

Weg zu EU7-Einführung Non-Exhaust Gesetzgebung



Kurzvorstellung:



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Zuständigkeitsbereich:

- Produkt Management
 - Break Wear Partikel Messtechnik
 - Non-Exhaust Partikel Messtechnik

Agenda

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About Us

Vorstellung AVL Partikelmessstechnik

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The Way to Euro 7

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United Nations Global Technical Regulation

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Zusammenfassung



Clean Affordable Mobility

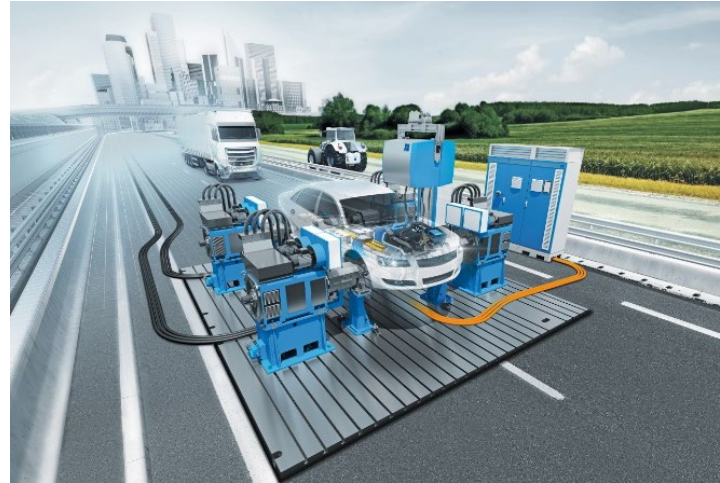
AVL is the world's largest independent company for development, simulation and testing in the automotive industry, and in other sectors. Drawing on its pioneering spirit, the company provides concepts, solutions and methodologies to shape future mobility trends.

Three Disciplines Under One Roof



ENGINEERING SERVICES

- Design and development services for all elements of ICE, HEV, BEV and FCEV powertrain systems
- System integration into vehicle, stationary or marine applications
- Supporting future technologies in areas such as ADAS and Autonomous Driving
- Technical and engineering centers around the globe



INSTRUMENTATION AND TEST SYSTEMS

- Advanced and accurate simulation and testing solutions for every aspect of the powertrain development process
- Seamless integration of the latest simulation, automation and testing technologies
- Pushing key tasks to the start of development



ADVANCED SIMULATION TECHNOLOGIES

- We are a proven partner in delivering efficiency gains with the help of virtualization
- Simulation solutions for all phases of the powertrain and vehicle development process
- High-definition insights into the behavior and interactions of components, systems and entire vehicles

AVL Particle Measurement

50+ years of experience

600+ global customers

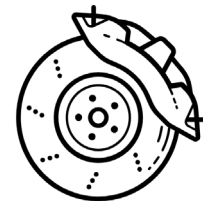
17.000+ installed devices

AVL powertrain engineering as major
device development contributor

Supplier of **industry standards**

Important stakeholder for
research and **legislation**





Published AVL's Work on Brake-Wear

PMP IWG on brake-wear:

- 11/2017: [Particle emissions from different types of brake pads](#)
- 05/2018: [Particle emissions from different types of brake pads – PM results](#)
- 07/2018: [Brake-wear PN: AVL/TUI experience with the novel test cycle](#)
- 11/2018: [First insights on brakewear PN over the novel cycle](#)
- 04/2019: [Brake Dust PM results measured on a dyno running the novel test cycle](#)
- 10/2019: [Challenges in brake-wear PM/PN measurements over the WLTP test cycle](#)

Collaborations



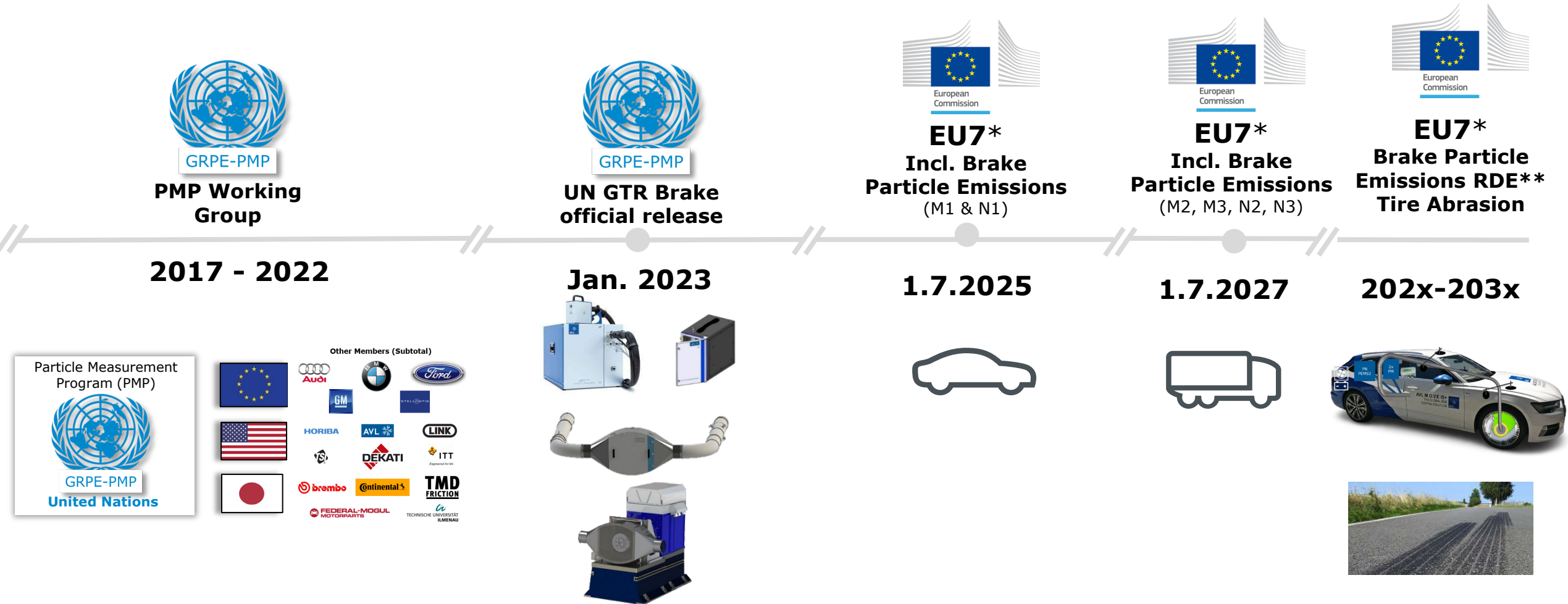
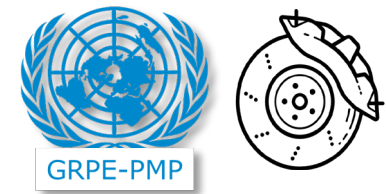
Journal publications/Conferences:

- Atmosphere 2019, 10(11), 639: [Physical Characterization of Brake-Wear Particles in a PM10 Dilution Tunnel](#)
- SAE 2020-01-1633: [Comparison of Particulate Matter and Number Emissions from a Floating and a Fixed Caliper Brake System of the Same Lining Formulation](#)
- CRC 2021: [Comparison of particulate emissions and disc temperature profiles from a commercial disc-brake system tested on two dynamometer sampling systems.](#)
- Atmosphere 2021, 12, x: Particle Emissions and Disc Temperature Profiles from a Commercial Brake System Tested on a Dynamometer under Real World Cycles. *Accepted for publication*
- Euro Brake 2022: Real-Driving emissions sampling system for brake particle measurement; Brake Wear PM- and PN instrumentation Round Robin
- SAE 2022-01-1197: Design of a Laboratory Sampling System for Brake Wear Particle Measurements



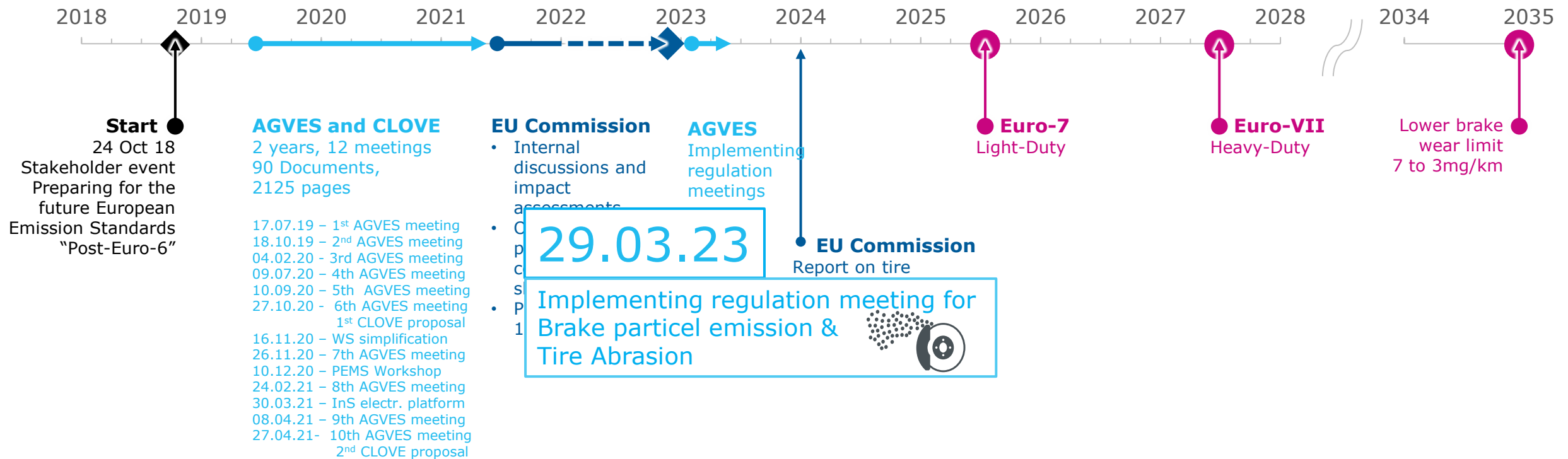
Way to Euro 7

From United Nations Global Technical Regulation UN GTR to EURO 7 – Brake Emission Measurement



*EU7 Proposal; Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL; 10th of November 2022
Brake Particle Emission: $PM_{10} \leq 7\text{mg/km/Vehicle}$ (for M1 & N1) Reduktion in 2035 $PM_{10} \leq 3\text{mg/km/Vehicle}$
**RDE...Real Driving Emissions

Euro-7/VII – Implementierung

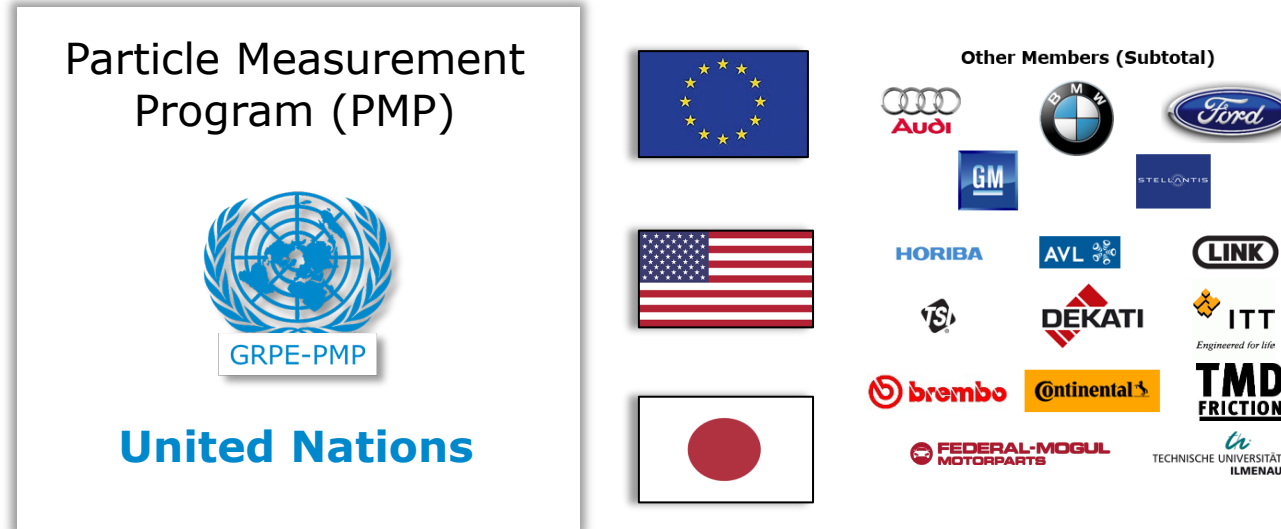


AGVES = Advisory Group Vehicle Emission Standards
CLOVE = Consortium for Low Vehicle Emissions



