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PHYSICAL METHODS AND INSTRUMENTATION

STANDARDIZATION OF LARGE AREA ALPHA AND BETA SOURCES WITH A WINDOW-LESS MULTI-WIRE PROPORTIONAL COUNTER

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Abstract. A measurement system was assembled and tested for the absolute standardization of large area alpha and beta sources. Such sources are employed to calibrate a variety of contaminometers. A window-less multi-wire proportional counter, donation of the "Laboratoire National Henri Becquerel" (LNHB, Saclay – France) was used, with pure methane as flowing gas. The needed electronics (high voltage, amplifier, discriminator, counter, clock, MCA) was a CANBERRA one. Point and extended sources of ^{241}Am, ^{90}(Sr + Y) and ^{204}Tl were standardized. The variation of the counting rate with high voltage provided "plateaus" of (300–500) V with a slope of (0.1–1.5)% for 100 V. The efficiency of the counter for a point beta source and a central area of (100 × 150) mm^2, varied with less than 0.2%. To avoid spurious pulses, adequate threshold and working high voltage were chosen, and an imposed 10 μs dead-time was inserted in the counting channel. A procedure for the threshold correction was established. A relative compound uncertainty of maximum ±2 % was obtained, a quite acceptable value for extended sources.

Key words: multi-wire counter, calibration, contaminometer, alpha source, beta source.

1. INTRODUCTION

In the Radionuclide Metrology Laboratory from IFIN-HH a measurement system was assembled and tested for the absolute standardization of large area alpha and beta sources. Such sources are employed to calibrate a variety of contaminometers. The standardized quantity is the "Emission rate" of particles (flux of particles) in 2πsr, expressed as particles/s in 2πsr.

The activity of the sources, as requested by ISO 8769 [1], is known by the producer (if the preparation procedure is well controlled) or by special-not simple-methods [2–5].

A window-less multi-wire proportional counter (MWPC) with an associated PA was used, with pure methane as flowing gas; it represents a donation of the "Laboratoire National Henri Becquerel – LNHB" from Saclay, France. The usual dimensions of large area sources are 100×150 mm^2; as radionuclide, ^{241}Am, ^{90}(Sr + Y) and ^{204}Tl were preferred.

The method is absolute because, with the corrections for background, dead-time and threshold, the real number of particles emitted per second in 2πsr is obtained. In the laboratory, another MWPC exists, with a thin Mylar window, which was attested as secondary standard equipment [6]. The activity value is obtained by relative measurement.

2. EXPERIMENT

The counter is of DEXTRAY AB710 type ($250 \times 400 \times 30$ mm) and the preamplifier PS 76-2B is produced by Eurysis Measures, France. The source is introduced in the counter with a shelter. The counter is shielded with 5 cm of Pb. The counter volume of 3000 cm^3 is fulfilled with pure methane in 1–1.5 hours.

The needed supplementary electronics (high-voltage amplifier, discriminator, counter, MCA) is a CANBERRA one. For data analyses a PC was used.

To avoid spurious pulses, adequate discrimination thresholds and working high voltages were chosen, and an imposed dead-time of 10 μs was inserted in the counting channel.

Alpha and beta spectra and the variation of counting rates with high voltage were studied. The variation of the efficiency of the counter for a point beta source, with the position of the source on the shelter (removal from the centre) was determined.

The background was subtracted in the usual way.

From the registered counting rate r, the corrected counting rate R was obtained with the usual formula:

$$R = \frac{r}{1 - r\theta} - F, \tag{1}$$

where θ is the imposed non-extended dead-time and F is the background.

Uncertainties were calculated in compliance with ISO-Guide to the Expression of Uncertainty Measurement – 1995.

3. RESULTS

Alpha background is 0.1 cps in the (1600–2100) V range, the MDA value (Minimum Detectable Activity), for 1000 s counting time, is 0.1 Bq. For beta sources the background is 33 cps and the MDA value is 1.5 Bq (Fig. 1).

