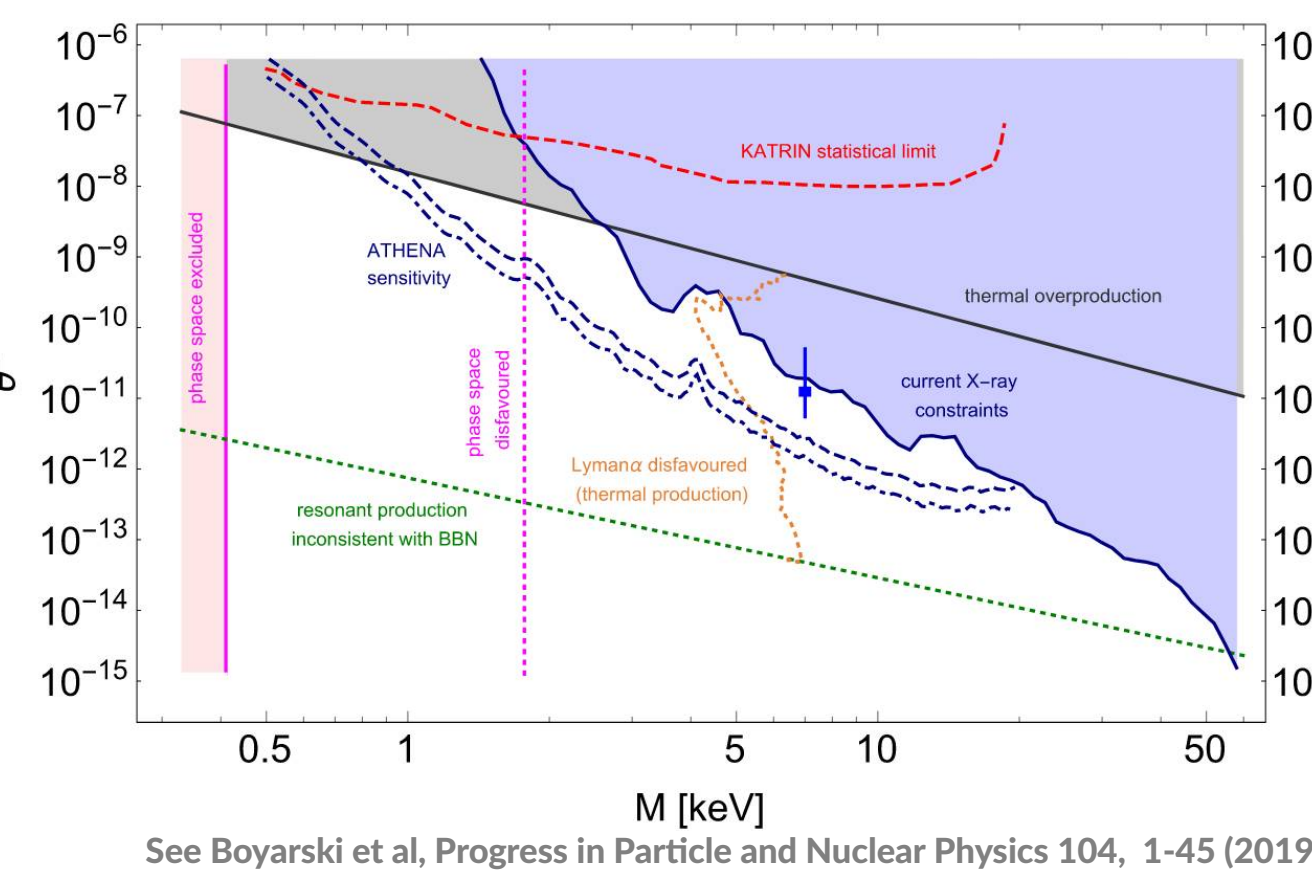


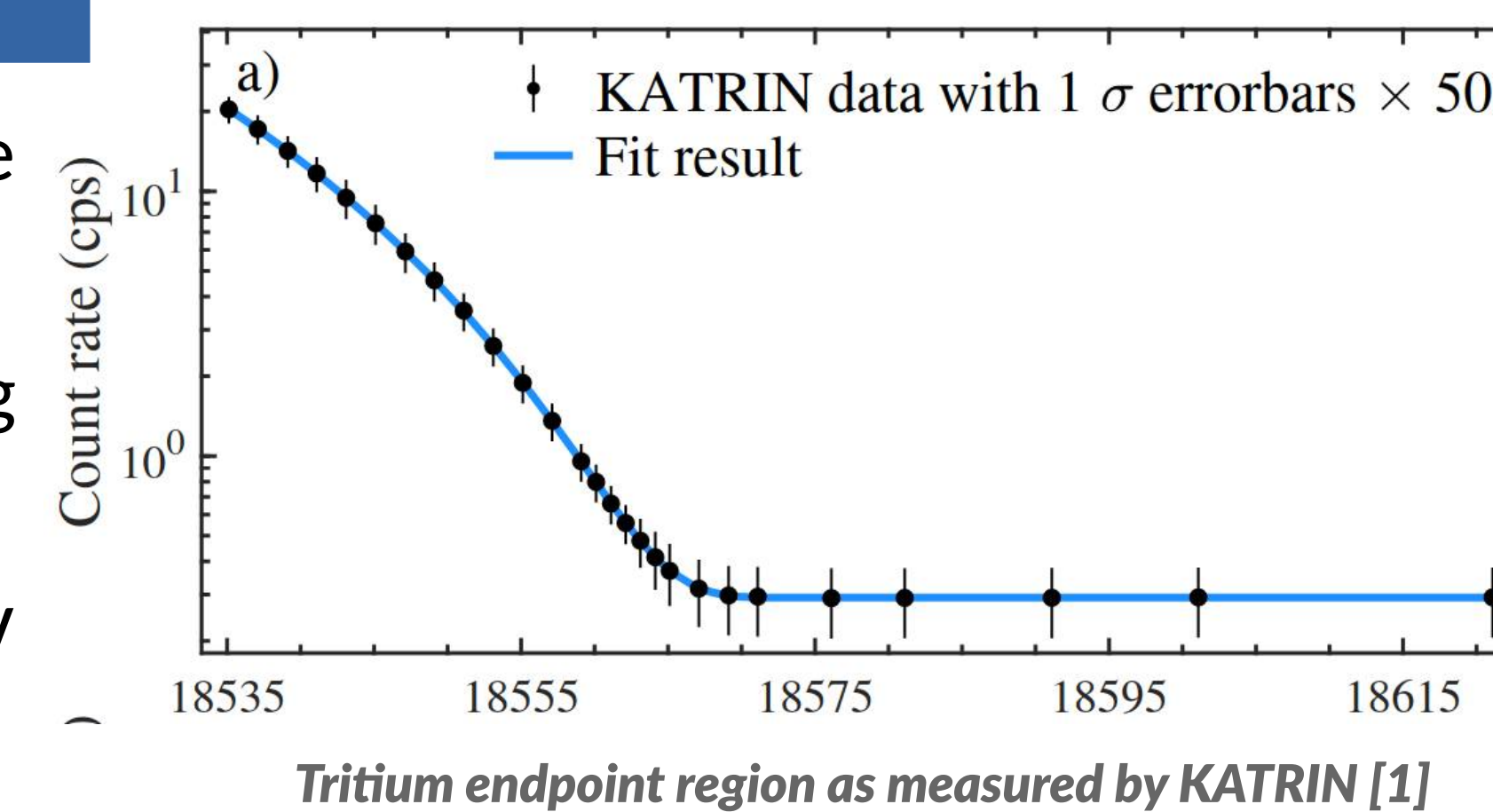
keV-sterile neutrinos

- ☐ Sterile neutrinos are a minimal extension to Standard Model
- ☐ keV-sterile neutrinos are viable dark matter candidates
- ☐ Stringent limits on its existence can be derived from astrophys. observations.



