EFCA Symposium Brussels May 15+16 2019

NPTI

New Periodic Emission Inspection to guarantee PN Emission Stability of all modern vehicles

Result of a VERT initiated International Task Force 2016-2018

A.Mayer, H.Burtscher, T.Lutz, V.Hensel

Modern «electronic» Engines provide much improved efficiency (CO_2) and power, but Emissions PN and NOx are still high

Petrol engines are high emitters and were only cleaned by the 3WC – John J.Mooney 1970 – still they emit high PN and the TWC let PN pass – GPF or 4WC is needed

Diesel engines need DPF to «eliminate» PM/PN-emissions from combustion, lubrication oil packages and wear.

Diesel Engines also need oxidation catalysis DOC to eliminate PAH, Nitro PAH and other highly toxic substances

Diesel engines need DeNOx to reduce NO2 and NO → SCR+

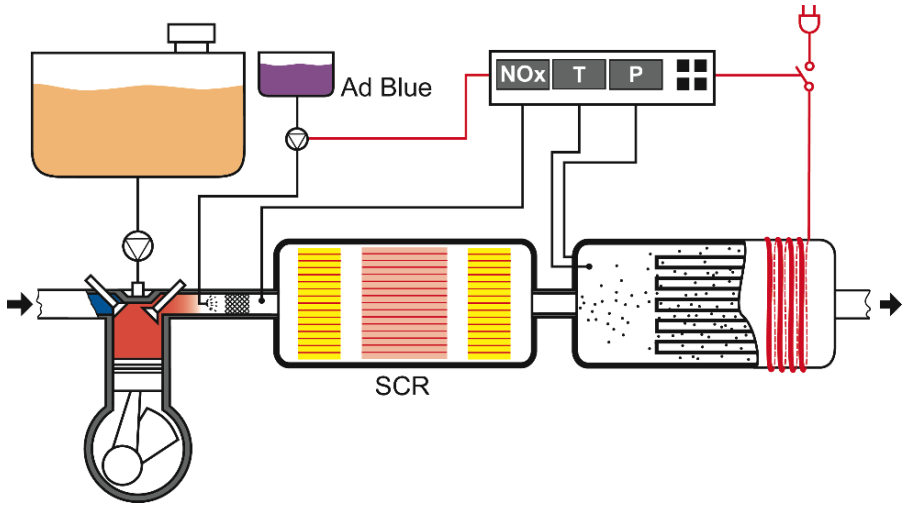
Modern Engines have ideally **de-coupled** functions:

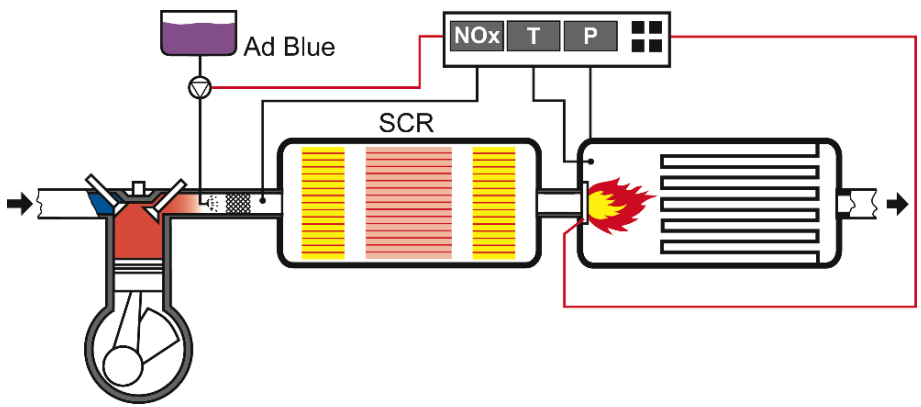
- The Engine operates at best Performance for CO2
- Aftertreatment EAC detoxifies perfectly the Exhaust Gas

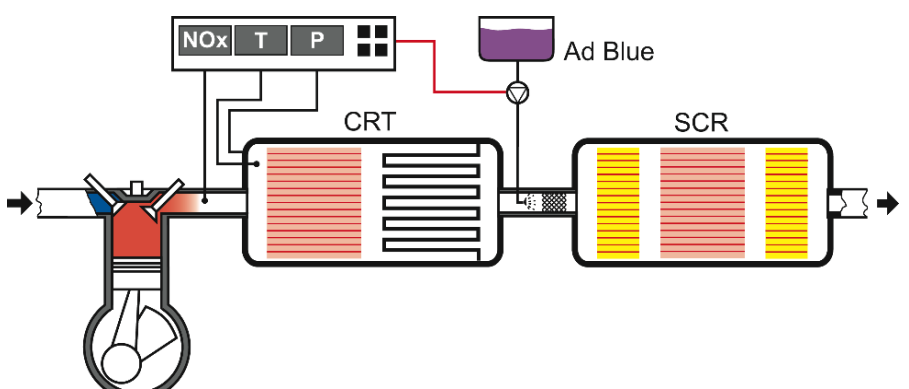
Emission Control by aftertreatment is indispensable

- very efficient > 99%
- but no plug and play
- depend on operation profile
- risk of wear, aging and poisoning, pollution
- **risk of tampering with and manipulation** by manufacturer and operator

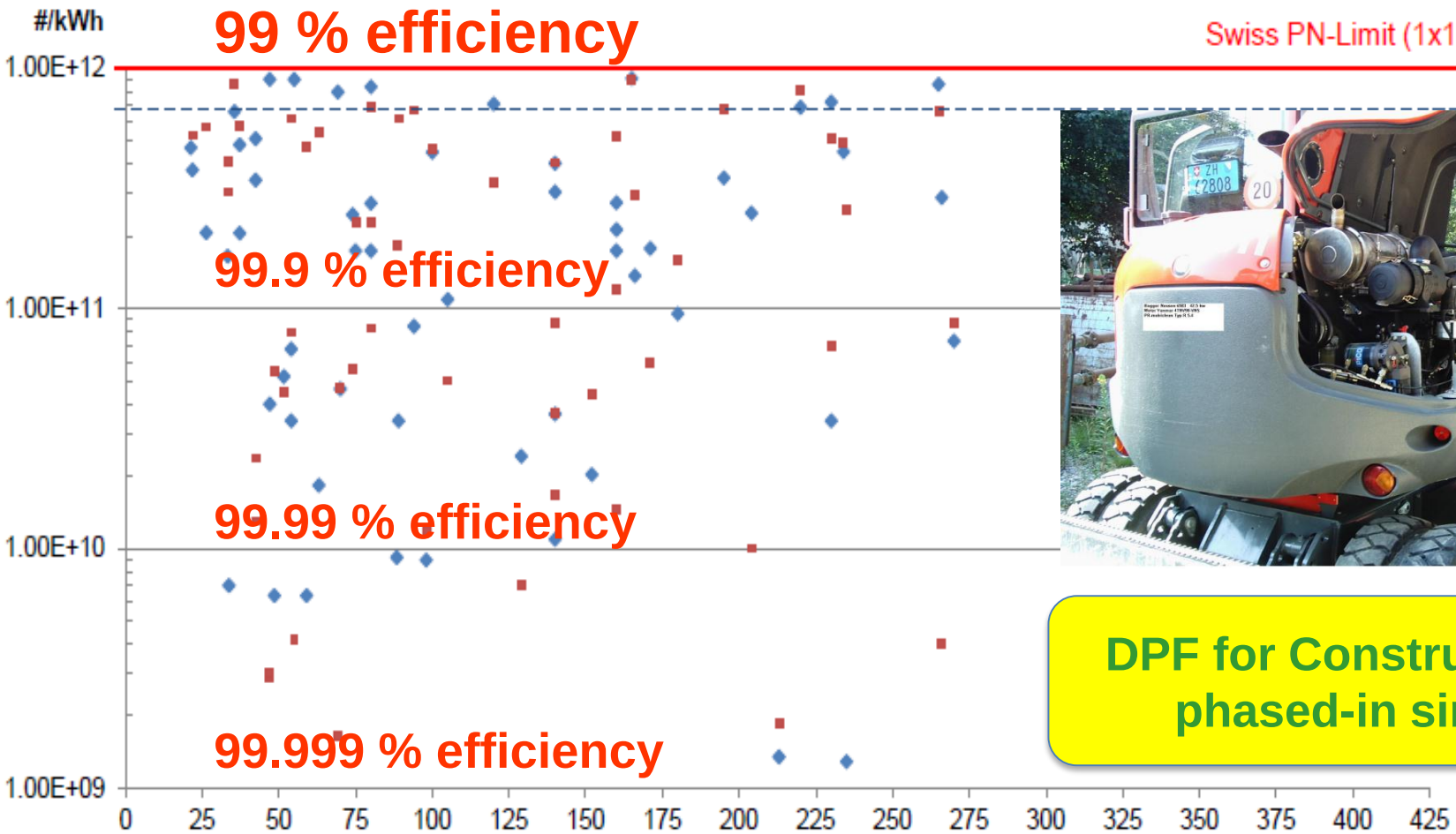
→ Control is required







PN-Test results



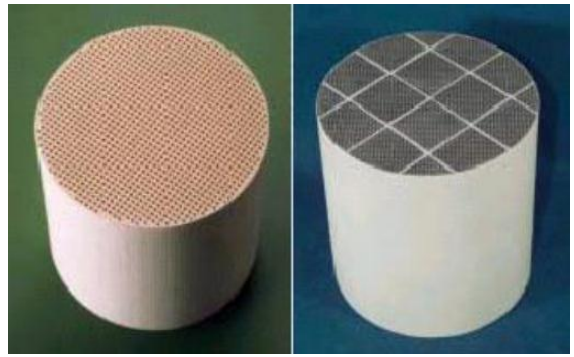
DPF for Construction in CH phased-in since 1998

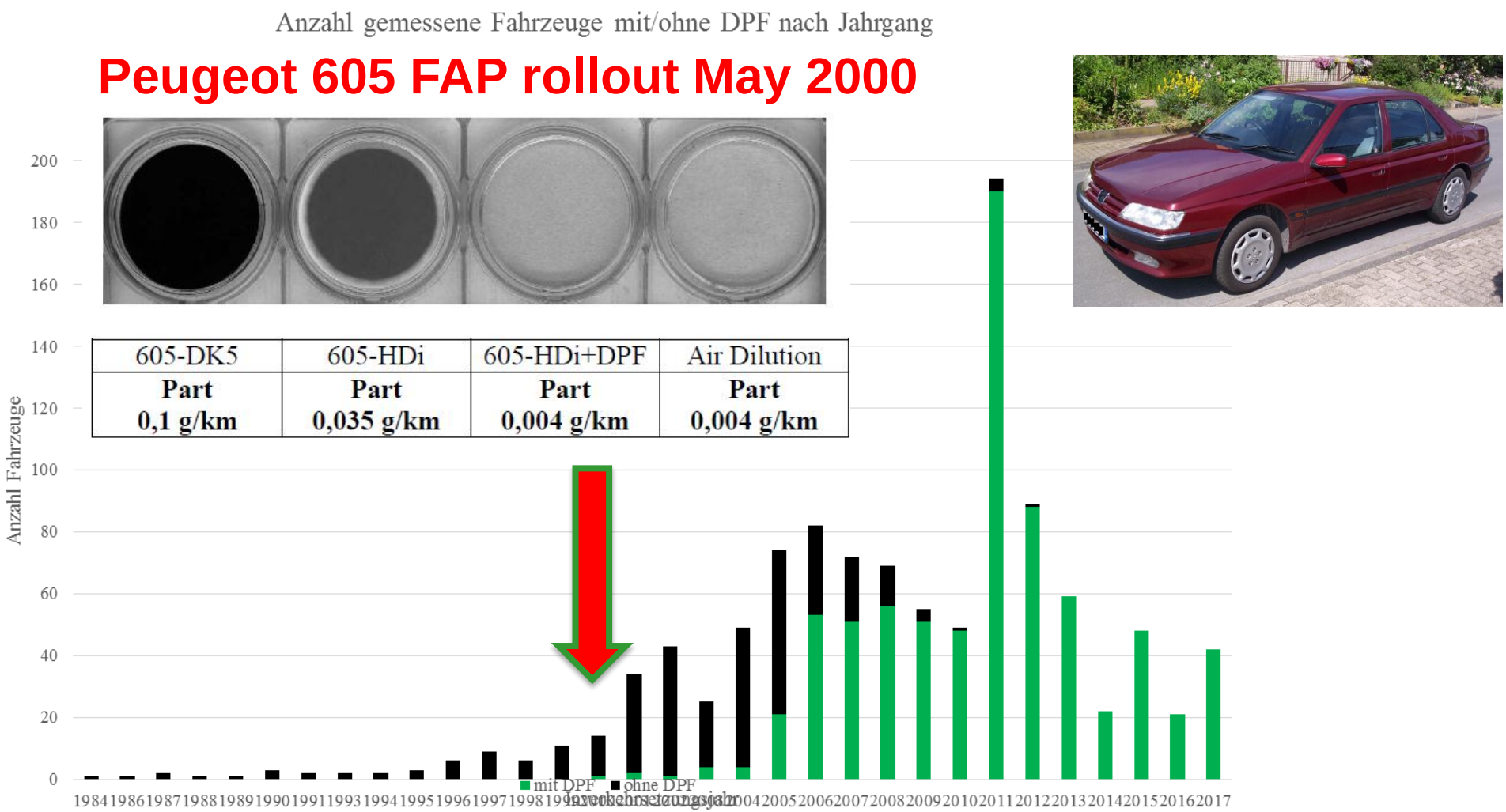
Type approval of imported construction machines in stationary and transient cycle
In function of engine power [kW]

