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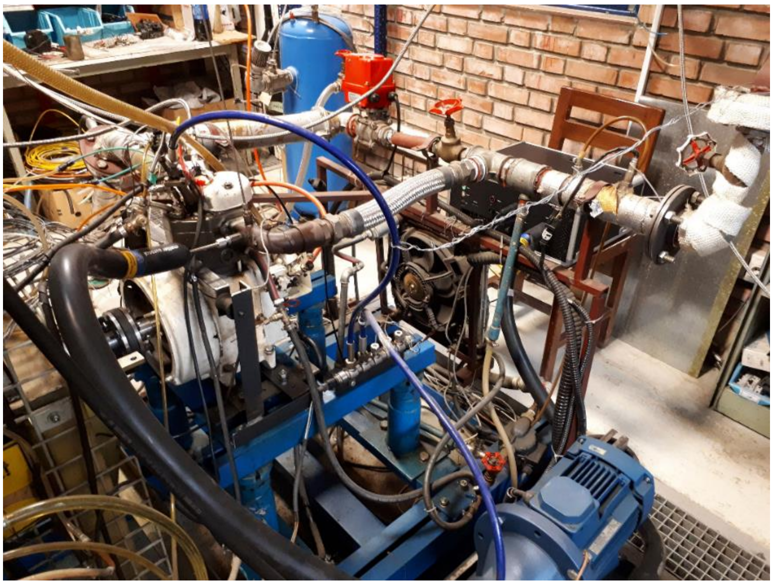
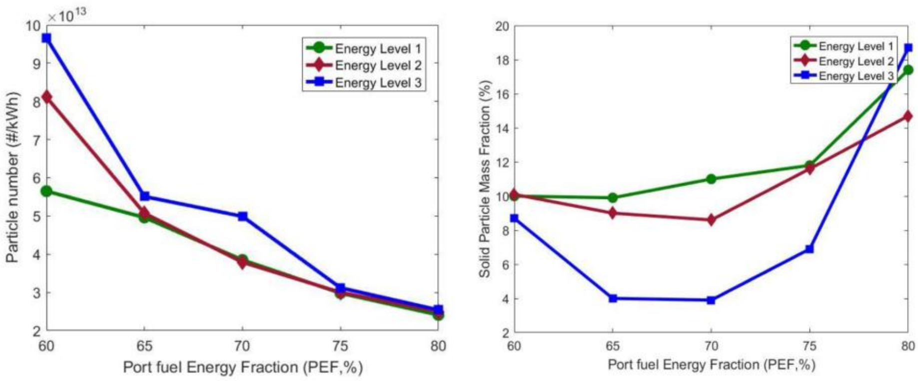
Publication title	Investigation of non-volatile nanoparticle emission of diesel-natural gas RCCI combustion
Publication type	Presentation
Introduction & Background	Combustion engines are a major source of air pollution and detox of them has to be the goal. Today, research and development on combustion engines aims to meet this goal by developing clean combustion methods to reduce the formation of pollutants from sources. Reactivity-Controlled Compression Ignition (RCCI) combustion strategy is the most recent method to mitigate formation of pollutants in internal combustion engines. It is a process which uses two fuels with opposing reactivity properties. The low reactive fuel is premixed with intake air and the high reactive fuel is injected directly into the combustion chamber. Ultra-low NOx and soot emissions along with high thermal efficiency are the characteristics of this type of combustion. In this project, an experimental study is carried out to investigate the pollutants formed in a light-duty diesel/natural gas RCCI engine focused on emitted solid and non-volatile nanoparticles characteristics such as particle number, size, mass and lung-deposited surface area.
Methodology	The experiments were conducted using a single-cylinder modified marine diesel engine. Driver circuit for the injectors were developed in-house using a commercial hardware. Diesel is injected as high reactive fuel in the cylinder directly. As premixed port injected fuel, natural gas is suitable because of high octane number and low emission and has caught numerous attention recently. MAHA MET 6 gas analyzer is used to measure the exhaust emissions such as NO, NO2, CO, HC, O2, CO2 and total PM. Testo NanoMet3 measures solid particle number, mass, size and lung deposition surface area by a diffusion charging method. It samples undiluted raw exhaust, which is then hot diluted and passes an evaporator to remove volatiles. Particles are charged by a corona discharge and the transported charge is measured on different stages downstream, which allows calibration of particle number concentrations. Regarding the thermo-dilution stage, only non-volatile and solid particles, which are often carbonaceous, are tested by this device. In this NG-diesel RCCI combustion mode, the effects of the NG energy fraction ratio and load were explored by varying the share of the premixed NG and the overall LHVs per-cycle. On the other hand, a diesel injection timing has a significant impact on the fuel mixing process and pollutant formation which is investigated in this experiment.
Results & Conclusions	The investigation shows, increasing Port fuel Energy Fraction (PEF) from 60 to 80% leads to a reduction in the solid and non-volatile particle number by 70% which is due to lower share of non-premixed combustion and lower precursors to nucleate carbonaceous particles. Also more premixed natural gas results in lower reactivity of mixture and more ignition delay, so better mixing and higher reaction temperature improve soot oxidation process and reduce the number of particles. Increasing PEF also reduces the mean size of solid particles from 70 nm to 50 nm (further particles in the nucleation mode) due to reduced particle agglomeration caused by diffusion flame. Advancing the Start Of Injection (SOI) of diesel fuel leads to more particle number with smaller size. Advanced injection causes the precursors to be distributed in the chamber more homogeneous and in more places there can be the possibility of particle nucleation. Retarded injection reinforces the diffusion flame and particle agglomeration to have bigger particles (up to 60%). Increasing the engine load as a result of an increase in energy level of the fuels in the cylinder will increase solid particle number (up to 70%), because there is less oxygen for soot oxidation.

	Particle Mass (total PM, including volatile and solid particles) is significantly reduced by increasing PEF. Solid particles have a similar trend, but their relative reduction is different and for PEF about 65-70%, solid particles have the lowest share of total mass which is about 5%. The highest mass fraction of solid particles to total mass is about 20%, which means that a large proportion of particles are composed of volatile compounds. With the increase in energy level of fuels and, in general, the engine load, solid particle mass fraction of the total mass has been reduced. Compared to conventional diesel combustion, particle number of RCCI combustion is about one or two orders of magnitude less, but particle mass reduction shows RCCI-emitted particles are substantially smaller (more particles in the nucleation mode). None of the above results alone is related to the health effects of solid particles of this combustion. The parameter of Lung Deposition Surface Area (LDSA) is suggested to quantify the health effects. By reducing PEF, LDSA has increased significantly (up to 85%). In high PEF, LDSA increases by advanced injection, but in PEFs lower than 70%, LDSA is first reduced and then increased, meaning there is an optimal diesel injection crank angle. In addition to particles, other pollutants (NO, NO2, CO and HC) are also investigated. The reasons for breaking the NOx and soot trade-off and adapting this type of combustion to new emission standards are other subjects in this study.
Images	
Caption Figure 1:	 An image from the inside of the lab
Caption Figure 2:	 Effect of PEF on non-volatile PN (left) and Solid Particle Mass Fraction (right) in three different energy levels

	Andersson Jon
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Coauthors	Mamakos, A.; Klug, A.; Bergmann, A.; Bainschab, M.; Karjalainen, P.; Keskinen, J.; Giechaskiel, B.; Lahde, T.; Haisch, C.; Thaler, K., Piacenza, O.; Ntziachristos, L.; Samaras, Z.
Publication title	Update on sub-23nm exhaust particle number emissions using the DownToTen sampling and measurement systems
Publication type	Presentation
Introduction & Background	The Horizon 2020 Green Vehicle “DownToTen” (DTT) project is developing a robust portable exhaust particle sampling system (PEPS) and methodology that will enhance the regulatory approach towards particle number (PN) emissions in the sub-23 nm region. The focus is on the newest generations of direct injection gasoline and diesel engines under real world conditions. Based on detailed investigations of the nature and characteristics of these particles, DownToTen has developed a sub-23 nm PN measurement approach using rigorous criteria under conditions of challenging aerosol from a variety of sources. Following the 2018 presentation at this conference, DTT now provides further results from the assessment of different vehicle technologies using a lab-based PEPS, and initial results obtained using the raw-exhaust capable PEPS, both in a chassis dynamometer environment.
Methodology	The lab-based DTT prototype is compliant with all stated current and future requirements for CVS-based PN sampling, while also providing improved measurement of 23nm, emissions from a range of vehicles tested in various chassis dynamometer facilities. These additional data complement and extend prior results, adding to knowledge on production and magnitude of
Results & Conclusions	Several lab-based DTT systems were employed to survey existing and development vehicles for the presence and magnitude of both sub-23nm PN, measured primarily with 10nm d50 particle counters, and the current regulatory range, nominally “PN23” emissions. For specific tests, some of 2.5nm, 4nm and 7nm d50 particle counters were also used. As reported in 2018, most measurements indicated that when standard emissions cycles are considered, including some from EU, Japan and US, plus steady state cruises, the majority of emissions were below the Euro 6c limit value of 6x10^11#/km for PN10 (Figure 1a). Apart from the short-term increases in PN observed with DPF regenerations, analysis of a wider range of modern vehicles is starting to reveal that there may be some vehicles, on some cycles, including GDI with GPF and technologies not currently subject to PN regulations, that may be emitting at levels above the current limit value (Figure 1b) for both >23nm and >10nm. These include some motorcycles and CNG-fuelled vehicles, where elevated levels of Many technologies show emissions below 6x10^11 #/km for both PN10 and PN23 The first series of measurements with the raw exhaust capable PEPS largely confirm the previous findings and expand our understanding. Figure 2 provides a first example with comparative GDI and CNG tests. The blue bars are solid particle emissions (SPN>23nm), all found well below the EURO 6c limits. As the particle emission investigation expands to a greater range, emission levels for PN10, PN5.6 and PN2.5 are increasing as the PNC d50 reduces, and are found at the same level for the two fuels. This indicates that PFI CNG operation is associated with particle emissions comparable with the GDI mode in the sub-23nm region.
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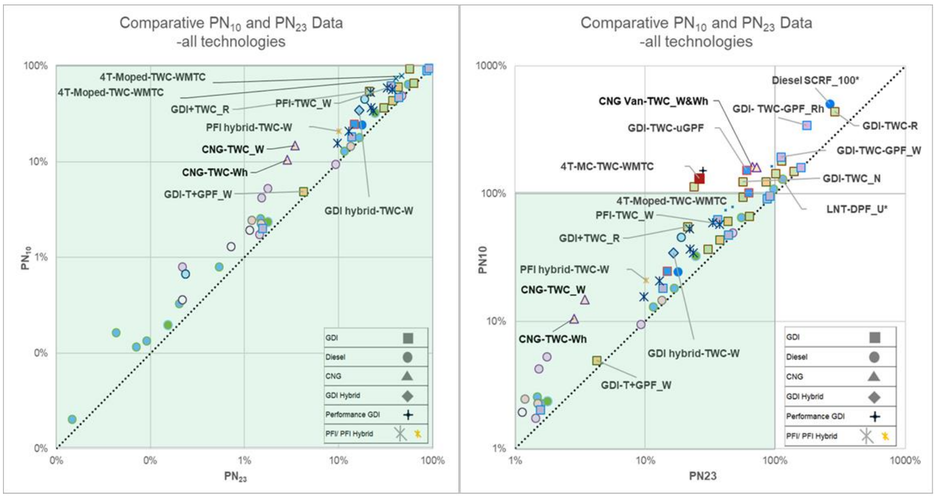

Many technologies show emissions below 6x10^11 #/km for both PN10 and PN23, but some are higher
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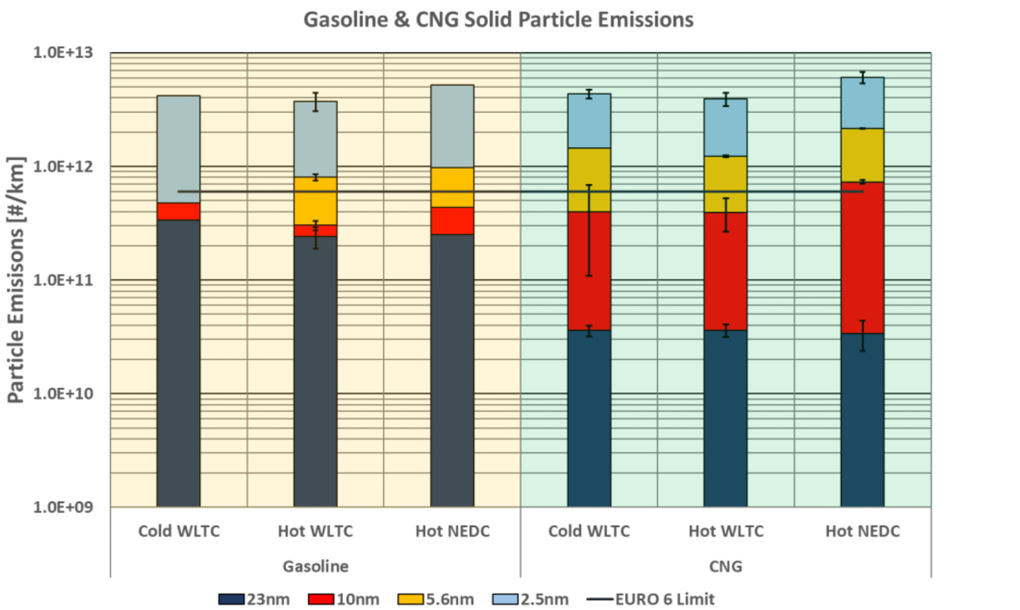

Aggregated SPN emissions for Gasoline (light yellow) and CNG (light green). Error bars shown the standard error of the mean including 2 to 4 repetitions. Emission bars with no error bar indicating a single measurement. Emission limit corresponds to EURO 6c (6*10^11#/km)
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	Barro Christophe
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Publication title	A Virtual Gasoline Particle Sensor for Direct Injection Spark Ignition Engines
Publication type	Presentation
Introduction & Background	Particle formation is a complex process, especially in spark ignition engines. The chemical process of soot formation contains multiple important steps. In direct injection spark ignition engines, the known sources of PM formation are pool fire locations coming from piston or wall interaction with liquid fuel as well as from insufficient air-fuel-mixing. It is also known that in very low load conditions or even motored condition, the majority of particles are not soot and coming from wear and lube oil. The interaction between soot and non-soot particles is not yet fully understood.
Methodology	In the present work, a virtual Gasoline Particle Sensor (vGPS) has been developed in the framework of the Horizon2020 project "Paregen" (http://www.paregen.eu). Within this project, novel detailed 3D and 1D/0D -modelling approaches as well as laser diagnostics for liquid fuel film and soot quantification in optical engines are used to further understand the soot formation process indirect injected spark ignition engines. The detailed models are combination of a validated flow field model, containing the local distribution of the mixture fraction as well as temperature including phenomena like spray-wall interaction or cycle to cycle variations, and a soot chemistry model. The Goal of this particular part of Paregen-project is to use the detailed models and measurements for gaining understanding and relations to develop a fast model. The fast model shall be able to run online as a virtual gasoline particle sensor; enable the opportunity for real time strategy adaptations or emission feedback control. The vGPS contains sub-models to describe the dominant phenomena for the soot formation/oxidation process. The sub-models are used to estimate the fuel mass, which is present under fuel rich conditions, the cylinder pressure and temperature and a time scale as input for a soot model, calculating soot formation and soot oxidation. The phenomena included in sub-models are air-fuel- mixing, wall impingement and evaporation, combustion and heat transfer. Unknowns and engine specific phenomena are addressed with model parameters, which need to be calibrated.
Results & Conclusions	The vGPS has been calibrated on a single cylinder engine under steady state conditions. The engine operation include stoichiometric, lean and fuel rich conditions. The calculated soot emissions are in good agreement with the measurements. Furthermore, the vGPS' behaviour on a variation in injection timing agrees well with expectations known from literature and allows additionally outputting the share between soot formation originating from pool fires and from insufficient airfuel-mixing. The calculation duration of one engine cycle requires ca. 10 ms on a state of the art Laptop.

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Publication title	Evaluation of Black Carbon Measurements Performances of the New Single Particle Soot Photometer - Extended Range (SP2-XR)
Publication type	Presentation
Introduction & Background	Black carbon (BC) particles, the most efficient absorbing aerosols in the atmosphere, have severe impacts on the climate and the anthropogenic BC radiative forcing is the second highest next to CO2. To better estimate BC climatic impacts, deeper knowledge of its atmospheric mass/number concentrations and size distribution is crucial. BC measurements are generally a challenge. The Single-Particles Soot Photometer (SP2, DMT) is a well-characterized instrument providing accurate BC mass/number concentrations and size distribution, and it has been deployed in many laboratory studies and field campaigns (e.g. Laborde et al., 2012). The SP2 is a single-particle instrument based on the laser-induced incandescence technique. Injected into a high intensity Nd:YAG laser beam (λ=1064 nm) each BC particle gets heated up to 4000 K, and the incandescence signal emitted before vaporization is recorded. The mass of each particle of refractory BC (rBC) is evaluated applying an empirical calibration to the signals intensity. The SP2 covers the size range from 90 to 600 nm BC mass equivalent diameter. The new DMT's Single-Particles Soot Photometer - Extended Range (SP2-XR) is based on the same physical principles, but has many advantages. The new hardware has been optimized reducing size and weight (13 kg), and improving the stability over time. From the software perspective, the new built-in data acquisition and analysis software was improved providing real-time results for BC number/mass concentration and size distribution. Those improvements aimed at making the SP2-XR more user-friendly requiring lower operational efforts from the operator, and more suitable for long-term observations. This robustness and user-friendliness comes at the expense of reduced information on particle mixing state.
Methodology	We evaluated the performance of the SP2-XR by comparing it to the SP2 during laboratory and field measurements. Specifically, we tested the stability of the incandescence/scattering calibration curves. We compared the SP2-XR response to different calibration materials and its size-resolved detection efficiency to that of a SP2. We compared the SP2-XR and the SP2 BC mass concentration and size distributions from ambient measurements in polluted and clean environments.
Results & Conclusions	Our results suggest that the SP2-XR incandescence calibration curves are stable over time, within a variability of 5% for each unit (Fig.1, Left) and that their shapes are comparable within 10% for different SP2-XR units (Fig.1, Right). The relative sensitivity to different calibration materials, fullerene soot and Aquadag, is comparable to the SP2. The scattering calibrations resulted to be less stable, showing a sensitivity variability up to 50 % for a single SP2-XR unit; however, the shapes of the calibration curves were comparable within 5 % between the three SP2-XRs. The SP2-XR has a superior signal-to-noise ratio for very small BC particles, being able to quantify their masses. The dimensional threshold where detection efficiency drops below unity is similar to the original SP2. The comparisons between rBC mass/number concentrations and size distributions as measured in parallel with an SP2 are remarkably in agreement. To conclude, our results suggest the SP2-XR as a valid, easier and simpler alternative to the SP2, especially suited for long term monitoring programs.
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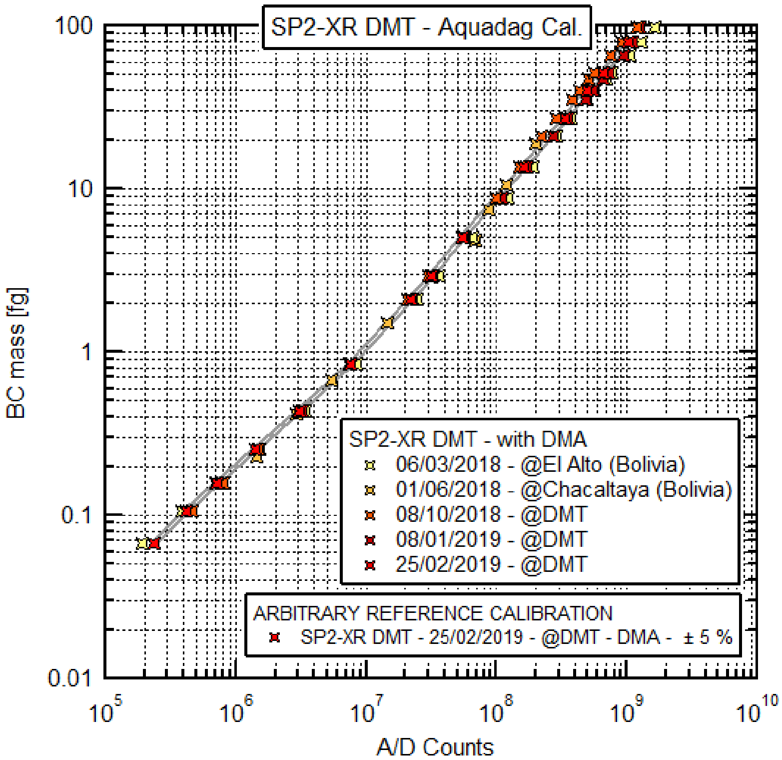
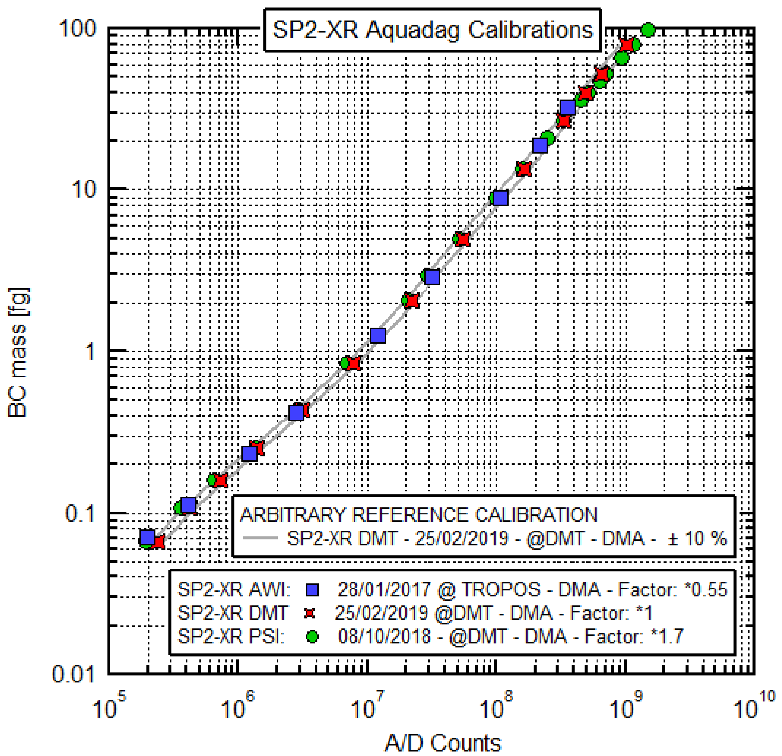
Caption Figure 1:



Stability of the slope of the Aquadag incandescence calibration curves over a two-year periods for the SP2-XR unit of DMT. The gray lines represent the 5% variability around an arbitrary reference calibration curve (see legend).

Caption Figure 2:



Stability of the calibration curve shape for different XR units: three exemplary Aquadag calibration curves for the three units: DMT, PSI and AWI. The calibration points from the SP2-XR of AWI and PSI were offset by an arbitrary factor (see legend). The gray lines represents the 10% variability around an arbitrary DMT reference calibration curve (see legend).

	Bisig Christoph
Affiliation	Comprehensive Molecular Analytics, HelmholtzZentrum München, D-81479, Munich, Germany
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Publication title	A Step towards Standardisation of Air-Liquid Interface Exposures using a Model Diesel Aerosol
Publication type	Presentation
Introduction & Background	It is undisputed that air pollution is associated with various diseases leading to increased premature deaths worldwide. However there is still a need for mechanistic studies (i.e. the "how"), since it is still not possible to extrapolate emission characteristics directly to adverse human health. Toxicologists are e.g. investigating the in vivo and in vitro effects of gasoline-, diesel-, ship-, and aircraft-engines, but so far no standard aerosol has been proposed, which could compare outcomes not only within a research group but also of different groups. Here we present the experiments performed using a soot generator (dieselCAST, Jing Ltd) combined with a cell exposure system (Vitrocell®) with the aim to have a standardisable model aerosol for in vitro toxicology at the air-liquid interface.
Methodology	The dieselCAST was fueled with commercial German diesel (usage 50 µL/min). Characterization of the emission was done using different mass (aethalometer) and particle counters (CPC and SMPS) as well as chemical analysis of the particles on filters (GC-MS and GC-GC-MS). For 2-4h the diluted exhaust was drawn into the cell exposure system containing a monolayer of epithelial cells (A549 and BEAS-2B cell lines) at the air-liquid interface. The cell cultures were divided into 4 groups: i) clean air control, ii) exhaust aerosol, iii) incubator control, and iv) chemical positive controls. Toxicological endpoints included cytotoxicity, inflammation, CYPs, oxidative stress, clonogenicity, and genotoxicity.
Results & Conclusions	This model aerosol can be produced by one person and leads to reproducible particle mass and number concentrations over a period of 4h. Different concentrations (0.2 - 3.5 mg/m3) led to no significant increased cytotoxicity (biochemical methods), small changes in inflammation or oxidative stress (qPCR), but increases in CYP1A1 (qPCR), clonogenicity (CFE), and genotoxicity (Comet Assay). For example a dose dependent genotoxic increase in BEAS-2B but not A549 cells was observed. The chemical positive controls confirmed that the cells are inducible under the performed conditions. With this setting it is possible to investigate multiple parameters the aerosol toxicologists could not have done before at the air-liquid interface, e.g. do mechanistic studies in the own laboratory without the need of big machinery or expensive campaigns. Further analysis is being performed using this standardisable aerosol, especially tests looking into its possible role as a general positive control for the aerosol toxicology community. This work was supported by the Swiss National Science Foundation under Grant P2FRP3_178112 and the HelmholtzZentrum München.
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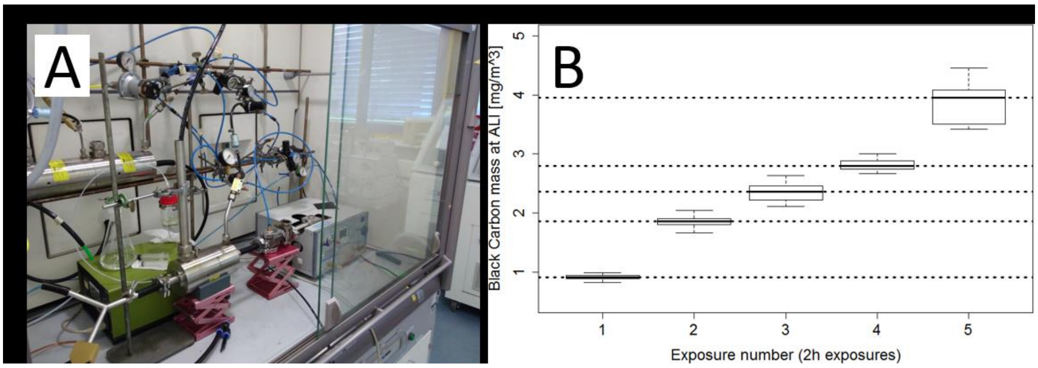
Caption Figure 1:	 A: The dieselCAST (right corner) and dilution systems. B: Boxplot of a dose-response experiment, PM mass measured with an aethalometer.

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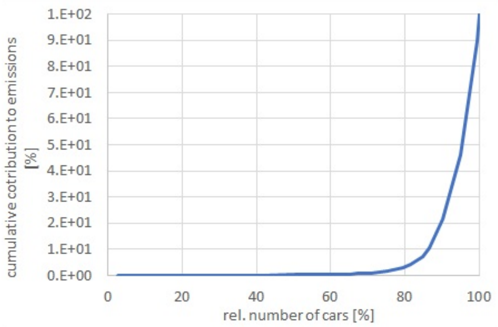
Coauthors	Thomas Lutz; Andreas Mayer
Publication title	The need for a periodic inspection of vehicle emissions
Publication type	Presentation
Introduction & Background	Particulate emissions from combustion engines are a great problem in ambient air pollution. The introduction of very efficient (>99%) diesel particle filters (DPF) reduced the particle emissions from diesel engines substantially. For gasoline engines, the introduction of direct injection strongly increased the particle concentration in the emissions of spark ignition engines. As they soon will have to meet the same limits as diesel engines filters gasoline particle filters (GPF) are being introduced too. However, already small defects in the filter can increase the emissions by orders of magnitude. These defects (or manipulations) cannot be detected by the on-board diagnostic system. Therefore, a number of countries decided to reintroduce a periodic technical inspection (PTI).
Methodology	In type approval testing emissions are measured in a test cycle. For PTI a much simpler and faster test is needed. Kadijk et al [1] showed that the emissions in the test cycle correlate quite well with particle concentration measured in low idle. A low idle measurement can be performed in less than a minute. Particle measurement can bve done by condensation particle counters (CPC) or diffusion charging (DC) based devices.
Results & Conclusions	The necessity of PTI is demonstrated by several studies. Measurements by Gloor [2] indicate for example that about 12% of the filters do not work properly. Other studies found similar values. Figure 1 shows the cumulative fleet emissions resulting from the measuremnt in[2]. 10% of the cars are responsible for more than 80% of all emissions. PTI is needed to identify thesde high polluters, which are responsible for a very significant fraction of total emissions. Measurement at low idle offers a simple and fast way.
Images	
Caption Figure 1:	 Figure 1: Cumulative contribution to fleet emissions

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Coauthors	Angela Bosch; Theresa Rohm; Shefaa AlAsfoor; Zora Baumann; Daniel Zeman
Publication title	Air pollution induced-diabetes is mediated via macrophages in the gut
Publication type	Presentation
Introduction & Background	Besides classical risk factors such as sedentary lifestyle and unhealthy diet, air pollution has emerged as unexpected risk factors for type 2 diabetes and is associated with visceral adiposity, dyslipidemia and hepatic steatosis. These epidemiological observations have been reproduced in preclinical studies as mice exposed to air pollution develop diabetes and other typical features of metabolic disease. However, the causal mechanism remains poorly understood. So far, it is believed that inhaled air pollution particles induce an inflammatory response in the lung, which precipitates systemic inflammation and diabetes. In this study, we propose an alternative mechanism via the gut. We aim to assess the hypothesis that air pollution particles reach the gut, where they trigger diabetes via yet unknown mechanisms. This hypothesis is based on labeling studies, which demonstrated that mucociliary clearance transports inhaled particulate matter quickly from the lungs to the gut. Further supporting a gut-driven disease mechanism, air pollution has been shown to alter gut microbiota, elevate gut permeability and increase the incidence of many gastrointestinal tract diseases.
Methodology	We exposed either male C57B6/N mice rendered diabetic by high fat diet (HFD) and a single dose of streptozocin (STZ; to prevent beta-cell compensation) or mice on standard diet (to exclude influences related to HFD or STZ) as follows: Diesel exhaust particles (DEP) or particulate matter (PM) dissolved in PBS or PBS alone as a control were administered either exclusively to the gut by gavage or the lung by intratracheal instillation for up to 7 months. To assess the role of distinct immune cell compartments, mice with defective adaptive (Rag2-/-) or innate immunity (CCR2-/- or C57B6/N mice fed a diet containing the Csfr1-inhibitor PLX5622) were orally exposed to DEP or PBS. Glucose metabolism was monitored by glucose and insulin tolerance tests. Immune cells of different tissues were characterized by flow cytometry, PCR and single-cell RNA sequencing upon sacrifice.
Results & Conclusions	Our results show that air pollution induces diabetes via gut exposure and not as previously thought via lung exposure. The metabolic phenotype is driven by a defect in insulin secretion, while insulin sensitivity is unchanged. In the gut wall, inflammatory intestinal macrophages become predominant, as anti-inflammatory, resident macrophages are lost upon oral air pollution exposure. Gut exposure of air pollution, however, does not lead to systemic and adipose tissue inflammation. Our findings suggest a link between the gut wall and decreased insulin secretion upon oral air pollution exposure and provide a new understanding of how environmental pollutants such as air pollution affect health.
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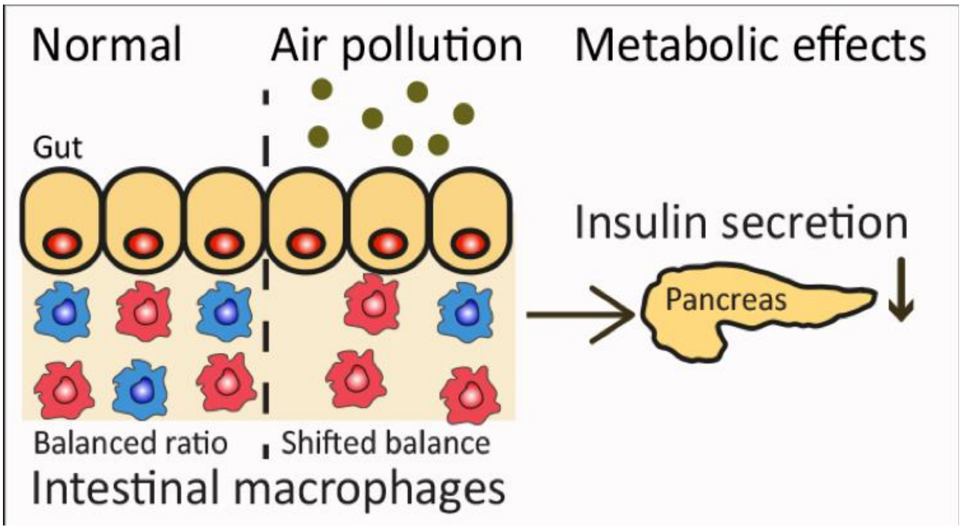
Caption Figure 1:	 Suggested model of air pollution-induced diabetes
Caption Figure 2:	

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Coauthors	Aliosha Reinoso; Pablo Busch
Publication title	A methodological proposal to estimate emissions deterioration in real-world driving conditions, on gasoline passanger cars fleet in Santiago de Chile
Publication type	Presentation
Introduction & Background	Despite several efforts deployed during more than 30 years, Santiago of Chile has yet one acute PM2.5 ambient concentration problem. Historical inventories have aimed to transport sector, specifically diesel emissions, as one of the major sources of primary PM and NOx, precursor of secondary particulate matter (nitrates and ammonia). However no major information has been collected or analyzed of PM coming from gasoline engines in Chile, and NOx emissions have been only estimated based on European labs cycles. This paper uses a Remote Sensing Device (RSD) to assess particulate matter emissions profiles in real-world driving and deterioration conditions of the gasoline passenger cars fleet. It also includes a characterization of NOx emissions and compares them to type approval certification as NOx zero-mile emissions.
Methodology	The RSD4600 system used in this study includes both PM and gaseous measurements. Vehicle emissions are measured by casting a narrow infrared (IR) and ultraviolet (UV) beam of light across the road. A transfer mirror module then reflects IR/UV light back to a series of detectors that monitor light intensity at characteristic wavelengths. By measuring the absorption of IR/UV light by the various pollutants in the air, the system is able to calculate the pollutant concentrations in the vehicle exhaust plume. Fuel based emission factors [g/Kg-fuel] are inferred from the carbon content of the fuel burned (the sum of carbon gases: HC, CO and CO2). For gaseous measurements, the IR source is used for CO2, CO, HC. The UV source is used for NO, and the UV source is used for PM measurement. The particulate emissions measured with the RSD are expressed as a "Smoke Factor". It is the theoretical ratio of soot mass to fuel mass at the instant of measurement, in grams of soot per 100 grams fuel. UV smoke factor is the UV absorbance at 230 nm divided by total carbon gases. Assuming a mass extinction factor, an emission factor [g/Kg-fuel] is calculated. As speed and acceleration measurements for an individual vehicle are an integral part of remote sensing measurements, the vehicle specific power (VSP) can be computed, and thus instantaneous fuel flow (consumption) rates in kg or L fuel per unit distance travelled can be calculated. These calculations were carried out using the method described in CONOX Task 1 Report Commissioned by the Federal Office for the Environment (FOEN), Switzerland. Chassis Dynamometer data correspond to the historical record of vehicle certification by the Center for Vehicle Control and Certification (CCCV), of the Ministry of Transport. This laboratory accredits compliance with Euro or EPA emission standards. Equipment, measurement method, ambient conditions, quality assurance and driving cycle all conform to standard for certifying Euro or EPA regulations.
Results & Conclusions	We computed the ratio of the measured emissions to the certified emissions. The results show a disparity of the RSD and the certification data even for vehicles with less than a year of age. But this disparity, measured as the ratio, increased monotonically with age. The effect was independent of the standard of the vehicle. These results show an important deterioration effect of both PM and NOx emissions for gasoline cars that should be considered when designing regulations.
UniqueID	bd72f550899dbaa27b01fbfd7d0b8d8d

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Publication title	PN Emissions of Passengers Cars – Potentials of GPF's
Publication type	Presentation
Introduction & Background	Reduction of PN-emissions from traffic and from IC-engines is a continuous and important objective. The merits of DPF are mostly neglected in the public information. The potentials and necessities of further introduction of GPF are not enough considered. In the present work, we show the potential of PN-reduction of different car concepts as demonstrated by the AFHB research activities.
Methodology	Emissions of several passenger cars were investigated on chassis dynamometer in dynamic driving cycles and in steady state operation. The PN-emissions were measured according to the legal requirement with CPC in CVS-tunnel and for the research purposes with SMPS at tailpipe.
Results & Conclusions	The important results are: • The modern SI-vehicles with MPI can emit a considerable amount of PN and PM. In an extreme case, the PN-emission was in the range of Diesel car (without DPF). • With the GPF's with better filtration quality, it is possible to lower the emissions below the actual European limit value of 6.0 x 1011#/km. • The PN-filtration efficiency of actually used GPF's is significantly lower than the efficiency of right-quality DPF's. • The improvement of GPF filtration efficiency by coating alone is not sufficient. • The variant Diesel + DPF offers the highest filtration quality, the lowest PN-emissions and it is considered by the authors as a recommendable bench-mark. • A modern CNG car would still have remarkable PN-reduction potentials with a right-quality GPF.

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Coauthors	Pascal Buekenhoudt; Laurent Chavatte
Publication title	New fine particle emission measurement for the assessment of the quality of the particulate filter during the periodic inspection of diesel vehicles
Publication type	Presentation
Introduction & Background	New fine particle emission measurement for the assessment of the quality of the particulate filter during the periodic inspection of diesel vehicles: During this presentation I will give an overview of the most important results of the PN-study perfomed by GOCA on about 1700 diesel vehicles.
Methodology	Live testing with PN counters on about 1700 diesel vehicles
Results & Conclusions	See PowerPoint presentation

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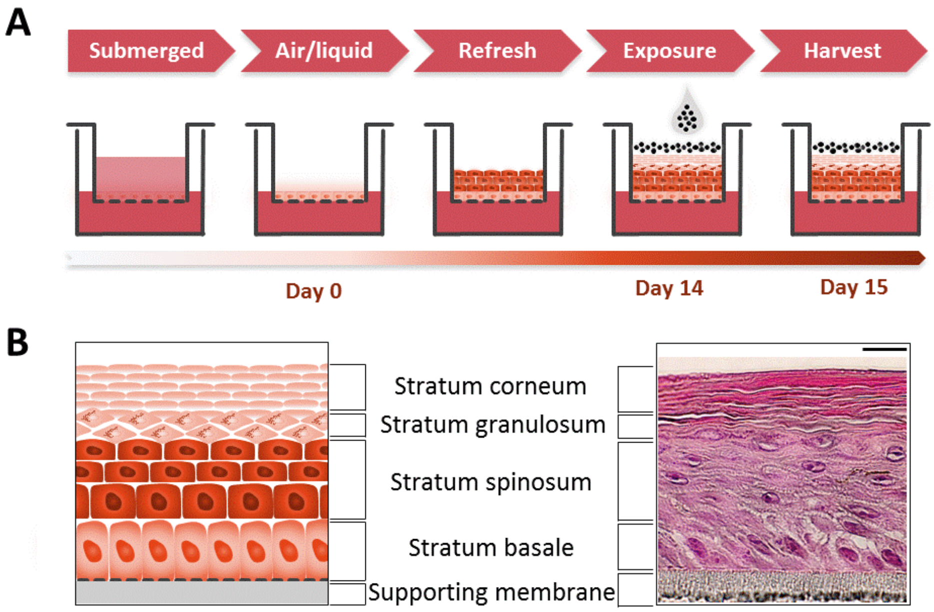
Coauthors	Barbara Drasler1; Marc Eeman2; Barbara Rothen-Rutishauser1
Publication title	Simulating the impact of diesel exhaust particles on human skin using a 3D in vitro epidermal model
Publication type	Presentation
Introduction & Background	One of the main contributors to air pollution is diesel exhaust and its detrimental effects on the pulmonary and cardiovascular system have been extensively studied. The impact of diesel exhaust on the skin barrier is studied less. Nevertheless it is known that ambient air pollution can affect the skin and its exposure has been associated with premature skin aging, inflammatory and allergic skin conditions. The outer layer of the skin, the epidermis, is composed of keratinocytes and structured into four different layers: the stratum basale, the stratum spinosum, the stratum granulosum, and the outermost layer, the stratum corneum (SC). The SC is comprised of terminally differentiated keratinocytes surrounded by a lipid matrix that provides the primary barrier of the skin and protects against environmental influences. However, due to its main constituents being lipids, SC is prone to oxidative damage when exposed to air pollutants, which could affect the skins barrier function. A breached barrier could further affect the lower layers of the epidermis, activating various oxidative cascades and inflammatory responses.
Methodology	To simulate the effect of diesel exhaust on human epidermis, a 3D in vitro epidermal model has been used and optimized. Primary human keratinocytes are stimulated with growth factors and cultured on a polycarbonate membrane at air-liquid interface for two weeks to form an epidermal tissue with the four structural layers in vitro. The tissues were then exposed topically to the standard Diesel Particulate Matter sample SRM 2975 from NIST at various concentrations, i.e. 1-100 µg/cm2. Following exposure of the tissue to diesel particles, the cytotoxicity, (pro-)inflammatory and oxidative stress responses were investigated.
Results & Conclusions	Preliminary results on the optimization of exposure conditions of these epidermal tissues to diesel exhaust particles have shown to trigger a pro-inflammatory response in the epidermal model with a compromised barrier. This study shows promises in determining how diesel exhaust particles are impacting the skin. However better understanding of pathways involved at both cellular and molecular levels upon exposure to complete diesel exhaust in skin is required to target these processes and develop solutions that could prevent and treat its damaging effects. This work is part of the CITYCARE project, which has received funding from the European Union’s Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 765602.
Images	

Caption Figure 1:	 A. Workflow of a 3D in vitro reconstructed human epidermal model for diesel exhaust particle (DEP) exposure. Skin model reconstructed from foreskin-derived neonatal human primary keratinocytes, cultured on a polycarbonate membrane. Topical application of DEP, SRM2975 at 1-100 µg/cm2 in 30 µL/cm2 PBS. B. Schematic representation of epidermal layers and morphology of 3D epidermal model. Paraffin embedded tissue sectioned at a 5 µm thickness and stained with Hematoxylin and Eosin. Scale bar represents 20 µm.

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Publication title	A novel methodology for the analysis of the particulate/gas phase partitioning in combustion emissions
Publication type	Presentation
Introduction & Background	Combustion is the largest anthropogenic source of solid particles with a direct and indirect impact on the climate and human health. It is commonly believed that polycyclic aromatic hydrocarbons (PAHs), known for their carcinogenic and mutagenic effects, are the molecular precursors of combustion generated particles (soot). To fully understand the formation mechanism of soot particles, predict their ageing process and asses the overall impact of such combustion generated emissions, their full chemical characterization (i.e. the composition of both their particulate and gas phases) is required. In this study we present an original method of separation and simultaneous sampling of particulate and gas phases.
Methodology	The separation and subsequent sampling of the particulate and gas phase was accomplished with a dual in-line quartz fiber filter sampler. The first (front) filter is used to collect the particulate matter while letting through the majority of the gas phase. The latter is captured on the second (back) filter, covered by a layer of activated black carbon. The separation method was tested on the exhaust of various soot generators, including a Combustion Aerosol Standard (CAST) generator and a single cylinder gasoline engine. To verify the validity of the method, both phases were chemically characterized with a custom-built two-step laser mass spectrometer (L2MS). Based on its resonant ionization step, this technique is especially well adapted for the ultra-sensitive (attomole range) detection of PAHs and enables a selective detection of different chemical classes, such as aliphatics and (poly)aromatics, when using multi-wavelength ionization schemes. Additional chemical mapping was performed with a Secondary Ion Mass Spectrometer (IONTOF) which provides a high sensitivity for both inorganic and organic species. Various statistical procedures such as principal component analysis (PCA) and hierarchical clustering analysis (HCA) were used to highlight the differences, as well as similarities, between the chemical compositions of the samples. These variations can be attributed to certain chemical species, therefore allowing a clear separation between the particulate and gas phase fractions.
Results & Conclusions	Mass spectrometric techniques in conjunction with statistical procedures showed a clear separation between the particulate and gas phase, thus validating the separation method. It was shown that the particulate fraction contains semi and non-volatile PAHs (high-mass PAHs) while the gas phase is characterized by volatile and semi-volatile compounds (low mass PAHs, up to m/z 250). The impact of different working regimes of soot generators on both phases will be presented.

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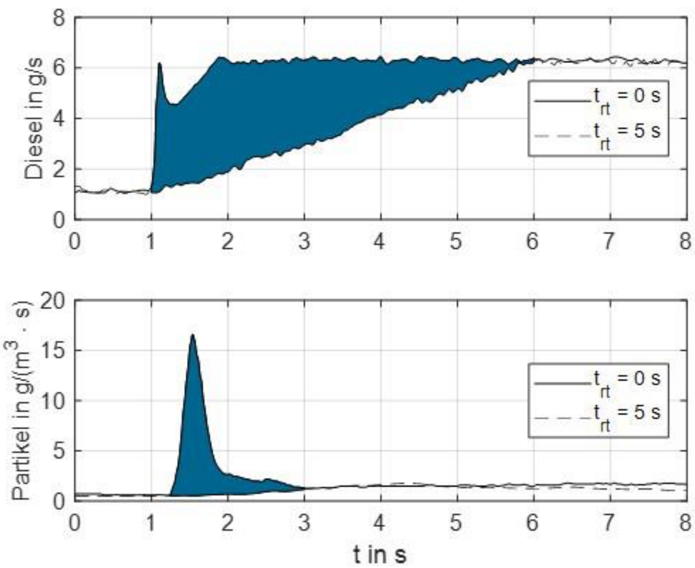
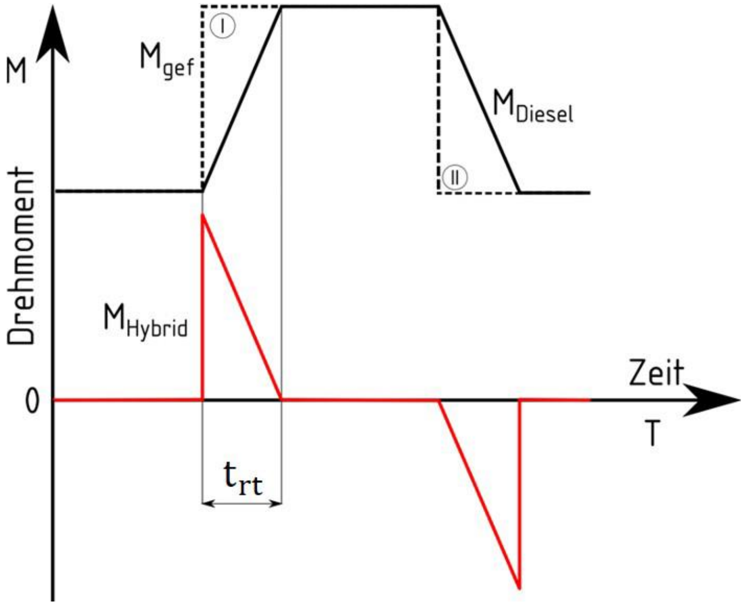
Coauthors	Felix Pult
Publication title	Phlegmatisation of a Combustion Engine for Reduction of Particle Transient Emissions
Publication type	Presentation
Introduction & Background	For mobile machines, which are mainly using diesel engines as power source, dropping emissions are a decisive factor for coming emission standards. Researches have shown that particle and NOx emissions are extremely high especially during transient opera-ting states. Within this transient operating states the turbocharger of the combustion engine is not able to fill enough air in the combustion chamber, which causes high particle and NOx emissions. These transient operating states occur repeatedly at working cycles of mobile machines, for example, in the case of transporting and stacking straw bales with a telehandler. Due to a great potential for recuperation of kinetic and potential energy in repetitive working cycles of mobile machines, this energy could be used in powertrain concepts with a hybrid module to reduce the engine-out emissions by phlegmatisation of the combustion engine.
Methodology	To enable this reduction, this paper will first examine in more detail the development of transient emissions and the underlying processes and mechanisms within the combustion engine. Measurements on a commercial vehicle engine underpin this explanations. They also show to what extent a slow acceleration of the com-bustion engine to a new load level (called phlegmatisation) can have a positive effect on transient emissions and thus on total emissions. A hybrid module will be used to counteract the limitation in system dynamics caused by phlegmatisation. This hybrid module will be presented and the relationship between the size of the hydraulic accumulator and the transient emissions saved will be briefly discussed.
Results & Conclusions	Since phlegmatisation reduces the transient emissions and thus also the total emissions, the paper con-cludes with an estimate of the extent to which phlegmatisation can reduce the effort for exhaust aftertreatment.
Images	
Caption Figure 1:	 Emission comparison transient vs. phlegamized operation

Caption Figure 2:	 Hybrid operation strategy at load demand
UniqueID	5902a0a50cfdb53642b8cb350e0decea

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Publication title	Cloud droplet activity of soot particles after long-term exposure to ozone and α-pinene
Publication type	Presentation
Introduction & Background	Freshly emitted soot particles are known to be poor cloud condensation nuclei (CCN) but from atmospheric measurements, it can be deduced that some soot particles act as CCNs. Soot particles have an average atmospheric lifetime of one week. During this time their properties can be changed due to different aging processes such as heterogeneous oxidation (e.g. with O3 or OH-radicals) or coating (e.g. with oxidized and hygroscopic organic compounds). The investigation of such processes in the laboratory is an experimentally challenging task due to the long time span, which has to be covered to achieve comparability to atmospheric aging.
Methodology	At ETH we performed aging experiments in which we exposed 100 nm size-selected soot particles to different atmospherically relevant conditions (O3-oxidation and/or α-pinene coating) for up to 16 h. The long aging time was achieved by applying the continuous flow stirred tank reactor (CSTR) concept. This concepts allowed us to conduct experiments in a rather small aerosol chamber (3 m3) while keeping the particle concentration below 1000/cm3 permitting for size selection prior to the aging steps. For the retrieval of kinetic data from these CSTR-experiments we applied the activation time concept. This is a newly developed mathematical framework that allows for the analysis of non-gradual transitions such as CCN-activity. Two soot types were produced with a miniCAST soot generator. An organic rich soot - CAST brown (CBw) and a soot low organics content - CAST black (CBk). Both soot types were either directly exposed to 200 ppb O3, or exposed to α-pinene vapor beforehand. For the coating step, the freshly produced soot aerosol was mixed with a 0.5 ml/min saturated α-pinene air flow in a premix volume. The α-pinene remaining in the gas phase was removed with a charcoal denuder prior to size selection. The remaining α-pinene-concentration in the gas phase was below the 1 ppb detection limit of the sensor.
Results & Conclusions	In the case of heterogeneous oxidation with O3 CBw particle became CCN-active after 1h:50min - at 1.4% super saturation (SS) and after 8h:30min at 0.6% SS. In contrast, CBk-particles had to be exposed 5 to 6 times longer to reach the similar CCN-activity at the same conditions. In the case of coating with α-pinene the CCN-activity for both soot types was equally high (35min aging for 1.4% SS and 3h:45min for 0.6% SS) which is an increase by factor 3 and 15 for CBw and CBk, respectively. Parallel to the CCN activity we measured the mobility particle diameter and the single particle mass. We found that exposure to 200 ppb O3 lead to a fast (< 15 min) increase in mass (CBw: +20%; CBk: +10%) and diameter (CBw: +4 nm; CBk: +3nm) due to O3 adsorption. A secondary increase in mass (+80%) and diameter (+10nm) over several hours of aging was detected in all α-pinene experiments. The overall increase in CCN-activity correlates well with the secondary mass increase.

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Publication title	Jet engine lubrication oil as major component of aircraft exhaust nanoparticles
Publication type	Presentation
Introduction & Background	Jet engine aircraft are a significant source of atmospheric nanoparticles and exist ubiquitously from ground level to the upper troposphere. A new particulate emission standard for turbofan and turbojet aircraft engines will come into effect from 2020. Therefore, research needs for particle emission characteristics from aircraft have been increasing greatly. However, little is known regarding the origin and detailed chemical composition of size-resolved particles and especially nanoparticles in aircraft exhaust. The purpose of this study is to determine the size-resolved chemical composition of particles emitted from jet engine aircraft during take-off and landing in real-world conditions, and to estimate the contribution of jet fuel and lubrication oil to the nanoparticle mass.
Methodology	We have collected ambient particulate samples from an area near a runway at the Narita International Airport, Japan, during the daytime and nighttime in winter (February 2019) using low-pressure cascade impactors (NanoMoudi II, MSP). The size-resolved samples were used for particle-mass weighing, elemental/organic carbon analysis, and organic analysis. We used thermal-desorption gas chromatography mass spectrometry (TD-GC/MS) to identify the organic composition of nanoparticles having diameters smaller than approximately 30 nm originating from real-world aircraft emissions, which is unprecedented.
Results & Conclusions	A chemical analysis of the size-resolved ambient particles suggests that nanoparticles having diameters of 10–32 nm mainly comprise organic carbon. We thus focus on the chemical characteristics of organic compounds for this size range, in comparison with those of jet fuels and jet lubrication oils. The daytime nanoparticle samples (10–57 nm) clearly show the presence of oil-marker peaks (likely fatty acid esters of pentaerythritol). The intensity ratios of these peaks were very similar to those of a jet lubrication oil. The mass spectra of these peaks in nanoparticles collected during the daytime were very similar to that of a jet lubrication oil. From these results, we conclude that approximately half the organic compounds in the This finding provides direct evidence for the importance of unburned lubrication oil as a source of aircraft exhaust nanoparticles and also has an implication for their environmental impacts near airports and in the upper troposphere. In the presentation, we will show some additional information. This work was supported by the Environment Research and Technology Development Fund (5-1709) of the Ministry of the Environment, Japan. Fushimi A., Saitoh K., Fujitani Y., Takegawa N. (2019) Identification of Jet Lubrication Oil as Major Component of Aircraft Exhaust Nanoparticles, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2018-1351.
Images	

Caption Figure 1:	 Measurement site in the Narita International Airport, Japan.

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Publication title	Short-Term Effects of Airport-Associated Ultrafine Particle Exposure on Lung Function and Inflammation in Adults with Asthma
Publication type	Presentation
Introduction & Background	Background: Exposure to ultrafine particles (UFP, particles with aerodynamic diameter less than 100nm) is associated with reduced lung function and airway inflammation in individuals with asthma. Recently, elevated UFP number concentrations (PN) from aircraft landing and takeoff activity were identified downwind of the Los Angeles International Airport (LAX) but little is known about the health impacts of airport-related UFP exposure.
Methodology	Methods: We conducted a randomized crossover study of 22 non-smoking adults with mild to moderate asthma in Nov-Dec 2014 and May-Jul 2015 to investigate short-term effects of exposure to LAX airport-related UFPs. Participants conducted scripted, mild walking activity on two occasions in public parks inside (exposure) and outside (control) of the high UFP zone. Spirometry, multiple flow exhaled nitric oxide, and circulating inflammatory cytokines were measured before and after exposure. Personal UFP PN and lung deposited surface area (LDSA) and stationary UFP PN, black carbon (BC), particle-bound PAHs (PB-PAH), ozone (O3), carbon dioxide (CO2) and particulate matter (PM2.5) mass were measured. Source apportionment analysis was conducted to distinguish aircraft from roadway traffic related UFP sources. Health models investigated within-subject changes in outcomes as a function of pollutants and source factors.
Results & Conclusions	Results: A high two-hour walking period average contrast of ~ 34,000 particles.cm-3 was achieved with mean (std) PN concentrations of 53,342 (25,529) and 19,557 (11,131) particles.cm-3 and mean (std) particle size of 28.7 (9.5) and 33.2 (11.5) at the exposure and control site, respectively. Principal components analysis differentiated airport UFPs (PN), roadway traffic (BC, PB-PAH), PM mass (PM2.5, PM10), and secondary photochemistry (O3) sources. A standard deviation increase in the 'Airport UFPs' factor was significantly associated with IL-6, a circulating marker of inflammation (single-pollutant model: 0.21, 95% CI=0.08 – 0.34; multi-pollutant model: 0.18, 0.04 – 0.32). The 'Traffic' factor was significantly associated with lower Forced Expiratory Volume in 1 second (FEV1) (single-pollutant model: -1.52, -2.28 – -0.77) and elevated sTNFrII (single-pollutant model: 36.47; 6.03 – 66.91; multi-pollutant model: 64.38; 6.30 – 122.46). No consistent associations were observed with exhaled nitric oxide. Conclusions: To our knowledge, our study is the first to demonstrate increased acute systemic inflammation following exposure to airport-related UFPs. Health effects associated with roadway traffic exposure were distinct. This study emphasizes the importance of multi-pollutant measurements and modeling techniques to disentangle sources of UFPs contributing to the complex urban air pollution mixture and to evaluate population health risks.

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Publication title	Measurement and reducing particulate number emission at single room wood log stoves
Publication type	Presentation
Introduction & Background	In combination with other energy sources, wood combustion can contribute considerably to the substitution of fossil energy sources. To ensure that wood combustion in small-scale units is a climate- and environmental friendly alternative to fossil fuels, the emissions have to be reduced significantly. For greenhouse gas emissions, soot particle and methane emissions must also be taken into account when burning wood. In addition, wood combustion should not lead to significantly higher emissions of harmful substances compared with alternative energy sources such as natural gas or oil. The resulting emissions are strongly dependent on the combustion conditions. The more optimal these conditions are the lower are the air pollutant emissions and the climate effects of the emissions. There is a big difference between modern small combustion boiler plants and up-to-date single room stoves. While sensor-controlled automatic control systems are used for pellet and wood chip boilers and also flue gas after-treatment techniques getting more common, the situation is different for single room stoves. The vast majority these furnaces available on the market today are characterized by several emission-promoting construction and operating characteristics. Log wood have so far not been standardized in either form or composition. Log wood stoves are used in batch operation, i.e. fuel must be added manually at regular intervals, whereby the combustion chamber is always opened and filled with fuel. The most log wood stoves have no combustion air control. The operator is completely free to set the combustion air. Despite the most undefined and thus most difficult wood fuel and the high variability and dynamics of the batch wise combustion process, the majority of single room log wood stoves have no automated sensor-supported air control and largely unrestricted fuel supply.
Methodology	For the acceptance of a log wood stove eco-label (e.g. "Blauer Engel") in society and for the application of the eco-label as an ecologically justifiable criterion for exemptions from future ban on solid fuels, a strict and demanding setting of limit values is mandatory for an eco-label. Therefore a new test method is needed which better reflects the real emission level and behavior of wood-burning stoves than the current type test. This new test method was developed and will be presented. Particle number concentration measurement devices developed for combustion engines were tested and the results were compared with scanning mobility particle size measurements.
Results & Conclusions	A good match of the measured values of the different measuring instruments could be observed. Actual ongoing research on market available log wood stoves showed, that particle number concentration of more than 10^7 cm^(-3) are emitted, when no emission abatement techniques are used. It was also determined, that no simple correlation between particulate mass and number concentration was observable. With electrostatic precipitation the particle number concentration could be reduced by more than 80 %. By using technologies (automated control, catalysts, and precipitator) already available on the market in an appropriate combination, low emission levels can be achieved in real operation, whereby user influence can be largely reduced. With increasing combustion quality and decreasing particulate matter emissions, the measurement uncertainty of gravimetric particulate matter measurement increases. A transition to particle counting may be advisable in the medium term, comparable to testing of combustion engines.

