Active removal of stored electrons in the KATRIN main spectrometer

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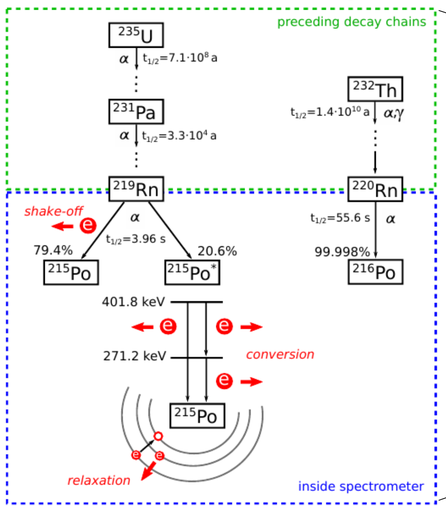
bmb+f - Förderschwerpunkt Astroteilchenphysik
Großgeräte der physikalischen Grundlagenforschung

Supported by BMBF under grant no. 05A11VK3 / 05A11PM2

Background in the Main Spectrometer

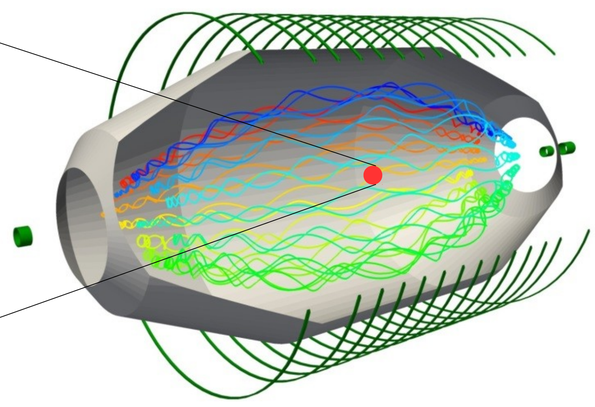
Where do background signals come from?

α-decay processes from ^{219}Rn & ^{220}Rn lead to production of high-energetic primary electrons which in turn produce low-energetic secondaries.



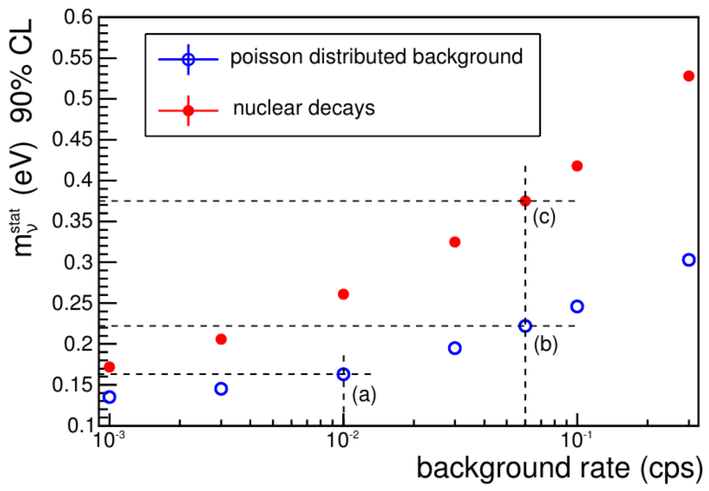
Why are stored electrons problematic?

The electromagnetic field setup can result in electrons becoming stored over long timescales, leading to a large amount of secondary electrons.

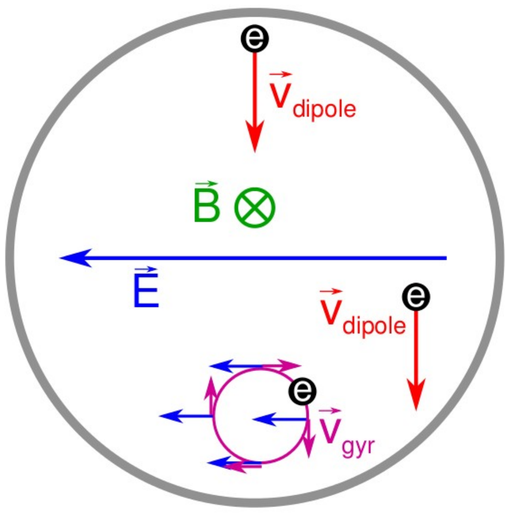


How does non-Poissonian background affect the neutrino mass sensitivity?

Background from Rn decays has a larger impact on sensitivity than Poissonian background.



