



CryoMet

Improving accuracy of liquid hydrogen measurements by development of dedicated reference measurement standards

European Cryogenic Days

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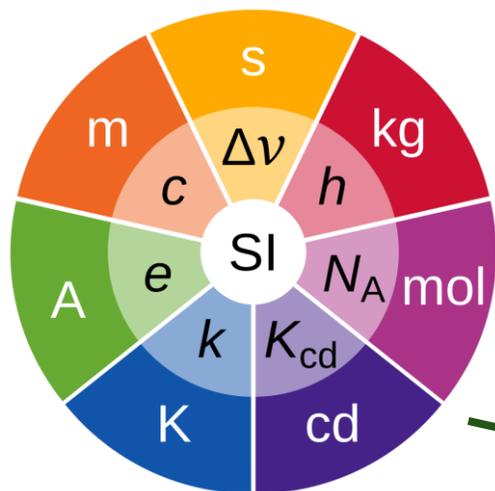
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METROLOGY
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Metrology: measurement science



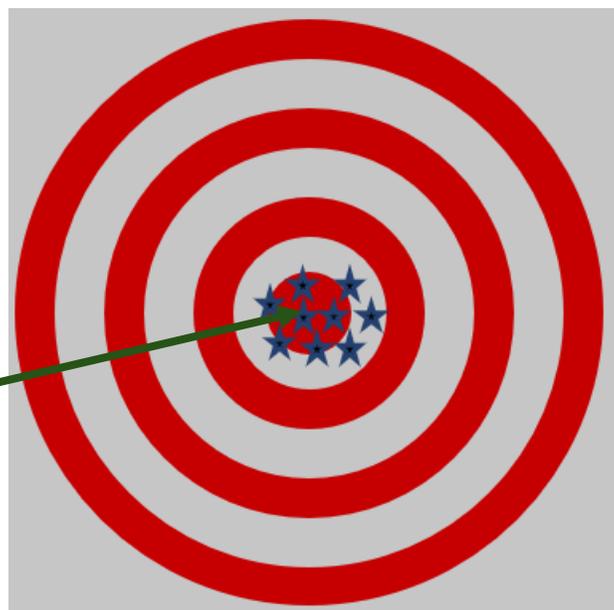
Metrology ≠ Meteorology



National
Metrology
Institute

National Metrology Institute:

- VSL in the Netherlands
- Maintains primary measurement standards
- Ensuring accuracy



How do you know that the gas meter measurements are correct?



