Optimization of Thick GEMs for photon detection

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Abstract

Experimental devices, especially particle detectors went through an extensive development which made particle physics one of the dominant research fields in modern physics. My aim is to optimize one of the novel micropattern gaseous detectors[1], the THGEM, which is used for detection of single photons.

1. Motivation

High energy physics (HEP) experiments provide the feasibility to investigate the evolution of early Universum, search for the signs of supersimmetry and extra dimensions. A typical HEP experiment consists of a particle accelerator and a large, compact detector system. With identification of secondary particles, we can study their production, correlation, ratios and can provide input for the abovementioned investigations. Cherenkov detectors can extend the particle identification (PID) capbility up to 5 GeV/c. The aim of our research to optimize the newly developed THick Gas Electron Multipliers (THGEM) for Cherenkov detectors.

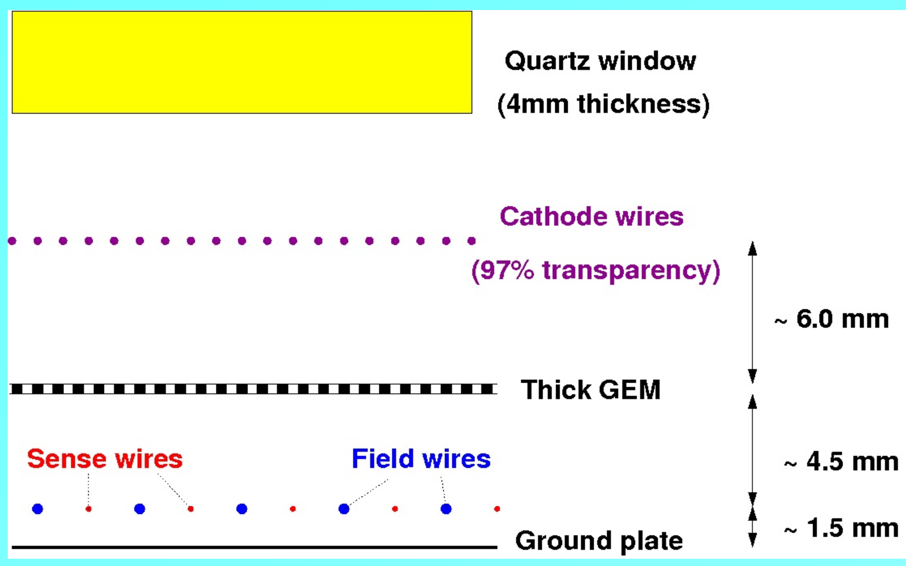

Fig. 1. The experimental setup

4. Experimental setup

The experimental setup was built by the REGARD Group with the support of the CERN RD51 Collaboration. An UV LED is used for simulating single UV photons, which is mounted on a stepping motor. The detector itself consists of two parts: the THGEM itself and a Close Cathode Chamber[3] which is used for further signal amplification and readout. The size of the light spot is about 50 micrometers and it can be moved by 10 micrometer steps[4]. A photo of the setup is shown on fig. 1.

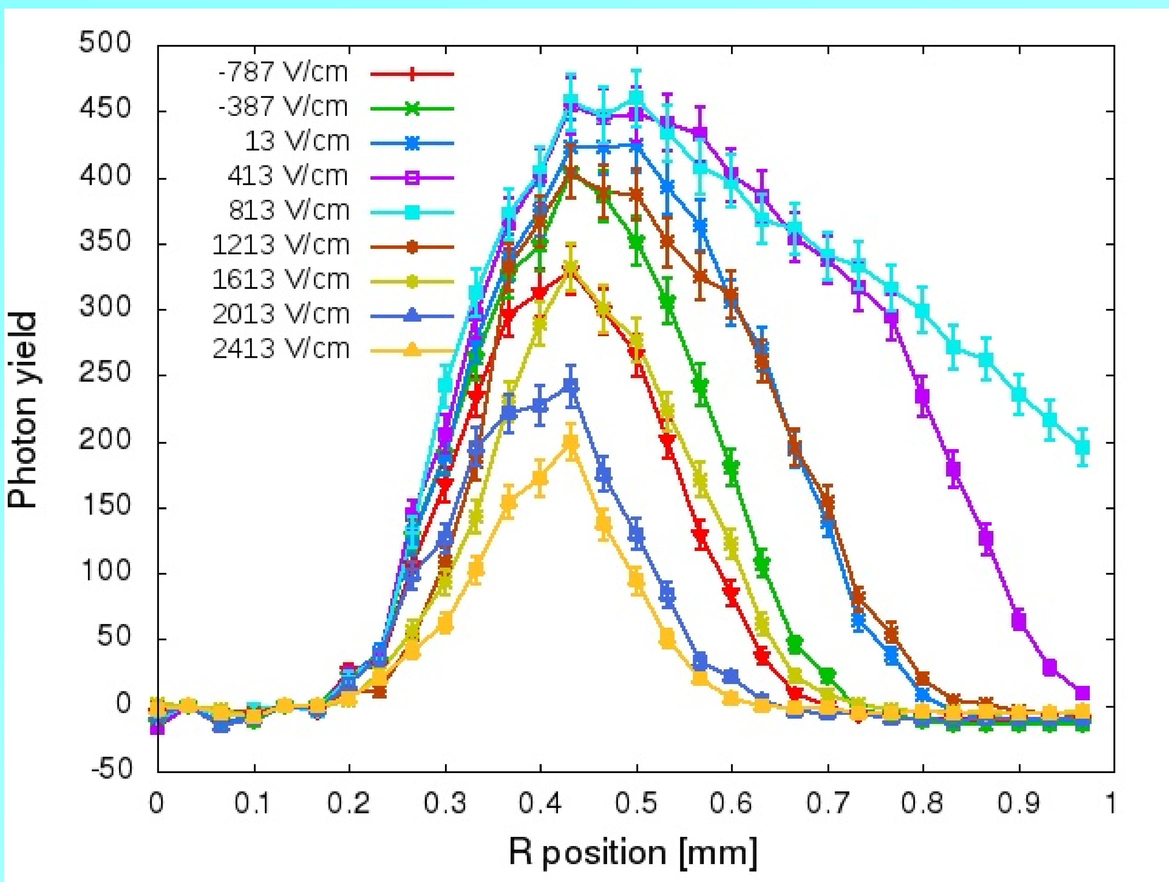

Fig. 3. Photon yield around a hole calculated from a map (hole distance of 1.5 mm)

