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Reference experiment on aerosol particle transport for dynamic situations

Referenzexperiment zum Aerosol-Partikel Transport in dynamischen Situationen

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Abstract: To study airborne transport of aerosol particles by mixed convection and dynamic situations within a closed room, the Cottbus Aerosol Particle Reference Experiment (CARE) was built and equipped, which includes thermal manikins and a spreader dummy. For various flow configurations (location of spreader, heating bodies, windows opened, air ventilation with and without air purification systems) flow visualisation was performed, particulate matter sensors (PMS) measured local particle concentrations, head-mounted camera systems counted particle concentrations of individuals and finally, large field of view Shake-The-Box Particle Tracking delivered velocity fields. The comprehensive experimental configuration of different measurement systems are discussed in terms of their aerosol transport properties and quantitative results, effective application and comparative efficiency explaining the flow dynamics. The findings from these experiments also provide information under which circumstances particularly high concentrations of aerosol particles can be found on which locations.

Keywords: aerosol; particulate matter sensors; PTV; room ventilation; STB; visualization.

Zusammenfassung: Zur Untersuchung des luftgetragenen Transports von Aerosolpartikeln durch gemischte Konvektion und dynamische Situationen innerhalb von geschlossenen Räumen wurde das Cottbus Aerosolpartikel-Referenzexperiment (CARE) eingerichtet, welches mit beheizten Körperdummys und einem Spreaderdummy ausgestattet ist. Für verschiedene Strömungskonfigurationen (Standort des Spreader, Heizkörper, geöffnete Fenster, Belüftung mit und ohne Luftreinigungs-System) wurden Strömungsvisualisierungen durchgeführt, Partikelsensoren (PMS) bestimmten die lokalen Partikelkonzentrationen, ein kopfgetragenes Kamerasystem entwickelt welches Partikelkonzentrationen von Personen misst und zusätzlich lieferte ein Shake-The-Box Particle Tracking mit großem Sichtfeld die Geschwindigkeitsfelder im Raum. Die verschiedenen Messsysteme umfassende experimentelle Konfiguration wird im Hinblick auf ihre Aerosoltransporteigenschaften diskutiert und die quantitativen Ergebnisse, effektive Anwendungen sowie verglichene Wirksamkeit erklären sich aus der Strömungsdynamik. Die Erkenntnisse aus diesen Experimenten geben auch Aufschluss darüber, unter welchen Umständen an welchen Orten besonders hohe Konzentrationen von Aerosolpartikeln zu finden sind.

Schlagwörter: Aerosol; Feinstaubsensoren; PTV; Raumlüftung; STB; Visualisierung.

1 Introduction

The pandemic SARS-CoV-2 started spreading at the end of year 2019. Since then, the world has already observed not only its devastating impact but also the weakness of available scientific information and evidences for an effective prevention. Although, vaccination has widely prevented

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deadly impact on humans but it is still less known, how virus transmission occurs in group dynamics such as in classrooms, briefing rooms or corridors.

Airborne transport of aerosol particles is the main path of SARS-CoV-2, measles and other respiratory virus infections in closed rooms. These aerosol particles are also responsible for the transmission of viruses to other living beings and their direct travel distance varies during different respiratory events such as breathing, coughing or sneezing depending on their sizes. Effects of preventive measures, for example different types of masks, air purifiers and air ventilation within group dynamic scenarios are scarcely investigated and need proper attention. Infection risks must be determined through parametric dispersion studies, which can be done by simulations and experiments.

Jayaweeraa et al. [1] has reported on the travel distances of aerosol particles with a wide spectrum of sizes on different respiratory events such as sneezing, coughing or during simply breathing. In a sneezing event the aerosol particles can travel as long as 7 m along a direct path. Another study from [2] suggested that COVID-19 genes are also present in the respiratory aerosols with mean diameters of $0.25 \sim 0.5$ µm. Particularly, smaller particles expose greater threats due to their infiltration capacity beyond normal masks and high viral loads depending on the place of production in the respiratory tract. Moreover, smaller particles have a much longer life span and travel long distances before sinking to the ground. Kähler and Hein [3] conducted an experimental study on the effectiveness of different masks and concluded, that simple surgical or home made masks does not provide efficient protection against small droplets with a diameter of 0.3–2 µm. Nevertheless, wearing such masks is recommended when no particle filtering respiratory mask is available.

Recently, the complete flow inside a 12 m^3 generic test room including a thermal breathing human model was investigated successfully by using sub-millimetre sized and neutrally buoyant Helium-Filled-Soap-Bubble (HFSB) tracers, pulsed LED arrays and the STB particle tracking technique [4]. Aerosol particle generation and detection systems were also applied to aircraft cabins [5] and train compartments [6]. The most approaches to study aerosol particle transport are in static situations, however, in real world, most situations are rather dynamic with e.g. people walking around, which is expected to have an impact on the aerosol distribution in the room. The factors influencing aerodynamic transmission becomes more complex for public spaces where heating, ventilation and air conditioning (HVAC) systems are also installed. Airborne transmission experiments for group dynamic scenarios have not yet been addressed. In addition, the static optical metrology such as conventional PIV similar to the one presented in Hasanuzzaman et al. [7] or flow visualizations are not sufficient to assess group dynamic scenarios. It is obvious that the dynamics of groups of persons will influence the individual infection risk, keeping security distance in narrow corridors is impossible and inside class rooms the dynamic situations of a moving teaching person and individual movement of students will change the transmission of aerosol particles. In addition, the effect of a ventilation system will also be assessed within the scope of the present manuscript.