Answer: its accuracy is verified by reference measurement standards

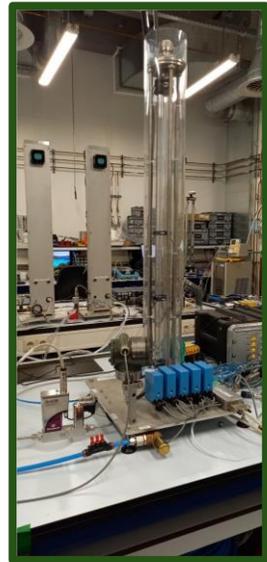


At NMI



Direct link to SI-units

- Experimental setups

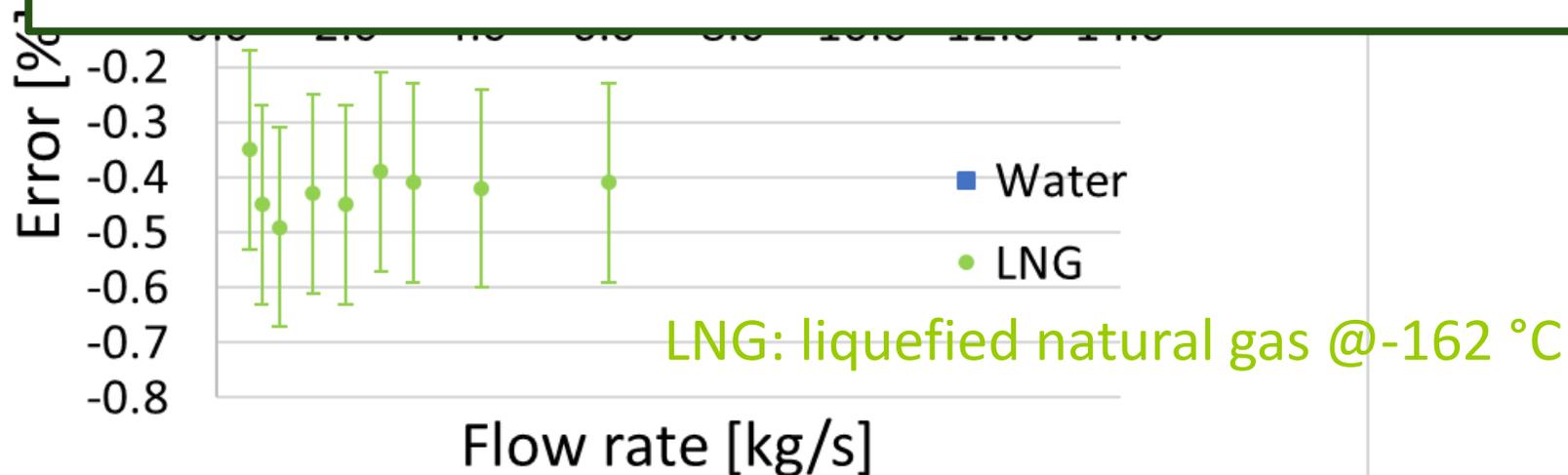


Workamp et al., 2024, IMEKO

- $Error = \frac{\text{"Meterstand"} - reference}{reference}$

Dedicated LH₂ reference measurement standards are needed

Ensuring accuracy in this way requires dedicated LH₂ reference measurement standards





CryoMet

Next slides

- The CryoMet European metrology project
- LH₂ reference measurement standards
 1. Temperature measurement
 2. Ortho- and para-spin isomer composition of liquid hydrogen
 3. Quantity determination (flow)
- Summary

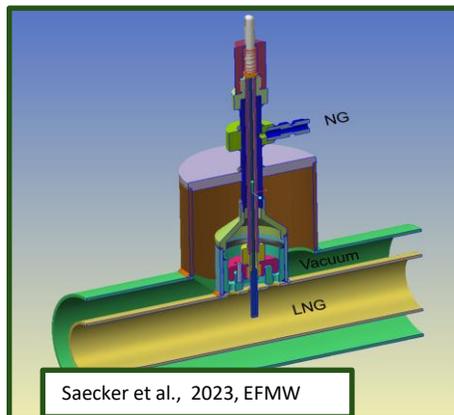
Background CryoMet – stakeholder measurement needs (simplified)

- Industry/academia:
 - *Consistent LH₂ isomeric composition measurements*
 - *LH₂ production plants can improve efficiency*
- Safety testing: *LH₂ temperature measurement at large-scale*
- Aviation: *Our interest is focused on traceability to LH₂ standards for producing operational aircraft*
- European Partnership on Metrology: metpart.eu

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METROLOGY
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CryoMet consortium



- NMIs/DIs
- Accredited laboratories
- Equipment manufacturers
- R&D institutes
- Universities



