P. Müschenborn, A. Trampe, J. Luo, F. Otten,
S. Neumann, H. Fissan
Universität Duisburg
Germany

Development of a new wide-range Differential Mobility Particle Sizer (DMPS)

Title: Development of a new wide-range Differential Mobility Particle Sizer (DMPS)

Authors: P.Müschenborn, A.Trampe, J.Luo, F.Otten, S.Neumann, H.Fissan
Gerhard-Mercator-University Duisburg, Process-and Aerosol Measurement Technology

The topic is the development of a measuring instrument for particle concentration distributions of atmospheric aerosols. The main requirements on the instrument which are to meet are:

1. A particle size range of 3nm to 1000nm.
2. Suitability for field measurements.
3. Short measurement time.

The basic principle which is used is a Differential Mobility Particle Sizer (DMPS), shown schematically in figure I.

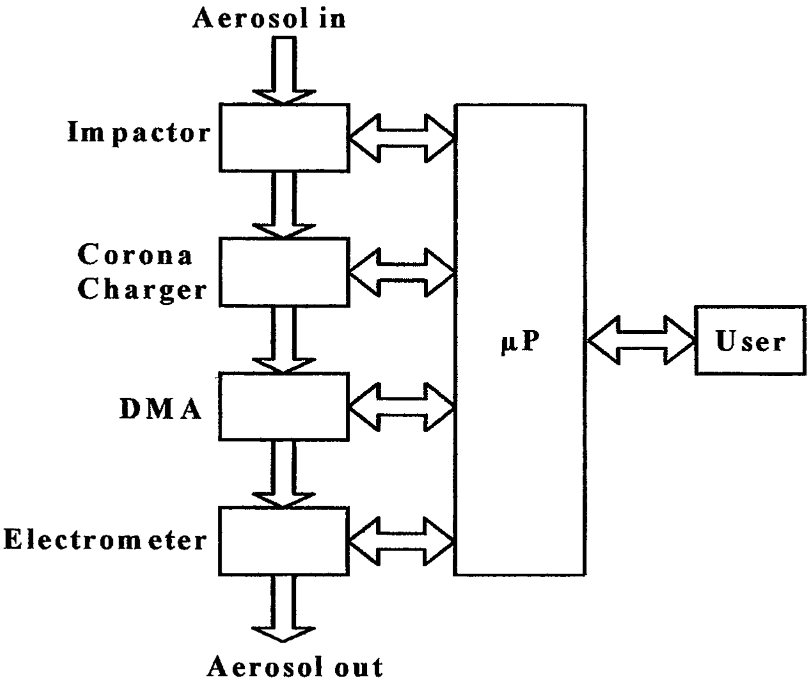

Figure I: Schematic diagram of a DMPS

The Differential Mobility Analyser (DMA) classifies airborne particles according to their electrical mobility and for equally charged particles according to their size. A particle sizing instrument using that principle needs a particle charger and a counter for the particles passing the DMA. The latter can be an electrometer measuring the electronic current given by the charged particles. The impactor is used to avoid that particles above the upper size limit enter the instrument.

In contrast to already existing instruments (TSI SMPS, TSI Twin DMPS) every single component of the new DMPS should cover the required particle range. In the following the focus is on the DMA.

The new DMA is of the radial type and sketched in figure II. It has two parallel electrodes providing a homogeneous electrical field. Particle free gas, the so called sheath air, flows in radial direction. The aerosol enters the instrument by a thin circular inlet slit and leaves it by a central outlet. Assuming that all particles have the same charge the Coulomb forces on the particles are equal no matter of their size. Due to different velocities in axial direction only particles within a small size range leave the instrument. The aerosol leaving the DMA is monodisperse.

