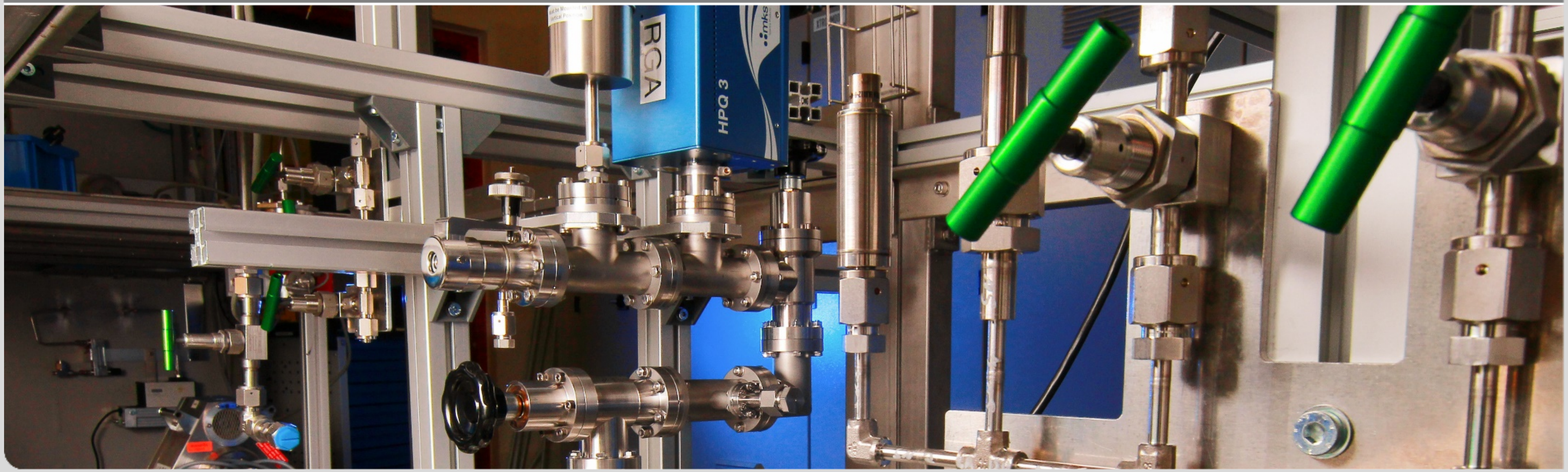
Karlsruhe Institute of Technology

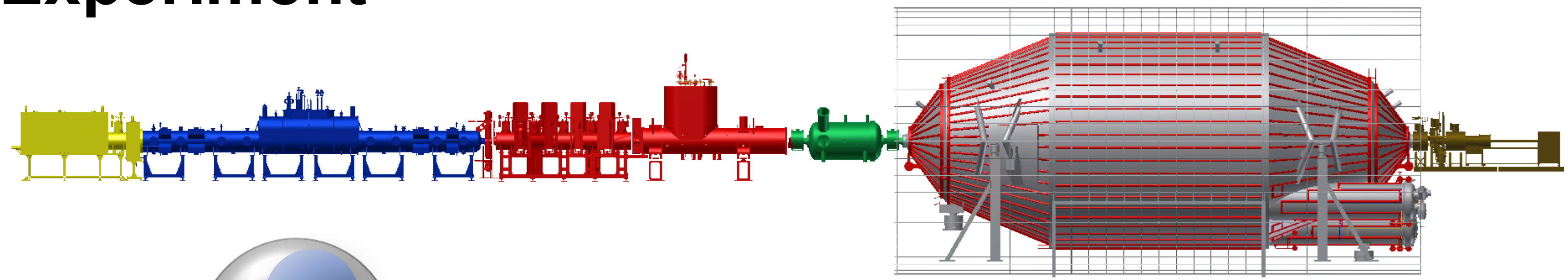
Tritium Laboratory Karlsruhe

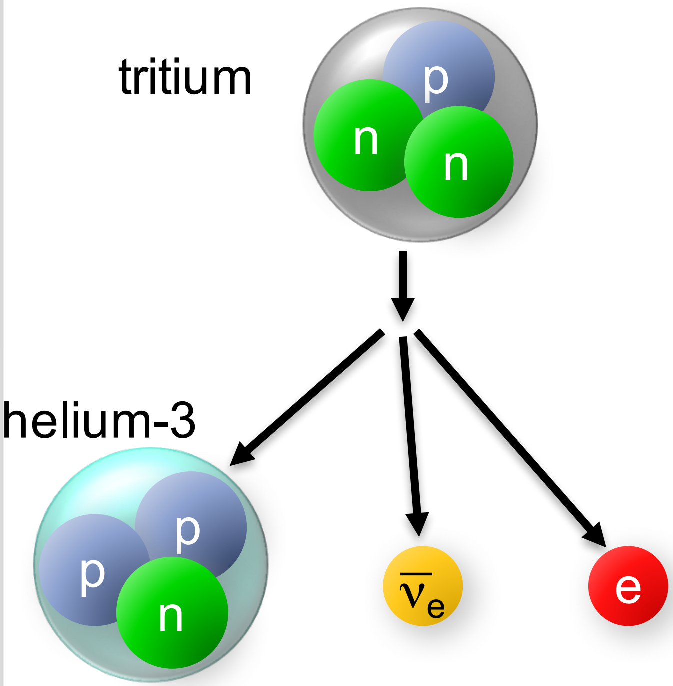
How to improve the trueness of tritium content measurement at TLK for KATRIN

INSTITUTE OF TECHNICAL PHYSICS, TRITIUM LABORATORY KARLSRUHE



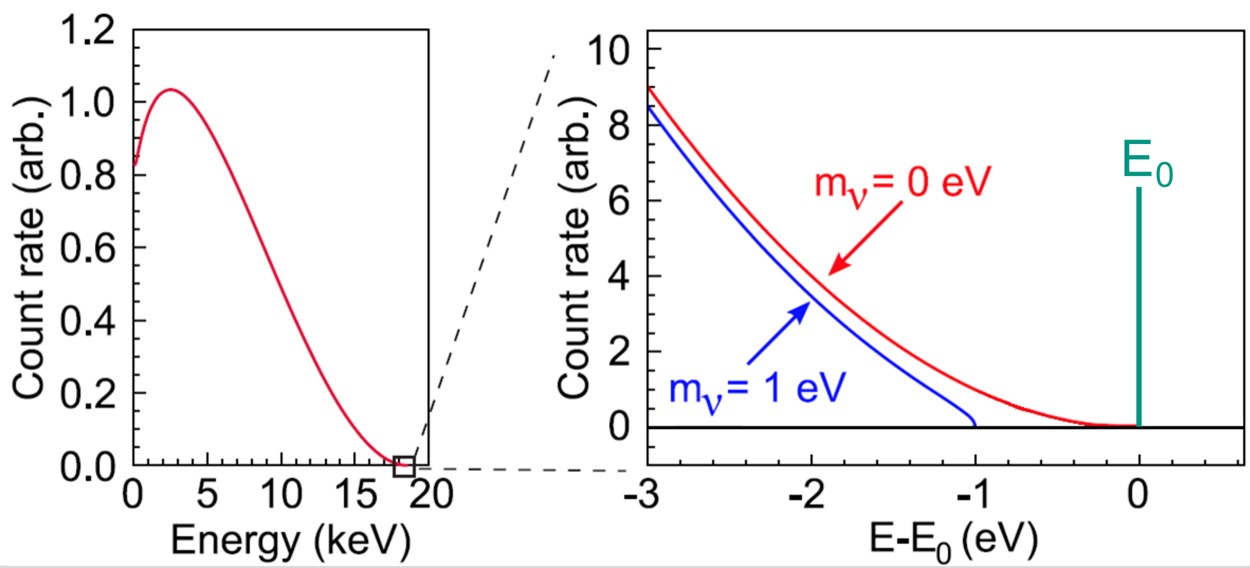
The KArlsruhe TRItium Neutrino Experiment





aim: measurement of the neutrino mass with 0.2 eV/c² sensitivity (90% CL)

E_0=18.6 keV



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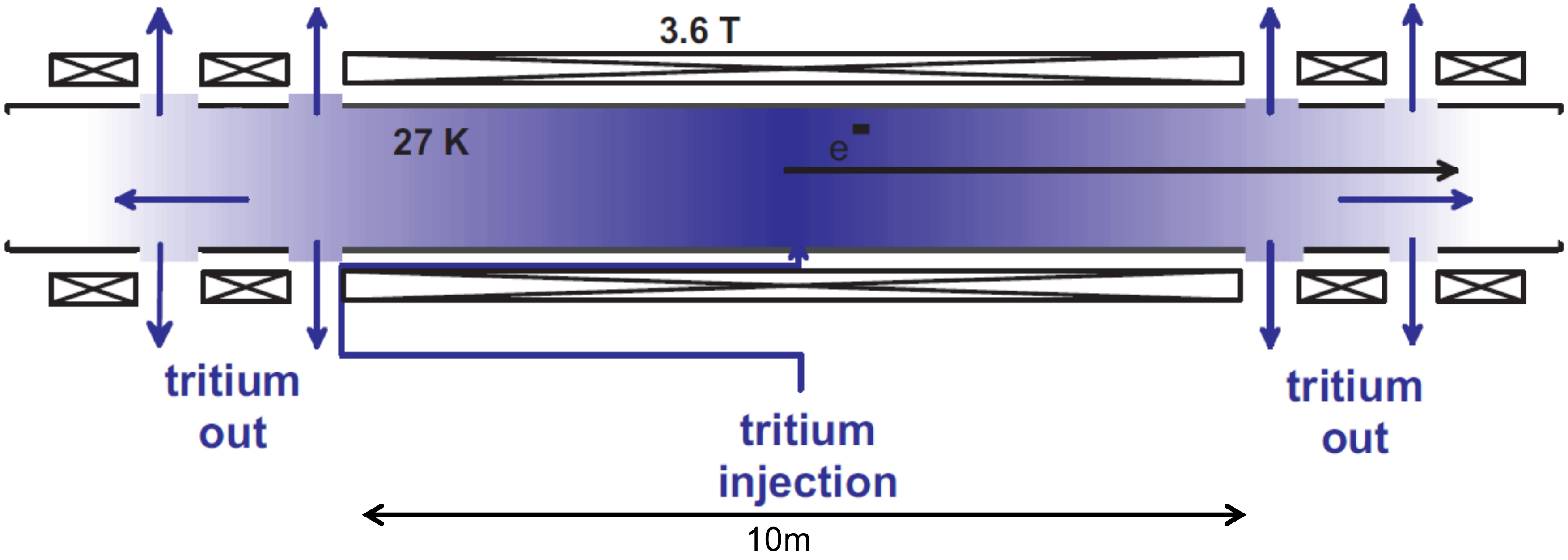
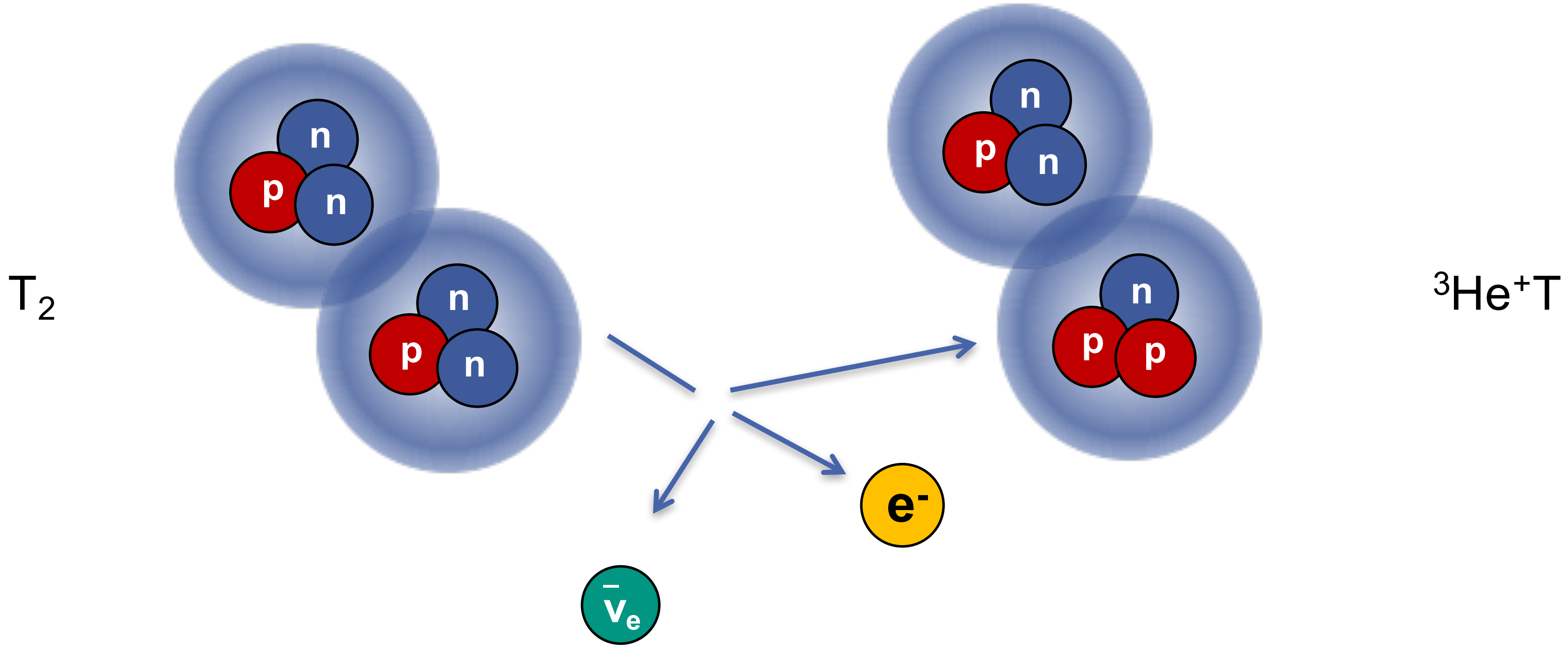
KATRIN WGTS

