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„Real Driving Emission“ Measurements at Frankfurt Airport

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Sampling at Blast Fence of 18 West / FraPort

- Performed in 2015 / airegEM
- 3 monitored days (19. – 21. Mai)
- 281 take-off events in sampling period

18 West / FraPort Runway

- Three different distances between blast fence and start position (100 m and 200 m distance could be analyzed)
- Plumes at the highest distance and from regional jets showed no significant deviation from the background concentration
- The respective aircraft information were recorded (type, company) and the engine information were derived from a database
- ∑ **168** quantified plumes from **46** different jet engines (incl. GEnx-engines)

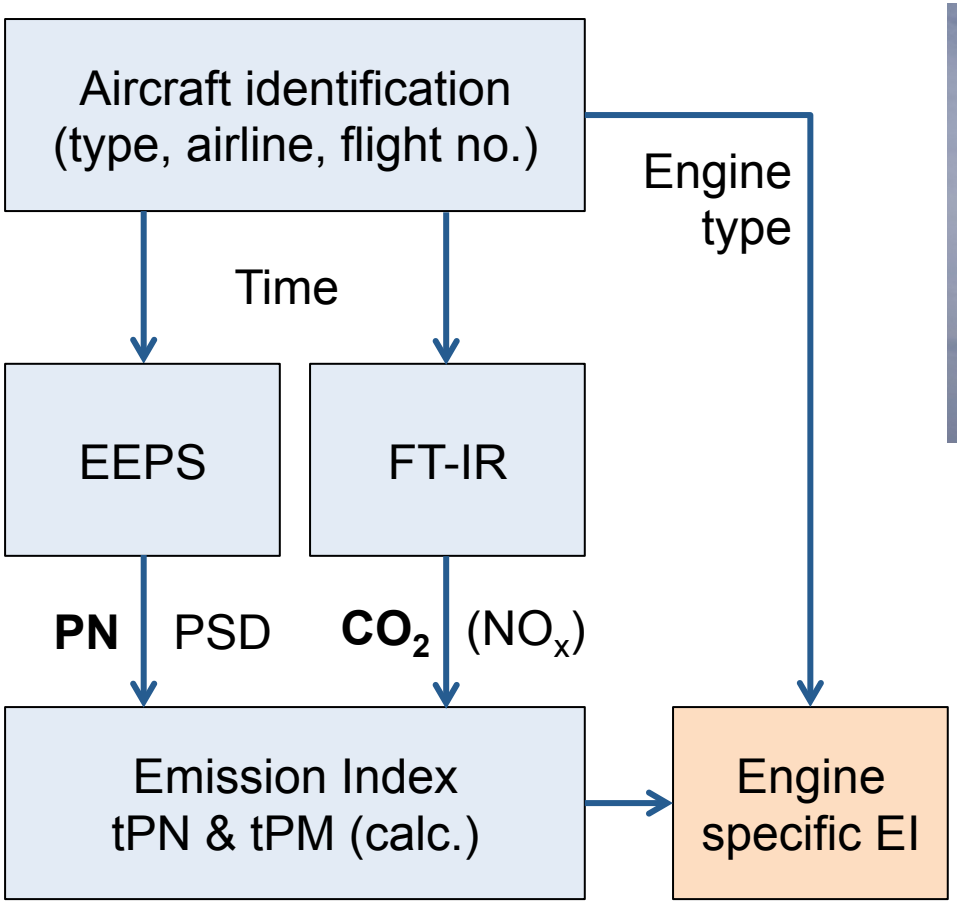
Instruments

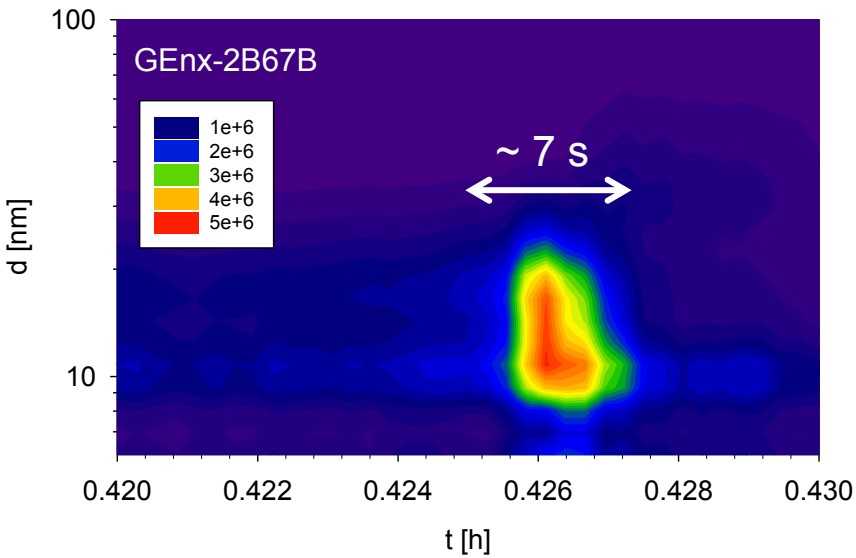
- Engine Exhaust Particle Sizer (EEPS)
  - 5.6 – 560 nm, 10 Hz
  - tPN / tPM (calculated)

- FT-IR (MKS MultiGas 2030)
  - CO2, NOx

- Setup with **high time resolution** / low sensitivity -> many plumes could not be detected / analyzed
- No aerosol conditioning -> **total particle number** without removal of volatile fraction (influence of fuel sulfur possible)
- **Aged aerosol** / does not match to test rig measurements

