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Research on fast grounding simulation method for the MPGD with resistive layer

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1. Introduction

Applying resistive layer between electron multiplying region and readout array:

Advantage:

- High sparking resistance
- High gain with single-layer MPGD
- Better stability and robustness

New challenge:

- Detector gain decrease at high counting rate
- Non-linear relationship between detector gain, counting rate and irradiation area

Detector design optimization:

- **Fast grounding** of the resistive layer

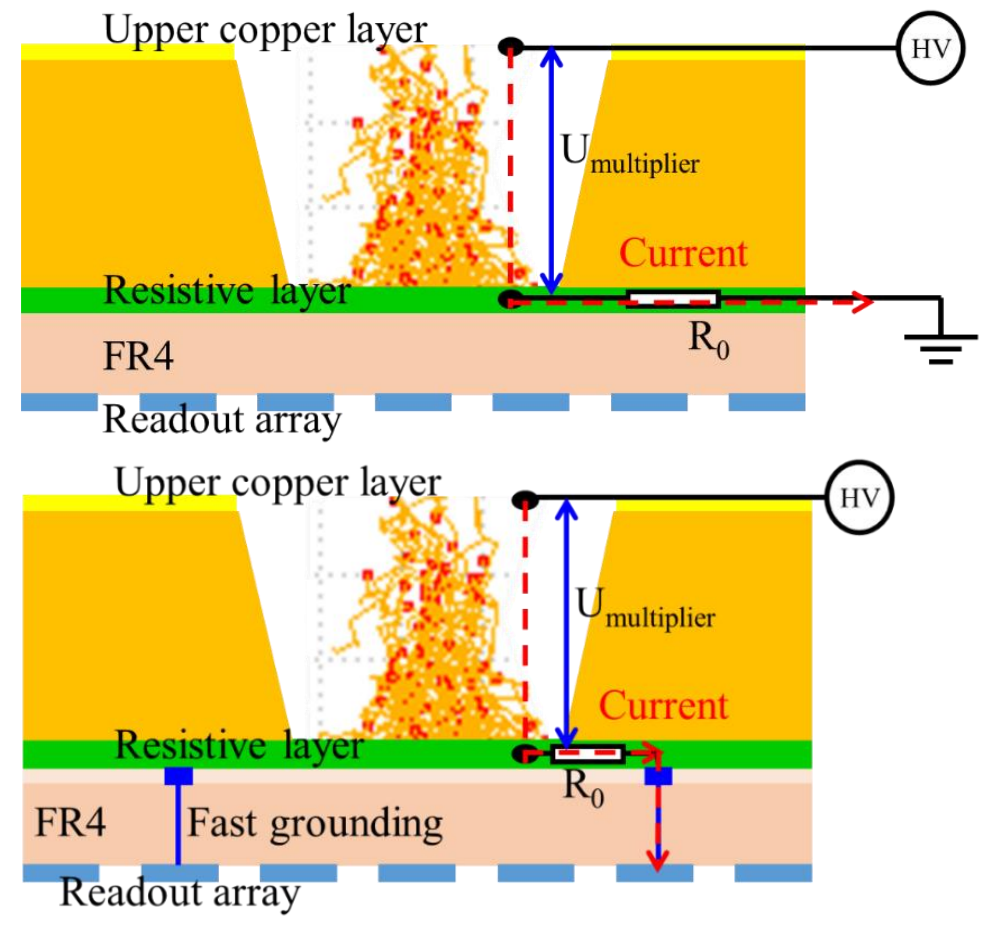

Fig. 1 μRWELL design without (upper) and with (lower) fast grounding resistive layer.

2. Principle analysis

Several effects will cause the gain decrease:

- **Flowing current effect**

  When the multiplied electrons flow into the ground via the resistive layer, there is a current on the resistive layer surface, leading to a voltage drop.

- **Charge accumulation effect**

  The electron discharge speed is limited by the time constant of the circuit loop between the resistive layer and ground, causing a charge accumulation on the resistive layer surface and affecting the electric field.

- **High voltage filter circuit influence**

  The protection resistor in the high voltage filter circuit connected to the upper copper layer of MPGD will also generate voltage drop on it.