DPF Technology permits limit strengthening by one order of magnitude

Number of Vehicles with/without DPF

for different immatr. years in Switzerland

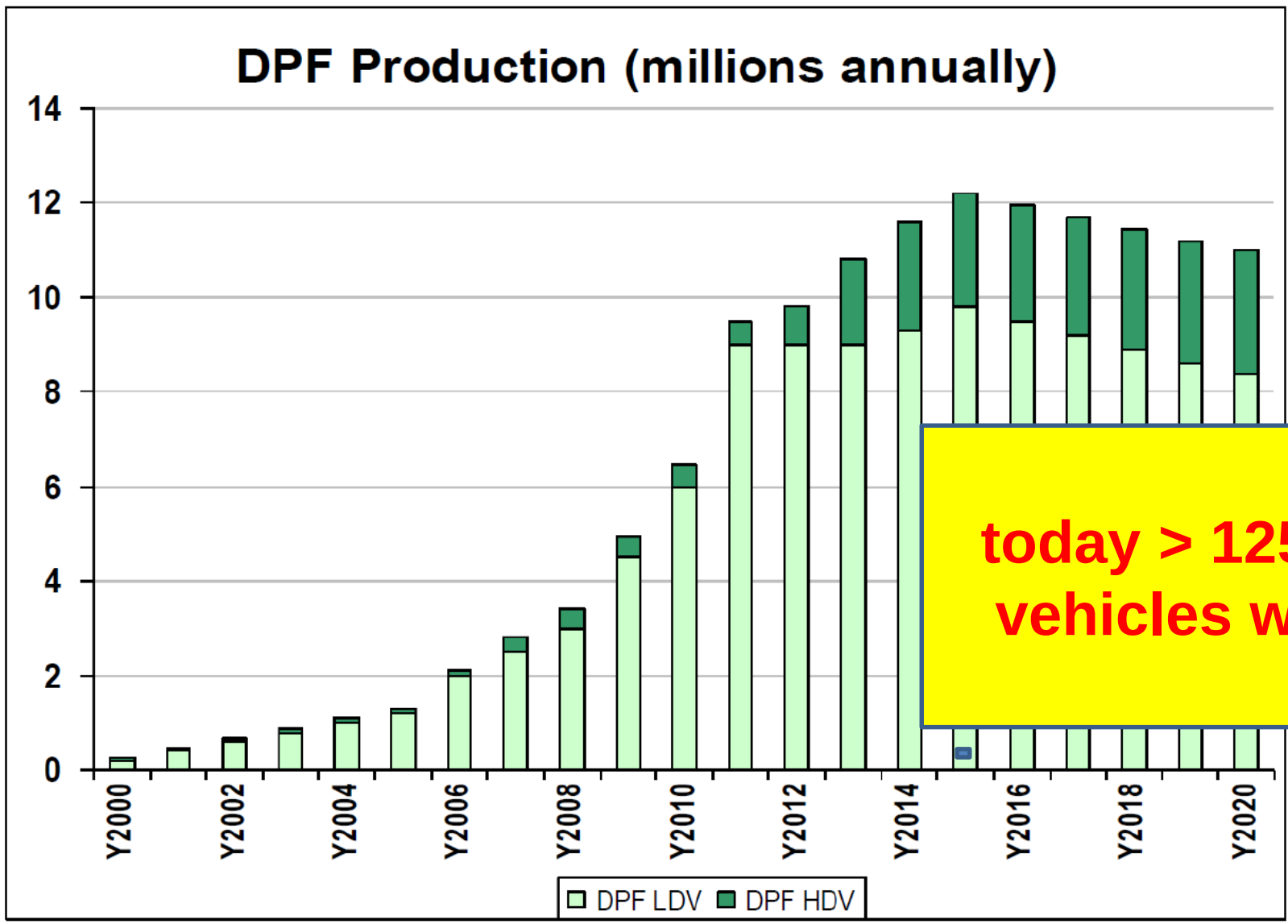




DPF-Installations in Europe

and GPF to come

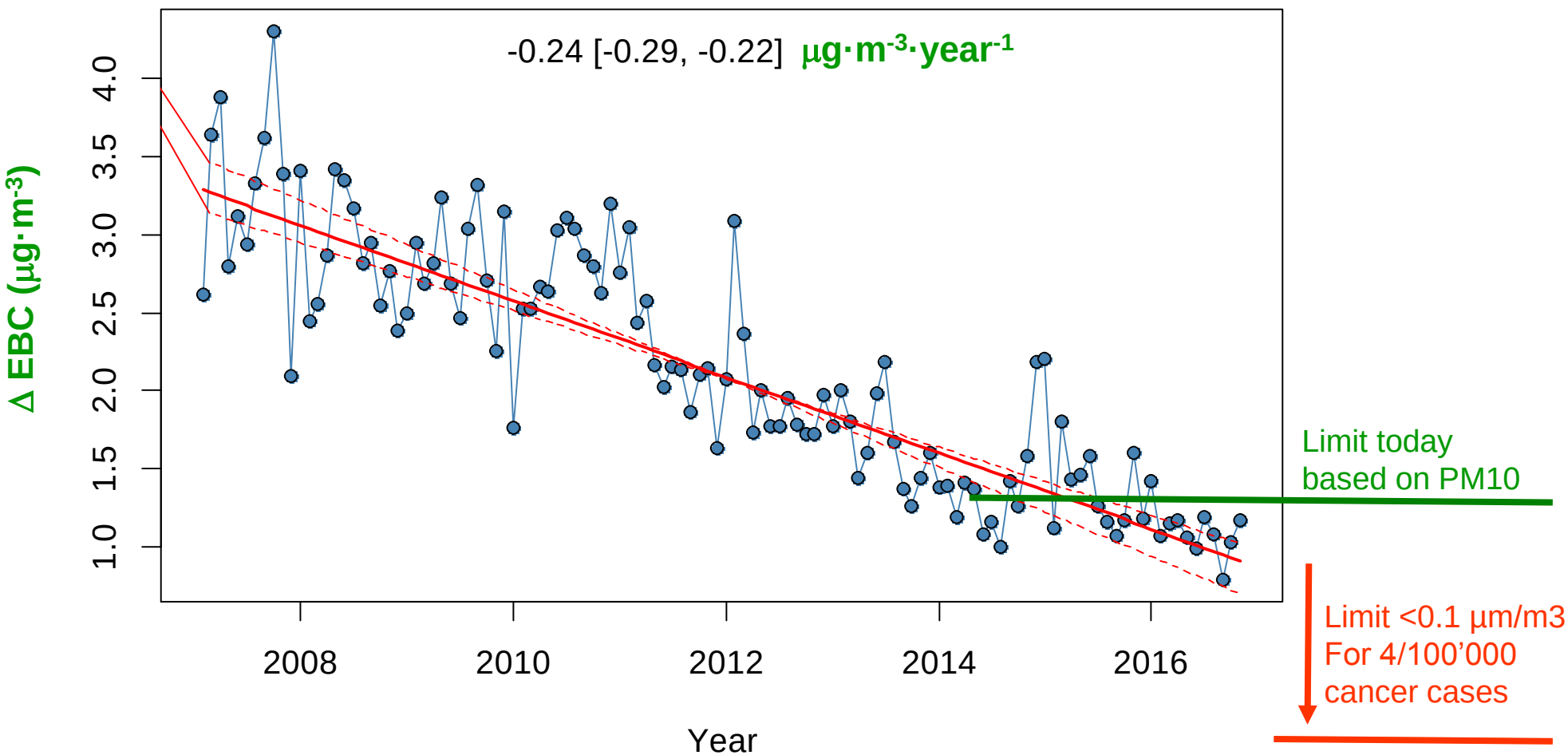
China, India, Israel
Iran and Latin America
are following



today > 125 million vehicles with DPF

and the Result:
Cleaning the Air by DPF in Switzerland

Monitoring BC at the motorway crossing Härkingen



With this we have reached

Orders of Magnitude

of Emission Reduction by EAC

to improve public health

but at the same time we are facing

a high risk for Emission Stability

due to serious flaws in Legislation

Implementation and Enforcement

Biggest Mistake of EU-Policy 2012

invited car makers to fraudulent hard-and software

Independent Control delegated to OBD

Control replaced by Selfcontrol

A. Homologation of New Vehicles

B. Manufacturing Conformity

C. In Use Compliance → never fully introduced

D. **Periodic Control PTI** → **abolished 2013**

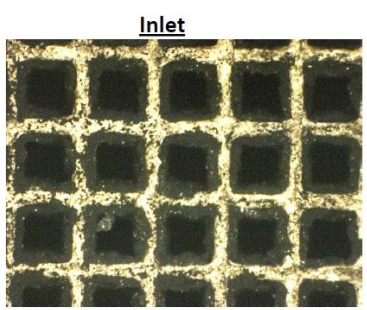
for safety and emissions replaced by OBD

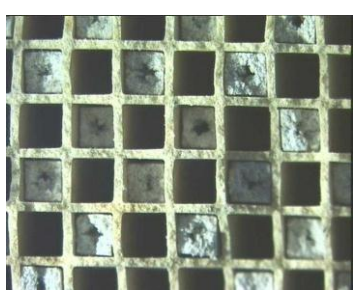
EU-Directive 2014/45

Control for Public Health must be independent

(Montesquieu: De l'esprit des lois 1748 → la séparation des pouvoirs 1748)

and this is what we are finding – why?



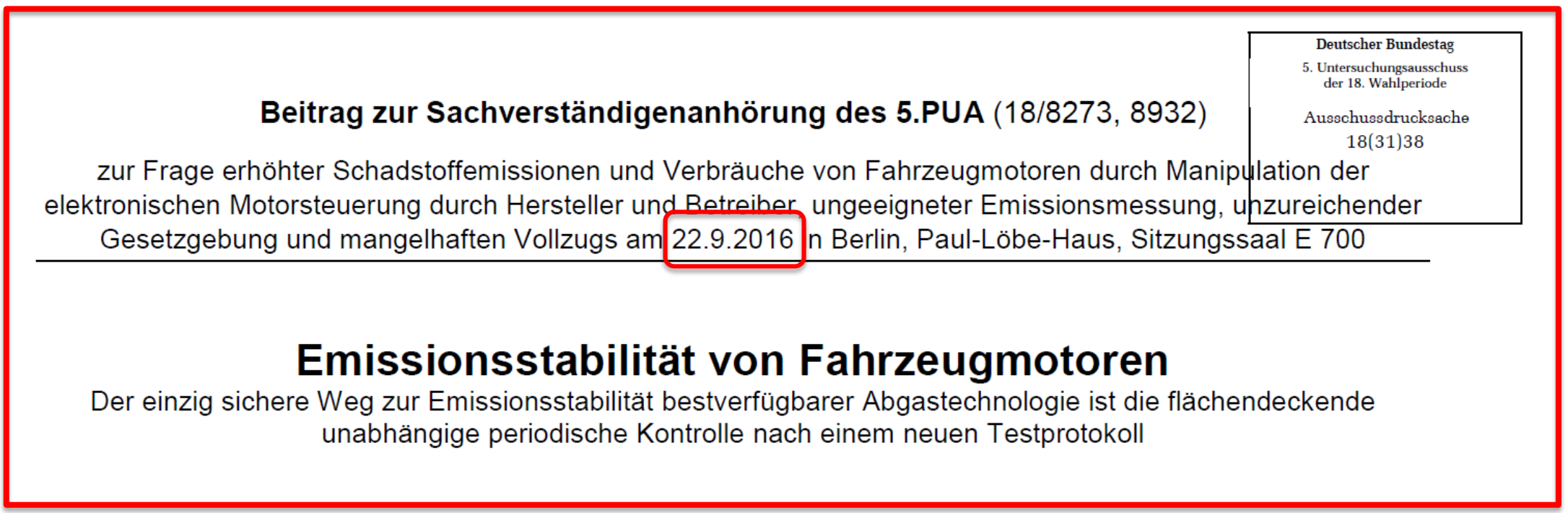


because they want to avoid cost for proper repair or cleaning

VERT at Expert Hearing Bundestag 5 PUA Berlin 22. Sept. 2016 on Dieselgate

→ **This must be reversed and Emission PTI must become EU-Regulation**

and here is my recommendation to the German government 9/2016



Deutscher Bundestag
5. Untersuchungsausschuss der 18. Wahlperiode
Ausschussdrucksache 18(31)38

Beitrag zur Sachverständigenanhörung des 5.PUA (18/8273, 8932)

