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MagMicro with Ultra-High Energy Resolution (FY20 Q1 Report)

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Disclaimer

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

Quarterly Progress Report: Q1 FY20 – October to December 2019

Project: MagMicro with Ultra-High Energy Resolution

Project Number: LL16-MagMicro-PD2La

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HQ Project Manager: Chris Ramos

Date submitted: 15 January 2020

Progress this quarter

Task 15 (Fabricate 32-pixel Ag:Er MMC Arrays): Completed ✓

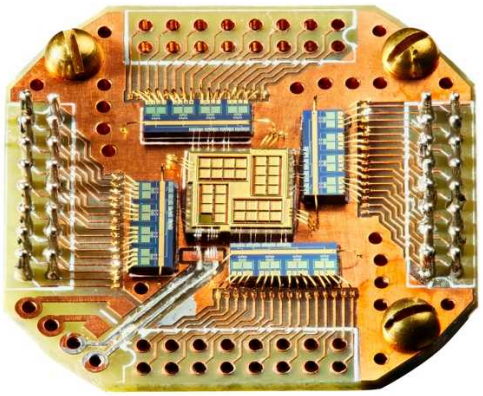

Fig. 1: Picture of the 32-pixel MMC gamma detector array. The central detector chip contains four 4 x 2 sub-arrays of MMCs with gold absorbers, each of which is read out by four SQUID preamplifiers on a separate (blue-ish) chip.

Task 16 (Demonstrate energy resolution <50 eV FWHM): Completed ✓

We have already achieved an energy resolution of 38 eV FWHM in FY17.

Task 17 (Integrate Compton Veto with MMC in Dilution Refrigerator): Abandoned ×

Task 18 (Operate 32-MMC array in LLNL dilution refrigerator):

We have tested the second 32-pixel MMC gamma detector array (whose magnetizing coil we knew was functioning) and confirmed that it is functioning properly as a gamma-ray detector. This is a major step towards the last goal of this LCP, i.e. to develop a high-resolution MMC gamma detector array.

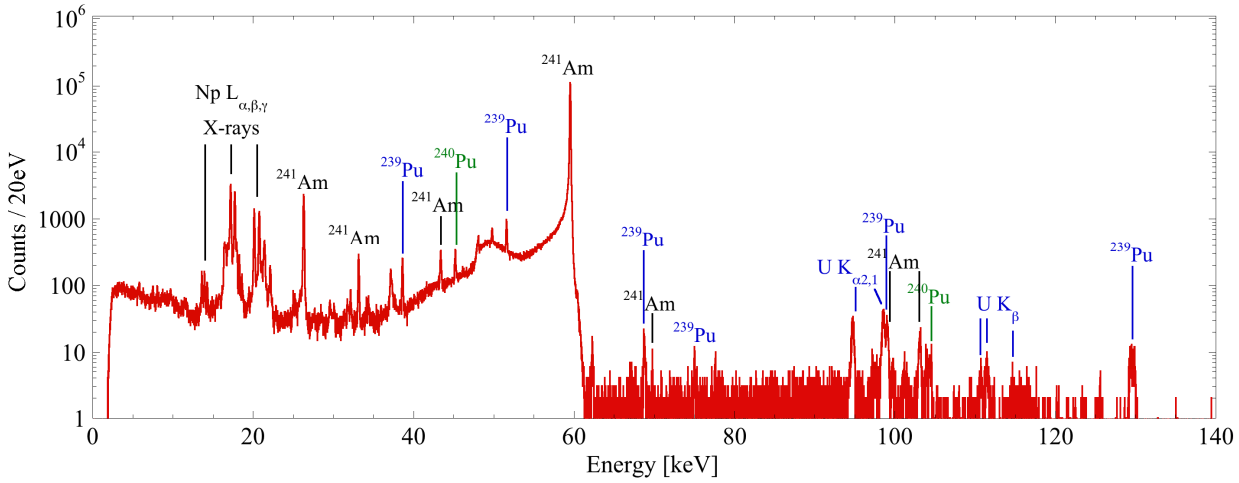

Figure 2: The sum spectrum of a WGPu source shows the gamma emissions from the three dominant isotopes in the sample. Since we did not use a Cd foil, the Am-241 line at 60 keV dominates the spectrum.

We tested the array with a weapon-grade Pu source that contains some Am-241 (rather that with our usual pure Am-241 source) to see whether we can accurately calibrate the spectrum over a wide energy range. We did not use a Cd filter that is typically used to suppress the strong Am-241 line at 60 keV, because we wanted to test whether we can extract an efficiency curve without being affected by the uncertainty of the Cd transmission. Due to time constraints, we only operated 6 of 32 pixels, and they had all similar (although not identical) spectra. However, they had an almost perfectly linear response as a function of energy, with a small quadratic correction. This allowed adding spectra with little loss in energy resolution (Figure 2). The spectrum was dominated by Am-241 and had an energy resolution around 100 eV FWHM. The strong Am-241 line and the low count rate of the MMCs limited the statistics of the other characteristic gamma-rays, especially in the 100 keV region that is typically used for Pu isotope analysis. We will eventually have to use a Cd foil after all.

Task 19 (Acquire Gamma Spectrum from Safeguards-Relevant Sample): Completed ✓

Task 20 (Present paper at INMM and report to NA-22): Completed ✓

Outlook

As the final test of this LCP, we will run the remaining 32-pixel array (which has a slightly different design that may allow higher energy resolution) to see if we can improve the energy resolution. We have also finalized the work plan for our follow-up project with the IAEA that will be funded by NA-241. It will focus on developing total decay energy spectrometers for accurate actinide analysis and will be based on the MMCs developed under the current LCP.

Publications

Both MMC papers that we have submitted for the 18th International Workshop on Low Temperature Detectors (LTD-18) have been accepted to the Journal of Low Temperature Physics “with minor revisions”.

The first paper is by Steve Boyd (UNM) on “Metallic Magnetic Calorimeters for High-Accuracy Nuclear Decay Data” and the second one is by Geon-Bo Kim (LLNL) on “A New Measurement of the 60 keV Transition in Am-241 Decays using Metallic Magnetic Calorimeters”. We have addressed the reviewers’ concerns, implemented the suggested changes and re-submitted the revised versions.

Lab Program Manager Comments [optional]: