

# AECC Light-duty Test Programme – PMP measurements

by AECC ([www.aecc.be](http://www.aecc.be))

GRPE/PMP meeting  
Geneva, 31 May 2005



# Association for Emissions Control by Catalyst (AECC)

AECC members: European Emission Control companies



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



# Outline of the presentation

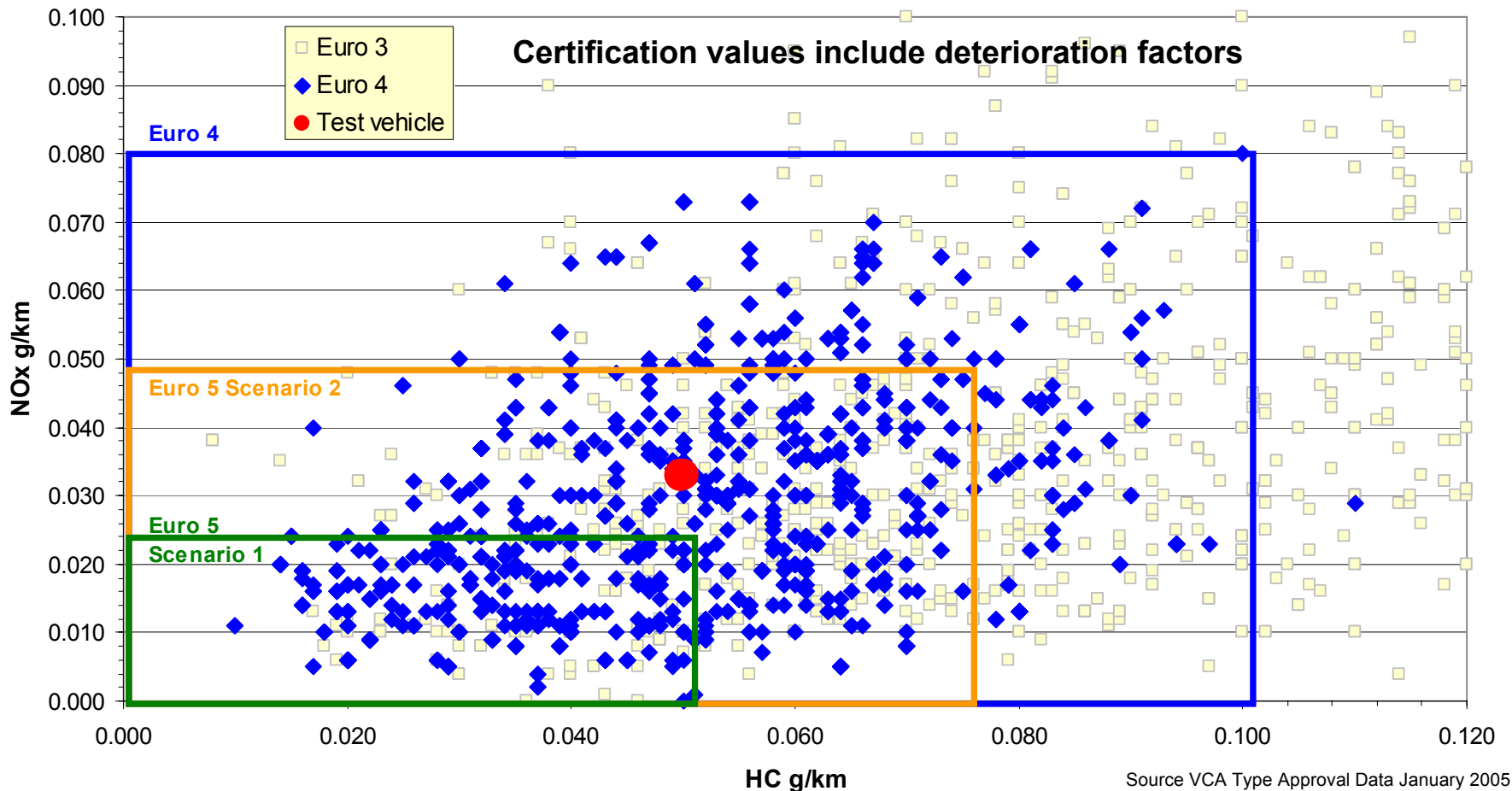
1. AECC light-duty test programme
  - a. AECC test programme outline
  - b. Particulate mass measurements
  - c. Particle number and size measurements
  - d. Particulate composition
2. Conclusions

# AECC Objectives & Test Programme

- Provide data for the PMP programme
  - improved particulate mass method.
  - new particle number measurement method.
- 4 current Euro 4 production vehicles.
  - 1 gasoline ( $\lambda 1$ , MPI)
  - 2 different diesels without DPF
  - 1 diesel with DPF
- 4 different vehicle manufacturers.
- Typical mid-sized vehicles.
- Diesel with DPF also tested at 160000km.
- Tests conducted at AVL-MTC, Sweden.

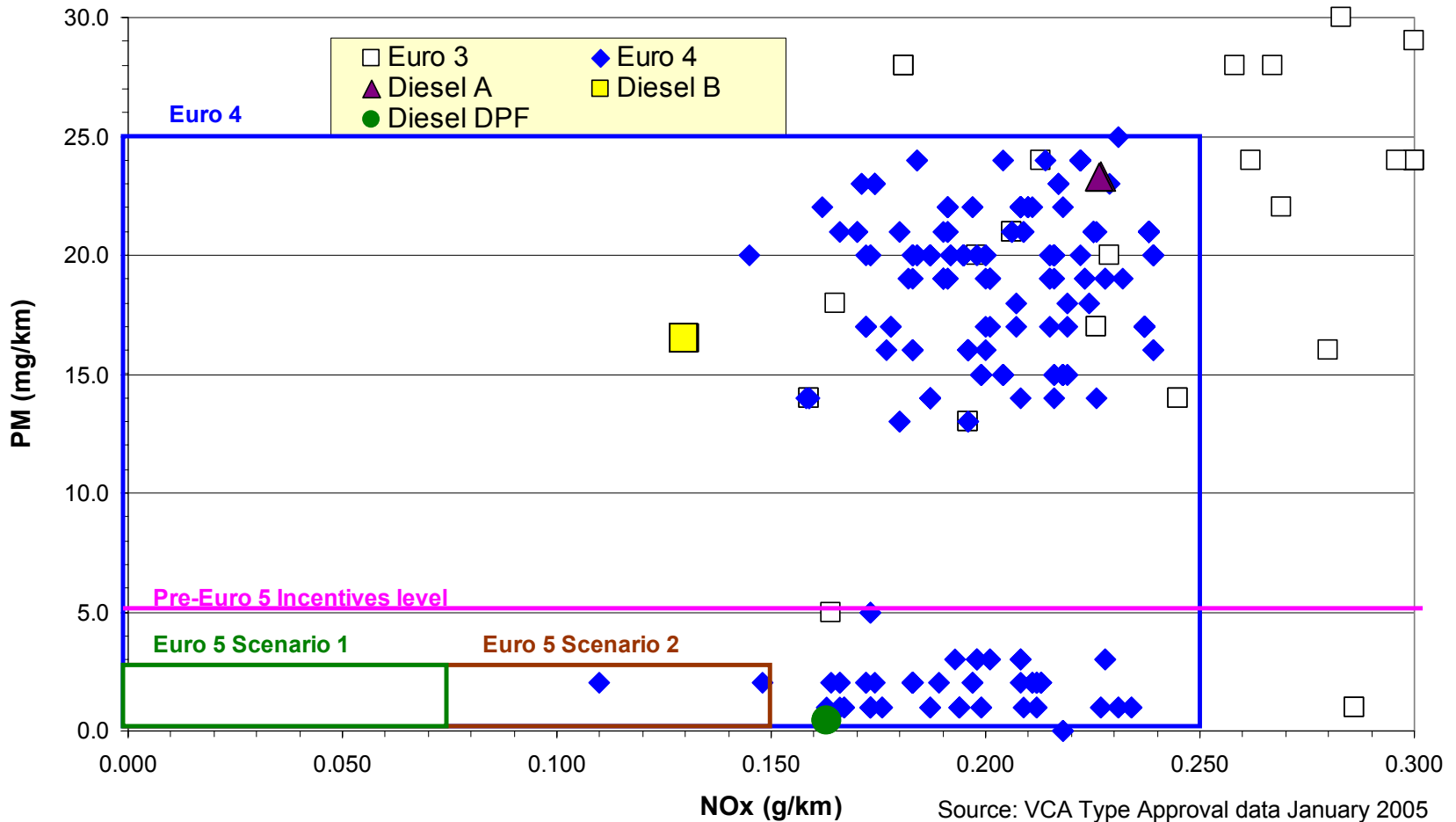


# Gasoline passenger cars Type Approval values



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

# Diesel passenger cars Type Approval values



# AECC Test Programme Outline

- Vehicles aged to 4000km.
- All vehicles tested on NEDC + CADC (Artemis) suite.
- 3 repeat tests for each cycle.
- Standard CEC Reference Fuels used for all tests.
- Standard Swedish Road fuels for de-greening / durability.
- Regulated g/km gaseous emissions.
- PM and particle number to 'frozen' PMP protocol.
- Particle size distribution measurements (ELPI).

