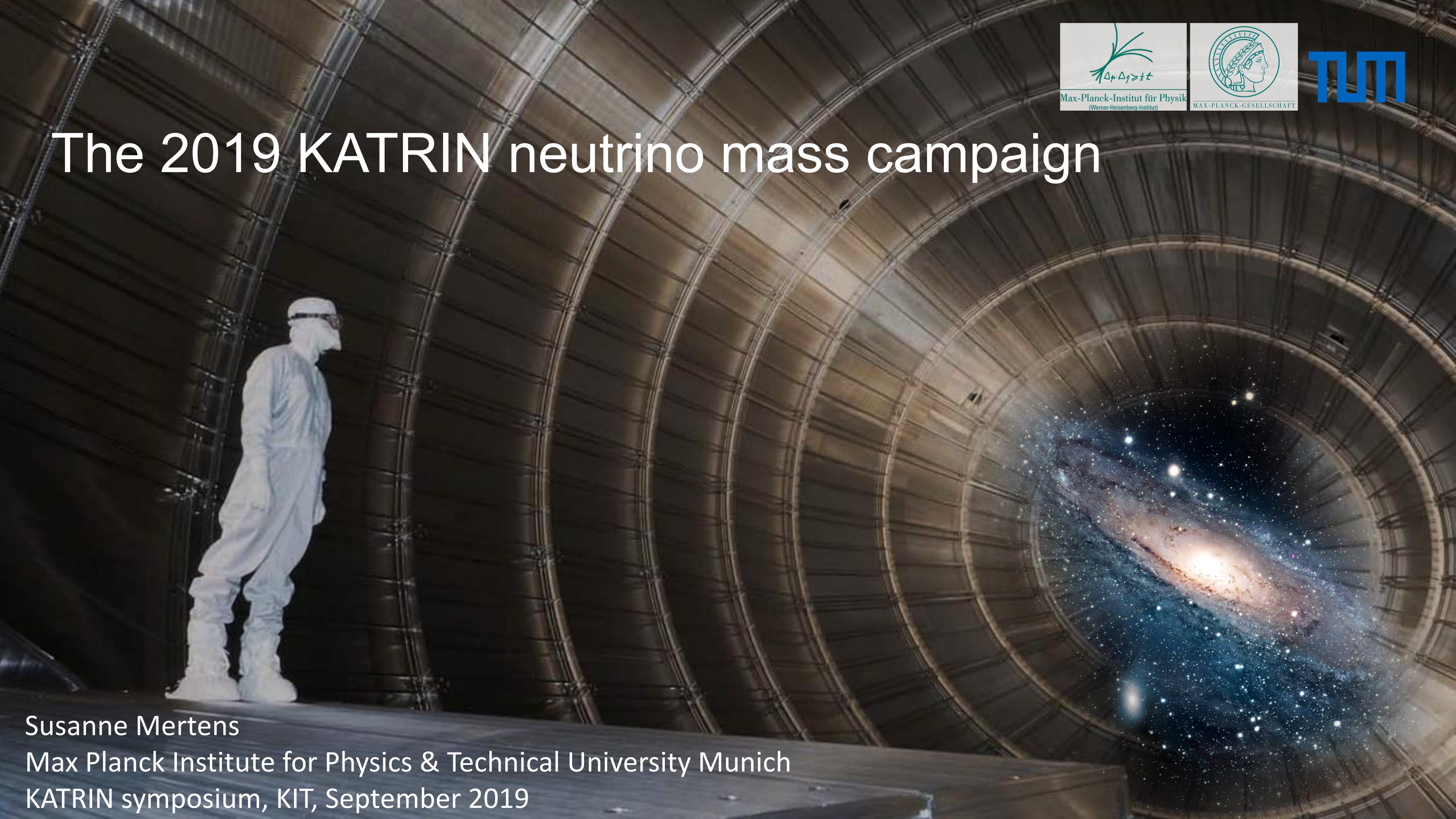


The 2019 KATRIN neutrino mass campaign

Susanne Mertens
Max Planck Institute for Physics & Technical University Munich
KATRIN symposium, KIT, September 2019

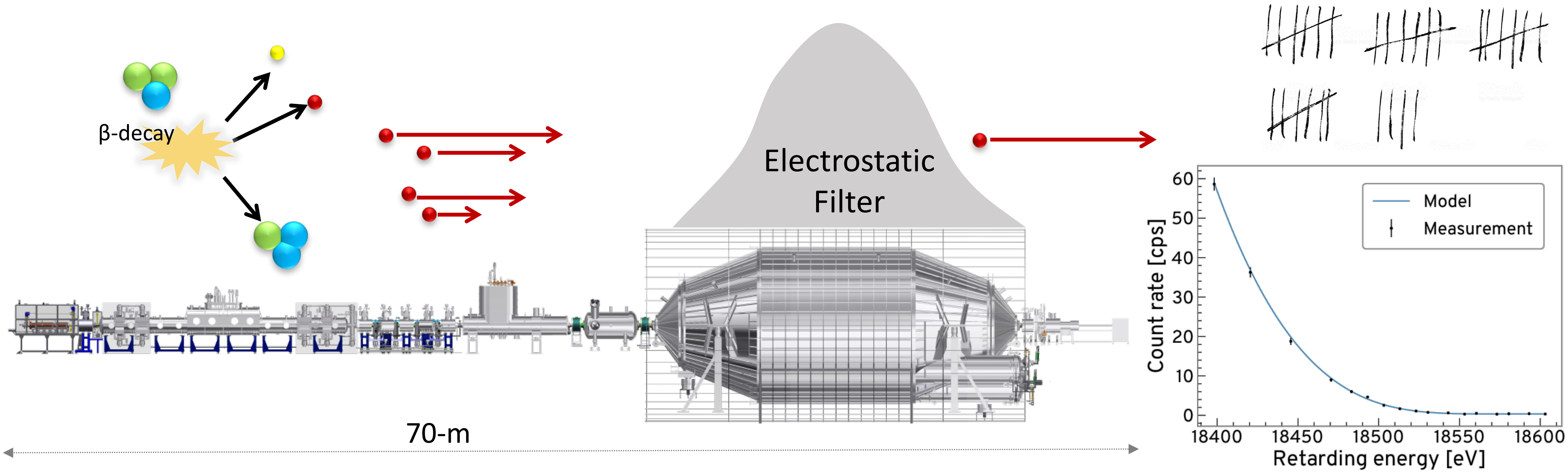
KATRIN neutrino mass campaign #1 (KNM-1)

- First ever high-activity tritium operation of KATRIN
- April 10 – May 13 2019: **780 h (~4 weeks)**
- high-quality data collected **2 million electrons**

✓ **First neutrino mass result ☺**

This talk:
What does it take to extract a high-quality data from KATRIN ?

The basic idea of KATRIN



high-luminosity tritium source

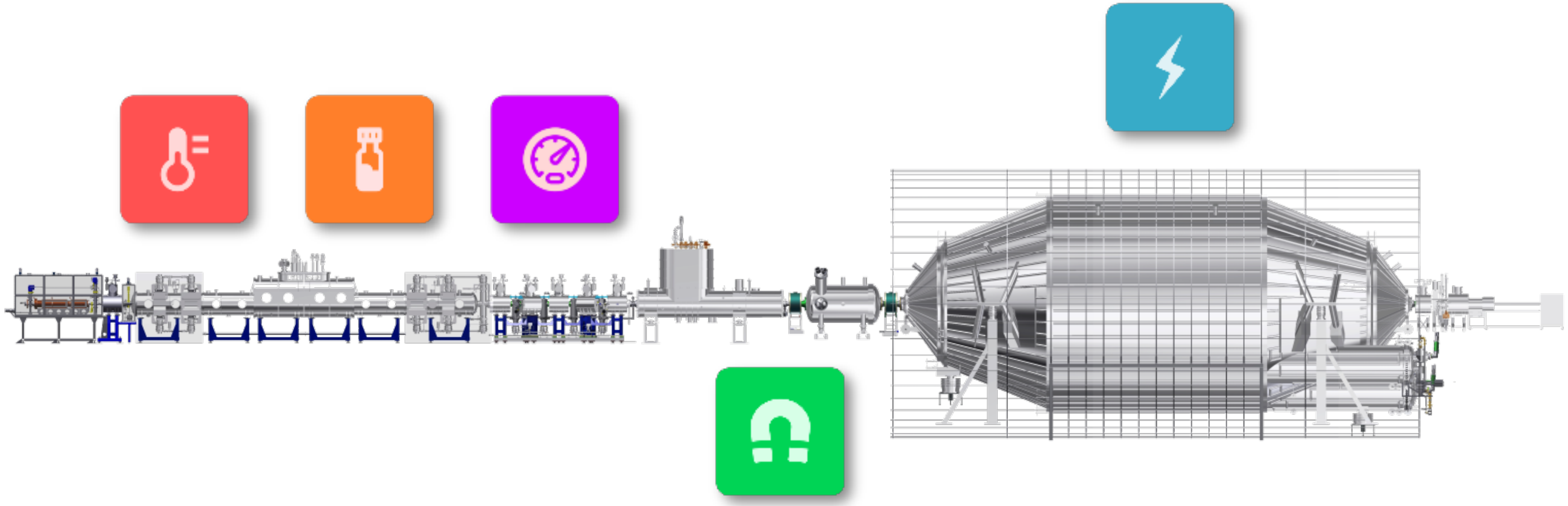
high-resolution spectrometer

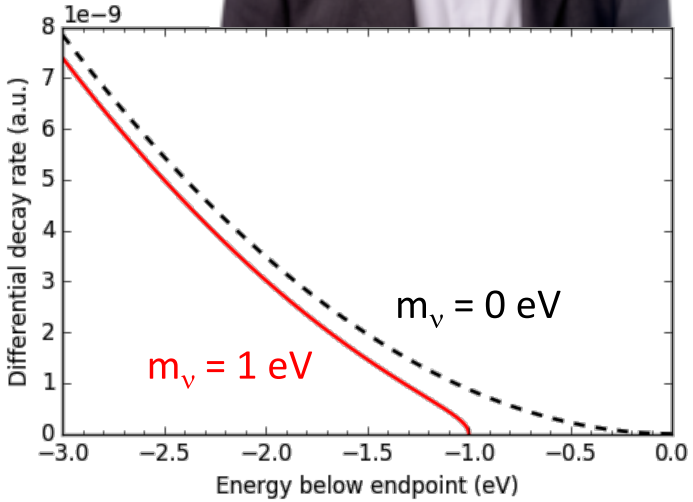
The challenge

The neutrino mass signal is a small shape distortion

✓Ultra-stable operating parameters

✓Ultra-precise understanding of the instrument





→ Monitoring and calibration are of key importance for KATRIN

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✓Ultra-stable operating parameters

