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Real time measurement of combustion aerosol size distribution

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Acknowledgements:

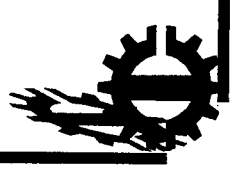
- Mikko Moisio, TUT Aerosol Physics
- Technology Development Centre of Finland, SIHTI2 Research Program
- Technical Research Centre (VTT) Aerosol Technology Group
- Imatran Voima Foundation

Continuous measurement of size distribution?

- Fine particles have more health related effects than their mass fraction would indicate
- Generation, collection and deposition of fine particles are size dependent
- Short time-scale emissions
- Unstable situations
- Research and development of processes, cleaning devices

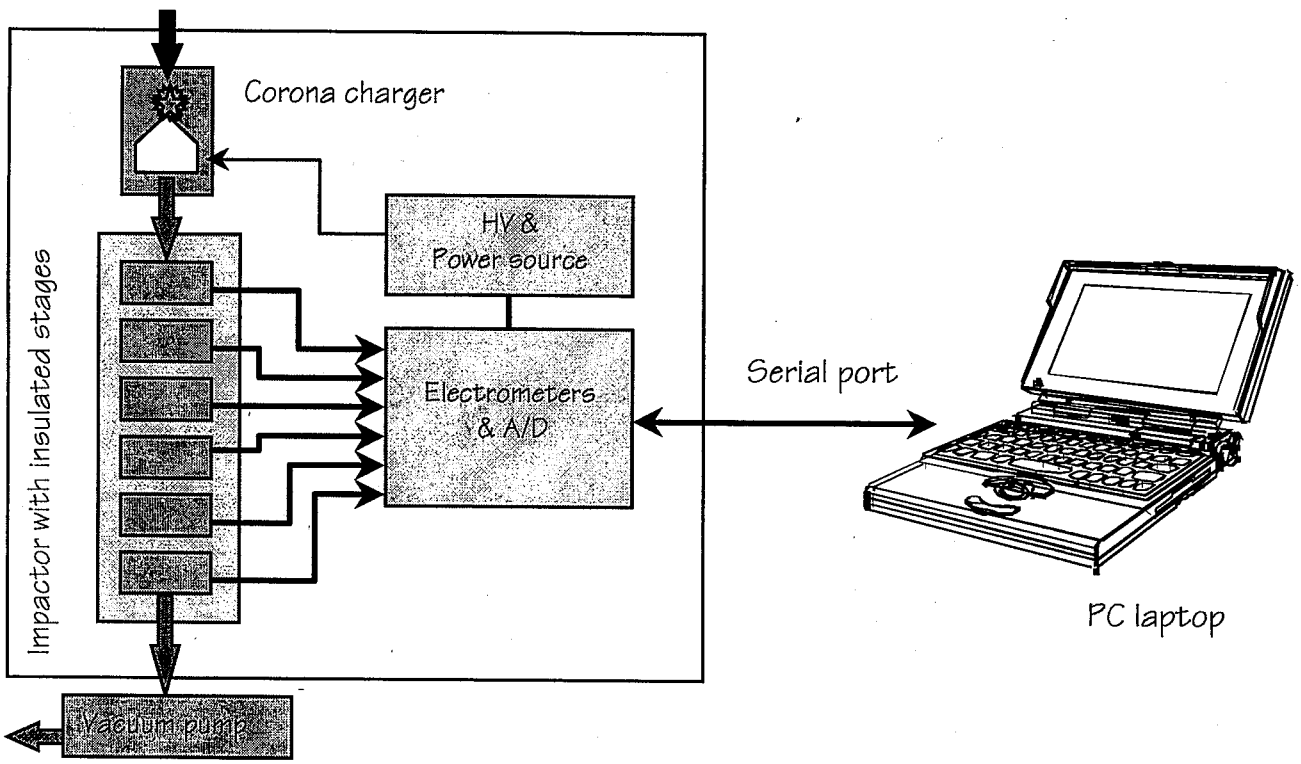
SIHTI2 -project

- Field Evaluation of new real-time instrument concept
- Evaluation and improving sampling system
- Size distribution measurements on several different power plant types
- Short time-scale emission measurement
- Long term emission monitoring evaluation



