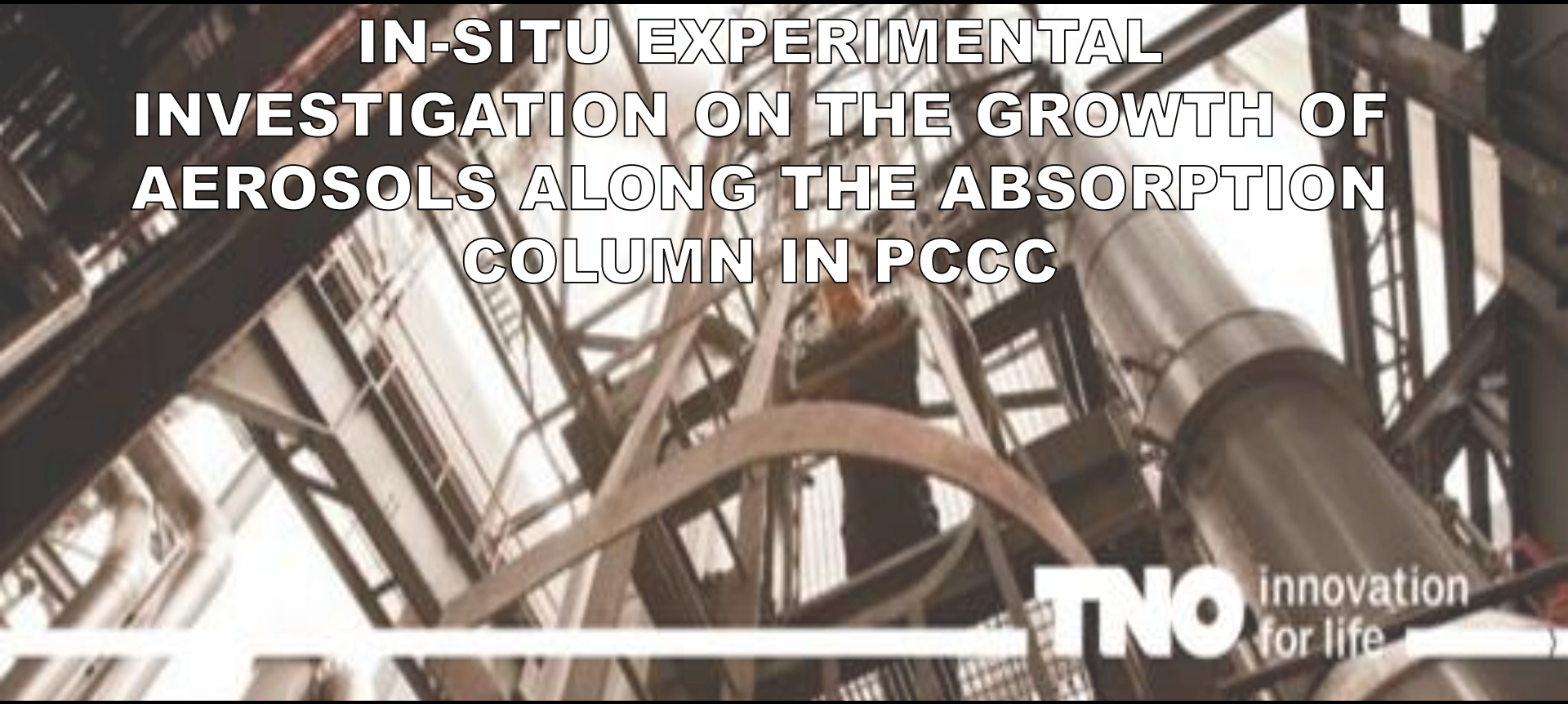


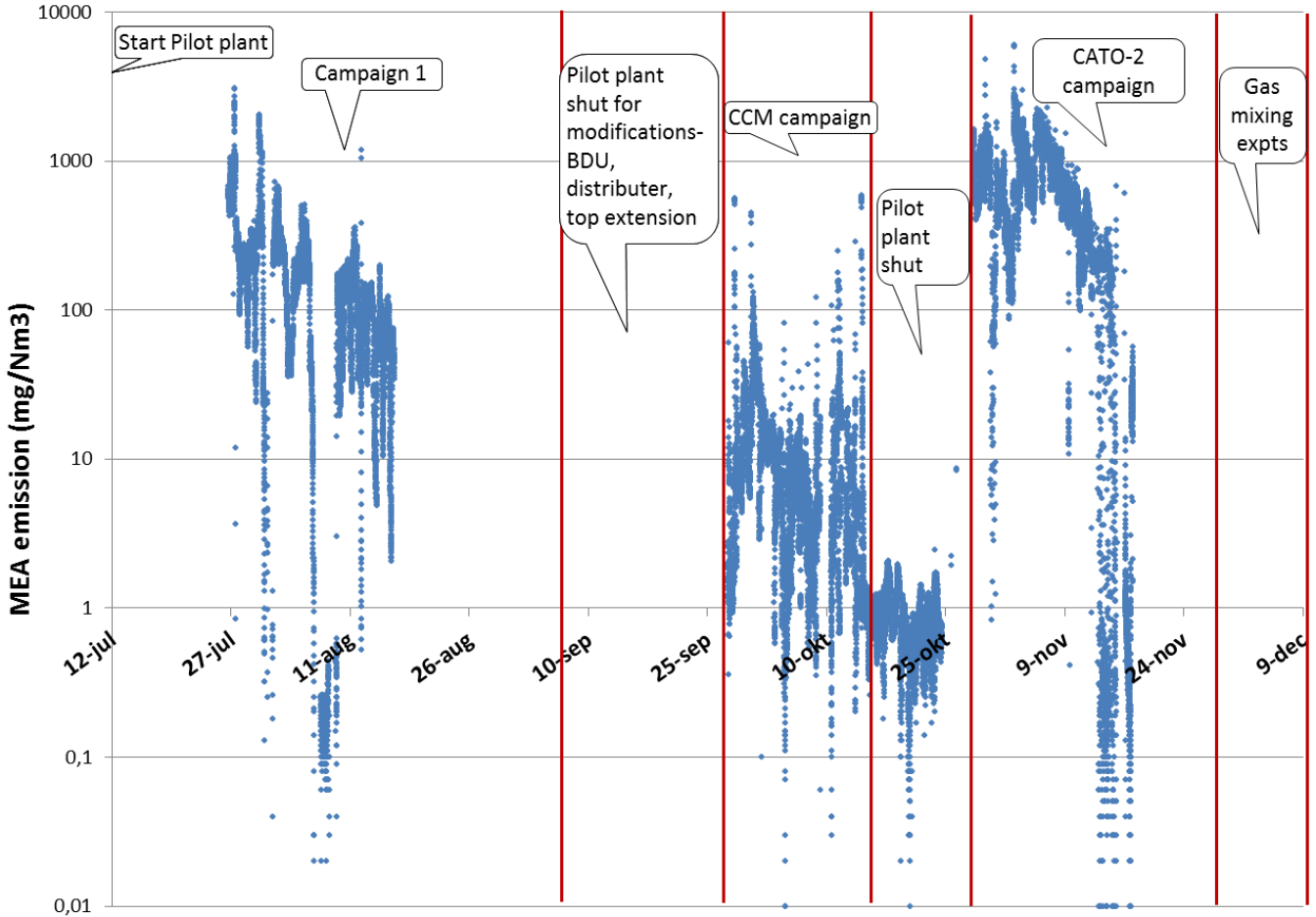
Shreyas Harsha, Purvil Khakharia, Arjen Huizinga, Juliana Monteiro, Earl Goetheer, Thijs Vlugt

CO2 CATCHER CARBON CAPTURE PLANT

Hard coal fired power plant
Maasvlakte, Netherlands

50 cm diameter absorber,
capacity 6 ton of CO2 captured per day

PILOT CAMPAIGN (CATO-2)

