Local Online Gas Analysis in PEFC

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Outline

- Measurement **Concepts** of Local Online Gas Analysis
- **Hardware** description
- **Applications**
- Summary

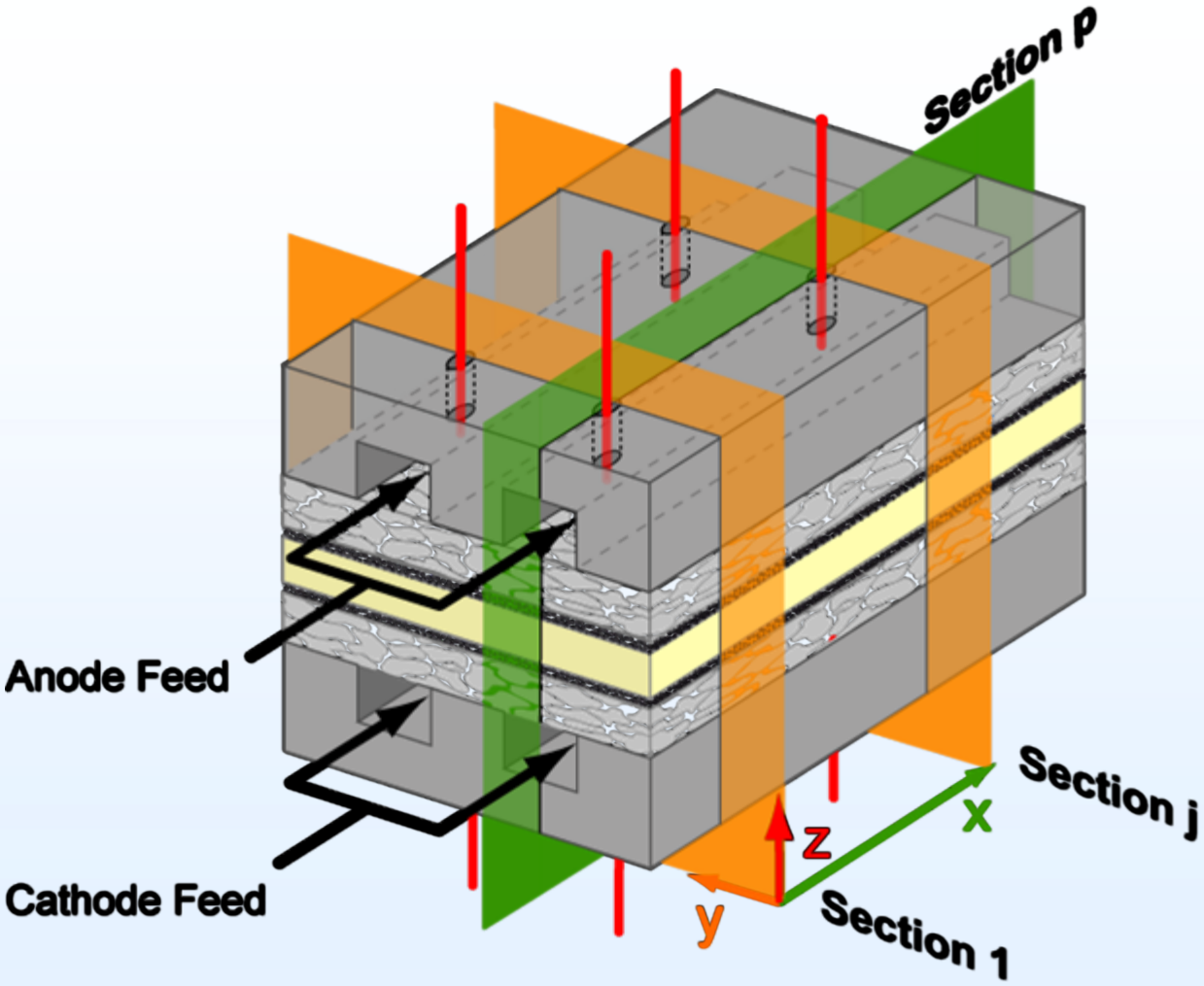
Why do we investigate the local gas phase in PEFC:

- Most mass transport processes in PEFC are related to gaseous species or transport in the gas phase:
  - Reactant transport in porous media
  - Gas permeation through the membrane

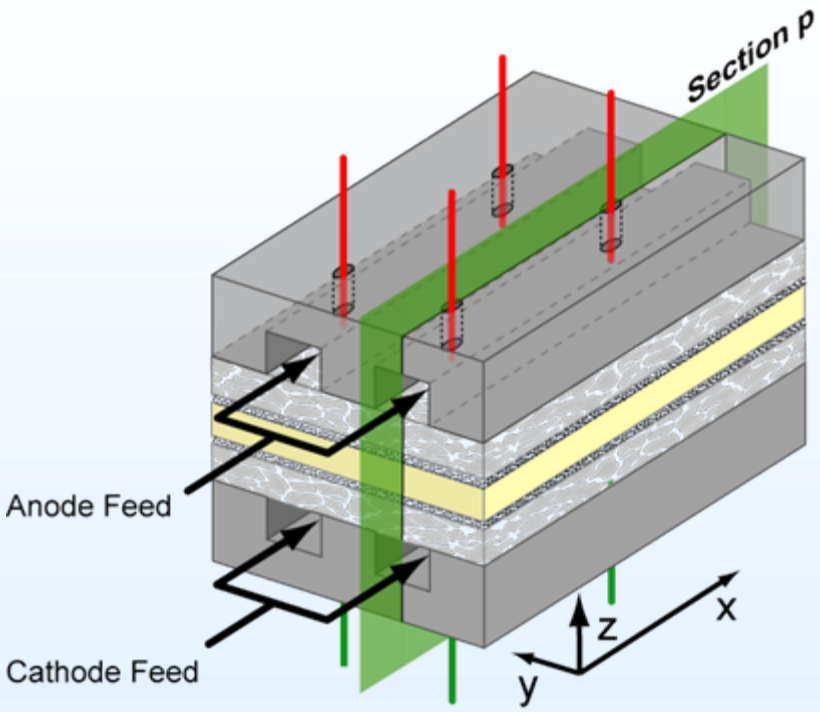
- Focus: Better understanding of local gas phase properties and transport processes under realistic operating conditions.

