

A model for a keV-scale sterile neutrino search with KATRIN

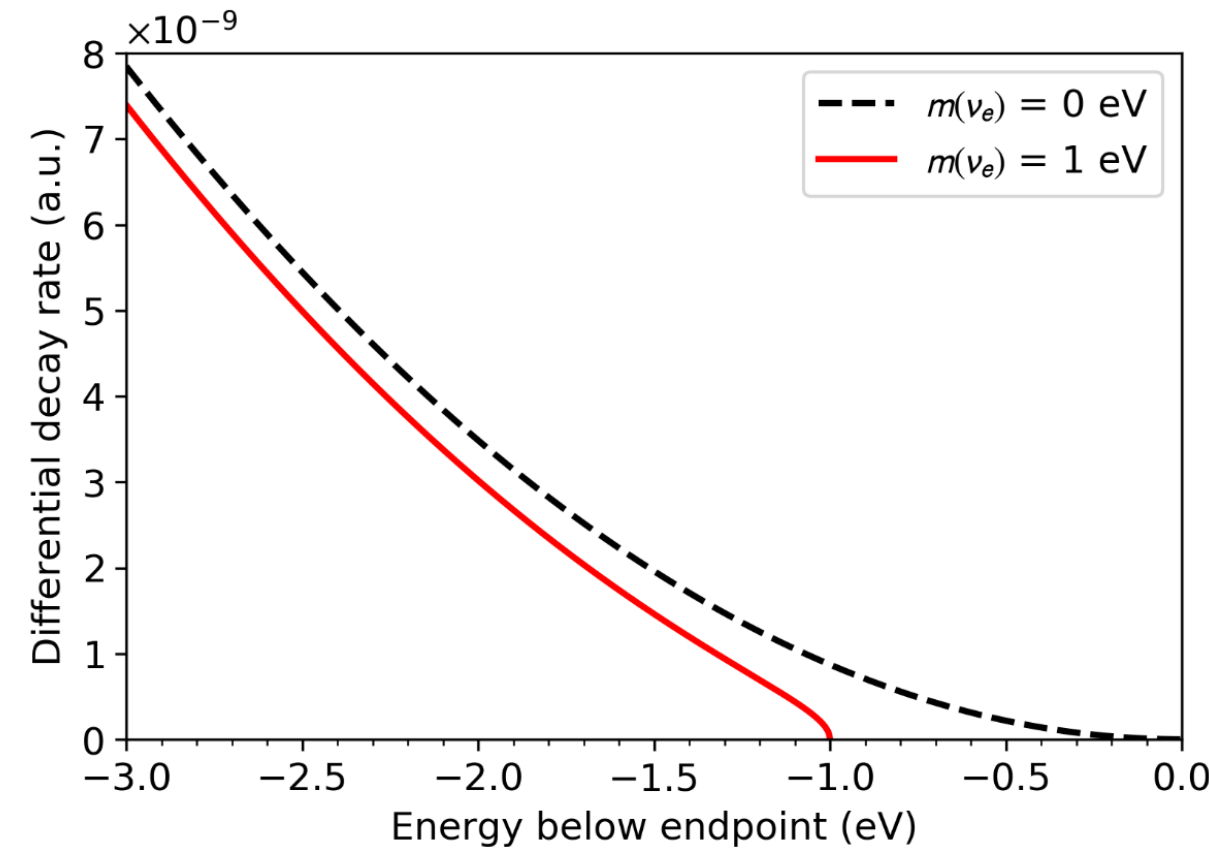
Martin Slezák, Alexey Lokhov, Susanne Mertens, Federico Roccati, Madlen Steven, Leonard Köllenberger, Anton Huber, Ellen Förstner, Marc Korzeczek for the KATRIN collaboration and David Radford
MPP, INR, TUM, KIT, ORNL



