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Commute exposure to ultrafine particles in the city of Basel, Switzerland

Background. A better understanding of exposure to ultrafine particles (UFP) in different transport microenvironments and the determinants is crucial for epidemiological exposure assessments as well as for policy intervention considerations.

Aim. Our study primarily aims to explore variability in personal exposure to UFP among five modes of transportation (bus, tram, car, walking, and bicycle) as well as in urban locations in the city of Basel, Switzerland. Additionally, we aim to assess the quantitative contribution of various commuter exposure determinants such as meteorological, traffic, route and temporal on personal exposures.

Methods. Three approaches are adopted. Firstly, personal measurements are done in different urban areas and transport microenvironments along a predefined route. The routes cover different urban areas as well as typical commute microenvironments such as bus stops and train stations. Measurements are taken twice a month on a Wednesday and Thursday morning in three seasons. Secondly, repeated measurements in various modes of transport on the same route are carried out. Samples are collected in three time slots: weekday rush hour, weekday non rush hour and weekend. During a measurement day, samples are collected four times (twice in each direction) for each mode and each time slot. The length of the route (class 1 main road) is 2.6km. Finally, the contribution of commute exposure to total daily exposure as well as the influence of the route in the commuter's personal exposure is explored. In particular, we investigate the effects of choosing a high and a low exposure route in urban streets when commuting by bicycle between home and work place. Measurements were carried out in three seasons during different times of the day and week in 2011. A portable miniature Diffusion Size Classifier (miniDiSC) is used to measure particle number concentration and average particle size in the range of 10 to 300nm.

Results. The personal in-transit exposure to UFP on a main road was found generally higher during rush hours than outside rush hours with higher levels in the morning. The averages of median trip UFP concentrations were higher in car (40'000p/cc), bicycle and walking (29'000-33'000 p/cc) compared to public transport (22'000-27'000 p/cc). In addition, we observed higher variability in exposure for the active modes, especially for bicycle, indicating the possibility of multiple exposure determinants. During weekends, the exposure levels were similar for all modes (10'000-16'000p/cc). The average particle size distribution diameter in transit was 48 ±9nm.

24-hours personal measurements showed an average daily exposure of 8'000 ±3'071 (particle size 63 ±20nm). Mean UFP exposure levels at home and at work were ~7'000p/cc. Comparatively, daily outdoor levels at a fixed station in Basel were 11'556 ±2'608 p/cc. Traveling along main streets by bicycle between home and work place (~25min) contributed 21% to total daily exposure in winter and 11% in summer. Avoiding main roads seems to reduce the commute exposure by one half in the city of Basel in all seasons.

Conclusions. Our results indicate an effect of transportation mode, season, time of day and week as well as road characteristics on commute exposures. Quantitative assessment of potential determinants of commute exposures using various statistical methods is underway.

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Epidemiology and Public Health
Environmental Exposures and Health

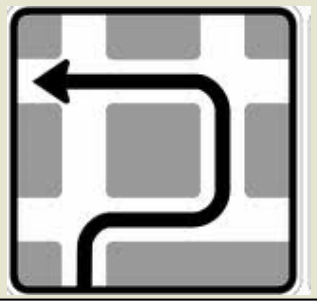
ETH Conference on Combustion Generated Nanoparticles, June 25-27, 2012

Commute exposure to ultrafine particles (UFP) in the city of Basel, Switzerland

Martina Ragettli, Harish C. Phuleria, Charlotte Braun-Fahrländer, Elisabetta Corradi, Christian Schindler, Mark Davey, Nino Künzli

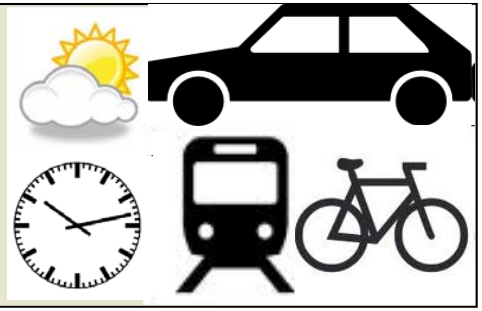
Commute exposure to ultrafine particles: Areas of interest

