Development of Micropattern Gaseous Detectors

Investigation of TGEMs as Cherenkov detectors

Gábor Galgóczi

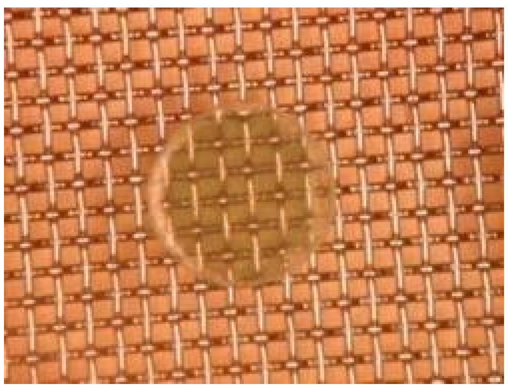
On behalf of the REGARD group of Wigner RCP

Outline

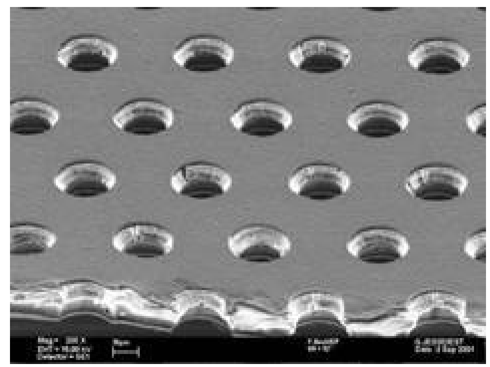
- MPGDs → TGEM (Thick Gas Electron Multiplier)
- Experimental setup
  - Local avalanche size and photoelectron yield
- Measurements:
  - The effect of drift field on the local yield and gain
  - Effects of faults
- AIDA-2020 project
- Summary