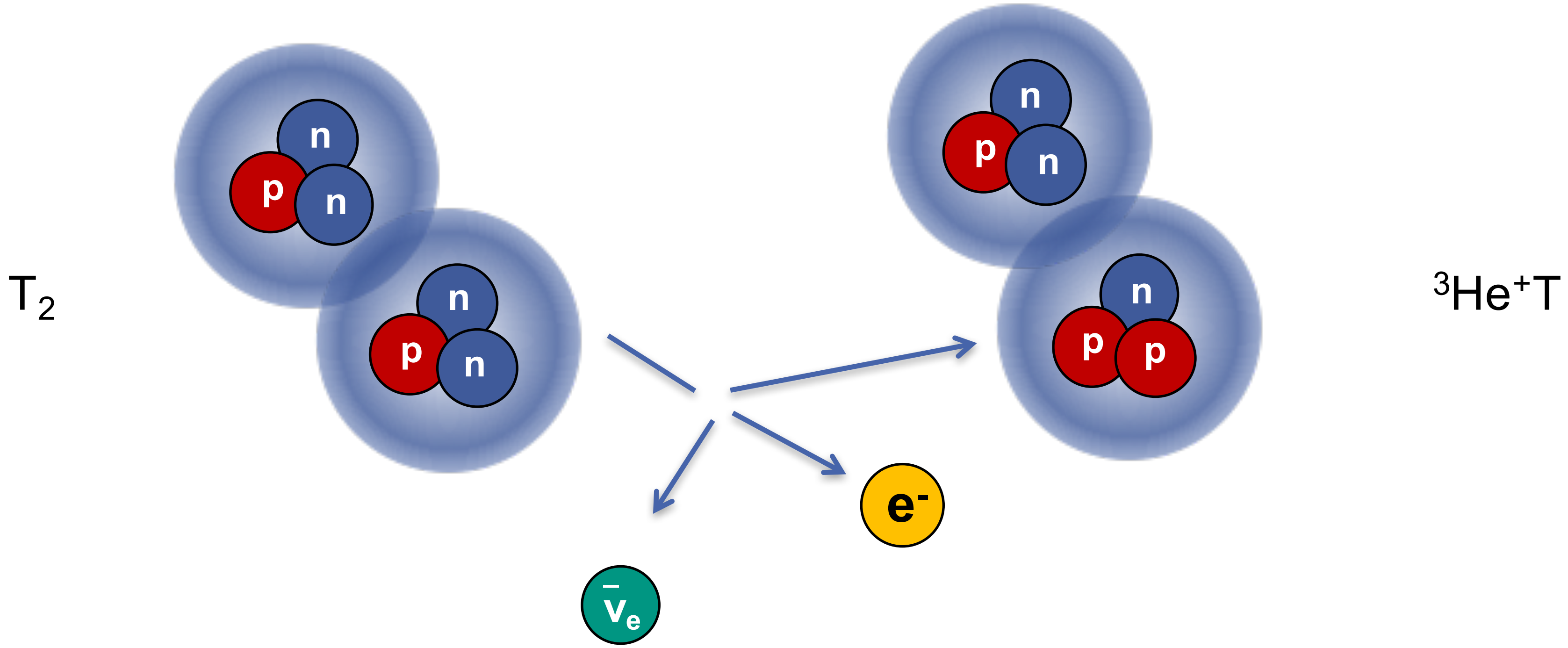


- ~27-30K
- ~10^{-3} mbar inlet pressure
- Tritium purity: 95 %

Molecular beta decay



Molecular beta decay

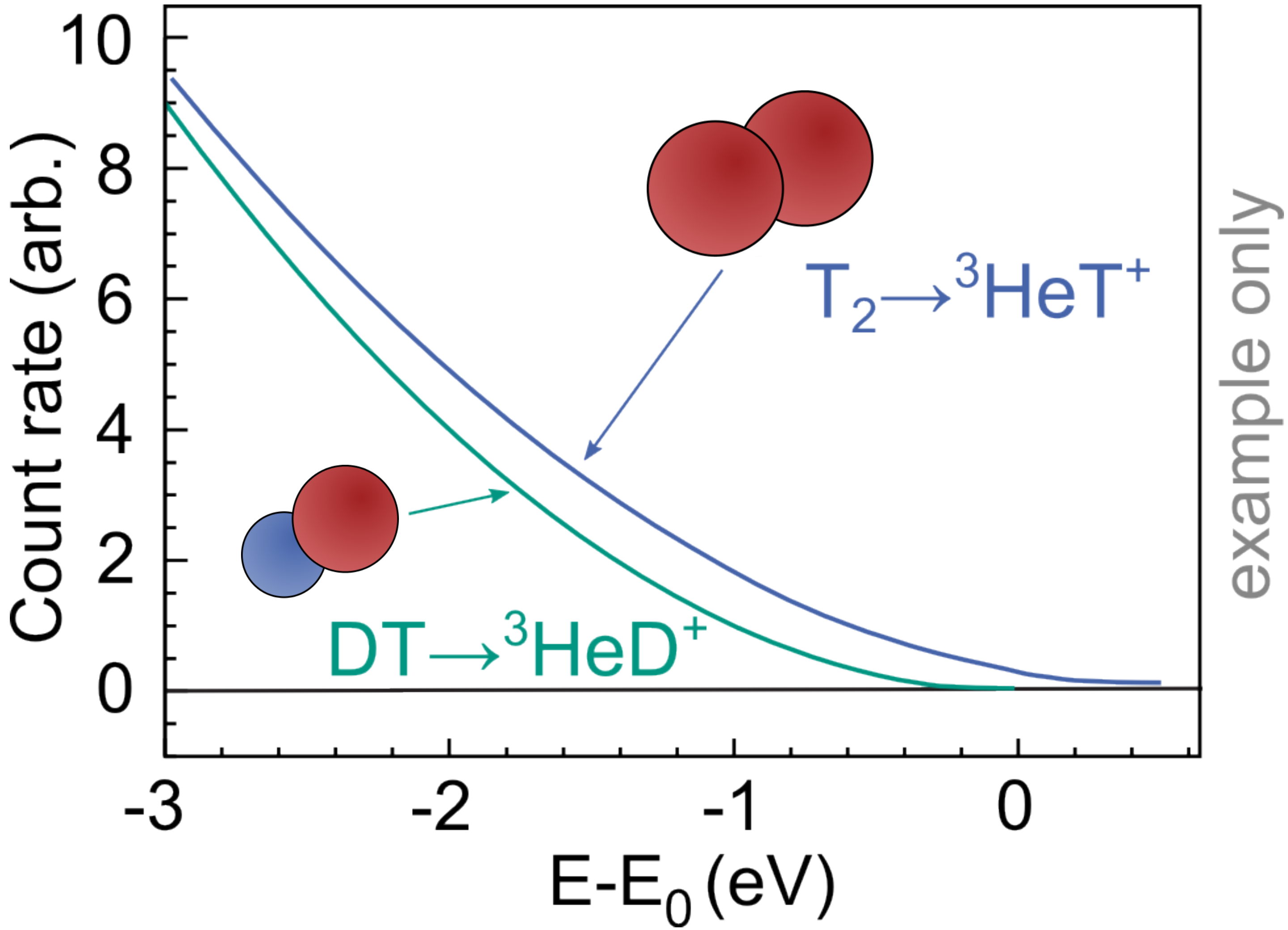


$\langle i|$ V $|f\rangle$

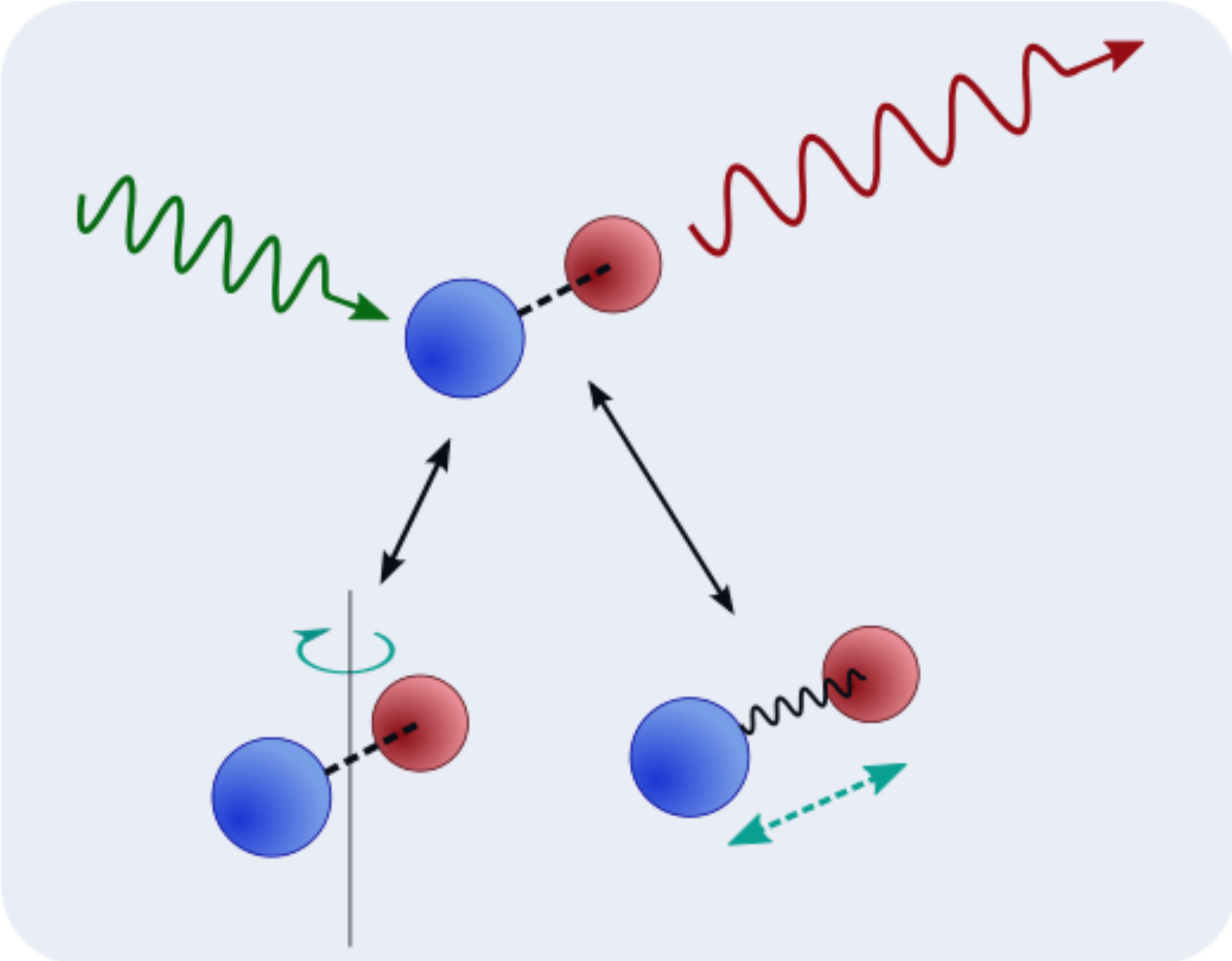
Fermi's golden rule: $W_{i\to f} = \frac{2\pi}{\hbar} |\langle i|V|f\rangle|^2 \rho(E_f)$

