

# Association of ultrafine particle exposure with lung and neurocognitive functions in elementary school children

Berlin-Brandenburg Air Study (BEAR)

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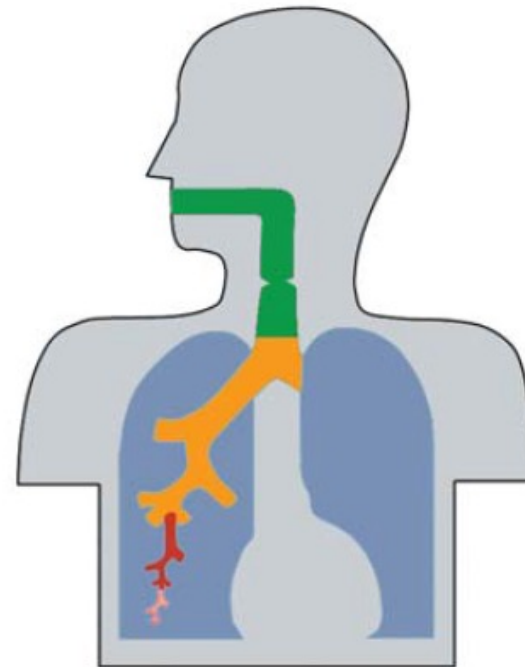
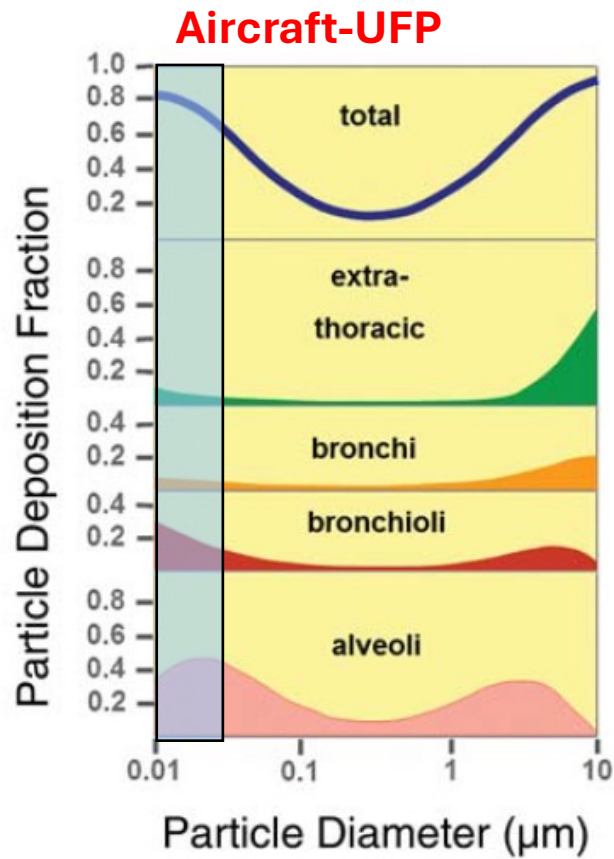
# Funding

Gefördert durch

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# Background



Particle density:  $1 \text{ g cm}^{-3}$   
Respiratory flow rate:  $300 \text{ cm}^3 \text{ s}^{-1}$   
Mouth breathing at rest, cycle period: 5 s

## Small particle size

- high alveolar deposition
- can escape alveolar cleaning mechanisms
- Diffusion through physiological membranes

## High surface area

- Adsorption of toxins
- Formation of free radicals

Kreyling et al. 2006

## Background

- UFP or AC-UFP ~ human health → insufficiently studied
- Children particularly vulnerable to UFP-mediated effects