MPGDs

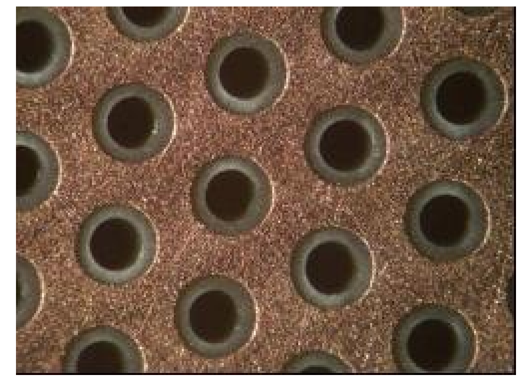
- MicroPattern Gaseous Detectors



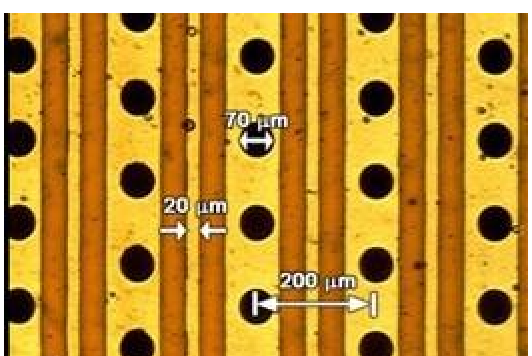
MicroMegas



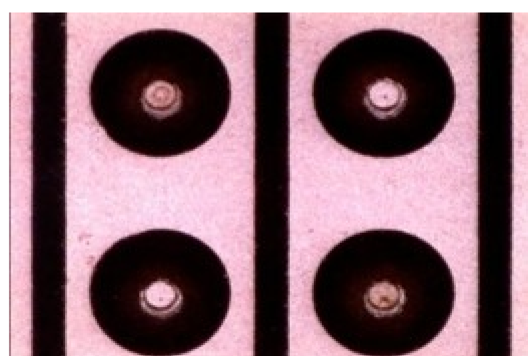
GEM



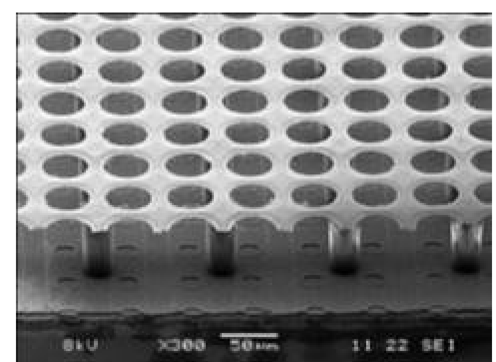
TGEM



MHSP



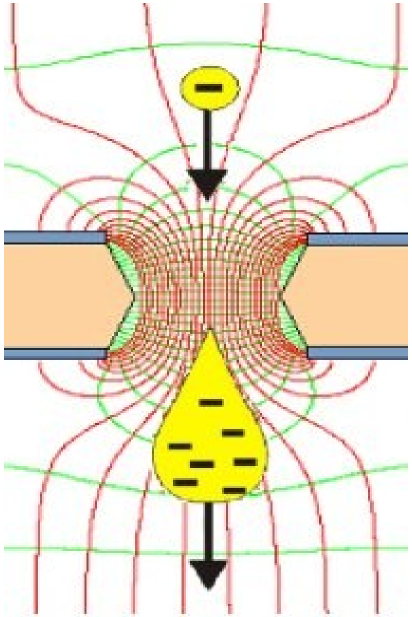
microPIC

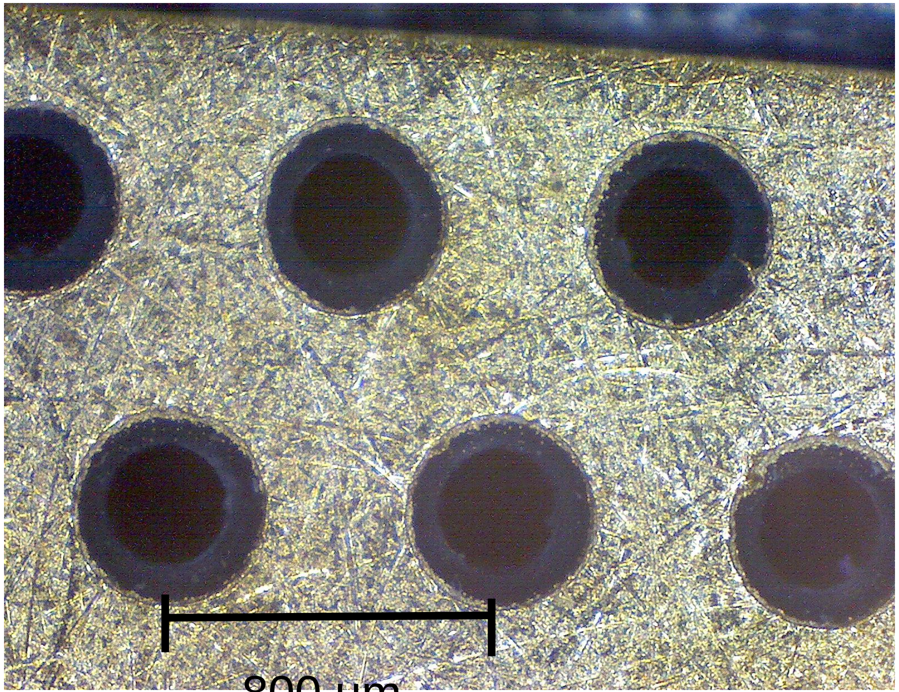


Ingrid

TGEM

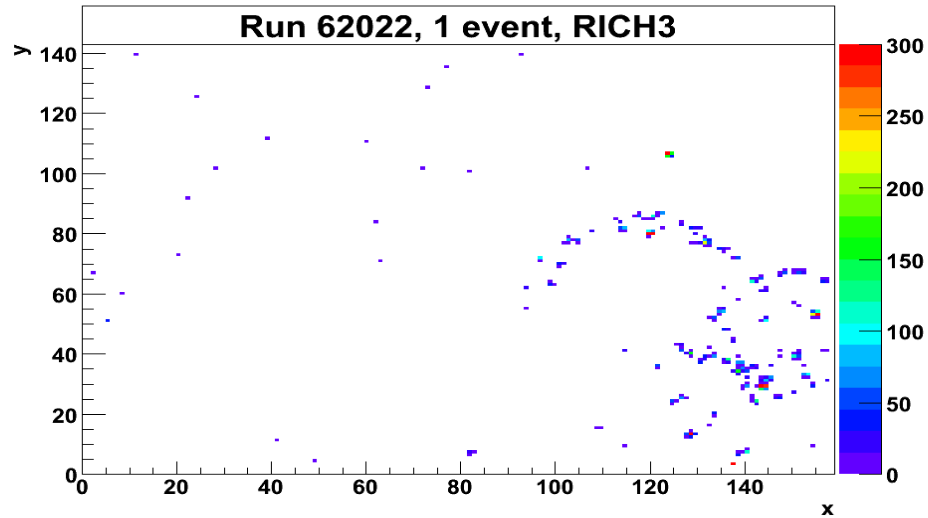
- Thick Gas Electron Multiplier
- Invented in the 2000s
- Hole size: 300-500 µm
- Large electric field
- Electron avalanche
  (typical 10-100 e^-)





TGEMs as photon detectors

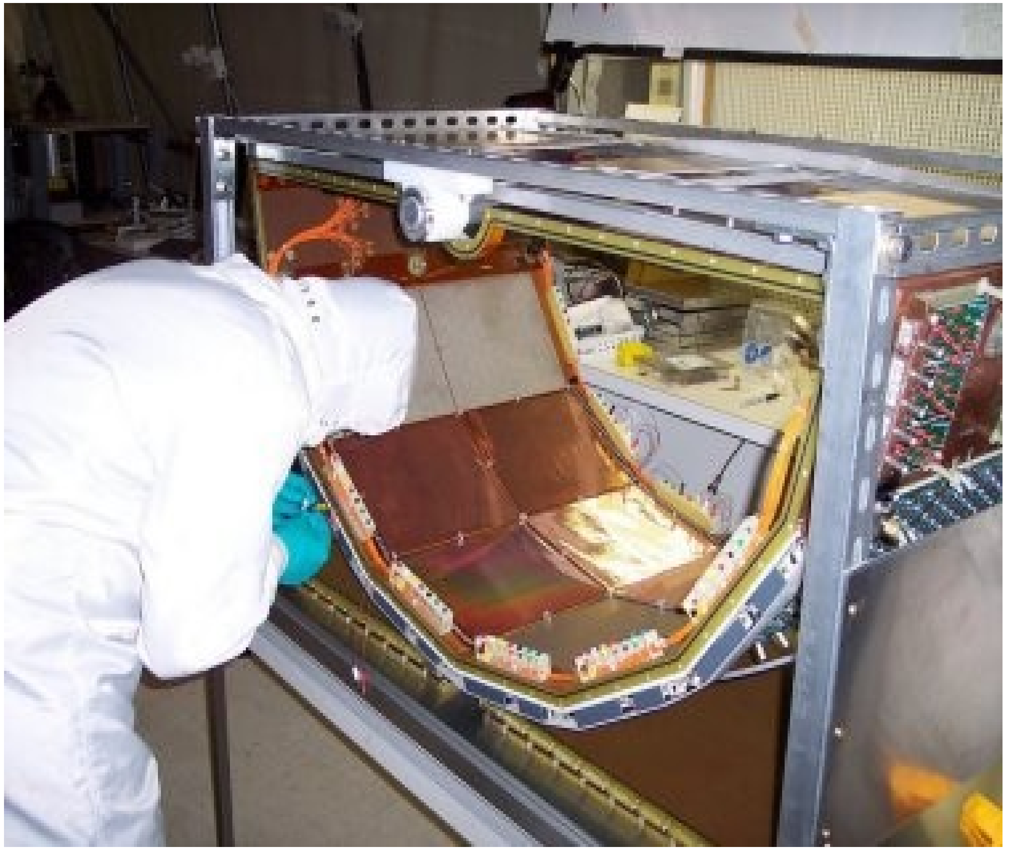
- So far MWPCs (Multi-Wire Proportional Chamber) have been used for Cherenkov photon detection
- TGEMs have many advantages[1]:
  - Direct, faster signal
  - Little secondary signal
  - MIP supression
  - Reduced ion backflow



[1]V. Peskov, M. Cortesi et al., Further evaluation of a THGEM UV-photon detector for RICH – comparison with MWPC, Journal of Instrumentation, vol. 5 page 11004-11029, 2010

TGEMs in experiments as Cherenkov detectors

- So far (GEM):
  - HBD at PHENIX (RHIC)
- Plans (TGEM):
  - VHMPID at ALICE (LHC)
  - RICH-1-Upgrade at COMPASS (SPS)

