CHARACTERISTICS OF THE PROPORTIONAL COUNTER FOR SOFT X-RAYS, DEVELOPED FOR CZECHOSLOVAK SPACE EXPERIMENTS

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Abstract: The paper reviews the experience with development and fabrication of the gas-filled proprotional counters with Be-window for energy region 1—15 keV. The characteristics of counters with Al and kovar cathode are presented and it is shown that kovar-counters have better properties. Also the production and filling technology is described and some basic characteristics, as spectral efficiency, energy resolution, plateau form, life-time and number of spurious pulses are given. From these measured characteristics of the simple counters we conclude, that for higher precision of X-ray flux measurement it is necessary to use double counter with automatic calibration facility. Short description of such detector is presented.

Czechoslovak instruments on the Intercosmos satellites, designed for solar X-ray flux measurement, were equipped with Czechoslovak detectors — with a scintillation detector, a gasfilled proportional counter and a solid-state detector. This paper reviews the development and characteristics of the proportional counters.

For the IK-1 and IK-4 experiments we used the first type of proportional counter, manufactured in this country, for the energy range of 1—10 keV. It is shown in Figure 1. The cathode of the counter is

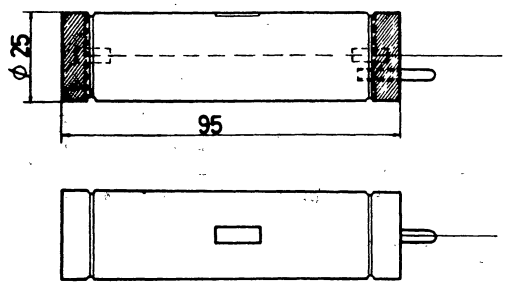

Fig. 1. Aluminium-cathode counter.

formed by an aluminium cylinder and the anode is a 0.05 mm tungsten wire, fixed by Araldit resin. The gas-mixture, pressure about 350 torr, was first composed of A + 10% CH_4 and later of A + 10% CO_2, to prolong life-time by one order at least. The energy resolution, the counter characteristic (or the counting-rate-versus-voltage dependence for a constant X-ray intensity) and the height of the pulses were sufficient. Figure 2 shows the height of the pulses plotted versus the voltage. The end of the proportional region is displayed on this curve. Compared to these principal characteristics, the

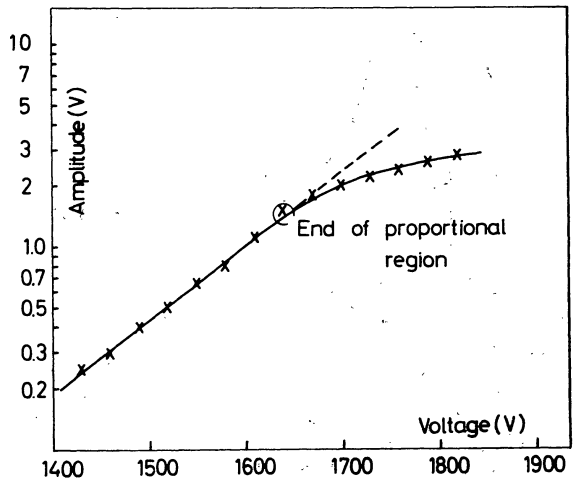

Fig. 2. Height of pulses versus voltage for aluminium-cathode counter filled with A + 10% CH_4, 300 torr.

spurious pulse number and its increase with temperature and voltage, and the time instability of the height of the pulses depreciated the properties of the counter very considerably. Figures 3 and 4 show the spurious pulse number versus the temperature and voltage. During long-term irradiation the height of the pulses decreased, as shown in Figure 5. After the voltage had been cut off for a short period the height of the pulse reached its initial

