C0BRA: Low background measurements with CdZnTe detectors

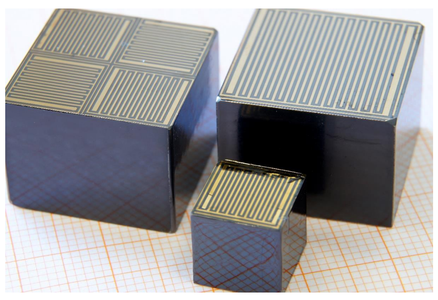
TECHNISCHE UNIVERSITÄT DRESDEN

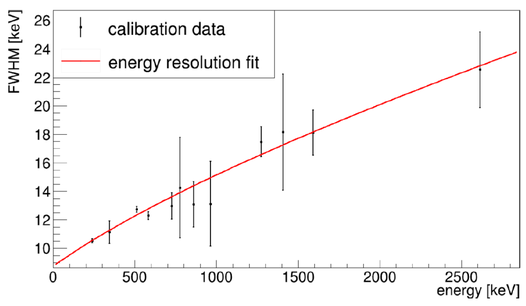
The C0BRA experiment

- **C**dZnTe **0** neutrino double **B**eta **R**esearch **A**pparatus
- 2013 construction of C0BRA demonstrator
- 2018 upgrade to C0BRA e**x**tended **dem**onstrator (XDEM)

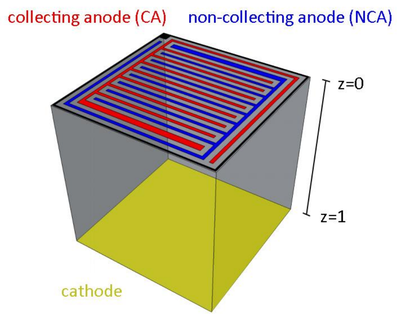
The CdZnTe detectors

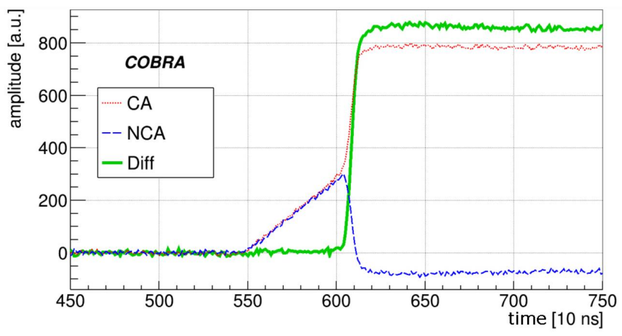
- CdZnTe is a commercially available room temperature semiconductor, offering a high energy resolution as well as a high efficiency. [1]





- In order to account for hole trapping in the material, the detector crystals are equipped with a coplanar grid electrode. Similar to a Frisch grid it provides a signal pulse independent of the positive charge carriers in the material. [2][3]

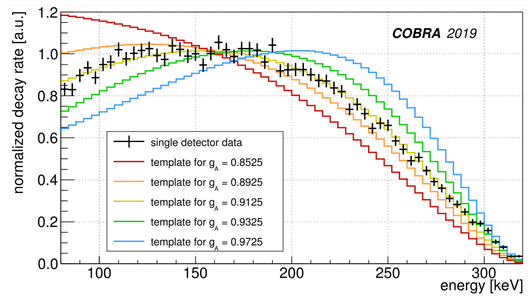


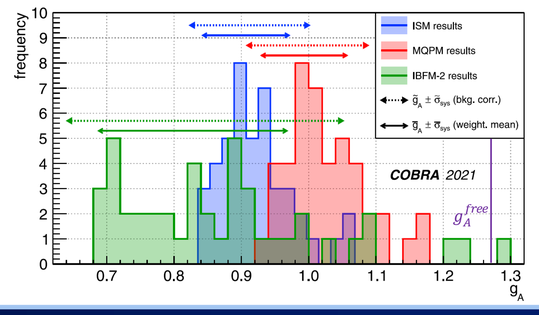


Research prospects

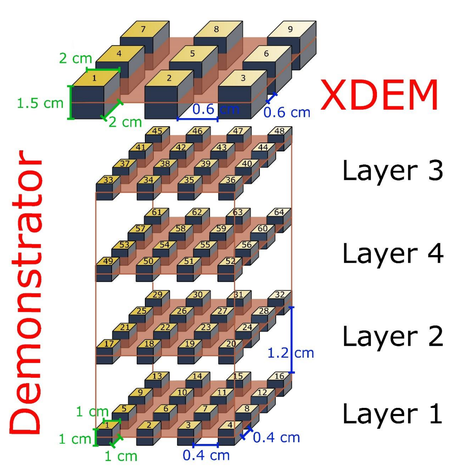
- The detector material contains nine different isotopes capable of various double beta decay modes.
- ^{113}Cd dominates the spectrum. Its spectral form is highly dependent on the strength of the axial vector coupling g_A. Hence, it can be used to test for a possible "quenching" of g_A. [4][5]

