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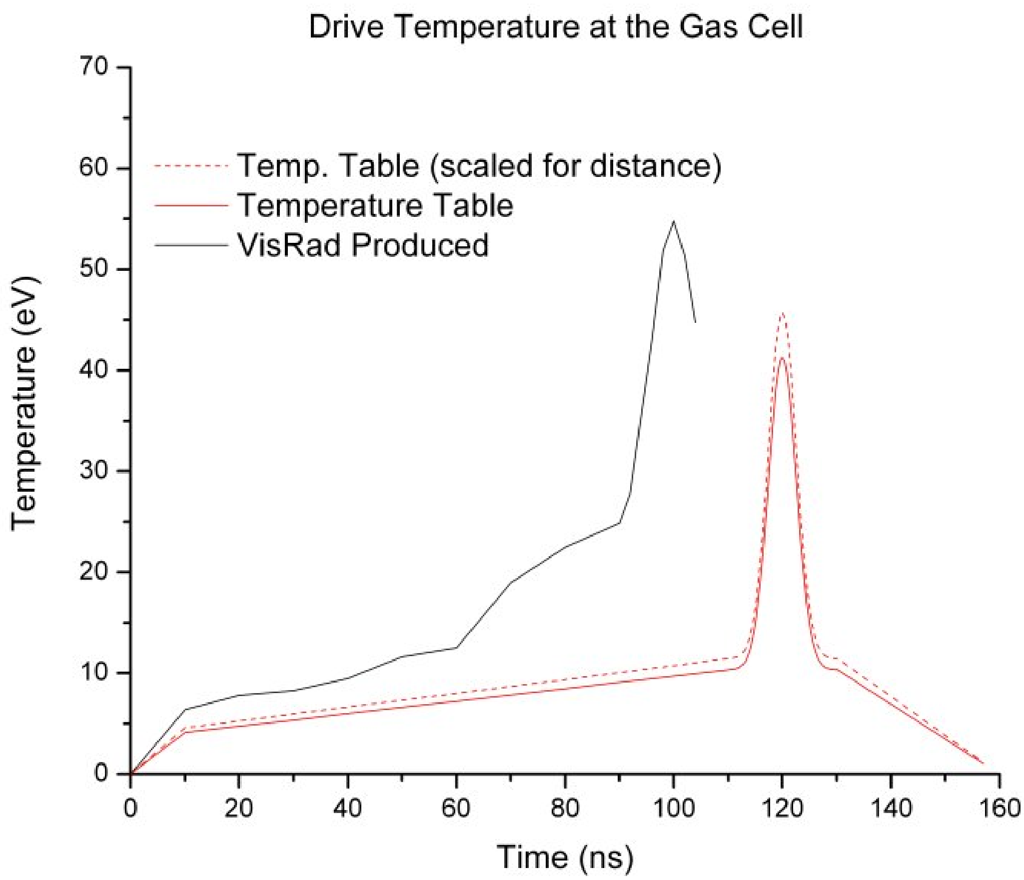
20 July 2007

