Characterisation and optimisation of targets for plasma wakefield acceleration at SPARC_LAB

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One of the most important features of plasma-based accelerators is their compactness because plasma modules can have dimensions of the order of mm/cm, providing very high accelerating fields up to hundreds of GV/m. The main challenge regarding this type of acceleration lies in controlling and characterising the plasma itself, and therefore in the synchronisation between it and the particle beam to be accelerated. This issue has a major influence on the quality of the accelerated bunches.

In this work, a full characterisation and optimisation has been carried on in the SPARC_LAB (LNF-INFN) laboratories on different plasma targets is presented. Two devices are considered: supersonic nozzles for experiments adopting the self-injection scheme of laser wakefield acceleration, and plasma capillary discharge for both particle and laser-driven experiments.

In the first case, a study regarding the variation of the generated plasma channel as a function of the supersonic nozzle geometry will be reported, from a theoretical and experimental point of view. In the second case, various channel and gas injection geometries and discharge voltages were considered. In detail, matching conditions for guiding laser pulses will be shown, in order to increase the particles acceleration length, as well as studies of the plasma plumes exiting the channels, to control the plasma density ramps.

Plasma density measurements were carried out for all the different plasma channels generated: using interferometric methods in the case of gas jets, spectroscopic methods in the case of capillaries. Specifically, for capillaries aimed at laser pulse guiding, a spectroscopic analysis of the channel transverse profile will be shown, together with the longitudinal one.