

Present and Future of the KATRIN Experiment

Susanne Mertens for the KATRIN Collaboration
DBD, October 2014



Karlsruhe Tritium Neutrino Experiment

- Next-generation direct ν -mass experiment
- International Collaboration: 120 members
- 15 institutions in 5 countries: D, US, UK, CZ, RUS
- Reference ν -mass sensitivity: $m(\nu_e) = 200 \text{ meV}$, after 3 years

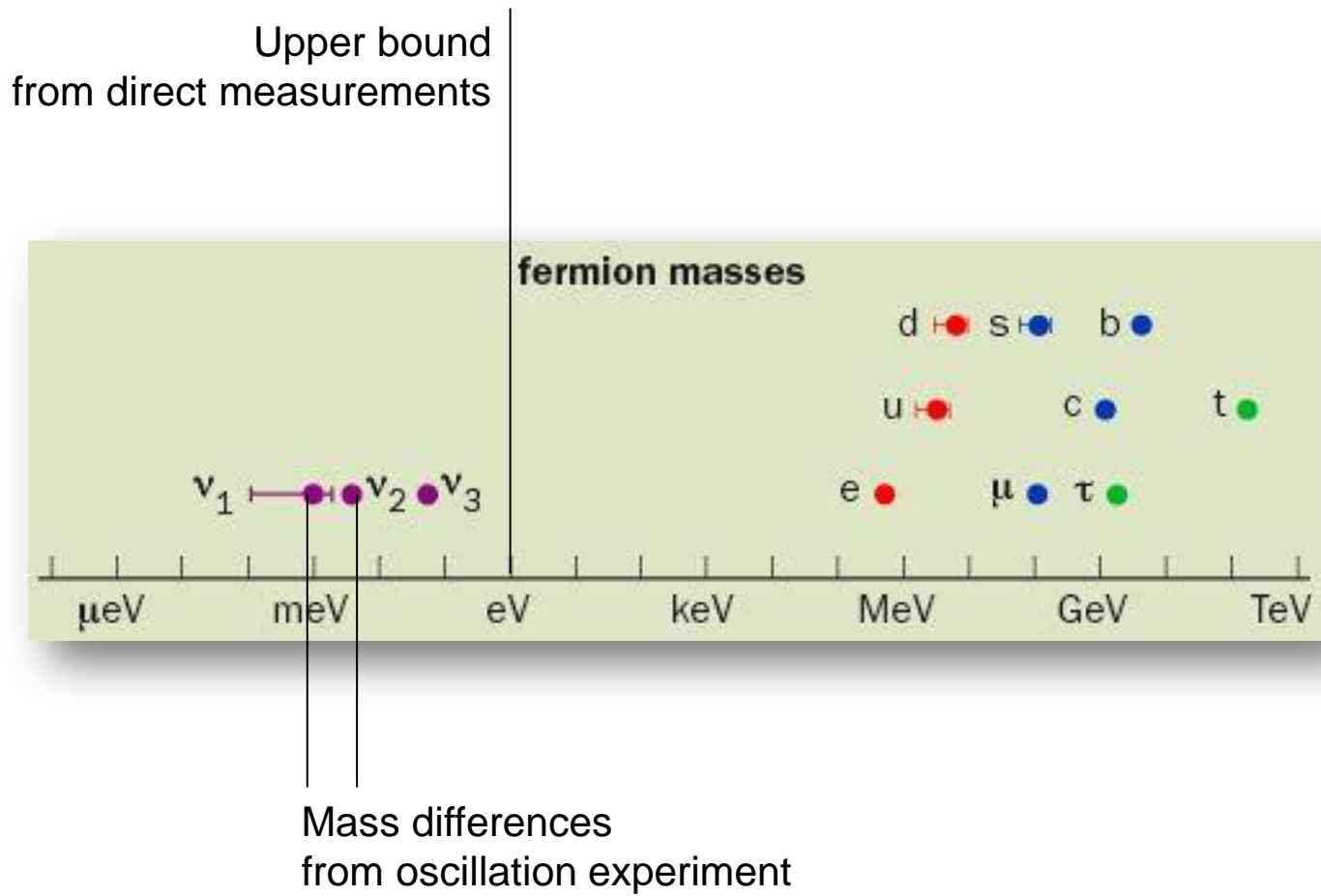


Overview

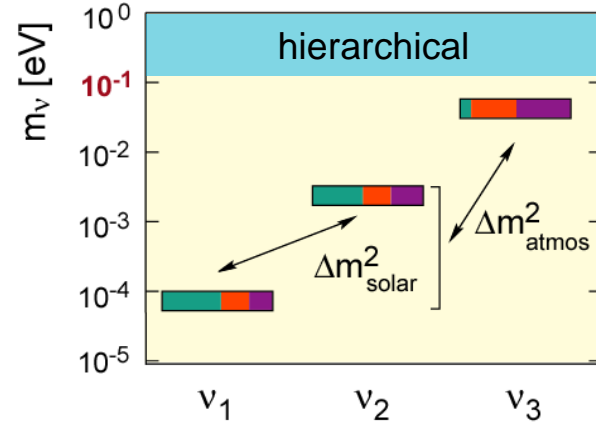
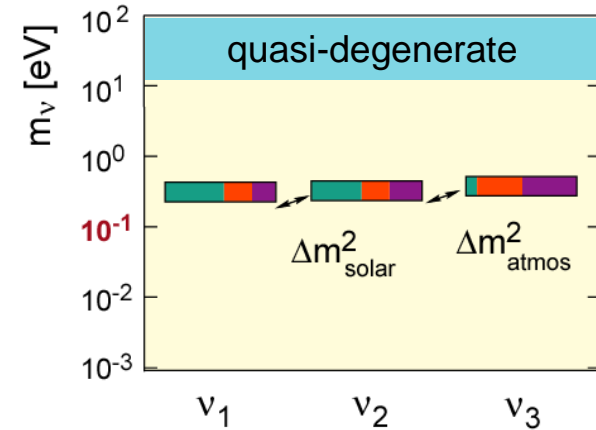
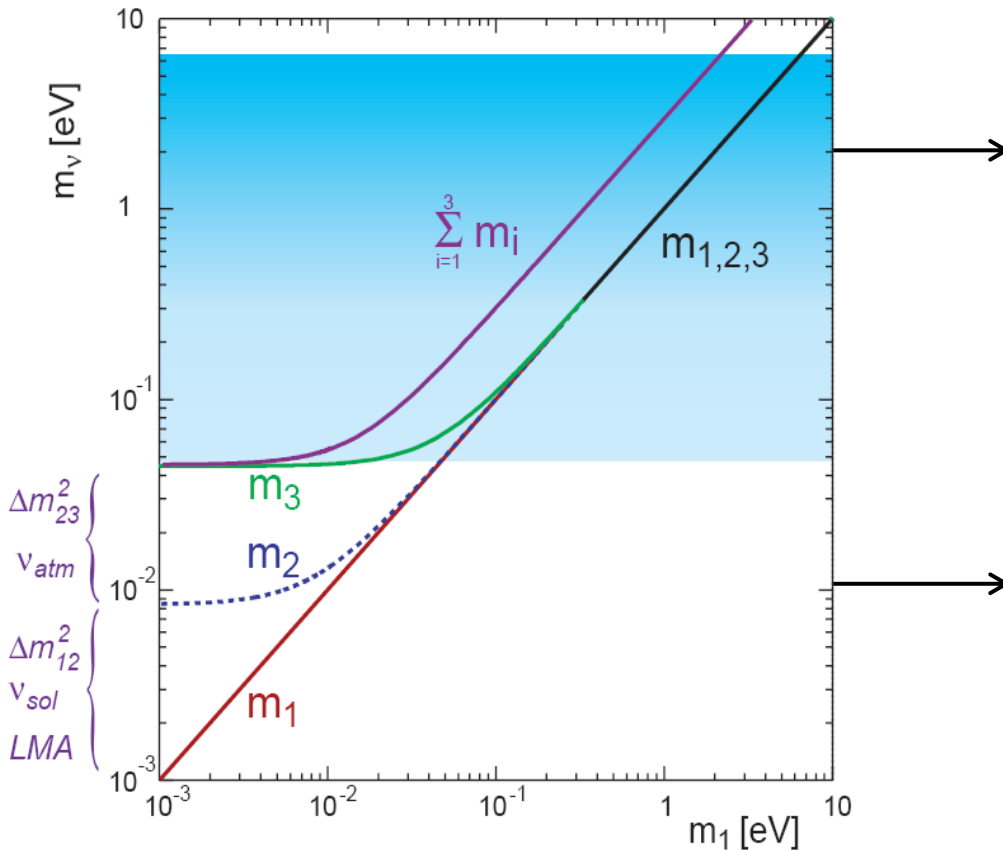
- Why are we interested in the neutrino mass?
- How does KATRIN work?

