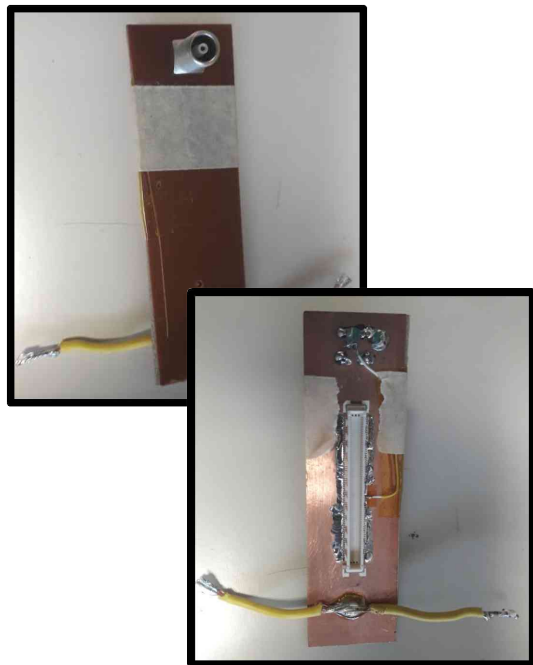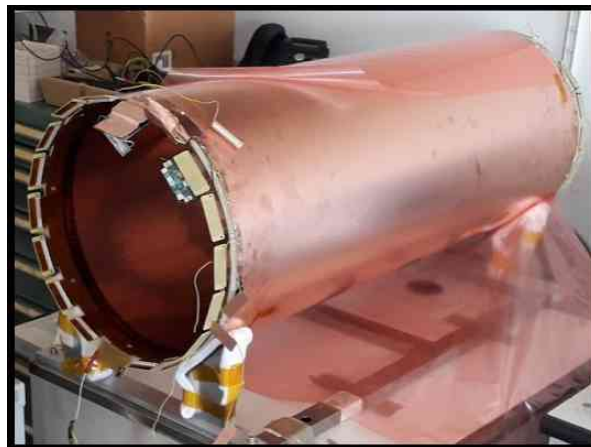# Signal propagation velocity

The setup

The connector

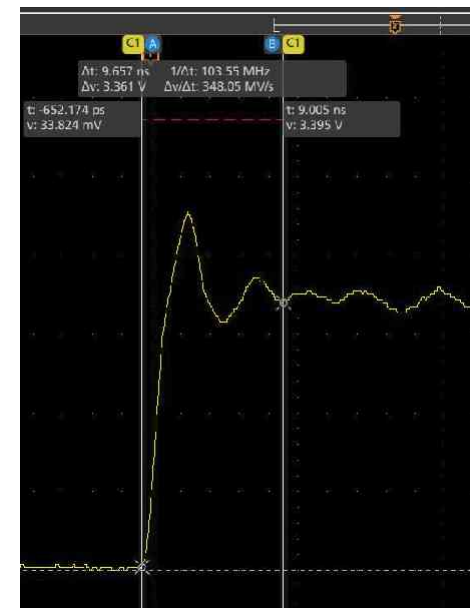One pin is connected to the Lemo, the others 143 are connected to ground

The detector

All the strips of the anode foil are connected to ground except of the one under test
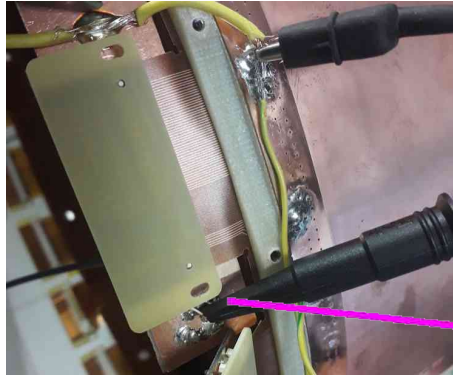
The signal

