Status of the KATRIN Experiment

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Carnegie Mellon University

DPF-Pheno, May 14th, 2024

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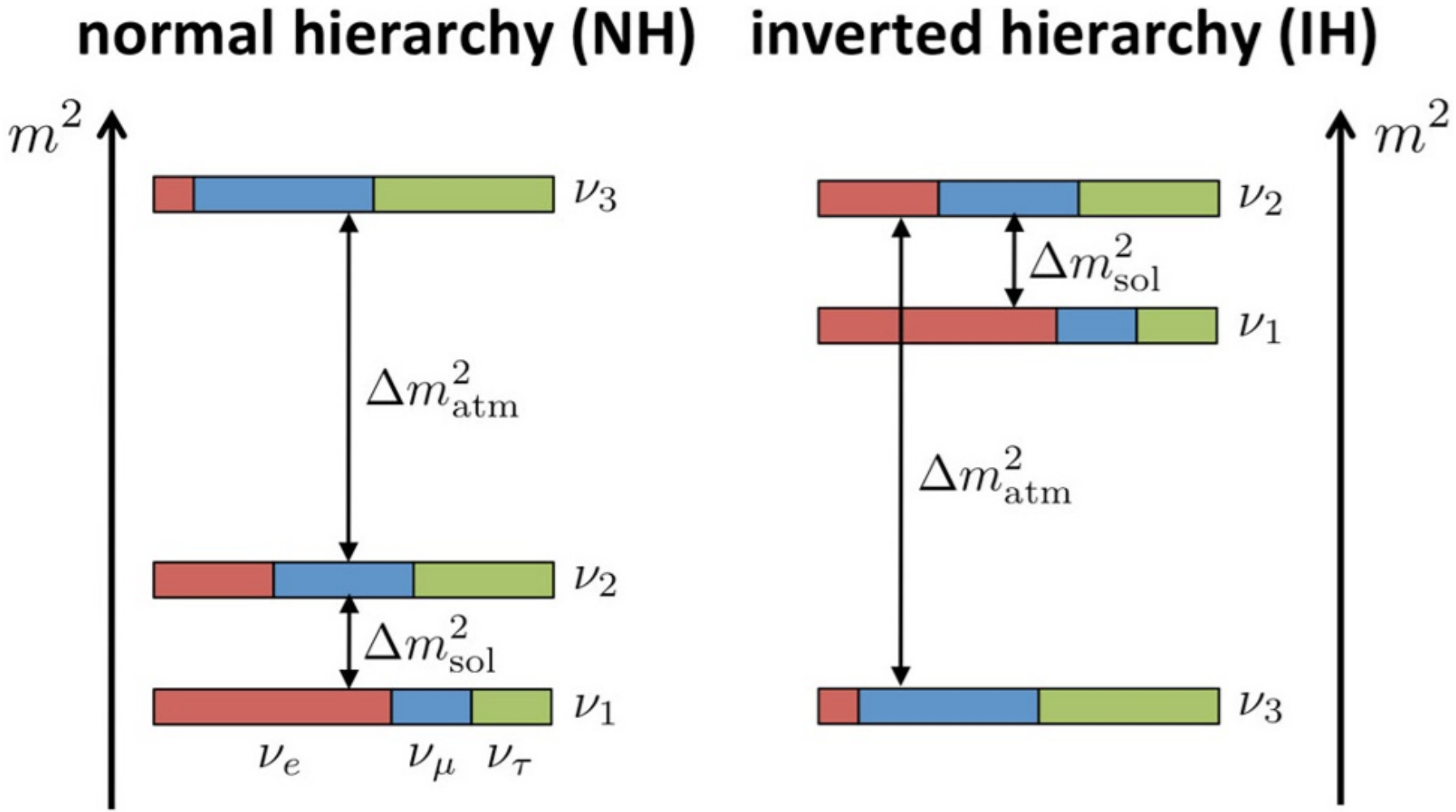
Determining Neutrino Mass Splittings via Oscillations



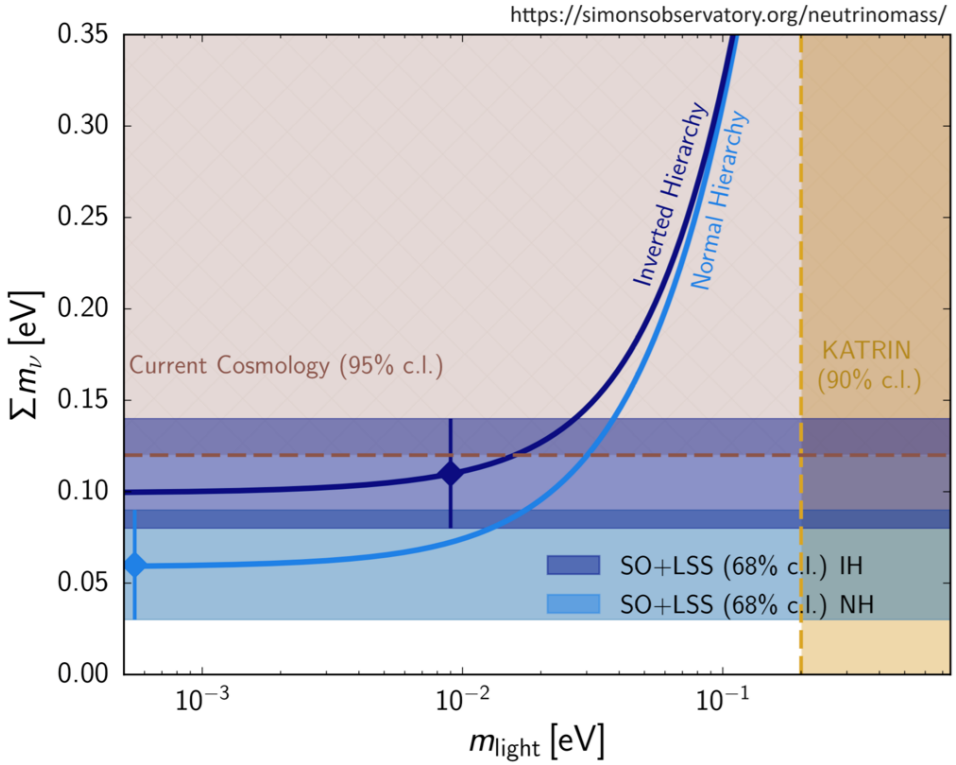
Which neutrino is the lightest? | All Things Neutrino (fnal.gov)

Determining the Sum of Neutrino Masses via Cosmology

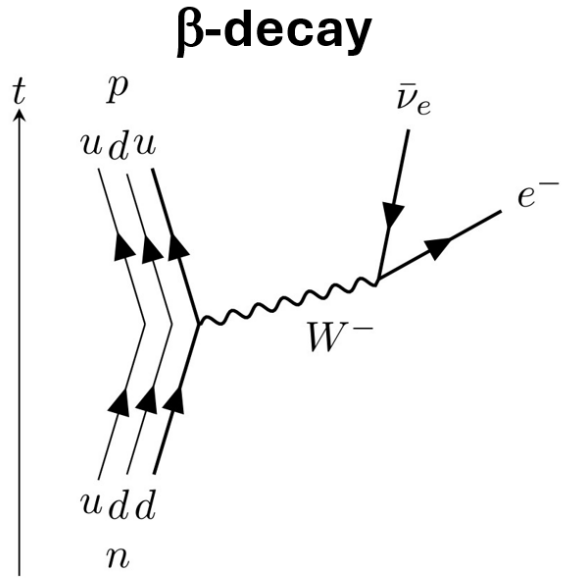
From cosmology, we can learn the sum of neutrino masses:

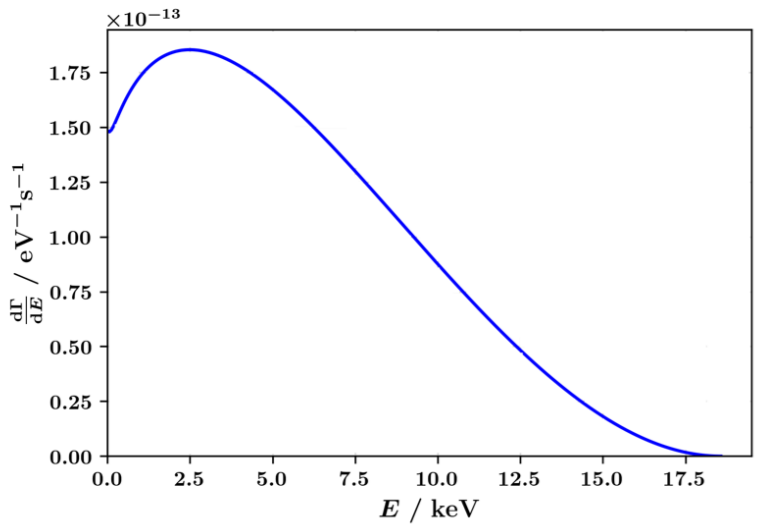
$$\Sigma_i m(\nu_i) = m(\nu_1) + m(\nu_2) + m(\nu_3)$$

This method is extremely sensitive, but the results are dependent on the model used...



