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Segmented plasma discharge capillary for staged particle acceleration

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Novel particle accelerators based on plasma technology allow a drastic reduction in size, due to the high accelerating and focusing fields established inside plasmas. In this regard, we present a compact gas-filled plasma discharge capillary for particle accelerators applications, including staged wakefield acceleration and active plasma lensing. A first design of the plasma source is characterized by two segments fed by parallel high voltage circuits, which establish two independent discharges. By synchronizing the circuits and setting the same voltage, the two discharges result in a uniform m-scale long plasma channel, with lower breakdown voltage compared to a single m-scale plasma discharge. On the other hand, a voltage difference between the pulses entails a density profile with a steep gradient between the segments. A second design consists in a three-staged capillary composed by two active plasma lenses and one plasma wakefield acceleration stage. For this source three independent discharges are created and properly synchronized with the beam, to obtain the focusing effect in the external segments and acceleration in the central one. As proof of principle, combined acceleration and focusing of electron beams with such three-staged source were demonstrated at SPARC_LAB accelerating facility in Laboratori Nazionali di Frascati (INFN).

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