Application

The VACUTEC proportional counter probe (hereinafter referred as to "PCP") is based upon a large volume gas-filled detector of high sensitivity towards photon radiation. As a stationarily operated device, it is provided to monitor environmental radiation. It features capability to perform quasi-spectroscopy by comparing continuously updated pulse height spectra with a basis set of response vectors to be considered as discrete probability distributions containing the local radiometric fingerprint. The local radiometric fingerprint represents the contamination-free situtation locally. To be more precisely, a current spectrum is deconstructed into a natural and a non-natural part by deconvoluting, whereby a reliable differentiation is obtained between the local background and contributions of artificial origin. The PCP responds to present contamination by an increase of rate components, which add up to exactly the overall count rate. Mathematically, the spectra registered by the PCP are compared as to shape and content with a linear combination of the underlying basis set. Deviations from the general spectrum shape, for example induced by present contamination, are quantified by the parameter χ^2, which is displayed as well. χ^2 responds very sensitively to spectral contributions not being part of the local background radiation. As a rule, the PCP only detects natural radiation, which may quite vary in intensity, for example as a result of precipitation, without however the spectrum shape changing. Aside from a general increasing of all count rates, nuclear contamination will primarily alter the spectrum shape. Thus, a rough analysis of the composition of local radiation provides the possibility of recognising the contingent presence of nuclear contamination.

Additionally, the PCP is equipped with two energy-compensated Geiger-Mueller tubes to measure the ambient dose rate $\dot{H}^*(10)$. Both Geiger-Mueller tubes are operated in a dead-time independent measuring mode. The idea is based upon measuring time intervals between consecutive Geiger-Mueller pulses instead of counting pulse numbers per time, which would be dead-time dependent. After every single pulse, the tubes are quenched and restarted automatically with a defined recovering time much larger than the inherent dead-time. The time up to the next pulse obeys the Exponential distribution with a mean being the inverse of the pulse rate. The pulse rate values of both tubes are used to calculate an overall dose rate taking the statistical precision of the measurements into account.

The PCP is designed for measuring photon radiation only. It is intended for application under ambient conditions and might be integrated in comprehensive monitoring networks. Compared to ordinary Geiger-Mueller probes, the PCP exhibits a much higher efficiency generating statistical reliable data in much shorter time. The PCP is not a spectrometer such as semiconductor or scintillator based devices.

Technical data (abstract)

measured quantities: count rates (total, natural, non-natural), χ^2 , ambient dose rate

radiation type: photon radiation

energy range: 24.6 keV ... 10 MeV

serial interface: EIA-485 (RS-485) and USB 2.0

temperature range: - 30 °C ... + 60 °C

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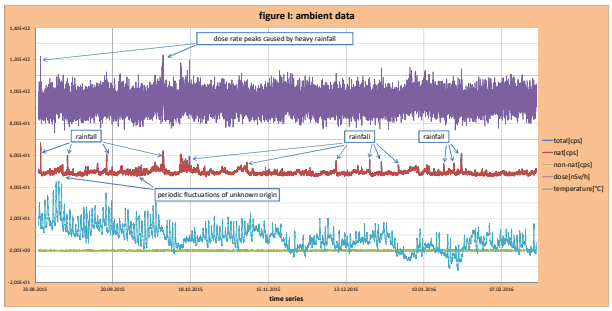
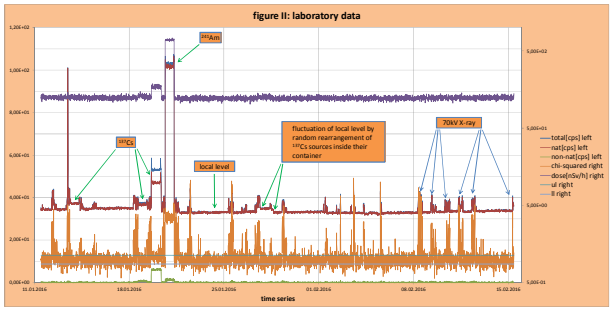
Test mode

A selection of data recorded on the rooftop of the company building in Dresden since August 2015 is shown in **figure I**. Dresden localised in the vicinity of known uranium deposits is characterised by a comparative high background radiation level around 100 nSv/h. Apparently, the natural component "nat" is subject to fluctuations from time to time. Typically, precipitation events generate distinct, clearly definable peak structures, whereas the non-natural component "non-nat" remains unimpressed and does not exceed the mean of its own noise level. With the non-natural component being so small, the natural component equals the overall count rate "total" approximately. Hence, any increase of overall count rate is clearly allocated to the natural component so far. The duration of precipitation events, their intensity and frequency may be considered as decisive for the individual characteristic of a natural radiometric event caused by precipitation. In addition, the extreme sensitivity of the PCP enables a fairly precise insight into the dynamics of a radiation field. By comparison, incisive dose rate peaks are only to be ascertained in connection with heavy rainfall after longer periods of dry weather. Otherwise, the course of the dose rate data would generally seem to indicate trends. To simulate situations where contaminations of unknown and unspecific origin are being present, the PCP was tested next to the company calibration facility, which is used regularly for development and manufacturing purposes. It provides various photon irradiation devices including ^{137}Cs and ^{60}Co sources of different activity as well as an X-ray system. The data shown in **figure II** comprise the dose rate, both rate components, the overall count rate as well as χ^2. They were measured during four weeks of normal business. As expected, the parameters provided by evaluation of spectra responded significantly to any additional radiation regardless of whether generated by the X-ray device or originating from ^{137}Cs sources. Even the random rearrangement of ^{137}Cs sources inside their storage container, where they are locked up if not being used, gave rise to a noticeable change of background intensity. Contrary, except for the PCP was being irradiated directly by using ^{137}Cs and ^{241}Am test sources, which was aimed to provoke a measurable effect on dose rates at all, this quantity has proved to be quite insensitive to detect local fluctuations induced by staff activity.





Conclusion

Applied to monitor the environmental radiation, the PCP enhances the extent of available information obviously. By evaluating pulse height spectra, PCP differentiates between natural and non-natural radiation components reliably. It could be integrated into comprehensive monitoring networks substituting commonly used Geiger-Mueller probes. As a standard device, the PCP is designed for routine operation under ambient conditions.

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