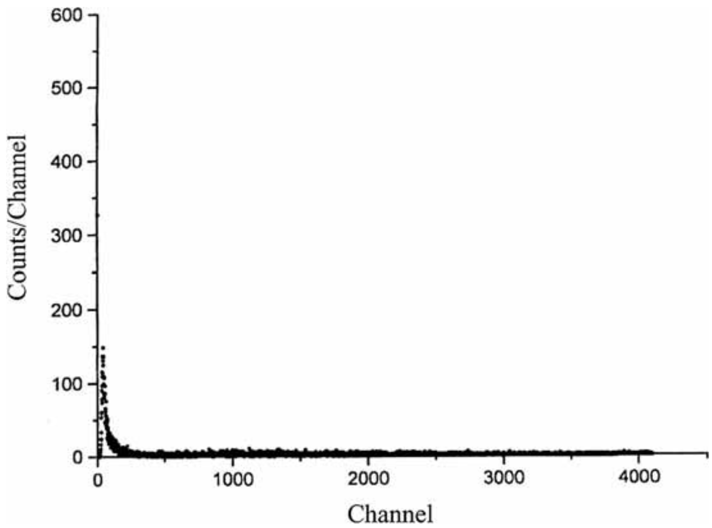

Fig. 1 – DEXTRAY AB710 Multi-wire Proportional Counter. Beta integral background = 33.0 counts/s: HV = 3200 V; threshold = 0.4 V; amplification = 240; gas = CH_4.

Both alpha and beta spectra present, for high voltages of 2000 V and 3300 V respectively, a minimum in the (0.2–0.4) V region; amplitudes lower than that are suspected to contain spurious pulses. So, the thresholds of registration were set at 0.2 V for alpha particles and at 0.4 V for beta particles and threshold corrections were made (Figs. 2–4).

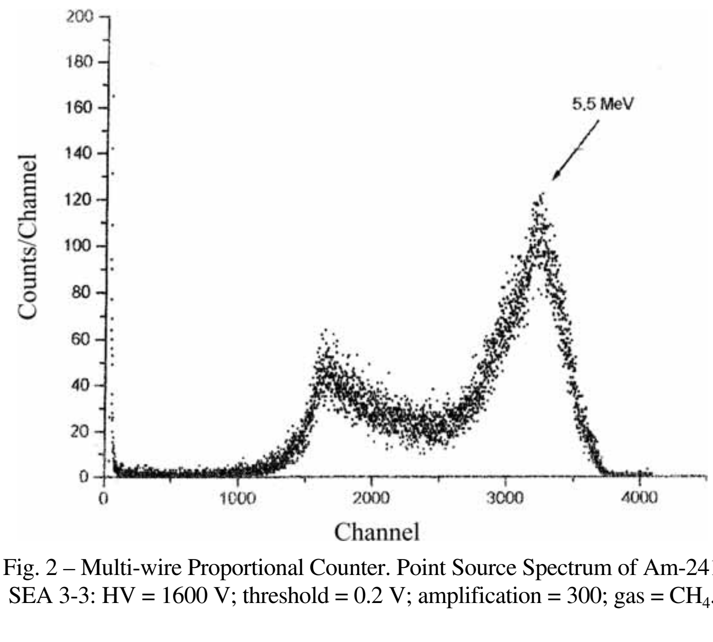

Fig. 2 – Multi-wire Proportional Counter. Point Source Spectrum of Am-241 SEA 3-3: HV = 1600 V; threshold = 0.2 V; amplification = 300; gas = CH_4.

