DANTE vs. Witness Plate Radiation Temperature Comparison

These calculations were performed by undergraduates David S. Conners, & Nate C. Shupe, under the direction of Prof. David H. Cohen

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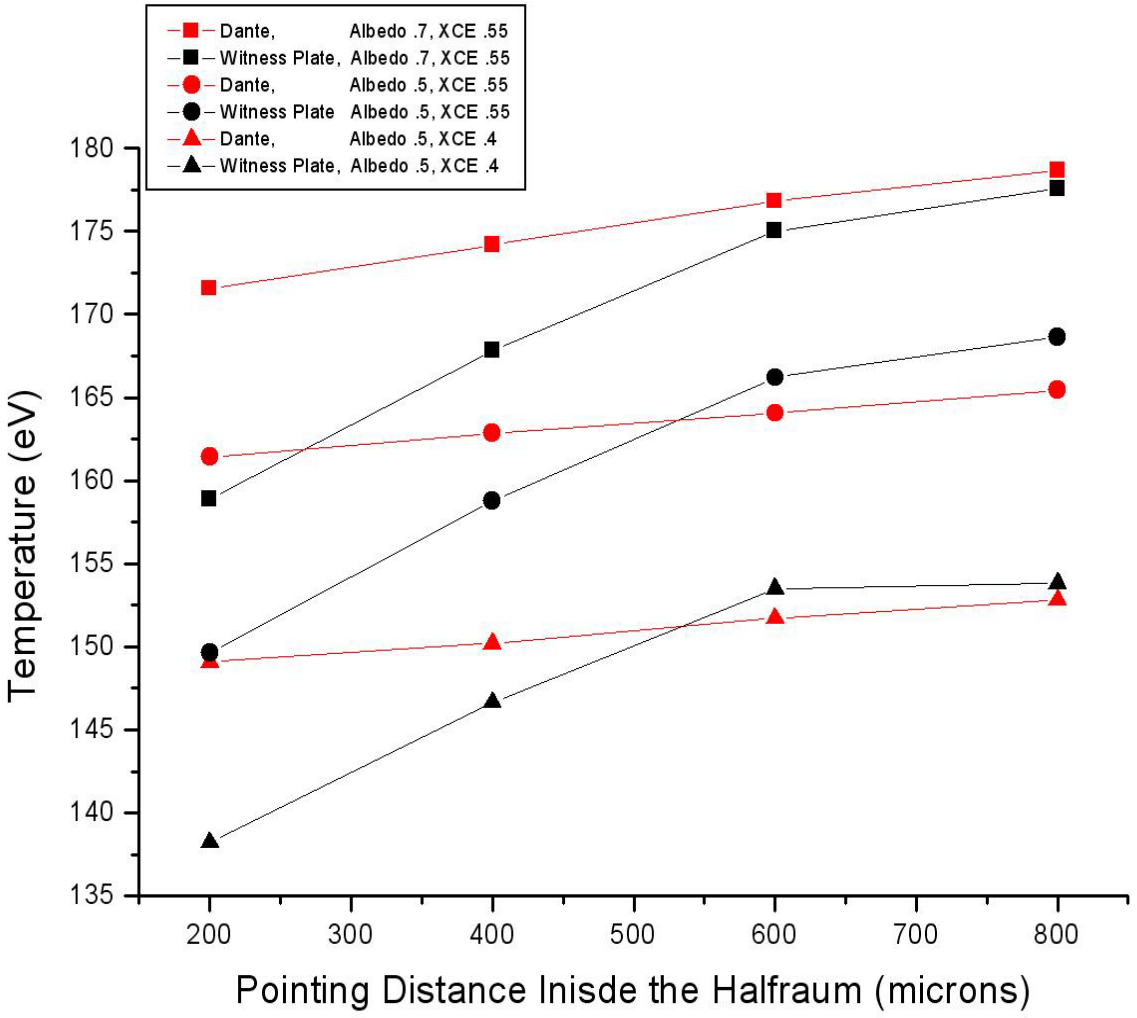
http:/astro.swarthmore.edu/~cohen/presentations/trad_comparison.ppt

Summary of Results

•The DANTE radiation temperature tends to be higher than the witness plate's, especially when the pointing is small. (i.e. the beams are relatively near the LEH.) This difference can be big (~15 eV, equiv. 10%, which corresponds to 46% in radiative flux).

•The main exception is with low albedo and deep pointing. Then the witness plate radiation temperature can actually be somewhat higher than DANTE's.



•And the witness plate incident spectrum is always harder than the DANTE spectrum.

Abstract: We investigate the radiation spectrum incident on the back end of a scale-1 halfraum, and compare it to that measured by DANTE, at $\theta = 37.4$ deg. We use a simplified beam pointing and halfraum geometry and test three representative XCE-albedo values and four pointings.

The radiation temperature seen by a witness plate on the end of a halfraum is up to 15 eV less than that seen by DANTE when the beams are pointed less than 500 μm into the halfraum. The temperatures are closer for deeper pointings, with the witness plate T_R exceeding DANTE's in cases of low albedo. These results are modified somewhat by the inclusion of a LEH lip on the halfraum, and by changes to the focus offset and more complex beam pointing schemes.

The spectrum seen by a witness plate on the end of a halfraum differs significantly from the spectrum seen by DANTE, even when their radiation temperatures are the same, with the witness plate spectrum being harder.

We were originally motivated by a desire to determine whether it is necessary to model the radiation incident on a package during a halfraum shot or whether the DANTE temperature can be used directly. This is in the context of using a scale-1 halfraum on the P6-P7 OMEGA axis (θ_{DANTE} = 37.4 deg), where the DANTE view seems similar to that of the witness plate, with the hotspot/wall ratio being roughly the same for this DANTE view and the the witness plate view.

