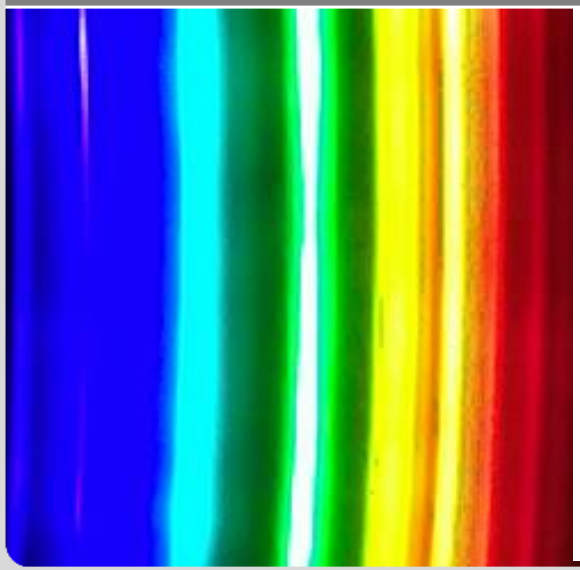
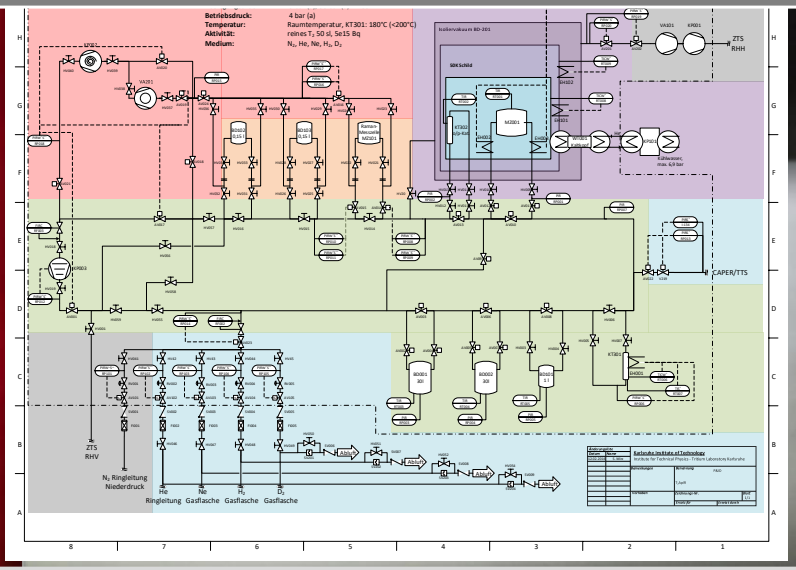
Karlsruher Institut für Technologie

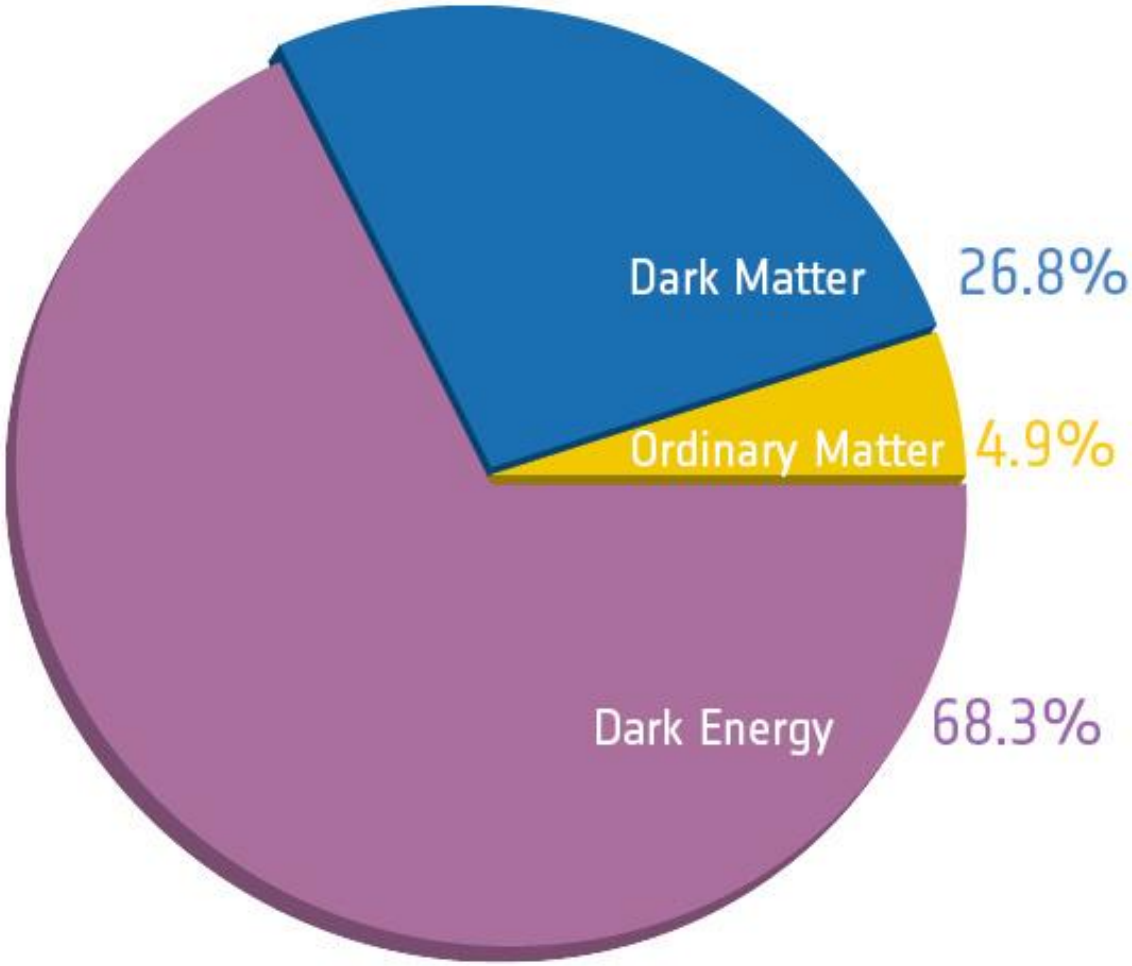
Spectroscopic Investigation of Molecular Effects in Cold Hydrogen Isotopologues