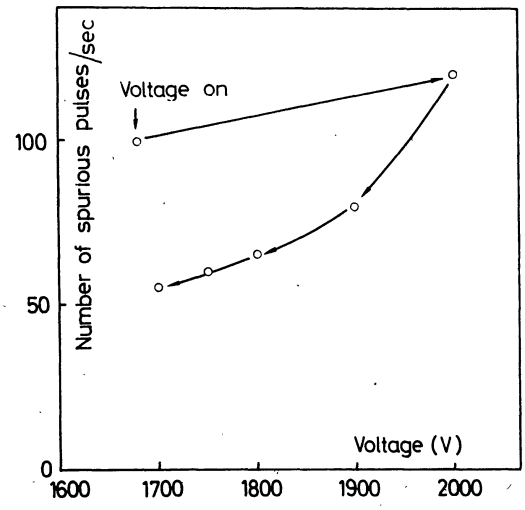

Fig. 3. Spurious pulse number versus voltage for aluminium-cathode counter filled with A + 10% CO_2, 300 torr. Amplification 100.

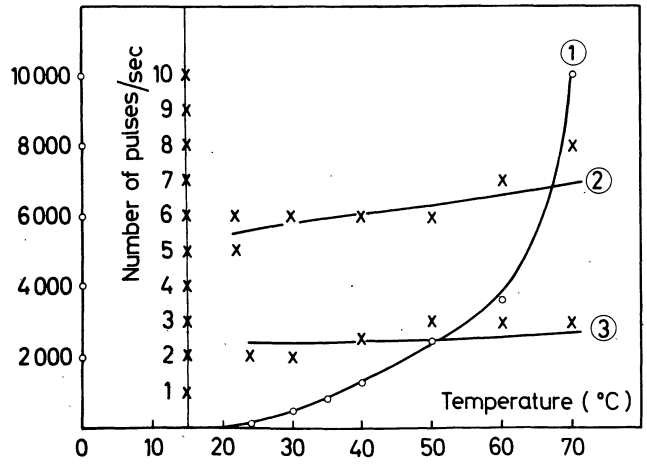

Fig. 4. Spurious pulse number versus temperature. Amplification 100. 1 — Al-cathode counter 300 torr U = 1620 V, 2 — kovar cathode counter 400 torr U = 1600 V, 3 — kovar-cathode counter 365 torr U = 1480 V.

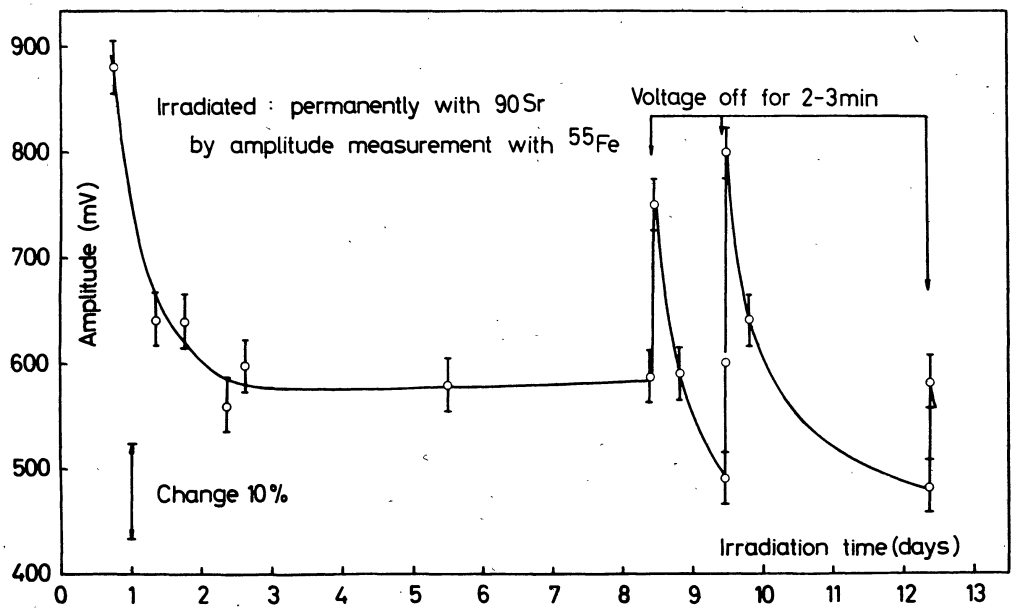

Fig. 5. Height of pulses versus time for long irradiated Al-cathode counter. Amplification 100.

