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New portable fine and ultrafine aerosol spectrometer

ETH Zürich 2001 paper (to be given Aug 2001)

Concept of the GRIMM Dust Measuring Instruments of the Series 1100

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[1] Development, [2] Production,

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INTRODUCTION

All devices of the series 1100 work according to light scattering principle. The Particulate Monitor performs particulate measurements via 90° laser light scattering. Air with multiply particle sizes passes through a flat laser beam, produced by an ultra-low maintenance laser diode. The scattered light signals are then detected at four or eight or fifteen different size-channel by a pulse height analyzer and counted in a defined period. Based on this results the

- Particle size distribution
- Particle Mass distribution
- Or conventions such as the EPA style PM-10 and PM-2,5 can be expressed in real time.

INSTRUMENT DESIGN

The dust measurement is based on the size measurement of the single particles. The aerosol to be measured is guided for this purpose into a test cell by a nozzle ,see picture 2. The particles pass then a very narrow light curtain, that through a laser diode and an optics is formed. The light pulses, that will arise from the illuminated dust particles bundled up about a spherical mirror onto a diode detector and converted into electric impulses in a preamplifier.

The size pulse amplitude becomes greater with increasing particle diameter. This connection is however non-linear and in addition also material properties and form of the particles play a role. The impulses become then, according to device type in counted differently to many channels. The measured particles re collected on a removable filter, see picture 3.

The older devices 1.102, (those ones were four different size channels are used), are five years ago been replaced with the devices 1.104, 1.105 and 1.106 with eight channels and finally today with the devices 1.108 and 1.109 those ones are 16 or 12 size channels that are determinate at each size scan. A complete system is shown in picture 4.

The units can be carried on a human body of transported by car or plane, as shown in picture 5. It is even possible to install this units outdoor, see picture 6.

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CALIBRATION METHOD

In all the 1.100 series of monitors is the measurement made for calculation (of the aerosols) in the count mode. All produced instruments where checked in the Count mode and over a so-called " *dust-ramp*" driven, simply for the purpose to see that the dust concentration in this arrangement is following the reduction, starting from a high initial value continuously uniform in a straight line falling in the twice logarithmic representation curve to the lowest possible level.
The behaviour of the different monitors can be judged over the whole measuring range quite well. The actual adjustment of the devices occurs through the change of the channel threshold voltages. This means that the production controls each device in each case against a mother instrument, in which all channel thresholds were determined by measurement of monodisperse latex aerosol. That means that at the respective channel size threshold diameter, for latex particles with this respective size was made with an efficacy of 50 % per channel.
If the mother device and the attached several daughter devices had a very good agreement (with the mother device) than the instrument where correlating. In case of multiple inspections of the mother devices showed, that except for the regular cleaning no further jobs or an adjustment was really necessary.

The complete process was before 1998 produced by hand, but since that time are all channel tensions changed by software about DAC. The calibration performance obtained in this case 8 bit, that the setting accuracy was now better when 0.5 % . Also these devices are now adjusted via software and working automatically . According to respective instrument, the edition of the dust concentrations occurs per channel or as a weighted dust (for example of PM10 and PM2.5.)

In spite of that, instrument synchronisation of R2 of 99,99% can be achieved and have been proven by official testing organisations, even so there are tolerances in the mechanics, optics and electronics. All new monitors, starting at 1.101 are 10 Bit-ADC's and the adjustment is fully automatic via software adjustment, carried out by computers and even more exactly.

From that it is reasonable to compare the devices in the Masse mode since into the mass calculation the particle diameter enters in the third exponential and small deviations outcrop more clearly, so one can decide more easily as an inevitable deviation will take effect.

DIESEL SOOT MONITORING

Total suspended Particulate (TSP) as commonly measured in with Environmental stations have shown that the daily dust concentrations have decreased annually. However the fine dust fraction, mainly below 0,5 µm may not show a large mass, but those particles are outnumbering the larger once and are inside urban environment nearly 80% of all the articles. In consequence the concentration of ultra fine Particles are epidemiological of concern and need to be monitored in the new coming outdoor networks for PM-2.5 and in the future even as PM-1.
The need for faster and simpler monitoring of the fine and ultra fine particles has let to the solution of a new battery operated portable unit, able to

- measure in real time
- in one second
- the size distribution from 100 nanometres upwards to over 1000 nanometres
- and in high concentrations up to 2×10^8 particles /Litre.
- And is low cost.

To assure correlation to the GRIMM SMPS system , count comparisons where made at different size channels, see picture 7 of ambient air and picture 8 of fine smoke.

RESULTS

Measurements on a light DIESEL engine where made with booth systems, as shown in picture 10 and 11, the results obtained [4] show in table 12 a stable base line and instant monitoring response in the count mode. The transient time in 13 and the size distribution obtained in table 14 and in 15 the the size distribution at different speed.

[4] References are made to US tests during 2000, made by SENSOR Inc in N.Y.

CONCLUSIONS

It is very well possible to measure with the GRIMM optical technology the DIESEL exhaust pipes, as shown in table 16, but it is also possible to verify the size distribution of these aerosols with an GRIMM SMPS system, as shown in table 17.

