Analysis of HAPL armor candidate materials with magnetic intervention using the BUCKY simulation code

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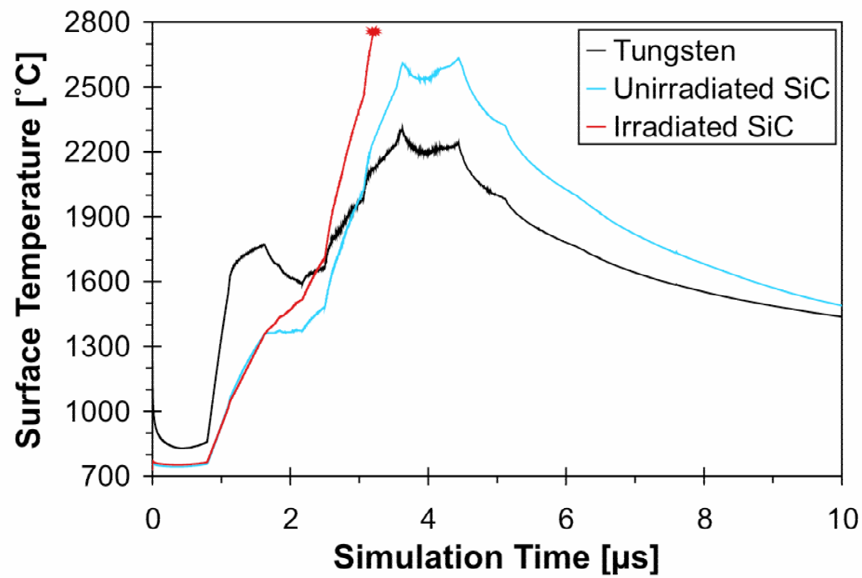
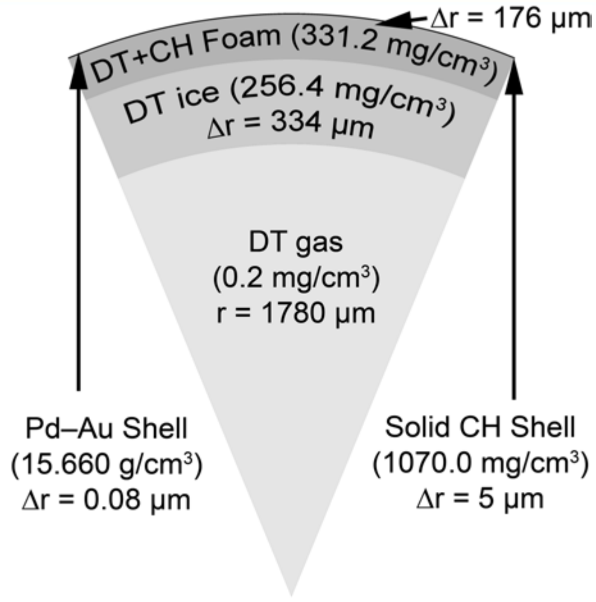
When last we met…

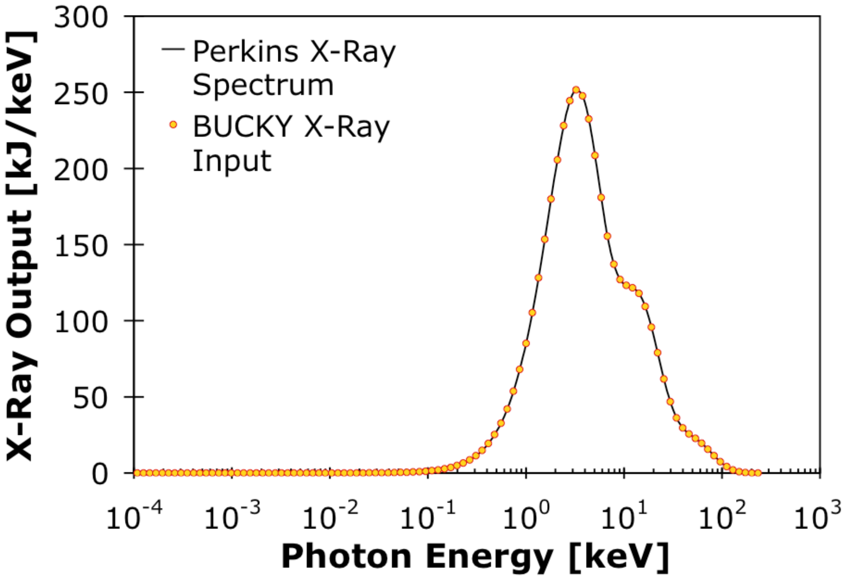
- We reported our simulation results for armor materials exposed to both x-rays and ions
- Our simulations indicated that using silicon carbide as an armor material necessitates the use of magnetic diversion of ions if we want to stay under our temperature limits of ~1000˚C
- We came to the conclusion that we needed to adjust our initial conditions to more accurately assess the impact of magnetic diversion on the chamber design