- Present: Main Spectrometer Commissioning
- Future: Search for sterile Neutrinos

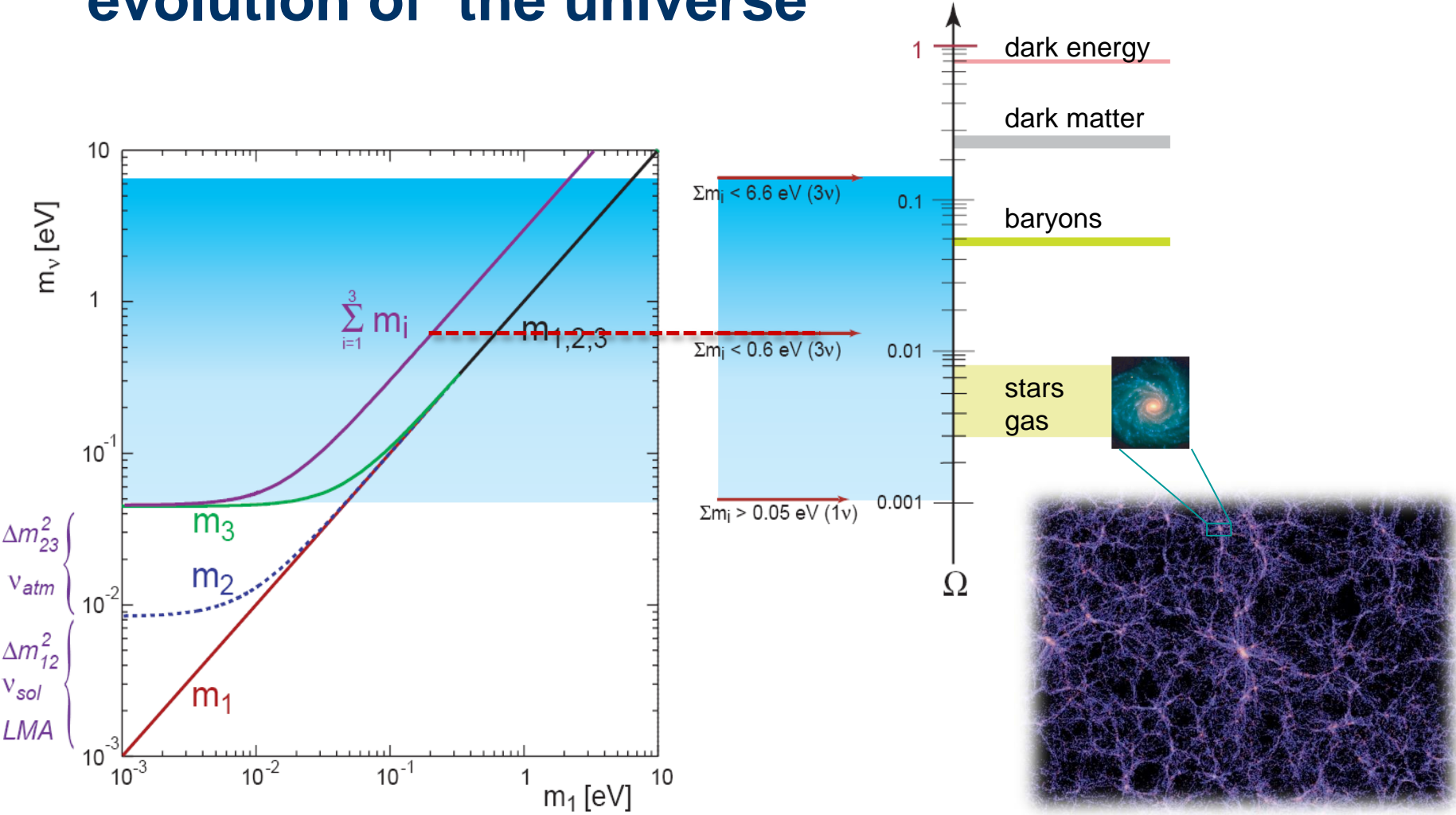
1) How are neutrino masses generated?



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2) What is the role of neutrinos in the evolution of the universe

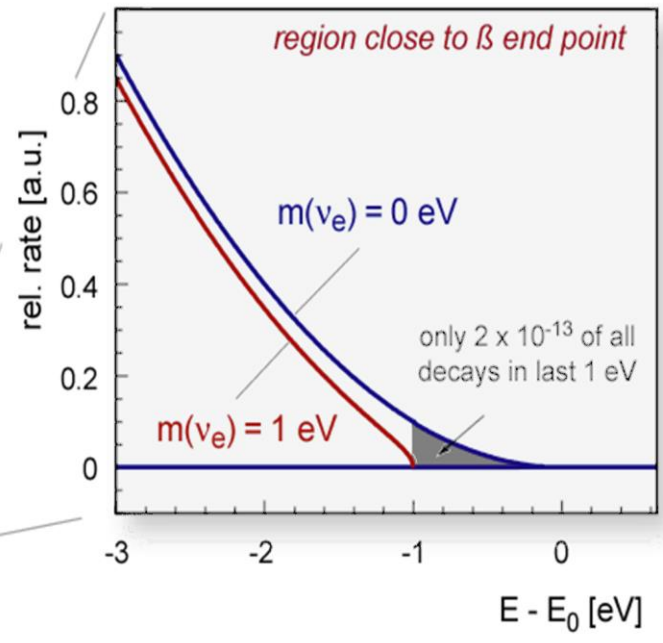
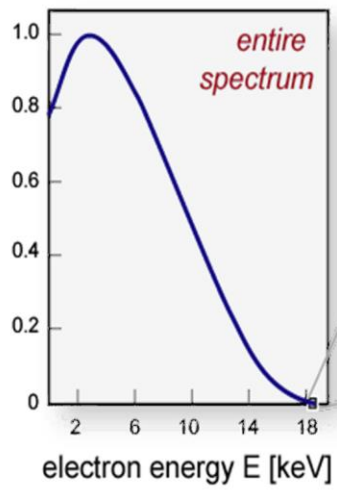
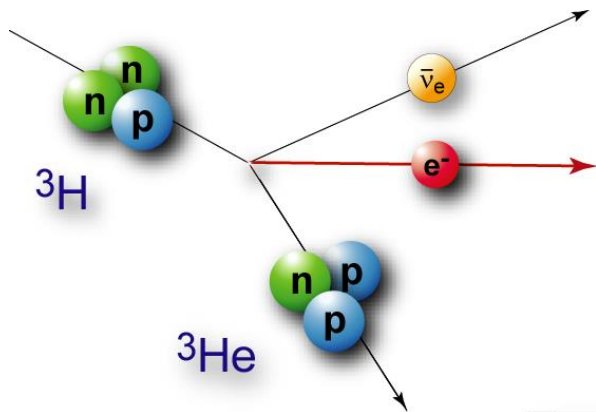


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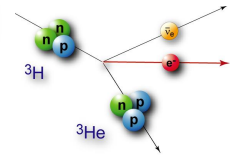
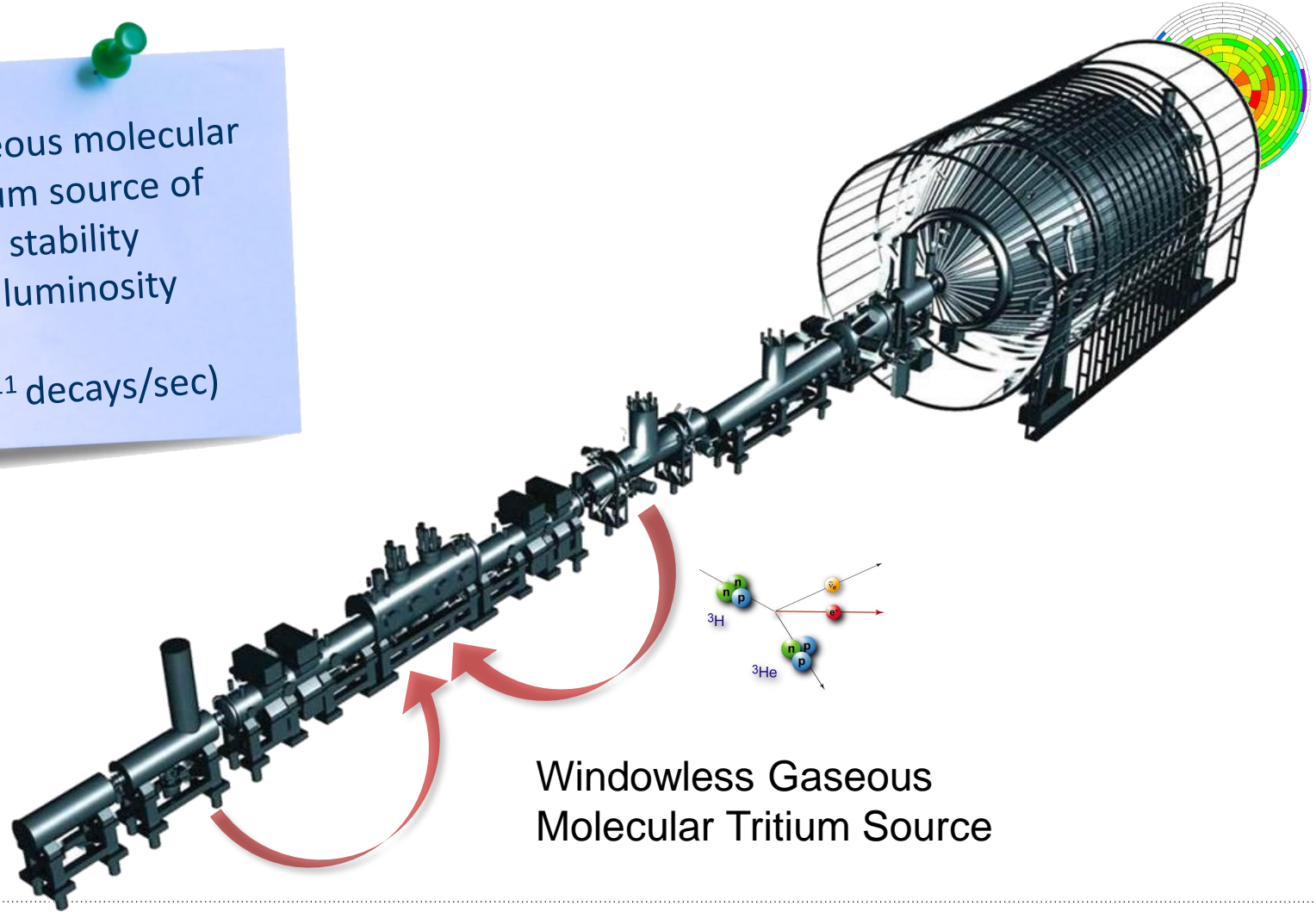
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KATRIN Overview



