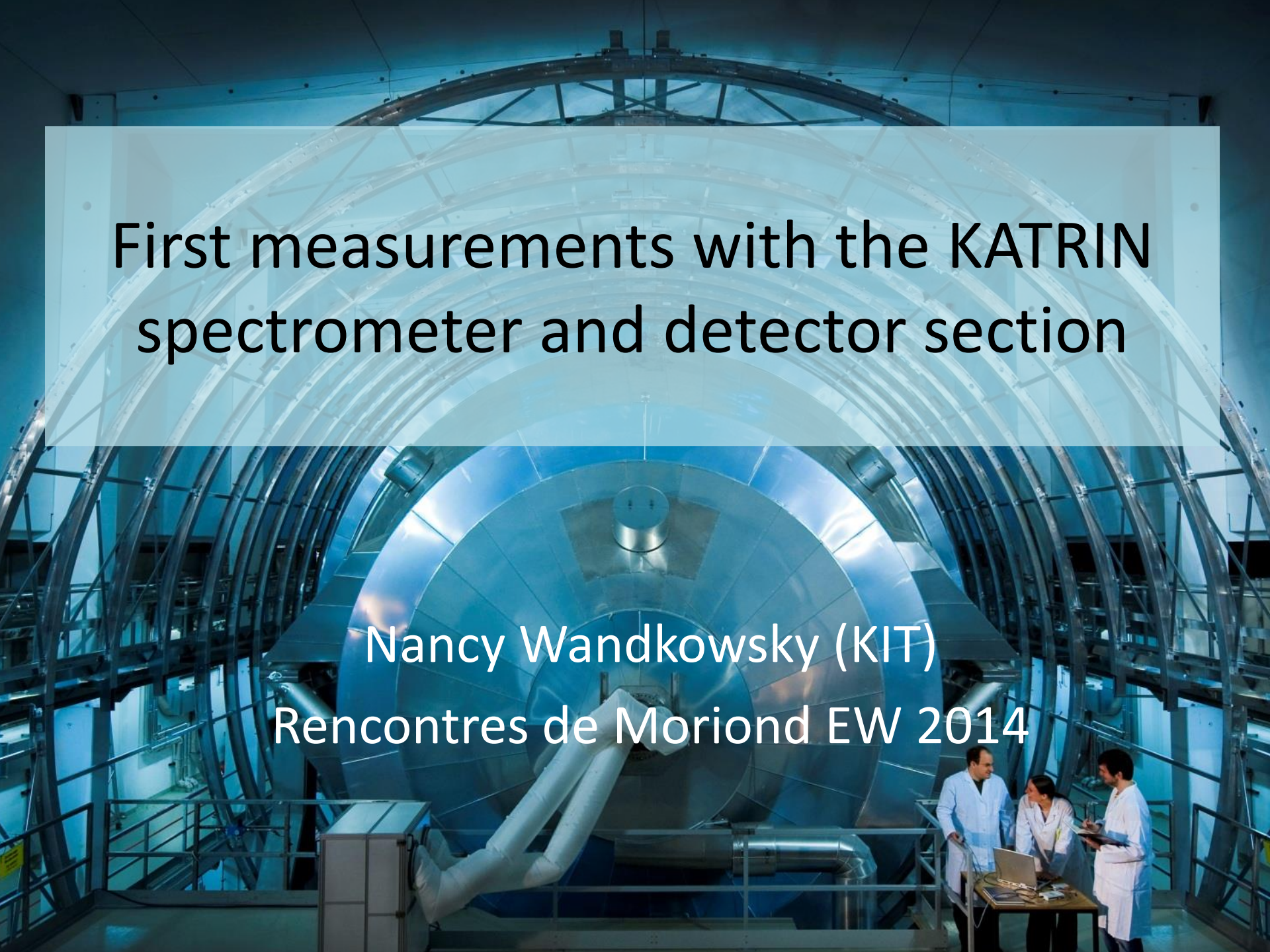


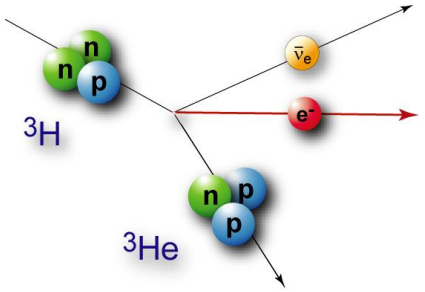
First measurements with the KATRIN spectrometer and detector section

Nancy Wandkowsky (KIT)

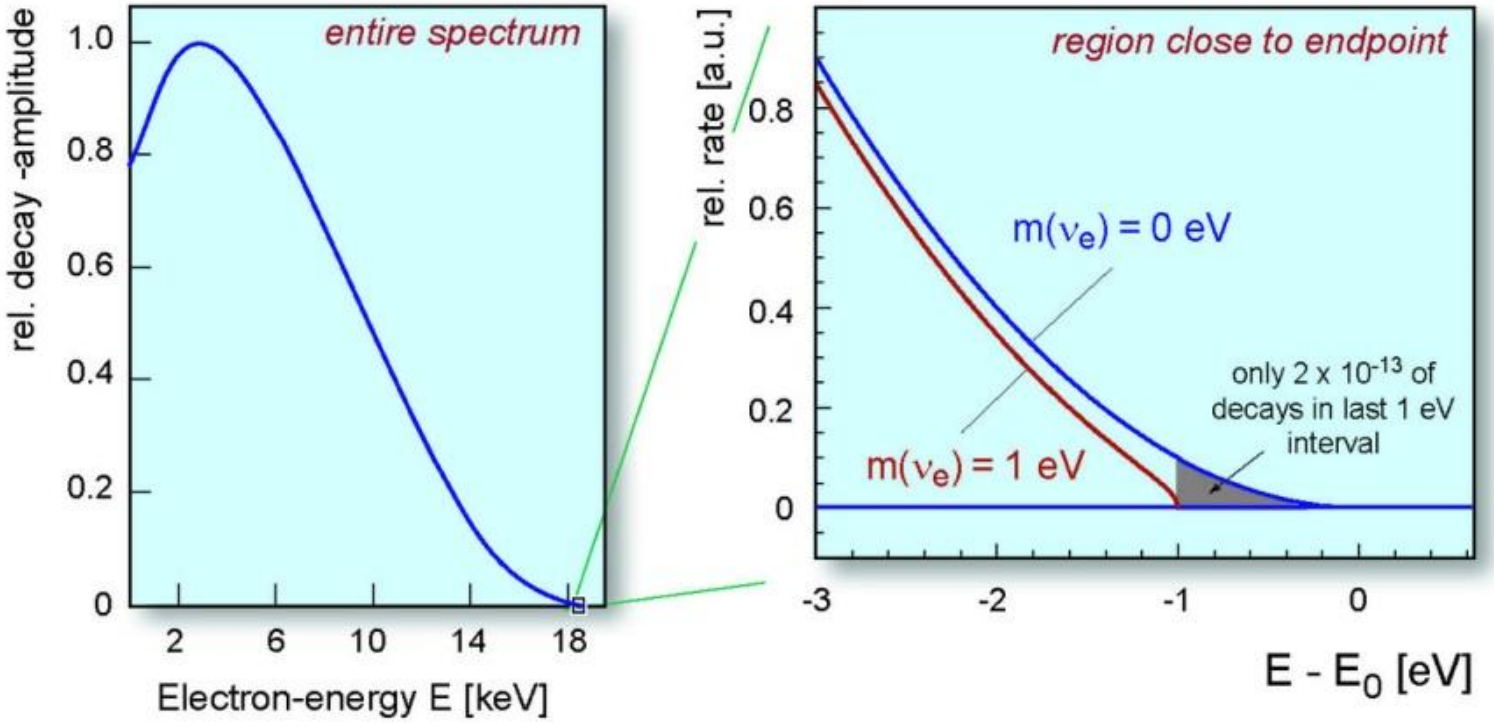
Rencontres de Moriond EW 2014

I. The KATRIN experiment

Direct determination of m($\bar{\nu}_e$)



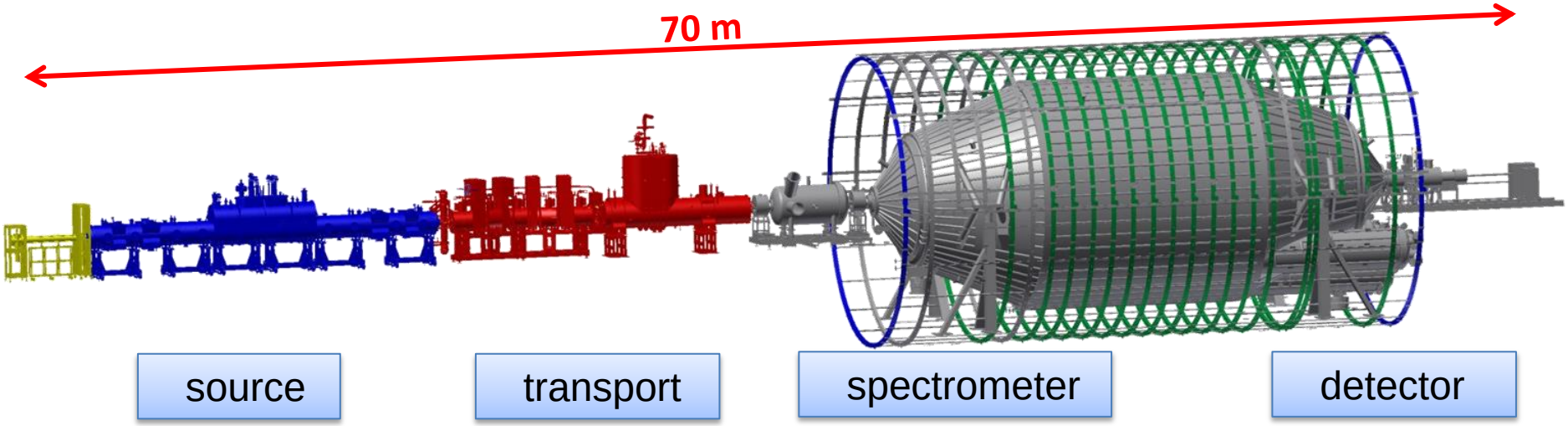
- β-decay: (A,Z) → (A,Z+1) + e$^-$ + $\bar{\nu}_e$
- Electron energy spectrum:



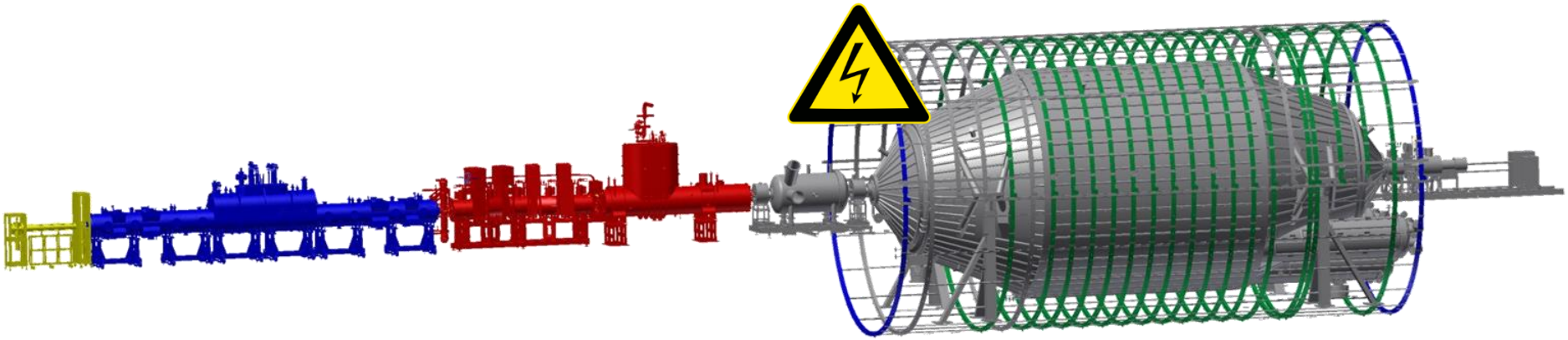
I. The KATRIN experiment

KArlsruhe TRItium Neutrino experiment (KATRIN)

- sensitivity:
  - upper limit: 200 meV (90% CL)
  - discovery: 350 meV (5σ)
- predecessor experiments (Mainz, Troitsk): $m(\bar{\nu}_e) < 2.1$ eV



