

Joint Research Centre (JRC)

Application of the Volatile Particle Removers (VPRs)
for sub-23 nm particle number measurements:
Preliminary results



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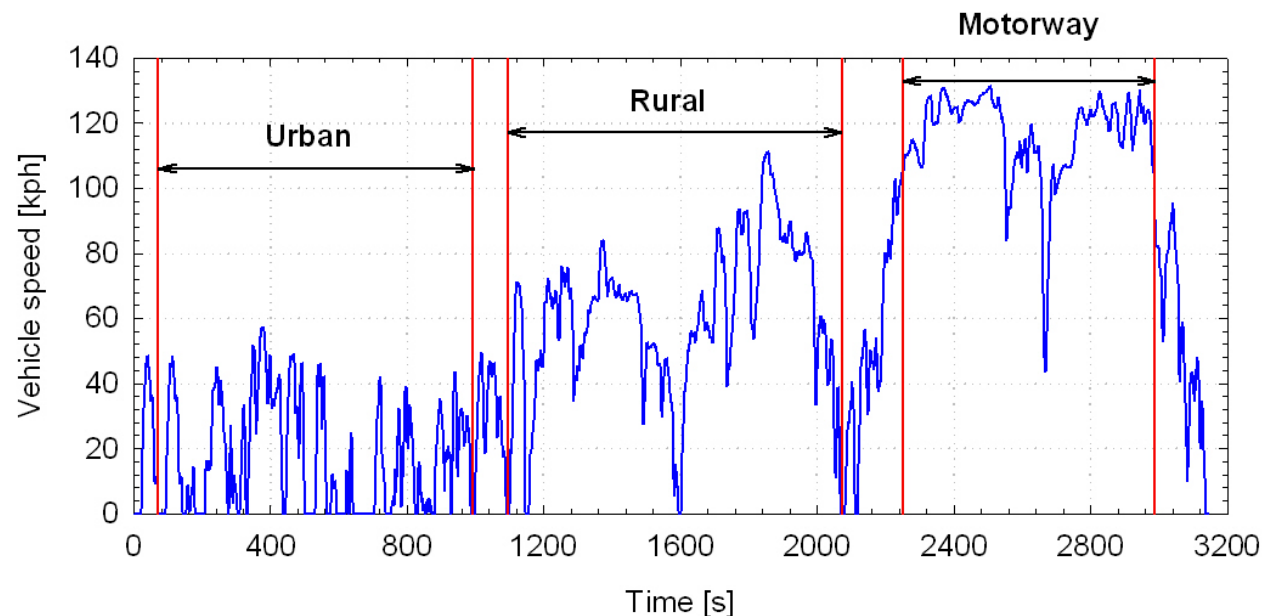
