

Concept and results for a new kind of portable SMPS + C system (Sequential Mobility Particle Sizer + Counter)

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INTRODUCTION

Concept and results for a new kind of portable nucleous condensation counter and classifier are presented. This new family of portable real time SEQUENTIAL MOBILITY PARTICLE SIZER and COUNTER (SMPS+C) is designed for mobility and easy setup for laboratory and field use. An integrated battery assures hours of operation, a data logger system storage of all optioned results and a user friendly powerful software easy operation. This technology not only simplifies the SMPS operation, but it permits new on site or on board applications up to a remote wireless telephone operation.

COUNTER CONCEPT

Instead of using several individual components combining to an operational system, all necessary items and appropriate functions have been combined into one portable system. This means the well known principle of "Nucleus Condensation Counting" was improved in such a way that:

1. an integrated air and DMA control system permits the attachment of any of Grimm classifiers, reducing not only the overall size, but also handling and system manipulation,
2. an integrated microprocessor system permits the operation of the complete system without an attached computer, status lights and a digital display show the measurement conditions,
3. the alcohol saturation chamber gets only as much alcohol from the integrated tank as needed, eliminating possible spill into the optic – an automatic refill system for external alcohol tanks assures long term operation,
4. a new moisture elimination system assures long reliable field measurements even at a high humidity in the sample air – alcohol exchange is not required,
5. the sample outlet air has an alcohol odor adsorber,
6. an additional port permits the attachment of external gas and/or climatic sensors, helping a better judgement of the sampling and measurement data obtained,
7. measurement, instrument and sensor data of up to ½ year can be stored on a removable data storage card,
8. the single counter and even the complete SMPS+C system can be operated remotely via a telephone modem,
9. an internal heat exchange system reduces drastically the electric power consumption, permitting hours of continuous operation with the integrated lead battery.

Table 1. Performance of the Particle Counter

Parameter	Range
Min. particle size in [nm] (50%)	4.5
Max. concentration [P/l]	10 ¹⁰
Count Rate [P/l]	10 ⁷
Sample flow rate [l/min]	0.3 or 1.5

CLASSIFIER CONCEPT

Any of the three Grimm column classifiers are completely controlled by the counter unit. Sheath air and sample air flow are supplied by the counter. The flows are controlled and monitored inside the counter with the internal microcontroller unit. For the user it is not any more possible to manipulate the flows which is very important for the reproducibility, intercomparison of different grimm SMPS+C systems and the reliability of the results.

Table 2: Parameter of Grimm DMA classifier

Model:	Small	Medium	Long
Range [nm]	3 – 150	7 – 350	17 – 875
Min. scan speed [s] *	< 30	< 50	< 100
Particles	Solids and non volatile droplets		
Sample air [l/min]	0.3	0.3	0.3
Sheath air [l/min]	3.0	3.0	3.0
Sheath air supply	From counter		
Impactor	Integrated and exchangeable		
Neutralizer	Am-241 source in stainless steel housing		
Classifier	Stainless steel		
Length [cm]	12.5 (5inch)	38 (15inch)	63 (25inch)
Diameter of cylinder [cm]		8 (2.8inch)	
Weight [kg]	3.4	4.5	7.8
Power supply	None, via counter		

*Prescan mode

SOFTWARE AND DATA REDUCTION CONCEPT

The 32-bit software includes the communication module to the SMPS+C system for setting the measurement parameters and for resolving the measured data. The raw data is immediately calculated by transfer algorithm for data reduction and presented in a graphic module. An integrated statistic module summarizes the results in several parameters of a particle size distribution like mean, mode, logN-fit parameter etc.

The Grimm SMPS+C system uses the stepping technology for a clear data reduction method. Different types of sequencing/stepping techniques in the software are available:

- the normal measurement mode (~ 3 – 6 min)
- fast mode (~ 1,5 – 3 min)
- prescan mode (<1 – 1,5 min)

depending on the DMA length.

The data reduction method for the Grimm SMPS+C is developed and built up at the University of Vienna (Reischl). The calculations include the transferfunction of the Grimm classifiers, the Fuchs theory and all required geometric and time-dependent parameters.

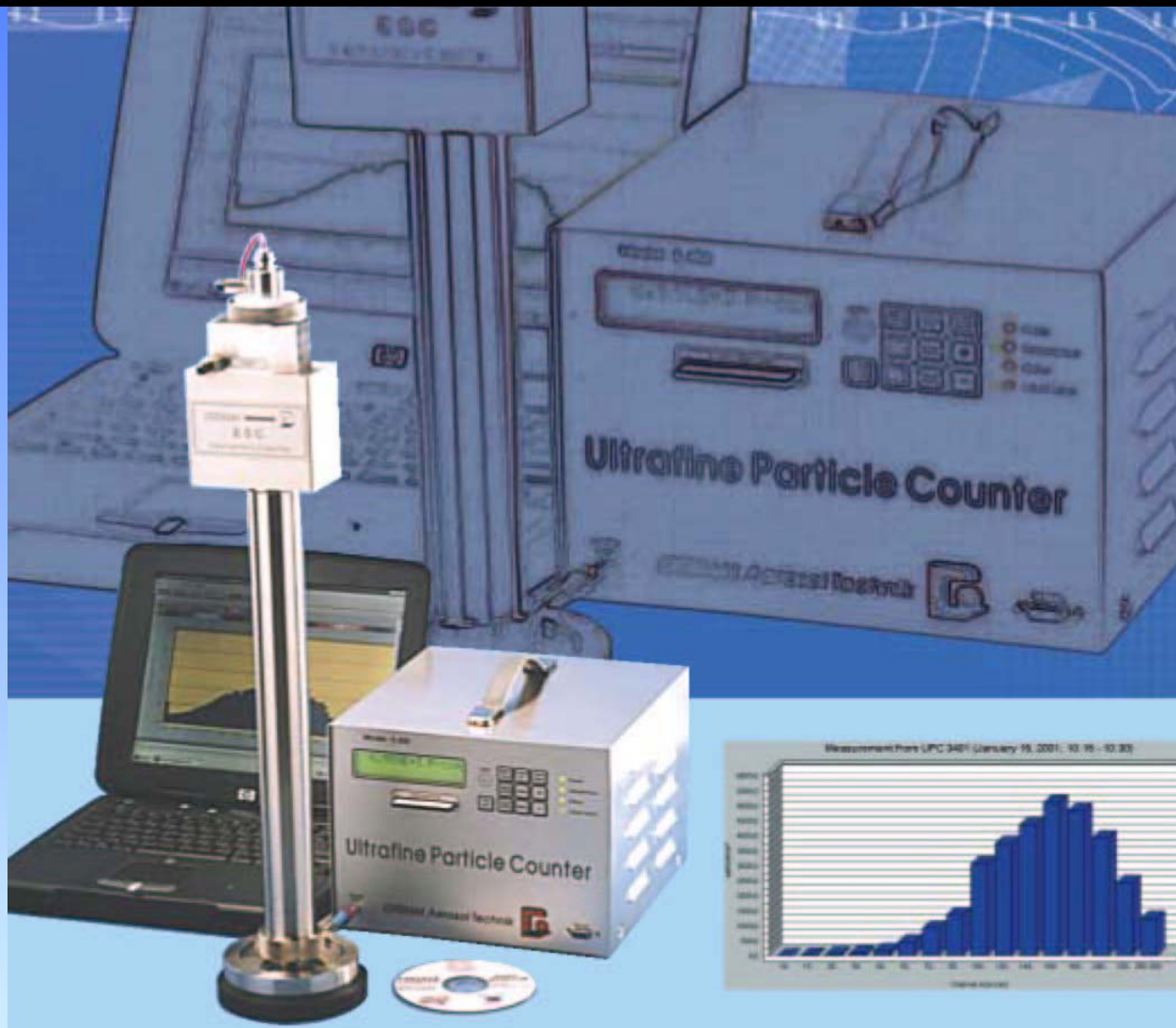
The system is validated in comparison with a reference system for aerosol size measurement < 1000 nm described by Winklmayr, et al. 1990.