ACKNOWLEDGEMENTS

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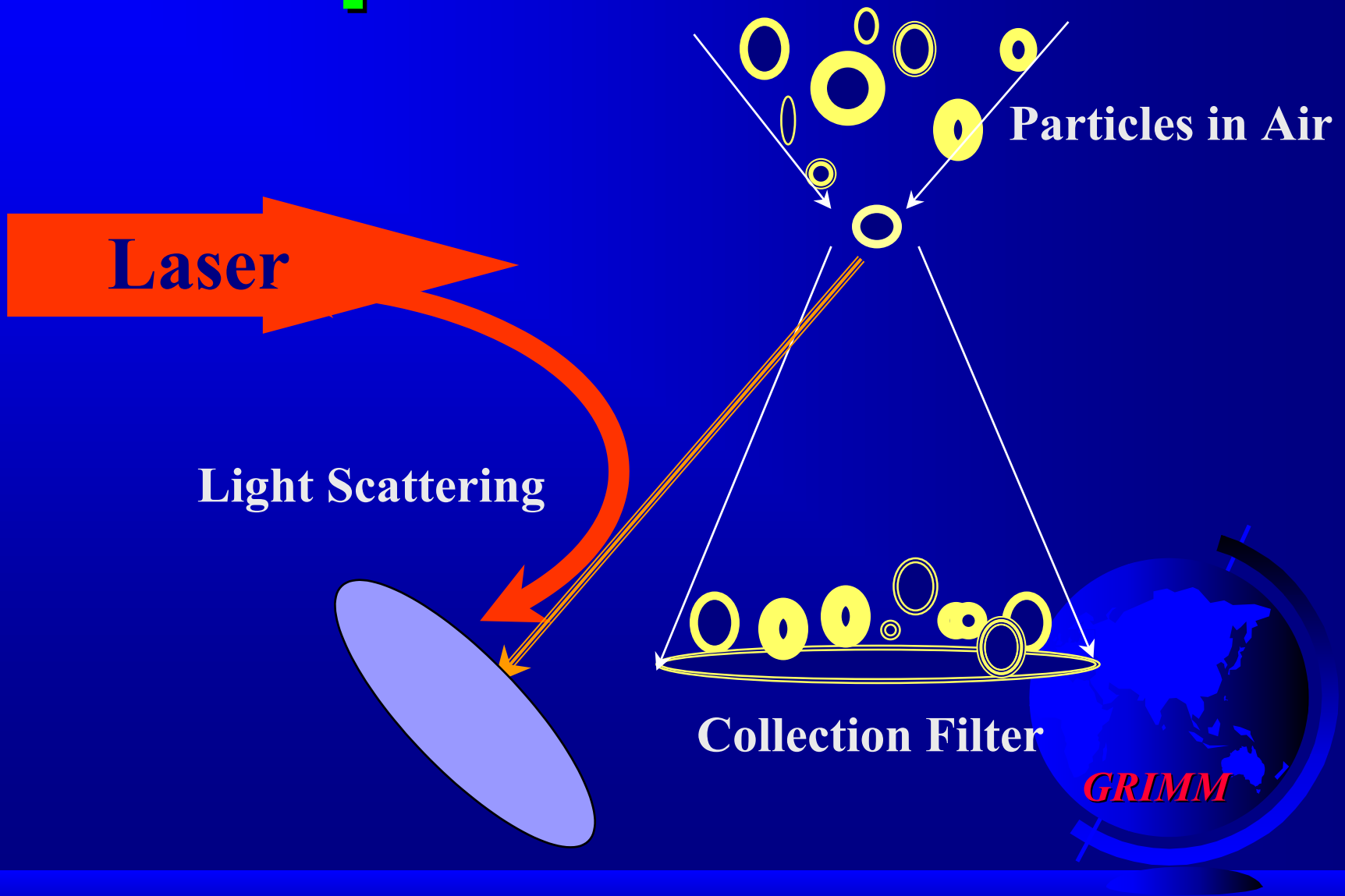
GRIMM

Aerosol Technik

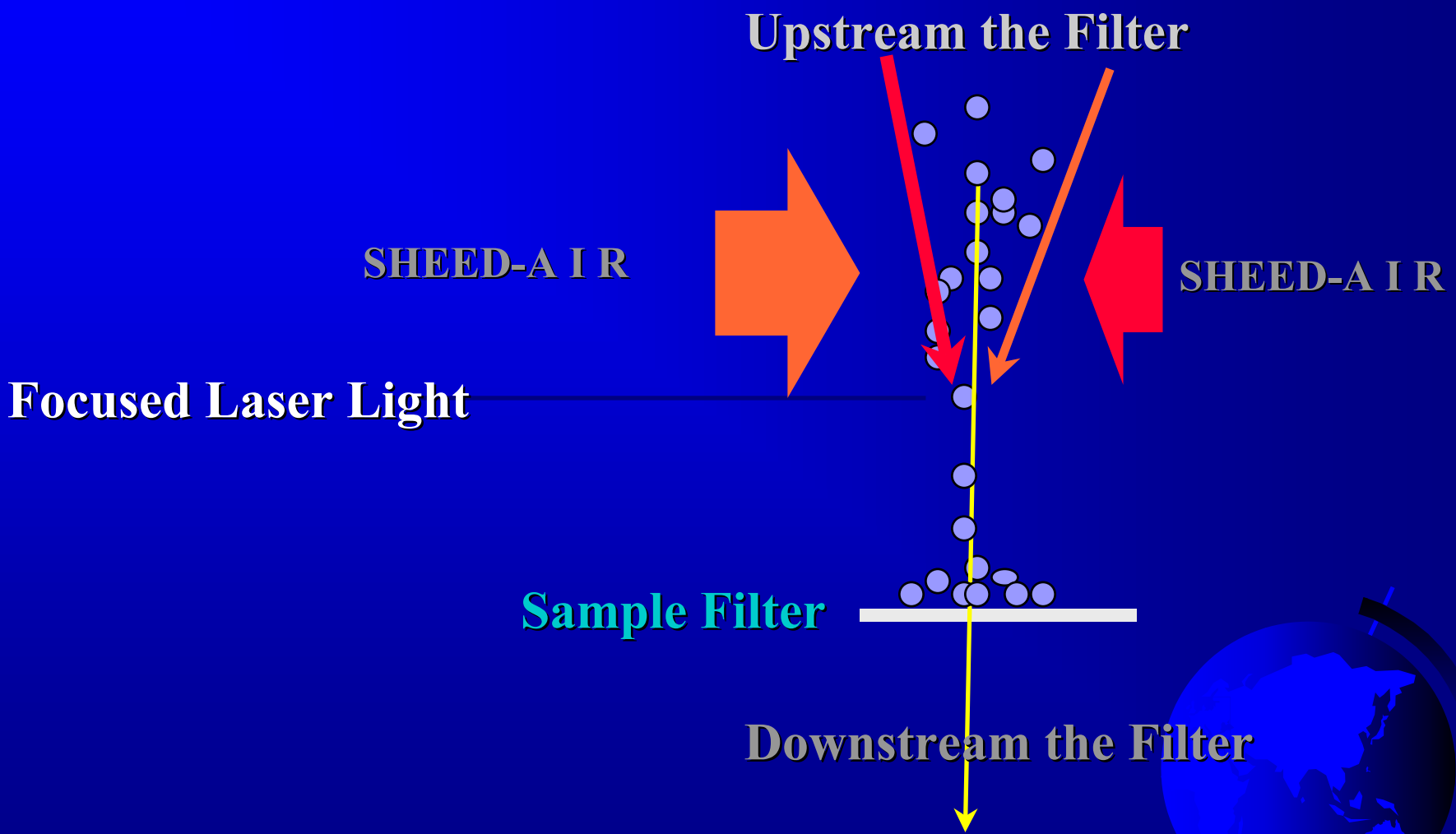
Portable Fine and Ultrafine Aerosol Spectrometer