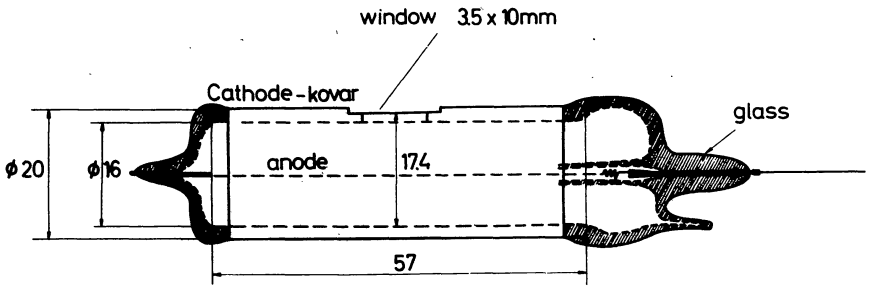

Fig. 6. Kovar-cathode counter.

value. Everything indicates that the larger spurious pulse number and amplitude instability are due to the oxides on the cathode surface and due to the impurities of the Araldit.

mm) is fixed in glass seals. The window is of 0.15 mm berylium as before. The A + 10% CO_2 gas mixture has a pressure of 350 torr. The carbon dioxide was specially purified before filling. This

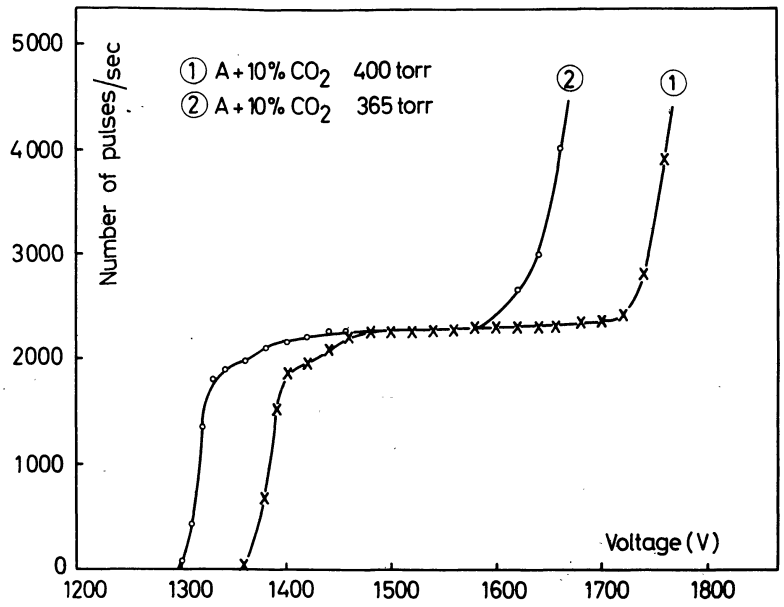

Fig. 7. Number of pulses versus voltage for kovar-cathode counters.

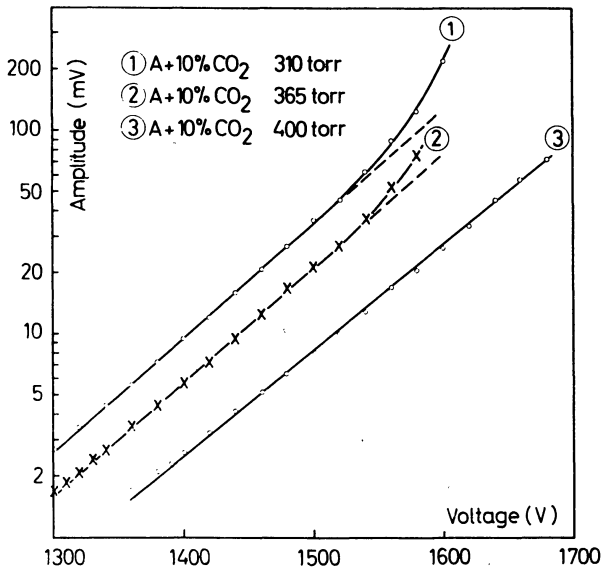

Fig. 8. Heigh of pulses versus voltage for kovar-cathode counters.