I. The KATRIN experiment

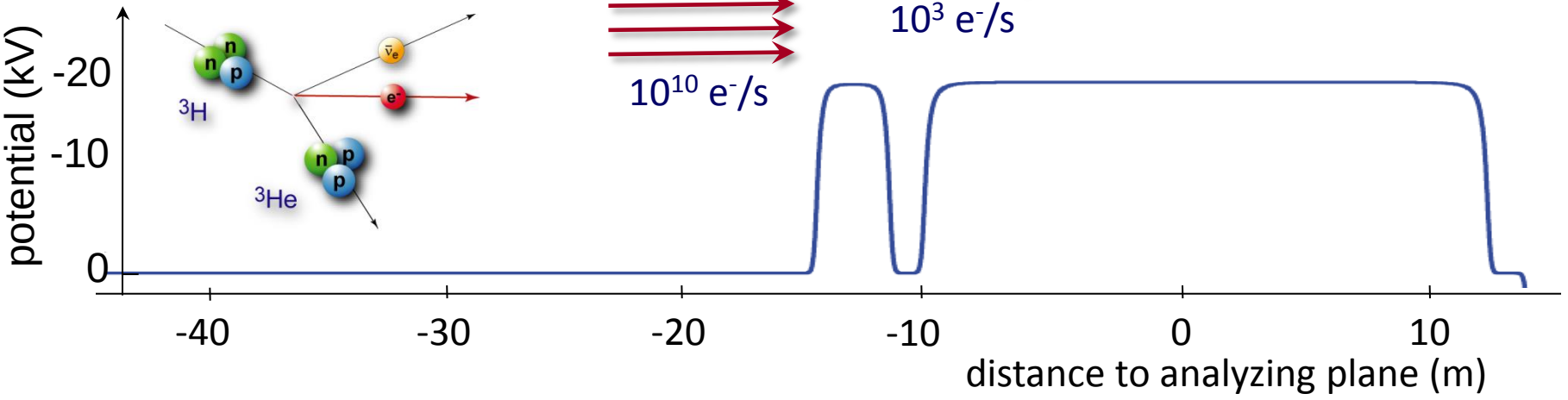


source | transport | spectrometer | detector

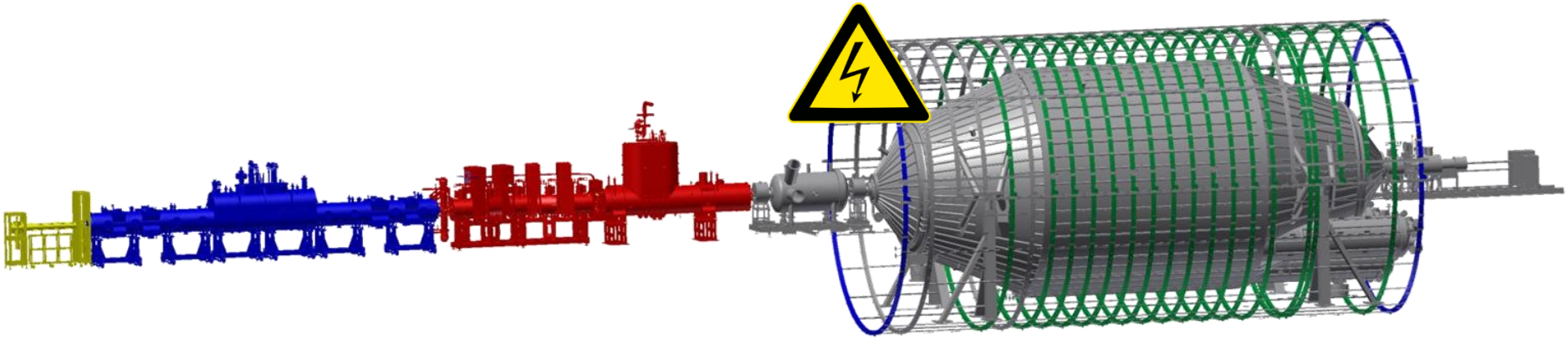
10^{10} e$^-$/s

10^{3} e$^-$/s

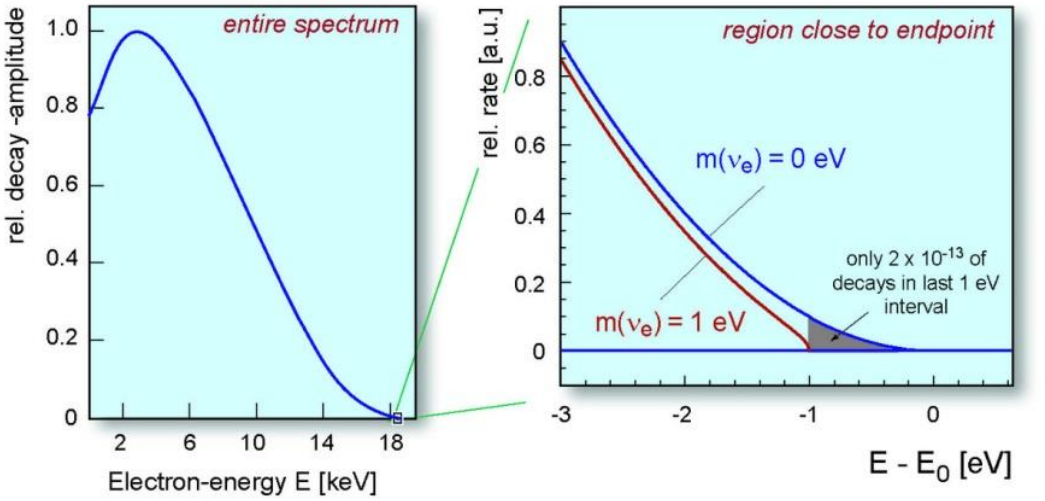
10^{-2} e$^-$/s

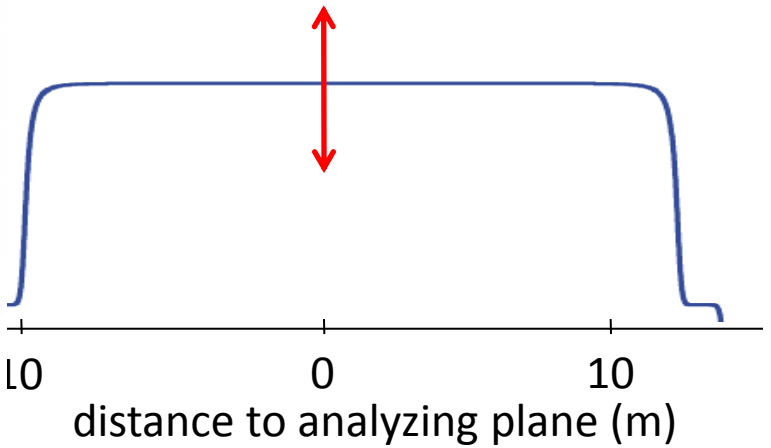


I. The KATRIN experiment



source | transport | spectrometer | detector

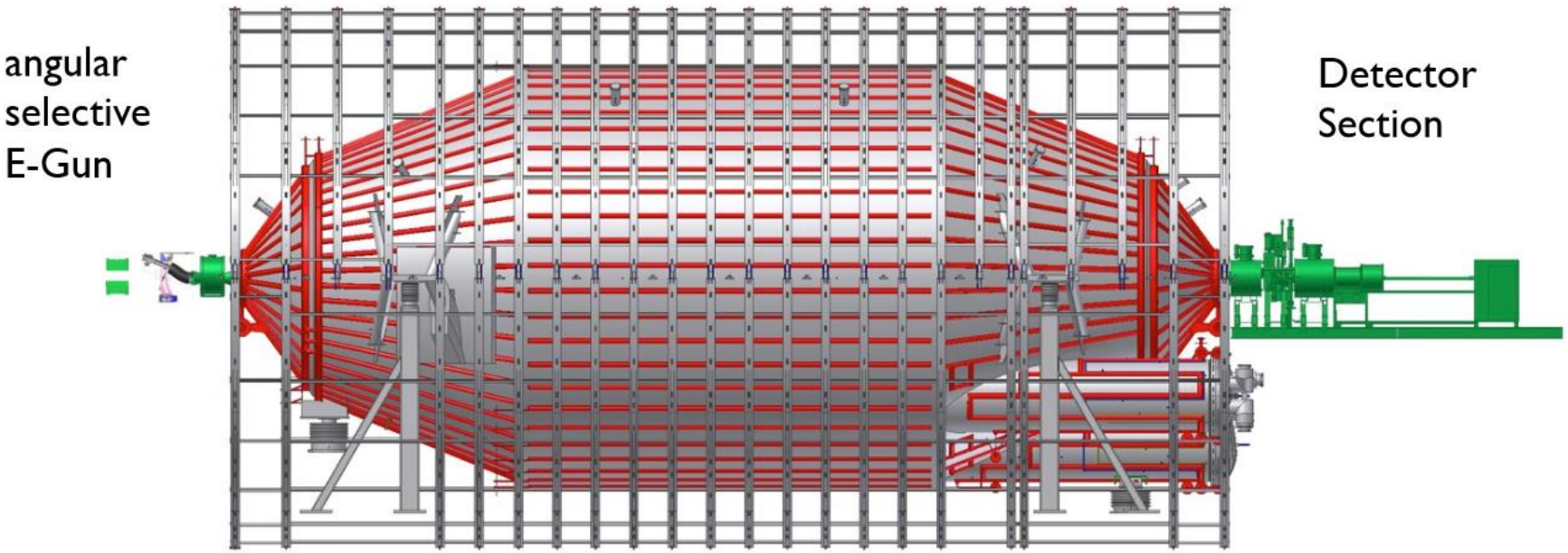




I. The KATRIN experiment

Spectrometer-Detector-Section commissioning in 2013

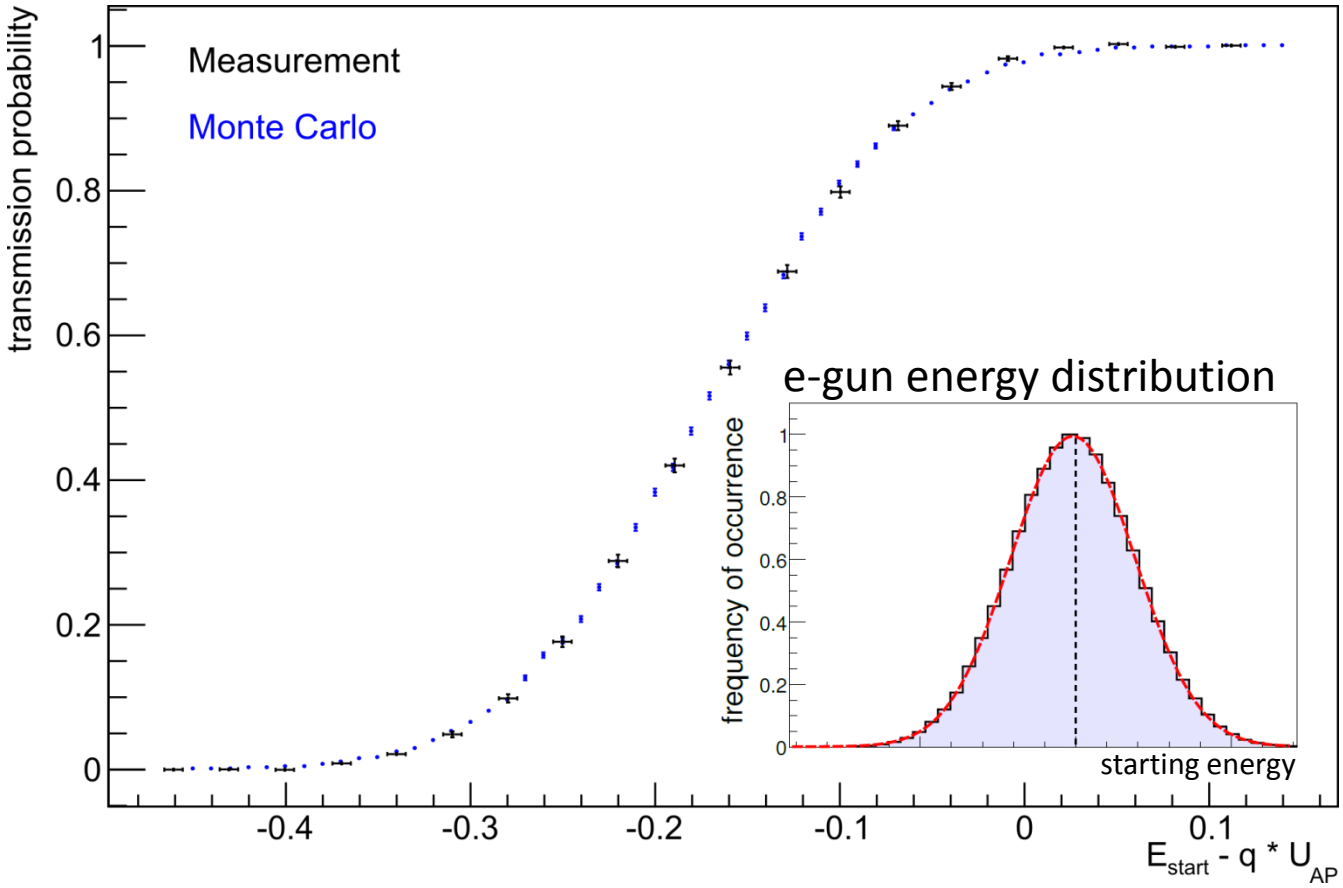
- test signal electron transport and filtering
- characterize and optimize background



