Measurement of ion mobility in Argon and Neon based gas mixtures

A. Deisting[abc], C. Garabatos[b], A. Szabo[d], D. Vranic[c] for the ALICE Collaboration

Introduction

After the ALICE TPC is upgraded with GEMs for the LHC Run 3, large space-charge distortions are expected due to the positive ion build-up in the drift volume. In order to understand these distortions and to correct for them, the ion mobility K of the drifting ions in a Ne-CO_2-N_2 mixture must be known.

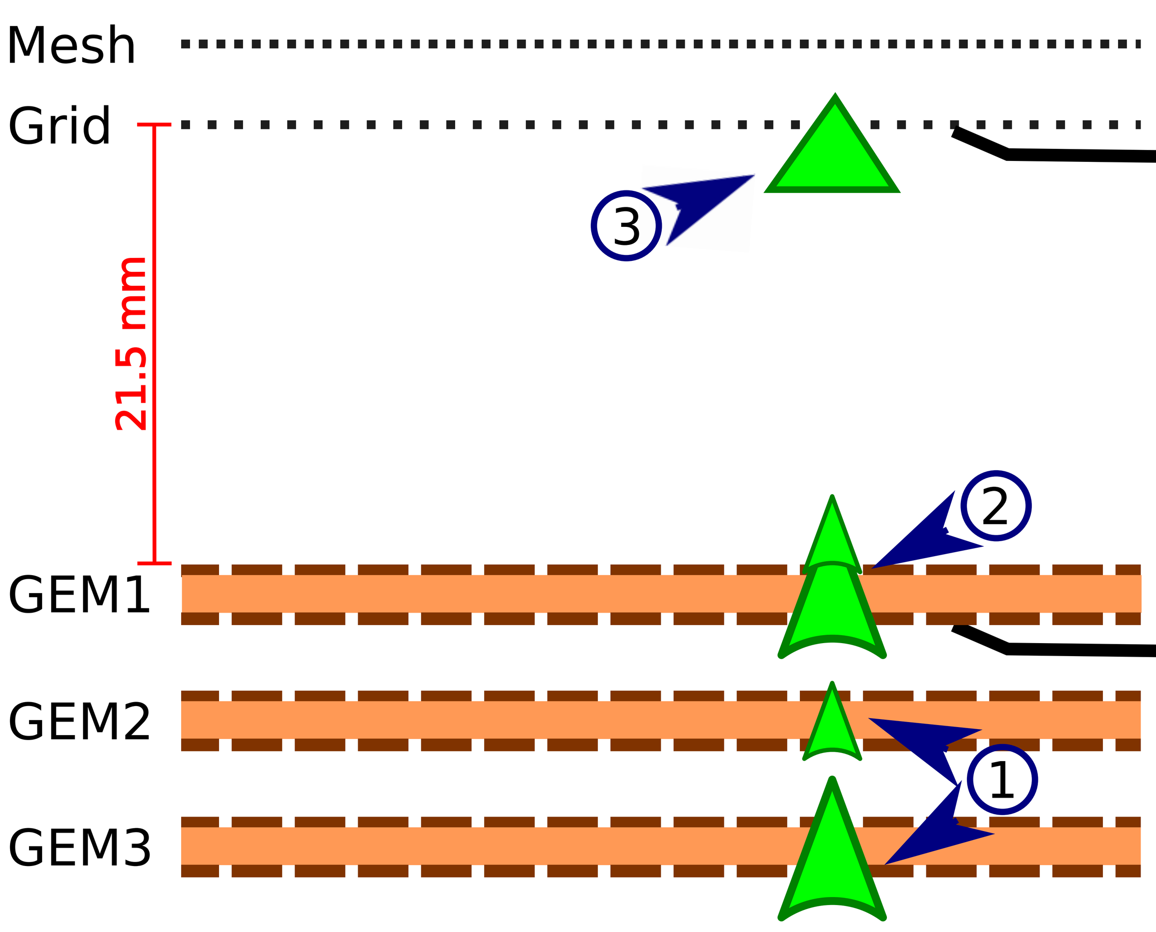
To this end, a small triple GEM detector with a particular cathode arrangement has been built. We discuss the generated ion signals and the processing of them in order to measure the ion drift time, with a robust method as confirmed with GARFIELD simulations. Results of mobility measurements in Ar-CO_2 and Ne-CO_2 are shown here. For the later gas mixture the influence of H_2O on the mobilty was studied as well.

