GAS DETECTORS R&D

WORK AT LIP-COIMBRA

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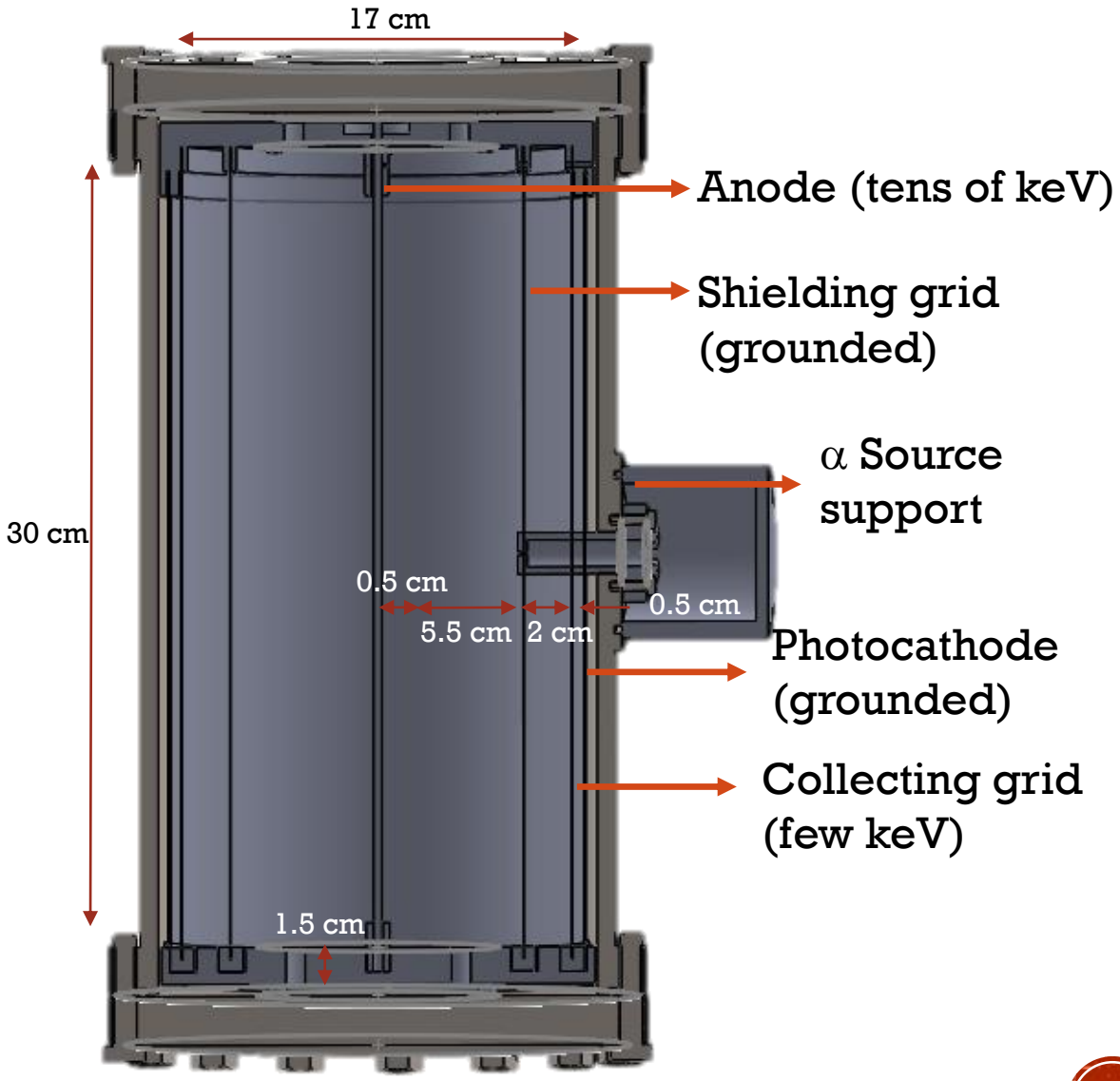
TOPICS DEVELOPED AND ASSOCIATED THESIS

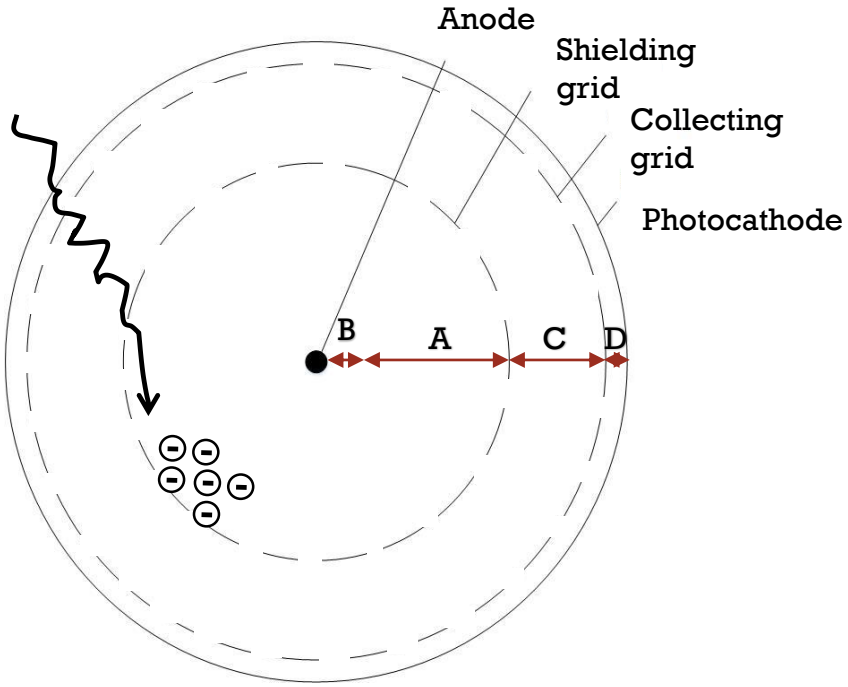
- High Pressure Xe GPSC
  - PhD thesis to be completed in 2018 (André Cortez)
- Ion Mobility measurement for gases of interest in large volume detectors
  - 2 MSc thesis completed (Pedro Encarnação, 2016; José Perdigoto, 2017)
  - 1 MSc thesis ongoing (Miguel Santos, 2018)
  - PhD thesis to be completed in 2018 (André Cortez)
- Experimental system to measure electron drift velocity in gases
  - 1MSc thesis completed (Daniel Cavaleiro, 2016)
- Experimental study of electrical discharges in HP gas detectors
  - 1MSc thesis completed (Bruno Rasteiro, 2016)
- Experimental study of the extraction efficiency of photocathodes in gases
  - Post Doc from KEK (Dr. K. Saito, 2015)
  - 1 MSc thesis completed (Francisco Rolo, 2016)