CONCLUSIONS

With the Grimm SMPS+C a new generation of field and laboratory particle sizer and counter was built up. Focused on mobility, ruggedness and stand alone operation an up-to-date compact high-tech concept for reliable and reproducible results.

With this complete mobile and portable system for the first time field tests even under rough treatment got possible – the construction of the system allows measurements during cross-country trips and flights in aeroplanes. The application ranges from climate research, workplace and medical studies to emission investigations such as exhaust gas and filter-efficiency tests.

Concept and results for a new kind of portable SMPS + C system (**S**equential **M**obility **P**article **S**izer + **C**ounter)



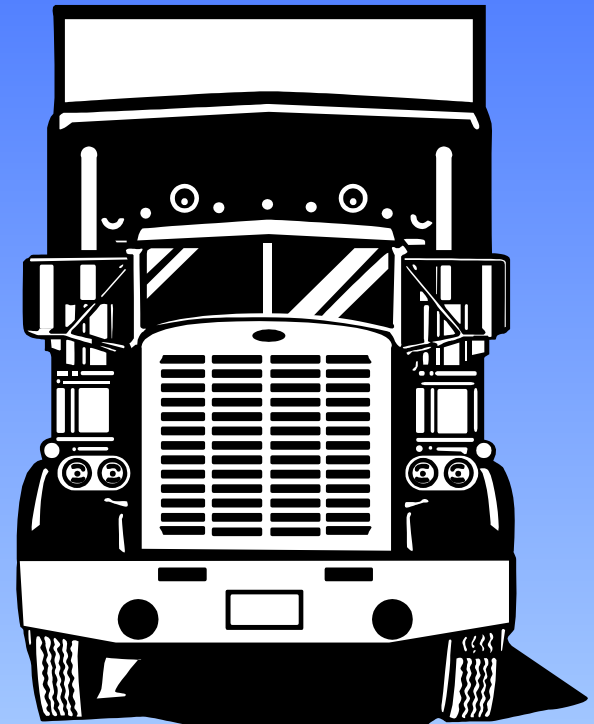


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1. Counter concept
2. Classifier concept
3. Software concept
4. Summary

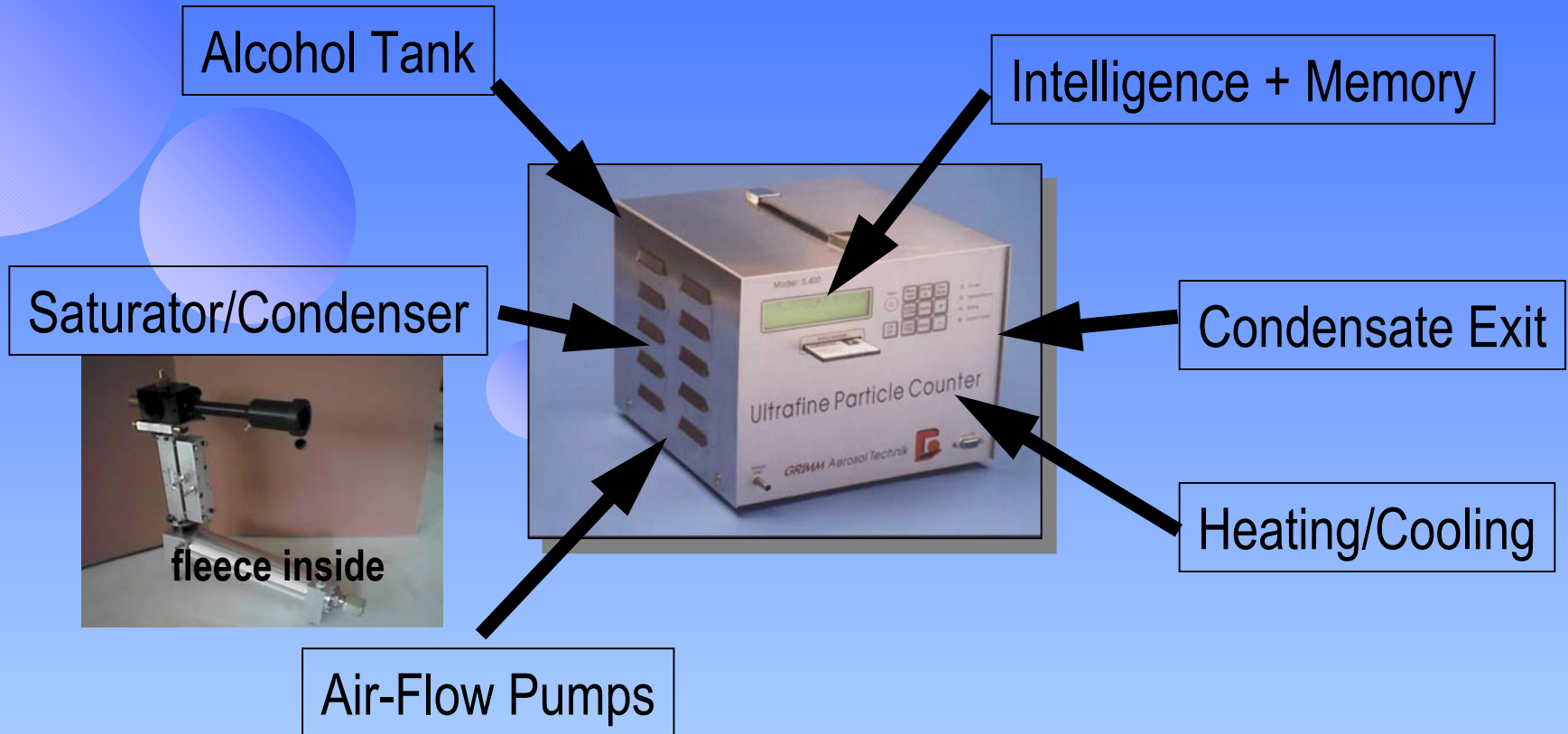
1. Counter Concept -Mobility-

- **Pumps + control integrated**
- Integrated alcohol tank
- Alcohol only in saturated fleece
- H₂O-drain off
- Battery operated