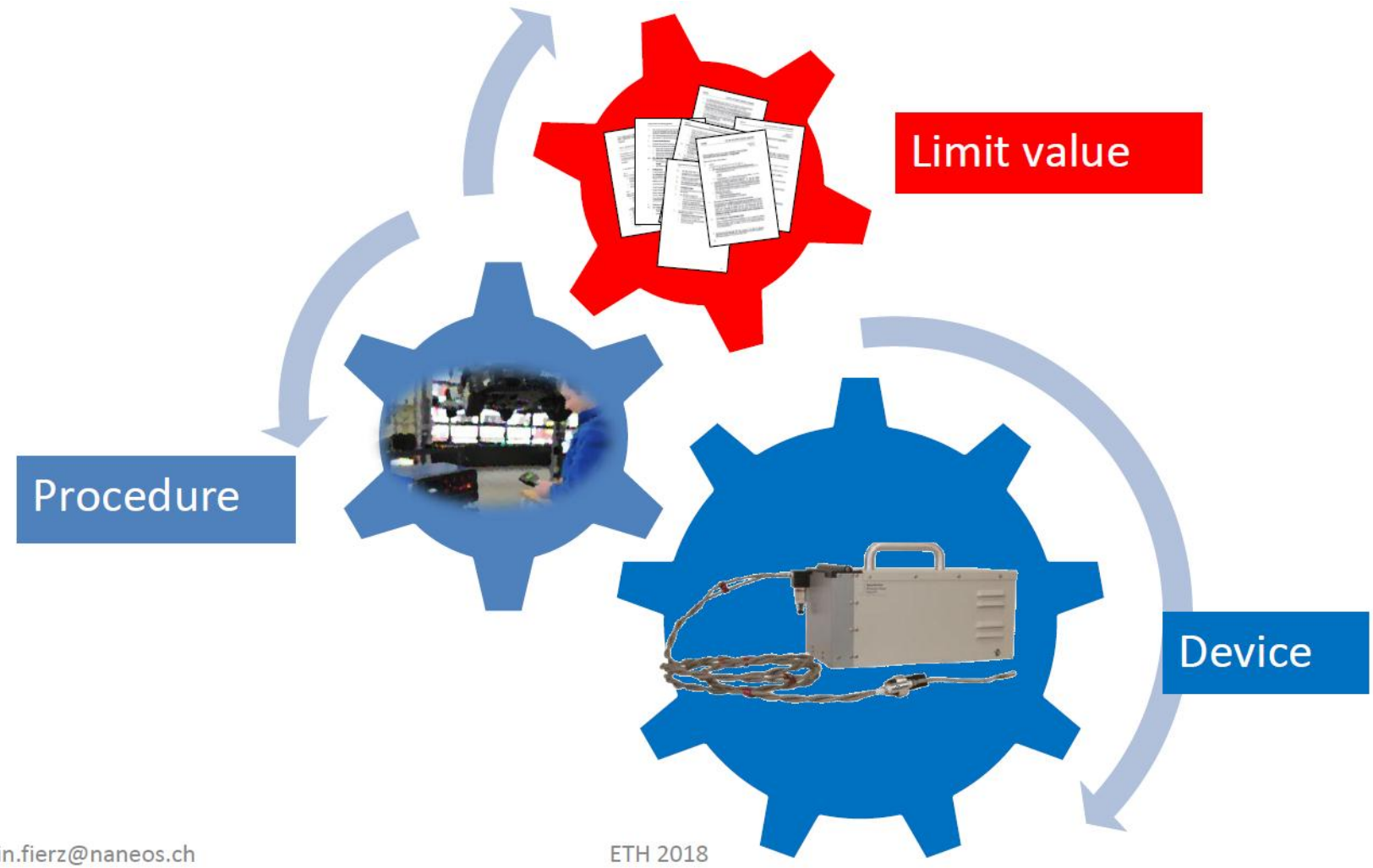
zur Frage erhöhter Schadstoffemissionen und Verbräuche von Fahrzeugmotoren durch Manipulation der elektronischen Motorsteuerung durch Hersteller und Betreiber, ungeeigneter Emissionsmessung, unzureichender Gesetzgebung und mangelhaften Vollzugs am 22.9.2016 in Berlin, Paul-Löbe-Haus, Sitzungssaal E 700

Emissionsstabilität von Fahrzeugmotoren

Der einzig sichere Weg zur Emissionsstabilität bestverfügbarer Abgastechnologie ist die flächendeckende unabhängige periodische Kontrolle nach einem neuen Testprotokoll

→ **Gemany Road Authority reacted immediately be re-activation of AU January 2017**

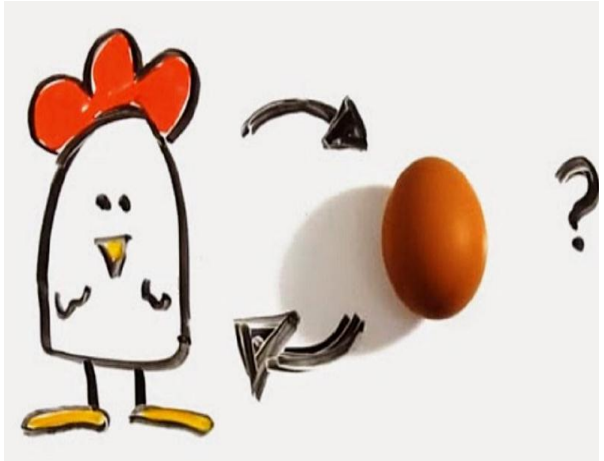
but New PTI is a package with 3 elements and EU member states are responsible



NPTI – Task Force

Kicked off by VERT and TNO 23.11.2016

NL, CH, DE, BE, EU … FR, GB, ES



The Netherlands: G.Kadijk , L.Zuidgeest, P.Kok, H.Peeters-Weem, H.Bussink
Switzerland: Th.Lutz, H.Burtscher, V.Hensel, A.Mayer / VERT
Germany: S.Limbeck/BASt; V.Ebert/PTB; D.Saar/DUH
Belgium: P.Buekenhoudt, B.Veldeman, Ph.de Meyer / GOCA
EU-JRC: R.Suarez-Bertoa

TSI: J.Spielvogel
AVL: K.Schulte, W.Lukesch
SENSORS: O.Franken, D.Booker, J.Morril
TESTO: M.Stratmann, M.Schumann, M.van Dam
DEKATI: M.Moisio
PREMIERDiagostics: R. Wilce
HJS: Ph.Schulte
MAHA: D.Mohr
EGEA: G.Petelet
TEN: Marc de Goede

Concept

for a very efficient and cost effective 100% in-use periodic emission control for DPF equipped vehicles

- **PN-Test at low idle**
- **Pass/Fail Criterion: < 100’000 1/cc**

This Test is much more than just Pass/Fail

It supplies **quantiative diagnostic** information for the **functionality** of each emission control component and the engine as well and permits **preventive repair and maintenance.**

Instruments available at that time

handheld, Battery-powered

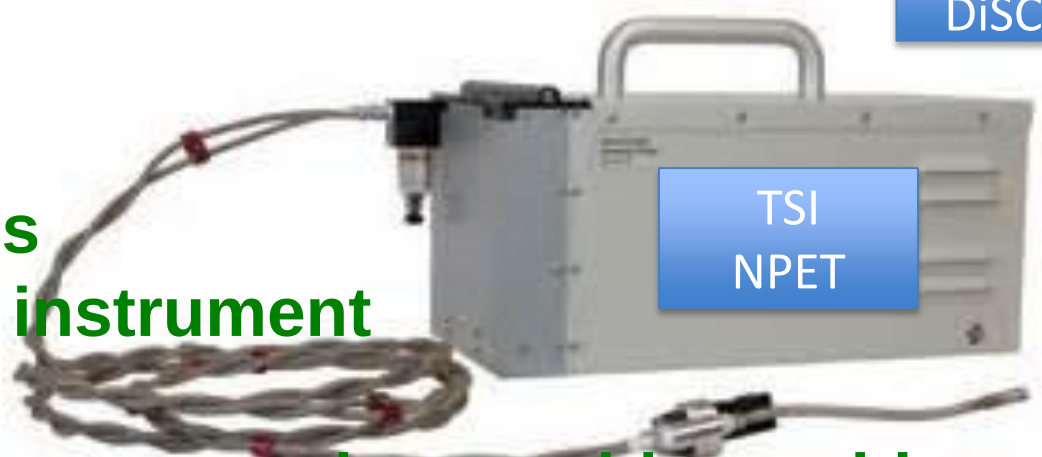
CPC and DC
For ambient
PN
measurment

TSI
P-Trak

TESTO
DiSCmini

Naneos
Partector

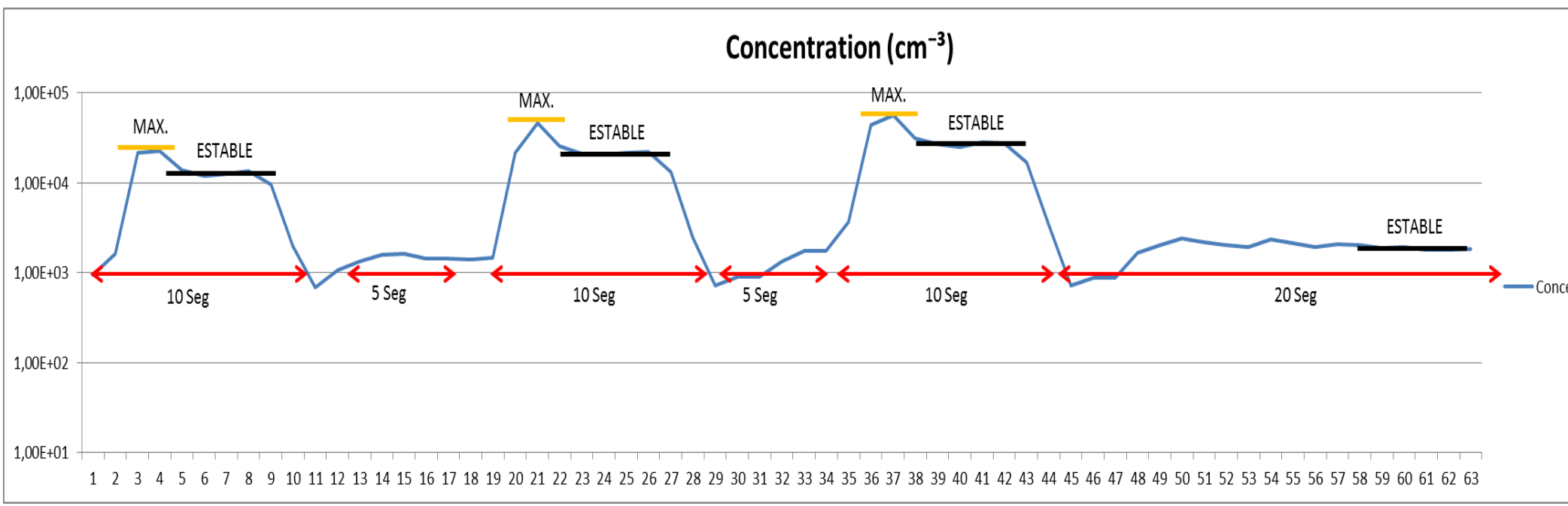
NPET
The Swiss
standard instrument
for PTI



TSI
NPET

of 60’000 construction machines with particle filters

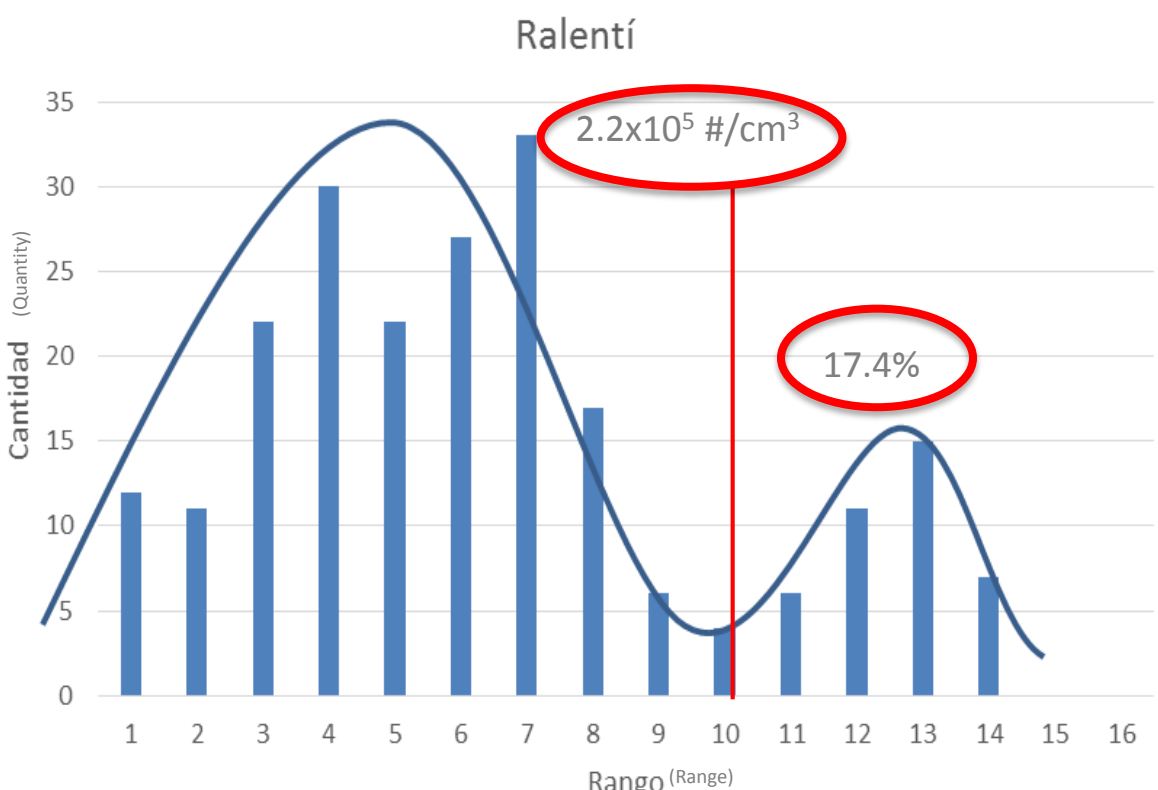
Start 2015 with VERT- SANTIAGO
Measurement Protocol Roadside
Opacity and PN at exhaust exit
during free acceleration, high idle and low idle
2015 - 400 vehicles



VERT in Santiago de Chile 2015

Quality Control of 400 DPF buses retrofitted 8 years ago stopped by police at roadside

