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Comparing Measured Pass-by Levels of Accelerating Battery Electric Cars and Combustion Engine Cars

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09.07.2025 – GRBP Vehicle Sound

Under which driving conditions

are electric cars quieter than combustion engine cars?

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3. Comparing Measured SELs
4. Pass-by Level Models
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Motivation

Among all transportation modes

road traffic noise impacts the most people (90M Europeans),

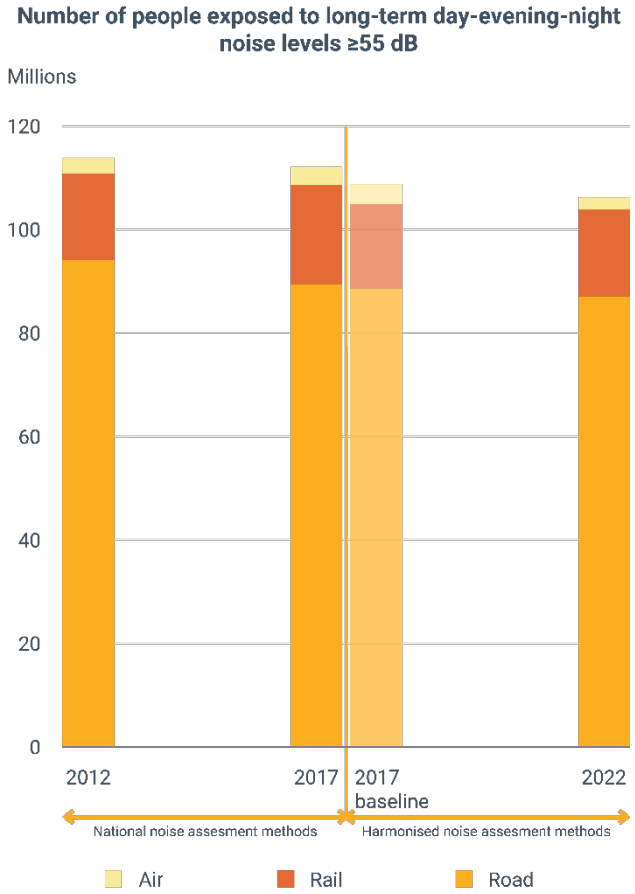
especially in cities and around major transit routes.

→ Every dB reduction counts!

BEVs gain popularity, but noise model data is still scarce.

→ Effect of the fleet's electrification is difficult to predict.

→ Need data on BEV/ICEV sound emission under typical urban driving conditions



Zero pollution monitoring and outlook 2025
EEA (Mar. 2025), doi: 10.2800/6470682

Measurement Campaign

- Controlled pass-by noise
- **9 pairs of comparable BEVs & ICEVs**
- 105 m long measurement section on a test track
- **Target speed/acceleration profiles**
- **8 microphone positions** (7.5 m / 1.2 m)
- **Kinematics** per satellite-based positional data at high precision (error < 10 cm) & high rate (15 Hz)

= 500+ runs → **1700+ microphone pass-bys with 18 cars**

Measurement Campaign

Acquired 9 relevant (Swiss fleet) BEVs.

→ Selected ICEV:

- Alternative car from a consumer perspective, i.e. similar
  - dimensions
  - price
  - power-to-mass ratio
- Automatic gearboxes, only

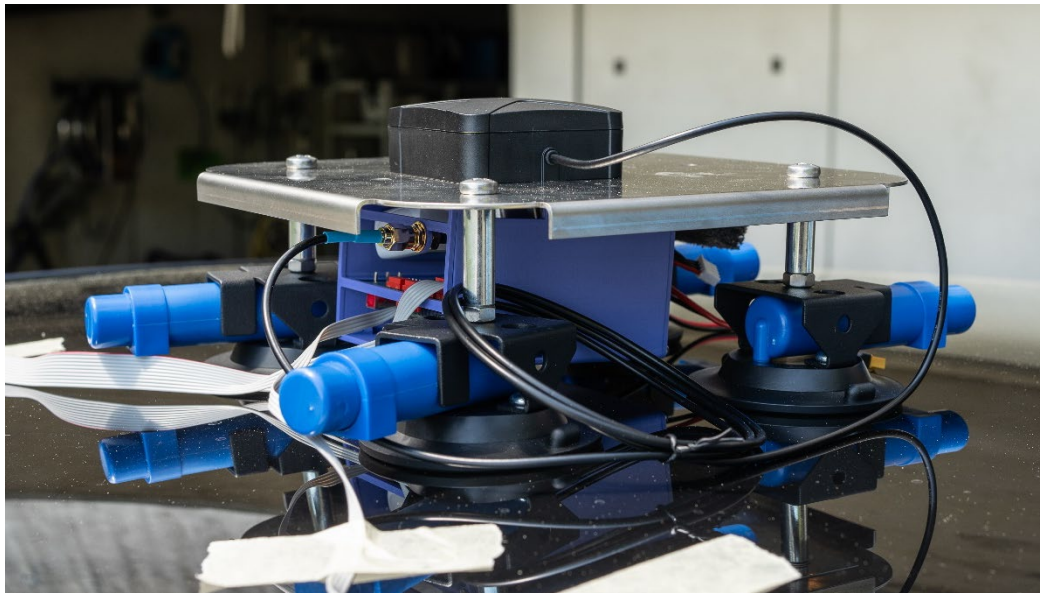
Pair ID	BEV	ICEV	Vehicle Category
1	Peugeot e-208	Peugeot 208	Compact
2	VW ID.3	Seat Leon	Lower-Range Mid-sized
3	Volvo EX40	Volvo XC40	Mid-sized SUV
4	Tesla Model Y	Skoda Kodiaq	Large SUV
5	Skoda Enyaq	Seat Tarraco	Large SUV
6	Tesla Model 3 Perf.	Mazda 6	Mid-Range Mid-sized
7	Volvo EX30	Mazda CX-3	Small SUV
8	Hyundai Ioniq5	Ford Kuga	Large SUV
9	VW ID.Buzz	VW Multivan T7	Large Van