II. Signal

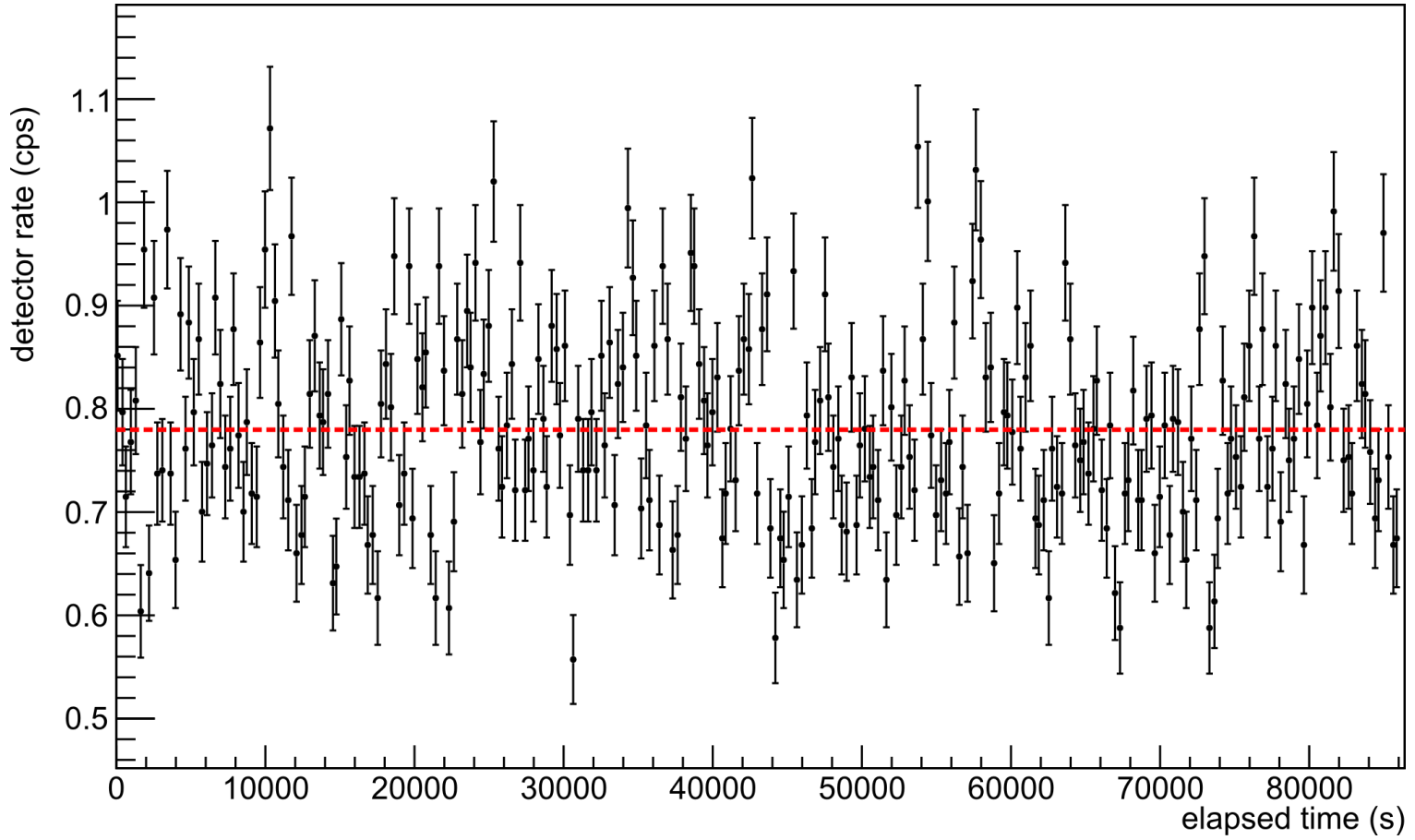
Transmission function measurement

- Spectrometer works as expected



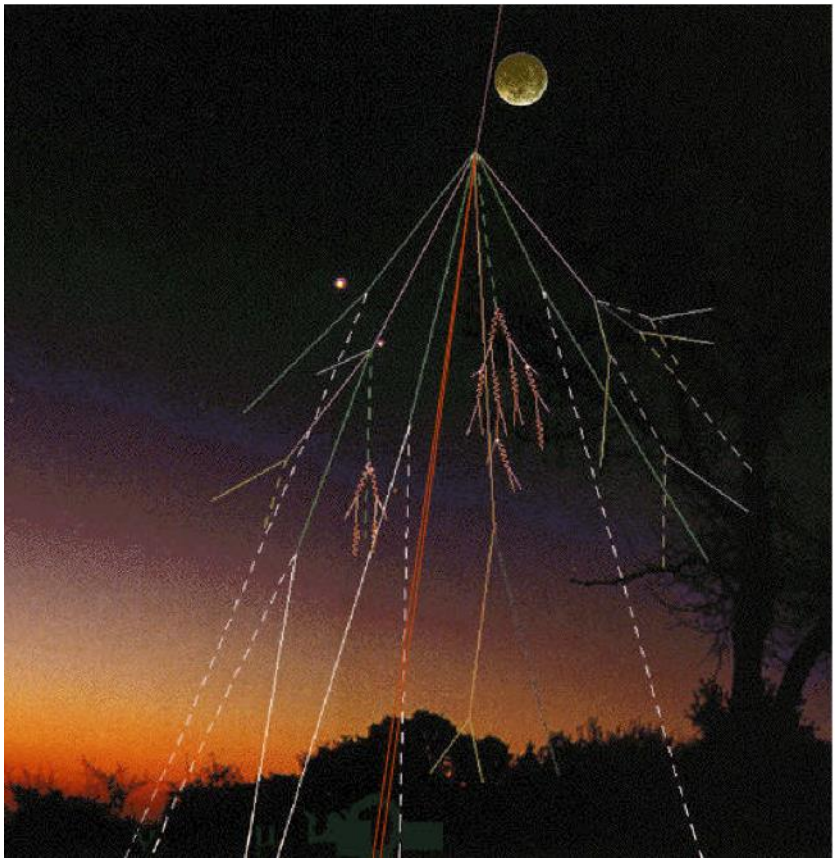
III. Background

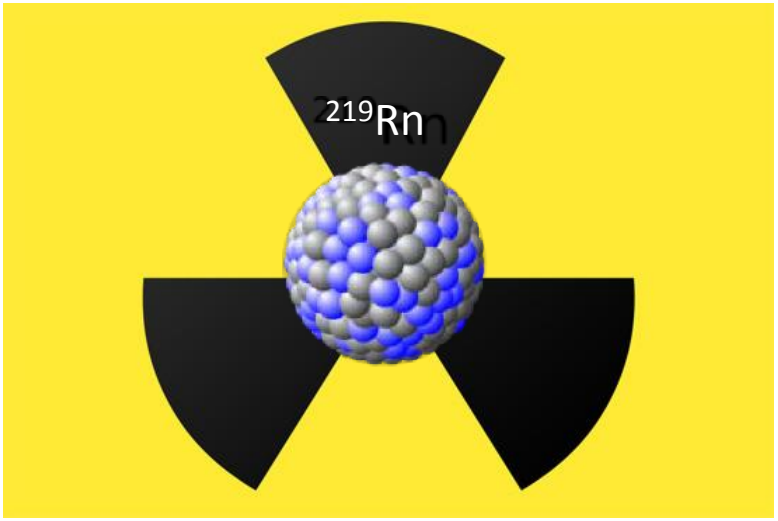
- Initial background already below 1 cps! (previous spectrometers: 10^5 cps)



III. Background

Background sources: muons and radon



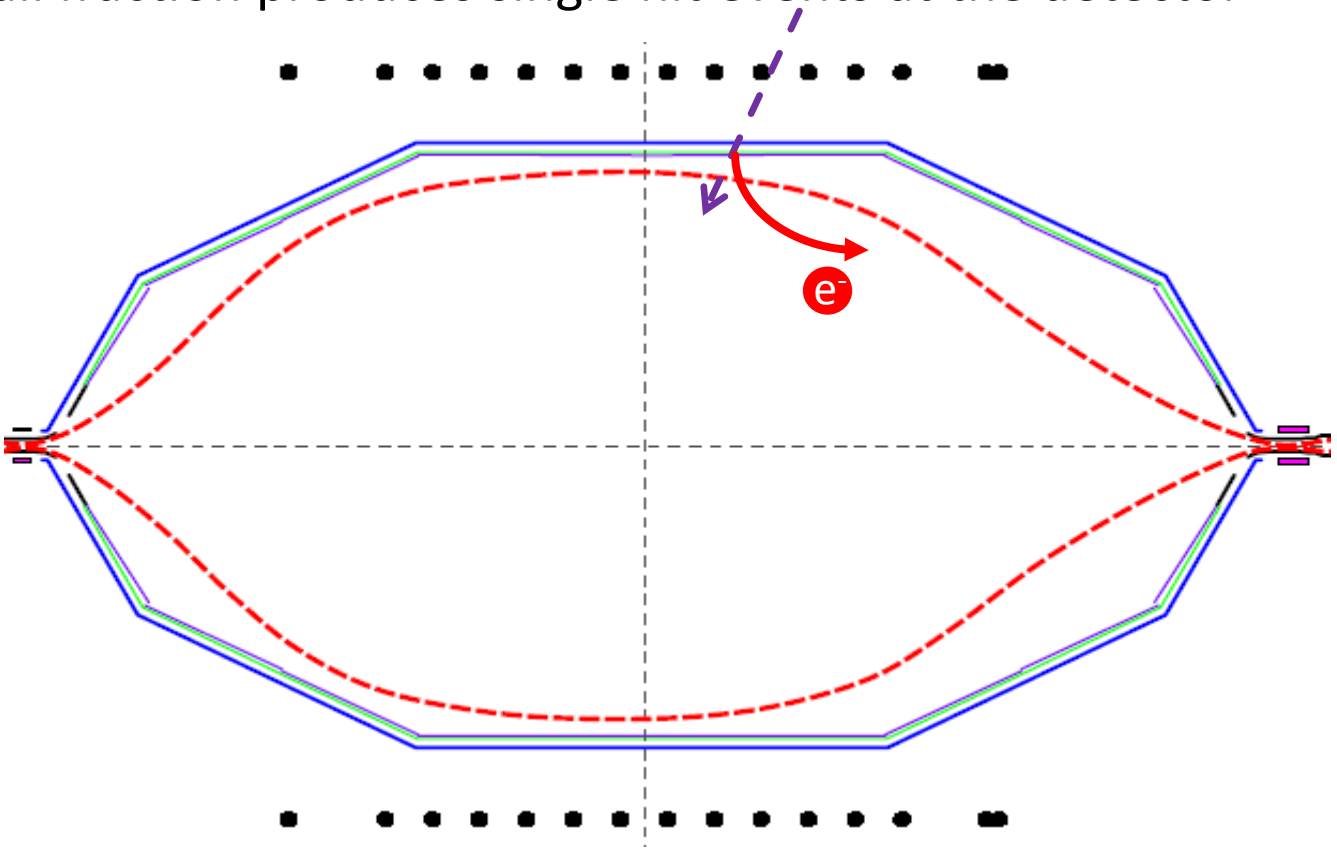


How large are the individual background contributions?

III. Background

Muon-induced background

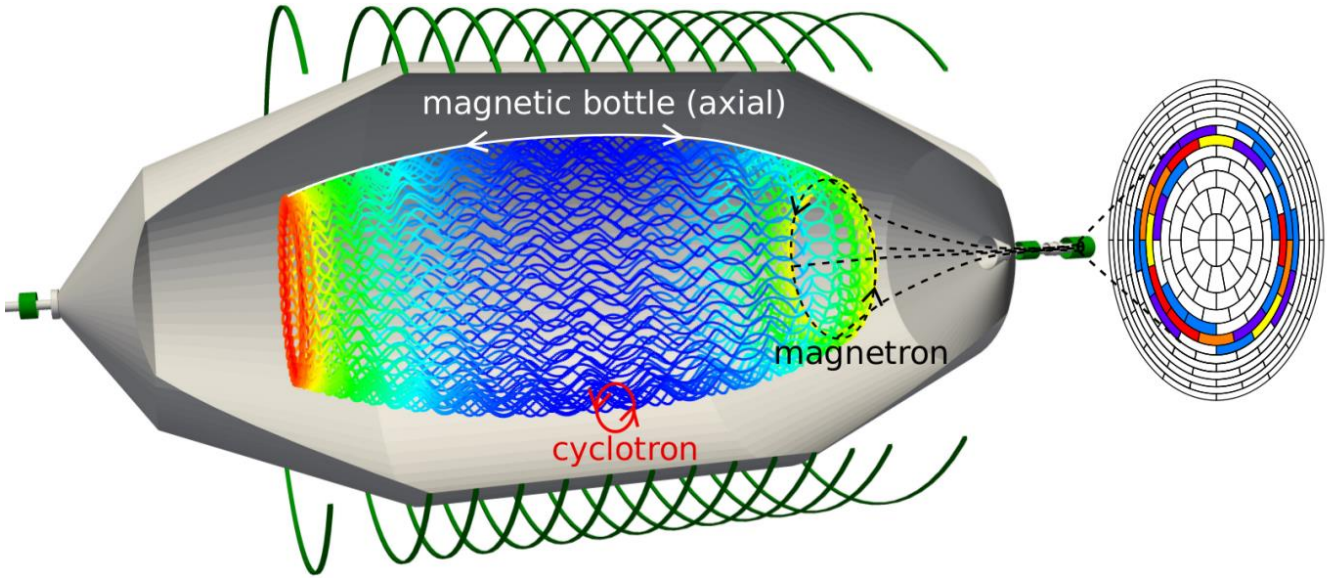
- total muon-flux onto spectrometer: 75 kμ/s
- a small fraction produces single hit events at the detector



III. Background

Radon-induced background

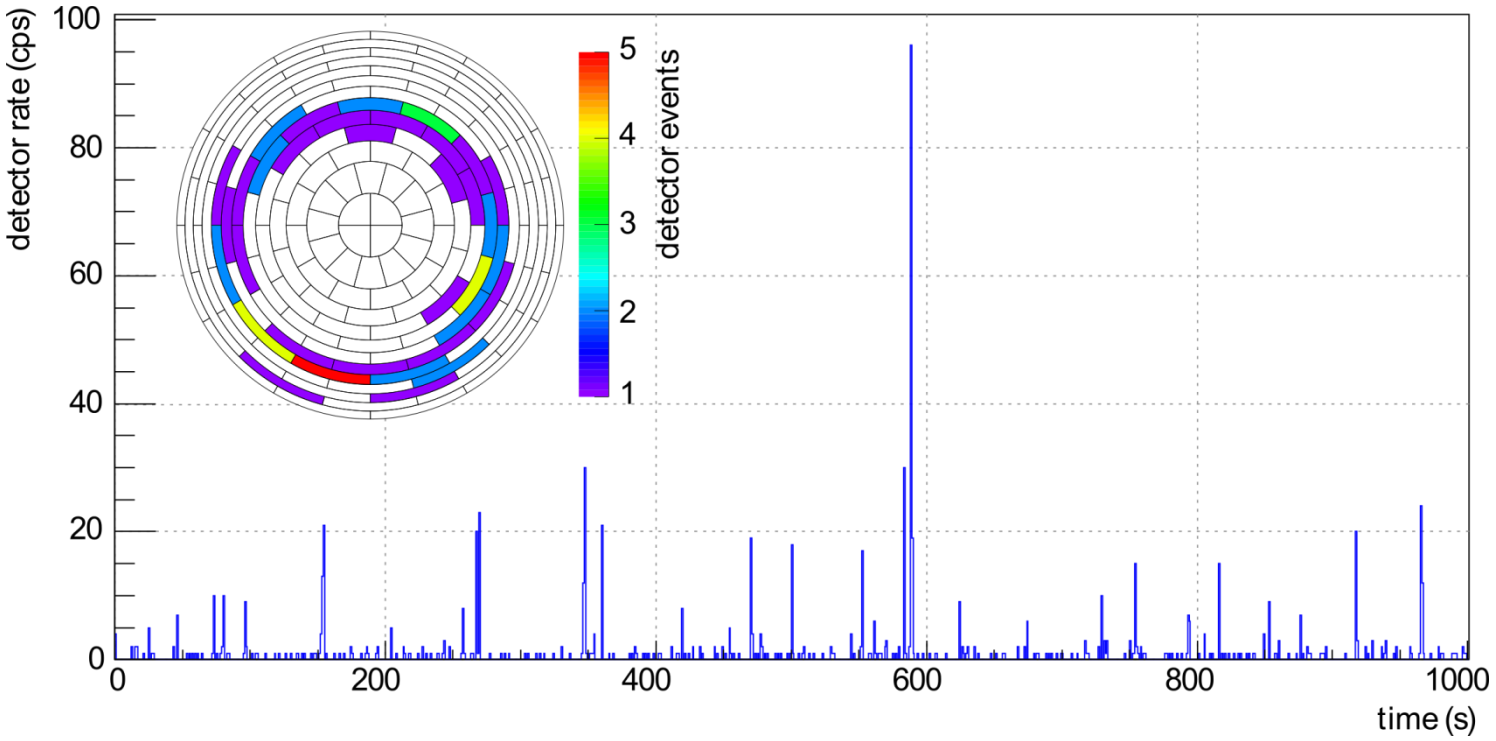
- nuclear decays inside spectrometer volume
- magnetic bottle effect: stored electrons
- ionization of residual gas → many secondary electrons on detector
- UHV (10^{-11} mbar) → storage time up to several hours



