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Verification of NPTI-Instruments for Diesel and Petrol Vehicles – first results

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Overview

- Since the introduction of Euro 5b standards diesel passenger cars must present PN emissions < $6x10^{11}$ #/km when tested on the duty cycle.

- The PN limit was achieved using DPFs

Overview - The issue - Part I

- Recent studies conducted in The Netherlands, Switzerland and Belgium have shown that ~10% of DPF-equipped passenger cars:
  - present a damaged DPF or
  - DPF has been removed.

Overview – Current method

- Opacity is used to evaluate compression ignition engine emissions during Periodic Technical Inspection - PTI (Directive 2014/45/EC; Reg. 24).

- Opacimeter: instrument for continuous measurement of the light absorption coefficients of the exhaust gases emitted by vehicles

Overview - The issue - Part II

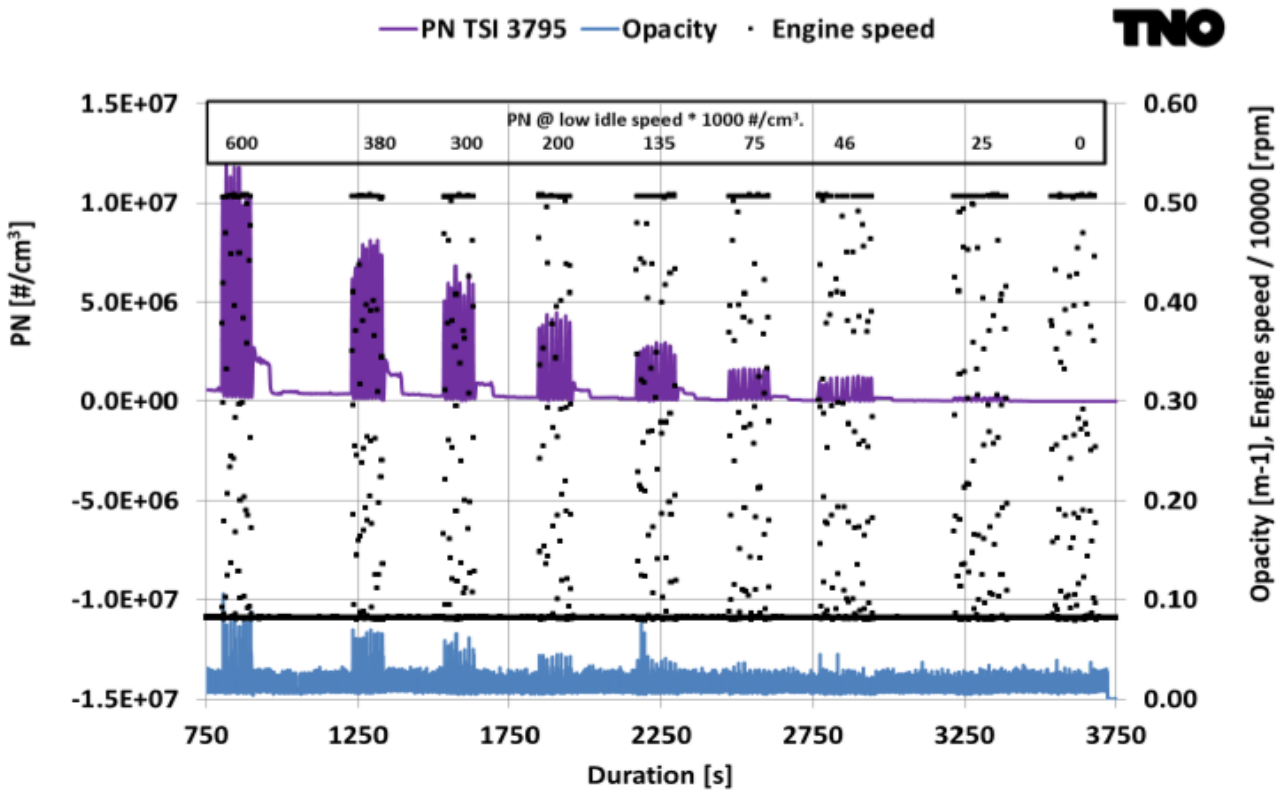


Figure 30: PN emissions and smoke emissions in free acceleration tests of a Peugeot Partner diesel Euro 6b with different DPF bypass exhaust flows.

Studies have shown that opacity fails to detect DPF damage or DPF removal.

Evaluation of an alternative procedure

- PN measurement
  - Instruments performance
- Engine operation
  - Low idle, “high idle” (~2000 rpm)
- Evaluation of plausible pass/fail limit
  - Limit should not be more stringent than type-approval ($6x10^{11}$ #/km)

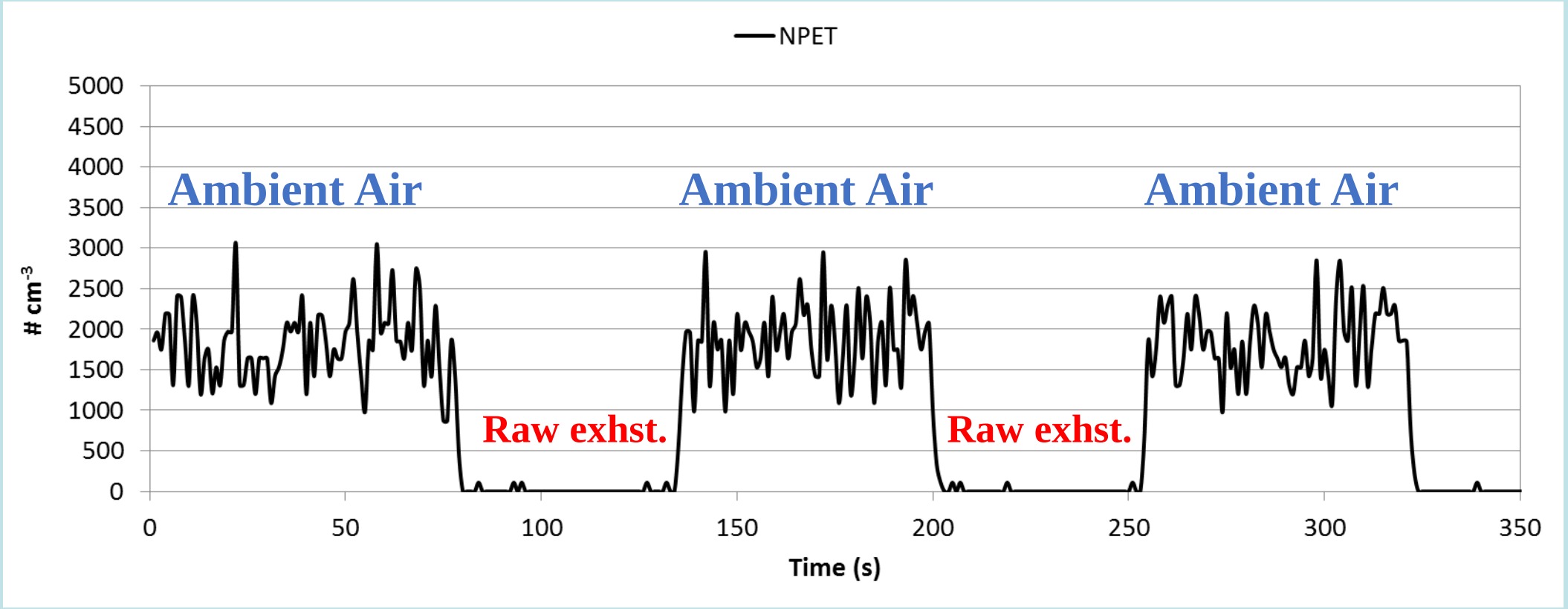
Vehicle and test sequence - 1st campaign

- **Euro 6b diesel vehicle (DPF-equipped) – Vehicle 1**
  - Partial bypass
- **Tested using WLTP**
- **Low idle measurements**
  - Ambient air (60’’), followed by raw exhaust at low idle (60’’)
- **High idle (2000 rpm) measurements**
  - Raw exhaust at low idle (60’’), follow by high idle (60’’)

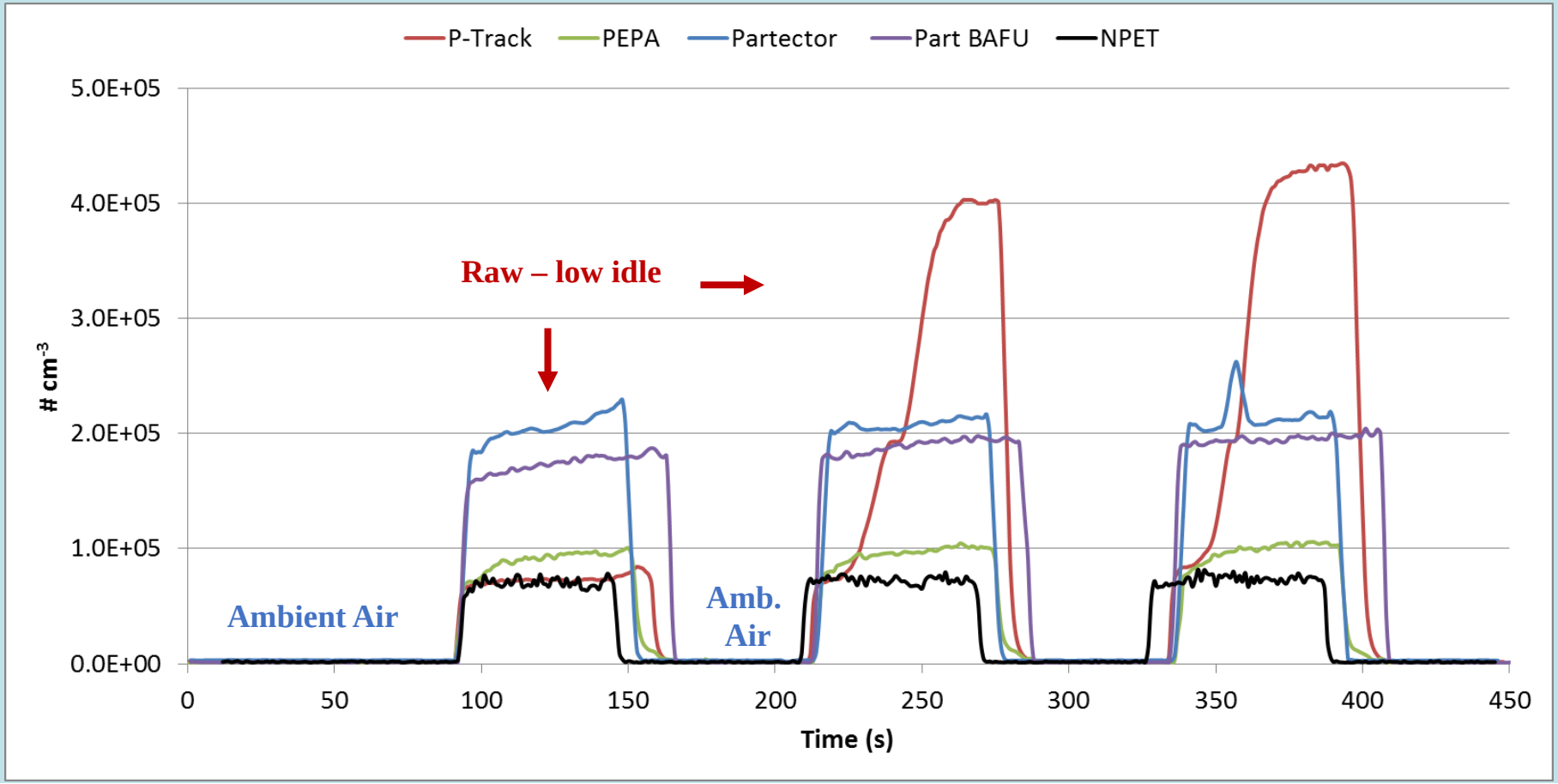
Instruments used during 1st campaign

• Modified TSI 3795 (NPET for PEMS)	Dil+CS+CPC
• Testo PEPA	Dil+DC
• TSI p-Track	CPC
• Naneos Partector	DC
• Naneos Automotive Partector	DC

Raw emissions – Vehicle 1- No bypass



Low idle- Bypass opened



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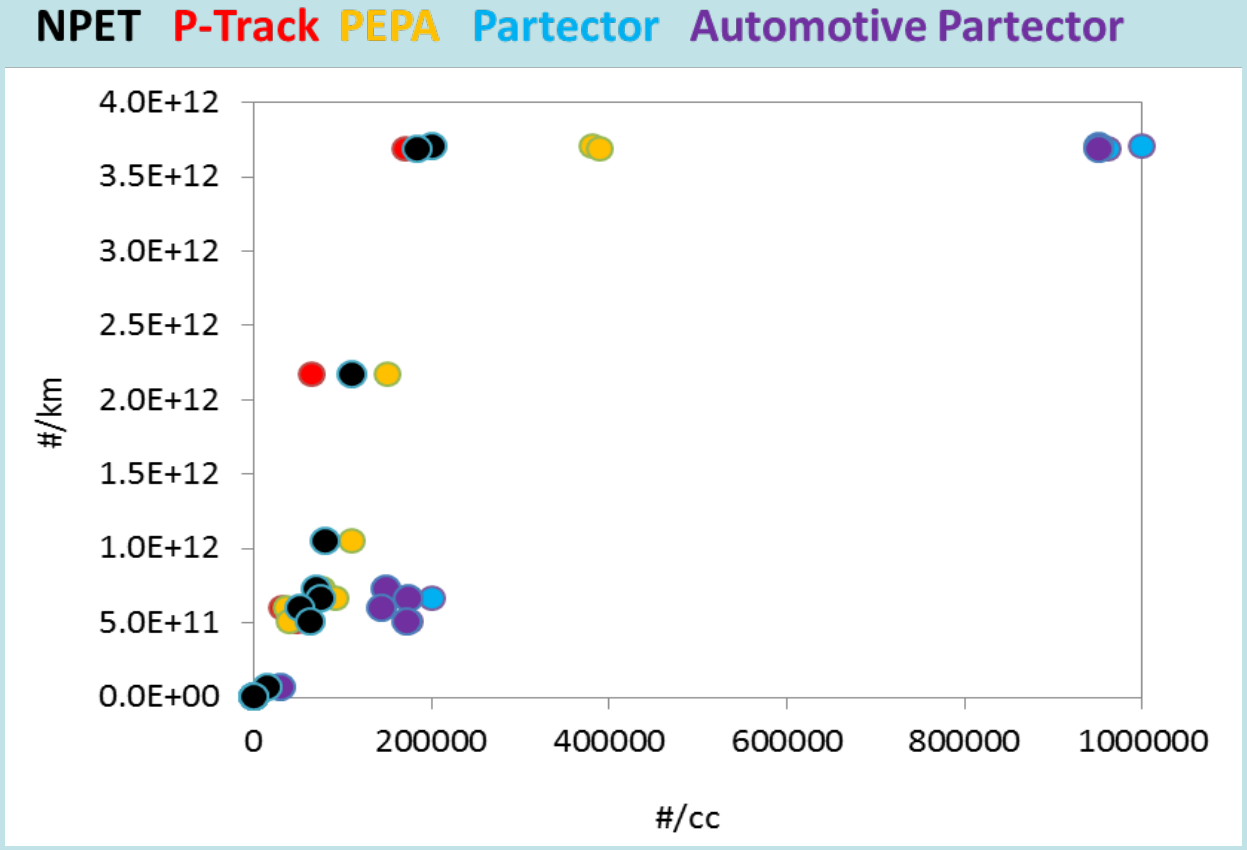
Emission factors *vs* low idle concentration– Vehicle 1



Different levels of partial bypass resulted Emission Factors during the WLTP:

- No bypass EF 2-8x 10^{9} #/km
- Near Euro 6 limit 5-7x 10^{11} #/km
- Wide opened 2-4x 10^{12} #/km

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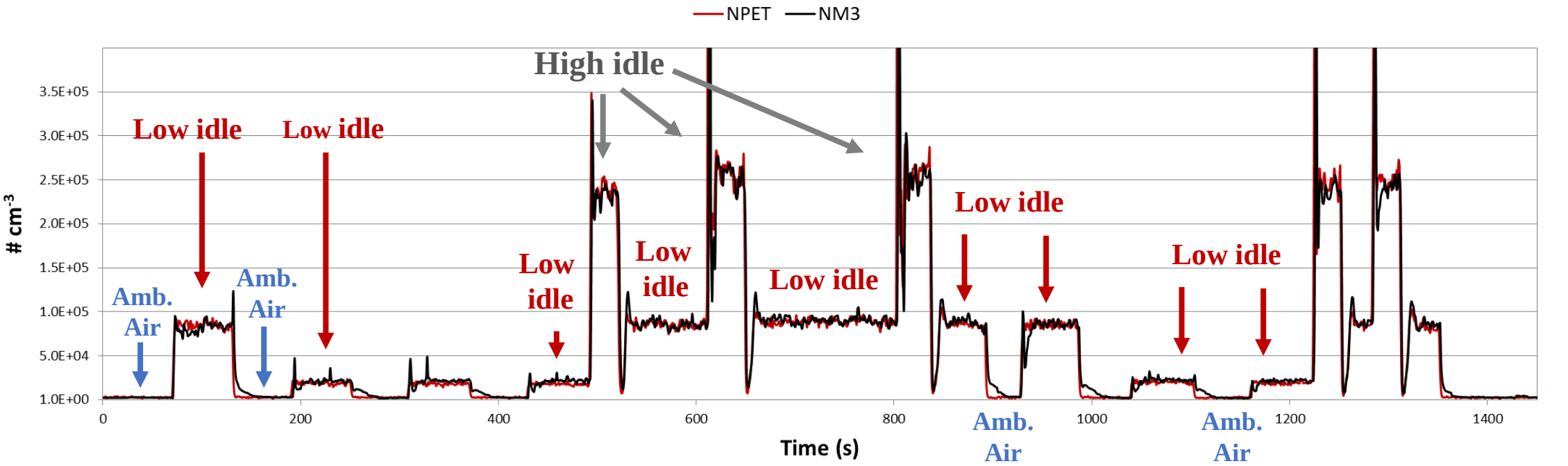
Vehicle 2- Euro 6b diesel

Both PN-PEMS



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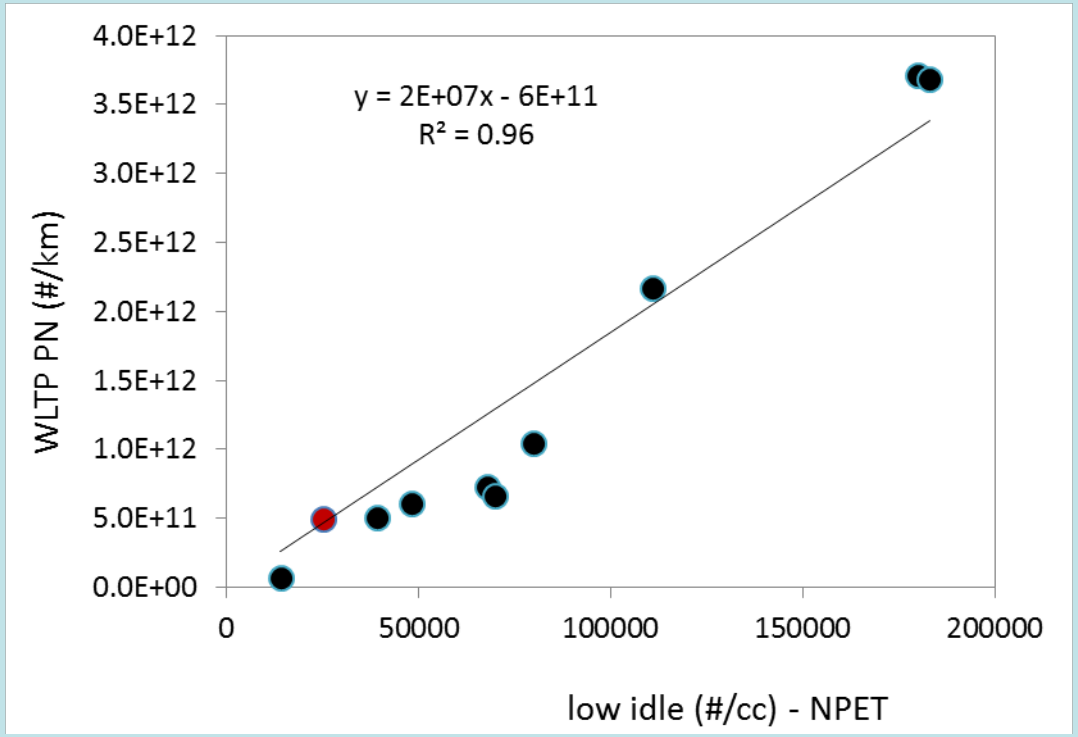
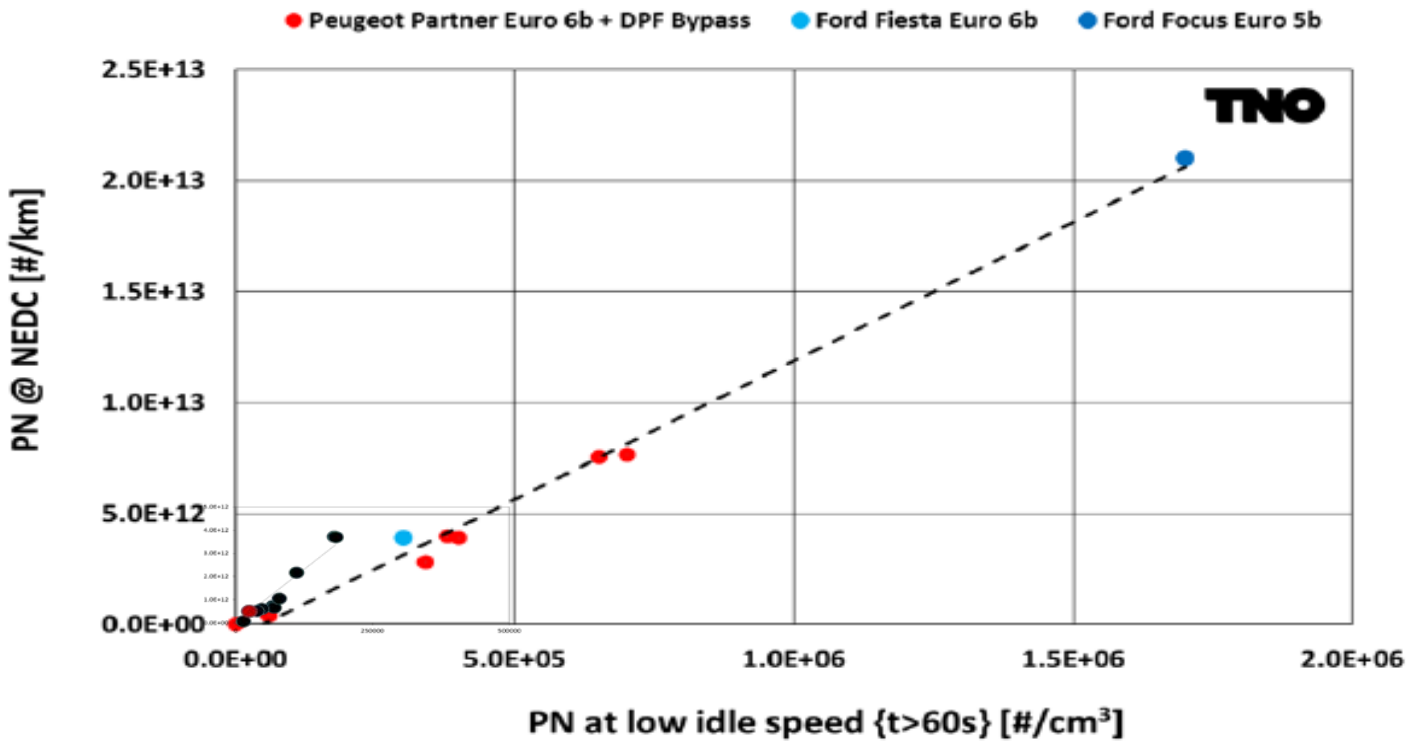
Emission factor *vs* low idle concentration



