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**Real time measurement of
combustion aerosol size distribution**



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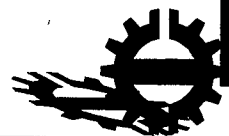
Acknowledgements:

- ◆ 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



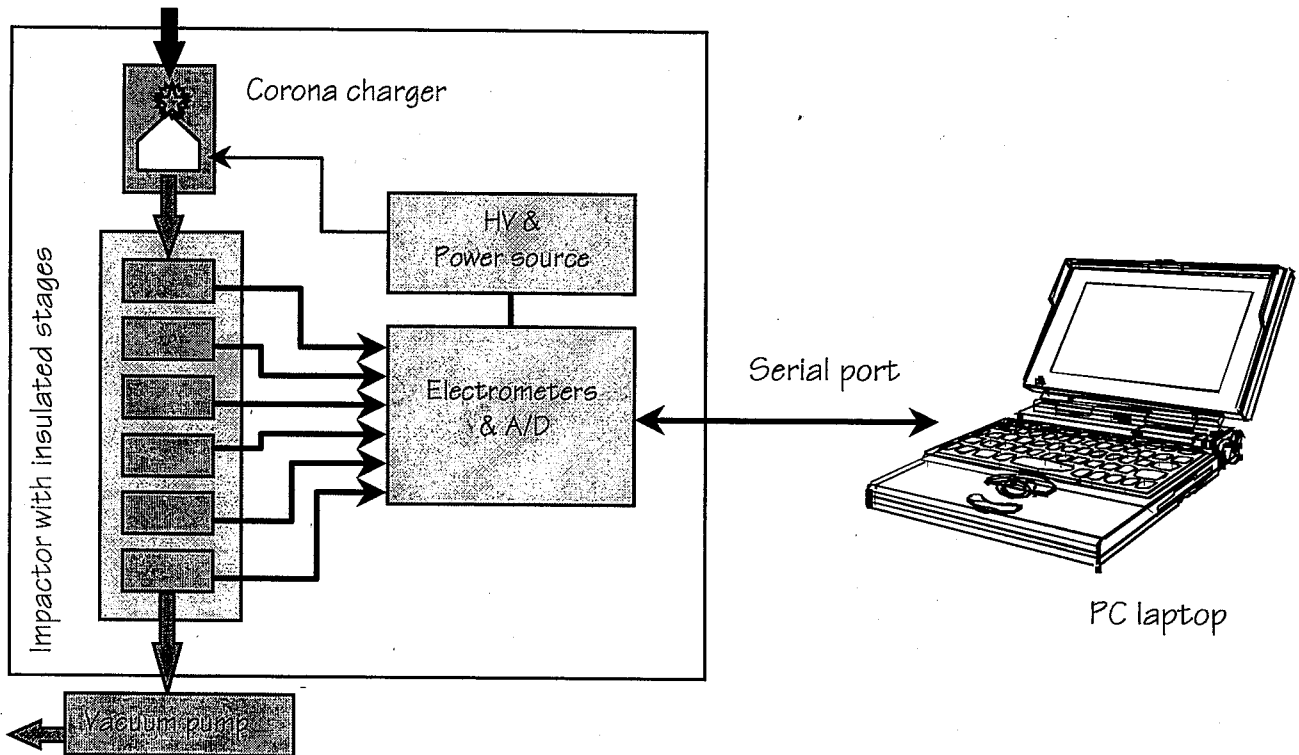
SIHTI2 -project