Prior to the measurements,
all cars were equipped with new tyres and run in for 500 – 1000 km.

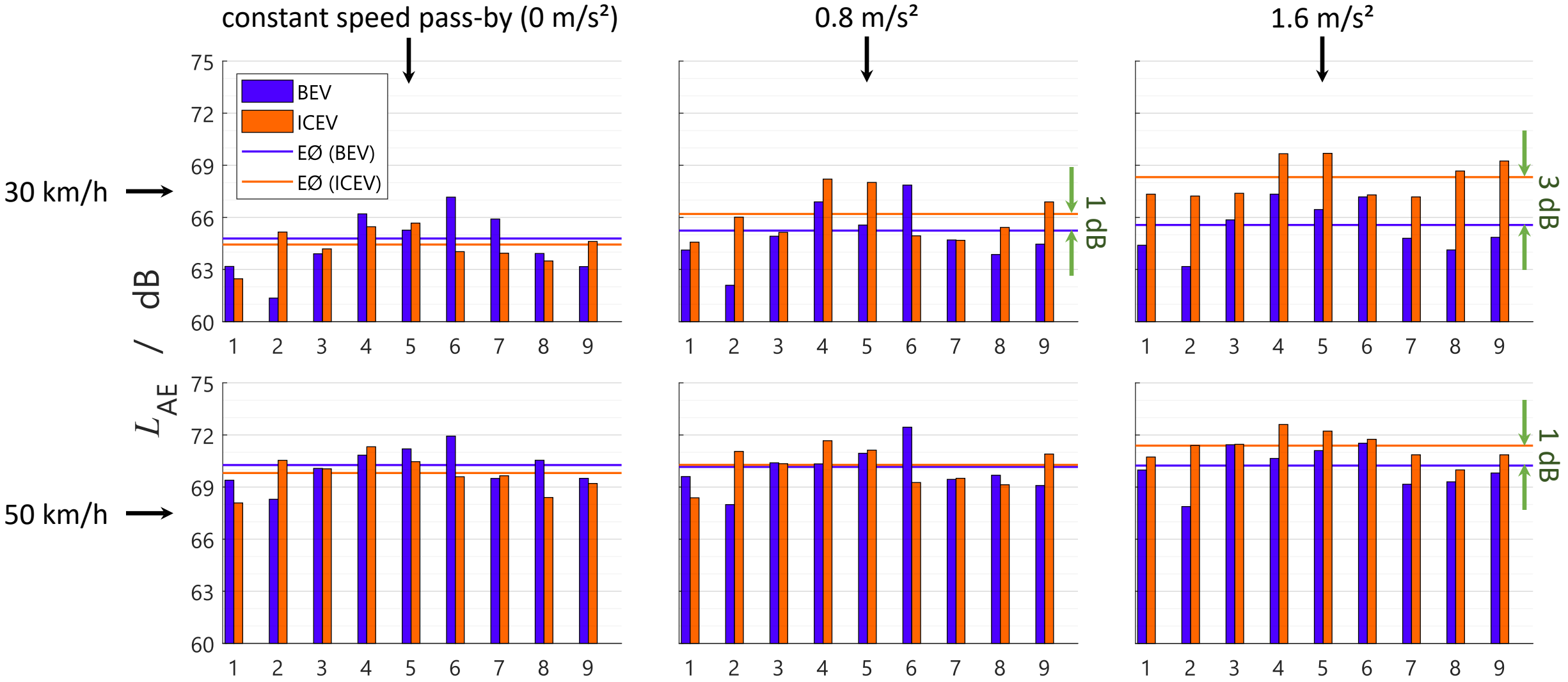
Measurement Campaign

Cars were equipped with an in-house developed and self made electronics board to

- record GNSS data,
- provide visual acceleration feedback for the driver.



