

Electroluminescence studies in He-CF₄-isobutane mixtures

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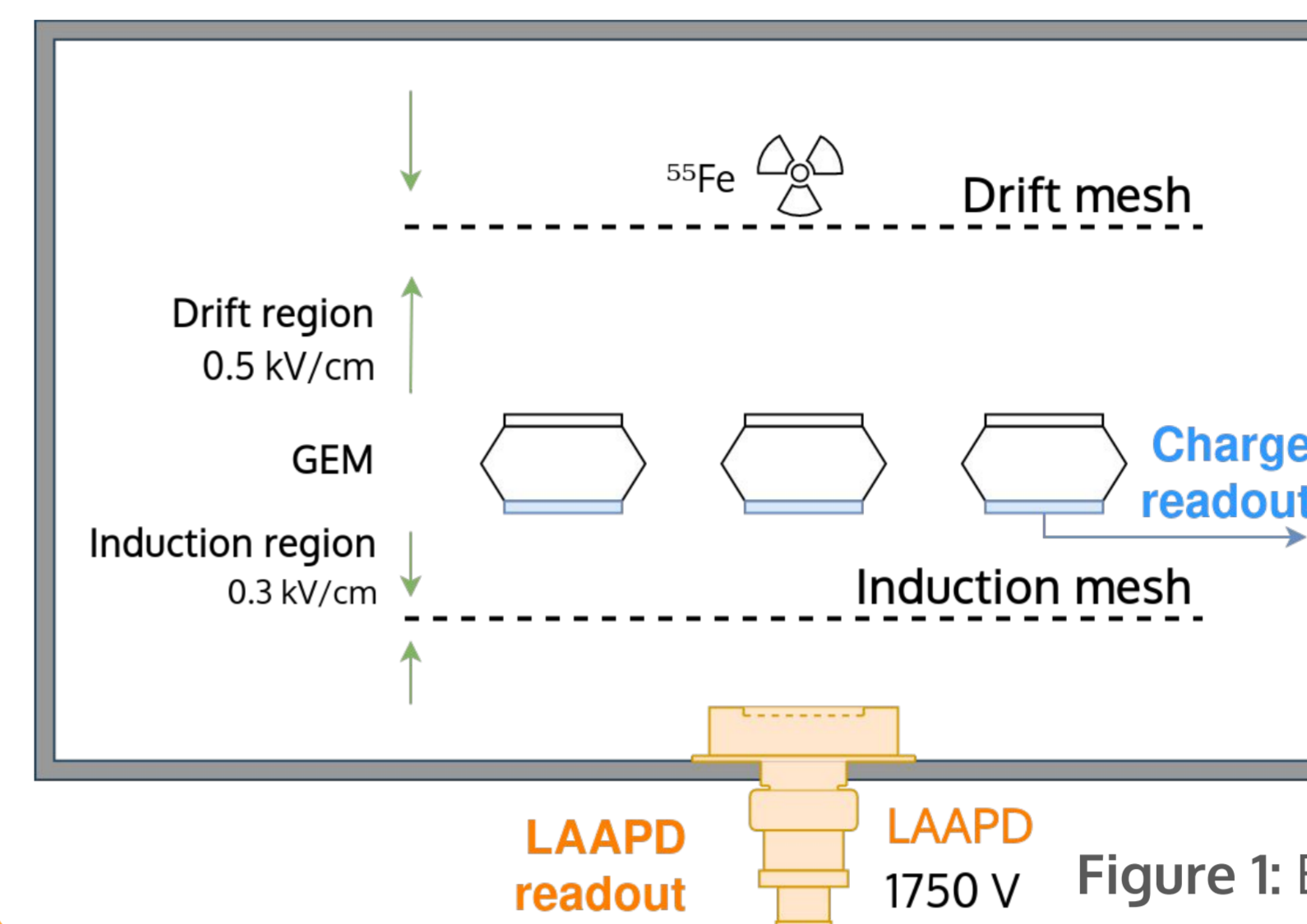
Summary

CYGN0 is part of the CYGNUS international proto-collaboration for the development of a distributed Galactic Nuclear Recoil Observatory for directional Dark Matter search at low WIMP masses (1-10 GeV/c²) and coherent neutrino scattering measurement. CYGN0 is developing a gaseous Time Projection Chamber (TPC), which will be hosted at Laboratori Nazionali del Gran Sasso, Italy [1]. The base mixture of the CYGN0 TPC will consist on He-CF₄ (60/40) [2] and the addition of isobutane and other gases with high H-content is currently under consideration.

This work aims at determining how the addition of small percentages of isobutane to the He-CF₄ (60/40) base mixture influences the Electroluminescence (EL) yield, charge multiplication and corresponding energy resolution.