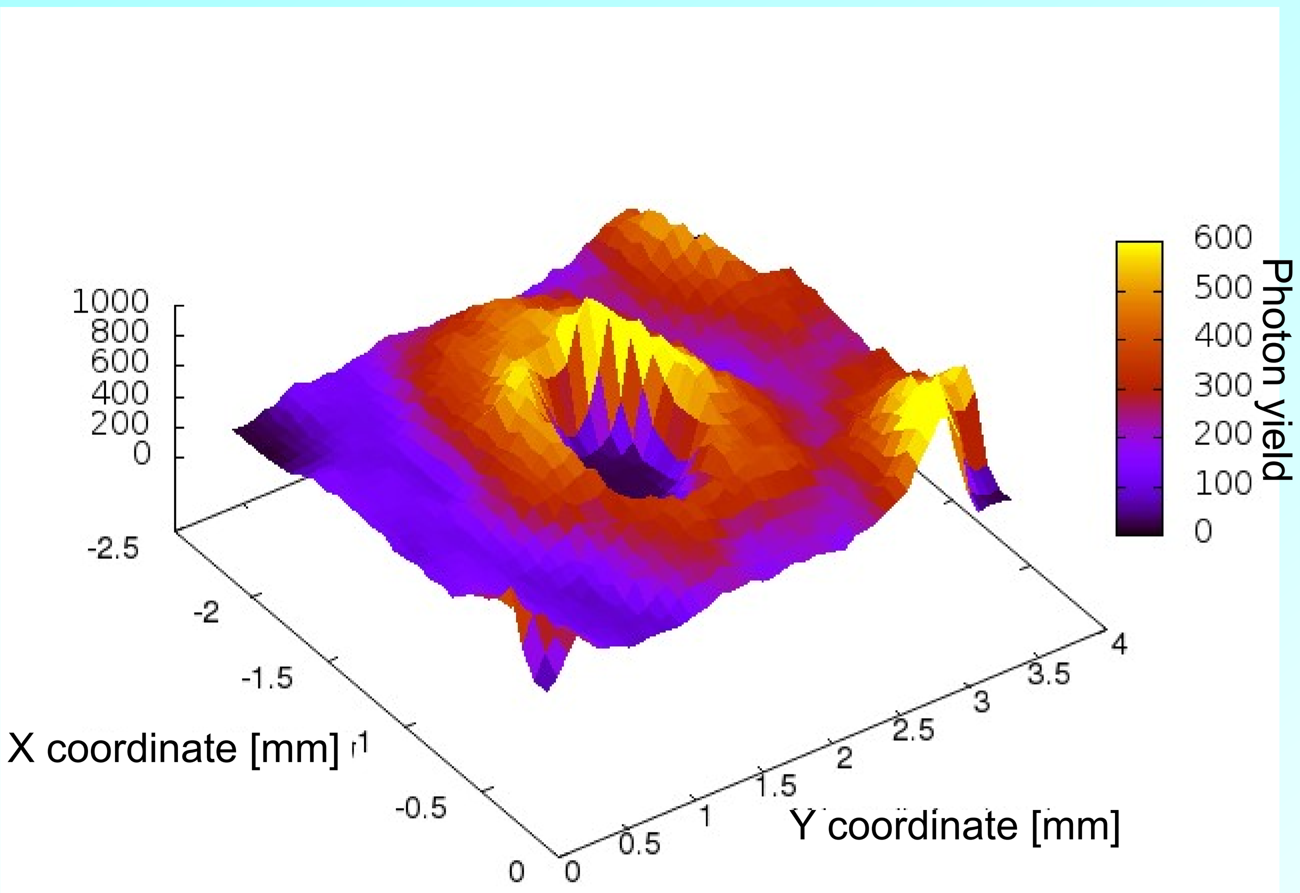

Fig. 7 Photon yield around a hole

2. Thick-GEM

Gaseous detectors are one of the main detectors types used for detection of charged particles. So far mostly Multi-Wire Proportional Chambers (MWPCs) were used for Cherenkov photon detection. Although the novel micropattern gaseous detectors have several advantages to MWPCs. (E.g. faster, direct signal and being more robust.) A member of the family of micropattern gaseous detectors is THGEM (THick Gas Electron Multiplier) is a typically few hundred micrometer thick Printed Circuit Board, which has several drilled holes. If high voltage is applied between the sides of the PCB, a strong electrical field appears. Multiplication occurs, when an electron enters a hole, accelerates and ionizes the molecules of the filling gas. This leads to an avalanche of electrons. The UV photons of the Cherenkov radiation can be detected if the top side of the PCB is coated with photoactive matter, which converts the photons to photoelectrons. The effiency of the THGEMs also depend on the applied electric field (called drift field) over the detector as it guides the photoelectrons towards the holes. So far in particle experiments no drift field was applied for THGEMs.

