MCP-PMT Ringing

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Panda-CM
PID-Cherenkov
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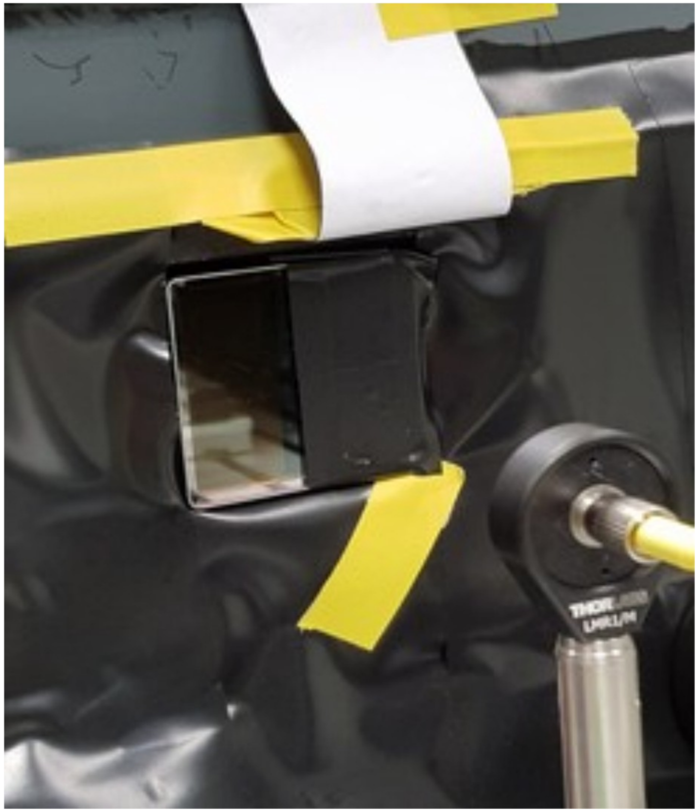
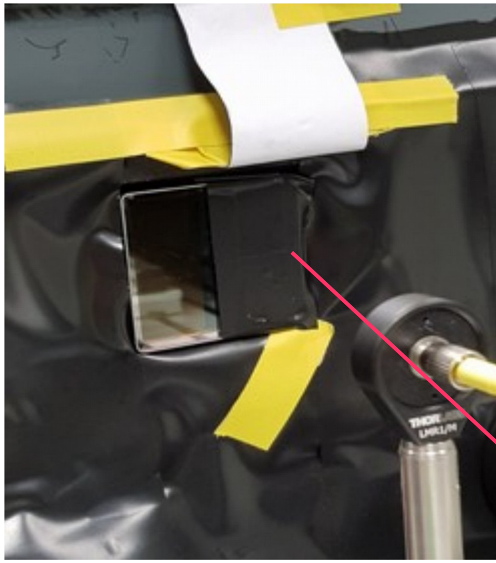
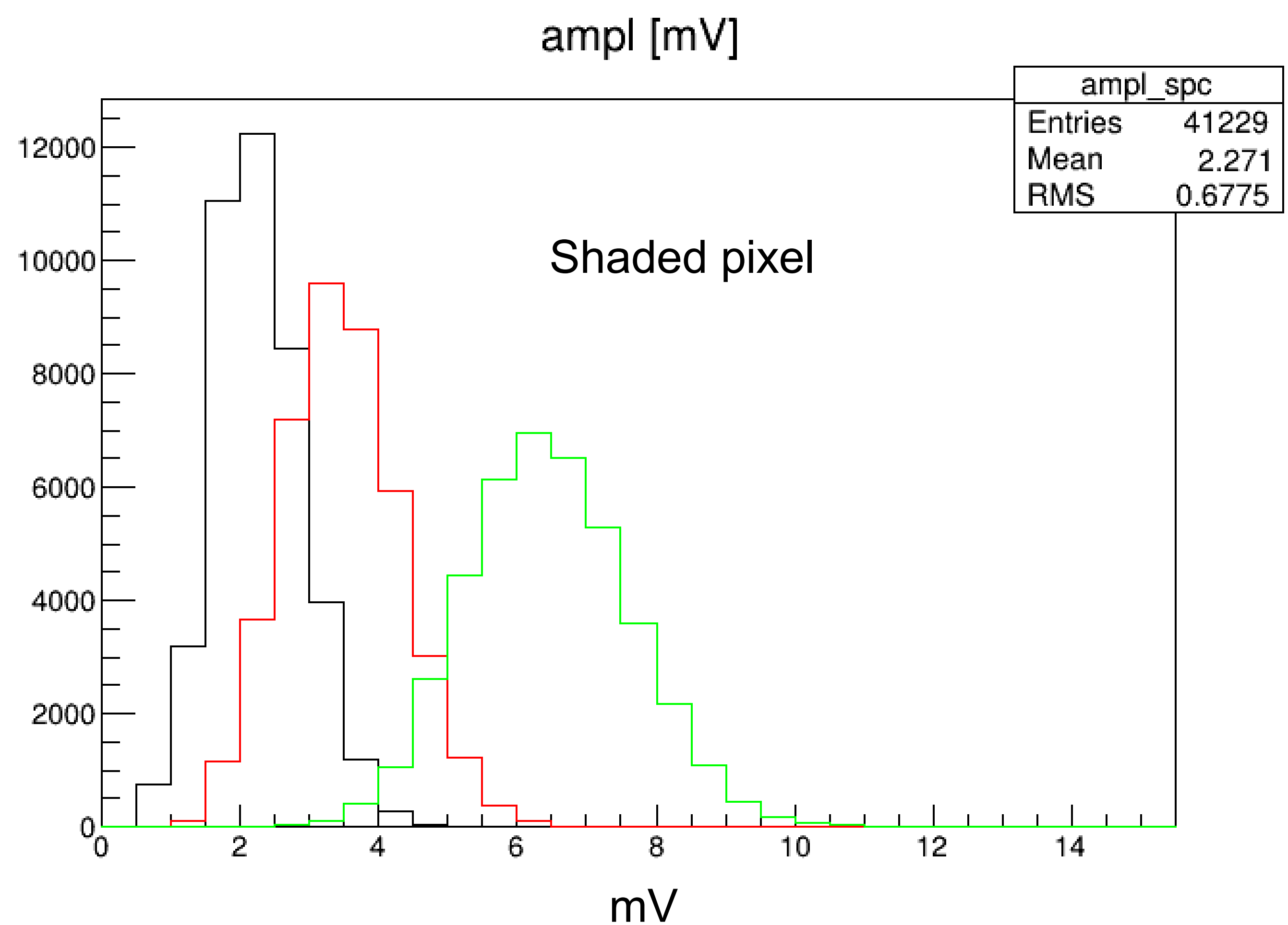