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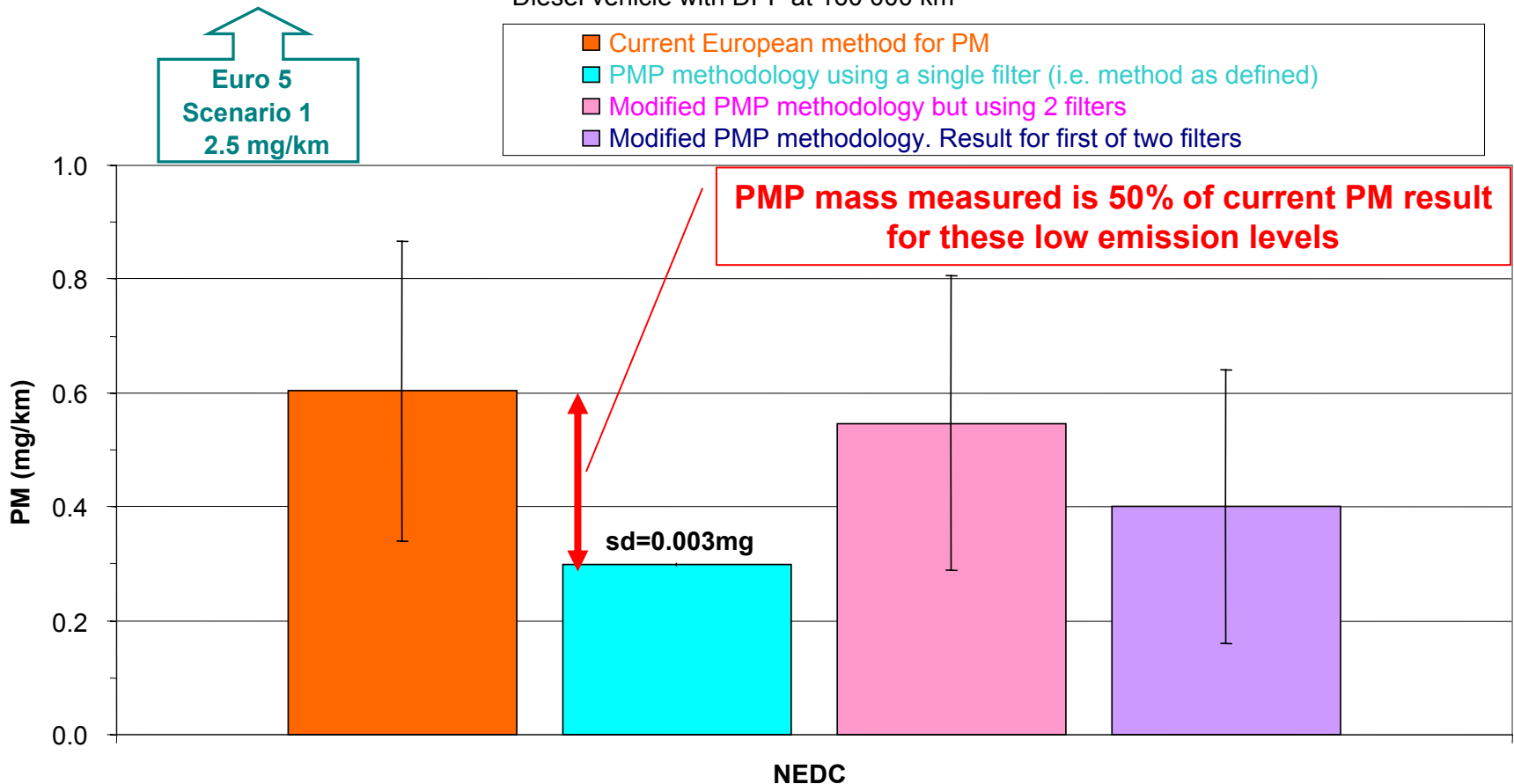
# Particulate mass measurements

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

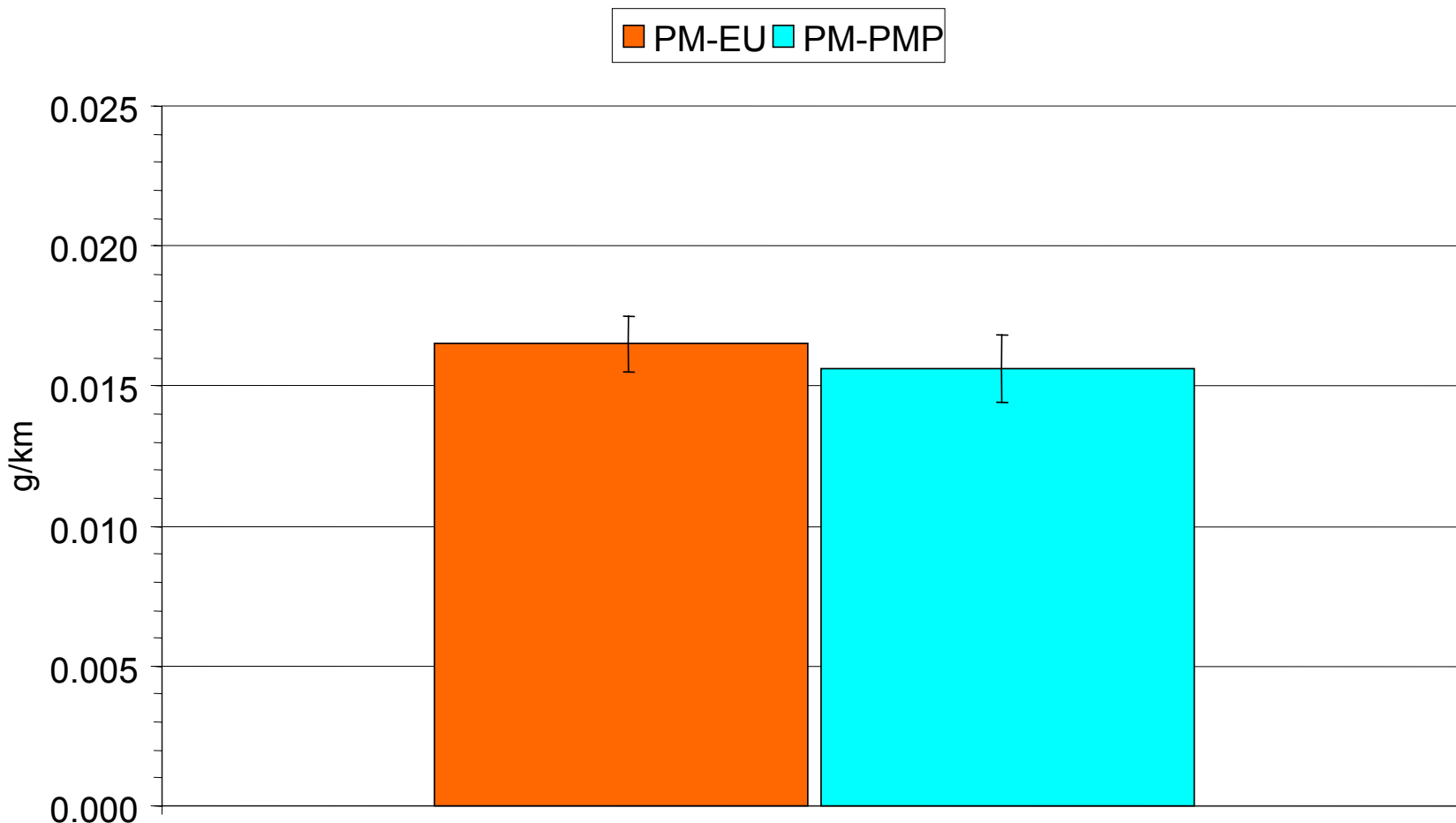
# PMP versus current EU gravimetric method

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 flowrate.