- ◆ 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

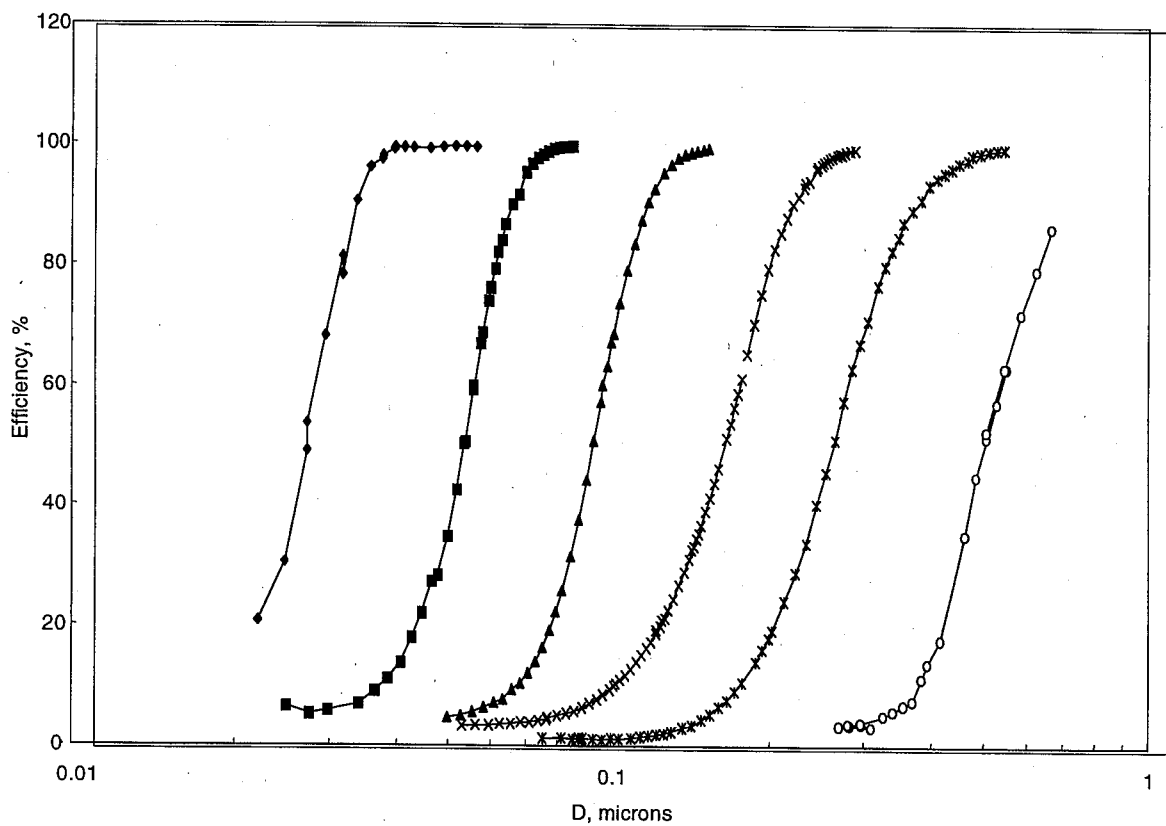


- ◆ **Electrical detection**
 - Real time response ($\sim 1s$)
 - Good sensitivity compared to gravimetry ($0.004 \mu g/m^3$ at $D_p = 0.03 \mu m$)
- ◆ **Aerodynamic classification**
 - Particle size distribution range $0.03 \dots 10 \mu m$



Calibration

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



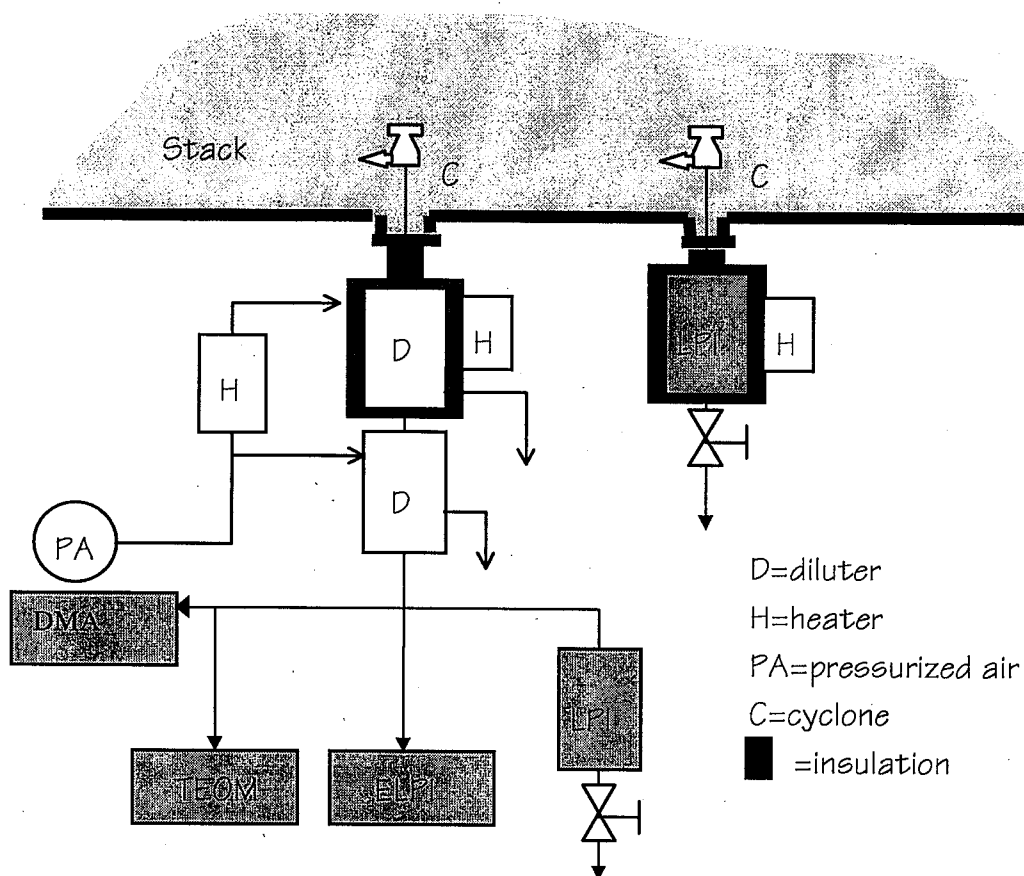
SIHTI2: measurement sites

- ◆ 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

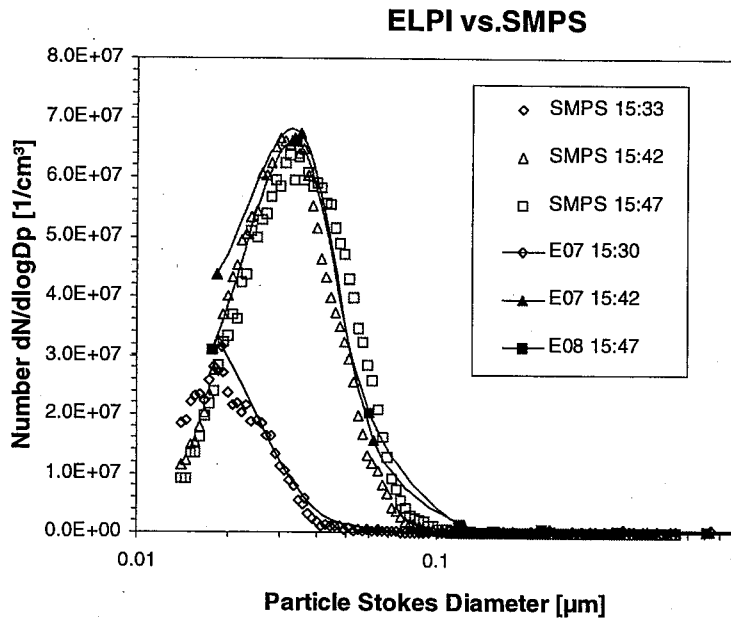
- ◆ Dilution
 - Ejector operated dilution (ratio 1:1-100)
 - Diluters heated to stack temperature
- ◆ Isokinetic sampling
- ◆ Pre cyclone ($D_{50\%}=3\ \mu\text{m}$)