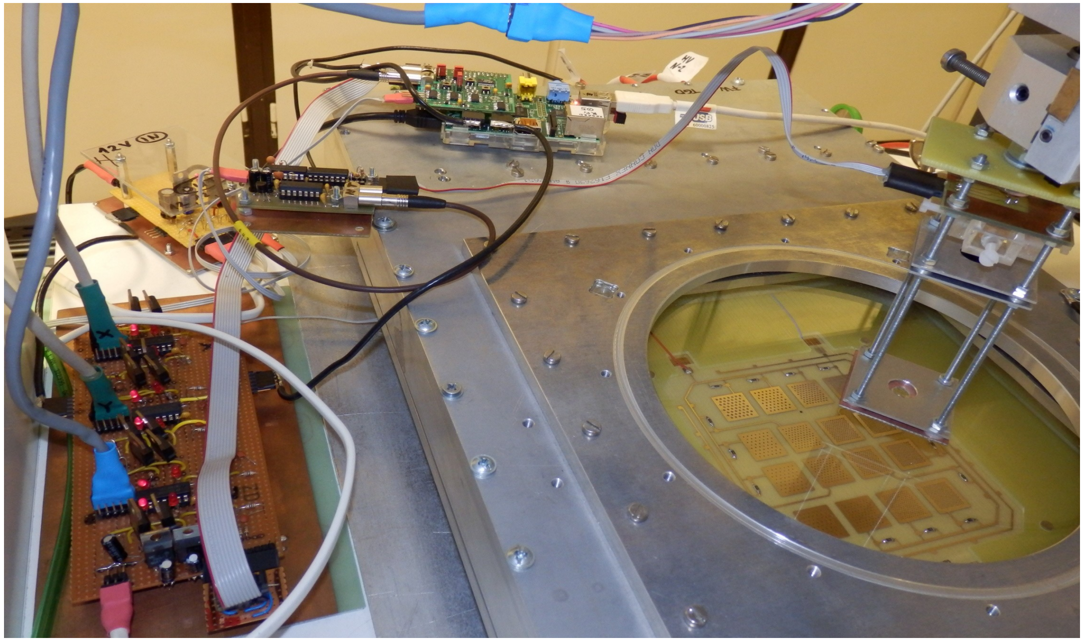


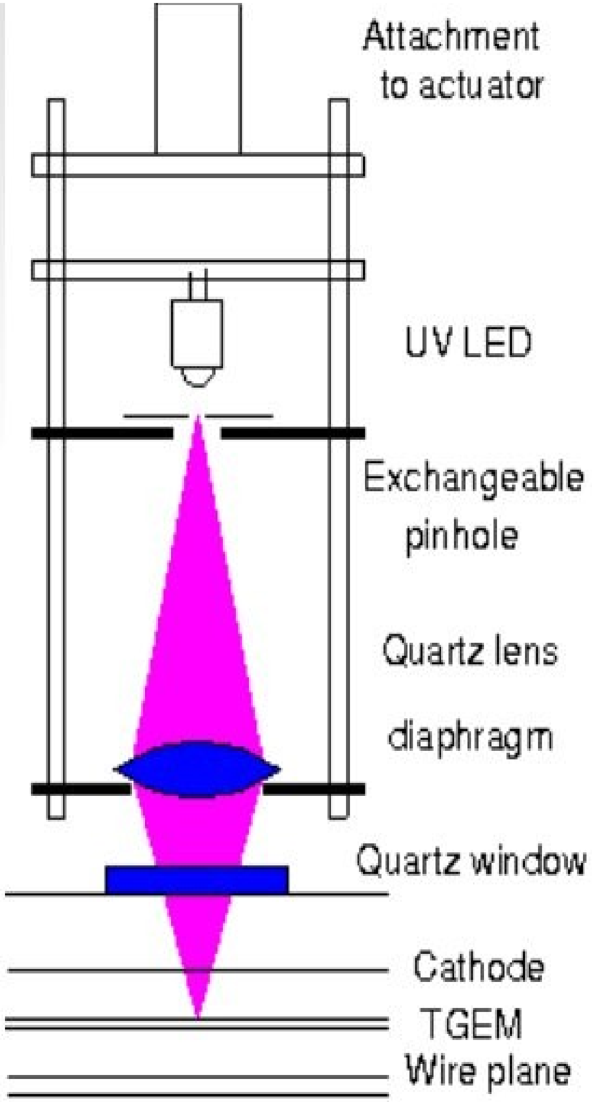
Hadron Blind Detector, PHENIX

Aims

- Precise description of microprocesses of single photo-electron detection in MPGDs
- **Optimization of geometrical parameters of TGEMs for Cherenkov applications (hole diameter, pitch, rim, thickness, lattice shape)**
- **Optimization of electric field configurations (amplification, drift, extraction)**
- Microscale measurements for finetuning the simulation codes
- Identify effect of production faults (over etching, drilling faults, etc.)

Experimental setup

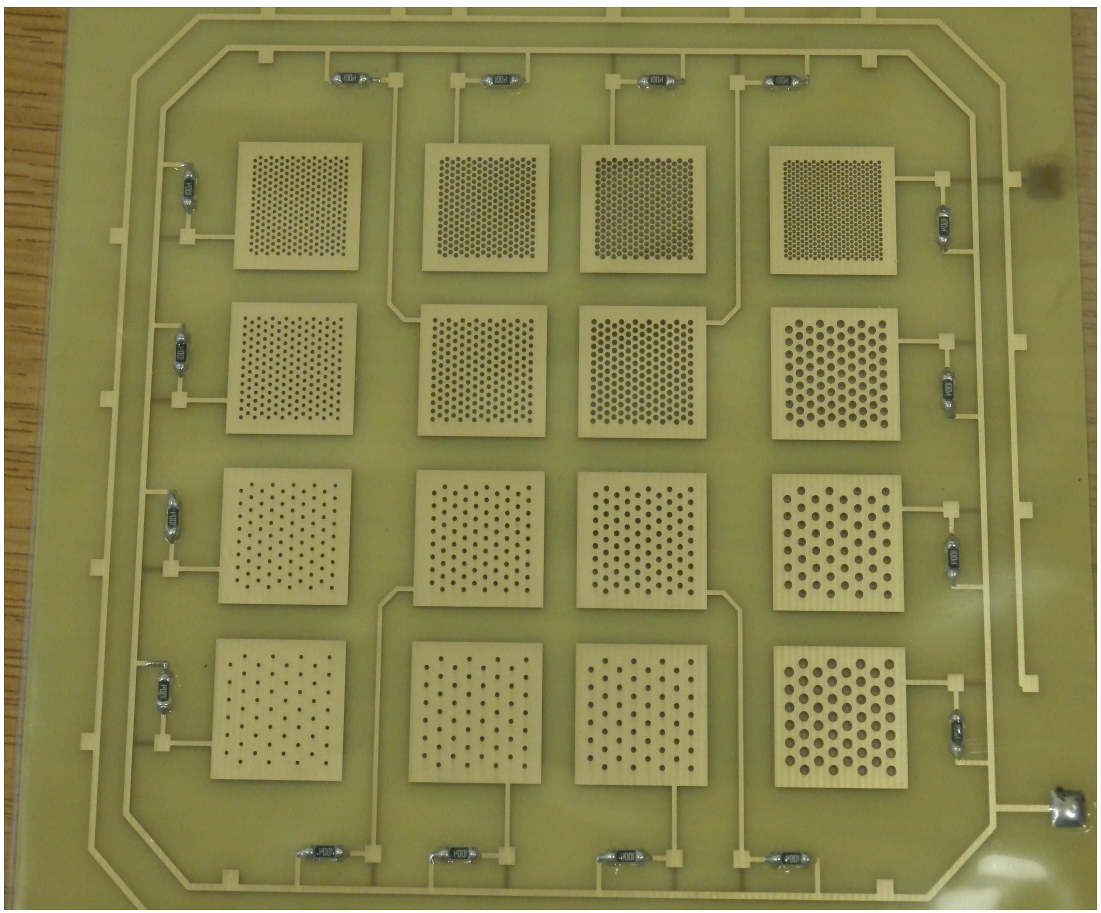


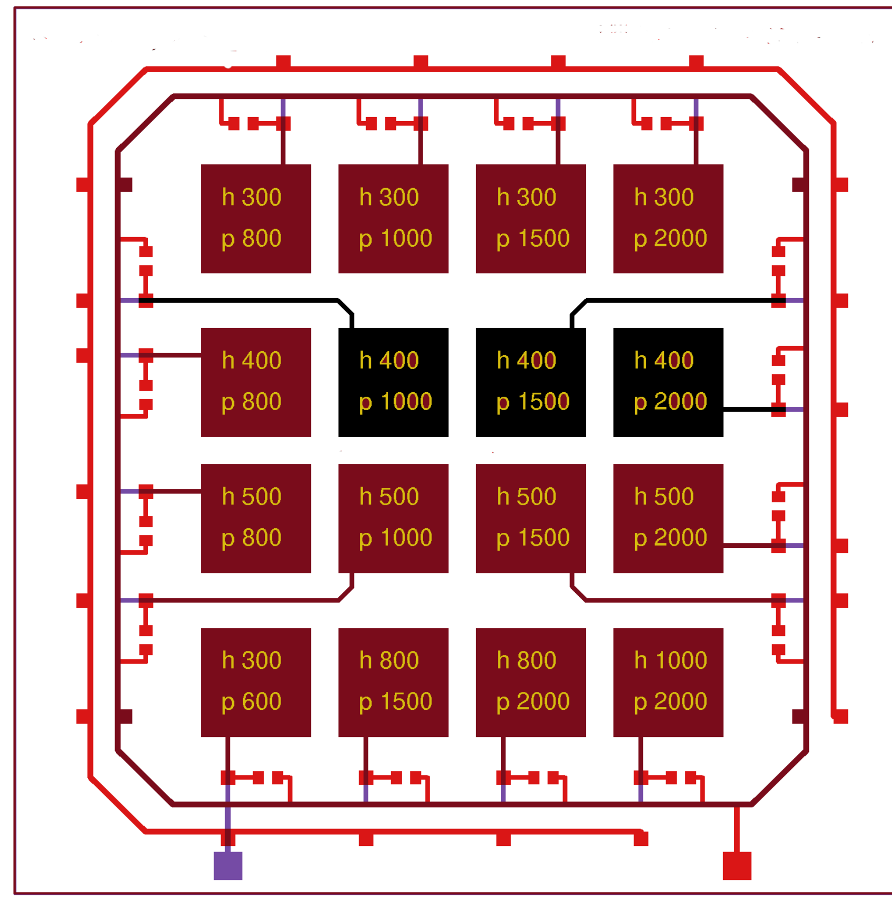


- New method for single photoelectron measurement[2]
- REGARD & RD51 collaboration
- Pulsed LED driven with 100 kHz
- 50 μm resolution

