DESIGN OF A LASER-BASED PROFILE MONITOR FOR LINAC4 COMMISSIONING AT 50 MeV AND 100 MeV

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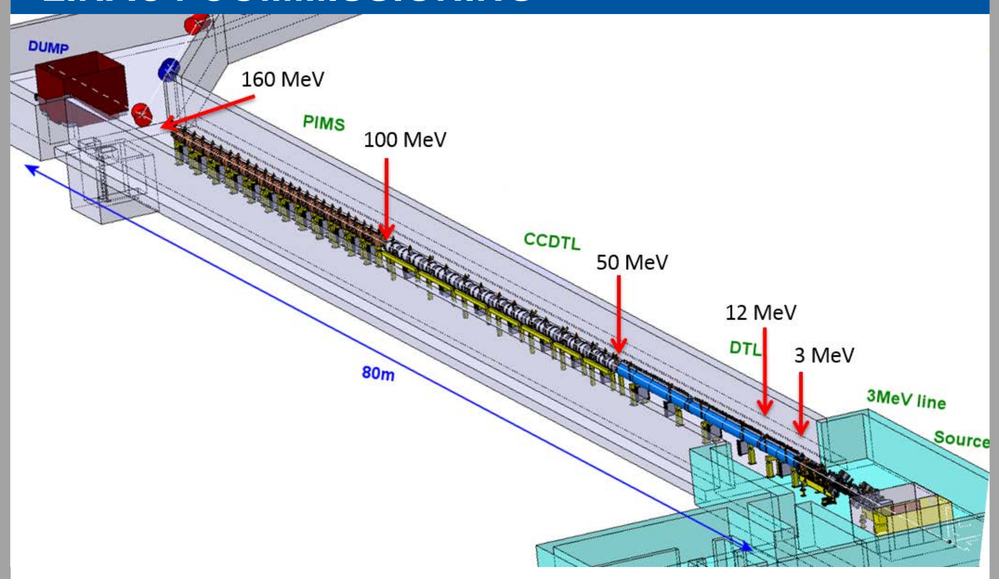
ABSTRACT

A laser-based profile monitor has been designed for commissioning of CERN's LINAC4 accelerator at 50 MeV and 100 MeV, as part of the development of a non-destructive profile and emittance monitor foreseen for the final 160 MeV beam. The system is based on a low power laser which is scanned through the H^- beam. Electrons, which are photo-detached from the ions by the laser, are deflected by a steerer magnet and measured by a diamond detector. The custom designed diamond detector is tailored to minimize the disturbance due to the electromagnetic field of the passing main beam. The laser source will be installed in the LINAC4 Klystron gallery located 75 m away from the profile station and an optical fiber will transport the laser to the tunnel. The laser propagation for different pulse length and peak power values was characterized with laboratory tests with such a long fiber. In this paper we describe the overall design, focusing on key elements such as the fiber-based laser transport and the electron detection with the diamond detector.

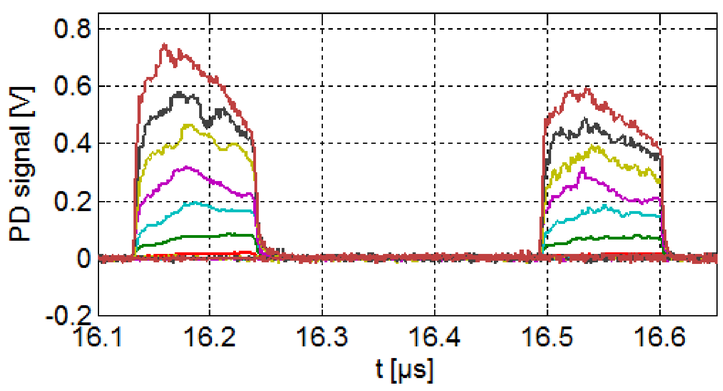
LINAC4 COMMISSIONING



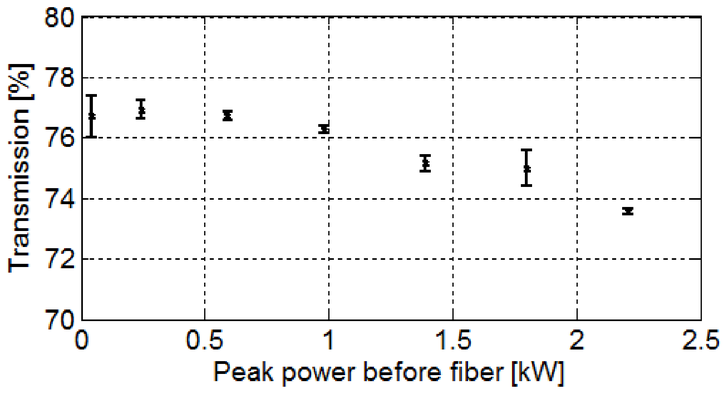
The LINAC4 commissioning is taking place in stages at different beam energies. During the 3/12 MeV commissioning, a non-invasive laser system was successfully operated to measure the vertical emittance of the H- beam, by collecting the neutralized H0 atoms.
The next two stages (50/100 MeV) will be used to check the performance of a modified version of the laser-based instrument, collecting the electrons that are photo-detached during the laser scan.

FIBER-BASED LASER DELIVERY

The laser is transported to the interaction point in a 75 m long optical fiber. Due to the laser peak power in the kilowatt range, Stimulated Brillouin Scattering (SBS) was suspected to limit the fiber transmission.
A transmission test with peak powers up to 2.2 kW provided evidence that the system works very reliably and is very little affected by SBS.

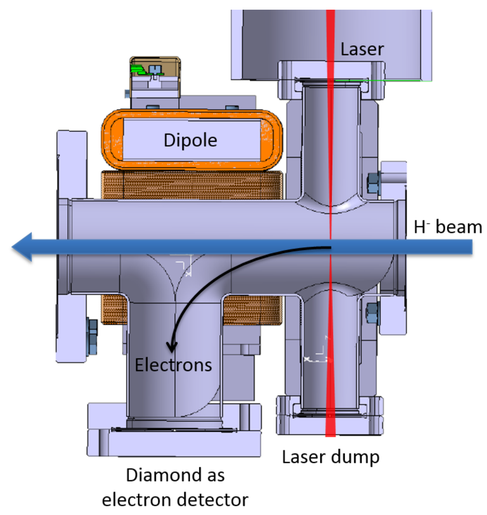


Laser pulses with different energies before (left) and after fiber (right)



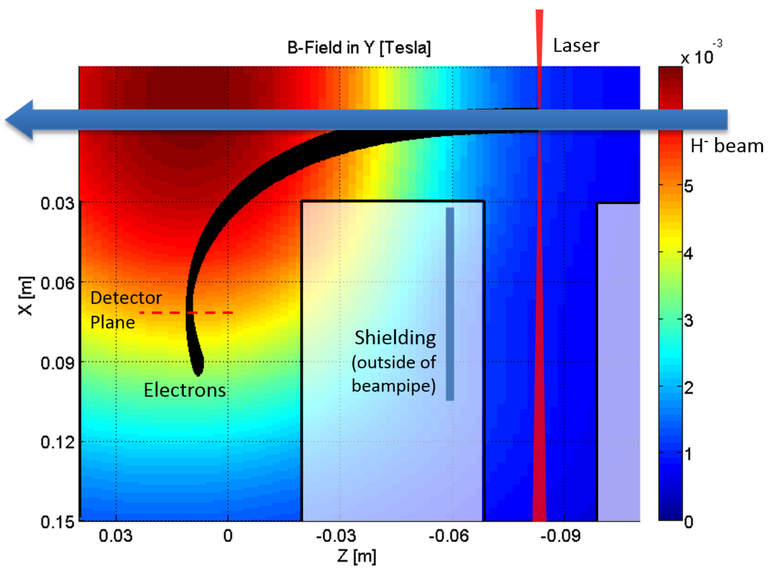
Laser transmission through the 75m LMA optical fiber

