STATUS OF AND FUTURE PLANS FOR THE CERN LINAC4 EMITTANCE METER BASED ON LASER ELECTRON-DETACHMENT AND A DIAMOND STRIP-DETECTOR

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ABSTRACT

LINAC4 has started its staged commissioning at CERN. After completion it will accelerate high brightness H^- beams to 160 MeV. To measure the transverse profile and emittance of the beam, a non-destructive method based on electron photo-detachment is proposed, using a pulsed, fibre-coupled laser to strip electrons from the H^- ions. The laser can be focused and scanned through the H^- beam, acting like a conventional slit. A downstream dipole separates the neutral H^0 beamlet, created by the laser interaction, from the main H^- beam, so that it can be measured by a diamond strip-detector. Combining the H^0 beamlet profiles with the laser position allows the transverse emittance to be reconstructed. A prototype of this instrument was tested while commissioning the LINAC4 at 3 and 12 MeV. In this paper we shall describe the experimental setup, challenges and results of the measurements, and also address the characteristics and performance of the diamond strip-detector subsystem. In addition, the proposal for a permanent system at 160 MeV, including an electron detector for a direct profile measurement, will be presented.

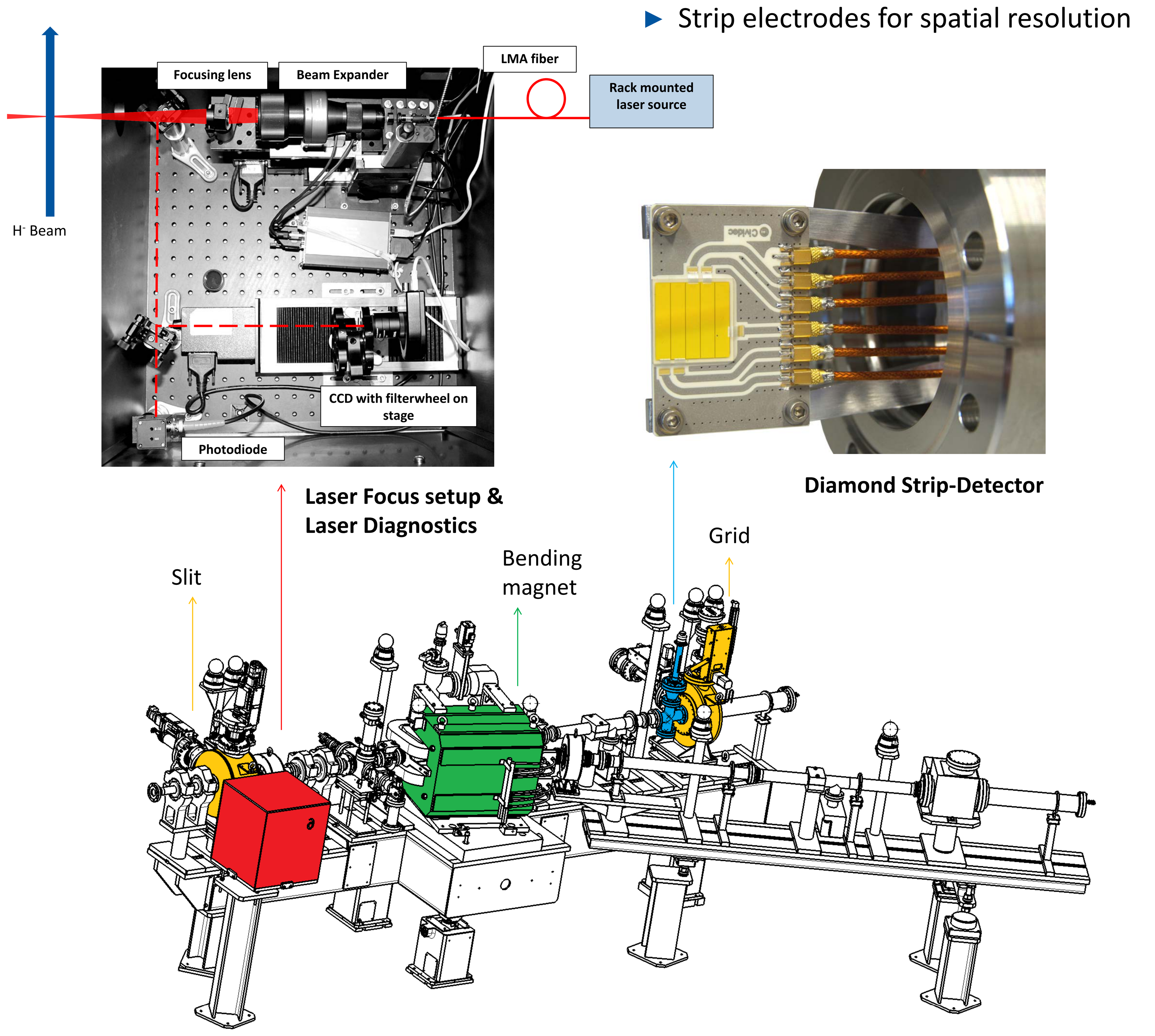
PROTOTYPE SETUP

Laser System

- Used to strip electrons from H^- ions
- Fiber based delivery to beampipe
- Low energy (~ 100 µJ) laser pulses
- 150 µm diameter at beam interaction

Diamond Strip-Detector

- Used to detect H^0 atoms
- High sensitivity (> 10^4 e^-/H^0)
- High bandwidth (~ 1.5 ns)
- Radiation tolerant (10^{-15} cm^{-2})
- Strip electrodes for spatial resolution



3 / 12 MeV diagnostics test bench at LINAC4 commissioning

SIGNAL & BACKGROUND SIMULATION

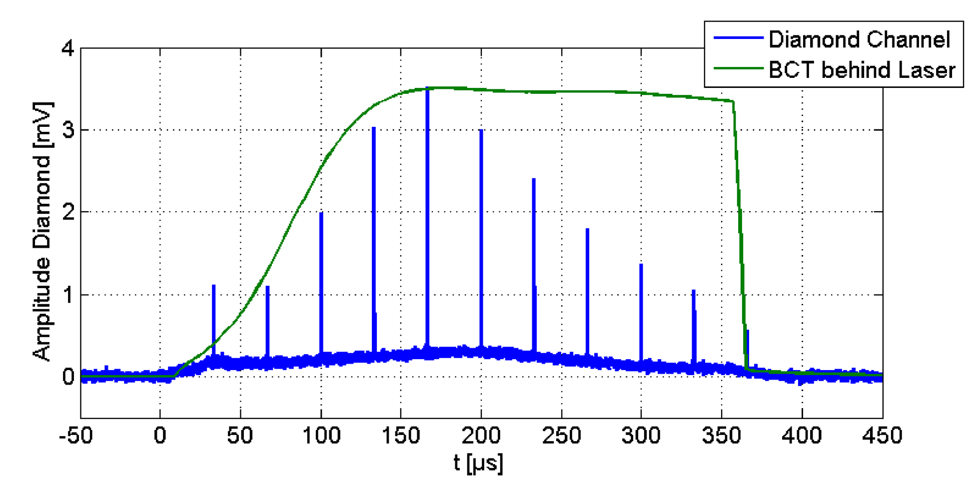
The H^0 background is expected to be dominated by H^- stripping upstream due to **collisions with residual gas atoms.** This has been simulated in order to estimate the signal to background ratio at the H^0 detector.
The signal values are calculated assuming a laser pulse with an energy of 67 µJ when crossing the center of the H^0 beam and a diamond strip detector with an area of 18 mm x 3.5 mm, used to integrate the arriving H0.