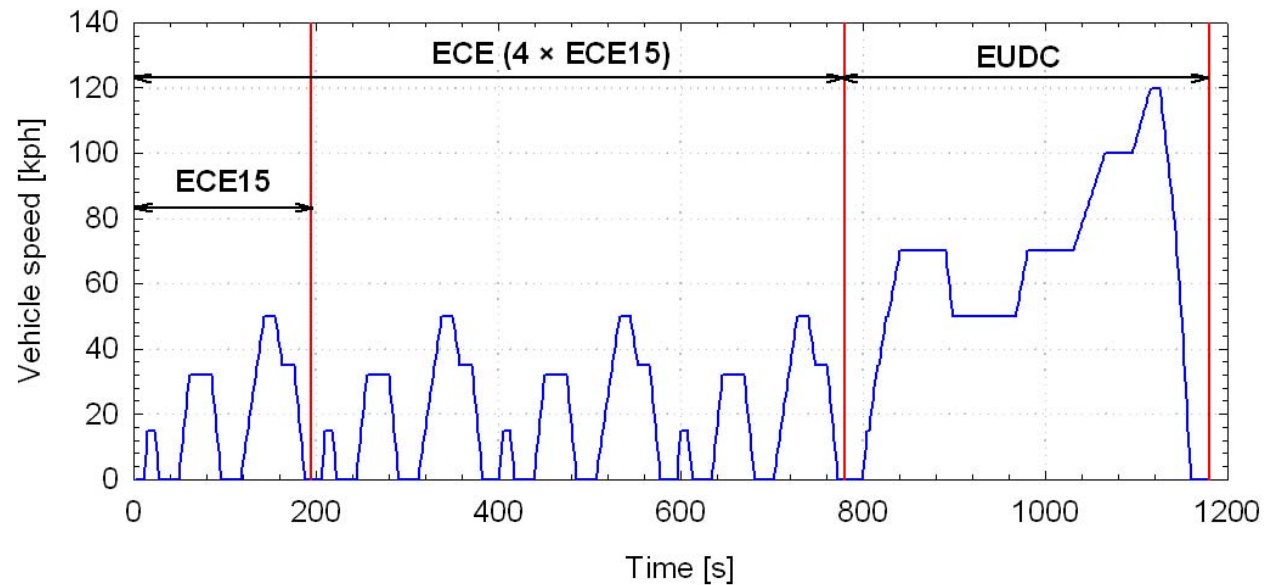
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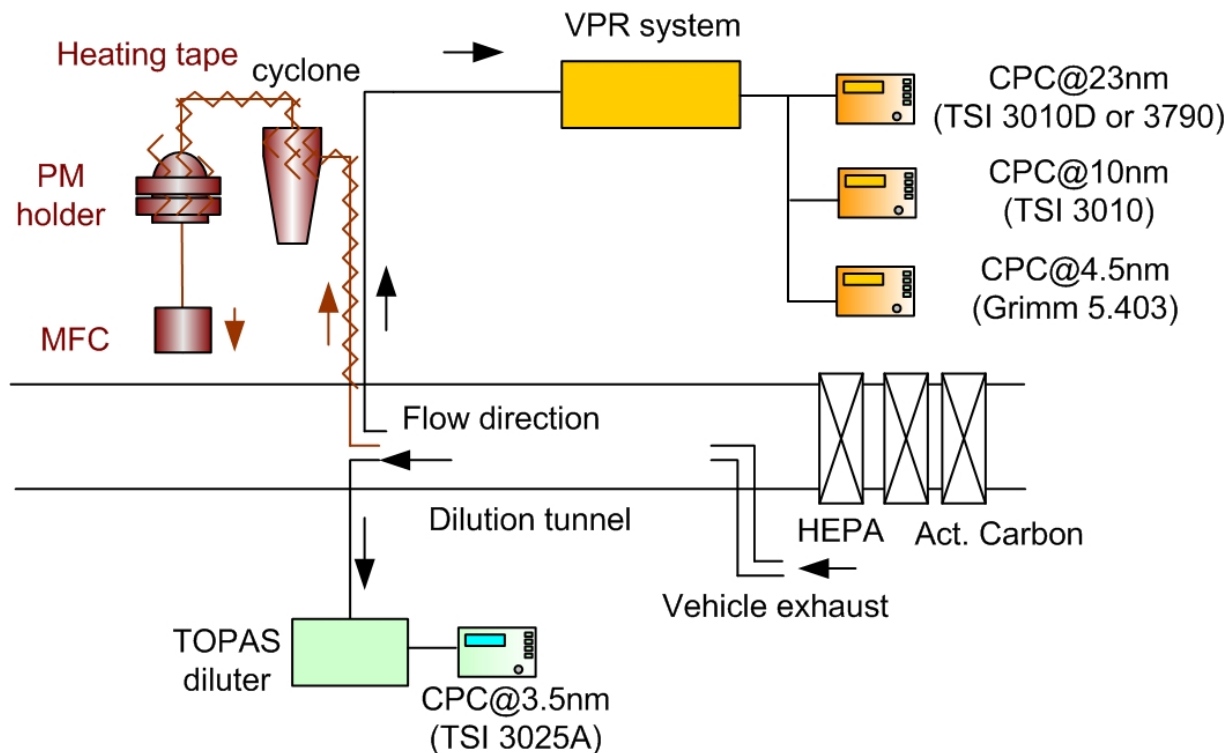
<http://www.jrc.ec.europa.eu/>

Vehicle fleet:

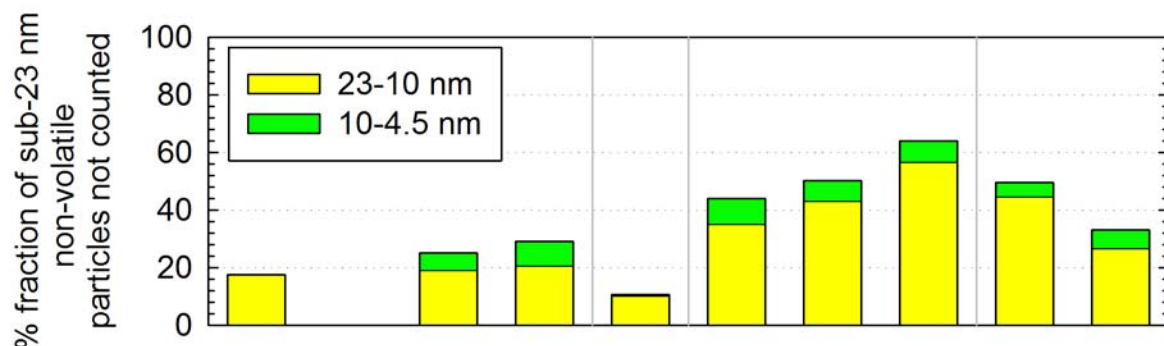
- **3×Gasoline Direct Injection (G-DI):**
 - 1 Euro 5 retrofitted with an optimized Gasoline Particulate Filter (GPF)
 - 1 Euro 5 Flexi Fuel Vehicle (FFV) tested on E5 and E85
 - 1 Euro 4 Twin Injection utilizing both direct injection and port fuel injection (G-DI/PFI)
- **2×PFI:**
 - 1 Euro 4 Bi-fuel running on Gasoline and CNG
 - 1 Euro 5
- **2×DPF:**
 - 1 Euro 5
 - 1 Euro 6 & SCR

- **NEDC:**
 - Cold start
- **Common Artemis Driving Cycles (CADC):**
 - Hot start
 - Urban, Rural, Motorway
- **Test cell temperature: 22 & -7°C**

