IAGOS Air Quality Package „P2e“

IEK8-Global Observations

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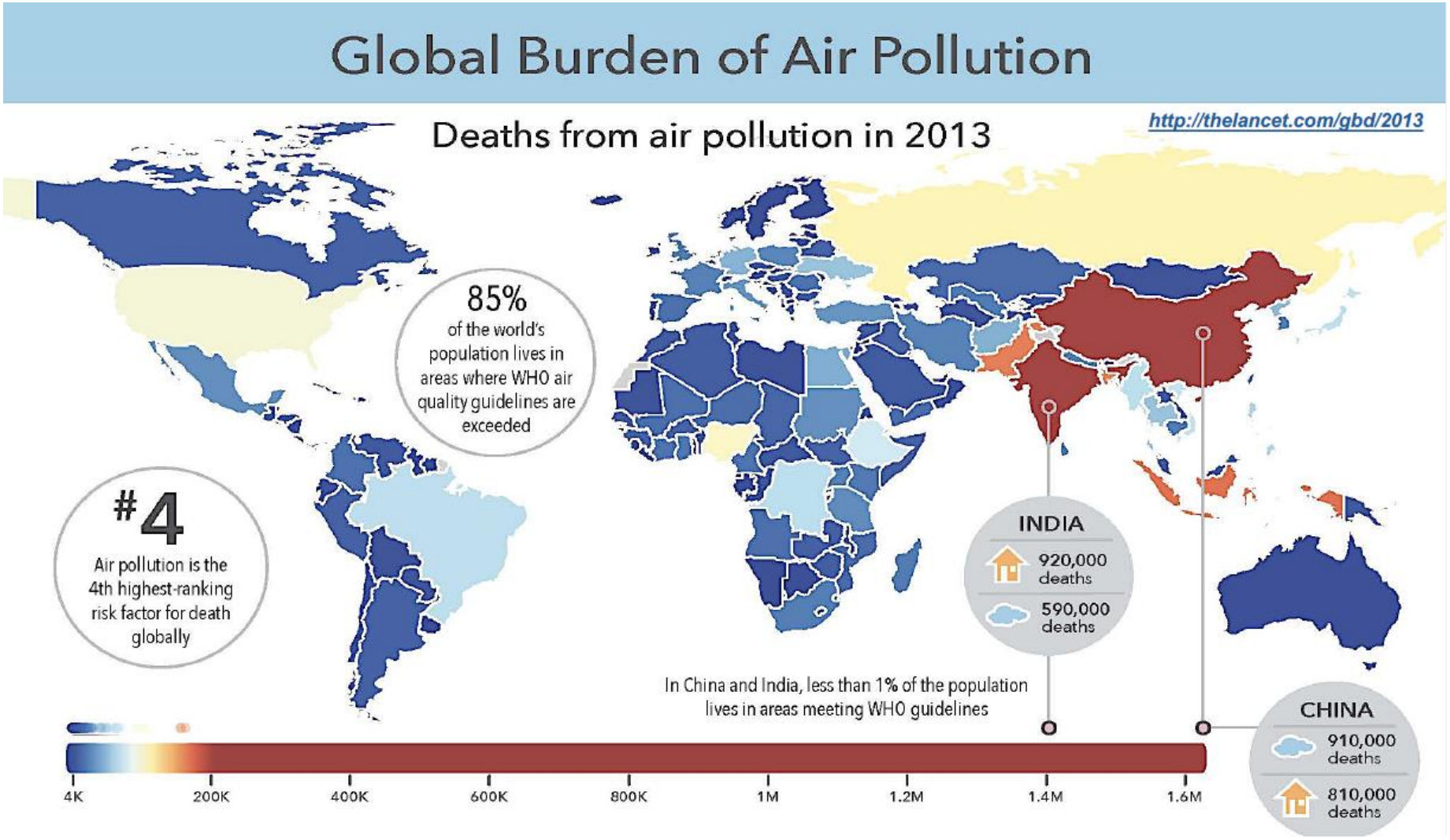
Picture by AWI

