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ULTRAFINE AND NANOPARTICLE EMISSIONS FROM WTE PLANTS

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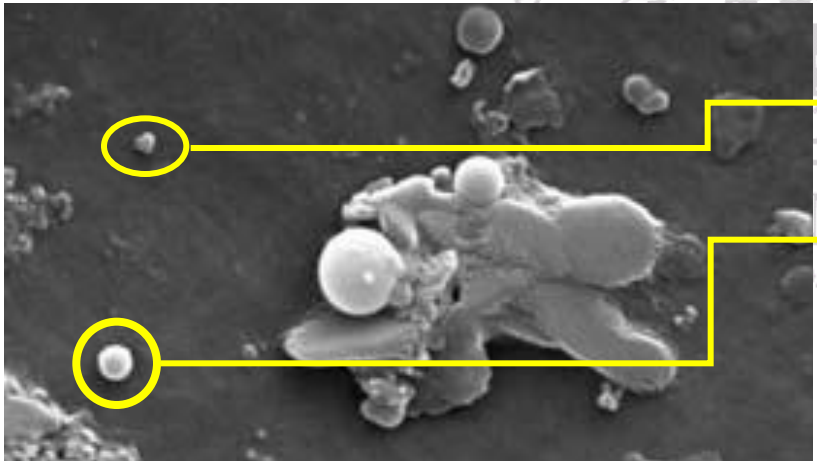
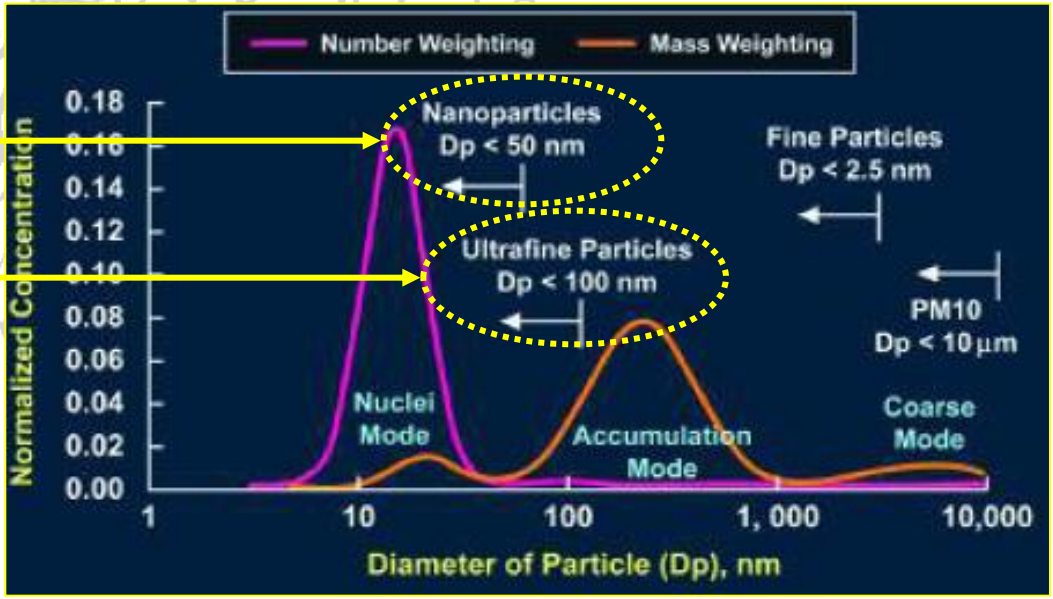
DIIAR Environmental Section

Background

Ultrafine (UP) and nanoparticles (NP)

- Dimensions < 0,1 µm (UP) - 0,05 µm (NP)
- **Main environmental** concerns → nanotechnologies, nanomaterials, indoor exposures
- Recent attention to **combustion emissions**
  - most data available for vehicle exhaust
  - limited investigations for stationary sources
  - **few studies for WTE plants**





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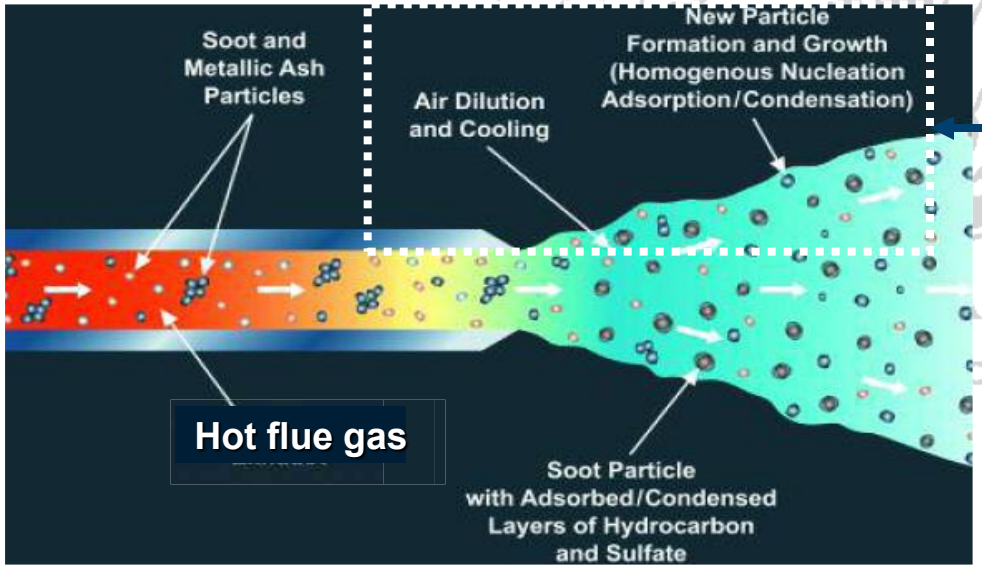
Ultrafine (UP) and nanoparticles (NP)

- **Measurement issues**
  - no standard protocol
  - significance in terms of **number** rather than mass
  - contribution of **condensable fraction** from semivolatiles driven by atmospheric gas dilution



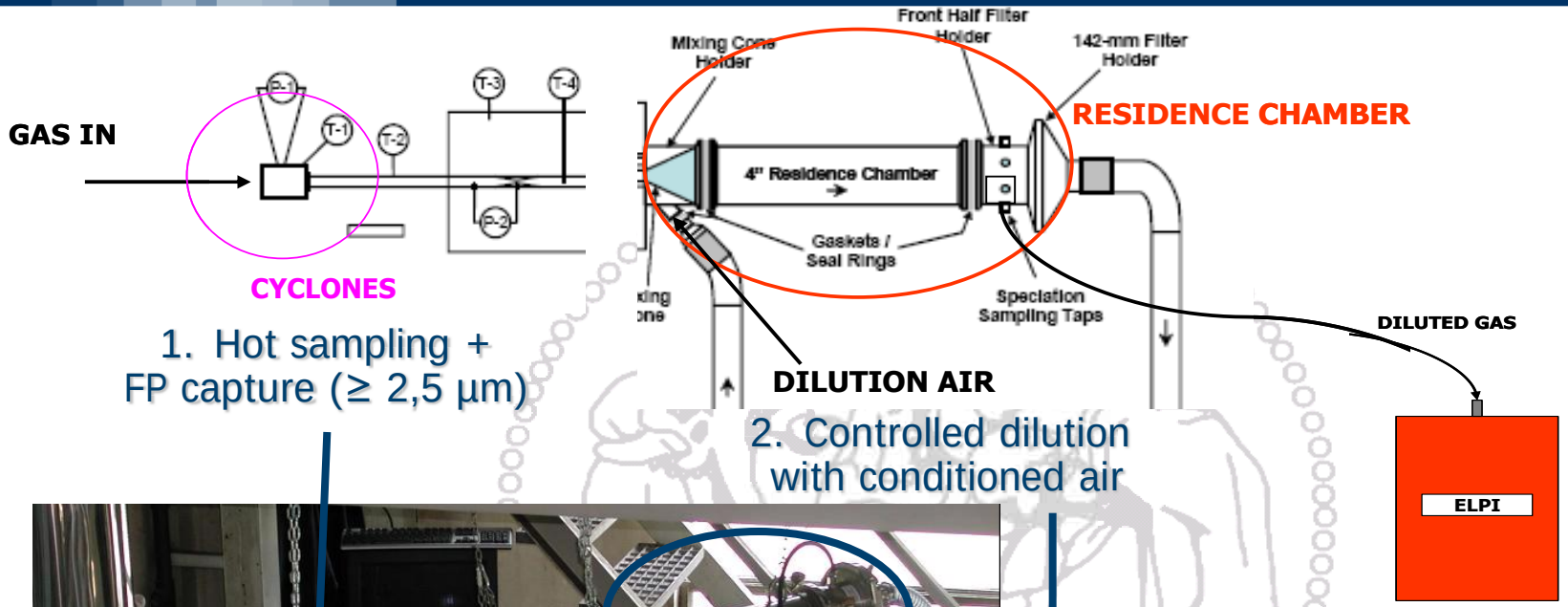
Condensable particles (semivolatiles nucleation/condensation driven by atmospheric gas dilution)

WTE emissions

ULTRAPART project

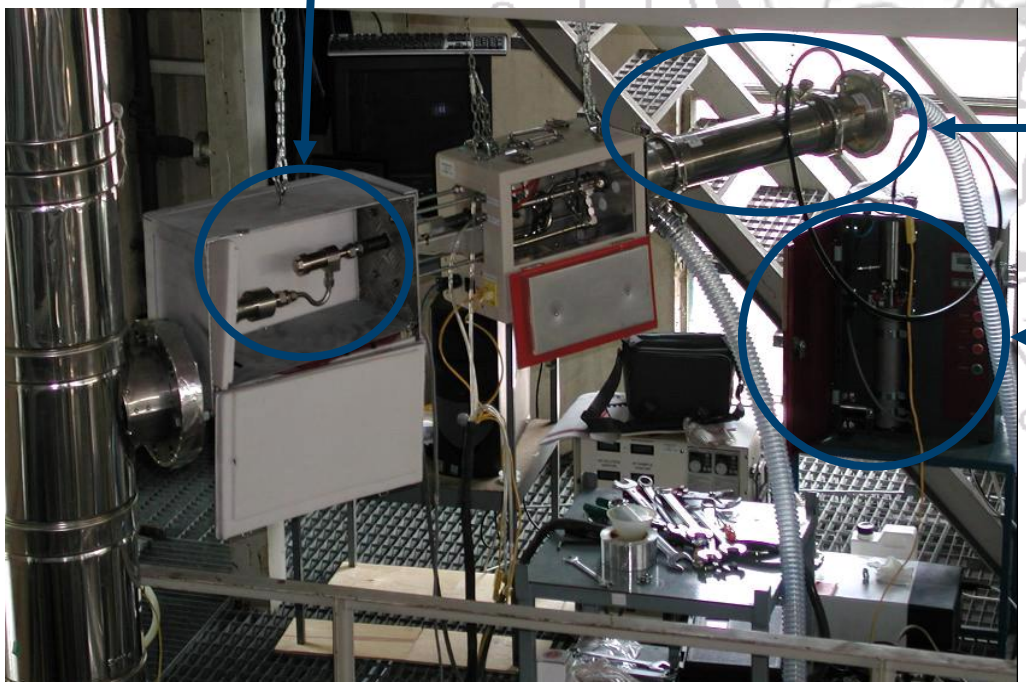
- Characterization of ultrafine and nanoparticle emissions from stationary combustion sources
  - **waste to energy plants**
  - residential boilers fuelled with biomass, light fuel oil and natural gas
- Particle number **concentration** and **size distribution**
- Evaluation of the **condensation effects** by **diluting** and **cooling** the exhaust gas prior to measurements

