Using a 125-µm thick COBRA to increase the light yield of He-CF_4 gas mixtures

Rita J. C. Roque, R.D.P. Mano, J.M.F. dos Santos, F.D. Amaro and C.M.B. Monteiro

LIBPhys, Department of Physics, University of Coimbra, 3004-516 Coimbra, Portugal

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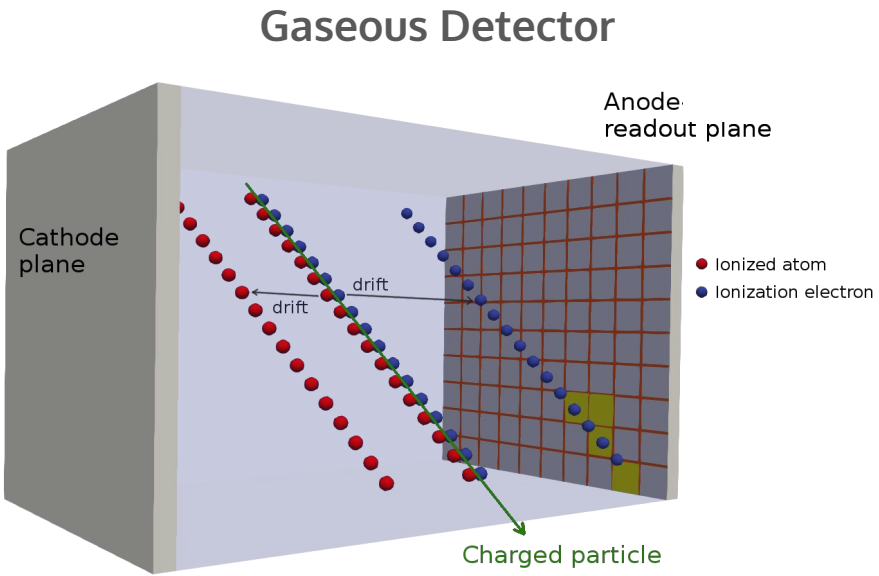
7th September 2023

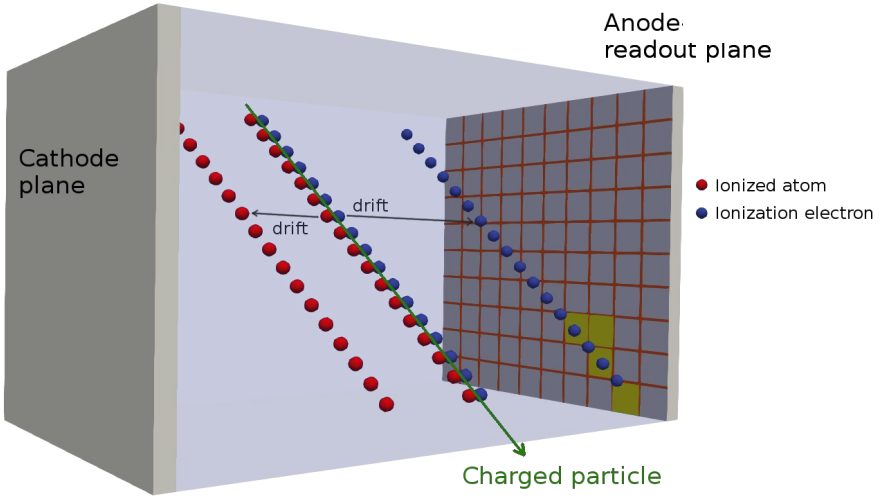
Signal amplification in gaseous detectors



Incoming particles leave a trail of primary ionisations in the gas. In most cases, the primary ionisation is not enough to produce a quantifiable signal. **We need amplification!**

Signal amplification in gaseous detectors

Gaseous Detector



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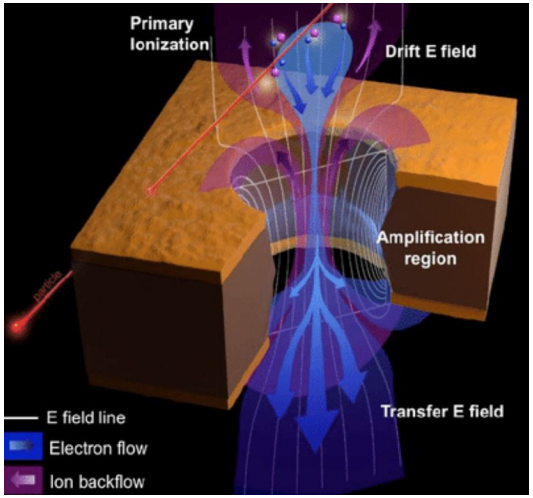
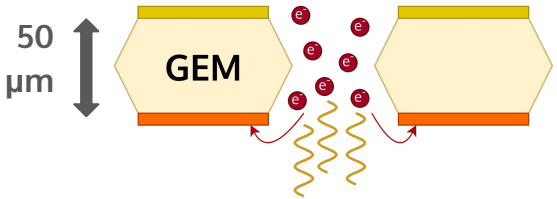
GEM: Gas Electron Multiplier



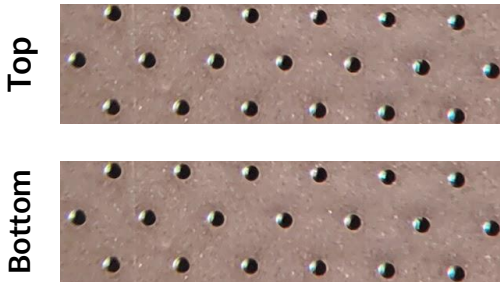
The high electric field inside the GEM holes produces:

- Secondary electrons -> Charge readout
- Secondary photons -> Optical readout

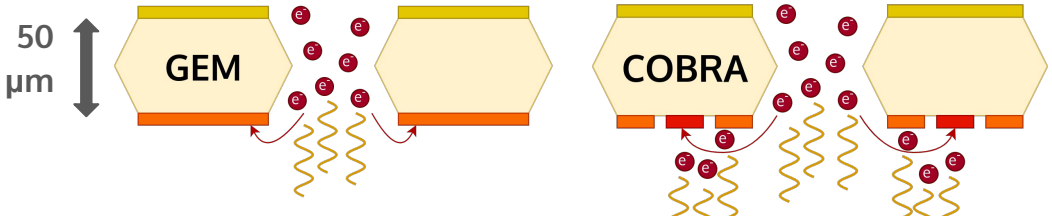
The 125-µm thick Cobra versus the Gas Electron Multiplier



A single multiplication region
inside the holes of the GEM.