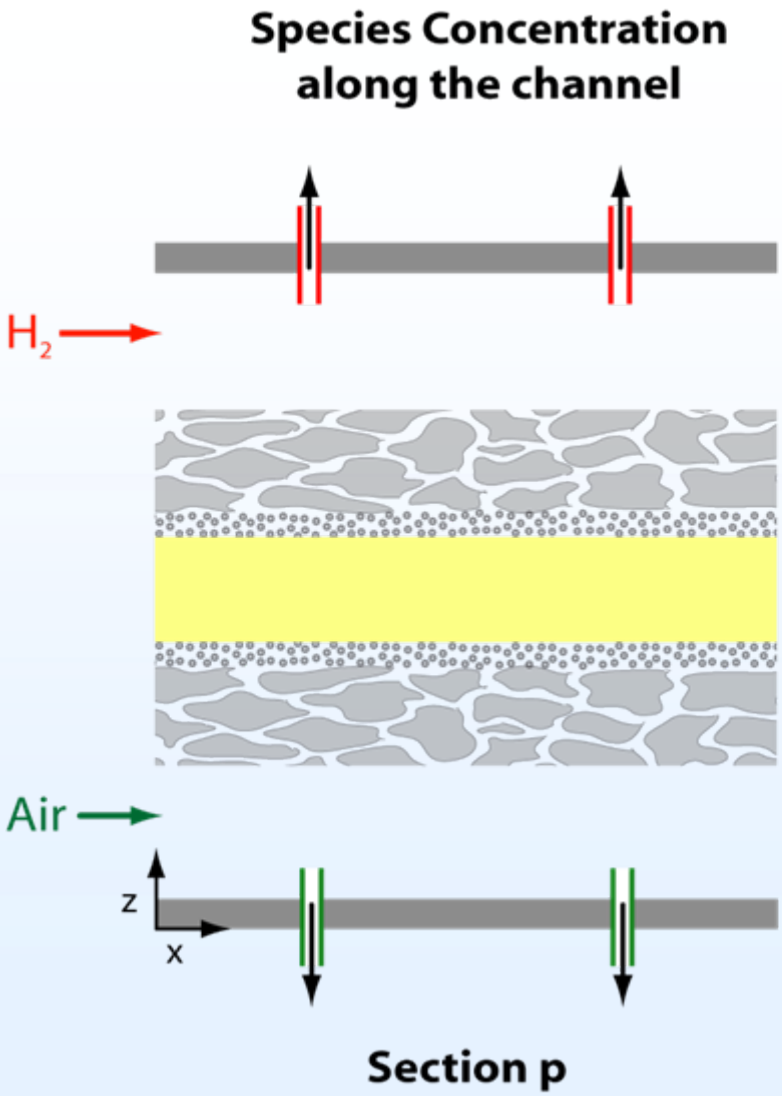
- Need for appropriate hardware to investigate temporal and local changes of the gas phase.

