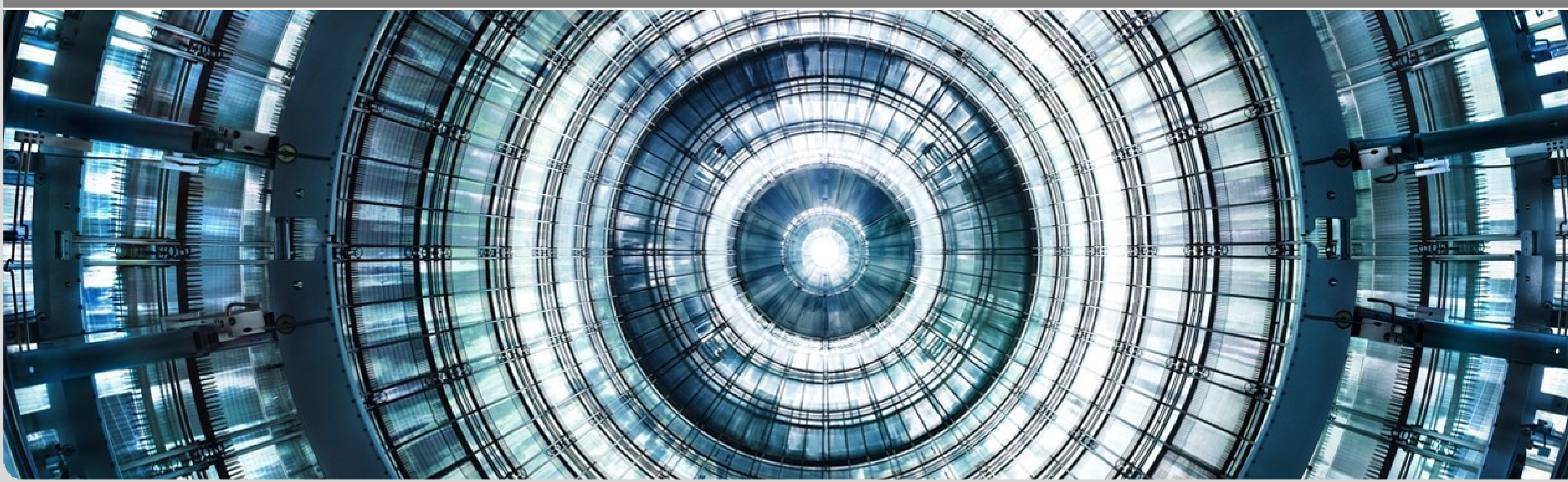
Status of the KATRIN experiment

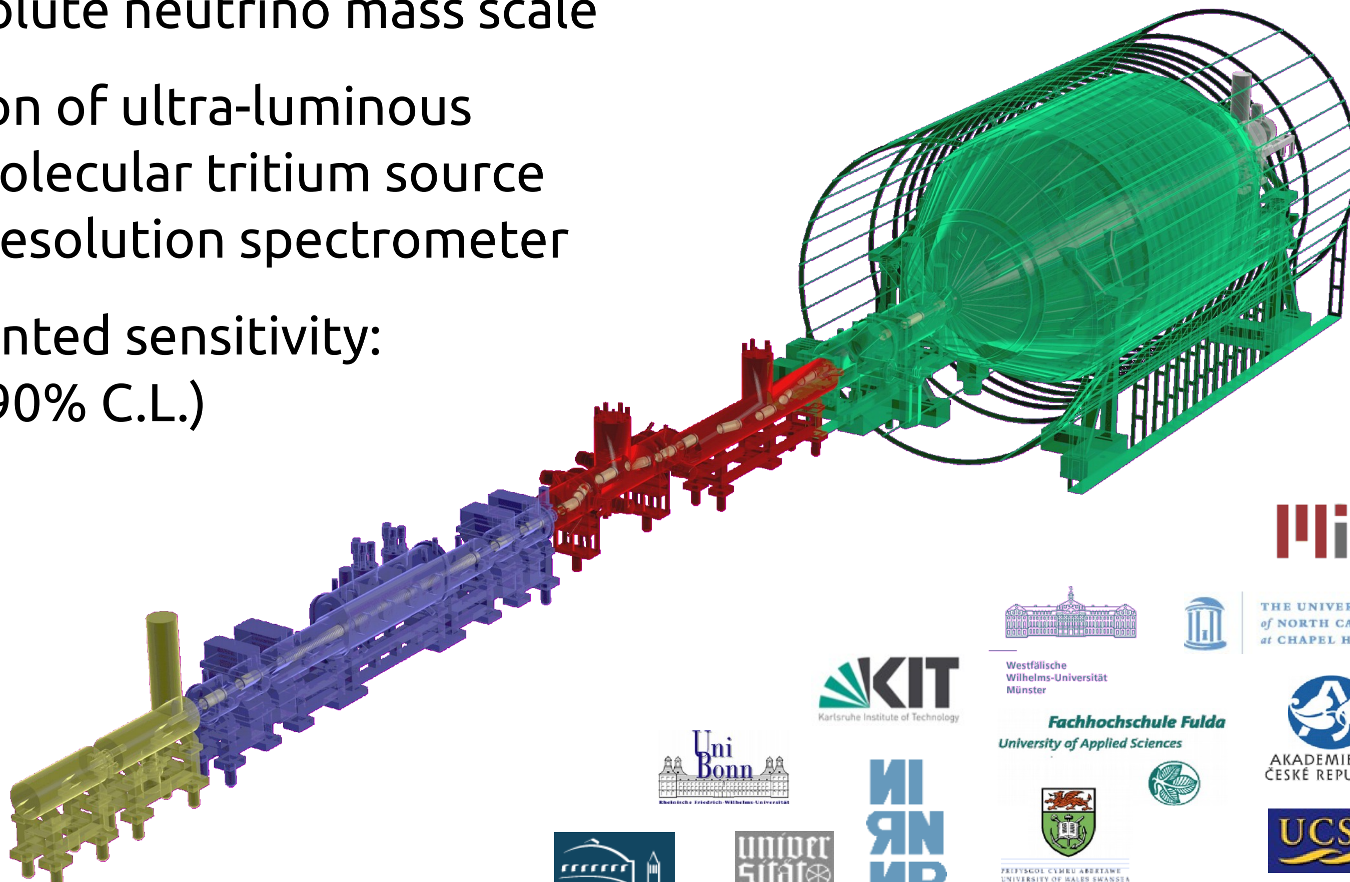
EPSHEP 2013 Stockholm, July 20th 2013

Marco Haag (Institute of Experimental Nuclear Physics)



The Karlsruhe Tritium Neutrino Experiment

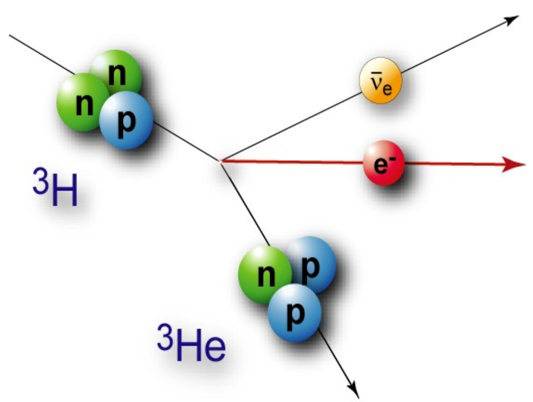
- model-independent measurement of the absolute neutrino mass scale
- combination of ultra-luminous gaseous molecular tritium source with high resolution spectrometer
- unprecedented sensitivity: 0.2 eV/c^2 (90% C.L.)