Beta spectrum depends on initial & final state distribution

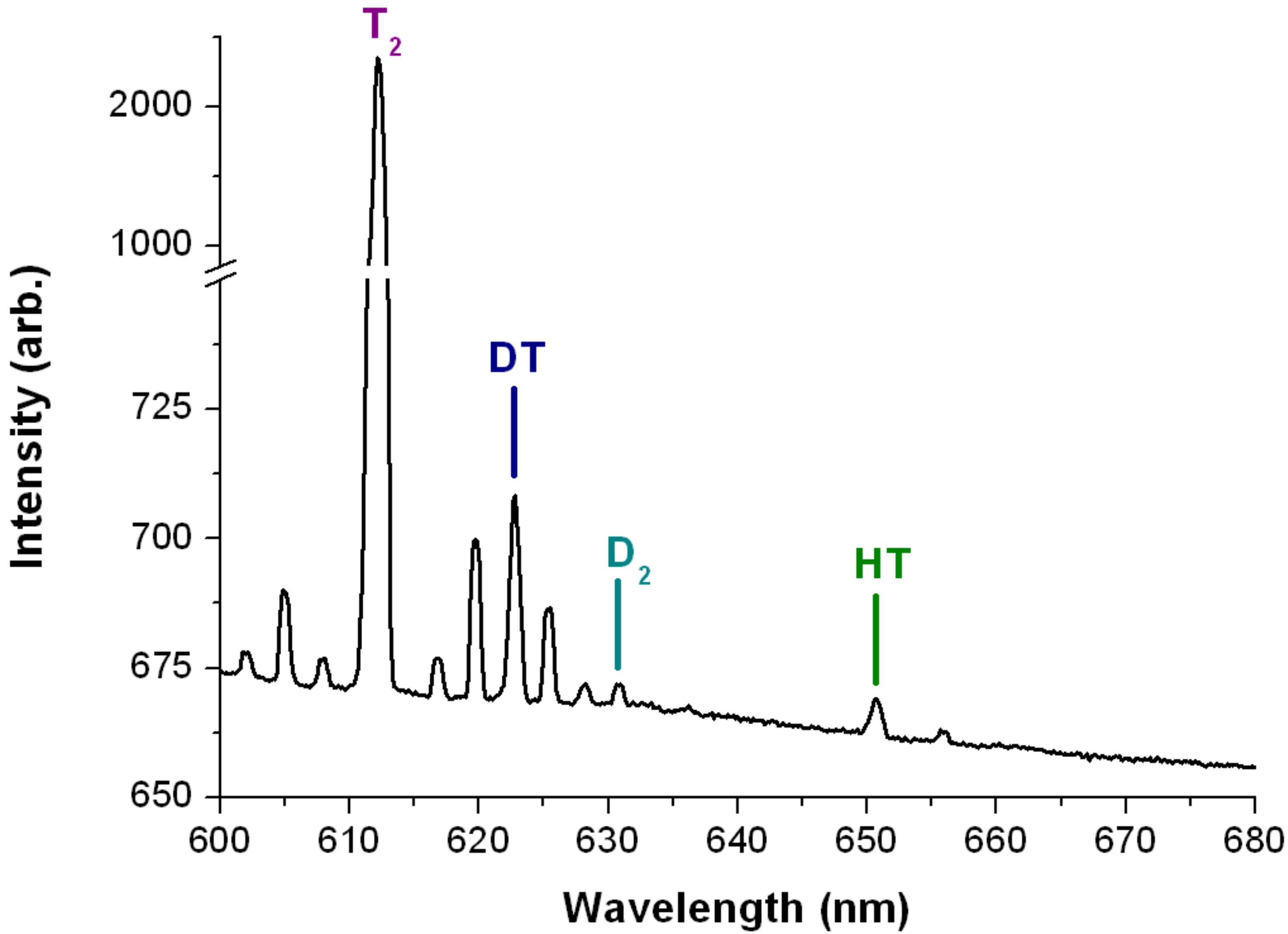
Isotopic composition monitoring



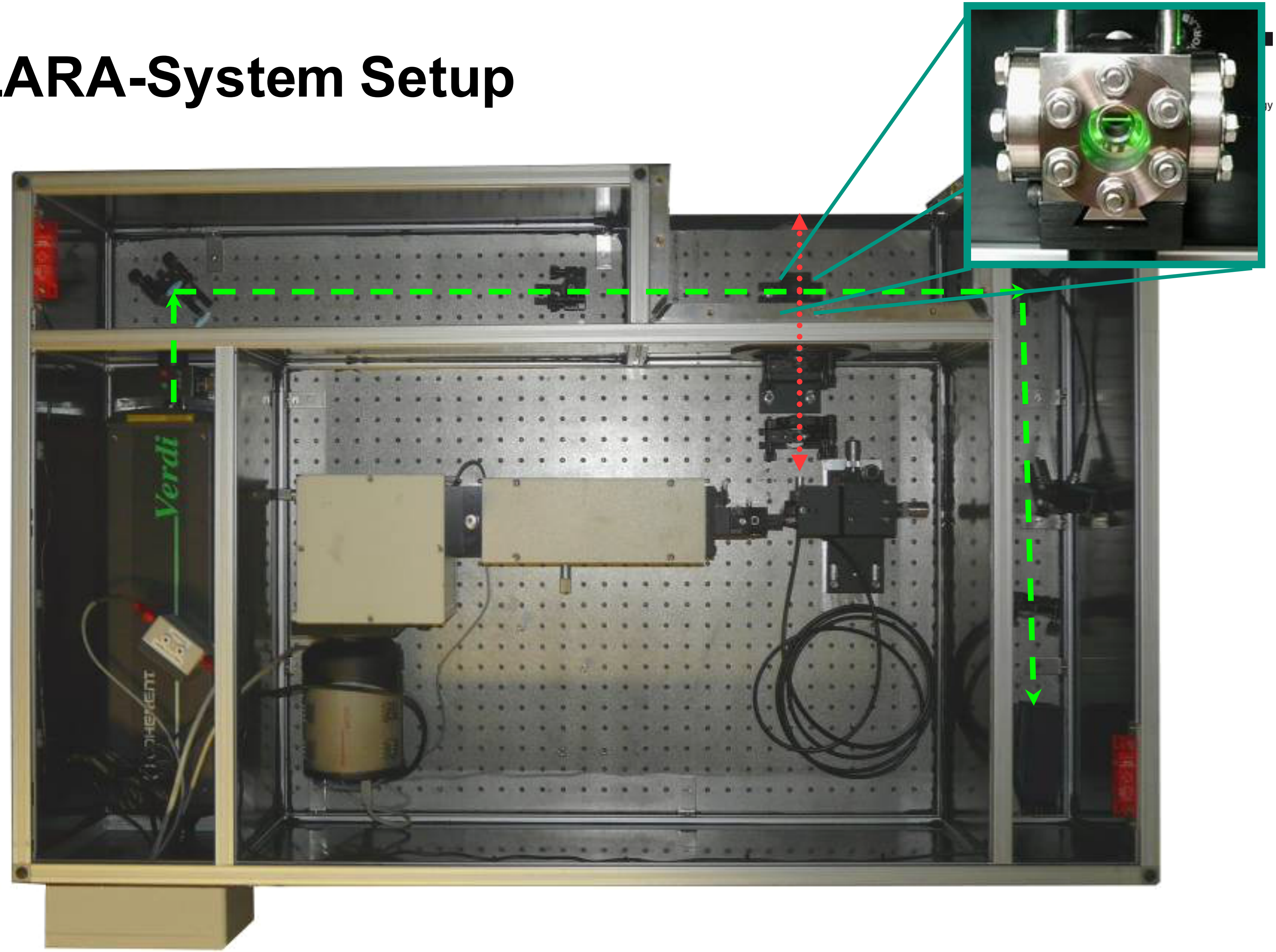
Raman Effect

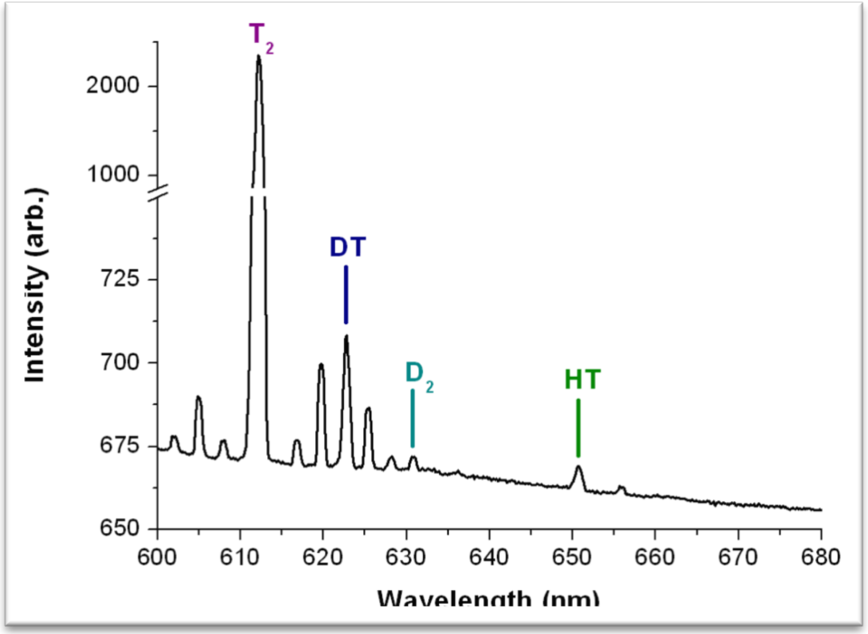


Raman spectrum



LARA-System Setup

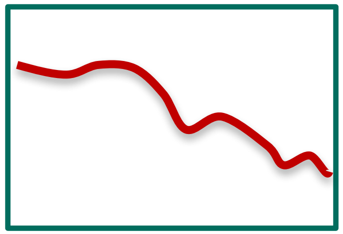




Line Intensity

No validated T2-data

Response Function



Concentration measurement

Open questions

- Absolute intensity calibration with tritium data?
- Characterisation over wide parameter range?
- Performance for standard KATRIN-like and non-standard mixtures?

Equilibrated calibration samples from all hydrogen isotopologues

!

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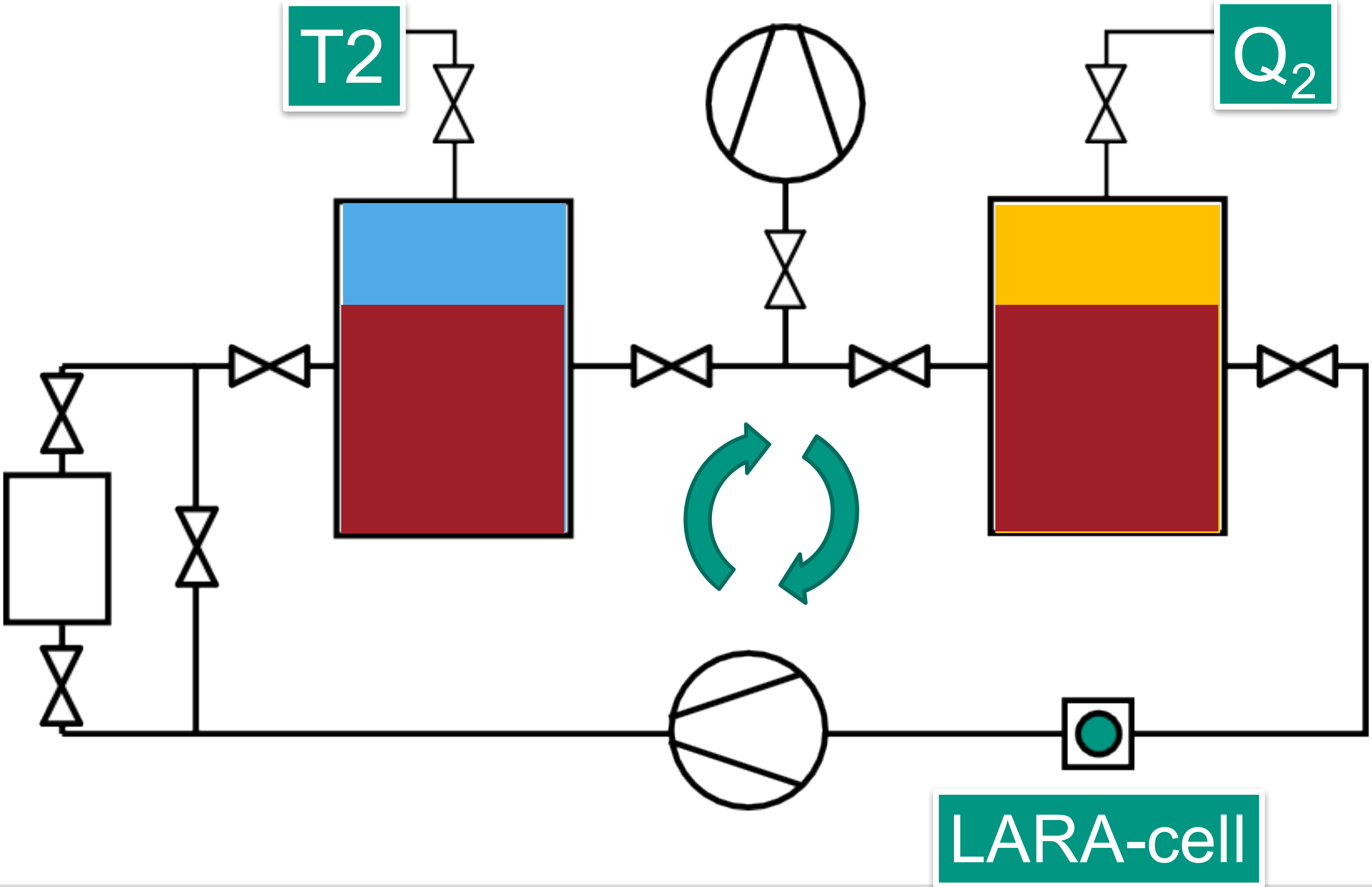
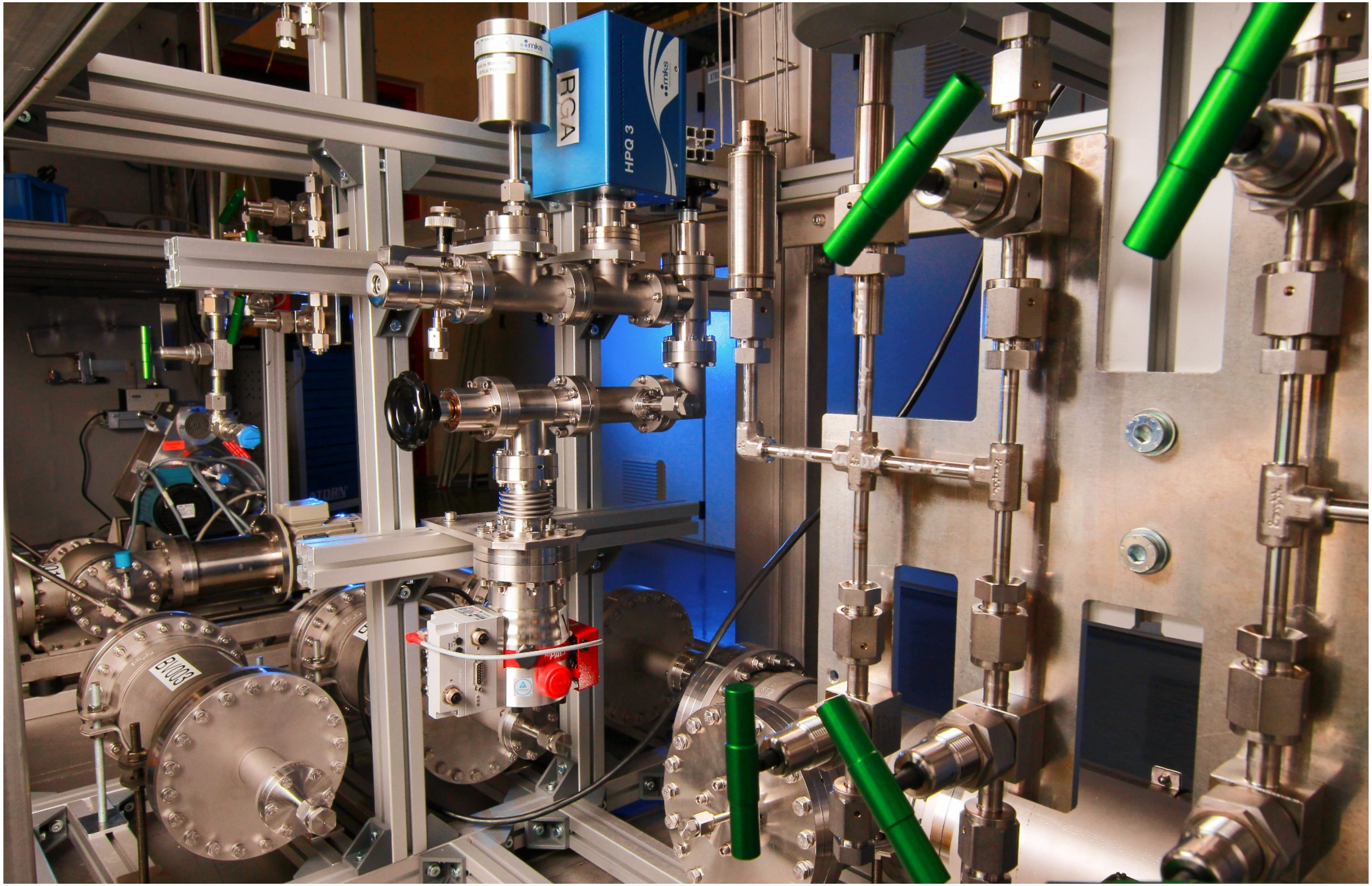
TRIHYDE

Tritium Hydrogen Deuterium Experiment

How does TRIHYDE work?


