Retention measurements of the KATRIN Cryogenic Pumping Section

Carsten Röttele for the KATRIN collaboration

Cryogenic Pumping Section (CPS)

- Required retention factor of molecular tritium flow > 10^7 (overall: 10^{14})
- Safety limit of capacity: 1 Ci
- Retention R directly correlated to mean sojourn time τ_{des}:

\[ \tau_{des} = \tau_0 \exp \left( \frac{E_B}{RT} \right) \]

- Cold Gate Valve
- Pump Port 1
- Pump Port 2
- LHe vessel (4.5 K)
- Cold trap:
  - stronger binding energy E_B & much larger surface

Performance of argon frost layer

- Injected deuterium pV amount equivalent to 5 KATRIN lifecycles
- Successful demonstration of CPS design performance → higher sensitivity with tritium operation

Temperature dependence investigation

- Retention directly correlated to the temperature:

\[ \text{retention factor} \propto \exp \left( \frac{E_B}{RT} \right) \]

- Pressure gauge behind PP2 sensitive only above 6 K
- Expected temperature dependency confirmed
- Extrapolated retention factor when operated in standard 3 K mode:

\[ R \approx 10^{15} \]

- limited by β-induced desorption

CPS exceeds specifications by 8 orders of magnitude

We acknowledge the support of Helmholtz Association (HGF), Ministry for Education and Research (BMBF), DAAD, E1A, and IPA, Helmholtz Alliance for Astroparticle Physics (HAP), and Helmholtz Young Investigator Group (VH-NG-1055) in Germany; Ministry of Education, Youth and Sport (CZ.MI.00.02.00.06.0004) and DAAD (TA01/2017), Helmholtz Alliance for Astroparticle Physics (HAP), and Helmholtz Young Investigator Group (VH-NG-1055) in the Czech Republic; and the Department of Energy through grants DE-FG02-97ER41020, DE-FG02-94ER40818, DE-FG02-05ER41373, DE-FG02-05ER41041, DE-AC02-98CH10886, and DE-SC0001091 in the United States.