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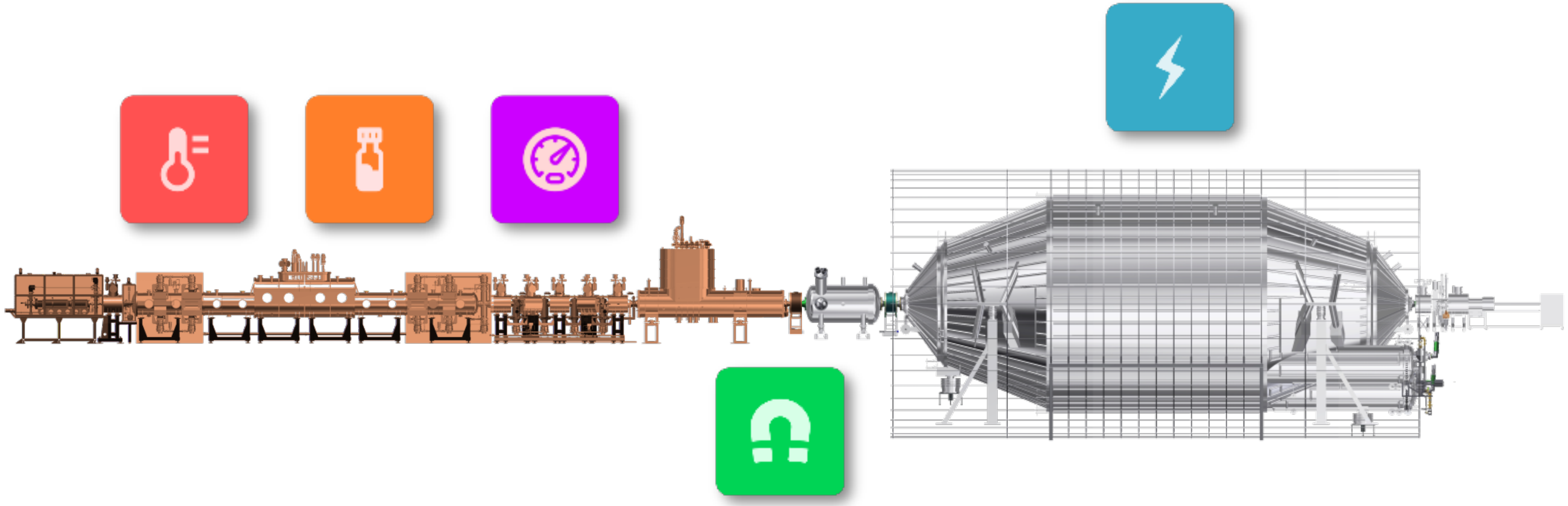
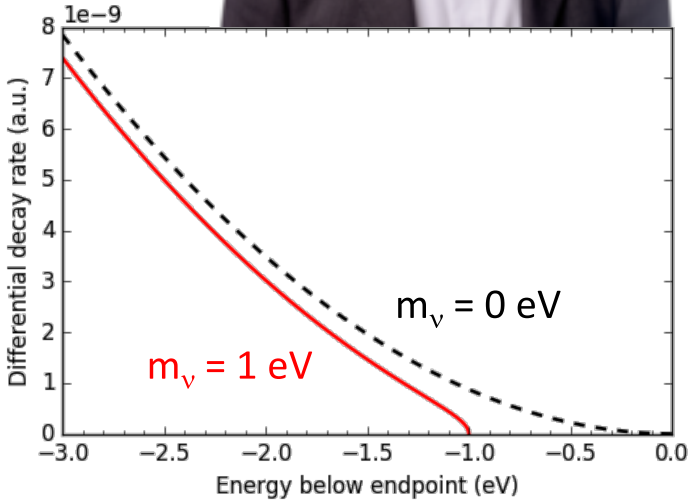


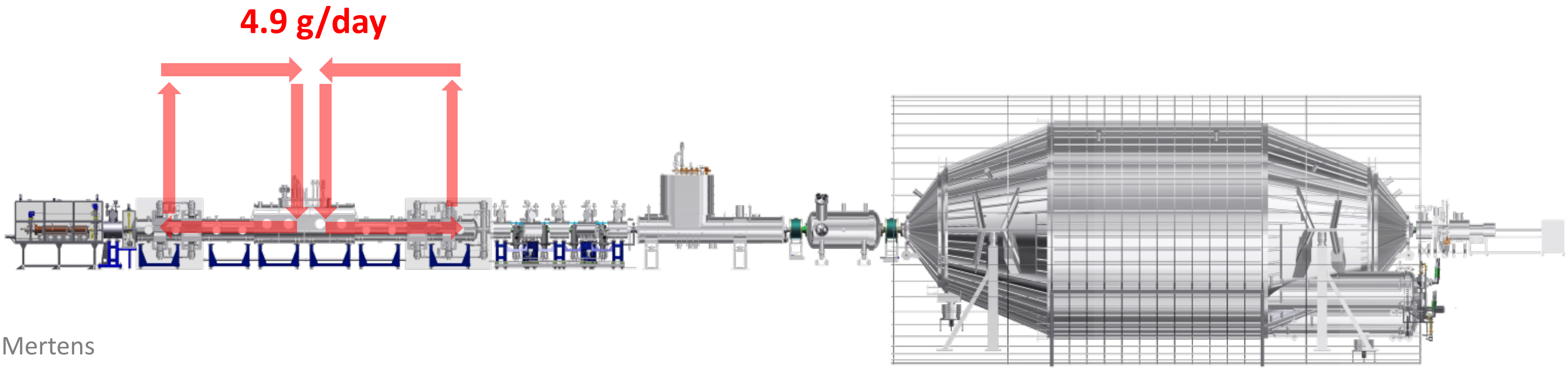


→ Monitoring and calibration are of key importance for KATRIN

Gaseous tritium source

Circulation of tritium gas in closed loops

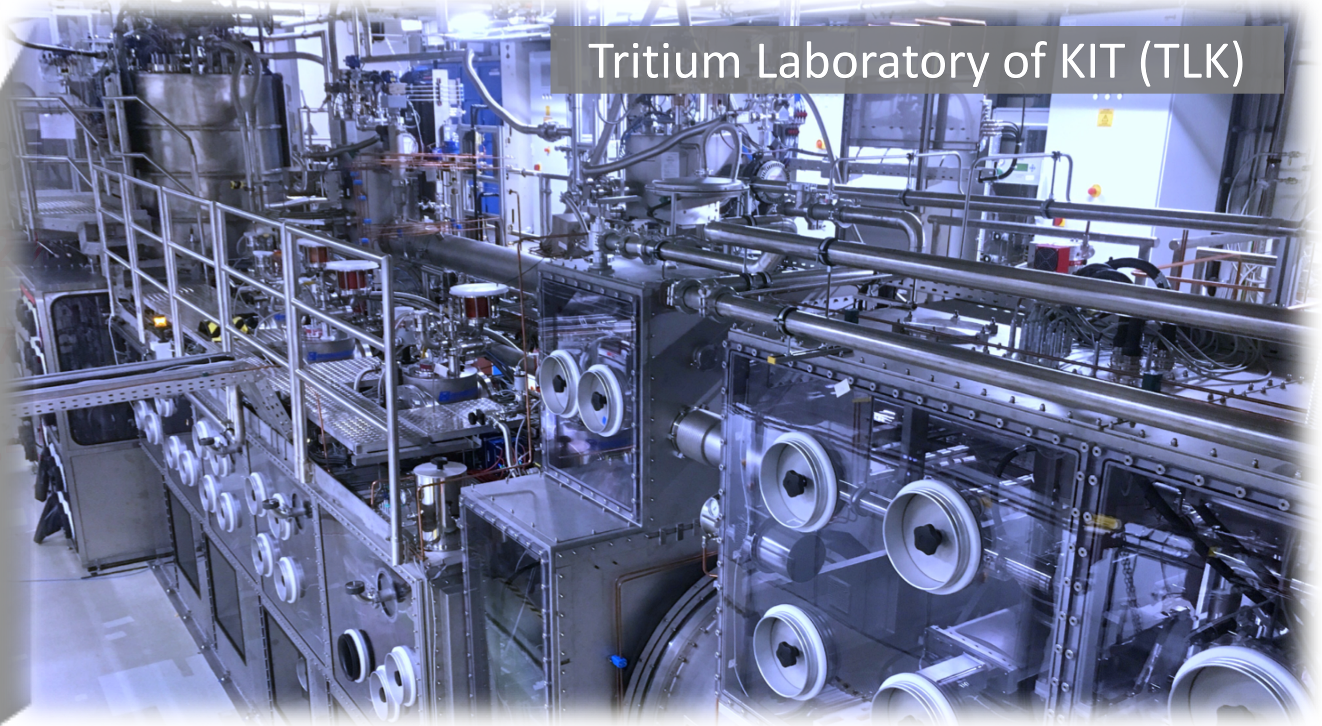
- tritium gas density: **22% of nominal (burn-in phase)**
- high isotopic tritium purity: **97.5%**
- high source activity: **$2.45 \cdot 10^{10}$ Bq (24.5 GBq)**

