Making Mobile Measurements Using an EEPS™ Spectrometer

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Outline

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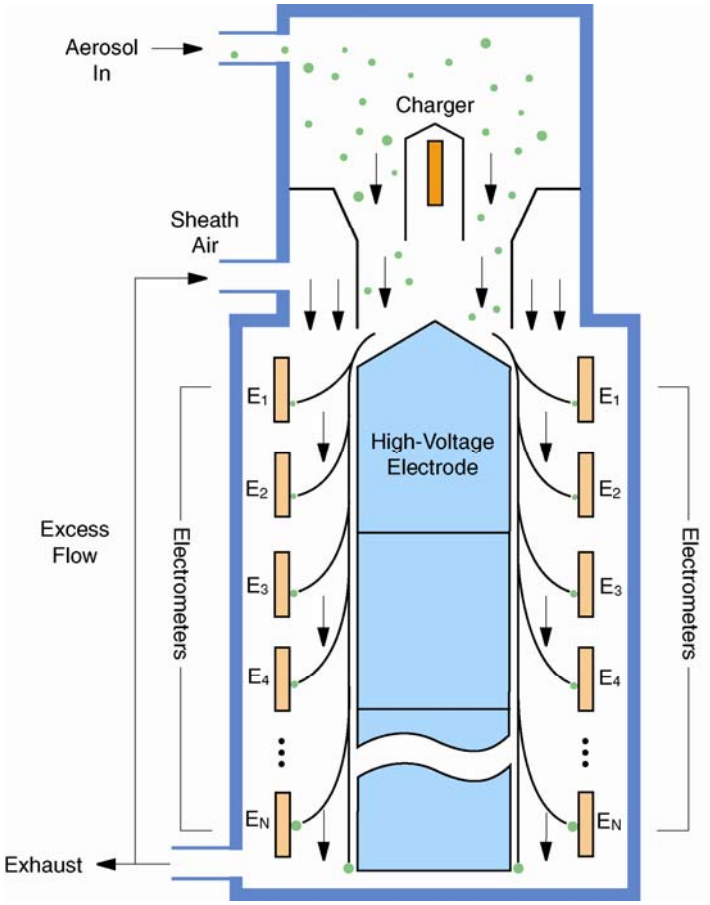
Mobile Measurements with EEPS™?

- Mobile Measurements
  - Dynamometer versus On-Road labs (size distributions and number concentrations)
  - On-Road measurements are transient and sizing with other methods (such as SMPS™ spectrometer) require stable distributions
  - The EEPS™ spectrometer is designed for the measurement of transient aerosols
- Vibration creates special problems for EEPS™ technology
- Proof of Concept testing was done to determine if the EEPS™ spectrometer can be used

How the 3090 EEPS™ works

- It uses a diffusion charger to create Ions which charge the particles
- Particles mix with the ions and produce a predictable charge level versus particle size
- Particles are surrounded by sheath flow and flow down between a central rod and outer cylinder
- A high voltage on the central rod creates an electric field which repels the particles outward from a central column.
- Charged aerosol particles are detected on a column of electrometers



Problem with vibration

Movement between the Electrometer rings and High-Voltage Electrode creates currents which adds to the noise level

Testing was done to quantify the noise and determine if the EEPS™ instrument could possibly be used for mobile measurements