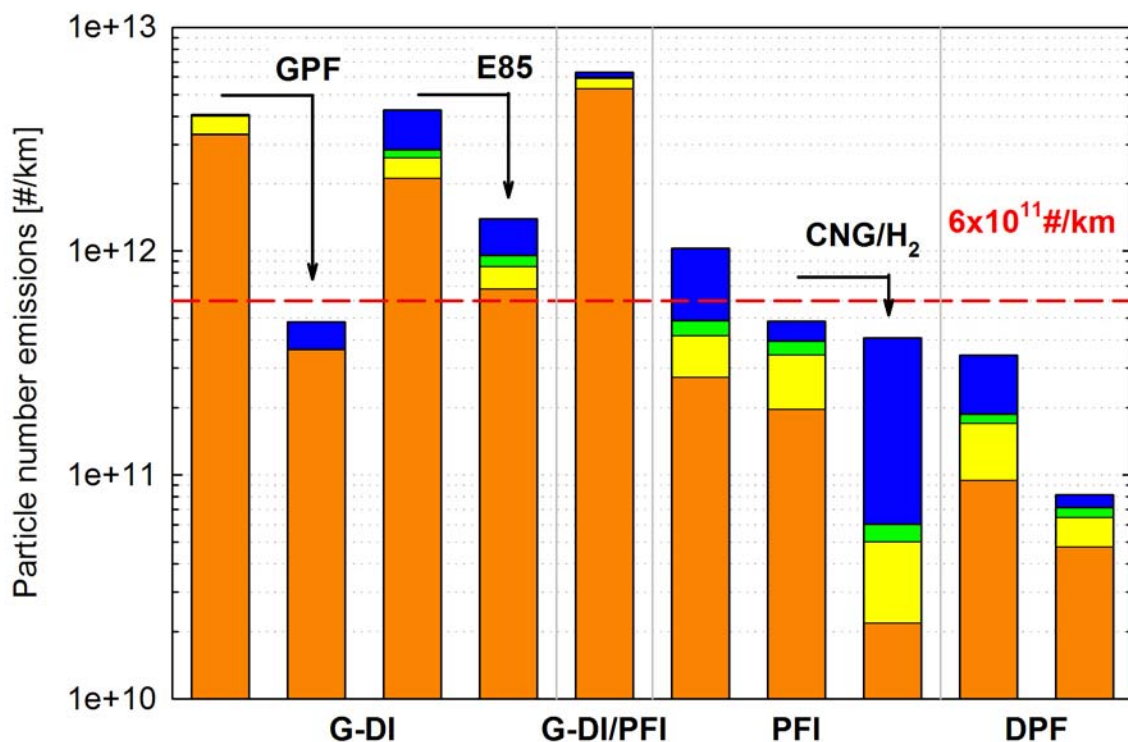




- **3×CPCs downstream of the VPR:**
 - d_{50} : 23, 10 & 4.5 nm
- **1×CPC with d_{50} at 3.5 nm measuring thermally untreated samples from the CVS**



