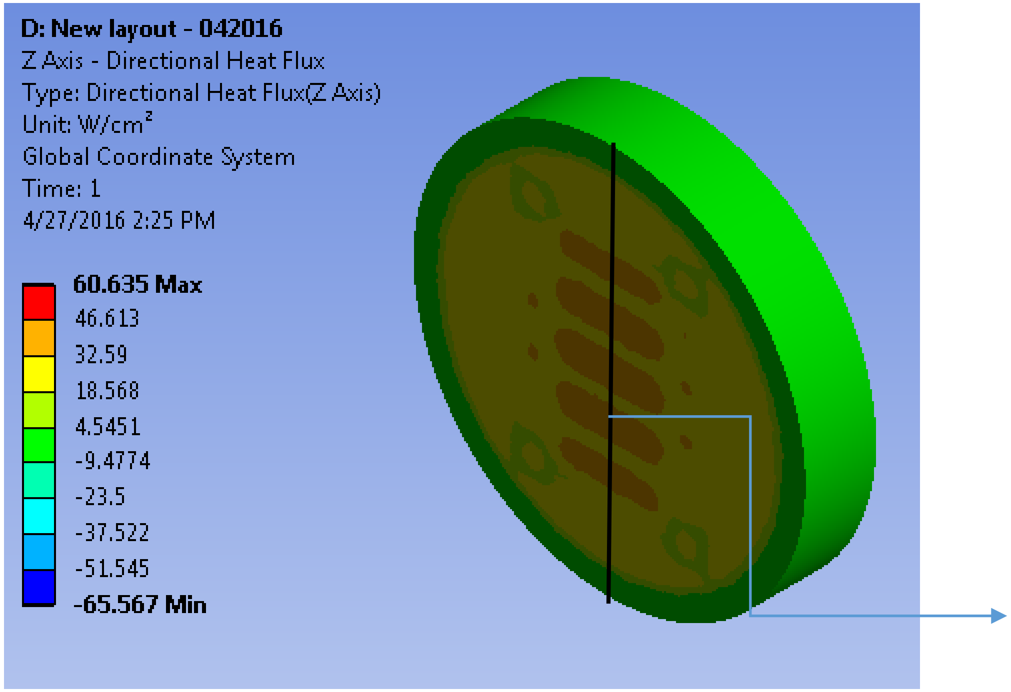


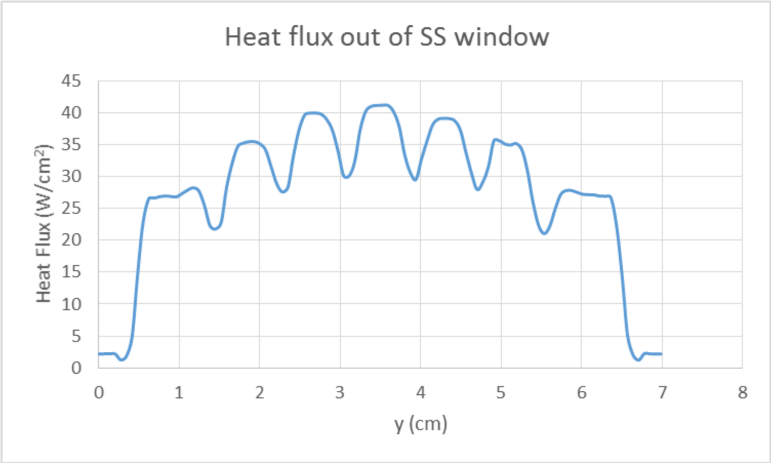




- Peak temperature ~ 580 °C

Beryllium capsule window heat flux





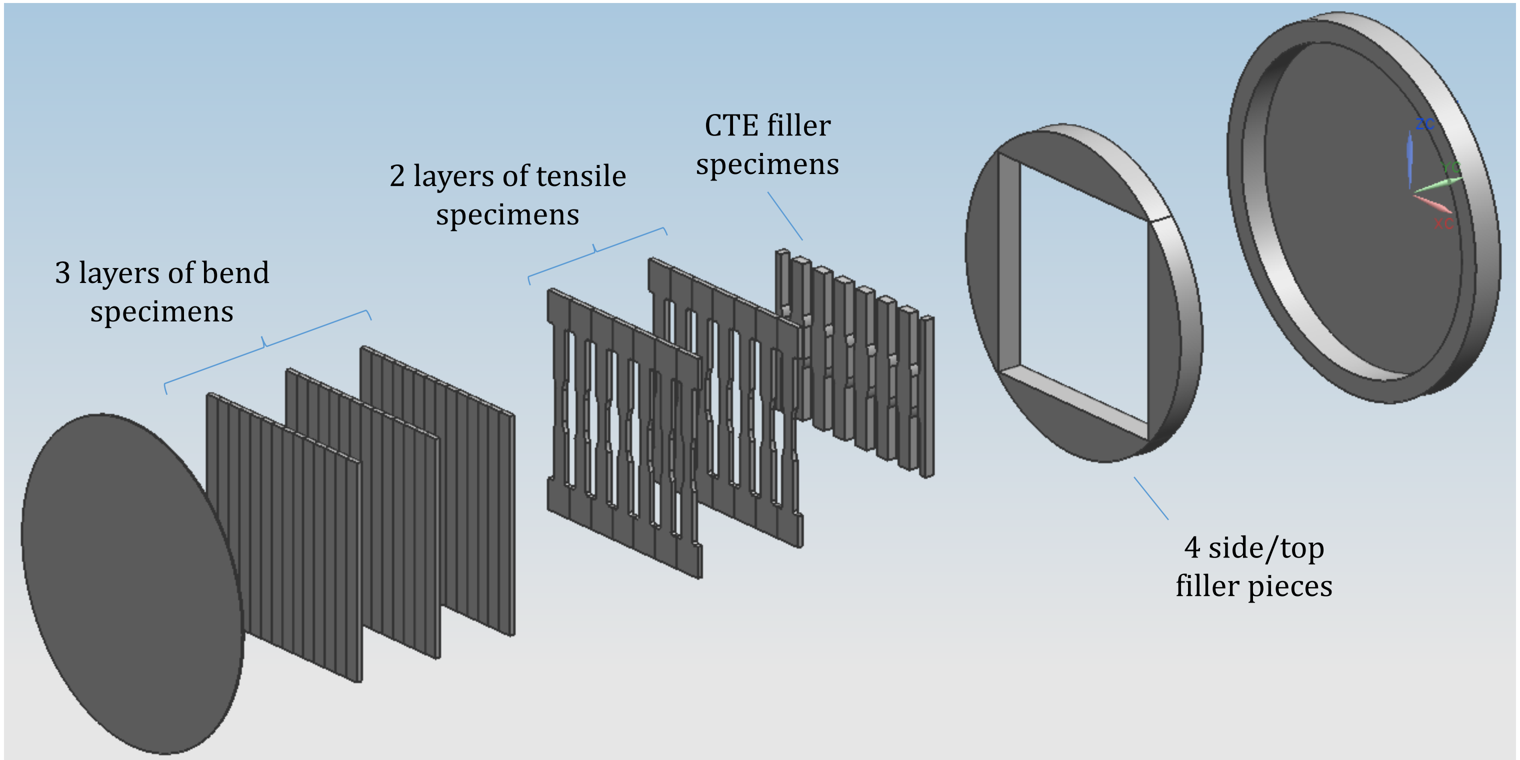
- Peak window temperature: 105 °C
- Peak heat flux: ~ **40 W/cm^2**

Graphite capsule specimens

Graphite grade	Specimen type	Thickness (mm)	Layers	Total thickness (mm)
ZXF-5Q	Tensile	1	1	1
	Bend/CTE	1	1	1
IG-430	Tensile	1	1	1
	Bend/CTE	1	1	1
GC	Bend/CTE	1	1	1
3D C/C	CTE	2	1	