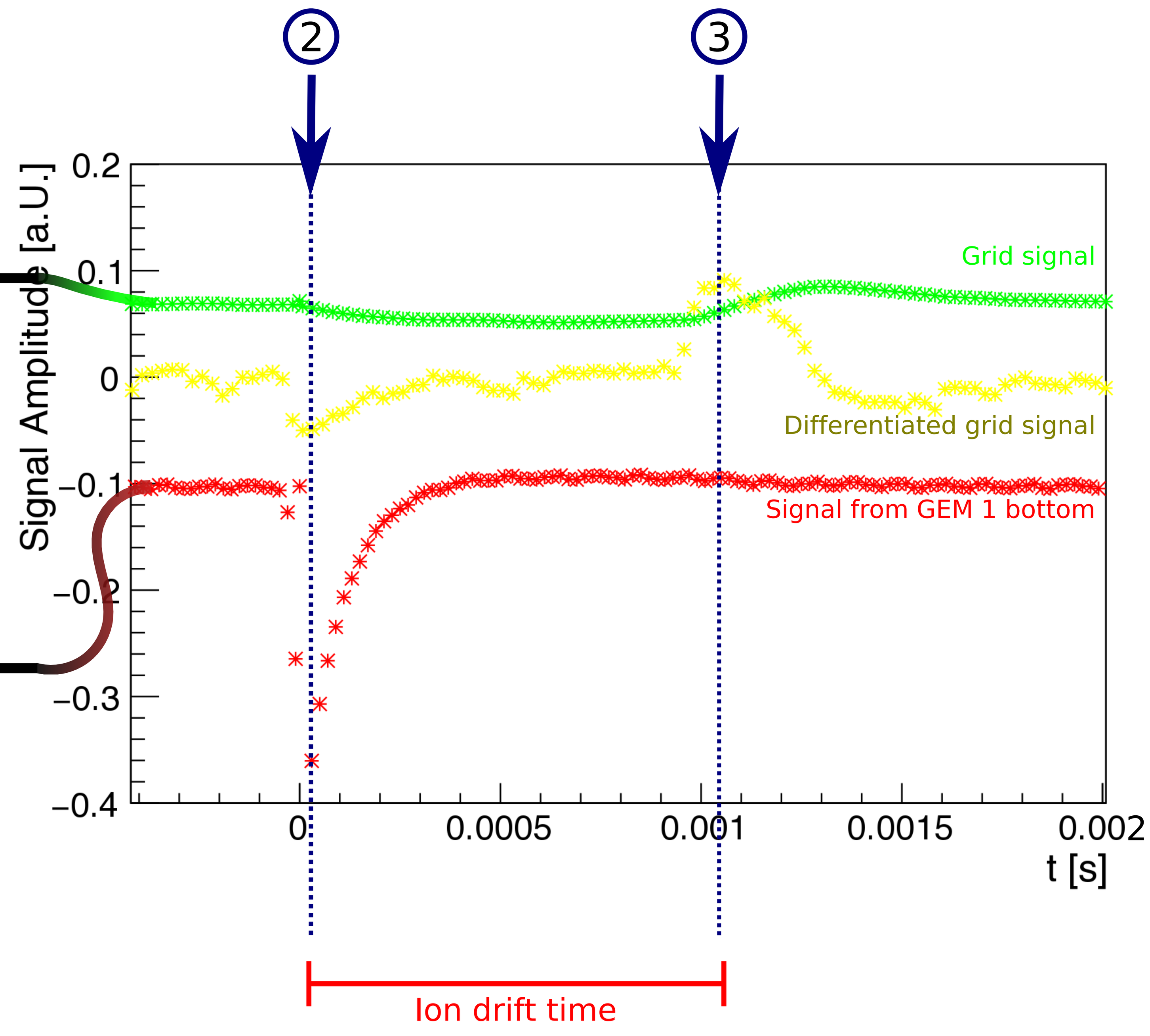
(1) During the gas amplification of electrons, ions (▲) are produced in the GEMs of the GEM stack.

(2) As the ions move towards GEM1, they induce a signal. Its peak indicates the time when most of the ions exit the GEM stack and enter the drift volume.

While the ions move through the drift space towards a wire grid, which defines the drift field, they induce a signal on it.

(3) As the ions cross the wire grid into a field defined by the electrode placed behind it, the induced signal on the grid changes sign. The inflection point in this part of the signal is used to define the ion 'stop' time. GARFIELD simulations confirm that this inflection point yields the correct ion drift time for a wide range of K values.