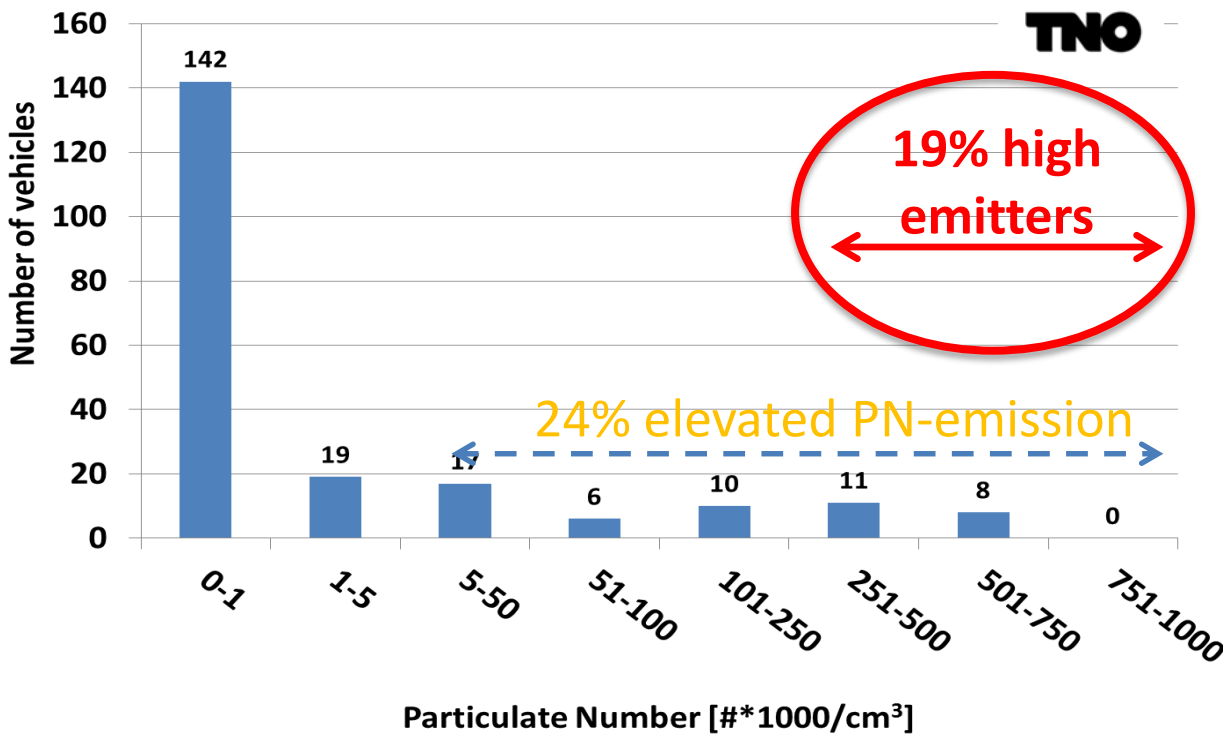
PN measurement by TSI NPET



Range	≥	<	N	Condition
1	1,00E+02	2,20E+02	12	Normal
2	2,20E+02	4,70E+02	11	Normal
3	4,70E+02	1,00E+03	22	Normal
4	1,00E+03	2,20E+03	30	Normal
5	2,20E+03	4,70E+03	22	Normal
6	4,70E+03	1,00E+04	27	Normal
7	1,00E+04	2,20E+04	33	Normal
8	2,20E+04	4,70E+04	17	Normal
9	4,70E+04	1,00E+05	6	Normal
10	1,00E+05	2,20E+05	4	Indifferent
11	2,20E+05	4,70E+05	6	Abnormal
12	4,70E+05	1,00E+06	11	Abnormal
13	1,00E+06	2,20E+06	15	Abnormal
14	2,20E+06	4,70E+06	7	Abnormal
15	4,70E+06	1,00E+07	0	Abnormal
16	1,00E+07	2,20E+07	0	Abnormal
		TOTAL	223	

A. Reinoso
ETH-NPC 2016

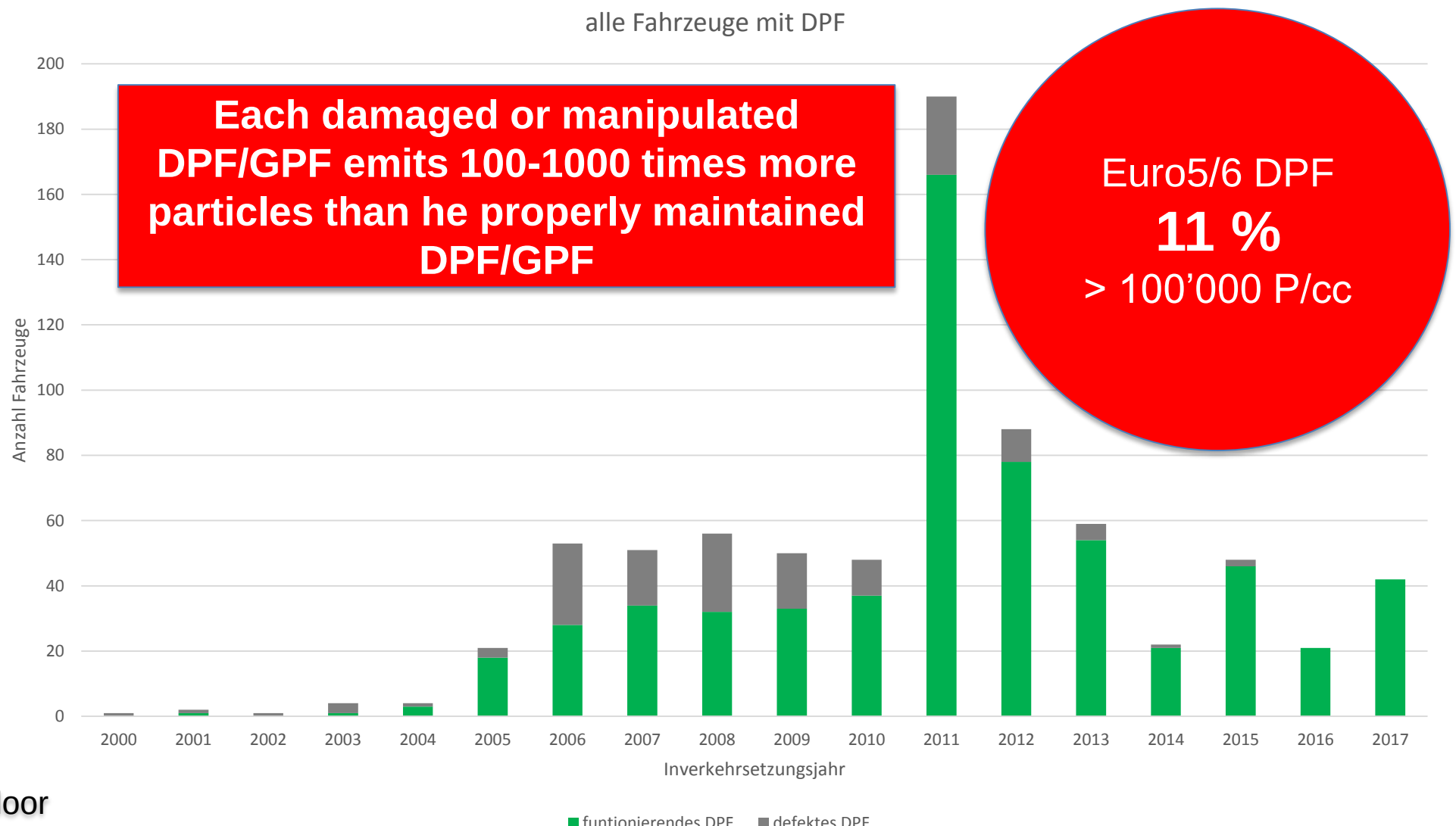
PN EMISSIONS @ low idle speed 2016



161 vehicles (76%) have a PN emission of < 5000 #/cm^3.
52 vehicles (24%) have an elevated PN emission of > 5000 #/cm^3.
10% of the vehicles have a PN emission of > 250.000 #/cm^3.

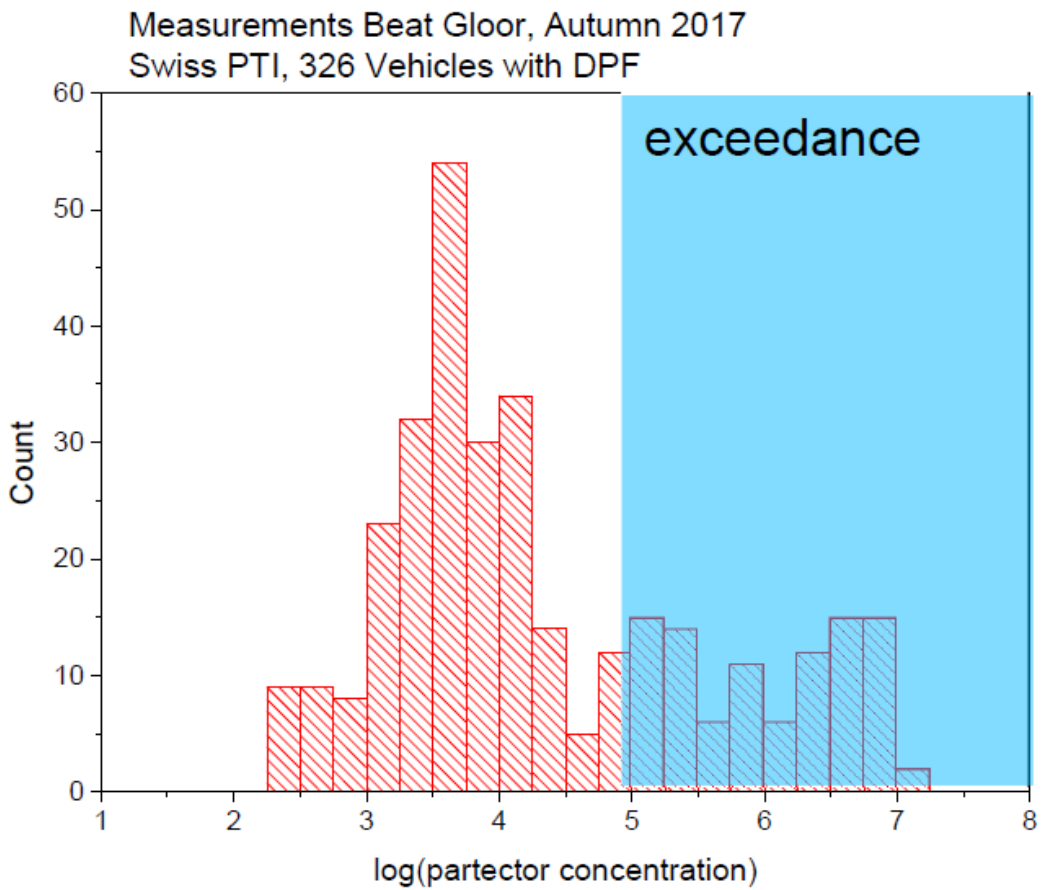
Kadijk
TNO 2016

DPF Failure Statistics in Switzerland



B.Gloor
NPTI meeting Dec. 2017

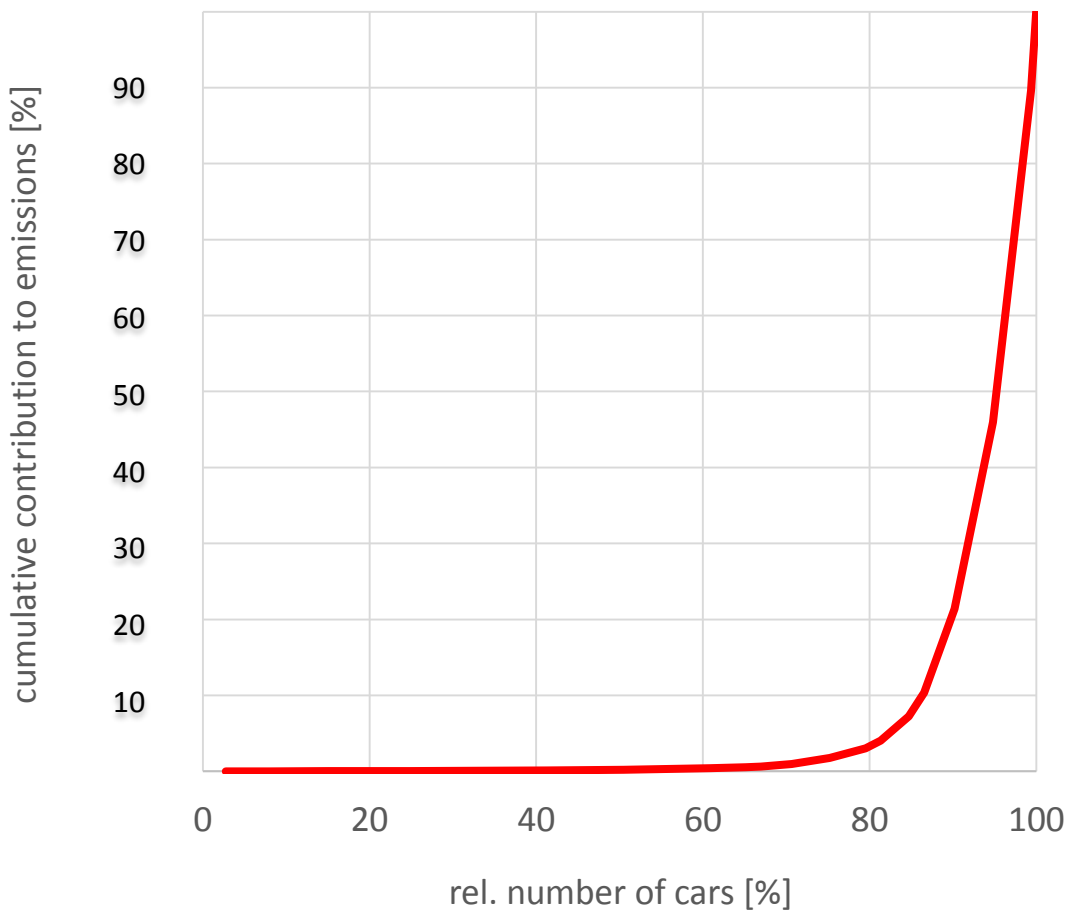
Failure Statistics Euro 5 in Switzerland
Zürich / PKW