The transient and dynamic scenarios are planned to be simulated in CARE, where closed and/or open windows in combination with air purifiers will also be tested. The aim is to investigate how aerosol particles that are exhaled from a model spreader are distributed in the room over time. In preparation, the Cottbus Aerosol Particle Reference Experiment (CARE) was set up and various measurement methods were used to determine the flow fields and, in particular, the aerosol transport and trajectories. Within the scope of this paper, the design and setup of CARE and various measurement methods to investigate the mixed convection and the particle distribution inside the room are discussed. In addition, a new measurement approach with Helmet Mounted Camera (HMC) was tested which will be inexpensive, robust and possible to operate remotely. This device consists of a measuring head, LED light, camera optics and a Raspberry Pi. To assess dynamic scenarios a HMC system is built and numerous PMSs are adapted inside the room, allowing a space and time resolution of the local aerosol particle concentration measurement.

Beside particle counting through sensor and HMCs, subsequently, the flow visualisation is performed for various flow configurations (a combination of different parameters such as location of spreader, heating bodies, windows opened, air purification system used) in order to qualitatively assess the aerosol dispersion. Furthermore, the "Shake-The-Box (STB)" method [4] is applied to get quantitative velocity fields and Lagrangian particle trajectories regarding the flow conditions inside the room. Large field of view 2D STB Particle Tracking delivers long time-series of several square meters sized Lagrangian and Eulerian velocity fields based on $\approx 10^5$ to 10^6 particles per time step.

Improving room ventilation is a well studied discipline [8], but this becomes challenging in terms of dynamic situations. Therefore, different measurement systems offer a combination of measurement data from different aspects, that helps to draw a comprehensive conclusion. The effect of ventilation systems installed in public spaces are still due with effective aero-thermo-dynamic assessment.

2 Cottbus Aerosol Particle Reference Experiment (CARE)

The reference room for aerosol particle transport (schematic presented in Figure 1(a)) is located in Cottbus at Brandenburg University of Technology. The room is divided into three principle segments, main experimental chamber, control room and measurement support chamber. All three segments are thermally insulated in order to prevent the loss of heat. The main experimental chamber has a rectangular shape with height of 2.8 m. One side of this chamber is equipped with four windows and an entrance door is located on the other side of the room. In order to conduct undisturbed measurements without any external influence, control equipment is placed in the control room. The main experimental chamber adjoins the measurement support chamber, where LED light arrays are located, a transparent window is attached within the partition for the optical access from LED arrays. Both the LED arrays and the transparent window are movable, so that the position of the illuminated volume can be changed. In addition, the cameras can also be placed in the front part of the room so that experiments can be carried out in the rear section.

A seating arrangement for 16 students is organized to replicate an ideal classroom scenario, alternating chairs are equipped with heated dummies (see Figure 1(a) and (b)). The energy input created by students is modelled with these dummies, which consists of a black cylinder and an 80 W incandescent bulb. The temperature on the outer shell of the cylinder stabilizes within 40 min to 37 °C.

For various flow situations (location of dummies and spreader, windows open, heater on, air purification systems used) the large-scale behaviour of the convective plumes and rolls are inspected by qualitative flow visualization (Figure 2). The flow visualization was done with a continuous-wave laser (model Ray power 450 from manufacturer Dantec Dynamics with a wavelength of 532 nm and power approx. 0.5 W) and Di-Ethyl-Hexyl-Sebacat (DEHS) particles with ∼0.3 μm size [9]. Figure 2 shows the flow visualization images where heated dummies create significant changes in the room flow, up- and down-washing due to thermal convection is indicated by the yellow and blue arrows respectively.

For extensive studies of aerosol particle transport of different sizes inside CARE, different measurement techniques are applied, leading to different requirements for the seeding particles. The DEHS particles are suited for the general aspect of aerosol transport as they can be seeded very easily and cost efficient while artificial saliva droplets are used for measurements using multiple PMSs. Both are representing the size distribution of aerosol particles exhaled by humans.