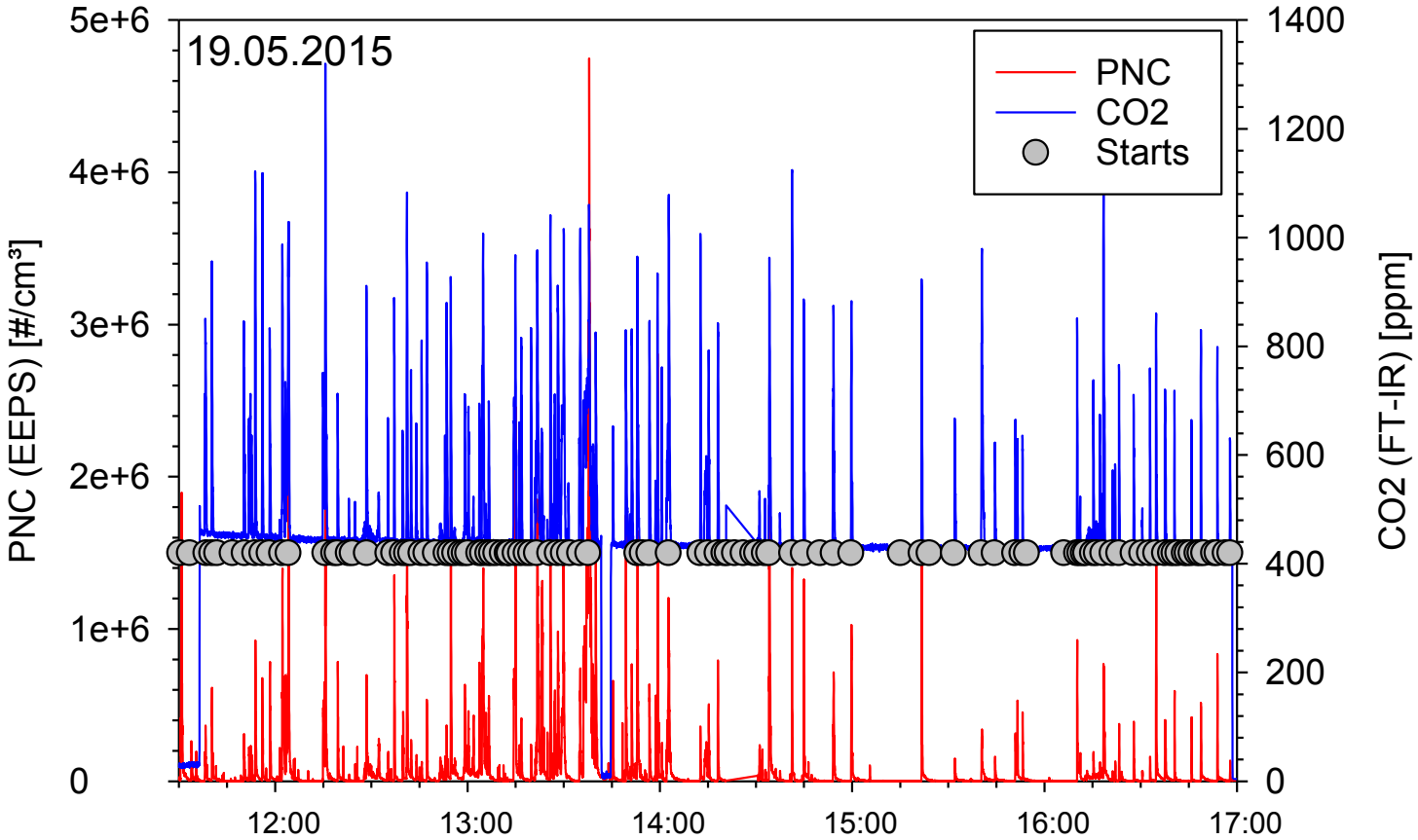
Data Analysis



