



# Ultrafine Particle Measurement Campaign in the City of Graz using an AVL CPC

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# Drivers & Legislation

**WHO global air quality guidelines**

Particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide

Latest Release: 2021



Air pollution caused 4.2 million premature deaths worldwide in 2019. (WHO, [Link](#))

Aerosol particles can have severe effects on human health

Governments globally search for countermeasures to reduce the economic burden caused by air pollution (OECD: 21 billion USD in 2015, [LINK](#))

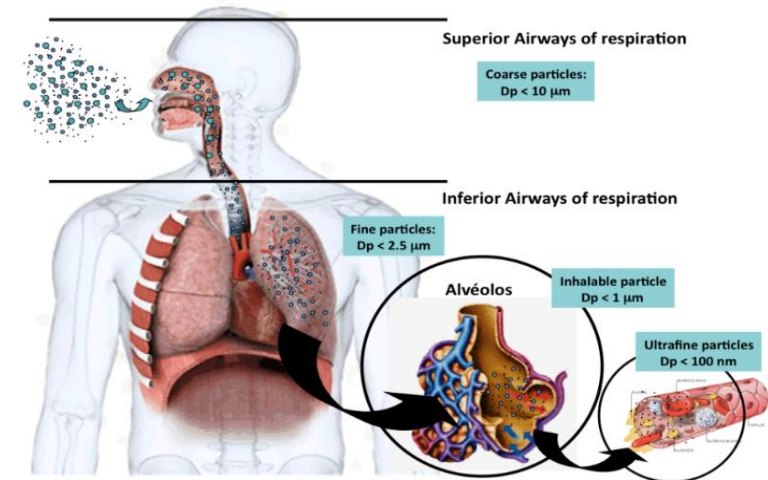


Fig.1: Health effects of aerosol particles (2)

**WHO AIR QUALITY GUIDELINE LEVELS ARE LOWER THAN 15 YEARS AGO**

Parameter	2005 long-term Air Quality Guideline levels	2021 long-term Air Quality Guideline levels
Fine particulate matter (PM <sub>2.5</sub> )	10 µg/m <sup>3</sup>	5 µg/m <sup>3</sup>
Particulate matter (PM <sub>10</sub> )	20 µg/m <sup>3</sup>	15 µg/m <sup>3</sup>
Ozone (8-hour season)	120 µg/m <sup>3</sup>	60 µg/m <sup>3</sup>
Nitrogen dioxide (NO <sub>2</sub> )	40 µg/m <sup>3</sup>	10 µg/m <sup>3</sup>

Recommended annually

WHO Air Quality Guidelines set goals to protect millions of lives from air pollution.

CLEAN AIR FOR HEALTH #AirPollution 

Source: web; 25.04.23;  
[WHO releases updated Global Air Quality Guidelines \(rehva.eu\)](#)

