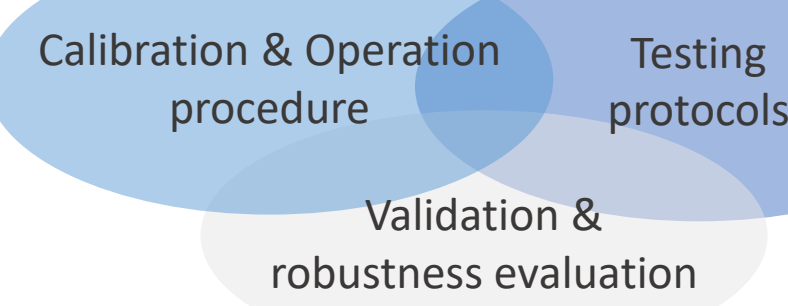
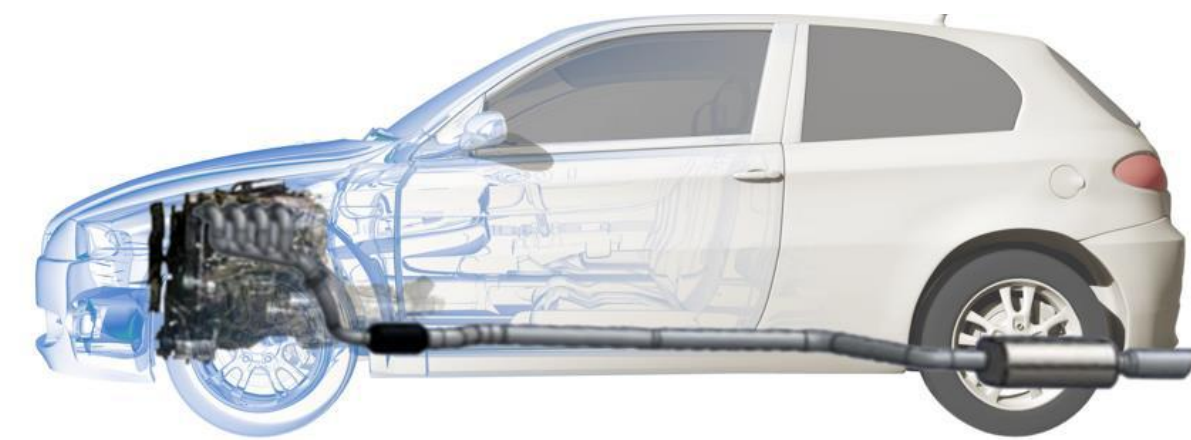


## Final validation and robustness evaluation of the equipment

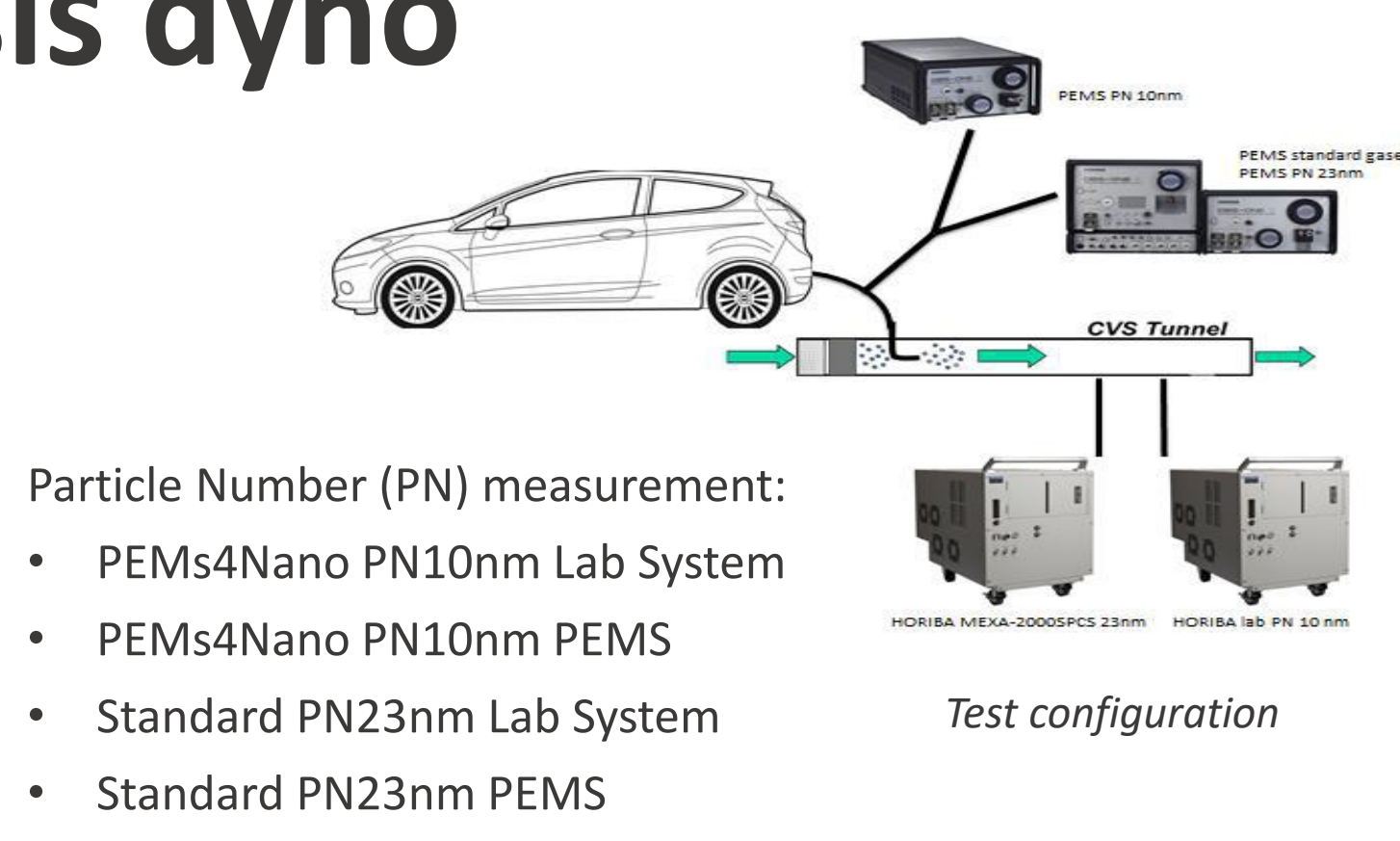