Oscillations



20 hit pixels

20% 25% 50% laser tune



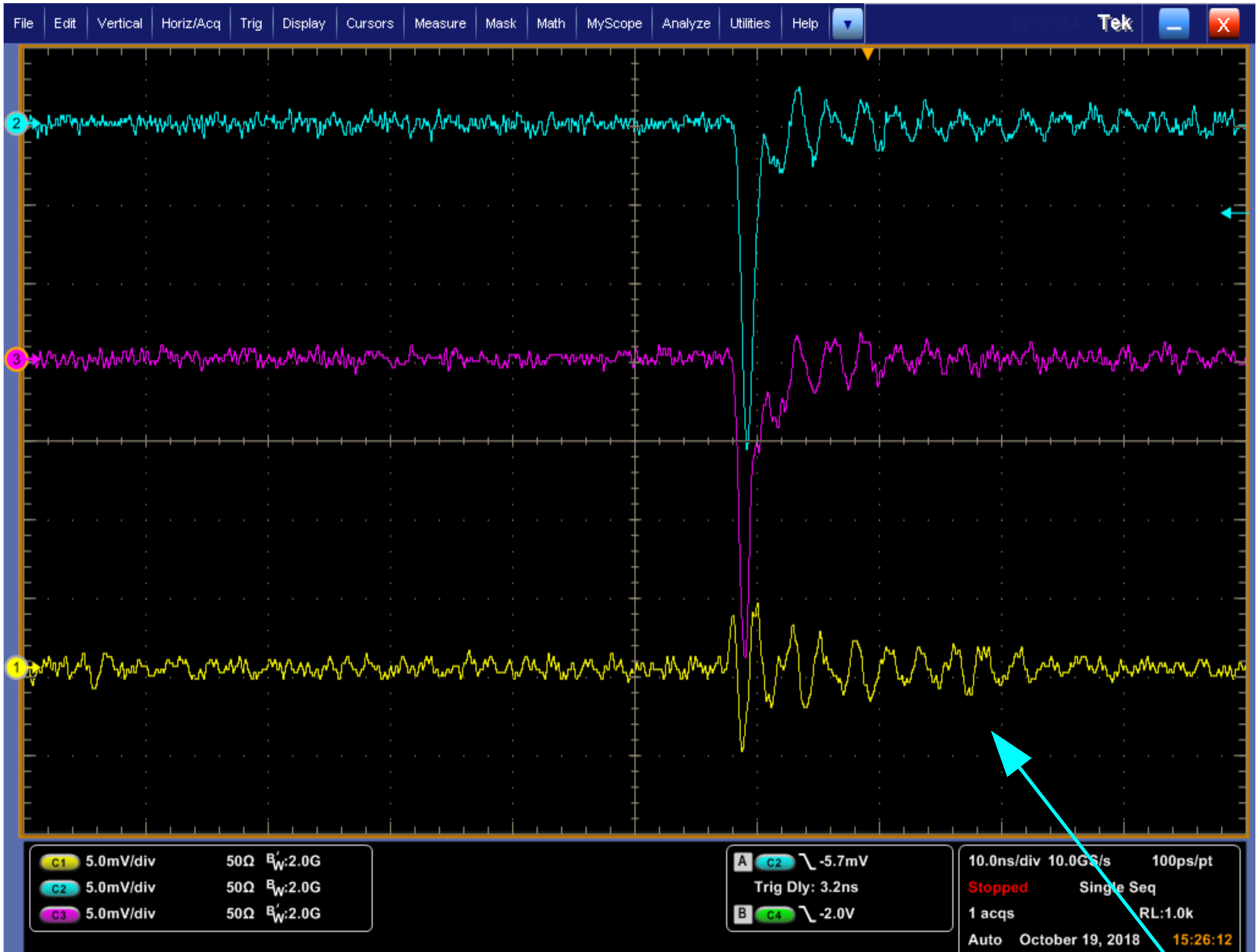
Masked pixels show signals

PILAS 20kHz 25% tune

Illum.
pixel

Illum.
pixel

shad.
pixel



All 5mV/unit

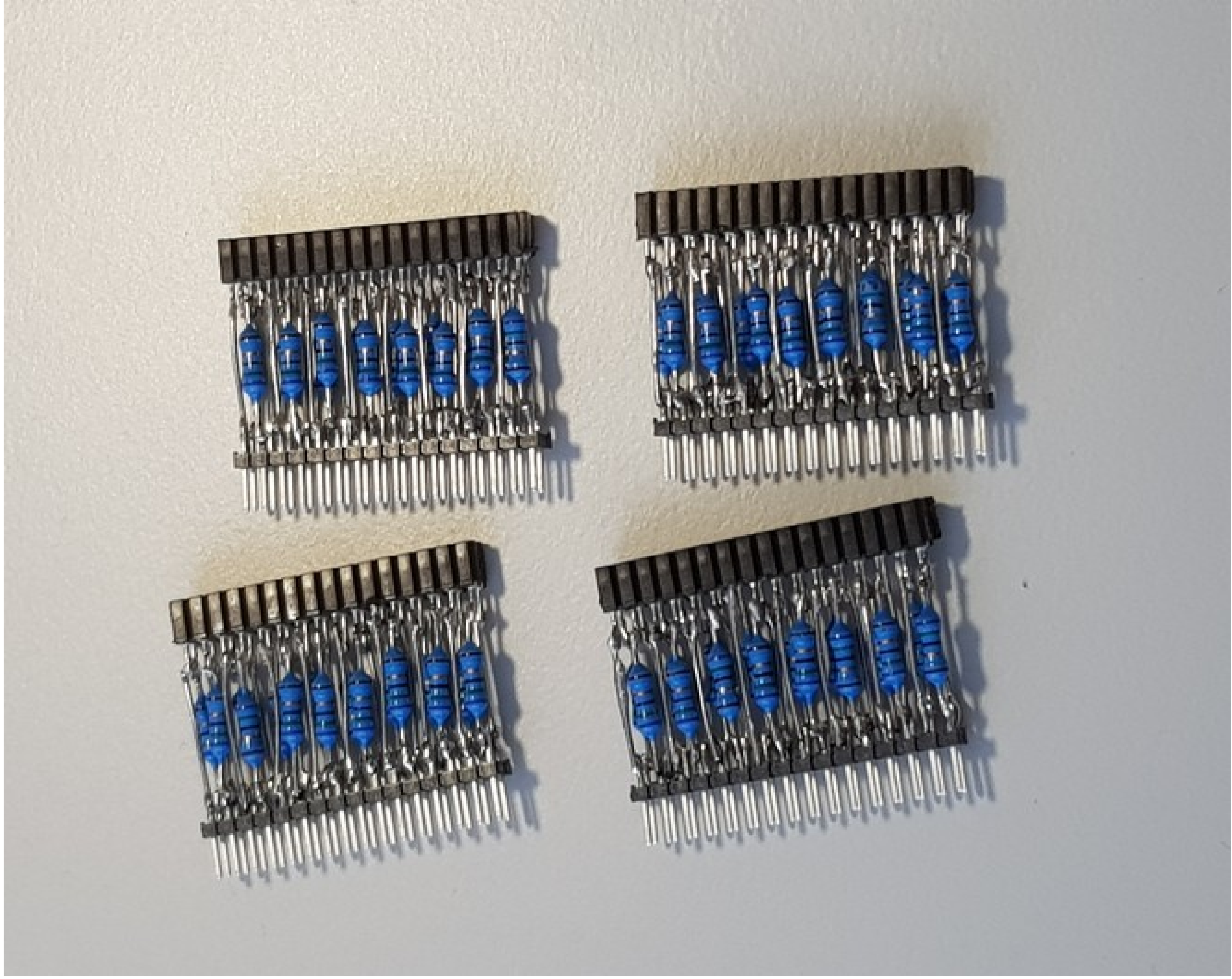
Ringing starts at ~20% tune (certain intensity)

400 MHz = 1 / 2.5ns

Idea:

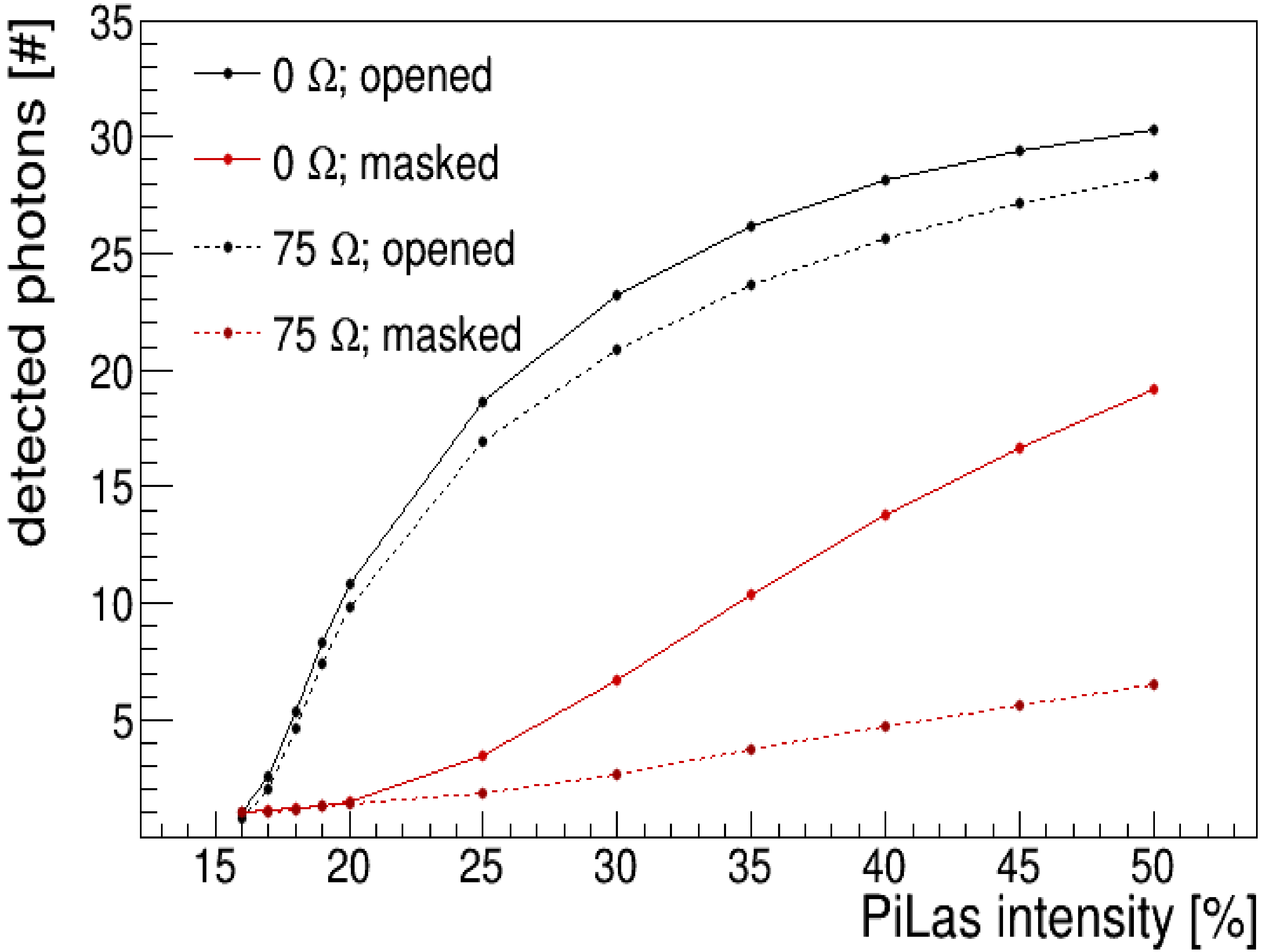
Damp oscillations/ringing by resistors.

