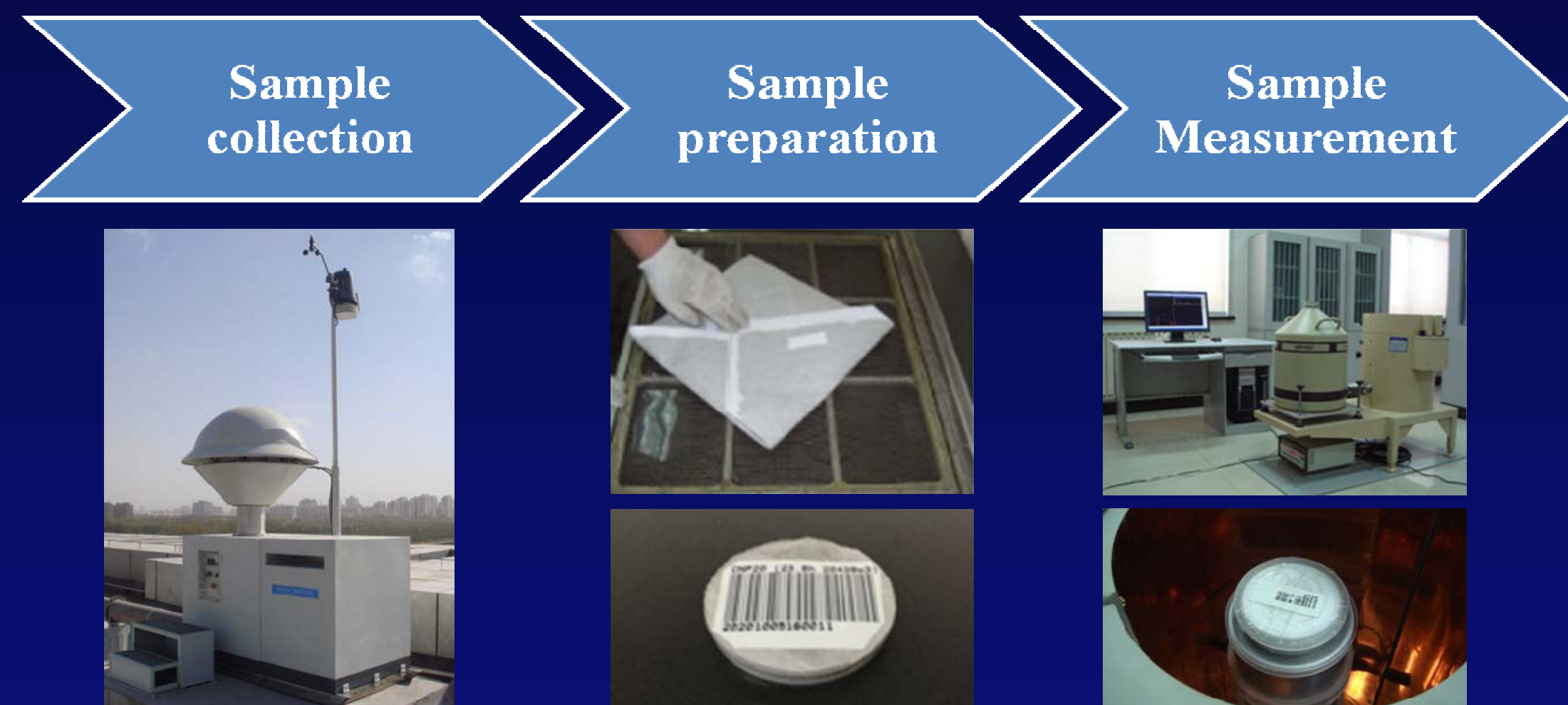


FAN Yuanqing, WANG Shilian, LI Qi, ZHAO Yungang, JIA Huaimao,  
ZHANG Xinjun, CHEN Zhanying, LIU Shujiang, CHANG Yinzong, SHI Jianfang  
Beijing Radionuclide Laboratory, EMAIL: Yuanqing.fan@nrl.org.cn, ADDRESS: No. 39, Maofang Road, Haidian District, Beijing, 100085, PRC

## 1. Introduction

The network of stations to measure radionuclides in the atmosphere shall comprise an overall network of 80 stations. All stations shall be capable of monitoring for the presence of relevant particulate matter in the atmosphere.

