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Results of the feasibility studies for ambient air measurements

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DEKATI Ltd

Contractors

DEKATI Ltd.
Osuusmylynkatu 13
FIN-33700 Tampere
FINLAND
Tel. +358 3 3578100
Fax +358 3 3578140
Email sales@dekati.fi
www.dekati.com

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1 Introduction

An ELPI+™ was installed at the emission measurement station of the city of Tampere (Pirkankatu). An Outdoor Air ELPI™ installed stationary in the same measurement room was used as the reference instrument. The Outdoor Air ELPI™ is a modified version of the standard ELPI™ instrument designed to meet requirements of continuous, long-time ambient air size distribution measurement.

The electrical currents measured by the ELPI+™ and the Outdoor Air ELPI™ were recorded during December 2010 – January 2011. The number and mass concentrations based on the measured currents were calculated and analyzed afterwards at Dekati.

2 Experiments

2.1 Measurement setup

The Outdoor Air ELPI™ was in its stationary installation place and the ELPI+™ was placed on the floor of the measurement room with a distance about 0,5 m from the Outdoor Air ELPI™. The sample flow of the ELPI+™ was taken from the sample line of the Outdoor Air ELPI with a Y-branch and a flexible hose with a diameter of 10 mm. The vacuum pump was placed on the floor about 1,5 m away from the ELPI+™. The connection between the pump and the ELPI+™ was made with a flexible hose.

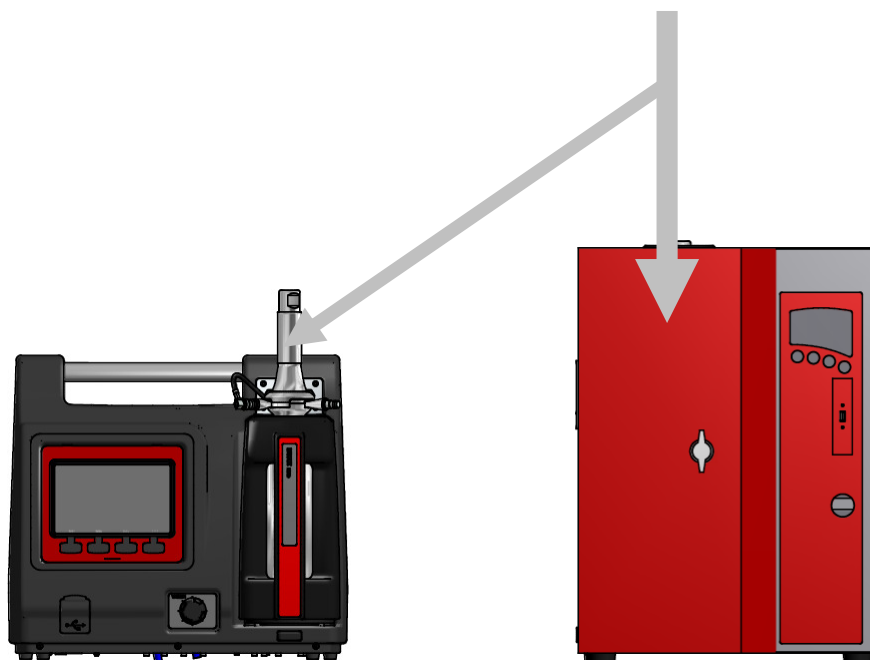


Figure 1. The measurement setup. The sample to the ELPI+™ was taken with a Y-branch installed in the sampling line of the Outdoor Air ELPI™.

The Outdoor Air ELPI operated in a continuous measurement mode saving its results into an internal file on the hard disk. The saving interval was 10 minutes and the saved samples were averaged values of this 10 minutes period. In addition, the measurement data of the Outdoor Air ELPI™ was saved with the ELPIVI software using the same 10 minutes saving interval.

The data measured with the ELPI+™ was saved on a USB-stick using a 10 minutes averaging time and a 10 minutes saving interval.

Sampling linen consisted of a PM-10 sampling head, sample heater and a Nafion® sample dryer to remove the excess water from the sampled aerosol. The instruments were kept in a temperature-controlled room.

2.2 Measurement results

The particle number and mass concentrations have been calculated from the corrected currents of the Outdoor Air ELPI™ and the ELPI+™ using the efficiency curves of the chargers of both devices. The correction of the currents is necessary because of the fine particle losses in the impactor.

2.2.1 Number concentration (PN10)

The PN10 values are calculated by summing the calculated number values of all impactor stages. An example of the 10-minute averaged PN 10 values of the ELPI+ and the Outdoor Air ELPI™ is shown in the Figure 1.