The KATRIN experiment

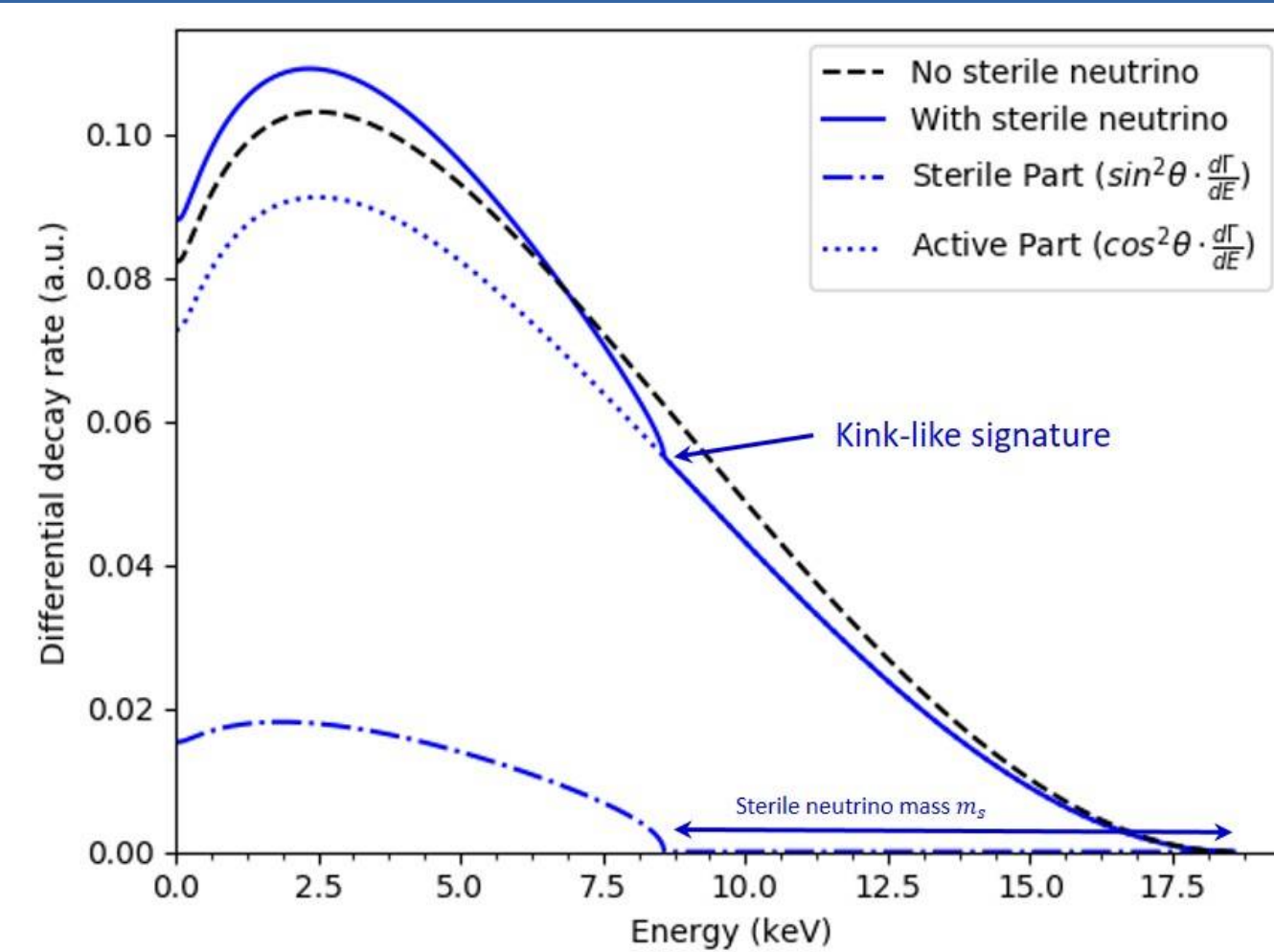
- ☐ MAC-E filter β -spectrometer and intense tritium source, located in Karlsruhe, Germany
- ☐ Neutrino mass measurement by investigating the tritium β endpoint region
- ☐ First results published in 2019, first sub-eV sensitivity to be published in 2021 [1]