Health effects & exposure assessments



Spatial exposure differences

Exposure determinants



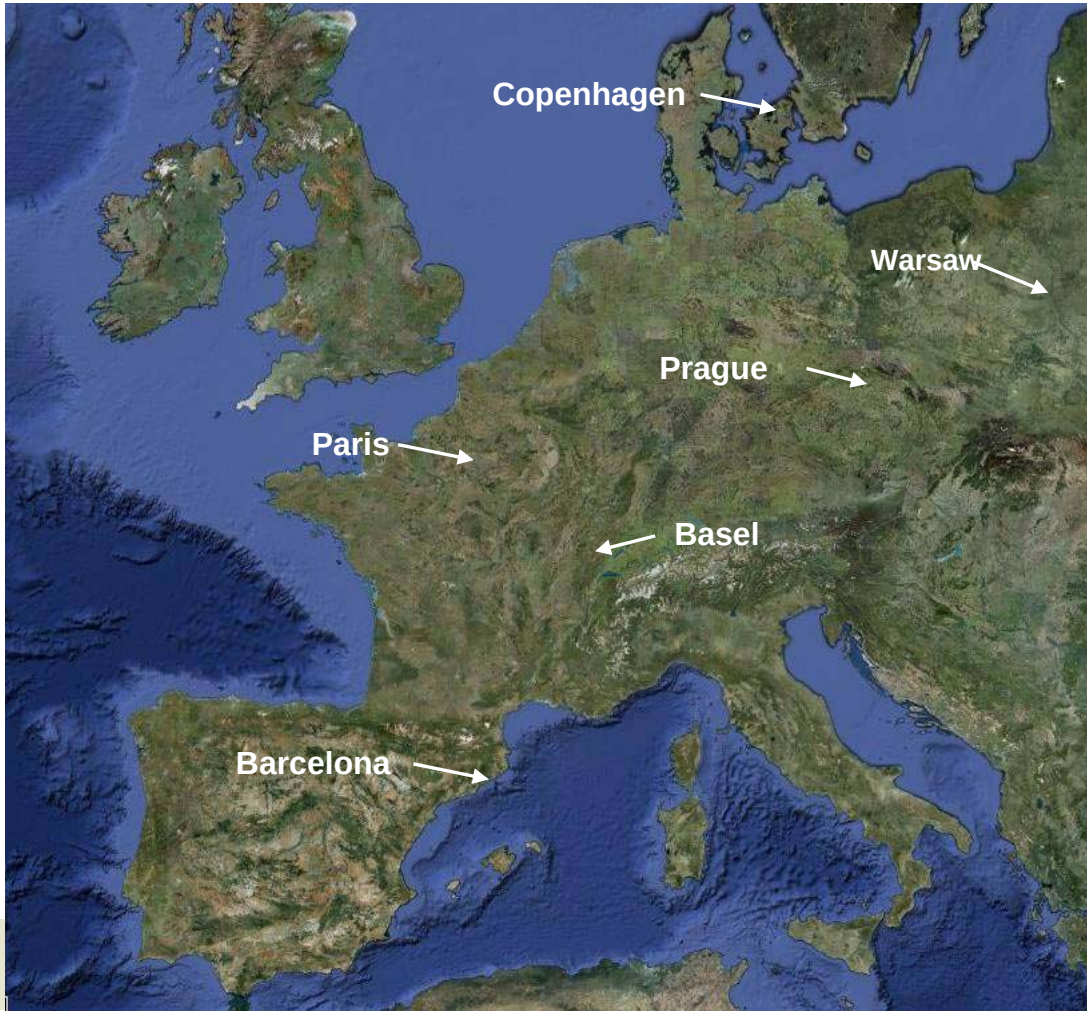
Investigation of commute exposure to ultrafine particles (UFP) in 2011

1. in different **urban areas** & **transport microenvironments**
2. in different **modes of transportation**
3. Difference between main street & avoid-main-street **route**
4. **Contribution to total daily exposure**

Swiss TPH

Project „TAPAS“ Transportation, Air pollution, and Physical Activities

tapas
ACTIVE TRANSPORTATION
HEALTH IMPACT ASSESSMENT



Coordination:
Centre of Research in Environmental Epidemiology (CREAL) in Barcelona

www.tapas-program.org

Swiss TPH

BASEL

- **171’000** Inhabitants
- Public transport, active transport **policies**, since many years
- **~50%** of households without car

Air quality levels 2011:
PM10 22 µg/m³
NO2 29 µg/m³
PN 11’160 p/cm³ (background)

Instruments being used

- **MiniDiSC**: particle number concentration (10-300nm) & average particle size
- Personal Data Ram (pDR): PM2.5 (filter-based analysis)
- HOBO: Temperature and relative humidity
- GPS