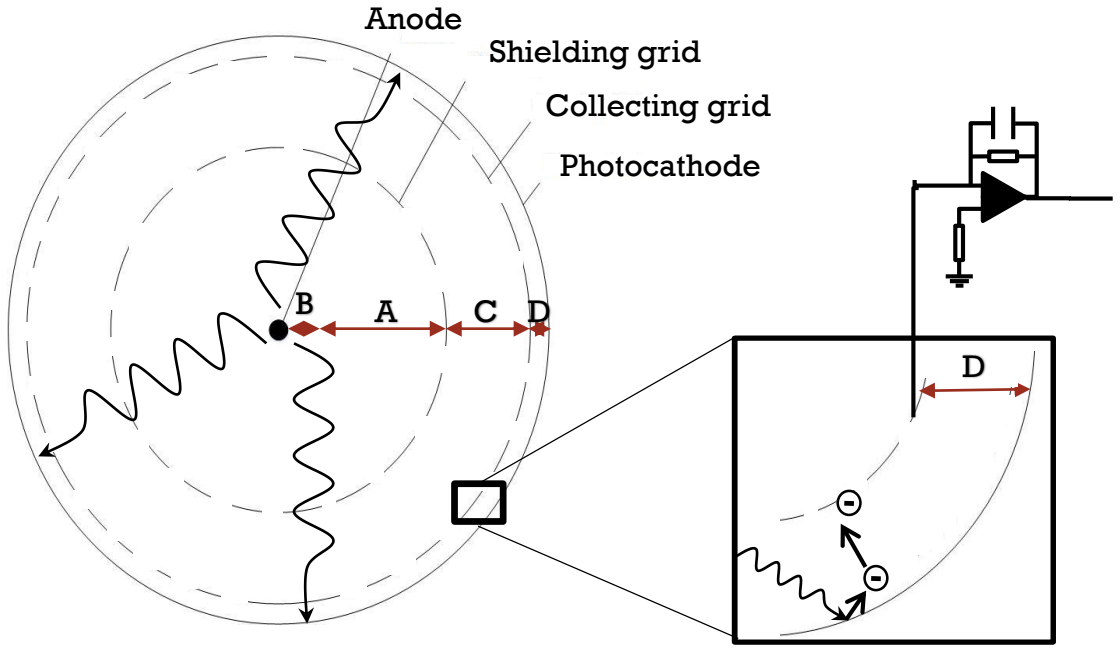
HP XE GPSC

- **Ruggedized detector for field aplications (hard X-rays and gamma detection):**
  - Homeland security;
  - Boreholes for geological prospection;
- **How is it achieved?**
  - Use of scintillation as amplification method;
  - Ruggedized photosensor (CsI deposit);
  - Drawbacks: lower gain/ tests of performance



HP XE GPSC – WORKING PRINCIPLE





A – absorption region (E/p<1 V.cm.Torr^{-1})
B – Scintillation region (E/p>1 V.cm.Torr^{-1})
C – electric field barrier region
D – photoe^{-} collecting region (E/p~1 V.cm.Torr^{-1})

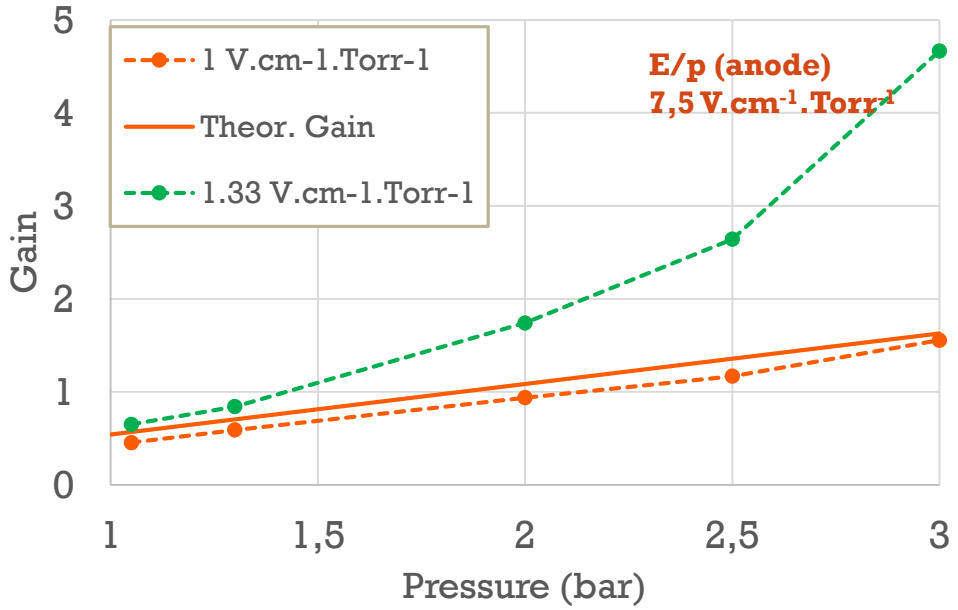
$$Gain = N_S(r).\Omega(r).T_{opt}.QE.\eta$$