Emission factor *vs* low idle concentration



Figuur 2: PN emissions at low idle speed and NEDC tests of 3 different diesel vehicles with (cracked) DPF or variable bypass.

Instruments used - Campaign II

• PMP >23nm and >3nm	Hot dil + ET + CPC
• Mod. NPET – TSI/HORIBA	Dil + CS + CPC
• NM3 – Testo	Hot dil +ET + DC
• PEPA - Testo	Dil + DC
• PN-PTI-Prot. – TSI	CPC
• APA-Prot. – Sensors	CPC
• METAS – Naneos	DC
• 2x Naneos Partector	DC
• CZ-Uni-Prot	Ionization chamber

Second campaign – Vehicles tested

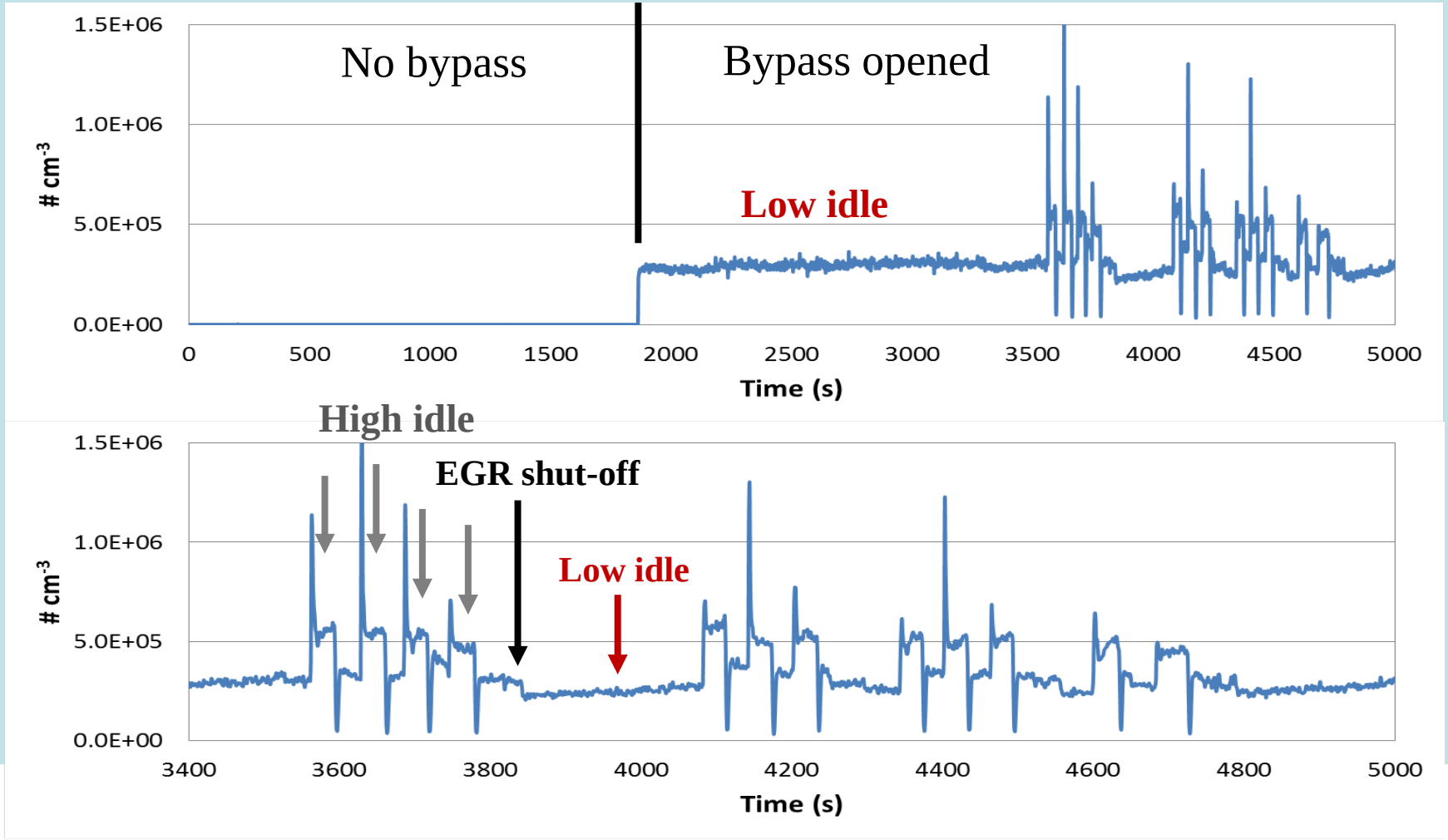
- Vehicle 1 - Diesel Euro 6b with and w/o a partial bypass
- Vehicle 2 - Diesel Euro 6b
- Vehicle 3 - Gasoline GDI Euro 6c– GPF equipped
- Vehicle 4 - Gasoline GDI Euro 6b