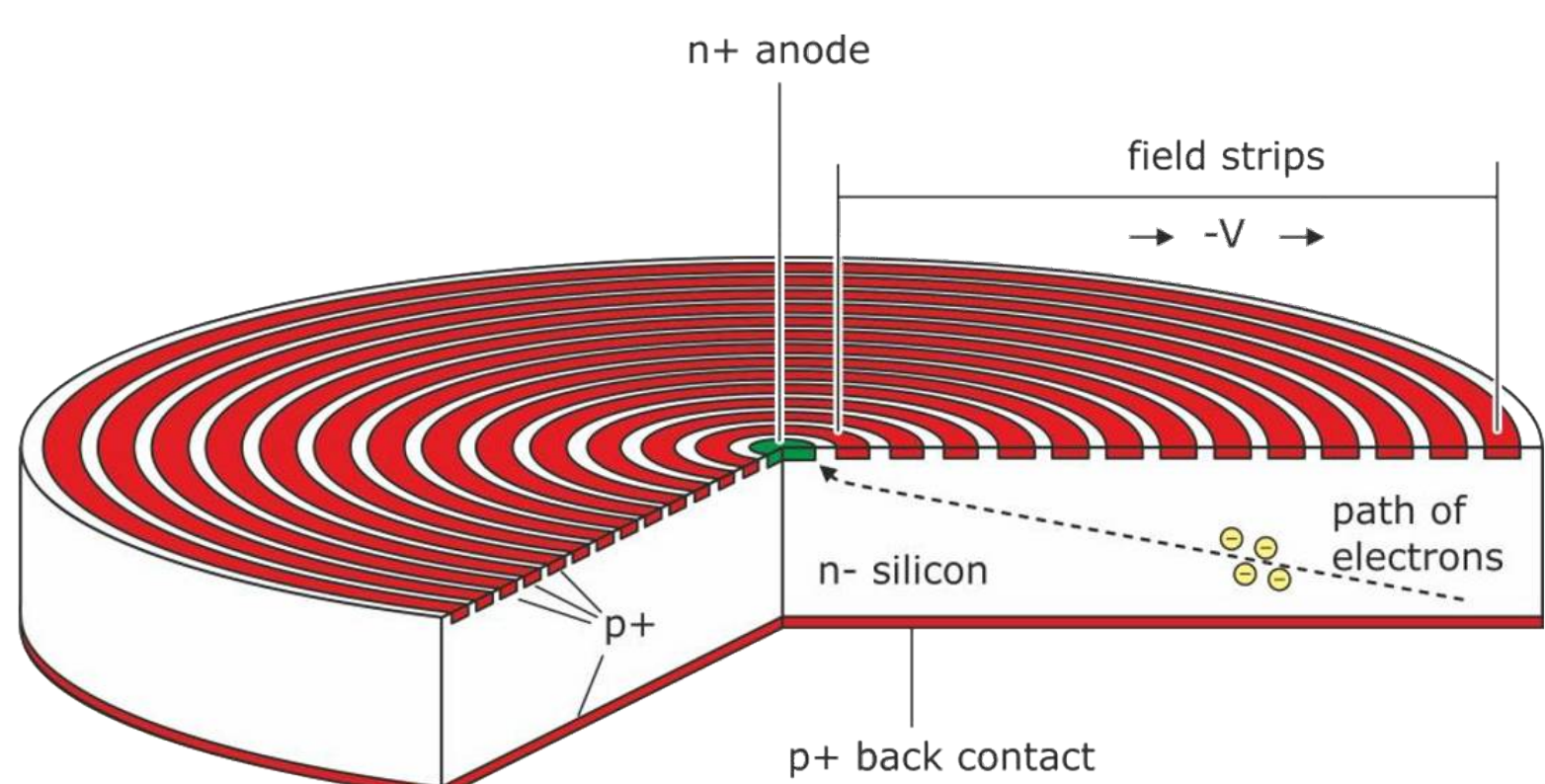
The TRISTAN project

- ☐ Search for keV-sterile neutrino in the entire tritium beta spectrum using KATRIN spectrometer.
- ☐ Imprint is a kink-like signature
- ☐ Sensitivity on mixing angle of 10^{-6} [2]