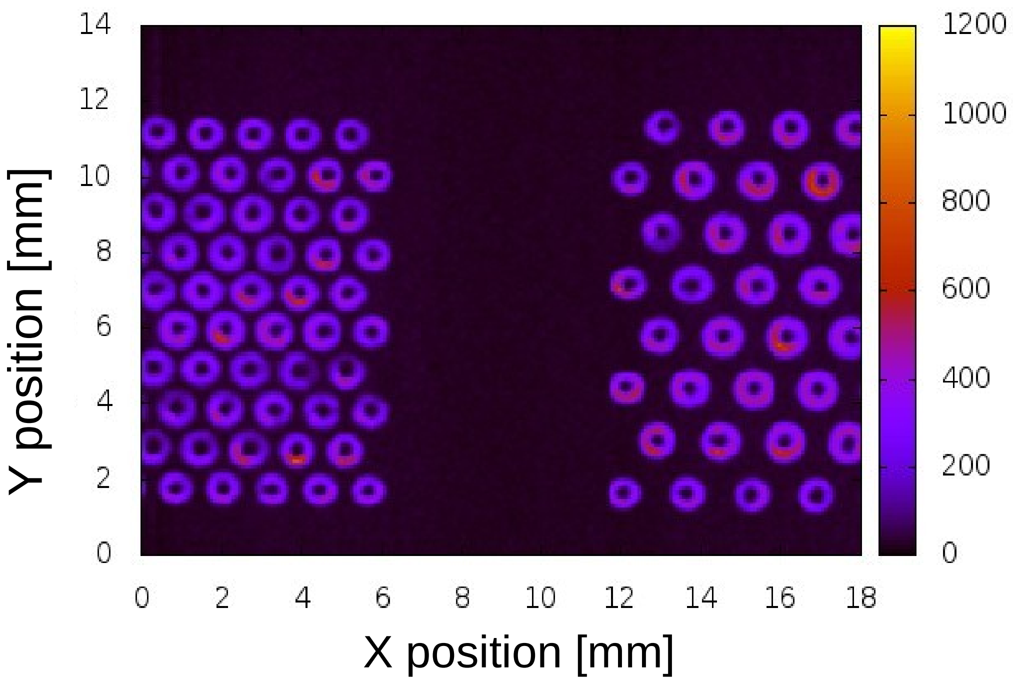
[2]High resolution surface scanning of Thick-GEM for single photo-electron detection, G. Hamar, D. Varga, NIM A 694, p 16-23, 2012

