

Gain of detection efficiency for multi coincidence studies

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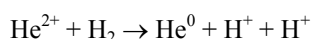
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Synopsis: We measured the efficiency of a common micro channel plate (MCP) as well as efficiency enhanced (so called funneled) MCP, once absolute via the break-up of H₂ and relative for a 5-atomic molecule, breaking-up completely.

The investigation of complex targets demands in many cases the detection of multiple emitted particles in coincidence. Hereby it is of great importance that the single particle detection efficiency ε becomes as close to 100 % as possible, as the overall efficiency scales with the power of detected particles ε^n . The single particle efficiency is a product of the transmission of the spectrometer (usually reduced by at least 20 % due to the use of a mesh for field separation), the quantum efficiency of the MCP [1] and its open area ratio (OAR). Typical MCPs have an OAR of 60 %. Already this causes a 5-particle efficiency of only 7 %. This asks for efficiency enhanced (so called “funneled”) MCPs, which – according to the manufacturer – have an OAR of 90 %. A dramatic 5-particle efficiency gain should be the result, reducing necessary data acquisition times by a factor 10. Combined with meshless spectrometers a factor 30 could be achieved.

To commission and prove this efficiency gain, we performed two experiments. At first we measured the absolute detection efficiency of protons. Therefore via investigated double ionization of H₂ via the reaction:



After detection of the neutral He⁰ projectile by definition two protons were created with 100 % efficiency [2,3]. We used a COLTRIMS type setup [4,5] with a spectrometer that was free of meshes. The geometry was chosen such that the ions already in the spectrometer field gain enough energy to saturate the quantum efficiency (20 cm acceleration length and an electric field of 100 V/cm) This ensured that all efficiency to compared the absolute detection efficiency.

In a second experiment, the two types of MCPs were also tested under identical conditions in a 5-particle coincidence experiment. During a continuous measurement, the two different MCPs, mounted on opposite sides of a symmetrical spectrometer were alternately used to detect the break-up of CHBrClF into 5 singly charged ions [6].

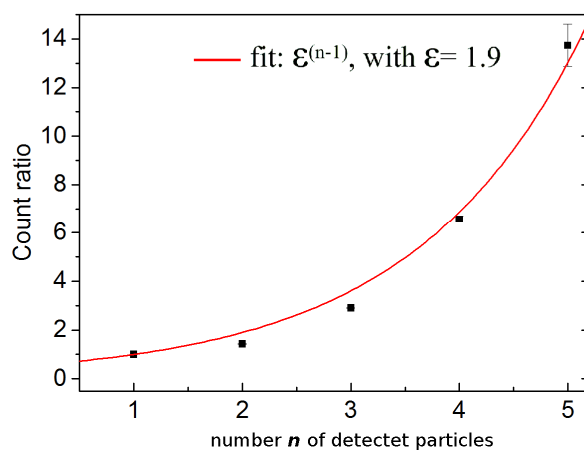


Figure 1 Gain in multi particle detection efficiency by use of new “Funnel MCPs” compared to the “Standard MCP”. The data are normalized to the same single ion count rate. The fit shows that the Funnel MCP increases the efficiency.

Normalized to the same single ion count rate, the enormous improvement of a gain increase by a factor of 14 for detecting 5 particles is presented in Fig 1. The count rates for the different numbers n of detected particles are derived by gating on a complete detection of one of the fragmentation channels for the break up in to n particles.

References

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