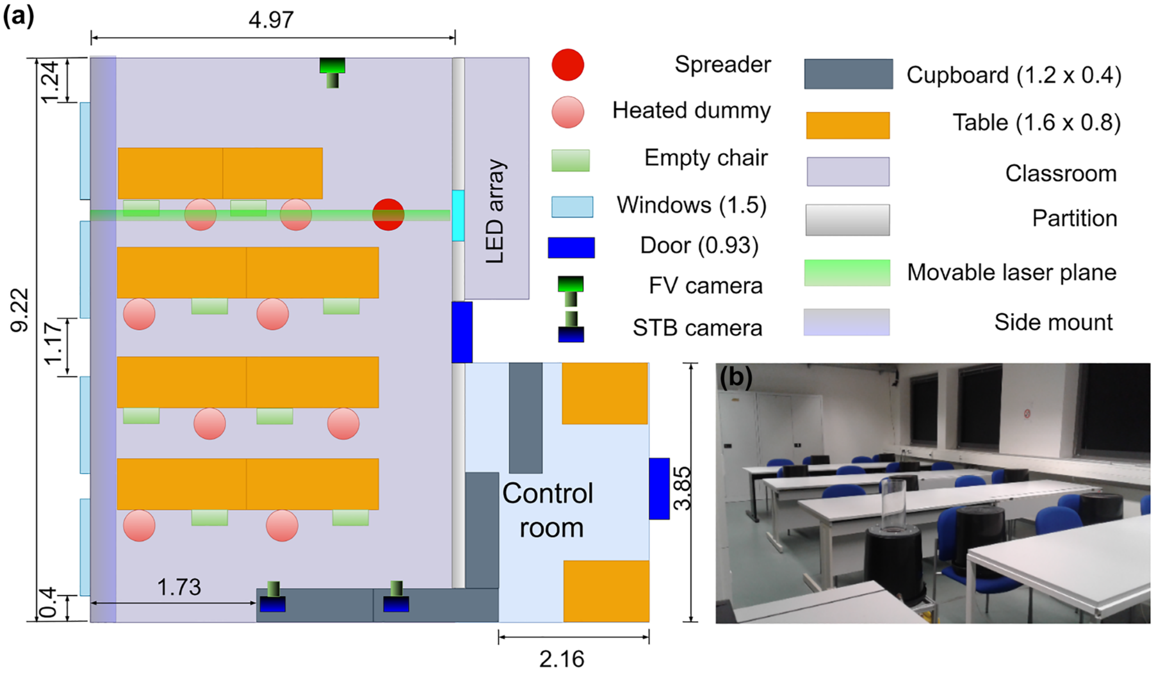

Figure 1: Schematic of the CARE in (a) and photograph in (b). All dimensions are given in meters.

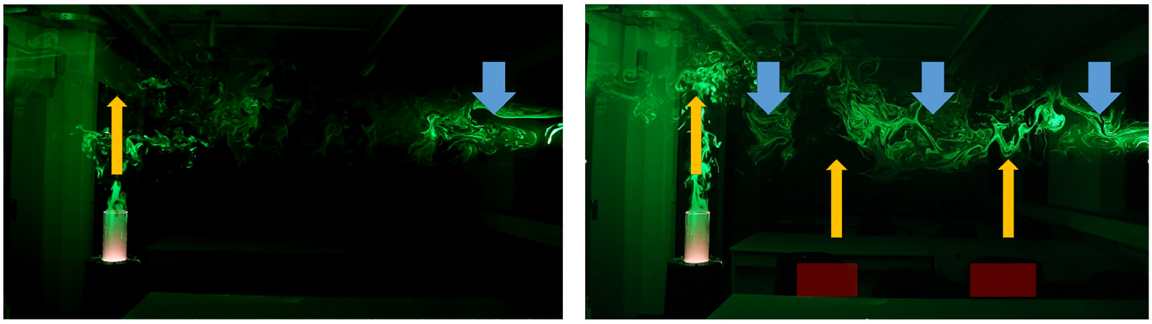

Figure 2: Flow visualization photographs of the case without heated dummies (left) and with heating (right). Here, heated dummies are presented with red boxes, orange and blue arrows indicate the mean movement of the convective plumes and rolls. Flow visualization is performed where the green plane in Figure 1(a) indicated the laser light sheet.

To follow particle tracks by STB or to count them in the head-mounted camera systems, larger particles are needed, where HFSB are used. HFSB are almost neutrally buoyant, thus, mimicing the aerodynamic properties of much smaller aerosol particles under investigation. By means of all three seeding techniques, all essential features of the aerosol transport inside rooms are analysed.

3 Multiple aerosol particulate matter sensors

For the time and space resolved analysis of the spreading of aerosol particles particularly DEHS and artificial saliva particles, an additional measurement system based on multiple Sensirion SPS30 PMSs were applied. The source is based on an atomization system, a reservoir of artificial saliva (according to Nuclear Respiratory Factor or NRF 7.5) and well-defined volume flow rates. This generator is connected via a pipe to a facial mask. For the detection, more than 30 PMSs were distributed in the room. Details can be found in [10]. The data acquisition is accomplished by a mobile measurement system (see [11, 12]). The aerosol generation and detection system were also applied to aircraft cabins [5] and train compartment [6]. The measurement layout of the PMS experiment is depicted in Figure 3(a).

Figure 3(b) shows the time-resolved local aerosol particle concentration measured on the rear right seat next to the aisle for four different cases: no-ventilation (=baseline), an interval window opening, an interval window opening with additional movement in the room, and an air purifier (model TROTEC TAC V+ with a HEPA Filter running at a flow-rate of 600 m^3/h. For the case with no ventilation (purple), the aerosol particle concentration significantly starts to increase after about 15 min of starting the aerosol emission. Until this point in time, the saliva/DEHS did not reach the sensor position. After this instant in time, the concentration increases rather monotonic reaching values up to 1200 particles per cm^3 towards the end of the measurement run. In contrast, the case with air purifier and movement (green) reveals much earlier increase of the local concentration, even before the person starts moving (black dashed line). The additional air flow in the room, induced by the air purifier, leads to a faster transport of the particles to the rear of the room. However, with the start of the movement, stationary aerosol particle concentration around 350–400 particles per cm^3 are found. Here the additional mixing in the room in combination with the cleaning capability of the air purifier balances the aerosol production rate of the source. The two window opening cases without (blue) and with (red) movement reveal similar concentration developments, both showing strong decreases of the concentration during window opening (light green areas). During this five minutes window opening period the local concentration falls by around 700 particles per cm^3. However, the additional movement in the room induces an additional air mixing in the room, which transports the saliva/DEHS faster to the rear (compare blue and red curve in time interval 10 min–20 min).

Figure 4 presents the time averaged particle concentration for selected sensor positions and cases. Here only cases are shown, where stationary particle concentrations were reached, i.e., no interval window opening (except the no-ventilation case). In Figure 4(a), the no-ventilation case reveals very high concentrations which decrease with increasing distance from the source (S). All other presented cases show much lower values and more homogeneous distributions in the room. Here the case with the purifier on 750 m^3/h (Figure 4(b)) shines out with lowest values. The case with the tilted windows (Figure 4(d)) reflects lowest values in the centre of the room close to the windows (left

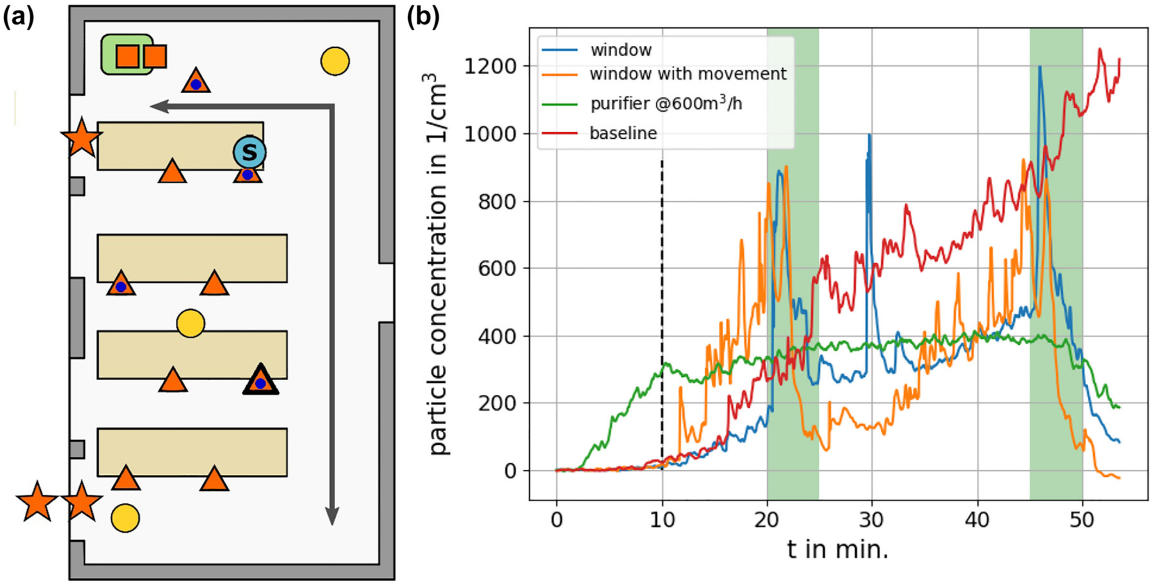

Figure 3: Particle concentration measurements conducted inside CARE. (a) Measurement configuration inside CARE. Sensor positions: triangle: on 1.1 m height, circle: four sensors on different heights, star: in window area (inside and out-side), square: suction and exhaust of air purifier, blue dots: locations for comparison with head mounted measurement systems, bold lined triangle indicates position depicted in (b). The arrow reflects the pathway of the movement. Windows are located on the left side of the room. The aerosol particle source, marked as *S*, is located on the front desk at the right end. (b) Local aerosol particle concentration [1/cm^3] at the location, indicated by bold lined triangle in (a), at aisle at 1.1 m height for no-ventilation (red), with air purifier turned on (green), with interval window opening (blue) and interval window opening with a moving person (orange). Light green background highlights periods of window opening. Vertical dashed line marks start of movement.

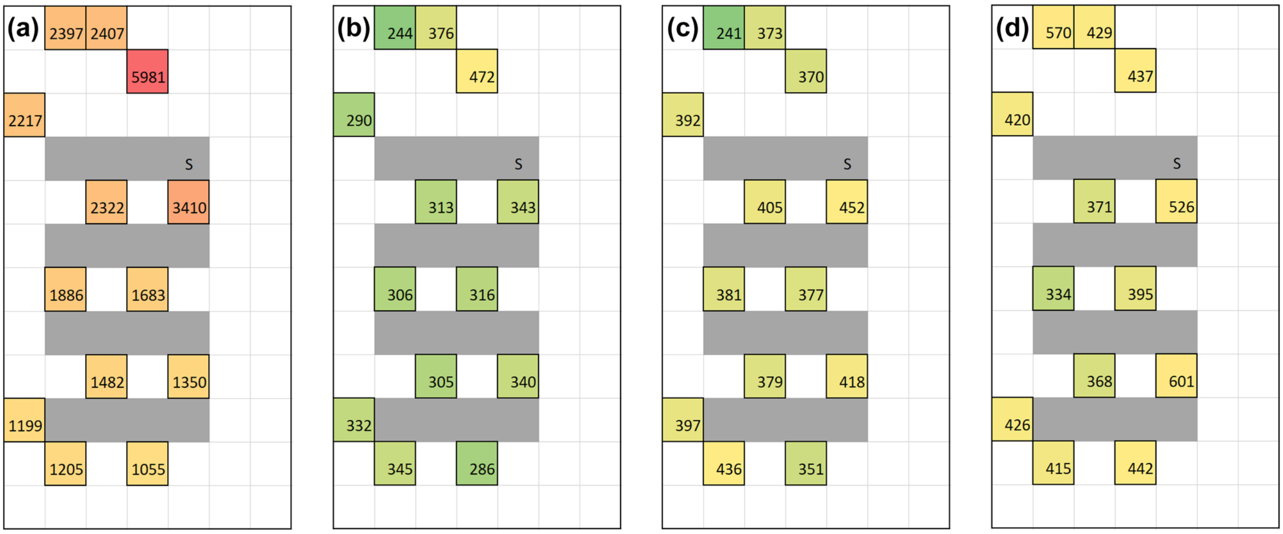

Figure 4: Spatial distribution of mean particle concentrations [1/cm^3], averaged over 300 s during stationary conditions, on breathing level of seated persons (1.1 m height) for four different test cases, (a) no-ventilation, (b) purifier at 750 m^3/h, (c) purifier at 600 m^3/h and (d) windows on tilt.

side), which increase in front, rear and side of the room. The briefly presented results in this section highlight two main points; firstly, the value of these fast, cost-efficient and easy to install measurement technique providing spatial and temporal resolution. Secondly, they show the clear effect of the different ventilation cases on both, the spatial particle distribution and the time-development of the particle concentration.

4 Large field of view Shake-The-Box particle tracking

In addition to the aerosol particle concentration measurements, experiments were conducted to investigate the mixed convective flow in a large-scale planar subvolume with 40 cm thickness in the front area of the model classroom using a 2D-Lagrangian-Particle-Tracking (2D-LPT) approach based on the volumetric Shake-The-Box (STB) algorithm [4]. Similar to [13], a corresponding 2D-LPT set-up is employed, while the reference case without moving people, open windows or running room air purifier is considered presently. Two 2.8 m long pulsed linear LED arrays with collimating lenses, developed in-house by the German Aerospace Center (DLR) were installed opposite a mirror array to produce a wide beam illuminating a 5 m × 2.8 m plane in the front row of seats (Figure 2). Two Bonito-PRO X-2620B cameras with a pixel size of 4.5 µm and a resolution of 5120 × 5120 pixels equipped with $f = 50$ mm Nikon lenses in the back of the room were used to acquire particle images with a greylevel depth of 10 bits. The German Aerospace Center (DLR) in Göttingen provided both LED arrays and cameras. Image acquisition and LED illumination were triggered synchronously with 38.5 Hz in order to resolve the Lagrangian particle tracks as well in regions of higher velocities. These appear especially in the thermal plumes created by the heated dummies, in vicinity to the air purifier or with opened windows. Due to the large volume, only particles that reflect a sufficient amount of light can be considered as seeding material. HFSB meet this requirement due to their mean size of 350 µm and their favorable reflection properties. To fill the room with neutrally buoyant particles a HFSB generator from LaVision with 130 nozzles was used. Due to the large number of nozzles, a sufficient particle density could be achieved despite the large illuminated volume and the mean limited lifetime of approximately 97 s [14] of the HFSB. To exclude influence of the momentum of HFSB generation onto the flow situation, image acquisition was started two minutes after seeding.

First, a camera calibration and the estimation of the particles Optical Transfer Function (OTF) for each camera and sub-plane has been processed [15]. The process determines the parameters of the average shape of particle images in dependence of the position on the camera sensor. Then the STB algorithm [4] has been applied to the series of time-resolved particle images from the two cameras. A two-pass 2D-STB approach was employed, which first tracks forward in time, then reverses the image order and elongates existing tracks backward in time, while reconnecting possible track-fragments. The special feature of the STB algorithm is not only the prediction of the particle's positions in the next time step by extrapolation of already existing tracks, but as well the corresponding correction of this predicted position by using the previously determined OTFs and a local steepest gradient method ('shaking'-approach). Each particle position is then adjusted via an iterative process (shaking), so that the intensity of the residual image is minimized. The resulting particle tracks are stored after a temporal filter using third order B-splines with optimal weighting coefficients is applied [16].

Figure 5 contains the Lagrangian particle tracks from both (partly overlapping) camera perspectives. Since the wide light section of about 40 cm thickness shows particle tracks one behind the other, the three-dimensional

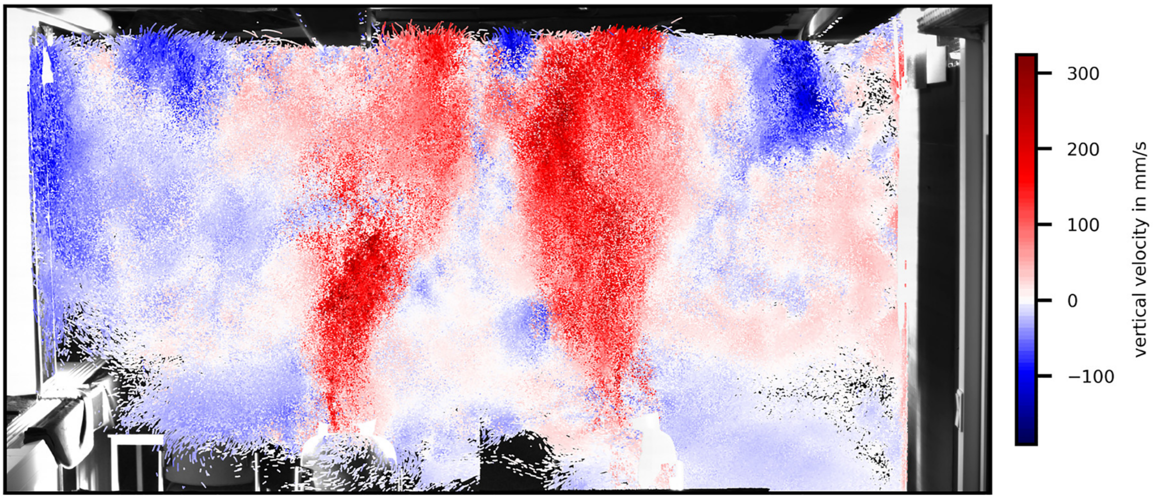

Figure 5: Lagrangian particle tracks of the reference case with no windows open, room air cleaner turned off, and no people moving. The tracks in the foreground are color coded with the vertical velocity component, while a negative of the classroom can be seen in the background.

nature of the flow can be observed. Using long time-series of particle images and corresponding Lagrangian particle tracks a bin-averaging procedure allows to create mean and Reynolds stress statistics. On the other hand, transient processes of dynamic conditions and their effect on the particle transport properties and respective flow structures can be investigated.

