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# Notes about particle measurements

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# Content

- Measurement concept & particle size
- Sampling from gases/aerosols
- Particle dispersion
- Measurement concepts:
  - → Particle mobility
  - → Counting
  - → Classification & counting
- SMPS-ICPMS (PSI & EMPA)

# Ranges of particle measurement techniques

**Single particle measurement**

**Aerosol measurement (ppb-ppm)**

**Suspension measurement (‰ bis %)**

**Bulk material measurement (10% bis >90% )**

**Solid concentration ($C_v$=$V_{disp}$/$V_{fluid}$)**

Clean lab technology

Particle Collection

Fluidized bed (pneumatic conveying)

Powder Technology 10% bis >90%

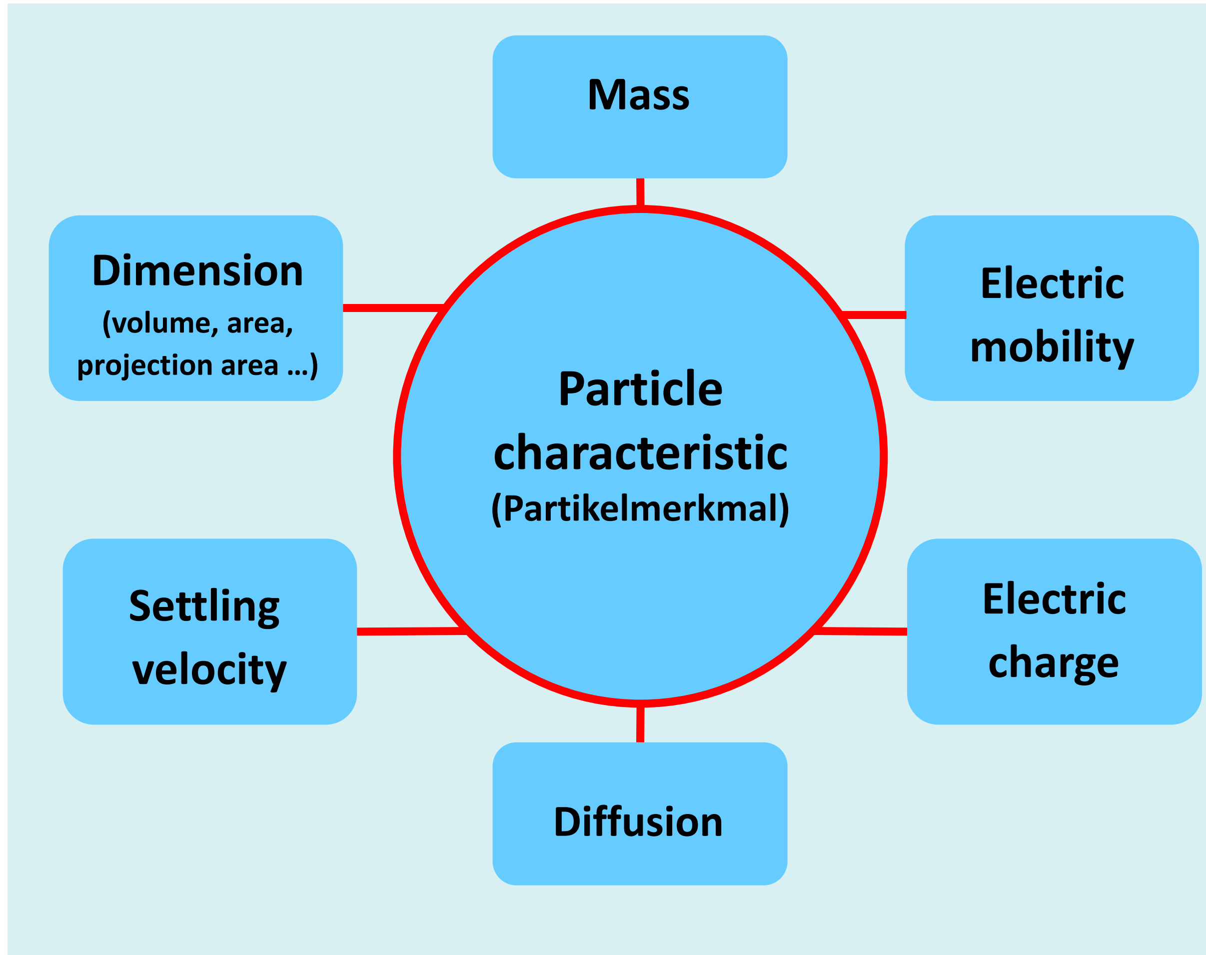
Water treatment

Solid-liquid separation

# Measurement: distribution = f (particle characteristic)



**Measuring: density distribution & cumulative distribution**




**(Because of missing information) For the description of particles with “irregular” form, we use:**

**Equivalent diameter**: diameter of a sphere, which posses by the determination of certain particle characteristic the same physical properties as the measured particle