Sampling/measurement train



1. Hot sampling + FP capture (≥ 2,5 µm)

2. Controlled dilution with conditioned air



3. Particle counting (0.007 µm - 10 µm in 12 classes) Inertial impactor ELPI™

WTE plants evaluation

Sources investigated

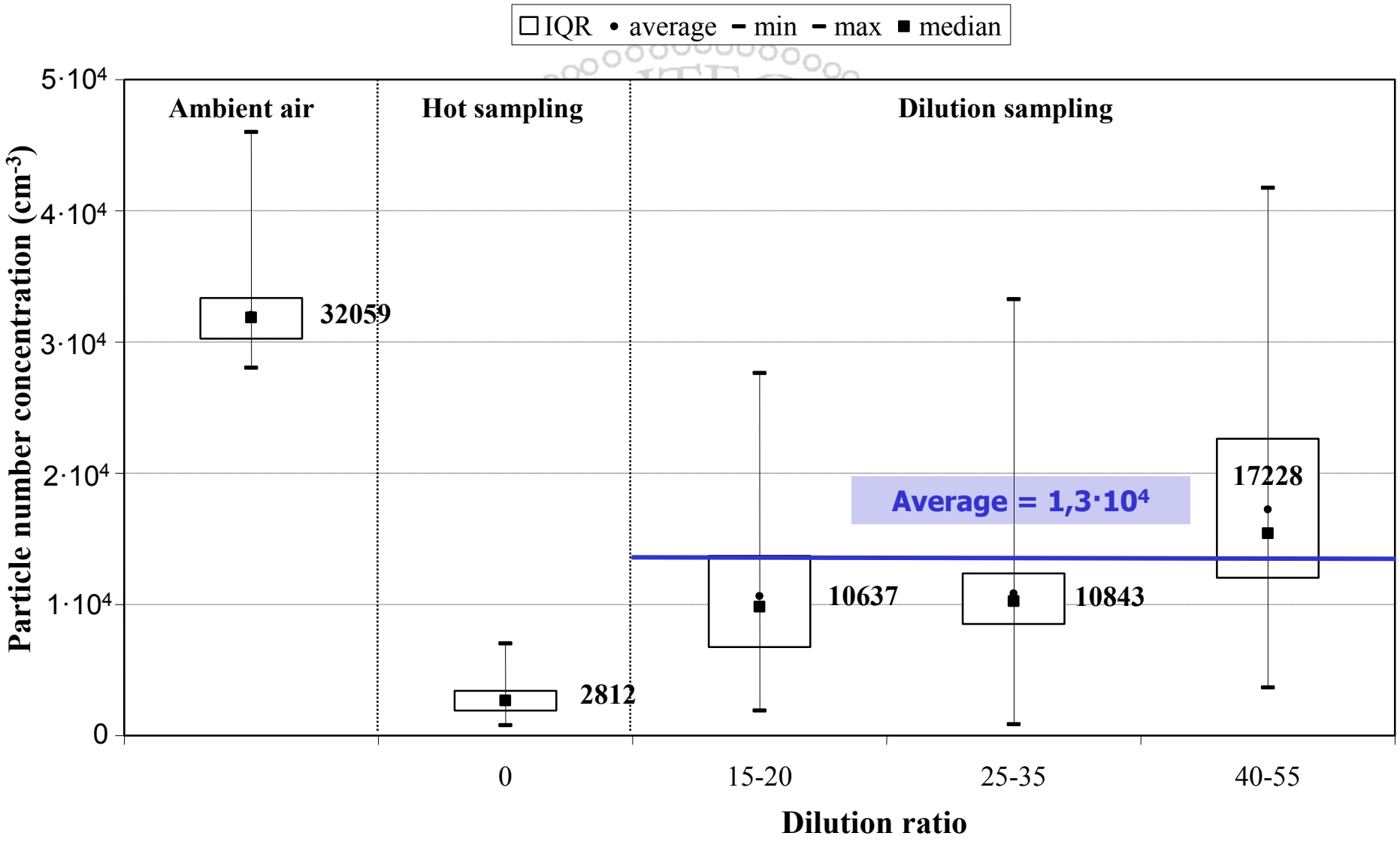
- Urban and commercial waste
- 5 plants, capacity 600 - 1200 tpd
- BAT design for flue gas treatment
  - dry removal + SCR (2 plants)
  - dry/wet removal + SCR (1 plant)
  - dry/wet removal + SNCR (2 plants)

Measurement campaigns

- Hot sampling
- Dilution sampling
  - low: DR =15 ➞ 20
  - medium: DR = 25 ➞ 40
  - high: DR = over 40
- Ambient air

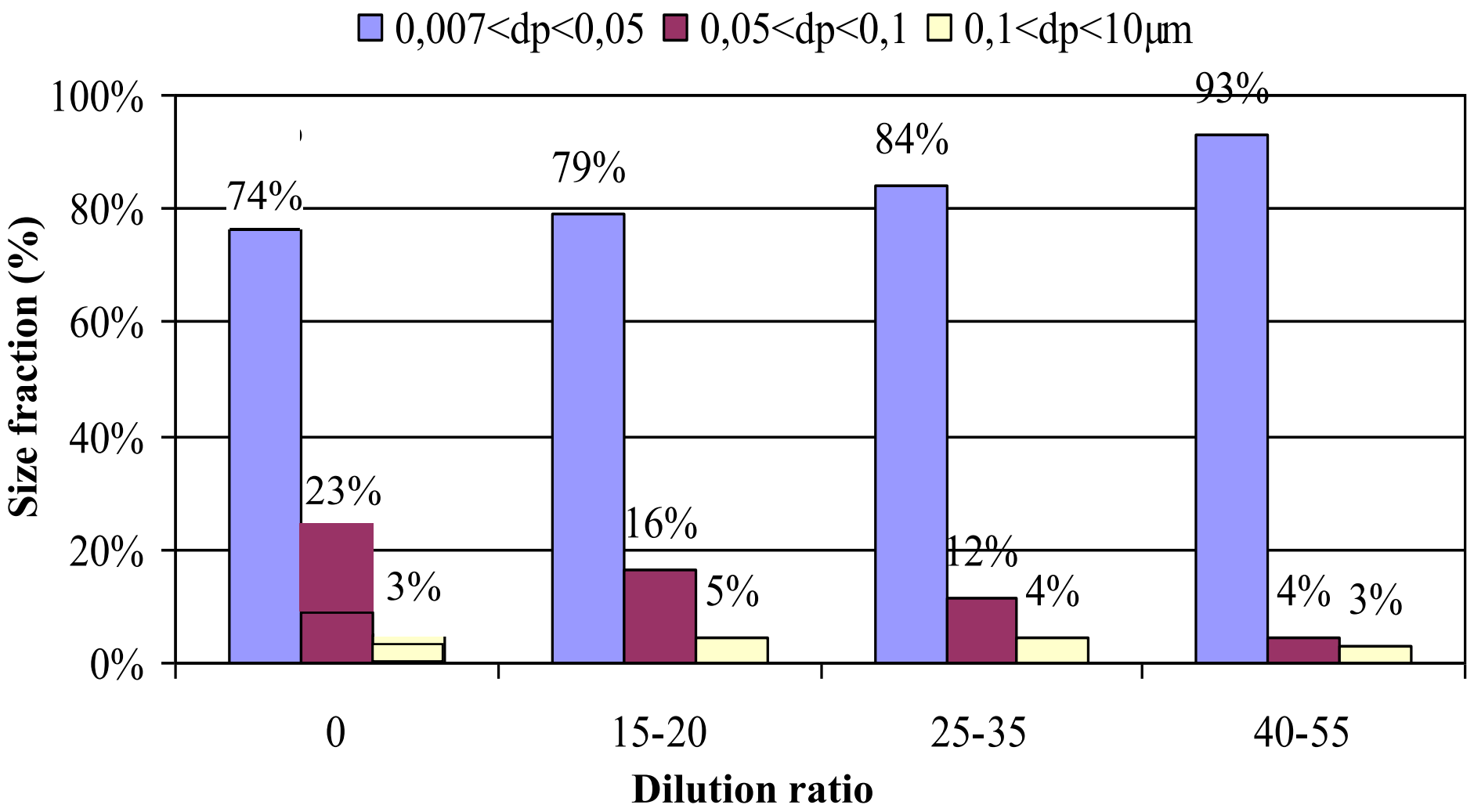
WTE 1 - Dry with final FF (170°C)

Number concentration (particles cm^{-3})



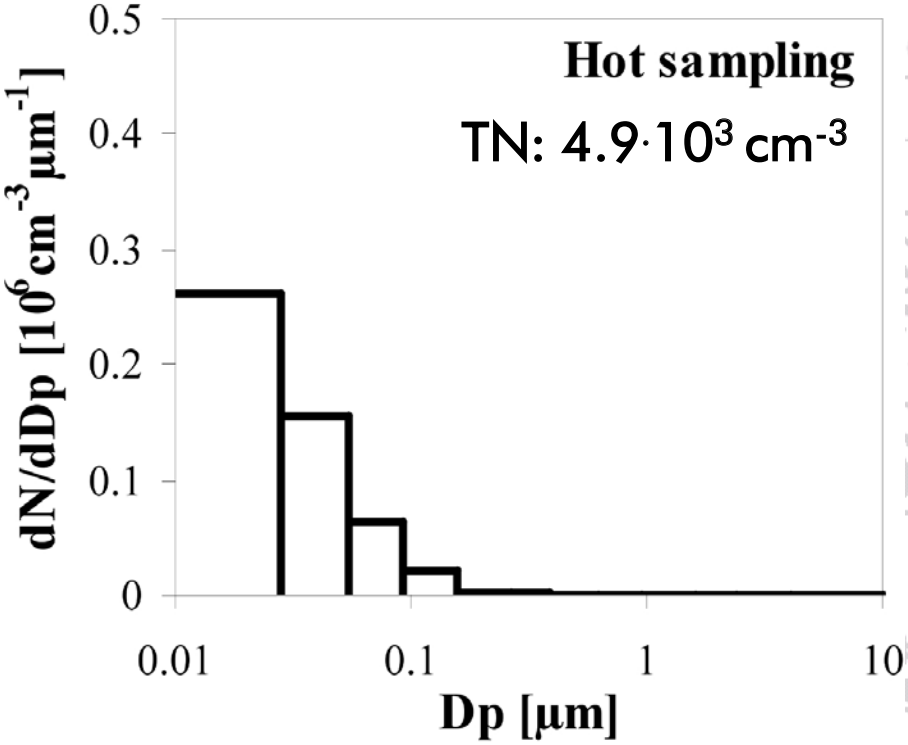
WTE 1 - Dry with final FF (170°C)