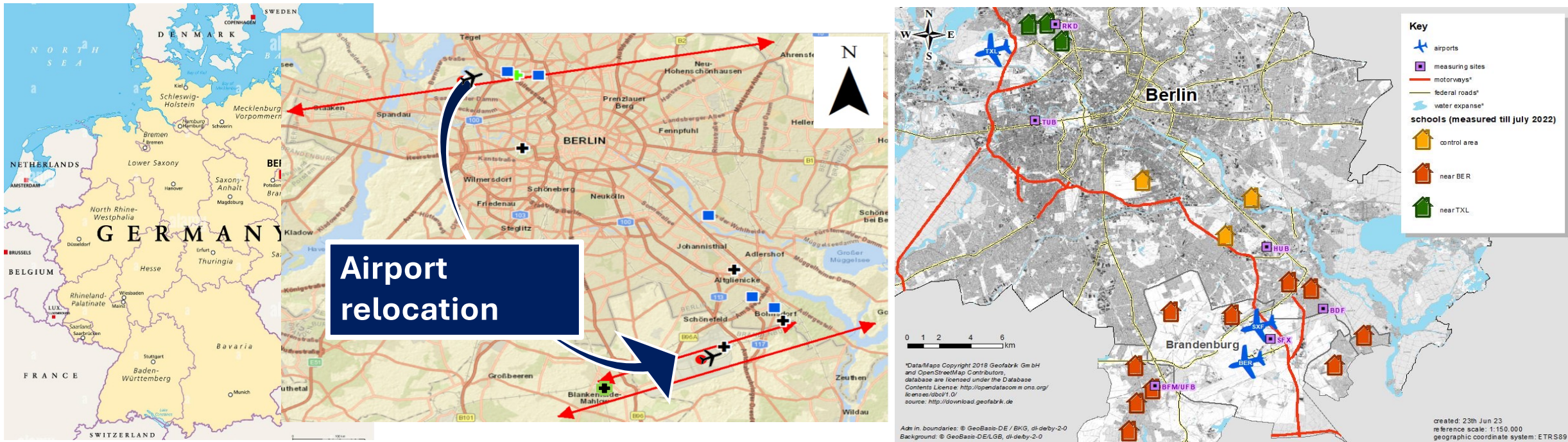
## Objectives

1. To **assess** short-, medium- and long-term **exposure** to source-specific UFP for schoolchildren in the vicinity of the BER Airport, as well as in the area of the former TXL Airport and control areas in Berlin
2. To **investigate the health impacts** of UFP, particularly AC-UFP

# BEAR

- a natural experiment (since January 2020)
- Berlin-Brandenburg Airport (BER) (opening November 2020), the former operating Airport Tegel (TLX) (closure in November 2020) and in control areas

16 Schools



## UPF Measurements

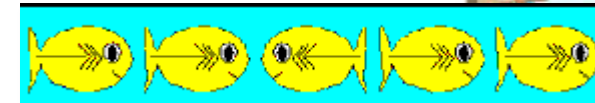
- UFP measurements (CPC) + meteorological parameters at the schools
- Continuous measurements of the particle size distribution and other air pollutants at several locations in Berlin (UltraFleb, TU Berlin, HU Berlin, Flughafen Berlin Brandenburg GmbH)
- Modeling of source-specific UFP at schools and residential addresses



CPC: Condensation Particle Counter

# Health examinations

- Questionnaire about the current state of health
- Quality of life
- Blood pressure
- Arterial stiffness (pulse wave analysis)
- Inflammation values in the exhaled air (FeNO test air)
- Lung function test (Spirometry)
- Cognitive development (N-Back-Test, ANT-Test)



## Material & Methods

- Exposure: PNC and meteorological parameters at schools since January 2020
- Outcome: School-based examination, at least twice (January 2020 – June 2023)
  - Spirometry test
    - Forced expiratory volume in 1 second (FEV1)
    - Forced vital capacity (FVC)
  - Standardized N-back Test
    - Hit Reaction Time (HRT)
- Short term effect
  - a nested linear mixed-effect model with random intercepts for school and participant