### Monitoring procedure of particulate matter in the atmosphere

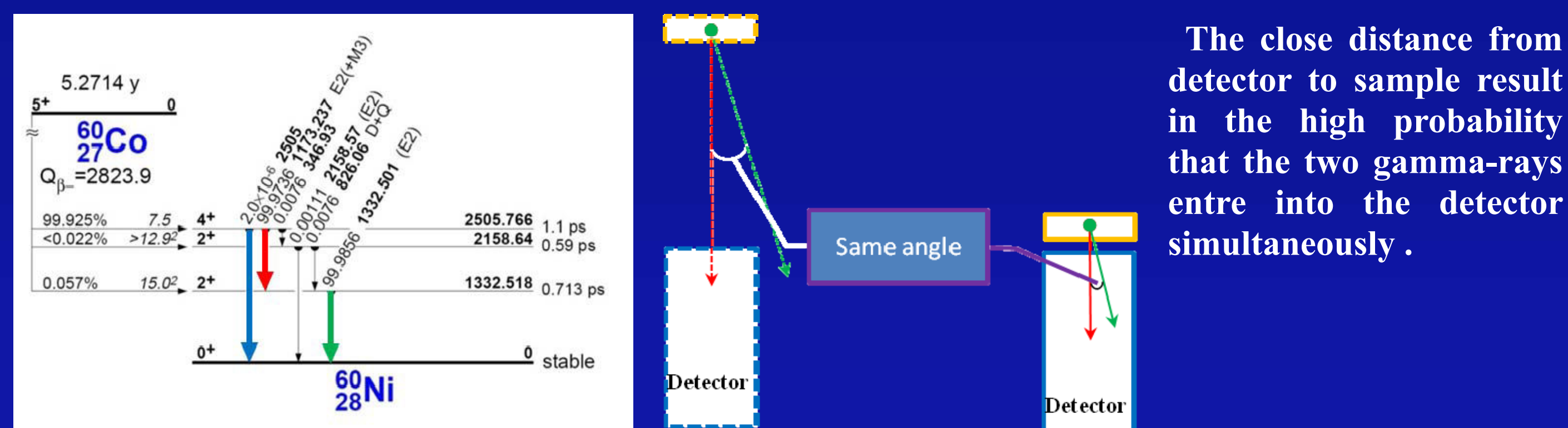


### The arrangement of filter sample measurement

- The filter collecting particle is piled or compressed into impact geometry. **Intention** To improve the efficiency of detection.
- The sample is located on the surface of detector. **Problem** For the multi-gamma radionuclide the coincidence summing effect is inevitable.

## 2. Coincidence Summing Effect

### Mechanism



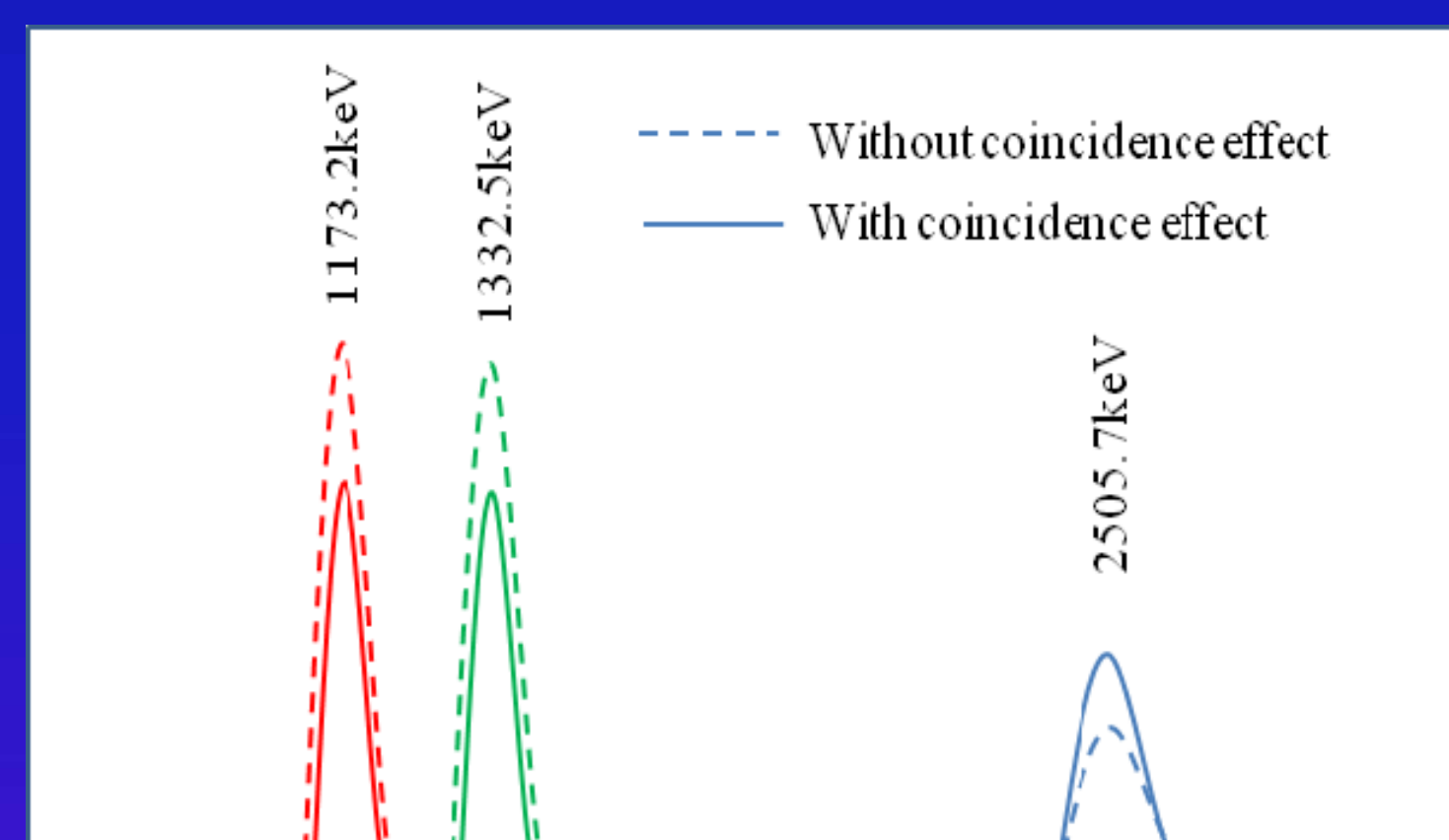
When gamma ray1(red) and gamma ray2(green) enter into detector simultaneously(<ps) and deposit energy, the detector can not resolve them because the detector's resolving time is ~us, then the coincidence summing effect happen.