Experimental Setup

The detector was irradiated with low-energy x-rays (5.9-keV) and a Large Area Avalanche Photodiode (LAAPD) was used to readout the EL produced in the avalanches of a single GEM [3].



Increasing concentrations of isobutane, from 1% to 5%, were added to the base mixture of He-CF₄ (60/40), continuously flowing at 4 L/h.

Figure 1: Experimental setup

Results

The charge signals were collected at the bottom of the GEM.

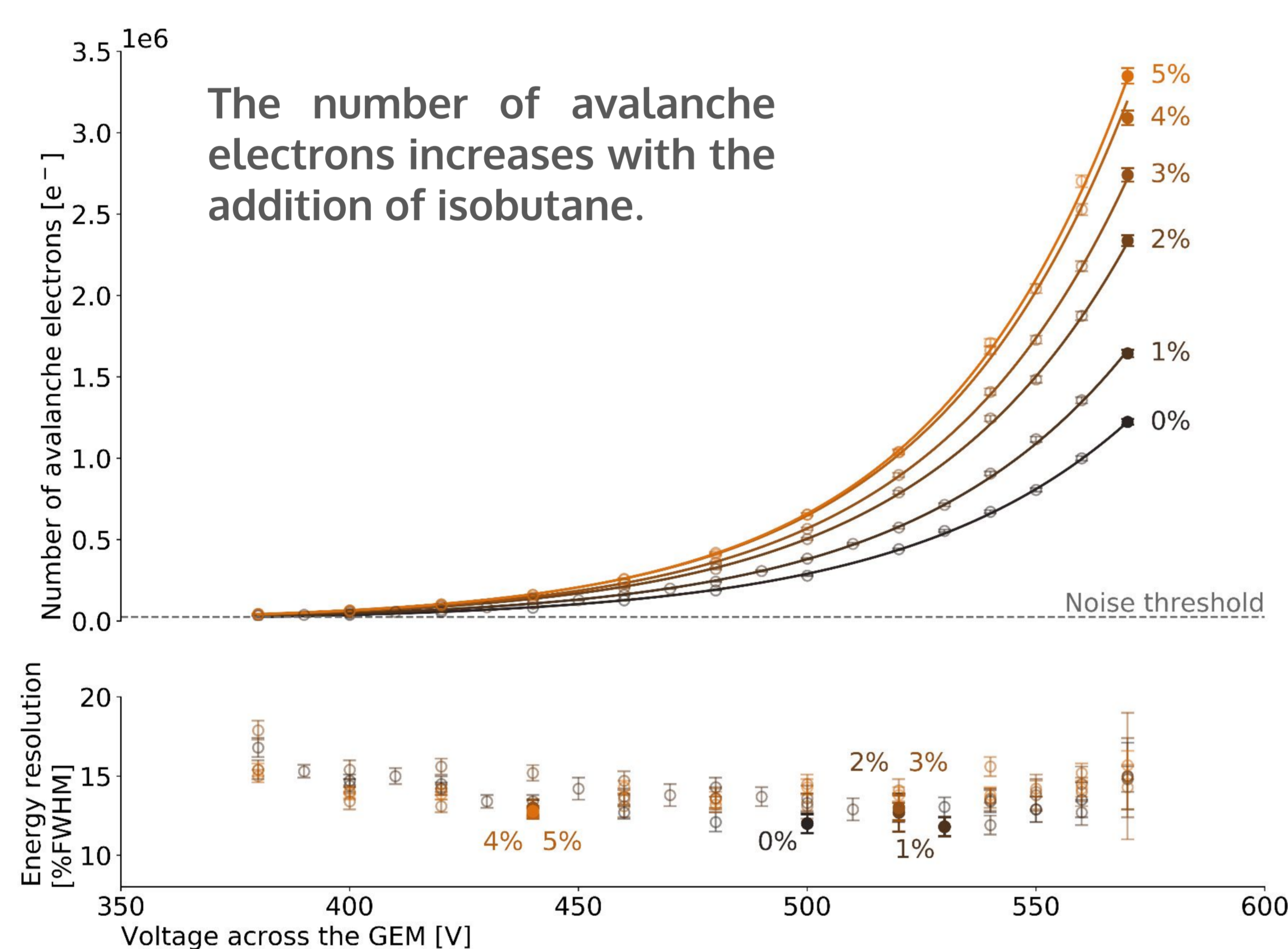


Figure 2: Number of avalanche electrons in function of the voltage across the GEM.

