Constraints on Light Sterile Neutrinos from the KATRIN Experiment

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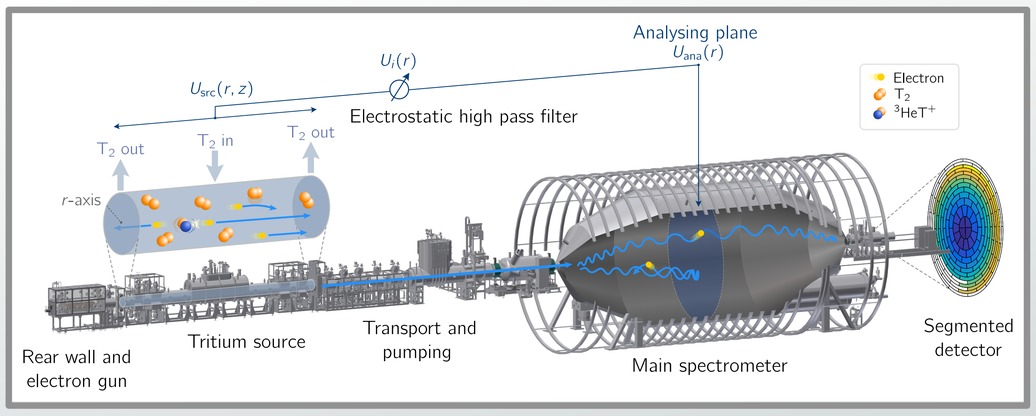
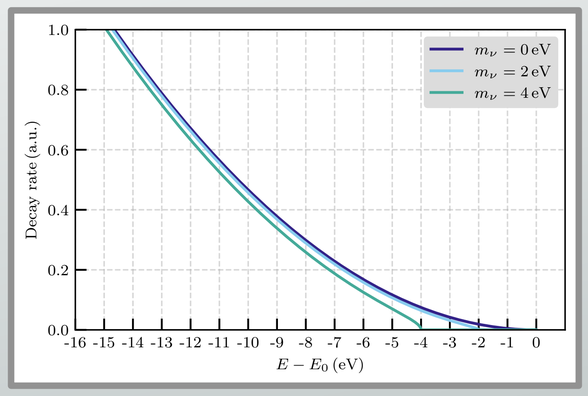


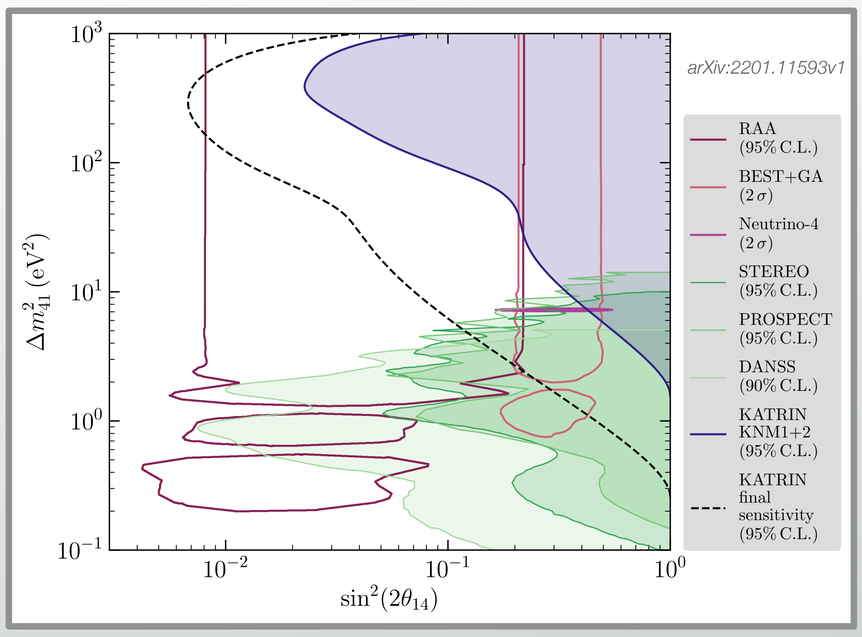
The KATRIN experiment

- **Ka**rlsruhe **Tri**tium **N**eutrino experiment
- Goal: direct measurement of effective electron anti-neutrino mass
- Measure the beta decay spectrum of T_2
- Current upper limit: $m_\nu < 0.8\,\mathrm{eV}$



