

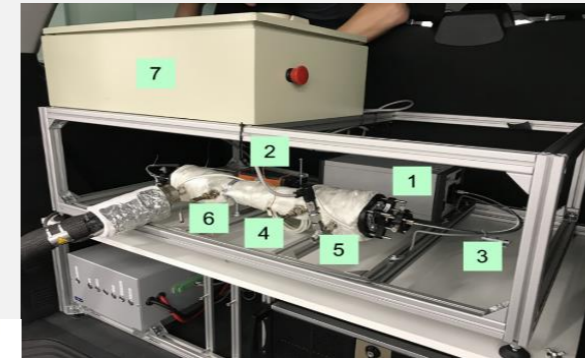
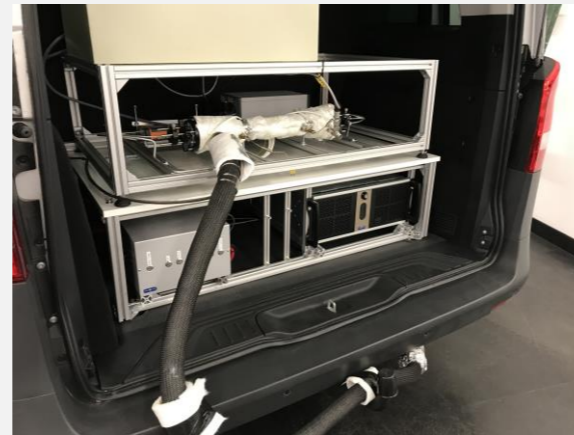


On road emissions of NH₃, NO and NO₂ of Euro 6c and Euro 6dtemp vehicles

Cajic, Fischbacher, Lechner

A3PS | 14.11.2019

- Motivation
- System Description
- Measurements
- Results
- Discussion



Fahrverbote für Diesel? So bewahren Sie ...
t-online.de



400 000 Europäer sterben durch Luftverschmutzung
 Süddeutsche Zeitung - 16 Oct 2019
 Die Belastung durch Verkehr und Landwirtschaft ist nahezu konstant geblieben,
 "Am Beispiel der Stickoxide erkennt man die Bedeutung ..."

Ammonium nitrate ~ 65 % of particulate matter

V. Borsari, J.V.d. Assunção / Transportation Research Part D 51 (2017) 53–61

Years of life lost:

PM_{2.5}: 4 200 000
 NO₂: 707 000
 O₃: 160 000



Berlin: Fahrverbote für Dieselaautos auf ...
 spiegel.de



Daimler zahlt 870 Millionen Euro Strafe wegen Dieselgate
 Reuters Deutschland - 24 Sep 2019
 Das Bußgeld, das bis auf vier Millionen Euro Strafe aus Gewinnabschöpfung
 bestellt, ... 870 M€ ... elastung, erklärte ...
 Daimler ...
 BLICK.CH - 24 Sep 2019

Daimler zahlt Bußgeld von 870 Millionen Euro
 t-online.de - 24 Sep 2019

[View all](#)



Table 10.1 Premature deaths attributable to the EU-28, 2015

Country	Population (1 000)	Annual mean (°)	NO ₂		Premature deaths (°)	Premature deaths (°)
			Annual mean (°)	Premature deaths (°)		
			19.8		1 200	
Austria	8 576	13.3				380
Belgium	11 237	13.0	7 400	20.9	1 500	2 790
Bulgaria	7 202	24.1	14 200	16.1	640	4 180
Croatia	4 225	17.4	4 500	17.3	430	6 240
Cyprus	1 173	16.9	750	14.1	30	6 390
Czechia	10 538	17.0	10 100	16.6	490	5 560
Denmark	5 660	9.7	2 800	10.5	80	2 200



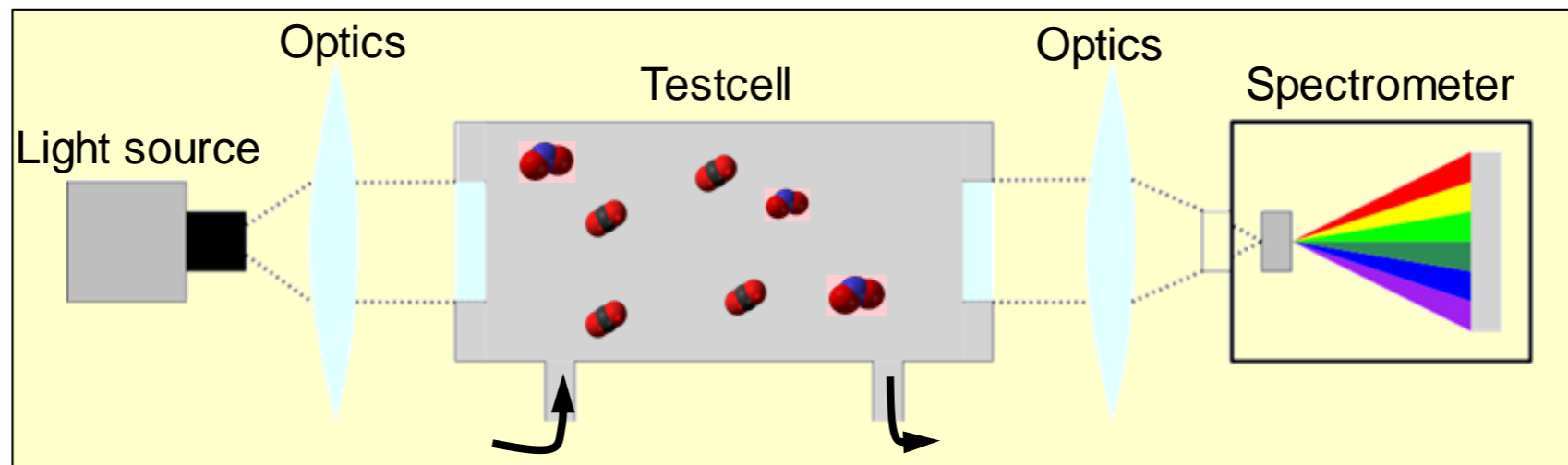
Aargauer Zeitung

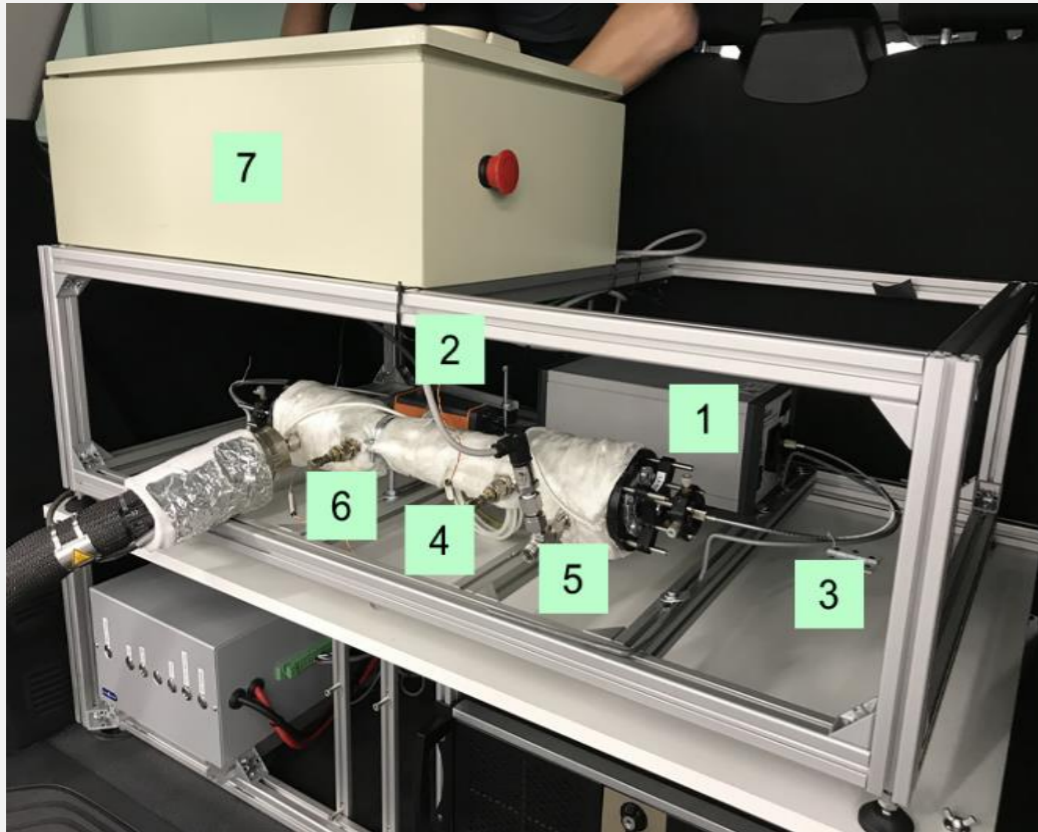
Mammut-Prozess gegen Volkswagen hat begonnen
 DIE WELT - 30 Sep 2019
 Allein in den USA hat ... 25 Mrd. € ... eßlich Strafen mehr als 25
 Milliarden Euro gekostet ... hland ...
 Richter im Prozess um VW-Sammelklage regt Vergleich an
 In-Depth - Aargauer Zeitung - 30 Sep 2019

Targets

- **Minimum detection limit: 1 ppm**
- **Robustness**
 - No moving parts
 - Gas temperature 190°C
 - Low production costs

- **Absorption spectroscopy in the deep ultraviolet region**
- Simple and robust technology
- Very high absorption features of NH_3 and NO
- No interference to H_2O , CO_2 and CO





