Characterization of a gas tracker prototype based on THGEM for the focal plane detector of the MAGNEX magnetic spectrometer

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for the NUMEN collaboration

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Introduction

NUMEN (Nuclear Matrix elements for Neutrinoless double beta decay) [1] is an ambitious project that aims at deducing information on the **nuclear matrix elements (NMEs)** of **neutrinoless double beta decay** by measuring cross sections of **double charge exchange (DCE)** nuclear reactions induced by heavy-ions.

The goals

- Give **constraints** to the nuclear structure theories for NMEs calculations
- Measure the **complete net of reaction channels** that may contribute to the final DCE cross-section **under the same experimental conditions** [2]

The challenge

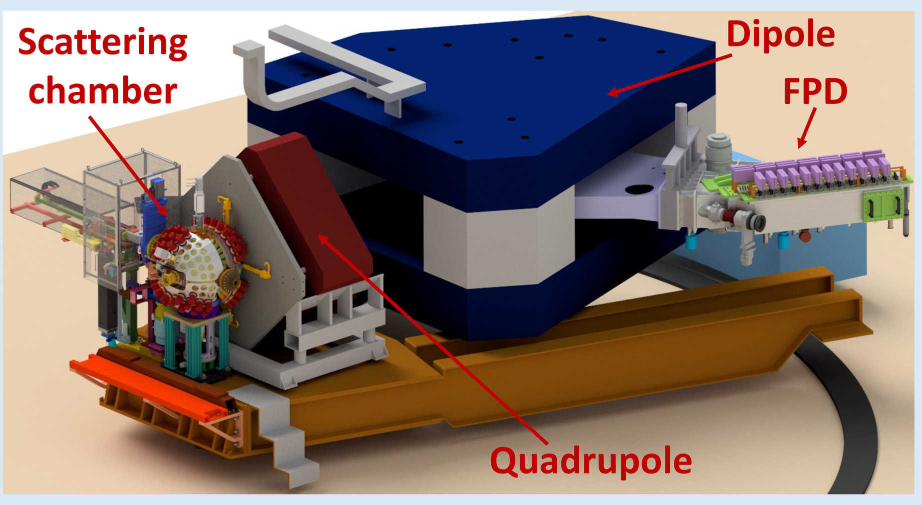
- DCE reactions have typically **very small cross sections**, of the order of few tens of nbarn [3].

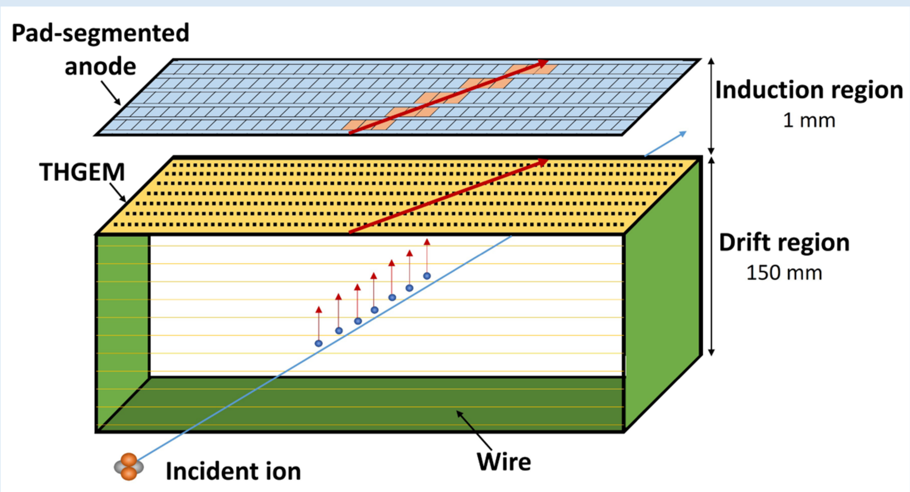
The solution

- Upgrade towards **high intensity beams** (about 2 kW)

