I. Khalek
SWRI
San Antonio
USA

SMPS and ELPI calibration using diesel exhaust particles

Performance of SMPS and ELPI with Diesel Exhaust Particles

Imad A. Khalek, Ph.D.
Southwest Research Institute, Department of Emissions Research,
San Antonio, Texas

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Summary

The performance of a scanning mobility particle sizer (SMPS) and an electrical low pressure impactor (ELPI) were examined with diesel exhaust particles. Examples of how the size distribution and number concentration changed as a result of changing scan range, scan time, and flow rate of the SMPS was reported in this work. It was also reported that the SMPS software version 3.0 underestimates the number concentration by about a factor of four compared to versions 2.4 and 3.2. Versions 2.4 and 3.2 agree with each other and data taken with 3.0 can be reanalyzed in either version. The ELPI required a size dependent correction factor in order to match the electrical mobility size distribution and concentration of the SMPS. Such correction factor may be attributed to particle density and range from about 1.5 g/cm^3 for particles with 30 to 50 nm in diameter to about 0.4 g/cm^3 for particles larger than 200 nm in diameter. However, a tighter density correction factor with less variability is desired.
This work highlights the need for a well-established standard operating procedure on instrument calibration and usage when sampling particles from diesel exhaust or other combustion sources. This is in addition to a well-defined protocol on particle dilution and sampling.

P.S. More elaborate discussion of this work is expected to be published in a future SAE publication or other sources.

Outline

- Background
- Objective
- Measurement Issues with SMPS
  - Scan Range, Scan Time
  - Flow Dependence
  - Direct Comparison with CPC
  - Software Version 3.2 and 2.4 versus 3.0
- Measurement Issues with ELPI
  - Concentration Level Sensitivity
  - Density Correction
- Conclusions
- Acknowledgements

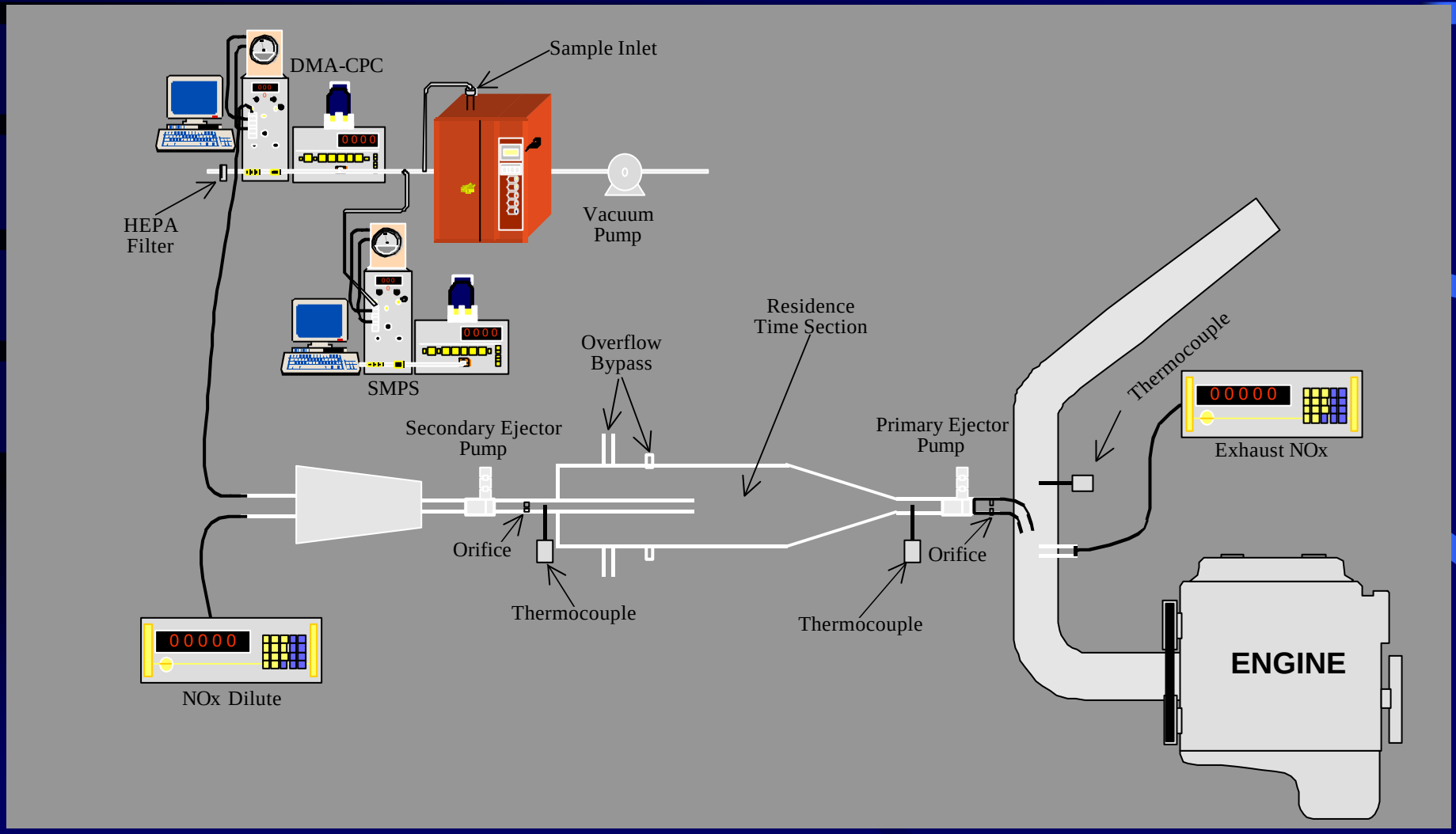
Background

- SMPS and ELPI are widely used to determine the size distribution and number concentration emitted from combustion sources, especially diesel engines. It is critically important to examine the performance of these instruments in a systematic way in order to define a step by step method in which by these instruments and others should be used to obtain accurate and repeatable measurement from combustion sources.