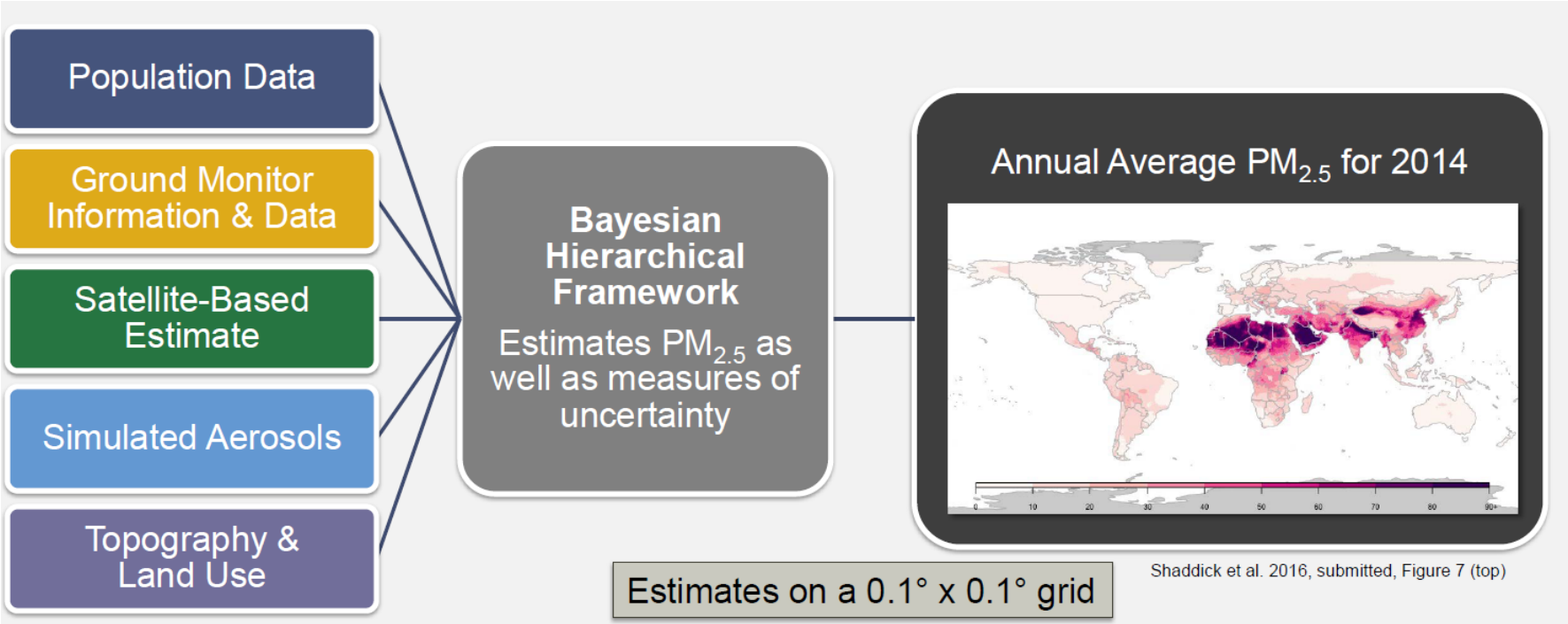
IAGOS AIR QUALITY MEASUREMENTS (NO_X & AEROSOLS)

Motivation / Background



- Air pollution was responsible for 5.5 million deaths in 2013

WHO DATA INTEGRATION MODEL FOR AIR QUALITY (DIMAQ)



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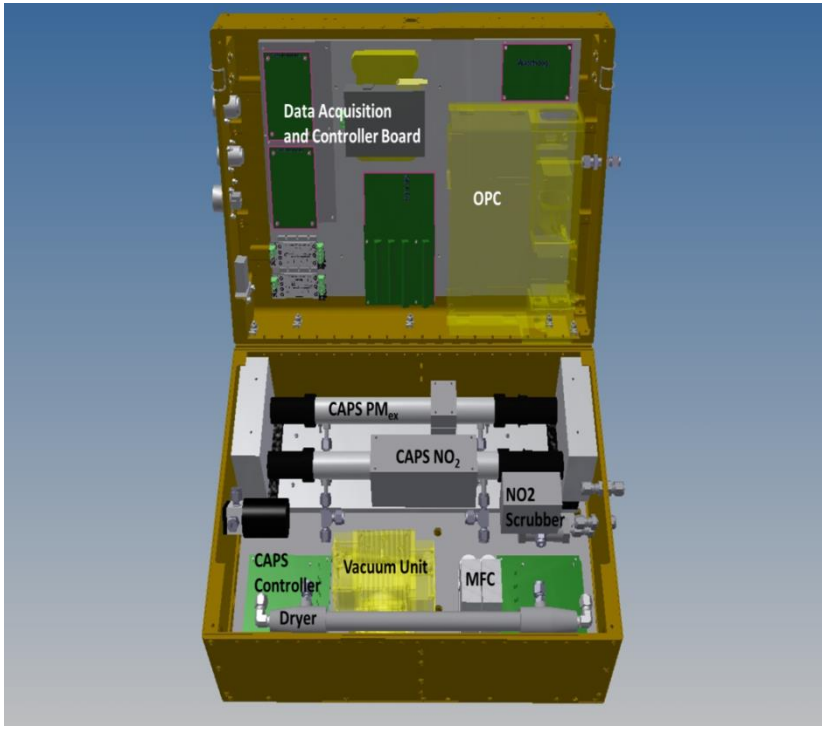
IAGOS Air Quality Package (P2e)

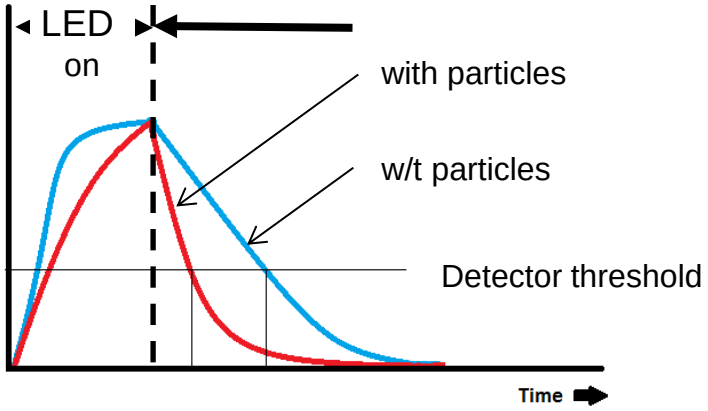
- Combines the measurement of NO_2, aerosol light extinction, and aerosol size distribution as proxy for aerosol mass
- Allows measurement of regular profiles of key air quality parameters.