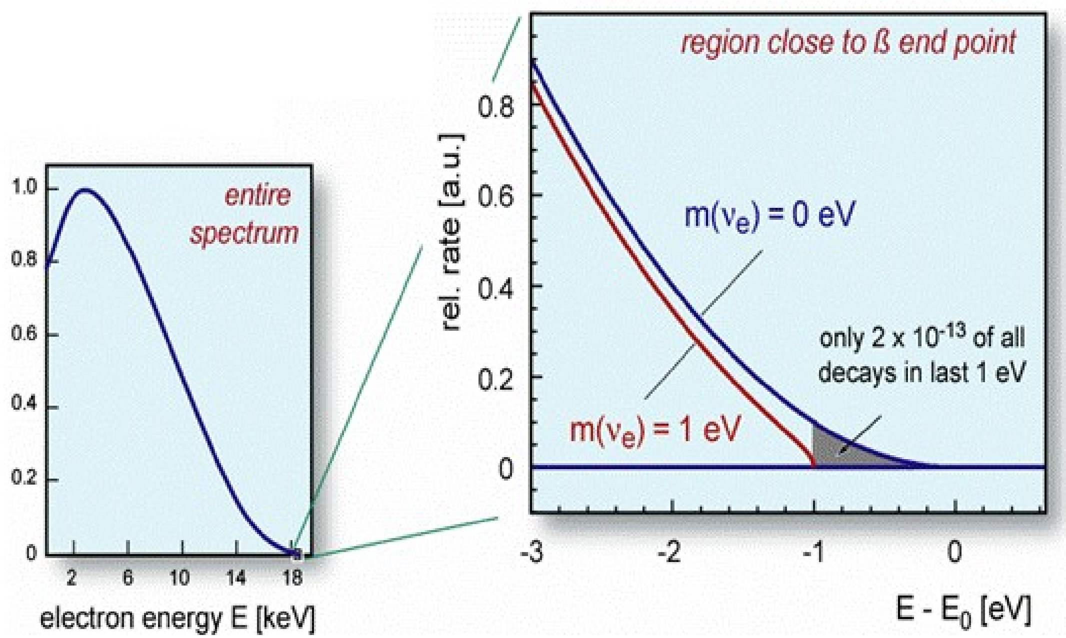


β-decay and neutrino mass

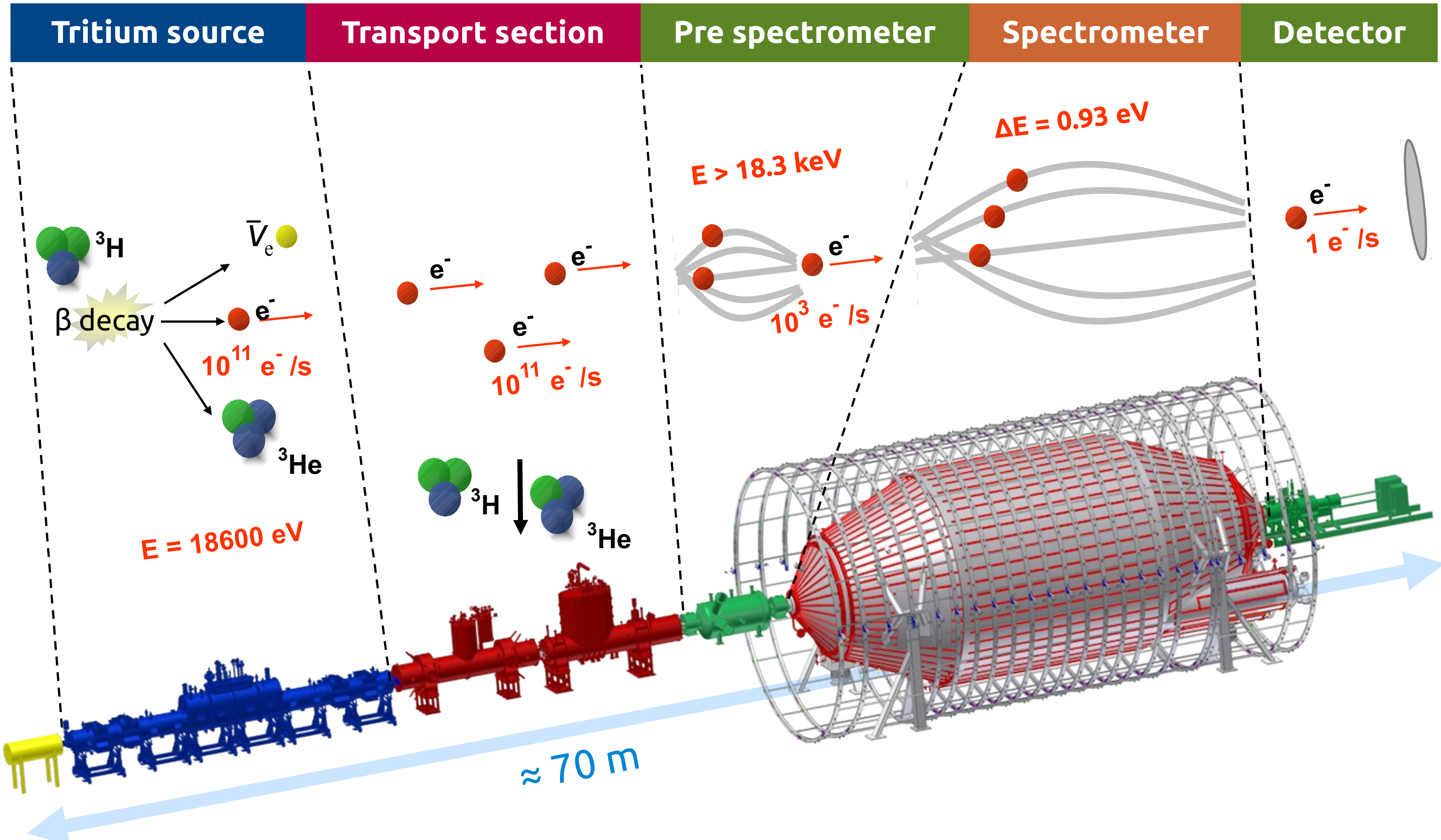
- Direct kinematic measurement of the effective neutrino mass
- Spectrum shape analyis close to the electron beta spectrum endpoint

