Characterization and development of a fast mixing type particle counter

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With deepening understanding of the interactions between aerosol particles and the climate ever more refined instruments are needed. Most commercial particle counters operate at 1 Hz sampling frequency, although some rapid models go down to ~10 Hz. At this point, applications requiring faster sampling frequencies often need to use either custom built instruments, or settle for a lower time resolution. One of these applications where very fast particle counting is required is the ambient aerosol particle flux measurements, where the motion of turbulent eddies requires sampling frequencies down to 10 Hz. Besides this, there are numerous other applications for such a refined tool, including rapid particle size distribution measurements, as well the ability to accurately observe changes even in laboratory experiments.

Here we would like to present our work on building a fast mixing type condensation particle counter (FCPC). The instrument development used as a starting point the works of Wang *et al*. (2002) and Wehner *et al.* (2011) in building rapid mixing type particle counters. Here also, we use a ready-made optical detection block from a TSI 3010 CPC for the particle detection, while connecting it to otherwise custom built instrument. The instrument presented here deviates from their works, by some design elements that are added for finer instrument control, such as inlet temperature control and a custom built mixing chamber. Besides the optical detection block, all parts are custom built for this instrument in the University of Helsinki.

This work aims to produce a robust, very rapid particle counter capable of detecting particles down to 5 nm suitable for use in the laboratory as well as in the field. The FCPC will be tested against already existing aerosol particle flux instrumentation at the SMEAR II site in Hyytiälä, Finland during the spring of 2016. The instrument will later also be a part of a large upcoming intercomparison study of CPC suitability for flux measurements in 2017 also to be performed at SMEAR II. The aerosol flux measurements at SMEAR II are part of the ACTRIS-2 project

The preliminary results that have been obtained thus far have shown to be very promising and in the current state the instrument has already shown to have a smaller than 100 ms response time, as shown in Fig. 1. This makes it already superior to most commercially available butanol based particle counters with respect to response time, and thus likely more suitable for aerosol flux measurements. In the current state, the 50 % lower detection limit of the FCPC was measured to be around 6 nm, with the optics and condenser temperatures being 39 and 10 °C, respectively. The process of instrument optimization is still underway, and we aim to both lower the minimum detection limit as well as the response time even further.

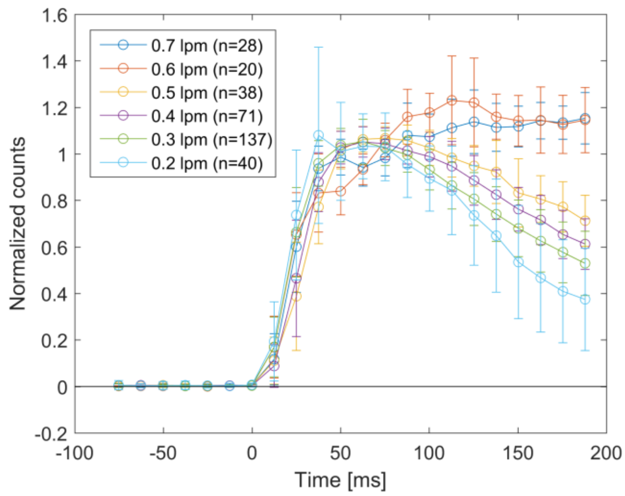

Figure 1. FCPC response time plotted for different saturator flow rates. The particles were generated using a spark generator. *n* indicates the number of averaged experiments used for each flow setting.

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