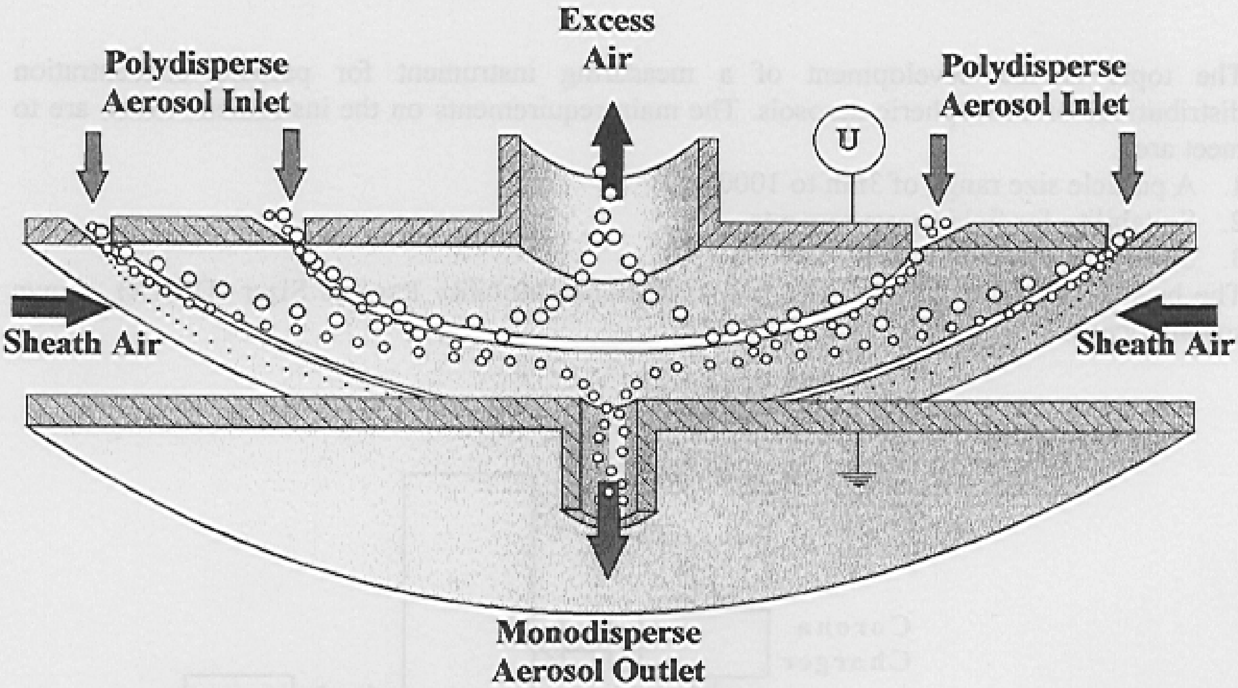

Figure II: Radial DMA

The problem with small particles is, that they are spread around the outlet caused by the Brownian motion of the gas molecules. The longer they stay within the DMA, the more they are spread. Furthermore particles collide with the walls and are lost the more, the more turbulent the gas flows are [1, 2].

In order to overcome these restrictions, the new DMA has the following innovative features:

1. Two concentrically circular inlet slits.
2. A special valve disc to open the inlets alternatively.
3. Almost no azimuthal flow component.
4. CFD simulated inlet areas
5. Design that allows the integration of DMA, charger and electrometer

The resolution of the DMA can be expressed by the half width *HW* of its transfer function.

Figure III compares the calculated resolution of the new radial DMA to those of already existing types. With small particles it shows a resolution even better than the TSI nano-DMA. The upper measuring limit of the new one, given by the maximum voltage, reaches 1000nm.

