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Comparison of TracePro and Micromega models for infrared heated ice layers inside of hohlraums.

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Target Area Technologies Program

Mail Station L - 472

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January 15, 2004

MEMORANDUM

TO: Distribution

FROM: Bernard Koziowski

SUBJECT: Comparison of TracePro and Micromega models for infrared heated ice layers inside of hohlraums.

I. SUMMARY

A reference calculation for the infrared absorption profile was settled upon to compare results using TracePro commercial raytracing software and the Micromega codes. I have re-run the TracePro model with updated parameters to better match those used in Micromega. While the general shape of the absorption curves are consistent, the fine details still differ considerably between the two software packages.

II. MODEL DESCRIPTION

The model is similar to our previous discussion with a few minor changes as we discussed. For this model, I used an input beam that has no divergence and has a uniform spatial profile, instead of the gaussian profile with a small divergence used previously. After our video-conference, I noticed that I had given the collimated input beam diameter as 2.5 mm. My first model used a beam radius as 2.5 mm, so my input was twice as large as the Micromega model. I corrected the TracePro model so that it now uses the 2.5 mm diameter input beam. The IR was not centered in the hohlraum when the smaller beam diameter was used, so I also moved the optics to center the IR along the hohlraum wall. The overall geometry and coordinate system is shown in figure 1. The corrected model has the 45 degree cone mirror with the tip at 141.1 mm. Thus, as illustrated in figure 2, the IR beam hits the cone from $z =$

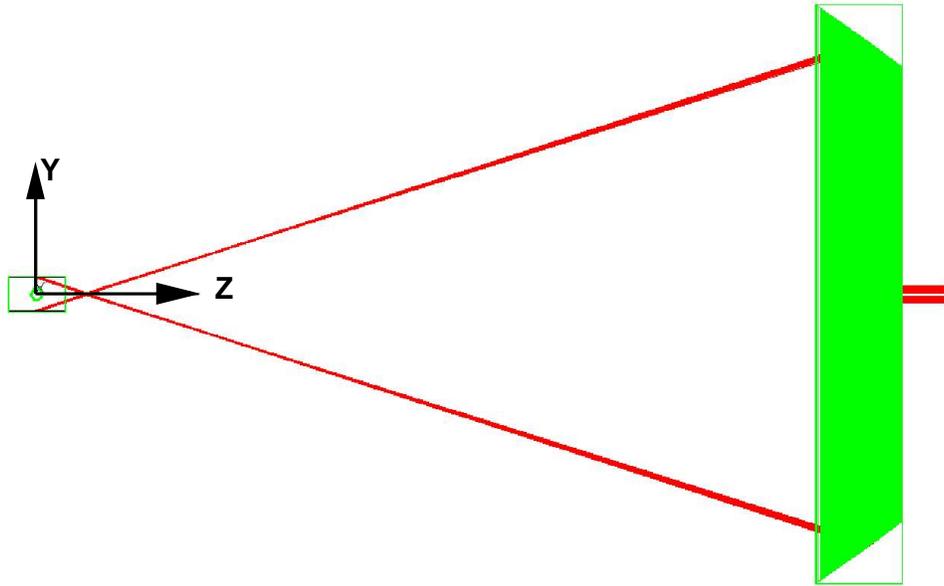


FIG. 1: Overview of the IR model. The IR enters from the right, is split by a 40 degree cone mirror, then focused into the hohlraum by the large ring mirror. The illumination is to be cylindrically symmetric. Only one side of the illumination is shown.

141.1 mm to 140.1 mm. The IR hits the ring mirror over the range ($y=42.08$ mm, $z=141.1$ mm) to ($y=42.8$ mm, $z=140.1$ mm). The edges of the ring mirror are also specified in the figure for reference.

Figure 3 shows a close up of the hohlraum. Only the IR beams in the plane of the figure entering through one LEH are shown. The IR entering the hohlraum has angles 17.5 degrees to 17.9 degrees relative to the surface plane. The IR is spread along the hohlraum wall from $z = -0.56$ mm to $z = +0.56$ mm. The scattering surface of the hohlraum wall is specified using the Harvey-Shack ABg model with the same coefficients as before.