Sebastian Mirz – Tritium Laboratory Karlsruhe

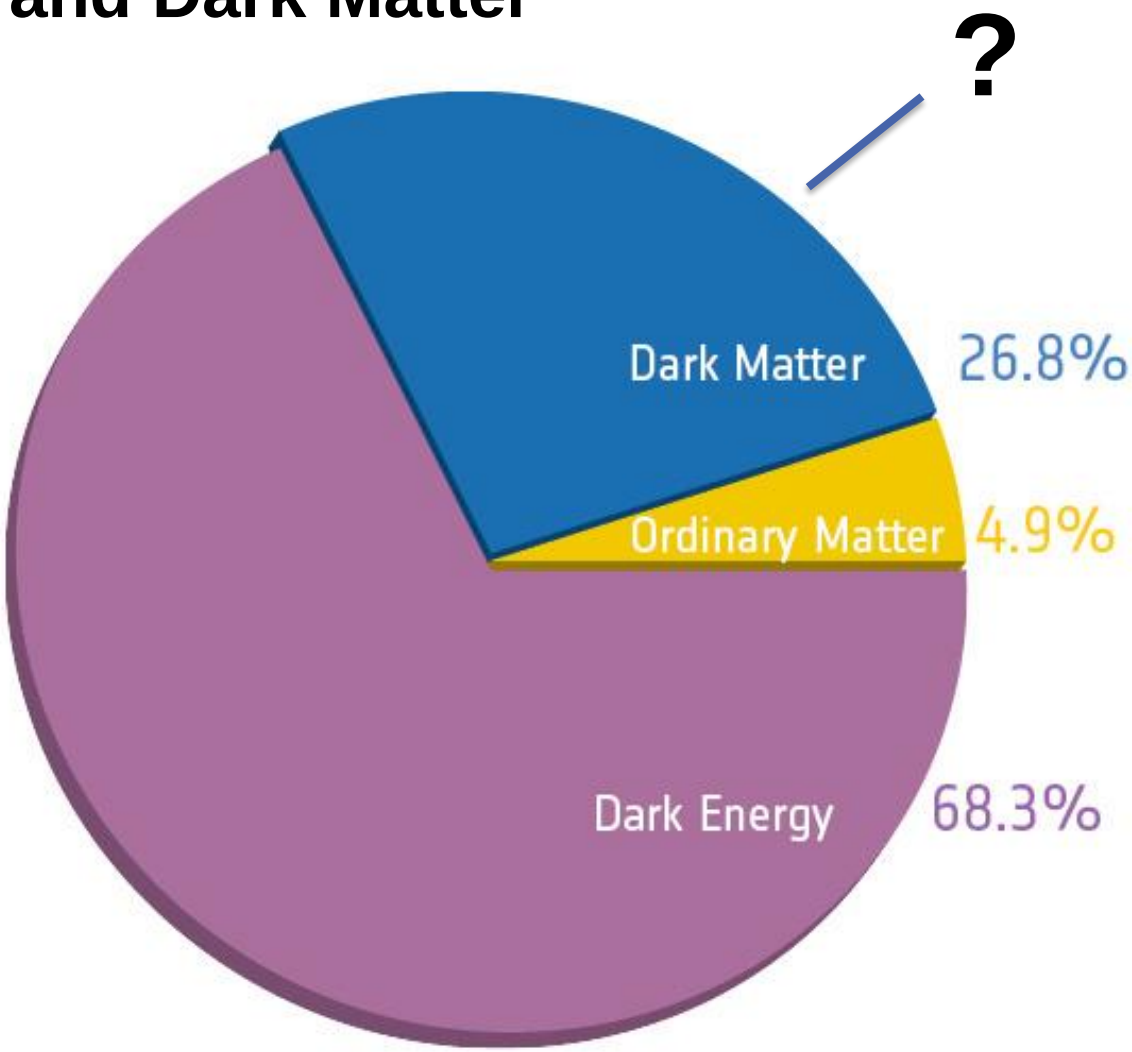




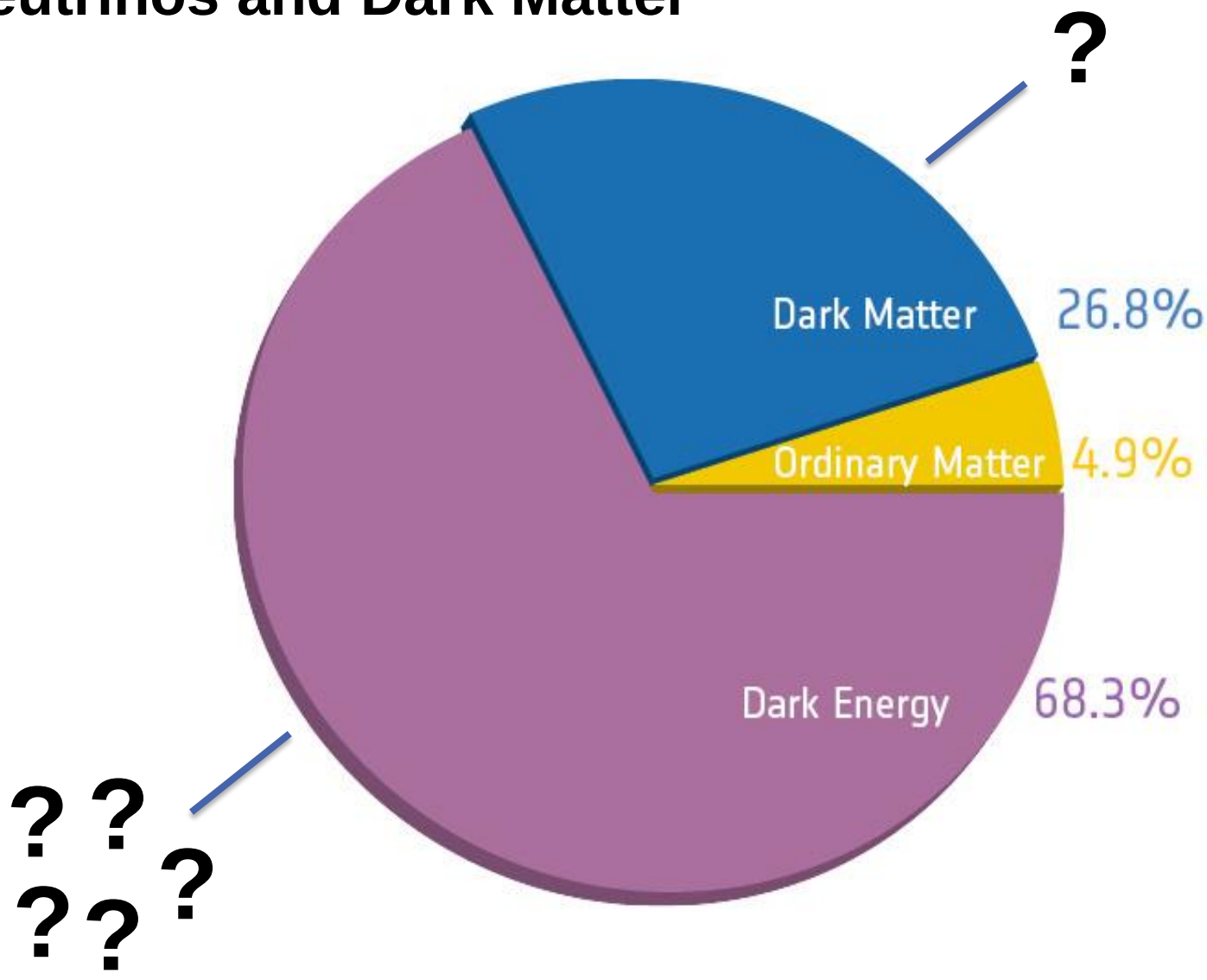
Neutrinos and Dark Matter



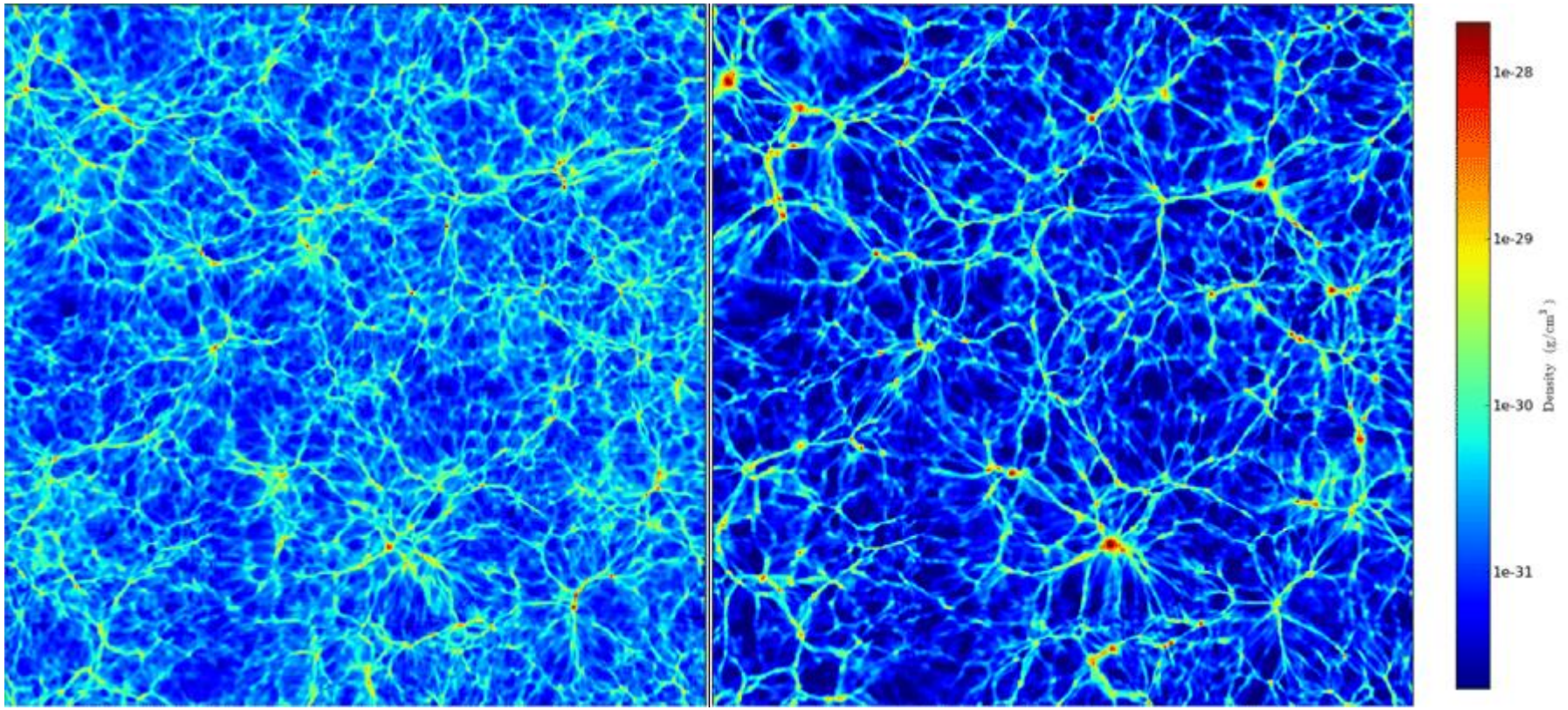
Neutrinos and Dark Matter



Neutrinos and Dark Matter



Structure formation

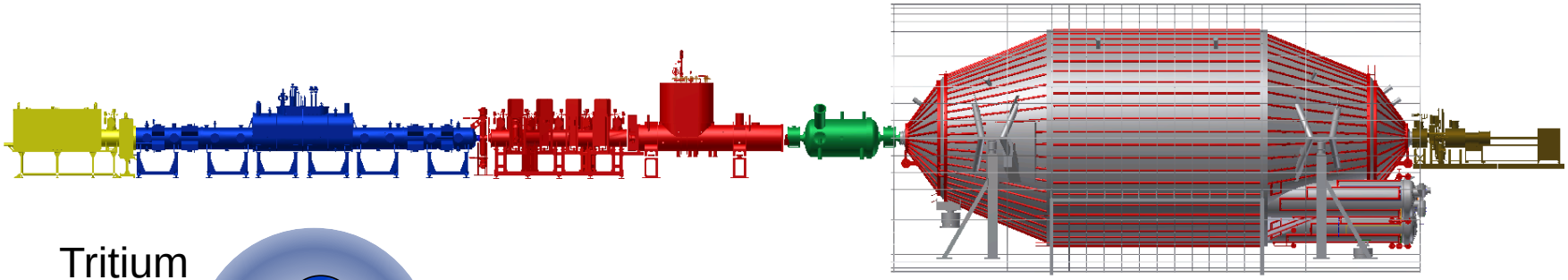


with massive neutrinos

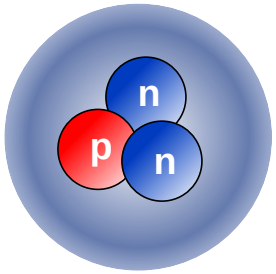
without massive neutrinos

How to weigh a neutrino?

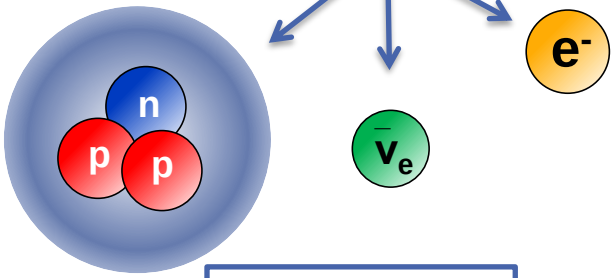
The KArlsruhe TRItium Neutrino Experiment



