



EMISSIONS



ELECTRIFICATION



CAV



DATA

# GLOBAL EMISSION REGULATORY TREND AND NEW ANALYTICAL SOLUTION

For the future clean air

2023.11.02. HORIBA Co. Ltd.,  
Kazuya Tsurumi



Event Organised by:  
**ECMA**  
Clean Air Today, Cleaner Air Tomorrow  
Emission Controls Manufacturers  
Association, New Delhi, INDIA

# Today's Topics

“Leaping to Cleaner Air for T

2<sup>nd</sup> and 3<sup>rd</sup> November 2023  
Radisson Blu Plaza  
Delhi Airport



Global Regulation Trend

Euro-7 Summary








New Analytical Technology  
for Euro / China-7

Confidential

# Roadmap for LDV legislation

< LDV >

Edited 7. Jul. 2023

Region	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
	Emission Std.	Euro 6b		Euro 6d-TEMP	Euro 6d-TEMP EVAP		Euro6d	Euro 6e	Euro 6e-bis	Euro6e-bis-FCM			
	Test Cycle	NEDC		WLTC									
	Test Procedure	692/2008(*1)		2017/1151, 1154, 1347, 2018/1832		Euro 7							
	Emission Std.	Tier2		Tier 3		Tier 4?							
	Test Cycle	FTP/US06/SFTP		FTP/US06/SC03/HFET									
	Test Procedure	CFR 86 subpartB		CFR1066									
 CALIFORNIA AIR RESOURCES BOARD	Emission Std.	LEV III		LEV IV									
	Test Cycle	FTP/US06/SFTP/SC03											
	Test Procedure	The California Low-Emission Vehicle Regulations											
	Emission Std.	Post new long term		Post new long term(WLTC)		Oct.1.'26 + SPN23 limit							
	Test Cycle	JC08		WLTC									
	Test Procedure	☆ 04. Apr. '17		☆30. Mar. '18		☆15. Feb. '19		☆30. Jun. '20		☆05. Aug. '21		Attachment42	
	Emission Std.	Bharat stage IV		Bharat stage VI									
	Test Cycle	MIDC											
	Test Procedure	MoRTH/CMVR/TAP-115/116 Issue No.4 PartX		AIS 137 Part 3									
	Emission Std.	CN5		CN6a (*2)		CN6b		China 7?					
	Test Cycle	NEDC		WLTC									
	Test Procedure	GB18352.5-2013		GB18352.6-2016									
	Emission Std.	PROCONVE L6(415/2009)		PROCONVE L7 (492/2018)		PROCONVE L8 (492/2018)							
	Test Cycle	FTP											
	Test Procedure	ABNT NBR 6601 (for Lab test)											

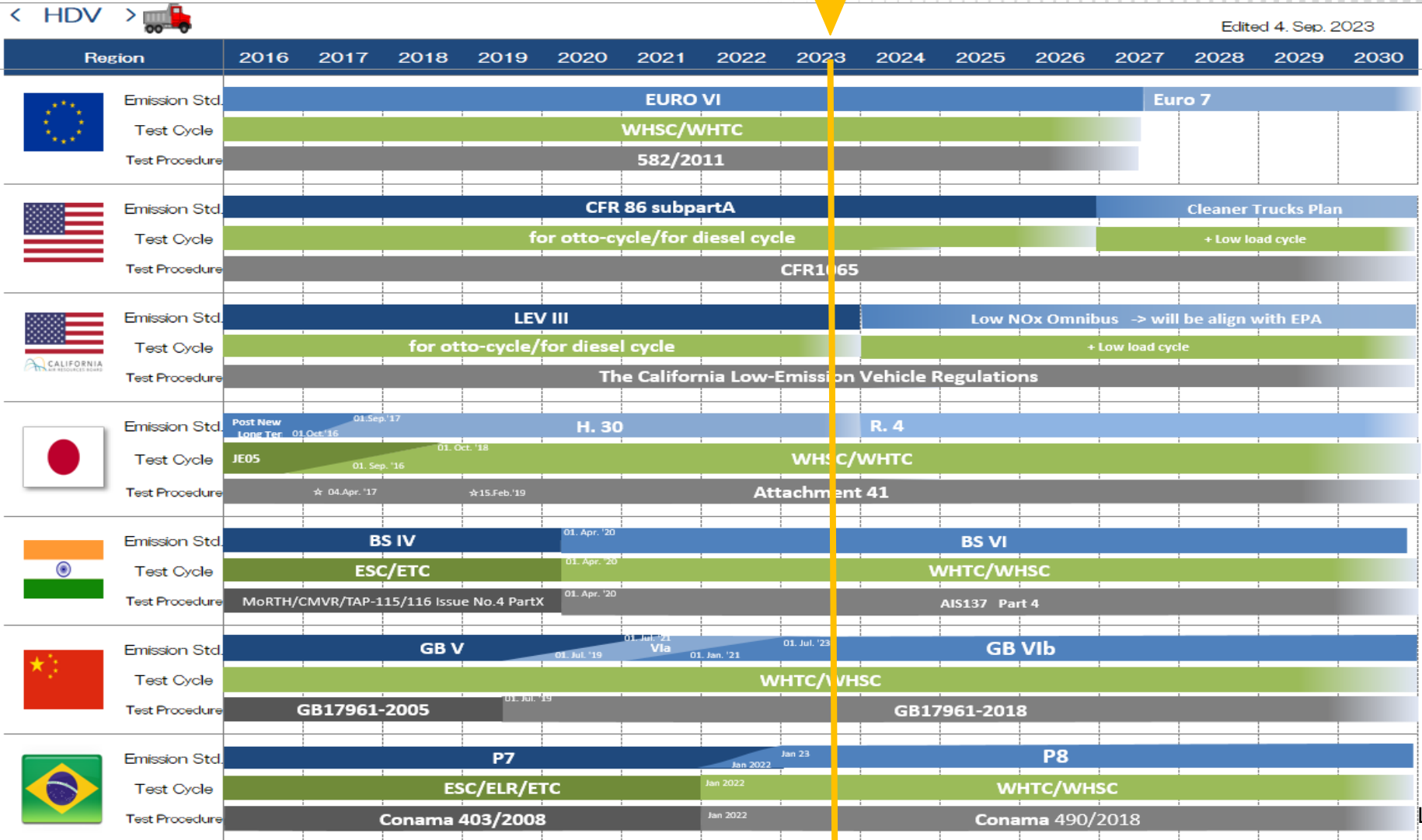
Advanced Clean Car II Regulations was adopted in 2022. Next emission standards, LEV IV will start from MY2026

SPN23 will be added as one of pollutant components from Oct.2023

Next emission regulation, China 7 is under discussion. Same as Euro 7, NH3, SPN10, Brake dust are considered.

PROCONVE L8 will start from 2025 RDE with Conformity Factor, unique NMOG limits

# Time schedule of HDV Emission Standards



Last update : 8<sup>th</sup> Sep 2023

# <HDV> Topics about emissions and fuel economy/CO<sub>2</sub>/GHG

● Finalized   ★ Underdiscussion



- Low NO<sub>x</sub> Omnibus Omnibus
- Cleaner Truck Plan MY2027 (EPA)
- ★ GHGs Phase 3 with part 1065 amendment for H<sub>2</sub> or NH<sub>3</sub> fueled engines



- ★ CO<sub>2</sub> target from 2030
- ★ Euro VII/7
  - Regulatory unification with LDV
  - RDE based limits
  - SPN 10, NMOG, N<sub>2</sub>O, CH<sub>4</sub>



- China VI a ('19-)
- China VI b ('21-)
  - Euro VI equivalent limits (NH<sub>3</sub>, PN, ISC by PEMS)



- Proconve P8 ('22-)
  - Euro VI equivalent limits (ICS by PEMS) (NH<sub>3</sub>, PN, ISC by PEMS)



- BS VI ('20-)
  - Euro VI equivalent limits (NH<sub>3</sub>, PN, ICS by PEMS)



- PN limits ('23 ~)



Event Organised by:  
**ECMA**  
Clean Air Today, Cleaner Air Tomorrow  
Emission Controls Manufacturers  
Association, New Delhi, INDIA

# Today's Topics

“Leaping to Cleaner Air for Transport”

2<sup>nd</sup> and 3<sup>rd</sup> November 2023  
Radisson Blu Plaza  
Delhi Airport



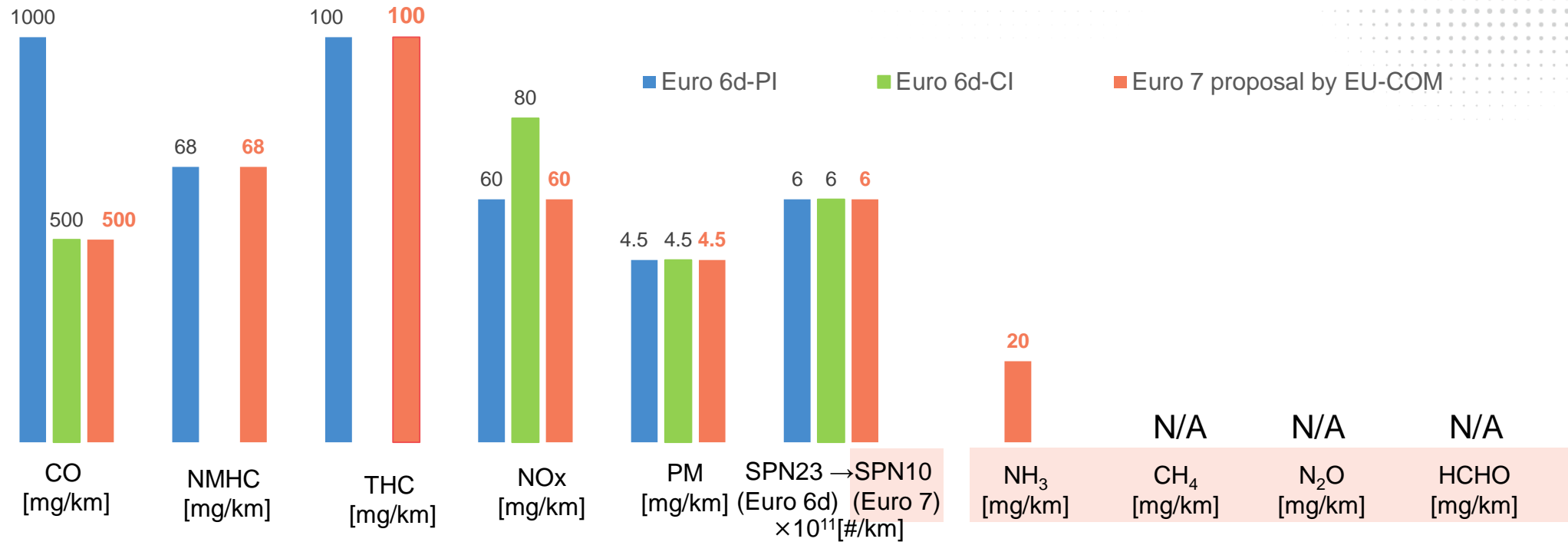
Global Regulation Trend

Euro-7 Summary

New Analytical Technology  
for Euro / China-7

# Exhaust Emission Limits

M1, N1 vehicles - Euro 7 Vs Euro 6d



**New Components**

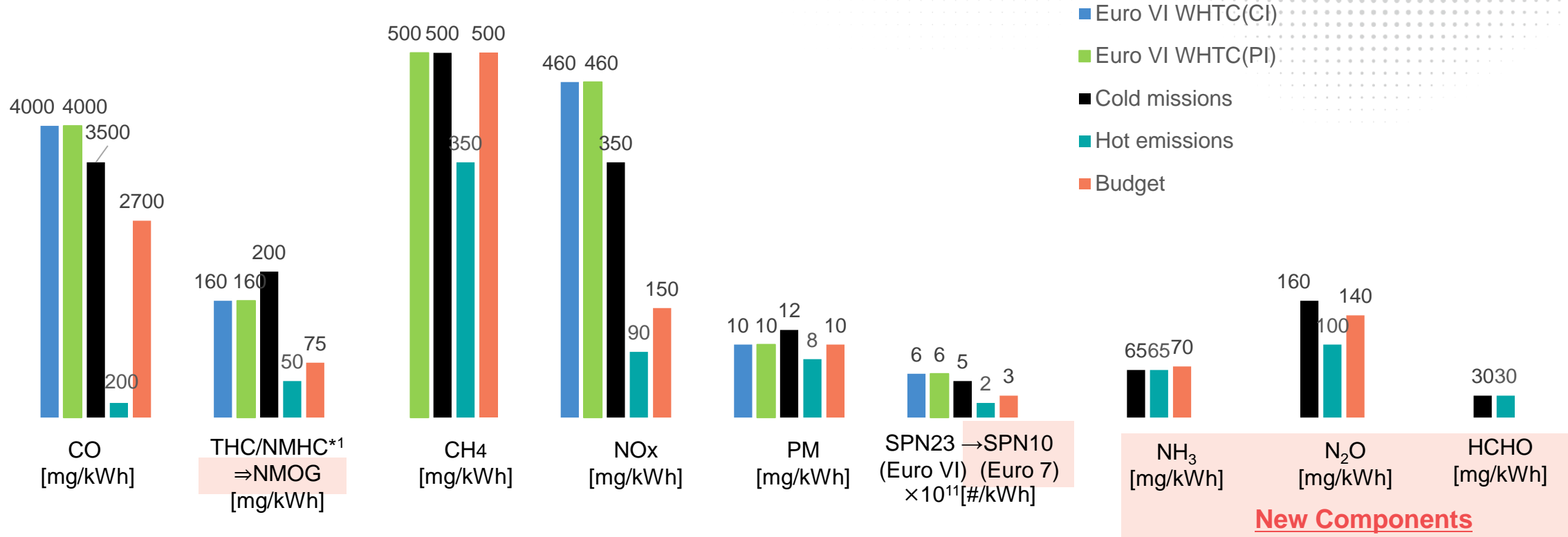
\*1 : NMHC is only for PI vehicles in Euro 6d, for all vehicles in Euro 7

\*2 : THC + NOx is only for CI vehicles in EU 6 changed to NMHC and NOx separated limits in Euro 7



# Comparison between Euro 7 and Euro VI emission limits

Cold emission, Hot emission, Budget limits



\*1 : THC is for CI engines and NMHC is for PI engines in Euro VI. NMOG is proposed for both in Euro 7.

\* Euro VI limits are Lab limits and proposed Euro 7 limits are RDE limits.