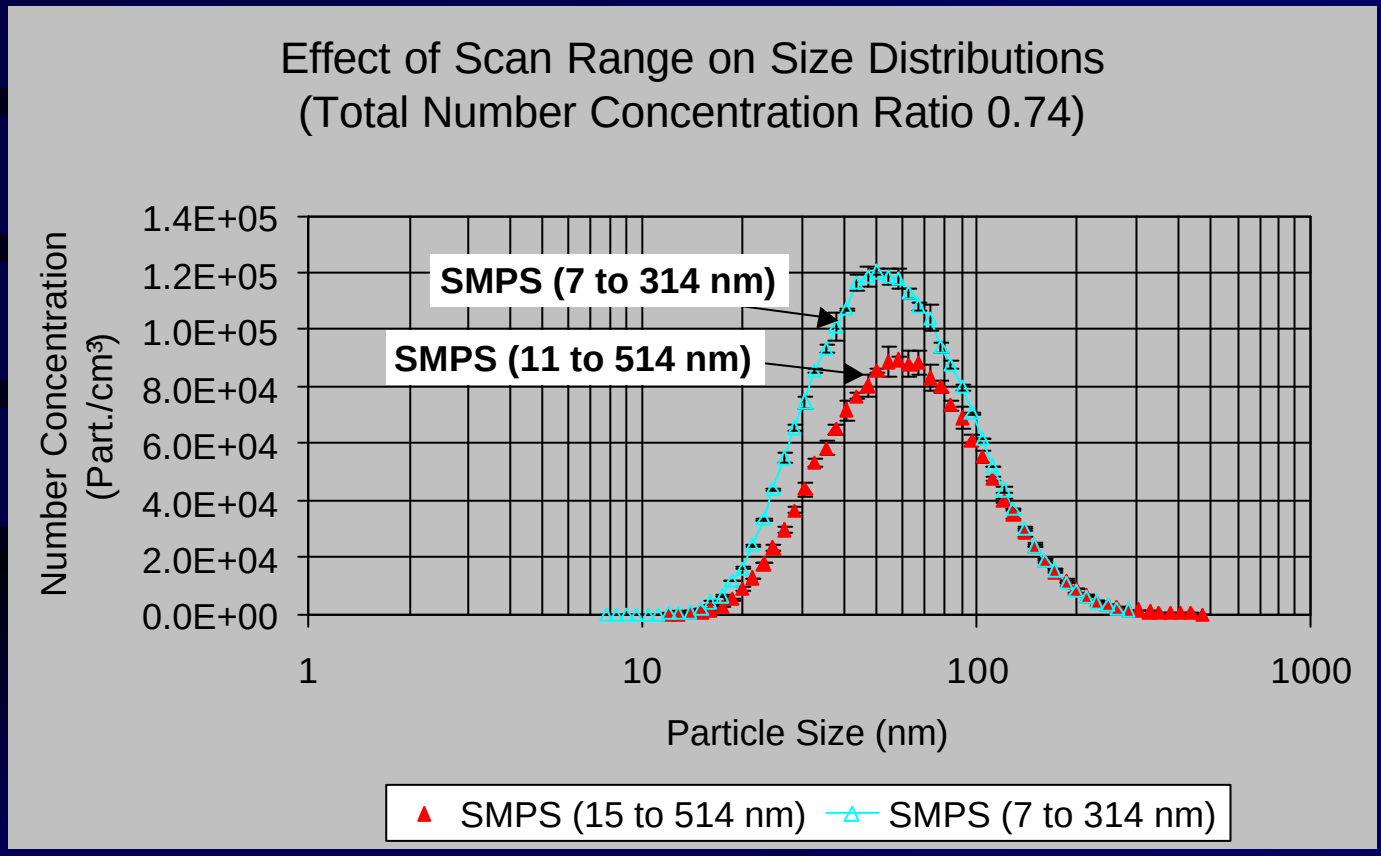
Objective

- The objective of this work was to examine the performance of the SMPS and ELPI with diesel exhaust particles. The engine was used as a stable aerosol generator operated with fuel sulfur level of 1 PPM.

