



**FACULTY
OF MECHANICAL
ENGINEERING
CTU IN PRAGUE**

BLACK SHEEP

DETECTING POLLUTING VEHICLES ON THE ROAD USING ROADSIDE PARTICLE MEASUREMENT



**Jan Skácel, Michal Vojtíšek, Vít Beránek
Czech Technical University in Prague**

**Martin Pechout
Czech University of Life Sciences,
Prague**

December 2018

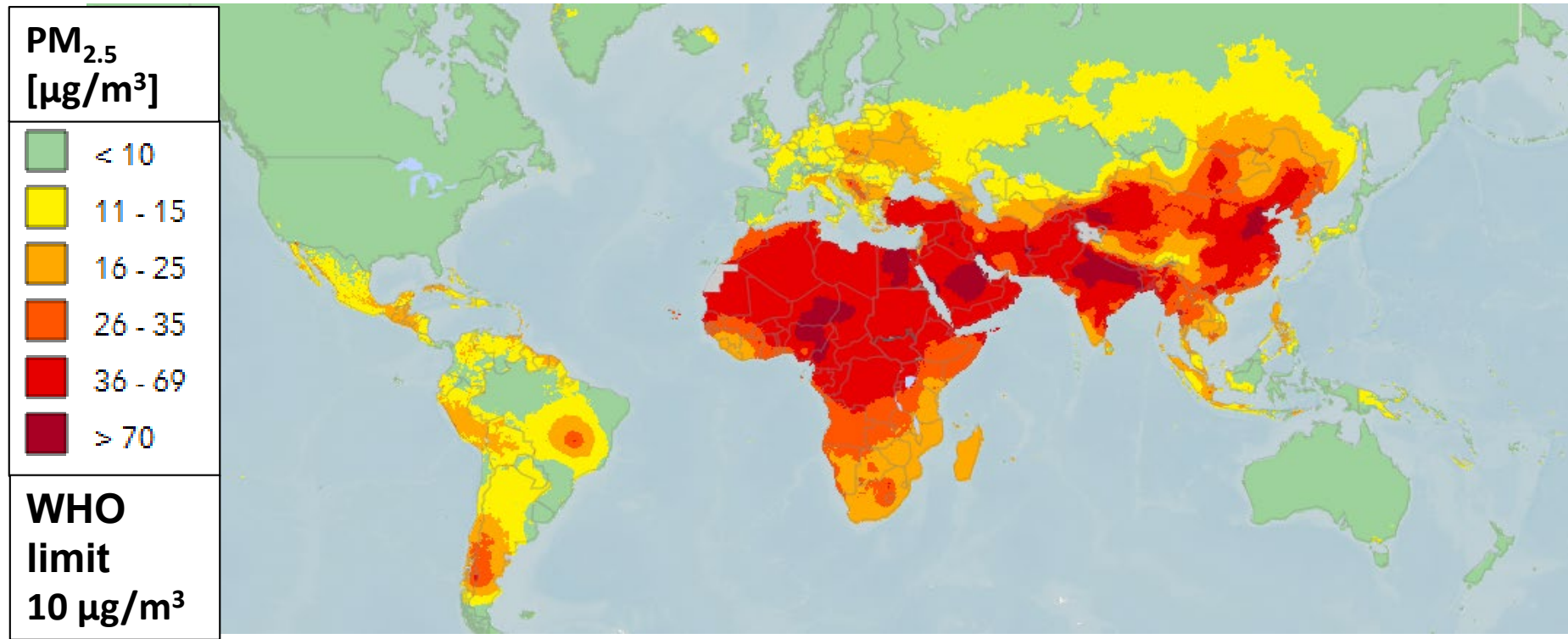
Particulate Matter - Main Air Pollution Issue



FACULTY
OF MECHANICAL
ENGINEERING
CTU IN PRAGUE

World Health Organization: 4.2 million death globally every year caused by outdoor fine particulate matter pollution – $PM_{2.5}$

European Environment Agency: over 400.000 premature death in EU annually caused by $PM_{2.5}$ – mainly from transportation



Annual average concentrations of fine particles in air $PM_{2.5}$ in 2016

Source: World Health Organization

Despite Tighter Vehicle Emission Regulation Air Quality is Not Always Improving – WHY?