Electrical Low Pressure Impactor

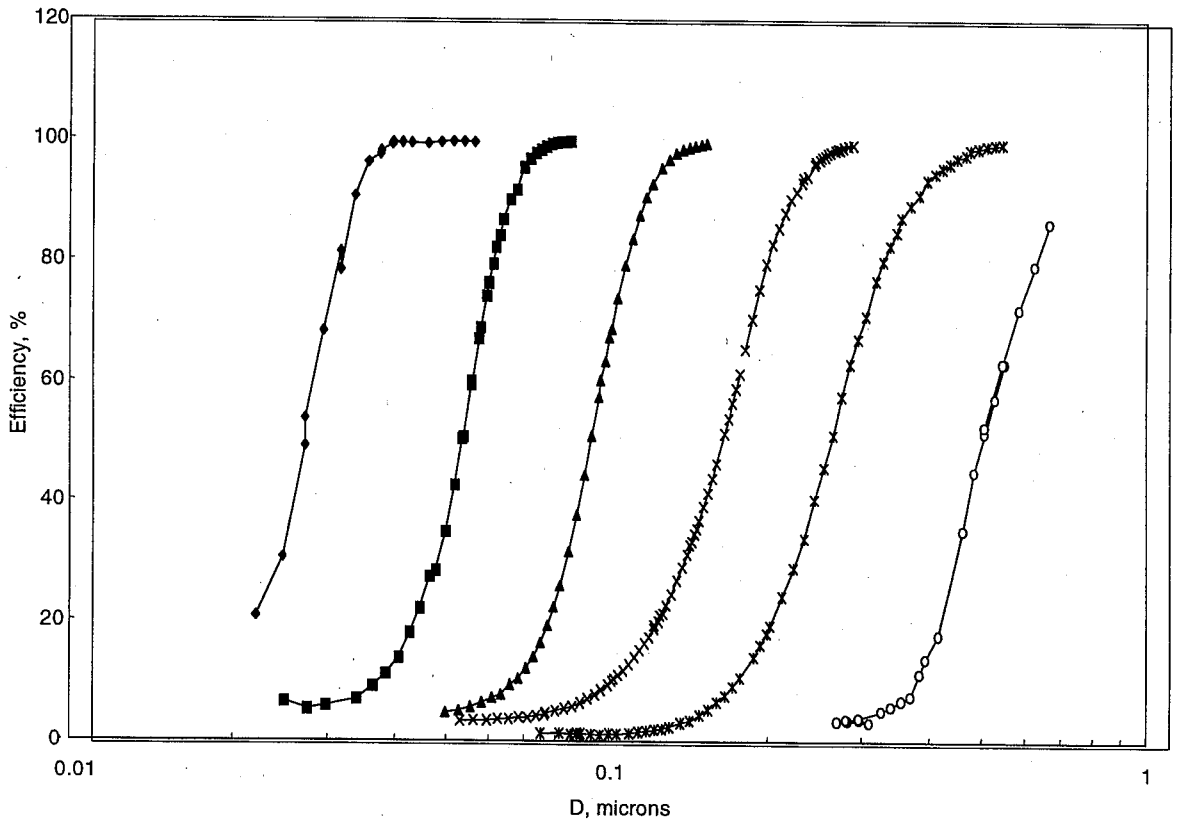
- Combines electrical detection with aerodynamic size classification



- Electrical detection
  - Real time response (~1s)
  - Good sensitivity compared to gravimetry (0.004 $\mu g/m^3$ at Dp=0.03 µm)
- Aerodynamic classification
  - Particle size distribution range 0.03 .... 10 µm