3. Simulation methods

- Flowing current effect can be simulated based on constant circuit with MATLAB. There are two effective methods:

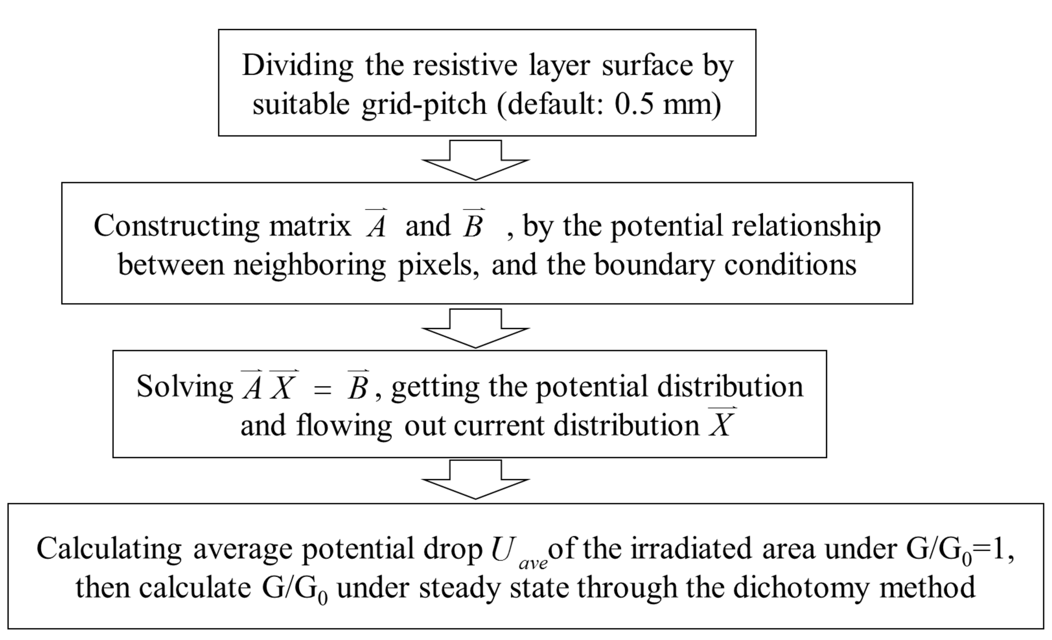

Fig. 2 Flowchart of Kirchhoff equation-based simulation.