MiniDiSC

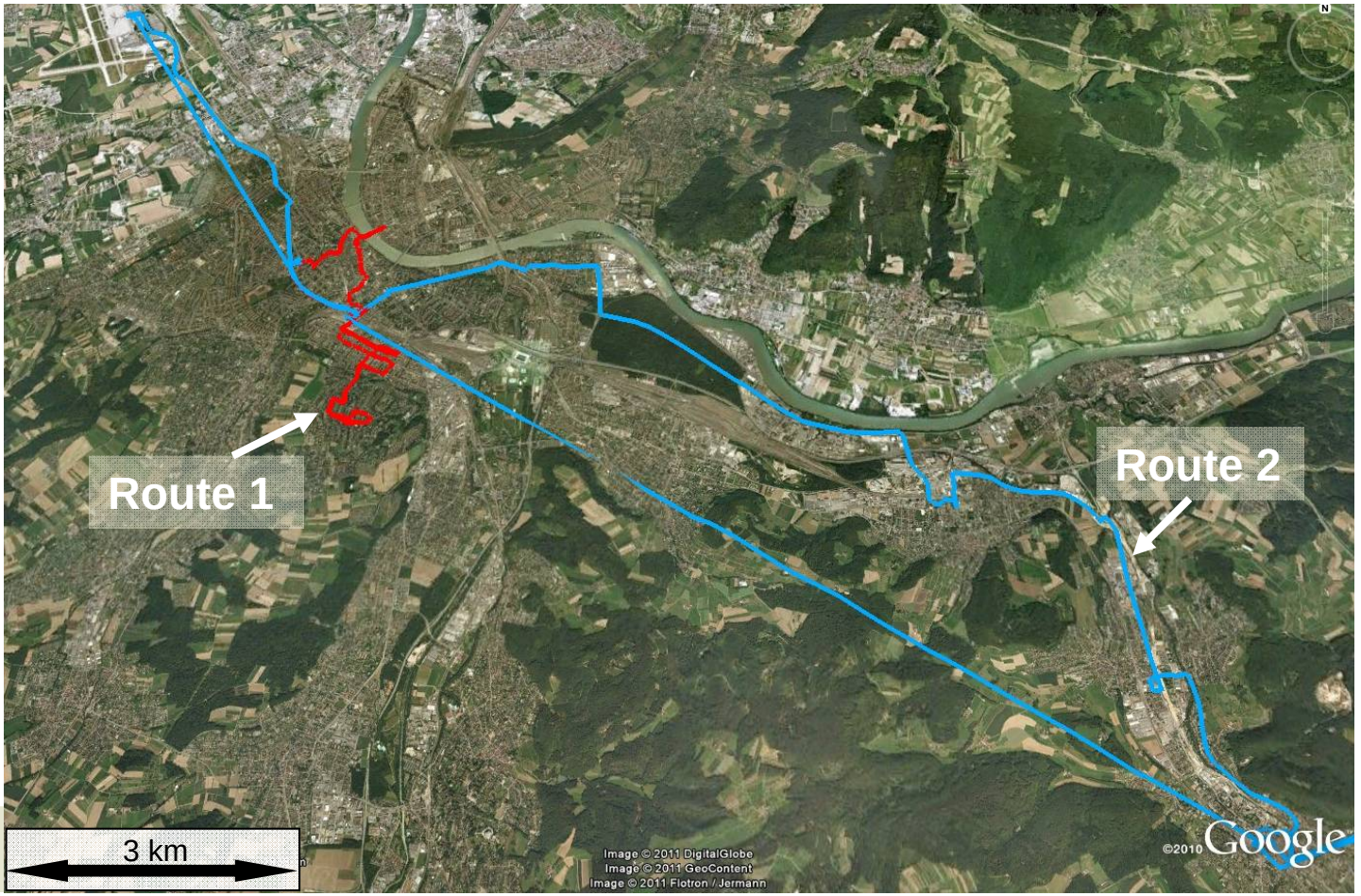
Personal pump for pDR

pDR

Three measurement approaches have been designed

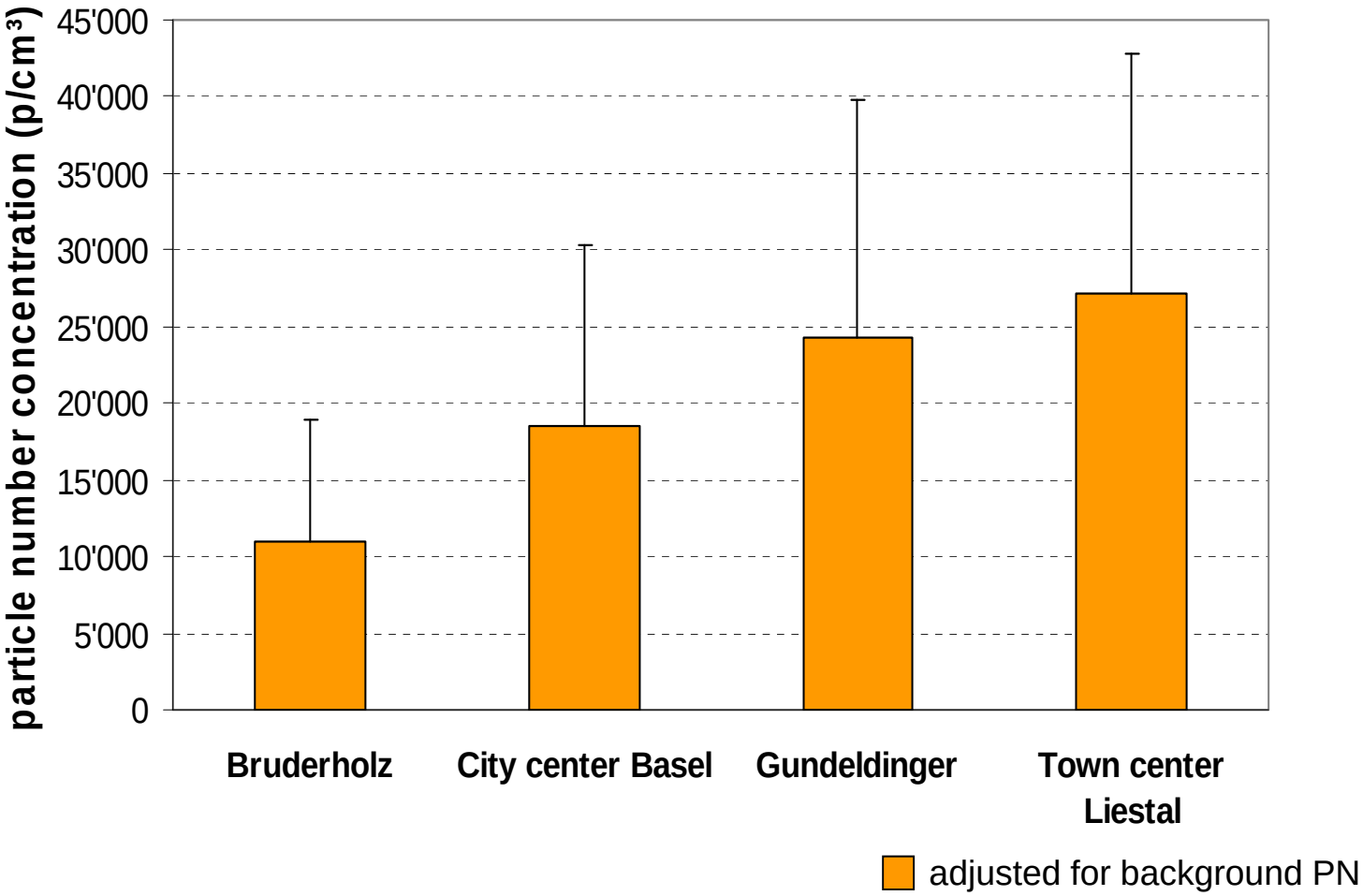
Approach 1: Different (sub)urban areas and microenvironments