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Publication title	Adsorbate chemistry of combustion generated nanoparticles from diesel- and gasoline-engines
Publication type	Presentation / **FOCUS**
Introduction & Background	It is an on-going debate if particle mass, surface or particle number are relevant criteria to assess the toxicity of combustion engine exhausts. This led to differing legislation for ambient air and vehicle control. The WHO air quality standards are based on particulate mass PM2.5 and PM10 µm with limits of 10 and 20 µg/m3 whereas particle number (PN) emissions are limited for vehicles in Europe at 600 billion particles/km. The WHO PM limit is based on epidemiological data, but the current PN limit is not. From a chemist's perspective neither the mass nor the number of particles are sufficient criteria. It is the chemical composition of these particles and their adsorbates that determine their toxicity. The chemistry of adsorbates of combustion-generated particles of diesel- and gasoline engines will be discussed.
Methodology	To identify critical compounds, complete exhausts including solid, condensed and gaseous material were collected with all-glass sampling devices in various campaigns. Exhausts of a diesel vehicle with particle filter (Peugeot 4008, 1.6L, Euro-5), a GDI vehicle (Volvo V60, 1.5L, Euro-5) and a gasoline MPI vehicle (Fiat Panda, Twintec, 0.9L, Euro-6b) were collected and compared with those of a heavy-duty diesel engine (6.1 L, type D914T, Liebherr). Tests were performed at the chassis and engine dynamometers of the UASB Biel. Vehicles were tested in the WLTC, engines in the ISO8178/4C1 cycle. Samples were recovered, purified and extracts were analyzed by GC-HRMS (Orbitrap, Q-Excective-GC, MAT95).
Results & Conclusions	All investigated combustion engines released large numbers of soot-like particles with diameters of 20-200 nm, which was expected for diesel and GDI engines but is a surprise for the gasoline MPI engine. It has to be mentioned that particle emissions of MPI vehicles are not regulated, despite the finding that their PN emissions are as high as those of GDI vehicles. Carcinogenic PAHs: The MPI vehicle released relevant amounts of PAHs, including those rated to be carcinogenic to humans. Emissions were as high as those of GDI vehicles, clearly exceeding those of the diesel vehicle. Mutagenic nitro-PAHs: Chemically related to PAHs are nitro-PAHs. They are PAH transformation products. Nitration of PAHs can occur during combustion, in the catalytic converter system, e.g. the particle filter, and in ambient air. We found evidence that nitro-PAHs including mutagenic ones are also present in particle adsorbates of the diesel engine. Estrogenic activity: Chemical structures of certain PAHs, especially the hydroxylated PAHs, resemble the one of estradiol. We found that estradiol-like compounds are present in diesel adsorbates that bind the estrogenic receptor and trigger hormone-like responses in exposed cells. In conclusion, all tested combustion engines produce large numbers of nanoparticles and semi-volatile compounds which condense on these surface-rich particles. We showed that these adsorbates contain carcinogenic, mutagenic or estrogenic compounds which can trigger various cell responses. Thus, it is the nature of these chemicals adsorbed on nanoparticles that determines particle toxicity and it is the particle size that determines where such material is deposited in the lung. This should be respected in future particle legislation.

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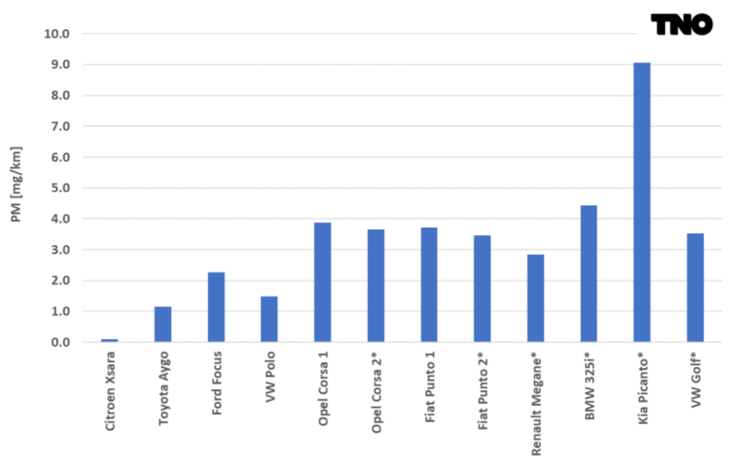
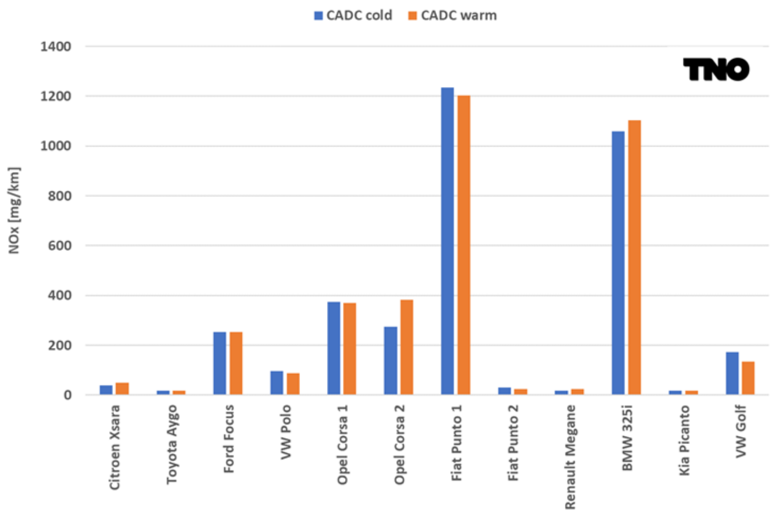
Publication title	Update Dutch PTI DPF test procedure and deterioration of older gasoline vehicles
Publication type	Presentation
Introduction & Background	The last years, on behalf of the Ministry of Infrastructure and Water Management, TNO, RDW and the Dutch Metrological Institute NMi have been developing a national PTI emission test procedure for particulate filter in diesel vehicles. In 2018 this project was presented at the ETH conference. In 2018 and 2019 major steps forward have been taken for the specification and calibration of a simple PTI-PN-tester, and the Dutch PTI-PN test procedure has been further developed. In parallel, on behalf of the Ministry of Infrastructure and Water Management, TNO measured the tailpipe emissions of twelve older petrol vehicles with odometer readings between 155.000 and 254.000 km, model year after 1998, with three-way catalysts.
Methodology	The specification of the simple PTI-PN-tester was developed in the international NPTI group which consists of representatives of governments, research and development organisations, automotive industry, metrology organisations and manufacturers of PN-testers. In several meetings the specification of the PN-tester and calibration procedures were investigated and defined. The gasoline vehicles were tested in the Dutch national in-use compliance test program. One Euro 2, three Euro 3, seven Euro 4 vehicles and one Euro 5 passenger vehicle, were tested on the chassis dynamometer according to a real-world (CADC) driving cycle, with representative mass and road loads.
Caption Figure 1:	 *Particulate mass (PM) emission of twelve gasoline vehicles with high mileages (155.000 to 254.000 km) in urban conditions with cold and warm start, rural and motorway conditions of a CADC emission test. The PM of the six * vehicles are determined with the extended CADC (urban-rural-motorway-urban).*

Caption Figure 2:	 NOx emission of twelve gasoline vehicles with high mileages (155.000 to 254.000 km) in CADC tests with cold and warm start. Half of the vehicles have elevated emissions but two out of the twelve dominate the average results.

	Kelesidis Georgios A.
Affiliation	ETH Zurich
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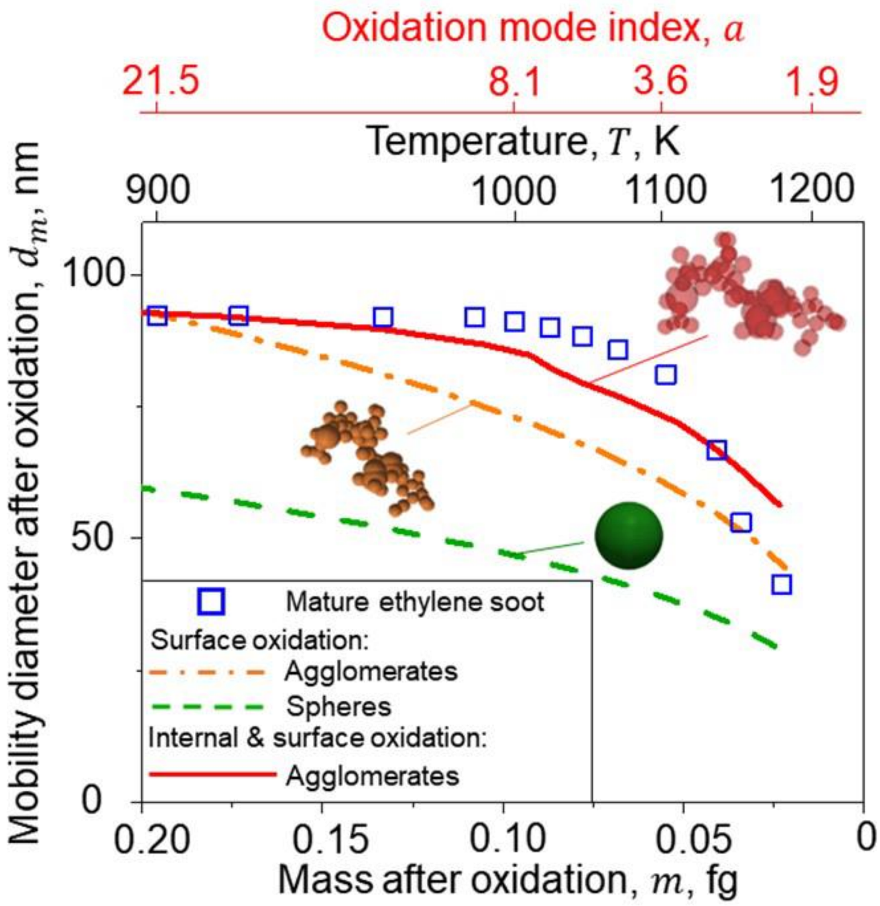
Publication title	Internal and External Soot Oxidation
Publication type	Presentation
Introduction & Background	Oxidation of soot determines its emitted mass concentration, size distribution & mobility diameter, dm. Soot oxidation takes place mostly by O2 and OH radicals at high temperatures, T (> 1100 K) and competes with agglomeration in determining its particle sizes (Stanmore et al., 2001). In diesel engine exhaust and regenerative traps of particulate filters, single or packed beds of soot agglomerates are oxidized at lower temperatures (ibid). Even though accurate oxidation kinetics over a wide T range are essential in both industrial uses and environmental impact of soot, they are often derived neglecting internal particle oxidation and the structure of such soot agglomerates.
Methodology	Here, the detailed evolution of the fractal-like agglomerate soot mass, m, and mobility diameter, dm, during both internal and surface oxidation is determined by a moving sectional model. The oxidation mode index, α, given by the ratio of the characteristic O2 reaction and diffusion times is used to quantify the contributions of internal and surface oxidation of soot (Essenhigh, 1988). At low T (e.g., < 1100 K), O2 diffuses into the primary particles and reacts with bulk soot, hardly altering the dm and yielding α > 3. As T increases, surface oxidation becomes dominant, decreasing both dm and α.
Results & Conclusions	Figure 1 shows the soot agglomerate dm as function of its m after internal and surface oxidation (solid line) compared to those of agglomerates (dot-broken line) and spheres after surface oxidation alone (broken line) at T = 900 – 1200 K (top abscissa), resulting in α = 21.5 – 1.9 (top abscissa). The surface oxidation model for spheres (broken line) underestimates the measured dm (Ma et al., 2013; squares) by 50 % on average over the whole T range. Accounting for the fractal-like agglomerate morphology during surface oxidation (dot-broken line) improves substantially the agreement with data for T > 1100 K, but underestimates soot dm up to 24 % for lower T, as oxidation takes place mostly within soot primary particles. Accounting for both internal and surface soot oxidation of agglomerates (solid line) results in good agreement with mature soot data (Ma et al., 2013; squares) over the whole T range. Coupling this detailed moving sectional model with mobility size distributions of nascent soot (Camacho et al., 2015) yields a specific oxidation rate that is on average more than 50 % smaller than that obtained when neglecting internal oxidation and the fractal-like soot morphology at [O2] = 0.2 - 0.78 vol %.
Images	

Caption Figure 1:	 Soot agglomerate dm as function of its mass, m, after internal and surface oxidation (solid line) at T = 900 – 1200 K (top axis) resulting in α = 21.5 – 1.9 (top axis) is compared to surface oxidation of spheres (broken line) and agglomerates (dot-broken line), as well as to mature ethylene soot oxidation data (Ma et al., 2013; squares).

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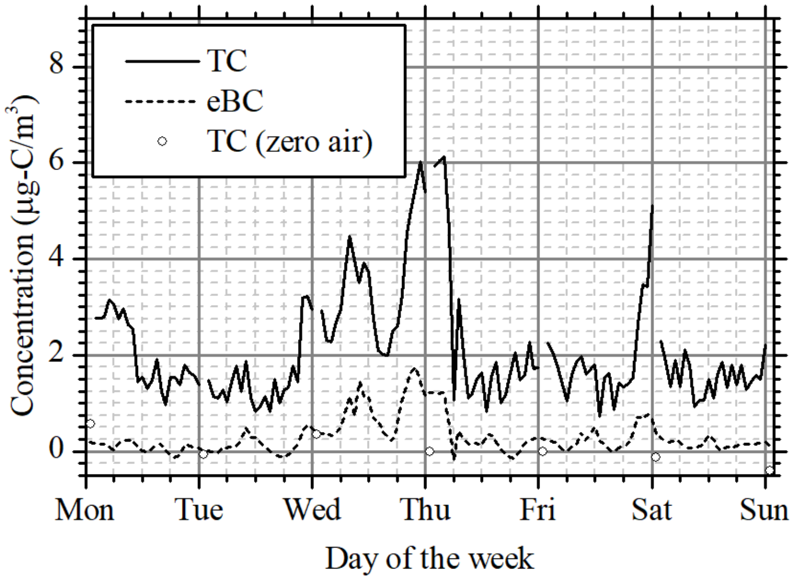
Coauthors	P. Steigmeier; E. Weingartner
Publication title	Stand-alone system for reliable determination of carbonaceous aerosol
Publication type	Presentation
Introduction & Background	Total aerosol carbon mass (TC) is a major constituent of the atmospheric fine aerosol particles. Comprehensive long-term measurements of TC are of paramount importance for assessing aerosol effects on climate and health, for establishing appropriate emission limit standards, and for devising effective mitigation strategies. However, this fraction is not yet continuously monitored at atmospheric measurement stations. Only the inorganic fraction of carbonaceous aerosol is indirectly monitored with high time resolution via the light absorption coefficient, which is a measure of the equivalent black carbon (eBC) content. The TC and organic carbon fractions are more poorly understood due to the absence of high-resolution historical data. We want to fill this gap by providing a measurement system for unattended long-term monitoring of TC. The instrument is a redesign of an in-house developed laboratory system for monitoring of biomass burning emissions.
Methodology	We developed the fast thermal carbon totalizator (FATCAT). Previously presented as a laboratory setup, FATCAT is now a portable semi-online instrument for the determination of TC. Our device collects a sample on a rigid filter, which is subsequently heated to 800°C under an oxidizing atmosphere. Further oxidation of carbonaceous material is achieved by a catalyser located downstream of the heating unit. TC detection is done by means of a CO2 measurement. The fast heating cycle of 50 seconds allows for a short analysis cycle, of less than two minutes, and generates a high CO2 signal that results in a low limit of detection of LoD=0.3 ug of carbon (ug-C). Sampling rates can be set to one cubic meter per hour for ambient concentrations, with typical collection time between 30 minutes and one hour (or as low as 100mL/minute and a few minutes of collection for emission measurements). FATCAT uses a rigid metallic filter for sample collection and is, thus, not affected by filter damages or filter displacement errors. This is, to our knowledge, unique among carbonaceous aerosol measurement systems. We will present data comparing FATCAT to other measurement systems using synthetic carbonaceous aerosol samples, as well as unattended measurement data for atmospheric samples at different locations (see, e.g., Figure 1). The data will be compared against other on-line measurement instruments and against off-line thermal-optical filter-based measurements.
Results & Conclusions	We have developed a stand-alone semi-online measurement instrument for unattended monitoring of the total carbon fraction of ambient aerosol. The low detection limit of LoD=0.3 ug-C and sampling rates up to one cubic meter per hour provide a time resolution between 30 minutes and one hours for most ambient measurement sites. The standardization and the development of a simplified continuous TC measurement method aim to fill a major gap in the aerosol monitoring programs, i.e., to provide an affordable method of carbonaceous aerosol measurement at monitoring sites and to assure comparability of data measured by different research groups. This work has been supported by the Swiss Federal Office for the Environment and by MeteoSwiss.
Images	

Caption Figure 1:	 Ambient carbonaceous aerosol fractions at Windisch, Switzerland, during several days. Lines correspond to TC (measured by means of FATCAT with a time resolution 1 hour), and eBC at 880 nm (Aethalometer AE33, Magee Sci.). Open dots show zero measurements performed for control at the start of each day.

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Publication title	State of Spark-Plug Sized Exhaust Sensors for Real World Emissions Monitoring
Publication type	Presentation
Introduction & Background	Spark-plug sized exhaust particle and NOx sensors are currently used for onboard diagnostics in the USA. The possible use of exhaust sensors for onboard emission monitoring and broadcasting into the cloud in real time is peaking the interest of the engine manufactures and regulators in United States, China and the European Union. Putting sensors on every vehicle for continuous emission monitoring achieves the ultimate goal of emission regulation in protecting the public from air pollution in the real world. Before widely spreading the use of sensors onboard vehicles for emission monitoring, one needs to assess the state of sensing technology available in the market place and their state of readiness to accomplish this mission providing reliable data.
Methodology	At Southwest Research Institute, we have been assessing the state of exhaust particle sensors since 2010 through the particle sensor performance and durability (PSPD) consortium. The investigation focused on five commercial sensors that included cumulative sensors that rely on soot being conductive, and real time sensors that rely on exhaust particle natural charge or active charge of particles using corona charging. The work included sensor variability, accuracy, interference, detection limit and durability equivalent to 435,000 miles of modern heavy-duty on-highway diesel engine operated in engine laboratory. Some limited work was also done on NOx sensors.
Results & Conclusions	The presentation will discuss the state of readiness of particle sensors and NOx sensors and will highlight some of the short coming that requires further research over the next five to 10 years. This work will also highlight that sensor development can offer the opportunity for a CO2-specific emission compliance metric that relies solely on the use of exhaust sensors.

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Publication title	Particle effective density measurements: alternative approaches
Publication type	Presentation
Introduction & Background	Electrical mobility sizing devices like the SMPS, EEPS, and DMS500 classify particles by electrical mobility and produce number weighted size distributions based on mobility diameter, the number of particles in each electrical mobility size bin is reported. Problems arise when it is necessary to convert number weighted size distributions to another weighting, for example surface area or mass, because information on particle shape and density is usually not available. A method commonly used to deal with this problem for mass distribution measurements is called the integrated particle size distribution method (IPSD). This method relies on separate measurements of size dependent particle effective density. The effective density is commonly determined using a differential mobility analyzer (DMA) to provide a stream of nearly monodisperse particles to a centrifugal particle mass analyzer (CPMA) to determine the mass of particles of that mobility size. Then the effective density is defined as the ratio of the measured particle mass to the particle volume calculated assuming a spherical particle of the selected electrical mobility diameter. This method has been shown to work quite well for calculating mass weighted size distributions and total mass provided that the density distribution and the test aerosol are from similar sources.
Methodology	A problem with this method is that the measurement of density is relatively slow, mainly because of the centrifugal particle mass analyzer scan time. An alternative method for measuring effective density reverses the order of the instruments, with a CPM followed by a DMA. Thus, the CPM is used to select a particle mass and the DMA to find the mobility diameter. This approach allows a size dependent density distribution to be measured much more quickly. In this work we compare density distributions measured using the two methods: (1) DMA first selecting mobility diameter and then measuring the mass with the CPM, in this case a Cambustion CPMA; and (2) CMPA first selecting mass and then measuring the electrical mobility diameter with the DMA. In both cases the effective density is calculated from the ratio of CPMA mass to DMA volume calculated assuming spherical particles with a diameter equal the electrical mobility diameter. Three particle sources were used: a BMW GDI engine, a J-85 turbojet engine, and mini Cast soot generator.
Results & Conclusions	Typical past measurements have shown an inverse relationship between effective density and electrical mobility diameter with rho_e α D_m^-n with n ranging from about 0.2 to 0.7. For the BMW engine and the mini Cast, density distributions followed that trend and the two methods gave results that were indistinguishable within experimental uncertainty. This was also the case for many test conditions with the J-85 engine, however, several conditions gave flatter density distributions using method (2) with n near zero, implying compact spherical particles. This suggests that the two methods are not looking at the same population of particles. This will be discussed.

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Publication title	Retrofitting a Danish inland ferry with DPF: Reduction in particle emissions, noise, and implication on the ambient environment
Publication type	Presentation
Introduction & Background	Particle and gas emissions from diesel engines have profound impact on human health. Namely emissions from marine engines are being scrutinised, because marine engines have not experienced the same regulations as the on-road sector (EU EURO norms). In 2015, the maximum allowed sulphur content in marine fuel was limited to 0.1% in emission control areas (ECAs) and will be globally limited to 0.5% in 2020. NOX emissions are also regulated and will be further restricted in 2021. Particulate matter (PM) is partly regulated through the maximum allowed sulphur content in fuel but PM and black carbon (BC) are themselves unregulated for marine engines. PM/BC is however expected to be regulated in the future. Emissions from ship traffic is a very hot topic, not least in Denmark, due to extensive its costal lines. In addition, the urban movement towards harbour fronts is making air pollution from ships highly unwanted in these city areas. Thus, development of sustainable mitigation strategies including implementation of emission-reducing technologies such as particle filters, SCR catalysts and scrubber systems are of utmost importance. This work includes comprehensive data on particle reduction (mass, number and size) measured several months following successful DPF installation on all four engines on a Danish inland ferry (TIER II, IMO regulation). Also, noise reduction and implication on the ambient environment is presented. The work is part of a larger Danish project co-financed by the Danish EPA (2017-2020) with the aim of retrofitting three ferries with DPF and NOx reducing technology.
Methodology	The emissions were characterized at various engine loads. Particle size distribution and number concentration (PN) was measured using a NanoScan SMPS (TSI) in connection with a rotating disc diluter (Testo) and further connected with a catalytic stripper (Catalytic Instruments) for measuring the solid particle fraction in accordance with the particle measurement program (PMP). PM was measured using both gravimetric (according to ISO 8178) and optical methods. Additionally, ambient measurement assessing the surrounding air quality have been conducted (CPC, DiSCmini and dust monitor).
Results & Conclusions	The PN concentration in raw exhaust from one of the two main engines (upstream of DPF) was measured to 4-5x107cm-3, dependent on engine load, and with a mean particle size of 80-90 nm. PM concentrations were around 25-30 mg/m3. Measurements downstream of DPF for both main and auxiliary engines show >99% reduction in both particle number and particle mass concentration indicating very efficient DPF installations. Also, noise is significantly reduced with about 22 dB(A) reduction of exhaust pipe noise, measured approx. 1.5m from the discharge pipe. Ambient measurements using handheld particle measurement equipment indicate no significant impact on the surroundings of the ferry emissions after DPF installations. This benefits both crew, passengers and citizens living in the harbor area.

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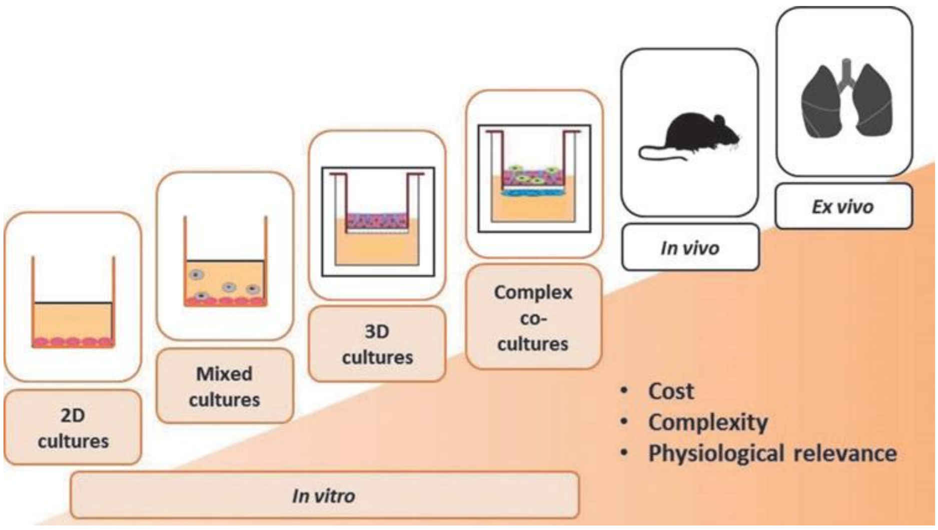
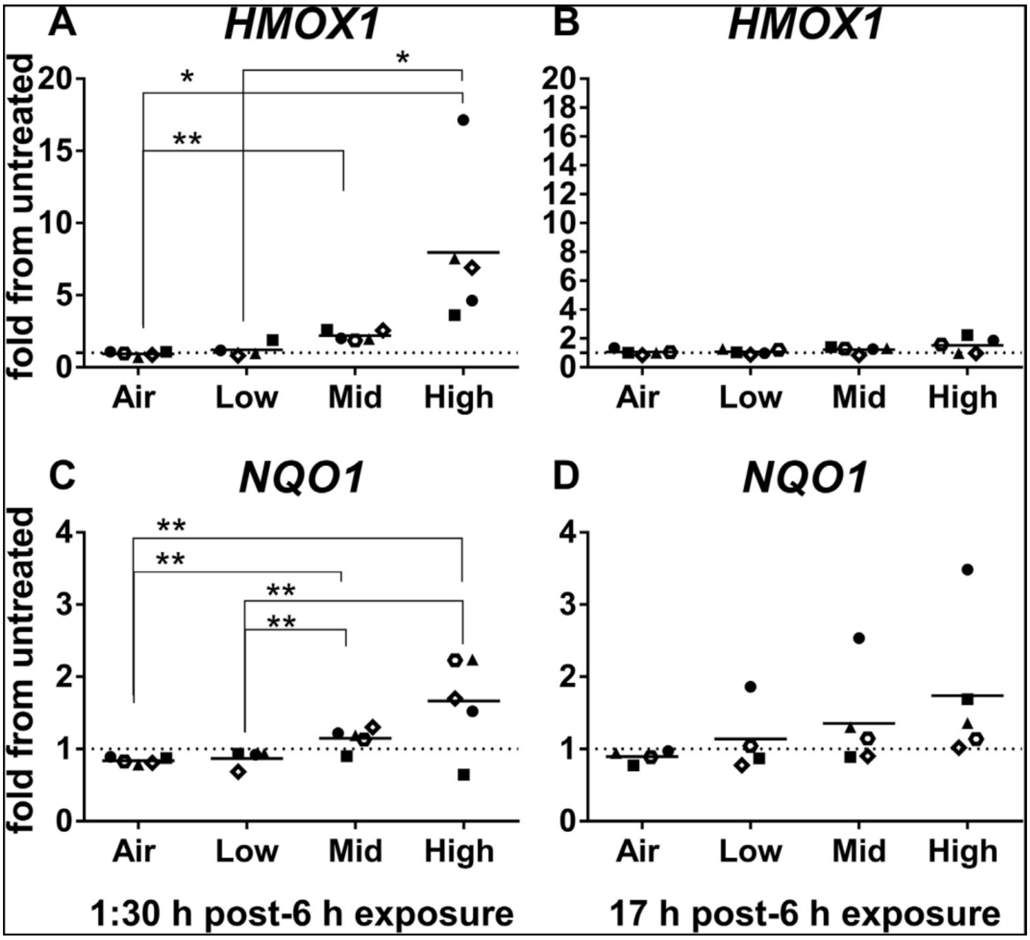
Publication title	A role for in vitro inhalation studies in the evaluation of the toxicity of emissions from combustion processes
Publication type	Presentation
Introduction & Background	The introduction of new emission standards lowers the limits of engine emissions from several transport modes. However, the implementation of new engine/emission control technologies and renewable fuels to meet the standards can lead to changes in the chemical mixture of emitted pollutants. Hence, while regulatory requirements are met, especially in respect to greenhouse emissions, the actual health effects of these reductions often are untested. Therefore, a comprehensive evaluation of the actual toxicity of emissions is absolutely needed. In vitro models relevant for human exposure can be the basis for such an evaluation to test for adverse health effects of source specific emissions.
Methodology	Different cell models (cell lines, co-culture systems or human epithelial cells) can be used to study the harmful effects of diesel emissions (Figure 1). In one of our studies primary bronchial epithelial cells (PBECs) at the air-liquid interface (ALI) were exposed to whole diesel exhaust generated by a Euro V bus engine. The effect of prolonged exposures was investigated, as well as the difference in the responses of cells from COPD and control donors.
Results & Conclusions	The rapid developments in both cell models (the 3D culture of primary epithelial cells, the use of stem cells, the development of organ-on-a-chip technology etc) as well as advanced exposure possibilities are important developments to use in vitro models in the toxicological evaluation of source specific emissions. In our study, human airway epithelial cells exposed to Euro V bus engine emissions showed a clear oxidative stress response, e.g. HMOX1 and NQO1 expression was transiently induced both in COPD and controls (Figure 2). Other markers were only pronounced in the COPD cells. The use of in vitro inhalation models can play an important and essential role for an effective hazard assessment which is critical in light of changing traffic derived air pollution mixtures including the impact of new technologies and renewable fuels. However validation and standardization of these techniques will be an important item.
Images	
Caption Figure 1:	

	Respiratory models available from simple to complex. Costs and also physiological relevance increase in line with the complexity of models (Lacroix AIVT et al. 2018)
Caption Figure 2:	 Oxidative stress response to prolonged exposure to diesel exhaust. Induction of HMOX1 (A and B) and NQO1 (C and D) in cells from 5 non-COPD donors exposed for 6 h to air or diesel exhaust (low, mid and high) and then further incubated for 1:30 (A and C) or 17 h (B and D). (Zarcone et al. TIV 2018)

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Coauthors	Anna Korzeniewska, Katarzyna Szramowiat, Karolina Kołczyk-Siedlecka, Dawid Kutyła, Faustyna Wierońska, Marta Marczak, Krzysztof Sornek, Mariusz Filipowicz, Janusz Gołaś
Publication title	Emission of heavy metals and solid particles from domestic wood combustion processes
Publication type	Presentation
Introduction & Background	Wood combustion is one of the main sources of domestic heating types all over the world. It has been widely demonstrated in the studies that wood combustion processes leads to much higher level of particulate matter emissions than the values obtained during the combustion of different types of biomass. Particles generated by the biomass burning, under poor combustion conditions, consist mainly of carbonaceous compounds, while during efficient combustion conditions, they are mainly formed by ash-related material. The work presented in this paper aimed at the investigation of chemical composition of collected particulate matter and bottom ashes from DHU.
Methodology	In the study there were carried out tests using commonly available biomass. Experiments were carried out in constant operational parameters affecting the fuel combustion process as the amount of fuel burned and inlet air flow. While fuel burning, the platform scale was used to measure variations in the mass of fuel and gaseous analyser was used to measure gaseous exhausts components as CO2, CO, O2, NOx and SO2. The control of combustion process was realized using dedicated algorithm developed in CoDeSys software and implemented to PLC controller. Moreover, the dust sampler equipped with a dilution tunnel, a filter holder with a filter cooling system and a pump was installed into the chimney. The samples of particulate matter were collected on quartz fiber filters with a diameter of 47 mm. The composition of particulate matter collected on the quartz fiber filters differed depending on burning phases. As well as the composition of bottom ashes collected after combustion processes. Thanks to the use of the SEM microscope, it was possible to carry out research and analysis of surface and subsurface areas as well as analysis of the chemical composition of the emitted solid particles and the resulting dust in the combustion processes. Ambient PM from wood burning was also quantified using measurements of polycyclic aromatic hydrocarbons and the ionic components measurements. The bottom ashes were analysed using the X-ray fluorescence and X-ray diffraction.
Results & Conclusions	The sampling of particulate matter was conducted during biomass combustion processes in the experimental stove. The ratios of amounts of specific polycyclic aromatic hydrocarbons may be a characteristic value for different fuels, which will be presented in further studies of the Authors. Further work should be conducted to propose the most environment-friendly solution of a domestic heating system with an application of a popular fuel and some innovative, possibly cheap, concepts to reduce the emission of harmful compounds. The results which were obtained demonstrated that many technological and thermodynamic factors affect the changes in the quality of the emissions. This furnishes an opportunity for further research. Acknowledgements The work was completed as a part of the research subsidy of the Faculty of Energy and Fuels at the AGH UST in Kraków (no. 16.16.210.476), with substantive and financial support of the Institute for Sustainable Energy and by means of the infrastructure of the Center of Energy, AGH UST in Kraków.

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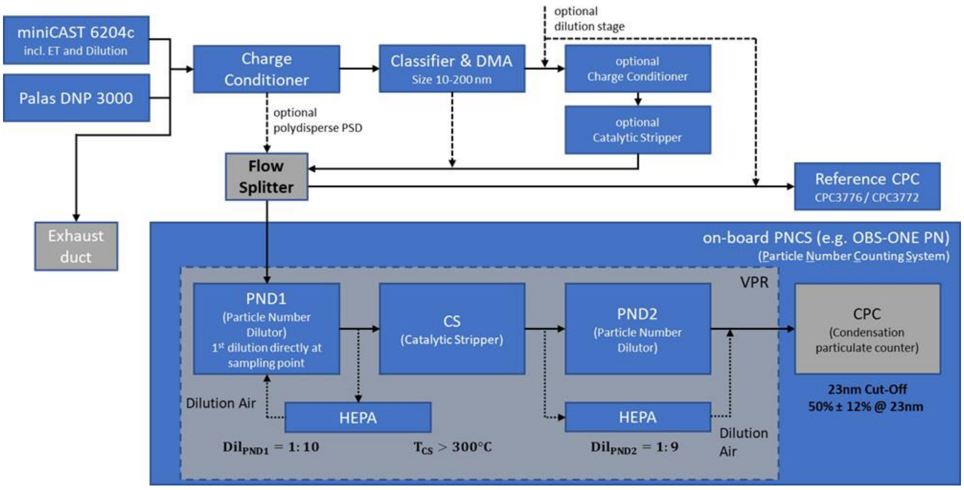
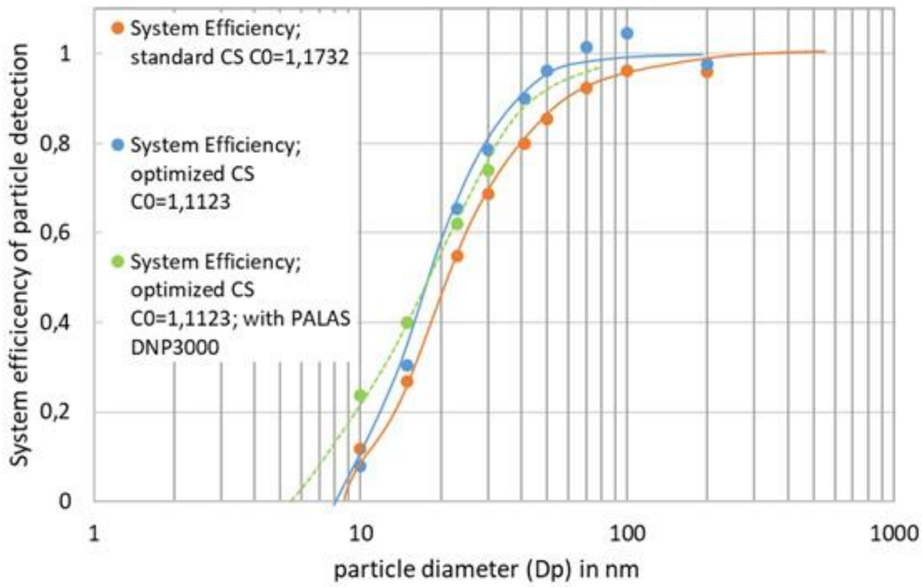
Publication title	The PEMs4Nano project: measuring engine emissions below 23 nm
Publication type	Presentation
Introduction & Background	On-road motor vehicles are the focus of intensive current research because of the importance to identify and quantify sources of ultrafine particle emissions. Constant improvement in engine technology has led to significant decrease in the number and mass of emitted particles but concern is raised nowadays by these ultrafine particles. There is a critical lack of certification procedures for the measurement of smallest-size (< 23 nm) particulate number emissions. The goal of the H2020 PEMS4Nano project (www.pems4nano.eu) is to develop robust, reliable and reproducible measurement technology, supporting the engine development process as well as future certification procedures on the chassis dyno and during RDE measurements. This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement no. 724145.
Methodology	A laboratory solid particle counting system (SPCS) has been developed. The exchange of the evaporation tube to a catalytic stripper, as one of the major modifications, has been done and the results are available. In addition, the condensation particle counter of the system was optimized and calibrated. For the on-board measurement equipment similar improvement steps are proceeded including further modifications of the instrument. Therefore, a calibration laboratory, including the implementation of a combustion aerosol standard (CAST) particle generator, has been set up to develop a robust methodology for future calibration and regulatory requirements. On the experimental particle characterization side, different operation regimes of a single cylinder engine (SCE) were characterized with several particle sizers (SMPS, EEPS). In this case the SCE was used as a particle generator. Produced particulates were sampled using a cascade impactor (NanoMoudi-II), which allows size-separation of the sampled particles into 13 different size bins. Chemical characterization of size-selected collected particles was performed in example by using mass spectrometry, which gives access to detailed molecular information on chemical classes. The results of the particle analysis as well as PN measurement are valuable input for the model guided application (MGA).
Results & Conclusions	Current evaluation and first tests with both the laboratory and the PEMS measurement equipment show that the ambitious targets within the project have been achieved so far. The condensation particle counters have been modified and calibrated to at least 50 % detection efficiency of particles at 10 nm. The exchange of the original catalytic stripper in the PEMS device has been optimized to achieve particle penetration rates of greater than 50 % at 10 nm. The particle concentration reduction factors (PCRF) for both systems have been successfully evaluated in the modified calibration setup to guide their definition in future legislations. The correlation between both measurement devices is under current evaluation in real emission tests on the chassis dyno as well as on the road. On the experimental characterization side an extensive database has been built, in example, mass spectrometric studies provided extensive information on the chemical composition of size-selected soot particles. Apart from the present chemical species, one can also derive important information regarding the elemental carbon content of the analyzed particles. MGA combines detailed physico-chemical simulation together with advanced statistical techniques of parameter estimation, computational surrogate generation and sensitivity analysis (Lee et al., 2019) to support the understanding of the particle characteristics. Lee, K. F., Eaves, N., Mosbach, S., Ooi, D., Lai., J., Bhave, A., Manz, A. Geiler, J. N.,

