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A length-scalable discharge plasma source for plasma wakefield accelerators

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A plasma source with length scalable up to hundreds of meters and controllable density can provide the acceleration medium for plasma wakefield accelerators and is required in the AWAKE research plan [1]. We propose a plasma made by impact ionisation using a direct electron current along a glass tube filled with a gas. Such a Discharge Plasma Source (DPS) will operate with short pulses ($\sim 10\ \mu s$) of high density currents ($\sim 200\ A/cm^2$) emitted from cold cathodes and using a hight voltage ($\sim 50\ kV$) ignition pulse. These discharge will have a length ranging from 1 m to 20 m and the length scalability will be achieved using a sequence of discharges with common cathodes and anodes.

Each DPS section uses a high-voltage single pulse that is able to ignite the plasma to a low current arc (20 A). The arc current is then increased to an high current (500 A) using a second circuit with a voltage lower than the tube ignition (10 kV). A DPS with two plasma sections, was developed for testing in the AWAKE experiment. This DPS is intended to provide limited discrete plasma lengths (from 3.5 m to 10.0 m) and will use different ion masses (He to Xe). We aim to demonstrate the DPS technology but the test will also provide information on the effect of ion mass, plasma length and density on the self-modulation instability of the long ($\sim 7\ cm$), high-energy ($400\ GeV$) proton bunches from the CERN SPS when interacting with the DPS plasma.

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References

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