Directly Measuring the Neutrino Mass via Kinematics





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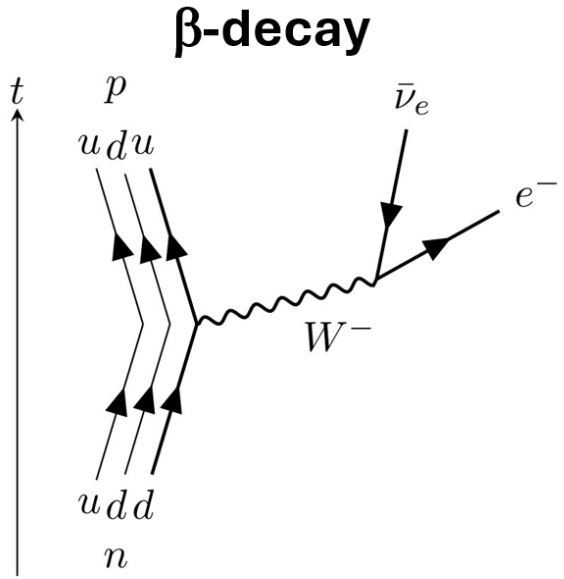
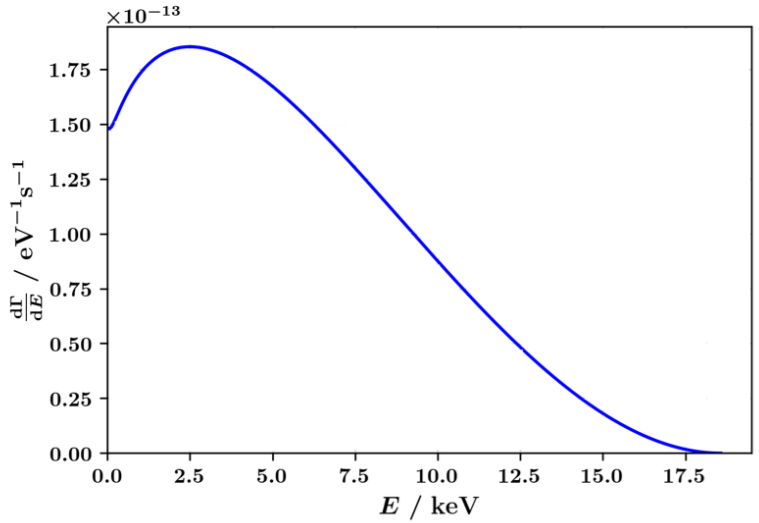
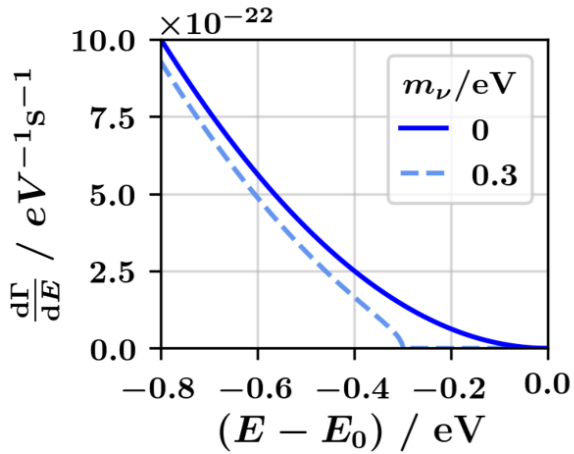
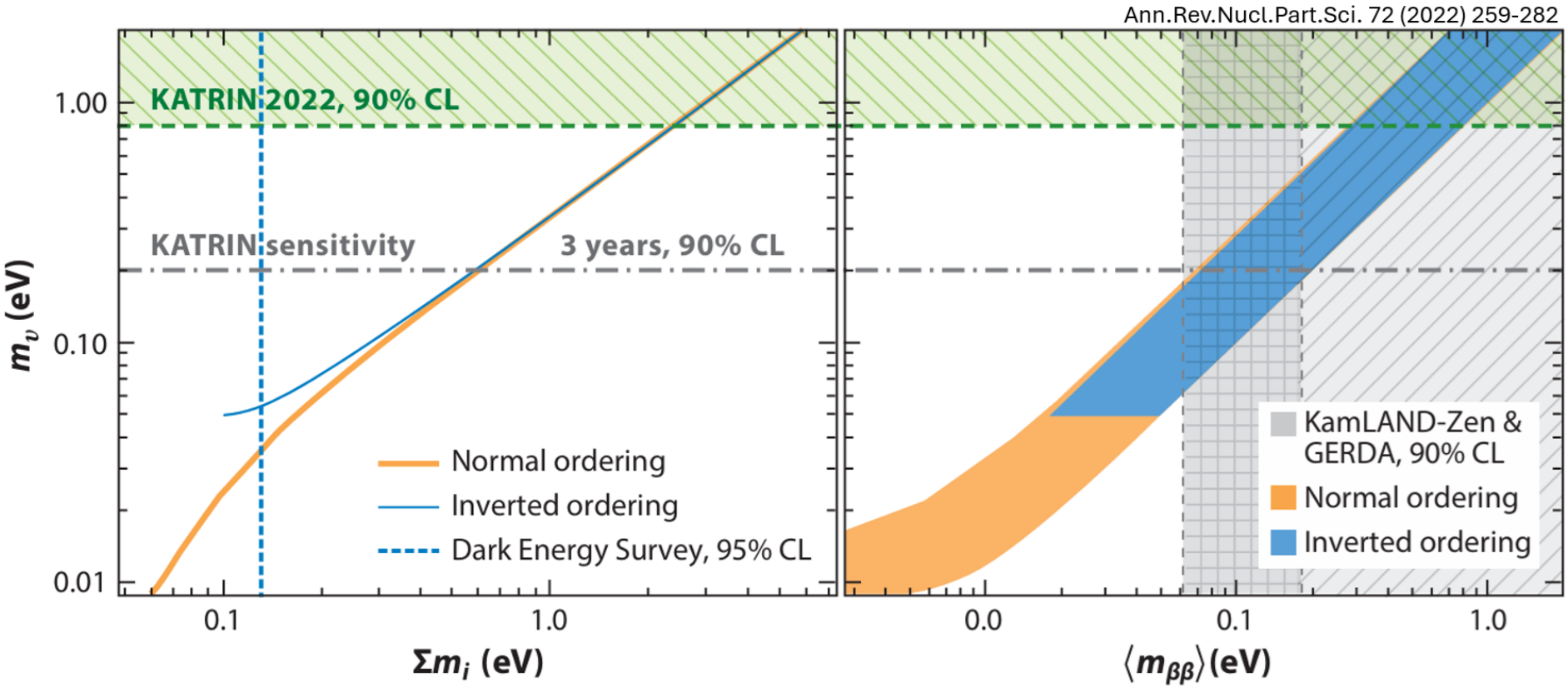




The neutrino mass scale can be probed by analyzing the shape change in the β-spectrum near the endpoint.



These Neutrino Mass Observables Are Interconnected...



Σm_i: Observable via cosmology

$$\Sigma_i m(\nu_i) = m(\nu_1) + m(\nu_2) + m(\nu_3)$$

$\langle m_{\beta\beta} \rangle$: Observable via neutrinoless double β-decay experiments

$$m_{\beta\beta} = |\Sigma_i U_{ei}^2 m(\nu_i)|$$

m_ν: Direct neutrino mass determination

$$m^2(\nu_e) = \Sigma_i |U_{ei}|^2 m^2(\nu_i)$$

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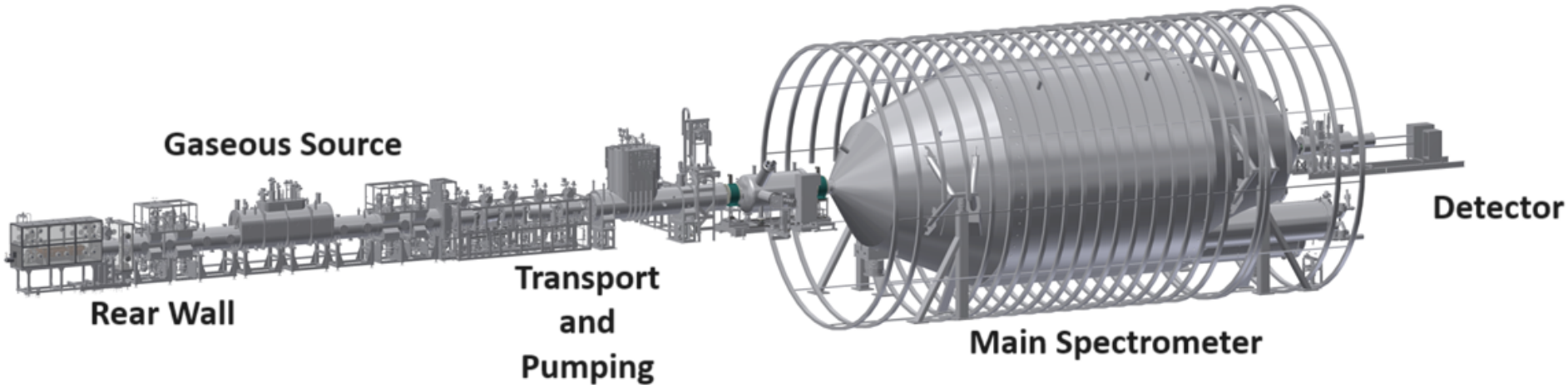
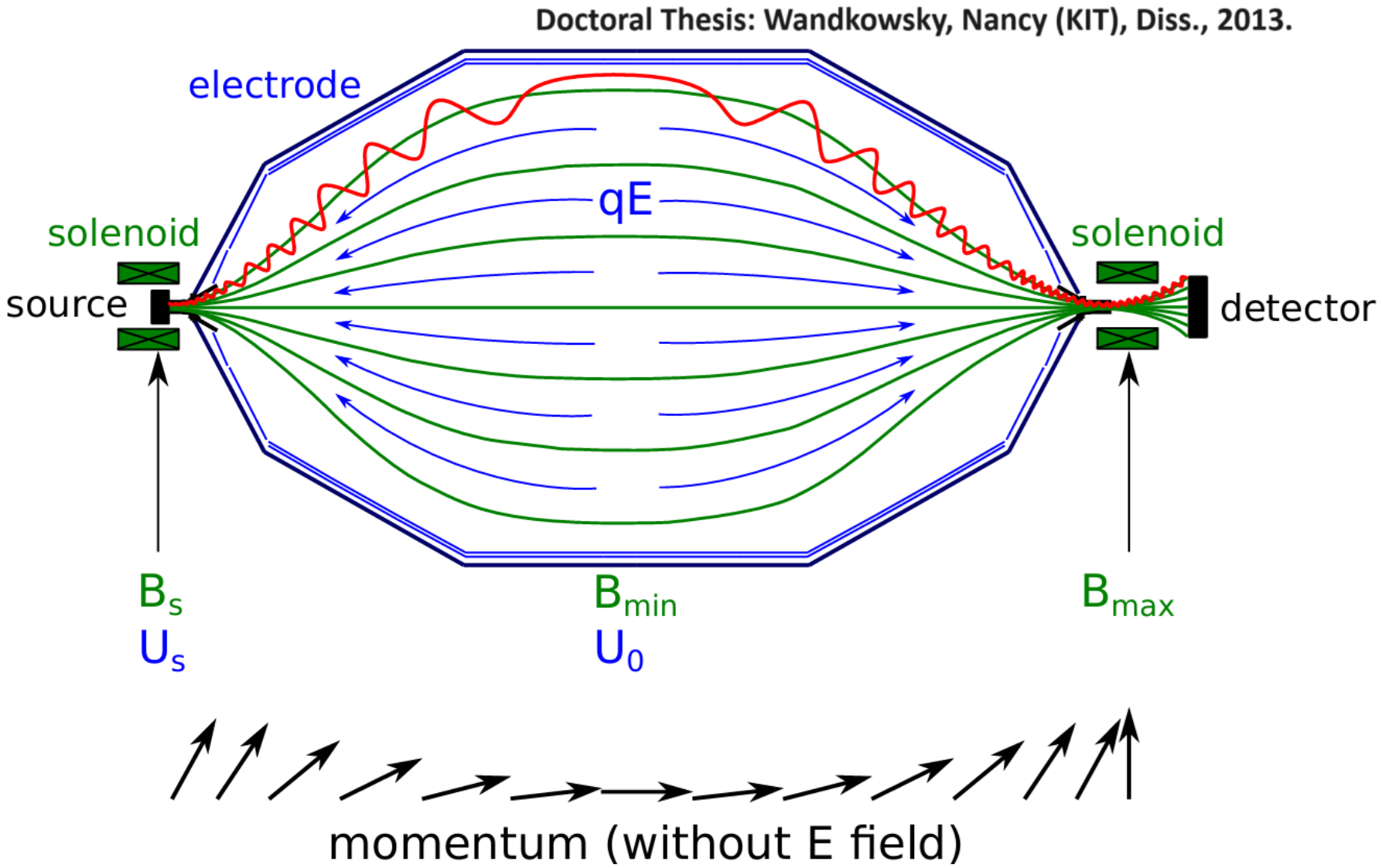
The Karlsruhe Tritium Neutrino (KATRIN) Experiment

