

Dynamic confinement in spherical geometry for WDM experiments*

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The "WDM" (Warm Dense Matter) collaboration proposes to investigate the radiation properties of matter under extreme conditions created by the intense SIS-100 heavy ion beam at FAIR [1]. The ion beams expected at this facility will be able to heat matter within a short time, so that the condition of isochoric heating which is preferable for heavy ion beam experiments is fulfilled. To start the WDM experiments with the SIS-18 heavy ion beam a special target configuration is needed to control the hydrodynamic response of the heated matter. The possibility for diagnostics access is also critical for the proposed target. The use of the PHELIX laser will provide X-ray scattering diagnostics yielding the temperature, density, charge state, and ion-ion correlations. This requires that the target is transparent for the diagnostics X-rays with an energy of few keV. A dynamic confinement scheme employing a thin low-Z tamper heated by the wings of the ion beam to produce confining pressure on the core target material was proposed recently in cylindrical geometry [2]. The performed hydrodynamic calculations have shown that the dynamic confinement of heavy ion beam targets can be extended to spherical geometry which allows using the mature technology for the production of ICF pellets. The target materials and the parameters of the ion beam are the same as in the cylindrical target [2]. Frozen hydrogen is used as a core, an appropriate tamper is a carbon phenolic composite. The 100 ns ion beam pulse consists of 8×10^{10} U ions with 200 MeV/u focused to a $350 \mu\text{m}$ spot (standard deviation of the Gaussian distribution). The calculations were made with the 2D Caveat code [3] using the Arbitrary Lagrangian-Eulerian technique. The radius of the target core and the thickness of the tamper were optimized to obtain the conditions of quasi-isochoric heating. The smallest density variation during ion beam heating was achieved for an H-core radius of $R_H = 400 \mu\text{m}$ and tamper thickness $\Delta R_c = 50 \mu\text{m}$. Figure 1 shows the density distribution in hydrogen for different times. At $t = 50$ ns the density near the target center is depressed, the tamper moves inwards and launches a weak shock wave. In the radial plane the core is less compressed than along the z -axis. At $t = 80$ ns the reflected shock wave and the C/H interface are moving outwards. At the end of the beam pulse the density distribution in the core is nearly uniform, which is an advantage for the diagnostics. In Fig. 2, the mean hydrogen density is plotted as a function of time. For a tamper thickness $\Delta R_c = 65 \mu\text{m}$ the mean density at the end of the bunch is equal to the initial density. The dynamic confinement scheme works in spherical as well as cylindrical geometry.

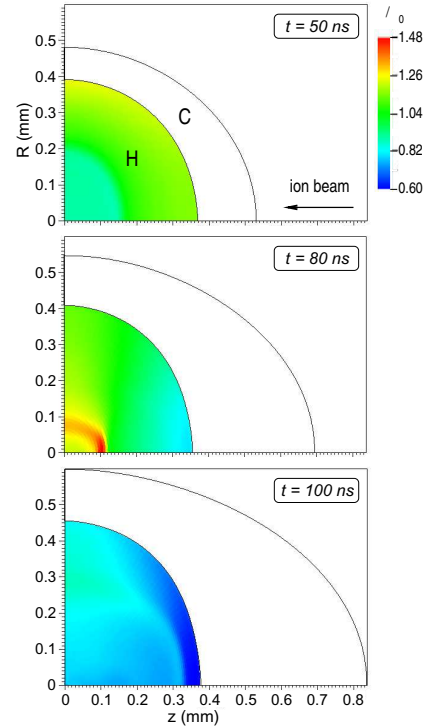


Figure 1: Density distribution of the hydrogen core in length - radius plane. The solid line shows the expansion of the carbon tamper.

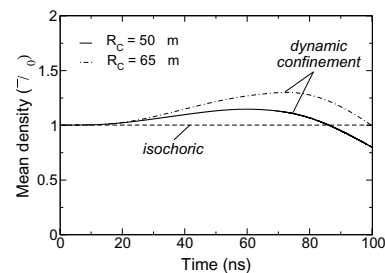


Figure 2: Evolution of the mean hydrogen density during ion beam heating for different tamper thickness.

References

- [1] <http://www.gsi.de/forschung/phelix/Experiments/FAIR/WDM/>.
- [2] A. Kozyreva et al., Phys. Rev. E **68**, 056406 (2003).
- [3] F. Addessio, Los Alamos Rep. LA-10613-MS-Rev. 1, 1990.

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