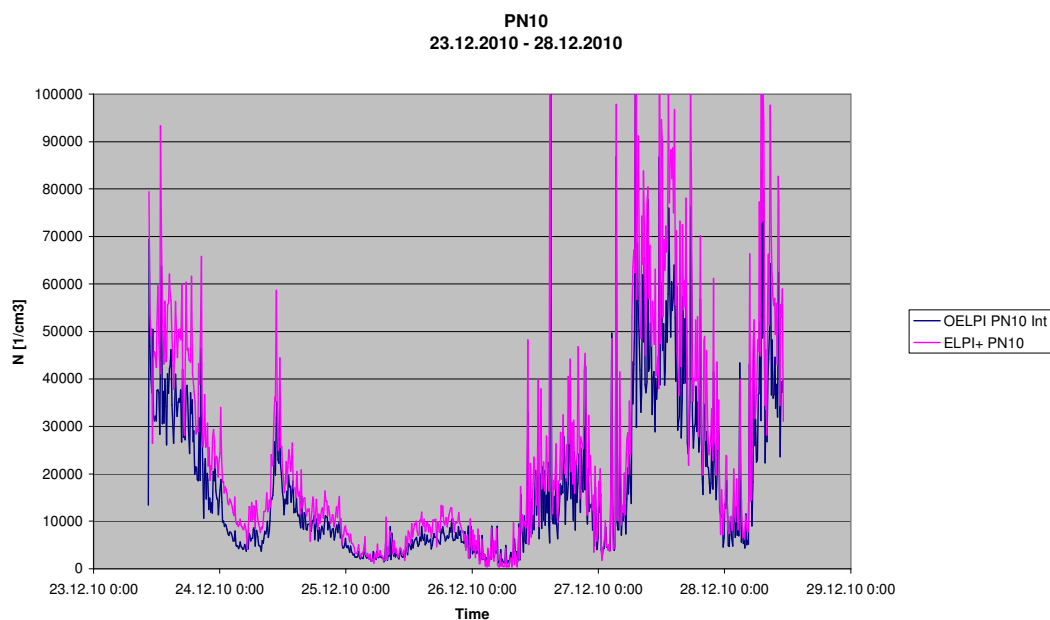


Figure 2. 10-minute averaged PN10 values of the Outdoor Air ELPI™ and the ELPI+™ during the period 23.12.2010 – 27.12.2010.

Figure 2 shows the PM concentrations during the Christmas holiday season. It is interesting to see how the particle concentrations are the highest December 23rd and after the Christmas; on Christmas day (25th of December) the PN levels are in the order of 5000 #/cm³. Most likely the reason is the lack of traffic in the city during holidays. After the Christmas the levels are approximately 10 times higher. There is also a peak in concentration during Christmas Eve morning; after that the levels start to decrease.

The 24-hour averaged (midnight-to-midnight) PN10 values are shown in the Figure 3. The ELPI+™ has measured higher number concentrations than the Outdoor Air ELPI™ especially when the concentration is high. The correlation between the two measured concentrations is nevertheless fairly good, Figure 3.

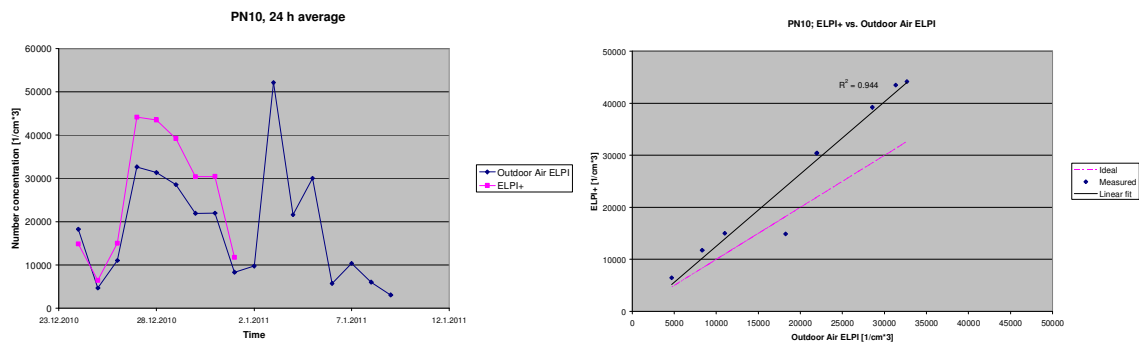


Figure 3. Midnight-to-midnight averaged PN10 values of the Outdoor Air ELPI™ and the ELPI+™ 23.12.2010 – 3.1.2011 (-10.1.2011) (left) and the correlation between these (right)

The correlation of the 24-hour averaged (midnight-to-midnight) PN10 values of ELPI+™ and the Outdoor Air ELPI™ is fairly good, although ELPI+™ has measured higher values than the Outdoor Air ELPI. One reason for the difference is the improved size resolution of the ELPI+ instrument compared to the classic model; however it is also probable that the calibration of the new instrument needs some verification.

