Fachhochschule Nordwestschweiz
Hochschule für Technik

Development of the new VERT NPTI instrument standard , from NPTI Group to an international standard

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VERT PTI Focus Event, July 7th2021

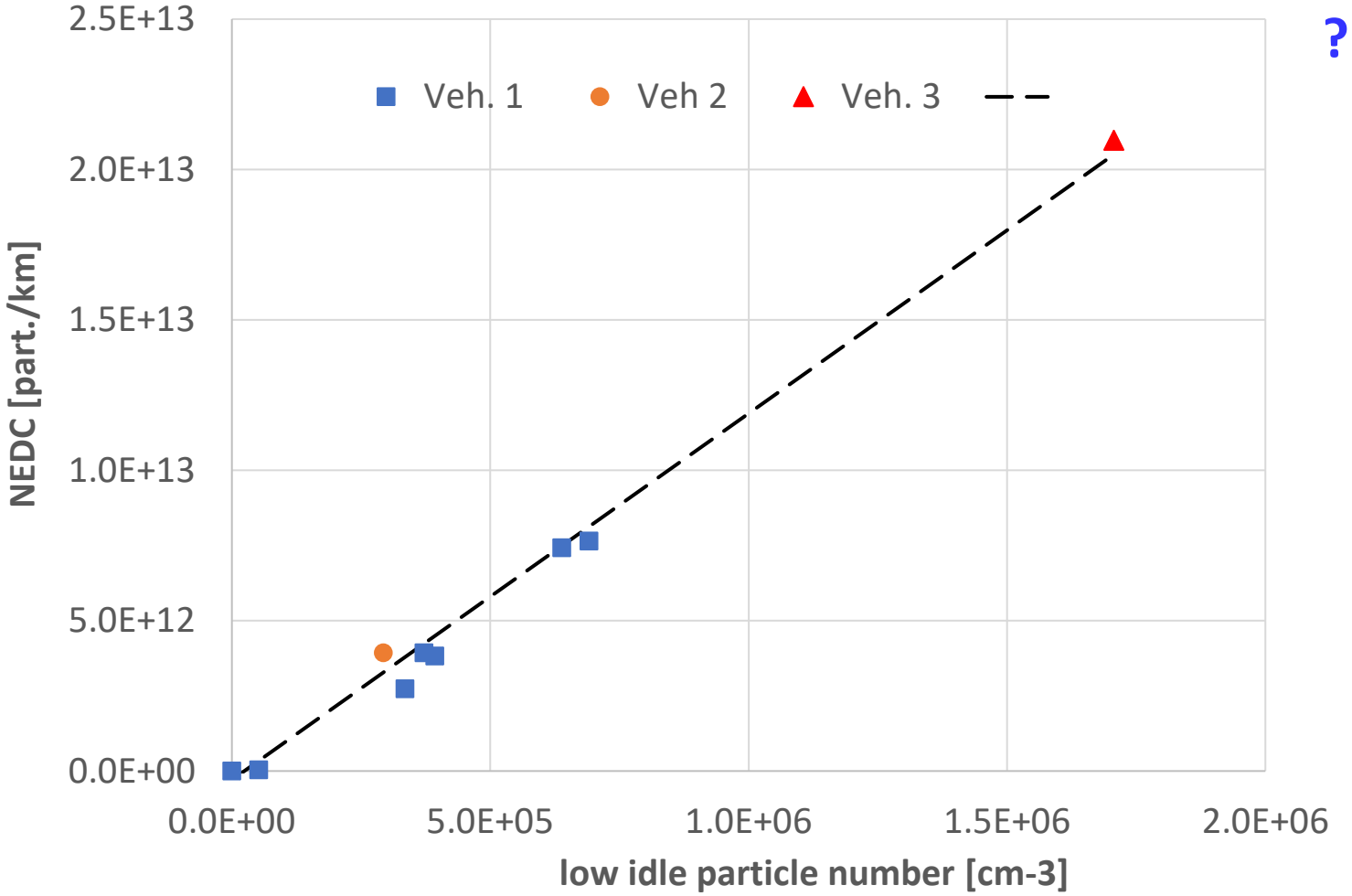
Goals of the NPTI working group:

- Establish Engine operation for measurement
- Measurement procedure
- Requirements for instruments
- Limit value
- Calibration

Main purpose: make sure that particle filter is existent and working properly

→ **as simple as possible, no precise measurement**

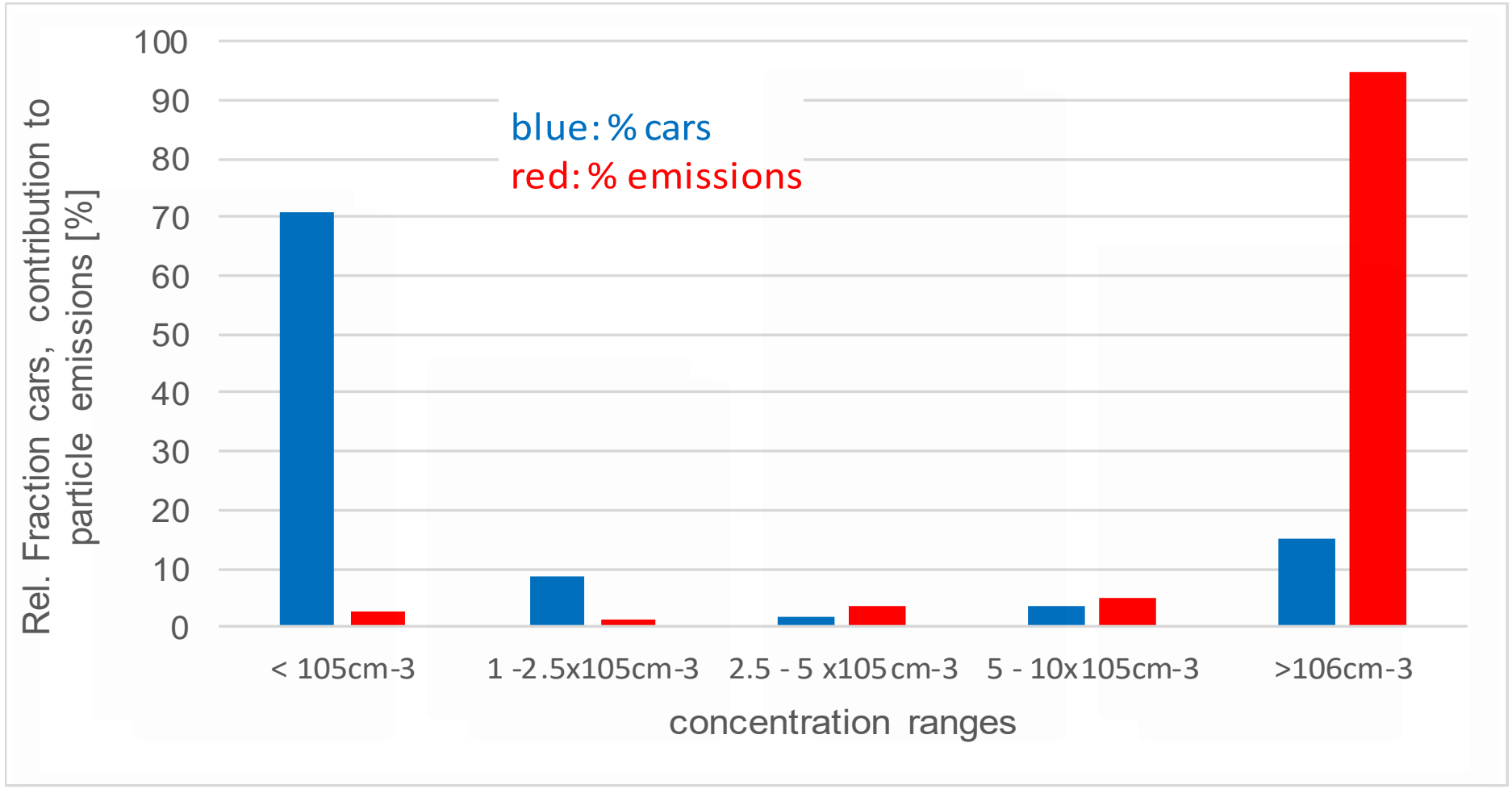
Has to be less stringent than type approval test
Reliably detect real high polluters

