Westfälische Wilhelms-Universität Münster

The KATRIN experiment

Status and comissioning

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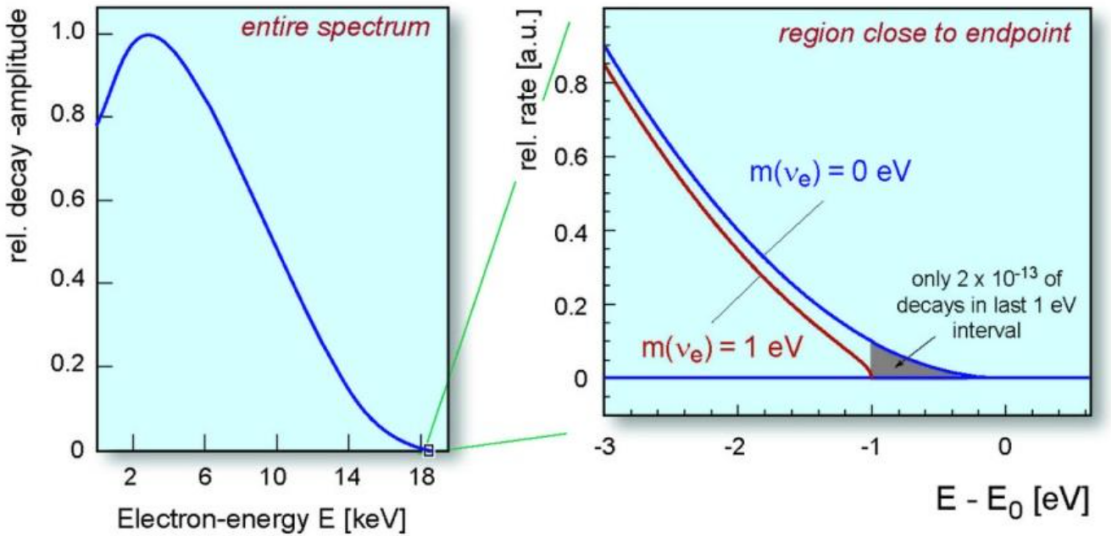
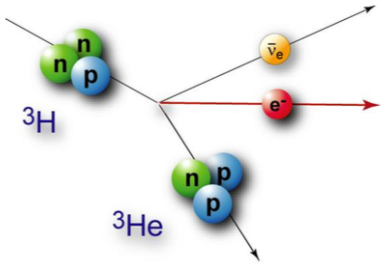
KATRIN
Karlsruhe Tritium Neutrino Experiment

(Tritium) β-decay and neutrino mass

β-decay: $^{A}_{Z}X_{N} \rightarrow ^{A}_{Z+1}X_{N-1} + e^{-} + \bar{\nu}_e$





Tritium ^{3}H:

$E_0 = 18.6$ keV

$T_{1/2} = 12.3$ y

Rhenium ^{187}Re:

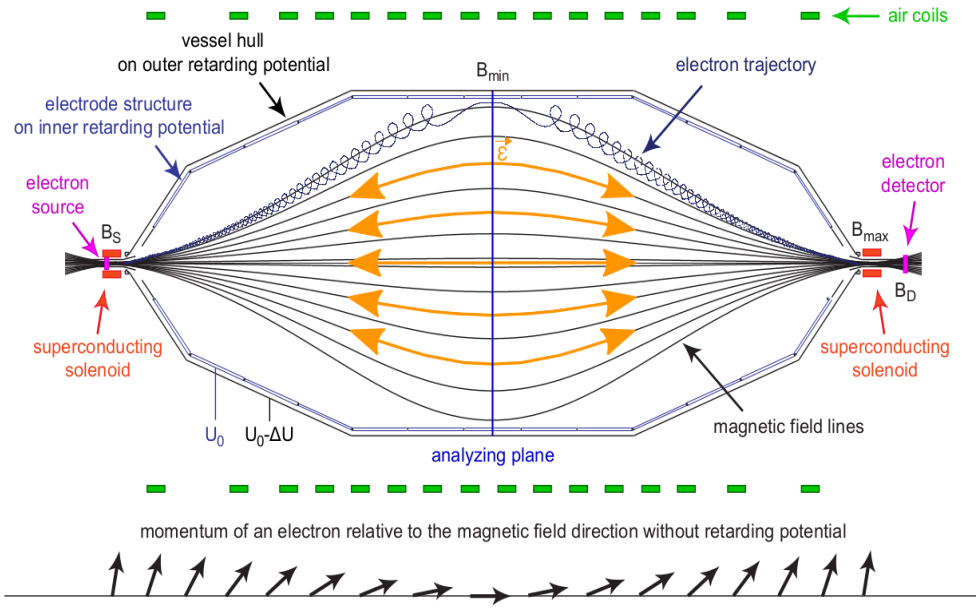
$E_0 = 2.47$ keV

$T_{1/2} = 4.3\ 10^{10}$ y

$$\frac{dN}{dE} = K\ F(E,Z)\ p\ (E_e + m_e)(E_0 - E_e)\sqrt{(E_0 - E_e)^2 - m(\bar{\nu}_e)^2}$$

MAC-E Filter

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



Magnetic guiding and collimation of e^-
- Transform $E_\perp$ to $E_{||}$

Electrostatic field for energy analysis
- Sharp transmission depending on:
  - Emission angle
  - Radius in at B_{min}

Integrated energy resolution:

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

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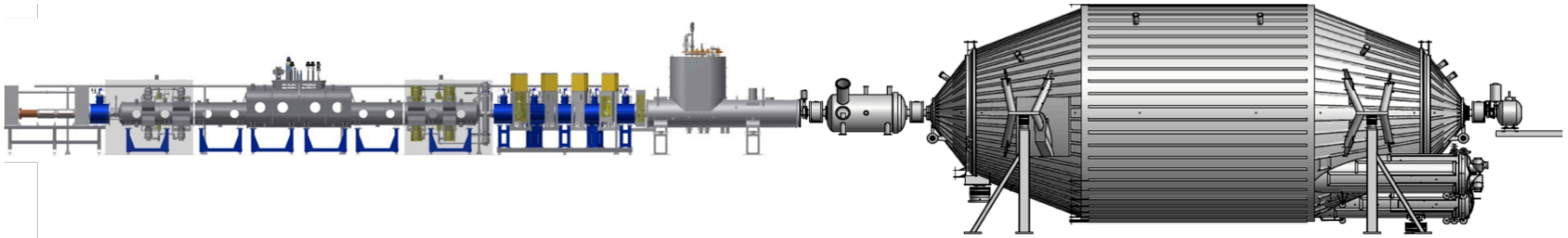
The KATRIN experiment



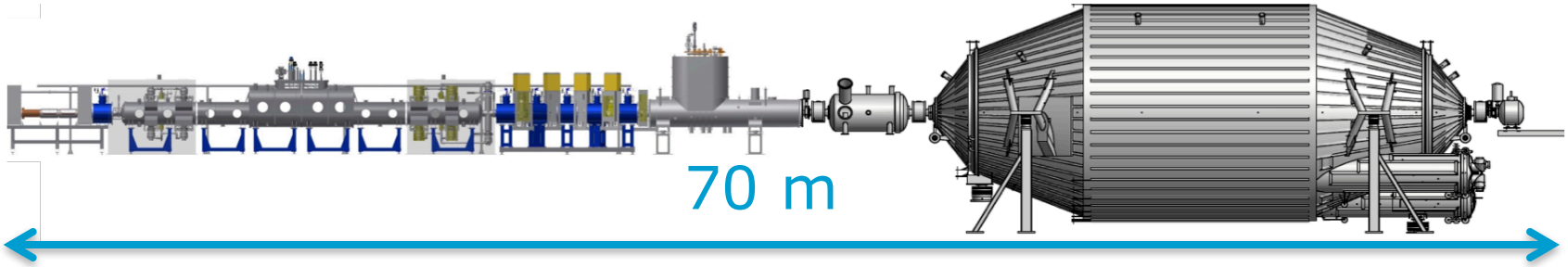
KATRIN primary goal:

- Measure neutrino mass with a sensitivity of m(ν) = 200 meV (90 % C.L.)

KATRIN beyond m(ν):

- Search for eV- and keV-scale sterile neutrinos
- Search for relic neutrinos
- Technological advances in many fields
- …

The KATRIN experiment



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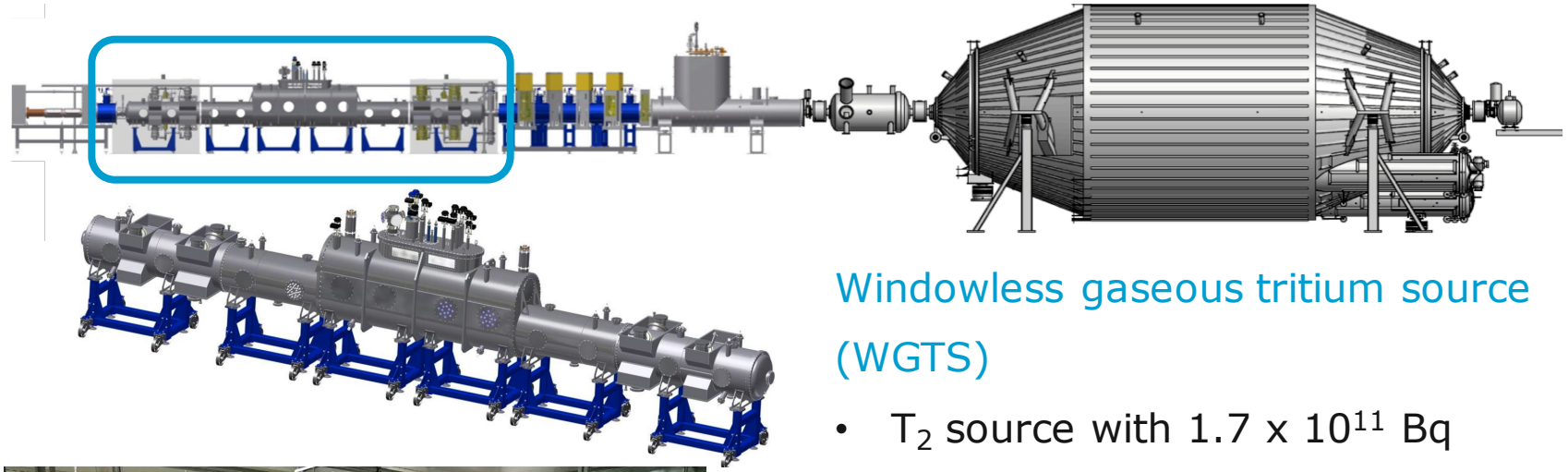
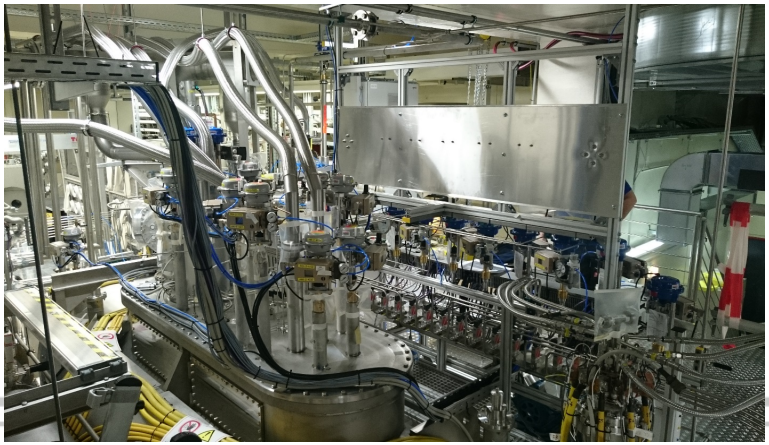
The KATRIN experiment