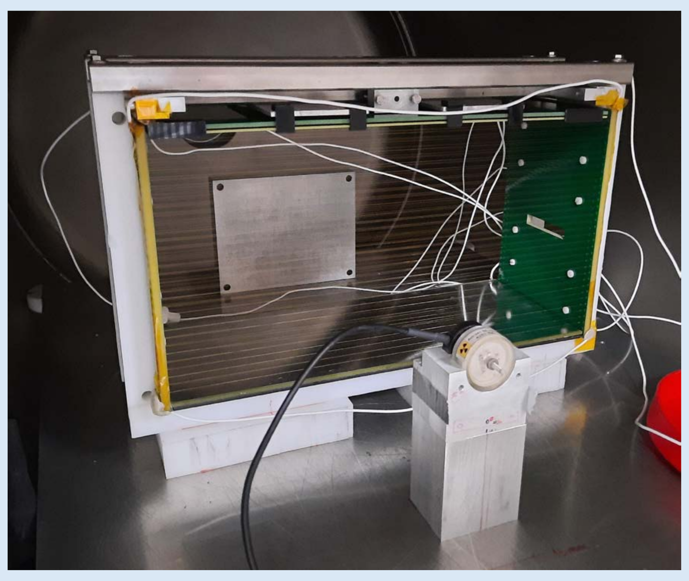
The R&D

- New focal plane detector (FPD) with **new gas tracker** and **PID wall** [4]
- **THGEM** technology suitable for coping with **high rates** and giving **sub –millimetric resolution**
- **Systematic tests** on different kinds of THGEM [5]





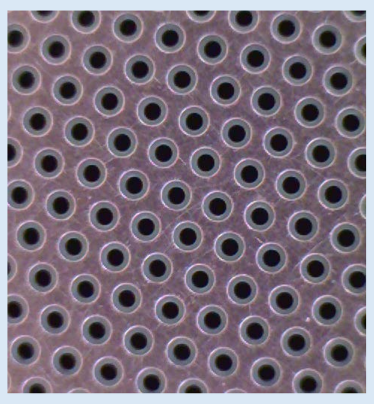
Experimental setup and method

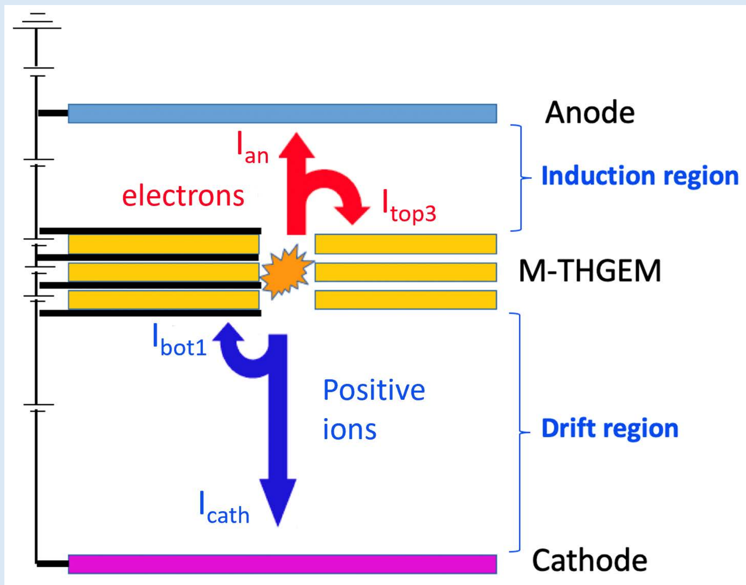


- Reduced size **prototype** of the gas tracker
  - **Active volume**: 300 × 150 × 108 mm^3
  - Gas: **Isobutane** at low pressure (10, 20, 30 mbar)
- **α -particle source**: ^{241}Am with 52 kBq activity
- **Picoammeter** with precision of about 15 pA
- Shutter

Three different kinds of THGEM were tested

	Layers	Thickness (mm)	Size (mm × mm)	Rim size (mm)	Holes diameter (mm)	Holes pitch (mm)
V0	3	1.340	300 × 108	0.1	0.30	0.75
V1	1	1.270	300 × 108	0.1	0.30	0.75
V3	3	1.340	300 × 108	NO	0.30	0.75