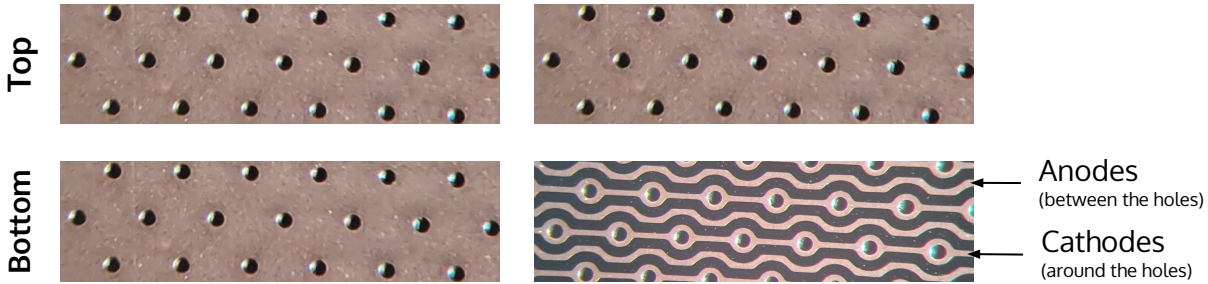


The 125-µm thick Cobra versus the Gas Electron Multiplier



A single multiplication region inside the holes of the GEM.

Two multiplication regions: inside the holes of the Cobra and around the strips.



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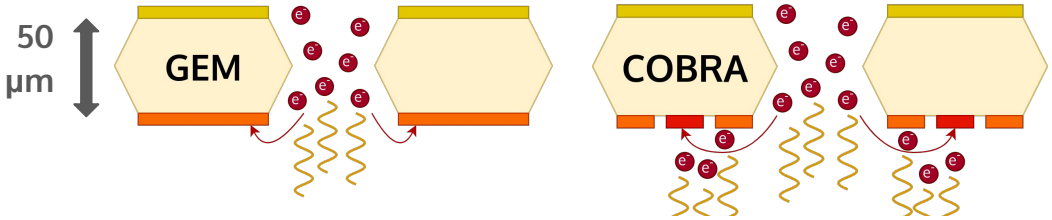

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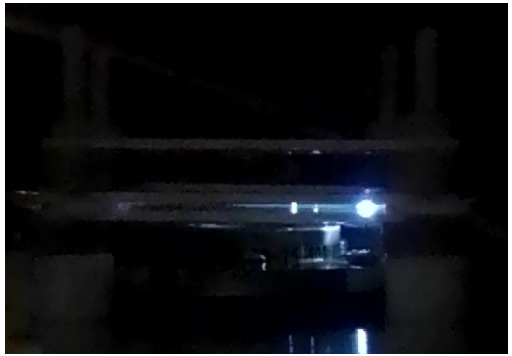
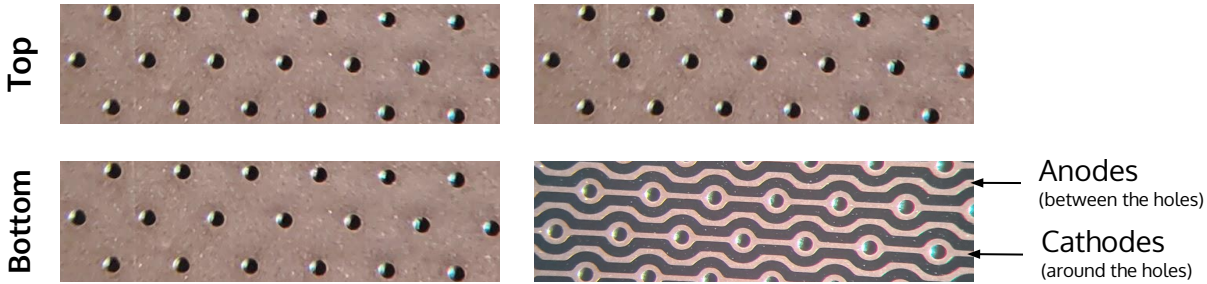
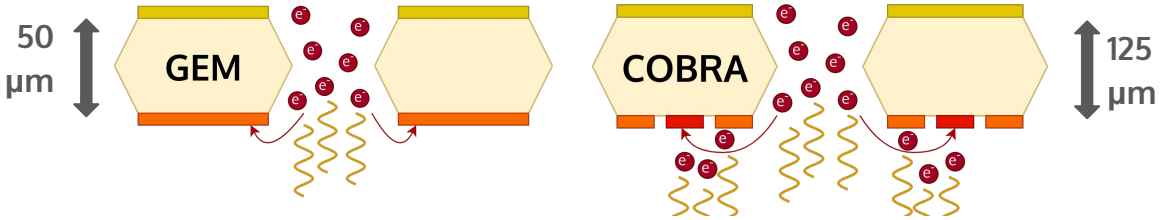
An electrical discharge in a GEM





GEM gains are limited by discharges between their top and bottom electrodes.