This expanded into a more general study of radiation conditions inside the halfraum, looking, for example at the spatial dependence of spectral energy distributions. A more detailed and longer presentation, containing elaborations on some of the slides presented here as well as aspects of the study not included in this presentation, is also available:

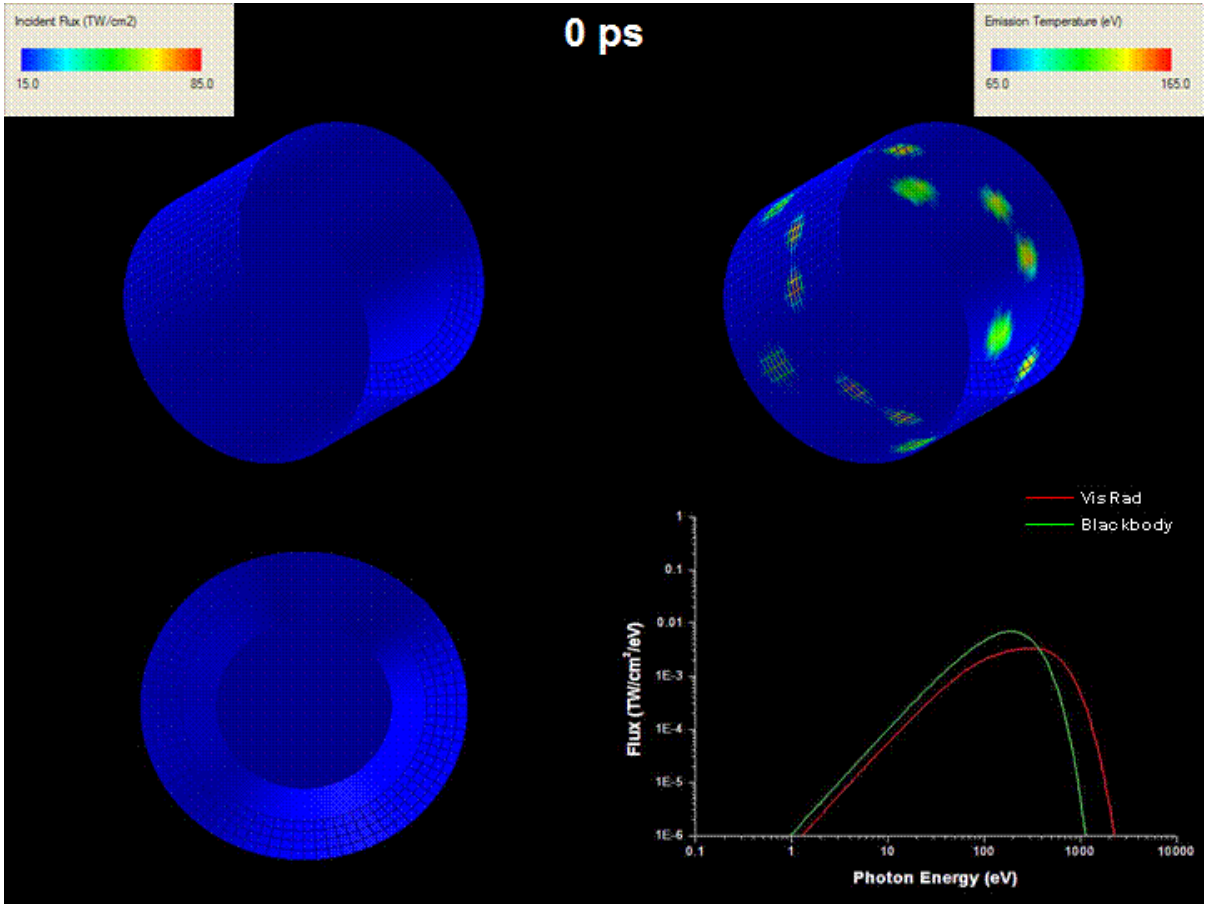
`http:/astro.swarthmore.edu/~cohen/presentations/trad_comparison_bkg.ppt`

This longer document represents more of the educational component of our program, as our undergraduate researchers developed their understanding of the experiments and modeling tools.

The radiation environment inside a halfraum during an actual shot is dynamic and complex: A simulation of a OMEGA shot 19526 (15 beams, 1 ns square pulse, 7 kJ, into a scale-1 halfraum)