Motivations

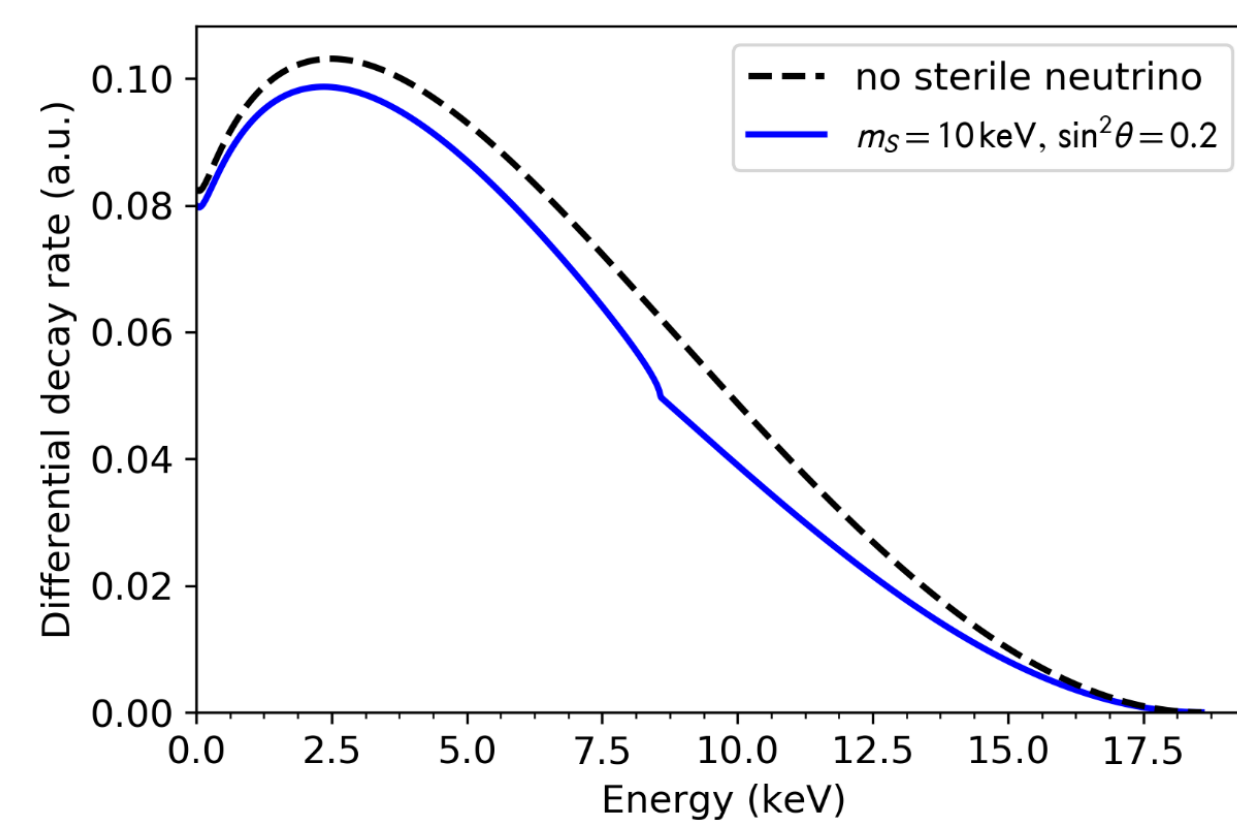
eV-scale: electron neutrino mass measurement