Measurements:
2 pre-defined routes
Jan – Sep 2011

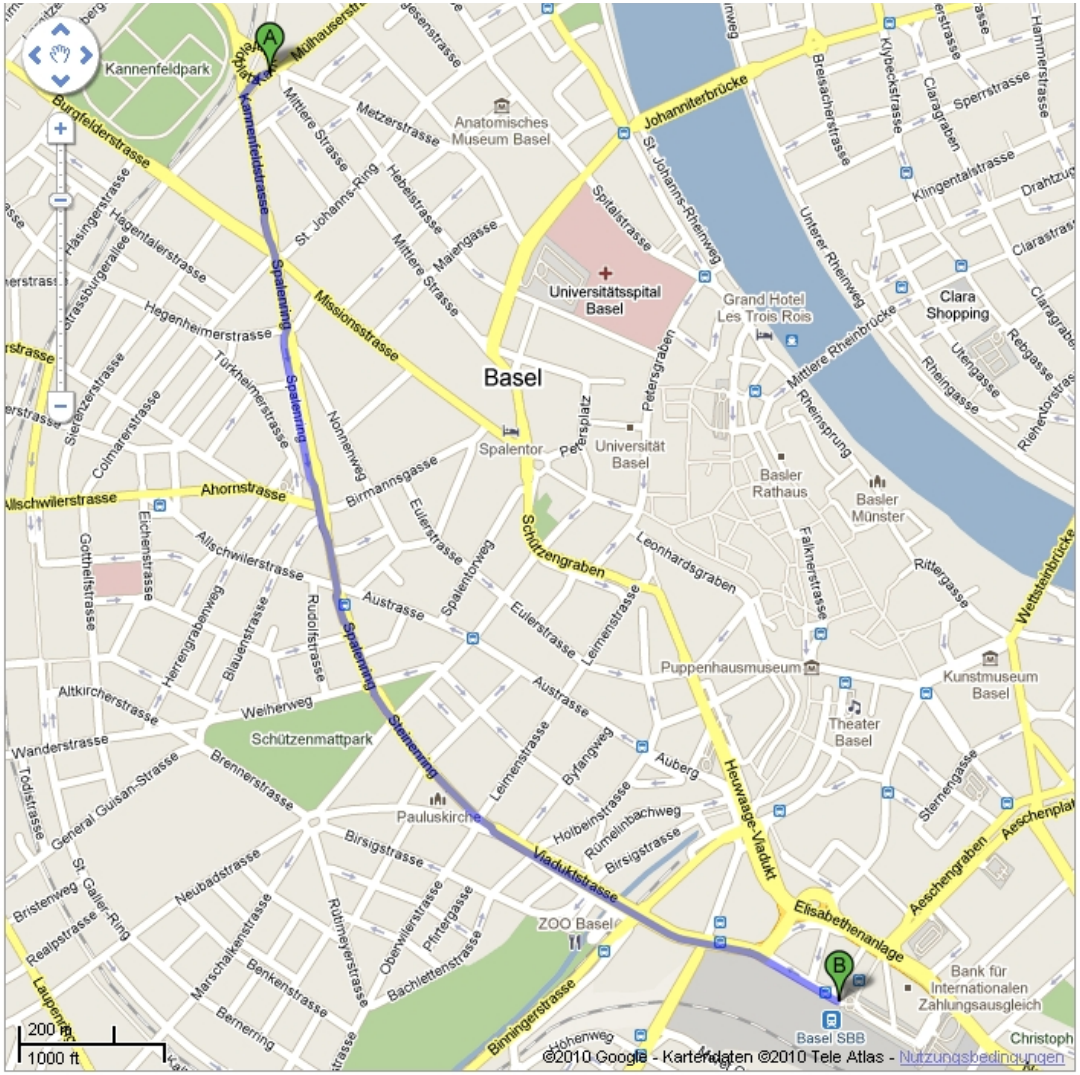


Walking outdoors in different urban areas (8days in 3 seasons)

mean (SD)



Approach 2: Five modes on the same route during different times of the day and week