T2
Q2
LARA-cell

TRIHYDE



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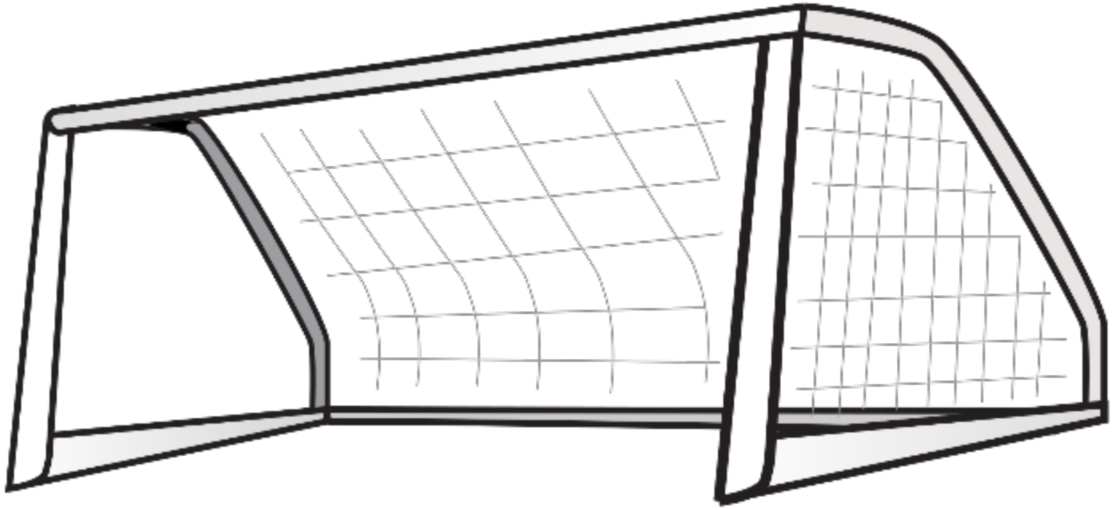
What is the goal?



Gas samples with better 1 % absolute accuracy

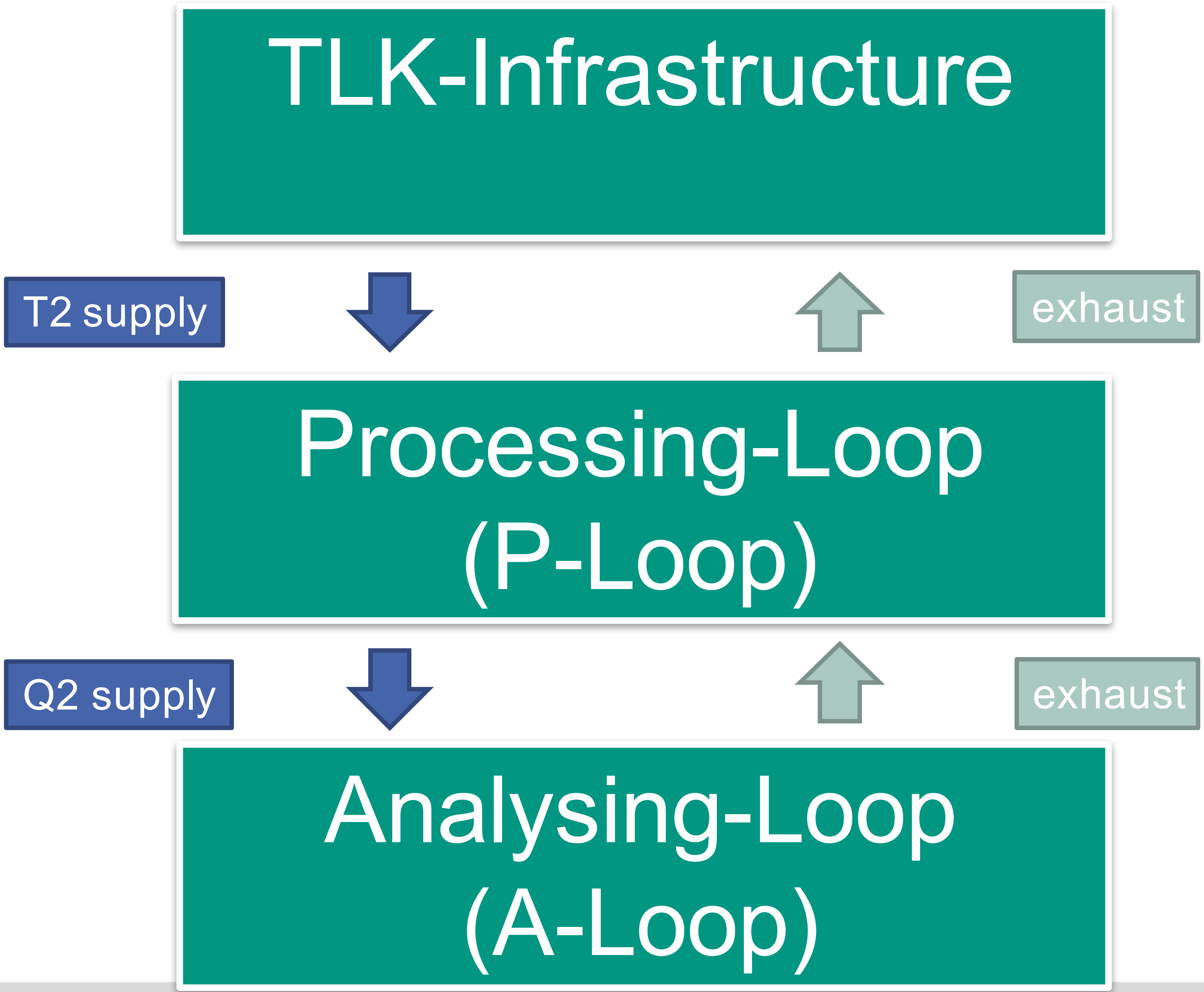
- Pressure uncertainty > 0.15 %
- Temperature uncertainty > 0.2 %
- Volume uncertainty > 0.25 %


BV005
Must be Mounted in
Vertical Position
Swagelok
OPEN
CLOSE
Swagelok
OPEN
CLOSE
Swagelok
OPEN
CLOSE

Requirements

- Integration to TLK infrastructure
- Infrastructure-independent operation
- T2-compatible primary system
- Operability and maintainability inside a glovebox
- Compatibility to various LARA-systems
- High-purity T2

TRIHYDE Setup



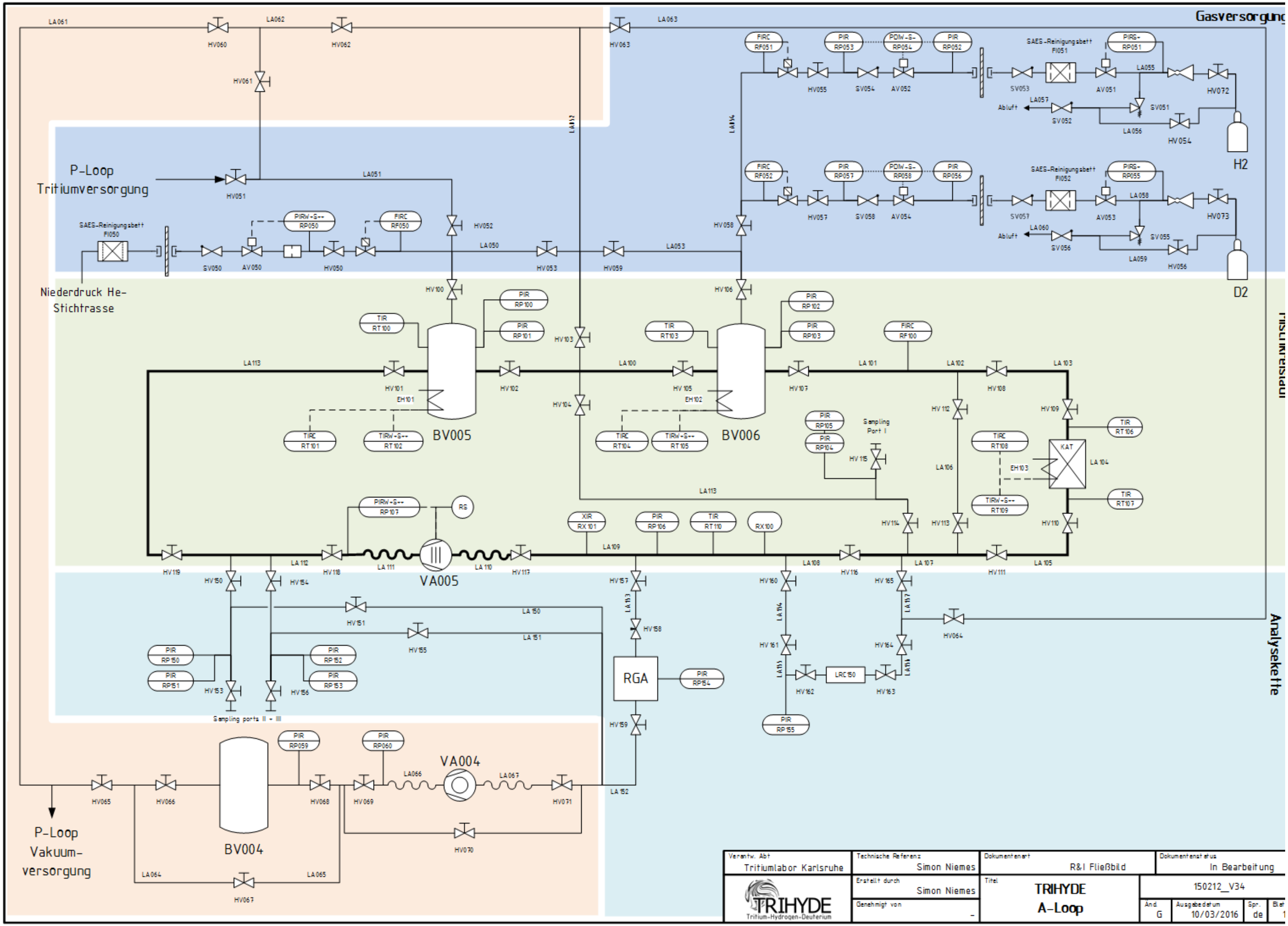
A-Loop setup

Gas supply

Mixing loop

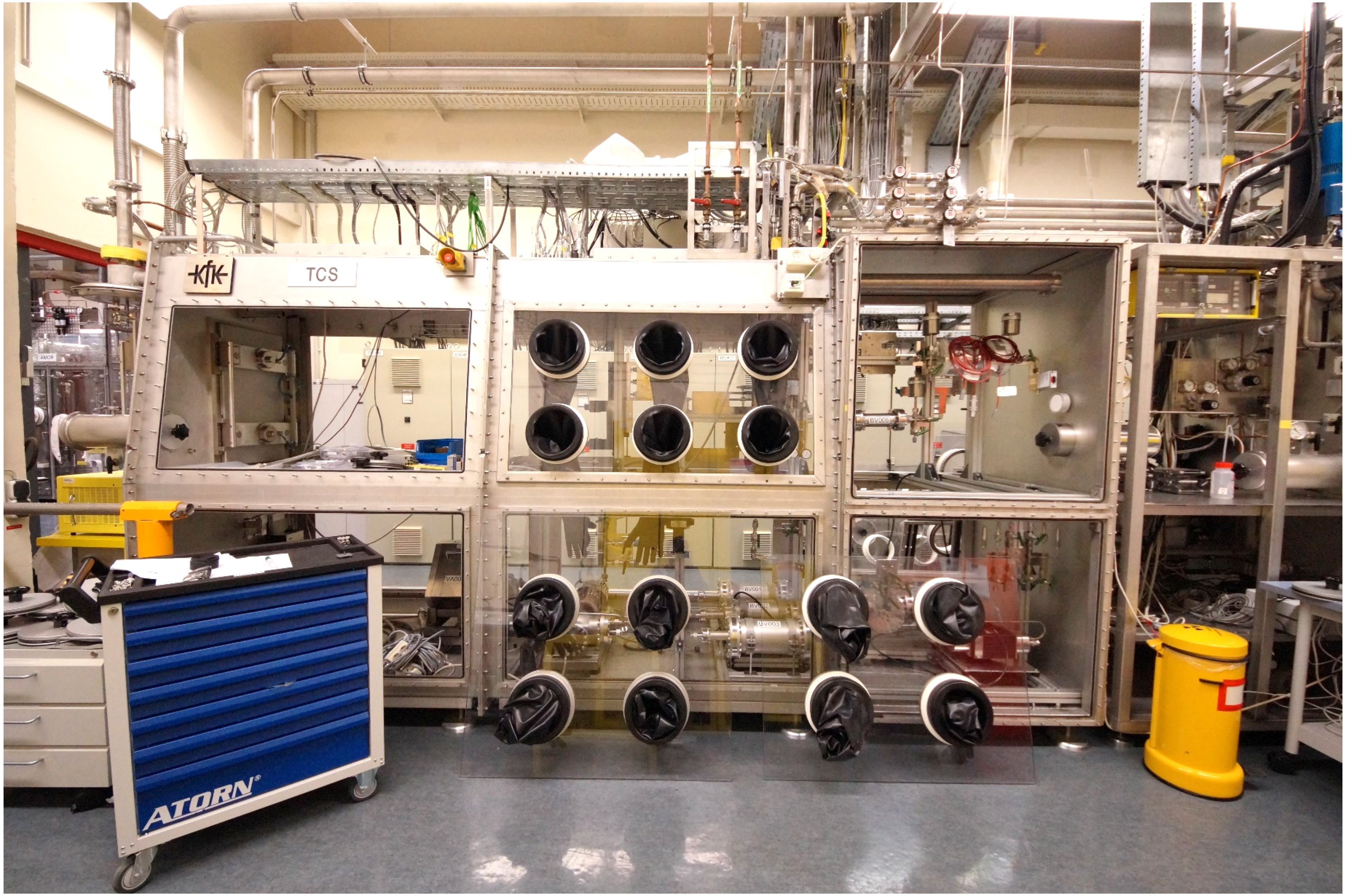
Analysing loop

Vacuum
supply + exhaust



Verantw. Abt	Technische Referenz	Dokumentenart	Dokumentenstatus
Tritiumlabor Karlsruhe	Simon Niemes	R&I Fließbild	In Bearbeitung
TRIHYDE Tritium-Hydrogen-Deuterium	Erstellt durch: Simon Niemes	Titel: TRIHYDE A-Loop	150212_V34
	Genehmigt von: -		Änd. G · Ausgabedatum 10/03/2016 · Spr. de