endpoint region of tritium β -spectrum

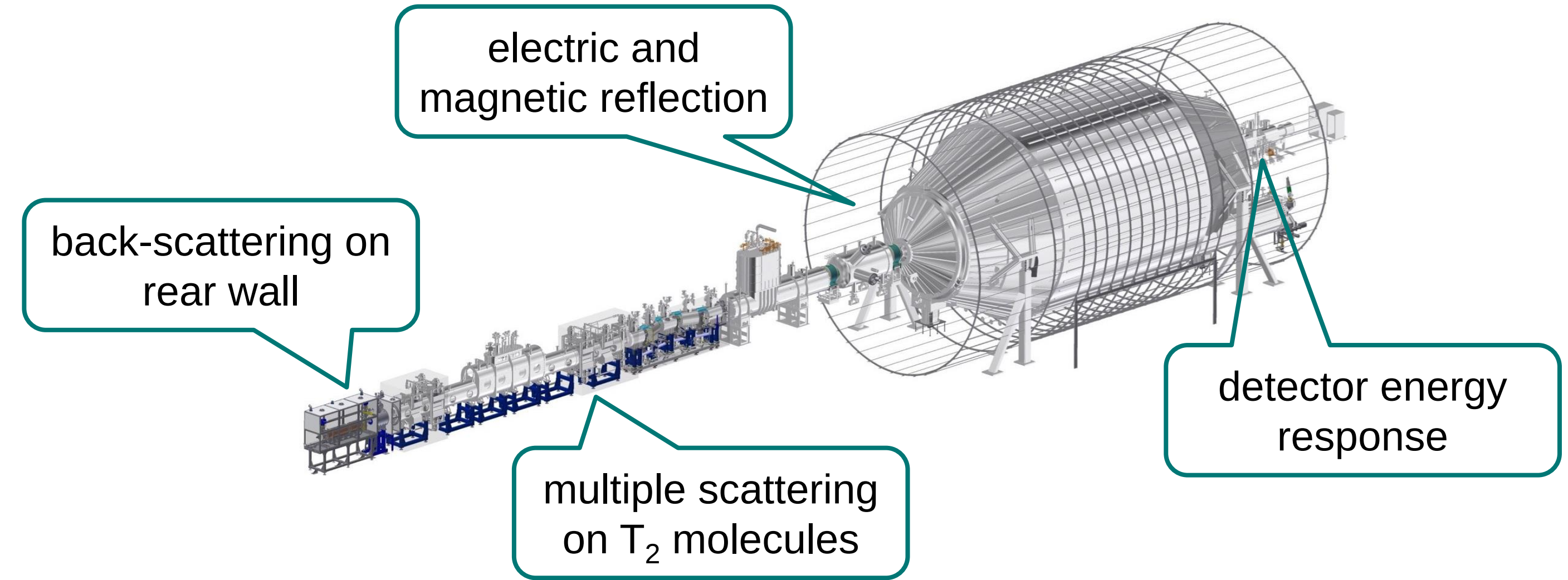


keV-scale: search for sterile neutrino

entire tritium β -spectrum

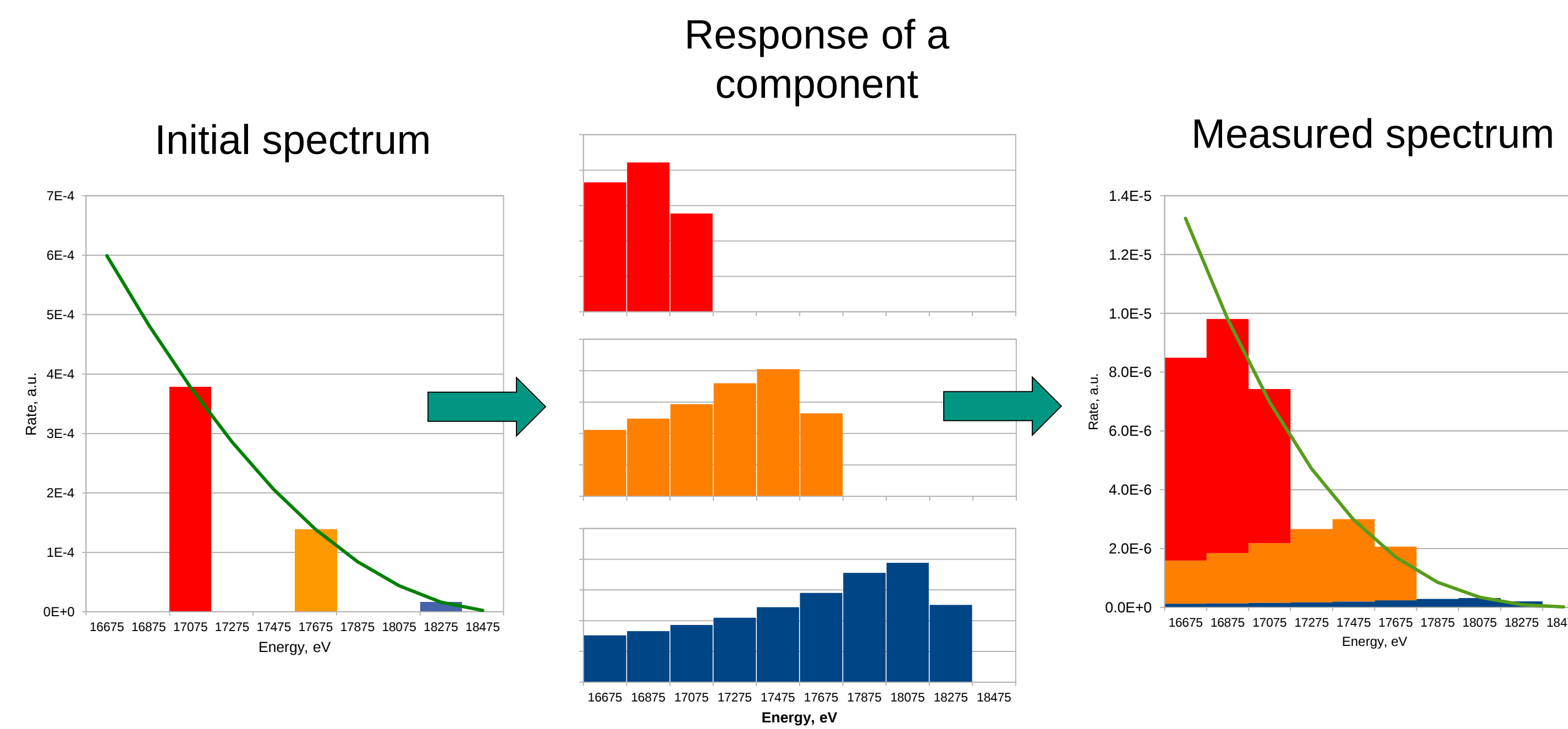