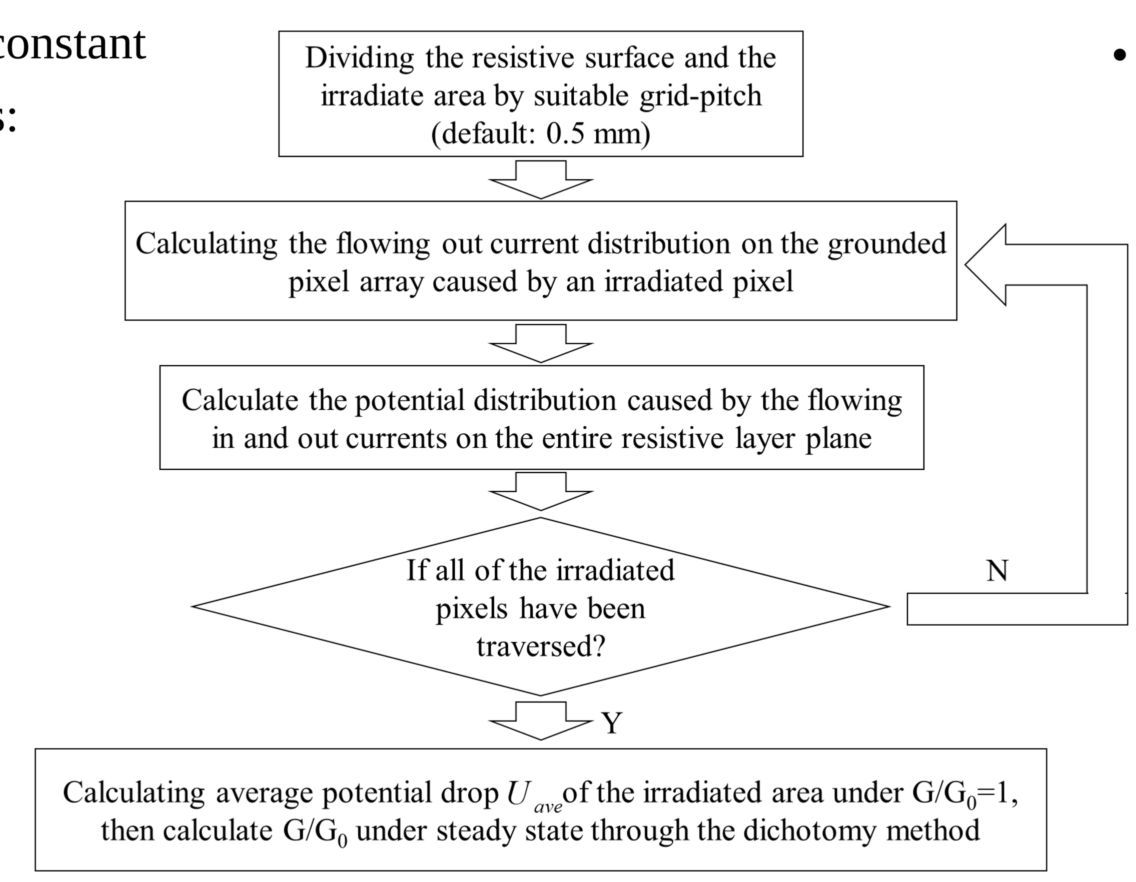

Fig. 3 Flowchart of Ohm's law-based simulation.

- Charge accumulation effect can be simulated by Garfield and MATLAB. Also, it needs the voltage drop distribution on the resistive layer to calculated the surface charge density at G/G_0=1.

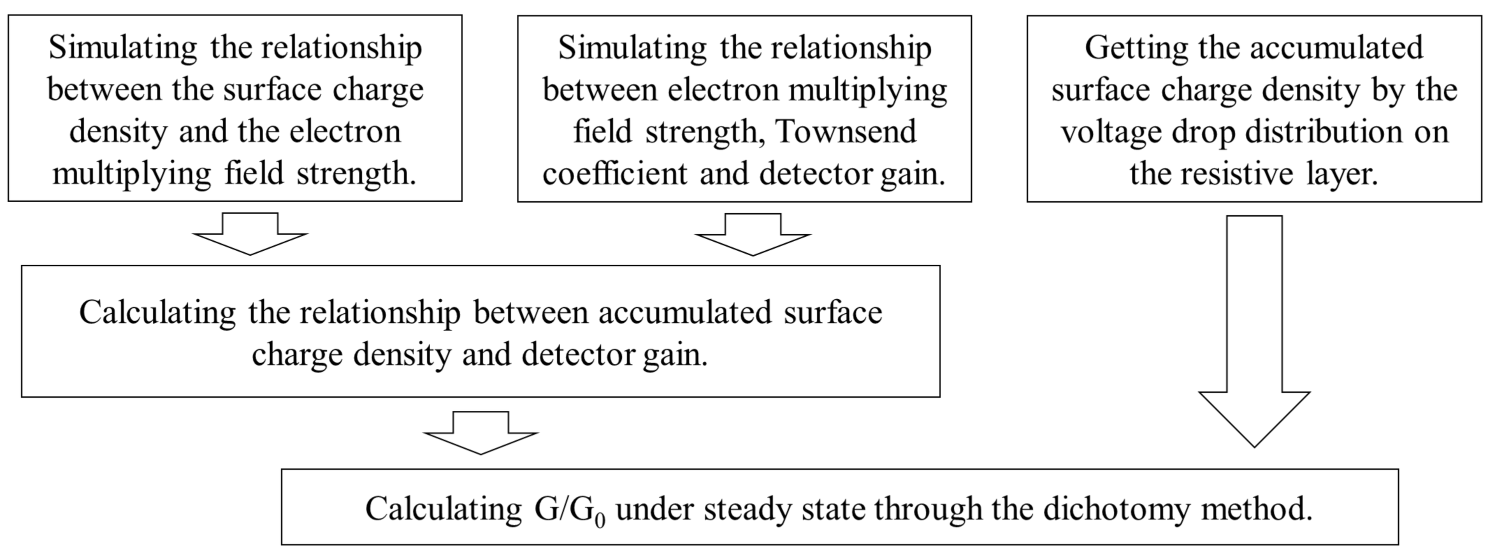

Fig. 4 Flowchart of charge accumulation effect.