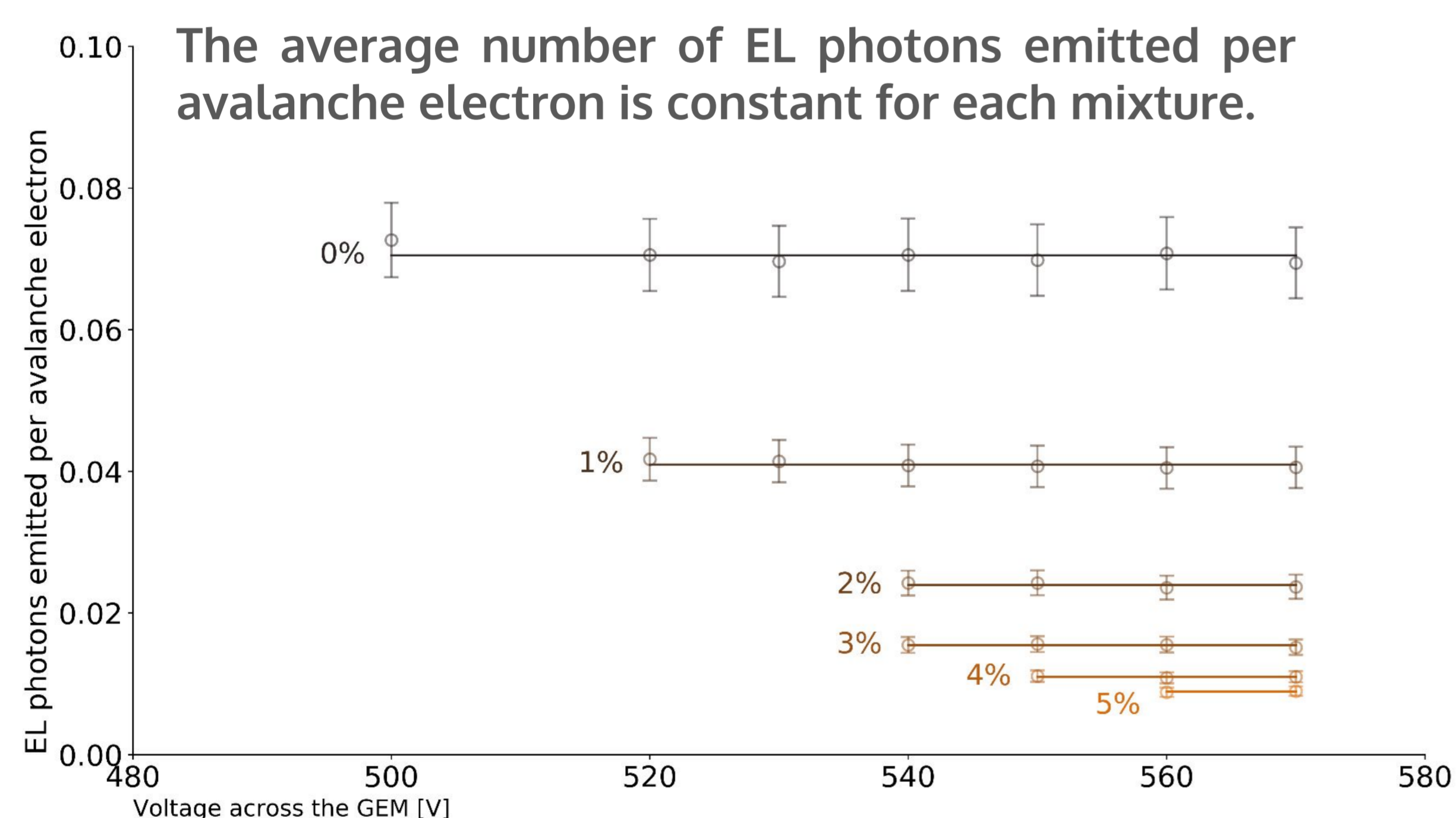


Figure 3: Average number of EL photons emitted per avalanche electron in function of the voltage across the GEM.