Dante view; incident flux

On-axis view; incident flux

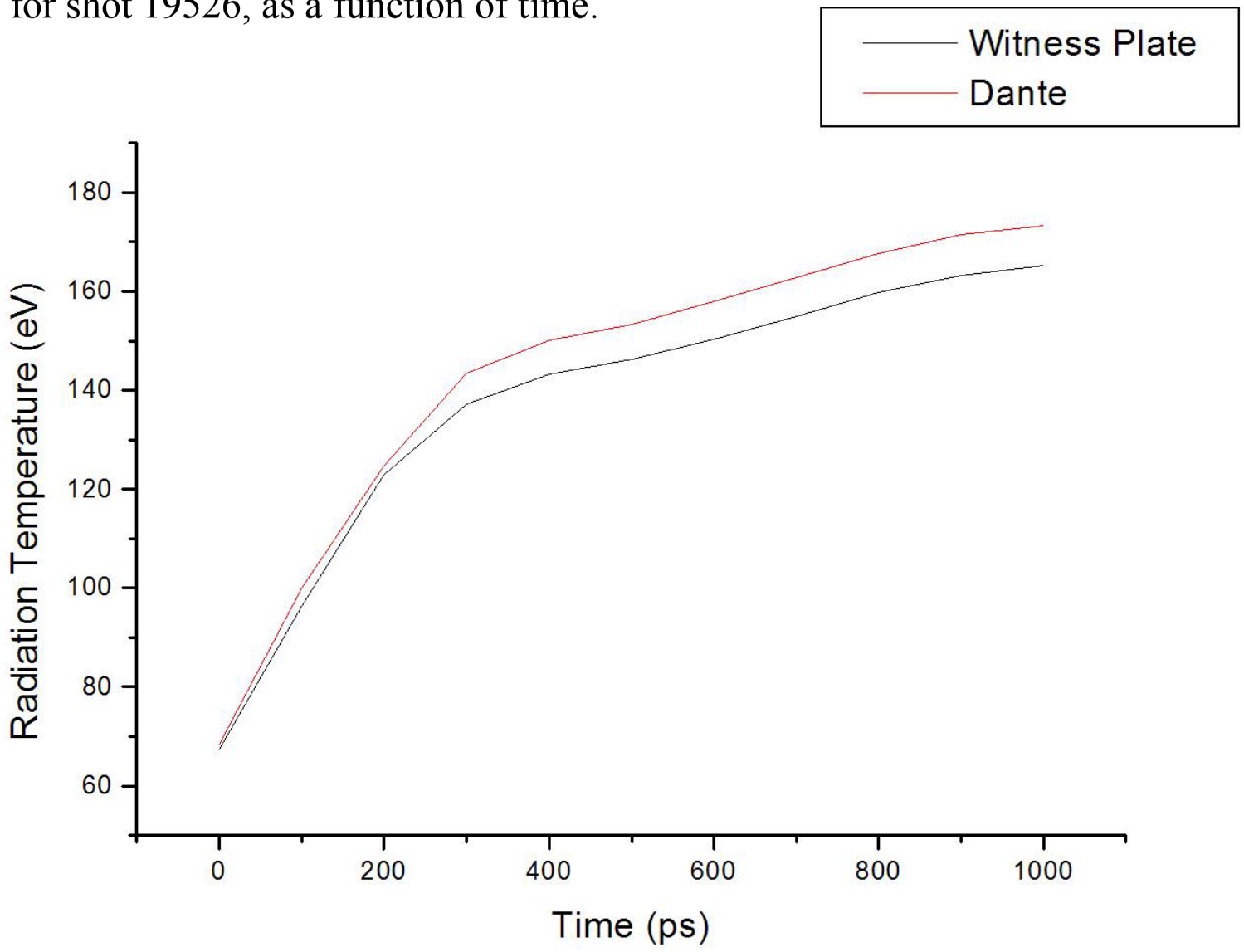


Dante view; T_{emis}

Incident spectrum (and BB equivalent) onto witness plate

This series of simulations was performed using ***VisRad***, a viewfactor code provided by Prism Computational Sciences. See http://www.prism-cs.com/Software/VisRad.htm

Detailed simulation of radiation temperature seen from the two different locations for shot 19526, as a function of time.



Note: Contrary to some earlier results presented in January at LLNL, the DANTE temperature is *higher* at all times. The earlier mistake was due to a mislabeling of two lines in a different plot, and not any problem with VisRad.

To study the problem in a more controlled way, we made the following simplifying assumptions:

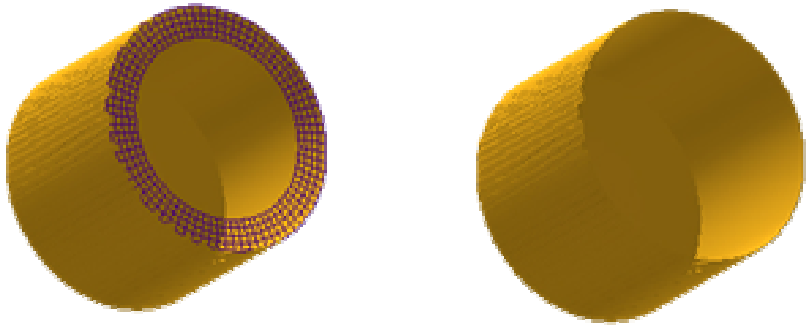
•The laser beam power is constant over a 1ns square pulse, and uniform for each beam (475 J/beam for each of 15 beams).

• There is no "lip" on the halfraum

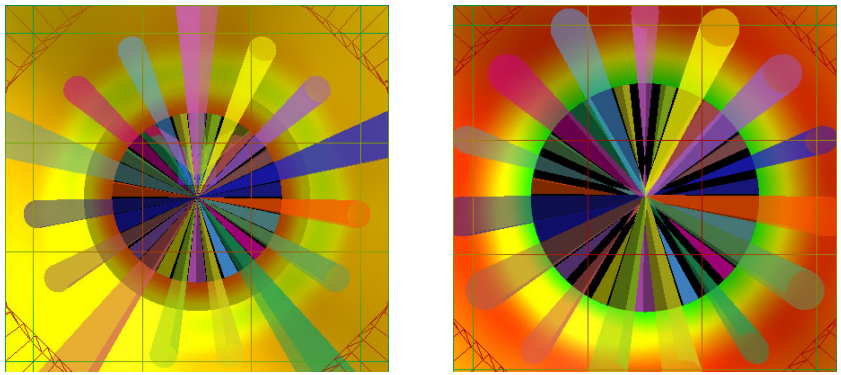
• The 15 laser beams were pointed to make a *single* ring of laser hot spots around the halfraum (note that this makes the spot sizes different for beams in different cones).

•The witness plate and the halfraum are both made of gold (maximum albedo = 0.7)

Later we show a comparison between these "no-lip" calculations and some with lips on the halfraum around the LEH.