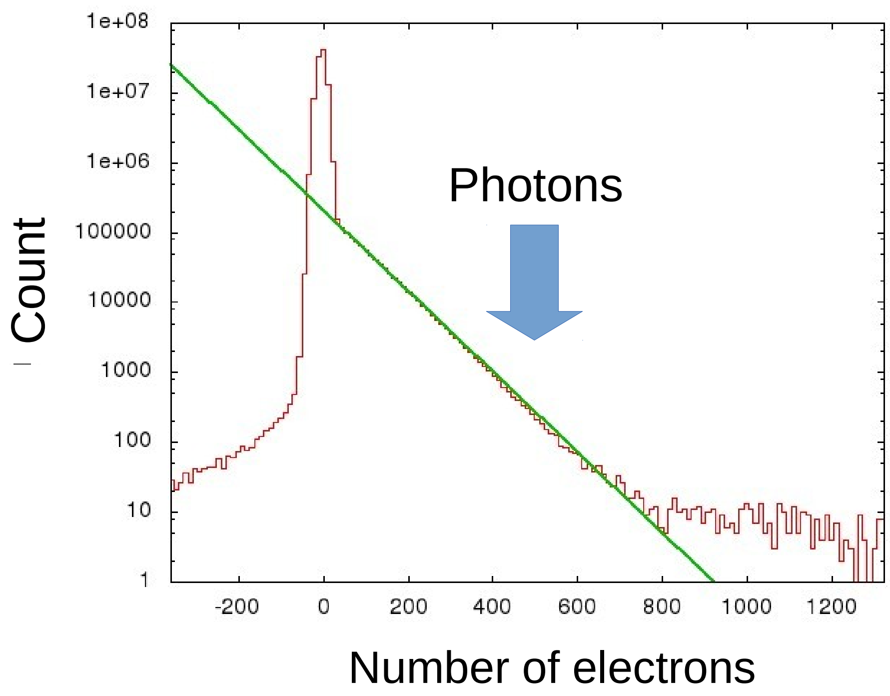
Experimental setup





Photoelectron yield maps

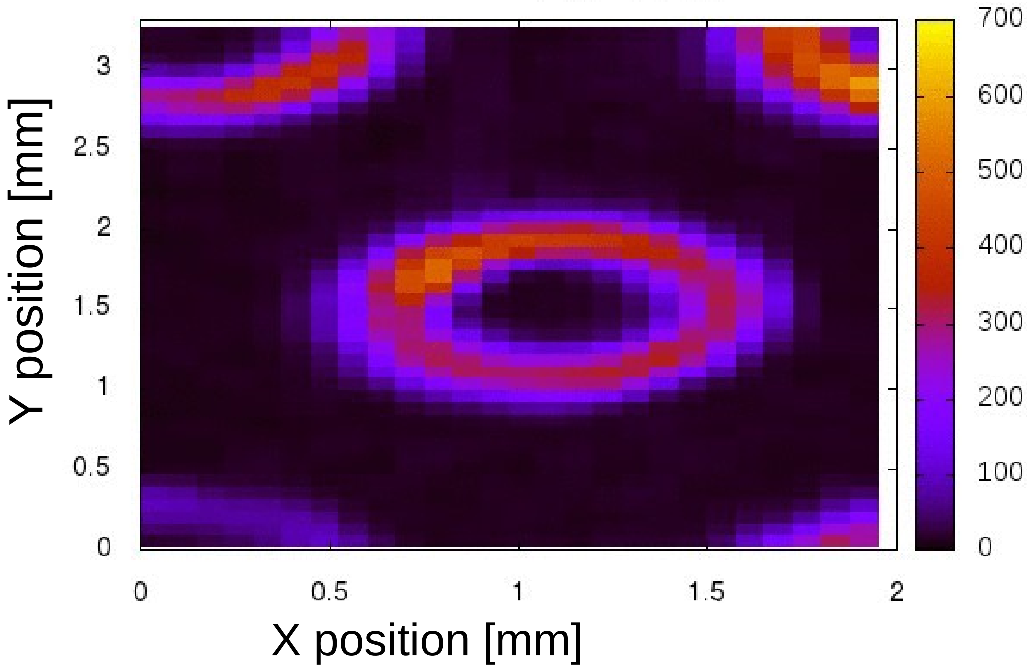




Different drift fields

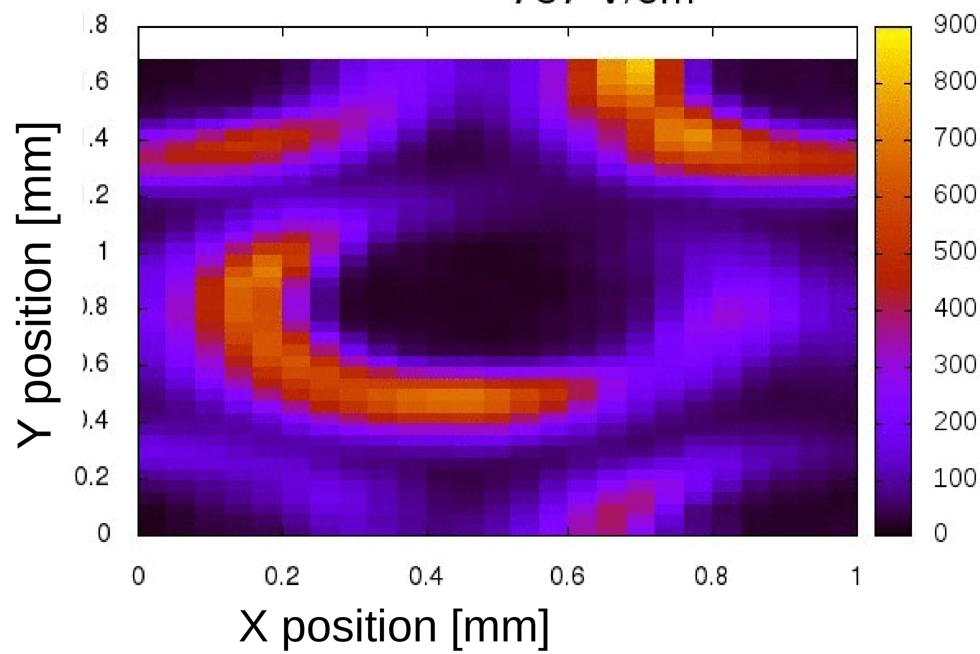
Hole distance of 2 mm

-787 V/cm



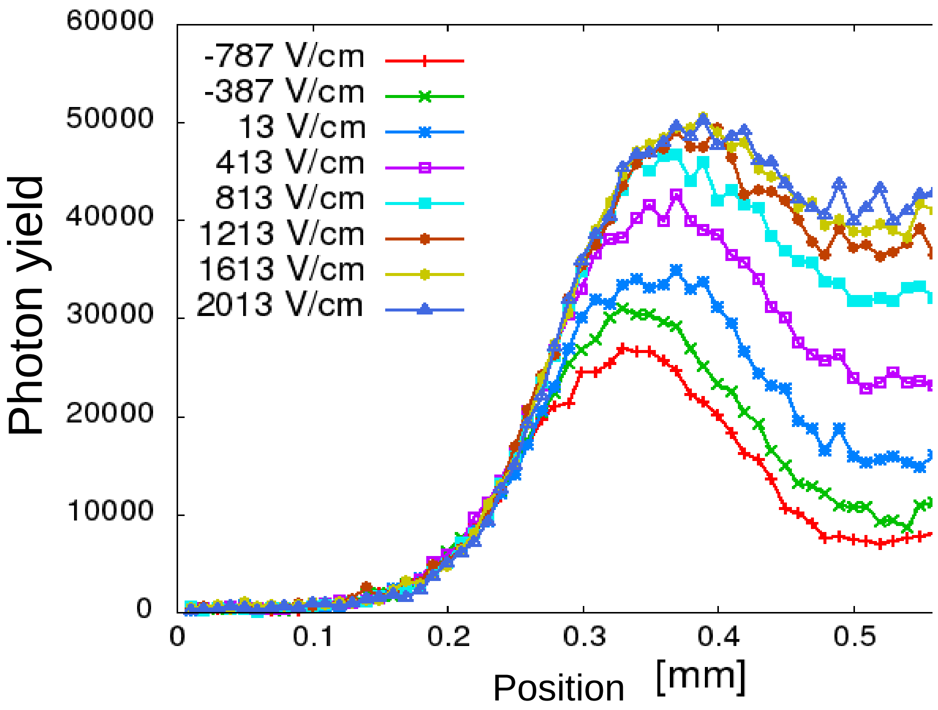
Hole distance of 1 mm

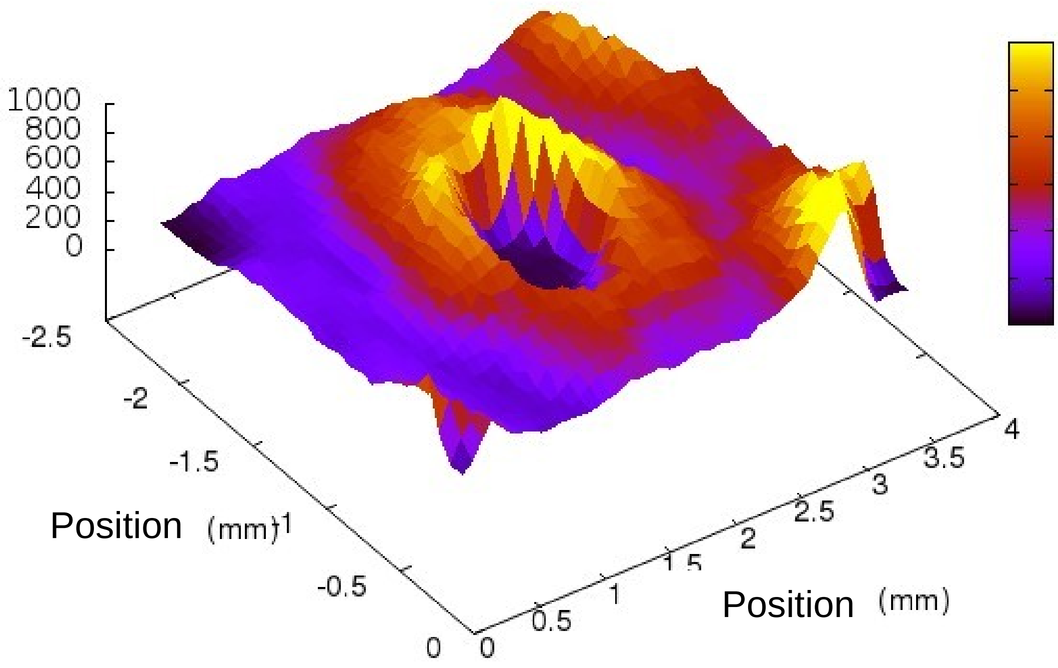
-787 V/cm



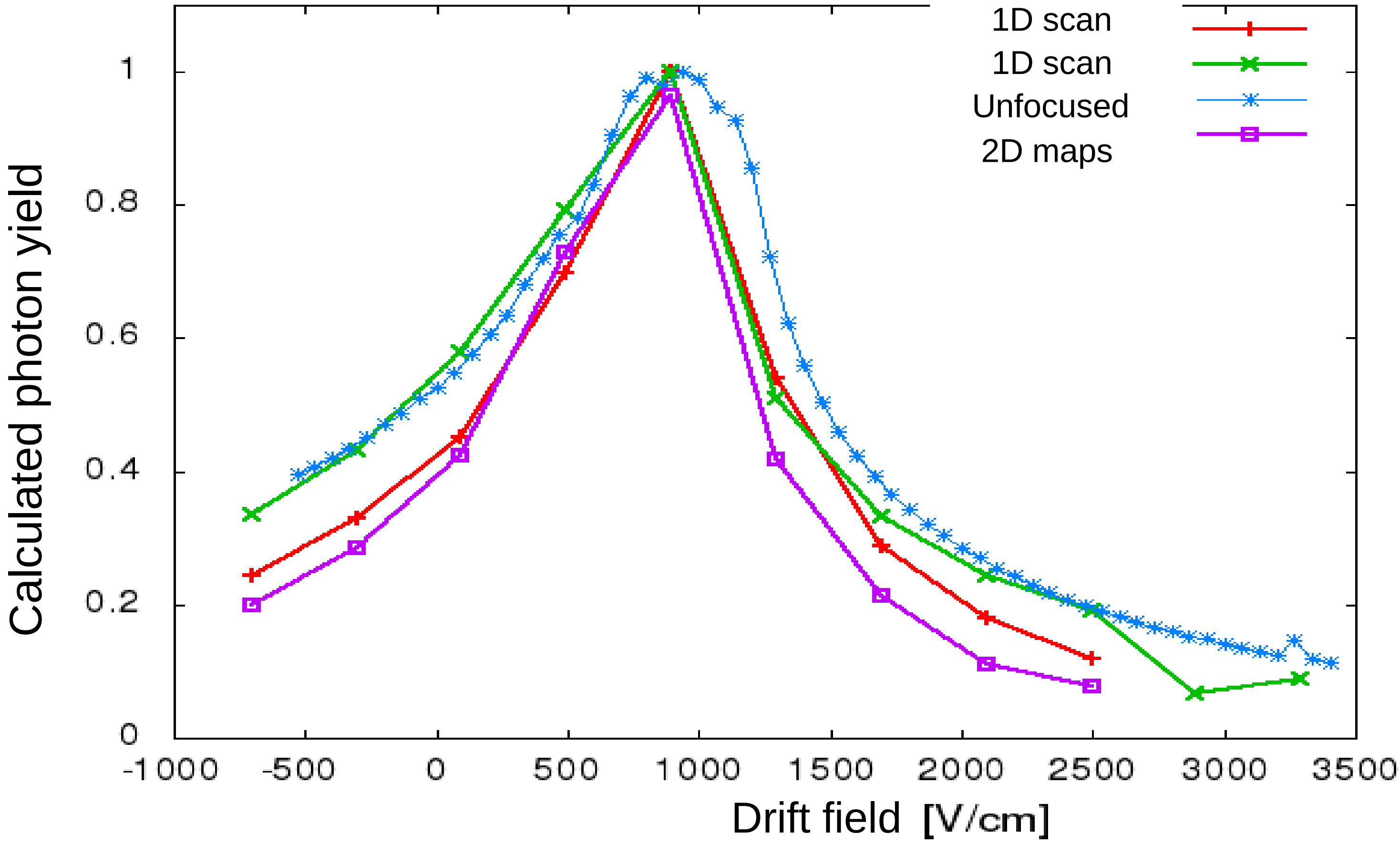
- Field of TGEM holes ↔ Drift field
- Integrated photon yield of each hole