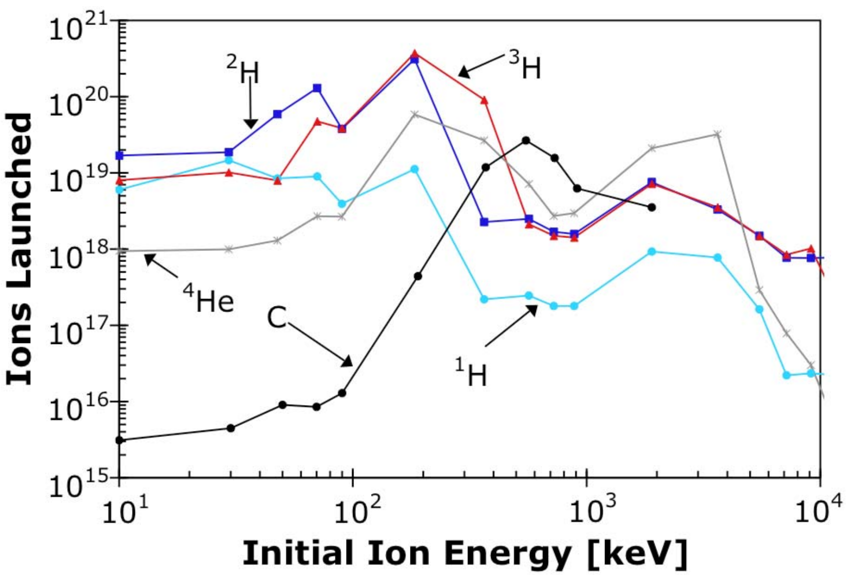
350 MJ Pd/Au Coated Target
Surface Temperature Simulations