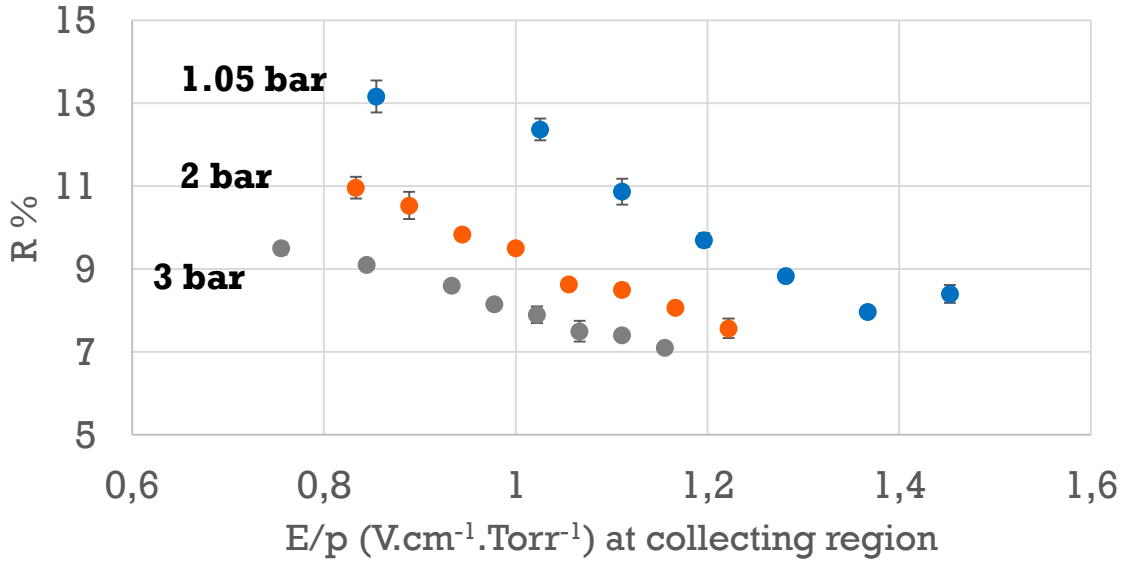
T_{opt} - Grid transmission
QE- Quantum Efficiency
η - Extract. Efficiency

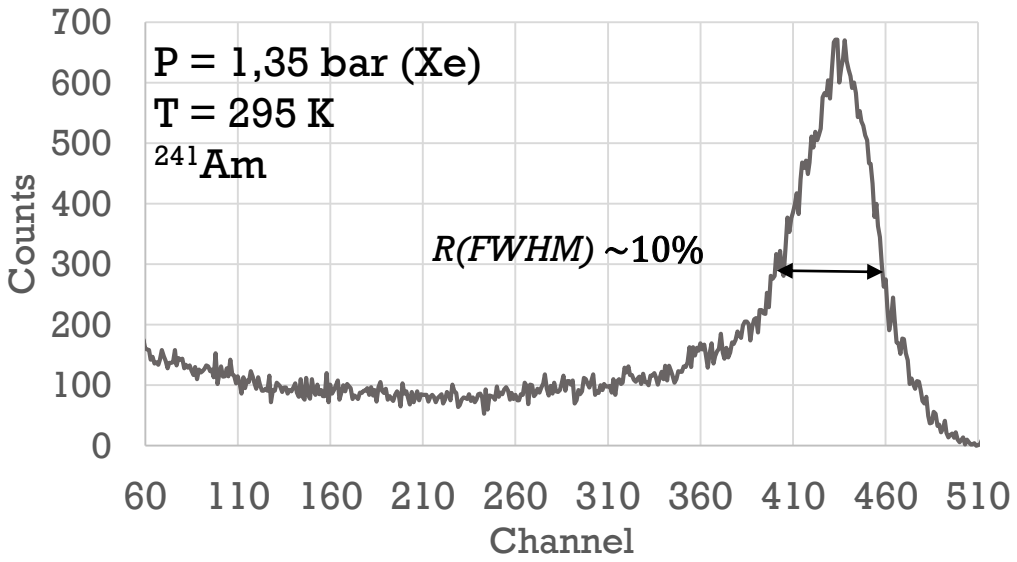
$N_S(r)$ – number of scint. photons

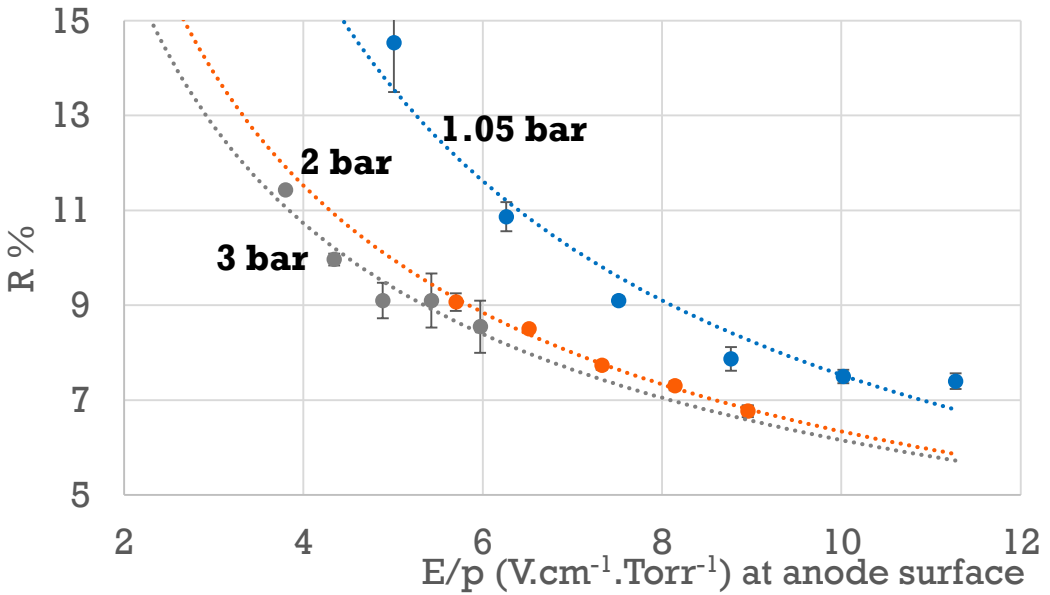
$\Omega(r)$ – fraction of photons "caught" by the CsI