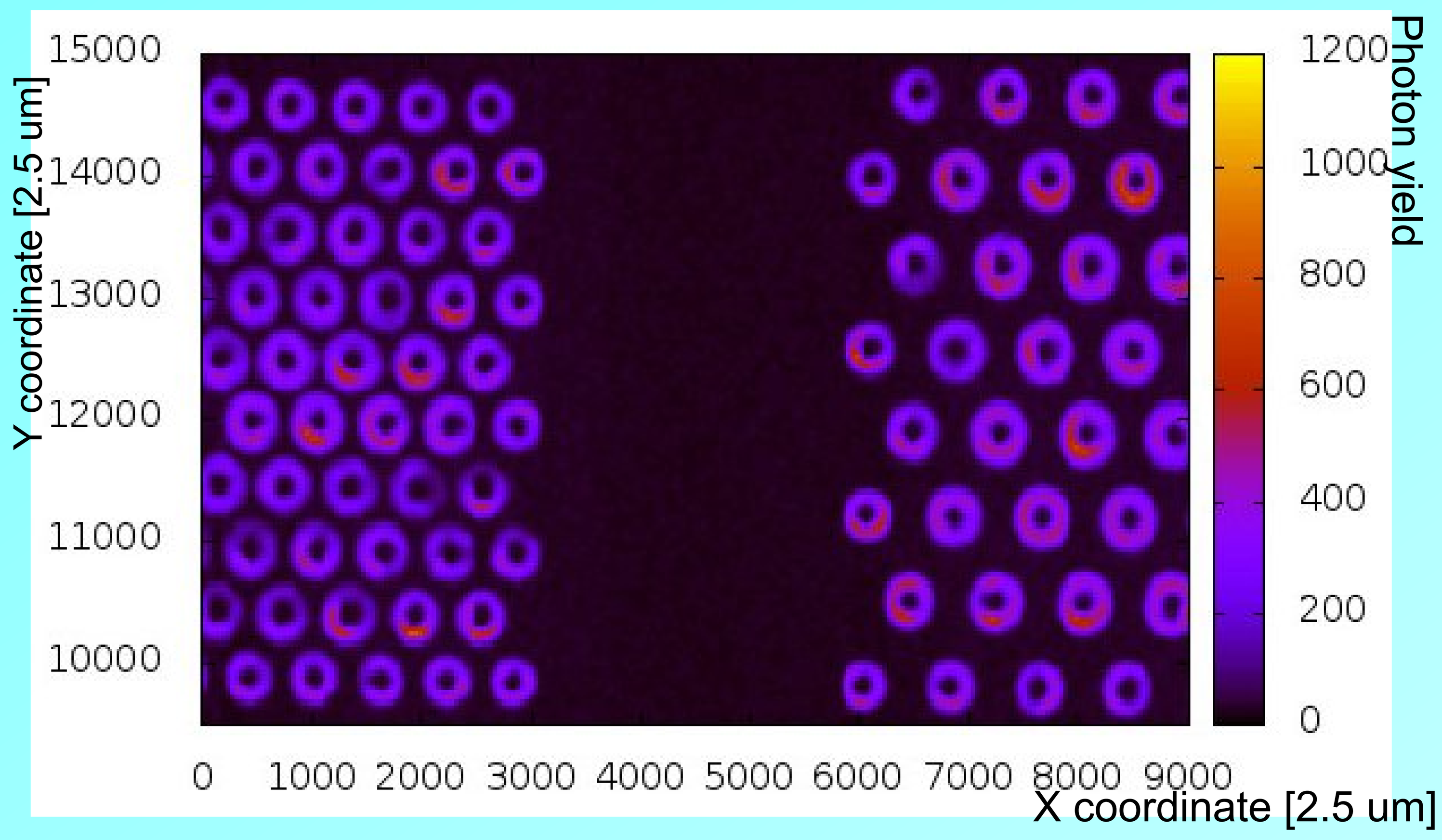

Fig. 2. Photon yield map including two different segments

5. Measurements

In order to understand how the efficiency of the THGEM depends on the drift field and hole distance I made several types of photon yield measurements. First the whole examined segments were illuminated by the UV LED to measure the dependence of the photon yield on the value of the drift field (as shown on fig. 5.). Secondly I made "1 dimensional" scans, when I measured the photon yield in spots along a line segment. Using the gathered data, the overal photon yield of single holes were estimated. Afterwards I produced "2 dimensional" maps (e.g. fig. 2. and fig. 7.), which were analyzed by a self-written clustering program.