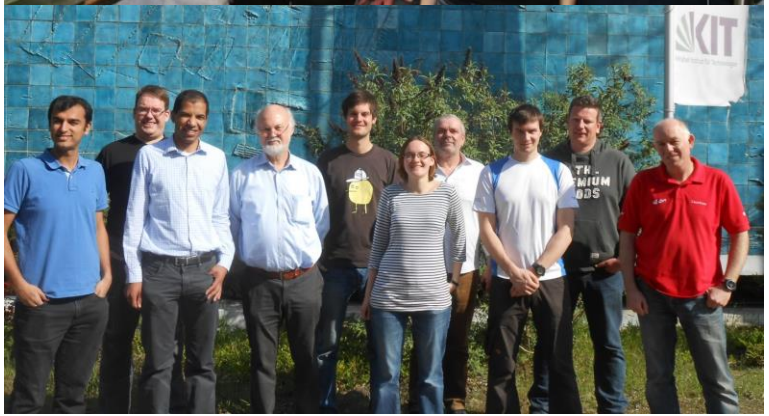


ISSUE AT HAND

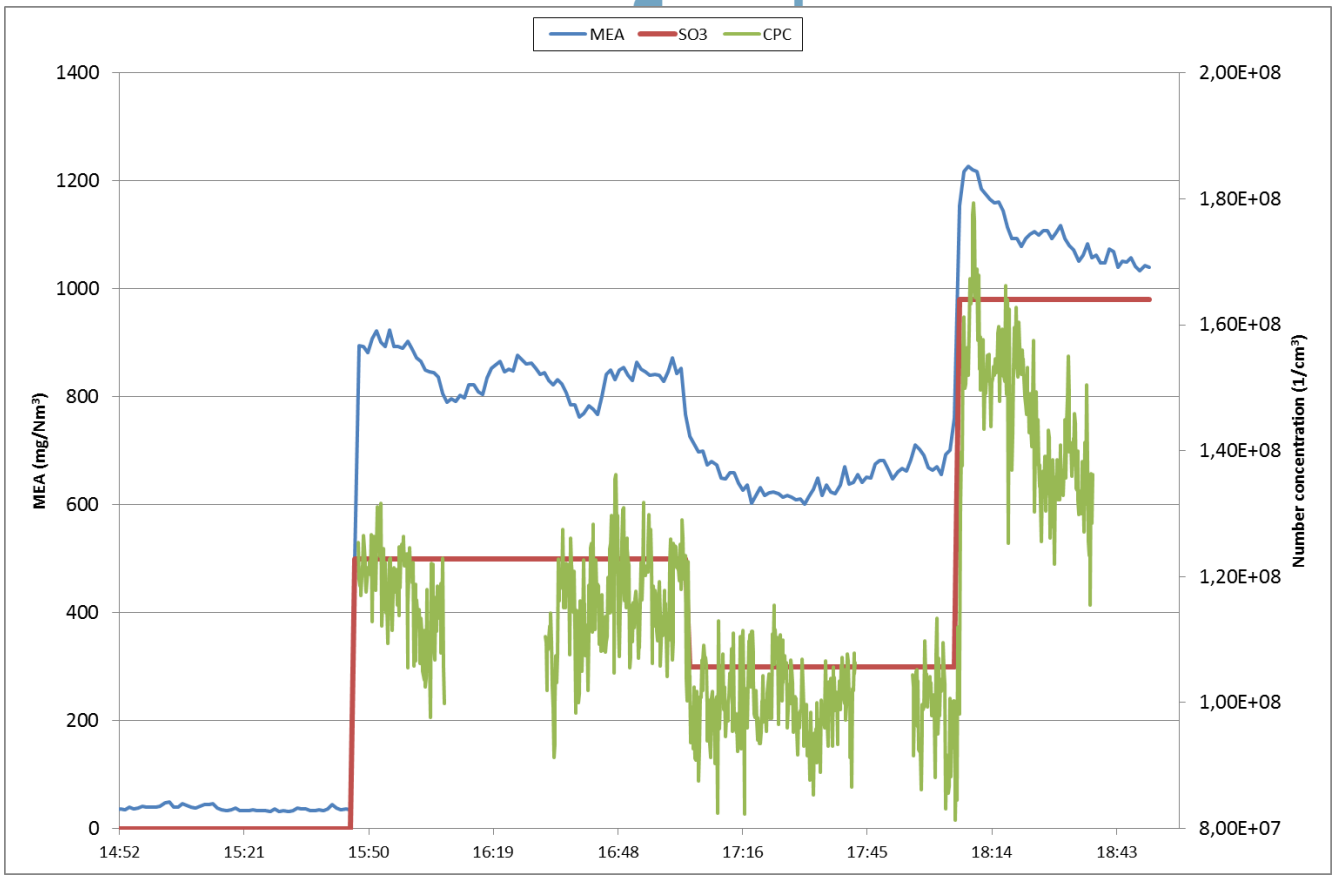
Volatile emission

Aerosol emission

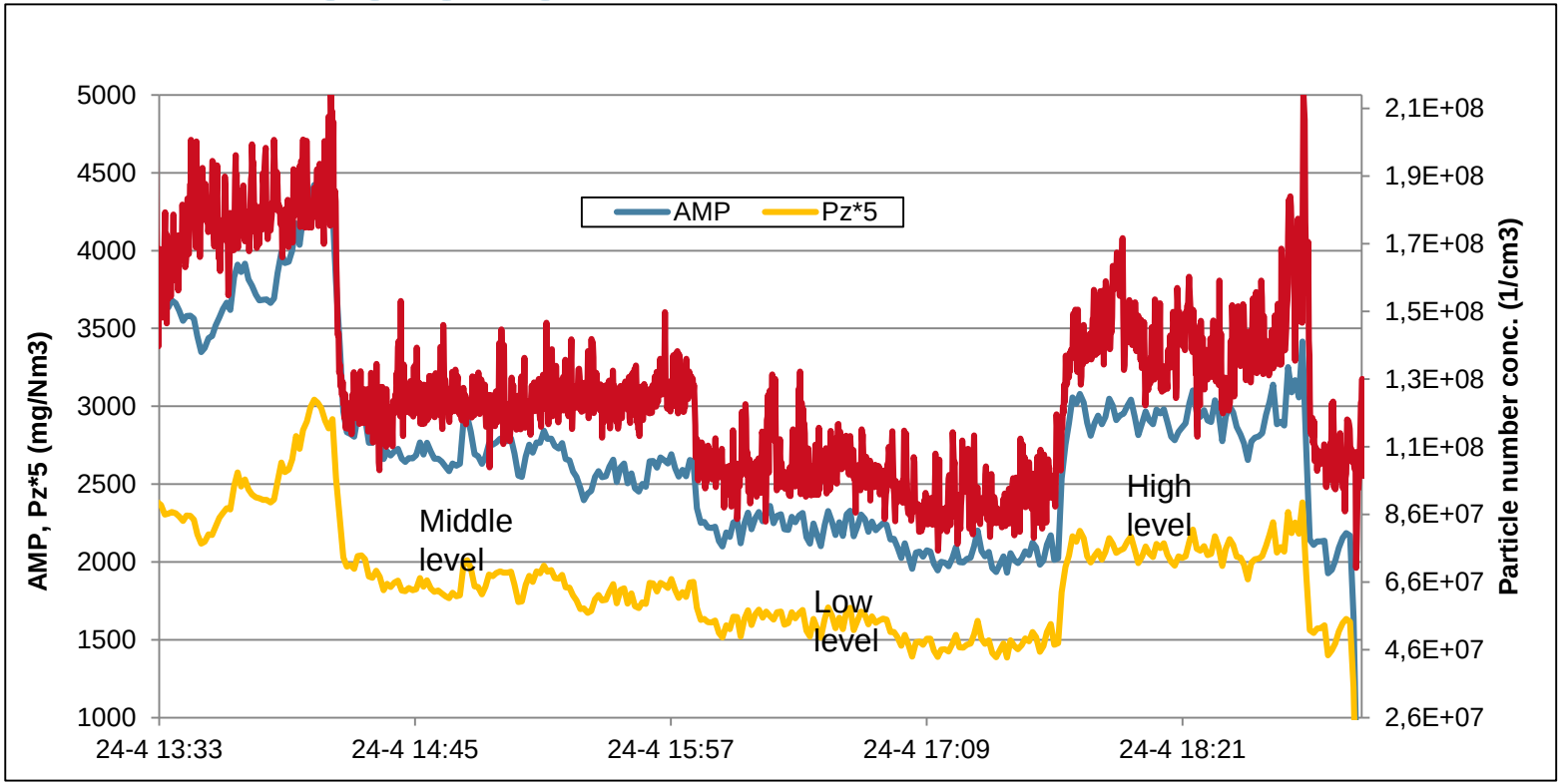
Karlsruhe testing campaigns - CATO



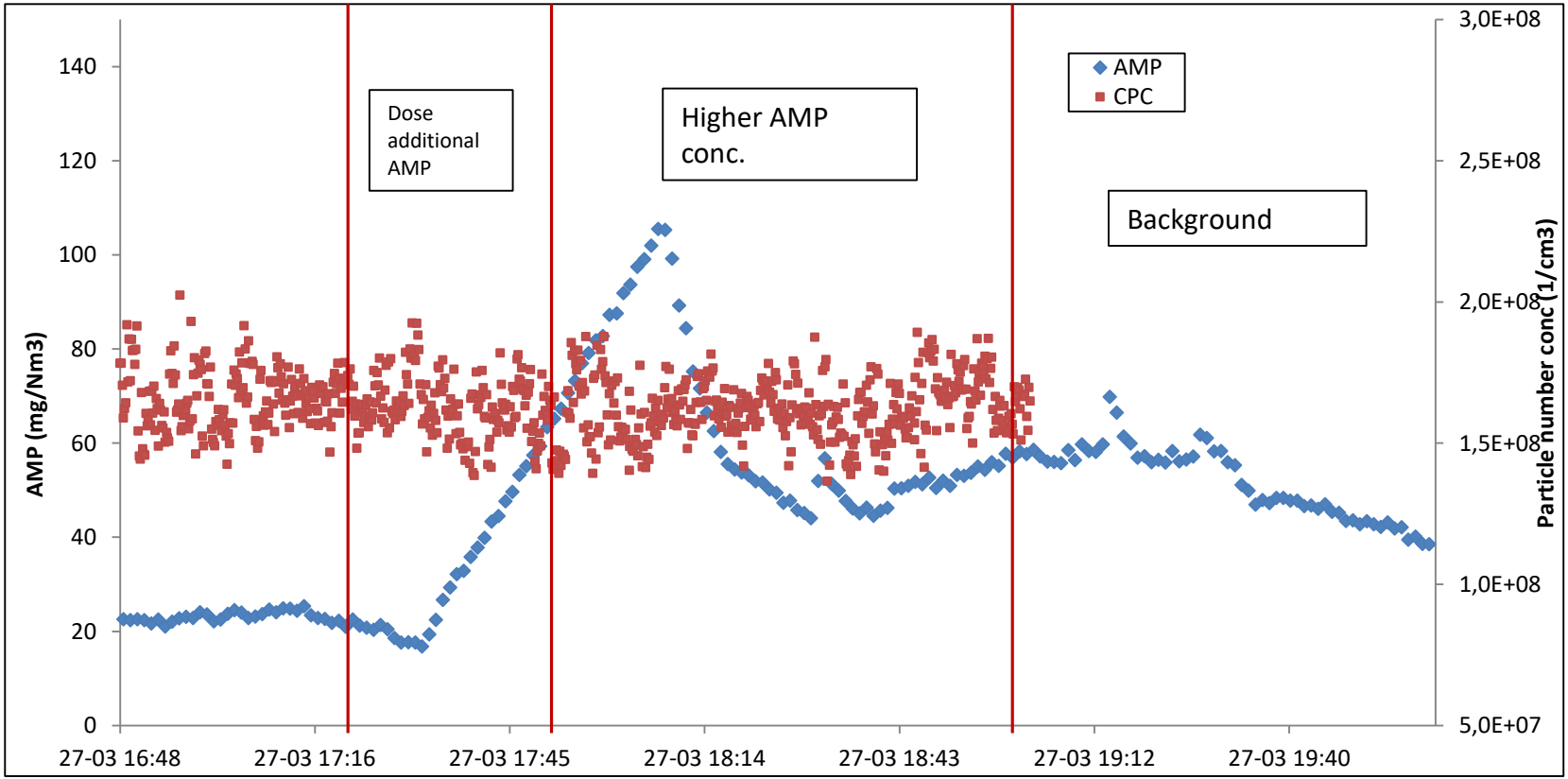
Effect of H_2SO_4 aerosols



EFFECT OF H_2SO_4 AEROSOLS ON AMP-PZ EMISSIONS



AMP KTAURATE

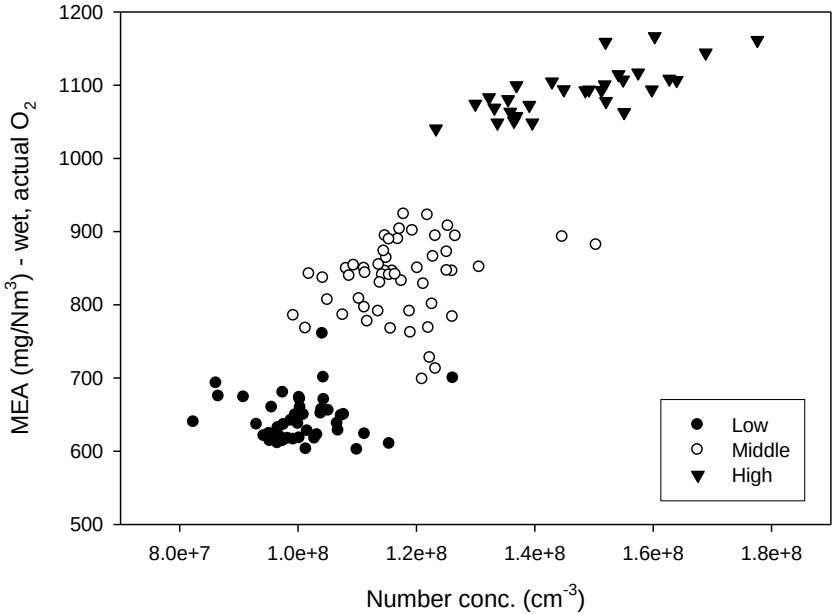


