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# Studies of vacuum photomultipliers at extremely low thresholds, photoelectron backscattering and photon detection efficiency

## Content

We present results of extensive studies of vacuum photomultipliers behavior at extremely low thresholds. Usually in case of low intensity light registration, like in Cherenkov and air fluorescent light detection experiments as well as in laboratory studies of single photoelectron response of photomultipliers, photomultipliers are operated at thresholds in the range of 0.1-0.5 photoelectrons (p.e.). But what will happen if to decrease threshold further down? For many years experimental physicists have been plagued by a sharp rise of the number of pulses with low charges in the charge distribution of pulses when they have been trying to decrease threshold. This part of spectrum is attributed to the noise and usually erroneously discarded. In our previous works [1, 2] it was shown that the part of the spectrum due to pulses with low charge are explained by photoelectrons inelastically backscattered on the first dynode. In present paper we show that this part of the spectrum is of crucially importancce for measurements and understanding of photon detection efficiency of vacuum photomultipliers.
Decreasing threshold working with some photomultipliers we managed to set a record threshold of as low as 0.002 p.e.. At such a low threshold beside main photoelectrons from photocathode we detected photoelectrons produced by direct photoemission at the first and even second dynodes, Fig.1 and 2. Although we reached such low threshold with photomultipliers of different types and sizes, from 1 cm to half a meter in photocathode's diameter, unfortunately not every photomultiplier is able to operate at such threshold. On the other hand photomultipliers able to work are more stable and have better single photoelectron response. So one can put forward a new criterion for photomultipliers quality – the ability to work at threshold lower than 0.01 p.e.
The developed method to work with extremely low threshold will allow to trace the fate of each photoelectron produced on the photocathode and will improve the accuracy of photon detection efficiency with vacuum photomultipliers.
References.

1. B.K.Lubsandorzhiev et al. NIMA. 2000. V.A442. P.452.
2. B.K.Lubsandorzhiev et al. NIMA. 2006. V.567. P.12-16./ physics/0601157.

## Author's Institution

Institute for Nuclear Research of RAS

## Co-author's Institution

Institute for Nuclear Research of RAS

**Primary author(s) :** Dr. LUBSANDORZHIEV, Bayarto (Institute for Nuclear Research of the Russian Academy of Sciences)

**Co-author(s) :** Mr. LUBSANDORZHIEV, Sultim (Institute for Nuclear Research of RAS); Dr. VYATCHIN, Evgeny (Institute for Nuclear Research of RAS)

**Presenter(s) :** Dr. LUBSANDORZHIEV, Bayarto (Institute for Nuclear Research of the Russian Academy of Sciences)

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