The KATRIN Beamline

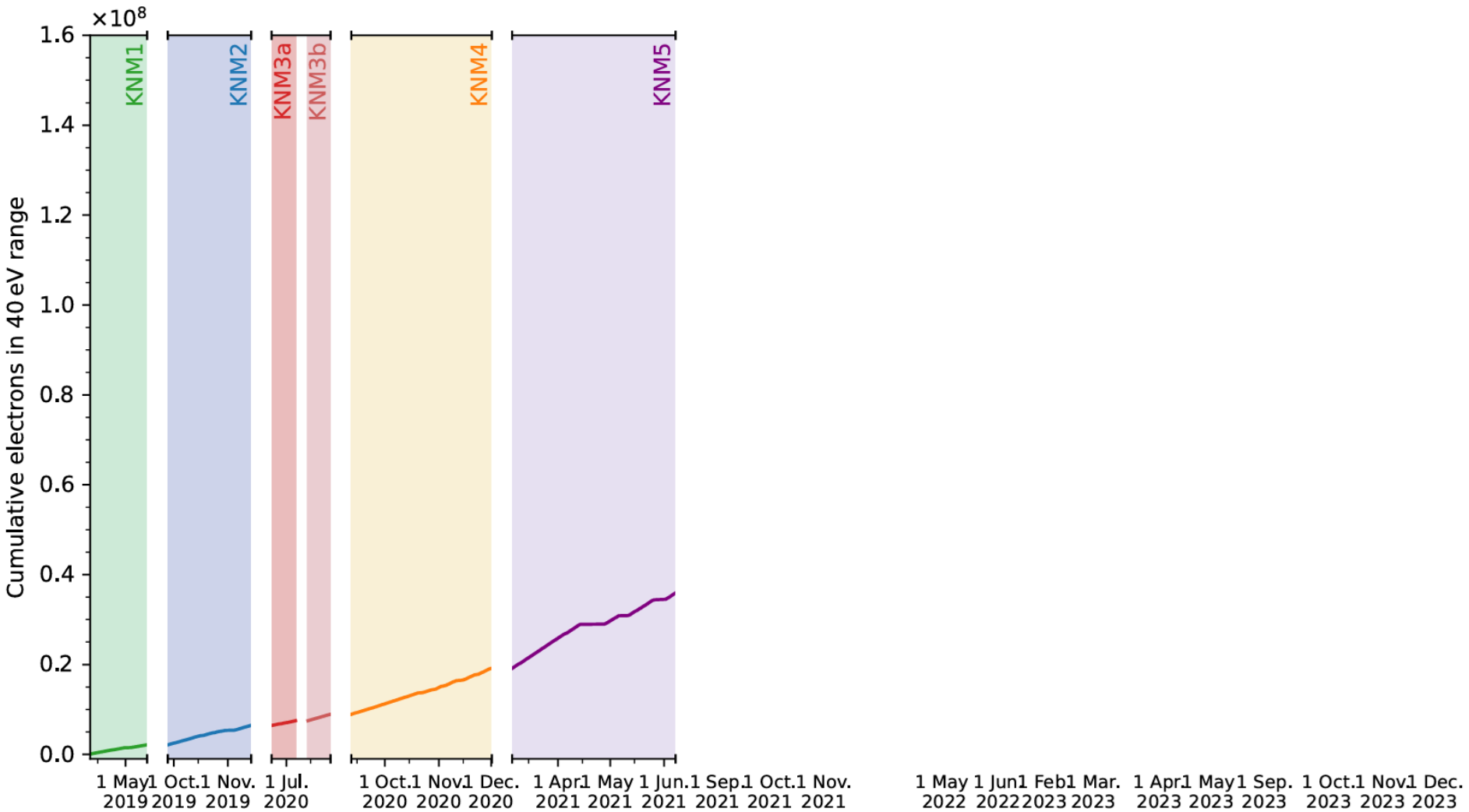


Magnetic Adiabatic Collimation with Electrostatic Filter

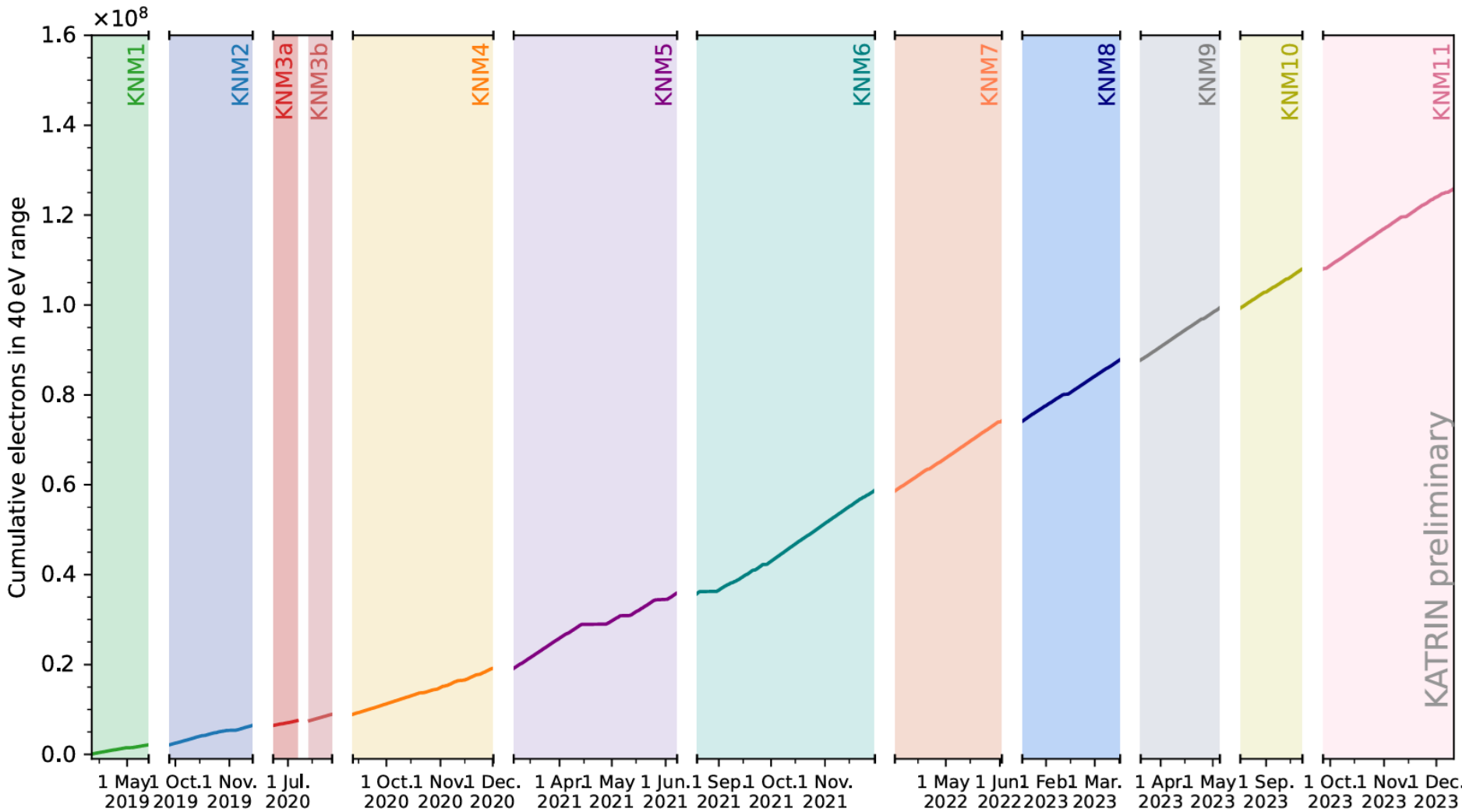


KATRIN Collected Electrons for First Results

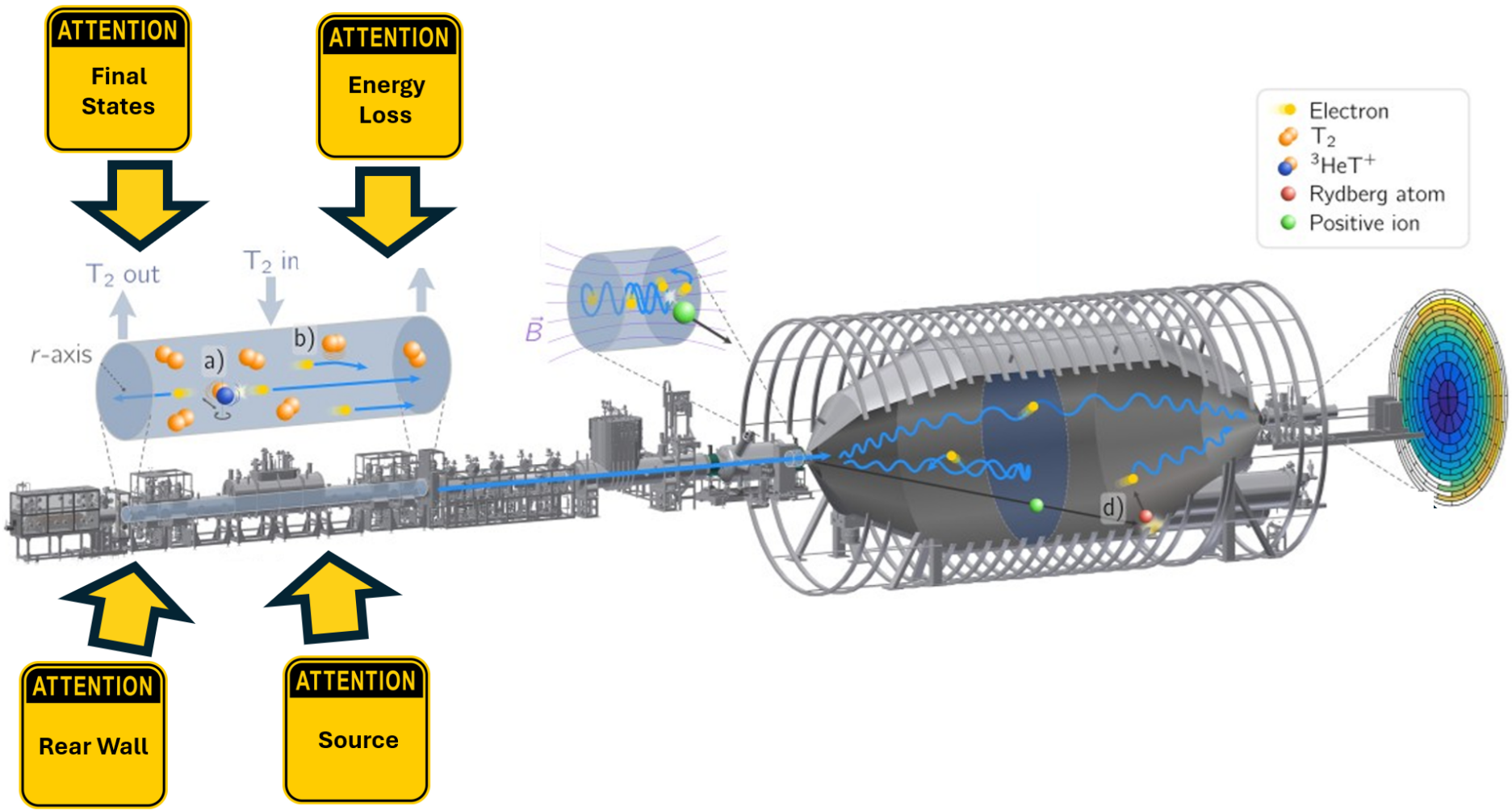