Type	Main Road (Class 1)
Length	2.6km

Mode	Travel times
Walking	32 min
Biking	15 min
Tram	11 min
Bus	8 min
Car	7 min

Modes of transportation: Public Transport & Car

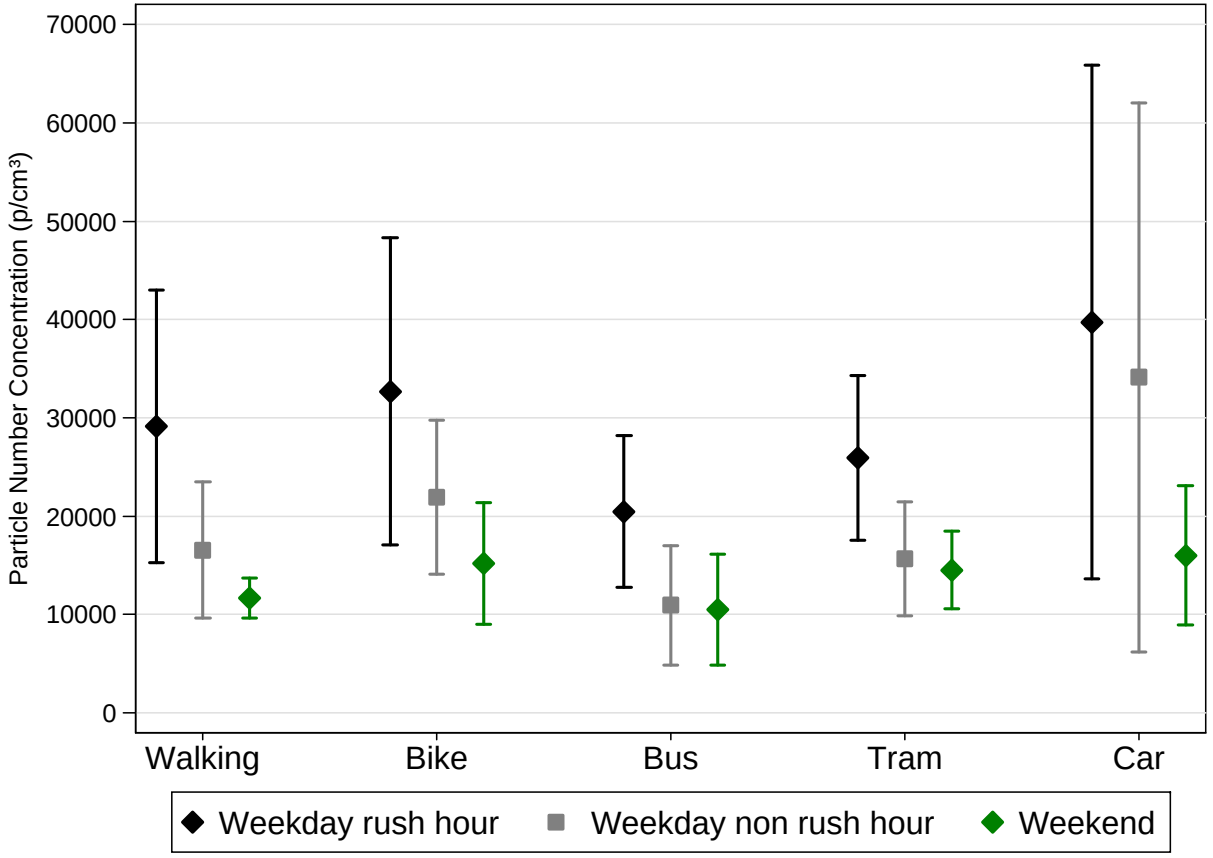
Tram

Renault Modus
Petrol powered

Bus
Diesel & compressed natural gas (CNG)

Particle Number Concentration by mode of transport & time of the day/week

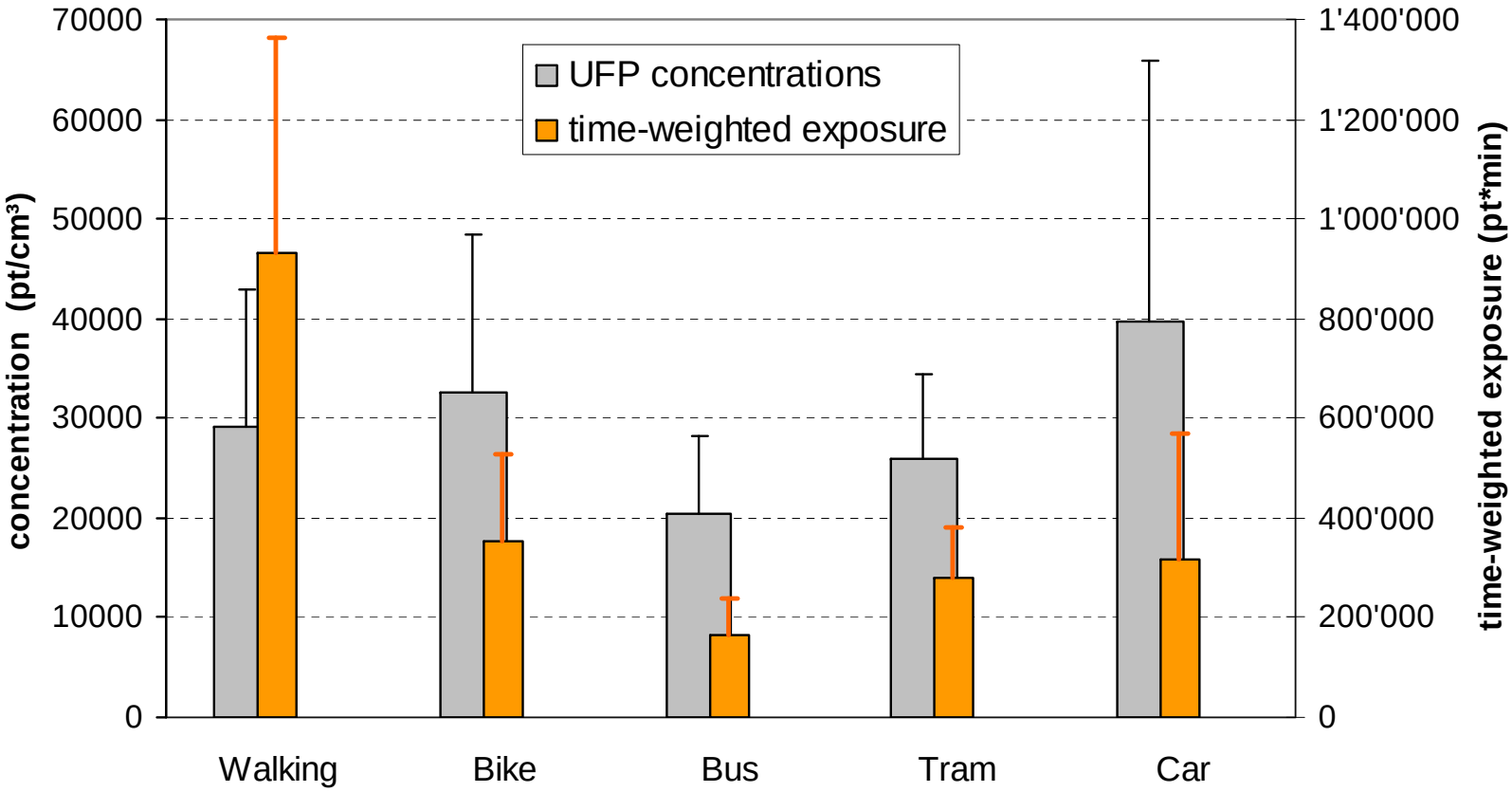
(mean ± SD)