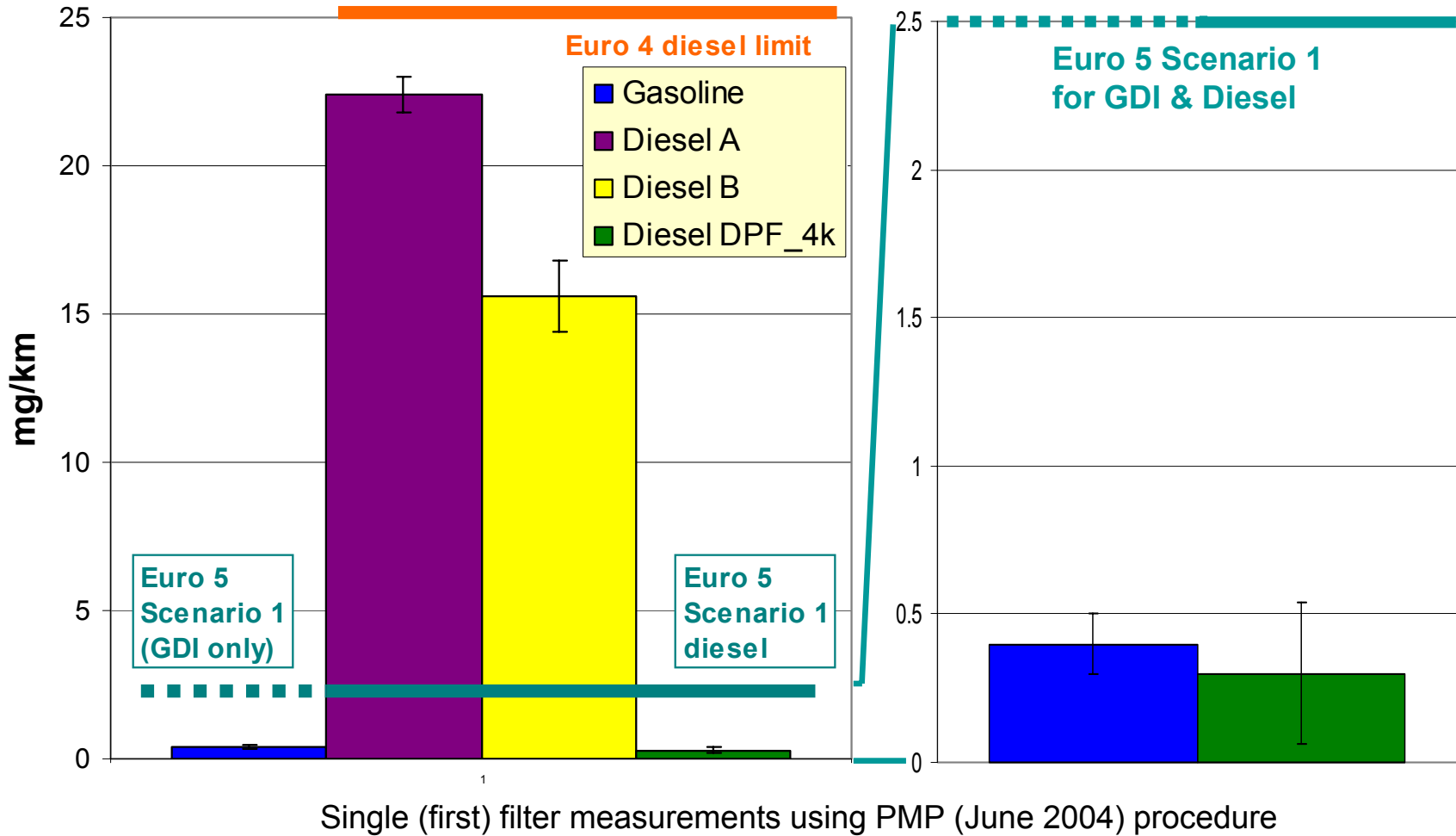
Diesel vehicle with DPF at 160 000 km



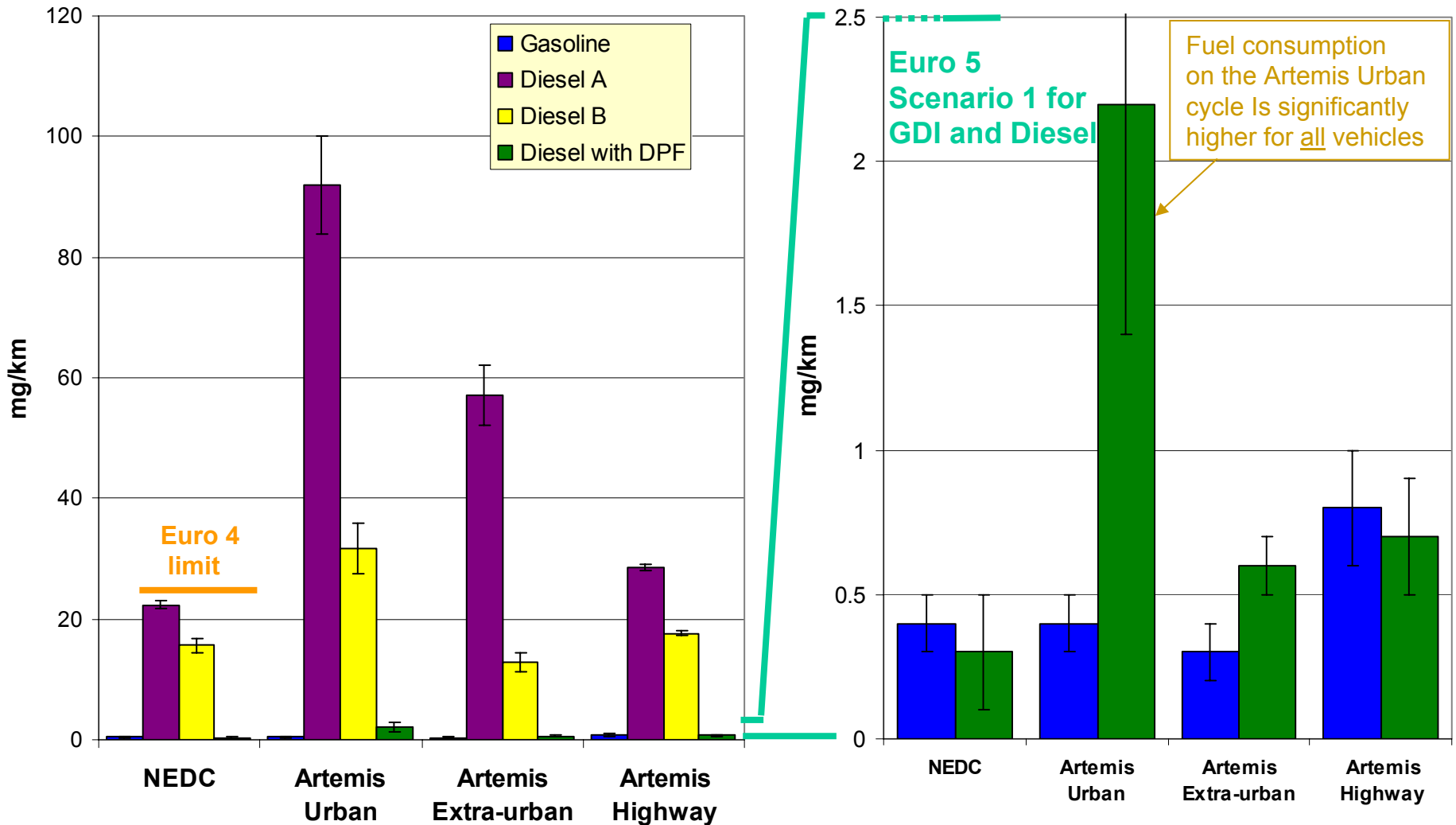
# PMP versus current EU gravimetric method – Diesel B (no DPF)



