A fast integrated mobility spectrometer (FIMS) for rapid measurement of aerosol size distribution

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Airborne Aerosol Size Distribution Measurements

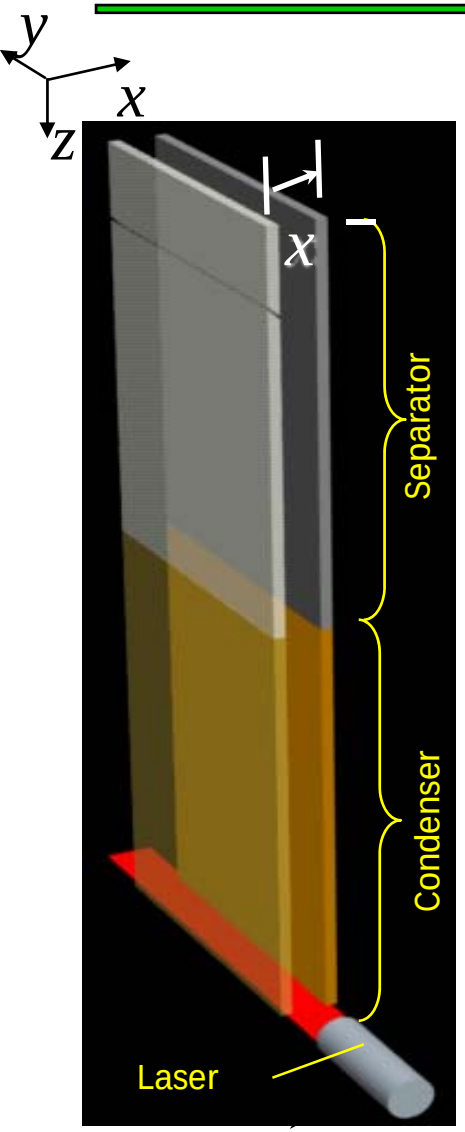
For aircraft-based measurements, an instrument need to have:

- fast response time for good spatial resolution.
- high sensitivity and good counting statistics.

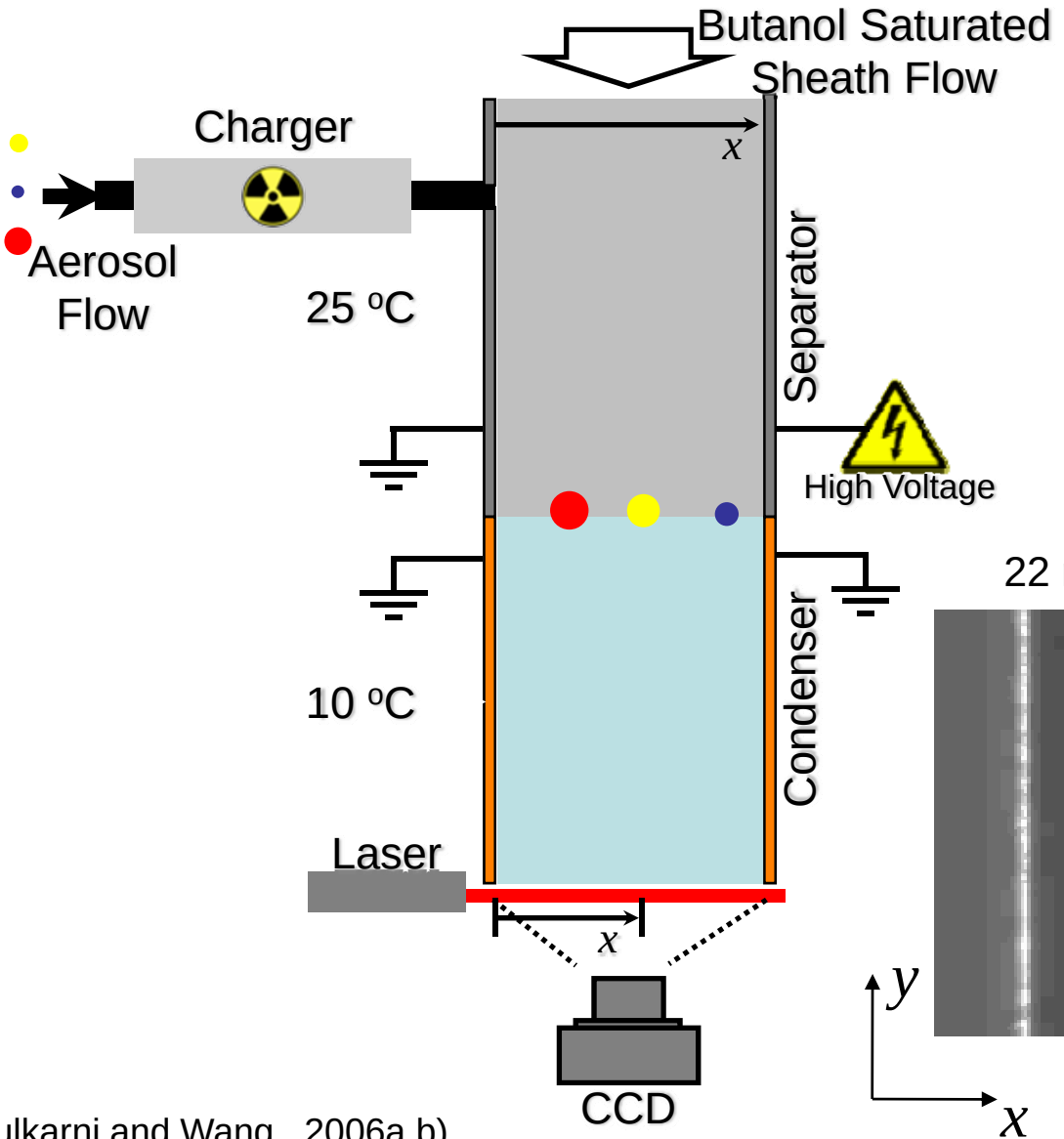
Current techniques for measuring aerosol size distributions:

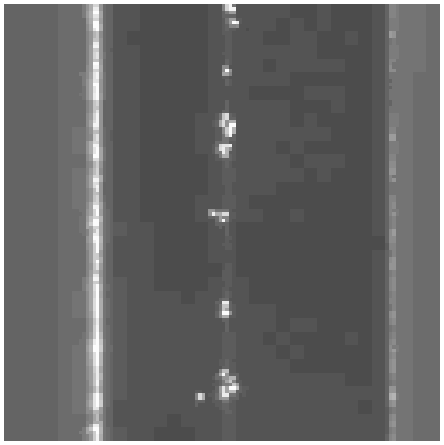
- Scanning Mobility Particle Sizer (SMPS) - The ‘industry standard’, but ~1 min is needed for each scan.
- Optical Particle Counter (OPC) - Fast measurements but range limited to D_p>100 nm, and uncertainties due to particle shape and refractive index.
- Electrical Aerosol Spectrometers (Cambustion’s DMS & TSI’s EEPS) - Response time less than 1 s, but have low sensitivity.

Principle of the Fast Integrated Mobility Spectrometer (FIMS)



Geometry



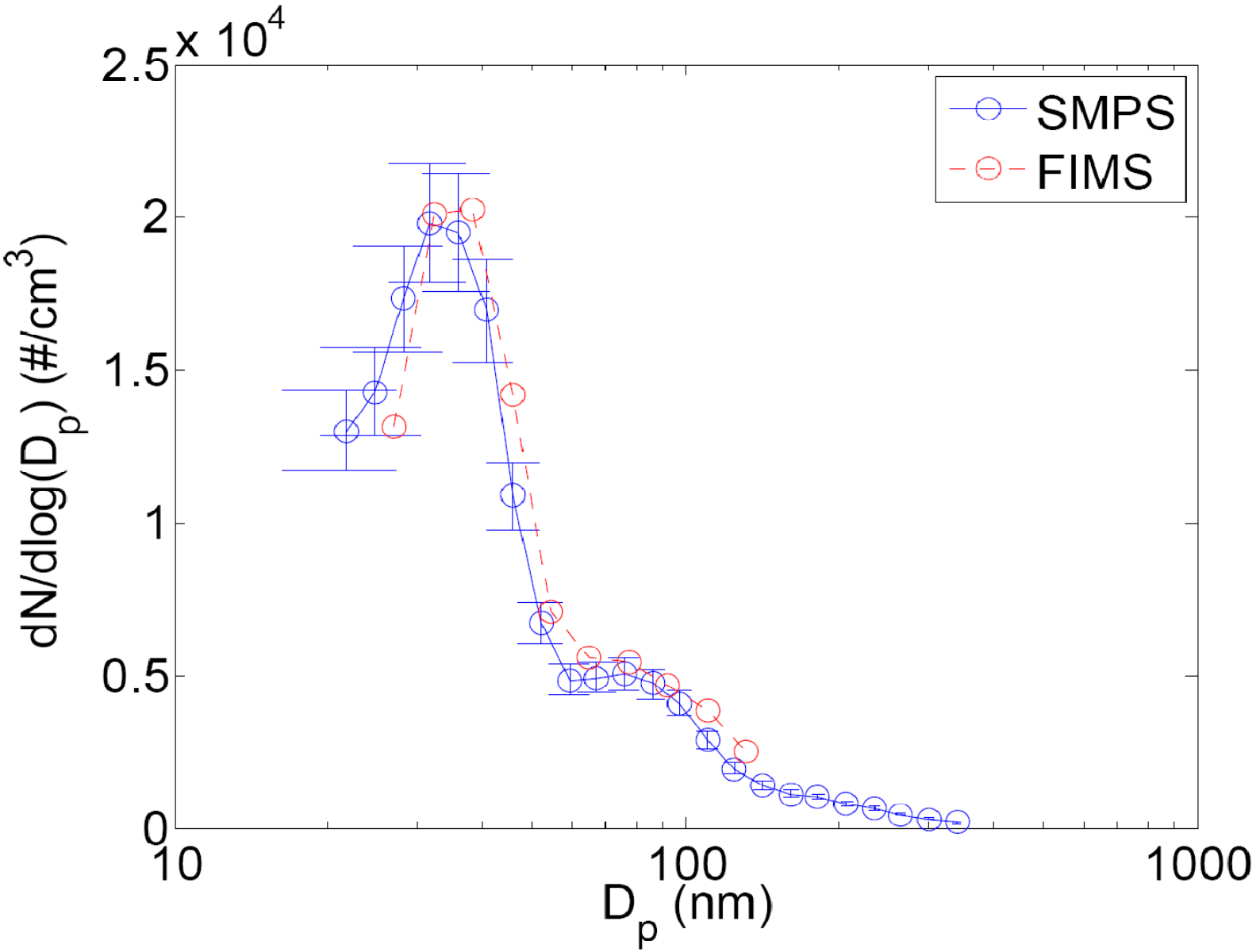


(Kulkarni and Wang, 2006a,b)

