

Simulations of Hydrodynamic and Thermodynamic Response of Solid Targets Heated By Future SIS-100 Beam

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The new 100 Tm magnetic rigidity synchrotron SIS-100 will be a powerful tool to induce very high-energy-density states in matter and then study the equation-of-state (EOS) properties of matter under such extreme conditions. According to the present design studies [1], the SIS-100 will generate a U^{28+} beam with a total number of 2×10^{12} particles with a particle energy range of 400 MeV/u to 2.7 GeV/u and this entire energy range will be useful to the plasma physics experiments. The particles will be delivered in a single bunch whose duration will depend on the particle energy. It has been estimated that beams consisting of 400 MeV/u and 2.7 GeV/u will have pulse durations of 90 ns and 20 ns respectively.

In this contribution we present numerical simulation results of thermodynamic and hydrodynamic response of solid as well as hollow lead cylinders that are irradiated with the future SIS-100 beam. These simulations have been carried out using a two-dimensional model, BIG-2 [2]. Different beam target geometries used in these calculations are shown in Fig.1 and we present these results in the following.

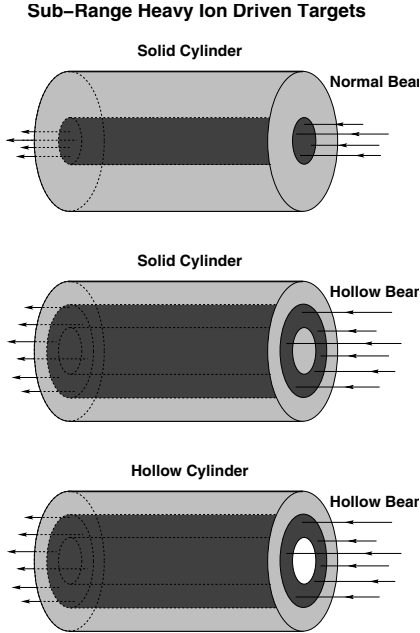


Figure 1: Different beam-target geometries considered

I: Solid lead cylinder and normal beam with circular focal spot

We consider a more conservative value for the beam intensity and assume a total number of 1.5×10^{12} particles of 2.7 GeV/u uranium that are delivered in a 20 ns long bunch. The range of 2.7 GeV/u uranium ions in lead is 5.95 cm. We assume a target which is 2.0 cm long and the energy deposition is still very uniform along the particle trajectory. The beam radius, r_b is another very important parameter as the specific energy deposition is inversely

proportional to the square of r_b . We assume two values for r_b (FWHM of the Gaussian distribution), namely 0.5 mm and 1.0 mm. In Fig.2 we plot the specific energy deposition, E_s along the target radius at $L = 1.0$ cm and at $t = 20$ ns. It is seen that for $r_b = 1.0$ mm, $E_s = 200$ kJ/g while for $r_b = 0.5$ mm, $E_s = 660$ kJ/g instead of 800 kJ/g. This reduction in E_s is due to hydrodynamic expansion[3]. Using an $r_b = 1.0$ mm we achieve a maximum temperature, T_{max} of about 18 eV and a maximum pressure, P_{max} of 9.2 Mbar. For an $r_b = 0.5$ mm, on the other hand, we get a T_{max} of 30 eV and a P_{max} of 18 Mbar.

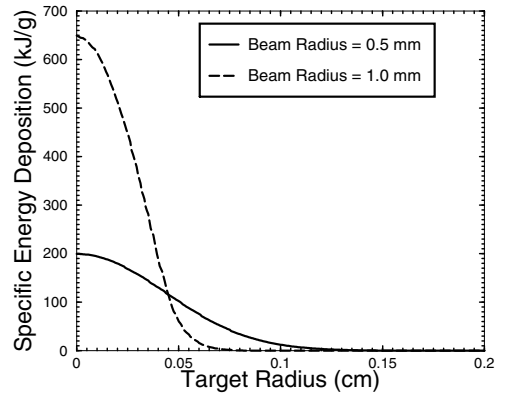


Figure 2: Specific energy deposition vs cylinder radius

II: Solid lead cylinder and hollow beam

This case corresponds to the second picture in Fig.1. The target is irradiated with a hollow beam which has an annular focal spot. A ring of hot material with very high pressure is created in the center of the target. The high pressure launches shock waves outwards and inwards along the cylinder radius. When the shock converges at the cylinder axis, a density of about 60 g/cm^3 , a pressure of 35 Mbar and a temperature of about 11 eV is created in this region.

III: Hollow lead cylinder and hollow beam

This case is shown in the third picture of Fig.3. The inner cylinder radius is taken to be the same as the inner radius of the focal spot and is 0.5 mm. When the target material collapses at the cylinder axis, a density of 74 g/cm^3 , a pressure of 124 Mbar and a temperature of 23 eV is created.

References

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