Tritium

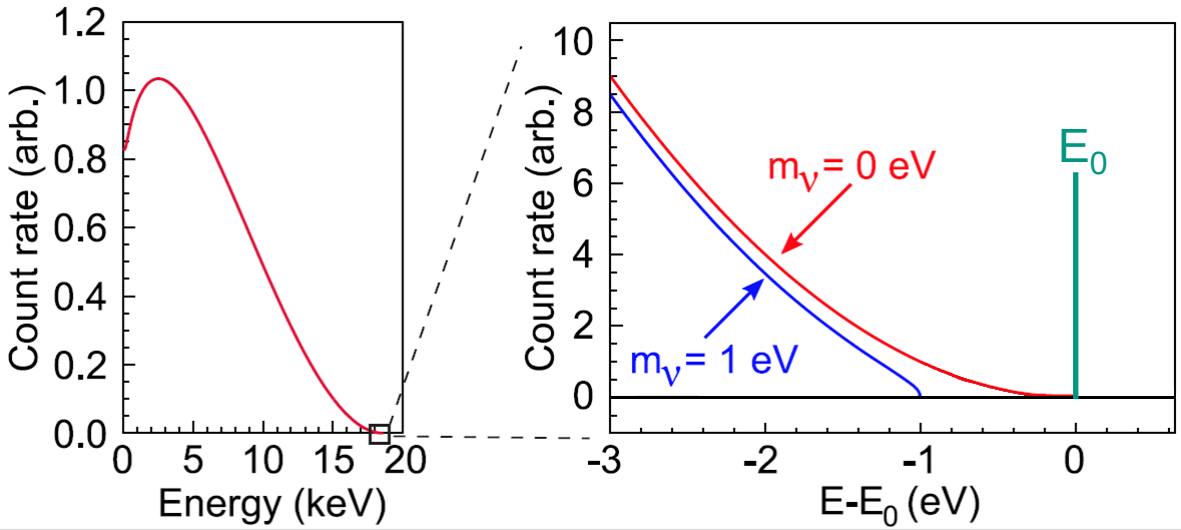


Helium-3

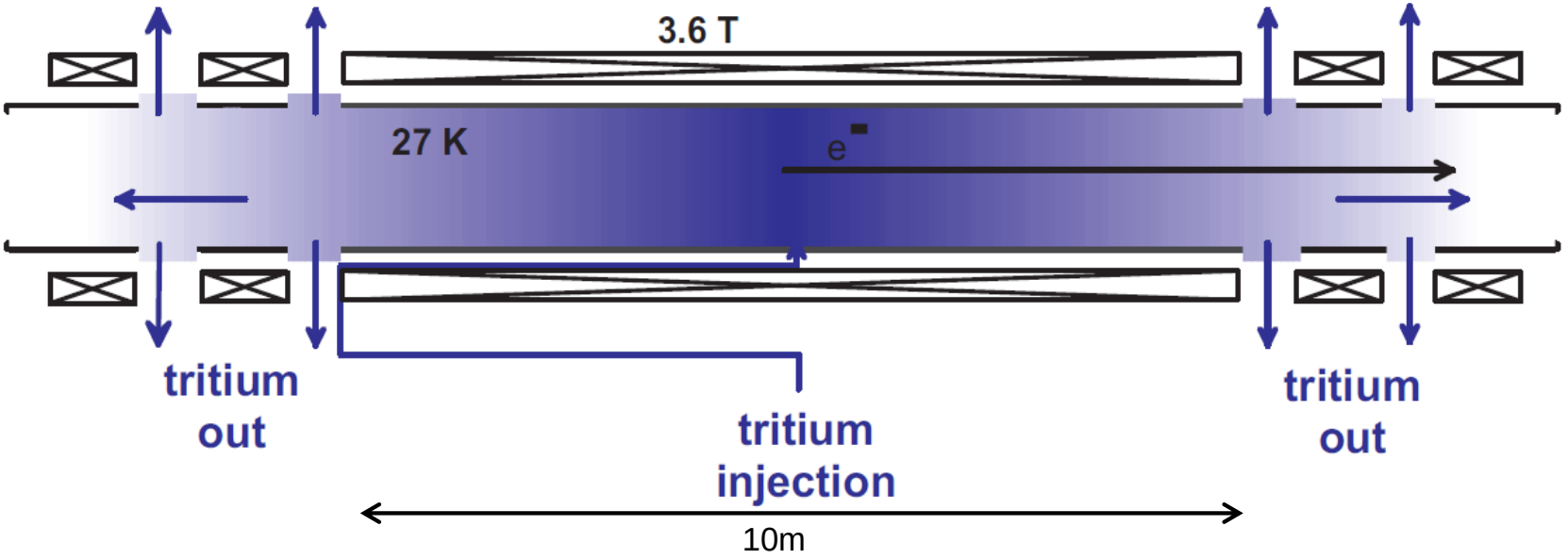


E_0=18.6 keV

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

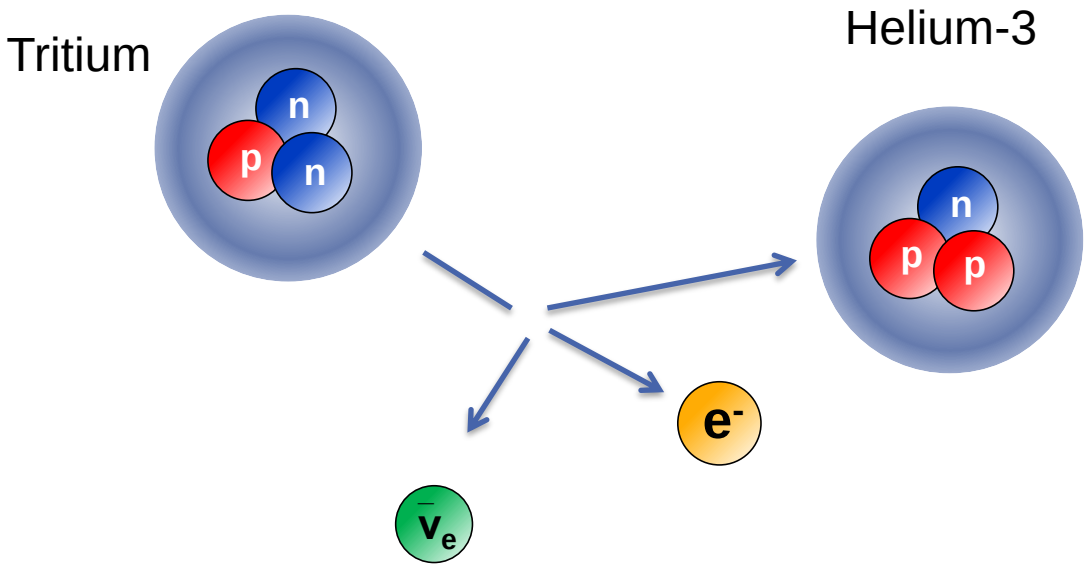


KATRIN WGTS

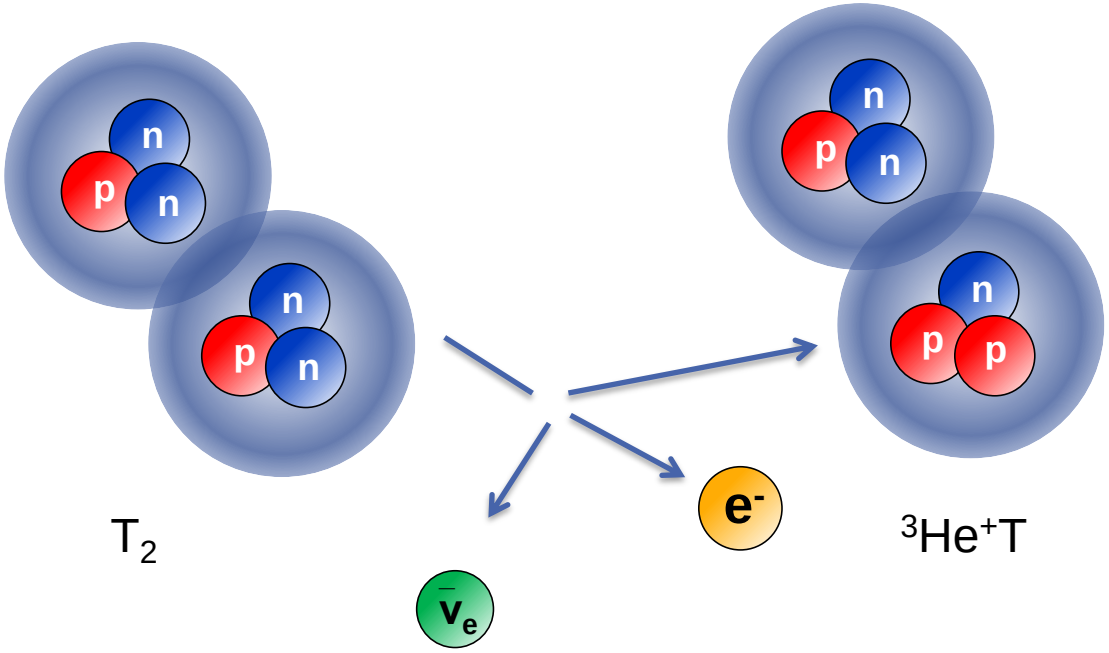


- ~27-30K
- ~10^{-3} mbar inlet pressure
- Tritium purity: 95 %

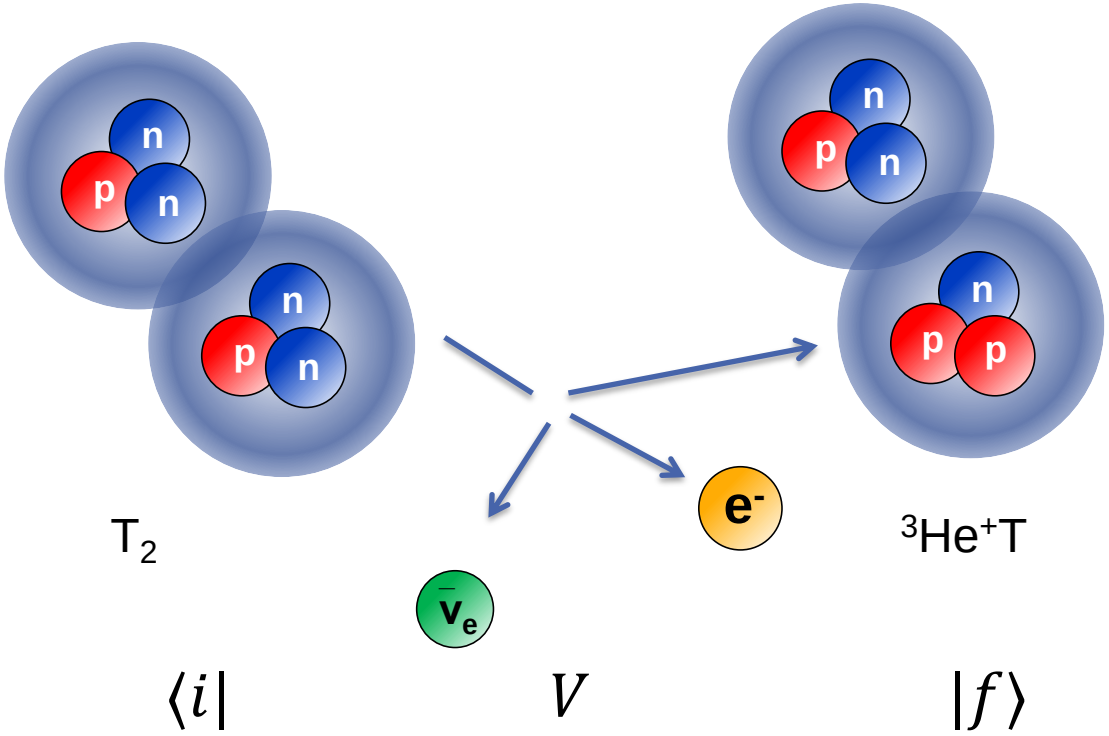
Tritium decay



Molecular beta decay



Molecular beta decay



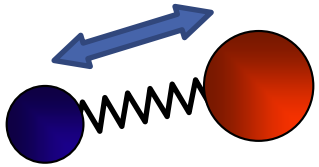
Fermi's golden rule:

$$W_{i\to f} = \frac{2\pi}{\hbar} |\langle i|V|f\rangle|^2 \, \rho(E_f)$$

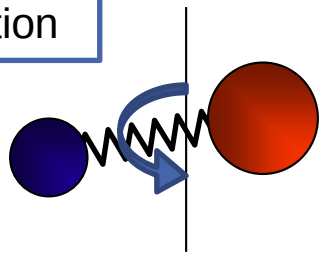
Beta spectrum depends on initial and final state distribution