Using long time-series of particle images and corresponding Lagrangian particle tracks a bin-averaging procedure allows to create mean and Reynolds stress statistics. The time averaged flow velocity over the complete measurement time of 230 s is visualized in Figure 6, showing the swirling motion induced by the thermal plumes at the ceiling of the room. It should be noted that the flow is only approximately stationary. Our 2D-STB approach is also able to assess transient processes of dynamic conditions and their effect on the particles transport properties and respective flow structures. In addition, the particles transported from a hypothetical spreader to other people can be visualised and counted to assess the risk of infection in different situations. These investigations as well as the statistics of the cases with open or tilted windows and air purifiers will be published separately.

5 Head-mounted camera systems

The measurement of the number of HFSB particles inhaled by people is only possible with devices worn on the body, as movement itself has an influence on the aerosol particle concentration. To ensure the safety of the test persons, the particles introduced for measurement must not be inhaled. A simple way to ensure this is to use buoyancy neutral HFSB as seeding particles, as they can easily be filtered through a FFP2 mask due to their size. Therefore an inexpensive head-mounted camera system to detect HFSB with a diameter of approximately 350 µm was developed. These buoyancy neutral particles are detected and counted with an integrated particle detection algorithm. The head-mounted part consists of a Dräger full face mask and a 3D printed inlet, instead of the usual gas filter (Figure 7 left). The inlet has a diameter of 11 cm. A tripod with a camera is attached above the inlet

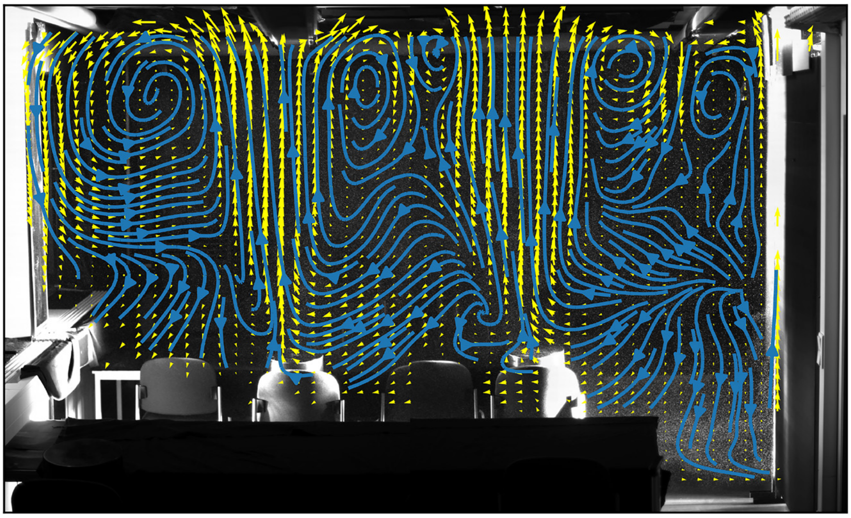

Figure 6: Mean velocity (yellow) and streamlines (blue) for the reference case with a negative of the classroom in the background.

Figure 7: Dräger mask with power bank and single board computer. Center: Inlet with camera mounted on a tripod. Right: Helium-filled soap bubbles (HFSB) captured with the head-mounted camera system (enlarged).

(Figure 7 center). It faces perpendicular to the inhalation hole and is connected via an elongated ribbon cable to a Raspberry Pi single board computer. The measuring area is illuminated with a ring light, which creates a light sheet that is about 1.5 cm thick. The HFSB that pass this area are detected by a standard Raspberry Pi V2 camera based on a Sony IMX219PQ sensor (Figure 7 right). It has a resolution of up to 3280 × 2464 pixel. The camera distance is around 7 cm away from the light sheet plane of LED ring light. The whole system (Raspberry Pi and LED ring light) is powered by a standard power bank with a capacity of 15 Ah in a small bag that is worn on the body. To supply the ring light with the needed voltage, a step-up converter is used to convert the 5 V to the needed 12 V for the LEDs. A charging station to easily recharge multiple power banks at once is also provided.