$$m_{\nu_e}^2 = \sum_{i=1}^{3} |U_{ei}|^2 m_i^2$$

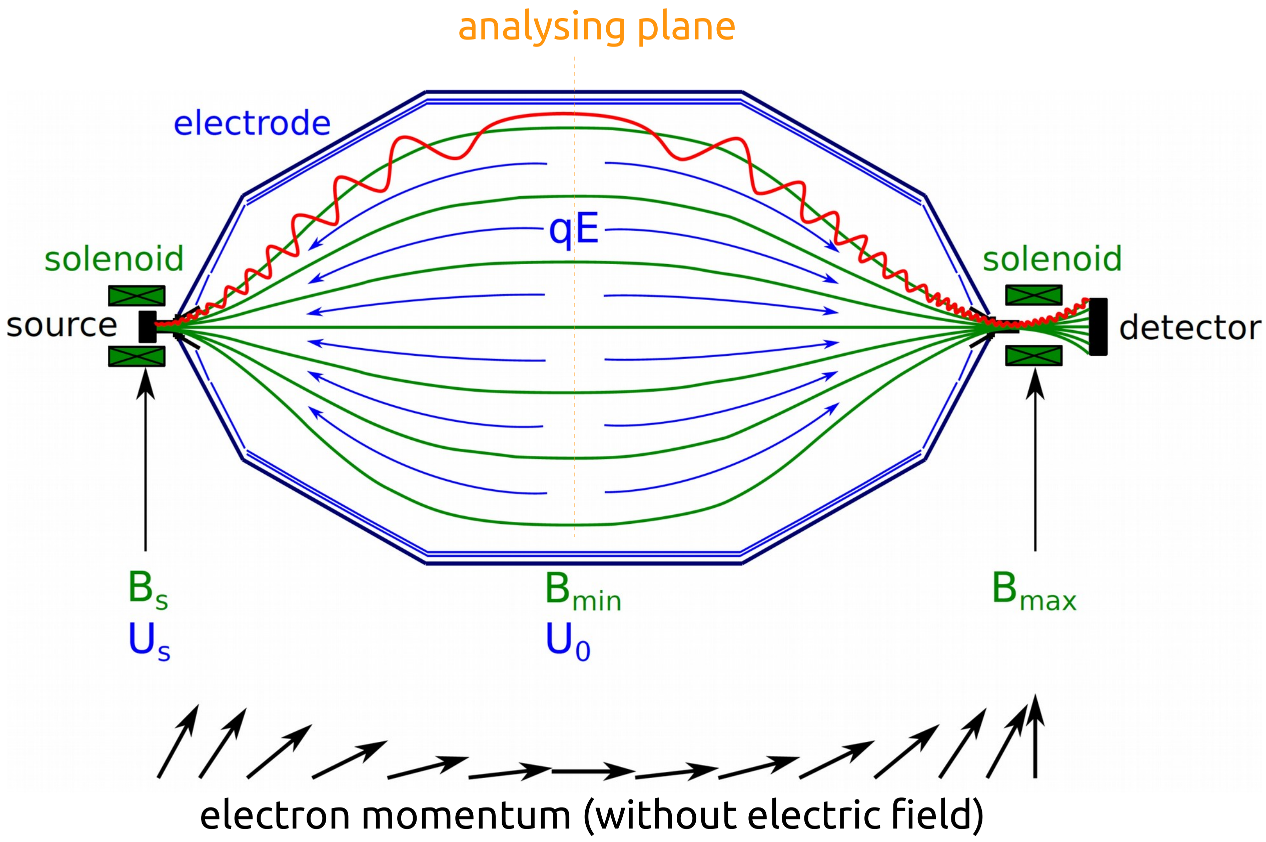




The KATRIN setup



The MAC-E Filter
(Magnetic Adiabatic Collimation with Electrostatic Filter)

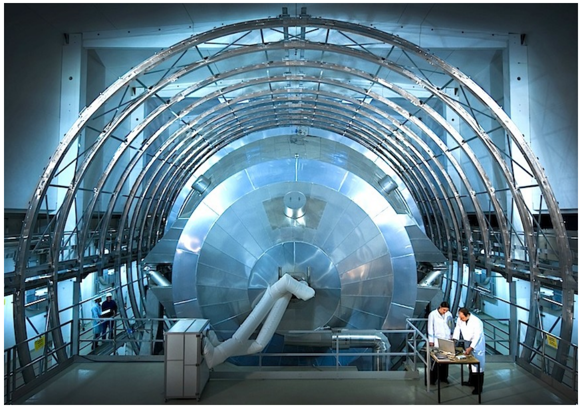


- High pass filter: electrons with $E_{e^- \parallel} > qU_0$ can pass the analysing plane

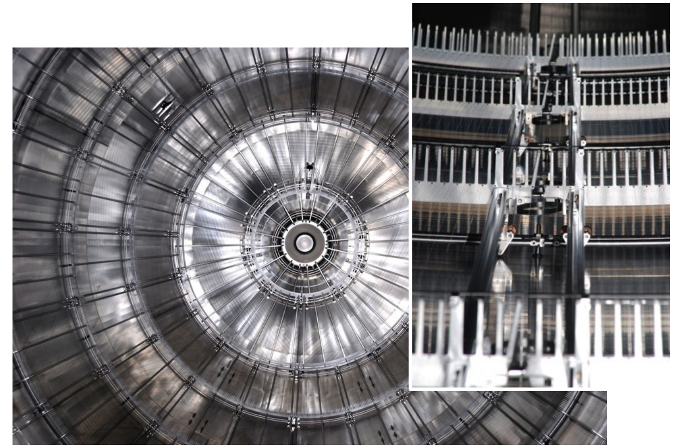
Key requirements for a successful mass determination

- Stable high luminosity beta-electron source:
  $O(10^{11})$ electrons per second, $\Delta T < 30$ mK
- Adiabatic guidance of source electrons by magnetic field
- Precise energy scan by a sharp retarding potential:
  high voltage stability on the ppm level
- Extremely low background:
  < 10 mHz
- Ultra high vacuum in a huge spectrometer:
  $O(10^{-11})$ mbar

