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Ion Transport Processes in Gaseous Detectors for Particle Physics

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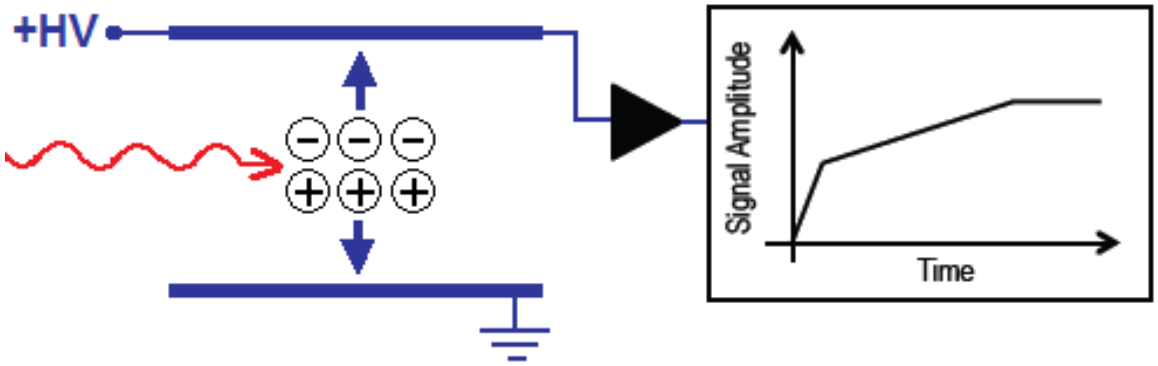
APPLICATIONS AND INTEREST

The study of ion transport in gases is a field of great interest in various areas:

1. **Physical Processes in Gaseous Radiation Detectors**



2. **Ion Mobility Spectrometry** → Technique that aims at identifying ionized molecules in a gas based on their mobility in a carrier buffer gas.

Main properties of interest:

- identification of the different ion species present;
- calculation and/or measurement of ion mobilities, K_0, and diffusion coefficients both transversal, D_T and longitudinal, D_L.

APPLICATIONS AND INTEREST

The information available in the literature for ion transport properties in gaseous mixtures for particle physics detectors is incomplete:

- does not identifies the types of ions present (molecular, monoatomic, etc.);
- nor the dependence of the mobilities on the reduced electric fields (*E*/*N*);
- nor gives information about diffusion coefficients.

Ion Transport Properties:
http://consult.cern.ch/writeup/garfield/examples/gas/trans2000.html

Gas	Ion	Mobility [cm^2/V.sec]	Reference
Ar	Ar^+	1.00	
Ar	$Methylal^+$	1.51	
iC_4H_{10}	$Methylal^+$	0.55	[38]
Methylal	$Methylal^+$	0.26	[38]
iC_4H_{410}	$iC_4H_{10}^+$	0.614	
Ar	CH_4^+	1.87	[4]
CH_4	CH_4^+	2.26	[38]
Ar	CO_2^+	1.72	
CO_2	CO_2^+	1.09	[38]
C_2H_6	$C_2H_6^+$	1.23,1.24	[38]
CF_4	$C_2H_6^+$	1.04	[2,4]
C_3H_8	$C_3H_8^+$	0.793	[2]
CF_4	CH_4^+	1.06,1.07	[2]
DME	DME^+	0.56	[2,4]
CF_4	$C_2H_6^+$	1.04	[3]
CF_4	$C_3H_8^+$	1.04,1.05	[2]
CF_4	$iC_4H_{10}^+$	1.00	[2]
Ar	CH_4^+	2.07,1.87	[2,4]
Ar	$C_2H_6^+$	2.06,2.08	[2,4]
Ar	$C_3H_8^+$	2.08,2.07	[2,4]
Ar	$iC_4H_{10}^+$	2.15,1.56	[2,4]

RECENT WORK

In recent work, using a new experimental technique developed by us, we have shown that more than one type of ion may be present simultaneously in a pure gas or in a gaseous mixture:

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Experimental measurement of the mobilities of atomic and dimer Ar, Kr, and Xe ions in their parent gases