Local Gas Extraction in 3 Dimensions

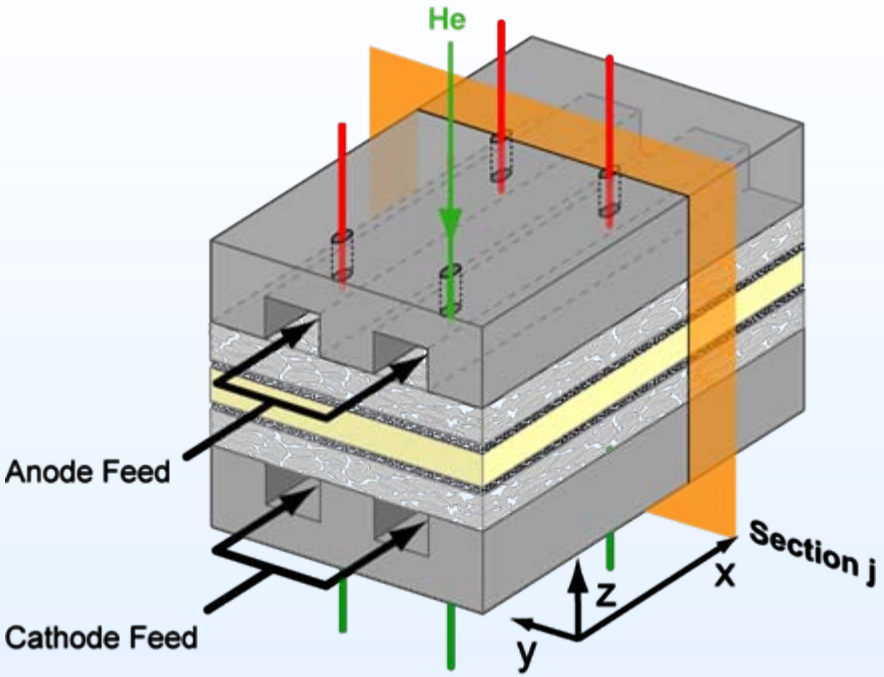


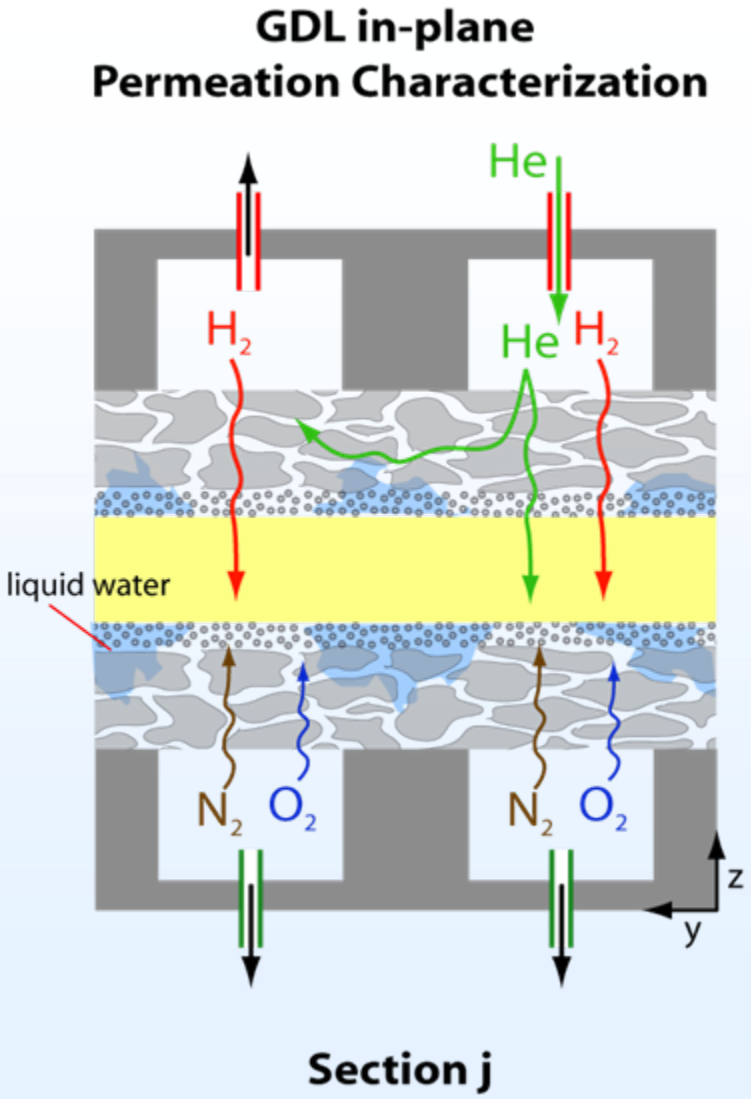
Measurement Concepts: X Direction



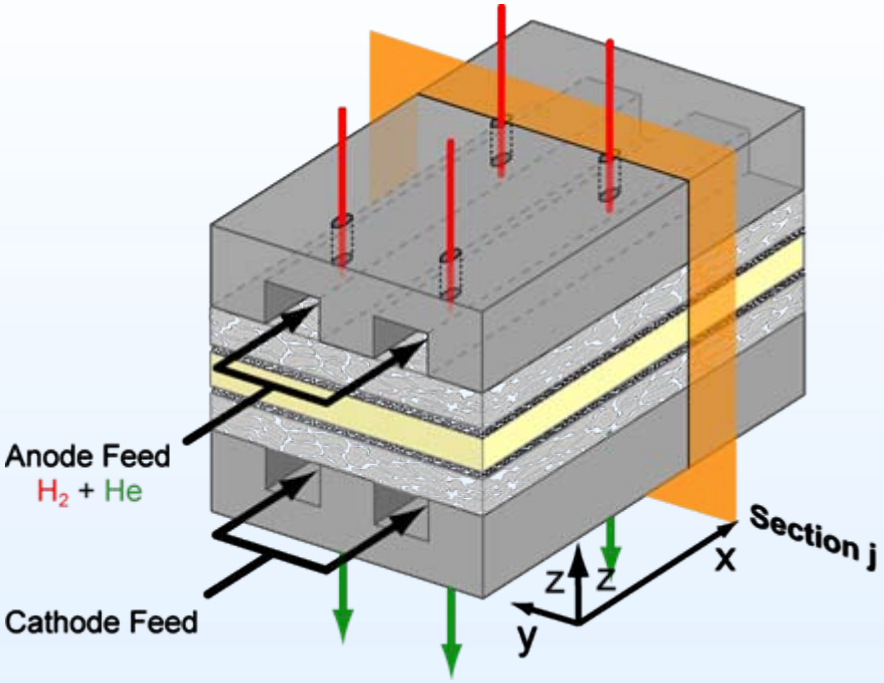


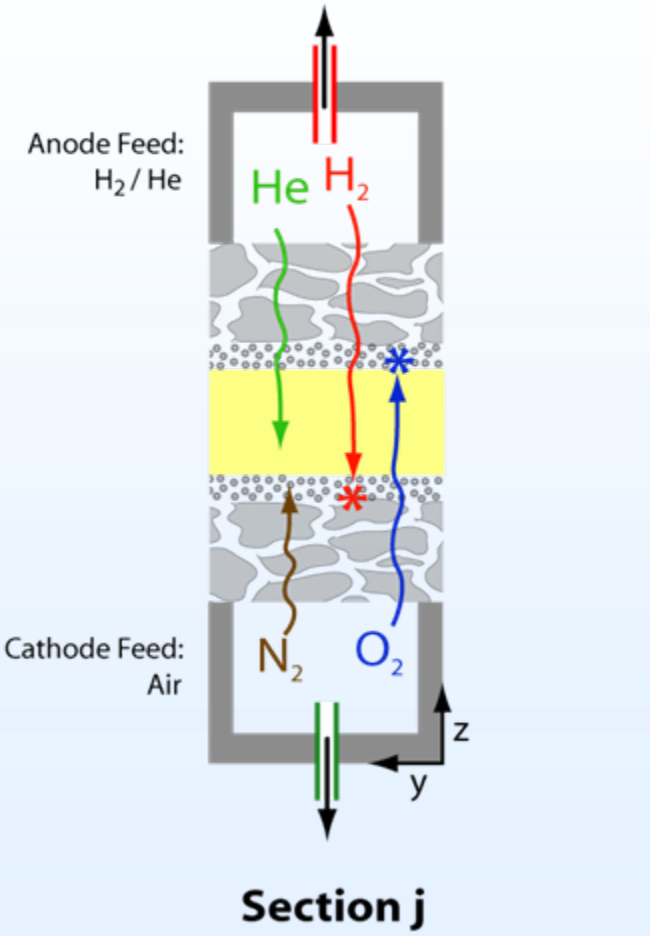
