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Pre-excitation studies for rubidium-plasma generation

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ABSTRACT

The key element in the Proton-Driven-Plasma-Wake-Field-Accelerator (PWFA) project is the generation of highly uniform plasma from Rubidium vapor. A scientifically straightforward, yet highly challenging way to achieve full ionization is to use high power laser which can assure the barrier suppression ionization (BSI) along the 10 m long active region. The Wigner-team in Budapest is investigating an alternative way of uniform plasma generation. The proposed Resonance Enhanced Multi-Photon Ionization (REMPI) scheme can be probably realized by much less laser power. In the following we plan to investigate the resonant pre-excitations of the Rb atoms, both theoretically and experimentally. In the following our theoretical framework is presented together with the status report about the preparatory work of the planned experiment.

1. Introduction

After building LEP and LHC, and planning ILC the size and cost of classical high energy particle accelerators are reaching their limits around 50 MeV/m.

In their historical article [1] in 1979 Tajima and Dawson predicted: "glass lasers of power density 10^{18} W/cm^2 shone on plasmas of densities 10^{18} cm^{-3} can yield gigaelectron volts of electron energy per centimeter of acceleration distance." With the availability of high power short pulse lasers their ideas are becoming reality.

It turned out that it is possible to build not only Laser Wake Field Accelerator (LWFA) but also Particle Driven Wake Field Accelerator (PWFA). In the laboratories 100 GV/m accelerating gradient was demonstrated with laser driven systems [2] and 50 GV/m with electron driven case in SLAC [3–5].

At CERN the AWAKE collaboration [6] has been formed in order to demonstrate proton driven plasma wake field acceleration for the first time, where the Wigner team is interested in the creation of high uniform plasma which is required to reach the plasma frequency stability at the percent level.

The SPS proton beam in the CNGS facility will be injected into a 10 m plasma cell where the long proton bunches will be modulated into significantly shorter micro-bunches. These micro-bunches will then initiate a strong wakefield in the plasma with peak fields above 1 GV/m. Though this peak field is much less than the one achieved by laser or electron driven systems, the future accelerator based on this technology can have a much reduced length compared to proposed linear accelerators.

In the proposal [7] a uniform plasma was assumed to be generated by high enough laser power with barrier suppression ionization (BSI), achieving saturation along the whole length of the 10 m plasma. In this paper we propose a much softer method by applying the so-called Resonance Enhanced Multi-Photon Ionization (REMPI) scheme. It is a three photon process which requires significantly lower laser power than the non-resonant BSI process. We will investigate the two-photon resonant excitation process with theoretical method and the whole ionization with an experimental setup.

2. Experimental setup

To study the resonant photoionization process in the near future we present our experimental setup which is under

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