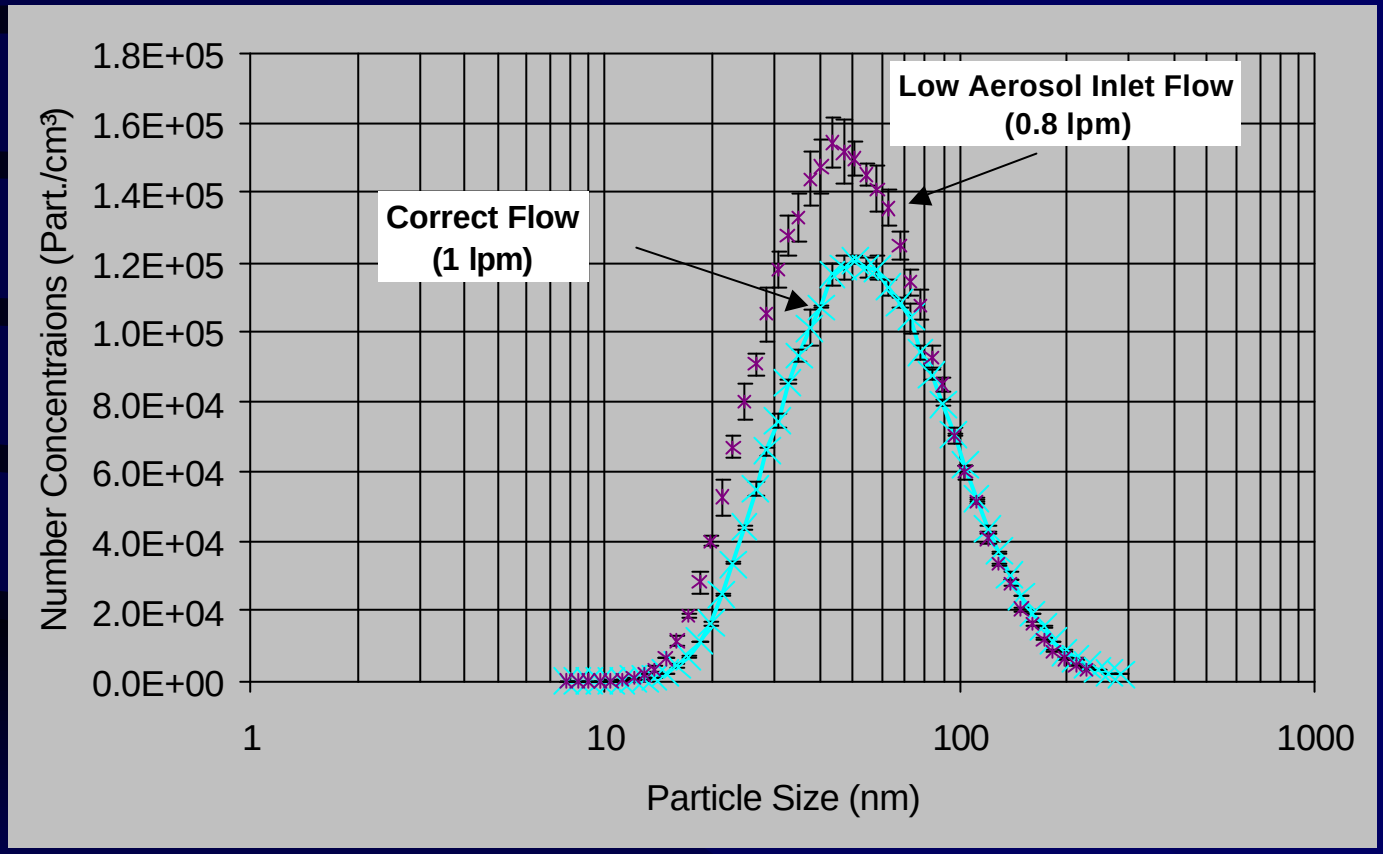
Experimental Setup



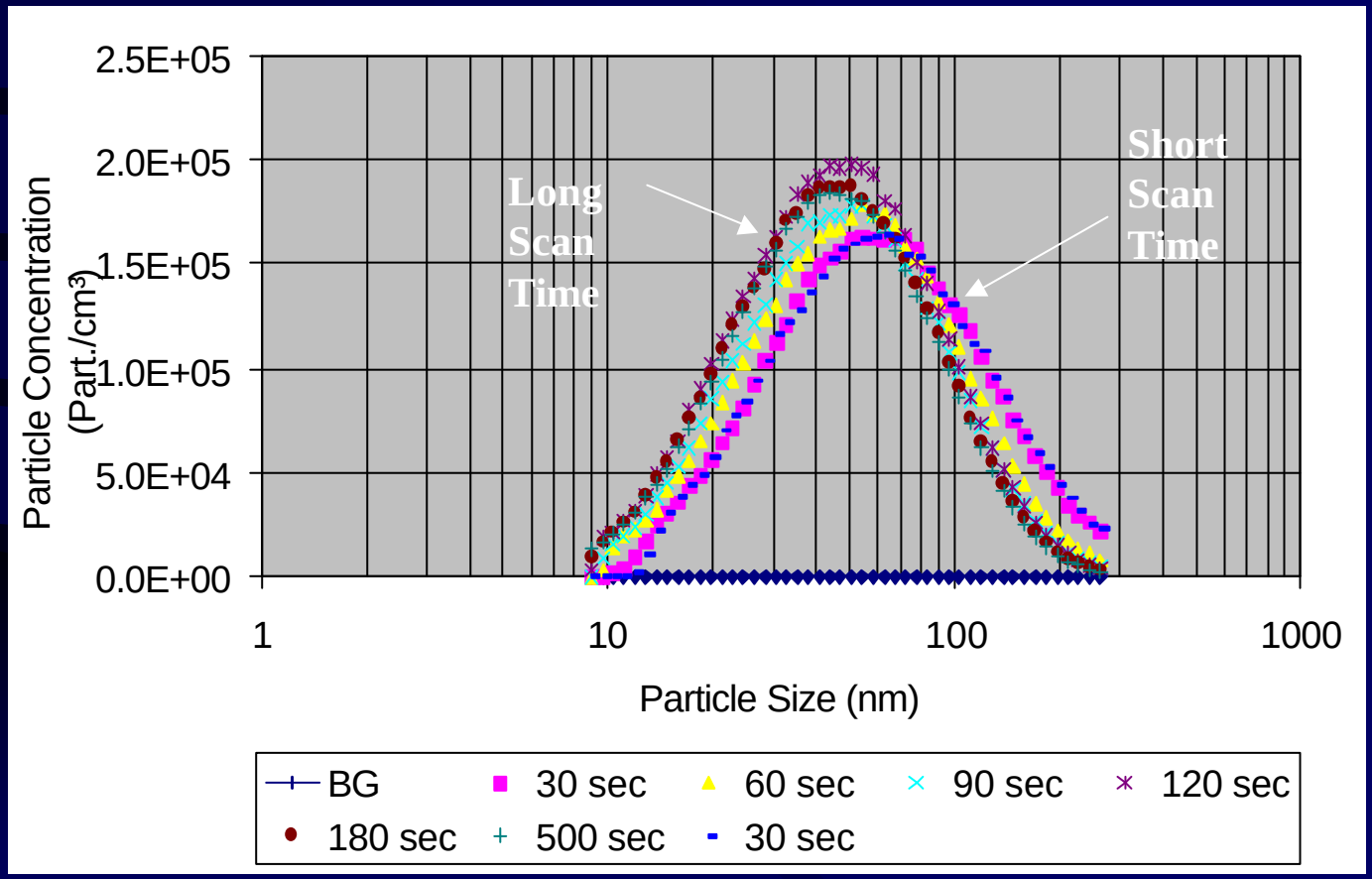
Influence of SMPS Scan Range