Comparing Measured SELs



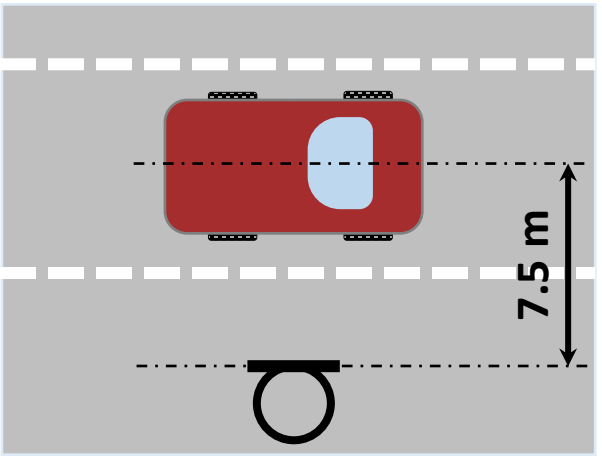
Pass-by Level Models

Measured Microphone Pass-bys

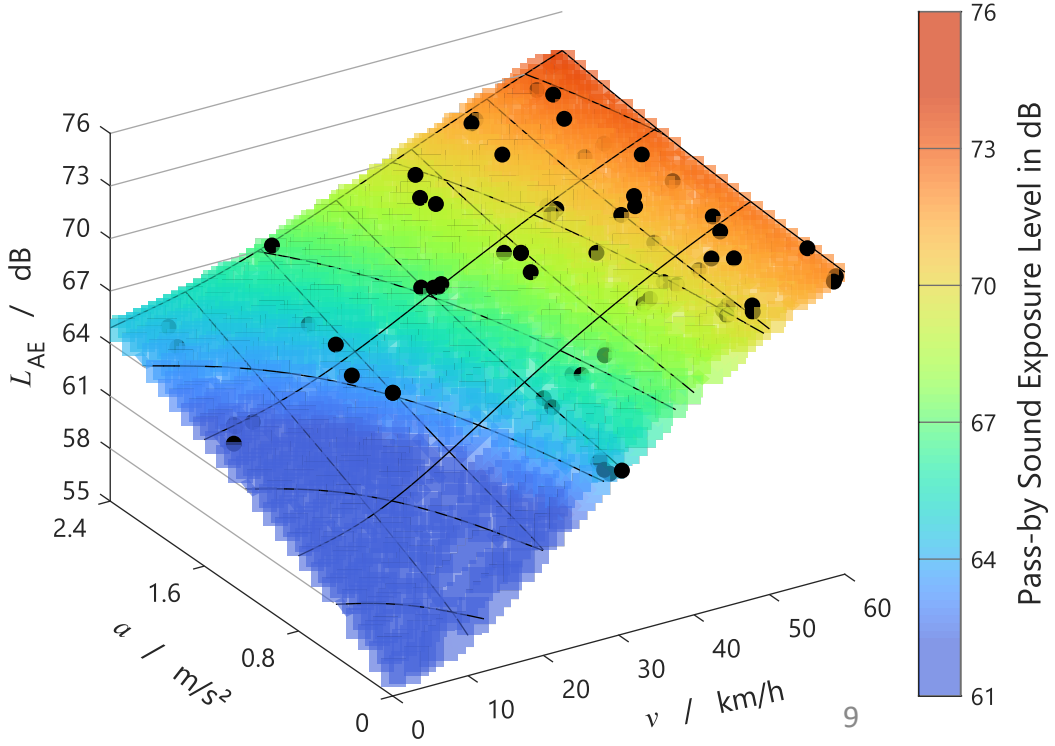
Value Triplets $[v_{\mathrm{PB}}, a, L_{\mathrm{AE}}]$

vehicle-specific models $L_{AE}(a, v_{\mathrm{PB}})$ by LSQ-fitting
7 parameters: $\gamma_{1\ldots5}, \delta_1, \delta_2$

$$L_{\mathrm{AE}}(v_{\mathrm{PB}}, a) = \left(\gamma_1 + \gamma_2 \cdot \left(\frac{a}{a_0}\right)^{\gamma_3} + \gamma_4 \cdot \left(\frac{v_{\mathrm{PB}}}{v_0}\right)^{\gamma_5}\right) \oplus \left(\delta_1 + \delta_2 \cdot \lg\left(\frac{v_{\mathrm{PB}}}{v_0}\right)\right)$$



v_{PB}	a	L_{AE}
50 km/h	0.0 m/s²	64.2 dB
51 km/h	1.6 m/s²	65.6 dB
59 km/h	0.8 m/s²	66.1 dB
30 km/h	2.4 m/s²	64.8 dB
⋮	⋮	⋮