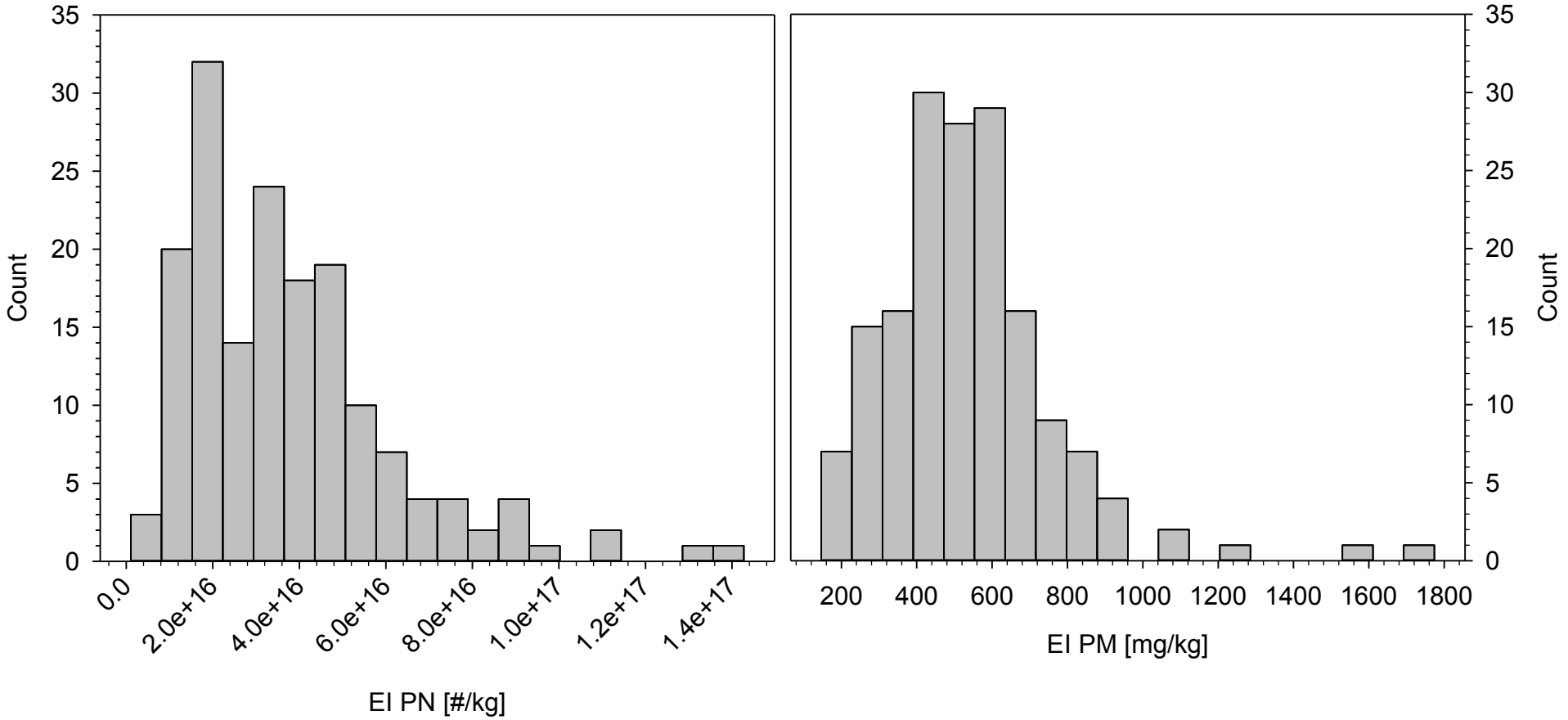


Data Analysis (2)

