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Mutual Interference of Alpha and Beta Signals in Counting

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When multi—wire proportional counters are used for montoring of mixed contamination of α and β radioactivity, both of the signals should be distinguished as far as possible from requirement of radiation protection. The rules provided by the recommondation standard of International Electical Committee (IEC) and the national standard of China indicate: For fixed personal surface contamination monitoring assembly, the response of the α—counting chennel to β events should be smaller than 1% of response of the α—counting channel to α events, and the response of β—counting channel to a events should be smaller than the respous of the response of α—counting channel to the same events. If the first letter of the footnote of quantity symbol is used for note of counting channel and the second for the kind of particules that the channel respense to. Then the respenses of α and β counting channel to α and β signals are expressed with $\eta_{\alpha\alpha}$、$\eta_{\alpha\beta}$ and $\eta_{\beta\beta}$ $\eta_{\beta\alpha}$ respectively. So:

$$\begin{cases} \eta_{\alpha\beta} < 0.01\eta_{\alpha\alpha} & (1-1) \\ \eta_{\beta\alpha} < \eta_{\alpha\alpha} & (1-2) \end{cases}$$

Sometimes, the ratio between count to interference source in a channel and total count is the same source in two channels—— called as cross interfering ratio (CIR) ——is also to express degree of mutual disturbance.

The two definition and different : The former limits the detection efficiency of channels and the relationships between their. And the latter only relate to quantity of interference count, in fact , it has not any significance for actual design, but the limitations just are necessary for correct operation of assembly.

When radioactivities of a mixed contamination source are respectively A_α and A_β. Then two channel counts are respectively.

$$\begin{cases} N_\alpha = A_\alpha\eta_{\alpha\alpha} + A_\beta\eta_{\alpha\beta} & (2-1) \\ N_\beta = A_\beta\eta_{\beta\beta} + A_\alpha\eta_{\beta\alpha} & (2-2) \end{cases}$$

Therefore,

$$\begin{cases} A_\alpha = \dfrac{N_\alpha\eta_{\beta\beta} - N_\beta\eta_{\alpha\beta}}{\eta_{\alpha\alpha}\eta_{\beta\beta} - \eta_{\alpha\beta}\eta_{\beta\alpha}} & (3-1) \\ A_\beta = \dfrac{N_\beta\eta_{\alpha\alpha} - N_\alpha\eta_{\beta\alpha}}{\eta_{\alpha\alpha}\eta_{\beta\beta} - \eta_{\alpha\beta}\eta_{\beta\alpha}} & (3-1) \end{cases}$$

If the ratios of mutual interference are noted by $K_{\alpha\beta}$ and $K_{\beta\alpha}$, then

$$\eta_{\alpha\beta} = \frac{\eta_{\alpha\alpha} K_{\alpha\beta}}{1 - K_{\alpha\beta}} \qquad (4-1)$$

and

$$\eta_{\beta\alpha} = \frac{\eta_{\alpha\alpha} K_{\beta\alpha}}{1 - K_{\beta\alpha}} \qquad (4-2)$$

Replacing $\eta_{\alpha\beta}$ and $\eta_{\beta\alpha}$ by formulas (4) into formulas (2) will also get A_α and A_β.

Self—absorption may be corrected while quality of monitored surface is examined.

To distinguish one kind of signal from another, amplitude discrimination method is used usually. On this mothod the geometrical structure of counter should make the difference of energy loss between the α and β particules be the greatest in the work space for distincting them, for this reason the average range of α particules is a determinative factor. The followed linear amplification circuits certainly reduce the amplitude difference between different kind of signals, so there should be sufficiently large dynamic range of amplitude of output signal in amplification stages and better amplification linearity to keep the difference for distinction. And the result may be better whill non—linear amplifier, for example exponential amplifier, is used. The variation of operation HV of counter will also effect the above mutual interference, the ditermination of HV biased value not only depends on background count and detective efficiency, but also on limitation of mutual interference. As a example in a very common counting channel the variation of the mutual interference which is expressed by cross interfering ratio with operation HV is shown in Fig 1. Though variation relationships of the curves involve effects of the above factors, they still have qualitative reference value.

In amplitude circuits the difference between both of higher and lower discrimination threshold values is very great. When the two discriminators are controlled by mixed pulse chain, the disturbance to lower discriminator may be caused by the trigger of higher discriminator. That is self—disturbance inside instrument. This of disturbance is produced from transparency inside the electronic devices and parasitic space coupling with unreasonable design and configration.

And there are factor to effect cross interference outside the counter also. When distance between the source and the window of the counter is shorter the checks in the cover of the counter have collimation fuction in some degree, so minimum incident angle of particules is limited. If incident angles are different for particules of the same energy. The average remainder range is different in the counter with range outside window and actually different thickness of window. So that the amplitude spec-

trum of the particles extend to lower energy. To experiment feasily the window of counter is exposed by collimated β particles beam with different angles (Fig 2) and the results is shown in Fig 3: the smaller is incident angle, the more is interference count, and the smaller is size of the cover ckeck, the greater is restricting interference fuction. But the latter will make the screen factor of the cover become great and detection efficiency reduce.

