Electromagnetic Design for the Rear Section of the KATRIN Experiment

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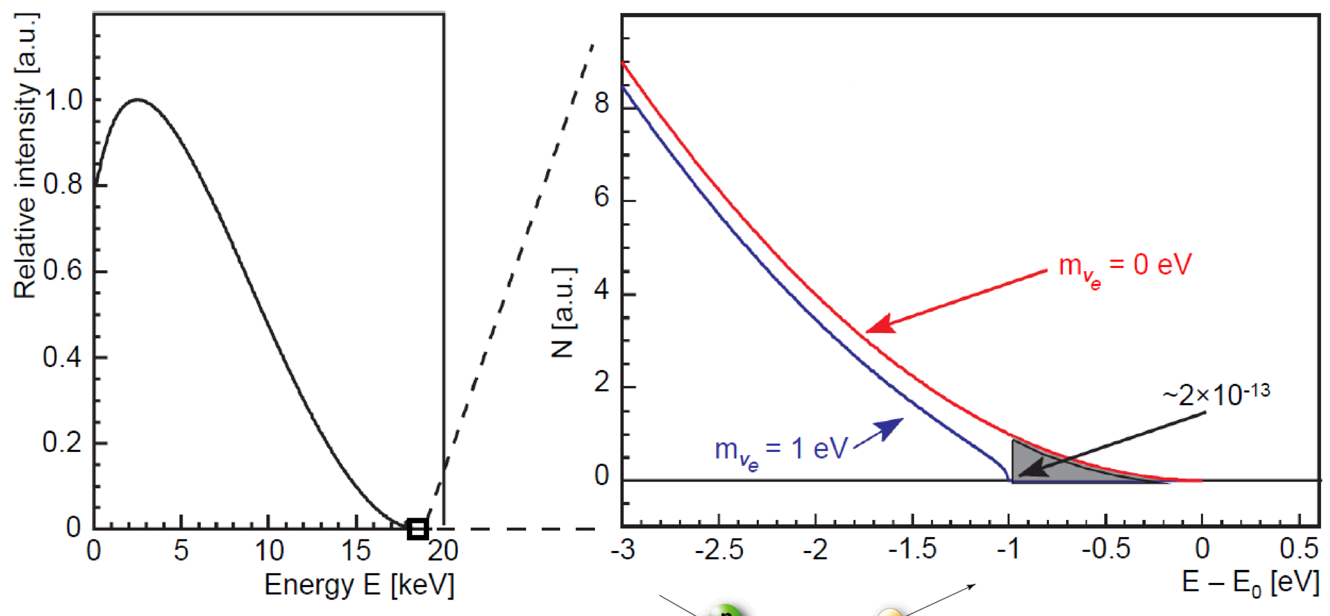
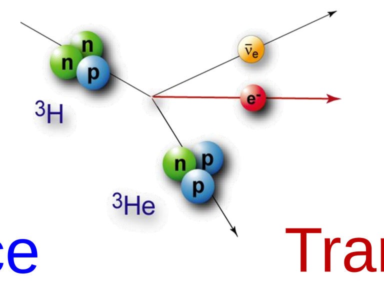


