

Measurement Artefacts from Evaporation and Recondensation of Volatiles in In-situ Aerosol Light Absorption Techniques

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Why in situ measurements?

- Aerosols in the atmosphere affect health, visibility and climate
- Established measurements of light absorbing aerosol are performed *ex situ* (i.e. particles are deposited into filters)
- These methods suffer from large systematic errors caused by the modification of determined particle properties due to the deposition of particles into the filter
- In situ* absorption measurements are free of these artefacts
- Light absorption by aerosols is typically low, so sensitive detection methods are required

In situ absorption techniques

Particle
Heated particle
Energy transfer to surrounding gas
Pressure waves measured with a microphone (PA)
or
Temperature changes measured with interferometry (PTI)

• Photoacoustic (PA) and Photothermal Interferometry (PTI) are both techniques that measure the light absorption of a sample

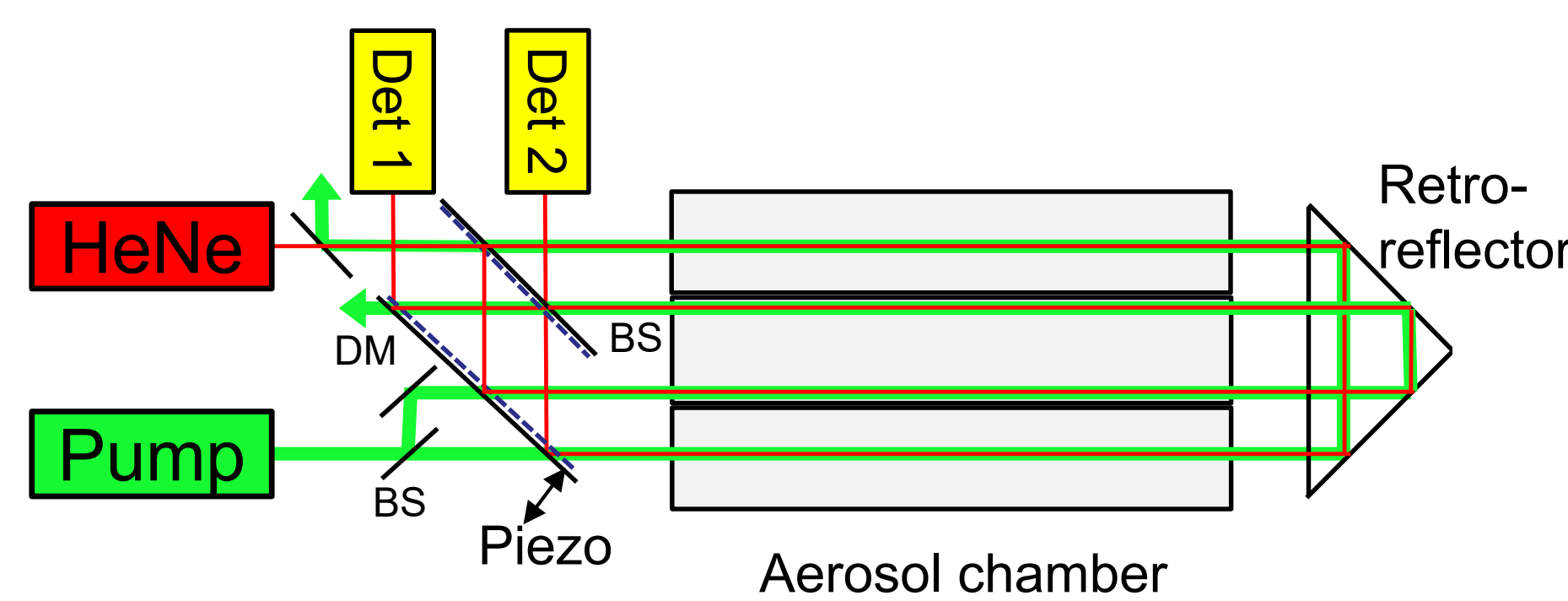
• PTI is a direct measurement with high temporal resolution, PA requires a resonator to amplify harmonic modes

Above: Principle behind PA and PTI techniques.