KATRIN Overview

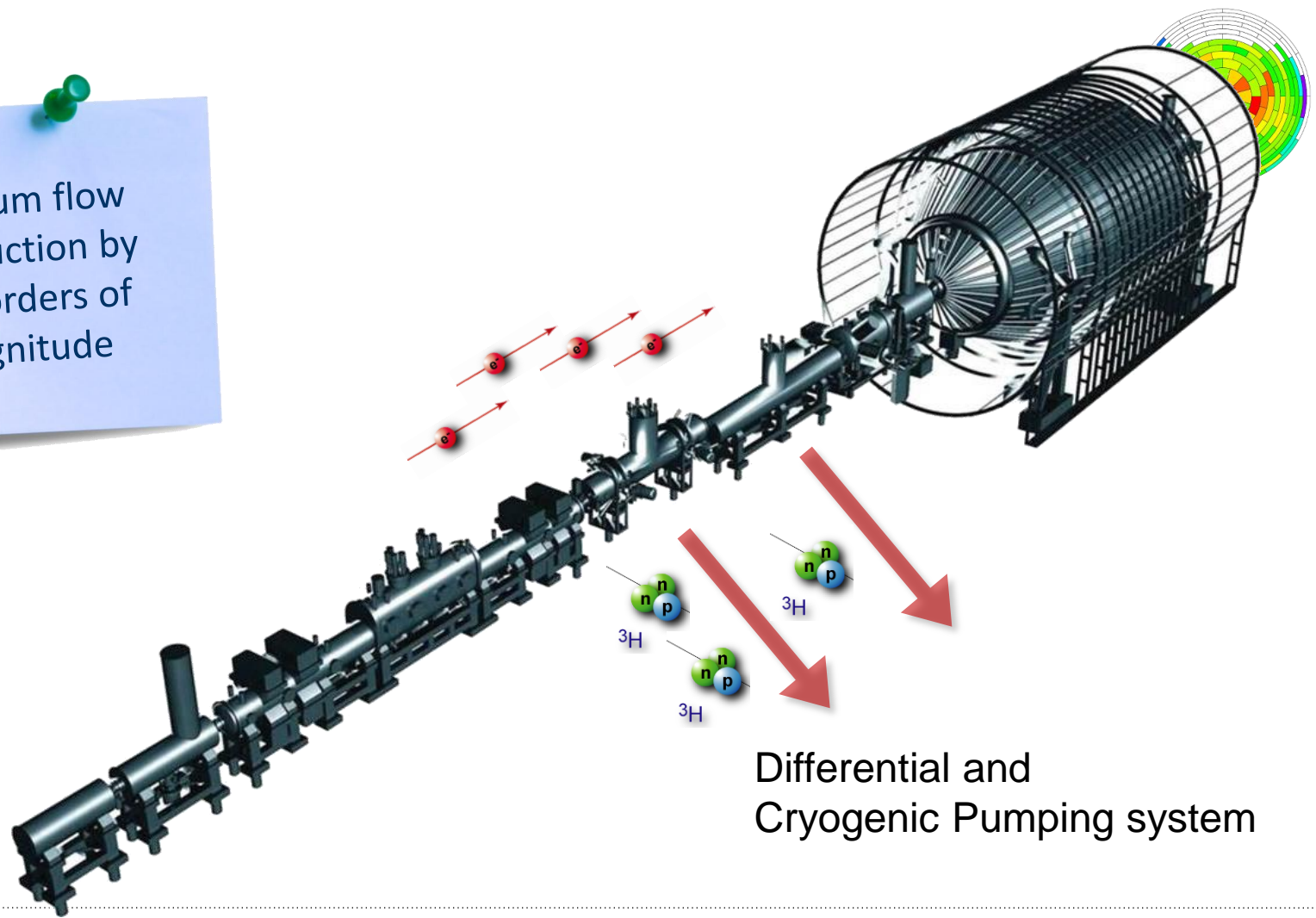
Gaseous molecular tritium source of high stability and luminosity
(10^{11} decays/sec)



Windowless Gaseous Molecular Tritium Source

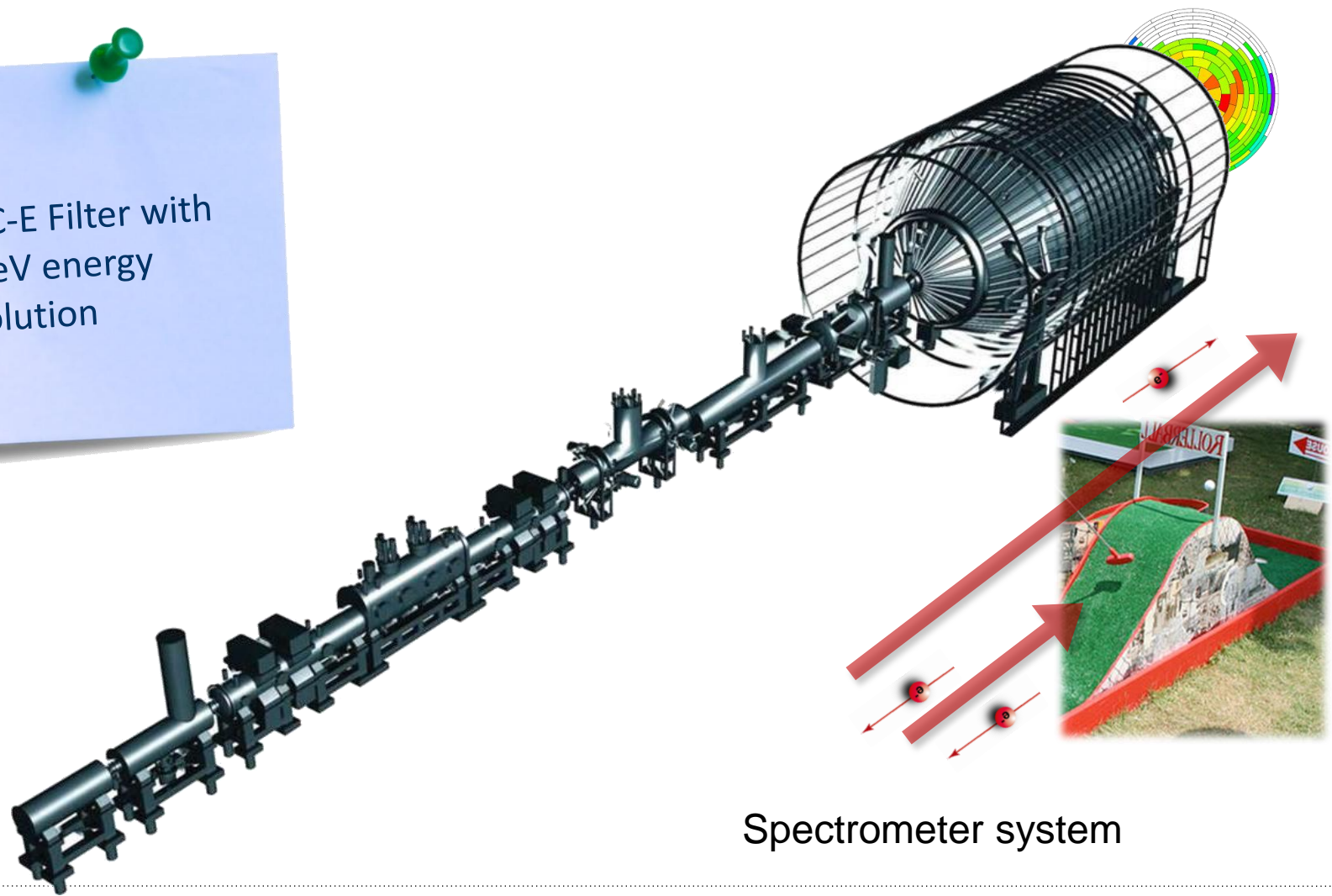
KATRIN Overview

Tritium flow reduction by 14 orders of magnitude



KATRIN Overview

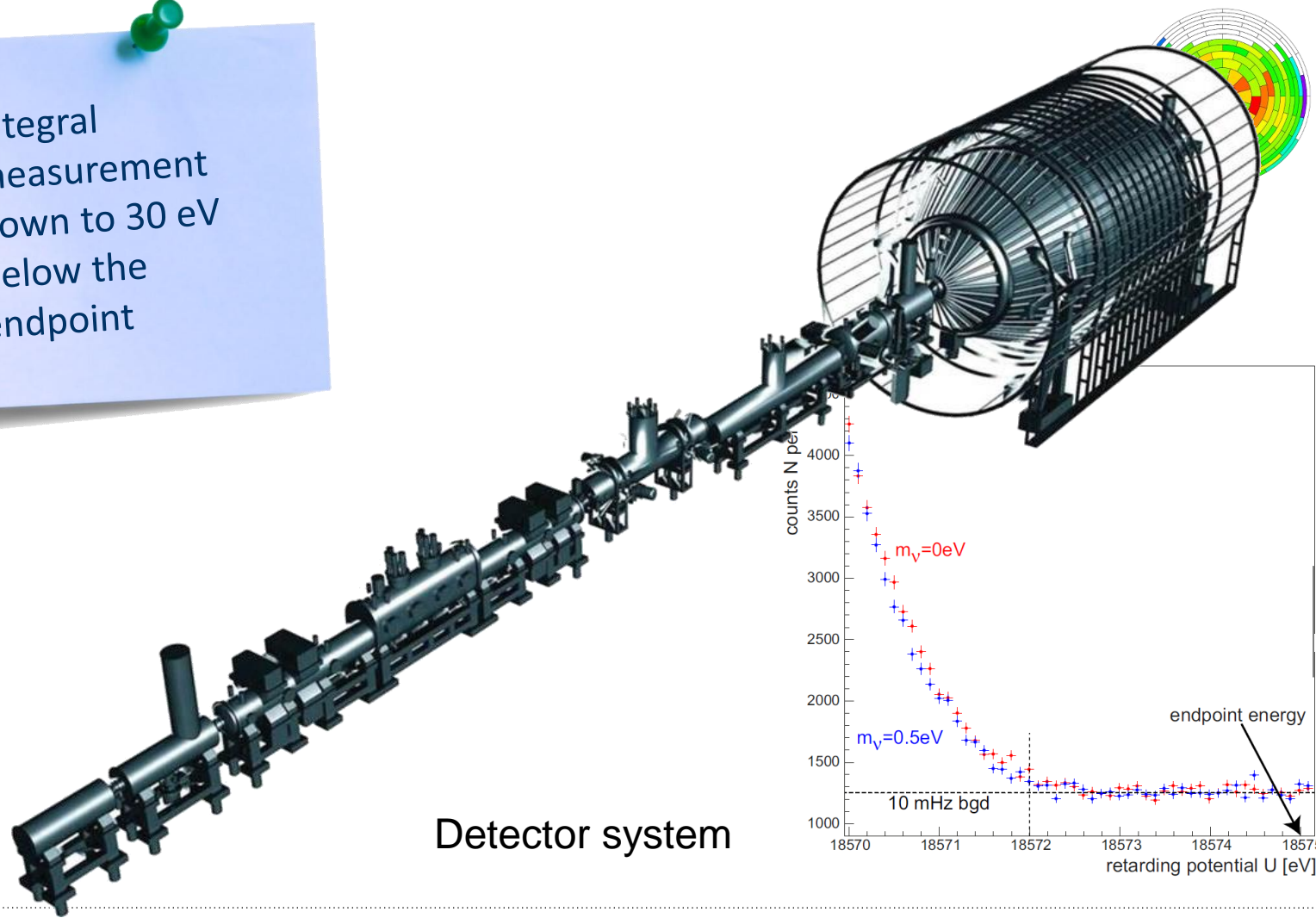
MAC-E Filter with
< 1 eV energy
resolution