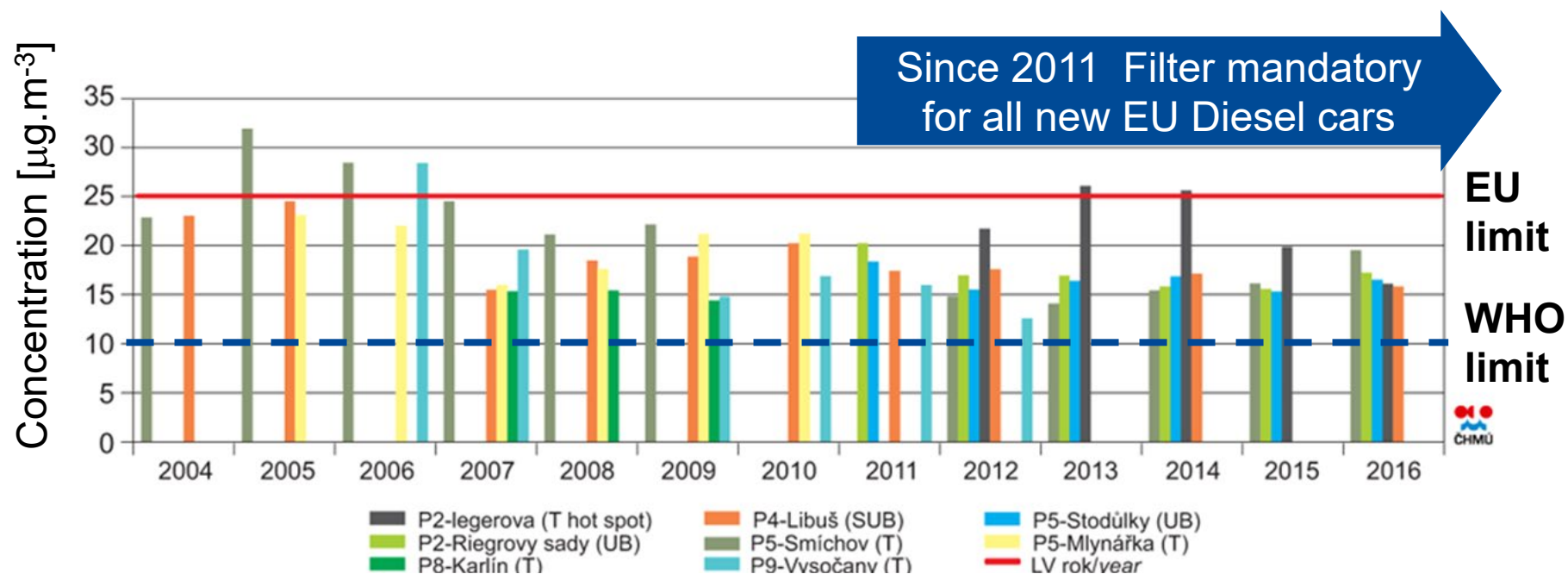


FACULTY
OF MECHANICAL
ENGINEERING
CTU IN PRAGUE

Since 2011 all new diesel vehicles in EU must have diesel particulate filter (DPF)
Most harmful dust particles PM_{2,5} levels not improving – e.g. data from Prague

Why we do not see benefit of all new clean vehicles?

Hypothesis: small number of super polluters major source



PM_{2.5} - Annual average concentration, Prague 2004-2016, multiple locations

Source: Czech Hydro-meteorological Institute

Roadside Particulate Matter Emission Measurement – Prague October 2017



FACULTY
OF MECHANICAL
ENGINEERING
CTU IN PRAGUE

- Goals:
- evaluate air pollution from real life traffic
 - determine contribution of individual vehicles
 - assess vehicle compliance – DPF function

Radar Speed
detection

3 Cameras

Sampling
line

5 Emission
measurement
instruments

- Quick facts:
- 10 days
- 25 000 vehicles
- Particulate matter measurement
PM PN
- Gaseous emissions -
CO₂ CO, NO_x



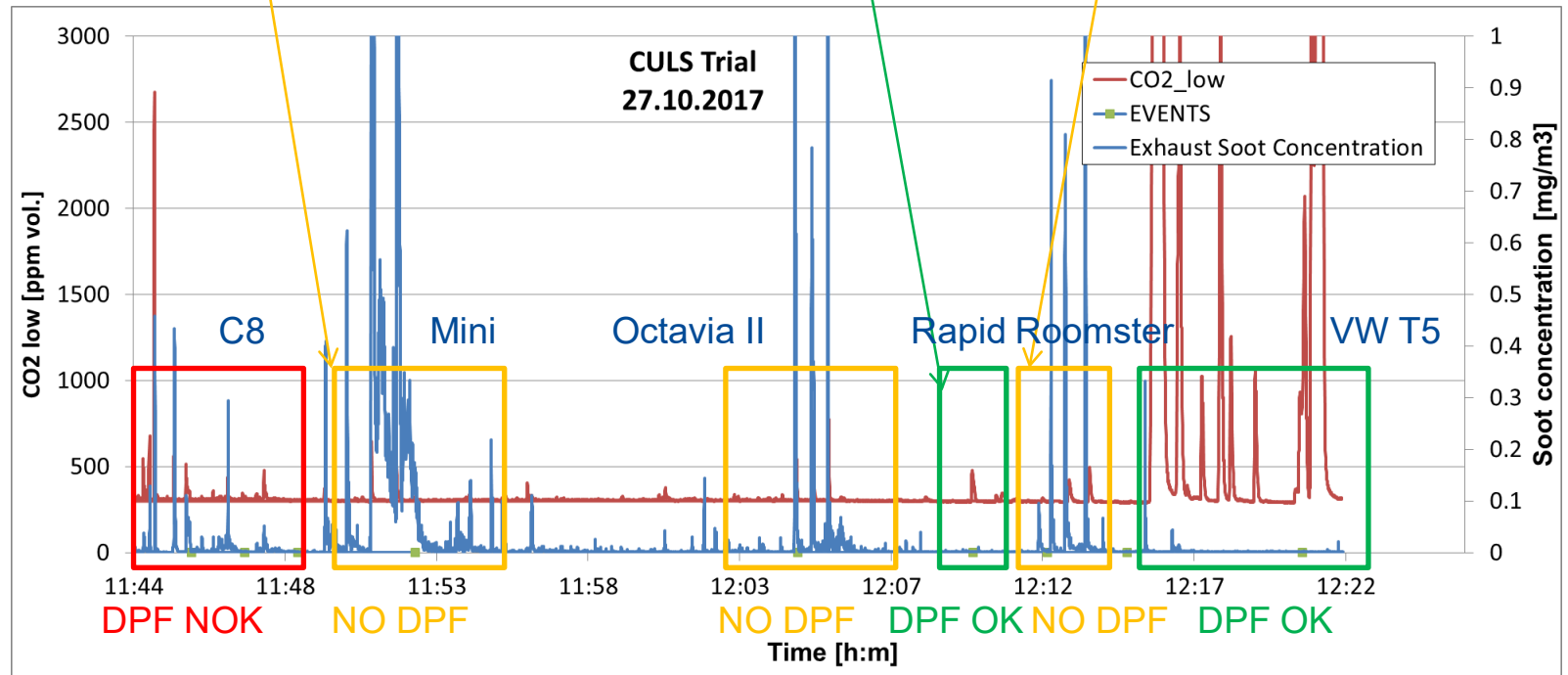
Roadside Extractive Measurement Concept Verification

Trial run @ CULS in Prague, 27th October 2017
Pattern: High CO₂ & no soot indicates good DPF