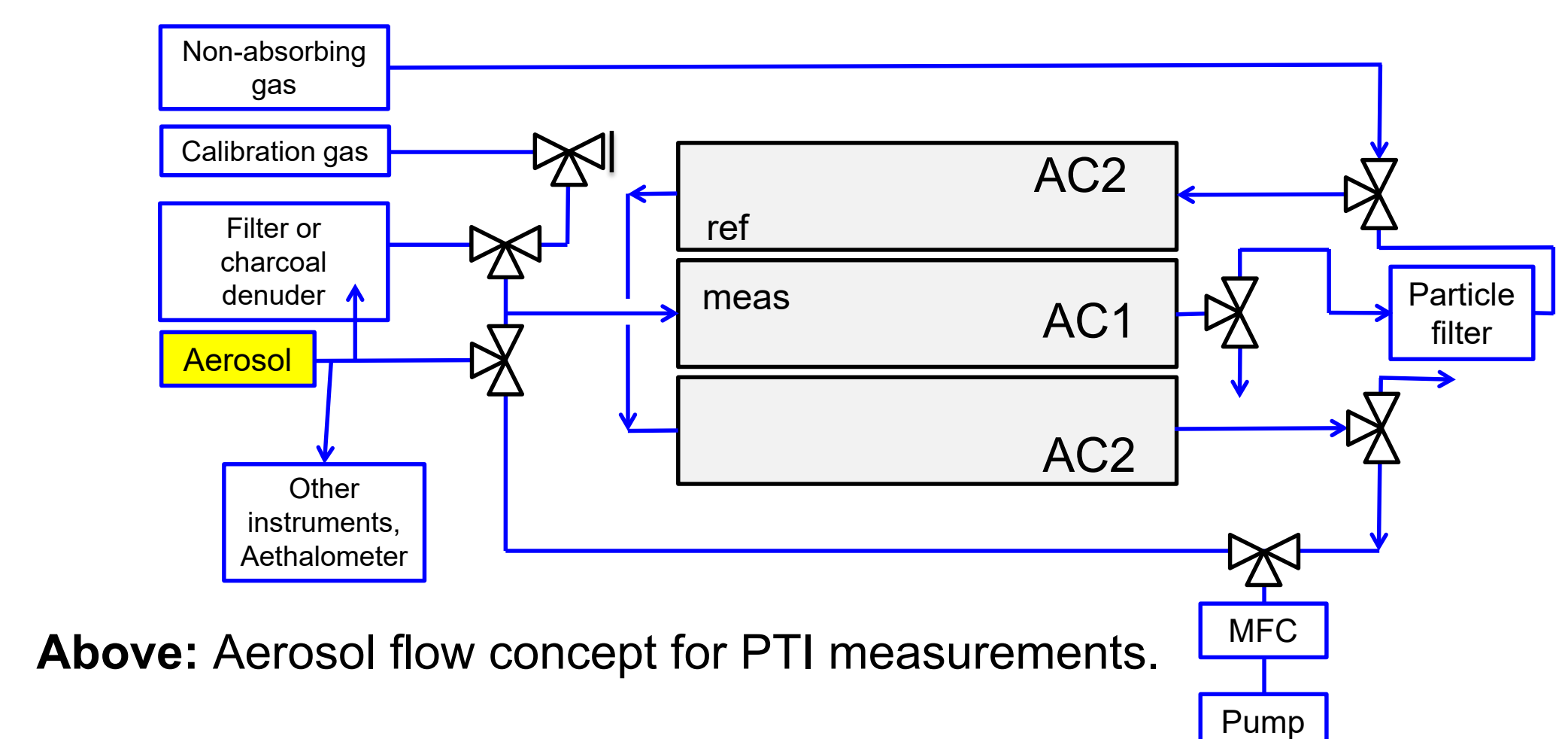
Left: Simulation of the first azimuthal mode in a cylindrical resonator showing the pressure gradient

Experiment

- We are currently working on a PTI setup for the measurement of ambient light absorbing aerosols.
- Using the PTI technique one can avoid the filter measurement artefacts.