Initial state distribution

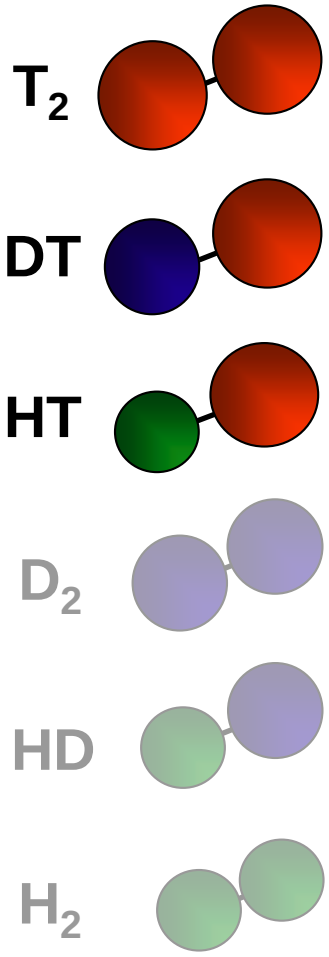
Vibration



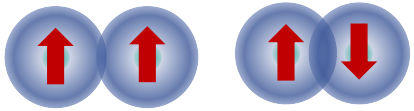
Rotation



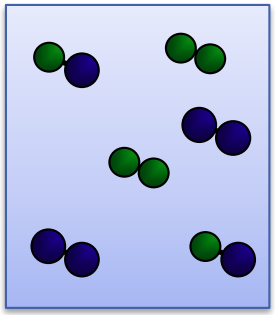
Concentration



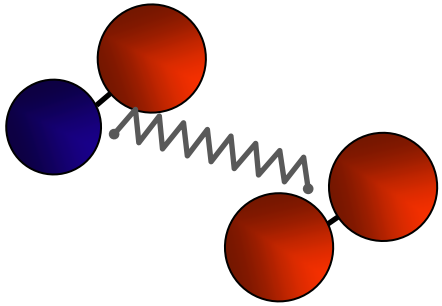
ortho/para T_2, D_2, H_2



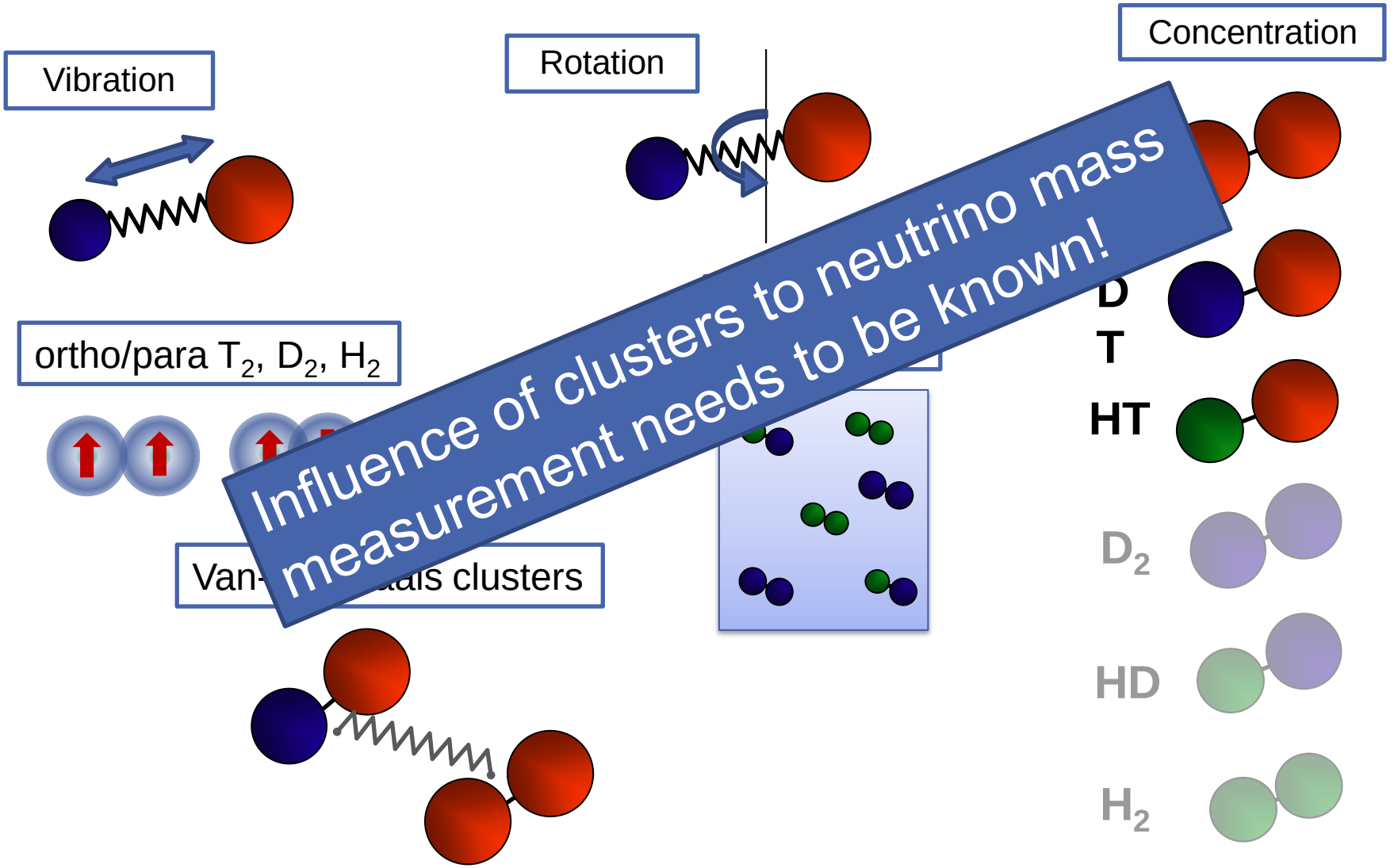
Temperature + pressure



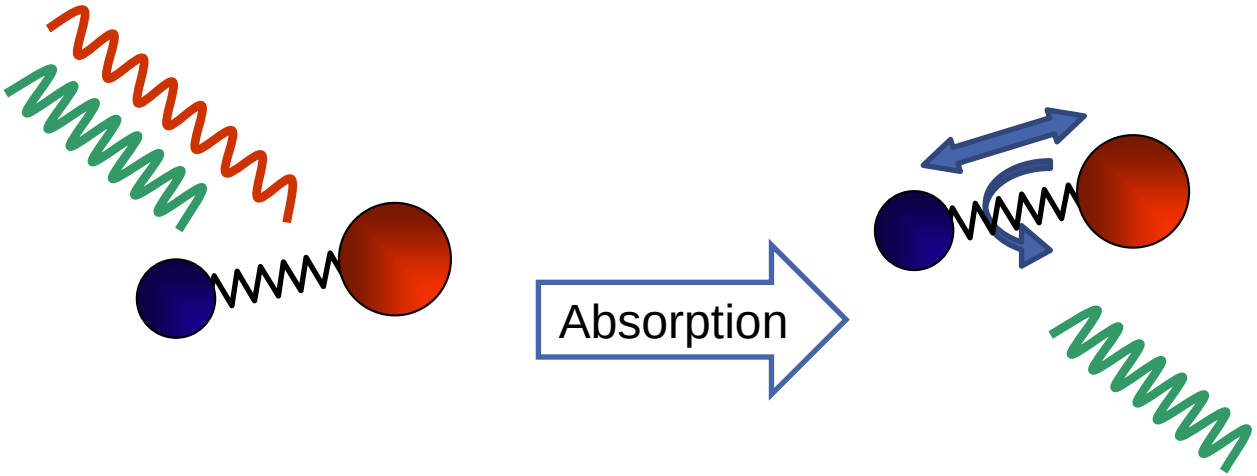
Van-der-Waals clusters



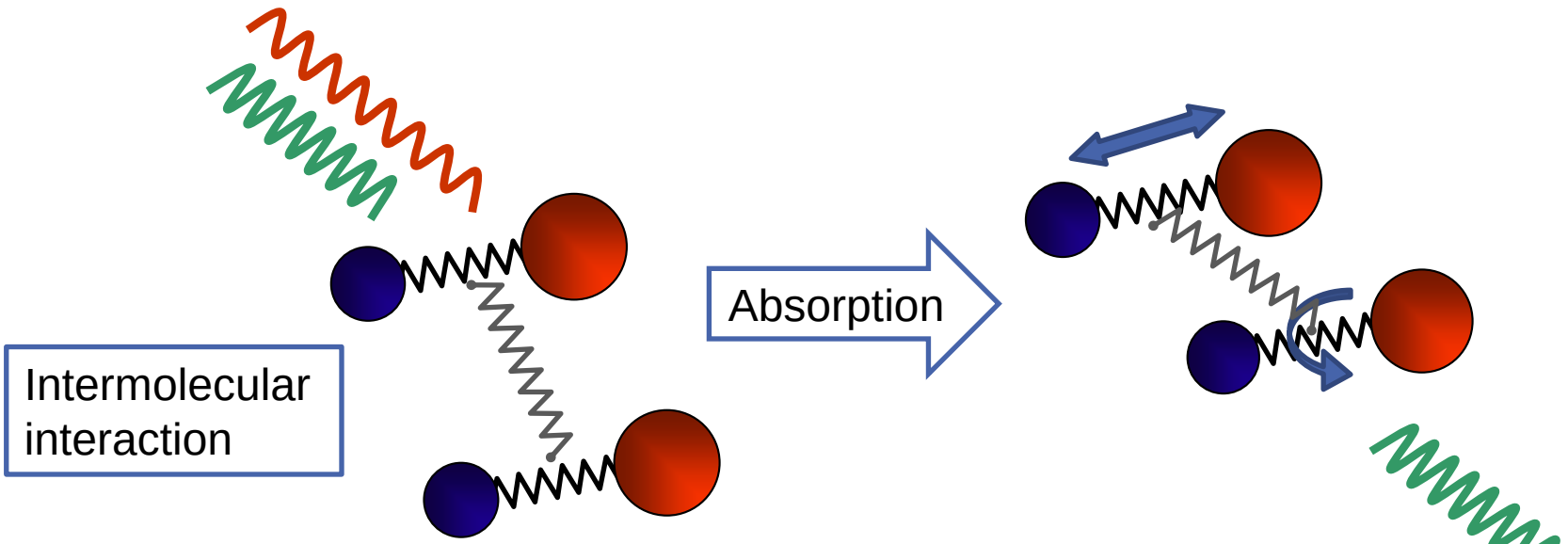
Initial state distribution



Experimental method: IR absorption spectroscopy



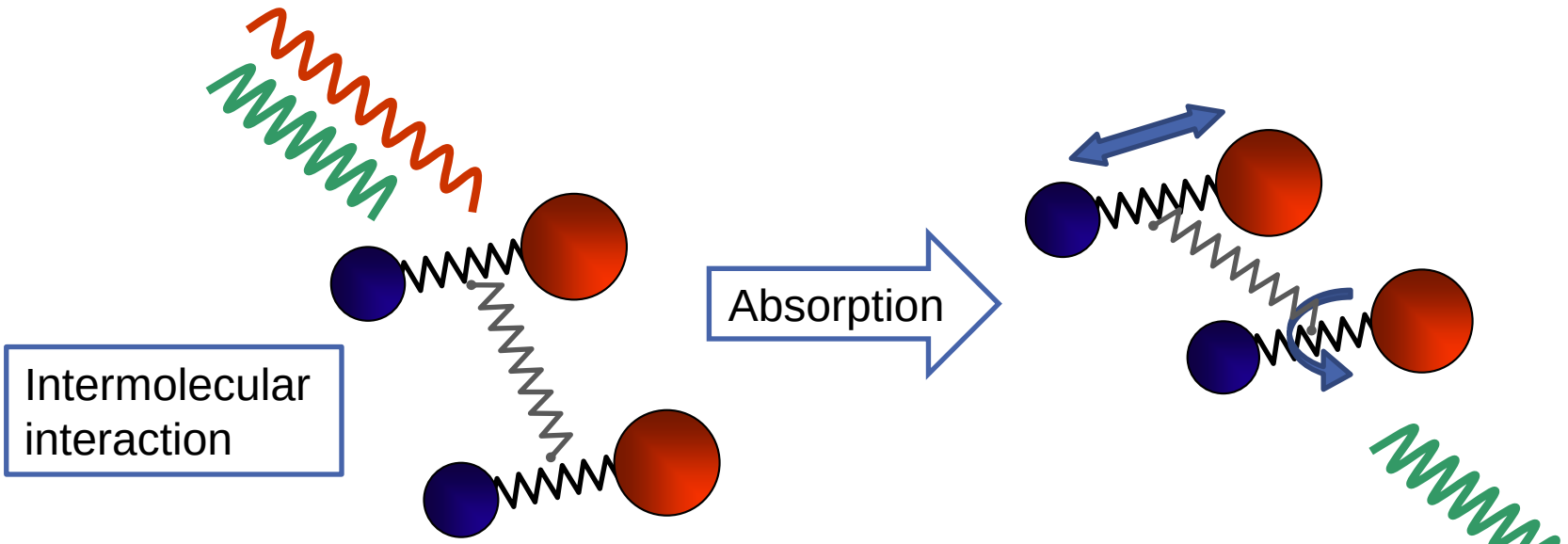
Experimental method: IR absorption spectroscopy



Sensitive to:
- Intermolecular interaction