18 sampling days (6 weekends, 18 weekdays) in spring & fall 2011

275 trips, based on individual trip medians

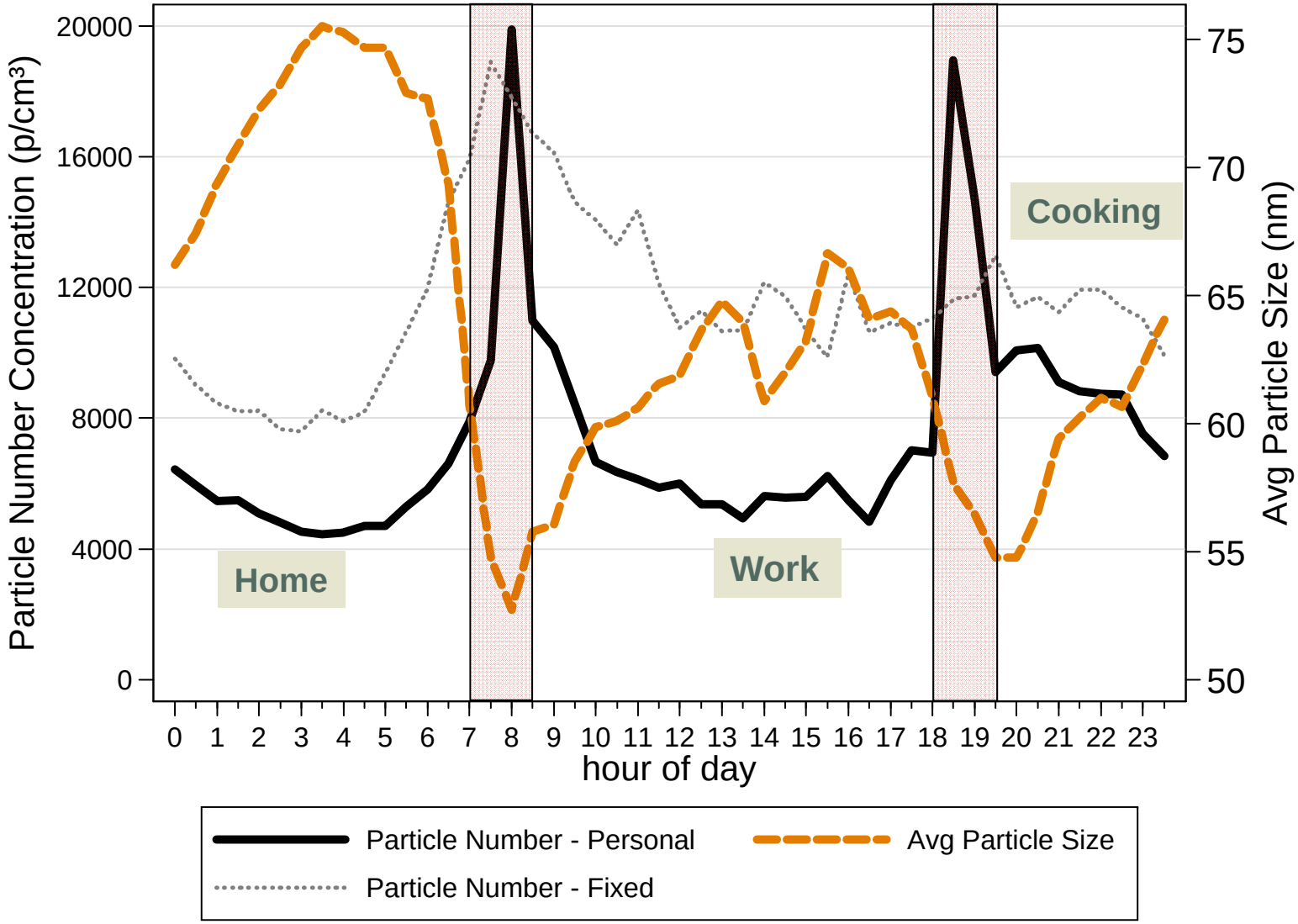
Time-weighted exposure by mode of transport during weekday rush hour



