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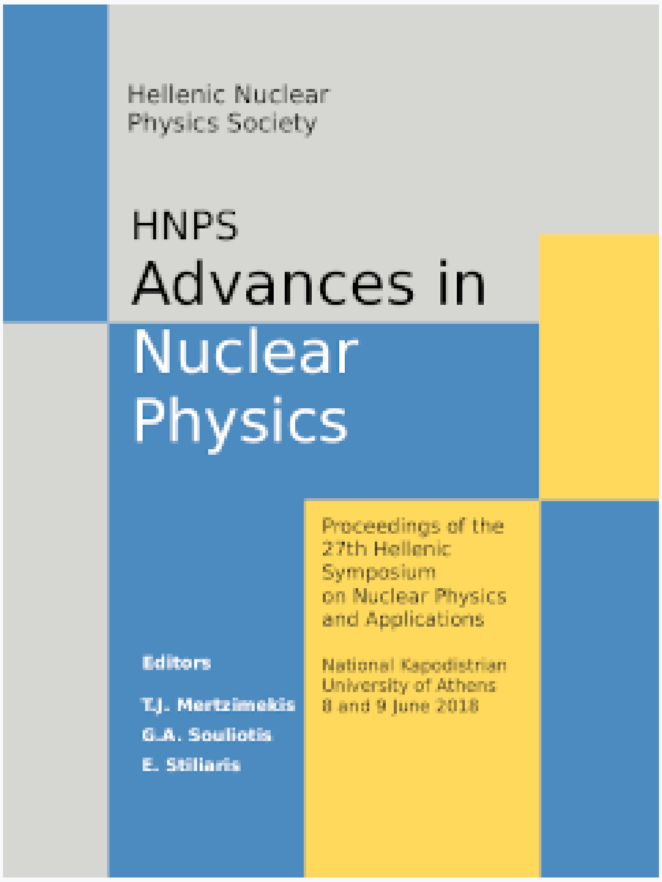

Development of a low–cost γ–ray spectrometry PMT adapter

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Development of a low–cost γ–ray spectrometry PMT adapter

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Abstract A crucial part of any scintillator–based spectroscopy experiment is the photomultiplier tube (PMT) and its associate electronics, typically coming in the form of a PMT adapter responsible for amplifying and digitizing the record pulses. Commercial adapters are typically expensive, therefore a more practical and costless solution is in dire need. In the present work, a light–weight, portable electronic circuit was constructed from scratch based on the open–access Theremino design [1] to play the role of a PMT adapter responsible for the processing of the PMT output signal. The adapter is universally compatible with PMTs and with any computer with a built–in sound card. The PC sound card acts as the digitizer of the signal, which is subsequently analyzed by the Theremino MCA analysis software [1]. The construction of this handmade, easily reproducible circuit, increases drastically the ability to perform spectroscopy measurements with the currently available scintillators in our lab.

Keywords PMT adapter, Theremino MCA, Soundcard

INTRODUCTION

A crucial part of any scintillator–based spectroscopy experiment is the photomultiplier tube (PMT) and its associate electronics, typically coming in the form of a PMT adapter responsible for amplifying and digitizing the record pulses. Commercial adapters are expensive, therefore a more practical and costless solution is in dire need.

In the present work, a light–weight, portable electronic circuit was constructed from scratch based on the open-access Theremino design to play the role of a PMT adapter responsible for the processing of the PMT output signal. The adapter is universally compatible with PMTs and with any computer with a built-in sound card. The PC sound card acts as the digitizer of the signal, which is subsequently analyzed by the Theremino MCA analysis software. The construction of this handmade, easily reproducible circuit, increases drastically the ability to perform spectroscopy measurements with the currently available scintillators in our lab.

EXPERIMENTAL DETAILS

Construction

The circuit was constructed from scratch using common electronic components. The total cost not surpassing €15. It is estimated that after some training, construction time could be reduced to less than a total of five hours, making mass production an achievable reality for every student or laboratory operator.

Operation

The circuit receives an input pulse from the PMT (marked by green in Fig. 1). The signal passes through filtering capacitors (marked red), and then gets pre-amplified. The signal is then transformed into an audio signal and the output is amplified through an added amplifier in order to boost it, while avoiding electrical shortages caused by the digitizer. As a digitizer, an external sound card is used although any computer sound card could work. The whole circuit is powered by the computer and two extra portable batteries for the amplifier. The PMT is sourced by an external high voltage. The final data analysis happens on the computer in use, via open–source software [1,2]. At last, the emerged spectrum is available in various common formats for spectrum analysis.