Test Vehicle

Toyota Sienna minivan was used as the test vehicle

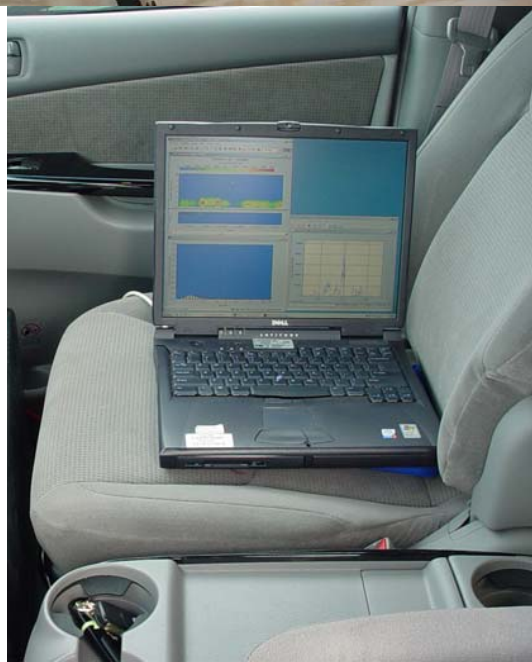
Modifications included the following

- Power was supplied using the power inverter
- Replace back seat with plywood platform to secure instruments
- Conductive sampling probe on the roof rack and back window open

Test Setup

The following equipment was used in the experiment.

- TSI model 3090 EEPS™ (Engine Exhaust Particle Sizer™)
- TSI model 3022A CPC (Condensation Particle Counter)
- A digital still camera and an analog Hi8 video camera
- Data was collected on a laptop