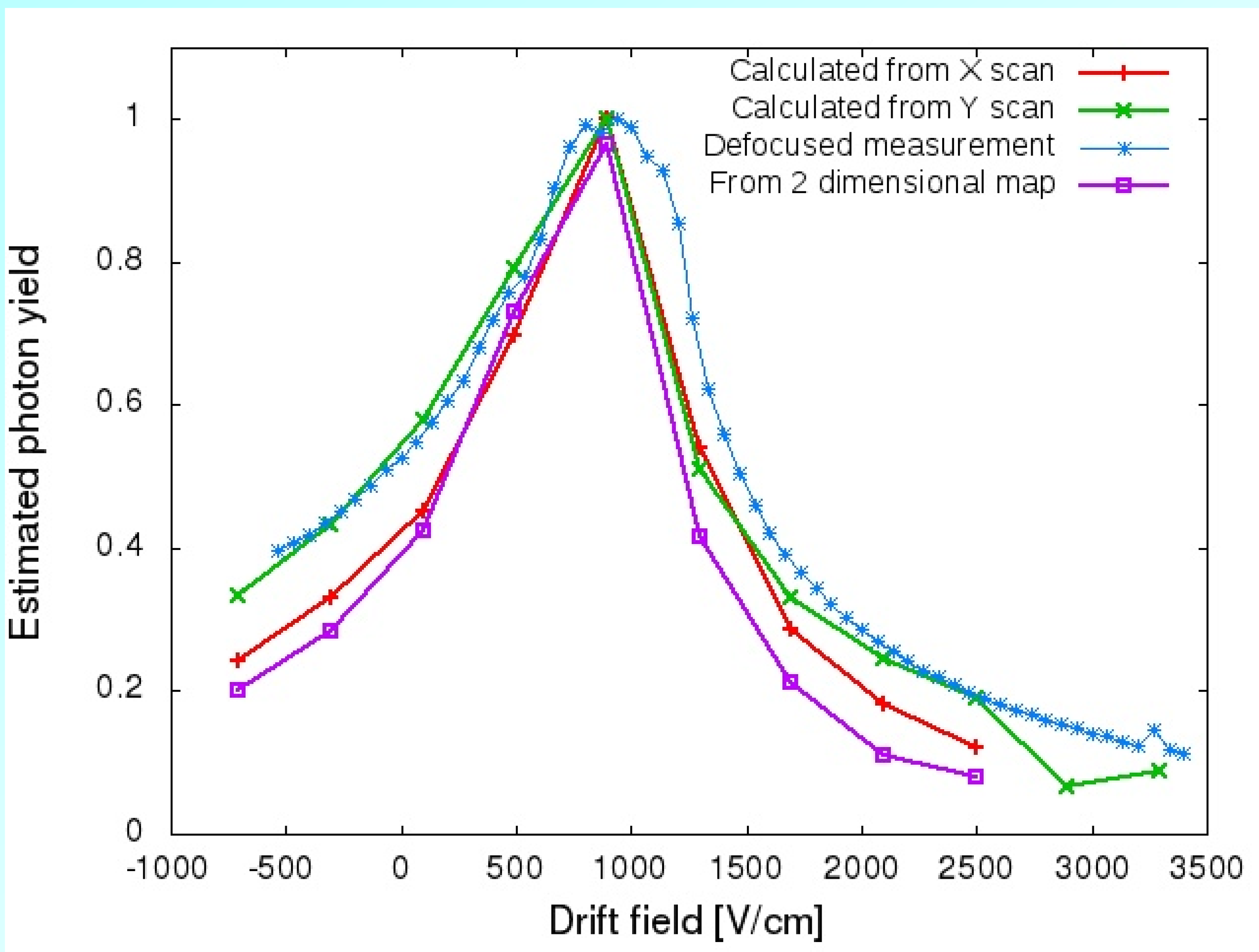

Fig. 6. Photon yield dependence on the applied drift field, the results of different estimations lead to the same result

3. Aim of my research

The aim of my research is to optimize the parameters of the THGEMs used for photon detection. The parameter space has too many dimensions. The effiency depends on the size of the holes, the rims, the hole distance, filling gas, PCB thickness, all the applied voltages, etc. Even advanced simulation cannot descibe the experimental data well enough, thus microscale measurements are needed to deepen out knowledge and finetune the simulations. The experimental setup was built to be able to scan the surface of a THGEM plate with single UV photons to obtain a sensitivity (photon yield) map.