All computers are accessible via a local Wi-Fi network using a high-speed WiFi router. Each single board computer is assigned to an individual static IP address and can be controlled via a simple web-based user interface, which offers a live video stream of the camera view. The web front-end allows the user to control basic settings like resolution, contrast, brightness, ISO and shutter speeds. Furthermore, the experimenter can set the calibration values for the horizontal and vertical pixel resolution and define a detection passe-partout within the camera view. Various commands like capturing still images, videos, image sequences or starting the integrated object detection can be triggered. Because all commands are simple HTTP requests, the cameras can also be remote-controlled by a script without the use of a graphical user interface. The recordings are stored on the device itself and can be downloaded from the provided web interface. In addition to the standard user interface, a master camera administration application is provided. Most of the options which are available to control a single camera are also available in a broadcast variant in this application. Commands like the image capturing functionality can be triggered for all cameras with a single request. The web-based software and the camera control logic was written in Python and is running on a stripped-down Raspberry Pi Linux operating system. When the system is switched on, the camera application starts automatically as a system service. In case of an error, this service will be automatically restarted. The head-mounted camera systems were additionally equipped with PMSs so that they are also able to measure particles in the order of magnitude of those exhaled by humans. Therefore, both DEHS and saliva can be used as seeding material. It is simpler to generate DEHS particles, as the generators required are available on the market, whereas saliva has to be generated using a DLR Göttingen in-house development. On the other hand, saliva particels reproduce the size distribution and evaporation characteristics of real exhaled aerosols better than DEHS. To check whether the head-mounted devices with DEHS seeding give comparable results to the distributed PMS with saliva seeding, four of them were attached to the dummies at the locations shown in Figure 3.

The scenario of continuous seeding for 45 min without ventilation served as a comparative case. However, instead of saliva, HFSB and DEHS was used as seeding particles. An array of 20 nozzles generated the HFSB, which were then fed into a flexible tube that served as an outlet. HFSB production requires a higher volume flow rate than the saliva source and thus, exceeds the mean exhalation flow rate for a calmly sitting person by a factor of about 13. A larger volume flow was also used for the DEHS source, so that the flow rate was exceeded only by a factor of 1.3 approximately. A preliminary experiment has shown that the results of the

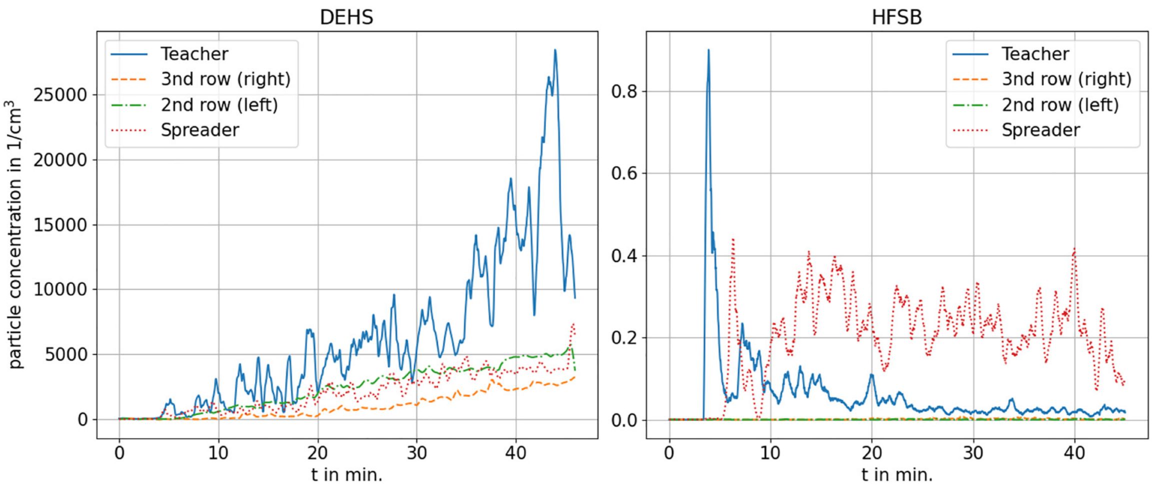

Figure 8: Local HFSB and DEHS particle concentration on breathing level of seated persons on four positions.