Tritium β -spectrum far from endpoint:



Need a model to describe the full tritium β -spectrum

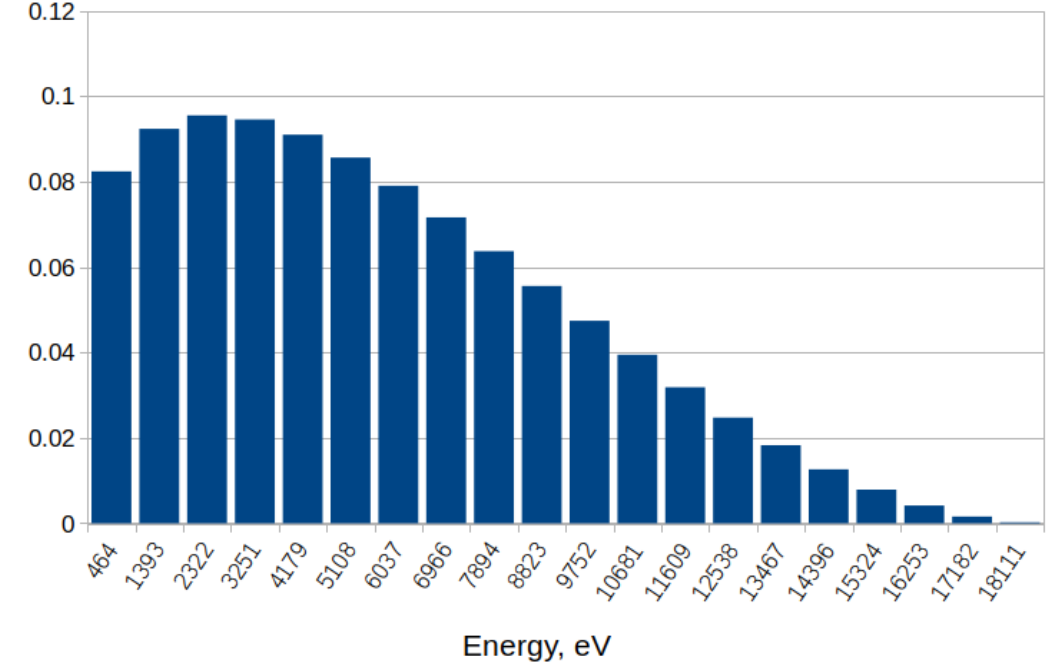
Modelling β -spectrum with response matrices



