POLITECNICO DI TORINO

Department of Energy "Galileo Ferraris"

AEROSOL TECHNOLOGY LAB

# Workshop 4 - Filter Forecast: The Future of Filtration

## Measuring Air Filter Efficiency Down to Single-Digit Nanometer Size


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KANSAS CITY

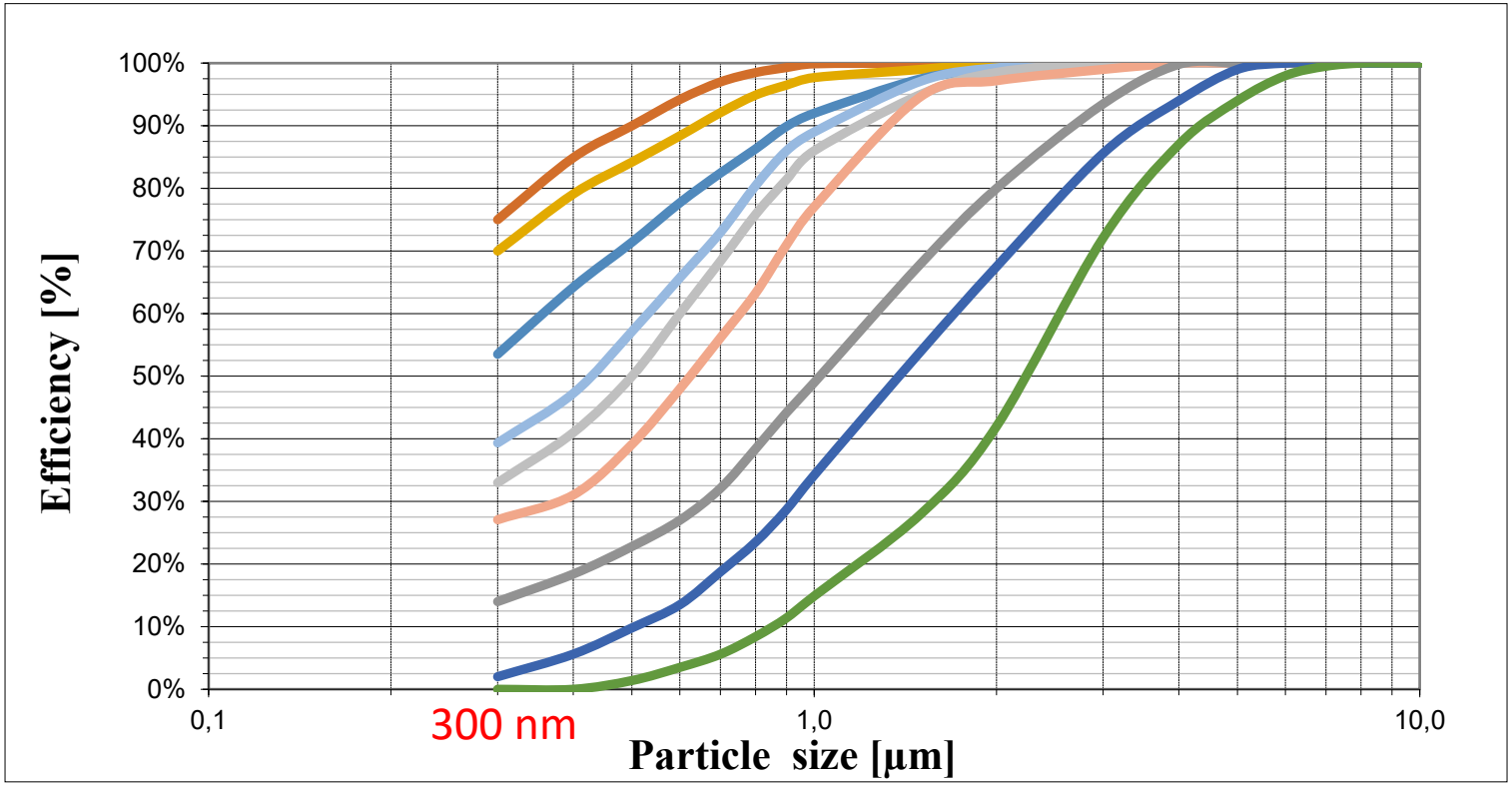
# Learning Objectives

1. Describe the trade off between clean air and energy burden of filters
2. Detail a simple means to estimate the trade off
3. Understand how well air filters perform for nano-particles
4. Describe how nano scale performance can be measured