Photon yield





Correlation of different methods

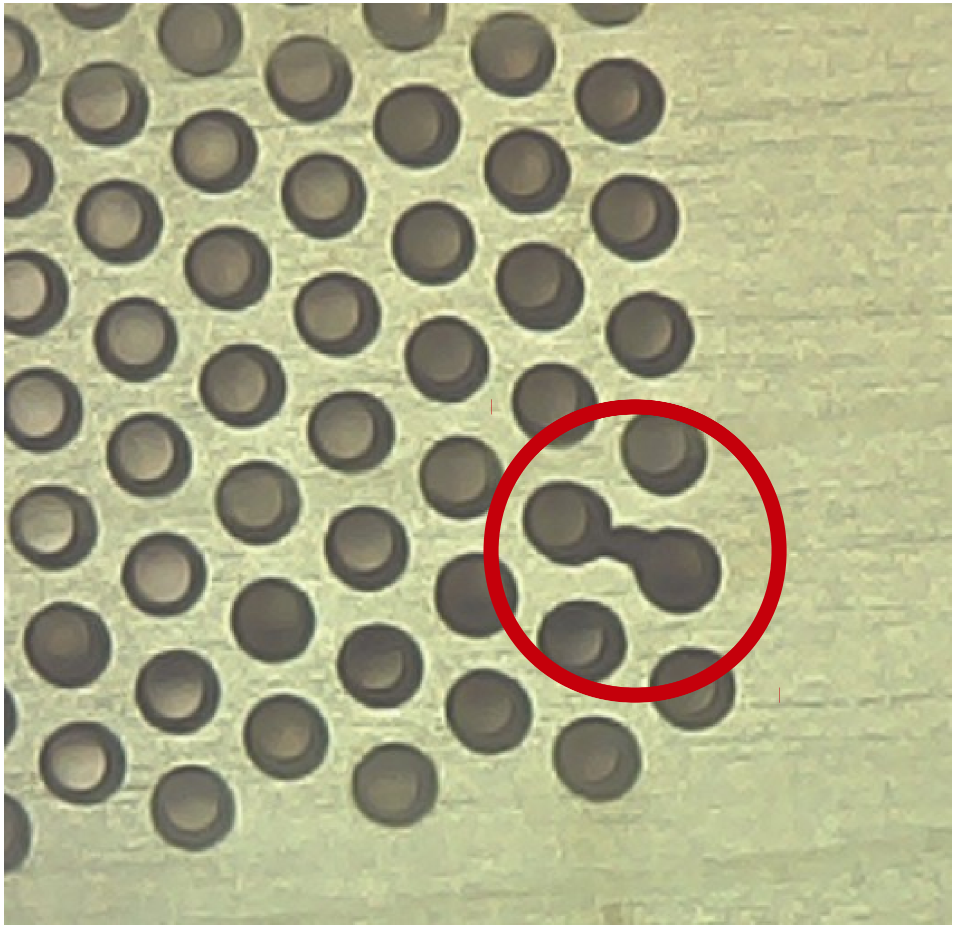


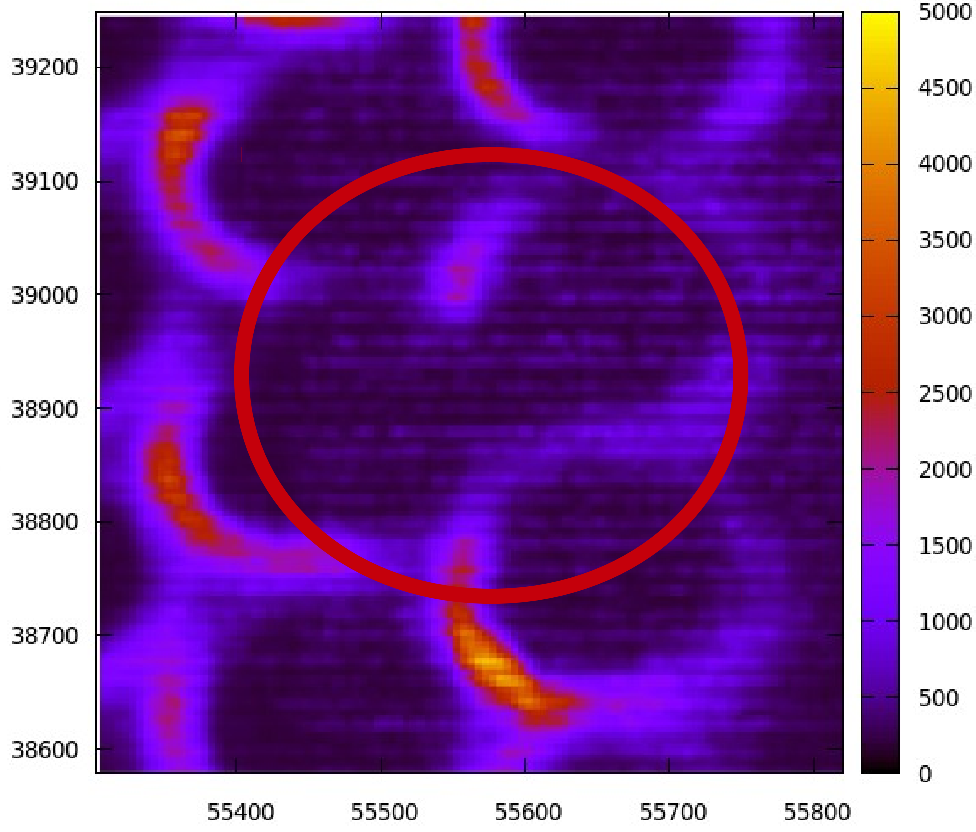
- Different methods → Correlate
- Optimal drift field

Effects of faults

- Typical GEM: 1000? holes
- Leopard was upgraded with a microscope
- Faults spotted by microscope
- Examined by Leopard
- Which kind of faults would lead to malfunction?