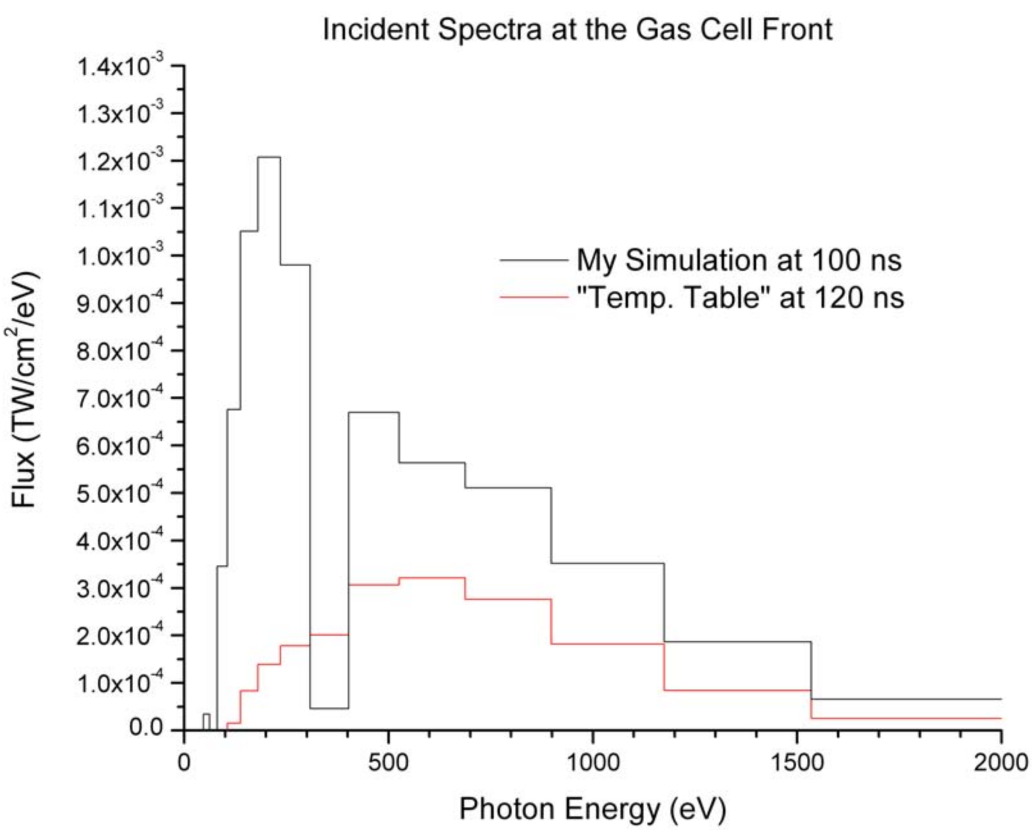
Memo: **Comparison of Helios modeling**

We think we have figured out the cause of the large temperature discrepancy between Iain's hydrodynamics simulation and ours. We used his incident radiation field – characterized by a blackbody emission temperature as a function of time, diluted by a solid angle factor of 0.0018, in place of our *VisRad*-produced time-dependent incident spectrum in our own *Helios* model, and came very close to reproducing the lower temperature in the neon that he had found.

Below is a comparison of the drive temperatures at the gas cell between the two models, with the dotted red line representing Iain's temperature table data scaled to account for the difference in distance from the pinch axis (5.7 cm in ours, 7 cm in Iain's; we assumed a simple d^{-2} scaling – see the final two figures of this memo as well). Note that we refer to our *Helios* run that uses Iain's drive profile as "Temperature Table" throughout this memo.