Correcting Failures with PN > 250’000 P/cc
improves fleet average emission by factor 30

Fierz / Burtscher
FHNW 2018

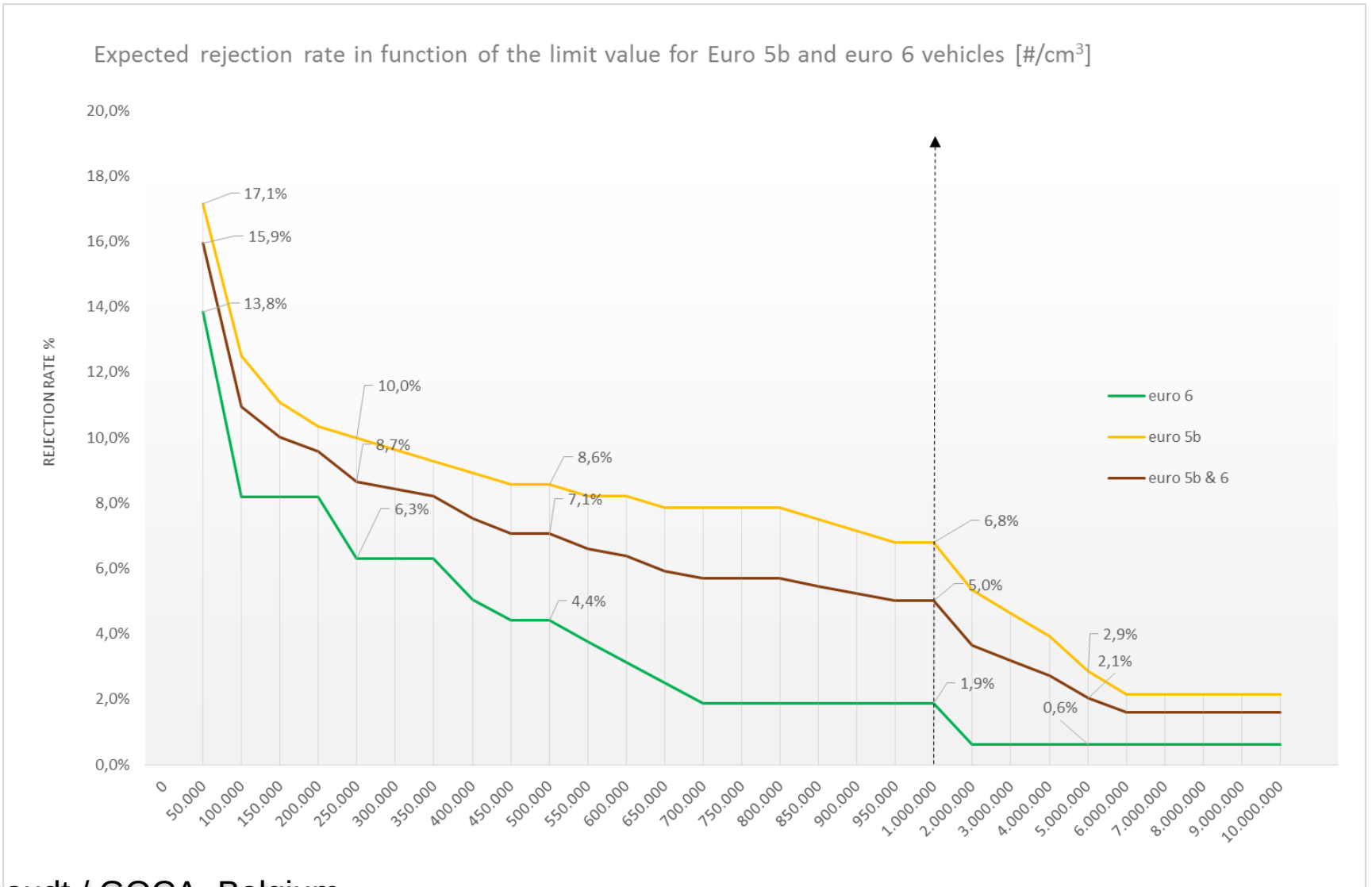
Cumulative contribution of High Emittors to fleet emission



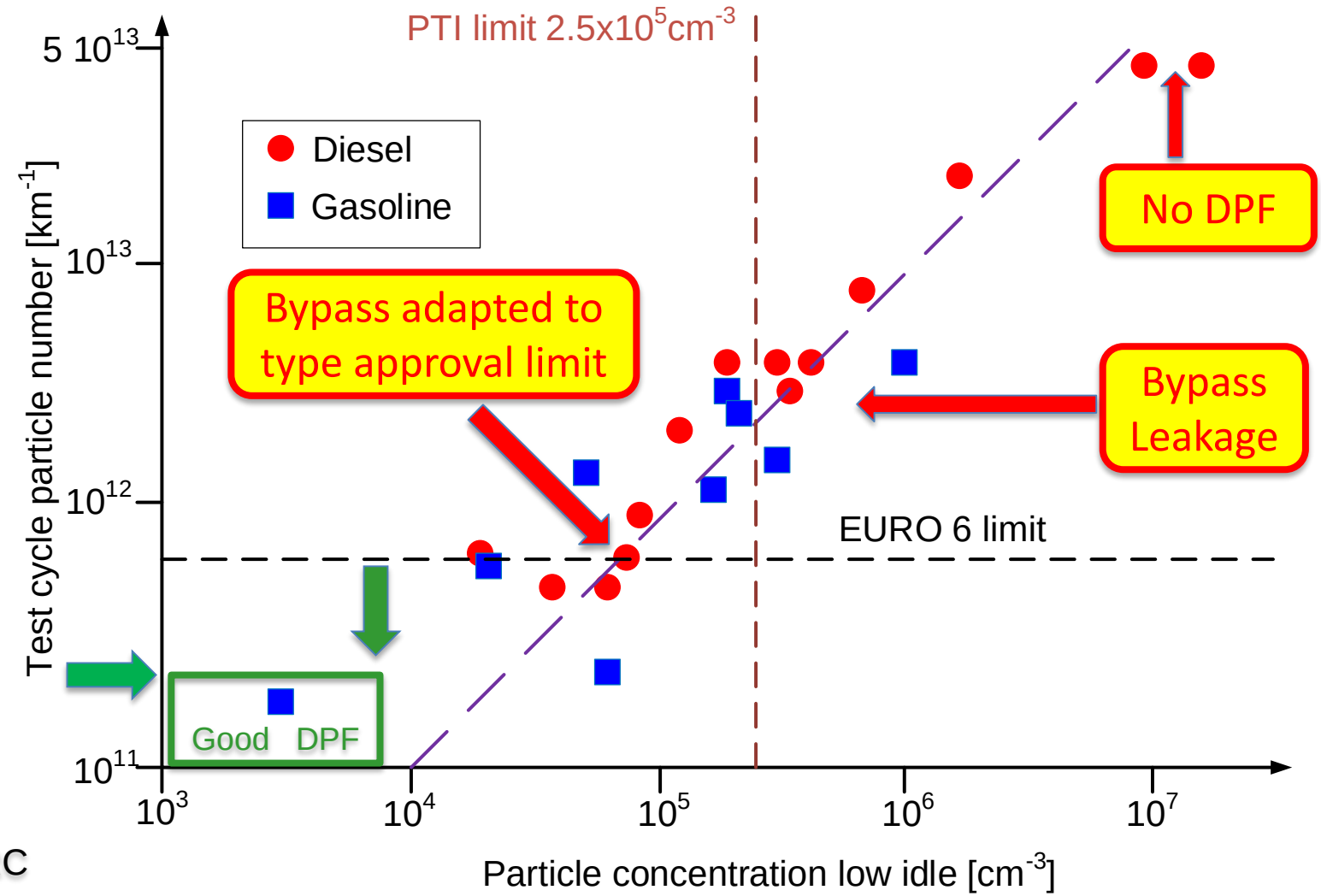
H.Burtscher / FHNW
VERT-Forum March 2019

Expected rejection rate

in function of the limit value for Euro 5b and **6**



Good Correlation of type approval test cycle and NPTI low idle tet with good/bad DPF to determine Pass/Fail Criterion

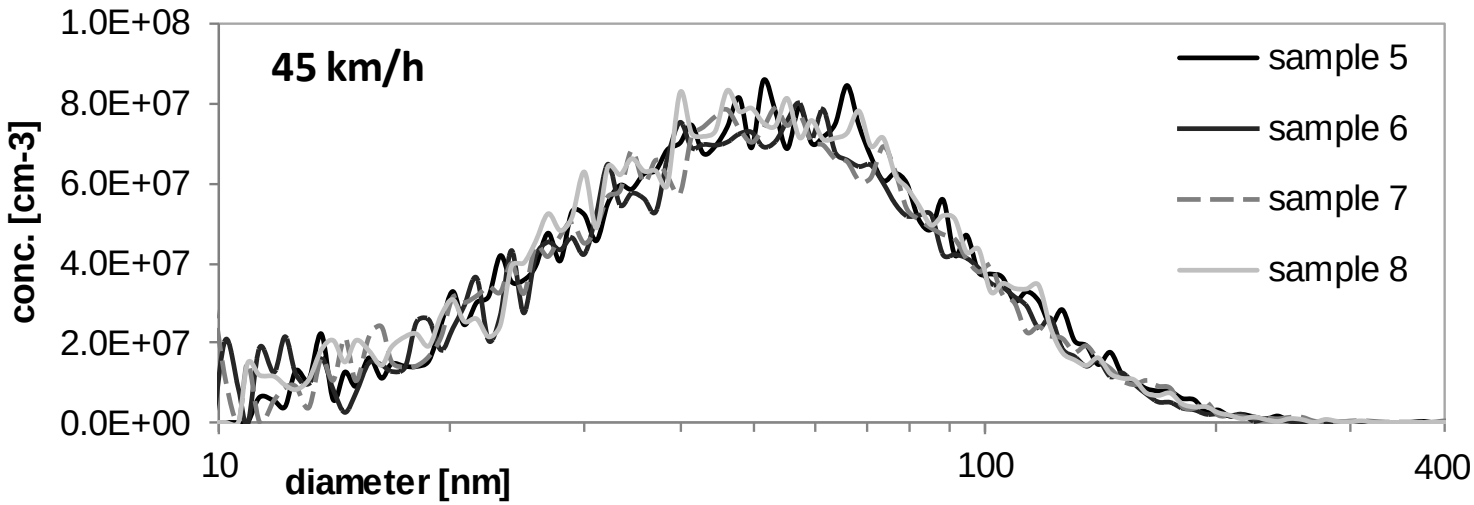


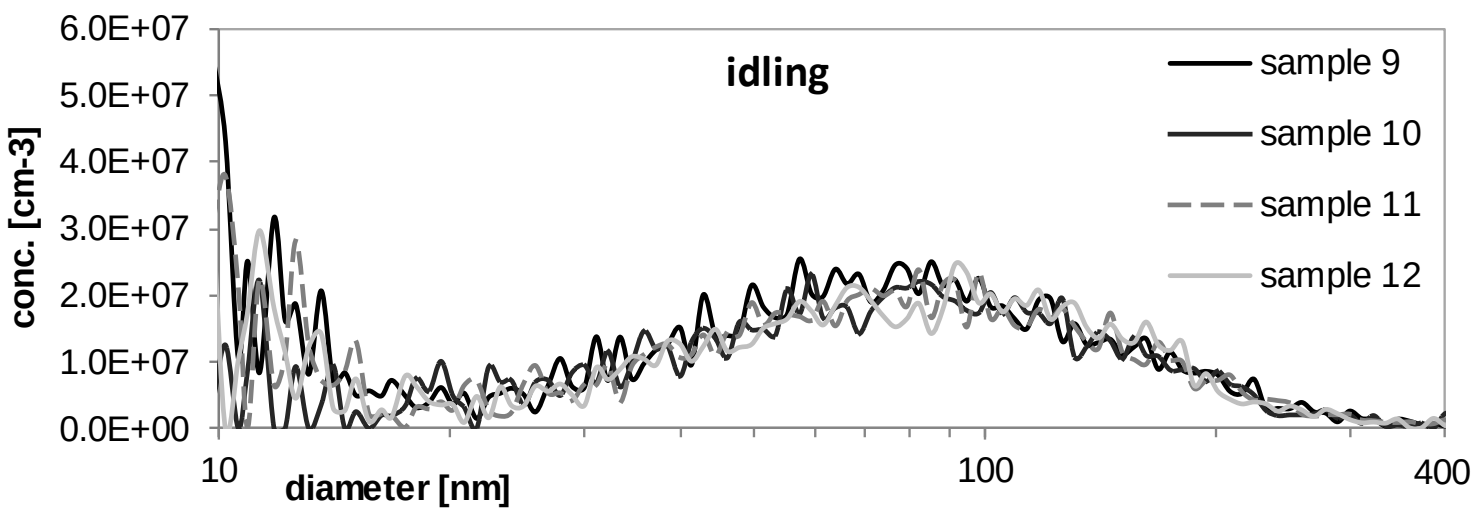
R. Suarez-Bertoa / EU-JRC
NPTI 2018 /
Combustion Engines, 174, 3-16(2018)

Particles Emissions at low idle and load are not much different, however idle has more oil ash

Size Distributions (PSD) at constant speed & idling without DPF.