Vehicle without DPF

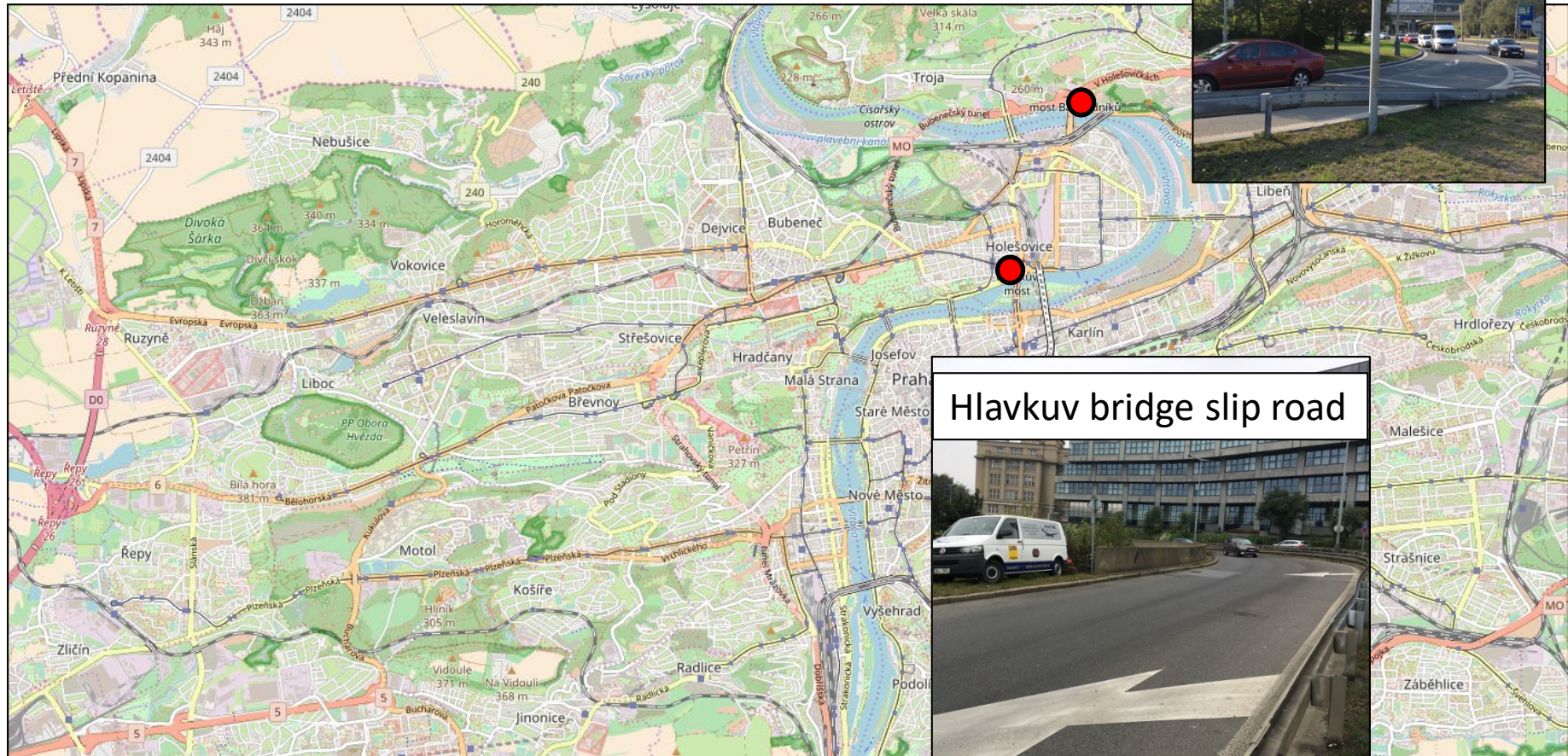


Vehicle with OK DPF



Roadside PM Emissions Measurement Sites - Prague October 2017

Slip roads - one way & single lane & uphill - engine loaded