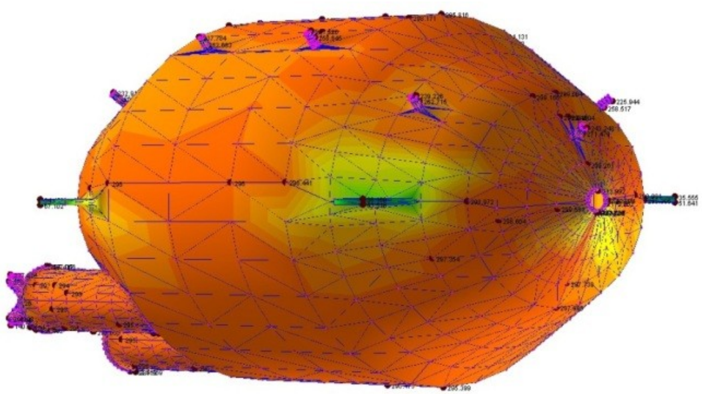
Spectrometer commissioning milestones



air coil installation (mid 2011)



wire electrode installation (mid 2012)

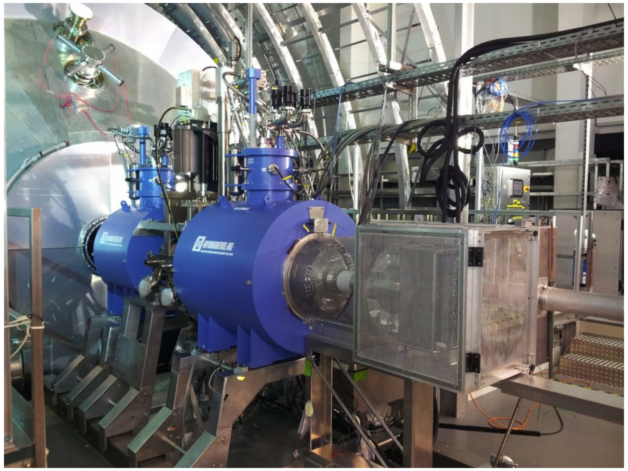


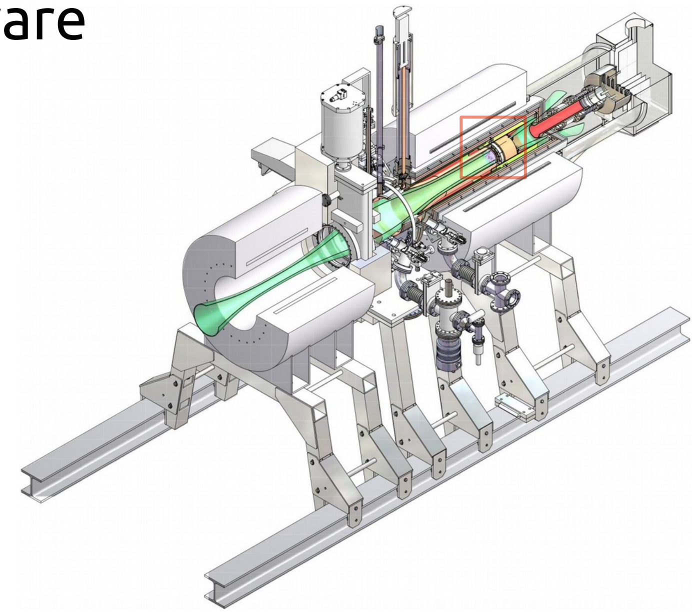
spectrometer bake-out (march 2013)

angular resolved egun (july 2013)

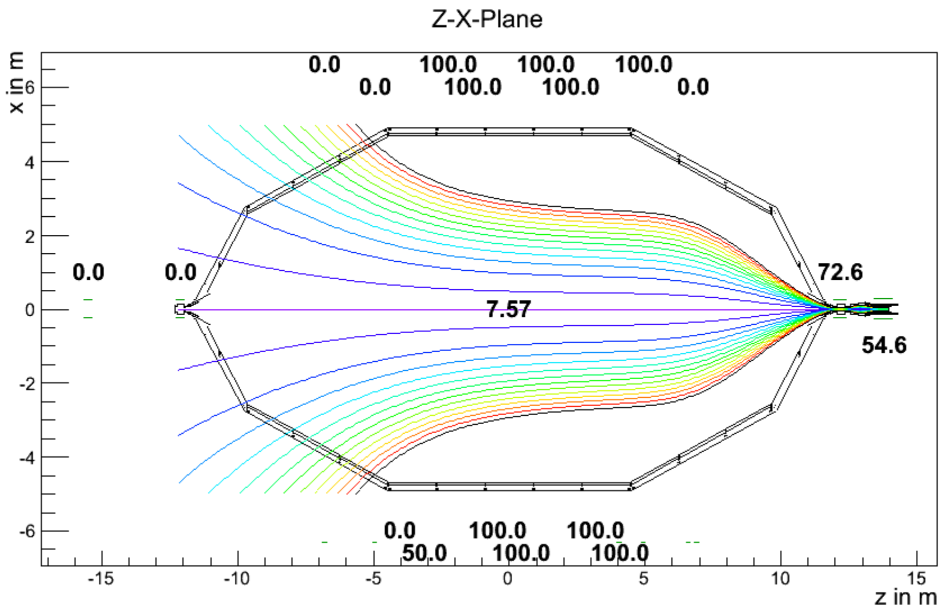
Spectrometer and Detector Commissioning Measurements

