



# Indoor and outdoor concentrations of ultrafine particles in selected homes of SAPALDIA subjects in Switzerland

Reto Meier, Marloes Eeftens, Harish C. Phuleria, Alex Ineichen,  
Elisabetta Corradi, Mark Davey, Martin Fierz, Regina E. Ducret-Stich,  
Inmaculada Aguilera, Christian Schindler, Thierry Rochat, Nicole  
Probst-Hensch, Ming-Yi Tsai, Nino Künzli



# SAPALDIA

## Swiss Cohort Study on Air Pollution and Lung and Heart Diseases in Adults

### SAPALDIA 1 started 1992/1993

with 9'651 subjects  
in 8 areas



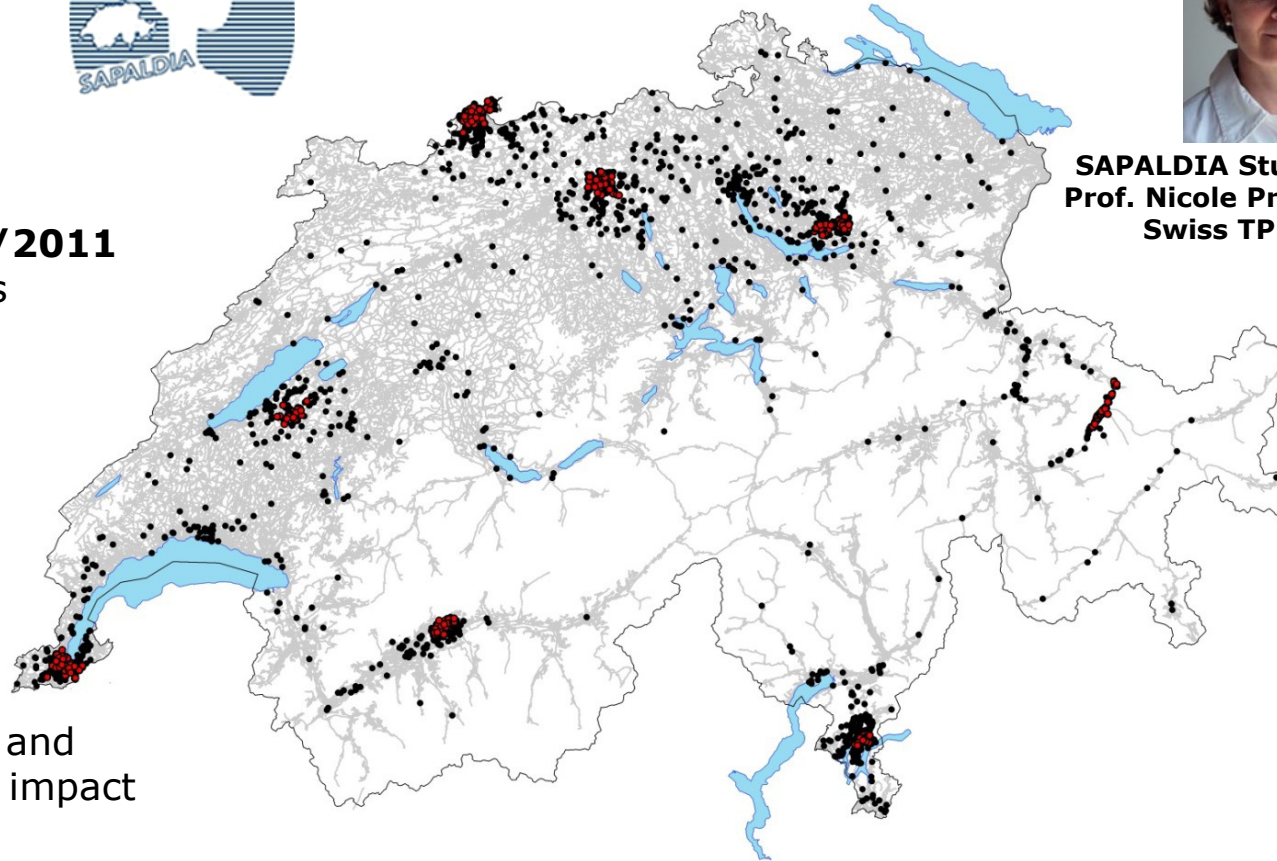
### SAPALDIA 3, 2010/2011

with ~ 6'200 subjects  
in 8 (!) areas

Data collection:

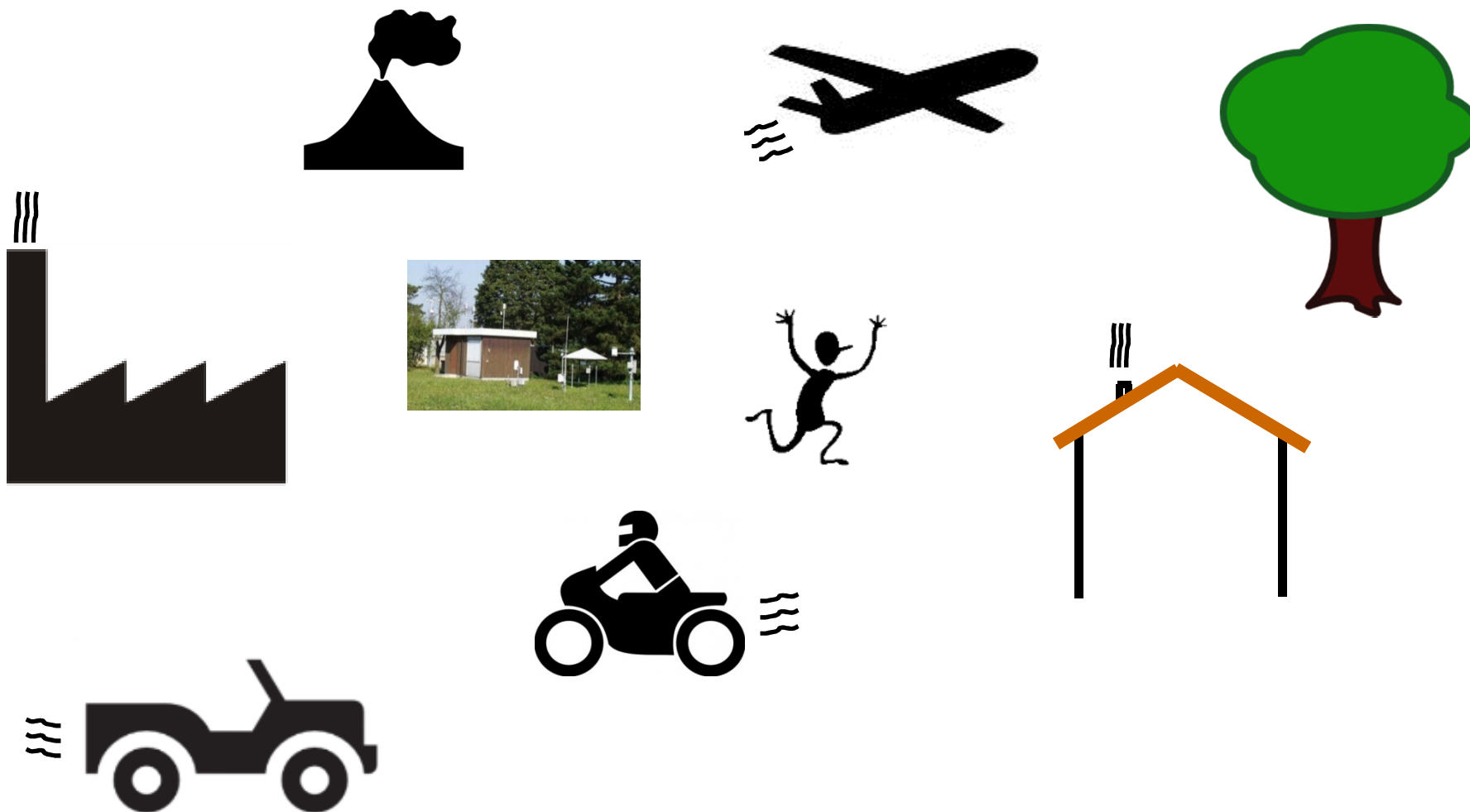
- Interview
- Health examination
- Air pollution measurements