  → Van-der-Waals complex

- Composition
- Vibration / rotation
- Ortho/para ratio
- Temperature

Experimental method: IR absorption spectroscopy



Sensitive to:
- Intermolecular interaction
  → Van-der-Waals complex
- Composition
- Vibration / rotation
- Ortho/para ratio
- Temperature

Ideal method: IR spectra only possible with intermolecular interaction

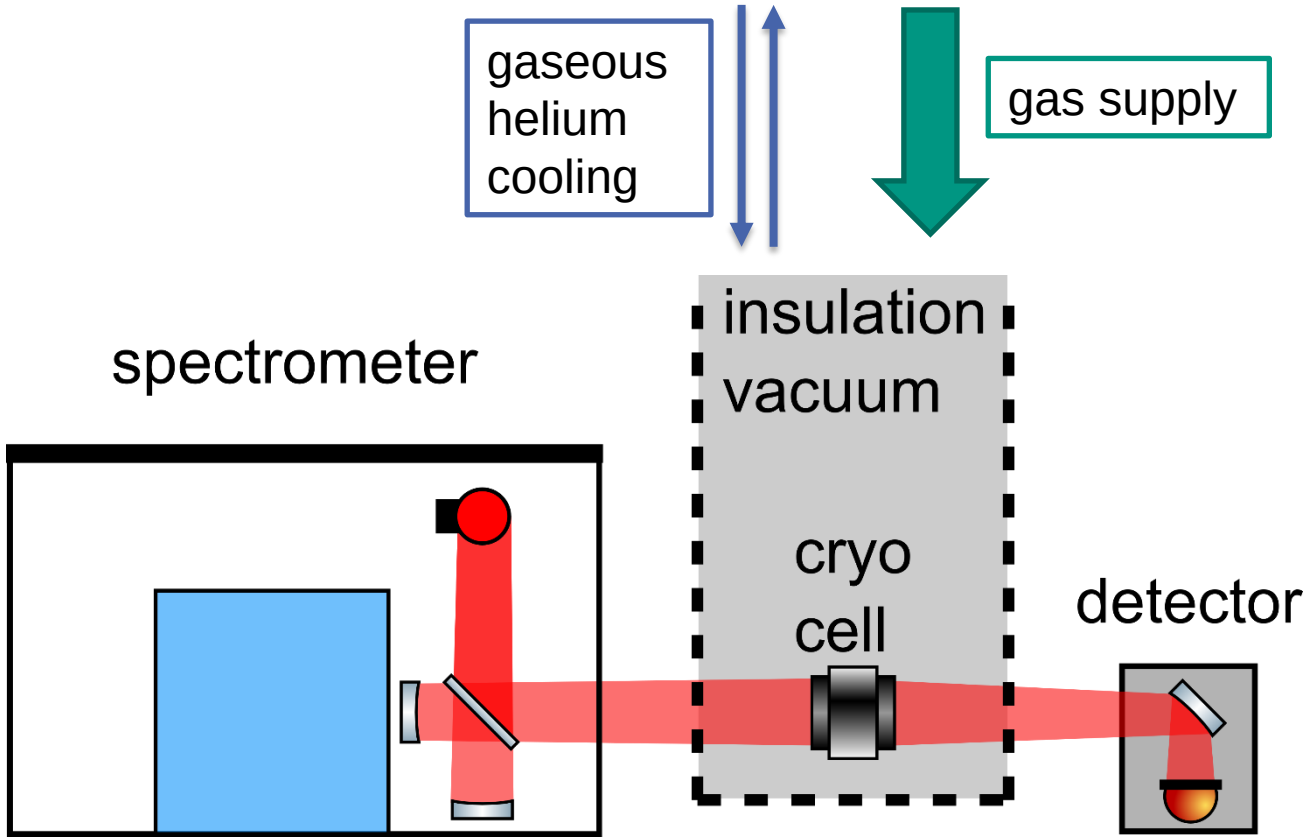
Strategy

- Demonstation in the liquid phase
  - High cluster density
  - High signal expected
- Gas phase without tritium
  - Temperature and pressure dependency studies
- Gas phase with tritium
  - New T_2ApIR experiment