H^- Beam Energy [MeV]	3	12	160
Laser Stripped [H^0 / ns]	1549	408	2400
Background [H^0 / ns]	105	69	67
SNR	**14.7**	**5.9**	**35.8**

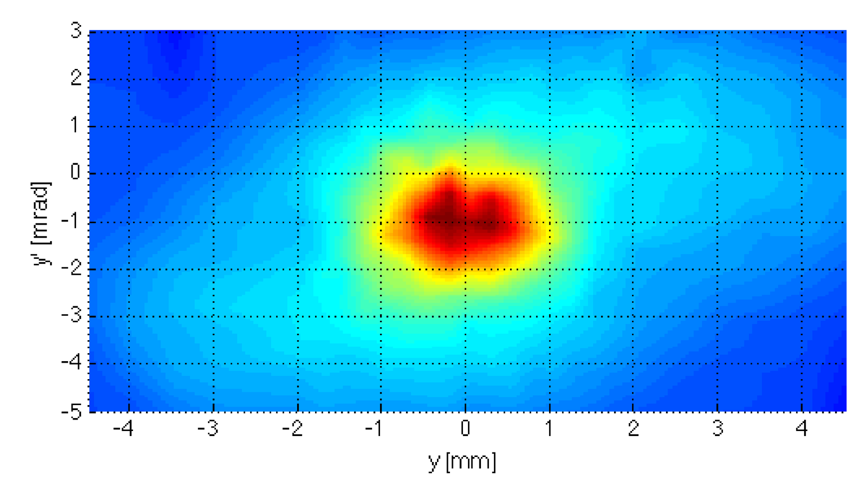
PROTOTYPE RESULTS

3 MeV campaign results

- Laser stripping & background in agreement with prior simulations (Table above)
- Problems due to implantation of protons into the diamond
  - Low signal amplitude (few mV)
  - Sensitivity not constant during LINAC4 pulse
- Emittance results nevertheless within 2% agreement comparing to the slit & grid system



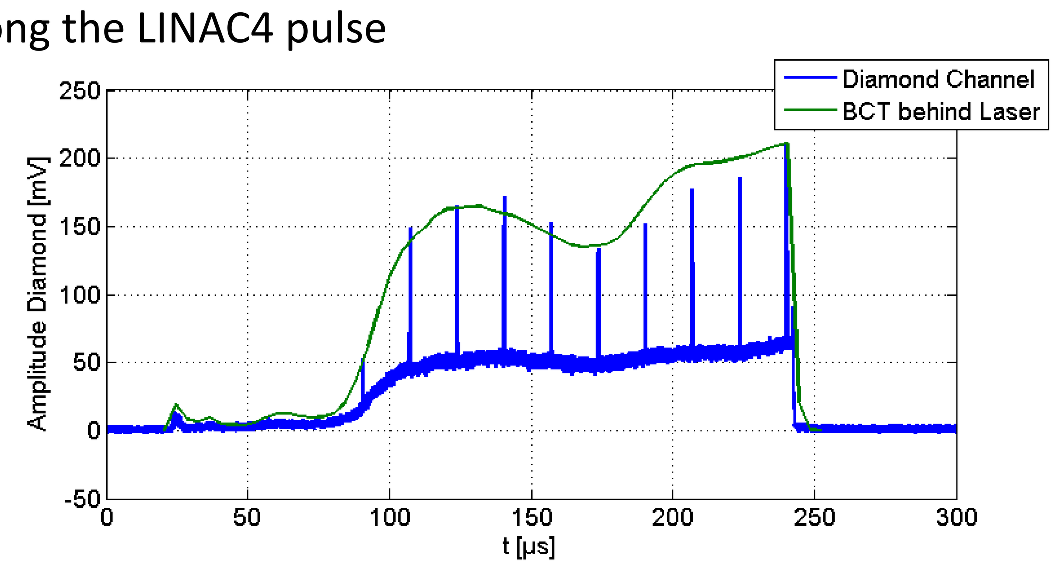
Comparison at the 3 MeV test with Beam Current Transformer (BCT) signal.
Diamond: Signal peaks -> laser stripped H^0 pulses; Signal floor -> H^0 Background