isotope	decay modes	natural abundance	Q-value [keV]
^{113}Cd	β^- (fourfold forbidden)	12.23 %	322.6
^{123}Te	EC (twofold forbidden)	0.91 %	53.7
^{64}Zn	EC/β^+, EC/EC	49.17 %	1094.7
^{70}Zn	$\beta^-\beta^-$	0.61 %	997.1
^{106}Cd	$\beta^+\beta^+$, EC/β^+, EC/EC	1.25 %	2775.4
^{108}Cd	EC/EC	0.89 %	271.8
^{114}Cd	$\beta^-\beta^-$	28.73 %	542.5
^{116}Cd	$\beta^-\beta^-$	7.50 %	2813.4
^{120}Te	EC/β^+, EC/EC	0.10 %	1730.4
^{128}Te	$\beta^-\beta^-$	31.69 %	866.5
^{130}Te	$\beta^-\beta^-$	33.80 %	2527.5

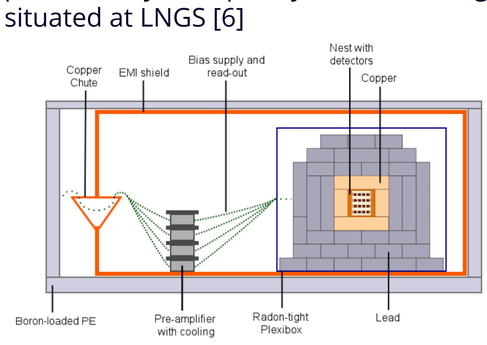




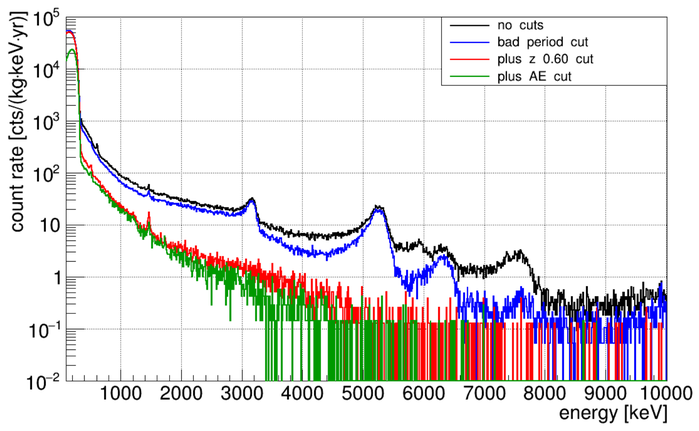
Setup at LNGS



- 64 detectors of the size 1 x 1 x 1 cm³
  9 detectors of the size 2 x 2 x 1.5 cm³
- protected by multiple layers of shielding, situated at LNGS [6]

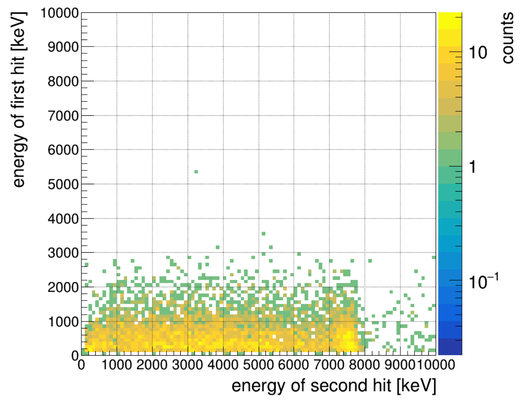


Background components



The detector's background is reduced significantly by the application of various cuts:

- a bad-period cut, which removes data sets with comparatively high rates
- the z and A/E cuts, removing surface events, which are dominated by alpha decays



- The granular structure of the detector system offers the possibility of investigating coincidence events between detector crystals.
- For example, the analysis of