	Noble, J. A., Duca, D. and Focsa, C. (2019) SAE International Technical Papers 2019-26-0062.
Images	
Caption Figure 1:	 PEMs4Nano: Schematic of the aerosol calibration setup for an on-board measurement PN system
Caption Figure 2:	 PEMs4Nano PEMS: System efficiency with standard and optimized catalytic stripper

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Publication title	Bringing science back to clean air policy making - a response to fakes celebrated by (a few) media in Germany
Publication type	Presentation
Introduction & Background	Since the unopposed featuring of a retired German lung physician as "expert in air pollution and health" by a TV station, German mass media have seen an unprecedented hype, crossing the borders to even reach the E.U. parliament. The physician - not a scientist - claims that the WHO Air Quality Guidelines lack scientific evidence and that the air quality standards for NO2 and PM should be eliminated. The political background of the celebration of these fakes in Germany is built by the after-math of the diesel engine manipulation scandals. The presentation puts the health science in perspective of 30 years of policy decisions where science got downplayed by vested interests and ultimately side-tracked by selective court decisions. The outlook will summarize "lessons learned" for the regulatory discussions for combustion related nanoparticles.
Methodology	-
Results & Conclusions	-

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Coauthors	H. Richter; L. Frazier; S. Schanzer; I. Gross; A. Patzelt
Publication title	Decontamination of the skin from environmental pollutants
Publication type	Presentation
Introduction & Background	Since many years, nanoparticles have been presumed to be potential drug delivery systems through the skin barrier. Although having been the topic of many investigations, there are no nanoparticle-based products on the market, which are able to actively transport drugs through the skin using the intercellular penetration pathway, which is the most relevant entrance for many topically applied substances. Instead, it has been shown, that the hair follicles represent an interesting penetration pathway especially for particulate substances. Particles with a diameter of approximately 600 nm penetrate very effectively into the hair follicles. This is probably based on the fact that the moving hair, which provides an uneven surface of overlaying cuticula cells, works like a ratchet transporting the particles deeply into the hair follicle. Whereas the upper part of the hair follicles has a skin barrier which is very similar to the stratum corneum barrier, the barrier of the lower hair follicle is mainly consists of tight junctions. The hair follicles represent a long-term reservoir that is capable of storing topically applied nanoparticles for several days. Thus, it has been recognized that nanoparticles can serve as effective transport systems delivering different kinds of actives into the hair follicles. Once delivered into the hair follicle, the active has to be released there in order to overcome the follicular barrier independently. It is assumed that the bioavailability of drugs, which is mostly very low and below 1% for most substances, can be increased by more than one order of magnitude. The hair follicles represent a very interesting target structure. They are surrounded by a close network of blood capillaries and are thus very important for the bioavailability of active substances. In addition, the hair follicles host the stem cells and are surrounded by dendritic cells. The process of particle-assisted transport also occurs in nature. Soot particles are released due to industrial and vehicle exhaust gases. This kind of air pollutants is able to uptake, among others, pollen allergens and polycyclic aromatic hydrocarbons. Skin contact and especially the penetration into the hair follicles has to be prevented as allergens released from soot particles might be able to induce sensitization. In the following study, different skin decontamination strategies are described and compared.
Methodology	The investigations were carried out on 10 volunteers. Soot particles were applied to untreated skin areas and skin areas pretreated with barrier creams. Afterwards, the soot particles were removed by either washing or highly absorbent textile materials. The distribution of soot particles on the skin and in the hair follicles was investigated by laser scanning microscopy.
Results & Conclusions	In the case of washing, the follicular penetration of the soot particles was even increased. Therefore, washing the skin cannot be recommended as the washing procedure is always combined with a massage, which increases follicular penetration. This might also increase the transfollicular penetration of released pollutants or allergens which can lead to inflammation or sensitization. In contrast, the pretreatment of the skin with barrier creams turned out to be a successful antipollution strategy. The skin decontamination was shown to be most effective, however, when the soot particle-contaminated barrier cream was removed from the skin by an absorbent textile material without any massage.

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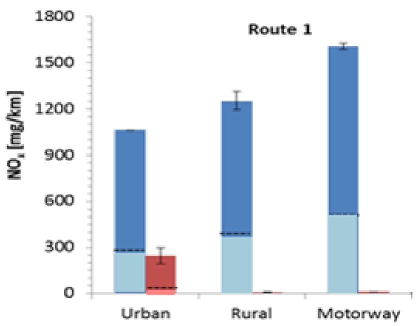
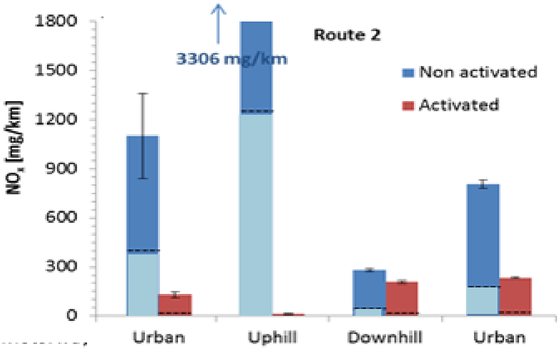
Publication title	Retrofits: an effective stopgap solution for current and future air quality problems? The results of the EU prize for the Cleanest Engine Retrofit
Publication type	Presentation
Introduction & Background	There are millions of quite new high NOx emitting cars in the fleet which are not likely to be scrapped any time soon, leading to air quality problems in many cities. Even though recent Euro 6d vehicles show better performance, and electric vehicle sales are growing, it will take years to replace these high emitters, so retrofitting is a promising short-term solution to improve air quality. Looking at PN emissions, many gasoline and natural gas vehicles have high emissions due to either PN not being regulated for certain categories, or because of higher emissions being allowed for some time
Methodology	The EU Commission launched a 1.5M€ prize to help fixing NOx issues with an effective and affordable retrofit system, imposing quite demanding targets for both regulated and EU unregulated emissions, such as ammonia and N2O, in order to ensure no new side issues are introduced. Additonal requirements have been set on increased fuel consumption, driveability, nois, safety and cost, in order to ensure marketability.
Results & Conclusions	The winning solution has proven to be effective in reducing NOx in both bench and RDE tests, conducted at JRC. These results might be further improved by small software modifications by the OEMs, to improve coordination and complementarity of the emissions control systems to improve in particular cold start performance. Ammonia emissions, controlled by a dedicated catalyst, were found not to be an issue. Nonetheless, attention should be paid to N2O emissions, which were already present in the base vehicle and were increased by the retrofit in high load condition. Recently concerns have been were raised about possible formation of particles from urea (or NH3) with sizes even lower than the current regulatory limit of 23 nm, but no such formation was noticed in our experiments, thus further reassuring on the environmental benefits of retrofitting high-emitting vehicles. Suitable retrofit solutions, probably at an even lower cost, might be developed for the high number of unfiltered gasoline and natural gas engines with high PN emissions. The need for such retrofits might soon emerge if nanoparticle number will be recognised as a serious health issue per se, as recommended by several authors, even when mass thresholds are not exceeded.
Images	
Caption Figure 1:	

	RDE test results on RDE compliant route
Caption Figure 2:	 RDE results on non-RDE compliant, high slope route

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Publication title	Periodic Emission Inspection of SCR-equipped cars and trucks
Publication type	Presentation
Introduction & Background	All modern Diesel engines in onroad and offroad vehicles are equipped with emission control by DPF and SCR, where DPF reduces PN emission by a factor of 100-10'000 and SCR reduces NOX by a factor of 25-100. While these new vehicles Euro 5 and 6 are very clean if the EAT is perfectly working, they deteriorate a lot if there is a technical failure, malfunction or manipulation. Roadworthiness investigators all over Europe report that about 10% of DPF and up to 20 % of SCR are not working properly and a large part of this is due to the fact that these systems can be manipulated and the independent PTI test has been given up all over Europe, in Switzerland 2013. Consequently there is an urgent need for re-introducing PTI but using a test protocol and intrumentation which reveals failurs, malfunctions and manipulations within a very short test time. While PTI for Diesel is solved by simple and fast PN at idle [1], SCR control may need a load stap, during which the functionality of the system can be analized.[2] which anticipates the availability of a chassis dynamometer making the testing time long and the whole procedure expensive and therby hard to implement.
Methodology	But using the properties of these new "electronic" vehicles, there might be better solutions to perform this load/temperature step, which is needed to test the function of a SCR system. As a matter of fact thes new vehicles all need a temperature management which permitts to increase exhaust emperature to levels of nearly 600°C for a forced DPF regeneration, desulfurization and other cleaning options. This is possible even at very light operation load. The tools for this sudden temperature step are usully - intake throttling [3] - late injection [4] - HC-dosing with catalytic combustion [5] Each of these or all three combined can produce the required temperaure step within on minute and avaliable insttrumentation at the tailpipe to measure NO, NO2, NH3 and temperature permit to diagnose the functionality of all elements of the SCR system.
Results & Conclusions	While this process permits a PTI at very low cost within very short time, it can only be performed if this process is pre-programmed in the OBD and can be triggerd by a simple command of the test inspector. So a legel regulation is required to basically provide this very efficient testing step with the aid of already available elements in the engine management system and to permit this test on demand. Having this regulation installed high emitters can be detected easily and the overall fleet emission could be very much reduced. The time needed to introduce such a procedure is just one car generation - an estimated 2-3 year period. [1] Kadijk et al, ETH-NPC 1917 [2] Czerwinski et al, SAE 2019 [3] Mayer et al, SAE 2003, 2004, 2006 [4] Belot et al, SAE 2000.01-0473 [5] Bosch ....

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Publication title	Ultrafine particles and health - the urban exposome perspective
Publication type	Presentation
Introduction & Background	Air pollution is the largest single environmental health risk. Inhaled particles exhibit broad adverse short- and long-term effects. These effects likely differ by particle size, source and therefore composition. They depend on the presence of personal and environmental co-factors. Technologies as available in the exposome era offer personalized approaches towards understanding the nanoparticle-health associations and mediating biological pathways.
Methodology	Personalized air pollution exposure measurements and -omics technologies were applied in the EU funded Exposomics project to study the short- and long-term effects of inhaled particles on blood biomarker profiles and health outcomes. Regression calibration was applied to derive de-attenuated dose-response relationships, using the personal exposure monitoring. Biomarker profiles were investigated for biological pathways perturbation as a result of air pollution.
Results & Conclusions	Results from the Exposomics project are consistent with a potential underestimation of health effects if based entirely on outdoor exposure modeled to the residential address. Several metabolome and methylome profiles were found to be associated with personal air pollution exposure and to be mediating its association with cardiovascular and respiratory outcomes. Results of the Exposomics project confirm the value of exposome methodology for improving mechanistic understanding of health effects related to the environment. Research in the next phase will need to focus on a truely exposome-wide approach taking the multitude of risk factors and their correlation into consideration. Furthermore, it needs to integrate a phenome perspective in the light of the multimorbid effects of many health risks. The goal of new research is to promote environments that allow citizens to age healthy. Urban settings are thereby of particular interest.

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Publication title	The first global regulatory limits for aircraft engine particle mass and number emissions
Publication type	Presentation
Introduction & Background	Emissions from aircraft gas turbines are regulated with global standards and recommended practices as described in ICAO Annex 16 Volume II (International Civil Aviation Organization). Presently regulated are emissions of oxides of nitrogen (NO and NO2), carbon monoxide, total unburned hydrocarbons and smoke (a non-visibility criteria for emission plumes). Increasing evidence for health impacts and negative climate impacts from ultrafine combustion particles was leading to particle emissions research and testing of aircraft gas turbines in the last fifteen years. Substantial development work for new aviation particle emission standards has been done in Switzerland, starting in 2011 with the prototype measurement system built by the Swiss Federal Office of Civil Aviation (FOCA) and installed at the SR Technics Engine Maintenance Facility at Zurich Airport. Following this effort, a number of international test campaigns lead by the Swiss Intstitute for Materials and Testing (Empa) took place in Zurich to bring instrumentation to maturity. The international activities culminated in the first global measurement standard for non-volatile particle mass and number, published in ICAO Annex 16 Volume II, applicable to all in-production engines from 1.1.2020. Meanwhile, government bodies and engine manufacturers made huge efforts to establish a particle emissions performance database for many of the current and most recent engine types, which was key to develop regulatroy limits over the past three years. In February 2019, the ICAO Committee on Aviation Environmental Protection (CAEP) adopted the first global regulatory limits for non-volatile particle mass and number emissions, which will be applicable for new engines from 1.1.2023. At the same time, the existing smoke number standard will be sunset for those engines, which are covered by the new particle standards. The presentation will recap the instrument specification for non-volatile mass and number instrumentation in the aviation regulation and how the regulation deals with particle losses in the measurement system. It will give insight into the design of the first global regulatory limits for aircraft engine non-volatile particle mass and number emissions and an outlook into the future.
Methodology	Technical Information Report
Results & Conclusions	See abstract

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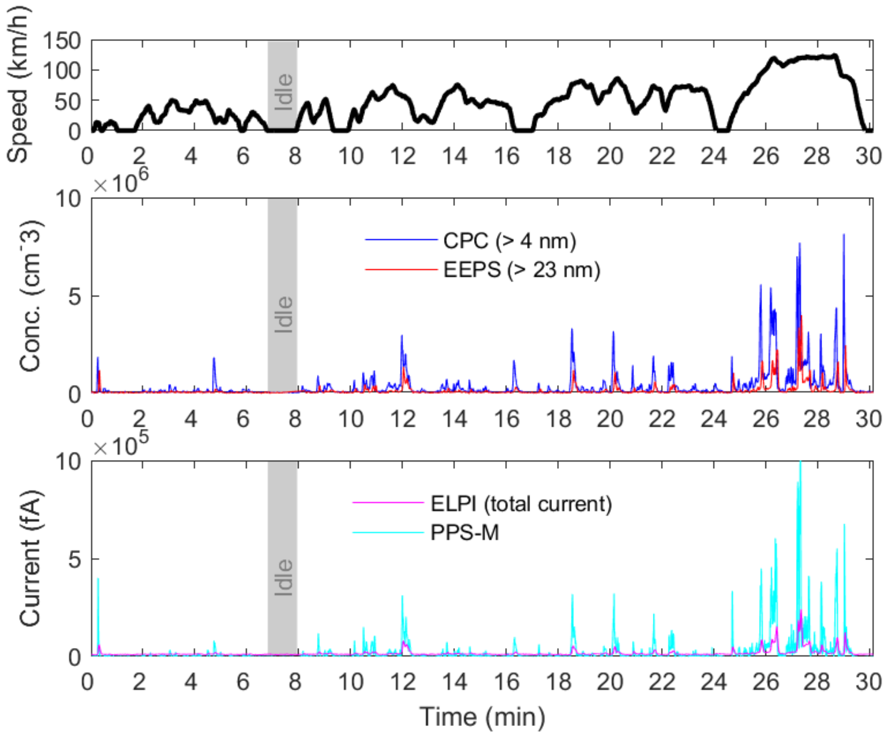
Publication title	Feasibility of diffusion chargers for particle emission measurement in periodical inspection
Publication type	Presentation
Introduction & Background	New diesel and gasoline vehicles are regulated by the maximum allowance of particle number (PN) emissions over a test cycle. Vehicles are tested according to type approval tests that apply the PMP (Particle Measurement Programme) protocol, which enforces low soot particle number emissions while PN emissions are not monitored from in-use vehicles. However, all in-use vehicles are tested frequently in so-called periodical inspection but the current methods for particle emission measurements have not been designed for ultrafine PN measurement, which is typical size range of soot PN. It would be highly important to frequently test all vehicles for particle emissions with a simple and robust instrument or sensor that is sensitive enough for the types of particles regulated by the PMP protocol. This way high emitters of on-road traffic, caused by tampering, wear or breakage of exhaust particle filters, could be banned from traffic or repaired more effectively. Motivated by this need, we studied the measurement of exhaust particle emissions by commercial diffusion charging based particle instruments, with special focus on how instruments can detect differences in emission levels from vehicles.
Methodology	We measured exhaust particle emissions from a diesel and a gasoline vehicle in laboratory conditions on chassis dynamometer. Measurements were conducted over NEDC and WLTC tests cycles, steady speeds and idle. We used partial flow sampling systems at ambient temperature and at elevated temperatures to draw the sample from vehicles' tailpipe to aerosol instruments. The measurement instrumentation included several diffusion charger based instruments and sensors: ELPI (Dekati), eFilter (Dekati), Partector (Naneos), PPS-M (Pegasor). Other state-of-the-art instruments (CPC battery, EEPS, SP-AMS, AE33) were used in parallel to produce reference data on particle number, size distribution and composition.
Results & Conclusions	Figure 1 shows an example of measurement results, i.e., a time series of non-volatile particle concentrations measured by CPC, EEPS, ELPI, and PPS-M from gasoline vehicle exhaust over WLTC. The figure shows that the number concentration measured by CPC and EEPS varies significantly during the driving cycle, from very low numbers up to ~106 #/cm3. Comparison of CPC and EEPS data shows that a significant fraction of exhaust particles are in the sub-23 nm particle size range, indicating that the CPC measurement can be relatively sensitive to the instrument's cut-off curve and calibration. Furthermore, it can be seen that the electric current measured by diffusion charging based devices (here ELPI and PPS-M) follows closely the pattern of exhaust particle number concentration. Finally, it should be noted that, with all the tested instruments, observing the DPF/GPF leakage can be challenging during idling when the concentrations are low. To conclude, our study indicates that the instruments based on diffusion charging of exhaust aerosol can be used in periodical inspections of vehicles to detect changes in exhaust particle emissions, and it seems that diffusion chargers are sensitive enough to measure nonvolatile soot particles down to low concentration levels both in diesel and gasoline vehicles exhaust. Thus, they are good candidates for particle emission monitoring of in-use vehicles by periodical inspections.

Images	
Caption Figure 1:	 Exhaust particle number concentration measured by CPC (Dp > 4nm), EEPS (Dp>23 nm) and electrical currents from diffusion charged particles, measured by ELPI and PPS-M. Measurement was conducted for gasoline passenger car over the WLTC driving cycle.