# Participating Schools & children

- 16 schools
- 1,094 children at T<sub>0</sub>
- 2,002 examinations
  - T<sub>0</sub> = 1,094
  - T<sub>1</sub> = 714
  - T<sub>2</sub> = 194

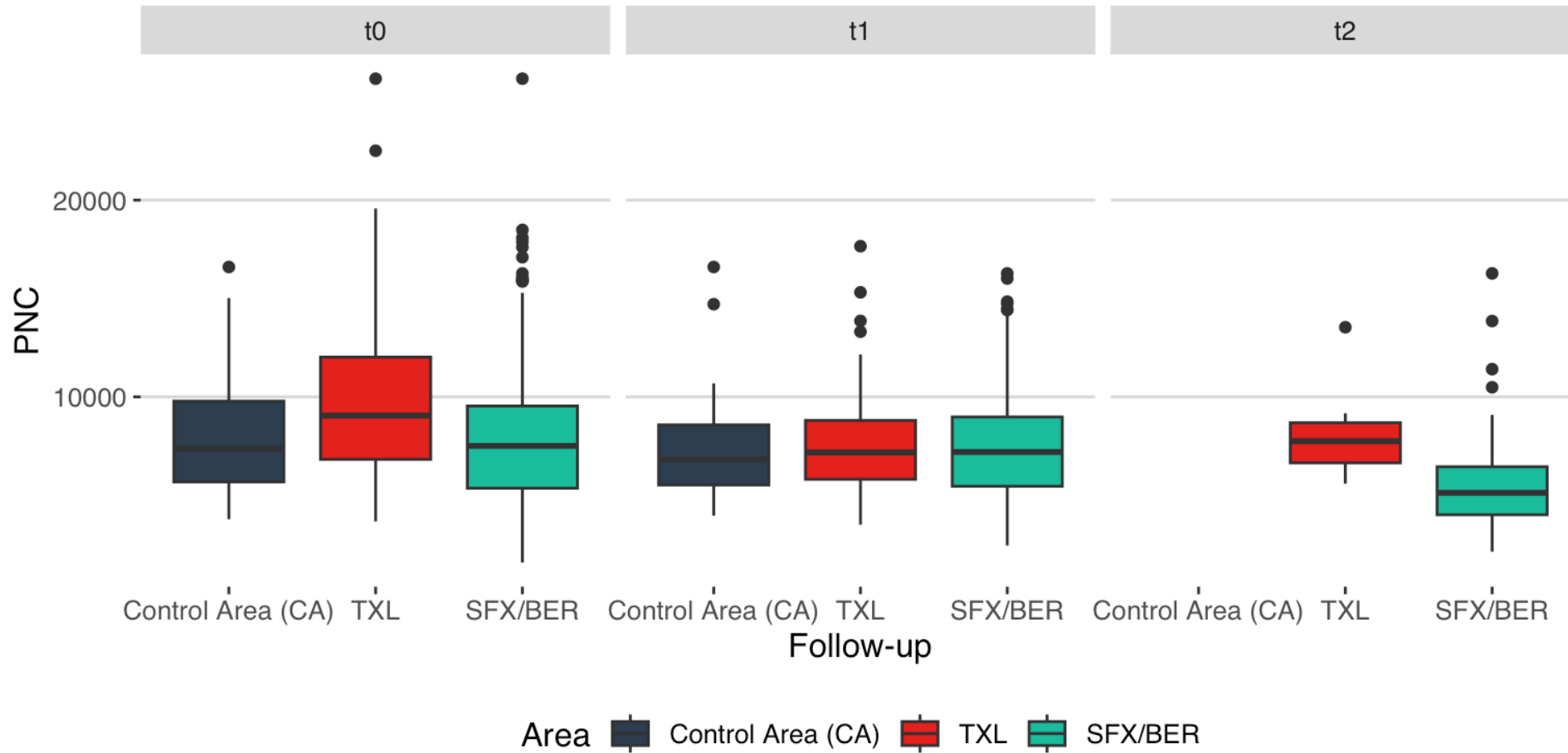
|  | t <sub>0</sub><br>(n=1094) | t <sub>1</sub><br>(n= 714) | t <sub>2</sub><br>(n= 194) |
|--|----------------------------|----------------------------|----------------------------|
| <b>Female</b> [n] (%)                  | 561 (51.3%)                | 373 (52.2%)                | 96 (49.5%)                 |
| <b>Age</b> [years] (mean ± SD)         | 8.6±1.1                    | 9.8±1.1                    | 11.0±0.9                   |
| <b>FEV<sub>1</sub></b> [L] (mean ± SD) | 1.86±0.4                   | 2.22±0.5                   | 2.55±0.4                   |
| <b>FVC</b> [L] (mean ± SD)             | 2.18±0.4                   | 2.61±0.6                   | 2.99±0.5                   |
| <b>HRT</b> [ms] (mean ± SD)            | 628±159                    | 566±139                    | 517±141                    |
| <b>PNC</b> [particles/m <sup>3</sup> ] | 8440±3650                  | 7700±2860                  | 6890±3450                  |