Short-baseline anomalies

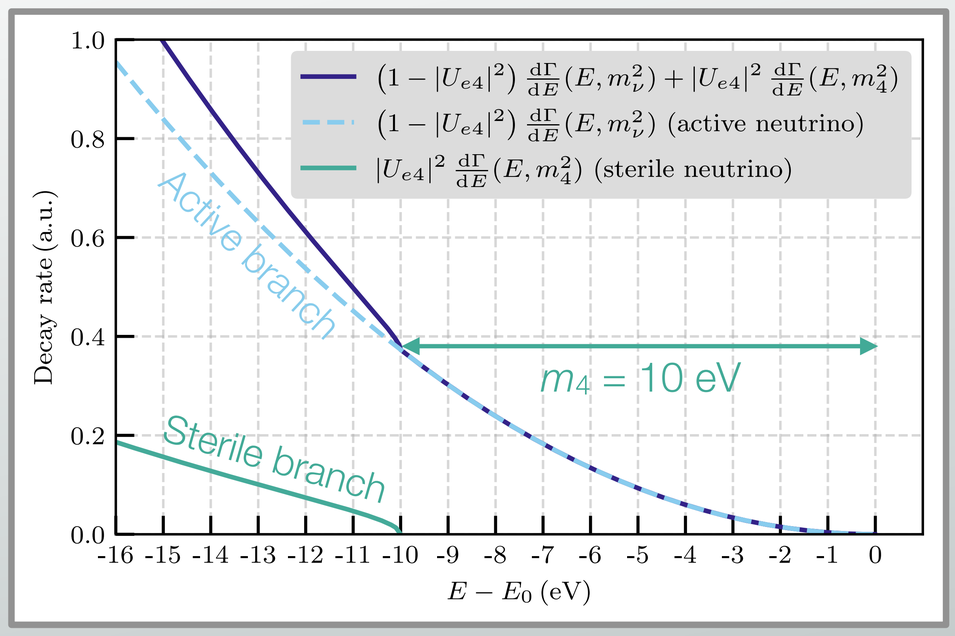
- Reactor anti-neutrino anomaly (RAA): deficit in $\bar{\nu}_e$-flux from nuclear reactors
- Oscillation experiments: investigate RAA → no oscillation found
- Gallium anomaly (GA): deficit in ν_e-flux
- Neutrino-4: claims to observe light sterile neutrino



→ Light sterile neutrinos as a possible explanation

Light sterile neutrinos and KATRIN

- Complementary to oscillation experiments
- Signature: "kink" in differential β-spectrum

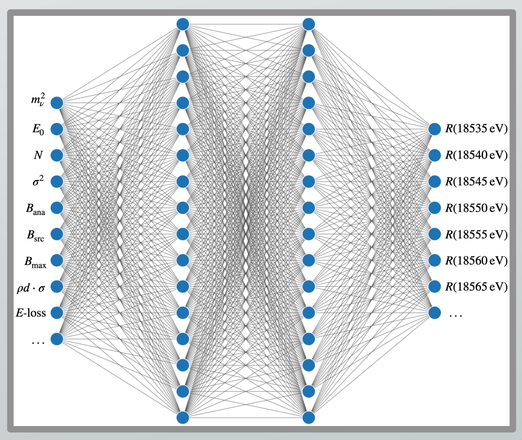


Netrium

- Python based software framework
- Utilizing neural network to interpolate the tritium β-spectrum model
- Trained on pre-calculated spectra with varied input parameters by minimizing the loss function