# Outline

- Measuring range of traditional air filtration standards
- Sizes of airborne particles
- New standards for measuring filtration media against airborne nanoparticles
- Challenges for scaling up to full size air filters
- Conclusions

# Typical efficiency by particle size curves



# Sizes of airborne particles

Chapter 10 "Indoor Environmental Health"

"Nanoparticles (<100 nm diameter) can enter the blood and be transported to the brain or other organs (Mühlfeld et al. 2008)"

2017 ASHRAE Handbook Fundamentals
Chapter 11 "Air contaminants"

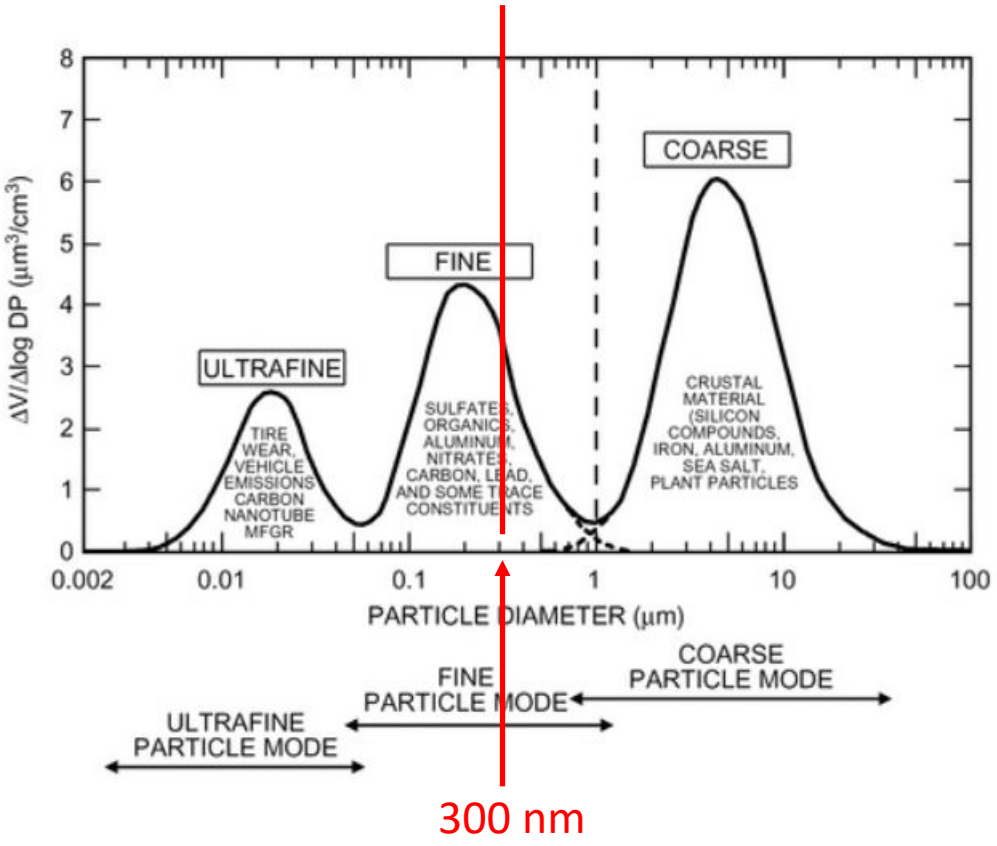
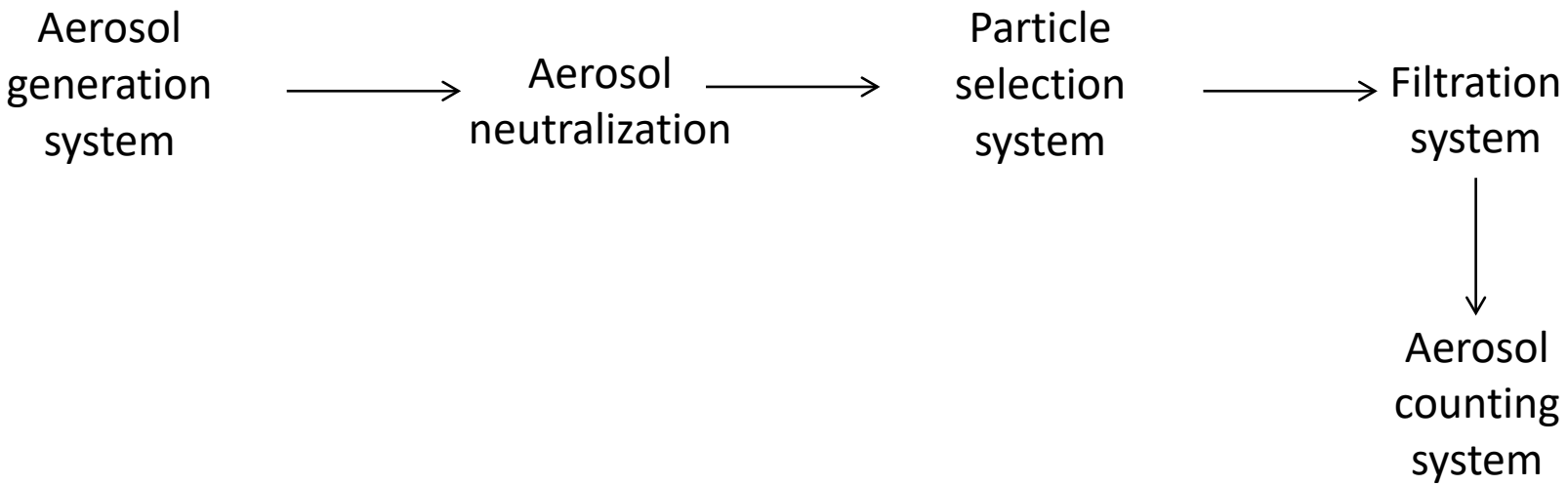