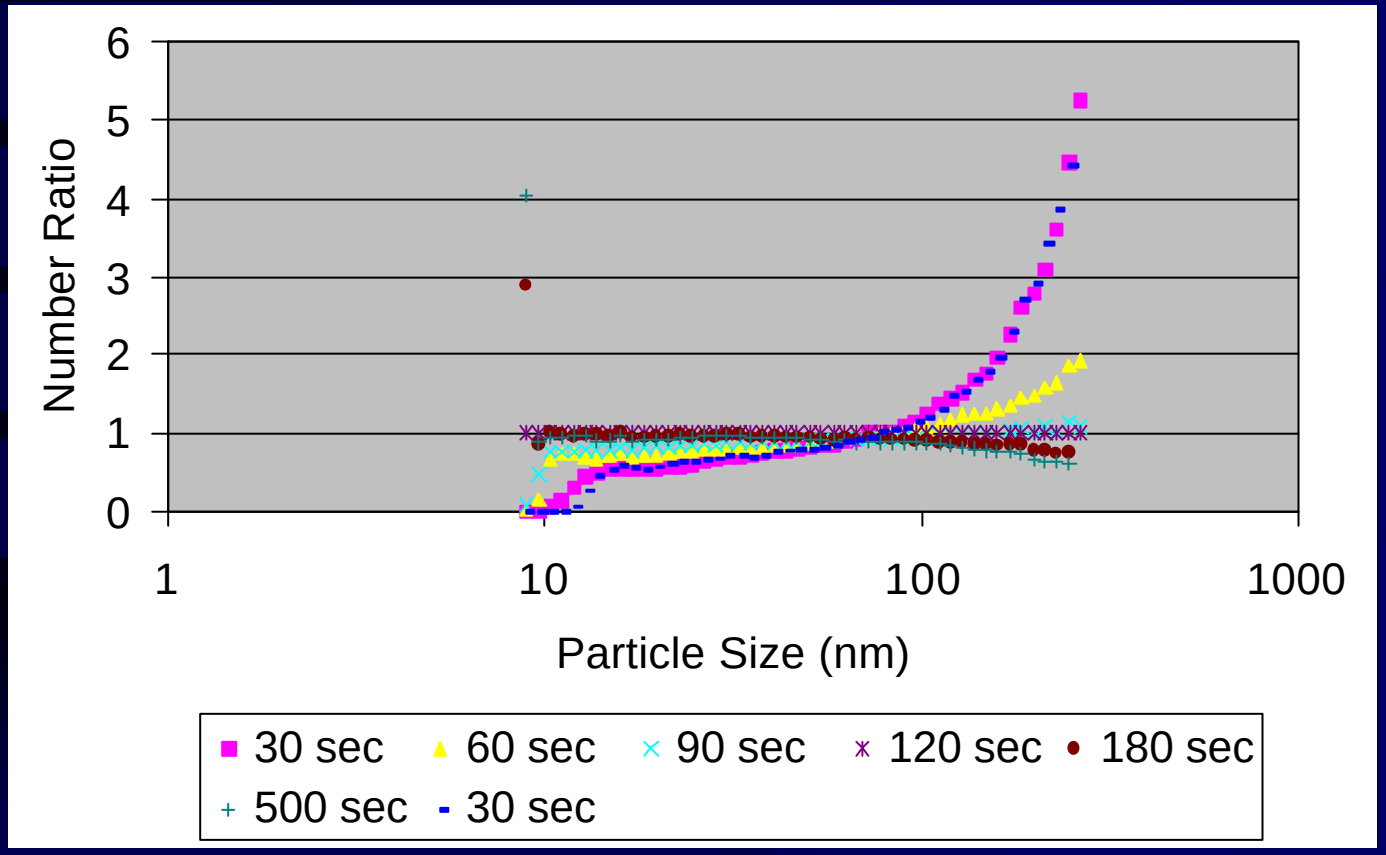
Influence of SMPS Flow Adjustment



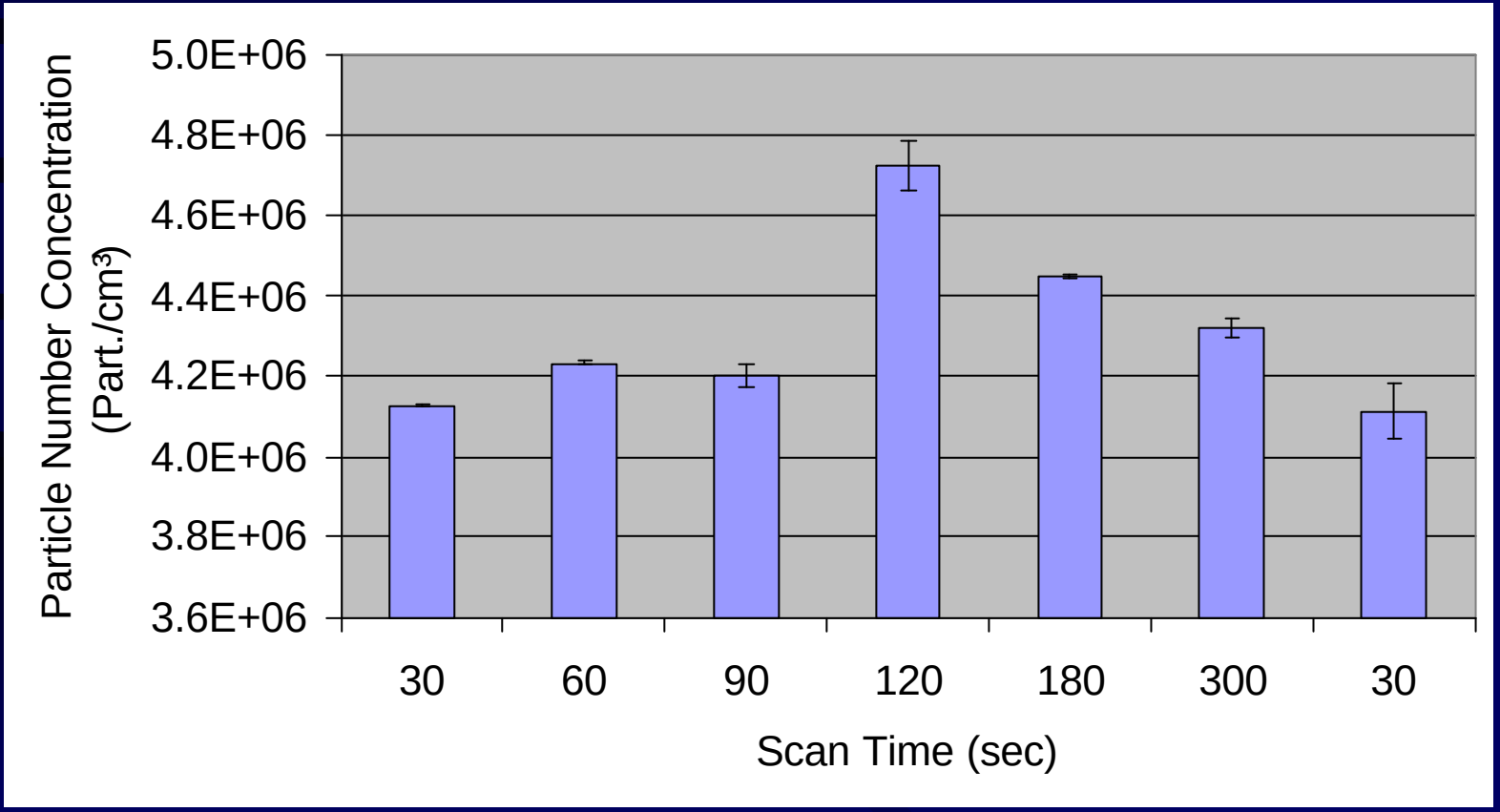
Influence of Scan Time On Size Distributions (SMPS)