United Nations Global Technical Regulation (UN GTR)

Der Weg zur United Nations Global Technical Regulation → UN GTR



Organisiert über Task Forces:

- **TF1:** Definition Brems Zyklus
- **TF2:** Definition der Mess-Methodik
- **TF3:** Round – Robin Tests
- **TF4:** Einfluss EV – Einfluss von Rekuperation

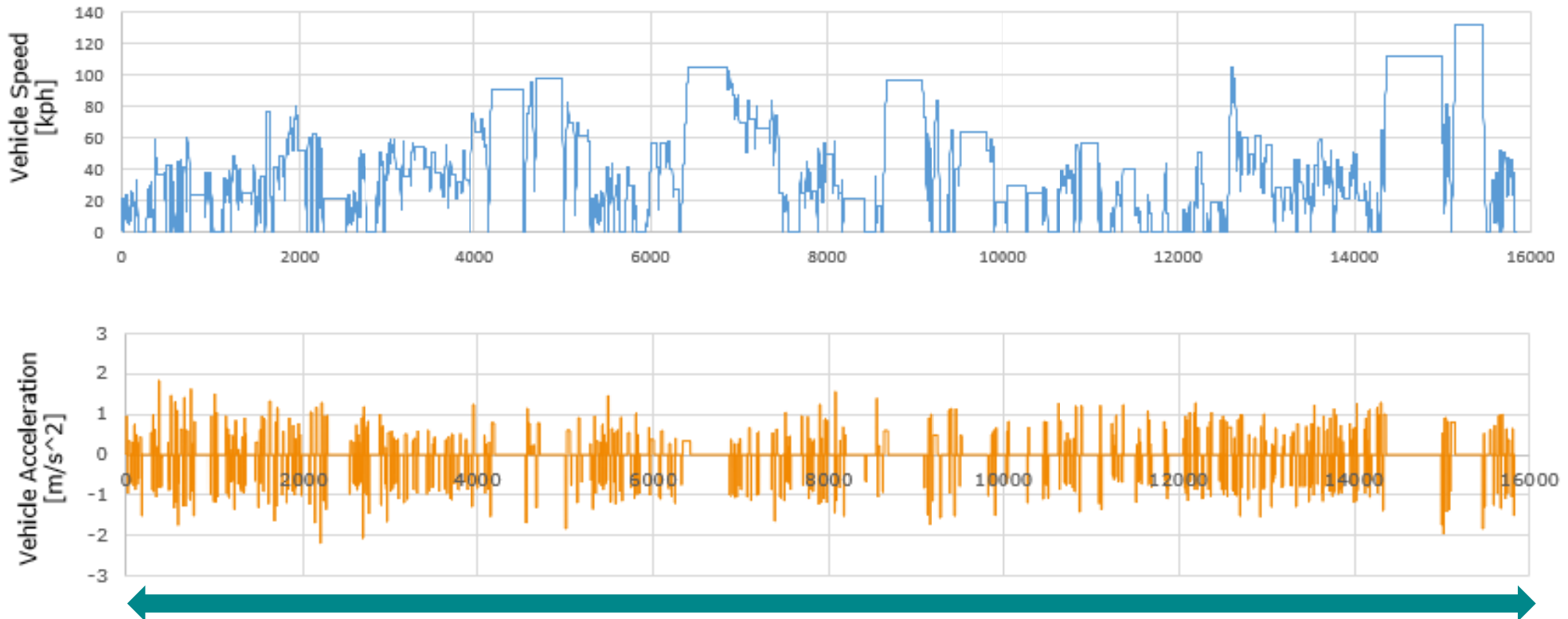


- **Brems Zyklus**
- **Test Umgebung**
- **Messmethodik**
- **Einfluss EV**

- ➔ **WLTP Brake & Prüfprozedur**
- ➔ **Prüfstand & System layout**
- ➔ **PM & PN**
- ➔ **Berücksichtigung Reku.**

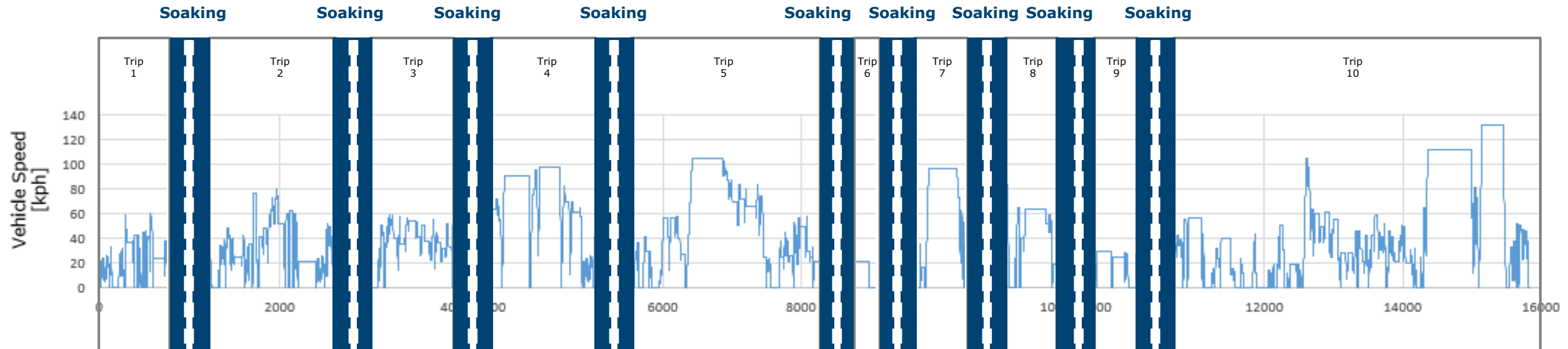
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WLTP – BRAKE



- 16.000 sec. = 4,5h
- 192 km
- 303 braking events

WLTP – BRAKE



← Cycle is split in 10 sections with intermediate cooling between (40°C) which leads to extended testing time. →