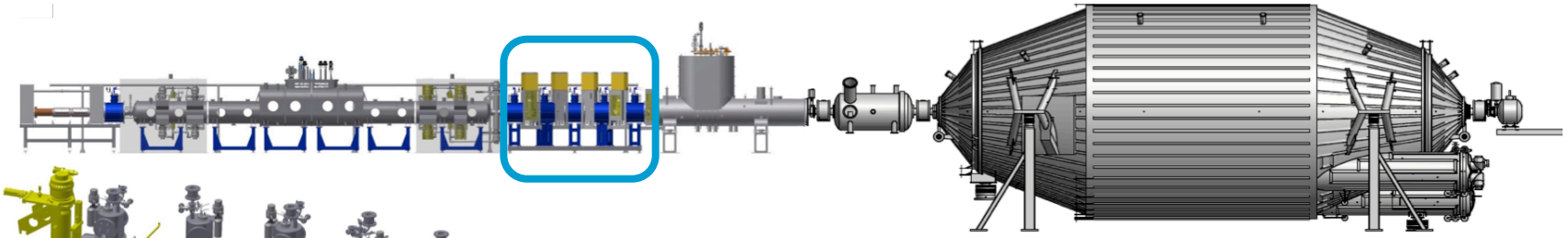


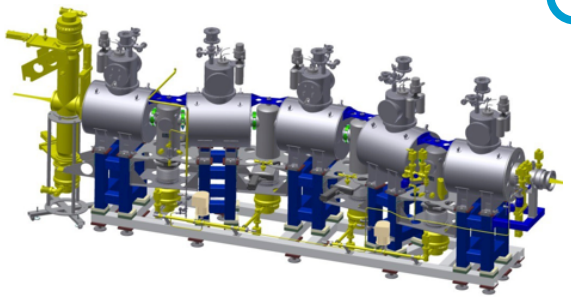


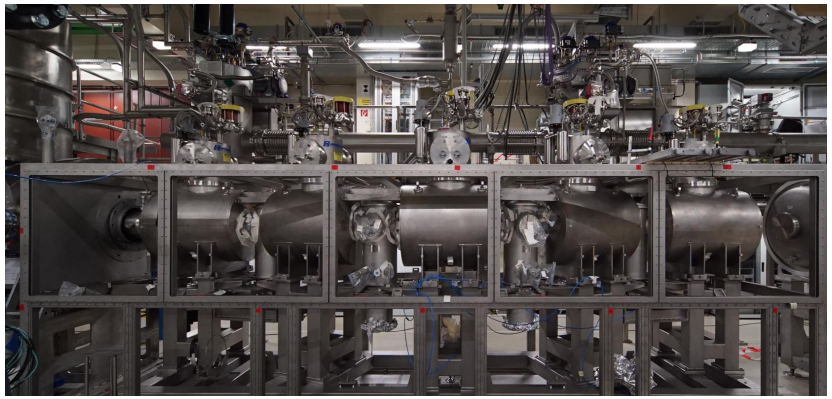
Windowless gaseous tritium source (WGTS)

- T_2 source with 1.7 x 10^{11} Bq
- 10 m long, ⦰ 9 cm tube
- T_2 gas, p = 10^{-3} … 10^{-6} mbar
- Stable on 10^{-3} level
- Arrived on Sept. 10th 2015
- Installation quickly progressing

The KATRIN experiment



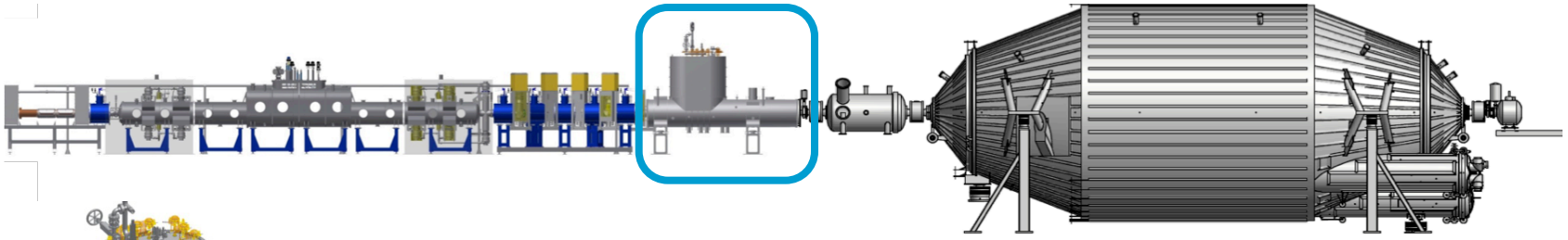


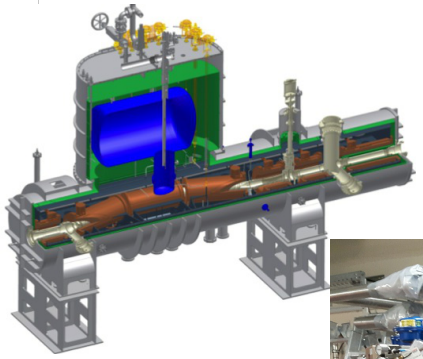


Differential pumping section (DPS)