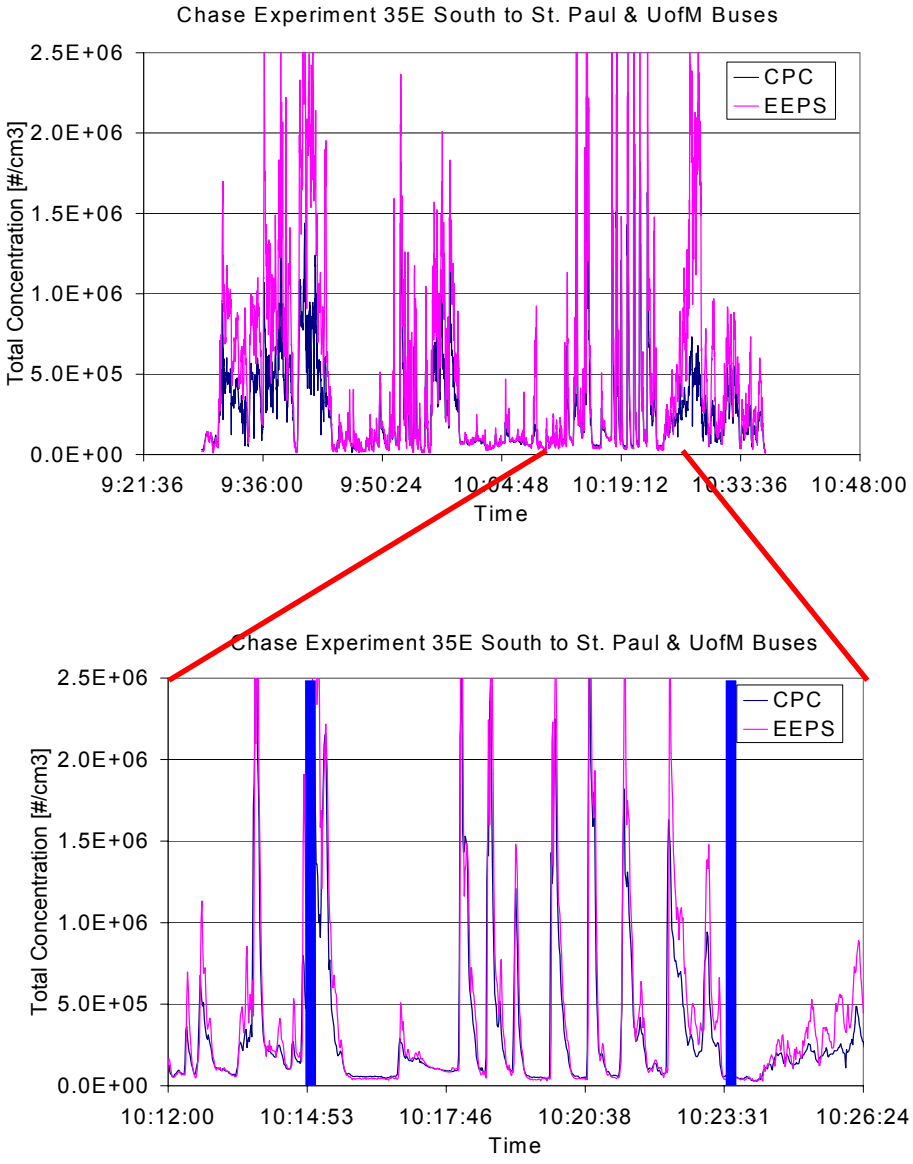
Sampling

- Conductive 12mm diameter sampling probe on the roof protruded about 50cm in front of the roofline to sample undisturbed aerosol samples
- Flexible conductive tubing allowed aerosol to be sampled through an open back window
- Aerosol flow is split and directed into the instruments
- Particle burst events were correlated using the Video camera with a time stamp on each frame
- A digital still camera recorded traffic conditions through the front window of the van
- Baseline levels of noise were measured by switching a HEPA filter into the sampling line while operating the vehicle over a bumpy road

Test Results

On Road testing was done by driving on some of the freeways in the Minneapolis/St. Paul area as well as driving around the University of Minnesota Campus. The driver attempted to get behind some large diesel vehicles such as those shown below.

