# Negative ions as charge carriers in gaseous detectors

## First results on $SF_6$ and Xe-$SF_6$ mixtures

**A. P. Marques** [a, b, *], F. P. Santos [a, b], F. I. G. M. Borges [a, b], J. F. Sousa [a, b], A. M. F. Trindade [a, b]

a) LIP - Laboratório de Instrumentação e Física Experimental de Partículas | b) Departamento de Física da Universidade de Coimbra, Portugal

*** Corresponding author: amarques@lip.pt**

## Motivation

Experiments operating **gaseous detectors** rely on the **production** (and some in detection) of **charge**. The **high electron diffusion** in high pressure noble gases is a problem, specially to **experiments relying on the electron track**, so a solution must be found.

### Why not use negative ions as charge carriers?

| Pros | Cons |
|---|---|
| ✅ Smaller diffusion | ❌ Space-charge effects |
| ✅ Longer drift distances | ❌ Scintillation production |
| ✅ Different ions produced | ❌ Charge multiplication |
| ✅ $(\Delta t)_{drift}$ of ions | ❌ Efficiencies (att., det., ...) |

## Experiments and $SF_6$

**Phan et al.**
Low-pressure TPC with $SF_6$
**THGEM**: attachment, amplification, diffusion

**DRIFT Experiment**
Low-pressure TPC for **dark matter search**
$CS_2$ / $CF_4$ / $O_2$

**NEWAGE Experiment**
Micro-TPC for **dark matter search**
$SF_6$ negative ion drift

**INITIUM Experiment**
GEM-based TPC for **dark matter search**
He / $CF_4$ / $SF_6$ at 1 atm

$SF_6$ is **non-toxic**, **non-flammable**, **inert** and **easily accessible**, but **has green-house effects**

We intend to find **optimal settings of operation** for larger experiments to **reduce the release of $SF_6$**

## Working principle

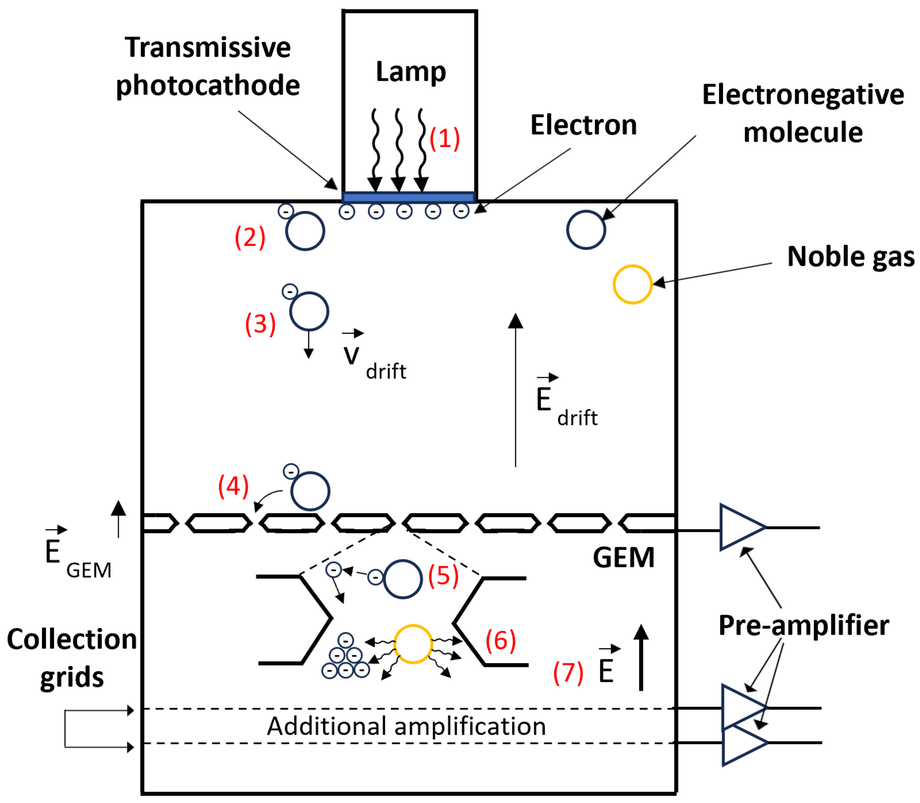


**Fig.1 – Working principle of the detector: (1) Electron production; (2) Attachment; (3) Negative ion drift; (4) Ions are guided to GEM holes; (5) Detachment; (6) Amplification; (7) Signal collected at grid for timing characteristics.**

