Spark properties of a Micromegas + GEM prototype

Wed, 23rd September 2009

Marco Villa – CERN

Two-stages amplification structure

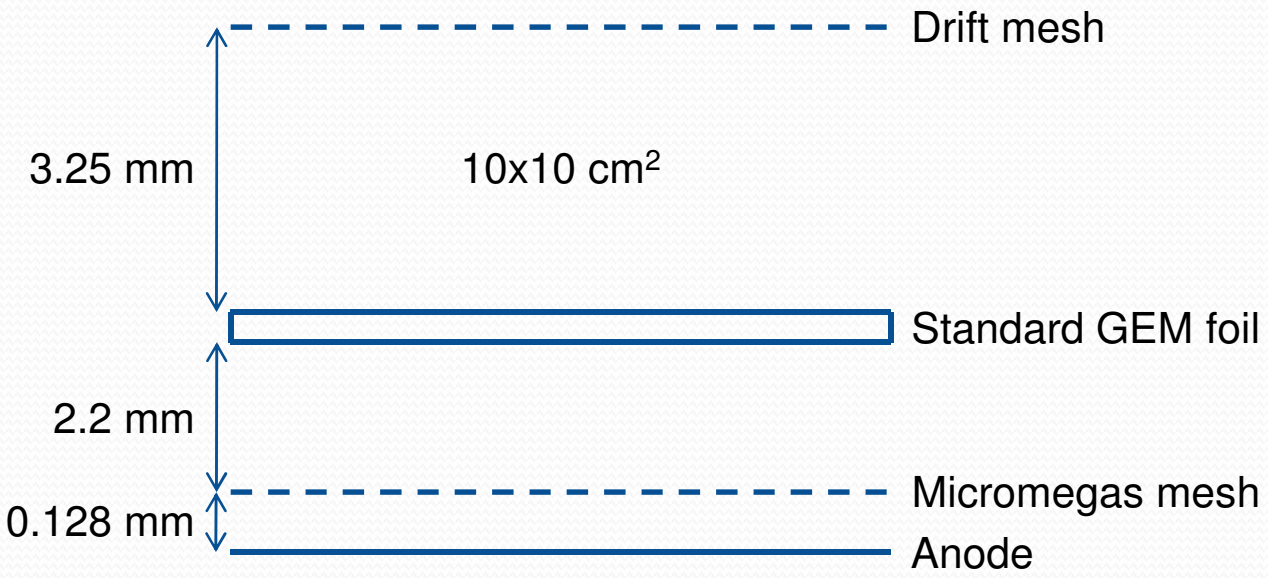
Reduce spark probability in a Micromegas detector

↓

Split the gain in two stages

- Double-mesh Micromegas
- Preamplification GEM above the Micromegas mesh

Detector schematic



Micromegas specifications:

- 45 µm mesh pitch
- 18 µm mesh wire diameter
- 2.5 cm pillar pitch
- 300 µm pillar diameter

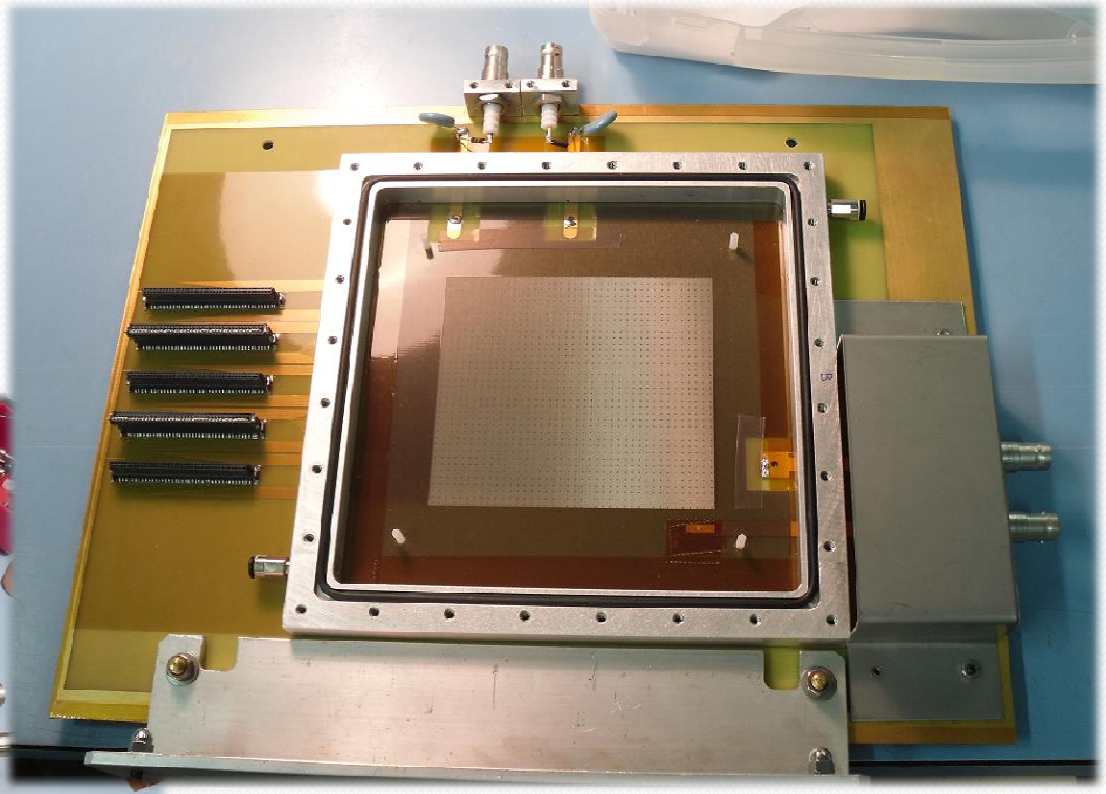
GEM specifications:

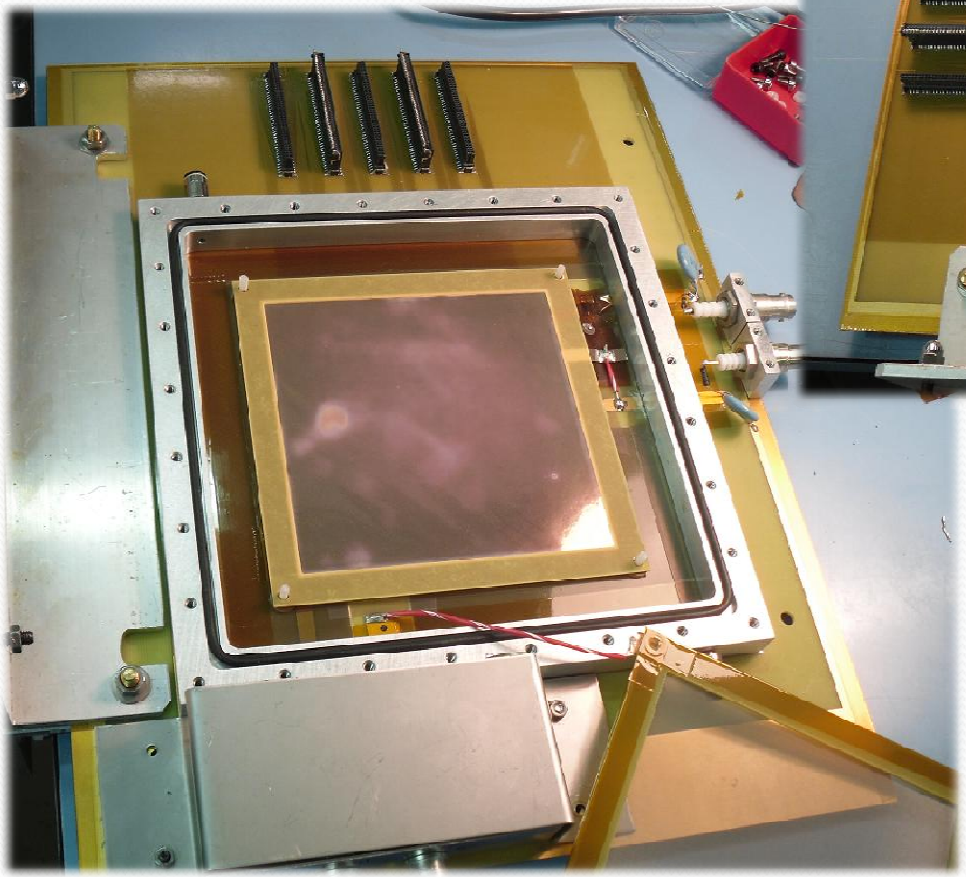
- hexagonal hole geometry
- biconical holes
- 140 µm hole pitch
- 70 µm hole outer diameter
- 50 µm hole inner diameter
- 50 µm kapton thickness
- 5 µm copper thickness

Detector assembly

Anode specifications:

- 360 strips
- 250 µm strip pitch
- 150 µm strip width

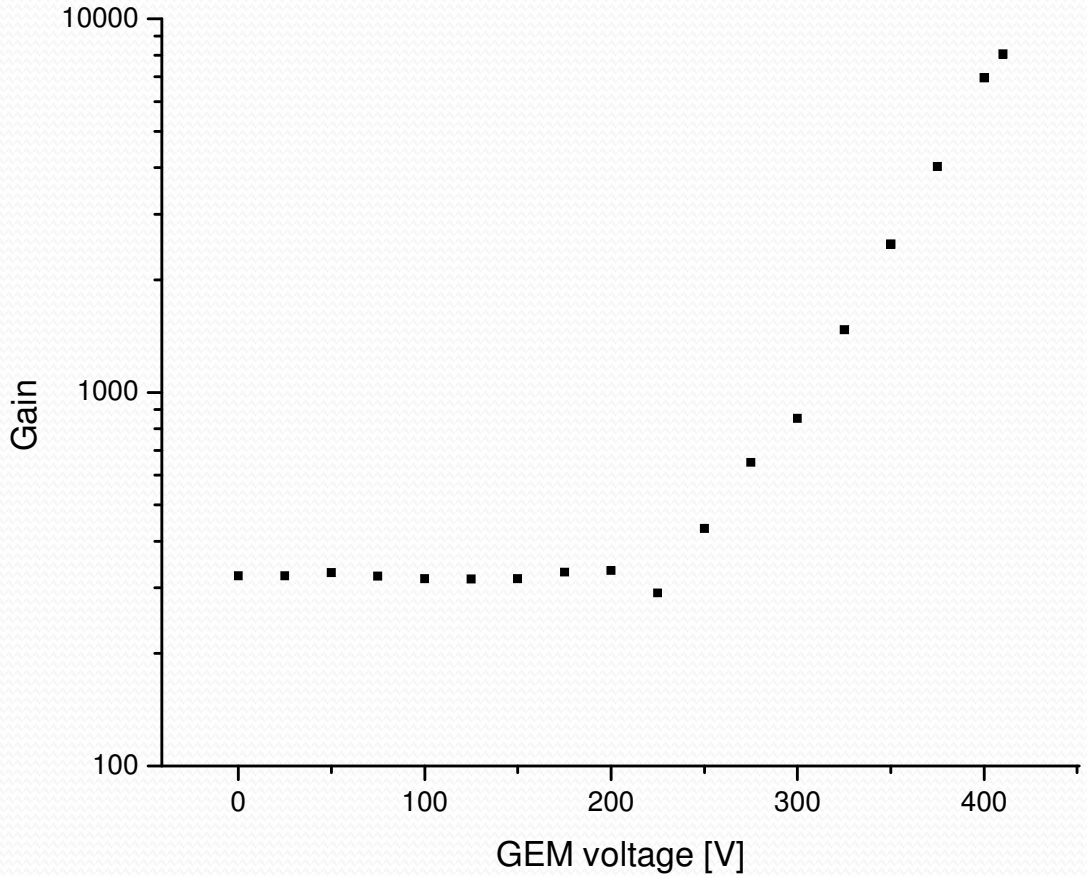




Readout connectors specifications:

- 5 independent connectors
- type ERNI 80 pins
- 8 external pins grounded

GEM voltage scan



Gas mixture Ar/CF_4 90/10

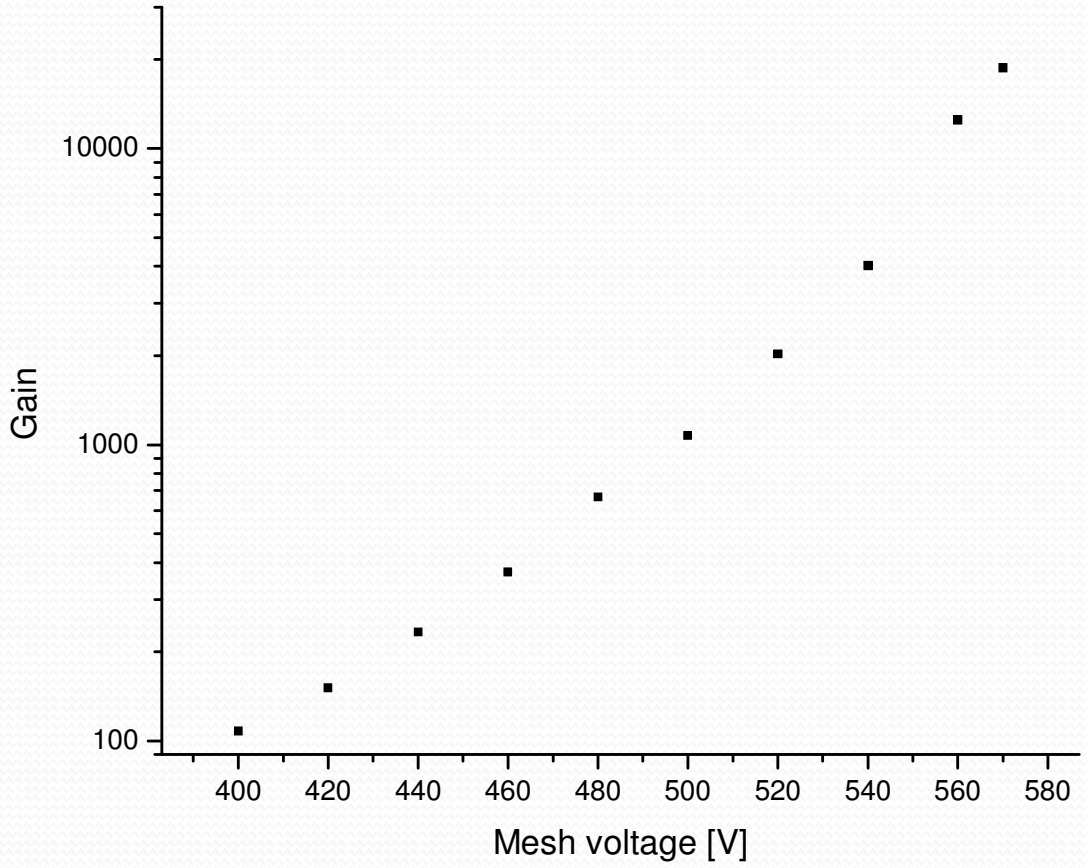
^{55}Fe source

Drift field 0.62 kV/cm

Transfer field 0.45 kV/cm

Mesh voltage 500 V

Mesh voltage scan



Gas mixture Ar/CF_4 90/10

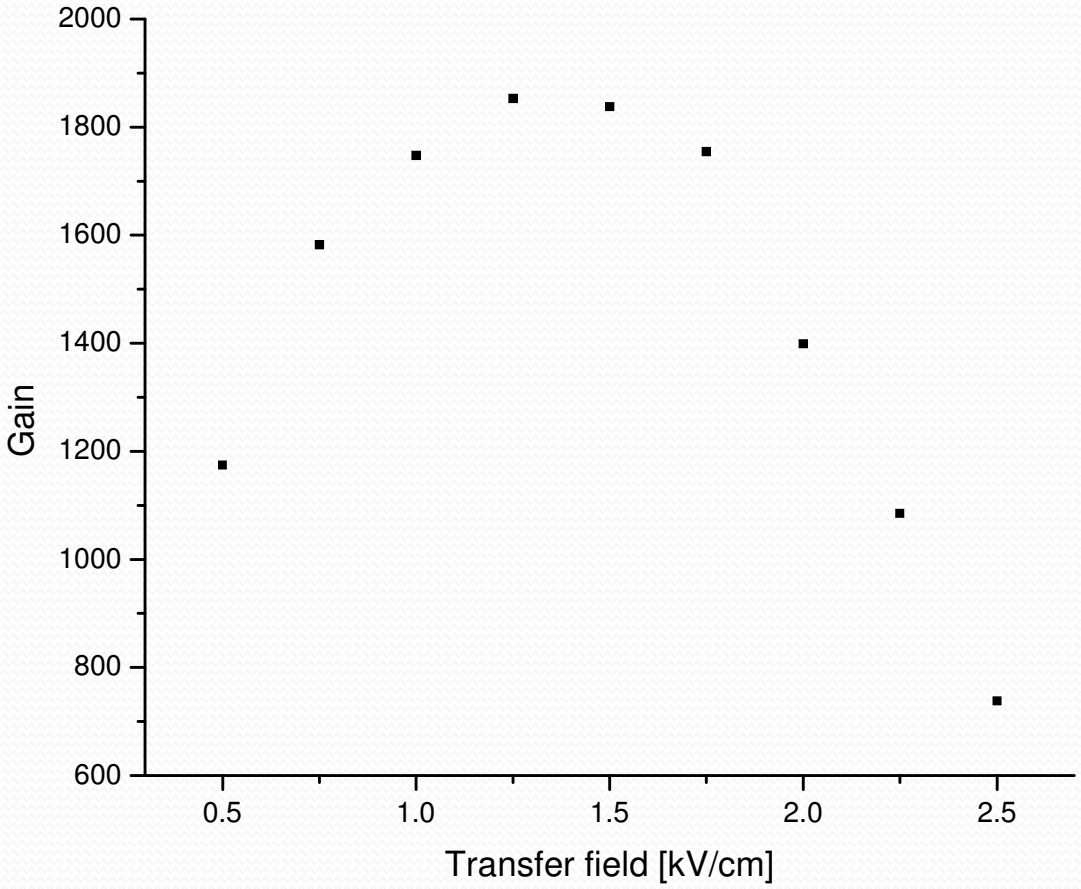
^{55}Fe source

Drift field 0.62 kV/cm

GEM voltage 325 V

Transfer field 0.45 kV/cm

Transfer field scan



Gas mixture Ar/CF_4 90/10

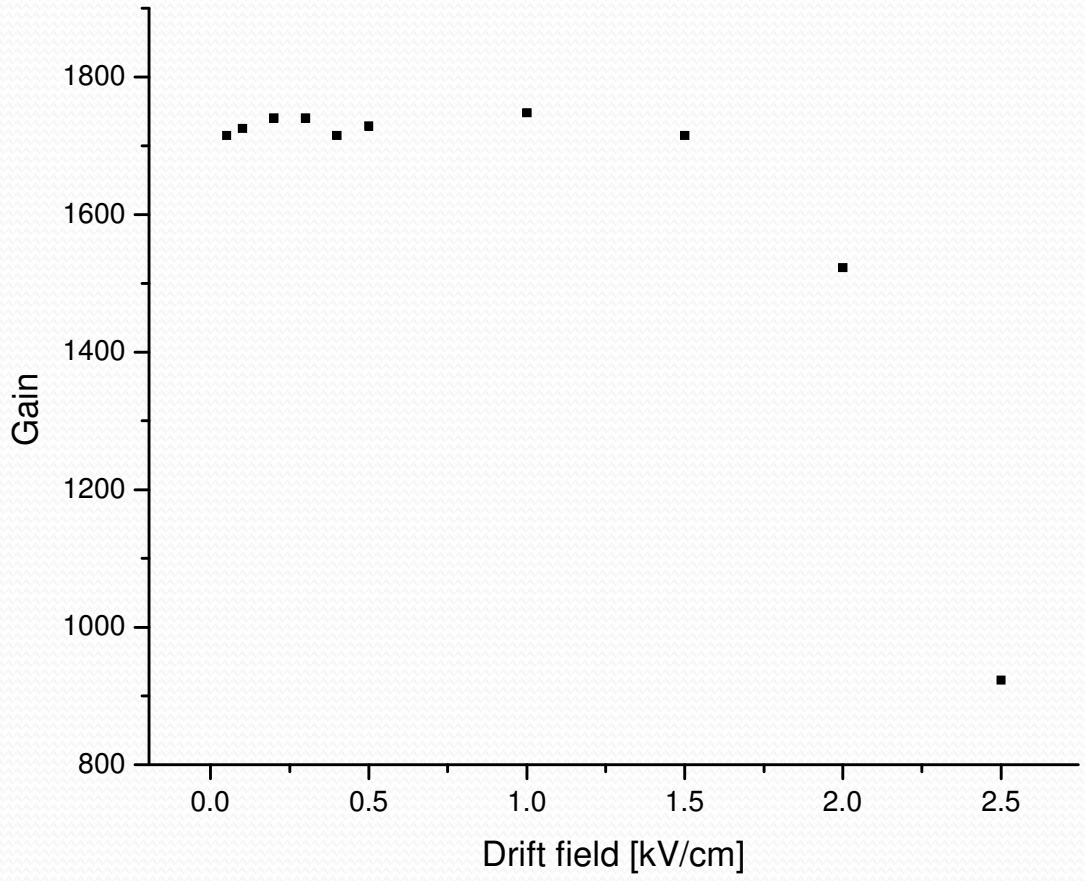
^{55}Fe source

Drift field 0.62 kV/cm

GEM voltage 325 V

Mesh voltage 500 V

Drift field scan



Gas mixture Ar/CF_4 90/10

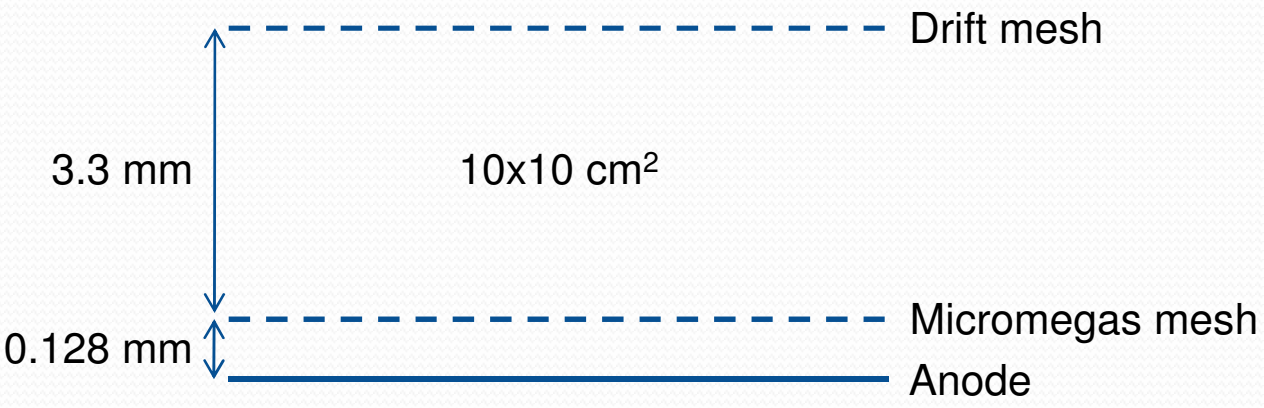
^{55}Fe source

GEM voltage 325 V

Transfer field 1.25 kV/cm

Mesh voltage 500 V

Detector schematic



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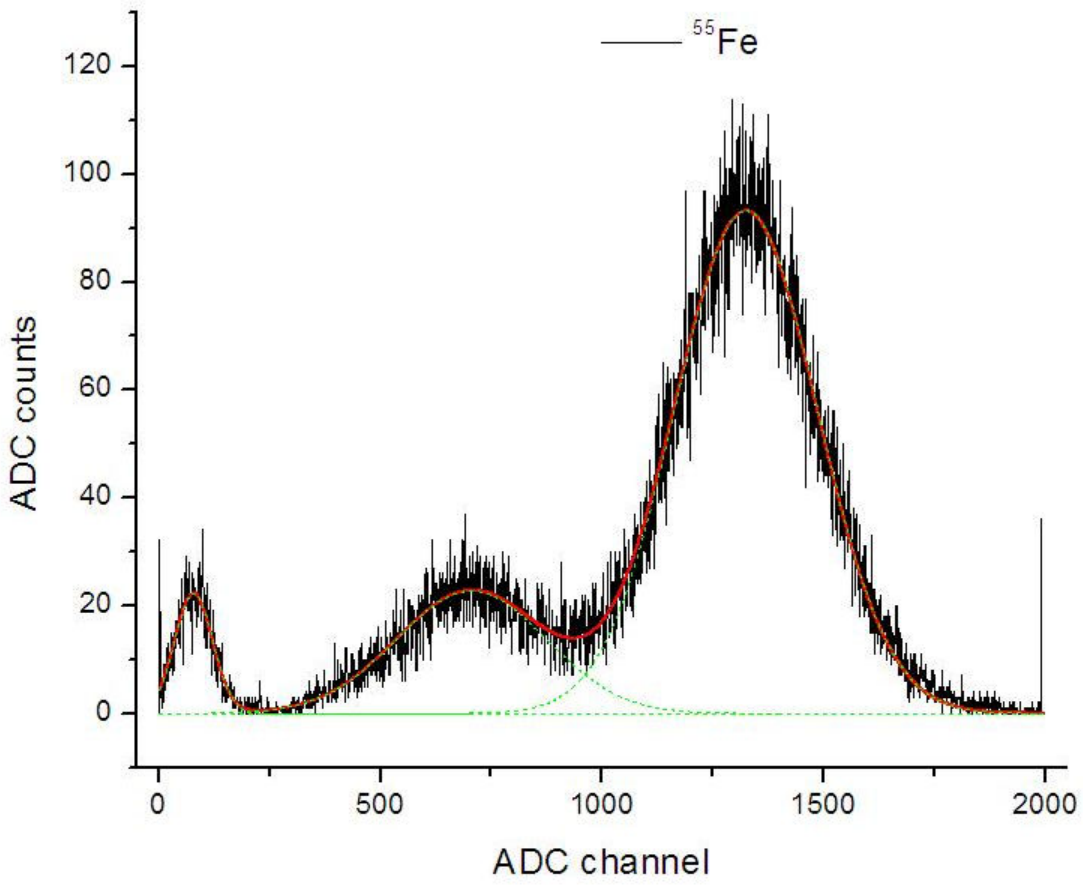
- 300 µm pillar diameter