Comparison Measurements

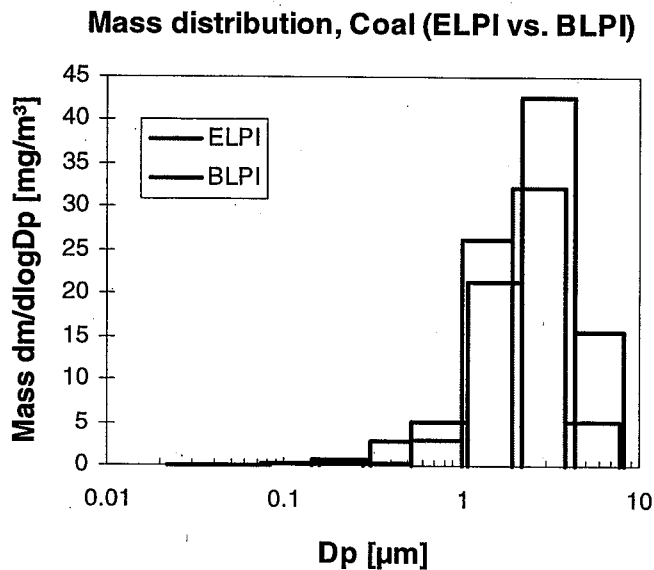
◆ ELPI vs. DMA

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



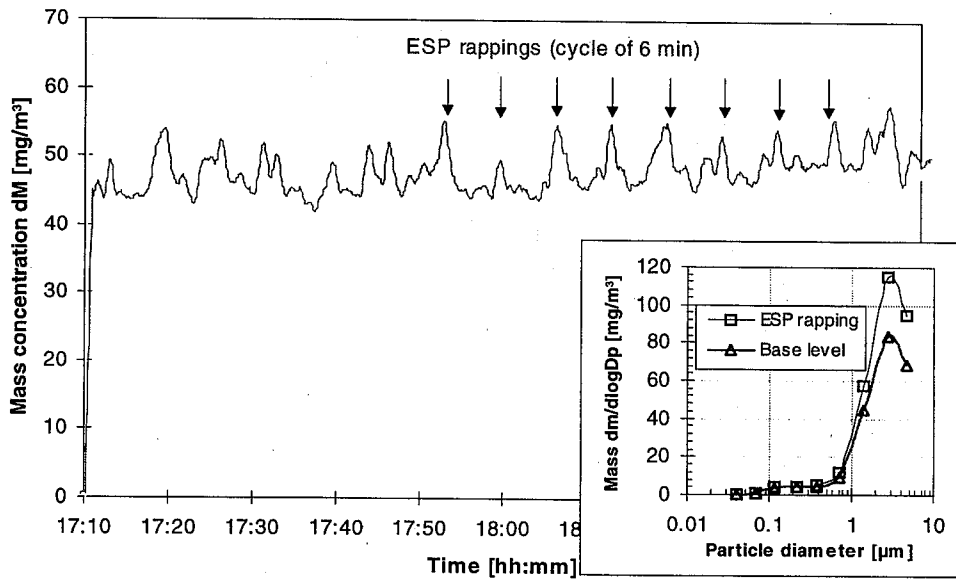
◆ ELPI vs. BLPI