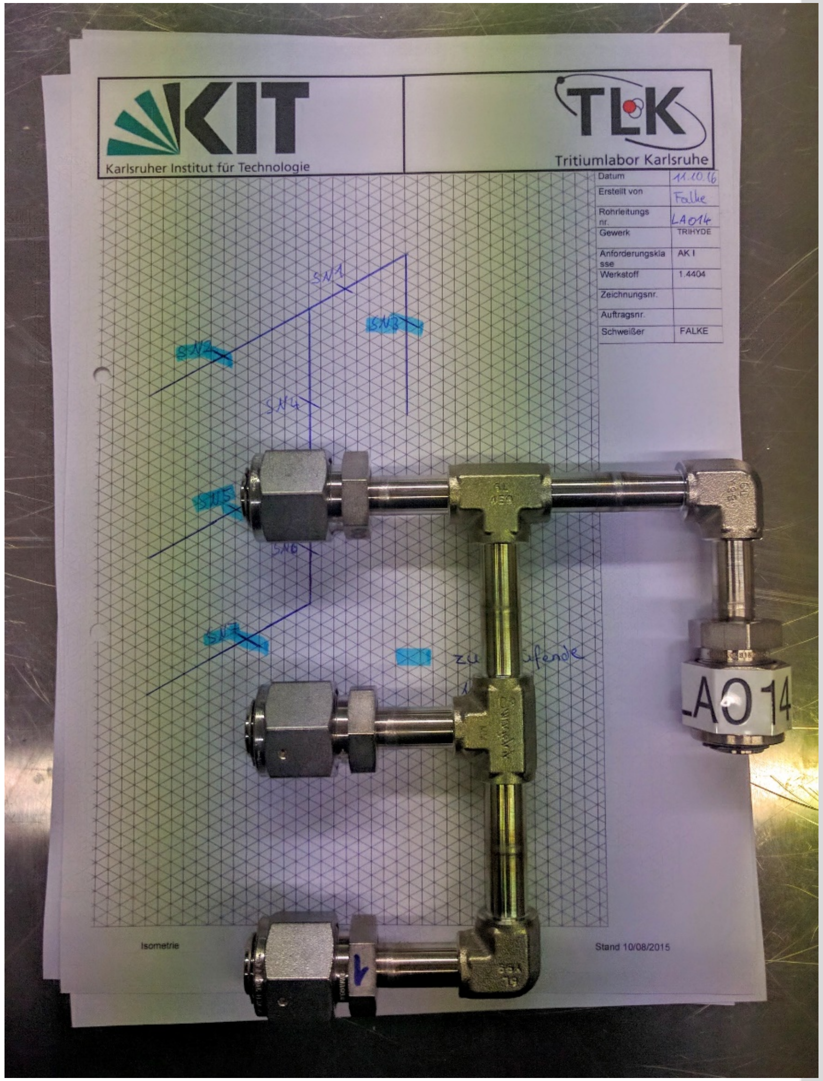
Glove Box




kfk
TCS

TRIHYDE in figures

- 104 valves
- 74 individual pipes with ~ 200 welds
- 39 pressure sensors
- 25 additional sensors
- 5 electrical cabinets



TRIHYDE in figures

- 104 valves
- 74 individual pipes with ~ 200 welds
- 39 pressure sensors
- 25 additional sensors
- 5 electrical cabinets
- 10 folders of Documentation

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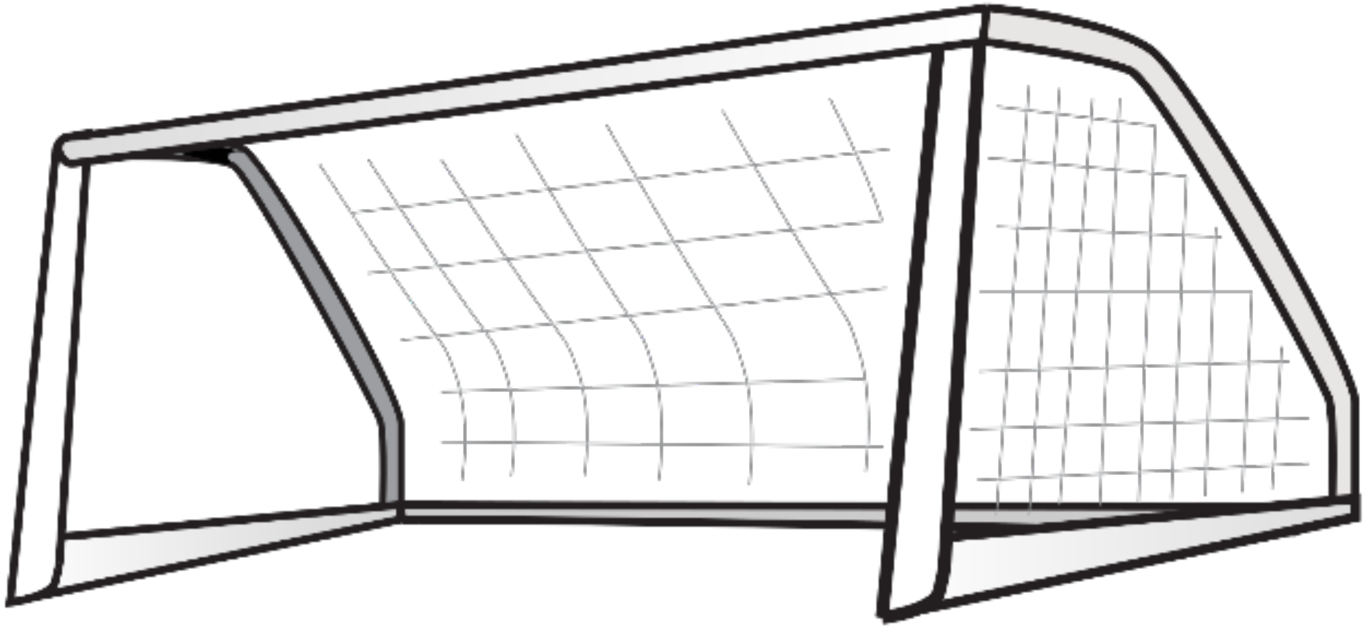
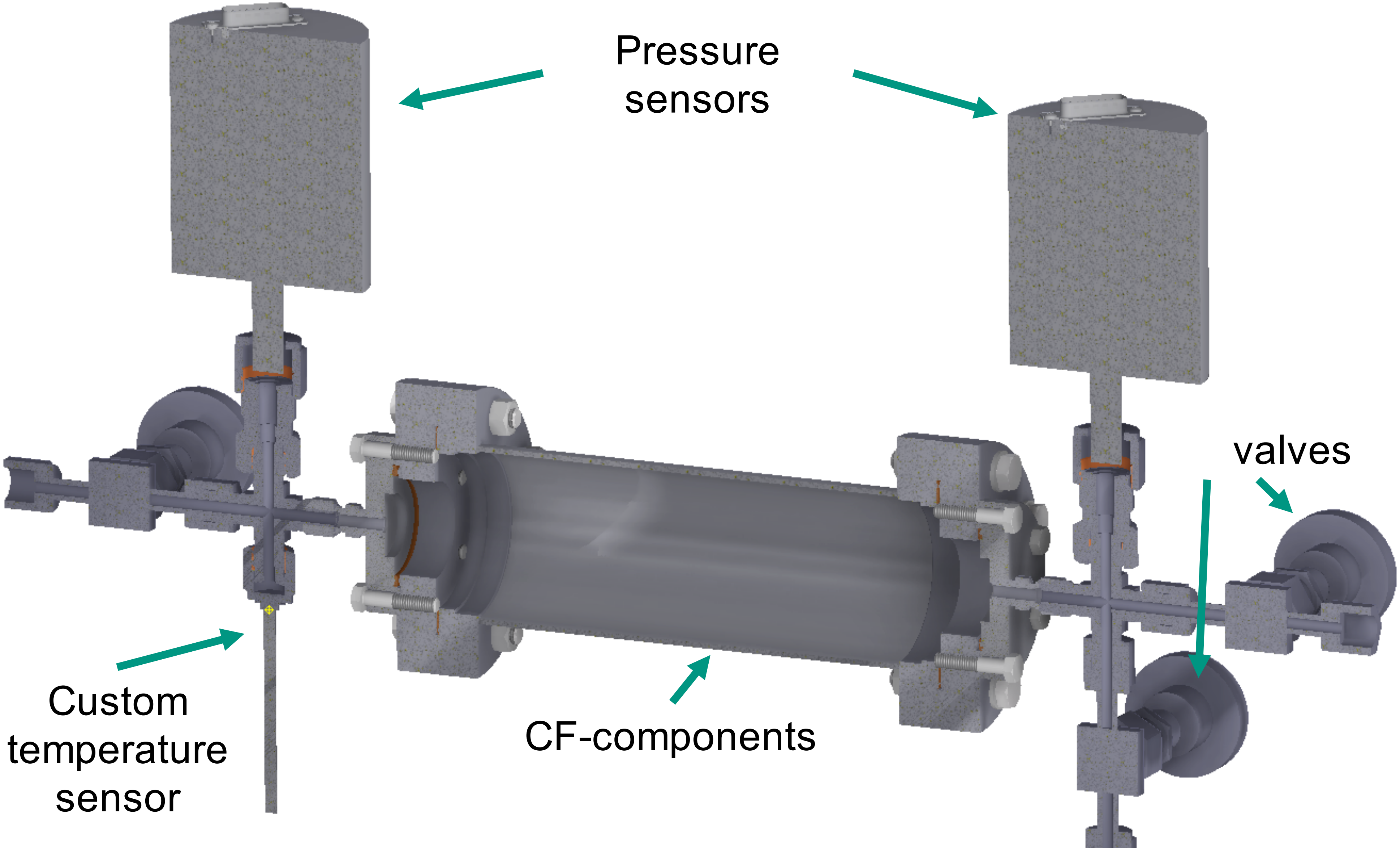


Gas samples with 1 % absolute accuracy

Uncertainty < 0.25%



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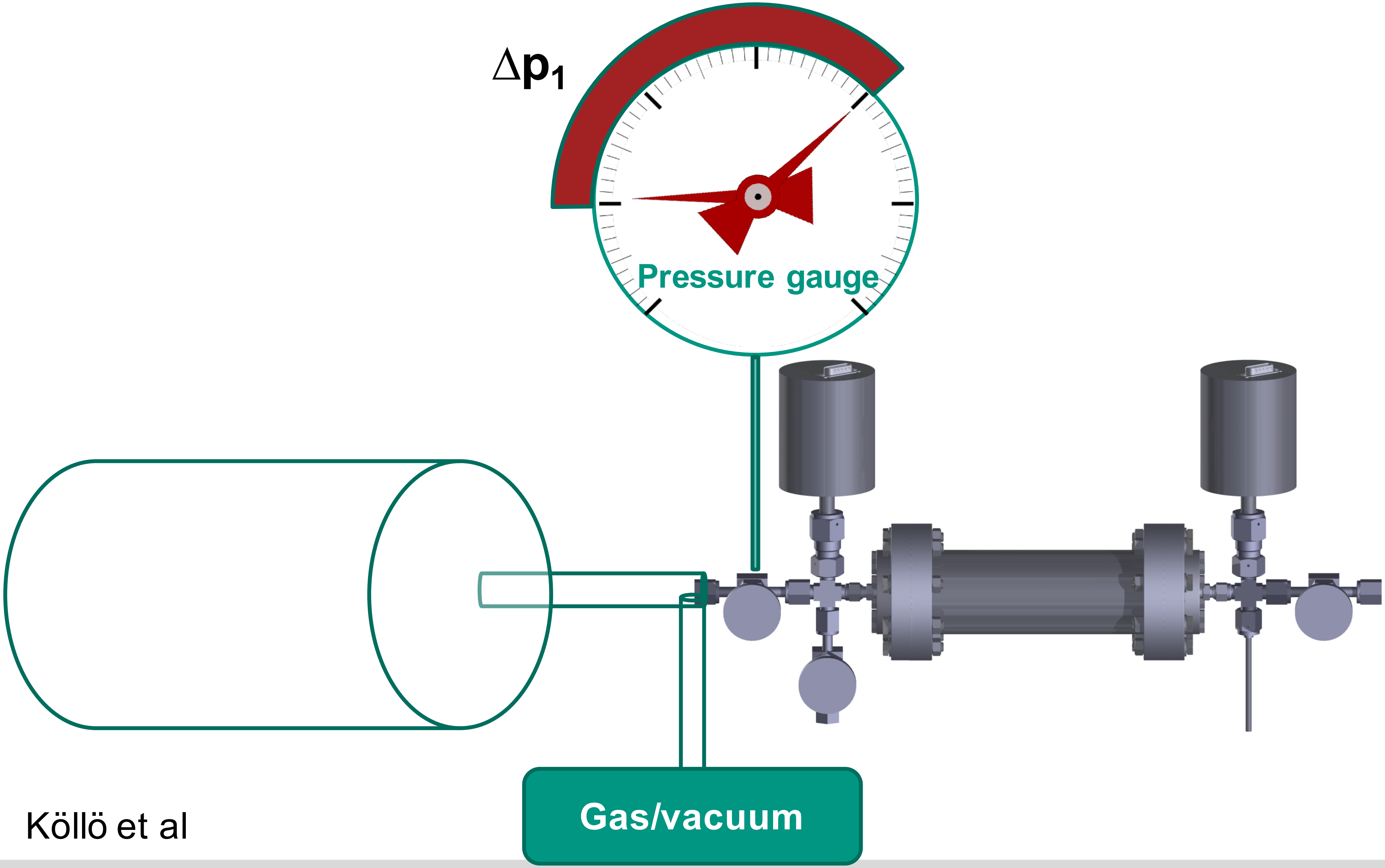
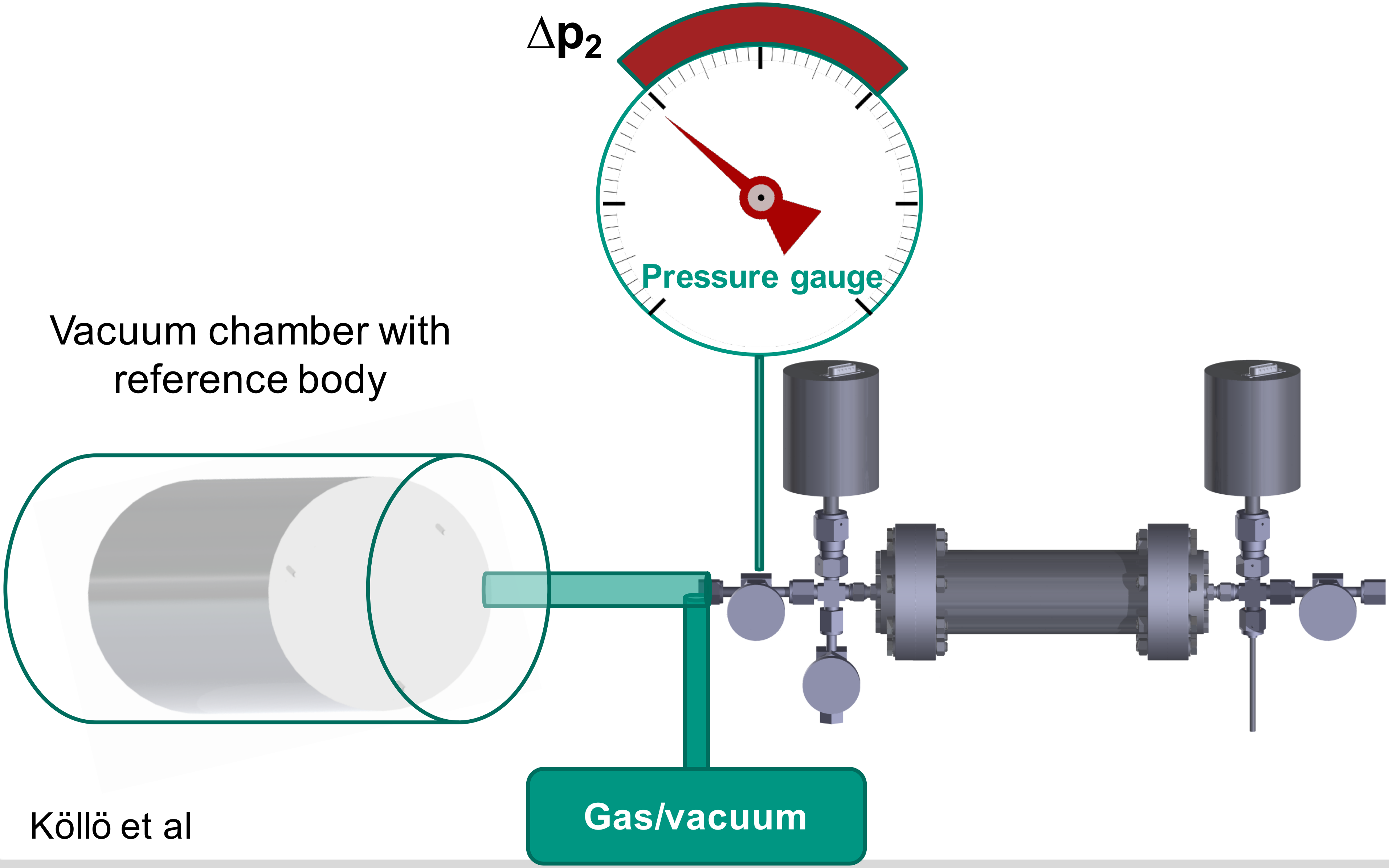
Volume determination with reference body