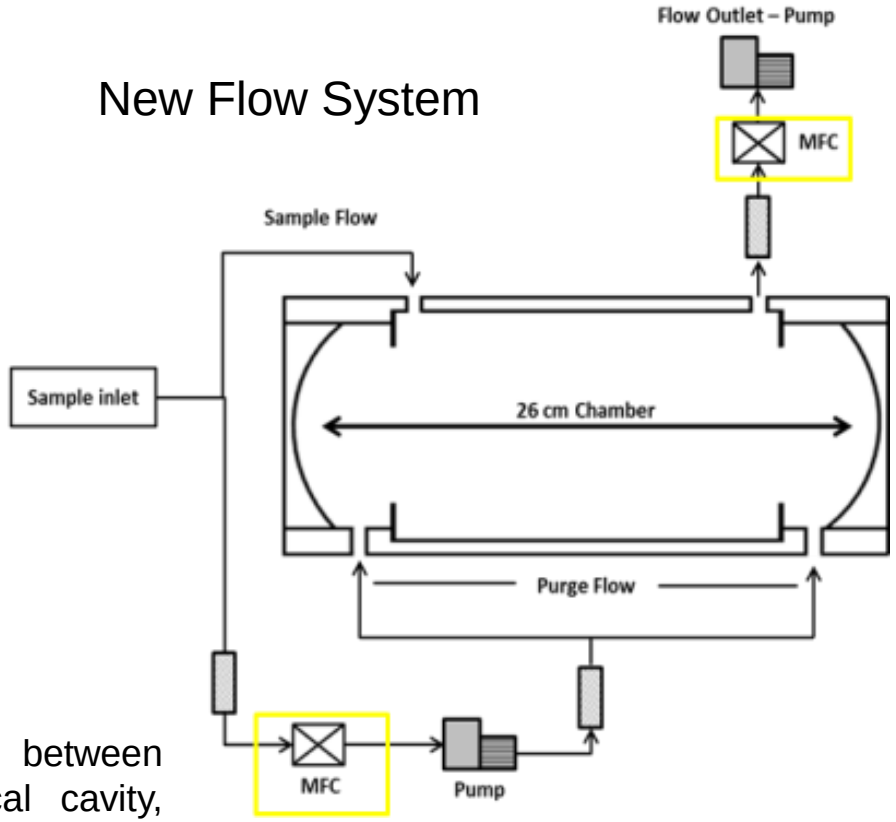
Bundke et al., EAC. 2016 De Faria et al., AST 2017

CAPS Priciple

Schematic of signal generation in CAPS



New Flow System



CAPS PM_{ex} measures extinction as phase shift between entering and exiting light of a high-grade optical cavity, applying the Lambert-Beer law:

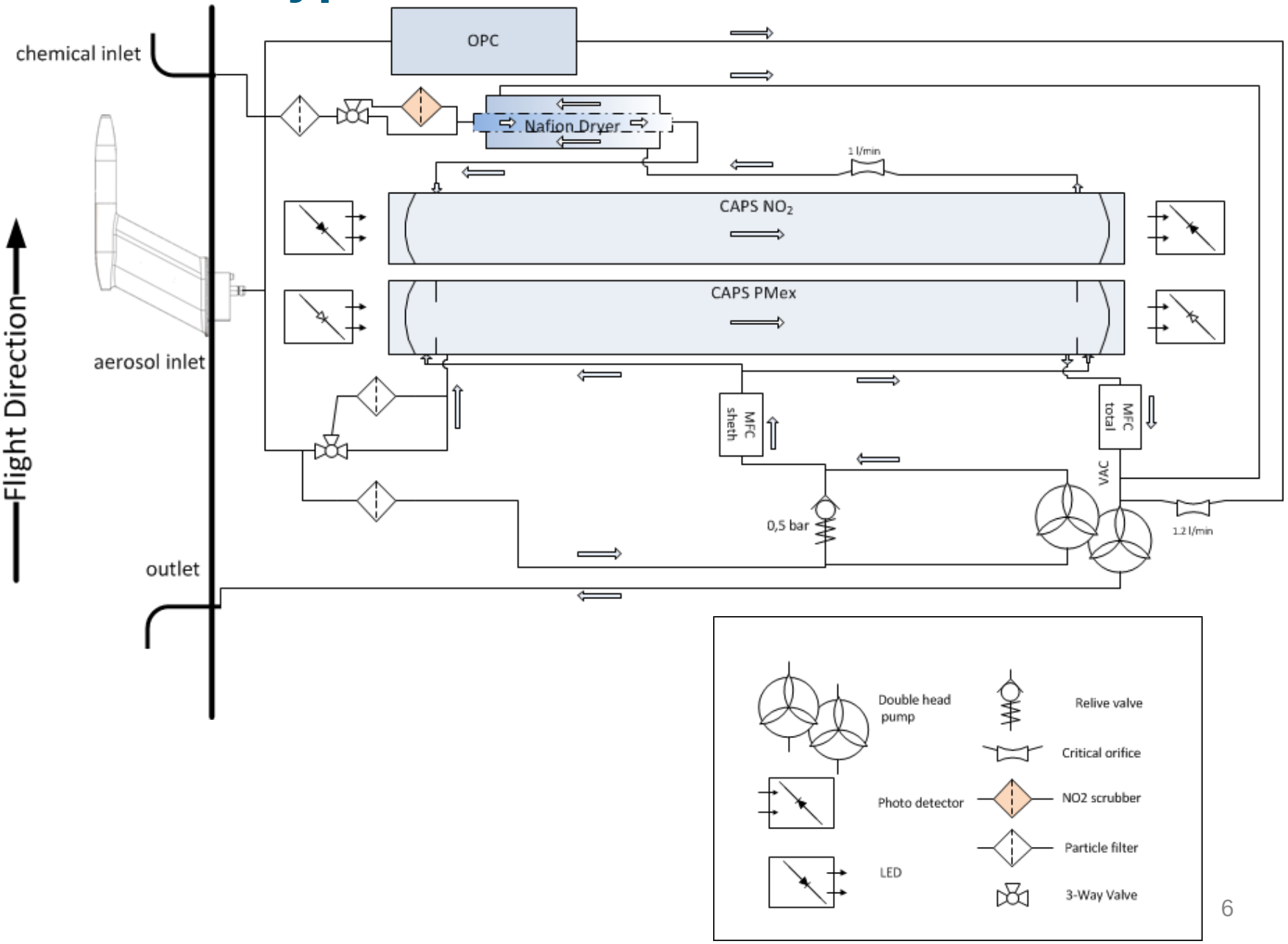
$$\cot\theta = \cot\theta_0 + \frac{c}{2\pi f}\,\sigma_{ext}\,, \quad \sigma_{ext} = \sigma_{ext,\,gas} + \sigma_{ext,\,particles}$$