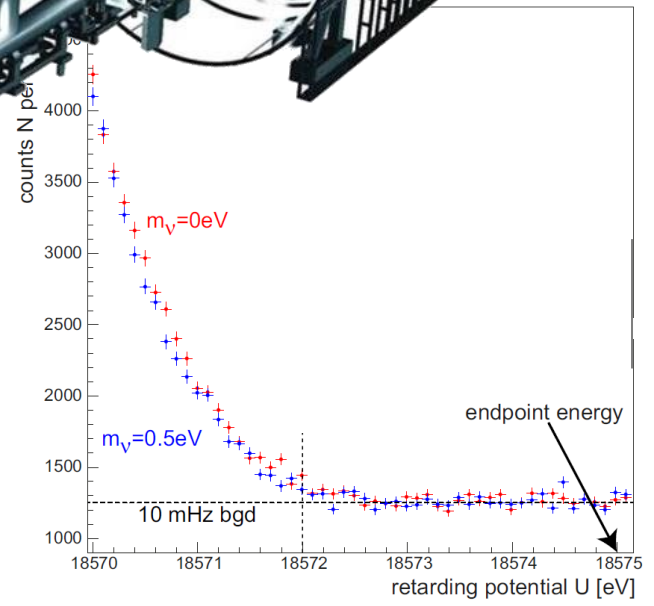
Spectrometer system

KATRIN Overview

Integral measurement down to 30 eV below the endpoint



Detector system



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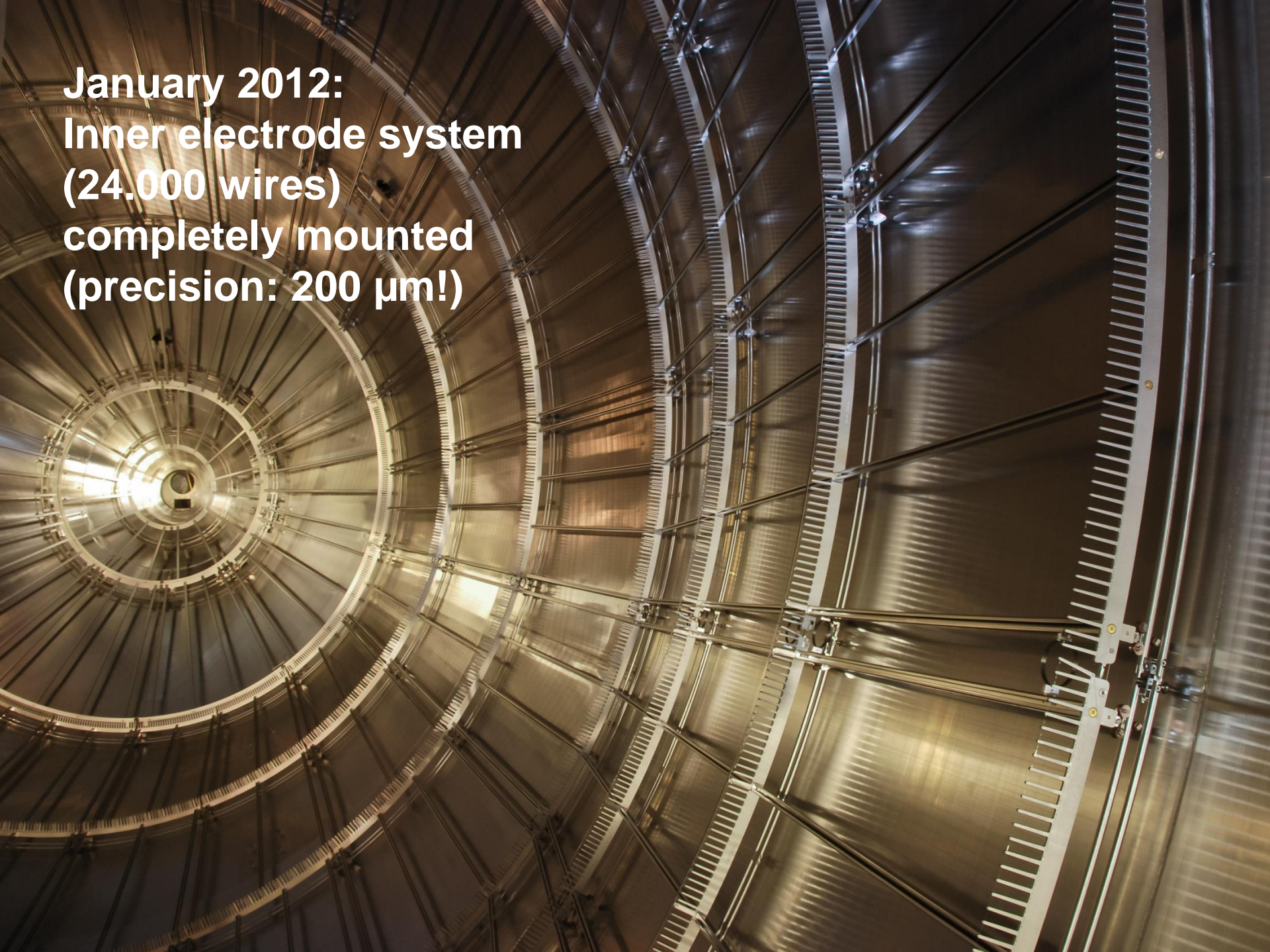
2006: Arrival of Main Spectrometer at KIT



**2011: fully
commissioned Aircoil
system**



**January 2012:
Inner electrode system
(24.000 wires)
completely mounted
(precision: 200 μm !)**

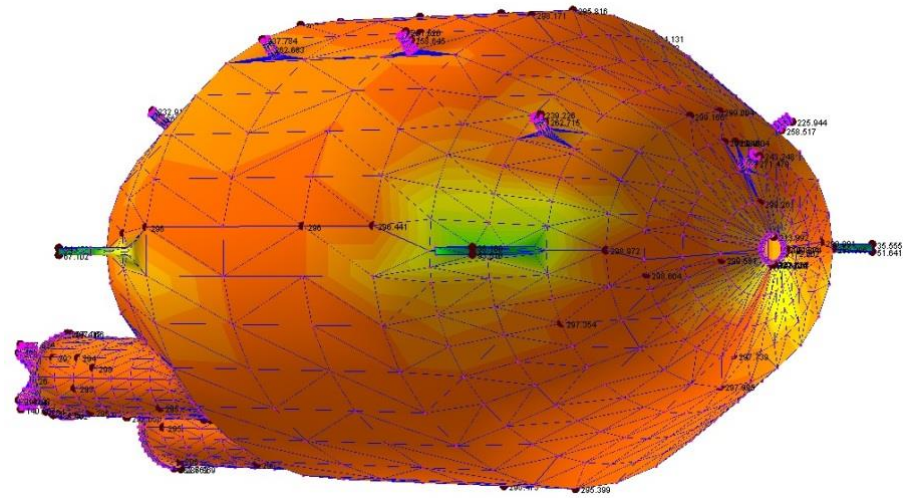


May 8, 2012 14:11
spectrometer pump
ports are closed



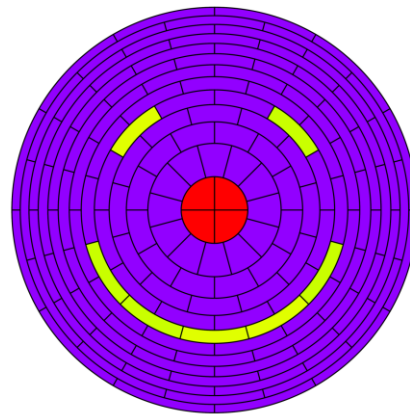
Commissioning of main spectrometer

- Successful bake-out of spectrometer vessel at 300° C
- NEG pump activated: pressure at 5×10^{-11} mbar
- Inner electrode system: no broken wire
- “First light” last summer