- Atmosphere: **Vacuum**
- Specimens will be arranged within each layer to achieve all 3 grades at all temperature regimes

Graphite capsule layout

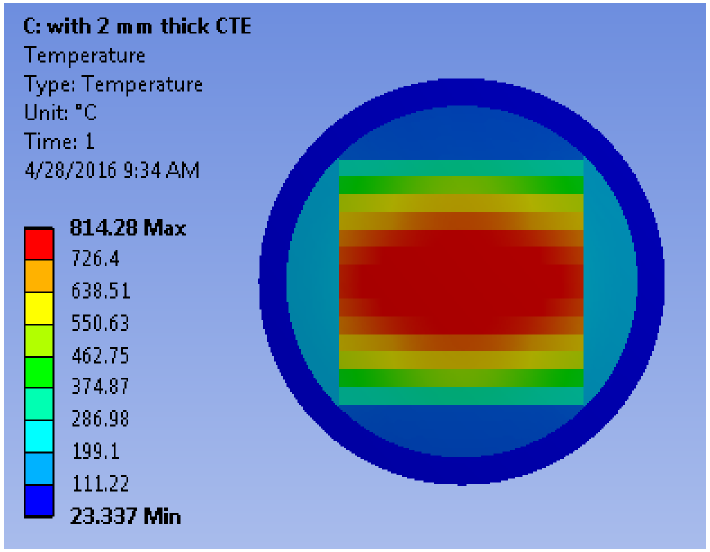


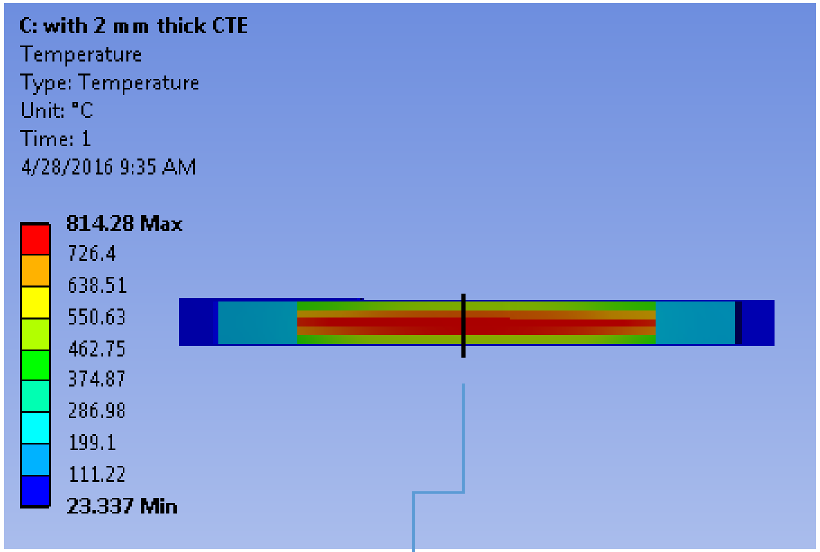
		Number of specimens	
Graphite grade	**Specimen type**	**In capsule**	**In peak ED area**
ZXF-5Q	Tensile	7	5
	Bend/CTE	14	8
IG-430	Tensile	7	5
	Bend/CTE	14	8
GC	Bend/CTE	14	8
3D C/C	CTE	6	4