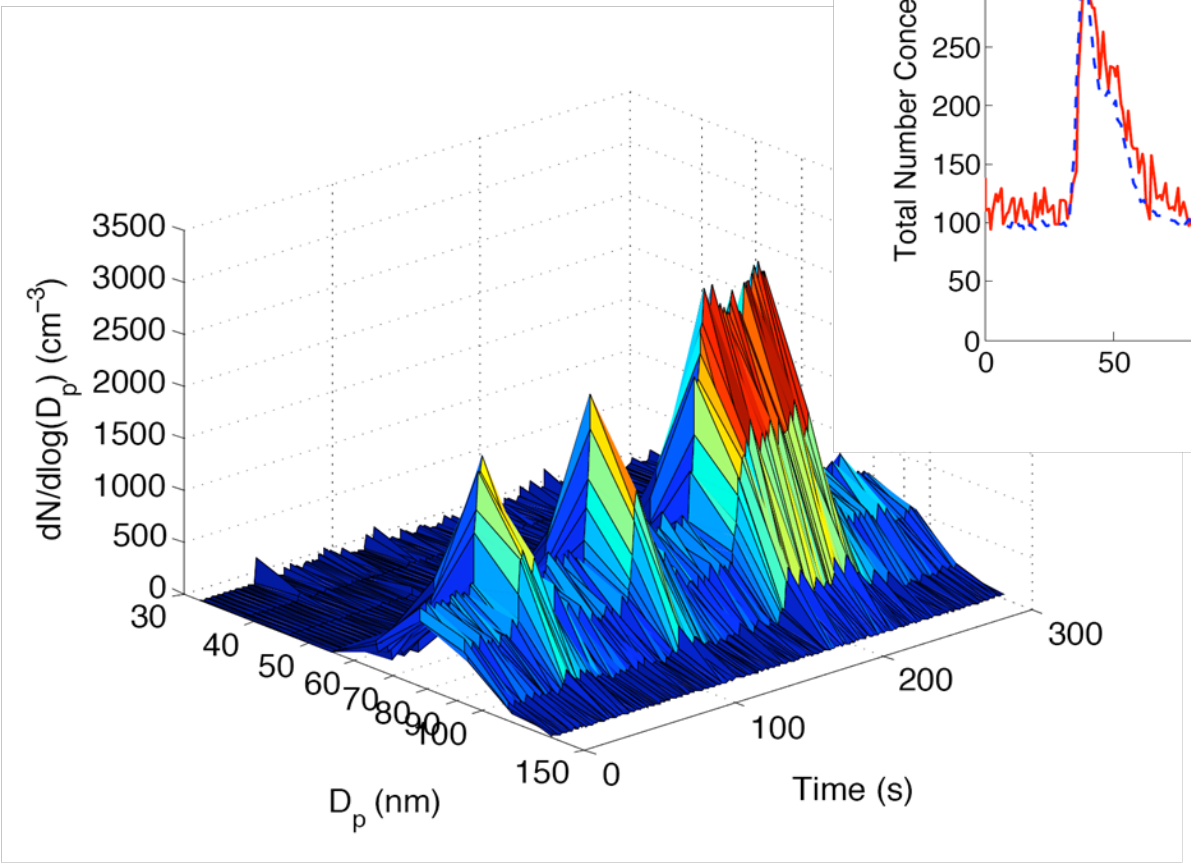
Current status of FIMS development

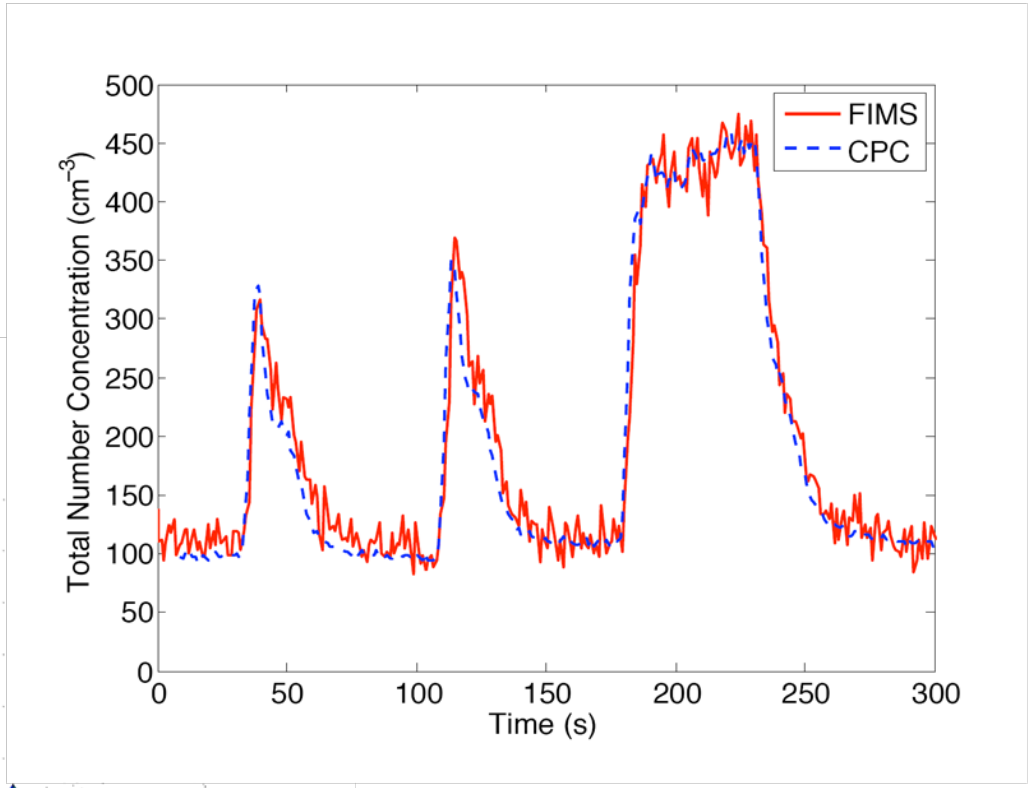
- A FIMS has been constructed for airborne measurement.
- The performance of the FIMS has been characterized. (Kulkarni and Wang, 2006a and 2006b. Olfert and Wang 2008).
- Data analysis procedure developed (Olfert et al., 2008).
- The FIMS was successfully deployed in the joint Cloud and Land Surface Interaction Campaign (CLASIC) and Cumulus Humilis Aerosol Processing Study (CHAPS) in June, 2007.
- The FIMS is currently being deployed in the VAMOS Ocean-Cloud-Atmosphere-Land Study - Regional Experiment (VOCALS-REx) in Chile.