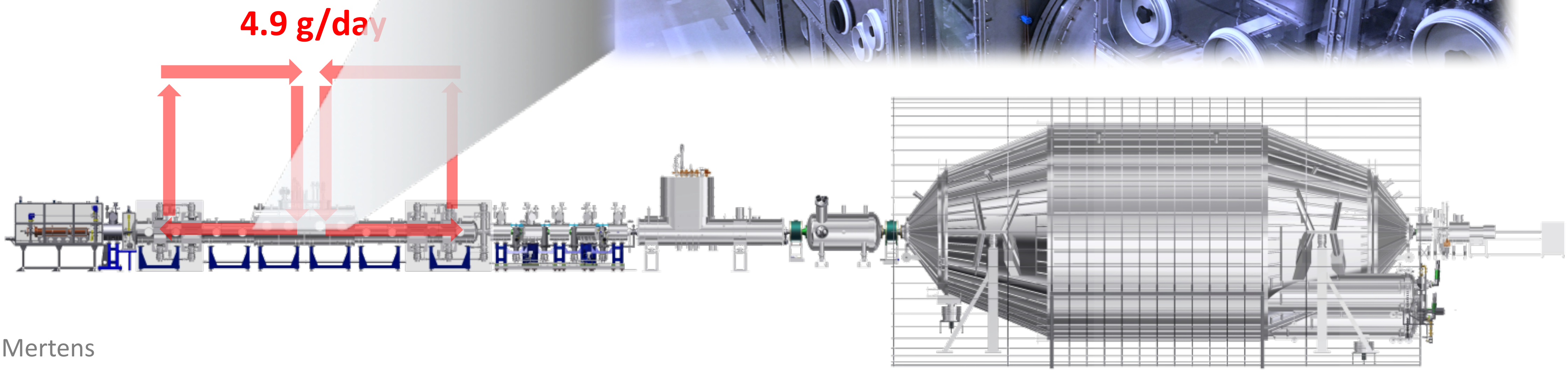


Gaseous tritium source

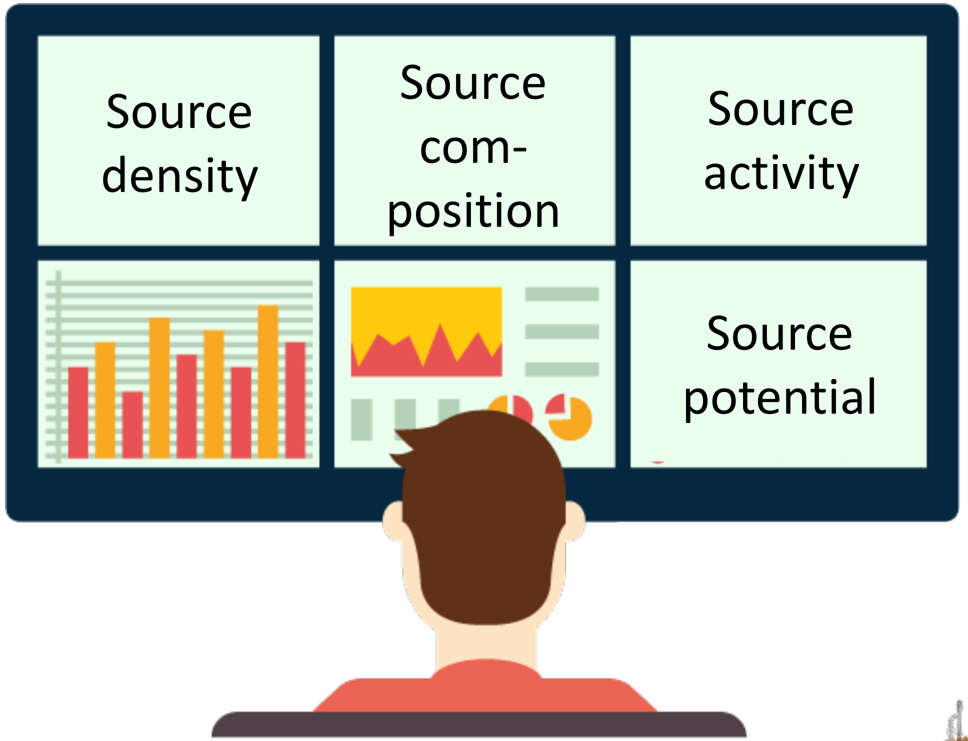
Circulation of tritium gas in close

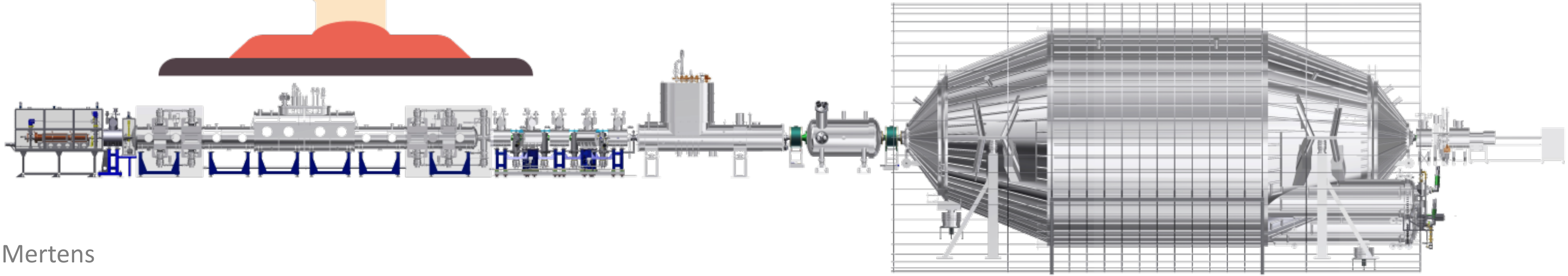
- tritium gas density:
- high isotopic tritium purity:
- high source activity:





Monitoring and characterization of source

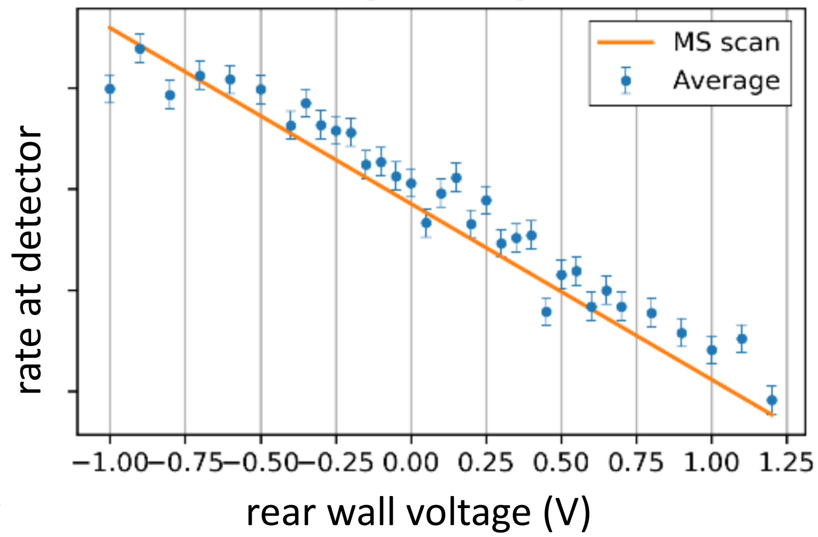


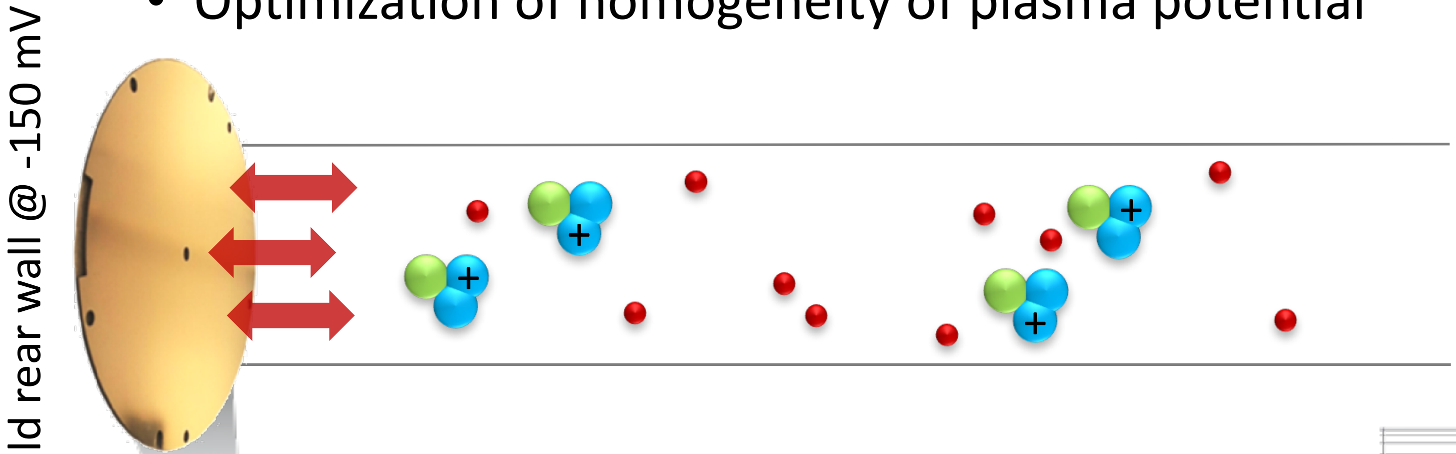


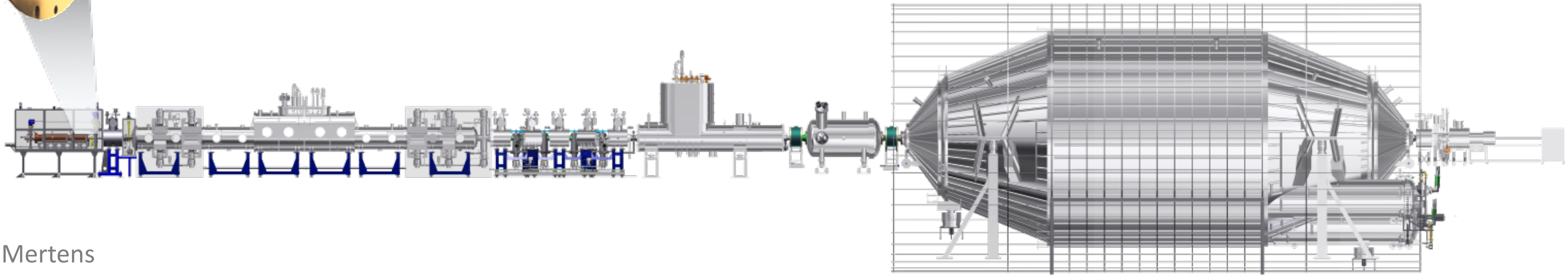
Plasma Potential Control

Detailed characterization measurements prior to data taking

- Optimization of coupling of rear wall to source plasma
- Optimization of homogeneity of plasma potential