The 125-µm thick Cobra versus the Gas Electron Multiplier



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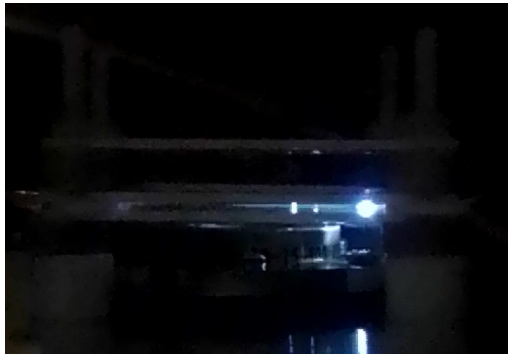

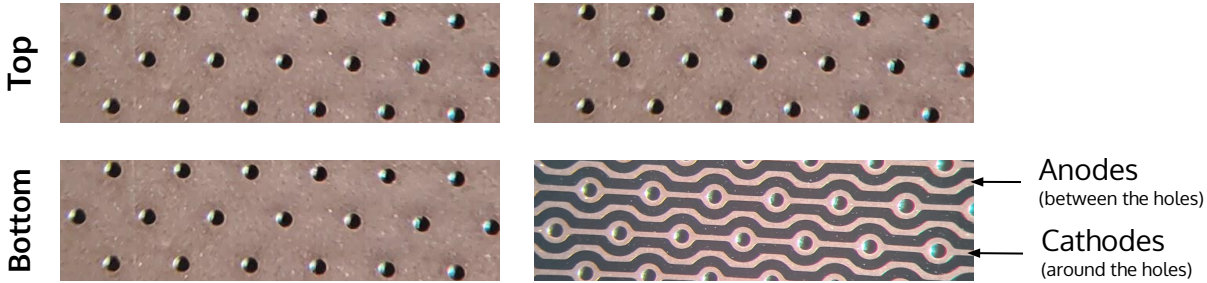

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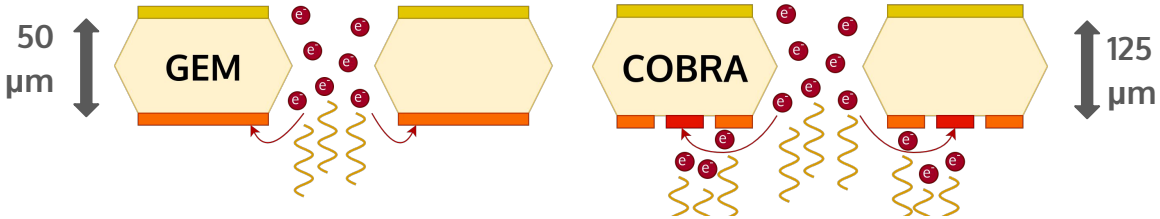
The 125-µm thick Cobra is more robust to discharges.

The 125-µm thick Cobra versus the Gas Electron Multiplier



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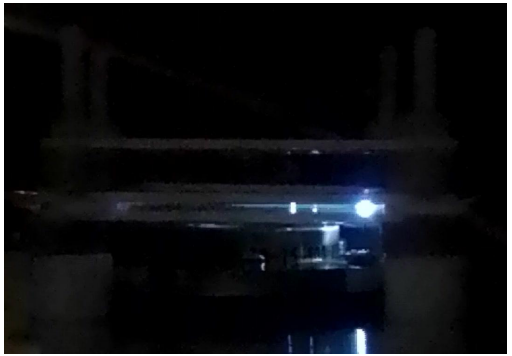
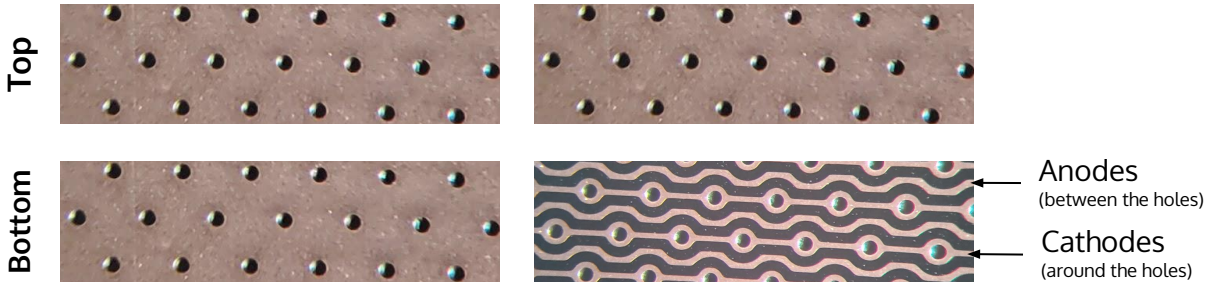