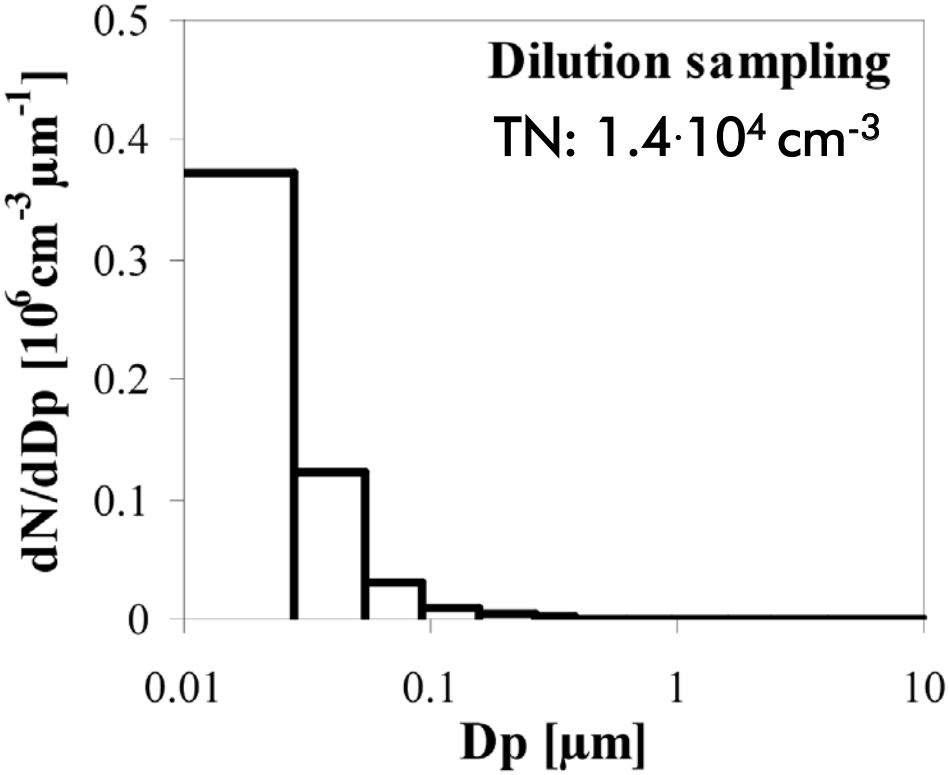
Size fractions



WTE 1 - Dry, FF at 170°C

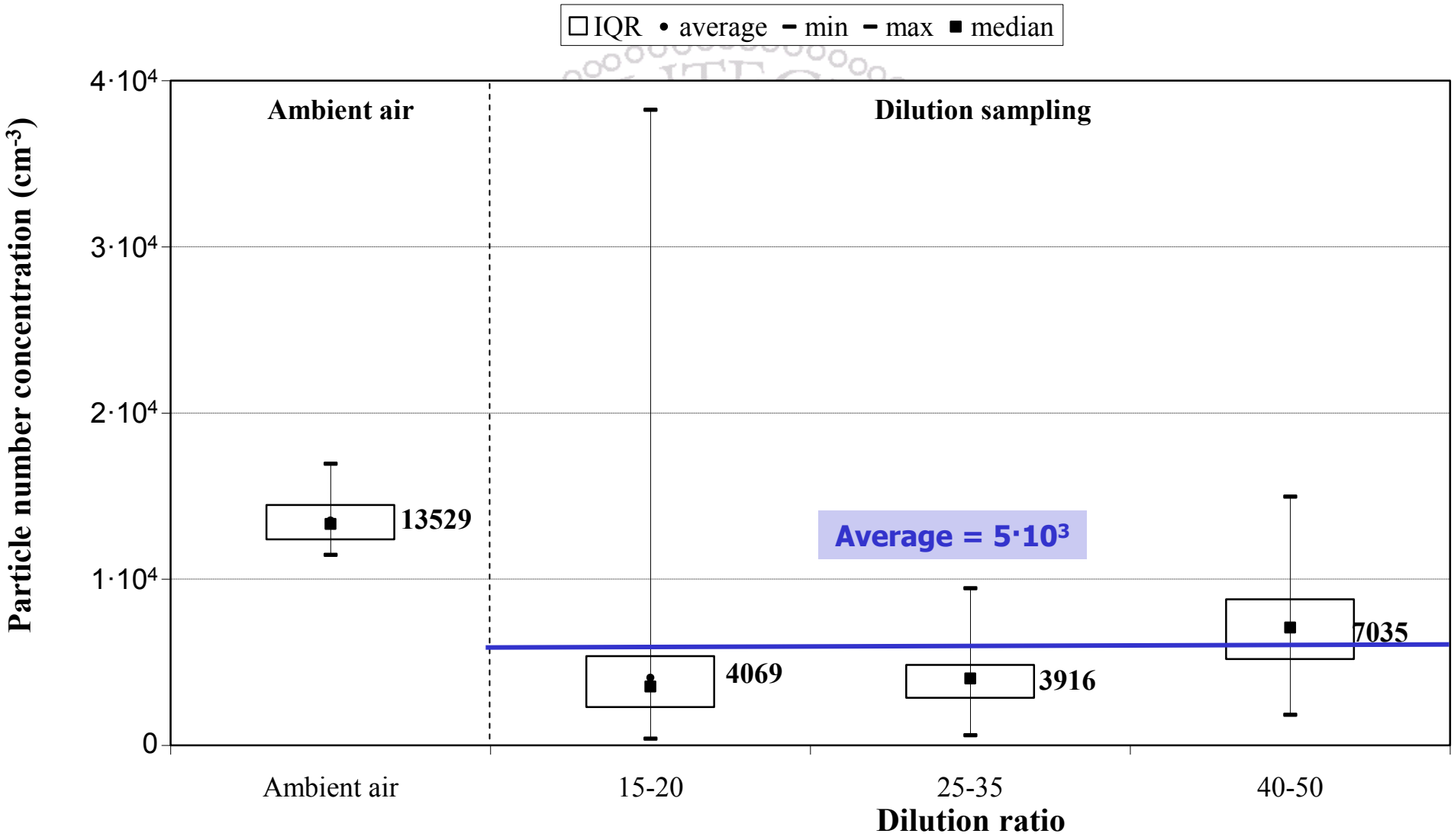
Size distributions



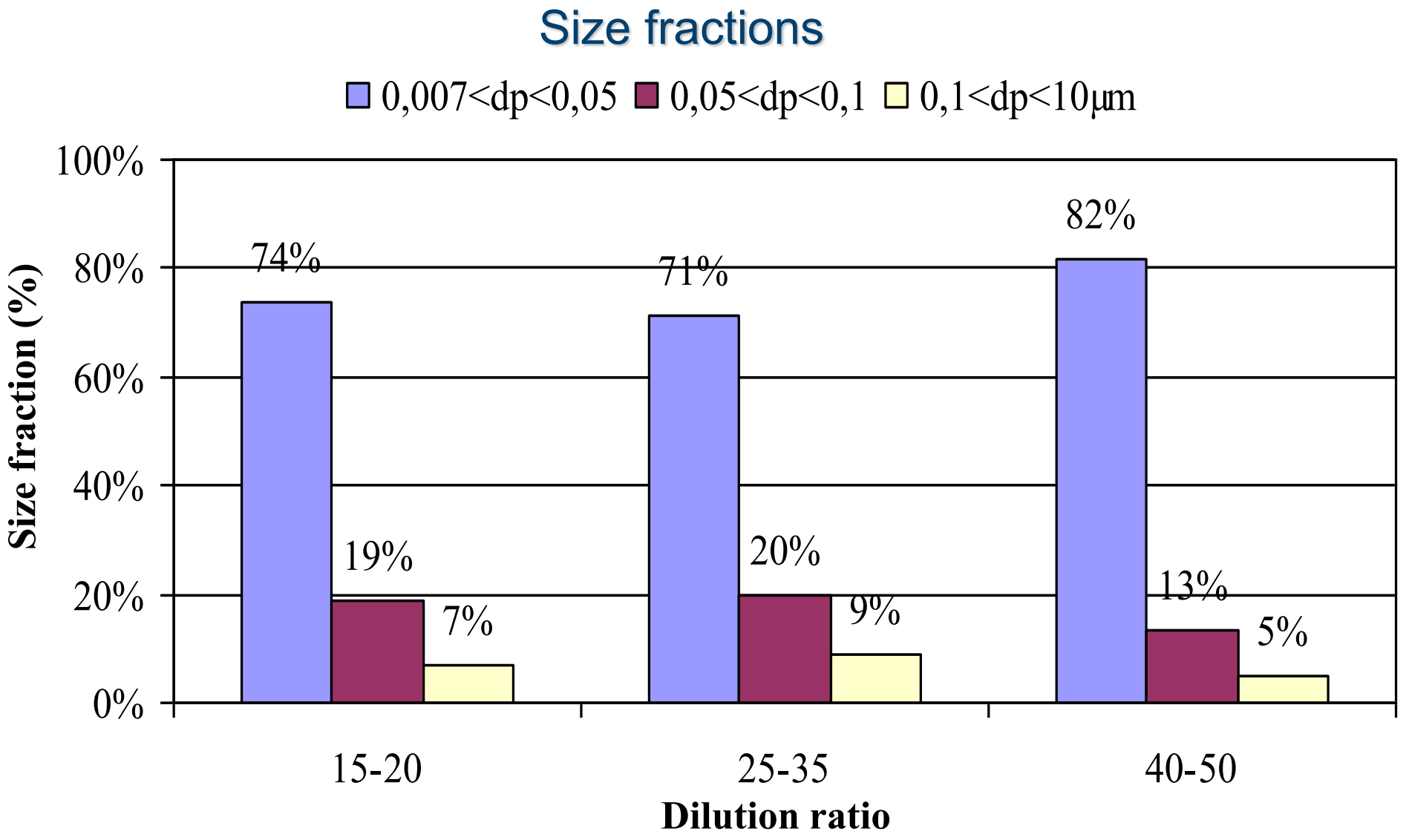


WTE 2 - Dry with final FF (130°C)

Number concentration (particles cm^{-3})

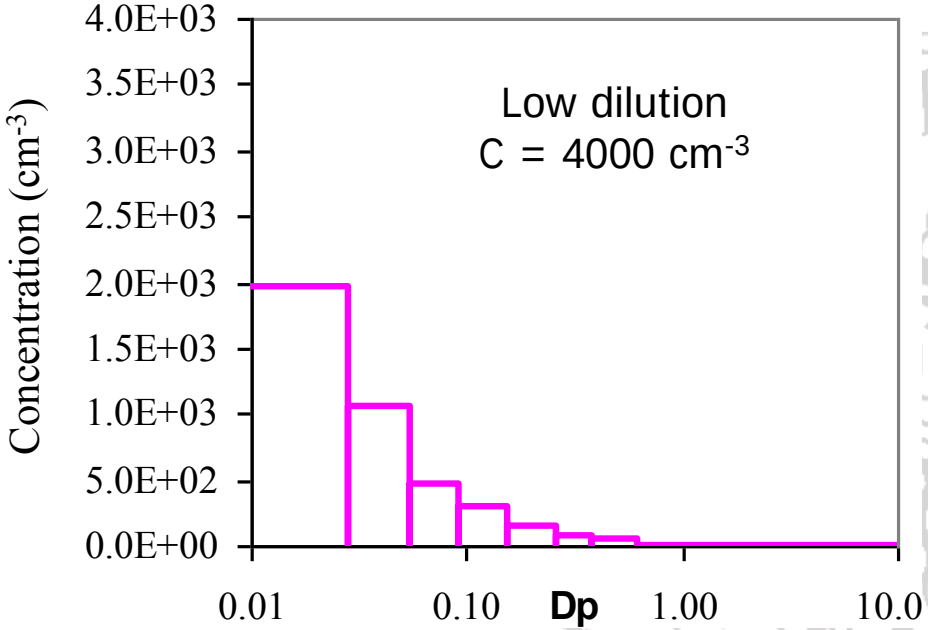


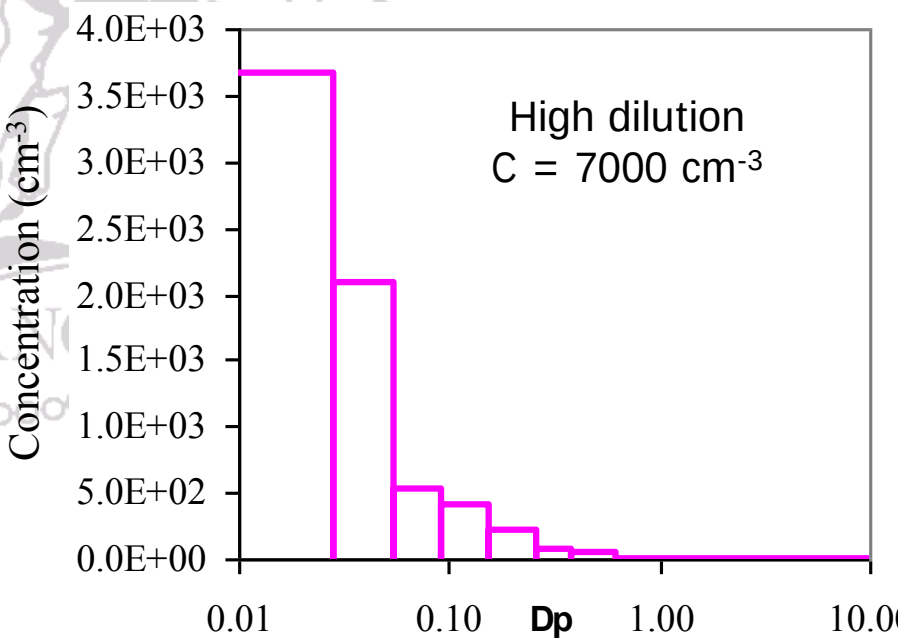
WTE 2 - Dry with final FF (130°C)



WTE 2 - Dry with final FF (130°C)

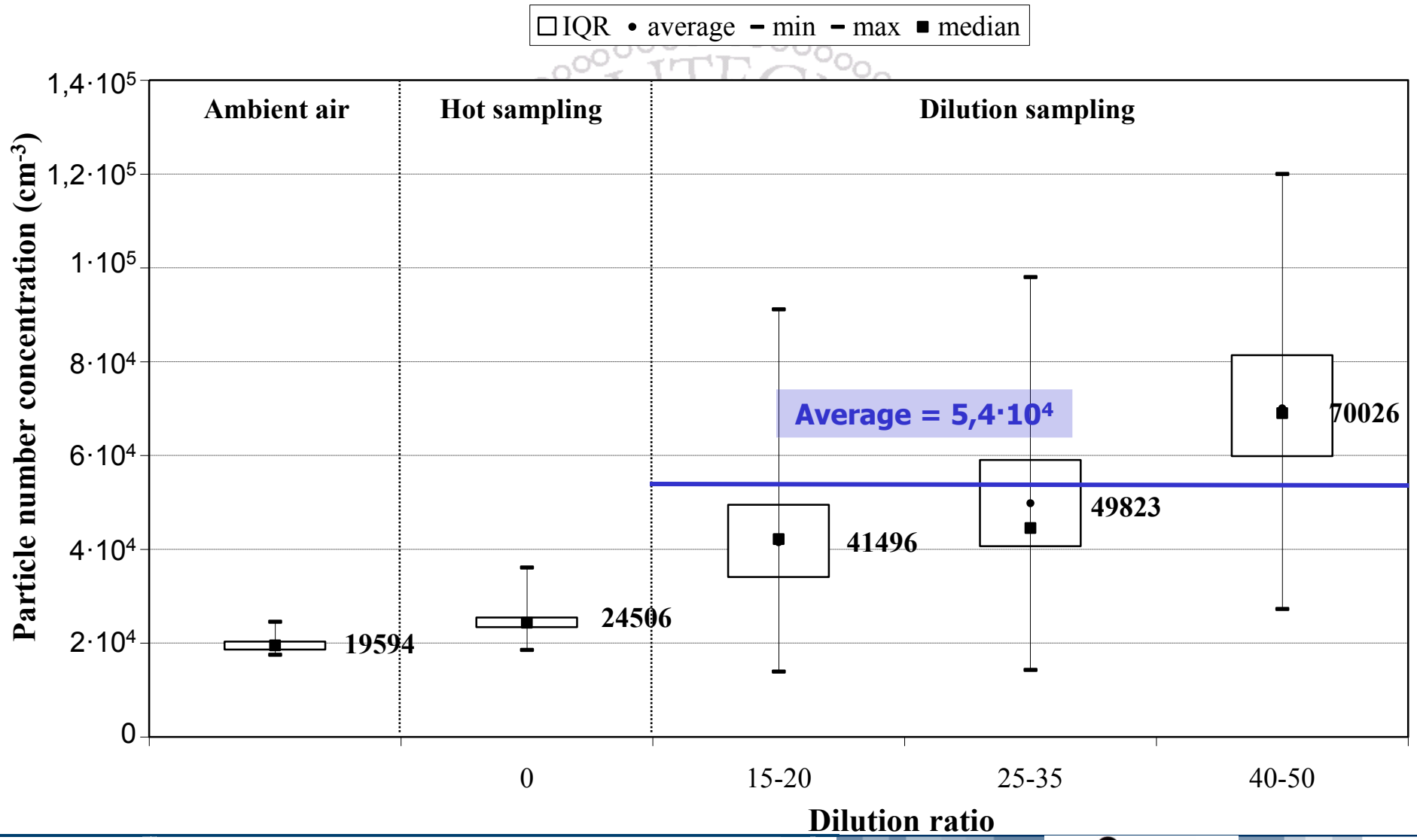
Size distributions



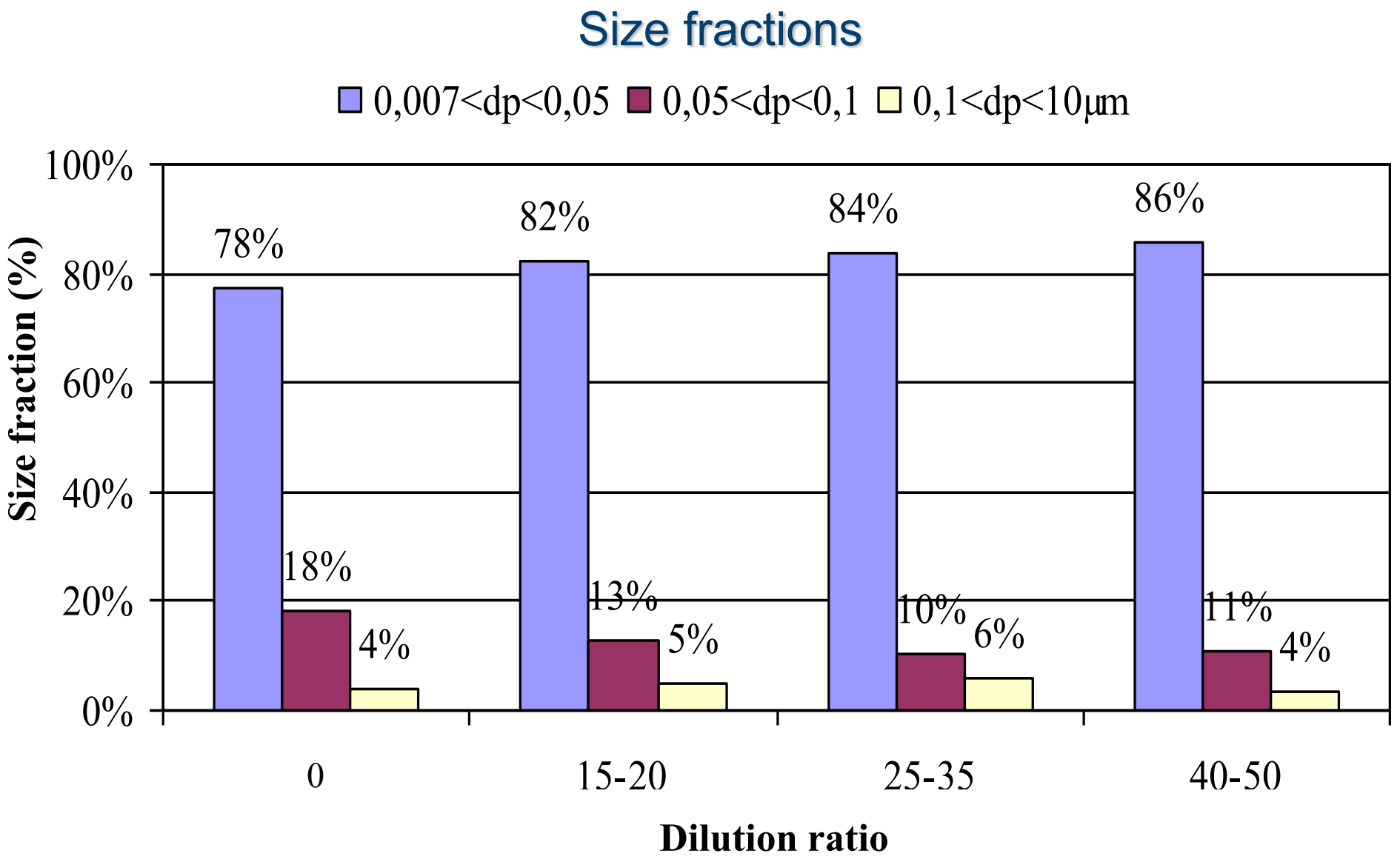


WTE 3 - Wet/dry

Number concentration (particles cm^{-3})

