TRISTAN: A novel detector for searching keV-sterile neutrinos at the KATRIN experiment

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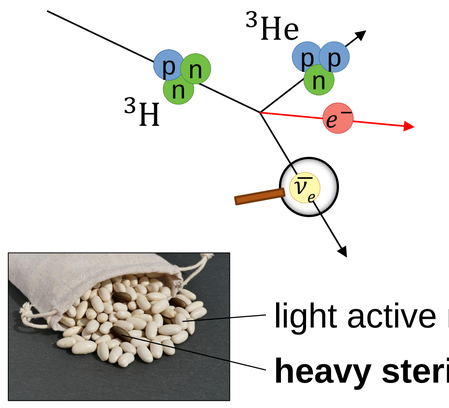
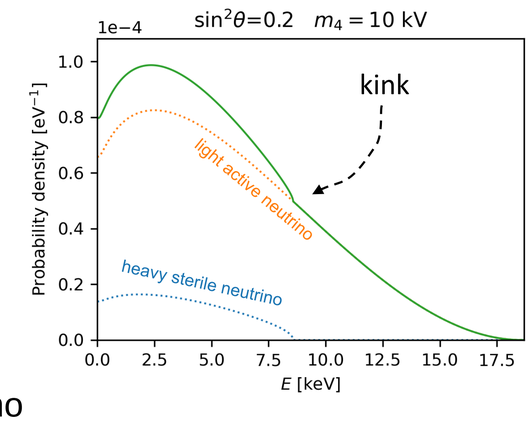
Motivation

Search for new particles in β-decay

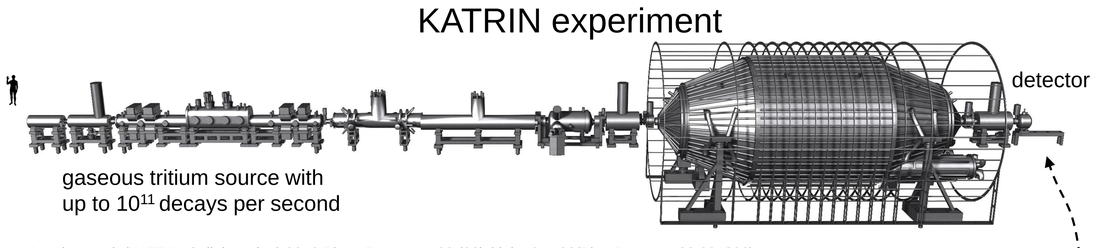




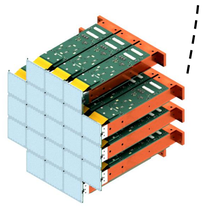
light active neutrino

heavy sterile neutrino

KATRIN experiment



M. Aker et al. (KATRIN Collaboration) 2019 Phys. Rev. Lett.123 (22) (doi: 10.1103/PhysRevLett.123.221802)
M. Aker et al. (KATRIN Collaboration) 2021 JINST 16 T08015 (doi: 10.1088/1748-0221/16/08/T08015)



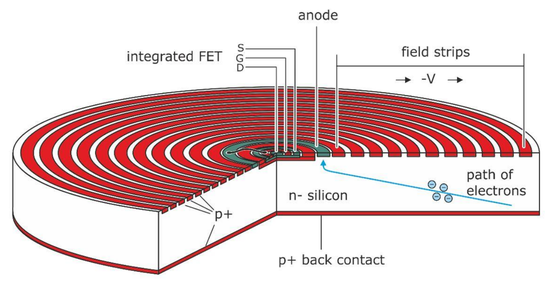
New detector required for high rate β-spectroscopy: TRISTAN