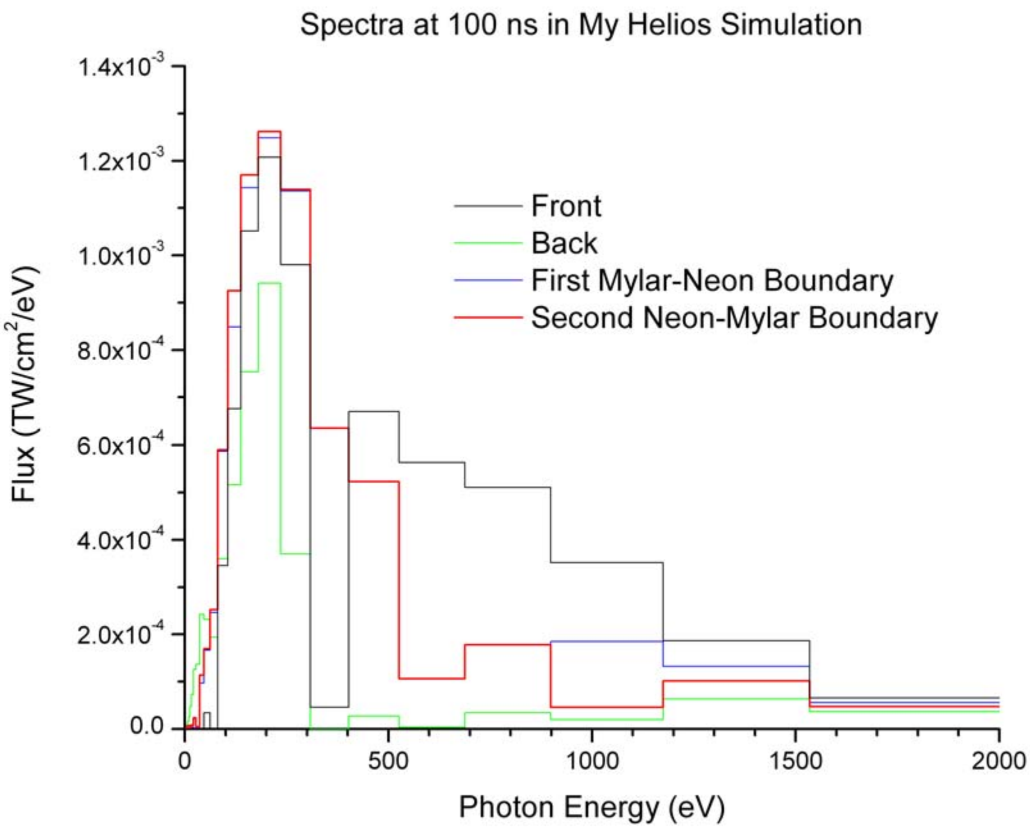


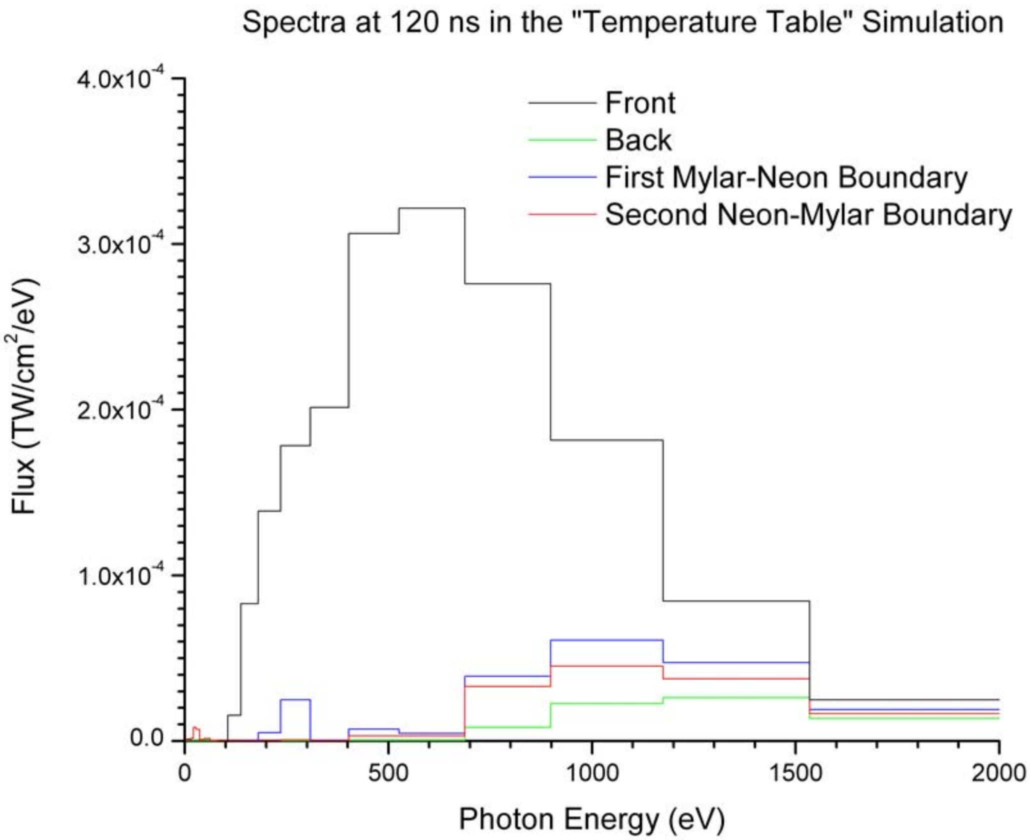
As noted at the bottom of my “Boundary Flux Comparisons” Helios subpage (http://astro.swarthmore.edu/~mrosenb2/Helios%20Subpages/Boundary%20Flux%20Comparisons.htm), the flux at the front of the gas cell is considerably weaker in this new “Temperature Table” simulation than in my previous simulation based on the *VisRad*-predicted incident radiation (at the end of this memo we will address the question of why our assumed drives are different). This difference is especially pronounced at low photon energies, around 200 eV, where the flux is 10 times weaker. Even at the peak of the “Temp. Table” flux at 600 eV, the original run is almost twice as strong. In the figure below, we show output from the two different *Helios* runs at the peak of the drive. The figure shows the frequency-grouped incident spectra. Note that the spectrum in our simulation is *not* characterized by a single blackbody, as it is calculated using *VisRad* and does not (yet) include an aperture. To see how the re-emitted radiation from various surfaces in the vicinity of the pinch affects the drive radiation incident on the gas cell, see:
http://astro.swarthmore.edu/~mrosenb2/VisRad%20Subpages/Incident%20Spectra.htm



