

# SL\_EXIN

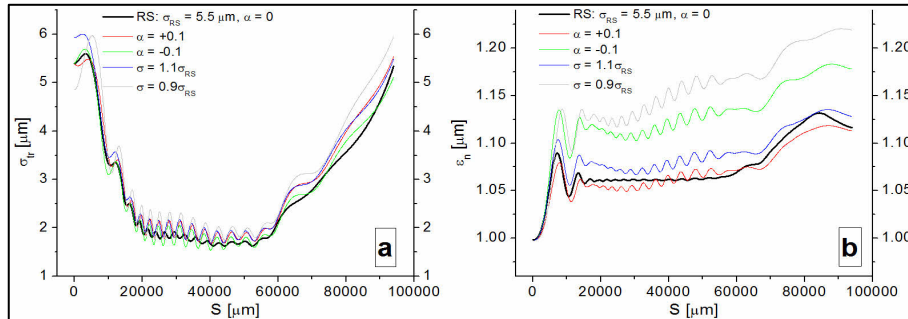
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The main aim of the EXIN (external injection) project is to use the high accelerating gradient that can be achieved with plasmas to further accelerate high brightness electron bunches coming from the SPARC conventional accelerator and above all preserve the high quality of the electron bunch (low energy spread, small emittance).

This will be done by shooting a high power laser beam inside a hydrogen-filled capillary tube: the laser beam will ionize the hydrogen and create plasma waves. High brightness electron bunches can be then injected on the crest of the wave to be further accelerated.

In the last year, all the mechanical equipment needed for the experiment have been purchased, from the vacuum interaction chamber to the transport line for the FLAME laser transport.

In parallel, simulations of the electron beam dynamic inside the plasma have been performed, showing that a maximum energy gain of about 300 MeV can be reached and that beam quality can be reserved (Fig. 1).



*Fig. 1: Simulation of the matching conditions of the electron beam inside a capillary, showing that matching size of electron bunches is of paramount importance in order to avoid unwanted oscillation of electron bunches and unwanted emittance growth.*

Also, simulations of laser transport inside the capillary have been performed, in order to see the modes that are excited inside the capillary and which will help when the laser beam will be aligned inside the capillary for the first times. We have decided to use mono-modes capillaries, which allows to have higher transmission efficiency and we have therefore find the conditions under which we can have the higher coupling efficiency (Fig. 2).

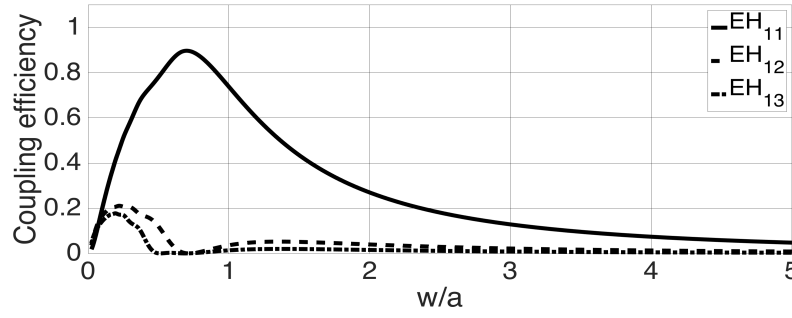


Fig. 2: Simulation of the matching conditions of the laser beam inside a capillary, showing that higher coupling efficiency (90%) is obtained with the first mode ( $EH_{11}$ ) when  $w/a = 0.7$  (where  $w$  is the laser waist in the focus and  $a$  is the capillary radius).

Starting from the results of the laser beam dynamic into the capillary and the results of the coupling efficiency, we have started to use a small part (very low energy) of the FLAME laser to couple it with a capillary tube (100  $\mu\text{m}$  diameter) and we have tried to align the laser into the capillary and get the better transmission at the end of the capillary. Fig. 3 shows the output laser transverse profile after travelling 3 cm in an empty mono-mode capillary tube proving good transport has been achieved.

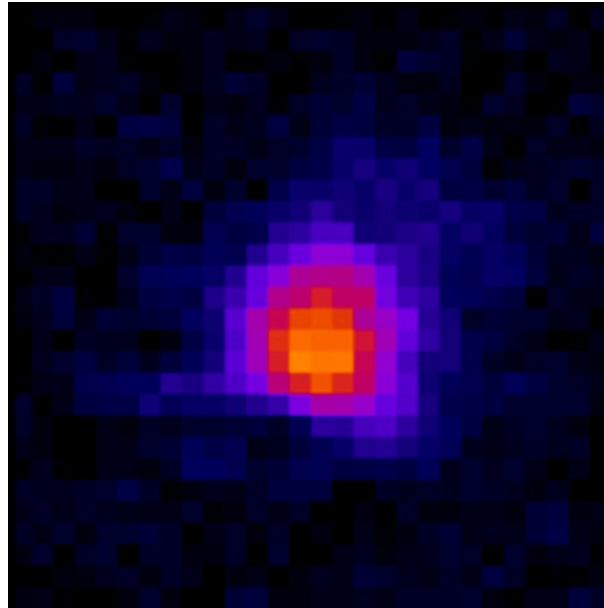


Fig. 3: output laser profile from a 3 cm mono-mode capillary tube.

Another step forward this year has been done on the synchronization part, which is one of the most critical aspects of this experiment. In fact, laser beam and electron beam have to be synchronized at the femtosecond level in order to be able to place the electron bunch exactly on the crest of the plasma wave. Last year we have installed a new optical line based on optical fiber and an optical phase cross-correlator which will allow to have much higher phase sensitivity ( $\sim 10$  mV/fs), which is the base for a more accurate phase lock to the SPARC reference oscillator.