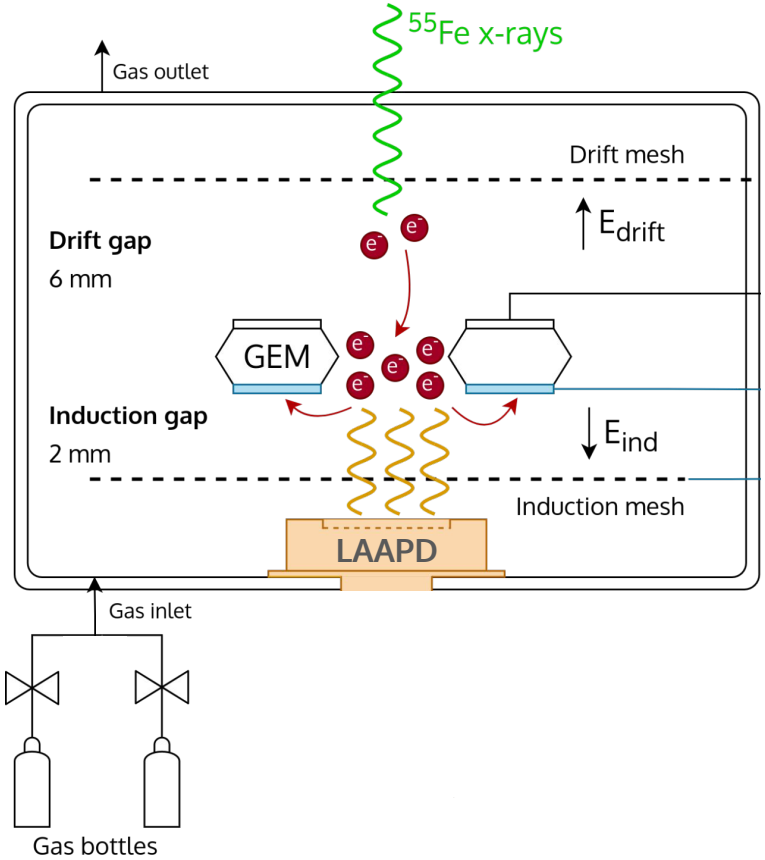
GEM gains are limited by discharges between their top and bottom electrodes.

The 125-µm thick Cobra is more robust to discharges.

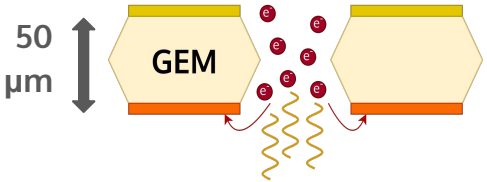
The 125-µm thick Cobra may increase the signal amplification of gaseous detectors.

But by how much?

Experimental Setup

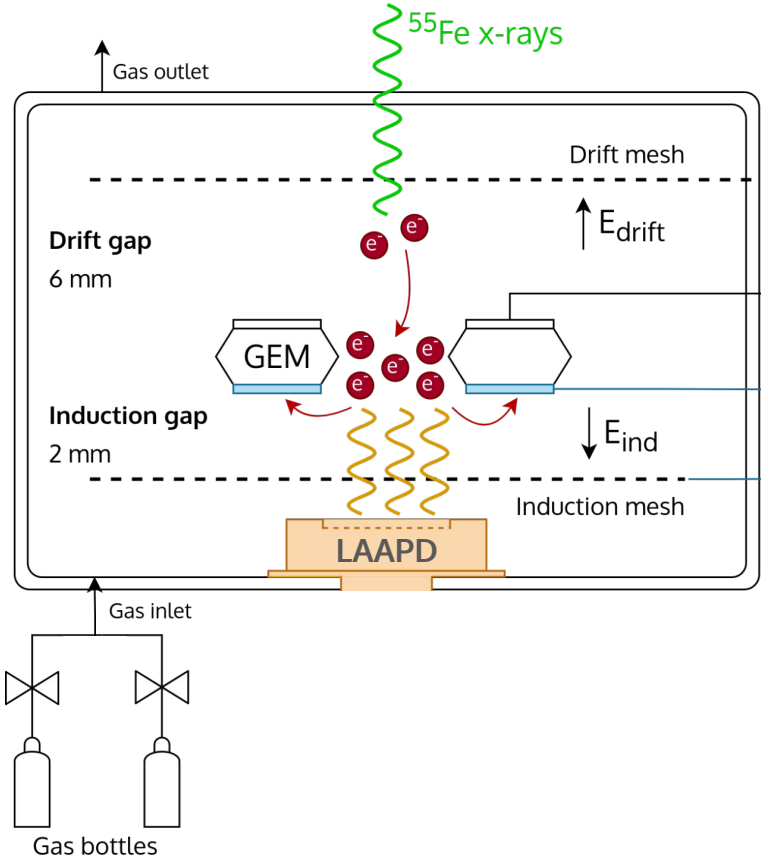


We measured the charge and optical amplification for:



sGEM:
the standard 50-μm thick GEM.

Experimental Setup



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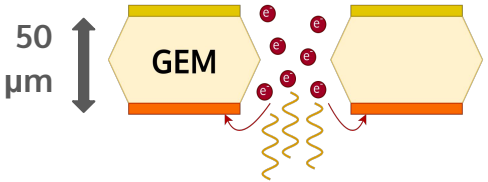

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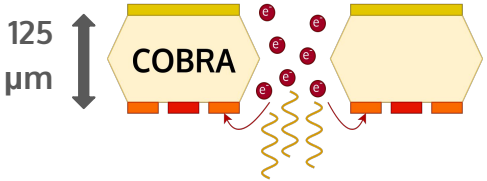
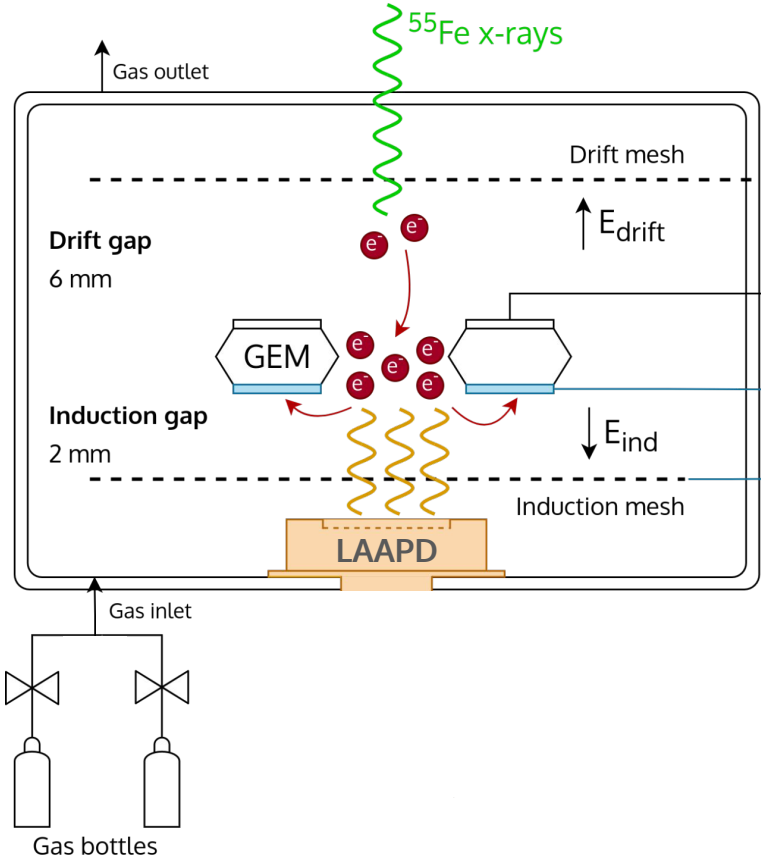


