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Scanning Mobility Particle Sizer with Faraday Cup Electrometer (SMPS+E)

The reference in the field of nanoparticle counting and sizing

Highlights:

- ✓ Counts & sizes particles from 0.8 to 1100 nm
- ✓ Sampling with up to 16 Hz
- ✓ Very low noise level
- ✓ Rinse air flow for fastest response time
- ✓ Three different DMAs available for maximum flexibility
- ✓ Compact and rugged
- ✓ Operates without any consumables
- ✓ Fully automated use with our software
- ✓ Three analog inputs
- ✓ Self-test upon start-up assures highest reliability

Applications:

- ✓ Fundamental aerosol research
- ✓ Studies on atmospheric nucleation
- ✓ Size distributions of airborne ion clusters
- ✓ Macromolecule studies
- ✓ Nanotechnology process monitoring
- ✓ Combustion studies
- ✓ Official reference for calibration of CPCs

2012

GRIMM has developed the SMPS+E system as a counter and sizer for nanoparticles in the size range of 0.8 nm to 1100 nm in a wide range of concentrations (100 to 10^8 particles/cm^3). The SMPS+E system includes:

- The fast and low noise Faraday Cup Electrometer (FCE - GRIMM model 5.705).
- The high performance Differential Mobility Analyser (DMA).
- The DMA controller (model 5.706) to control DMA voltages, electrical settings of the FCE, and air flows.

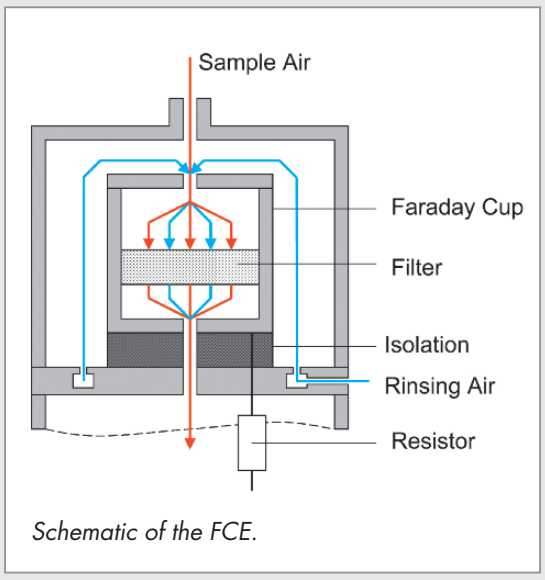
GRIMM's unique design of the FCE avoids internal contamination virtually completely by using rinsing air around the isolation of the Faraday Cup. Other electrometers often degrade in their performance because particles that settle on the isolation cause eventually small leak currents. As a consequence, other electrometers require periodic cleaning and verification. Furthermore, the instrument was designed to minimize the effects of mechanical shocks and pressure variation for the use as a reliable reference for the calibration of nano particle counters.

Detection System

High sensitivity, low noise, Faraday Cup Electrometer (FCE)

Charged particles are detected with a Faraday Cup Electrometer (FCE). The Faraday Cup gains a net charge whenever charged particles enter it. Particles are permanently retained in the Faraday Cup with a filter of hight loading capacity. The isolated Faraday Cup is then discharged by a current through a 1 TΩ resistor. This current is converted to a voltage and amplified.

Minimizing the noise of the electrometer requires a sophisticated geometry with a wide space between Faraday Cup and outer casing. This space is continuously flushed with a rinse air flow in order to achieve the shortest possible response time and to avoid any contamination of the surface of the insulators.



Schematic of the FCE.