Drawing on this experience, a new type of proportional counter was manufactured for the IK-7 experiment. It is shown in Figure 6. The cathode is of kovar and the gold-plated tungsten anode (0.05

counter is free of a greater part of the imperfections of the former one. The principal characteristics are presented in the following figures. Figure 7 shows the form of the counter characteristic, when ir-

radiated by ^{55}Fe; its length is about 200V. The height of the pulses versus the voltage is plotted for three different values of the gas pressure in Figure

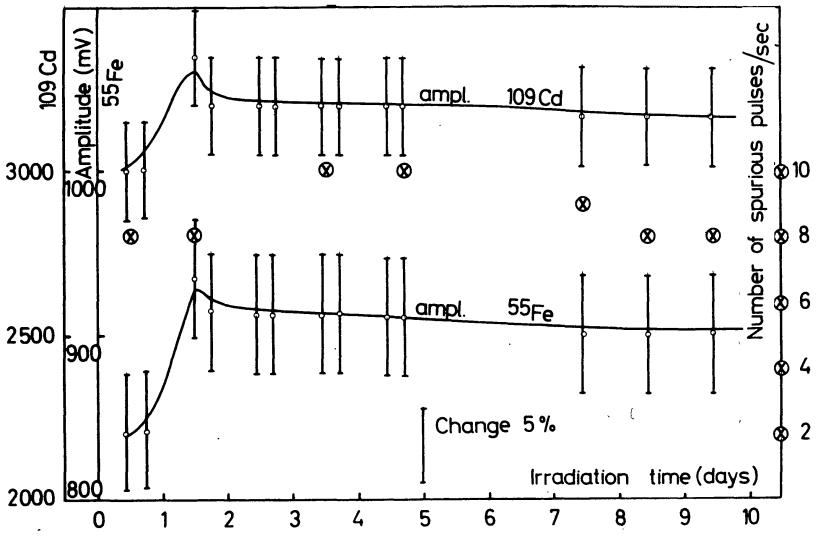

Fig. 9. Height of pulses versus time for long irradiated kovar-cathode counter. Except for the time of amplitude measurement the counter was permanently irradiated with 90 Sr. Amplification 100.

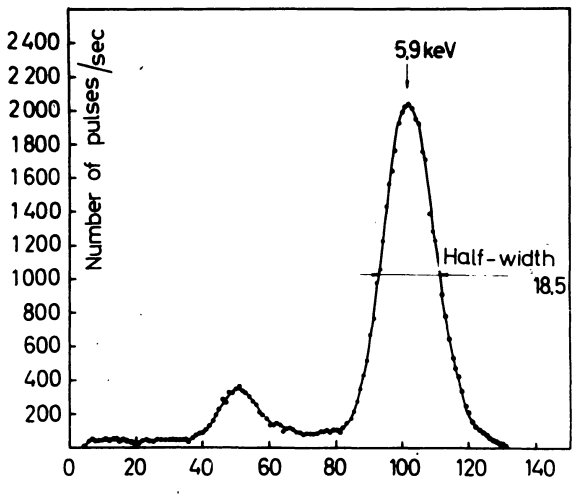

Fig. 10. Spectrum of ^{55}Fe as measured with 400-channel laboratory analyser.

8. In Figure 9 it is evident that the time variation of the height of the pulses is much less for the kovar-cathode counter than for the aluminium-cathode one. The spurious pulse number is small and independent of time (Fig. 4). From the ^{55}Fe spectrum (in Fig. 10) the energy resolution of abouth 18% can be determined for an energy of 5.9 keV. The spectral efficiency was calculated theoretically from the tabulated values of the absorption coefficients and tested experimentally by a collimated X-ray beam of ^{55}Fe (Fig. 11). The life-time test proved that the counter was able to record more than 10^{10} counts without a change to spectrometric properties.