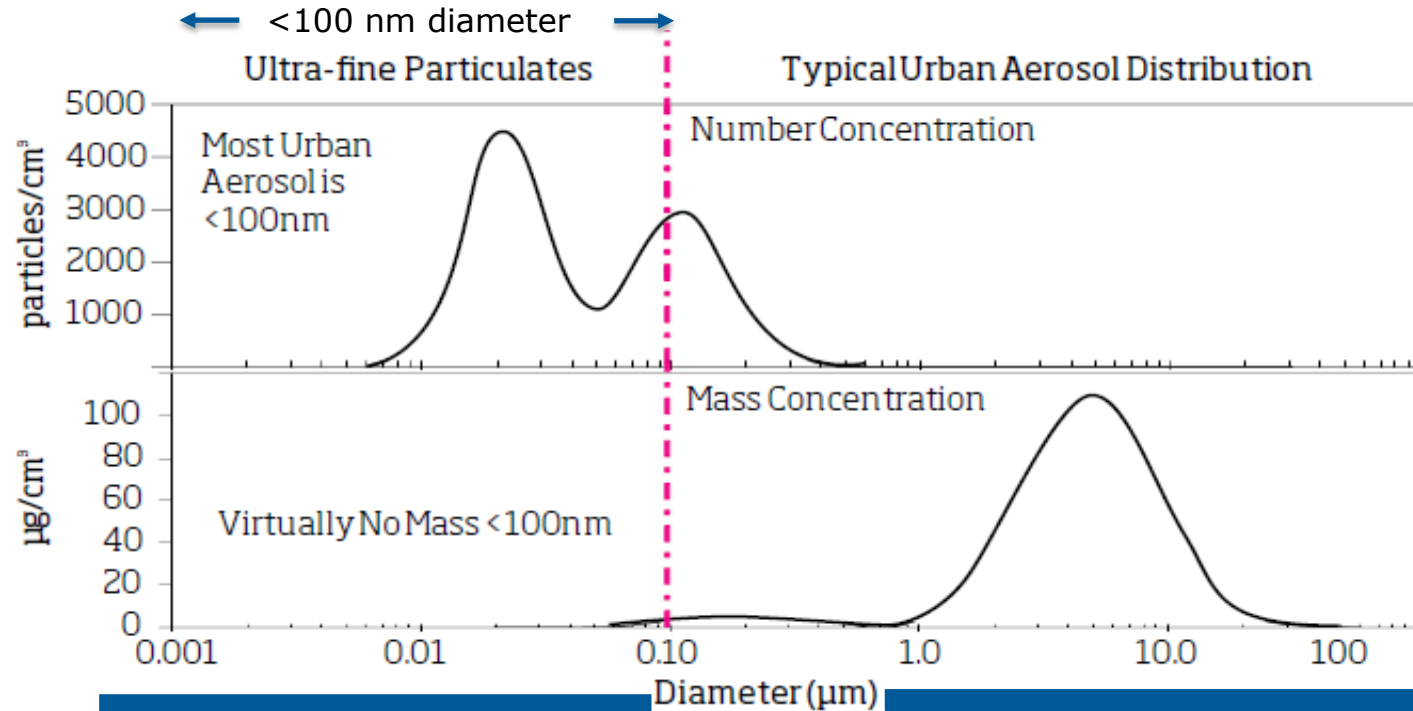
Air Quality Guidelines (AQG) include + cont. limit refinement : SO<sub>2</sub>, NO<sub>2</sub>, O<sub>3</sub>, CO, PM<sub>10</sub>, PM<sub>2.5</sub>

**Ultra Fine Particles(UFP) = <100nm** for the 1<sup>st</sup> time introduced as "metric of interest"; recommendation to expand container equipment by UFP devices due to shortcomings of other methods

Harmonization of UFP measurement procedure needed:  
CEN 16976 – technical specification

TECHNICAL SPECIFICATION	<b>CEN/TS 16976</b>
SPÉCIFICATION TECHNIQUE	
TECHNISCHE SPEZIFIKATION	August 2016
ICS 13.040.20	
English Version	
Ambient air - Determination of the particle number concentration of atmospheric aerosol	
Air ambiant - Détermination de la concentration en nombre de particules de l'aérosol atmosphérique	Außenluft - Bestimmung der Partikelanzahlkonzentration des atmosphärischen Aerosols
This Technical Specification (CEN/TS) was approved by CEN on 26 June 2016 for provisional application.	
The period of validity of this CEN/TS is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the CEN/TS can be converted into a European Standard.	

# Why Ultra-Fine Particles?



**Consequent step to link existing Emission Regulation to Ambient Air Monitoring Metric → UFP**

Occur in massive numbers in urban air (most common source: vehicle exhaust) but essentially have no mass

Traditional mass-based measurements may not be fully representative



# Expertise

... in Particle Number Counting:

- 15+ years in the field of emission testing
- Installed Base: 1600+ units worldwide
- **Applications:** Automotive, Non-Road Mobile Machineries and Aviation
- **Global Customer's:** OEM's, Tier 1, Legal Authorities (e.g.JRC), Universities, Institutes
- **Global available** service and repair centers

## AVL UltraFine Particle Monitor



Laminar full flow butanol-based CPC: 100% AVL Technology (0 ... 100,000 #/cm<sup>3</sup>)

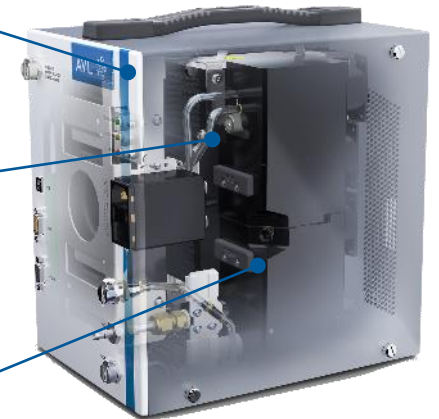
Fully compliant to the CEN16976 requirements and specifications