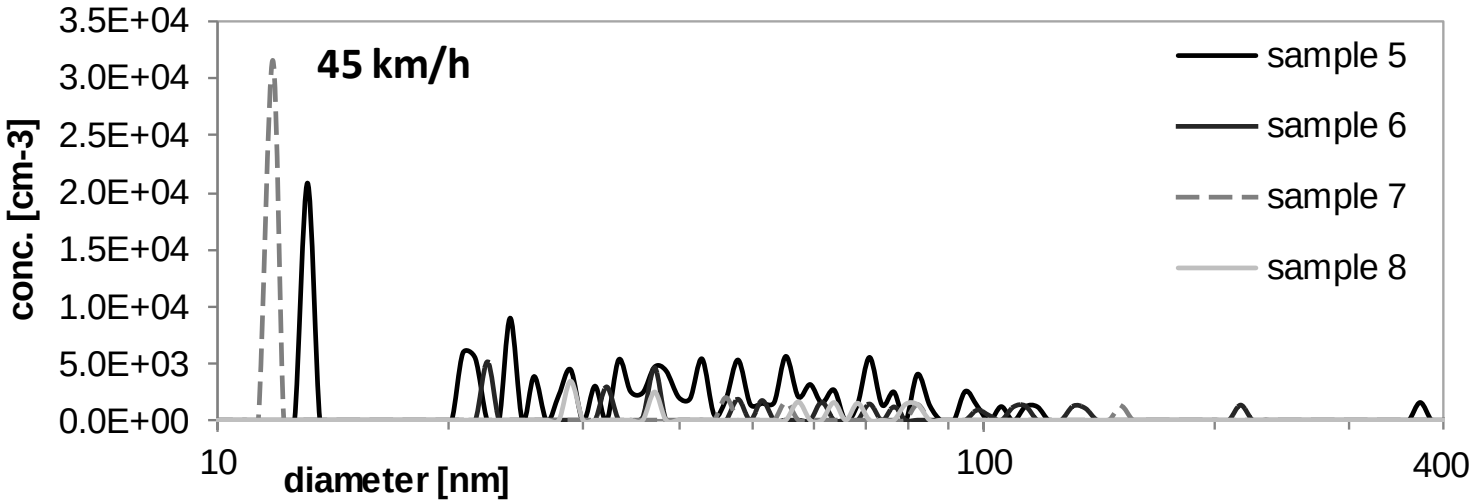
Opel Astra; DOC; fuel: Diesel

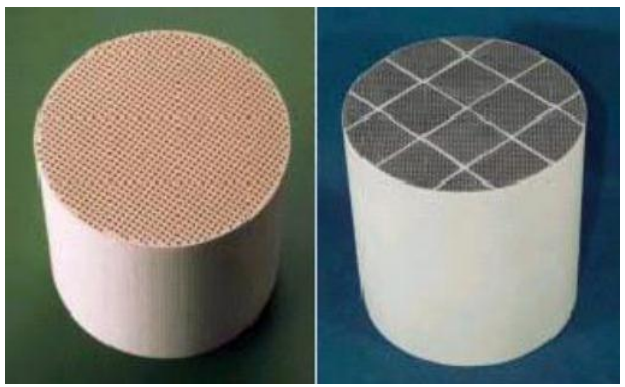


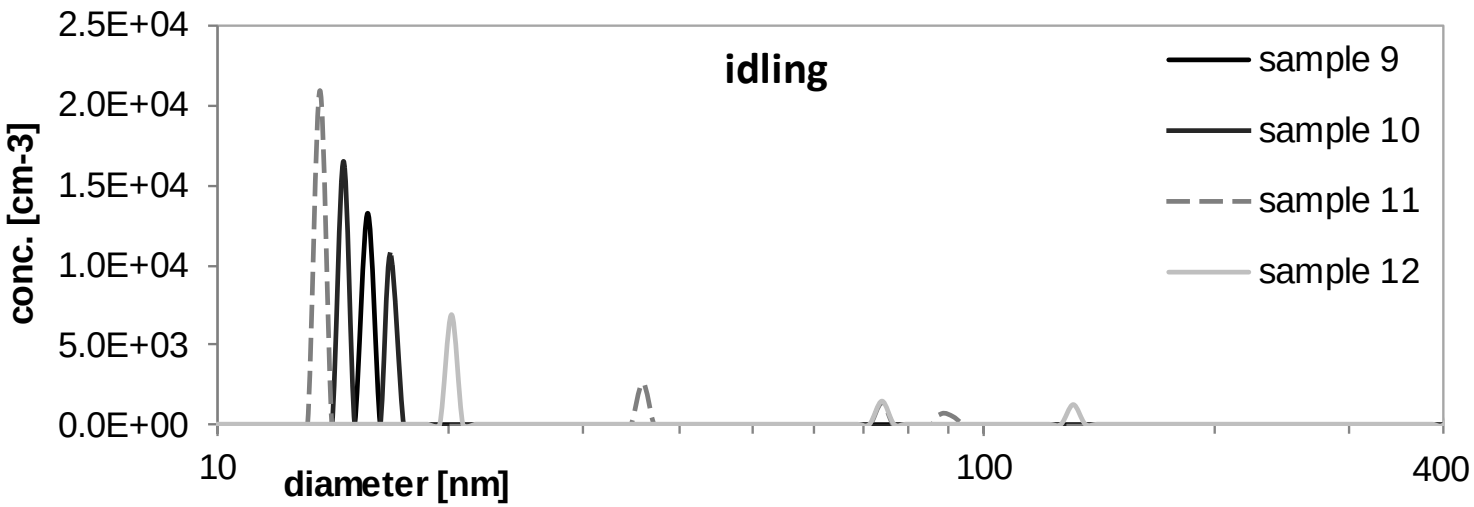


Particles Size Distributions with DPF at load and low idle – filtration by > 99.99 %

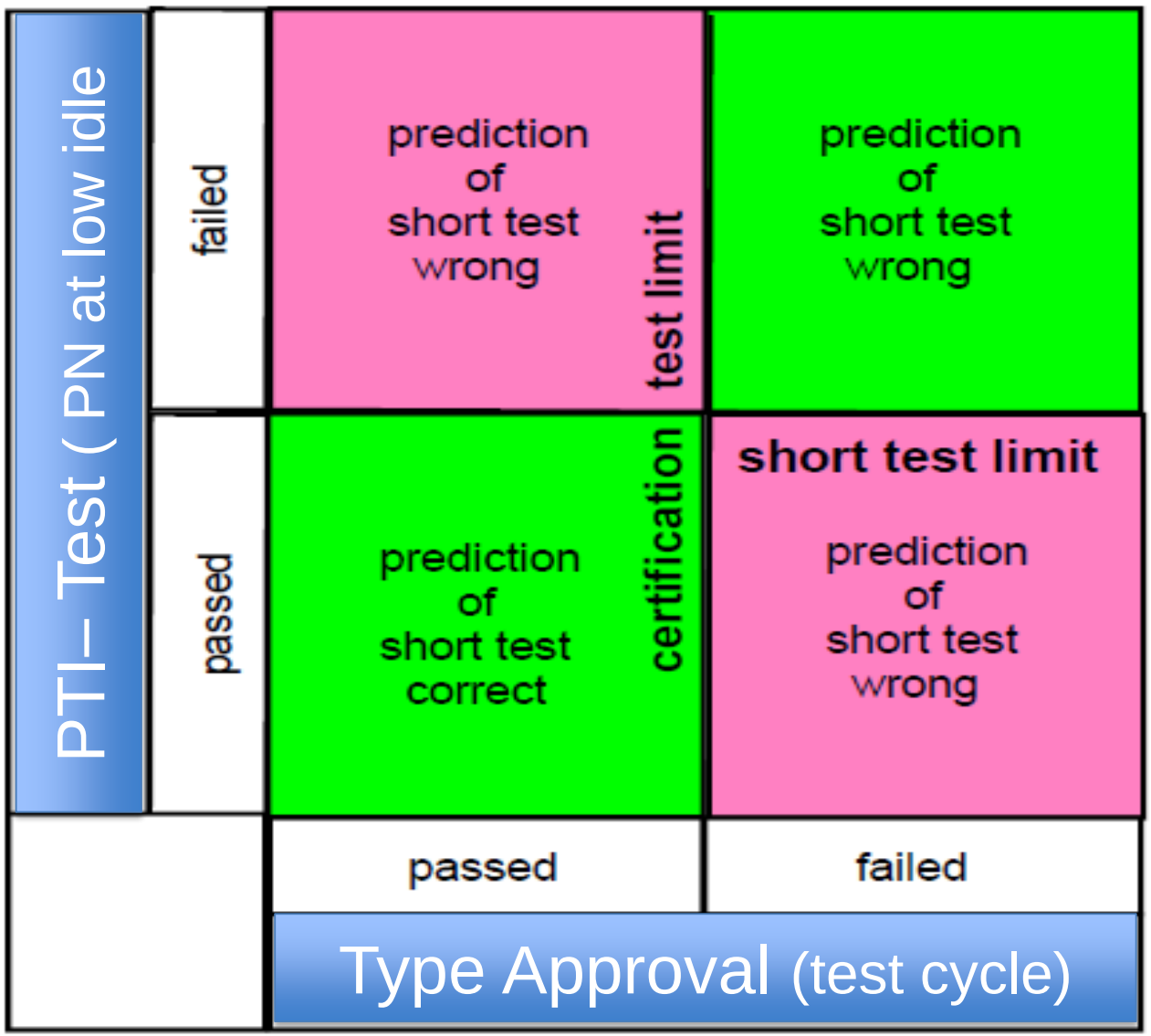
VW Passat Variant V 2.0TDI; DOC, DPF, SCR; fuel: Diesel







