A novel plasma source for plasma wakefield accelerators

E. Öz¹, P. Muggli¹

¹ Max Planck Institute for Physics, Munich, Germany

A novel plasma source² developed at Max Planck Institute for Physics for world's first proton driven wakefield accelerator experiment to be conducted at CERN by the AWAKE³ collaboration is presented. There is a strict requirement on the plasma density uniformity, which stems from the resonant mechanism used to create the plasma wake (~GV/m). A train of micro-bunches of plasma wavelength size (~1 mm) is effectively formed when the self modulation instability⁴ transversely modulates the long (~12 cm) proton bunch. In order for the externally injected electrons to stay in the accelerating and focusing phase so that they can be accelerated to high (> GeV) energies, plasma density uniformity better than % 0.2 is required. This condition is satisfied by the Rubidium vapor with ~10^14 to 10^15 cm-3 density confined in a stainless-steel tube of 10 m length 4 cm diameter and heated to ~200°C by an oil heat exchanger. The vapor is fully tunnel ionized by a short laser pulse forming a 2 mm diameter plasma channel with a density uniformity of better than % 0.2 during beam plasma interaction. The access to the source during interaction is provided by custom built fast valves. We describe the source as well as its expected performances.

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