Test sequence

- **Low idle**
  - Ambient air (30’’), followed by raw exhaust at low idle (30’’)

- **High idle - 2000 rpm**
  - Raw exhaust at low idle (30’’), follow by high idle (30’’ at 2000 rpm)

Emission profile during test sequence – Veh.1



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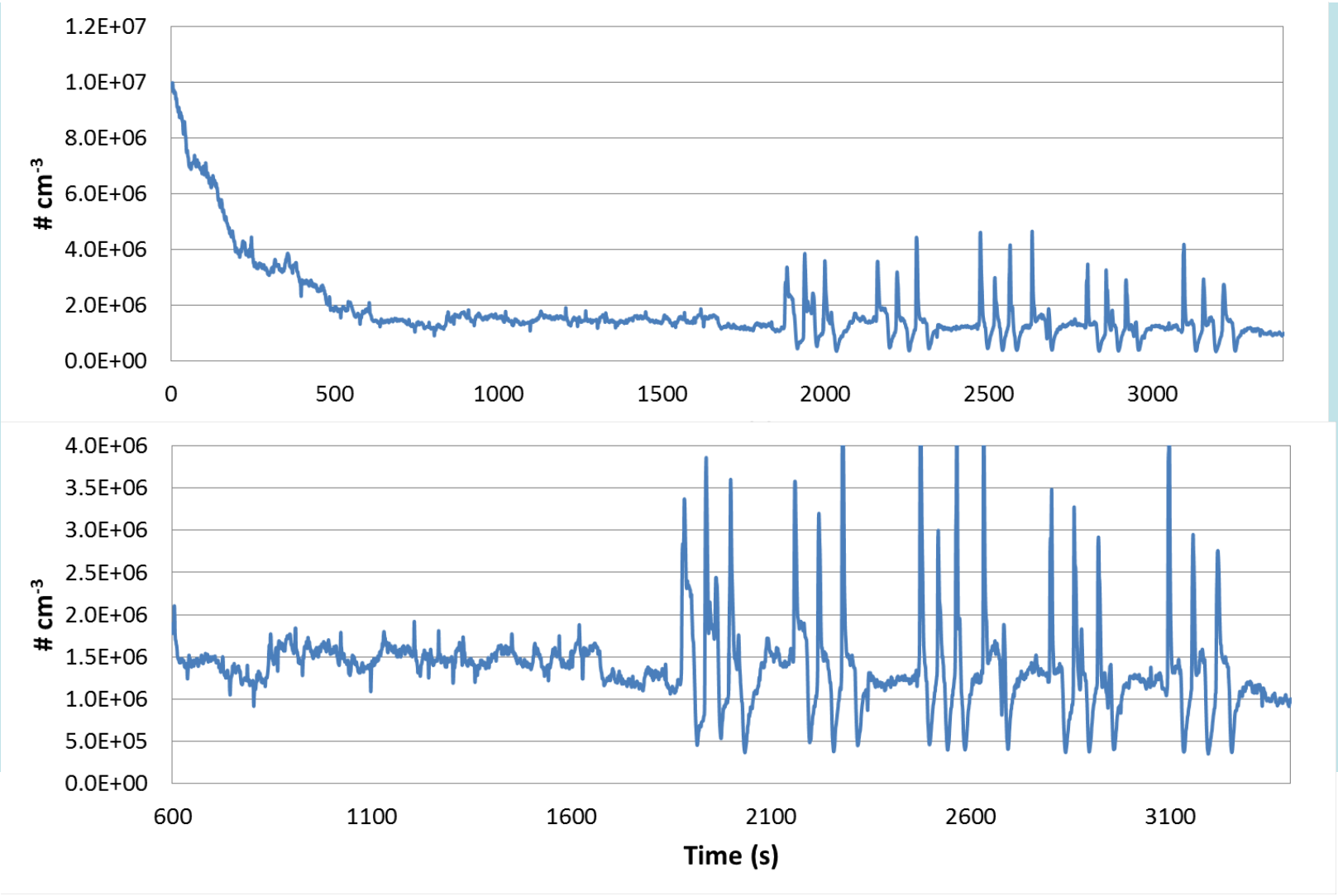
Emission profile GDI during test sequence



- Engine hot but exhaust emissions not stable
- Highly variability over time
- Very high PN emissions
  - GPF-equipped >100 # cm^{-3}

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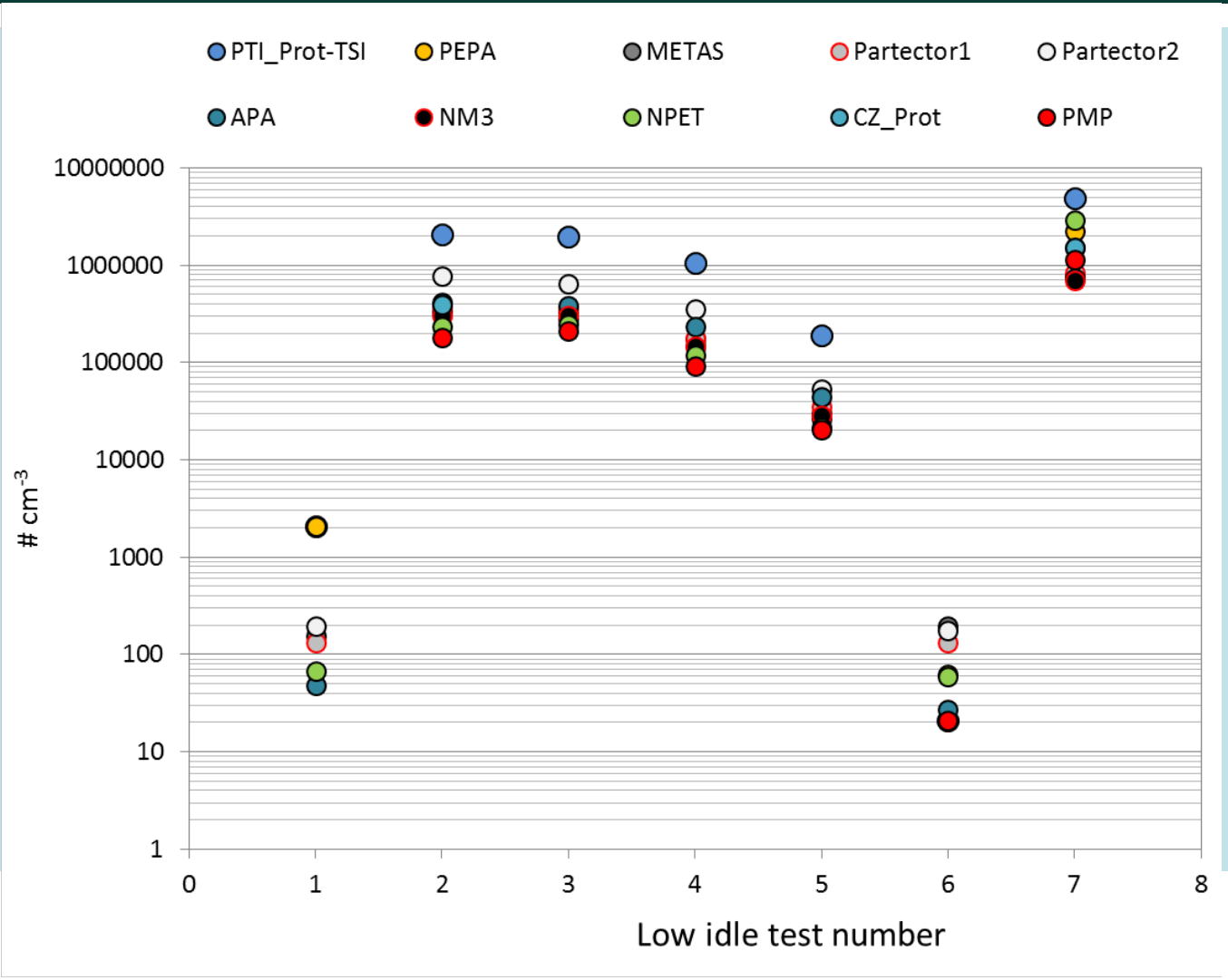
Low idle concentrations measured