III. Background

Disentanglement of background sources

- Measurement at increased pressure: 10^{-11} mbar → 10^{-8} mbar
- Individual radon events as spikes in count rate
- Background contribution: radon : muon ≈ 40 : 60




Thank you for your attention!

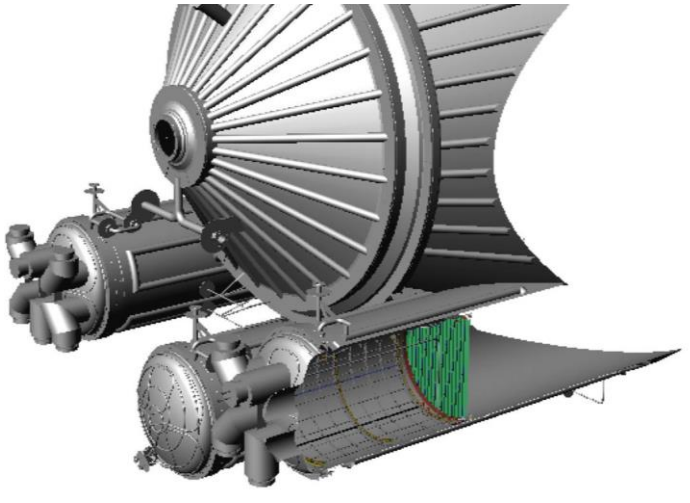
BACKUP

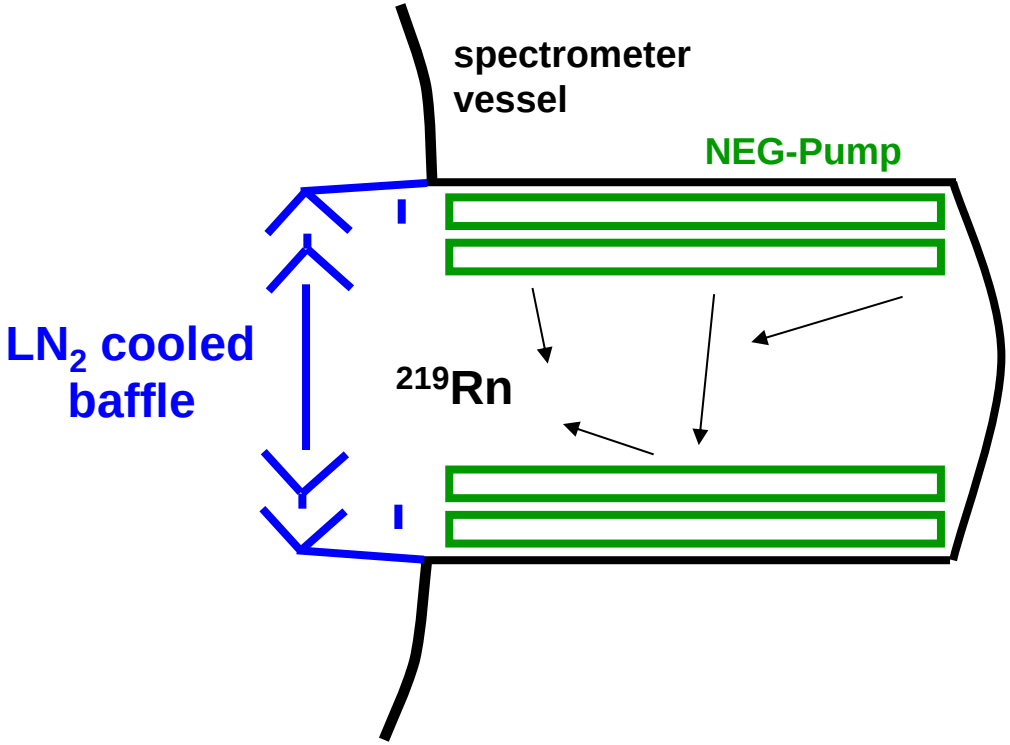
IV. Background: Radon-induced

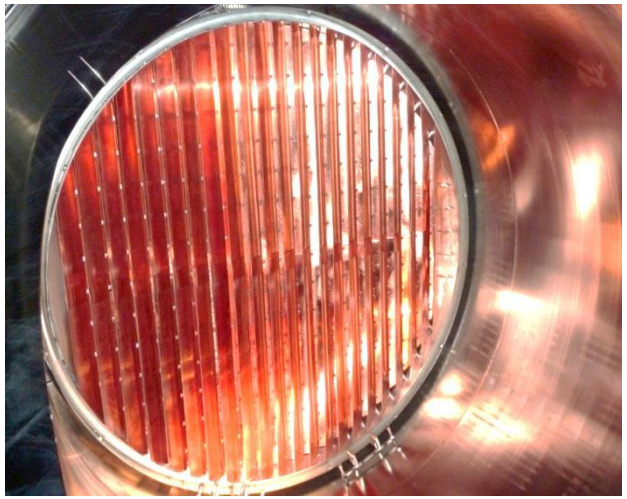
Passive background reduction

- freeze radon to cold surface
- short half-life

  → decay outside of sensitive volume



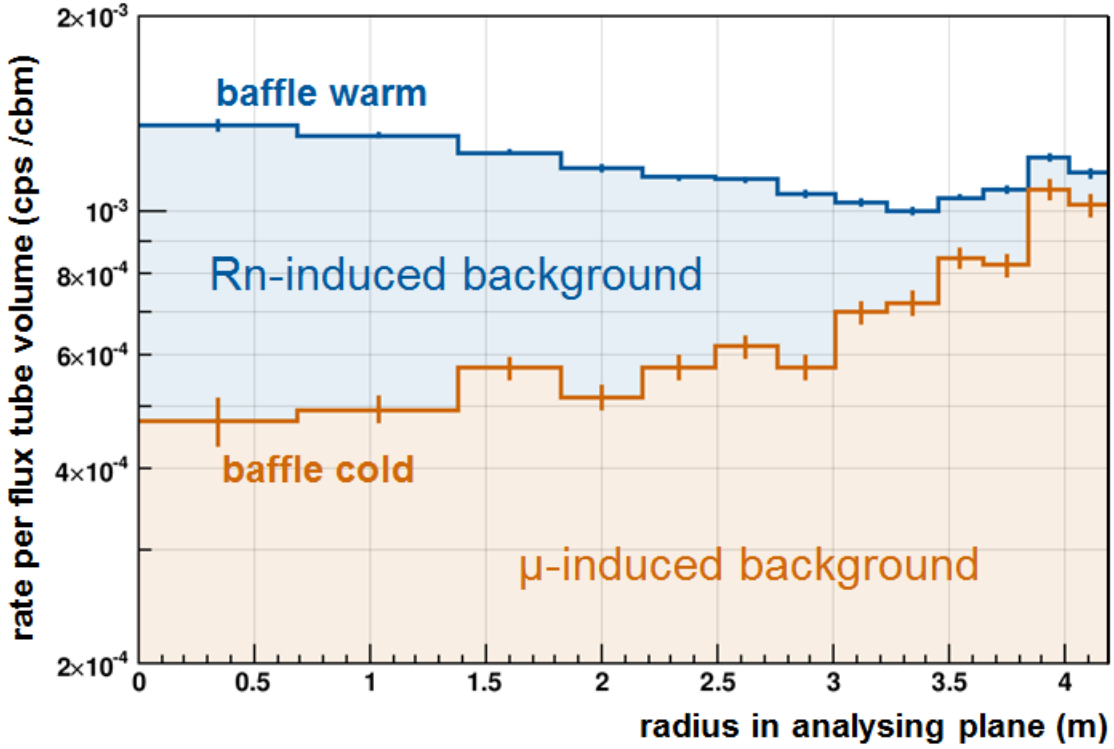


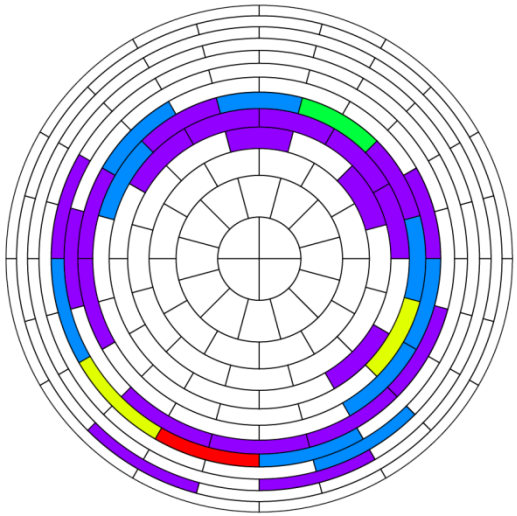


IV. Background: Radon-induced

Main spectrometer: passive background suppression

- Cold baffle → total background reduced by ~40%
  → μ-induced background dominant





I. The KATRIN experiment

Direct determination of m(ν_e)