ACTRIS Whitelist approved and certified

Automatic re-boot functionality ensures consistent data flow

Advanced drift detection leads to long measurement stability

Plug and Play: Bayern-Hessen, TCP/IP & UIDE



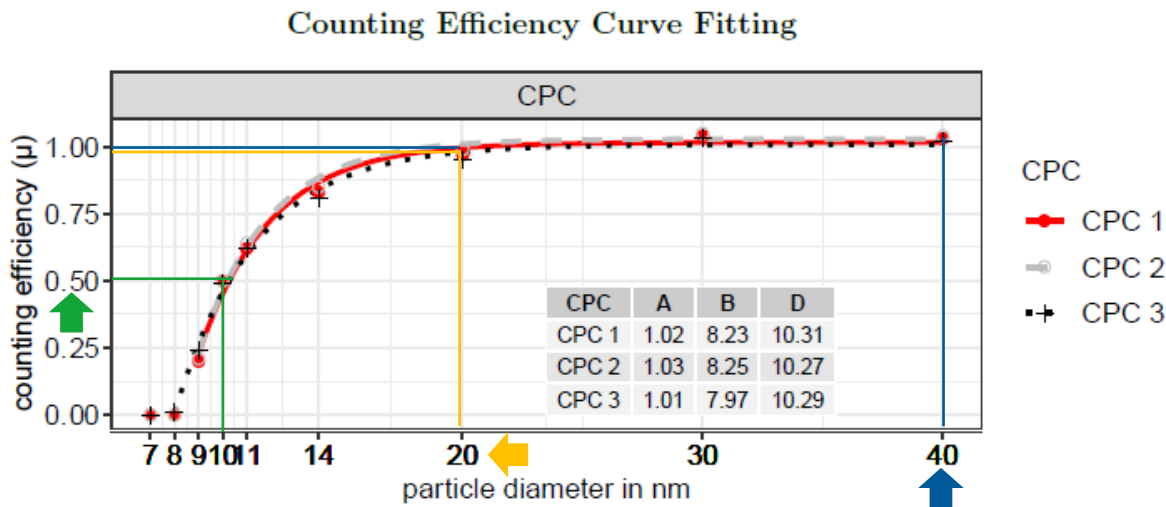


# AVL UFPM Performance Evaluation ACTRIS Compatibility According CEN/TS 16976:2023

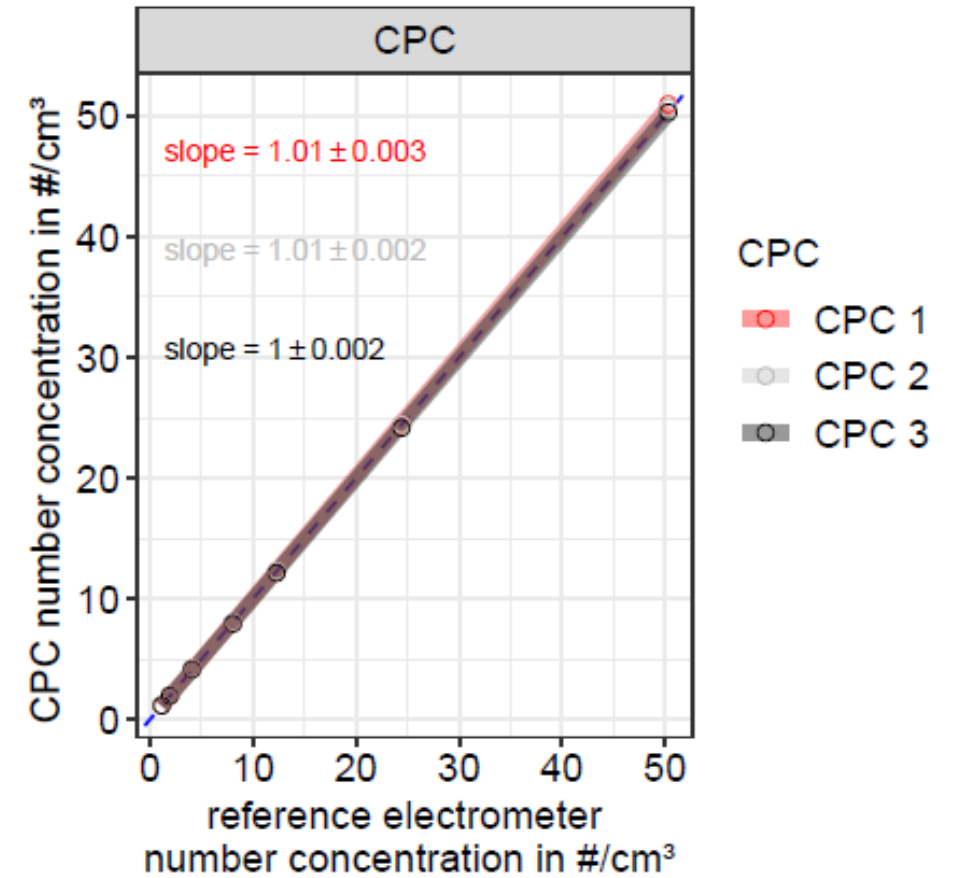
Instrument Model	AVL Ultrafine Particle Monitor
Evaluating Unit	WCCAP, Leipzig, Germany