KATRIN Collected Electrons for Upcoming Results



KATRIN Collected Electrons through 2023



Systematics Breakdown



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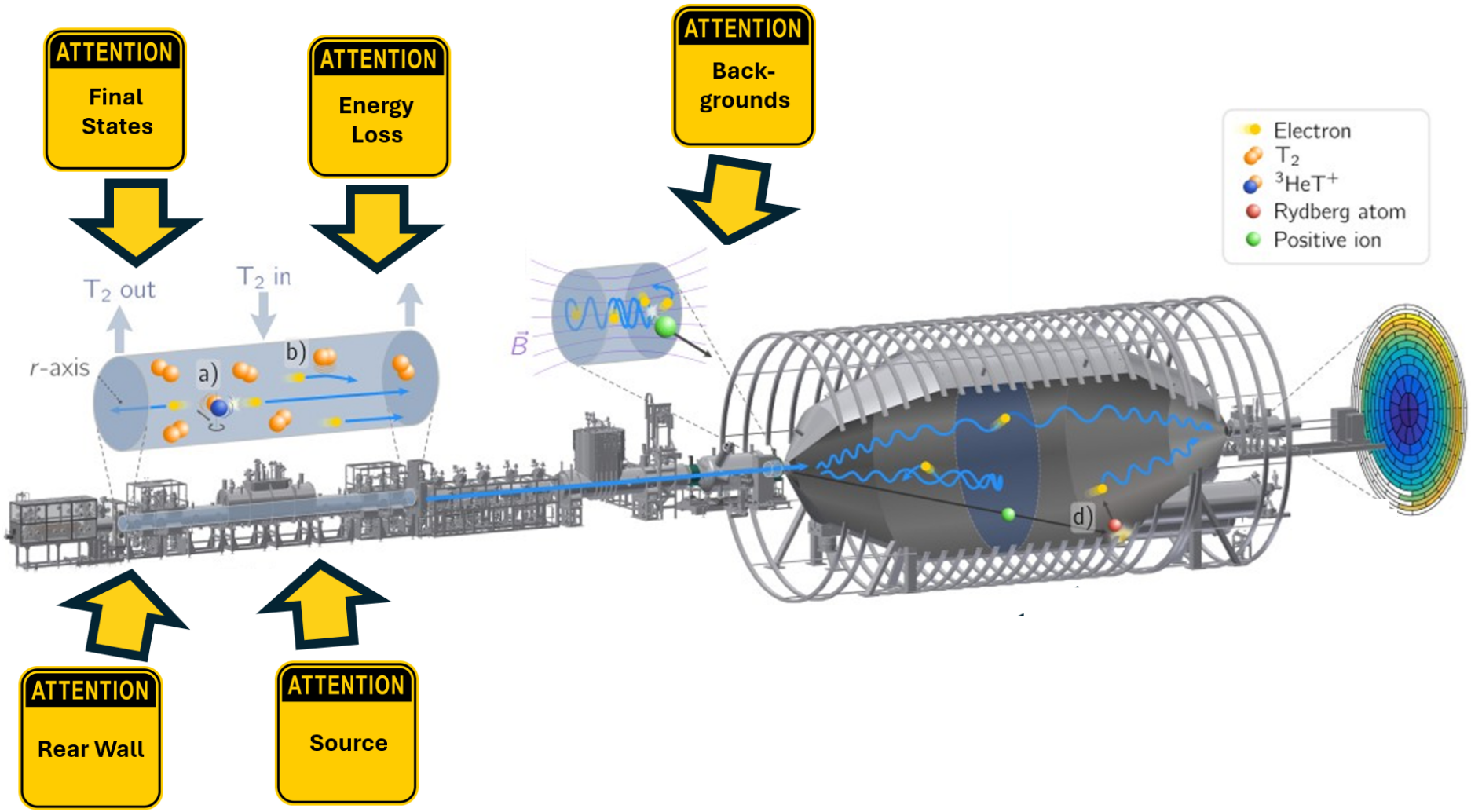