Comparing FIMS to SMPS

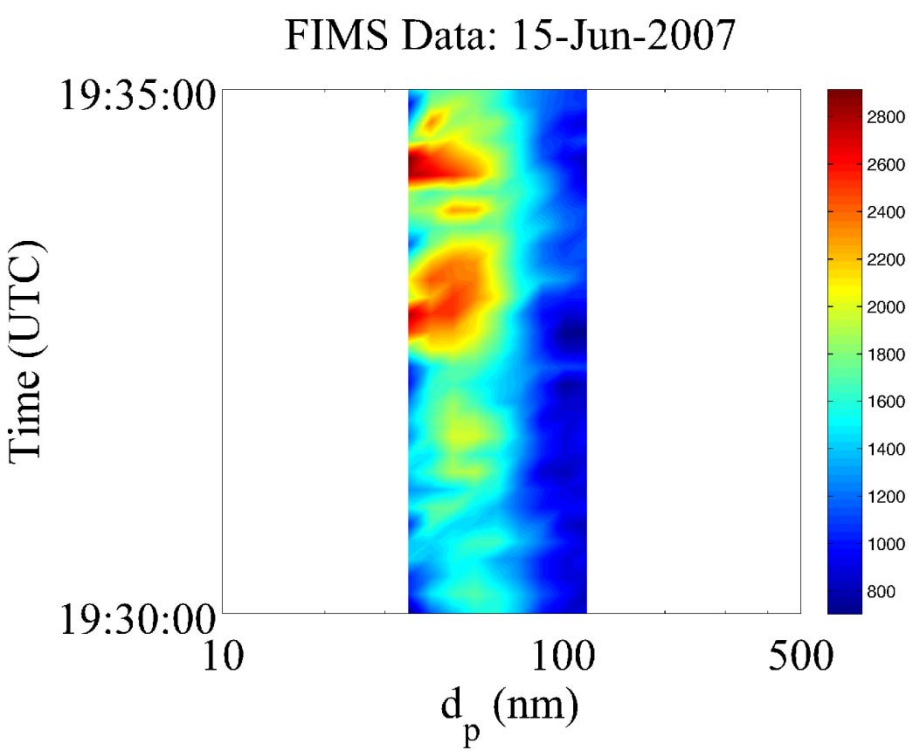


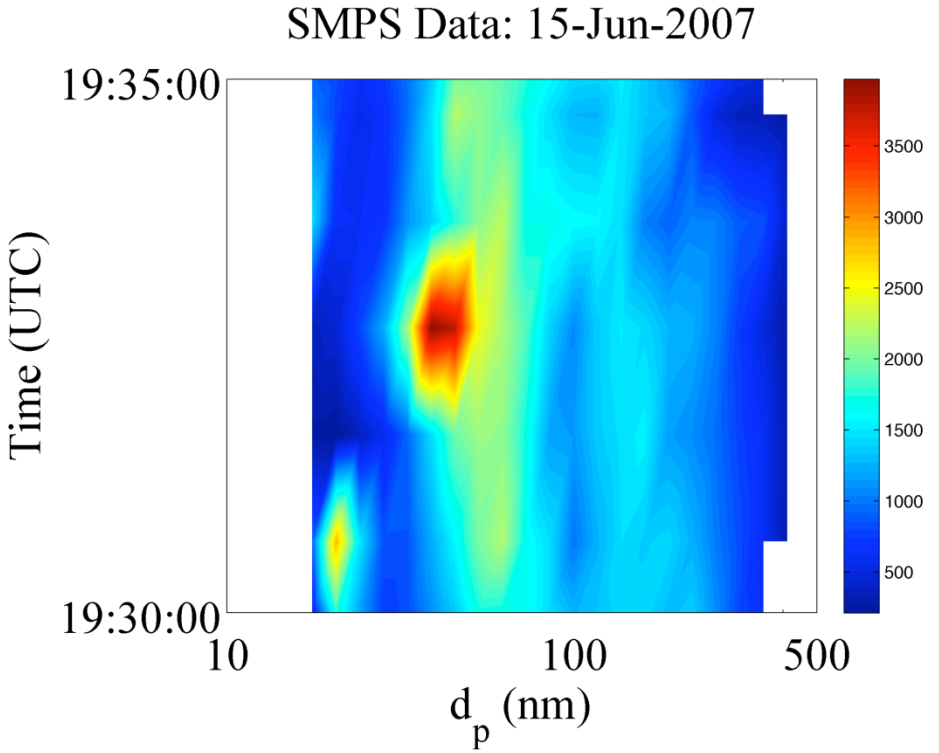
Examples of fast FIMS measurements