## Performance Evaluation Results:

Performance Characteristics	Criteria	CPC1	CPC2	CPC3	Unit
Detection efficiency at $40 \pm 10$ nm	$\geq 95\%$	102	103	101	%
Particle diameter where efficiency is $\geq 50\%$	$D_{50} = 10 \pm 1$ nm	10.31	10.27	10.29	nm
Detection efficiency at $< 20$ nm	$\geq 90\%$	97	99	95	%
Concentration response (linearity)	$100\% \pm 5\%$	101	101	100	%



## Linearity against reference electrometer



# Ultrafine Particle Measurement Campaign in the City of Graz

- **Location:** Air quality measuring station Graz-Süd Tiergartenweg
- **Time:** Nov. 22 – April 23
- **Setup:** 2 x UFP devices measuring in parallel (different suppliers)



## Main Findings:

- ❑ Re-filling of butanol frequency
- ❑ Integration of the UFP device
- ❑ No UFP “calibration gas” available → long measurement stability is key
- ❑ Diurnal cycle shows “traffic fingerprint”
- ❑ Short-term max. UFP concentrations up to 150.000 #/cm<sup>3</sup>

# Long Measurement Stability

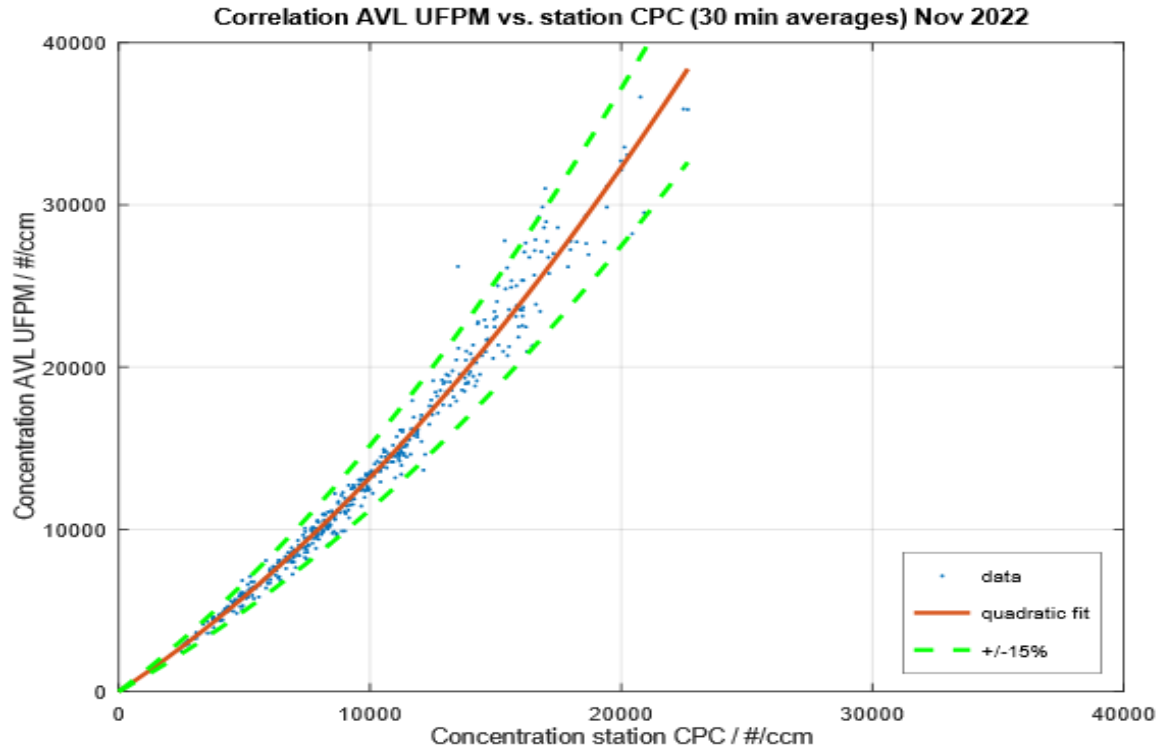


Fig. 4a Correlation between AVL UFPM and station CPC in Graz before service of station CPC