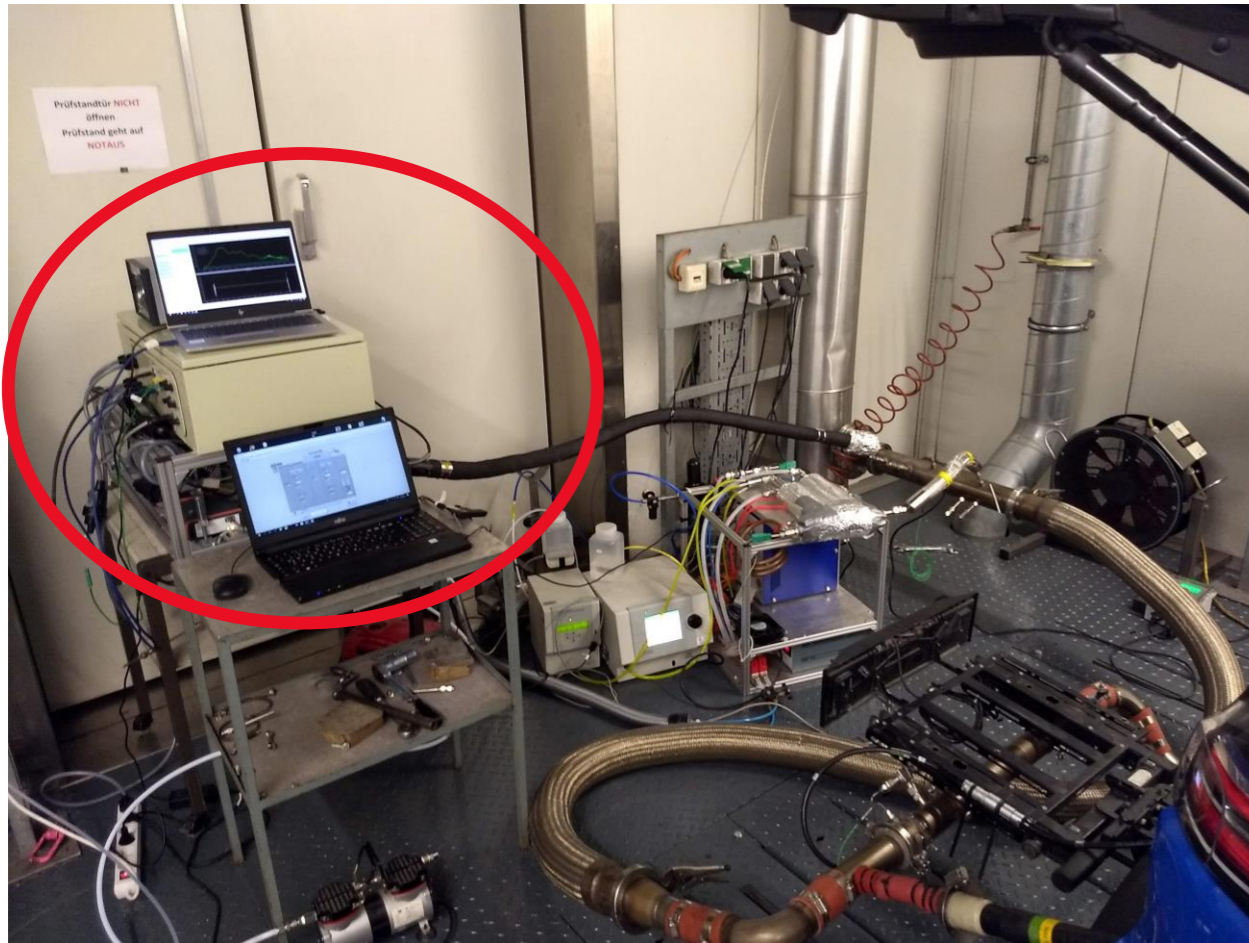
Components

1. Lightsource
2. Spectrometer
3. Optical fiber
4. Test cell (path length 0.5 m)
5. Temperature and pressure sensors
6. Heating
7. Data acquisition

