News about the ECHo experiment

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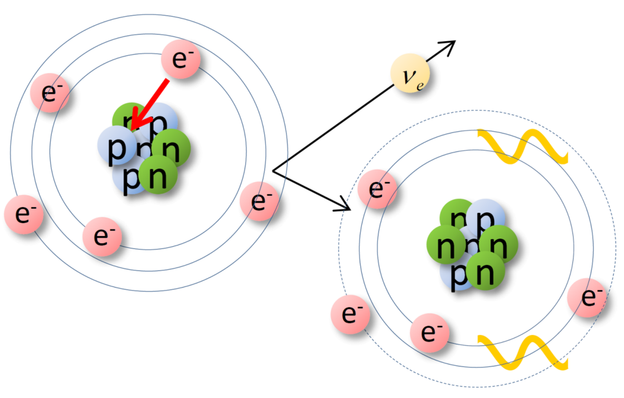
^{163}Ho and electron neutrino mass



$$^{163}_{67}\mathrm{Ho} \rightarrow ^{163}_{66}\mathrm{Dy}^* + \nu_e$$

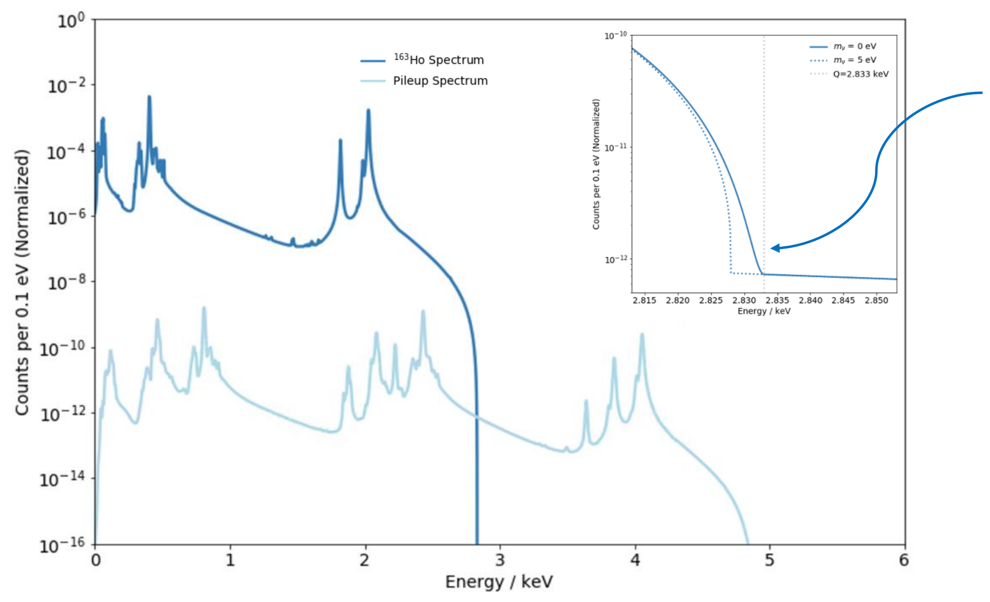
$$^{163}_{66}\mathrm{Dy}^* \rightarrow ^{163}_{66}\mathrm{Dy} + E_C$$

- $\tau_{1/2} \cong$ 4570 years (2*10^{11} atoms/1 Bq)
- Q_{EC} = (2863 ± 0.6) eV

C. Schweiger *et al.*, *Nat. Phys.* (2024). https://doi.org/10.1038/s41567-024-02461-9

Calorimetric measurement: all the energy released in the EC besides the one of the neutrino is measured

- Increases sensitivity to the electron neutrino mass
- Leads to intrinsic background – unresolved pile up



Fraction of events in the last eV ~10^{-12}

Theoretical spectral description in:

M. Braß and M. W. Haverkort, *New J. Phys.* **22** (2020) 093018

ECHo will perform high energy resolution and high statistics calorimentric measurements of ^{163}Ho spectra by enclosing ^{163}Ho in metallic magnetic calorimeters

The ECHo Collaboration EPJ-ST 226 8 (2017) 1623

MMCs with enclosed ^{163}Ho

MMCs are suitable detector for ECHo because:

Eccellent linearity
calibration of the spectrum

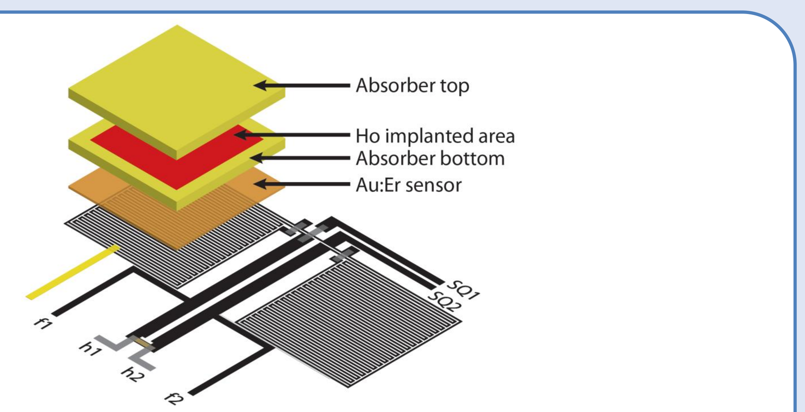
Eccellent energy resolution
Reduction
Smearing of the spectrum

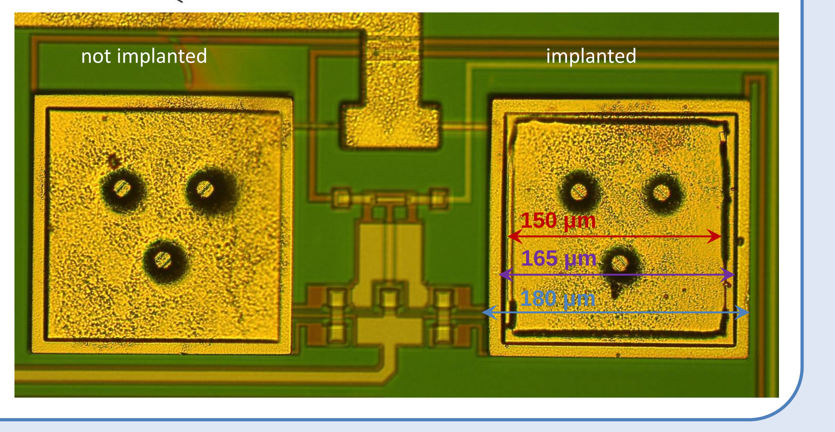
Fast response time
Reduction
unresolved pileup

Ion implantation @ RISIKO, Institute of Physics, Mainz University

- Resonant laser ion source → (69 ± 5^{stat} ± 4^{syst})% efficiency
- Reduction of ^{166m}Ho in MMC → ^{166m}Ho/^{163}Ho < 4(2)10^{-9}
- Optimization of beam focalization

F. Mantegazzini et al., *NIM. A* **1030** (2022) 166406
H. Dorrer et al, *Radiochim. Acta* **106**(7) (2018) 535–48
F. Schneider et al., *NIM B* **376** (2016) 388
T. Kieck et al., *Rev. Sci. Inst.* **90** (2019) 053304
T. Kieck et al., *NIM A* **945** (2019) 162602