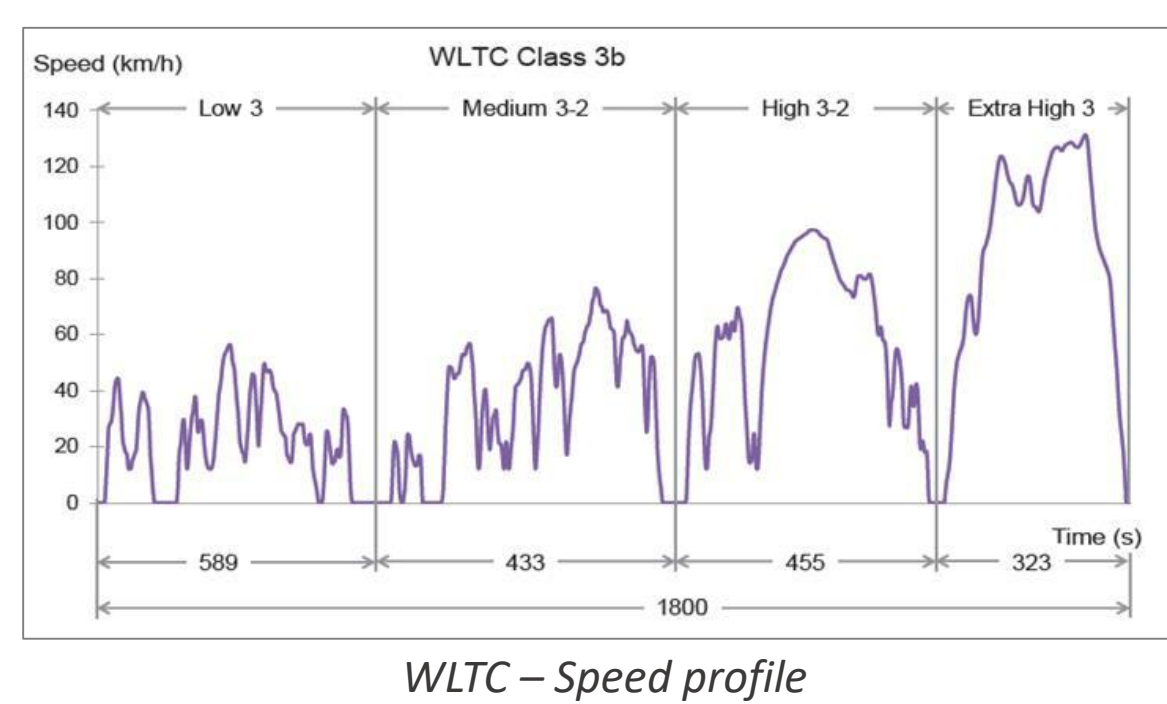
### Context & Objectives

Within the **PEMs4Nano project**, complete testing was carried out using the technology developed through physical testing in the laboratory. The final objective was to ensure the correct operation of the PN measurement system to measure small particles down to 10 nm.



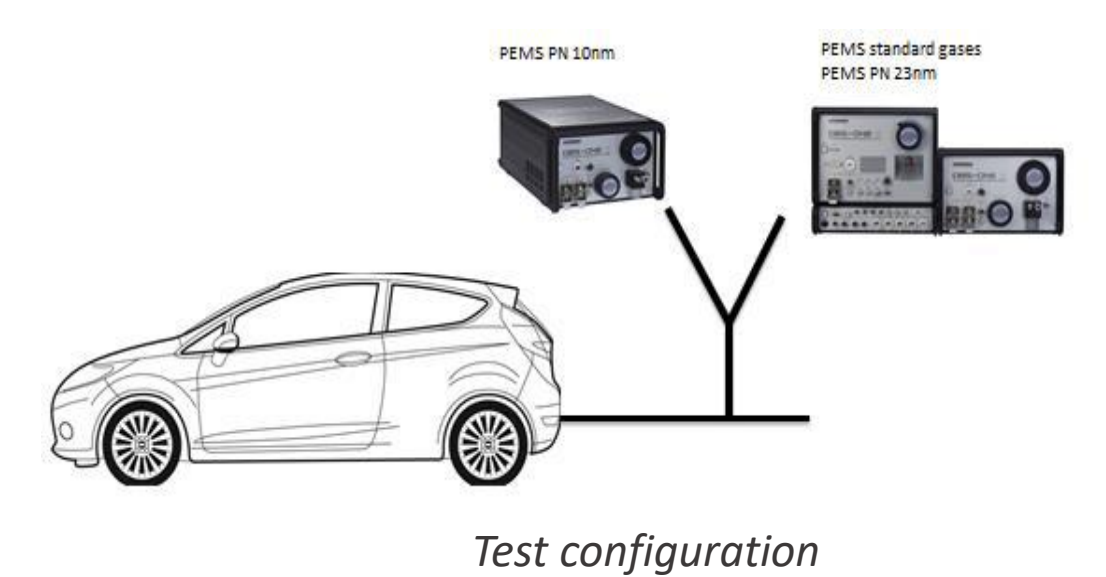
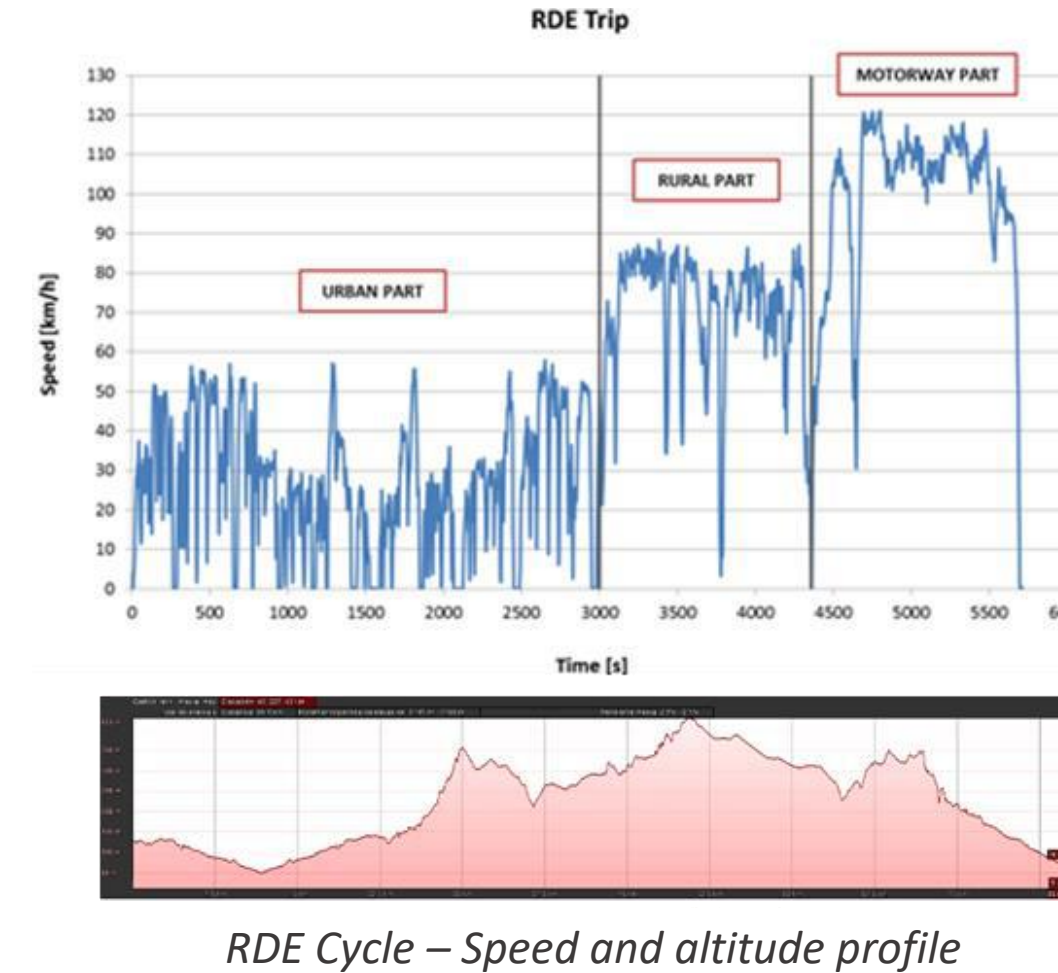
The **final validation of the measurement procedure and equipment** and a **robustness evaluation** were performed.

### WLTC Cycle on chassis dyno



- Particle Number (PN) measurement:
- PEMs4Nano PN10nm Lab System
  - PEMs4Nano PN10nm PEMS
  - Standard PN23nm Lab System
  - Standard PN23nm PEMS

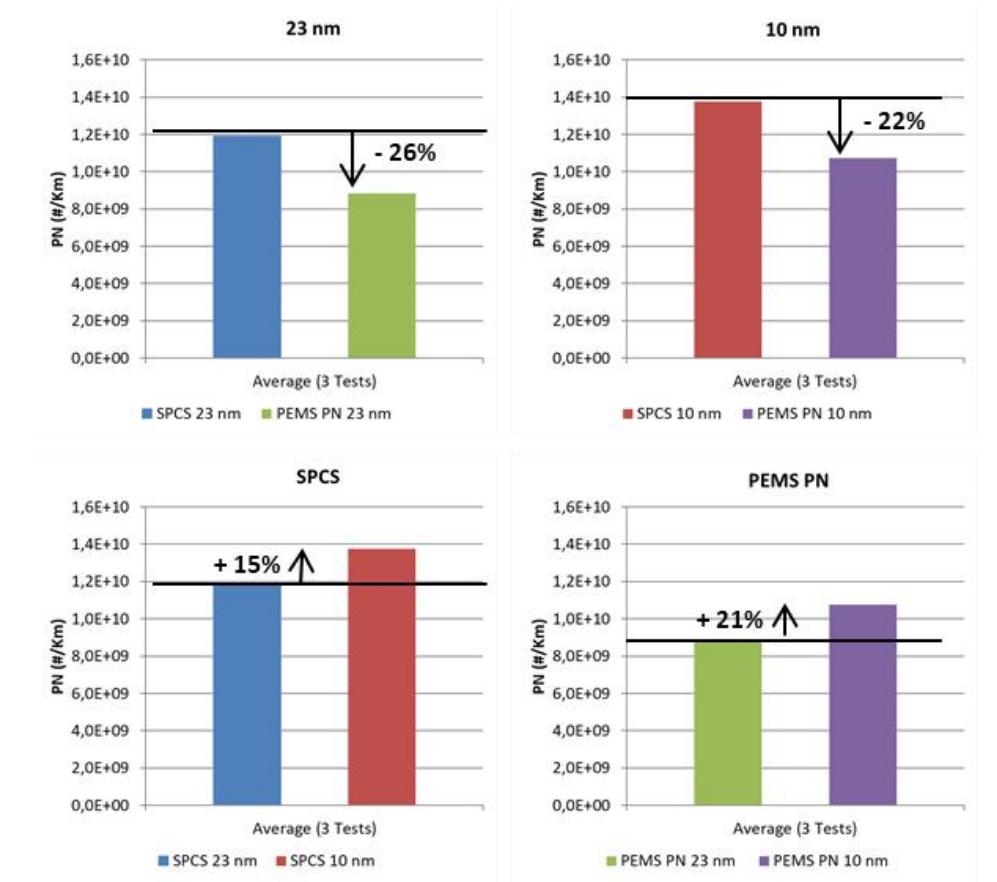
### RDE cycle on real road



- Particle Number (PN) measurement:
- PEMs4Nano 10nm Lab System
  - HORIBA PEMS PN (PEMS PN23nm)

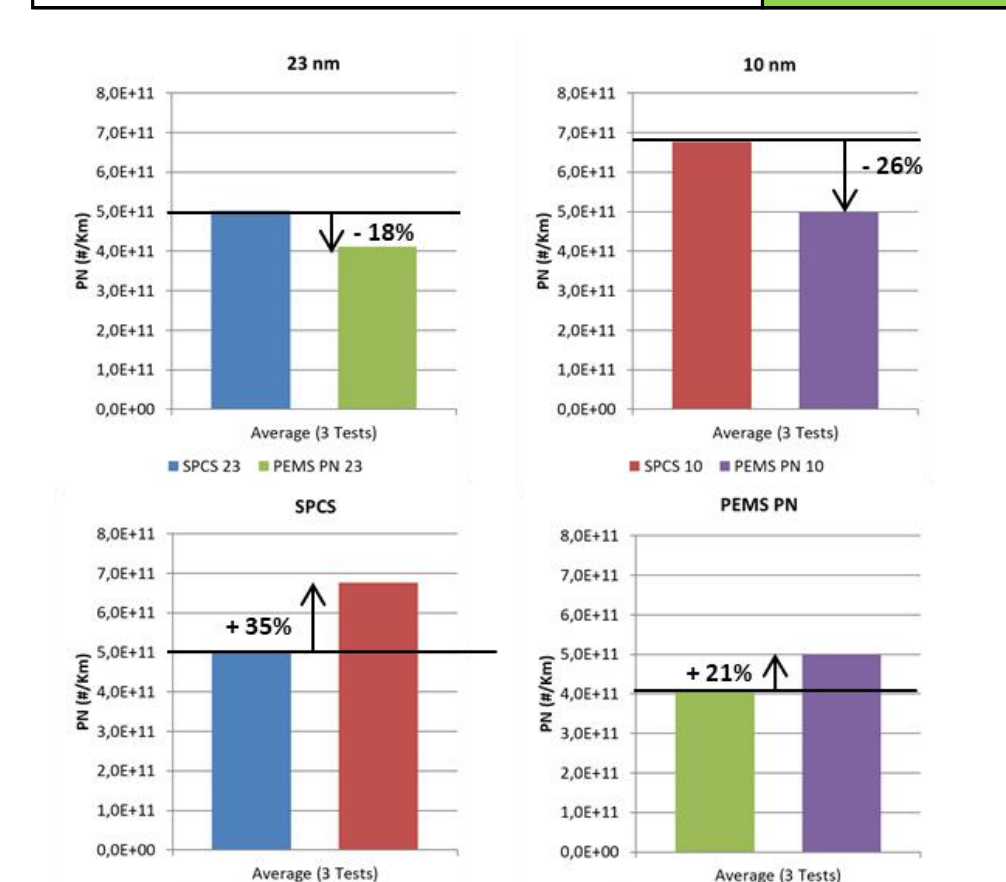
#### 1.0L GDI with GPF (Segment C)

Average (3 Tests)		PN (#/Km)
Lab System	SPCS PN23	1,2E+10
Data	SPCS PN10	1,4E+10
Correlation SPCS 10 vs SPCS 23		15%
OBS System	OBS PN23	8,8E+09
Data	OBS PN10	1,1E+10
Correlation OBS PN 10 vs OBS PN 23		21%
Correlation SPCS 10 vs OBS PN 10		22%
Correlation SPCS 23 vs OBS PN 23		26%



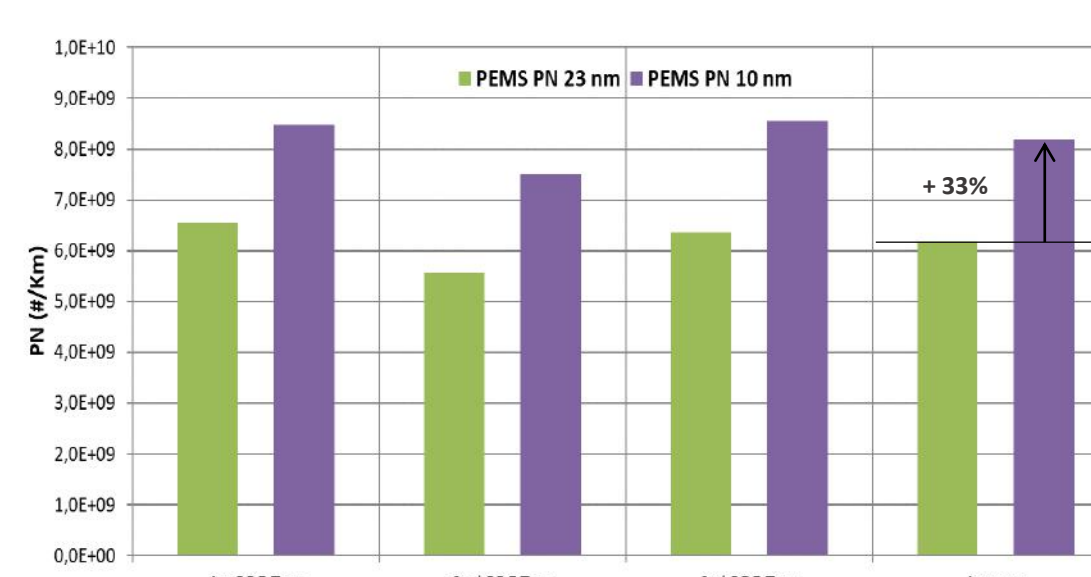
#### 1.4L GDI without GPF (SUV)

Average (3 Tests)		PN (#/Km)
Lab System	SPCS PN23	5,0E+11
Data	SPCS PN10	6,8E+11
Correlation SPCS 10 vs SPCS 23		35%
OBS System	OBS PN23	4,1E+11
Data	OBS PN10	5,0E+11
Correlation OBS PN 10 vs OBS PN 23		21%
Correlation SPCS 10 vs OBS PN 10		26%
Correlation SPCS 23 vs OBS PN 23		18%



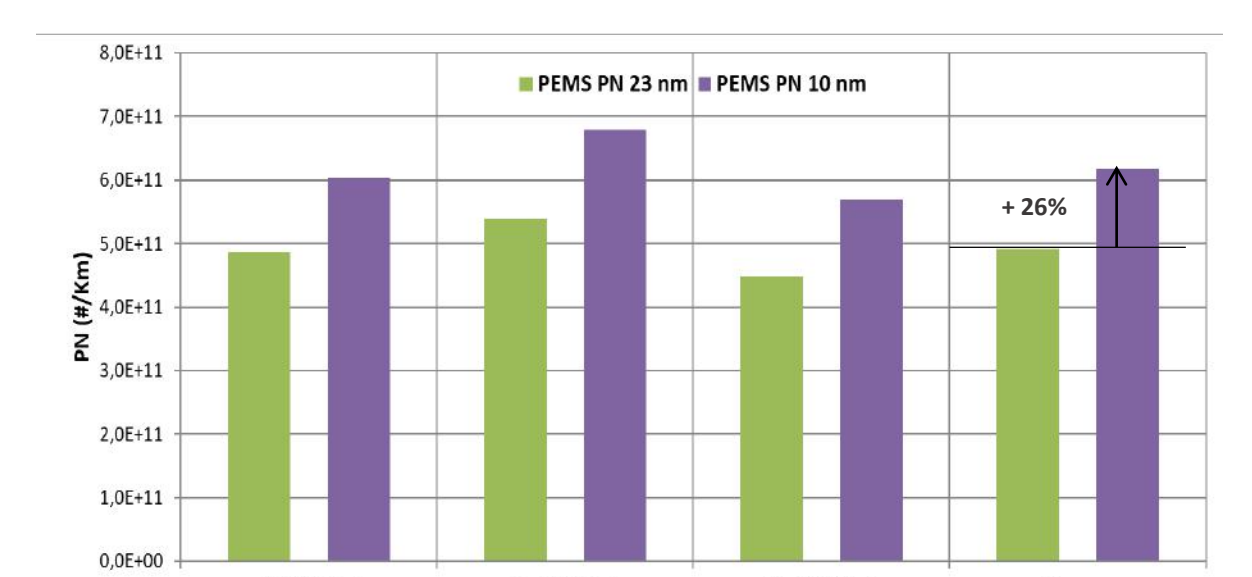
#### 1.0L GDI with GPF (Segment C)