- The identification of the plumes based on the combined particle/CO2 signal, recorded take-off time and aircraft type

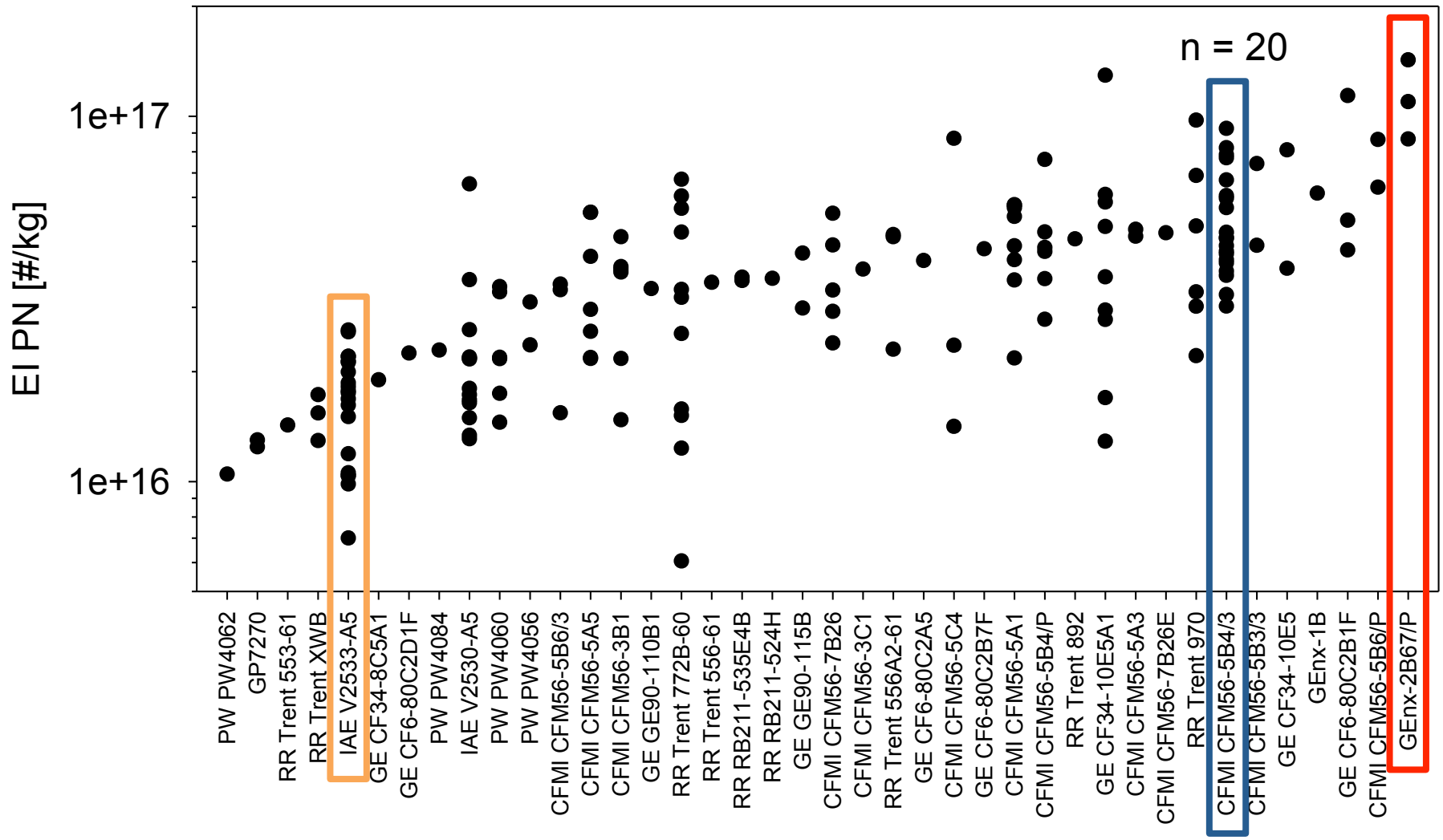


Statistics

