VISRAD Benchmark Calculation: OMEGA Hohlraum Radiation Temperatures

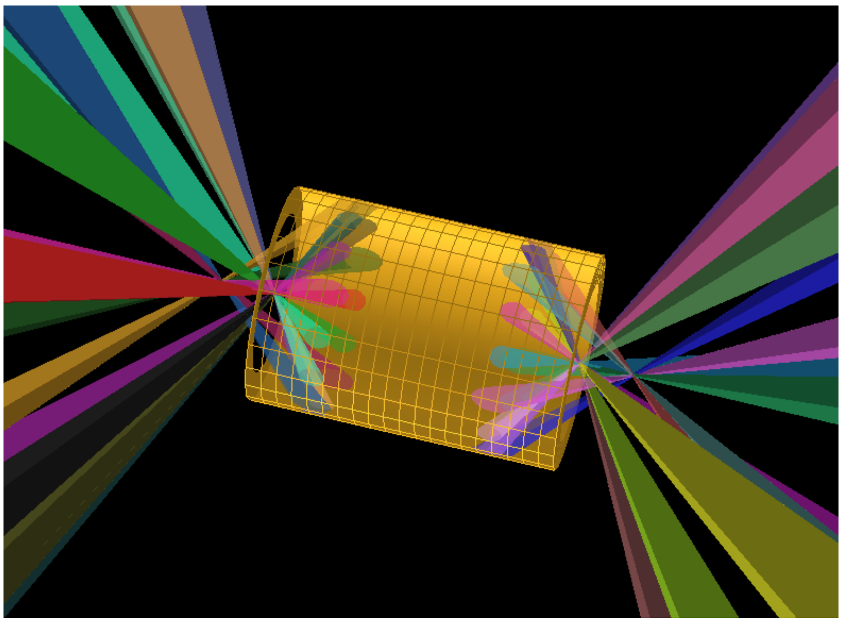
In this VisRad benchmark calculation, we compare OMEGA hohlraum radiation temperatures computed using VisRad with those obtained in experiments. The OMEGA data are based on results reported by Decker *et al.* (PRL **79**, 1491, 1997). Hohlraum dimensions, laser parameters, and Dante orientation are based on the Decker *et al.* paper.

In these experiments, 15 laser beams enter each laser entrance hole (LEH) of a hohlraum of length 2300 μm. The radiation temperature is inferred from Dante measurements. Dante views the hohlraum radiation through one of the LEH's, and is oriented at an angle of 37.4° with respect to the hohlraum.

<u>Simulation setup:</u>

- Cylindrical hohlraum:
  - diameter = 1600 μm; length = 2300 μm; LEH radius = 600 μm
- Laser beams:
  - 15 into each LEH: Cone angles of 42° and 59°
  - 15 kJ total energy in a 1 ns flat top pulse => each beam has a constant power of 0.5 TW
  - beams are pointed such that the 42° and 59° cones hit the hohlraum at about the same depth with respect to the LEH (see Figure 1).
- Hohlraum properties:
  - albedos (see Figure 2):
    - based on 1D radiation-hydrodynamics simulations of Au foils
  - x-ray conversion efficiencies (see Figure 3):
    - assumed to be 0.55 at times > 0.2 ns
    - at times < 0.2 ns, assumed to ramp up from 0.0 to 0.55 linearly with time.

Figure 1. View of target setup and laser beams.



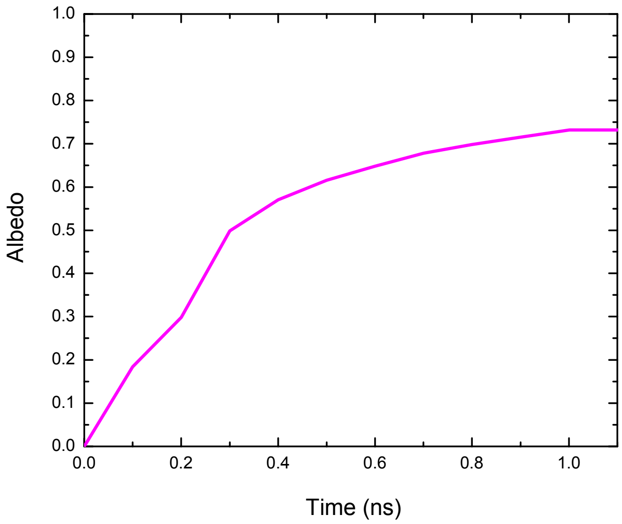


Figure 2. Albedo vs. time computed from a *HELIOS* 1D radiation-hydrodynamics simulation of a radiation-driven Au foil.