Concept and results for a new kind of portable SMPS + C system

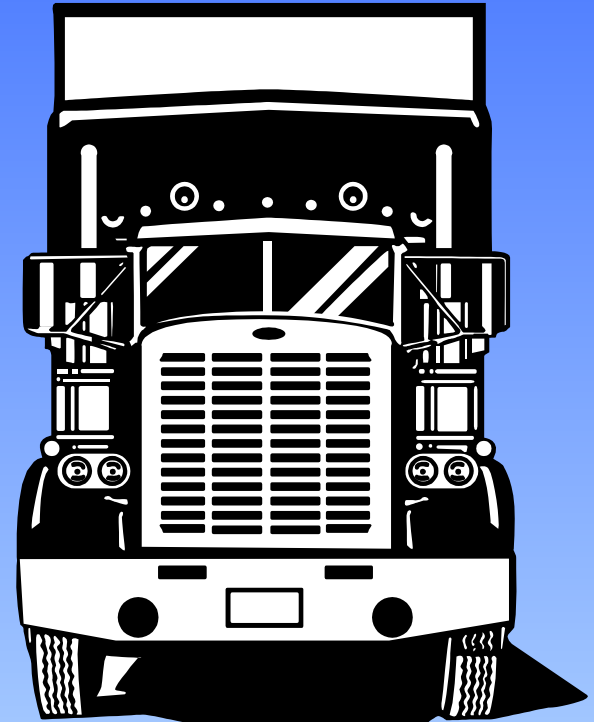
1. Counter Concept -Mobility-



Concept and results for a new kind of portable SMPS + C system

1. Counter Concept -Mobility-

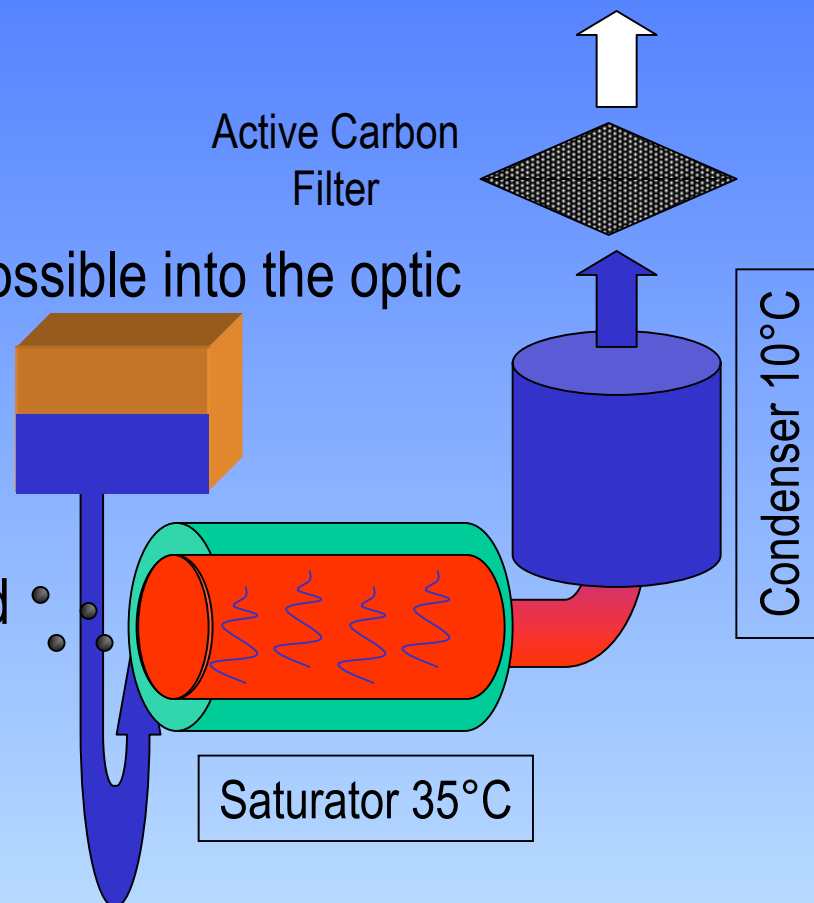
- Pumps + control integrated
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1. Counter Concept -Mobility-

Problem I : alcohol spill and odor

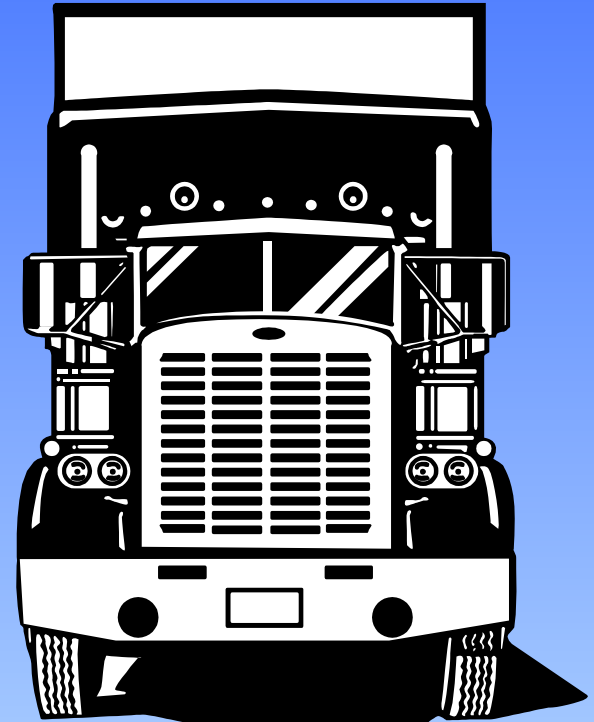
- Due to mobility alcohol spill possible into the optic
- Integrated alcohol tank with
 - automatic feeding and
 - level control system
 - and refill automatic