The capsule and ice layer are as previously specified, but in the interest of being thorough, I'll repeat the values here. The capsule is assumed to be composed of the CD material with a 1.0 mm outer radius and 0.850 mm inner radius. The capsule has absorption coefficient $\alpha_{\text{cap}} = 2.3$ 1/mm and refractive index of 1.59. The ice layer was taken to be deuterium with an outer radius of 0.85 mm and inner radius of 0.75 mm, $\alpha_{\text{ice}} = 0.4$ 1/mm, and refractive index of

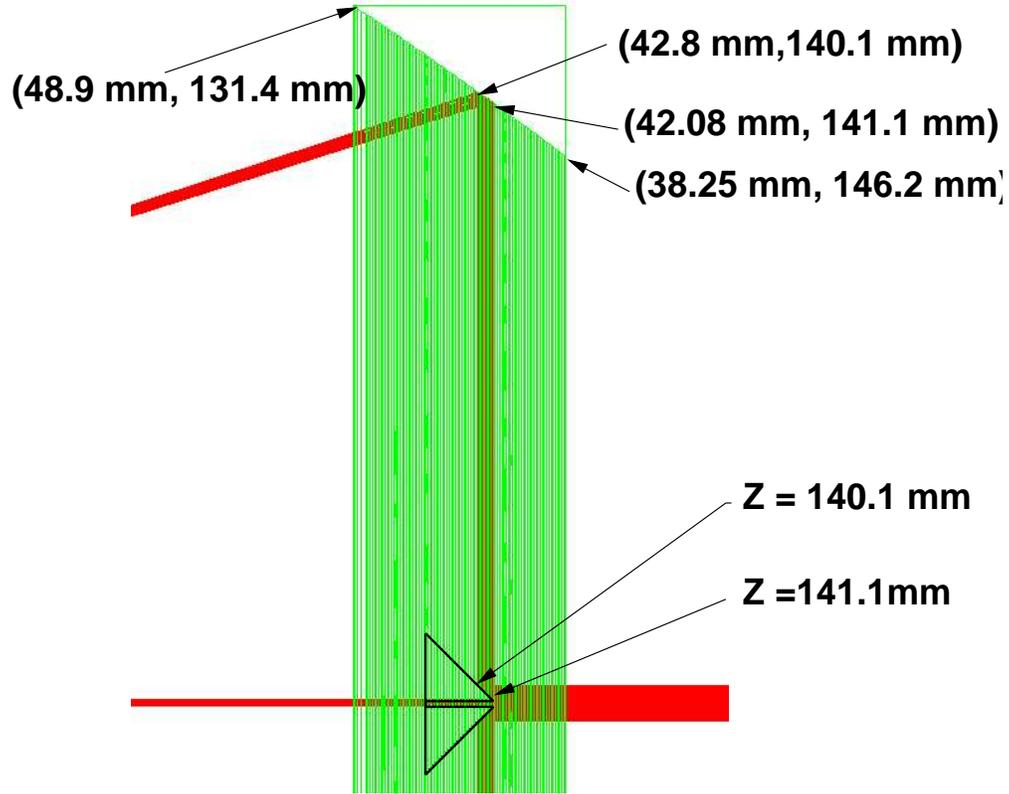


FIG. 2: Close up view of the IR passing from the cone mirror to the large ring mirror. The arrows mark the position where the IR hits the cone mirror and ring mirror in the corrected model.

TABLE I: ABg coefficients used to model the roughened, $4\mu\text{m rms}$, gold hohlraum surface.

| θ_i (deg.) | A | B | g | Absorbance |
|-------------------|-------|-------|-------|------------|
| 10 | 0.229 | 0.346 | 1.523 | 0.128 |
| 40 | 0.279 | 0.322 | 1.184 | 0.115 |
| 70 | 0.247 | 0.076 | 1.168 | 0.060 |

1.15.