# PM using PMP on NEDC at 4000km



# PM using PMP on all cycles



Single (first) filter measurements using PMP (June 2004) procedure

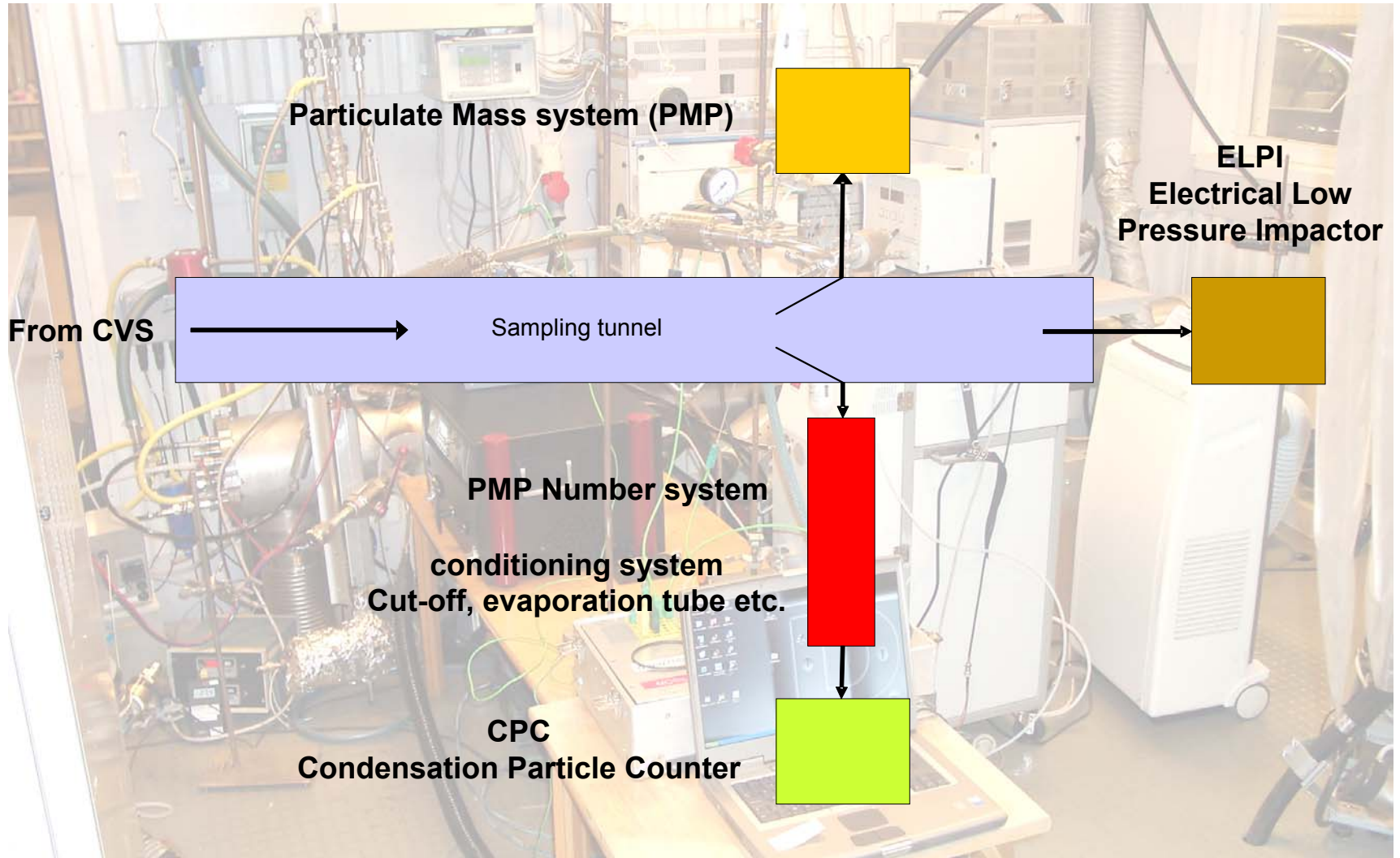
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# Particle number and size measurements

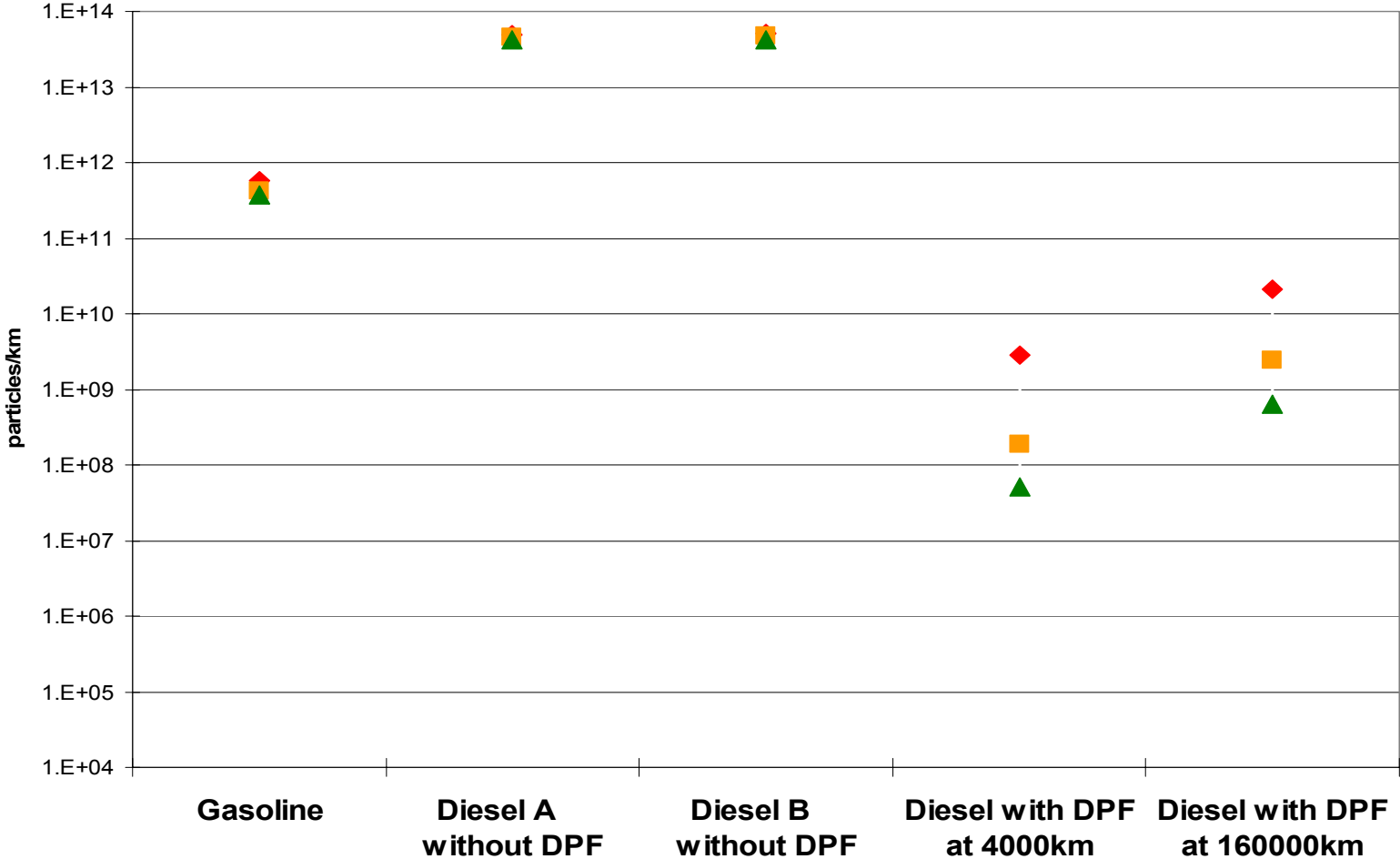
- PMP (Particulate Measurement Protocol) system
  - Particle number measurement (total number per km) to the June 2004 (frozen) protocol using cyclone cut-off, evaporation tube, and Condensation Particle Counter (CPC) with 23nm cut-off.  
Also provides continuous data (number per second).
- ELPI – Electrical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