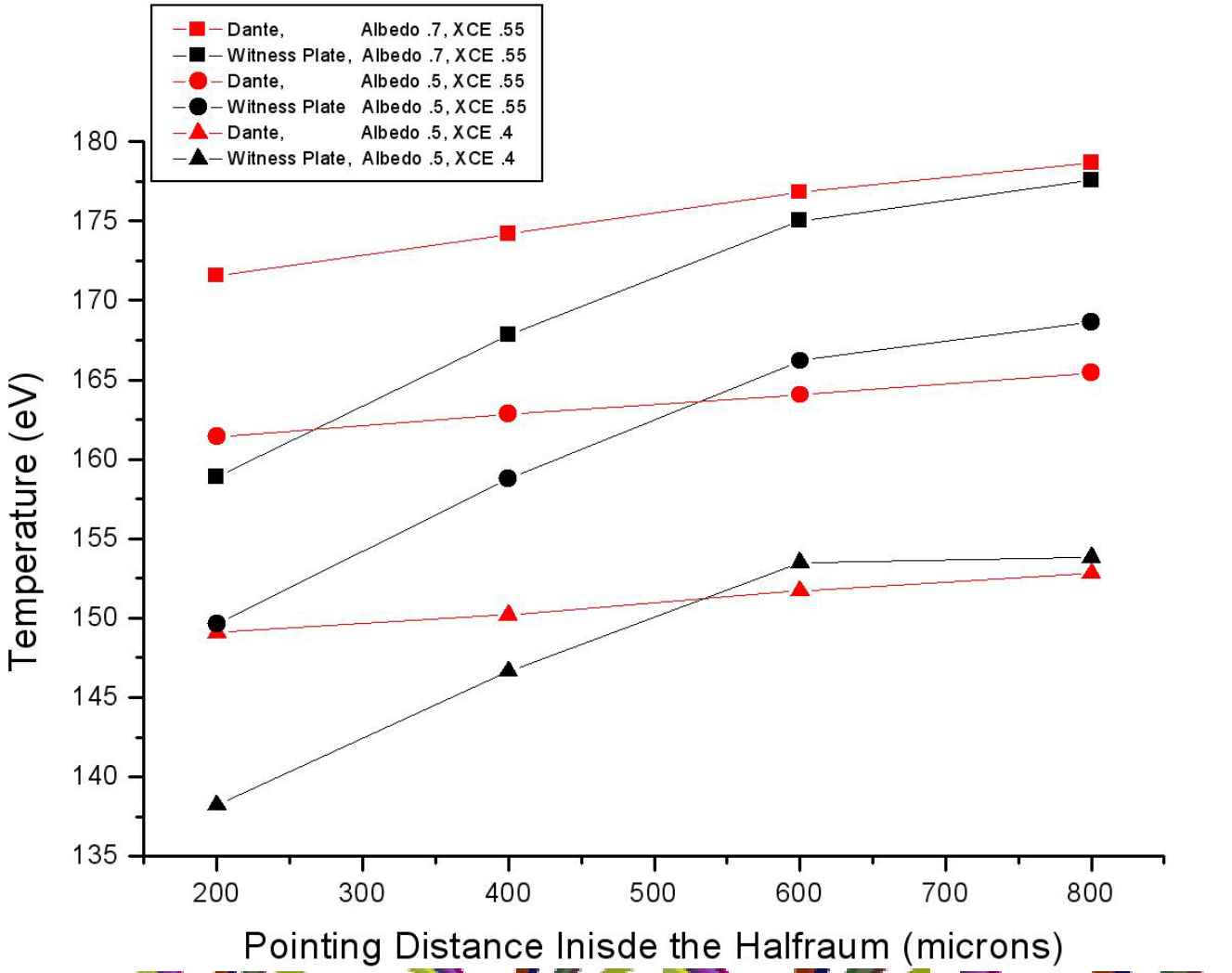


Left: A typical halfraum with a (1/4) lip over the LEH. Right: A simplified halfraum with no lip. Some surfaces in the VisRad simulations are shown as 'mesh' so the viewer can see what's behind them.



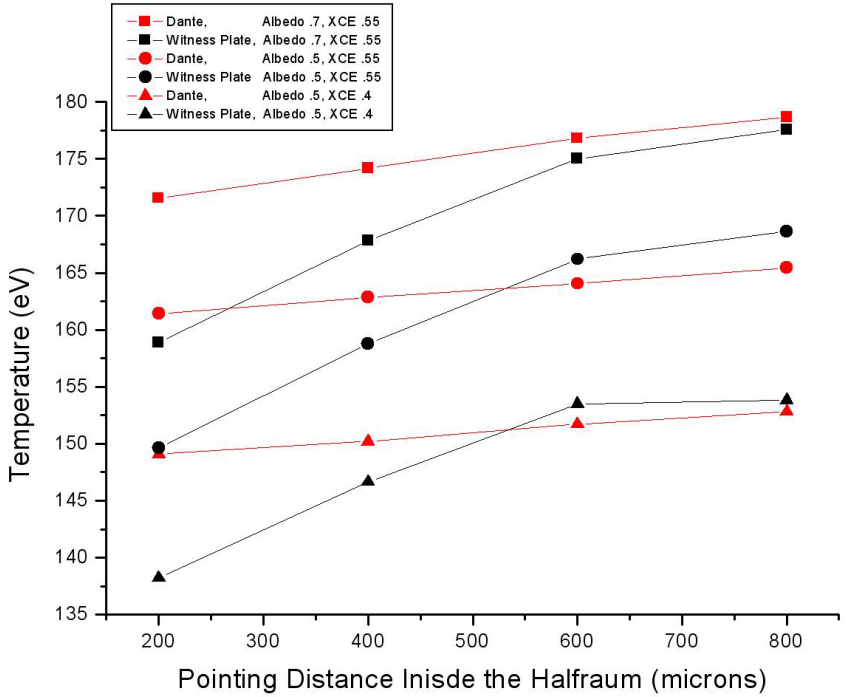
View from center of witness plate, looking out the LEH. On the left, a more typical configuration with cone 2 and cone 3 beams pointed differently and an LEH lip included. On the right, the result of implementing the simplifying assumptions.

Radiation temperature as a function of beam pointing for three different albedo/XCE combinations, comparing DANTE (red) and WP (black) values.



These albedo/XCE pairs are somewhat representative of conditions at different times in a typical shot.

The high values for late time and the low for early times. The intermediate case (low albedo, high XCE) was used to investigate the relative effects of these two parameters on the overall T_R and also on the relative DANTE and witness plate values.