# Background: Euro 6/VI→7/VII Topics

		CO	HC + NOx	NOx	HC	NMHC	CH <sub>4</sub>	NMOG	HCHO	NH <sub>3</sub>	N <sub>2</sub> O	PM	SPN23	SPN10
LDV	6d SI PI	✓	-	✓	✓	✓	-	-	-	-	-	-	-	-
	6d SI DI	✓	-	✓	✓	✓	-	-	-	-	-	✓	✓	-
	6d CI	✓	✓	✓	-	-	-	-	-	-	-	✓	✓	-
	7	✓	-	✓	✓	✓	-	-	-	✓	-	✓	-	✓
HDV	VI PI	✓	-	✓	-	✓	✓	-	-	10ppm	-	✓	-	-
	VI CI	✓	-	✓	✓	-	-	-	-	10ppm	-	✓	✓	-
	VII	✓	-	✓	✓	-	✓	✓	✓	✓	✓	✓	-	✓

## ■ Euro 7 Difficulty for the customer

- ✓ No RDE Limit
- ✓ Additional regulated component
  - Reduction of emission of harmful substances : **NMOG, HCHO, NH<sub>3</sub>, N<sub>2</sub>O**
  - from SPN23 to **SPN10 \*1**
- ✓ Especially **NH<sub>3</sub> reduction**, mass production technology has not been established.

\*1 SPN10 : Number of solid particles of 10nm or more  
 SPN23 : Number of solid particles of 23nm or more



Event Organised by:  
**ECMA**  
Clean Air Today, Cleaner Air Tomorrow  
Emission Controls Manufacturers  
Association, New Delhi, INDIA

# Today's Topics

"Leaping to Cleaner Air for Transport"

2<sup>nd</sup> and 3<sup>rd</sup> November 2023  
Radisson Blu Plaza  
Delhi Airport



Global Regulation Trend

Euro-7 Summary

New Analytical Technology  
for Euro / China-7

Confidential

# What is “IRLAM”?

Newly developed gas analysis technology by HORIBA

More info:

[https://www.horiba.com/en\\_en/irlam/](https://www.horiba.com/en_en/irlam/)



IRLAM : InfraRed Laser Absorption Modulation

## ◆ High accuracy

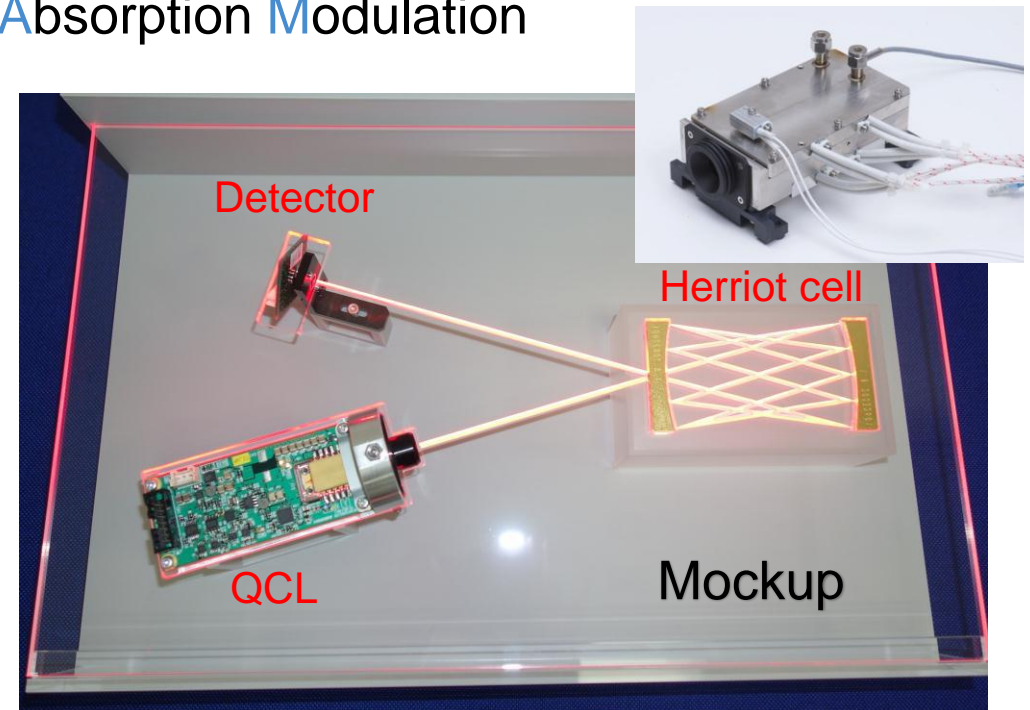
- Infrared absorption utilizing QCL(Quantum Cascade Laser)
- ✓ Apply a latest technology to PEMS

## ◆ Compact

- Small gas cell (Herriot cell)
- ✓ PEMS optimized hardware design

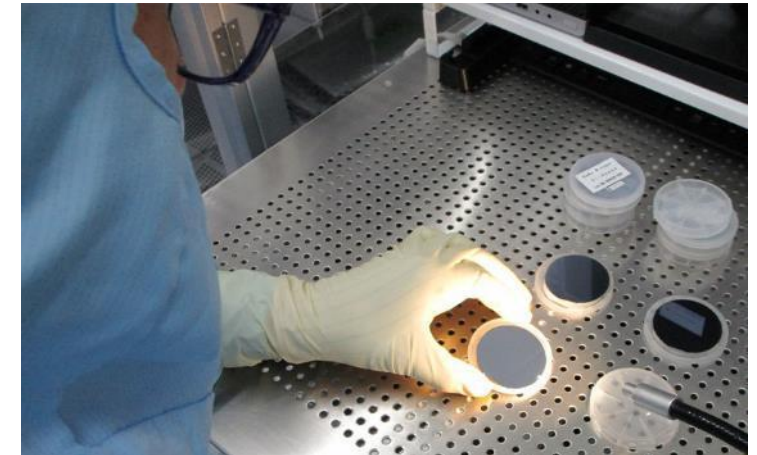
## ◆ Utility free

- Unnecessity of purge gas, liquid nitrogen (LN2)
- ✓ Unnecessity of mounting gas cylinder in vehicle



# IRLAM is in-house made core components

- A type of semiconductor laser emitting light with wavelength in the mid-infrared region, where many gas molecules exhibit the strongest absorption.
- The laser chip consists of several hundred layers of semiconductor thin film, and by controlling the material composition and film thickness, the emitting wavelength can be arbitrarily designed.
- HORIBA is capable of designing and manufacturing QCLs from 4 to 10  $\mu\text{m}$ .



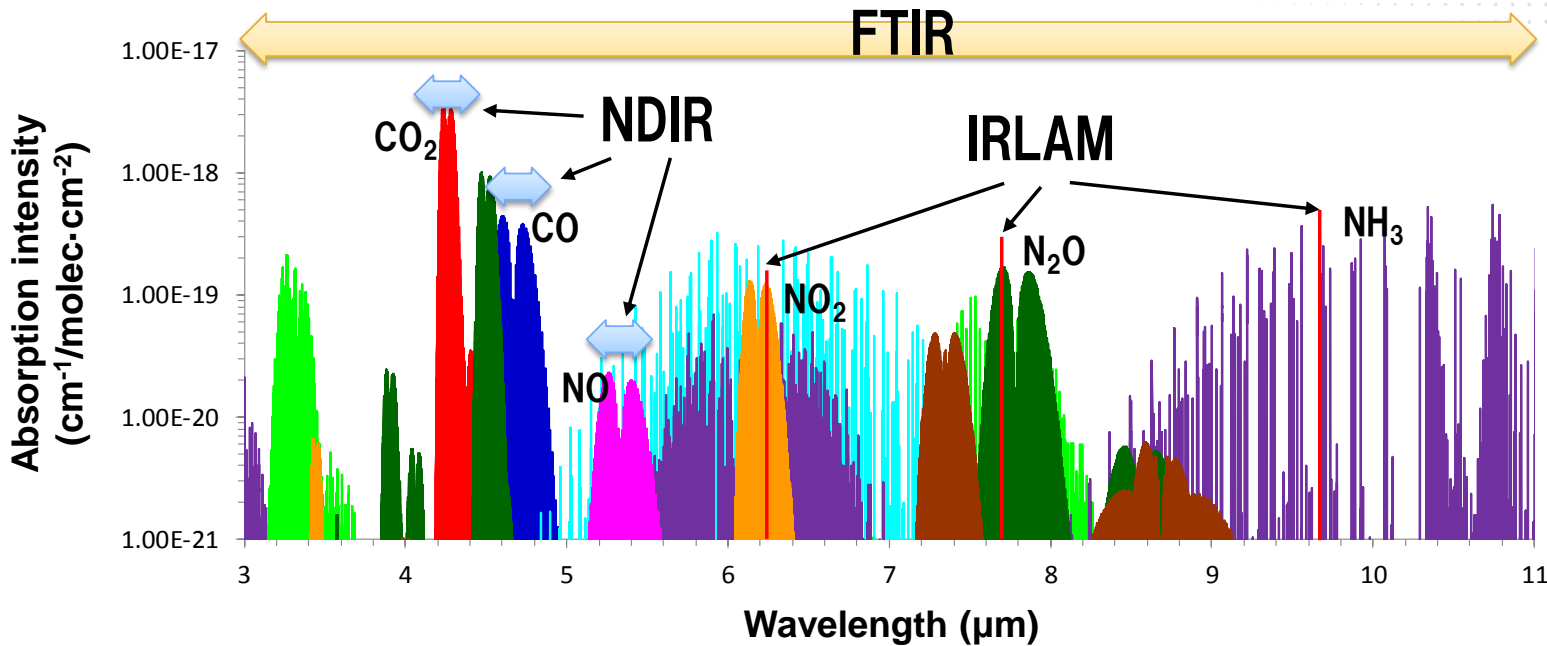
**HORIBA** Automotive QCL module

HORIBA in-house QCL  
© 2025 HORIBA, Ltd. All rights reserved

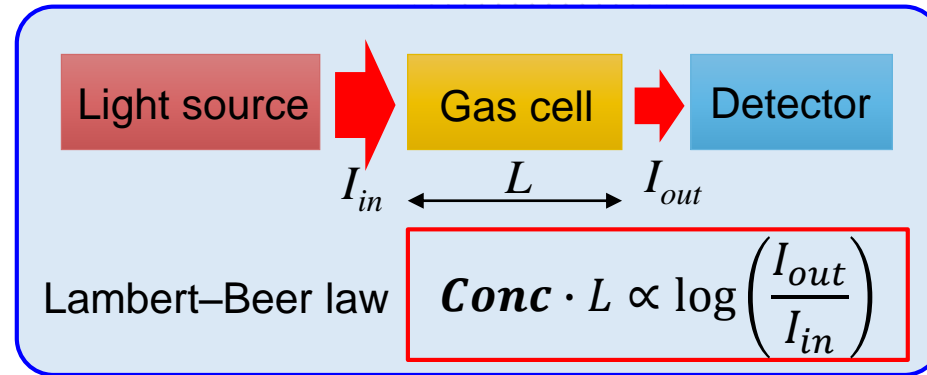
QCL manufacturing process

Confidential

# Mid-infrared absorption spectroscopy for gas analysis

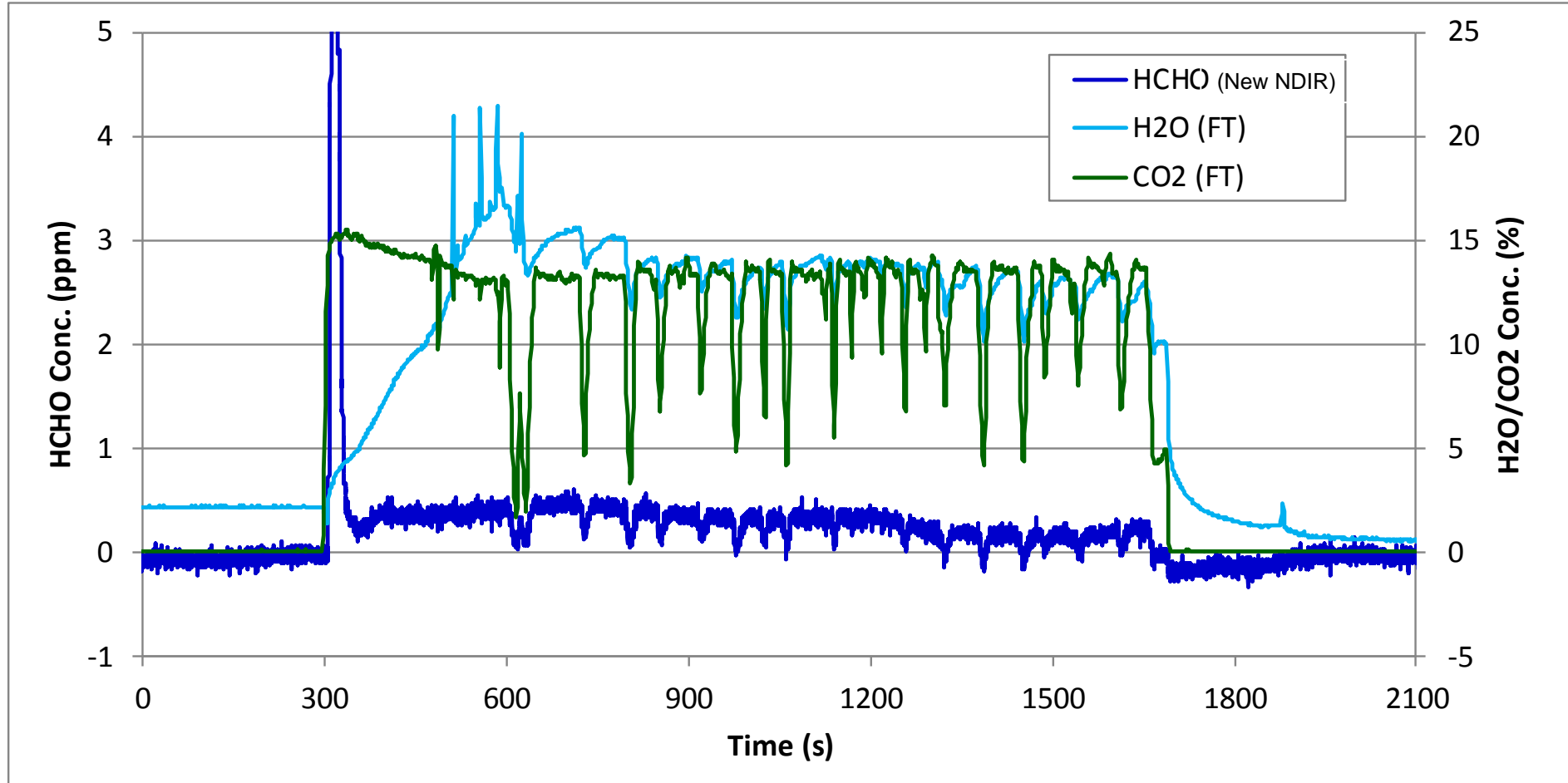


- The mid-infrared region (3 to 10 μm) is useful for gas analysis because many gas molecules show the strongest absorption in this wavelength region.