Results – Vehicle Registry Data

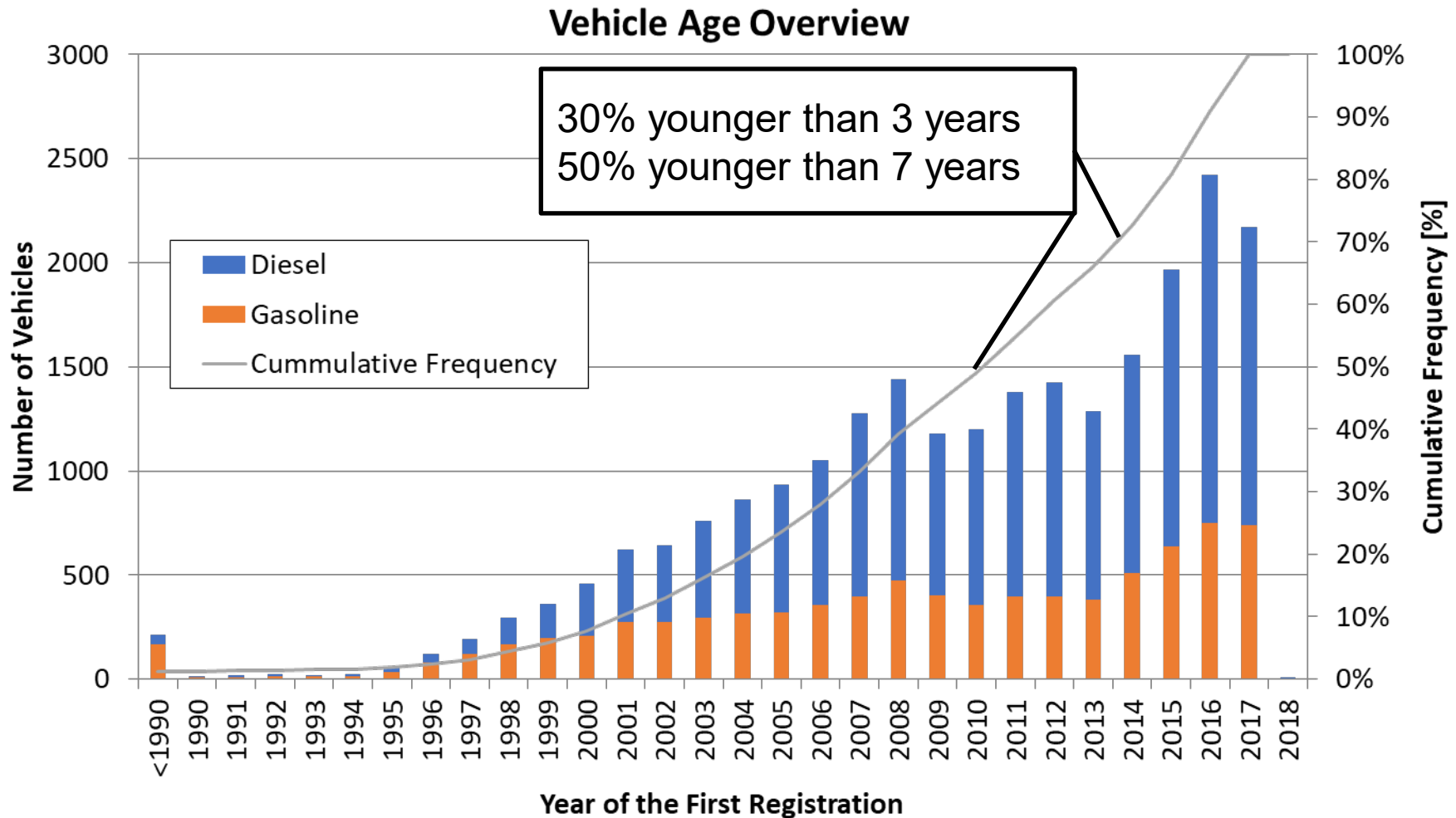
Vehicle Age Distribution



FACULTY
OF MECHANICAL
ENGINEERING
CTU IN PRAGUE

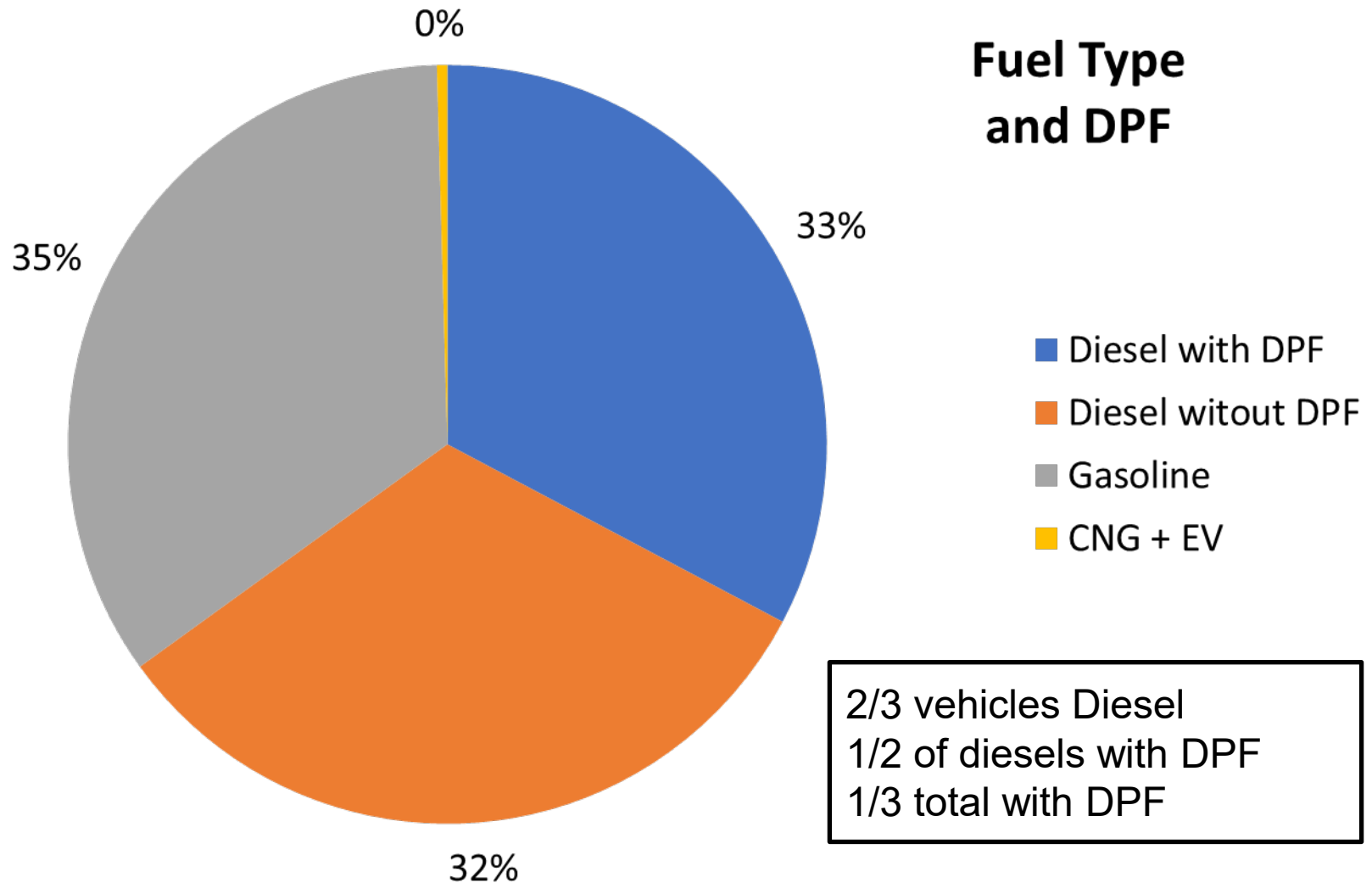
Registration plate recorded for 25 971 vehicles