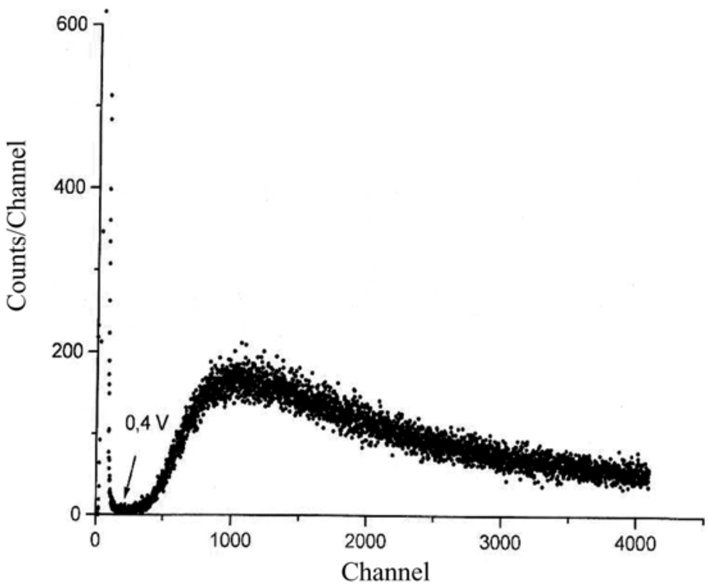

Fig. 3 – DEXTRAY AB710 Multi-wire Proportional Counter. Point Source Spectrum of Sr-90 SEB 7-3646: HV = 3200 V; threshold = 0.4 V; amplification = 240; gas = CH_4.

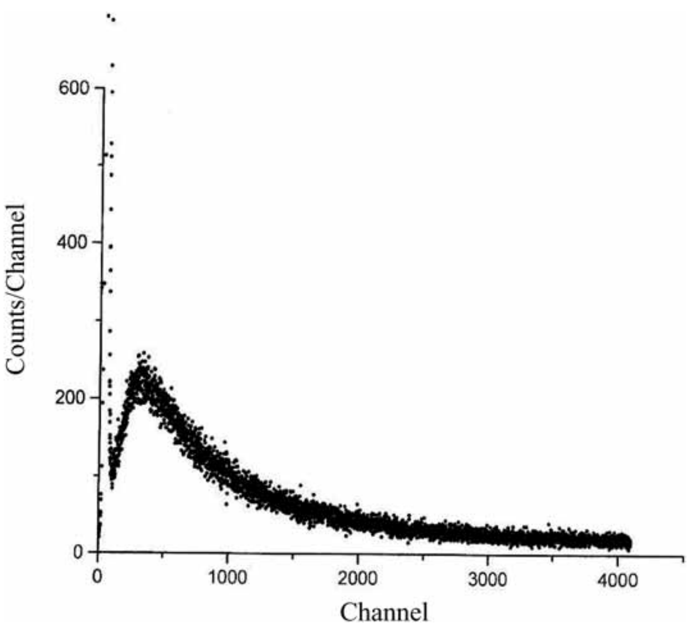

Fig. 4 – DEXTRAY AB710 Multi-wire Proportional Counter. Extended Source Spectrum of Sr-90, SEB 7-4196, 100 × 150 mm: HV = 3200 V; Threshold = 0.4 V; Amplification = 240; Gas = CH_4.

The spectrum for secondary electrons produced by an external gamma source is presented in Fig. 5; though the ionization is produced too in the most "hidden" corners of the counter, the spectrum differs from that of an internal source.

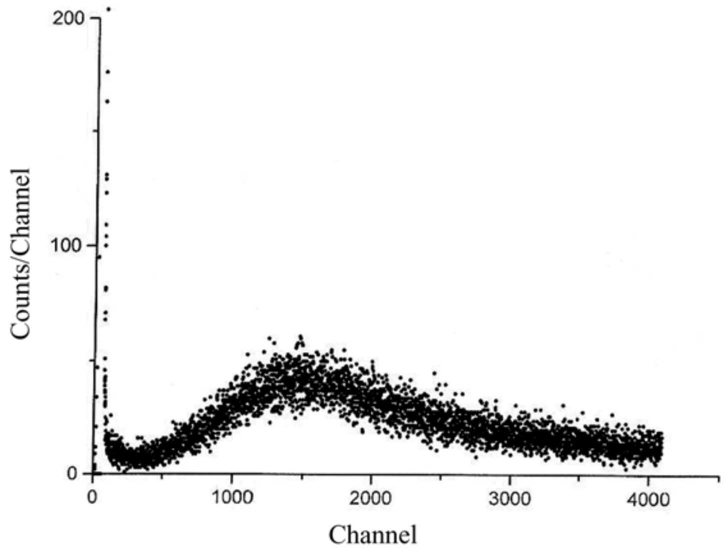

Fig. 5 – DEXTRAY AB710 Multi-wire Proportional Counter. Spectrum of secondary electrons by gamma irradiation with an external Co-60 Source: HV = 3200 V; threshold = 0.4 V; amplification = 240; gas = CH_4.