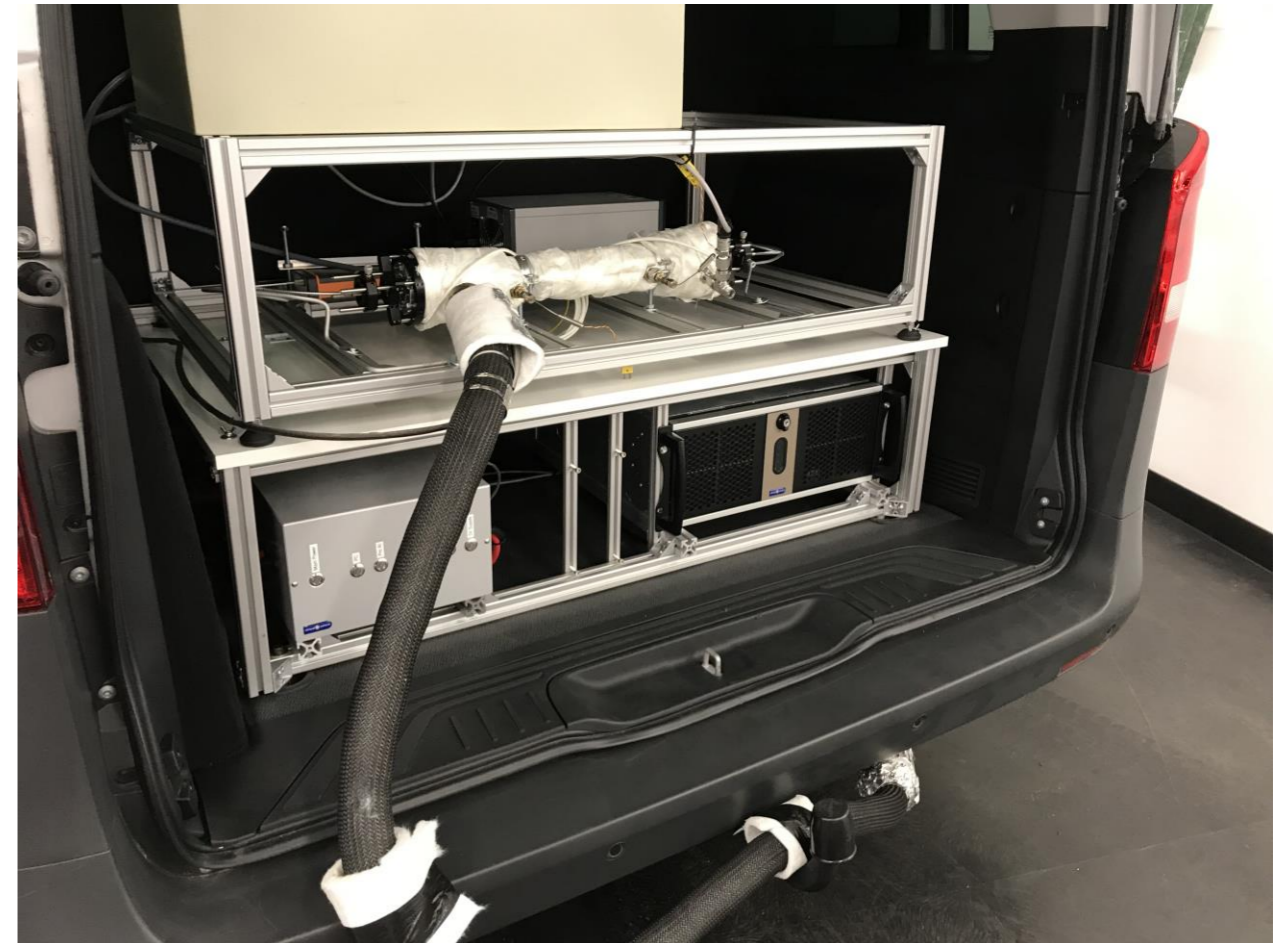
Sampling rate

NH₃ and NO as fast as necessary
NO₂: 1 Hz

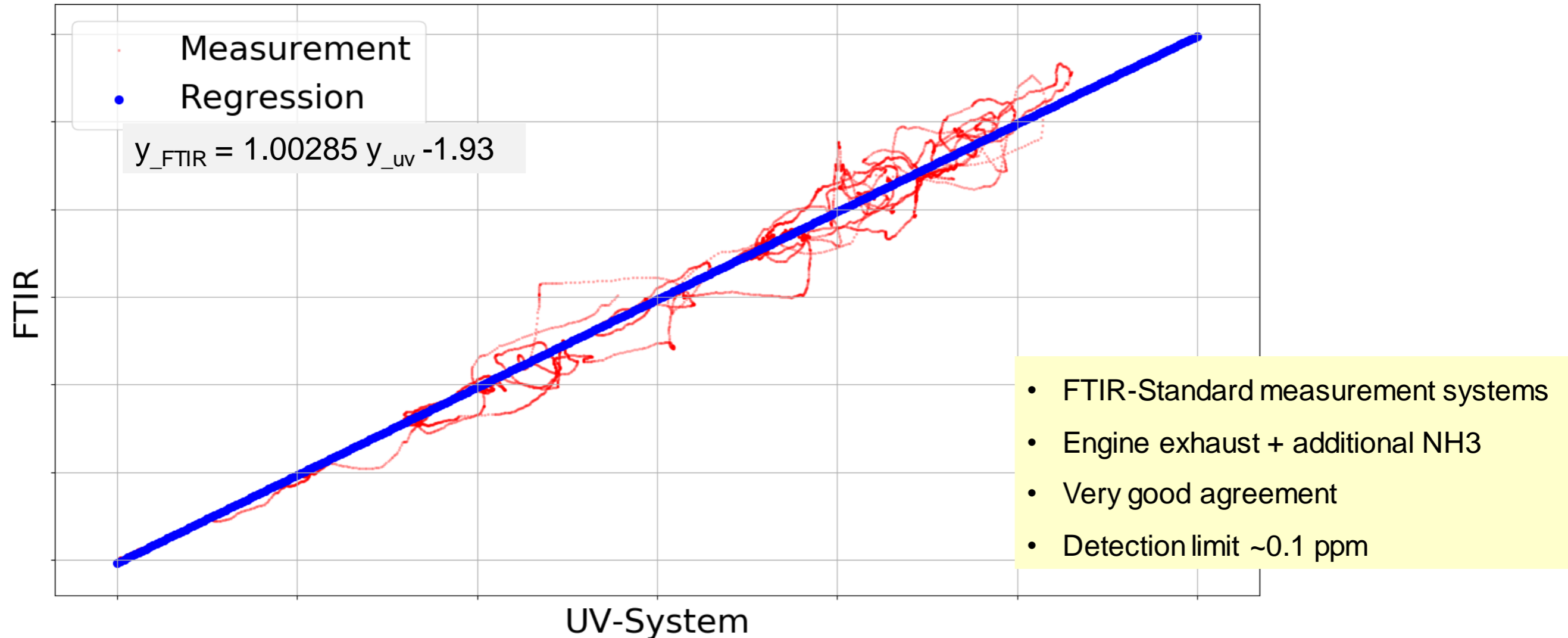
Chassis dynamometer



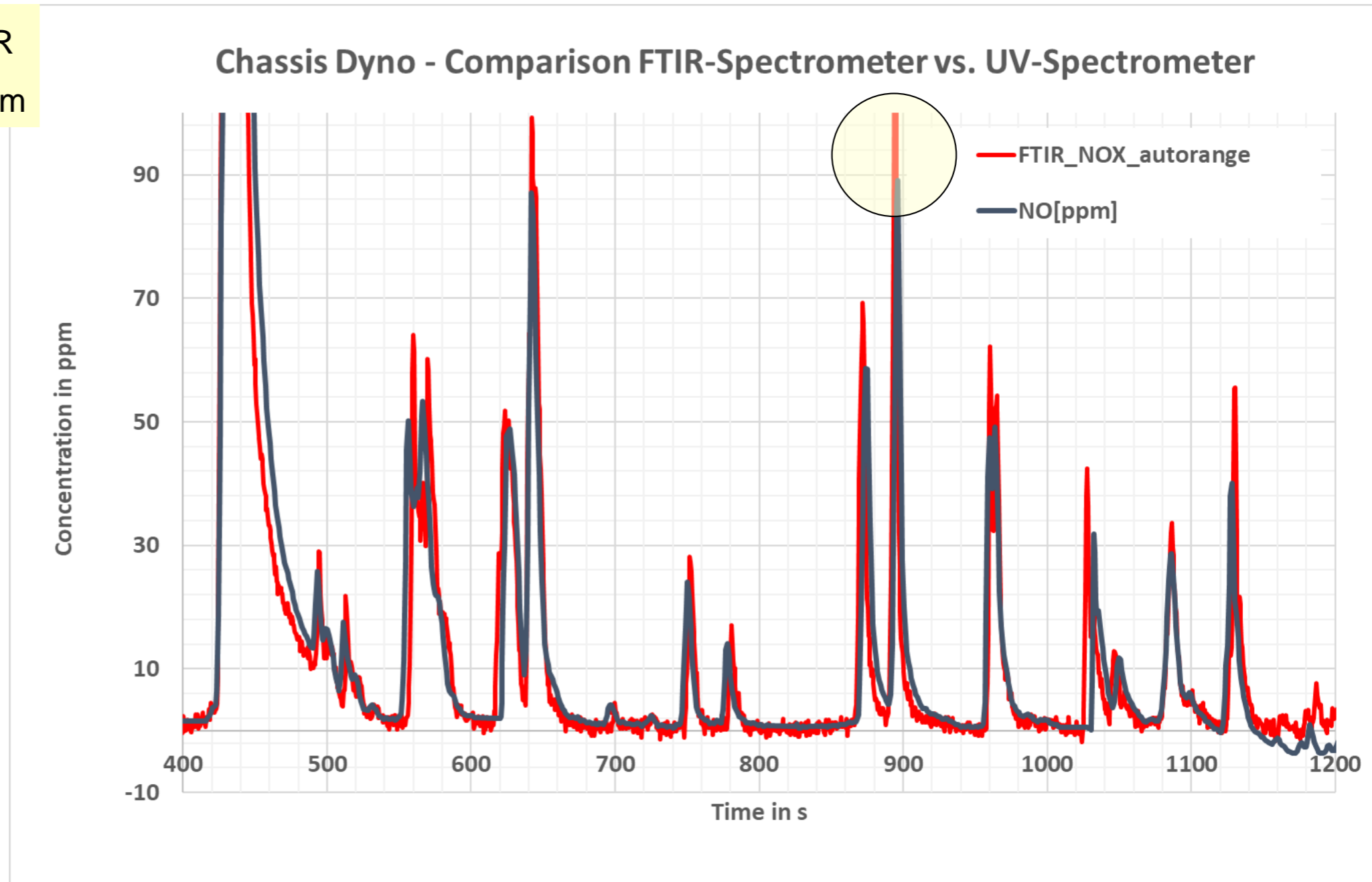