Weg zu UN GTR – WLTP Brake Prüf-Prozedur



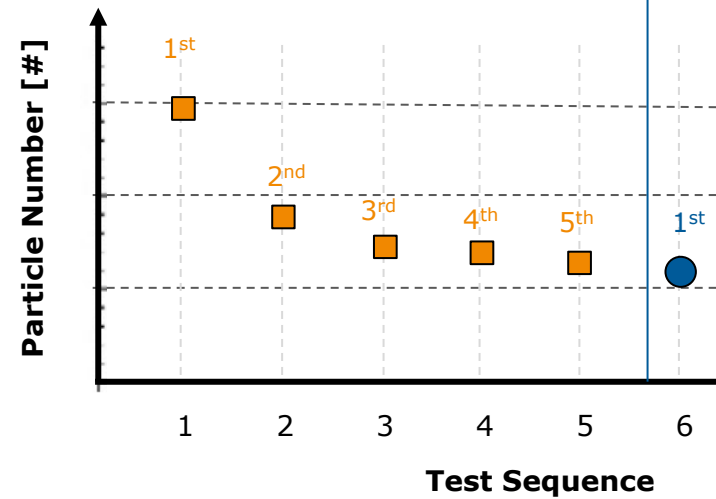
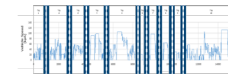
Air Flow
Adj.



Bedding Procedure

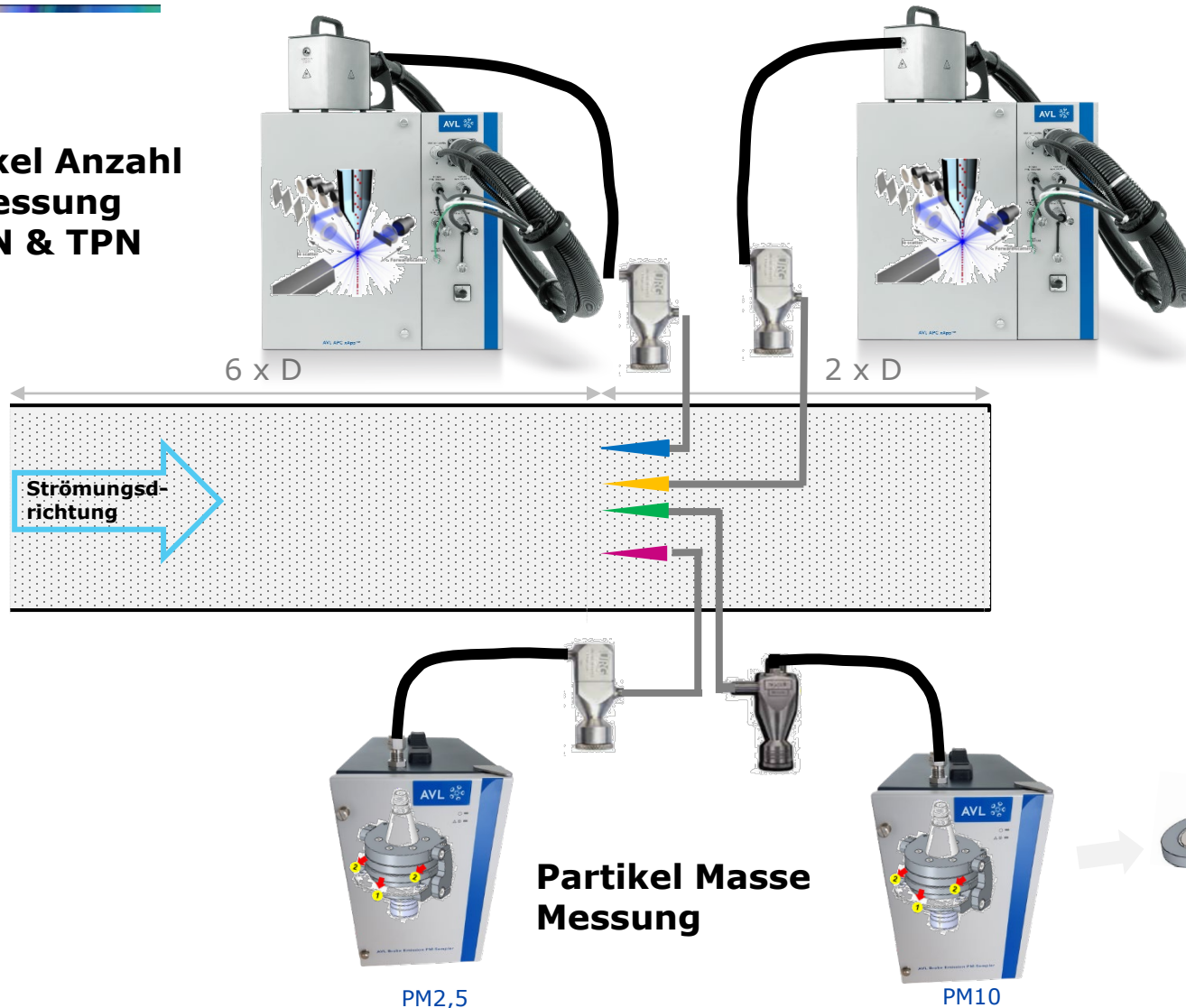


Emission Measurement
Procedure



Definition der Messmethodik

Partikel Anzahl Messung SPN & TPN



Partikel-Anzahl PN:

- Messung von Solid & Total PN
- Mobilitätsdurchmesser ≥ 10 nm (Fokus auf 10 nm – 2.5 μ m Bereich)
- Iso Kinetische Probenentnahme

Partikel-Masse PM:

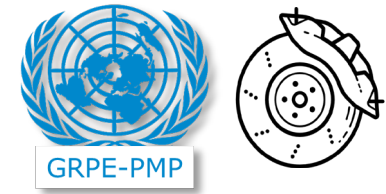
- Gravimetrische Messung (Filterwiegung)
- PM2.5 & PM10
- Iso Kinetische Probenentnahme



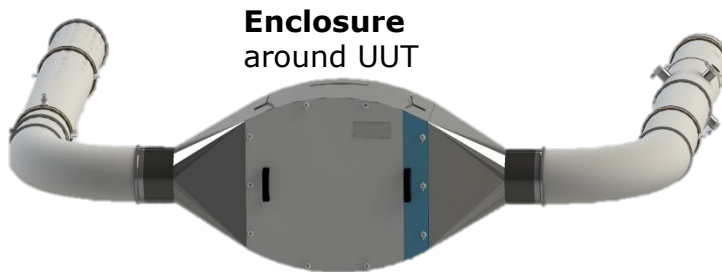
Filter Wägekammer

AVL Brake Emission Solution

Messtechnik gemäß GTR-Anforderungen



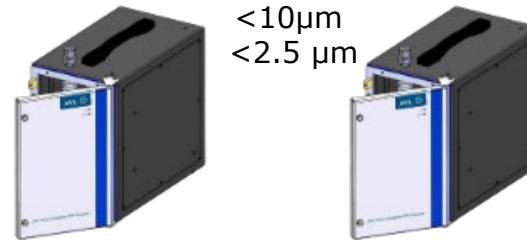
BW – Sampling System



Partikel Masse - PM

Gravimetrisch PM:

<10µm
<2.5 µm



**PM Sampler
PM10**

**PM Sampler
PM2.5**

Partikel Anzahl - PN

CPC-based PN:
>10 nm

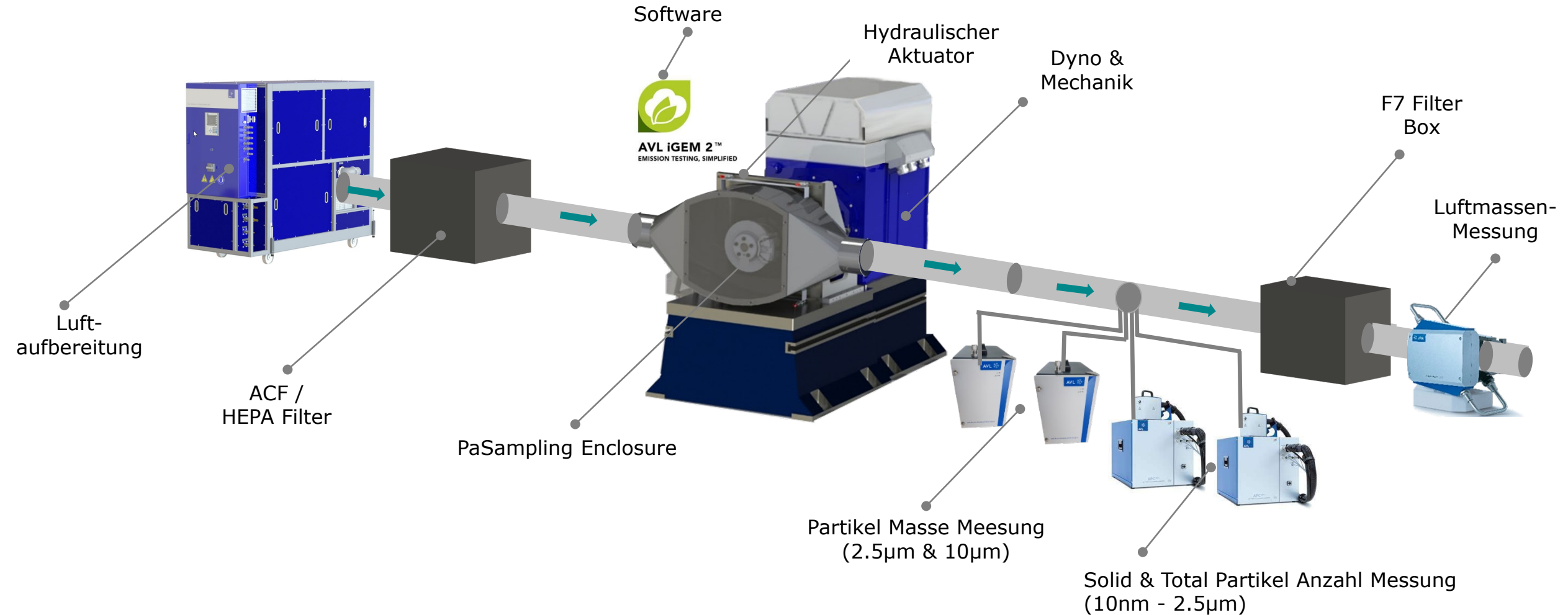


**APC xBrake
For Total PN10
(Solid + Volatile PN)**

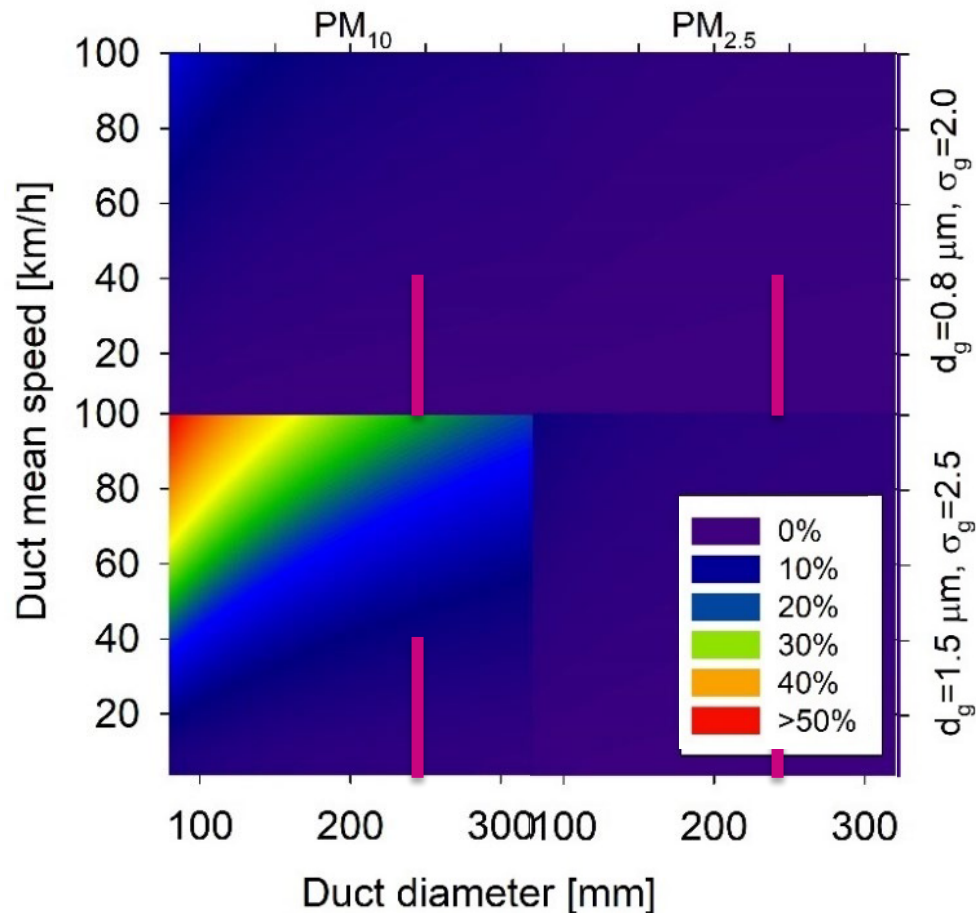
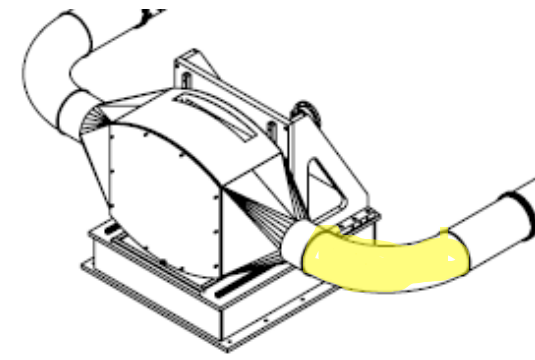
**APC xBrake
For Solid PN10**