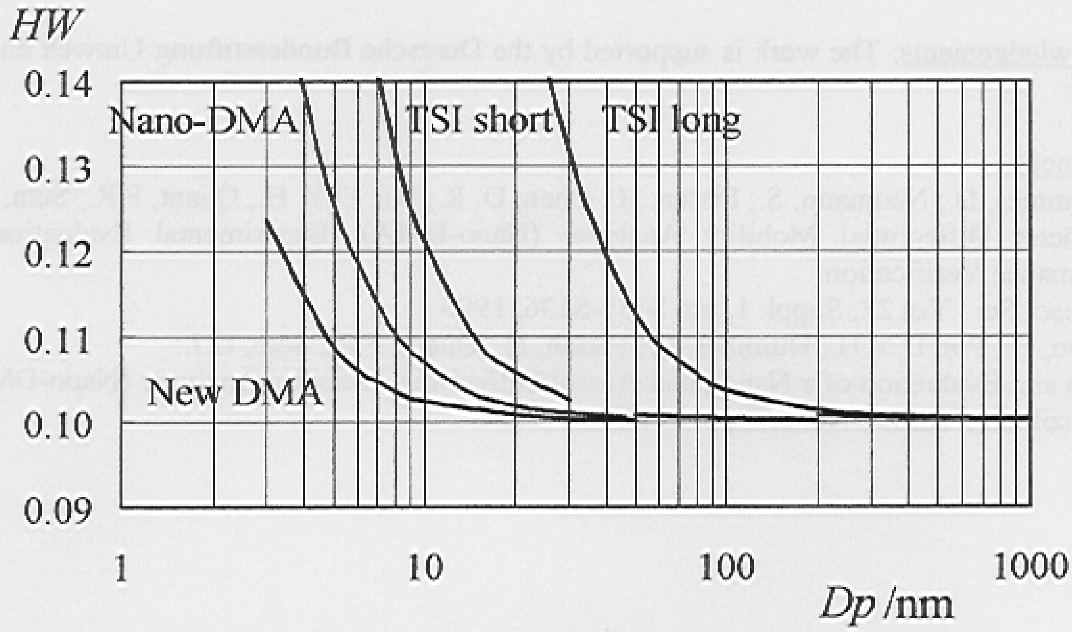

Figure III: Calculated resolution of the new DMA compared to those of already existing ones

The diagram in figure III shows, that the new DMA has a very wide measuring range.
The components impactor, charger, DMA and electrometer are designed that way that they fit together. The losses are expected to be comparatively small because the distances between the single components are very short.

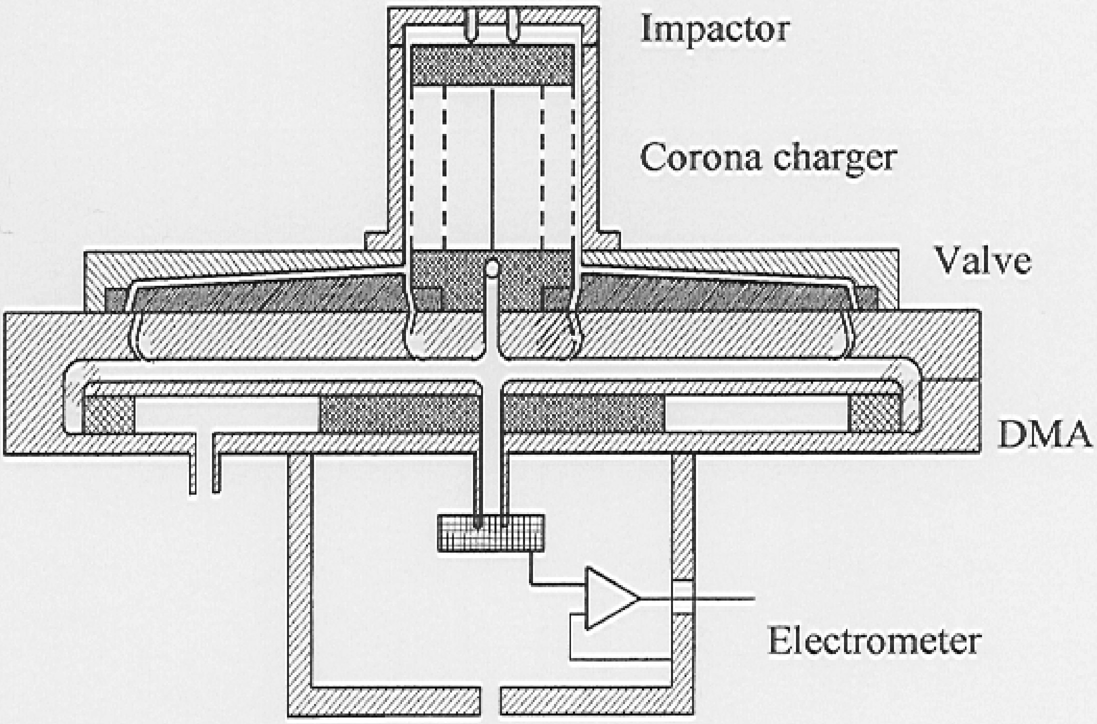

Figure IV: Crossectional sketch of the integrated components

Acknowledgements: The work is supported by the Deutsche Bundesstiftung Umwelt and TSI GmbH

References:

[1] Hummes, D.; Neumann, S.; Fissan, H.; Chen, D. R.; Pui, D.Y. H.; Quant, F.R.; Sem, G.J.: Nanometer Differential Mobility Analyzer (Nano-DMA): Experimental Evaluation and Performance Verification.
J. Aerosol Sci., Vol.27, Suppl. 1, pp. S135-S136, 1996

[2]Chen, D.; Pui, D.Y.H.; Hummes, D.; Fissan, H.; Quant, F.R.; Sem, G.J.:
Design and Evaluation of a Nanometer Arosol Differential Mobility Analyzer (Nano-DMA).
J.Aerosol Sci., Vol.29, No. 5/6, pp. 497-507