Energy spectrum



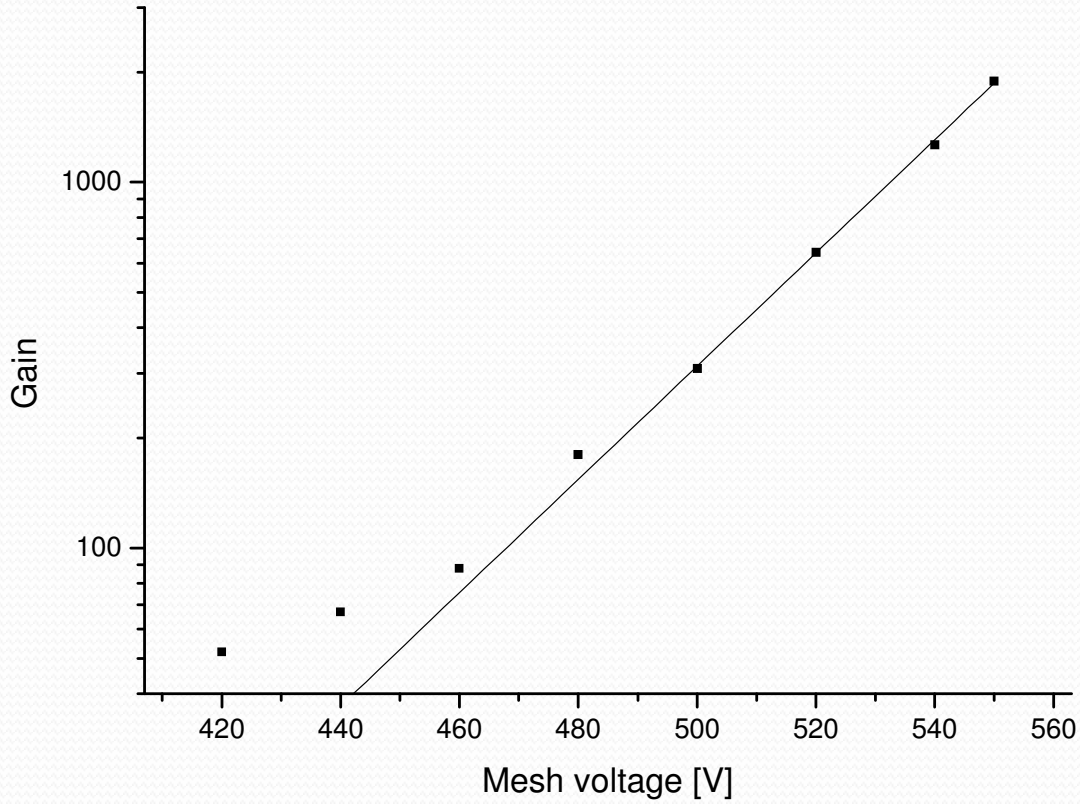
Gas mixture Ar/CF_4 90/10

^{55}Fe source

Drift field 1.25 kV/cm

Mesh voltage 500 V

Gain calibration



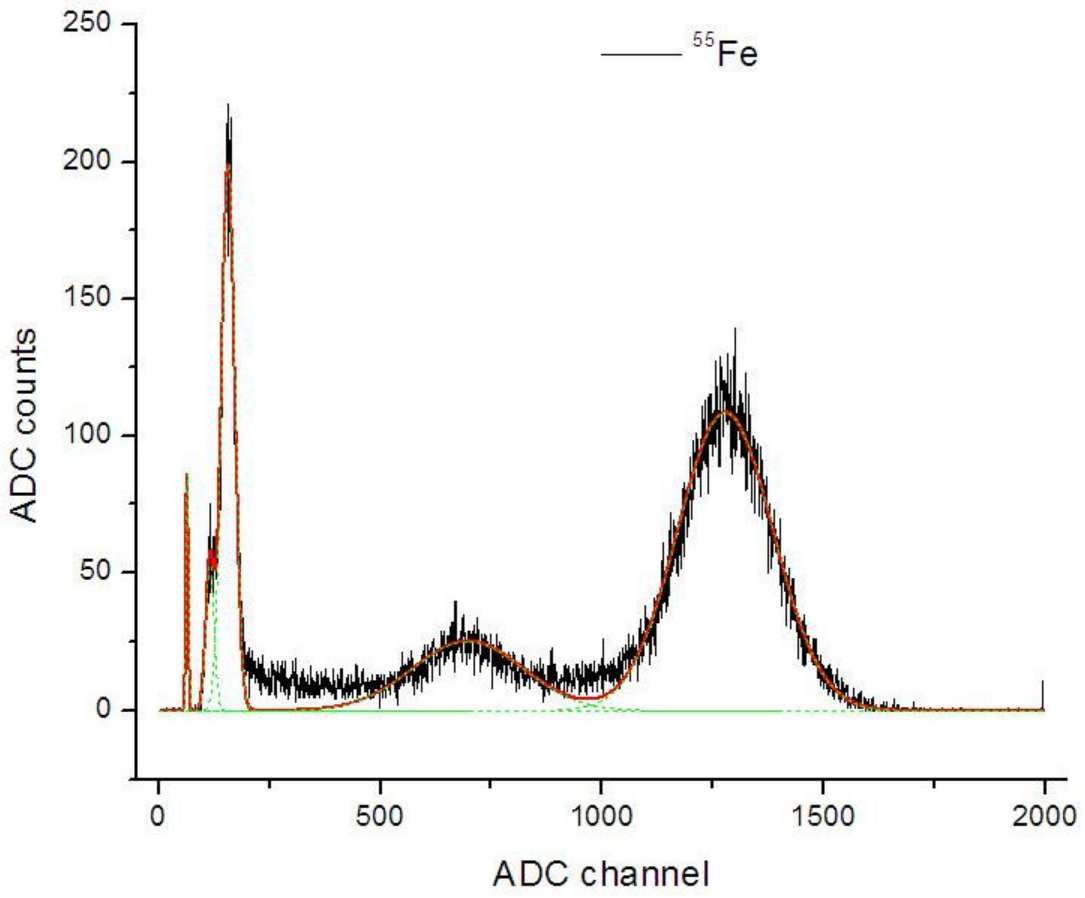
Gas mixture Ar/CF_4 90/10

Cu X-ray tube

Drift field 1.25 kV/cm

$$G = \frac{I \cdot \#_{L,w} \cdot \Delta t}{\#_{p/\gamma} \cdot \#_{H,w} \cdot \#_{L,wo} \cdot e}$$

