Lowcost ambient UFP monitoring with diffusion chargers

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Motivation

Over the past years, there has been increased interest in measuring ultrafine particles (UFP) in ambient air to complement existing particle mass metrics (PM10, PM2.5), driven by new WHO recommendations and the new EU air quality directive.

Unfortunately, traditional UFP measurements (condensation particle counters CPC or mobility particle size spectrometers MPSS) are complex and expensive, so spatial coverage of UFP measurements remains low, which is unfortunate in view of the large spatial variability of UFP concentrations. For better spatial coverage, cheaper and more reliable instruments are necessary, and they need to be able to operate outside of traditional climate-controlled measurement stations. We have developed the OLS (OEM LDSA sensor) and a weatherproof enclosure with internet connectivity. This robust lowcost solution can be deployed anywhere as long as power (~4 Watt) is available. It measures lung-deposited surface (LDSA) rather than particle number, a UFP metric that is less common but might be more health-relevant.

Sensor

The OLS is essentially a ruggedized version of the original naneos Partector, which uses a contactless principle to measure charge transfer to an aerosol via induced currents. The charge transfer is approximately proportional to LDSA. Compared to our handheld devices (Partector, Partector 2), the OLS has a similar size, but as an OEM sensor, it has no battery or display. In the design, we used lessons learned from our previous devices to increase the longevity and service intervals of the device. The design was simplified and optimized for cost. The sensor is miniature (~12x8x3cm) and only needs about 500mW of power for operation, except if the internal heating is used.

Enclosure

For easy deployment in the field, we have developed a weatherproof enclosure, which contains the OLS and a dedicated data uplink. The uplink uses the mobile phone network with a global SIM card to transmit measurement and status data to our cloud infrastructure and also allows over-the-air updates of the device firmware. At high ambient RH, the OLS is heated slightly, so internal RH is limited to at most 40% - this corresponds to the recommendations of the ACTRIS network.

Figure 1: OLS, Partector 2, ambient enclosure open, and deployed.

Deployment + Measurements

33 OLS units have been running since March 2025 in the EU project "net4cities". 3 devices each are running in 11 European cities. Additionally, about a dozen more instruments are running in and around Zürich. Therefore, we have had over 40 devices running for a bit more than one year by now. 3 units are collocated on purpose on a roof in Winthertur, 3 other units were supposed to be deployed in Southampton, but due to logistical difficulties, they operated for nearly one year together in Derby, UK, giving us a second collocation of 3 devices. While the OLS only measures LDSA, its signal can be used in conjunction with a CPC to also calculate a mean particle diameter of the aerosol.

