

Regulated and Particle Emissions from Current Production Vehicles

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AECC

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Association for Emissions Control by Catalyst AISBL

Association for Emissions Control by Catalyst (AECC)

AECC Members: European Emission Control companies



DELPHI



ENGELHARD

IBIDEN CO., LTD.



Johnson Matthey



NGK Europe GmbH



Electronics & Catalysis



Technology for exhaust emissions control on all new cars
(OEM and Aftermarket) and an increasing number of
commercial vehicles & motorcycles



Association for Emissions Control by Catalyst AISBL

Outline of the presentation

1. AECC light-duty test programme
2. Conclusions

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 - a. AECC test programme outline
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AECC test programme objectives

- Provide input to Euro 5 process.
- Provide data for the GRPE/PMP programme
 - improved particulate mass method
 - new particle number measurement method.
- Compare DPF-equipped and ‘state-of-the-art’ non-DPF Diesel vehicles
 - including particulate mass and particle number emissions.
- Demonstrate the durability of Diesel Particulate Filtration.
- Provide data on ‘real world’ & ‘unregulated’ emissions.
- Examine emissions performance of a mid-range Euro 4 gasoline vehicle.

*Complementary technical papers are to be presented at
3rd Emissions Control conference, Dresden & SAE 2006, Detroit*



AECC test programme

- 4 current Euro 4 production vehicles
 - 1 gasoline with TWC
 - 2 different Diesels without DPF
 - 1 Diesel with DPF.
- 4 different vehicle manufacturers.
- Typical mid-sized vehicles.
- Vehicles aged to 4000km.
- Diesel with DPF run to 160000km (on-road ageing) and then the test programme was repeated.
- Tests conducted at AVL-MTC (a Type Approval agency in Sweden).



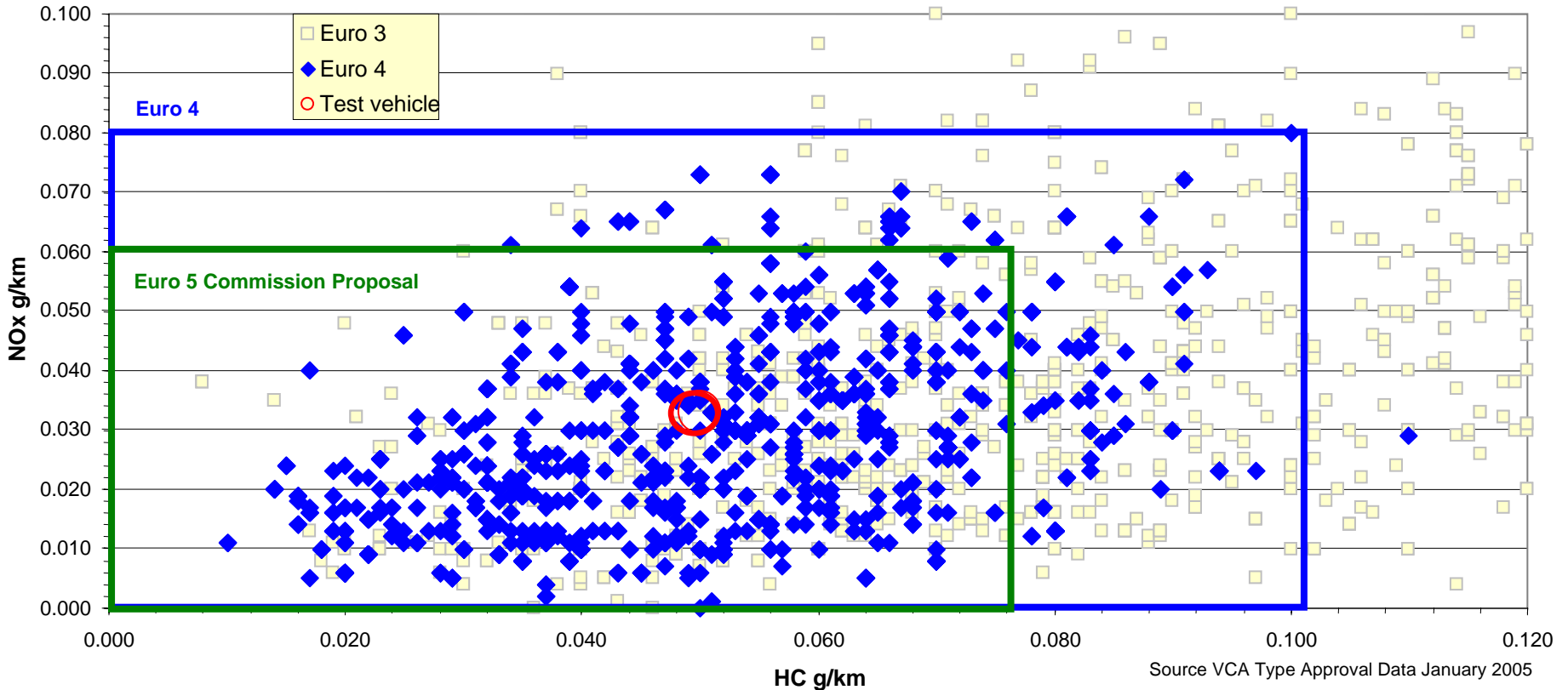
Euro 4 test vehicles

	Gasoline vehicle	Diesel 'A' without DPF	Diesel 'B' without DPF	Diesel with DPF
Engine Type	In-line 4 16 valve	V6 24 valve	In-line 4 16 valve	In-line 6 24 valve
Injection system	Sequential MPI	Distributor pump DI	Common Rail DI	Common Rail DI
Displacement (cm³)	1791	2496	2204	2993
Power (kW@rpm)	90@6000	120@4000	103@4000	160@4000
Emission Control	TWC 2 lambda	EGR 2 x DOC	cooled EGR 3 x DOC	EGR DOC underfloor C-DPF

Gasoline passenger cars

Type Approval values

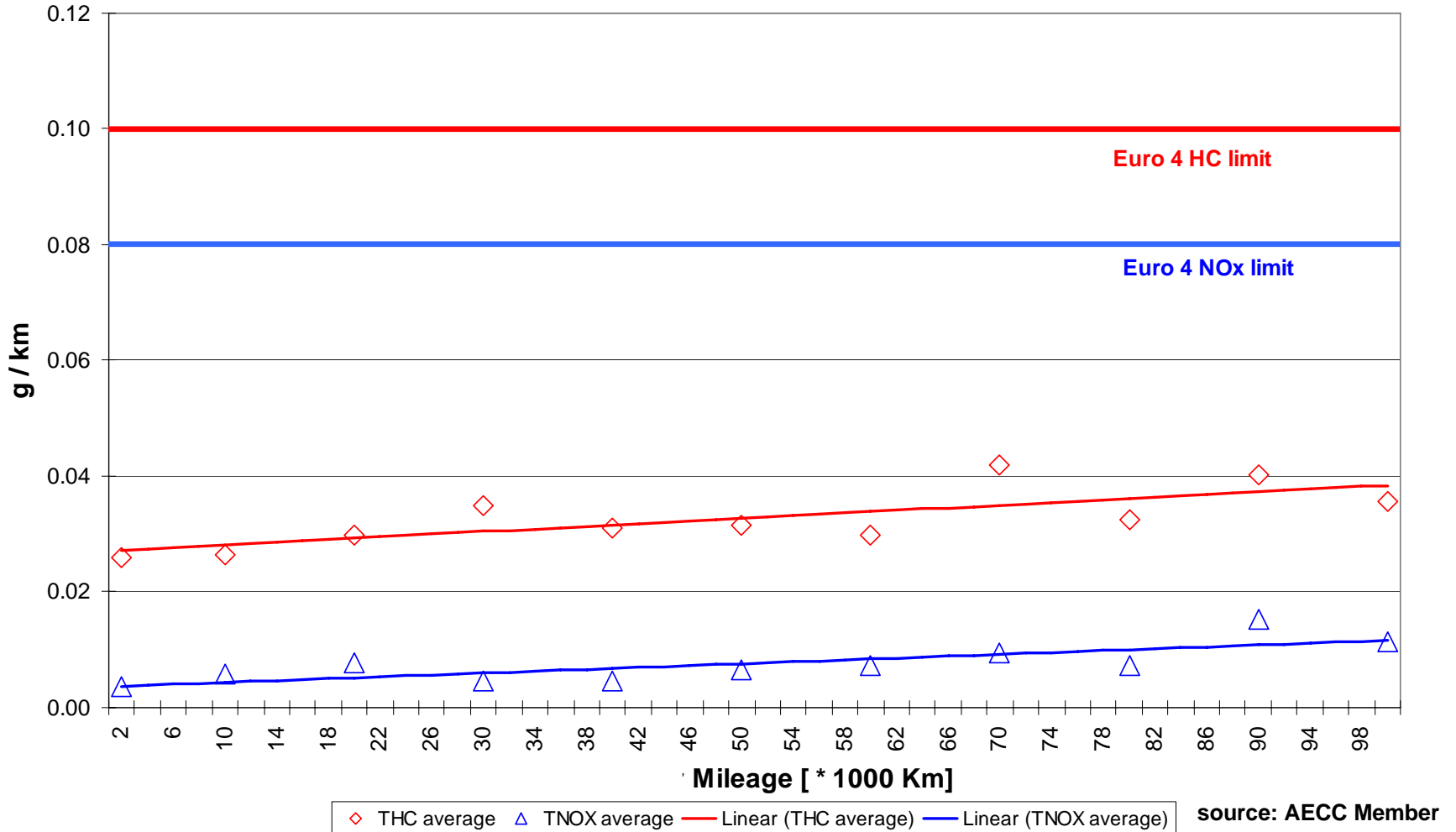
Certification values include deterioration factors