# Sampling from gas streams (online analysis)



**"No-representative" sampling**

**No-isokinetic sampling**

**→ pressure difference**

**Condensation**

**Sedimentation (large particles)**

**Adhesion (on walls)**

**Flow deflections**

**Diffusion (small particles)**

**….**

**Required**

**Problems**

**Systematic sampling**

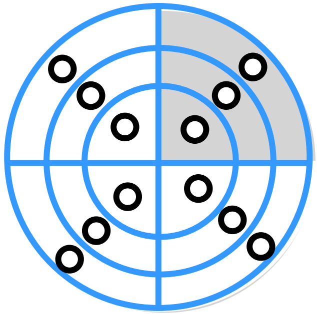
**Isokinetic sampling**

**Tube tempering**

**Vertical sampling relative to tubing**

**Larger curvature**

**…**



Systematic sampling
VDI-guideline 2066

# Particle dispersion (offline analysis)

**Binding forces in dispersion of dry aerosol:**

Surface forces

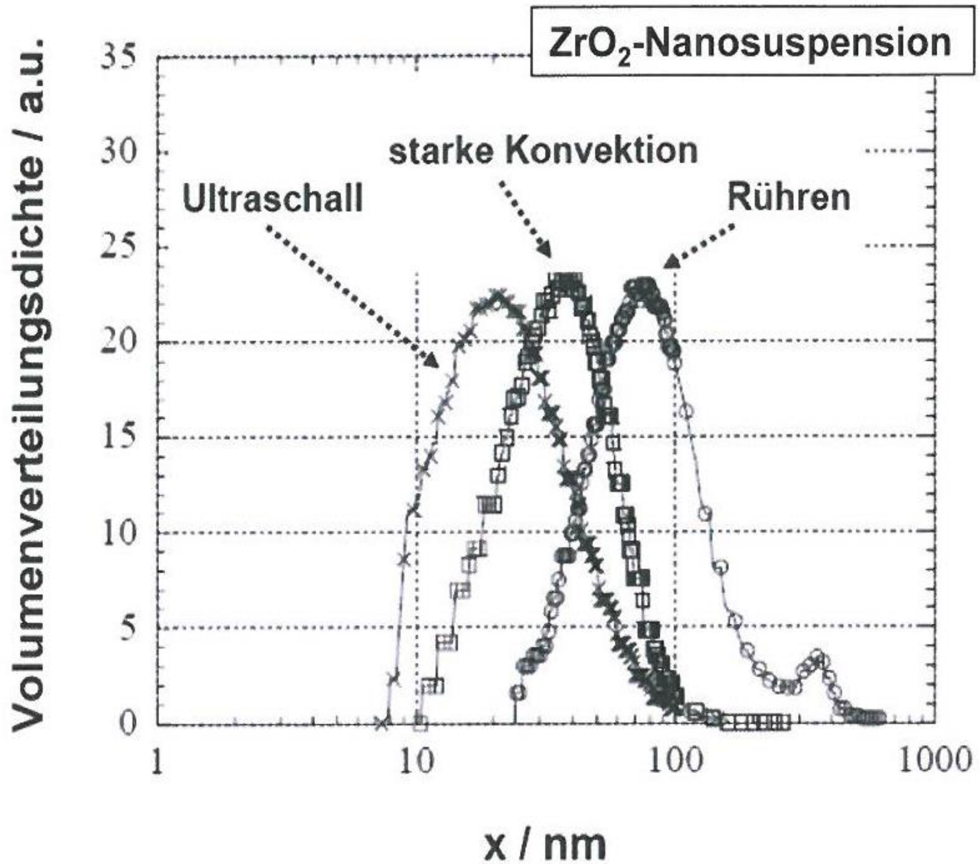
Adhesion forces (e.g. adsorption)