Calibration

- Example of TUT ELPI impactor calibration: Collection efficiency of submicron stages (Keskinen et al. (1997) JAS, to be published)

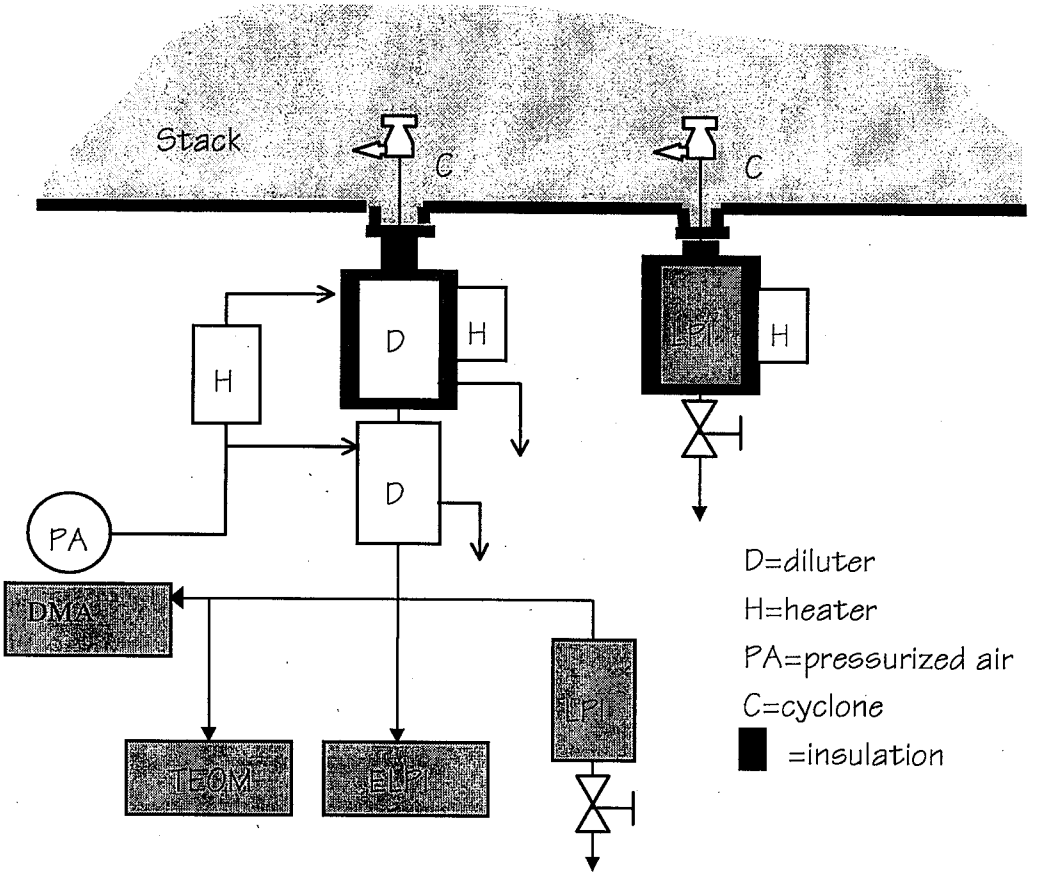


SIHTI2: measurement sites

- Pulverized coal power plants
- Mixed fuel (oil, natural gas, and peat) burners
- Kraft recovery boiler
- Lignosulfonate drying plant
- Sludge waste (paper/bio), fluidized bed
- Bark burning, circulating fluidized bed

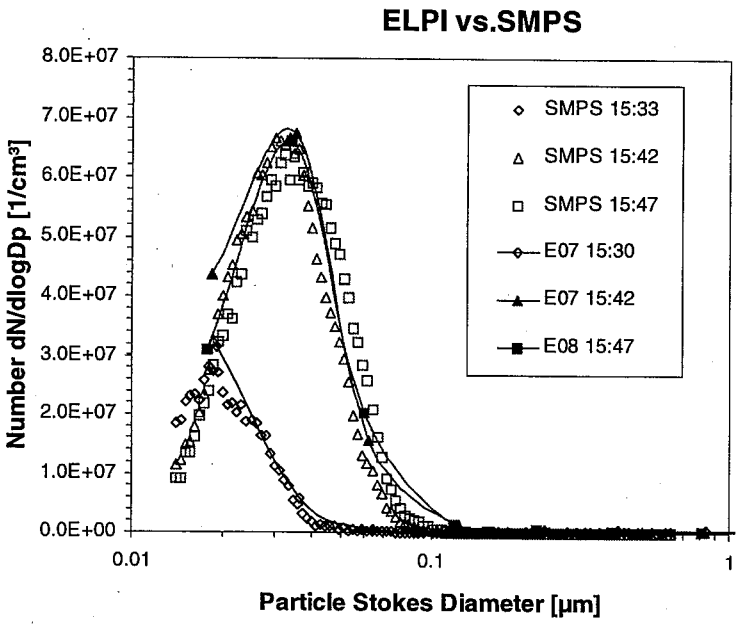
Sampling

- Dilution
  - Ejector operated dilution (ratio 1:1-100)
  - Diluters heated to stack temperature
- Isokinetic sampling
- Pre cyclone (D50%=3 µm)

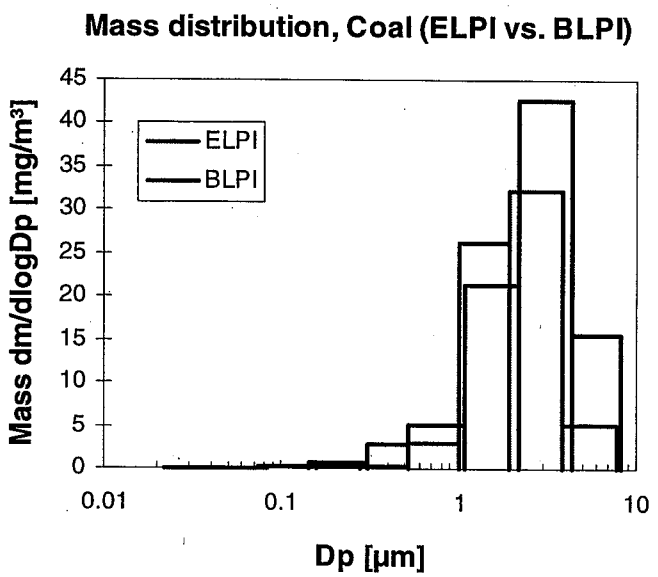


Comparison Measurements

- ELPI vs. DMA
  - sludge waste fluidized bed (data from Latva-Somppi et al., JAS 1997 (in press).