Vehicle

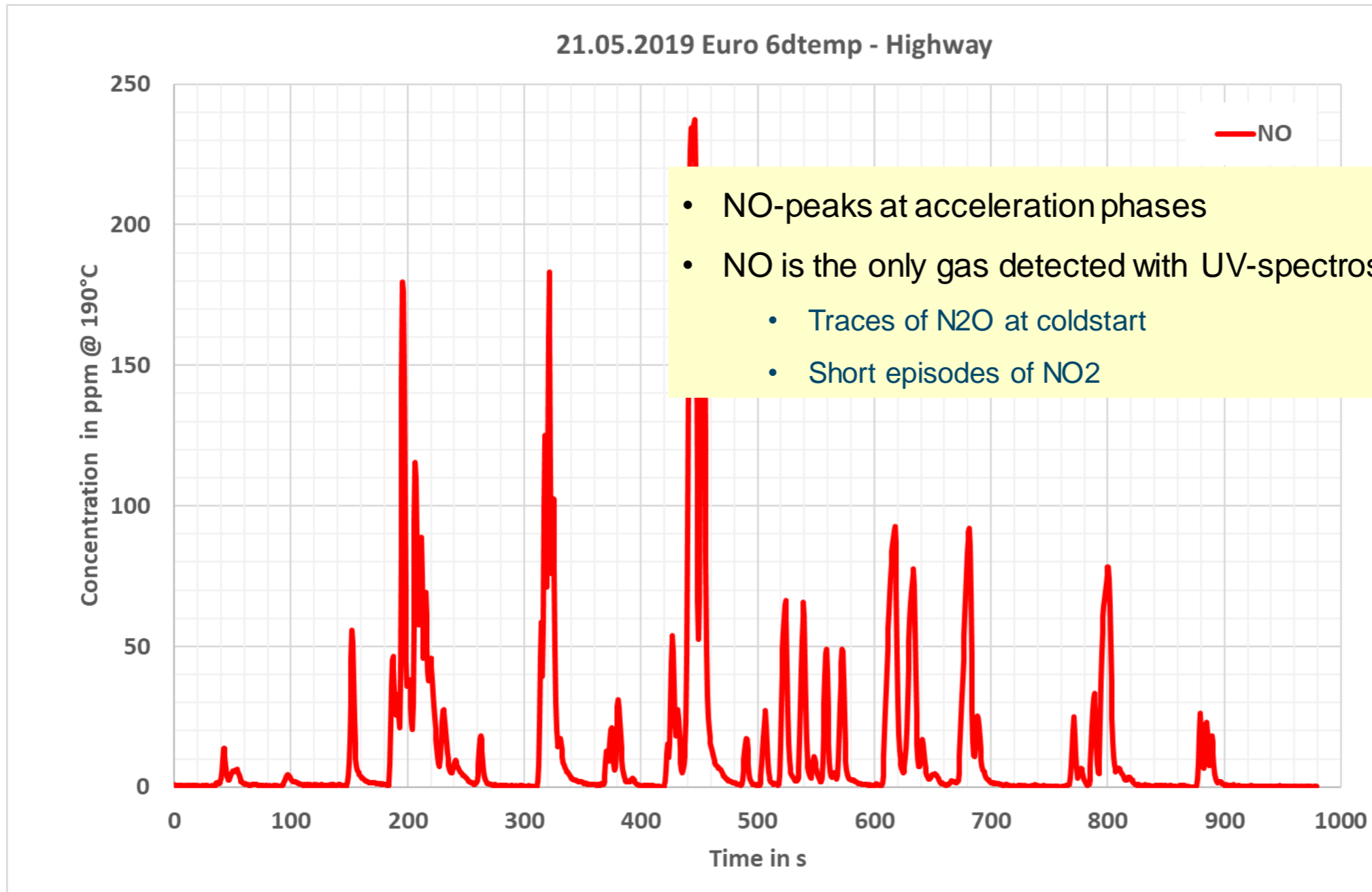


Comparison NH3 FTIR-Spectrometer - UV- Spectrometer



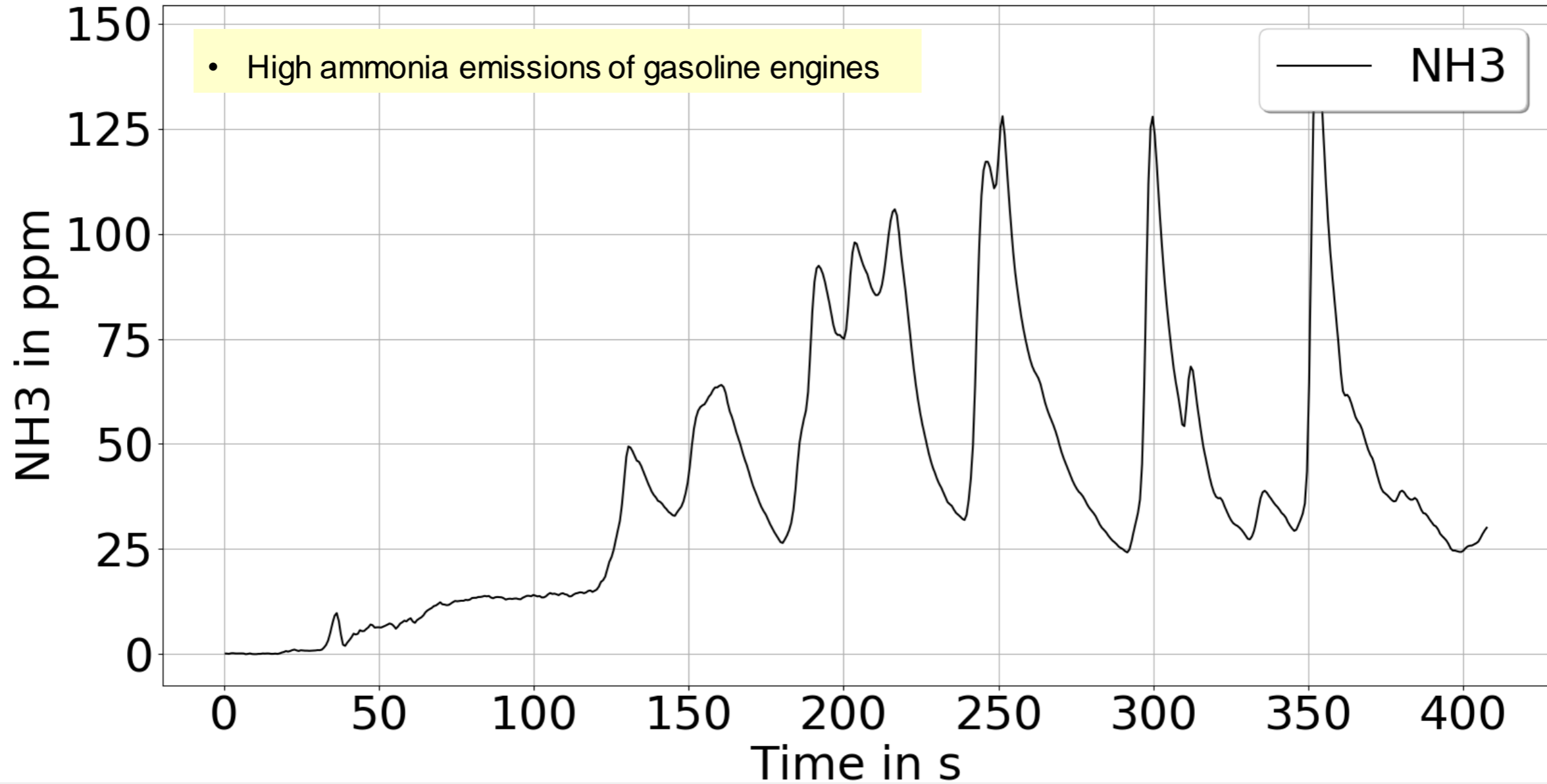
Good agreement with FTIR
Lower Peaks @ ViF-system