No strip are connected in the following picture. This is the noise level.
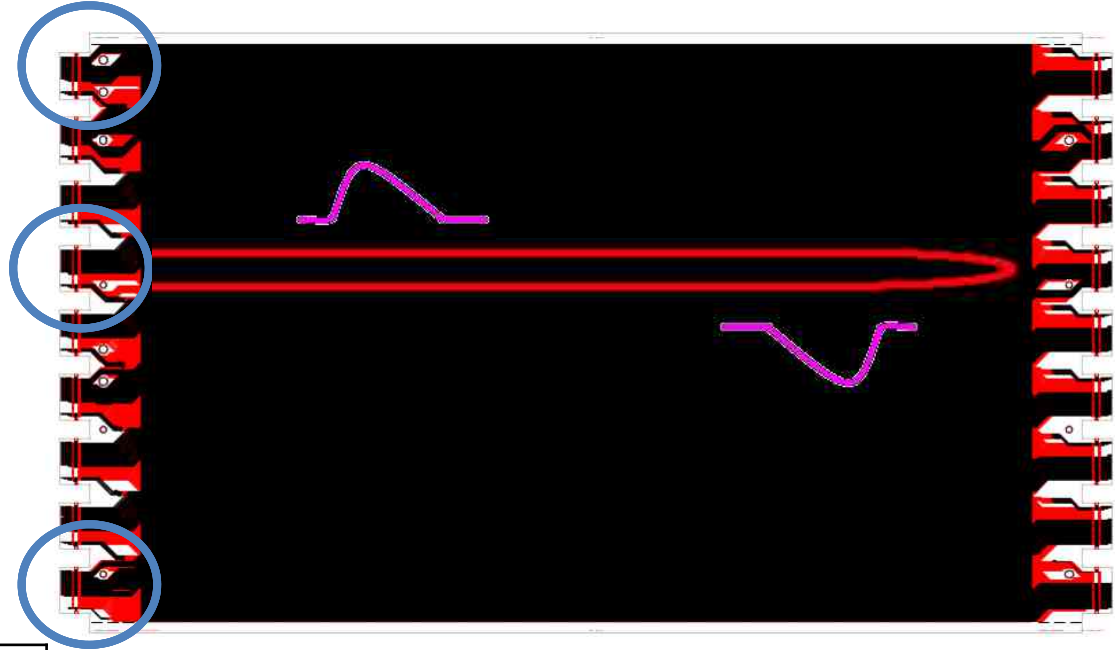
The setup

At least three measurements are performed for each layer (L2 and L3) and view (X and V)
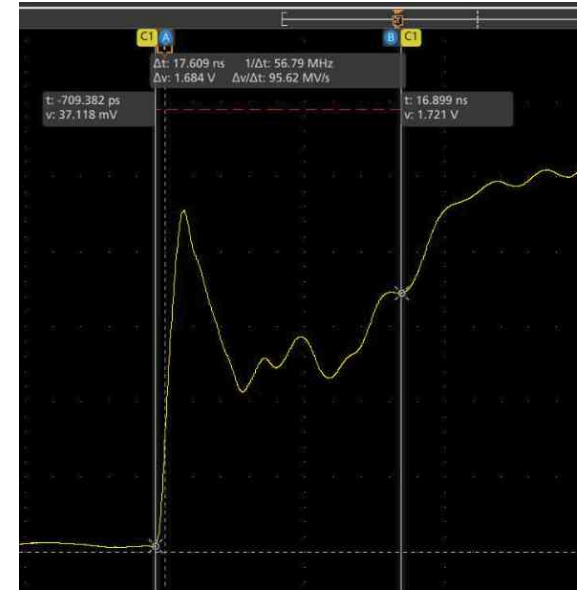
Injector