Concentration comparison to CPC



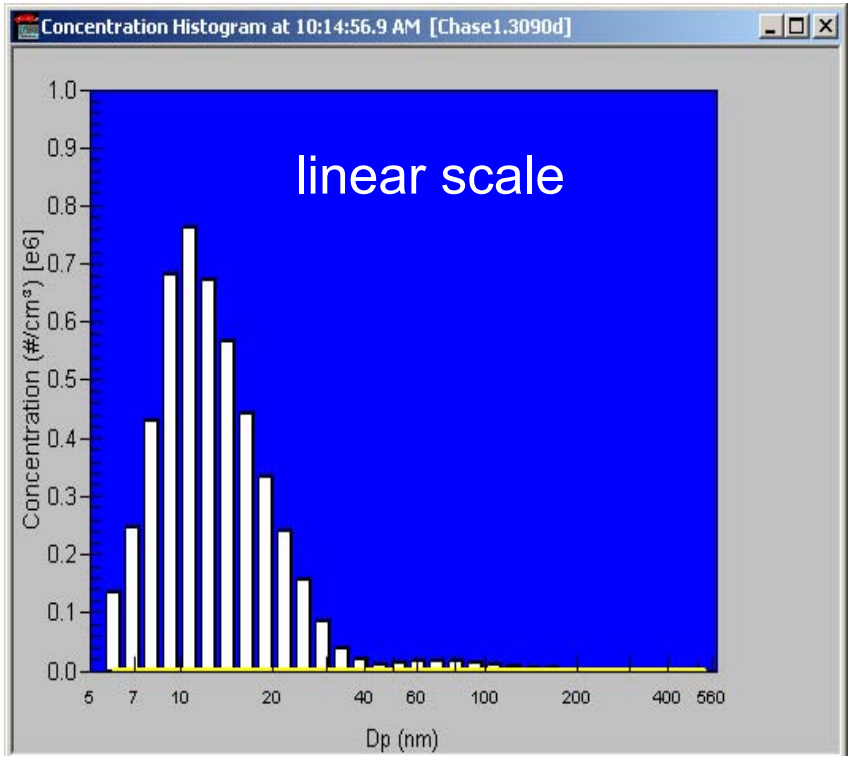
EEPS™ and CPC compared

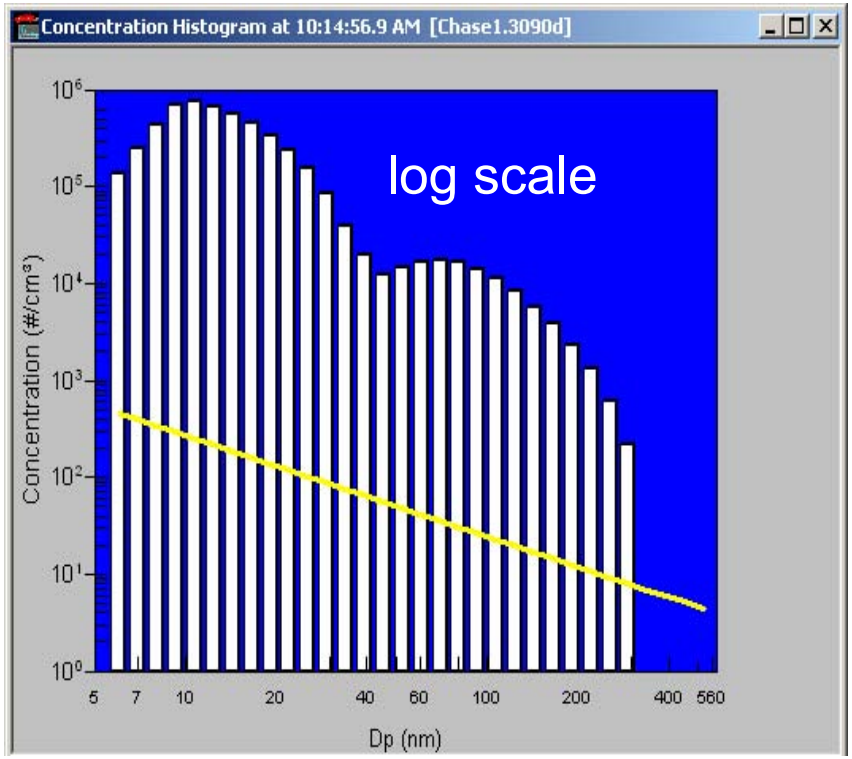
Top figure shows long term results and bottom figure shows an enlarged portion of the drive

- The slower response time of the 3022A CPC results in peaks that do not go as high as the EEPS™