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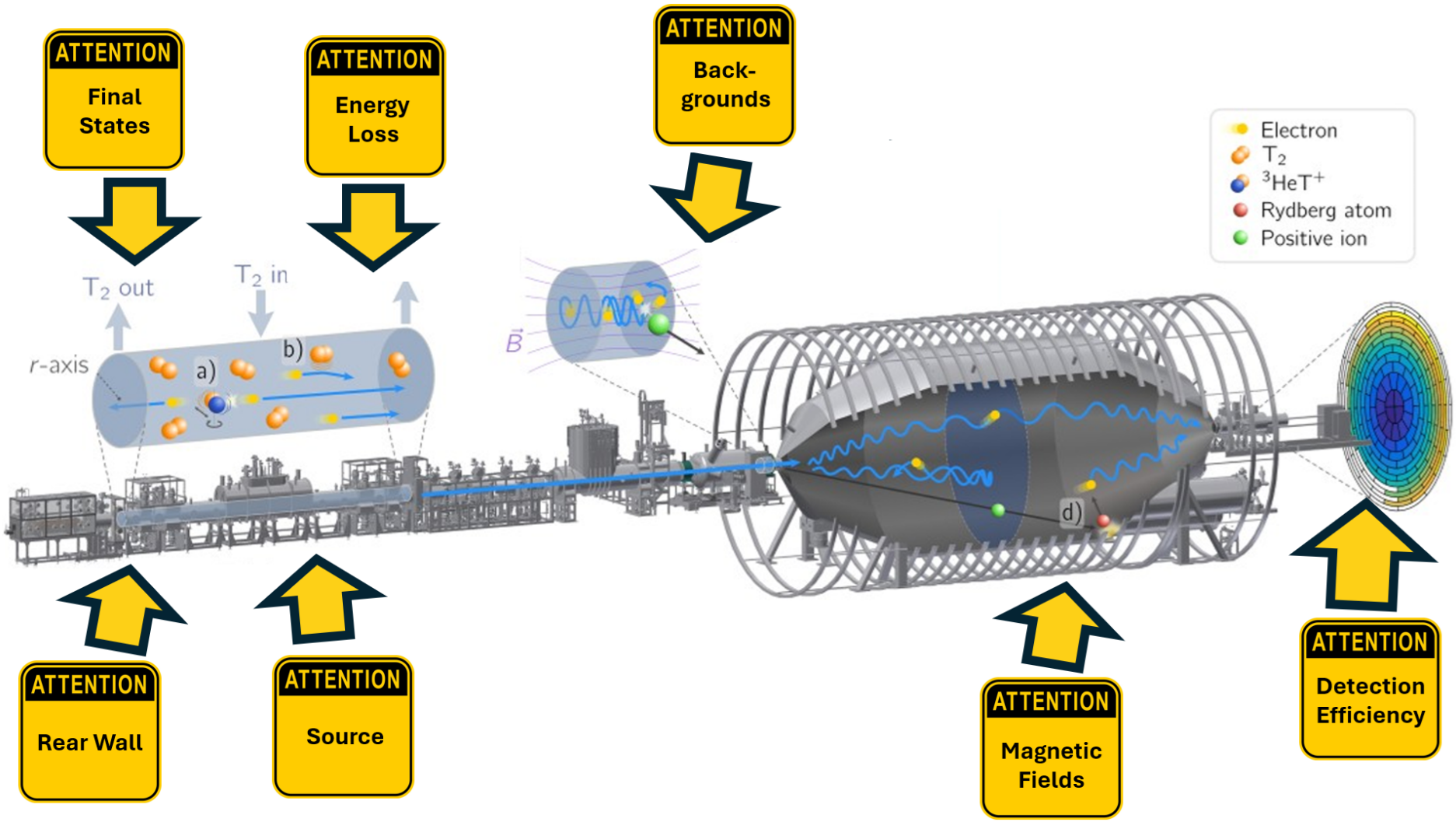
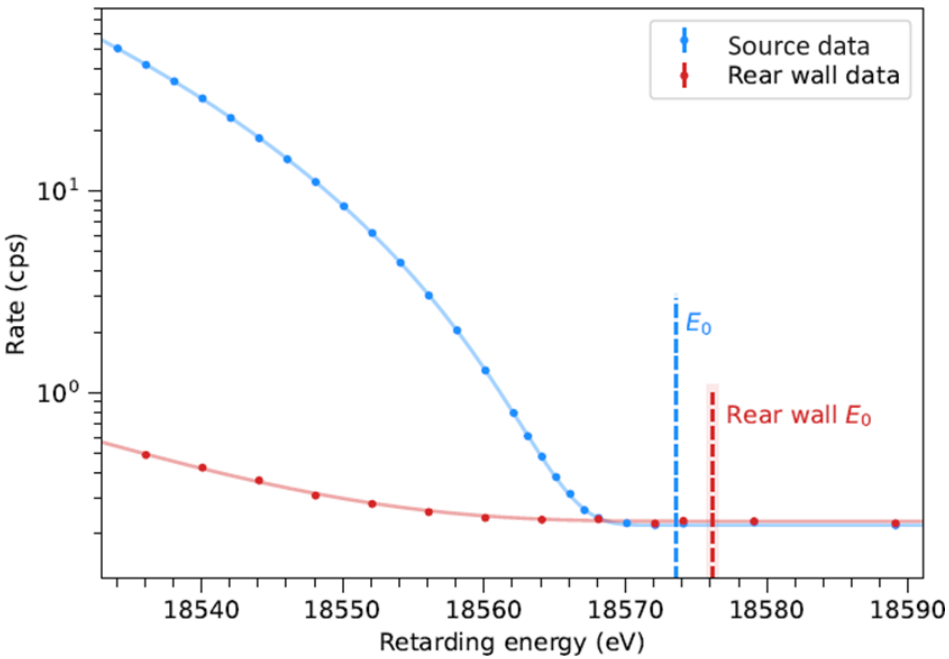


Example KATRIN Systematic: The Rear Wall



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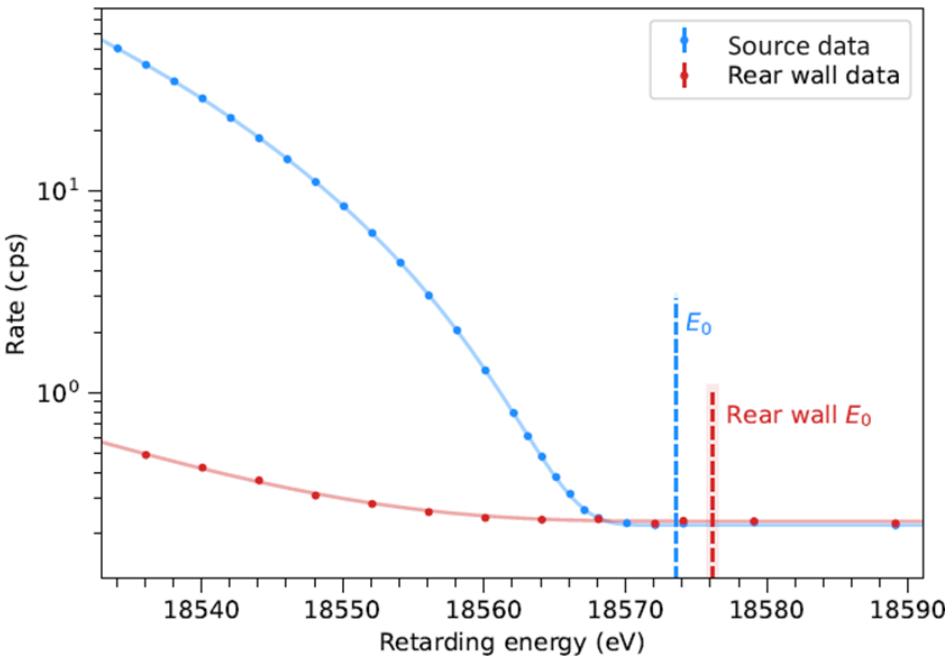

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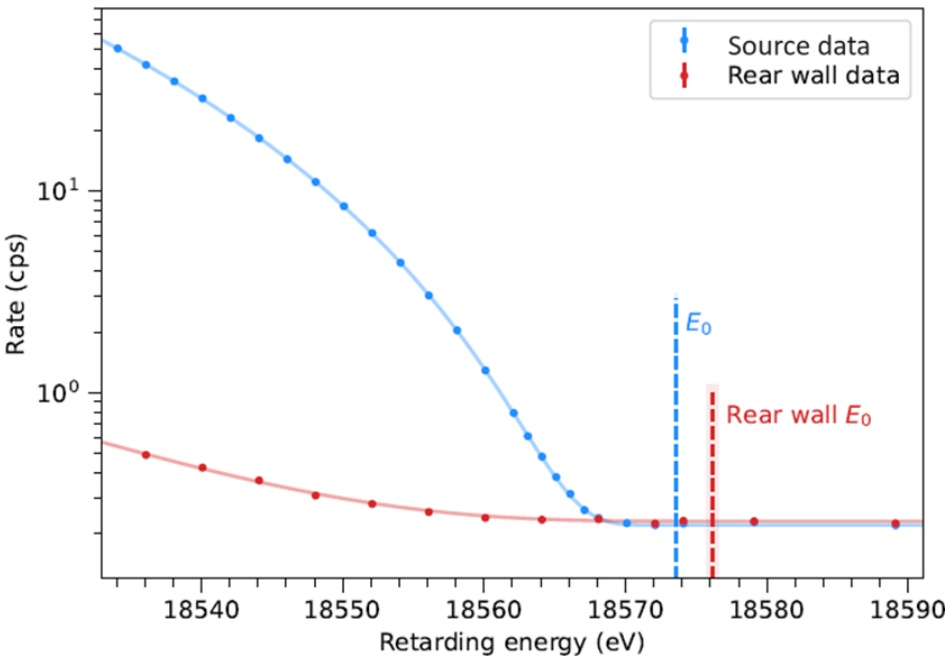

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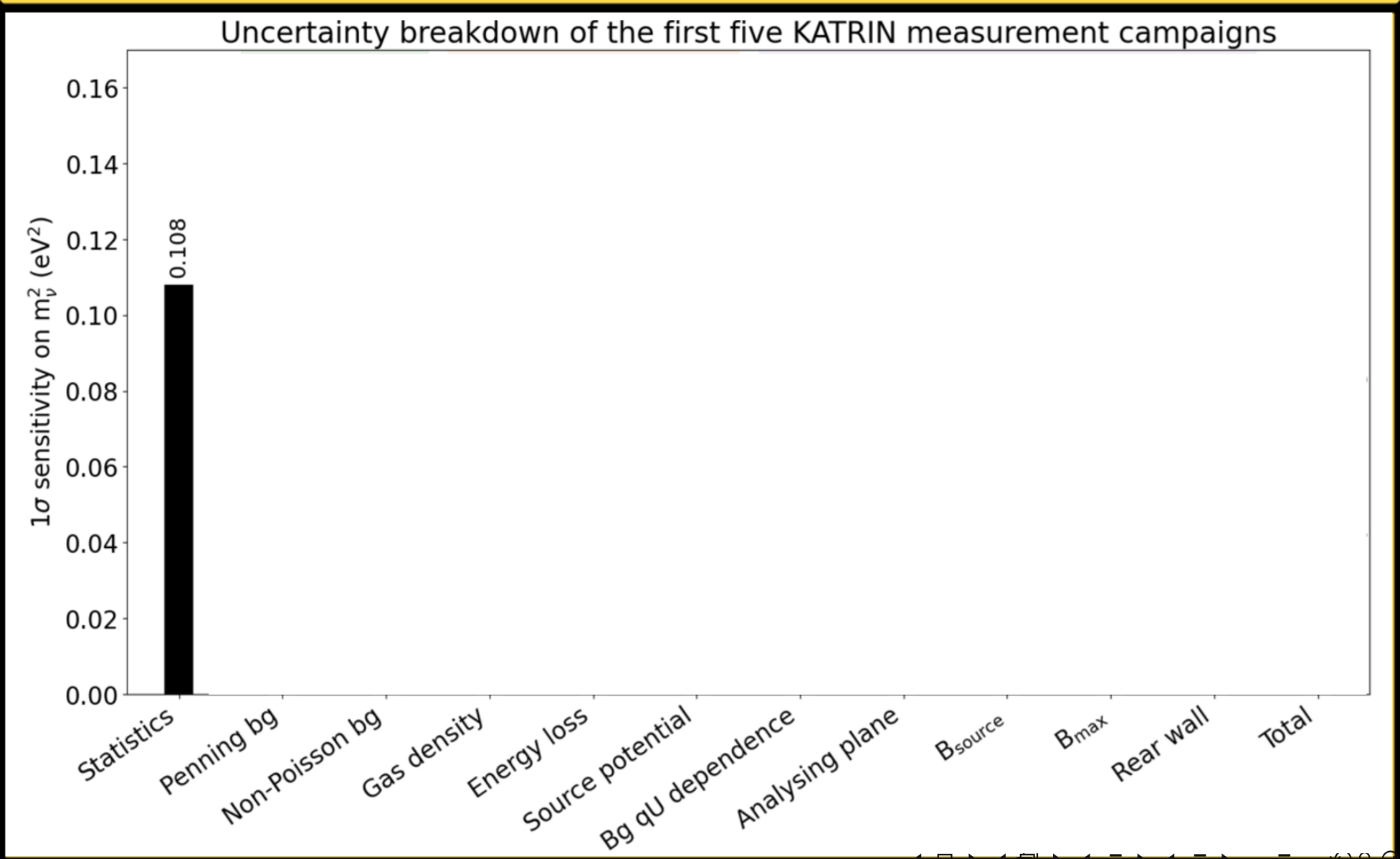
- Tritium from the beamline chemisorbs onto the Rear Wall during operation, and this results in a tritium spectrum with a different shape and endpoint.
- Modeling a Rear Wall spectrum in fits mitigates this systematic.