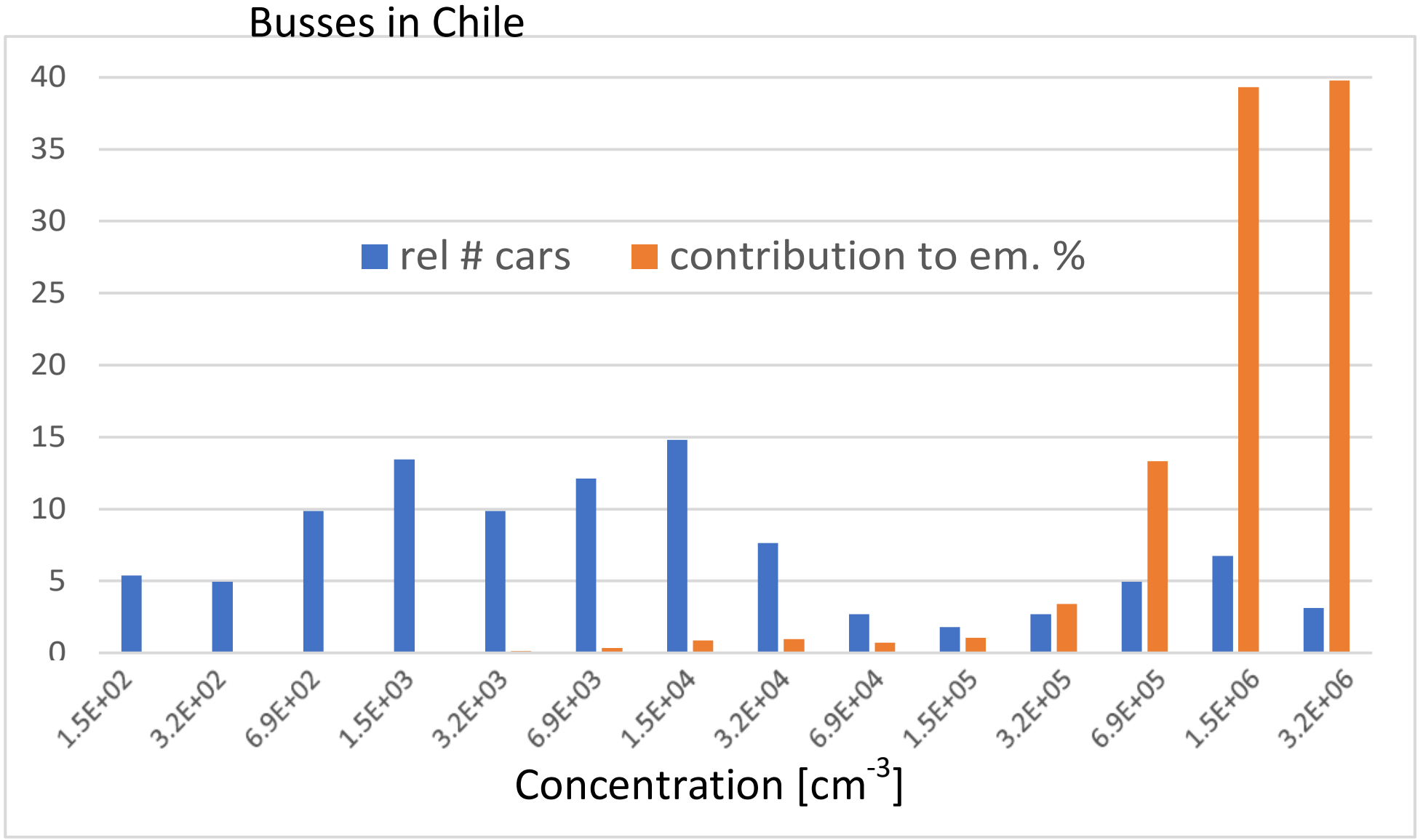


? Engine operation ?