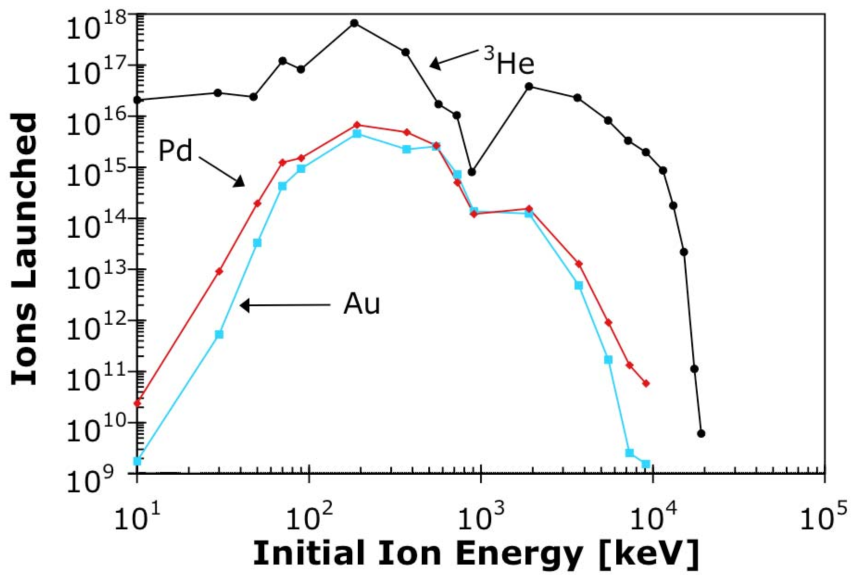


HAPL 350 MJ class high-Z coated target was used for these simulations

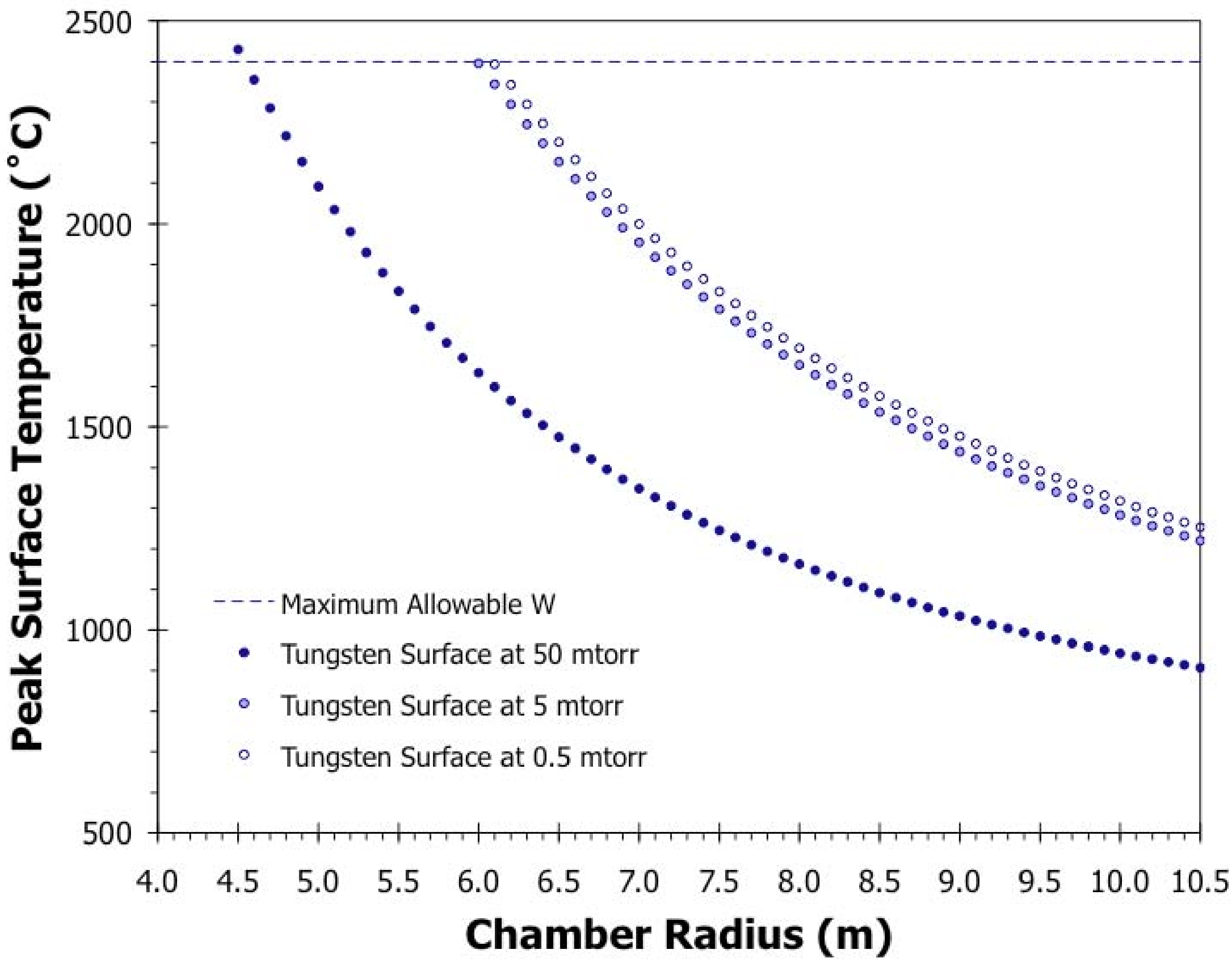




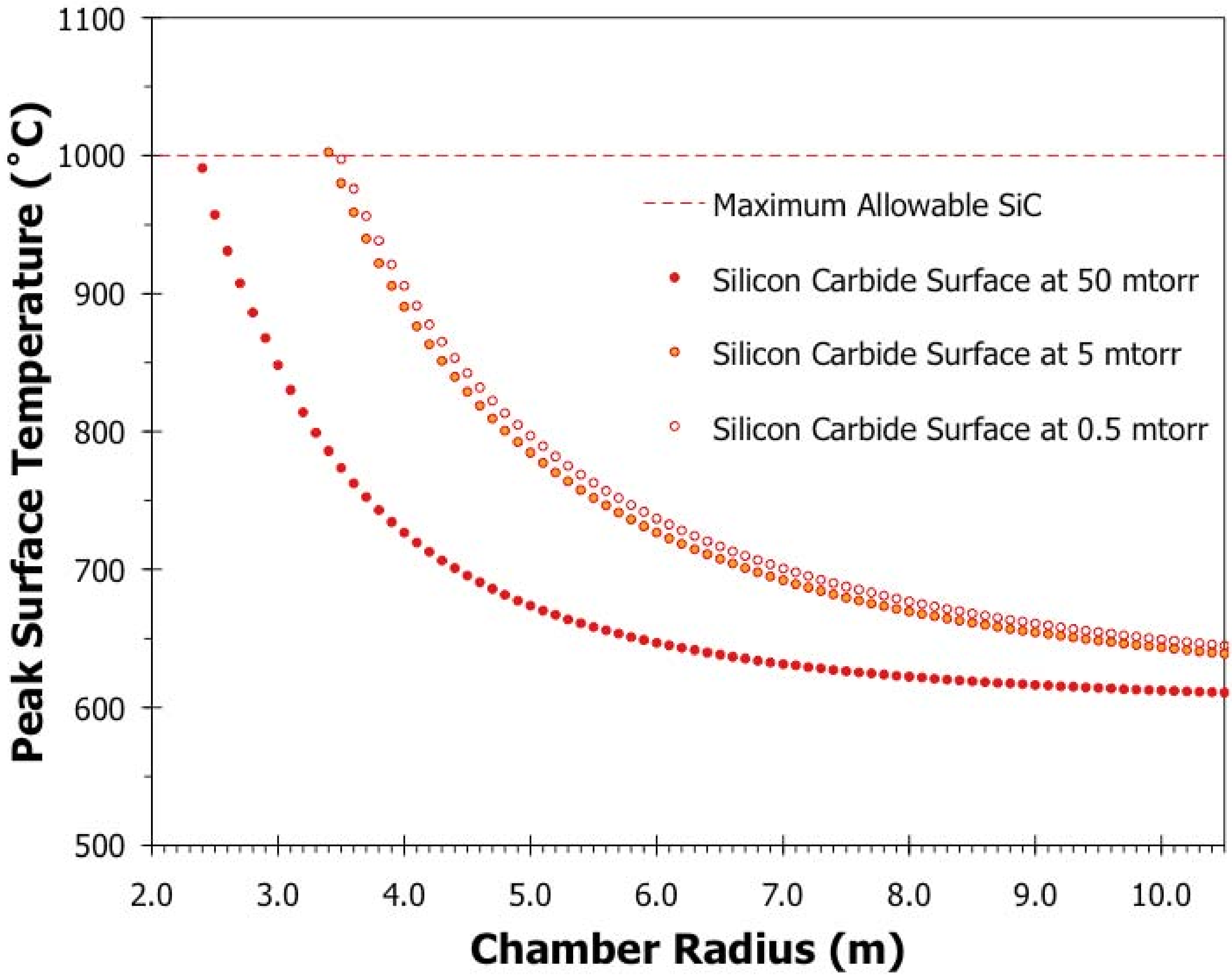




Surface temperature rise in tungsten armor due to the x-ray flash