Example Results

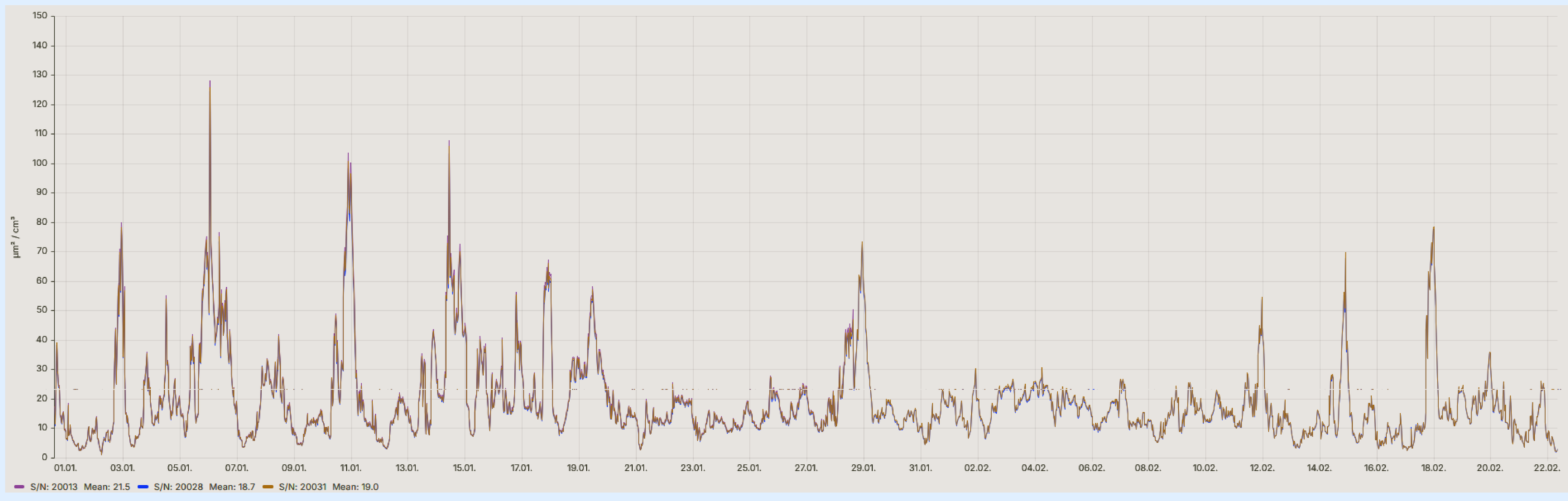

Figure 2: LDSA for the 3 collocated OLS in Southampton for the first 6 weeks of 2026 (after nearly 1 year of deployment)

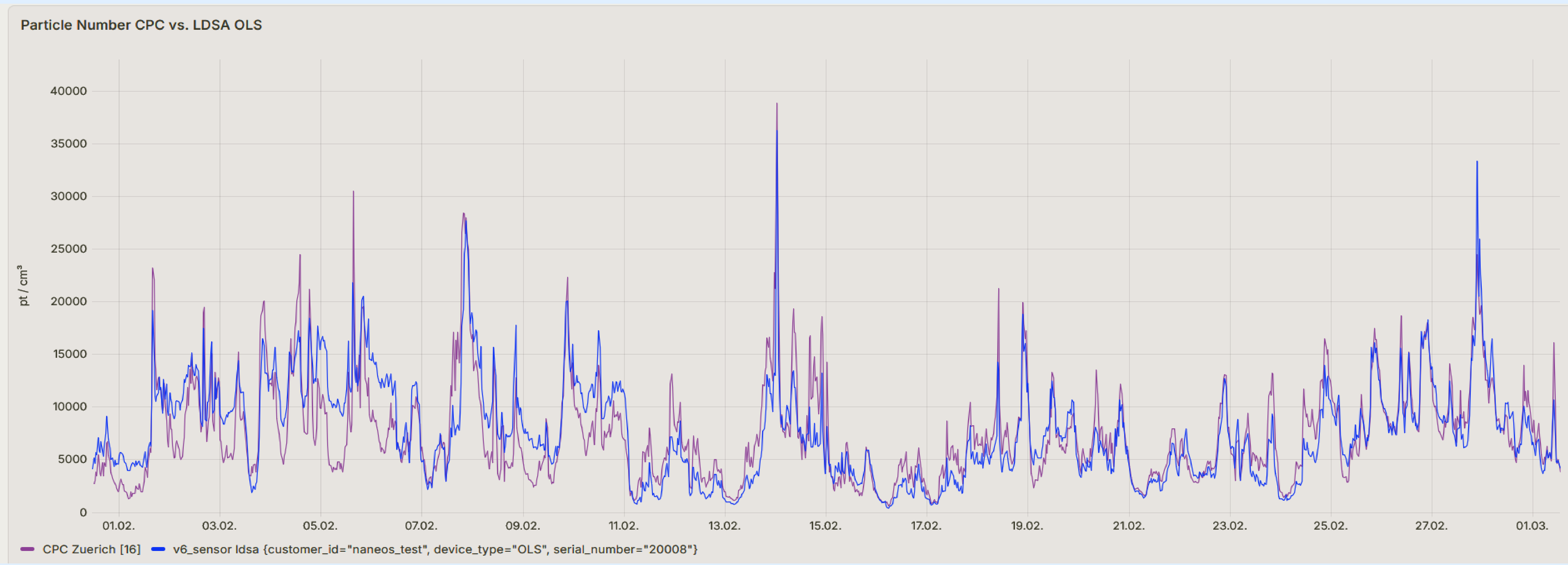

Figure 3: Particle number concentration (purple, CPC) and OLS LDSA scaled by factor 400, for February 2026 at Zürich-Kaserne