2.2.2 Mass concentration

The PM1, PM2.5 and PM10 values for ELPI+™ and the Outdoor Air ELPI™ (with filter stage) have been calculated as the sum of the following channels

	ELPI+™	Outdoor Air ELPI™
PM1	1 – 9	1 – 8
PM2.5	1 – 11	1 – 10
PM10	1 – 14	1 - 12

The 10-minute averaged PM2.5 values are presented in the Figure 5, which shows that the ELPI+™ has followed the same trend with the Outdoor Air ELPI™. The correlation is even better between the PM1 values of the ELPI+™ and the Outdoor

Air ELPI™ than between the PM2.5 values. The reason to this is that the currents of the four uppermost stages of the ELPI+™ have been negative due some unknown reason, and so their contribution to the total mass concentration has been zero in the calculation.

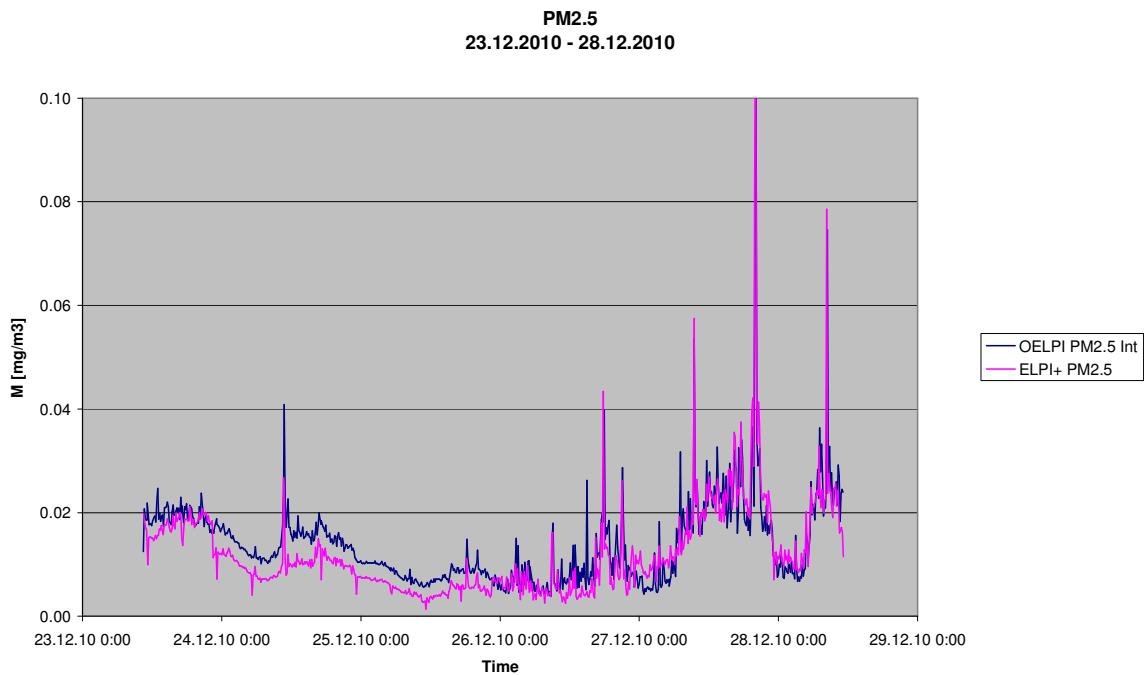


Figure 4. 10-minute averaged PM2.5 values of the ELPI+™ and the Outdoor Air ELPI™.

The trend is the same than in number based measurement but the differences are smaller. In number based measurement the high concentrations are dominated by the smallest particles that are most likely caused by vehicle emissions and VOC nucleation during the ambient dilution; this results to huge number of particles.

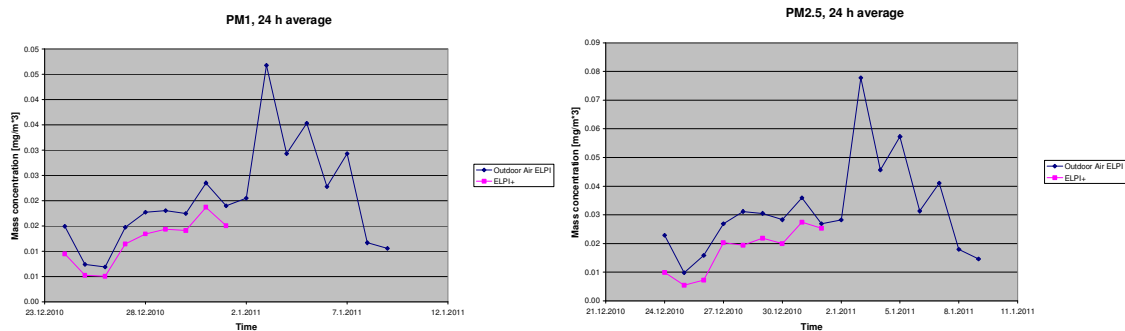


Figure 5. 24-hour averaged PM1 values (left) and PM2.5 (right) of the ELPI+™ and the Outdoor Air ELPI™.

