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# A Model for Crosstalk in Micro-Pattern Gas Detectors

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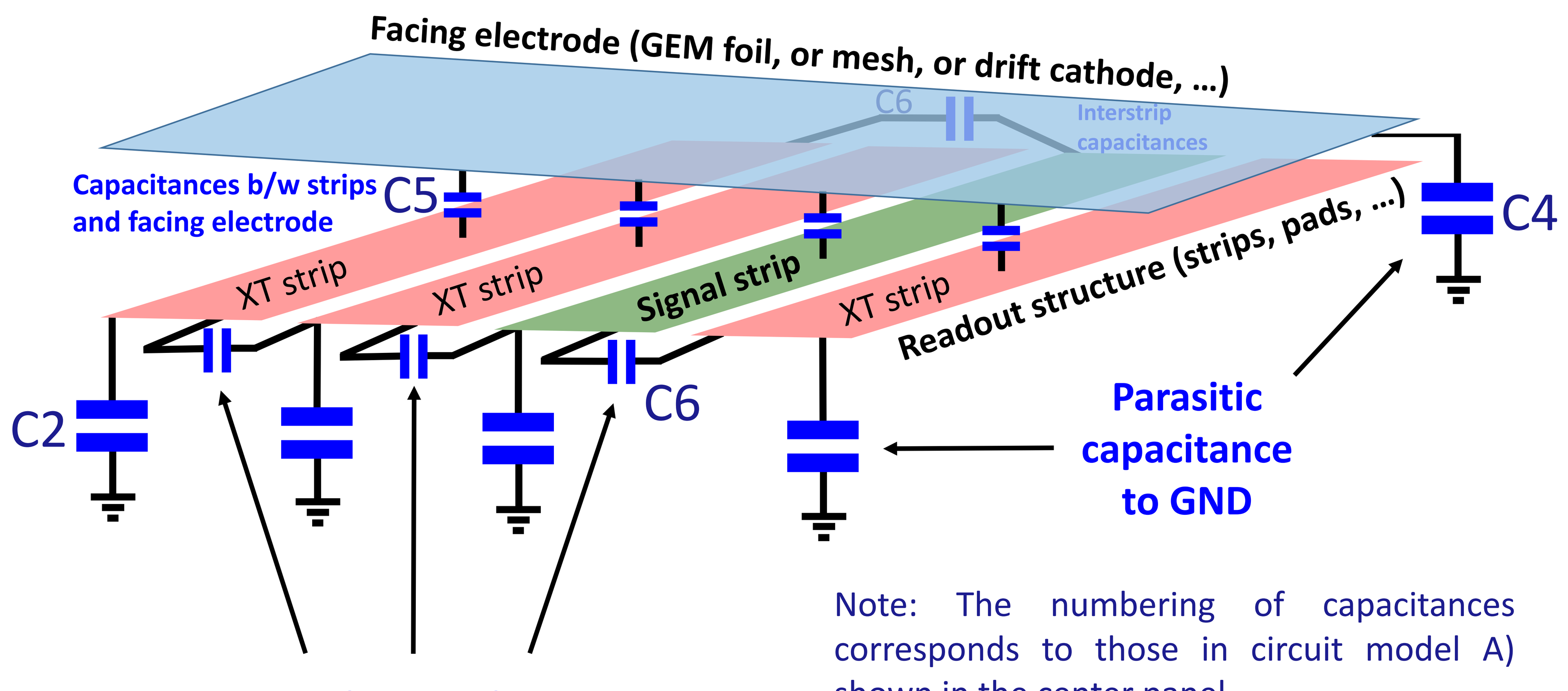
## Abstract

Crosstalk (XT) characteristics such as pulse amplitude and shape are studied with a simple PSPICE model of the capacitive couplings within an MPGD. The crosstalk pulse shape can be understood as due to a CR-differentiator. Crosstalk can occur simultaneously through more than one capacitive coupling path. The crosstalk signals on these paths add differently if the signal is induced via a current source as in normal detector operation or via a voltage source as is often done in benchtop tests with an external voltage pulse generator. A few means for reducing the crosstalk are investigated with the model. It shows that a low-impedance AC path from the amplification electrode that faces the readout structure to ground is important for achieving low crosstalk, which implies a need for a sufficiently large capacitance of that amplification electrode to ground. This result has consequences for how much an amplification electrode can be segmented.