The variation of alpha counting rate with high voltage provided, in the range (1600–2100) V, a "plateau" with a slope of only 0.4% for 100 V (Fig. 6). For beta sources, the plateau was situated at (3100–3400) V, with a slope of less than 0.1% for 100 V, for point sources, and less than 1.5% for 100 V, for extended sources (Fig. 7–9). High voltage values for routine work were chosen at 2000 V for alpha sources and 3300 V for beta sources, than is 100 V below the end of the plateau.

The alpha and beta counting rates for point sources varied with less than 0.2% on a centered area of 100×150 mm^2. So, one does not need an extension correction for extended sources up to 100×150 mm^2! Nevertheless, the possible "non uniformity" of the source must be checked with other method.

The correction for the pulses lost below the threshold was made considering the shape of the spectra near the threshold (constant value or a trend to zero) [7].

The correction amounted to 0.4% for alpha sources and (0.2–2)% for point and extended beta sources. Half of theses values were considered as type B (systematic) components of uncertainty.

An alternative procedure for considering the threshold correction is to estimate the growth of the counting rate between the working point on the plateau and the end of the plateau, using the determined slope. We preferred the first method, though the correction values obtained by the second method were practically the same.

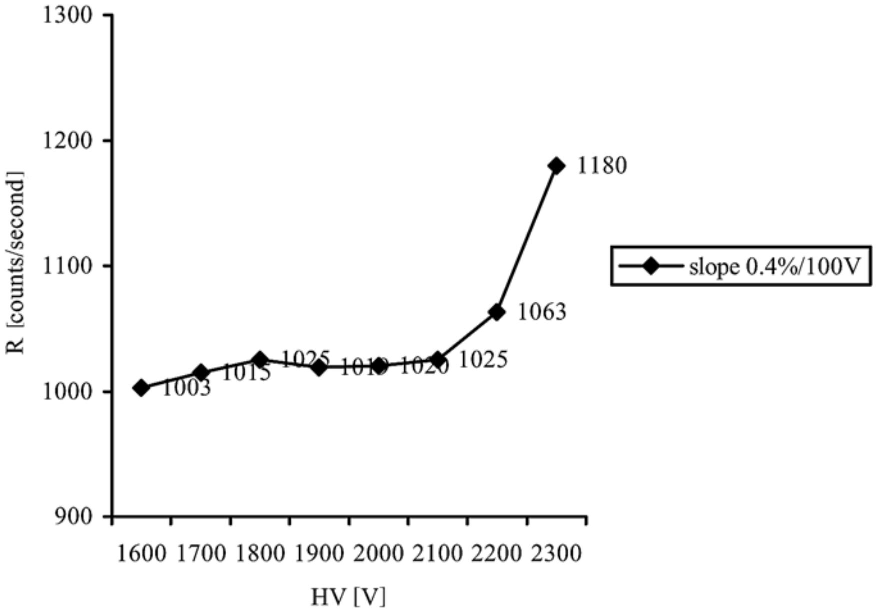

Fig. 6 – Alpha plateau with point source of Am-241, SEA 3-3, uncertainty ±1%.