Concept and results for a new kind of portable SMPS + C system

1. Counter Concept -Mobility-

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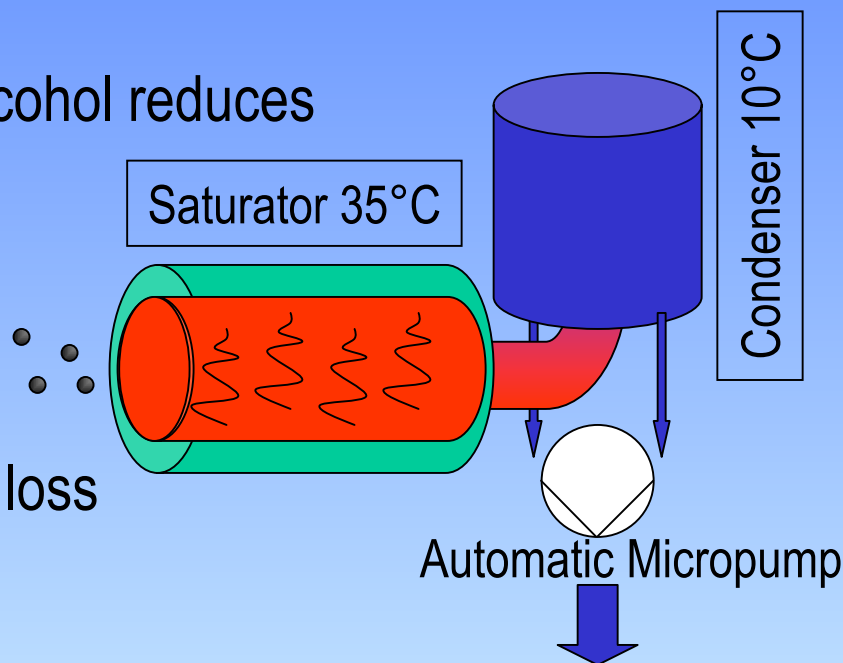


1. Counter Concept -Mobility-

Problem II : condensation of ambient humidity
in the condenser

-condensated water in the alcohol reduces
count-efficiency

-long-term environmental
monitoring without efficiency loss





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Differential mobility analyzer

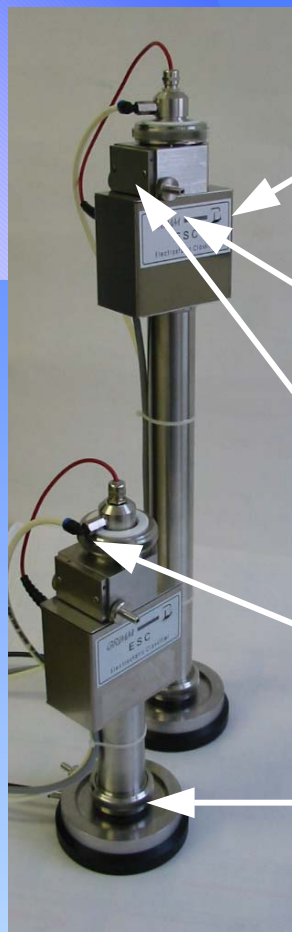
Large: 15 - 900 nm

Medium: 7 - 340 nm

Small: 5 - 100 nm



2. Classifier Concept -Design-



Differential mobility analyzer

Integrated high-voltage power supply
(power and control -16bit- by counter)

Interchangeable impactor nozzles (sample inlet)

Neutralizer: Am-241 source attachable

Sheath air from counter

Sample flow to counter



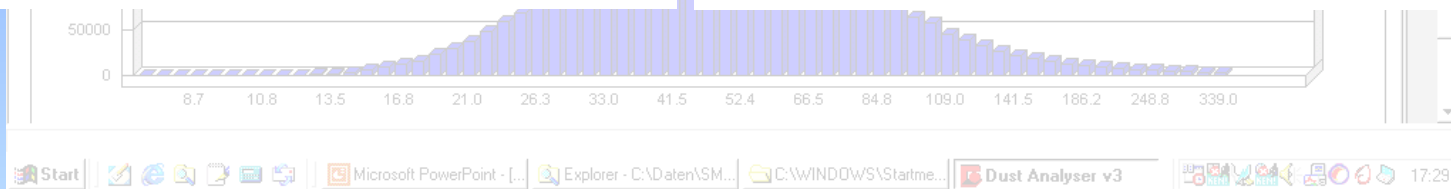
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32-bit software for counter and complete SMPS+C systems