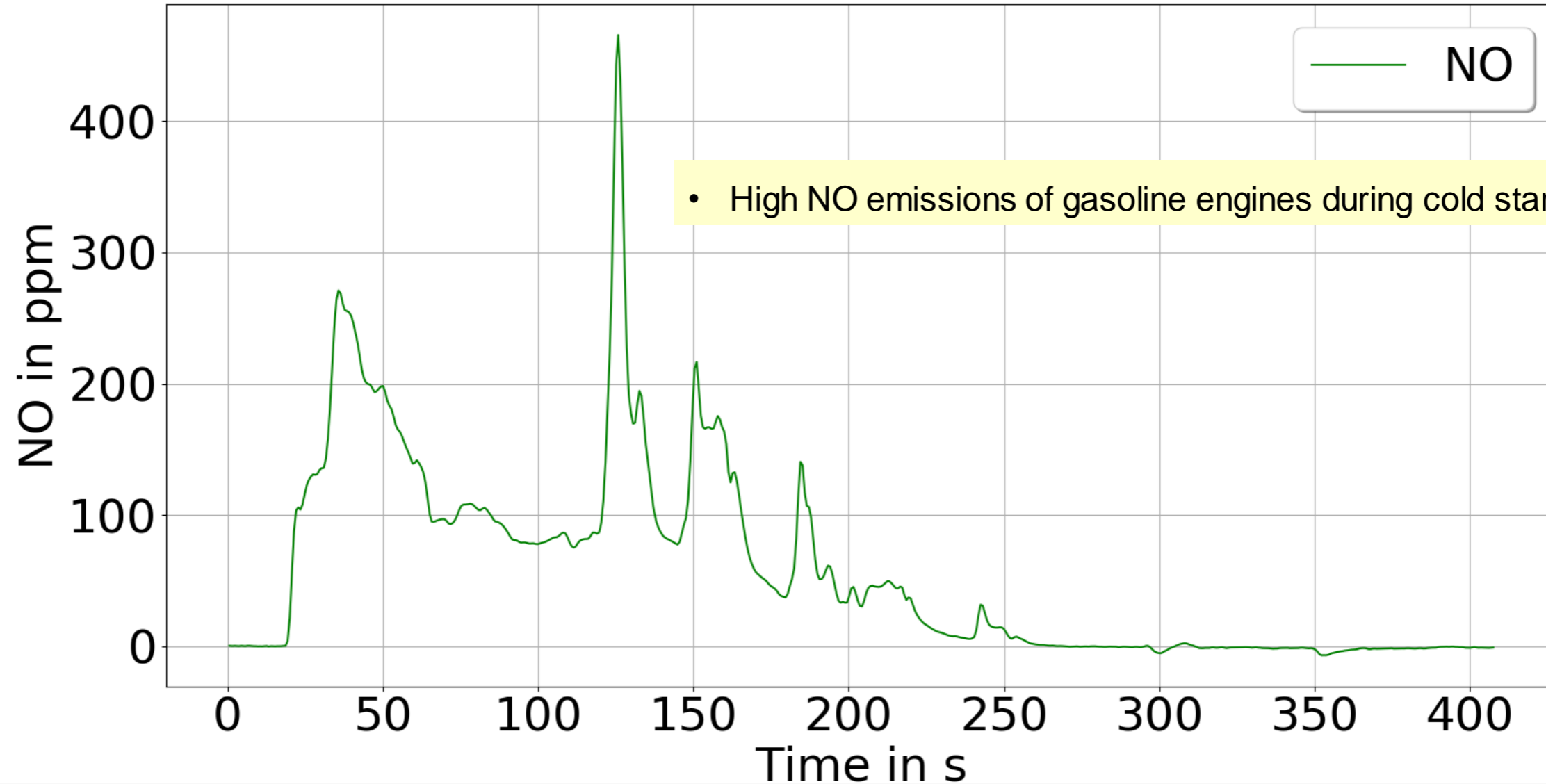


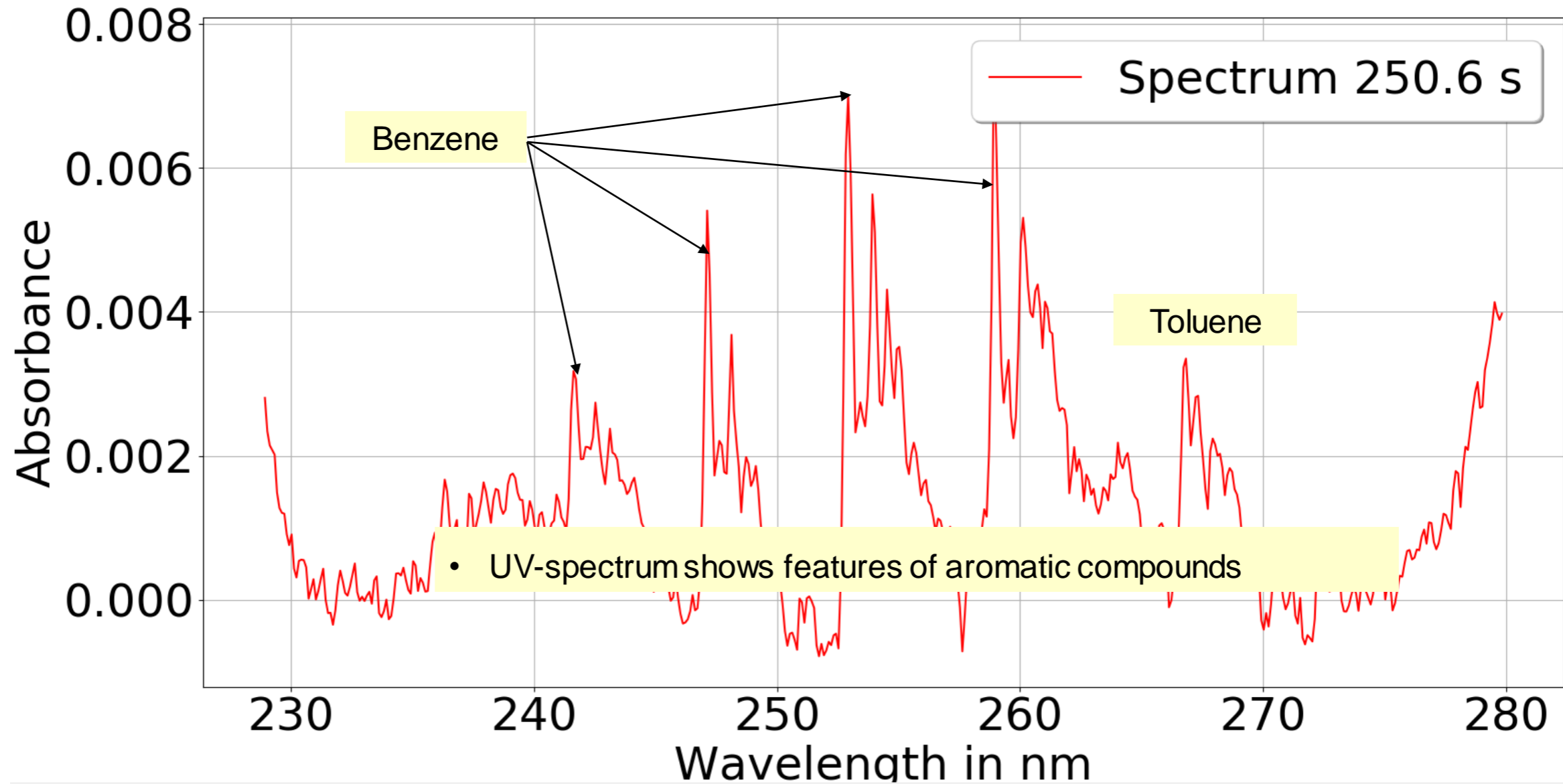


Acknowledgement:

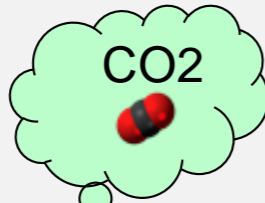
This dataset was generated by a test vehicle provided by AVL List GmbH and the authors want to express their thanks.







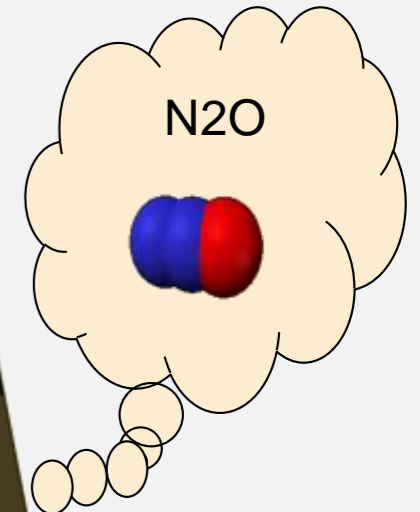
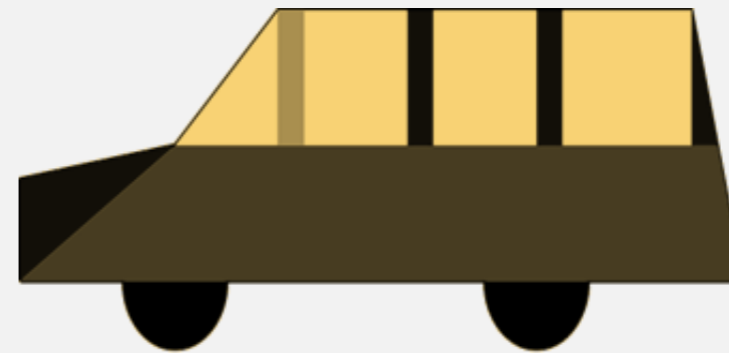
Well known – diesel engine more efficient



Not in the scope of this study

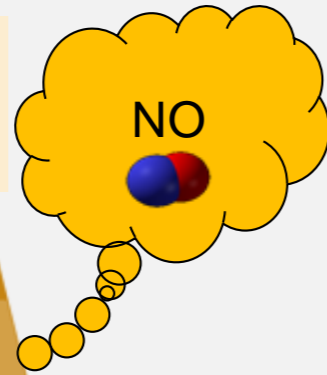


Very high emissions of gasoline engines @ cold start (some 10000 ppm)
Gasoline will never meet any regulation

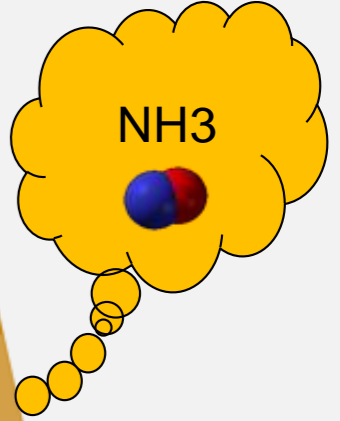


<https://en.wikipedia.org>

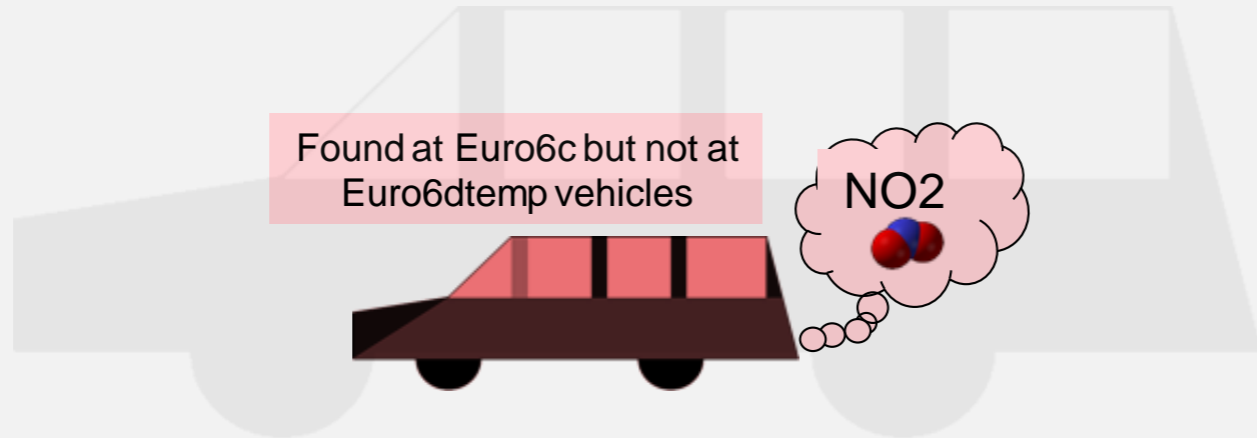
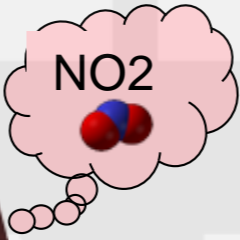
About the same for both fuel types – more highway data needed for gasoline



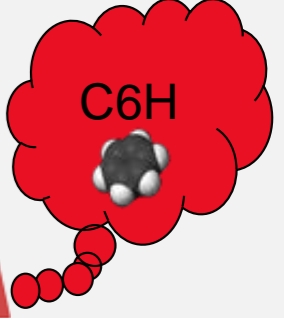
High emissions of gasoline engines @ cold start
Slip at SCR



Found at Euro6c but not at Euro6dtemp vehicles



Benzene
Found at gasoline engines



<https://en.wikipedia.org>

- **Euro 6dfinal good enough for NO, NO2**

- No further restriction needed

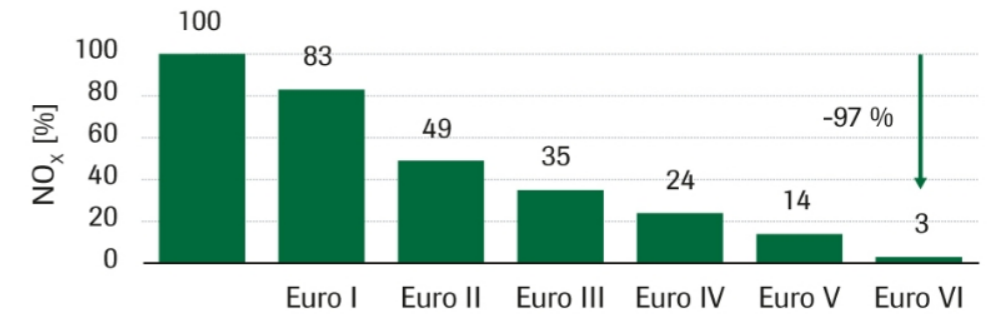
- **Restriction of NH3 necessary**

- Selective catalytic reduction: overdosing of urea

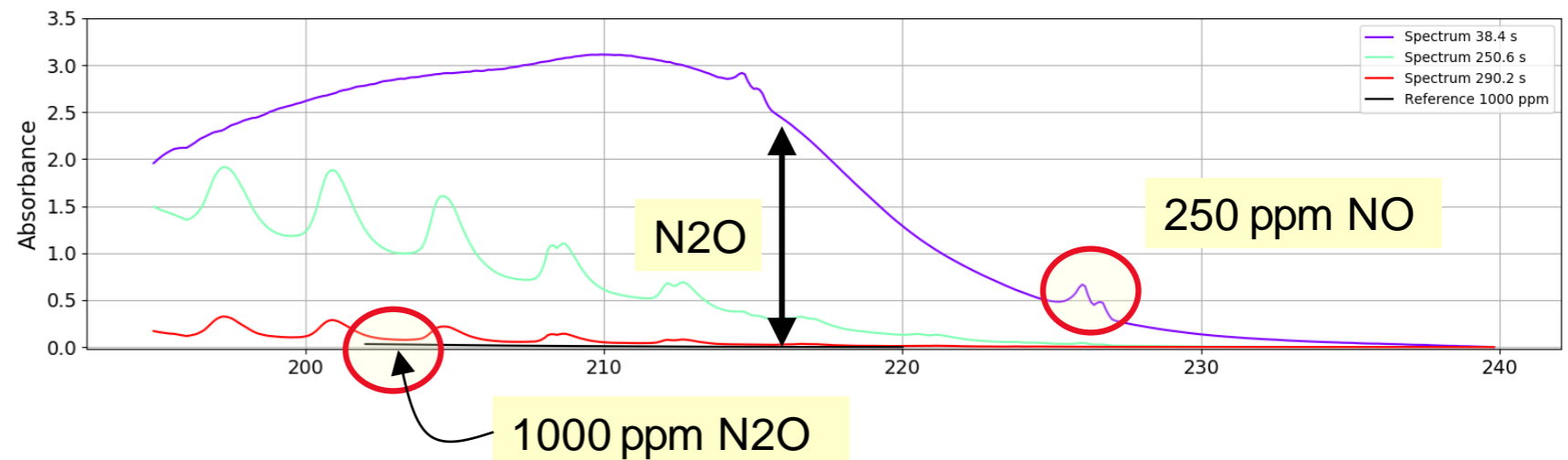
- Low Nox- emission → limits are met
- Ammonia slip
- Isocyanic acid slip