=> Exposure models and  
assessment of health impact

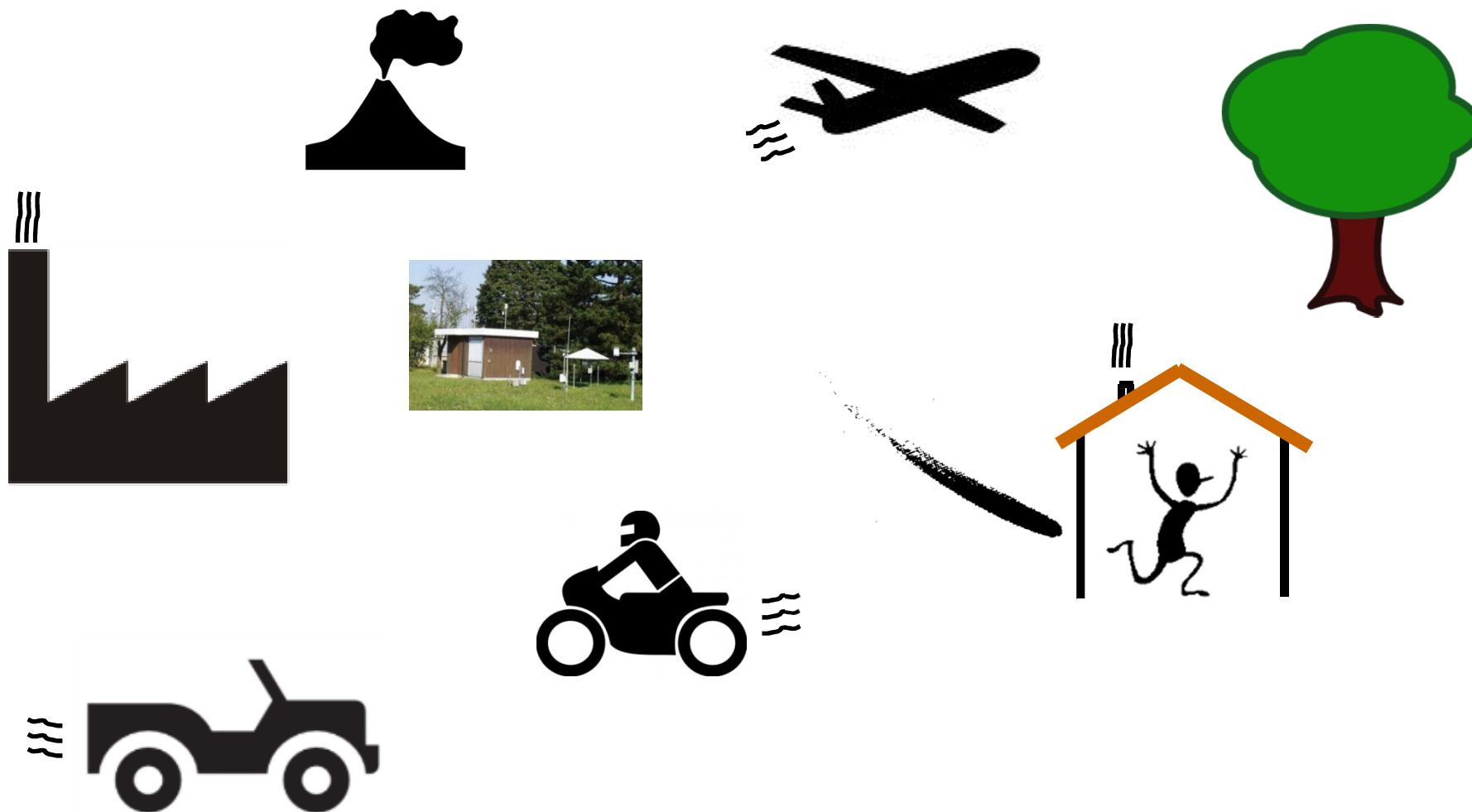


**SAPALDIA Study Director**  
**Prof. Nicole Probst-Hensch**  