- Tritium retention by 10^5 by active pumping with 4 TMPs
- 5 superconducting solenoids
- Magnets set up & working at KIT
- Beam line assembly finishing up
- Integration into T_2 infrastructure

The KATRIN experiment

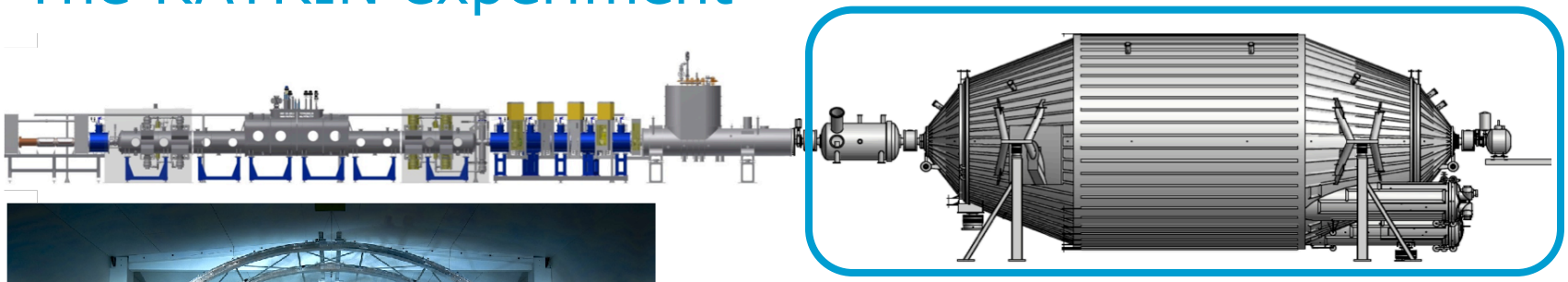


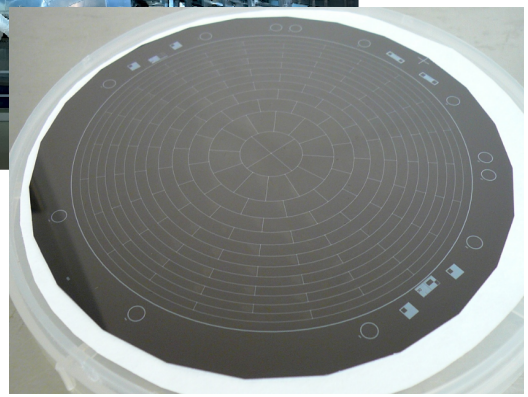


Cryogenic pumping section (CPS)

- Tritium retention > 10^7
- Cryo-pumping of residual gas
- 7 magnets @ 5.6 T
- Delivered to KIT on July 30, 2015
- Leak test are finishing up
- Preparation of first cold tests