EXTENSIVE TEST CAMPAIGNS

TNO innovation for life

Unique facilities:
Fully controlled SO3 and soot spiking in flue gas before capture

Aerosol research:
- Determined relation between flue gas quality and emission
- Detailed models constructed



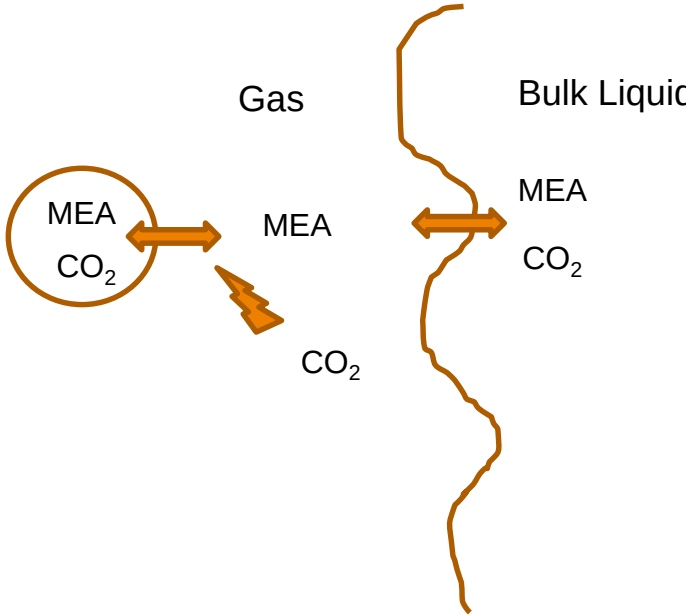
Aerosol testing done
At power plants:
- Maasvlakte
- Electrabel Nijmegen
- ENBW Heilbronn
- RWE Niederaussem