Swiss TPH Basel

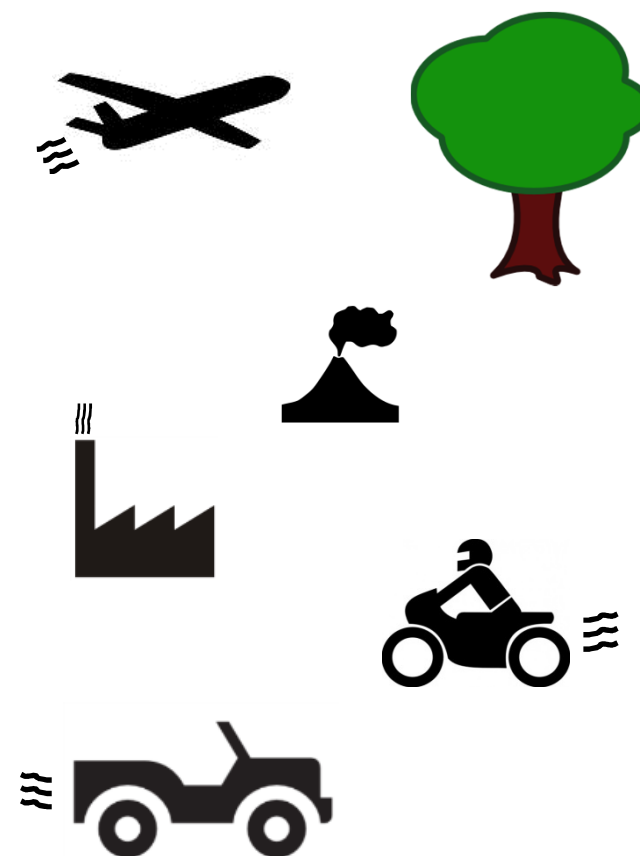
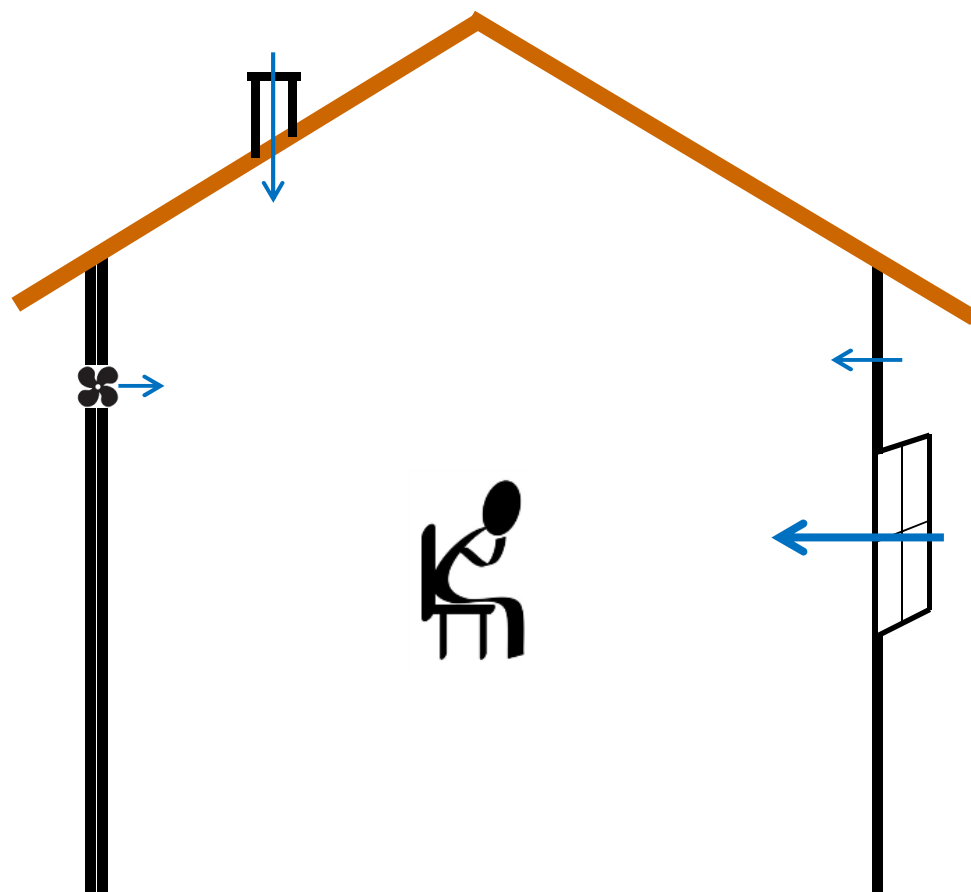
## Air pollution is usually measured outdoors

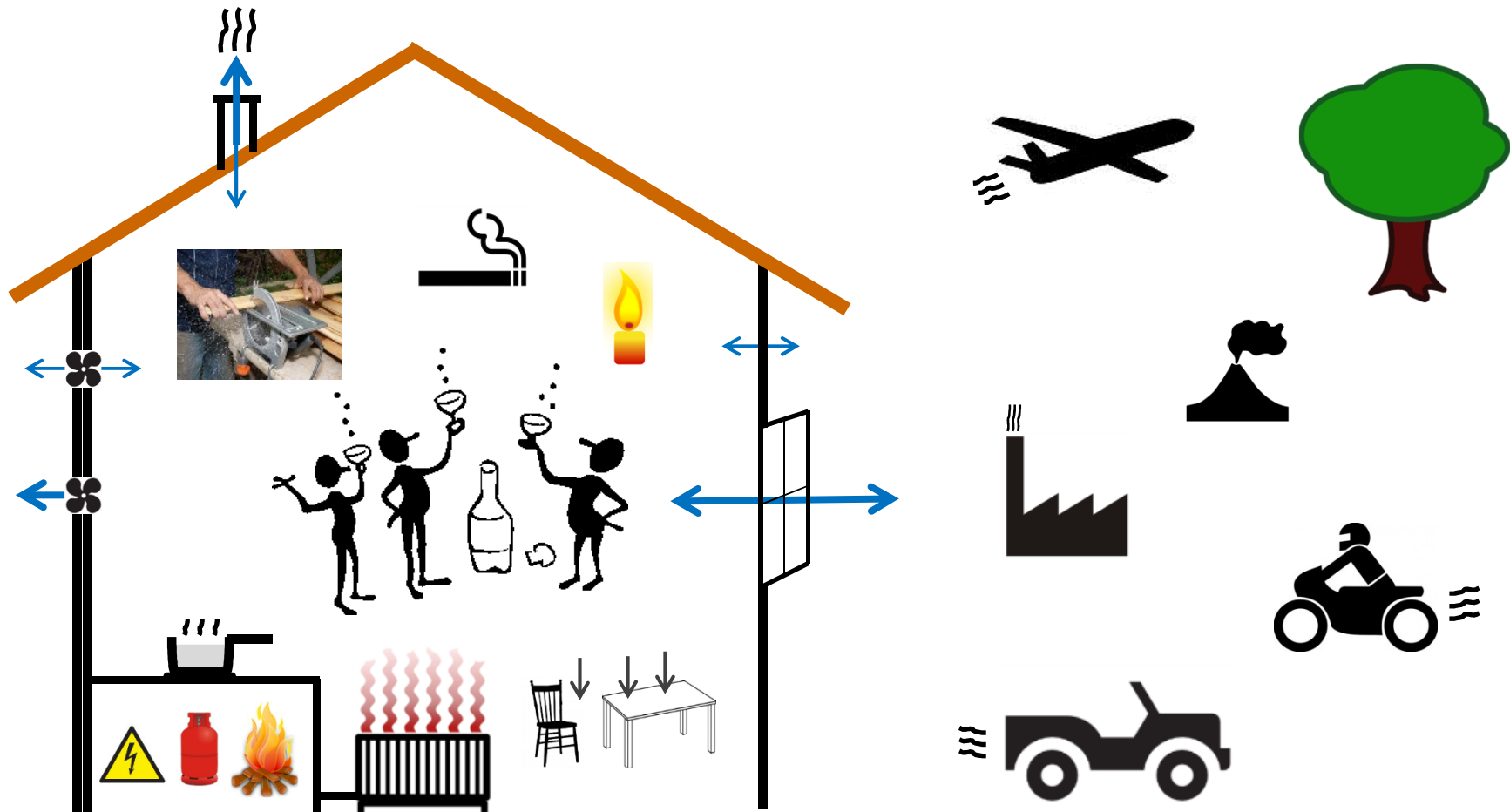


## Air pollution is usually measured outdoors



# Ventilation determines indoor exposure to outdoor pollutants







## Main research question

- What are the long-term exposure levels to traffic air pollution among general Swiss population?

## Objective of this study

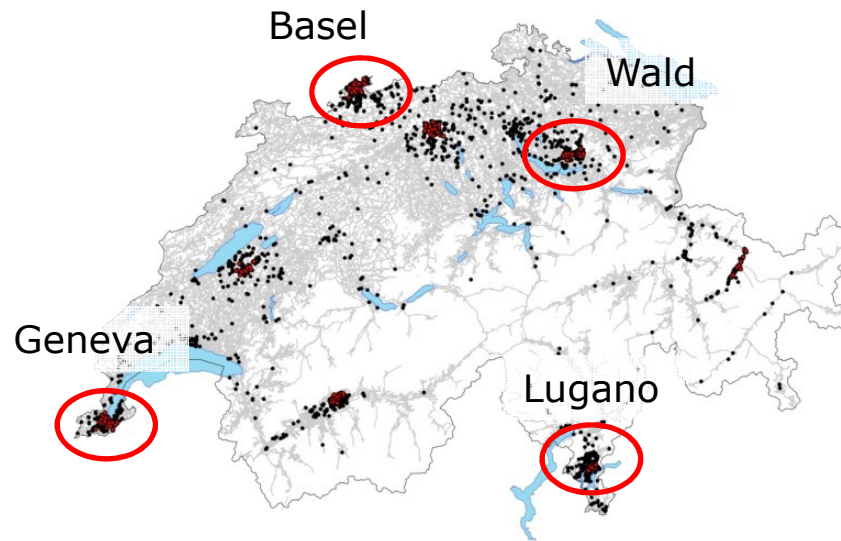
- Describe indoor and outdoor levels of air pollutants with a focus on ultrafine particles (UFP) within and across four SAPALDIA areas
- Investigate indoor/outdoor relationships

## Aim

Development of indoor models to predict indoor exposure to air pollutants with outdoor origin

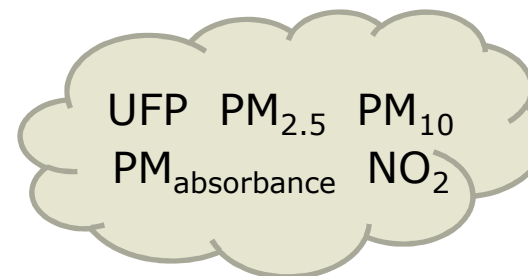






20 sites per area

Repeated measurements  
3 seasons x 2 weeks



Questionnaires





## Ultrafine particles

- miniDiSC
- 1-2 week real-time measurements
- Size range ~15-300 nm

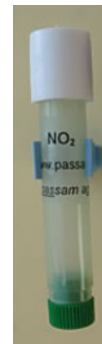


## PM<sub>2.5</sub> & PM<sub>10</sub>

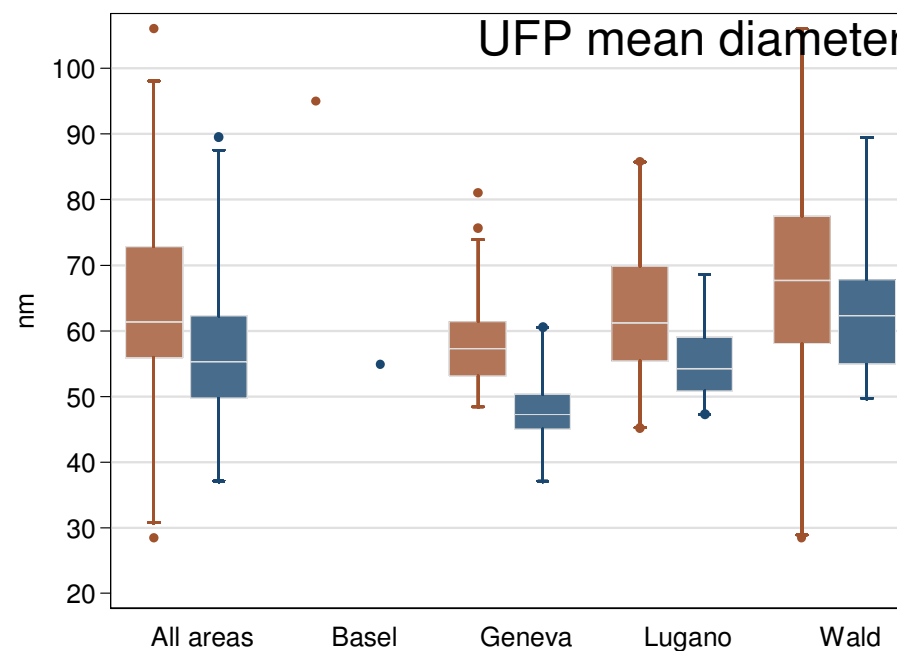
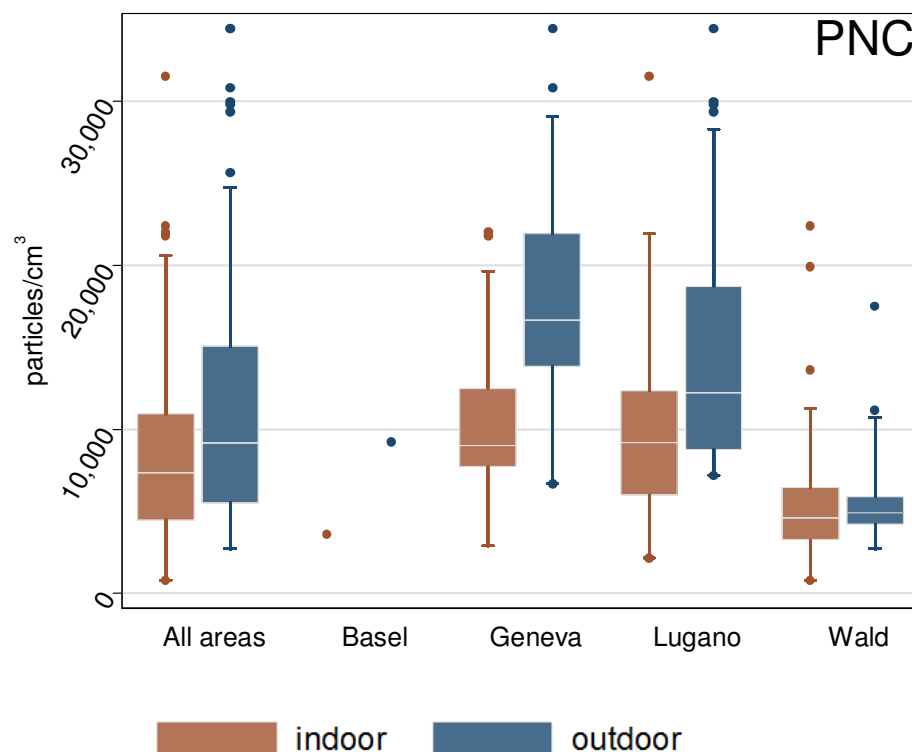
- Harvard Impactors (4 L/min)
  - 37mm Teflon filter (23±2°C 35±5% RH)
  - 2-week samples
- ⇒ **PM<sub>absorption</sub>** (smokestain reflectometer)