S. Mertens et al 2019 J. Phys. G: Nucl. Part. Phys. 46 065203 (doi: 10.1088/1361-6471/ab12fe)

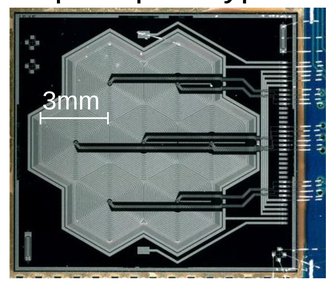
TRISTAN SDD

- High rate capability (total 10^8 cps)
- Good intrinsic energy resolution

Multipixel silicon drift detector (SDD)



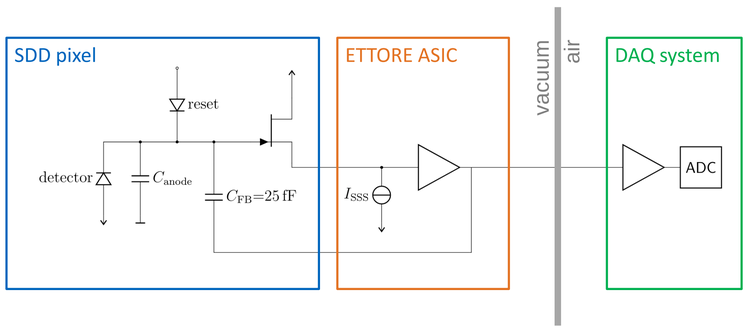
7-pixel prototype

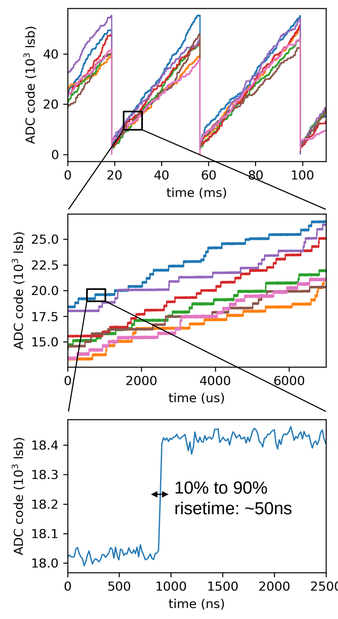


Challenges:

- Scaling to focal plane array (>1000 pixels)
- Electron spectroscopy (thin deadlayer)
- Difficult environment (UHV, magnetic fields etc.)

Readout Chain



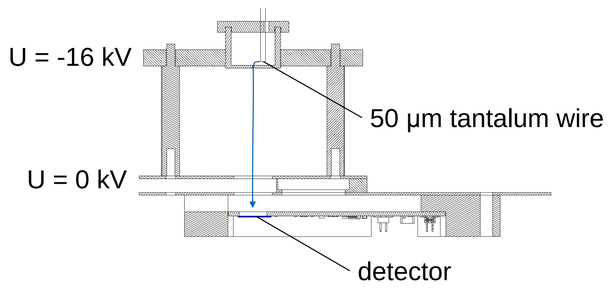


Preamplifier:
ETTORE, 12-channel
low noise ASIC

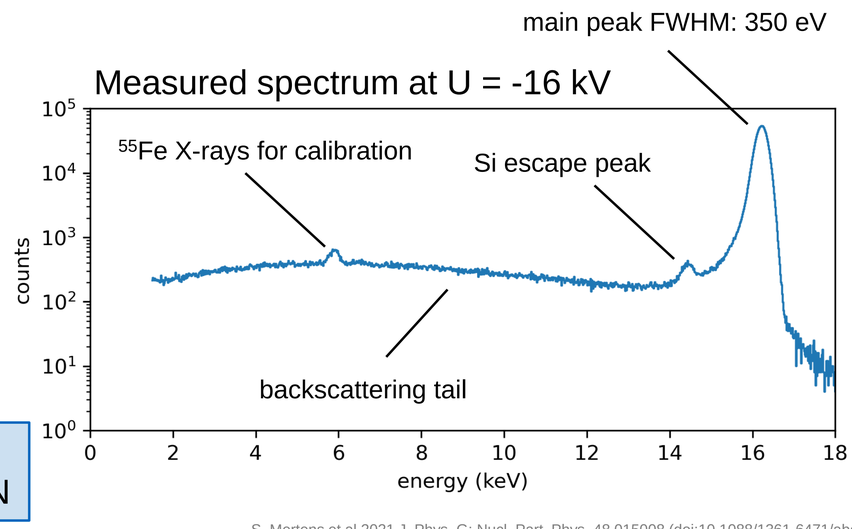
P. Trigilio et al., 2018 IEEE Nuclear Science Symposium and Medical Imaging Conference Proceedings (NSS/MIC), 2018, pp. 1-4 (doi: 10.1109/NSSMIC.2018.8824675)