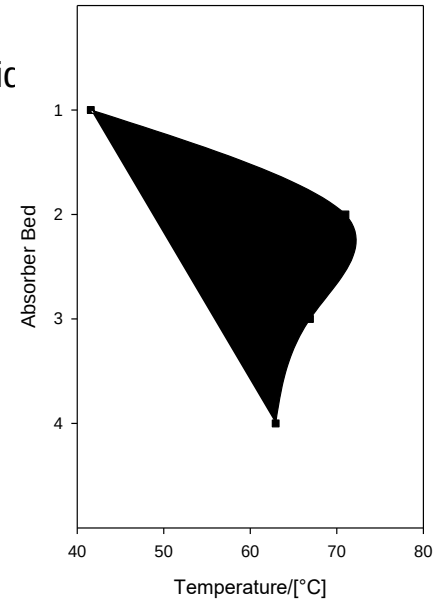
At waste incinerator
- AVR

At dedicated aerosol generator setups
- Karlsruhe

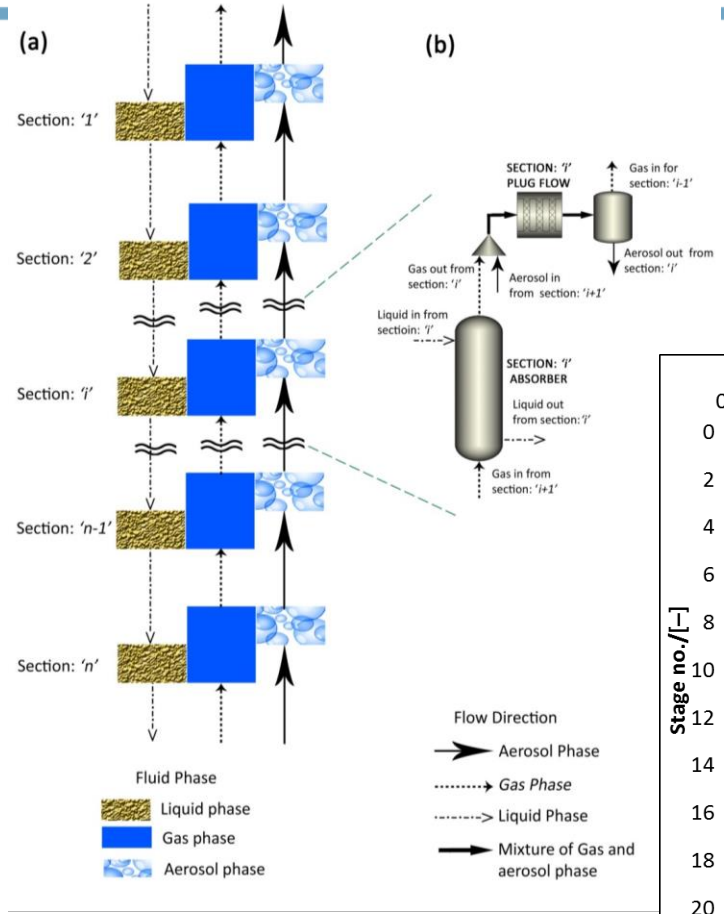
MECHANISM FOR AEROSOL EMISSIONS

Volatility and reactivity is key

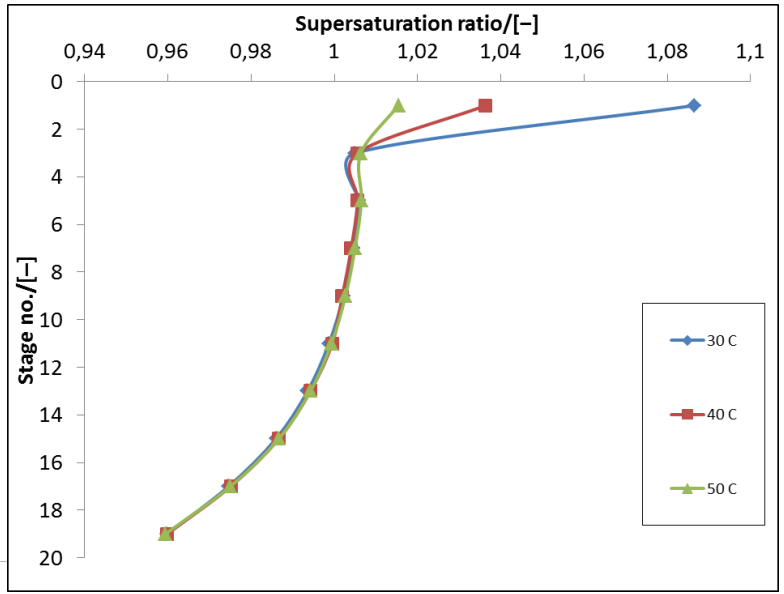




$$S = \frac{P_C\ (T, y_1, y_2\ \ldots . y_n)}{P_{CS}\ (T, y_1, y_2\ \ldots . y_n)} \qquad \text{Eq (1)}$$

