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HE and EMNs: challenges & opportunities

EURAMET SC-H Snapshot – 20.04.2023

Hydrogen production and utilisation

Steam Methane Reforming (SMR)

- Accounts for >95% production
- Uses natural gas as feedstock
- High energy requirements
- CCS required
- “Grey” and “blue” hydrogen

$$CH_4 + H_2O \xrightarrow[\text{SMR}]{} CO + 3H_2$$

$$CO + H_2O \xrightarrow[\text{WGSR}]{} CO_2 + H_2$$

Electrolysis

- H_2 production from water
- “Green” hydrogen if electricity generated from renewables
- Otherwise “blue” hydrogen

$$2H_2O \rightarrow 2H_2 + O_2$$

ISO 14687-2

Hydrogen fuel — PEMFC for road vehicles

Impurity	Amount fraction (ppm)
Helium	300
Nitrogen	100
Argon	100
Water	5
Oxygen	5
Carbon dioxide	2
Total hydrocarbons	2
Formic acid	0.2
Carbon monoxide	0.2
Ammonia	0.1
Total halogenated	0.05
Formaldehyde	0.01
Total sulphur	0.004

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H2 and NG utilisation: needs from stakeholders

- ❖ Optimization of the processes of H2 liquefaction and storage
  - Need at production/storage with impact on industrial processes and end users (mobility, residential, long-term storage).

- ❖ Methods and technologies of H2 blending/deblending in NG networks to meet different customer requirements
  - Need in many applications with impact in **gas quality** and optimization of separation processes.

- ❑ On-line process measurements and on-site traceability at production facilities, storage vessels, and pipelines for gas quality assurance
  - Calibration standards for (trace) water in H2 and HENG – wider pressure range
  - Deployable infrastructure (transportable/mobile standards) – in situ sensor calibration.

On-going projects focused on H2 and HENG

- JRP 19ENG03 MefHySto “Metrology for advanced hydrogen storage solutions ” (2020-23)
- JRP 20IND13 DECARB “Metrology for decarbonising the gas grid” (2021-2024)
- *JRP 20IND06 PROMETH2O “Metrology for trace water in ultra-pure process gases” (2021-2024)*
- JRP 21GRD05 Met4H2 “Metrology for the hydrogen supply chain” (2022-2025)
- HORIZON-JTI-CLEANH2 THOTH2 “Novel methods of testing for measurement of natural gas and hydrogen mixtures” (2023-2025)

MefHySto
Metrology for Advanced Hydrogen Storage Solutions

Metrology for decarbonising the gas grid

PROMETH$_2$O

MET4H$_2$

THOTH2

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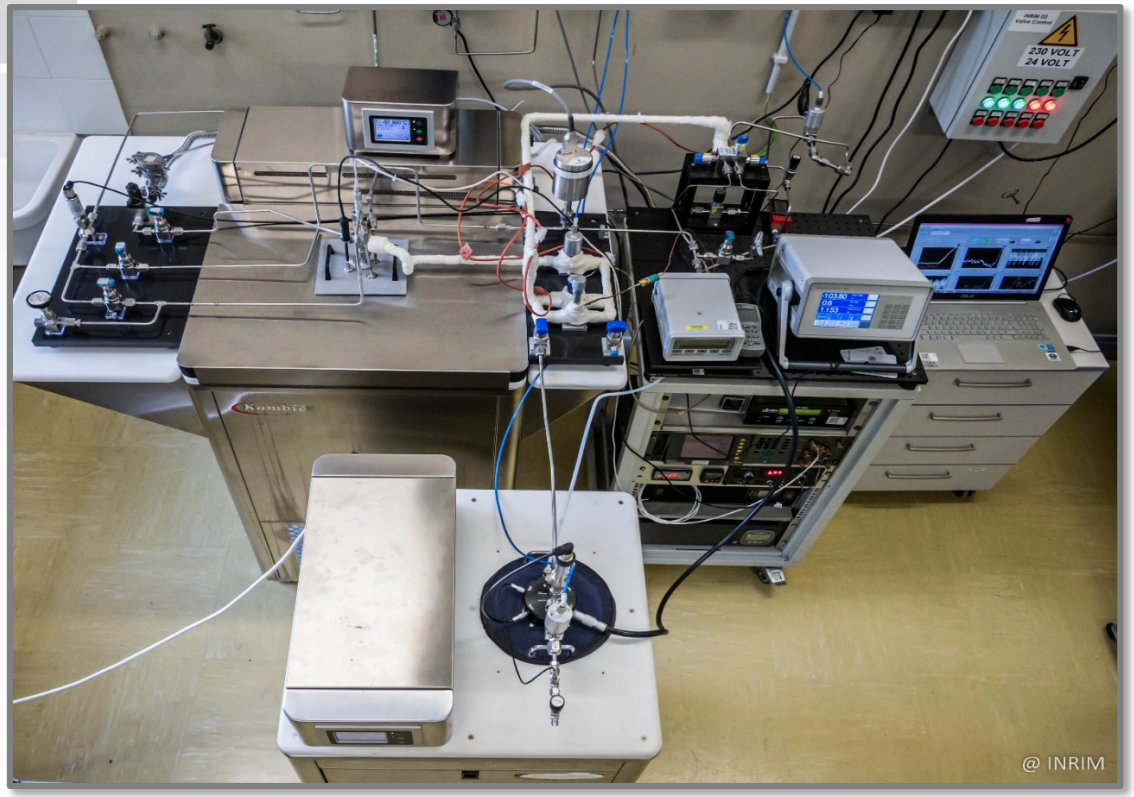
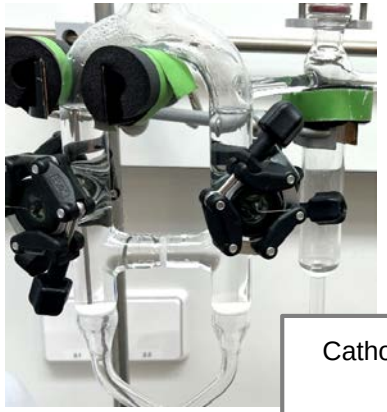
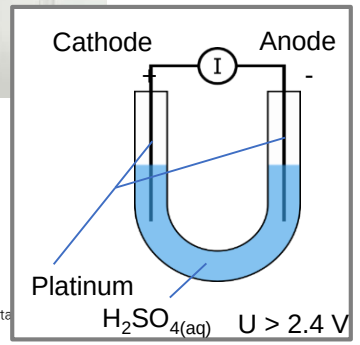
PROMETH2O **achievements: primary standards for trace water**



LFP primary humidity generator - Mark 2

- Frost-point temperature: -105 °C to -20 °C
- Water vapour amount fraction: 5 ppb to 1500 ppm
- Pressure: 200 hPa to 0.68 MPa (N_2 and Ar)





PTB
Physikalisch-Technische Bundesanstalt
Nationales Metrologieinstitut

Details of the electrolysis cell

Coulometric Trace Water Generator (CTWG)

- Amount fraction > 5 ppb
- Rel. uncertainty: 8 %

Permeation system based on a passivated MSB

- Range: 50 ppb to 5 ppm

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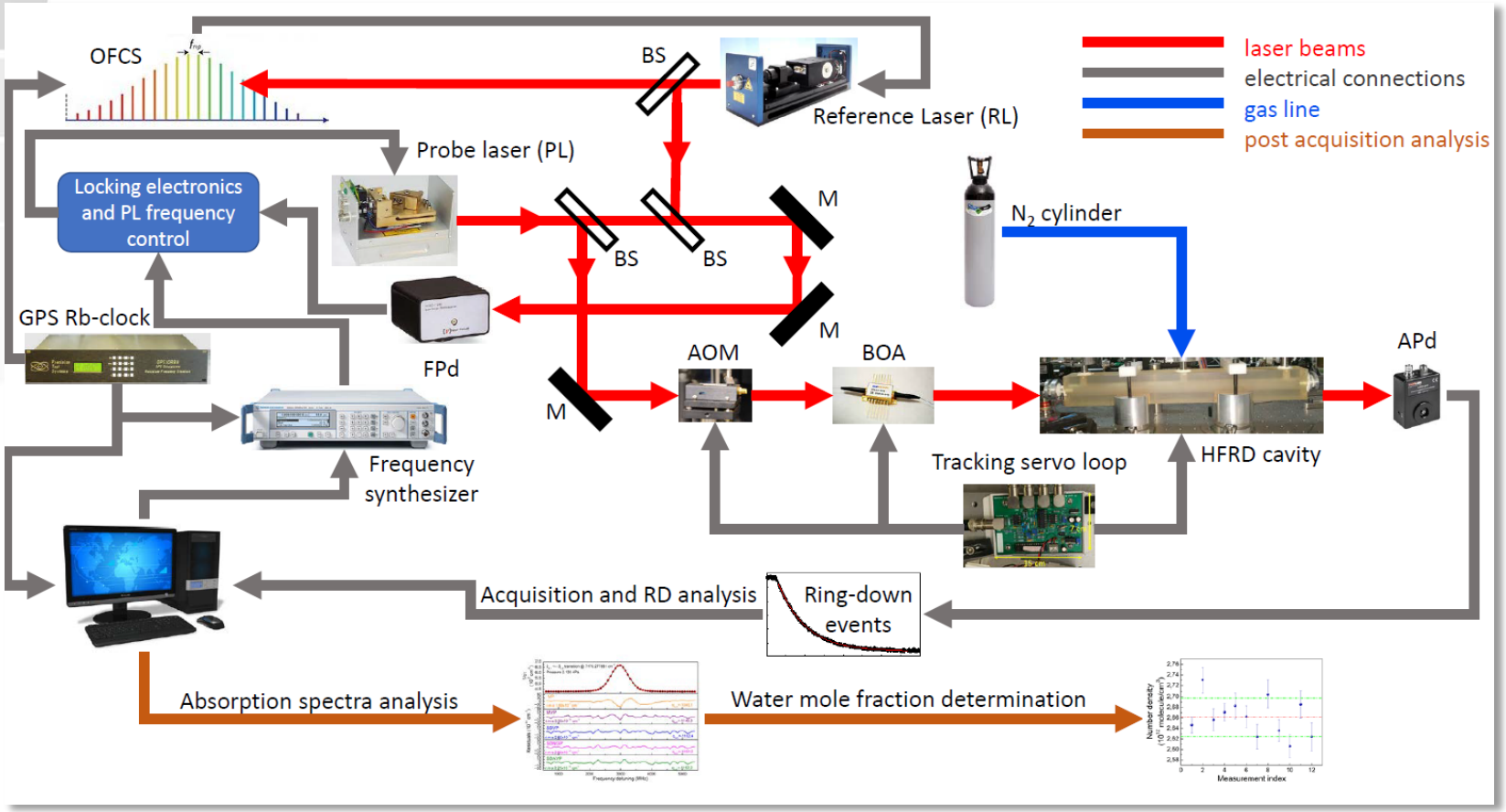
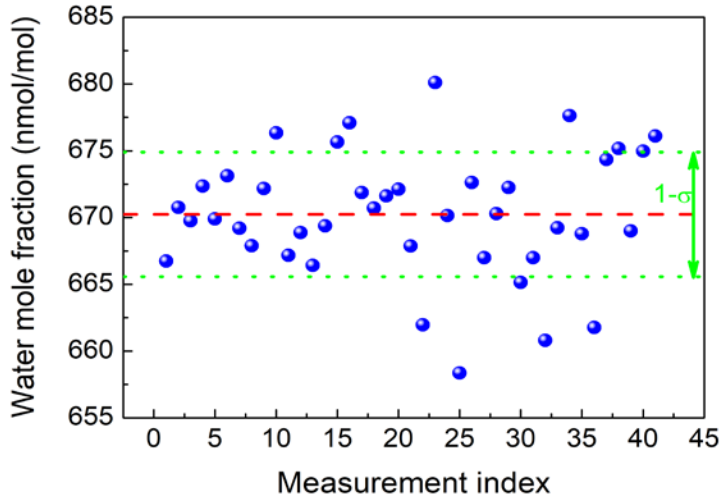
PROMETH2O **achievements: improved comb-assisted CRDS optical analysers**





$$x_w = (671 \pm 4)\ nmol/mol$$

Contribution (k=1)	Type A (%)	Type B
Statistical	0.5	
Line strength		0.3
Frequency scale		Negl.
Line shape model (SDVP)		0.1
RD per point & frequency step		< 0.2
Laser scan width		< 0.2
Gas temperature		0.05
Partition function		0.04
Pressure		0.05
Overall combined uncertainty = 0.7 %		

Università degli Studi della Campania *Luigi Vanvitelli*

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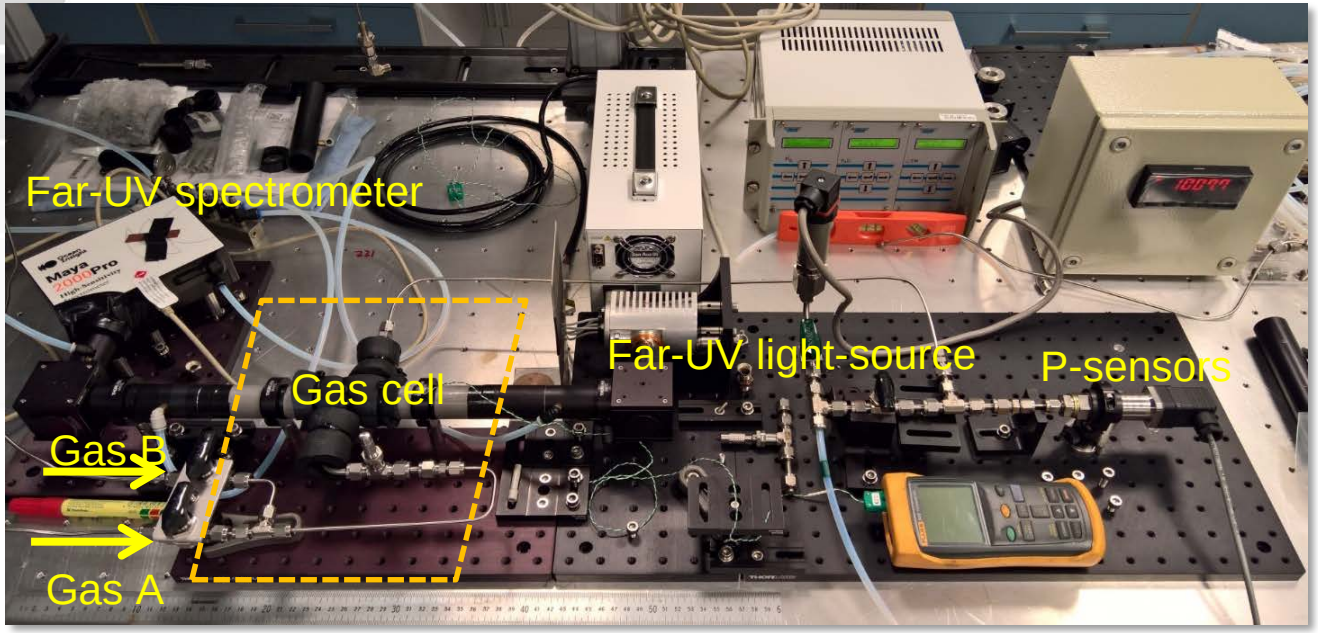
PROMETH2O **achievements: improved trace water analysers and enhancement factor measurements**

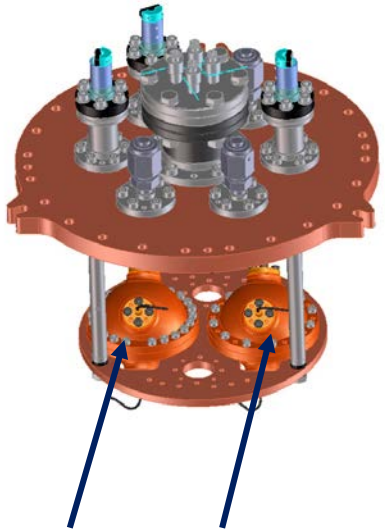


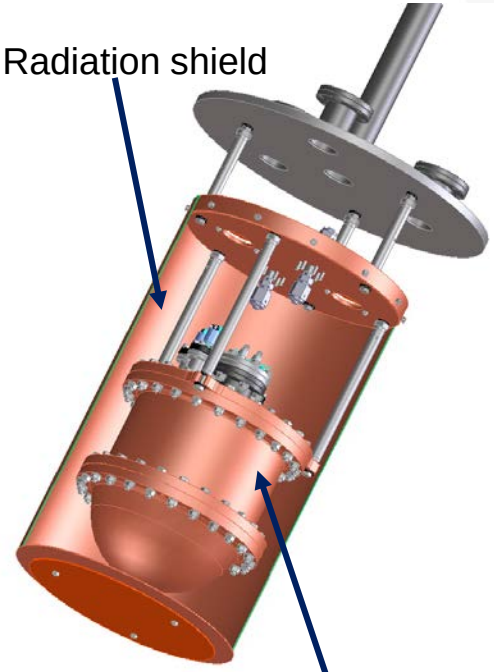
Far-UV system

- highly-modular gas cells: (0.5 to 100) cm;
- flow or static measurement: (0 to 100) bar;
- 100-cm cell with DURSAN® coatings;
- two-way spectra analysis: “full” and “DOAS”

Microwave-based trace water hygrometers

to measure the enhancement of H_2O vapour in **N_2, Ar, and H_2**





What's next?

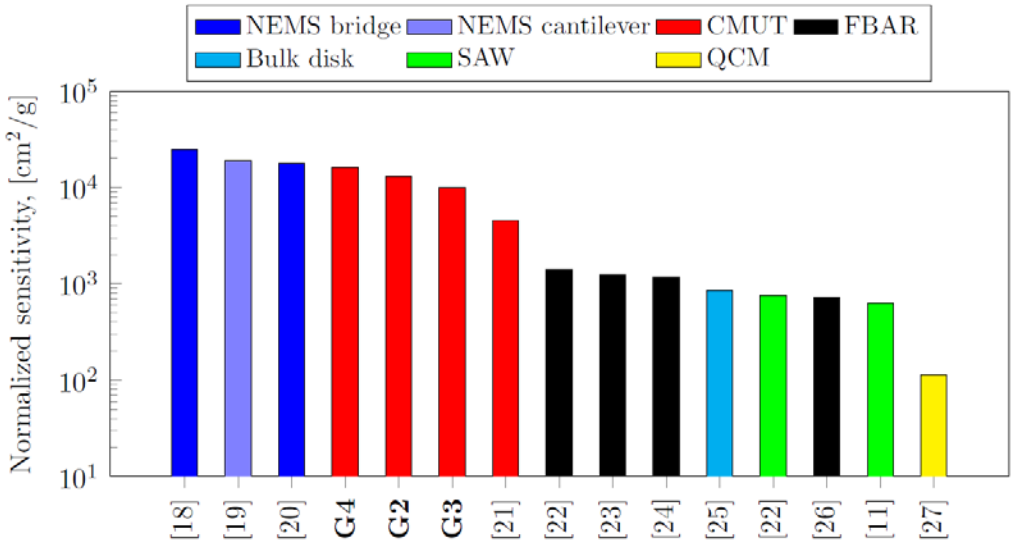
I. Hydrogen economy
- Storage of hydrogen (hydrides, NG grid, geological)
- EU "Hydrogen Valleys"
- ❑ (Trace) water measurement [@ sub-ppm]
- ❑ Sensor stability issues, e.g. on-site calibration

II. Novel humidity sensor concepts
- MEMS, NEMS, and photonics RR
- Resonators with mass sensitivities ($\partial f/\partial m$) better than 1 Hz/fg
- ❑ IIoT, traceability issues, …

III. Future Comparisons
- ❑ *"Are we ready for a KC in the trace water regime?"*

Clean Hydrogen Partnership

EUROPEAN HYDROGEN VALLEYS PARTNERSHIP



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