



Contribution ID: 91

Type: **talk**

Laser-ionized plasma source for plasma wakefield accelerators

Tuesday, 15 September 2015 15:00 (20 minutes)

In 2016, AWAKE will be the first experiment to use a high energy, 400 GeV, CERN proton bunch to drive a plasma wakefield. AWAKE requires a unique plasma source. It is a 10 meter long, 2 mm diameter, laser-ionized Rb plasma with a density range of 10^{14} to 10^{15} cm⁻³. Plasma density variations as small as 0.2 % can have a detrimental effect on the acceleration of the injected electron bunch since the large (GeV/m) wakefield is driven by self-modulation-instability formed micro-bunches. This strict requirement on the density uniformity is satisfied by a laser ionized Rb vapor. The 10 m long 4 cm diameter vapor is heated uniformly by an oil heat exchanger and is dynamically confined in by continuous flow of Rb provided by precisely controlled Rb reservoirs located at both ends. The vapor and plasma density along the source are controlled by adjusting the reservoirs temperature, allowing for generation of positive or negative density gradients. Here we present the details of the plasma source along with the initial experimental and analytical studies on the laser ionization.

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Session Classification: WG5 - High-gradient plasma structures/Advanced beam diagnostics

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