Concept



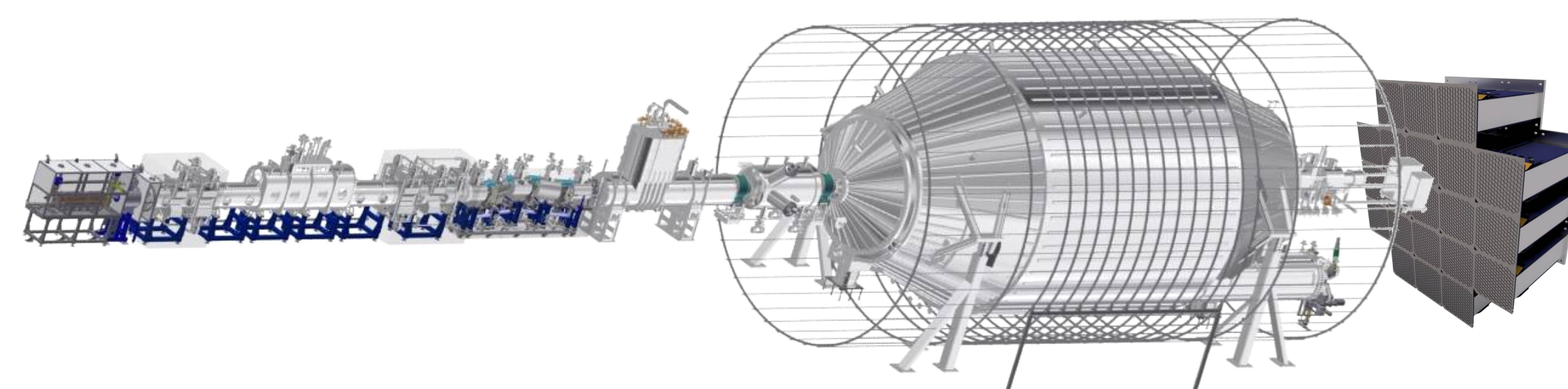
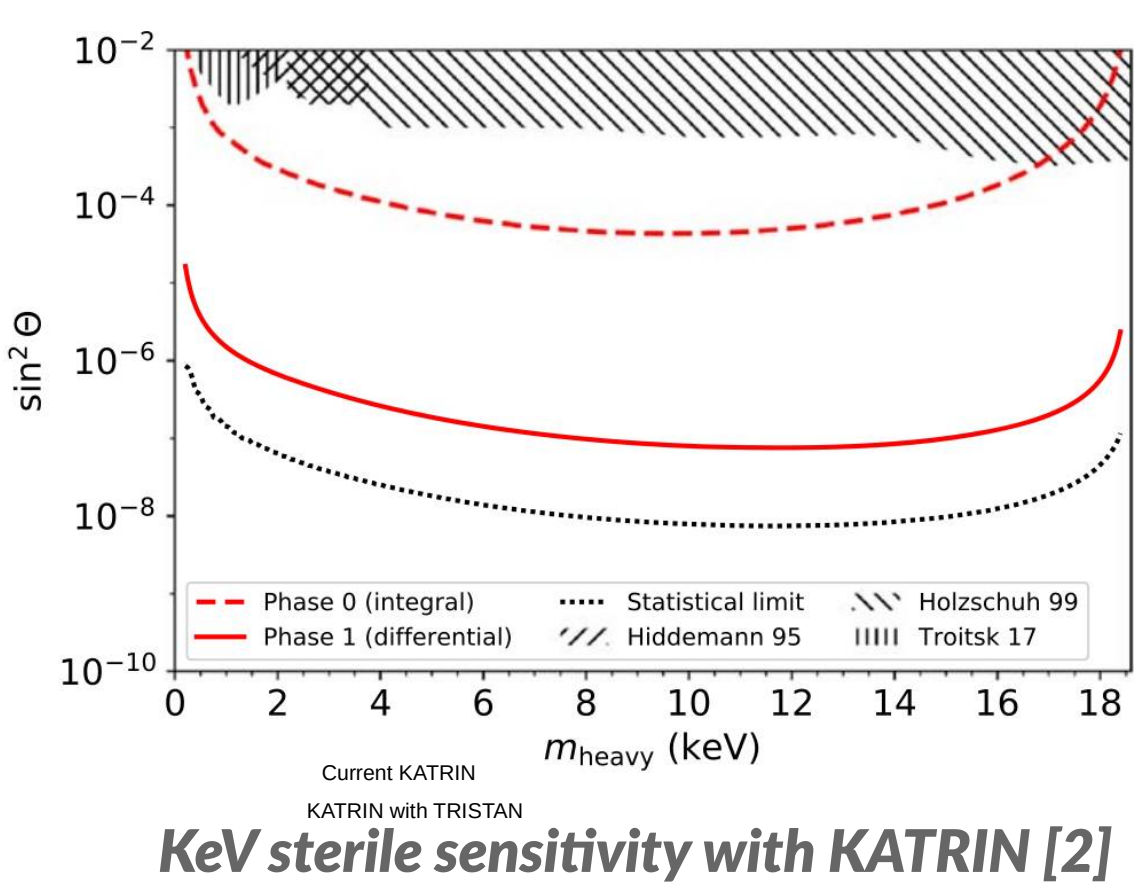
Requirements