Measurement principle name	Light source	Gas cell	Features
NDIR (Non-dispersive infrared spectroscopy)	Thermal radiation source + optical filter	Straight tube cell	Low cost small size
FTIR (Fourier transform infrared spectroscopy)	Thermal radiation source + interferometer	Multi-pass cell (White cell)	Multi-component measurement
<b>IRLAM</b> <b>(Infrared laser absorption modulation)</b>	<b>Quantum cascade laser (QCL)</b>	<b>Multi-pass cell (Herriott cell)</b>	<b>High sensitivity</b> <b>low interference</b>

# Interference with H<sub>2</sub>O and CO<sub>2</sub>



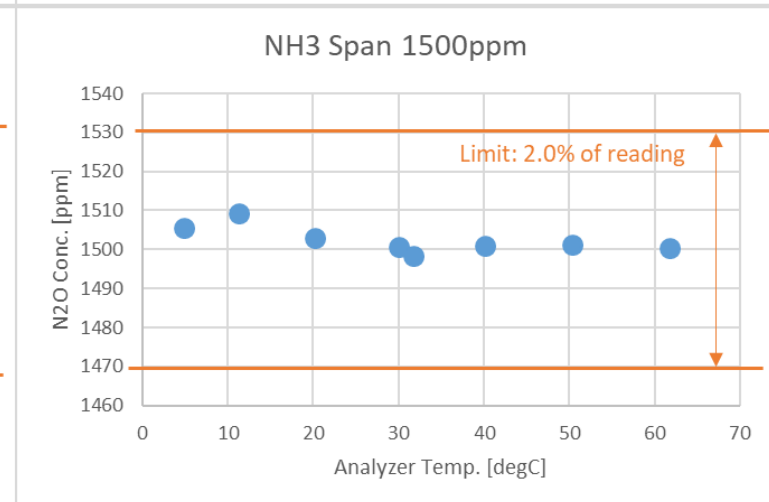
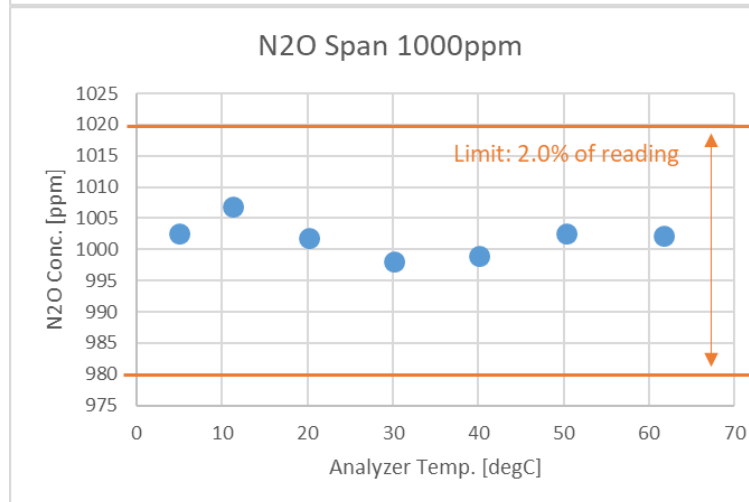
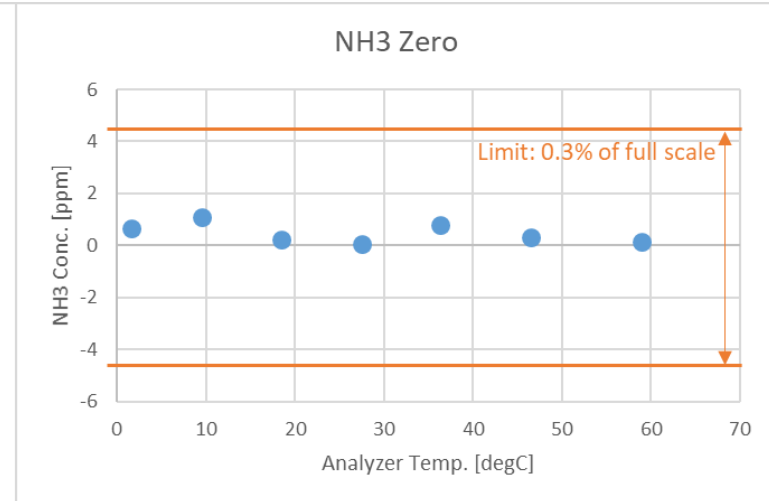
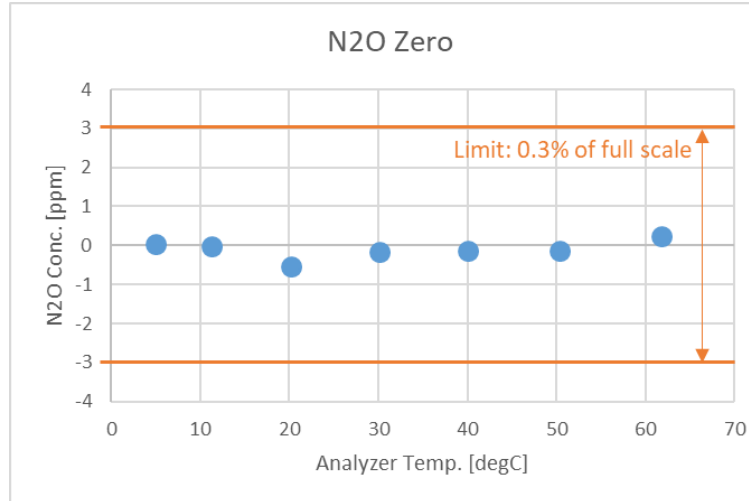
■ This sub-ppm offset probably comes from H<sub>2</sub>O and CO<sub>2</sub>

© 2023 HORIBA, Ltd. All rights reserved

# Why IRLAM for PEMS? – Robust Against Temperature

Former OBS weakness was robustness against climate. IRLAM could be countermeasure.

**IRLAM is very stable method  
against temperature change**  
Zero: <2ppm, Span: <10ppm

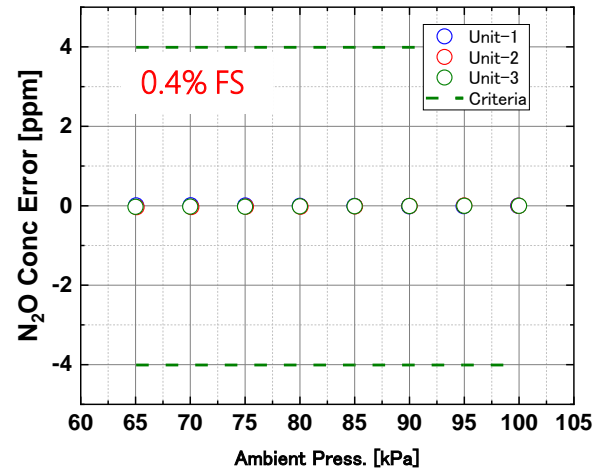


# Why IRLAM for PEMS? – Robust Against Barometric Pressure

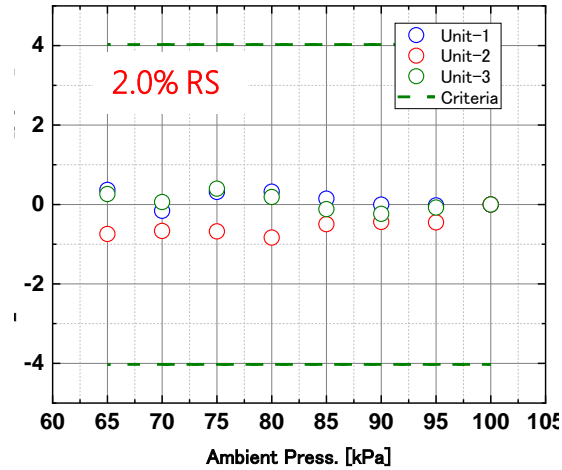
Former OBS weakness was robustness against climate. IRLAM could be countermeasure.

IRLAM keeps stable up to 3000m elevation,  
Zero: <1ppm,  
Span: <2%RS

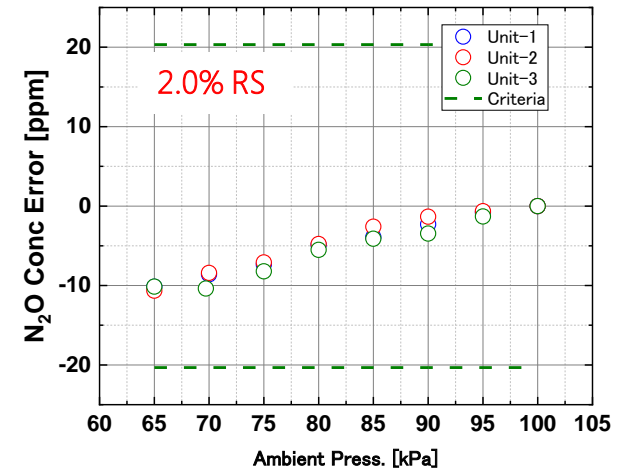
**N<sub>2</sub>O Zero**



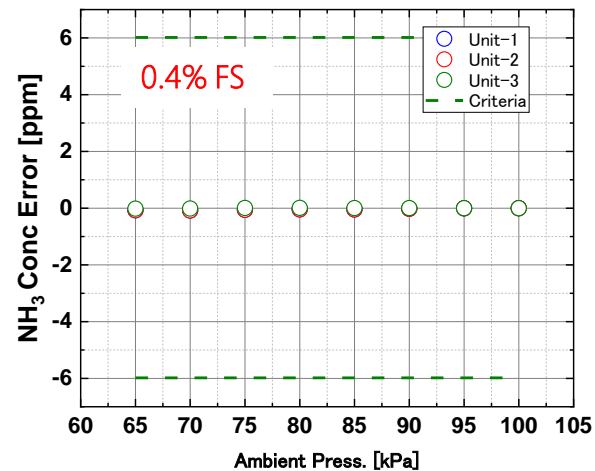
**N<sub>2</sub>O 200ppm**



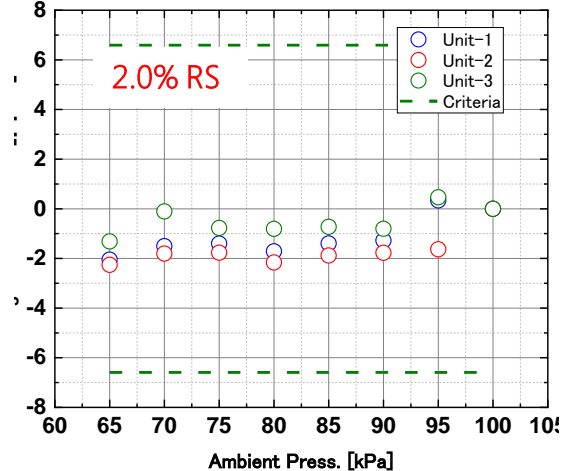
**N<sub>2</sub>O 1000ppm**



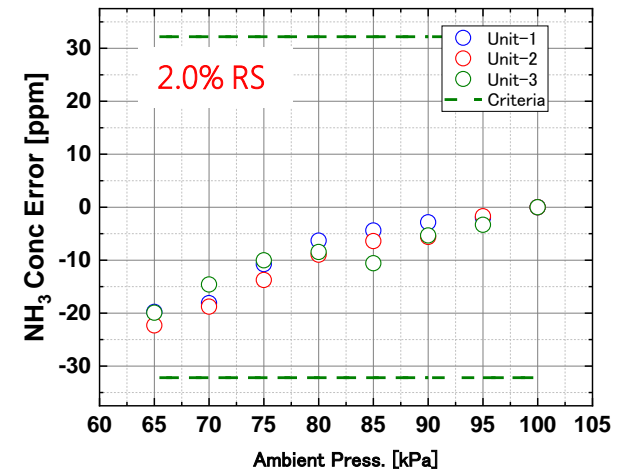
**NH<sub>3</sub> Zero**



**NH<sub>3</sub> 300ppm**



**NH<sub>3</sub> 1500ppm**





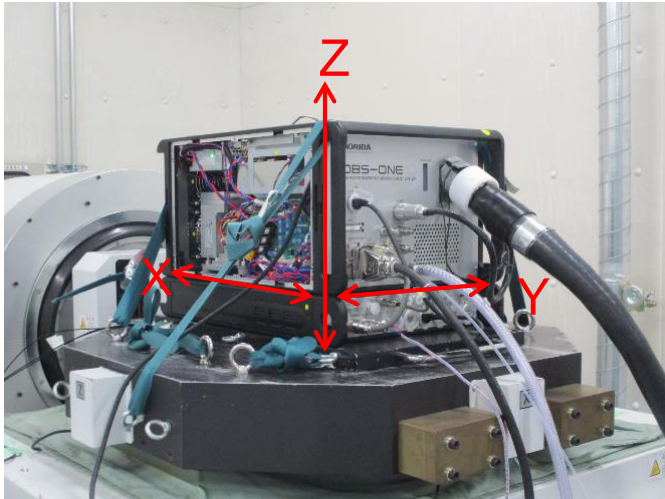
# IRLAM is very strong against vibration.

FTIR uses moving average to capability to cancel vibration affect, it causes slow response.

IRLAM data below is the raw data.