III. SOFTWARE COMPARISON

I'll discuss both the absorbed energy in each part of the problem as well as the power distribution in the capsule and ice layer.

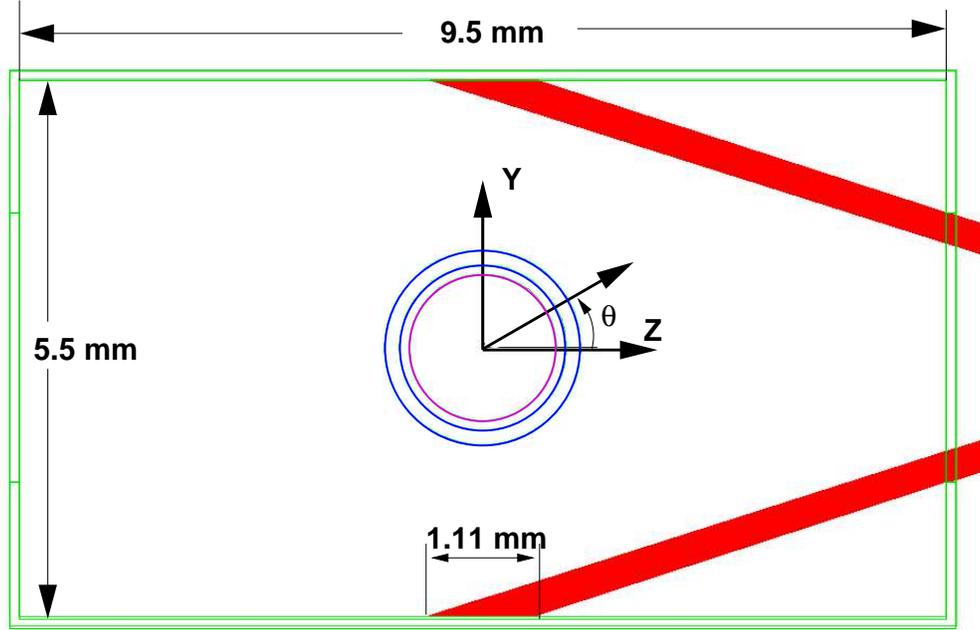


FIG. 3: Close up view of the IR entering the hohlraum. Only the IR in the plane of the figure is shown. The IR is centered in the hohlraum for this model and the beam width is 1.11 mm. The model is mirrored to take advantage of the symmetry of the hohlraum. Illumination from the right will overlap the beam from the left on the hohlraum wall.

A. Absorbed energy

Our TracePro analysis returns values for the energy absorbed in terms of the number of rays. I'll use the same scaling as was specified in the video-conference and assume that the goal is to have $1.5 Q_{DT} = 75300 \text{ W/m}^3$ absorbed in the ice layer. I do this as follows. For a trial run 19154 rays enter the hohlraum. I find 9024.4 absorbed by the hohlraum, 2959.3 absorbed by the capsule, 465.4 absorbed by the ice, and the remainder, 6704.9 escape from the hohlraum. This represents the total power absorbed by each part. To set the scaling, I use that 1.5 QDT in the ice gives a total power, P , of

$$\begin{aligned}
 P &= 1.5 Q_{DT} V \\
 P &= 75300 \text{ W/m}^3 \left(\frac{4\pi}{3} \left((850.0 \mu\text{m})^3 - (750.0 \mu\text{m})^3 \right) \right) \\
 P &= 6.064 \times 10^{-5} \text{ W}.
 \end{aligned} \tag{1}$$

Thus, I take 465.4 rays to be $60.64 \mu\text{W}$ of power in the model. Then the capsule has absorbed power of $P_{\text{cap}} = 386 \mu\text{W}$ and the hohlraum absorbs $P_{\text{hoh}} = 1.176 \text{ mW}$. The power input to the optical system needs to be 2.61 mW to reach $1.5 Q_{\text{DT}}$ in the ice layer. This value includes the power lost through the 0.5 mm diameter hole in the cone mirror, but does not include losses at optical windows or the mirrors. Our value is low compared with the value of 3.25 mW of input power in the Micromega model.