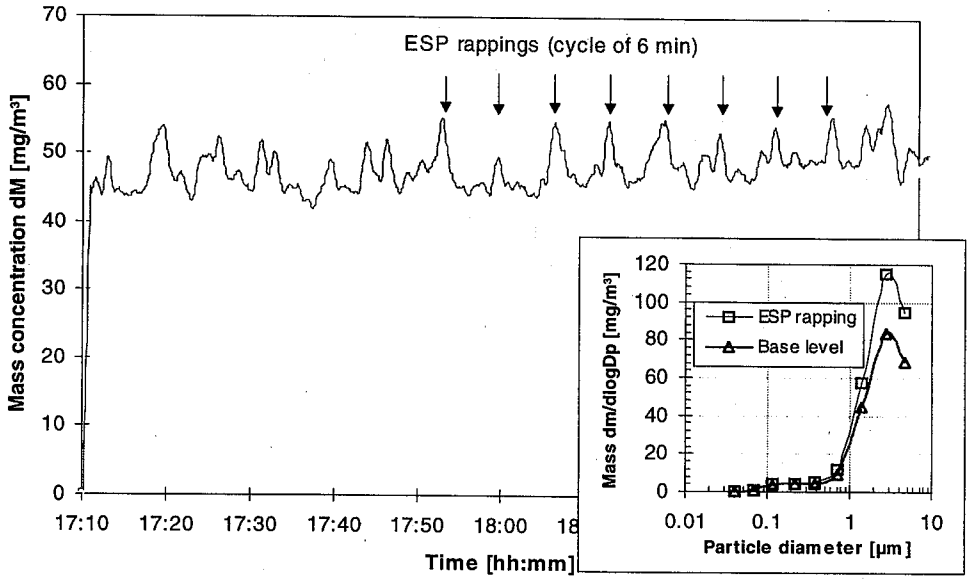


- ELPI vs. BLPI
  - Pulverized coal

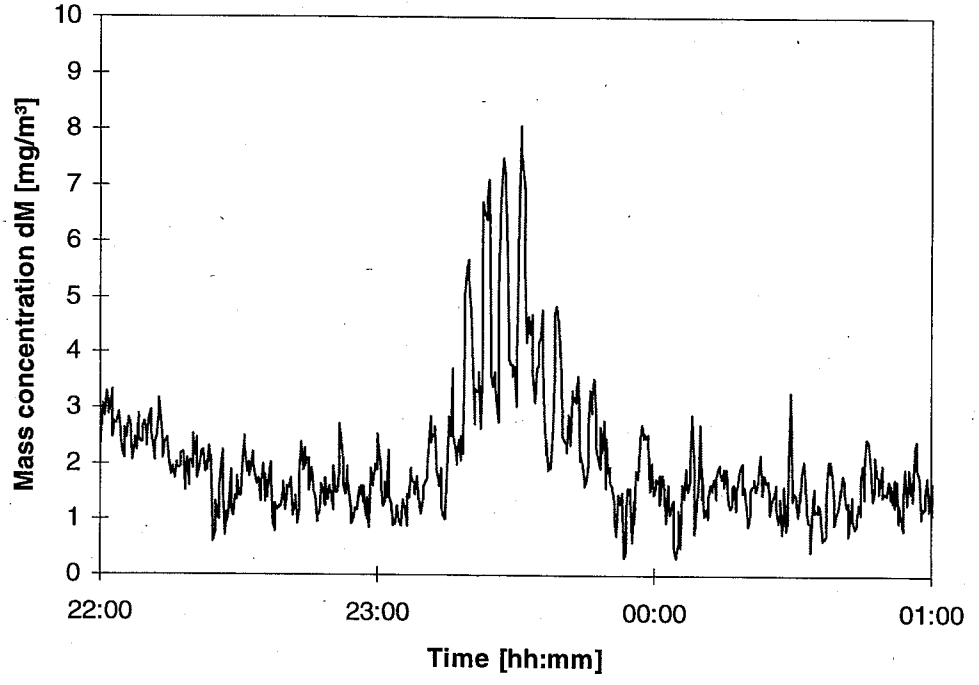


ESP rapping and soot blowing

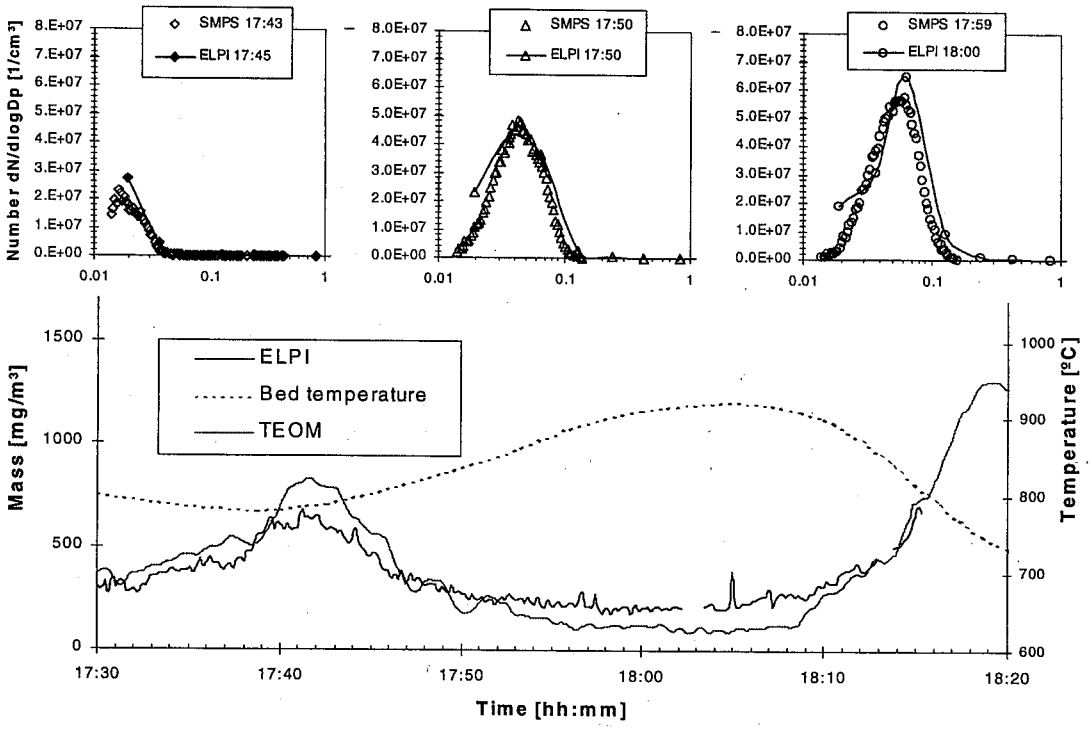