- **Restriction of N2O**

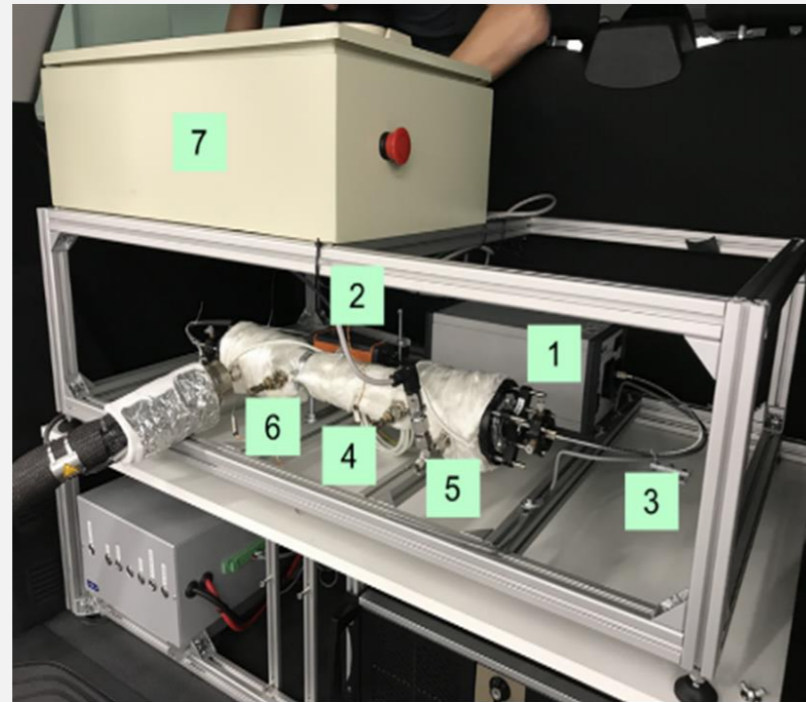
- Problems for gasoline engines



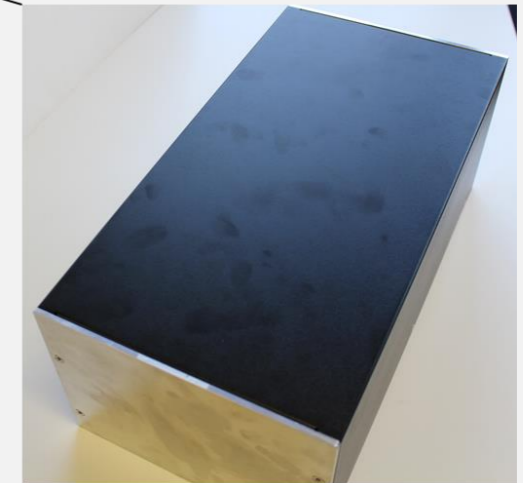
Quelle: VDA



Miniaturization



210 x 160 x 410 mm



Integration of N₂O and HNCO

Detection limit 10 ppm

- **Measurement system based on absorption spectroscopy**

- Deep ultraviolet region
- NH₃, NO and NO₂

- **Diesel Euro 6c and Euro 6dtemp**

- NO₂ at Euro 6c but NOT at Euro 6dtemp
- Traces of NO₂ and NH₃
- NO main exhaust gas (besides CO₂ and CO)

- **Gasoline Euro 6c**

- NO up to 400 ppm
- NH₃ up to 150 ppm
- High amounts of N₂O ~%-Level
- Traces of benzene and aromatic compounds

Acknowledgement

The publication was written at VIRTUAL VEHICLE Research Center in Graz, Austria. The authors would like to acknowledge the financial support of the COMET K2 – Competence Centers for Excellent Technologies Programme of the Federal Ministry for Transport, Innovation and Technology (bmvit), the Federal Ministry for Digital, Business and Enterprise (bmdw), the Austrian Research Promotion Agency (FFG), the Province of Styria and the Styrian Business Promotion Agency (SFG). They would furthermore like to express their thanks to their supporting scientific project partner, namely to the Graz University of Technology, Institute of Electronic Sensor Systems.



BACK-UP

NO2

Mortality cardio vascular: 5966 ± 3935
 Asthma: 439.000
 Diabetes: 437.000

Rather large confidence intervall

ERGEBNISSE UNSERER BERECHNUNGEN

Stickstoffdioxid (NO₂) bedingt eine Krankheitslast in der Bevölkerung Deutschlands im Jahr 2014

- TOXISCHE AUFWAND: KARDIOVASKULÄRE ERKRANKUNGEN ZURECHENBAR MIT NO₂: **≈ 6.000**
- ASTHMA ZURECHENBAR MIT NO₂: **≈ 439.000**
- DIABETES ZURECHENBAR MIT NO₂: **≈ 437.000**

VERKEHR 61% (davon 72,9% Diesel-PKW)

QUELLEN AUßERHALB DER STADT

- INDUSTRIE 4%
- HEIZUNG 8%
- 23%

Smoking HR ~ 1.93

Epidemiology. 2018 Jul; 29(4): 460–472.

Published online 2018 Jun 1. doi: [10.1097/EDE.0000000000000847](https://doi.org/10.1097/EDE.0000000000000847)

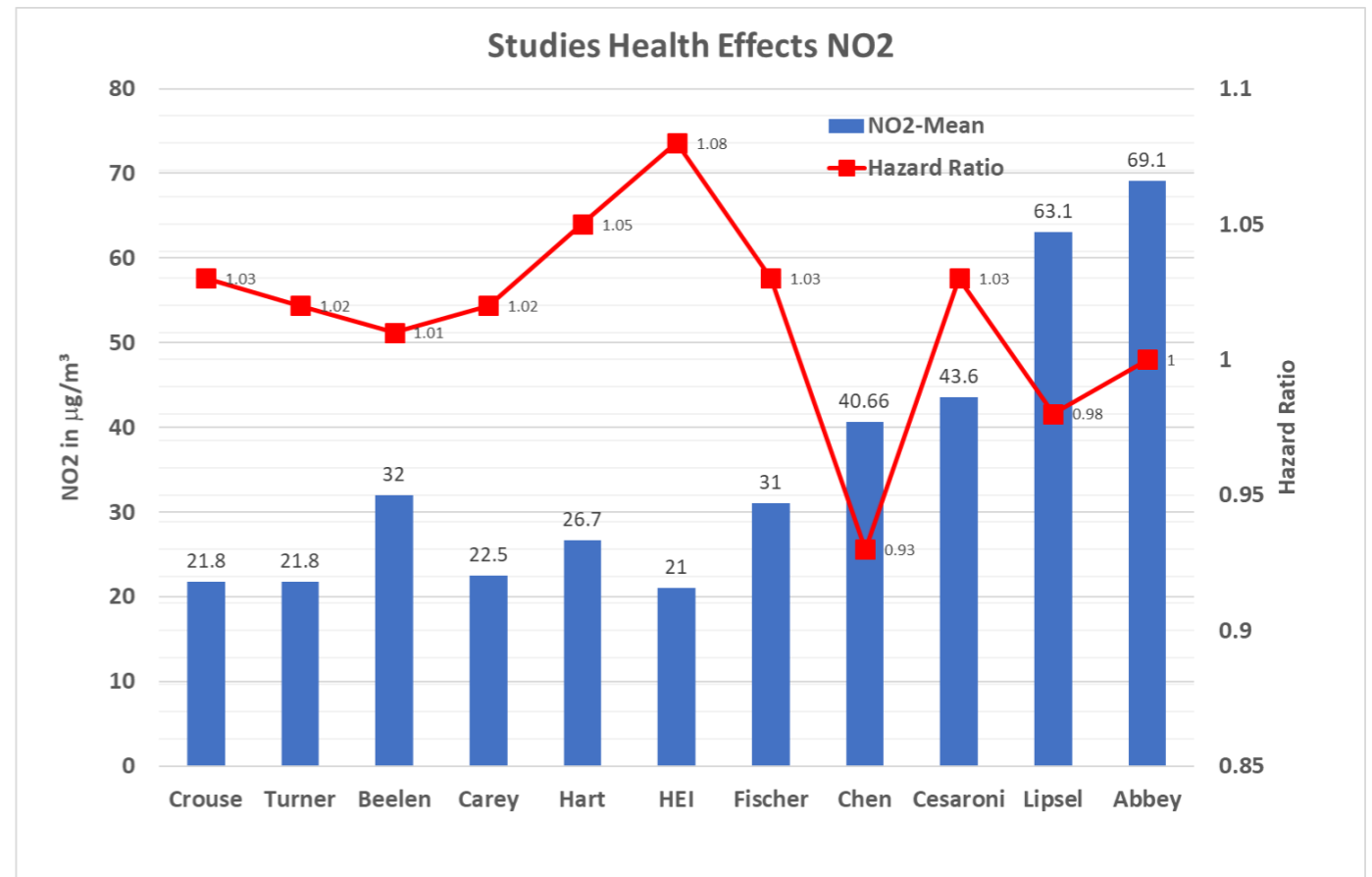
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PMID: [29746370](https://pubmed.ncbi.nlm.nih.gov/29746370/)