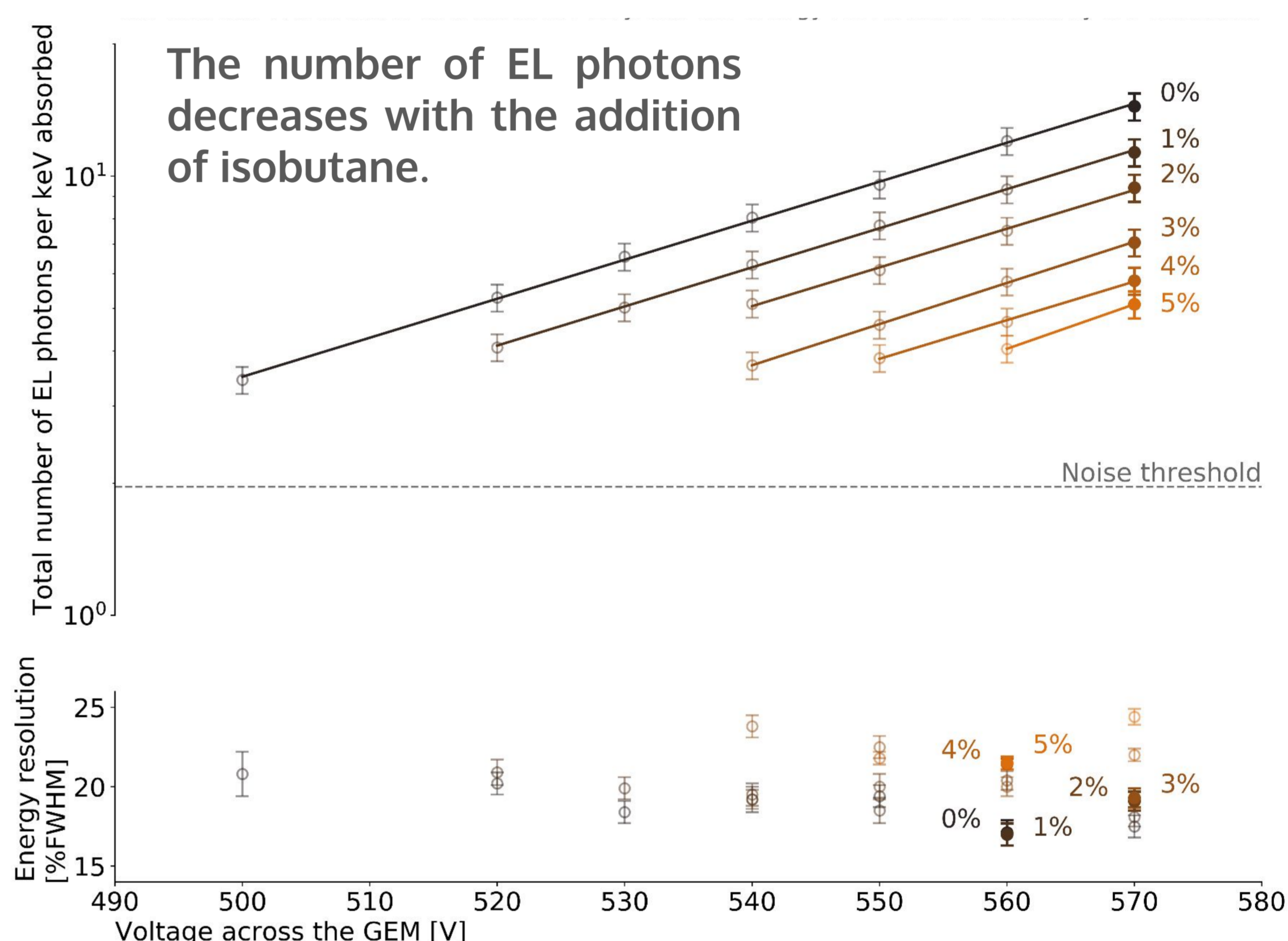


Figure 3: Total number of EL photons per keV absorbed in function of the voltage across the GEM.

Our results show that the number of avalanche electrons increases with the addition of isobutane, with a 2.7-fold increase for 5% isobutane content relatively to 0%.

Although a 7.9-decrease in the number of EL photons emitted per avalanche electron was measured for 5% isobutane relative to 0%, there was only a 2.8-fold decrease in the total number of emitted EL photons.

The concentration of isobutane seems to have no influence on the energy resolution of the charge signals. The gradual energy resolution degradation of the EL signals observed for higher percentages of isobutane is attributed to the statistical fluctuations due to the low amount of EL photons.

Conclusions

The results obtained show that adding isobutane to the He-CF₄ (60/40) base mixture decreases the amount of EL photons but does not compromise the EL readout and is therefore a good option to study for possible applications in the CYGN0-TPC.

References

- [1] Baracchini, E. *et al.* "CYGN0: a gaseous TPC with optical readout for dark matter directional search." *Journal of Instrumentation* 15, no. 07 (2020): C07036. DOI: 10.1088/1748-0221/15/07/C07036.
- [2] Fraga, M. M. F. R., *et al.* "The GEM scintillation in He-CF₄, Ar-CF₄, Ar-TEA and Xe-TEA mixtures." *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* 504, no. 1-3 (2003): 88-92. DOI: 10.1016/S0168-9002(03)00758-7.
- [3] Monteiro, Cristina. "Determination of argon and xenon absolute electroluminescence yields in Gas Proportional Scintillation Counters". PhD diss., Universidade de Coimbra, 2010.