Effects of faults





Yield map

Outlook: AIDA-2020 project

- Advanced European Infrastructures for Detectors at Accelerators
- Joint Research Activities:
  - “R&D with emphasis on detector qualification, on quality insurance and on infrastructures leading towards large scale production”
- Quality control tool for detailed (hole by hole) gain maps in (T)GEM-s
- AIDA-2020 Sub-task 13.4.4 (WP13)

Summary

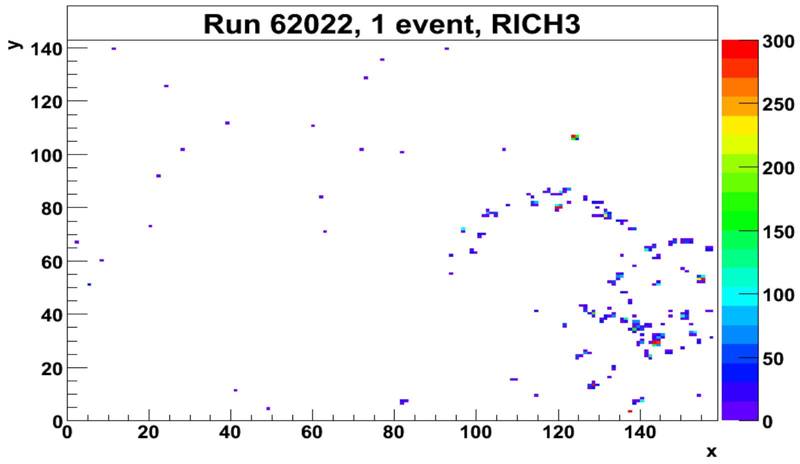
- TGEM technology
- Remotely controllable system to study (T)GEMs
- High resolution gain and photoelectron scanning
- Drift field
- AIDA-2020
- R&D:
  - Optimazition
  - Quality assurance

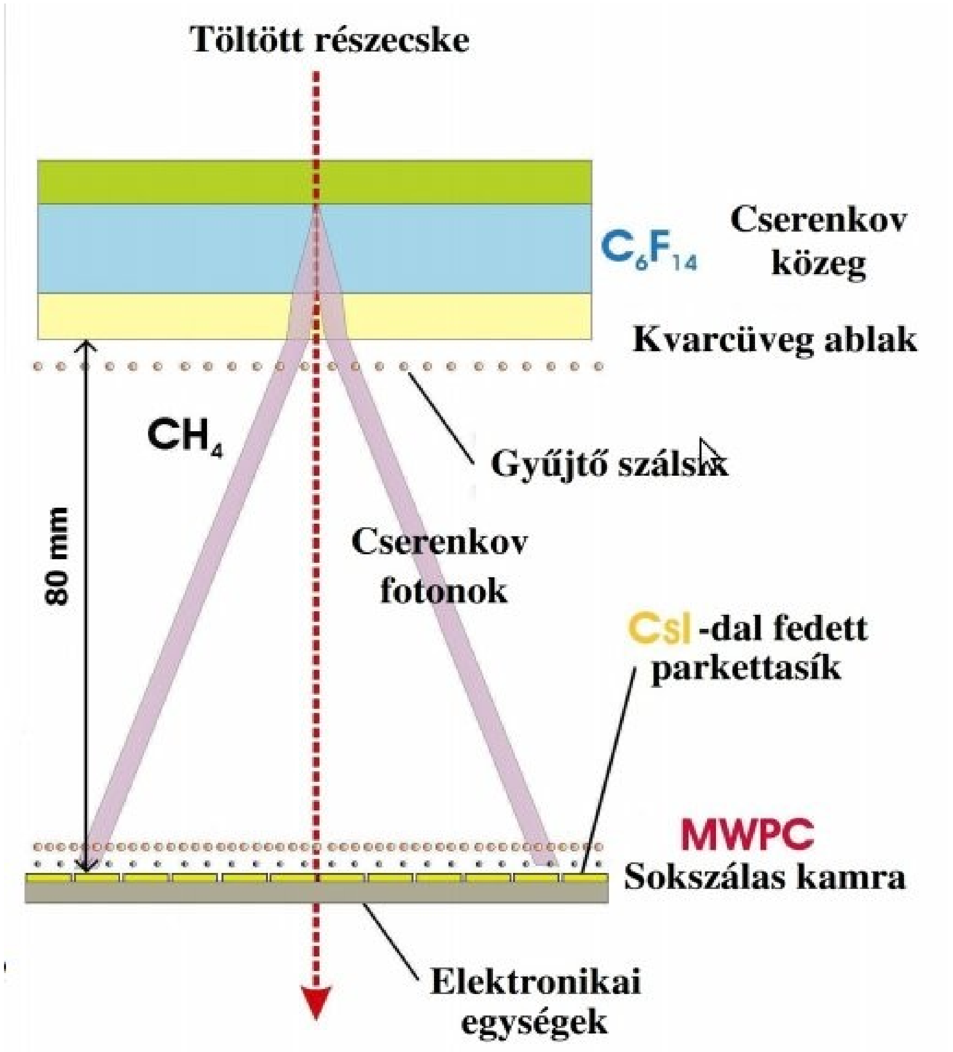
Thank you for your attention!