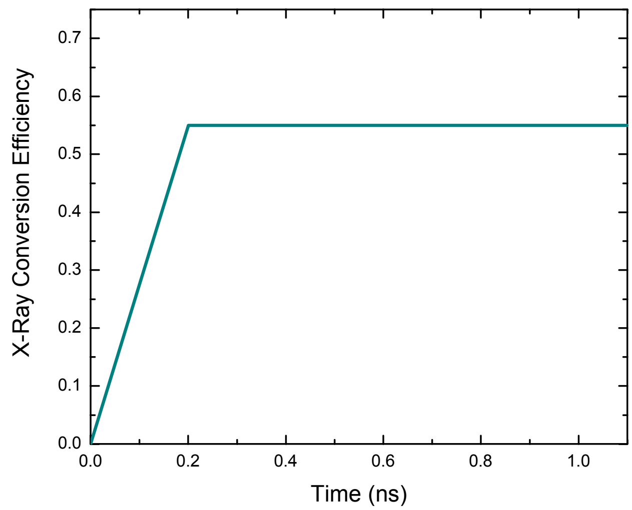


Figure 3. X-ray conversion efficiency vs. time.

In this VisRad simulation, we oriented the hohlraum along the P6-P7 axis. Dante was represented by a simple rectangle located at a distance of 10 cm from the hohlraum, and oriented at an angle of 37.4°. The flux incident on the Dante surface was computed, and from that the hohlraum temperature was determined from the relation:

$$T_R \quad = \quad [\, D \,/\, R_{LEH} \,]^{\,0.5} \quad [\cos\,\theta\,]^{\,-0.25} \quad (\, F_{inc} \,/\, \sigma \,)^{\,0.25}\ ,$$

where F_{inc} is the incident flux onto the Dante detector, D is the distance to Dante, R_{LEH} is the LEH radius, θ is the angle to Dante, and σ is the Stephan-Boltzmann constant. The above relation simply assumes that a disk the size of the LEH emits like a blackbody.

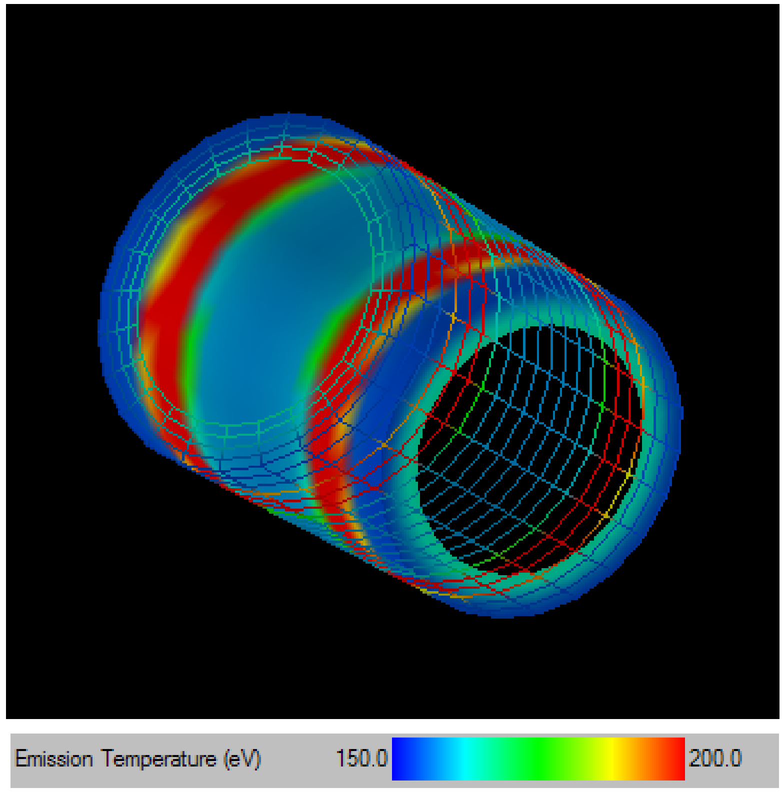
Simulation Results

Figure 4 shows the distribution of emission temperatures (*i.e.,* the temperature corresponding to the outgoing flux from each surface element) at a simulation time of 0.5 ns. The view correspond to that seen by Dante. The peak emission temperatures at this time are just under 300 eV, and occur where the laser beams hit the hohlraum. It is clear that a significant component of the emission seen by Dante is from the laser hot spots.

Figure 5 compares the radiation temperatures determined from the VisRad simulation (red curve) with the OMEGA experimental values (blue curve). The VisRad results are seen to be in good agreement with the experimental values. At times $\gtrsim$ 0.2 ns, the rise in temperature is due to the increase in the hohlraum albedo, as both the laser beam powers and x-ray conversion efficiencies are constant at these times.

Figure 4. Distribution of emission temperatures computed by VisRad at $t = 0.5$ ns. View is from Dante.

(Surface elements facing away from observer are shown as wire frame; toward observer are shown as filled surfaces.)