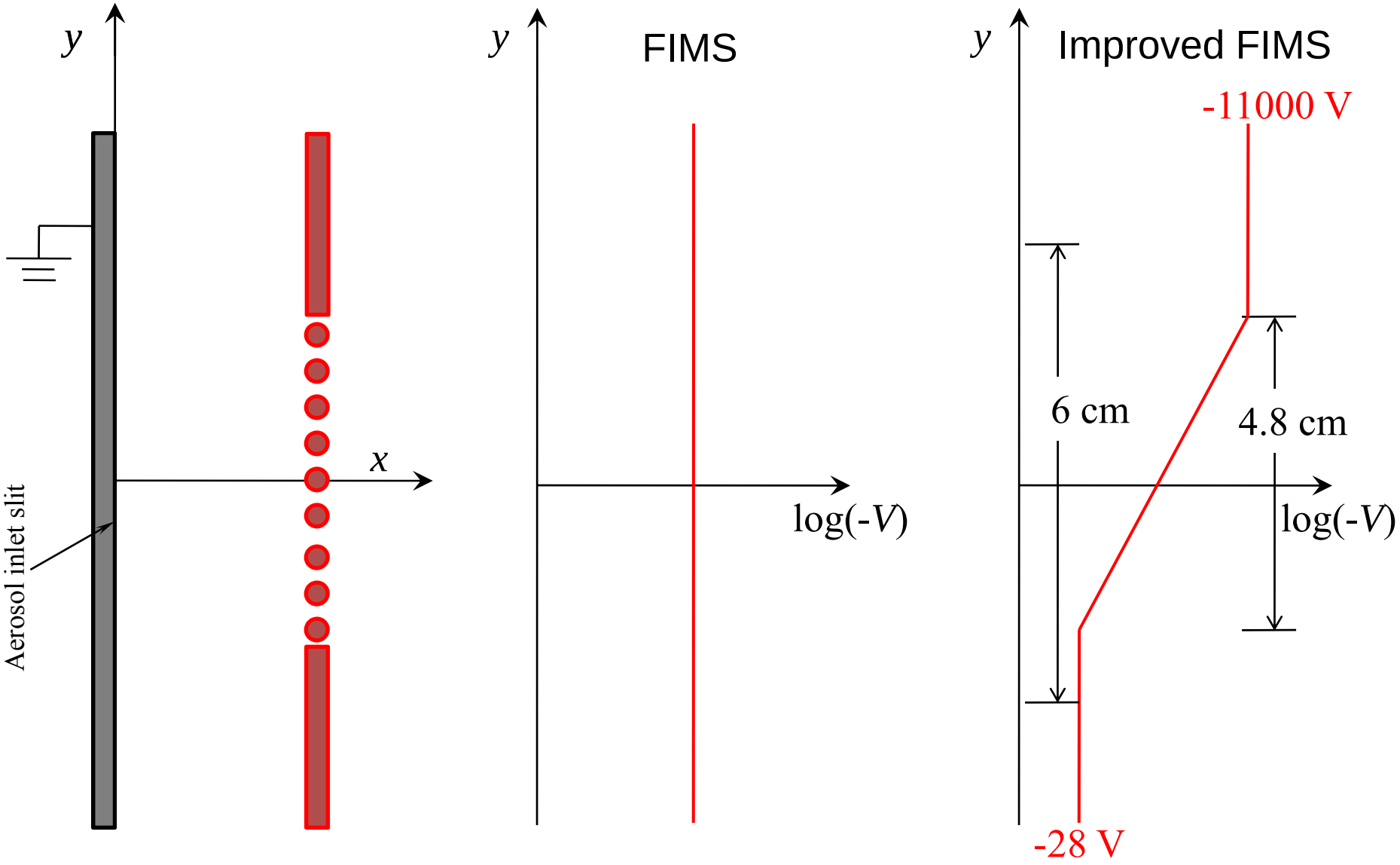


Examples of fast FIMS measurements





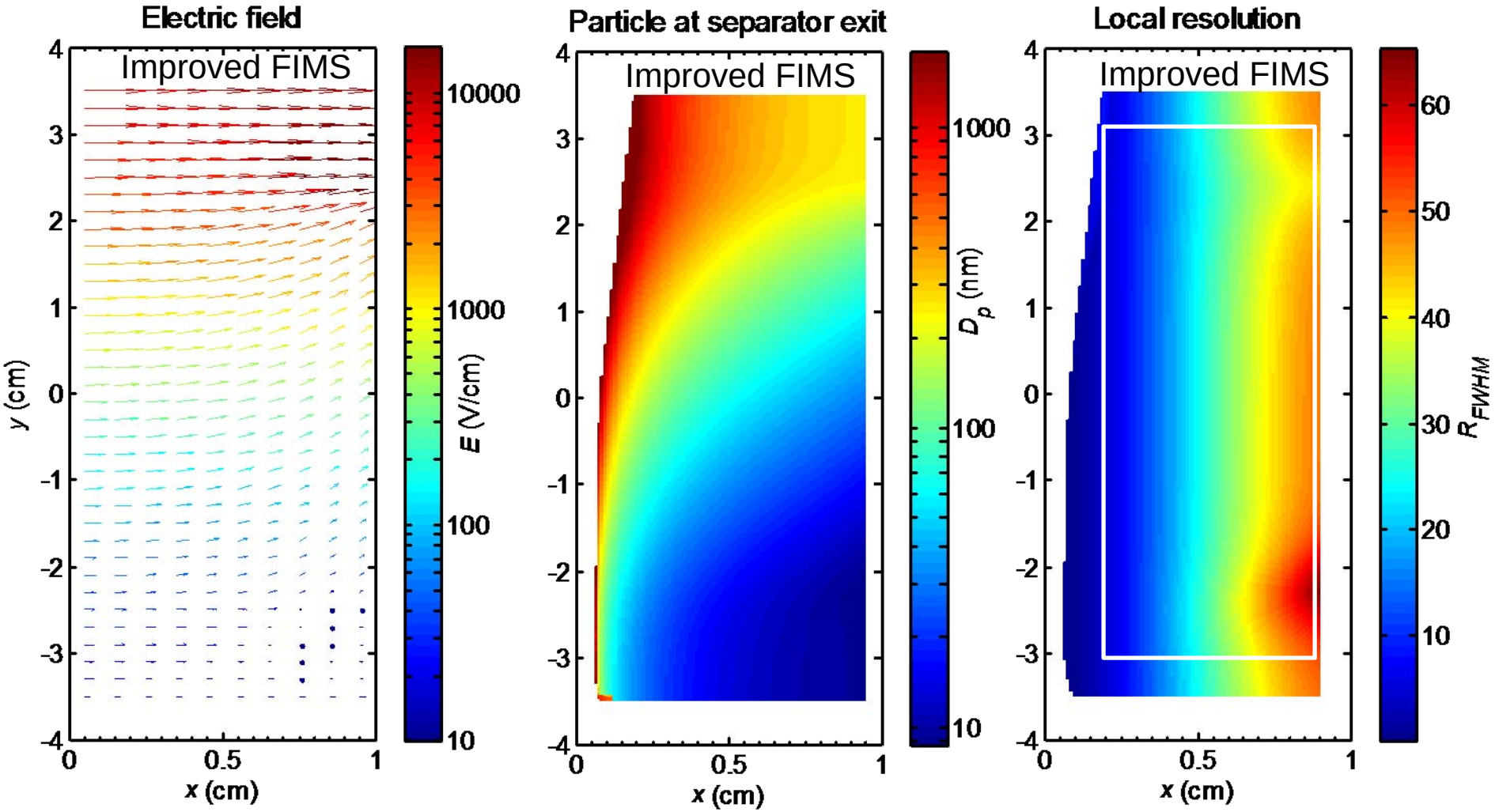
Size range of FIMS measurement



Simulation of the improved FIMS