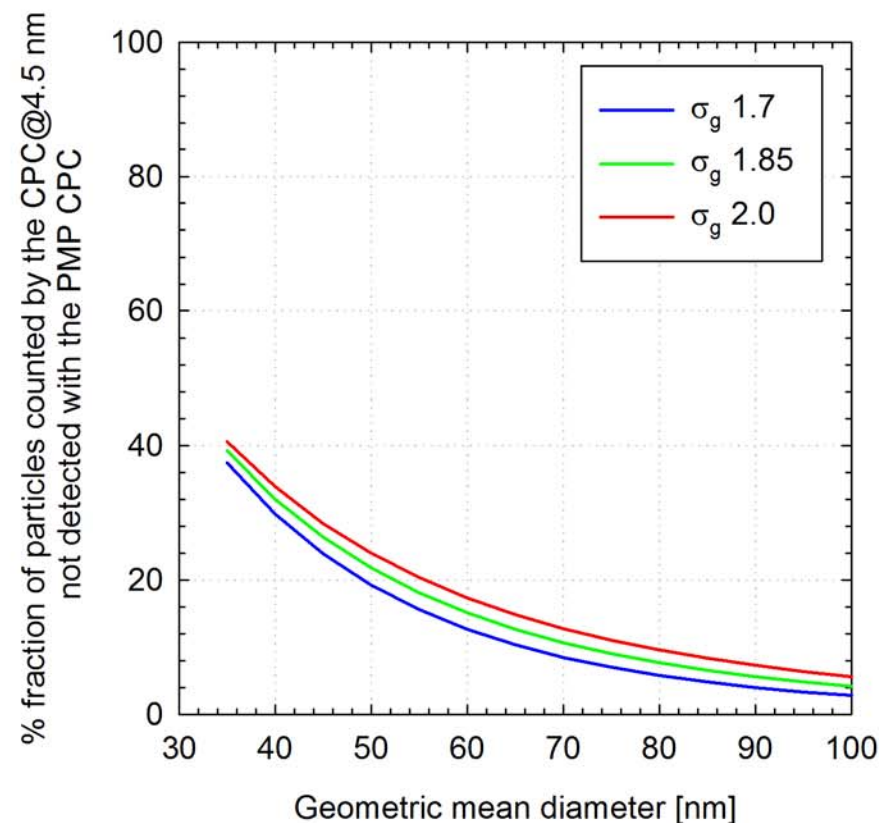
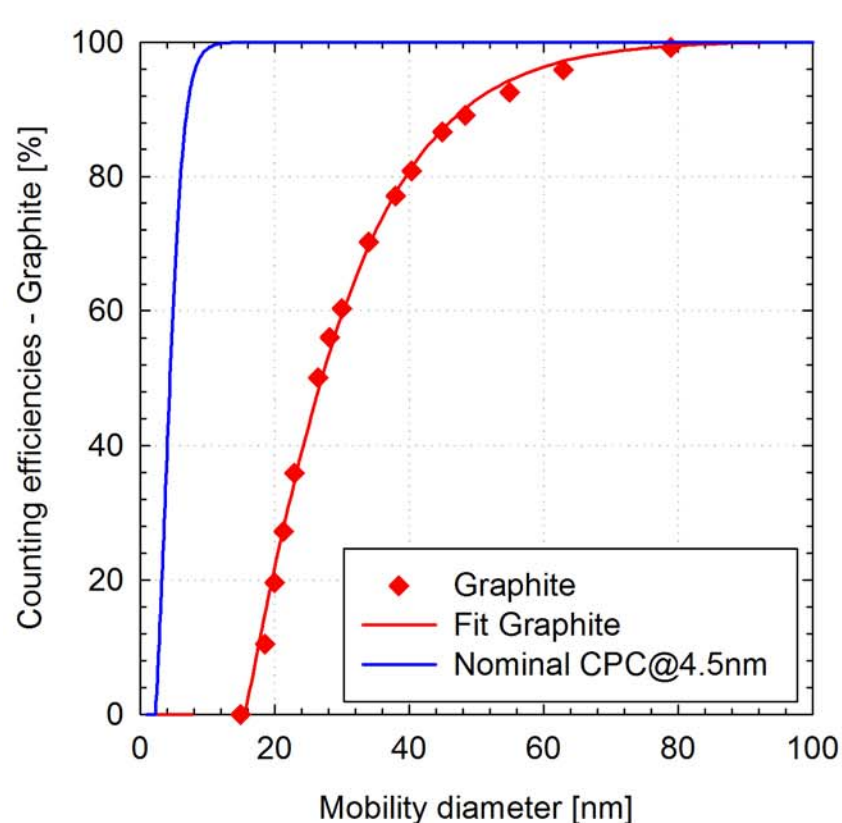
- “10-23 nm”:
 - 10-20% for G-DIs
 - 35-56% for PFIs
 - 26-45% for DPFs