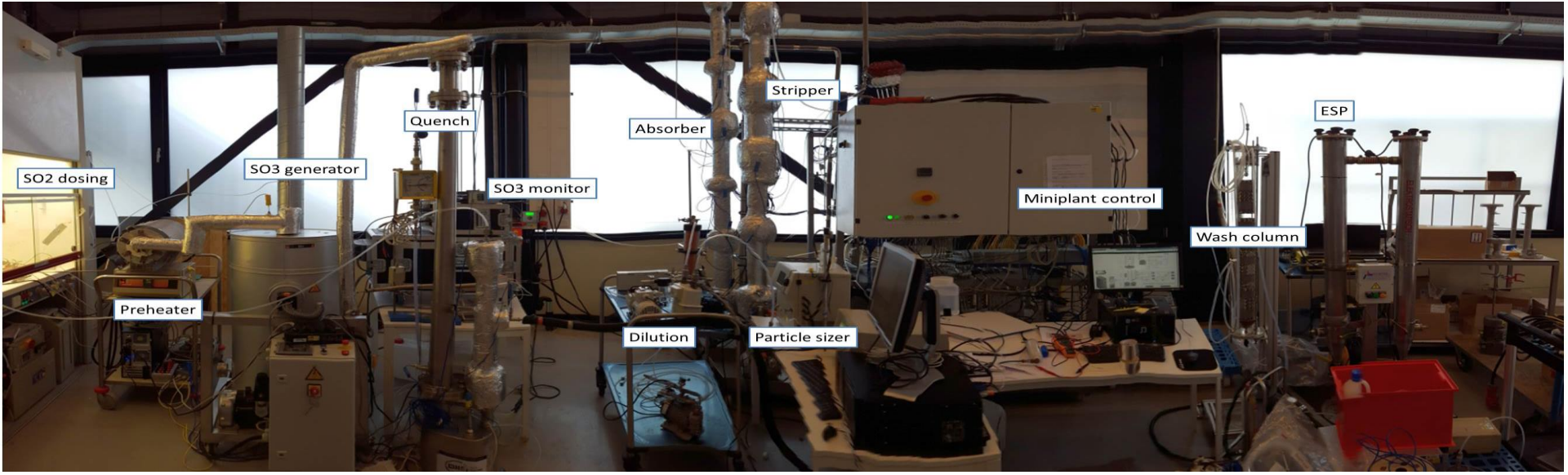


Supersaturation>1, indicates area for excessive aerosol growth

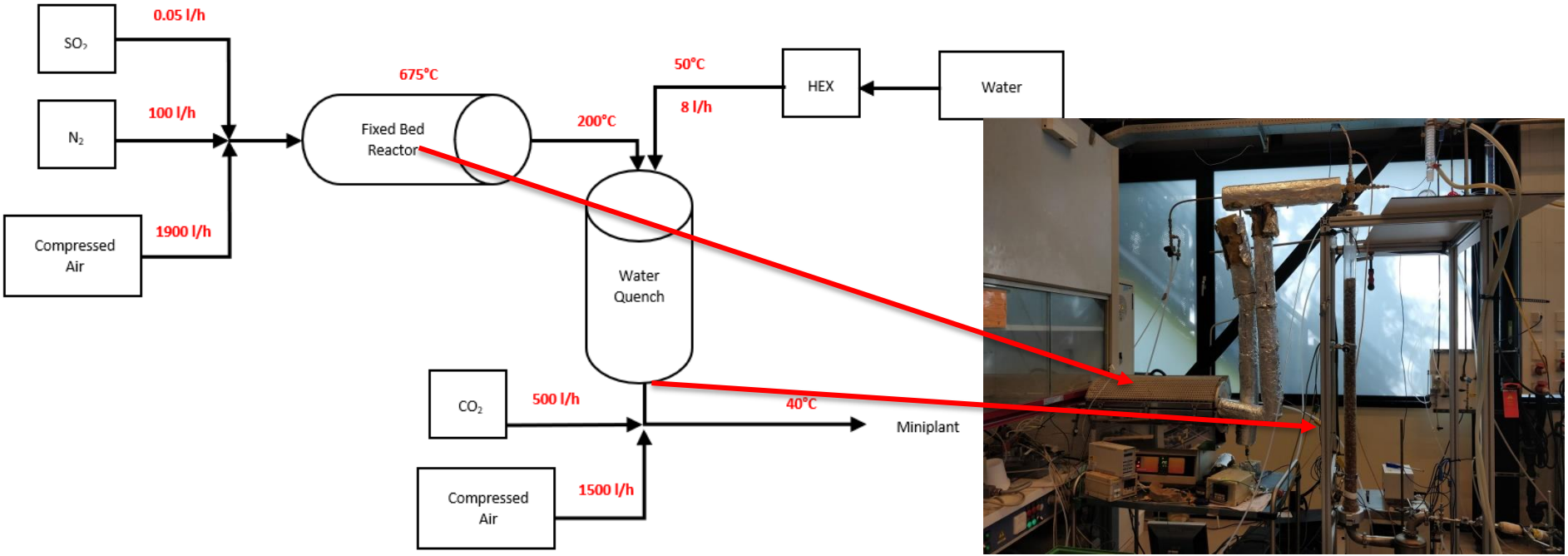


TEST EQUIPMENT

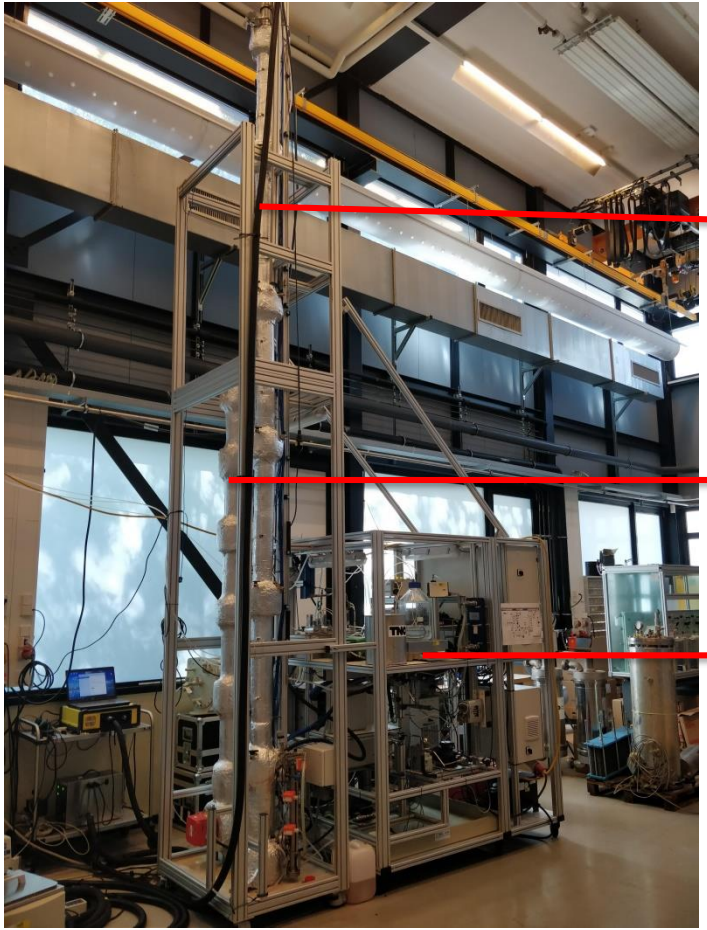
- TNO has recently developed infrastructure to generate H_2SO_4 aerosol droplets in-house, simulating the aerosols as observed in a power plant. A wide range of H_2SO_4 concentrations and thus, particle number and size distribution can be obtained from this setup.