$^3H \rightarrow 3He + e^- + \bar{\nu}_e$

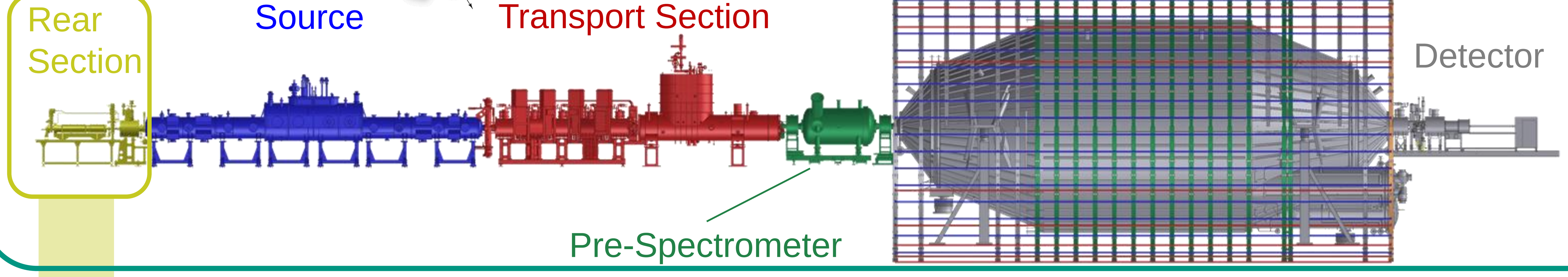


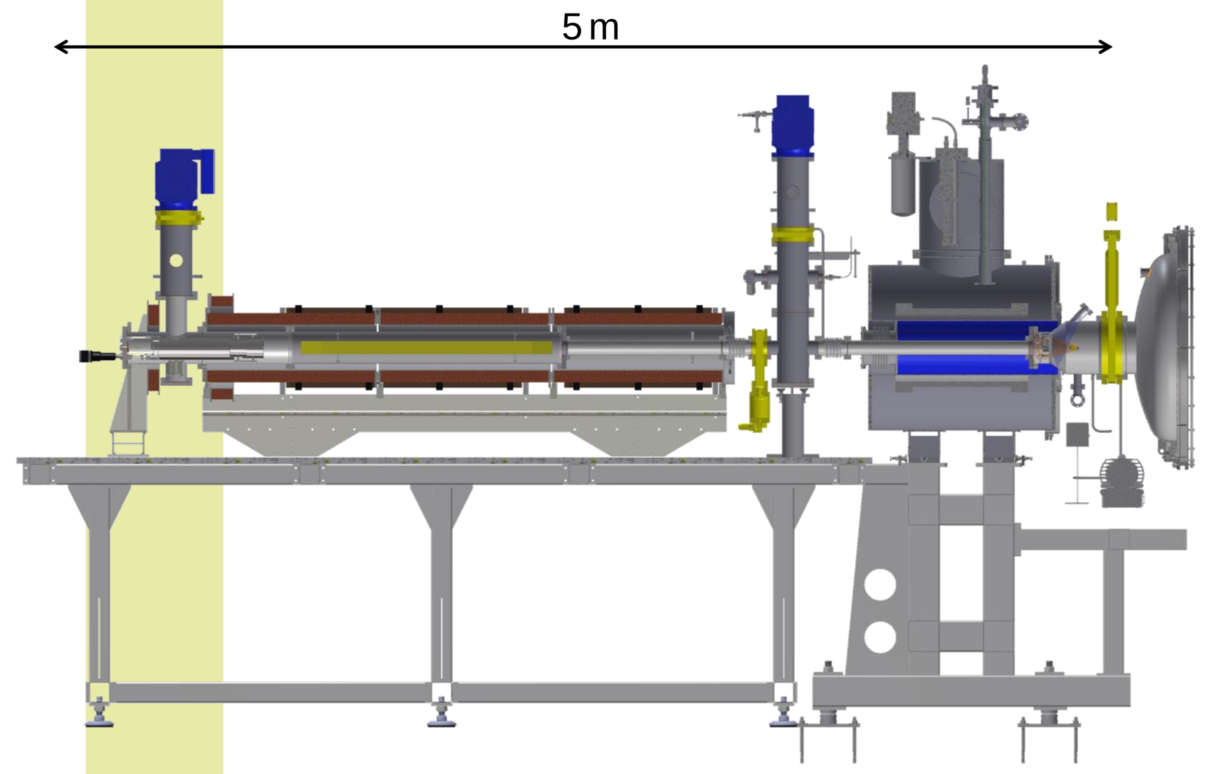
The KATRIN Experiment

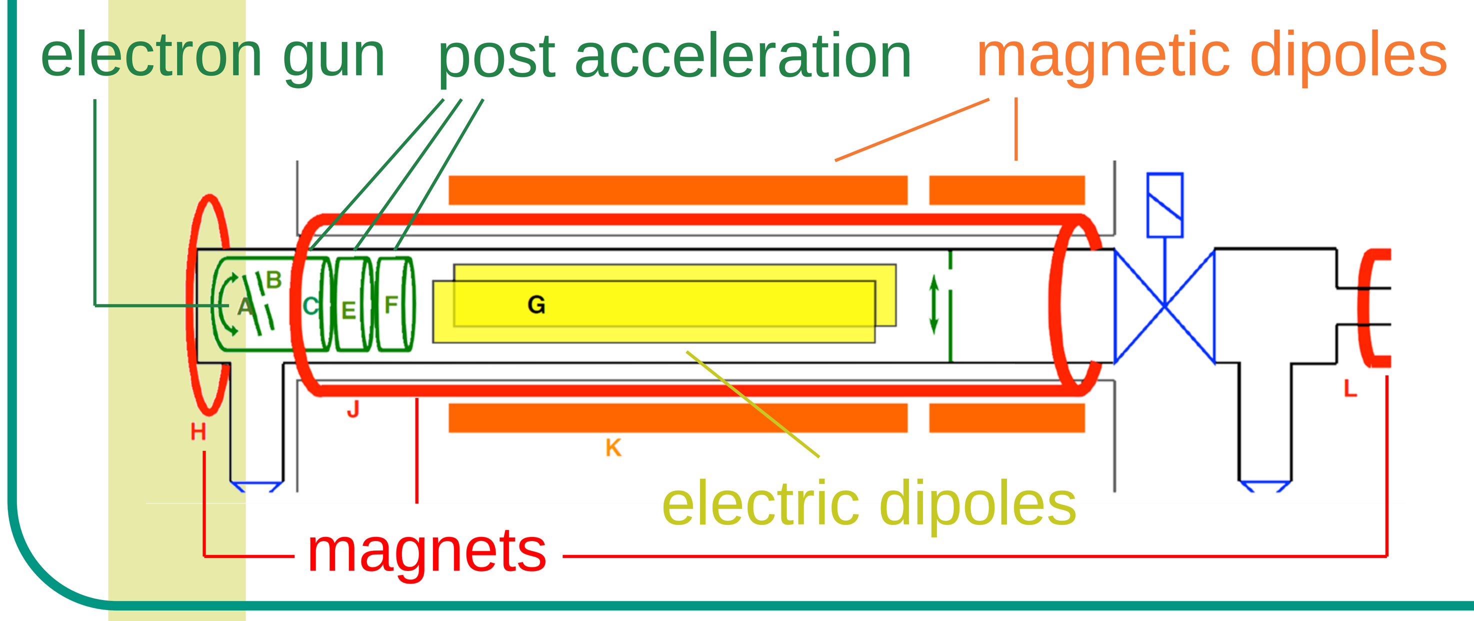
Karlsruhe Tritium Neutrino Experiment

- direct, model-independent measurement of the neutrino mass scale by investigating the kinematics of tritium β-decay
- combination of ultra-luminous gaseous molecular tritium source with high-energy resolution spectrometer