GEM Mode:
there is only amplification in the Cobra holes.

Experimental Setup



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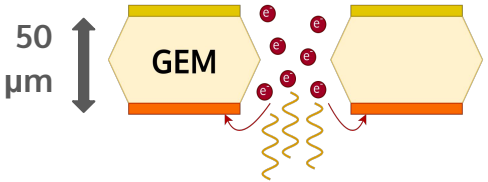

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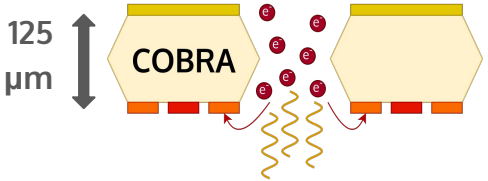

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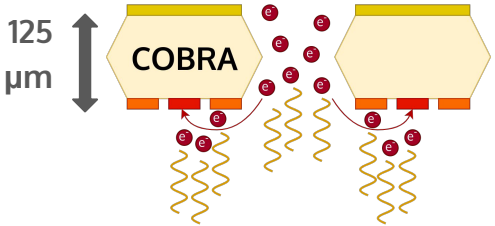
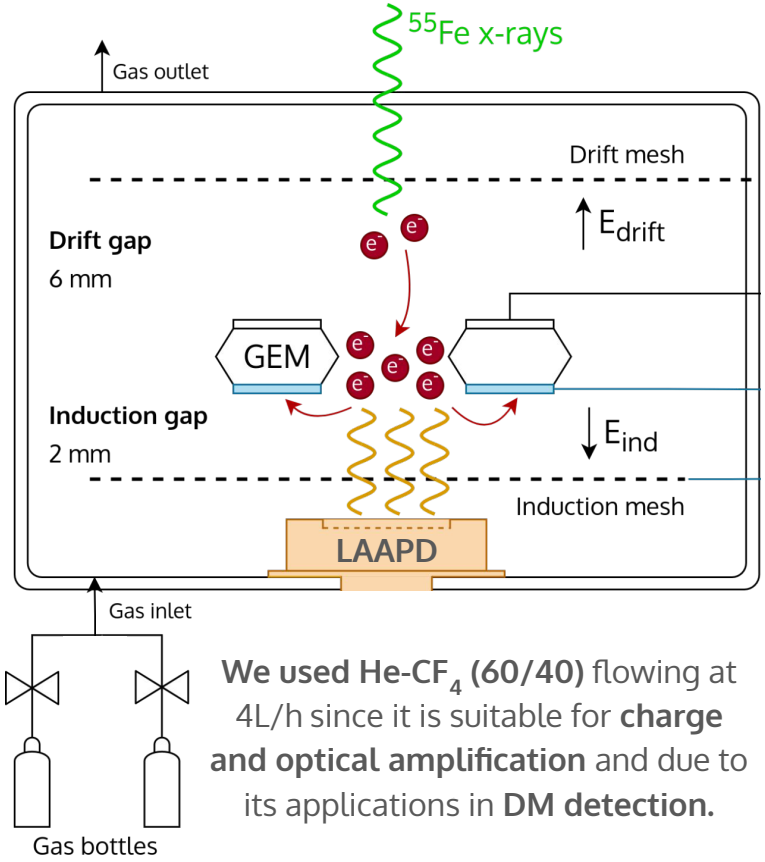


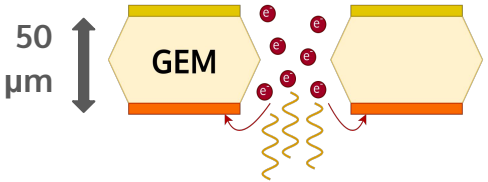
Full-Cobra Mode:
there is amplification in the Cobra holes and around the strips.

Experimental Setup



We used He-CF_4 (60/40) flowing at 4L/h since it is suitable for **charge and optical amplification** and due to its applications in **DM detection.**

We measured the charge and optical amplification for:



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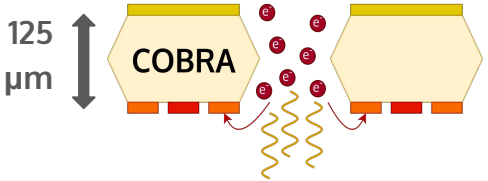

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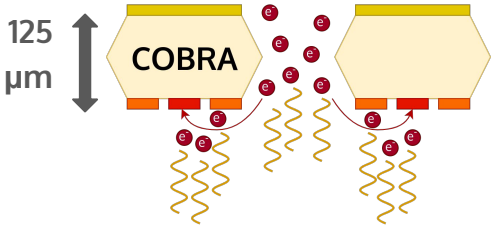