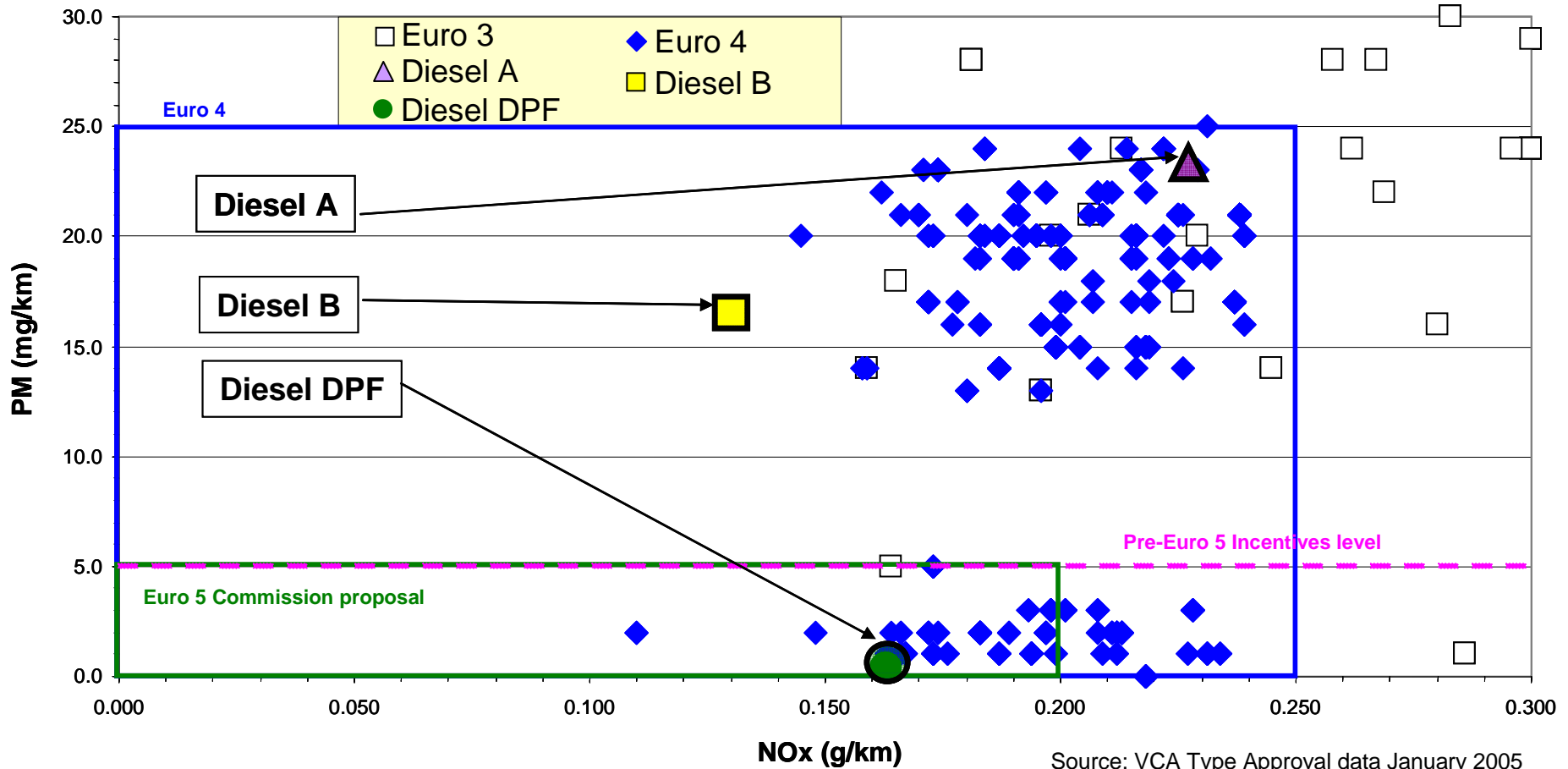
The gasoline vehicle selected for testing was a 'standard' mid-range car with emissions near the middle of the 'cloud' and with known durability

Gasoline vehicle durability

NEDC emission test results during Euro 4 road durability test



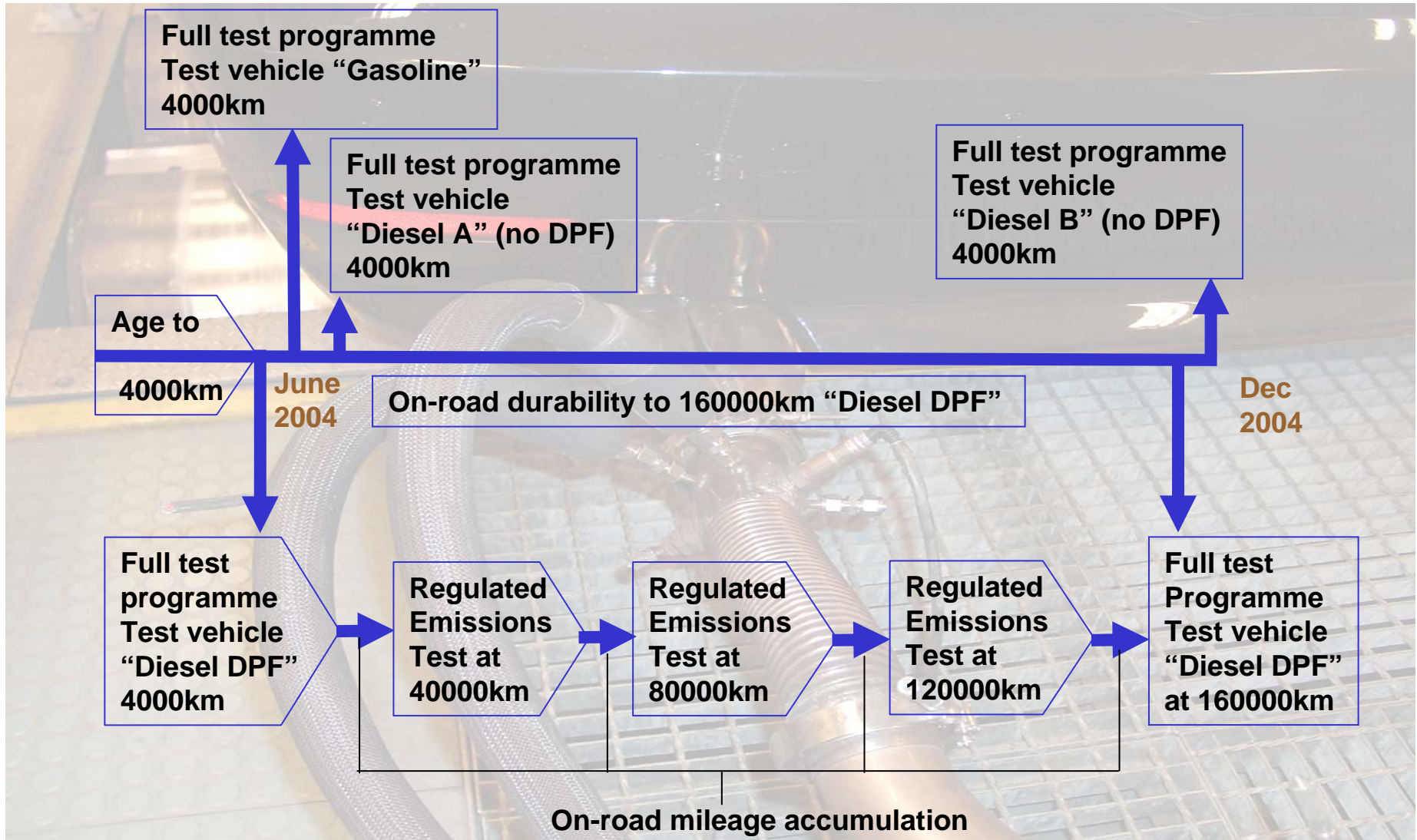
Diesel passenger cars Type Approval values



AECC test programme outline

- All vehicles tested on NEDC (& Artemis suite).
- Standard CEC Reference Fuels used for all tests.
- Standard Swedish Road fuels for de-greening / durability.
- Regulated g/km ('bag') emissions.
- Engine-out and continuous tailpipe regulated emissions.
- PM and Particle Number to 'frozen' PMP protocol.
- Particle Size distribution measurements (ELPI).
- Continuous Size & Number distribution.
- NO₂ & PM speciation.
- Tests repeated for Diesel with DPF at 160000km.