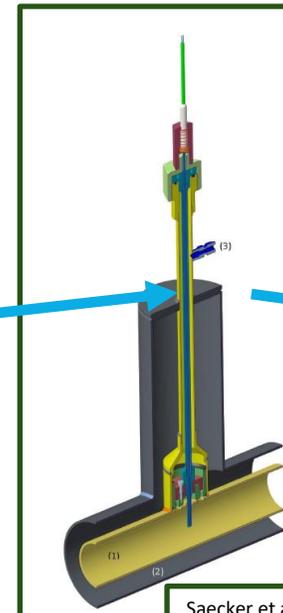
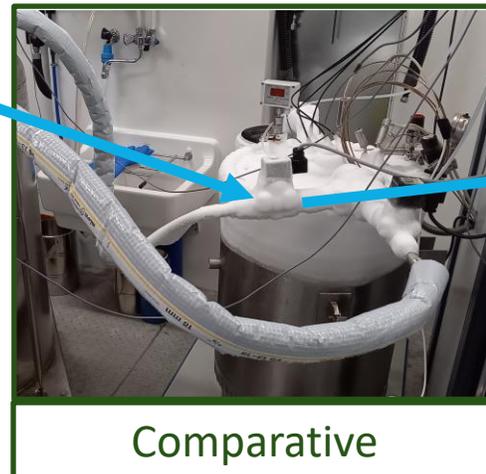
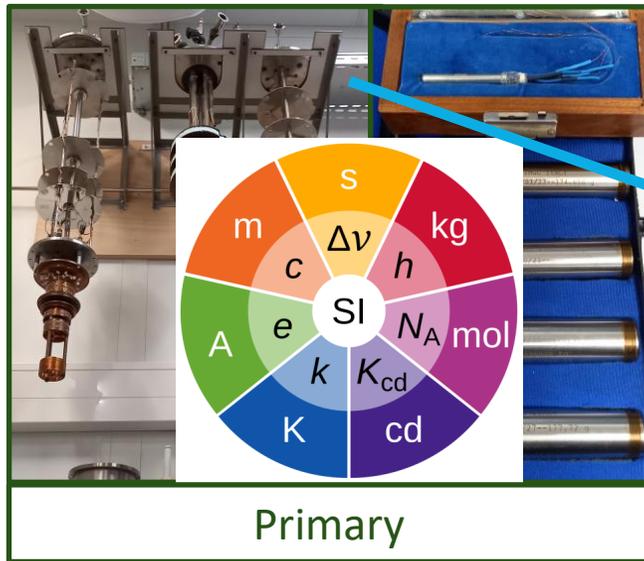


LH₂ temperature measurement reference

- Temperature measurement: reference measurement standards do exist
- However: they are (too) scarce and not fit-for-purpose

+ Modelling:

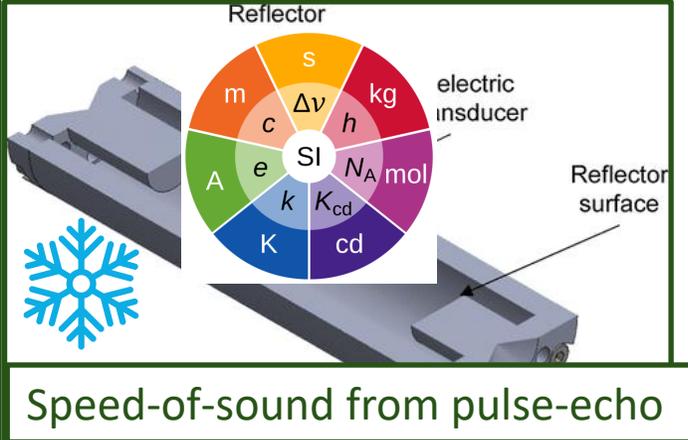
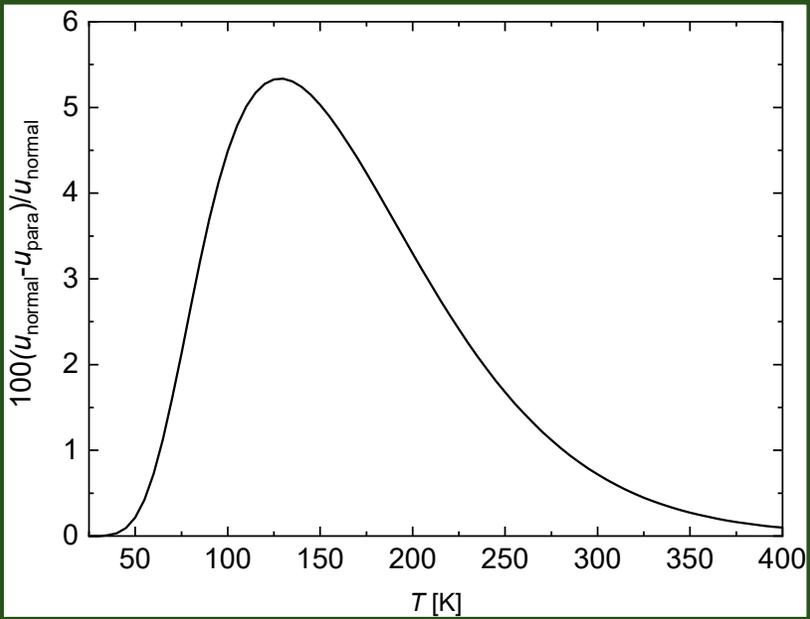
- static
- dynamic



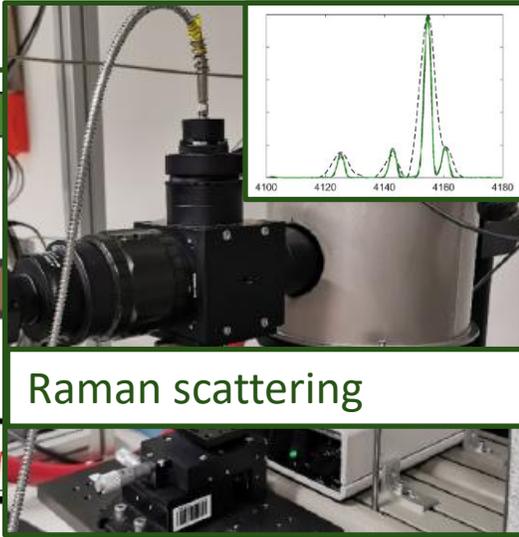
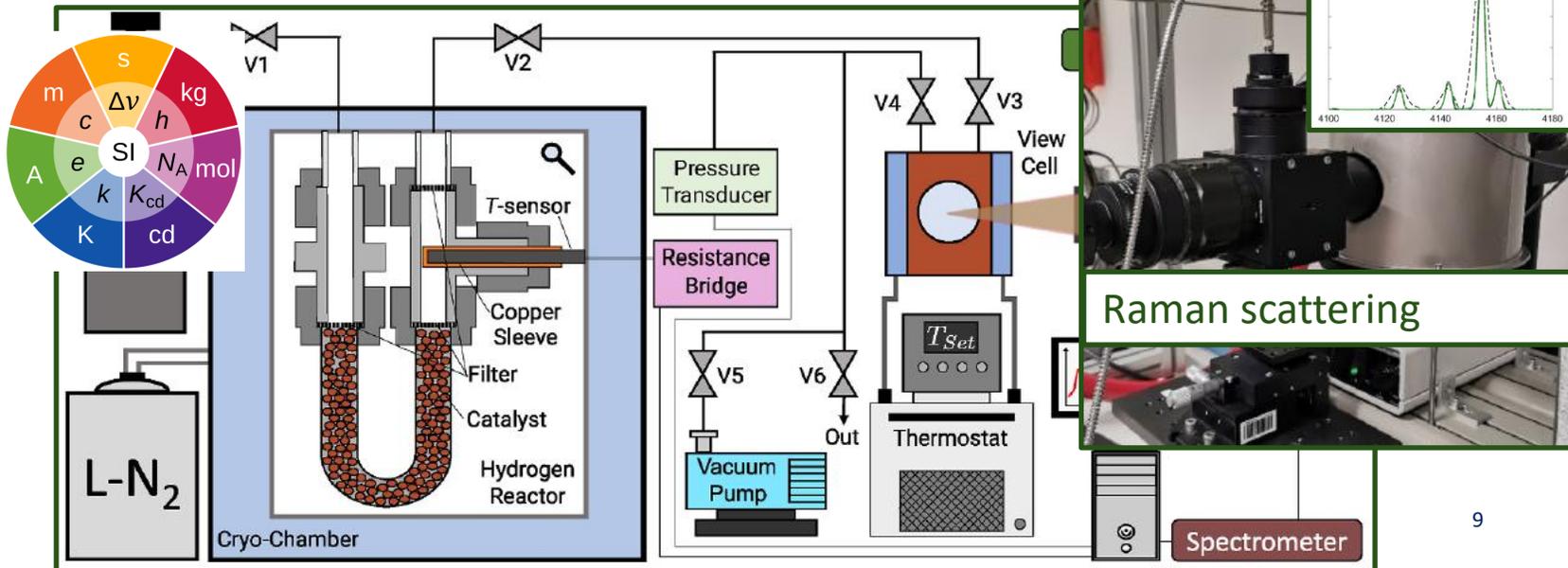
LH₂ ortho/para spin ratio measurement reference