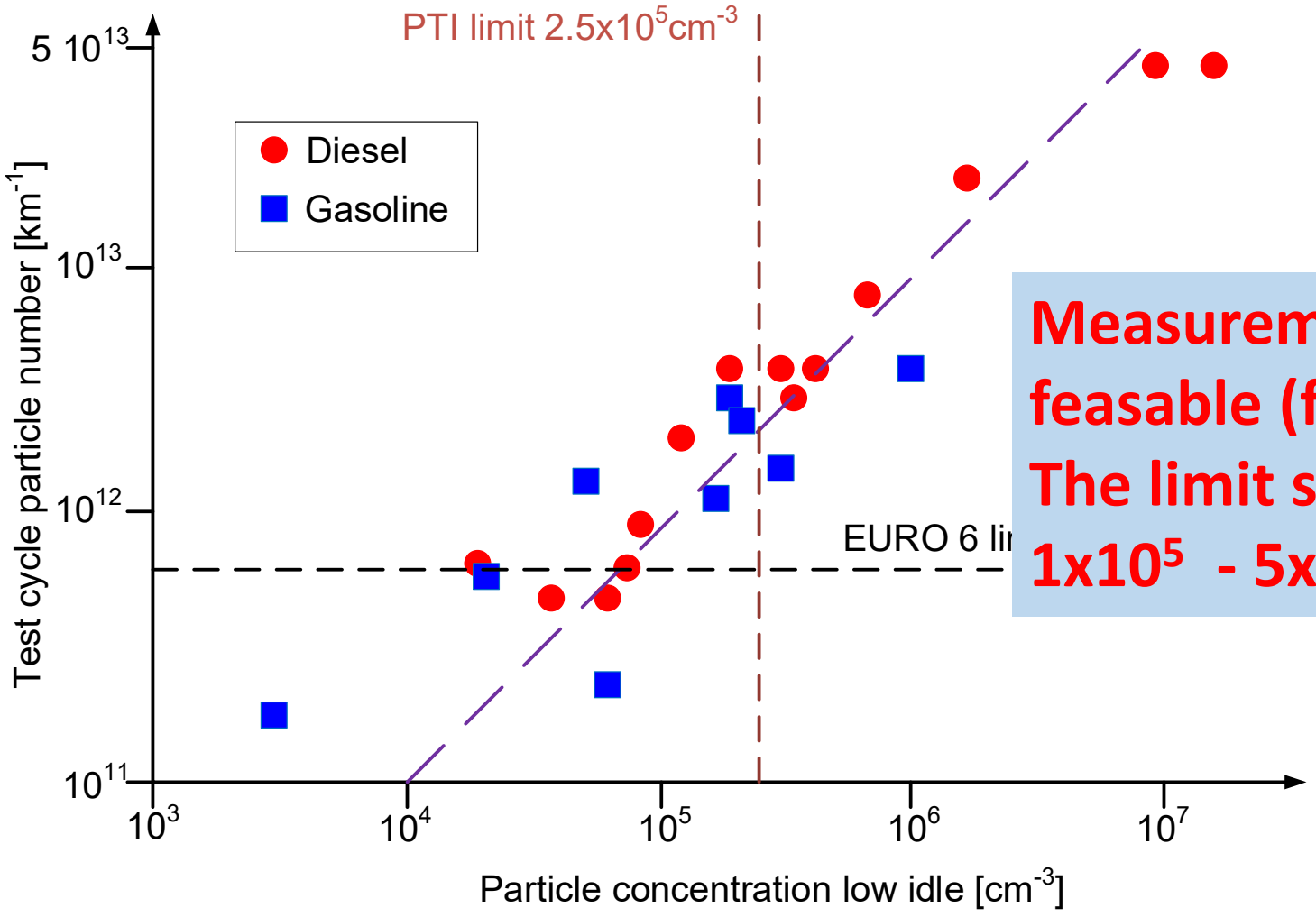
A study by Kadijk et al. (2016) shows a good correlation between results from a test cycle and a simple measurement at low idle