Energy spectrum



Gas mixture Ar/CF_4 90/10

^{55}Fe source

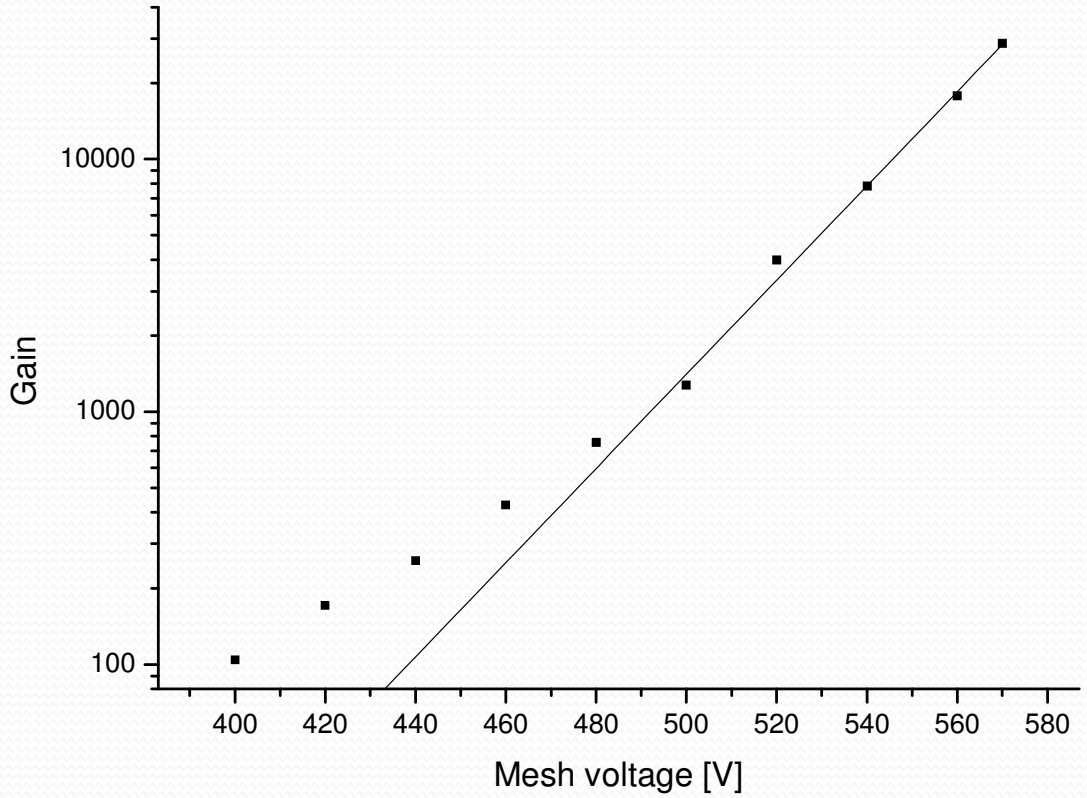
Drift field 0.62 kV/cm

GEM voltage 325 V

Transfer field 1.25 kV/cm

Mesh voltage 520 V

Gain calibration



Gas mixture Ar/CF_4 90/10

Cu X-ray tube

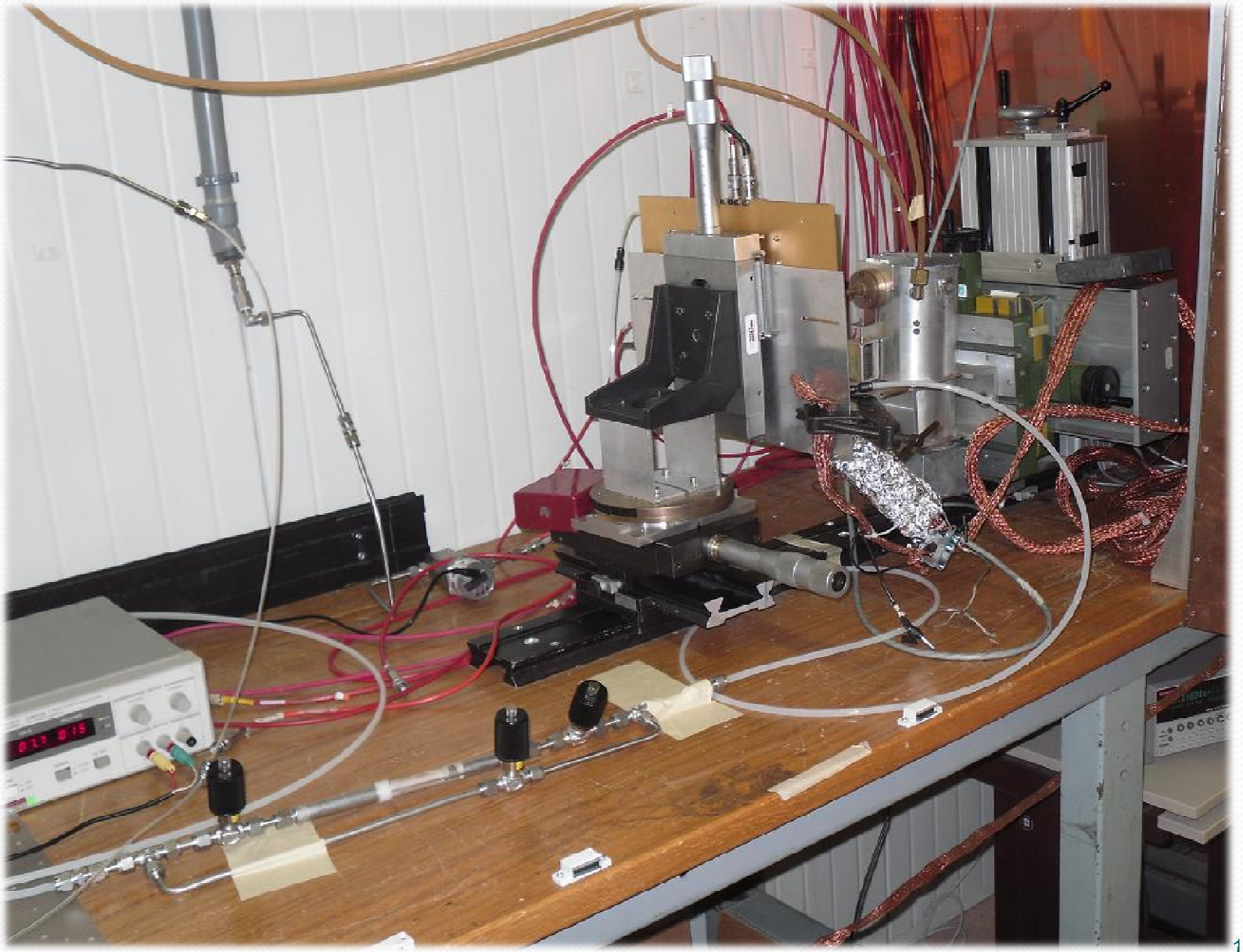
Drift field 0.62 kV/cm

GEM voltage 325 V

Transfer field 1.25 kV/cm

$$G = \frac{I \cdot \#_{L,w} \cdot \Delta t}{\#_{p/\gamma} \cdot \#_{H,w} \cdot \#_{L,wo} \cdot e} \cdot \frac{\sum_{i=2}^{3} p_i \cdot A_i}{\sum_{i=1}^{3} p_i \cdot A_i} \cdot \frac{\sum_{i=1}^{3} A_i}{\sum_{i=2}^{3} A_i}$$