- Setup of parameters
- Zero test with classifier
- Immediate result presentation with conversion calculations
- Data transfer by pcmcia
- Schedule and alarm management

- Data presentation: frequency, cumulative distribution, number,, volume (mass), etc.
- Statistical analysis: modes, deviations, etc.
- Data fitting (logN, RRSB, multimodal)
- Data export (ASCII, MS-Excel)



Data Inversion:

(Number Size Distribution Function)

$$F_C(d_P) = \sum_{i=1}^{\infty} \alpha(d_P, i) \cdot Tr(Z) \cdot F(d_P)$$

with: $\alpha(d_P, i)$ = station. charging state (Fuchs, 1963)
 $Tr(Z)$ = transfer function of DMA
 $F(d_P)$ = orig. number size distribution

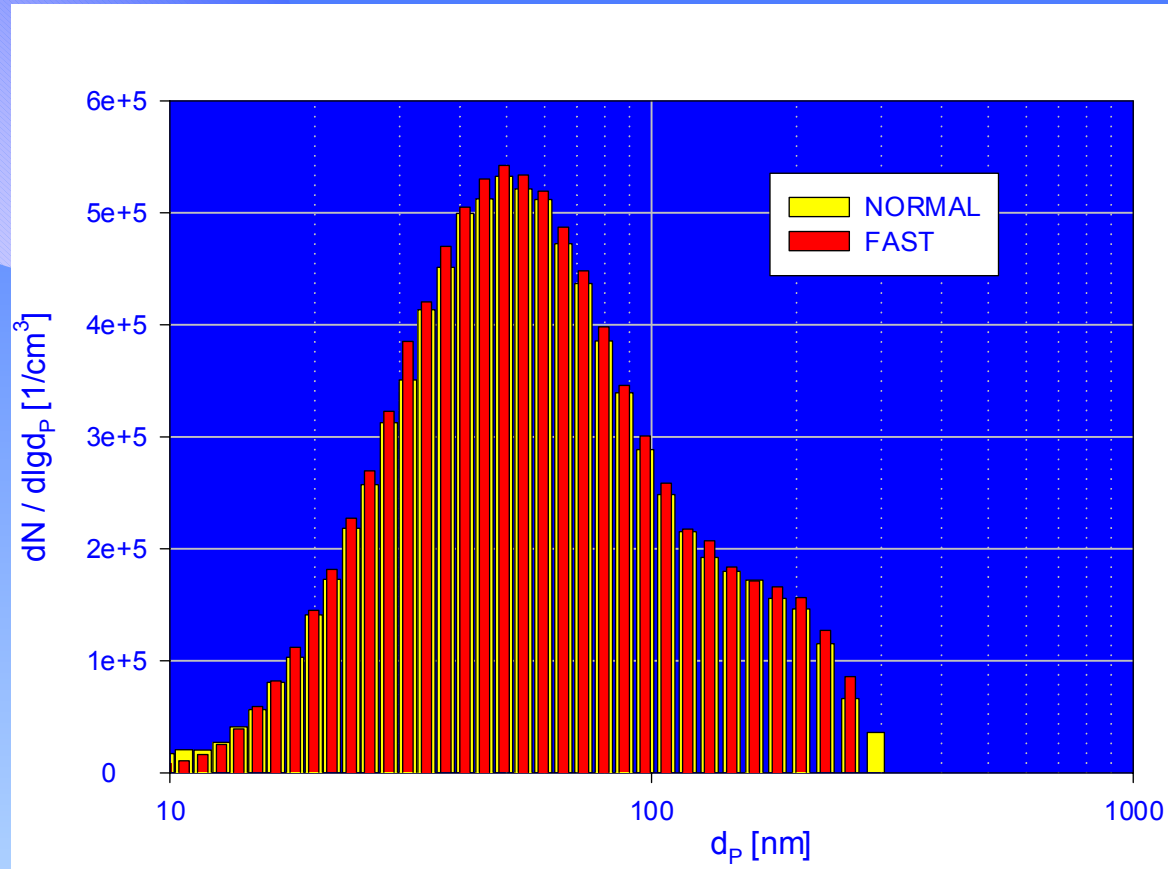
Solved only if:

- Knowledge on DMA $Tr(Z)$
- Knowledge on charge distribution $\alpha(d_P, i)$
- Limited upper particle size (impactor => < 900 nm)
- Fixed voltage steps / mobility channels

by REISCHL (1991)

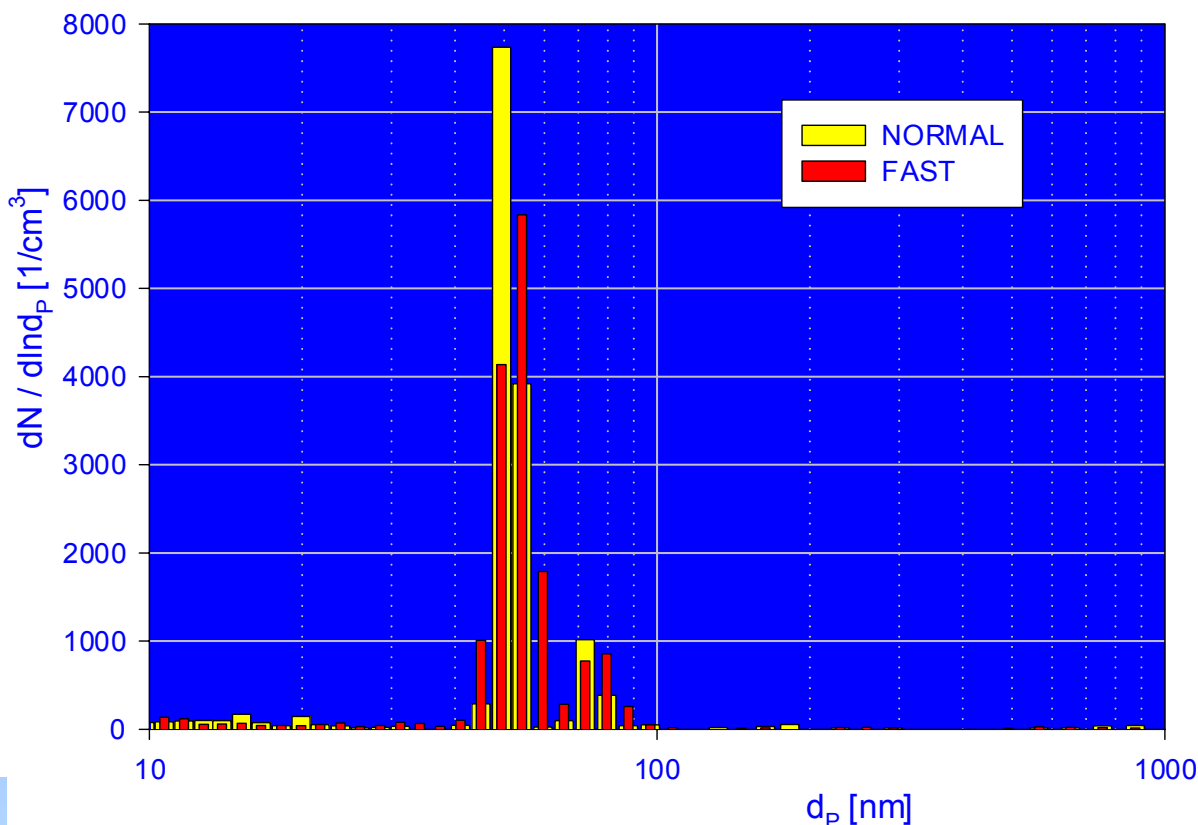
Only with a sequential stepping method and well defined delay times of the respective DMA and the counter is the calculation back to the original input aerosol size distribution possible.

3. Software Concept -Results-



- normal mode
(~ 3 – 6 min)
- fast mode
(~ 1,5 – 3 min)
- prescan mode
(<1 – 1,5 min)

depending on the DMA length



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- no free liquids, no spill - saturator with fleece
- very compact all-in-one design
- control and supply of DMA integrated
- H₂O condensation outlet & data storage cards for long time measurements
- remote control by telephone
- stepping for clear data reduction

END