Chosen:
R=75 Ω



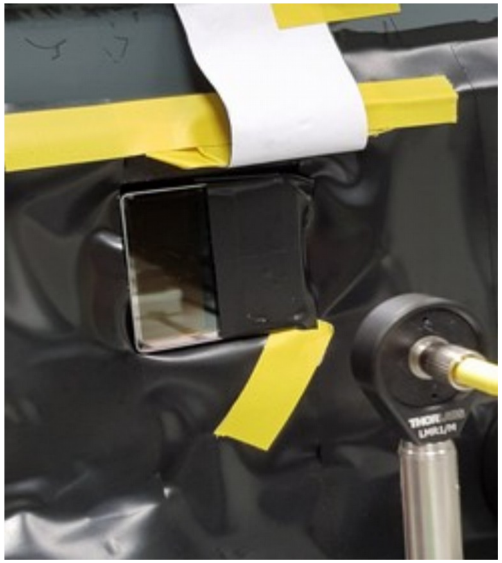
Hit number saturates at 32 pixels,
Double photon hits are still increasing.

1 mV threshold

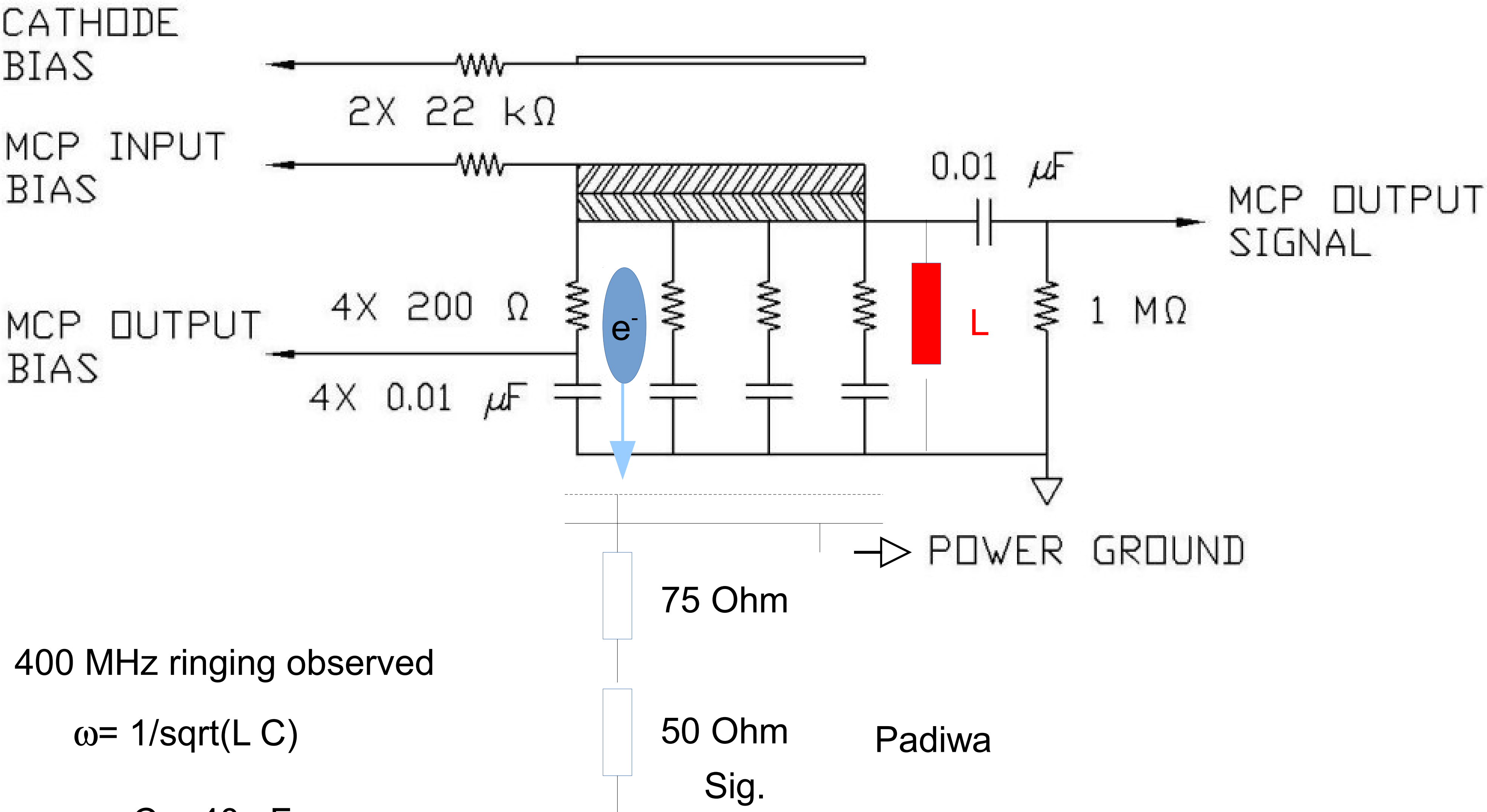


7%

drop unclear



Resistor helps to decrease ringing



400 MHz ringing observed

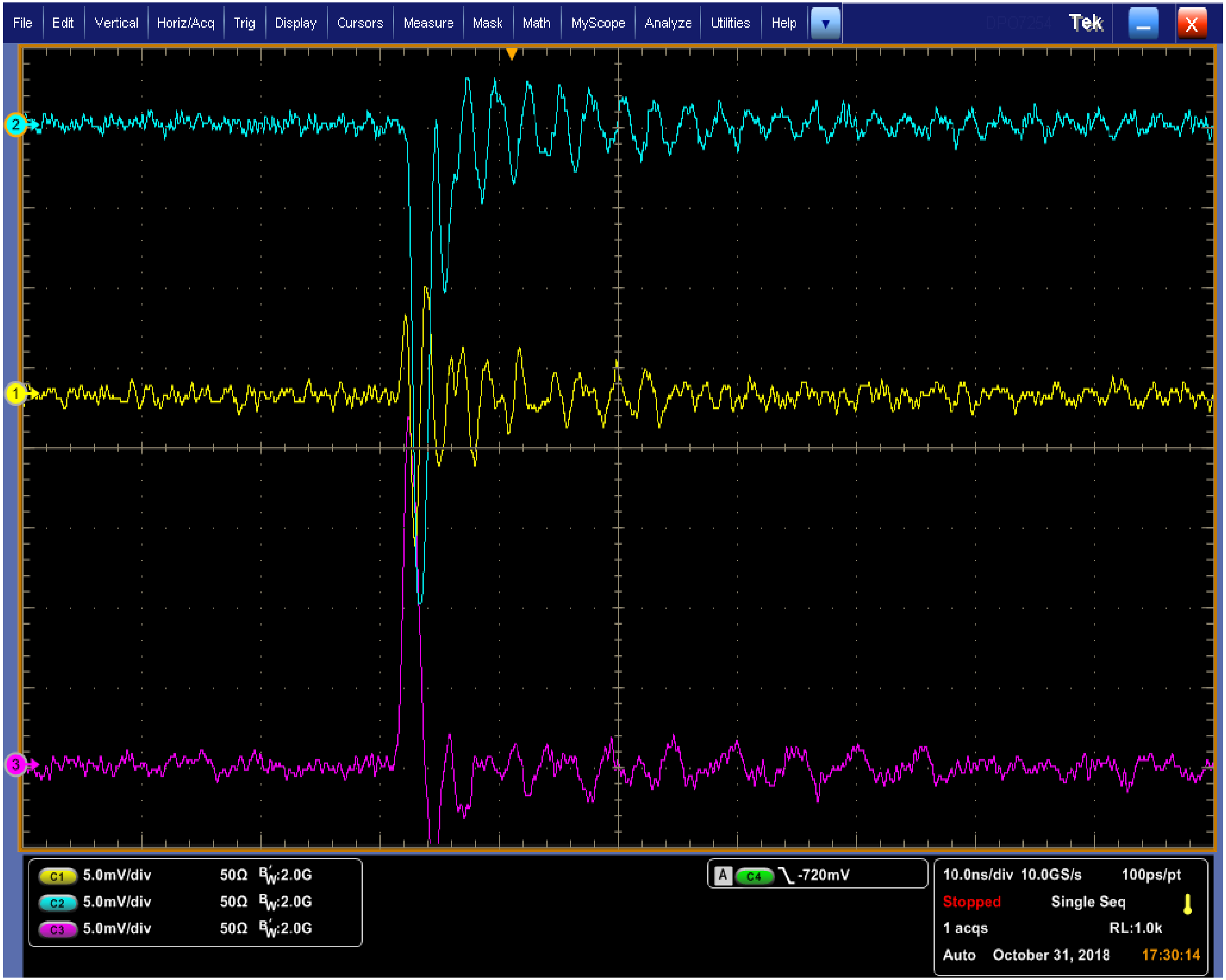
$\omega = 1/\mathrm{sqrt}(L\ C)$

C = 40 nF

→L= 4 pH very small, **too small** ←→ PCB path 0.25mm width: 10 nH/cm