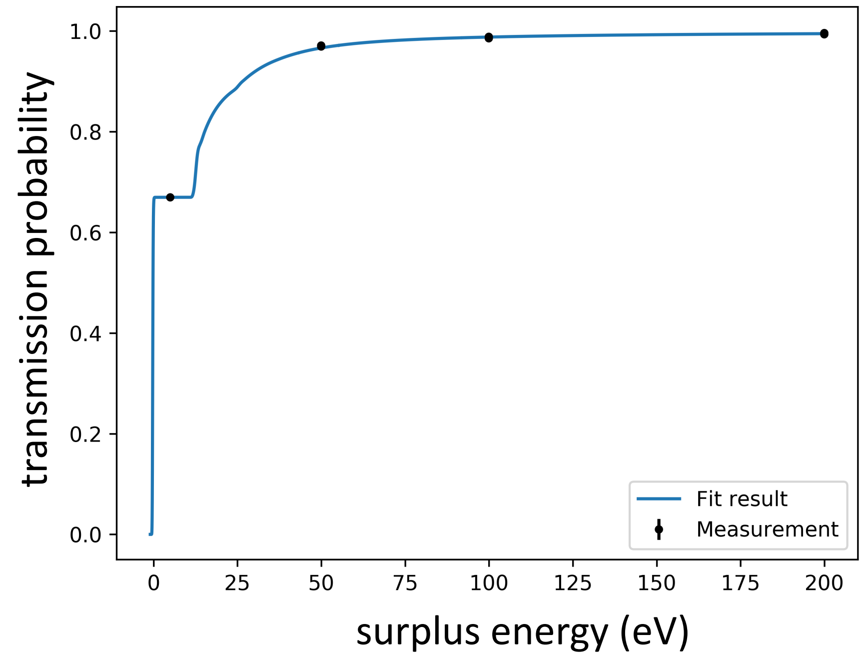


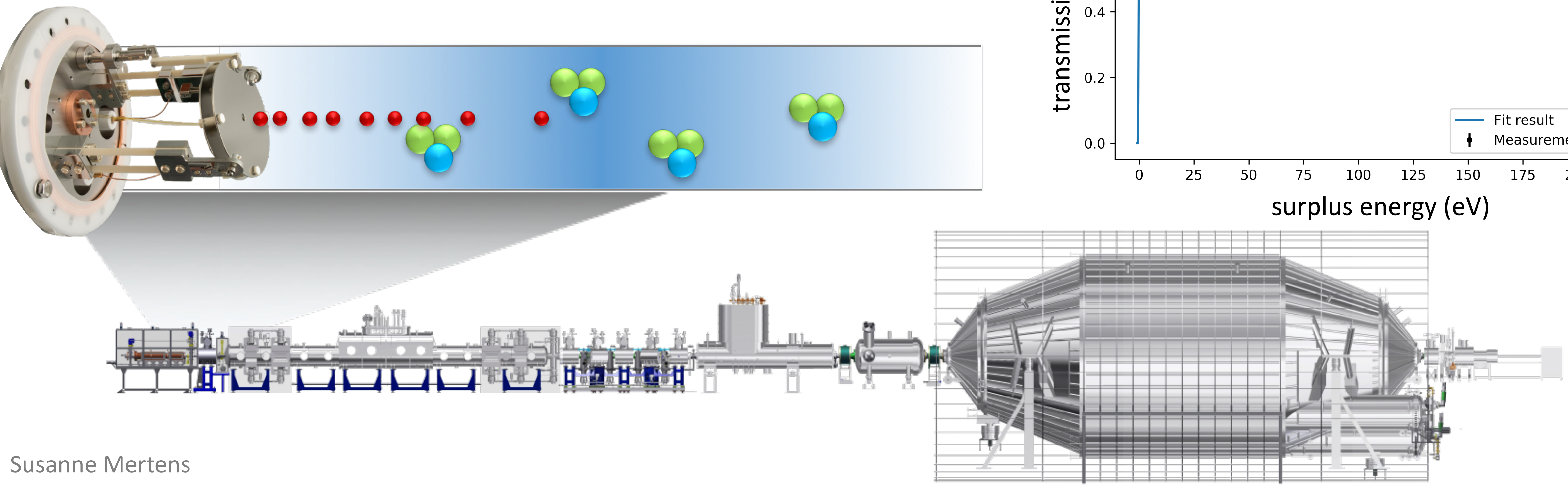


Determination of the gas density

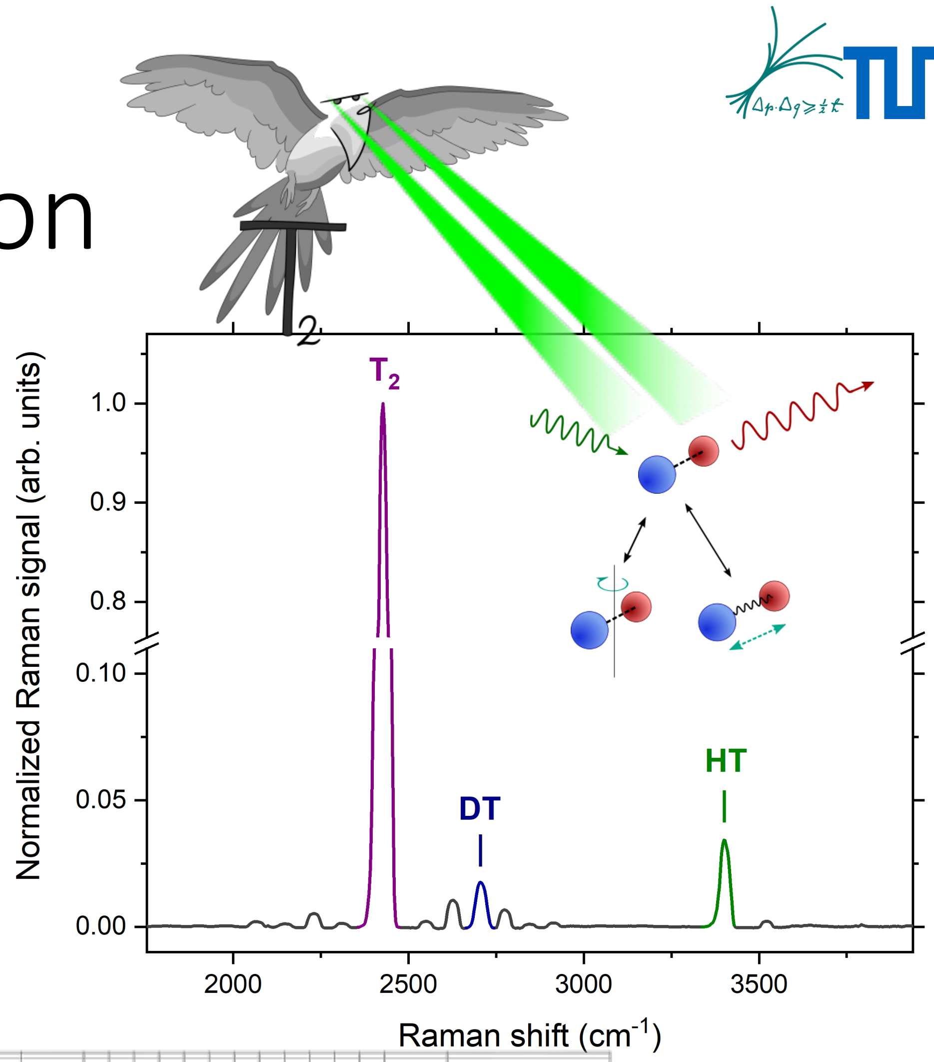
Regular calibration of gas density

- High-intensity beam of mono-energetic electrons
- Gas density $1.1 \times 10^{21}\ \mathrm{m}^{-2}$ (precision of < 1 %)



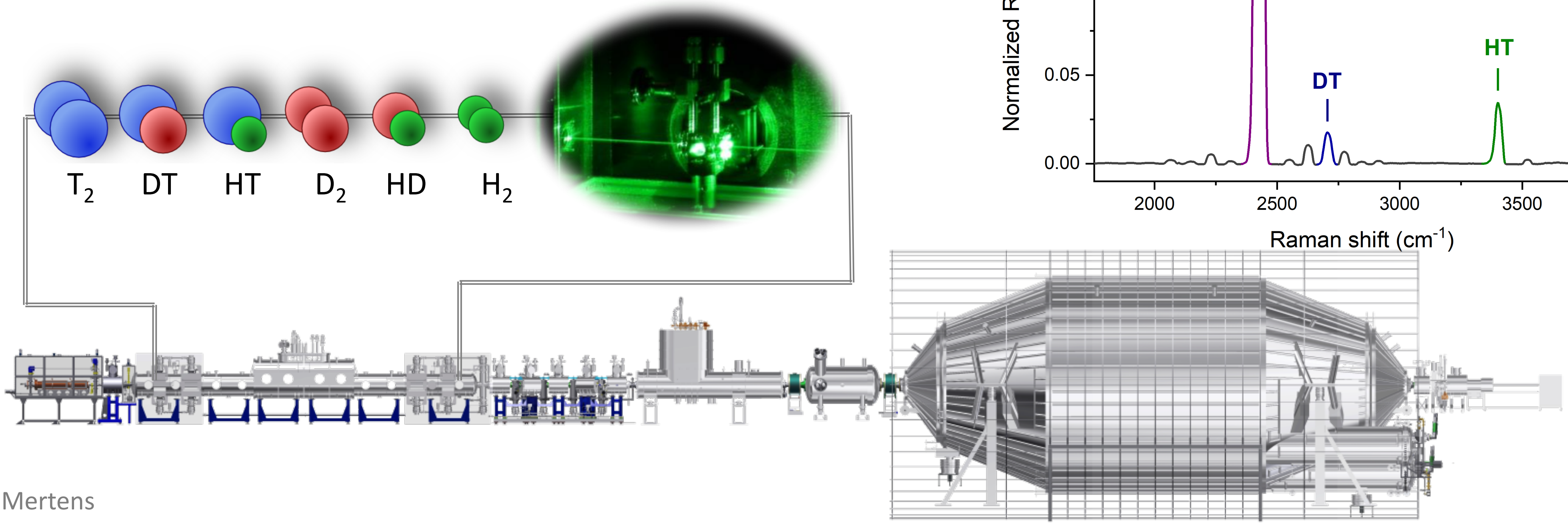


Monitoring source composition



Laser Raman System monitors isotopologues

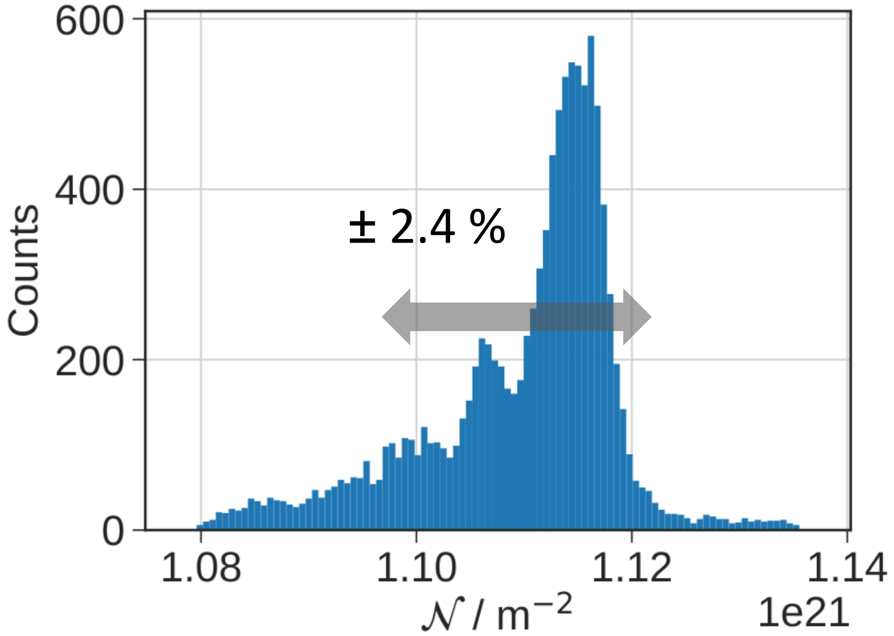
- High purity established (97.5 %)
- High stability of concentration (< 0.5% / day)



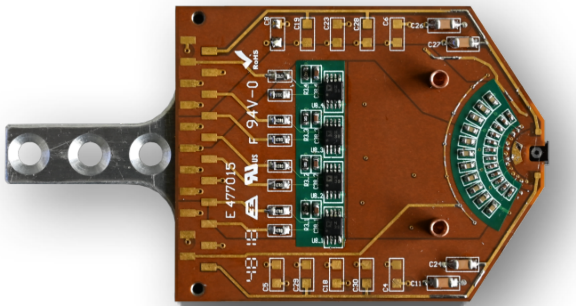
Monitoring the activity

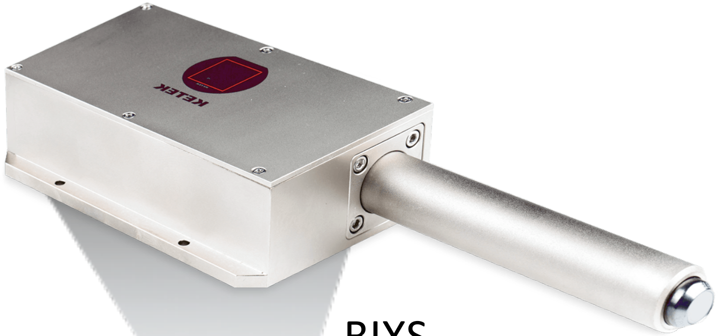
Source activity continuously monitored via

- Forward beam monitor, BIXS System, multiple Sensors
- Stability at the 2% level achieved

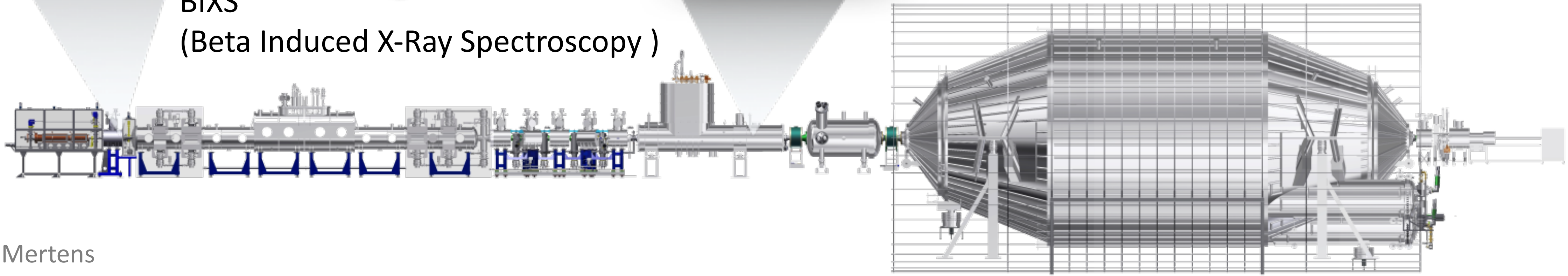


FBM

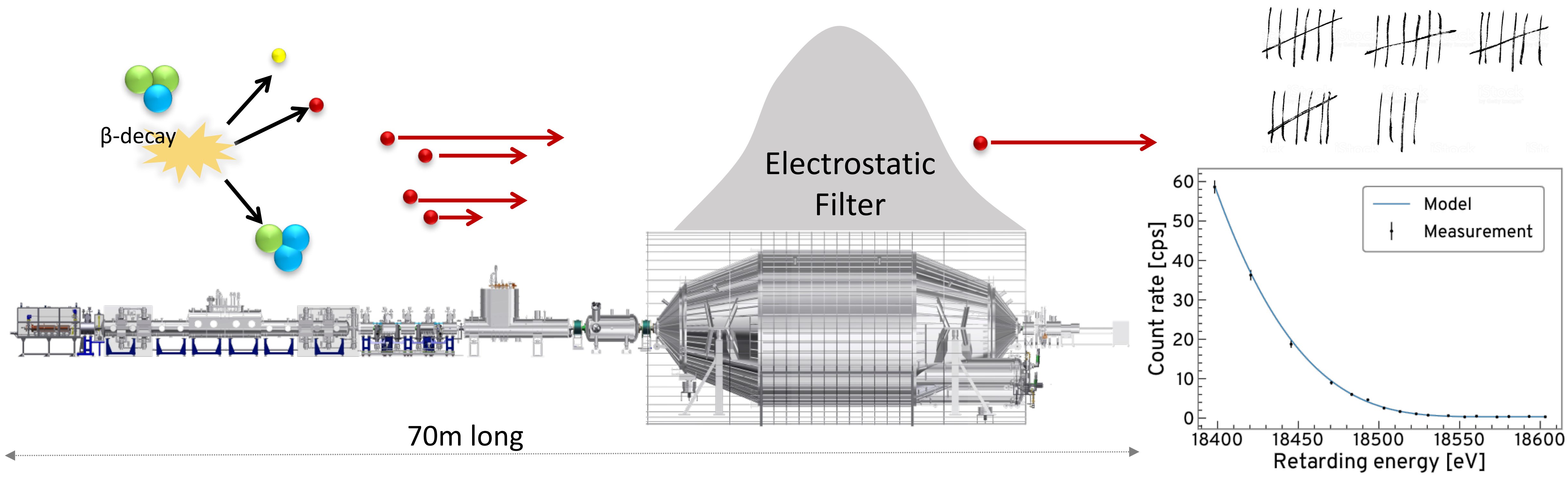




BIXS
(Beta Induced X-Ray Spectroscopy)