Ministry of transportation provided data for 24 379 (94%)



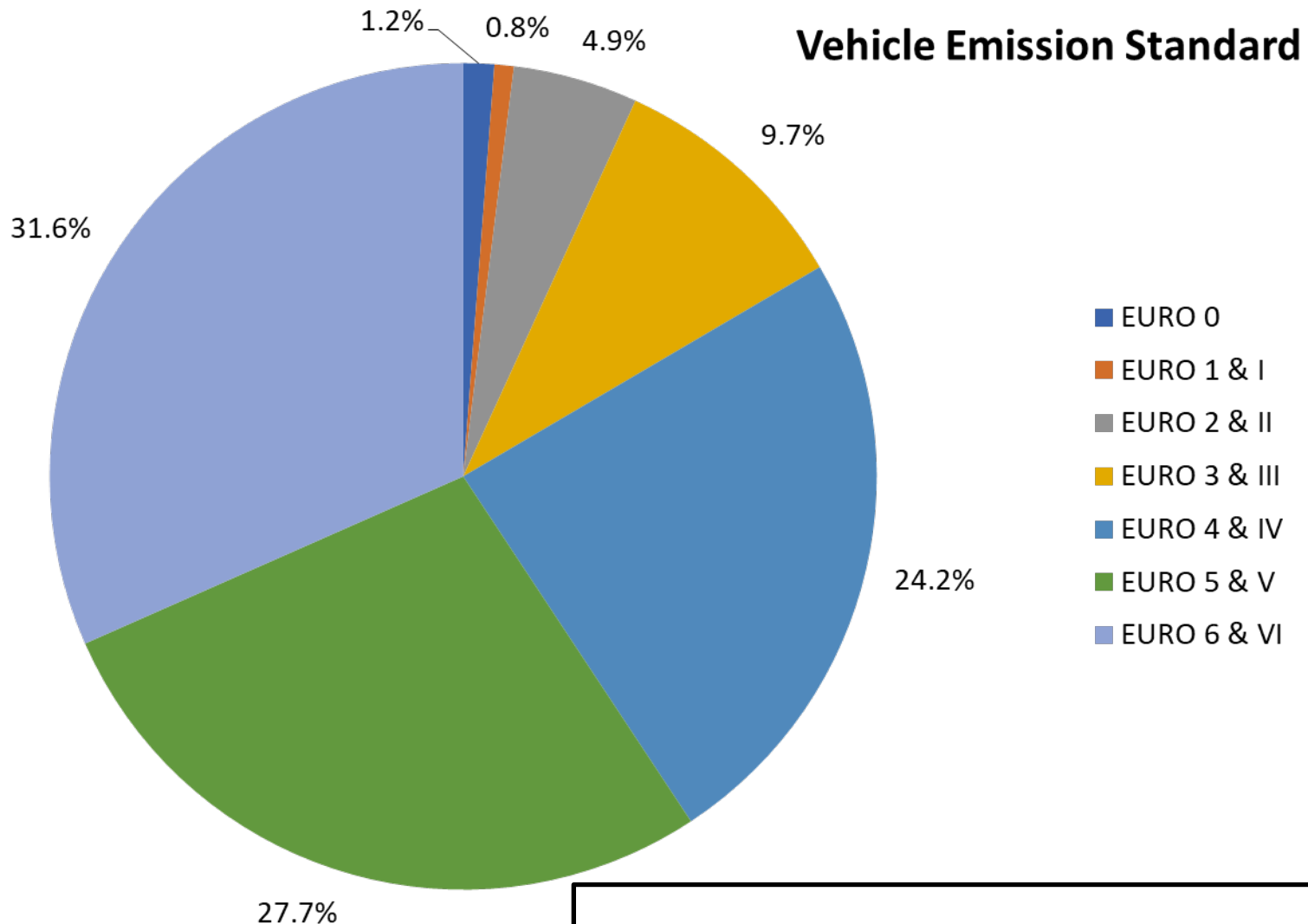
Results – Vehicle Registry Data

Fuel Type and DPF



Results – Vehicle Registry Data

Vehicle Emission Standard



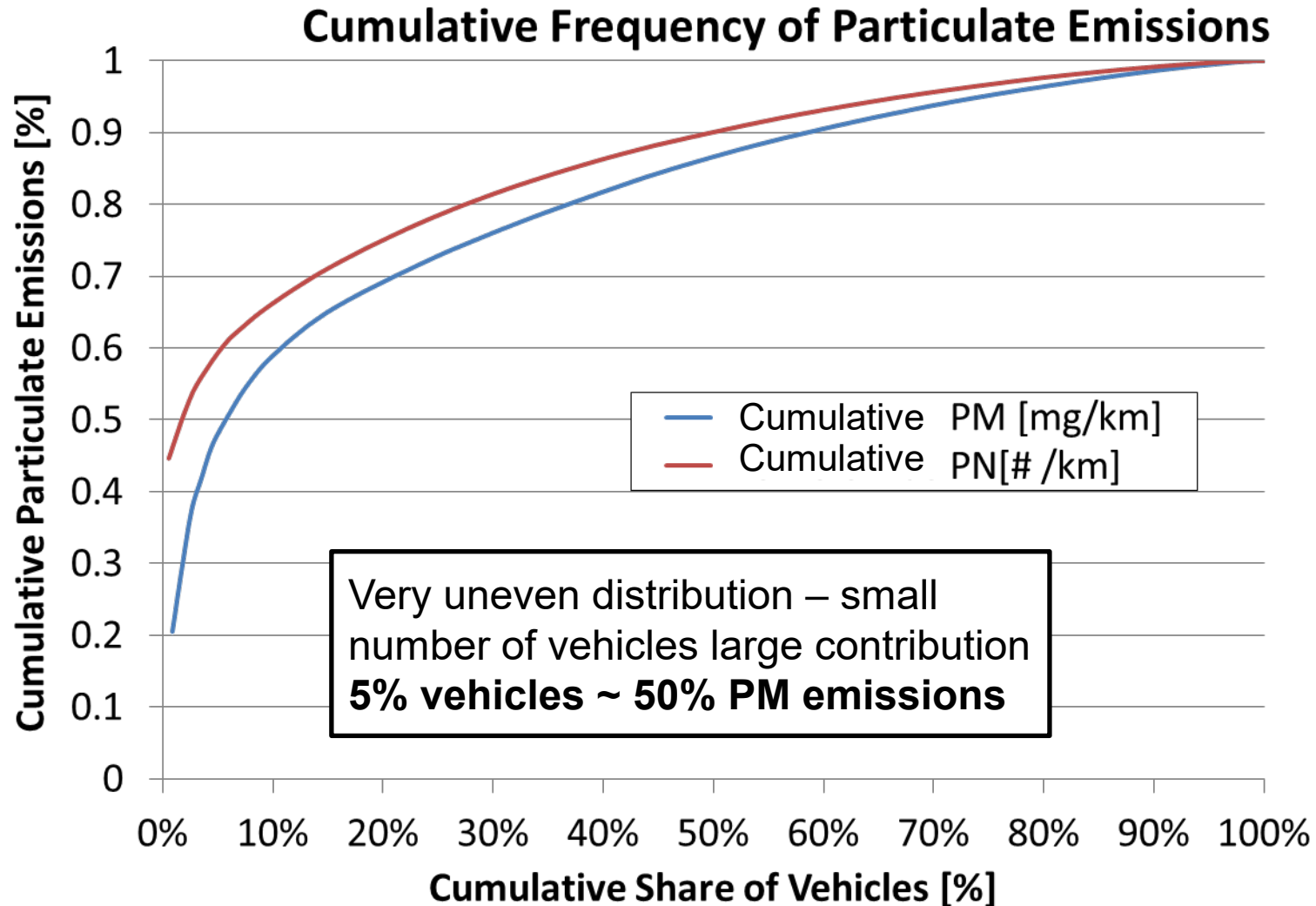
Over 50% of vehicle EURO 5 / V or 6 / VI

Cumulative Frequency Analysis Particulate Matter Emissions



FACULTY
OF MECHANICAL