P. N. B. Neves,[1,a)] C. A. N. Conde,[1] and L. M. N. Távora[1,2]
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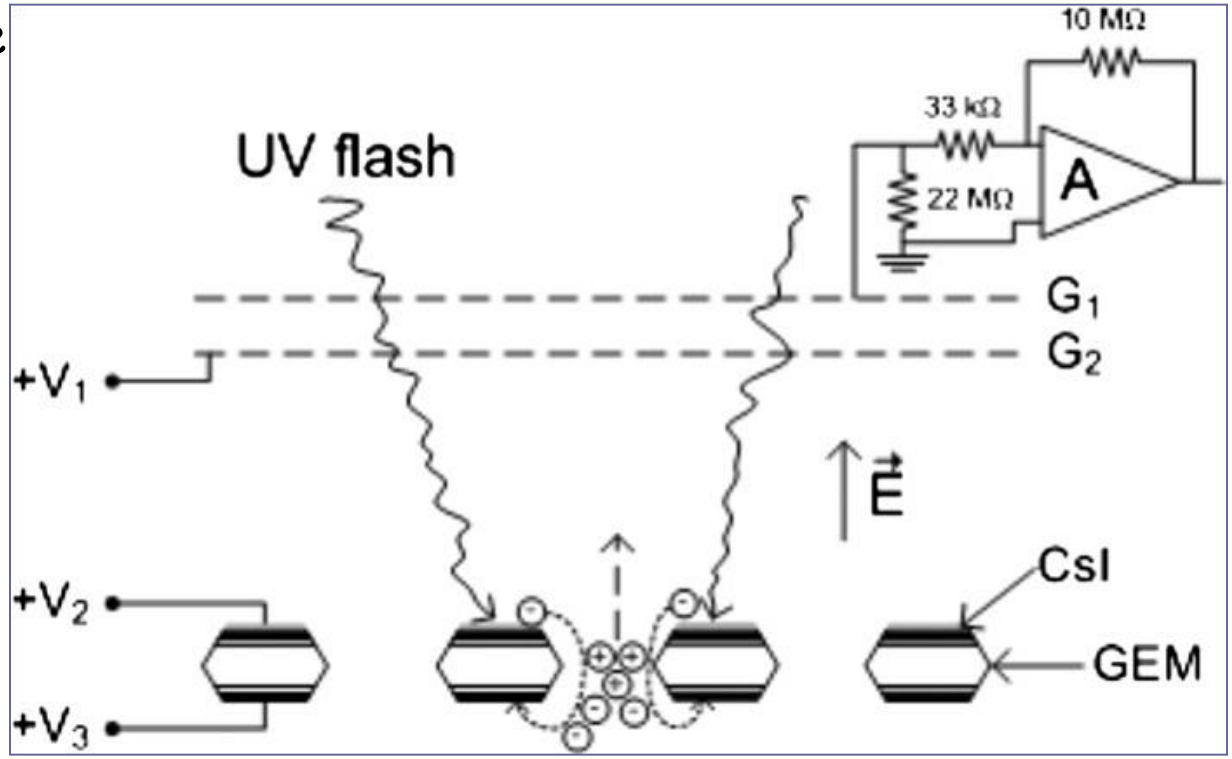
Experimental Measurement of the Ne^+ and Ne_2^+ Mobilities in Ne and the Reaction Rate Coefficient for $Ne^+ + 2Ne \rightarrow Ne_2^+ + Ne$

P. N. B. Neves, A. N. C. Garcia, A. M. F. Trindade, J. A. S. Barata, L. M. N. Távora, and C. A. N. Conde, *Life Member, IEEE*