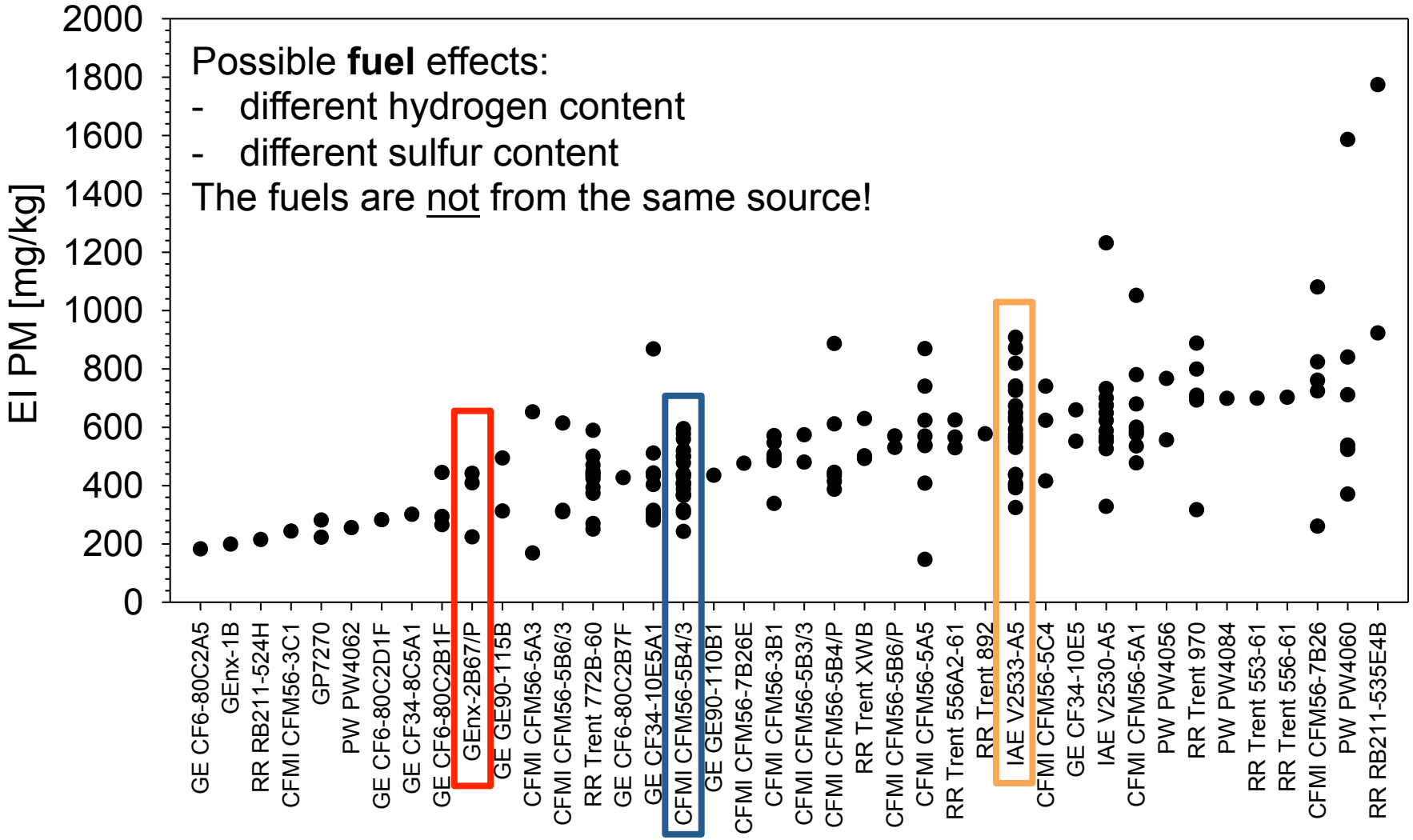


- PN is higher than anticipated / measured values include volatile particle fraction (aged aerosol) / transient engine conditions