Ringing probably not due 10 nF capacitors...

Pilas, 20 kHz, 30% tune



Illuminated px.

Shaded px.

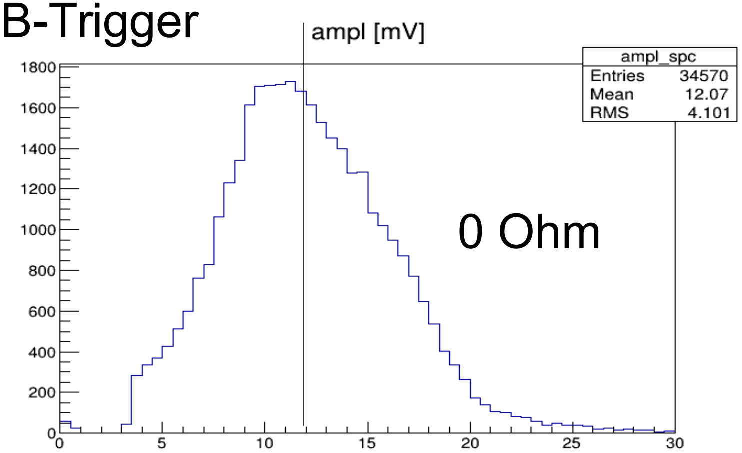
MCP-out

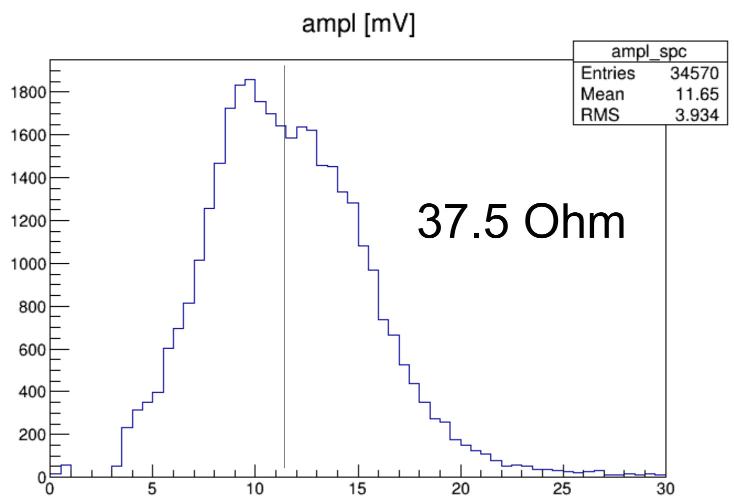
Less ringing?

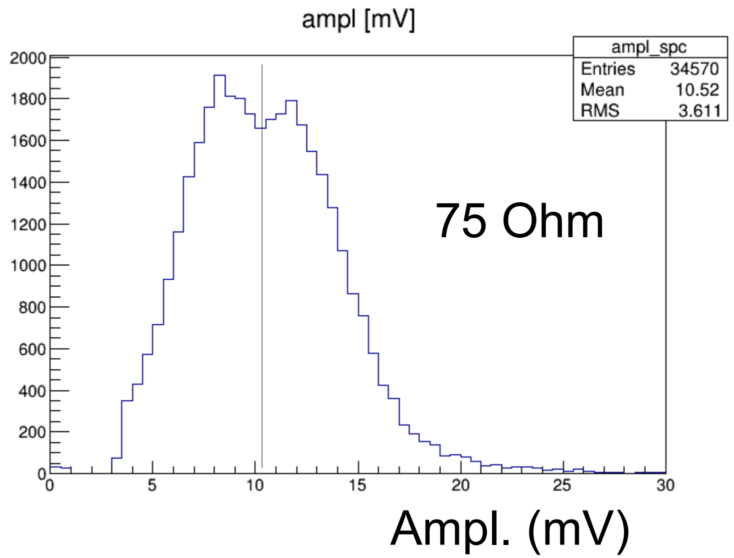
No change in signal shape, when MCP-out terminated by 0, 50 or ∞ Ohms

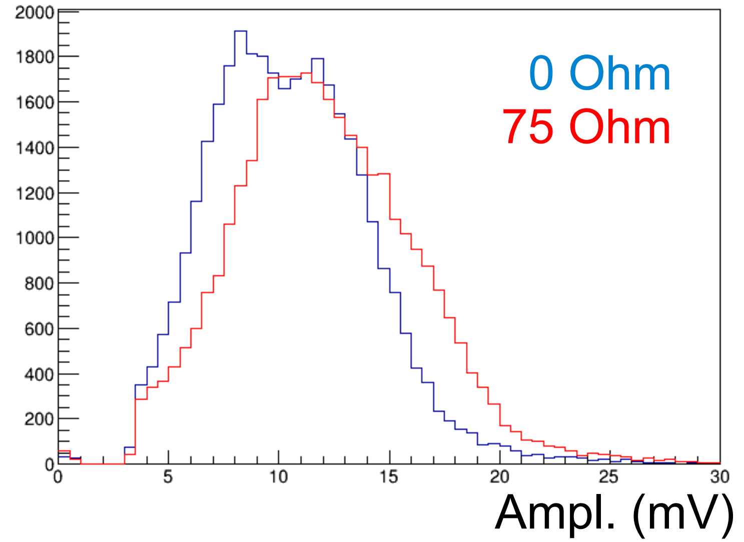
Amplitudes of a single pixel (complete mask with hole)
For 0 / 37.5 / 75 Ohms