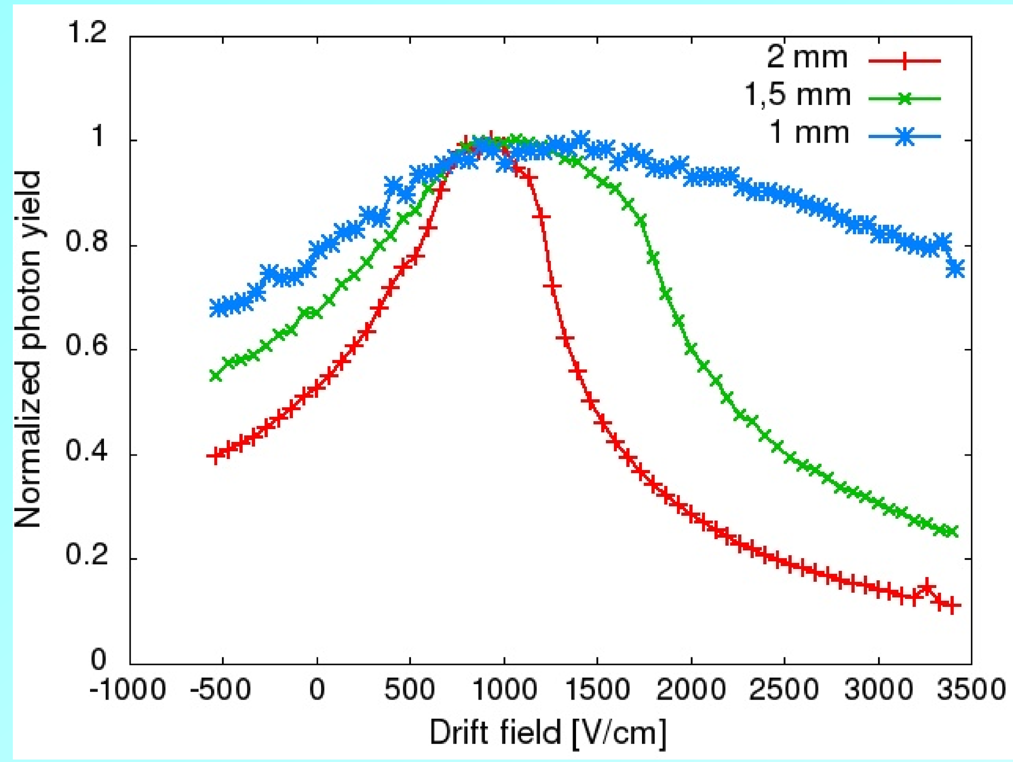

Fig. 5. Photon yield of full segments when the light of the LED was not focused

6. Results

It has been measured, that the efficiency of the THGEM-s can be almost tripled by applying an optimal drift field. In the case of the three geometries investigated, namely a hole distance of 1 mm, 1.5 mm and 2 mm, the optimal drift field was around 800 V/cm.

Also I proved that the micro and macro measurements show a very strong correlation, therefore not only the microprocesses can be understood with these measurements but investigating a little area is enough to determine the behavior of the whole THGEM plate.

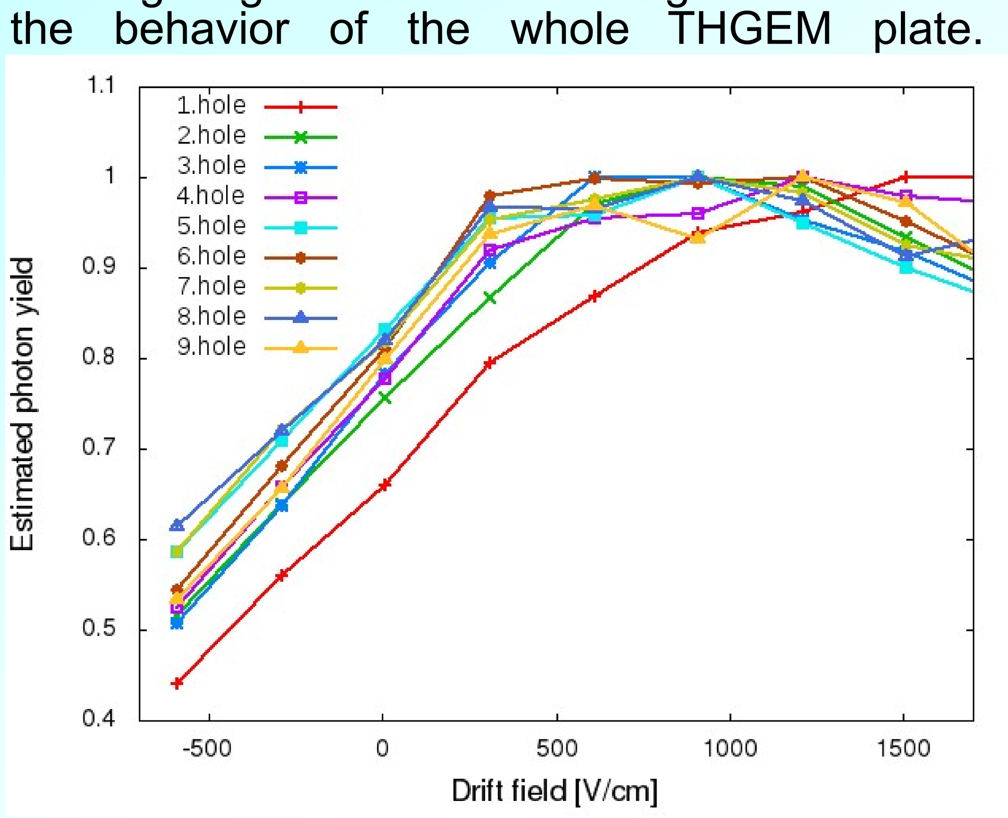

Fig. 4. Estimated photon yield of several holes depending on the drift field

7. Acknowledgement

I would like to express my sincere gratitude to Gergő Hamar and Dezső Varga, my supervisors and I would also like to extend my appreciation for the fruitful discussions with Gábor Kiss, László Oláh and Kornél Kapás. This work has been funded by the LP2013-60 Momentum grant of the HAS.

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