Oscilloscope

L3 - X measurements

$\Delta l = 92$ cm

$\Delta t\_1 = 17.4$ ns
$\Delta t\_2 = 17.3$ ns
$\Delta t\_3 = 17.6$ ns
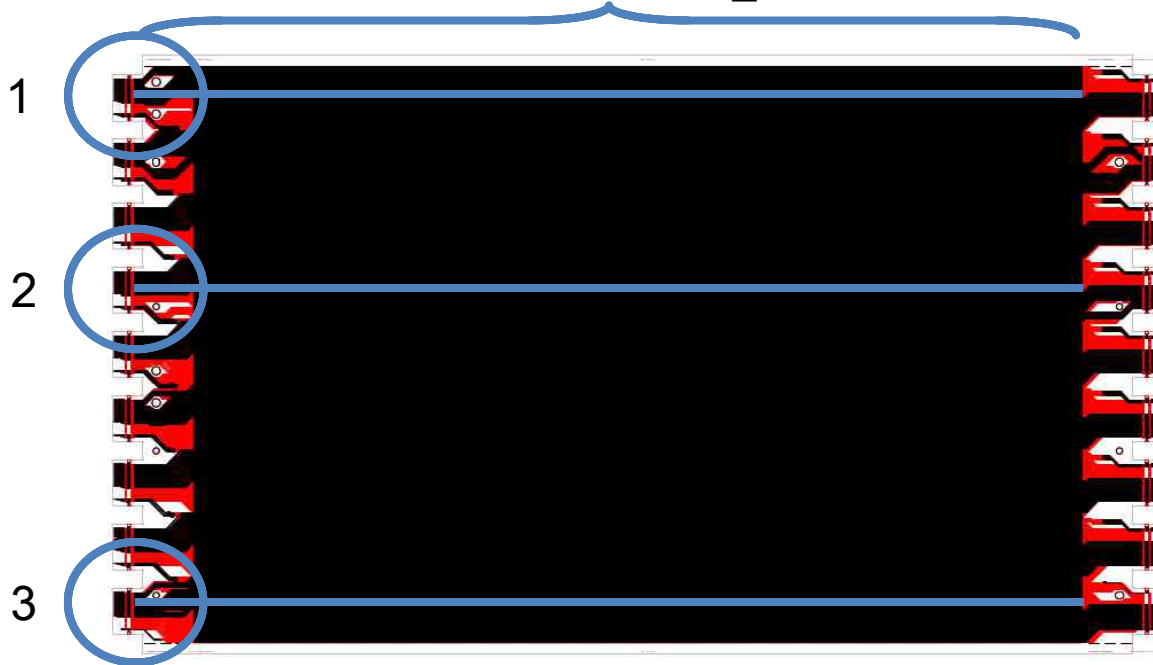
L3 - V measurements