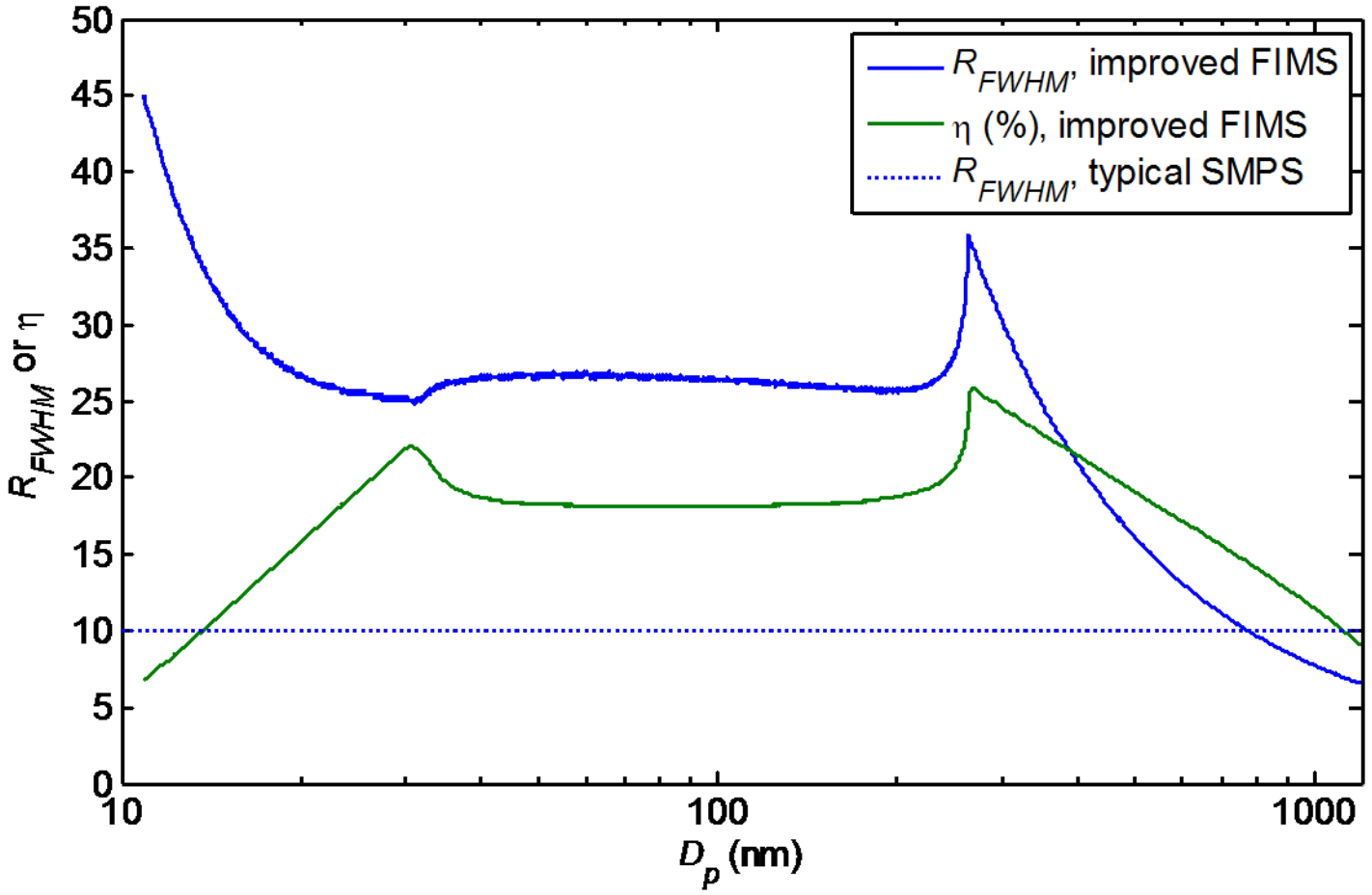
Dimension and operation parameter	**Improved FIMS**
Distance between separator electrodes	1 cm
Width of separator	10 cm
Width of viewing area	6 cm
Length of separator	25 cm
Minimum Voltage	28 V
Maximum Voltage	11,000 V
Sheath flow rate, Q_{sh}	10 L/min
Aerosol flow rate, Q_a	0.2 L/min