sensitivity on m_ν : 200 meV/c² (90% C.L.)







Rear Section

a calibration and monitoring system for KATRIN featuring a versatile photoelectron source

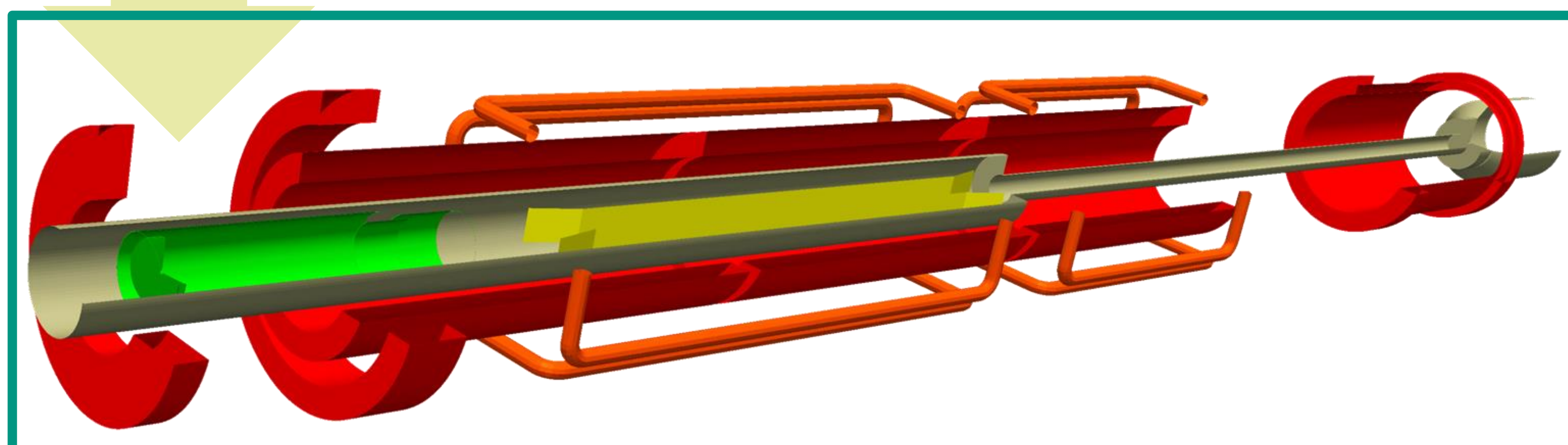
Requirements

- angular range: up to largest transmissible pitch angle
- angular spread ≤ 4° at full angle
- energy range: up to 25 keV
- energy spread: 0.2 eV
- highly stable rate: $\Delta R/R < 10^{-3}$ over 3 min at $R \leq 10^5\ s^{-1}$