5. ETH Conference on Nanoparticle-Measurement
ETH / Hönggerberg, Zürich, 6. / 7. and 8. August 2001

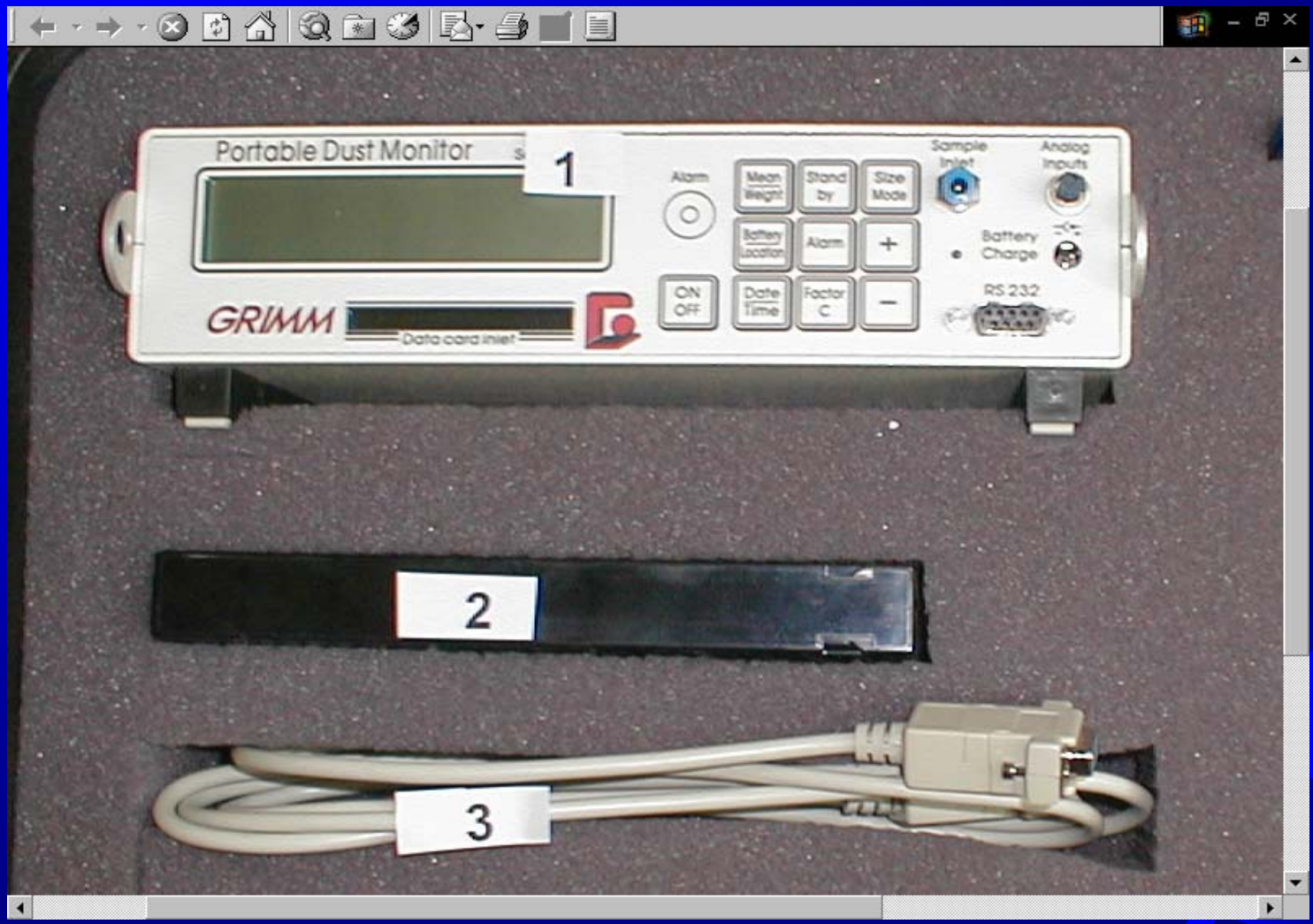
Optical Method

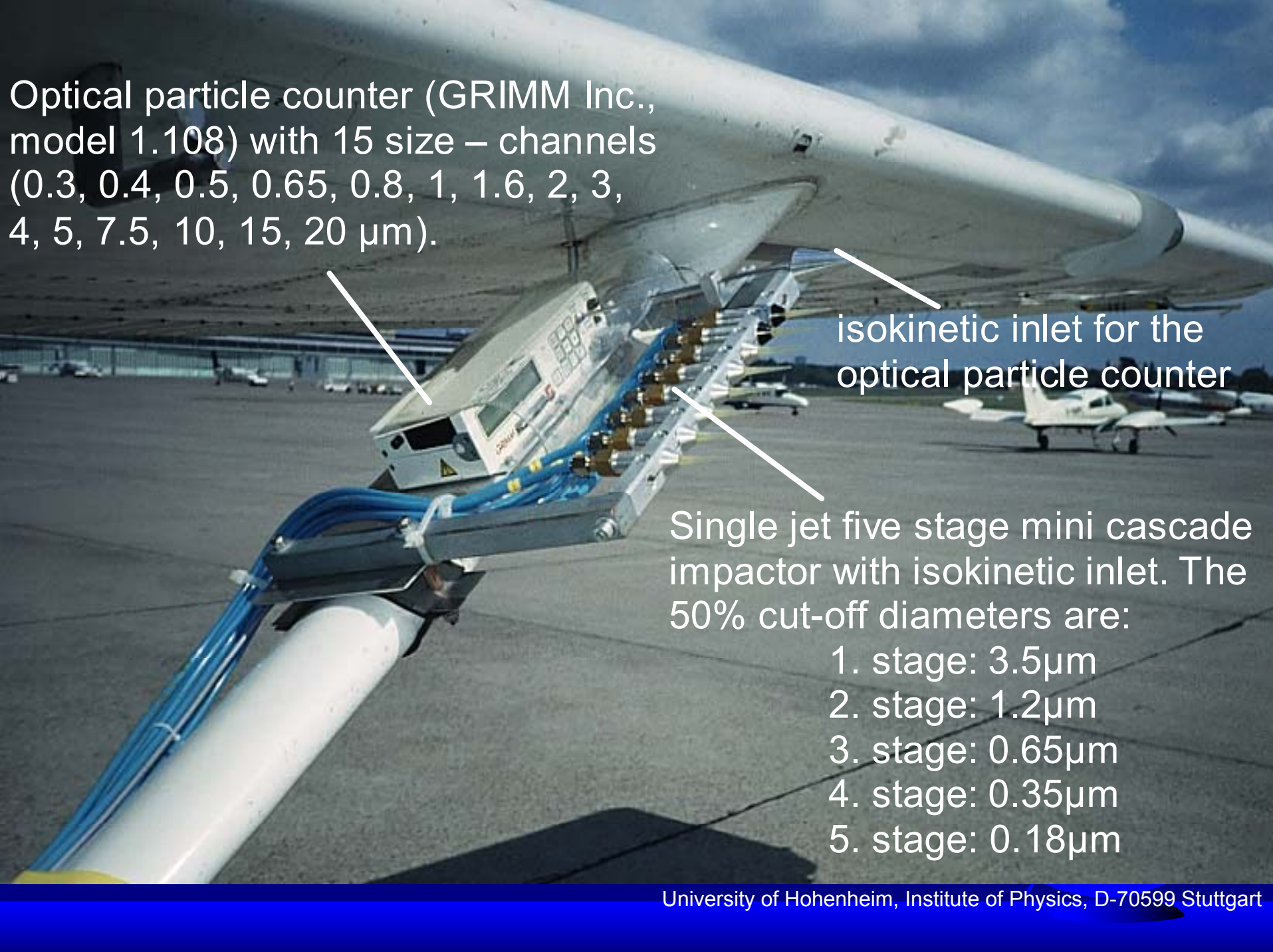


Detection principle



Instrument Size and Shape




Optical particle counter (GRIMM Inc., model 1.108) with 15 size – channels (0.3, 0.4, 0.5, 0.65, 0.8, 1, 1.6, 2, 3, 4, 5, 7.5, 10, 15, 20 µm).
isokinetic inlet for the optical particle counter
Single jet five stage mini cascade impactor with isokinetic inlet. The 50% cut-off diameters are:
1. stage: 3.5µm
2. stage: 1.2µm
