report for NaI analysis

Kazuhiro Ishikawa

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Contents

1 analysis of NaI

1.1 Energy calibration

The analog data of DALI were calibrated by using standard γ-ray sources of ^{137}Cs (662 keV),^{60}C0 (1173 keV and 1333 keV) and ^{22}Na(511 keV and 1275 keV). By fitting the energies with a linear function of channels ,calibration functions to convert channel to energy were deduced for each crystal of DALI. The energy calibration was checked by comparing the photo-peak positions in the energy spectra summed up for all the 152 NaI(Tl) scintillation detectors with the energies of the standard sources.

source	Energy(keV)	exp Energy(keV)	deviation(keV))
^{137}Cs	661.660	660.7	-0.3
^{60}C0	1173.237	1174.	0.6
	1332.501	1335.	2.5
^{22}Na	1274.532	1276.	1.5
	511	506.2	-4.8
^{9}Be+^{241}Am	4439.1	4428.	-11.1
	3928.1	3955.	27.
	3417.1	3402.	-15.

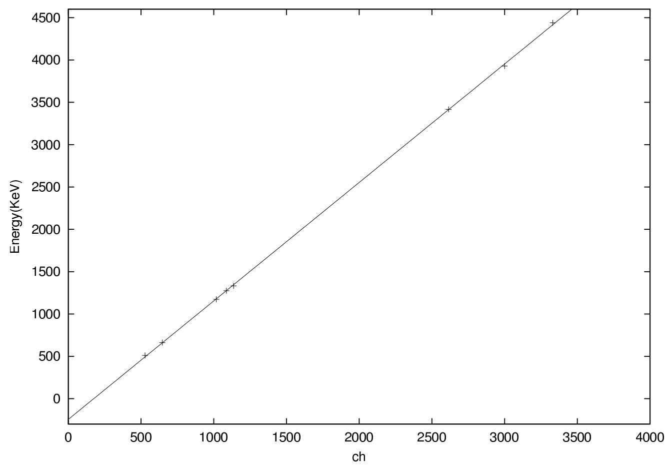

Figure 1: ch vs keV

function is

$$E_\gamma = \mathrm{a}E_{\mathrm{ch}} + \mathrm{b} \quad (1)$$

a and b are constant parameters.

1.2 timing calibration

I must arrange a timing of NaI detectors that these are same timing. This difference is caused by mainly different length of cables at each detectors.

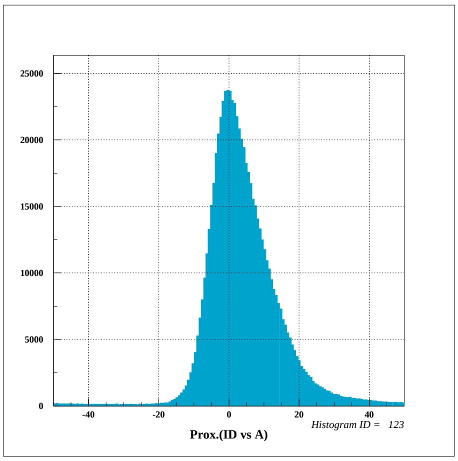

Figure 2: DALI timing (ns) after calibration

$$y = \mathrm{P1exp}[-\frac{(\mathrm{T}-\mathrm{P2})^2}{2\mathrm{P3}^2}] + \mathrm{P4} \tag{2}$$

$$\mathrm{T} = \mathrm{T}_{\mathrm{F2}} - \mathrm{T}_{\mathrm{Dali}} \tag{3}$$

P4 is independent of a time.So this is interpreted as background components. So by rejecting this region which independent of physics that, S/N ratio will be up.

1.3 appendix of NaI

I used radioactive sources of ^{137}Cs,^{22}Na,^{60}Co and ^{241}Am-^{9}Be in this experiment.

1.3.1 ^{241}Am-^{9}Be

In that composition which include ^{241}Am and ^{9}Be, the following reaction is performing.

$$^{241}\mathrm{Am} \rightarrow \alpha + {}^{237}\mathrm{Np}$$
$$\alpha + {}^{9}\mathrm{Be} \rightarrow {}^{12}\mathrm{C}^{*} + \mathrm{n}$$

