# report

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## Contents

# 1 efficiency calculation

## 1.1 calculation

I used the radio active source data to estimate the efficiency. The $^{137}$Cs,$^{22}$Na and$^{60}$Co was used. Efficiency is estimated following equation.

$$\epsilon = \frac{Yield_{\text{detected}}}{Yield_{\text{emission}}} \tag{1}$$

| **source** | $^{137}$Cs | $^{22}$Na | $^{60}$Co |
|---|---|---|---|
| Energy[keV] | 661 | 1173,1332 | 511,1274 |
| intensity(T=0)[kBq] | 46.6 | 359 | 41.2 |
| half time($t_{1/2}$)[year] | 30.07 | 2.6019 | 5.2714 |
| emission probability[%] | 0.8521 | 0.999,0.9998 | 0.9994 |

Firstly, I calculate the efficiency from the source run.

| **source** | $^{137}$Cs | $^{60}$C | | $^{22}$Na | |
|---|---|---|---|---|---|
| Energy[keV](exp) | 661 | 1173 | 1332 | 511 | 1274 |
| $Yiled_{\text{emission}}$ | $4.25\times10^{7}$ | $3.82\times10^{7}$ | $3.82\times10^{7}$ | $2.20\times10^{8}$ | $1.10\times10^{8}$ |
| $Yiled_{\text{detected}}$ | $3.17\times10^{4}$ | $1.96\times10^{5}$ | $1.77\times10^{5}$ | $6.40\times10^{5}$ | $1.74\times10^{5}$ |
| $Yiled_{\text{detected}}$(calibrated) | $1.35\times10^{6}$ | $6.31\times10^{6}$ | $5.70\times10^{6}$ | $7.80\times10^{7}$ | $2.14\times10^{7}$ |
| efficiency[%] | 31.7 | 16.5 | 14.9 | 35.4 | 19.4 |

$Yiled_{\text{detected}}(calibrated)$ means

$Yiled_{\text{detected}}$(calibrated)=$\frac{\text{ungatedevent}}{\text{gatedevent}} * (\text{DS} - \text{Dalitrigger})$*$Yiled_{\text{detected}}$

- DS-dali trigger:Down scale factor
- $\frac{\text{ungatedevent}}{\text{gatedevent}}$:livetime of Dali trigger
- $Yield_{511} = 2 * Yield_{1274\text{KeV}}$ in $^{22}$Na

I calculated the efficiency by using the **GEANT** code which reproduces well the measured efficiencies.

| Energy[keV] | 661 | 1173 | 1332 | 511 | 1274 | $E$(2020kev; $2^{+} \rightarrow$ g.s) |
|---|---|---|---|---|---|---|
| efficiency[%](calc) | 31.0 | 20.2 | 18.5 | 38.4 | 19.1 | 13.6 |

Figure shows plot of photo-peak efficiencies as a function of $\gamma$-ray energies.The solid line was calculated by the **GEANT** code. For 2 MeV, efficiencies was estimated attained to be about 18 % and this curve is within the 15%ddeviation. This concluded that this systematic error $\Delta\epsilon$ is 15%.

In 2 Mev $\gamma$-ray, I estimated 13.9 % of the efficiency and determined 15% of the systematic error from this figure.

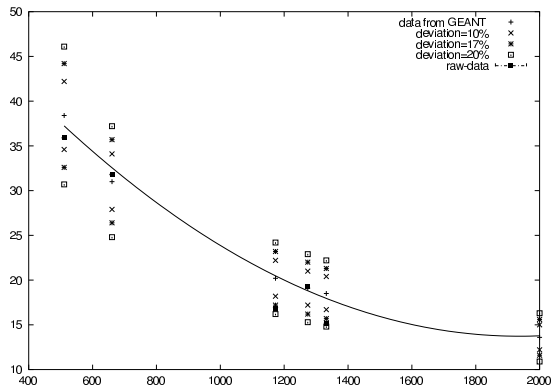


Figure 1: comparison calculation data from raw data

## 1.2 appendix

$$A = -\tau \frac{dN}{dt} = \tau N \tag{2}$$

$$N(t) = N(0)e^{-t/\tau} \tag{3}$$

$$\tau = t_{1/2} \log 2 \tag{4}$$

- A:the number of decay
- $\tau$:decay constant
- $t_{1/2}$:half time
- $N(t)$:Yield