- The 3022A CPC also doesn't detect particles as small as the EEPS™ which results in lower concentrations

EEPS™ Data from Diesel Plume

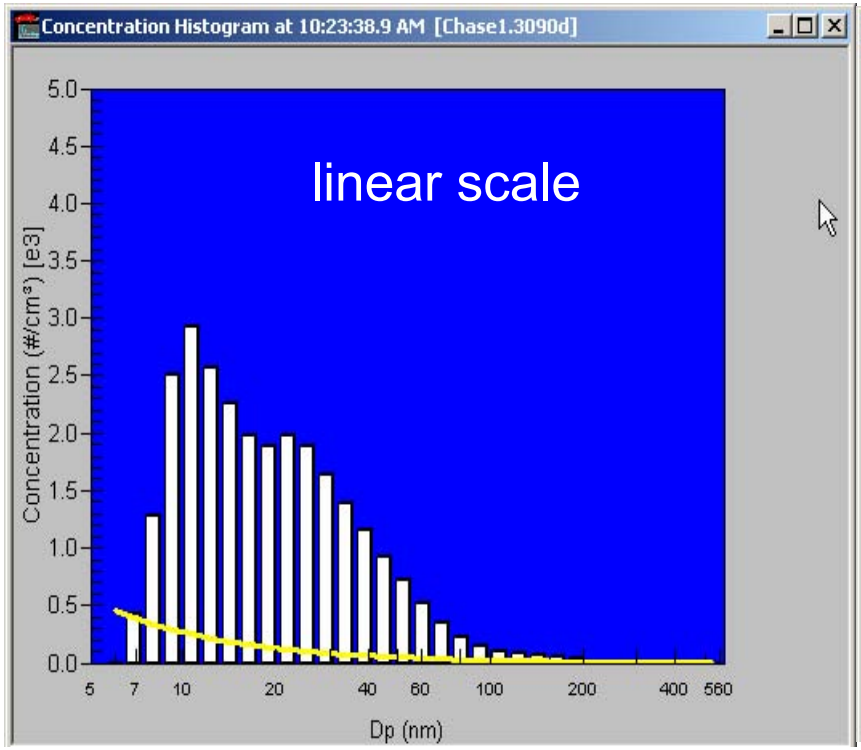
- The yellow line (on graphs) shows the typical RMS noise level for the EEPS™ (under laboratory conditions)
- The time at the top of the graphs indicates when the data was taken
- Data was taken with 0.1 second averaging on the EEPS™