The space position of the secondary ionization can be different for α and β particles and dispersed degree of the position is also different. So that for the transient process of electrical signal of α and β events there are different characteristic, which supply another discrimination method for distinguishing the different radioactive evente—waveform discrimination method. This method will also require limitations to the counter and followed circuits to keep the difference produced in formed process. At present the results of 1% have been already getted respectively for α (or β) to β (or α)

Just as in amplitude discrimination method, there are also effect factors to confuse the difference on the waveform of signals corresponding to different radioactive particles. First, there are random variations in the time and space position of secondary ionization, so that in the original conditions are not desirable to form leading time of signals. Secondly, according to calculation of distribution of electrical field intensity in the count it is not even and identical, and generally electrical field distribution is not very identical around anode wire, the latter occupy in about 1/3 of work—space of counter. Particularly, the electrical field is very weak in part of the above space. That will make the time characteristic of signals to be more dispersive. Therefore it may be the reason that effect of the waveform discrimination method may be limited. In fact, if the results shown in Fig 1 are payed attention to, the improvements can be done. Then just now the advantage using waveform discrimination method is not abvious, but expense for circuit is higher .

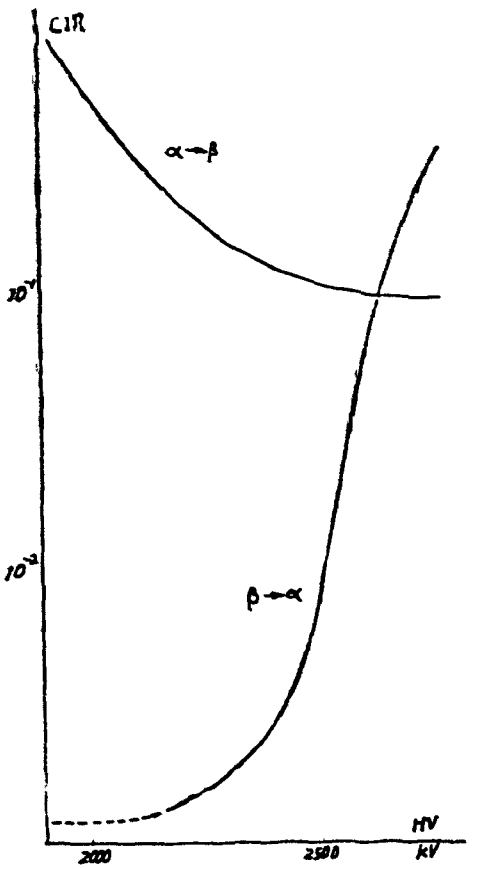

Fig. 1

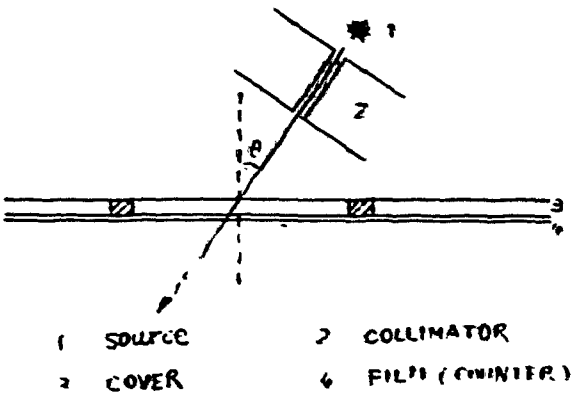

Fig. 2

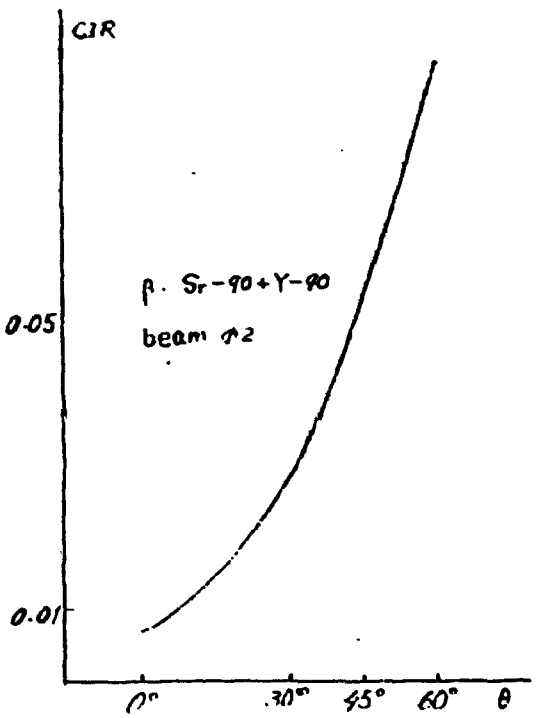

Fig. 3