P44

High energy density material produced by heavy ion beam drive

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The purpose of this report is to demonstrate the potential for high energy density physics (HEDP) research on the HIAF facility. The study of HEDP involves a wide range of fundamental and applied physics. For example, astrophysics, planetary science, geophysics, plasma physics, hydrodynamics, radiation hydrodynamics, magnetohydrodynamics, materials science, condensed matter physics, the interaction of intense radiation with matter, and atomic and molecular physics and so on. In addition, the field has great potential for many lucrative industrial applications. The study of the fundamental properties of HED matter is therefore not only of great scientific importance, but also of great technological significance[1, 2].

The study of high energy density physics based on heavy ion beams has unique advantages. The Aardvark programme developed based on the hydrodynamic equations. The equation of state for warm dense matter is calculated from first principles. The Aardvark program was used to simulate the beam-target coupling experiment, which provides guidance for the HIAF facility to carry out high energy density physics experiments in the future. The thermodynamic and hydrodynamic response of a solid lead cylindrical target was investigated by one-dimensional hydrodynamic simulations. One side of the target is irradiated by a uranium ion beam such that the beam axis coincides with the cylindrical axis. The range of the ions is much larger than the length of the target, so that the Bragg peak is located outside the target and uniform energy deposition occurs along the beam trajectory. A radial outward shock wave is produced. The results are shown in Figure 1.

Simulation parameters consistent with the HAIF facility are selected. To verify the stability and robustness of the procedure, we conducted extensive simulations, systematically altering the beam and target parameters. Simulation results indicate that the ion beam from the HIAF facility will have sufficient power for the production of high energy density materials in a laboratory environment. These studies will enhance our comprehension of the creation, development and essential characteristics of high-energy-density matter. They will give theoretical backing and practical direction for possible implementations in domains such as defence, energy and astrophysics.

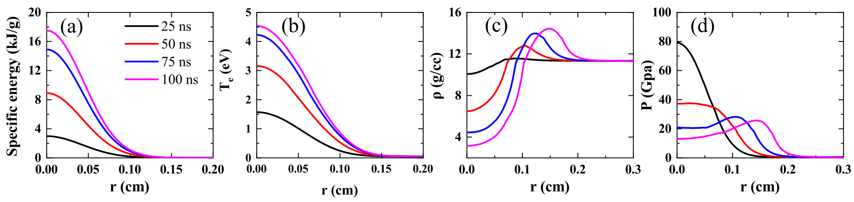

Figure 1: Evolution of deposited energy, electron temperature, density and pressure along the radial direction at the ion beam intensity of 10^9 particle per pulse

[1] Tahir, N. A. et al., Phys. Rev. Lett. **95**, 035001 (2005).
[2] Tahir, N. A. et al., ApJS. **238**, 27 (2018).