Progress with the TAMU-ORNL BaF_2 array re-coupling

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The re-coupling of the TAMU-ORNL BaF_2 Array detectors [1] is still underway and progresses well. We encountered some issues during the process and figured out solutions. The light leak due to the peeling off of the isolating electrical tape at the junction of the crystal and the photomultiplier tube (PMT) has been resolved by surrounding it with black heat shrink tube. The other main issue that we have is the energy resolution. It's well known that the typical BaF_2 energy resolution for the 662 KeV gamma photoelectric peak from the ^{137}Cs is about 12% [2] but the resolution of our detectors is consistently between 15 and 25%. The most likely explanation is the age of the phototubes that may have caused vacuum and photocathode sensitivity degradation. To test this hypothesis, we ordered two specially designed brand new PMTs from Hamamatsu and tested them with two of our BaF_2 crystals. The energy resolution test comparison is shown in Fig. 1. The same crystal coupled with one of the old PMT has a resolution of 17.7%. With the new PMT, it improves to 11.6%. The other new PMT coupled with another crystal gives a similar result (11.5%).

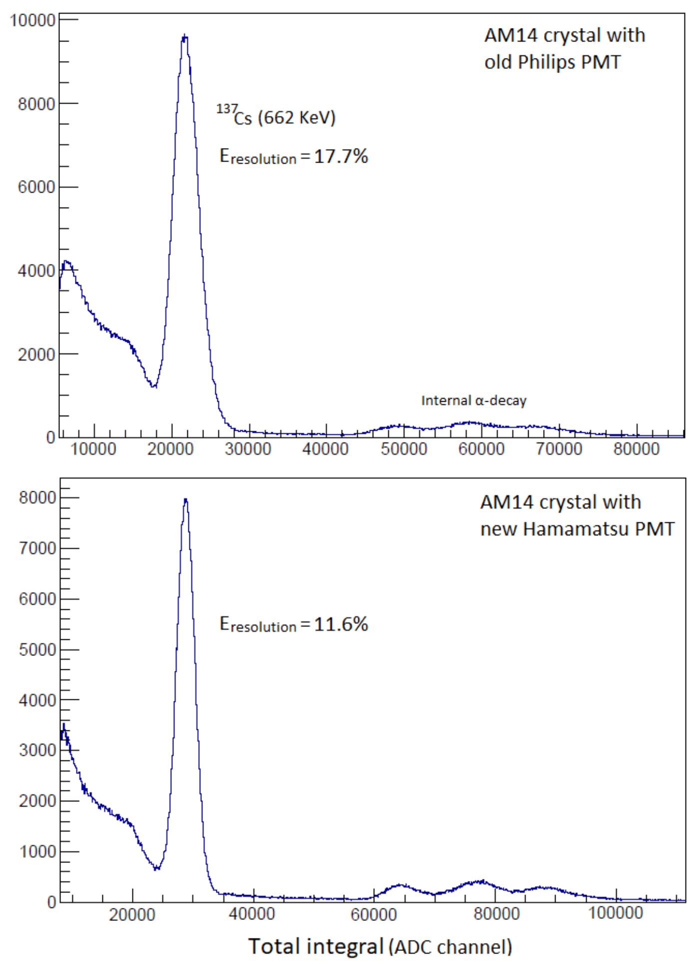

FIG. 1. Old and new PMT energy resolution comparison.

In Fig. 2, we show the calibrated spectra from the ^{137}Cs and ^{60}Co sources acquired by the new PMT coupled with the AM14 crystal. The better resolution provides good separation of the two cobalt peaks.