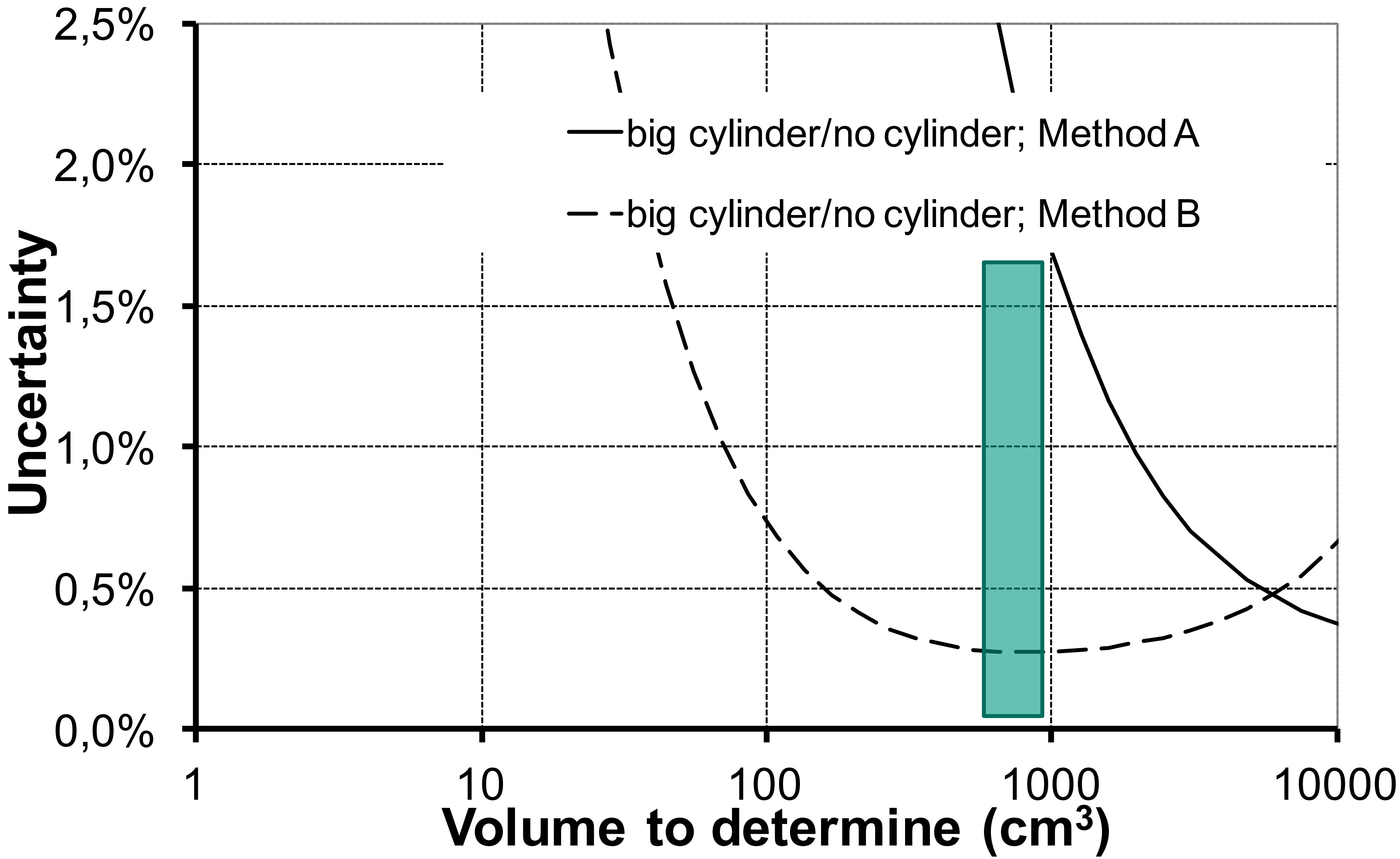


Köllö et al

Volume determination with reference body



Köllö et al



2,5%
2,0%
1,5%
1,0%
0,5%
0,0%
Uncertainty
big cylinder/no cylinder; Method A
big cylinder/no cylinder; Method B
1
10
100
1000
10000
Volume to determine (cm³)

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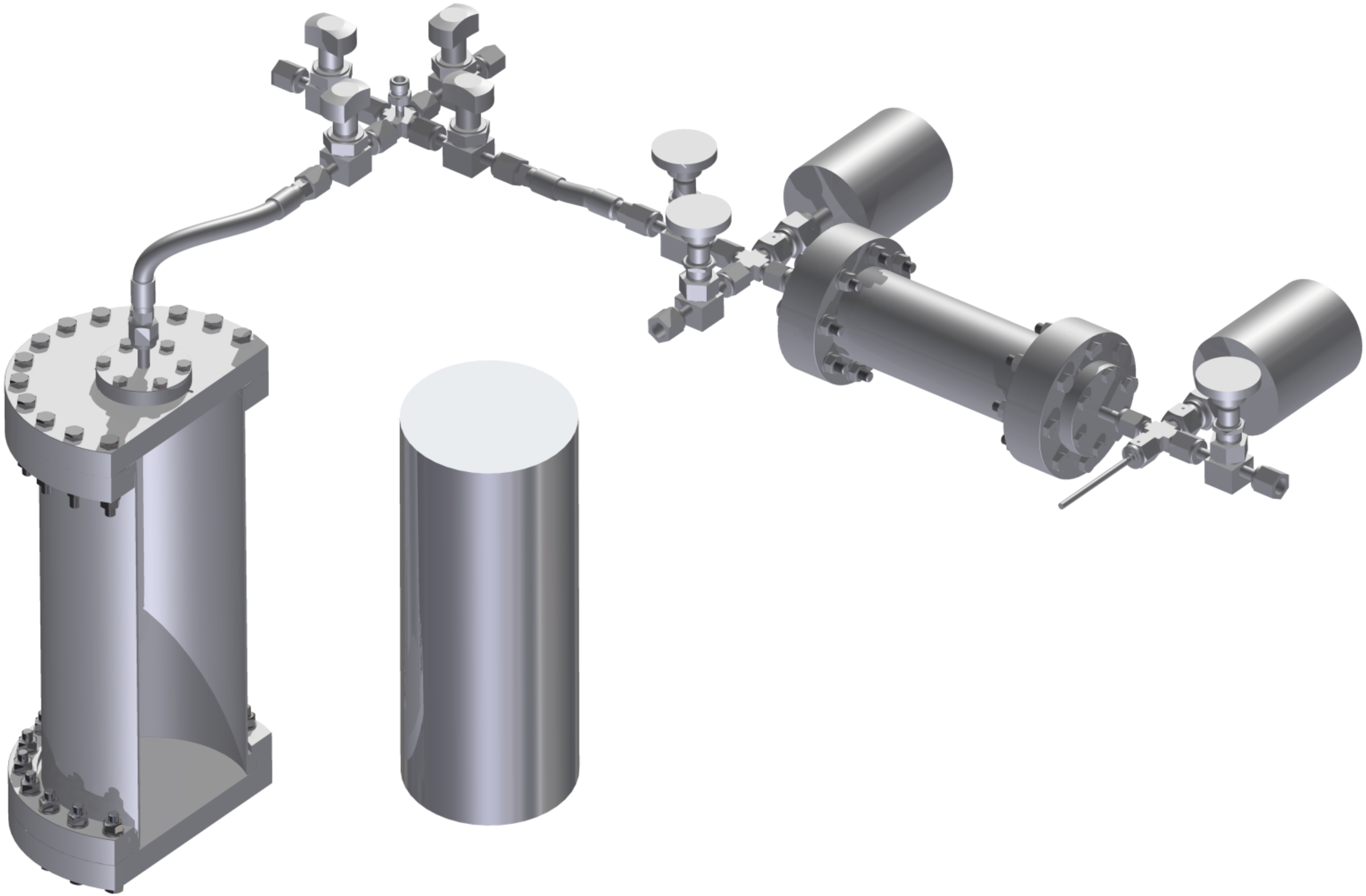
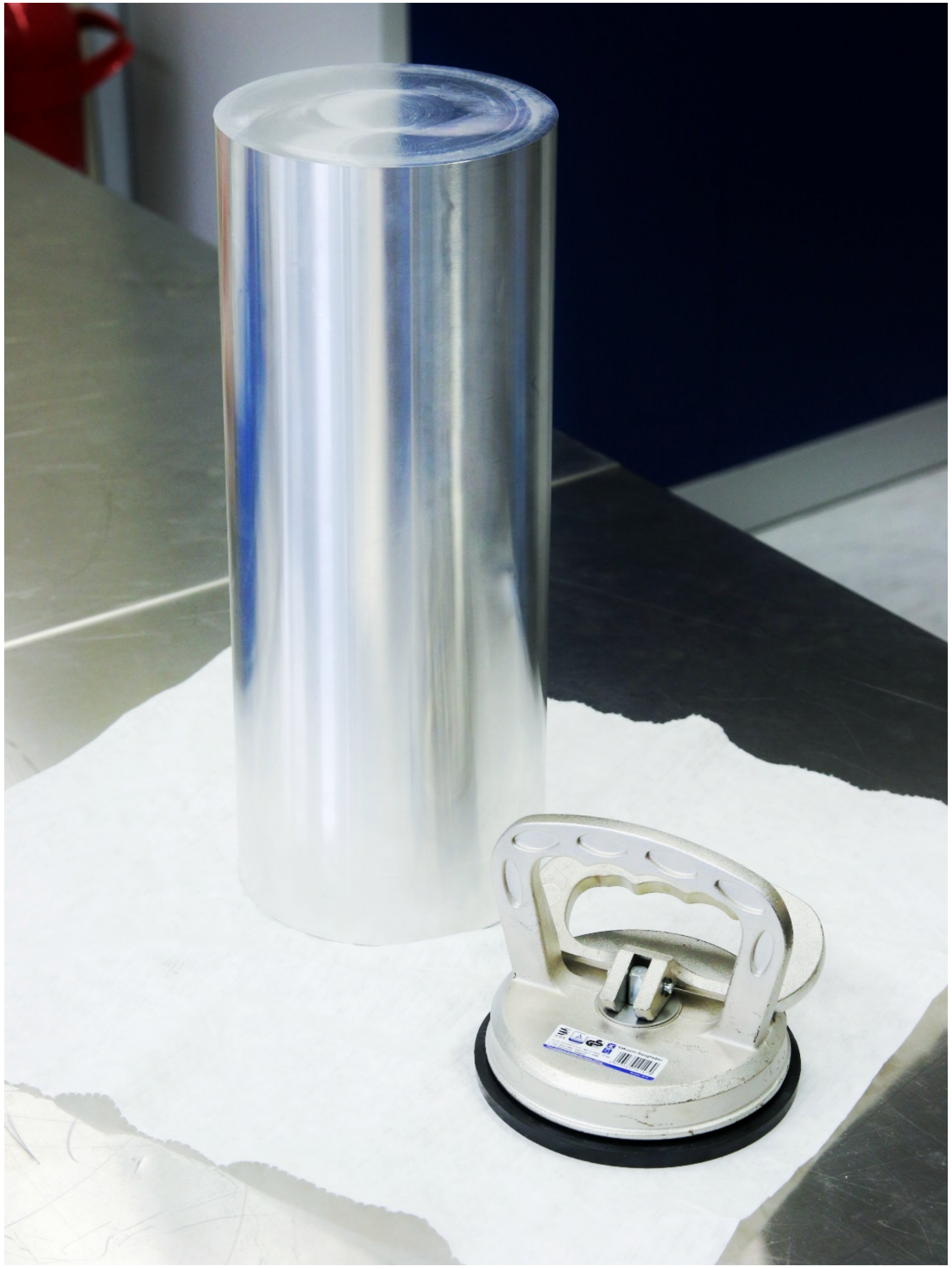