The KATRIN experiment

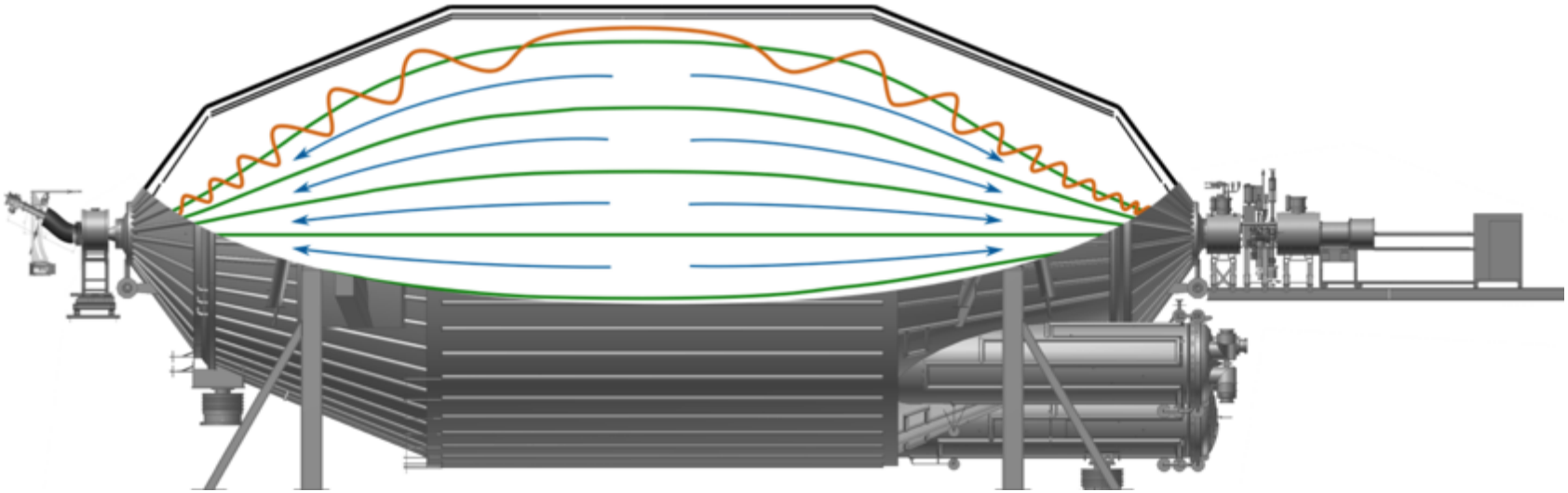




Spectrometer and detector section

- Tandem spectrometer setup
  - Pre-Spectrometer
    - Pre-filter 10^{10} e$^-$/s $\Rightarrow$ 10^3 e$^-$/s
    - Used for R&D for Main Spec
  - Main Spectrometer
    - Main energy analysis
    - ΔE = 0.93 eV
  - Focal plane detector (FPD)
    - 148 Pixel Si-PIN diode
    - ΔE ~ 2 keV
- Everything on site

Spectrometer and Detector commissioning



Two phases: SDS-I 2013; SDS-II(a+b): late 2014 to mid 2015

Subsystems:

- Main spectrometer
- Focal plane detector
- Angular selective e^--source

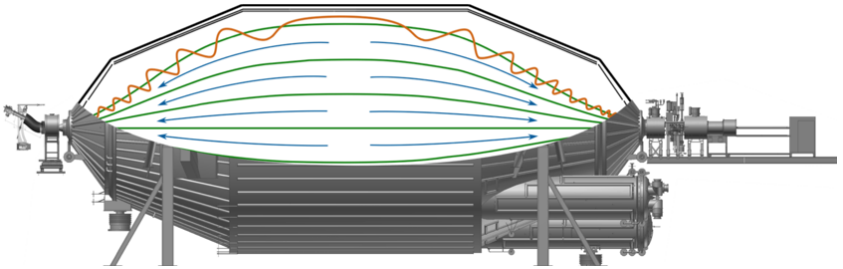
Tests:

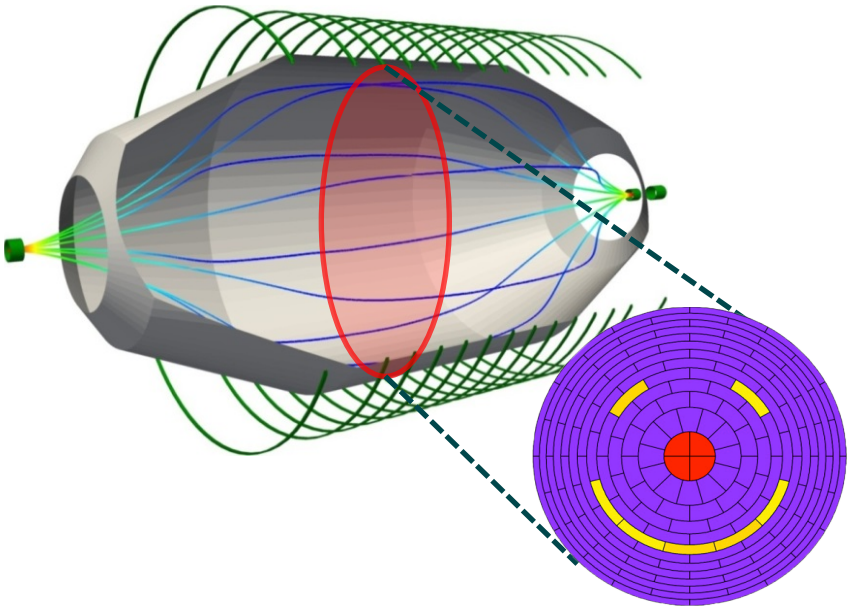
- Hardware, Software, Slow Control
- Transmission Properties
- Background

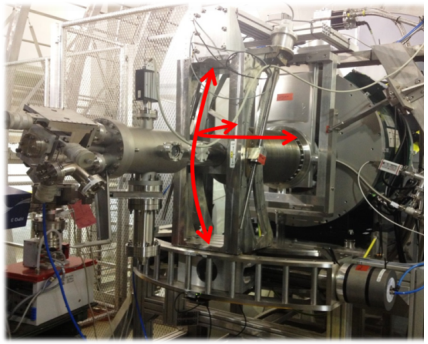
Spectrometer and Detector commissioning

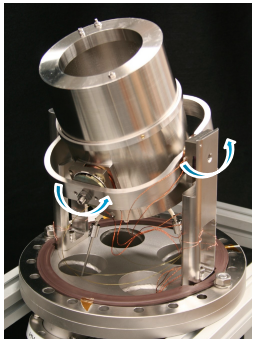
Electron transmission properties

- Mono-energetic, angular selective electron gun
- Test the effect inside MS of
  - electric potential
  - magnetic field