## Capacitances in MPGDs

Numerous capacitances among MPGD electrodes, which can be substantial (tens of pF) due to the small gaps in MPGDs, as well as parasitic capacitances between MPGD electrodes and detector ground play a role in the generation of crosstalk between readout structures via capacitive coupling:

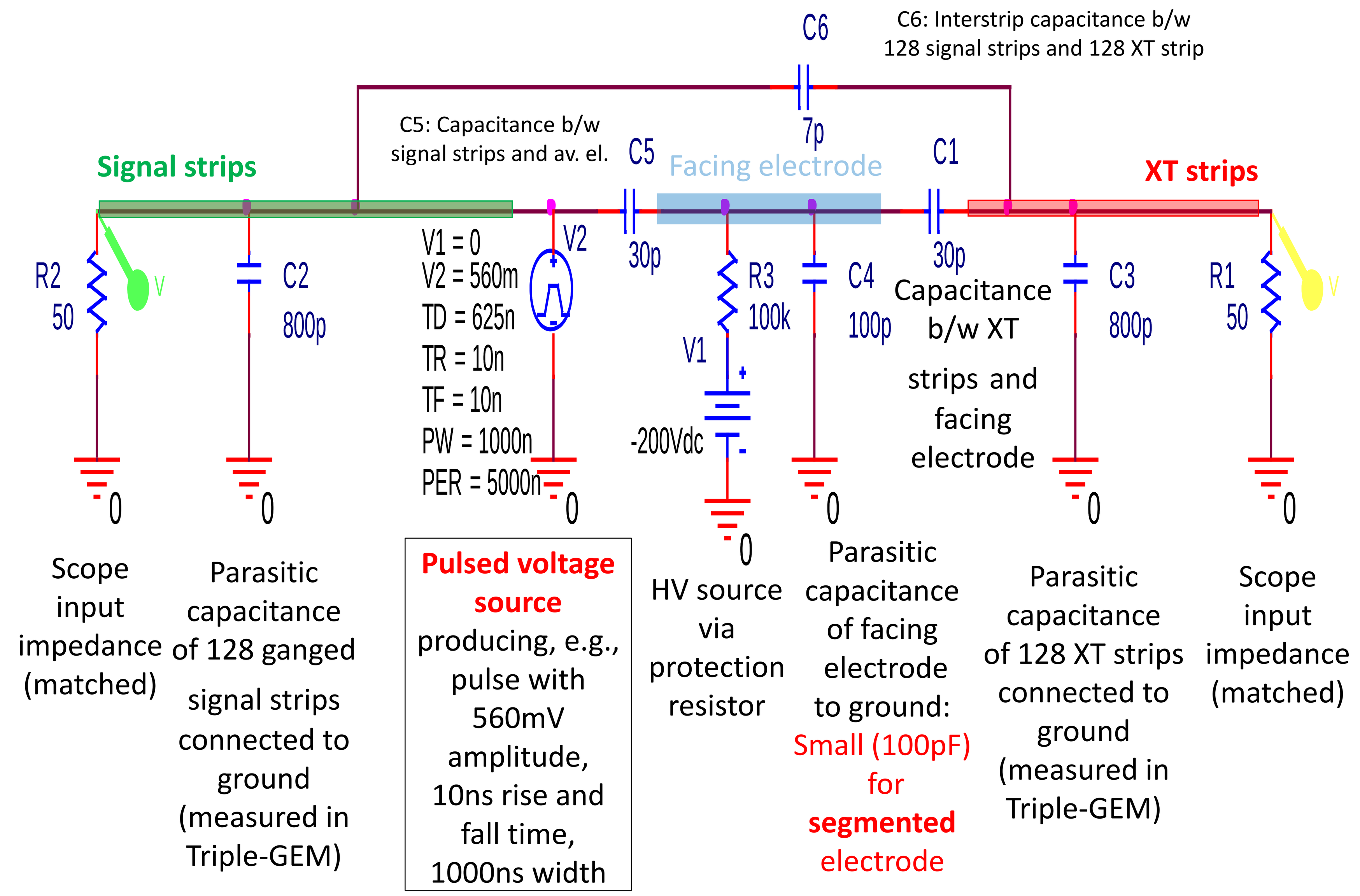



Note: The numbering of capacitances corresponds to those in circuit model A) shown in the center panel.