- ☐ Energy resolution : FWHM 300 eV@20 keV
- ☐ Large area of coverage : 20 cm
- ☐ Low energy threshold for electrons : ~1 keV
- ☐ Handling high rates : 10^8 cps
- Silicon Drift Detector technology

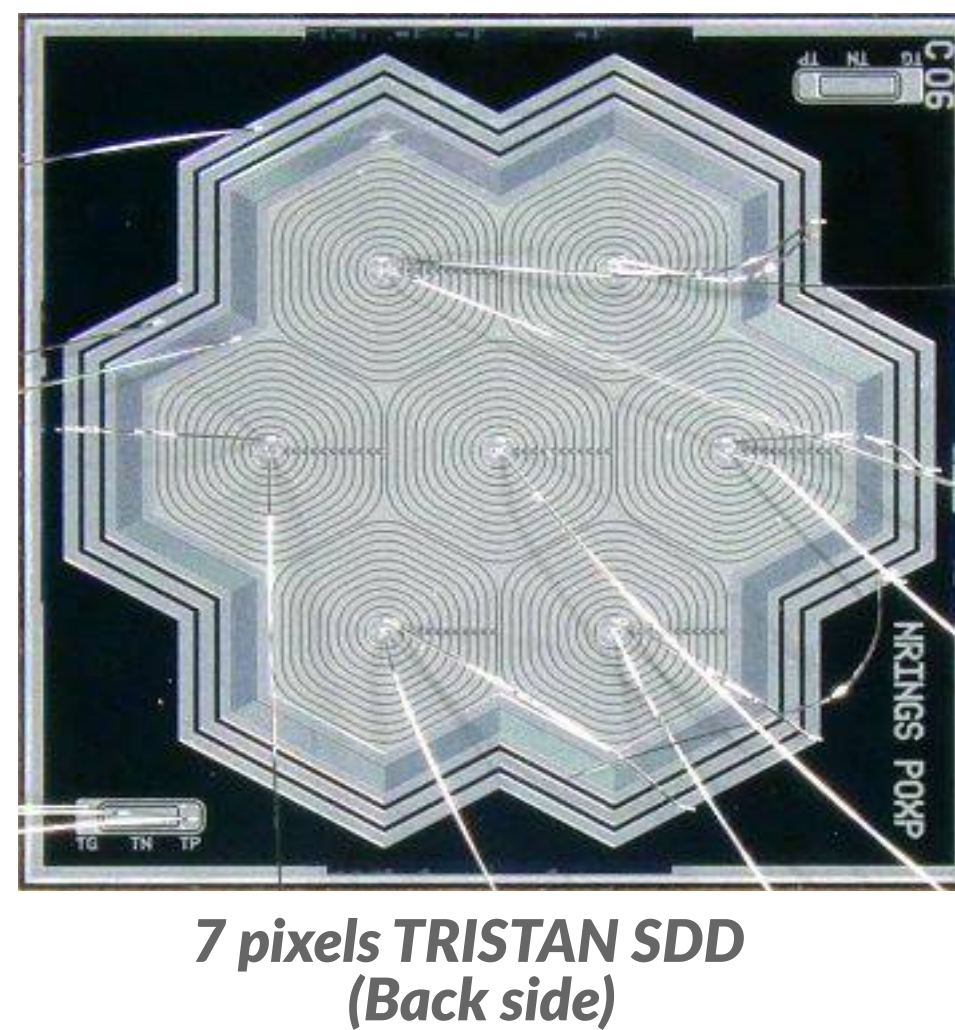
Projet

Development of a novel detector and read-out system for the KATRIN spectrometer, made of 21 modules for a total of 3486 SDD pixels.