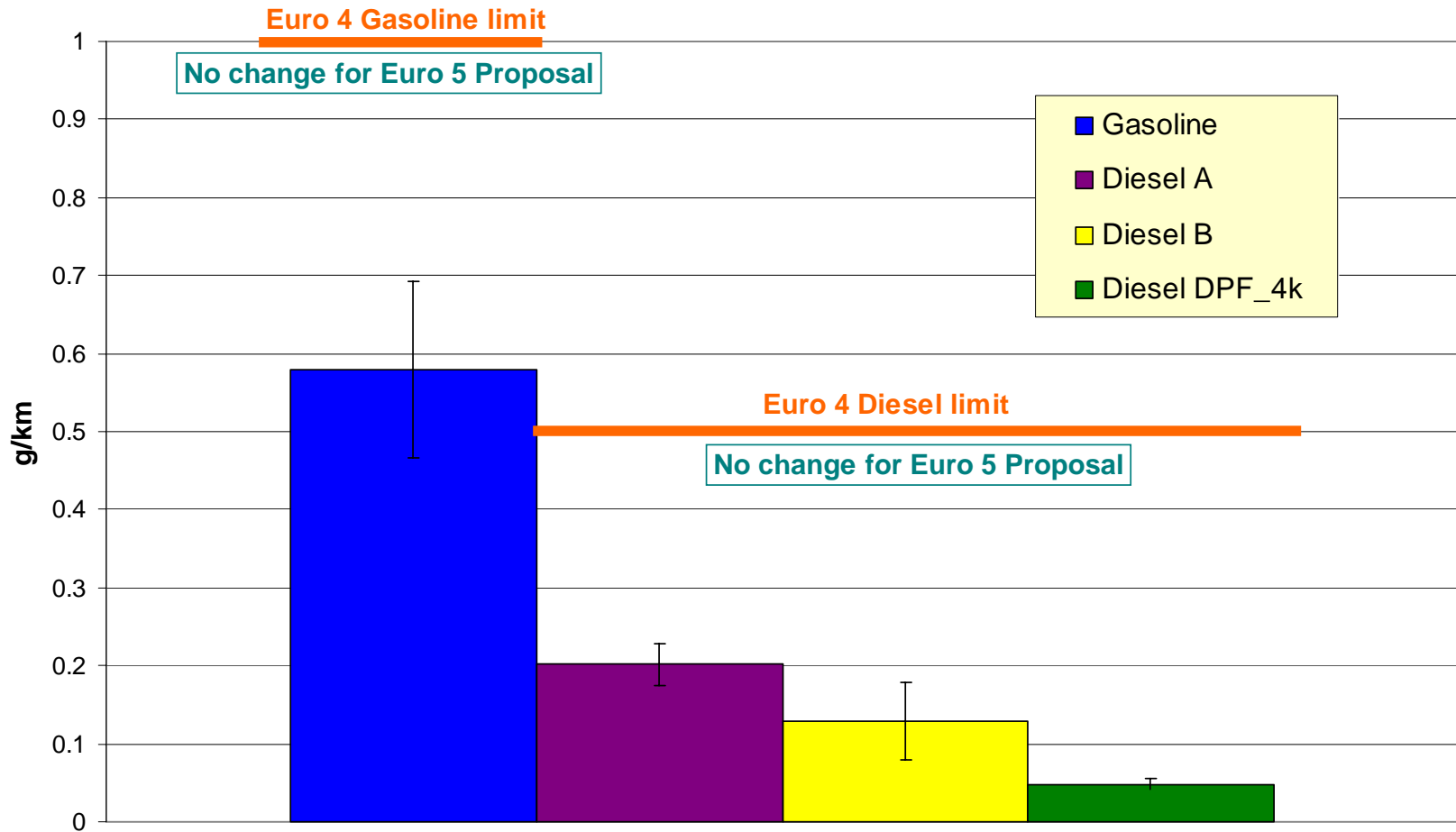
AECC test programme timeline



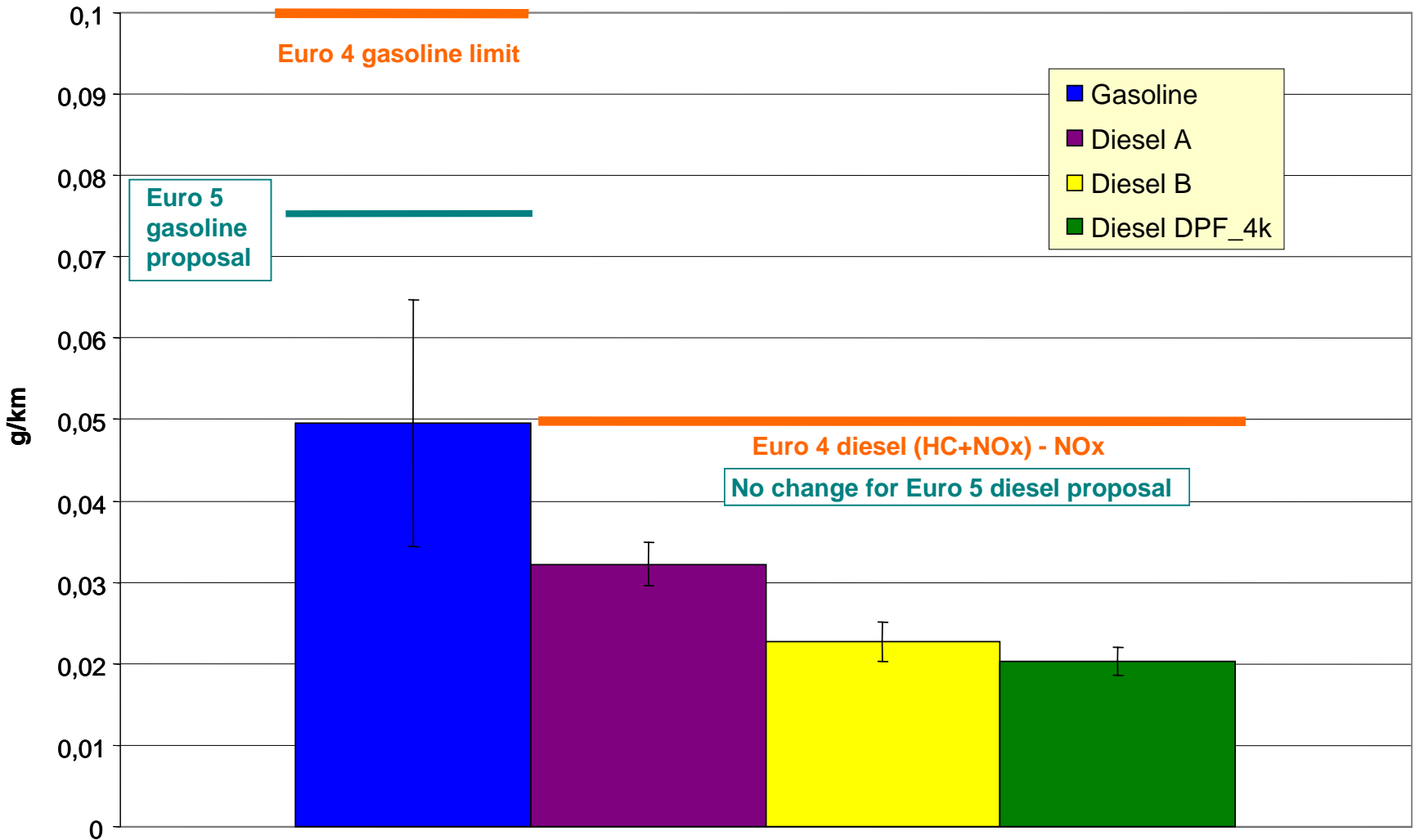
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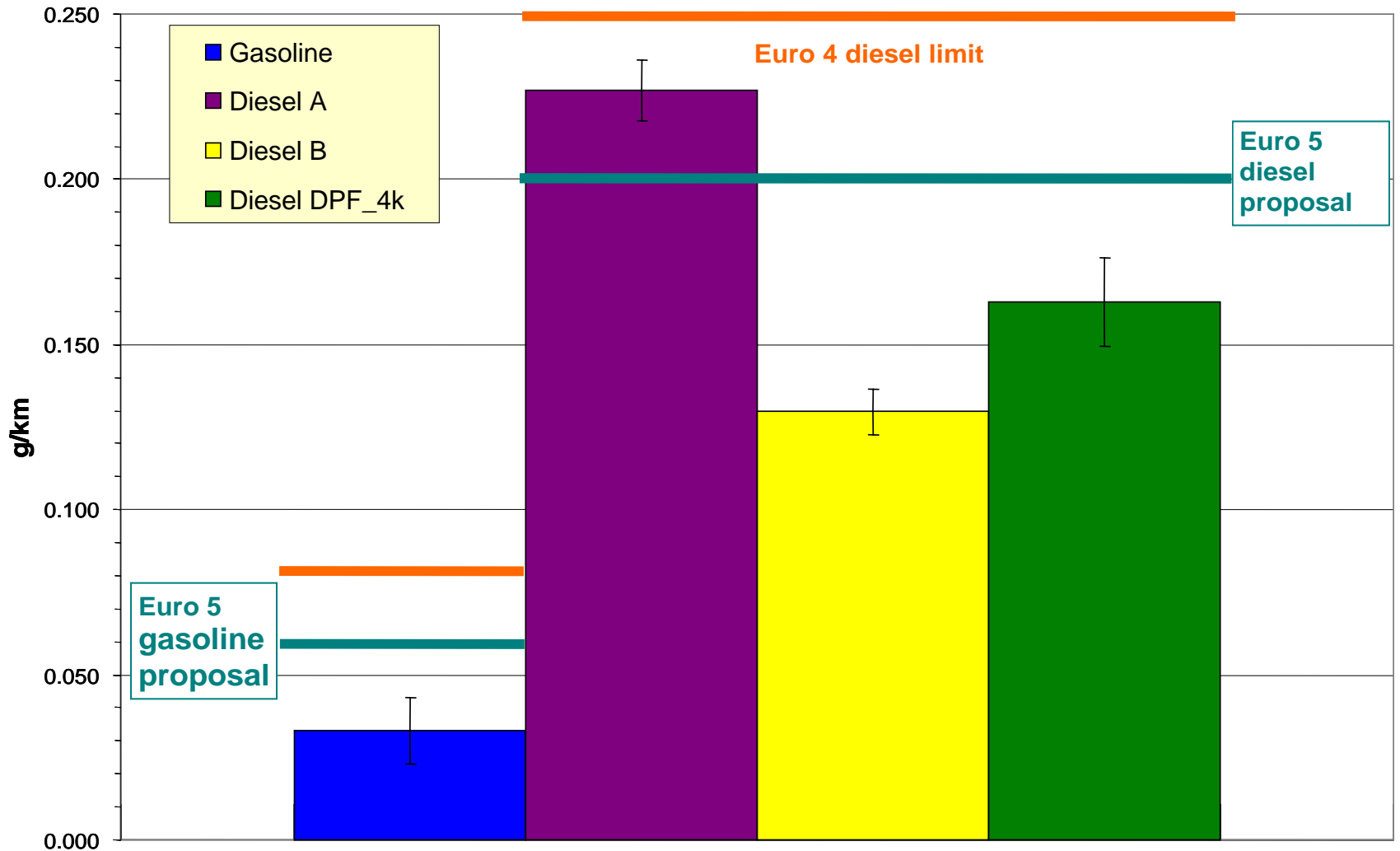
NEDC tests at 4000km: CO emissions



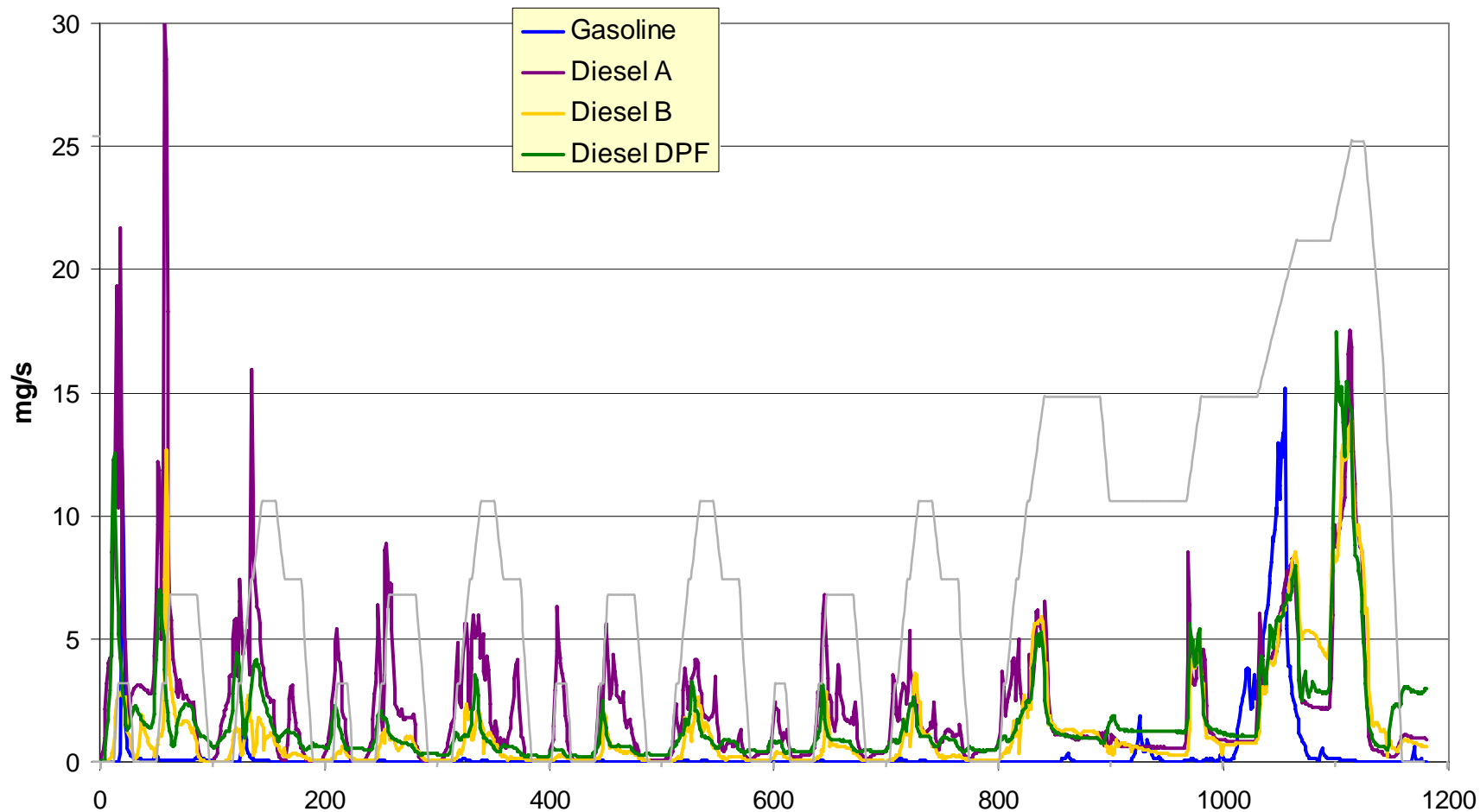
NEDC tests at 4000km: HC emissions



NEDC tests at 4000km: NOx emissions



Comparative tailpipe NOx emissions (NEDC)