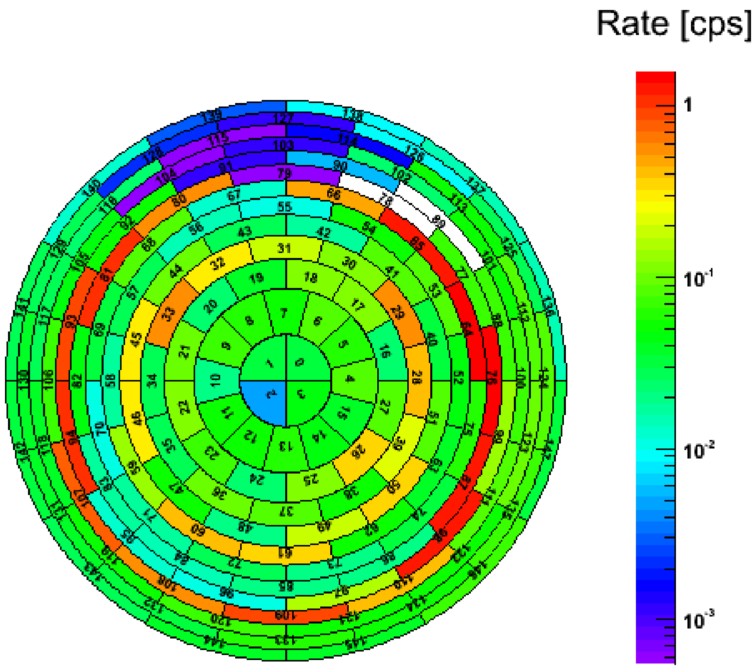
- verification of system functionality
- transmission function measurements (spectrometer resolution)
- detailed background studies
- optimization of hardware and software



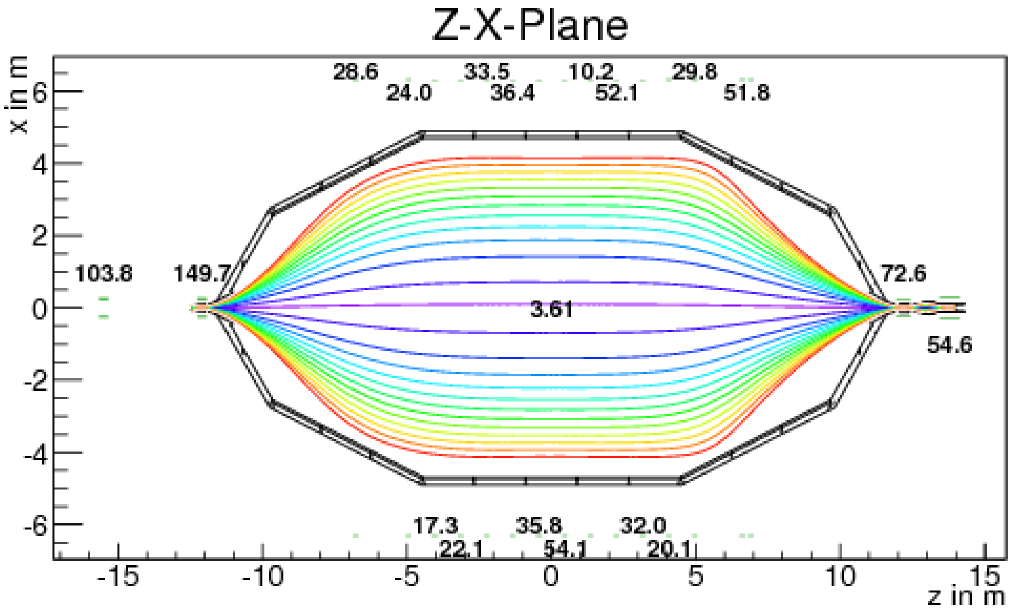


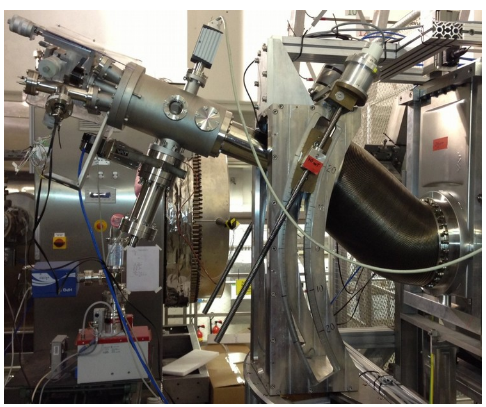
Background studies with asymmetric field configurations