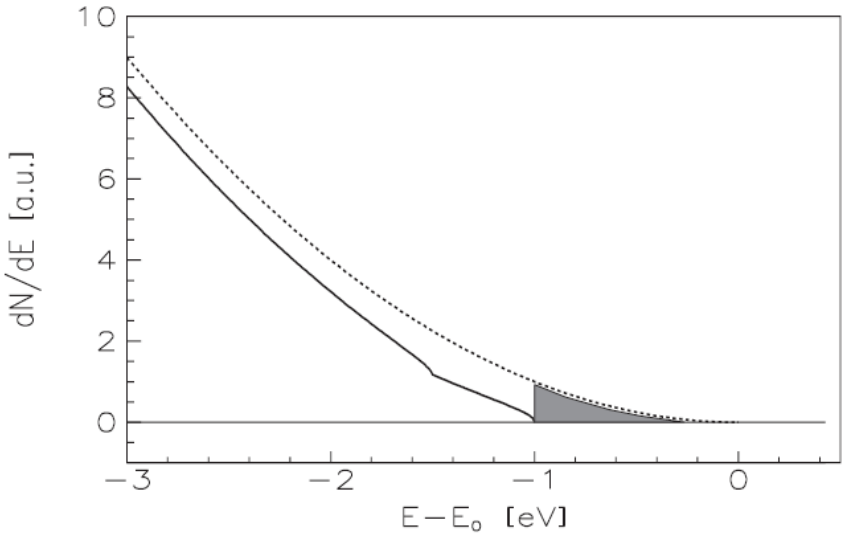
- β-decay: (A,Z) → (A,Z+1) + e^- + $\bar{\nu}_e$
- Electron energy spectrum:

$$\frac{dN}{dE} = K \cdot F(E,Z) \cdot p \cdot E_{tot} \cdot (E_0 - E_e) \cdot \sqrt{(E_0 - E_e)^2 - "m(\nu_e)"^2}$$

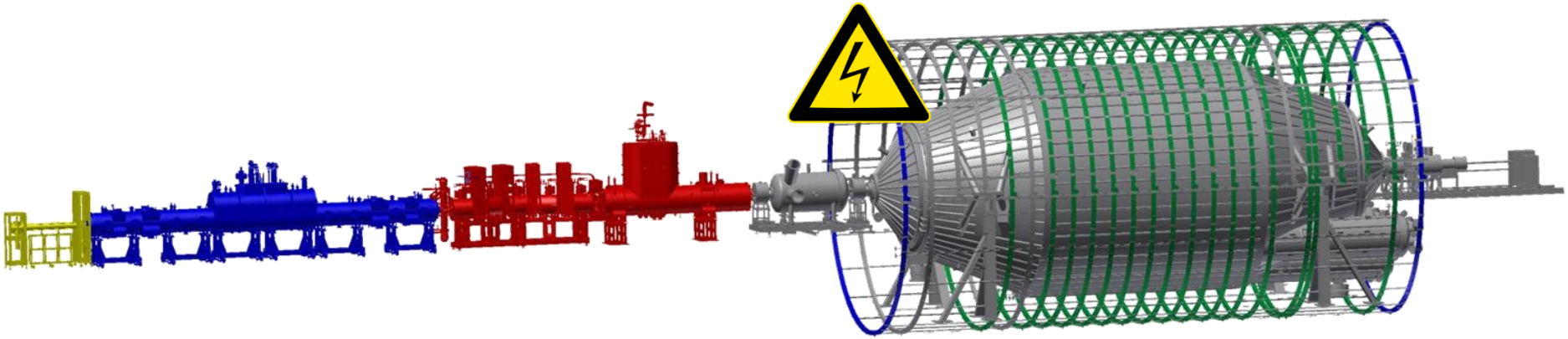
(modified by electronic final states, recoil corrections, radiative corrections)

effective neutrino mass:

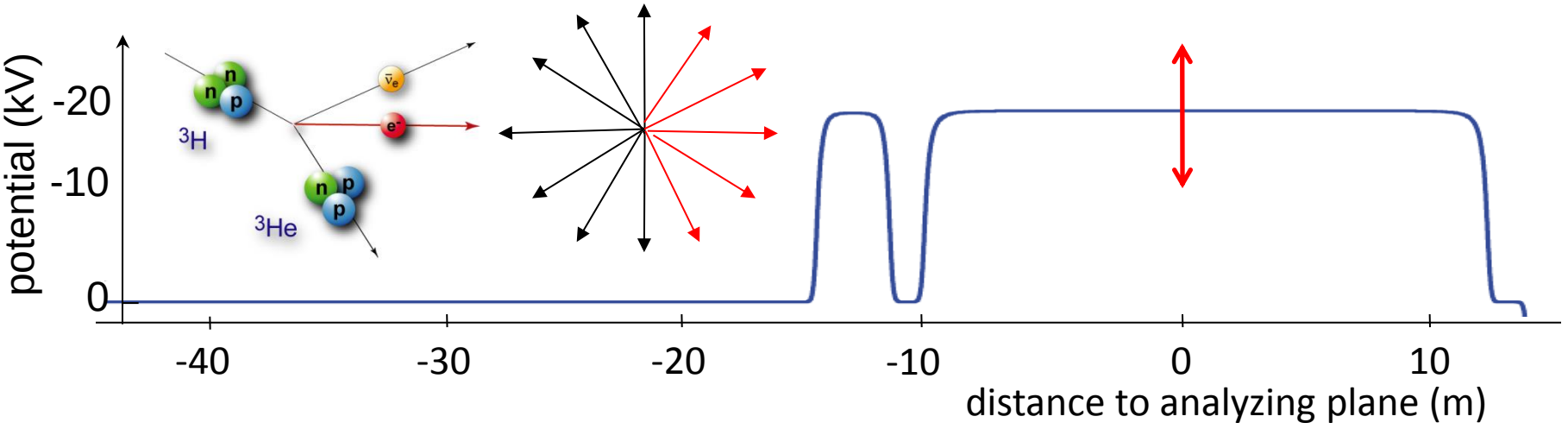
$$"m(\nu_e)"^2 = m^2(\nu_e) = \sum_i |U_{ei}|^2 \, m_i^2$$