Preliminary Systematics Breakdown for KNM1-5



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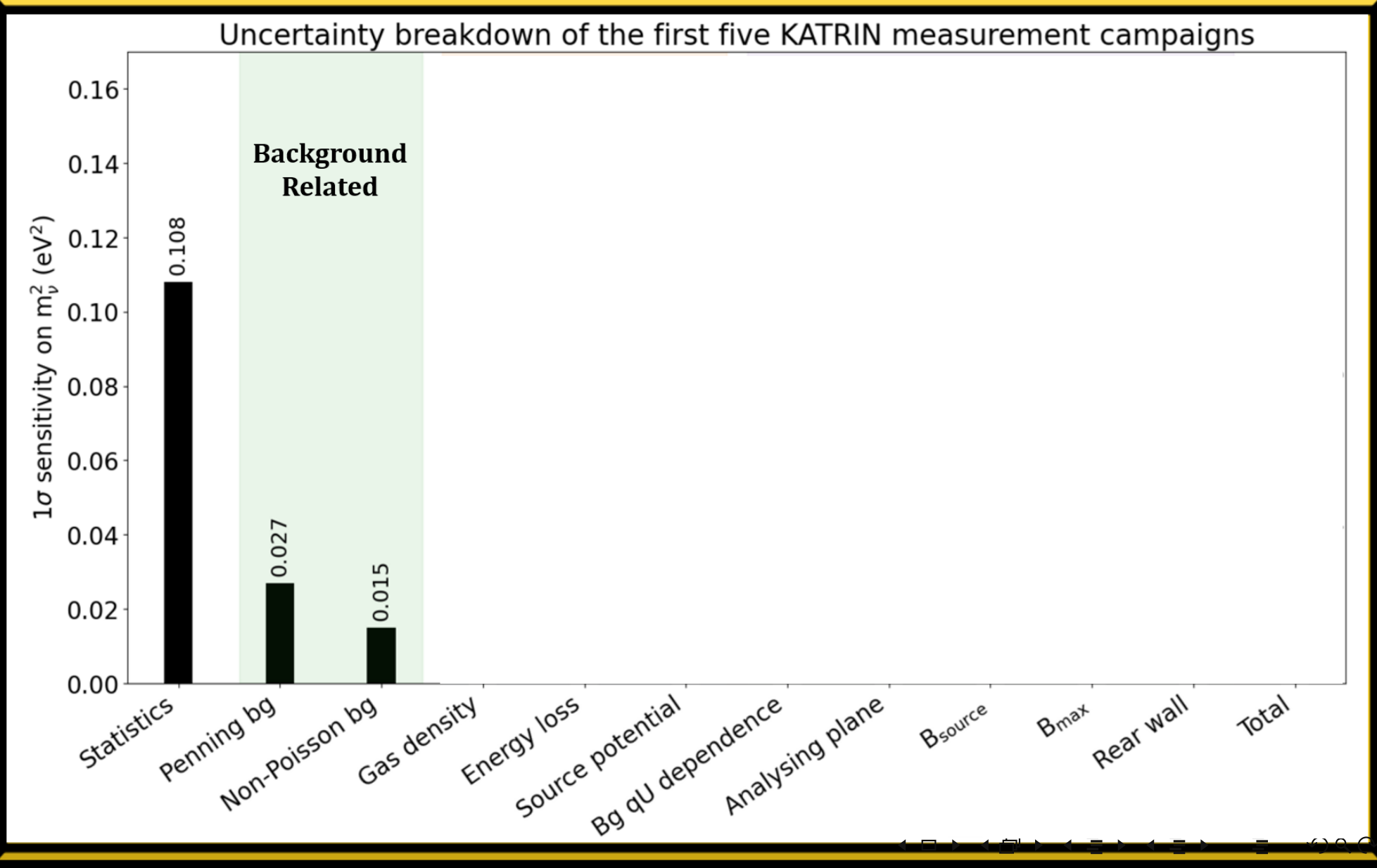

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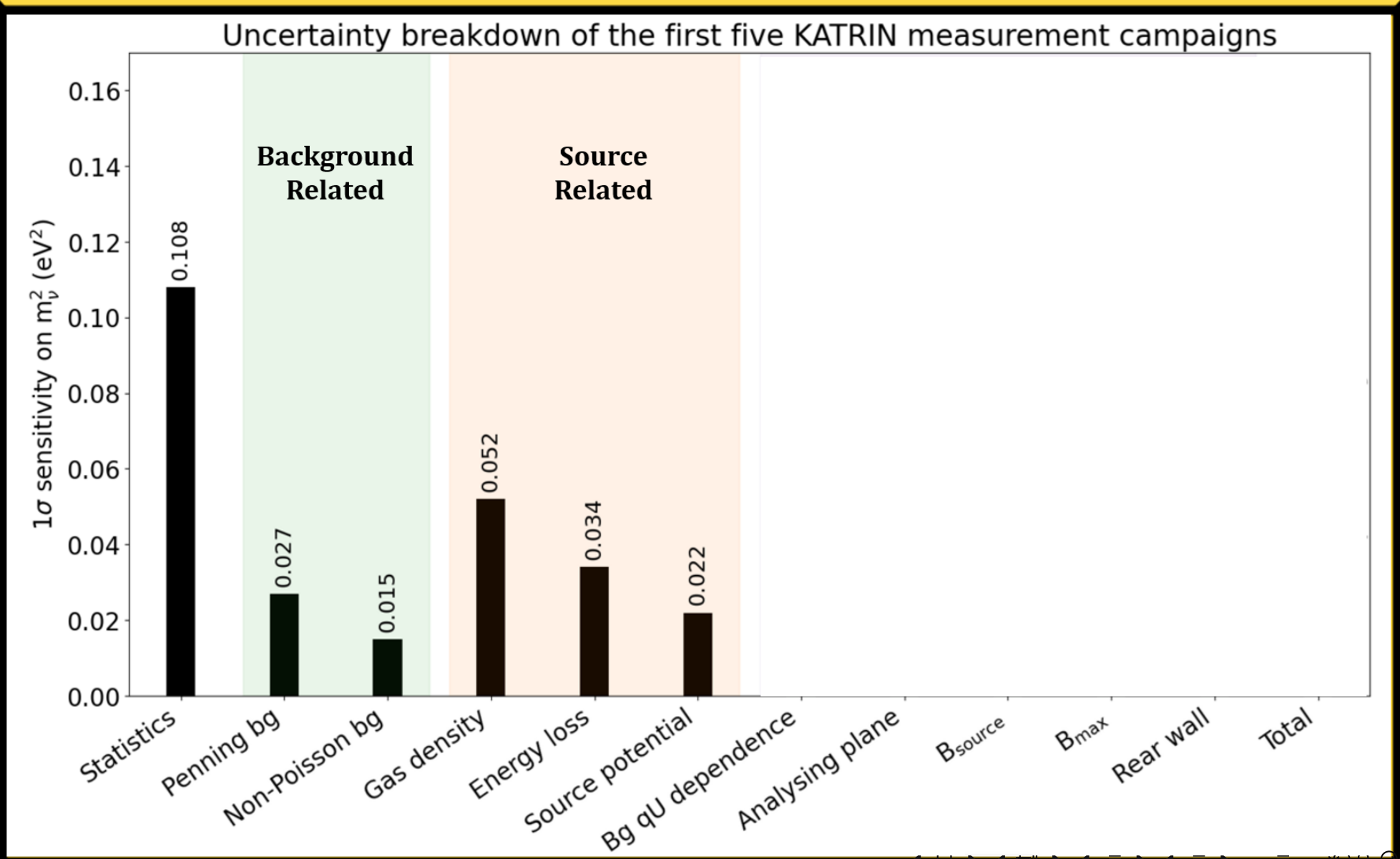