Full-Cobra Mode:
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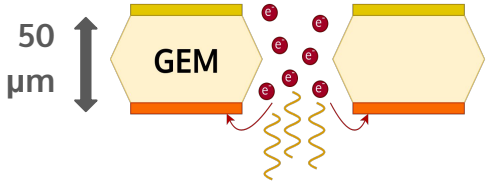
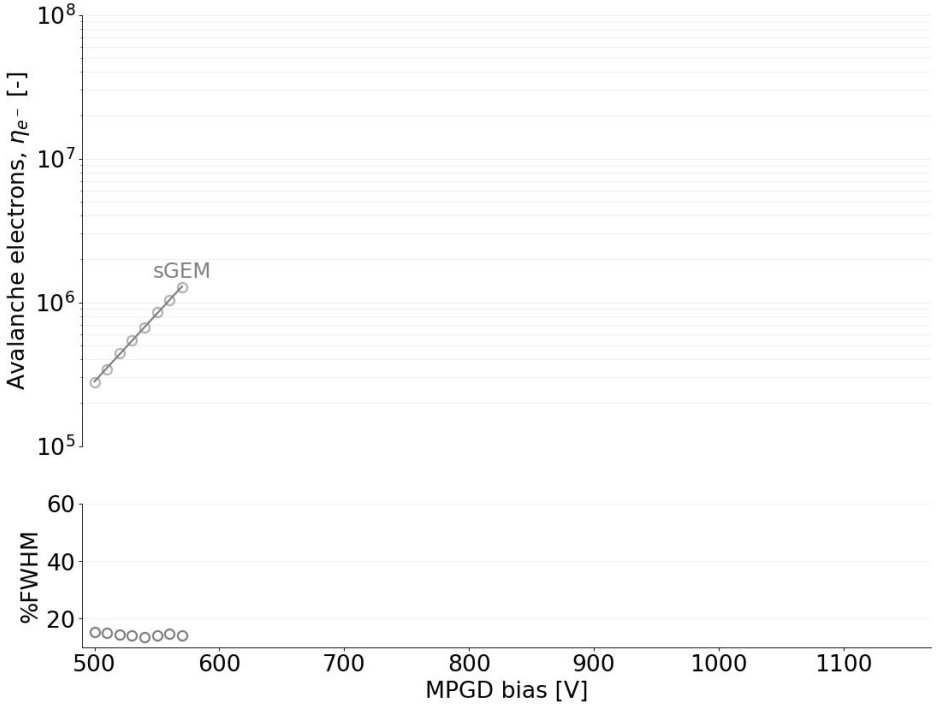
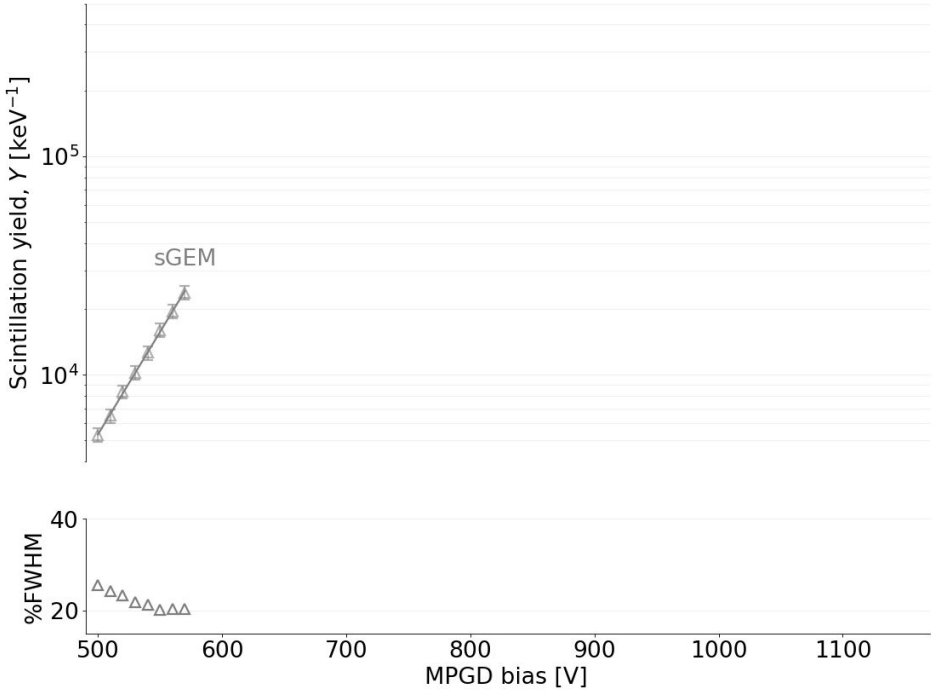
sGEM in He-40%CF_4



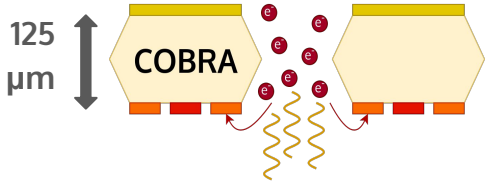
Light and charge gain increase exponentially with increasing bias voltage.

Minimum energy resolution (FWHM) is ~13% for the charge readout and ~20% for the optical readout.