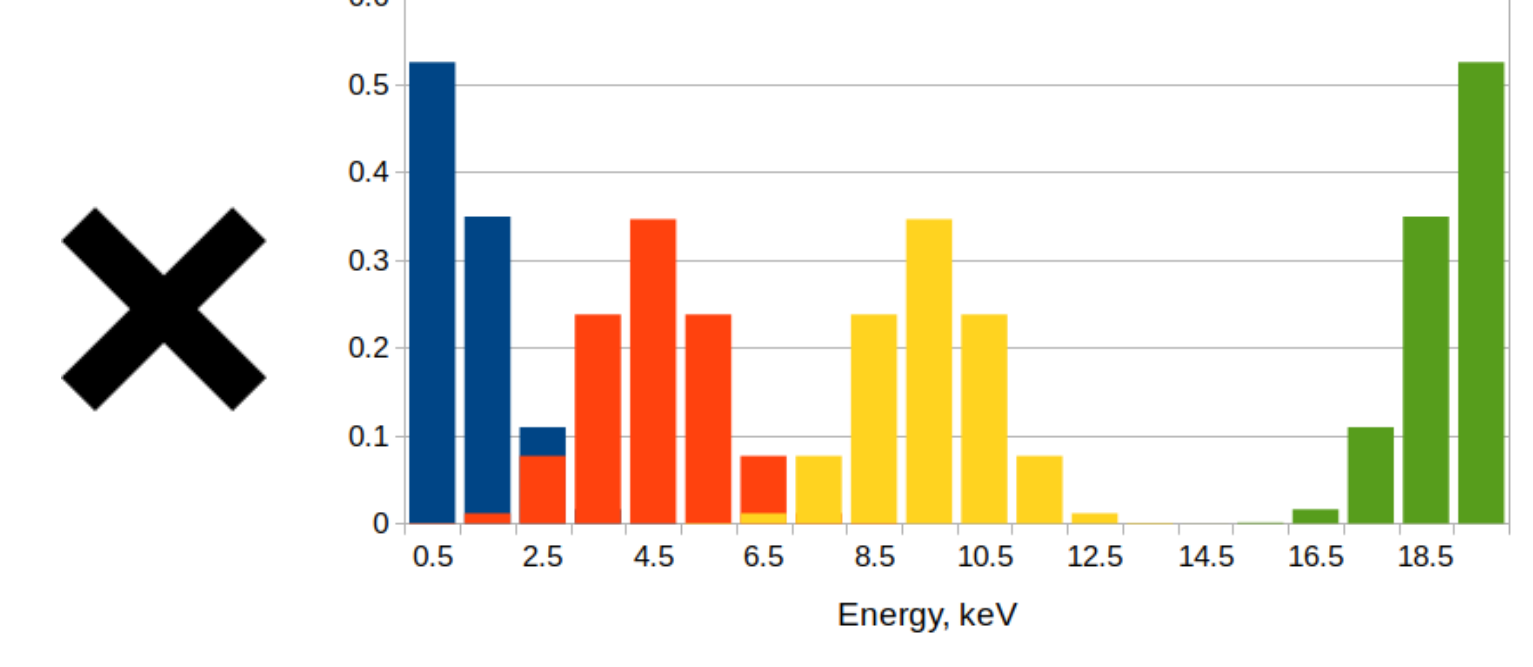
Each component of KATRIN influences the spectrum shape
→ pre-calculate response to monoenergetic & monoangular electrons
→ combine to get the complete spectrum