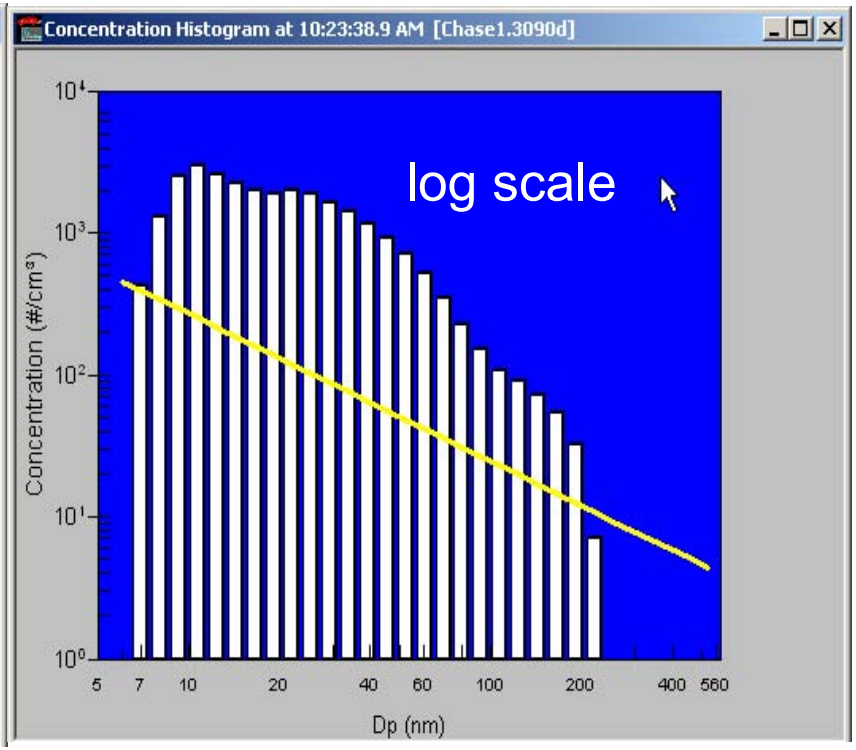




Data from Highway Background

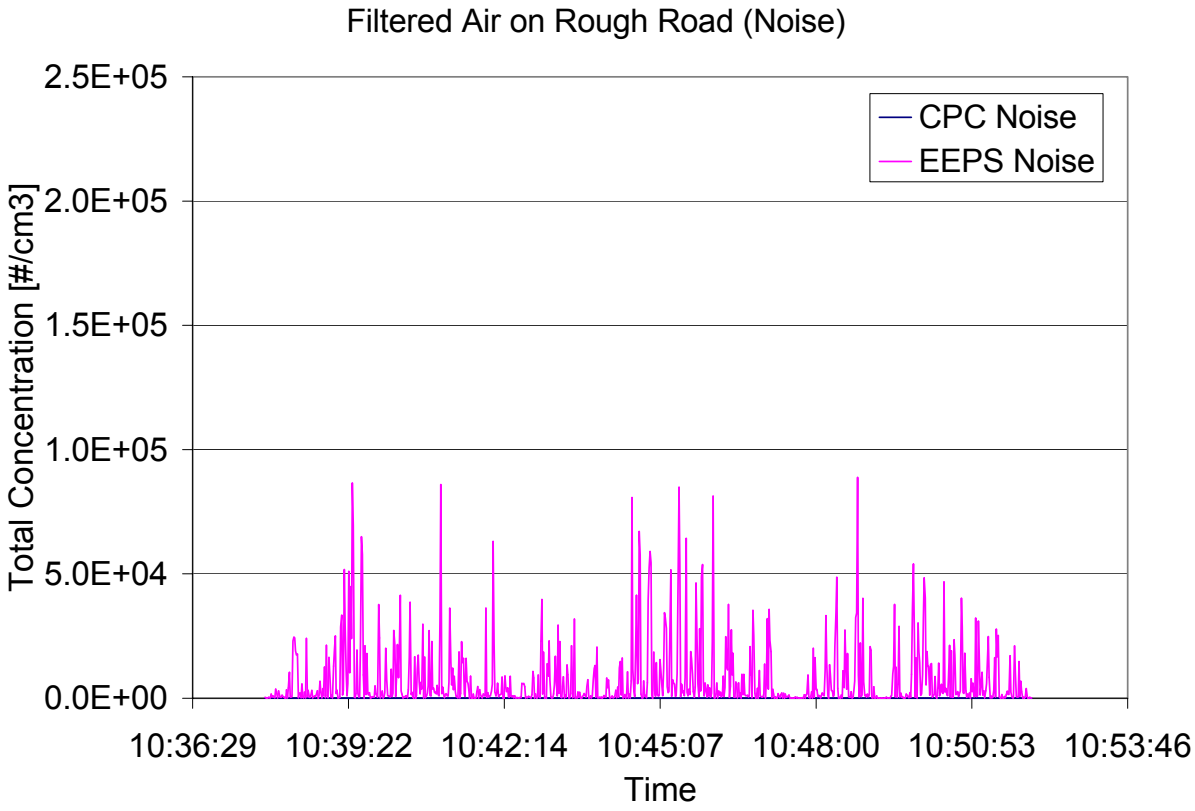
- Signal is much closer to the noise level it is still significantly above the noise level
- This data was also taken with 0.1 second averaging with the EEPS™





Measuring Baseline Noise – On Road

- Baseline noise levels were measured by collecting data with filtered air entering the EEPS™ while operating the vehicle on a bumpy road (Right wheels off onto shoulder)