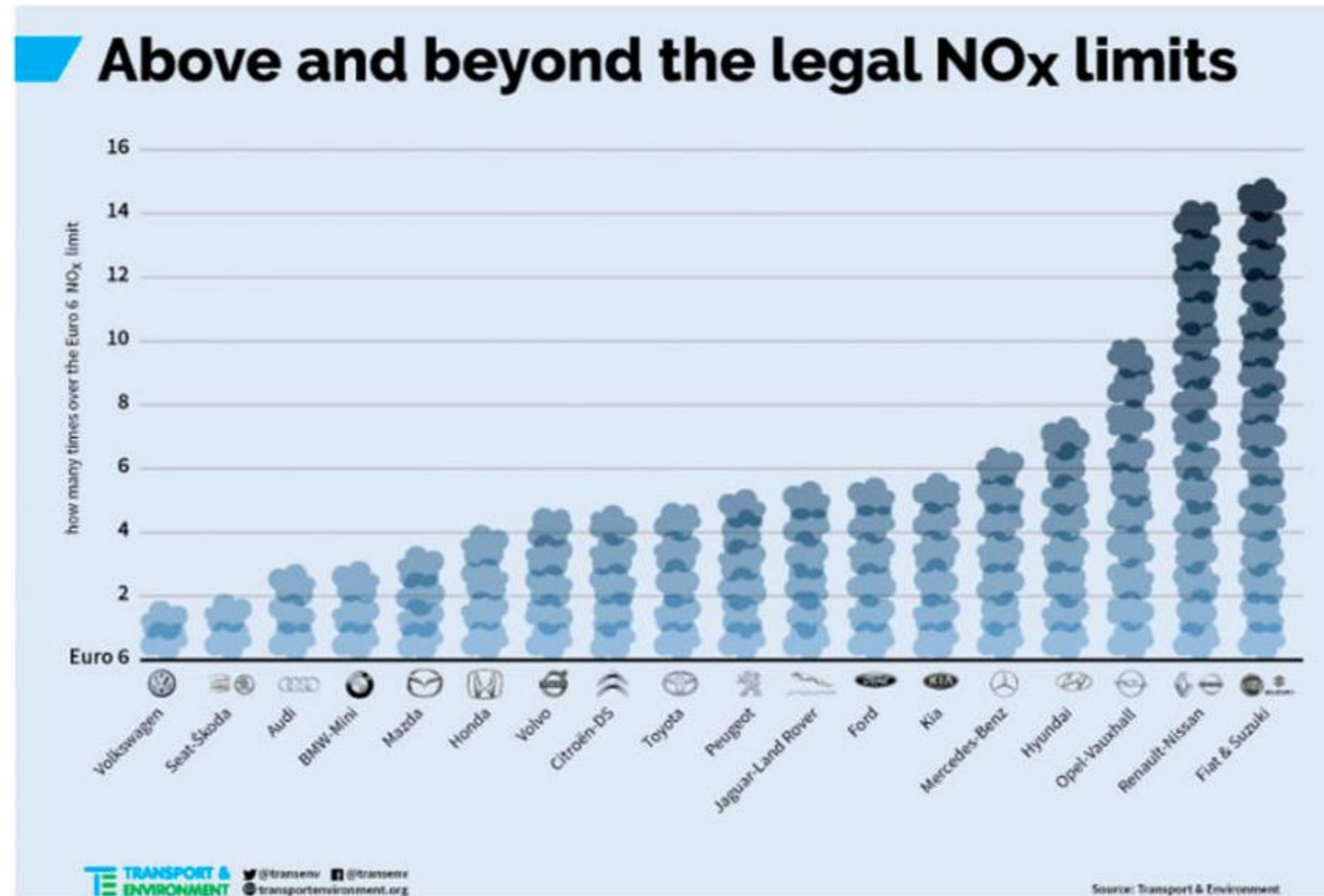
Long-term Concentrations of Nitrogen Dioxide and Mortality A Meta-analysis of Cohort Studies

Richard W. Atkinson,¹ Barbara K. Butland,^a H. Ross Anderson,^{a,b} and Robert L. Maynard^c

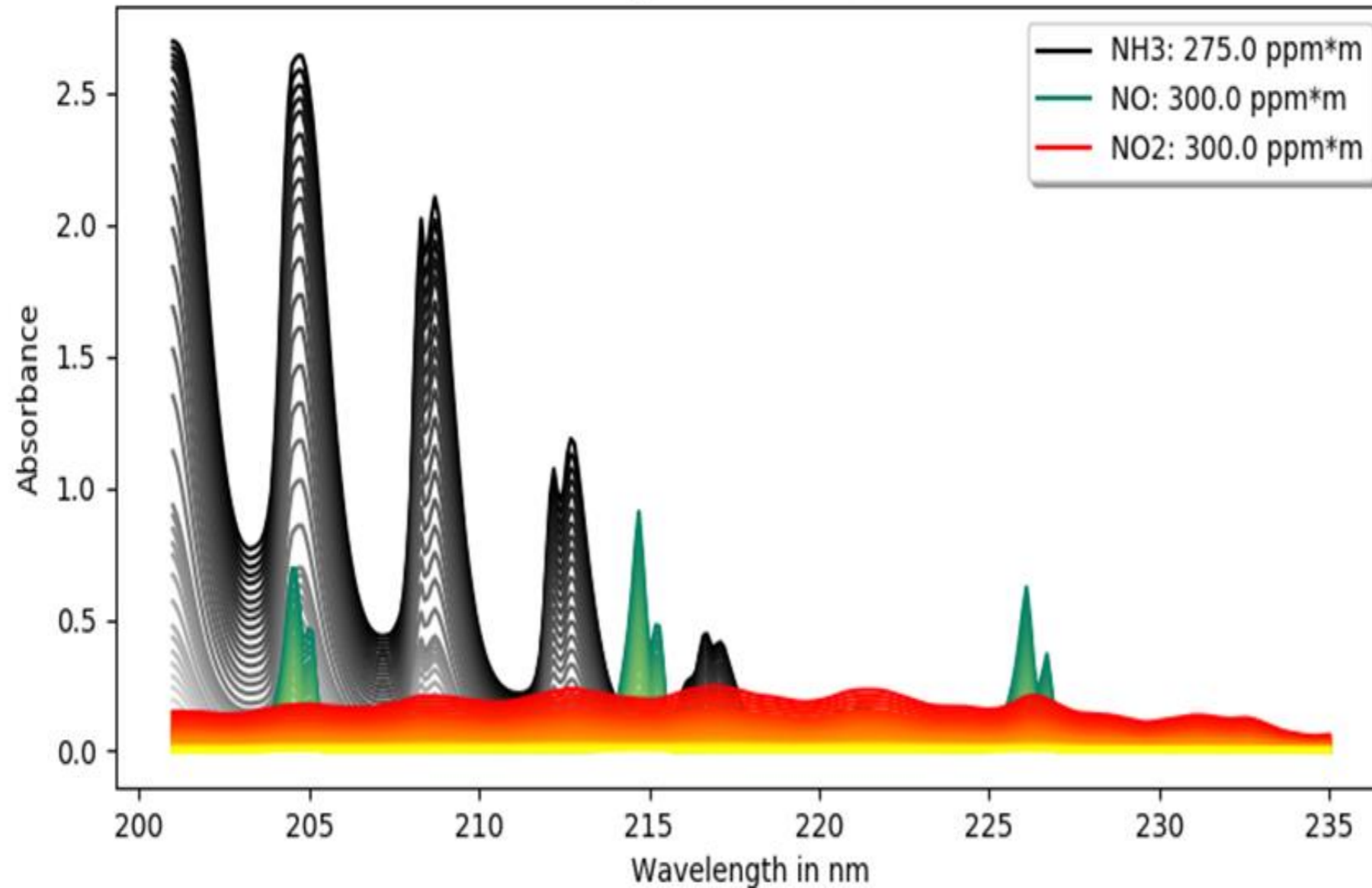
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Gas	STE in ppm	Level in ppm	Ratio	Annotation
NO2	6	2	0.333	
NO	25	100	3	Precursor to NO2
N2O	400	50000	125	
NH3	50	100	2	
Isocyanic acid	0.02	?	?	
Benzene	4	2	0.5	carcinogen



<https://www.trend.at/branchen/auto-mobilitaet/nox-skandal-dieselauto-modelle-schadstoff-grenzwerten-7590976>

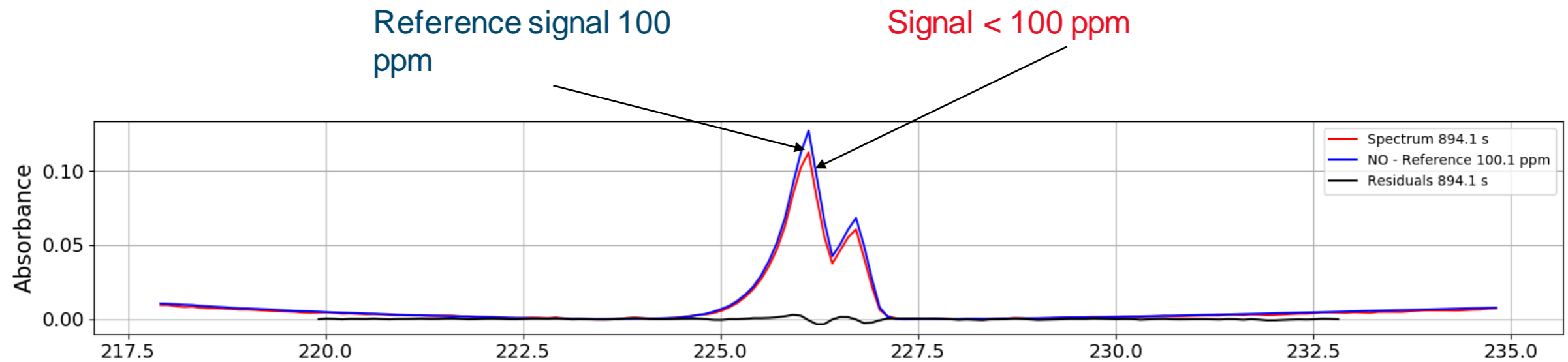


Additional Gases

- SO2 (already included)
- Benzene
- Toluene
- Xylene

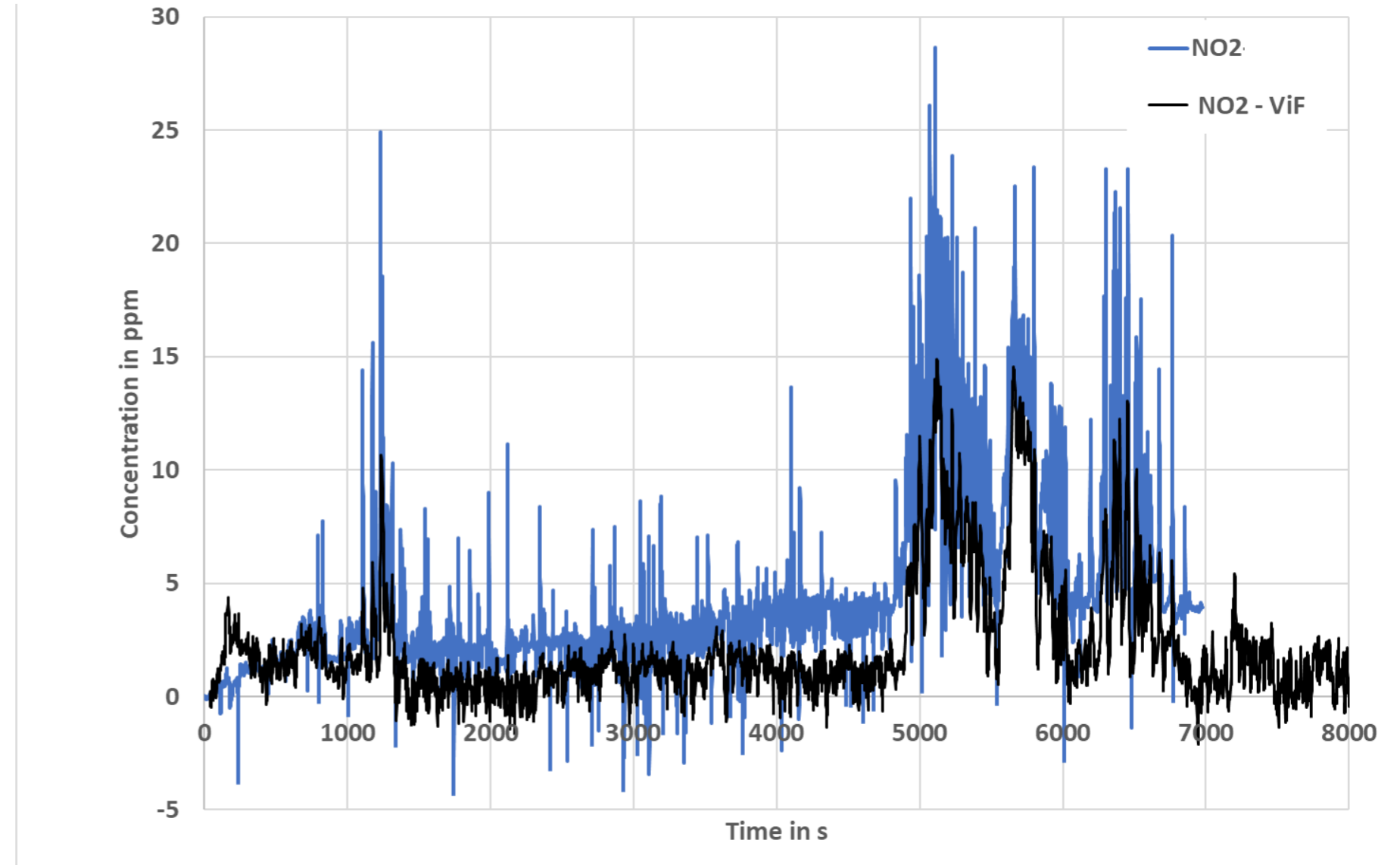
- Focus on
 - Isocyanic acid
 - Nitrous oxide

- FTIR gets 100 ppm
- PEMS gets 90 ppm
- Raw data:
 - Only error source is a unprecise calibration spectra
 - Highly unlikely



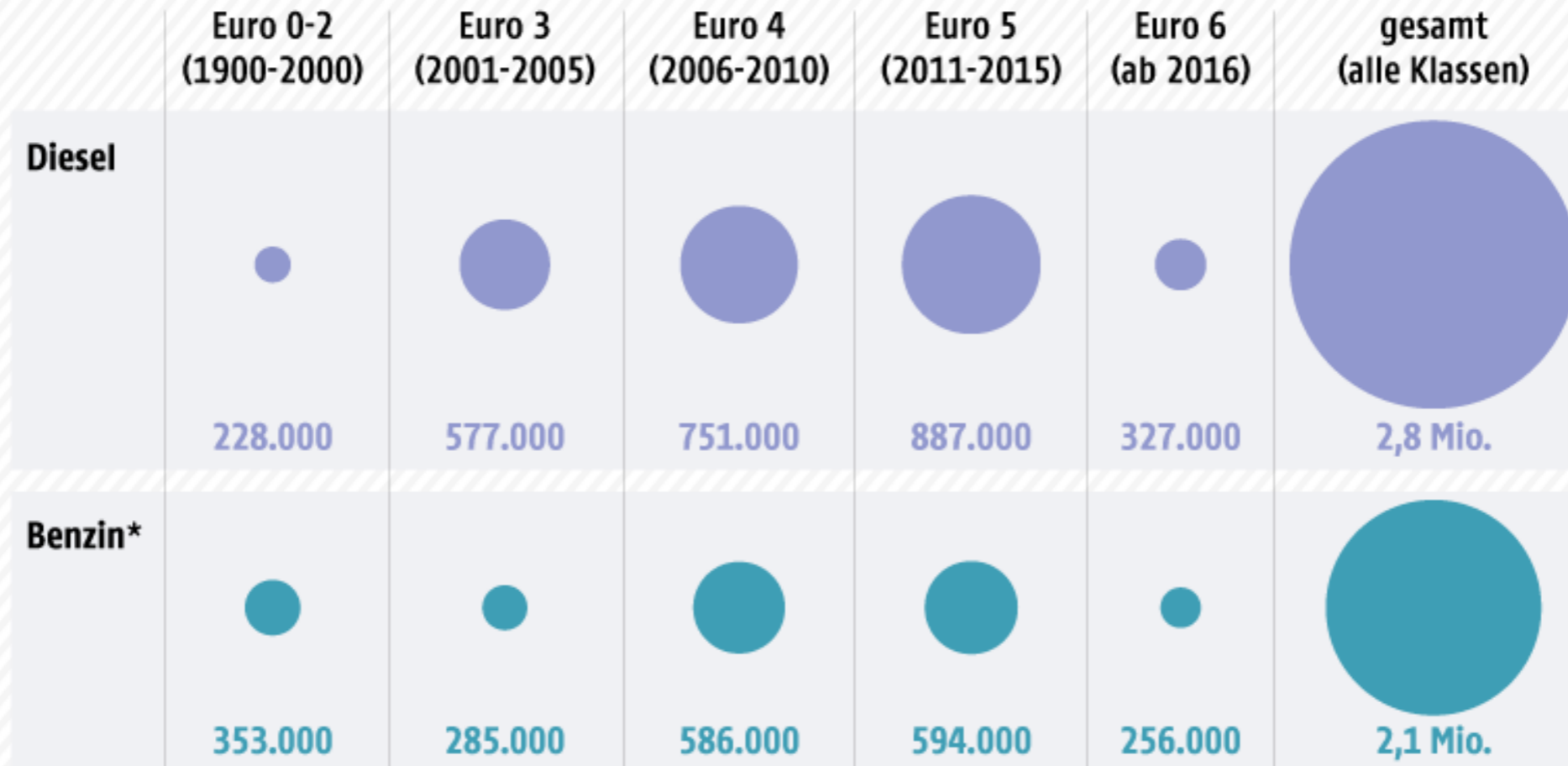
NO2 – Good agreement

ViF – less noise



Pkw-Bestandsstatistik in Österreich

Zugelassene Fahrzeuge nach Euro-Schadstoffklassen
Werte gerundet, Stand 31.12.2017



*exklusive flex-fuel