A-B-Trigger

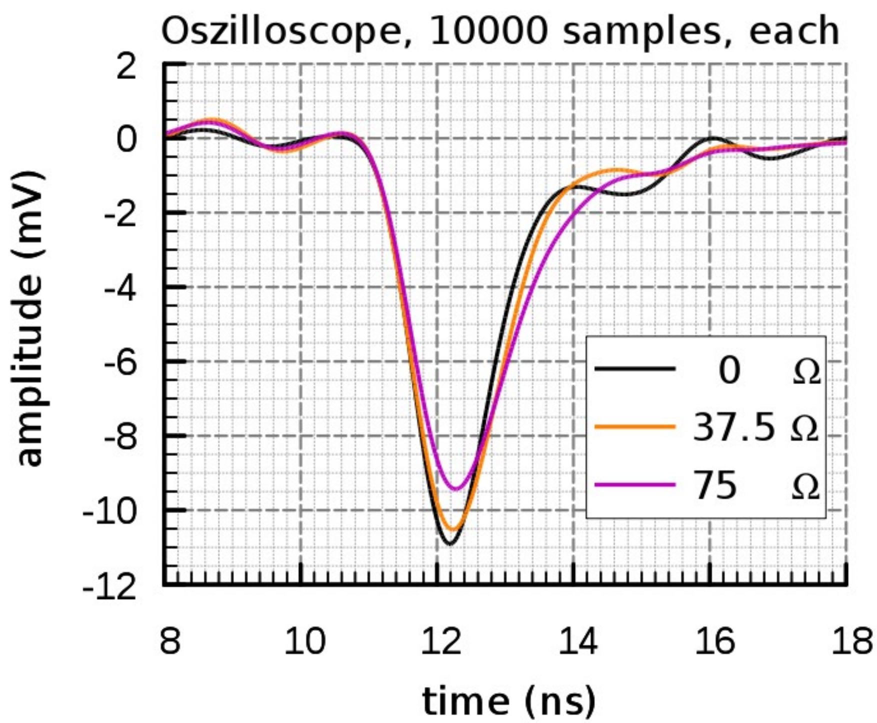








Low laser tune

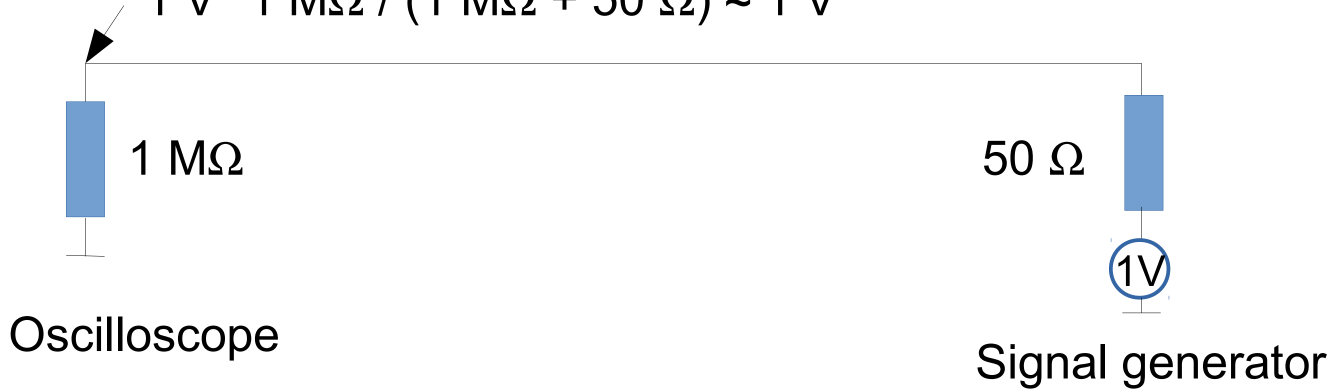


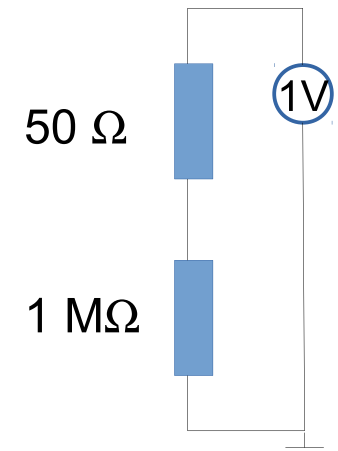
75 Ohms: attenuation of only x 0.87

What attenuation is expected?