ENGINEERING
CTU IN PRAGUE

2000 vehicles matched with their unique emission trace, of which ~500 with sufficiently strong CO₂ emission level



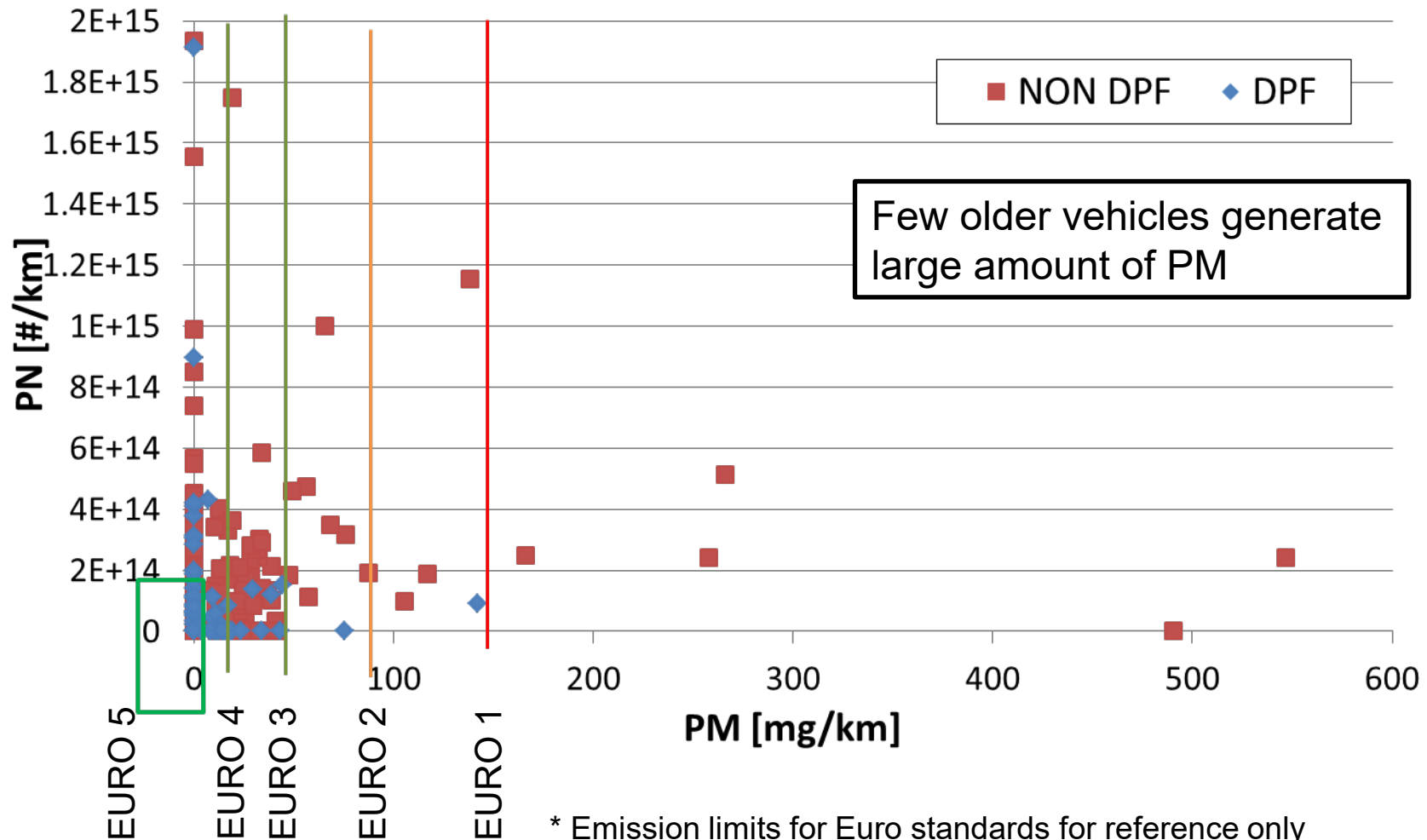
Specific Particulate Matter Emissions

PN and PM calculated per 1 km travelled



FACULTY
OF MECHANICAL
ENGINEERING
CTU IN PRAGUE

Particulate Matter Emissions calculated per 1 km
PN, PM [# /km, mg/km]