3. stage: 0.65µm
4. stage: 0.35µm
5. stage: 0.18µm

Environmental Dust Monitoring

PM-10 & PM-2.5

- By **SIZE** and **MASS**
- As **EPA Values**
- As Count Distribution
- With climatic Sensors
- With remote Modem control

Instrument Calibration

as Counts, Size distribution and as Mass in Microgram /m3

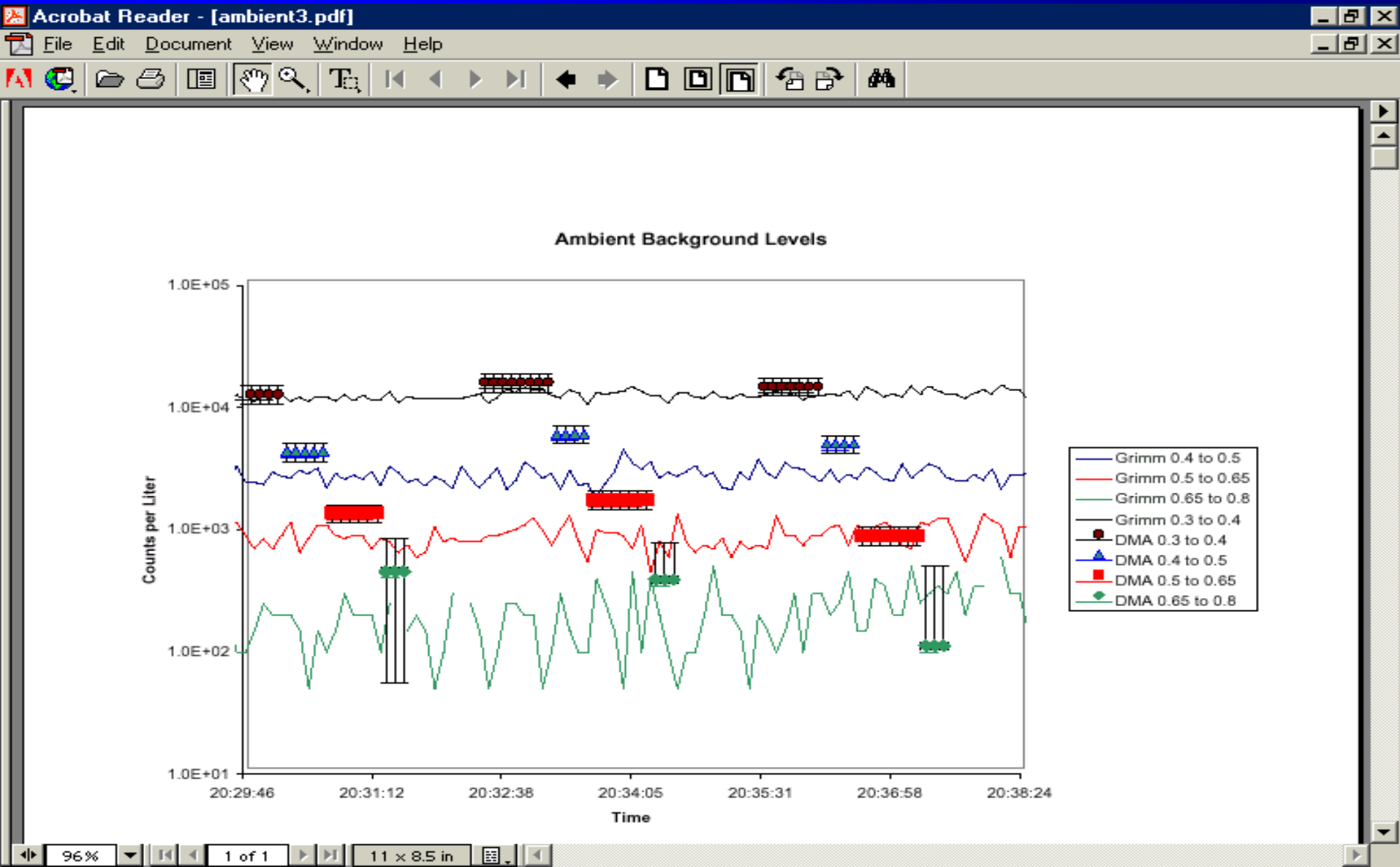
Factory Calibration

- By **SIZE** with Mondisperse Latex in different sizes
- By **MASS** polydisperse Stearin Mass for correlation
- For DIESEL by HC-Density
- Against a Reference unit
- Aautomatic by Computer
- ***GRIMM PATENED TECHNOLOGY***