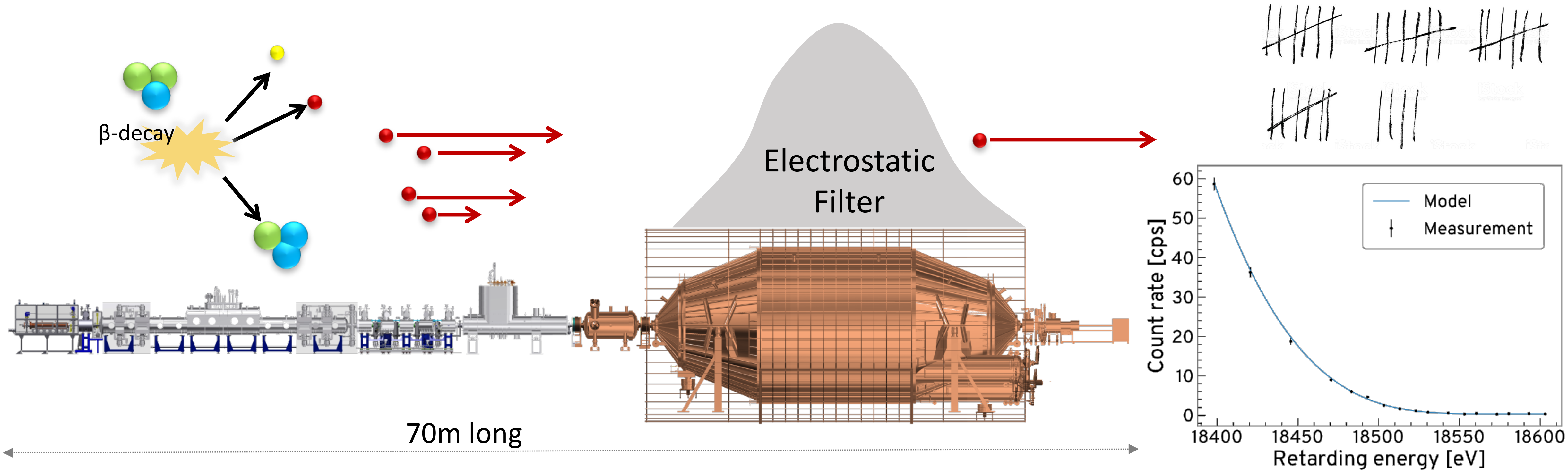
The basic idea of KATRIN



high-luminosity tritium source

high-resolution spectrometer

The basic idea of KATRIN

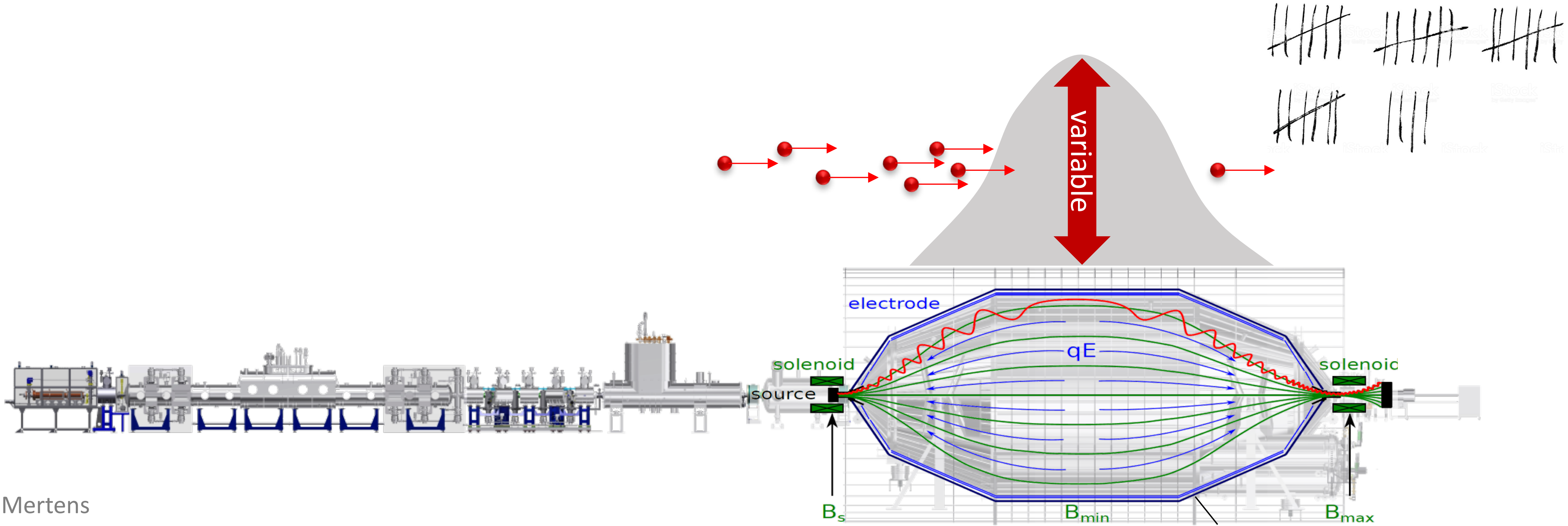


high-luminosity tritium source

high-resolution spectrometer

Scanning Strategy

- Idea: count electron as a function of retarding potential
- **… but at which retarding potentials and how long at each potential?**

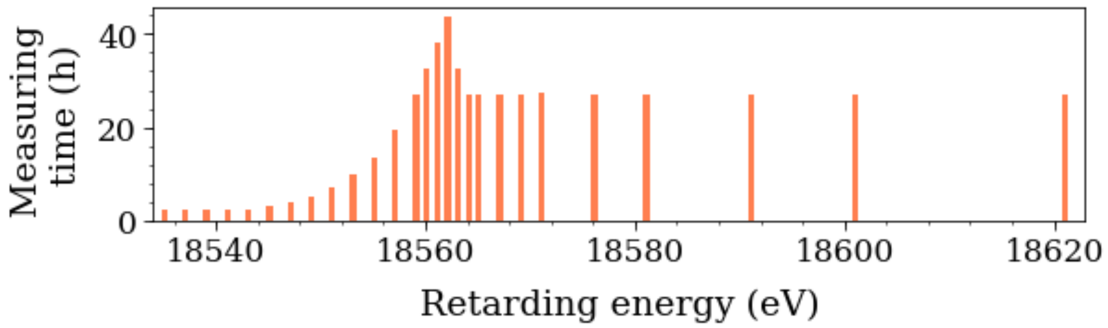


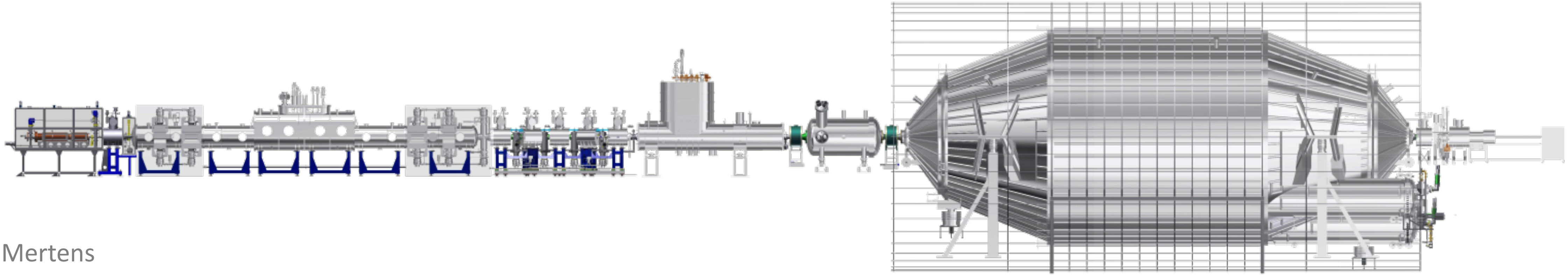
Scanning Strategy

Measurement time distribution

➢ optimized to maximize ν-mass sensitivity

- interval: E_0 – 40 eV , E_0 + 50 eV
- # HV set points: 27
- scanning time: 2 hours
- Number of scans: 274