# PNC at the schools

| Study Area                      | N      | Median | 25th<br>percentile | 75th<br>percentile |
|---------------------------------|--------|--------|--------------------|--------------------|
| Control Area                    | 5,238  | 7,610  | 5,012              | 10,336             |
| Tegel Airport Area              | 7,876  | 6,872  | 4,786              | 10,150             |
| Berlin-Brandenburg Airport Area | 18,616 | 6,371  | 4,286              | 9,597              |
| CA, TLX, BER                    | 31,730 | 6,200  | 4,100              | 9,500              |

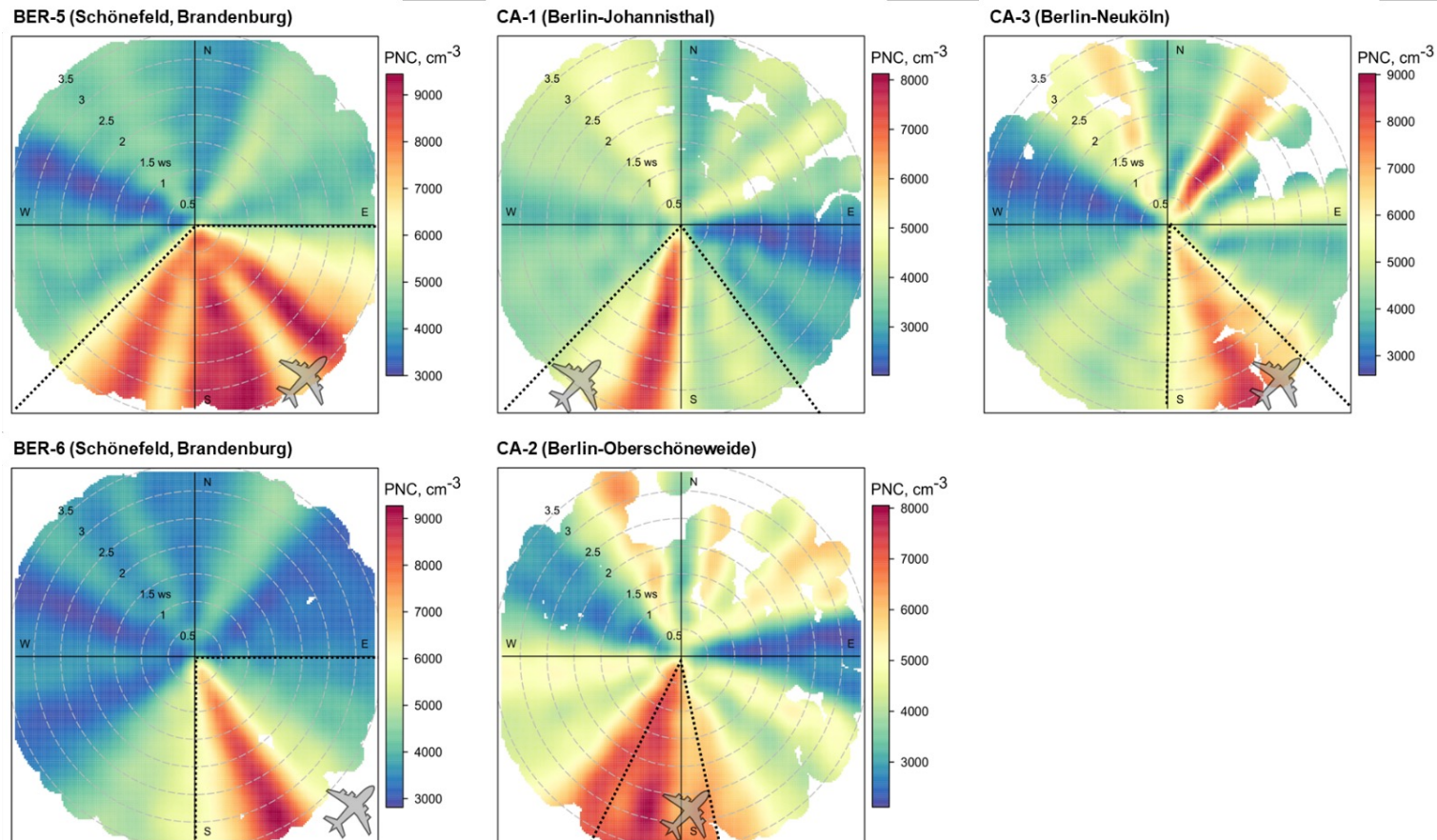
Measurement period: January 2020 to December 2022.

