



HAL
open science

Energy nonlinearity correction of a high resolution metallic magnetic calorimeter

Mostafa Zahir, Matias Rodrigues, Martin Loidl, Arshjot Kaur

► **To cite this version:**

Mostafa Zahir, Matias Rodrigues, Martin Loidl, Arshjot Kaur. Energy nonlinearity correction of a high resolution metallic magnetic calorimeter. IRRMA 11 - 11th International Topical Meeting on Industrial Radiation and Radioisotope Measurement Applications, Jul 2023, Bologne, Italy. , 2023. cea-04799473

HAL Id: cea-04799473

<https://cea.hal.science/cea-04799473v1>

Submitted on 22 Nov 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Energy nonlinearity correction of a high resolution metallic magnetic calorimeter

Zahir Mostafa Lokman, Rodrigues Matias, Loidl Martin, Kaur Arshjot

Université Paris-Saclay, CEA, List, Laboratoire National Henri Becquerel (LNE-LNHB), F-91120, Palaiseau, France

Photon spectrometry is commonly used to analyse the elemental composition or radioactive content of a sample. It is also used to study the structure of nuclei or the interactions of electrons with nuclei in fundamental quantum physics. The latter field requires a great precision on the measured photon energies to be able to experimentally confirm theoretical values predicted by quantum electrodynamics. To do so, X-ray energies below 100 keV must be measured with an energy uncertainty below 0.1 eV, like the hydrogenoid lamb shift [1]. Others projects aim to measure gamma-ray energies with the same order of precision for the development of future nuclear clocks based on the low-lying isomeric state of $^{229\text{m}}\text{Th}$ [2]. Wavelength-dispersive spectrometers (WDS) and energy-dispersive spectrometers (EDS) are the two main kinds of X-ray and gamma-ray spectrometers: WDS have high energy resolution but lose their efficiency at high energy while EDS are more suitable for high X-and gamma-ray energy measurement. Semi-conductor detectors are frequently used as EDS but their energy resolution, close to their theoretical limit, e.g. around 300 eV at 60 keV, is not sufficient.

As an alternative, cryogenic detectors are developed as EDS with ultra-high energy resolution, more than one order of magnitude better than that of semi-conductor detectors. The used cryogenic detector is a magnetic metallic calorimeter (MMC). It can measure energetic particles with an energy resolution of 20-50 eV below 100 keV when operated at 15 mK [3]. However, they are intrinsically nonlinear in energy. It is then important to correct for their nonlinearity in order to achieve the required uncertainty for accurate photon energy measurements.

In this work, we report the measurement of photon energies below 100 keV from the decay of ^{241}Am , ^{152}Eu , ^{210}Pb and ^{139}Ce with a MMC to study his nonlinearity. The experimental nonlinearity of the detector is compared with its theoretical nonlinearity calculated from the thermodynamic properties of MMC. The influence of the signal processing on the nonlinearity is also investigated through different methods of pulse energy determination.

[1] P. Egelhof, H.F. Beyer, D. McCammonb, F. v. Feilitzsch, A. v. Kienlin, H.-J. Kluge, D. Liesen, J. Meier, S.H. Moseleyd, T. Stihlker, Nuclear Instruments and Methods in Physics Research A 370 ,(1996) ,263-265.

[2] T.Sikorsky, J.Geist, D.Hengstler, S.Kempf, L.Gastaldo, C.Enss, C.Mokry, J.Runke, C. E. Düllmann, PeterWobrauschek, K.Beeks, V.Rosecker, J.H. Sterba, G.Kazakov, T.Schumm, A.Fleischmann, Physical Review Letters 125, 142503 (2020)

[3] M.Rodrigues, M.Riham, M.Loidl, EPJ Web of Conferences 146, 10012 (2017)