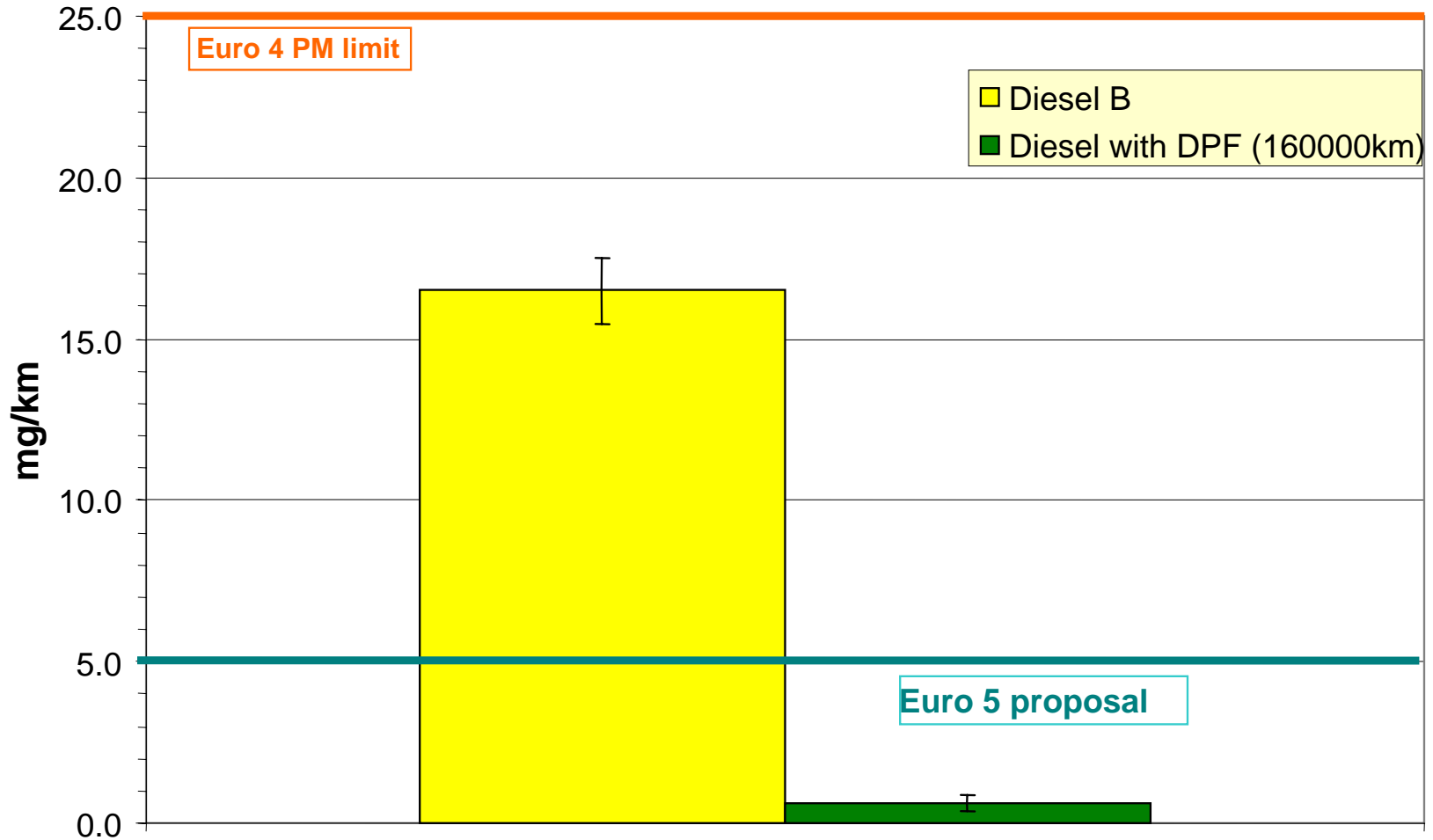


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 - c. Particulate Mass & Particle Number
 - Particulate Mass PM
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PM to current methodology (NEDC)

PM to current EU methodology
(Gasoline & Diesel A vehicles not tested to this procedure)

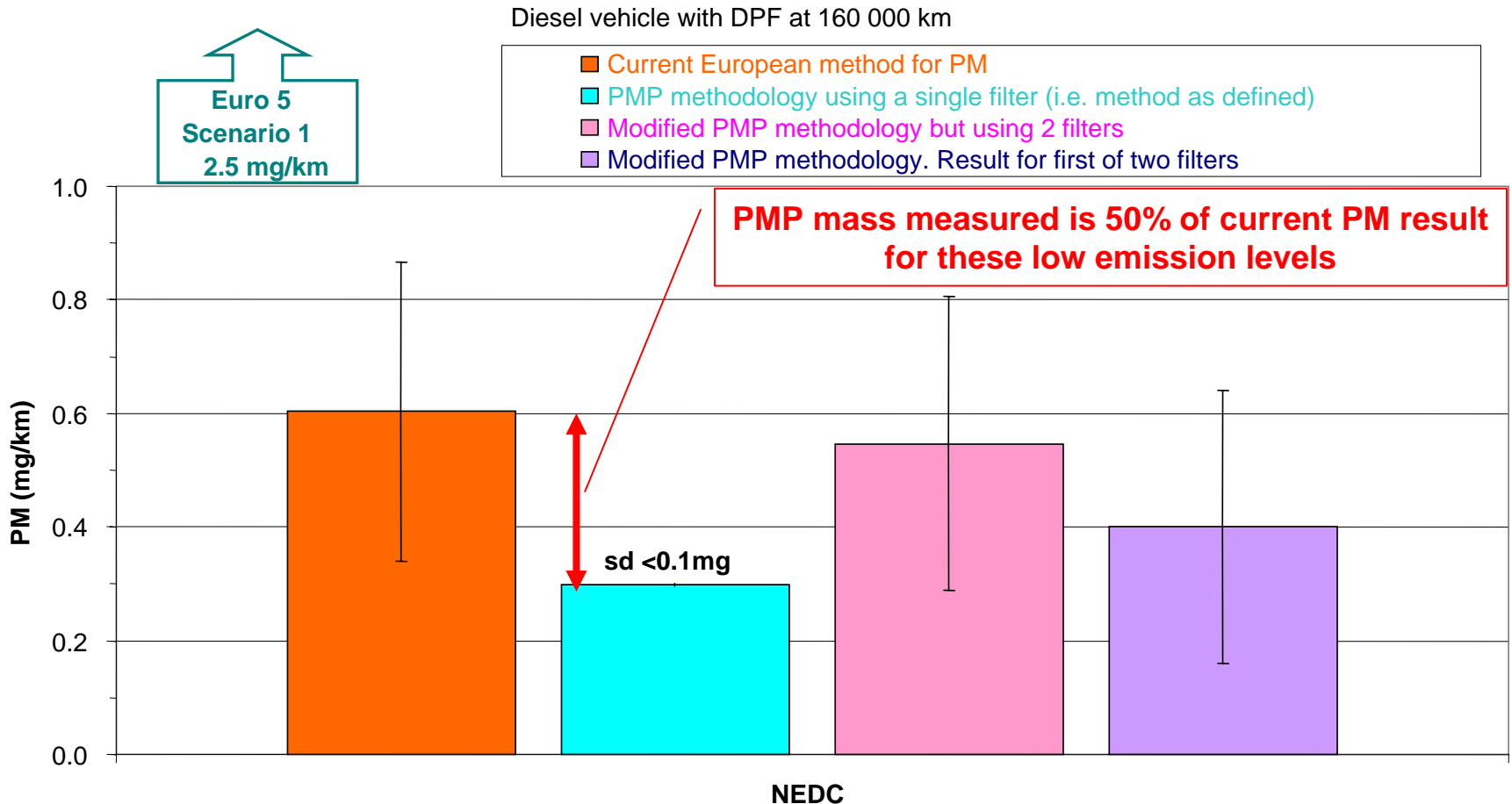


Particulate Mass PM

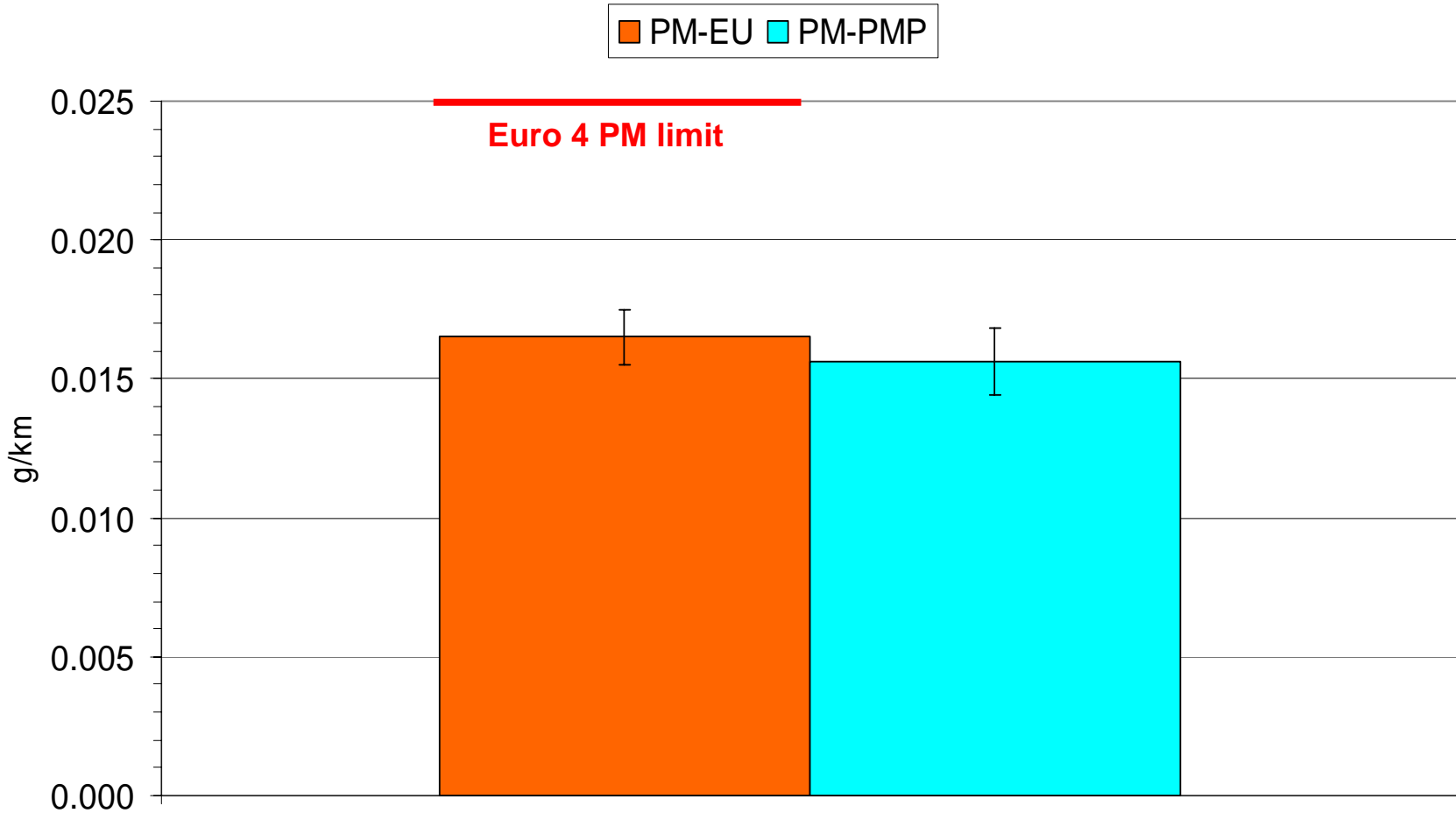
- PMP system:
 - Modified particle mass measurement to June 2004 (frozen) protocol except 2 filters used in 1st phase of testing.
 - Data for single (first) filter and 2 filters to examine effect of 2nd filter on repeatability and mass.
 - Simultaneous sampling with single filter PMP system and 2 filter PMP system in 2nd phase of testing to allow direct comparison.
- Conventional EU system:
 - 2 filters; used in 2nd phase of testing simultaneously with 1 and 2-filter PMP systems.
- The same flow rate was used for each measurement and each test.

PMP versus current EU gravimetric method

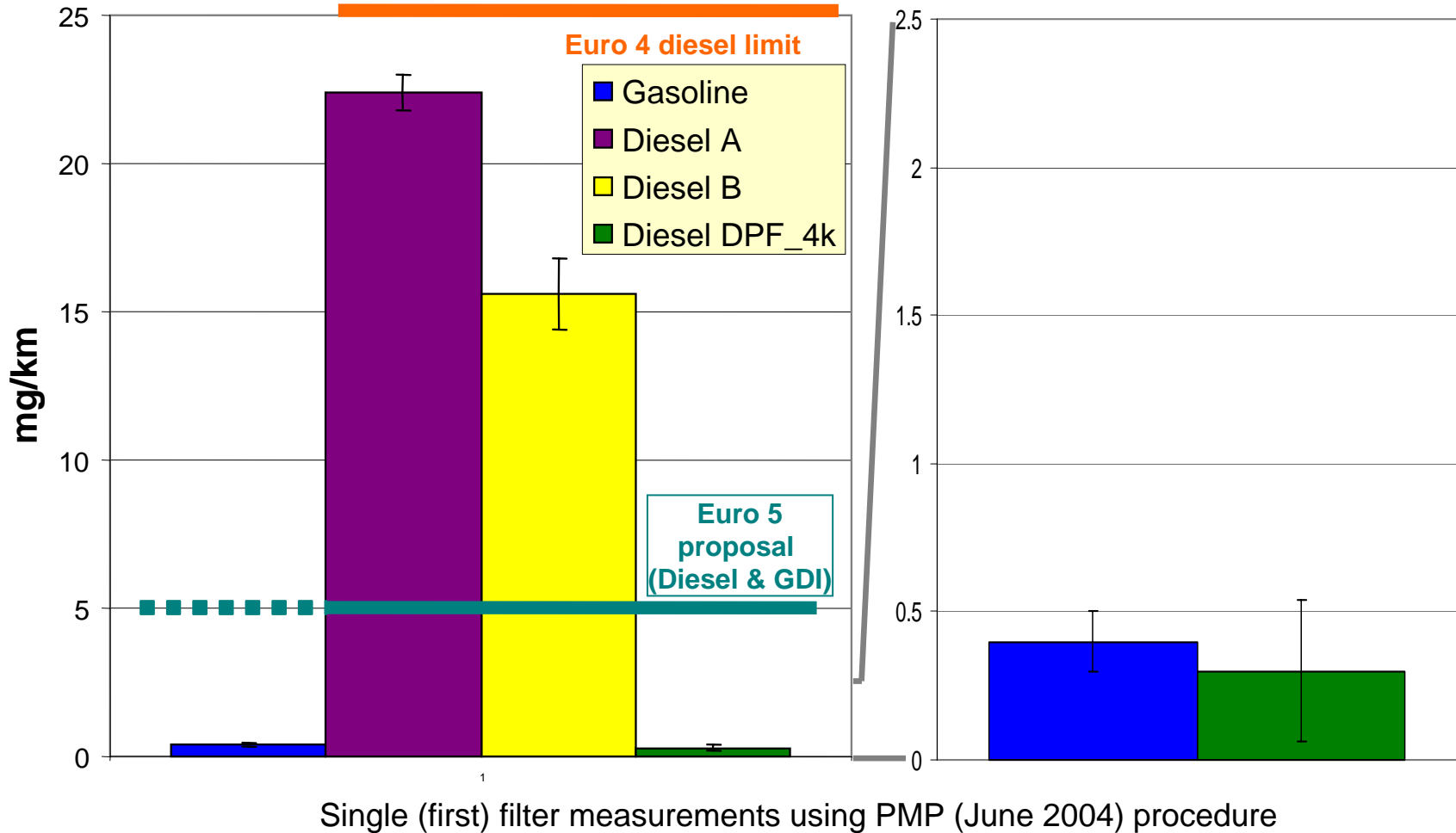
Tests were conducted using **a)** the current European method for PM (2 filters), **b)** the revised PMP methodology (as frozen June 2004) which uses a single filter, cyclone pre-classifier, heated samples etc., and **c)** a modified version of the PMP method retaining two filters. In this case measurements were obtained using both filters and using only the first filter, for comparison. All used the same flow rate.



PMP versus current EU gravimetric method - Diesel B (w/o DPF)



PM using PMP on NEDC at 4000km



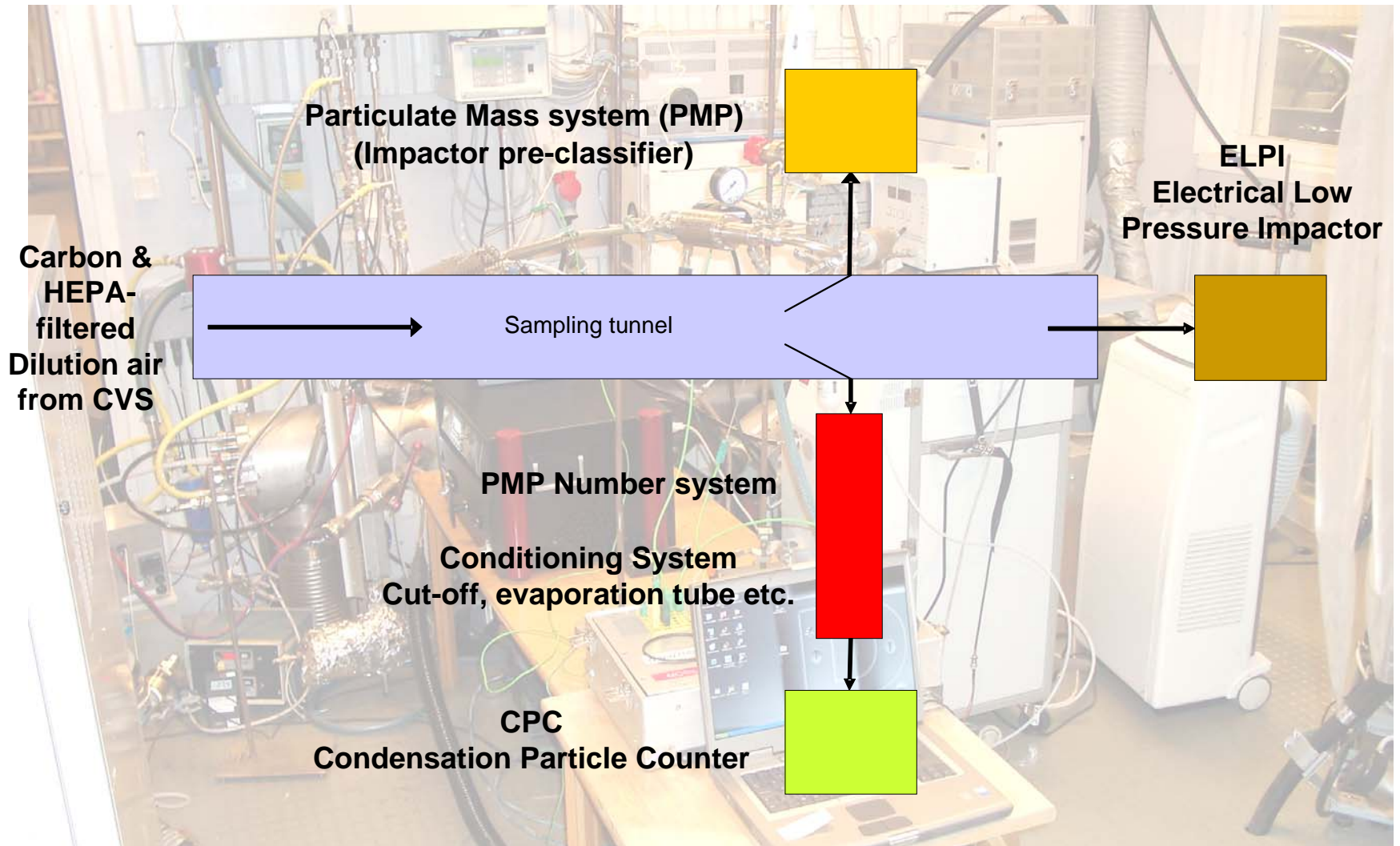
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 - Particle Number and Size
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Particle Number and Size

