Effects of hydrocarbon admixtures to the electroluminescence yield of He-CF_4

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Summary

He-CF_4 is a very attractive gas mixture for Optical Readout Detectors in Dark Matter Search [1]:

See G. Dho poster for more on this!

He extends the sensitivity to low WIMP masses.

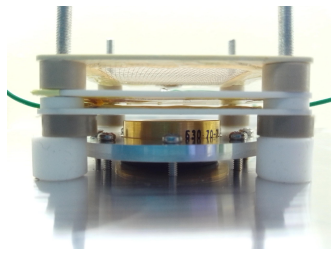
CF_4 improves gas scintillation and is sensitive to Spin-Dependent WIMP-nucleon interactions.

Hydrocarbons like methane or isobutane would further improve the sensitivity to low WIMP mass [2].

But won't they compromise the optical readout?

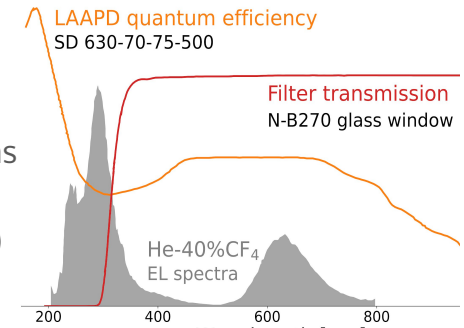
We evaluated the electroluminescence (EL) yield of methane and isobutane admixtures to He-40%CF_4 to find the best ternary mixture.

Setup



A Large Area Avalanche Photodiode (LAAPD) was used to readout the EL produced in the avalanches of a Gas Electron Multiplier (GEM).

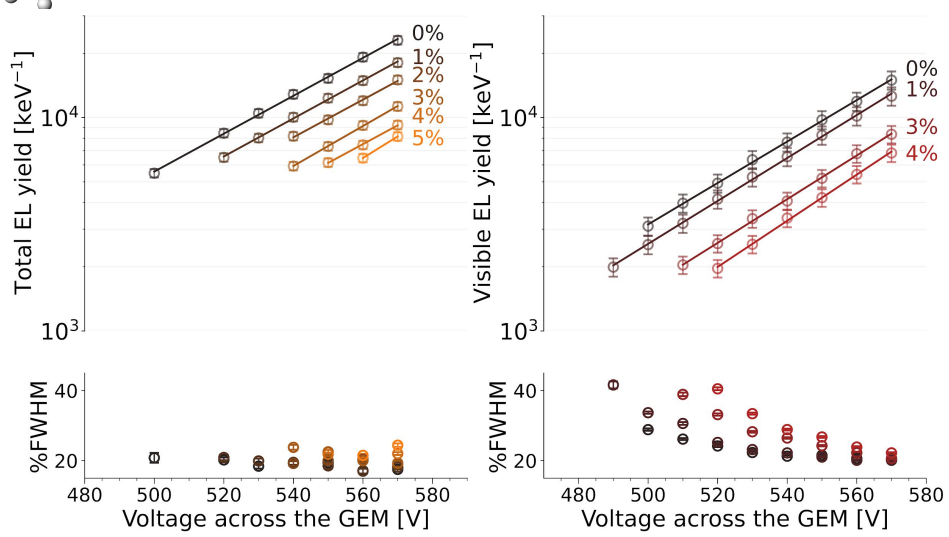
A borosilicate glass window was placed on top of the LAAPD to filter the UV photons (<300 nm) and evaluate the **visible EL**.



We kept He-40%CF_4 flowing at 4 L/h and then added the required percentage of hydrocarbon.