Electric field, particle trajectory, and local resolution



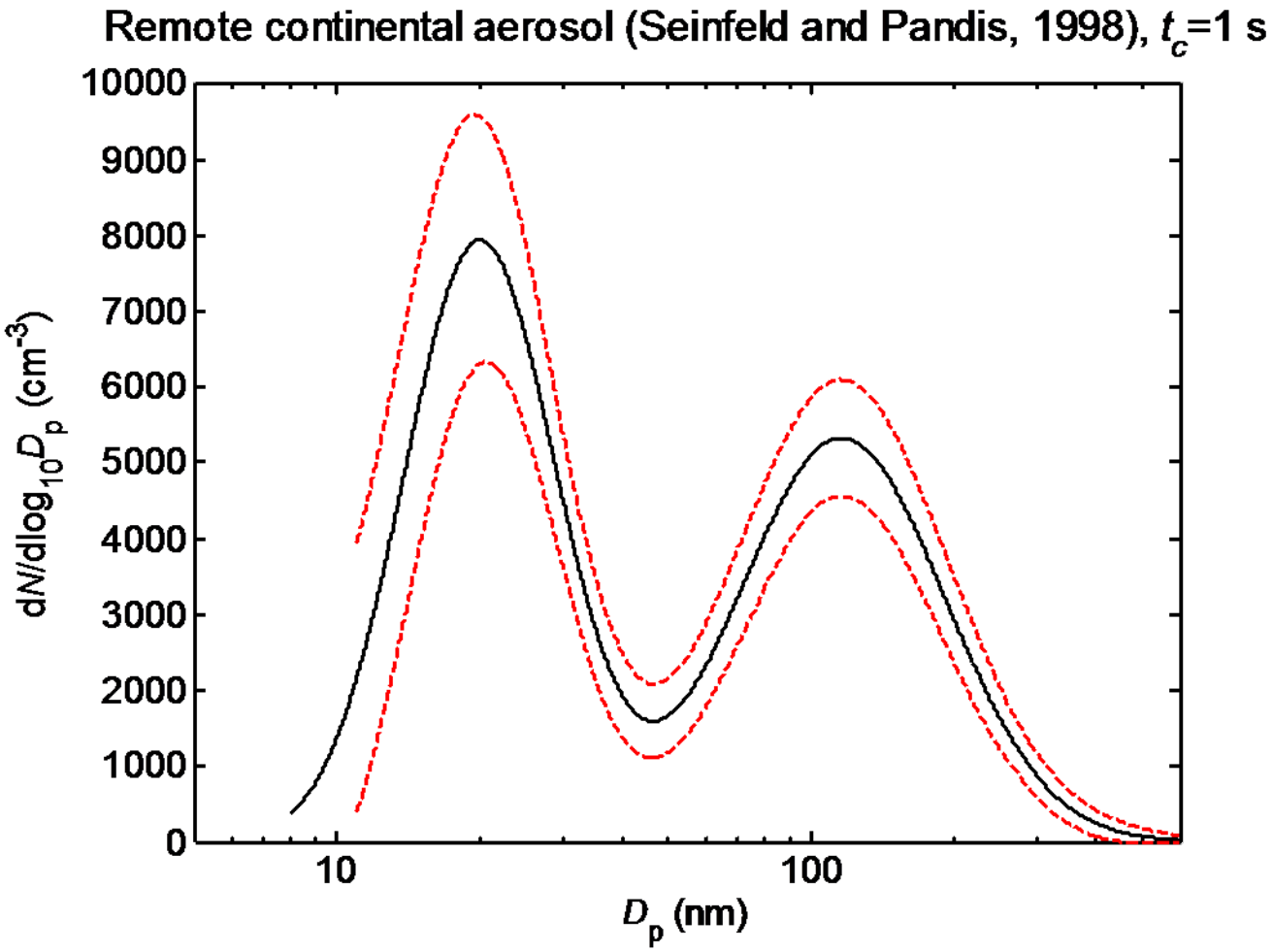
$0.20 \leq x \leq 0.87$,
$-3 \leq y \leq 3$

Overall resolution and transmission efficiency



Counting statistics of the improved FIMS

$$S/N = \frac{C}{\sqrt{C}} = \sqrt{C} = \left[Q_a t_c \eta_{chg} \eta \left(\frac{dN}{d \ln D_p} \right) \Delta \ln D_p \right]^{1/2}$$



Conclusions

- The FIMS is a fast and highly sensitive instrument that is ideal for aircraft-based measurements of aerosol size distributions.
- The size range of the FIMS can be significantly increased by redesigning the HV electrode in the separator.
- The improved FIMS can measure entire sub-micrometer size distribution within 1 second.

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Thank you!
Any questions?