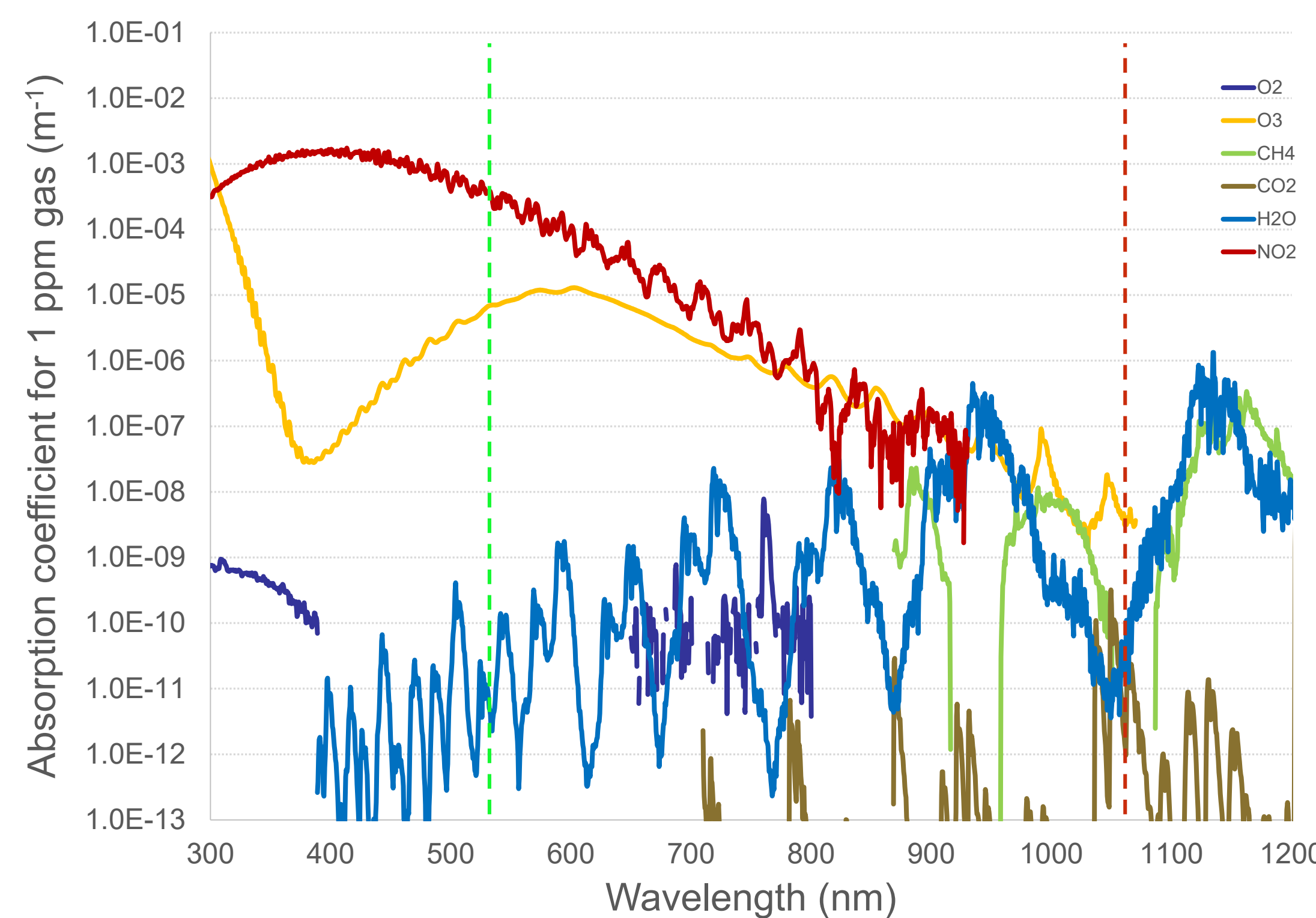
Above: Interferometer design for the PTI experiment. BS is a beamsplitter and DM a dichroic mirror.