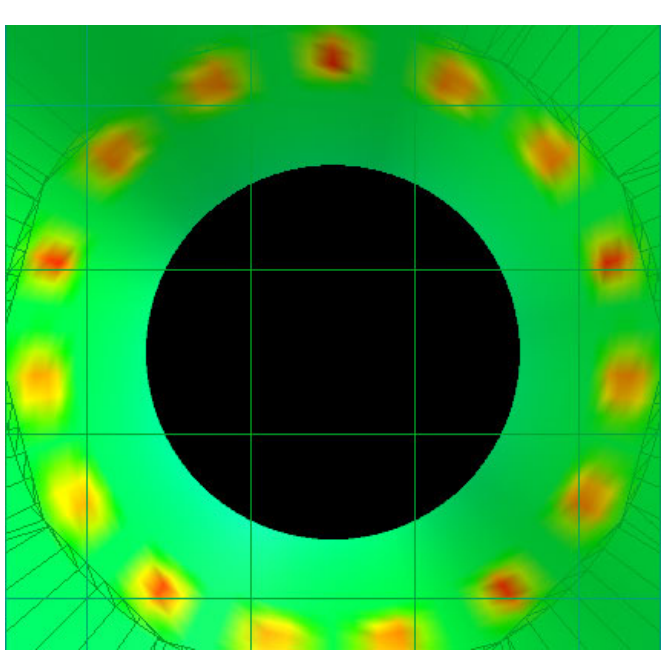


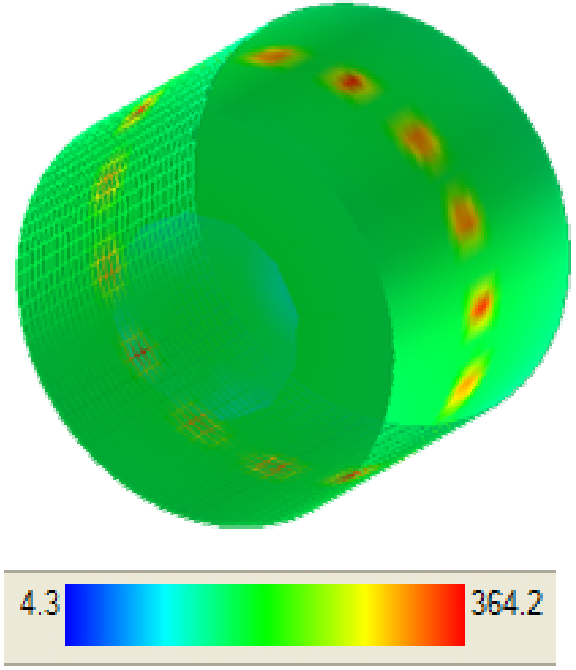
General Trends:

- T_R differences between DANTE and the witness plate are large when the beam pointing is not so deep, but they are closer when the pointing is deeper;
- The radiation temperature on the witness plate exceeds that on DANTE for these deeper pointings when the albedo is relatively low.
- Lowering the albedo significantly lowers the radiation temperature in the halfraum, even if the XCE is kept high.

We should be able to understand trends in the respective radiation temperatures by examining the distribution of surface element temperatures seen from the relevant perspectives. This should also provide insight into the differences in the spectral energy distributions seen from different positions (see next two slides).

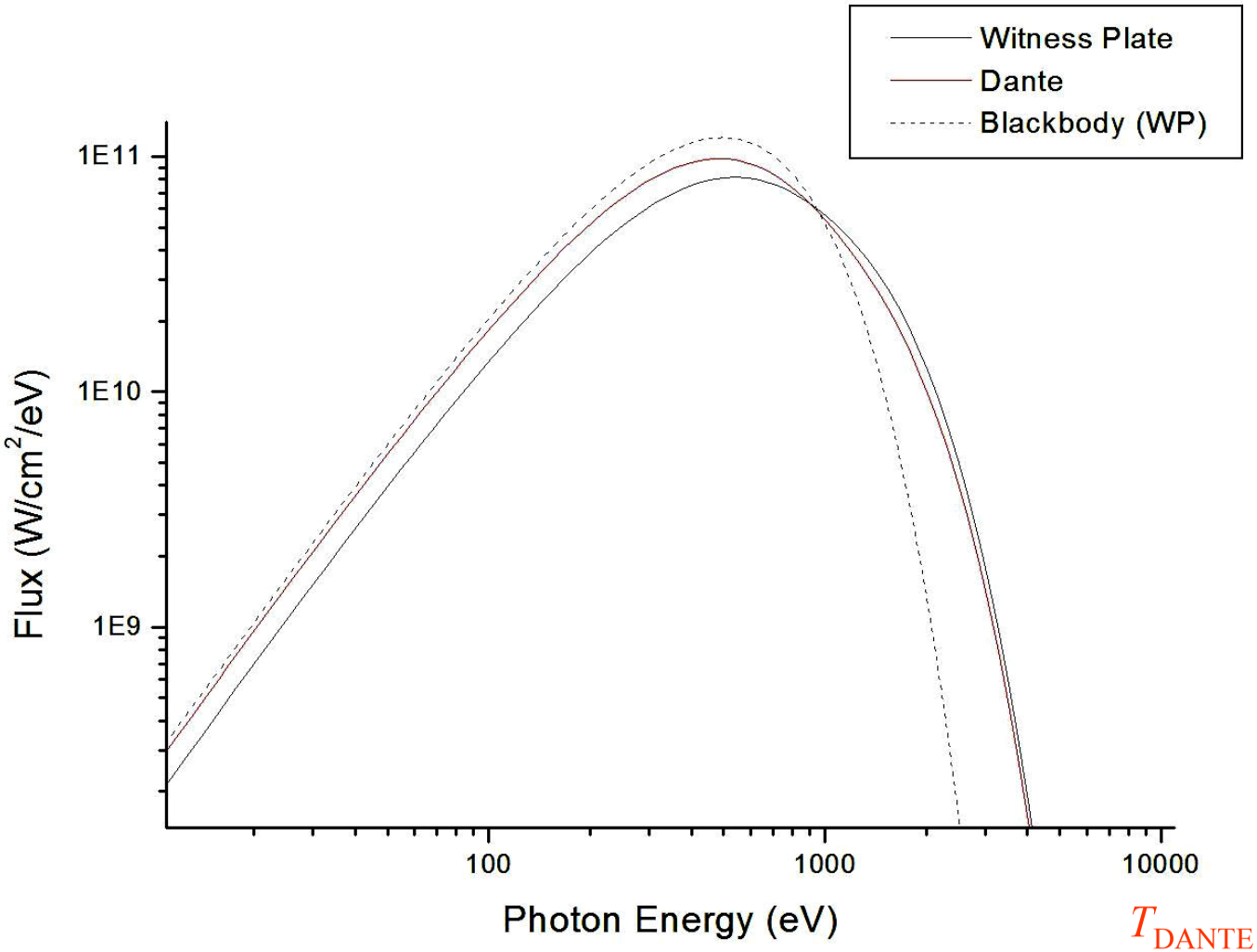
Below are the results of a simulation done with the beams pointed 600 μm into the halfraum with the focus at the plane of the LEH, an albedo of 0.7 and an XCE of 0.55. Note that the witness plate (left) sees more hot spots than DANTE (right), but it also sees the cold LEH.





We would like to quantify this by post-processing these simulations in order to make a *histogram* of solid angle vs. temperature (future work).

DANTE vs. witness plate incident spectrum for a simulation where their radiation temperatures are almost identical. The witness plate spectrum is somewhat harder than the DANTE spectrum as well as the equivalent blackbody, especially below 1 keV. It sees more hot spots, but also more LEH.