### Influence

The activity of radionuclide in the particle sample was calculated by the equation,

$$A = \frac{n}{\varepsilon p}$$

A=source activity;  
n=count rate **observed in spectrum**;  
p=emission probability of gamma ray;  
 $\varepsilon$ =full-energy-peak efficiency at E;



When gamma ray1 and gamma ray2 was detected simultaneously, it could lead to a single pulse corresponding to an apparent energy different from either original pulse.  
NO count increase at 1173 or 1132keV.

Coincidence summing effect will increase or decrease the observed counts in the spectrum compared to the pulse counts generated by gamma-ray, and it will influence the accuracy of calculated activity.

### Example

In PTE2016, reference sample was located on the surface of a HPGc detector. For activity of cobalt-60, the corrected activity is accord with the reference activity. There is the obvious difference between the uncorrected activity and reference activity.

Energy /keV	Half-life /d	Count rates /s <sup>-1</sup>	Probability	Efficiency	Uncorrected activity/Bq	Correction factor	Corrected activity/Bq	Reference activity/Bq
1173.24	1925.22	1.729	0.9985	0.0303	57.15	1.1361	64.93	64.62
1332.60	1925.22	1.575	0.9998	0.0277	56.87	1.1419	64.94	64.62

### Conclusion

For multi-gamma radionuclide the coincidence summing effect should be corrected.

## 3. Correction

In the absent of coincidence summing, the rate of pulses  $n_1$  in the full-energy peak for gamma ray1 (red) is

$$n_1 = Ap_1\varepsilon_1$$

A=source activity  
 $p_1$ =emission probability of gamma ray1  
 $\varepsilon_1$ =full-energy-peak efficiency at  $E_1$

In fact the observed rate of pulse of gamma ray1(red) is

$$n_1 = Ap_1\varepsilon_1 - Ap_1\varepsilon_1\varepsilon_{12} = Ap_1\varepsilon_1(1 - \varepsilon_{12})$$

The correction factor of gamma ray1(red) is

$$C_1 = \frac{n_1}{n'_1} = \frac{1}{1 - \varepsilon_{12}}$$

$\varepsilon_{12}$ =total efficiency at  $E_2$

The correction factor of gamma ray2 (green) is

$$C_2 = \frac{1}{1 - \frac{p_1}{p_2}\varepsilon_{11}}$$

$p_2$ =emission probability of gamma ray2  
 $\varepsilon_{11}$ =total efficiency at  $E_1$

The correction factor of gamma ray3 (blue) is

$$C_3 = \frac{n_3}{n'_3} = \frac{1}{1 + p_1\varepsilon_1\varepsilon_2/(p_3\varepsilon_3)}$$

$\varepsilon_2$ =full-energy-peak efficiency at  $E_2$   
 $p_3$ =emission probability of gamma ray3  
 $\varepsilon_3$ =full-energy-peak efficiency at  $E_3$