- Pulverized coal

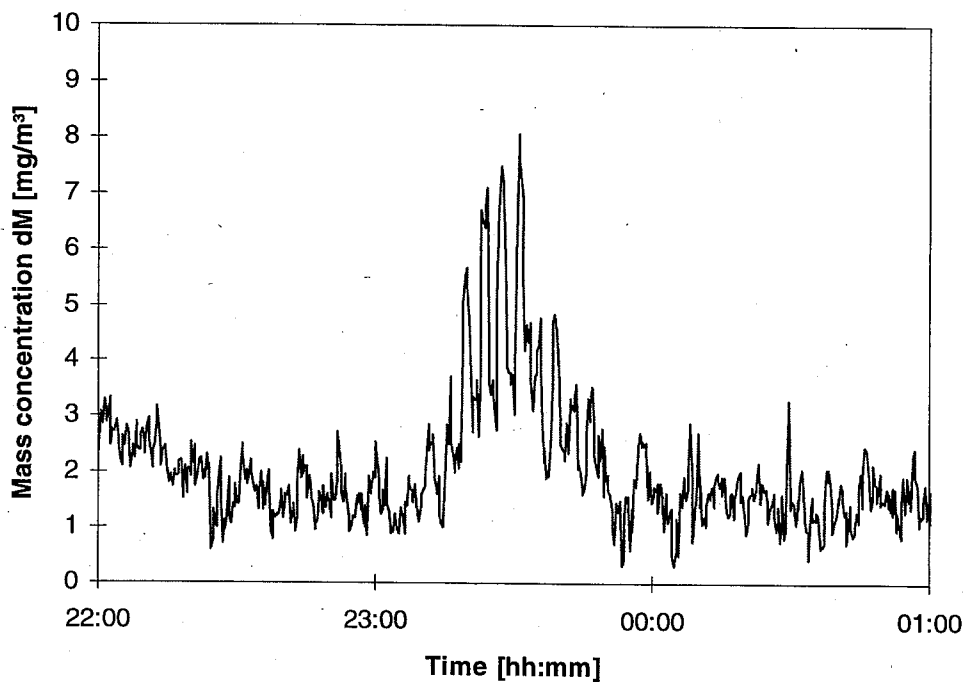


ESP rapping and soot blowing

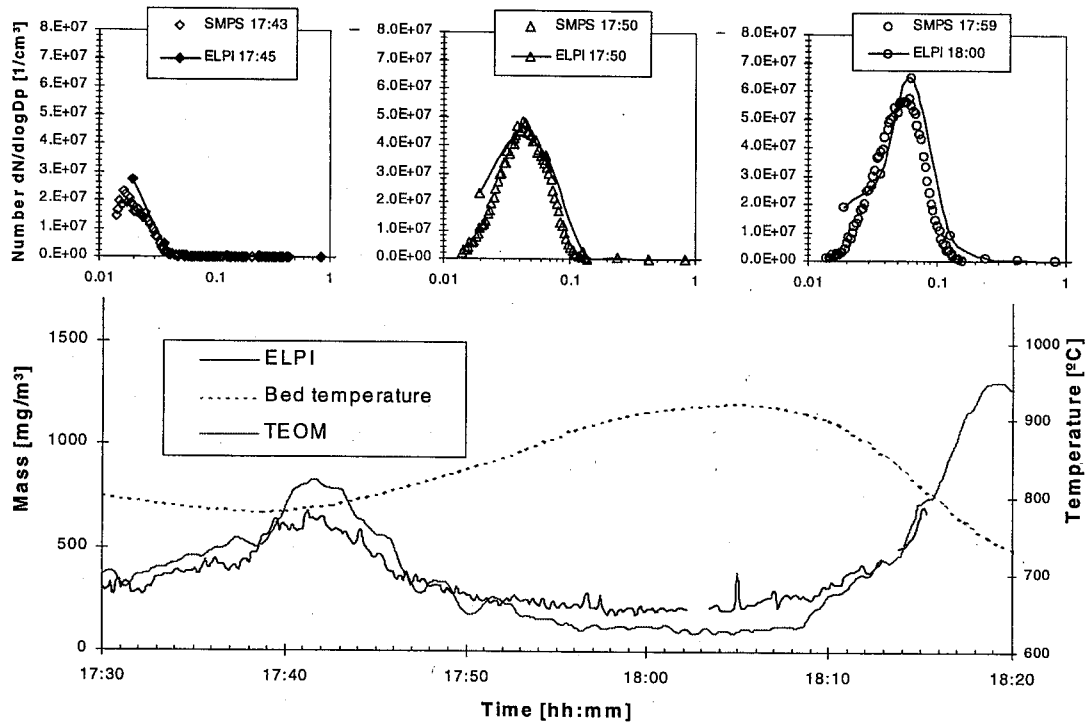
ESP rapping emission



Peat, boiler soot blowing emission