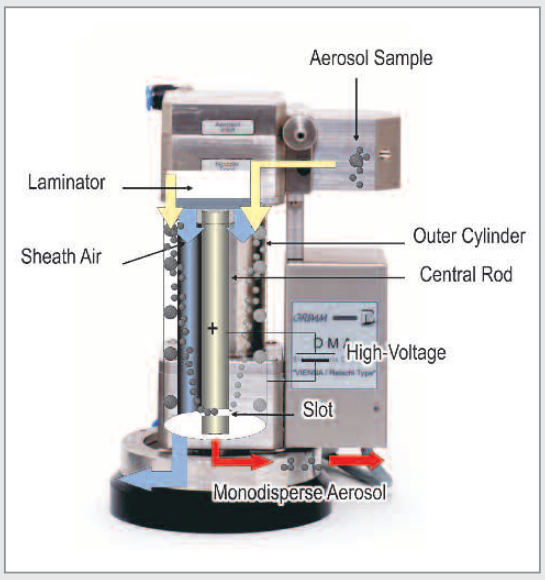
Classifiers

Ultrafine particles are classified with a Differential Mobility Analyser (DMA). A bipolar charger upstream the DMA serves to establish a well defined charge distribution on the particles. The classification (i.e. the selection of a well defined fraction from a broad size distribution) occurs in the electrostatic electric field in the annulus between inner and outer electrode of the DMA.

The airflow in the annulus, on the figure in downward direction, is composed of two components: The sample air (yellow) with the charged particles flows into the annulus along the wall of the outer electrode, and the particle free "sheath air" (blue) along the wall of the inner electrode.

When a **positive voltage** is applied to the inner electrode, negatively charged particles in the sample air drift through the initially particle free sheath air towards the inner electrode, this drift is superimposed to the downward movement of the air flow. Because small particles drift faster than large particles (they feature a higher "mobility"), only particles of a certain size reach a narrow slit at the bottom of the inner electrode and thus a downstream detection system.

The size of the particles can be selected with the applied voltage, hence size distributions can be measured by changing this voltage. If the DMA voltage is fixed, the DMA acts as particle generator with well defined narrow distribution.
When operating the DMA with a DMA controller model 5.706, size range, sensitivity and size resolution can be adjusted by varying flow rate of sample air and of sheath air.



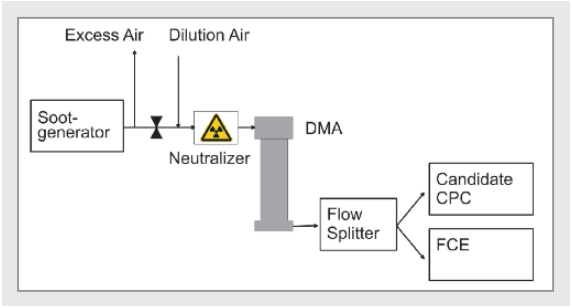
Size range and dimensions of the **three GRIMM DMAs.** The DMAs share the same bottom part that contains the high voltage supply thus allowing easy exchange of the electrodes for maximum experimental flexibility through different size ranges.

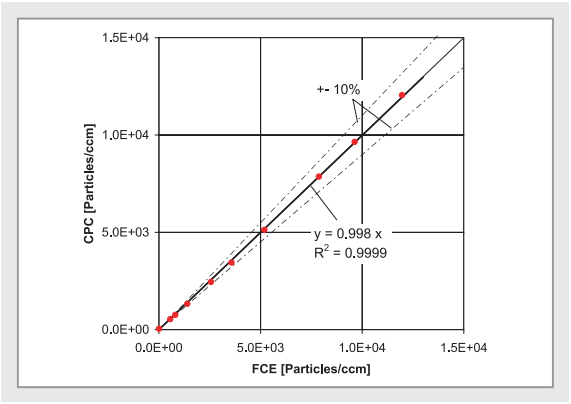
DMA type	Model	Total Height [mm]	Active Length of Electrodes [mm]	Size Range at 3.0 L/min Sheath Air [nm]	Size Range at 20 L/min Sheath Air [nm]
L-DMA	55-900	492	350	11 - 1110	4.2 - 247
M-DMA	55-340	230	88	5.4 - 358	2.1 - 103
S-DMA	55-100	157	15	2.2 - 112	0.9 - 39

Application Example

The EURO 5 regulations for Diesel emissions include the measurements of particle number concentrations (amendments to regulation 83). The measurements are accomplished with a CPC which has to be calibrated every year.

During calibration the candidate CPC is operated in parallel with a Faraday Cup Electrometer (FCE) that serves as a primary reference. Both counters - candidate CPC and reference FCE - are supplied with identical concentrations of monodisperse soot particles from a Combustion Aerosol Standard (CAST), classified with a DMA. Number concentrations measured by the CPC are then evaluated against the concentrations measured by the reference FCE.