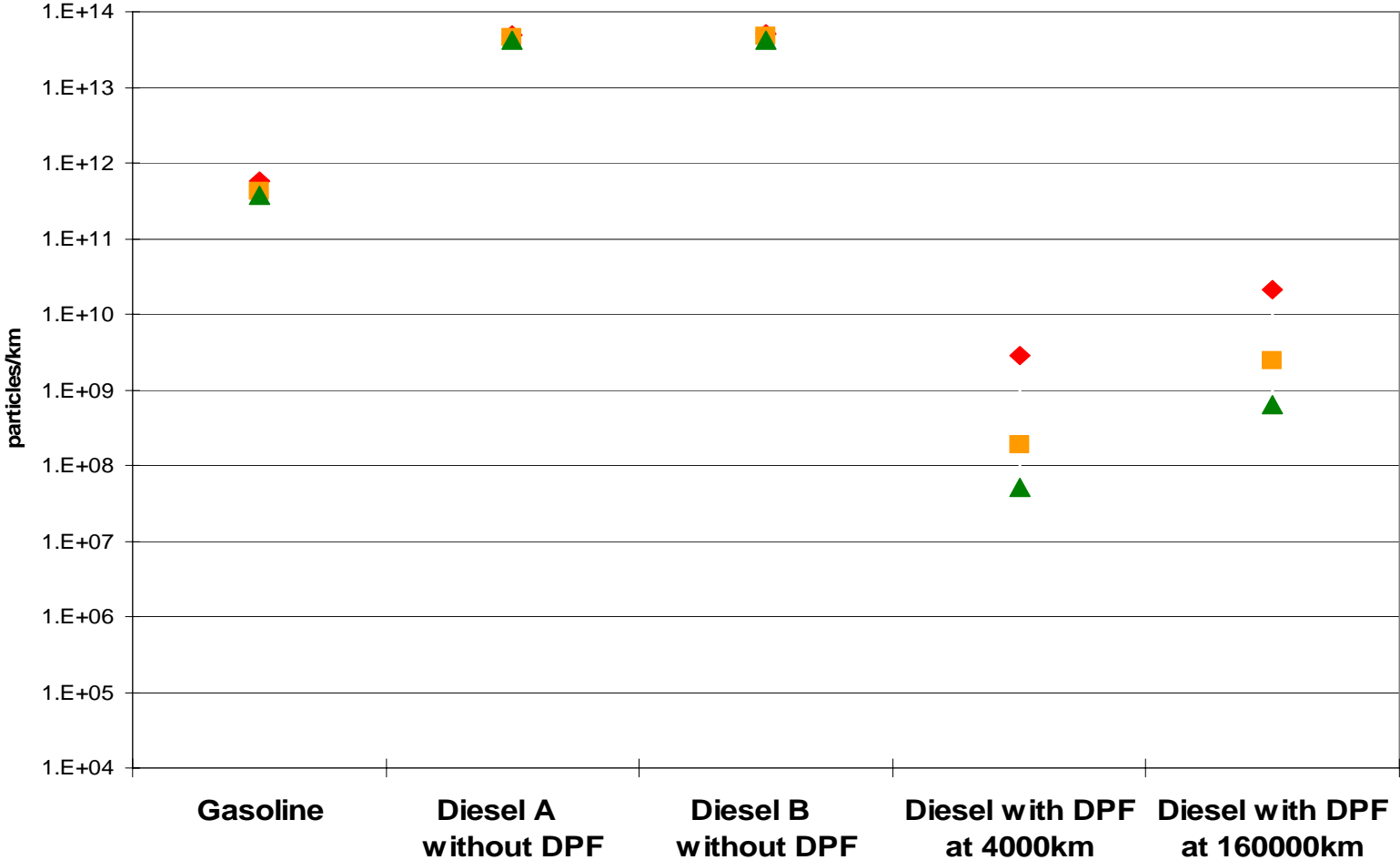
- PMP (Particulate Measurement Protocol) system
 - Particle Number measurement (total number per km) to the June 2004 (frozen) protocol using cyclone cut-off, evaporation tube, and Condensation Particle Counter (CPC) with 23nm cut-off.
Also provides continuous data (number per second).
- ELPI – Electrical Low Pressure Impactor (Dekati)
 - 1 Hz Particle Number and Size distribution (7nm to 6µm) direct from tunnel without evaporation tube, so includes volatile HCs.

General arrangement: PMP Particulate Mass & Particle Number measurement

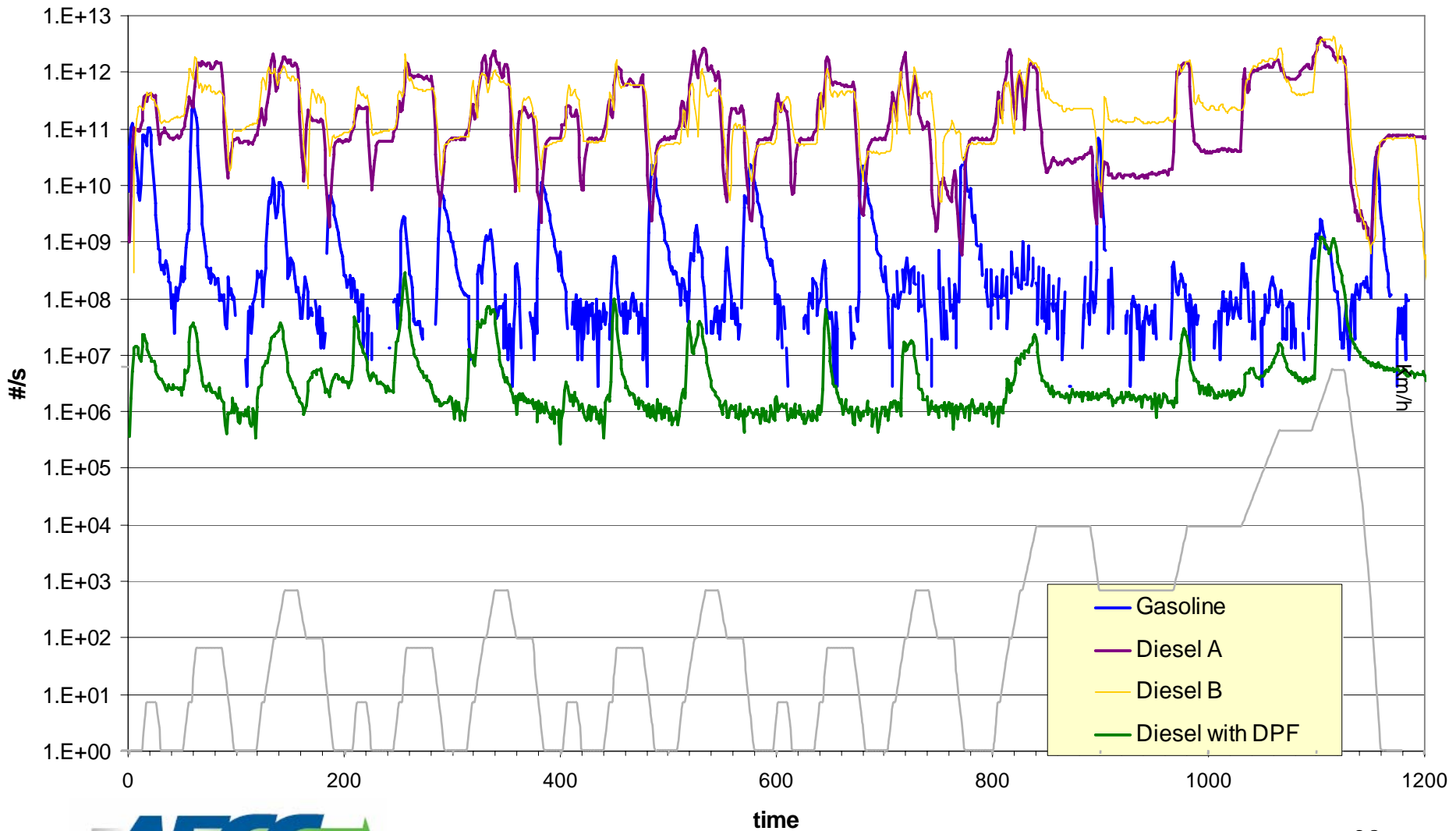


Particle Numbers using PMP (NEDC)

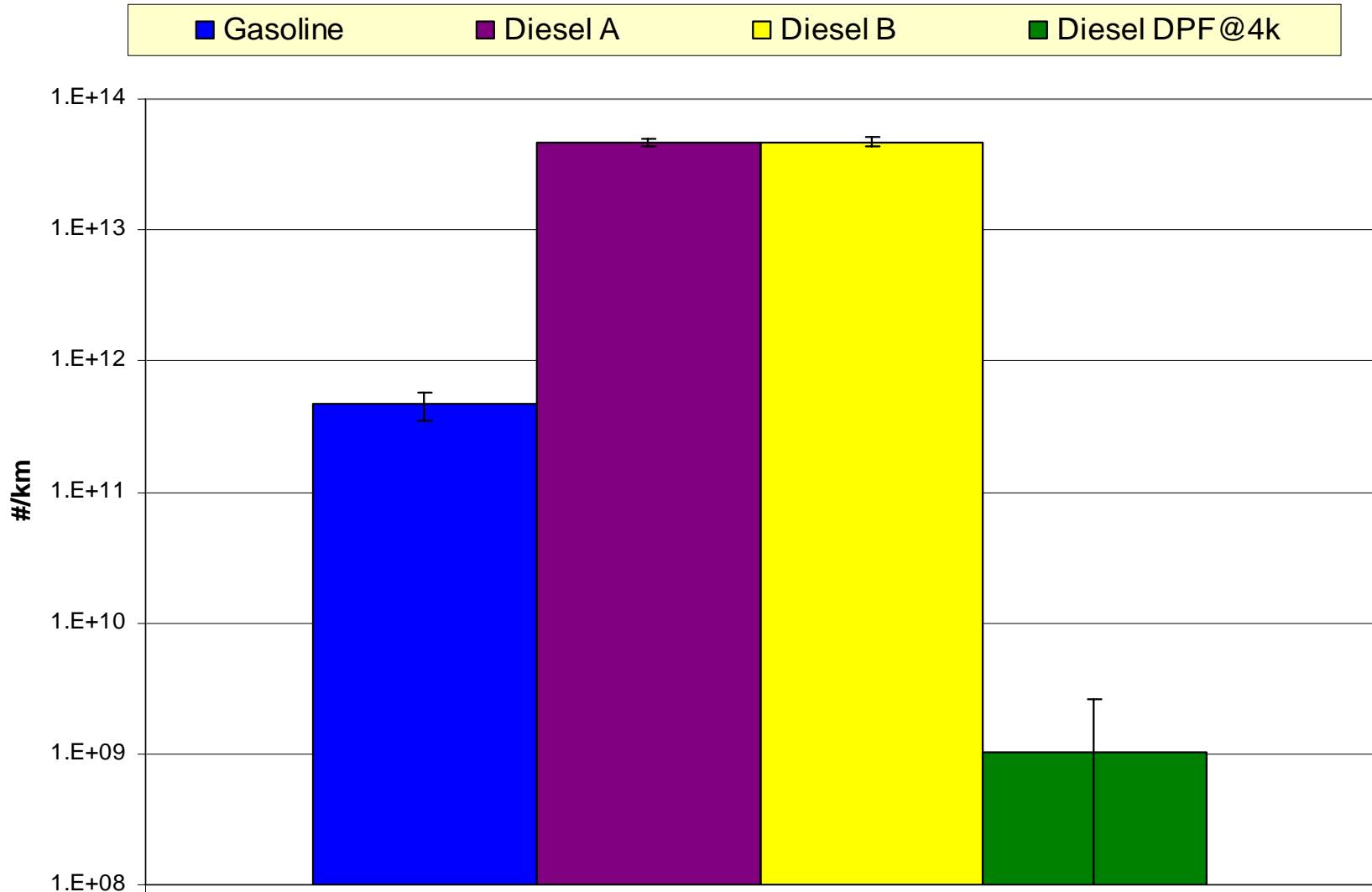
Showing individual test results for each vehicle