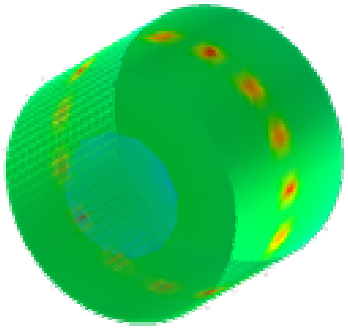


T_{DANTE} = 176.7 eV

T_{WP} = 175.0 eV

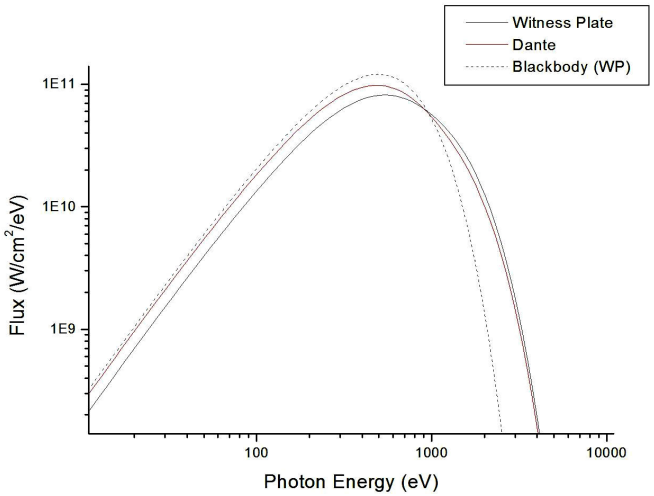
600 micron pointing;
emergent flux (~T^4) shown

TW/cm^2



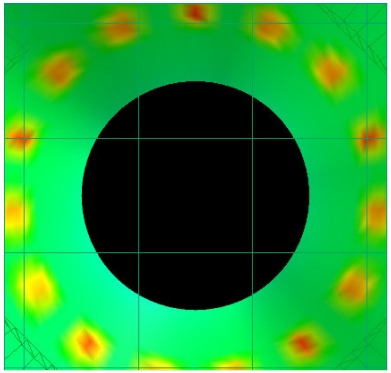
Dante View

175 eV



Witness Plate View

174 eV



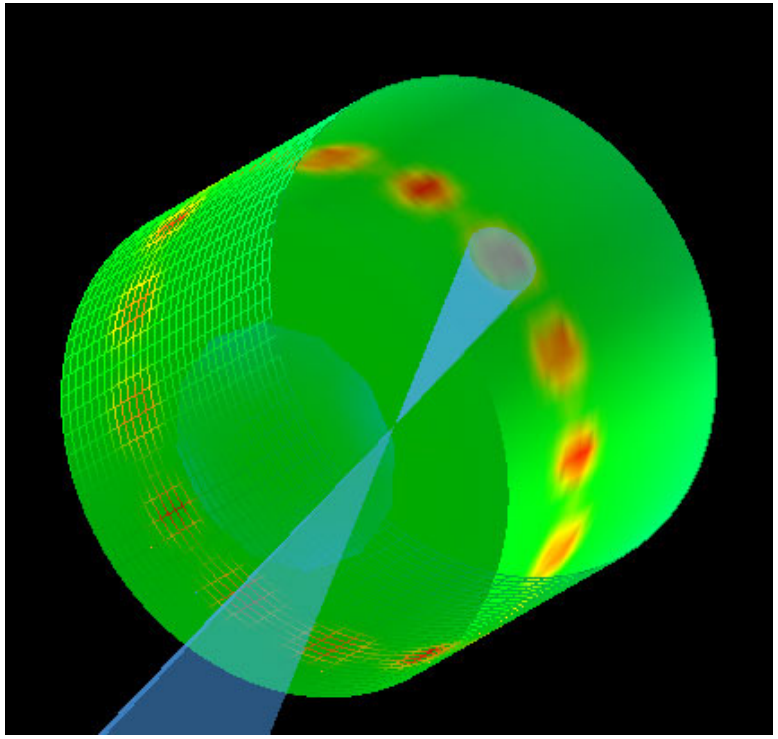
Two notes:

1. You can see the somewhat different laser spot sizes (and peak temperatures) for the beams in the two different cones.
2. *VisRad* does not incorporate detailed opacities. Each surface element is taken to re-emit as a blackbody. Of course, the net spectrum incident on any one surface, being the sum of multiple blackbodies, is itself *not* a blackbody.

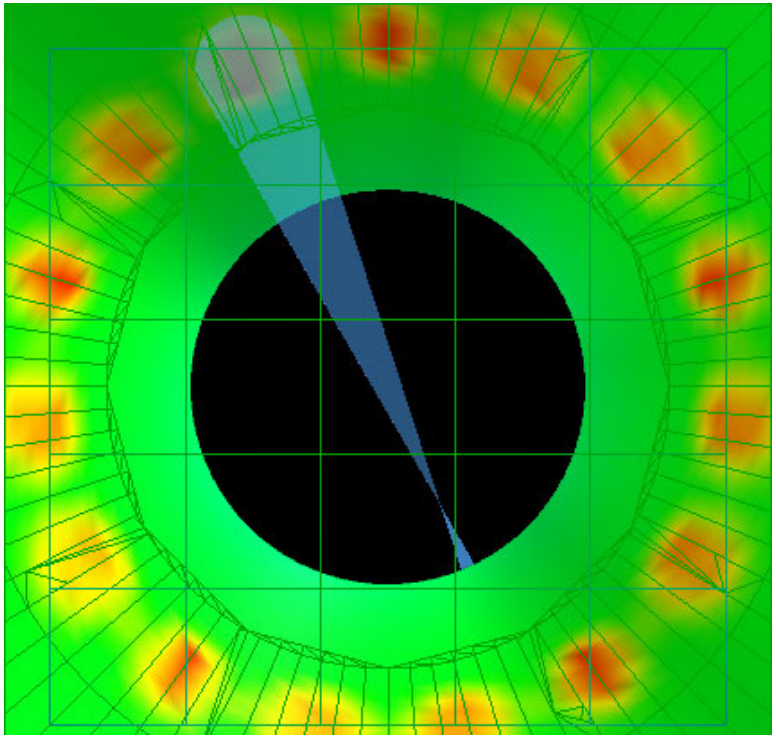
The witness plate view (left, bottom) has the harder spectrum: these two views in this simulation have nearly identical T_Rs (listed next to the respective figures on the left). The witness plate view sees more hot spots, and also has a completely cold object (LEH) in its field of view. The net effect is to reduce the soft emission (LEH replacing wall) while enhancing the hard emission (more hot spots).