Experimental setup

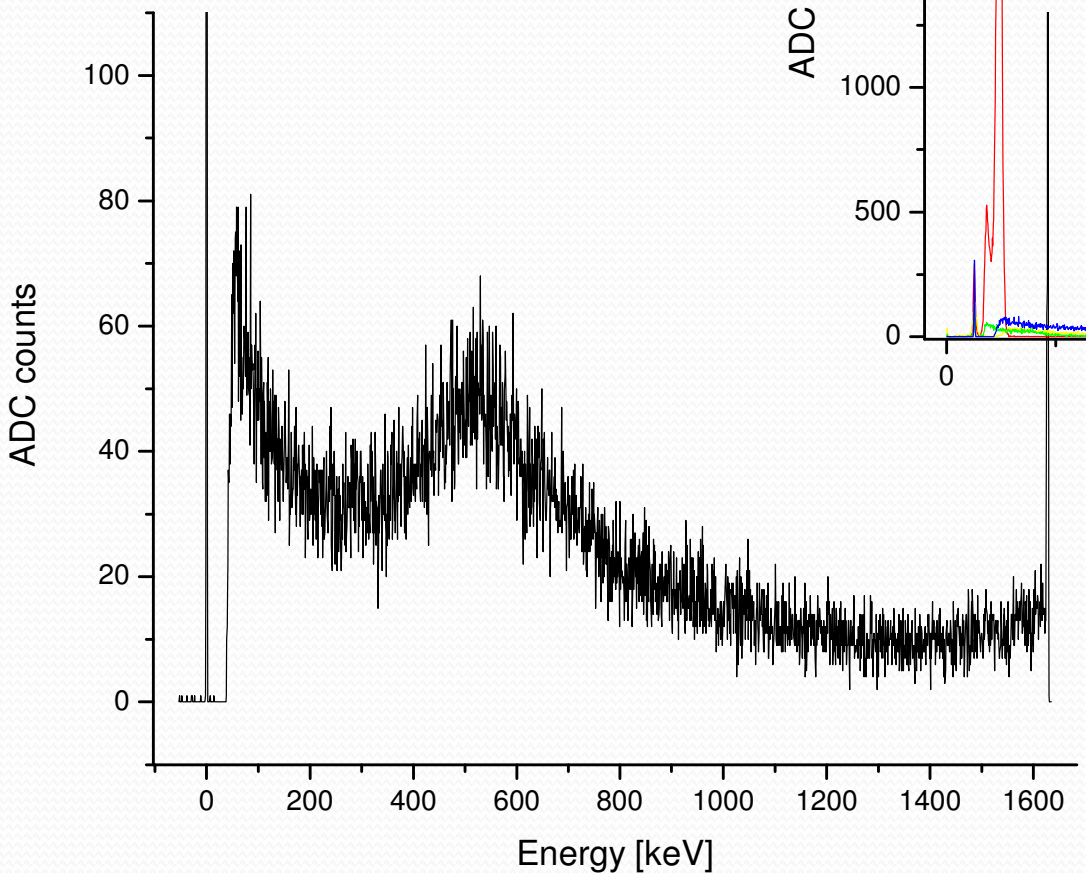


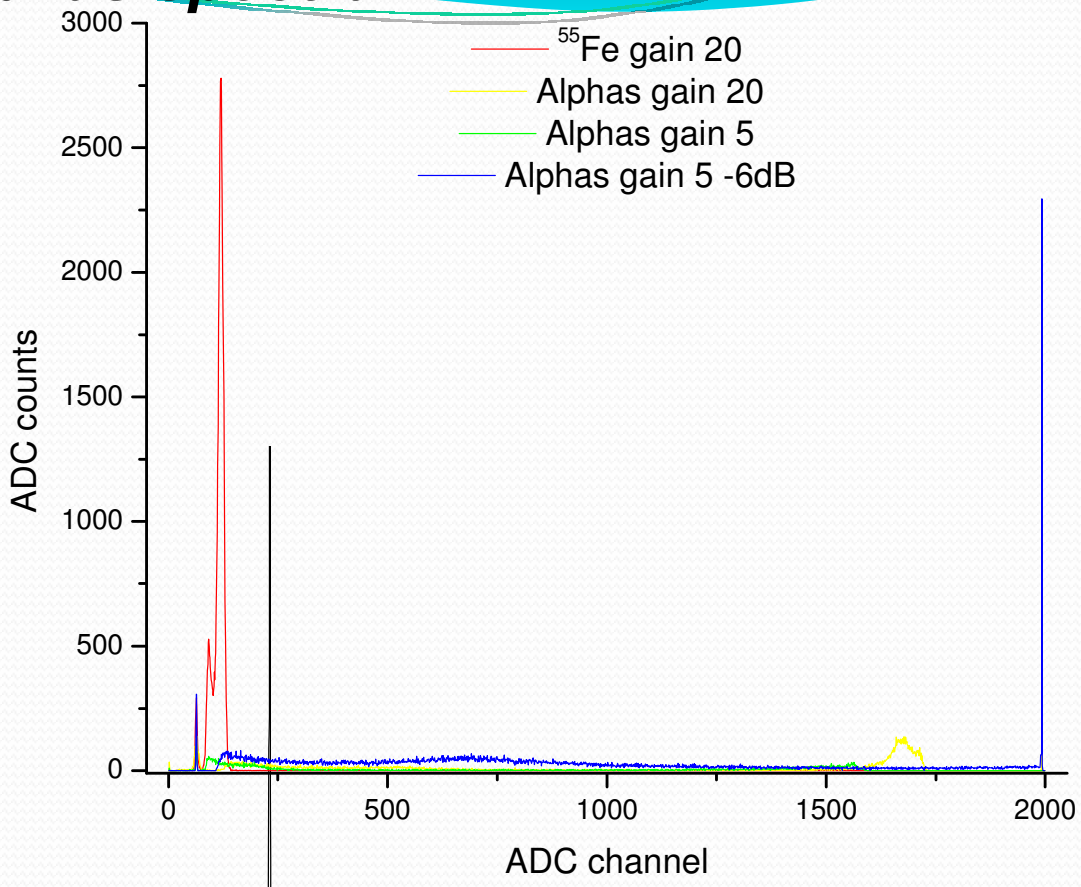
Alphas spectra

Gas mixture Ar/CF_4 90/10

^{232}Th source → α

Drift field 0.62 kV/cm



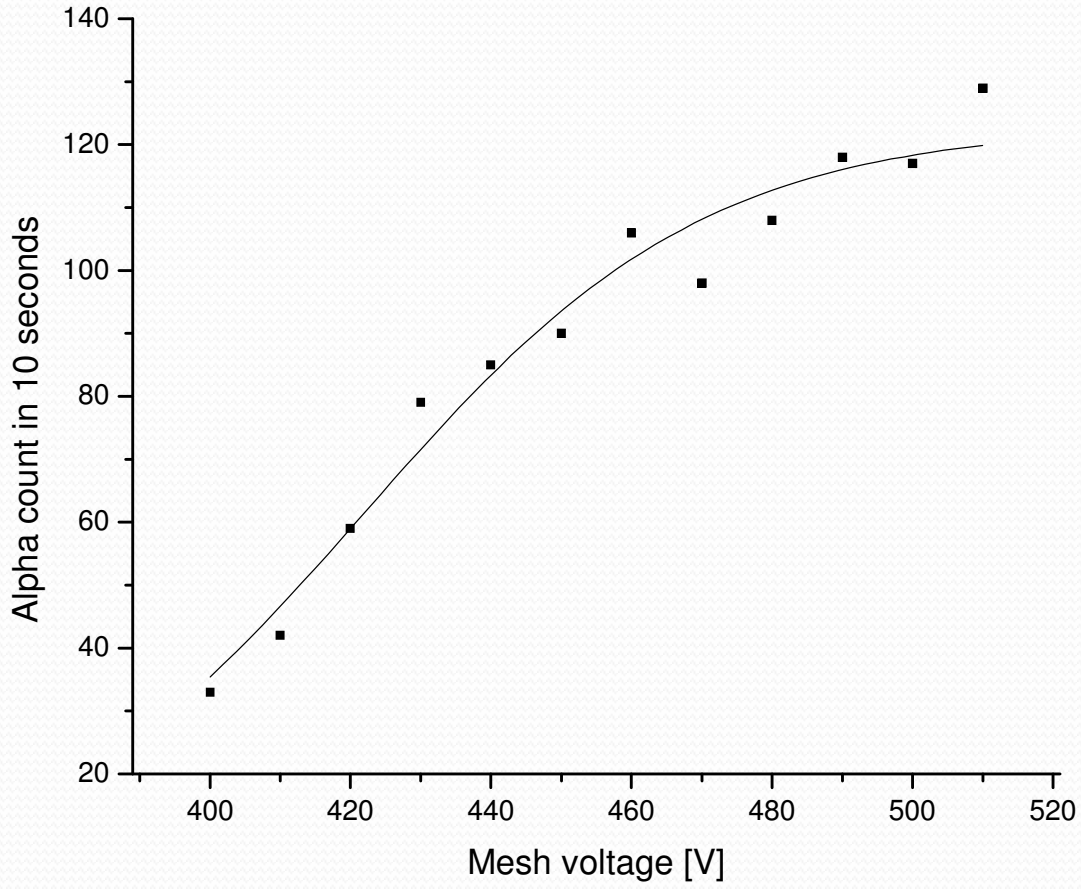


GEM voltage 325 V

Transfer field 1.25 kV/cm

Mesh voltage 440 V

Alphas counts and alpha rate

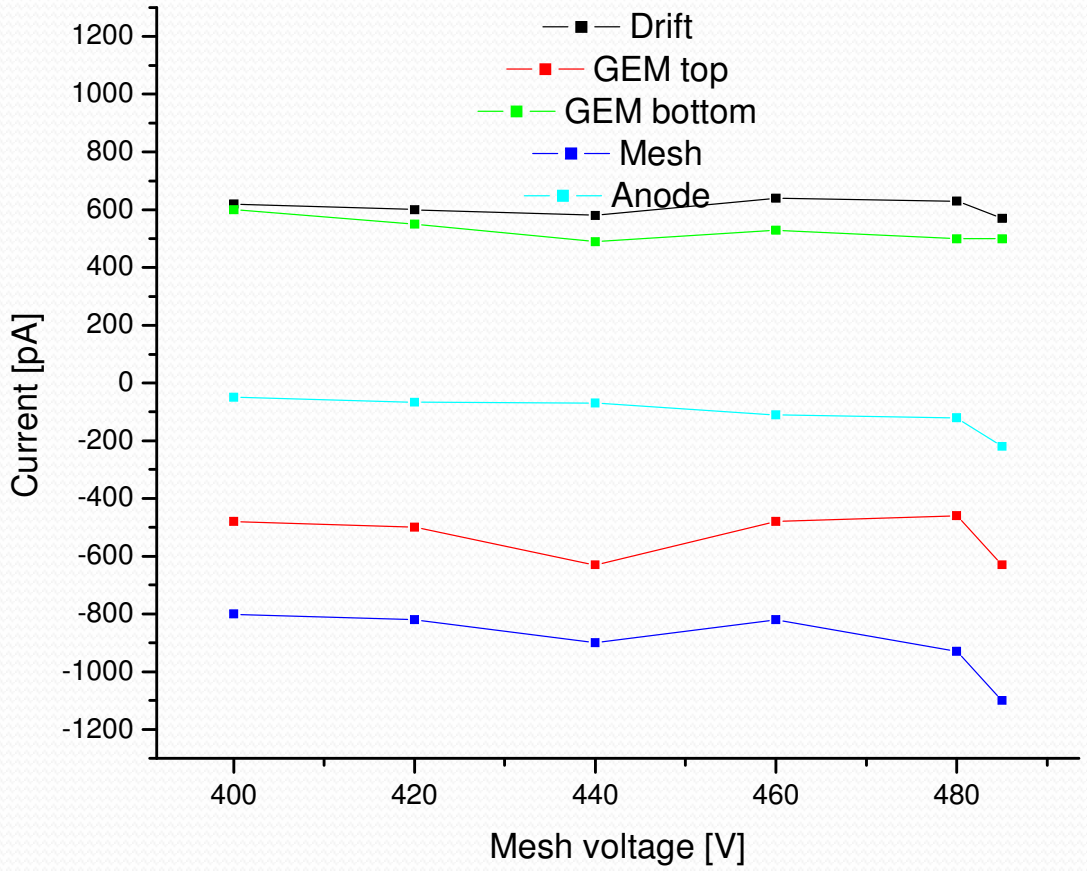


Gas mixture Ar/CF_4 90/10

^{232}Th source $\rightarrow \alpha$

Drift field 1.25 kV/cm

Measuring the currents on the electrodes…



Gas mixture Ar/CF_4 90/10

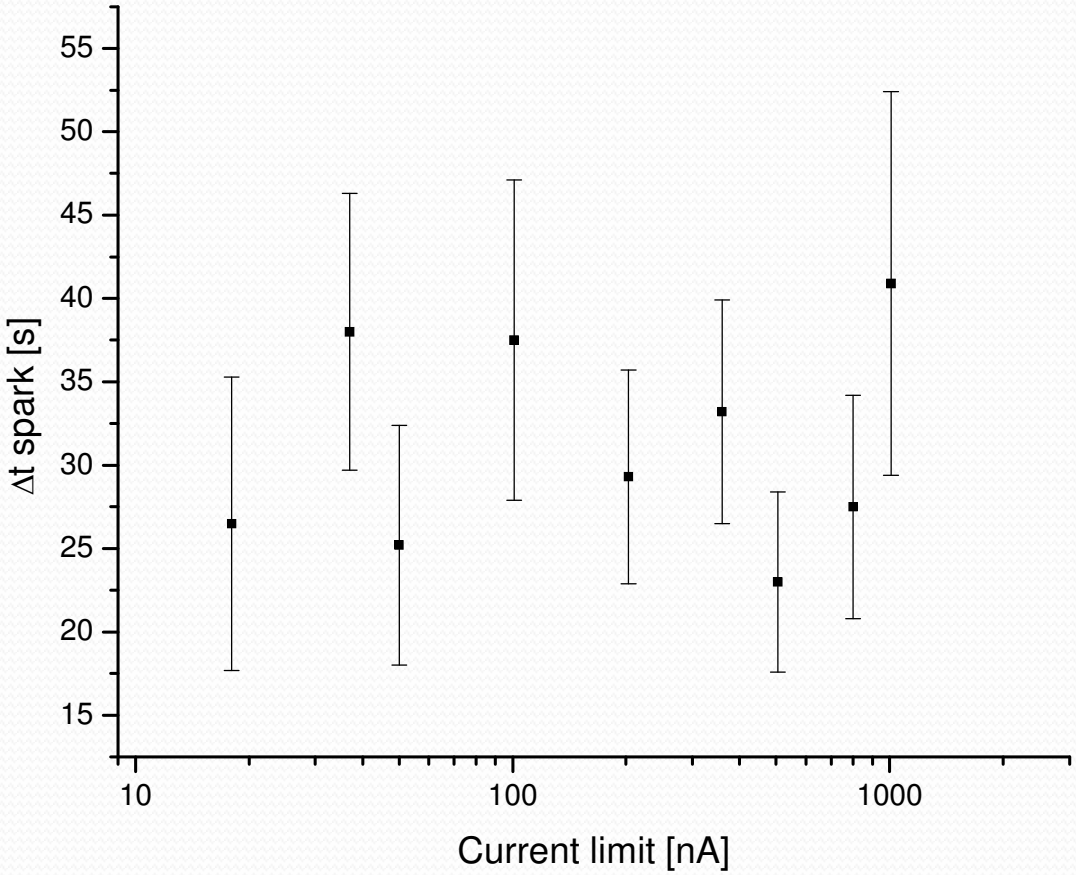