How to respect Contingeny:
PTI can not be stricter than Type Approval



Size Distribution must be respected

Diesel

Sootpeak: 80 nm; 10^6 P/cc

Ashpeak: 10 nm; 10^7 P/cc

Petrol

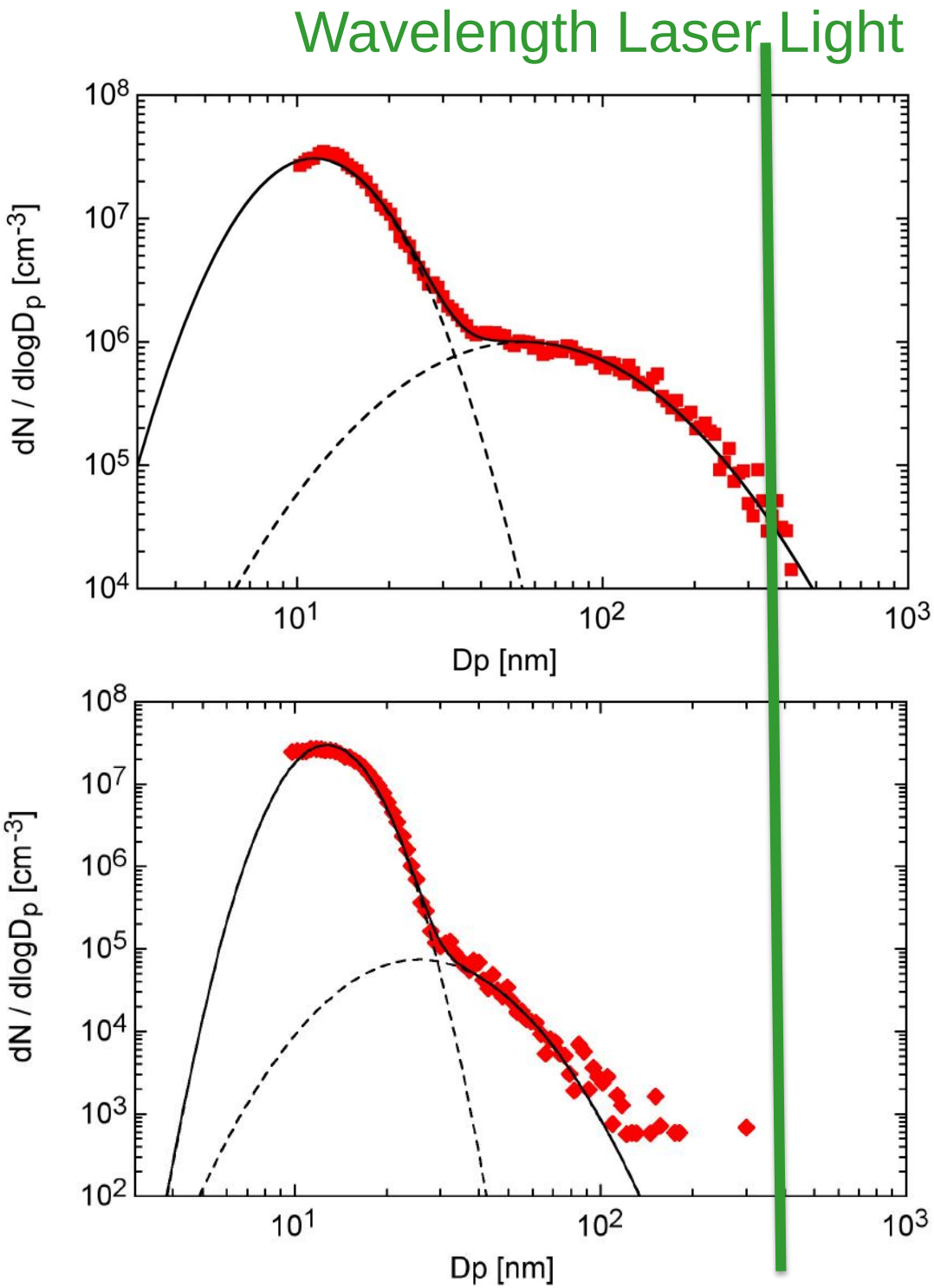
Sootpeak: 40 nm; 10^5 P/cc

Ashpeak: 10 nm; 10^7 P/cc

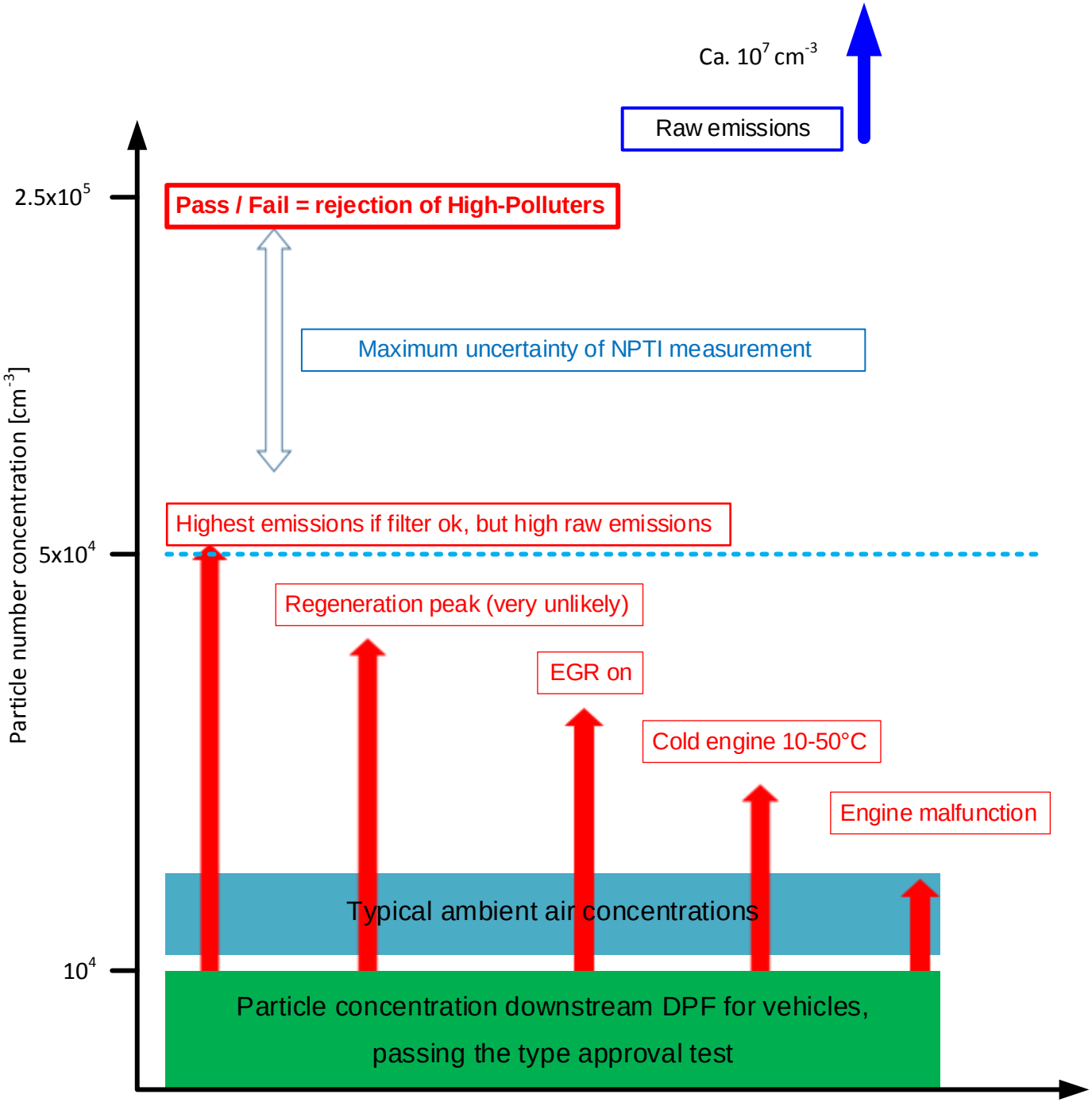
Leight absorption prop D^4

Leight dispersion prop. D^5

Raleight scattering prop D^6



How to determine the Pass/Fail Criterion



Instrument Specification

Paul Kok | Innovation Engineer|
D +31 786332340 | www.nmi.nl
NMi Certin B.V. | Hugo de Grootplein –
NL-3314 EG Dordrecht

INTERNATIONAL

Particulate Number Counter

RECOMMENDATION

Draft 2018-03-08 (E)

Instruments for measuring vehicle exhaust particulate number emissions

- For engines running idle

Part 1: Metrological and technical requirements
Part 2: Metrological controls and performance tests

OIML

Organisation Internationale de Métrologie Légale

International Organization of Legal Metrology

Based on the "mutual recognition" principle of the European Union this must be recognized and can be can be adopted by member states

Functional Specifications NPTI

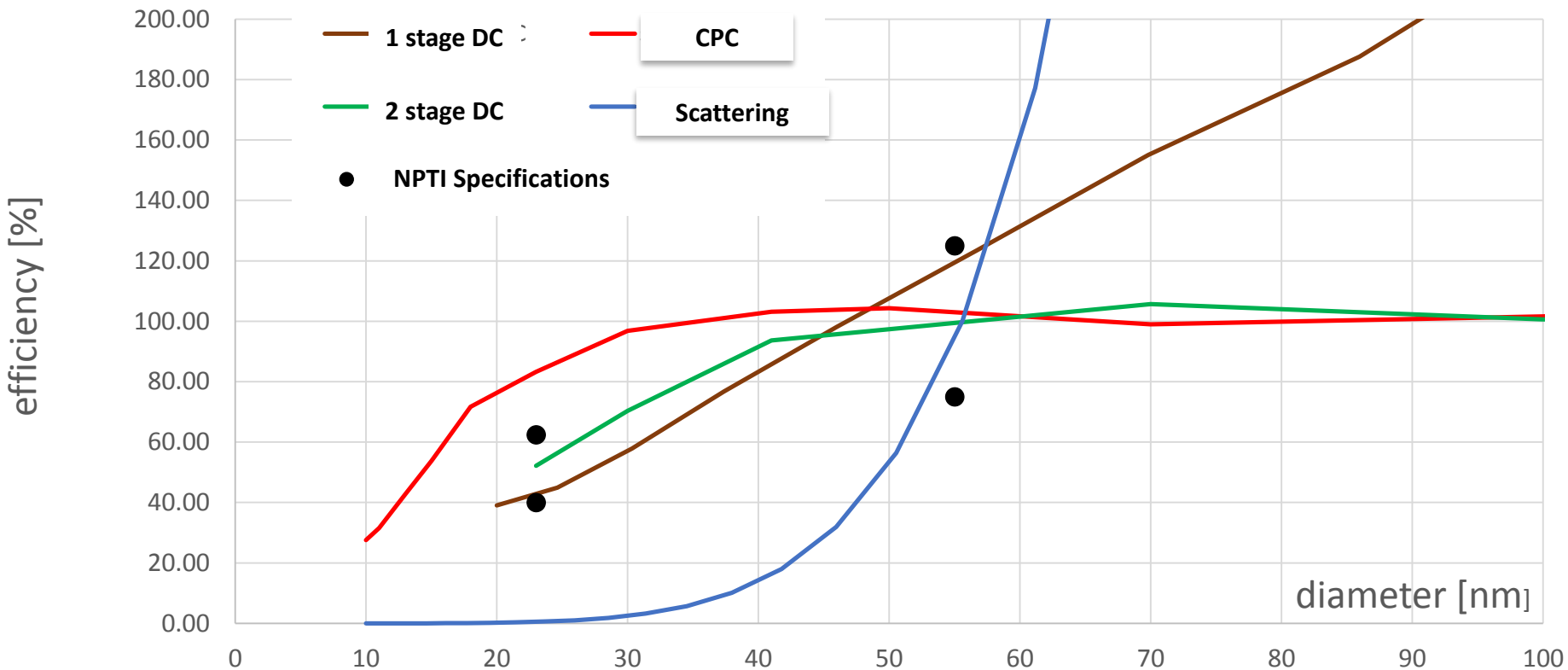
- The PTI test has case to be short (< 2 min) and simple
- applicable for road checks, in workshops and in the roadworthiness test centers.
- The NPTI working group has elaborated specifications for such a device.
  - Counting accuracy 100% ±25% at 80 nm
  - Counting accuracy 100% ±25% at 50nm
  - Counting accuracy 50% ±25% at 23nm
  - Removal of Volatiles by Tetracontane test: >90%
    for 30nm particles with a number concentration $<10^5 cm^{-3}$

Light Scattering (blue) must be excluded

size characteristic (Raleigh scattering) follows D^6 → far too steep

→ small particles are invisible

But instruments based on DC and CPC fullfil the requirements

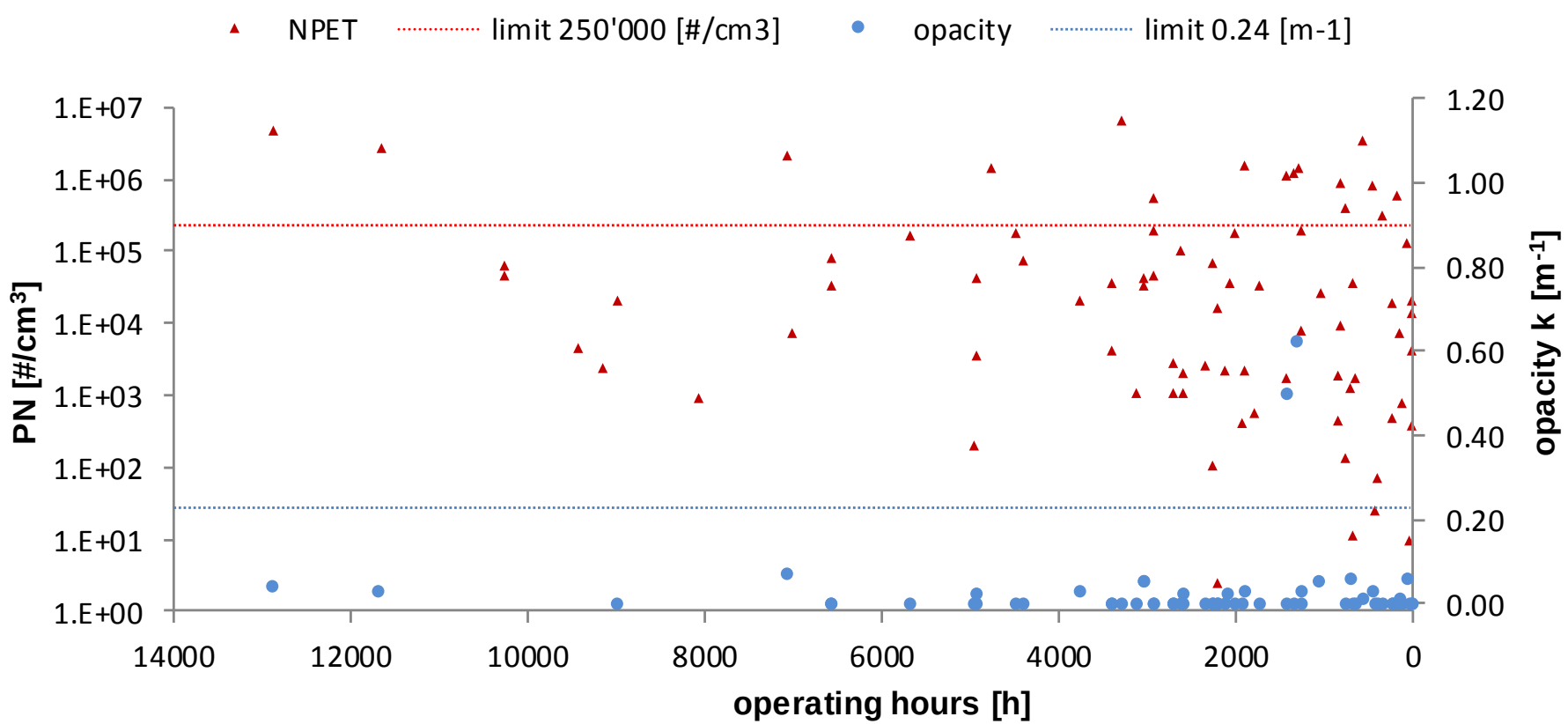


H.Burtscher
FHNW 2019

Opacity measurement must be excluded

→ too insensitive → small particles invisible

107 machines 2016 Switzerland AFHB 2016



Comparison NPET@high idle Opacity@free acceleration

J.Czerwinski
AFHB 2016

Low Cost High Quality Instruments to be used in workshops:

Based on the fact that Diesel at low idle performs at Lambda >8 with low humidity content
Instruments might not need expensive sample treatment with volatile evaporation and dilution.
Volatiles must be excluded

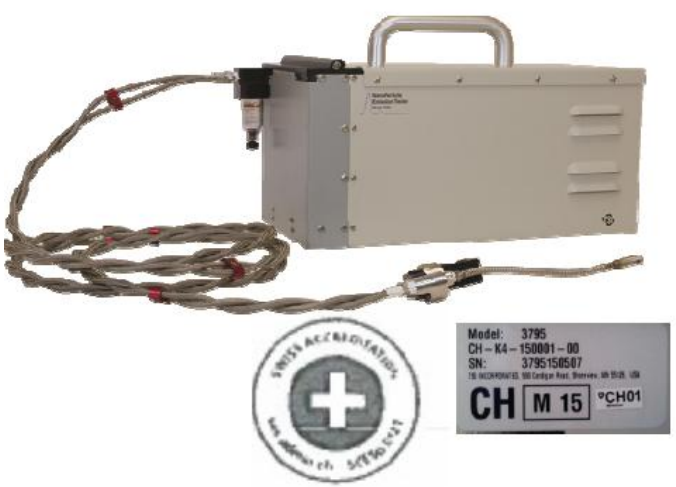
GPF shall be included

Instrument price should be < 8’000 EURO

CPC Instruments by TSI et al. for NPTI

Due to:

+ Only certified instrument at this time
  - METAS certification to stringent requirements of Swiss Regulation SR 941.242 (2014) for NRMM
+ Measurement of ***solid*** particle number concentration only
+ Link to type approval test results



NANOPARTICLE EMISSION TESTER FOR PERIODIC INSPECTION

PORTABLE, FAST, PASS-FAIL RESULTS

The PTI-PN tester is a light-weight, battery powered, mobile solution for garage shops, service stations and technical inspection facilities to test for nanoparticle emission levels of vehicles. Sampling emissions straight from the tailpipe with a pass/fail result in less than one minute, this tester is perfect for easy Diesel or Gasoline Particle Filter Testing (DPF or GPF).