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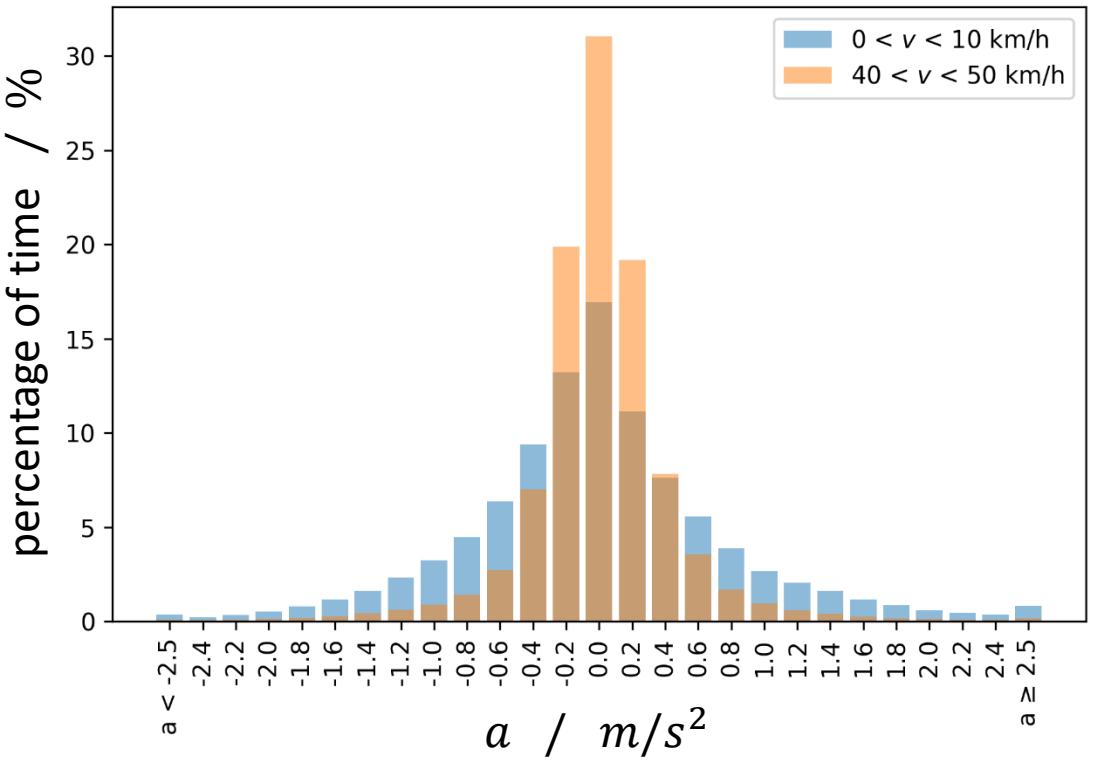
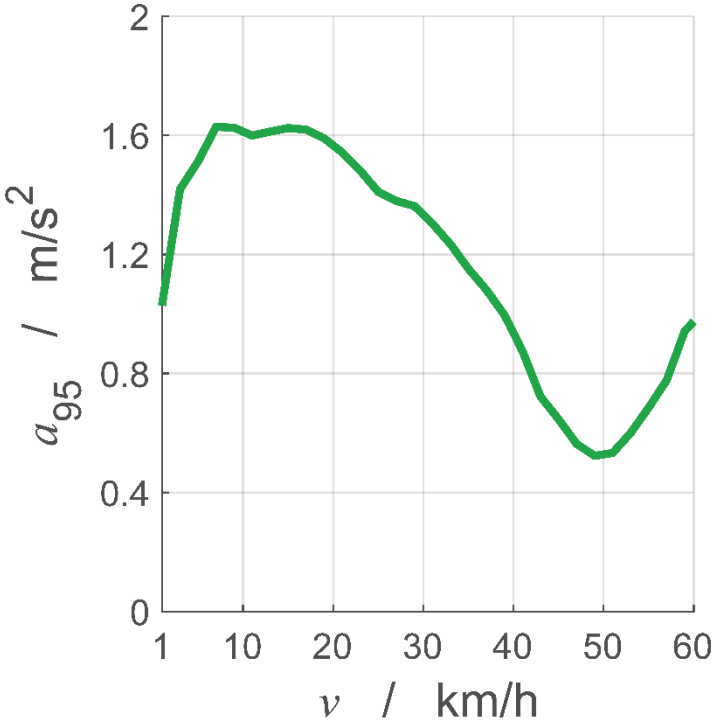
Comparing Modeled SELs

