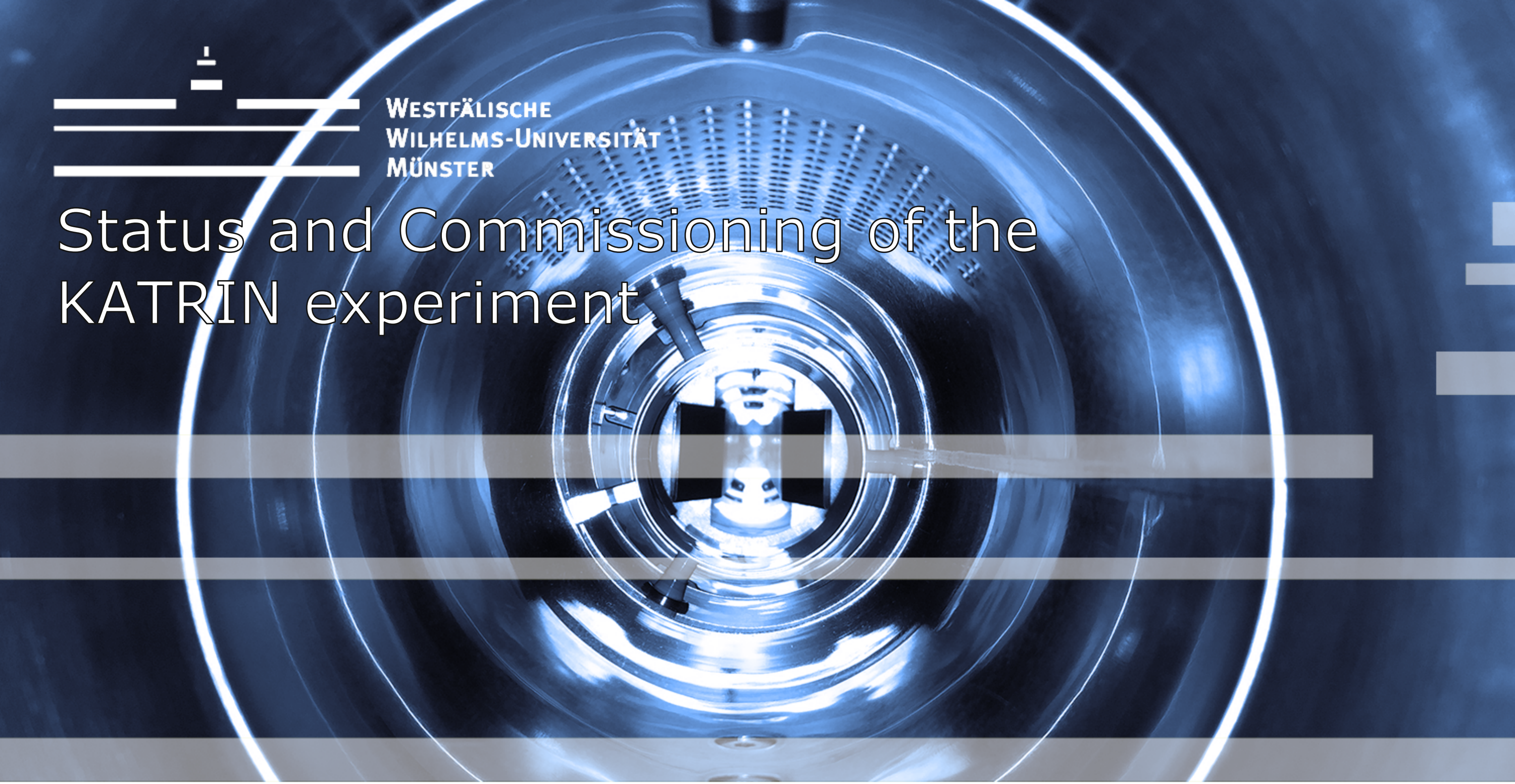


Westfälische
Wilhelms-Universität
Münster

Status and Commissioning of the KATRIN experiment

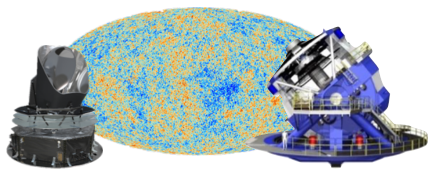
living.knowledge
WWU Münster

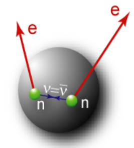
Philipp Ranitzsch, WWU Münster

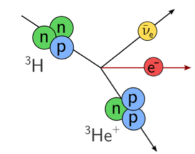
KATRIN
Karlsruhe Tritium Neutrino Experiment