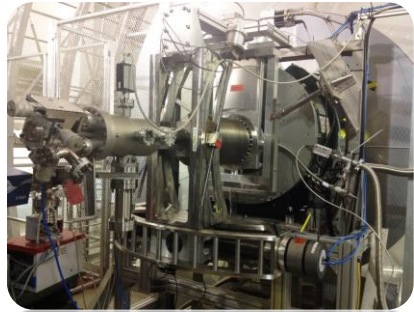


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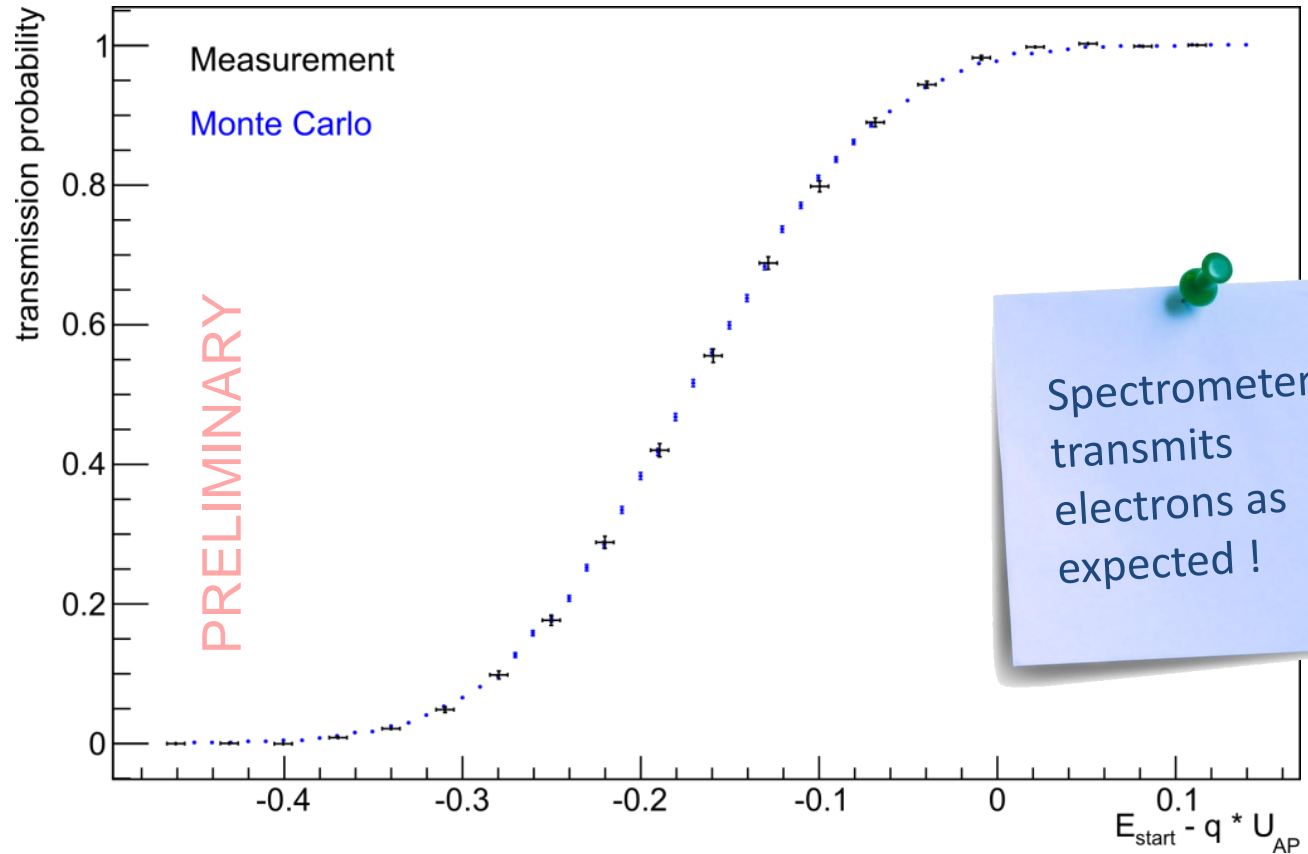
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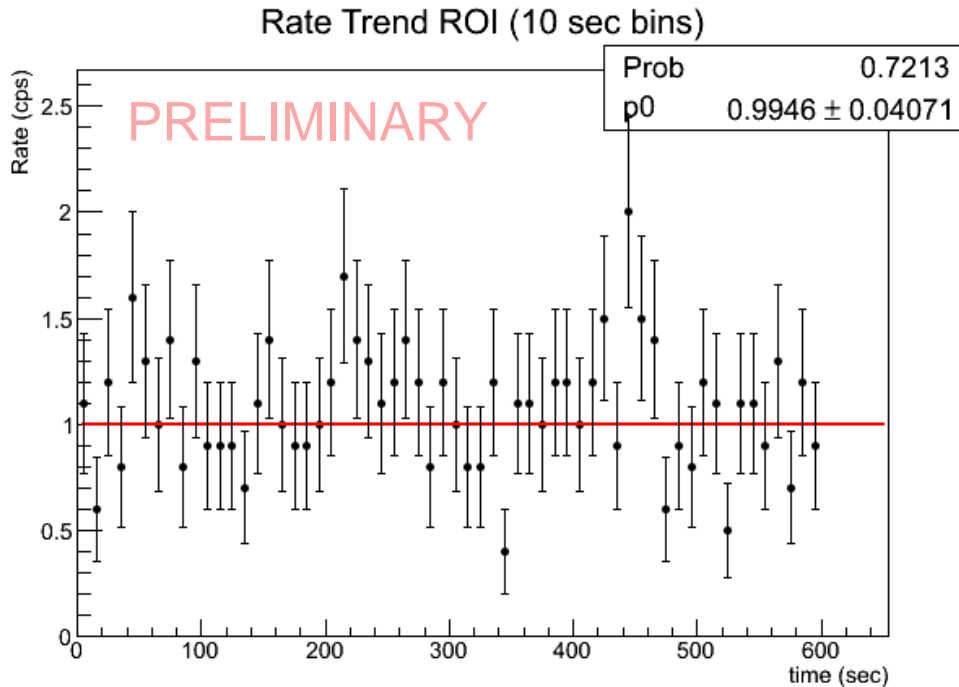
First Transmission Measurement



angular
selective egun



First Background Measurement

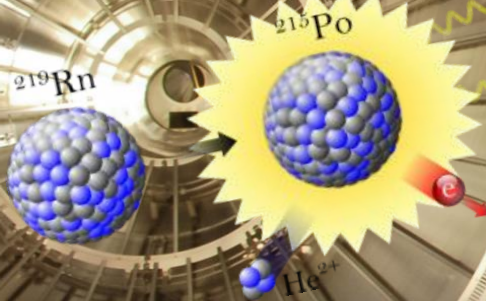


Desired background rate: 10 mcps
Initial measured rate: 1 cps

No Penning
discharge !!!

Magnetic shielding
works !

Radon-induced Background

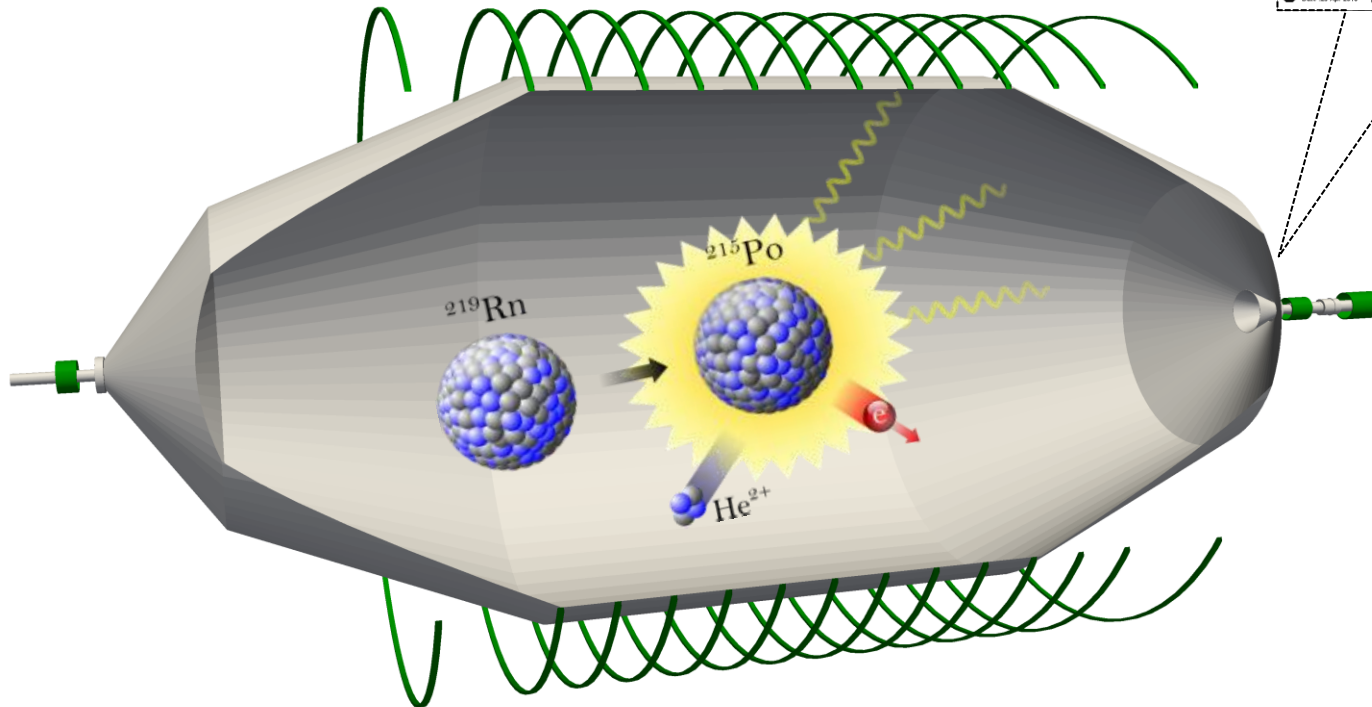
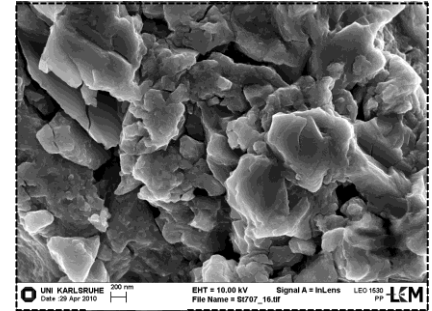