CONCEPTUAL DESIGN – PROFILE MONITOR

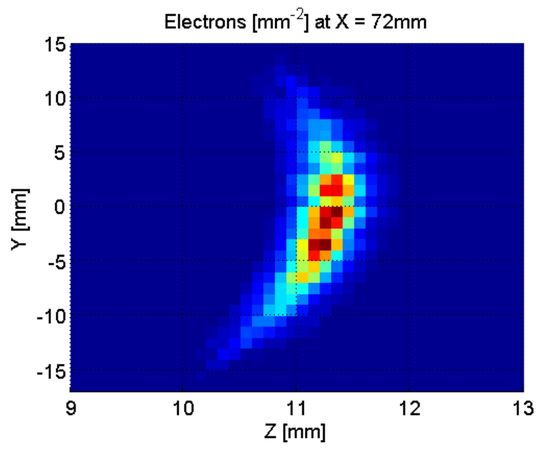


The laser beam diameter is relatively small with respect to the H- beam size, hence the vertical position of the liberated electrons is well defined and counting the stripped electrons as function of the laser position during a scan allows to reconstruct the beam profile.
A dipole magnet located just after the laser interaction point (IP) is used to extract the electrons toward the diamond detector designed to integrate the electron signal. Due to the much lower energy of the stripped electrons with respect to the H- ions, the magnetic field necessary to extract the electrons has a very weak effect on the main beam.

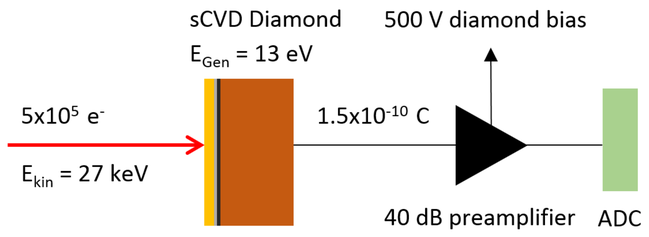
ELECTRON MONITORING



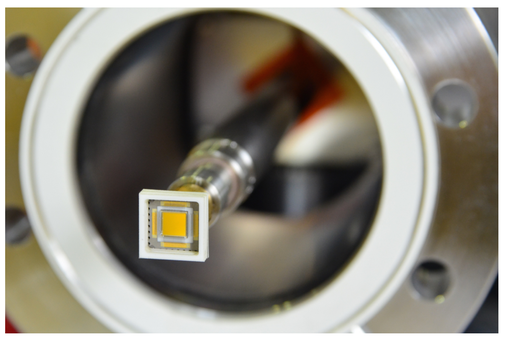
Magnetic field map and electron trajectories (black) from the laser interaction point to the diamond detector at X = 72 mm.



Expected electrons distribution at the detector plane, accounting for all laser positions during a scan.

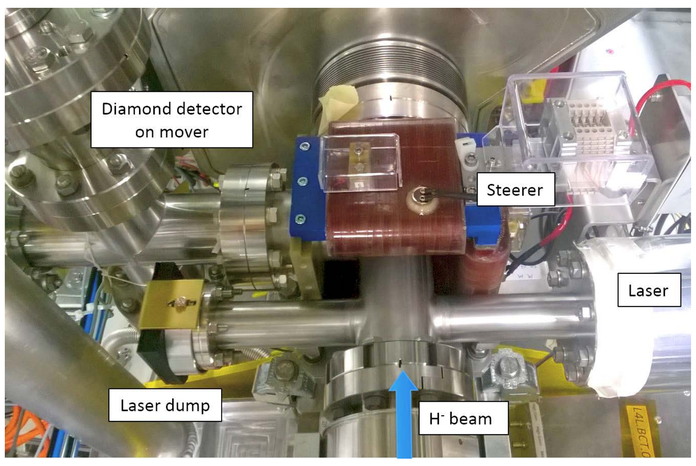


Signal creation and readout of diamond detector



sCVD diamond detector
mounted on the vertical actuator

SUMMARY & OUTLOOK



The picture on the left shows the system installed at LINAC4, as part of the 50/100 MeV test bench. First beam tests at an energy of 50 MeV are foreseen in October 2015.
The final system will be installed permanently at the LINAC4 top energy of 160 MeV to monitor both, horizontal and vertical transverse profiles and the transverse emittances. The design is currently ongoing.

ACKNOWLEDGMENTS

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