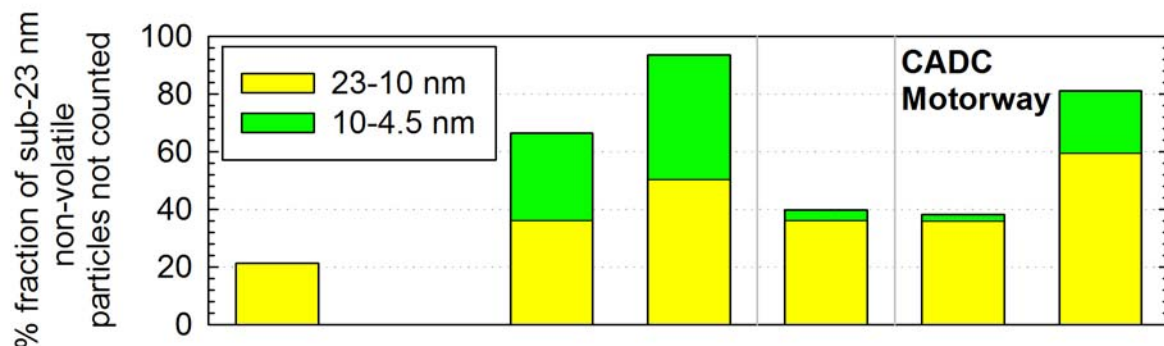
- “4.5-23 nm”:
 - 10-30% for G-DIs
 - 43-64% for PFIs
 - 32-50% for DPFs