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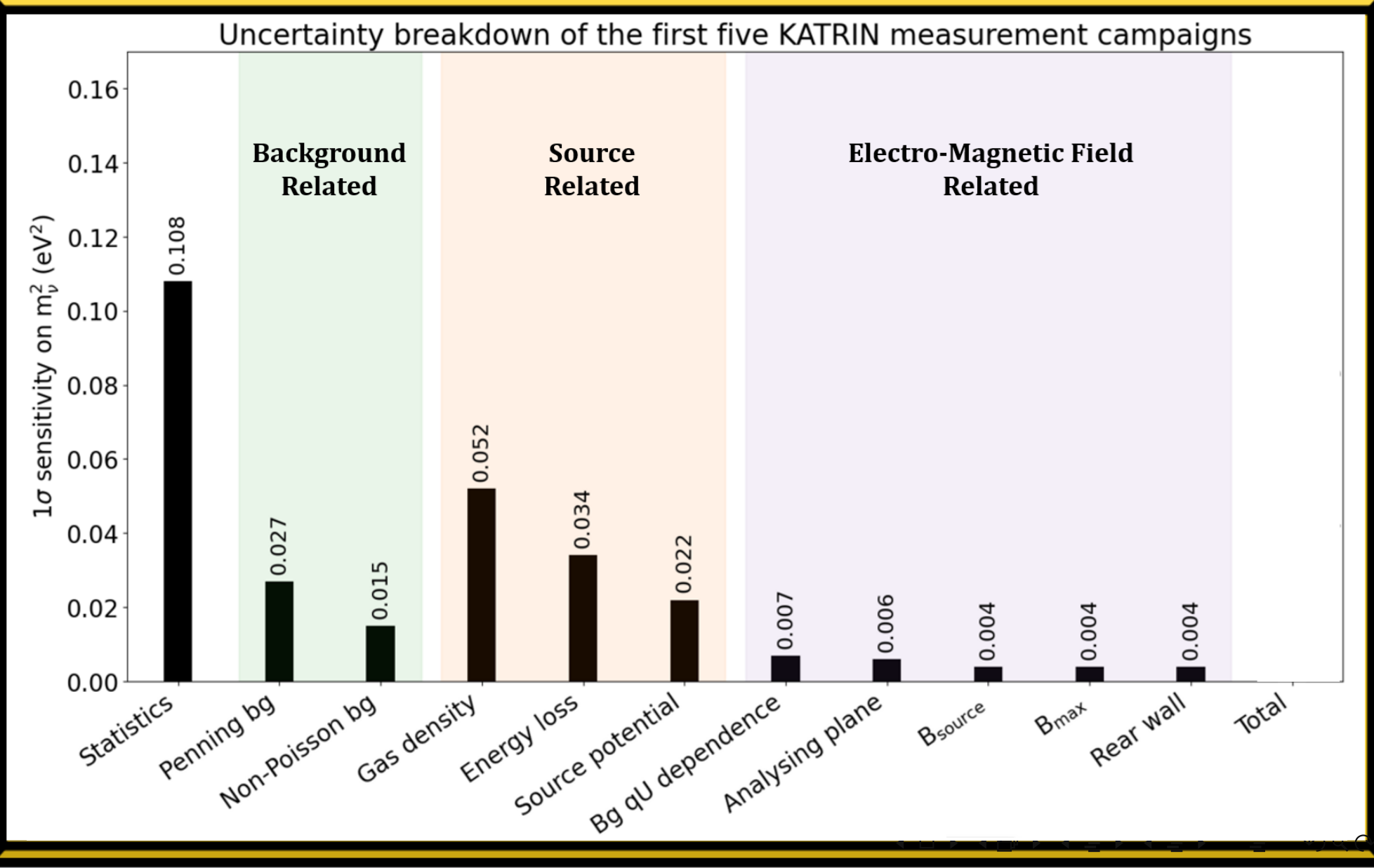

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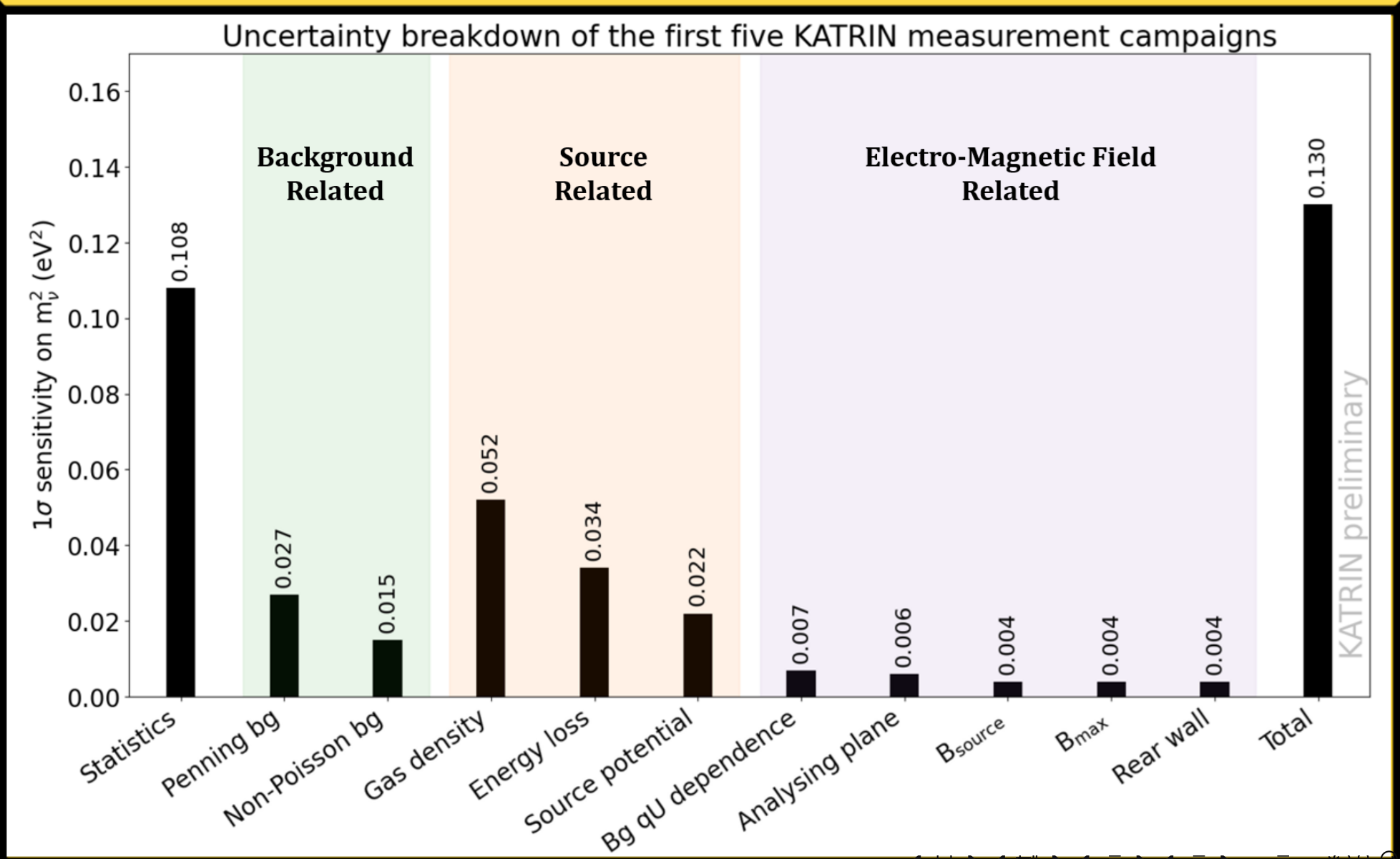

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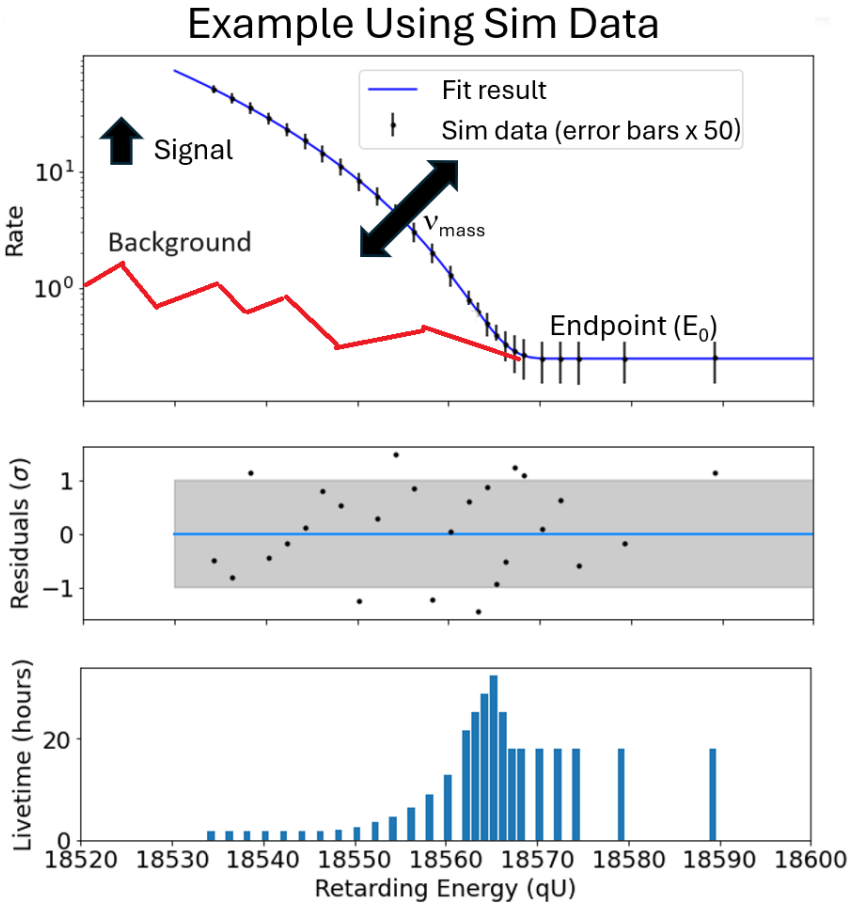
How Does KATRIN Extract m_ν^2 from the T β-Spectrum?