Implementation

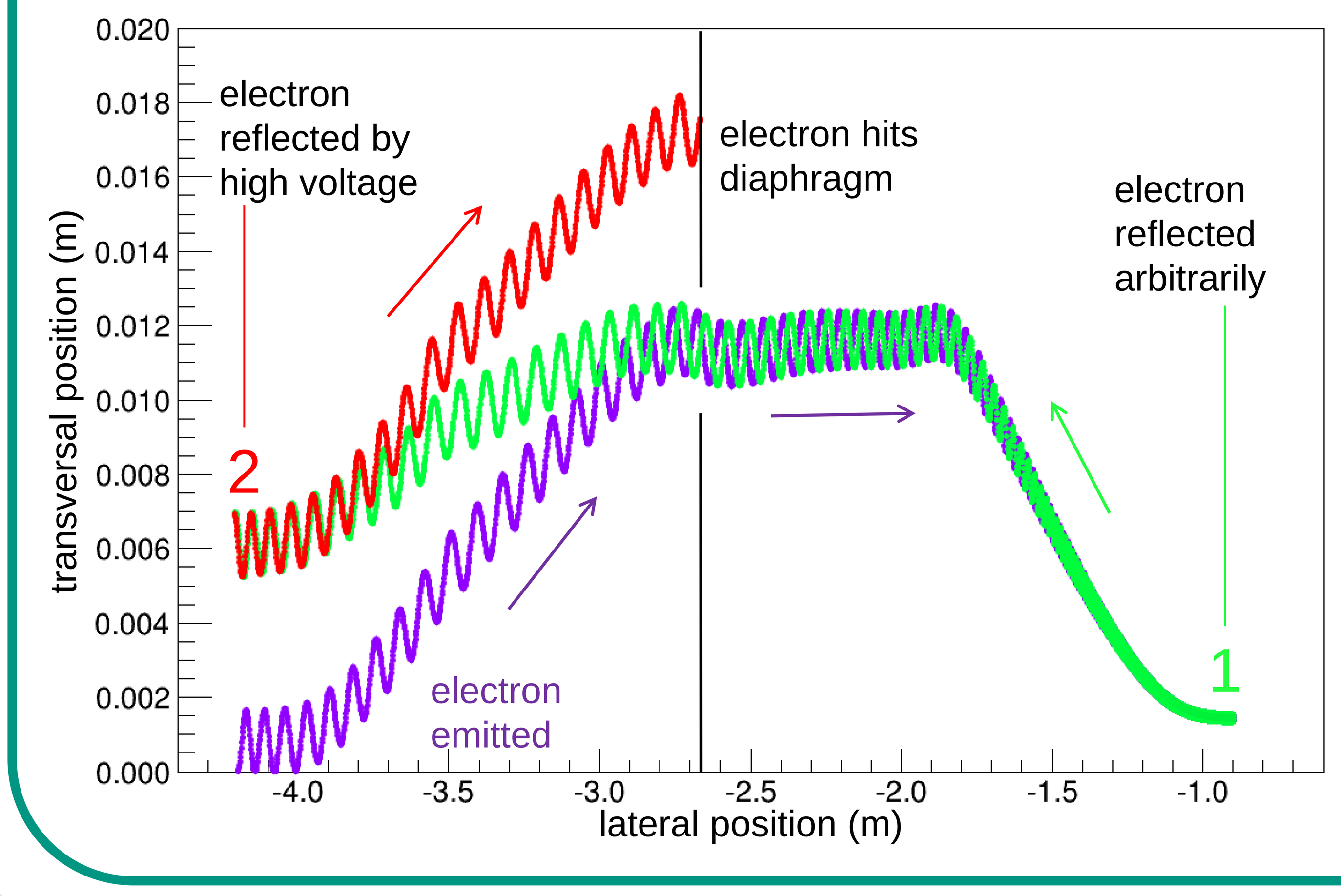
- UV-light based photo emission of a gold surface
- electrons guided adiabatically by magnetic field
- kinetic energy controlled by post acceleration electrodes
- electric dipoles break electron trap by $\vec{E} \times \vec{B}$ drift
- magnetic dipoles steering electron beam