in which θ is the measured phase shift, θ_0 is the phase shift at particle-free conditions, c is the speed of light and f is the LED modulation frequency.

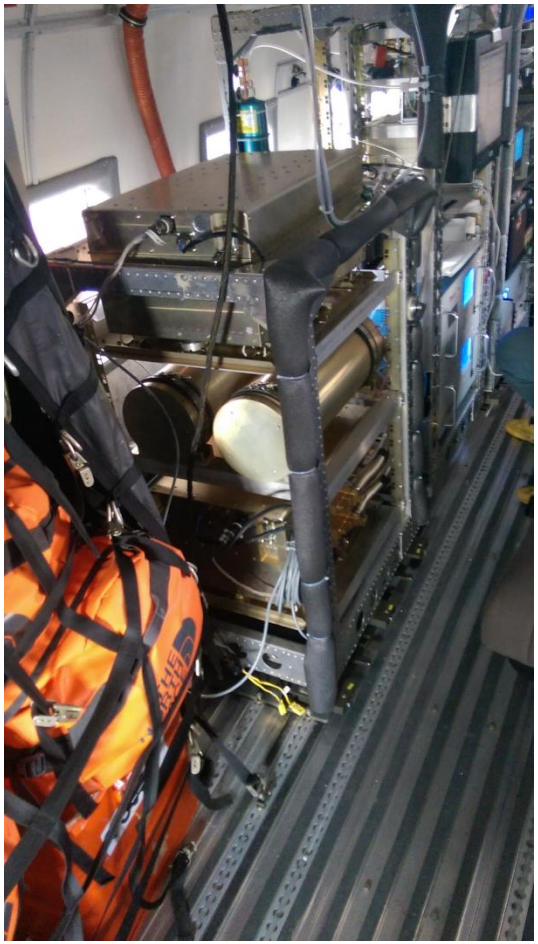
The measurement is absolute = no need for calibration.