HP XE DETECTOR - TESTS WITH α PARTICLES









HP XE DETECTOR

Future work

- Tests with gamma rays
- Solid angle correction for events in upper/lower regions
- Improvement in detector electronics /digital processing considered

(M. Nakhostin from Surrey University)

Publications

- 1 International Conference Proceedings Paper
- 2 oral presentations at Scientific meetings/Conferences
- 6 Poster presentations at Scientific meetings/Conferences

ION MOBILITY MEASUREMENTS

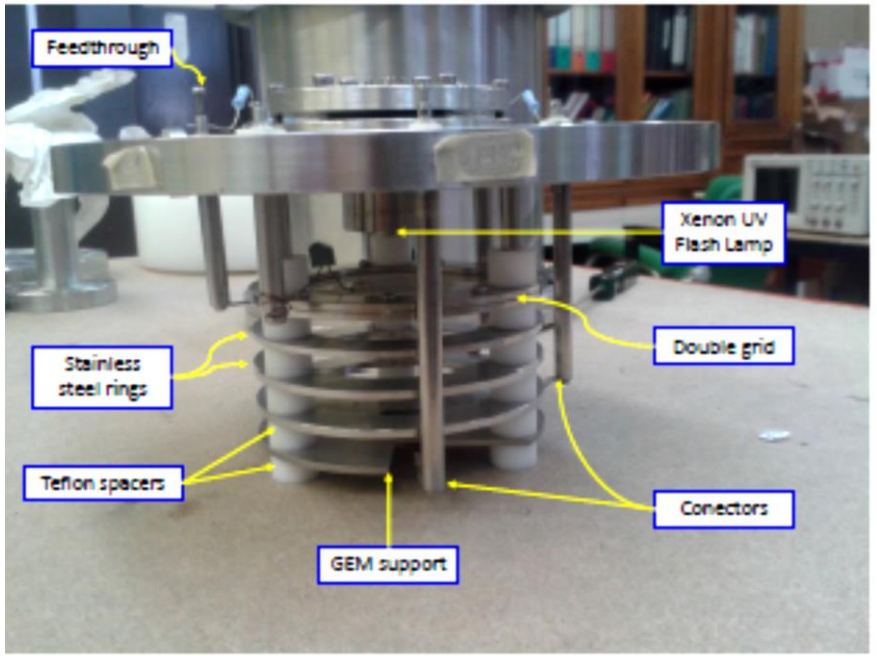
- Existing experimental system since 2007 (Neves, Távora and Conde)

Interest and applications

- Signal processing in gas detectors;
- Ion mobility spectrometry (IMS)
- High energy physics (NEXT, ALICE TPC, LCTPC)
- Negative Ion TPC's