I. The KATRIN experiment

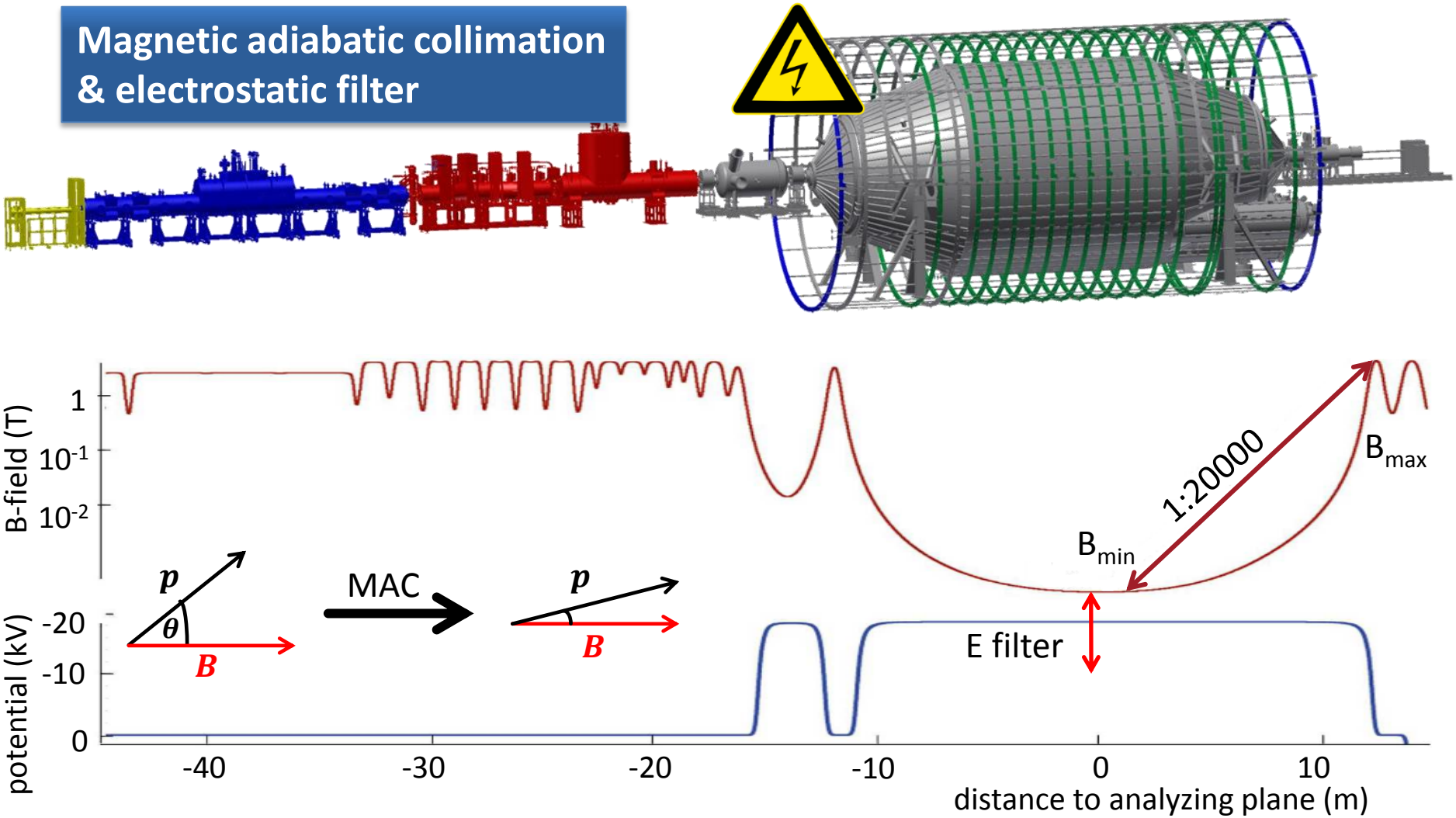


source | transport | spectrometer | detector



I. The KATRIN experiment

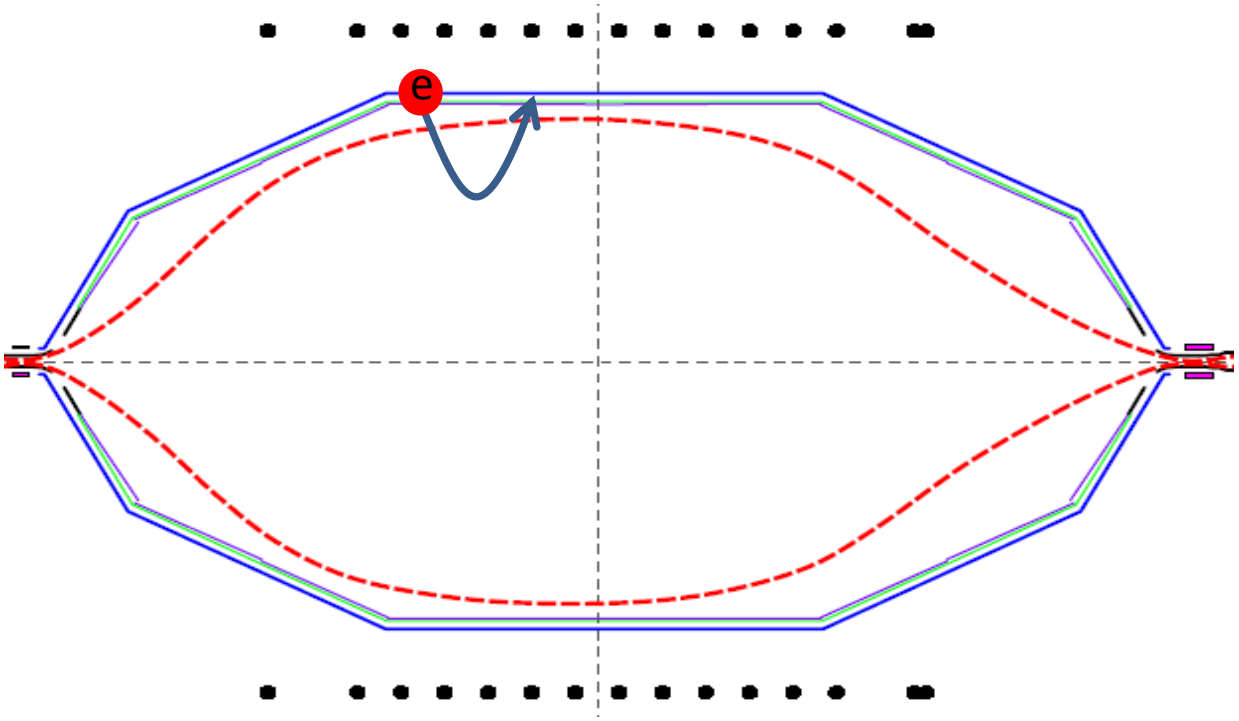
Magnetic adiabatic collimation & electrostatic filter



V. Background: Muon-induced

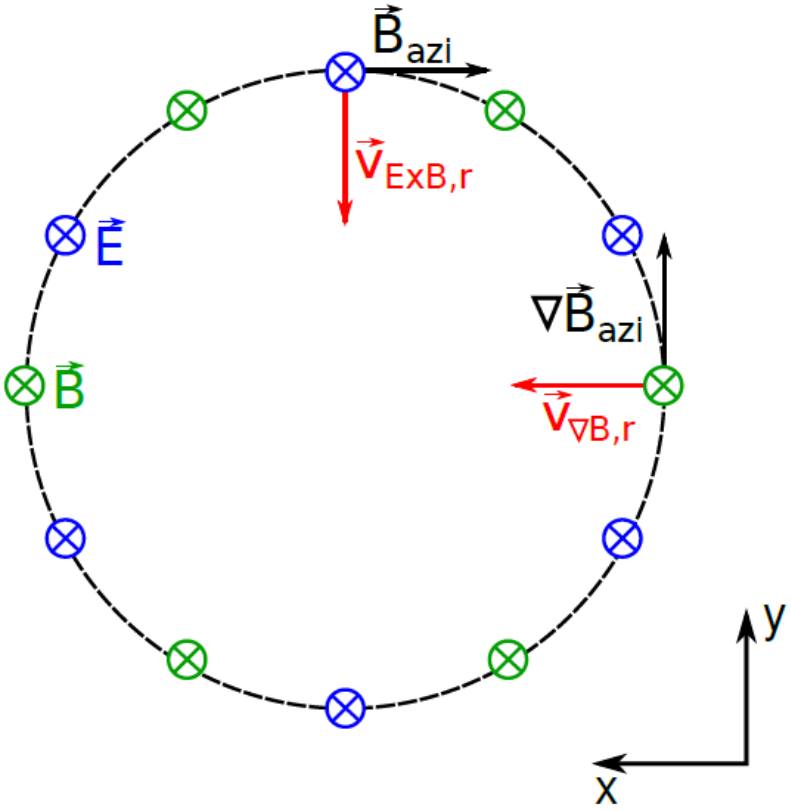
Background generation mechanism

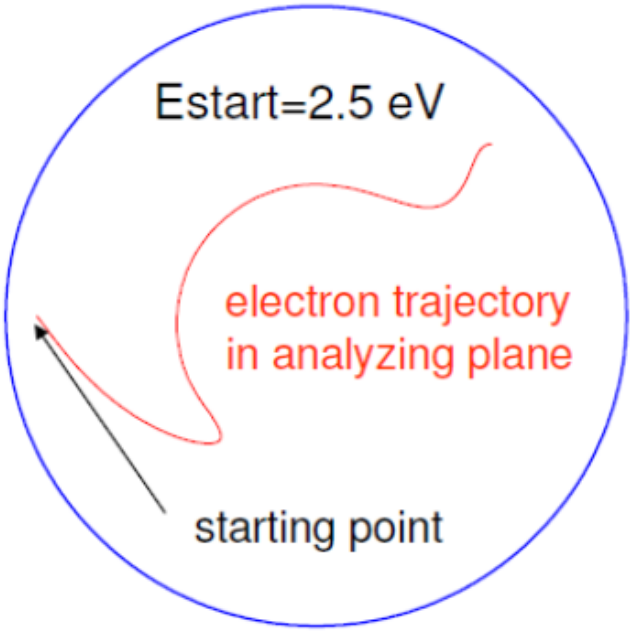
- Magnetic shielding



V. Background: Muon-induced

Background generation mechanism





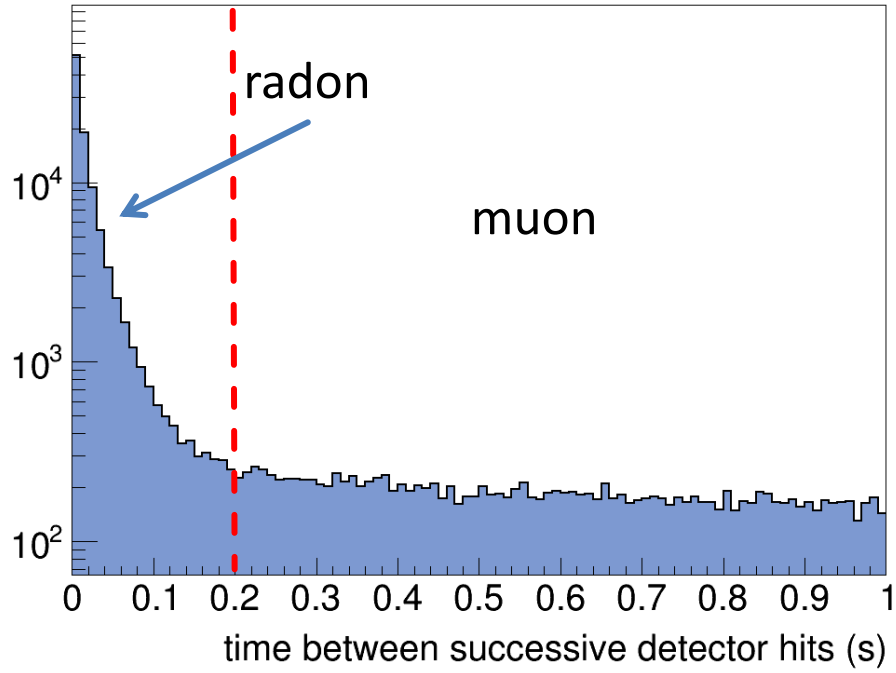
large non-axially-symmetric field

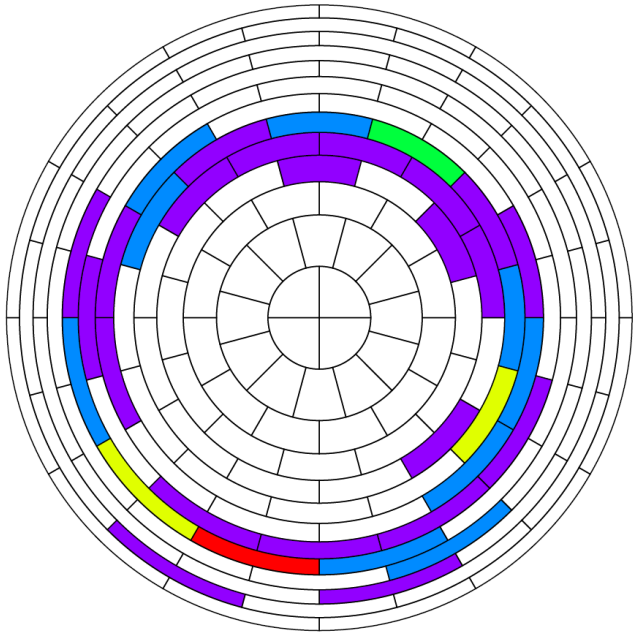
IV. Background: Radon-induced

Main spectrometer: background contributions

- Measurements at increased pressure
- Disentanglement of coincident (radon) and random (muon) events