Spectrometer and Detector commissioning

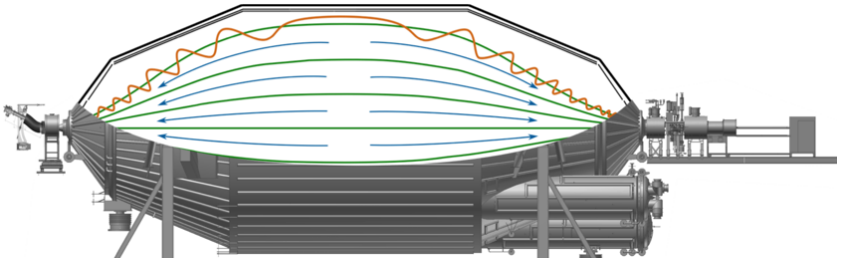
Electron Optics

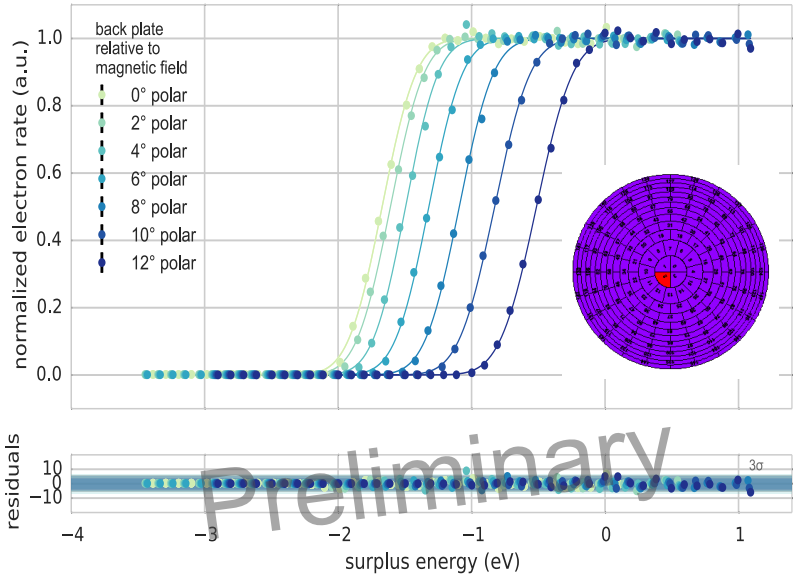
Angular selectivity shown

- Width: $\Delta E \approx 1.2 \text{ eV} \approx E \frac{B_{\min}}{B_{\max}}$

  $E = 18.6$ keV; $B_{\min} = 0.38$ mT; $B_{\max} = 5$ T

- Consistent with calculation





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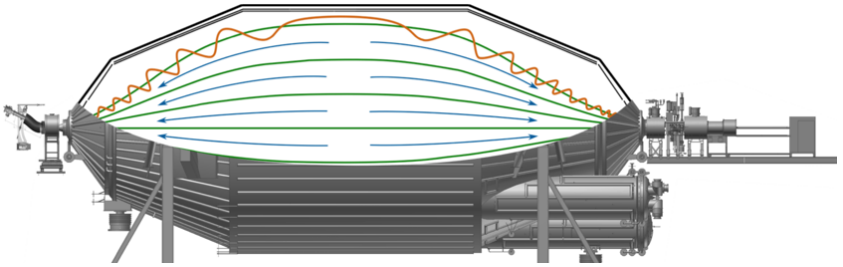
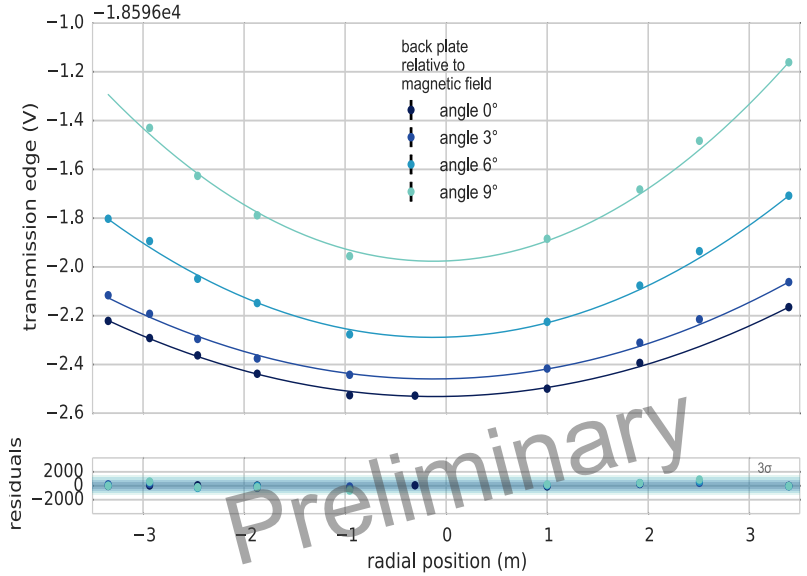
- Consistent with calculation