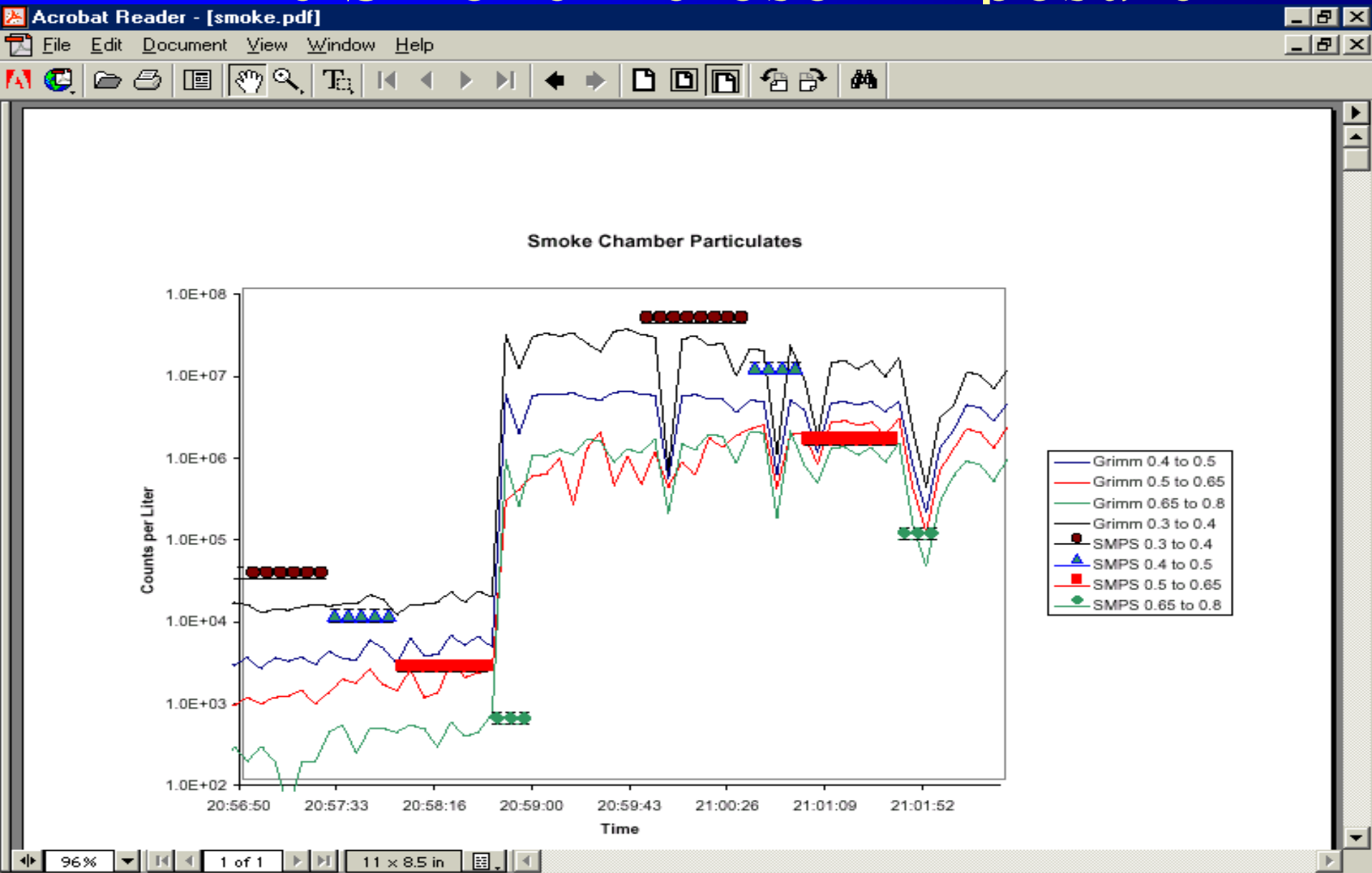
FieldCalibration

- By the build-in **FILTER** as mass correlation of the real dust at the spot
- By automatic **ZERO** verification at each start
- By recording all the SERVICE data of the instrument during operation