Emittance of the LINAC4 beam at 3 MeV measured with laserwire & diamond detector

12 MeV preliminary results

- Lower SNR in agreement with prior simulations (Table above)
- No proton implantation
  - Much higher signal amplitude (> 100 mV)
  - Signal of laser stripped H^0 atoms proportional to BCT-signal along the LINAC4 pulse



Comparison at the 12 MeV test with BCT signal.
Diamond: Signal peaks -> laser stripped H^0 pulses; Signal floor -> H^0 Background

160 MEV SYSTEM DESIGN

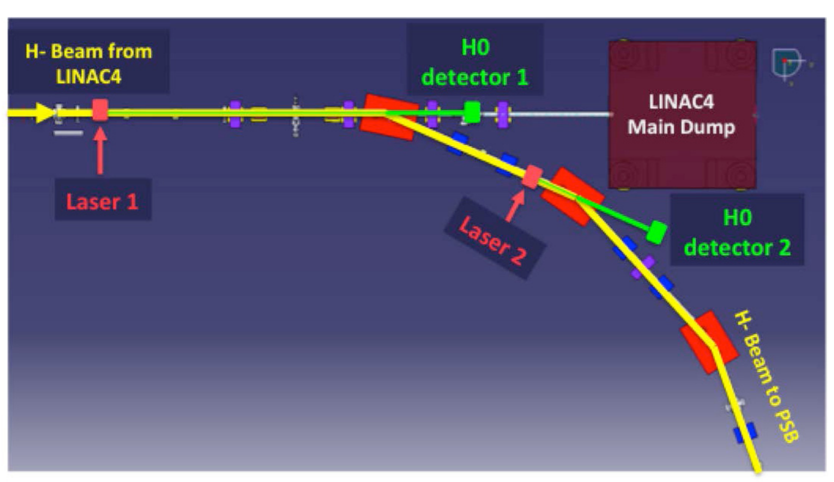
Two independent stations to measure transverse emittance and profile in x and y plane

Laser System

- In cabinet on surface to shield from radiation
- Laser delivery via Large Mode Area (LMA) optical fiber (about 20 m)

H^0 Detector

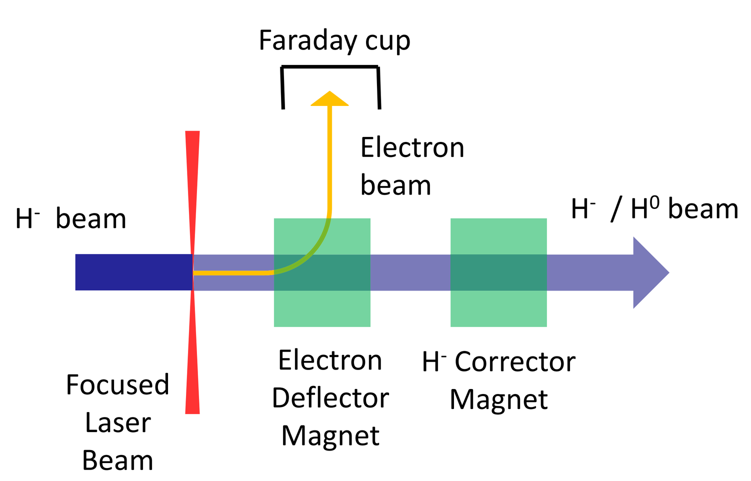
- Diamond detector tested at 3 and 12 MeV is first candidate
- Strip width of 500 µm to accommodate 35 channels
- Calibration mechanism to compensate radiation damage is in development



Layout of 160 MeV area

Profile measurement by electron collection

- Weak bend (~ 20 mT) is sufficient to deflect stripped electrons into Faraday cup
- High time resolution for Faraday cup needed to distinguish the 80 ns laser signal from the background



Principle of electron collection

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