Measurement Concepts: Y Direction



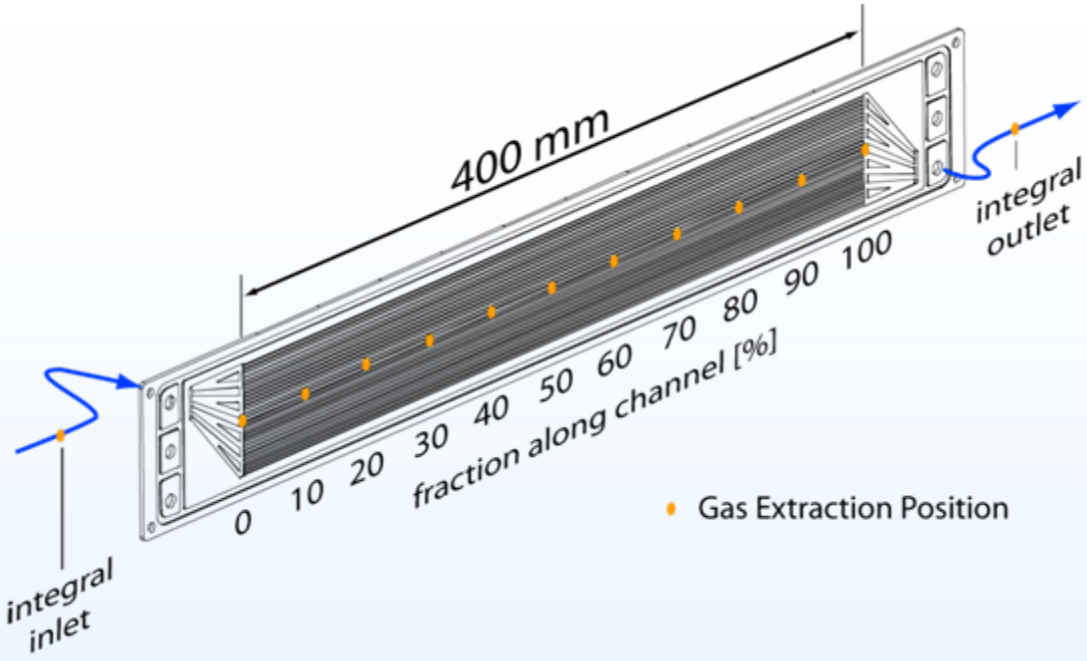


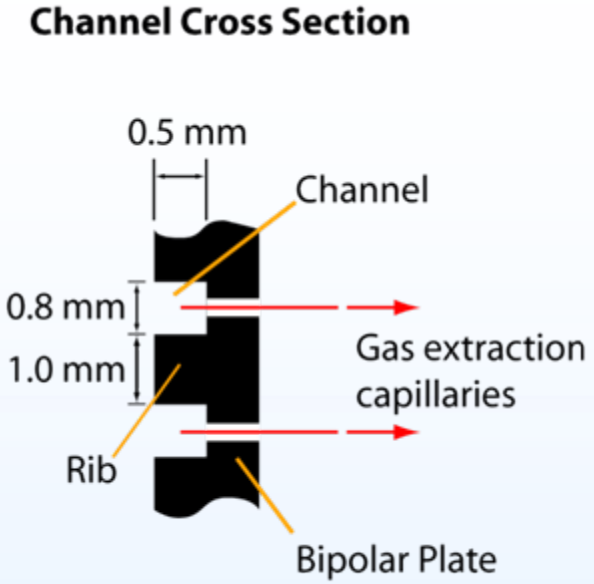
Measurement Concepts: Z Direction





Cell Design

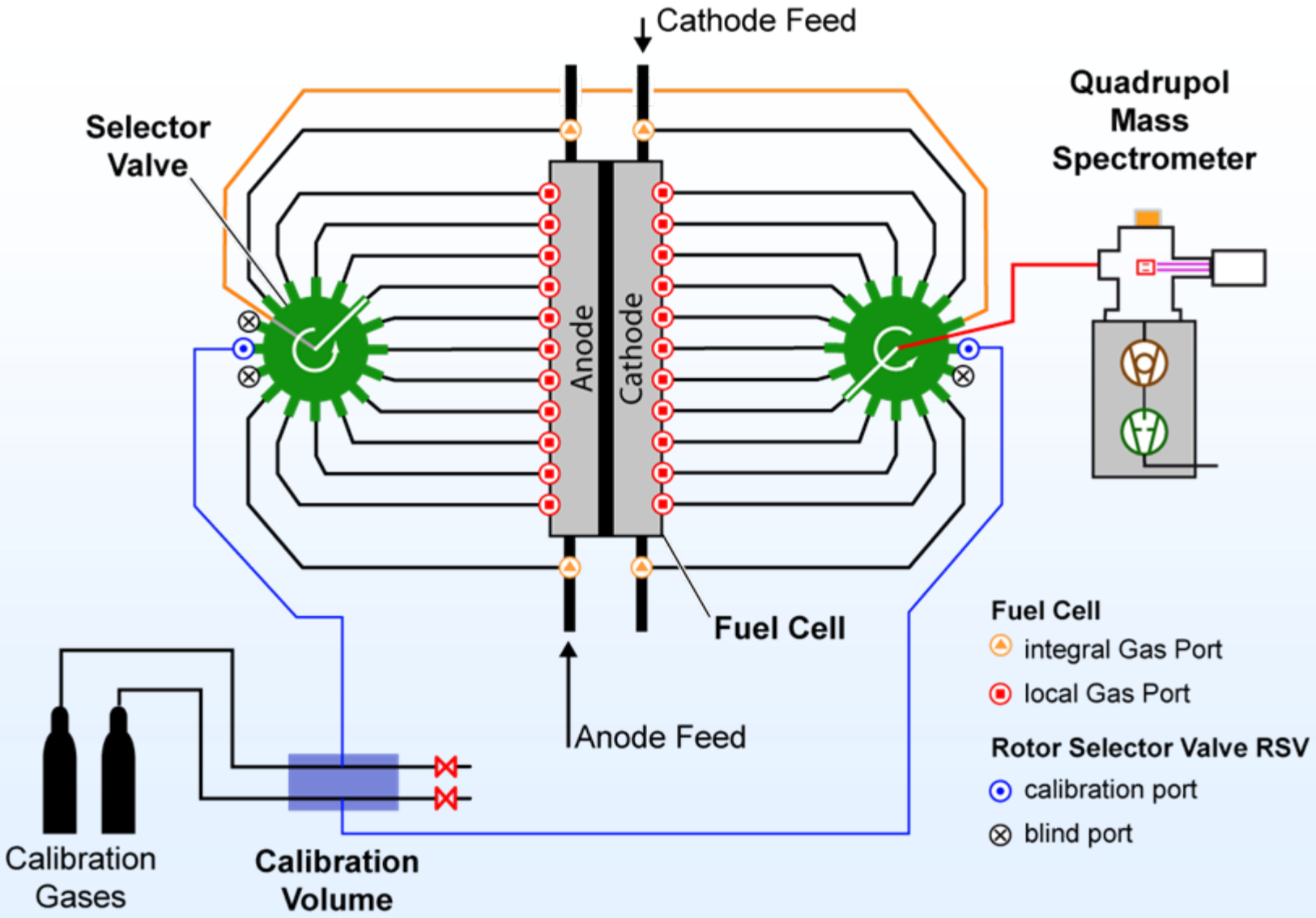