^{232}Th source → α

Drift field 0.62 kV/cm

GEM voltage 325 V

Transfer field 1.25 kV/cm

…and setting the current limit on the power supply



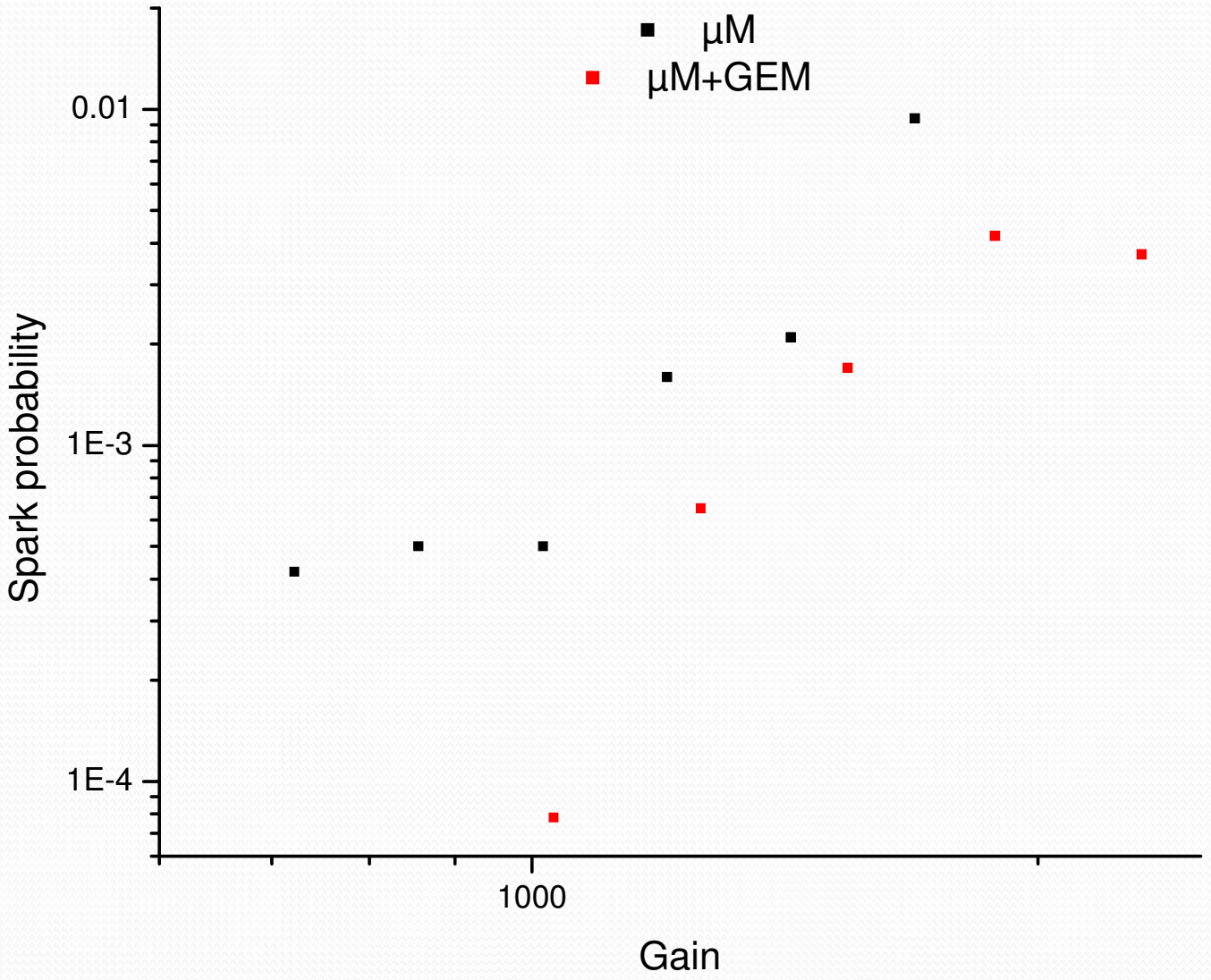
Gas mixture Ar/CF_4 90/10

^{232}Th source → α

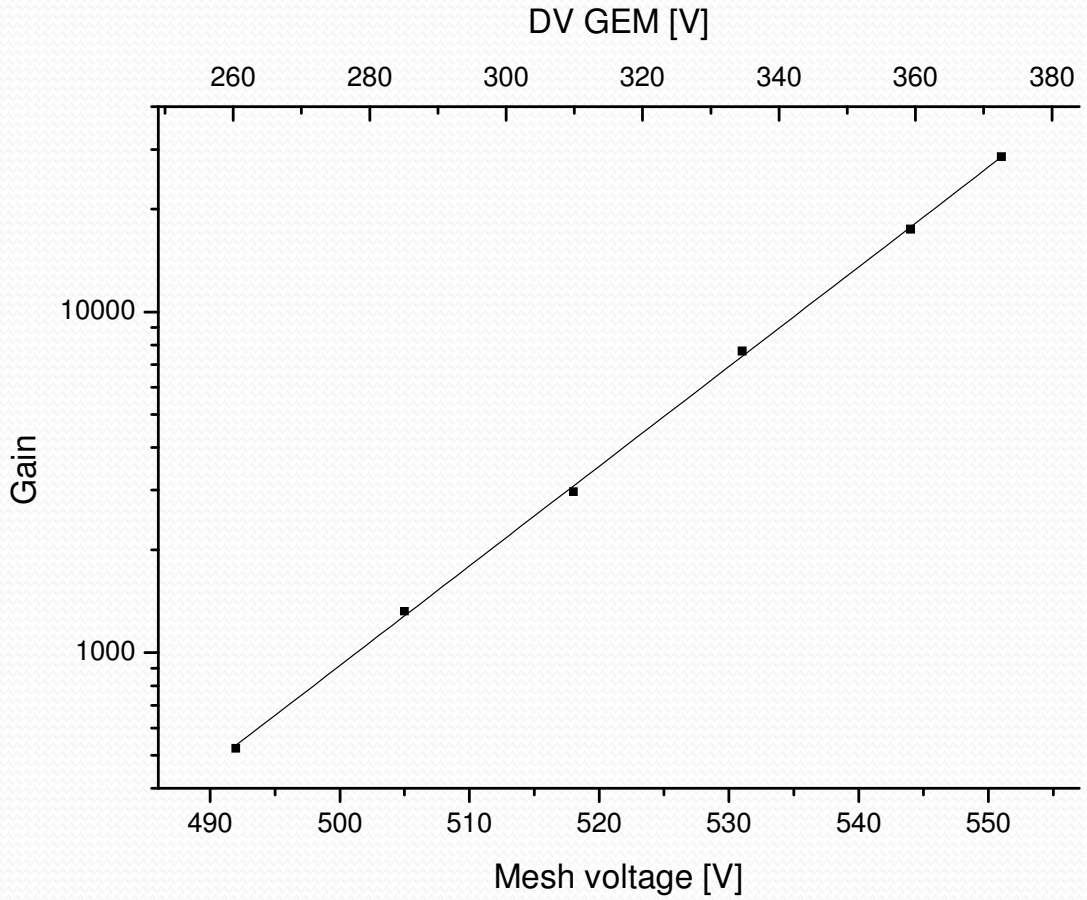
Drift field 1.25 kV/cm

Mesh voltage 525 V

Spark probability



Gain calibration



$$G = \frac{I \cdot \#_{L,w} \cdot \Delta t}{\#_{p/\gamma} \cdot \#_{H,w} \cdot \#_{L,wo} \cdot e} \cdot \frac{\sum_{i=2}^{3} p_i \cdot A_i}{\sum_{i=1}^{3} p_i \cdot A_i} \cdot \frac{\sum_{i=1}^{3} A_i}{\sum_{i=2}^{3} A_i}$$

