Monitoring of the high voltage stability in the KATRIN experiment

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**TECHNICAL CHALLENGE**
sensitivity of 200 meV/c² (90% CL) on the effective mass of $\nu_e$ from tritium $\beta$-decay
- high voltage (HV) stability within ≤ 60 mV @ 18.6 kV (3 ppm)
- continuous monitoring for a 2-month run

**HIGH VOLTAGE MONITORING CONCEPT**
Monitor spectrometer conversion electrons with constant energy
HV instability shift of measured energy
Direct HV measurement
high precision HV-dividers K35 & K65 and precise voltmeters

**GENERAL FEATURES**
- integrating spectrometer
- high energy resolution 0.93 eV @ 18.6 keV
- ultra-high vacuum 10⁻¹⁰ mbar
- 3D positioning of source and detector

**CONVERSION ELECTRON SOURCE**
- K-32 electrons of $^{83m}\text{Kr}$ 800 eV below tritium $\beta$-spectrum endpoint
- $^{83}\text{Rb}$ implanted into solid substrate (Pt, HOPG) @ ≤ 30 keV

**DETECTOR**
- central – circular Si PIN-diode, area 1.5 cm²
- for counting electrons
- auxiliary – PIN-photo diodes
- for alignment
- cooled to ≈ -45 °C with LN₂

**CONVERSION LINE SHAPE**
- naive expectation: symmetrical Lorentzian function
- observed: numerical convolution

**ANALYSIS OF MoS ELECTRON SPECTRUM**
- solid-state effects (Gaussian)
- loss-energy part (not considered)
- line position = energy of the conversion electrons
- line position uncertainty from this fit: 21 meV ± 1.2 ppm
- meas. time: ≈ 25 min
- # of fit parameters: 5

**TRANSMISSION FUNCTION**
- analytically:
  - ideal MAC-E filter, point-like source
  - in reality:
    - source with finite dimensions
    - inhomogeneous activity distribution
    - non-trivial electron flux tube over the analyzing plane

**EXPERIMENTAL PROOF OF K-32 ENERGY STABILITY**
- series of measurements at the standalone MoS
  - optimization
  - substrate
  - implantation dose
  - implantation energy
  - beam contamination
  - reproducibility
  - stability
- latest results: K-32 line position stable at the level of 0.3 ppm/month

**CONCLUSION**
The monitor spectrometer will serve as a powerful and independent tool for continuous monitoring of the high voltage stability in the KATRIN experiment.

**REFERENCES**
- KATRIN collaboration, KATRIN design report 2004, Karlsruhe (2005), http://www.katrin.kit.edu
- M. Erhard et al., High-voltage monitoring with a solenoid retarding spectrometer at the KATRIN experiment, accepted in J. Instrum. (2014).

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