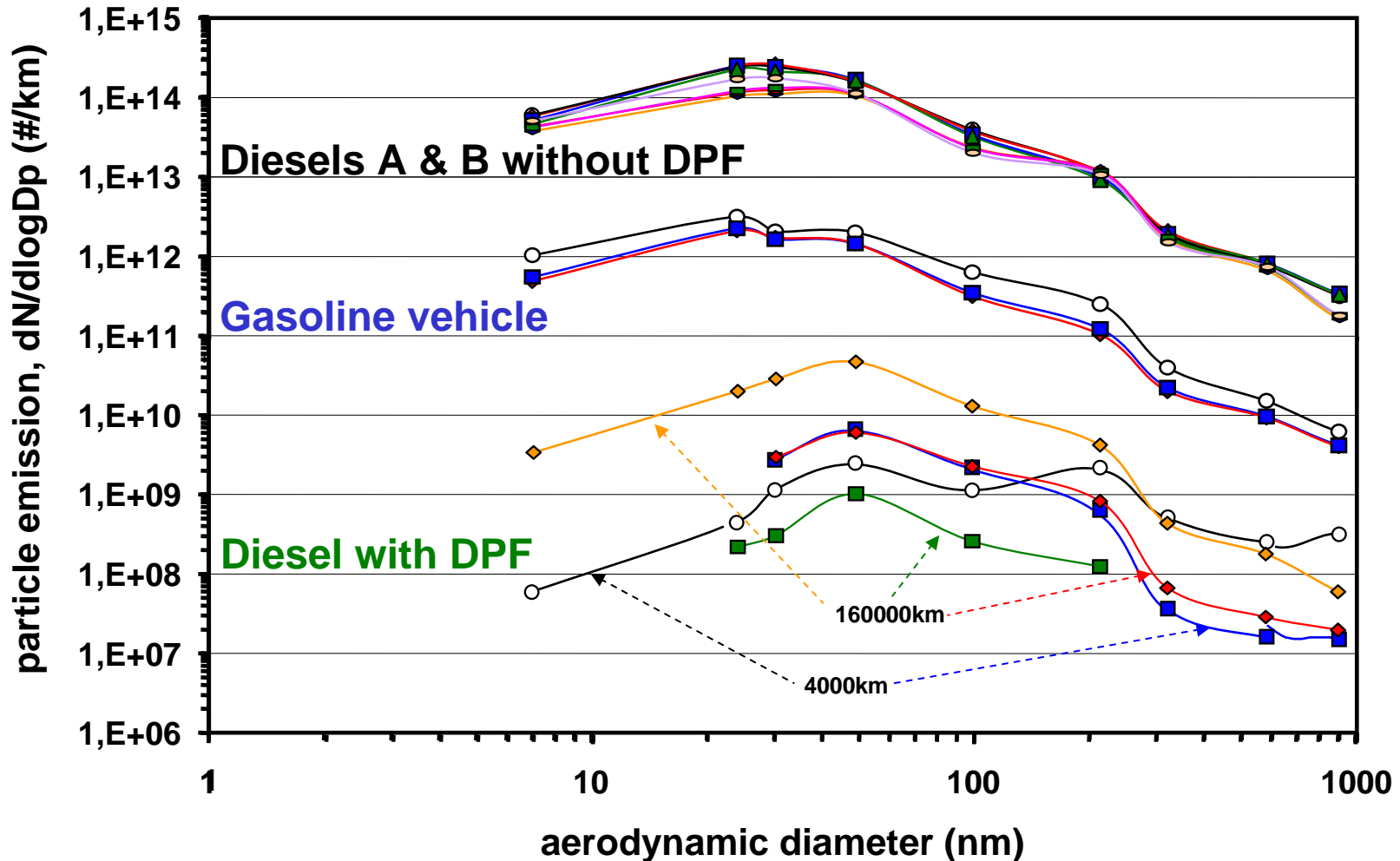
Continuous CPC Particle Numbers - comparison of 4 vehicles (NEDC)



Average Particle Numbers using CPC (NEDC)



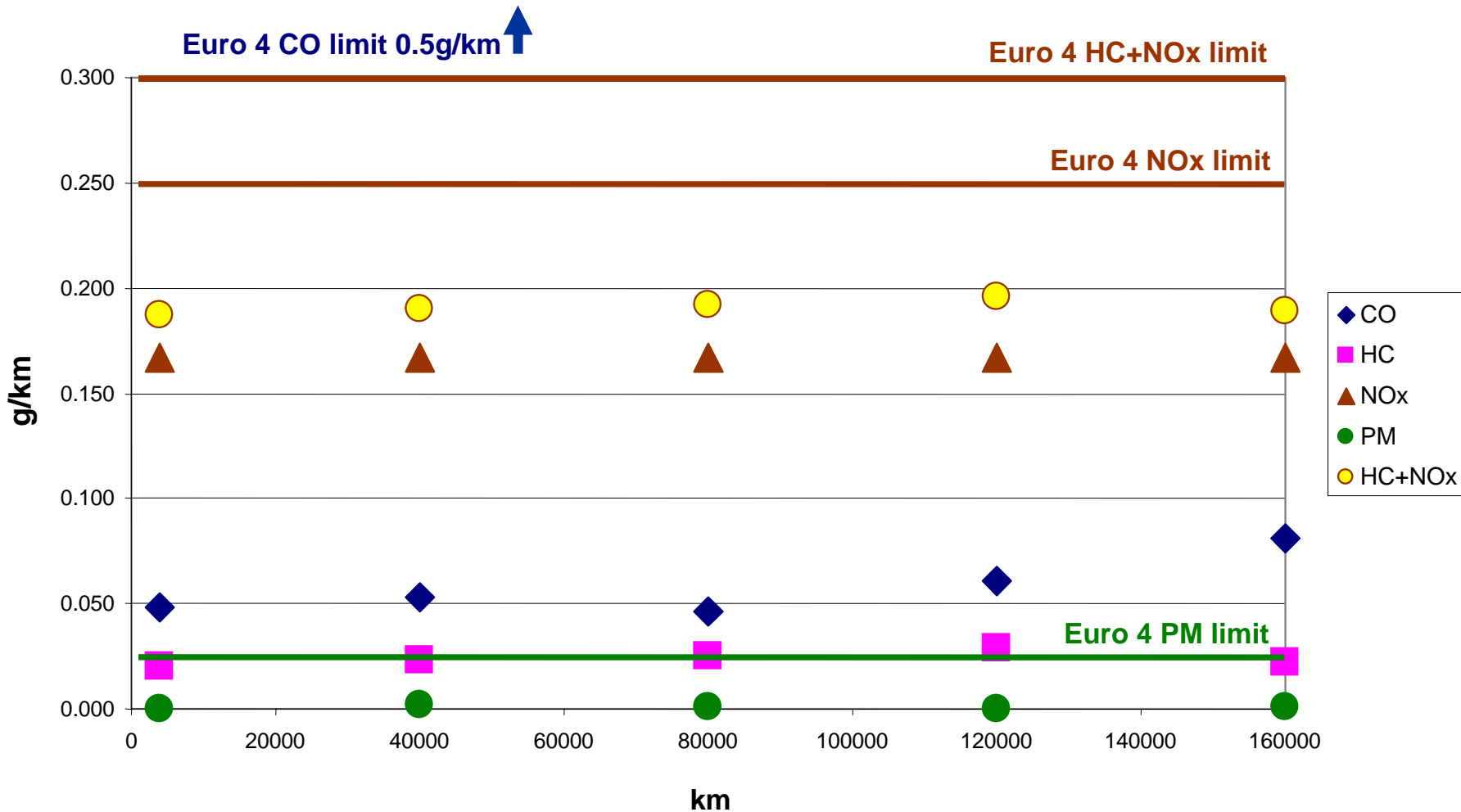
ELPI Particle Size distribution (NEDC)



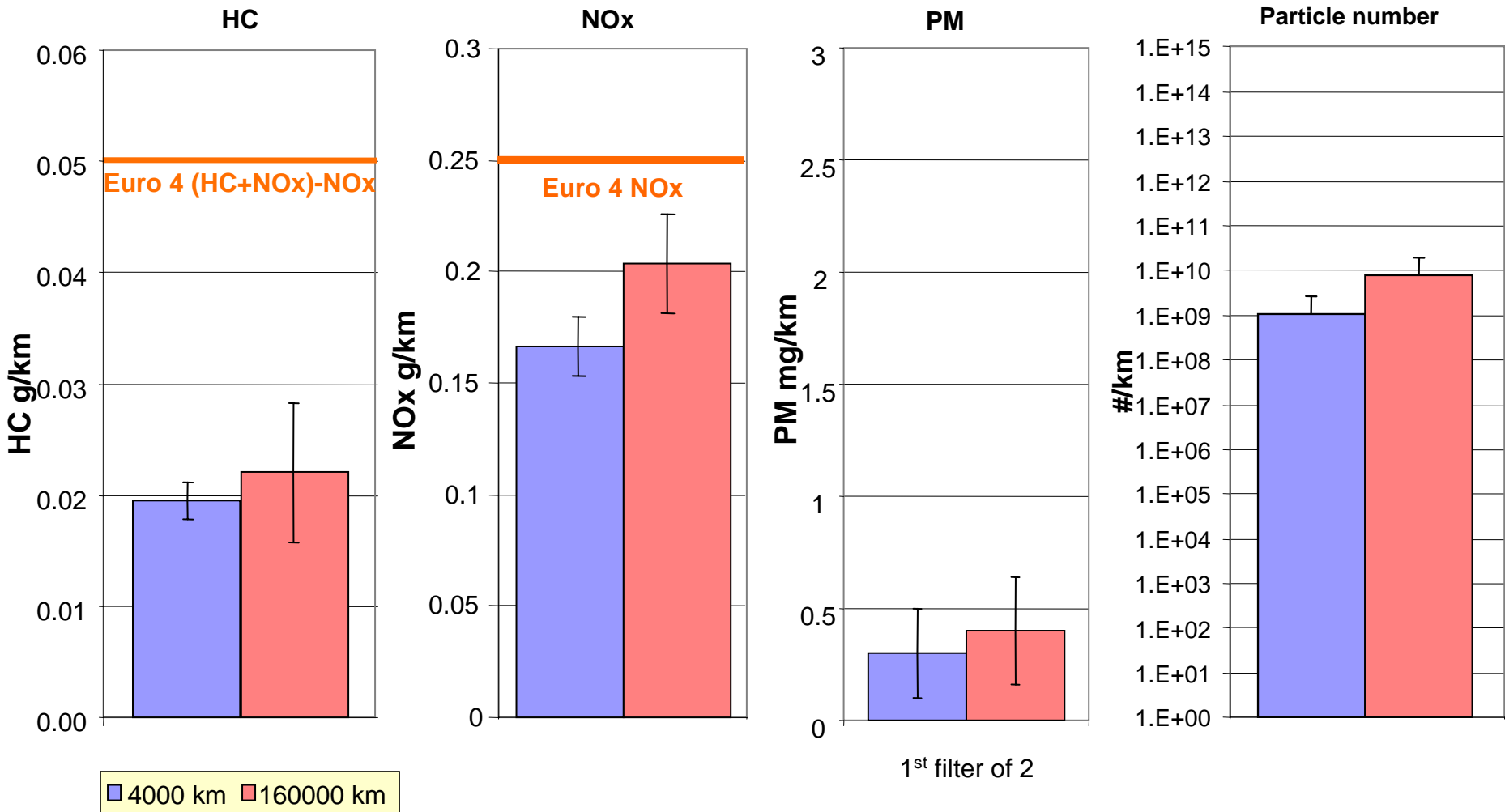
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Regulated emissions over 160000km - Diesel with DPF (NEDC)



Emissions at 4000 and 160000km - Diesel with DPF (NEDC)