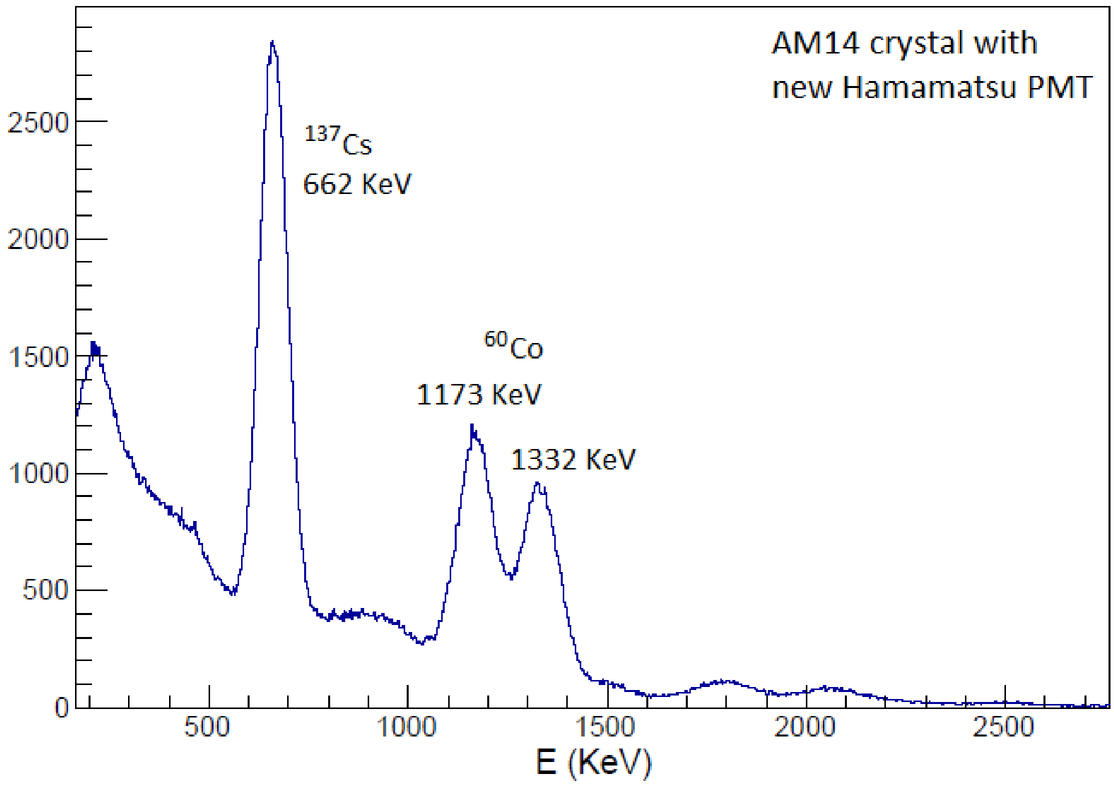

FIG. 2. New PMT calibrated spectra of ^{137}Cs and ^{60}Co sources. Calibration is calculated from the total integral.

Moreover, we determined that the cause of the problem with the pulse shape particle separation was the RTV (*Room-Temperature-Vulcanizing* silicone) we used to re-couple the detectors. Since RTV has a cutoff wavelength very close to the wavelength of the UV light from the BaF_2, a too-thick layer applied induces a suppression of the fast component that is enough to degrade the separation and in some case, completely cancel it. We used heating tape to warm up the crystal-PMT junction at 100^{o} C in order to decouple the detectors with RTV and replaced it with silicon oil. As we can see in Fig. 3 (top and middle panels) this operation allowed us to recover the particle separation. The bottom panel of Fig. 3 shows the new PMT with oil coupling. The separation is slightly better than the one with the old PMT and we can clearly see the better energy resolution on the x axis.

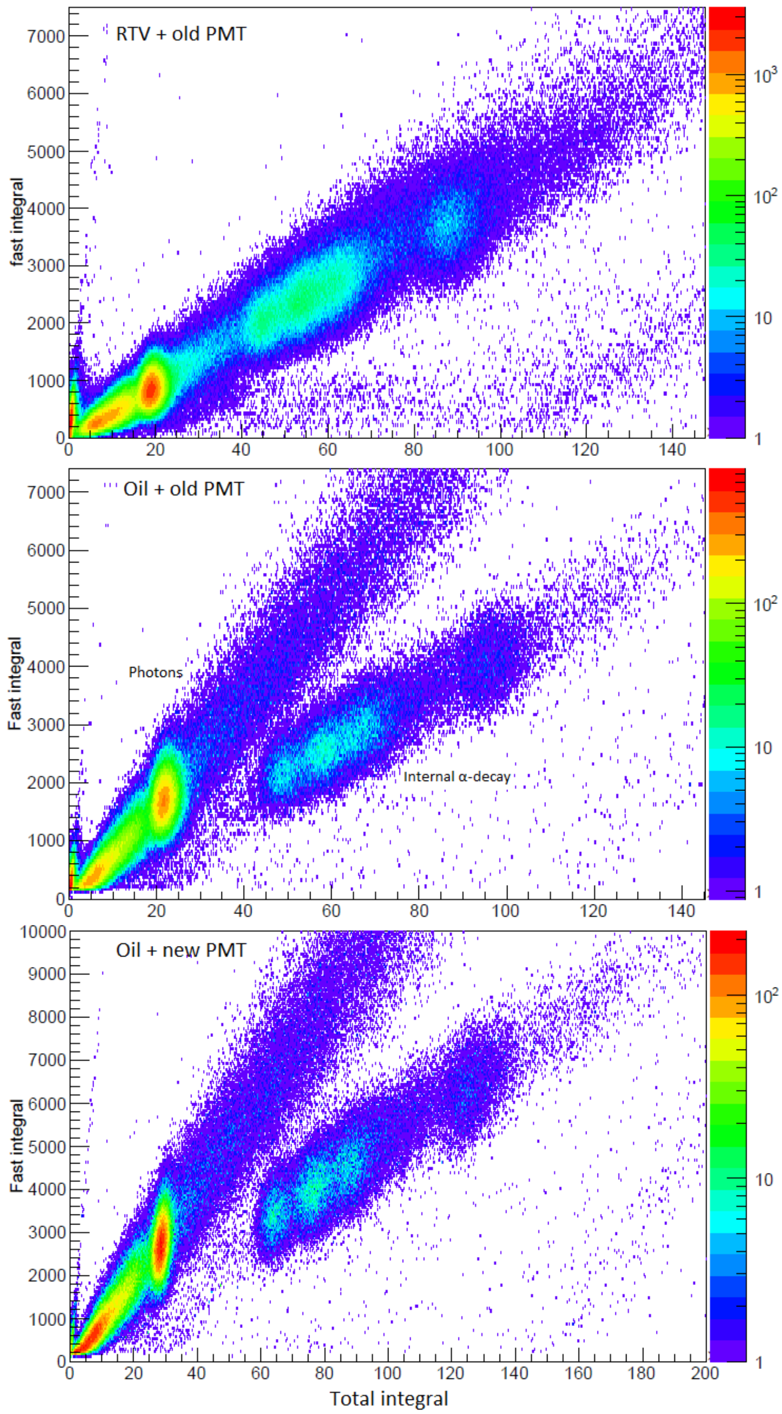

FIG. 3. Fast vs Total integral comparison. Old PMT with RTV coupling is compared with old PMT with silicon oil. The spectrum from the new PMT with oil is shown as well. A ^{137}Cs source was used in all three cases.

[1] A.B. McIntosh *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2016-2017), p. IV-40.

[2] P. Kozma *et al.*, Nucl. Instrum. Methods Phys. Res. **A314**, 26 (1992).