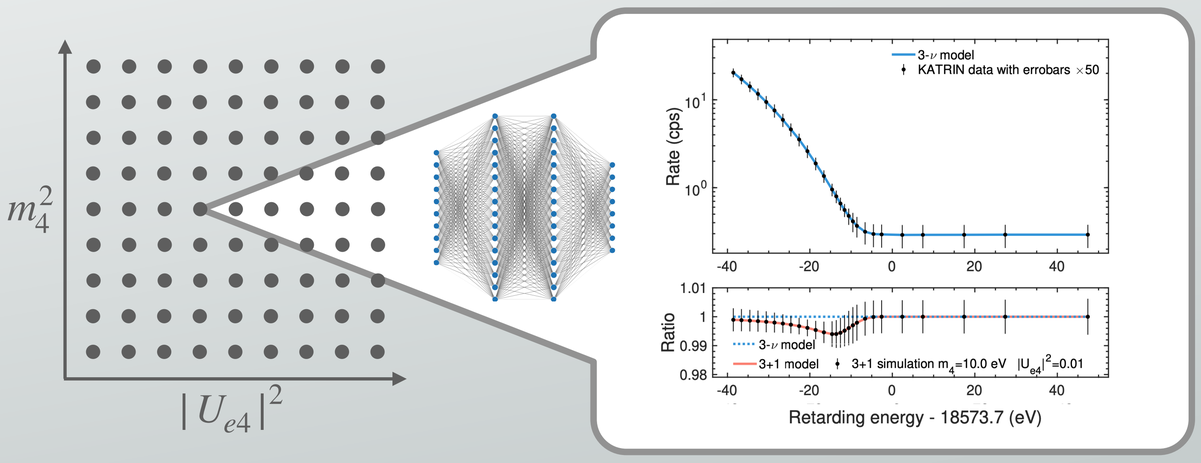
$$\frac{1}{N}\sum_{i=0}^{N}\left(\frac{R_{i,\mathrm{net}} - R_{i,\mathrm{true}}}{\langle R_{i,\mathrm{true}}\rangle}\right)^2$$

- Computationally expensive calculation of integrals in model is sped up → improved computing time and easier handling of complex data sets
- Paper: *arXiv:2201.04523v1*

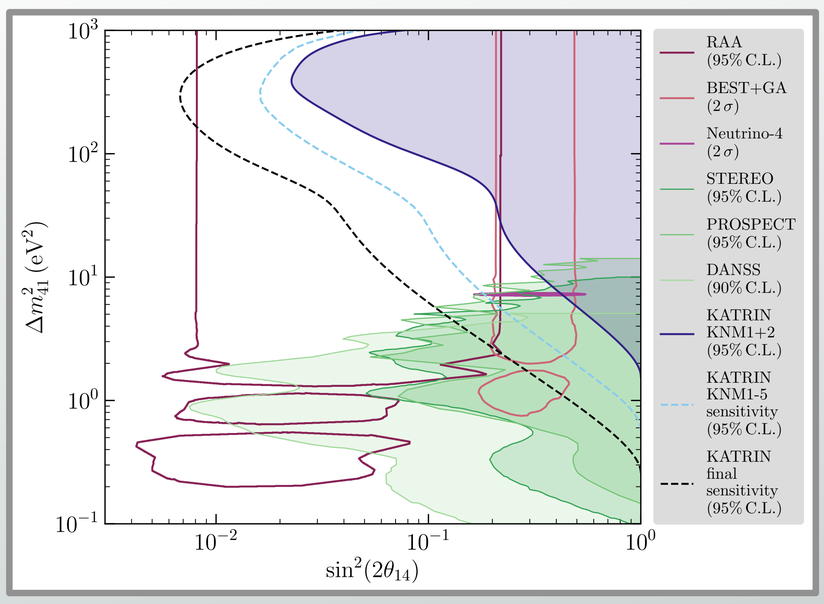


Analysis procedure

- Grid over sterile neutrino parameter space of $|U_{e4}|^2 \times m_4^2$
- Maximum likelihood fit of the spectrum at every point in the grid using a neural network (**Netrium**)
- $E_0 - 40\,\mathrm{eV}$ fit range
- Fix sterile neutrino parameters and fit $E_0, A_{\mathrm{sig}}, R_{\mathrm{bkg}}$
- Obtain a map of χ^2 values → draw the exclusion contour



New sensitivity on the parameter space



- Huge improvement in sensitivity with new data (KSN1-5)
- $m_\nu^2 = 0\,\mathrm{eV}^2$
- Cover more of the large Δm^2_{41} region of the RAA
- Potentially rule out light sterile neutrinos as an explanation for the GA together with oscillation experiments
- Probe almost all of the Neutrino-4 parameter space

Outlook

- Finalizing analysis on real data (KSN1-5)
- Additional studies ongoing:
  - Inclusion of non-zero active neutrino mass in analysis
  - Extended fit range beyond 40 eV
- Aimed **release of new result this year** → Stay tuned!

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