➡ precise electromagnetic design simulations required, consisting of field calculation, optimization and electron tracking



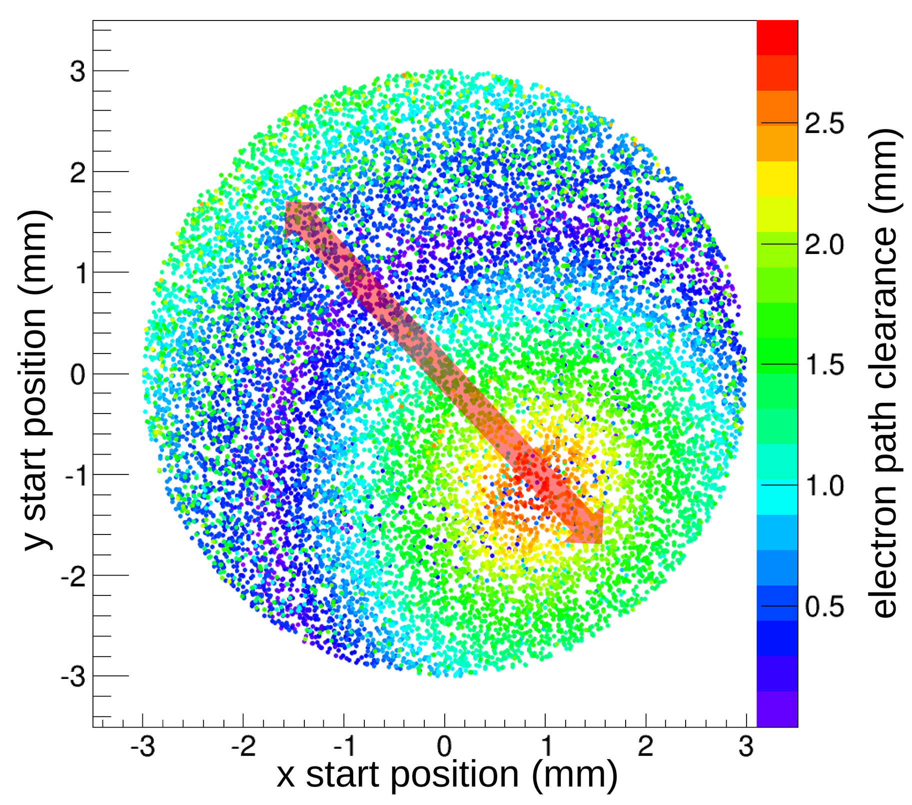
implemented rear section 3D model in Kassiopeia3.0 (KATRIN specific simulation package)

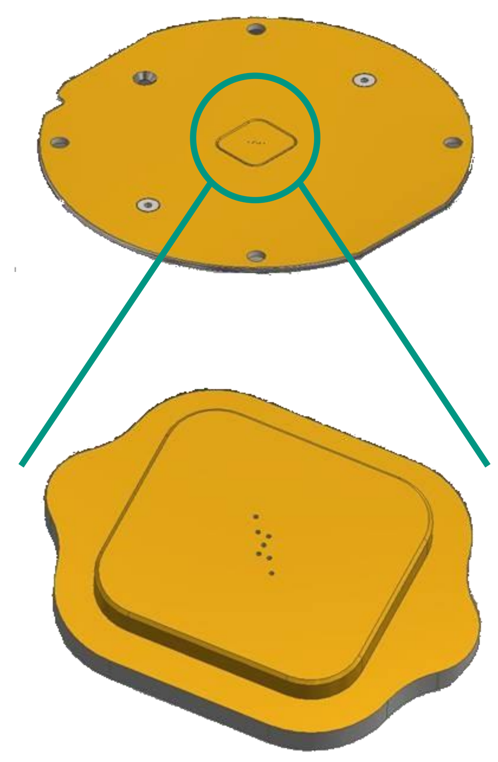
$\vec{E} \times \vec{B}$ drift to remove trapped electrons



Results

- electron gun angle of 10°, 1500 simulated electrons with gaussian energy distribution: mean 0.15 eV, sigma 0.075 eV
- mechanical fiber positioning determined by simulations searching for the optimal starting position





- electron gun angles up to 10° sufficient for covering full angular range
- small beam spot size is elementary to reduce angular spread
  ➡ 200 µm optical fibers

KIT – University of the State of Baden-Wuerttemberg and National Research Center of the Helmholtz Association

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