Reference Cylinder

< 30 µm tolerance for total geometry

Next Steps

I. Commissioning phase

II. Measurement phase

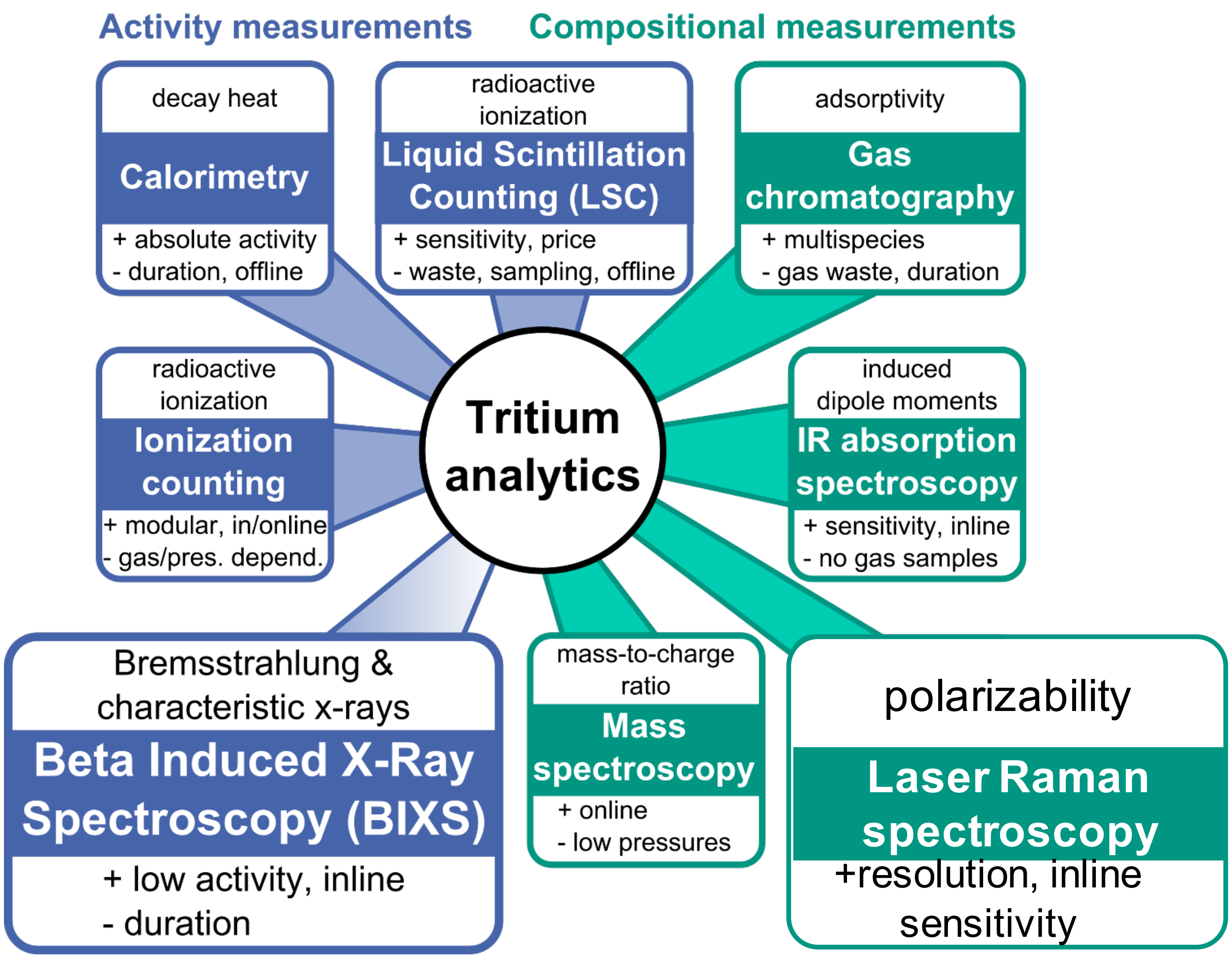
Take-home message

- Isotopic composition monitoring vital for neutrino mass measurement
- Verification of LARA-systems with T2-data necessary
- Complex system for calibration gas sample for all hydrogen isotopes

TRIHYDE

[redacted]

Tritium analytics



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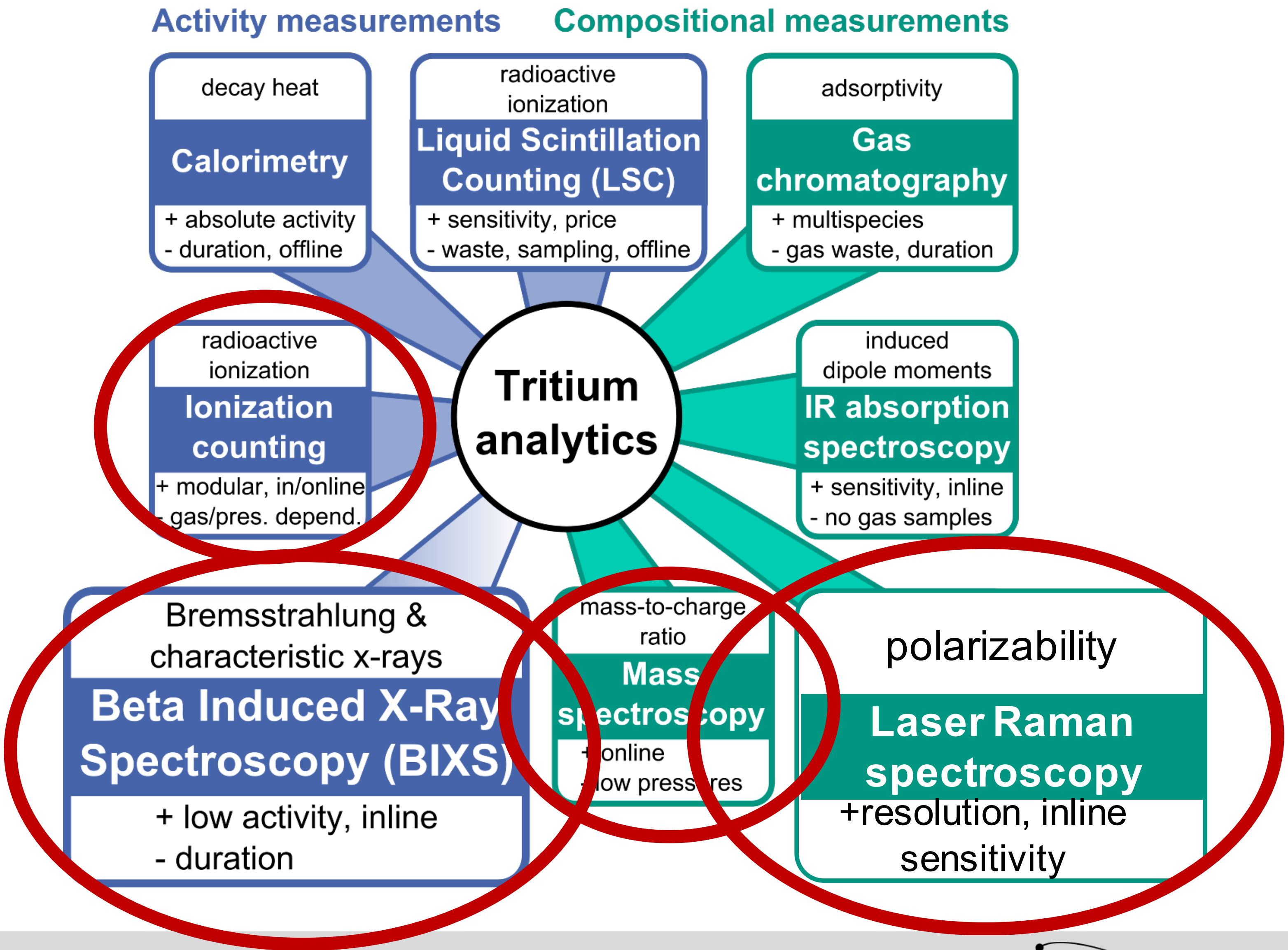
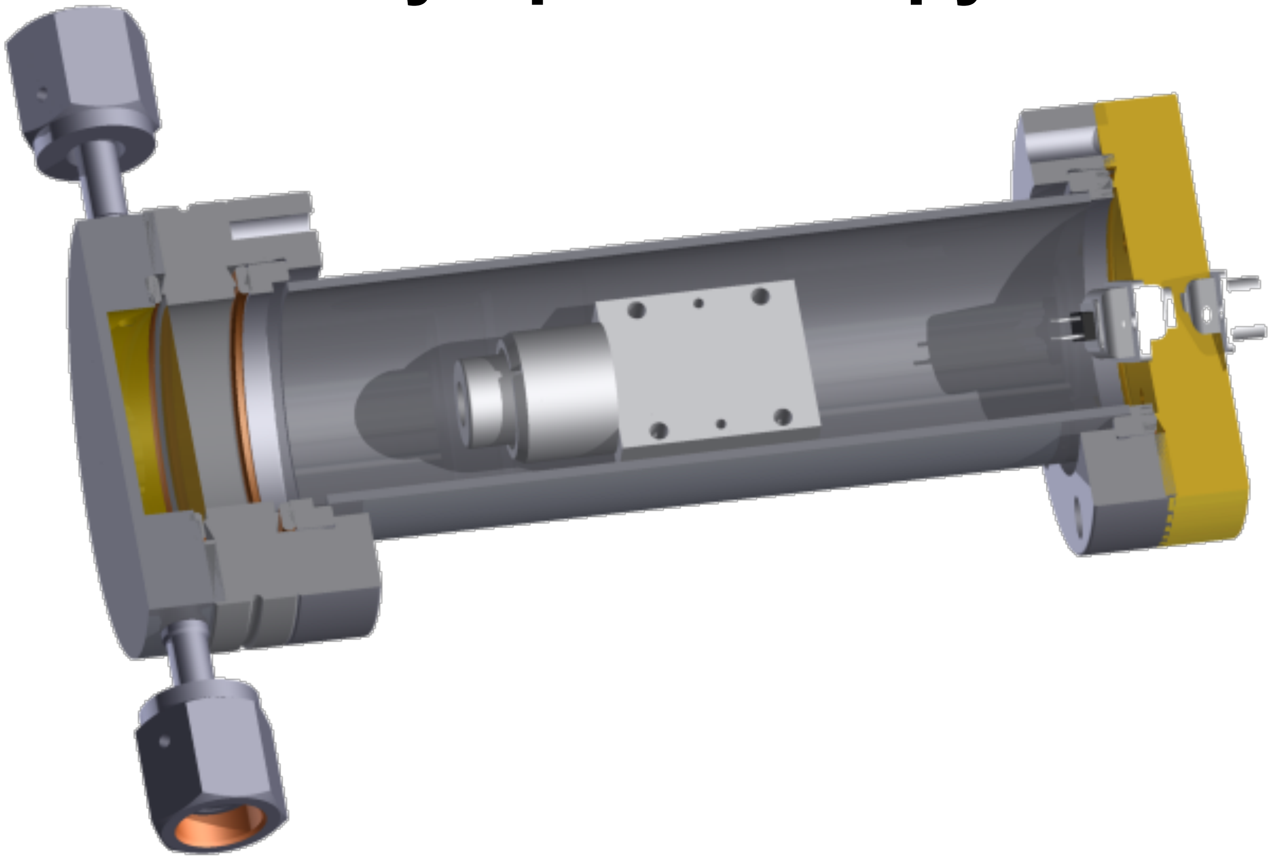
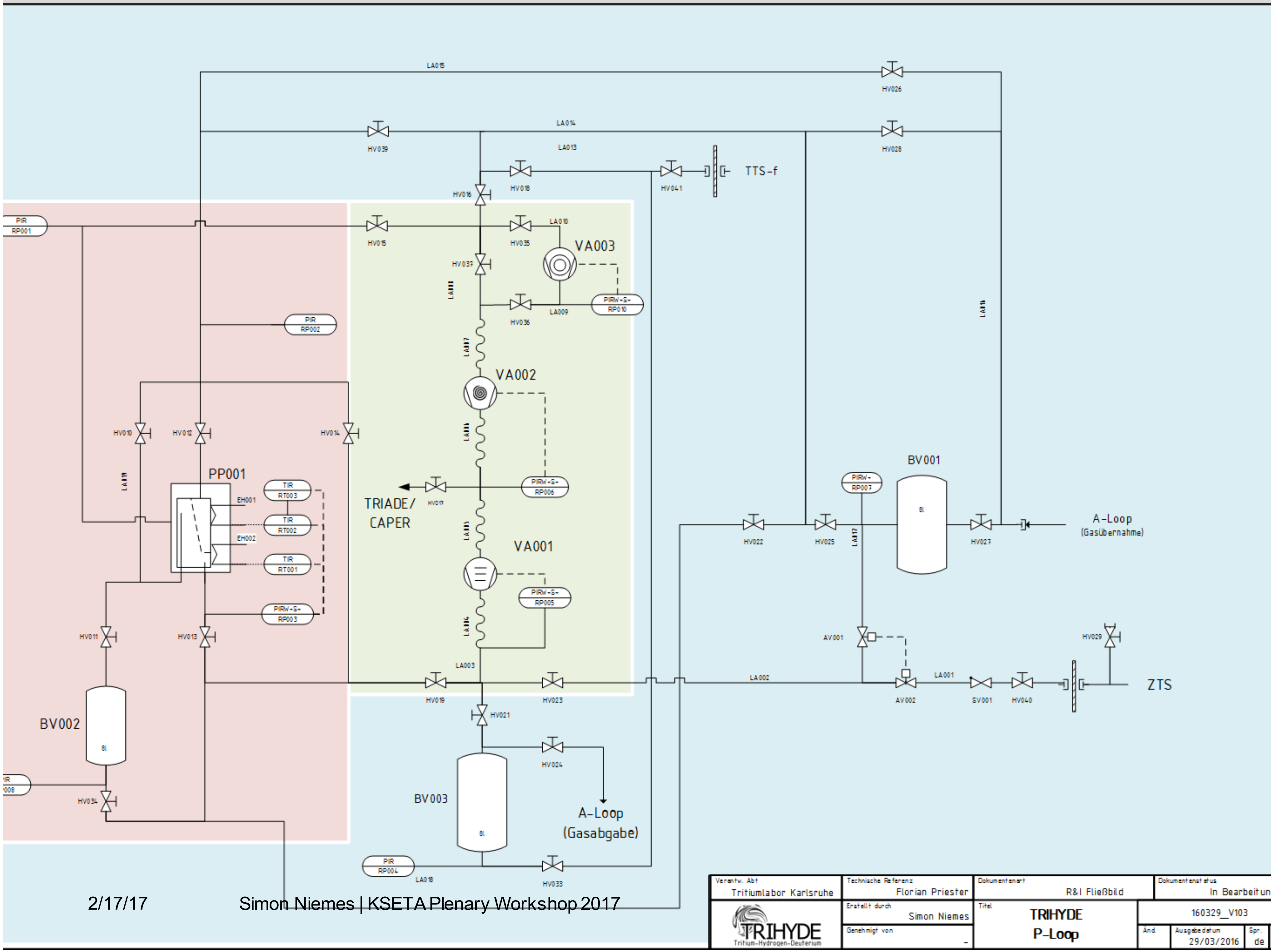
Tritium analytics