### General formulae for complex decay schemes

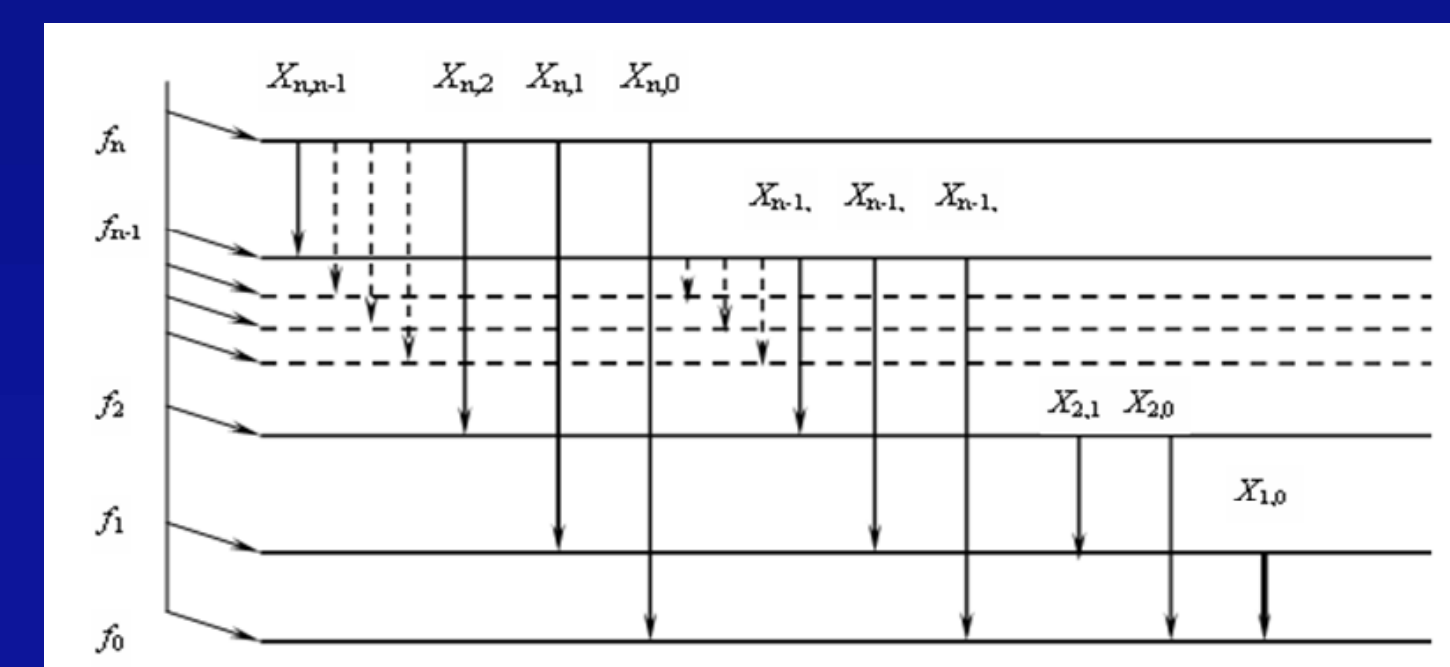


Fig. A general decay scheme.  $f_i$  are respectively the probability of direct decay to the  $i$ -th level;  $X_{ij}$  is the branch ratio (gamma-ray plus conversion)of the transition from  $i$ -th to  $j$ -th level.

$$p_i = \frac{f_i}{p_{1,0}} \prod X_{i,j}$$

$i=1,2,3,\dots,n; j=0,2,\dots,n-1,$

$$g = 1/(1 + \alpha)$$

$\alpha$  denote the internal conversion coefficient; $\omega_K$  is K-shell fluorescence yield

### Procedure

#### Efficiency calibration

- To Calibrate the peak efficiency
- To Calibrate the total efficiency

#### Decay scheme Analyzing

- To simplify the decay scheme. For radionuclide with complicated decay scheme the contribution from gamma ray with tiny probability should be ignored.

#### Factor calculation

- To calculate the coincidence summing correction factor
- To evaluate the uncertainty of the factor

### Procedure in Beijing Radionuclide Laboratory

Energy	Obs. Efficiency	Cal. Efficiency	Uncertainty
1173.24	0.009000	0.002000	10.0
1332.60	0.010000	0.004500	10.0
2505.70	0.020000	0.008000	10.0

## 4. Discussion

### Necessity

- For multi-gamma radionuclide the coincidence summing effect should be corrected.

### Requirement

- Coincidence summing effect factor is the function of the total efficiency and peak efficiency, so it is important to calibrate or calculate both efficiencies accurately.

### Technique

- In order to reduce workload, it is necessary to simplify the decay scheme of some radionuclides.

### Suggestion

- To calibrate the peak and total efficiency of the detectors in all the RN stations.
- To calculate the coincidence summing correction factor for all the detectors in RN stations.