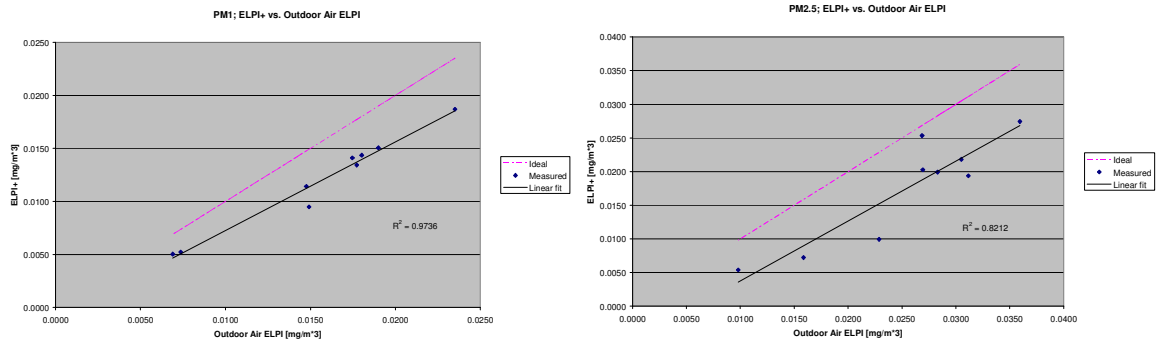


Figure 6. The correlation between the 24-hour averaged PM1 (left) and PM2.5 (right) values of the ELPI+™ and the Outdoor Air ELPI™

Correlation is fairly good, although the ELPI+™ has measured lower values than the Outdoor Air ELPI.

2.2.3 Number distributions

The number size distributions of the ELPI+™ and the Outdoor Air ELPI™ have been compared for the following time periods

- 25.12.2010, 00:00 – 24:00
- 29.12.2010, 00:00 – 24:00

The first one is the Christmas Day and the particle concentration has been very low. The second day is one of the working days between the Christmas and the New Year's Day.

The results correlate fairly well at the upper stages, but the filter stage of the ELPI+ shows higher value in all cases. The reason to this might be

- Improved size resolution of the ELPI+ for the smallest particles
- the temporary fine particle loss calculation
- the mean diameter of the filter stage used in the calculations
- the temporary charger efficiency curve

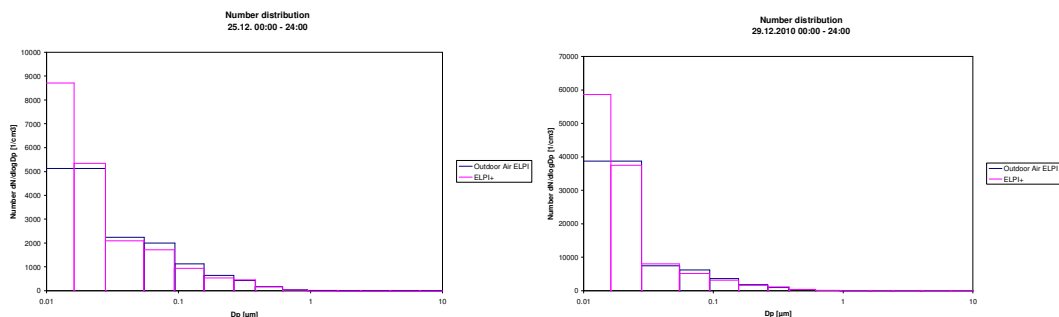


Figure 7. Size distribution measured with the ELPI+™ and the Outdoor Air ELPI™

3 Performance Summary

The results of the measurements made at the measurement station of the city of Tampere (at Pirkankatu) with the ELPI+™ and the Outdoor Air ELPI™ have been compared.

The correlation between the calculated PN10 values of the ELPI+™ and the Outdoor Air ELPI™ is fairly good.

The correlation between the calculated PM1 values of the ELPI+™ and the Outdoor Air ELPI™ is good. The PM2.5 and the PM10 values of the ELPI+™ are lower than the values of the Outdoor Air ELPI™, especially in the beginning of the measurement period. A likely reason to this is that the currents of the uppermost channels of the ELPI+ have been negative, and therefore, their contribution to the total mass has been zero.

The number and the mass size distributions calculated from the current measurements of the ELPI+™ and the Outdoor Air ELPI™ correlate quite well despite the temporary calibration of the instrument.