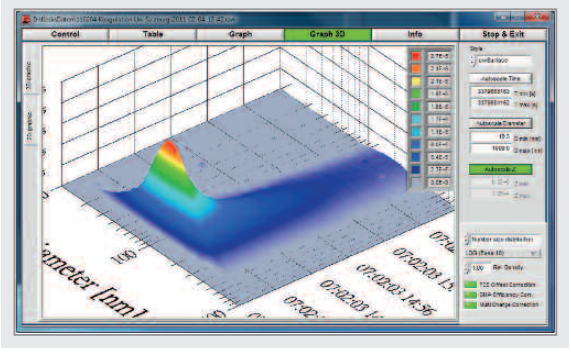


Setup (left) and results (right) for the calibration of the CPC using the FCE as a reference.

Software

The GRIMM universal software for nanoparticle instruments records measured data and a complete set of instrument parameters. Results are shown as graph or as table, and can be exported to common file formats. The use of data loggers and the online transfer of data to internet servers via mobile networks is supported.

The software operates CPCs as counters, Differential Mobility Analyzers (DMAs) in generator mode, or SMPS systems for measuring size distributions. SMPS systems can be used as SMPS+C (with CPC as detector) or as SMPS+E (with Faraday Cup Electrometer, FCE). Data inversion is done in real time and the algorithms, developed by Professor Reischl (University of Vienna), were adapted to the new standard for calculating size distributions from mobility spectrometers, ISO 15900. The software calculates number, surface, and mass size distributions, optionally with or without corrections, and a variety of statistical parameters.



Screenshot of the software for nanoparticle instruments.

Specifications

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Faraday Cup Electrometer

Particle Size Range	0.8 to 1100 nm	Signal Filter	Optional, low pass (250, 500, or 1500 ms)
Particle Concentration Range	up to 10^8 particles/cm^3	Pressure Range	400 – 1100 mbar
Response Time	T90 = 200 ms	Aerosol carrier gas	Air and inert gases
Resistor	1 TΩ	Power Supply	12 VDC ± 10%
Sensitivity	0.1 fA at 1 Hz	Dimensions	∅ 88 mm, height: 190 mm
Maximum Current	± 4000 fA	Weight	1.36 kg (3.0 lbs)
Noise	0.35 fA (τ = 0.25 s, 90%), i.e. 65 charges/cm^3 at 2 L/min	Operating Conditions	
		Ambient Temperature	0 to 40°C (32 to 104°F)
Zero Point Adjustment	Automatic and performed electronically	Ambient Humidity	0 to 95% RH, noncondensing

Classifiers / DMAs

Inner Diameter of Outer Electrode	40 mm
Outer Diameter of Inner Electrode	26 mm
Output of High Voltage Module	5 – 10.000 V, positive inner electrode (negative available on request)
Input of High Voltage Module	0 – 10 V, from CPC or DMA controller
Safety Shutdown of HV	Automatic when opening the DMA
Sensors (internal)	Temperature, absolute pressure, and pressure difference across impactor nozzle

DMA Controller

Sampling Frequency	0.25 – 16 Hz
Size Channels	Up to 255
Flow Rates of Sample Air	1 – 5 L/min in 8 steps
Flow Rates of Sheath Air	3 – 20 L/min in 9 steps
Flow Rate of Rinse Air	0.3 – 0.6 L/min
Flow Control	Volumetric flow controller
Status Indication	4 LEDs with 3 colors and messages on the digital display
RS-232	9-pin D connector, ASCII based command set
Internal Memory	80 kB
Memory Card	PCMCIA SRAM 4MB
Analog Inputs	Port for 3 optional analog climatic or gas sensors, plug and play
Power Requirements	230 VAC, 50 – 60 Hz (optional 120 V, 50 – 60 Hz)
Dimensions (HxWxD)	31 x 25.5 x 22 cm (12.2 x 10.0 x 8.7 in)
Weight	12.2 kg (26.9 lbs)

For applications that require **ultra fast measurements** of particle size distributions, such as transient emission measurements in automotive, GRIMM offers the Fast Automotive Particle Emission Spectrometer (FAPES) with 25 channels that are updated every 200 milliseconds. **Please refer to our FAPES datasheet for more information.**

Further publications and application examples can be obtained from your friendly and knowledgeable GRIMM representative. Just give us a call or visit our website.

Publications

M. Kulmala et al. 2007. Toward Direct Measurement of Atmospheric Nucleation. Science 318: 89-92

Dealer:

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