Karlsruhe Institute of Technology

A Look at General Neutrino Interactions with KATRIN Data

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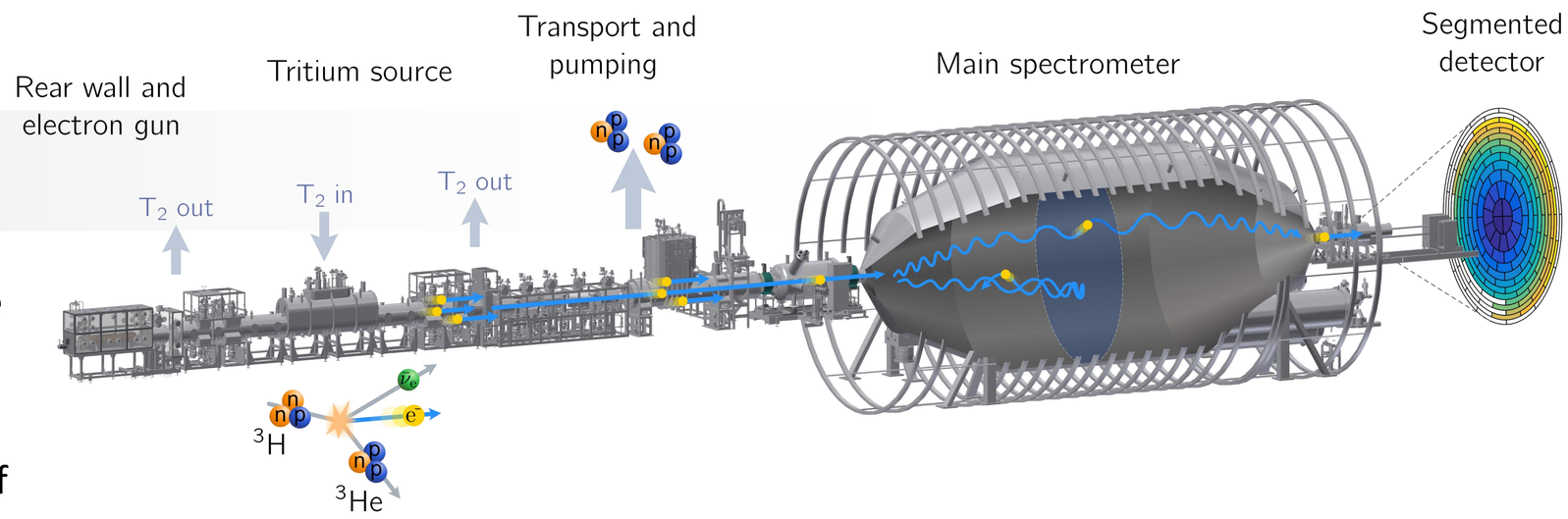
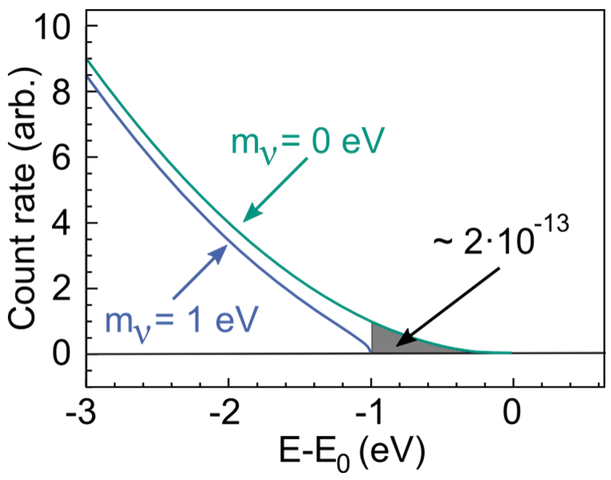


- KATRIN aims at measuring the **mass of the electron neutrino** with a sensitivity of 0.2 eV at 90 % CL.
- For this purpose **precision spectroscopy** of the **tritium β decay** is performed.