- 7-coefficient models for all 18 cars → L_{AE} prediction for arbitrary v and a
- Vehicle kinematics measured in real urban traffic → distribution of $a(v)$



highest acceleration during 95% of the time the car is driven



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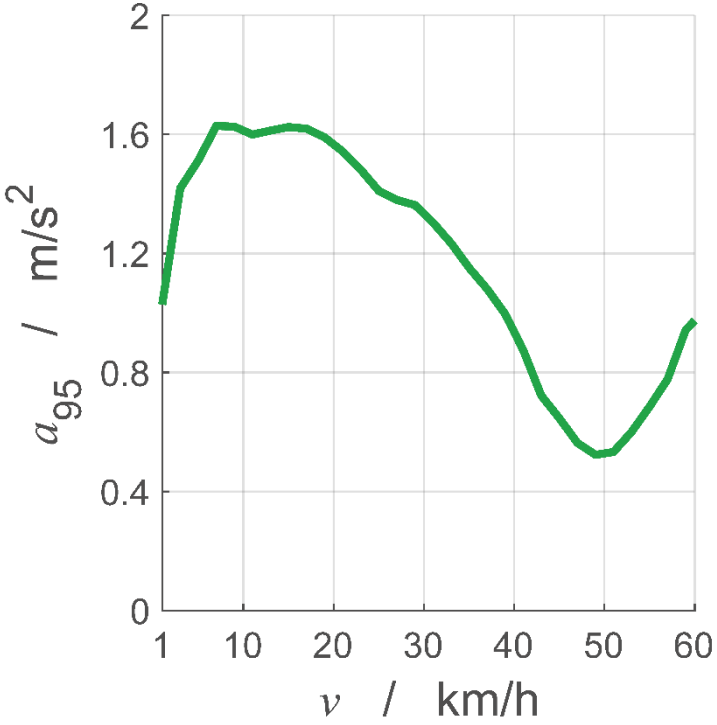
Comparing Modeled Results

- 7-coefficient models for all 18 cars → calculate L_{AE} for arbitrary v and a
- kinematics measured in real urban traffic → distribution of $a(v)$

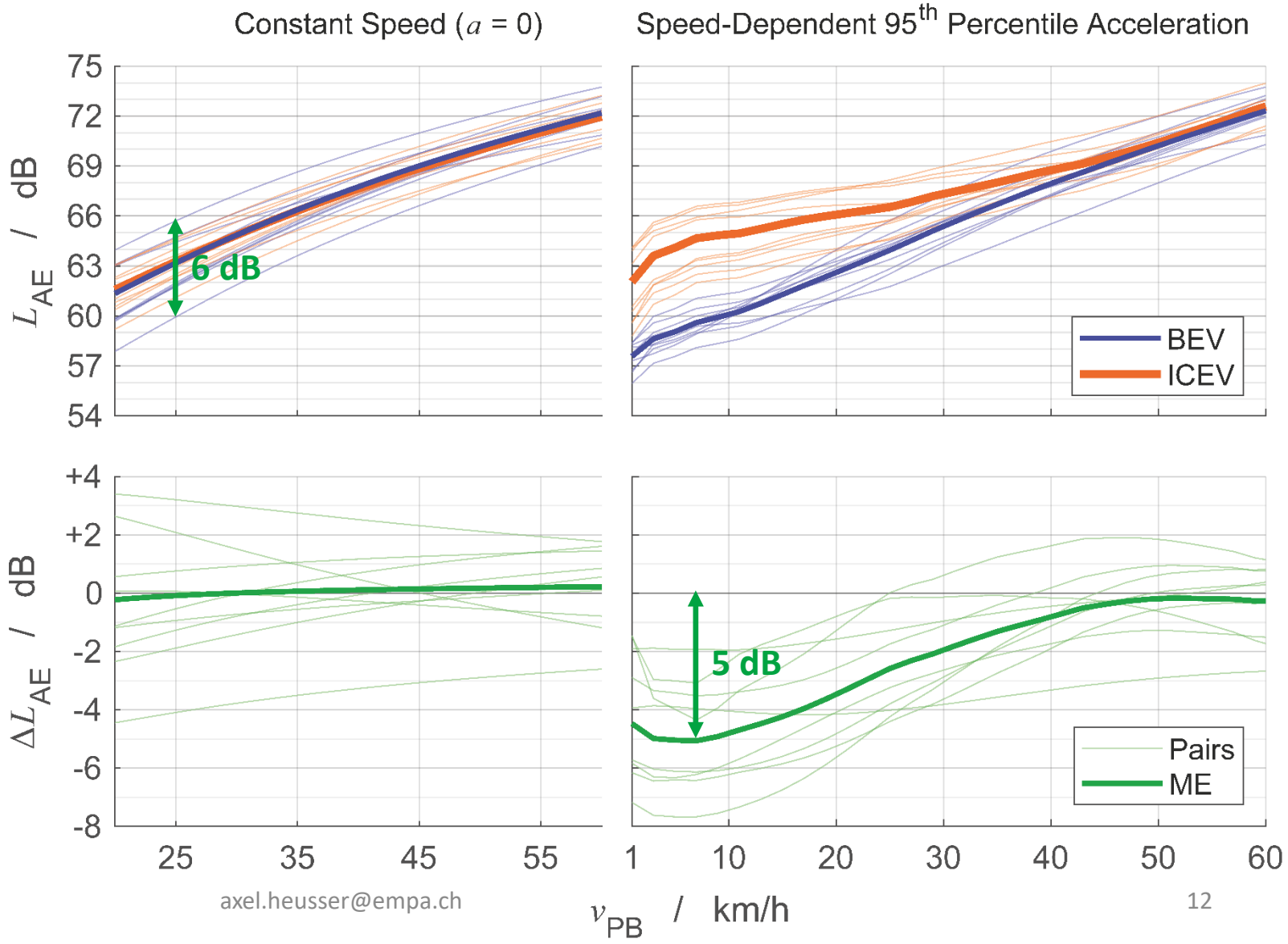
highest acceleration during 95% of the time the car is driven