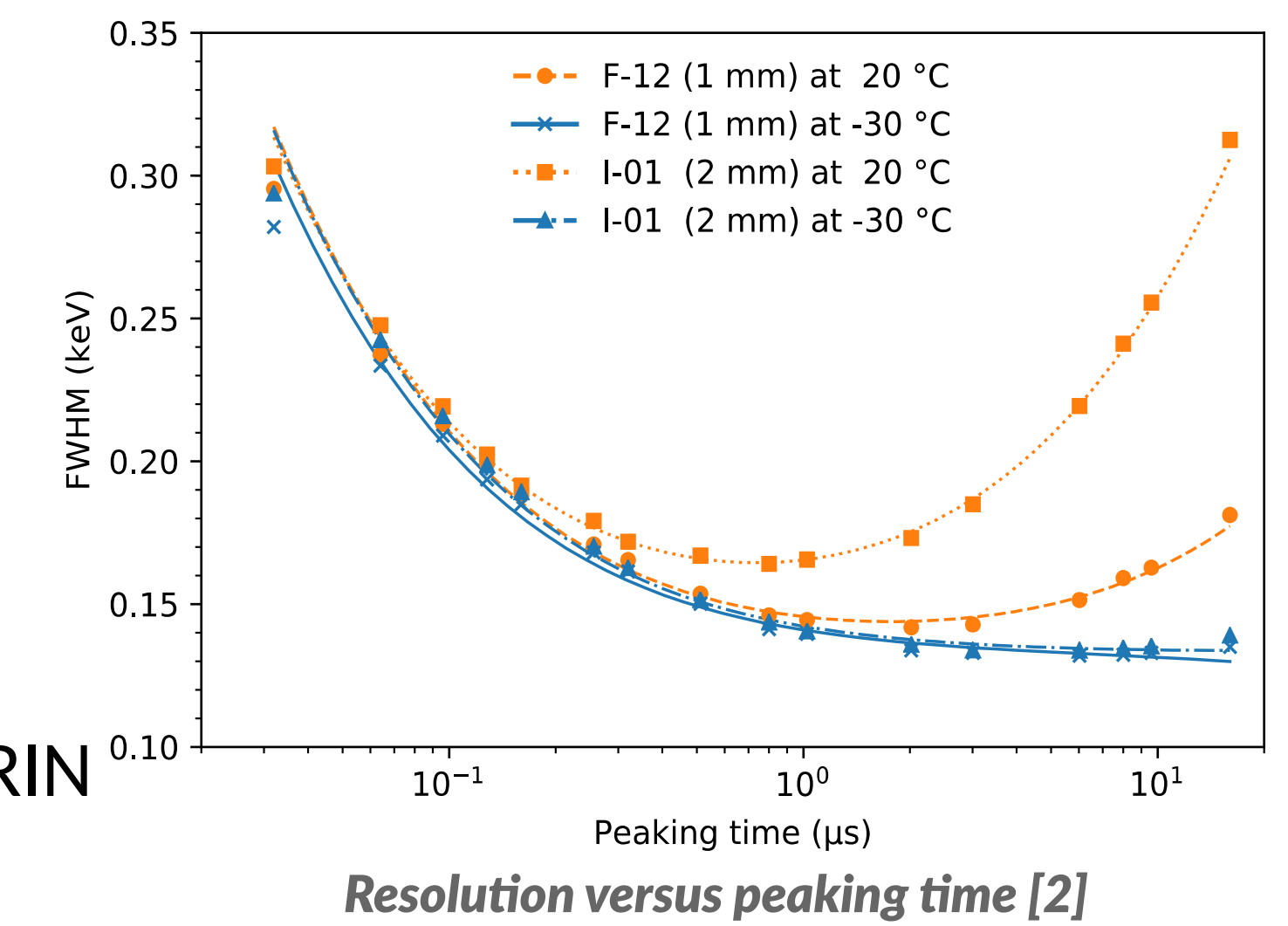


- ☐ Targeted sensitivity : $\sin^2(\theta) \sim 10^{-7}$
- ☐ Careful study of the systematics is on-going