Aerodyne Research

P2e Prototype Schematic



P2e insight



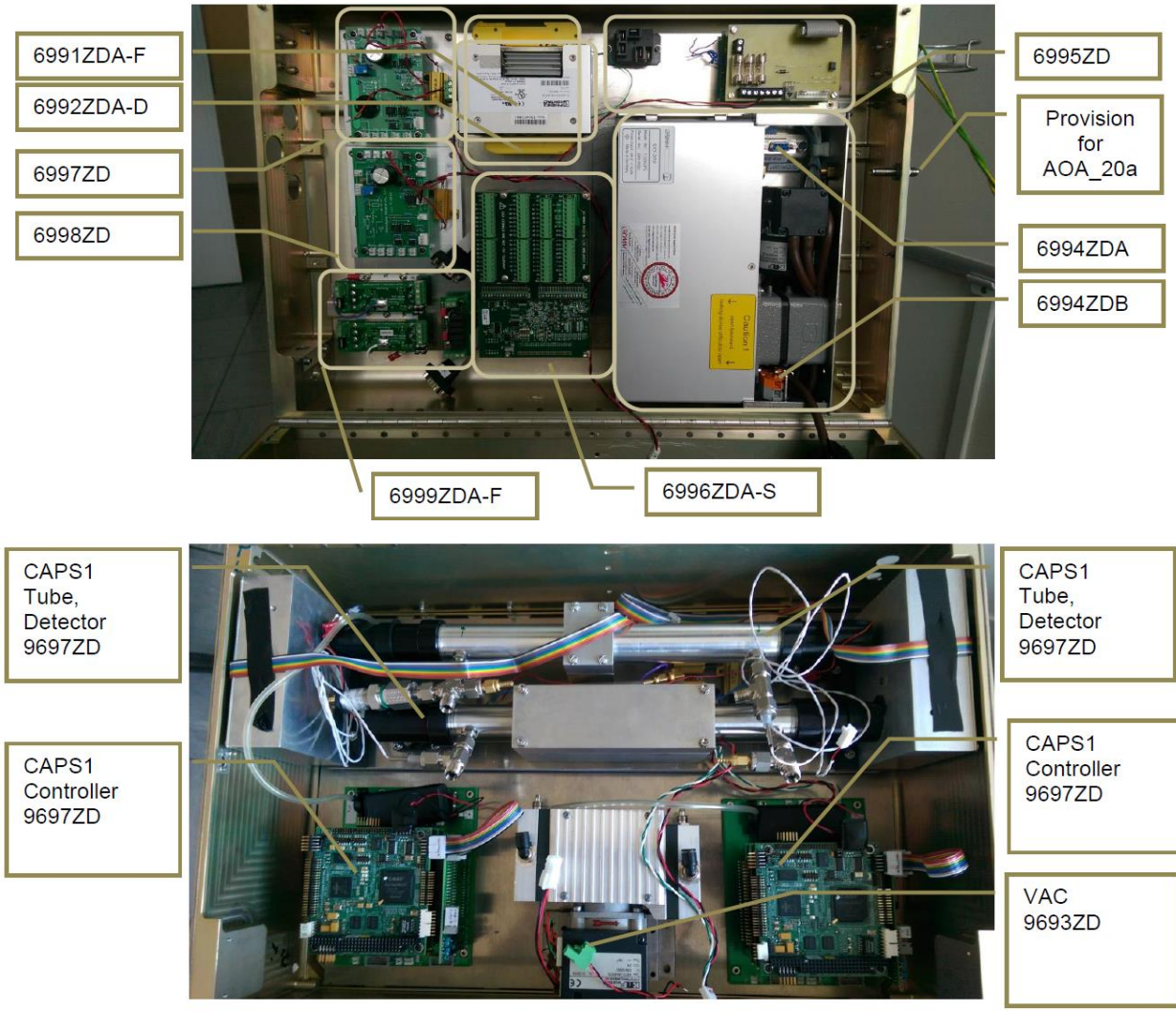
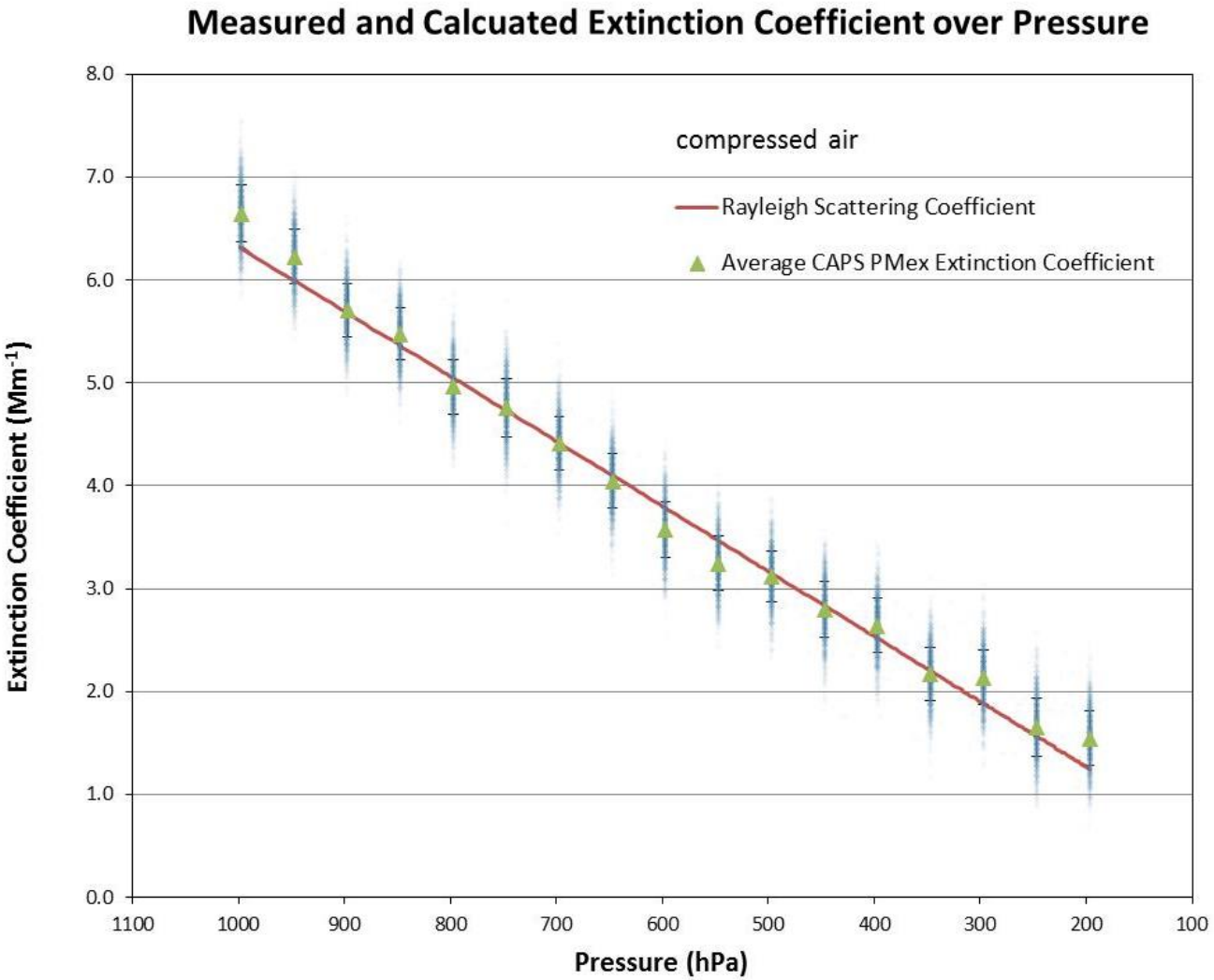


Figure 10 AOA_00 open, Top view. The CAPS system is opened only with main components installed for demonstration