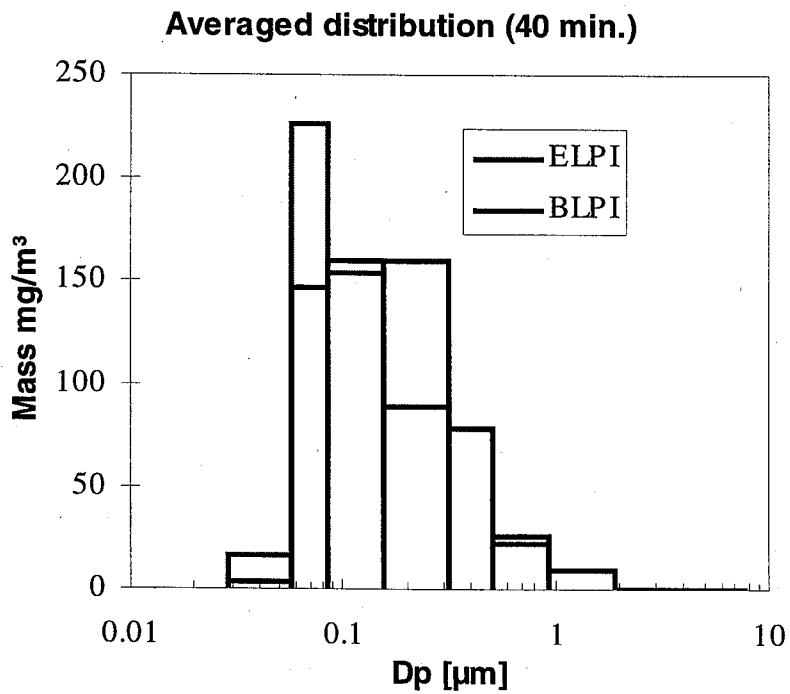
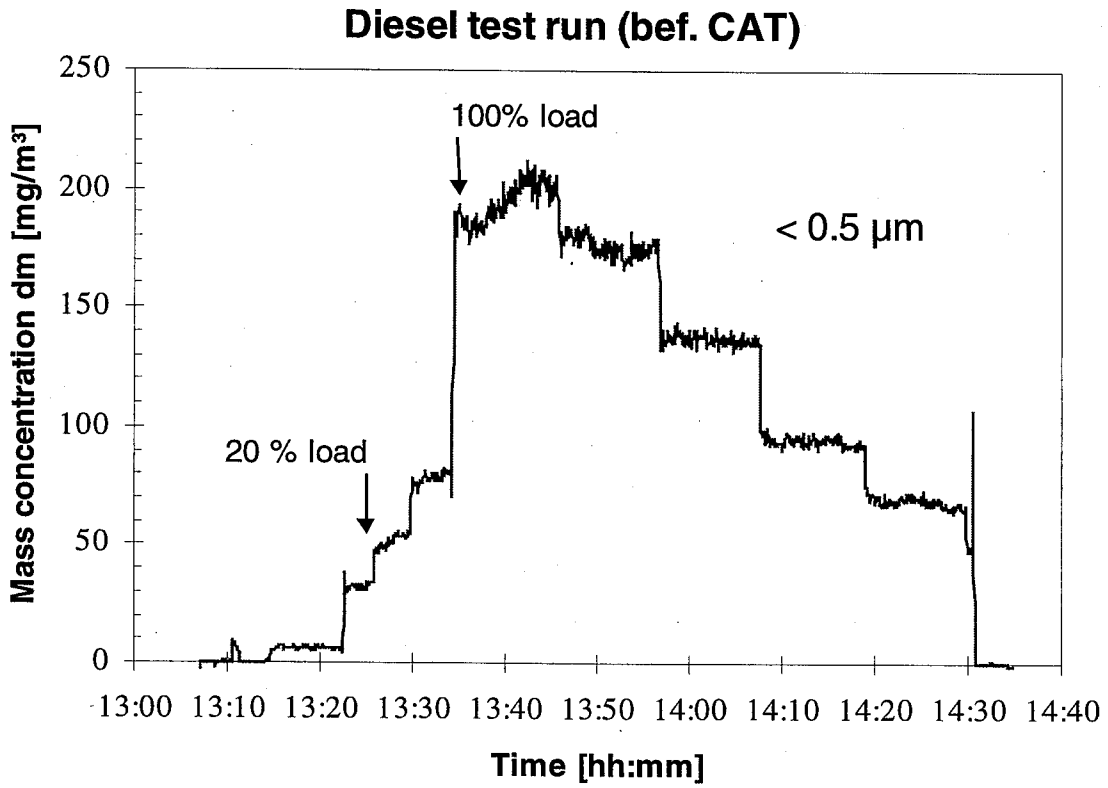
Size distribution change in fluidized bed combustion*



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