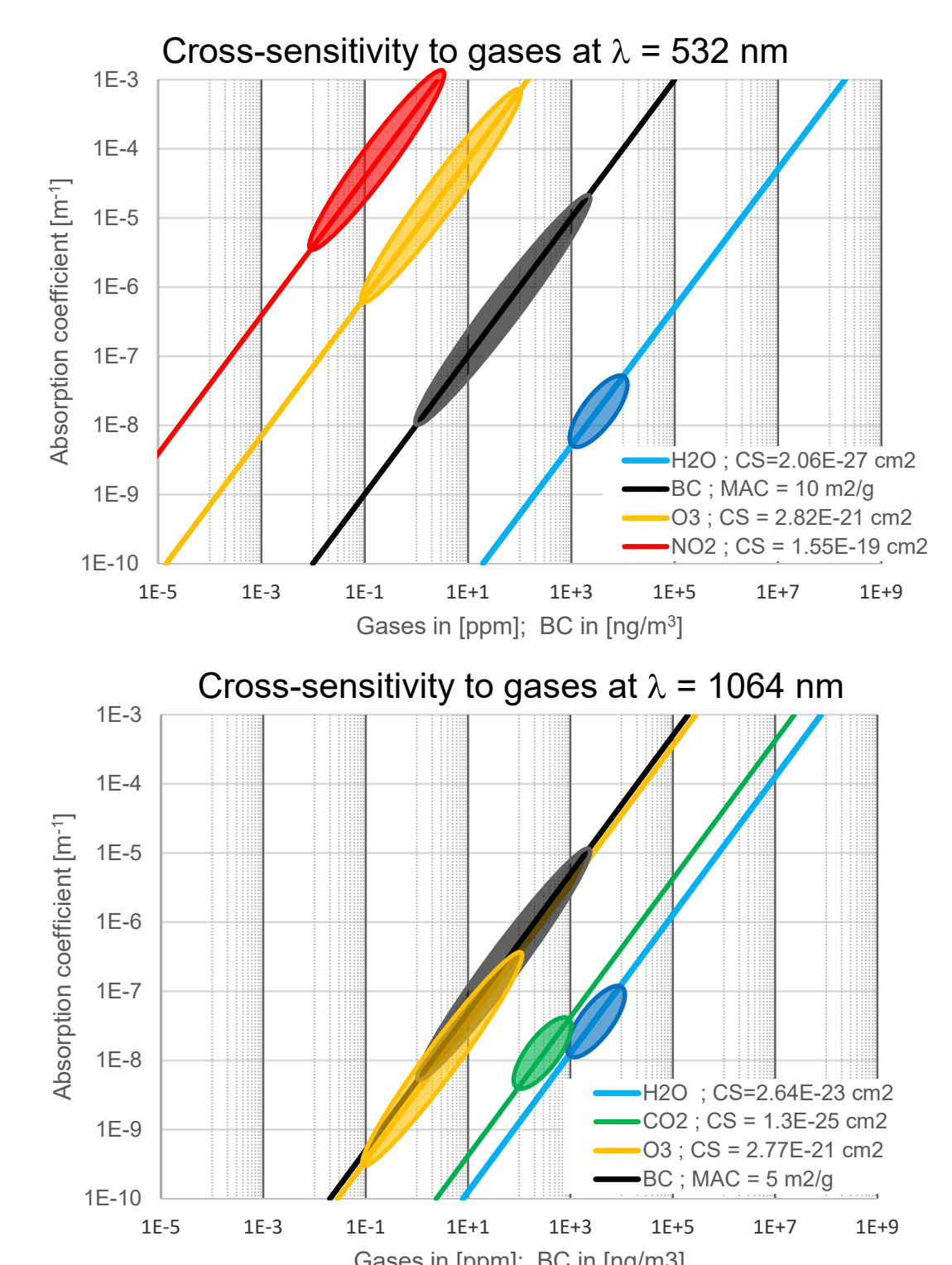
Above: Aerosol flow concept for PTI measurements.

Background gas absorption

- In addition to aerosol particles, naturally occurring gases can contribute significantly to light absorption measurements
- Either the gases need to be separated before the measurement or the light absorption of the gas measured without aerosol particles
- With an appropriate experimental set-up absorbing gases can be used to calibrate the instrument response
- Absorption features of gases are very specific
- Which gases contribute to the measured absorption is wavelength dependent

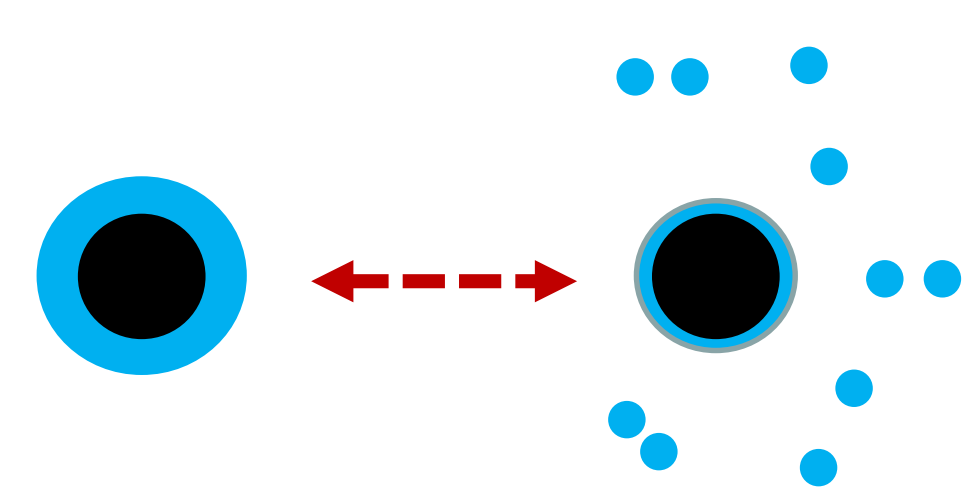


Above: Absorption data for a range of potential calibration gases calculated for 1 ppm of gas. Data is averaged over a 1 nm interval to approximate the spectral bandwidth of the heating laser.