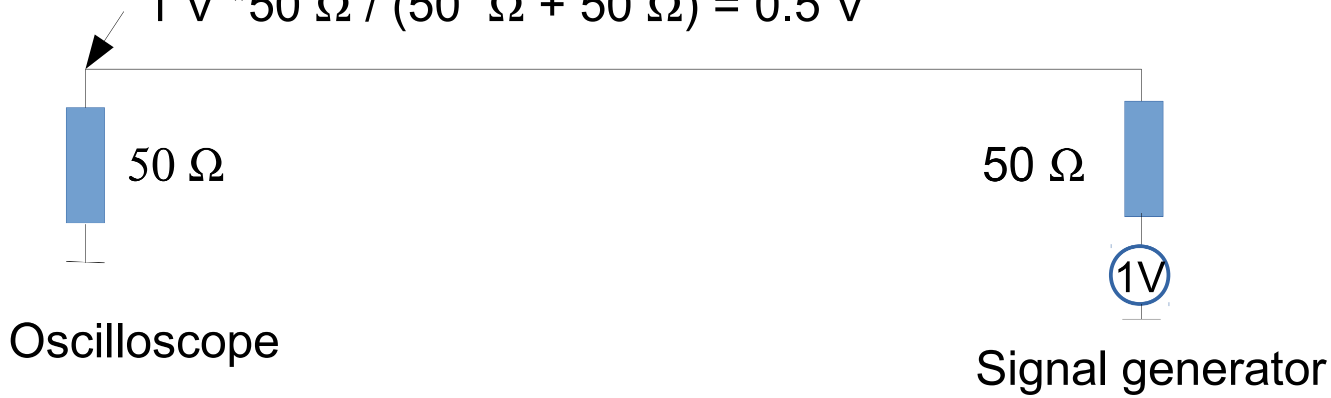
Neclected:
mismatch to 50 Ω cable

1 V *1 MΩ / (1 MΩ + 50 Ω) ≈ 1 V



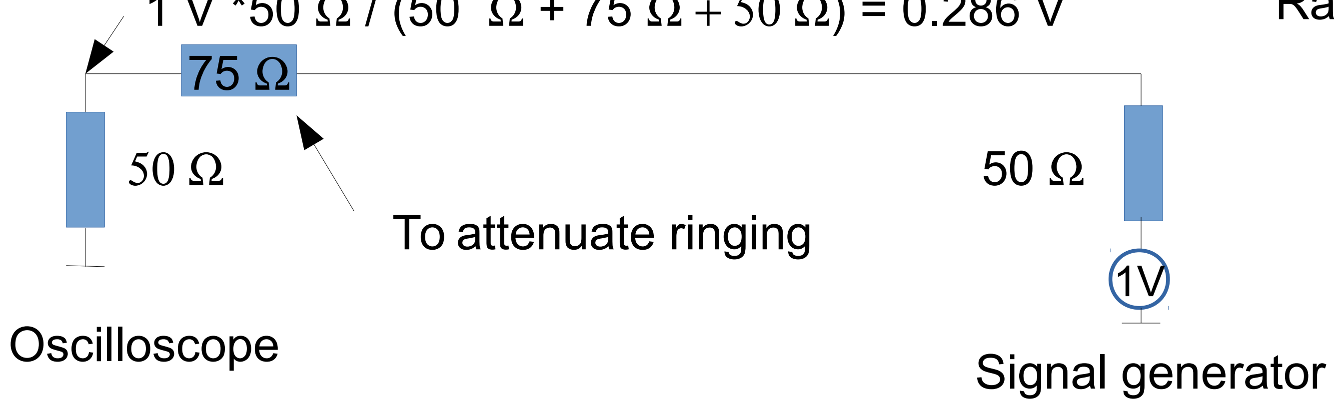


1 V *50 Ω / (50 Ω + 50 Ω) = 0.5 V

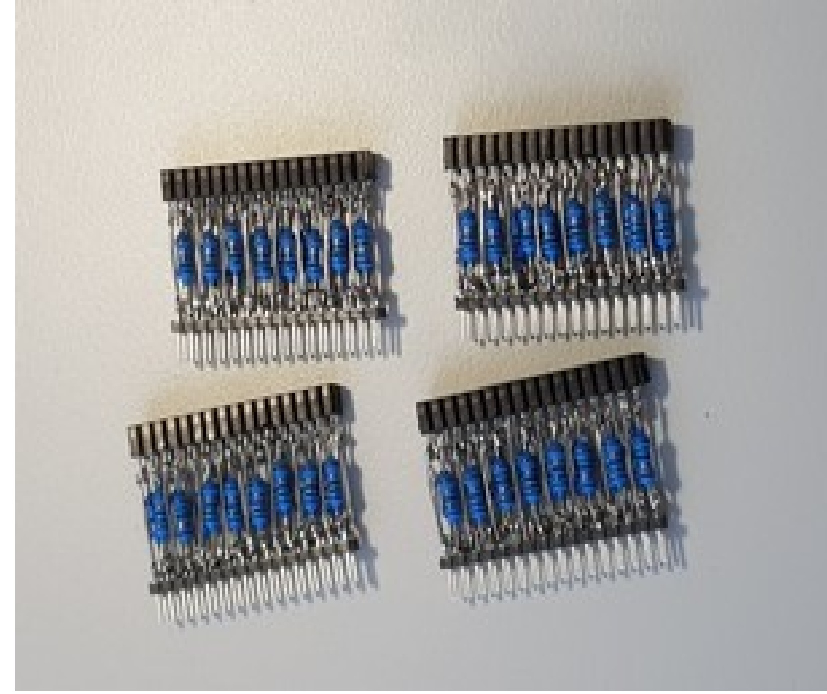


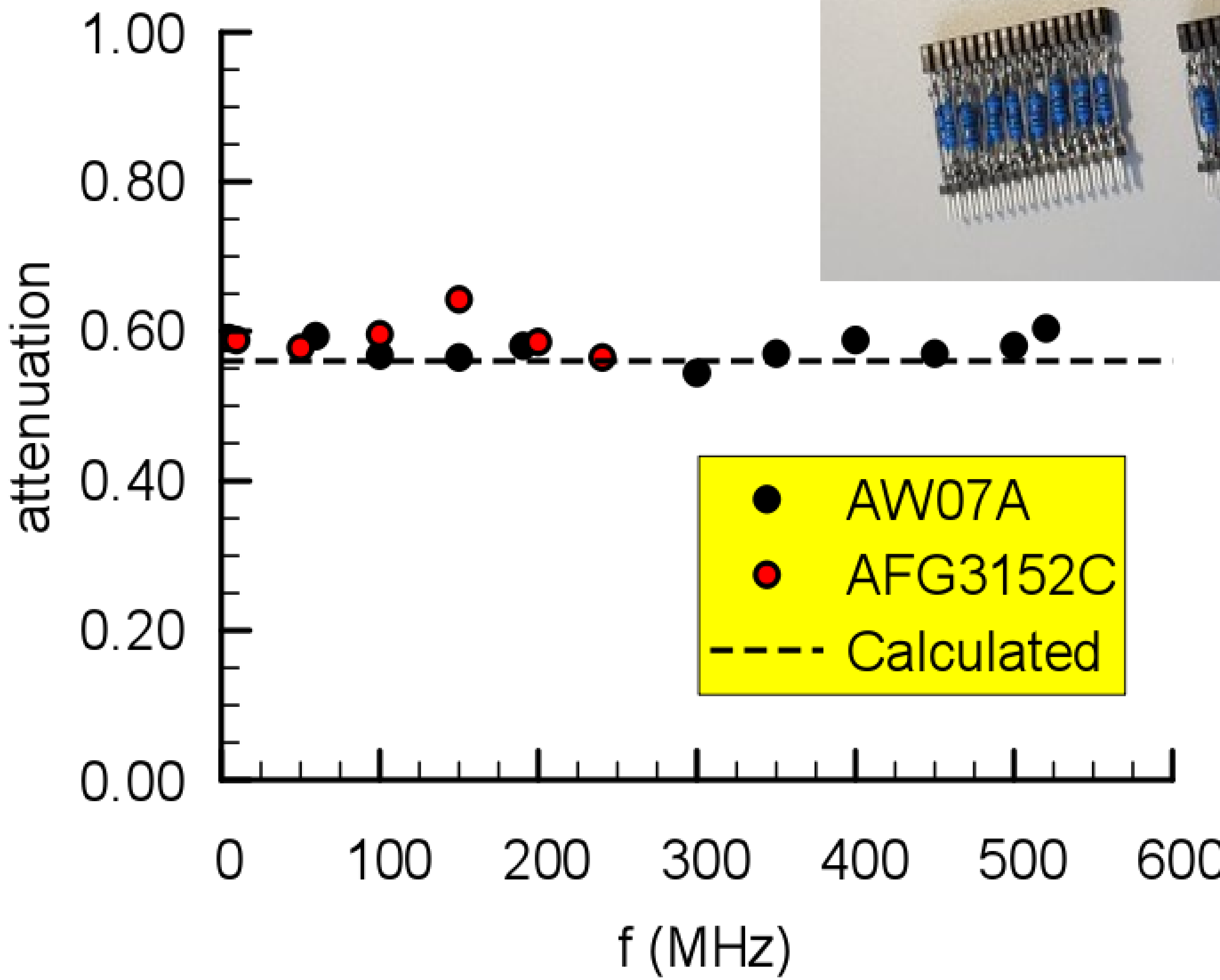
1 V *50 Ω / (50 Ω + 75 Ω + 50 Ω) = 0.286 V