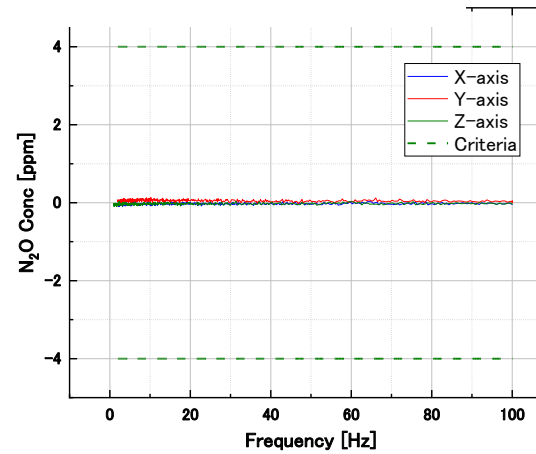
## Profile

- ✓ Sweep : 1-100 [Hz], 9.8 [m/s<sup>2</sup>]
- ✓ Shock test : 50 [m/s<sup>2</sup>]

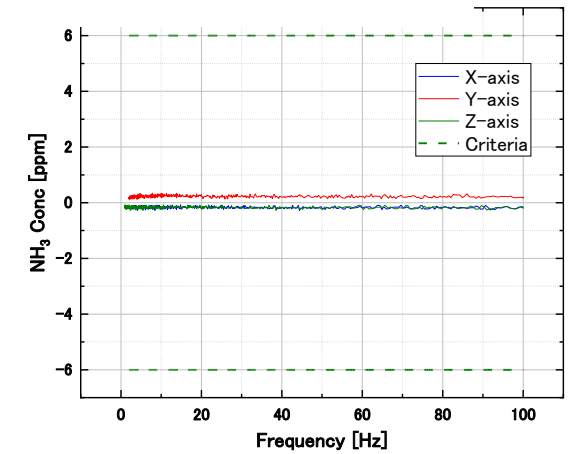


Very strong against vibration

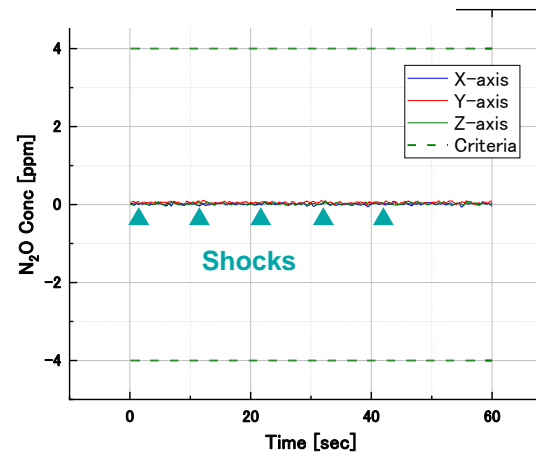
### N<sub>2</sub>O Sweep Zero



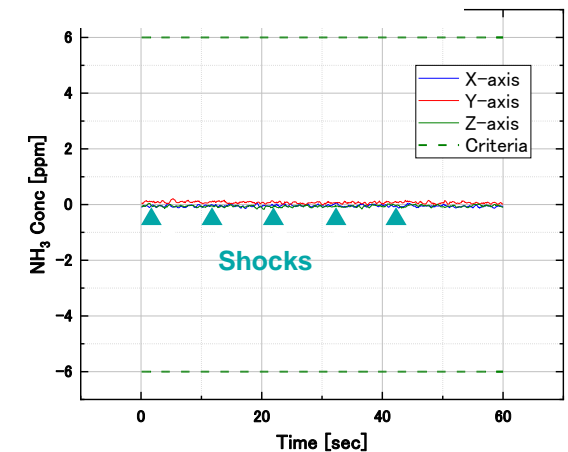
### NH<sub>3</sub> Sweep Zero



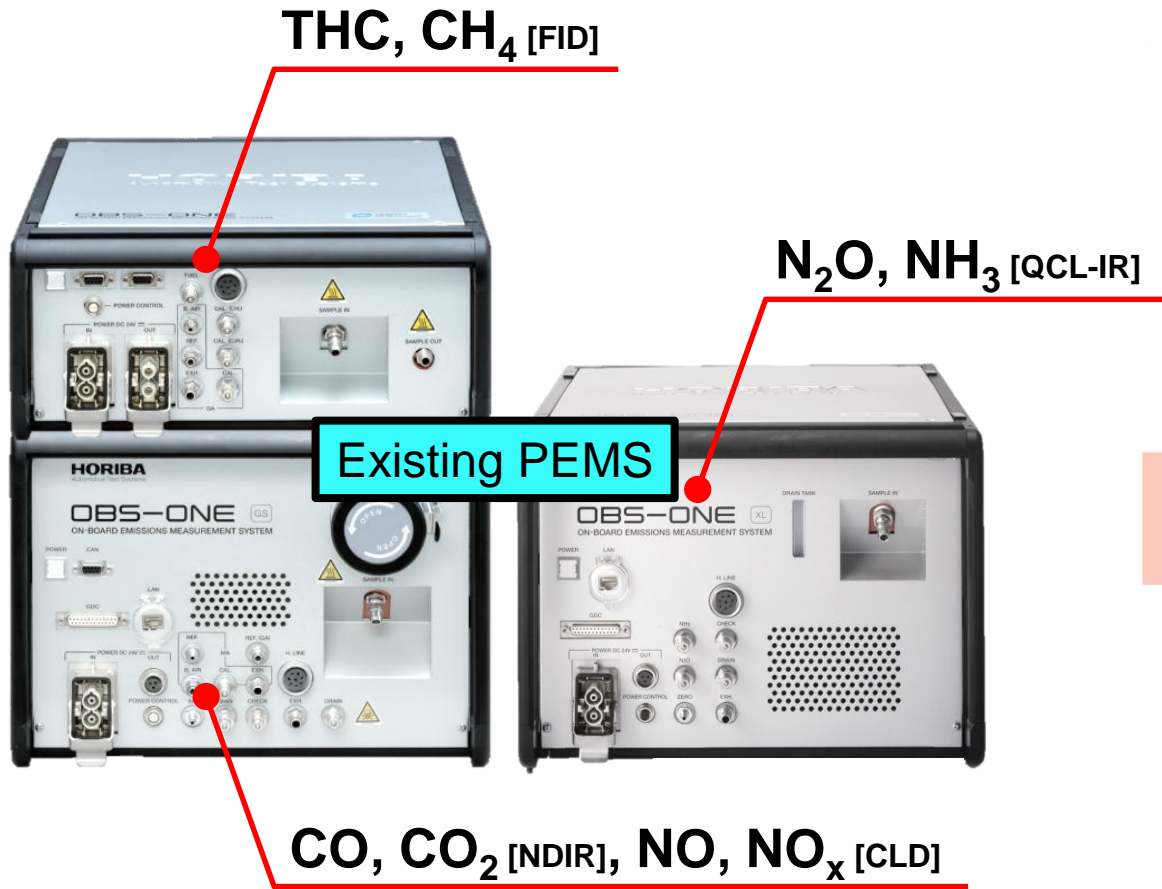
### N<sub>2</sub>O Shock Zero



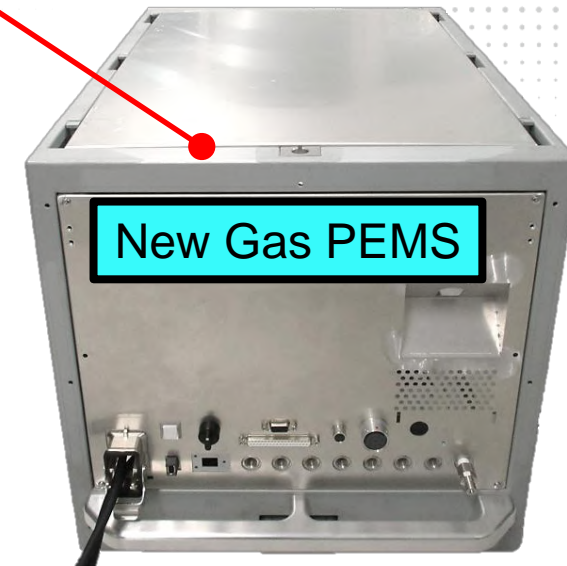
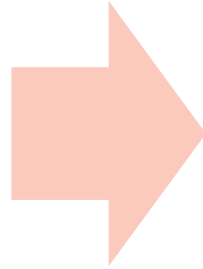
### NH<sub>3</sub> Shock Zero



# New Gas PEMS for Euro 7

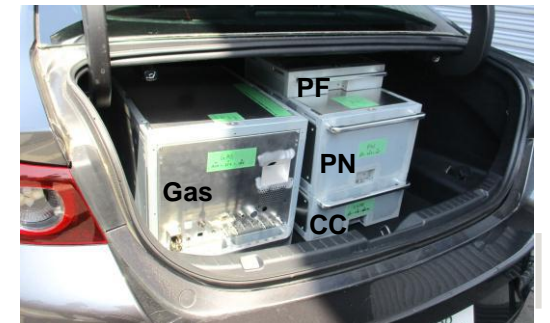


CO<sub>Low / High</sub>, CO<sub>2</sub>, NO, NO<sub>2</sub>, NH<sub>3</sub>, N<sub>2</sub>O, HCHO, CH<sub>4</sub> Low / High [QCL-IR], THC [FID]