		PN (#/Km)
1st RDE Test	OBS PN23	6,55E+09
	OBS PN10	8,48E+09
Correlation		29%
2nd RDE Test	OBS PN23	5,57E+09
	OBS PN10	7,50E+09
Correlation		35%
3rd RDE Test	OBS PN23	6,37E+09
	OBS PN10	8,55E+09
Correlation		34%
Average	OBS PN23	6,16E+09
	OBS PN10	8,18E+09
Correlation		33%

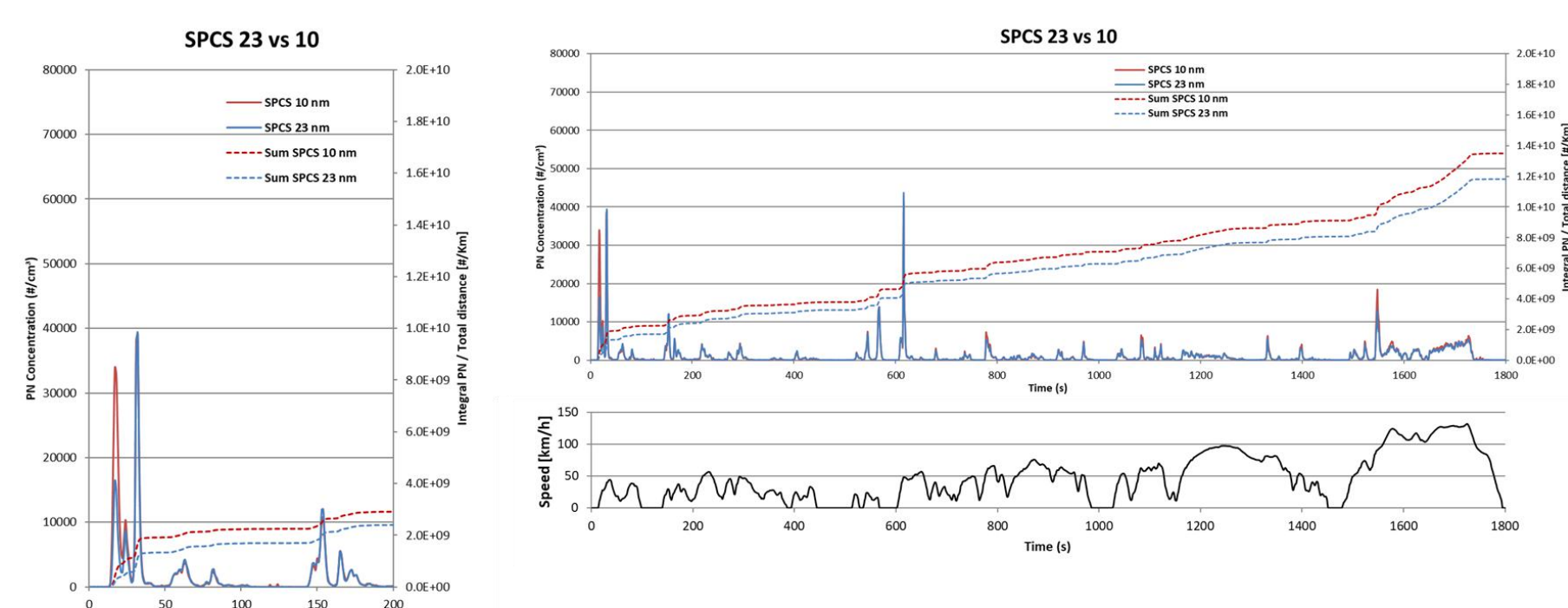


#### 1.4L GDI without GPF (SUV)

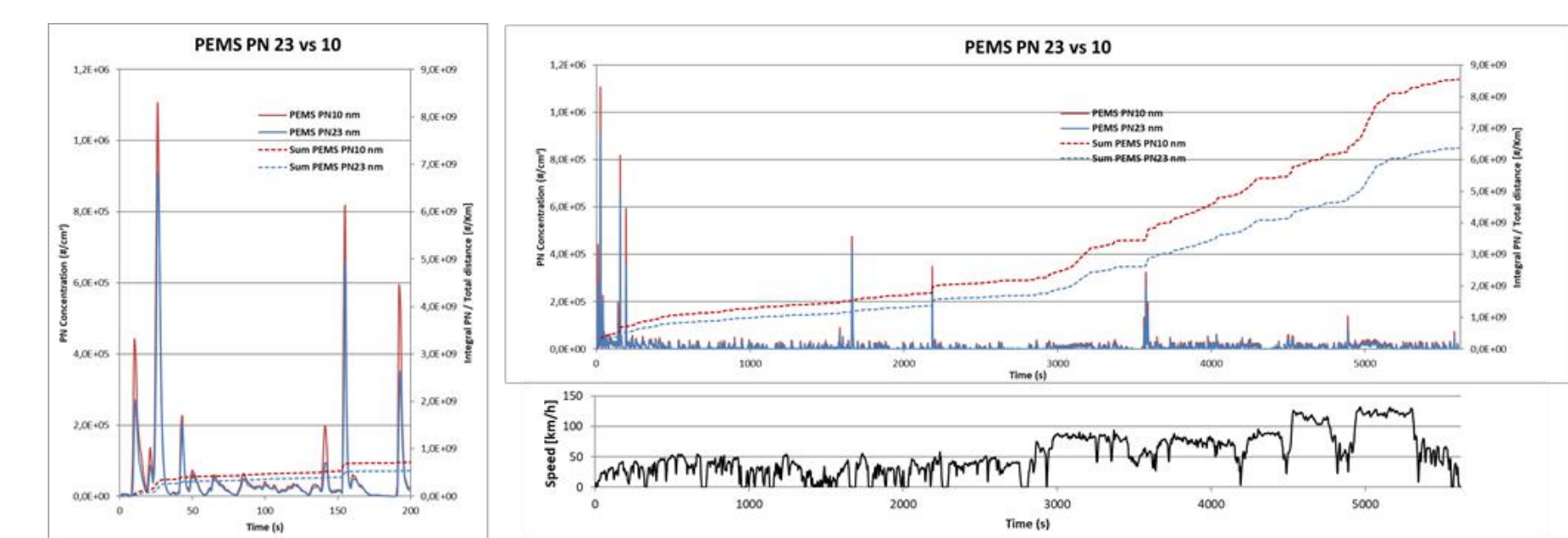
		PN (#/Km)
1st RDE Test	OBS PN23	4,87E+11
	OBS PN10	6,04E+11
Correlation		24%
2nd RDE Test	OBS PN23	5,39E+11
	OBS PN10	6,79E+11
Correlation		26%
3rd RDE Test	OBS PN23	4,48E+11
	OBS PN10	5,68E+11
Correlation		27%
Average	OBS PN23	4,91E+11
	OBS PN10	6,17E+11
Correlation		26%



#### Second-by-second measurement



#### Second-by-second measurement



### Conclusions

- Sub-23nm laboratory and on-board systems can be applied and handled as the established PN23 nm measurement system
- As expected, PN10 devices measure more particles than standard PN23 systems (between 15% and 35% depending on the cycle and vehicle)
- Sub-23 nm particles are mainly generated at engine cold start and acceleration phases
- Total PN10 nm values (#/km) of an individual test are similar to the average values (WLTC and RDE Cycle) → **Good repetitiveness**
- Same trend shown in second-by-second data in the two vehicles studied (vehicle 1 with GPF measuring more particles, as expected)

**NOTE:** The results presented are inherent to these particular vehicles and test conditions, they are not extended to general conditions