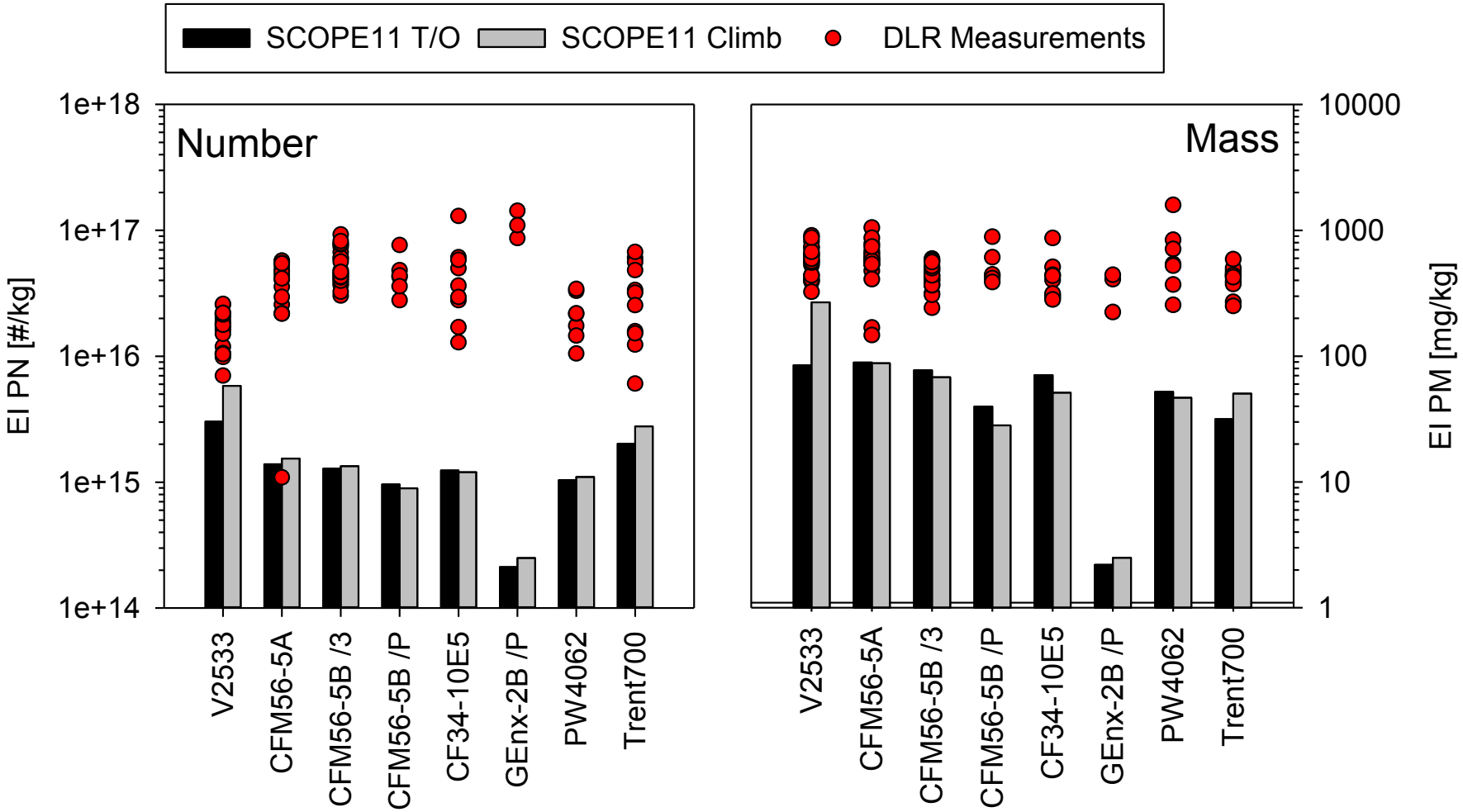
Particle Number Emission Index



Particle Mass Emission Index



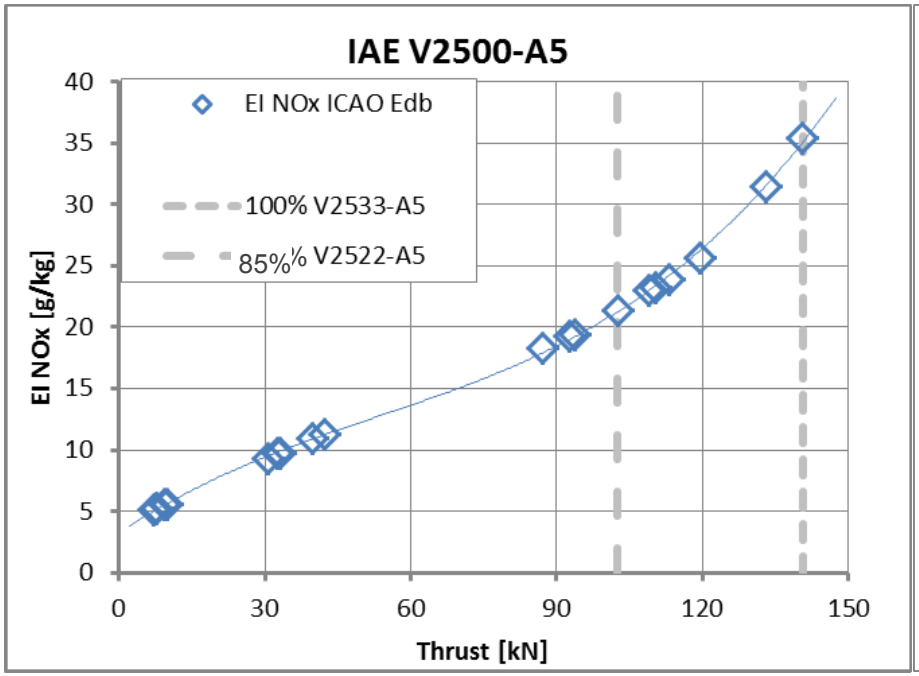
Comparison with SCOPE11 Emission Model



Indication of Engine Operating Condition

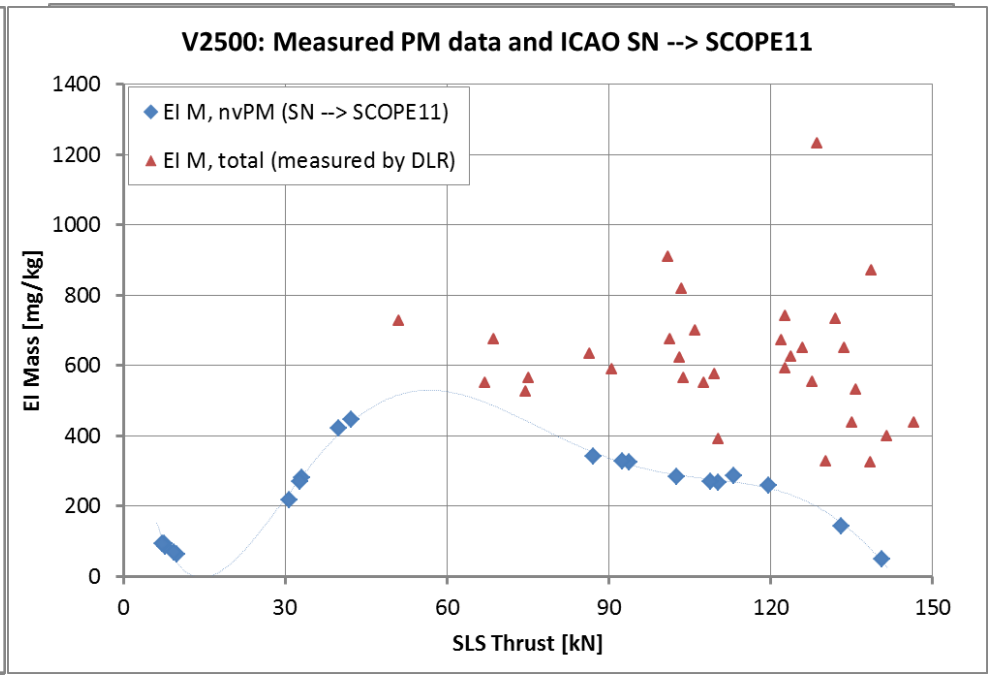
- Example: IAE V2533-A5 engine
- Comparison with DLR engine simulation model (DLR-AT, M. Plohr)

EI NOx



EI NOx data of all variants from ICAO engine emissions data bank

Smoke Number



SN data and max. SN of all variants from ICAO engine emissions data bank

Comparison to Similar Studies

SCIENTIFIC DATA

OPEN

Data Descriptor: Take-off engine particle emission indices for in-service aircraft at Los Angeles International Airport