SO3 GENERATION SYSTEM



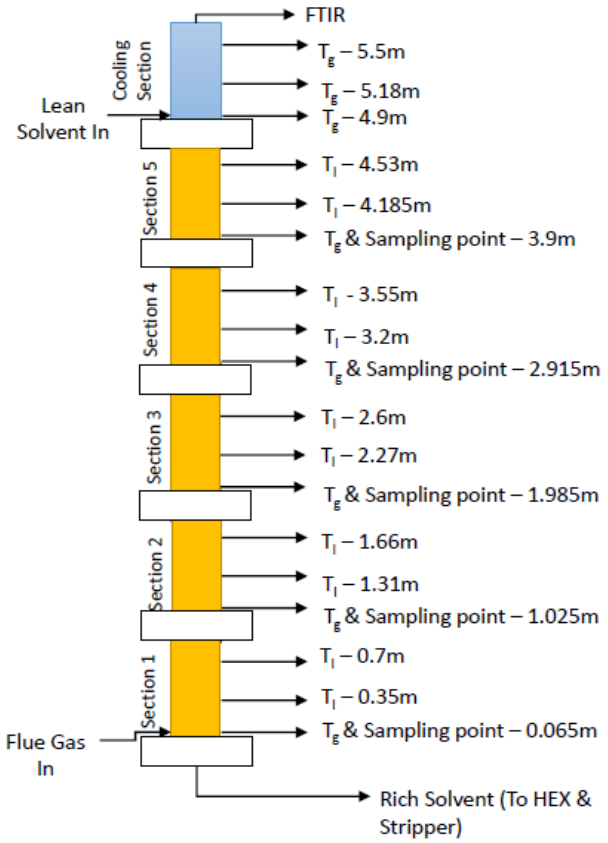
CO2 CAPTURE MINI-PLANT



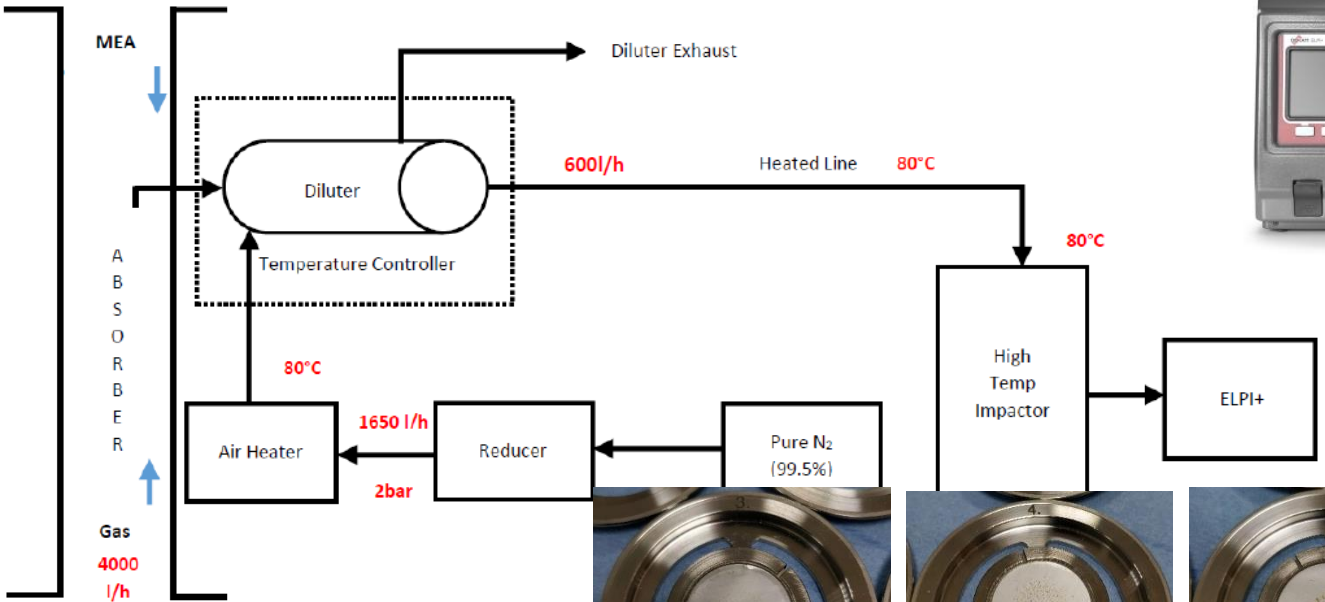
Absorber

Stripper

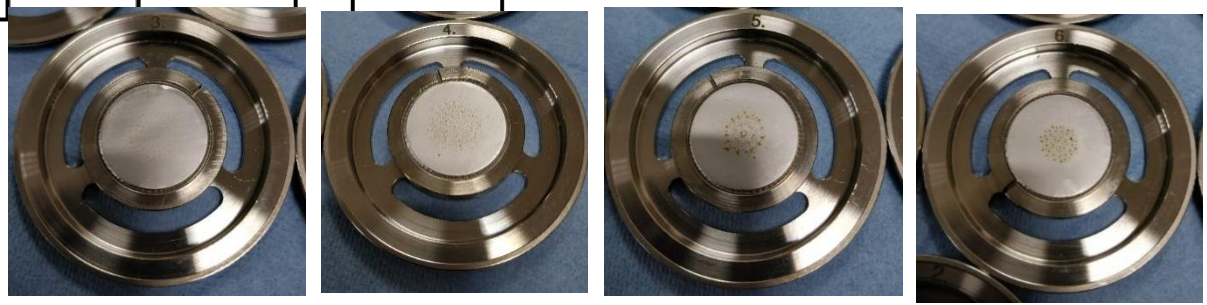
Heat exchangers, pumps, …



TEST SETUP



ELPI – Particle Measurement



From top left: Stage 3 (0.0265µm), Stage 4(0.0485µm), Stage 5 (0.087µm) and Stage 6 (0.147µm)

TEST PLAN

- A first “empty column” test was conducted to understand survival of particles across the column and understand sampling methodology related influences.
- This was followed by a test in the absence of H_2SO_4 aerosol in flue gas
- Test with H_2SO_4 aerosol in flue gas is termed as “Benchmark test”
- Once the CO_2 capture unit is stable, perform particle measurement and measure gas composition at 5 different gas sampling points across the column – **FTIR & ELPI** (5-8 mins at every sampling point)

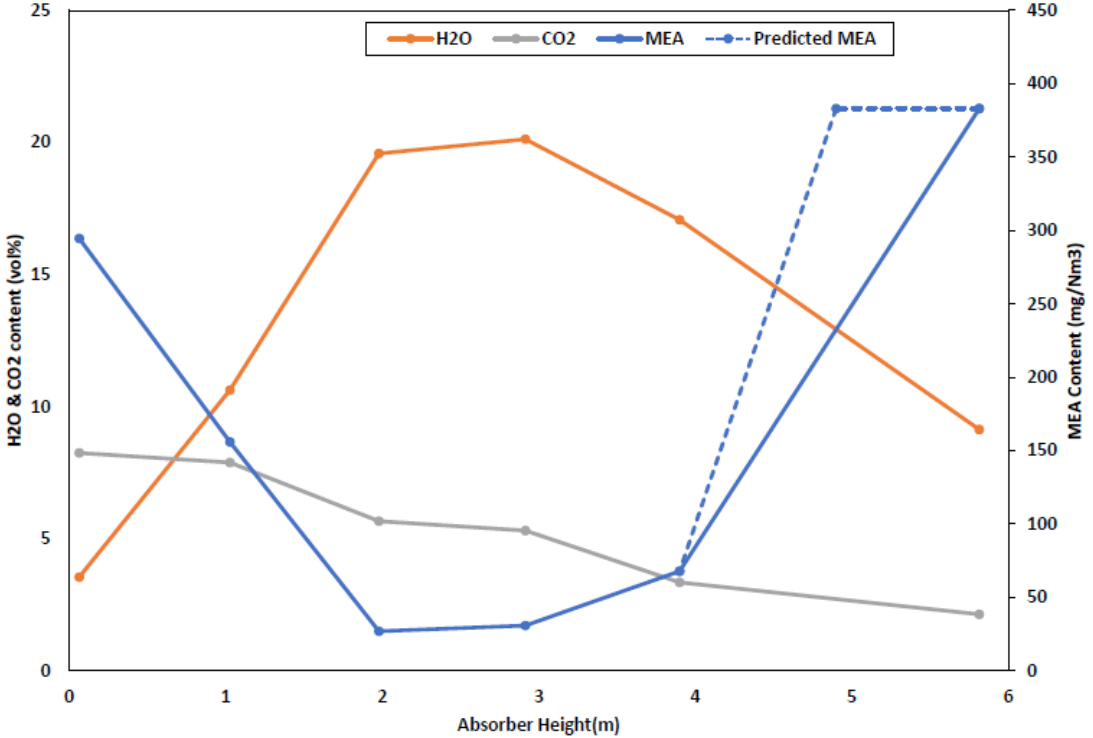
Test no	Total Particle Number
1	Measurements in absence of solvent flow→ Empty column test
2	Absence of H_2SO_4 aerosol in flue gas
3	Benchmark test

Benchmark test parameters

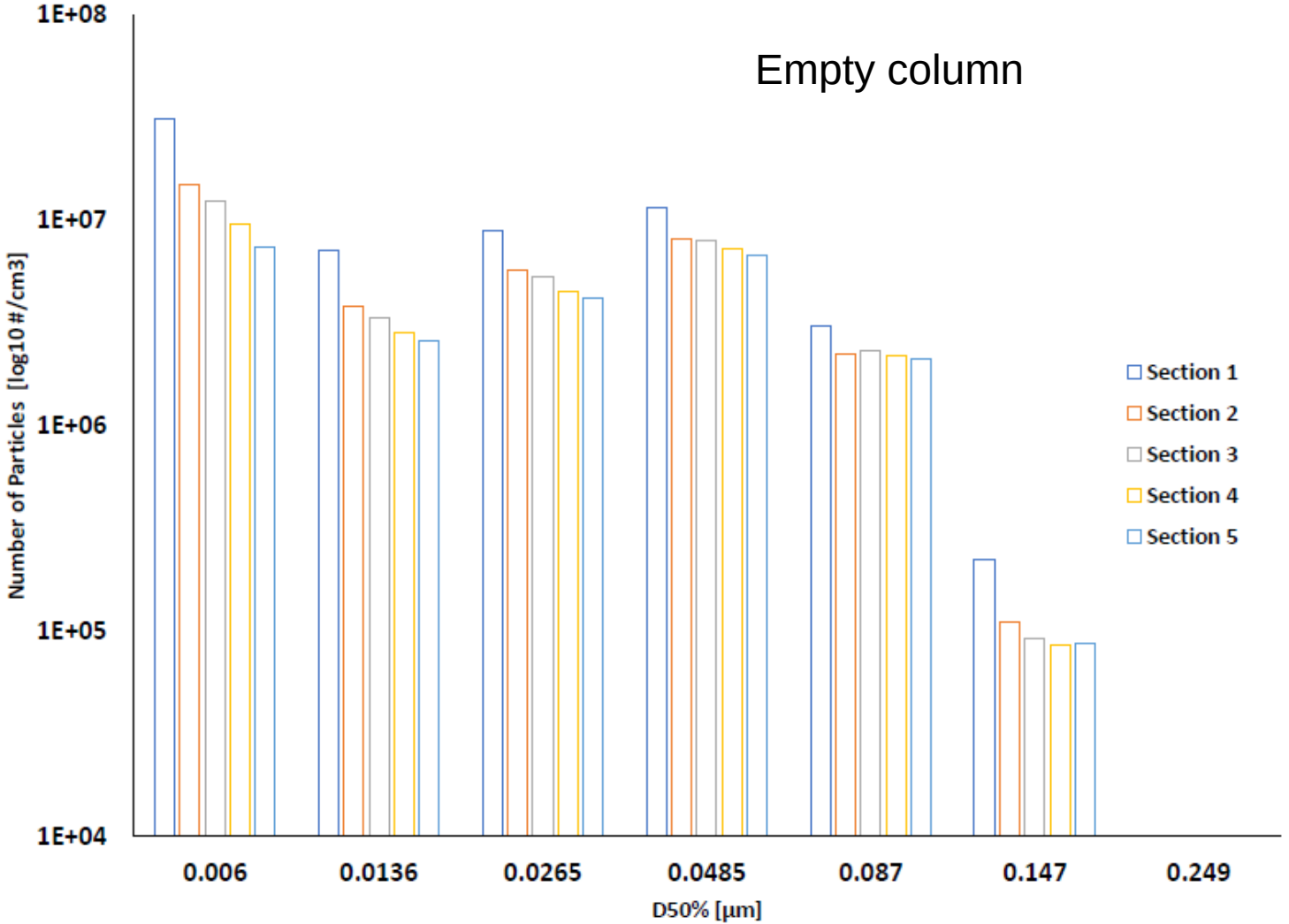
Parameter	Value
Flue Gas Flow Rate	4 m^3/h
CO_2 in Flue Gas	12.5 vol.%
Flue Gas Temperature	40°C
SO_3 in Flue Gas	5.25 ppm