- **GPF *per se* efficient in removing sub-23nm particles**



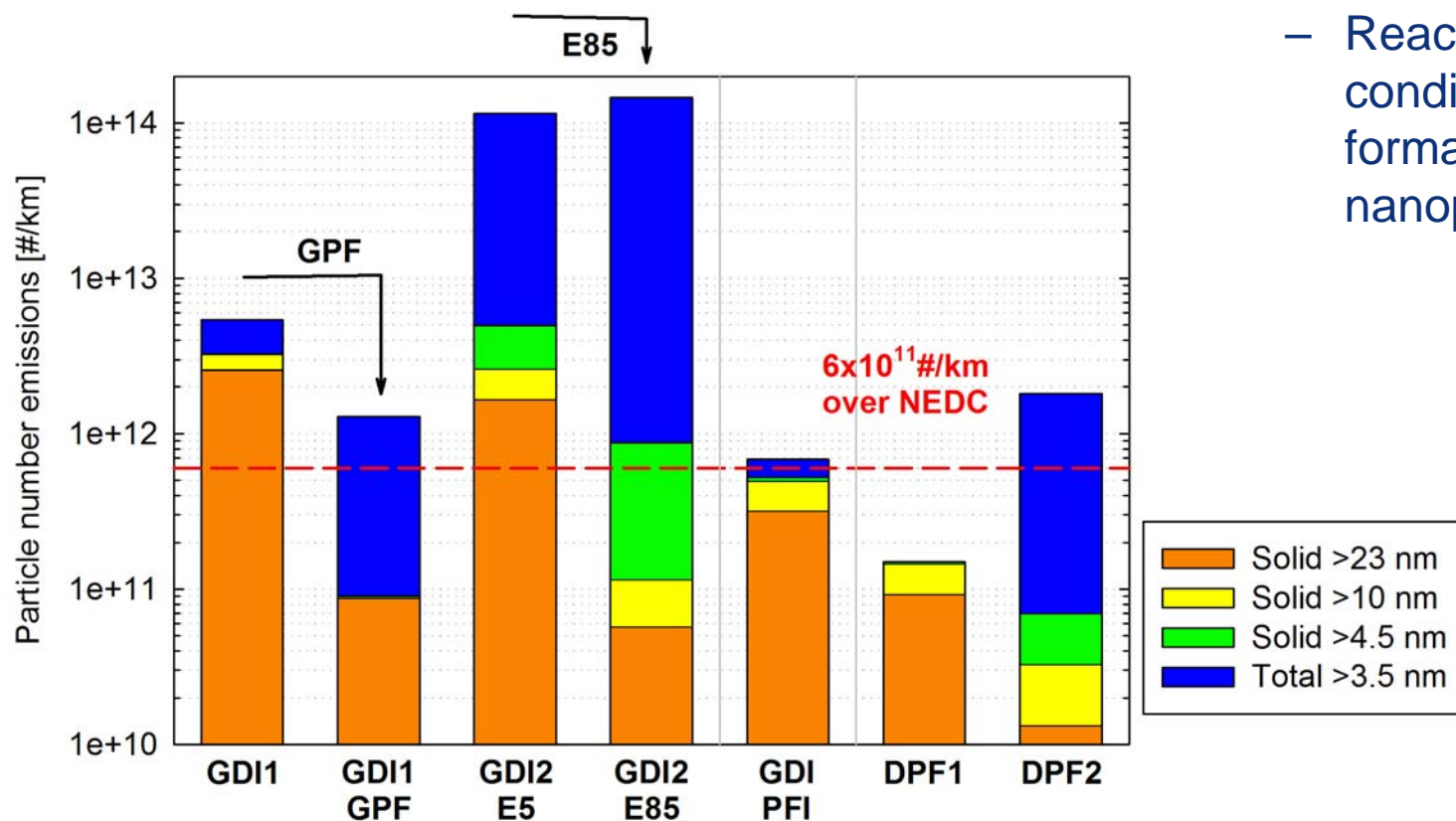


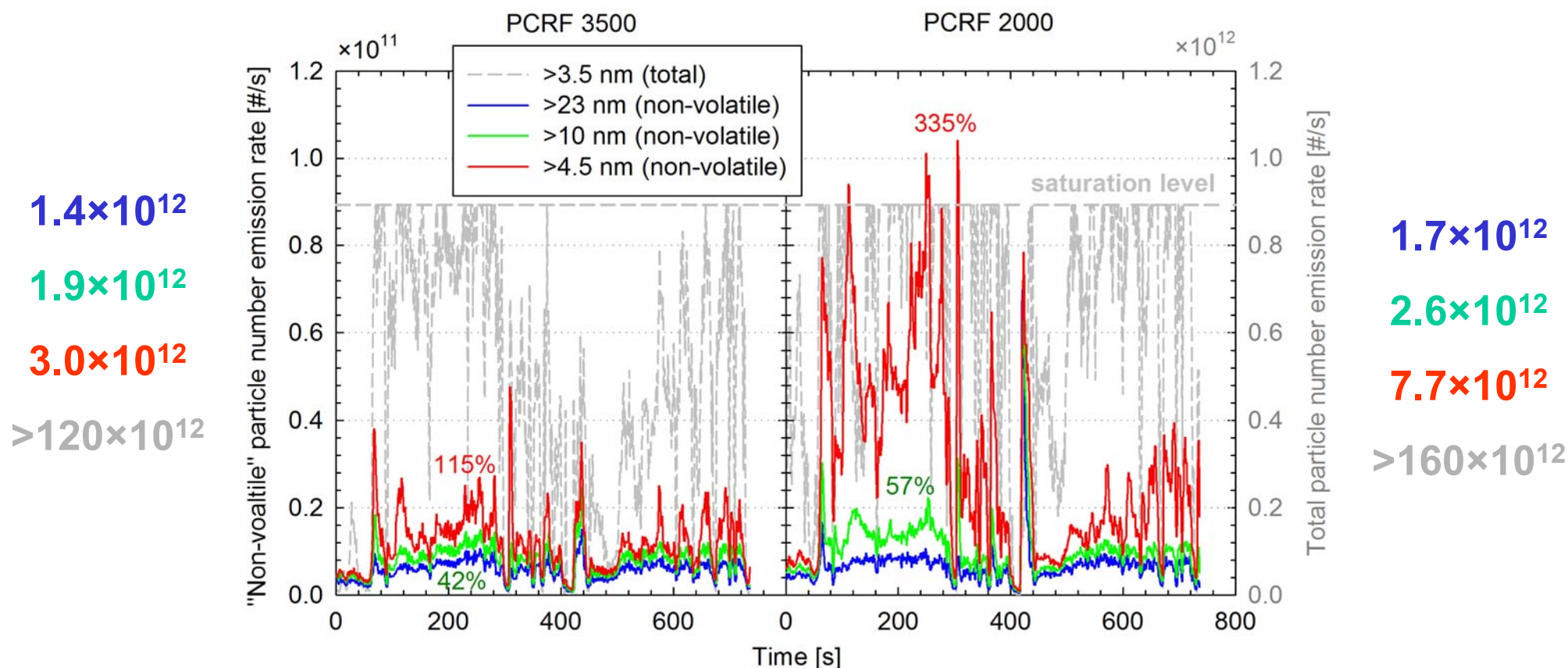
- Depending on the (mainly) mean diameter and (to a lesser extend) the geometric standard deviation of the distribution, 3 to 40% of the particles counted with the CPC@4.5 nm will not be detected with the PMP CPC.



