Radiation-hydrodynamic simulations of foils heated by hohlraum radiation*

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An attractive way to generate a uniform plasma state for measurements of the ion stopping power is to heat a sample indirectly with the radiation of a millimeter-scale hohlraum. Recently, simulations of such a hohlraum target with an attached carbon foam [1] have been carried out with the newly developed code RALEF-2D. Now, new simulations are in progress to support another experimental approach at GSI. The target consists of two hohlraums, a primary spherical one irradiated by the PHELIX laser for the indirect X-ray heating of a secondary cylindrical hohlraum with two attached carbon foils. Simulations of the primary hohlraum [2] have shown to stay in good accordance with the experiment. Here we want to present the preliminary results of a series of simulations of the secondary hohlraum with the goal to find the optimum target configuration and to verify the ion stopping measurements [3].

The RALEF-2D code solves the one-fluid one-temperature hydrodynamic equations in two spatial dimensions and incorporates thermal conduction as well as radiation transport. The applied EOS, thermal conductivity, and spectral opacities were provided by the THERMOS code. Figure 1 shows the lateral cut of the simulated Cartesian (x, y) configuration which extends to infinity along the z-axis. Each carbon foil has an initial thickness $l_f = 1$ μm and areal density $<\rho_f l_f> = 0.1$ mg cm^{-2}. The supposedly empty parts of the simulated domain were filled with gases at density $\rho = 10^{-5}$ g cm^{-3}. The incoming X-rays of the primary hohlraum were set up in accordance with experimental measurements with a peak Planckian temperature of 93 eV. The X-ray heating ends at $t = 5$ ns. In the presented preliminary simulation the spectral energy transport by thermal radiation was treated with one frequency group. The final simulation will be done with 24 discrete groups $h\nu_i$ which implies a much longer computational time. The angular dependence of the radiation intensity was calculated with the S_{30} method, which offers 960 discrete ray directions over the entire 4π solid angle.

Figure 2 shows the free electron density and the LTE ionization degree at $t = 5.3$ ns when the expanding carbon plasma clouds collide. At this time the ablated gold plasma is close to get into the way of the ion beam. Before the collision the carbon free electron densities are of the order $n_e \approx 1 - 4 \times 10^{20}$ cm^{-3} with an ionization degree of $Z \approx 3.2 - 3.8$ at plasma temperatures $T \approx 10 - 16$ eV. Hence a time window of nearly 6 ns exists with appropriate plasma conditions for the ion stopping measurements.

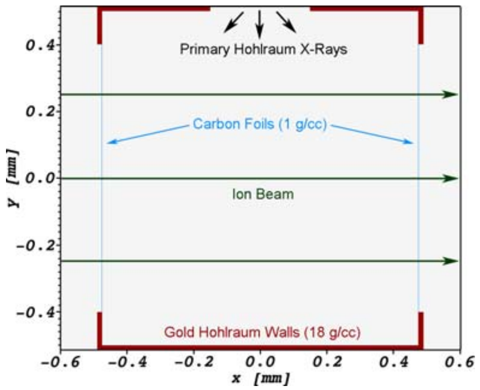

Figure 1: 2D lateral cut of the simulated configuration.

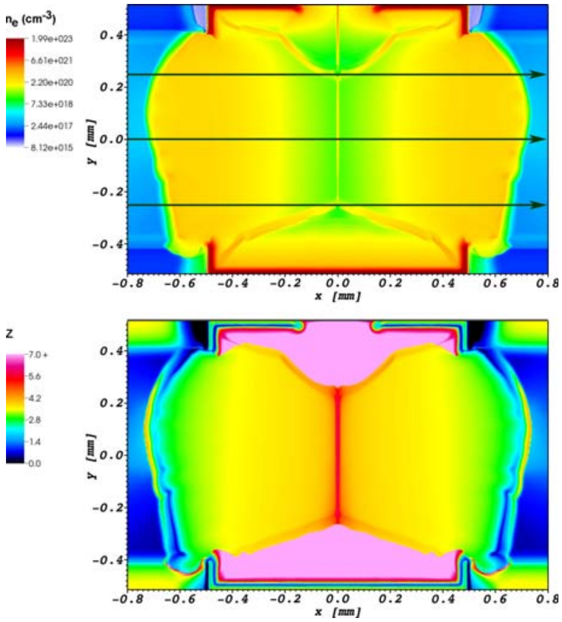

Figure 2: Color contour plots of the free electron density n_e and the LTE ionization degree Z at t = 5.3 ns, when the carbon plasma clouds collide at the hohlraum center.

References

[1] S. Faik et al., HEDP 10 (2014) 47.

[2] M. M. Basko et al., GSI Report 2011-03.

[3] A. Ortner et al., GSI Report 2013-1.

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