Surface temperature rise in silicon carbide armor due to the x-ray flash

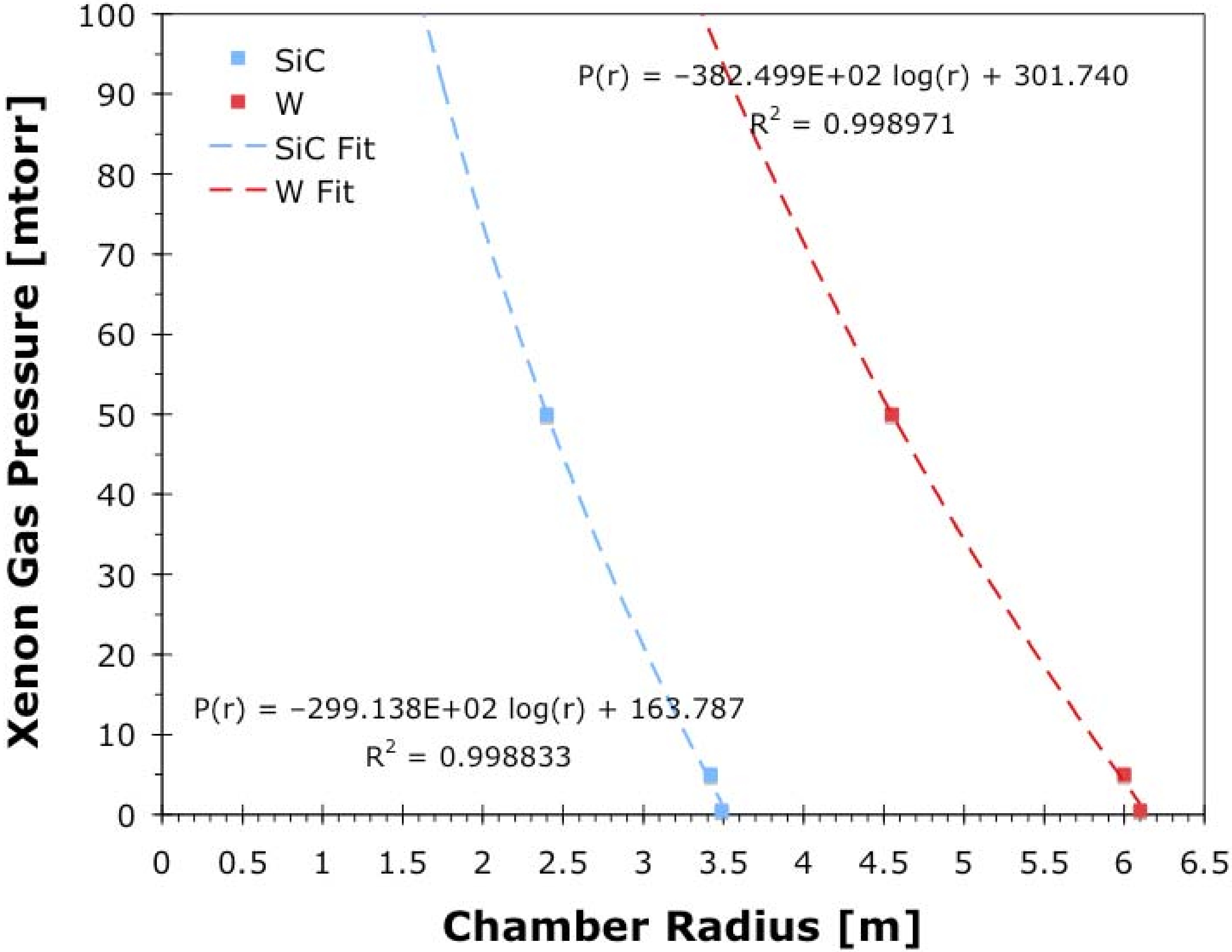


Results of the x-ray flash parametric study

- Tungsten armor results
- 0.5 mtorr xenon gas
  - $T(r) = 4.5957 \times 10^4\ r^{-2} + 4.7508 \times 10^3\ r^{-1} + 3.8211 \times 10^2$
  - $R^2 = 0.99999$
  - $r_{min} = 6.10$ m
- 5 mtorr xenon gas
  - $T(r) = 4.6495 \times 10^4\ r^{-2} + 4.3488 \times 10^3\ r^{-1} + 3.8271 \times 10^2$
  - $R^2 = 0.99999$
  - $r_{min} = 6.00$ m
- 50 mtorr xenon gas
  - $T(r) = 3.4188 \times 10^4\ r^{-2} + 1.2344 \times 10^3\ r^{-1} + 4.7550 \times 10^2$
  - $R^2 = 0.99996$
  - $r_{min} = 4.55$ m