# PNC at the schools



# PNC & wind direction

Polar plot of average PNC for selected sampling locations



# Associations of PNC and health outcomes

Effects are given per IQR of 4,390 particles/m<sup>3</sup>

Models were adjusted to sex, age at baseline, temperature, relative humidity, day of a week, season and area.

|                          | Estimate (95%CI)         |                          |
|--------------------------|--------------------------|--------------------------|
|                          | FEV1, liter              | FVC, liter               |
| PNC, lag 0               | -0.11<br>[-0.13 – -0.08] | -0.14<br>[-0.17 – -0.11] |
| PNC, lag 1               | -0.10<br>[-0.12 – -0.07] | -0.13<br>[-0.16 – -0.10] |
| PNC, lag 2               | -0.06<br>[-0.08 – -0.03] | -0.08<br>[-0.11 – -0.04] |
| <b><i>N obs.</i></b>     | <b>1139</b>              | <b>1139</b>              |
| <b><i>N children</i></b> | <b>854</b>               | <b>854</b>               |

# Associations of PNC and health outcomes

Effects are given per IQR of 4,390 particles/m<sup>3</sup>

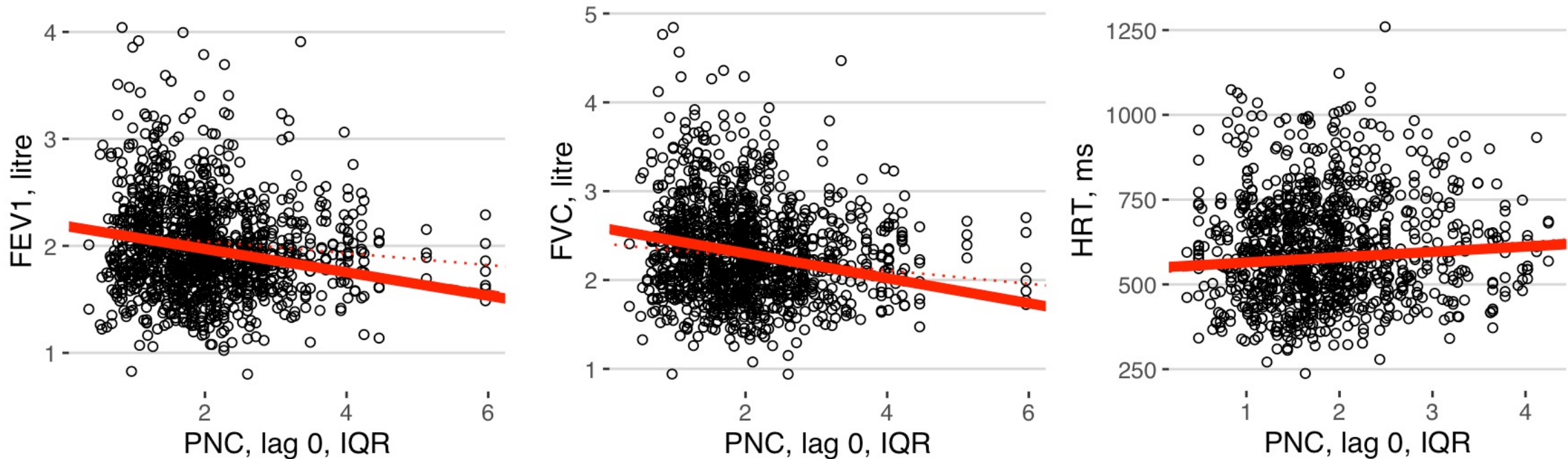
Models were adjusted to sex, age at baseline, temperature, relative humidity, day of a week, season and area.

|                          | Estimate (95%CI)         |                          |                         |
|--------------------------|--------------------------|--------------------------|-------------------------|