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Publication title	Combustion engine exhaust – Current knowledge of adverse effects and underlying cellular mechanisms
Publication type	Presentation / **FOCUS**
Introduction & Background	According to the World Health Organization ambient air pollution is still one of the major cause of death and disease [1]. The most prominent components in polluted air include photochemical oxidants (ozone, O3), sulfur dioxide (SO2), carbon monoxide (CO), nitrogen oxides (NOx), hazardous air pollutants (e.g. benzene), mercury, lead, aromatic hydrocarbons (PAHs), and particulate matter (PM) [2].
Methodology	Evidence for public health concern has been shown for all components and especially the risks for PM are well documented in the literature [3]. Particles with an aerodynamic diameter smaller than < 1 µm can reach the gas-exchange region, i.e. the alveoli [4]. PM2.5 and PM0.1 (also defined as ultrafine particles) are predominantly produced by combustion processes. Ultrafine particles with their greater surface area can carry a large amount of adsorbed pollutants, oxygen gases, organic compounds and transition metals [5], thus function like Trojan horses, allowing semi-volatile and non-volatile chemicals access to organs, fluids and cellular compartments they could not reach without particles as carriers.
Results & Conclusions	The exact causal connection between combustion engine exhaust and adverse health effects is still not fully understood, but certain molecular and cellular mechanisms are generally assumed to play a key role. In the past the toxicity of the exhaust was mainly analyzed by measuring specific components; recent studies, however, revealed that adverse health effects of any combustion-derived exhaust not only emerge from its chemical composition, but also from the interplay between its physical properties, the physiological and cellular properties and function of the human respiratory tract [6,7]. As a conclusion there is clear evidence that combustion engine exhaust components result in adverse health / cellular effects and that the complete exhaust might lead to a different toxicity than only the single components. Reference List [1] https://www.who.int/airpollution/ambient/health-impacts/en/. [2] Outdoor air pollution. Volume 109. Edited by World Health Organization. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. 2016. Lyon, France. [3] Wichmann HE, Spix C, Tuch T, Wolke G, Peters A, Heinrich J et al.: Daily mortality and fine and ultrafine particles in erfurt, germany part I: role of particle number and particle mass. Res Rep Health Eff Inst 2000, 5-86. [4] Heyder J, Gebhart J, Rudolf G, Schiller CF, Stahlhofen W: Deposition of particles in the human respiratory tract in the size range 0.005–15 µm . J Aerosol Sci 1986, 17: 811-825. [5] Oberdorster G: Pulmonary effects of inhaled ultrafine particles. Int Arch Occup Environ Health 2001, 74: 1-8. [6] 2nd Information Report for IEA Implementing Agreement AMF, Annex XLII, international activities 2012. 2012. [7] Steiner S, Bisig C, Petri-Fink A, Rothen-Rutishauser B: Diesel exhaust: current knowledge of adverse effects and underlying cellular mechanisms. Arch Toxicol 2016, 90: 1541-1553.

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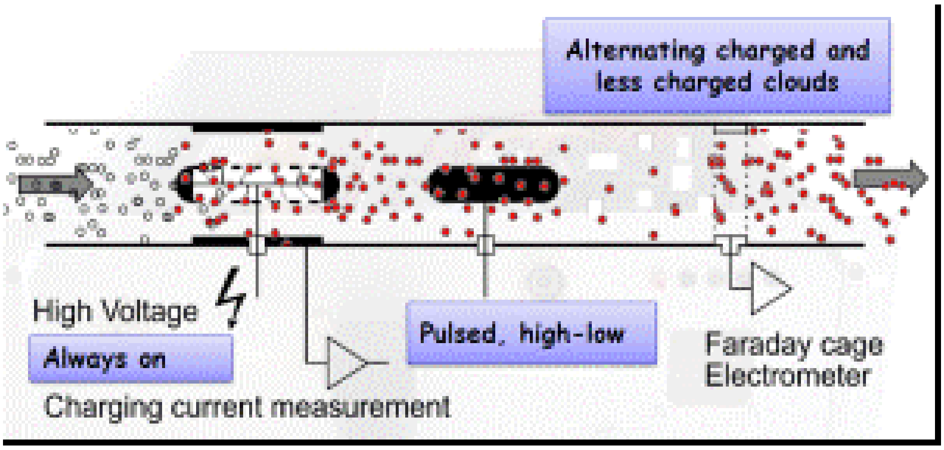
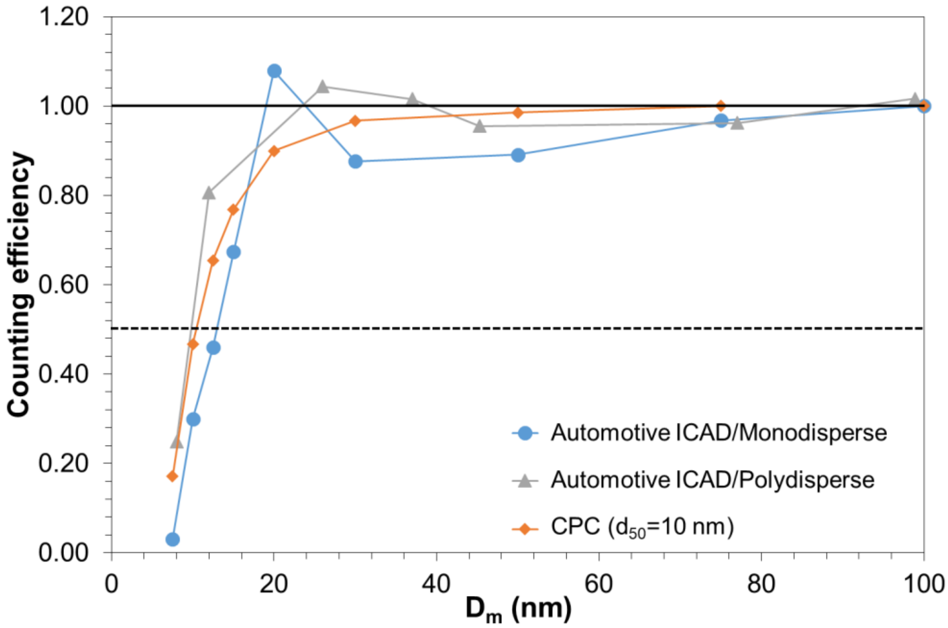
Coauthors	H. Burtscher; M. Fierz; A. Melas; D. Deloglou; E. Papaioannou; A.G. Konstandopoulos
Publication title	Measuring combustion emissions down to 10 nm with DC-sensors
Publication type	Presentation
Introduction & Background	Current particle number emission limits for vehicles in the European Union are based on the PMP protocol. Only solid particles smaller than 23nm are considered. Since some time, there is an ongoing discussion if smaller particles should also be considered. In the framework of three different EU Horizon2020 projects, the nature of sub 23nm particles is investigated and techniques to characterize and measure them are developed. Beside lab instrumentation also robust, low cost devices, which can also be used for field applications (e.g. on-board measurements for RDE or field inspection) are needed. Within the sureal23 project, we work on such a sensor to measure the number concentration of solid particles down to 10 nm. Very often, devices based on CPC's are used for this purpose. This is an accurate and proven technology, but has some drawbacks for field applications (Temperature control, working fluid, dilution) that present challenges in the RDE application. An alternative is unipolar diffusion charging of particles and a subsequent electrical measurement.
Methodology	Figure 1 shows the setup of the DC sensor. It is based on the AVL automotive partector (Schriefl et al., 2019). The automotive partector is tuned to meet the PN-PEMS requirements. For SUREAL-23, the first goal was to move the d50 to a smaller particle diameter, ideally to around 10nm. The partector (and all other DC-devices mentioned above) are designed for ambient air measurements or for use after a dilution/conditioning system to avoid problems with condensation or nucleation of volatile species. These conditioning on the one hand is complex, on the other hand causes losses for very small particles. To avoid this we redesigned the device to enable the operation at much higher temperatures, up to 150°C. The entire electronics PCB of the AP had to be removed from the housing and replaced with a new PCB with better insulation properties. Also, all temperature-critical components had to be removed from the new PCB, i.e. most electronic components. The separation of the electronics from the mechanical part allowed us to heat the mechanical part of the device to 150 °C. The only part that could not be removed from the new PCB was the electrometer, which needs to be close to the Faraday cage detection tube. The electrometer is cooled by a blower so that it remains at tolerable temperatures (T ≈ 60°C).
Results & Conclusions	A prototype of a DC-sensor optimized to measure down to 10 nm has been developed . The sensor can be heated up to 150°C allowing an operation with no or at least only very small dilution. This helps to minimize losses for very small particles. Figure 2 shows the efficiency versus size compared to the response of a 10nm CPC. First performance tests measuring diesel emissions show that the results agree very well with those obtained with a CPC , also in transient tests Acknowledgements This work is part of SUREAL-23 project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 724136. Schriefl, M. A. , Bergmann, A. , Fierz, M.: Design Principles for Sensing Particle Number Concentration and Mean Particle Size with Unipolar Diffusion Charging. IEEE Sensors Journal, 19, 1392-1399 (2019)
Images	

Caption Figure 1:	 Figure 1: Diffusion charging sensor. Particles are charged by attachment of ions, produced by a corona discharge. A pulsed electrostatic precipitator removes most particles (pulse high) or only small ones (pulse low). The current, induced by the passing charge clouds is then measured by a Faraday cage electrometer.
Caption Figure 2:	 Figure 2: Counting efficiency of the prototype for monodisperse and polydisperse soot particles compared to a 10nm CPC.

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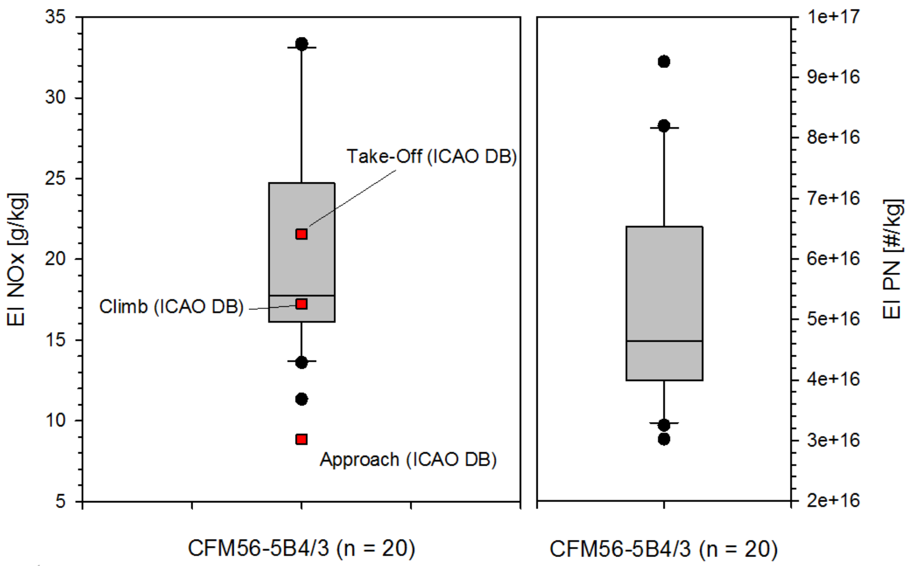
Coauthors	Claus Wahl; Martin Plohr; Patrick Oßwald; Markus Köhler
Publication title	"Real Driving Emission" measurements at Frankfurt Airport
Publication type	Presentation
Introduction & Background	The impact of aviation on the local air quality near airports attracts more and more attention. In particular, the release of fine and ultrafine particles from jet engines is an important aspect. Overall, the particle emission of jet engine is well known and the respective test standards are continuously improved. However, emission tests focus on standardized stationary power settings since the number of parameters changing in a jet engine during transient processes (e.g. take-off) is vast. Real world emission studies are scarce and often deviate significantly from the values gained during the approval process of the engine. This is caused by individual factors like maintenance status, environmental conditions, fuel quality or the transient processes occurring during take-off and landing. Thus, statistical information from real operation is a vital aspect in the prediction of total emission from airports. The presentation will summarize particle measurements from 168 aircraft plumes from 46 different engines measured at a Frankfurt airport runway. The state of the engine will be estimated from the observed NOx emissions and compared to previous soot measurements.
Methodology	The runway measurements were performed at a blast fence in 2015 at Frankfurt airport. The probe was installed in front of the blast fence and captured plumes from aircrafts starting at distances between 100 – 200 m. Overall, 281 take-offs were recorded and 168 aircraft plumes could be analyzed. The engine exhaust was characterized with an Engine Exhaust Particle Sizer (EEPS, 5.6 – 560 nm) and an FT-IR (MKS MultiGas 2030) that provided CO_2 and NO_x. Volatile particles were not removed. The NOx emission was compared with reference engine values from the ICAO database in order to estimate the state of the engine.
Results & Conclusions	The variability of the observed particle number emission indices is high even for the same engine type (Figure 1). This is likely to be caused by the amount of volatile particles in the aged aerosol. The particle mass variability is far less. For instance, the standard deviation of the particle mass emission index is approx. 22% for the CFM56-5B4/3 engine (n = 20). The recorded nitrogen oxide emission indices exceed the values of the ICAO database. These deviations are expected since the NOx emission is affected by the ambient temperature conditions. Nevertheless, the values for "take-off" and "climb" (near to median value) are an acceptable representation for the observed plumes. The SCOPE11 model predicts a non-volatile particle emission in the range between 1.4 – 4.2 *10^16 #/cm³ during take-off at the engine exit plane. This is at the lower end of the box plot analysis of the present data set (Figure 1).
Images	

Caption Figure 1:	 Box plot analysis for the most frequent engine type in the data set. The emission of nitrogen oxides is given on the left together with the respective values from the ICAO database.

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Affiliation	Indian Institute of Technology Bhilai
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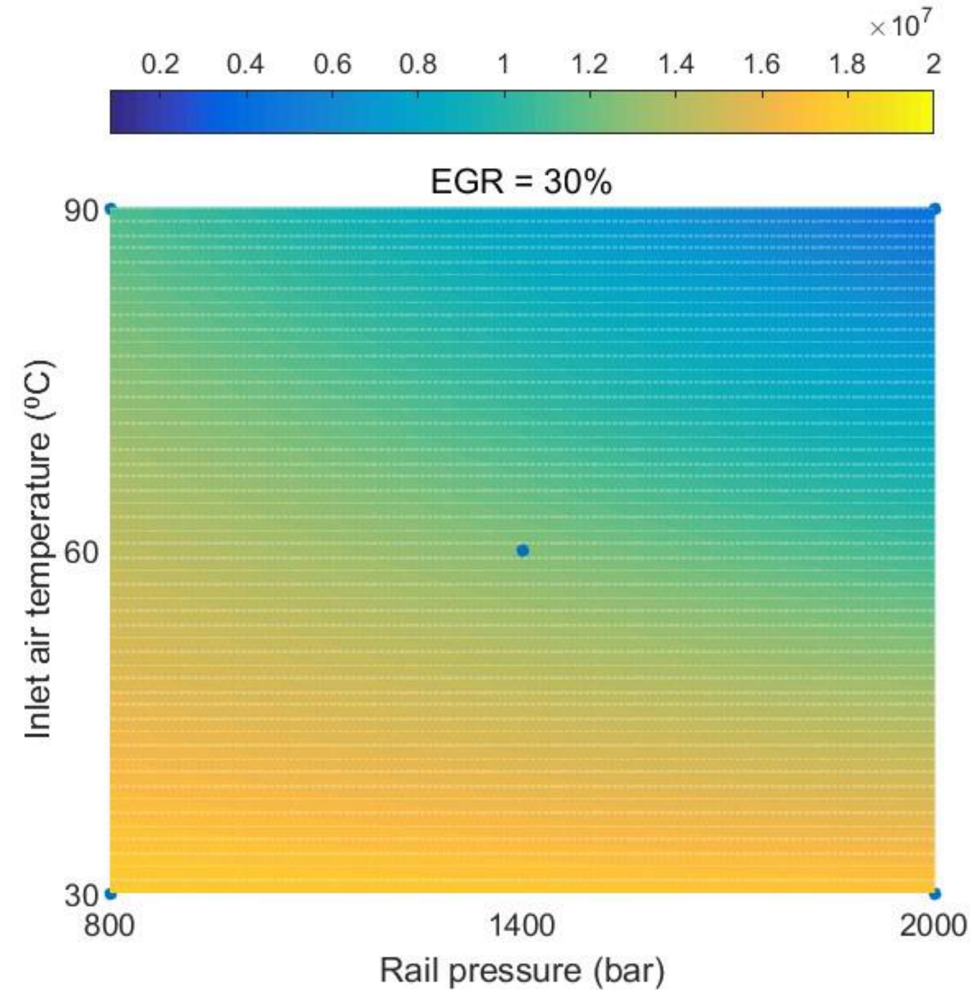
Publication title	Influence of exhaust gas recirculation (EGR), fuel rail pressure and inlet air temperature on the particle number emission from a compression ignition engine fueled with HVO
Publication type	Presentation
Introduction & Background	Introduction of high pressure fuel injection technologies have significantly reduced the PM emission from compression ignition engines. Particulate number emission is one of the major issue in modern vehicles. These tiny particles can be easily inhaled and are probable cause for carcinogenic problems. The present study involves the particle number emission investigation of hydro-treated vegetable oil (HVO) from a modified single cylinder compression ignition engine.
Methodology	The study involves the investigation of particle number emission for three important engine operating parameters; exhaust gas recirculation (EGR), fuel rail pressure and inlet air temperature. HVO and diesel fuels were investigated for regulated emissions, combustion and particle number emission measurement. A six cylinder 13-liter heavy duty engine was modified for operation with a single cylinder. Engine was equipped with an extra high pressure fuel pump (XPI) with a common rail. Exhaust valves, inlet valves, high pressure fuel lines were removed from cylinders 1-5, however piston remained in the engine. This modification facilitated engine to run with a single cylinder. For regulated gaseous emission measurements, AVL AMA i60 model was used which uses flame ionization detector, infrared detector, chemiluminescence detector and a paramagnetic detector for CO, CO2, THC, NOx and O2 measurements respectively. Further, soot measurement (Equivalent Black Carbon) was performed by using AVL (model 483) micro soot sensor which uses a photoacoustic technique. Particle number size distribution was measured using DMS500. DMS500 produces particle number-size spectra by measuring electrical mobility diameter. In the present setup, it was configured to measure particle size in the range of 5-1000 nm with two stage dilution system.
Results & Conclusions	During the experiment, inlet air temperature varied between 30 to 90C and it was observed that total particle number concentration decreased with increasing inlet air temperature at 30% EGR. General trend shows that number concentration increases with higher fuel injection pressure for a given inlet air temperature. Detailed analysis is currently being investigated and will be presented during the conference.
Images	

Caption Figure 1:



Total particle number variation for varying rail pressure and inlet air temperature for HVO at 30% EGR

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Coauthors	Andy Thawko; Harekrishna Yadav; Michael Shapiro
Publication title	Particle emissions of direct injection IC engine fed with a hydrogen-rich gaseous fuel
Publication type	Presentation
Introduction & Background	Thermochemical Recuperation (TCR) is a promising waste heat recovery method that enables utilization of the engine waste heat together with onboard hydrogen production resulting in a significant improvement of thermal efficiency and a dramatic reduction of gaseous pollutants emission. The developed in the Technion High-Pressure TCR approach presumes direct injection of the hydrogen-rich reformate and confirmed its great potential of efficiency improvement and gaseous pollutants mitigation. Most of publications dealt with particle emissions of IC engines fed with hydrogen or hydrogen-rich fuels, considered hydrogen supply to the engine intake manifold. These works reported on reduction of particles emission as compared to gasoline. There is a limited amount of studies investigated engine performance with direct hydrogen injection. No information is available on particles emission by direct injection engine burning a hydrogen-rich reformate and a comparison with gasoline and port reformate injection cases. The main goal of this presentation is to investigate particles formation in a direct injection SI engine fed with a gaseous reformate fuel containing 75% mol. hydrogen and 25% mol. CO_2, and to compare with gasoline and port reformate injection cases.
Methodology	The experiments were carried out with two single-cylinder laboratory engines with very low and very high compression ratios. In all the experiments the same reformate composition was used (75% mol. H_2 and 25% mol. CO_2). Particles concentrations and size distribution were measured with TSI EEPS-3090 instrument. he results of particle emissions measurement with direct injection of the reformate are compared with a baseline case of the same engine fed by gasoline at the same engine load and speed. A comparison of particle emissions by IC engine with direct and port reformate injection was performed as well.
Results & Conclusions	The results of particle number concentration and size distribution measurements show that the total particle number emission of engine fed with the reformate is 170% higher than with gasoline fuel. The particle mass size distribution shows that reformate-fueled engine emits 42% higher mass in accumulation mode than the its gasoline-fed counterpart. The particle size distribution results indicate that a remarkable difference between the particle emissions with the hydrogen-rich reformate and gasoline fuels lies in the nucleation mode. A direct experimental comparison between the port and the direct reformate injection with the same engine prove that the increase in particles formation is a result of the applied direct injection method. We assume that the observed higher particles formation with direct reformate injection are attributed to the lubricant involvement in the combustion process. The peculiarities specific for direct reformate injection that could result in the enhanced particles formation are: jet – lubricated wall interaction, lubricant vapor entrainment into the reformate jet and shorter flame quenching distance of hydrogen compared to gasoline.