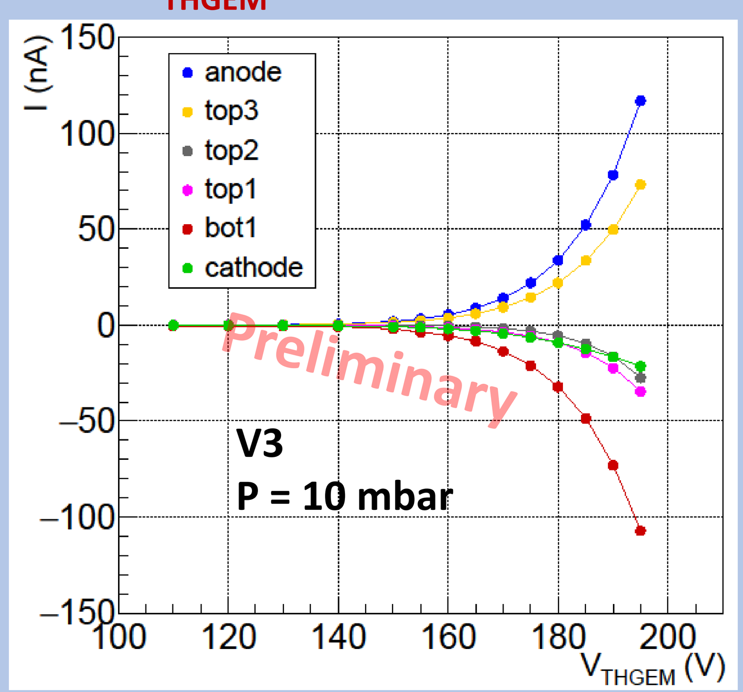




- Measure the **currents** changing **one parameter at a time**
- Experimental runs have the following structure:
  - 60 s shutter **closed**
  - 120 s shutter **open**
  - 15 s shutter **closed**