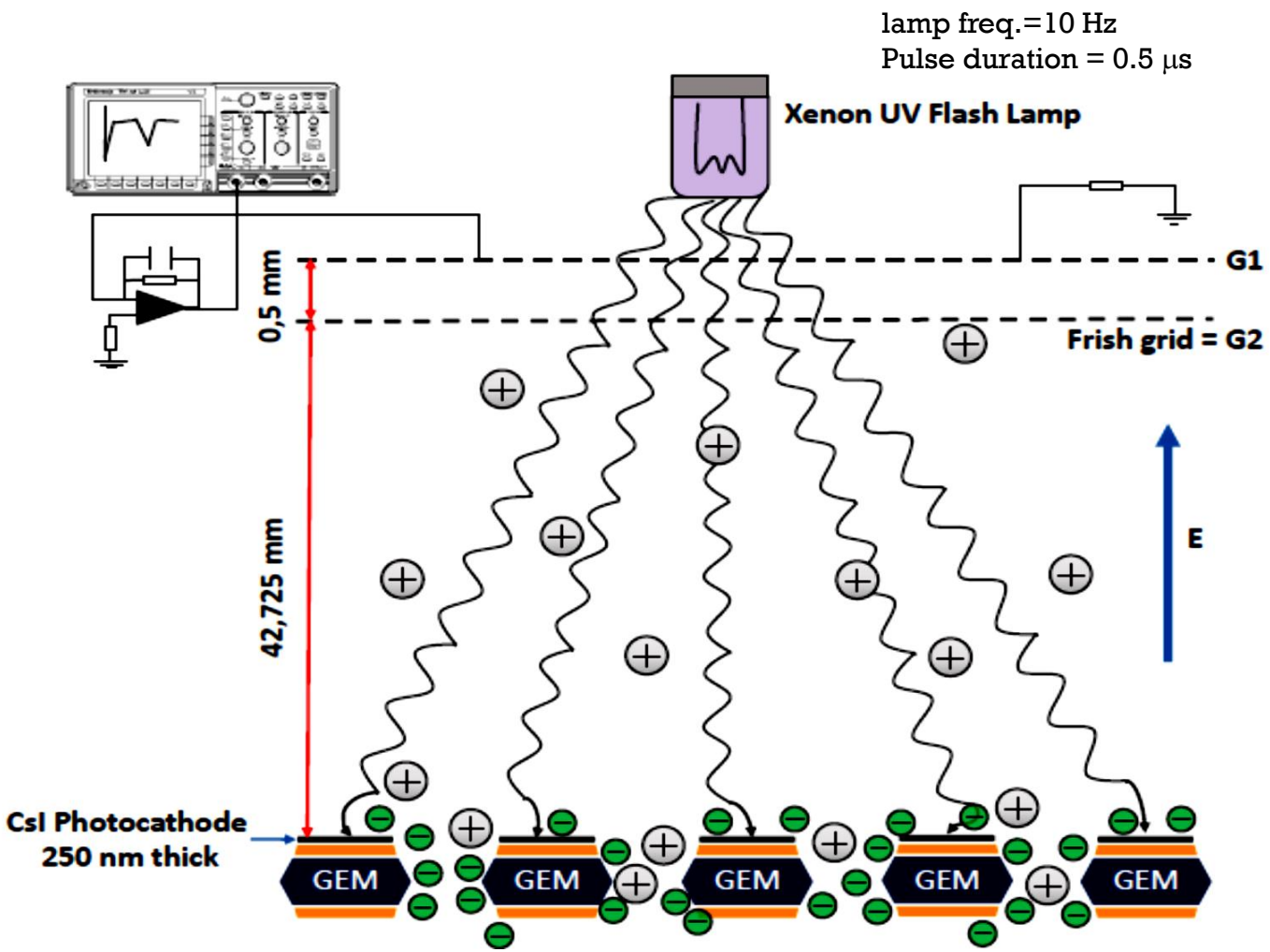
Gases and their mixtures

- Xe
- Ar
- Ne
- CO_2
- CH_4
- CF_4
- C_2H_6
- SF_6



ION MOBILITY MEASUREMENTS

Working principle



Drift velocity

$v_d = \Delta s / \Delta t$

Δs – drift distance

Δt – drift time

Ion Mobility

$K = v_d / E$

E - Electric Field

v_d - Ion drift velocity

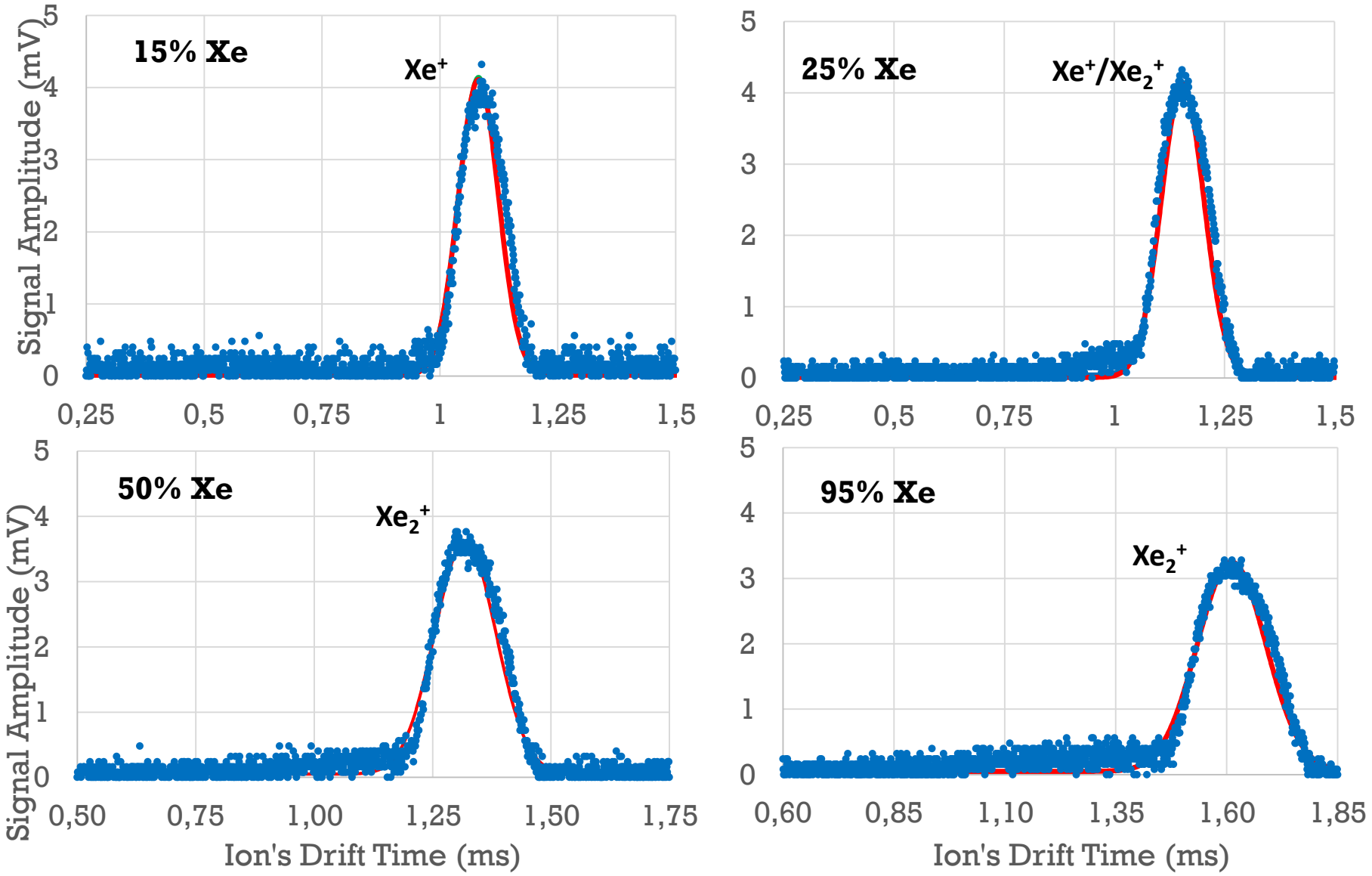
Reduced Mobility

$K_0 = KN/N_0$

N – Gas number density

N_0 – Loschmidt Number

ION MOBILITY: RESULTS – XE-CO_2

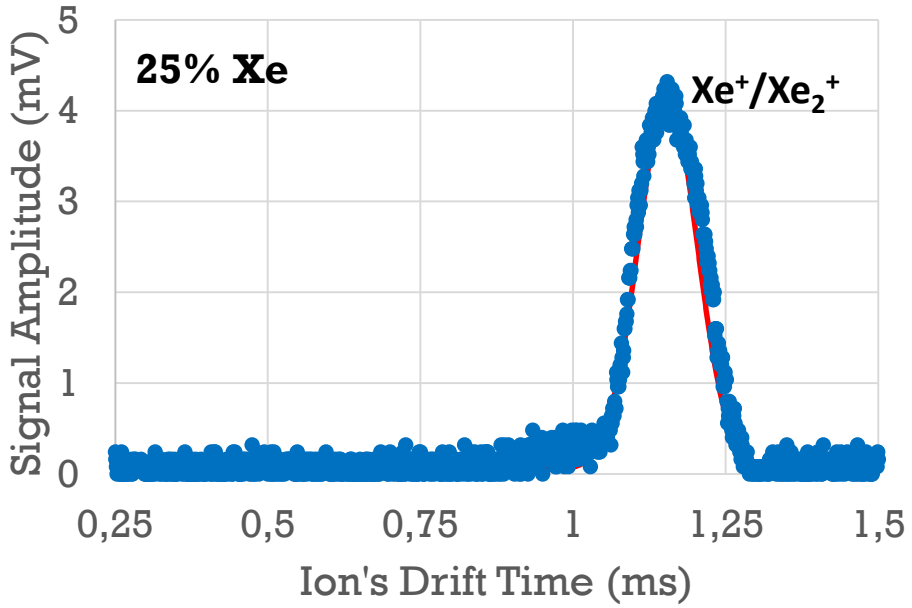


Time of arrival spectra:

- Average 128 pulses;
- Background subtracted
- How are ions identified?