Related questions include: By how much does lowering the albedo reduce the wall temperature? Do the lower albedo cases have a larger portion of the total emission coming directly from hot spots?

We will look at a wall area element and compare it to an area element under a hot spot, and see how its temperature changes with albedo.



Dante View



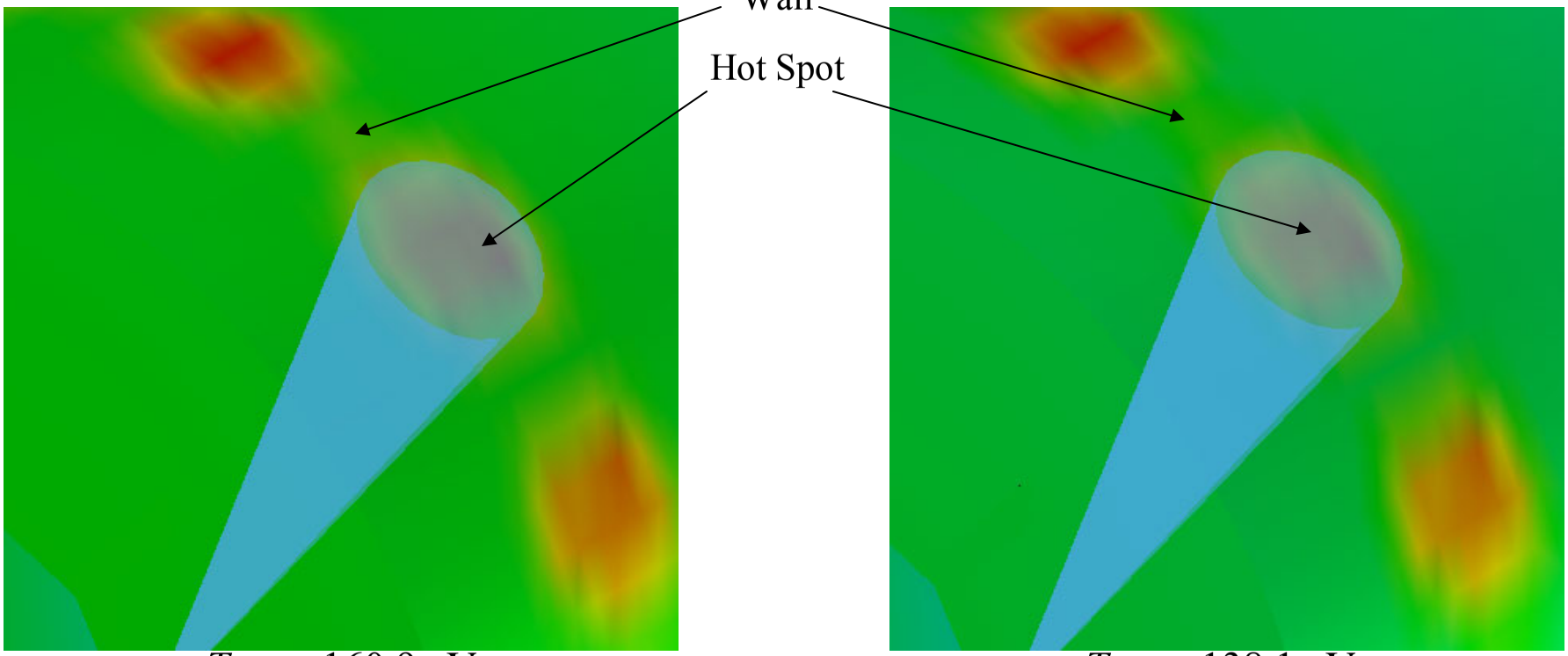
Witness Plate View

800 micron pointing with albedo = 0.7 and xce = 0.55

800 micron pointing with xce = 0.55

albedo = 0.7

albedo = 0.5



T_{wall} = 160.9 eV

$T_{hotspot}$ = 274.34 eV

T_{wall} = 138.1 eV

$T_{hotspot}$ = 270.5 eV

The albedo decreased to 0.71 its original value, and T^4_{wall} decreased to 0.54 its original value. This implies that a significant amount of flux seen by the wall is re-emitted by other wall locations, and also implies that a reduction in the albedo has a strong effect on the fraction of the total emission coming from hot spots.

Finally, we show in the next two slides what happens when we relax our simplifying assumption of no LEH lip on the halfraum.

We compare two different pointing cases on each slide.