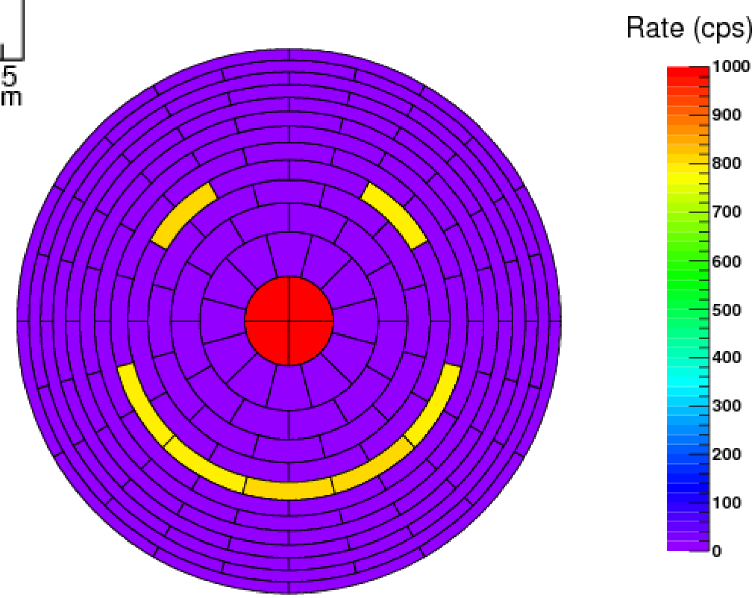




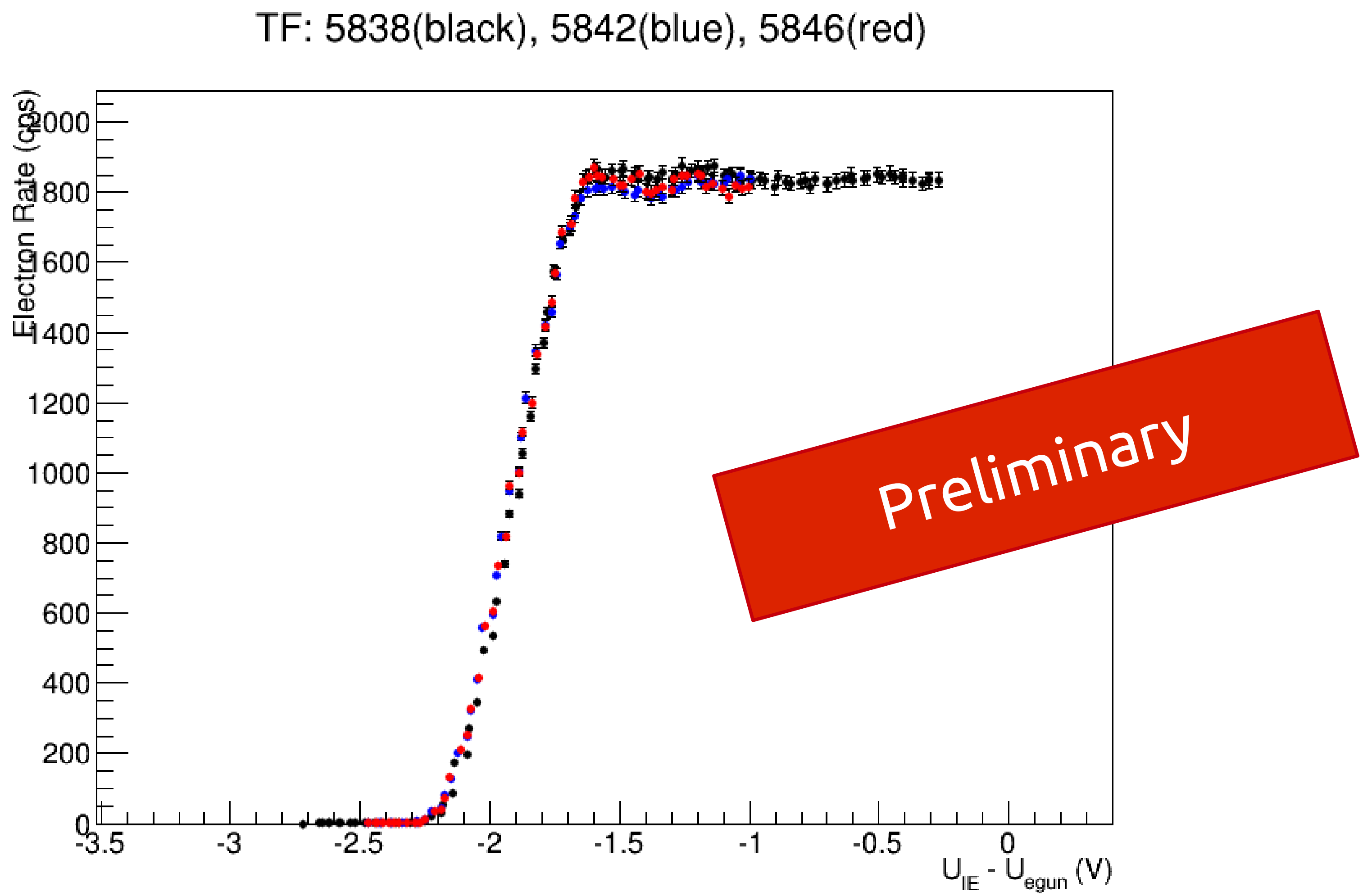
E-gun positioning and detector alignment







Transmission function measurement
(fixed electrode potential – variable egun voltage)