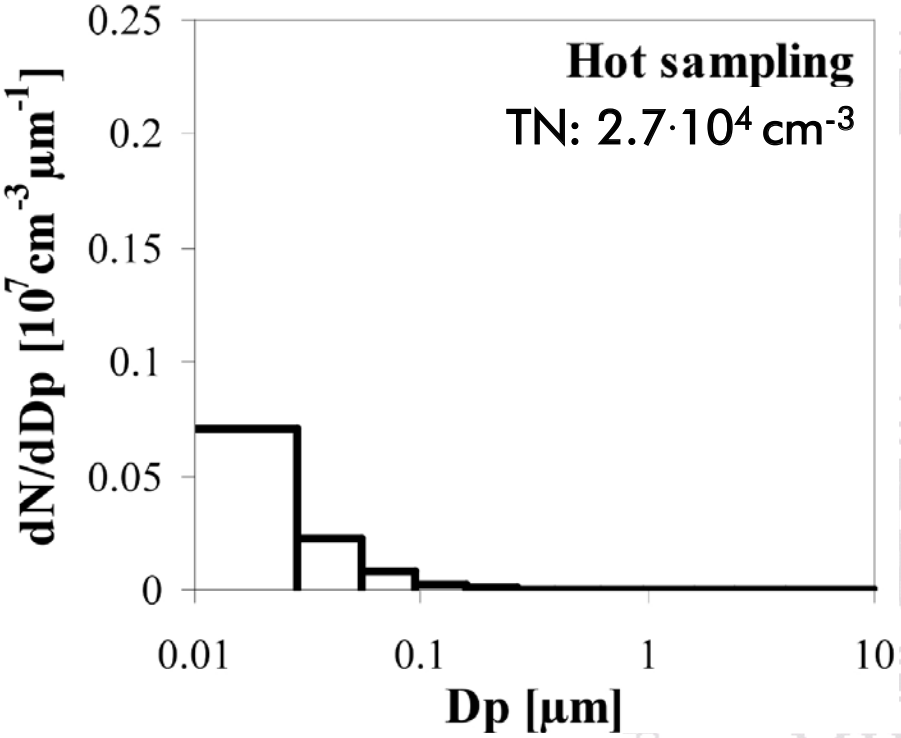


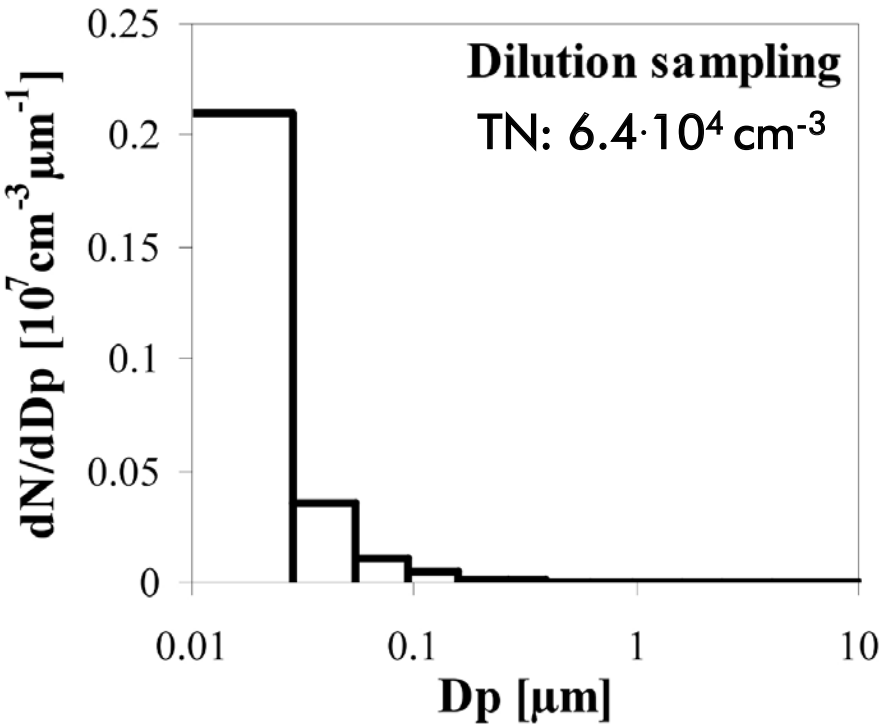
WTE 3 - Wet/dry


Size fractions
0,007<dp<0,05
0,05<dp<0,1
0,1<dp<10µm
100%
80%
60%
40%
20%
0%
Size fraction (%)
78%
18%
4%
82%
13%
5%
84%
10%
6%
86%
11%
4%
0
15-20
25-35
40-50
Dilution ratio

WTE 3 - Wet/dry

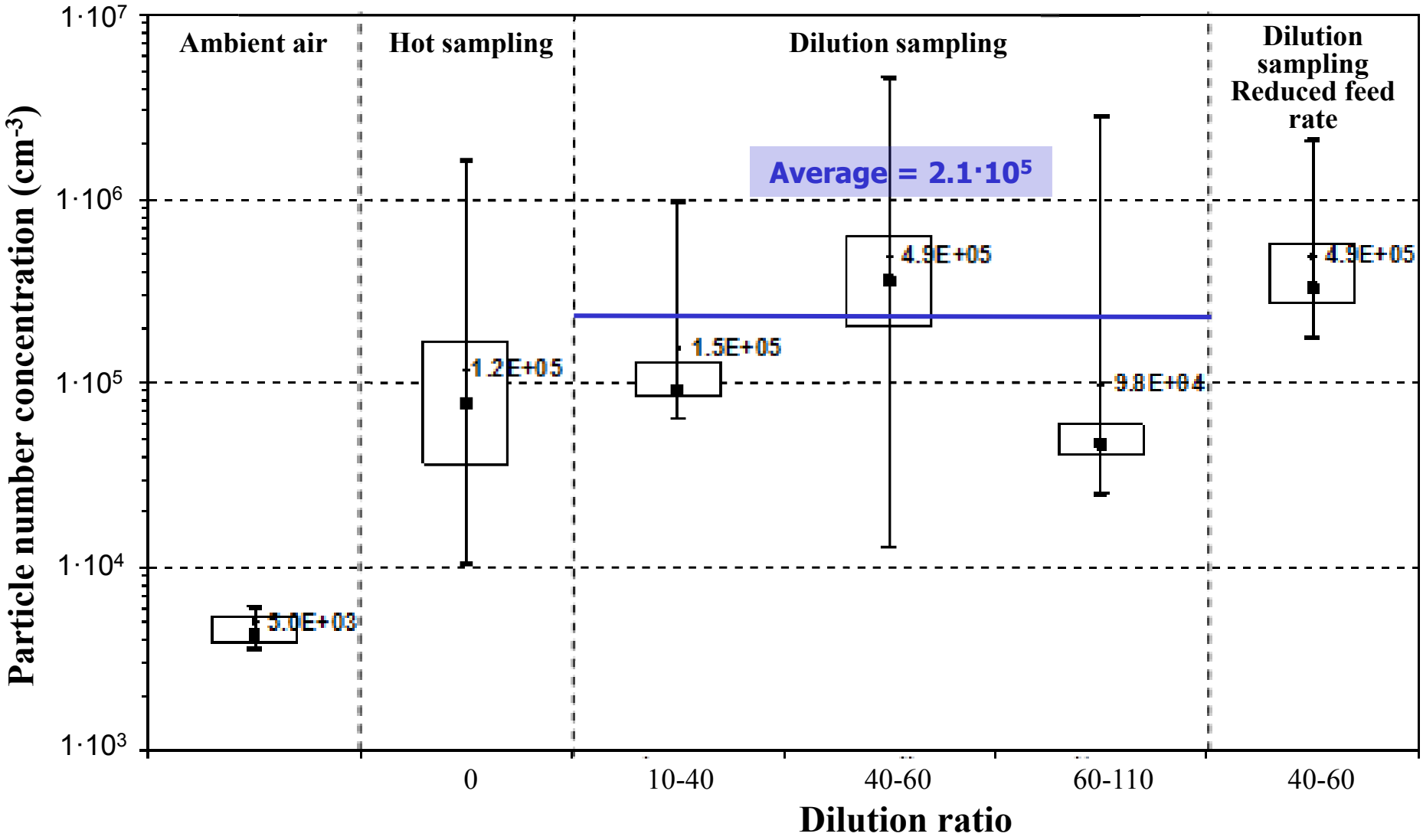
Size distribution



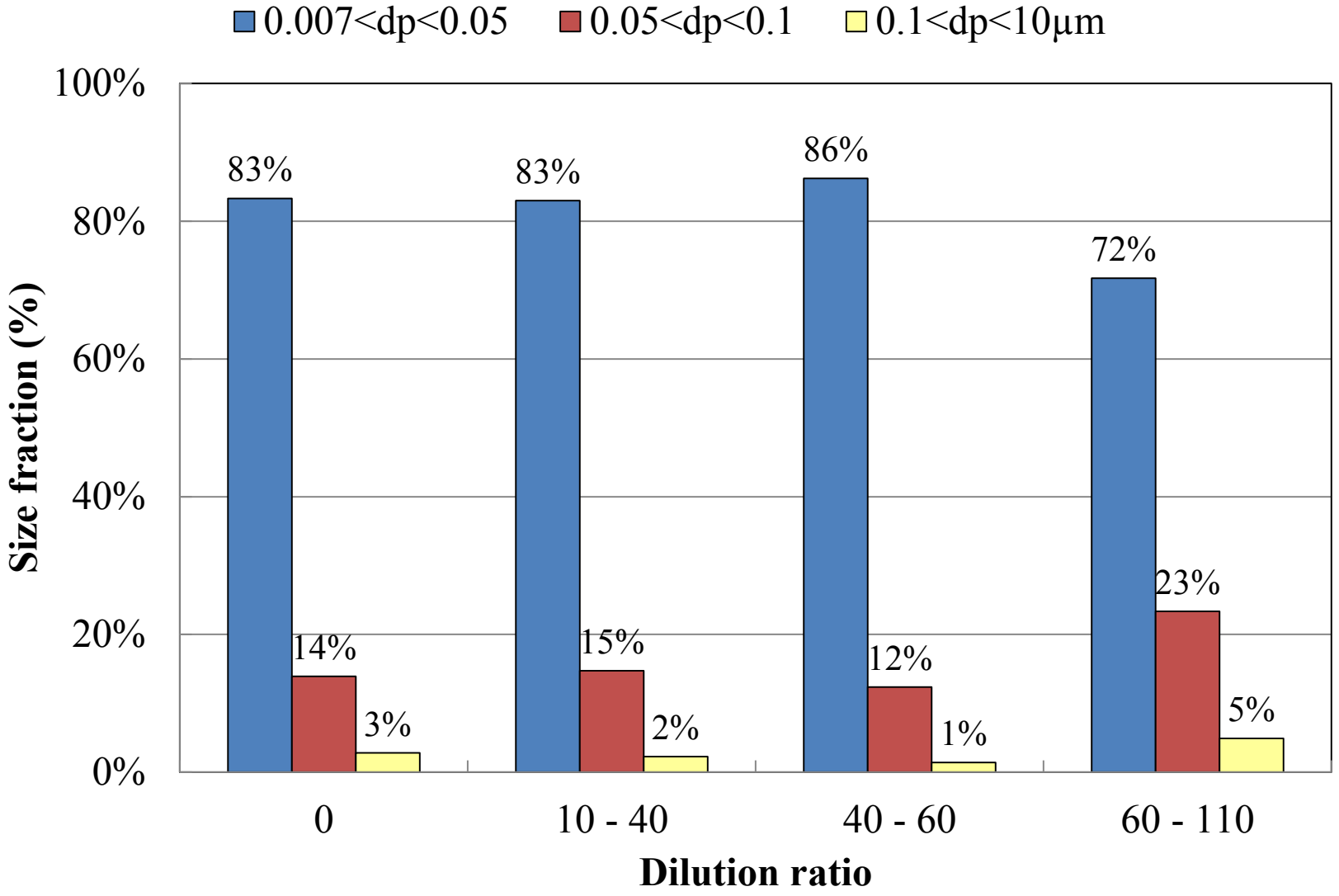


WTE 4 - Wet/dry

Number concentration (particles cm^{-3})