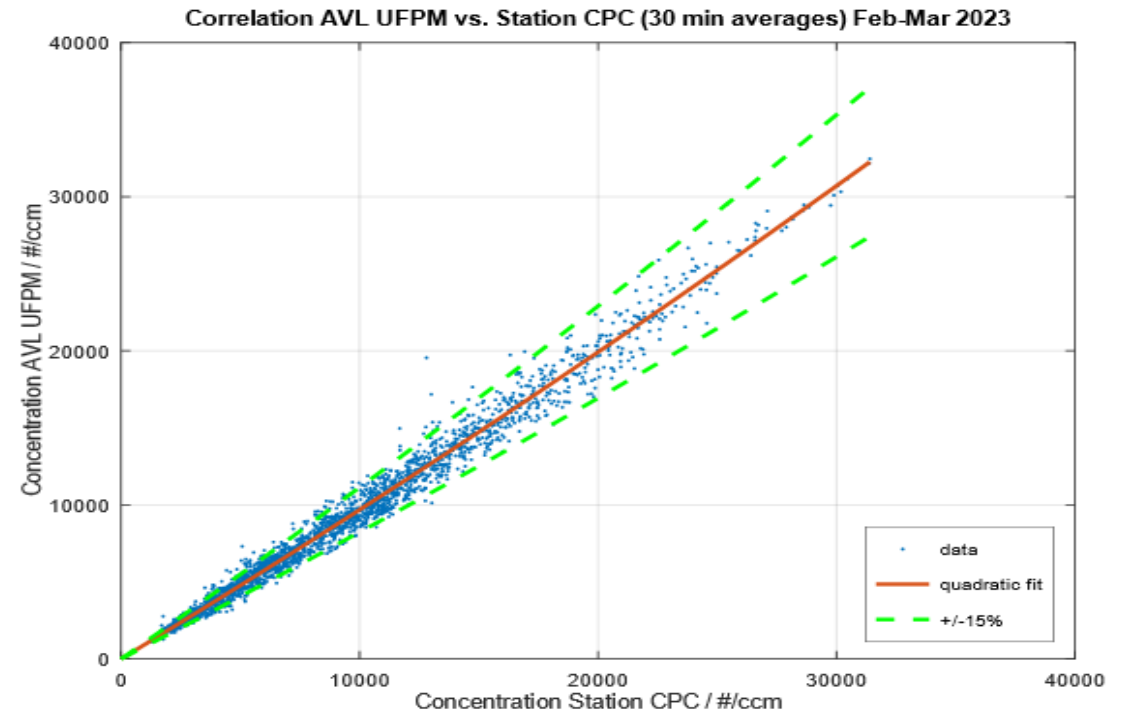


Fig. 4b Correlation between AVL UFPM and station CPC in Graz after service of station CPC