1. Generate a model for the integral tritium β-spectrum and response of the apparatus

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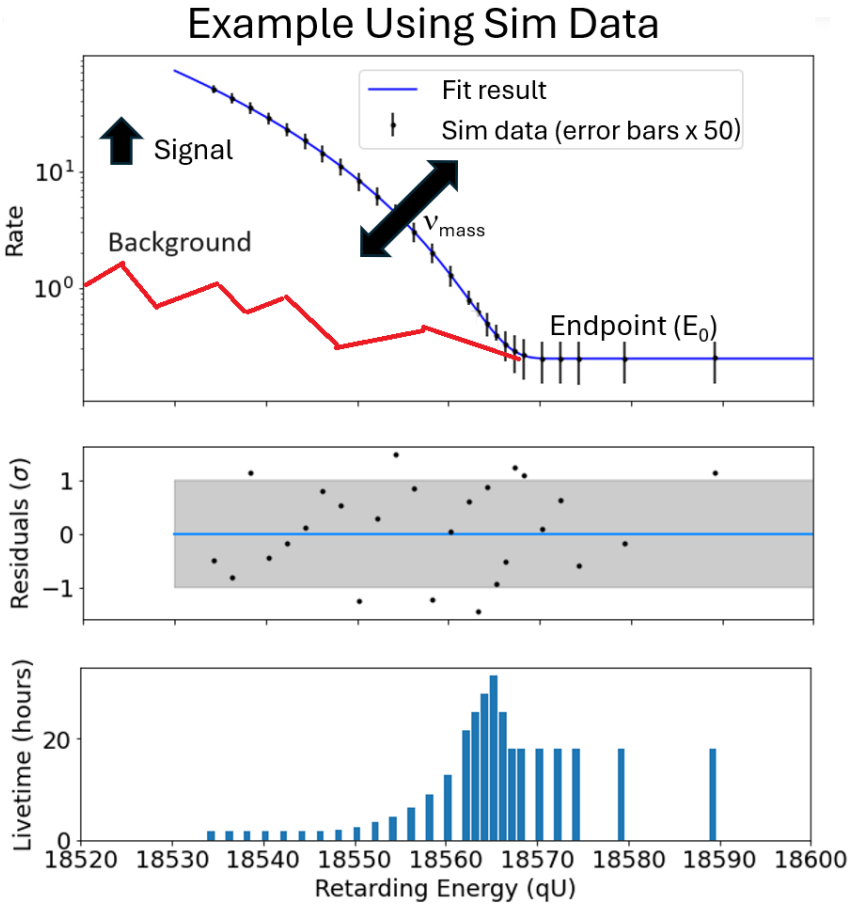

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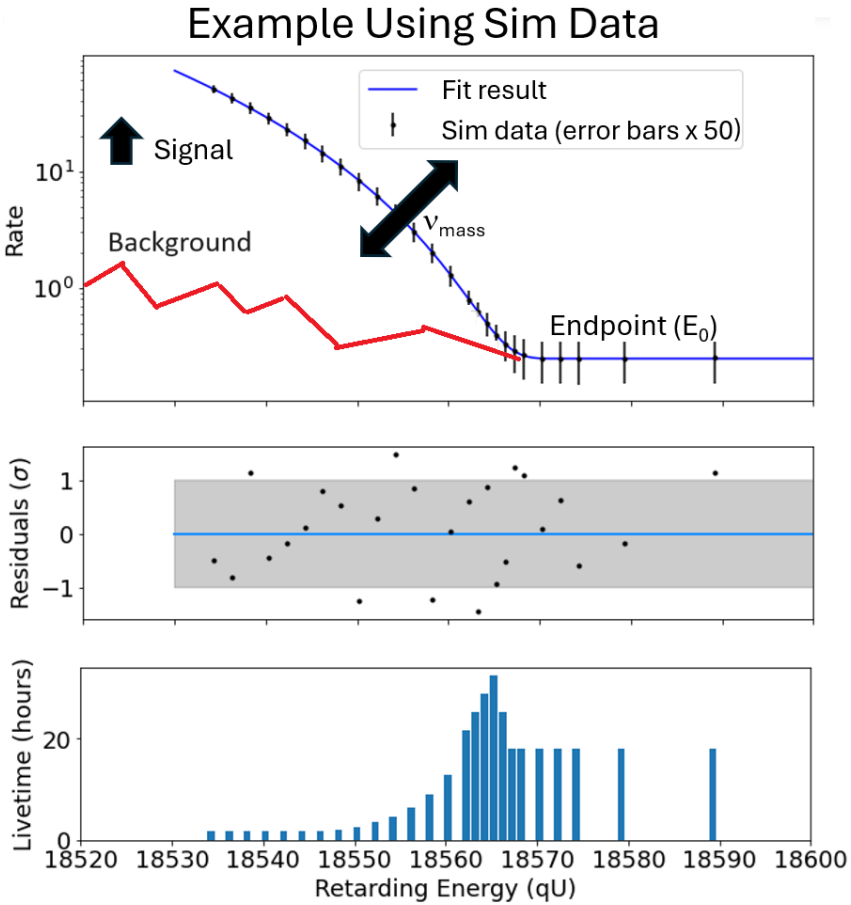
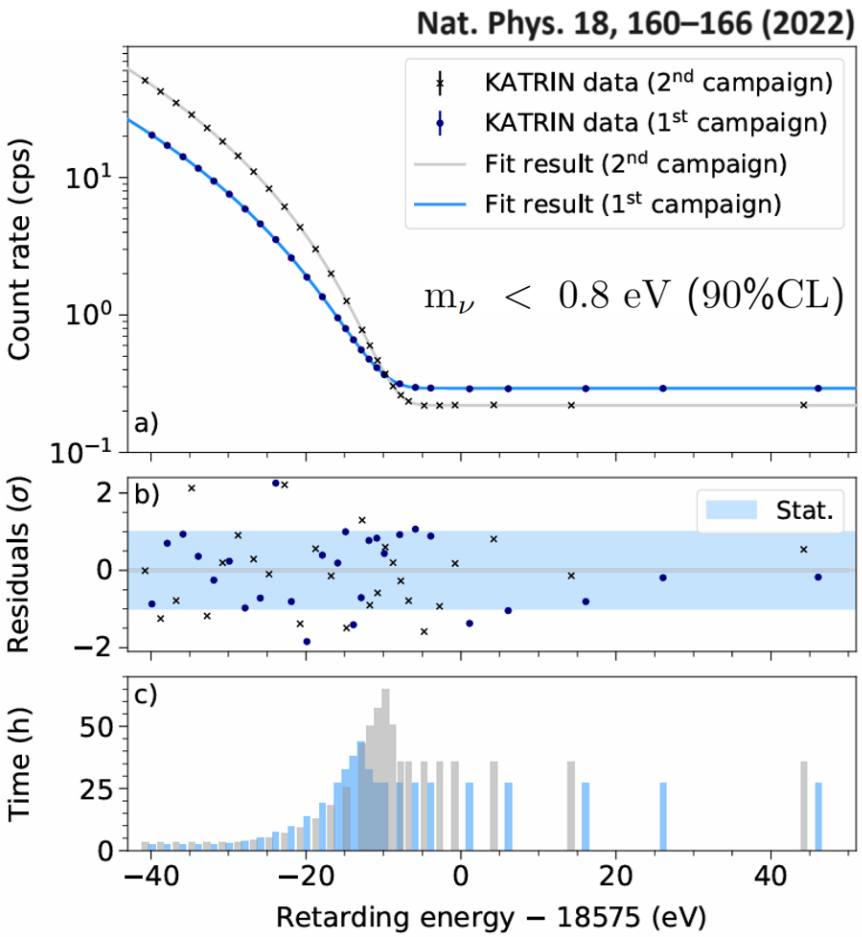
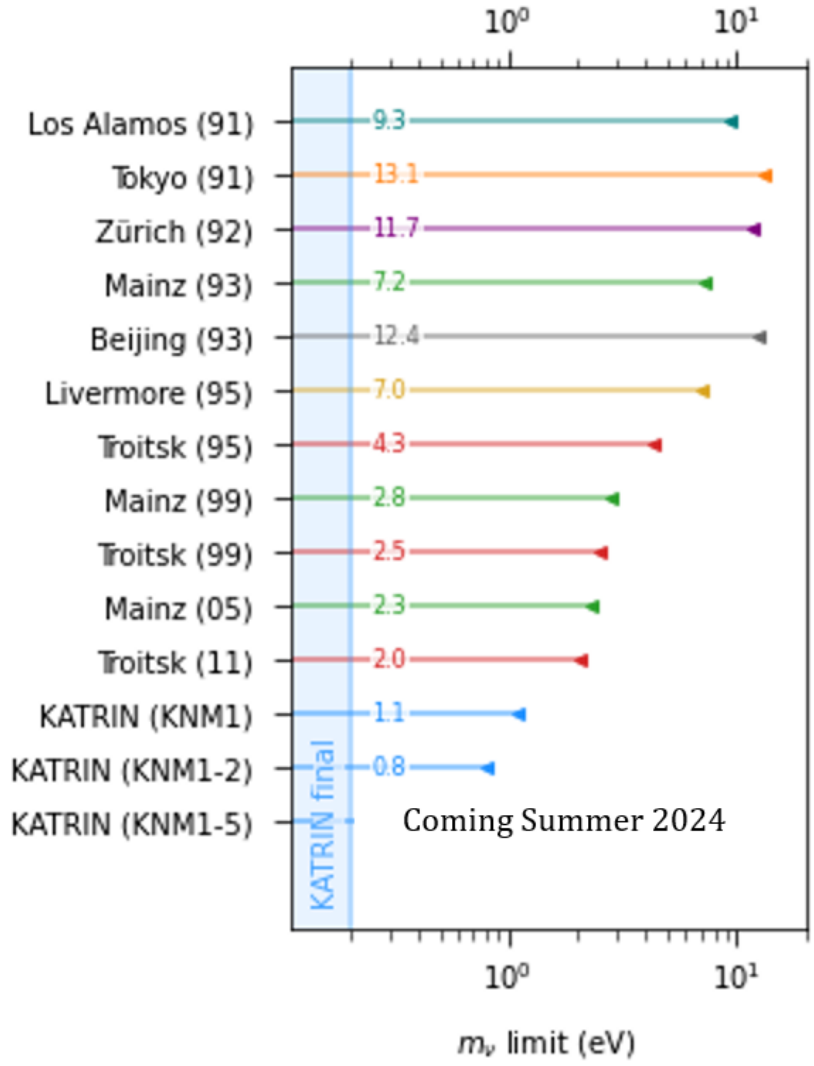


1. Generate a model for the integral tritium β-spectrum and response of the apparatus
2. Count the number of electrons produced with a specific amount of energy
3. Fit the measured data to the generated model and extract the spectrum parameters: neutrino mass, amplitude, endpoint, and background.

Currently Published KATRIN Results for KNM1-2





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  - Significant improvement of systematics and reduction of background
  - x6 the total statistics
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- Multiple beyond the neutrino mass searches: (Please look at recent Snowmass White Paper: J Phys G 49.10 (2022): 100501)

The KATRIN Collaboration

KATRIN DOE Award Number: DE-SC0019304