Electromagnetic Design for the Rear Section of the KATRIN Experiment

The KATRIN Experiment
Karlsruhe Tritium Neutrino Experiment
- direct, model-independent measurement of the neutrino mass scale by investigating the kinematics of tritium $\beta$-decay
- combination of ultra-luminous gaseous molecular tritium source with high-energy resolution spectrometer

sensitivity on $m_\nu$: 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 $\leq 4^\circ$ 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 $E \times B$ drift
- magnetic dipoles steering electron beam

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

Results
- electron gun angle of $10^\circ$, 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

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

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$E \times B$ drift to remove trapped electrons

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mechanical fiber positioning determined by simulations searching for the optimal starting position

electron gun angles up to $10^\circ$ sufficient for covering full angular range
small beam spot size is elementary to reduce angular spread

200 μm optical fibers