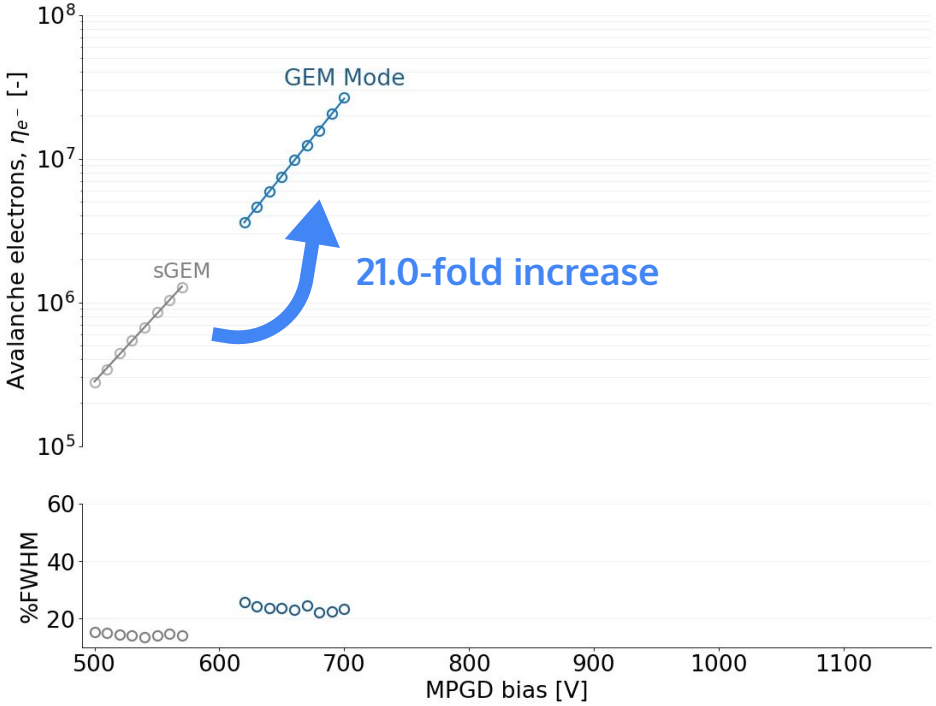


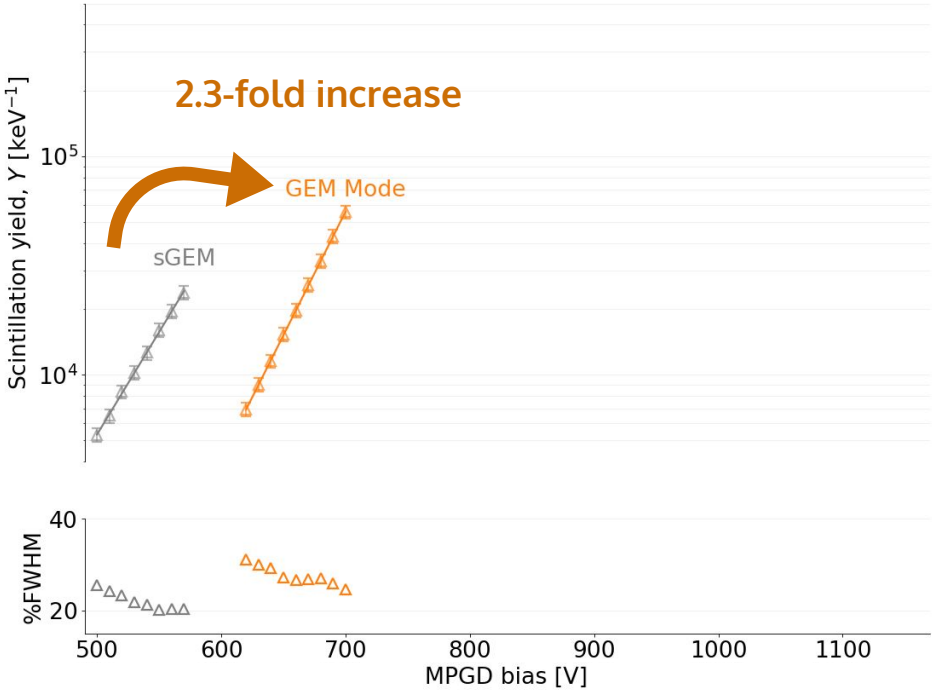
GEM Mode in He-40%CF_4



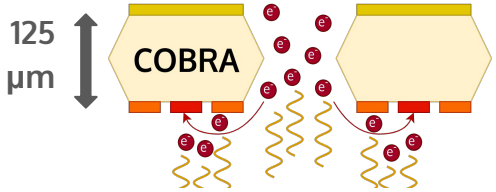
Light and charge gain increase exponentially with increasing bias voltage.

Minimum energy resolution (FWHM) is ~22% for the charge readout and ~25% for the optical readout.