RECENT WORK

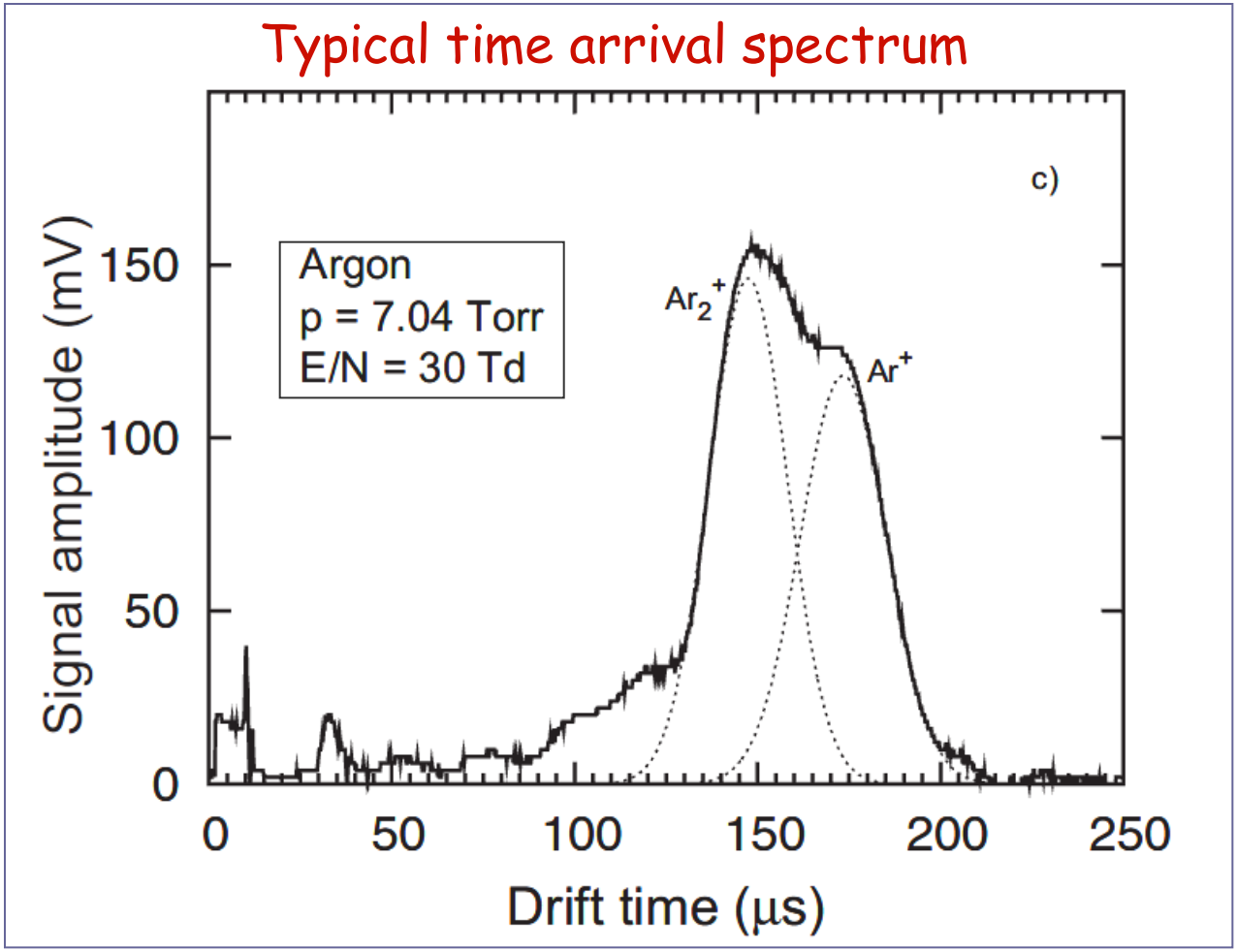
- A pulsed Xe UV lamp releases electrons from a CsI covered GEM which start an avalanche producing a variety of positive ions;
- Ions drift towards a collecting grid shielded by a Frisch grid.
- The number and type of ions can be controlled by varying the GEM voltage.
- It may be used to make measurements at high pressures and low *E/N* values.

Experimental System:



RECENT WORK

- A time-of-flight spectrum generally allows positive ion identification and the determination of their drift velocities:



The drift-time spectrum shows two distinct peaks, corresponding to two types of ions with different mobilities

WORK TO BE CARRIED OUT

1. Theoretical calculations of low energy ion-atom/molecule elastic scattering cross sections and calculation of ion transport parameters:

   - Calculation of differential and integral elastic collision cross sections, for center-of-mass energies in the 0.001 eV to 10 eV energy range, using the JWKB approximation and interaction potentials taken from the literature for:

     - Ar^+ and Ar_2^+ ions with CH_4;
     - and CH_4 ions with CH_4 and Ar.

   - Monte Carlo calculation of the diffusion coefficients, D_T and D_L, and mobilities, K_0, of Ar and CH_4 ions in their parent gases and in gaseous mixtures of Ar/CH_4.

WORK TO BE CARRIED OUT

2. Experimental measurement of ion mobilities:

- Improvement of the experimental system making possible the measurement of drift time with better resolution;
- Identification of the ions present in gaseous mixtures with interest for high energy physics detectors like Ar/CH_4 and Ar/C_2H_6;
- And experimental measurement of their mobilities.

Ion Transport Processes in Gaseous Detectors for Particle Physics

Research Team

Project coordinator: João Barata

Name	Status	% of time in project
Alexandre F. Trindade	Master (LIP)	40
Carlos Conde	Researcher (LIP)	20
Filipa Borges	Researcher (LIP)	20
João Barata	Researcher (LIP/UBI)	40
Mangiarotti Alessio	Researcher (LIP)	20
Filomena Santos	Researcher (LIP)	15
Pedro Neves	Researcher (ATP-Group, CMAF)	15
Teresa Dias	Researcher (LIP)	20