# Diurnal Cycle Shows “Traffic Fingerprint”

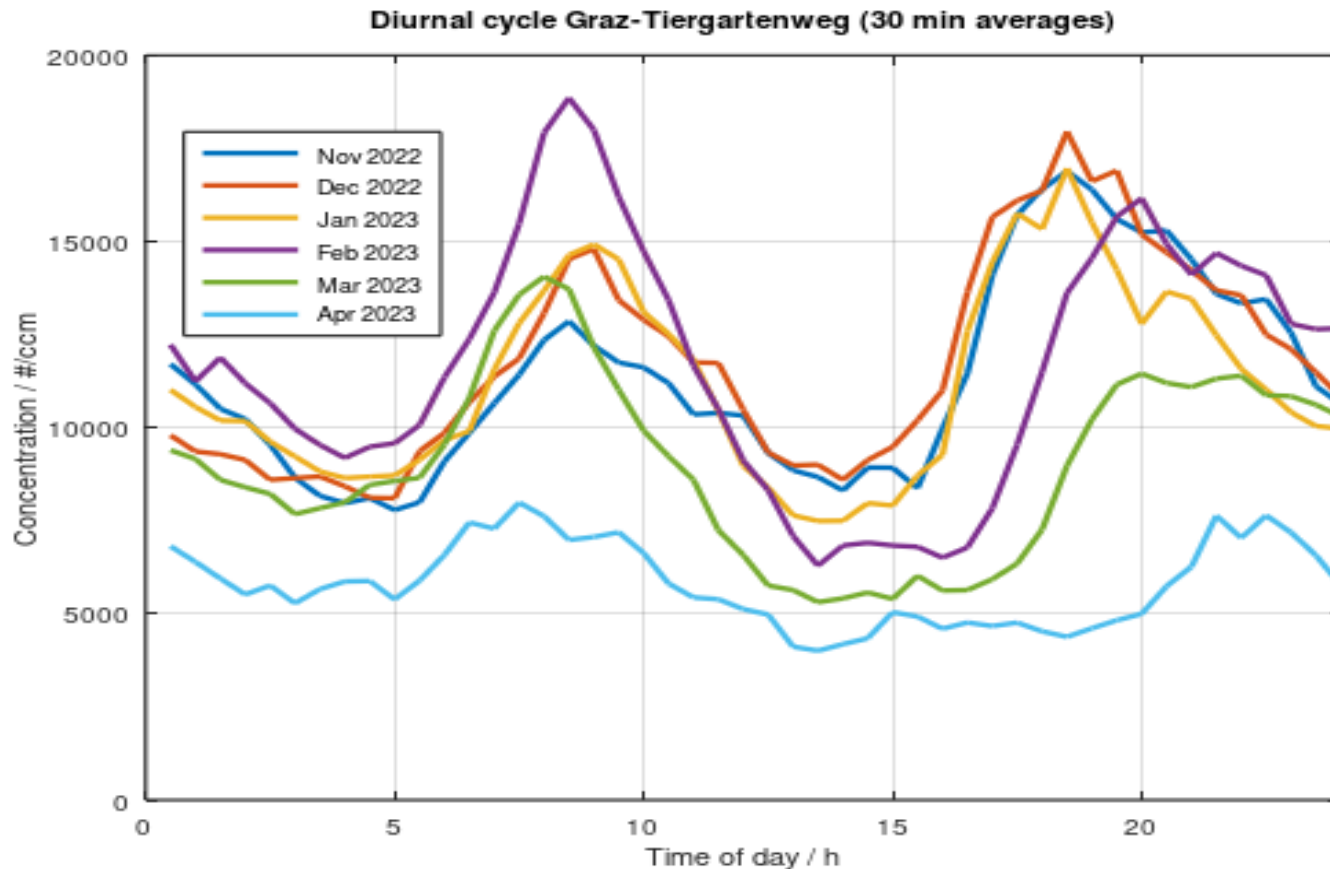
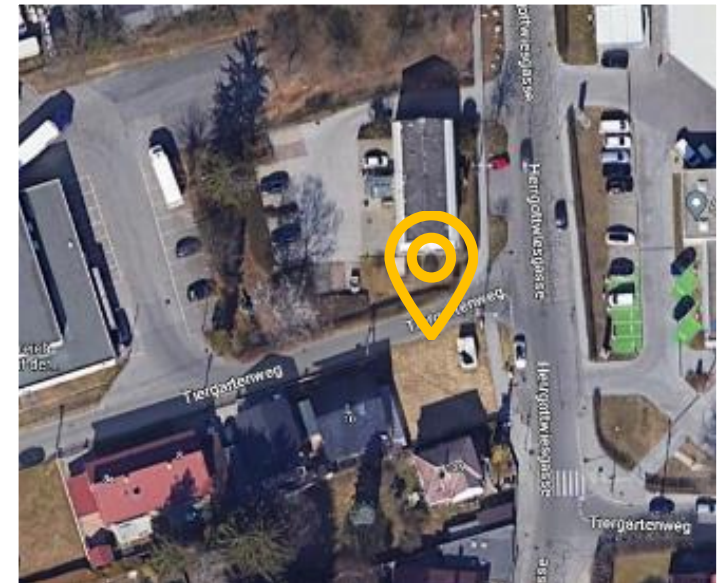


Fig. 6 diurnal cycle from Nov-22 to Apr-23

The measurements show a clear diurnal cycle, with maximum concentrations twice per day. These are most likely related to traffic peaks in the morning and late afternoon.