Even more striking is the amount of that flux that is absorbed in the front mylar wall, or conversely, the amount of flux left to pass through the rest of the gas cell (blue line in the two plots below, which show the frequency-dependent radiative flux at four different material boundaries in the two *Helios* simulations; by comparing the blue lines in the two plots below, you can see how the frequency-dependent flux transmitted through the mylar window differs in the two simulations, and by comparing the blue line to the black line in the same plot, you can see what the frequency-dependent transmission of the mylar is in a given simulation).

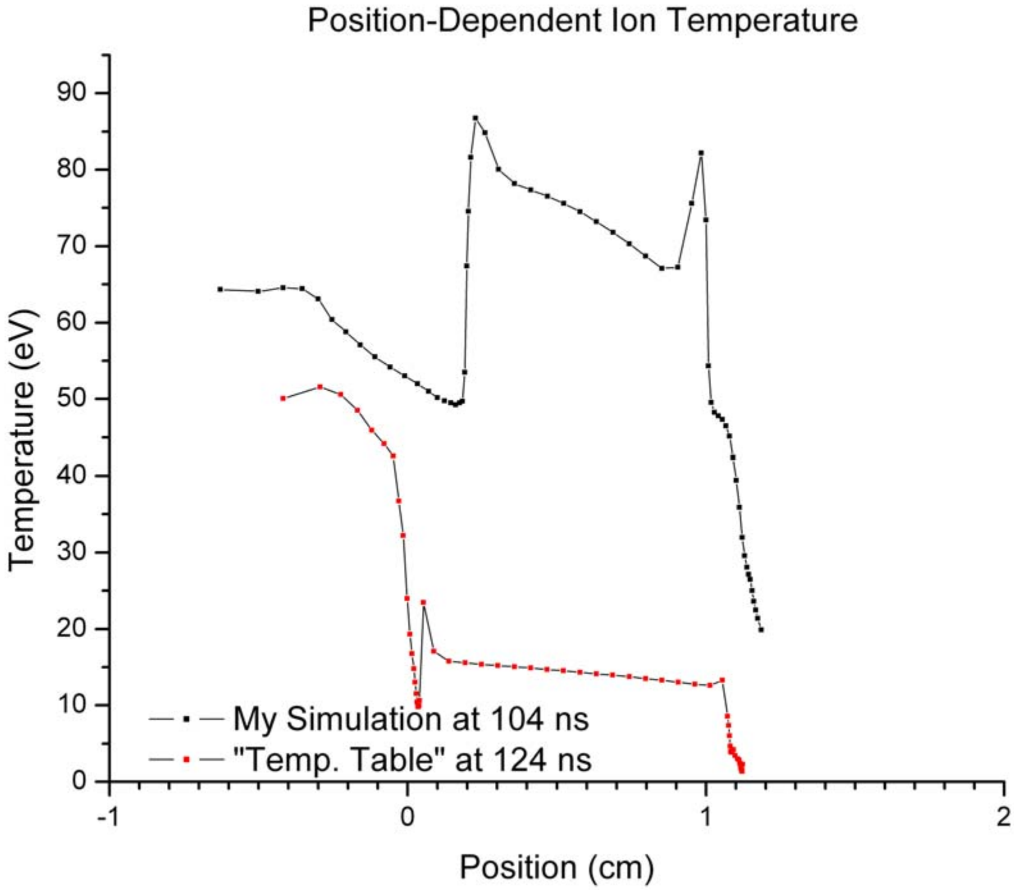
At the peak of the spectrum at the first mylar-neon boundary, between 900 and 1200 eV, our simulation has about 3 times more flux. In the “Temp. Table” run, virtually all of the flux below 700 eV is absorbed in the front mylar wall. We believe this is because lower temperatures in the mylar lead to a greater opacity and, therefore, more absorption. (see http://astro.swarthmore.edu/~mrosenb2/Helios%20Subpages/Opacities.htm).