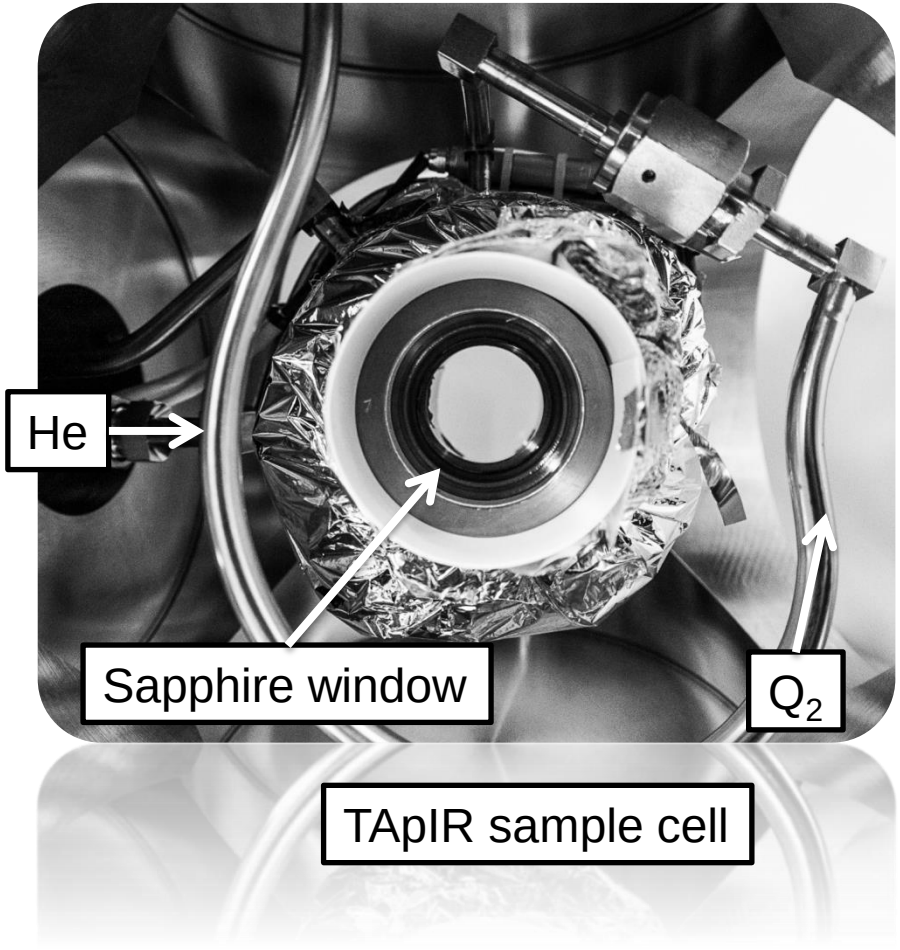
With existing TApIR experiment

TApIR Setup

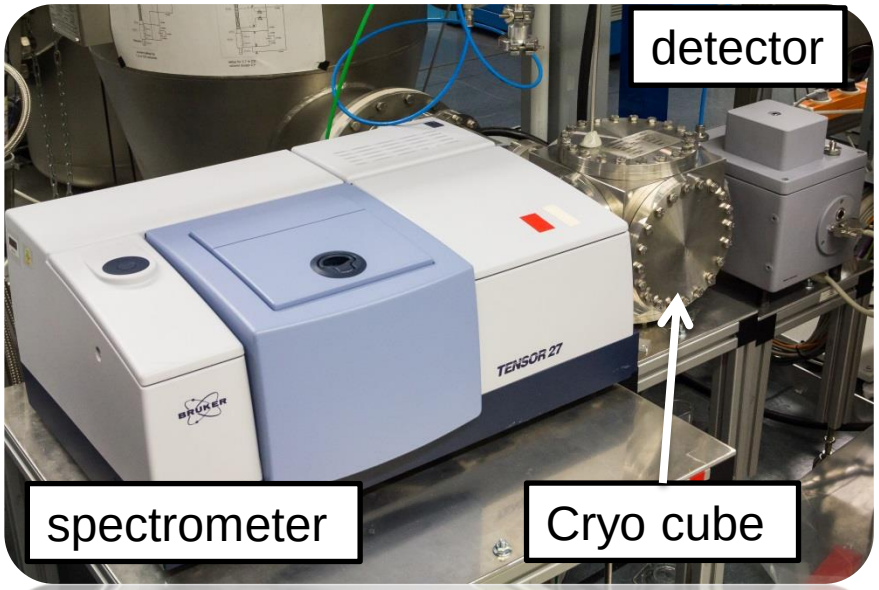
- Temperature: 18 K to 35 K
- Only H2 HD D2 mixtures



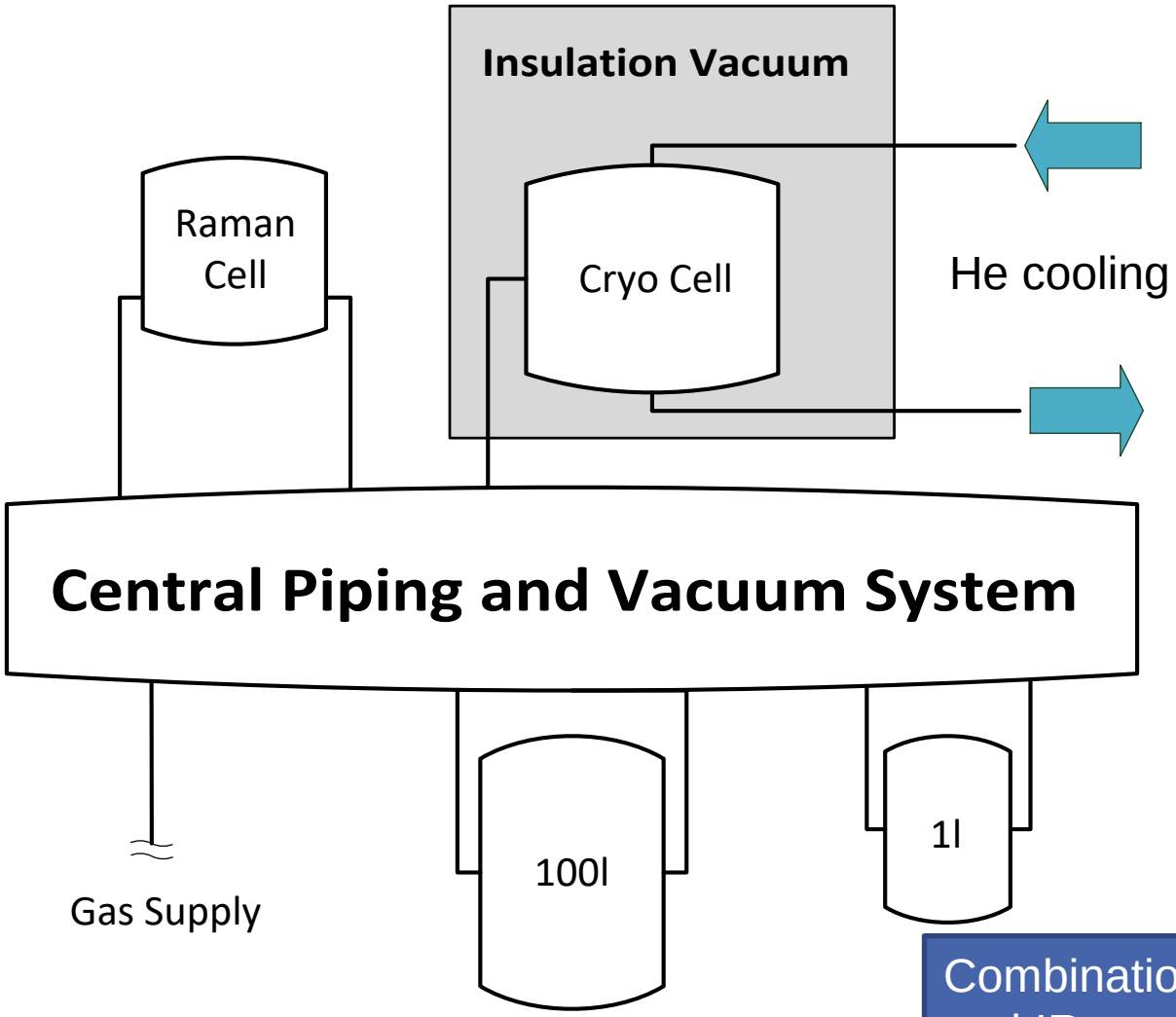
Experimental Setup



TApIR sample cell



Simplified Flow Chart



Combination of Raman and IR spectroscopy system

Strategy

- Demonstation in the liquid phase
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  - Temperature and pressure dependency studies
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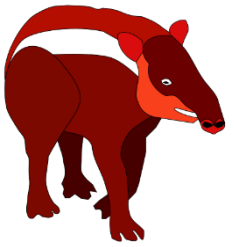
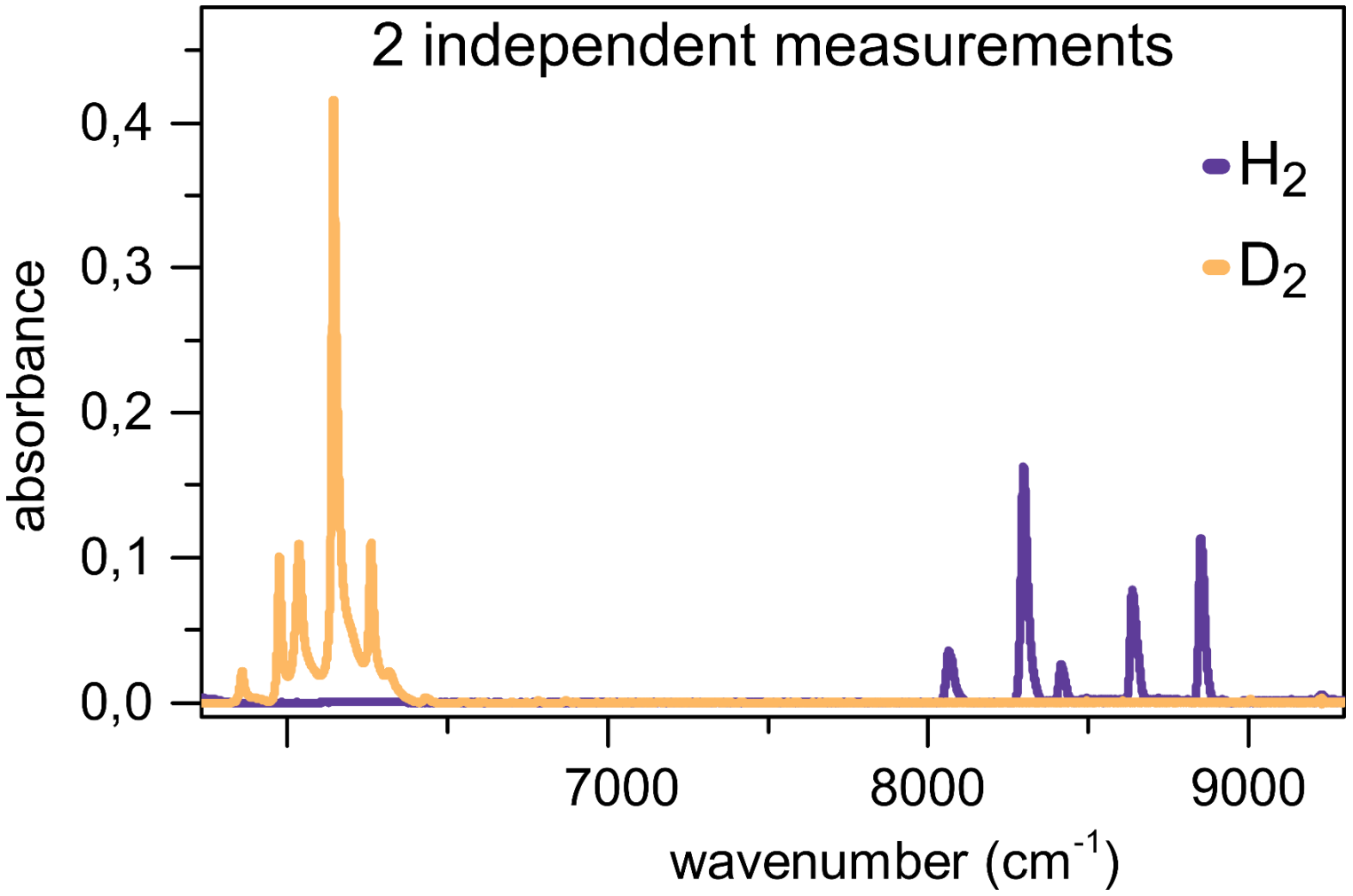
With existing TApIR experiment