- Voltage drop caused by high voltage filter circuit is proportional to the total ion current and the resistance in the filter.
- The above three effects are equal and independent. The gain decrease under the negative feedback can be regarded as the superposition of the three effects, and can be effectively calculated by the dichotomy method .

4. Experiment evaluation and comparison

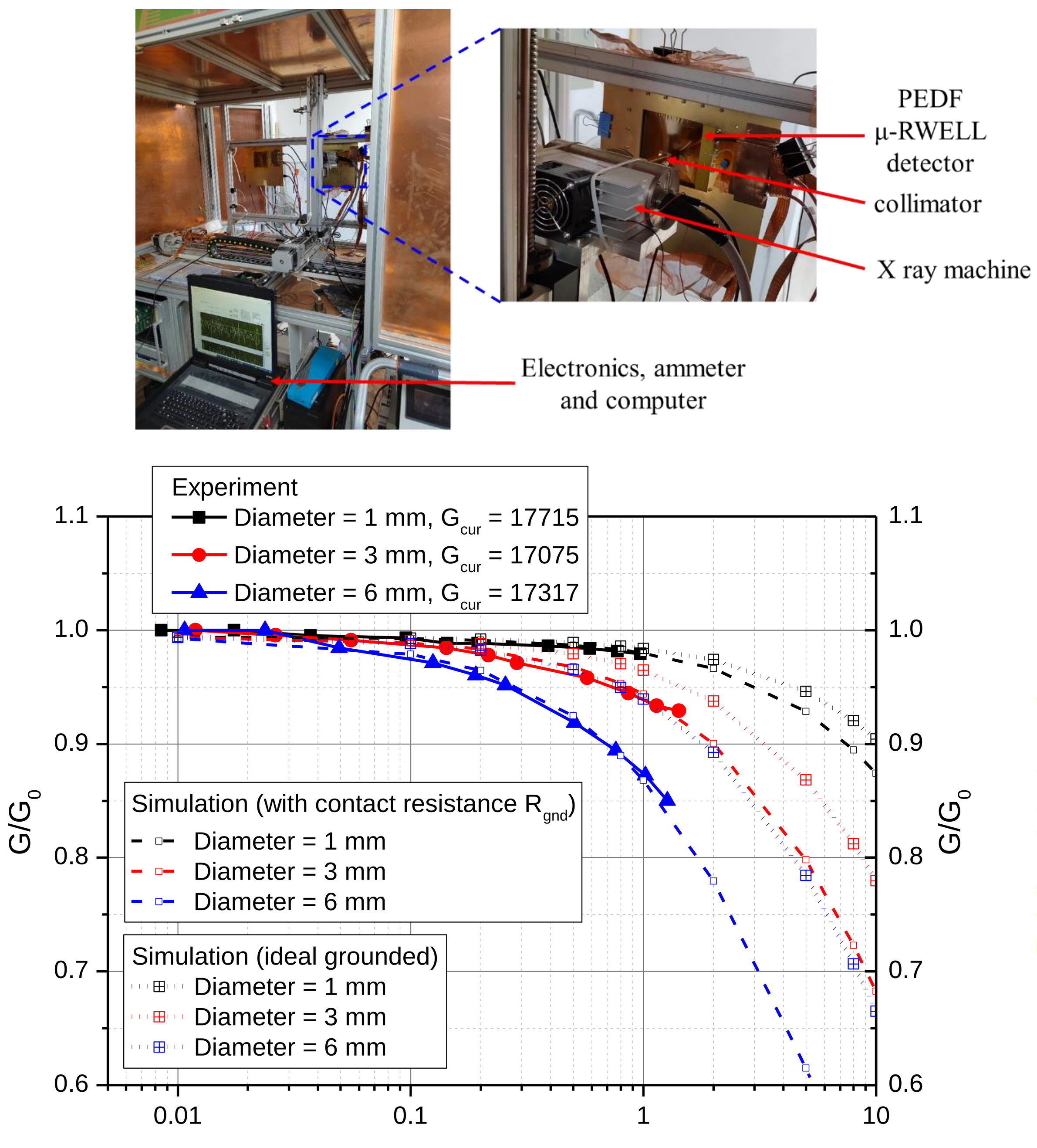

Fig. 5 (Upper) μRWELL detector experiment layout. (Lower) Simulated and experimental gain curve, with small irradiation area.

