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Definition of the Q-PETE Experiment for Investigation of Hydrogen Isotopes Permeation through the Metal Structures of a DEMO HCPB Breeder

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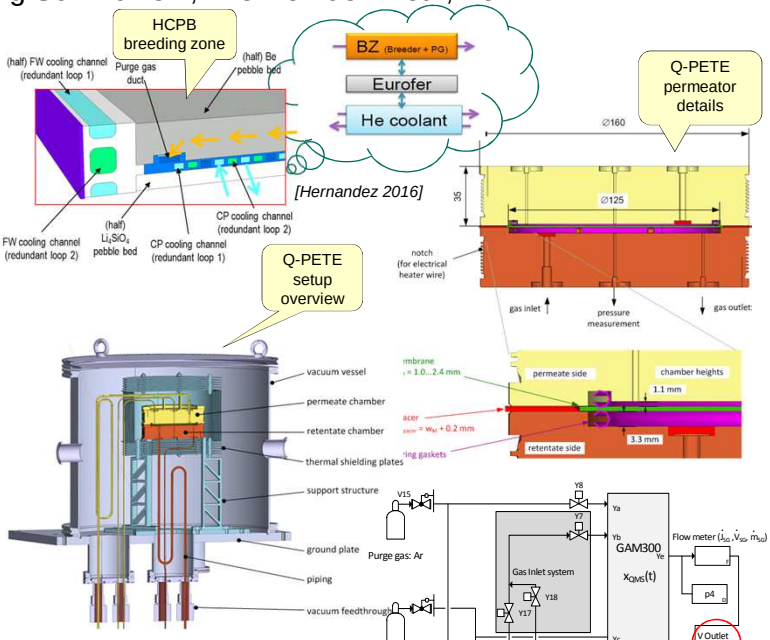
Objectives and rationale of the Q-PETE experiment

In the **HCPB**, bred tritium is **purged** by a flow to the tritium extraction system. Tritium **permeates** into/through structures (cooling plates, pipes).

➔The **Q-PETE (Hydrogen Permeation and Transport Experiment)** was designed as a *"purged permeation setup"* with *morphology*, *materials*, *temperatures* and *hydrogen partial pressures* relevant for the HCPB :

1. To produce relevant **benchmark data for codes** to predict the tritium losses in purged scenarios (application for safety and tritium budget).
2. To directly derive **material properties** (Diffusivity, Sieverts constant).



Experimental setup and procedure

The Q-PETE/D2 experiment al setup in composed of

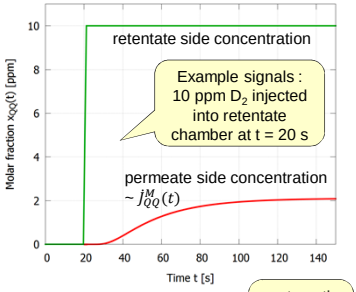
1. A temperature controlled permeator setup enclosed in a vacuum vessel:
   a. The **"retentate chamber"** (formed by a stainless steel flange) is flooded and continously supplied with hydrogen containing feed gas (Argon + Deuterium),
   b. The **"membrane"** (1.2 mm Eurofer disk), through which the hydrogen permeates (time dependent flux $j_{QQ}^{M}(t)$),
   c. the **"permeate chamber"** receives the permeated hydrogen from the membrane.
2. A pure argon sweep flow collects the permeated hydrogen from the permeate chamber and transports it to a **quadrupole mass spectrometer** for time resolved quantitative detection.
3. The setup is completed with a **vacuum system**, controlled **purge gas supply** and a **temperature control** system (200-600℃).

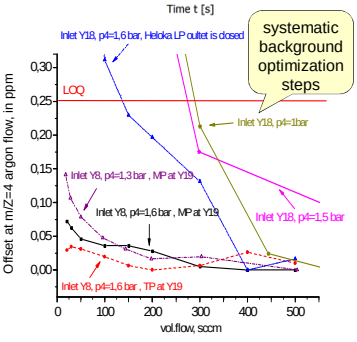
Characterization of mass spectroscopy method

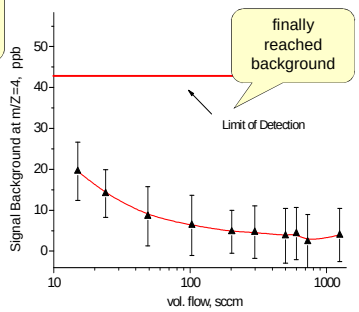
Low noise and **low background level** of the mass spectrometer are **key properties for successful experiments**, because this allows sufficiently high purge gas flow rates to minimize residence time induced signal distortions.

- The **noise level** was characterized dependent on the deuterium concentration, spectrometer dwell time and secondary electron multiplier (SEM) voltage (selected value 1400 V). We envisage signal levels of 0.5 – 20 ppm and sampling times 0.1 – 2 s.
- The **background level** at m/z=4 (D_2, He) was systematically optimized:
  1. A needle valve was installed at the spectrometer outlet to **keep the system pressure near 0.4 bar (g) over atmospheric pressure** (to antagonize possible (helium) leaks in the valves of the inlet system).
  2. The unused part of the spectrometer inlet system are **continuously evacuated** by a membrane pump or turbomolecular pump to avoid any leakage into the measurement.

➔ The background is well suppressed and significantly lower than the corresponding **limit of detection LOD 43 ppm** of the GAM300. (See diagrams)



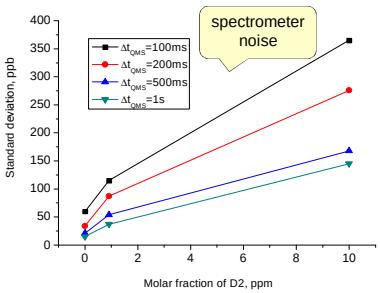




Summary and Conclusions

- Q-PETE/D2 was designed and optimized for HCPB-relevant D_2 permeation through metal membranes at 200 - 600 ℃ for code validation.
- Time resolved measurements will be performed with mass spectroscopy. The method was optimized to suppress the background to ~ 5 – 20 ppb (below limit of quantification!) .
- The limit of detection is 43 ppb and limit of quantification 141 ppb are well suited for measuring the expected signals with levels of 0.5 - 20 ppm (D_2).

➔ The Q-PETE experiment is assessed to be fit for its purpose and is currently under construction.



See further posters at ISFNT-13:
F. Arbeiter et al. „Q-PETE simulation",
A. v.d Weth et al. „Q-PETE analysis".

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