Interaction of heavy ions with warm dense plasma using hohlraum targets (combined experiment with PHELIX and UNILAC)

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Measurement of the energy loss and the charge state distribution of heavy ions in dense plasma, generated by indirect laser heating with double hohlraum cavities.
In 2011 we carried out a first proof of principle experiment using a double gold hohlraum to convert laser light into x-rays and to use them to generate a warm dense carbon plasma. The main result of this campaign was the measurement of the radiation temperature inside hohlraum [3,4]. The laser light, coming from PHELIX with 150 J in 1.5 ns at 528 nm, generates 100 eV of Planck radiation in the primary hohlraum, which leads to 33 eV radiation temperature in the secondary hohlraum. These measurements are in good agreement with theory and simulations. However, we found that the gold flow off of the walls inside the secondary hohlraum is expanding too quickly into the path of the probing ion beam and disturbes the energy loss measurement (see Fig. 2 a). Hence, in 2012, we put a lot of effort into improving the hohlraum geometry and the shielding. The new design as shown in Fig. 2 b) was studied in RALEF2D simulations [5] and experimentally verified. As shown in Fig. 1 a) the interaction area stays free of gold plasma for more then 4 ns which is enough time to probe the plasma with the ion beam. Fig. 1 b) shows a simulation with carbon foils attached to the back and front side of the hohlraum where electron densities of up to 10^{22} cm^{-3}, an electron temperature of 15 eV and an ionization degree of 3.5 can be reached. All simulations were benchmarked by experimental temperature and density measurements.

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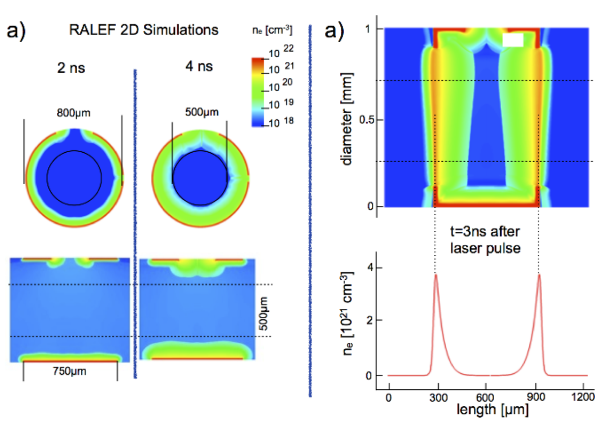

Figure 1: RALEF2D simulations: **a)** Gold flow in an empty hohlraum. With 1000 μm in diameter the hohlraum stays free of gold for more than 4 ns. **b)** Hohlraum with attached carbon foils and the resulting electron density of the carbon plasma after 3 ns of heating.

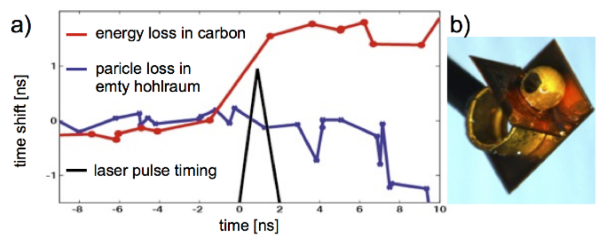

Figure 2: **a)** Results of the energy loss measurement. The upper (red) curve shows the measurement in dense carbon, the lower curve (blue) the signal drop in an empty hohlraum due to gold plasma flowing in **b)** New sub millimeter hohlraum targets with shielding.

The upper curve (red) in Fig. 2 a) shows the measured energy loss in the plasma which increases by about 40% compared to cold carbon. The lower curve (blue) shows a reference measurement in an empty hohlraum. After 6 ns the signal drops due to gold plasma completely stopping the ion beam. These results will be compared to theoretical models. Especially, we enhance a microscopic description of the energy loss as developed by [1,2] to enter this new regime. As we have an interaction of a partly ionized projectile with a partly ionized plasma, charge exchange processes will become relevant for the energy loss process. For this reason we are going to conduct a another experimental campaign at the end of 2013 where the charge state distribution after interaction will be measured precisely.
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