Improvement of Positron Annihilation Lifetime Spectrometer Resolution: AComparative Study

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Introduction

Positron life time spectroscopy (PALS) is a variant of positron annihilation spectroscopy (PAS), which is of great interest to researchers for a wide range of applications such as medical sciences: Molecular imaging by positron emission tomography[1,] tumors[2], as it can also provide a plus regarding the harmfulness of a new drug[3], or biology[4].It is also used in astrophysics[5], development and manufacturing of telecommunication equipments[6] for high reliability critical service applications. The objective of my work is to improve the PALS coincidence system, to have a better instrumental (temporal) resolution combined with a high count rate.For this purpose, we opted for a FAST-FAST system.

Experimental Study

The FAST-FAST device with only one circuit (anode). For this system the pulses coming out of the photomultiplier (PMT) are selected in amplitude and shaped in time at the CFDD (Constant Fraction Differential Discriminator). The temporal signals coming from the START and STOP channels are then injected into the TAC (Time-Amplitude Converter). The amplitude of the electrical signal at the output of thismodule is proportional to the time interval between the two START and STOP events. The signal is finally digitized using the ADC (Analog to Digital Converter). The accumulation of a large number of events allowsobtaining a temporal spectrum of positron annihilation. This system allows obtaining better statistics and a good resolution at the level of two scintillator detectors.

Results and Discussion

Different combinations (scintillator + photomultiplier + base) have been chosen and tested on polymer CR39 and silicon samples. We have shown that for the study of polymers (lifetime > 2 ns), all combinations (scintillators + PMT + base) can be used. However, in the case of metals and semiconductors which are known to have low lifetimes (< 0.22 ns), the most suitable combinations are: BC418 scintillator + H3378-51 and BC418 scintillator + R329-02 + ORTEC265. These combinations give resolution values of 0.2390 ns and 0.266 ns, with high count rates. The preferred combination for studying various types of materials is BC418 + H3378-51 which give better resolution with a higher count rate in addition to its low cost compared toother combinations.

Conclusion

Our work is part of the improvement of the instrumental resolution of a positron lifetime spectrometer (comparative study of coincidence systems). Several combinations have been chosen

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based on the characteristics of the different parameters that constitute them. Indeed, a study has been initiated on the different parameters such as (rise time, refractive index, wavelength of the maximum response and decay time). In our study and with regard to the obtained results, we can say that, for the study of polymers (CR39) which are characterized by high values of the positron lifetime (>2 ns), all the combinations (scintillators + photomultiplier + base) can be used. However, in the case of metals and semi conductors which are known to have small lifetimes (<0.22ns), the most suitable combinations are: BC418 + H3378-51 and BC418 + R329-02 + ORTEC265. These combinations offer us small resolution values which are respectively 0.23890 ns and 0.26601 ns with highcounting rates equal to 20.5 and 11.35 counts/second. On the other hand, the preferred combination for the study of various types of materials is BC418 + H3378-51 which offers a better resolution with the highest count rate in addition to its low cost compared to the other combinations.

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