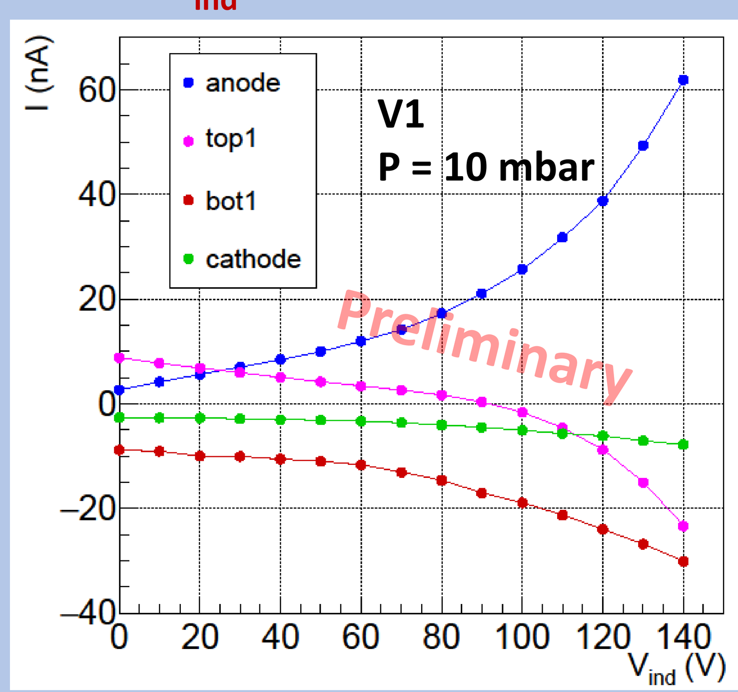
Current-voltage characterization

V_{THGEM} characterization



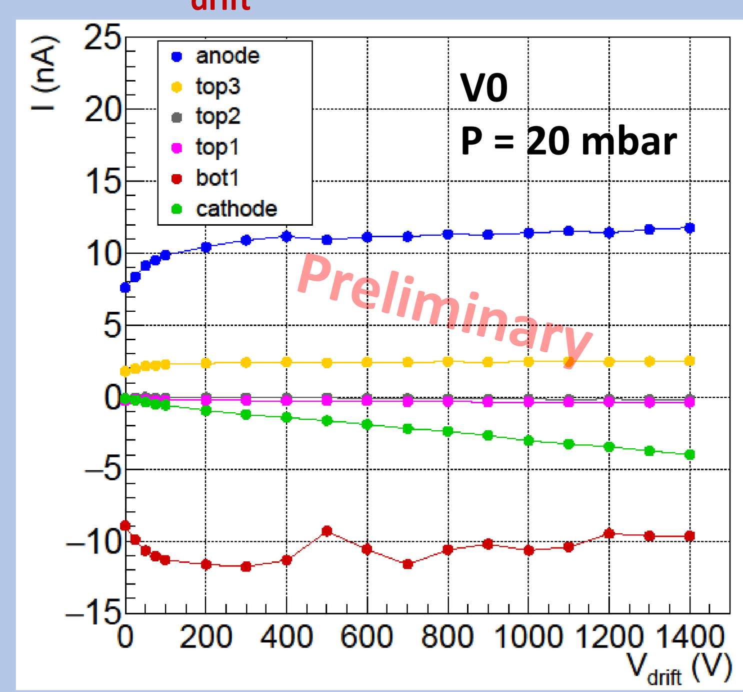
- Exponential increase of the currents

V_{ind} characterization



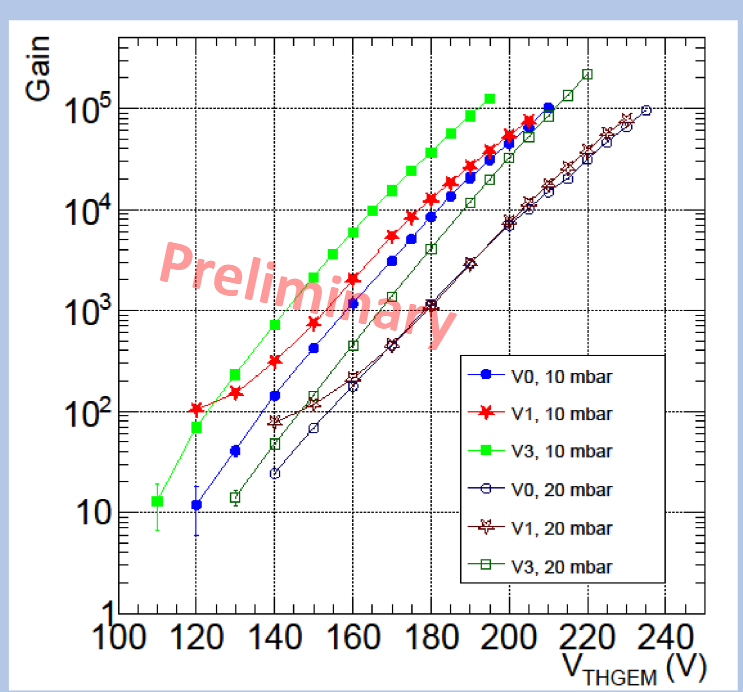
- Change of the charge sharing between anode and top electrodes
- Above 75 V there is an exponential increase of the currents