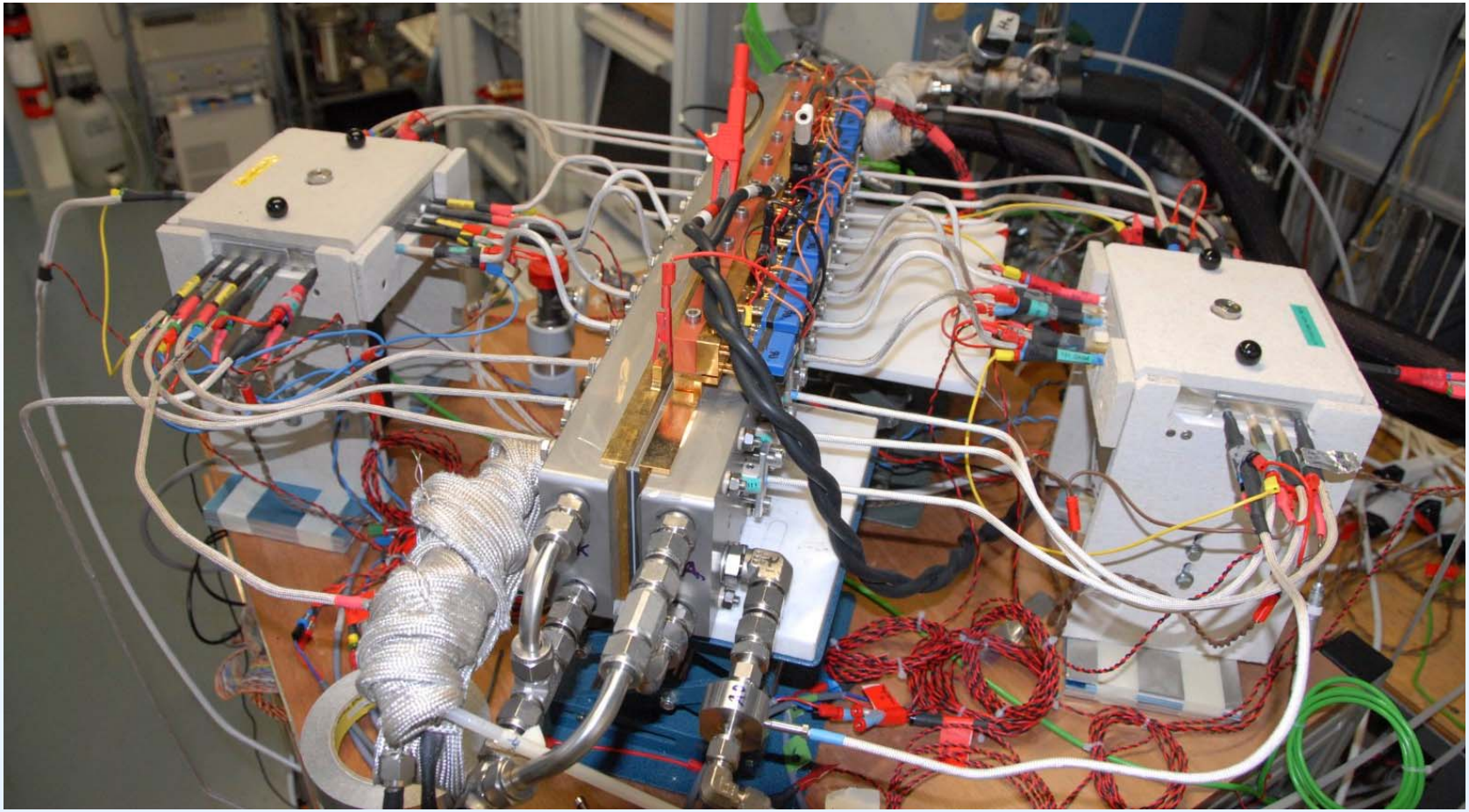
- 200 cm^2 active area
- 11 Gas port within the flow field
- 2 integral gas ports (feed and outlet)

- Fused silica capillaries:
  - internal diameter 50µm
  - max. 37µl/min gas extraction