B. Volumetric heating in ice and capsule

The total number of rays run in each case was 4.0×10^6 . The model assumes azimuthal symmetry, so the data is averaged over all ϕ values. I segmented the data in 10 degree bins as well as our original binning method. Since the data is plotted as the power per unit volume, there is no difference in the shape of the curves as the volume of each binning element is calculated for the specific binning geometry. The resulting curves look similar to our previous correspondence, with a small difference due to repositioning and re-sizing the IR beam. The data was scaled as described above to have a total power of $1.5 Q_{\text{DT}}$ deposited in the ice.

Using the data in the video conference presentation sent to us, I was able to compare the TracePro and Micromega results directly. These are shown in figures 6 and 7. The Micromega data in the capsule shows a stronger peak at the equator than the TracePro data. There are substantial excursions in the Micromega ice data compared to the TracePro data. The origin of these differences is not currently known.

One possible difference comes from the evanescent wave. This may describe the ordering of the curves. As discussed by video-conference, the Micromega model results may be improved by averaging over ϕ and increased number of rays. This is evident in the comparison of the TracePro ice layer results with the Micromega results. The noise in the Micromega model is substantial compared with the TracePro model. Future comparisons should help to understand the remaining differences.

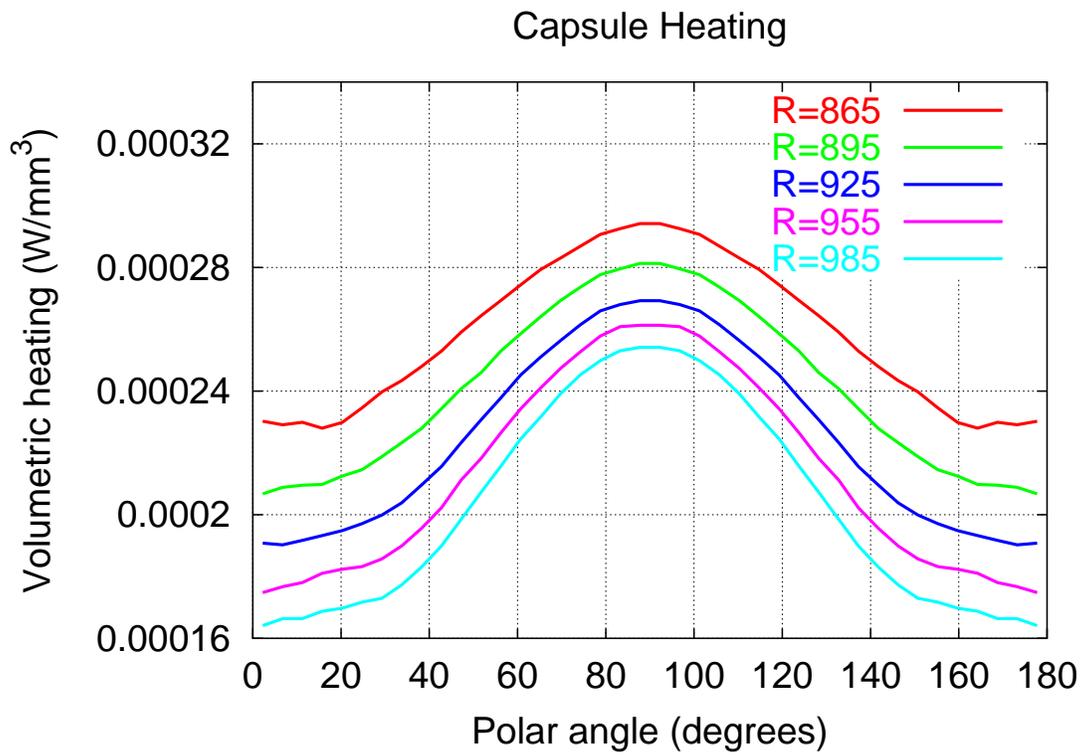


FIG. 4: Volumetric heating of the capsule with the IR centered in the hohlraum. Averaging was done over the ϕ angular direction. The volumetric heating increases monotonically with decreasing radius.