Outlook: Automatic Filter Changer

AVL Brake Emission Solution System gemäß GTR-Anforderungen



Berechnung – PM₁₀ & PM_{2.5} Partikelverluste Rohrleitung - 90° Bogen



Trägheitsverluste (Bögen) - $f(v, d)$

- PM₁₀ Verluste können 50% übersteigen
- PM_{2.5} Verluste sind vernachlässigbar

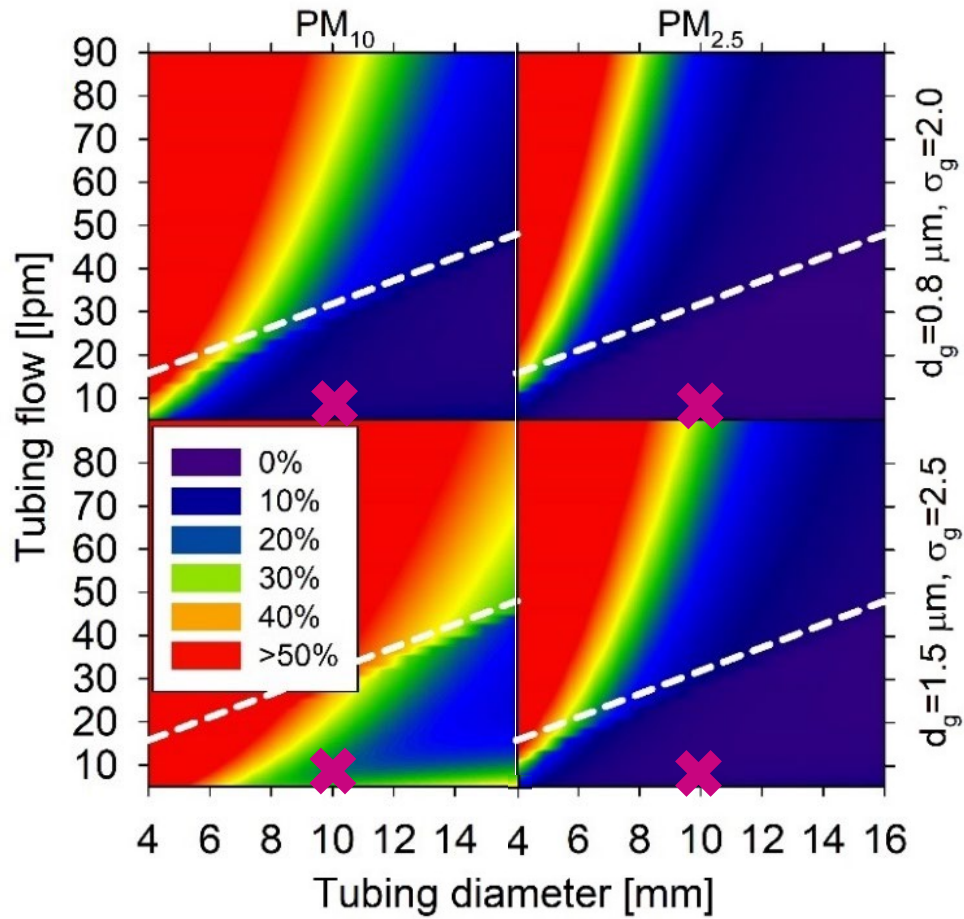
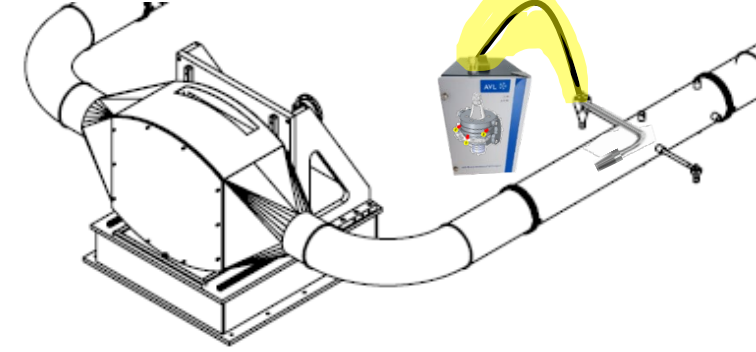
Ø 220 mm Rohrdurchmesser – 1 Bogen

Großer Kühlbereich

300 - 1500 m³/h = 8 - 40 km/h

Minimale Verluste → PM₁₀ < 10%

Berechnung – PM₁₀ & PM_{2.5} Partikelverluste Sample Pfad



- Hohe Verluste von PM_{2.5} & PM₁₀ möglich
- Vermeidung von PM_{2.5} -Verlusten im laminaren Bereich
- Probennahme-Pfad ist der kritische Pfad