Complete response and practical usage

Binned theoretical β -spectrum

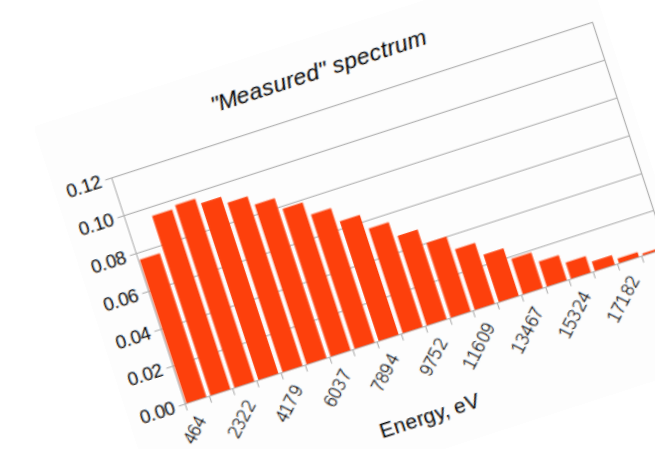


Response matrix of a component



$$S^T = \{S_1 \quad S_2 \quad \dots \quad S_N\}$$

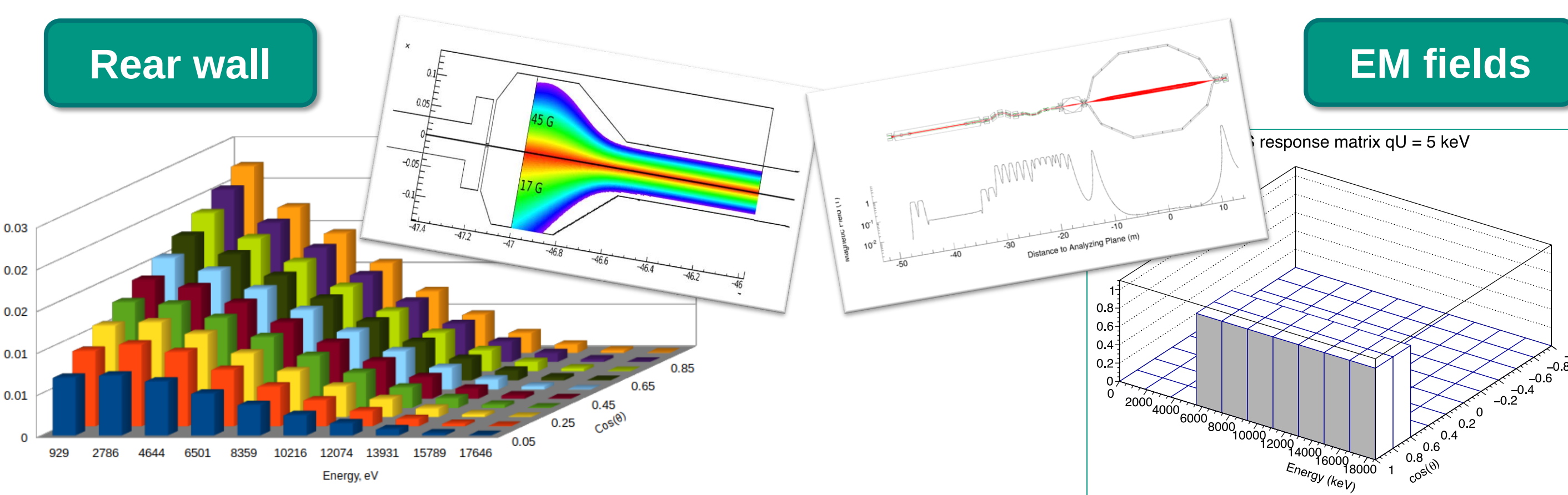
$$R = \begin{pmatrix} R_{11} & \dots & R_{1K} \\ R_{21} & \dots & \dots \\ R_{N1} & \dots & R_{NK} \end{pmatrix}$$