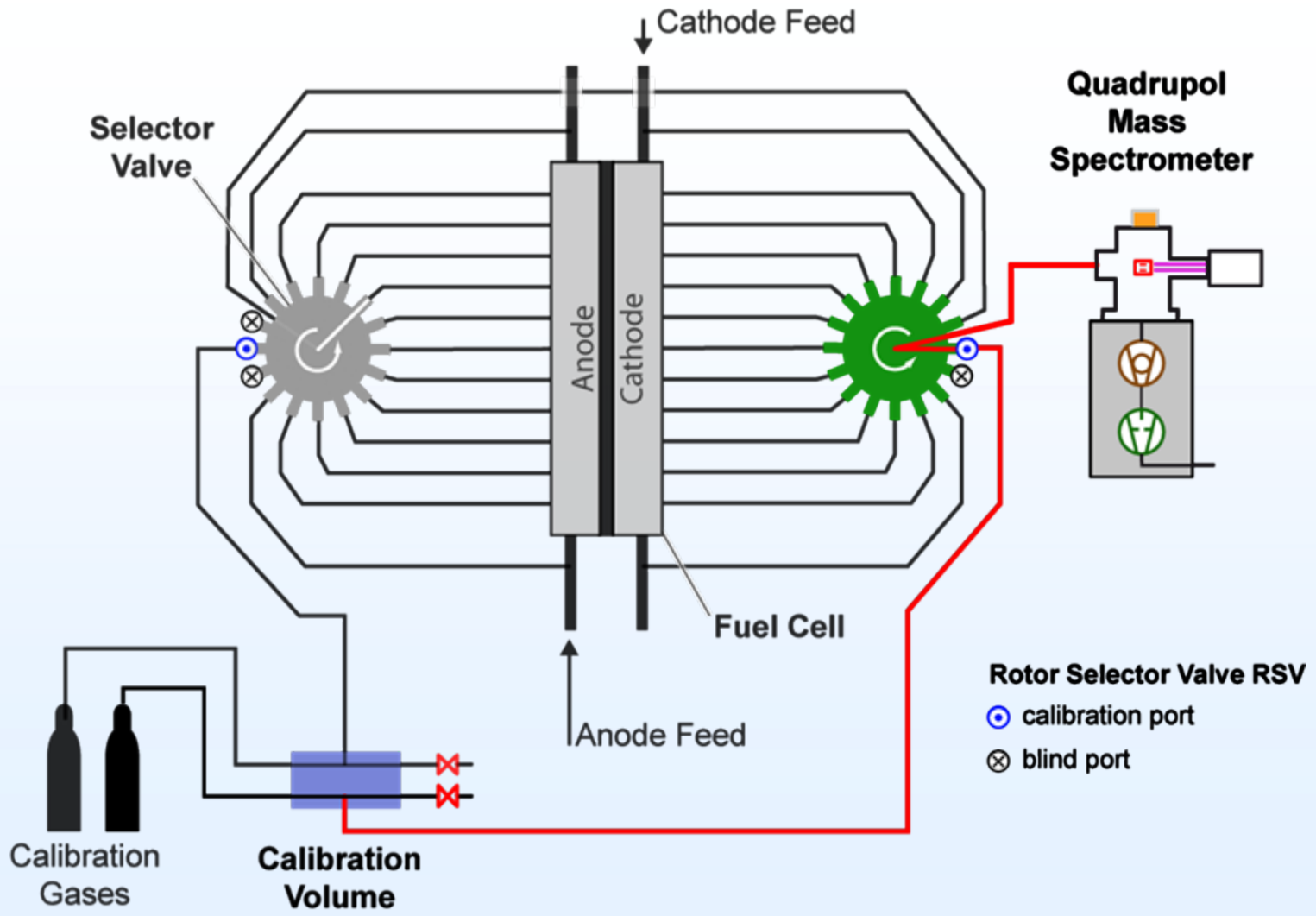
Gas Analysis Overview



Gas Analysis Overview



Quality of the Gas Extraction System



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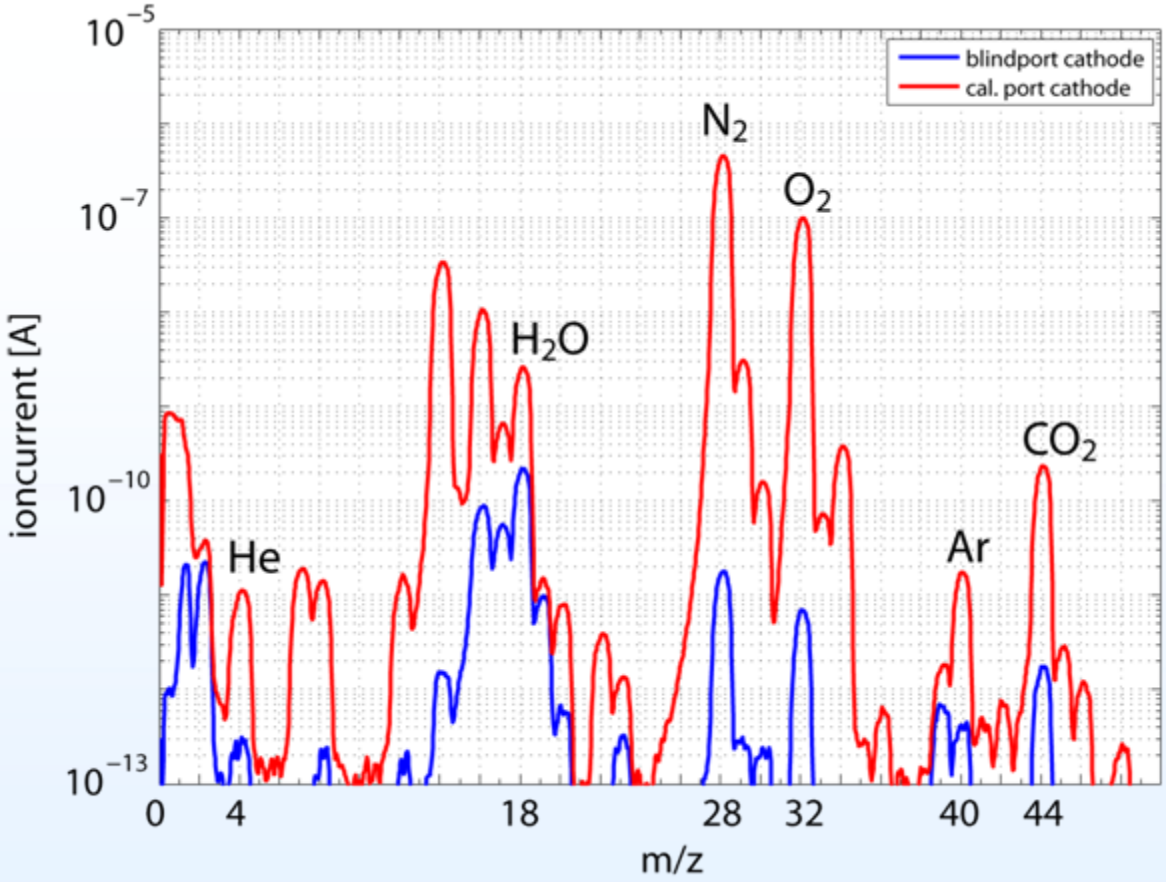


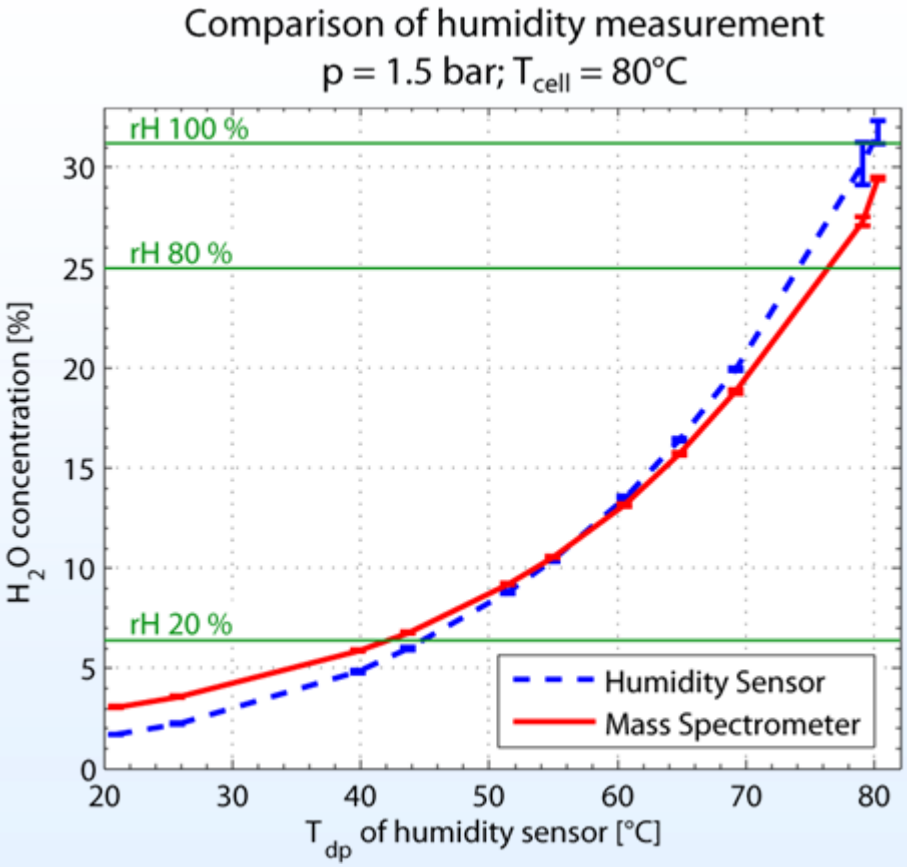
Quality of Gas Extraction System:

- Air leakage limits trace gas analysis flexibility (no trace gas analysis of N_2, O_2)
- Restrictive peak analysis allows for sufficient fuel cell investigation accuracy

Water Vapor Measurement

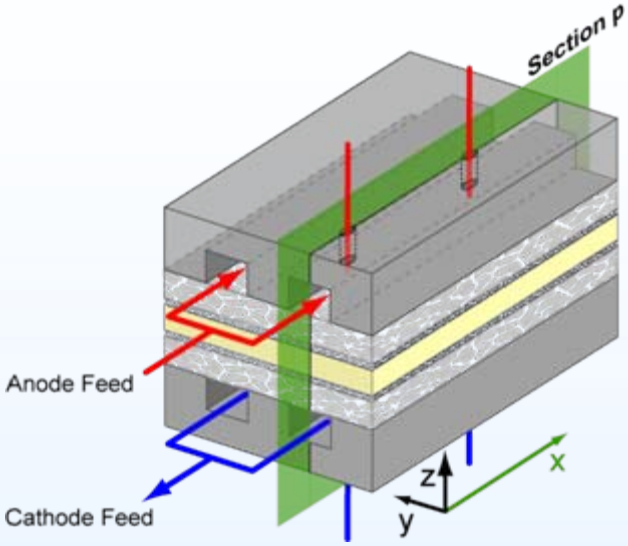
Water Vapor Measurement:

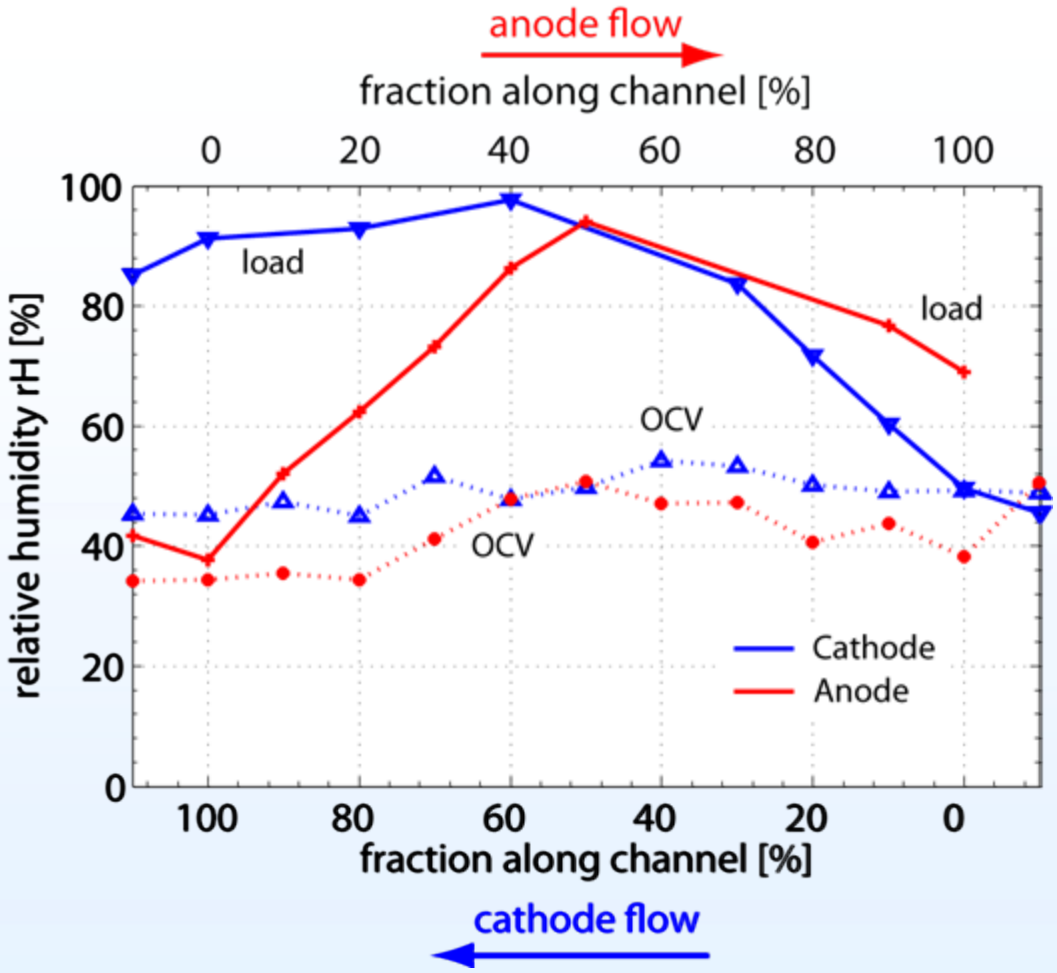
- Identical ionization probability of N2 and H_2O for electron impact ion sources simplify water calibration [1].
- Comparison with capacitive humidity sensor (Vaisala HMP247).
- Absolute humidity error < 2% within the relevant humidity range of rH 20% to rH 100% and lies within the error of the humidity sensor.



[1] A. Karlegärd, A. Götz, I. Bjerle, Chem. Eng. Technol. 18 (2004) 183–192.