Vermeidung von Trägheitsverlusten

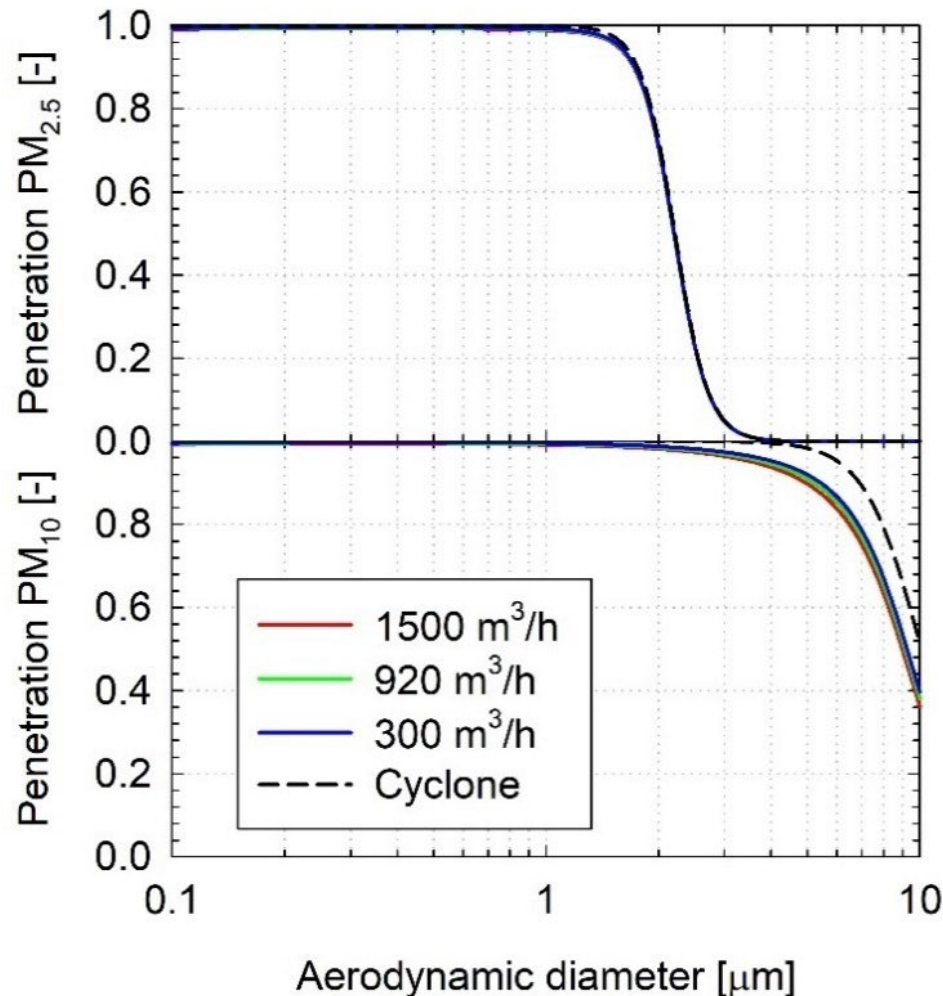
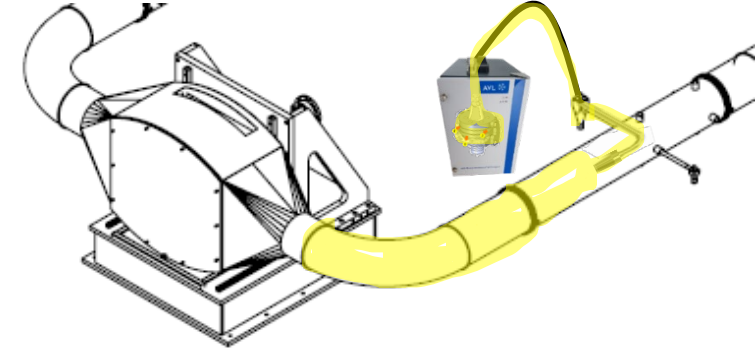
→ Fluss ↓ – SchlauchØ ↑

Vermeidung von Gravitationsverlusten

→ Schaluchlänge < 1m

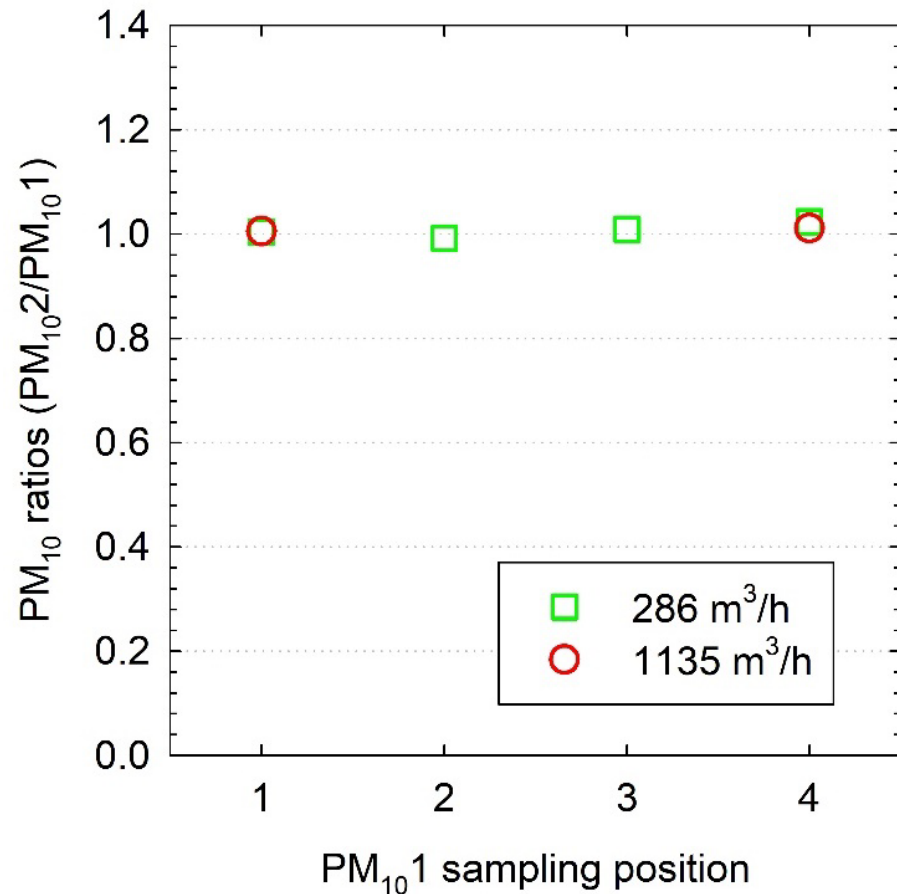
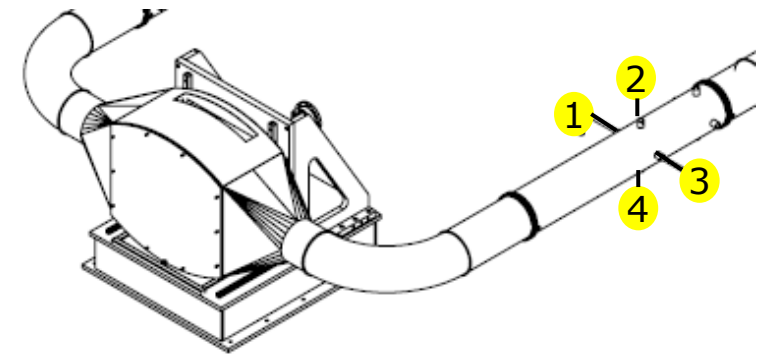
→ Minimierung der horizontalen Abschnitte