It can be seen that this type of detector, besides its advantages, also has some shortcomings, in the first place the time variation of the height of the pulses (because of the gas-amplification instability). This variation would cause a substantial error in the calculation of the reduced values, particularly when measurements are made in several narrow energy channels.

For this reason we concluded that a fundamental improvement in accuracy can only be achieved by in-flight calibration. The easiest technical solution of this problem would be the application of the double proportional counter with common gas filling and with two windows, anodes and cathodes. The first window is coated by radioactive ^{55}Fe and its pulses are used as a reference source. Through the window of the second half of the counter the measured radiation goes in. Both halves of the counter are supplied from one high-voltage power source and the voltage is varied automatically to render the reference pulses from ^{55}Fe constant.

Correct energy calibration is thus guaranteed. In the picture (Fig. 12) one can see the first type of double proportional counter. The cathode is made of steel with kovar transition to glass seals. Other parts, including the gas filling, do not differ from that of the simple type.

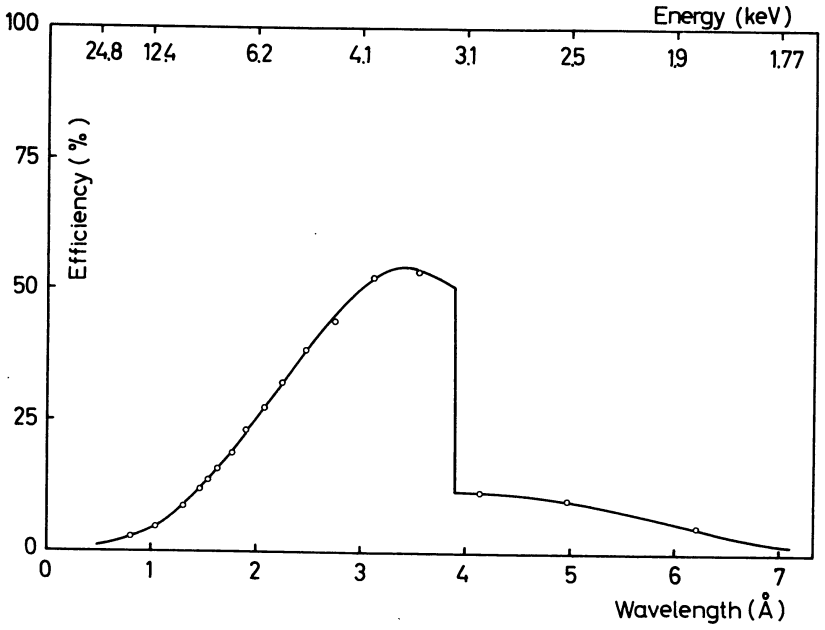

Fig. 11. Spectral efficiency of kovar-cathode counter filled with A + 10% CO_2, 360 torr.

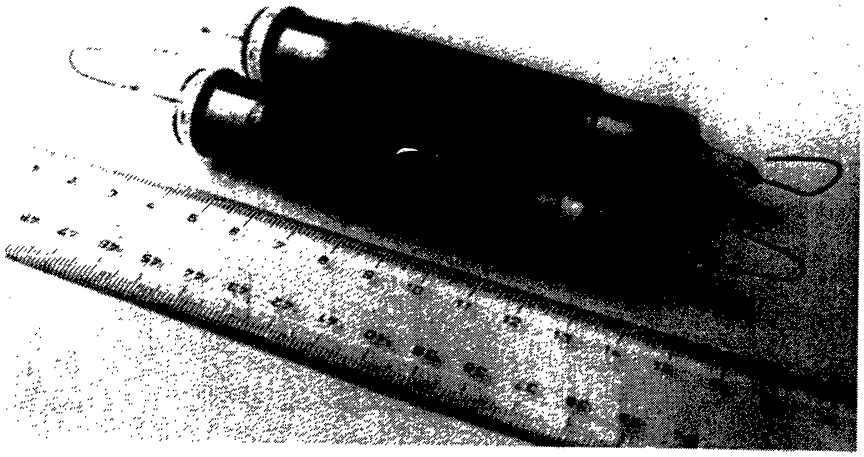

Fig. 12. The latest type of double proportional counter.