Ratio 0.286/0.5 = 0.572



Test of 75 Ω device

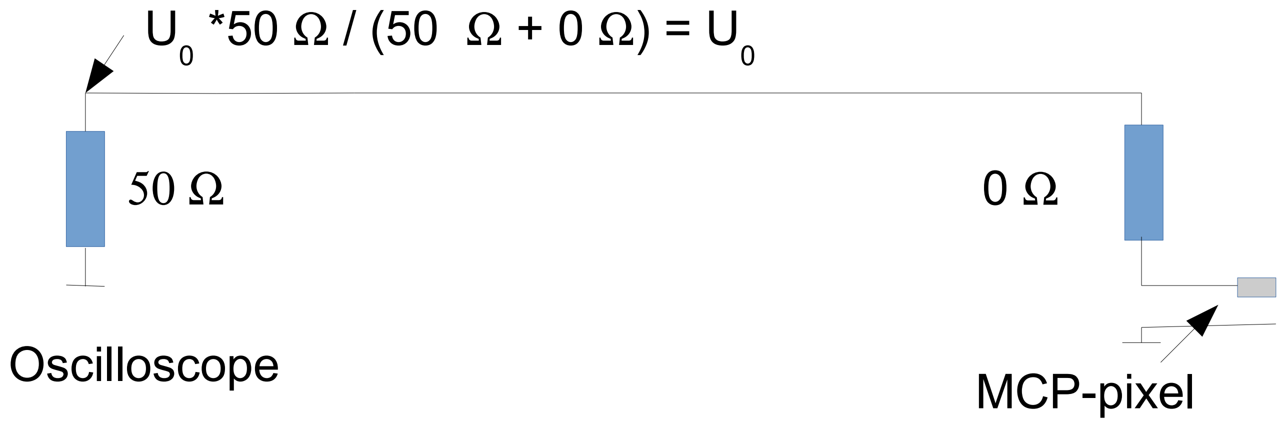


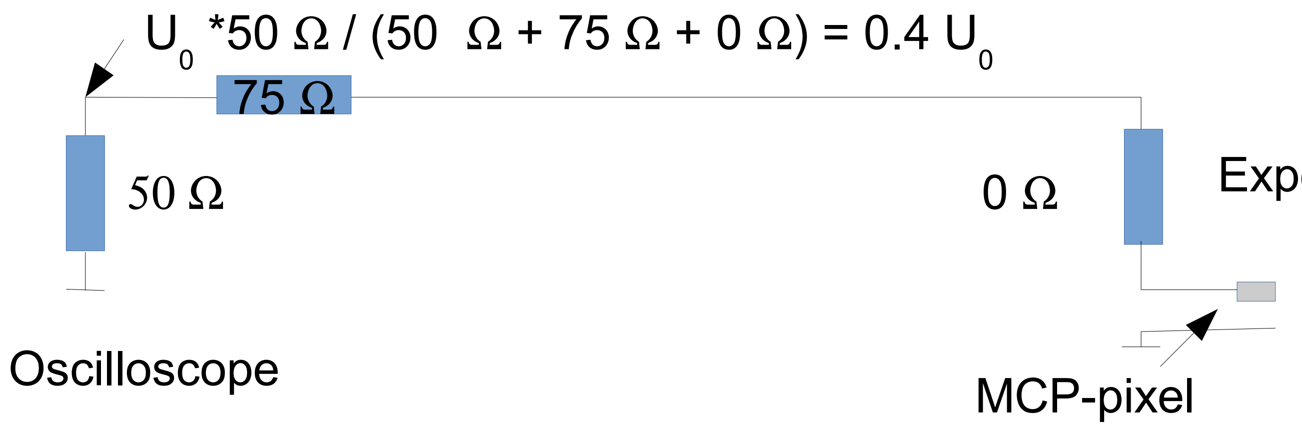


Signal generator

Impedance not zero. Right value of attenuation for impedance of 452 Ω

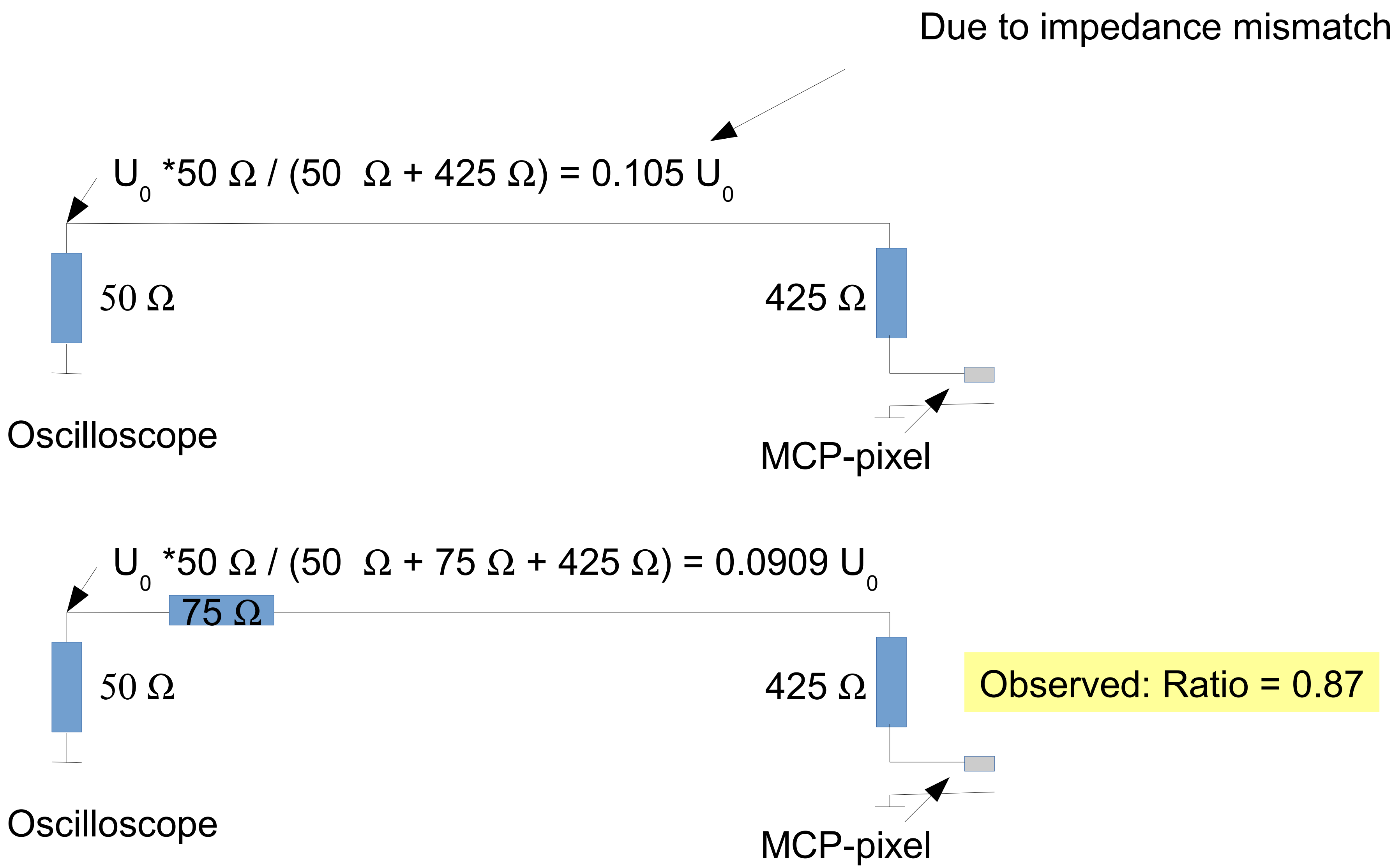
What attenuation is expected?



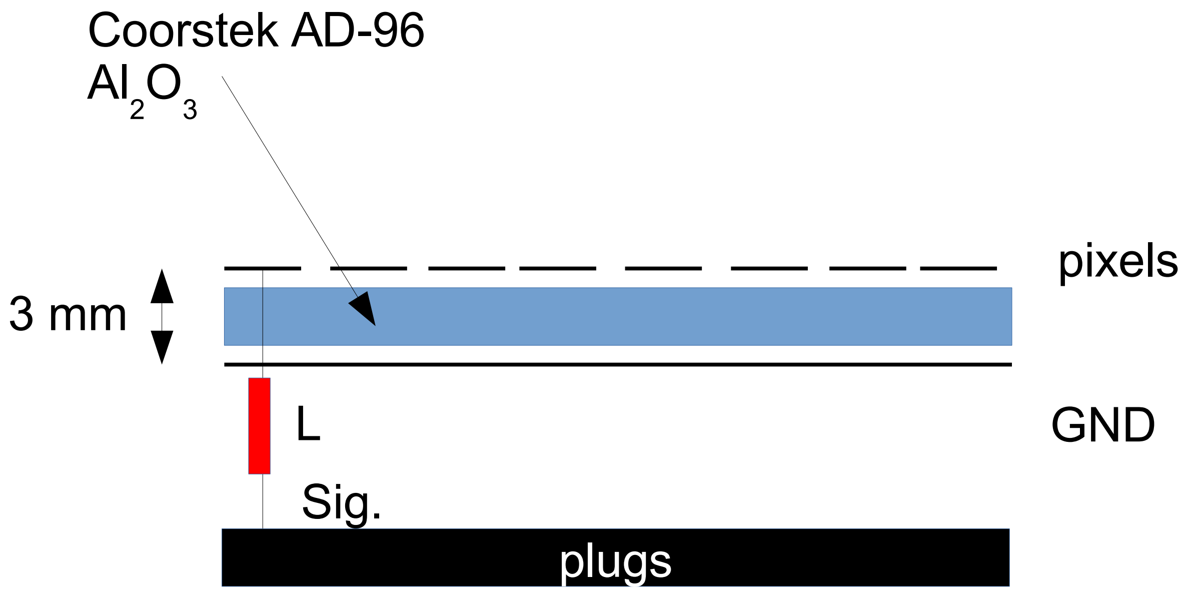


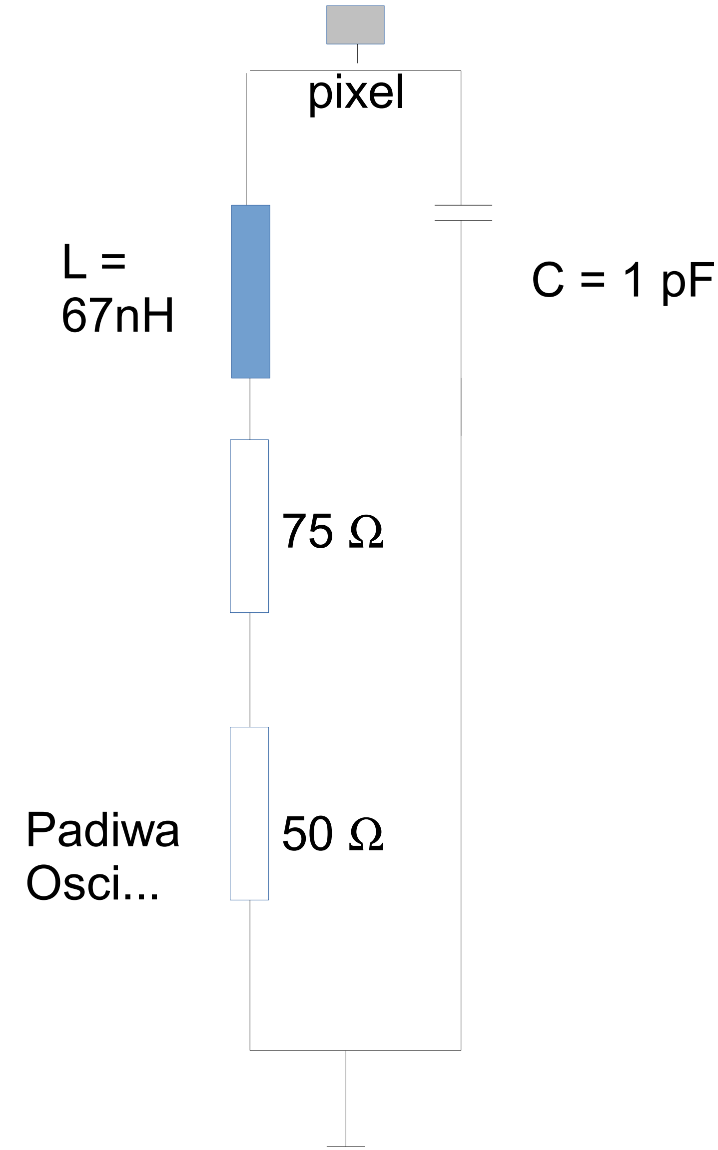
Expected Ratio w/o 75 Ω: 0.4

But: observed: Ratio = 0.87


Due to impedance mismatch
U0 *50 Ω / (50 Ω + 425 Ω) = 0.105 U0
50 Ω
425 Ω
Oscilloscope
MCP-pixel
U0 *50 Ω / (50 Ω + 75 Ω + 425 Ω) = 0.0909 U0
75 Ω
50 Ω
425 Ω
Observed: Ratio = 0.87
Oscilloscope
MCP-pixel

Assume anode plate oscillations





$$C = 8.85\text{e-}12\ \text{As/(Vm)} * \frac{\overset{\varepsilon_r}{9} * (6\text{e-}3\ \text{m})^2}{3\text{e-}3\ \text{m}} = 1\ \text{pF}$$

