ANGER CAMERA DEADTIME

In a paper by Adams and Zimmerman (*1*) the statistical nature of the decay process has not been taken into account. Therefore, the deadtime of the system appears to depend on the input rate. The following reasoning makes this an unnecessary statement.

The following notation will be used: n is true input rate, r represents measured input rate, $\Delta r = r - n$ is error of the measurement, and $\epsilon = \Delta r/n$ represents relative error of the measurement.

From the fact that the decay process is a Poisson process, the following frequency distribution of time intervals between p decay events can be derived (T mean interval) (*2*):

$$\frac{g(p,t)}{n} = \frac{p^p}{(p-1)!}(nt)^{p-1}e^{-p(nt)} \qquad (1)$$

For $p = 1$, i.e., for every two adjacent events the formula reduces to

$$\frac{g(t)}{n} = e^{-nt}; \int_0^\infty \frac{g(t)}{n}\,dt = 1. \qquad (1a)$$

If such a signal enters a system with deadtime τ, the following amount of events is lost:

$$\epsilon = -\int_0^\tau \frac{g(t)}{n}\,dt = -(1 - e^{-n\tau}). \qquad (2)$$

Therefore

$$r = n(1 + \epsilon)$$

$$r = ne^{-n\tau} \qquad (3)$$

$$n = re^{n\tau}. \qquad (3a)$$

A first order approximation of the exponential function leads to

$$r \approx n(1 - n\tau).$$

This might be the link to the relations given in the paper by Adams and Zimmerman.

Now the deadtime may be calculated using Eq. 3a in combination with the two-source measurement described by

$$n_{12} + n_b = n_1 + n_2 \qquad (4)$$

$$r_{12}e^{n_{12}\tau} + r_b e^{n_b\tau} = r_1 e^{n_1\tau} + r_2 e^{n_2\tau}. \qquad (5)$$

This equation must be solved using numerical methods on a digital computer. A first guess can be obtained as follows: if two sources of almost equal rates are used and the background is omitted, Eq. 5 reduces to

$$r_{12}e^{2n\tau} = 2re^{n\tau};\ n_1 \approx n_2 = n;\ n_b = 0 \text{ and}$$

$$\tau_0 = \frac{r_{12}}{2r^2} - \ln\frac{2r}{r_{12}}. \qquad (6)$$

The following results have been obtained with a gamma camera (Picker) linked to a computer (DEC-PDP 11/20). Four point sources (2 mCi ^{99m}Tc) in about a 2-ft distance were measured for 20 sec in the following combinations:

$$r_A = 243{,}323 \text{ counts}$$

$$r_B = 208{,}257 \text{ counts}$$

$$(r_A + r_B) = r_1 = 363{,}189 \text{ counts}$$

$$(r_\tau + r_0) = r_2 = 380{,}913 \text{ counts}$$

$$(r_1 + r_2) = 503{,}895 \text{ counts}$$

$$r_b = 1{,}082 \text{ counts/100 sec}$$

$$r_A,r_B:\ \tau_0 = 15.518\ \mu\text{sec} \quad \tau = 15.584\ \mu\text{sec}$$

$$r_1,r_2:\ \tau_0 = 14.190\ \mu\text{sec} \quad \tau = 14.193\ \mu\text{sec}$$

Method 2 from the article by Adams and Zimmerman would give the following results:

$$r_A,r_B:\ \tau^* = 21.5\ \mu\text{sec}$$

$$r_1,r_2:\ \tau^* = 25.6\ \mu\text{sec}$$

It should be pointed out again that the complexity of data acquisition equipment may influence strongly these calculations. If some intermediate storage of only a few events ($p = 3;5$) should allow queuing and, therefore, averaging of time intervals, Eq. 1 must be evaluated accordingly. Deadtime of a device should not depend on its imput signal.

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REFERENCES

1. ADAMS R, ZIMMERMAN D: Methods for calculating the deadtime of Anger camera systems. *J Nucl Med* 14: 496–498, 1973

2. FÜNFER, NEUERT: *Zählrohre und Szintillations-zähler.* Karlsruhe, 1959

THE AUTHORS' REPLY

In the definition and measurement of deadtime, two extreme limiting types of deadtime performance may be considered (*1,2*):

1. Paralyzable. This type of equipment remains insensitive for an elapsed "deadtime" τ after each "true" event. The response time τ to an initial event is further extended for an additional time τ by any additional true events which occur before full recov-