Key Findings from the Study

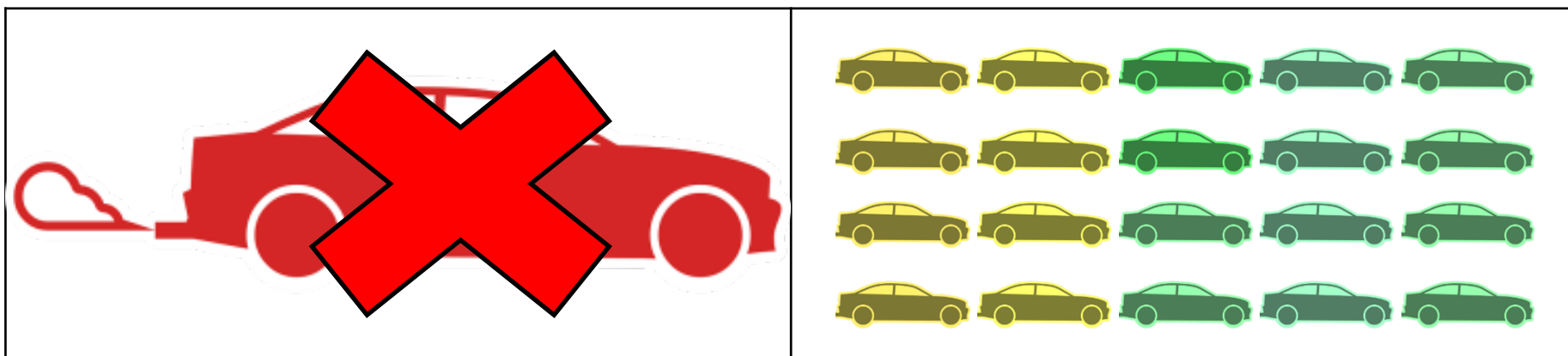


FACULTY
OF MECHANICAL
ENGINEERING
CTU IN PRAGUE

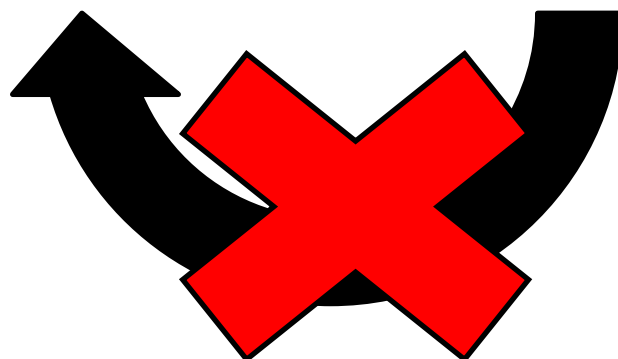
5:50 – 5% cars = 50% pollution

Quick facts: from 25.000 vehicles measured in Prague

- 2/3 diesel, from which 50% with DPF (1/3 from total)
- 50% particulate matter pollution from 5% vehicles
- Most pollution from older vehicles, ~ 9% DPF's faulty



**FIX IT!
OR
DUMP IT!**



**Law Enforcement
In-use Inspection
PTI, on-road screening**

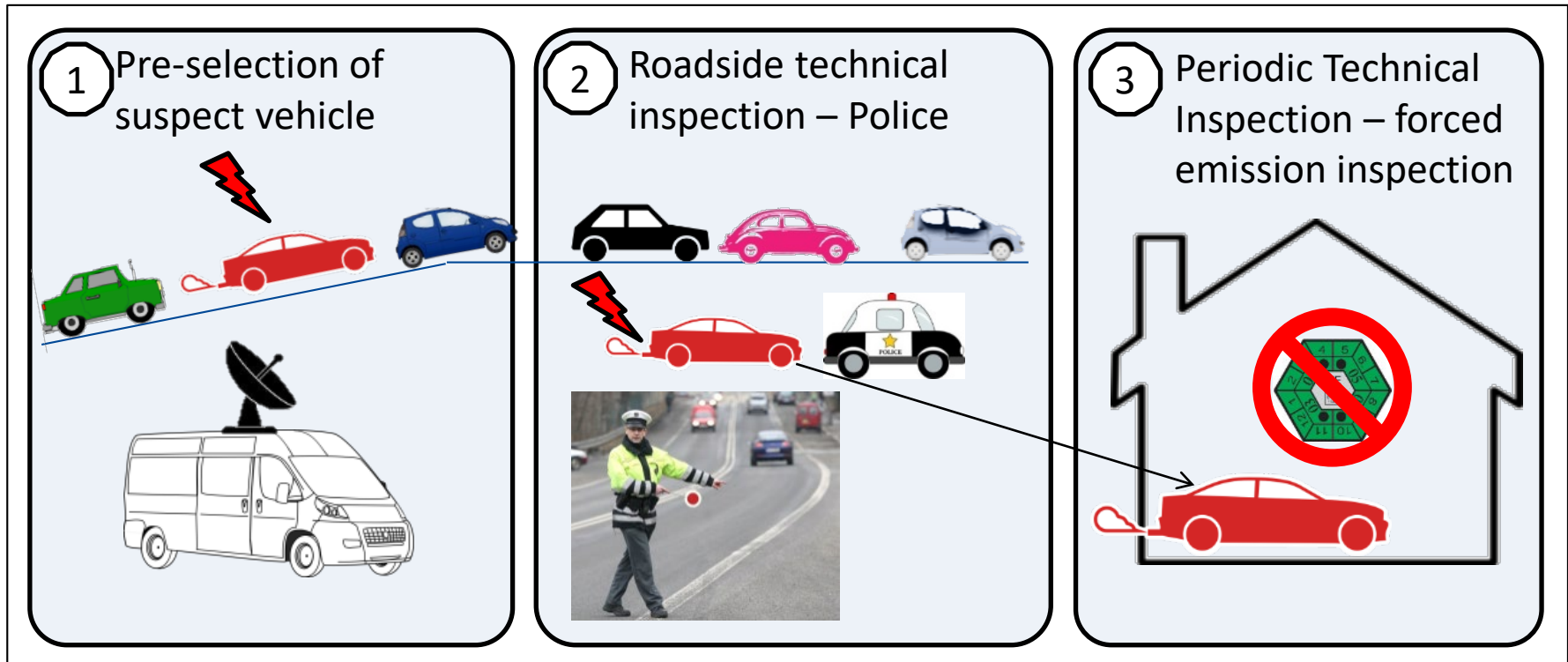
Law Enforcement - Remote Sensing as Pre-selection for Roadside Technical Inspection