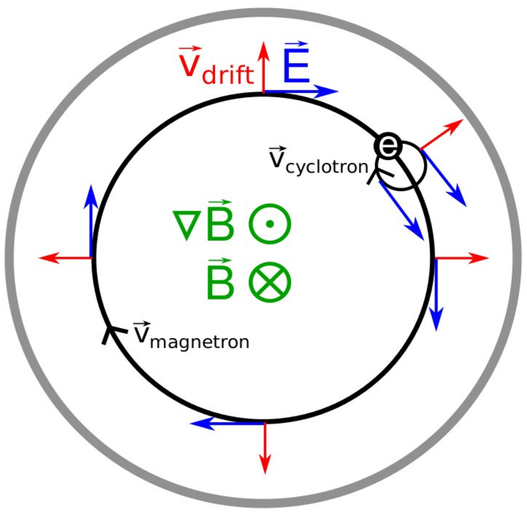
Background removal by forced extraction of stored electrons

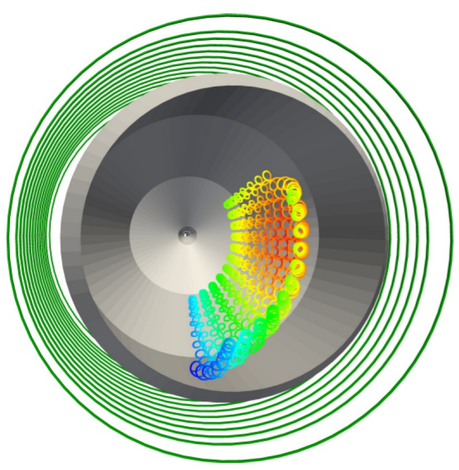


Goal: Break storage condition for primary and secondary electrons from Rn α-decay.

Principle: Modification of electromagnetic fields within the main spectrometer with electric dipole and magnetic pulse in a time scale of seconds.

Result: Background electrons drift against the vessel wall and are removed from the sensitive volume.



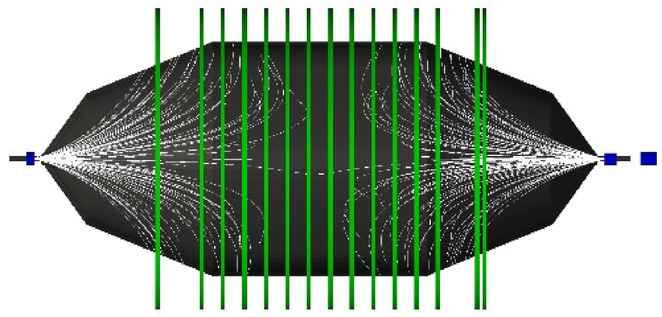


Electric Dipole:

- Inner electrode system of KATRIN consists of two half shells.
- Ability to apply potential difference of ΔU = 1 kV.
- Together with the magnetic guiding field, stored electrons can be ejected via E×B drift.
- Method efficient for low-energetic stored electrons up to E_{kin} = 500 eV.

Magnetic Pulse:

- Inverting the magnetic field via reversal of the current in the existing air coils for a short time.
- The effect is further enhanced by an induced radial E×B and an increase of the cyclotron radius.
- The magnetic pulse affects electrons of a large energy range from few eV to several hundred keV.



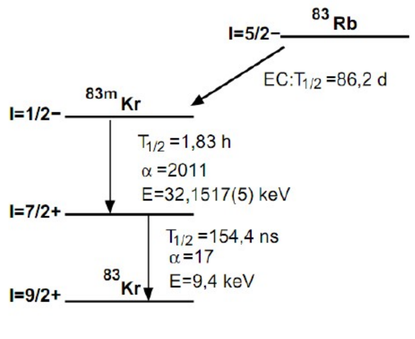
Electric Dipole

Magnetic Pulse

Commissioning Measurements 2013

First functionality tests of electric dipole and magnetic pulse

- Increase background from stored electrons by installation of a ^{83m}Kr emanator.
- Investigation of the removal efficiency.



- **Magnetic Pulse:** In a non-standard field configuration, reverting the current of 3 aircoils near the analyzing plane reduced the electron rate by a factor of 20.
- **Electric Dipole:** Removal of low-energy electrons with a reduction factor of up to 10 in a standard configuration.
- In context of the upcoming 2nd measurement phase, the combination of the two methods will also be tested extensively.