## Mobility of $SF_6^-$ ions

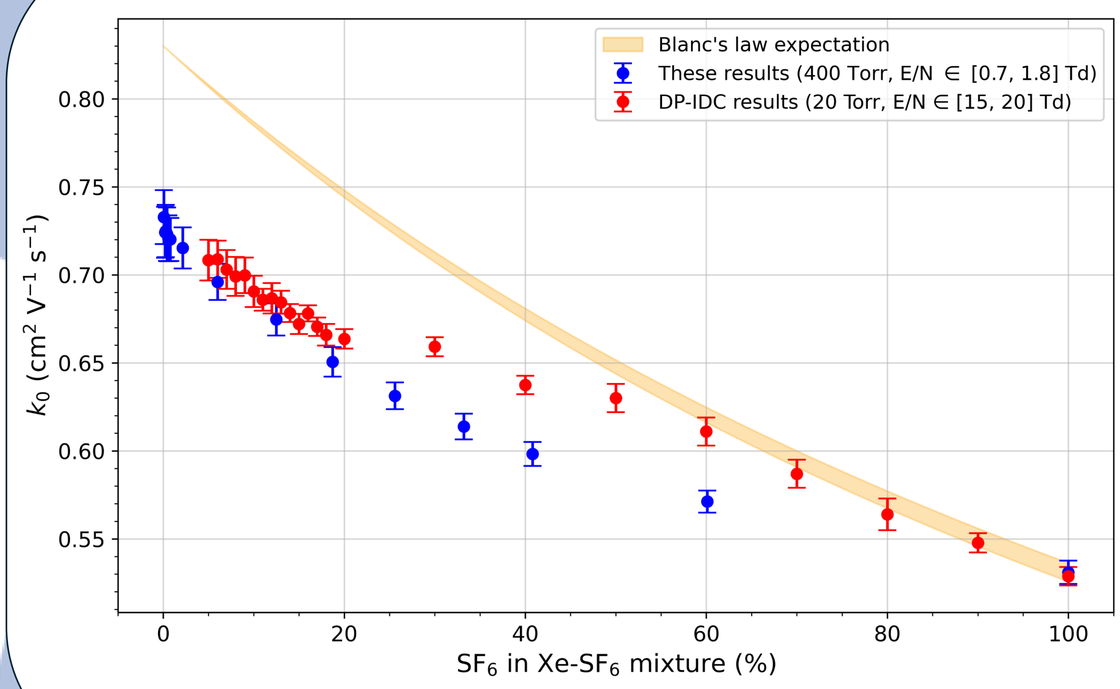


**Fig.2 – Reduced ion mobility for $SF_6^-$ and comparison with previous results and Blanc's prediction (T = 25 °C, $V_{GEM}$ = 50 V).**