$\Delta l\_1 = 104$ cm $\Delta t\_1 = 12.7$ ns
$\Delta l\_2 = 75$ cm $\Delta t\_2 = 7.3$ ns
$\Delta l\_3 = 14$ cm $\Delta t\_3 = 2.0$ ns
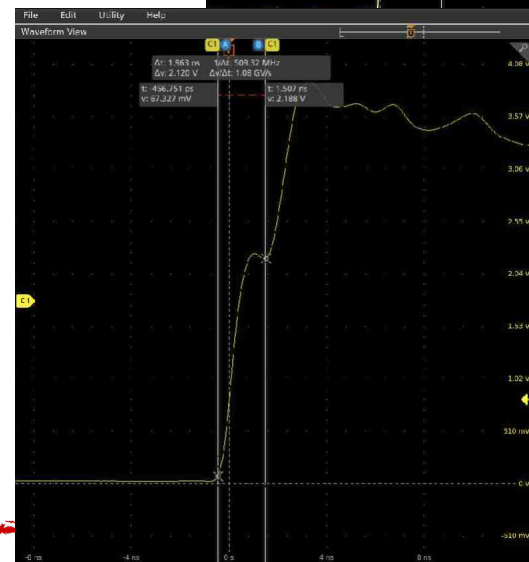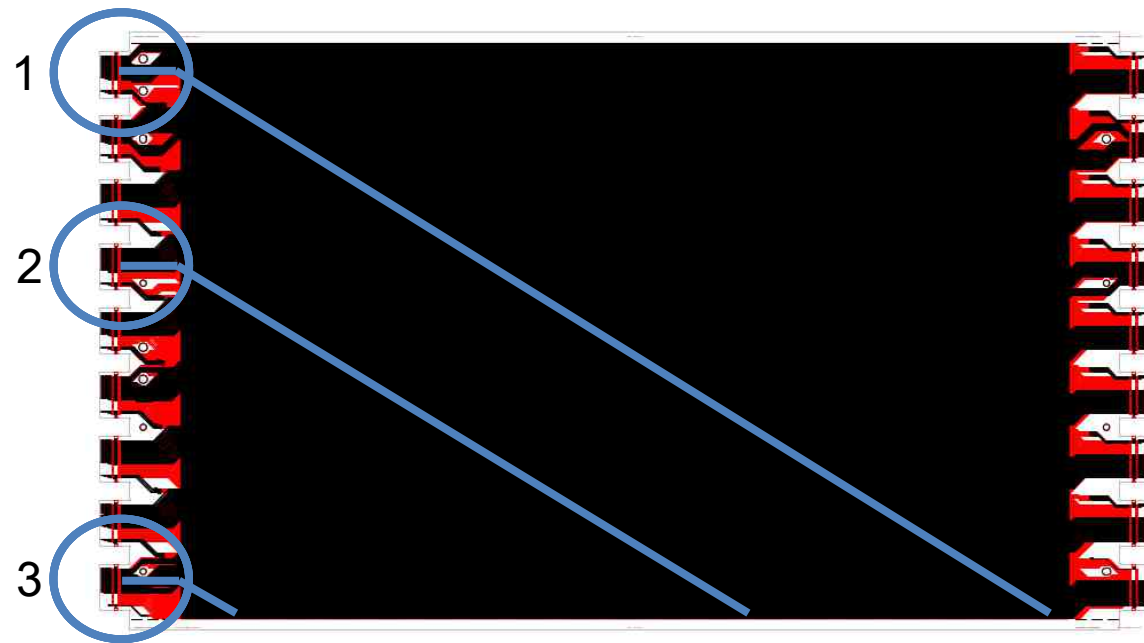
L2 - X measurements