$R = \omega L = 425\ \Omega \rightarrow L = 67$ nH @ 1 GHz (7 cm wire)
$L = 34$ nH @ 2 GHz (3 cm wire)

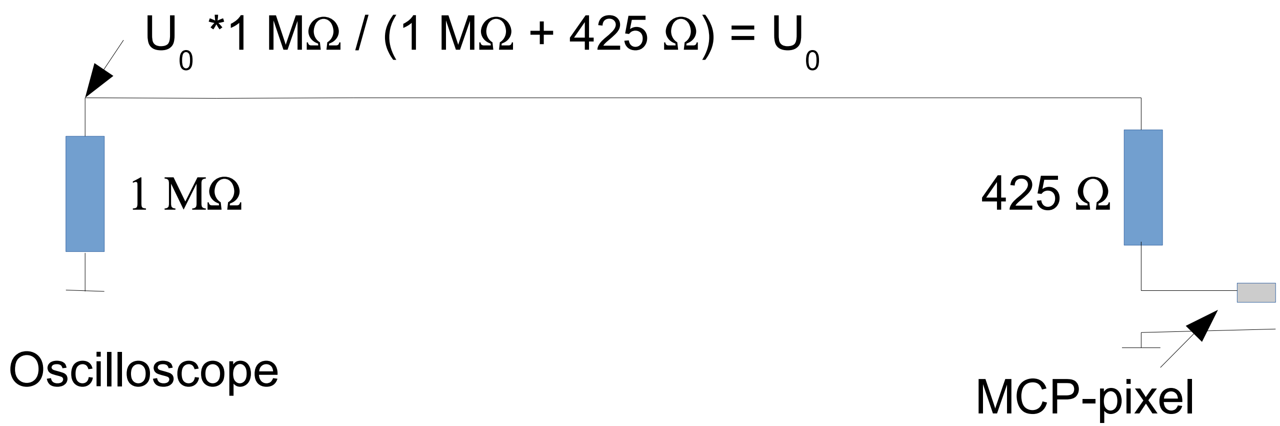
→ $\omega = 1/\text{sqrt}(L\ C)$ f= 615 MHz ringing for signal of 1 GHz

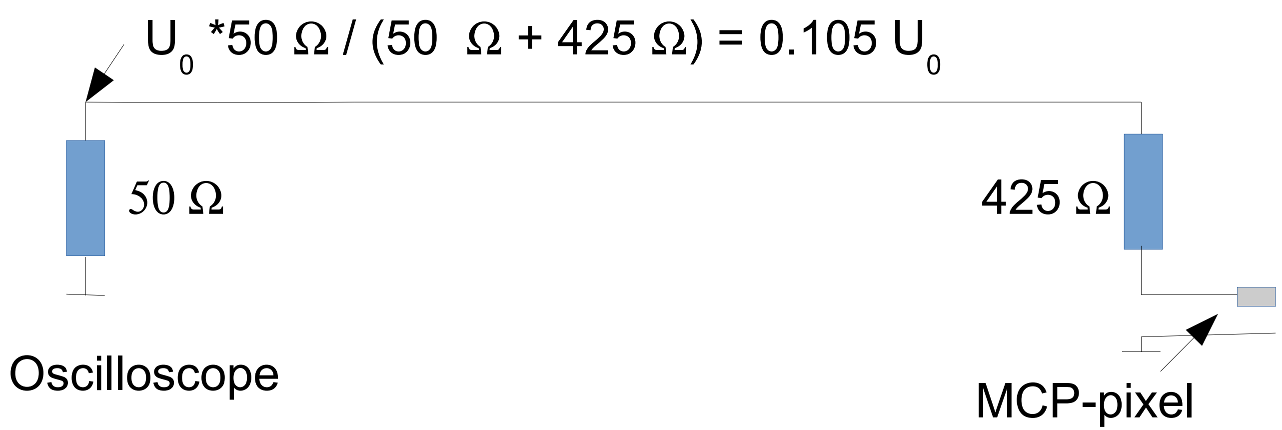
f= 435 MHz ringing for signal of 2 GHz

Right order of magnitude

Is there really an impedance of 425 Ω ?

Switch oscilloscope to 1 MΩ



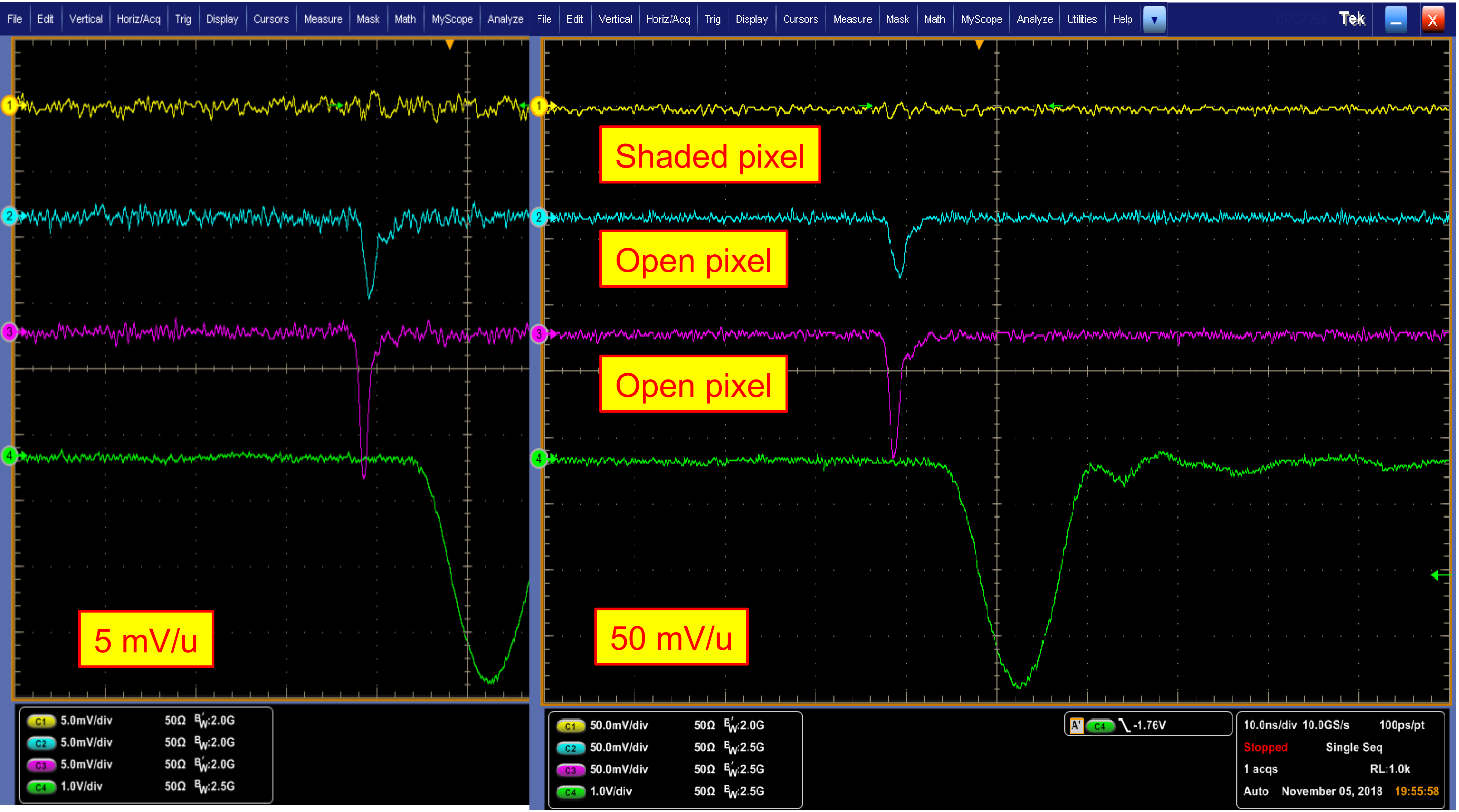


Adding up the reflections it might be true, signals are 10x larger

No damping 75 Ω

16% laser tune

50% laser tune



The ringing “disappeared”

Here it is in the noise

Here the ADC cannot resolve it

Summary

The damping resistors help to minimize ringing.

There is a large impedance of the pixel

If impedance due to inductance of wires

There is room for possible improvement of the backplane
for **larger signals** and
less ringing

Still unclear: how the ringing couples to shaded pixels

Remark: Typical values for the carbon-composition resistor (with 1/4-inch leads) might be 14nH of series inductance and 1-2pF parallel capacitance.