Electron Response

Hot-cathode electron source setup



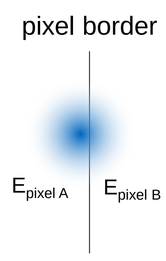
Measured spectrum at U = -16 kV



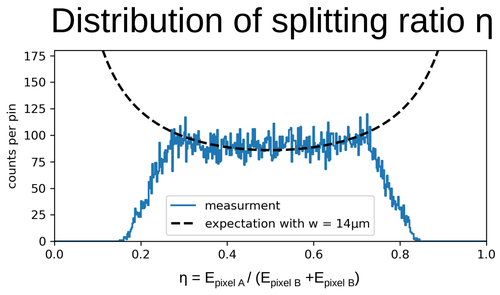
Precise measurement of electron response is very important for TRISTAN

S. Mertens et al 2021 J. Phys. G: Nucl. Part. Phys. 48 015008 (doi:10.1088/1361-6471/abc2dc)

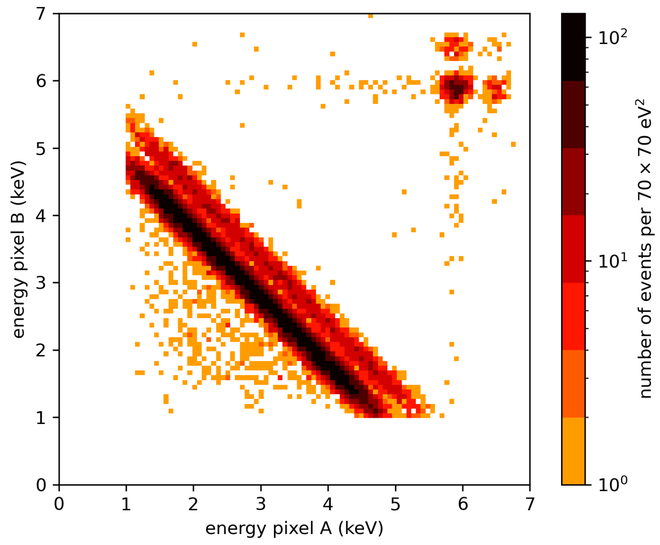
Multi-pixel-effect: Charge Sharing



Distribution of splitting ratio η

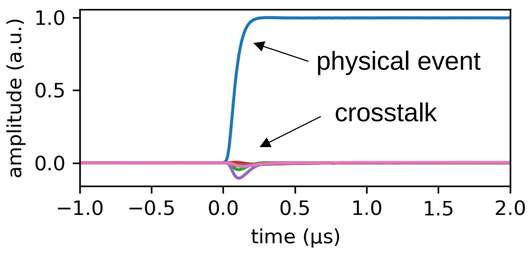


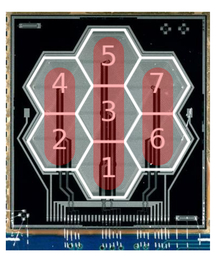
Charge sharing events in an ^{55}Fe measurement