Attractive forces (e.g. van der Walls, electrostatic)

…

**Aggregate & agglomerate formation**

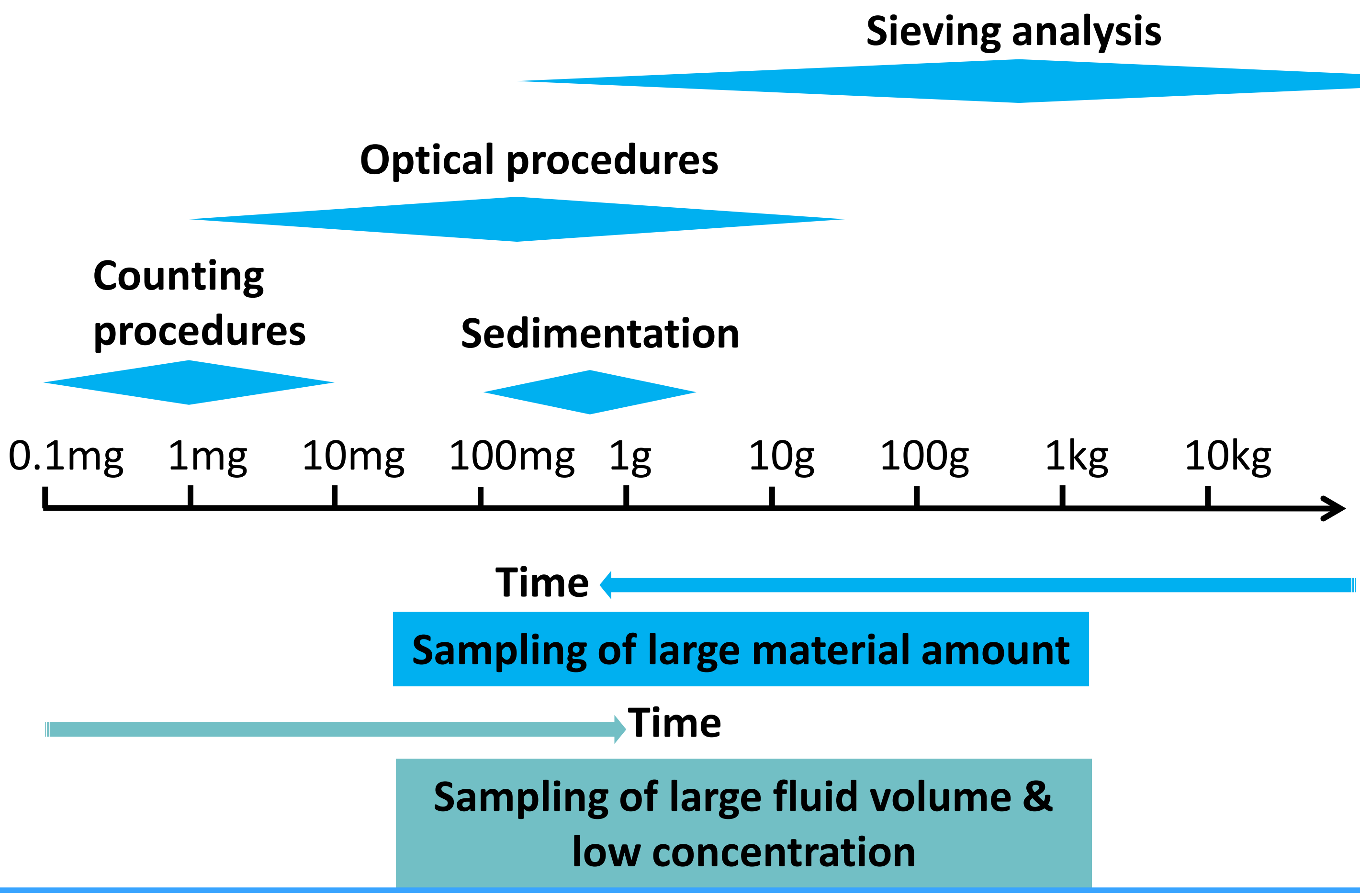
**Dry and wet dispersion methods**



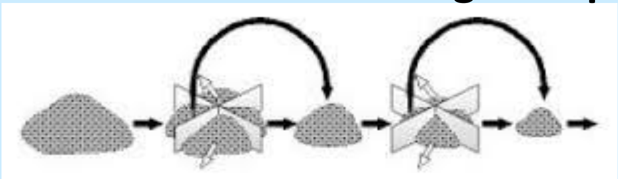

(adaptiert aus Möller, Doktorarbeit, Darmstadt, 2000)

**Dispersion prior (offline) measurements**

# Sampling and measurement concept



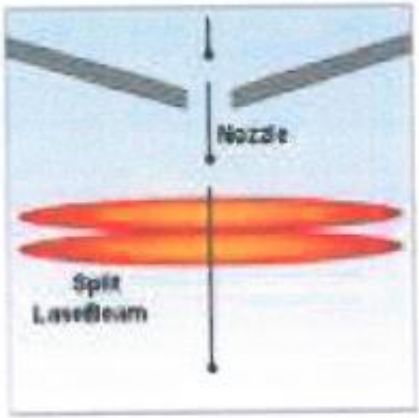

**Large material amount: coning and quartering**



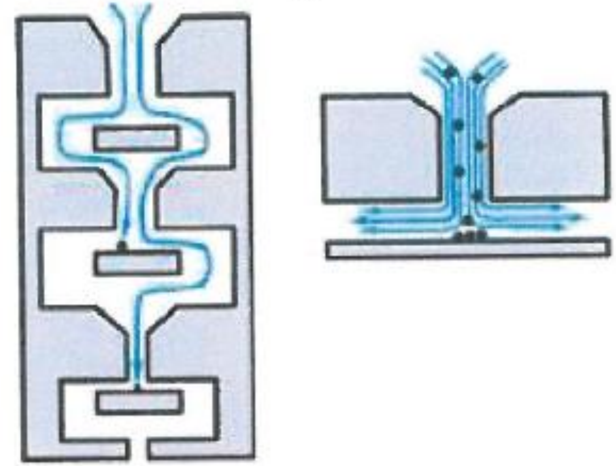
# Examples of particle measurement concepts