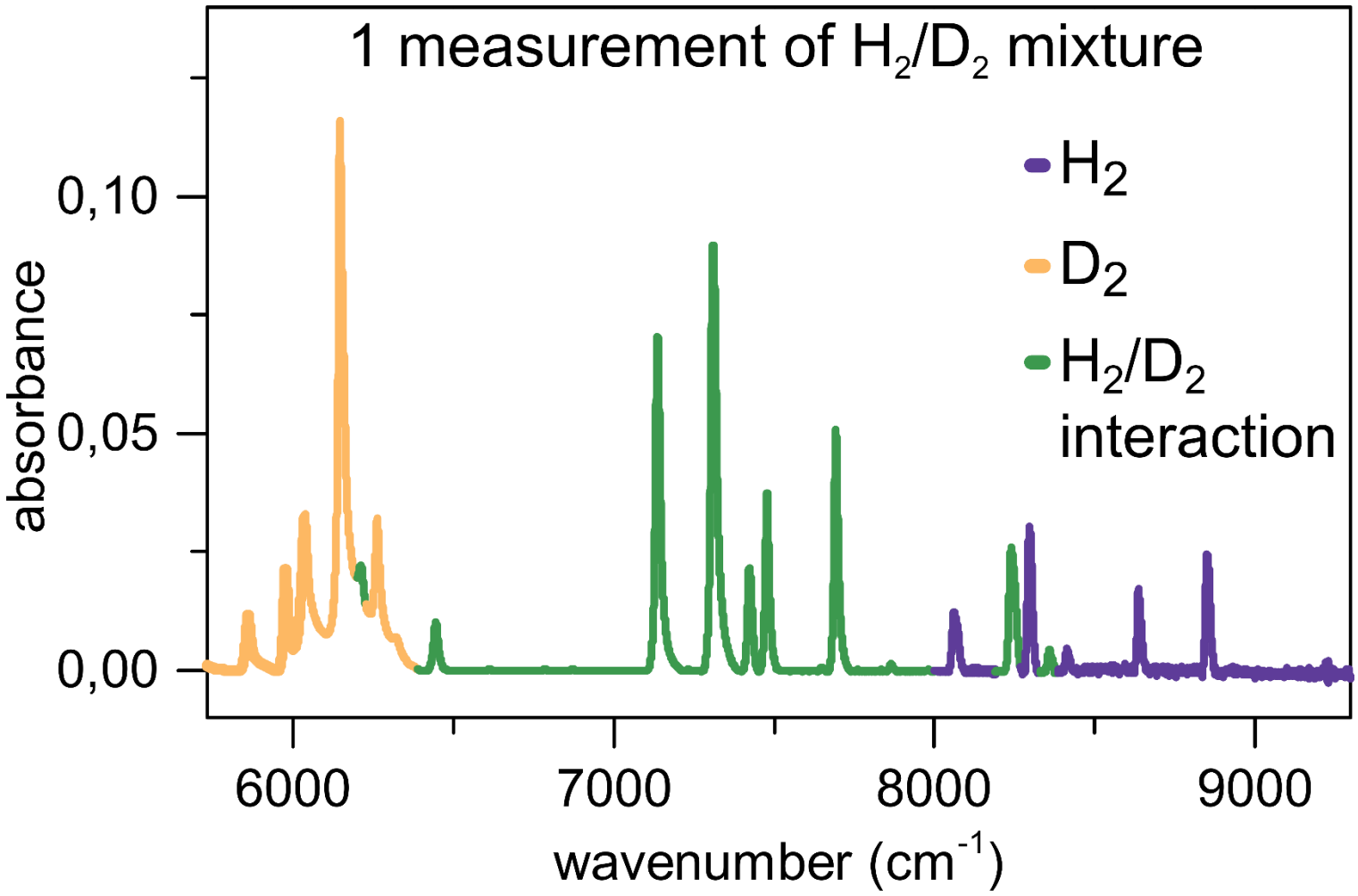
TApIR



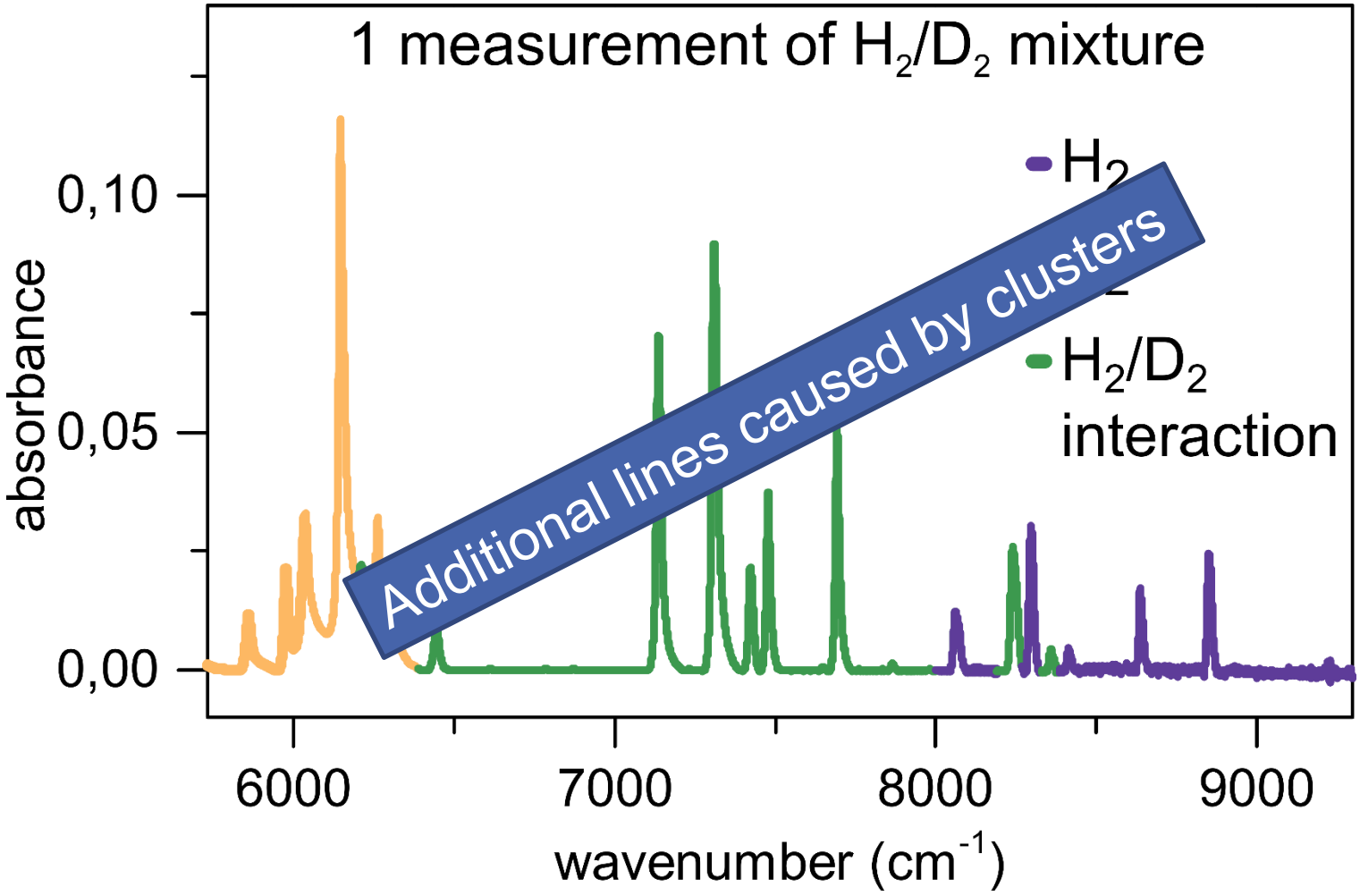
Liquid phase, ~20 K



Liquid phase, ~20 K



Liquid phase, ~20 K



Strategy

- Demonstation in the liquid phase
  - High cluster density
  - High signal expected

With existing TApIR experiment

- Gas phase without tritium
  - Temperature and pressure dependency studies
- Gas phase with tritium
  - New T_2ApIR experiment

Strategy

- Demonstation in the liquid phase
  - High cluster density
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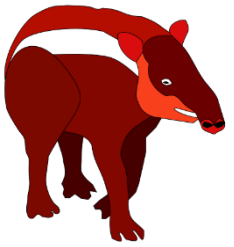
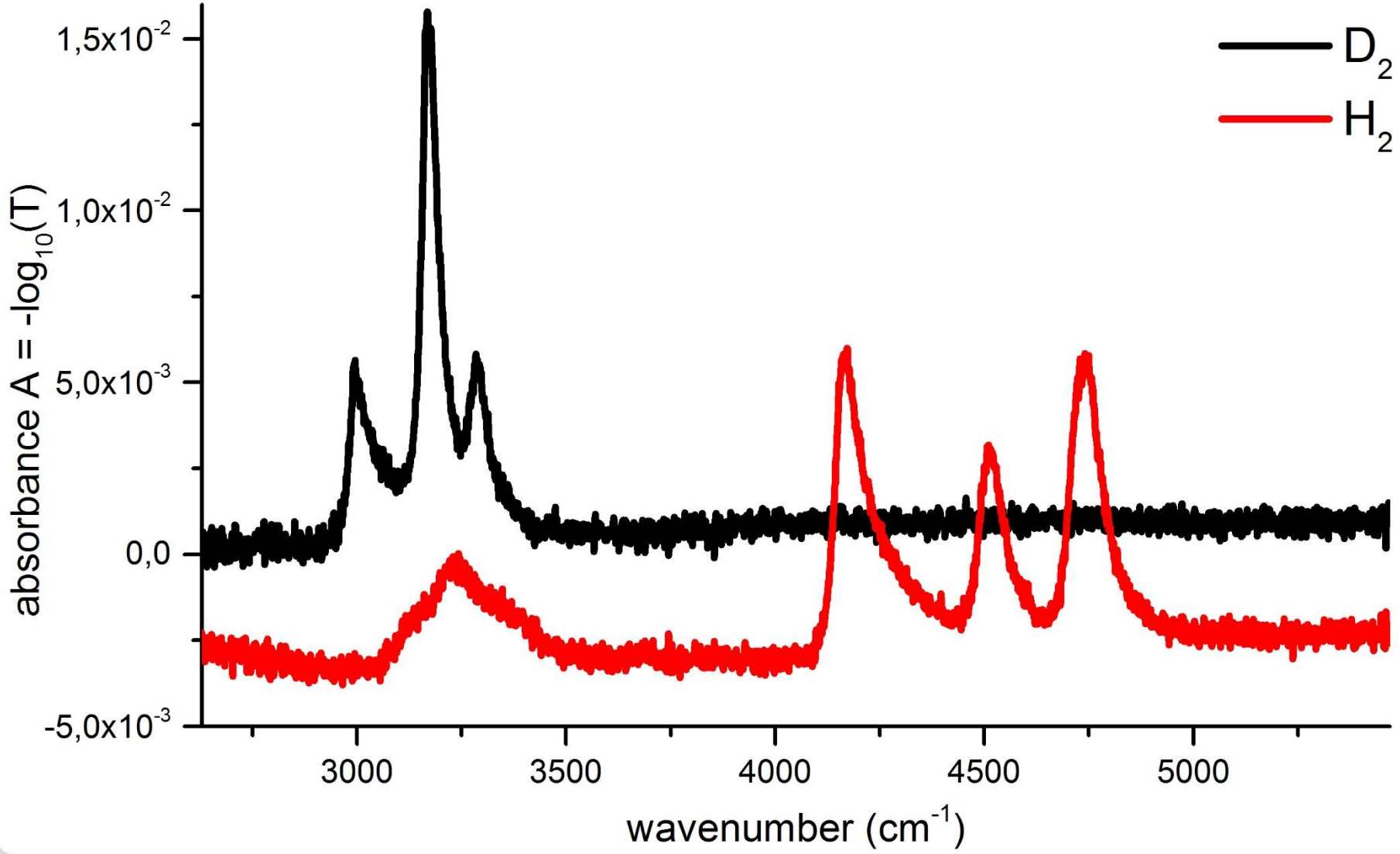
With existing TApIR experiment

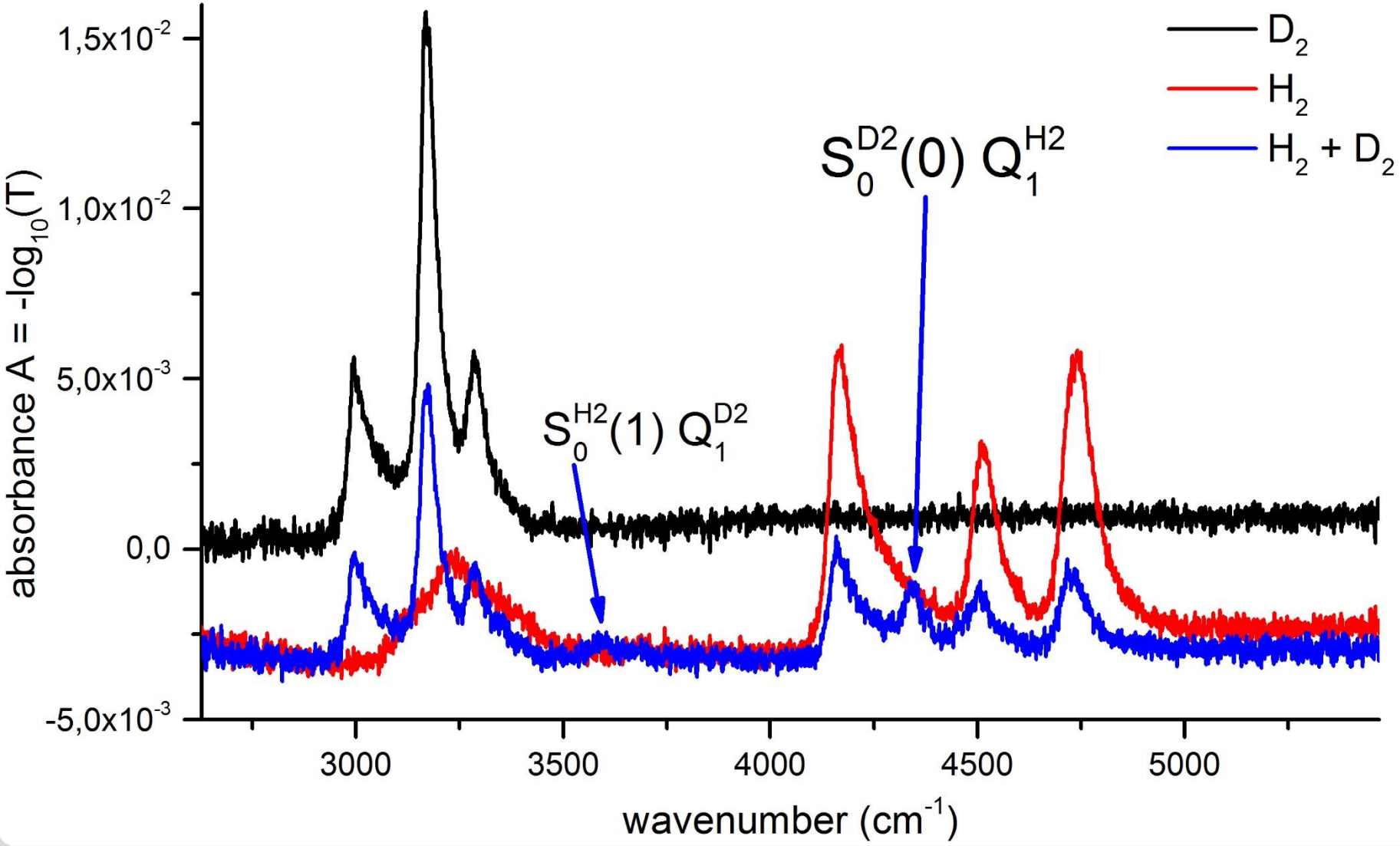
TApIR



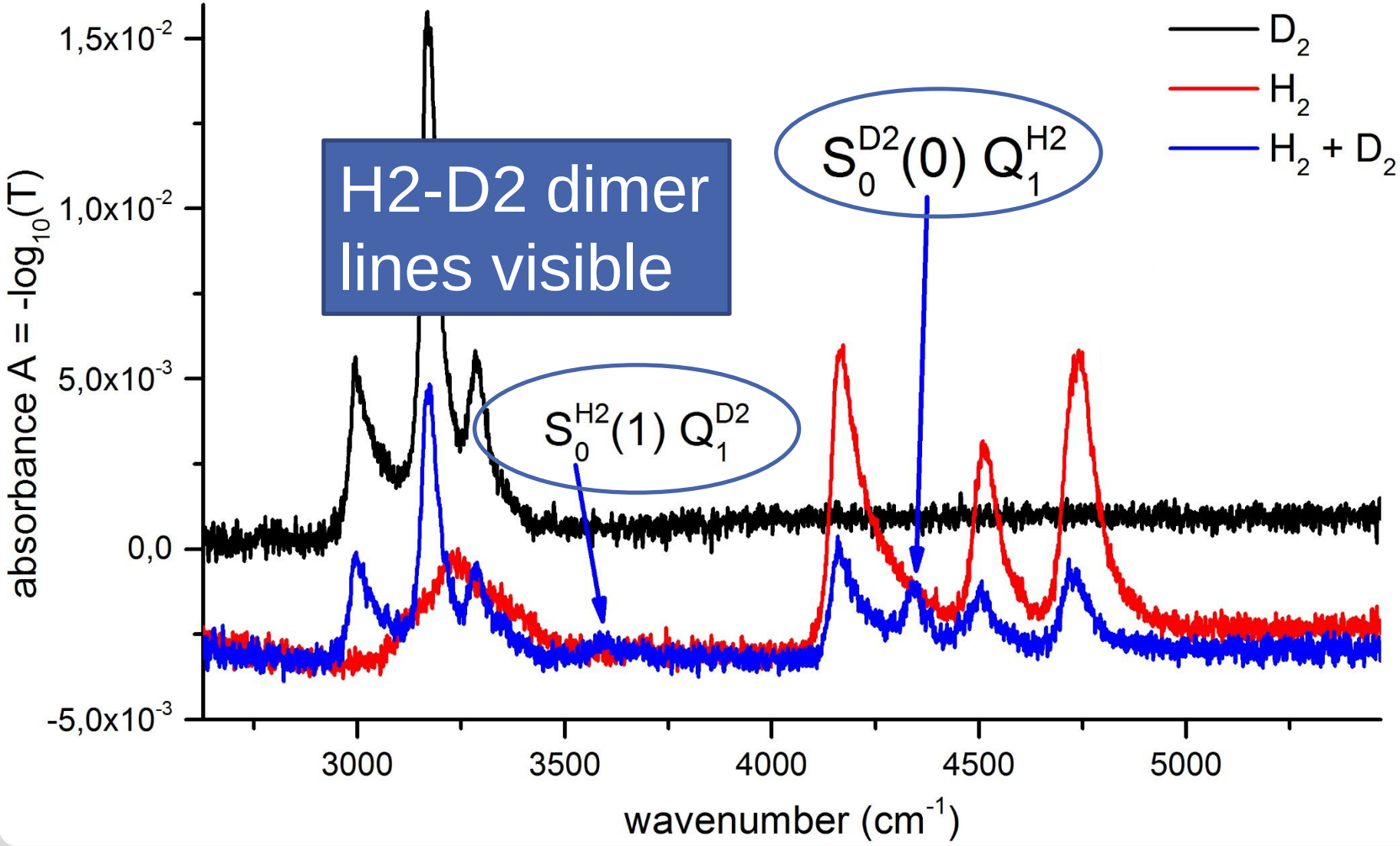
H_2-D_2-Dimers in the gaseous phase at ~30K, 2 bar pressure



H_2-D_2-Dimers in the gaseous phase at ~30K, 2 bar pressure



H_2-D_2-Dimers in the gaseous phase at ~30K, 2 bar pressure



Summary

- Demonstation in the liquid phase
  - High cluster density
  - High signal expected

With existing TApIR experiment

- Gas phase without tritium
  - Temperature and pressure dependency studies

running at the moment

- Gas phase with tritium
  - New T_2ApIR experiment

TApIR

Outlook

- Gas phase with tritium
  - New T_2ApIR experiment
    - → commissioning 2017

- Impact on KATRIN
  - Temperature and pressure influence on clusters, WGTS between ~27 and 33 K
  - Cluster concentration?

→ systematic influence on neutrino mass can be simulated

THANK YOU FOR YOUR ATTENTION!

Spectroscopic Notation

$$\Delta J_{\Delta\nu}(J_i)$$

$\Delta J = O$	P	Q	R	S
-2	-1	0	1	2