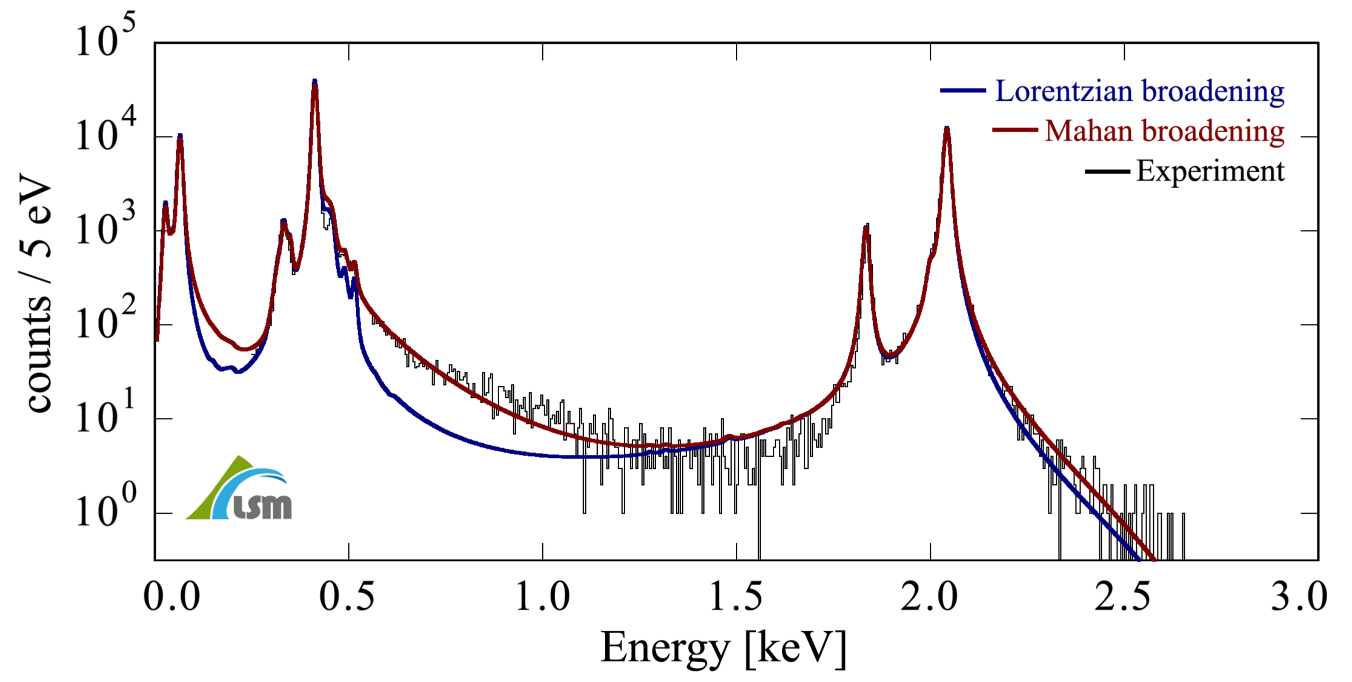




ECHo results

4 day measurement with 4 pixels loaded with ~0.2 Bq ^{163}Ho

- measurement performed underground
- test for data reduction and spectral shape analysis



Energy resolution
ΔE_{FWHM} = 9.2 eV

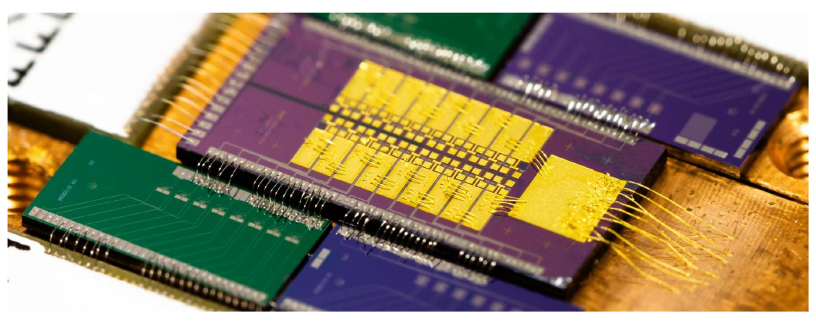
Background level
b < 1.6 × 10^{-4} events/eV/pixel/day

- Q_{EC} = (2838 ± 14) eV
- $m(\nu_e)$ < 150 eV (95% C.L.)

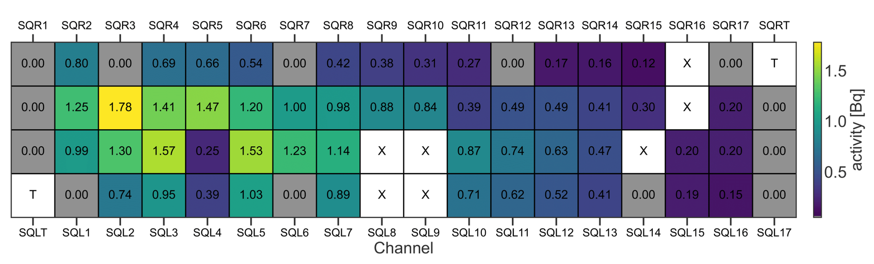
C. Velte et al., EPJC **79** (2019) 1026