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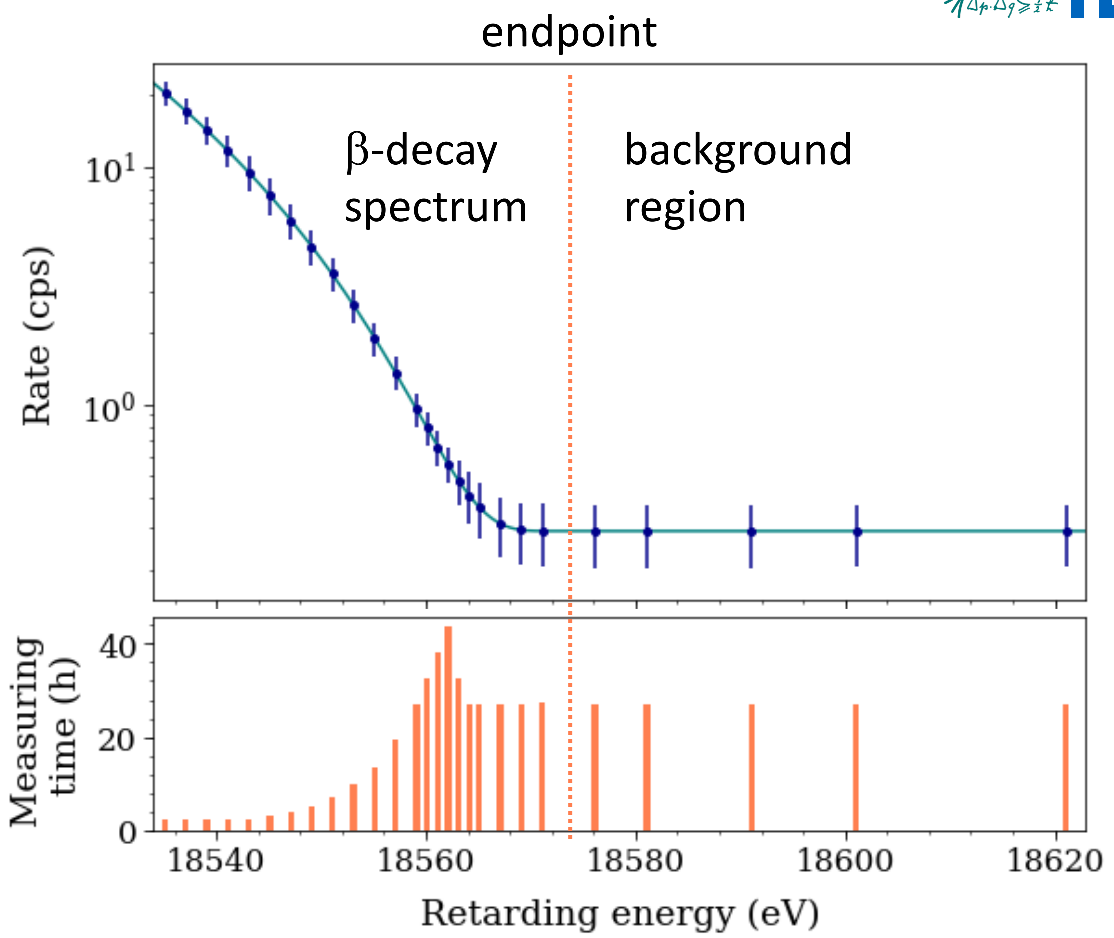
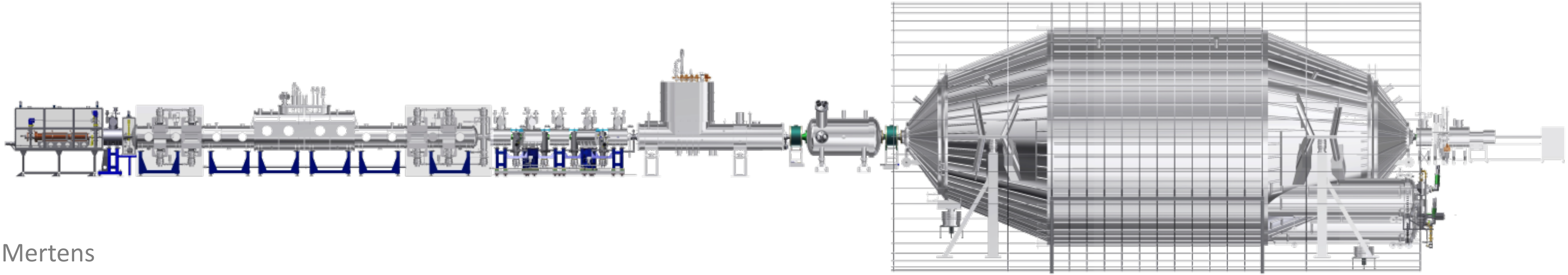
➢ One β-decay spectrum for each scan

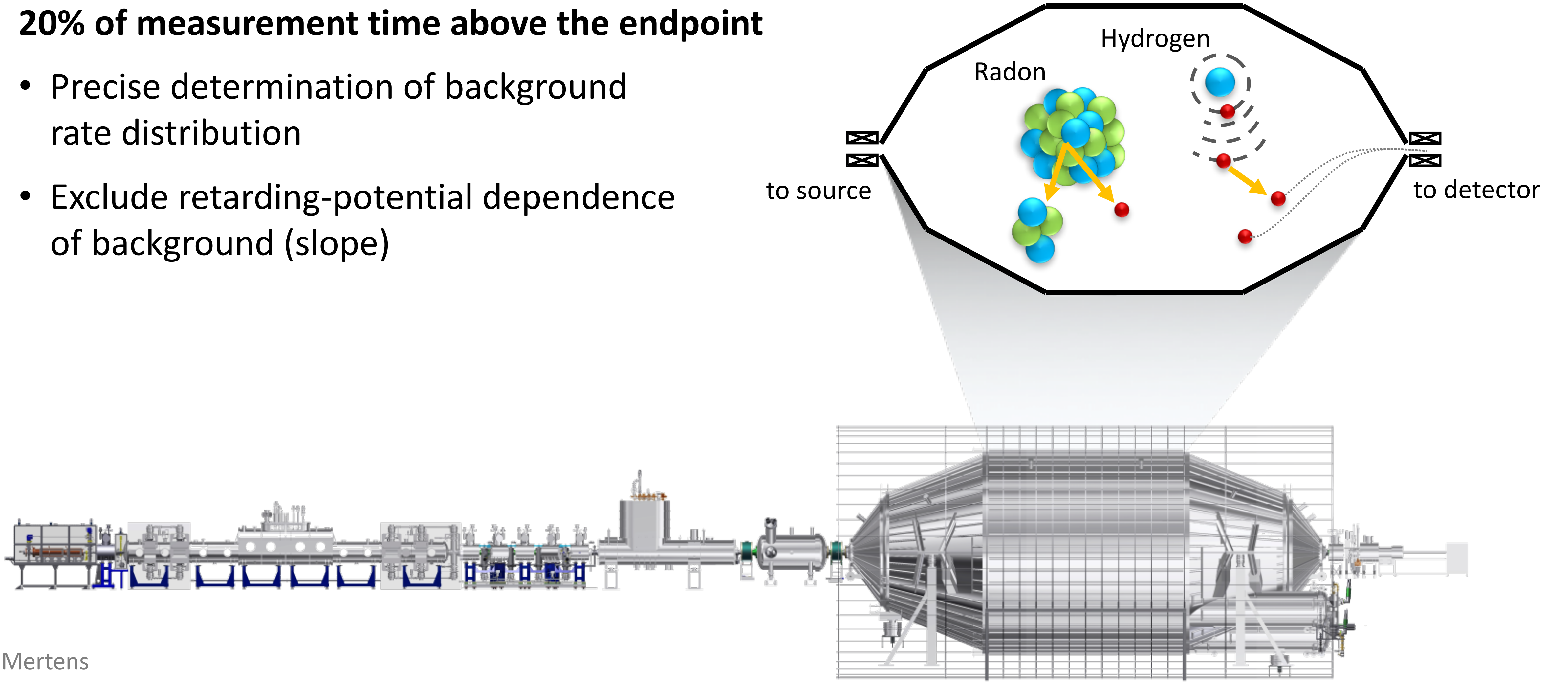




Background characterization

20% of measurement time above the endpoint

- Precise determination of background rate distribution
- Exclude retarding-potential dependence of background (slope)

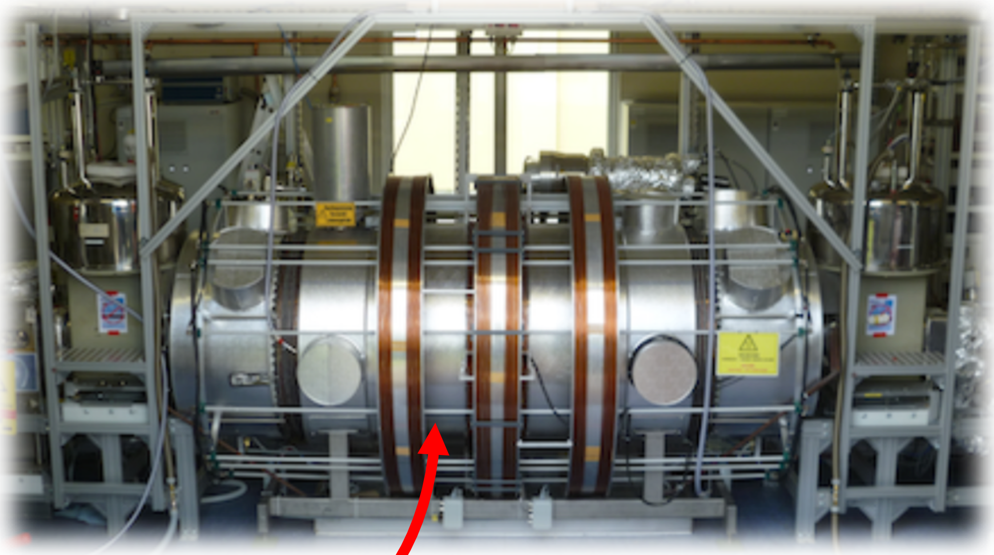


High voltage stability

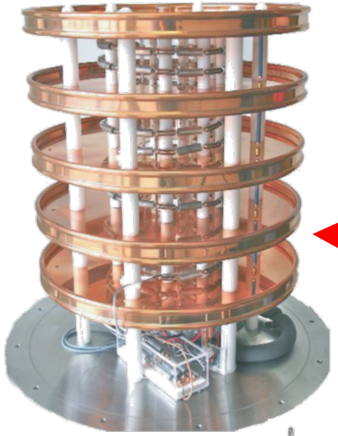
High-precision monitoring of High Voltage (HV)

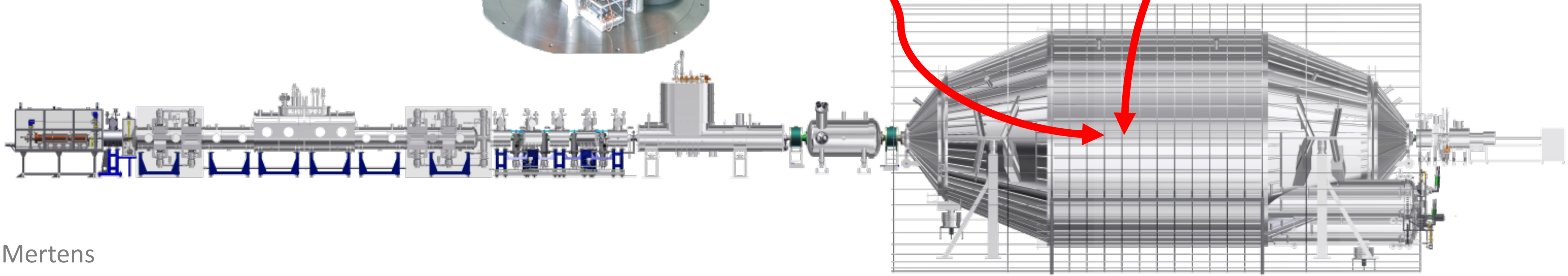
- Short term (seconds) HV stability: < 20 mV
- Long-term (days) HV stability: < 20 mV/day