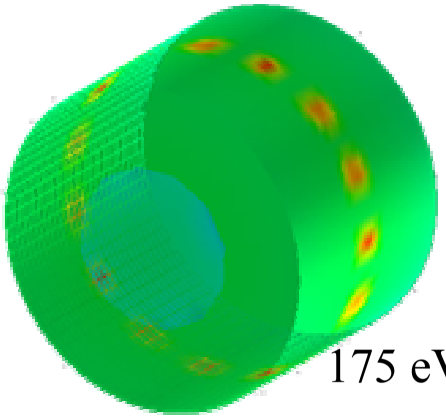
TW/cm^^2

Without LEH lip

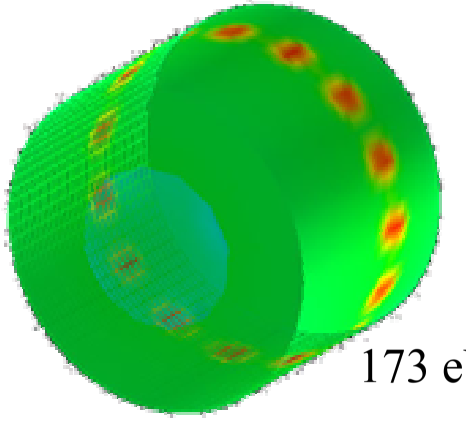
600 micron pointing

400 micron pointing

Dante View



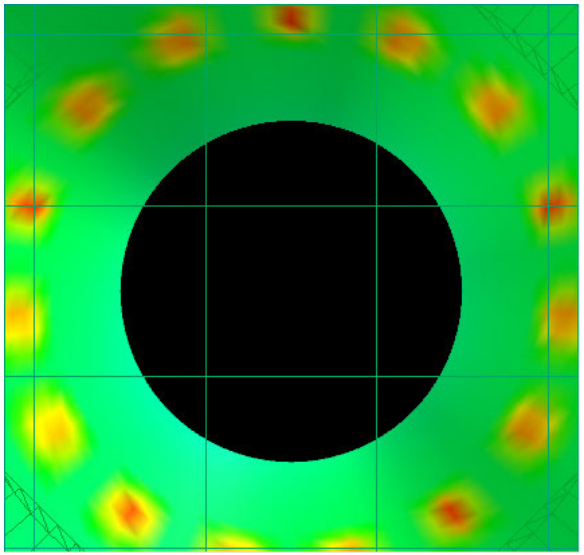
175 eV*



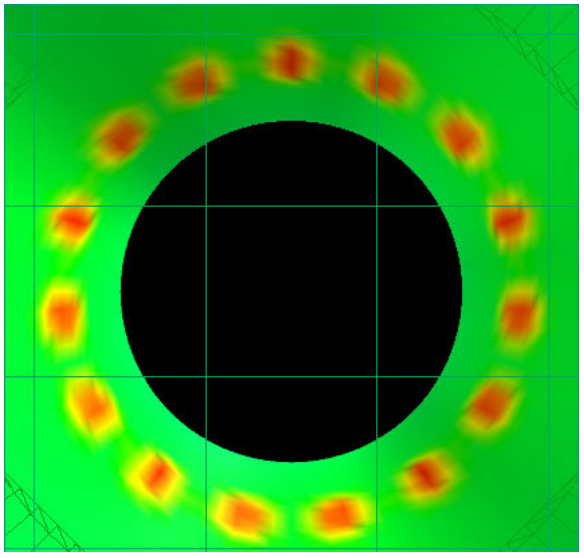
173 eV

Witness Plate View

174 eV



167 eV



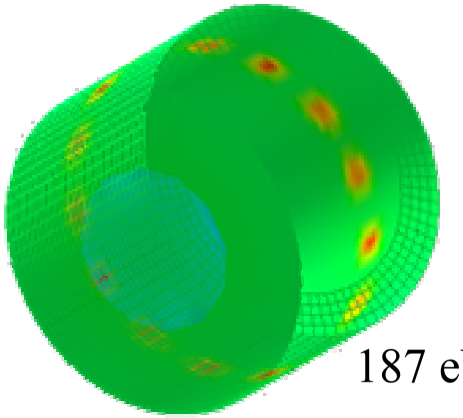
*Listed temperatures are radiation temperatures, seen by DANTE and the w.p., respectively.

With LEH lip

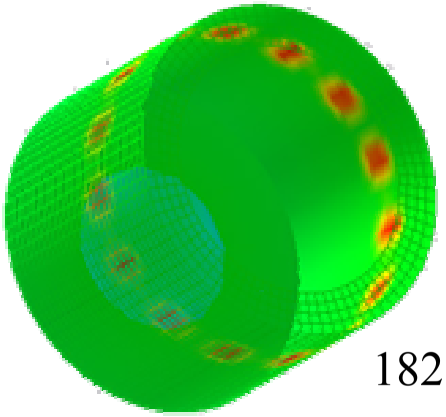
600 micron pointing

400 micron pointing

Dante View

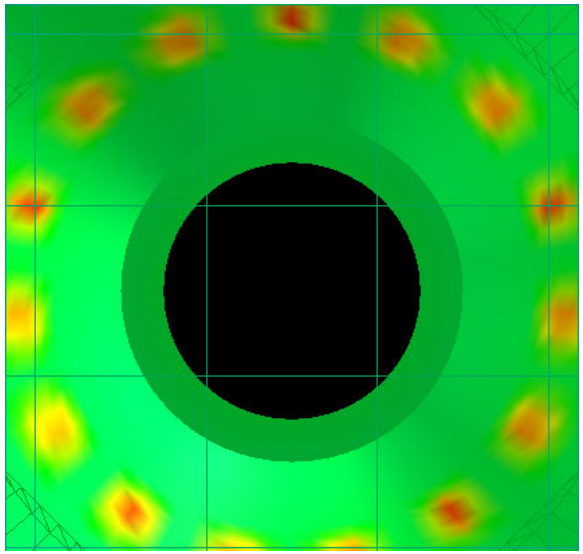


187 eV

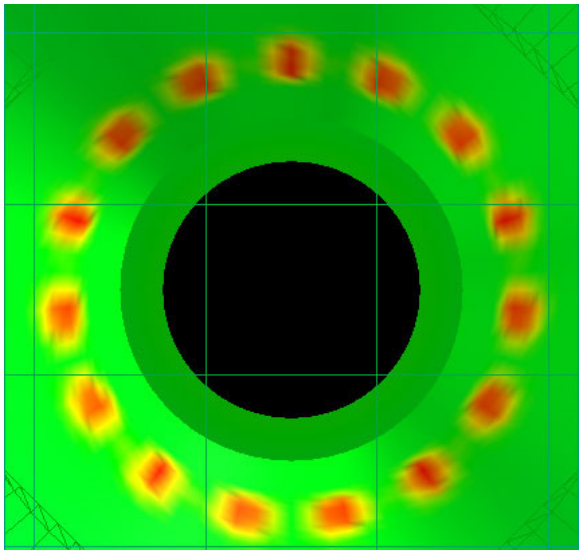


182 eV

180 eV



174eV



Witness Plate View

The inclusion of an LEH lip on the halfraum *increases* both the DANTE and the witness plate temperatures.

But the increase is *bigger for the DANTE temperature*, and the disparity is greater for the deeper pointing (12 eV vs. 6 eV for the 600 micron pointing; 9 eV vs. 7 eV for the 400 micron pointing).

Primary Conclusions

The DANTE radiation temperature tends to be higher than the witness plate's, especially when the pointing is small. (i.e. the beams are relatively near the LEH.) This difference can be big (~15 eV). This represents a difference in the incident radiative flux of almost 50%.

The main exception is with low albedo and deep pointing. Then the witness plate radiation temperature can actually be somewhat higher than DANTE's.

The witness plate incident spectrum is always harder than the DANTE spectrum.

The LEH lip makes both temperatures higher, but the DANTE temperature gains more than the witness plate temperature (typically 10 eV vs 5 eV).

General Conclusions

Assuming $T_{dante}=T_{wp}$ is a relatively good approximation when the beam pointing position is deeper than ~500μm, but even then, the spectral energy distributions differ significantly.

But if accuracy and precision are desired, or the spectral energy distribution of the incident radiation is needed, modeling is necessary.