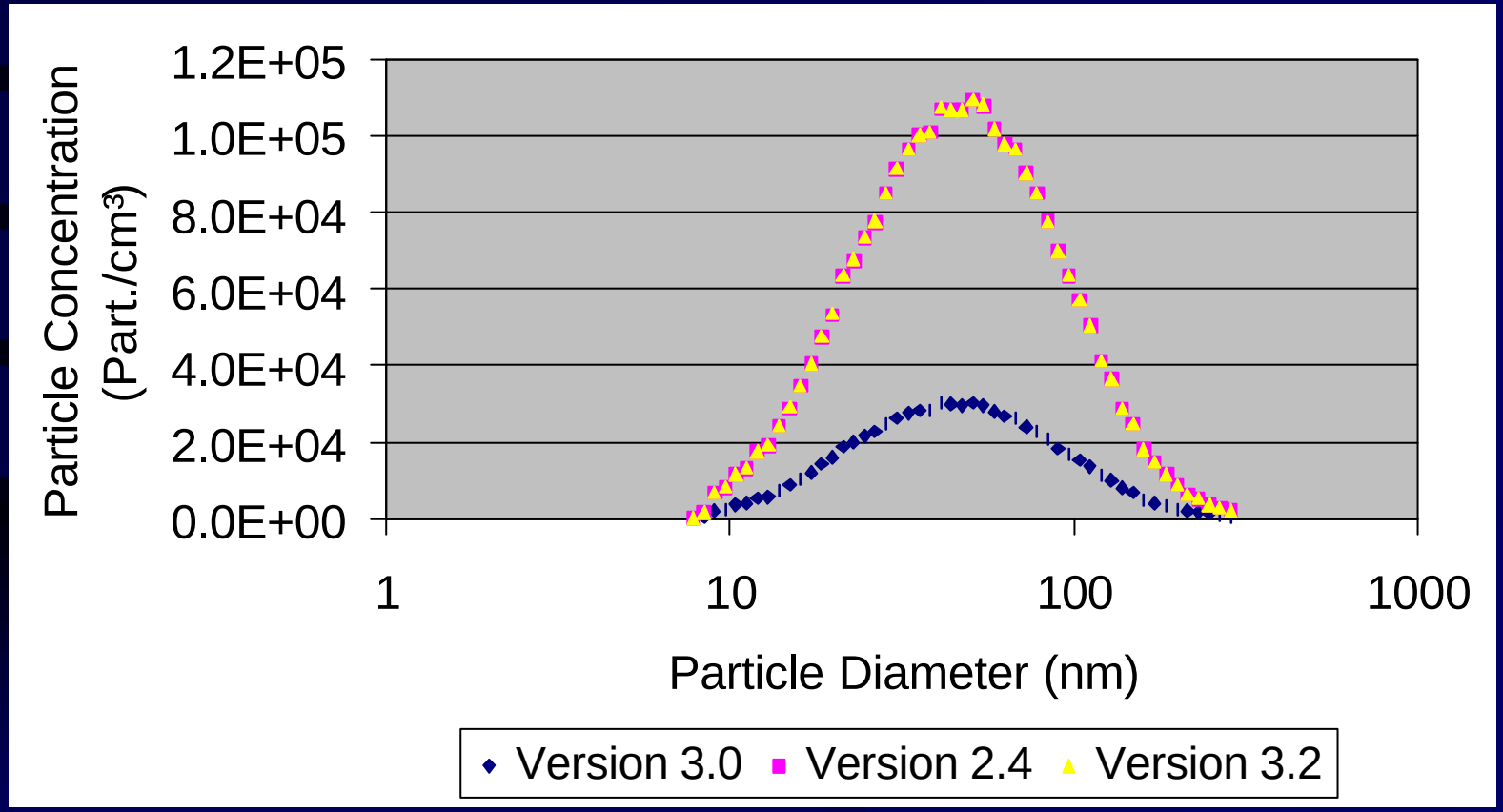
Size Based Number Ratio for Different Scan Times Relative to a Reference Scan Time of 120 Seconds



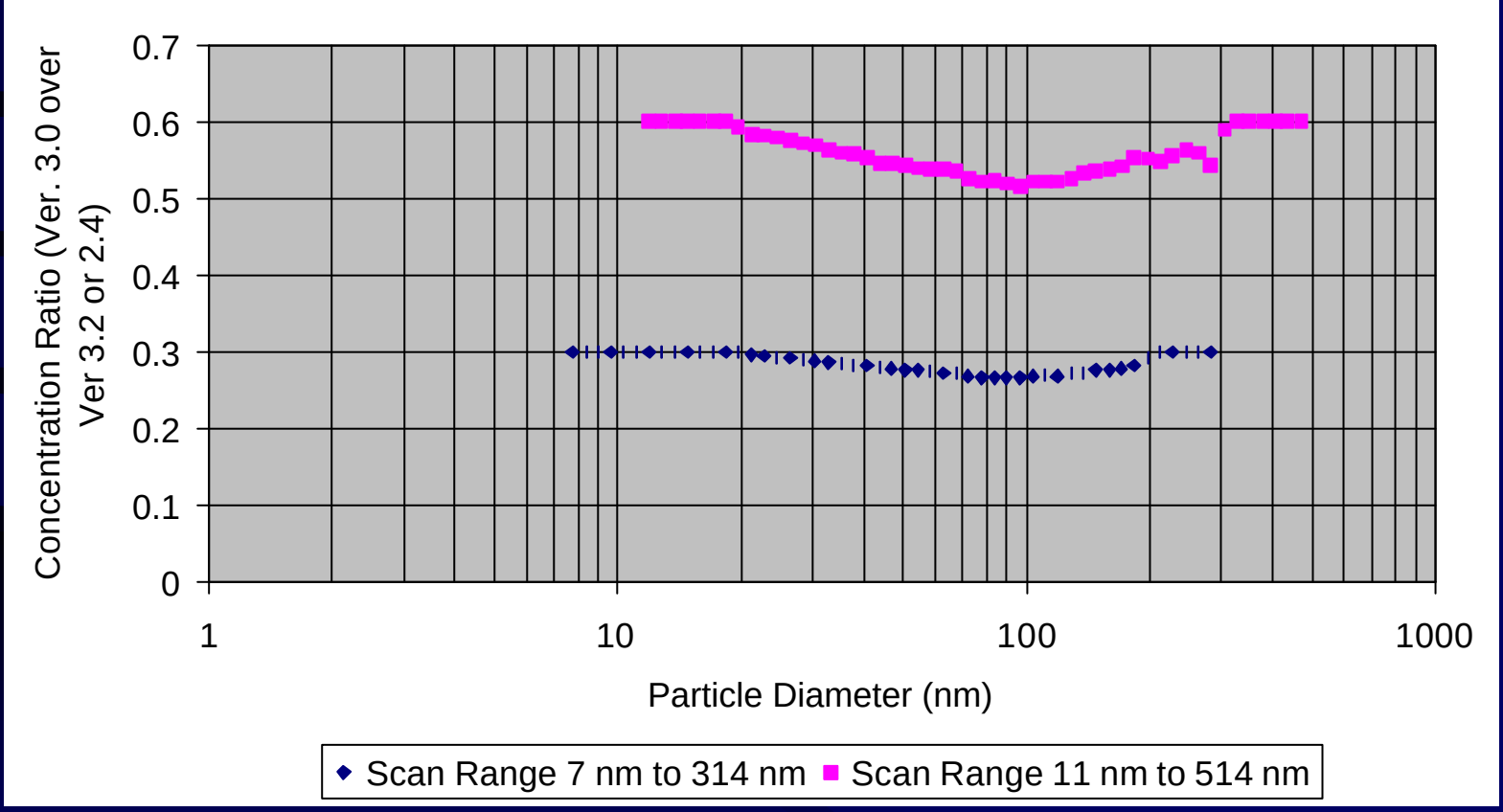
Total Number Concentration at Different Scan Times