# General arrangement: PMP Particulate mass & Particle number measurement

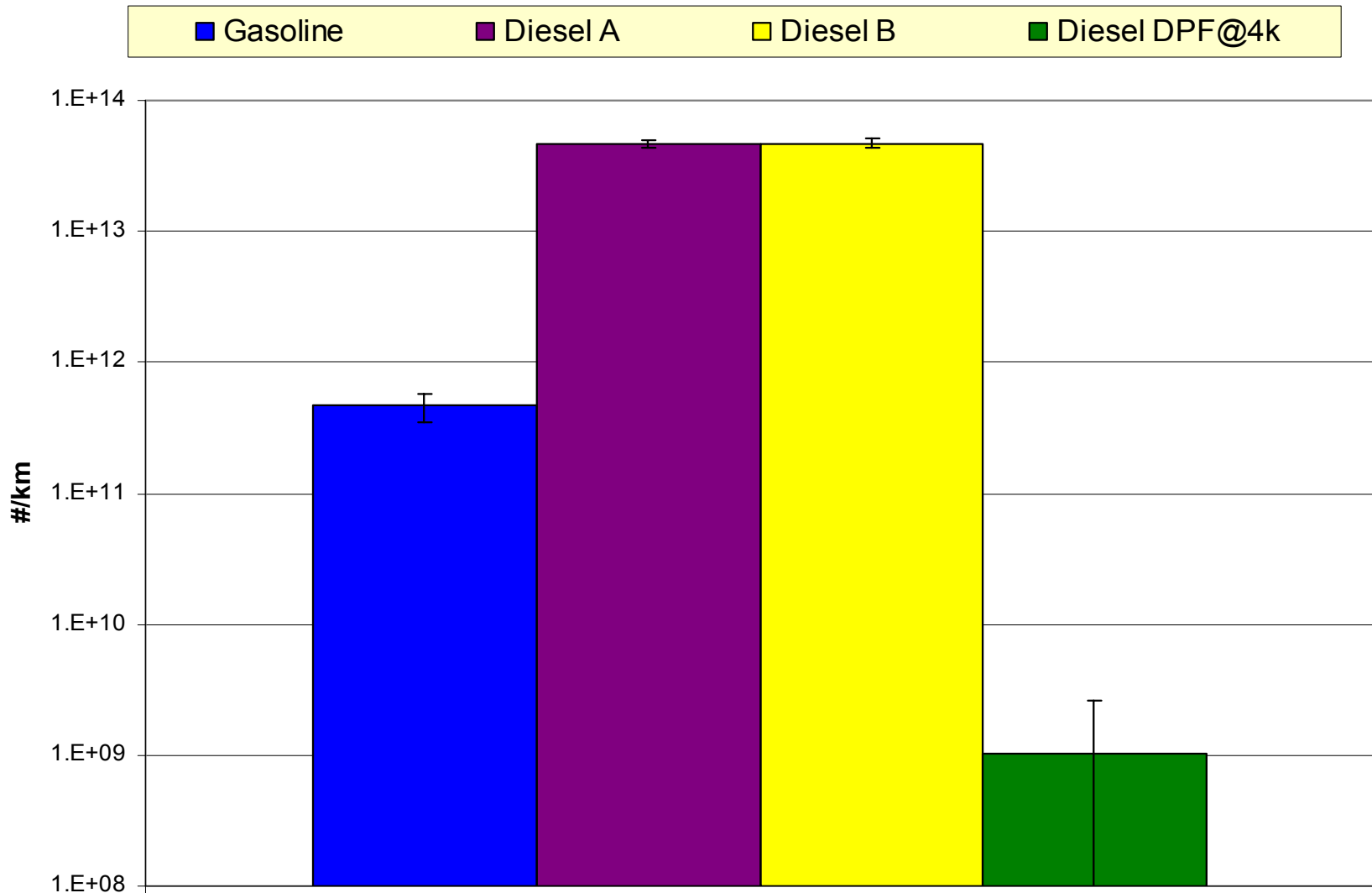


# Particle Numbers using PMP (NEDC)

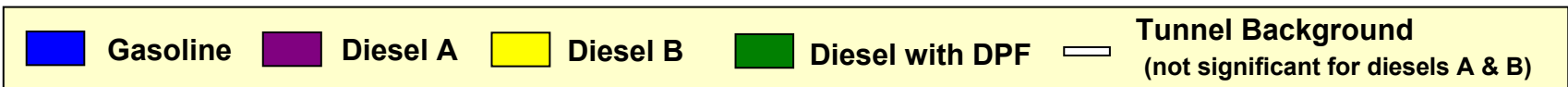
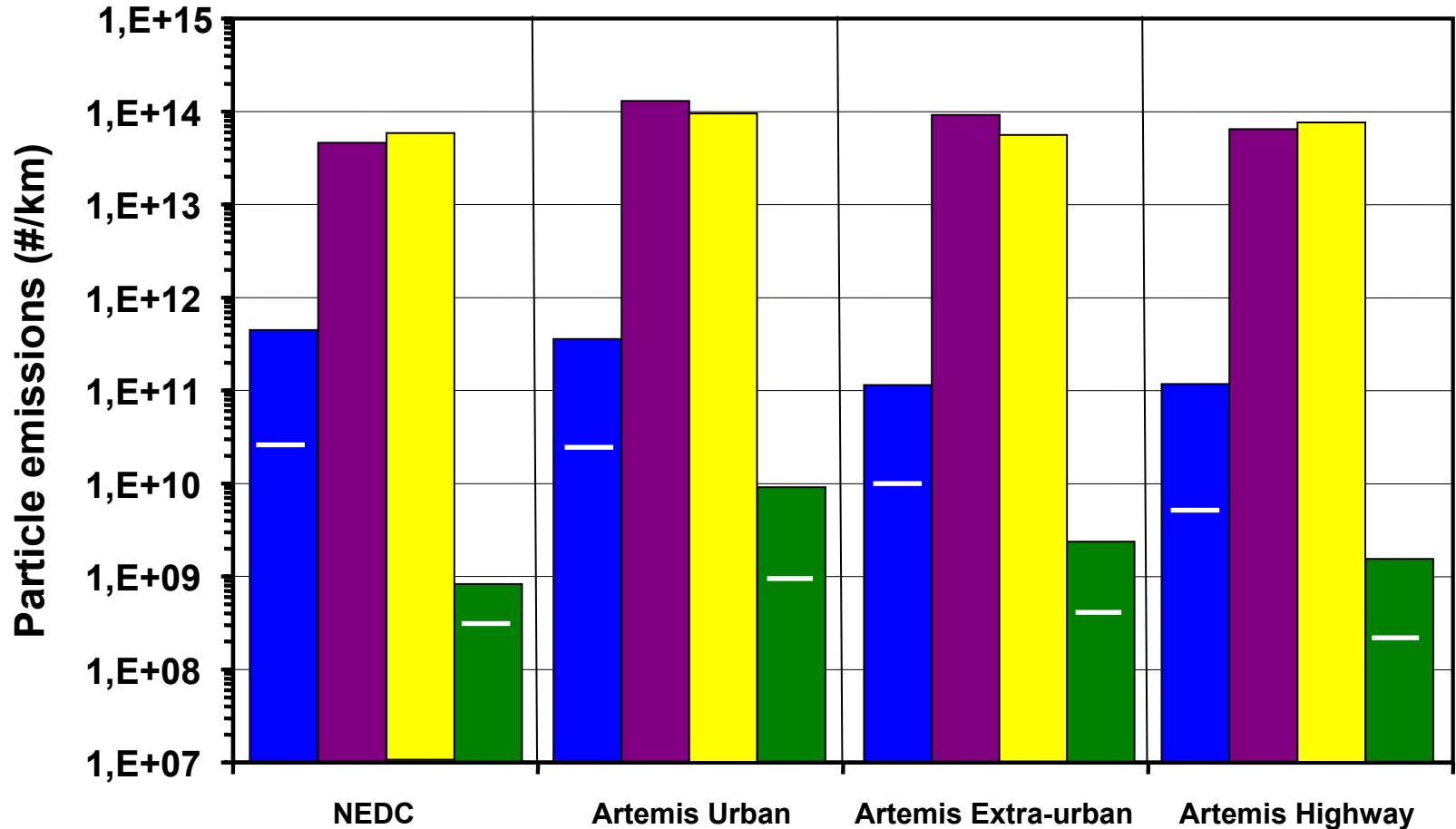
Showing individual test results for each vehicle