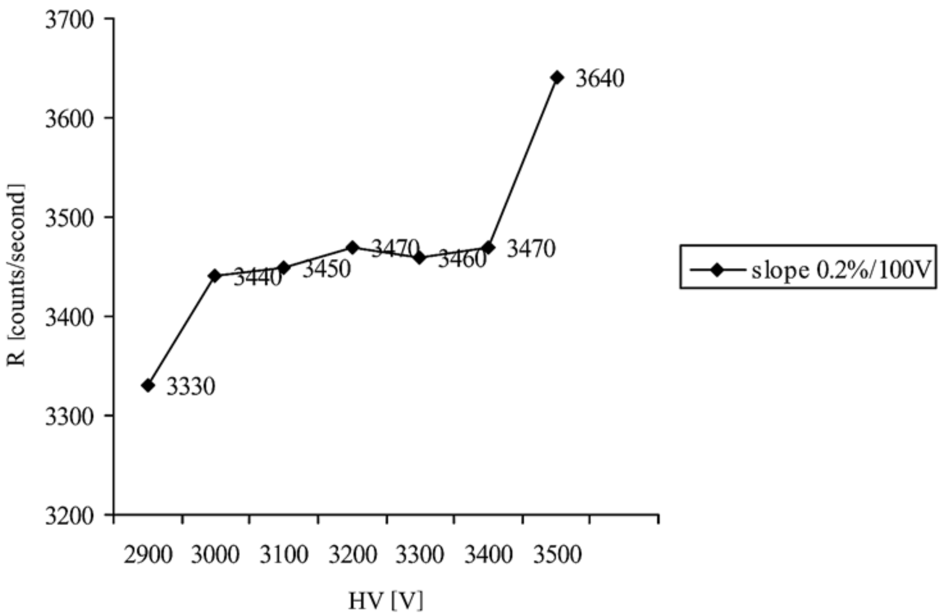

Fig. 7 – Beta plateau with point source of Sr-90, SEB 7-3646, uncertainty ±1%.

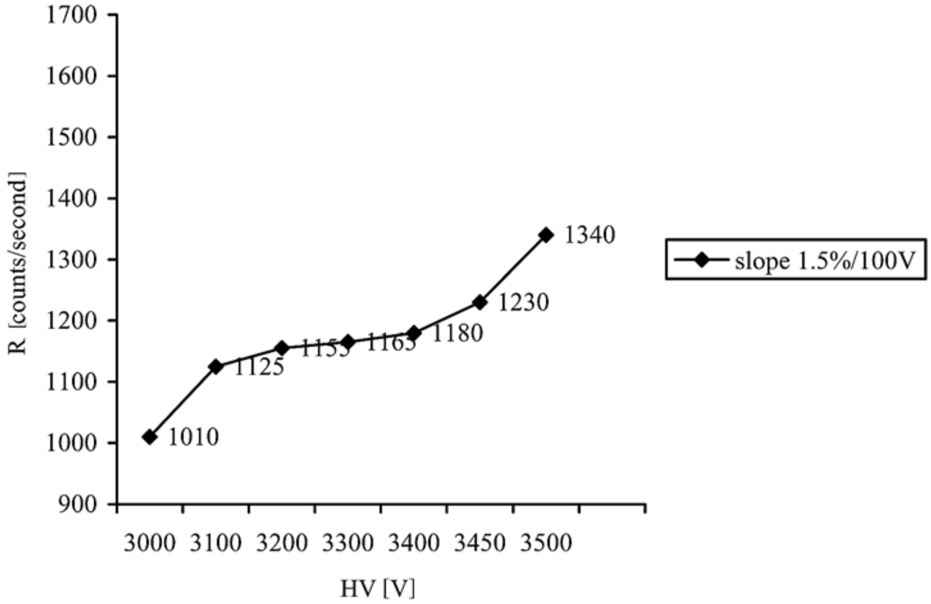

Fig. 8 – Beta plateau with extended source of Sr-90, SEB 7-4196, uncertainty ±1%.

