AN INSTRUMENT FOR SIMPLE CLUSTER ION COUNT MEASUREMENT

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INTRODUCTION

We present a new instrument for measuring the total concentration of both positive and negative cluster ions – the Cluster Ion Counter (CIC). The instrument is designed to be simple and robust to provide reliable cluster ion measurements for both long term field montoring as well as laboratory experiments.

METHODS

The CIC uses two independent first order cylindrical differential mobility analysers (Tammet, 1970) to measure the ions of positive and negative polarities in parallel (Figure 1). The inlets of the analysers are short to keep particle diffusion losses low.

The measured ions entering the analysers are repelled by a central electrode which is held at a steady but software adjustable voltage. The ions deposit on outer wall which is divided into three separate collecting electrodes. The electric current produced by the deposited ions is measured using high precision integrating electrometers.

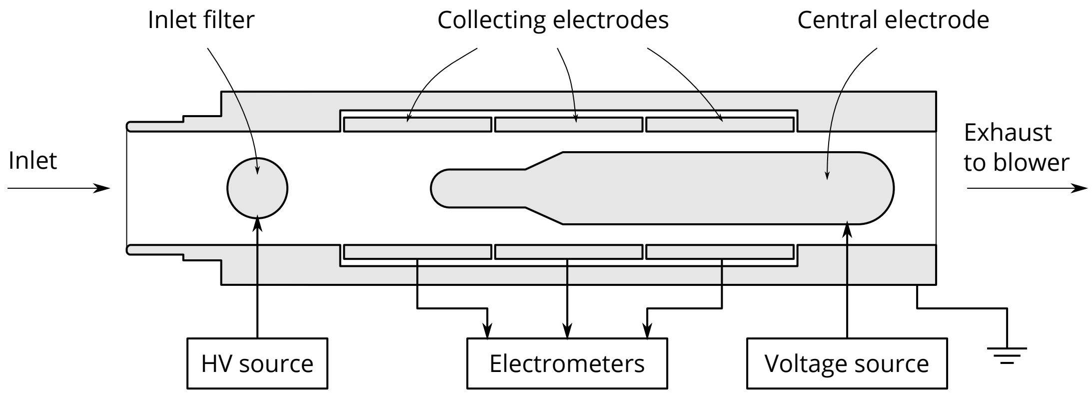

Figure 1: The principal schematic of the analysers in the CIC.

The measurement rate of the electrometers is 30 measurements per second to allow high time resolution. The offset currents and noise level estimates of the electrometers are periodically measured by swithing on a high voltage electrical inlet filter which prevents ions from entering the analyser.

The outlets of the analysers are internally connected flow meters followed by software controlled blowers. This allows sample flow rates of both analysers to be freely specified in the range from 10 l/min to 60 l/min. The central electrode voltages are automatically adjusted to keep the detected ion mobility range constant.

The instrument also includes air pressure sensors to take into account the relation between particle mobility and air pressure. This allows the instrument to operate on-board aircrafts and in chamber experiments.

The size resolution of the CIC is low by design (Figure 2). However the three separate electrodes allow the instrument to acquire more information about the ion mobility distribution than a simple integral counter. The limiting mobilities of the collecting sections are chosen so that the combination of the signals from the first two electrodes can be used to estimate roughly the average cluster ion mobility and air conductivity. The third electrode is used to find the signal of larger ions beyond the cluster ion band and subtract it from the total concentration.

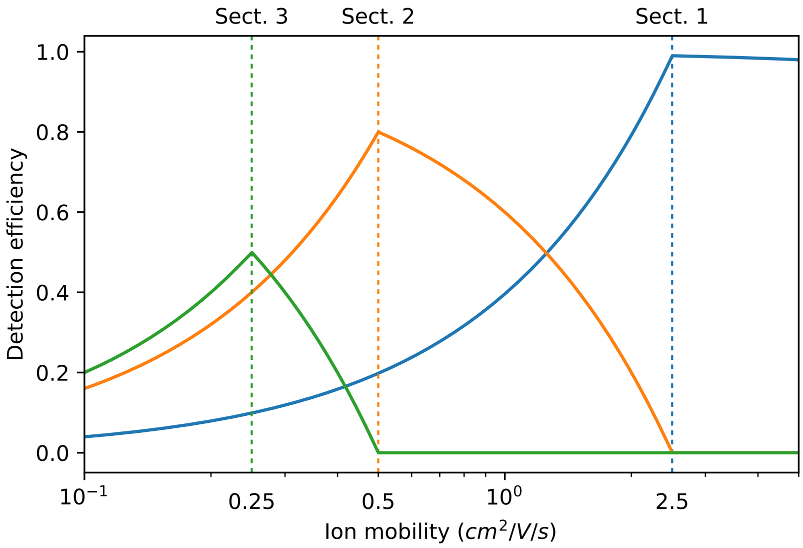

Figure 2: The theoretical transfer functions of the three collecting sections without considering ion diffusion losses. Section number 1 is nearest to the inlet, number 3 the furthest.

RESULTS AND CONCLUSIONS

The CIC was compared to the UT-8401 reference ion counter, an older instrument developed at the University of Tartu. Calibration experiments showed that the cluster ion detection efficency of the CIC is 70% at 10 l/min sample flowrate and 80% at 30 l/min sample flowrate.

The standard deviation noise level of 1 second average measurements is 20 #/cm^3.

The CIC is a simple and robust ion counter. The instrument is easy to deploy and maintain. It works well in various environments as an independent instrument as well as a reference instrument to confirm the measurement result of more advanced devices, for example the Neutral cluster and Air Ion Spectrometer (NAIS, Mirme 2011).

ACKNOWLEDGEMENTS

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