Ambient Background Levels



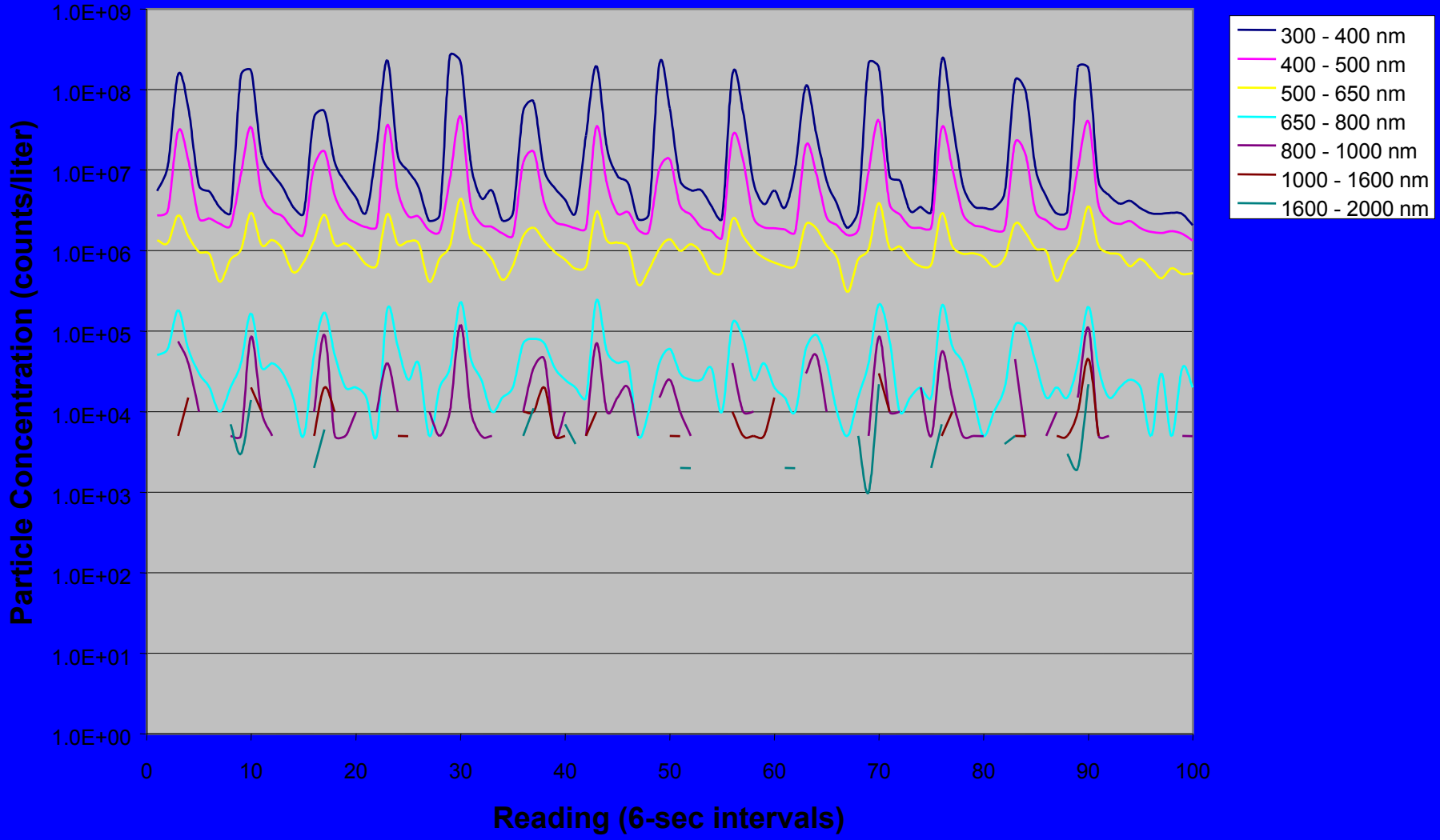
Fine Smoke Aerosol Exposure



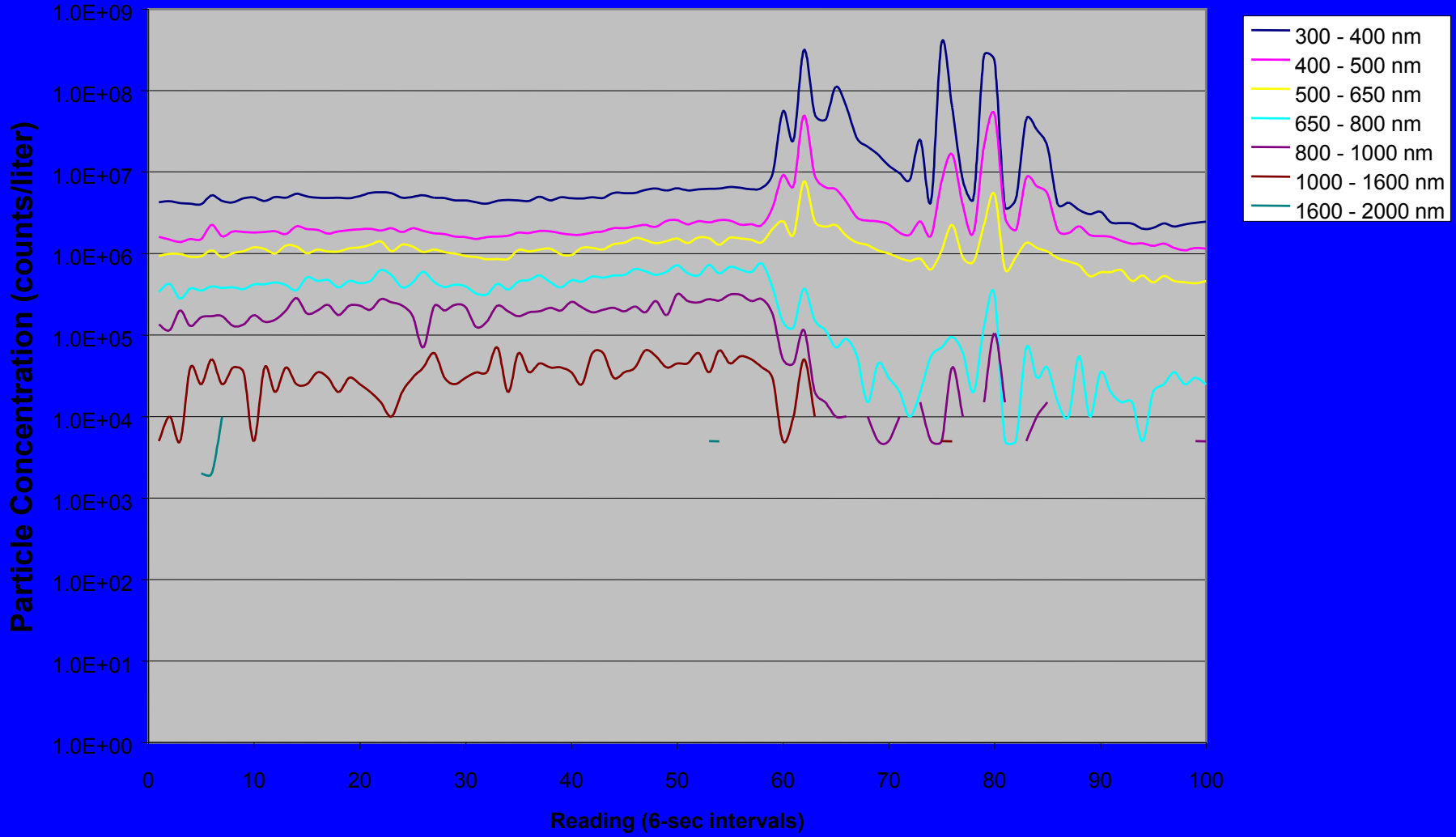
Diesel-Probennahme.jpg - Image Preview

DMA and LAS Sample Preparation

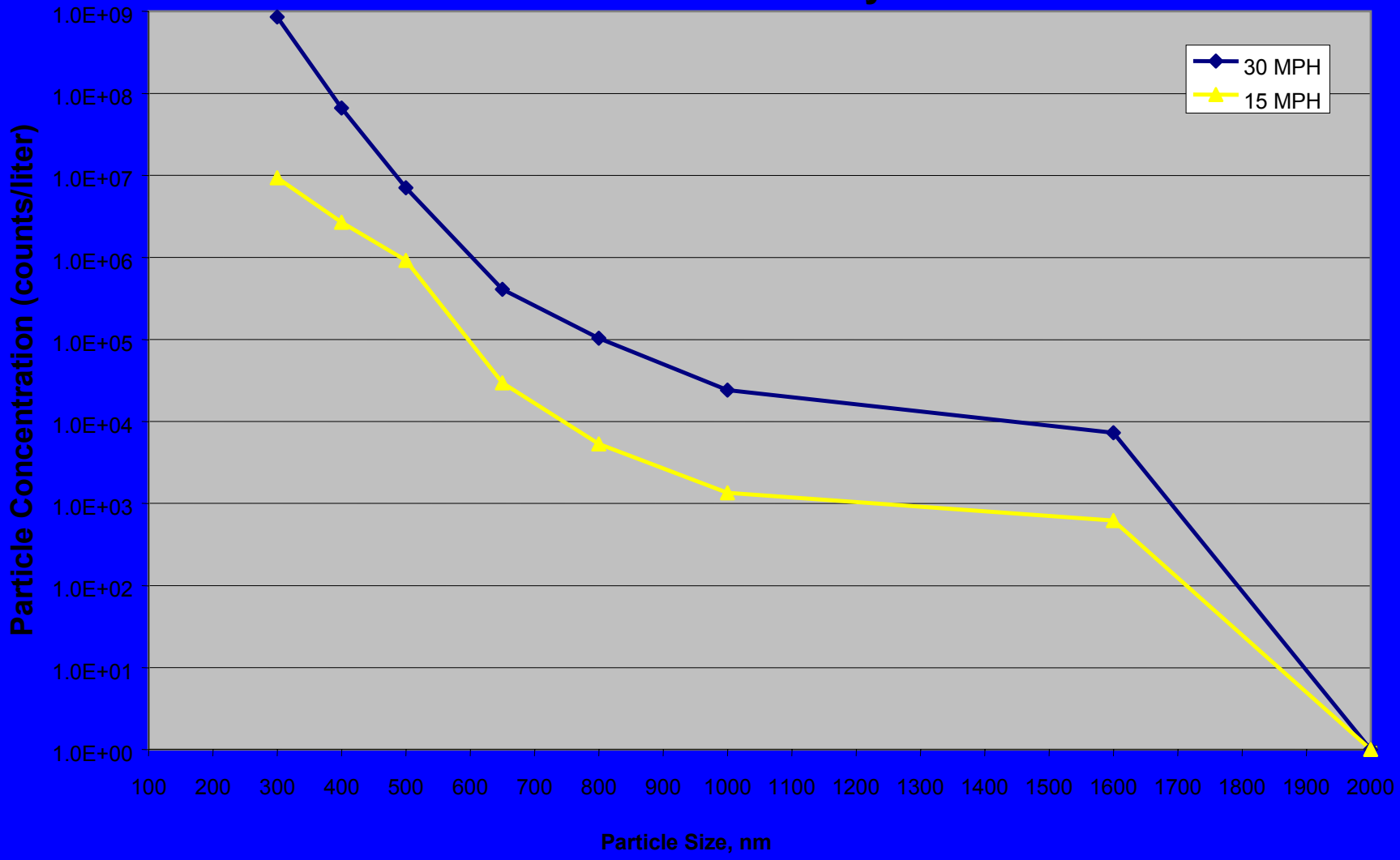
Transient Particulate Concentrations:



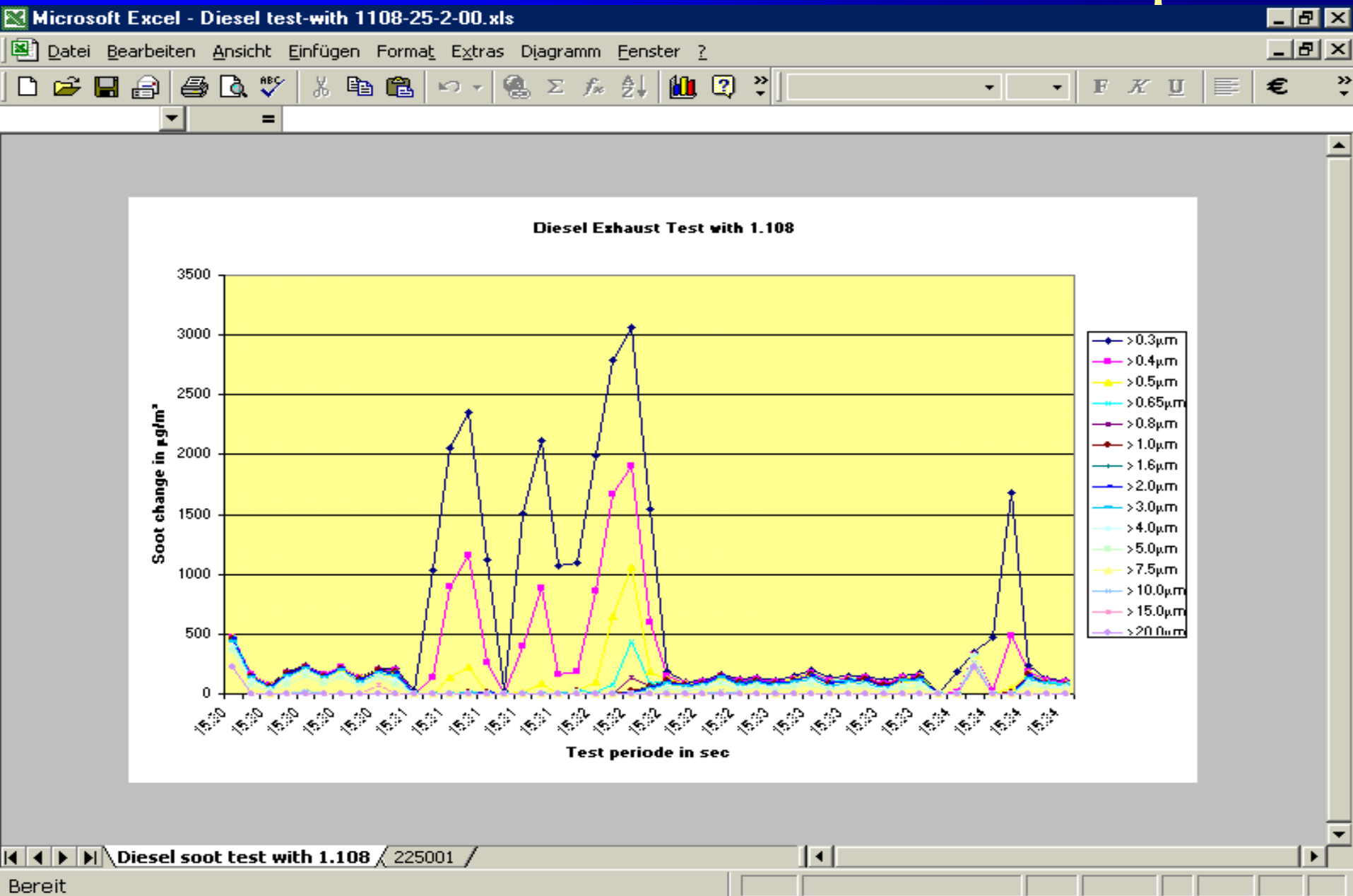
Transient Particulate Concentrations: Post Test Idle