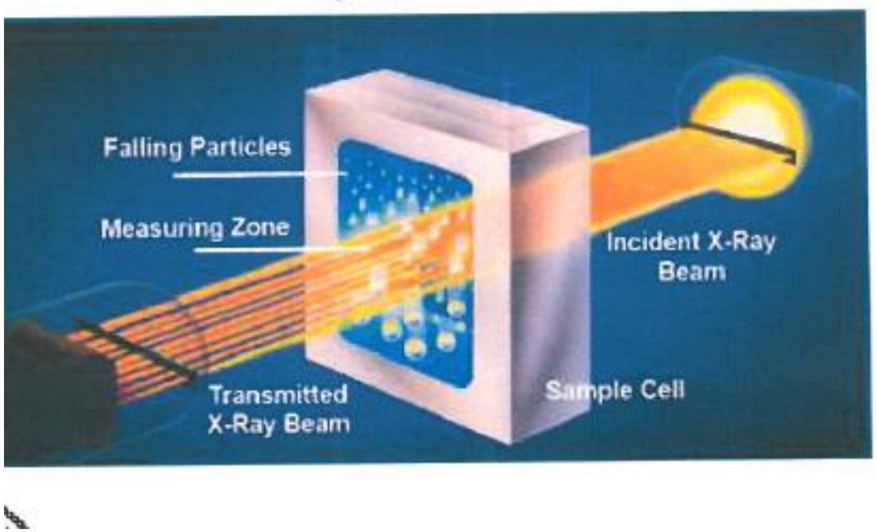
## Aerodynamic Particle Sizer



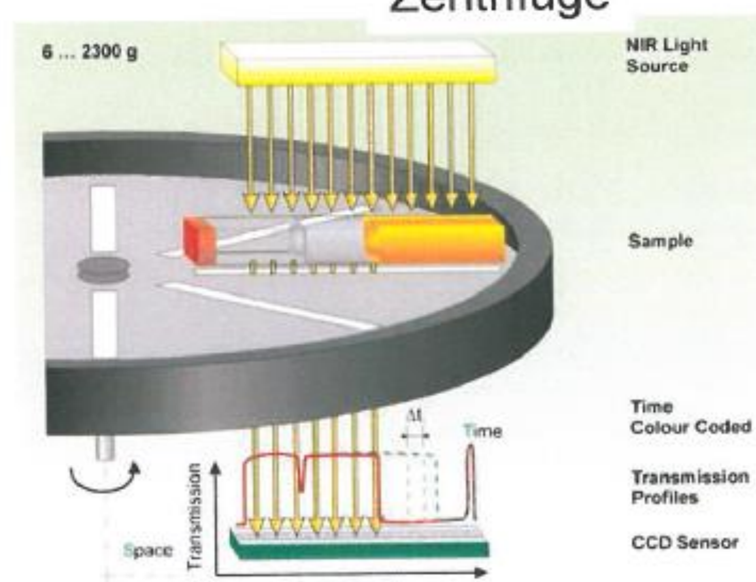

## Kaskadenimpaktor



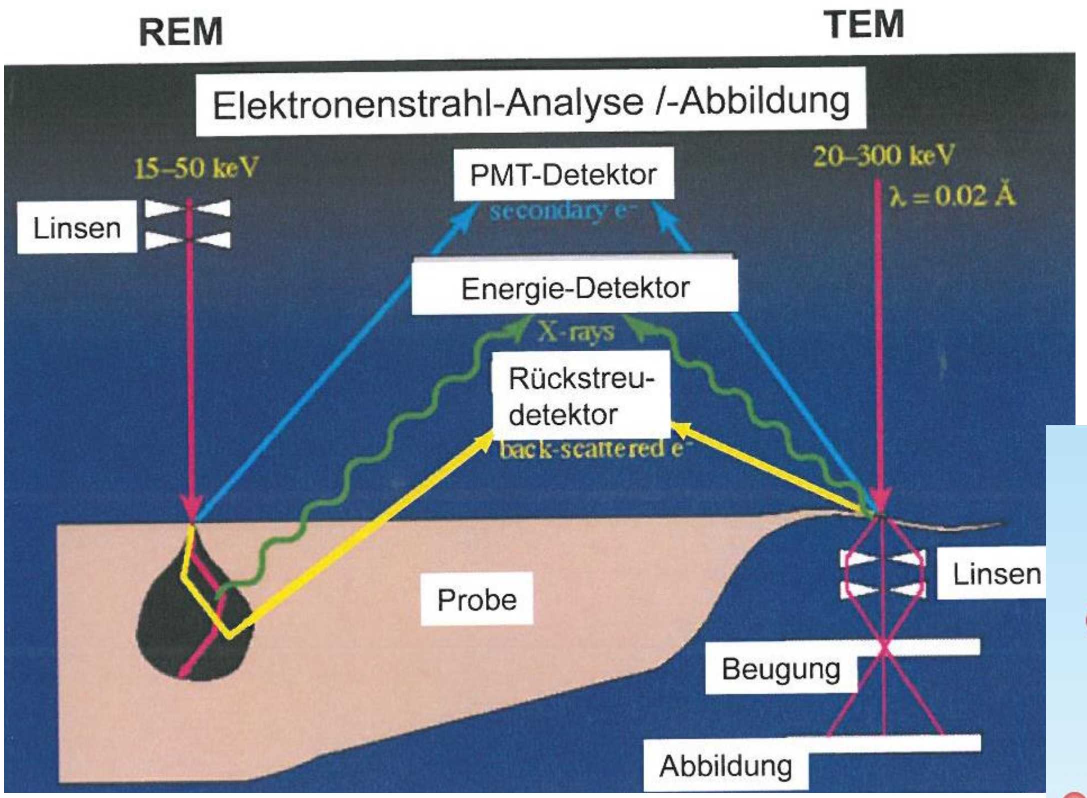
## Sedigraph

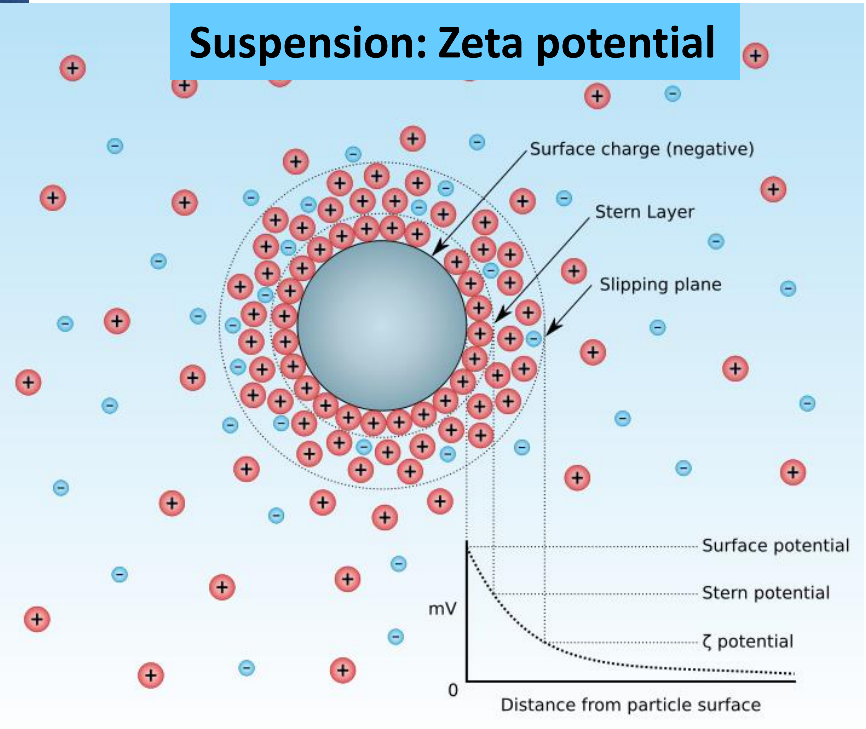



## Zentrifuge



# Examples of particle measurement concepts

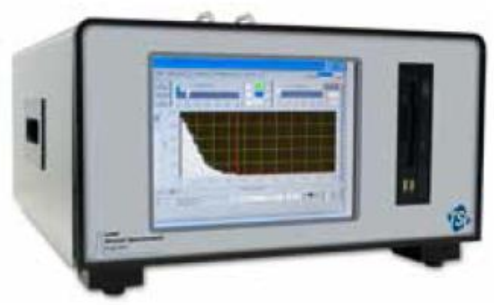


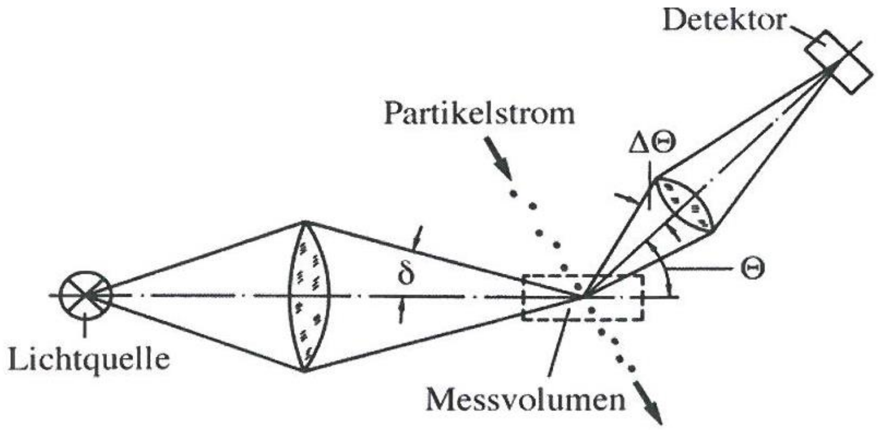
# Counting concept



**Light scattering:** scattering, diffraction, refraction, reflection, absorption, extinction
**Example: DLS** (dynamic laser scattering)
**Apparatus example:**

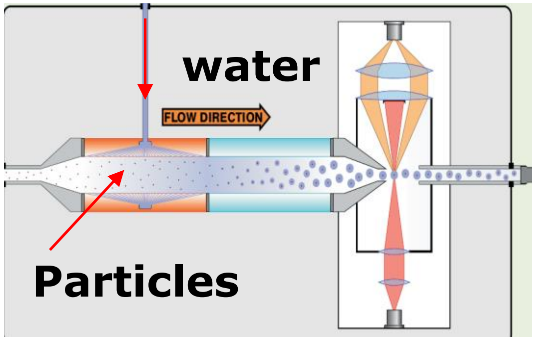


**Laser aerosol spectrometer, TSI**




## Condensation particle counter (CPC)

**Principle:** vapor condensation to grow small particles to sufficiently large size that can be optically detected
**Use:** size fractionation between 15 and 660 nm
**Example of instrument:** CPC, Model 3787, TSI
**Measured parameter:** particle number (#/cm3)