Diesel engines in Switzerland, Data from B.Gloor, AWEL





From Reinoso, 2019



Measurement at low idle is feasable (for diesel engines)
The limit should be in the range $1x10^5$ - $5x10^5 cm^{-3}$

Data from Giechaskiel, 2018

The limits for PTI must be less stringent than for type approval testing. This is fulfilled for a limit >$10^5 cm^{-3}$

Metric:

Number concentration (NC) well established (mainly because it was the only for metric allowing reliable Measurement during PMP) but not necessarily the best metric.

Other possible metrics:
LDSA: better reflects health effects, would allow a very simple and robust DC-charging based sensor

EC/BC: used in occupational health, directly related to ambient air concentrations. No simple commercial device available now, but technology exists

For PTI all metrics are feasible, NC best stablished, LDSA and EC more potential for robust low-cost instruments.
So far, all approaches based on NC

Number concentration measurement requires definition of size dependence

VERT suggestion:

counting rate:

23 nm: 0.2 – 0.6
50nm: 0.6 – 1.3
80nm: 0.7 – 1.3
200nm: <2
Particles >200nm are irrelevant, no restrictions needed

- idling: ->high concentration of very small particles (also below 20nm) possible, for measurement of number concentration the efficiency in this size range therefore has to be well defined (also the particles, used for calibration).
- if LDSA or EC are used as metric, the weight of the sub 20 nm particles is very small anyways, at least to my opinion in this case no specific requirements need to be defined for lower size limit for applications like NPTI.

Measurement duration:

Initial suggestion:
20sec measurement after stabilization phase, average value and standard deviation determined,
for valid measurement: standard dev. <20%

VERT suggestion:
3 x 15 s sampling

Limit Value:

- **Values for really good filters < 5000 cm^{-3}**
- **Type approval limit corresponds to about 100’000 cm^{-3}**
- **Essential to significantly reduce fleet emissions: <500’000 cm^{-3}**

Switzerland, off road:	**250’000 cm^{-3}**
Netherlands	**1’000’000 cm^{-3}**
Germany	**250’000 cm^{-3}**
VERT	**50’000 cm^{-3}**

Requirements to dynamic range:

To decide, if limit is exceeded or not: 3x below and 3x above limit value sufficient
(for values outside this range evident if below or above)

If limit 250’000 cm^{-3} this could be $5x10^4$ - $10^6 cm^{-3}$

To get more information a wider range may be useful (at the price of a more complicated instrument)

Netherlands: 5’000 ÷ 5'000’000 cm^{-3}
PTB: 5’000 ÷ 500’000 cm^{-3}
VERT: 3’000 ÷ 1’000’000 cm^{-3}

Conditioning

low idling during measurement (-> λ=8 -> no or only small dilution needed to avoid nucleation)

If temperature always (in sampling line and sensor) >120°C no nucleation will occur, in this case no dilution is required.
(This is for diesel engines only)

Requirement for instruments:
Tetracontane removal efficiency for 30nm particles: >95%

Other requirements:

- Maintenance interval: 1 year
- electromagnetic compatibility class E2
- mechanical robustness: class M2

Environmental conditions:

Temperature:	10°C to 40 °C
Pressure:	860 hPa to 1060hPa
Humidity:	rh < 80%

Final considerations:

- Finding a solution is trying to find a compromise between the very pragmatic approach: detect super polluters as easily as possible
  and one leading to more precise results at higher cost
- unfortunately, different countries have different solutions, harmonization very essential
- Beside just distinguishing between go and no go PTI may help to detect problems before they become severe.