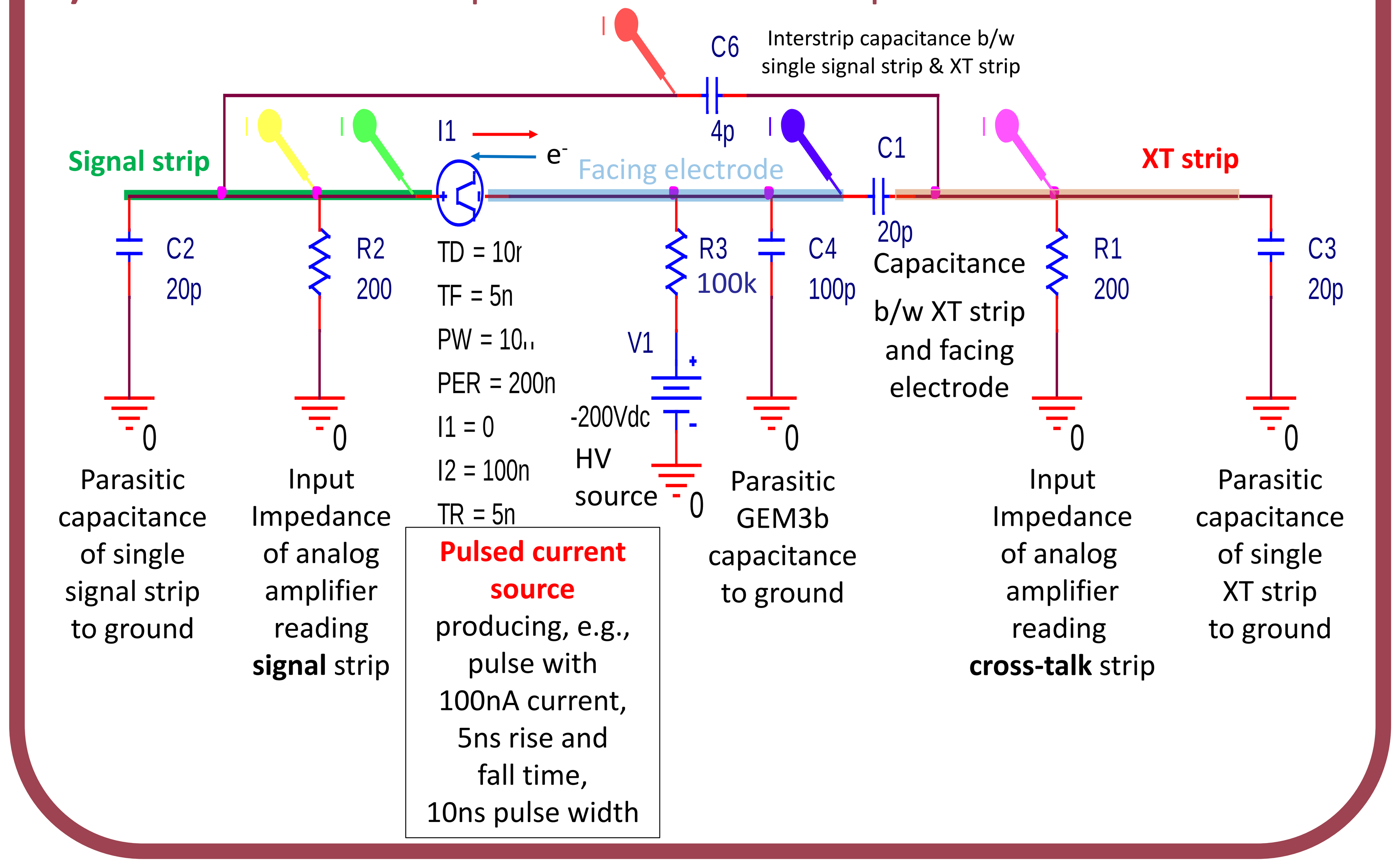
The motivation for this study is an experimental observation that a segmentation of the bottom of the third GEM foil (facing electrode) in a Triple-GEM intended to reduce discharge propagation causes substantial opposite-polarity crosstalk.