ABSENCE OF H_2SO_4 AEROSOL IN FLUE GAS

- Gas phase FTIR measurements across different sections are as expected for CO2 and water vapour.
- MEA emissions of 381 mg/Nm^3 , mainly in vapour phase.

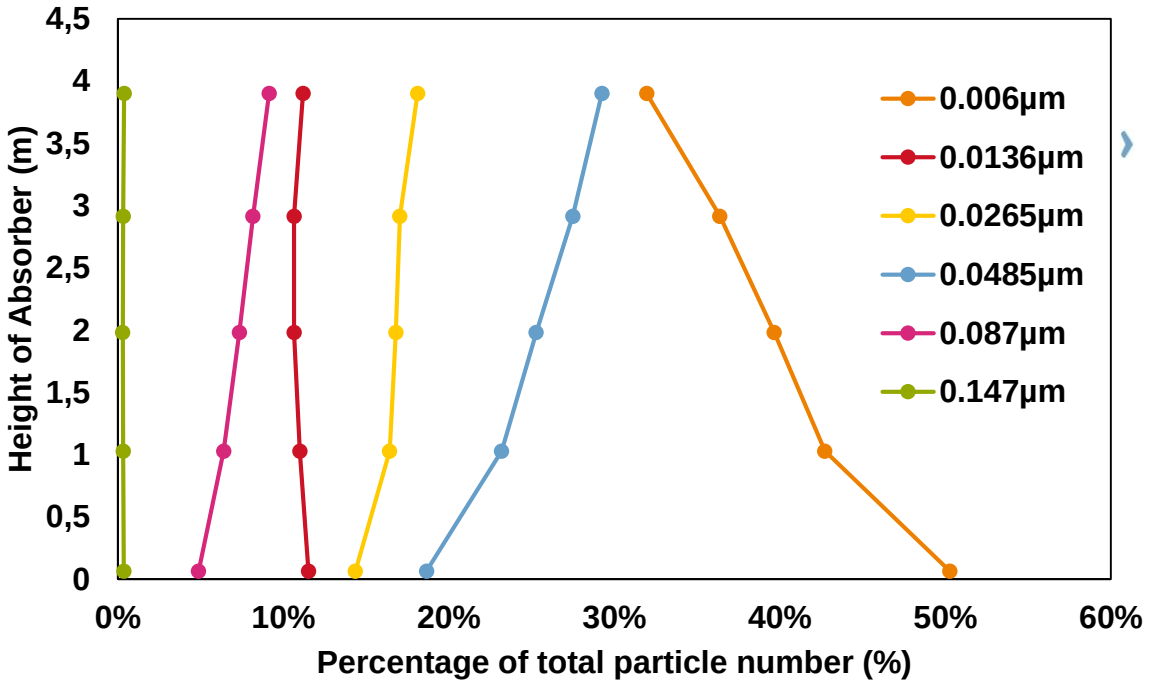


Empty column



Kill ratio: ~70%

RESULTS- BENCHMARK TEST



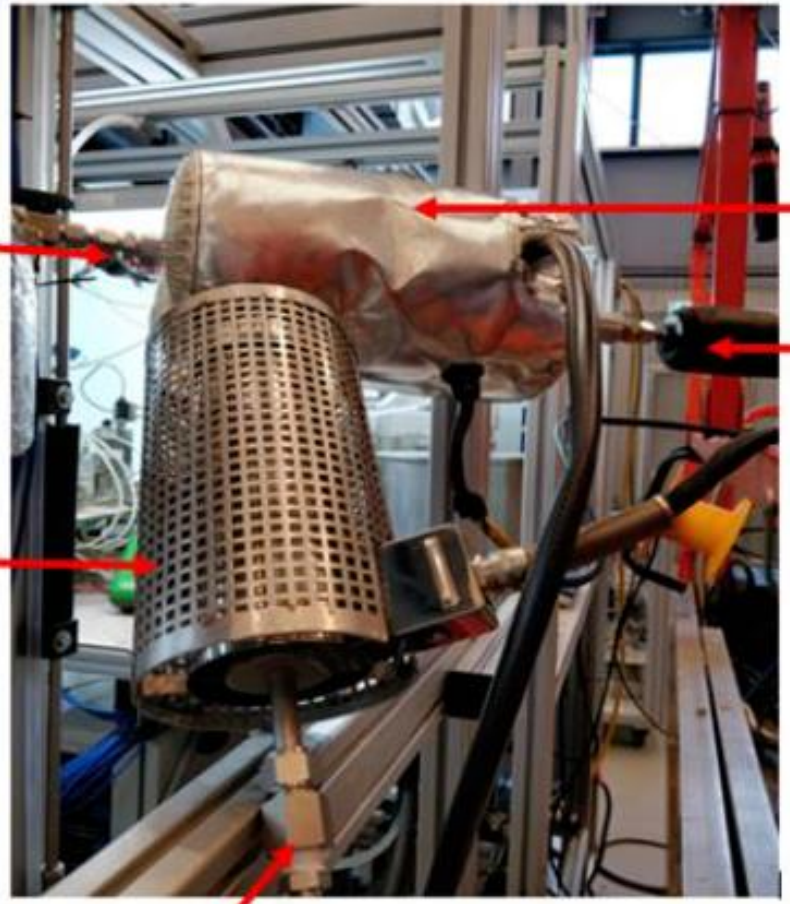
- Reduction in contribution of 0.006 & 0.0136µm to total number along the column
- Increase in contribution of 0.0265, 0.0485, 0.087 & 0.147 µm to total number

Shift in Particle Size Distributions towards right (Larger Particles):