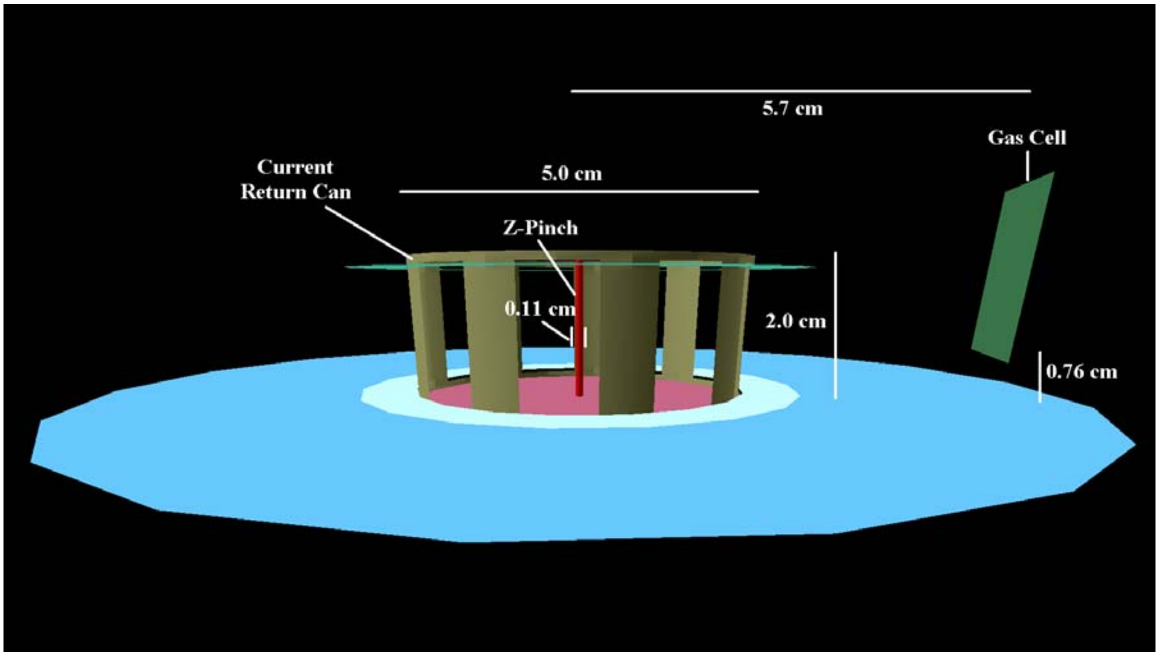
There is considerably less flux absorbed by the neon in the “Temp. Table” simulation than in my original simulation.

The more telling figure appears at the bottom of my “Ion Temperatures” subpage. (http://astro.swarthmore.edu/~mrosenb2/Helios%20Subpages/Ion%20Temperatures.htm) As is evident there, the “Temp. Table” simulation produces ion temperatures in the neon much lower than our original run. Directly comparing Iain’s ion temperature at 124 ns to the one I produced shows rather similar results. (Compare the lower curve in the figure below to the light blue curve in the ion temperature plot in Figure 5 of Iain’s “Neon gas cell” presentation.) My simulation using the same radiation field has neon temperatures around 15 eV (compared to ~12 eV for Iain’s) and left mylar wall temperatures around 45 eV (~35 eV in Iain’s). We assume that these modest differences are due primarily to our different treatments of EOS and opacity.