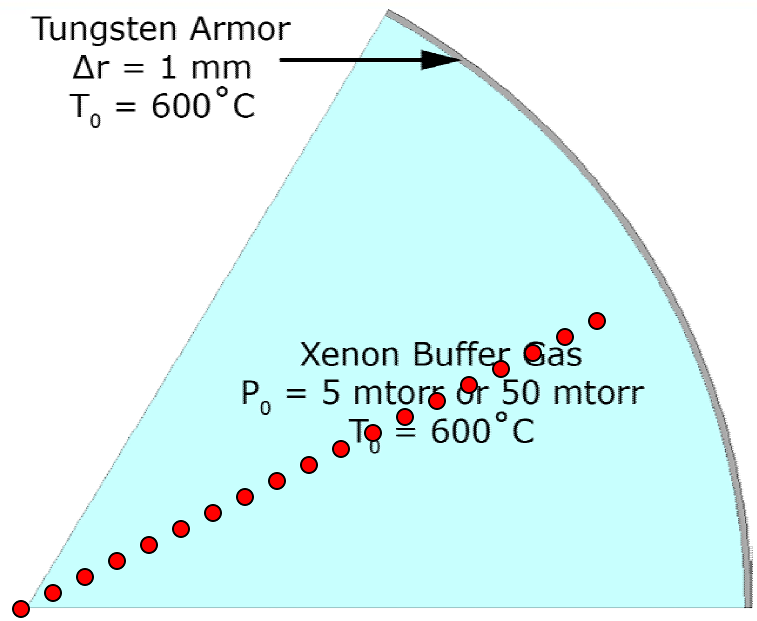
- Silicon carbide armor results
- 0.5 mtorr xenon gas
  - $T(r) = 4.6816 \times 10^3\ r^{-2} + 7.1560 \times 10^1\ r^{-1} + 5.9511 \times 10^2$
  - $R^2 = 1.0000$
  - $r_{min} = 3.49$ m
- 5 mtorr xenon gas
  - $T(r) = 4.6847 \times 10^3\ r^{-2} + 7.7135\ r^{-1} + 5.9566 \times 10^2$
  - $R^2 = 1.0000$
  - $r_{min} = 3.42$ m
- 50 mtorr xenon gas
  - $T(r) = 2.6773 \times 10^3\ r^{-2} - 1.6708 \times 10^2\ r^{-1} + 6.0144 \times 10^2$
  - $R^2 = 0.99967$
  - $r_{min} = 2.40$ m

The results of the parametric study simulations allow us to estimate the required xenon gas pressure for any desired armor radius



Xenon buffer gas re-radiation analysis methodology

- Re-radiation from the buffer gas due to ion slowing down can be a significant heating load over long time scales
- In order to study re-radiation effects of a gas filled chamber with magnetic diversion, the BUCKY code required minimal modification
- The ions were allowed to stream through the buffer gas and were removed when they approached within 25 cm of the armor, simulating diversion by the cusp field
- For these simulations, removal of the ions meant zeroing out their kinetic energy, allowing BUCKY to remove the ions from the simulation through ion accounting routines already present in the code



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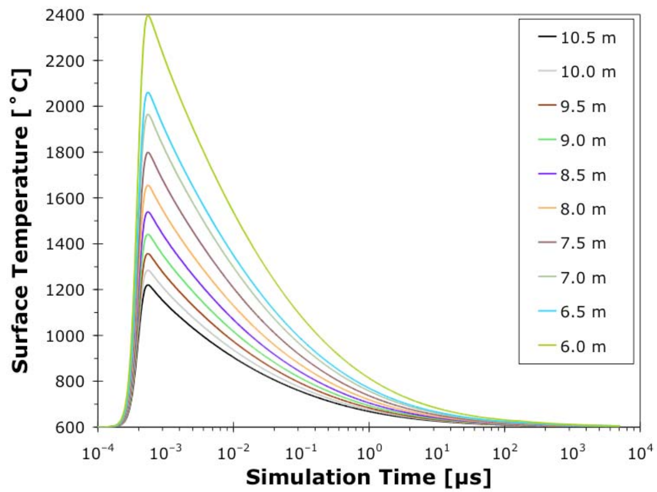
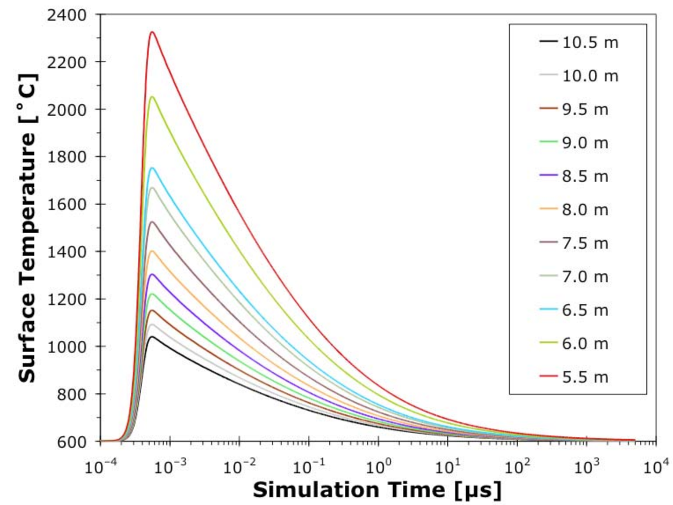
Simulations of the target chamber with buffer gas plus magnetic diversion show no significant surface temperature rise from re-radiation