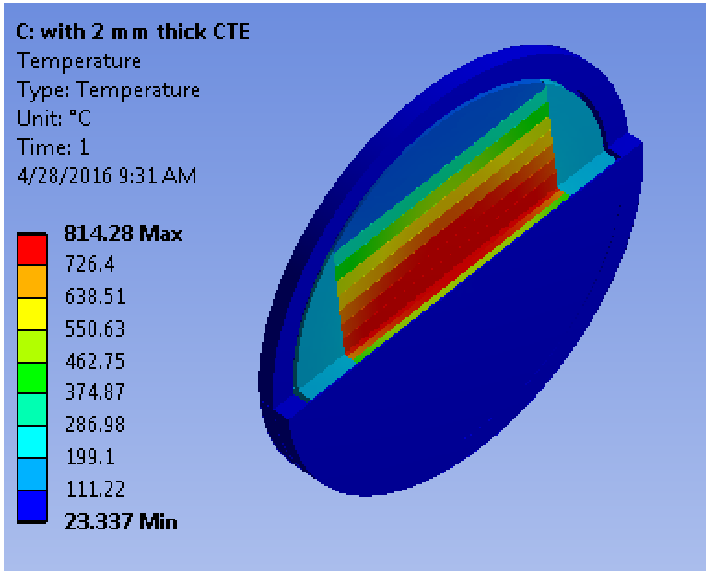
Graphite capsule thermal analysis

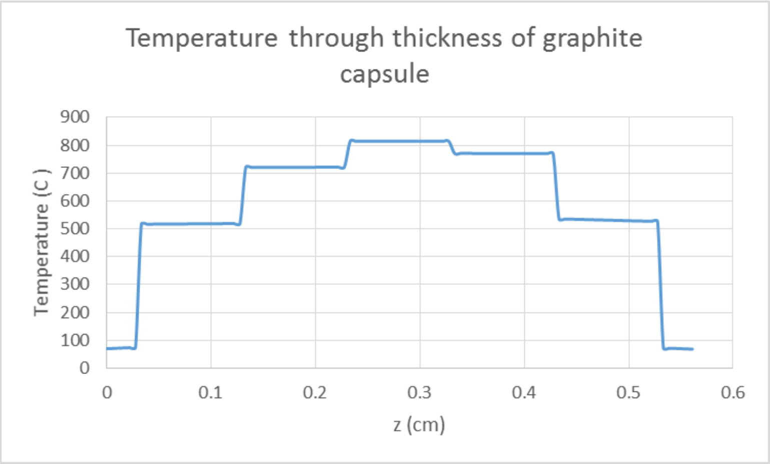
- Temperature dependent thermal conductivity for Glassy Carbon and Graphite
- Thermal contact conductance ~ **400 W/m^{2}K**
  - Value N. Simos used in previous analysis
  - Literature values range from 200 – 2000 W/m^{2}K
- Heat transfer coefficient on SS windows ~ **6000 W/m^{2}K**
  - Based on 22 GPM water flow through target box
  - Analytical calculation (Gnielinski Equation for Nu number)
- Assumed no heat transfer at radial edge of capsule
- Beam current: **150** μA
- Total energy loss: ~ **5.27 MeV** (including SS windows)
- Total heat deposition in capsule: **790 W**

Graphite capsule temperature distribution (1)