$\Delta l = 81$ cm

$\Delta t\_1 = 10.1$ ns
$\Delta t\_2 = 10.7$ ns
$\Delta t\_3 = 10.9$ ns

1

2

3
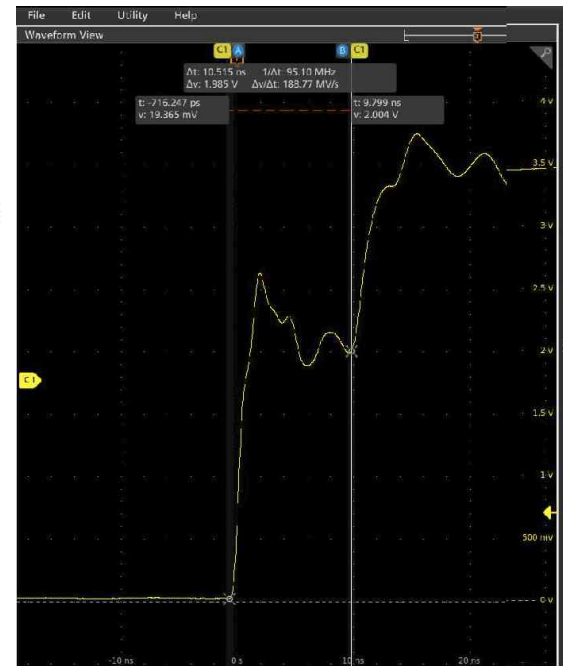
L2 - V measurements

$\Delta l\_1 = 95$ cm

$\Delta l\_2 = 71$ cm

$\Delta l\_3 = 24$ cm

$\Delta t\_1 = 9.7$ ns

$\Delta t\_2 = 8.3$ ns

$\Delta t\_3 = 2.9$ ns

1

2

3
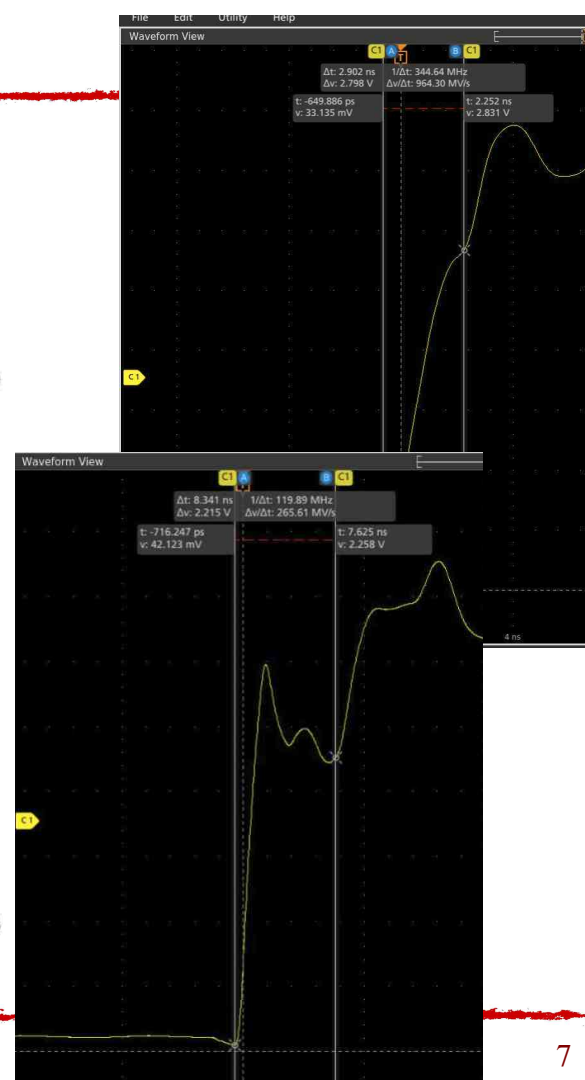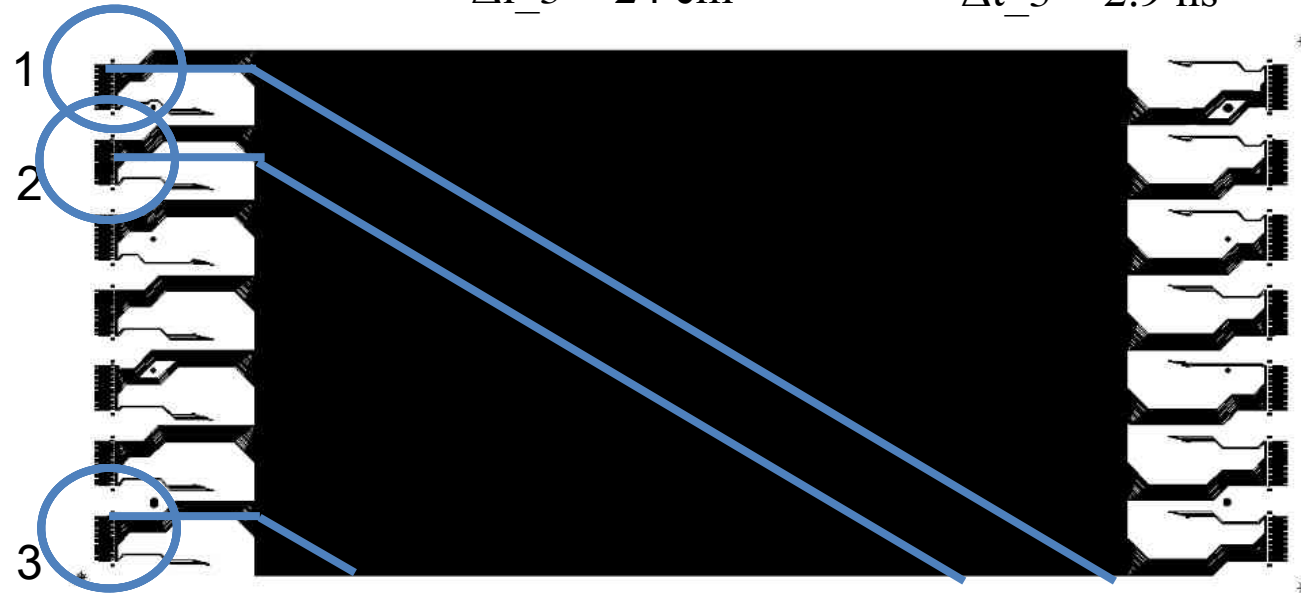
Simulations