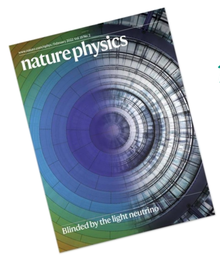
- Spectrum **shape for non-zero m_ν^2 is distorted** close to the Endpoint energy E_0:

$$\frac{d\Gamma}{dE} \propto (E_0 - E) \cdot \sqrt{(E_0 - E)^2 - m_{\nu_e}^2} \cdot \theta(E_0 - E - m_{\nu_e})$$

- With the **model-independent** kinematic approach, the **effective neutrino mass** is probed:

$$m_{\nu_e}^2 = \sum |U_{ei}|^2 \, m_i^2$$

- **MAC-E filter** principle:
  β spectrum is measured in an integrating mode.



$m_{\nu_e} < 0.8$ eV
(90 % CL)

10.1038/s41567-021-01463-1

General Neutrino Interactions (GNI):

- **Novel interactions** which contribute to the **weak interaction**
- **Effective Field Theory** based on Standard Model, including all possible interactions with neutrinos, close to no presumptions needed.

$$\mathcal{L}_{SMEFT}(\phi_{SM}) = \mathcal{L}_{SM}(\phi_{SM}) + \sum_{n\geq 5} \sum_i \frac{1}{\Lambda^{n-4}} \, C_i^{(n)} \mathcal{O}_i^{(n)}(\phi_{SM})$$

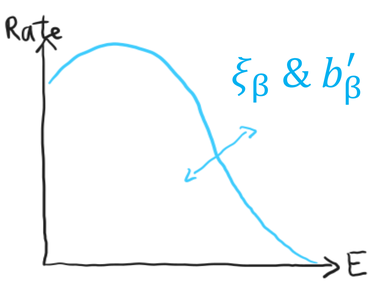
- Only considering terms relevant for β decay. ϵ_j describes the coupling strength for vector-like, scalar, pseudo-scalar and tensor-like interactions:

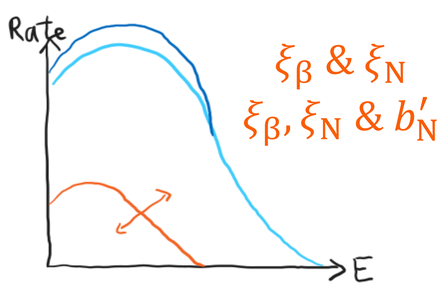
$$\mathcal{L}_{GNI}^{CC} = -\frac{G_F V_{\gamma\delta}}{\sqrt{2}} \sum_{j=1}^{10} \left(\overset{(\sim)}{\epsilon}_{j,ud}\right)^{\alpha\beta\gamma\delta} \left(\bar{e}_\alpha \mathcal{O}_j \nu_\beta\right)\left(\bar{u}_\gamma \, \mathcal{O}'_j \, d_\delta\right) + h.c.$$

- **Total differential decay rate** for active neutrino and sterile neutrino. The GNI coefficients ξ_k and b'_k are defined in terms of ϵ_j.

$$\frac{d\Gamma}{dE} = \frac{d\Gamma_{SM}}{dE} \sum_{k=\beta,N} \xi_k \left[1 - b'_k \frac{m_k}{E_0 - E}\right] \Theta(E_0 - m_k - E)$$

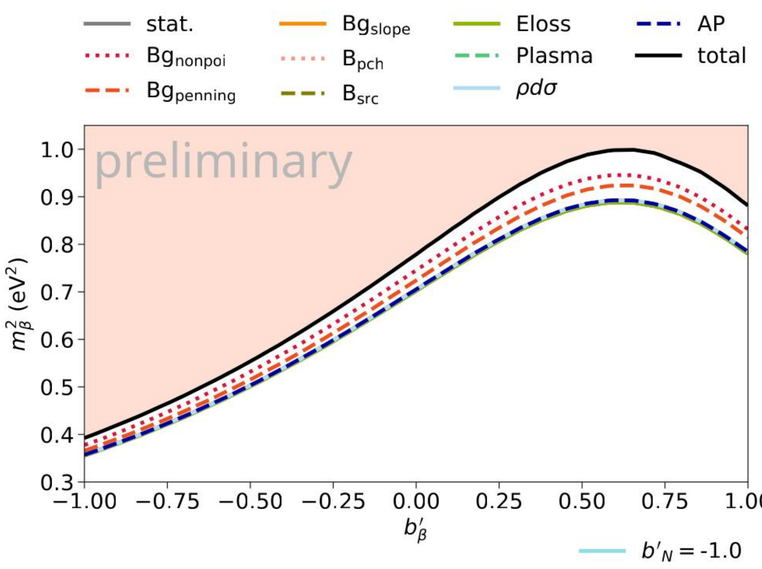
- GNI cause modifications to the β spectrum
  → **Energy-dependent contributions to the rate in KATRIN**