	Weichenthal Scott
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Publication title	Emerging Health Impacts of Within-City Spatial Variations in Ambient Ultrafine Particles and Deep Learning for Environmental Exposure Assessment
Publication type	Presentation
Introduction & Background	Traffic and other combustion processes such as biomass burning are important sources of ambient ultrafine particles (UFPs) in urban areas. However, little is known about the long-term health effects of UFPs as only a small number of epidemiological studies have examined the chronic health impacts of these pollutants. This is an important knowledge gap that should be addressed if we aim to develop future regulatory guidelines for UFP number concentrations.
Methodology	This presentation will provide an overview of existing Canadian cohort studies evaluating the chronic health impacts of within-city spatial variations in ambient UFPs including studies of cardiovascular outcomes and cancer. In particular, new evidence related to the association between long-term exposure to ambient UFPs and incident brain tumours in the Canadian Census Health and Environment Cohort (CanCHEC) will be presented. Moreover, we will present a new method of expanding the spatial scale of traditional land use regression models for UFPs that pairs satellite images with deep convolutional neural networks. This new method of exposure assessment allows us to extend exposure estimate to populations not otherwise covered by existing land use regression models for major cities in Canada.
Results & Conclusions	Emerging evidence suggests that long-term exposure to ambient UFPs may have important public health impacts independent of other air pollutants including fine particle mass concentrations. In particular, the potential neurological health impacts of UFPs deserve further evaluation as these pollutants are known to reach the human brain. Innovative approaches to exposure assessment may be needed to facilitate this process, and deep learning image analyses may offer a cost-effect method of extending exposure estimates to large populations suitable for epidemiological analyses.

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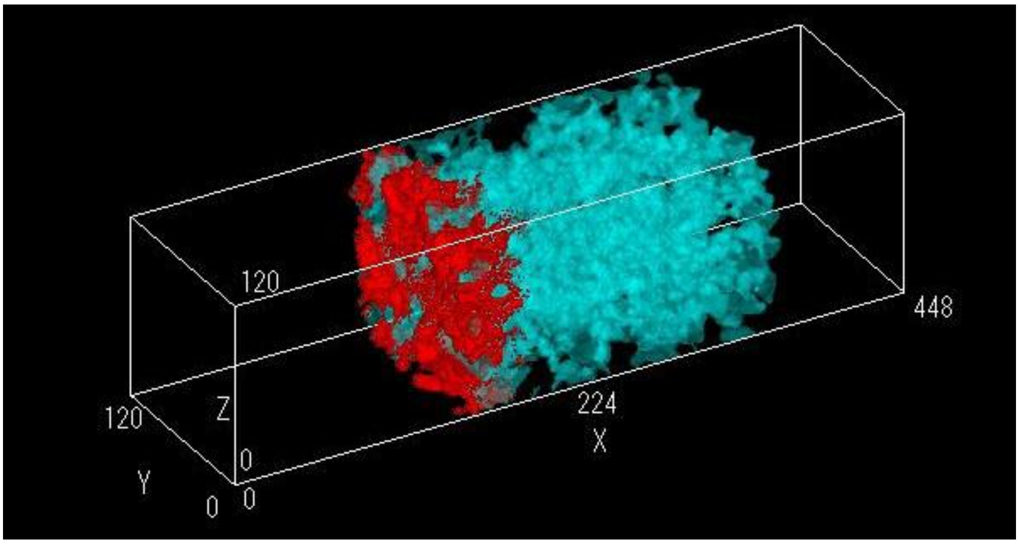
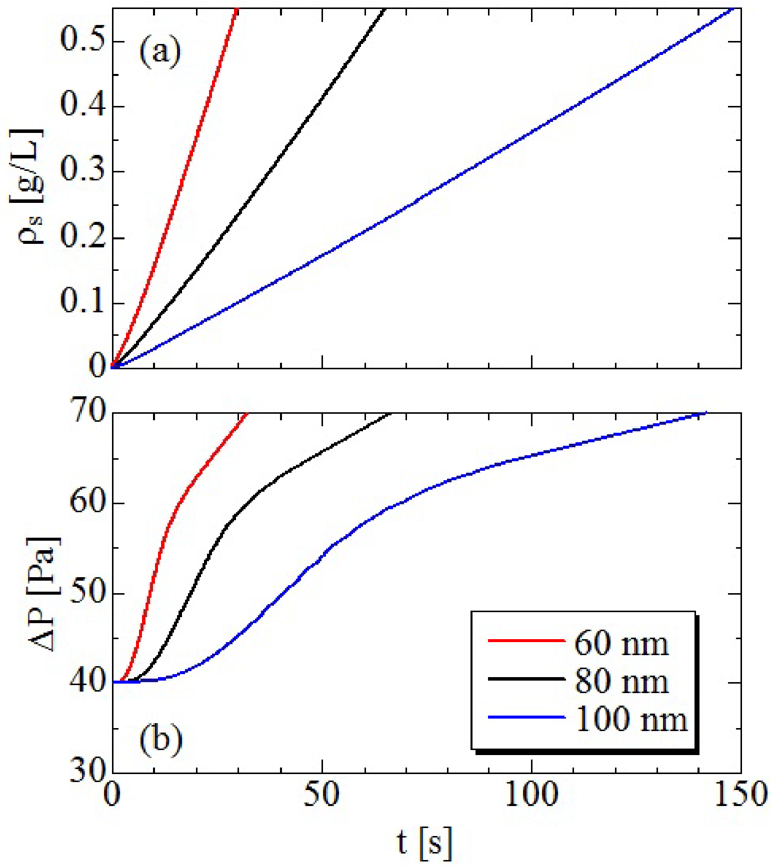
Publication title	Evaluation of Pressure Drop during Filtration of Gasoline Particulate Filter
Publication type	Presentation
Introduction & Background	In Japan, all of automakers have established a research association of automotive internal combustion engines (AICE) in 2014. It is a joint research organization mainly for realizing further improvement of fuel economy and reduction of tailpipe emissions. Like in the European countries, Japanese government will announce a new regulation for PM emissions of gasoline direct injection (GDI) vehicles in 2022, because GDI engines emit considerably higher PM emissions, compared with port fuel injection (PFI) engines. Our group in Nagoya University has started a new research project in AICE to develop a gasoline particulate filter (GPF) which has low pressure drop and high filtration efficiency.
Methodology	Similar to a diesel particulate filter (DPF), it is possible to trap gasoline particulates by using a wall-flow ceramic honeycomb ceramic filter, but the deposited particles inside the filter could be a barrier or block for the flow, resulting in unexpected pressure rise. It should be noted that the size of gasoline particulates is relatively smaller than that of diesel particulates. Also, the gasoline exhaust gas temperature is much higher. Thus, an establishment of a new filtration system with enough thermal durability as well as the lower filter backpressure would be urgently required. In the present study, we numerically simulated a particle trap for discussing the filtration efficiency and pressure drop of the real GPF. Especially, we focused on the parameters of particle size, exhaust temperature, particle concentration, and the exhaust gas velocity. These would be important parameters for optimizing the filter structure.
Results & Conclusions	First, we investigated the effect of soot aggregation size on the filtration process. Figure 1 shows a three-dimensional distribution of soot deposition region inside the filter. The blue region is the substrate of the gasoline filter, which was obtained by an X-ray CT technique. The red region is the soot deposition layer. It is found that soot is mainly trapped on the filter surface, but some of soot could penetrate into the filter along the larger pores. Figure 2(a) shows time-variations of deposited soot mass. The resultant pressure drop caused by the soot filtration is shown in Fig. 2(b). In this simulation, we set the soot size to be 60, 80, 100 nm. Since the soot with different size has different mass, we kept the same mass of soot in the inflow at the filter inlet. Interestingly, the mass of deposited soot is different when the soot size is changed. This corresponds to the fact that the filtration efficiency largely depends on the soot size. Simultaneously, the rise of the pressure drop is different when the soot size is changed. More results will be presented, showing the effects of exhaust temperature, particle concentration, and the exhaust gas velocity.
Images	

Caption Figure 1:	 Three-dimensional distribution of soot deposition region of soot size of 60 nm
Caption Figure 2:	 Time-variations of (a) deposited soot mass and (b) pressure drop by changing soot size

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Coauthors	Michaela N. Ess, Alejandro Keller, Konstantina Vasilatou and Marianne Geiser
Publication title	The role of laboratory-generated soot particles in respiratory health impairment
Publication type	Presentation
Introduction & Background	Atmospheric particulate matter (PM) has been linked to a broad spectrum of health effects including respiratory problems, cardiovascular diseases, dementia and cancer. Thereby, the effects depend not only on physical, but also on chemical properties of PM. However, it has proven difficult so far to disentangle the relative contribution of PM constituents to the reported health effects. The aim of this research is to combine well-controlled and chemically defined synthetic reference aerosol with state-of the-art cell analysis to identify specific aerosol properties, which are responsible for impairing essential functions of the respiratory epithelium. We developed stable and reproducible “tailored” reference aerosols to mimic atmospheric processes. The lab-generated soot particles were then deposited on the primary target tissue of inhaled particles at the air-liquid interface using realistic in-vitro technology.
Methodology	Coated soot particles mimicking the properties of aged carbonaceous aerosols in the atmosphere were synthesized in the laboratory. The soot core particles were generated with a "miniCAST 5201 BC" burner and subsequently mixed with vapors of 1,3,5-trimethylbenzene (TMB) in a photo-oxidation reactor known as Micro Smog Chamber. TMB has been frequently used in previous studies as surrogate for volatile organic compounds of anthropogenic origin. To test effects of aerosol exposure on the respiratory epithelium, we used the (Nano)-Aerosol Chamber for In Vitro Toxicity (NACIVT), a portable exposure chamber with a controllable cell culture environment (37°C, 85% relative humidity and 5% CO2), which can be connected to virtually any aerosol source. We connected NACIVT to the aereosol generation system and exposed the cell cultures to one of the following model aerosols: 30 nm or 90 nm soot particles, uncoated or coated with oxidized products of TMB. Air-liquid interface cultures of fully re-differentiated human bronchial epithelia (HBE) were exposed to the aerosols in NACIVT for 60 minutes. We assessed the induction of cell death by measuring the release of the cytoplasmic enzyme lactate dehydrogenase (LDH) from damaged cells into the apical compartment at 4 h and 24 h after exposure to the aerosol. We further screened 102 cytokines released by the cells into the basal compartment at 24 h after aerosol exposure to evaluate the inflammatory response.
Results & Conclusions	Exposure of HBE to fresh or aged soot particles led to an increase of cell death, as compared to control cell cultures, which either were left untreated in the incubator, or were exposed to particle-free or synthetic air. The highest statistically significant ($p < 0.001$) increase in LDH release was registered after exposure to the 90-nm aged particles. This suggests that secondary organic aerosol (SOA) coating might be important for induction of cell death. This study provides unique insights into adverse effects to the human respiratory epithelium caused by exposure to stable and reproducible laboratory-generated soot particles.
Images	

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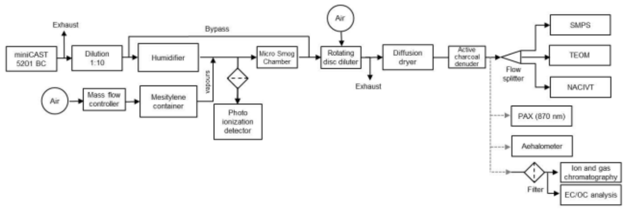

Schematic representation of the experimental setup in METAS
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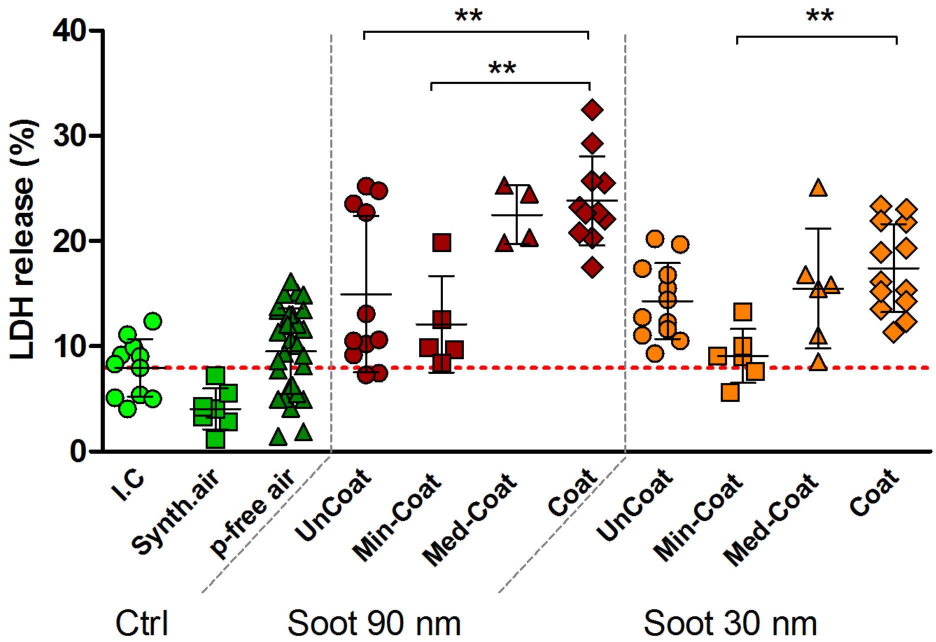

Exposure of HBE cells to fresh and aged soot particles
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Publication title	SUREAL-23 project : Measurement of sub-23 nm particles on Gasoline Direct Injection Engine under various conditions.
Publication type	Presentation
Introduction & Background	Since the Euro 5b regulation, the total particle number (PN) at the exhaust of light-duty vehicles (LDV) is regulated, but the associated protocol developed by the PMP sub-group defined a 50% cut-off at the 23 nm particle diameter to avoid any measurement artefacts. Recent studies have demonstrated that the last generation of Euro 6 engines can emit as many particles in the range 10 - 23 nm as beyond 23 nm. The SUREAL-23 project, funded by Horizon 2020 EU-program, aims to develop sampling, conditioning and measuring instruments and associated methodologies to extend the existing protocol down to at least 10 nm. This communication focuses on the test phase using a modern Gasoline Direct Injection (GDI) engine with a large panel of measurement devices, mixing prototypes and references.
Methodology	Evaluations were carried out on a last generation supercharged GDI engine on the engine test bench, under multiple operating conditions: moderate and aggressive driving cycles, starts at 20 °C and hot starts, with and without Gasoline Particle Filter (GPF). Sampling and conditioning were done with a two-stage dilution system, with a built-in catalytic stripper. Two prototype instruments, Induced Current Aerosol Detector (ICAD) from Fachhochschule Nordwestschweiz (FHNW) and the Half-Mini Differential Mobility Analyzer (HM-DMA) from Sociedad Europea de Análisis Diferencial de Movilidad (SEADM), have been compared to commercial reference soot particle analyzers (TSI SMPS and CPCs, Cambustion DMS500, Magee AE33). Additional tests were done by simulating a typical duty cycle of an hybrid vehicle, alternating the phases where the vehicle runs in pure electric mode and the phases where the thermal engine and the electric motor are used in combination to power the vehicle.
Results & Conclusions	As expected, the results demonstrated extra PN emissions when lowering the 50% cut-off diameter at 10 nm, especially in the absence of GPF. In return, when a catalyzed GPF is installed in the exhaust line, only few additional PN emissions are measured in the 10 – 23 nm range. This can be explained by the good ability of the filter to remove the particles in this 10 - 23 nm range, both solids and volatiles. The start temperature and the driving cycle harshness plays a major role in the total PN emitted on the driving cycle. Even worse, the combination of these two conditions leads to dramatically high emission levels. However, the 10-23 nm particle ratio tends to decrease significantly when the total PN emission levels are high. With regard to the hybrid operating mode, total PN emissions are measured from 2 times to 4 times higher in comparison with a conventional vehicle, depending on the considered driving conditions. In spite of the shorter running time of the thermal engine, the strong puffs of PN that occurs just after each of its restart phase contribute to a negative overall balance.
Images	

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<td>Caption Figure 1:</td>
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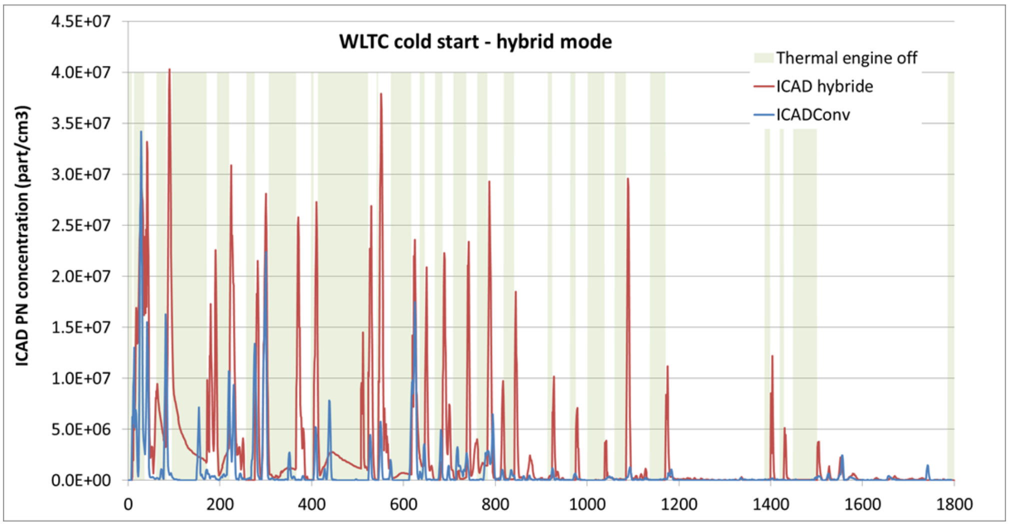

PN emissions and Particle Size Distribution downstream 3WC and downstream GPF
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<td>Caption Figure 2:</td>
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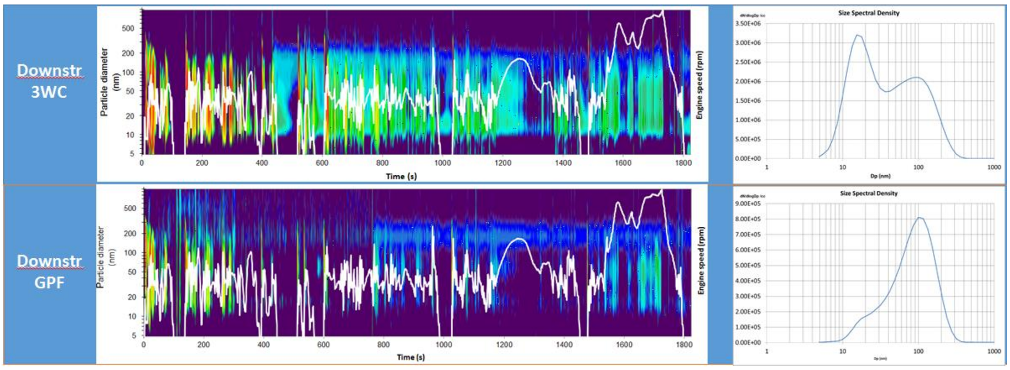

Comparison of instantaneous PN emissions in conventional and hybrid modes
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