ECHo-1k

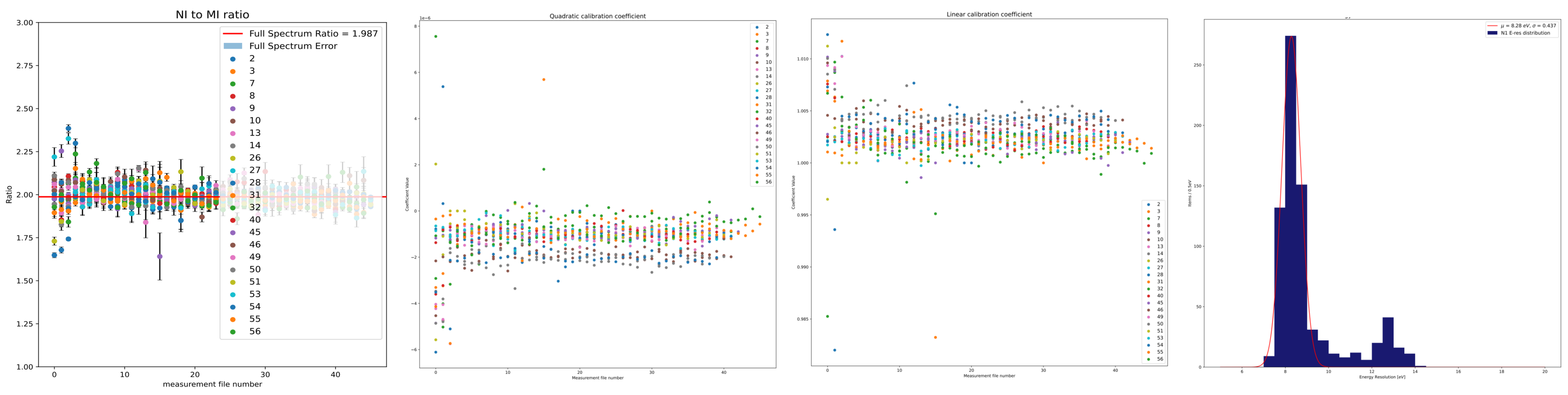
ECHo-1k chip-Au
23 pixel with implanted ^{163}Ho
3 background pixels
average activity = 0.94 Bq
total activity of 28.1 Bq



ECHo-1k chip-Ag
34 pixel with implanted ^{163}Ho
6 background pixels
average activity = 0.71 Bq
total activity of 25.9 Bq



F. Mantegazzini et al., *Nucl. Instrum. Meth. A* **1030** (2022) 166406
R. Hammann et al., *Eur. Phys. J. C* (2021) 81:963



Energy independence data reduction → event in NI-line / events in MI-line

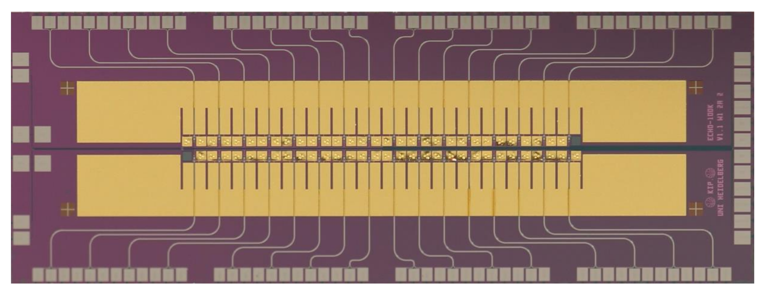
Stability of the detector operation → stability of calibration parameters over time → stability of energy resolution