Wedler et al., 2023, J. Ch. & Eng. Data
 Luther et al., 2025, Int. J. H2 En.
 Leachman et al., 2009, J. Phys. Chem. Ref.
 C. Günz, M9 MethHyInfra Cryogenic training <https://www.methyinfra.ptb.de/>

Method 2



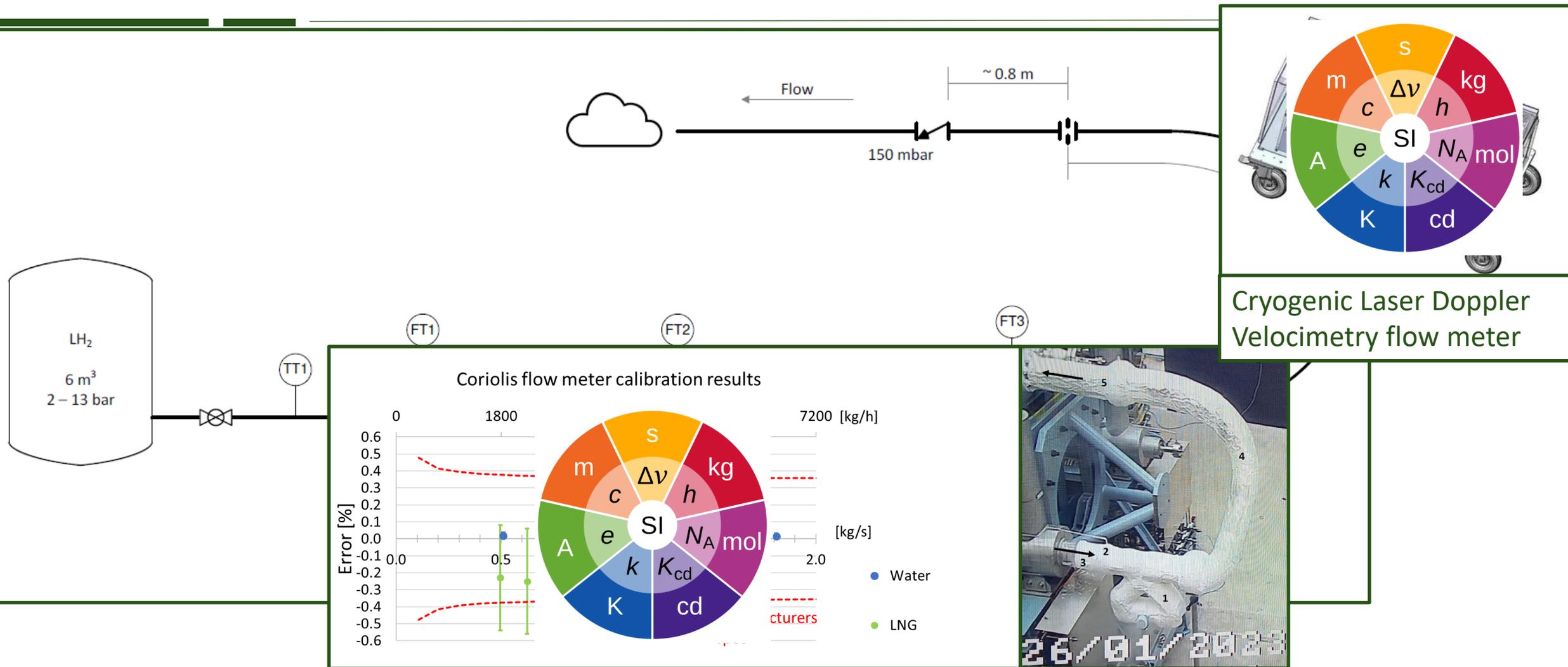
Method 1





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LH₂ flow (quantity) measurement reference



Cryogenic Laser Doppler Velocimetry flow meter

Summary

- Metrology ensures accuracy by direct link to the SI-units of measurement
- Reference measurement standards are maintained at National Metrology Institutes, one per country
- Rise of LH₂ projects leads to requests for accurate and reliable measurements
- Dedicated reference measurement standards for LH₂ are needed
- CryoMet project is Europe's response to develop these standards
 1. Temperature measurement
 2. Ortho- and para-spin isomer composition of liquid hydrogen
 3. Quantity determination



THANK YOU



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