## Circuit Models

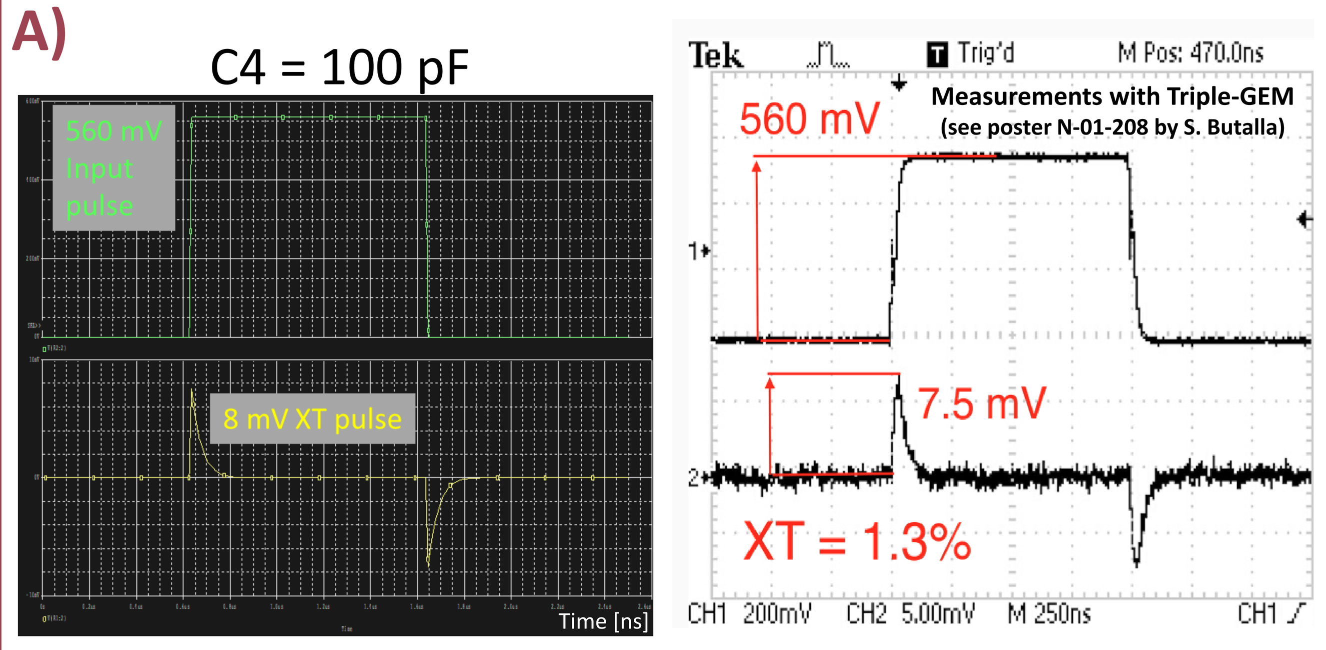
**A) Bench test with external voltage pulser modeled as voltage source:**