# Short-term max. UFP concentrations

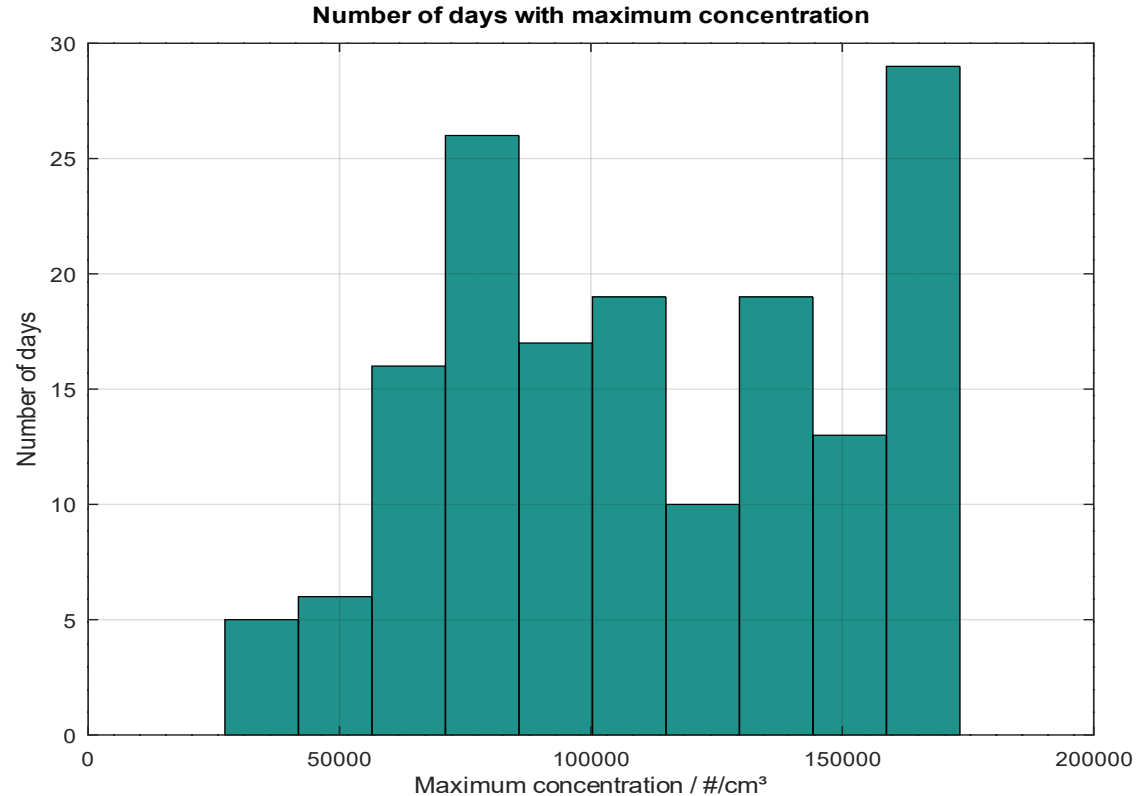


Fig. 5 concentration statistics from the measurements in Graz

- 60 days of the campaign show less than  $1.0 \cdot 10^5$  #/cm<sup>3</sup> and therefore are within the linearity of the measurement device.
- 97 days were over  $1.0 \cdot 10^5$  #/cm<sup>3</sup>
- 29 days exceed even  $1.5 \cdot 10^5$  #/cm<sup>3</sup>

# Conclusions

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- Three different AVL UFPM were calibrated at WCCAP and fulfil the CEN/TS 16976:2023 standard, therefore fulfilling ACTRIS conformity
- The 6-month ambient measurements prove that the AVL UFPM shows a very stable performance without an error over a measurement period of 6 months and a 24/7 operation → Device still in operation
- Long-term ambient measurements show that no operator interaction was necessary beside refilling the operating fluid bottle
- The calibrated maximum concentrations were exceeded during the urban measurements
- The diurnal cycles show two peaks in the morning and late afternoon, which are most likely due to increased traffic in these time periods



Thank You

# About Us

At AVL, we are one of the world's leading mobility technology companies for development, simulation and testing in the automotive industry, and in other sectors. Drawing on our pioneering spirit, we provide concepts, solutions and methodologies for a greener, safer and better world of mobility.