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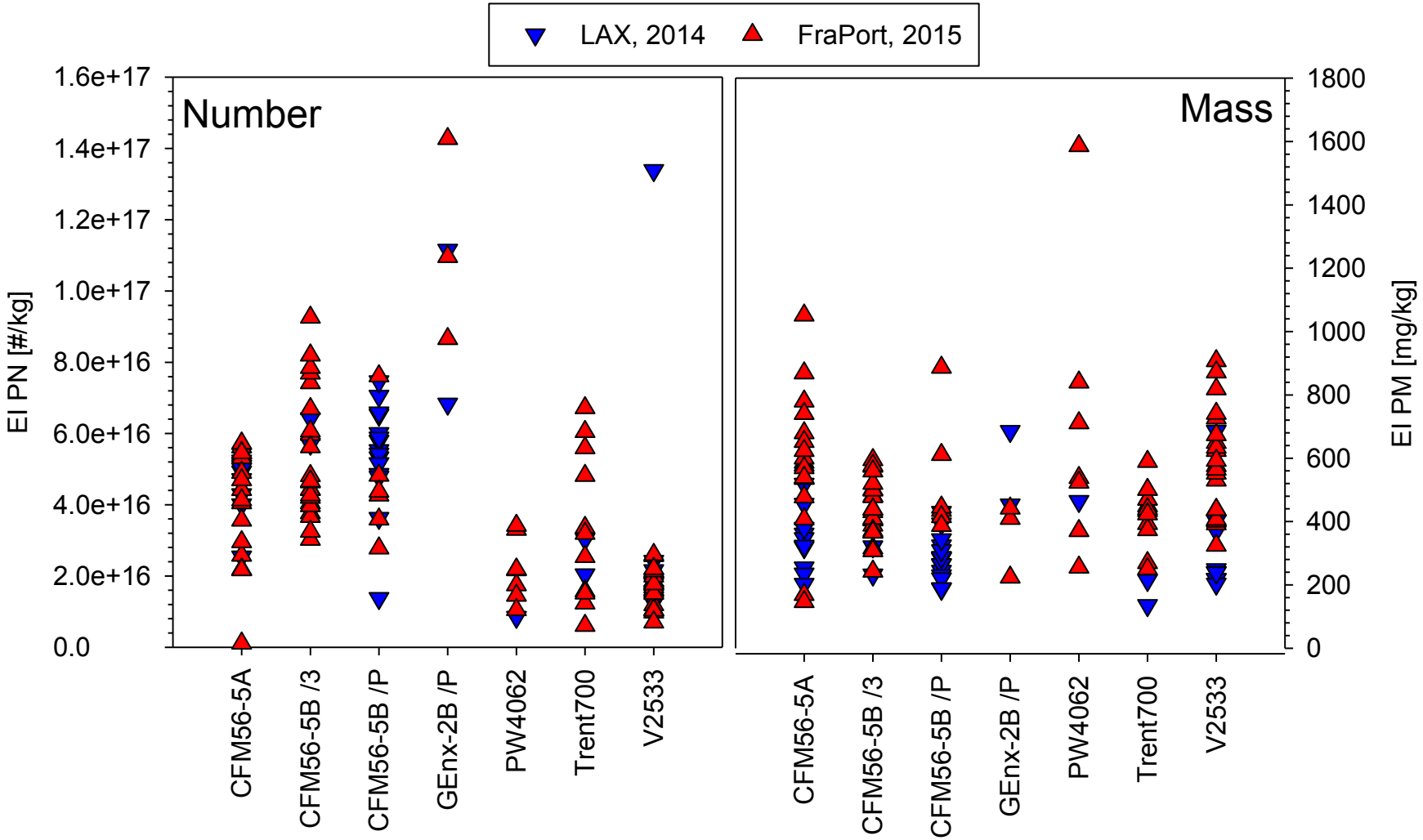
Richard H. Moore[1], Michael A. Shook[1,2], Luke D. Ziemba[1], Joshua P. DiGangi[1], Edward L. Winstead[1,2], Bastian Rauch[3], Tina Jurkat[4], Kenneth L. Thornhill[1,2], Ewan C. Crosbie[1,5], Claire Robinson[1,2], Taylor J. Shingler[1,5] & Bruce E. Anderson[1]

- 18. – 25. May 2014 at LAX
- 275 plumes at a distance of 400 m
- CO2 (LICOR), tPN (CPC), nvPN (CPC), EEPS (**tPN**, PSD)

DLR

Comparison to Similar Studies



Conclusions

- The experimental setup is excellent to provide real engine exhaust emission data / The selection of instruments can be improved (incl. nvPM).
- The operating condition of the respective engines can be estimated on the basis of the nitrogen oxide data.
- The correlation to SCOPE11 estimations is very limited due to a number of factors (volatile particles, unknown fuel composition).
- The two relevant ICAO points (T/O and climb) are not enough to describe the transient engine operation.
- In order to estimate the real engine emission at airports further research should focus on transient engine operation.

Thank you for your attention!