Berechnung – PM₁₀ & PM_{2.5} Partikel Verluste gesamtes Sampling System



- PM_{2.5} hängen ausschließlich von der Abscheiderate des Zyklons ab
- Verringerung der PM₁₀-Penetration um 10-15 % im Vergleich zum 10μm Zyklon
- Großteil der erwarteten Verluste im Sample-Pfad (Verschlauchung)

Experimentelle Resultate Partikel Vermischung



Ein PN/PM-Messgerät hat immer an Position 2 gemessen, das zweite PN/PM-Messgerät hat die Position gewechselt (1, 3, 4)

PN Messung:

- Abweichung 2 – 4%
ordnungsgemäße Partikelvermischung

PM Messung:

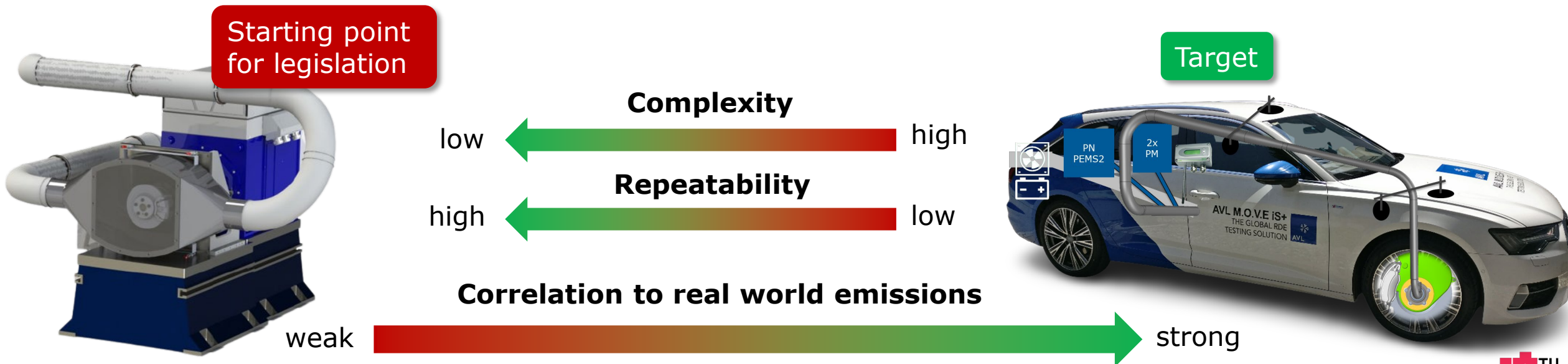
- PM10 Resultate innerhalb $\pm 2\%$
→ ordnungsgemäße Partikelvermischung



Ausblick

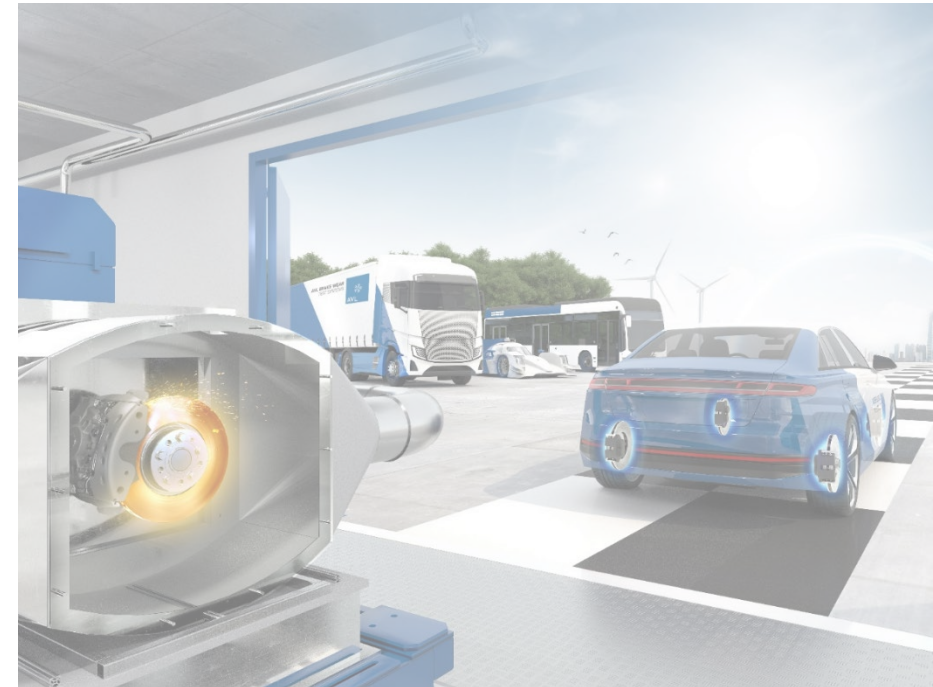
Brake Wear - Real Driving Emissions (RDE)

- Untersuchung der Auswirkungen unterschiedlicher Fahreigenschaften und Umgebungsbedingungen
- Temperatur- und Emissionsverhalten im realen Fahrbetrieb
- Geografisch unterschiedliche Emissionen - Einfluss von Gefällen
- Wissenslücken schließen - regeneratives Bremsen
- Treiber für die Gesetzgebung



Zusammenfassung

- Non-Exhaust Emissions → **Einführung mit EU7** (Brake Emission & Tire Abrasion)
- Etablierung eines neuen und komplexen Messverfahrens
- **AVL** unterstützt mit state-of-the-art **Instrumentierung und Methodik**
- **RDE** Ansatz für Brake Emissions → Ankündigung bereits im EU7 Proposal
- **Weitere kooperative Forschungsanstrengungen erforderlich**





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Vielen Dank!

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