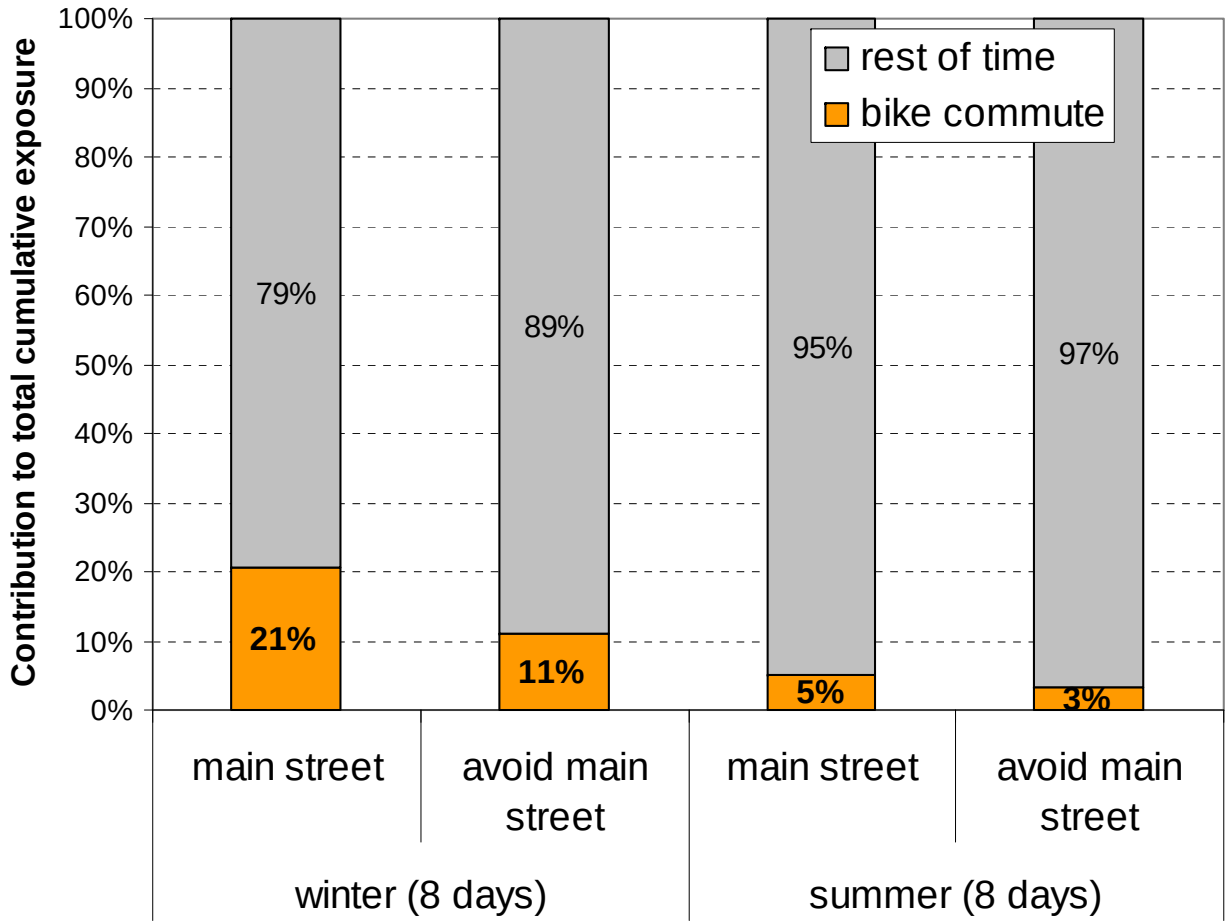
Approach 3:
24h personal measurements

Commute mode	**Bicycle**
Measurements	24 x 24h-measurements in 3 seasons
Per 24h-measurement	4 commute trips btw home-work during rush hours ► 2 x **main street** route ► 2 x **avoid-main-street** route
Commute time	10-15 min per trip

30min averages of 24 measurement days in 2011



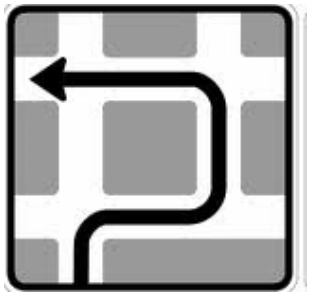
Contribution of bike commute to total daily exposure
(time-weighted median exposures)



Our UFP measurements in Basel suggest…

- Higher exposure levels for **car** (40’000 particles), **bicycle** and **walking** (29’000-33’000 particles) compared to public transport (21’000-26’000 particles)

- Commuting by bike contributes to **daily exposures**, especially in winter (21%)



- **Avoiding main streets** reduce commute exposure by one half

Outlook

- Analysis of quantitative contribution of exposure determinants

- Commute exposure simulations & refinement of air pollution exposure estimates in air pollution exposure assessments (SAPALDIA)