Beta-Induced-X-ray-Spectroscopy

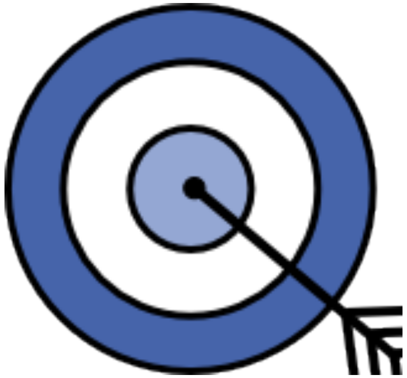


- Tritium Activity Chamber Experiment 2.0
- Bakeable, easy to integrate in system
- Evaluation over wide pressure, activity and flow regime



TTS-f
VA003
VA002
VA001
PP001
BV001
BV002
BV003
TRIADE/ CAPER
A-Loop (Gasübernahme)
A-Loop (Gasabgabe)
ZTS
Tritiumlabor Karlsruhe
Florian Priester
R&I Fließbild
In Bearbeitun
Simon Niemes
TRIHYDE
P-Loop
160329_V103
29/03/2016
de
TRIHYDE
Tritium-Hydrogen-Deuterium

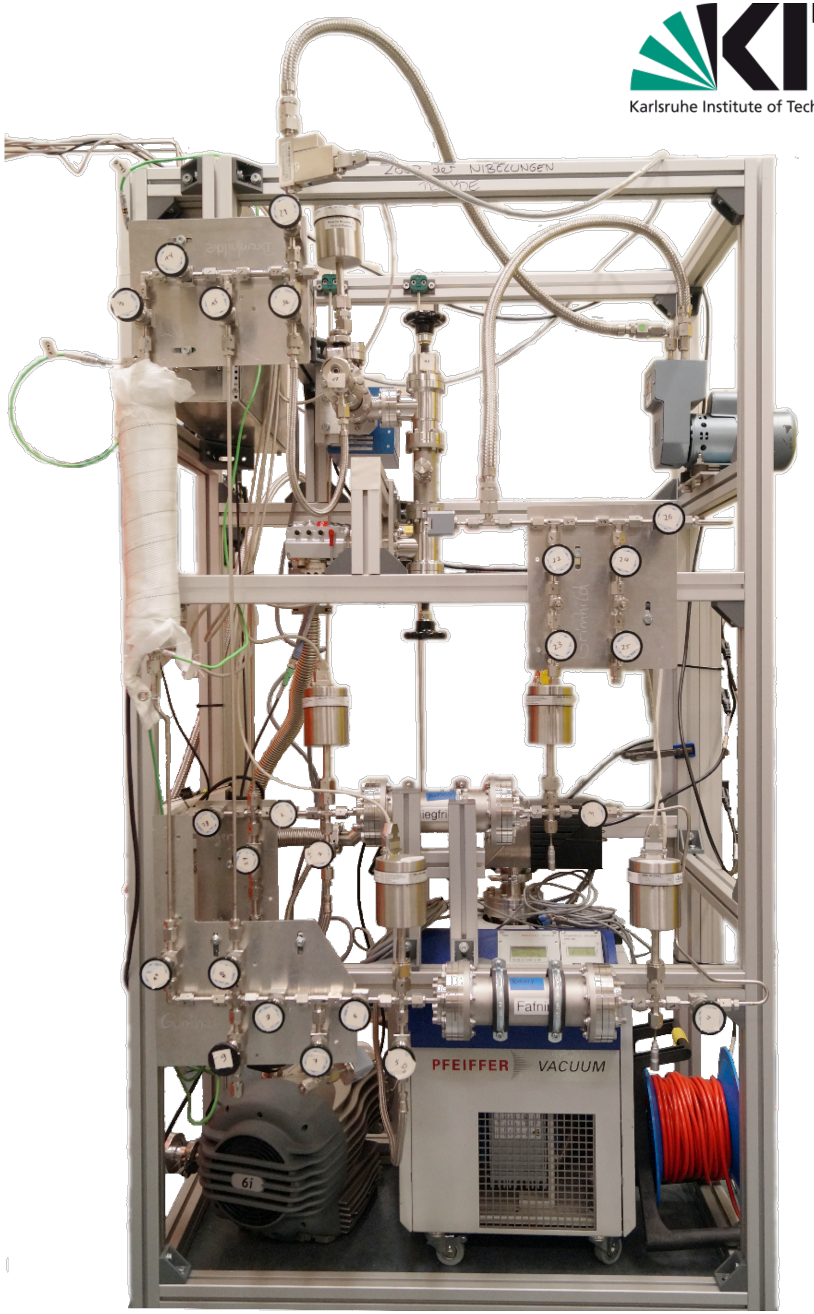
How to compare and calibrate tritium analytics?



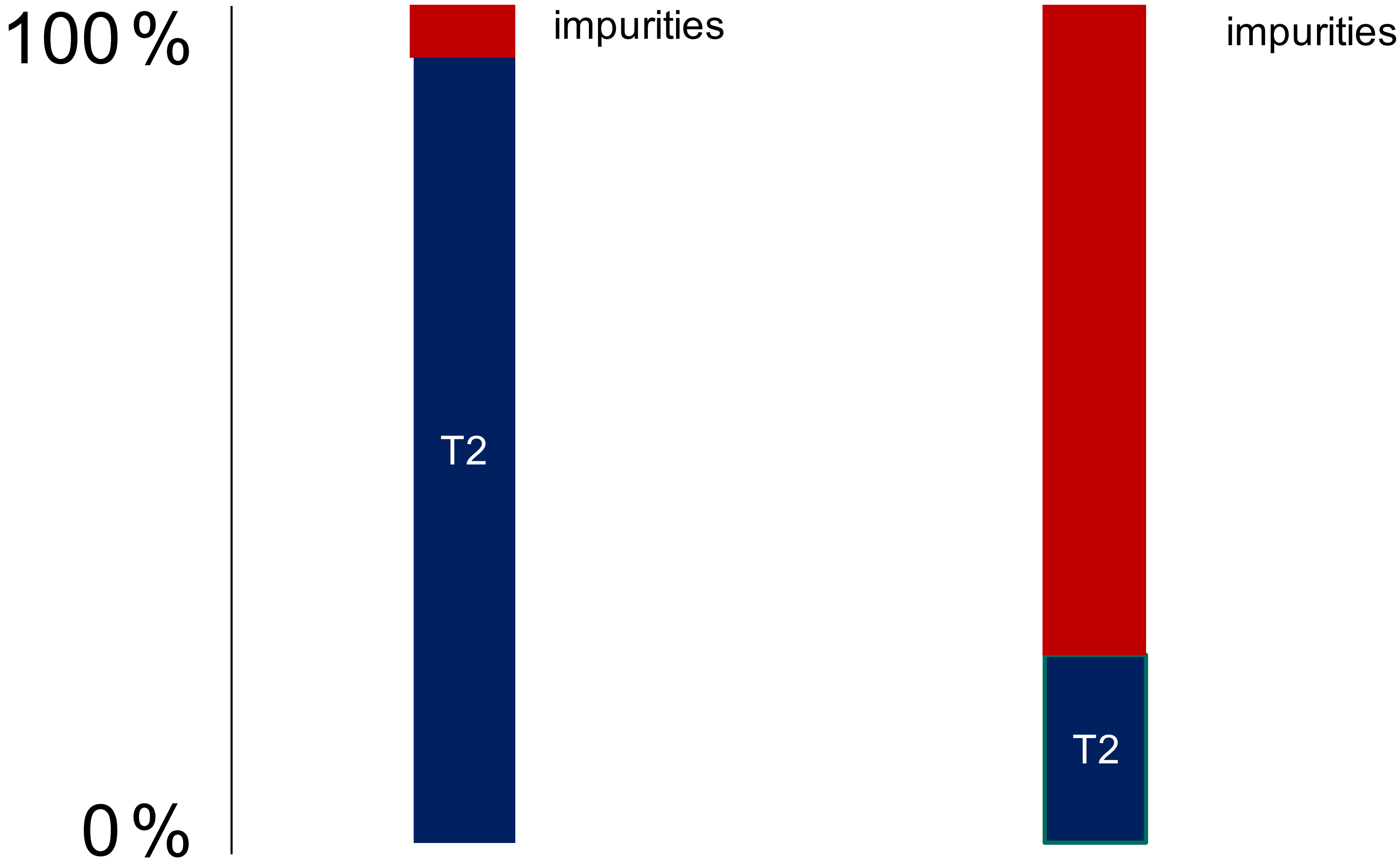
Gas samples with known composition!

Test Setup

- Main components of mixing loop
- Evaluation of uncertainty budget
- First measurements with LARA



Source gas composition



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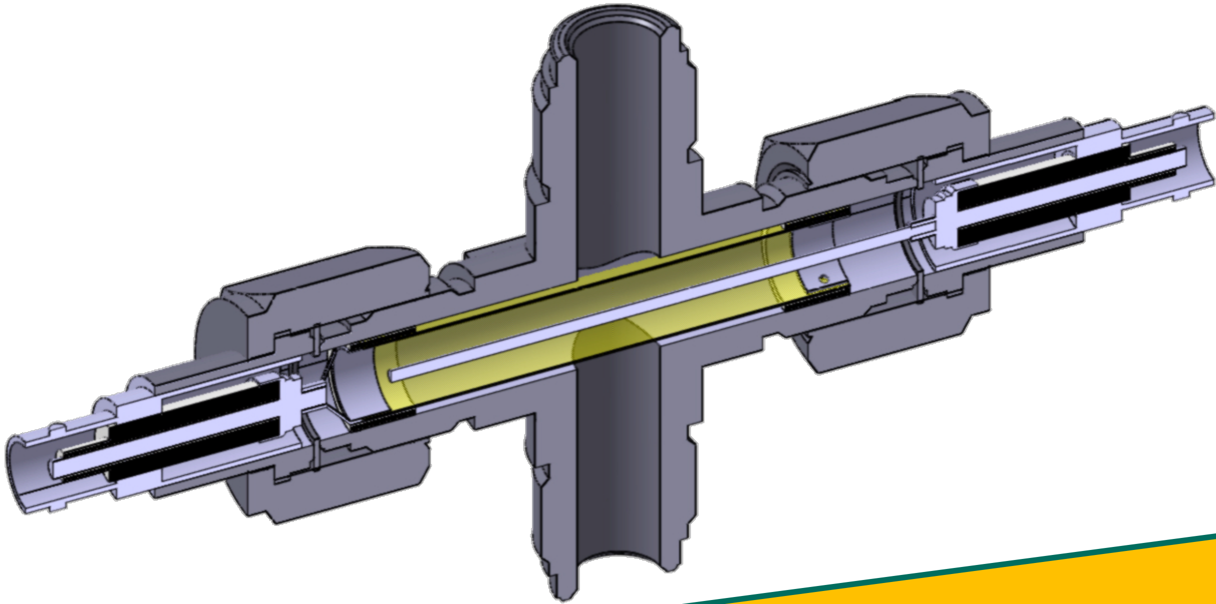
PFEIFFER VACUUM

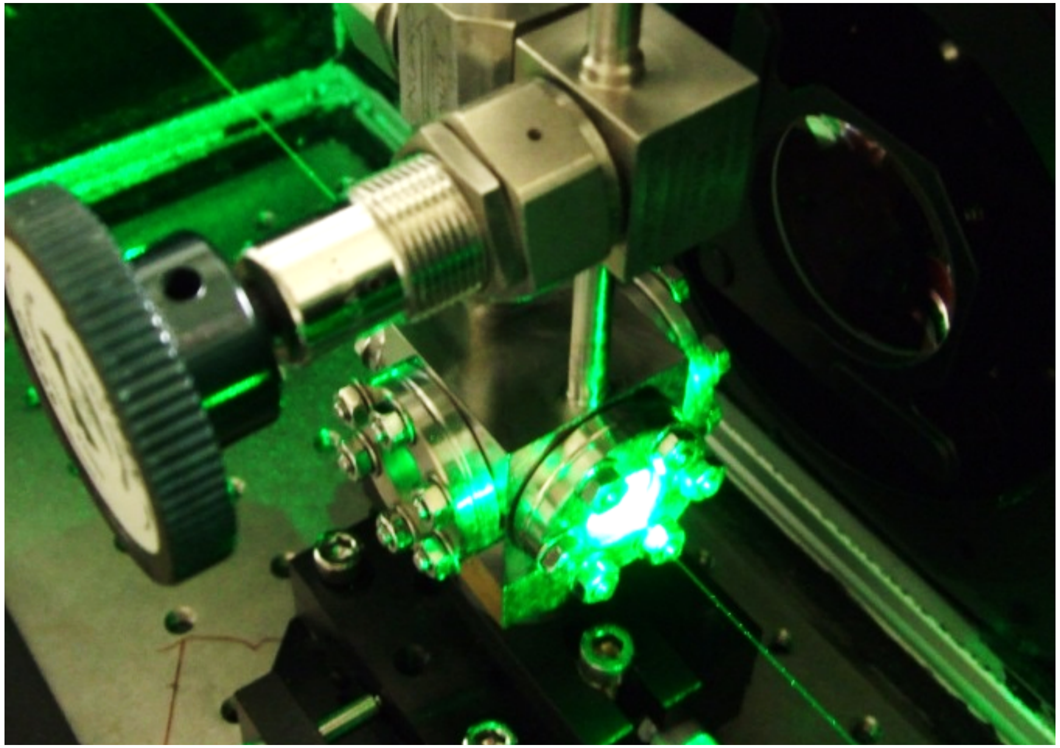
Ionisation-Chamber



Will order soon at main workshop -> consider if you need some as well

- Chamber designed @TLK
- Easy to integrate in loop
- Extended benchmark for e.g. against BIXS

Laser-Raman-Spectrometry



- First possibility to calibrate all LARA-Systems with Q2-gas sample
- Verification of trueness

Residual Gas Analyser

- Quadrupol Mass Spectrometre
- Working pressure ~1E-5 mbar

P-Loop Tasks

1. Get T2 from TTS-f for A-Loop
2. Accept waste gas from A-Loop
3. Remove impurities from Q2 via permeator
4. Give waste gas to CAPER or ZTS