

# Using a battery of Airmodus A20 butanol Condensation Particle Counters for fast aerosol particle number size distribution measurement

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TRAFFIC IS A SOURCE OF PARTICLES < 20 nm.

CLAIM: THE SMALLER THE PARTICLE SIZE, THE HIGHER THE NUMBER CONCENTRATION,

i.e. 1 nm > 3 nm > 10 nm > 23 nm

## Introduction & Background

Ultrafine aerosol particle size distribution measurement often relies on electrical mobility based size classification method using a differential mobility analyser (DMA) together with a condensation particle counter (CPC). Such technologies have low sensitivity for the smallest particles due to losses and low charging probability, and low temporal response.

In this work we used CPCs with different cut-offs and an A11 nano Condensation Nucleus Counter (nCNC) to measure fast response size distribution starting from 1.3 nm in particle diameter in an urban street canyon. The sample aerosol was conditioned to determine the concentration of non-volatile particles.

Table 1. Temperature settings and cut-off diameters of the CPCs

| Instrument | Saturator temperature (°C) | Condenser temperature | Cut-off diameter (nm) |
|---|---|---|---|
| "A11" | 77 | 3 | 1.3 |
| "3 nm" | 37 | 2 | 2.6 |
| "10 nm" | 35 | 20 | 10.9 |
| "23 nm" | 39 | 32 | 22.5 |

## Methodology

Temperature difference of the saturator and the condenser of a CPC can be used to tune the lowest cut-off size, and lowering absolute temperatures of both elements can enhance the detection efficiency for the smallest particles even further (Kangasluoma et al. 2013, Barmbounis et al. 2017). In this work we changed the temperature settings and tuned the optical detectors of the A20 to achieve cut-off sizes from 3-23 nm (Table 1). In the 3 nm case also other changes were made to reduce diffusion losses and increase counting statistics.

Using these three A20 CPCs and an A11 nCNC in parallel, we had

- number size distribution in the size range 1–23 nm,
- total particle number concentration > 23 nm,
- with time response of 1 Hz.

The system can be used to measure also very low concentrations due to extremely high signal to noise ration of a CPC, and no need for a charger/neutralizer because the CPCs are sensitive for both electrically charged and neutral particles.

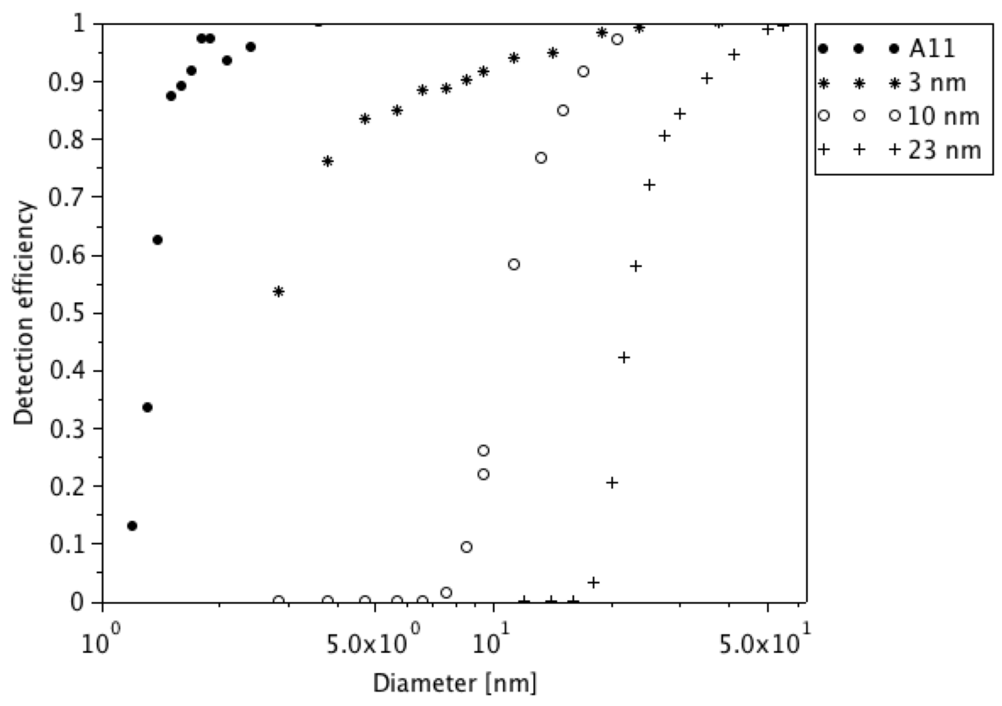


Figure 1. Detection efficiencies of the A11 nCNC (for NiCr-oxide) and A20 CPCs (for silver)