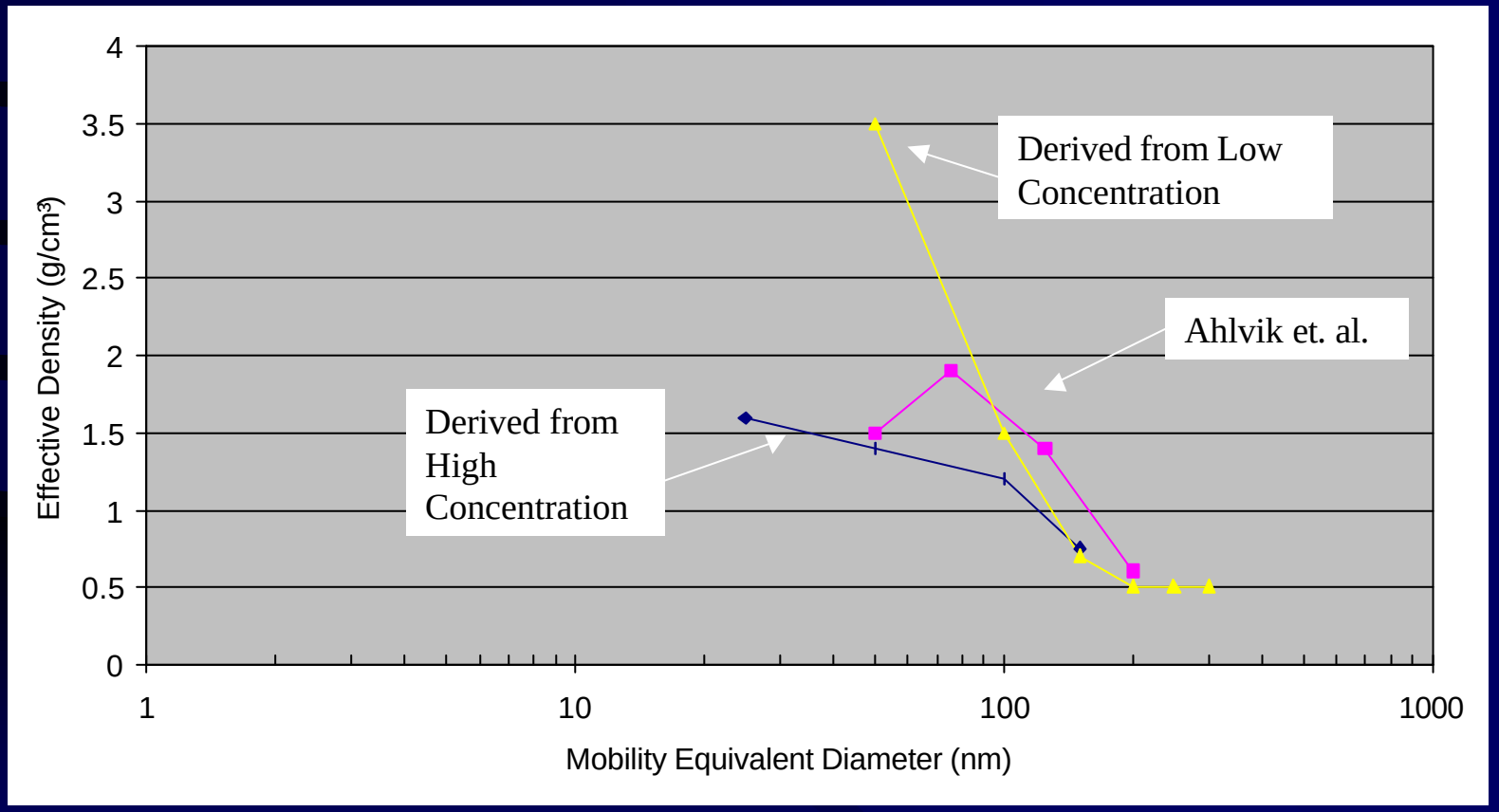
Influence of SMPS Software Particle Number