Radon-induced Background

$$t_{1/2}(^{219}\text{Rn}) = 3.96 \text{ s}$$

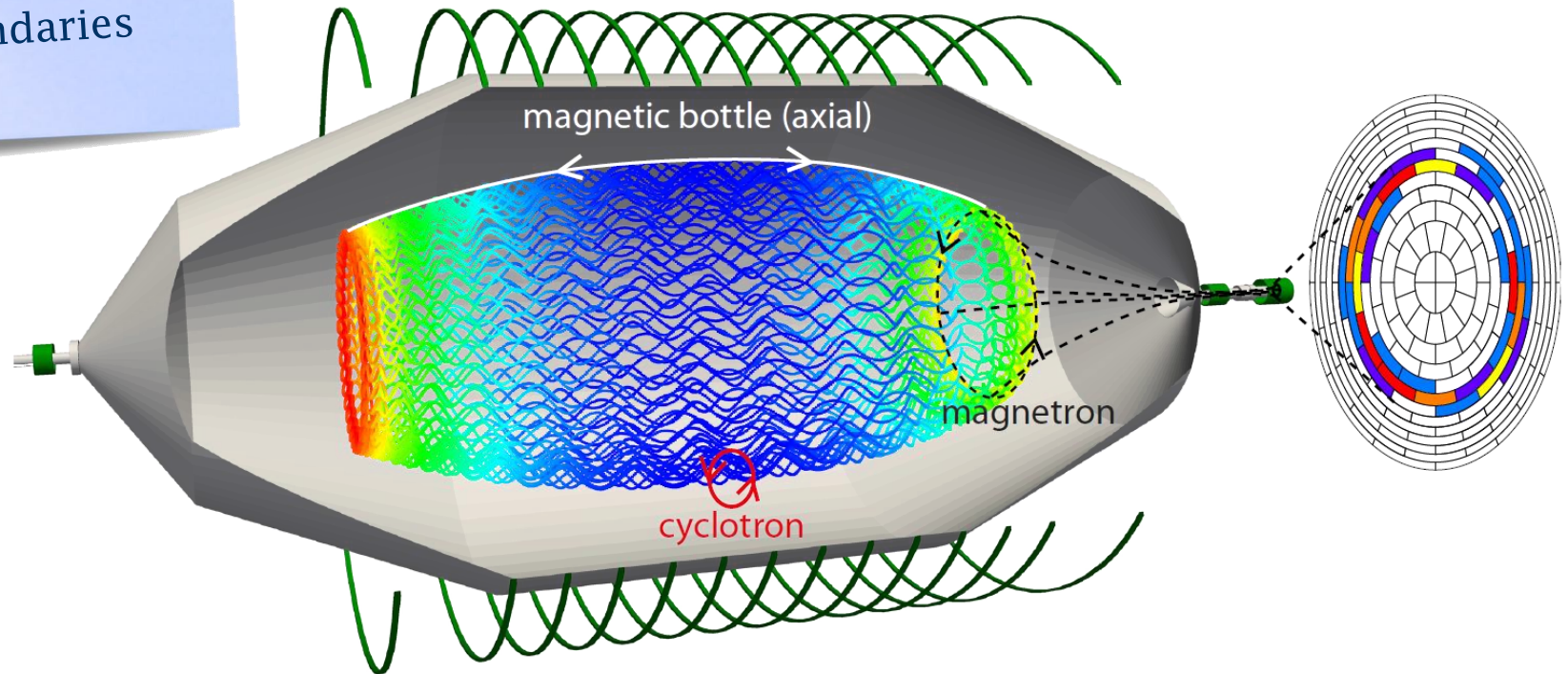
$$t_{1/2}(^{220}\text{Rn}) = 55.6 \text{ s}$$