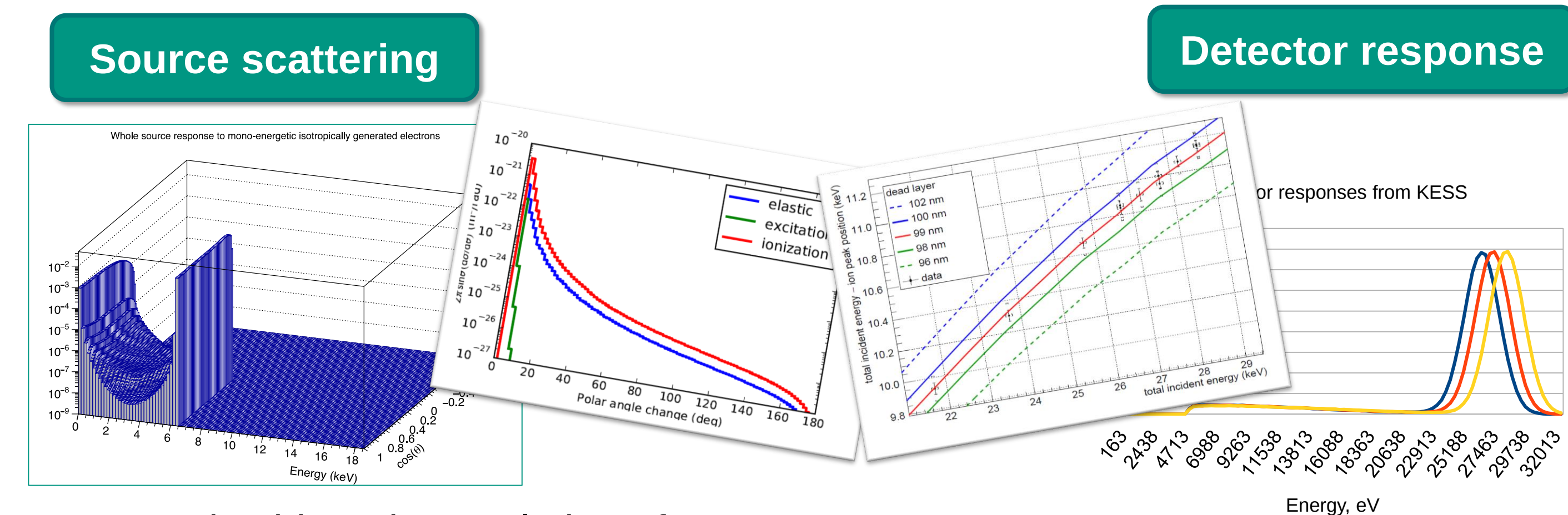
$$M^T = S^T \times R = \{M_1 \quad M_2 \quad \dots \quad M_K\}$$

Sterile neutrino parameters independent of experimental setup
→ matrix multiplication to add a component response
→ complete response calculated once → use it for analysis/fitting

Responses of KATRIN components



- Geant4 particle tracking simulation
- Includes secondary Auger electrons
- Analytical assuming adiabatic transport
- Kassiopeia particle tracking simulation