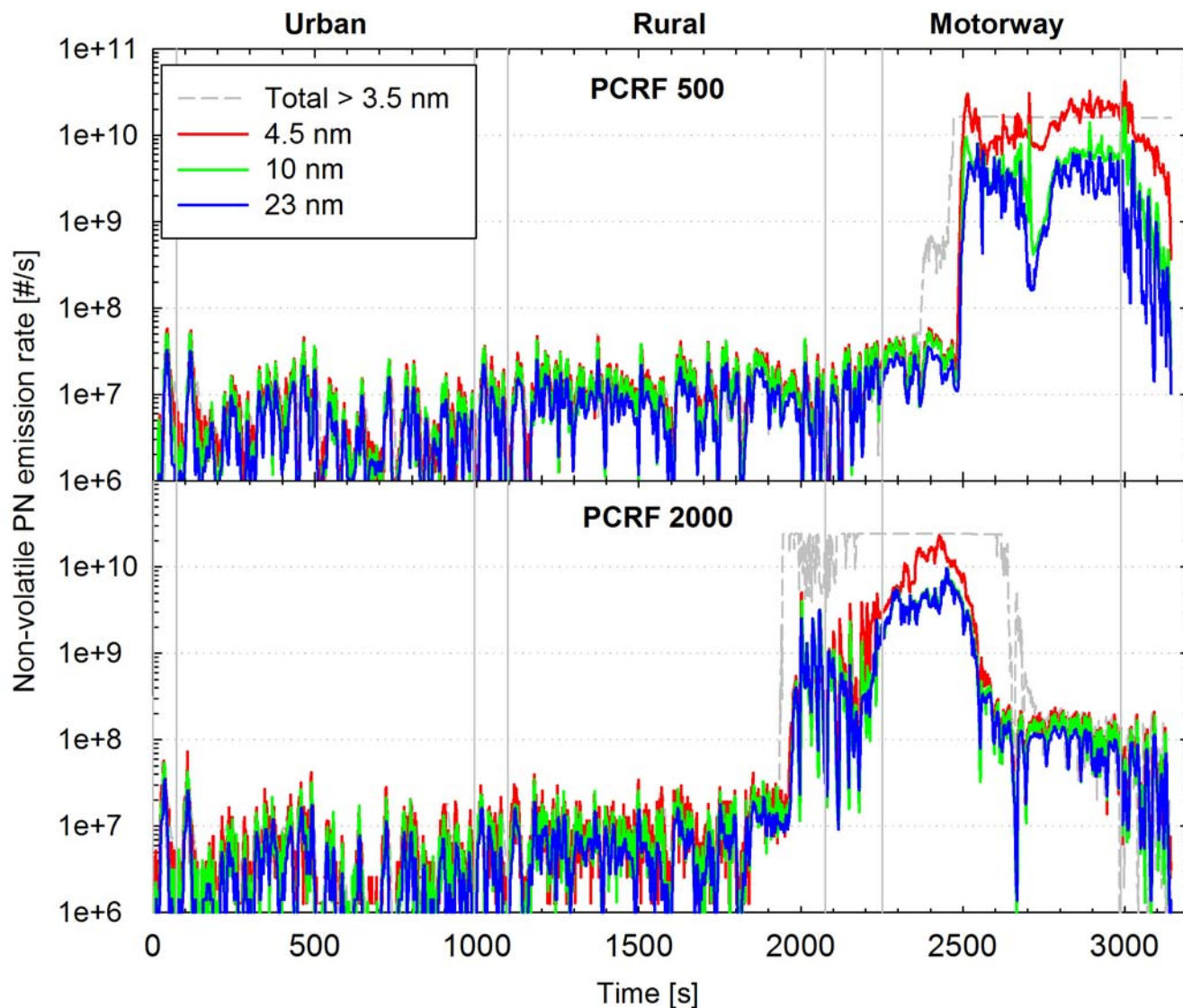
- “10-23 nm”:
 - 20-50% for G-DIs
 - 36-60% for DPFs

- “4.5-23 nm”:
 - Reaching up to 93% under conditions where extensive formation of volatile nanoparticles occurs





- Indications that in the case of substantial nucleation mode particle formation, the concentration of sub-23 nm particles counted downstream of the VPR depends on the PCRF
→ Volatile artifact interference



- **DPF regeneration results in elevated PN emissions over the entire regeneration event.**
- **Difficult to assess the performance of the VPR using a single system.**

- When limited formation of volatile nanoparticles took place, the fraction of non-volatile particles not counted with the PMP compliant CPCs was higher for PFIs (43-64%, CPC@4.5 nm as a reference) compared to G-DIs (10-30%, CPC@4.5 nm as a reference). This suggests that smaller particles are emitted from PFI vehicles.
- To a large extent the concentration levels of these excess “sub-23 nm” particle emissions could be attributed to the relatively blunt counting efficiency of the PMP CPC.
- The GPF tested was efficient in removing such nanoparticles. However, relatively high (32-50%) sub-23 nm emissions were observed with the two DPF equipped diesels.

- **Under conditions favouring nucleation mode particle formation, excessive “sub-23 nm” counts were detected especially with the CPC@4.5nm.**
- **Comparison of tests conducted using different PCRF values suggest that these excess sub-23 nm particles are suppressed at higher dilutions. This is indicative of volatile artifact.**
- **Elevated emissions of both volatile and non-volatile particles were observed during DPF regeneration. More investigations are required in order to assess the performance of VPR systems under these conditions.**

Thank you for your attention

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