# Counting concept

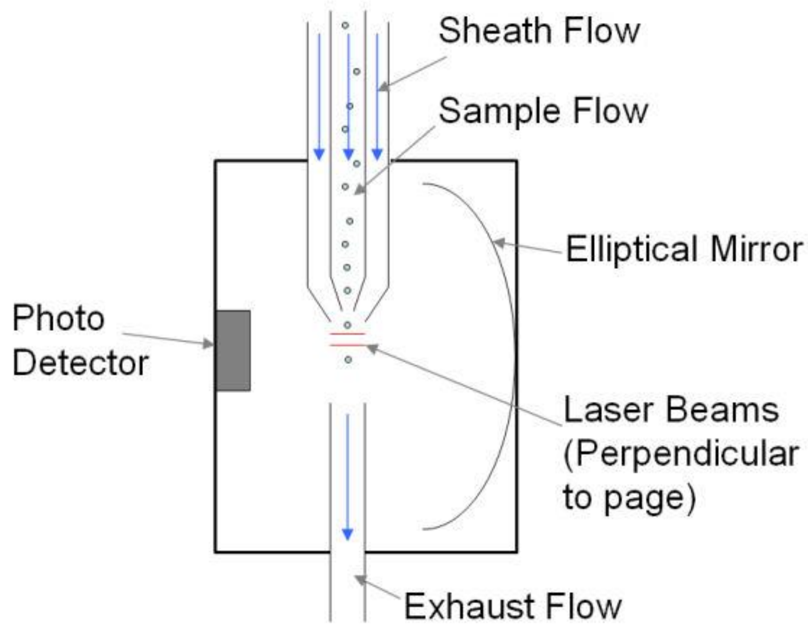
## Aerodynamic particle sizer (APS)

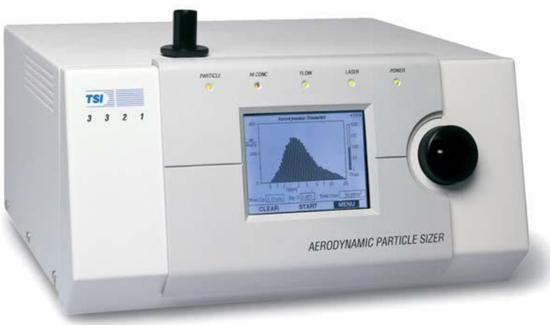
**Principle**
Particle size distribution using light-scattering

**Use**
size fractionation between 0.5 and 20 um

**Example of instrument**
Aerodynamic particle sizer, TSI, Model 3321

**Measured parameter**
aerodynamic particle diameter



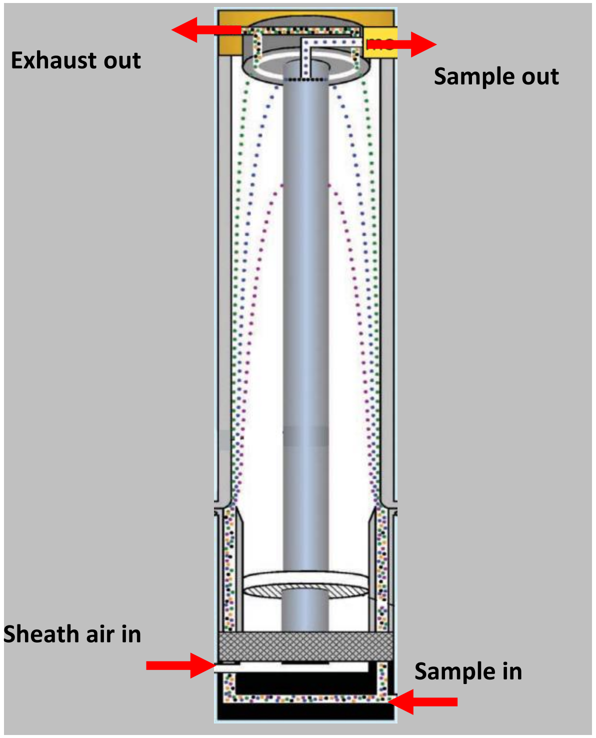
# Classifying systems

## Scanning mobility particle sizer (SMPS) = DMA +CPC

**Example of instrument**
SMPS, Model 3936N87 (DMA + CPC), TSI

## Differential mobility analyzer (DMA)

**Principle**
Classification of particles according to their electrical mobility (using electric field)
**Use**
size fractionation between 10 and 1000 nm
**Example of instrument**
DMA, Model 3081, TSI
**“Measured parameter”**
equivalent electrical mobility diameter