Latest prototype

Size that can be installed inside car



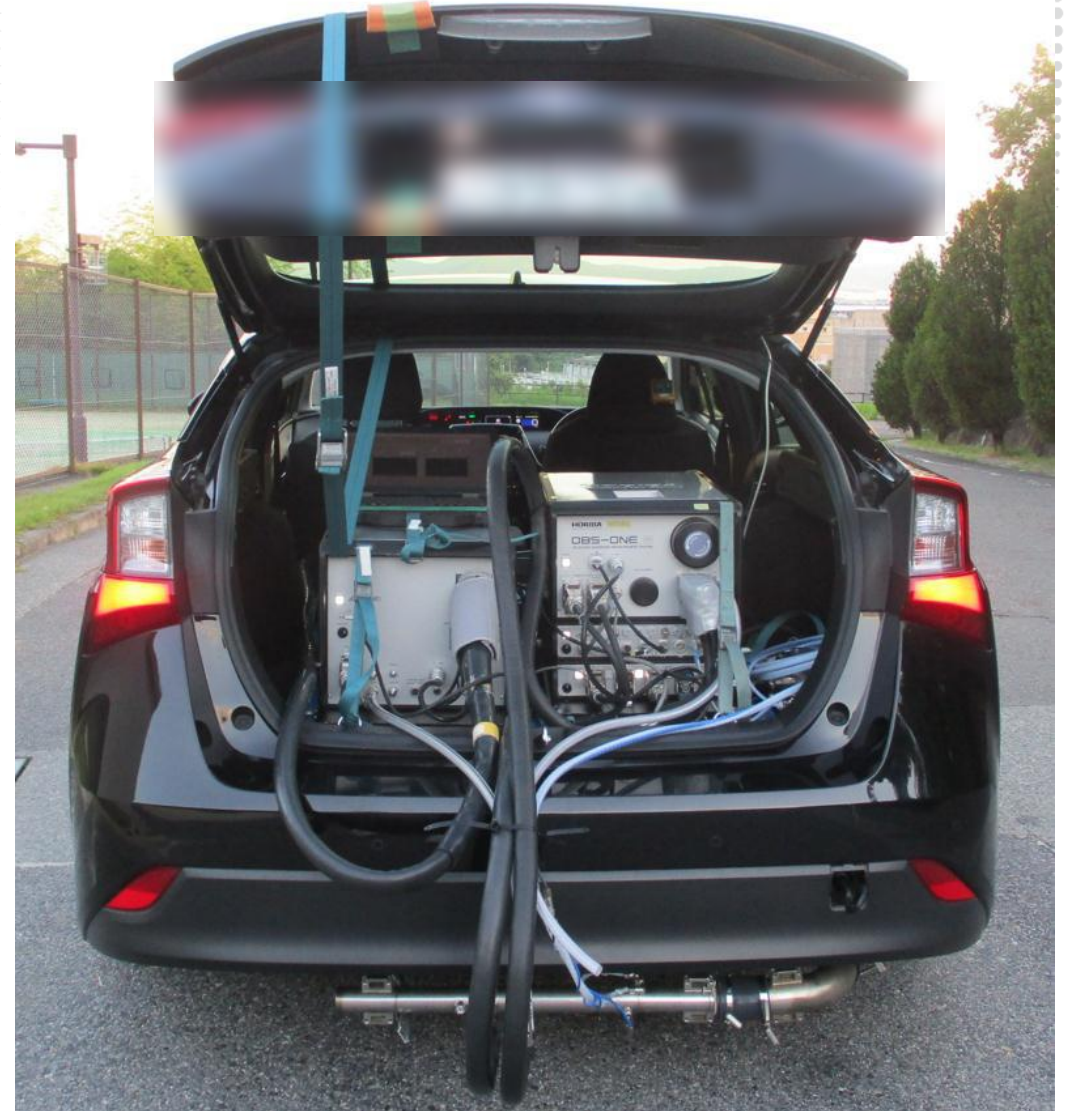
# RDE Test Setup

## Test Vehicle

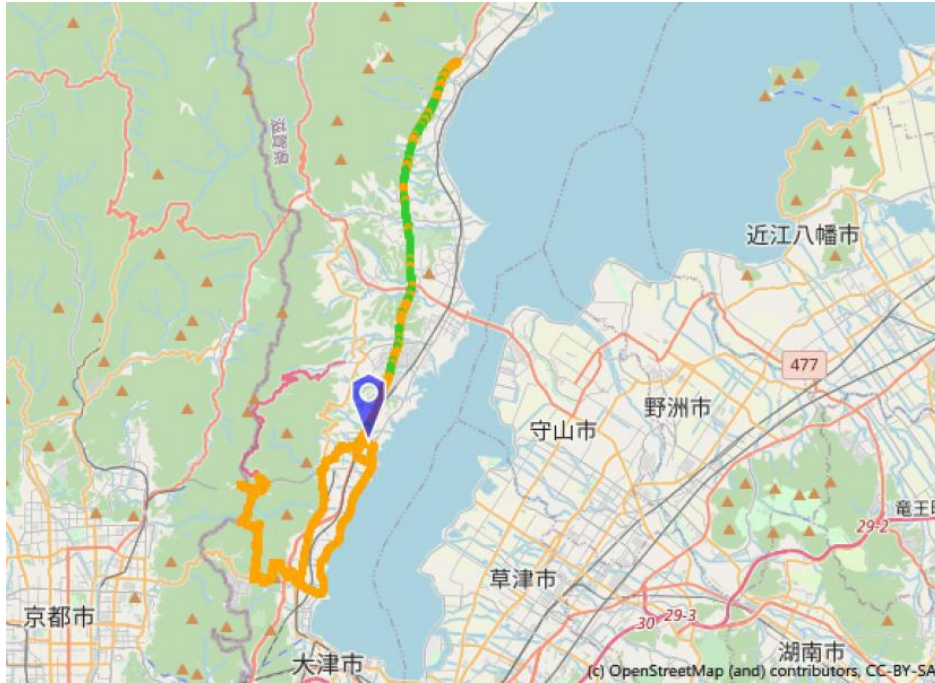
- 1.8 L / Gasoline / NOVC-HEV

## Equipment

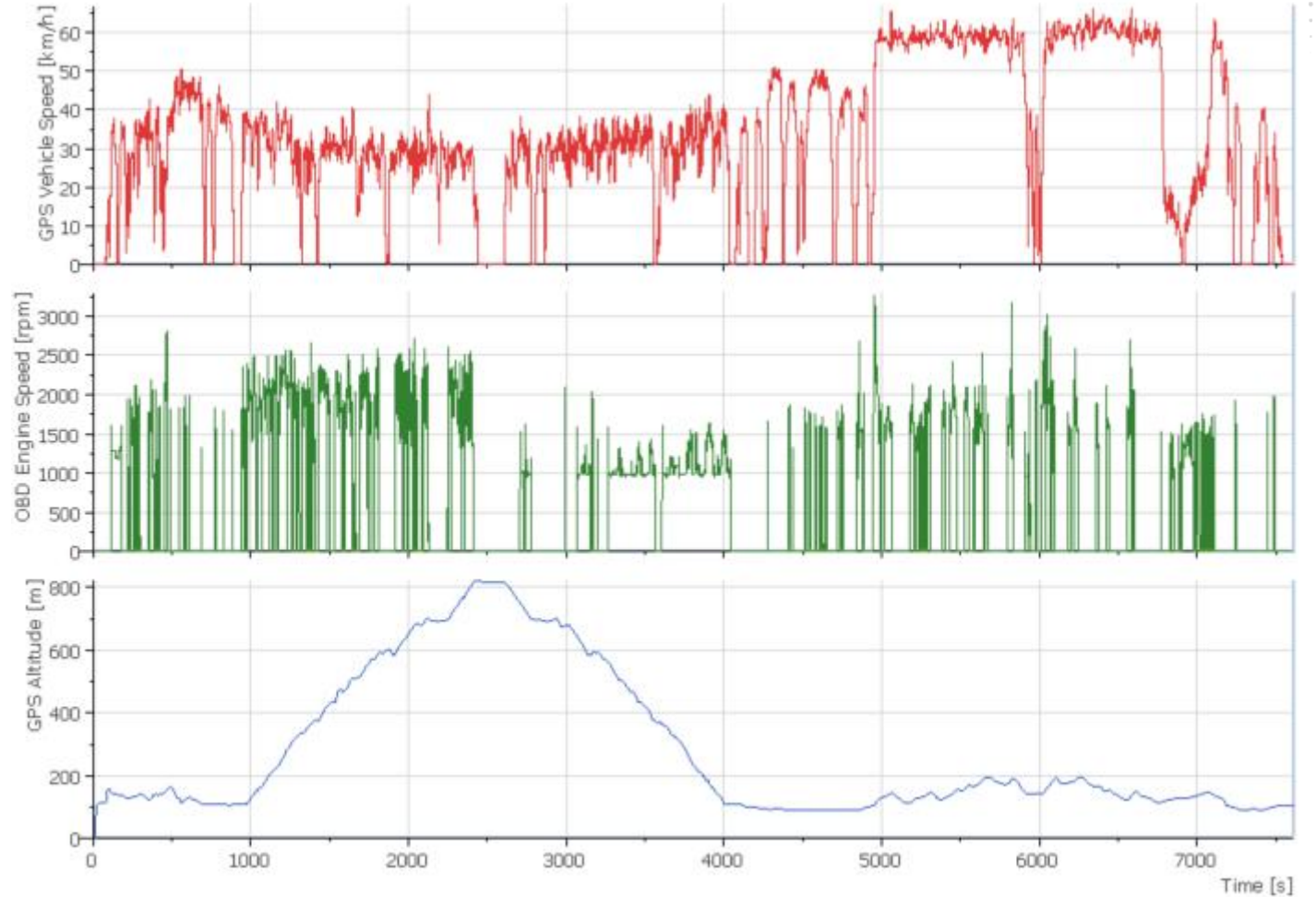
- New Gas PEMS  
(CO, CO<sub>2</sub>, NO, NO<sub>2</sub>, N<sub>2</sub>O, NH<sub>3</sub>, HCHO, CH<sub>4</sub>)
- OBS-ONE-PN10
- OBS-ONE EFM (Max. 4.5 m<sup>3</sup>/min)



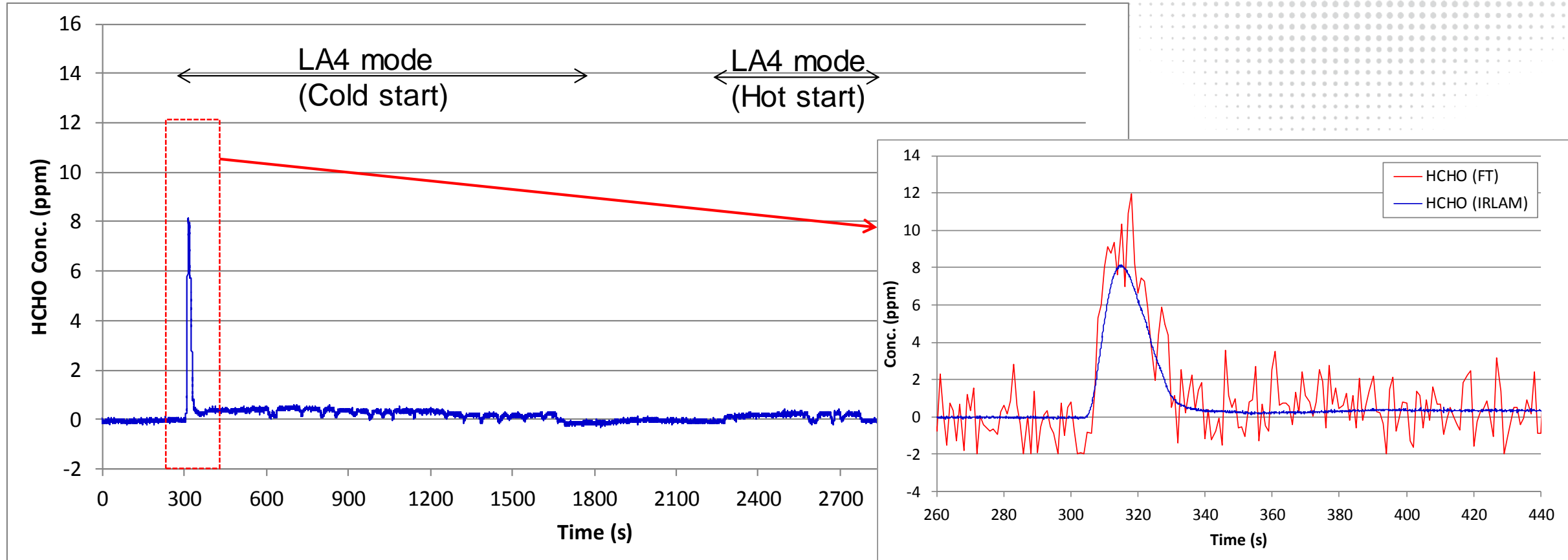
# RDE Trip Information



- Urban >> Mountain >> Rural
- Total distance: 71.9 km
- Total duration: 123 min



# Emission Measurement by IRLAM

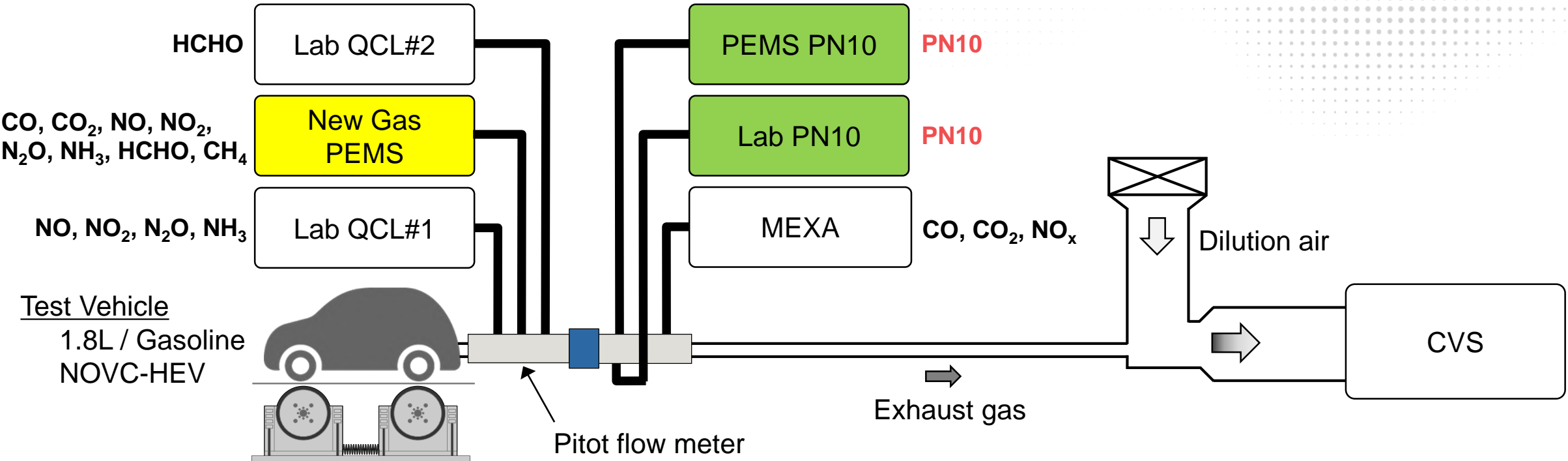


- Good correlation with FT-IR results
- Much higher resolution in concentration than FT-IR

# Analyser Drift Check Result

			CO-L	CO-H	CO <sub>2</sub>	NO	NO <sub>2</sub>	NO+NO <sub>2</sub>	N <sub>2</sub> O	NH <sub>3</sub>	HCHO	CH <sub>4</sub> -L	CH <sub>4</sub> -H
Drift Result	[ppm]	Zero	1.0	96	66	0.3	0.1	0.2	0.1	0.0	0.19	0.5	0.7
		Span	11.7	154	441	3.9	0.8	4.7	7.6	6.5	0.03	8.5	17.2
	[% of rdg]	Span	0.2	0.1	0.2	0.2	0.1	0.3	0.8	0.5	0.1	0.5	0.2
EU7 LDV Proposal	[ppm]	Zero	75	-	2000	-	-	3	-	2	-	10	-
		Span	75	-	2000	-	-	3	-	2	-	10	-
	[% of rdg]	Span	2	-	2	-	-	2	-	2	-	2	-

# Correlation test setup with new analyzer



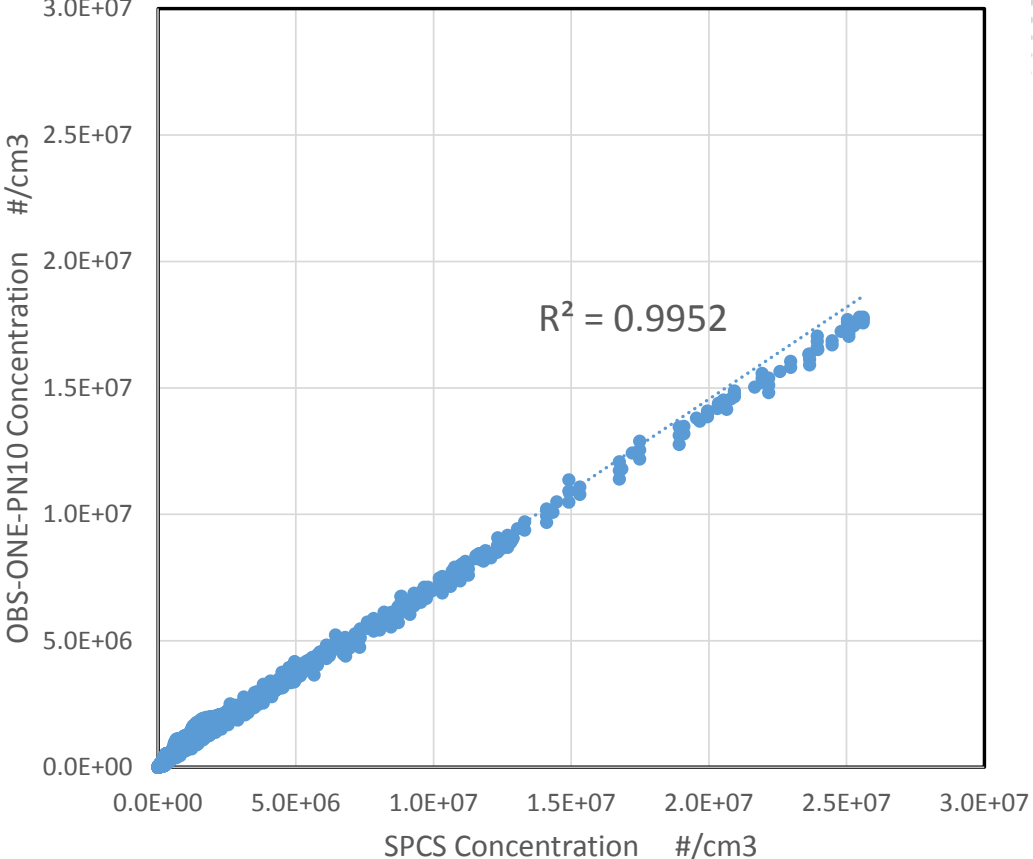
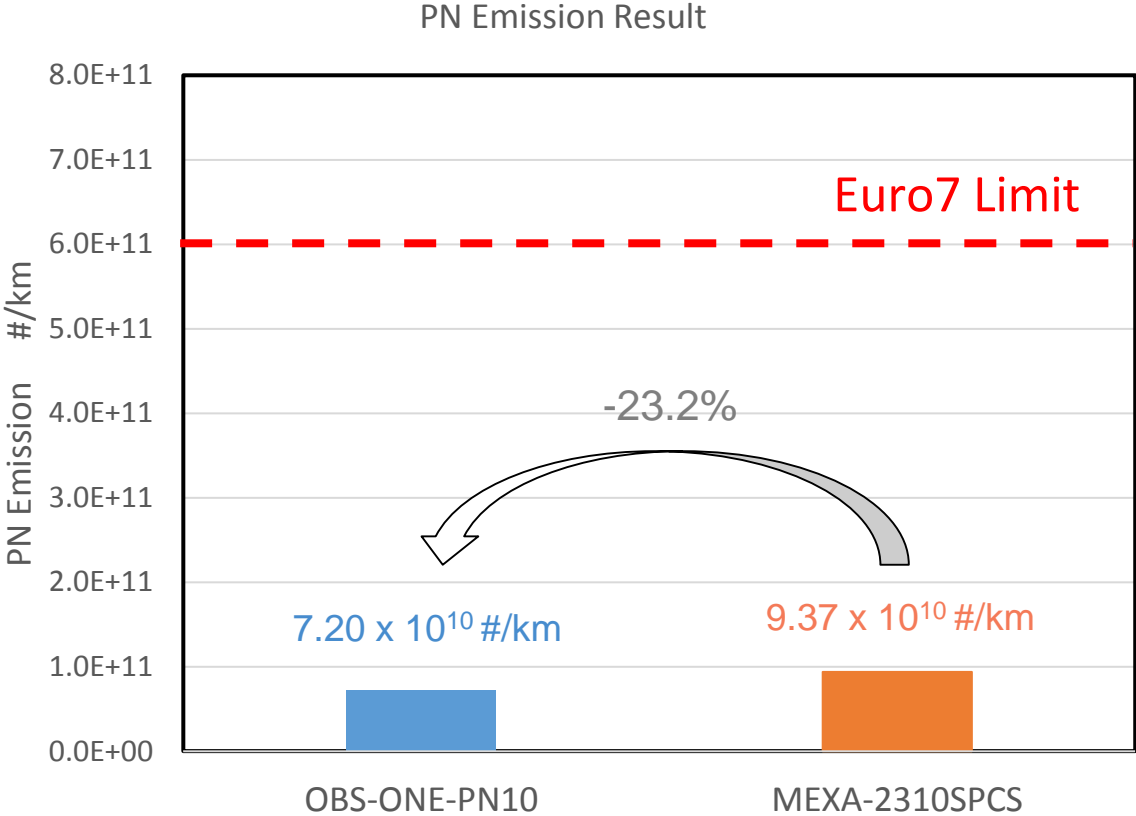
Test Vehicle  
1.8L / Gasoline  
NOVC-HEV