Water Vapor Measurement





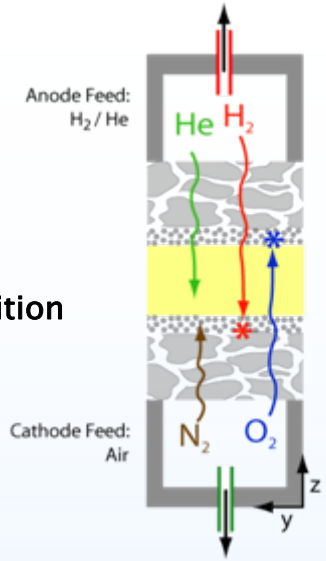
Counterflow operation

T_{cell}:	80°C
Load:	0.375 A/cm²
Membrane:	N112
Electrode:	ETek ELAT A6 V2.1

Anode: 90% H2, 10% He, rH 46%, p_a =1.5 bar, λ = 3

Cathode: 100% Air, rH 50%, p_c =1.5 bar, λ = 2

OCV Helium Permeation Measurement



OCV condition

Membrane: **Nafion 112**

Electrode: Etek Elat A6V2.1

Anode: **90% H2, 10% He**

V=0.5 l_n/min

rH 46%

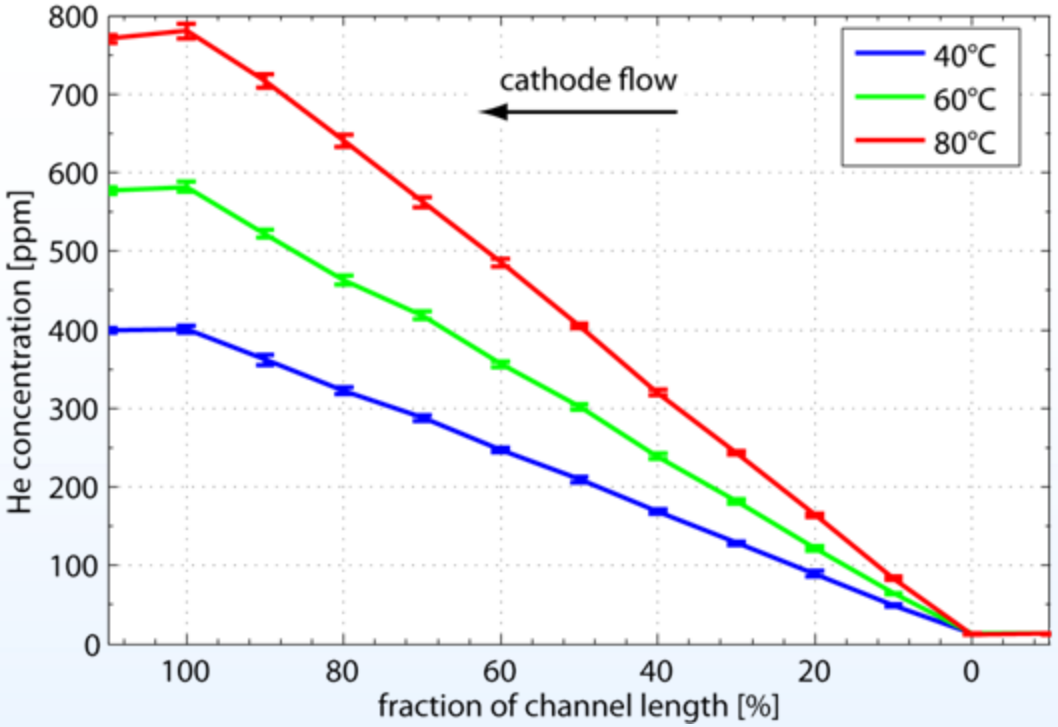
p_a = 1.5 bar

Cathode: **100% Air**

V=0.5 l_n/min

rH 50%

p_c = 1.5 bar



T_{cell} [°C]	c_{He} [ppm]	P_{He} [mol/m/s/Pa]	Equivalent P_{H2} [mol/m/s/Pa]
40	400	2.5E-14	5.8E-15
60	577	3.6E-14	8.3E-15
80	770	4.8E-14	1.1E-14

OCV Helium Permeation Measurement

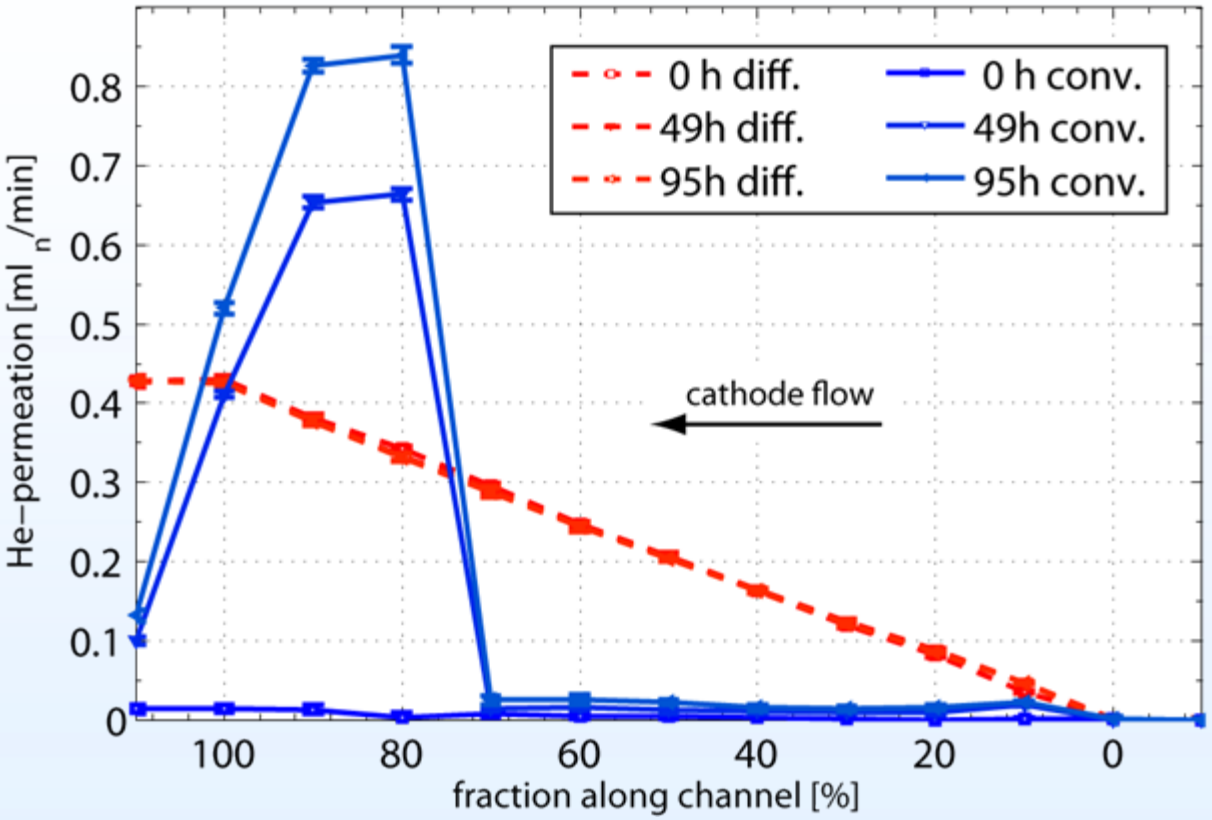
Membrane: Nafion 112

Electrode: Etek Elat A6V2.1

T_{cell}: 80°C

Anode: 90% H2, 10% He
rH 46%
p_a = 1.5 bar

Cathode: 100% Air
rH 50%
p_c = 1.5 bar



Summary

Local Online Gas Analysis in PEFC:

- High flexibility:
  - measurement concepts
  - operating conditions
- Linear fuel cell of technical size
- Mass spectrometry based system
- Local online gas species investigation:
  - dry gas species
  - water vapor