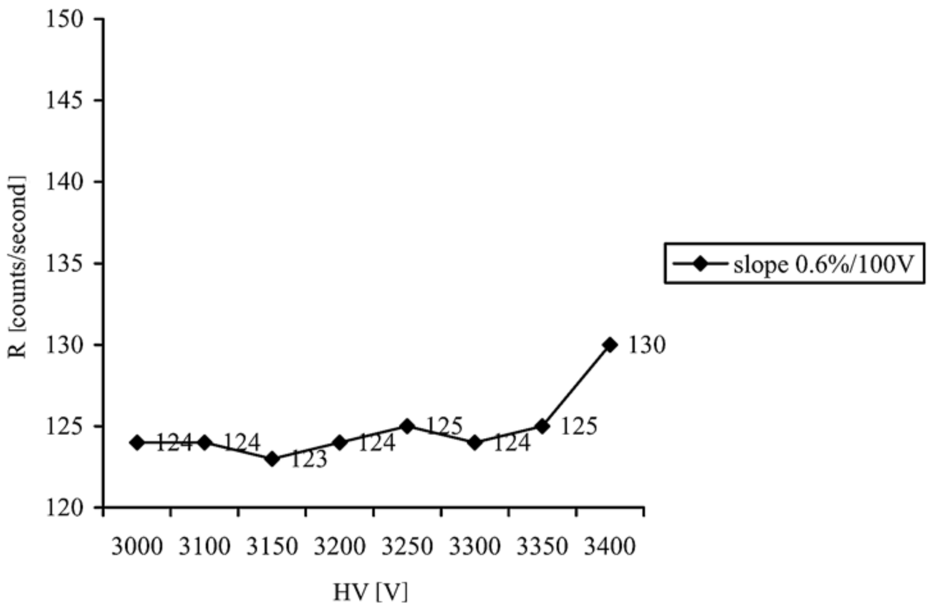

Fig. 9 – Beta plateau with extended source of Tl-204 SEB 8-323, uncertainty ±1%.

The relative combined uncertainty was calculated as:

$$u_c^2 = u_r^2 + u_F^2 + u_t^2 + u_\theta^2, \tag{2}$$

where u_r and u_F are components of the type A (statistic) and u_t (threshold correction) and u_θ are components of type B (systematic).

For u_c, a maximum value of (1.5–2)% was obtained, which is quite acceptable for extended sources.

Several sources, standardized with other systems, were measured; the obtained differencies of the emission values were less then:

$$\sqrt{u_c^2 + u_s^2}\,, \tag{3}$$

where u_c (absolute value) refers to the measurement and u_s is the absolute combined uncertainty value written down in the source certificate.

4. CONCLUSIONS

An efficient system for the standardization of extended alpha and beta sources was realized.

It uses a large area multi-wire proportional counter without window and pure methane as flowing gas.

Sources of ^{241}Am, ^{90}(Sr + Y) and ^{204}Tl, point and extended, were standardized.

The graphs of the counting rates versus high voltage provided plateaus of (300–500) V, with slopes of (0.1–1.5) % for 100 V.

The efficiency of the counter is practically constant on a centered area of 100×150 mm^2.

A procedure for the threshold correction was established.

The obtained relative combined uncertainty, u_c, was of maximum $\pm 2\%$, which is quite acceptable for extended sources.

REFERENCES

1. *** *Reference sources for the calibration of surface contamination monitors – Beta emitters and alpha emitters*, ISO 8769, Geneva, 1988.
2. H. Janssen, R. Klein, *Characterization of large area reference sources for the calibration of alpha-contamination monitors*, Nucl. Instrum. Methods in Phys. Res., **A339**, 318–321 (1994).
3. H. Janssen, R. Klein, *Characterization of large-area reference sources for the calibration of beta-contamination monitors*, Nucl. Instrum. Methods in Phys. Res., **A369**, 552–556 (1996).
4. A. Svec, H. Janssen, L. Pernicka, R. Klein, *A modified method for the characterization and activity determination of large area sources*, Appl. Rad. Isot., **64**, 1207–1210 (2006).
5. K. B. Lee, Jong Man Lee, Toe Soon Park, Phil-Je Oh, *Preparation and activity measurement of electro-deposited alpha-emitting sources*, Appl. Rad. Isot., **64**, 1260–1264 (2006).
6. M. Sahagia, A. Razdolescu, C. Ivan, *Equipment and standards for surface contamination measurements*, Proceedings IRPA Congress, Vienna, Vol. 3, pp. 34–36 (1996).
7. K. B. Lee, J. M. Lee, T. S. Park, *Measurement of beta surface emission rate from an extended area ^{36}Cl source using a multi-wire proportional counter*, Appl. Rad. Isot., **63**, 99–105 (2005).