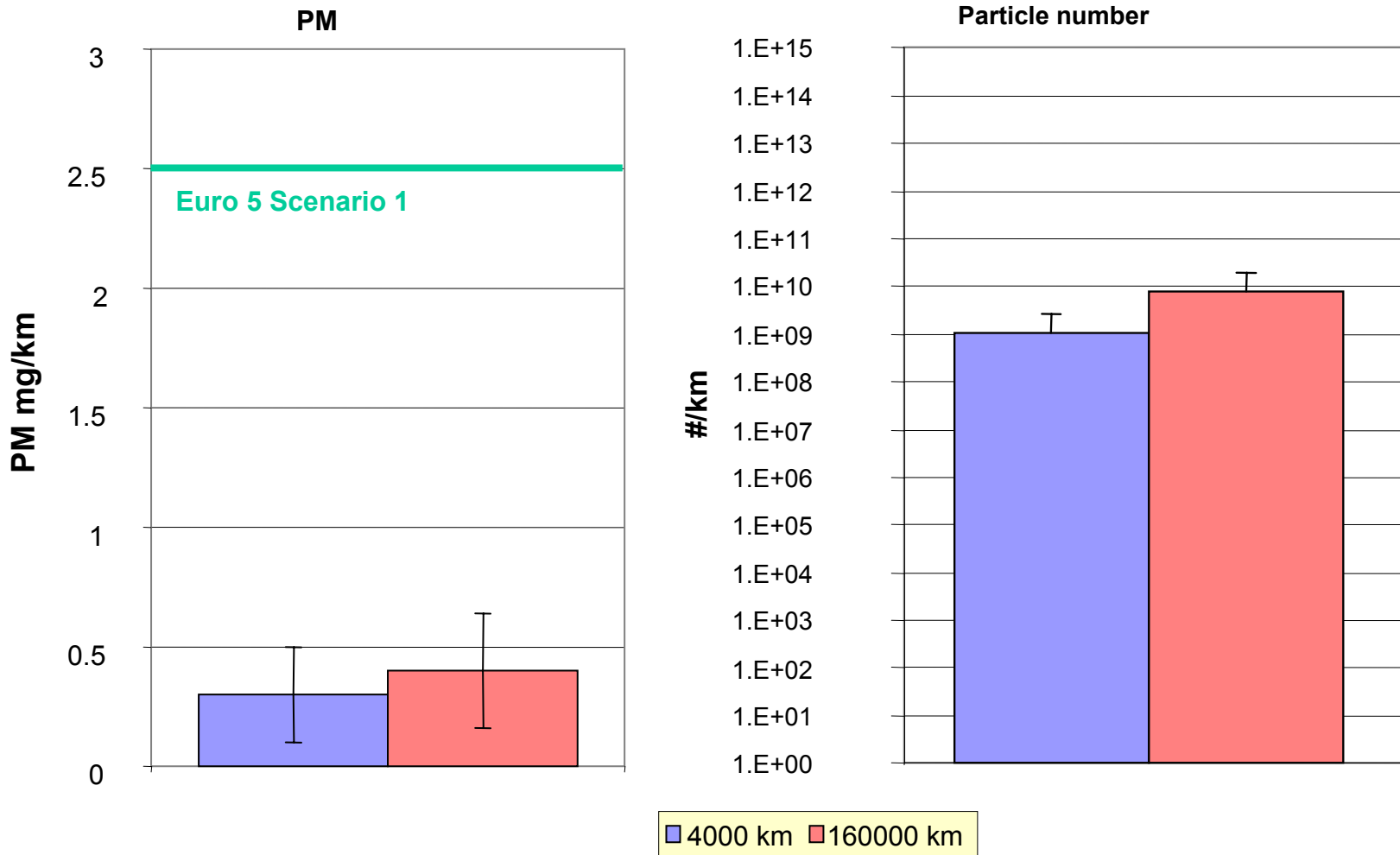
# Average particle numbers using CPC (NEDC)