Knowing the drift time $t_{\text{Ion Drift}}$, the distance d_{Drift} between GEM1 and the grid as well as the applied electric field E_{Drift} the ion mobility K can be calculated:

$$K = \frac{d_{\text{Drift}}}{t_{\text{Ion Drift}} \times E_{\text{Drift}}}$$

This mobility needs then to be corrected by the temperature and pressure present during the measurement (T_{Meas} and P_{Meas}) in order to obtain the reduced mobility K_0.

$$K_0 = K \times \frac{273.15\,\text{K}}{T_{\text{Meas}}} \times \frac{P_{\text{Meas}}}{1\,\text{atm}}$$

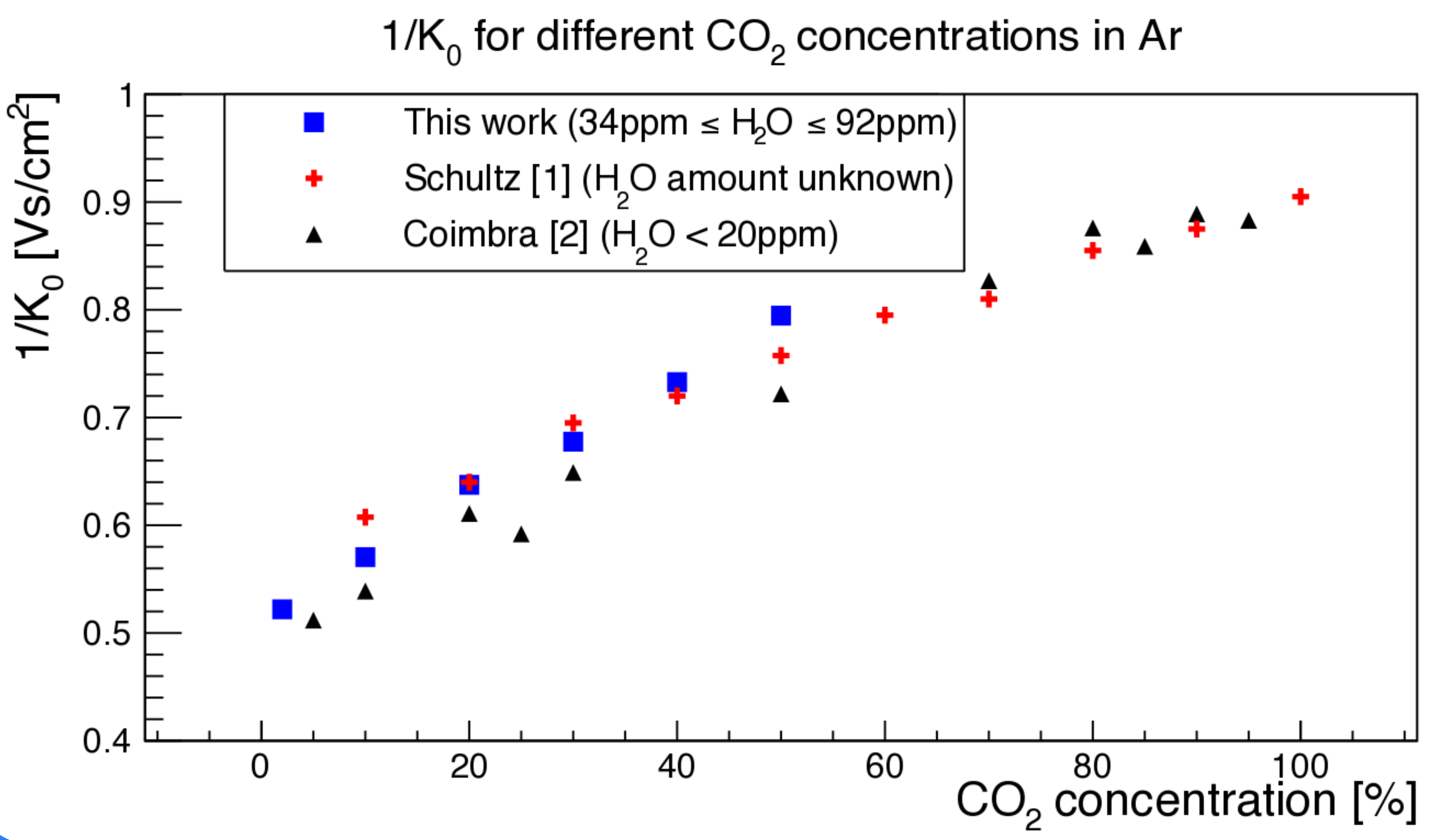
During the measurement the H_2O content is monitored as well, to allow studies of the influence of water on the ion drift velocity.