Chassis dynamometer

Test Cycle  
WLTC / 23°C / Cold start

# Correlation between OBS-ONE-PN10 and SPCS

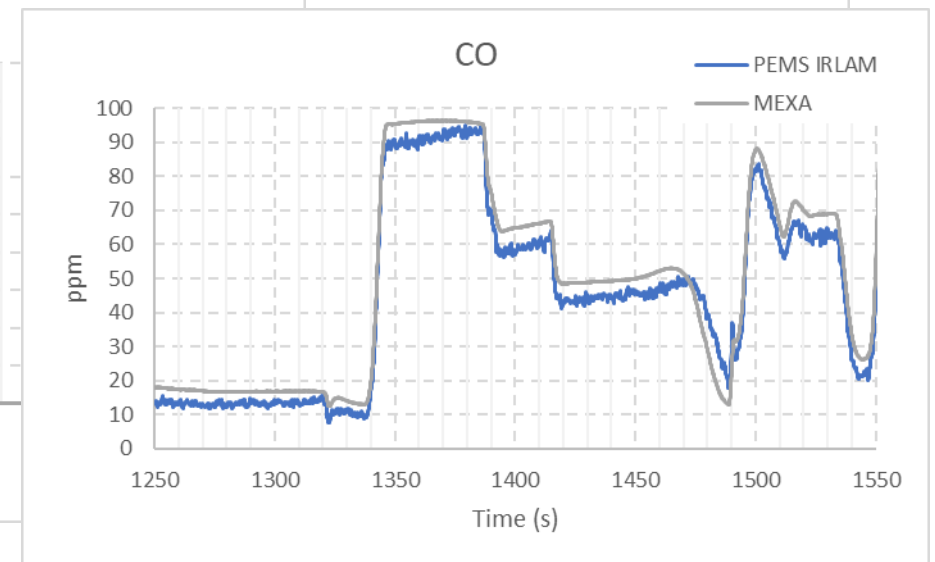
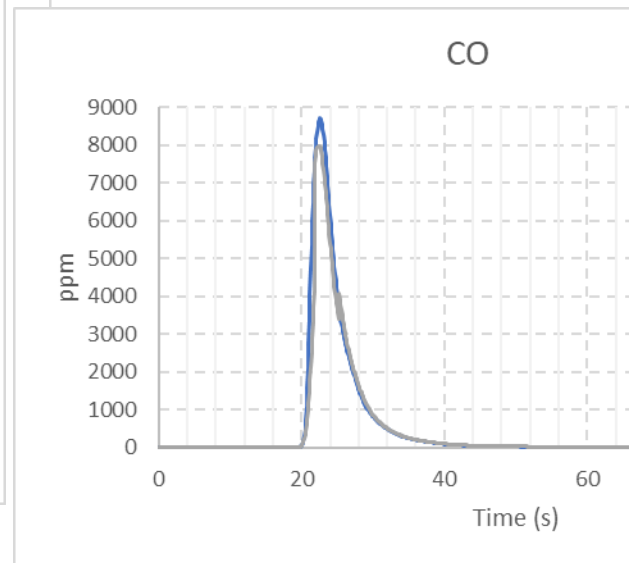
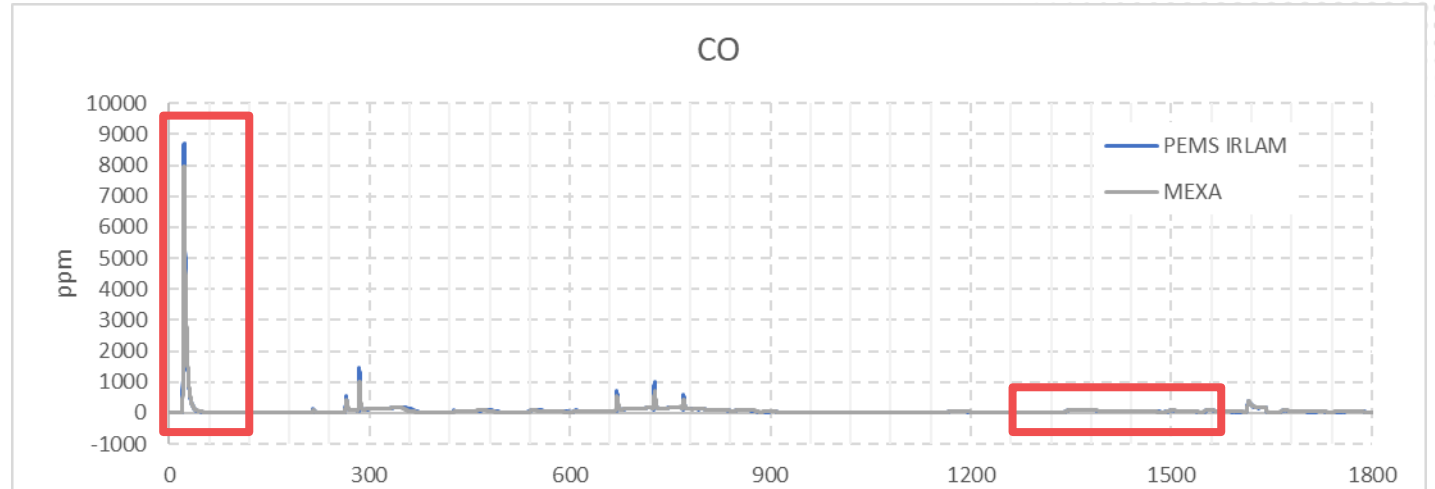
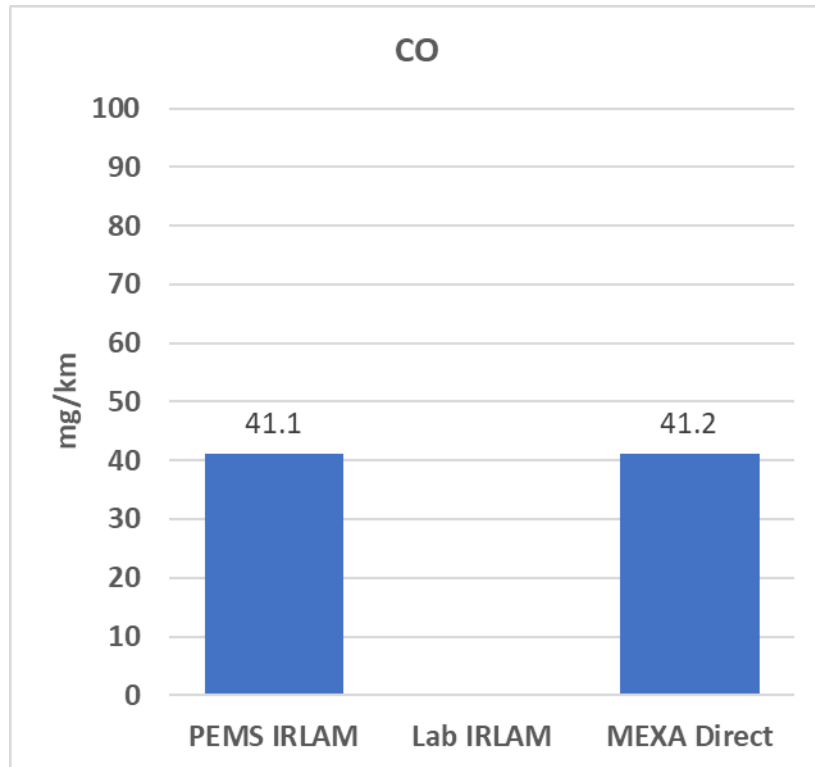
## Emission result and Correlation





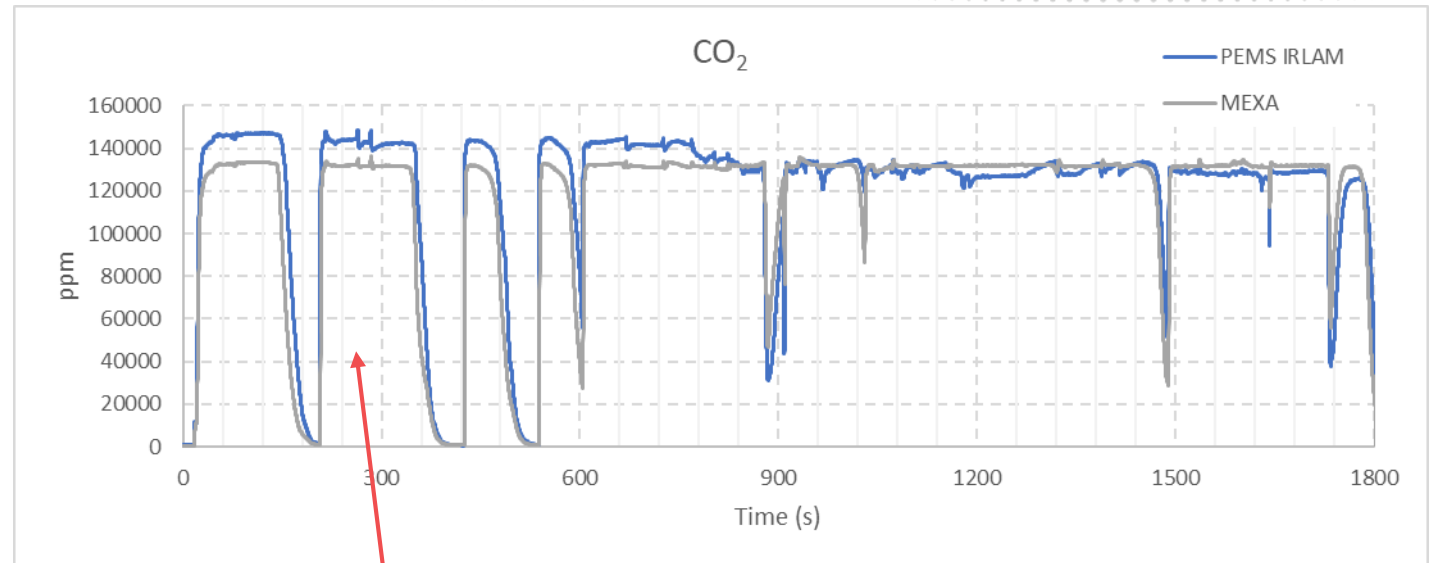
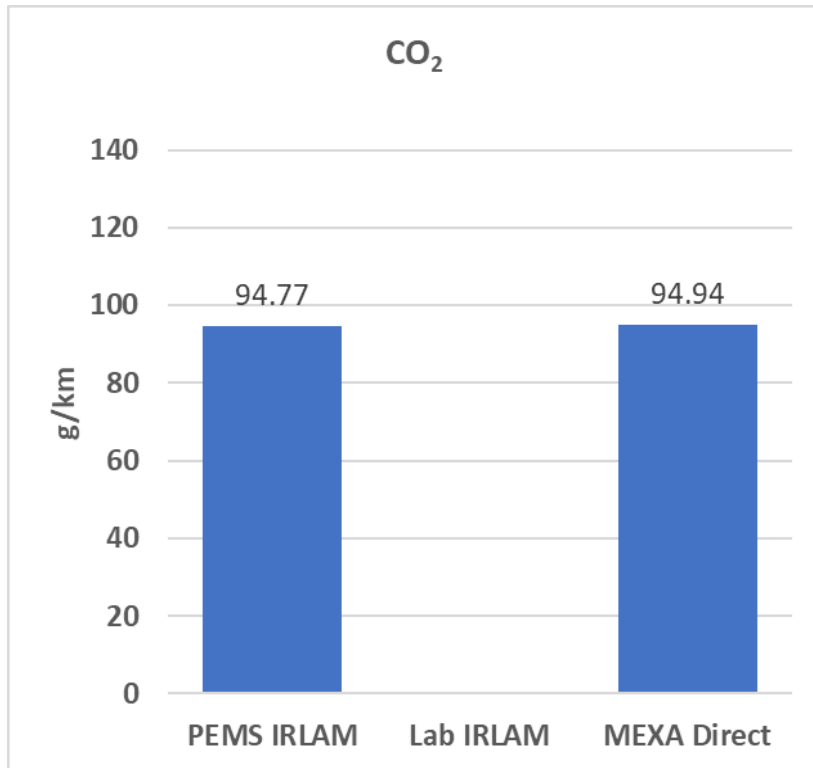
# CO