## Charge multiplication

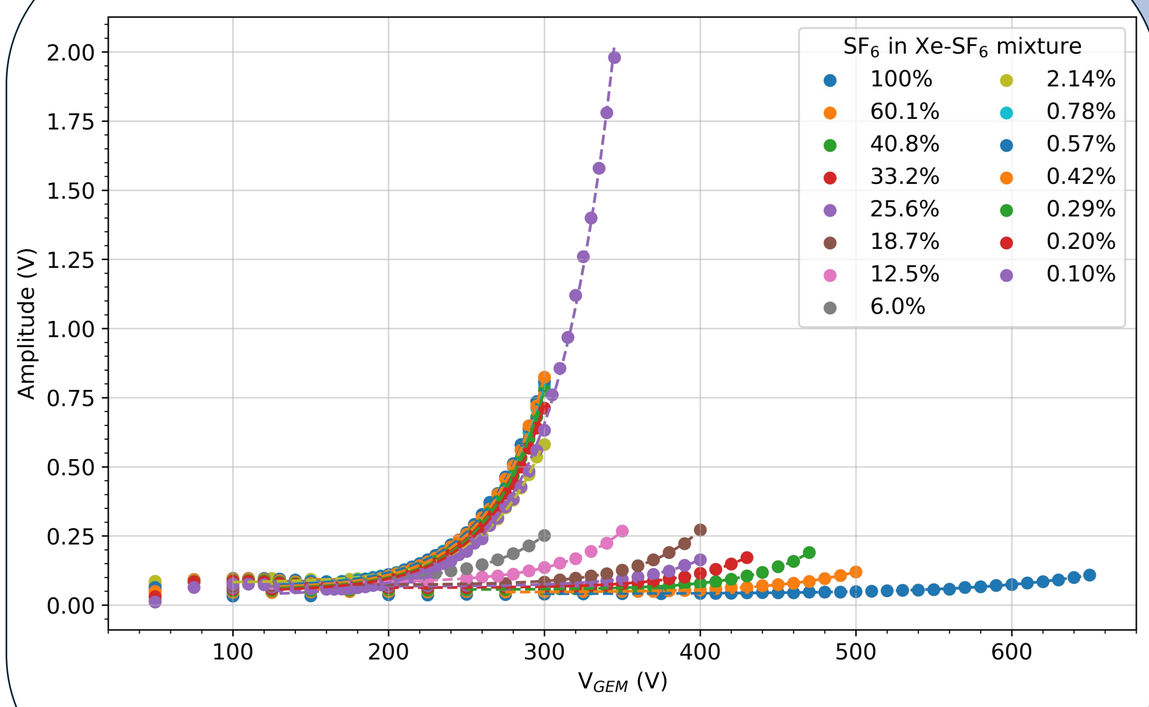


**Fig.3 – Charge collected at first collection grid as a function of $V_{GEM}$ for different fractions of $SF_6$ ($(E/N)_1$ = 1.5 Td, $(E/N)_2$ = 12.5 Td, T = 25°C, p = 400 Torr).**

## Voltage required

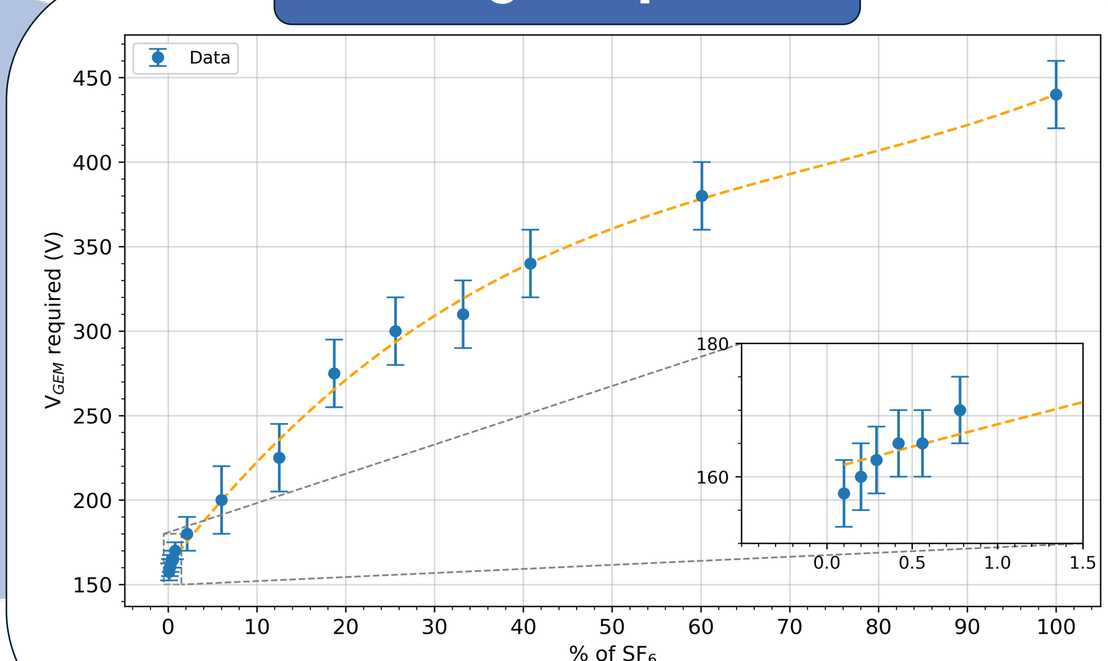


**Fig.4 – Voltage $V_{GEM}$ required for charge multiplication for different fractions of $SF_6$ ($(E/N)_1$ = 1.5 Td, $(E/N)_2$ = 12.5 Td, T = 25°C, p = 400 Torr).**

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## Future work

More pressure regimes will be studied, a **PMT for VUV light** will be **inserted in the system to measure the possible electroluminescence yield, and the use of more GEMs will be considered.**