ESP rapping emission



Peat, boiler soot blowing emission



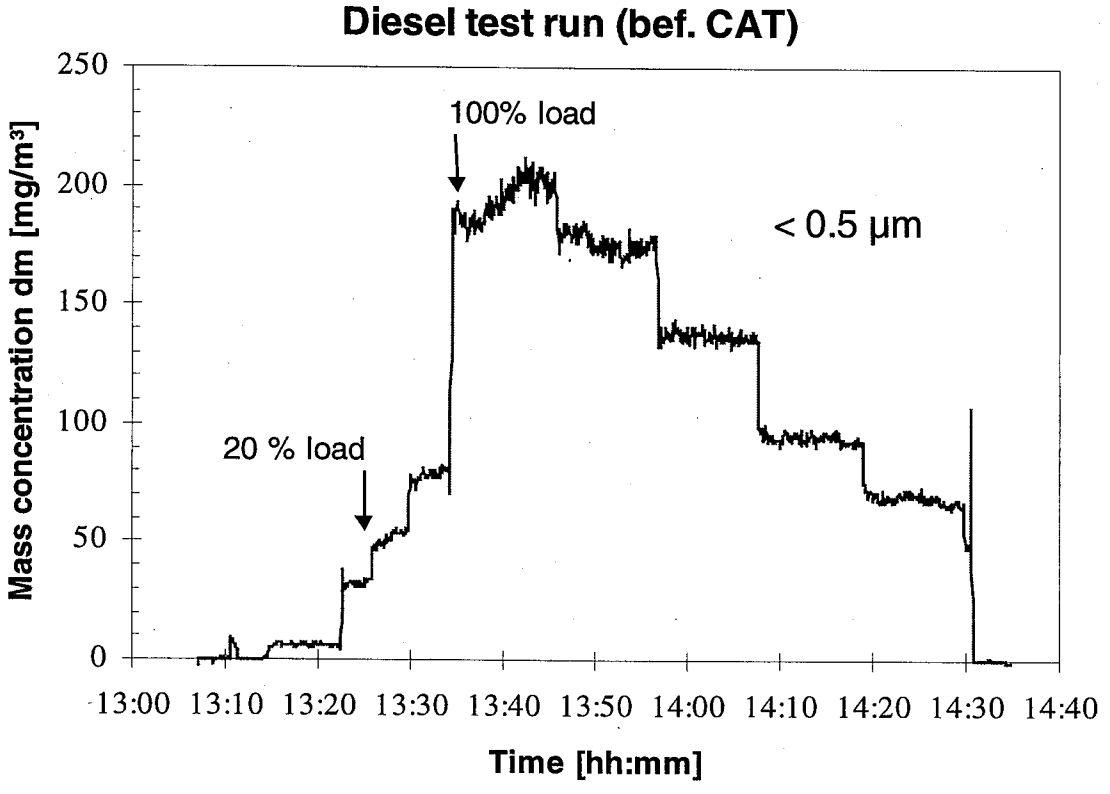
*Size distribution change in fluidized bed combustion**