$$L_{\mathrm{AE}}(a,v) = \left(\gamma_1 + \gamma_2 \cdot \left(\frac{a_{95}}{a_0}\right)^{\gamma_3} + \gamma_4 \cdot \left(\frac{v}{v_0}\right)^{\gamma_5}\right) \oplus \left(\delta_1 + \delta_2 \cdot \lg\left(\frac{v}{v_0}\right)\right)$$

Comparing Modeled Results

- At constant speed,
  - BEVs and ICEVs produce the same exposure levels L_{AE} during pass-by,
  - both, the loudest and quietest cars, spanning 6 dB, are BEVs.
- Under acceleration,
  - differences ΔL_{AE} are largest at speeds < 10 km/h when acceleration is high (up to 8 dB, average 5 dB),
  - above 40 km/h, the mean difference is < 1 dB.



Conclusions

→ At constant speeds 30 – 60 km/h, no SEL difference between BEVs and ICEVs was found.

→ Under acceleration, BEVs produce lower SELs than ICEVs,
particularly at low speeds and high acceleration rates.

→ At the 95th percentile acceleration rate in urban driving conditions:

- below 10 km/h (a_{95} = 1.6 m/s²): BEVs can be quieter by up to 5 dB
- 10 – 40 km/h (a_{95} = 1 … 1.6 m/s²): difference steadily decreases
- above 40 km/h (a_{95} < 1 m/s²): negligible average difference < 1 dB