Prototype



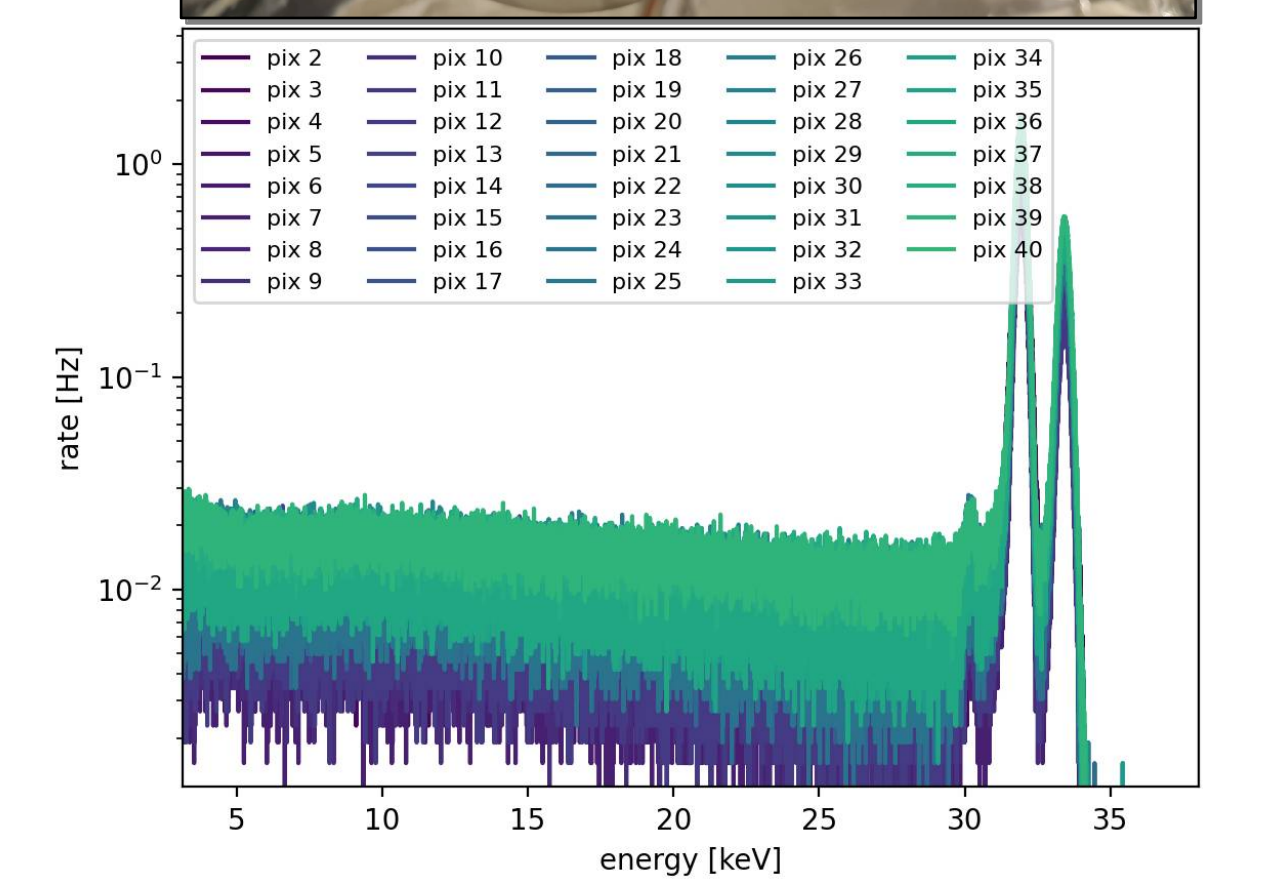
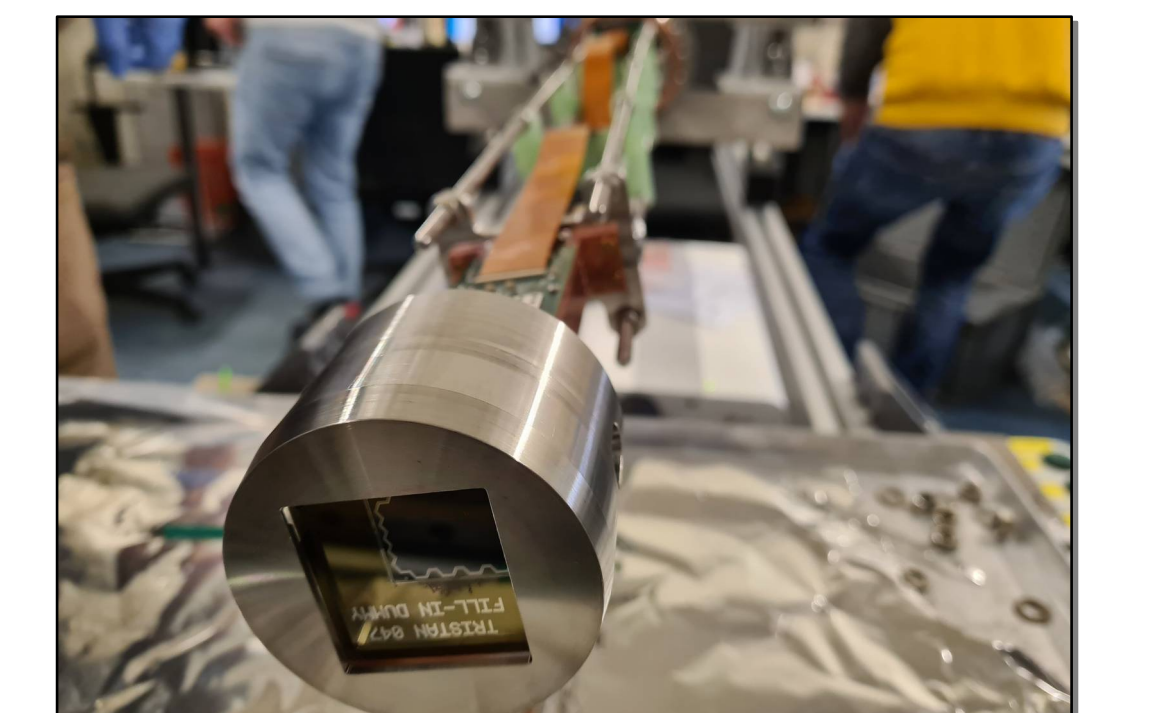
- 7 pixels, \varnothing 2 mm, hexagonal, external CMOS (CUBE)
- ☐ Resolution : 140 eV FWHM @ 6 keV
- ☐ Threshold : ~ 300 - 500 eV
- ☐ Count Rate : up to 10^5 Hz/pixel
- ☐ Dead layer measured : < 50 nm
- ☐ Response to photons [2] and electrons [3]
- ☐ Applications : on keV-sterile with Troitsk^[4] and as the KATRIN Forward Beam Monitor detector



