**Temporally and spatially resolved characterization of capillary discharge plasma density profile using emission spectroscopy**

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Study of a plasma produced by an electrical discharge in a gas filled capillary is one of the crucial aspects in the development of modern, state-of-the-art Laser Wakefield Accelerators. In such capillaries, generated plasma provides a specific radial electron density profile that effectively creates a guiding plasma channel. The formation of a plasma channel allows for creation of tailored wake fields and for the efficient transport of the driver laser beam over long distances by avoiding the laser diffraction.

The target plasma is generated via a capacitive discharge circuit designed to provide a discharge voltage of up to ~25 kV and current of up to ~350 A over 1--3 cm long square-shaped sapphire capillary with varying edge length from 300 μm to 500 μm with a total discharge duration of a few hundreds nanoseconds. For achieving required gas pressure inside the capillary a continuous hydrogen gas flow is controlled via multiple input channels with separate mass flow controllers. The use of other gasses or gas mixtures is also possible.

Plasma density is measured by analyzing the Stark broadening of hydrogen Balmer lines in the visible wavelength range (mainly Hα and Hβ lines). Estimation of plasma temperature is also possible by applying Boltzmann equation. The experimental setup allows for both longitudinal and transverse plasma density profiles to be reconstructed with a very high spatial resolution. The evolution of the plasma density profiles is measured with 10 - 20 ns steps by utilizing fast gated, intensified scientific Complementary Metal–Oxide–Semiconductor camera.

Here we present an overview of the plasma diagnostics laboratory designed for a comprehensive plasma target characterization. The setup is built in the frame of laser-driven Free Electron Laser development project - LUIS at ELI-Beamlines in Czech Republic. Design features and a description of all the instrumentation used to characterize the plasma target and diagnostic systems will be presented.