Trutnov, May 2018



FACULTY
OF MECHANICAL
ENGINEERING
CTU IN PRAGUE

Pilot study with Ministry of Transportation, Ministry of the Environment and Police
3-phase high emitter vehicle detection



700 passing vehicles
28 suspect high emitters
selected for roadside insp.

Opacity measurement
12 vehicles confirmed with
repeatable excessive smoke

9 failed forced PTI
not roadworthy
1 month to fix and repeat PTI

Roadside Technical Inspection

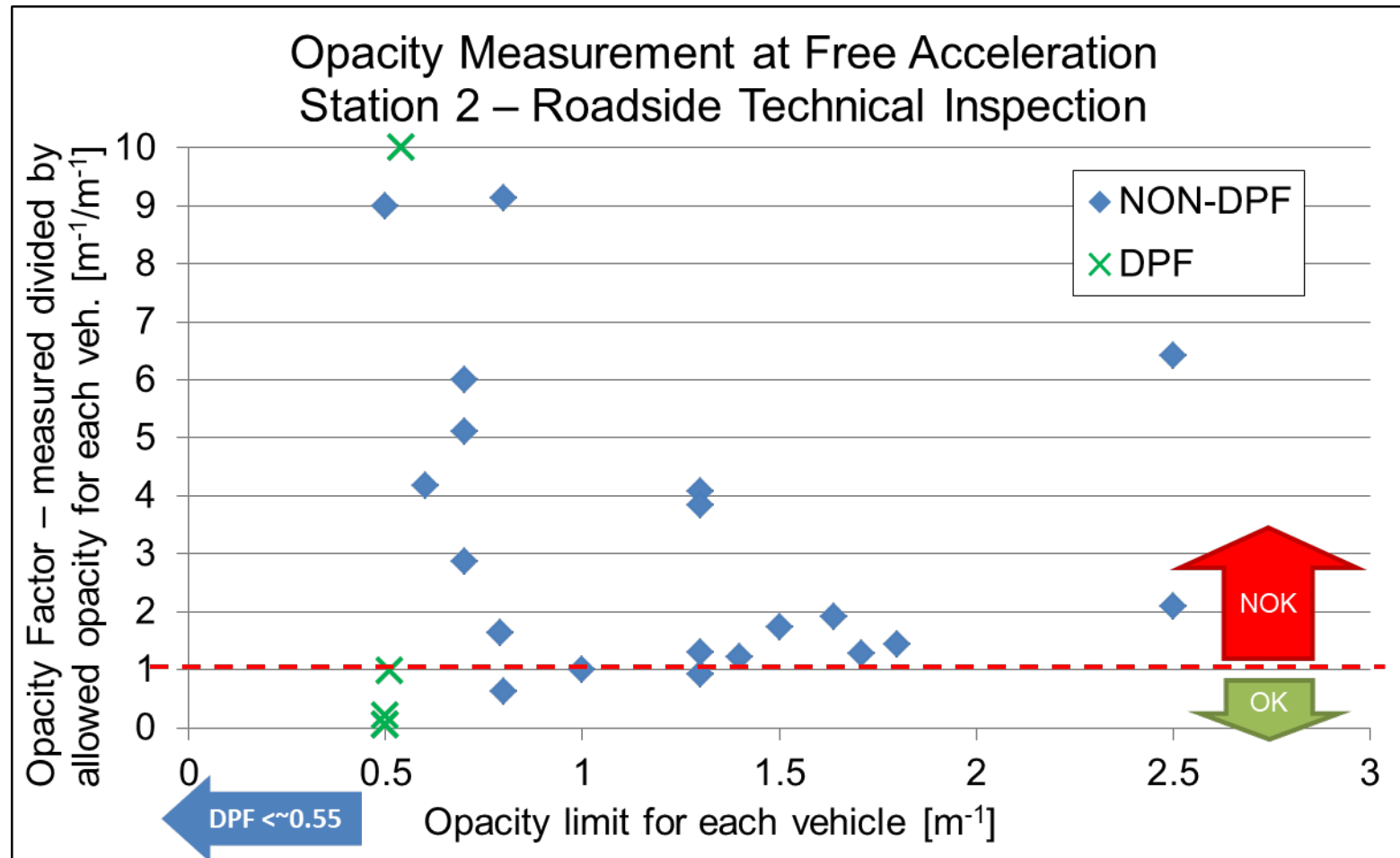
Opacity Measurement, Trutnov, May 2018



FACULTY
OF MECHANICAL
ENGINEERING
CTU IN PRAGUE

28 vehicles subject roadside technical inspection by Police

- 12 vehicles found noncompliant - repeatable excessive smoke over the limit
- 9 failed the PTI test – mostly older vehicles without PDF



There is Still Work to Do

Thank you!