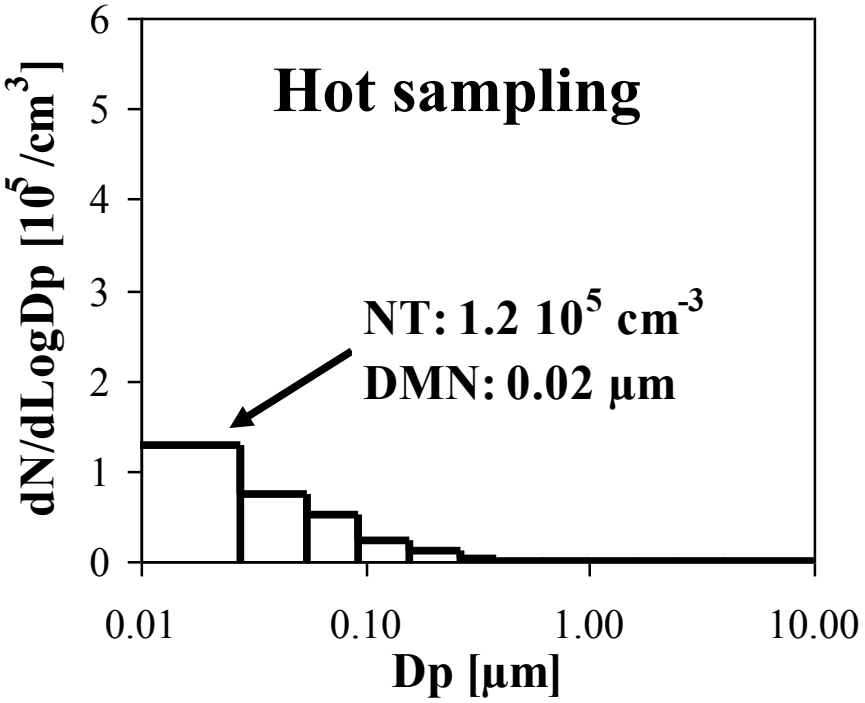


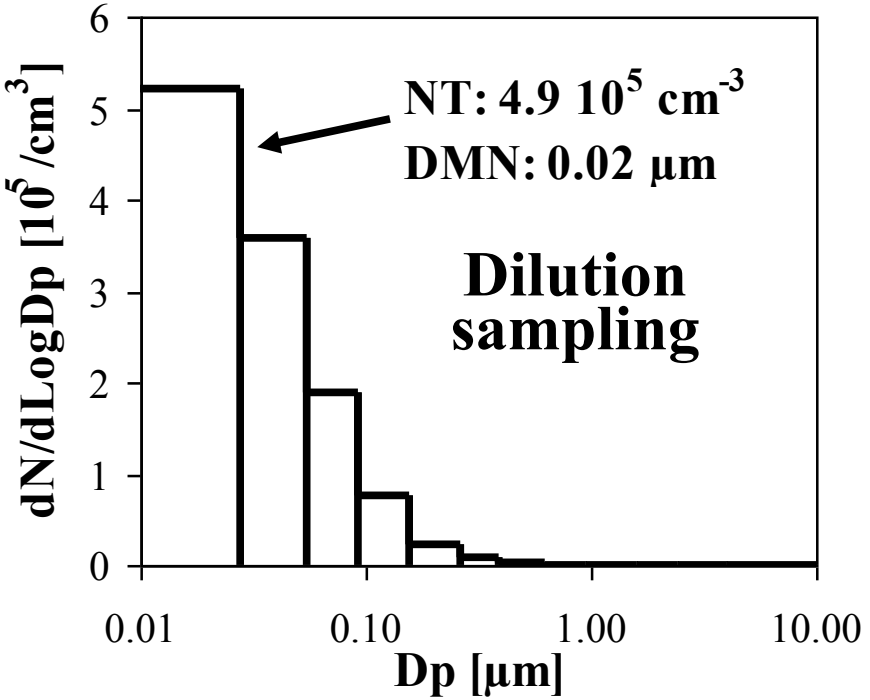
WTE 4 - Wet/dry


Size fractions
0.007<dp<0.05
0.05<dp<0.1
0.1<dp<10µm
100%
80%
60%
40%
20%
0%
Size fraction (%)
83%
14%
3%
83%
15%
2%
86%
12%
1%
72%
23%
5%
0
10 - 40
40 - 60
60 - 110
Dilution ratio