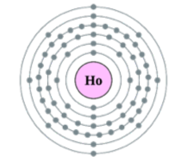
WESTFÄLISCHE WILHELMS-UNIVERSITÄT MÜNSTER

Absolute Neutrino Mass scale









	Cosmology	Search for 0νββ	weak decays (β + EC)
Observable	$M_\nu = \sum_i m_i$	$m_{\beta\beta}^2 = \left\lvert \sum_i U_{ei}^2 m_i \right\rvert^2$	$m_\beta^2 = \sum_i \lvert U_{ei}\rvert^2 m_i^2$
Present upper limit	0.17 – 0.72 eV	0.15 – 0.33 eV	2 eV
Potential	15 – 50 meV	15 – 50 meV	40 meV
Model dependence	Multi-parameter cosmological model	• Majorana ν: LNV • BSM contributions other than m(ν)? • nucl. matrix elements	Direct, only kinematics; no cancellations in incoherent sum

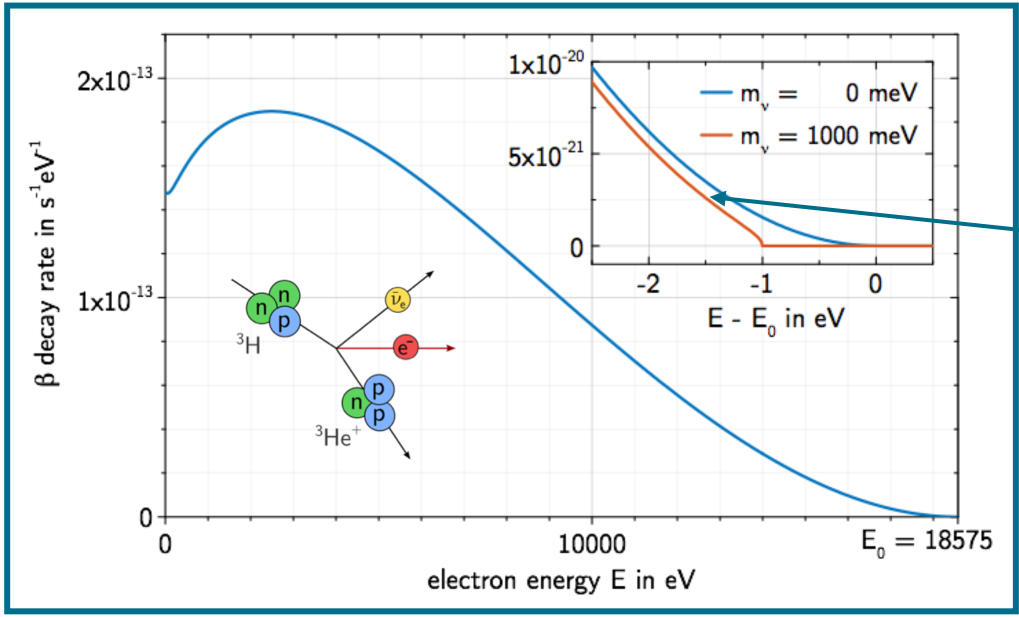
P.A.R. Ade et al., A&A **594** (2016) A13

M. Agostini et al., Nature **544** (2017) 47-52

C. Kraus et al., EPJ-C **40** (2005) 447-468
V.N. Aseev et al., PRD **84** (2011) 112003
A.A. Esfahani et al., JP-G **44** (2017) 054004

Tritium β-decay and neutrino mass

$$\frac{\mathrm{d}\Gamma}{\mathrm{d}E} = C\, F(Z,E) p(E+m_e)(E_0 - E) \sum_i |U_{ei}|^2 \sqrt{(E_0-E)^2 - m^2(\nu_i)}$$



Key requirements:

- Low end point energy E_0
- Excellent energy resolution
- High activity source

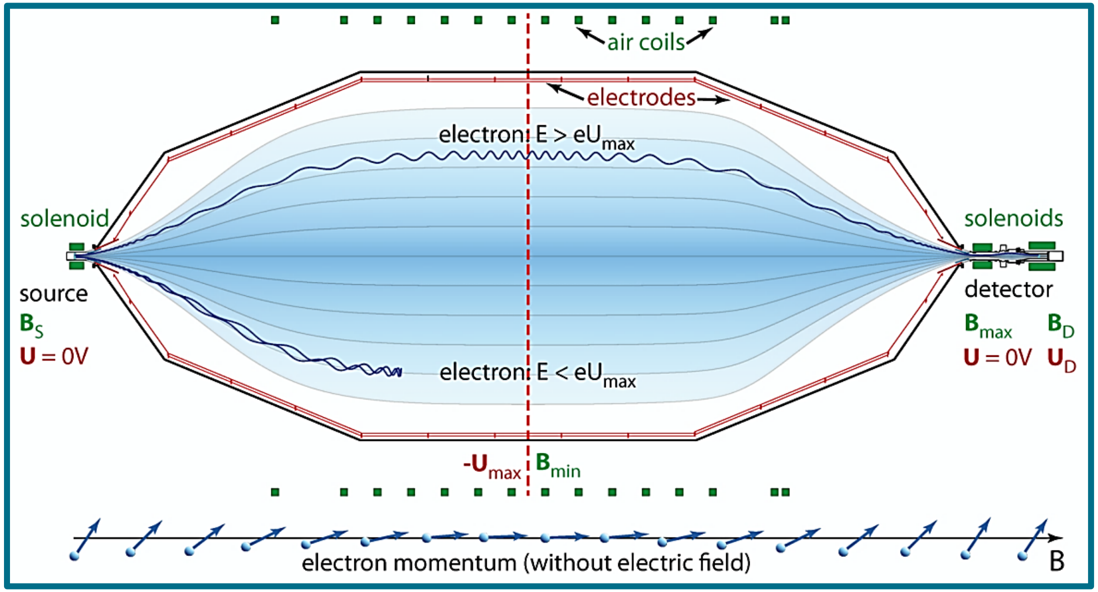
Most information in spectral distortion
Measures effective neutrino mass:
$m^2(\nu_e) := \sum_i |U_{ei}|^2 m^2(\nu_i)$

Key Tritium properties:

- $E_0 = 18575$ eV
- $T_{1/2} = 12.3$ y
- Superallowed transition ($J^\pi = 0^+ \rightarrow 0^+$)
- Readily available in required amounts

High resolution β-spectroscopy: MAC-E-Filter

Magnetic **A**diabatic **C**ollimation and **E**lectrostatic Filter:



Magnetic guiding and collimation of e⁻

- Transform $E_\perp$ to $E_{||}$

$$\mu = \frac{E_\perp}{B} = \text{const.}$$

Electrostatic field for energy analysis

- Sharp transmission depending on:
  - Emission angle
  - Radius at B_{min}

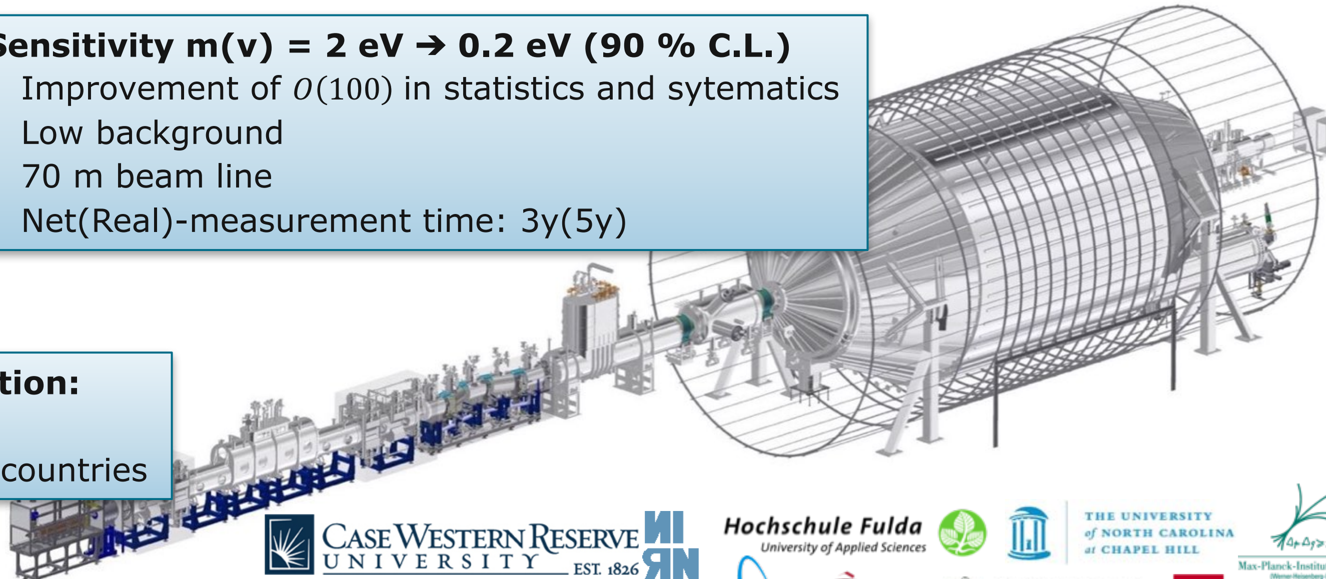
Integrated energy resolution:

$$\Delta E = qU_{\max} \frac{B_{\min}}{B_{\max}}$$

e.g. A. Picard et al., NIM-B63(1992) 345-358

The Karlsruhe Tritium Neutrino Experiment

Sensitivity m(ν) = 2 eV → 0.2 eV (90 % C.L.)
- Improvement of $\mathcal{O}(100)$ in statistics and sytematics
- Low background
- 70 m beam line
- Net(Real)-measurement time: 3y(5y)

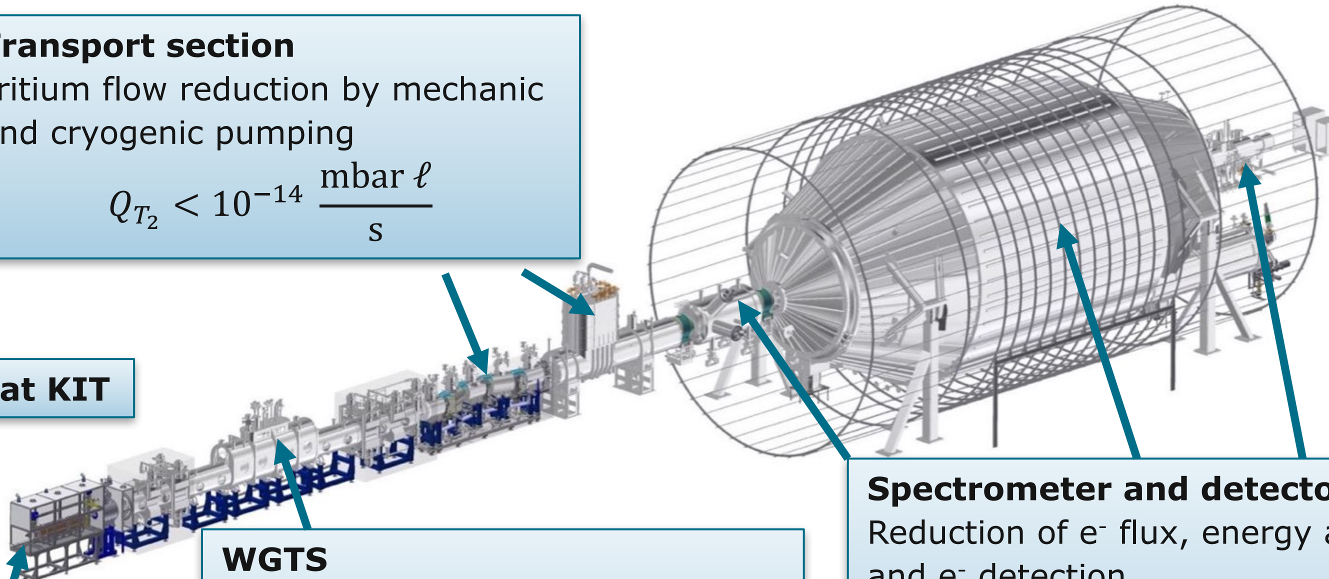


KATRIN collaboration:
- ~150 people
- 19 institutions, 6 countries

The Karlsruhe Tritium Neutrino Experiment

Transport section
Tritium flow reduction by mechanic and cryogenic pumping

$$Q_{T_2} < 10^{-14}\ \frac{\text{mbar}\ \ell}{\text{s}}$$



Everything on site at KIT

CMS
Calibration and Monitoring System

WGTS
Windowless gaseous Tritium source

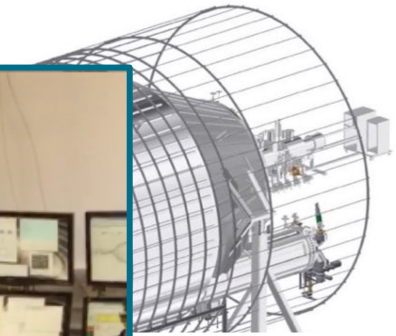
$$Q_{T_2} = 1.8\ \frac{\text{mbar}\ \ell}{\text{s}};\ A = 10^{11}\ \text{Bq}$$