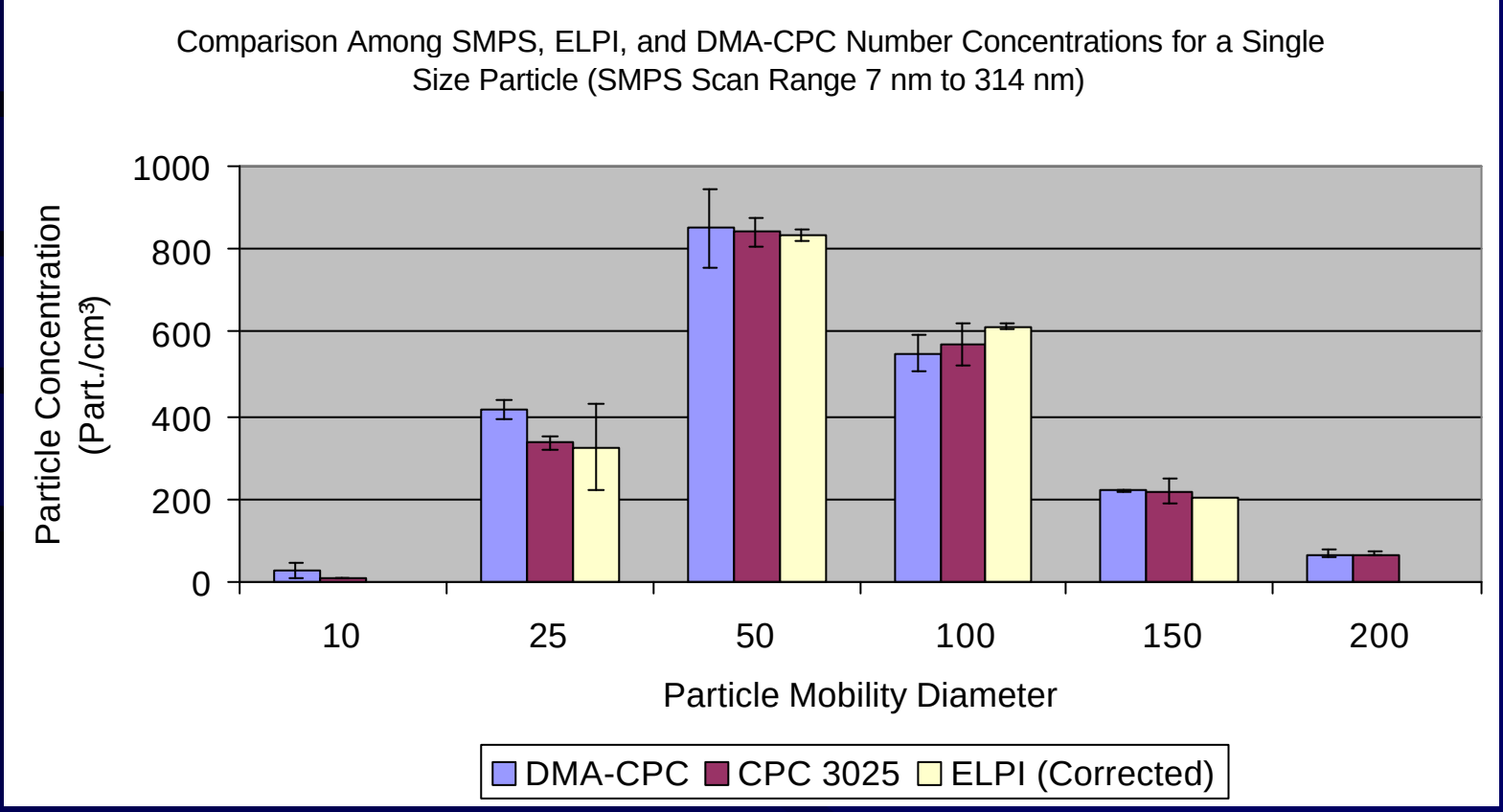
SMPS Version 3.0 Size Based Number Ratio Relative to other Versions



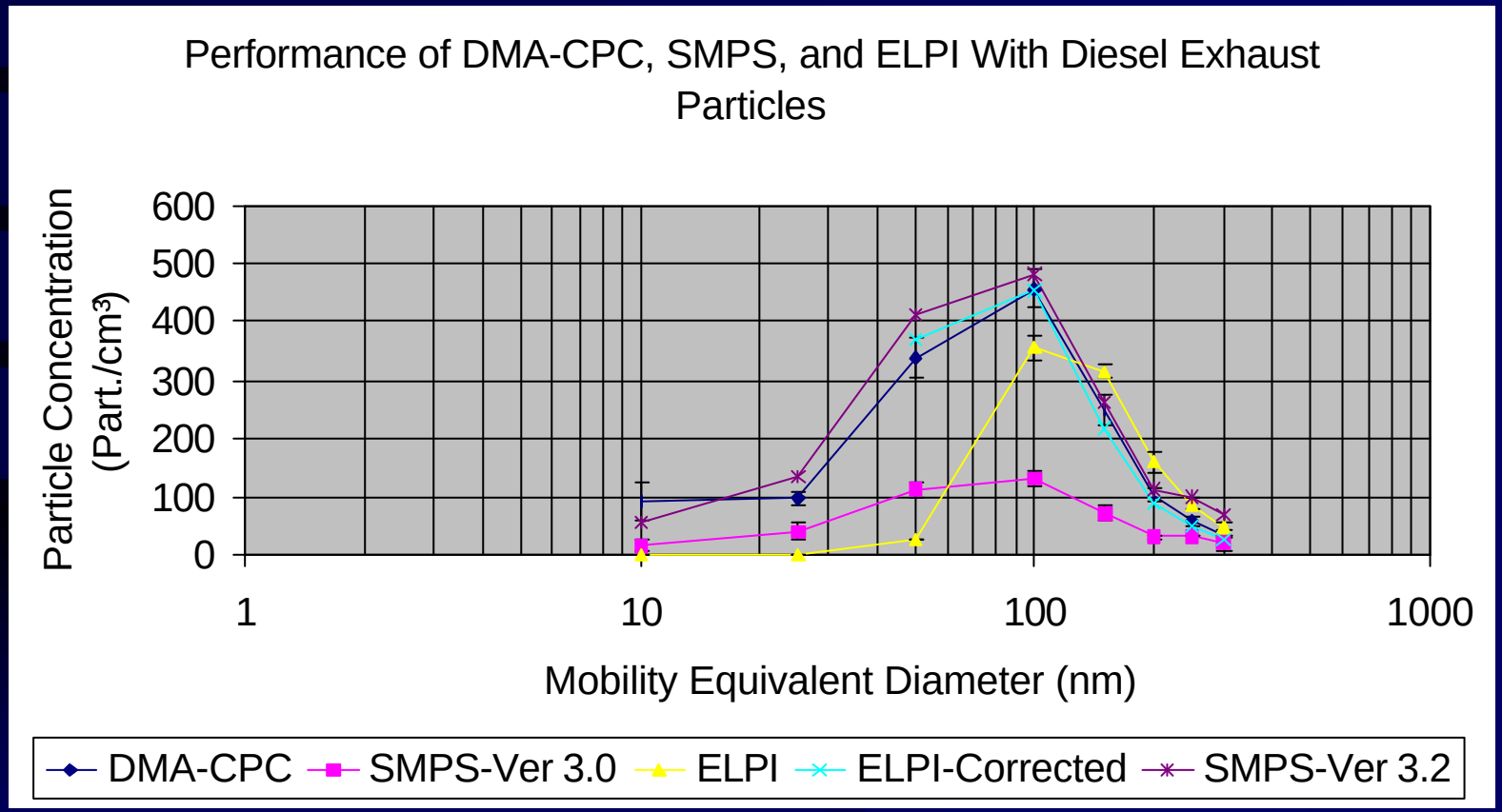
Changes in Effective Density Correction for ELPI (Sensitive to Concentration Level)



