Measurements of the Heavy Ion Stopping in X-ray heated low-density nanostructured targets

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Measurements of the enhanced ion energy loss in plasma compared to those in non-ionized matter have been carried out in the frame of the project U272. The plasma targets were produced via volumetric heating of CHO-foam layers (cellulose-triacetate-TAC; $C_{12}H_{16}O_8$) by soft X-rays. X-ray source with close to the Planckian spectral distribution was generated by irradiation of a gold cylindrical hohlraum with the PHELIX-laser at 0.54 µm, 150J, 1 ns, 5.10^{14} W/cm^2 [1]. 80% conversion of the laser energy into soft X-rays with $T_{Planck} \sim 45$eV has been reached. Hydrodynamic stable homogeneous plasma with electron density of $n_e \sim 10^{21}$ cm^{-3} and 20-30 eV temperature is then produced in the state close to the thermodynamic equilibrium. This plasma is partially ionized and presented by He-like states of Carbon and Oxygen and fully ionized Hydrogen ions. Calculations of the 4.7 MeV/u Ti-ions energy loss on free and bound target electrons in dependence on plasma temperature/ionization degree (see Fig.1) have been done using a numerical code, described in [2].

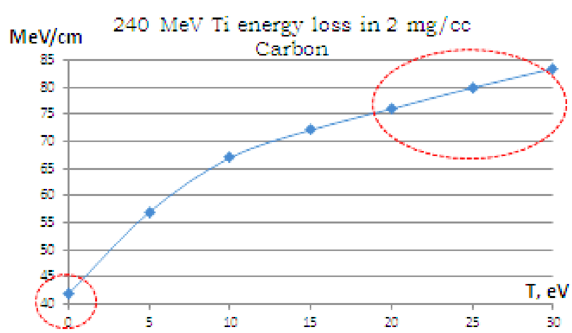

Figure 1: Expected energy loss of 240 MeV Ti-ions in a 1mm thick 2 mg/cm^3 carbon–plasma layer in dependence on plasma temperature.

The experimental set-up for the plasma production and ion energy loss measurements was similar to those used in [3]. Plasma target was probed by Ti-ions with a variable delay between the laser pulse and the ion micro-bunch. The ion velocity after interaction with target was measured using Time of Flight method. The results are shown in Fig. 2. Comparison of the TOF data for vacuum and cold target conditions results into the time of flight difference of 6.9 ns. After interaction with plasma layer the ions reached the stop detector 2.8 ns later than in the case of the cold target, this corresponds to1.4-times enhancement of the ion energy loss due interaction with free electrons in plasma. Energy loss of Ti-ions in plasma was measured for different time-delays and two plasma target densities, the results are presented in Fig. 3. At later times (>10ns) plasma temperature in the interaction region, placed 0.75mm apart from the hohlraum bottom, reached 20-30 eV and for both densities the enhancement of the ion energy loss is between 1.4 – 1.8 in accordance with [2]. The low enhancement factor at earlier times can be explained by lower plasma temperatures (see Fig.1) as a results of finite time needed for the heating process.

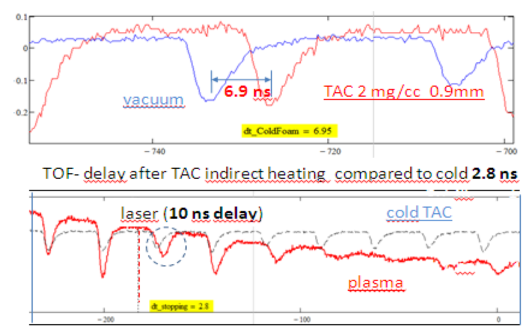

Figure 2: Ti –ion beam micro-bunch structure measured in vacuum and after interaction with foam and plasma.

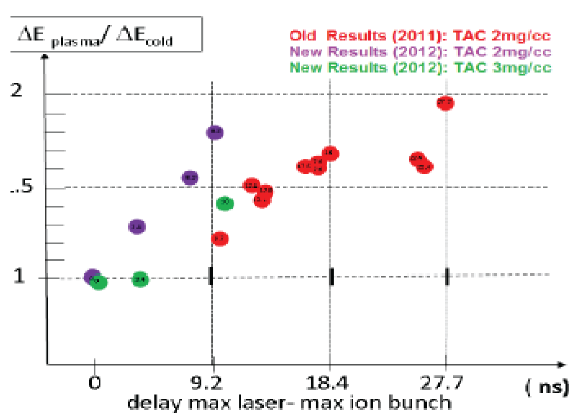

Figure 3: Enhancement of the ion energy loss in plasma depending on the delay between the laser and ion pulses.

References:

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