- Test1 - Test4 Vehicle 1
  - Test 1 no bypass
  - Test 2-3 valve fully opened
  - Test 4 valve partially opened
- Test 5 Vehicle 2
- Test 6 Vehicle 3 (GDI with GPF)
- Test 7 Vehicle 4 (GDI)

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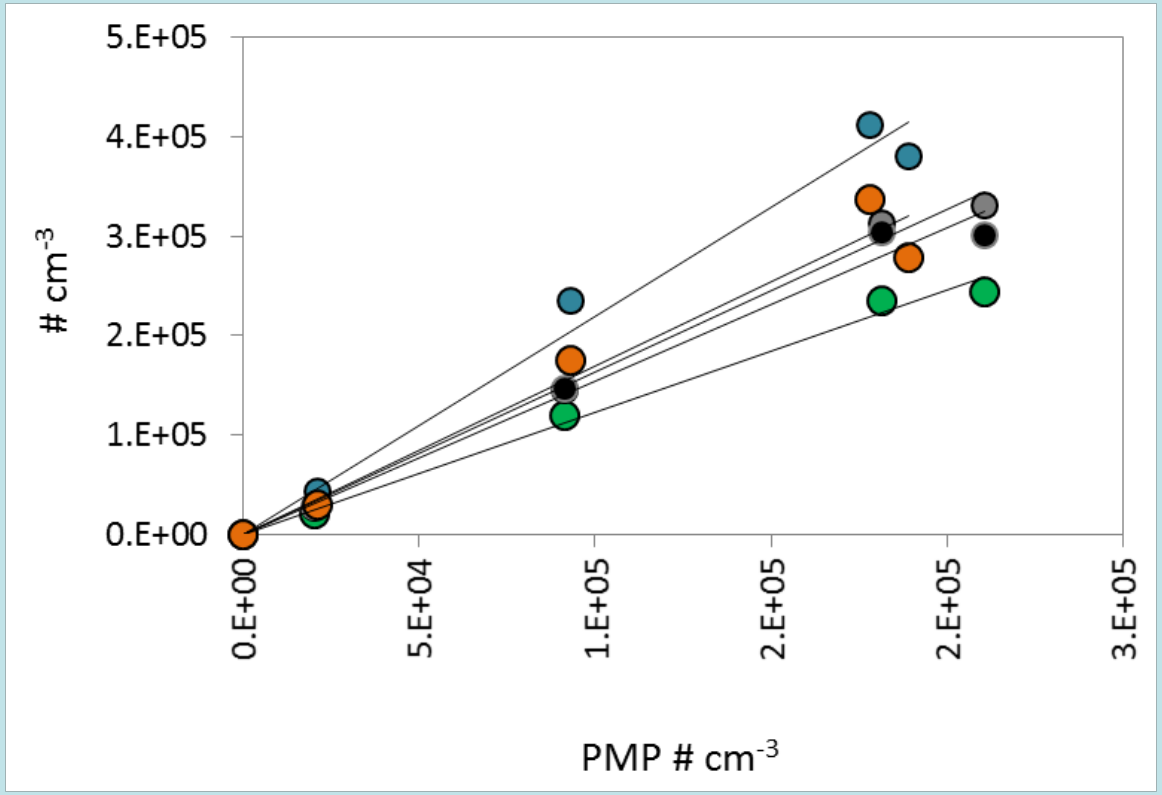
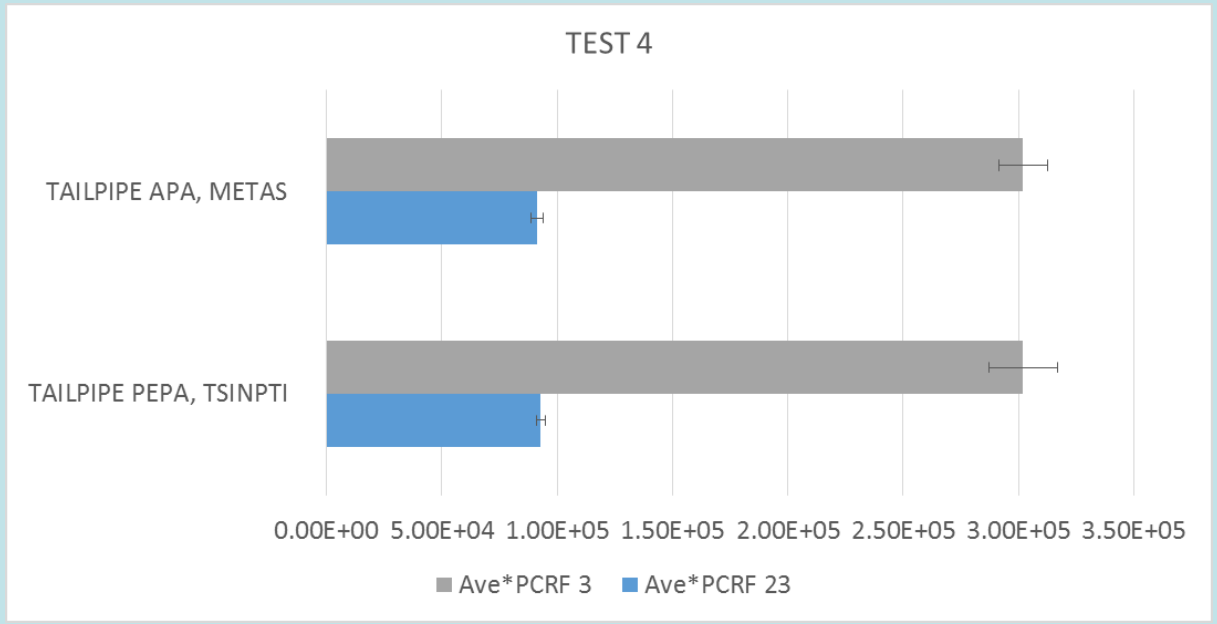
Instruments *vs* PMP (Diesel vehicles)