Getter pump

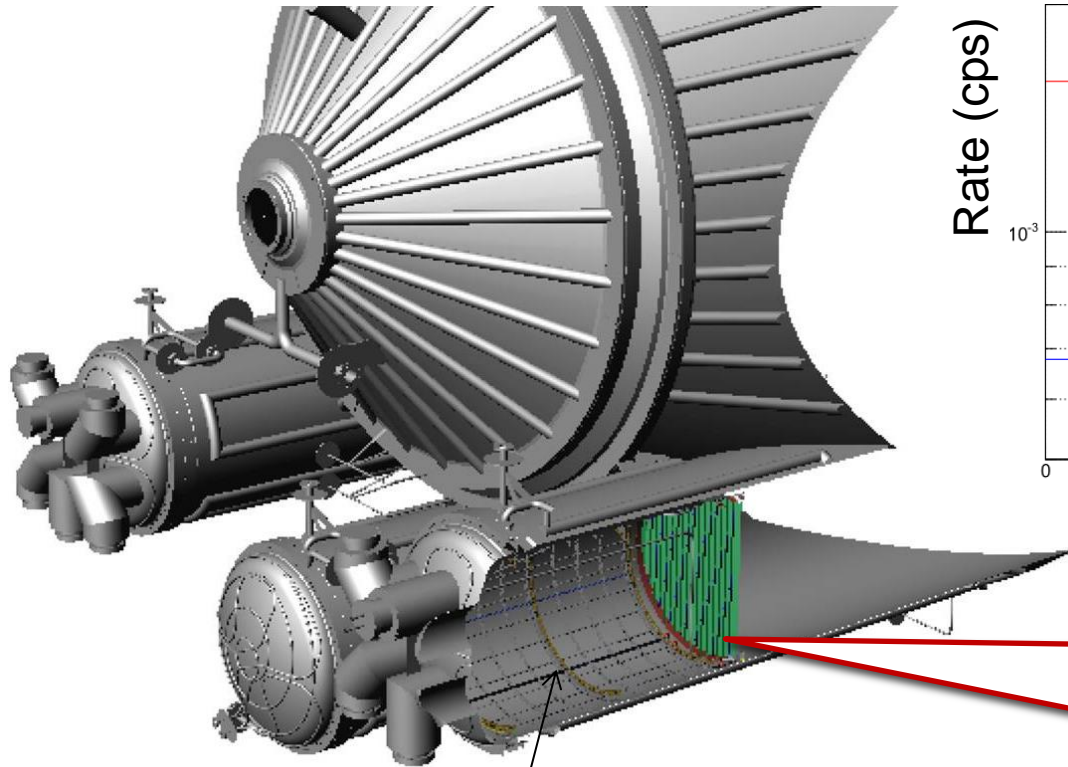


Radon-induced Background

Single Radon decay produces hundreds of secondaries

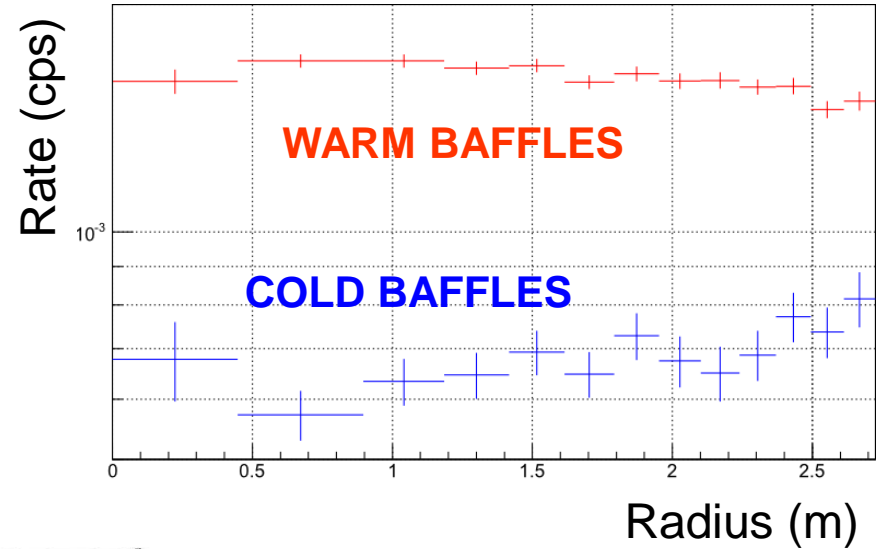


Passive Reduction Technique



Getter pump

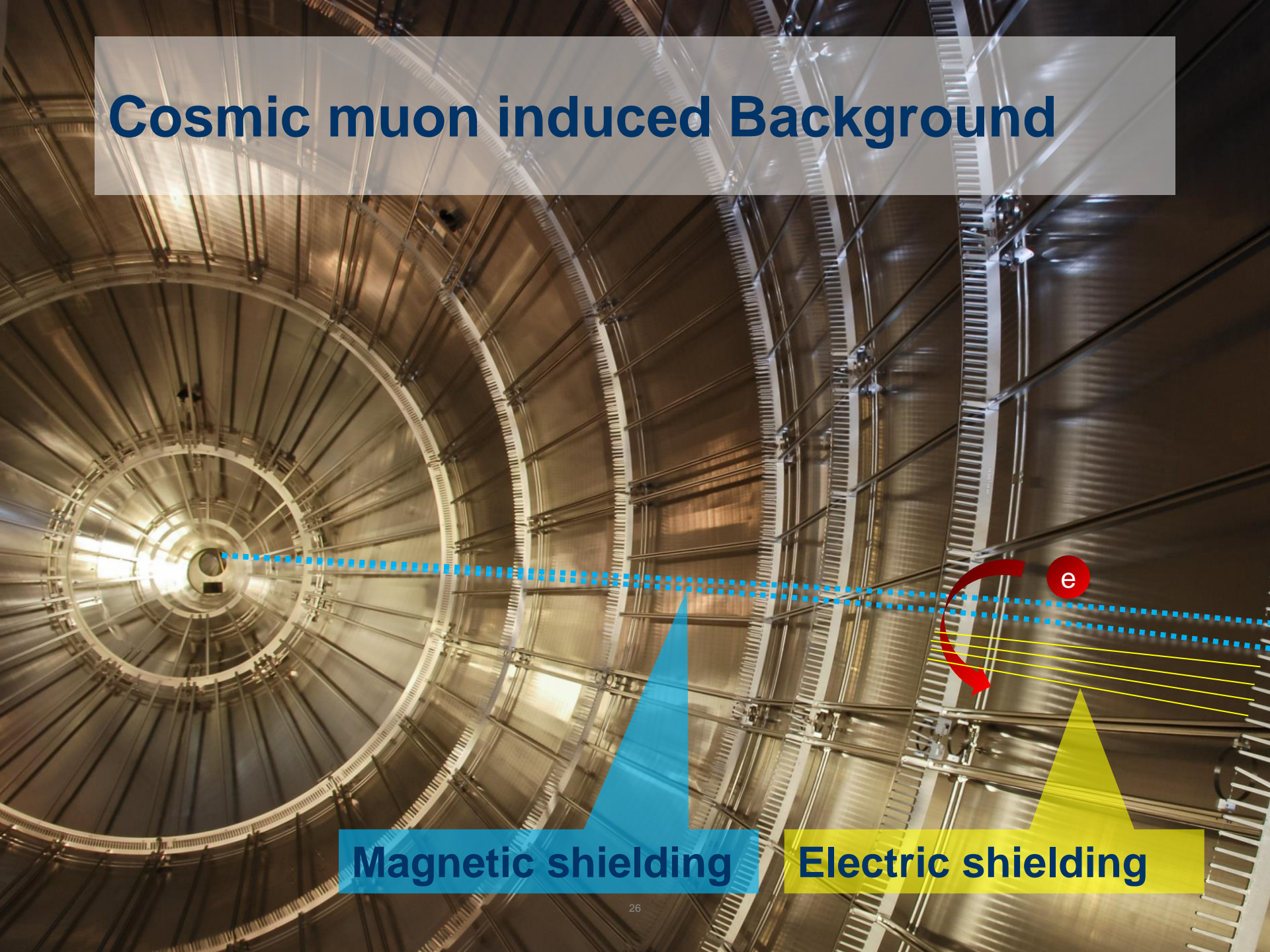
LN2 cooled baffle



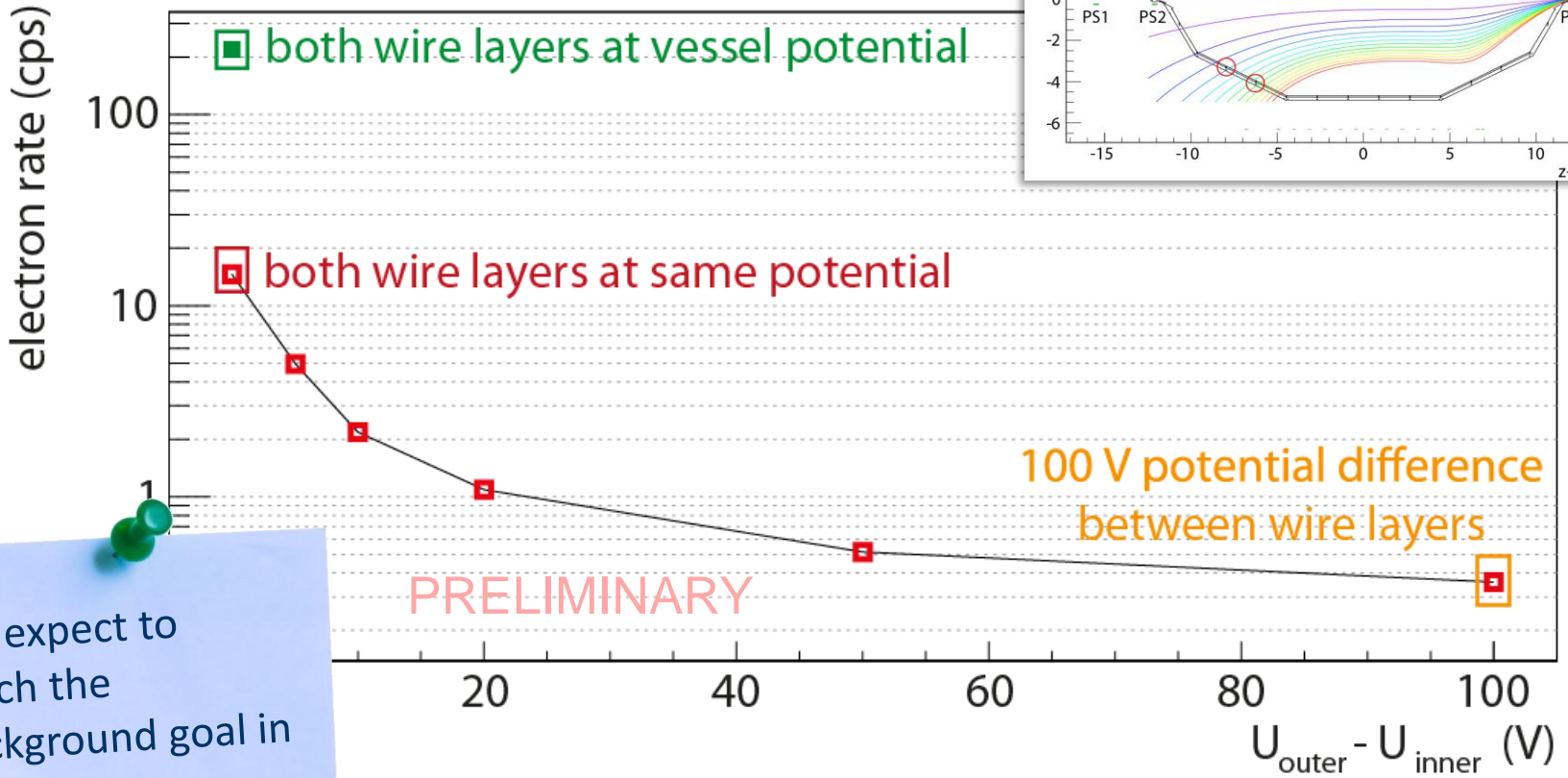
Cosmic muon induced Background

Magnetic shielding

Electric shielding



Effect of wire electrode



We expect to reach the background goal in the next measurement phase!

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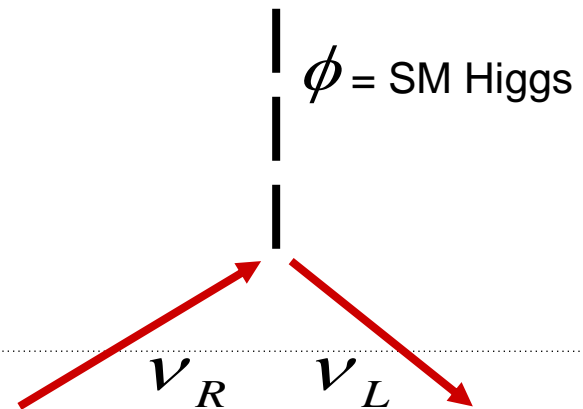
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Sterile neutrinos

$$\begin{array}{ccc}
 \begin{pmatrix} u \\ d \end{pmatrix}_L & \begin{pmatrix} c \\ s \end{pmatrix}_L & \begin{pmatrix} t \\ b \end{pmatrix}_L \\
 u_R & c_R & t_R \\
 d_R & s_R & b_R
 \end{array}$$

$$\begin{array}{ccc}
 \begin{pmatrix} \nu_e \\ e \end{pmatrix}_L & \begin{pmatrix} \nu_\mu \\ \mu \end{pmatrix}_L & \begin{pmatrix} \nu_\tau \\ \tau \end{pmatrix}_L \\
 \hline
 - & - & - \\
 e_R & \mu_R & \tau_R
 \end{array}$$

Right-handed neutrinos do not interact
 ... but can mix with the active neutrinos
 ... and form new mass eigenstates



Sterile neutrinos of different masses

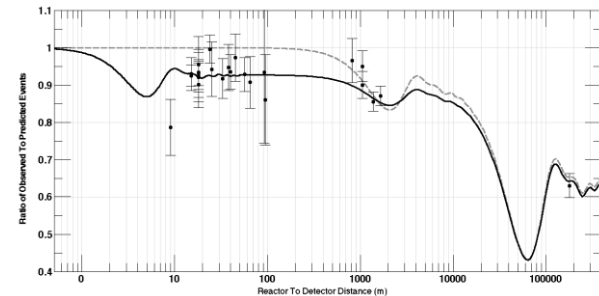
Heavy sterile neutrinos (\sim GeV)

- Lightness of neutrinos via See-saw mechanism



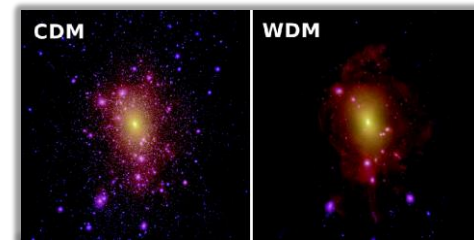
Light sterile neutrinos (\sim 1 eV)

- Reactor anomaly, Gallium anomaly, Short baseline accelerator results



KeV-scale sterile neutrinos (\sim 1- 50 keV)

- Warm and Cold dark matter candidate



Sterile neutrinos of different masses

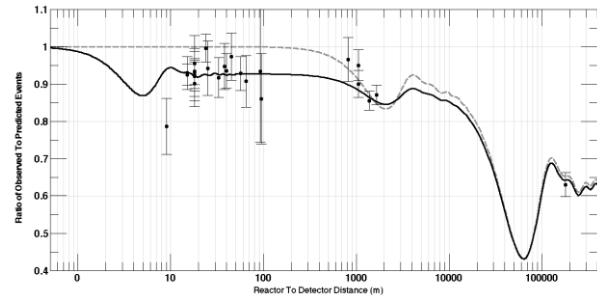
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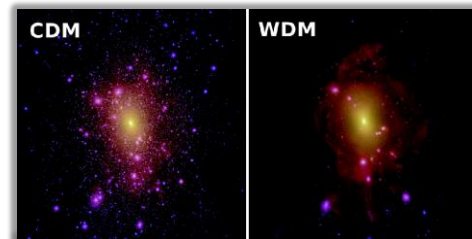
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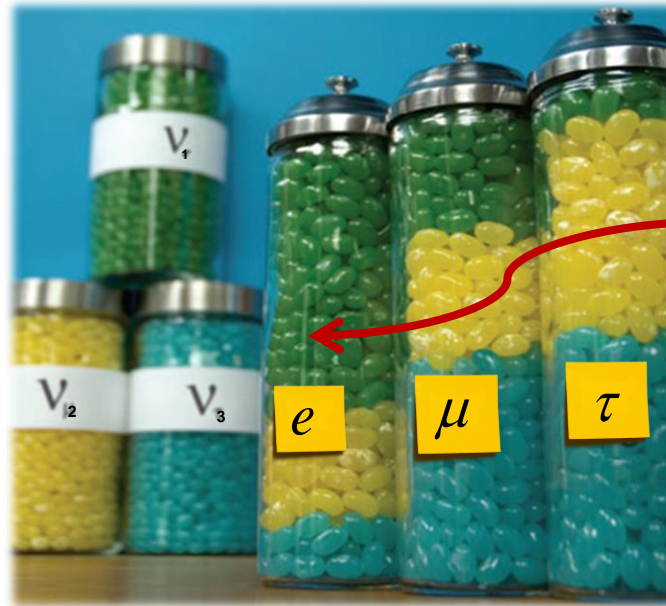
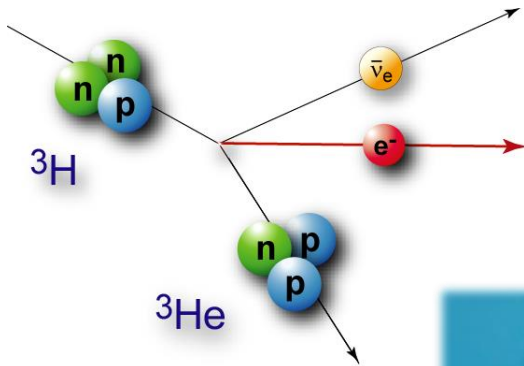