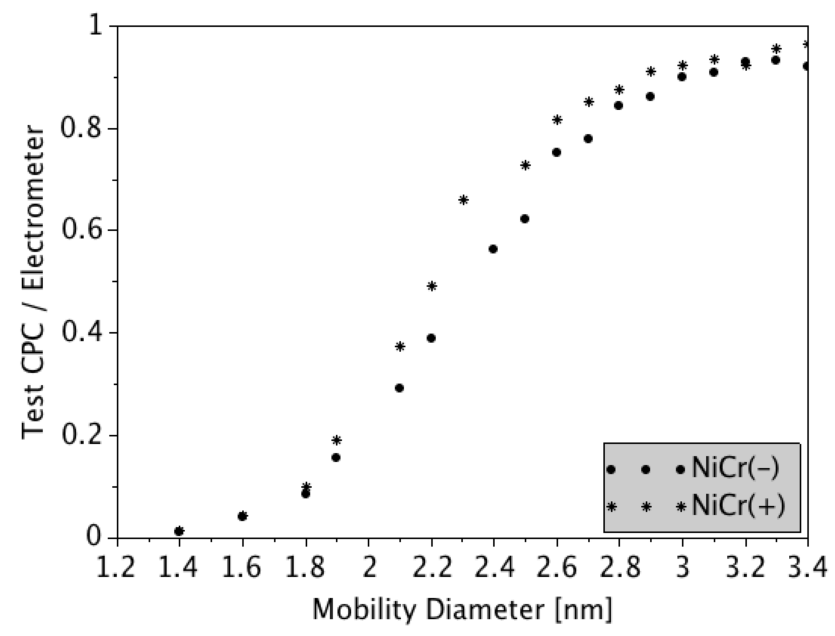


Figure 2. Detection efficiency of the "3 nm" CPC for negatively and positively charged NiCr-oxide particles

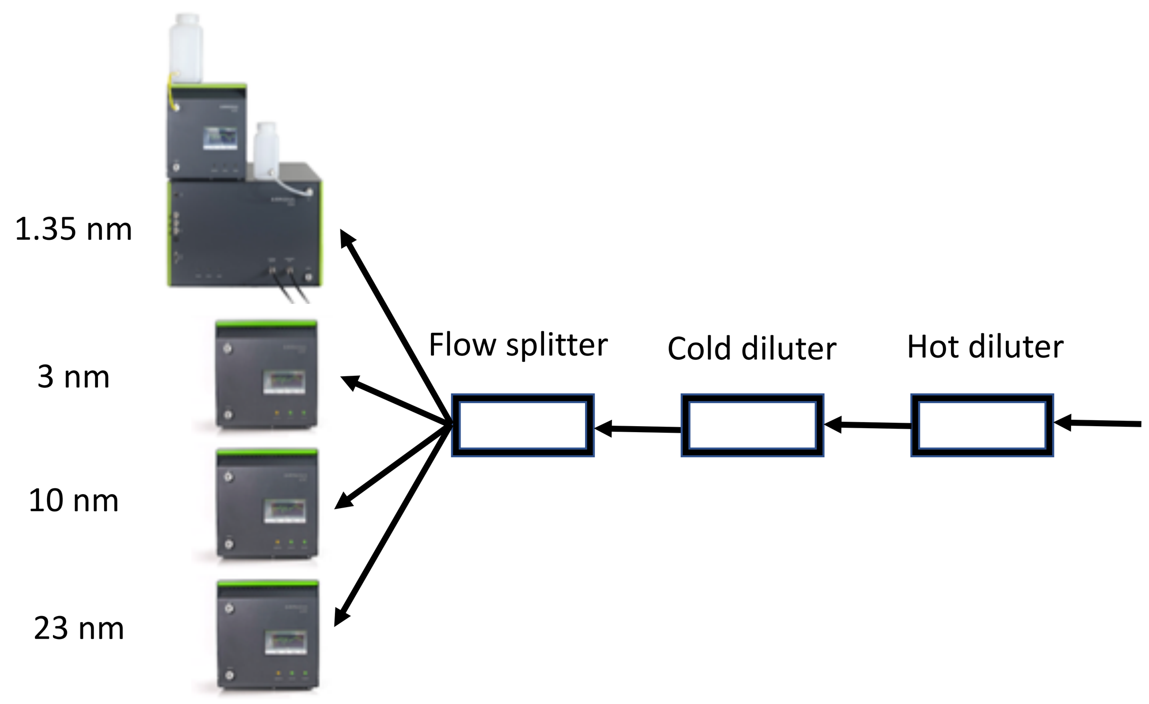


Figure 3. In the urban measurements, both hot and cold dilution were used before the instruments, with the total dilution ratio of 34.