- Euro 7 proposal < 500 mg/km



# CO<sub>2</sub>

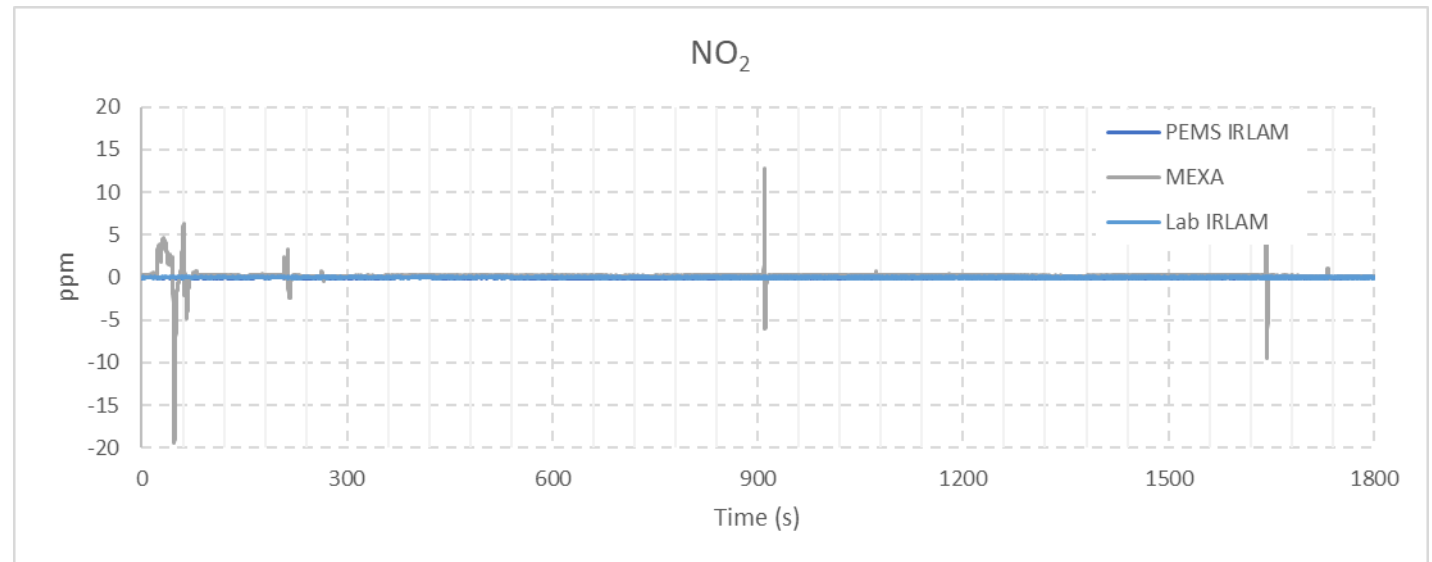
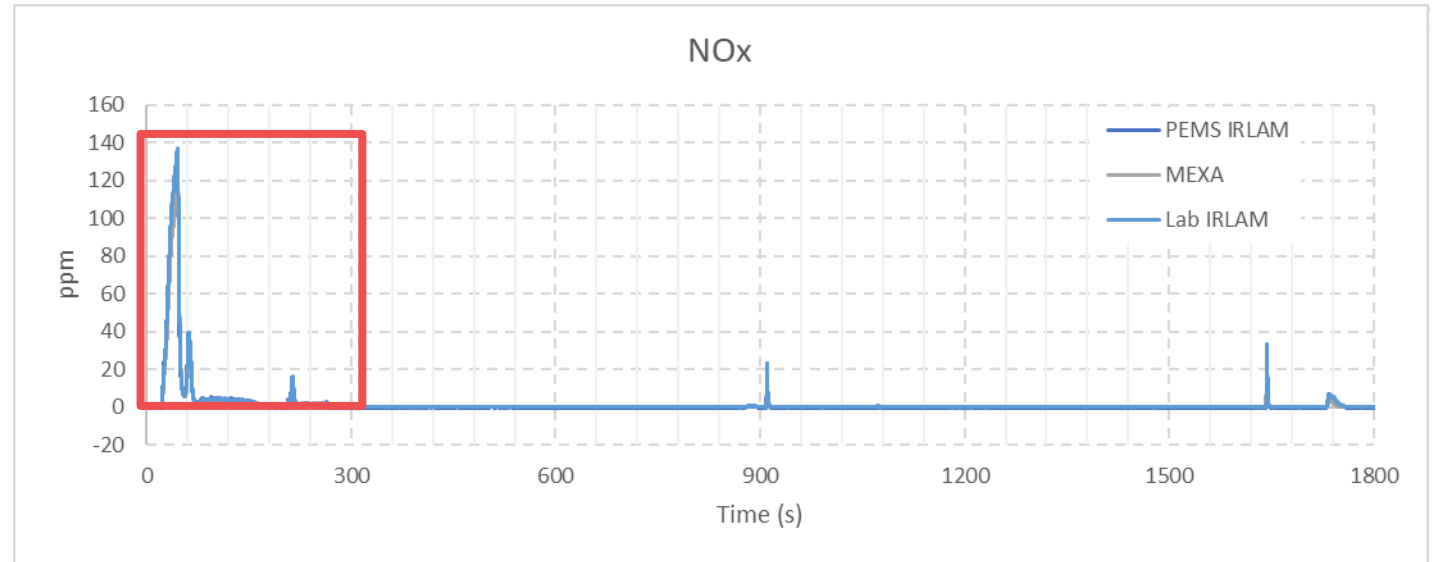
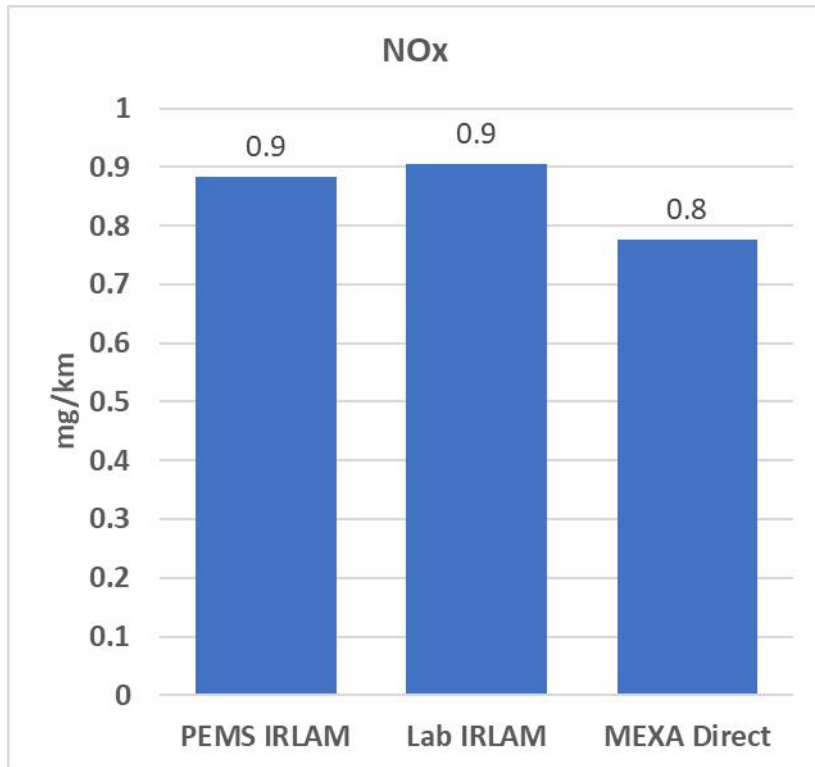
■



Error from Dry-Wet conversion

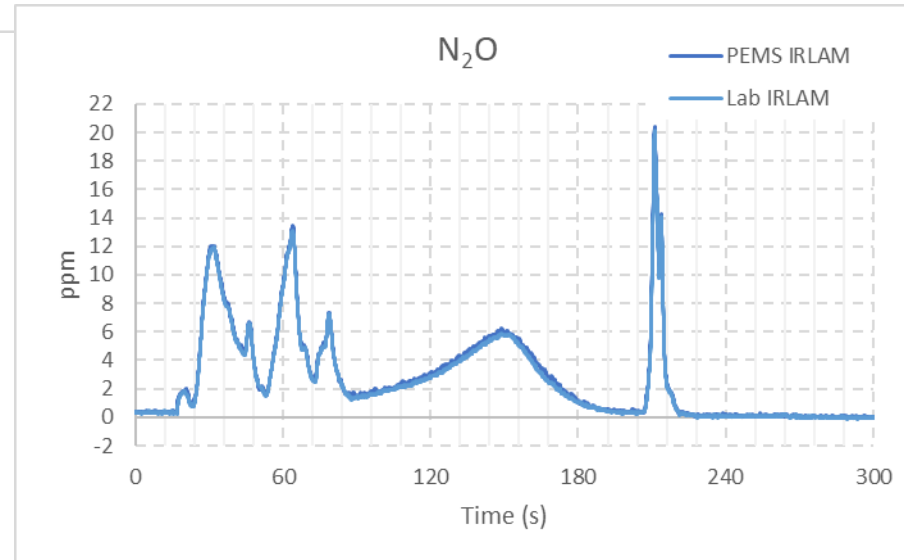
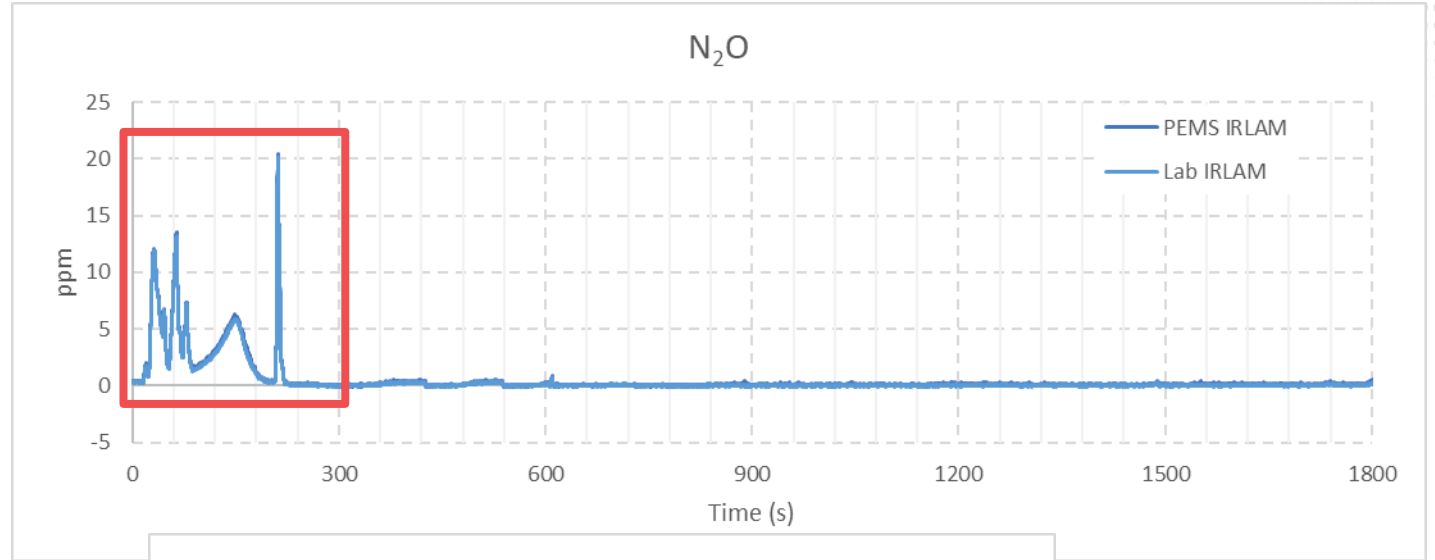
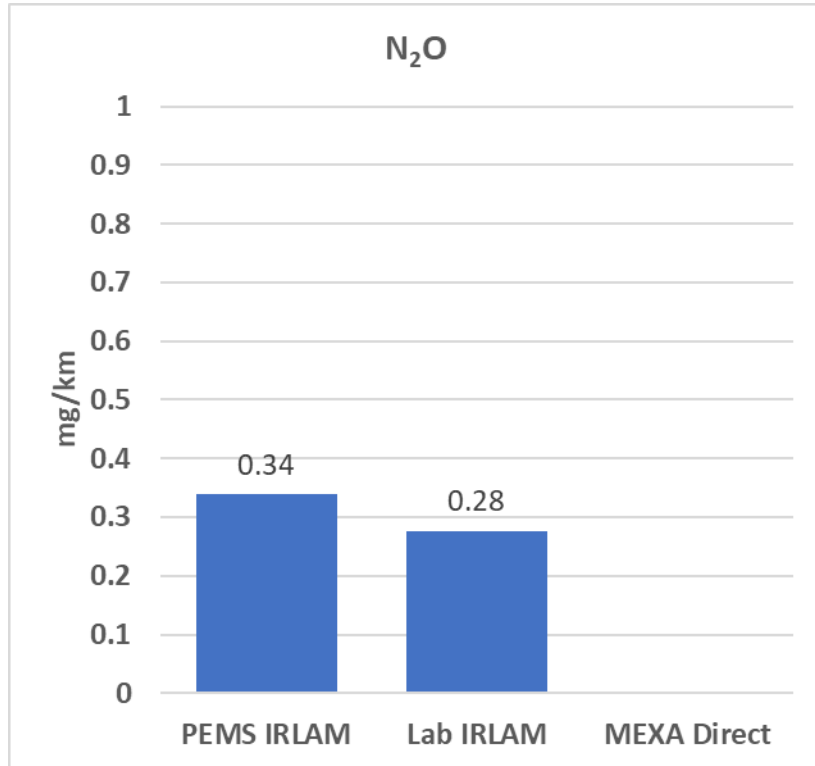
# NOx