Spectrometer and detector section
Reduction of e^- flux, energy analysis and e^- detection

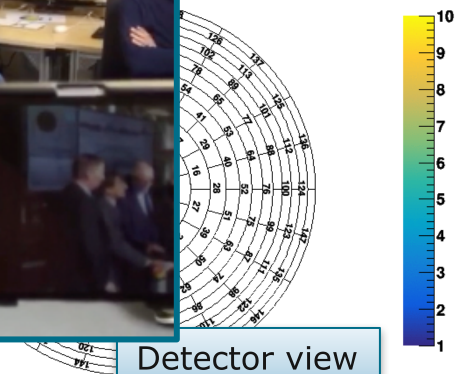
$$10^{10}\ \frac{e^-}{\text{s}} \rightarrow \mathcal{O}(1)\ \frac{e^-}{\text{s}}$$

$$\Delta E \sim 1\ \text{eV}$$

KATRIN FirstLight Oct. 14th 2016



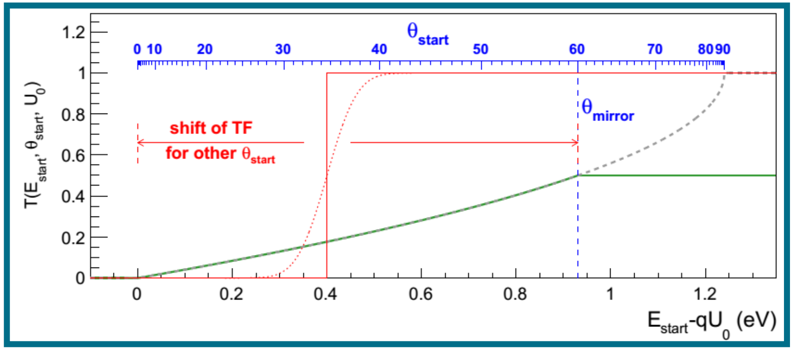
UV
Re



Detector view

FirstLight+
- 24 SC magnet
- All cryostats c
- No tritium yet
- Latest comissioning campaign

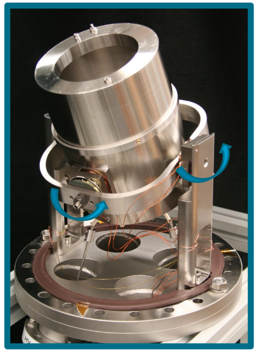
Commissioning - Electron optics



Transmission width

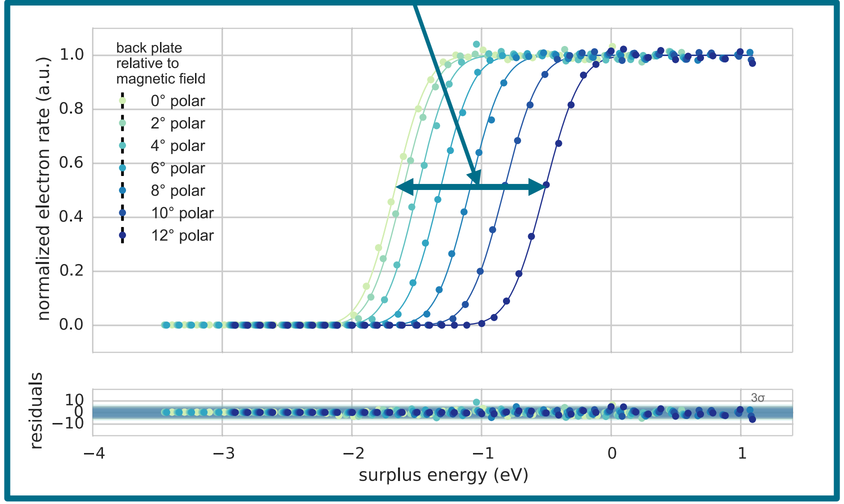
$$\Delta E = 1.17(1)\ \text{eV} \approx E\,\frac{B_{min}}{B_{max}}$$