**B) Normal avalanche operation modeled as pulsed current source:**

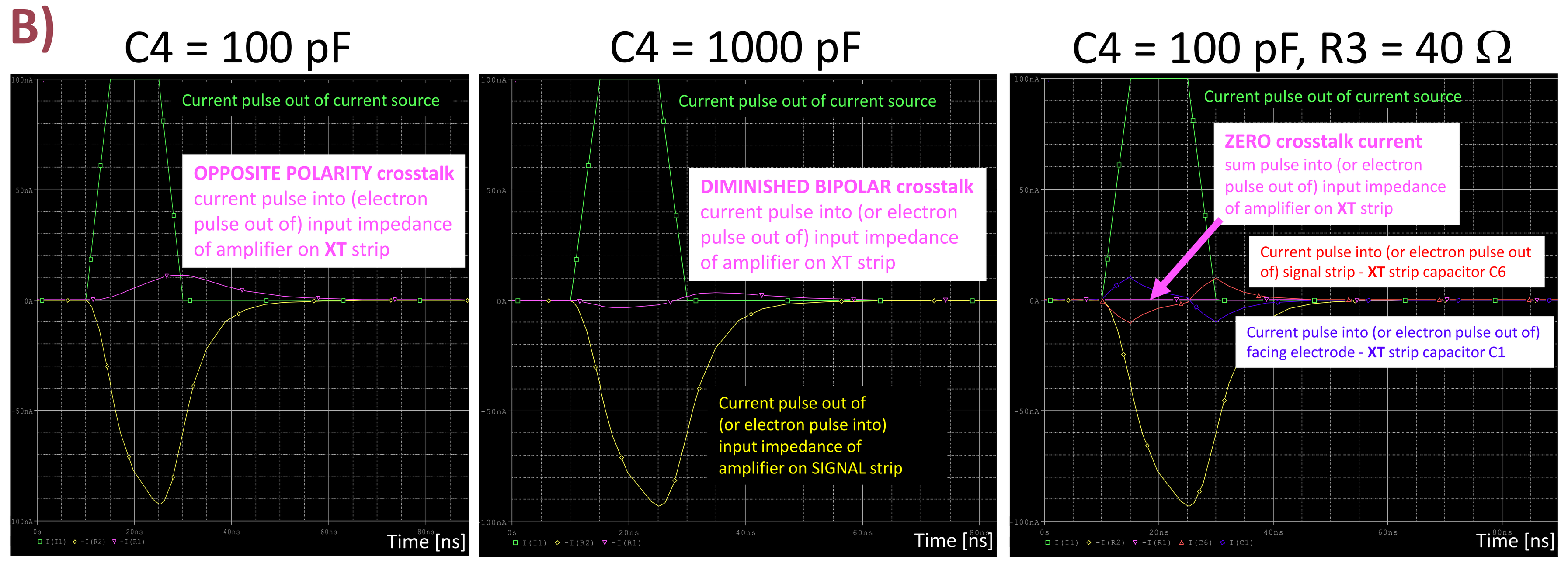



## Simulation Results With Pspice




**Observations:**

- The simulation **reproduces measured** XT amplitude (1.3 %) and pulse shape very well
- The XT pulse has the same **polarity** as the input pulse on the leading edge and opposite polarity on the trailing edge
- The XT pulse shape is due to **clipping** of the input pulse shape by the **CR filter circuit** composed of the C1,C6, and R1 circuit components




**Main observation:** The electron pulses into the amp on the **signal strip** (yellow) and the amp on the **XT strip** (purple) have **OPPOSITE polarity!**

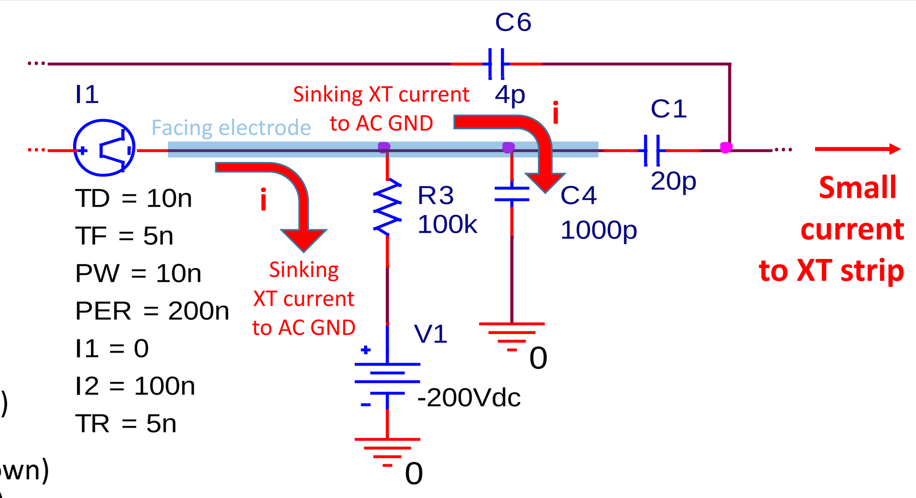
**Main observation:** The amplitude of the XT pulse (purple) is **diminished by a factor ≈ 4** and has become **bipolar.**

**Main observation:** The two XT contributions (red & blue) have opposite polarity and cancel out. The net XT current (purple) is zero! The signal current (yellow) is unaffected.

## Observations & Conclusions

**The results from the PSPICE model**

- **replicate** experimental XT results obtained for a Triple-GEM MPGD with a voltage pulser
- **explain** why tests with a voltage pulser produce *same-sign* XT pulses while tests with a GEM in normal operation produce *opposite-sign* XT pulses as due to the difference between an external voltage source and an internal current source
- **show** that any method for reducing the impedance Z of the facing electrode to AC GND & **sinking XT current to AC GND** (see circuit section on right) will reduce crosstalk:
  - facing electrode with larger area and capacitance ($Z = 1/\omega C_4$)
  - connection of facing electrode without protection resistor
  - bypass capacitor around 100 kΩ protection resistor (not shown)
  - direct bypass cap. from facing electrode to GND (not shown)
- **show** that by reducing the protection and HV filter resistances to specific values, the XT components from facing electrode and from interstrip capacitance can cancel out and the net XT vanishes
- **show** that this mitigation has no big impact on signal integrity




- **caution** that the mitigation via the "facing electrode to ground impedance" has its limits due to the additionally present impedance from the interstrip capacitance and due to its frequency dependence