Session S3

Towards innovative optical gas standards for N_2O – advancing metrological traceability for greenhouse gas quantification and control

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TILSAM and Optical Gas Standards

- To complement existing CRMs, especially for sticky and reactive gases, or applications which cannot be provided with static gas cylinders,
- alternative calibration and traceability strategies are required,
- and have been demonstrated based on instrumental standards.

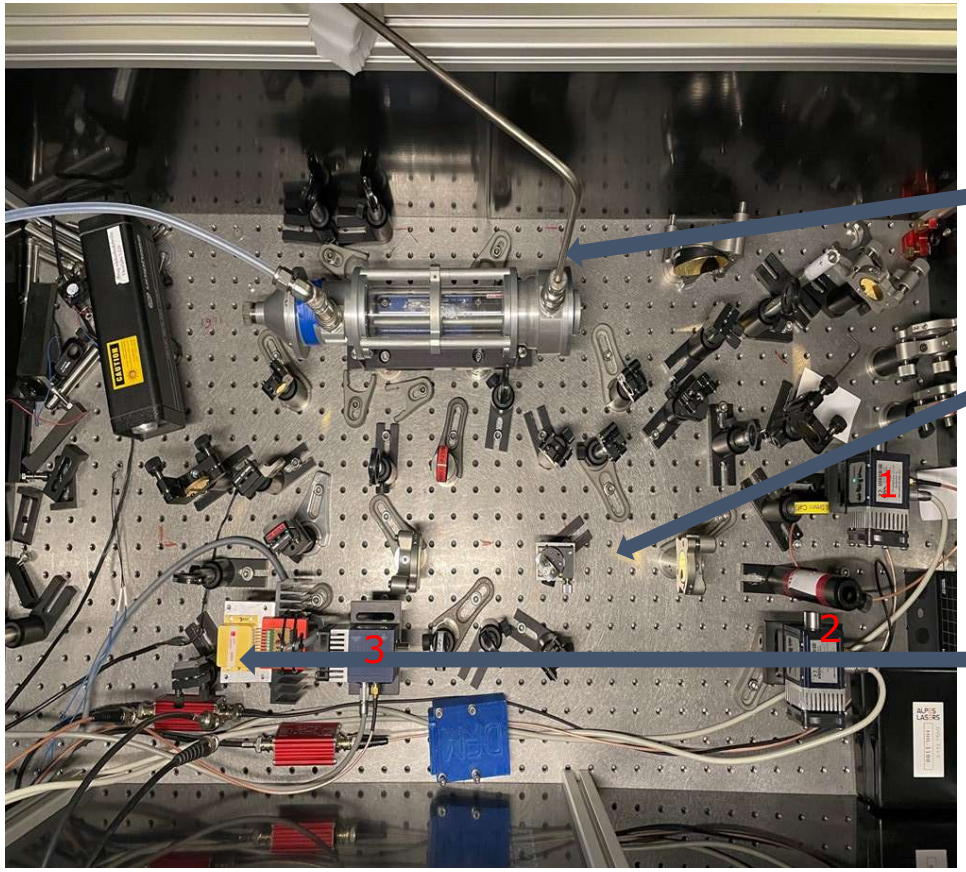
TILSAM and Optical Gas Standards

- **T**raceable **I**nfrared **L**aser-**S**pectrometric **A**mount fraction **M**easurement;
- publicly available technical protocol for the TILSAM method;
- has been demonstrated based on realised instrumental standards for a number of species (H_2O, NO_2, CO_2, CO);
- underlying method of a published CMC on HCl (https://si-digital-framework.org/kcdb-cmc/EURAMET-QM-DE-00000OIY-1)
- makes use of first principle modelling of the linear absorption process by gas phase molecules.

Current situation with N_2O gas standard

N_2O in Atmosphere	337.91 nmol/mol		
Service-Provider	Matrix	CMC	Expanded Uncertainty CMC
China NIM	nitrogen or air	[200 to 400] nmol/mol	[0.3 to 0.15] %
Japan NMIJ AIST	nitrogen or air	[200 to 2.00E7] nmol/mol	[0.2 to 0.1] %
Korea, Republic of KRISS	air	[200 to 2.00E4] nmol/mol	[0.2]%
Netherlands VSL	synthetic air	[100 to 3.00E4] nmol/mol	[2 to 1] %
Russian Federadtion VNIIM	synthetic or real air	[200 to 400] nmol/mol	[1]%
United Kingdom NPL	nitrogen or air	[50 to 1.00E4] nmol/mol	[2 to 0.34] %
United States NIST	synthetic air	[200 to 2.00E4] nmol/mol	[3.5 to 2] %
WMO - International Organization NOAA/ESRL	natural air	[260 to 370] nmol/mol	[1 **[0.4 to 0.3] %** ol

Work-in-progress 1.65 µm wavelength range



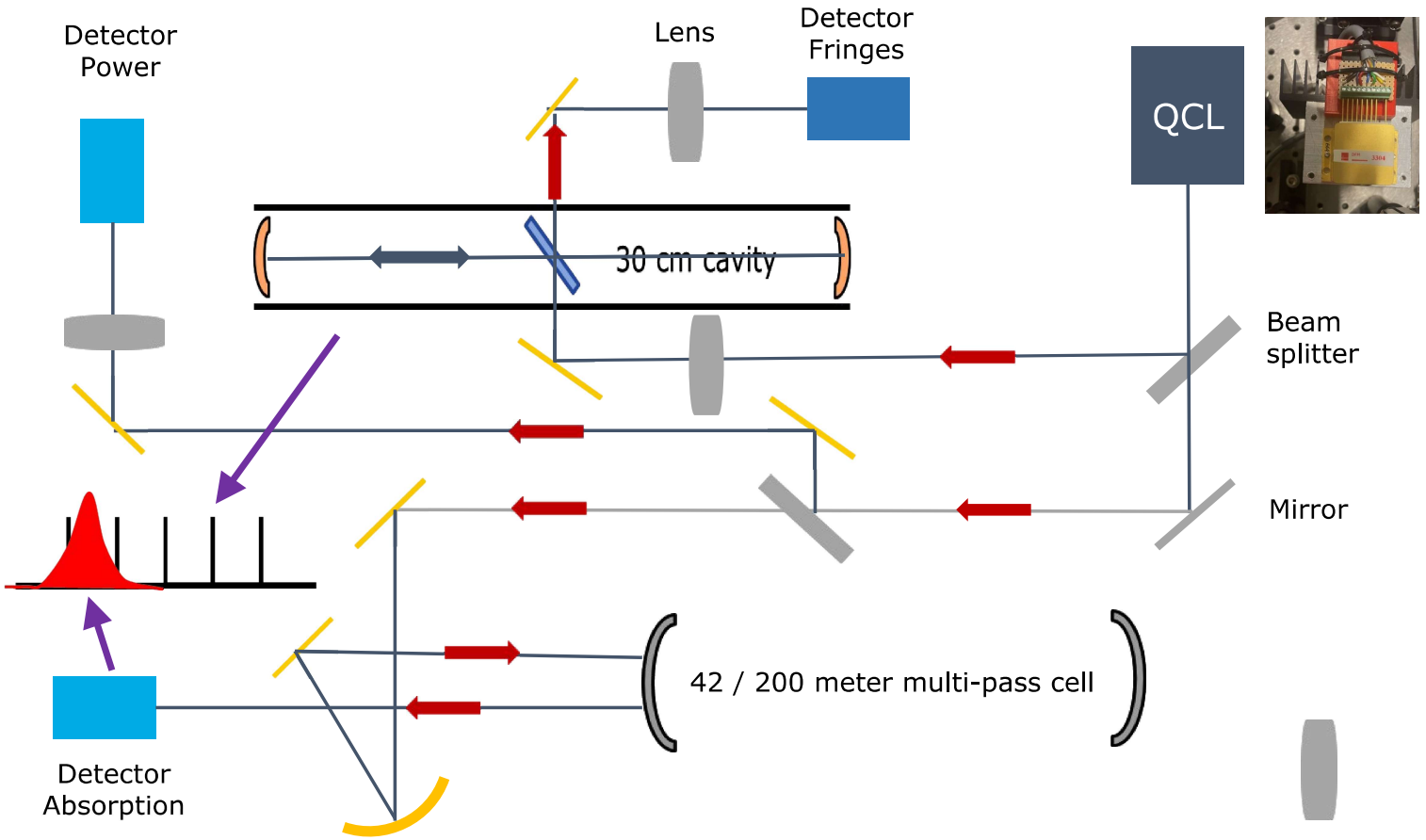
Multipass gas cell
42 m

Frequency
reference cavity

Detectors 1, 2 and 3
monitor absorption,
power and reference
fringes, respectively.

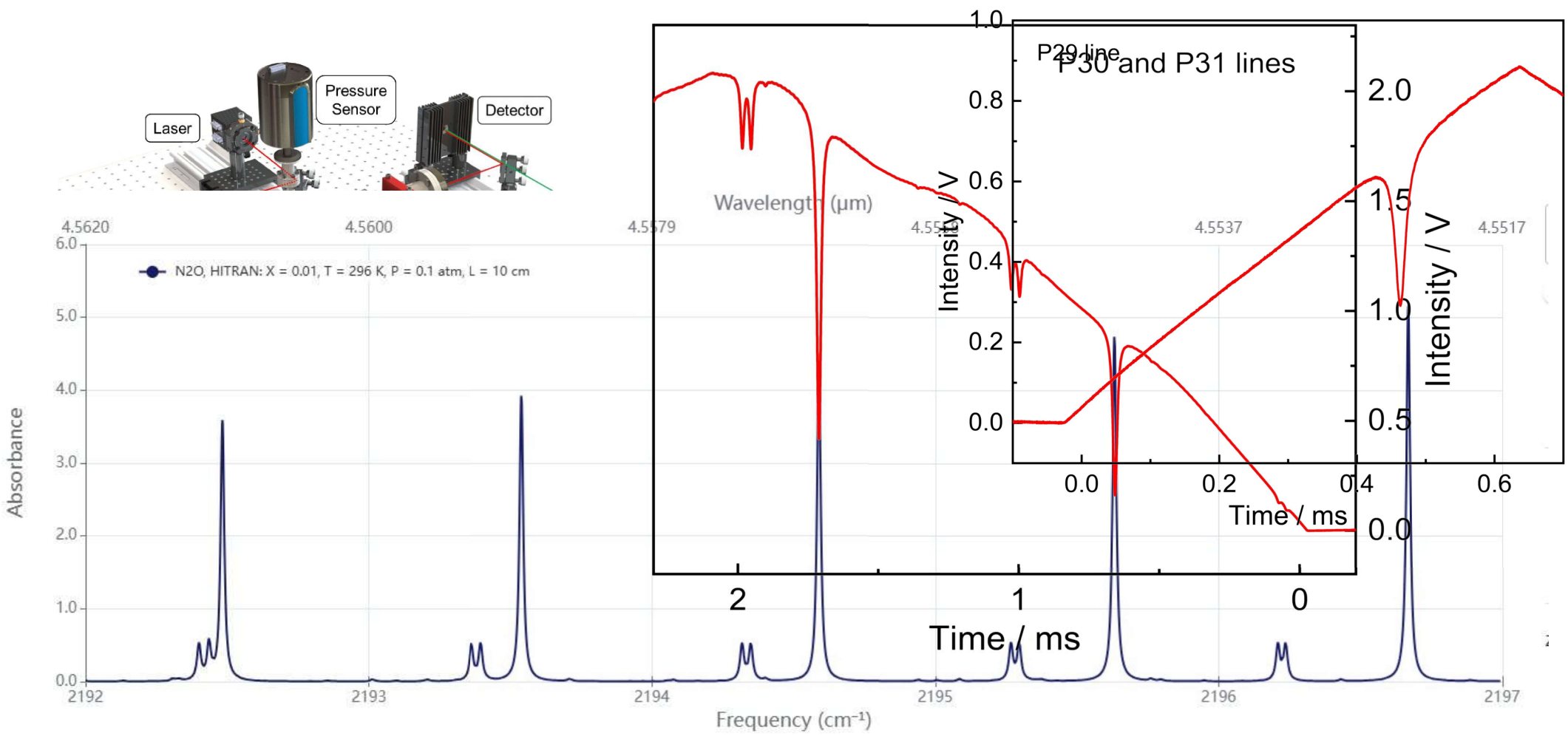
QCL laser for
monitoring N_2O in the
MIR region.
(Tunable diode laser
for monitoring in the
NIR region available)

Work-in-progress 1.65 µm wavelength ra



DFM
Danmarks Nationale Metrologiinstitut

Work-in-progress 4.5 µm wavelength rang



Proposed comparison study of N_2O gas standards

- The latest Key Comparison: CCQM-K68.2019 (model 2)
  - Measurand: 325-350 nmol/mol N_2O in air.
  - Approach: Standards sent to the BIPM headquarters for analysis.
  - The corresponding data to the Key Comparison is now entering the 5-year ago, and there is no active plan for the next one at the moment.

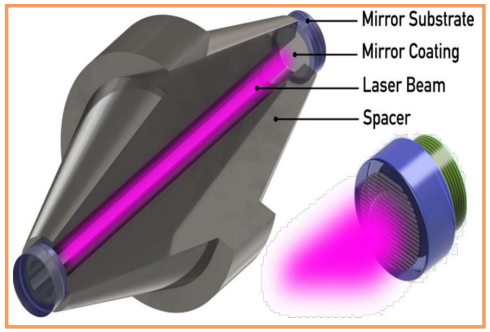
- Study: comparison in the range of 300 to 3000 nmol/mol N_2O in N_2
  - Begin in summer / autumn 2026, running 1 year.
  - Potential participants: PTB (optical gas standard), KRISS? (reference material-based gas standard), DFM? (optical gas standard), *NN*.

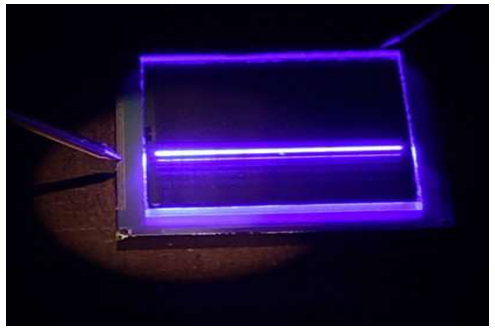
- Purpose
  - To evaluate the level of comparability of newly developed optical N_2O gas standards and classical reference material-based N_2O gas standards.
  - To prepare and support potential participation in future key comparisons.

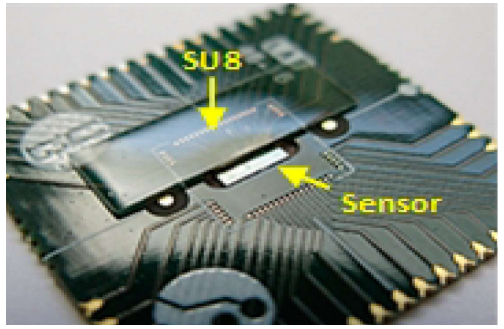
Quantum Technology-based implementations

Progress:

- Prototype instruments with optical measurement methods available.
- Inhouse QT-hardware and software development with TU-Braunschweig.
- Micro-cavities on chip for modern spectroscopy techniques with smallest footprint projected.
- Sizes of a modern mobile phones.
- Communication protocols and DCCs for data transport.
- Outline: calibration at PTB's new optical gas standards.







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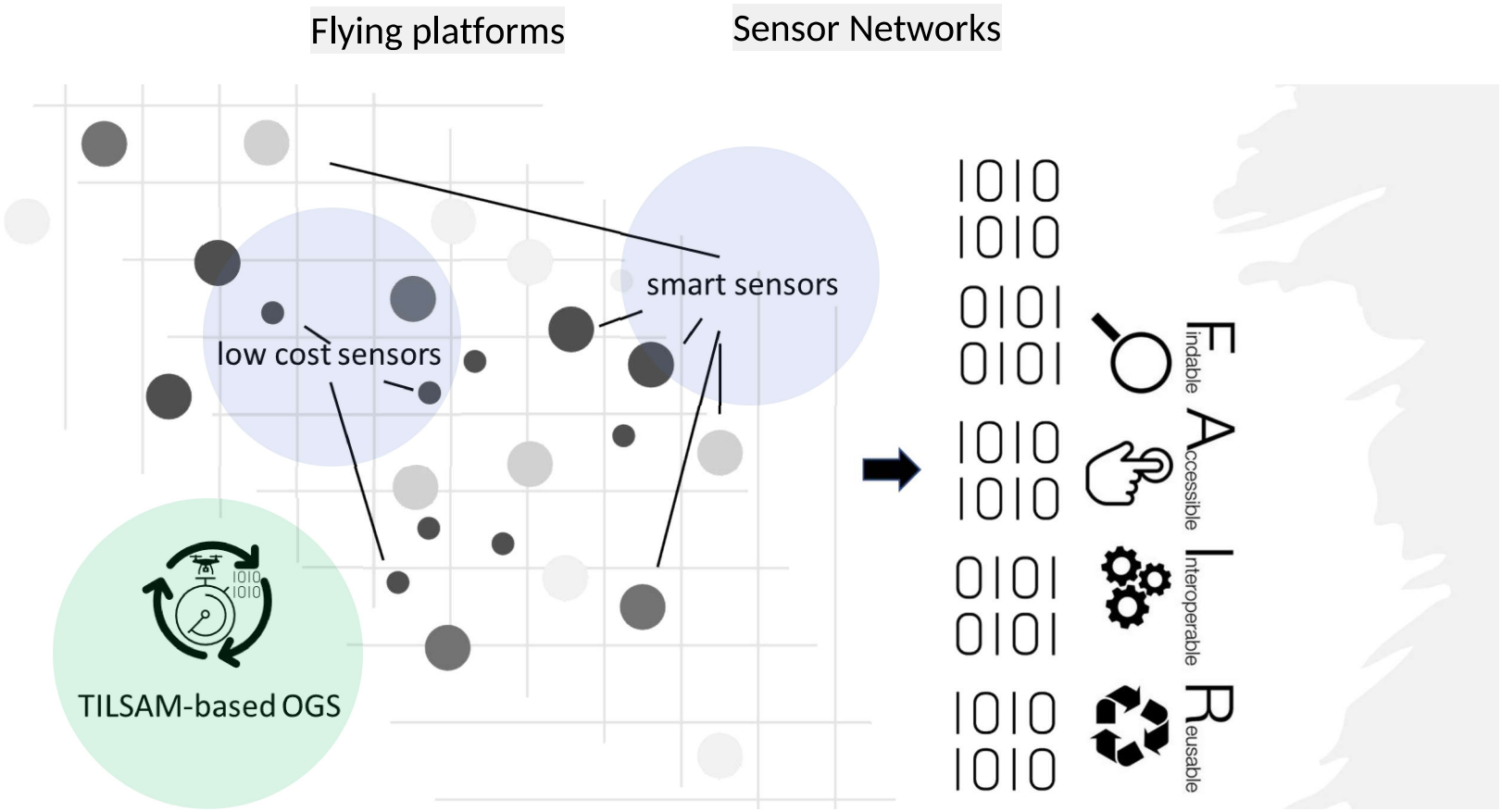
Outlined Applications

Metrology Study

Flying Platforms

Air quality sensor networks



Conclusions

Metrology for Environment and Climate with the example of nitrous oxide (N_2O)

- is an interdisciplinary topic best tackled with expertise from very different scientific areas
- PTB, DFM , and TU-Braunschweig have set out to address this by combining forces within a joint-N_2O-project

New optical gas standards for N_2O

- at PTB: metrology @ 4.5 µm laser wavelength – OGS development – sensor networks
- at DFM: metrology @ 1.65 µm laser wavelength – OGS development – maritime emission monitoring applications
- at TU-BS: quantum technology-based instrument development for micro-sensors

Thanks for your attention.

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UN environment programme

Food and Agriculture Organization of the United Nations

GLOBAL NITROUS OXIDE ASSESSMENT

N2O

CLIMATE & CLEAN AIR COALITION
a UNEP convened initiative

INMS