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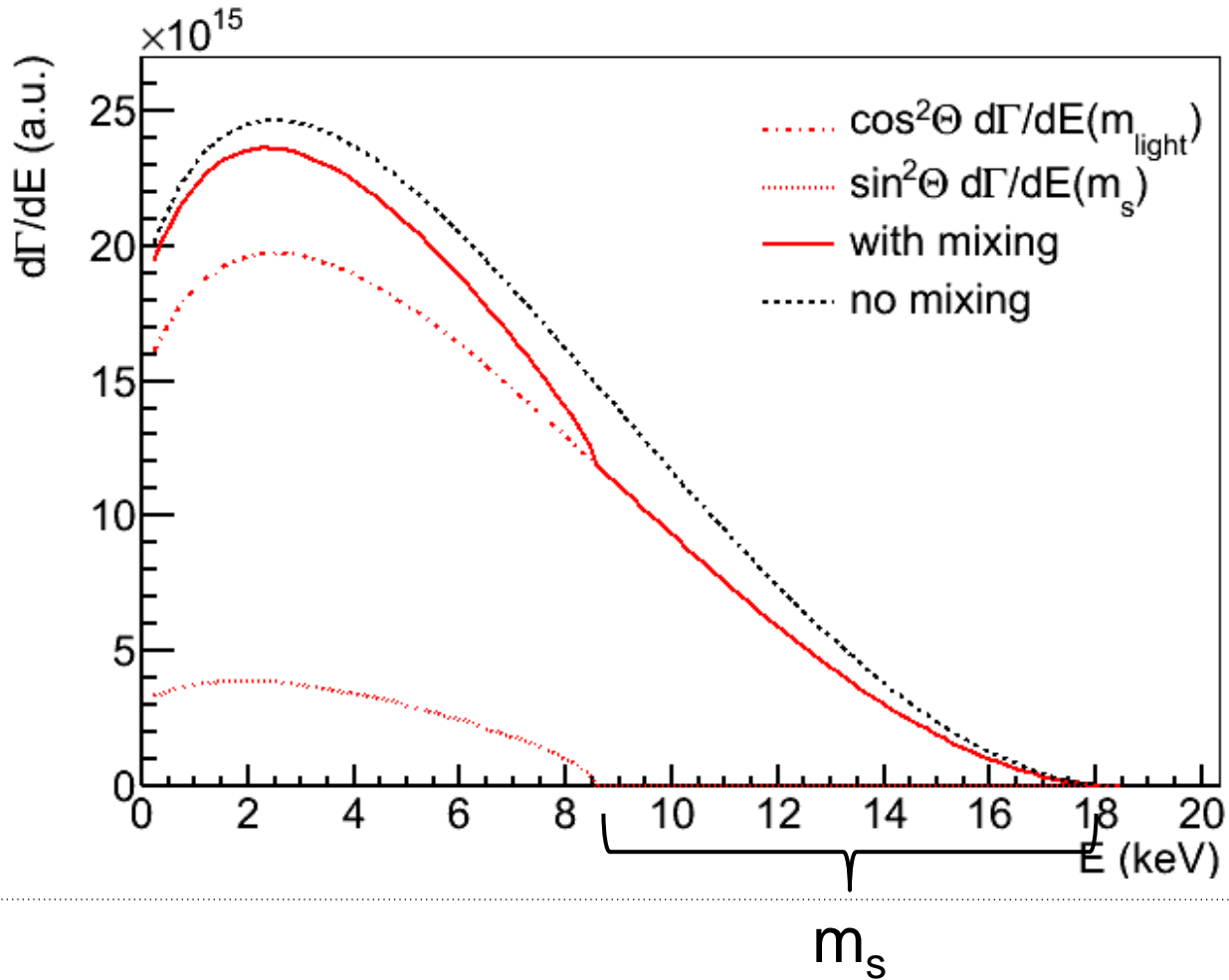


Imprint of sterile ν 's on β -spectrum

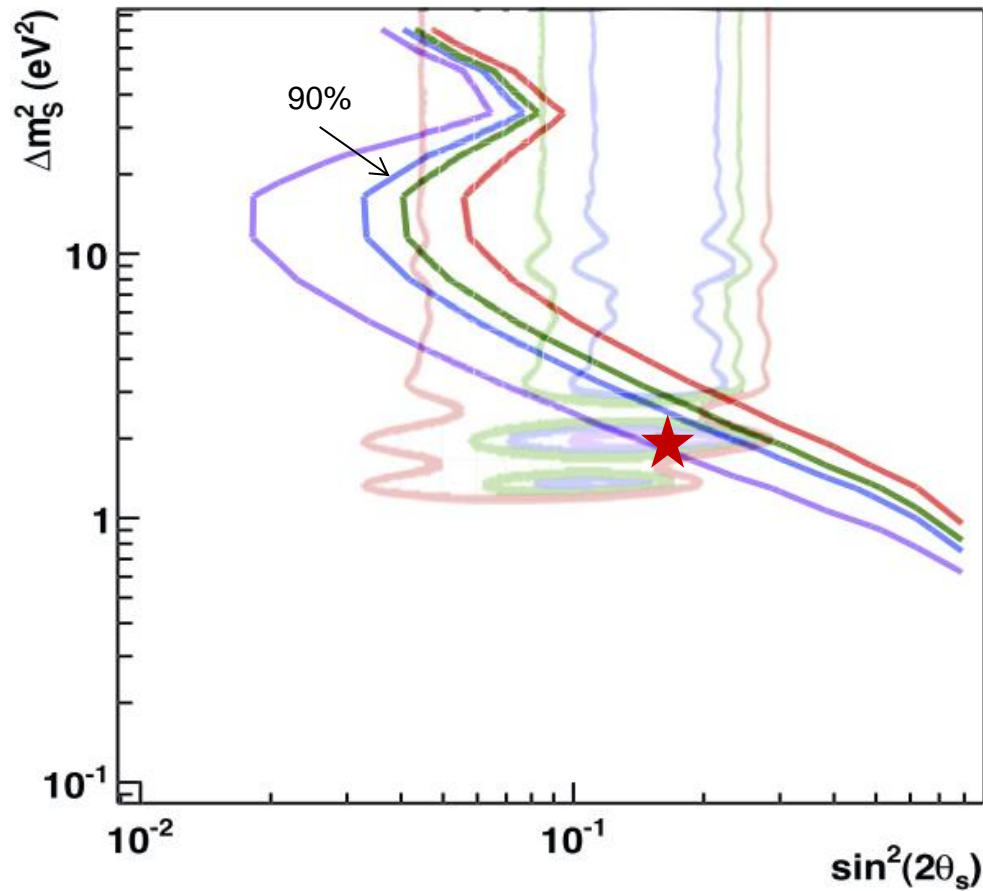


New mass eigenstate

Imprint of sterile ν 's on β -spectrum



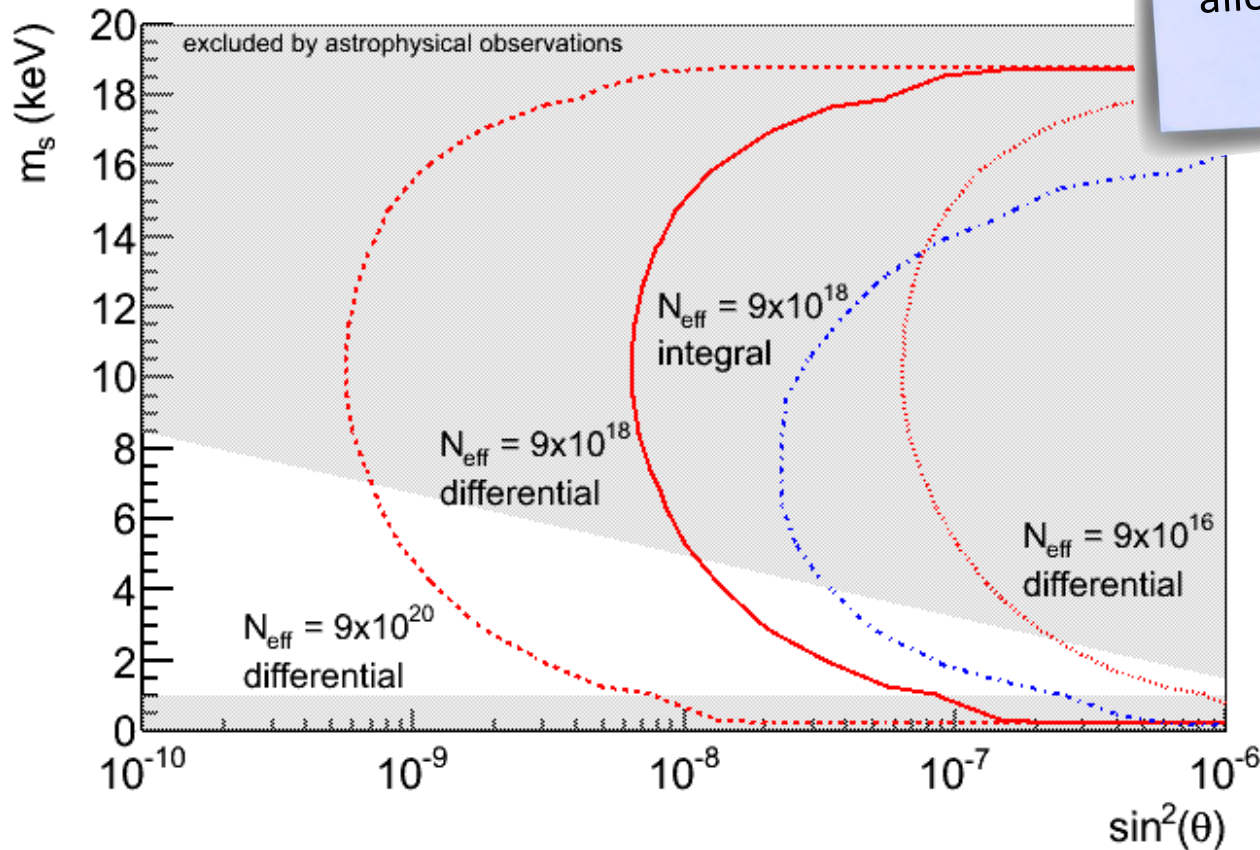
KATRIN's sensitivity for eV ν 's



KATRIN probes the favored parameter space

Statistical Sensitivity for keV ν 's

Upgraded "KATRIN"
provide interesting
statistical sensitivity
to astrophysically
allowed region



Summary

- KATRIN is designed to directly measure the neutrino mass with a sensitivity of 200meV (90%CL) after 3 years of measurement time
- Successful commissioning of main spectrometer
 - Vacuum
 - Transmission
 - Background
- Next measurement phase starts next week
- Start of Tritium measurements: 2016
- Promising potential for sterile neutrino search

Thanks for your attention

Signature of eV neutrinos