- Euro 7 proposal NOx < 60 mg/km



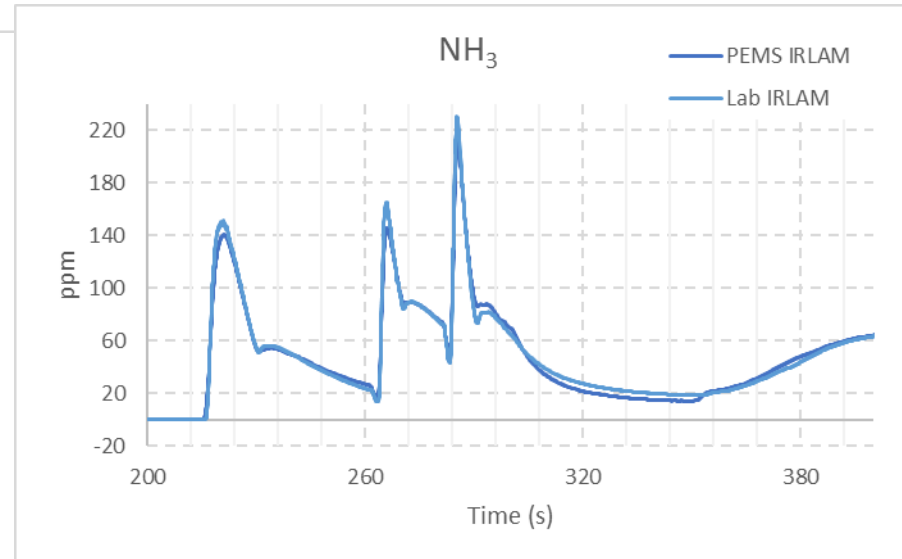
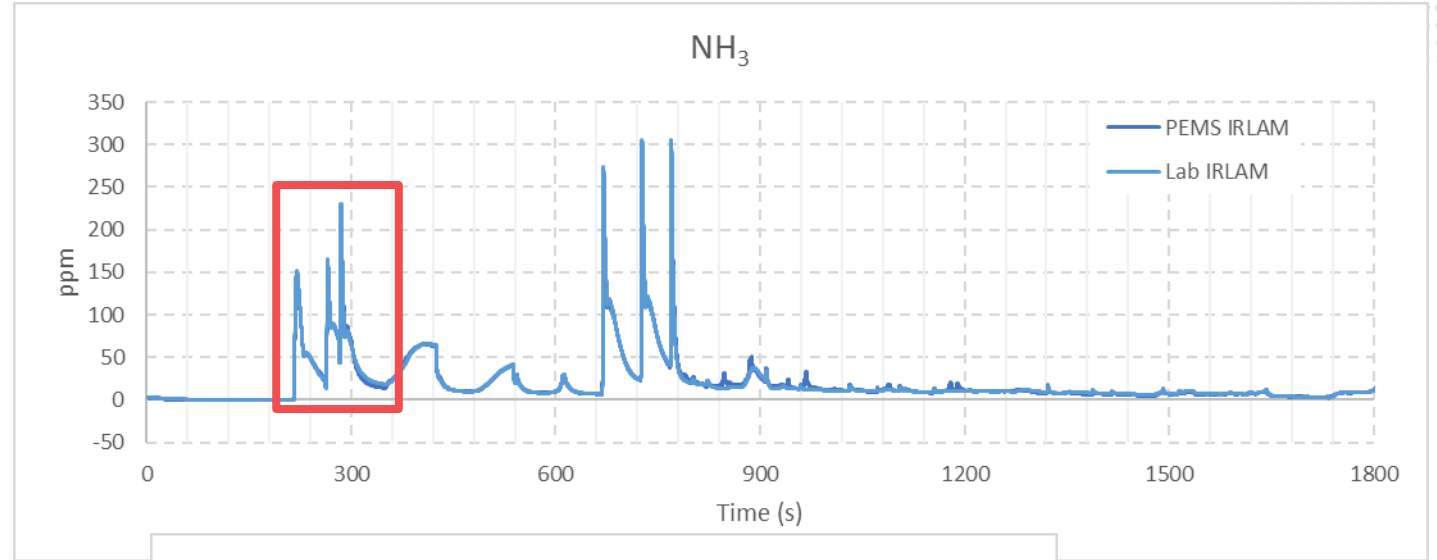
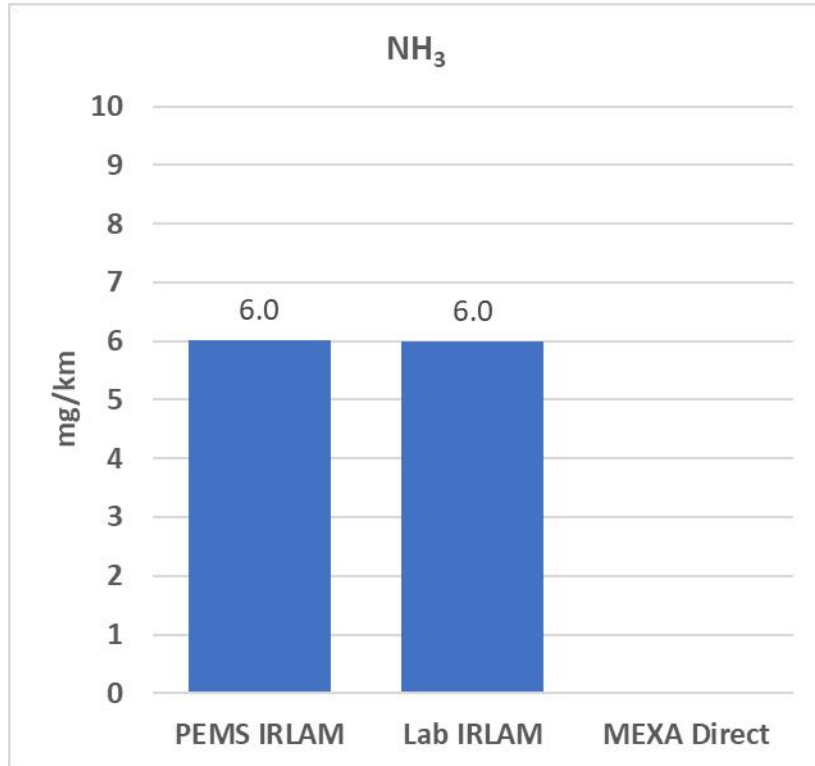
# N<sub>2</sub>O

■



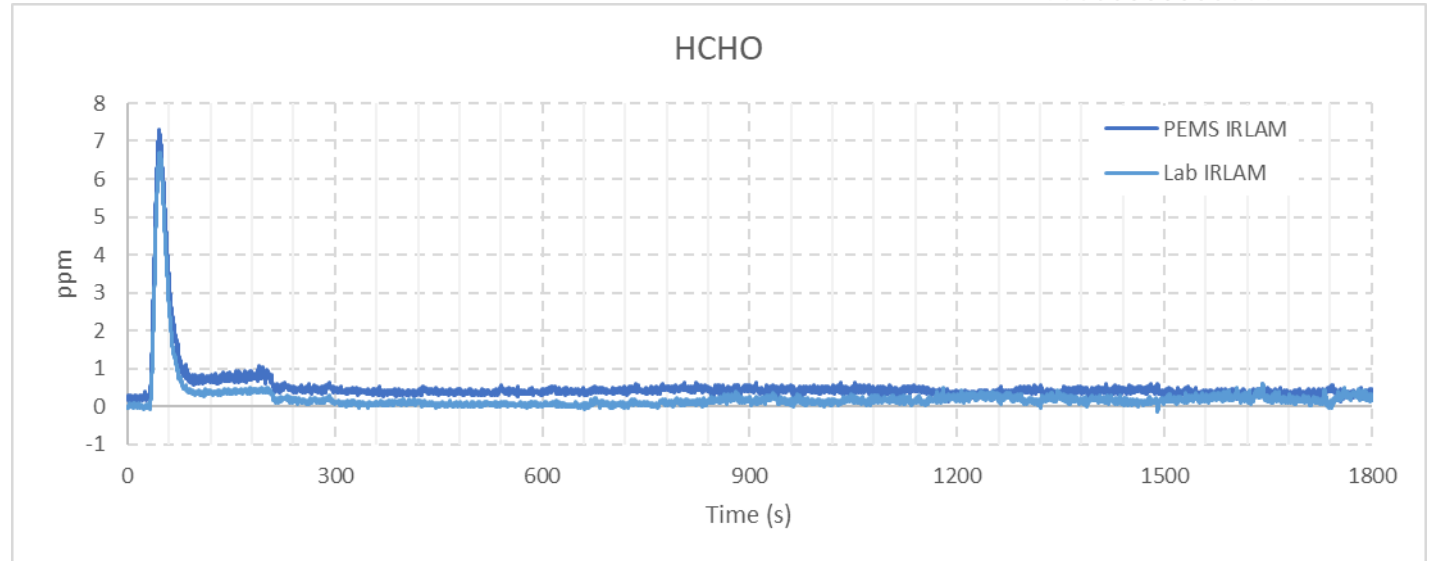
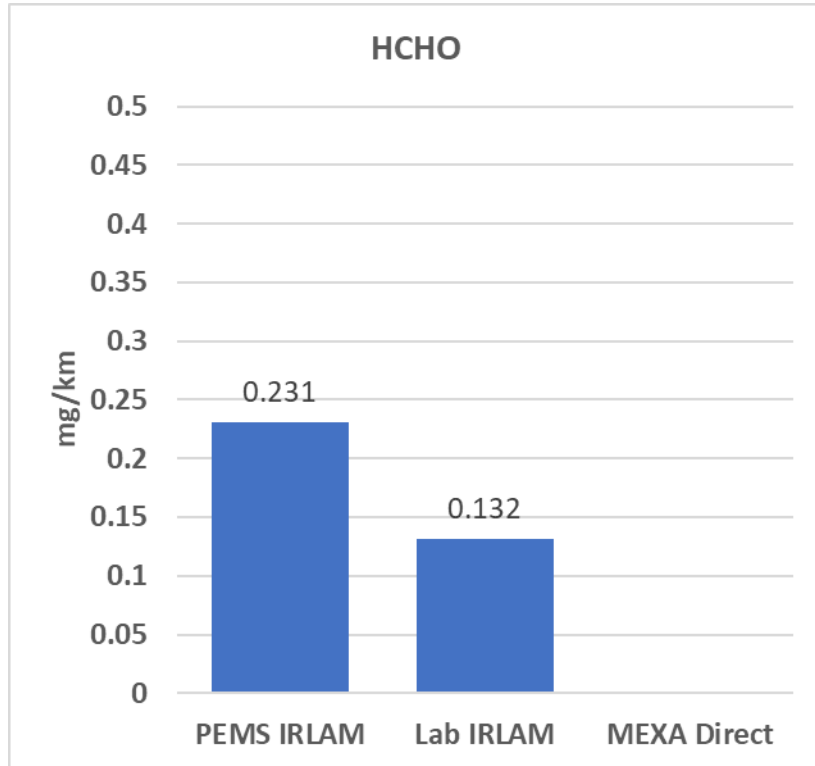
# NH<sub>3</sub>

- Euro 7 proposal < 20 mg/km



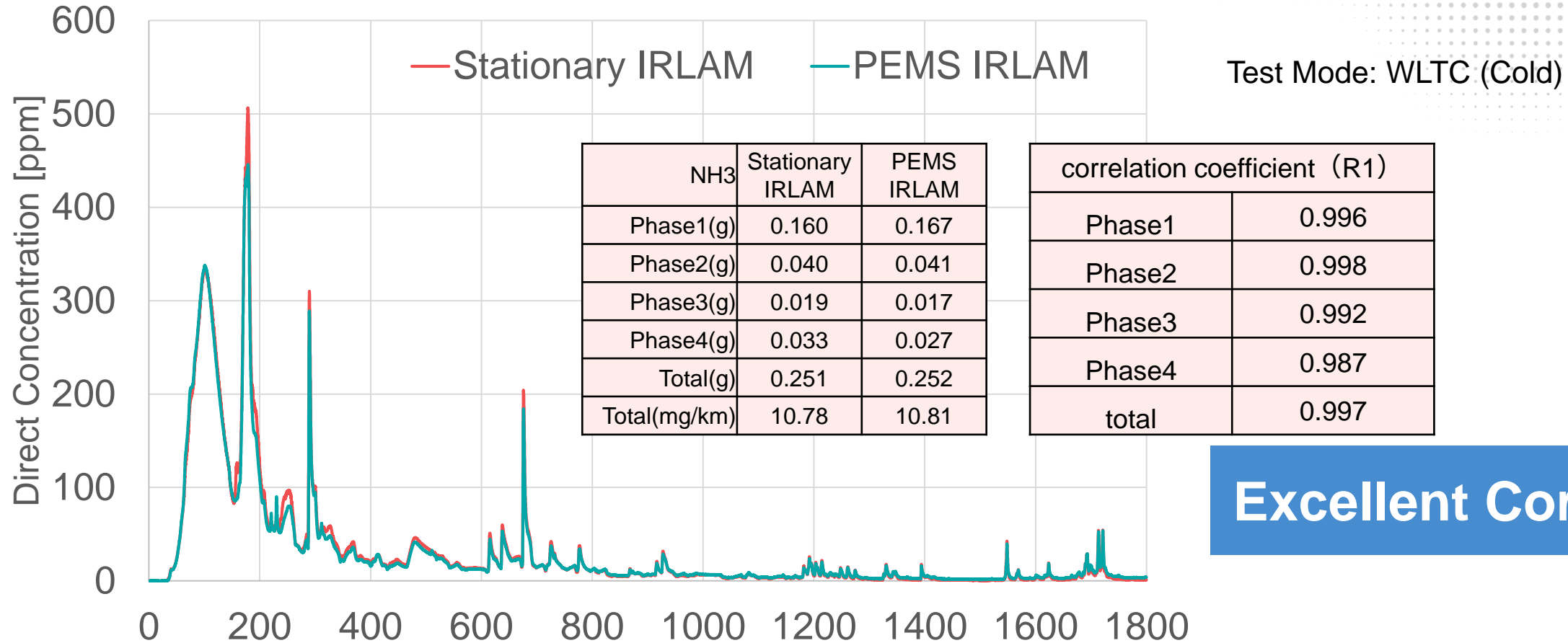
# HCHO

■



# HORIBA choose IRLAM for PEMS. Therefore, HORIBA supply Laboratory Test Equipment by IRLAM, too.

NH<sub>3</sub> Measurement by PEMS (OBS-ONE XL-1) and Stationary Equipment (MEXA-ONE XL-NX)

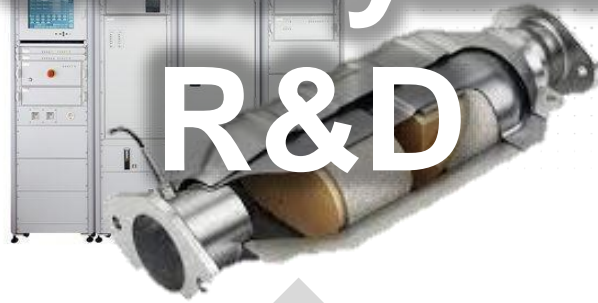


**Excellent Correlation.**

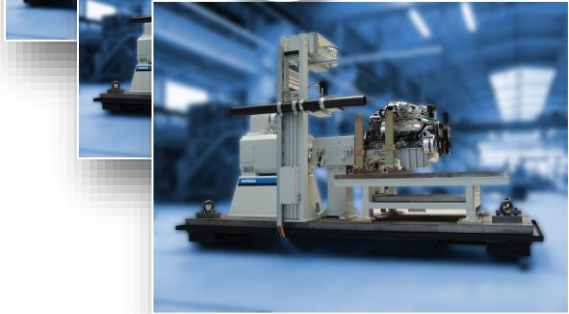
**IRLAM Stationary Equipment can be used for NH<sub>3</sub> Reduction R&D in Test Cell.**

# All-in-one Compact analyzer can be used not only RDE.

## Catalyzer R&D



## Engine



1 Analyzer can be used for several test cells.



## Chassis



Analyzer can put inside car and ready in soak room.





Omoshiro-okashiku  
Joy and Fun



Danke

Grazie

Tack ska du ha

ありがとうございました

Dziękuję

Gracias

Σας ευχαριστώ πάρα πολύ

**THANK YOU**

ขอบคุณครับ

Obrigado

Большое спасибо

Cảm ơn

நன்றி

Terima kasih

谢谢

धन्यवाद

شُكْرًا

Merci

감사합니다