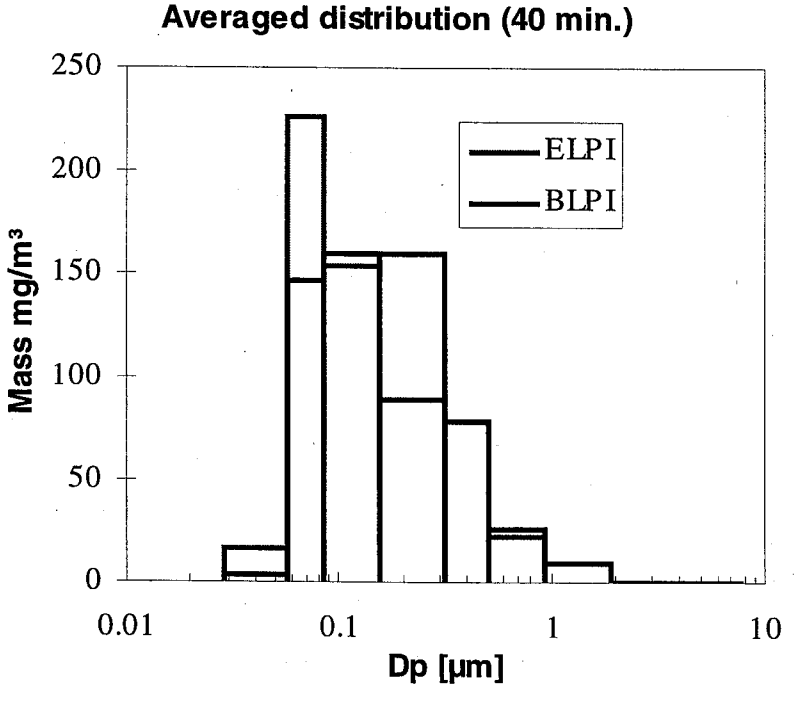


Lower figure shows the bed temperature and fly ash mass concentration (as measured by ELPI and TEOM) during sludge and bark co-firing in a BFB. Upper figures compare ELPI and SMPS number size distributions during the period shown in the lower figure. Note the change in number concentration in just five minutes.

*From: Latva-Somppi, J., Moisio, M., Kauppinen, E.I., Valmari, T., Ahonen, P., Tapper, U. and Keskinen, J. (1997) Ash Formation During Fluidized Bed Incineration of Paper Mill Waste Sludge. *J. Aerosol Sci.* (in press).

Diesel emissions





Conclusions

- Representative dilution possible below 5...10 µm, but sample conditioning critical
- SMPS needs semi-stable conditions
- LPI use requires extreme care below 100 nm
- ELPI
  - Rugged
  - LPI resolution
  - Overall correlation with TEOM, LPI, DMA good
  - Spurious mass at coarse particles, when mass distribution peaks at fine particles: correction algorithm or size restriction
  - Reading dependent on particle density
  - Time resolution useful in R&D work
  - Transient capability for vehicle emission measurement

Vehicle emission application

- Time resolution now 2-5 s
- Possibilities for full transient capability
- Coarse particle size limited to 0.5...2 microns
- Lowest particle size now 30 nm
- Reading depends on particle density