

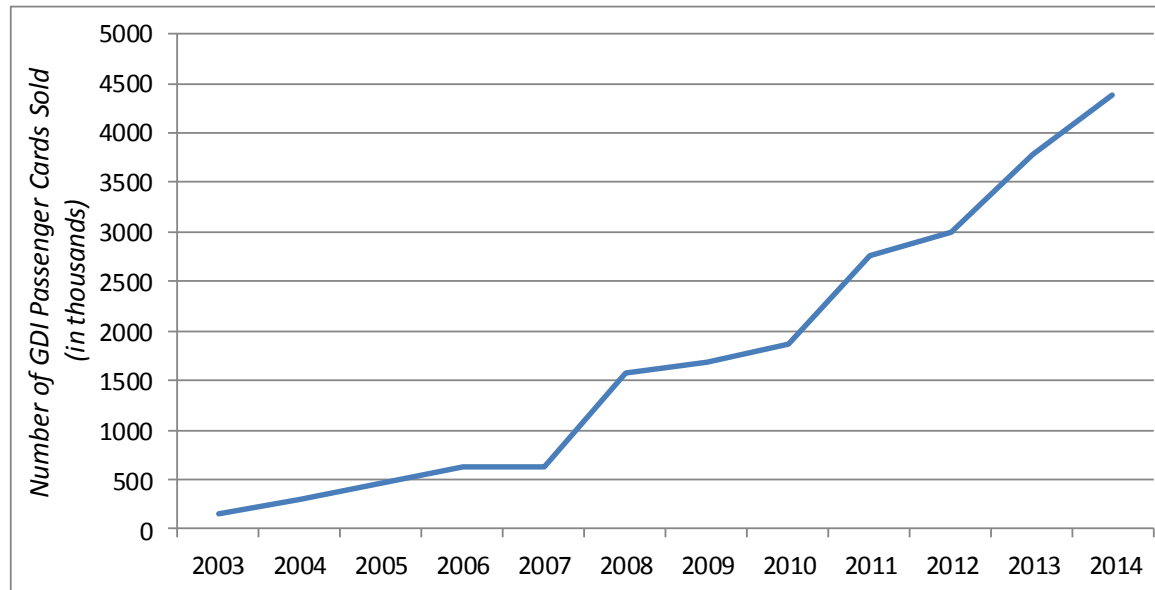


Issue of PN in GDIs

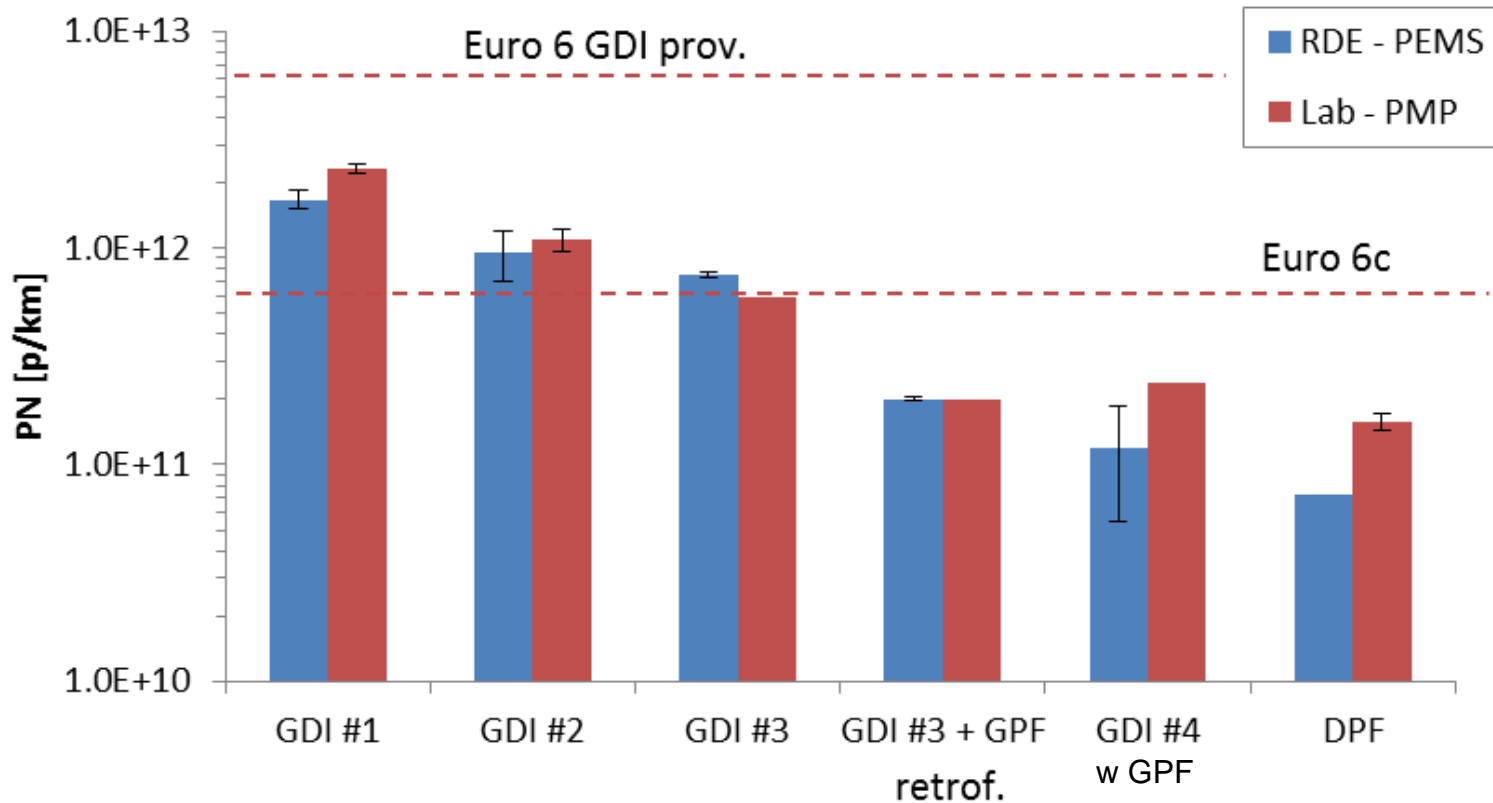
Slides presented during preparation of RDE3