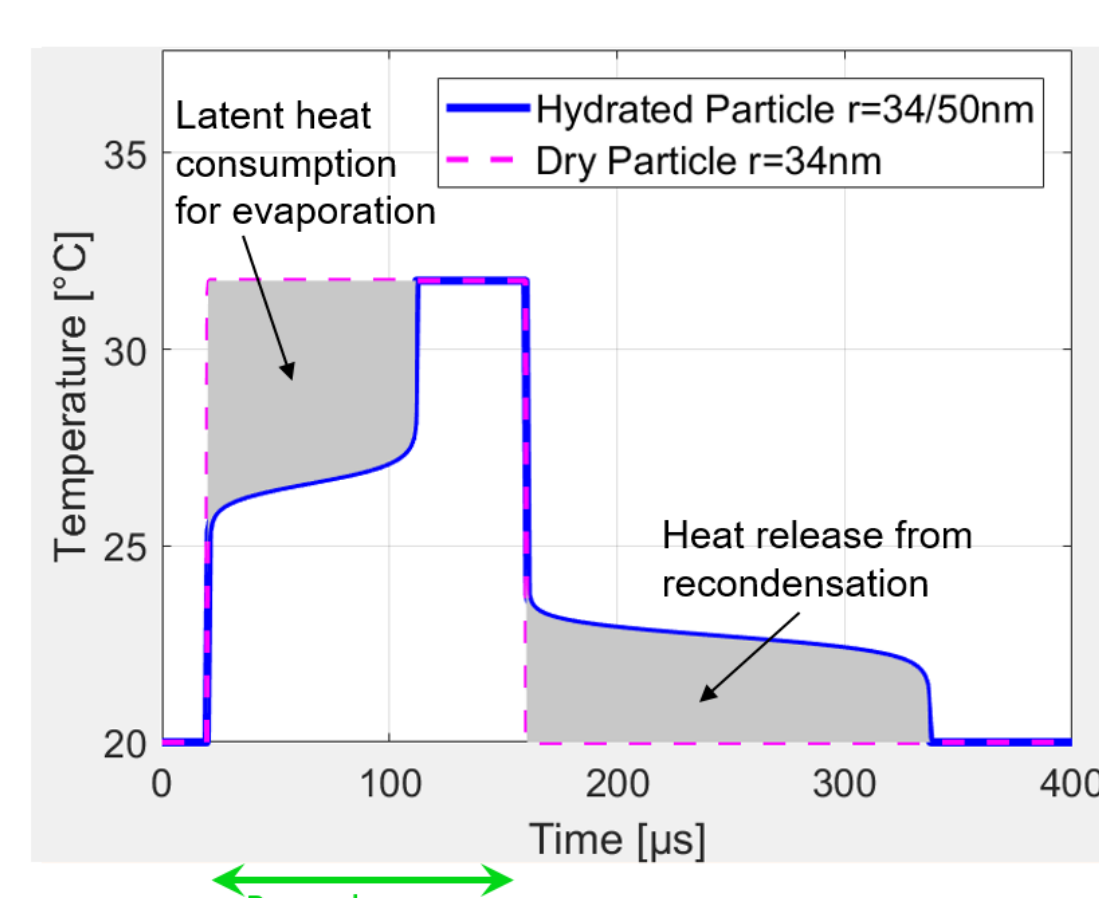
Above: Absorption data for major absorbing species at 532 and 1064 nm. Circles show typical ambient concentrations of the respective species.

Volatiles and latent heat



Left: Ambient light absorbing particles often have volatile coatings, which can evaporate when the temperature of the particle rises and recondense when the particle cools.

Right: The evaporation and condensation cycle changes the phase of the energy release of the aerosol to the surrounding gas. This effect significantly affects the strength of a PA signal, but could possibly be measured and corrected for in PTI measurements.



Conclusions

- In situ* absorption measurements of ambient aerosols are complicated by artefacts arising from light absorption by gases and evaporation of volatiles
- These issues can be mitigated by careful experimental design
- PTI has the potential to determine the influence of volatile coatings in *in situ* absorption measurements

References

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