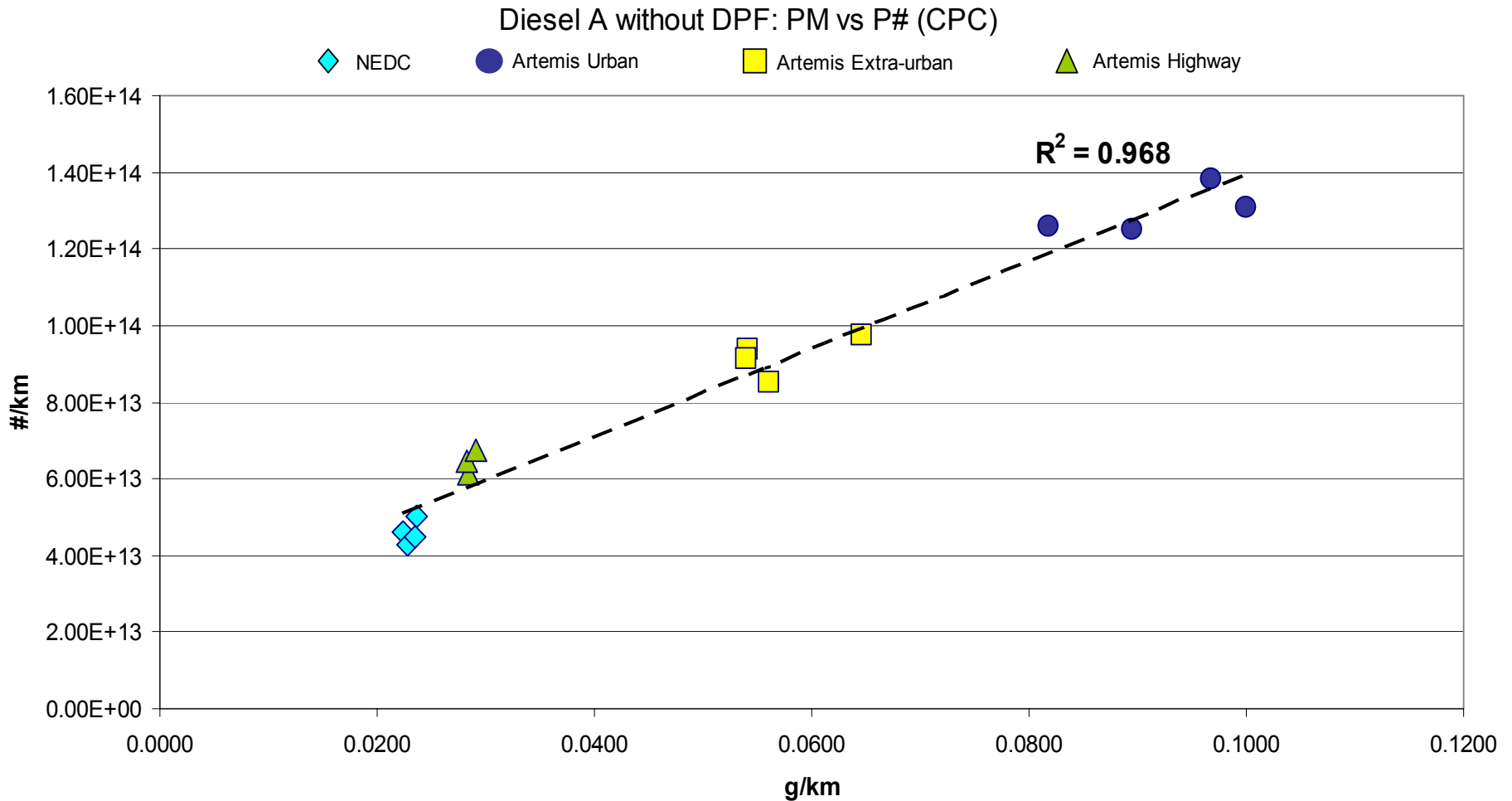
# Average particle numbers using CPC



# 160000km durability - vehicle with DPF

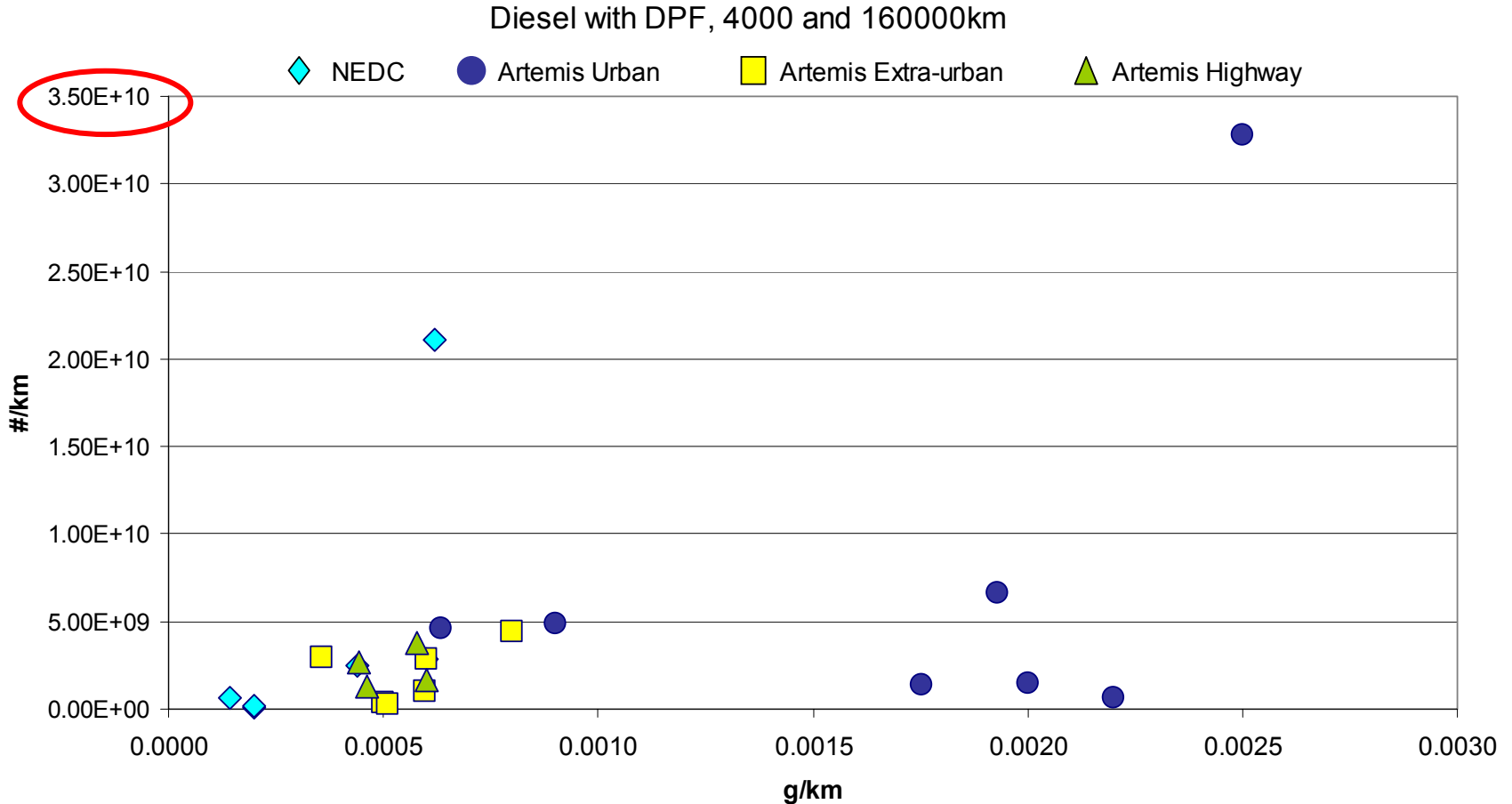


# PM / particle number correlation: diesel A without DPF



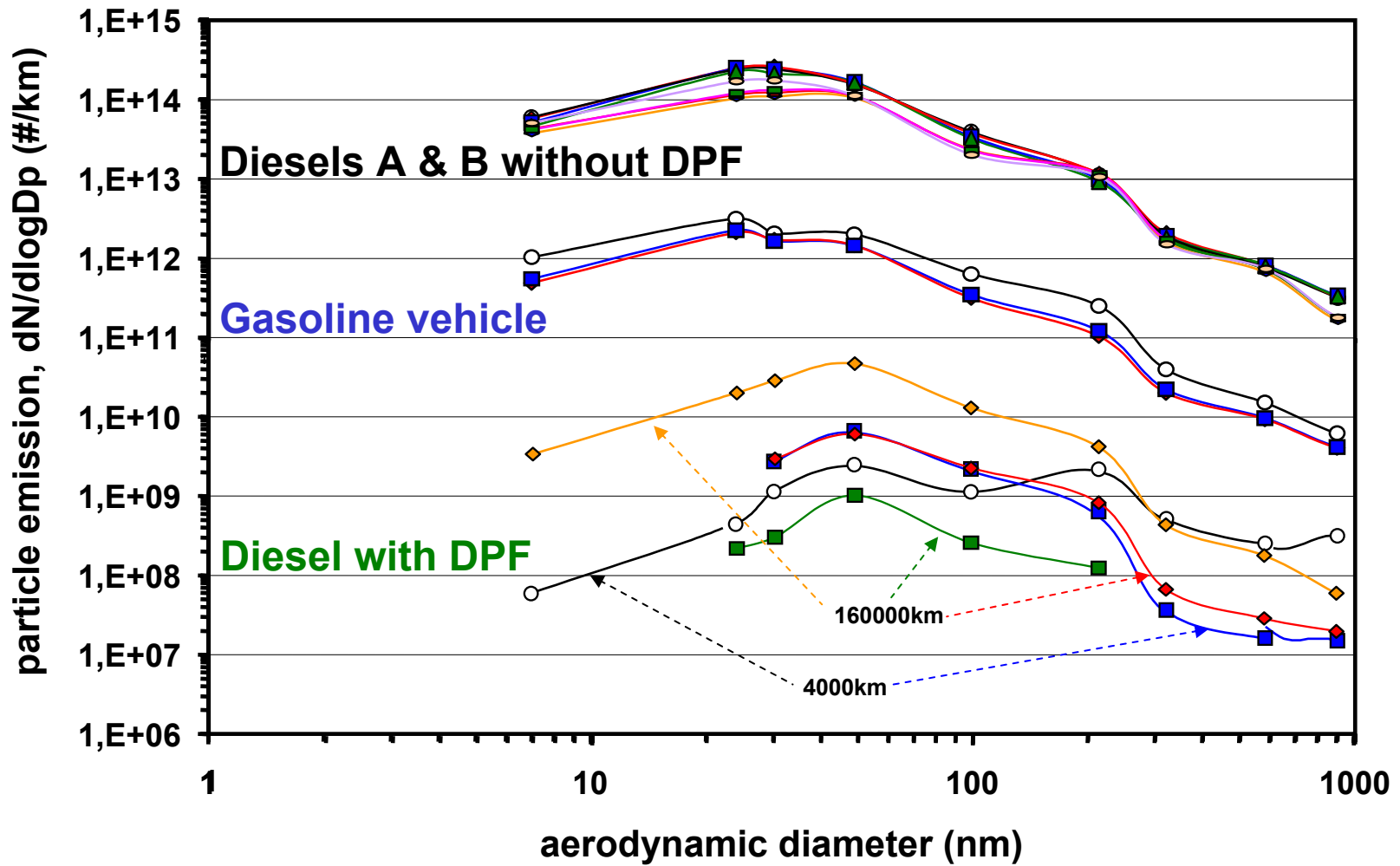
**Diesel without DPF shows the expected increased mass with increased particle number relationship**