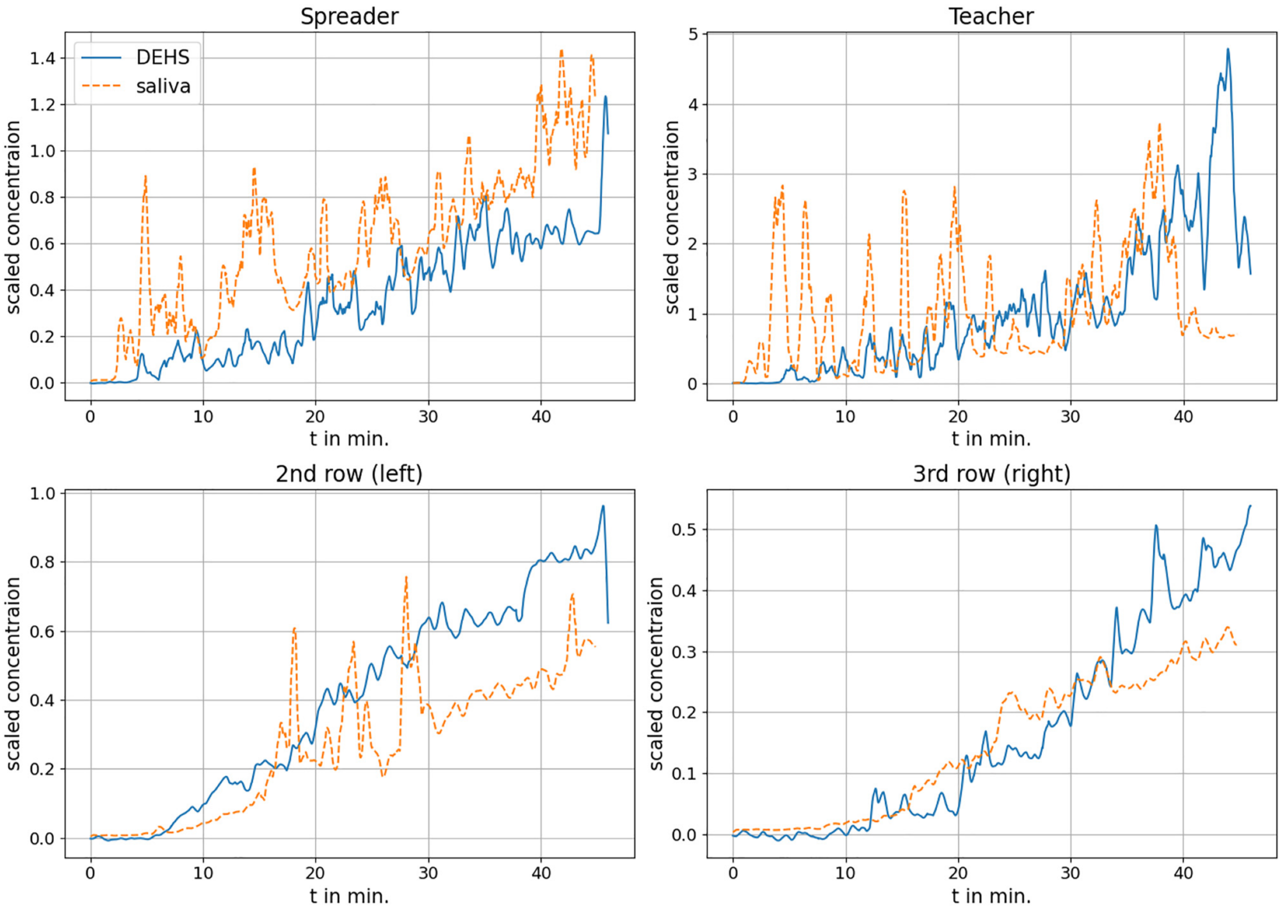

Figure 9: Comparison of the scaled local particle concentrations of the DEHS measurement with four head-mounted measurement systems with the result of the saliva measurement (no ventilation case).

particulate matter sensors are distorted by seeding with HFSB, so the runs using the different seeding devices were performed individually.

Figure 8 shows the time-resolved local HFSB concentration measured with the camera system and the local DEHS concentration measured with the particulate matter sensors attached to the devices respectively. The data demonstrates that the camera-based approach leads to substantially different results than the particulate matter sensors. Although the different flow rates of the DEHS- and saliva seeder limit the comparability of the results, it seems reasonable to assume that the relatively small number of HFSBs and their limited lifetime is the main reason for the qualitative differences. Figure 9 shows a comparison of saliva and DEHS concentrations relative to the mean concentration at the spreader position over the entire 45 min. Given the unsteady nature of the flow, the results are in good agreement with each other. It can be concluded that the different characteristics of the DEHS and saliva particles in terms of their evaporation property and size distribution do not seem to have a major impact on their transport behaviour for the aero-thermo-dynamic flow investigated here.

6 Conclusions

A reference room for aerosol particle transport was established at BTU Cottbus-Senftenberg (CARE), where various classroom situations were analysed using seated thermal manikins, inducing turbulent thermal plumes and mixed convection flows inside the test room. Four measurement techniques with different approaches were applied to reveal the flow fields with a focus to the particle count, aero-thermo-dynamic transport and accumulation. The experimental configuration of simultaneous particle counting, tracing and velocity measurements have been discussed in details.

As a source of preliminary qualitative analysis, flow visualisation is performed to study various configuration matrices (a combination of different parameters such as location of spreader, heating bodies, windows opened, air purification systems used). Later, a more quantitative approach by 2D-LPT using STB was used to obtain long time-series of velocity fields in a large field-of-view. Local particle concentration for the different configuration were counted using PMSs.

The study was further extended towards the assessment of measurement equipment for use in dynamic situations. Evaluation of the moving dynamics will complement the particle counting of potentially inhaled aerosol particles at the locations of the target individuals with static sensors.

Within the present literature, the novel prototype of body-worn measurement system have been designed and tested which is capable of measuring HFSB particles. The results from HMC system along with the particle detection algorithm have shown that the camera-based approach is not yet comparable to the capabilities and accuracy state of the other methods presented here, because of the low number of detected HFSB. However, some changes in the experimental setup have the potential to make this measurements applicable too. These include the usage of more nozzles, using HFSB soap with a longer lifetime and choosing a scenario with more movement leading to an increased particle density in the measurement volumes. We have extended the HMCs with PMS so that smaller particles like DEHS or saliva can also be used as seeding for the dynamic experiments with moving people.

Moreover, results from PMS along with the DEHS particles showed a high degree of comparability with the results from PMS using saliva particles. It is therefore recommended to use both DEHS and saliva as seeding material for similar aerosol transport experiments.

Summarizing, the CARE facility was set up to study aerosol particle transmission in class rooms for various situations. Measurement techniques to reveal the local particle concentration in various flow configurations are established and validated and a large field-of-view 2D-LPT system has been applied to understand the global flow features inside the room quantitatively. The experiment and the measurement systems are used to study first configurations of different situations inside a class room. In a further study, the dynamic situations involving several moving persons in combination with the above described measurement techniques will evaluate the amount of potentially inhaled aerosol particles at the individuals. Finally, the combination of these measurement devices and approaches will allow us to study dynamic situations in public spaces such as public transport, supermarkets, cultural events, restaurants etc. and subsequently, the effectiveness of preventive measures such as masks, social distancing, air purifiers and so on can be assessed.

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