Simulation: Approach and Assumption

G3B

1 mm

Strip V width: 130 μm — Strip_V (3 μ thickness)

50μ - Kapton dielectric constant: 3.4 @ 25 μm, 1kHz

Strip X width : 580 μm — Strip_X (3 μ thickness)

4 mm

GND
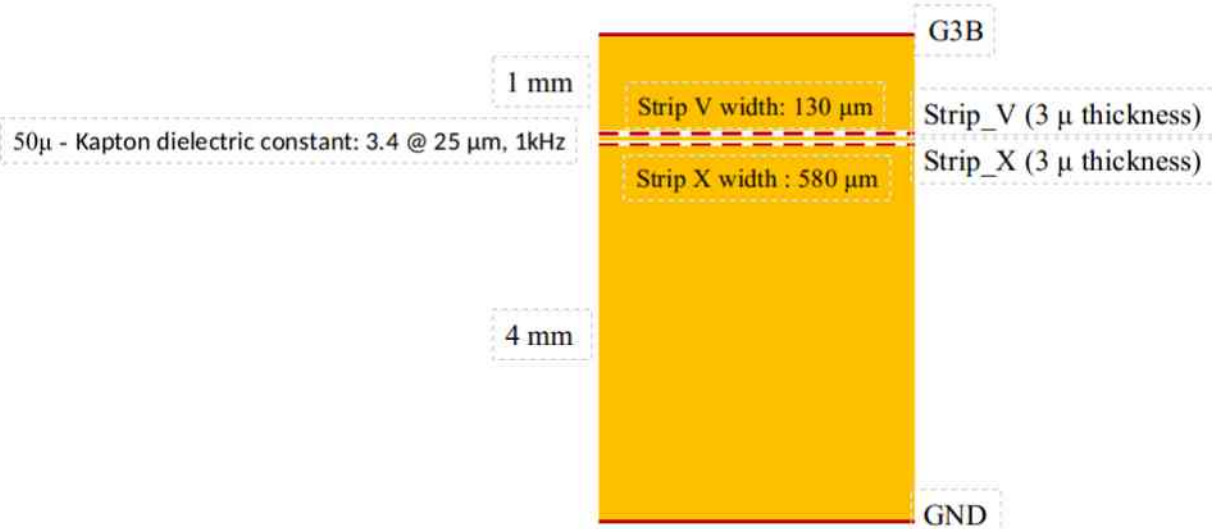
Strip X: reference for strip V simulation - Strip V: reference for strip X simulation
G3B and GND contribution discarded

G. Felici   Approach and Assumptions   2

Simulations

- Assuming lossless trasmission line a simulation of X and V strips has been carried out

- 50 cascaded R-L-C sections have been considered in simulation
    - R,L,C are the distributed Resistance/unit length, Inductance/unit length and Capacitance/unit length
    - The propagation delay of each section is smaller than the signal rising time (lumped approach)

- Simulation/formulas reliability is a function of parameter definition
    - Small error for V strips (W/H < 3)
    - Not predictable for X strips (W/H > 10)

- Both strip V and X average simulated delay is in good agreement with measurements
    - X_measured = 92 ps/cm; X_simulated = 91 ps/cm; Z_simulated = 20 Ω
    - V_measured = 60 ps/cm; V_simulated = 58 ps/cm; Z_simulated = 45 Ω

Results

	Strip X	Strip V
Layer 2	$0.51c$	$0.59c$
Layer 3	$0.35c$	$0.57c$

The main difference between Layer 2 and 3 is the carbon fiber.
This influences the measured value on the X strip of L3.
The L3X result is significantly different from the others.

Simulation have been performed. More reliable results are simulated for V strips
while on X strips the approssimations used are not precise.