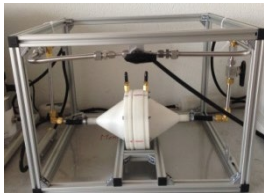

Figure 1. Typical Outdoor Aerosol Composition by Particle Size Fraction (adapted from Wilson and Suh 1997)

# Experimental set up overview for ISO 21083 series

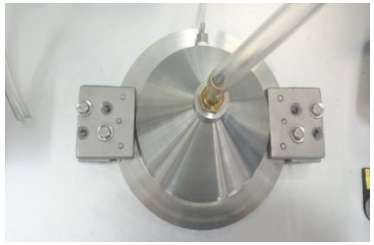



- The experimental set up to measure filtration efficiency can be slightly different depending on the approach taken
- Each part needs to be qualified
- The test method was validated by an interlaboratory exercise

# Measuring filter media performance down to 3nm



| Tested area ($cm^2$) | Size (mm) | Shape |
|---|---|---|
| 100 | 113 | circular |
| 11.34 | 38 | circular |
| 11.17 | 37.72 | circular |
| 100 | 113 | circular |
| 900 | 300x300 | square |
| 95.03 | 110 | circular |



Three different test section sizes are used in the experiments

# ISO 21083-1 and ISO ISO/TS 21083-2 test results

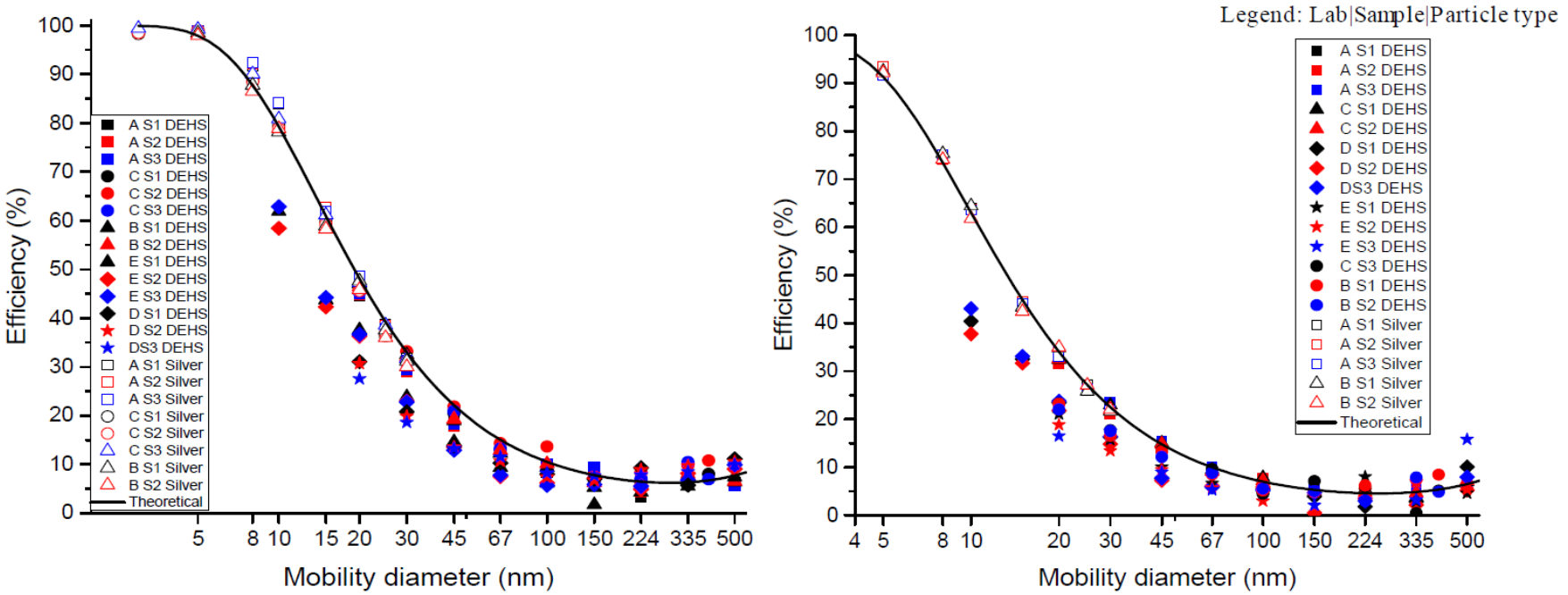



**Fig. 2.** Filtration efficiency test results for the wire mesh at 5 cm $s^{-1}$ (left) and 10 cm $s^{-1}$ (right).

Sachinidou et al., "Inter-laboratory validation of the method to determine the filtration efficiency for airborne particles in the 3 – 500 nm range and results sensitivity analysis", *Aerosol and Air Quality Research*, 2017.

# Challenges for full scale filter test method

Nanoaerosol generation

- polydisperse aerosol should have very large concentration at nanosizes
- vapor condensation generators are better suited

Particle losses

- losses for Brownian diffusion increase significantly at nano-sizes

Particle measurements

- more than one measurement device required to cover a wide size range
- optical particle spectrometers have limitations at smaller particle sizes
- electrostatic classification needed below 100 nm

# Conclusions

- Fibrous filter media can effectively remove particles down to 3 nm
- Measuring equipment available on the market to measure reliably the performance of filter media
- Changes from current test standardized test rigs involve aerosol generation techniques and particle sensing equipment

# Bibliography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# Questions?

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