De Faria et al AST 2017

Labwork

Low-pressure tests – Rayleigh Scattering

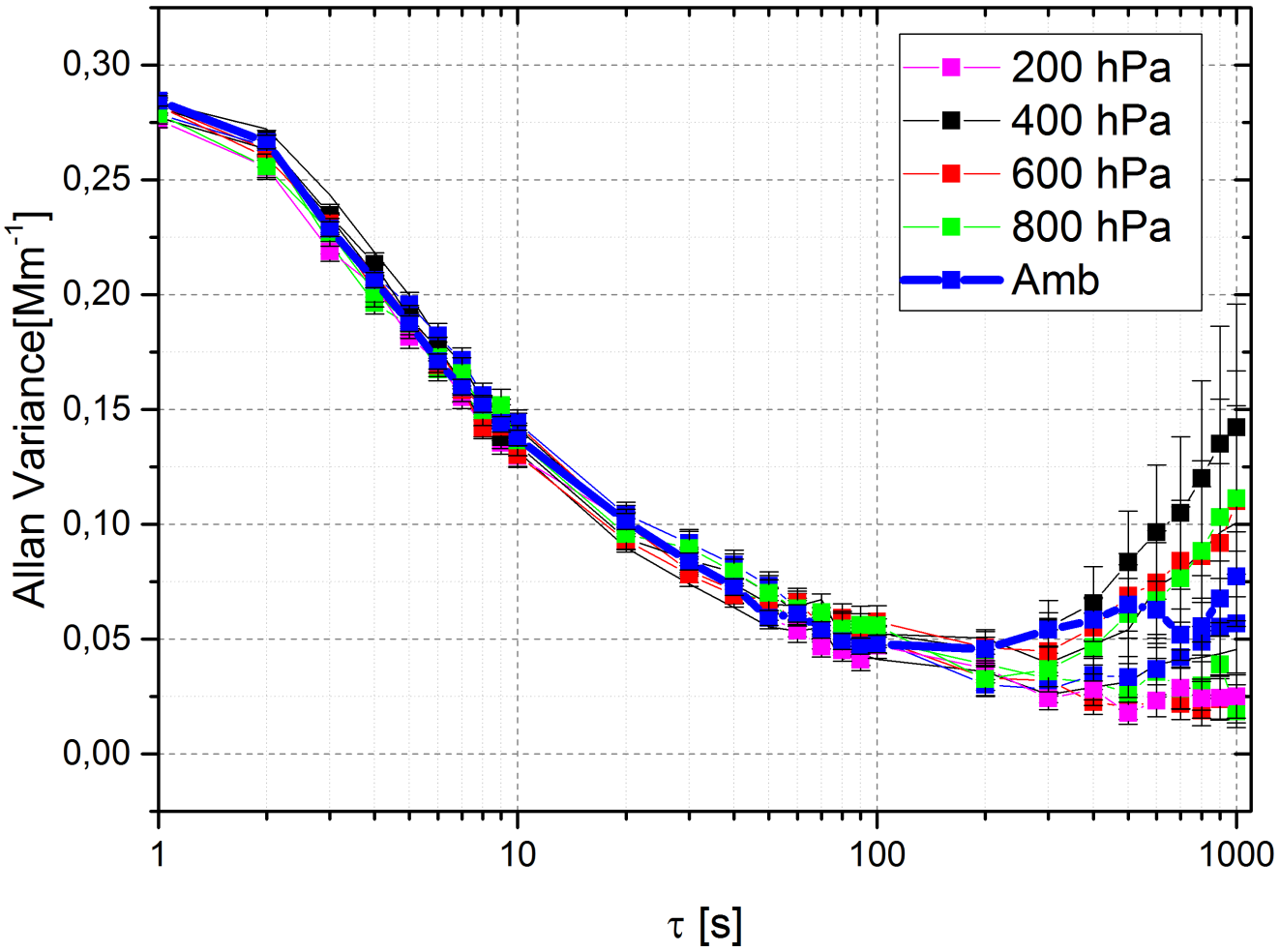


Comparison of measured and calculated σ_{ext} (air) for 9 h duration test run.

De Faria et al AST 2017

Labwork

Low-pressure tests – Allan analysis



CAPS Lab test results

- Physical principle is operative down to p ≅ 200 hPa.
- There is no dependence between instrument noise and operation pressure; the LOD permits observations in the upper troposphere and tropopause regions.
- Response of the instrument when sampling particles at p ≥ 200 hPa in accordance with Mie Theory.
- New flow system operates properly at low pressure; LOD is still within the range of the targeted atmospheric layer

De Faria et al AST 2017

Closure Experiment

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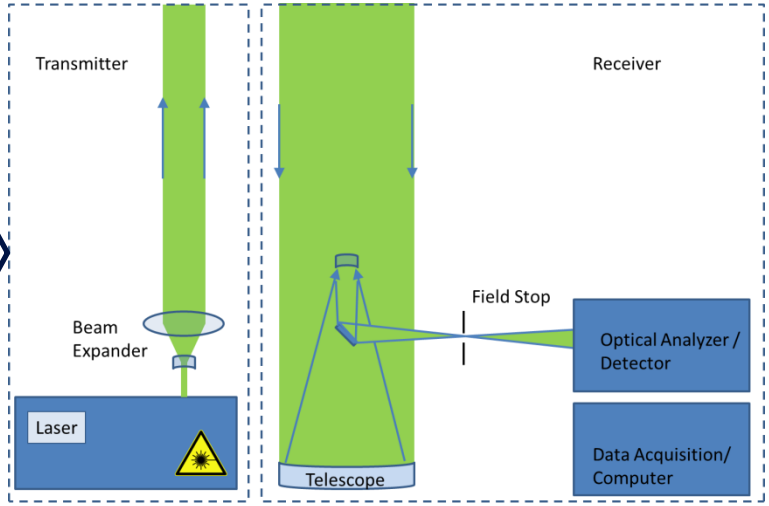
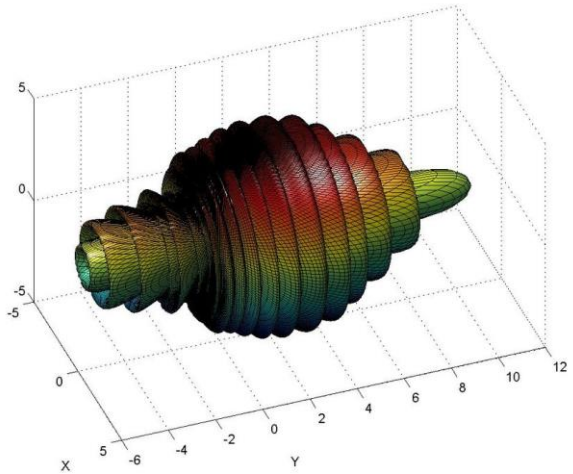
IAGOS

