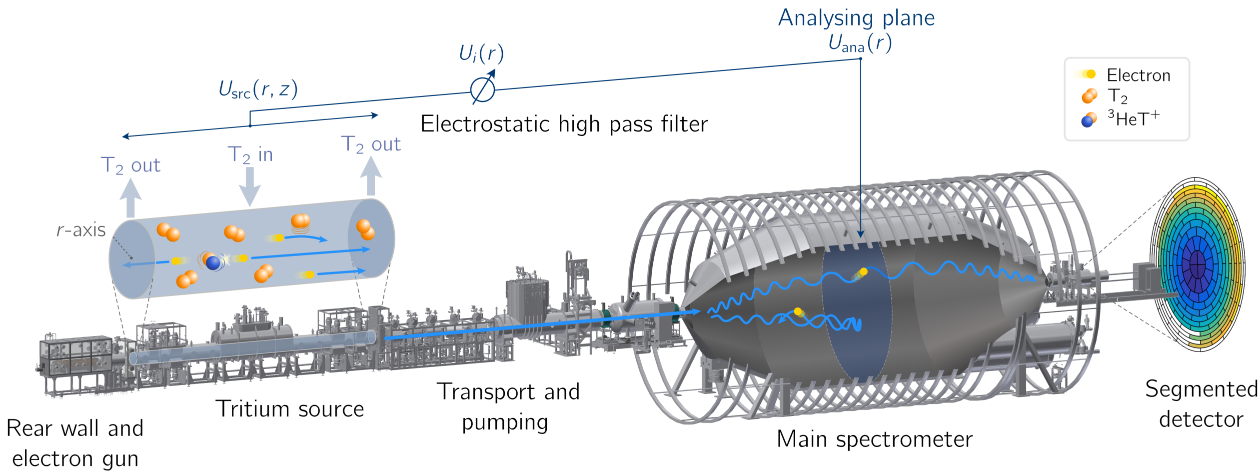
Master thesis:
Non-adiabatic electron transport in the spectrometer

In the KATRIN experiment, electrons are guided/transported from the tritium source to the detector by a magnetic field. The transport usually happens adiabatically, i.e. the movement of the electron is well-described by simple formulae. On their way to the detector, the electrons pass the main spectrometer, where the magnetic field is comparatively low. For the keV sterile neutrino search, the electrons allowed through the spectrometer have much larger energy than the spectrometer's electrostatic retarding potential. Therefore, they are no longer guided adiabatically which leads to changes of their angle respective to the magnetic field direction and even chaotic movement. This causes undesired reflections due to the magnetic bottle effect when the electrons reach the high magnetic field at the end of the spectrometer.



Description of tasks Understanding and controlling the systematic effect from non-adiabaticity is crucial for the success of the keV sterile neutrino measurement. For this purpose, our team in Karlsruhe is working on optimizing the magnetic field to mitigate the effect. Experimental tests of this optimized setting have been performed recently and the data requires further analysis. Furthermore, the non-adiabatic transport affects the electron angular distribution at the detector. This has an influence on the detector backscattering which is another crucial systematic for keV sterile search. Hence, the effect of non-adiabatic angle changes must be modeled based on detailed monte carlo simulations (using the Kassiopeia software) and by studying the theory of non-adiabatic motion in electromagnetic fields. The results of these investigations must then be implemented into the TRISTAN spectrum model (TRModel) to quantify the impact on the sterile neutrino sensitivity.

Summary

- Scope: Master thesis
- Fundamental subject areas:
  Particle tracking in electromagnetic fields, monte carlo simulation, convolution-based modeling
- Outline / Structure:
  - Introductory training concerning KATRIN and the keV sterile neutrino measurement with TRISTAN, usage of the Kassiopeia simulation software, basic usage of TRModel
  - Analysis of KATRIN data concerning new measure against non-adiabatic transmission loss (measurement in February 2024)
  - Determine amplitude of non-adiadbatic angle change in the main spectrometer from Kassiopeia simulations and theory / literature
  - Implement non-adiabatic angle changes in TRModel and determine the impact of this systematic on the sensitivity
- Helpful skills: Python (or similar) for analyzing measurement + simulation data, some knowledge on data analysis (convolution, statistical tests)
- Location: Building 402 on KIT Campus North
- Commencement: April 2024
- Scientific support, advisors, and contact:
  - Prof. Dr. Guido Drexlin / Prof. Dr. Kathrin Valerius
  - Dr. Ferenc Glück (ferenc.glueck@kit.edu)
  - Dr. Martin Descher (martin.descher@kit.edu)