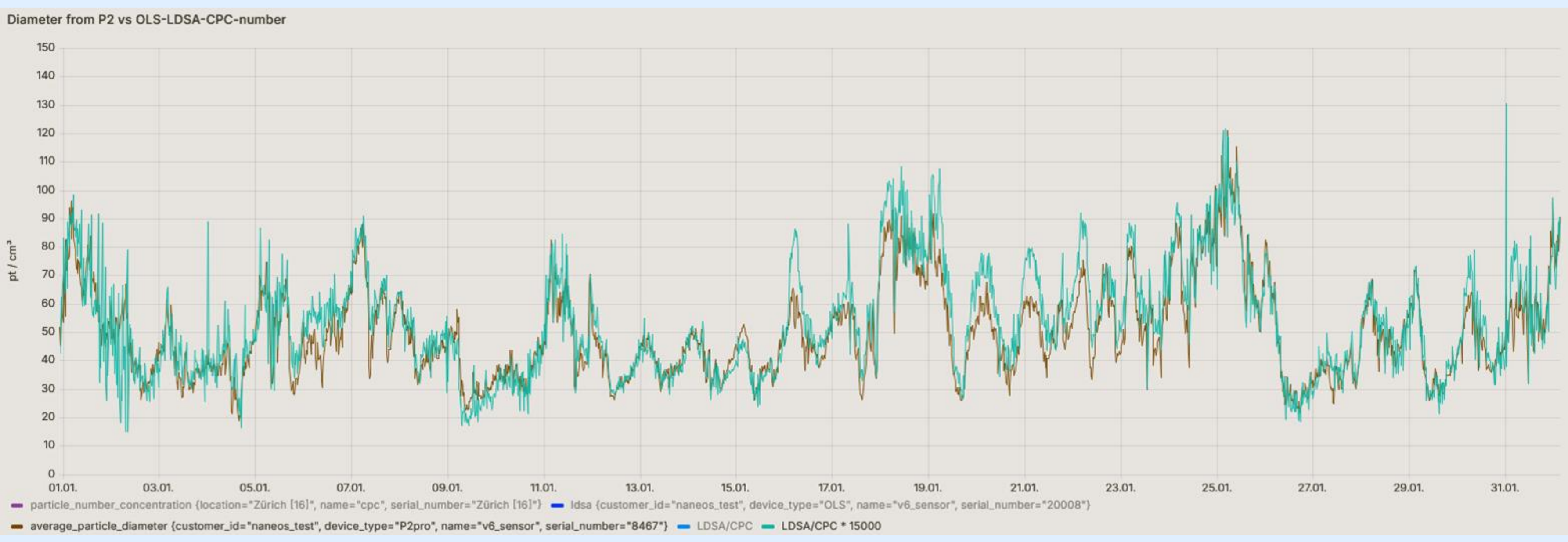

Figure 4: Average particle diameter measured by a Partector 2 pro (brown) and by the combination of CPC and diffusion charging sensor signal (green) for January 2026 at Zürich-Kaserne

Recalibration

After 13 months of 24/7 deployment, 9 OLS deployed in and around Zürich were serviced and recalibrated, giving first indications of long-term performance. We calculated the average calibration constant relative to the initial calibration of the instrument at the return of the devices, finding $c_{avg} = 1.00 \pm 0.06$, with maximal deviations of +0.11 and -0.08, i.e. with one exception, the 9 devices were still measuring to within 10% of their initial calibration.

Discussion + Conclusions

The first 40 first-generation OLS deployed have held up well so far. The reliability is excellent (data availability>99%), the long-term performance as seen in the good agreement during collocation shown in figure 2, and in the recalibration of 9 devices after 13 months is also good with a maximal error of 10% and no overall bias.
Figure 3 shows that LDSA and particle number concentration are reasonably well correlated (R^2 for hourly values of ~0.7), unlike PM2.5 and particle number. This demonstrates that LDSA is a UFP-related metric that can be used instead of particle number to quantify UFP. Finally, figure 4 shows that the ratio of LDSA and particle number can be used to infer an approximate mean particle diameter, adding another dimension to UFP measurements.
The service of the sensors after 13 months of deployment showed little internal contamination, as expected due to the contactless measurement principle. We anticipate that the instruments are capable of long service intervals (2 to 3 years), at least in the European cities where our instruments are currently deployed, where air pollution is generally low. The low initial cost and low maintenance allow large UFP monitoring networks to be created.

We thank the net4cities consortium for providing data of the Southampton deployment