Monitor Spectrometer

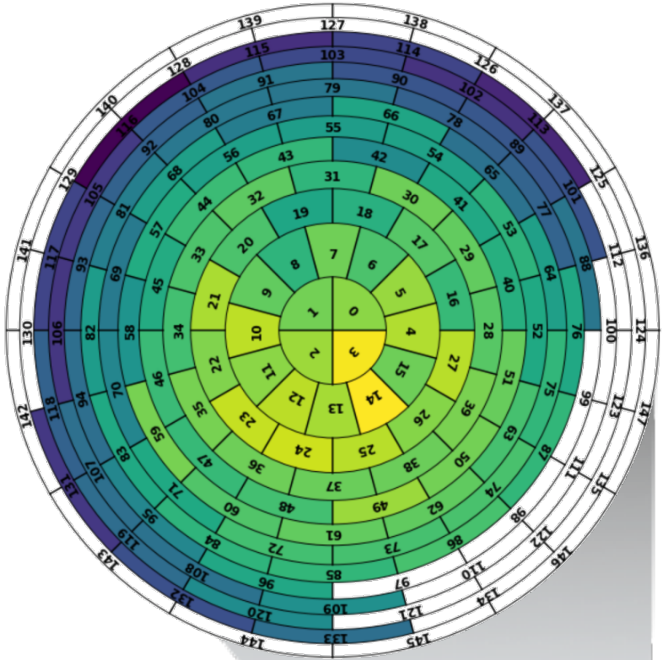


High Voltage Divider





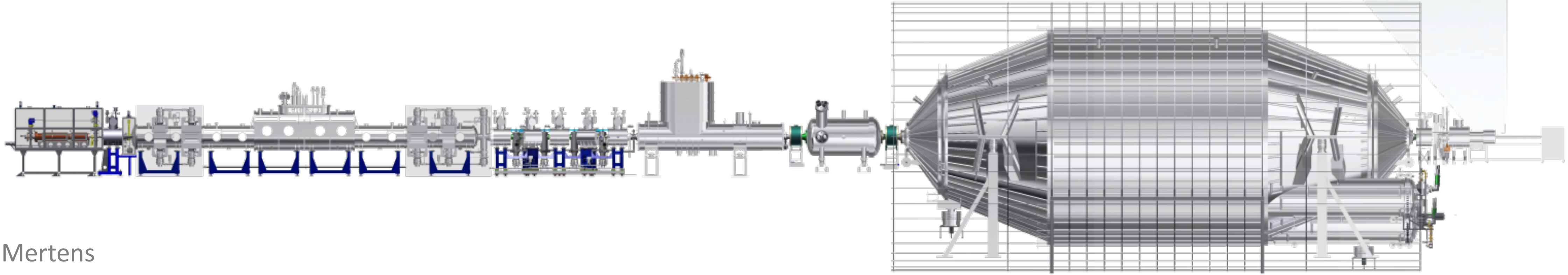
Detecting electrons



148-pixel Si-PIN detector detects electrons

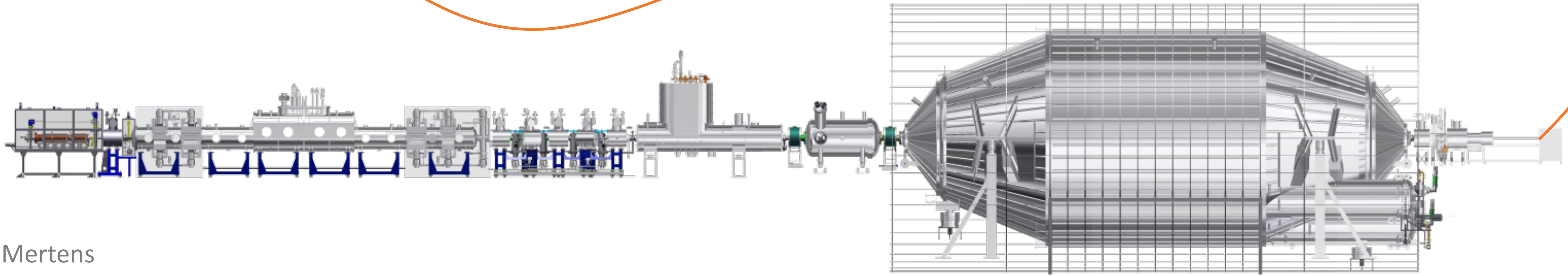
- 117/147 (79%) of all pixels used
- high detection efficiency (90%)
- negligible retarding-potential dependence of efficiency

➢ One β-decay spectrum for each pixel

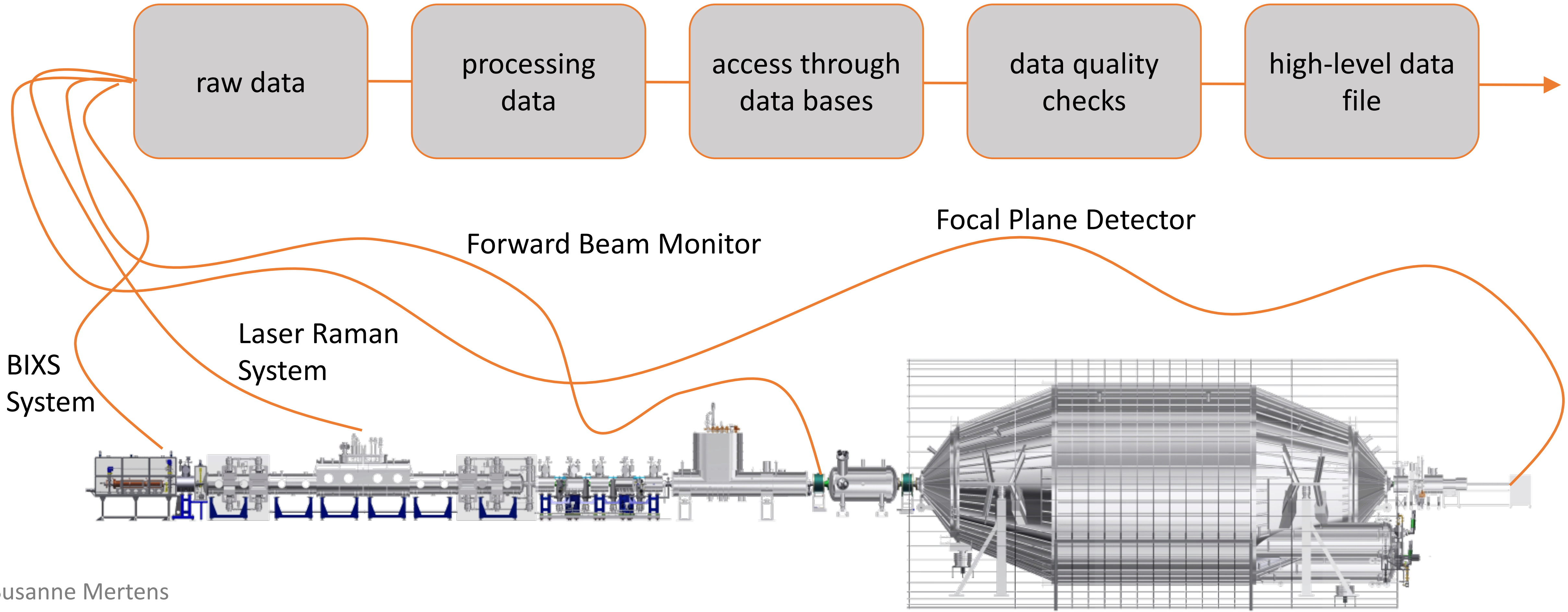


Data handling

raw data → processing data → access through data bases → data quality checks → high-level data file →