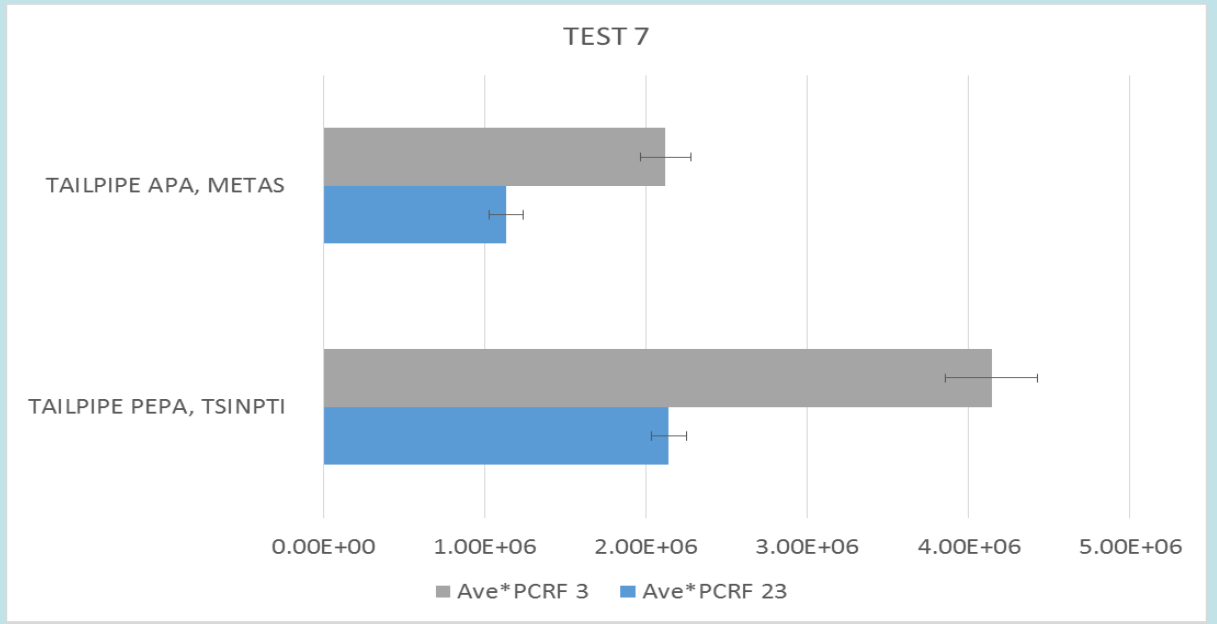
PMP *vs*	ax	R^2
NPET	1.23	0.99
NM3	1.55	0.98
METAS	1.64	0.99
PEPA	1.77	0.96
APA	2.06	0.95
PTI-Prot-TSI	11.1	0.99

PMP >23nm and >3nm

Vehicle 2- Diesel



Vehicle 4 - GDI



- High concentration of small solid particles
- Diesel vehicle stable over time. GDI highly variable

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Lessons learned and Next steps

- Low idle measurement appear to be suitable to detect DPF failures
  - Should measurements be performed when EGR is active?
- Instruments should avoid measuring volatile fraction.
  - Cutting size must be defined. Reasonable cut 23nm?
- More data is needed to be able to provide a general pass/fail limit for diesel vehicles.
- Petrol vehicles need to be studied further.

Thank you

Any questions?

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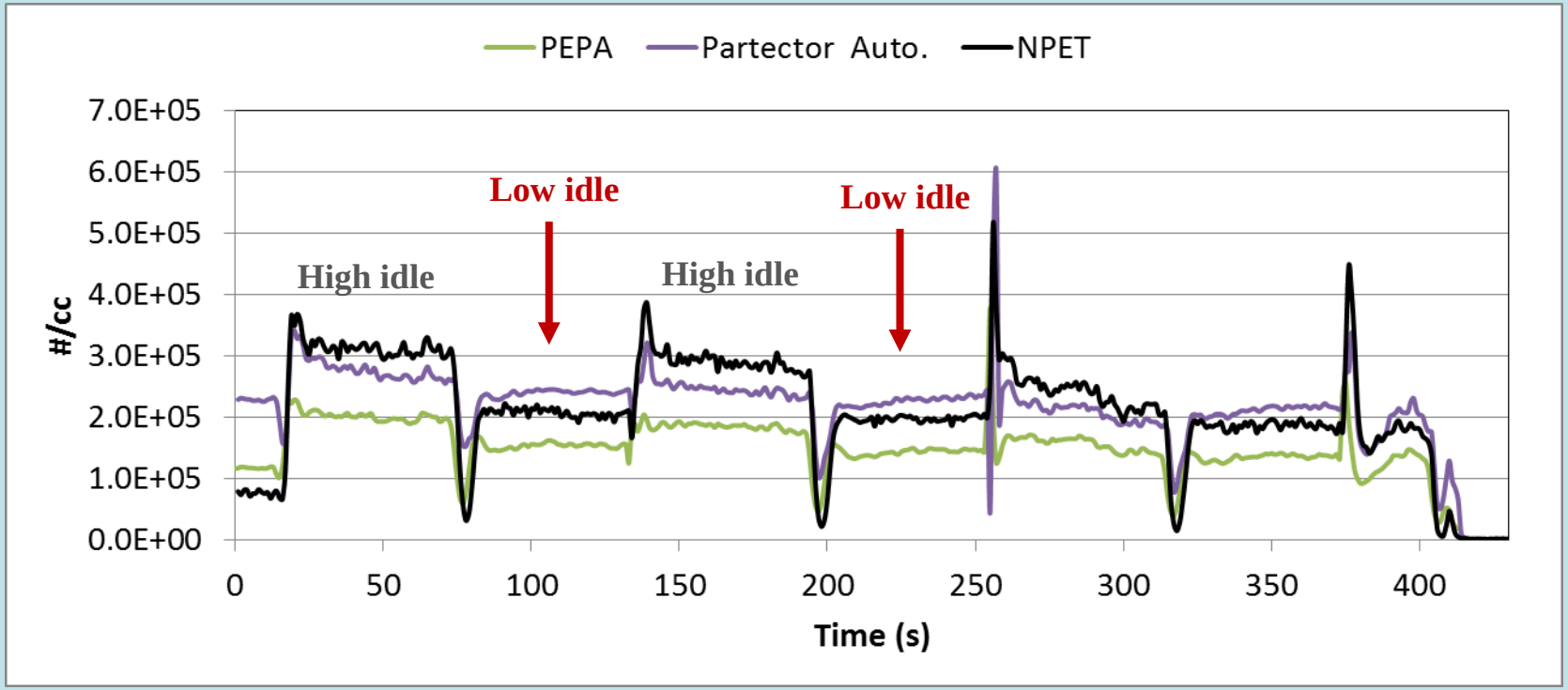
High idle- Bypass opened