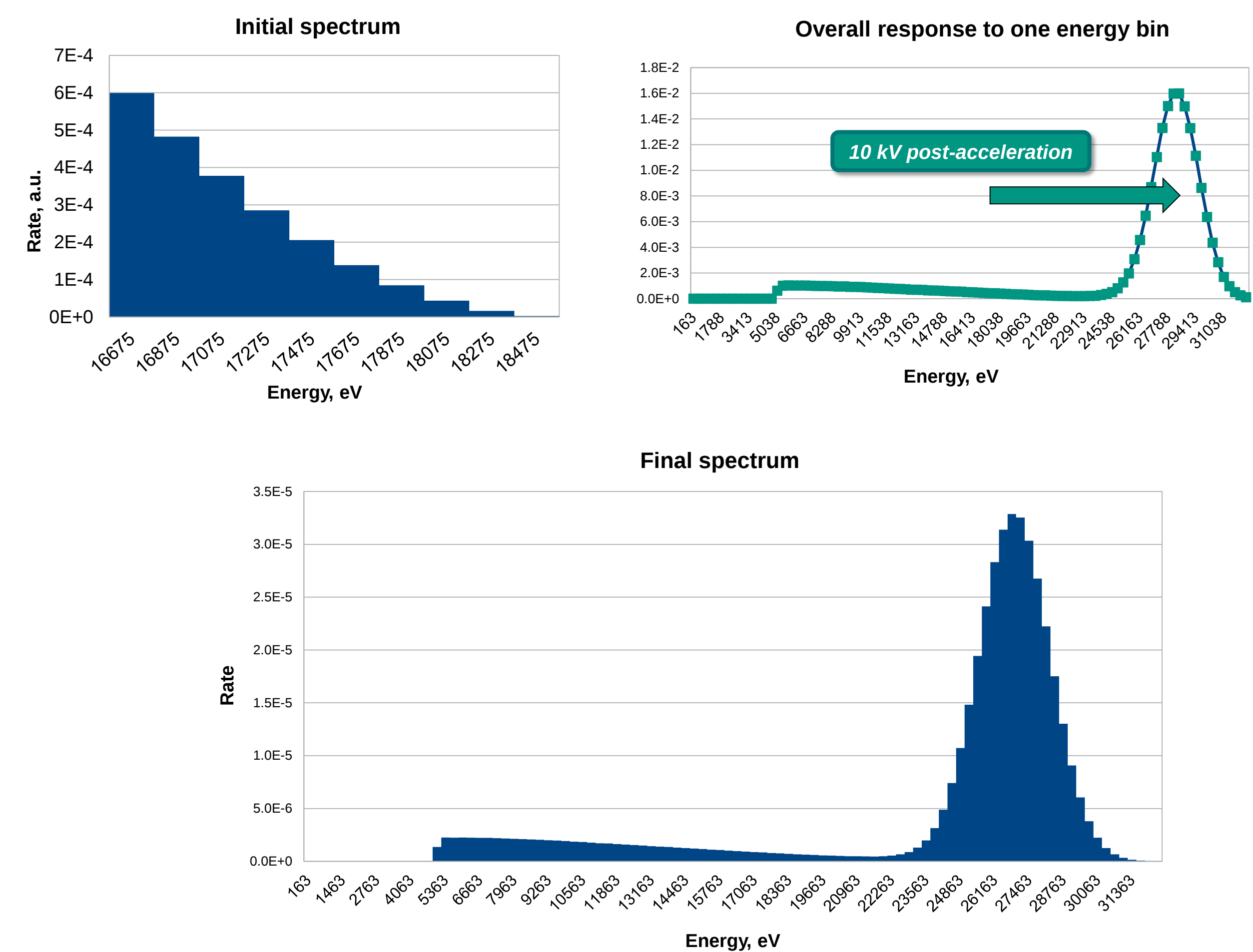


- Iterative binned convolution of electron distribution with scattering differential cross section
- Energy-dependent total cross-section
- KESS particle tracking simulation in Si
- Backscattering, charge sharing, pile-up, dead layer energy losses

Current applications:

- First tritium data of KATRIN
- Forward beam monitor (poster by S. Hickford)
- Troitsk sterile neutrino measurement with TRISTAN detector

Simulated β -spectrum (last 2 keV)



Future activities:

- GPU-version of response matrix approach
- Phase-0 sterile ν search with KATRIN (poster by S. Mertens)
- Studies of systematic effects (see also poster by A. Huber)

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