Data handling



The tritium spectrum

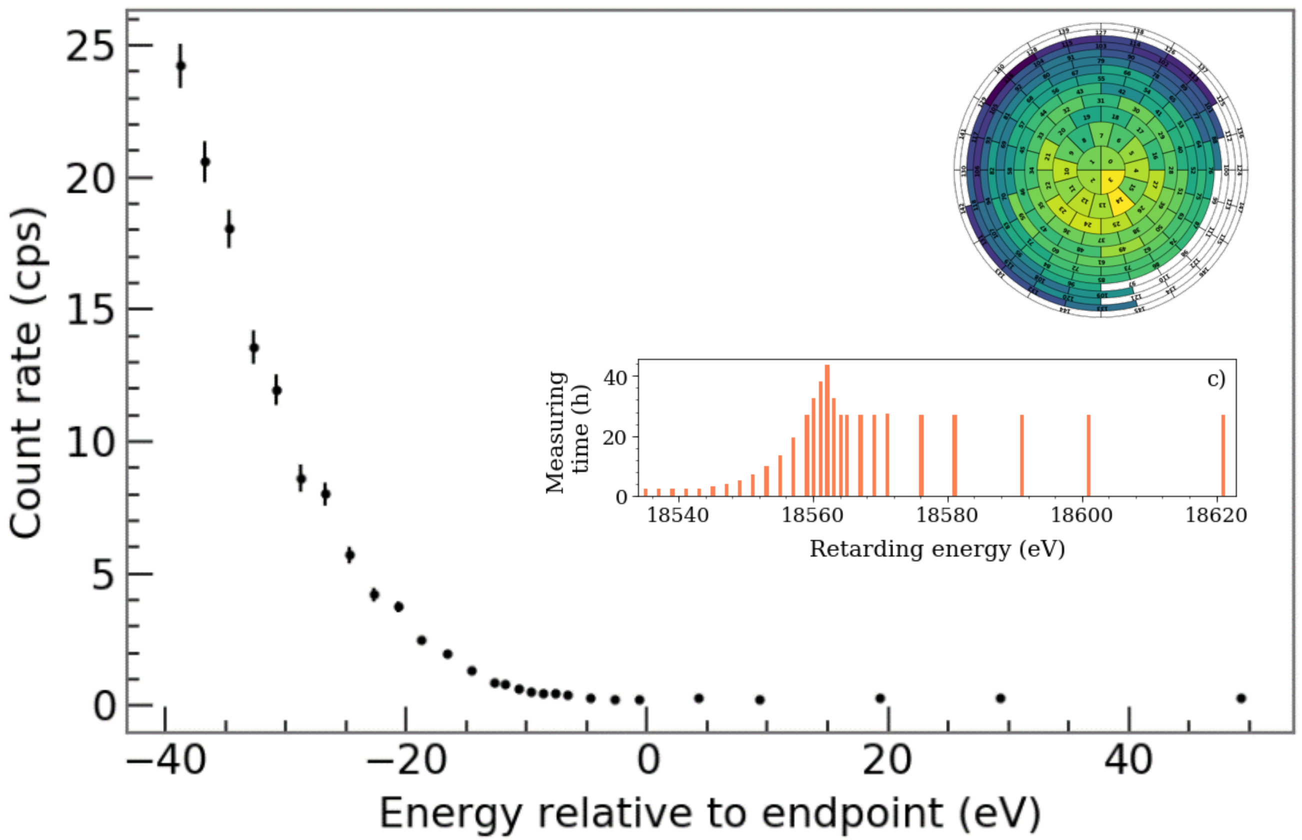
32058 β-decay spectra

- for each detector pixel
- for each scan

Task of “fitting” teams

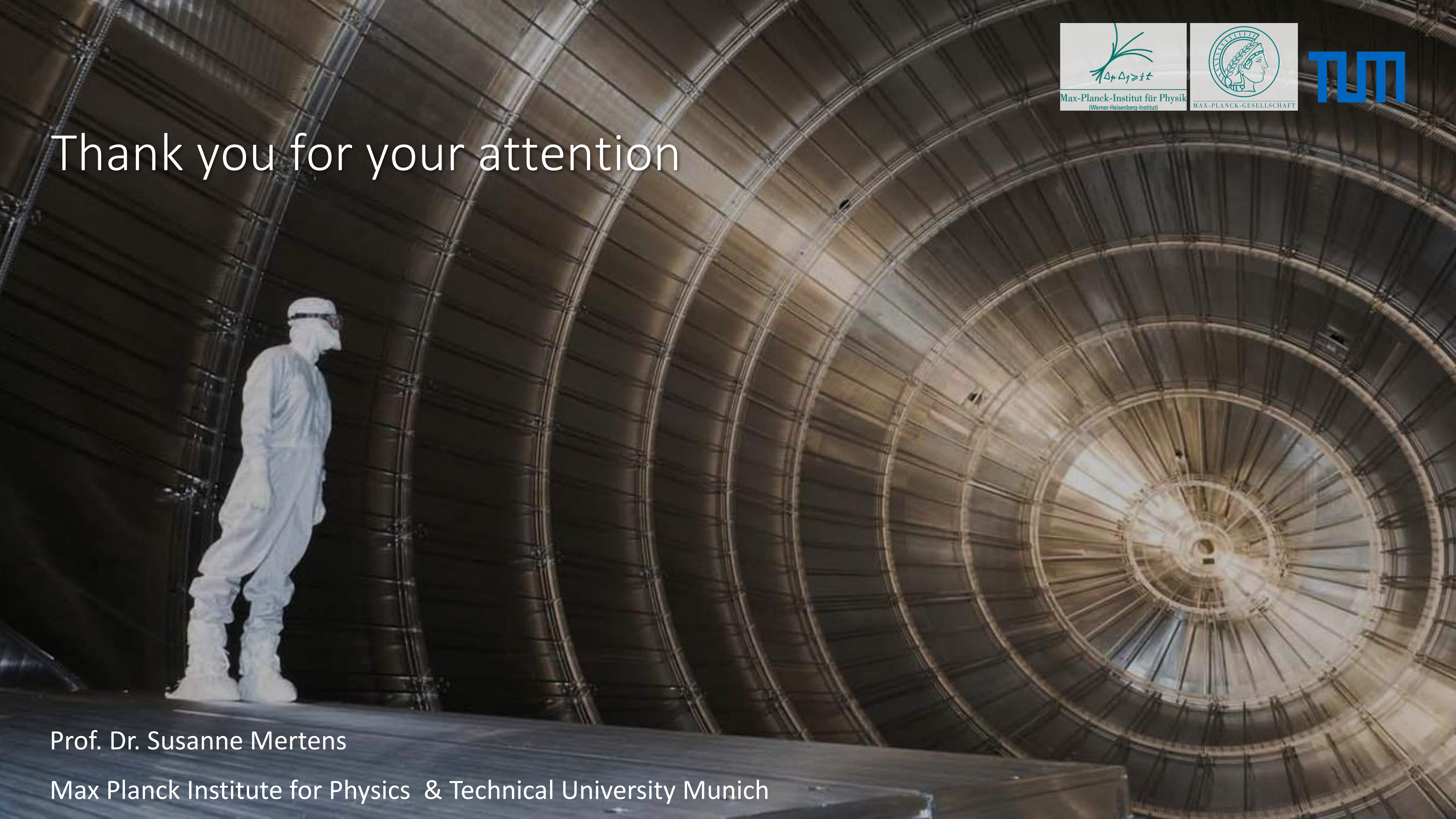
- combine spectra in a smart way
- infer physics parameters
- estimate uncertainties

➢ see next talk



People

- Students and senior scientists from all over the world @ KIT
- Highly motivated team of shifters, technical staff, data analysts
- Special thanks to Dr. Magnus Schlösser for a great coordinating of the data taking



Thank you for your attention

Prof. Dr. Susanne Mertens

Max Planck Institute for Physics & Technical University Munich

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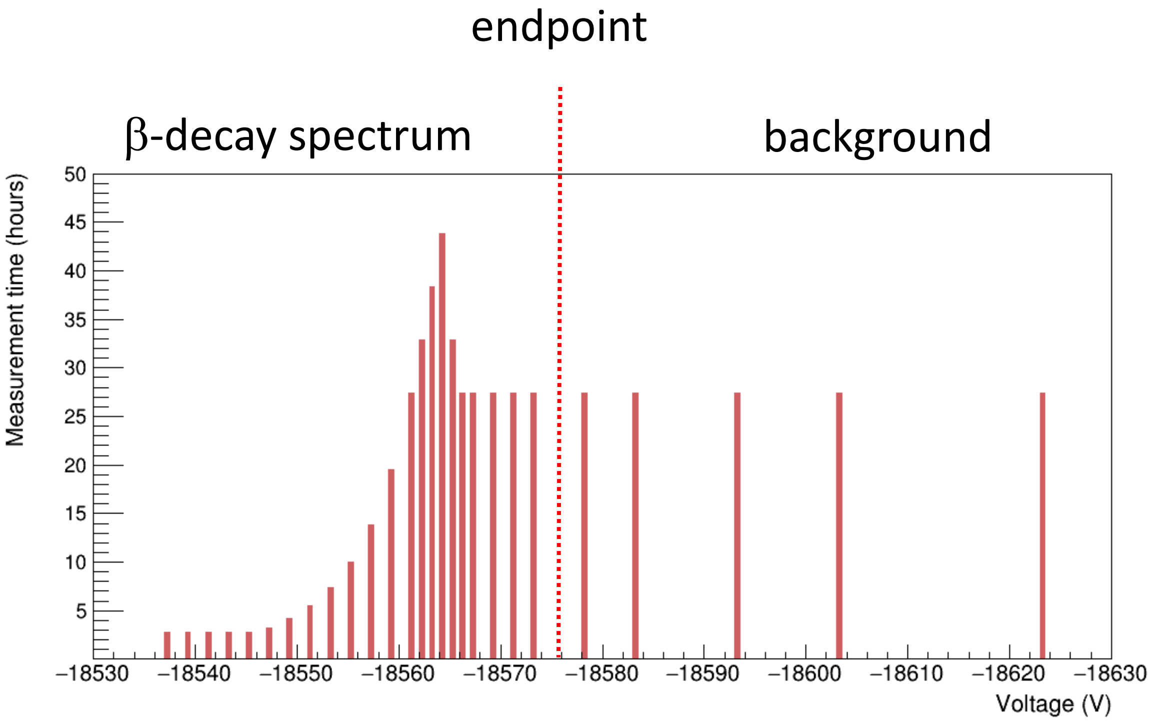
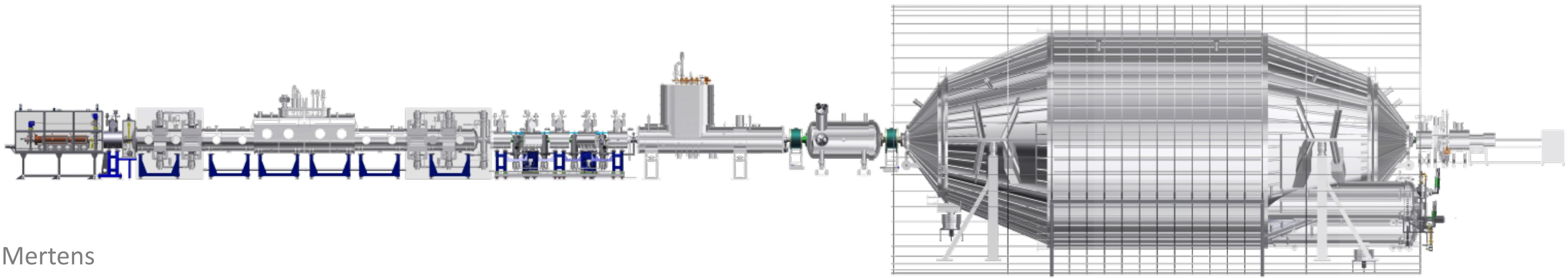
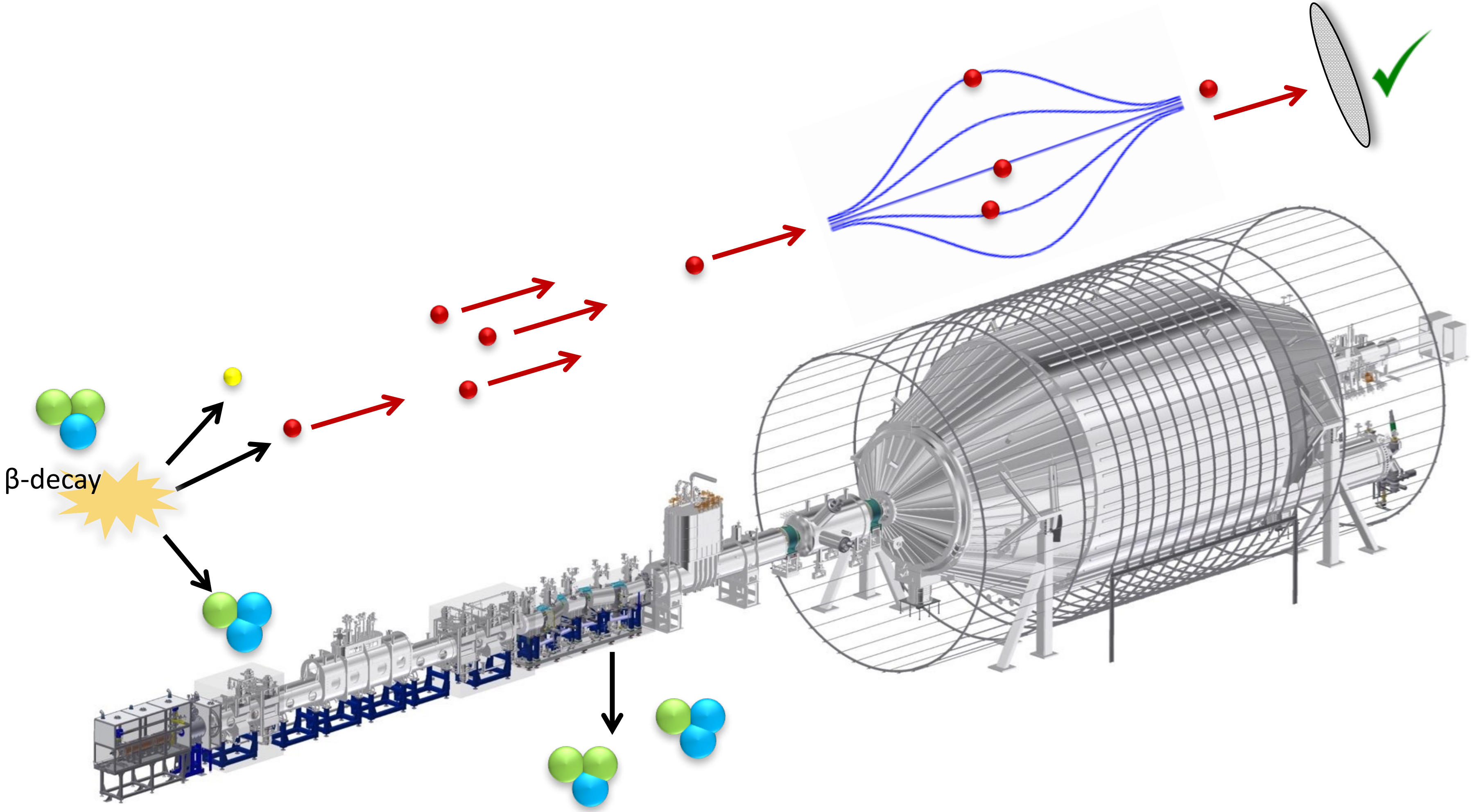
- ➢ optimized to maximize ν-mass sensitivity
- interval: $E_0 - 40$ eV , $E_0 + 50$ eV
- scanning time: 2 hours
- HV set points: 27
- Number of scans: 274
- alternating up- / down- scans

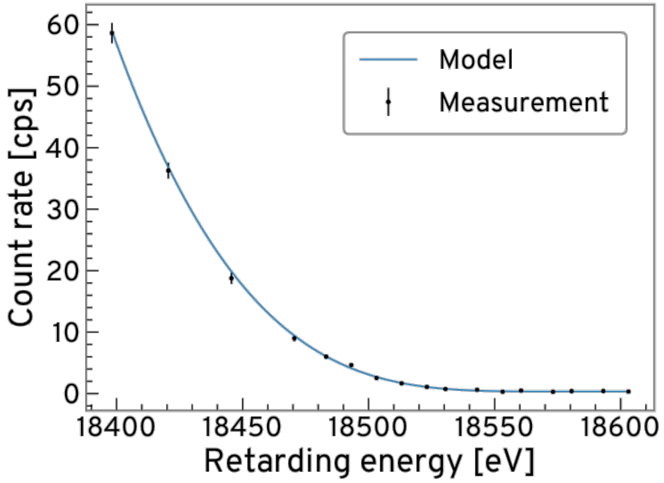




Basic measurement idea



Integral beta decay spectrum



The challenge

Neutrino signature is a small spectral distortion

✓ Ultra-stable operating parameters (e.g. source activity)

✓ Ultra-precise understanding of the instrument

→ Monitoring a re essential for KATRIN