$E = 18.6$ keV; $B_{min} = 0.38$ mT; $B_{max} = 5.0$ T



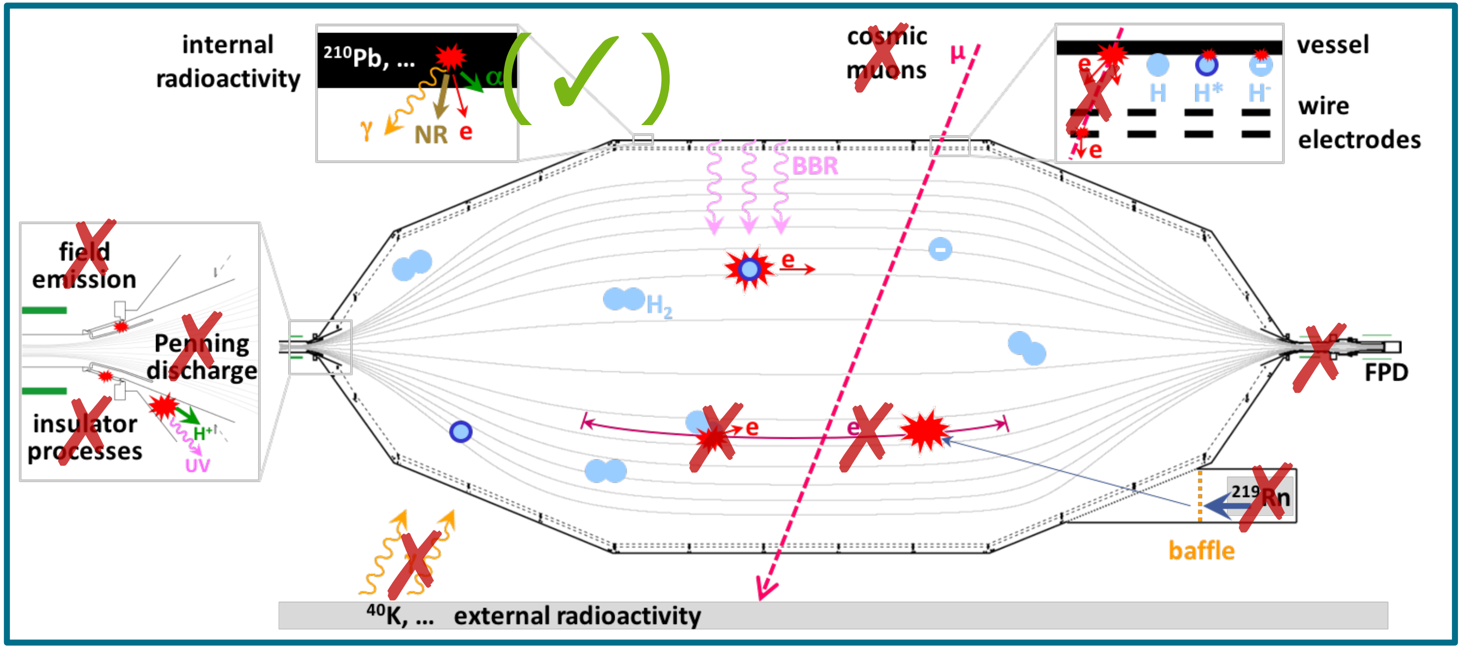
E-Gun

- Mono-energetic
- Angular selective
- Test e^- transmission properties
- Larger pitch angle
  ➔ more $E_\perp$, less $E_\parallel$
  ➔ larger total E



K Valerius *et al* (2011) *JINST* **6** P01002
M. Beck *et al* (2014) *JINST* **9** P11020
J. Behrens *et al (*2017) *EPJ-C* **77** 410

Commissioning - Background processes



Background properties

- All previously known background sources successfully supressed
- Unexpected contribution: Background about factor 50 higher than design value of 10 mcps
  - No (big) problem: Sensitivity m(ν) = 200 meV ➔ 240 meV (90 % C.L.)

Conclusion

The KATRIN experiment

- Successful spectrometer comissioning since 2013
- Main beam line inaugurated on Oct. 14th 2016
- First combined comissioning phase „FirstLight+“

Upcoming

- Measurement with radioactive ^{83m}Kr currently ongoing
- Full combined inactive comissioning in Autumn 2017
- First Tritium in 2018
- Careful systematics studies
- Search for new physics

Thank you!