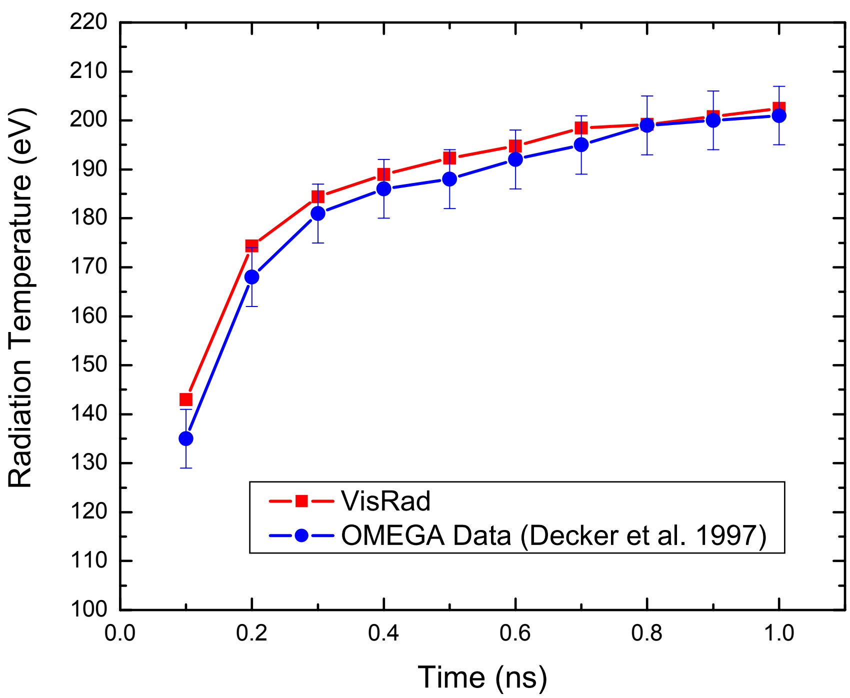


Figure 5. Comparison of VisRad radiation temperatures with OMEGA experimental values (from Decker *et al.* 1997).

It is also interesting to compare the radiation temperature inferred from Dante with the radiation temperature within the hohlraum itself. Figure 6 shows a plot similar to Figure 5, but with the radiation temperature (*i.e.,* the temperature corresponding to the incident flux) at the hohlraum mid-plane added (green curve). It is seen that the radiation temperature at the hohlraum mid-plane is about 14 eV lower than the Dante-inferred temperature. This 14 eV difference in temperature corresponds to about a 30% difference in flux (flux ~ T^4). Thus, the Dante temperature can deviate somewhat from the temperatures in the hohlraum interior. We also note that these results can be sensitive to the beam pointing and hohlraum albedos.

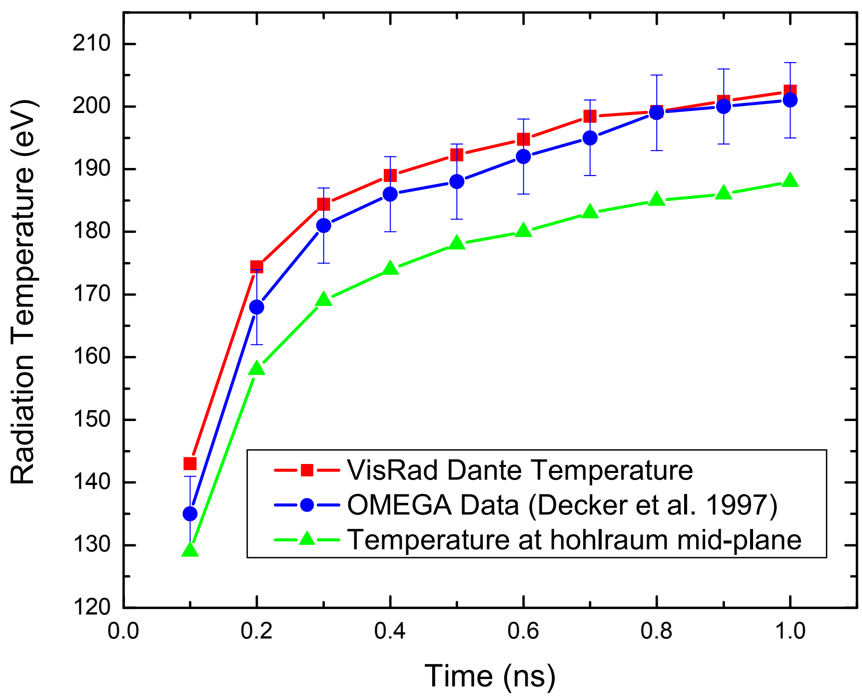


Figure 6. Same as Figure 5, but with curve added for the radiation temperature at the hohlraum mid-plane.