10.1016/j.nuclphysb.2019.114746

Sensitivity studies on Asimov MC with statistics of 31 days showing the 95% CL

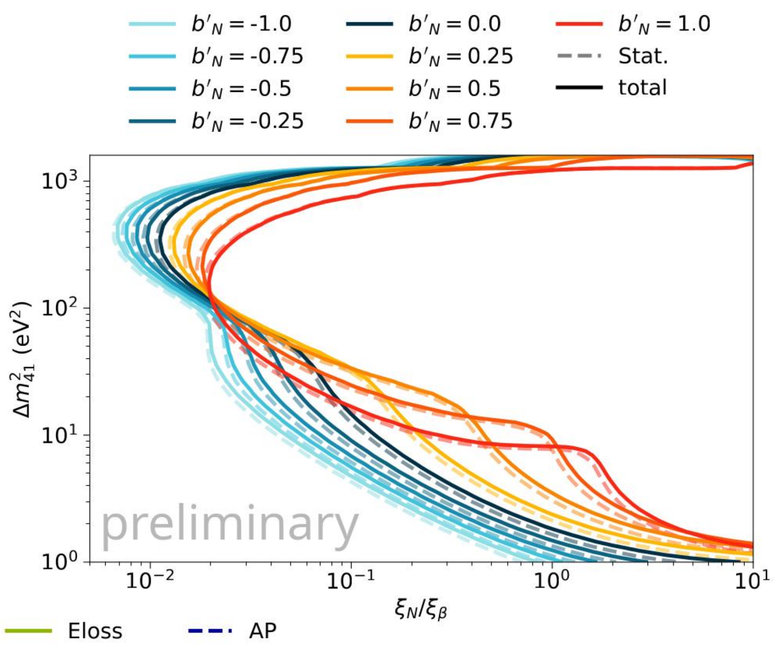


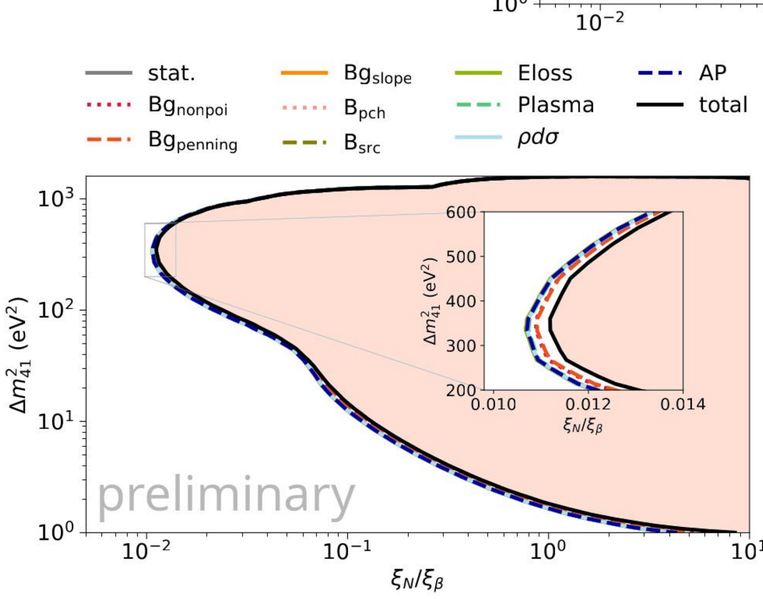
Active neutrino case:

- Slight effect of b'_β on neutrino mass sensitivity
  → possible to probe different GNI scenarios

Sterile neutrino case:

- Case $b'_N = 0$ is equivalent to sterile neutrino analysis.
- Case $b'_N \neq 0$ modifies sterile signature.
  → possible to probe different GNI scenarios





- Sensitivity dominated by statistics
- Ordering of systematic effects for GNI (shown for $b'_N = 0$) agrees with neutrino mass and sterile neutrino analysis, respectively.

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