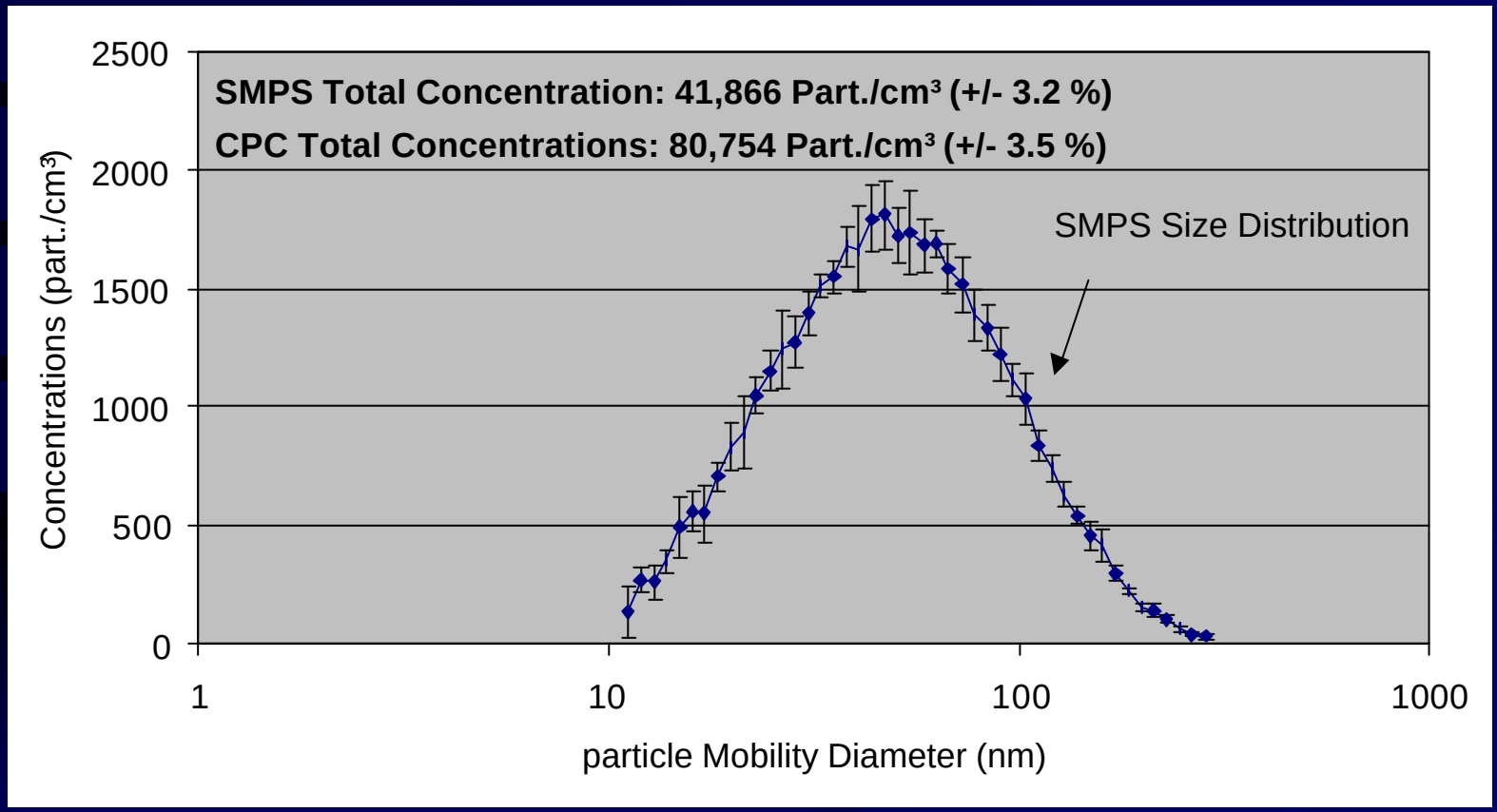
Performance of DMA-CPC, SMPS, and ELPI on Number Emissions Using Mondisperse Diesel Exhaust Particles



Size Based Comparison Among DMA-CPC, SMPS, and ELPI Using Monodisperse Diesel Exhaust



SMPS Performance with Polydisperse Diesel Exhaust particles Compared with a Direct CPC Concentration Measurement



Conclusions

- SMPS Software Version 3.0 underestimates the number concentration by a factor that depends on particle size and the scan range. This version should be replaced with Version 3.2. Version 3.2 agrees with previous version 2.4

- The SMPS performance is sensitive to scan time and scan range. This information should be reported when data are presented. Perhaps a selected scan time and range should be universally applied for consistency.

- The ELPI requires density correction in order to match the concentration of a DMA-CPC system. However, density correction variability as well as instrument sensitivity to low concentration level remains a concern.

- The number concentration of a monodisperse size measured with a CPC agrees with the number concentrations measured with an SMPS. However, the SMPS underestimates the number concentration of a polydisperse aerosol when compared with a CPC. This issue needs further investigation.

Remarks

- This work highlights the need for a well defined protocol on instrument calibration and performance to assure repeatable and accurate particle size distribution measurement. This is in addition to the need for a well defined protocol on particle sampling and dilution.

Acknowledgements

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