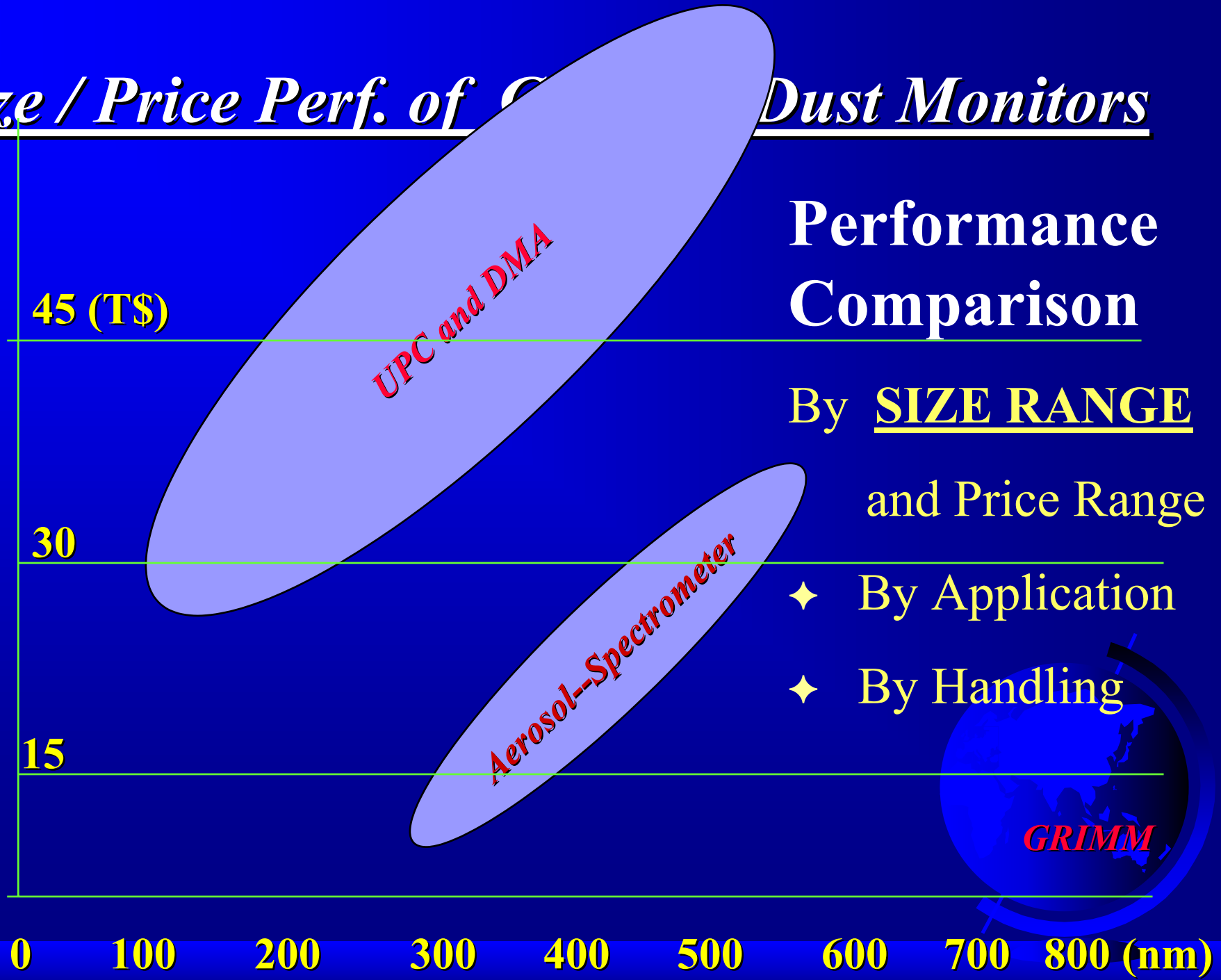
Average Particle Size Distribution: 50 /30 Km/h Steady State



P.-Size at DIESEL Exhaust Pipe



Size / Price Perf. of C… Dust Monitors



Performance Comparison

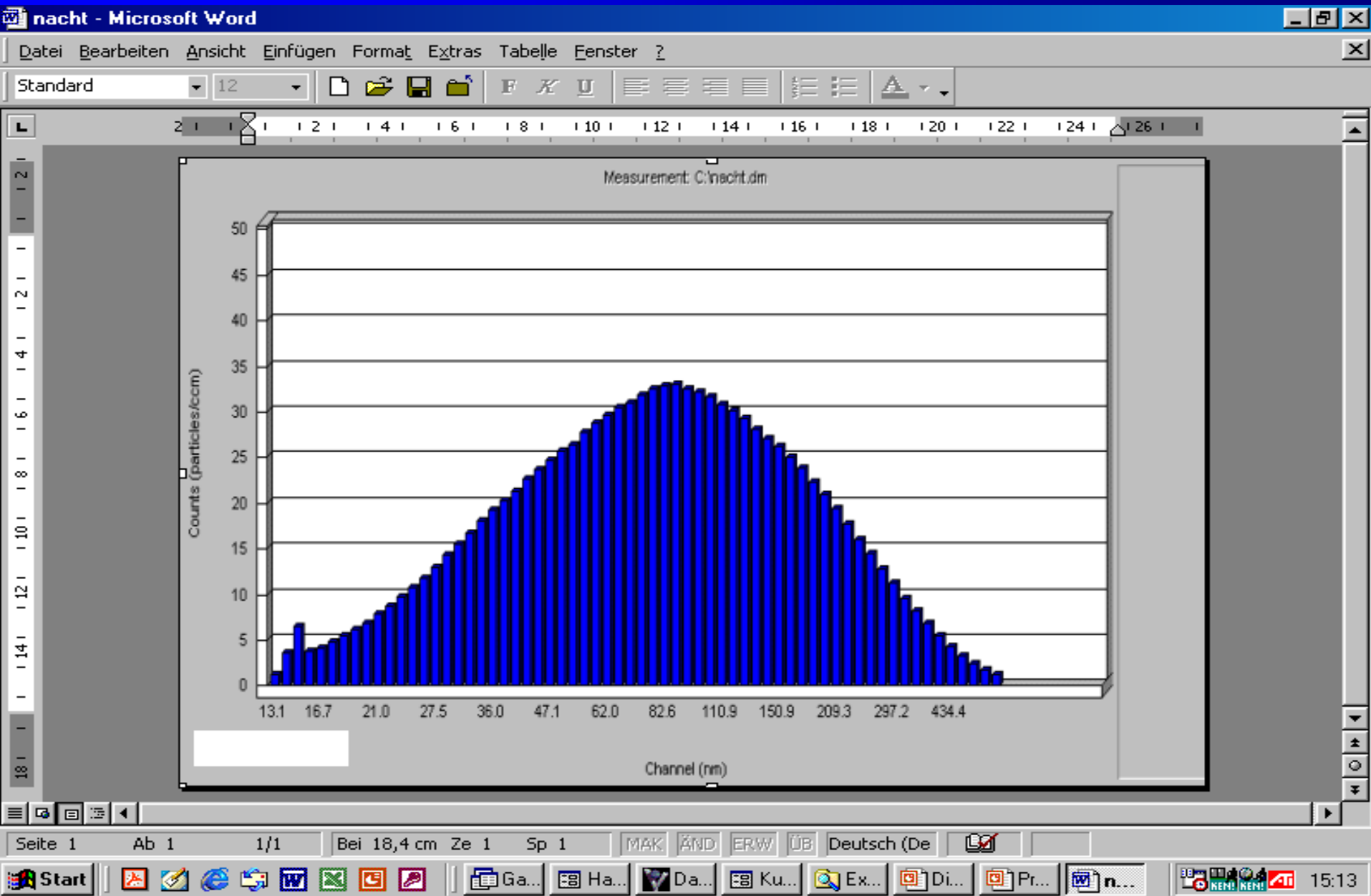
By **SIZE RANGE**

and Price Range

- By Application
- By Handling

GRIMM

DMPS


nacht - Microsoft Word
Datei Bearbeiten Ansicht Einfügen Format Extras Tabelle Fenster ?
Standard
Measurement: C:\nacht.dm
Counts (particles/ccm)
50
45
40
35
30
25
20
15
10
5
0
13.1 16.7 21.0 27.5 36.0 47.1 62.0 82.6 110.9 150.9 209.3 297.2 434.4
Channel (nm)
Seite 1 Ab 1 1/1
Bei 18,4 cm Ze 1 Sp 1
MAK ÄND ERW ÜB Deutsch (De
Start
15:13