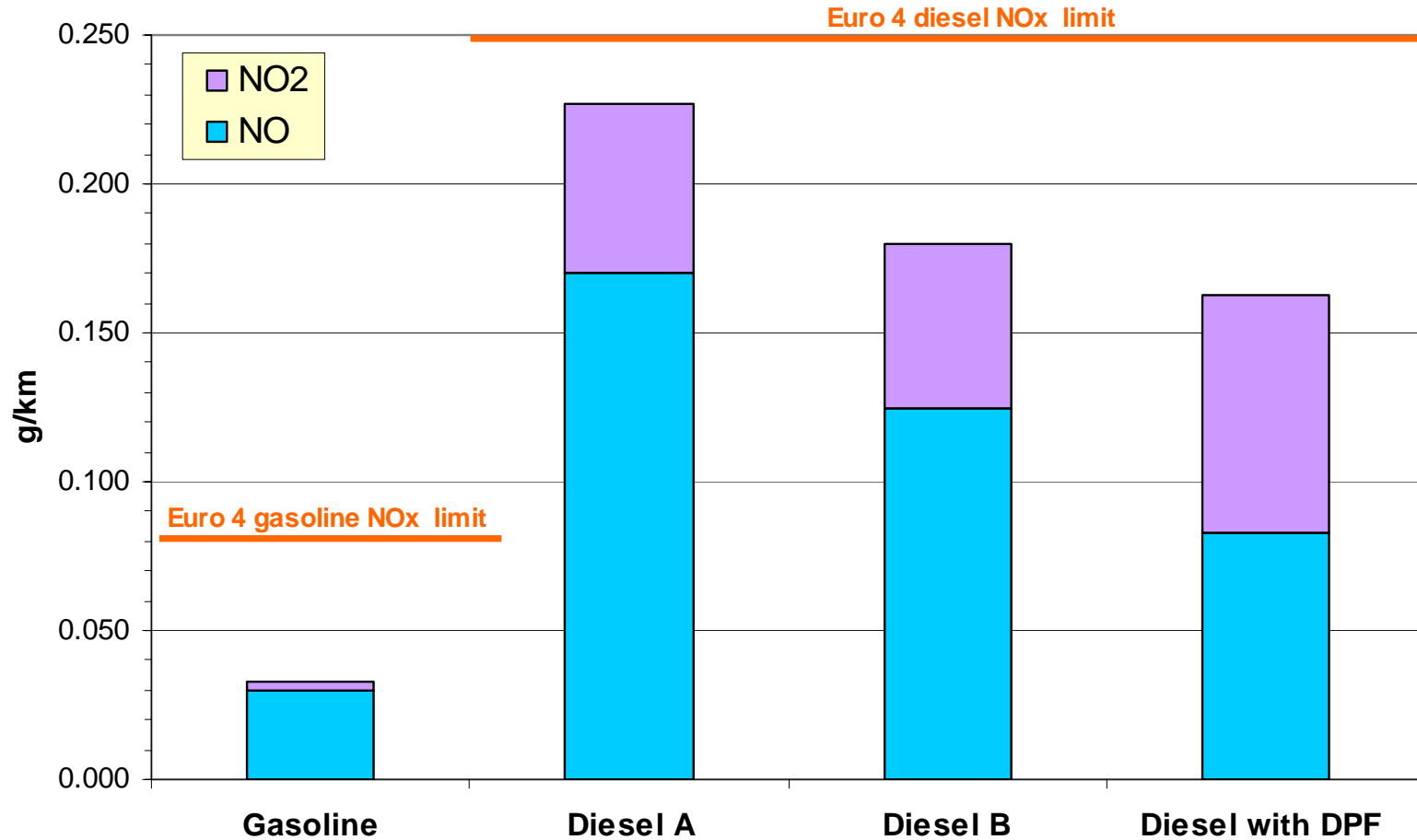


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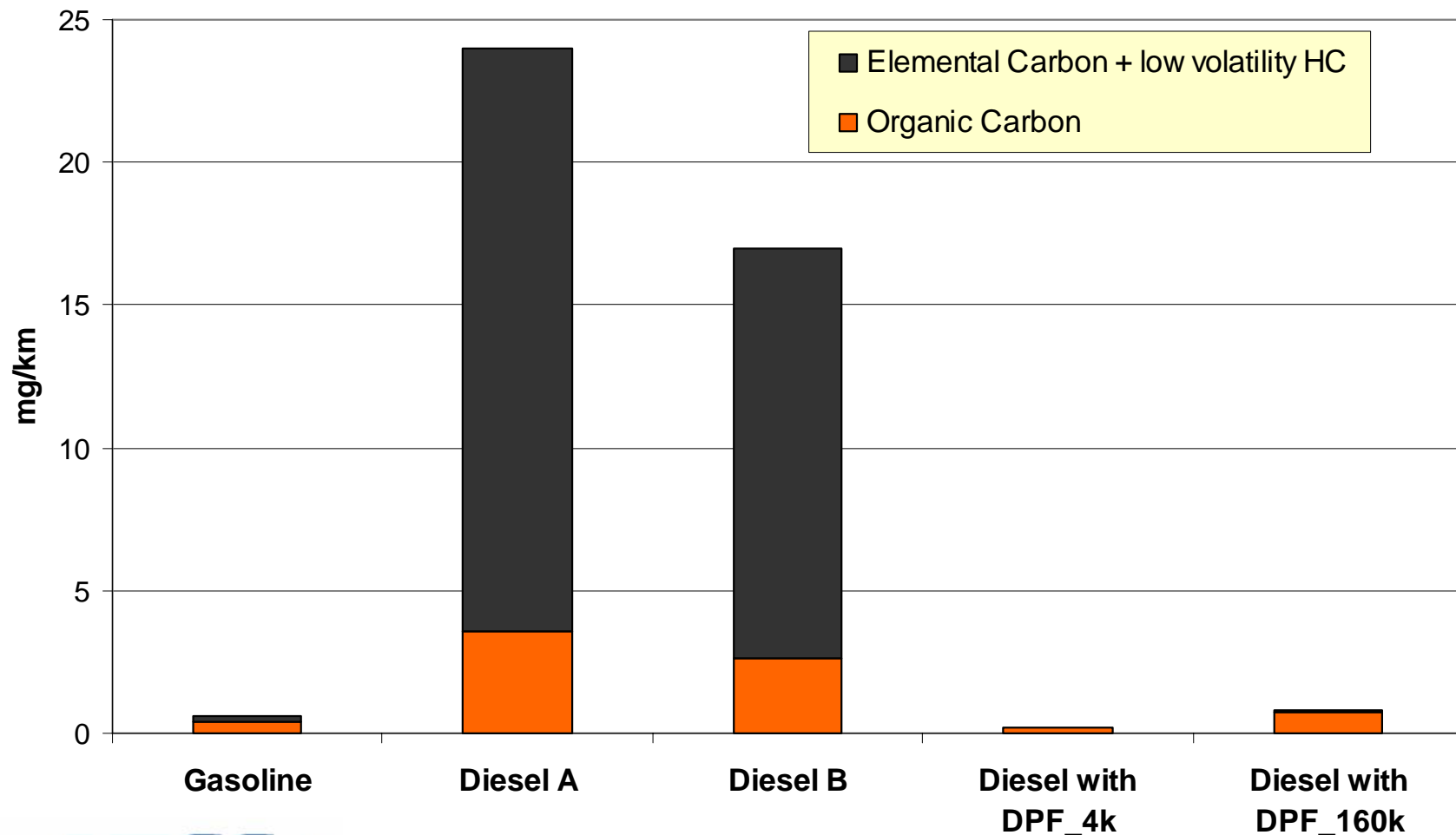
NO₂ Emissions (NEDC)

average NO and NO₂, NEDC tests at 4000km



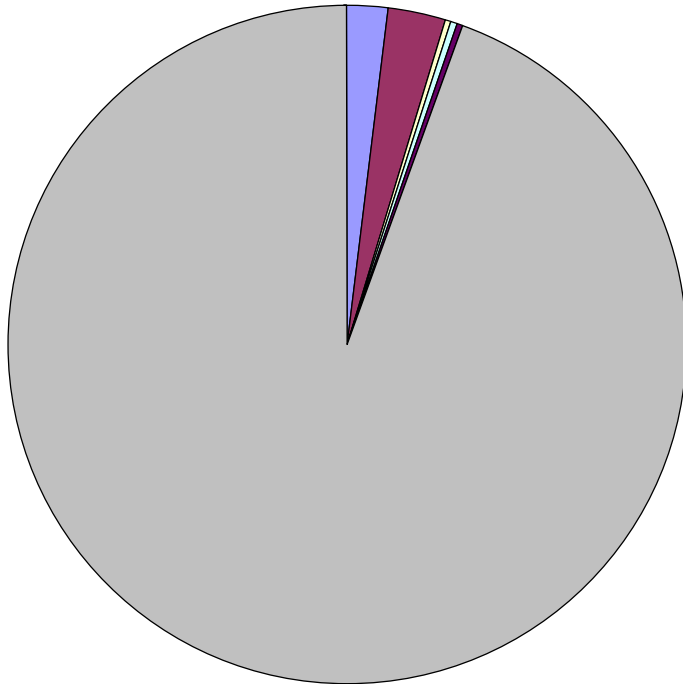
Elemental Carbon + low volatility material & Organic Carbon relative to total PM (NEDC)

Note: Indicative only - EC/OC ratio and total PM are taken from different filters; ignores non-carbon content

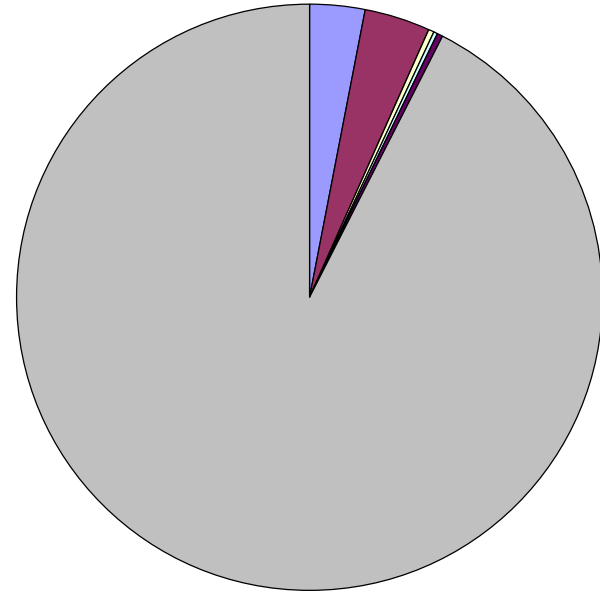


Particulate speciation (NEDC)

Diesel A without DPF: NEDC
Total: 24mg/km



Diesel B without DPF: NEDC
Total: 17mg/km



Diesel with DPF at
4000km: NEDC

Total: 0.2mg/km



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Conclusions from the AECC test programme

- Particulate filters reduce Particulate Mass and Particle Numbers of Diesel emissions by a considerable margin.
- Light-duty Diesel vehicles with DPF are durable and effective to at least 160000km.
- The PMP protocol permits measurement of Particulate Mass PM at low levels typical for DPF-equipped vehicles and robust Particle Number measurements.
- PMP mass measurement provides better consistency than the existing gravimetric measurement method but also reduces the mass measured by up to 50% for the low PM levels obtained on DPF-equipped vehicles.
- Gasoline Three Way Catalysts are highly effective.

Thank you for your attention

www.aecc.be