<table>
<tr><th></th><th>5 mtorr</th><th>50 mtorr</th></tr>
<tr><td>Tungsten</td><td>
</td><td>
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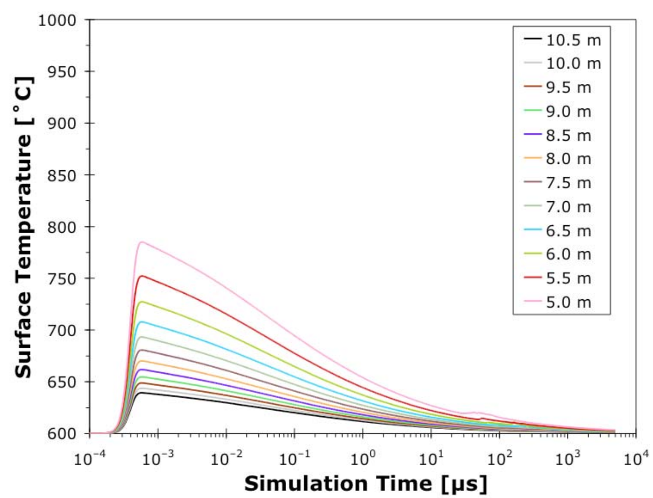
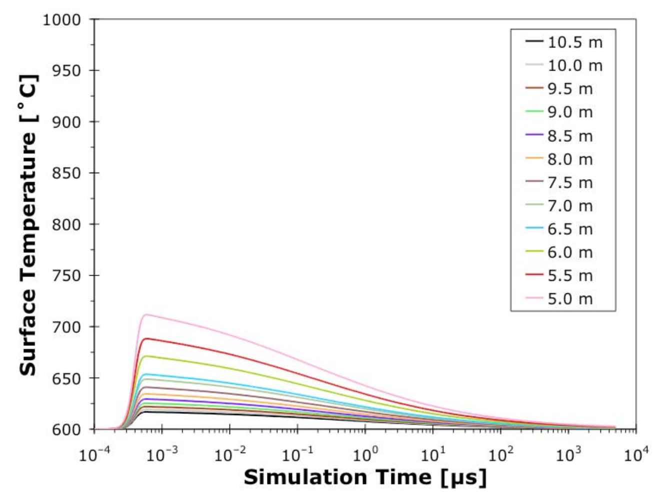
<tr><td>Silicon Carbide</td><td>
</td><td>
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Conclusions

- Magnetic diversion of ions in conjunction with 0.5 mtorr xenon buffer gas allows the inner radius of the armor material to be reduced from 10.5 m to:
  - 6.1 m for tungsten
  - 3.5 m for silicon carbide
- Increasing the buffer gas pressure to 5 mtorr reduces the minimum chamber radius to:
  - 6.0 m for tungsten
  - 3.4 m for silicon carbide
- Increasing the buffer gas pressure to 50 mtorr reduces the minimum chamber radius to:
  - 4.6 m for tungsten
  - 2.4 m for silicon carbide
- Increasing buffer gas pressure can significantly reduce the minimum radius of the armor
- The effect of re-radiation from the xenon buffer gas is negligible for gas pressures up to 50 mtorr

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