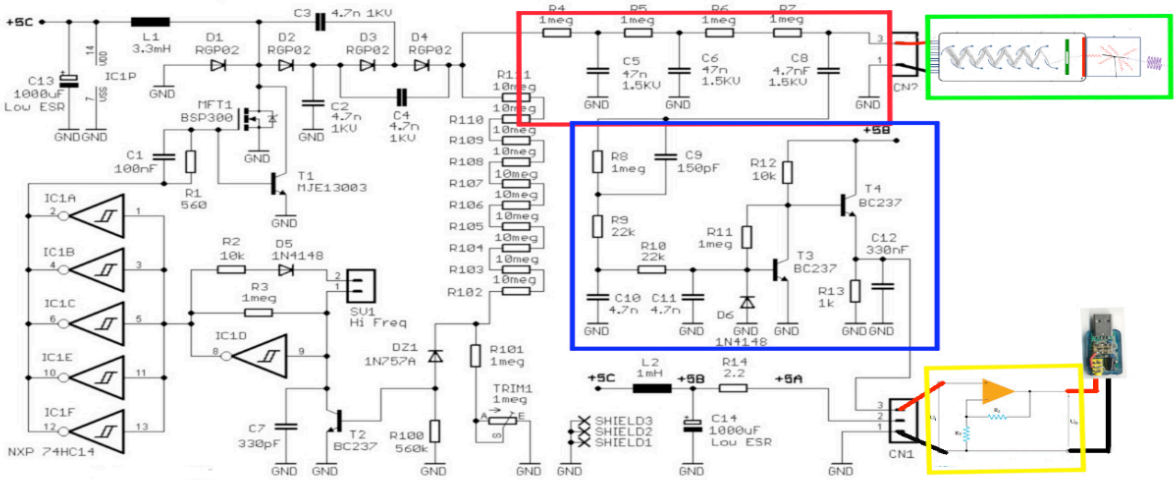


Figure 1. The electronic circuit

Operation Testing

For the very first testing an oscilloscope was used in order to check the characteristics of the output signal (wavelength, height, shape etc.). The circuit was then tested and found to be operating optimally using a nuclear signal pulser and secondly with standard calibration gamma sources in front of a real NaI detector coupled to a PMT. For the data recording the freely available Theremino MCA [1] and PRA [2] software suites were used.

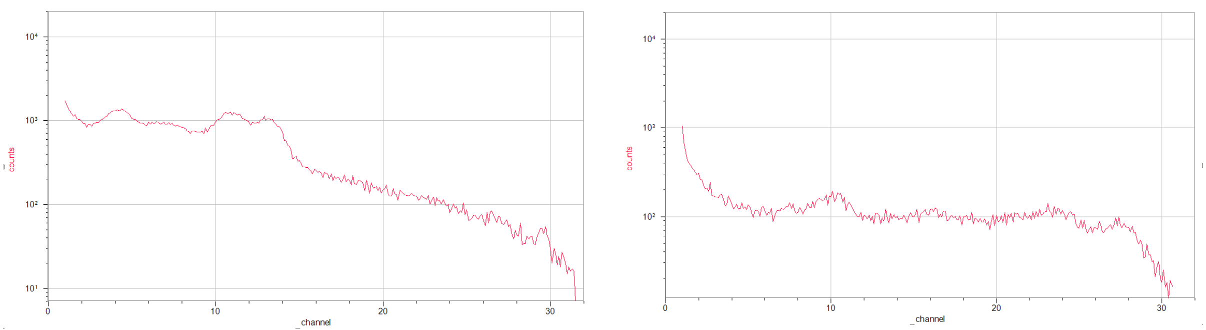
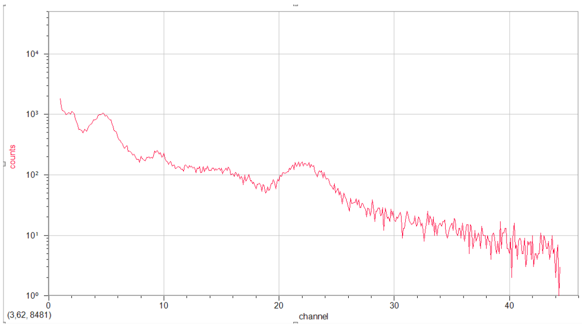


Figure 2. A $^{137}Cs/^{60}Co$ source close to the NaI detector (left) and away from it (right) (Δt=15 min)



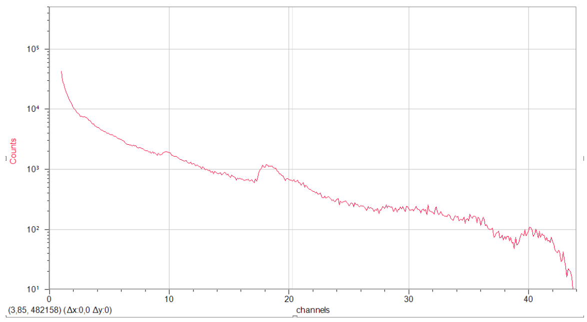


Figure 3. A ^{22}Na source close to the NaI detector for ~15 min (left) and a background measurement in the UoA NPL for ~24 h (right)

RESULTS AND DISCUSSION

As of this moment the main circuit board has been built and tested with calibrated electronic pulses, as well as radioactive sources, showing an overall stable performance. Further reduction of the electronic noise and the improvement of its efficiency are currently in the works, as well as the construction of an easy–to–use–and–carry case for the module. Optimization of the software configurations is needed, as well as an accurate calibration.

CONCLUSIONS

The ultimate goal is to create a self–sufficient, universally compatible, reproducible and easily transportable, versatile and low–cost system, both for laboratory and open field experiments, so that everyone could support applications of gamma–ray spectroscopy. This circuit stands as a prototype in our lab paving the way, and creating a baseline for future, more advanced versions to come.

References

[01] Theremino MCA, url: http://www.theremino.com/en/blog/gamma-spectrometry
[02] Gamma Spectacular PRA, url: http://www.gammaspectacular.com/pra-spectrometry-software