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Uniform implosion of fuel target in heavy ion fusion

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In inertial fusion, the fusion fuel compression is essentially important to reduce an input driver energy [1]. In order to realize inertial confinement fusion (ICF), a sufficient energy gain is required. A uniform fuel implosion is essentially required to release the fusion energy. In order to realize the uniform implosion, the non-uniformity of the implosion acceleration should be less than a few % [2, 3]. In this research, we propose to employ wobbling heavy ion beams (HIBs) to reduce the HIB illumination non-uniformity and the Rayleigh-Taylor instability (RTI) growth.

The wobbling HIBs would provide a small oscillating acceleration perturbation in an inertial fusion fuel target during the target implosion. Therefore, the RTI growth is reduced by the phase-controlled superposition of perturbations in heavy ion inertial fusion (HIF) [4, 5].

Figure 1 shows a schematic diagram for the spiral wobbling beam. When we employ the spiral motion of each HIB axis, the initial imprint of the HIBs irradiation non-uniformity is significantly reduced. Figure 2 presents a successful non-uniformity smoothing effect on the fuel target temperatures for the case with the spiral wobbling HIBs at 29ns before the void closure. Figure 2 confirms the mitigation of implosion non-uniformity by the wobbling HIBs. Figure 3 shows non-uniformity histories of the target ion temperature. The non-uniformity is evaluated by the total relative root-mean-square. Figure 3 demonstrates that the implosion non-uniformity of the DT fuel target is reduced well by the spiral wobbling HIBs. Figure 4 demonstrates that the fusion energy gain increases in high rotation frequency.

In conclusion, we have confirmed that the implosion non-uniformity is successfully mitigated by using the spiral wobbling HIBs for the HIBs irradiation system.

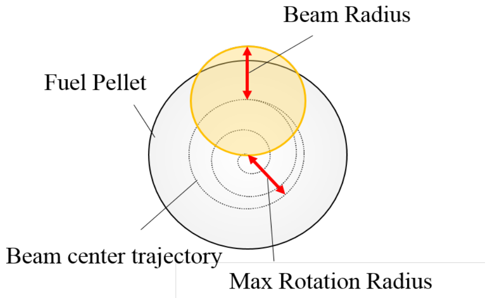

Figure 1. Schematic diagram for the spiral wobbling beam.

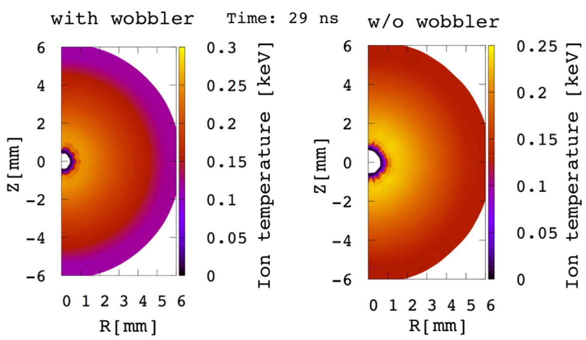

Figure 2. Ion temperature distribution diagram at 29ns.

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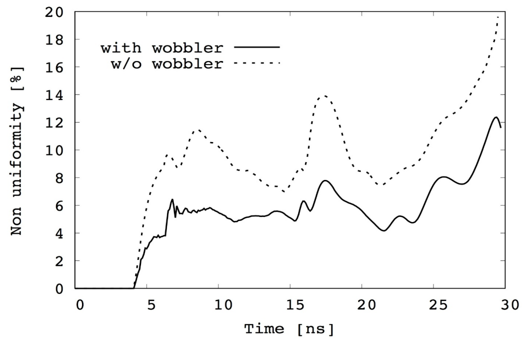

Figure 3. Non-uniformity histories of the target ion temperature.

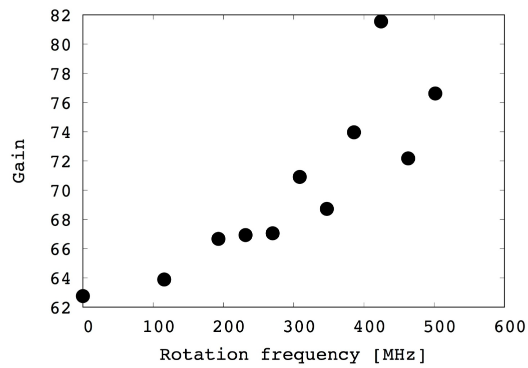

Figure 4. Target energy gain vs rotation frequency.