## NO<sub>2</sub>

- Passive samplers (passam)
- 2-week samples

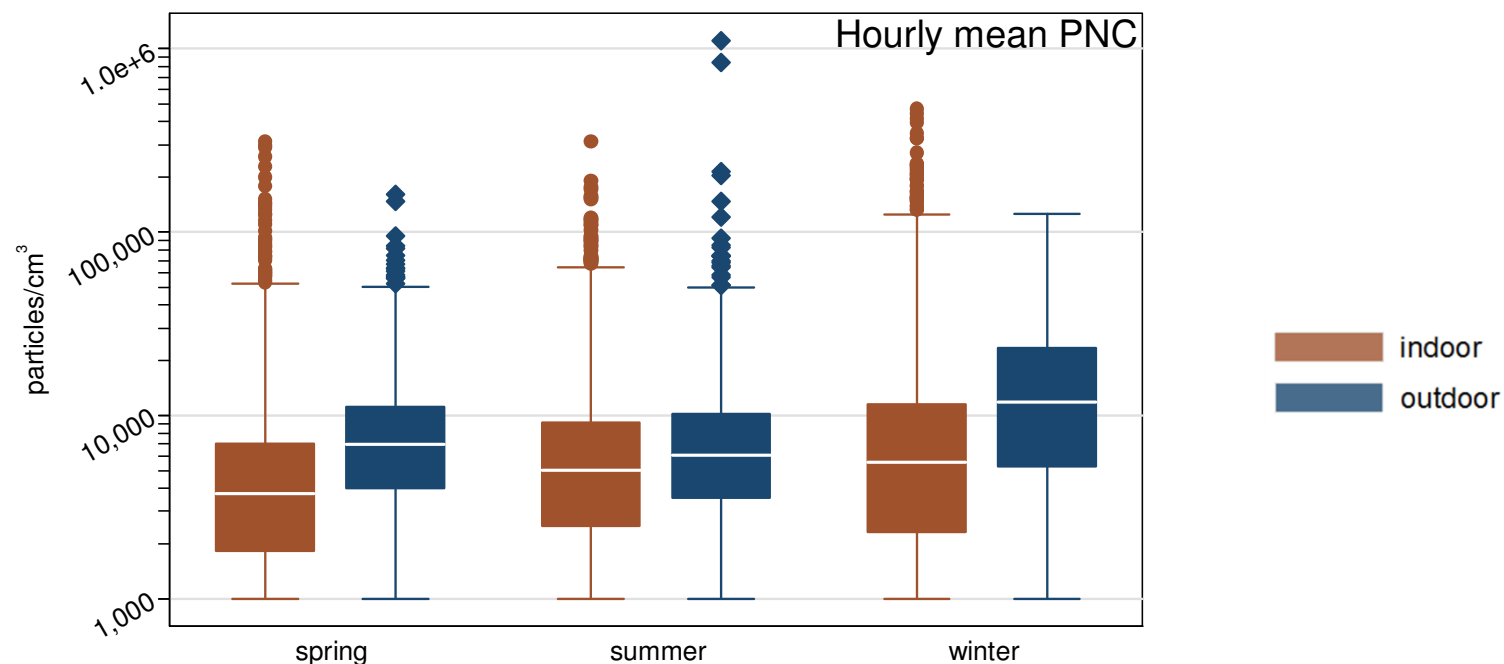


## Indoor UFP: numbers are lower and diameters are higher



Weekly averages from 90 measurements (48 sites) without tobacco smoke influence

Hourly averages from measurements without tobacco smoke influence



Number of averages:

Spring	4'568 hours
Summer	7'290 hours
Winter	6'579 hours

Averages below 1'000 particles/cm<sup>3</sup> not plotted

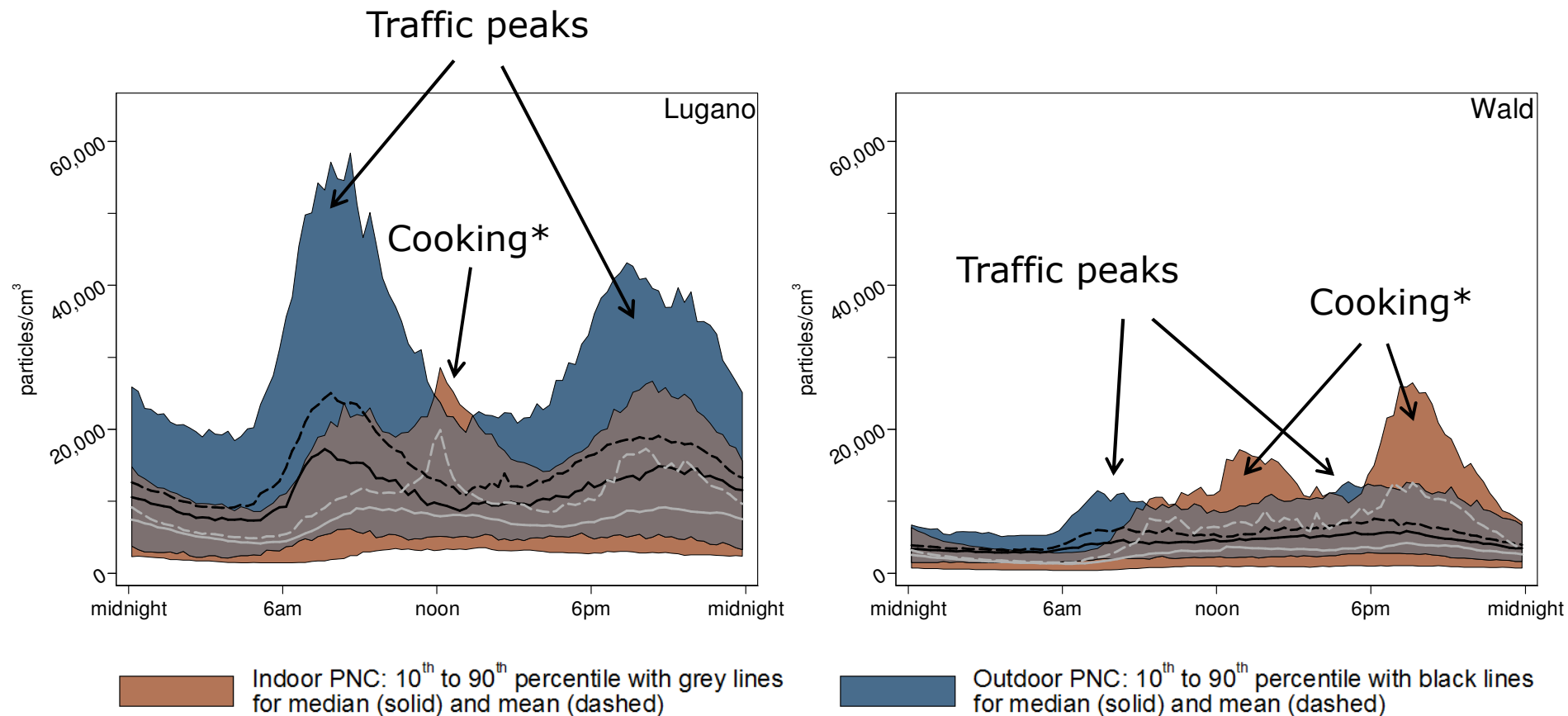
## Correlation of indoor and outdoor hourly PNC are generally higher in summer