New results for the conference

Towards ECHo-100K

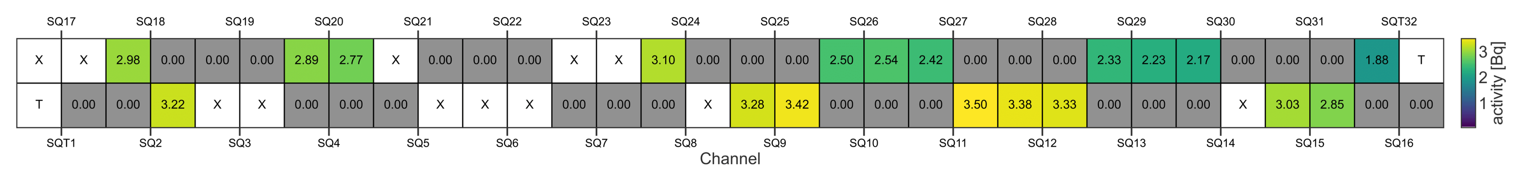
ECHo-100k baseline: large arrays of MMCs

Number of detectors:	12000
Activity per pixel:	10 Bq

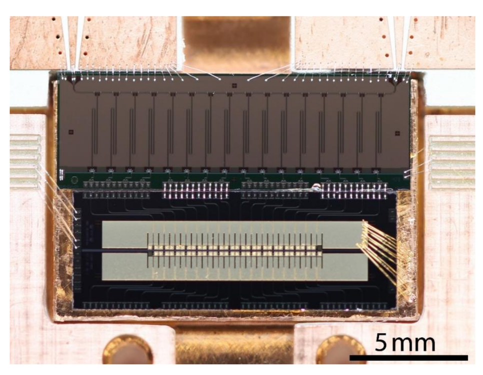


Present status:

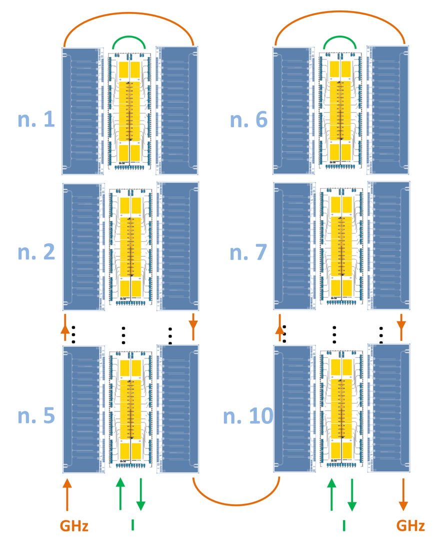
MMCs arrays:	reliable fabrication of large MMC array succesfull characterization of arrays with ^{163}Ho
High Purity ^{163}Ho source:	available about 30 MBq
Ion implantation system:	demostrated co-deposition of Ag for larger activities

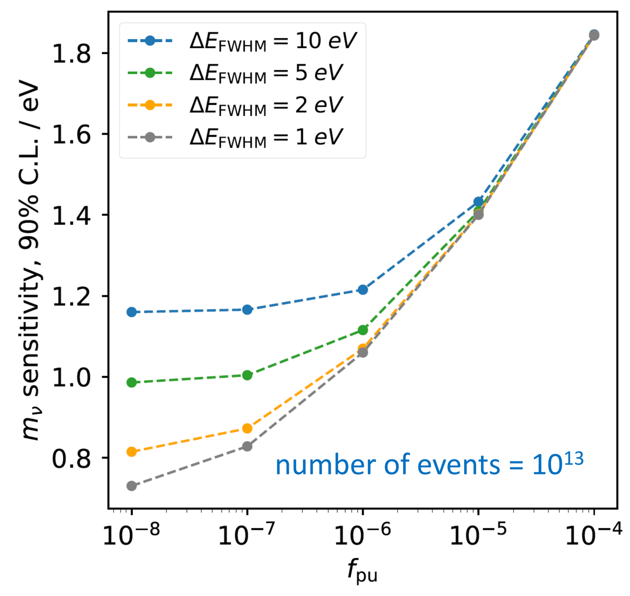


Multiplexing: demostrated for 8 channels
development of the SDR electronics



S.Kempf et al., *J. Low. Temp. Phys.* **175** (2014) 850-860
M. Wegner et al., J. Low Temp. Phys. **193**, 462 (2018)





Foreseen sensitivity: ~1 eV/c^2
Based on Brass+Haverkort theory and new *Q*-value

Deutsche Forschungsgemeinschaft

The ECHo-Experiment