Results

Isobutane Admixtures to He-40%CF_4

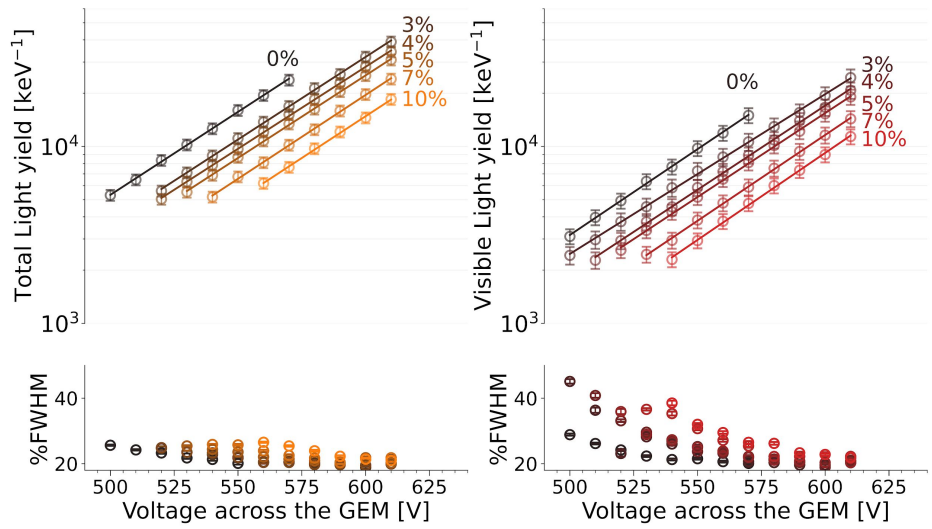


Small percentages of isobutane and methane quench the visible and UV photons emitted by He-40%CF_4, but they do not completely compromise the optical readout.

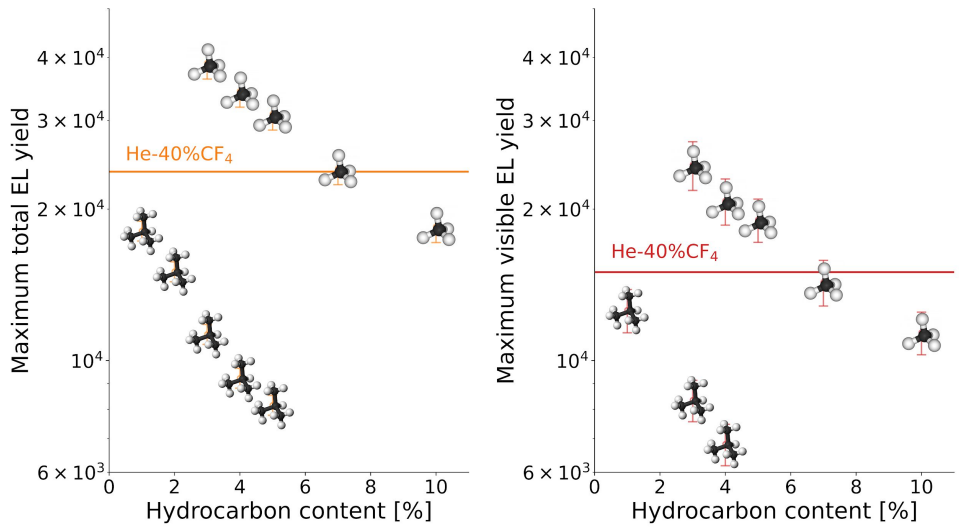
Isobutane admixtures decrease the maximum attainable EL yield, relatively to He-40%CF_4, but the optical readout is possible for concentrations up to 5%.

Methane admixtures increase the electrical stability of the detector, meaning that higher GEM voltages could be achieved. Because of this, methane admixtures up to 7% attain higher maximum EL yields than He-40%CF_4.

Methane Admixtures to He-40%CF_4



Maximum attainable EL yield



Conclusions

Using up to 7% methane to increase the WIMP sensitivity of Dark Matter Detectors filled with He-40%CF_4 will also improve their optical readout.

References

[1] Costa, I. Abritta, et al. "CYGNO: Triple-GEM optical readout for directional dark matter search." Journal of Physics: Conference Series. Vol. 1498. No. 1. IOP Publishing, 2020.

[2] Amaro, Fernando Domingues, et al. "The CYGNO Experiment." Instruments 6.1 (2022): 6.

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