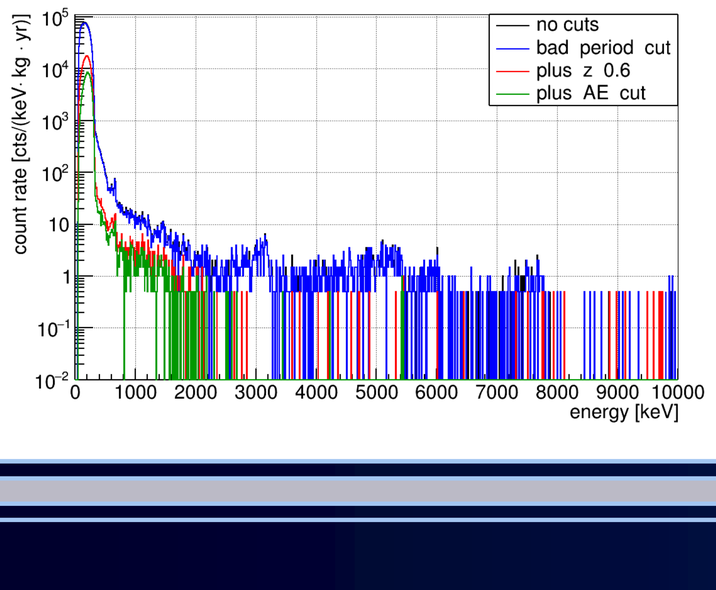
$$^{214}\mathrm{Bi} \xrightarrow{\beta} {}^{214}\mathrm{Po} \xrightarrow{\alpha}$$

0-3300 keV 7687 keV

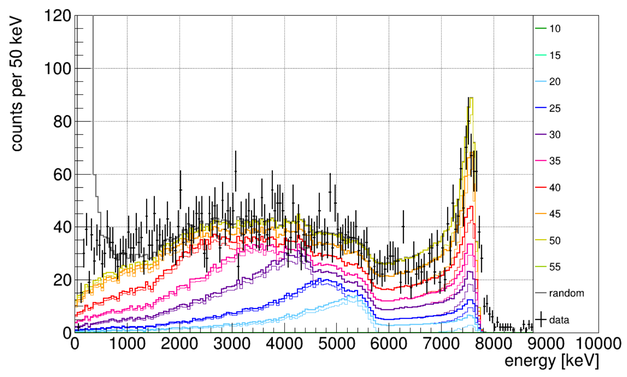
coincidences can help to understand the detector's background.

◂ energies of all two-detector coincidences within a time window of 1 ms

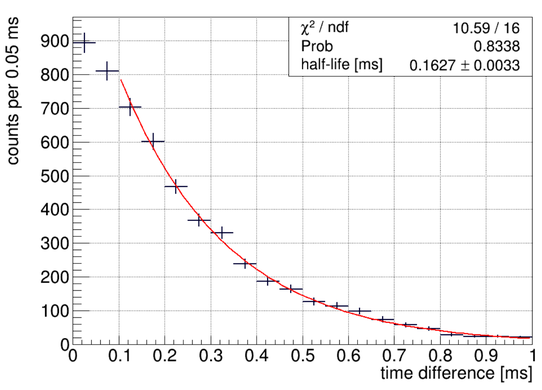
Compared to the C0BRA demonstrator, many improvements regarding background reduction have been made during the construction of XDEM [7]:



- stricter use of radiopure materials and minimized exposure to radon
- larger detector size, reducing the influence of alpha surface events
- implementation of an additional guard ring electrode, actively reducing surface events



▴ spectrum of ^{214}Po events, compared to simulated spectra assuming different thicknesses [nm] of the lacquer around the crystals



▴ time between the ^{214}Bi and ^{214}Po events, literature value: $T_{1/2}(^{214}\mathrm{Po}) = 0.1636\ 3$ ms

References

[1] A. Heimbold – master thesis

[2] M. Fritts *et al.* – Nucl. Instrum. Methods Phys. Res. A 749 (2014)

[3] J. Ebert *et al.* – Nucl. Instrum. Methods Phys. Res. A 807 (2016)

[4] L. Bodenstein-Dresler *et al.* – Phy. Let. B 800 (2020)

[5] J. Kostensalo *et al.* – Phy. Let. B 822 (2021)

[6] N. Heidrich – PhD thesis

[7] kindly provided by Y. Chu

DFG

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