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Epidemiology and Public Health
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Thank you for your attention

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Nino Künzli

Charlotte Braun-Fahrländer

Elisabetta Corradi

Mark Davey

Chantal Wullimann

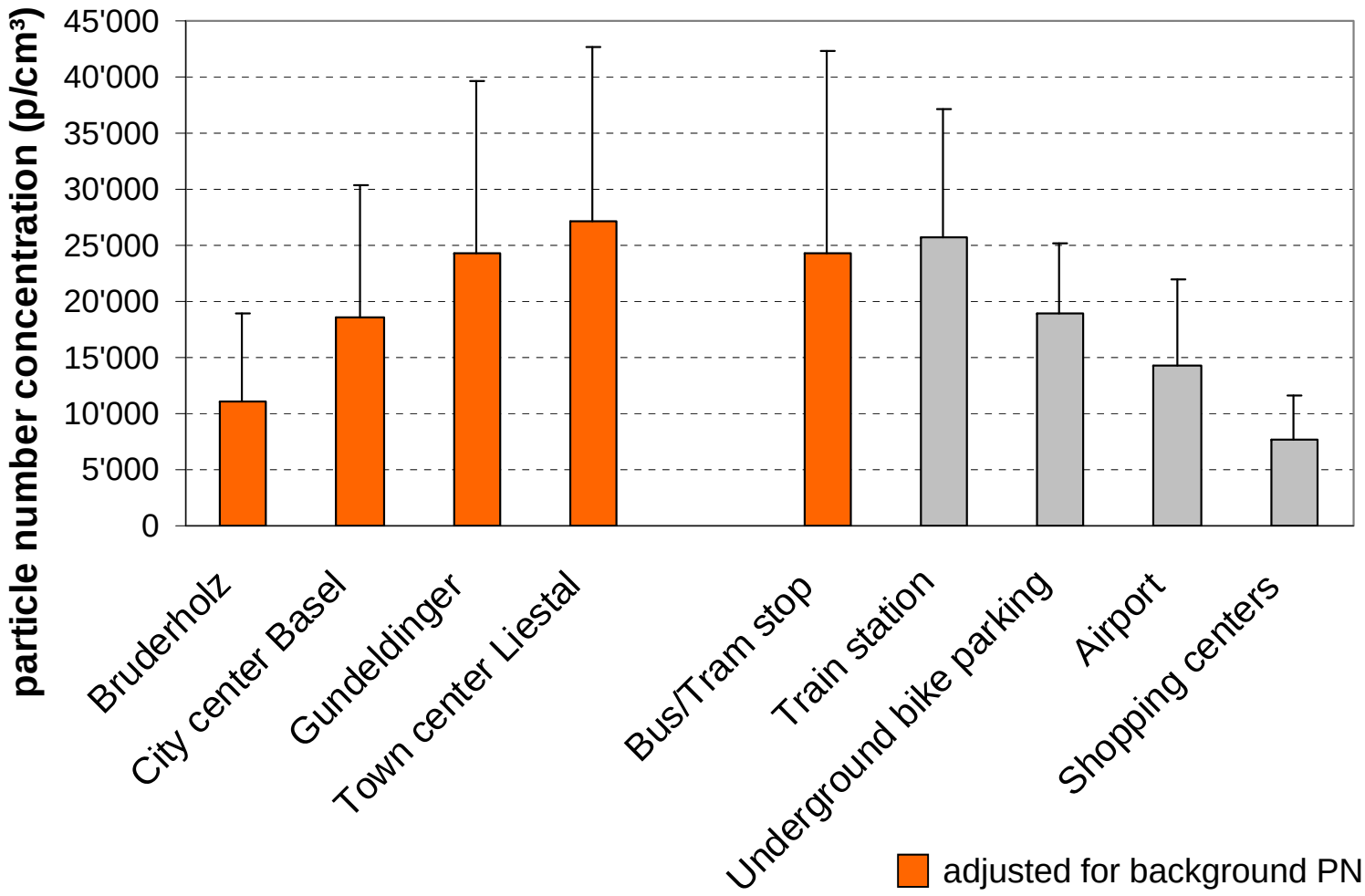
Christian Schindler

Additional slides

MiniDisc (Miniature Diffusion Size Classifier)

Number concentration & average diameter (size range 10-300nm)

Principle of operation:	Unipolar diffusion, current detection
Time resolution:	1 second
Size:	45×80×500mm
Weight:	~1kg
Battery life:	36h
Company:	Institute of Aerosol and Sensor Technology, FHNW, Windisch, Switzerland


particle number concentration (p/cm³)
45'000
40'000
35'000
30'000
25'000
20'000
15'000
10'000
5'000
0
Bruderholz
City center Basel
Gundeldinger
Town center Liestal
Bus/Tram stop
Train station
Underground bike parking
Airport
Shopping centers
adjusted for background PN

The Project TAPAS

Purpose:

Help decision makers design urban policies that address climate change & promote other health-related outcomes

Focus:

Assessment of conditions and policies that hinder or encourage active travel, and resulting health impacts

Underlying idea:

Shifting the population towards active modes of transportation is promising strategy with a potential of

- public health benefits (increase of physical activity)
- improvements in environmental quality
- Improvements in quality of urban life

Objective:

Development of a **quantitative model** of inter-relationships between active transportation policies and public health