Potential drop towards center

- $\Delta U = 0.3 \ldots 1.0$ V
- Consistent with simulations

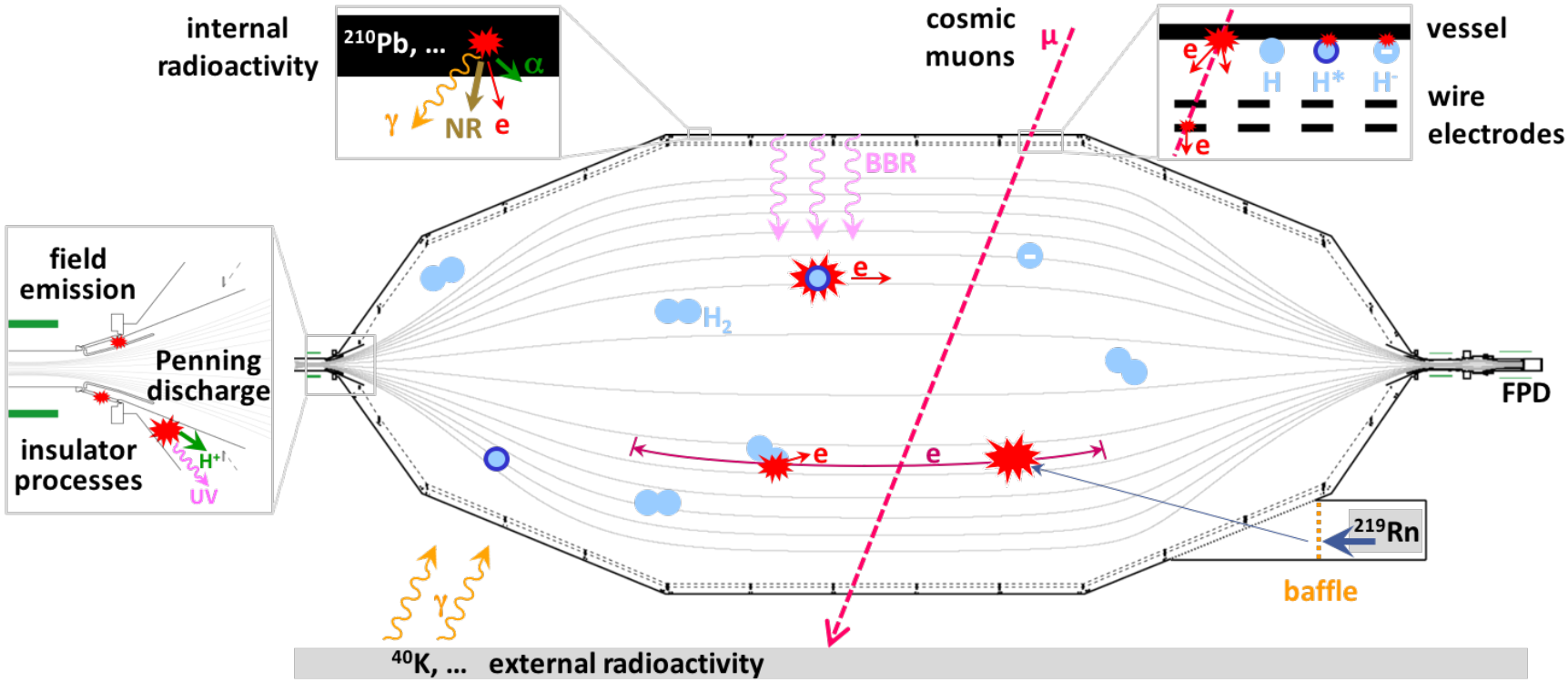
Detailed analysis ongoing





Spectrometer and Detector commissioning

Background processes



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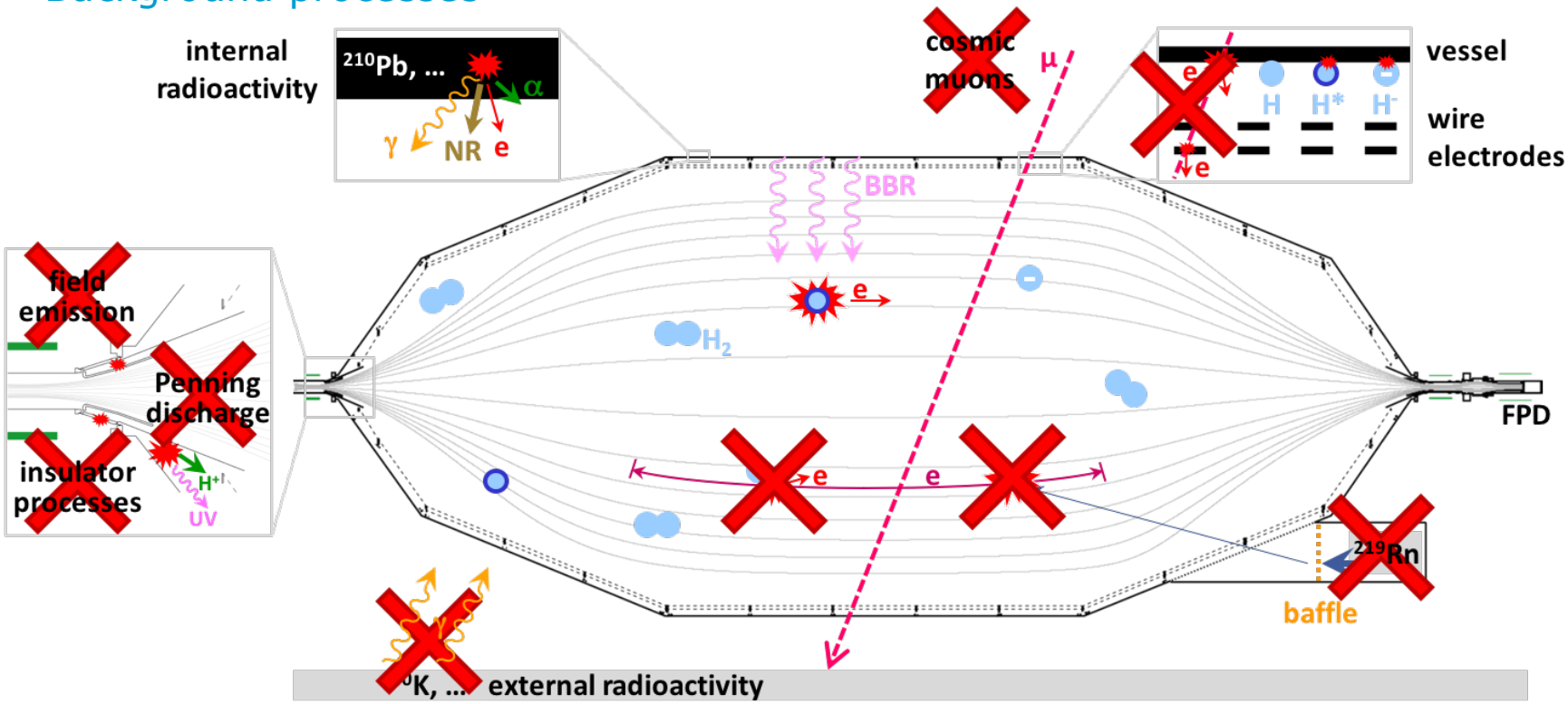
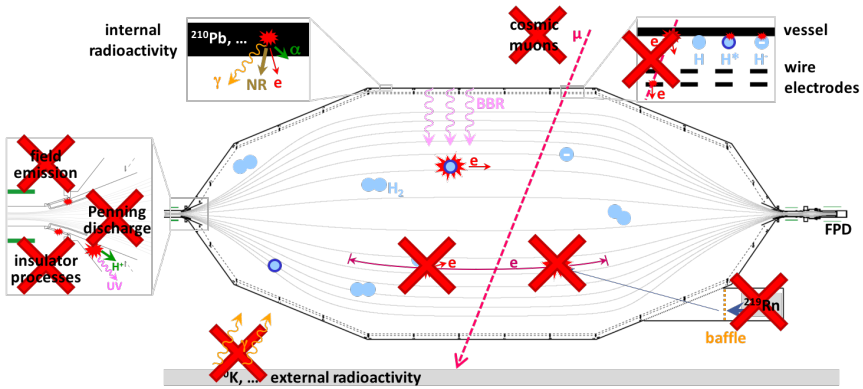