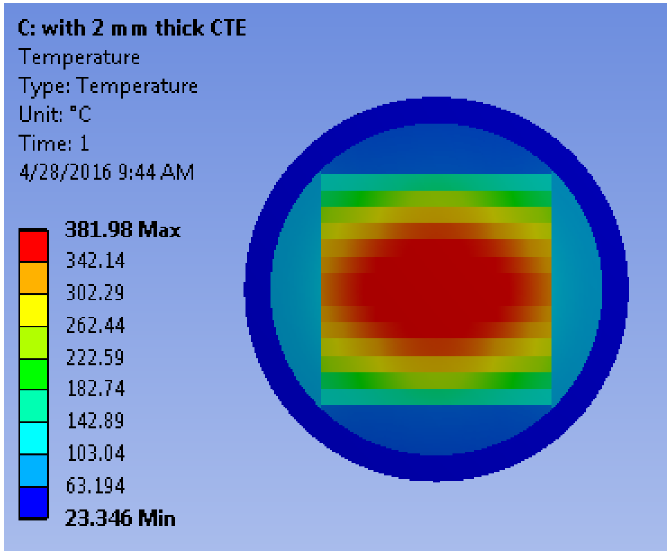


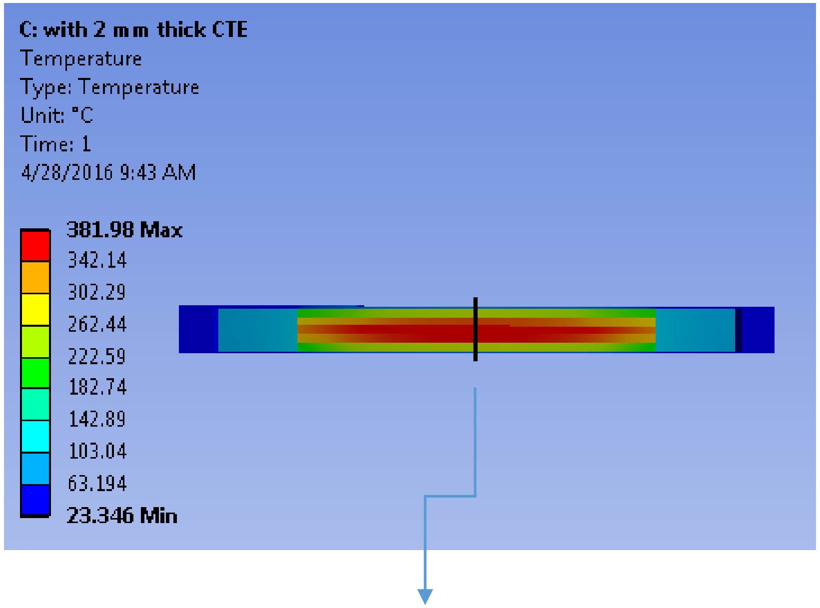


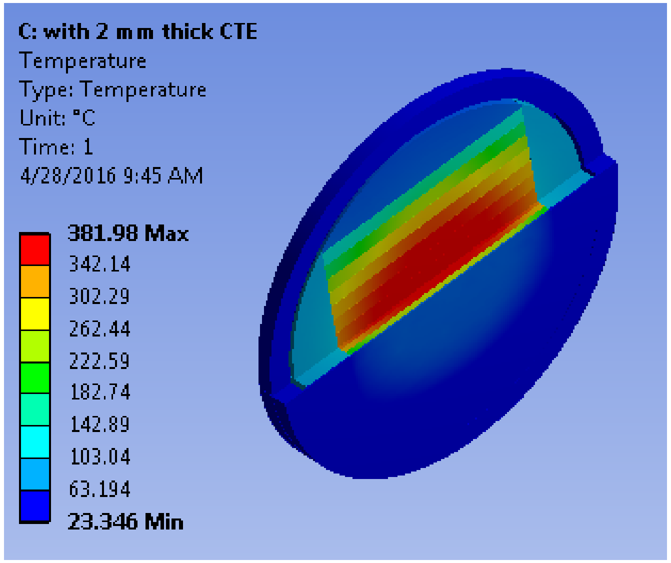


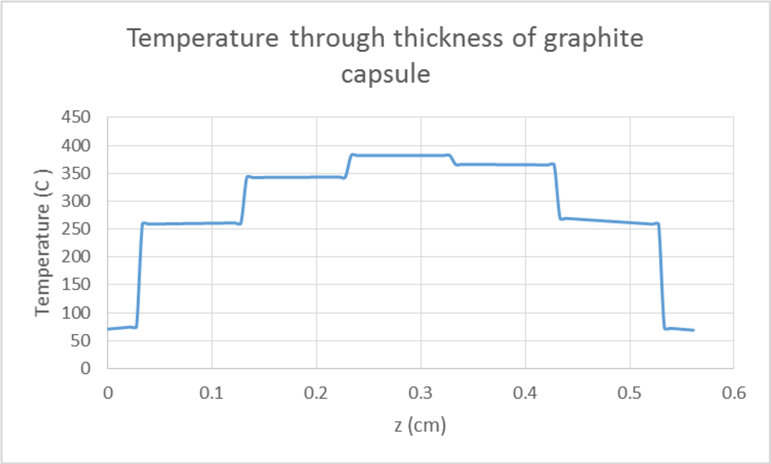
- Peak temperature ~ 815 °C
- Gap conductance = 400 W/m²K