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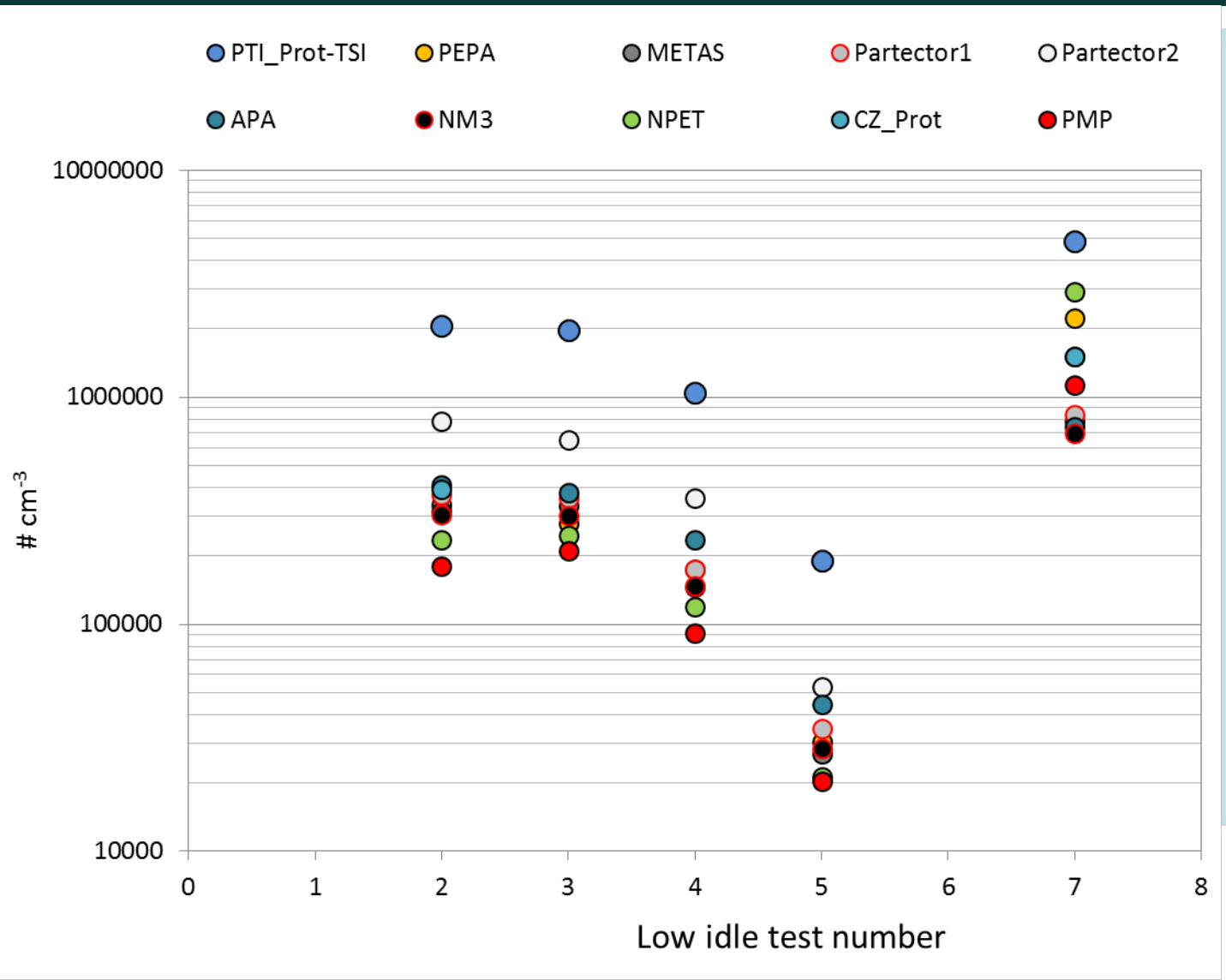
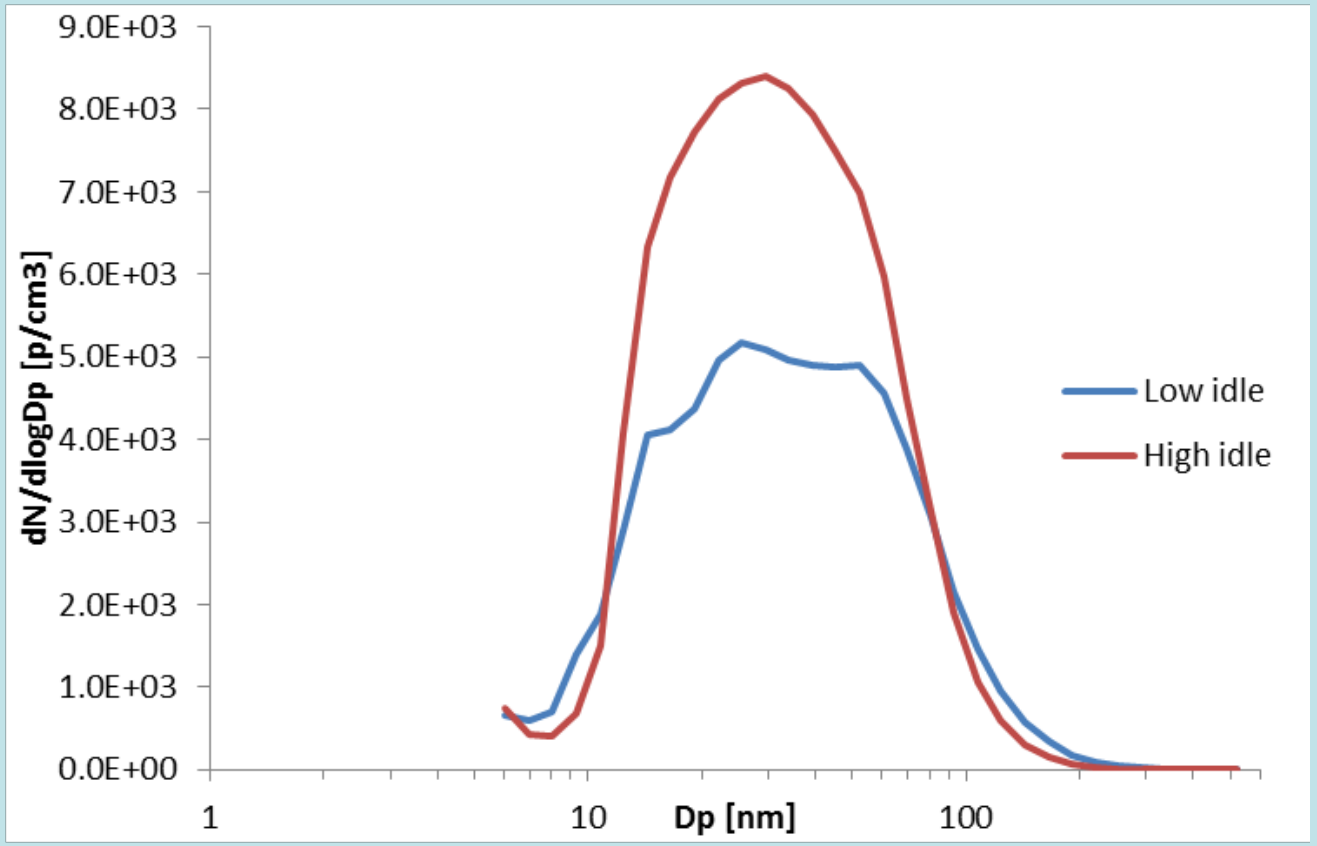
Low idle concentrations measured



- Test1 - Test4 Vehicle 1
  - Test 1 no bypass
  - Test 2-3 valve fully opened
  - Test 4 valve partially opened
- Test 5 Vehicle 2
- Test 6 Vehicle 3 (GDI with GPF)
- Test 7 Vehicle 4 (GDI)

EEPS measurements of Vehicle 4 - GDI



- GMD ~30nm
- More than 60% were solid sub-23 nm
- Very important to define the cutting size of the instruments that could be use during PTI of diesel and petrol vehicles.

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