Spectrometer and Detector commissioning

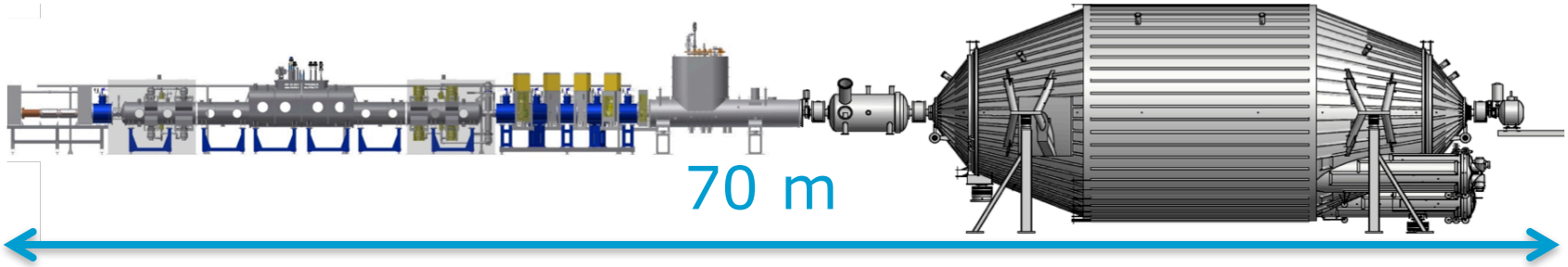
Background processes

- Most known and understood background sources excluded
- Remaining background level: ~312±3 mcps (design goal 10 mcps)
- Current working theory:

  Internal radioactivity + neutral messenger particle
- Third commissioning phase in autumn



Commissioning of whole beam line

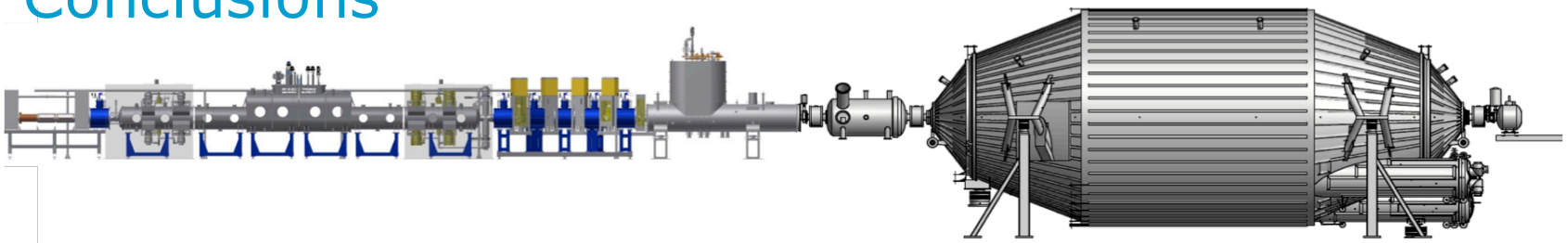


All sub-systems will come online in the next few months

Combined commissioning:

- Interaction of different sub-systems
- Guide electrons from start to end
- Start with inactive source gases (H_2, D_2)
- Slowly increase tritium content (point of no return)

Conclusions



The KATRIN experiment

- Complete beam line on site since Sept. 2015
- Final assembly, site acceptance tests and commissioning ongoing
- Successful SDS commissioning phases already done ➔ more to come
- Combined commissioning of whole system in late-2016
- First light (tritium) in 2016/2017
- Nominal intensity runs in 2017

Thank you!