# PM / particle number correlation: diesel with DPF



**No correlation for diesel with DPF indicates the insensitivity of the mass approach**

# ELPI Particle size distribution (NEDC)

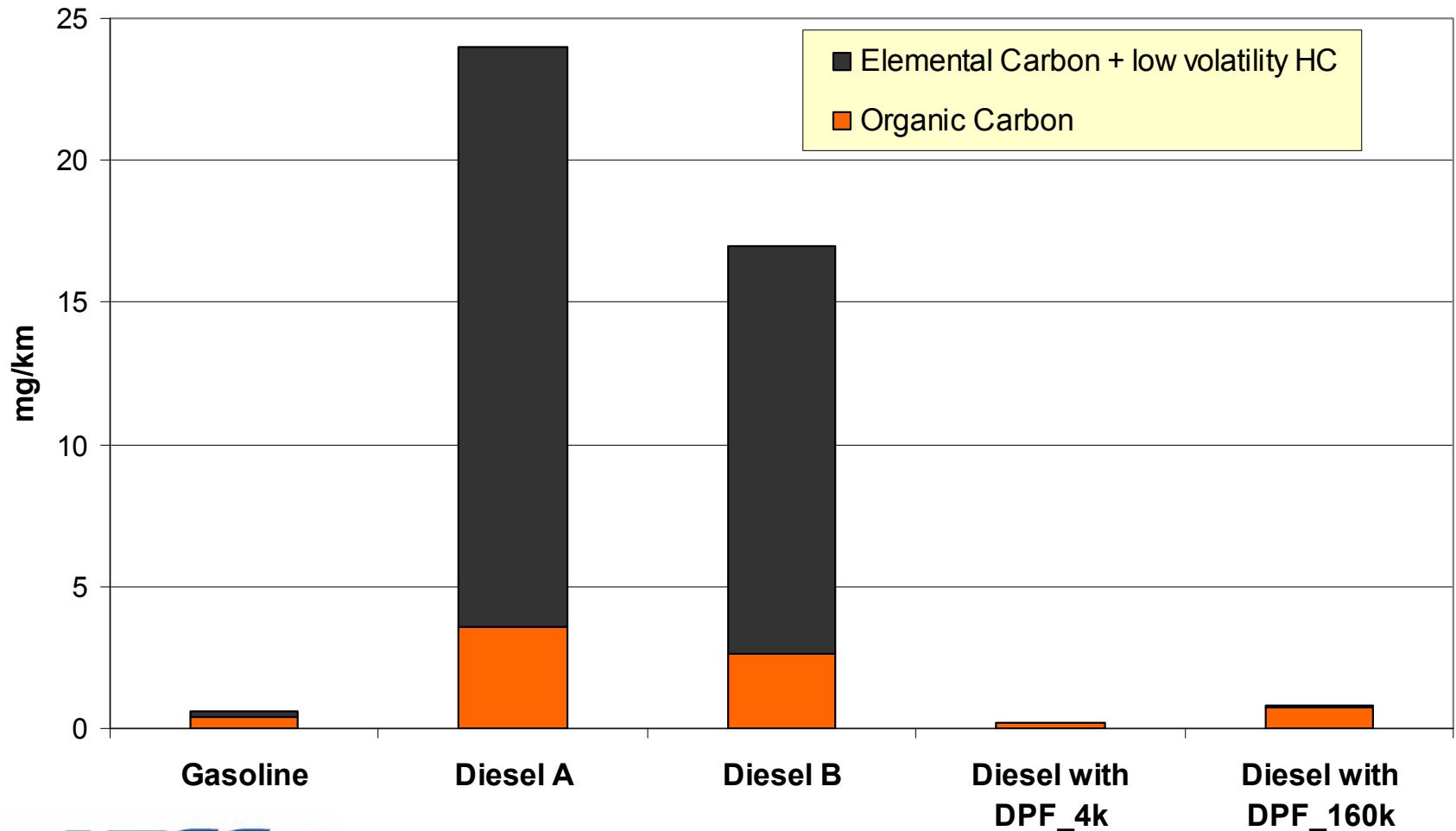


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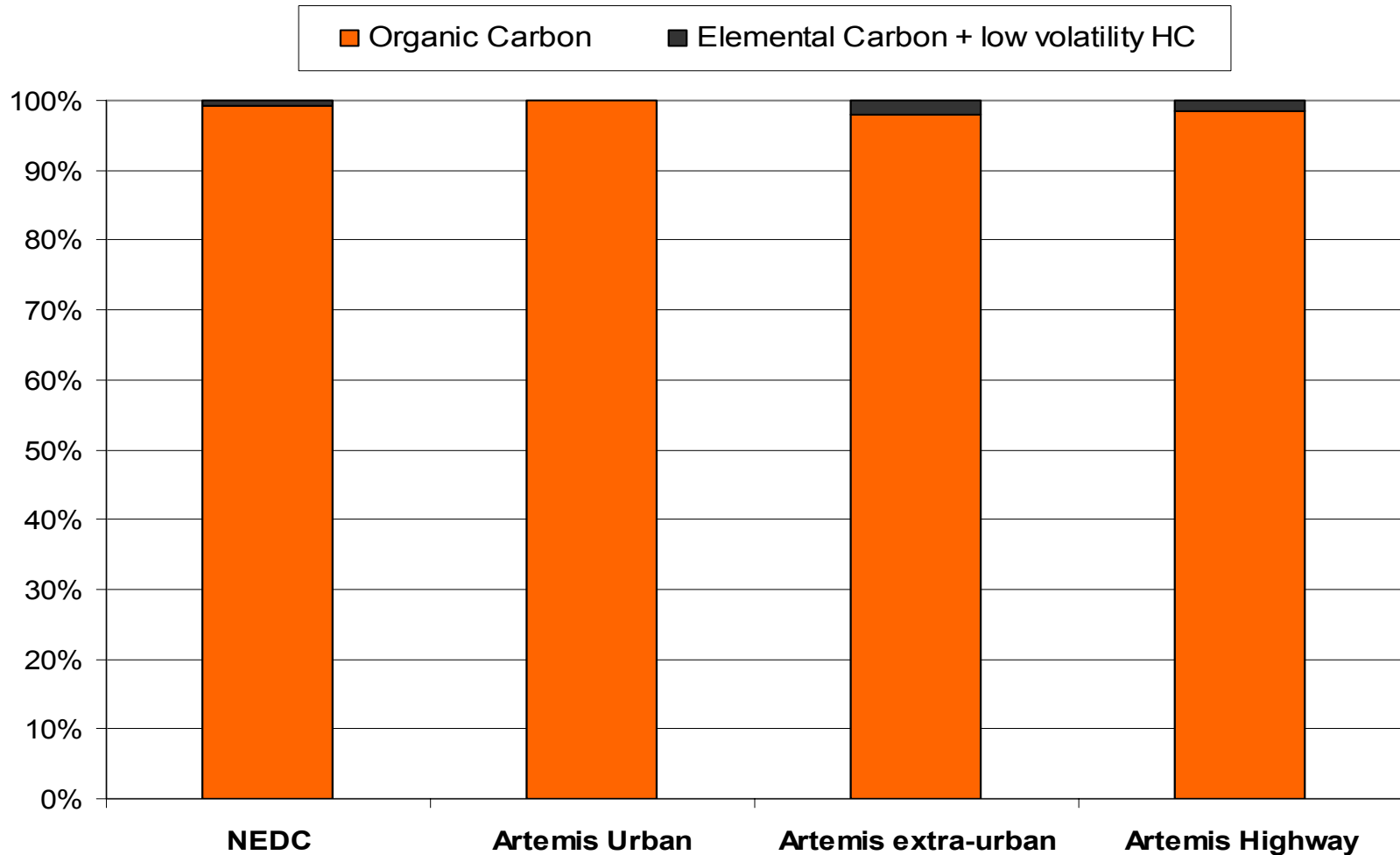
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# Elemental carbon + low volatility material & organic carbon relative to total PM NEDC tests

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



# EC/OC ratio for different cycles - Diesel with DPF



The elemental Carbon fraction measured by thermo-gravimetric analysis will include some heavy, non-volatile hydrocarbons

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# AECC Light-duty Programme – Conclusions

- The PMP protocol permits measurement of particulate mass well below 2.5mg/km.
- The PMP protocol also permits robust particle number measurements.
- PMP mass measurement provides better consistency than the existing gravimetric measurement method.
- PMP mass measurements also reduce the mass measured by up to 50% for the low PM levels obtained on DPF-equipped vehicles.
- The DPF reduces particulate mass and particle numbers of diesel emissions by a considerable margin.
- The DPF for light-duty diesel is durable and effective to at least 160000km.

# Thank you for your attention

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