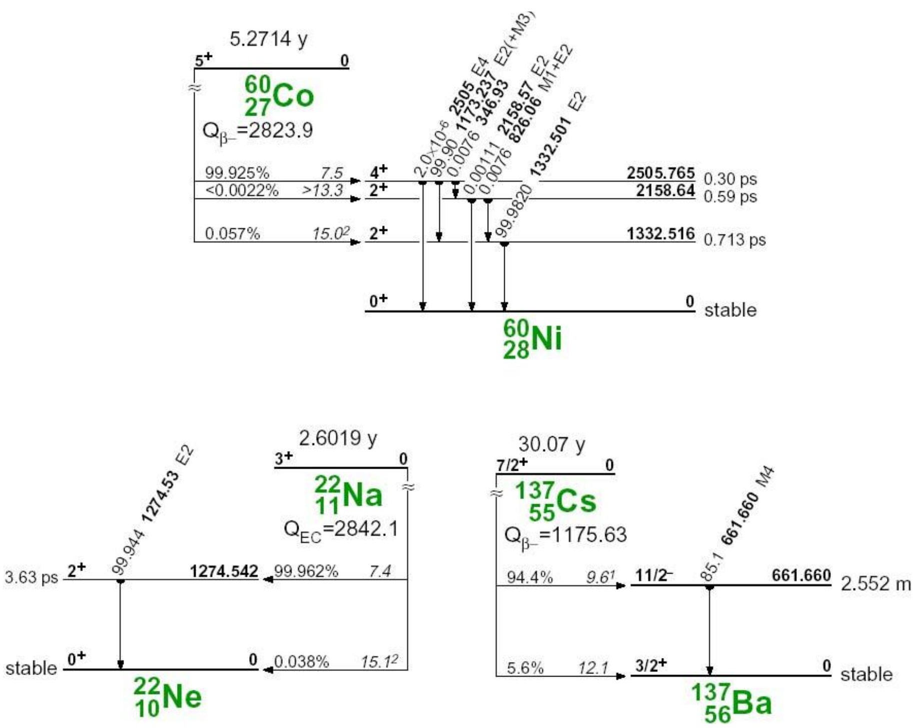

Figure 3: decay table

$^{12}C^*$ is immediately de-excited to the ground state though emitting γ-ray at 4.391 MeV. And in high energy γ-ray, pair productions are much arisen compared to the low energy.

$$\gamma \rightarrow e^- + e^+$$

e^+ is annihilated when this catches e^- within a matter. Two γ-ray,511 keV emitted after that. If NaI detector deposits energy from 2 γ-ray and $e-$ accompanied from pair creation , deposited energy is same asγ-ray energy from de-excited states. But if one γ-ray escapes from the detector and all other particle energy from pair creation is detected , NaI deposits

$$E_{\text{detected}} = E_\gamma - m_e c^2 \tag{4}$$

If two γ-ray escapes from that, NaI deposits

$$E_{\text{detected}} = E_\gamma - 2m_e c^2 \tag{5}$$

So from $^{12}C^*$, 3 type spectrum of energy ,4.4391 keV, 3.9281 keV and 3.417 keV is deposited by the NaI detector.

1.3.2 other radio active source

γ-ray is emitted from excited states of daughter nuclei after β decay table of radioactive sources in my experiment is shown following.

Only ^{22}Na decay though β minus decay

$$^{22}\text{Na} \rightarrow {}^{22}\text{Ne} + e^+ + \overline{\nu_e}.$$

So 511 keV γ-ray caused by this process.

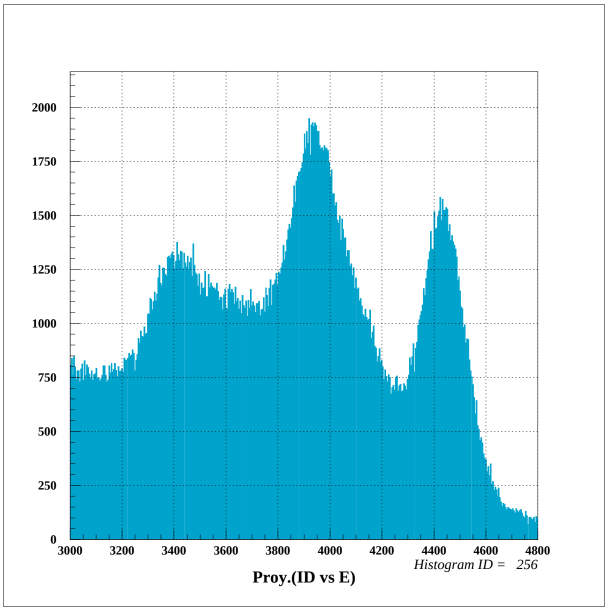

Figure 4: γ-ray from $^{12}C*$ and escape peaks