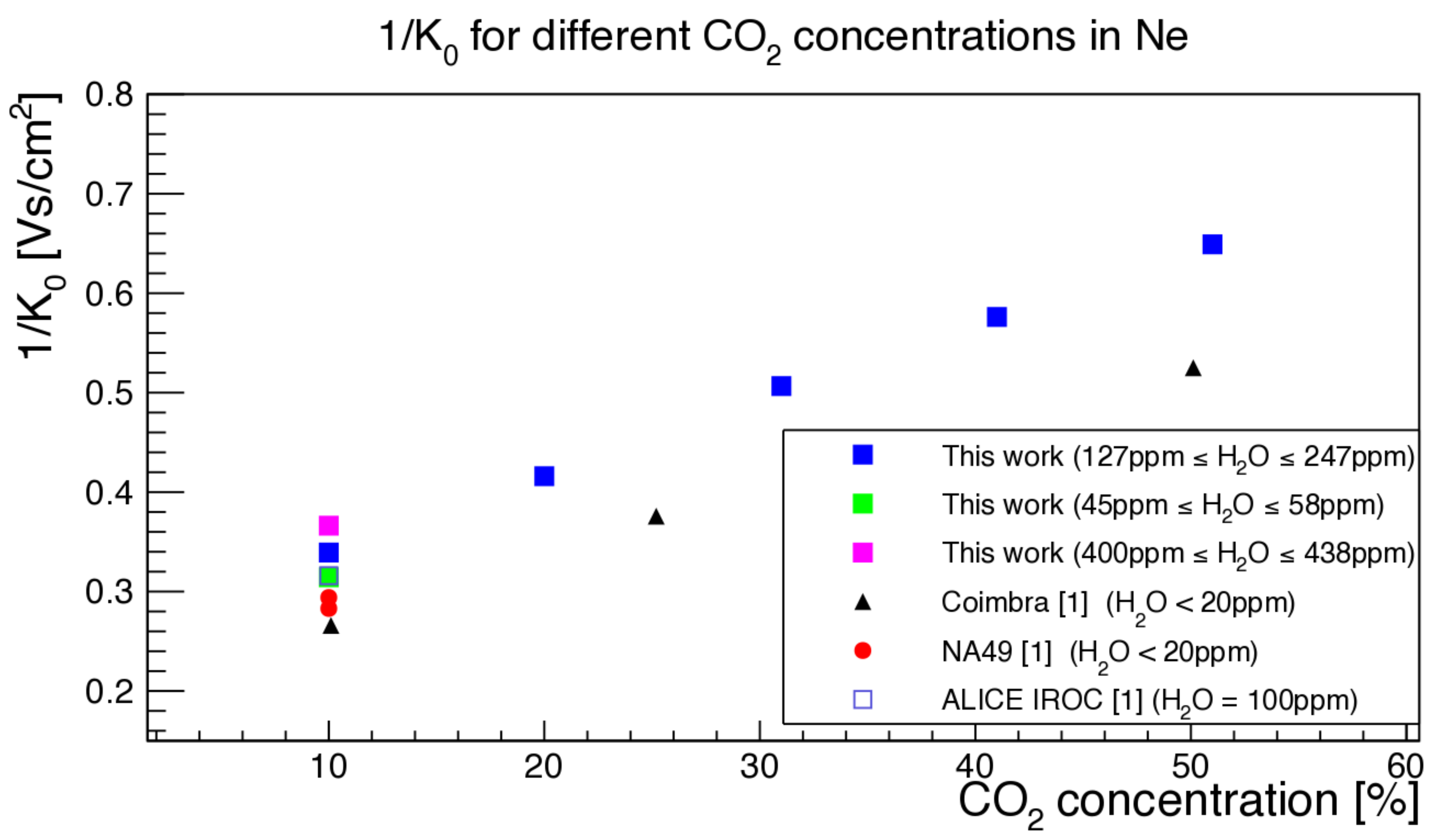
Results

	Ar	CO_2
mobility in pure:	$1.94\,\text{cm}^2\,\text{V}^{-1}\,\text{s}^{-1}$	$0.93\,\text{cm}^2\,\text{V}^{-1}\,\text{s}^{-1}$

	Ne	CO_2
mobility in pure:	$3.77\,\text{cm}^2\,\text{V}^{-1}\,\text{s}^{-1}$	$0.98\,\text{cm}^2\,\text{V}^{-1}\,\text{s}^{-1}$

From [1] it is expected that in Ar-CO_2 as well as in Ne-CO_2 mixtures CO_2 ions or clusters of such ions drift. If Blanc's law is fitted to the below displayed results, one yields the mobility of the drifting ions in the pure gas. The results of such a fit are given in the table. Comparing the mobilites of the drifting ions in CO_2 shows that both measurements agree with each other. From the difference in the two values an estimate on the precision of the measurement can be made.





[1] Y. Kalkan et al, "Cluster ions in gas-based detectors". In: Journal of Instrumentation 10.07 (2015), P07004

[2] PMCC Encarnação et al, "Experimental ion mobility measurements in Ar-CO_2 mixtures". In: Journal of Instrumentation 10.01 (2015), P01010

[a]Corresponding author - alexander.deisting@cern.ch; [b]GSI Helmholtzzentrum für Schwerionenforschung, [c]Universität Heidelberg, [d]Univerzita Komenského Bratislava