Evolving from original nanoparticle sensors and sensors for compliance testing, TSI's PTI-PN tester enables the measurement of particle number emissions accurately and reliably. TSI's tester provides touch screen guidance for the technician through the test cycle, step-by-step, ensuring measurements are taken correctly. The test cycle requires the vehicle's engine to be warmed up and in idle conditions and the ambient air measurement precedes the tailpipe emission test. A total of four measurements are taken, each last five seconds where the average of the engine emission test is compared to a pass/fail threshold setting. In addition to the test cycle, manual measurements can be enabled for diagnostic or research purposes.

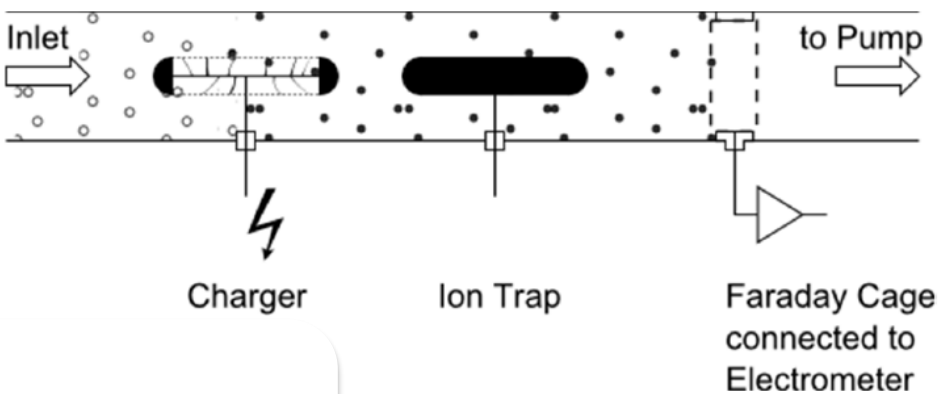
Features and Benefits

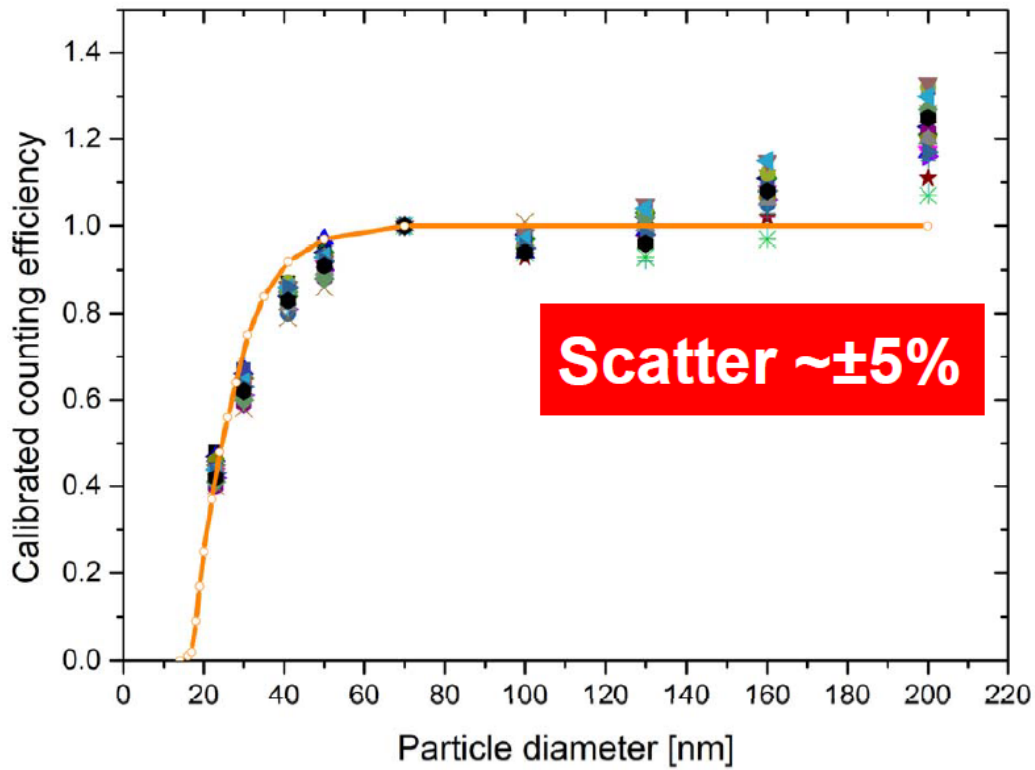
- Light-weight, battery powered mobile tester
- Easy Diesel or Gasoline Filter Testing (DPF, GPF)
- Sample straight from the tailpipe with included probe
- Pass/fail result in less than a minute
- Results backed up in internal memory
- Test Cycle and Manual measurement mode

Sampling	Ambient Air				Tailpipe Emission											
PN Measurement																
Time (seconds)					0	5	10	15	20	25	30	35	40	45	50	55

The time sequence of a pre-defined test cycle in 5-second intervals. Nano particles in ambient air are sampled as reference point, before the sampling probe is attached to the tailpipe. Three measurements are recorded at the tailpipe and averaged, and the pass or fail result is based on comparing the average to a defined limit value.

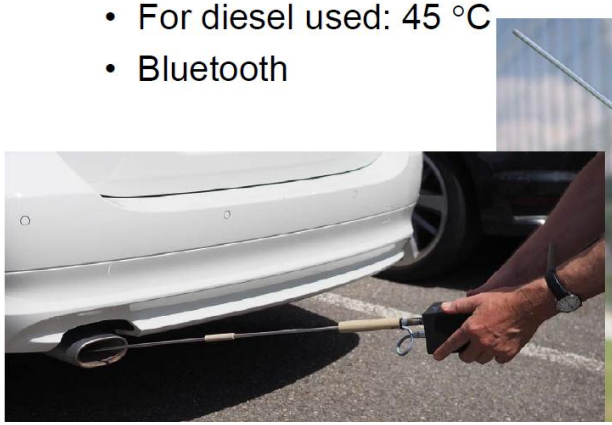
DC-Instruments by NANEOS et al. for NPTI





Sensors for NPTI

- Inlet heating: up to 190 °C.
- Senor heating: up to 80 °C
- For diesel used: 45 °C
- Bluetooth



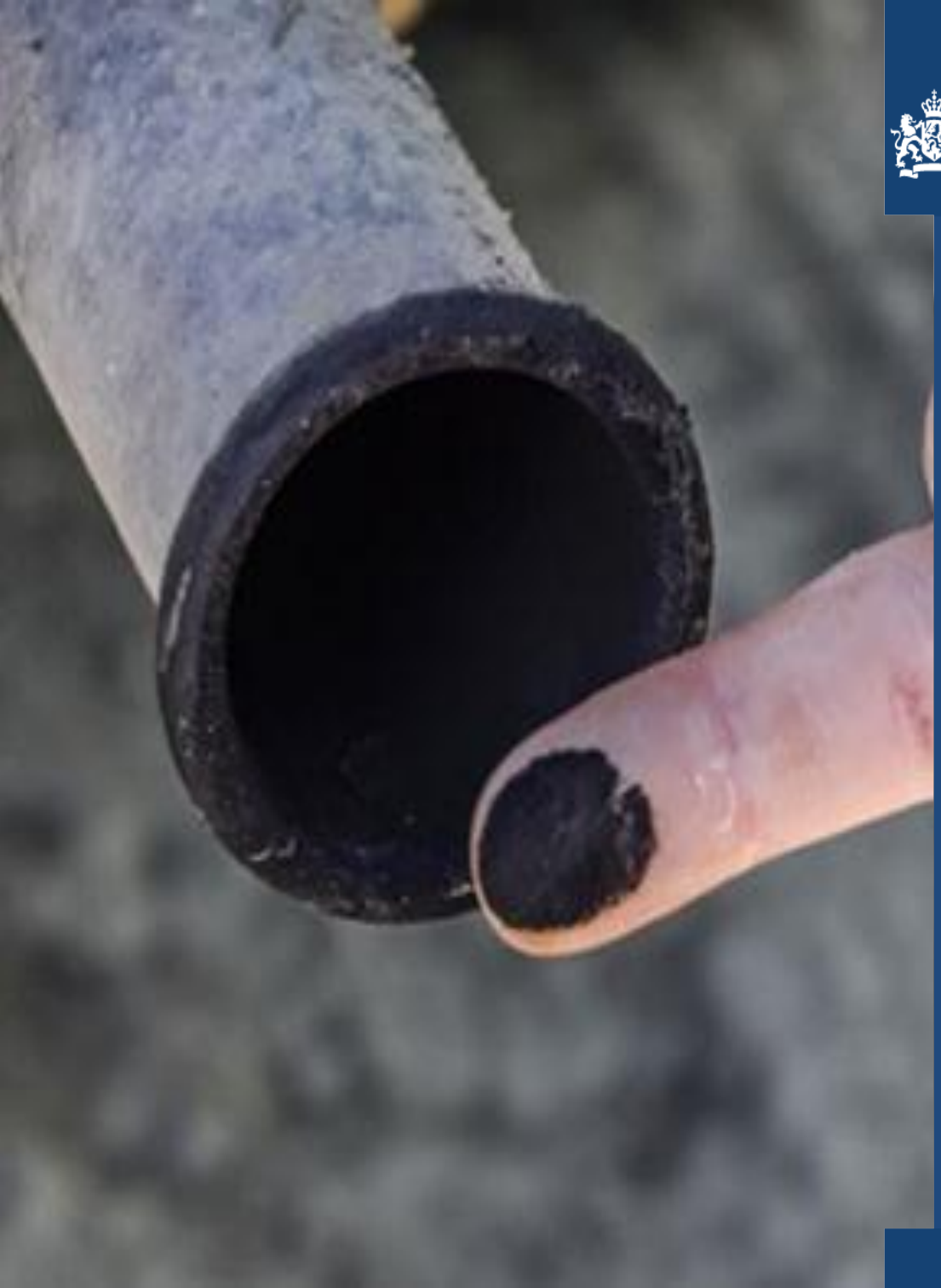
Suppliers of PN testers for NPTI:

- TSI
- Testo
- Naneos
- Sensors
- AVL
- Dekati

12 companies

develop these new instrument

so we will see a strong competition



and what about legal Implementation?

Phased introduction of a particle test for DPFs in the Netherlands

Louis Zuidgeest

14 March 2019

VERT-Forum

Ministry of Infrastructure and Water management

The Netherlands are first followed by BE Phase 1 and 2: RDW stations and RSI in 2019

- Regulation published in September 2019.
- DPF tests can be done with the TSI NPET:
  - Certification by METAS equivalent.
  - Measuring equivalent to NL proposal.
- RDW carries out RSI tests in the role of technical support to police.

Louis Zuidgeest
Ministry of Infrastructure and Water management NL

Planning of phase 3:
DPF test in the PTI this by Garages

- NMI certification of PTI particle counters in 2019.
- As soon as in 2020 sufficient counters available: DPF test becomes a mandatory part of the PTI.
- Making the test mandatory on base of regulation to be published in September 2019.
- Target date for introducing DPF test in the PTI: 2021.

Louis Zuidgeest
Ministry of Infrastructure and Water management NL

NPTI-Legislation in Germany

- **Änderung der Richtlinie für die Durchführung der Untersuchung der Abgase von Kraftfahrzeugen nach Nummer 6.8.2 der Anlage VIIIa Straßenverkehrs-Zulassungs-Ordnung (StVZO) (AU- Richtlinie)**
- **Muster eines Nachweises über die Durchführung der AU nach Anlage VIII StVZO**

Bonn, den 20. September 2017
LA 27/7355.2/2

VkBl. Amtlicher Teil 853

3. **Nummer 1.3 wird wie folgt gefasst:**

„1.3 Inkrafttreten der Änderungen zu dieser Richtlinie

1.3.1 Ab dem 01.01.2018 ist die Funktionsprüfung Abgas verpflichtend für alle AU-pflichtigen Kraftfahrzeuge durchzuführen.

1.3.2 Ab dem 01.01.2019 gelten die angepassten Sollwerte für alle Kraftfahrzeuge ab Emissionsklasse Euro 6/VI.

1.3.3 Ab dem 01.01.2021 wird ein Verfahren zur Messung der Partikelanzahl bei Kompressionszündungsmotoren eingeführt."

NPTI Mission for DPF accomplished

- Netherlands will introduce NPTI in 2019, Belgium follows with the already Swiss-METAS certified instrument TSI NPET
- Germany has re-started AU in Jan. 2017, includes PN 2021
- Switzerland will follow as soon as instruments are available
- Spain, UK and France are in a similar process
- Six Instrument manufacturers will provide test samples 2019
- JRC performs instrument validation and reports to EU
- Instrument certification by NMI from end of 2019,

Repair Cost ? → Liability of the manufacturers for emission stability within a period of 160’000 km (2005/78/EG)