V_{drift} characterization



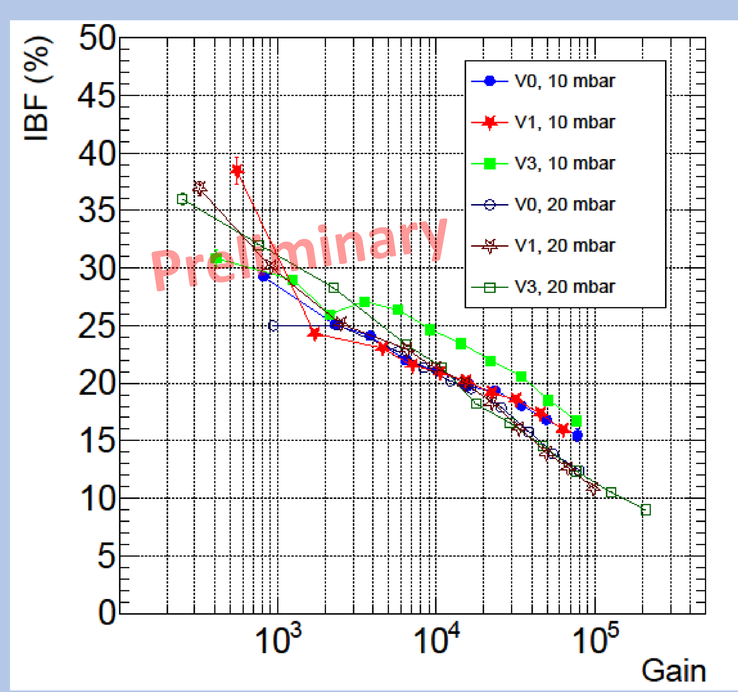
- I_{an} reaches a saturation value above 500 V

Gain



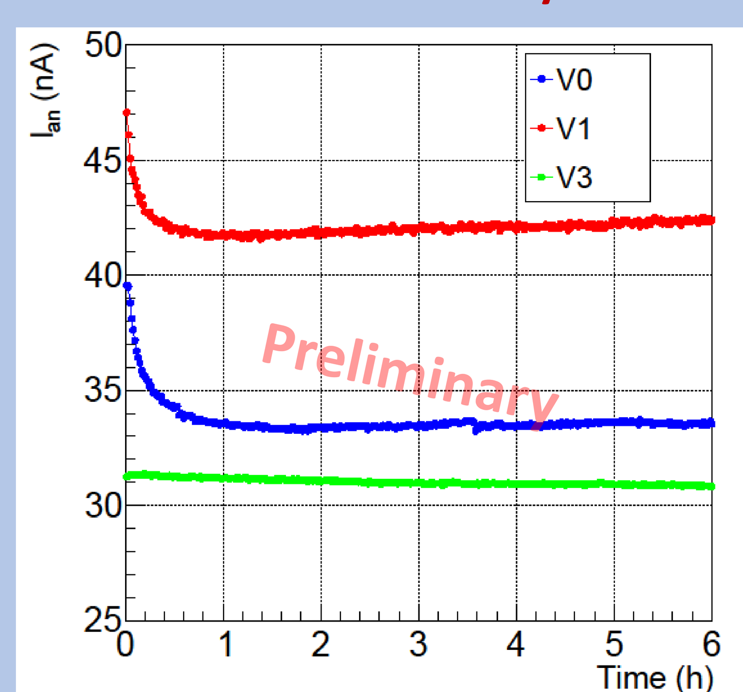
- Gain defined as: $\frac{I_{an}+I_{top3}}{I_{prim}}$
- Maximum gain value of about 10^5
- Note: V_{THGEM} values for V1 should be multiplied by 3

Ion backflow



- IBF defined as: $\frac{I_{cath}}{I_{cath}+I_{bot1}}$
- IBF of about 30% for gain of about 10^3

Currents stability



- V0 and V1 need about 1/2 hour to reach stability
- V3 shows a negligible time dependence of the gain
- Similar behaviour for the other currents

References

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[4] F. Cappuzzello, C. Agodi, L. Calabretta *et al.*, Intern. J. Mod. Phys. A **36** (2021) 2130018
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Concluding remarks and perspectives

- ✓ A **current-voltage characterization** of three kinds of THGEM was performed
- ✓ Maximum **gain of about 10^5** was observed for all the tested THGEMs
- ✓ The **measured IBF** as a function of the gain is **similar** for the three tested THGEMs
- ✓ Good gain stability for the **THGEM without rim** (it is **less affected** by charging up effects)

- ❑ Characterization at different rates with a **high intensity α-particle source** (^{241}Am with 11.1 MBq activity)
- ❑ Study of the tracking performances with a **pad-segmented read-out anode**
- ❑ **In-beam** tests