WTE 4 - Wet/dry

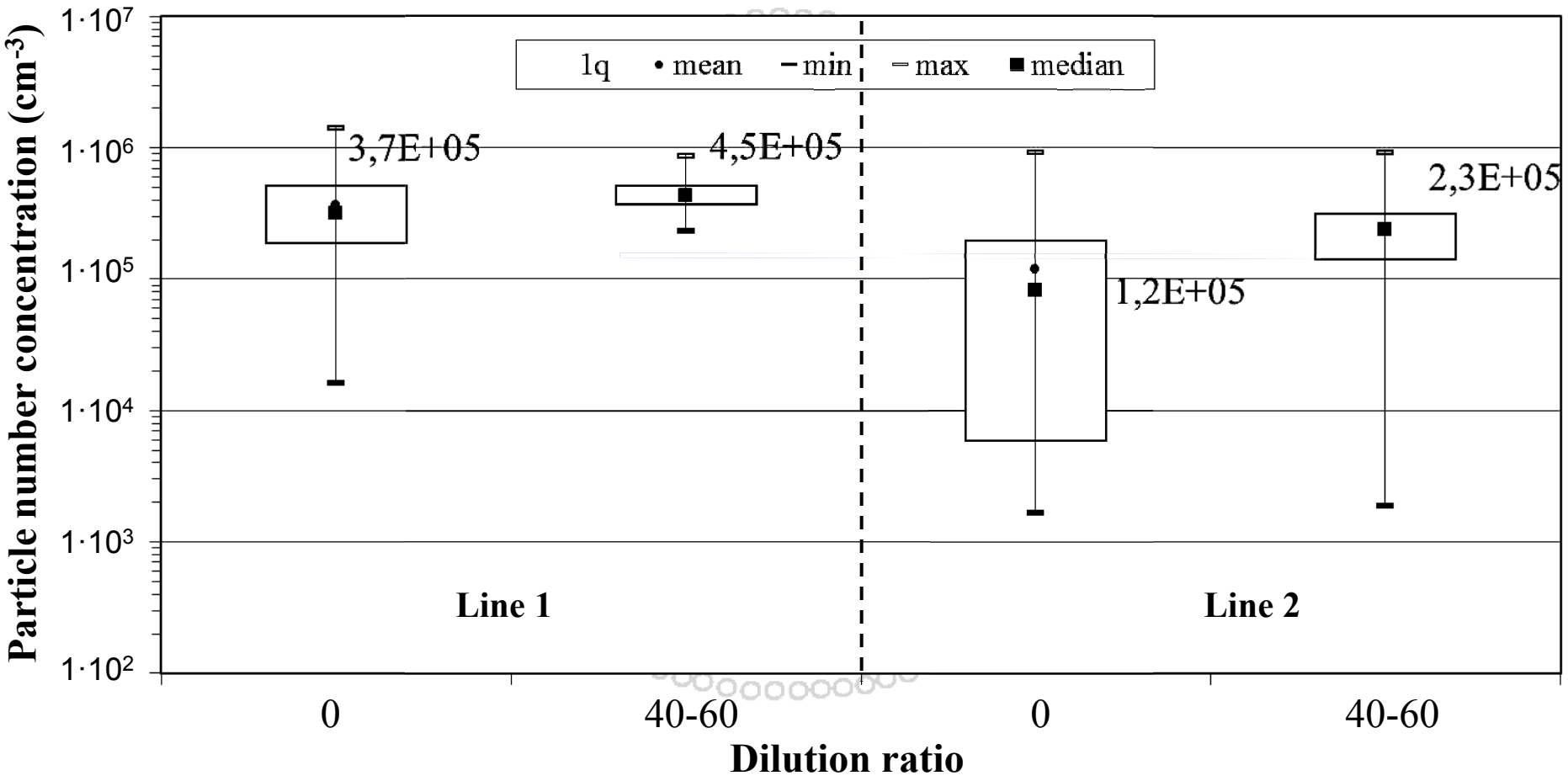
Size distributions





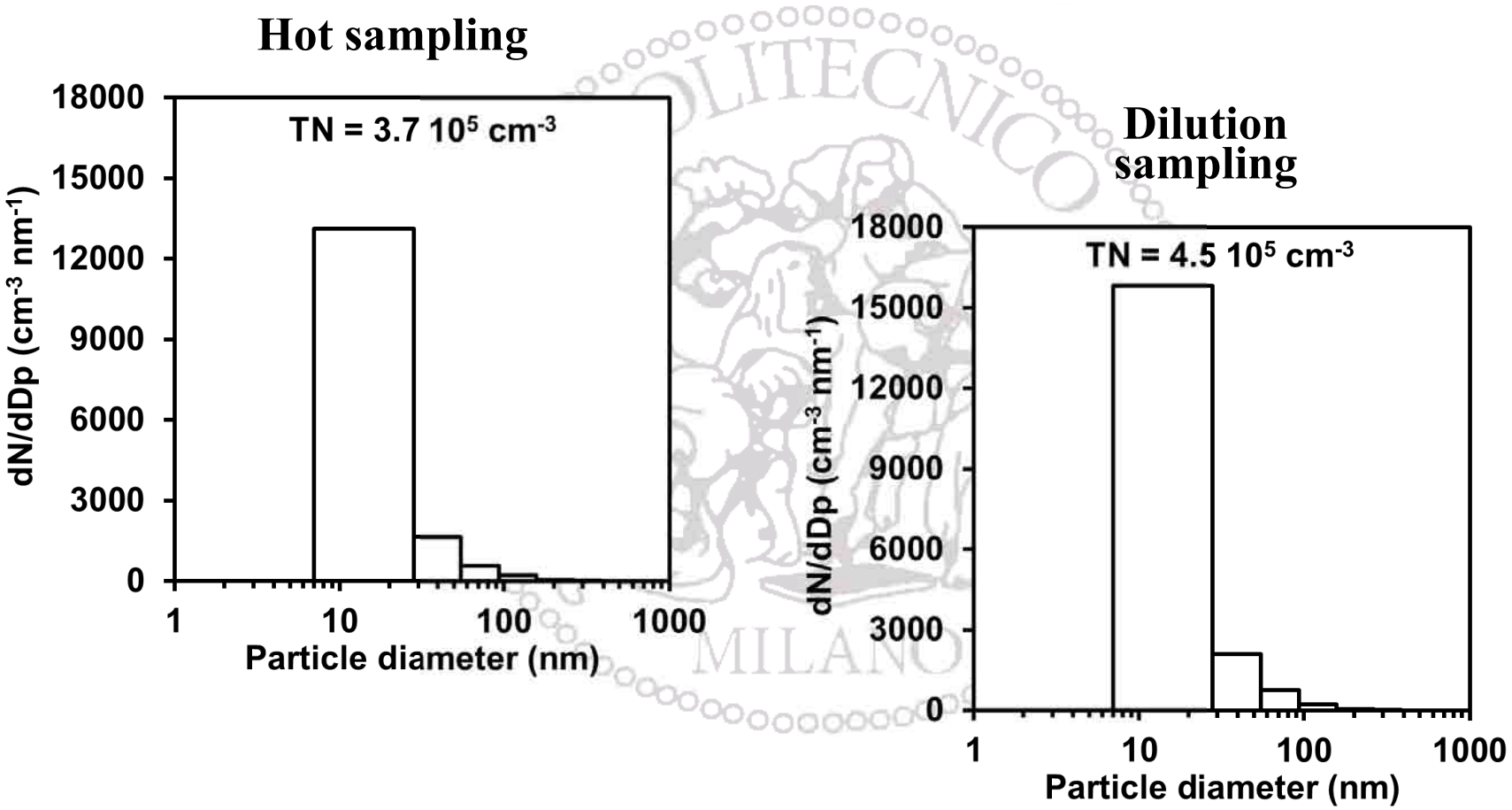
WTE 5 - Wet/dry

Number concentration (particles cm^{-3})

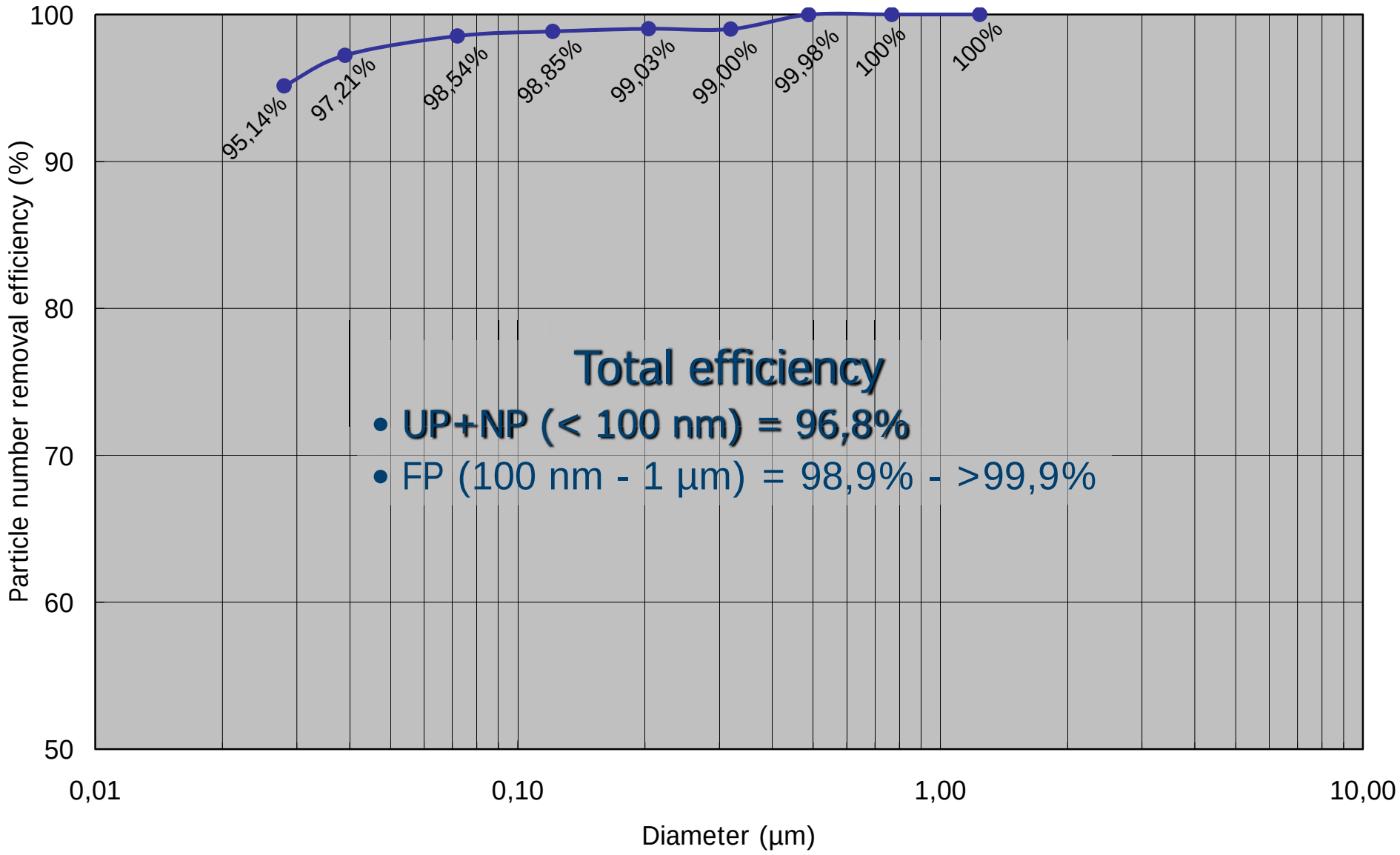


WTE 5 - Wet/dry

Size distributions

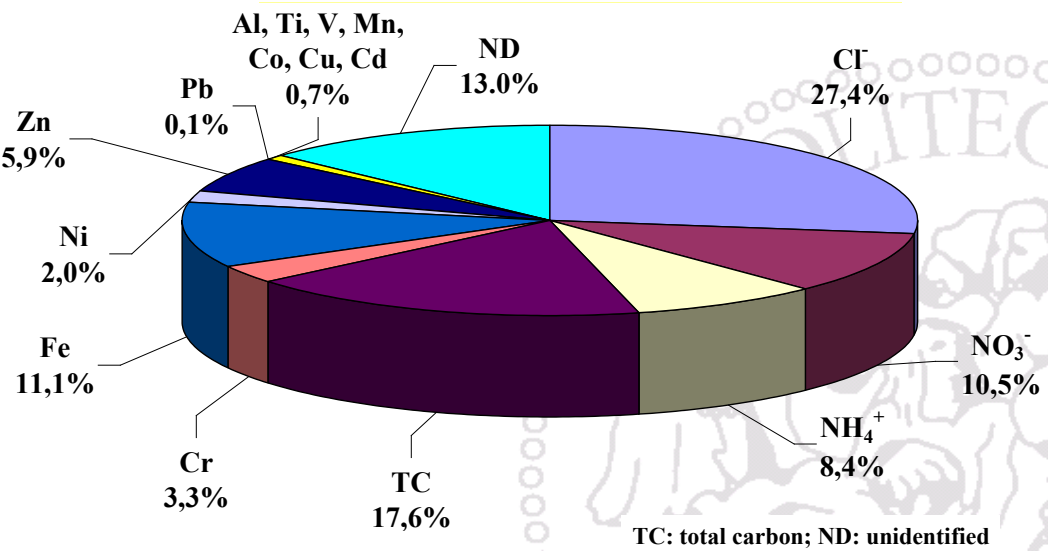


FF - removal efficiency



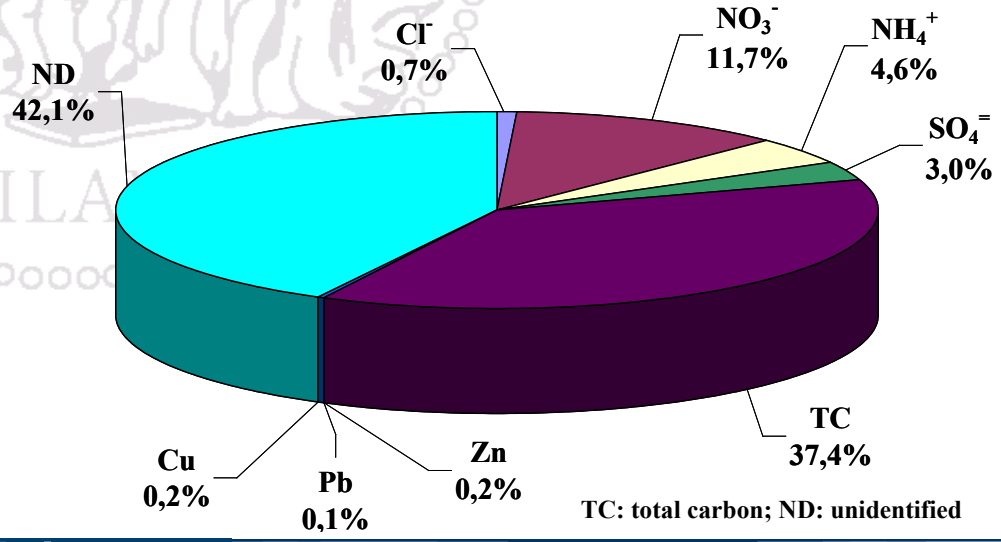
UP chemical characterization

WTE ultrafine fraction chemical composition



TC: total carbon; ND: unidentified

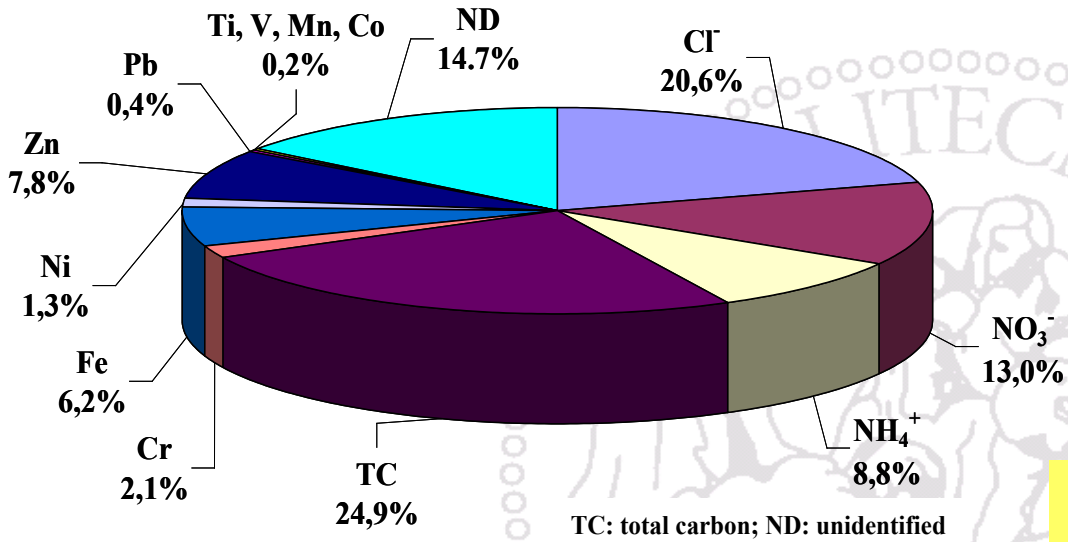
Background air
Ultrafine fraction chemical composition



