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Simulation and measurement of the deuterium retention in the cryogenic beamline of the KATRIN experiment

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The KATRIN neutrino experiment aims to measure the effective mass of electron anti-neutrinos with an unprecedented sensitivity of 0.2 eV/c^2 by measuring the energy spectrum of beta-electrons from tritium decays close to the endpoint of the spectrum. The decays take place in a high-intensity windowless gaseous tritium source (WGTS). The electrons are guided by strong magnetic fields through a beamline with super-conducting solenoids to the huge main spectrometer (10^{-11} mbar) for energy measurement. Since only a fraction of $2 \cdot 10^{-13}$ of all electrons have a kinetic energy within 1 eV below the spectral endpoint, the sensitivity of the measurement depends on a low background rate in the spectrometer. Therefore the tritium flow from the source (10^{-3} mbar) has to be reduced by at least 14 orders of magnitude before it reaches the spectrometer section. This large reduction in the 90-mm-diameter beamline is achieved with a combination of differential pumping, using turbo-molecular pumps (TMP) and a cryogenic pumping section (CPS) with an argon frost layer at around 3 K.

This talk describes the Test Particle Monte Carlo (TPMC) simulation of the beamline of the CPS for the non-radioactive gas deuterium with MolFlow+. Since the gas flow through the CPS is reduced by far more than 7 orders of magnitude, the simulation is done in several consecutive steps. The results are combined in the post processing of the TPMC results. In the post processing algorithm we also investigate the time dependence of the reduction factor by considering a finite sojourn time of the deuterium on the cryogenic argon layer. This leads to a slow migration of deuterium in downstream direction. In a final step the half-life and migration of tritium is taken into account by a reduced sojourn time.

After finishing the construction of the KATRIN setup, the commissioning of the experiment started in October 2016. The results of the commissioning measurements with deuterium will be compared with the TMPC simulations. First traces of tritium are planned to be admitted into the beamline in May 2018.

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