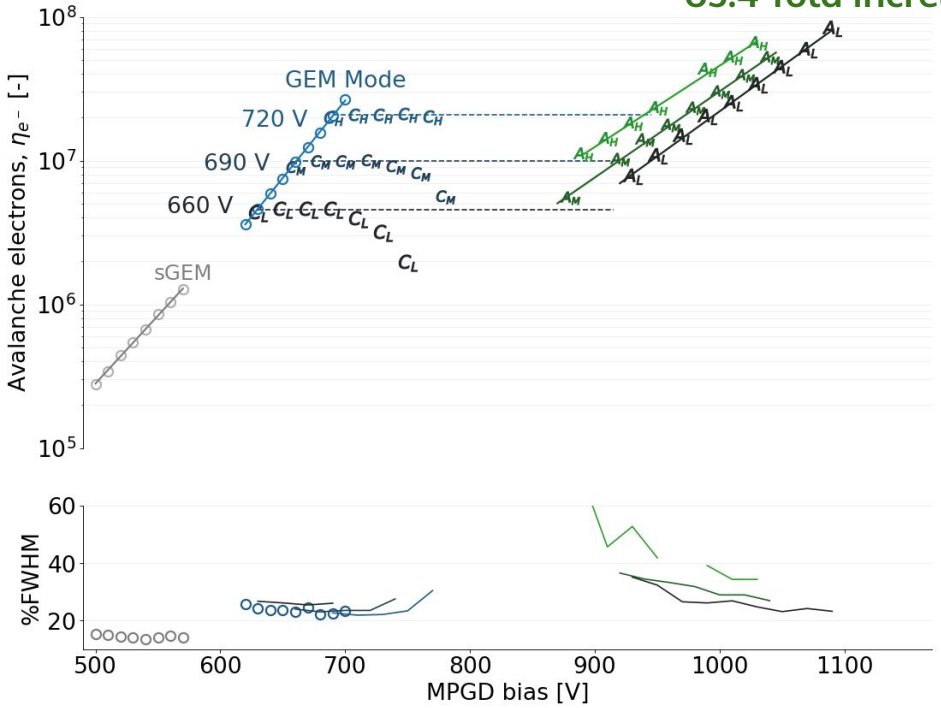


Full-Cobra Mode in He-40%CF_4



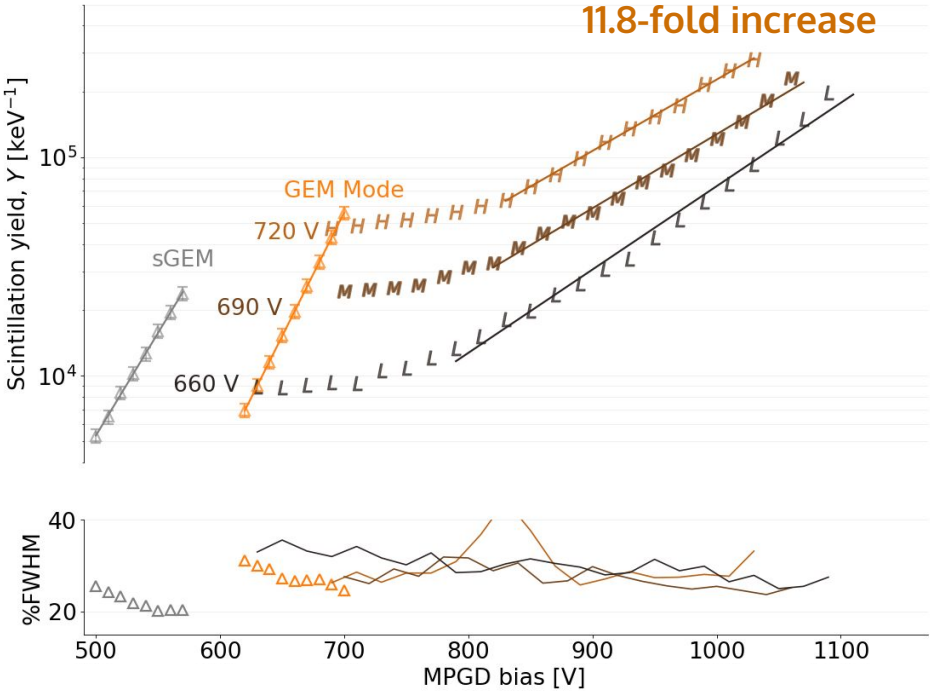
Charge is transferred to the anode and then increases exponentially with increasing bias.

65.4-fold increase



Light first increases linearly and then exponentially.

11.8-fold increase

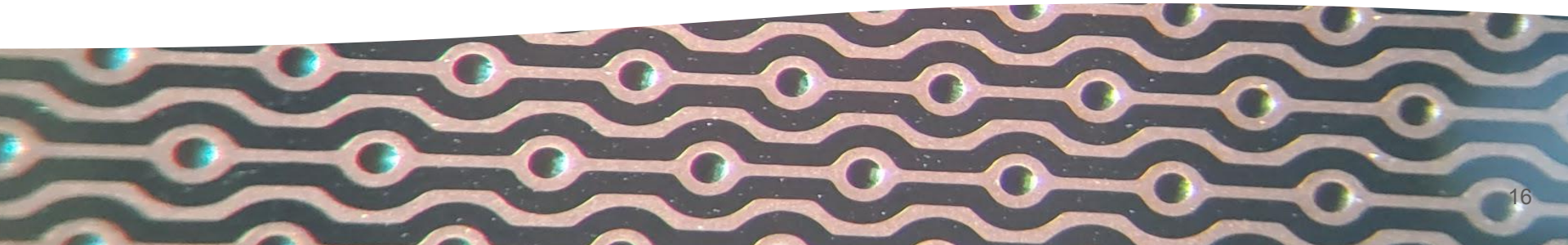


Conclusions

Charge and optical gains can be increased with a 125-μm thick Cobra due to:

- **The thickness of the COBRA:** increases the threshold for self-sustained micro-discharges.

He-CF_4 (60/40)	Charge increase	Light increase
GEM Mode	**21.0x** sGEM	**2.3x** sGEM



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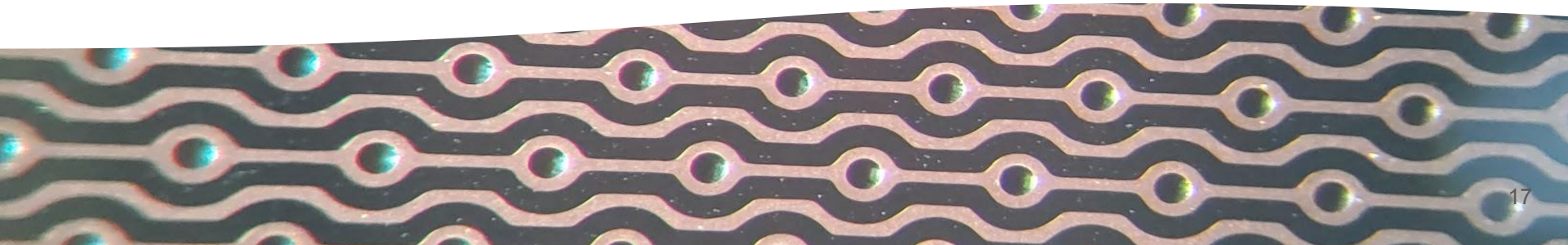

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The 125-µm thick Cobra is a promising solution to increase the signal of charge and optical readout gaseous detectors.

Questions?

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