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Development of a Segmented Capillary for Inner Plasma Density Control and High Repetition-Rate Plasma Generation in Wakefield Acceleration Experiments

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To address the limitations of conventional RF acceleration methods, plasma wakefield acceleration techniques and the development of suitable plasma sources have been actively pursued for decades. While there has been considerable progress, there still remain issues such as poor beam quality, and structural limitations that impede high repetition-rate beam acceleration.
Various methods have been proposed to enhance beam quality by controlling the plasma density distribution within the capillary plasma source. On the other hand, a major challenge to achieving high repetition rates in beam acceleration lies in the difficulty of increasing gas injection rates. This problem could be alleviated through continuous gas injection. Nevertheless, none of these methods can be fully implemented with the traditional simple capillary design.
Recognizing these technical limitations, we propose a segmented capillary, which divides the conventional capillary into sections based on functionality. By modifying the internal cylindrical shape of the capillary, we demonstrated through numerical simulations that a certain degree of density control is achievable, and we confirmed the formation of a stepwise plasma density distribution through direct plasma density measurements. We also indirectly verified this feature by observing improved beam quality in laser-driven wakefield acceleration experiments. Additionally, we designed a specialized structure that enables continuous gas injection while minimizing its impact on the high vacuum outside the capillary. Experimental validation of this new structure's effectiveness is currently underway.

Paper submission Plan

No

Best Presentation

No

Contribution track

ICABU WG3. Beamline and Instrumentation

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