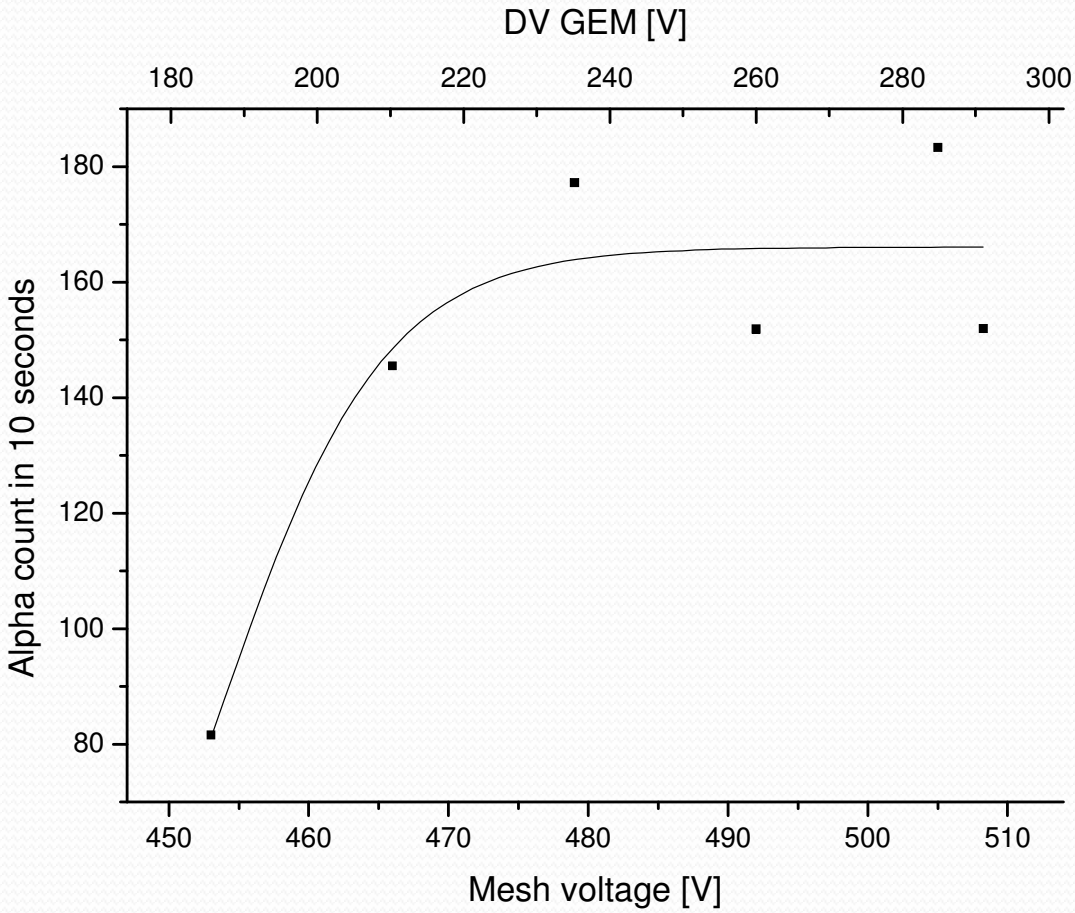
Gas mixture Ar/CF_4 90/10

Cu X-ray tube

Drift field 0.62 kV/cm

Transfer field 1.25 kV/cm

Alpha counts and alpha rate



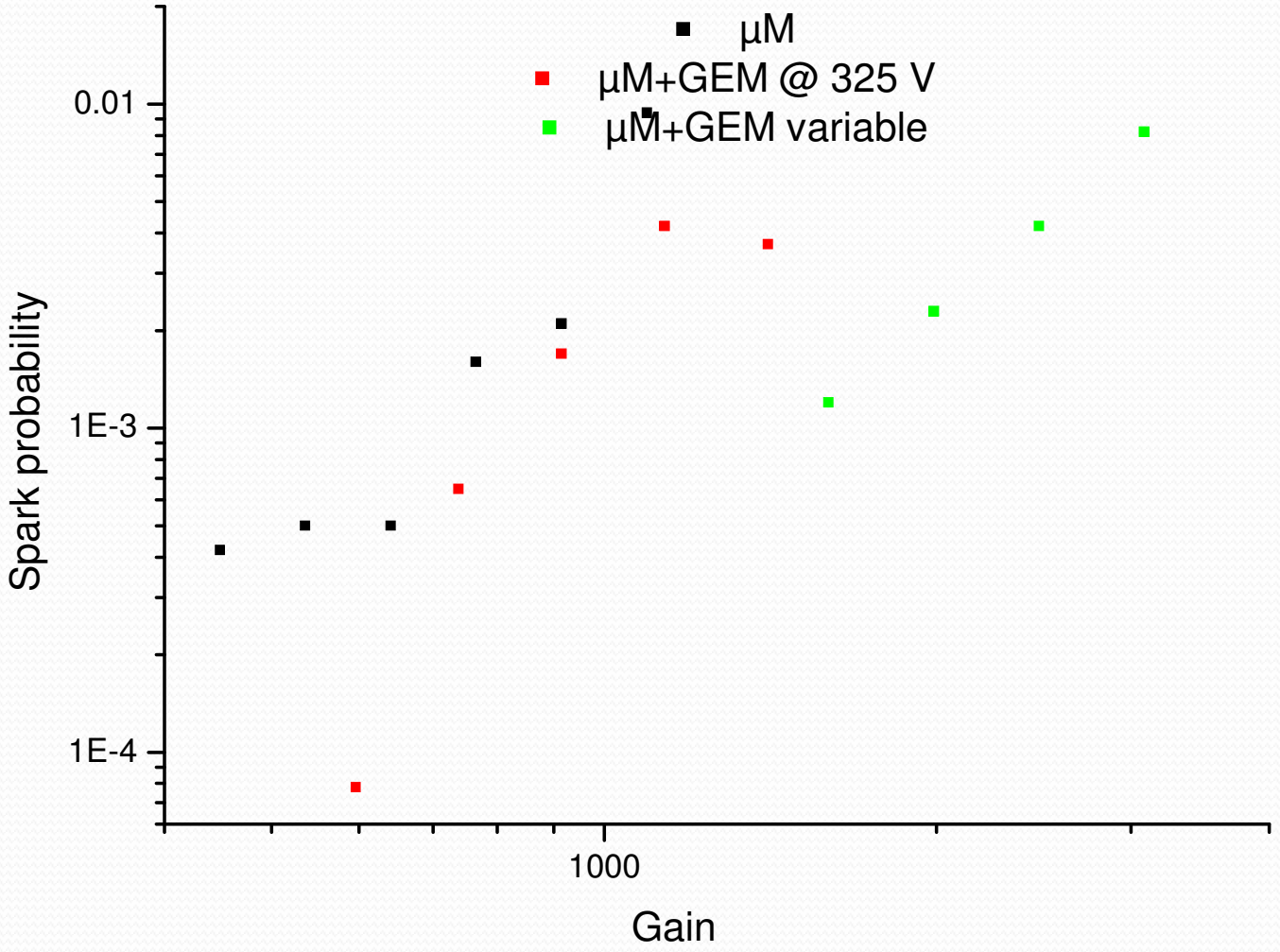
Gas mixture Ar/CF_4 90/10

^{232}Th source $\rightarrow \alpha$

Drift field 0.62 kV/cm

Transfer field 1.25 kV/cm

Spark probability



Conclusions

- A 10x10 cm^2 bulk Micromegas + GEM detector has been characterized and its spark properties have been investigated

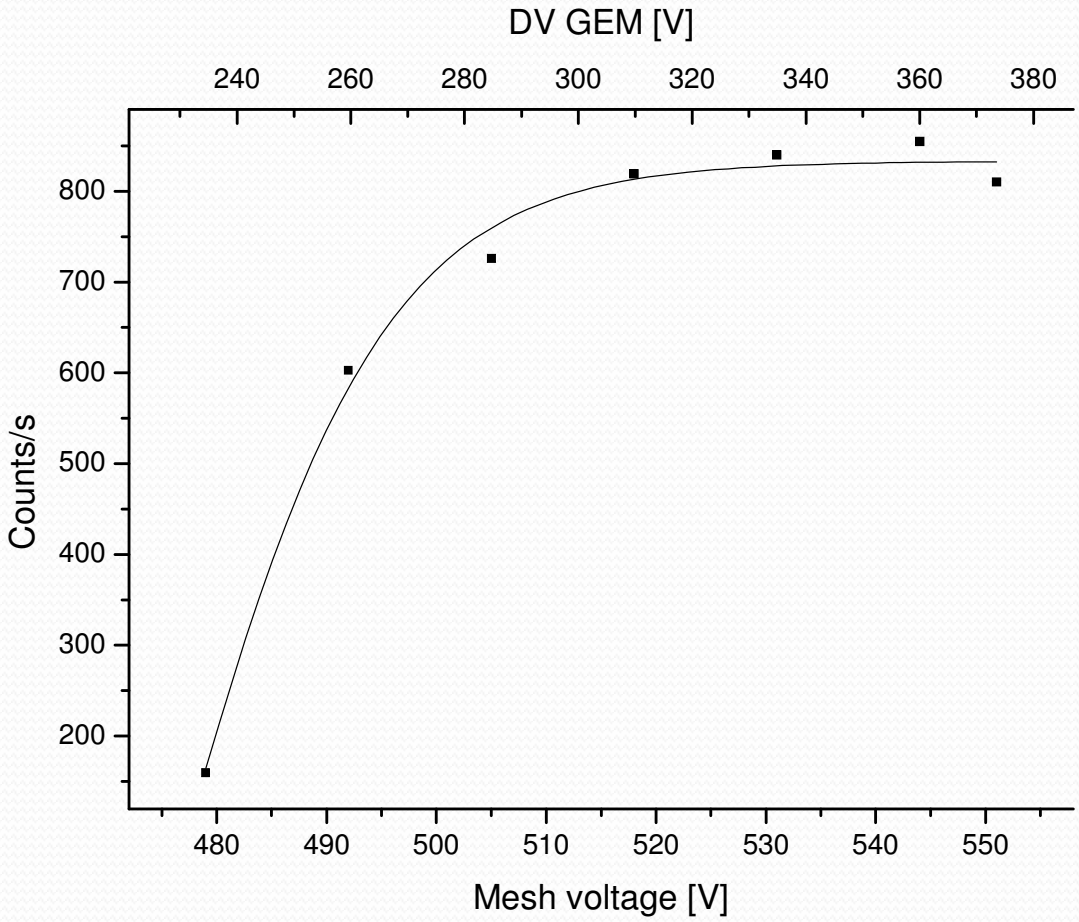
- The detector performance has been compared to that of a standard bulk Micromegas

- A GEM-based preamplification stage above the Micromegas mesh proves to be a good solution to decrease the spark probability for a given gas gain

- Better performance is achieved increasing the effective gain on the GEM

Spare slides

Efficiency plot



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