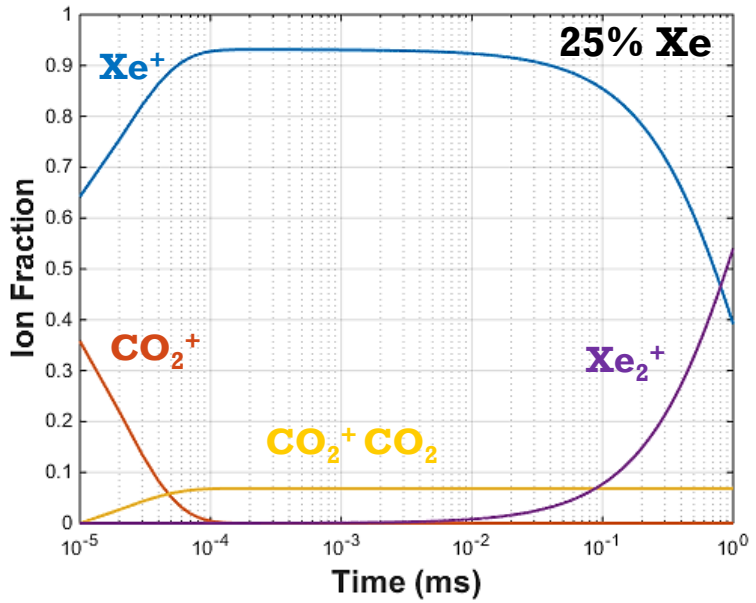
ION MOBILITY – SPECTRA INTERPRETATION

Direct Ionization	Cross Section (20 eV) (10^{-16} cm^2)	Final Ion
$CO_2 + e \rightarrow CO_2^+ + 2e$	0,452	CO_2^+
$Xe + e \rightarrow Xe^+ + 2e$	2,43	Xe^+