Growth of Aerosols

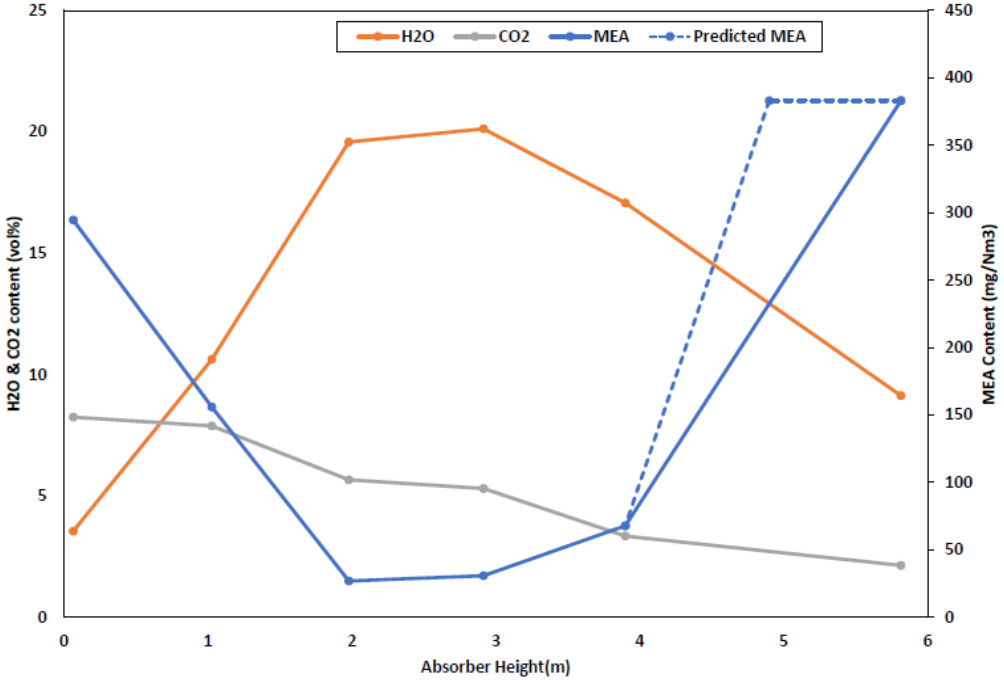
BENCHMARK TEST

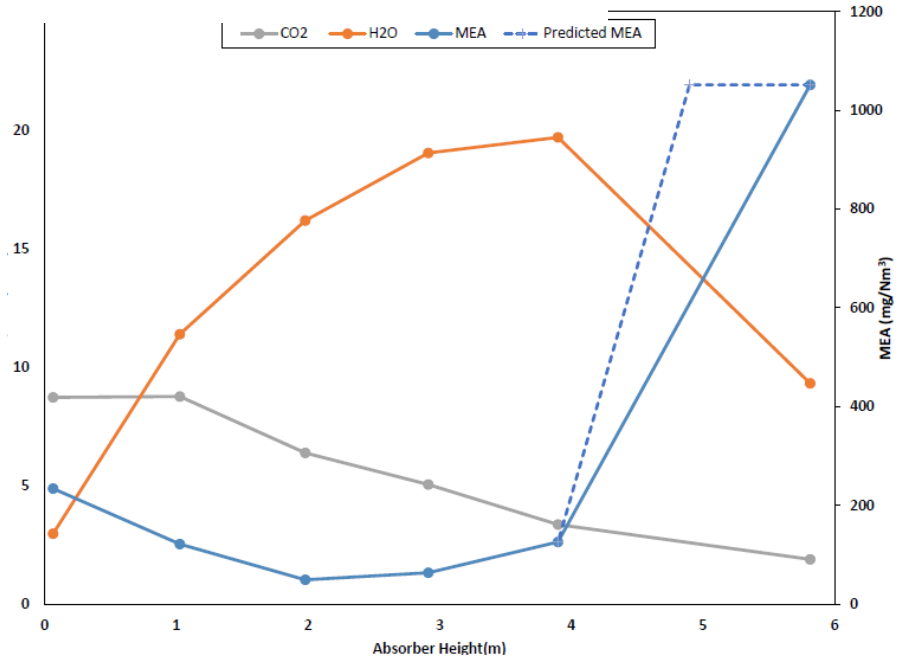
- Total aerosol mass at absorber outlet is 1.32mg/m^3. However, MEA aerosol mass is 850mg/Nm^3
- Assuming MEA in aerosol is 850mg/Nm^3 and, each droplet contains 5 mol/L of MEA, and a total number of 2.3E+07/cm^3, the total aerosol mass should be 2700 mg/Nm^3
- To account for the above mismatch;
  - Either each aerosol droplet contains much more than 5 mol/L of MEA (highly unlikely)
  - Larger particles not recorded by the ELPI+ leads to gross underestimation of aerosol mass


Gas sampling position in absorber
Diluter & Diluter heater
Heated Line – Towards ELPI
Diluter Air heater
Dilution Air

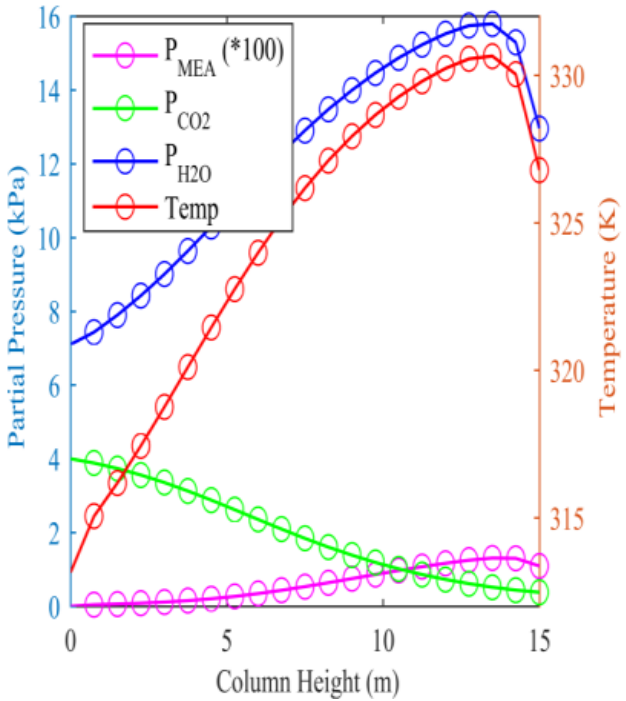
FTIR MEASUREMENTS

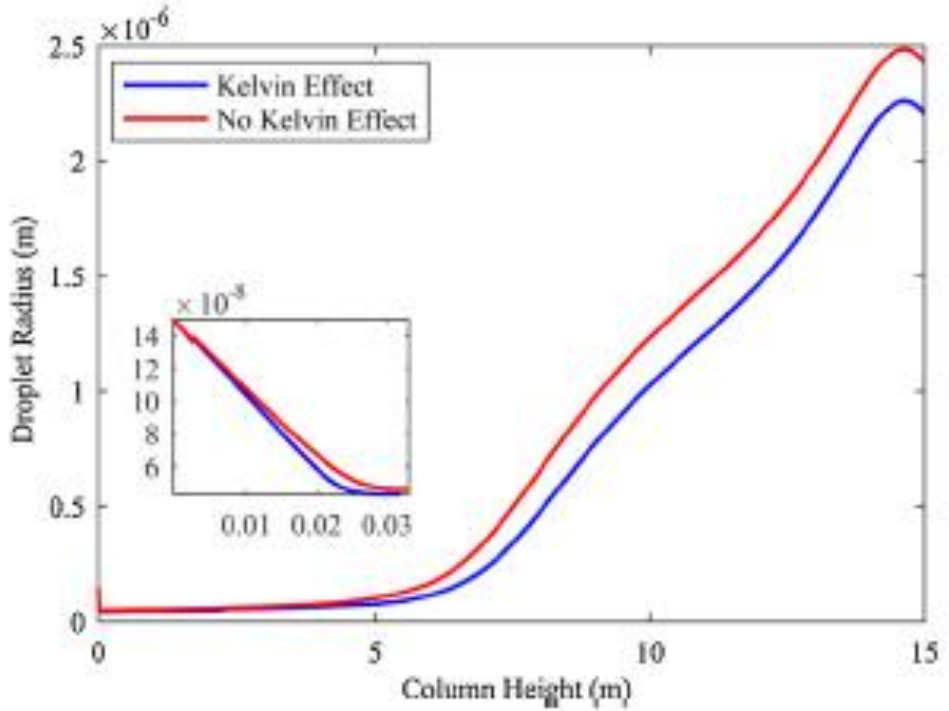
Number of particles at inlet (Section 1) (#/cm^3)	Number of particles at exit (Section 5) of absorber (#/cm^3)	Absorber Outlet CO_2 content (vol%)	CO_2 capture rate (%)
6.24x 10^7±1.78x 10^6	2.3x 10^7±5.86x10^5	1.9±0.003	87±0.25





COMPARISON RIGOROUS MODELLING NTNU





Characterization and modelling of aerosol droplet in absorption columns
Maheed et al, Int. J. Green. Gas Control. 58 (2017) 114–126

CONCLUSIONS

- Typically 30-70% of the aerosols agglomerate or collide with the wall
- ELPI measurements size distribution strongly temperature and sampling method depended
- FT-IR measurements along the column can give insights in the mechanism
- Total vapor-aerosol MEA measurements along the column indicate the majority of the MEA transfer to Aerosol emission takes place at the top of the column (as suggested by rigorous modelling NTNU)

FUTURE WORK

- Improve sampling method
- Mixed amine systems


THANK YOU FOR YOUR ATTENTION
TNO innovation for life
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