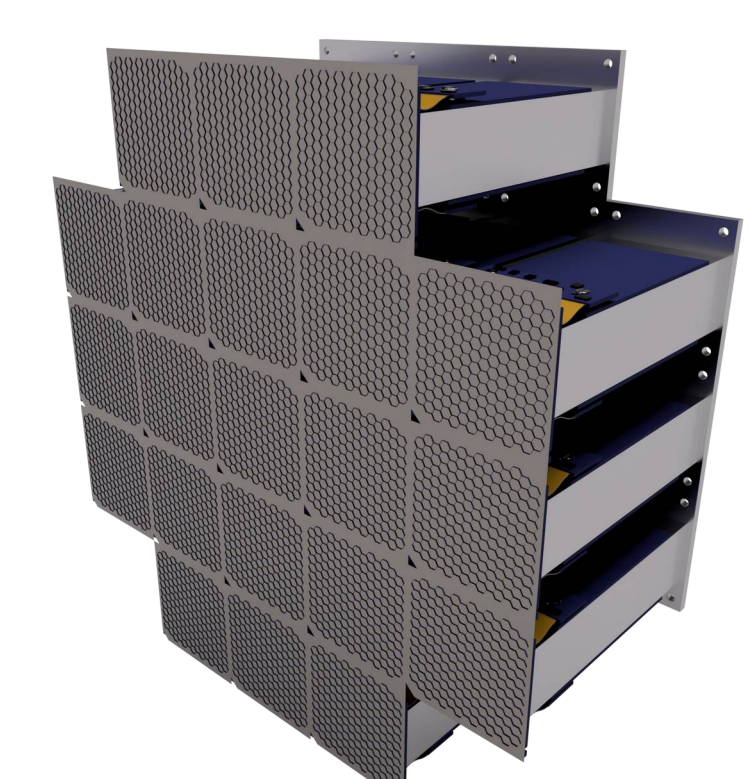
Module



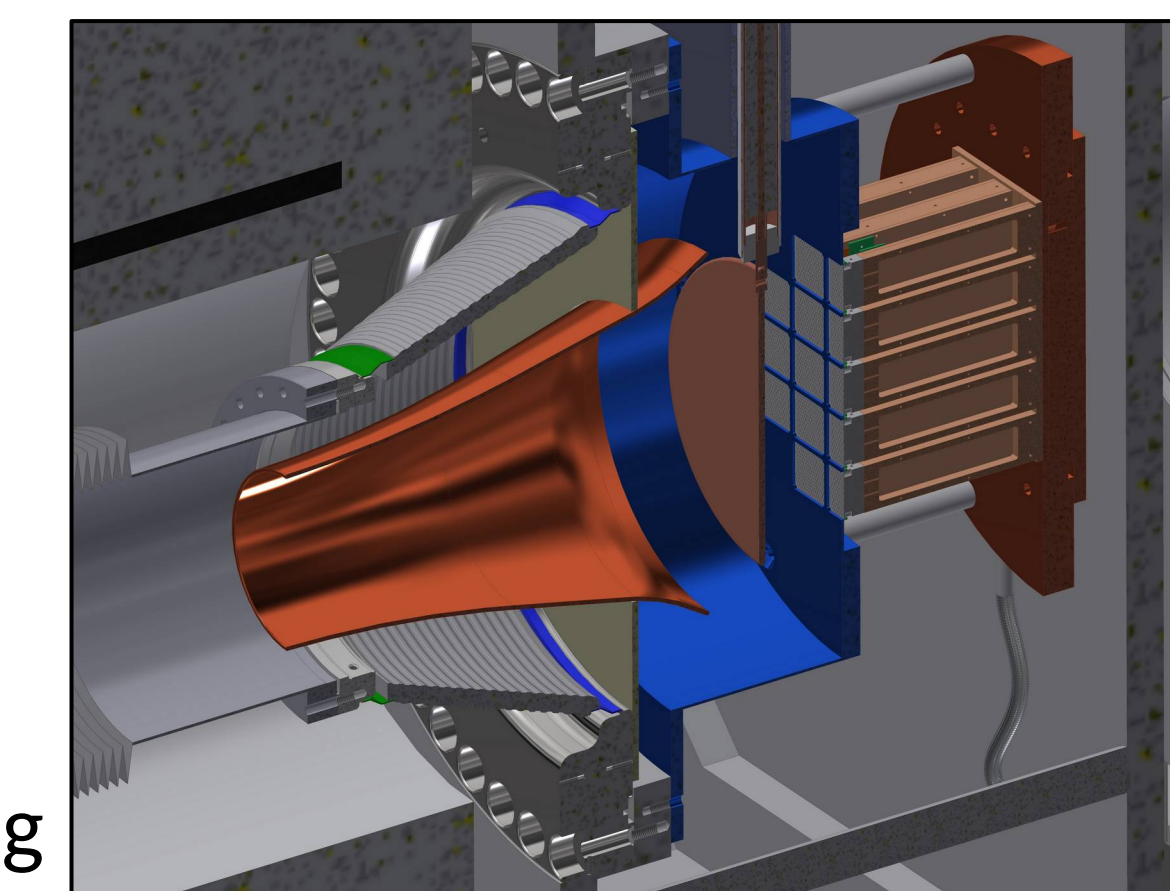
- 166 pixels, \varnothing 3 mm, integrated FET, design ready [5]
- ☐ Operating 1/21 final detector with realistic conditions
- ☐ Stable cooling system and ultra-high vacuum compatible design
- ☐ First implementation in KATRIN as Monitor Spectrometer detector in Mars 2021,
- ☐ Dedicated ASIC developed for TRISTAN SDD (Ettore)
- ☐ Dedicated DAQ developed for TRISTAN (Kerberos)
- ☐ Homogeneous response among pixels and stability investigations over time



Final detector



- 21 modules, ~3500 pixels
- ☐ New detector chamber for KATRIN
- ☐ Design a dedicated DAQ with full waveform digitalization
- ☐ Implementation planned after the mass campaign
- ☐ Post-acceleration electrode 30 kV
- ☐ Systematics studies on DAQ non linearities, charge sharing, backscattering effects



[1] M. Aker et al. (KATRIN Collaboration), An improved upper limit on the neutrino mass from a direct kinematic method by KATRIN, PRL 123, 221802 (2019)
 [2] S. Mertens et al., A novel detector system for KATRIN to search for keV-scale sterile neutrinos, Journal of Phys. G, 46-6, (2019)
 [3] S. Mertens et al., Characterization of Silicon Drift Detectors with Electrons for the TRISTAN Project, Journal of Phys. G, 48-015008 (2021)
 [4] T. Brunst et al., Measurements with a TRISTAN prototype detector system at the "Troitsk nu-mass" experiment in integral and differential mode, JINST 14 P11013 (2019)
 [5] T. Houdy et al., Hunting keV sterile neutrinos with KATRIN: building the first TRISTAN module, J. Phys.: Conf. Ser. 1468 012177 (2020)

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