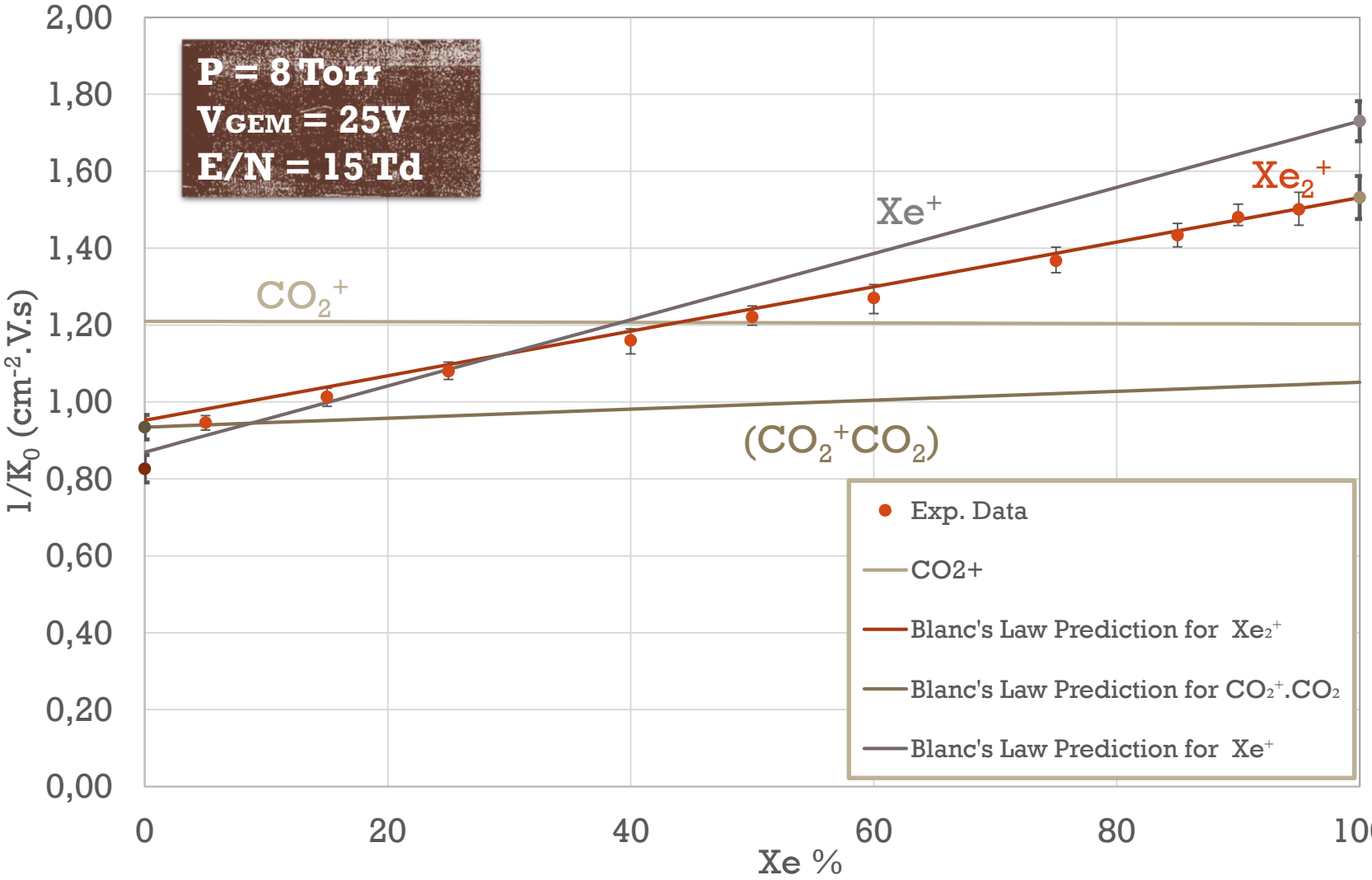


$K_{01} \sim 0{,}93\ cm^2V^{-1}s^{-1}$

Secondary Reactions	Rate Constant cm^3.s^{-1} or cm^6.s^{-1}	Final Ion
$CO_2^+ + Xe \rightarrow CO_2 + Xe^+$	6E-10	Xe^+
$Xe^+ + Xe \rightarrow Xe + Xe^+$	2,5E-10	Xe^+
$Xe^+ + 2Xe \rightarrow Xe_2^+ + Xe$	2E-31	Xe_2^+
$CO_2^+ + CO_2 + M \rightarrow CO_2.CO_2^+ + M$	2,1E-28	$CO_2CO_2^+$
$CO_2^+ + CO_2 \rightarrow CO_2 + CO_2^+$	3,7E-10	CO_2^+



ION MOBILITY – BLANC'S LAW



Langevin Limit

$$K_0 = 13.88\left(\frac{1}{\alpha\mu}\right)^{\frac{1}{2}}$$

μ – reduced mass

α – neutral polarizability

Blanc's Law

$$\frac{1}{K_{0mix}} = \frac{f_1}{K_{0g1}} + \frac{f_2}{K_{0g2}}$$

f_1, f_2 – molar fraction of gas 1, 2

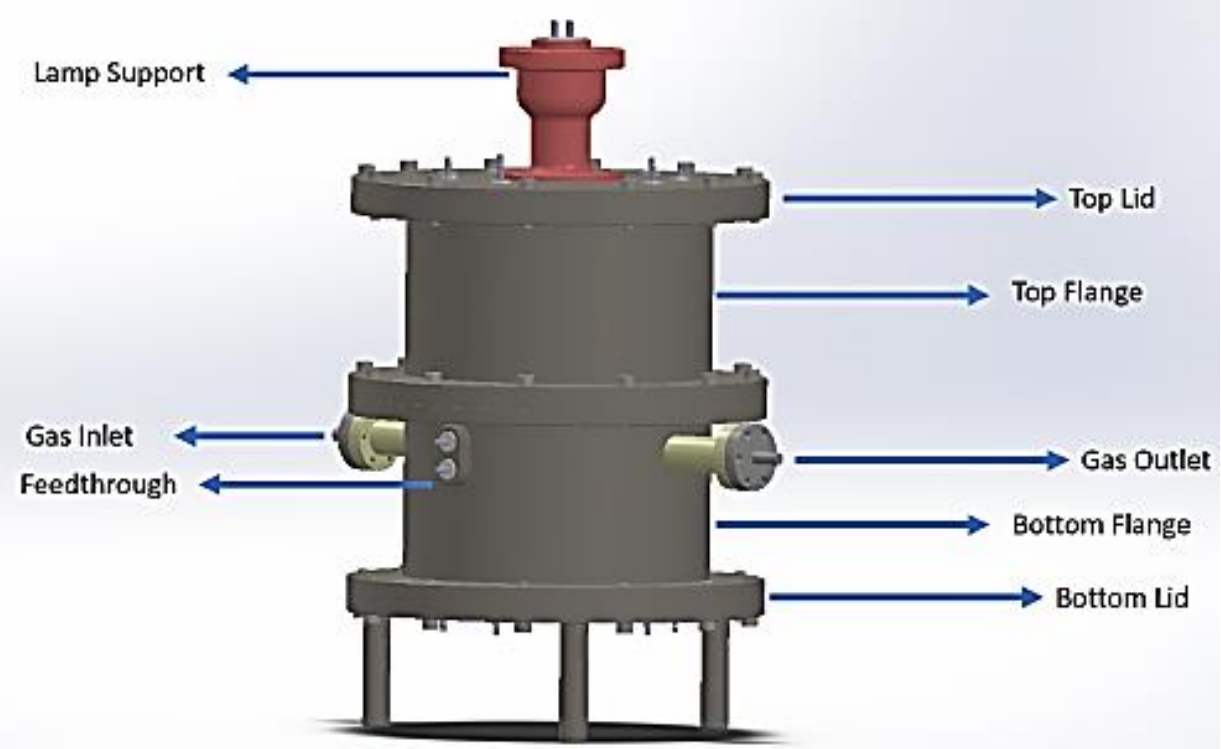
K_{0g1}, K_{0g2} – ion mobility in gas 1 and 2

NEGATIVE ION MOBILITY

Interest

- Negative ion Time Projection chamber (NITPC)
- Use of ions instead of electrons as charge carriers
- Track reconstruction/slow electronic components