GDI passenger cars in the EU

- In 2014 the market share of GDI represented 35 % of new car registration or **4,379,784 vehicles sold in the EU**
- Rising by 178% since 2008
- These vehicles conform to a temporary EURO6 emission limit of $6 \cdot 10^{12}$



PN emissions with in lab (PMP) and on the road (PEMS)

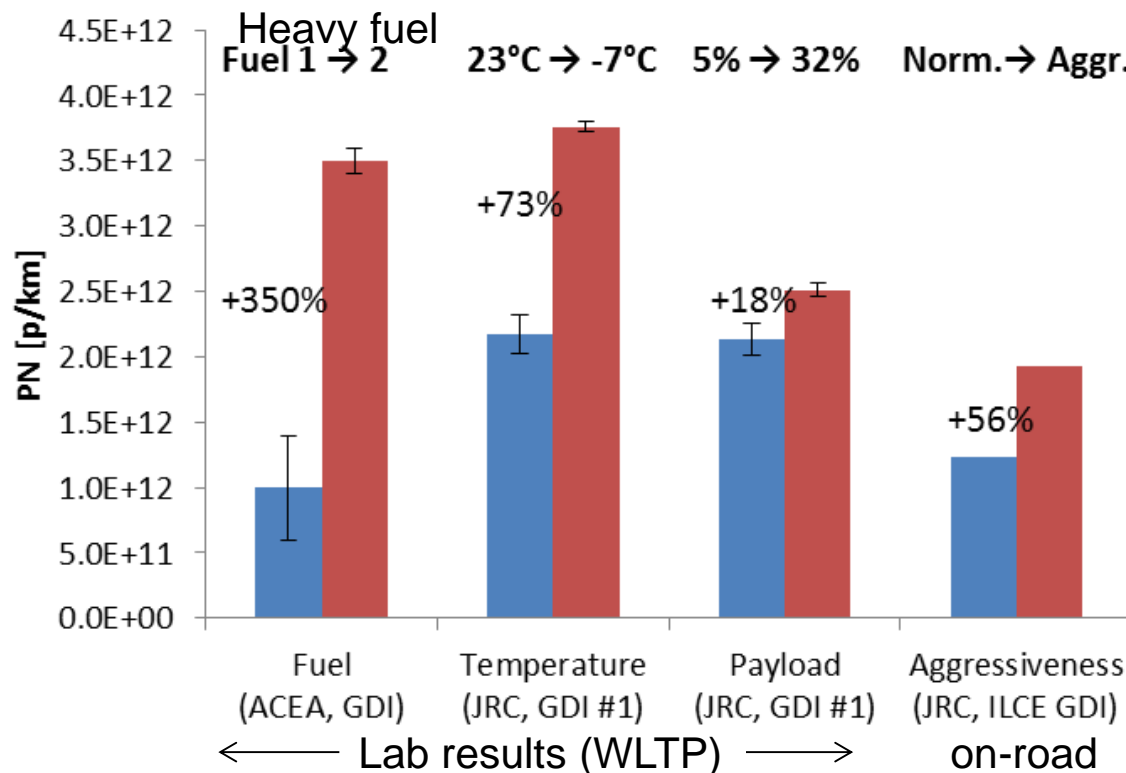


GDI1,2, DPF : Giechaskiel et al. 2015, Frontiers in Env. Sci. Air Pollution
 GDI3: Demuynck (AECC) 2016, Bonn, ICPC 4
 GDI4: Bosteels (AECC) 2016, ICPC 3rd

Real world influence on particle generation

- The previous was just a snapshot
- Many other influences:

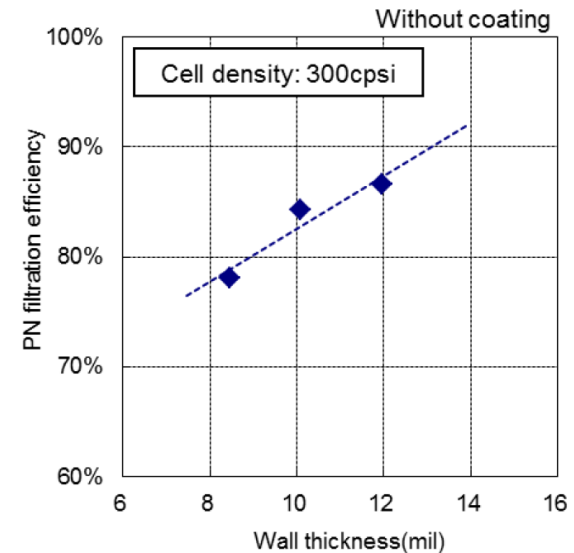
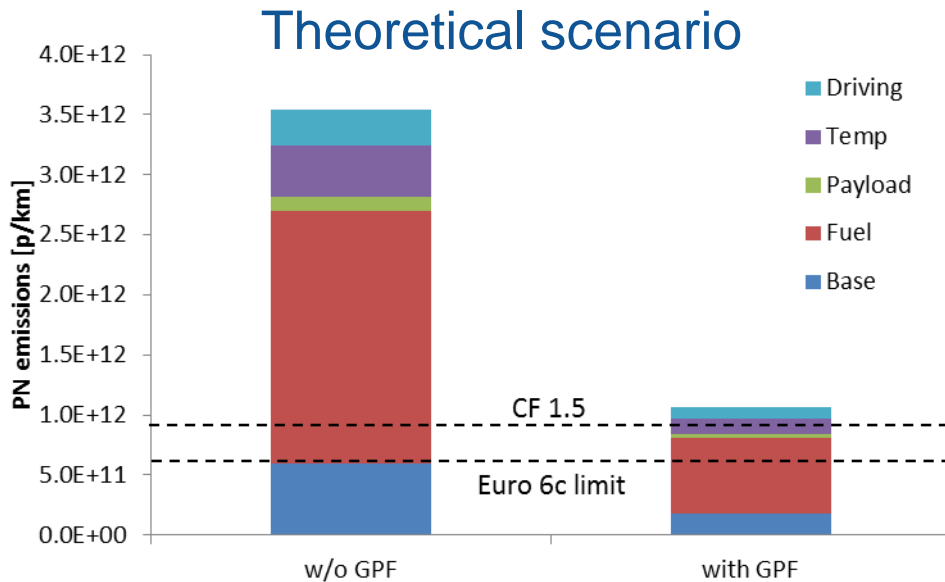
Fuel
Ambient temperature
Payload
Aggressive Driving



- Giechaskiel et al. 2015, Frontiers in Env. Sci. Air Pollution
- Riccobono et al. 2016
- ACEA/JAMA presentation

How low can PN from GDIs go in real life?

- Even with a Gasoline Particle Filter (GPF) these influences can amount to a significant contribution
- Care needs to be taken to have efficient GPFs
- Current practice suggests 60% efficiency, but can go up to 80% or even higher



Summary of results from LDV PN-PEMS investigations

- Equipment improved a lot and are improving continuously.
- Issues: Condensation at electrometers, dilution ratio uncertainty, failure of heated line, noise at low temperatures

PN-PEMS	Phase I (LDV)	Phase II (LDV)	ILCE (LDV)
	End of 2013	Sep – Dec 2014	Sep – Dec 2015
AVL (DC)	-40% to +80%	-49% to +48%	-
Horiba (DC) ^ \$	-100% to +100%	+11% to +150%	-
Horiba (CPC)	-	-21% to +49%	-41% to 54%
Testo (DC)	-6% to +114%	-48% to +55%	-39% to 42%
Pegasor (DC) ^	-50% to +120%	-58% to +199%	-
Sensors (DC) \$	-50% to +200%	-85% to +309%	-
Sensors (CPC)	-	Technical issues	-
Maha (CPC)	-	-45% to +49%	-
Shimadzu (DC) ^	-	-35% to +97%	-

^ Not compliant with latest technical specs

\$ Concept prototype. Discontinued

PN-PEMS Measurement uncertainty

Need to translate the EURO-6 limit (measured by PMP at CVS) into the equivalent measured with PN-PEMS

PN-PEMS vs	Theory	1 lab – many cars	1 car – many labs
PMP_TP	<25%	<35%	<40%
PMP_CVS	<50%*	<55%	<54%
TP vs CVS (PMP)	<30%	<40%	<35%

* Assuming 25% effect of sampling location (losses + exhaust flow uncertainties)

Proposal for PEMS-PN

- Inclusion of PN for RDE is technically feasible
- Equipment fulfill the technical specifications and have shown good behaviour during extensive testing
- Since technology exists (GPF) that allows even GDIs to be significantly lower than the EURO 6 limits, only the measurement uncertainty may be recognised
- Theory and the most extensive set of data available (JRC interlab and own tests) show that the uncertainty of measuring at the EURO 6 limit is at maximum 50%
- **NTE_{PN} : 1+ Margin PN (with Margin PN=0.5)**
- **With annual review clause**
- **In 2017 for new types, in 2018 for new vehicles**