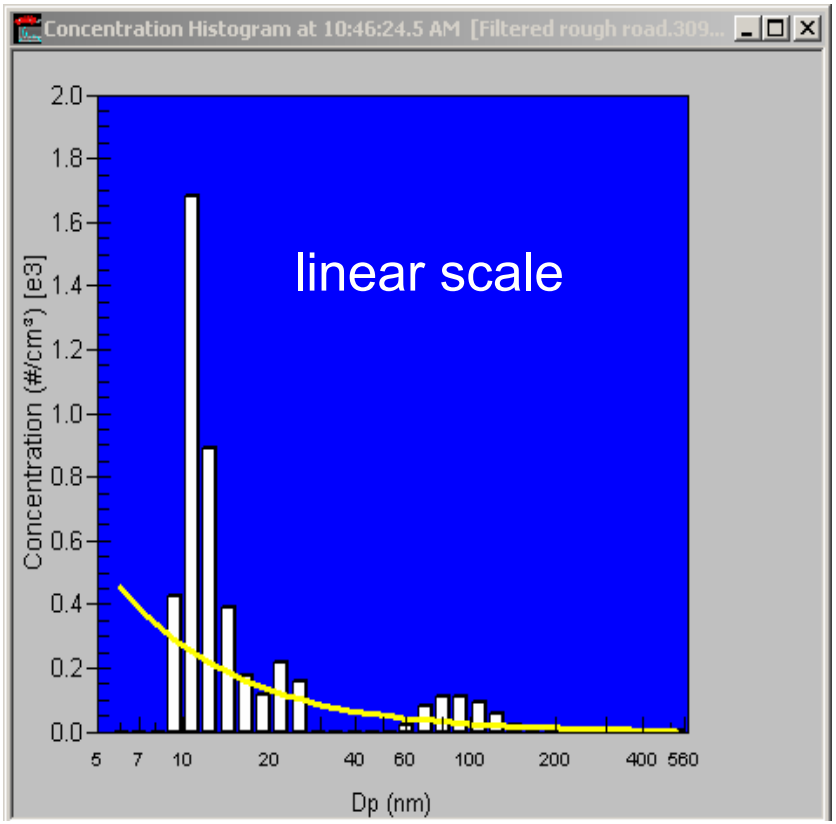


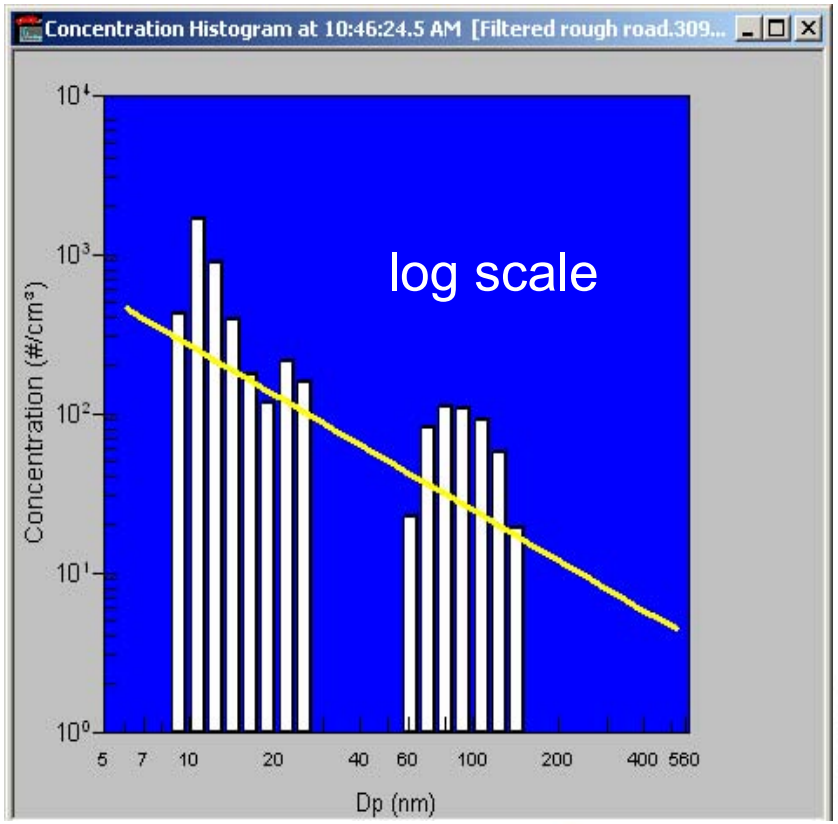
Baseline Noise Results On Road

- Results showed that although the baseline RMS noise for bumpy road conditions is considerably higher the bench top levels
- Sufficient signal to noise to clearly show urban highway background above noise
- The RMS noise on road was approximately 3 times that of the same instrument in the laboratory
- The average on road signal was approximately 50 times the on road noise level. This gives us sufficient signal to noise for this urban roadway example

Example of On Road Noise

- Typical noise size distribution results during the On Road baseline readings
- This data was also taken with 0.1 second averaging with the EEPS™
- Longer averaging times would lower the noise level.





Conclusions

- Results showed that although the baseline RMS noise for bumpy road conditions is more than 3 times the bench top levels
- There is sufficient RMS signal to noise (50:1) to clearly show particle burst events from most diesel sources (examples: trucks, buses, semi-trailers)
- EEPS™ total concentration closely matched the CPC concentrations and correlated very well with particle bursts

- The data shows that the EEPS™ Spectrometer should prove to be a valuable tool for mobile on-road chase experiments and other mobile measurements in urban environments
- Away from urban sources the background may not be sufficiently high to be seen above the higher noise level that occurs due to the vibration
- Other mobile measurements have since been tried successfully

Thank You!

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