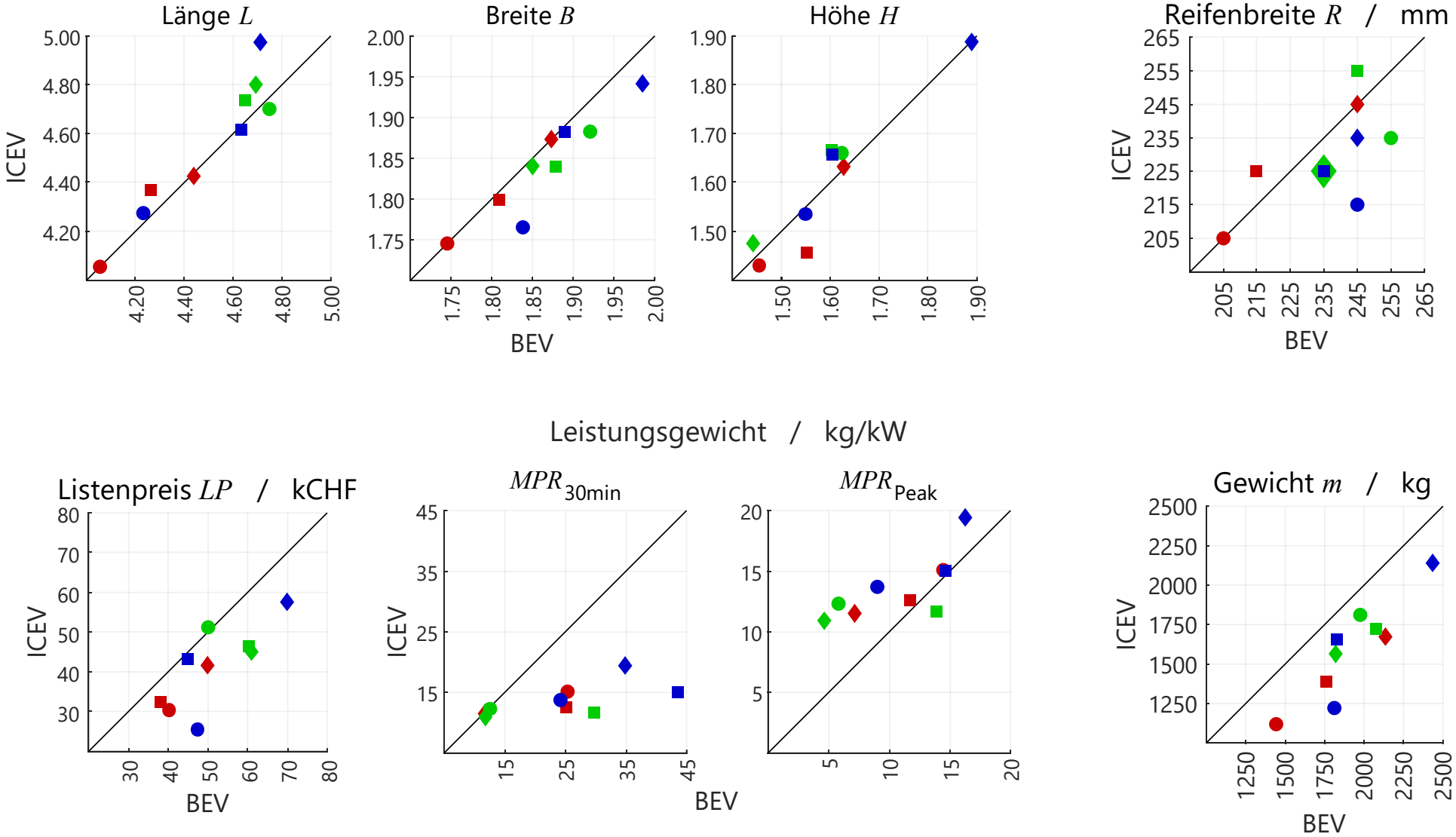
Outlook

- Spectral analyses and modelling
- Quantify local effects: urban intersections / roundabouts, where speed is unsteady
- Investigating further influencing parameters
  - Pavement
  - Temperatures
  - EU tyre label

Comparing Measured Pass-by Levels of Accelerating Battery Electric Cars and Combustion Engine Cars

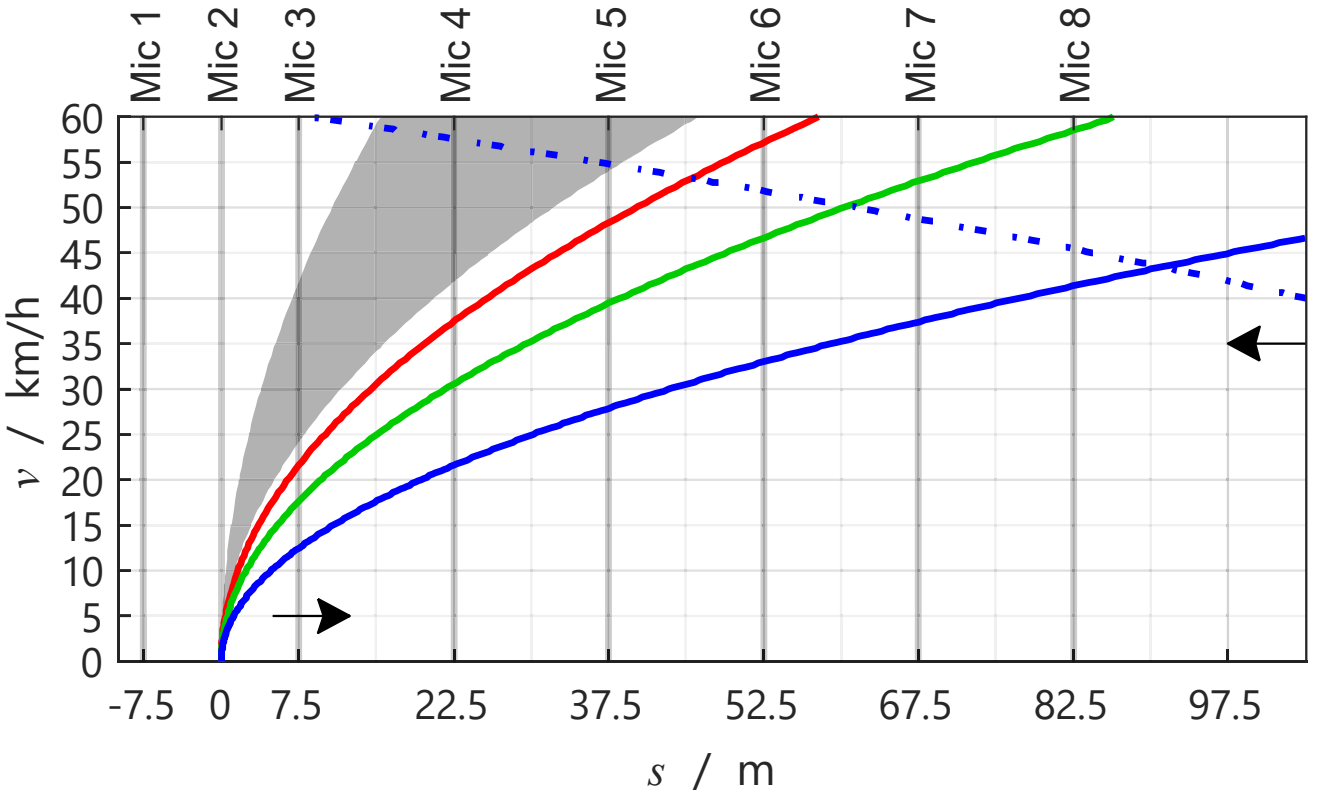
Thank you!
I'm happy to answer your questions.