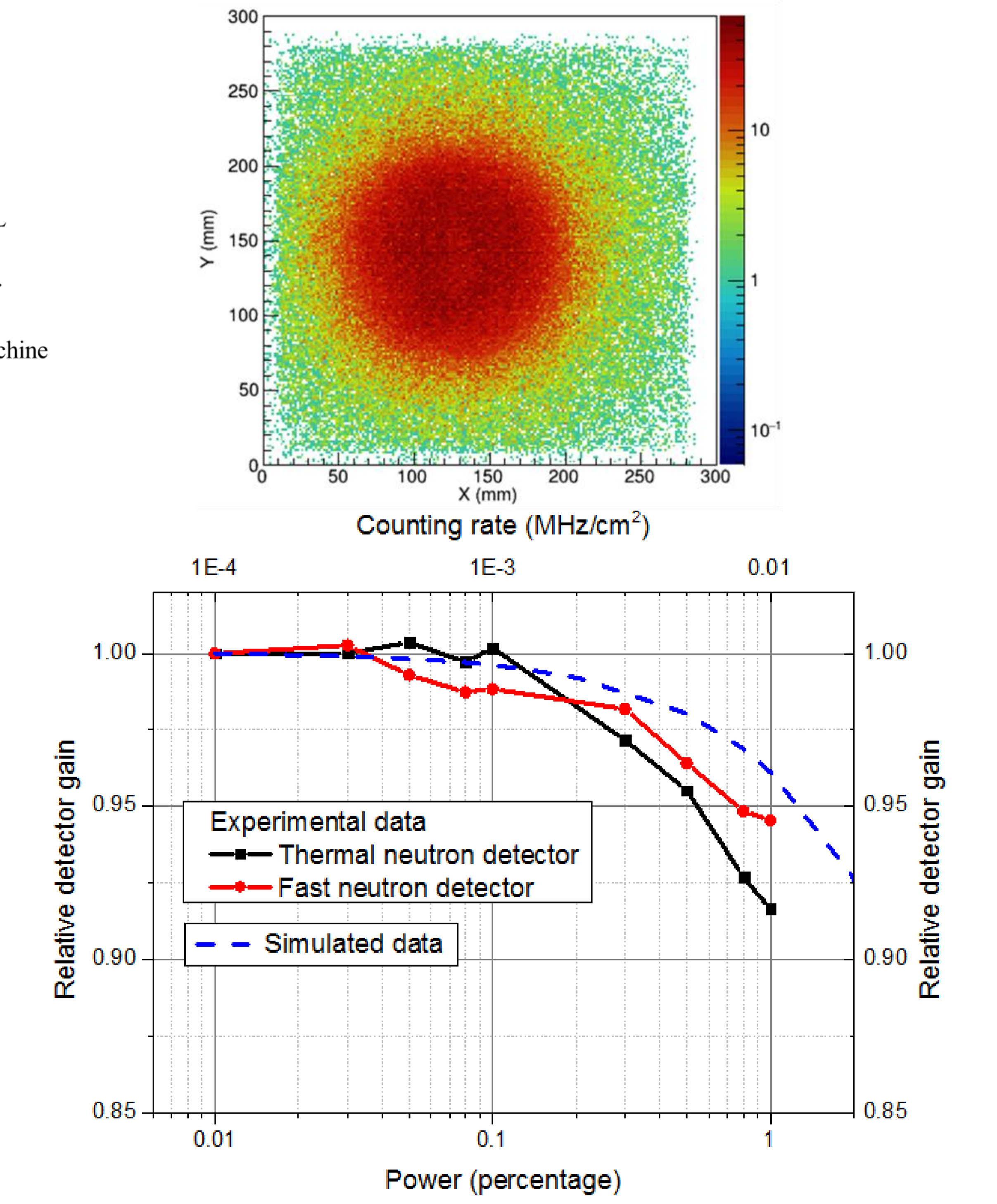

Fig. 6 (Upper) ~Φ150 mm large irradiation experiment with resistive-Micromegas detector. (Lower) Simulated and experimental gain comparison.