Graphite capsule temperature distribution (2)



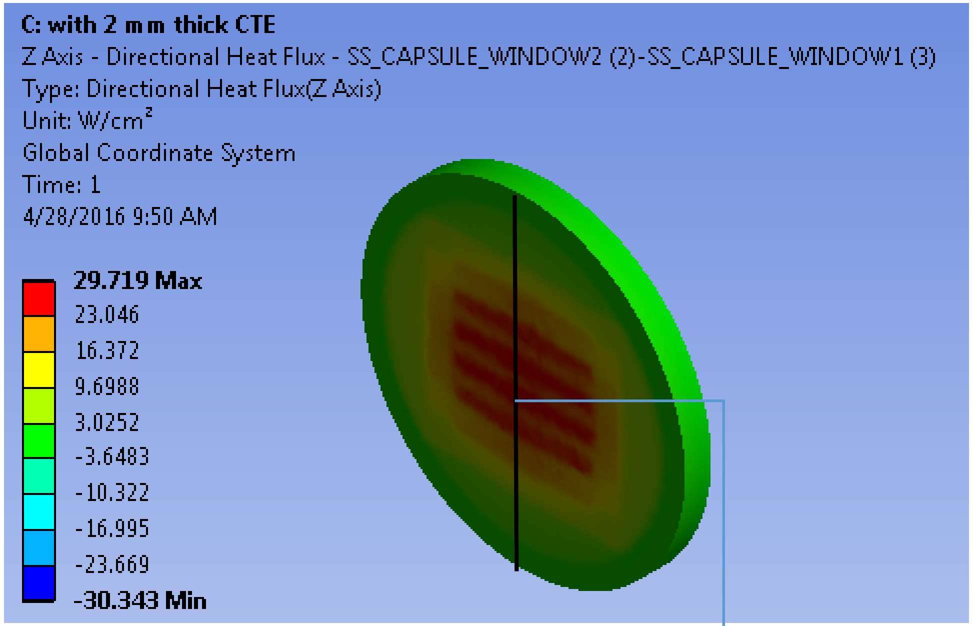


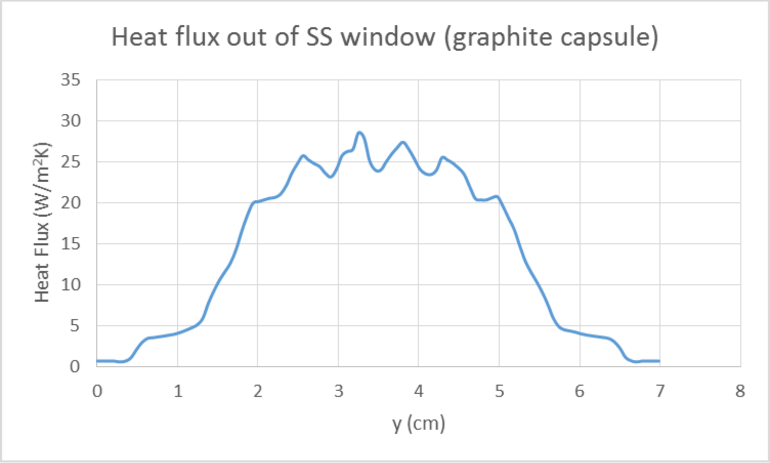




- Peak temperature ~ 380 °C
- Gap conductance = 1000 W/m^2K

Graphite capsule window heat flux





- Peak window temperature: 80 °C
- Peak heat flux: ~ **30 W/cm²**
- Thermal gap conductance: 400 W/m²K