BEV/ICEV Comparability

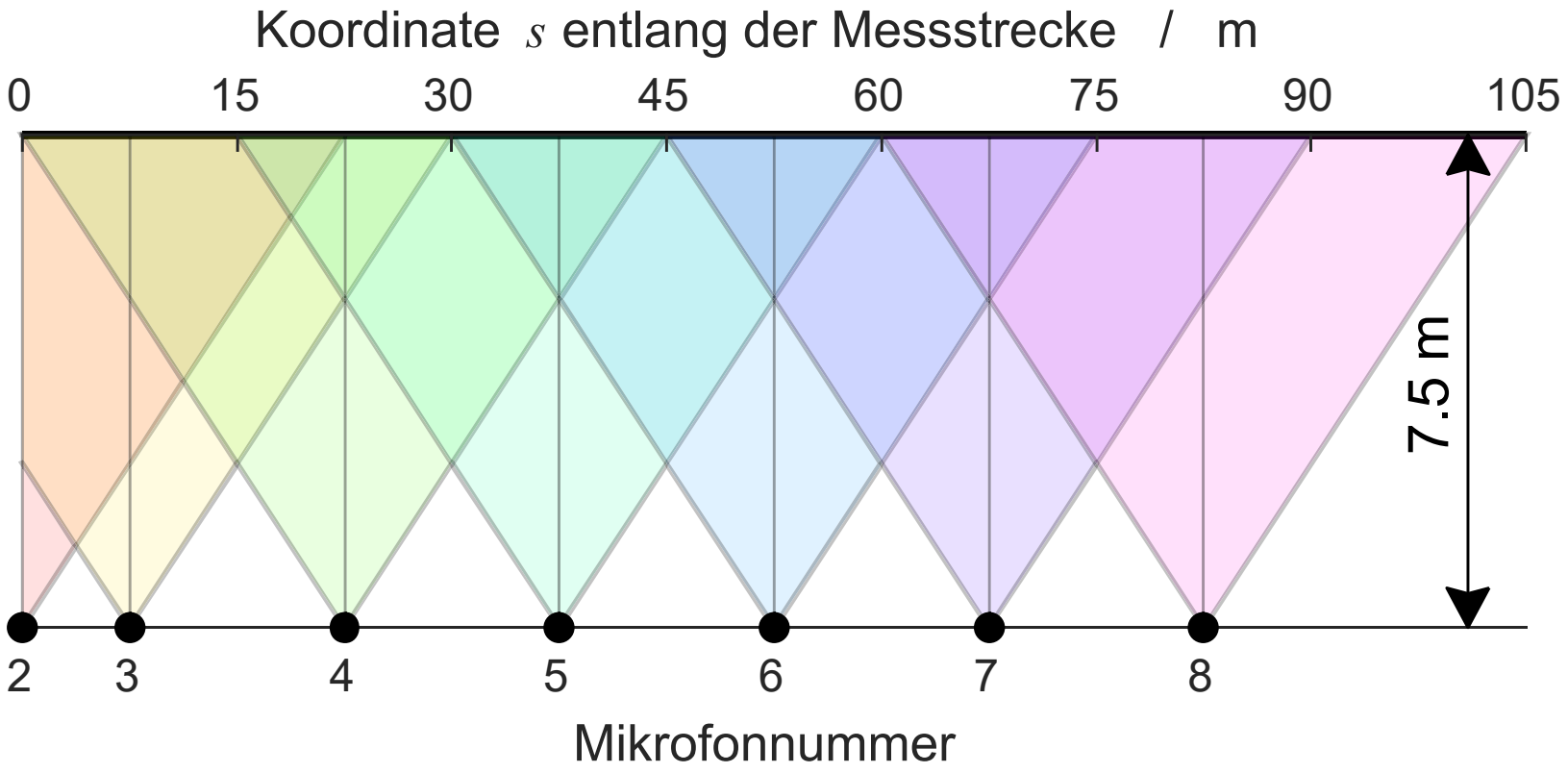


Speed / Acceleration Profiles

Constant Speed: 10, 30, 50, 60 km/h
Target acceleration rates: 0.8, 1.6, 2.4 m/s² & Full Throttle



Measurement Setup



Measurement Conditions