|                          | FEV1, liter              | FVC, liter               | Mean HRT, ms            |
| PNC, lag 0               | -0.11<br>[-0.13 – -0.08] | -0.14<br>[-0.17 – -0.11] | 15.70<br>[0.94 – 30.47] |
| PNC, lag 1               | -0.10<br>[-0.12 – -0.07] | -0.13<br>[-0.16 – -0.10] | 21.78<br>[5.42 – 38.14] |
| PNC, lag 2               | -0.06<br>[-0.08 – -0.03] | -0.08<br>[-0.11 – -0.04] | 19.09<br>[2.35 – 35.83] |
| <b><i>N obs.</i></b>     | <b>1139</b>              | <b>1139</b>              | <b>872</b>              |
| <b><i>N children</i></b> | <b>854</b>               | <b>854</b>               | <b>735</b>              |

# Associations of PNC and health outcomes

Effects are given per IQR of 4,390 particles/m<sup>3</sup>

Models were adjusted to temperature, relative humidity, day of a week, season and area.



# Conclusion

- The BEAR Study is a unique experiment investigating effects of AC-UFP on children.
- The observed negative associations between PNC, measured in the proximity to Berlin airports, and lung and cognitive function in children raise concerns about potential health impact of AC-UFP



# BEAR – Berlin-Brandenburg Air Study

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# Expo-Team and Cooperation Partners



**Helmholtz Munich**  
Simonas Kecorius  
Susanne Sues  
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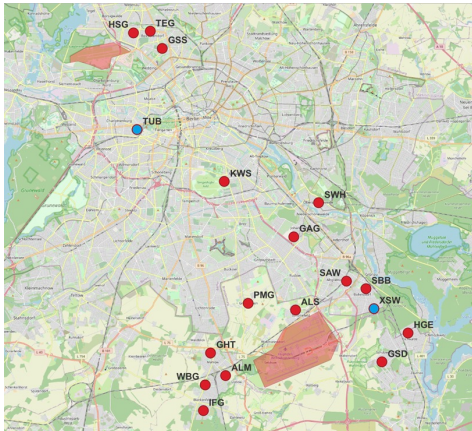
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Thank you!

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