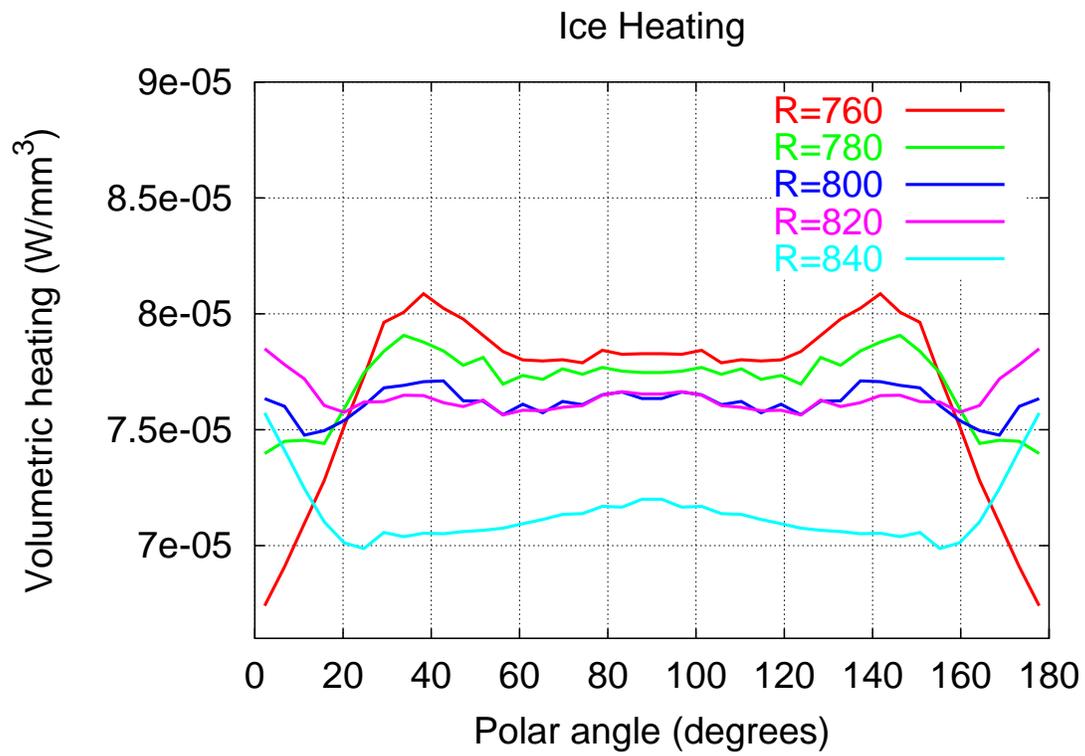


FIG. 5: Volumetric heating of the ice layers with the IR centered in the hohlraum. Averaging was done over the ϕ angular direction. The volumetric heating increases with decreasing radius.

