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Accelerating and guiding carbon ions in laser plasma by mechanism of breakout afterburner with a tapered channel

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A novel scheme with a tapered channel attached an ultra-thin carbon foil is proposed to accelerate and guide carbon ions by the breakout afterburner mechanism. This scheme is investigated by using two-dimensional particle-in-cell simulations. It is demonstrated that the tapered channel can efficiently accelerate and guide carbon ions and result in a much better quality C^{6+} beam with a higher order of magnitude in density and 22% larger in cut-off energy than those without the tapered channel. These enhancements are mainly attributed to the guidance of the longitudinal electric field and the focus of the transverse electric field as well as the convergence effect of the tapered channel. All of them lead to guide greatly carbon ions to move along the longitudinal direction. Moreover, during the simulation time, the ion beam with a tapered channel can remain eight times smaller in divergence angle than that without the tapered channel. It is expected that such a target may be beneficial to many applications such as ion fast ignition in inertial fusion, high-energy physics, proton therapy and so on.