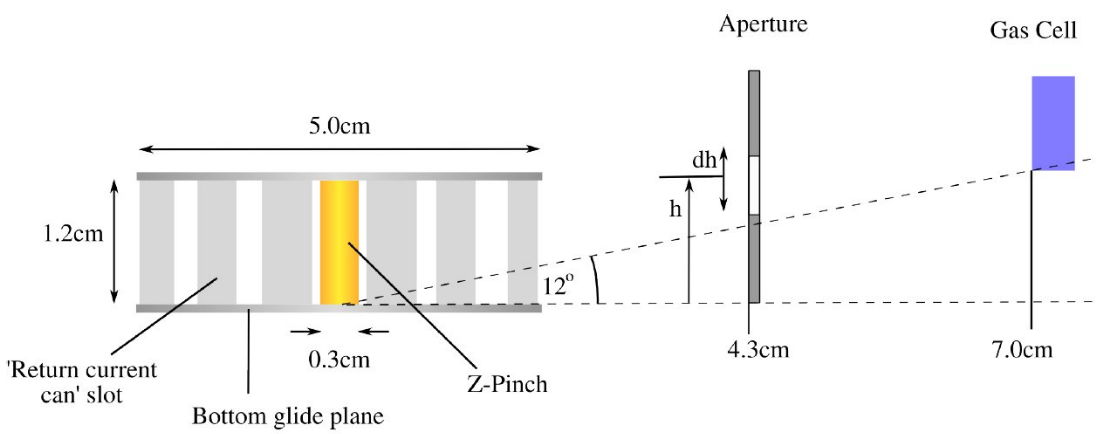


Considering that this change in the incident radiation source in our own simulation led to a significantly lower temperature, and that our results mirror those found by Iain, we can conclude that this factor almost completely accounts for the difference between our simulations.

Questions: What assumptions went into the formulation of your drive profile? Why a Gaussian centered at 120 ns with a 200 eV peak? Does that factor of 0.0018 represent the solid angle subtended by the aperture, and does the pinch entirely fill the aperture (at all times)? Given the changing pinch dimensions, could that factor be time-dependent? Why is the gas cell positioned 7 cm from the pinch axis, as opposed to only 5.7 cm in ours? (see http://astro.swarthmore.edu/~mrosenb2/VisRad%20Subpages/Experimental%20Setup.htm)



Ours is above and yours is below.



Our *VisRad*-calculated drive is stronger than the drive Iain assumes. Part of this is clearly due to the greater distance of the gas cell in Iain's calculation. But this is only a small part of the difference. Maybe some of it is due to different assumptions about the emission temperature (the color temperature) of the pinch. (See the first bullet point below regarding our assumptions about the pinch power.) But part of this effect must also be due to the aperture. We wonder if we should further explore the trade-offs in using an aperture at all. Achieving high-enough ionization parameters to make these experiments astrophysically relevant is an issue, and perhaps if we can model the non-Planckian, un-apertured drive, then the theoretical advantage of using an aperture is diminished.

In summary, we think that our two different sets of simulations are in good agreement from a computational (*Helios*) point of view, and that it is primarily the assumptions about the drive that are leading to the large discrepancies in the neon ion temperature that we had initially been concerned about.

Notes:

- Our *VisRad* setup (gas cell position and time-dependent albedos and pinch radius and temperature) come from correspondence with Greg Rochau, with the pinch power profile based on shot Z541 at Sandia. We set up this calculation to try to reproduce the data taken in the earlier experiments, reported on in Bailey et al., *JQSRT*, 71, 157, 2001.
- In our simulation, we use multigroup opacities calculated with *Propaceos,* which assume LTE, for both the mylar and neon, selecting the "non-DCA" option in *Helios*. Radiation transport is done with 500 frequency groups (though we did not optimize the frequency grouping for the drive, so there are many fewer groups in the frequency range of interest).
- A simulation using a DCA atomic model to do in-line CRE opacity calculations in *Helios* produces lower temperatures in the neon than in the non-DCA simulation referred to here (but still higher than those found using the weaker drive; about 40 eV). See: http://astro.swarthmore.edu/~mrosenb2/Helios%20Subpages/Ion%20Temperatures.htm. We could certainly make comparisons between the two drives using the DCA/in-line CRE capabilities in *Helios*, but to keep things simple – and to make this comparison as directly related to the simulations Iain's already done – we have used only the multi-group, LTE opacities (from *Propaceos*) here.