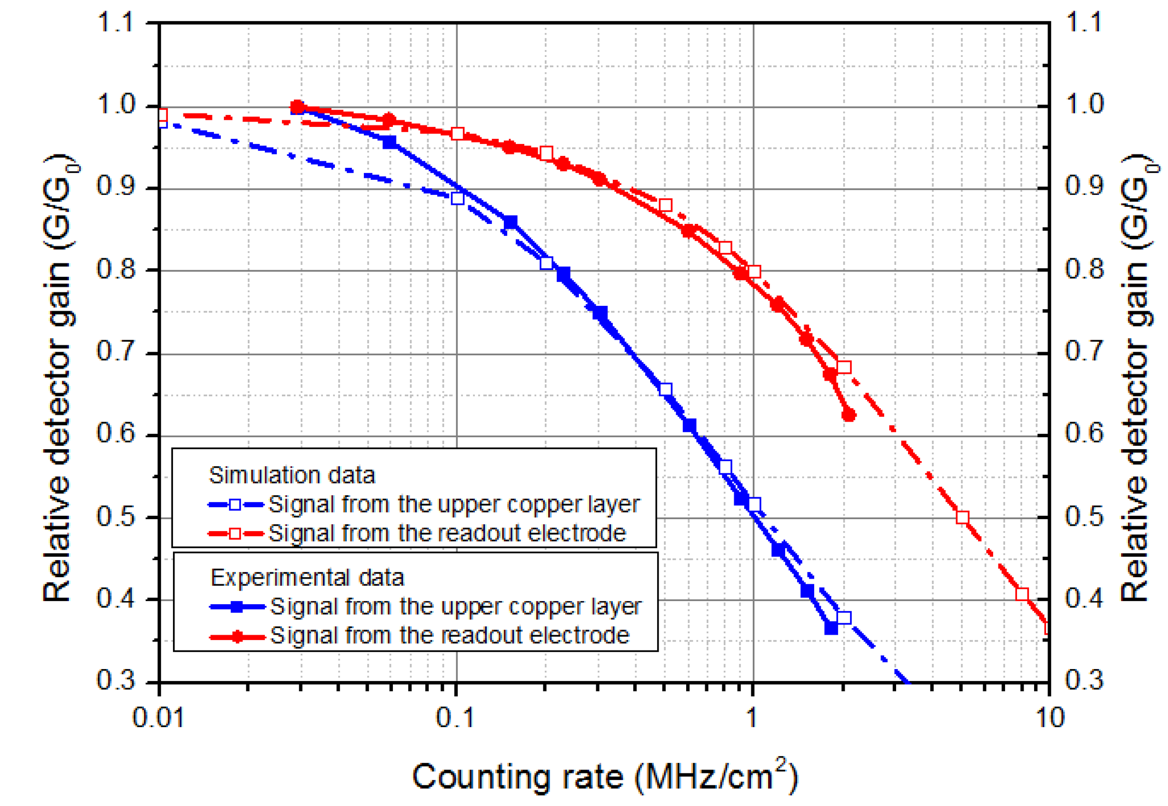

Fig. 7 Influence of high voltage filter circuit, using ORTEC 142AH preamplifier in measurements.

5. Conclusion

- There are three effects influences detector gain: flowing current effect, charge accumulation effect, and high voltage filter circuit influence. The first two has the main contributions.
- Simulation method based on MATLAB is proposed. It is suitable for several kinds of fast grounding designs: strip-grounded, double-layer-point grounded, point grounded array.
- Experiments with μRWELL and Micromegas detector verify the correctness of the simulation. The experiments with large irradiation indicates a more significant gain decrease.

Reference: Z. Fang, *et al.*, Simulation and optimization of fast grounding designs for micro-pattern gas detectors with a resistive layer, *NIMA*, vol. 1032, 2022.

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