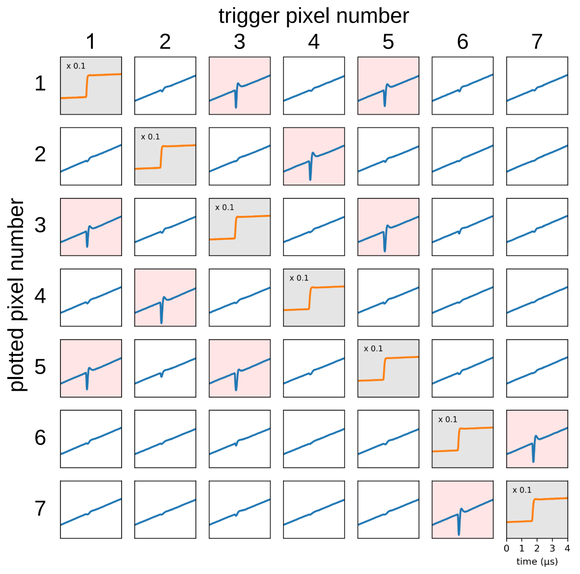


- No significant charge is lost at saddle point between pixels
- Measured Gaussian charge cloud size: ~ 14µm

Multi-pixel-effect: Crosstalk



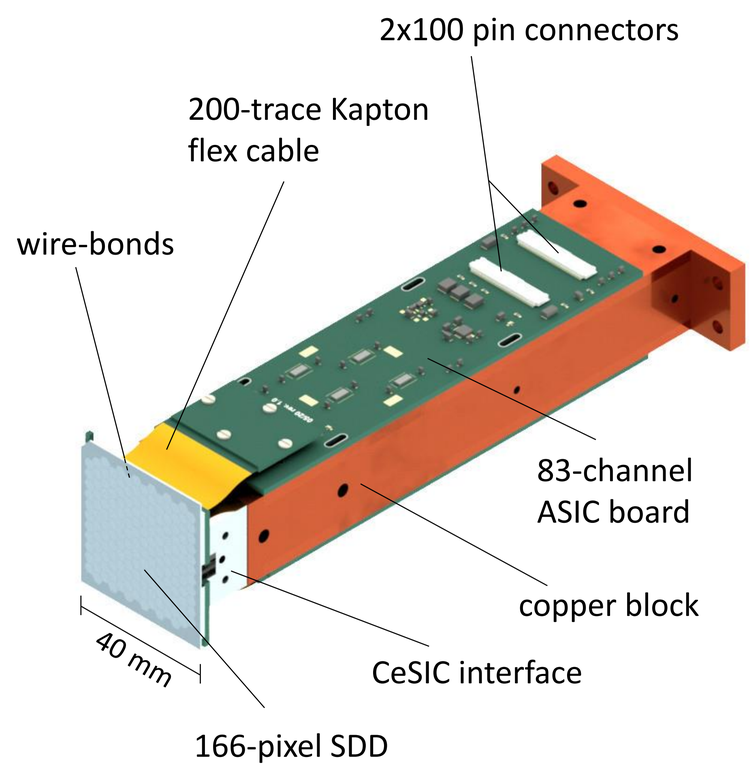




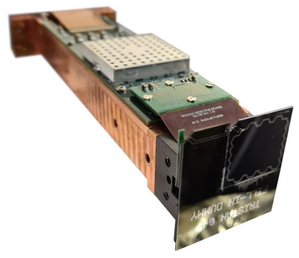
- differential effect within vertical readout columns

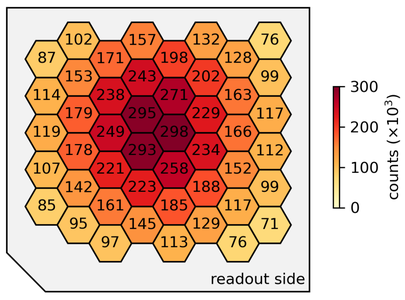
→ Better electrical separation between readout lines needed

Outlook: 166-pixel module



First operation of a 47-pixel module





Milestones:

- ✓ First successful operation of a 47-pixel detector module
- Next step: Operation of a full 166-pixel detector module

Supported by Cusanuswerk

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