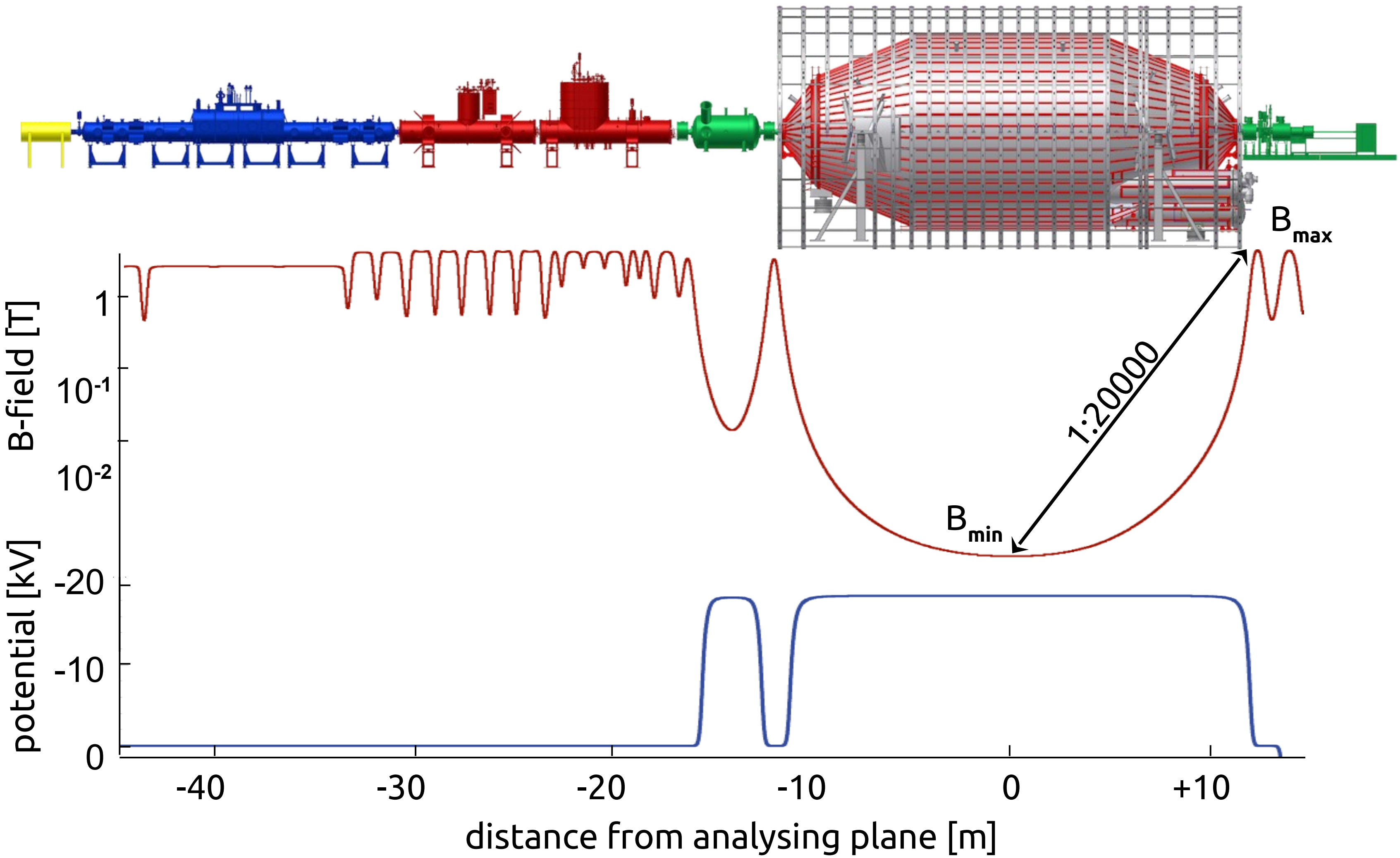
Summary and Outlook

- β decay is a model independent method to determine m_ν
- KATRIN is designed to reach a sensitivity of 0.2 eV/c^2 (90% CL) on m_ν
- **KATRIN is running commissioning measurements**
- Transport section (DPS, CPS) under construction, to be delivered spring 2014
- Tritium source (WGTS) under construction, to be delivered early 2015

Thank you for your attention.

KATRIN collaboration, March 2013

magnetic field & electrostatic potential



Differential Spectrum

$$\frac{dN}{dE} = C \cdot F(Z,E) \cdot p \cdot (E + m_e c^2) \cdot f_{rad}(E) \cdot \sum_f \left[P_f \cdot (E_0 - E_f - E) \cdot \sqrt{(E_0 - E_f - E)^2 - m_\nu^2 c^4} \cdot \Theta(E_0 - E_f - E - m_\nu c^2) \right]$$

Response Function

$$R\,(E, qU) = \int_0^E T\,(E - \epsilon, qU) \cdot (P_0 \delta(\epsilon) + P_1 f(\epsilon) + P_2 (f \otimes f)(\epsilon) + \cdots)\, d\epsilon$$

Rate at a fixed retarding potential

$$N_{qU} \propto t_{qU} \int_0^{E_0} \frac{dN}{dE}(E_0, m_\nu^2)\, R(E, qU)\, dE$$

Simulation & Data Analysis

- Automated centralized data processing
- Analysis and Simulation modules within one coherent C++ package
- Data access through C++ remote procedure calls