# Classifying systems

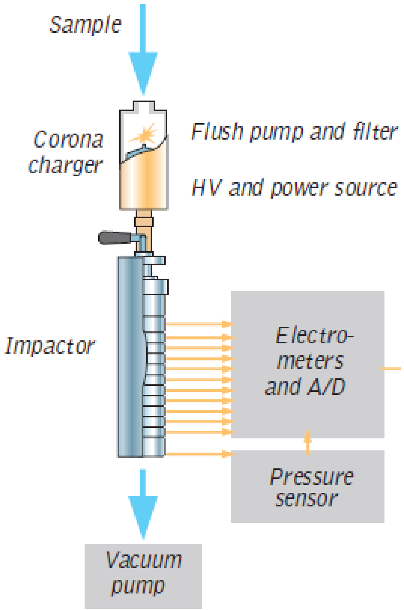
## Electrical impactor

**Principle**
classification in a cascade impactor and electrical detection

**Use**
particle size distribution and concentration

**Example of instrument**
Electrical low pressure impactor (ELPI) Classic, Dekati

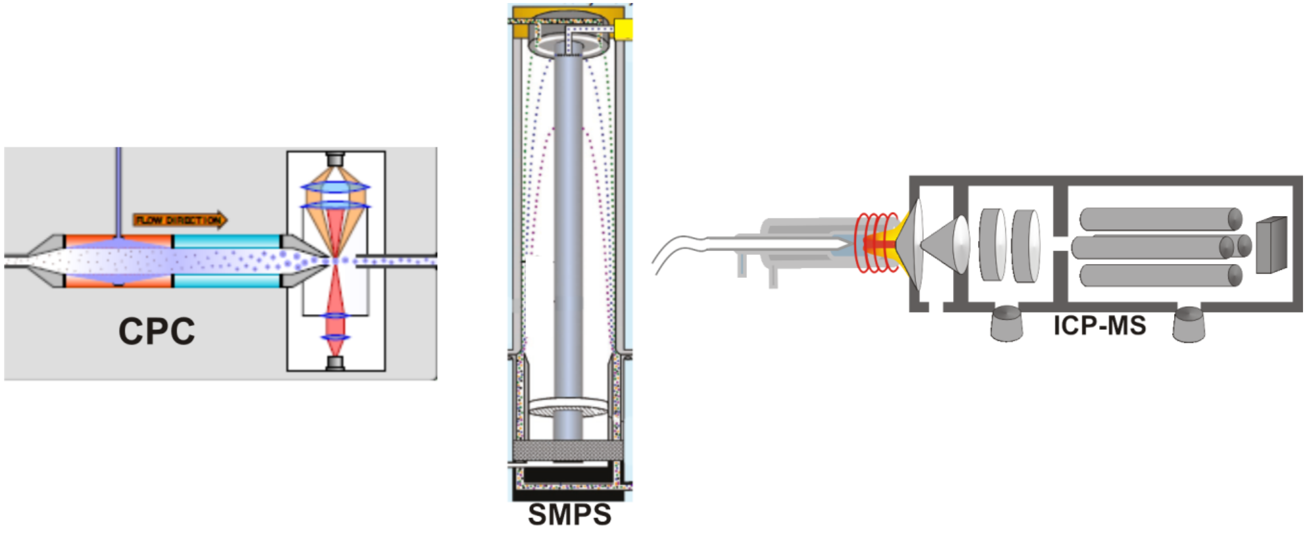
**Measured parameter**
electrical charge




# PSI: development of SMPS-ICP-MS



**SMPS-ICP-MS:** Online coupling of a **S**canning **M**obility **P**article **S**izer to an **I**nductively **C**oupled **P**lasma **M**ass **S**pectrometer




- Online determination of size distribution and elemental composition of nanoparticles (**NPs**) in aerosols
- Avoiding the contamination and NPs structure alteration in conventional analysis
- Fast analysis (monitoring of transient processes )
- Potential applications: combustion processes, airborne aerosols & engineered nanoparticles
- Preliminary results: resolved SMPS-ICPMS signal from nanoparticle mixture