	Basel	Geneva	Lugano	Wald
All seasons		0.43	0.42	0.21
Spring	-0.22*	0.51*	0.40	0.20
Summer		0.51	0.59	0.25
Winter		0.42	0.32	0.17

Measurements without tobacco smoke influence

*\*based on only one weekly measurement*

## Outdoor PNC are reflected indoors



Diurnal 15 min averages from measurements without tobacco smoke influence

\*or other indoor source

				I/O ratio	Pearson Correlation
		N	Sites	Median (10 <sup>th</sup> ; 90 <sup>th</sup> Percentile)	
<b>PNC</b>	All areas	90	48	0.72 (0.27; 1.54)	0.38
<b>PM<sub>2.5</sub></b>	All areas	156	64	0.73 (0.37; 1.28)	0.61
<b>PM<sub>abs</sub></b>	All areas	156	64	0.74 (0.41; 1.12)	0.79
<b>NO<sub>2</sub></b>	All areas	175	66	0.55 (0.21; 0.99)	0.63

One week (PNC) and two week measurements (PM<sub>2.5</sub>, PM<sub>abs</sub>, NO<sub>2</sub>) without tobacco smoke influence

- In general, indoor UFP levels were lower compared to outdoor levels
- Average indoor and outdoor PNC were 7'300 particles/cm<sup>3</sup> (IQR=6'500) and 9'100 particles/cm<sup>3</sup> (IQR=9'500), respectively
- Diurnal patterns of outdoor ultrafine particle levels were distinctly observed indoors
- Large variability of I/O ratios between sites was found
- Data will be used for indoor models to estimate indoor exposure to air pollutants with outdoor origin

## Acknowledgements

SAPALDIA team and study participants;  
BAFU & NABEL; Cantonal air monitoring agencies



FONDS NATIONAL SUISSE  
SCHWEIZERISCHER NATIONALFONDS  
FONDO NAZIONALE SVIZZERO  
SWISS NATIONAL SCIENCE FOUNDATION



# Spearman correlations between time-matched measurements of air pollutants

	PNC_in	PNC_out	PM <sub>10_in</sub>	PM <sub>10_out</sub>	PM <sub>25_in</sub>	PM <sub>25_out</sub>	PM <sub>coarse_out</sub>	PM <sub>coarse_in</sub>	PM <sub>abs_in</sub>	PM <sub>abs_out</sub>	NO <sub>2_in</sub>
PNC_out	0.54 (90)	1									
PM <sub>10_in</sub>	0.80 (27)	0.51 (45)	1								
PM <sub>10_out</sub>	0.65 (24)	0.70 (46)	0.55 (155)	1							
PM <sub>25_in</sub>	0.76 (27)	0.59 (45)	0.91 (169)	0.66 (153)	1						
PM <sub>25_out</sub>	0.62 (24)	0.67 (46)	0.50 (158)	0.94 (167)	0.62 (156)	1					
PM <sub>coarse_out</sub>	0.58 (24)	0.49 (46)	0.42 (154)	0.70 (167)	0.47 (152)	0.49 (167)	1				
PM <sub>coarse_in</sub>	0.54 (27)	0.15 (45)	0.74 (169)	0.19 (153)	0.46 (169)	0.16 (156)	0.22 (152)	1			
PM <sub>abs_in</sub>	0.81 (27)	0.78 (45)	0.59 (169)	0.74 (153)	0.66 (169)	0.74 (156)	0.48 (152)	0.27 (169)	1		
PM <sub>abs_out</sub>	0.68 (24)	0.87 (46)	0.47 (158)	0.84 (167)	0.56 (156)	0.86 (171)	0.49 (167)	0.16 (156)	0.85 (156)	1	
NO <sub>2_in</sub>	0.83 (27)	0.70 (49)	0.60 (168)	0.58 (163)	0.60 (166)	0.51 (166)	0.53 (162)	0.39 (166)	0.67 (166)	0.59 (166)	1
NO <sub>2_out</sub>	0.66 (27)	0.88 (50)	0.40 (167)	0.75 (165)	0.48 (165)	0.76 (168)	0.47 (164)	0.13 (165)	0.82 (165)	0.92 (168)	0.65 (175)

Measurements without tobacco smoke influence  
(in parenthesis the number of co-located and time matched measurements)