  → approximately equal contributions to background rate

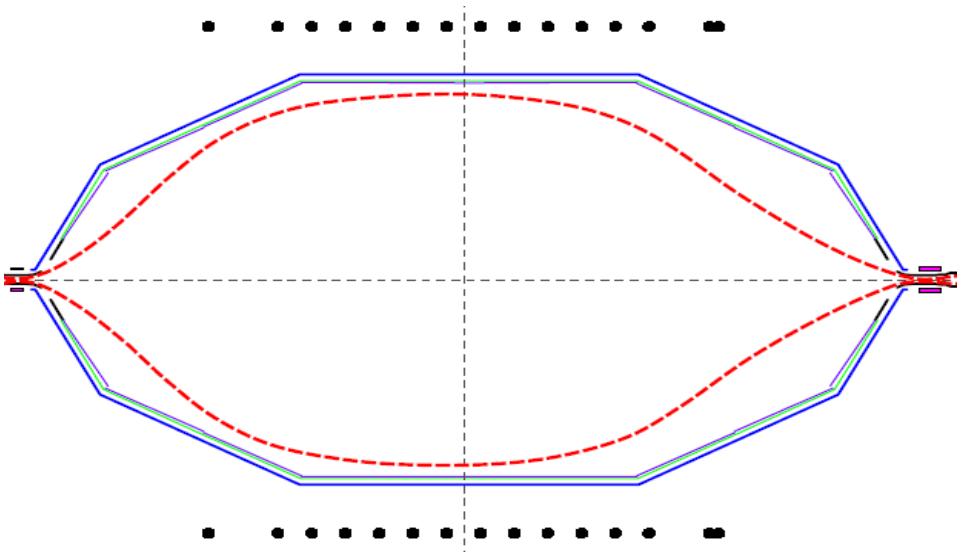


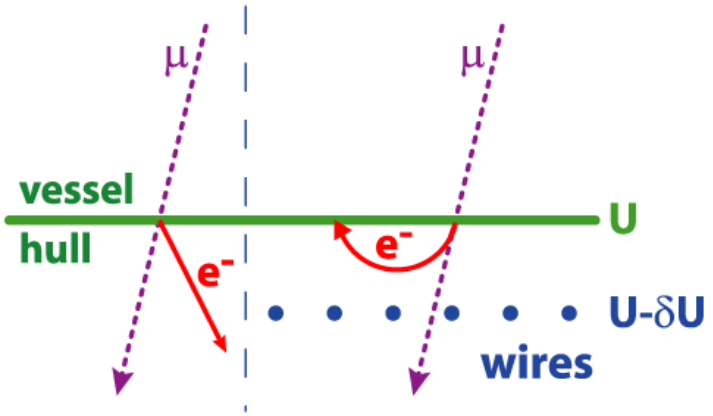


V. Background: Muon-induced

Muon induced background

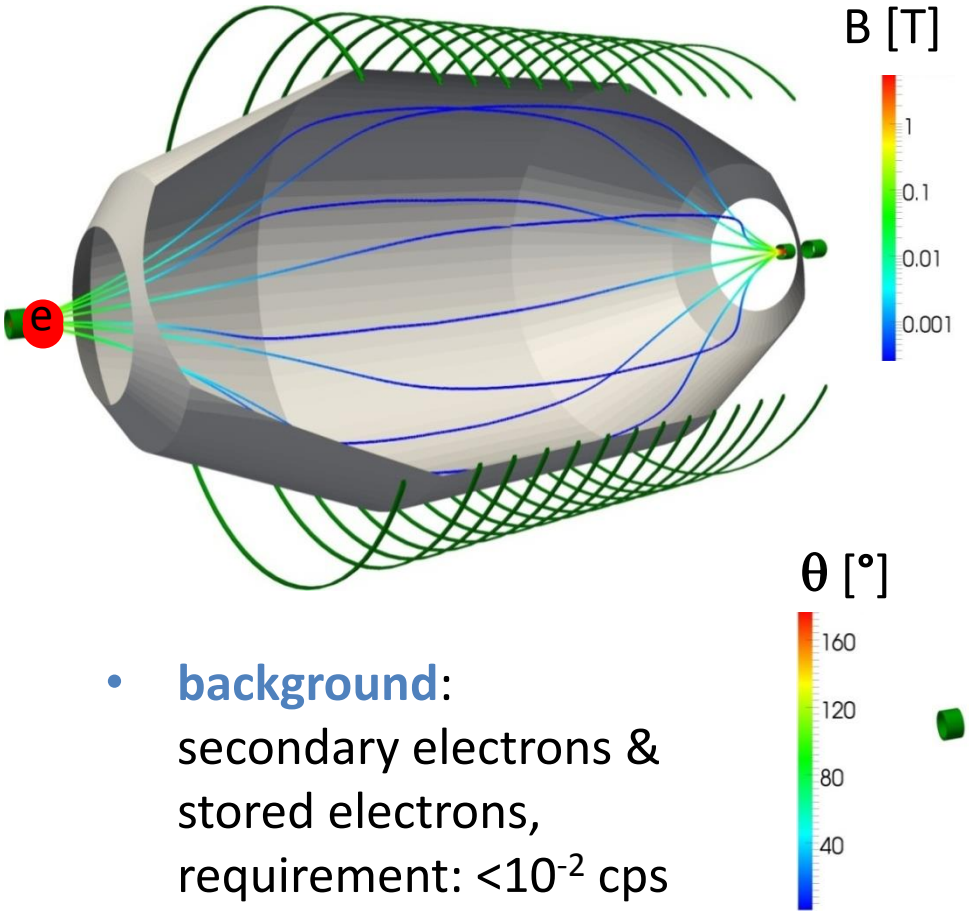
- Background rate: ~0.6 cps → magnetic shielding factor: ~10^5
- Required background: <0.01 cps → additional electric shielding
  (was not tested in this measurement period)





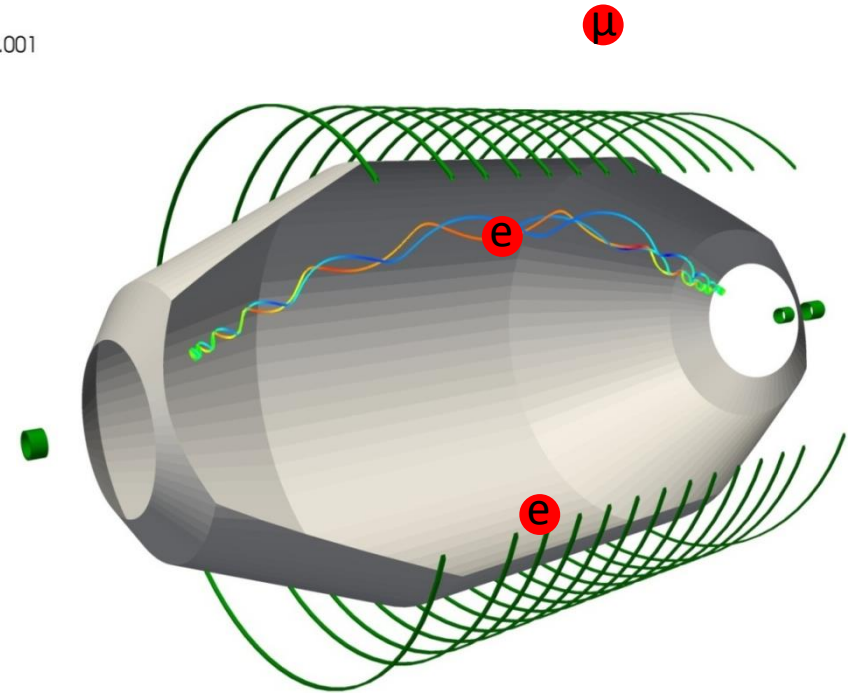
I. The KATRIN experiment

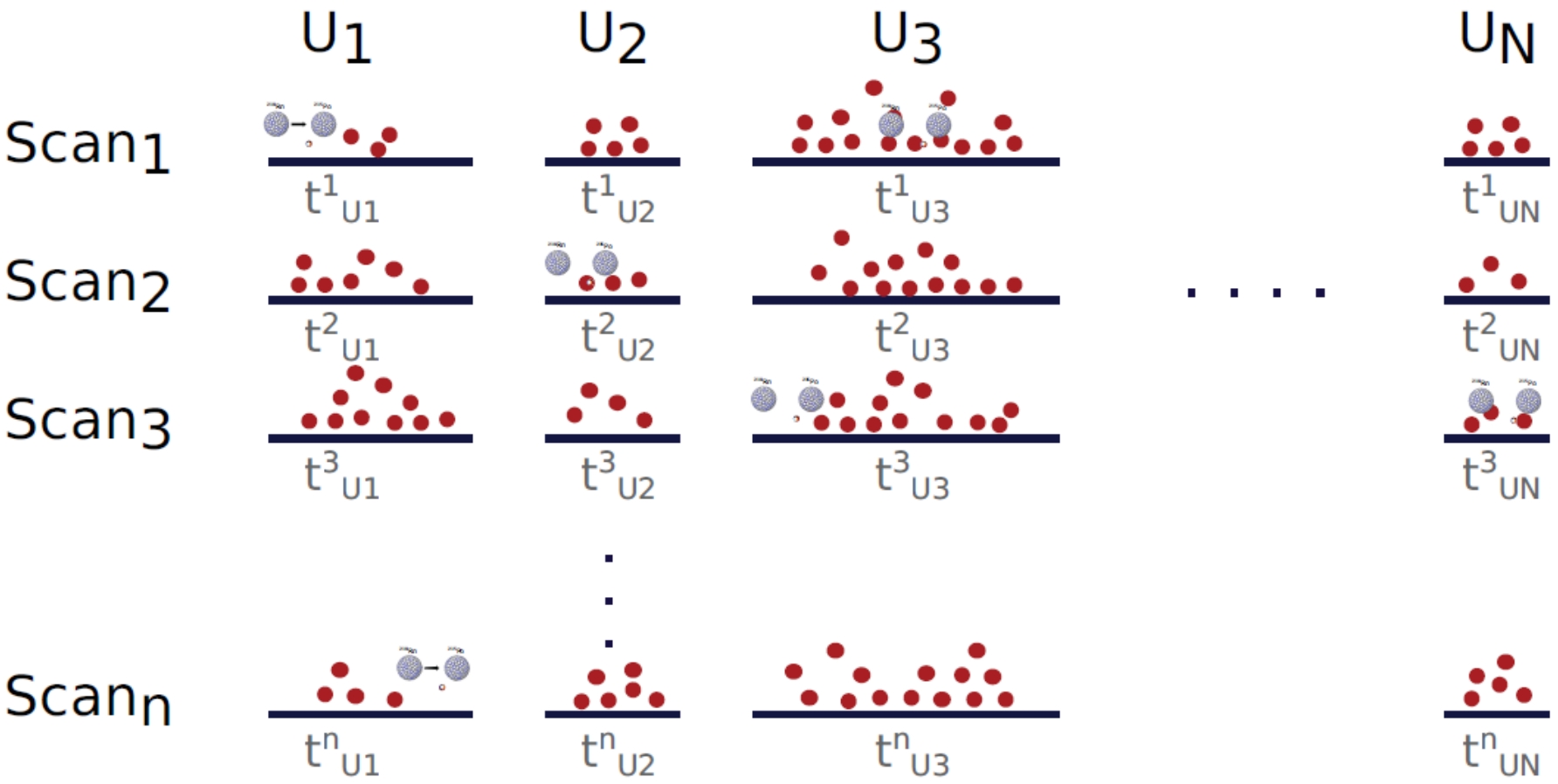
Spectrometer-Detector-Section commissioning in 2013



- **transmission of ß-electrons**
  magnetic guiding &
  electrostatic retardation

- **background**:
  secondary electrons &
  stored electrons,
  requirement: $<10^{-2}$ cps

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