Experimental setup



ION MOBILITY

Future work

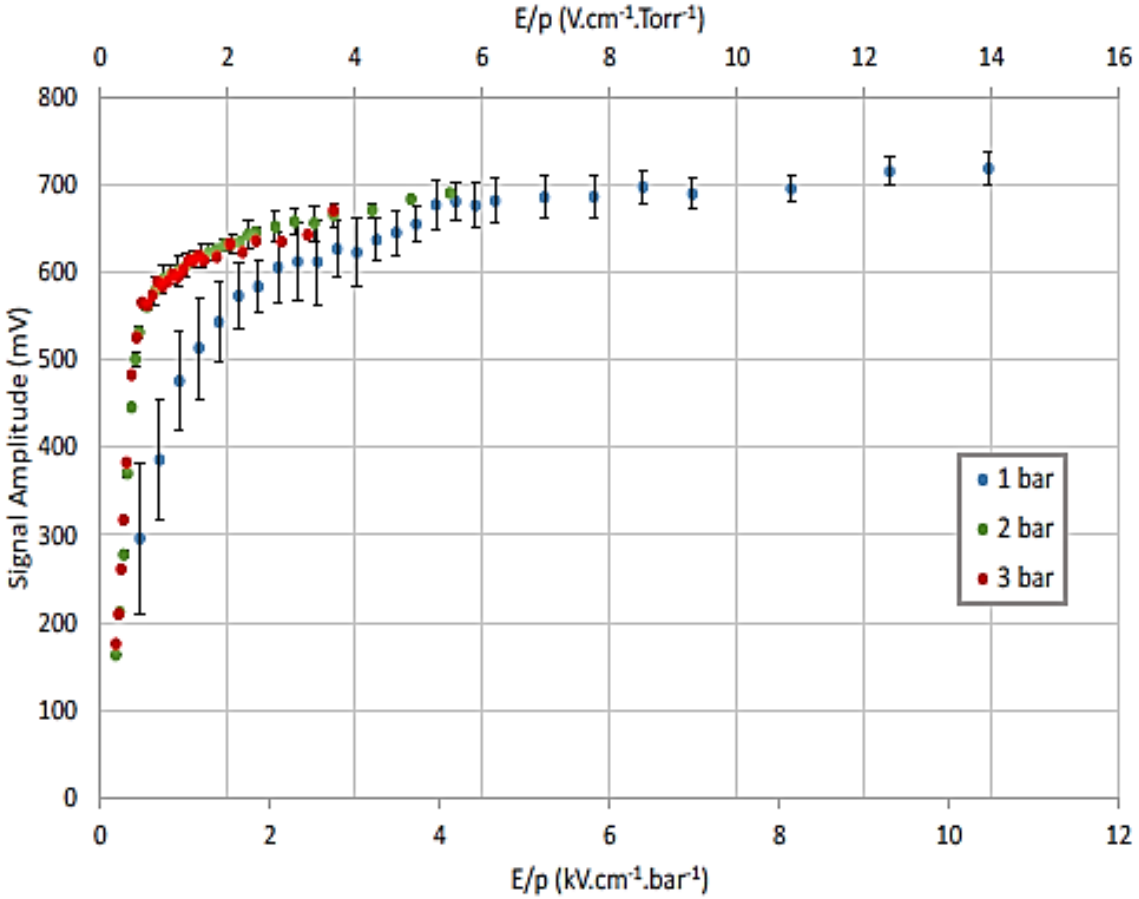
- Measurements of ion mobility for mixtures of interest in large volume gas detectors
- Negative ion mobility measurement for gas mixtures of interest for NITPC (dark matter and double beta decay experiments)
- Ion diffusion measurement?

Publications (2015-2017)

- 9 international journal papers
- 10 oral presentations at Scientific meetings/Conferences
- 2 poster presentations at Scientific meetings/Conferences

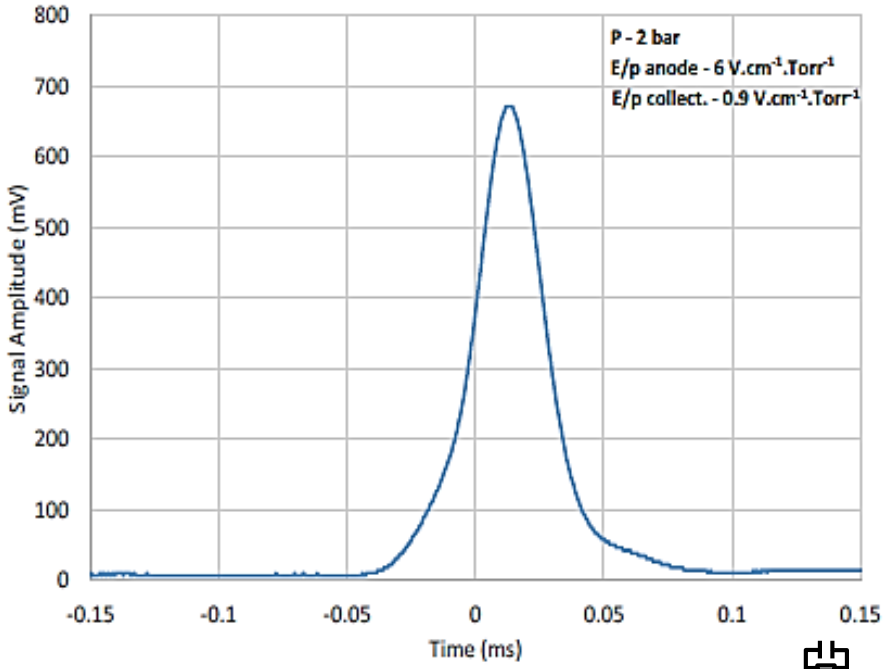
THAT'S ALL FOR NOW!
THANK YOU!

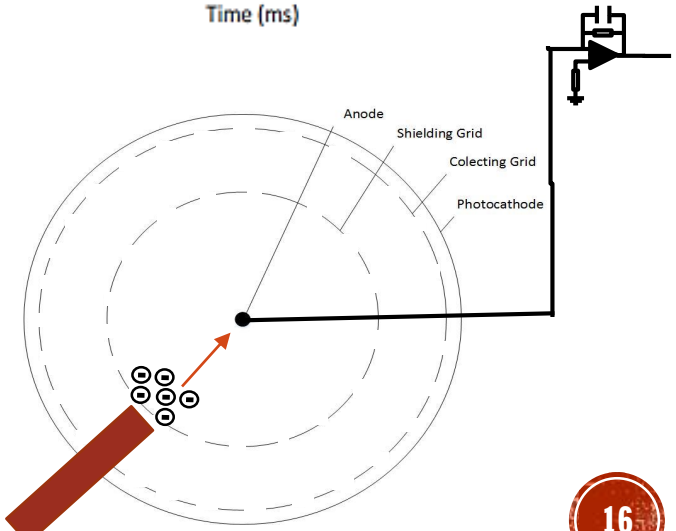
HP XE GPSC - TESTS WITH α PARTICLES



- Low E/p: some recombination prevents total charge collection;
- E/p at anode surface > 3-4 kV.cm.bar^{-1} charge collection ok!

Pulse in the oscilloscope (average of 128 events) from charge collected at the anode;





^{241}Am
α source