The Scintillation Properties of Encapsulated NaI(Tl) Crystal

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1. Introduction

The NaI(Tl) was reported by R. Hofstadter in 1948 [1]. The NaI(Tl) is one of the most widely used scintillator material. It is used in such as nuclear physics, nuclear medicine, radiation detection. The short decay time component of the NaI(Tl) is 0.23 µs and long component is 1.5 µs [2]. The energy resolution of the NaI(Tl) is around 6.6 % at 662 keV photo peak from ^{137}Cs [3]. The NaI(Tl) has high light yield, large size growth and low price than other scintillator crystal. However, NaI(Tl) is easy to be hygroscopic, it must be sealed with encapsulation. Therefore, encapsulation is one of important process for using the NaI(Tl) crystal. To study scintillator properties of encapsulated NaI(Tl) crystal, we study difference between the NaI(Tl) before and after encapsulation. Also, we compare each scintillator properties of encapsulated NaI(Tl) with Teflon tape and with MgO powder.

2. The encapsulation method

To encapsulate the NaI(Tl), we use Al cylinder as shown in Fig 1, its radius is 5.80 mm and height is 5.66 mm. It is need to fill reflector to reduce light leak of the scintillator, we use two reflectors respectively, the one is Teflon sheet and the other one is MgO powder. When we use Teflon sheet for encapsulation, first, fill the Al cylinder with optical cement (EJ-500). Second, wrapped the NaI(Tl) (NaI_1) with Teflon sheet and put in to the Al cylinder. Lastly, close the Al cylinder with quartz cover. We use a different way for using MgO powder. First, we attach NaI(Tl) (NaI_2) with quartz cover together using optical cement. Second, fill the Al cylinder with MgO powder and put the attached one in the Al cylinder. Fig 2 shows encapsulated NaI(Tl) with Teflon sheets and MgO.

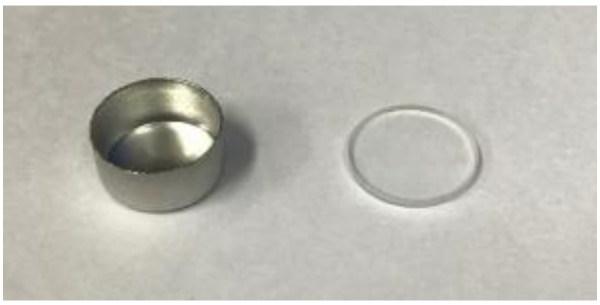

Figure 1. The aluminum cylinder used for encapsulating (left) and quartz cover (right).

Figure 2. The encapsulated NaI_1 with Teflon sheet (left), encapsulated NaI_2 with MgO powder (right).

3. The scintillation properties of encapsulated NaI(Tl)

3.1 Measurement of the energy resolution and light yield

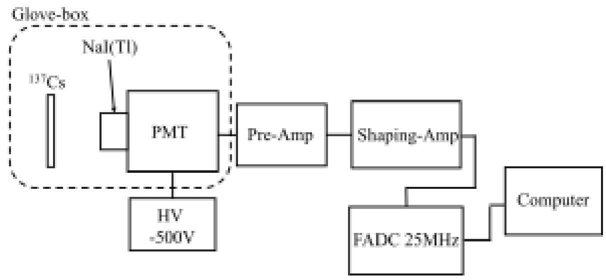

Figure 3. The schematics of the experimental setup for measurement of the energy resolution and light yield of the NaI(Tl) crystal.

We measure the energy resolution before and after encapsulating by using the ^{137}Cs gamma-ray source. We put the NaI(Tl) crystal on the PMT (photo multiplier tube, R6233, Hamamatsu) and value of high voltage is -500 V. The PMT signal passes the pre-amplifier and shaping-amplifier. The signal which is through the shaping-amplifier go to FADC 25 MHz (25 MHz USB2 based flash analog to digital converter), FADC 25 MHz send the signal to computer. We analyze the data with ROOT which is free software provided by CERN. The schematics of the experiment is shown in Fig 3.

3.2 Measurement of the decay time

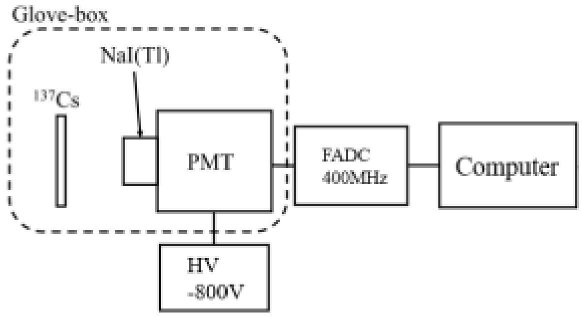

Figure 4. The schematics of the experimental setup for measurement of the decay time of the NaI(Tl) crystal

We measure the decay time of the NaI(Tl) by using the ^{137}Cs gamma-ray source. We put the NaI(Tl) crystal on the PMT and value of high voltage is -800 V. The PMT signal passes FADC 400 MHz (400 MHz USB2 based flash analog to digital converter), FADC 400 MHz sends the signal to computer.

4. Results

Before encapsulating, we measure the energy distribution of NaI(Tl) crystals. The NaI_1 has less light yield than NaI_2. We calculate each energy resolution using FWHM (full width half maximum) method. The energy resolutions of NaI_1 and NaI_2 are around 8 %.

After encapsulating, we measure the energy resolution of NaI(Tl). The energy resolution of encapsulated NaI_1 and NaI_2 are around 8 %. The light yield of both encapsulated NaI_1 with Teflon sheet and encapsulated NaI_2 with MgO are decreased and decreasing rate of encapsulated NaI_1 with Teflon is lower than encapsulated NaI_2 with MgO powder.

The short decay time component is around 0.185 μs. Also, there is no difference between before and after encapsulation.

5. Conclusions

The energy resolutions and decay time of both NaI(Tl) crystals have similar results and there are no significant differences of energy resolution between after and before encapsulation. However, the light yield is decreased in both encapsulated NaI(Tl). The light yield decreasing rate of encapsulated NaI_1 with Teflon sheet is lower than encapsulated NaI_2 with MgO powder. It seems that the gap by quartz between PMT and NaI(Tl) makes decrease of light yield.

REFERENCES

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