## Results and discussion

The system was tested with ambient aerosol in an urban street canyon, *preliminary data presented in figures 4. and 5*, and with test aerosol in laboratory. We also studied the effect of particle charge on the detection efficiency of the "3 nm" CPC: The CPC detected positively charged NiCr-oxide particles slightly better than the negatively charged ones, but the difference was not significant.

In the urban measurements, presented in figures 4. and 5., we noted that

- the concentration of non-volatile sub-23 nm particles was an order of magnitude higher than that of particles larger than 23 nm
- All the monitored sizes, down to nano cluster aerosol, were detected at all times.
- Most of the time all the studied sub 23 nm particles had similar temporal variations, but also differences were detected -The bursts of different sizes of nano particles may for example be caused by certain types of vehicles driving by.

The used setup proved to be a useful tool for studies of quickly changing urban aerosol, and the importance of monitoring size classes in addition to the total particle number was proven.

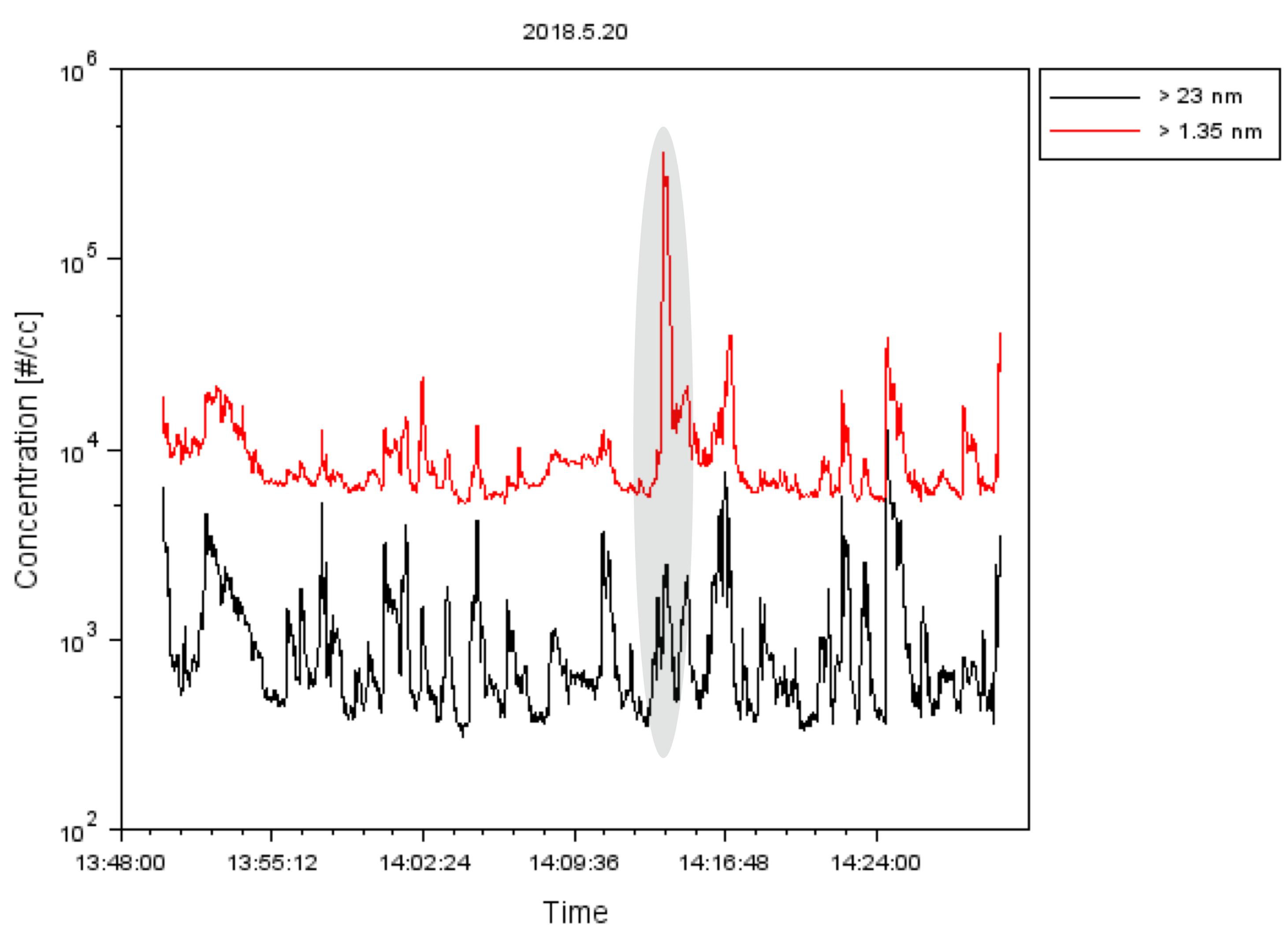


Figure 4. Total number concentrations of non-volatile particles above 1.35 nm (red) and 23 nm (black) for ambient aerosol measured in an urban roadside environment. *Preliminary results*

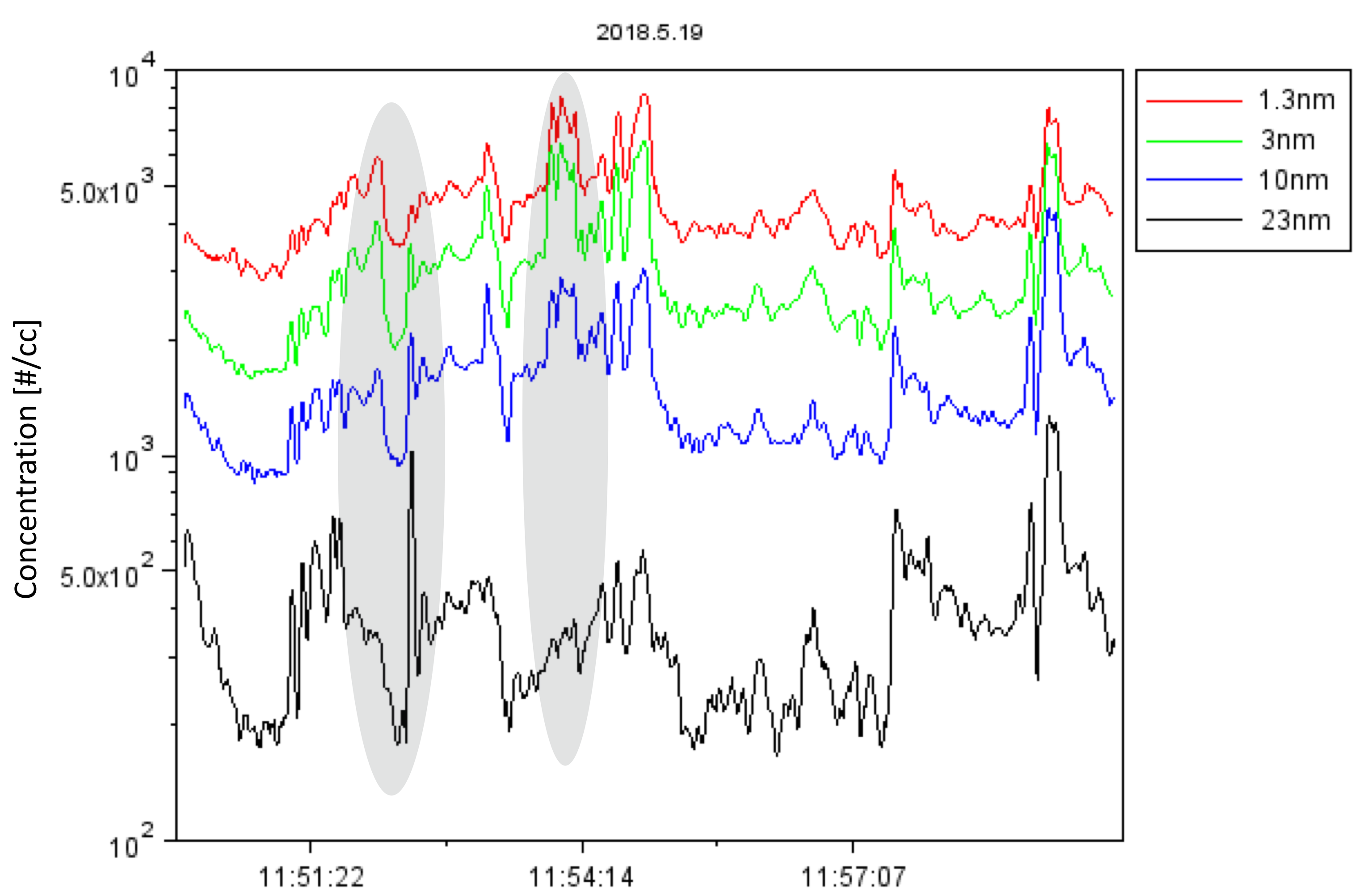


Figure 5. Total number concentrations of non-volatile particles in an urban roadside environment. Different colours correspond to the particle counters with different cut-off diameters. *Preliminary results*

## References

Barmbounis, K., et al. (2018) *Journal of Aerosol Science* 117, 44-53.
Kangasluoma, J. et al. (2013) *Aerosol Science and Technology* 47:5, 556-563.

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