TC: total carbon; ND: unidentified

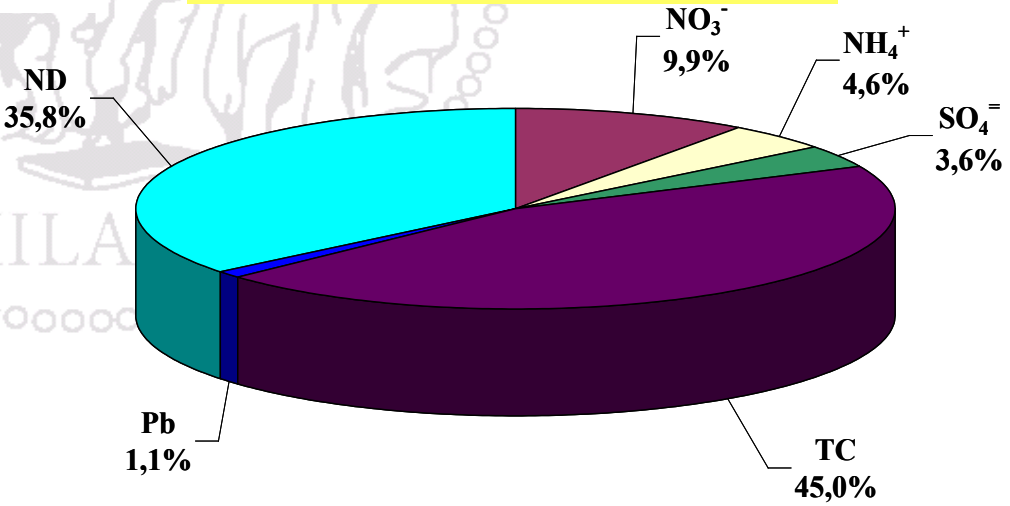
NP chemical characterization

WTE nanoparticle fraction chemical composition



TC: total carbon; ND: unidentified

Background air
Nanoparticle fraction chemical composition



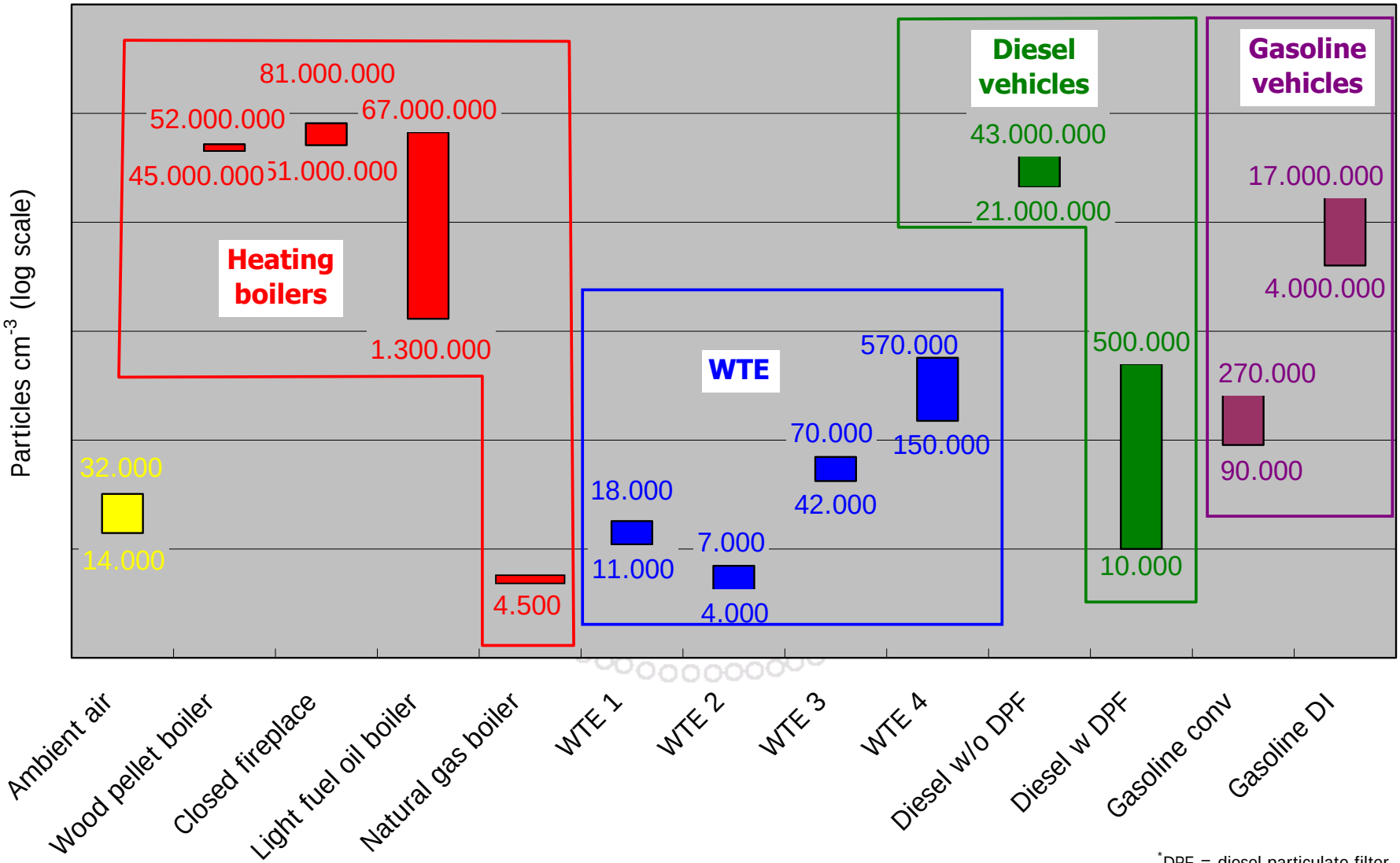
TC: total carbon; ND: unidentified

Conclusions

- Stack particle number concentrations
  - effects on concentration levels arising from fractions of condensable origin
  - influence of flue gas treatment process configuration (scrubber, T baghouse)
  - generally comparable or slightly higher than ambient air
  - very high capture efficiency for FF: ≈ 97% for NP+UP, 98-99,9% for FP (0,1 - 1 µm), both for primary than for condensable particles
- UP and NP fractions largely prevailing in size distributions for all sampling conditions
- Chemical characterization
  - in accordance with waste composition and combustion process influence (presence of chlorides, Fe, Zn, Cr)

Conclusions

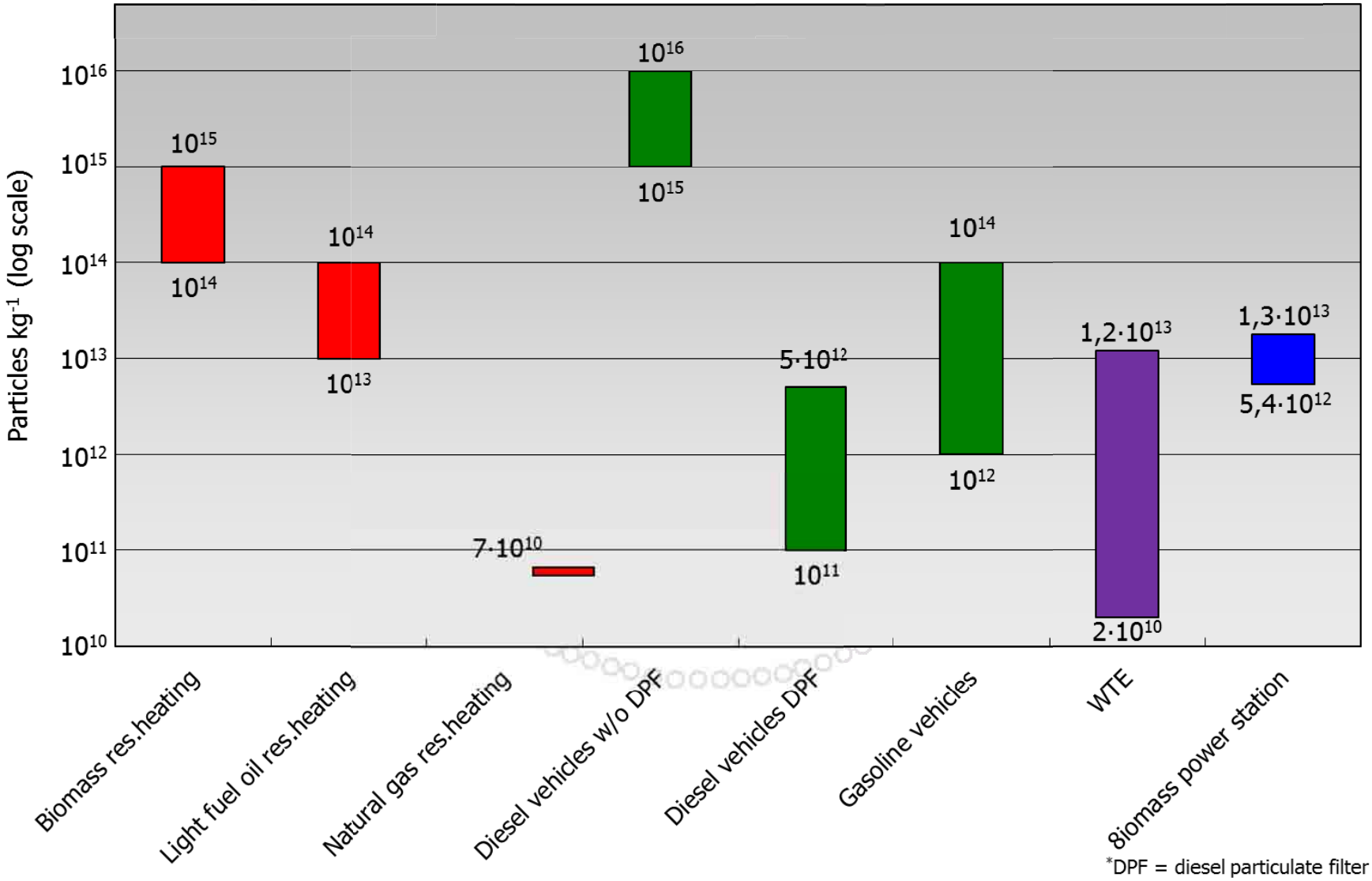
Comparative assessment – concentrations



*DPF = diesel particulate filter

Conclusions

Comparative assessment – emission factors



*DPF = diesel particulate filter

Laboratorio Energia e Ambiente Piacenza

(Energy and Environment Laboratory Piacenza)

A Consortium participated by Milan Polytechnic

Emissions of fine and ultrafine particles from stationary combustion plants

Final Report

www.cewep.eu

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