ACTRiS

- Cavity Attenuated Phase Shift (CAPS) allows in situ observation of light extinction
- Mie Scattering using Size Distribution measurement (OPC)

plus ENVRI



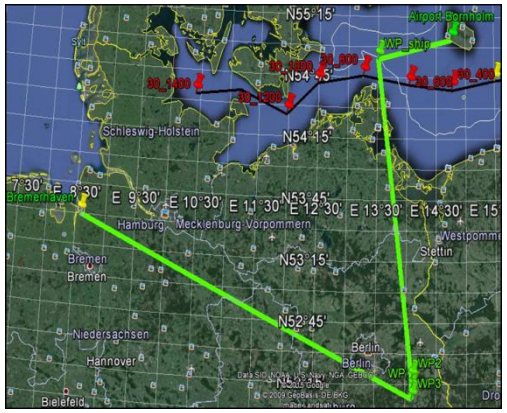


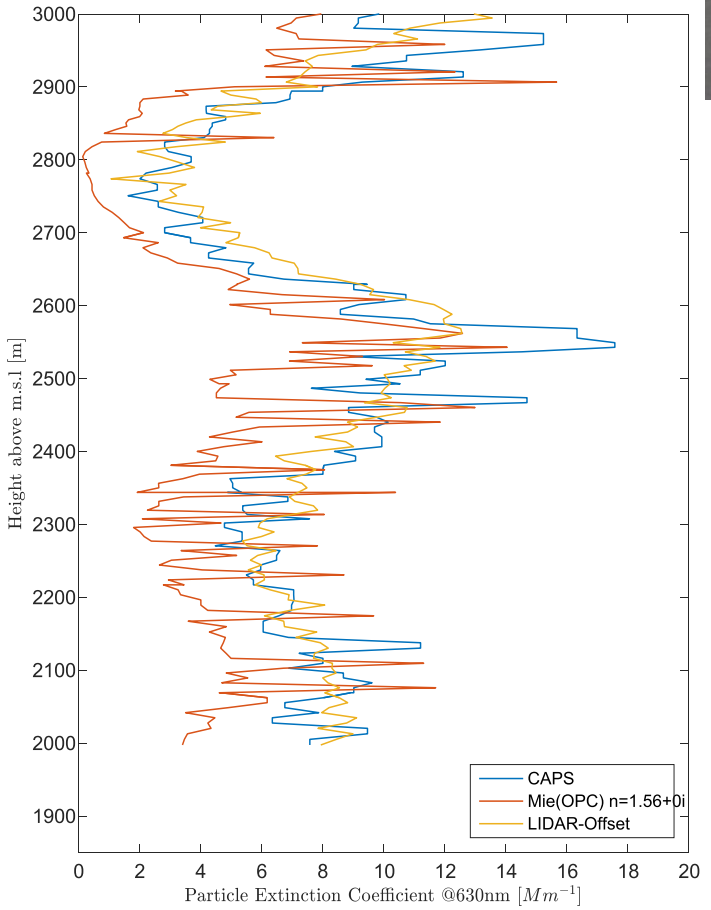
- LIDAR techniques represent the optimal tool to provide range-resolved aerosol data
- Several LIDAR techniques (Raman, HSRL) are suitable for dedicated aerosol studies

