Beam Transverse Profile Measurements at the CERN LINAC 4

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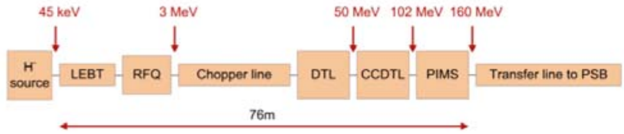
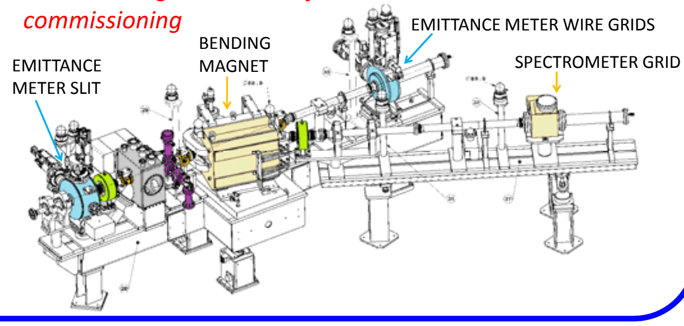
The LINAC 4 project and the 3 MeV test stand

The CERN LINAC4 will represent the first upgrade of the LHC injection chain. It will replace the old 50MeV proton linac (Linac2) by accelerating H- ions from 45 KeV to 160 MeV for charge-exchange injection into the PS Booster. The ion source, the 3 MeV RFQ and the medium energy transport (MEBT) hosting a chopper, have been commissioned in a dedicated test stand. A movable diagnostics bench is used to characterize the beam at the end of the RFQ and the chopper line at 3 MeV.

LINAC 4 layout



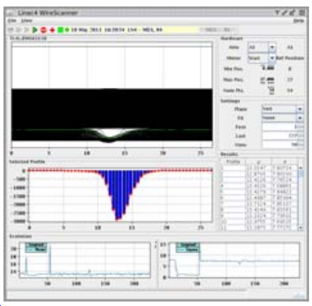
Movable diagnostic bench for 3-12 MeV commissioning



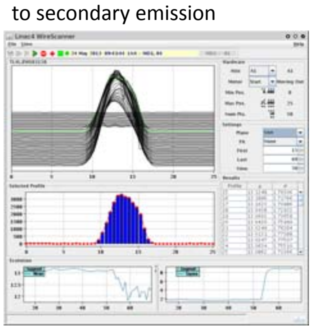
Beam Transverse Profile and Emittance Measurements

Typical beam transverse profiles acquired by the Carbon wire scanners hosted in the chopper line

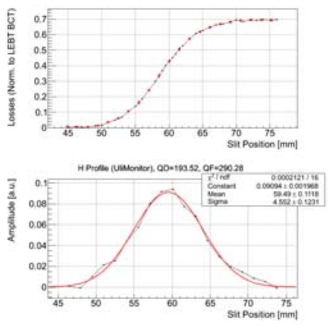
H- beam → negative signal dominated by stripped electrons



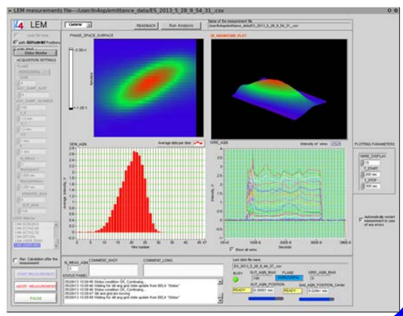
H+ beam → positive signal due to secondary emission



Transverse profile acquired by using the emittance meter slit as a scanning scraper and by measuring the transmission with a downstream current transformer

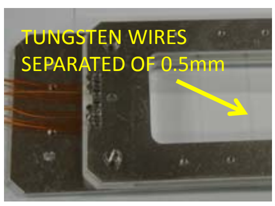


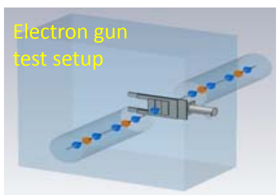
Emittance measurement performed through a slit-grid system. The slit is made of graphite plates mounted with a 15° angle with respect to the beam axis in order to dilute the energy deposition.



Scattering of H- stripped electrons

The wire signal generated by the H- beam is determined by the balance between the number of stripped electrons stopped in the wire and the secondary emission yield. A portion of the stripped electrons are scattered away from the wire and can reach the neighboring wires. An evaluation of the cross-talk in a wire grid has been performed by a laboratory experiment using a 70 keV electron gun beam, reproducing the case of 128 MeV H- beam.

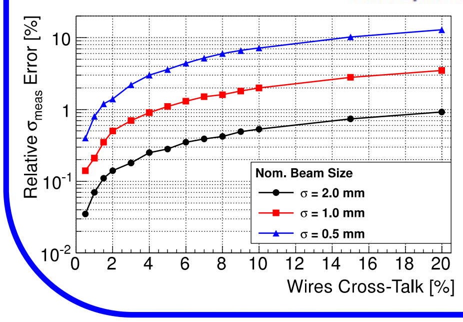




A set of three 40 µm tungsten wires was mounted on a fork support with 0.5mm pitch. The electron beam was collimated on the central wire through a 0.4 mm slit, so that the lateral wires could be reached only by the electrons scattered by the central wire.

Wire Pol.	Cross-Talk		Central wire signal*	
	Meas.	Simul.	Meas.	Simul.
0 V	4%	1.4%		
20 V	13.5%	7%	+27%	+12%
50 V	15.4%	14.4%	+36.5%	+35.5%
100 V	N.A.	13.0%	N.A.	+39.0%

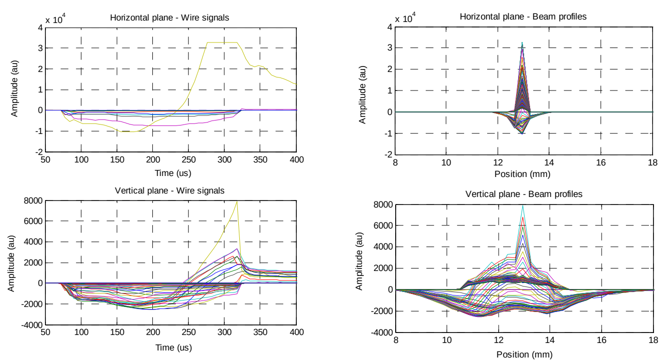
* w.r.t. 0 V polarization



With a cross-talk of 5 %, which is a realistic estimation with no wire polarization, the error on the measured beam size is less than 4 % even for a σ=0.5 mm beam, smaller than what expected at LINAC4.

Wire heating and thermionic emission

Wire heating has to be monitored for the wire scanners in the chopper line which intercept the full 3 MeV beam. When the optics is adjusted to generate a waist condition, thermionic emission is clearly visible and affects the beam profile measurement → σ_x= 0.3 mm σ_y = 1.8 mm I_{pulse}= 11mA (average) T_{pulse}=250µs (pulse length) Repetition Rate = 1Hz



Temperature simulation with the wire standing in the beam center for 10 consecutive pulses (with radiative + conducting + thermionic cooling)

Time evolution of the peak temperature on the wire center

Temperature profile along the vertical wire at the end of the beam pulse