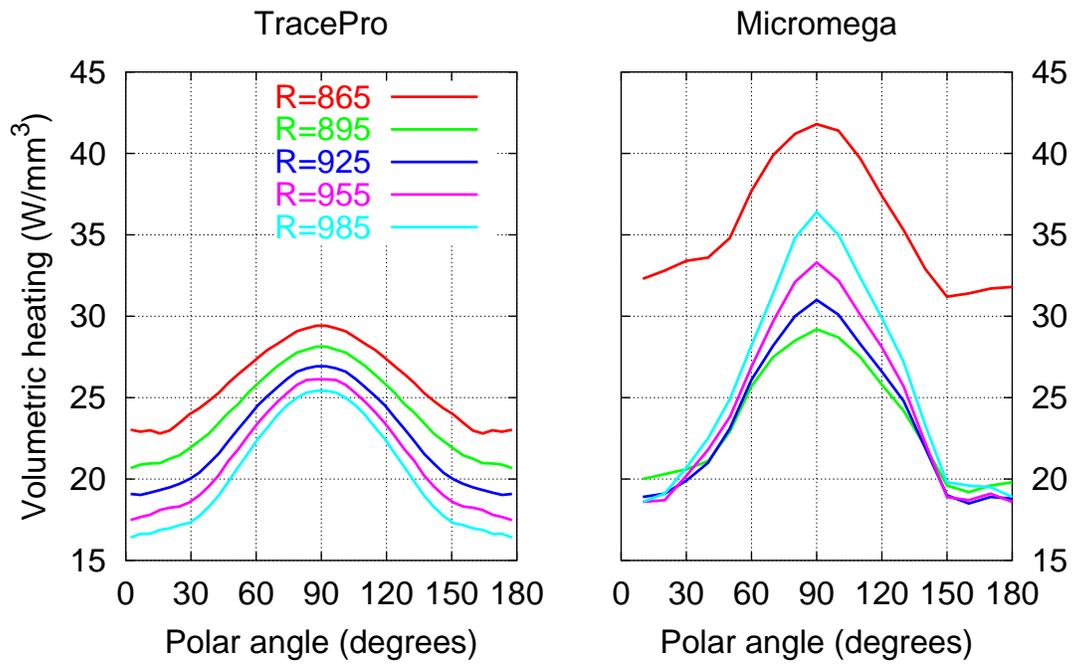


FIG. 6: Volumetric heating in the capsule using the TracePro (left) and Micromega (right) software. The colors correspond to the same radii in both plots.

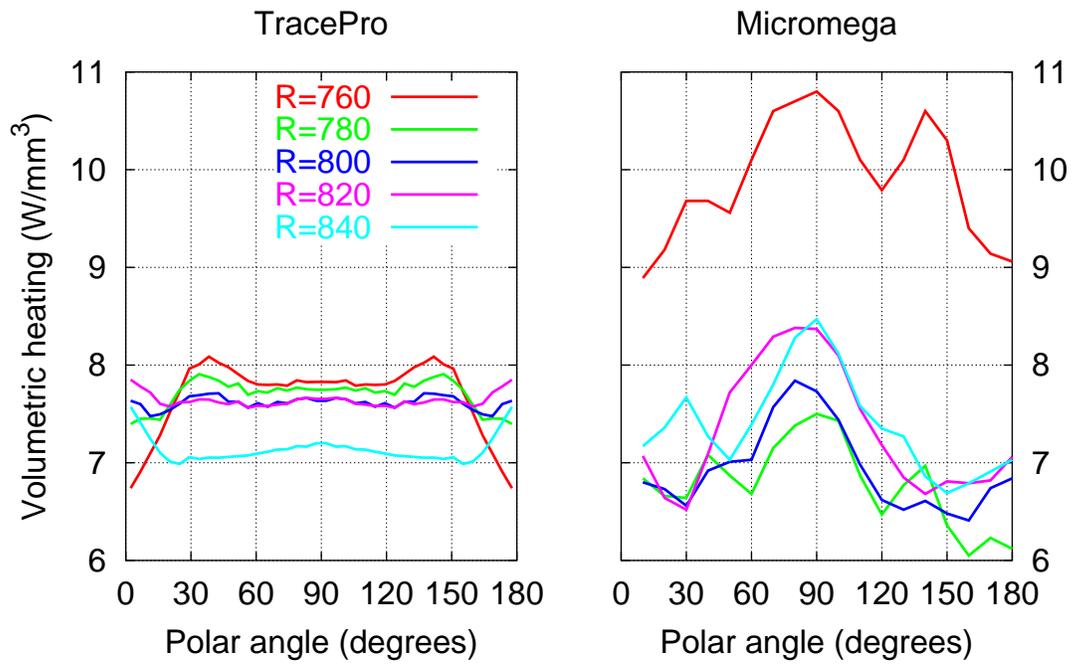


FIG. 7: Volumetric heating in the ice using the TracePro (left) and Micromega (right) software. The colors correspond to the same radii in both plots.