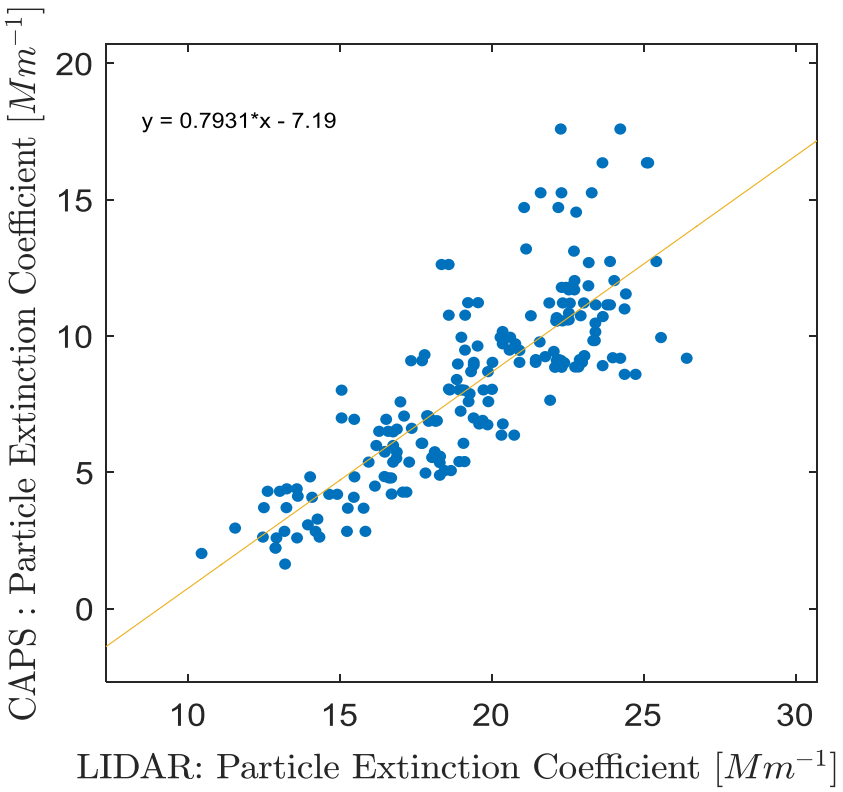
Aerosols, Clouds, and Trace Gases RI

IAGOS – ACTRIS Closure Experiment

CAPS PM_{ex} vs. Lidar
DWD Lindenberg observatory







TROPOMI VALIDATION (SENTINEL 5P)

(foreseen KNMI Cooperation)

Product	Main parameter
Aersol Layer Height	mid-level pressure
Carbon Monoxide (CO)	total column
Cloud	fraction, albedo, top pressure
Formaldehyde (HCHO)	total column
Methane (CH4)	total column
Nitrogen Dioxide (NO2)	total and tropospheric columns
Ozone profiles	total profile and tropospheric profile
Sulphur Dioxide (SO2)	total column
Total Ozone column	total column
Tropospheric Ozone column	tropospheric column
UV Aerosol Index	aerosol index
UV[1]	surface irradiance erythemal dose

Cooperation first contact made (Petzold, Berkes) for NOx / NO2 profiles

www.Tropomi.eu

INSTRUMENT DEVELOPMENT

Development and field test of IAGOS Air Quality Package P2e

Measured properties:

- NO2 concentration (CAPS NO2)
- Aerosol Extinction (CAPS: 650nm ,450nm)
- Aerosol Size Distribution
  (POPS OPC) 150 nm- 3 µm

Cooperations:

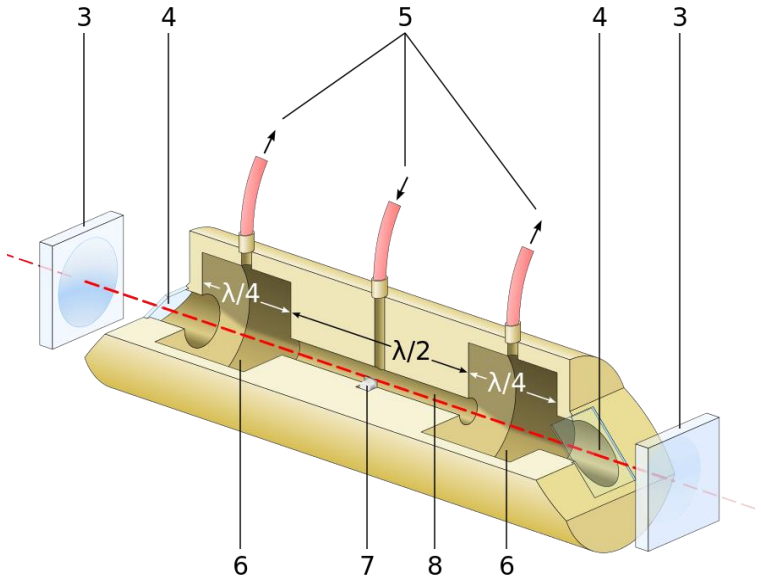
Aerodyne, NOAA (POPS) , Enviscope (PDR, CDR, …)

OUTLOOK INSTRUMENTS DEVELOPMENT:

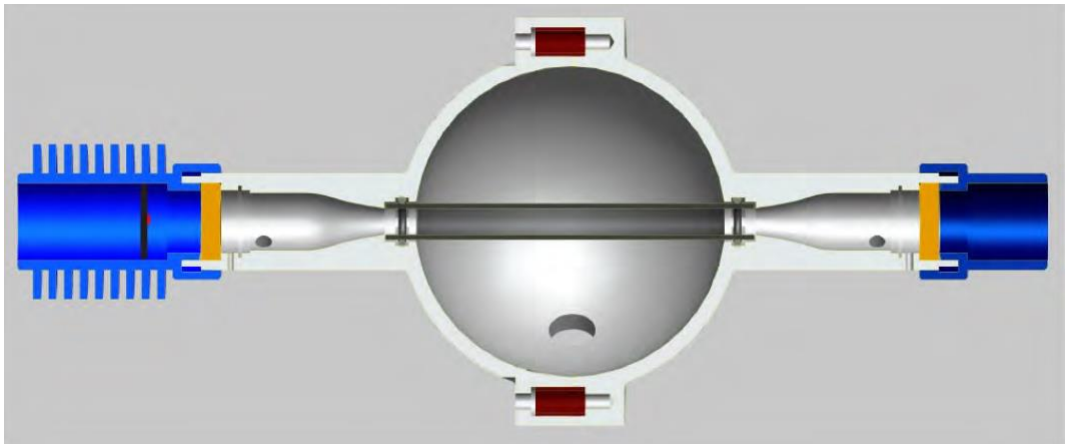
ADD ABSORPTION CHANEL TO THE AIR QUALITY INSTRUMENT

(BC Proxy, Lab stage)

Classical photoacustic Resonator
Unsing resonance the detection signal is amplified 100 times (40db‘)



Aerodyne SSA monitor, combining
The CAPS tecnology for extinction measurement and the integrating sphere fpor scattering measurements



Thanks to the Team!