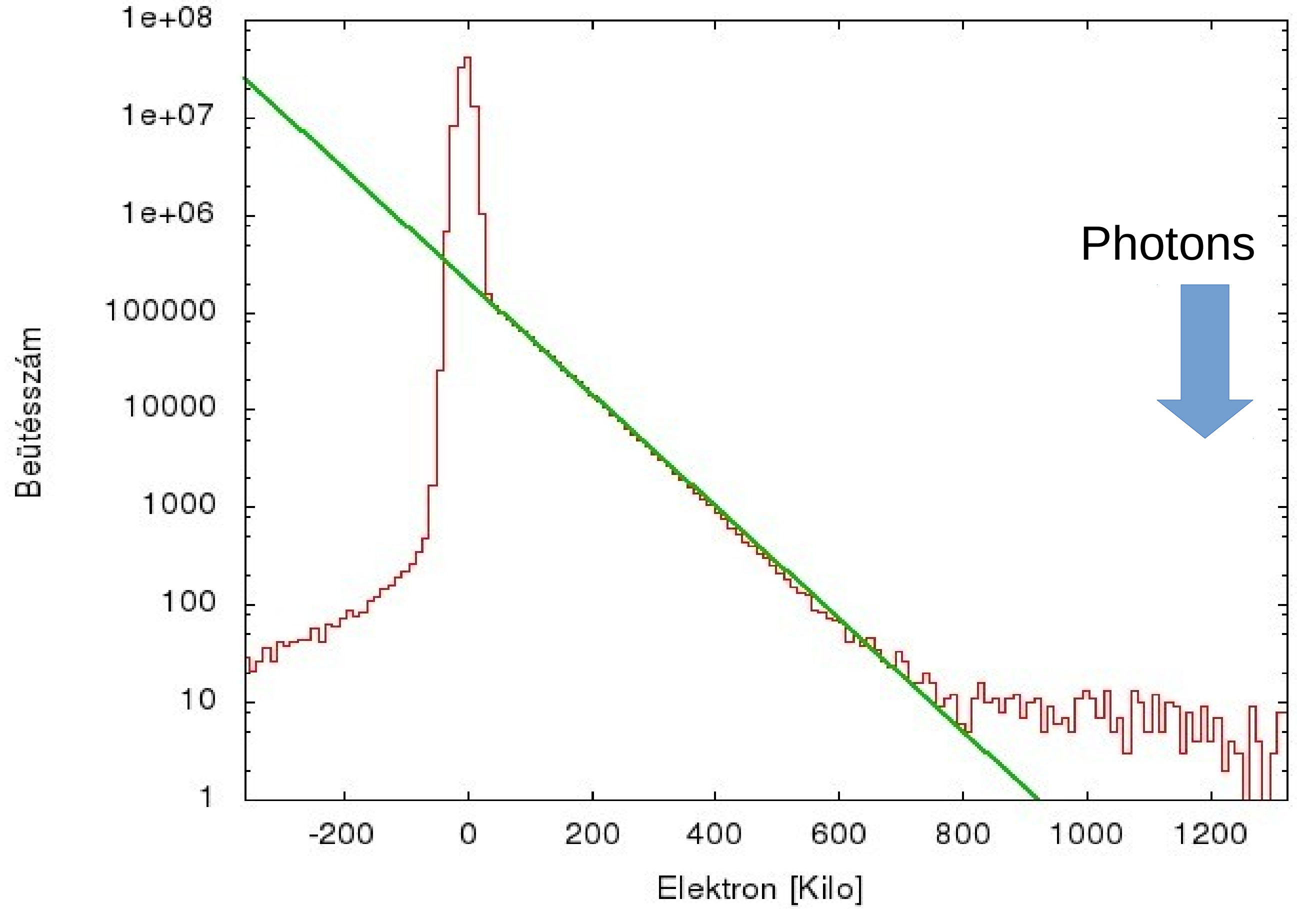
Backup slides

PID

$$\cos\varphi = \frac{c}{nv} = \frac{c'}{v}$$



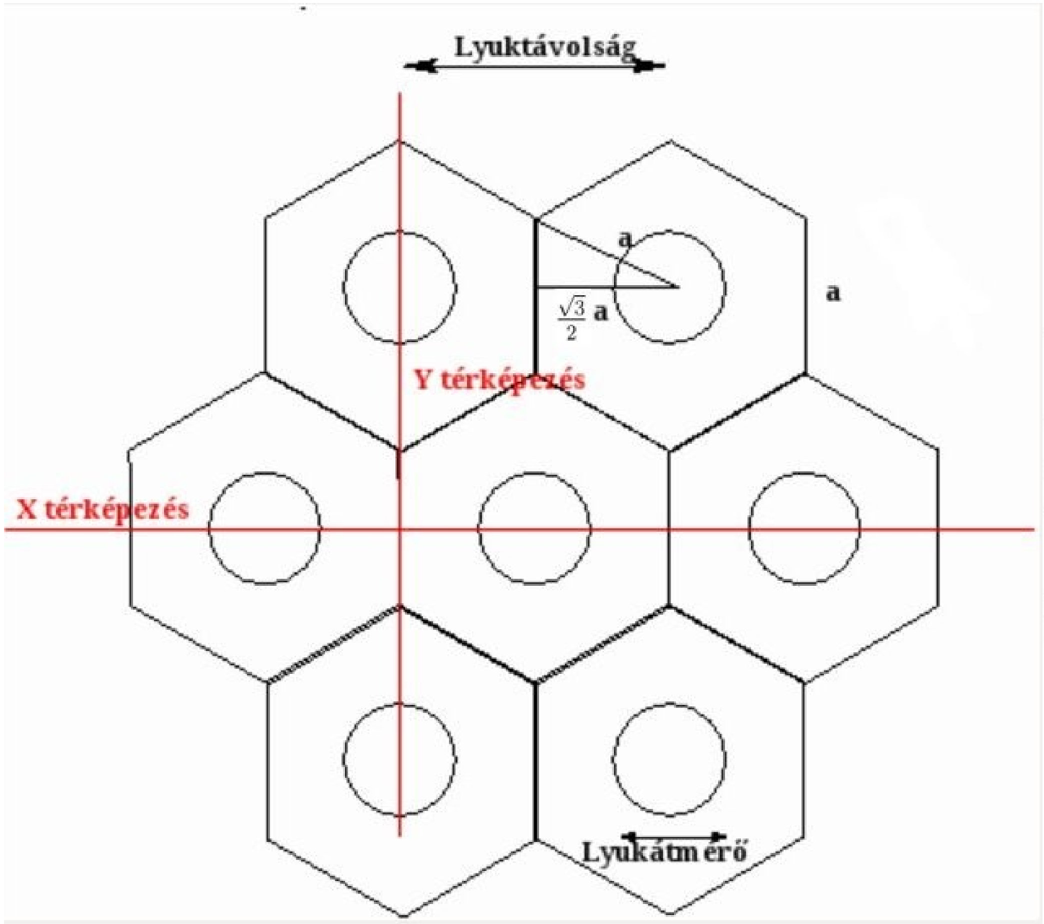



1e+08
1e+07
1e+06
100000
10000
1000
100
10
1
-200
0
200
400
600
800
1000
1200
Beütésszám
Elektron [Kilo]
Photons

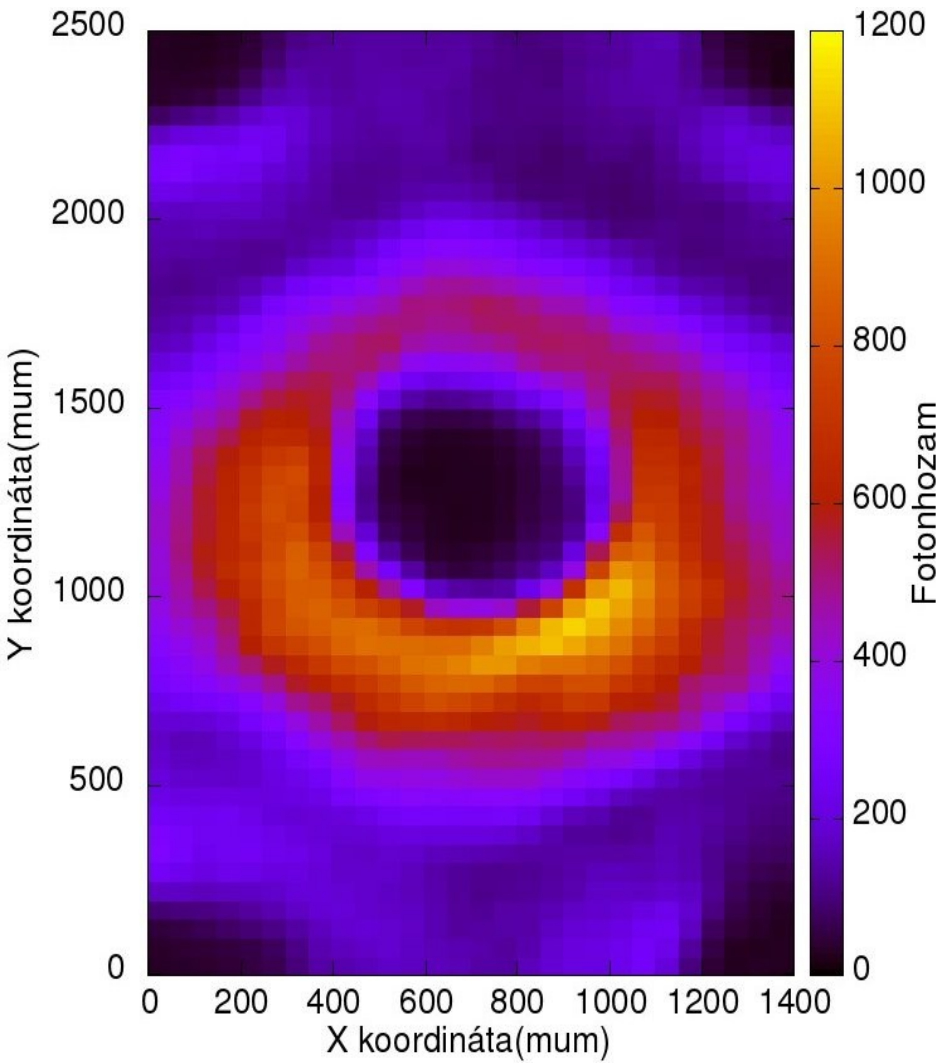
100 million

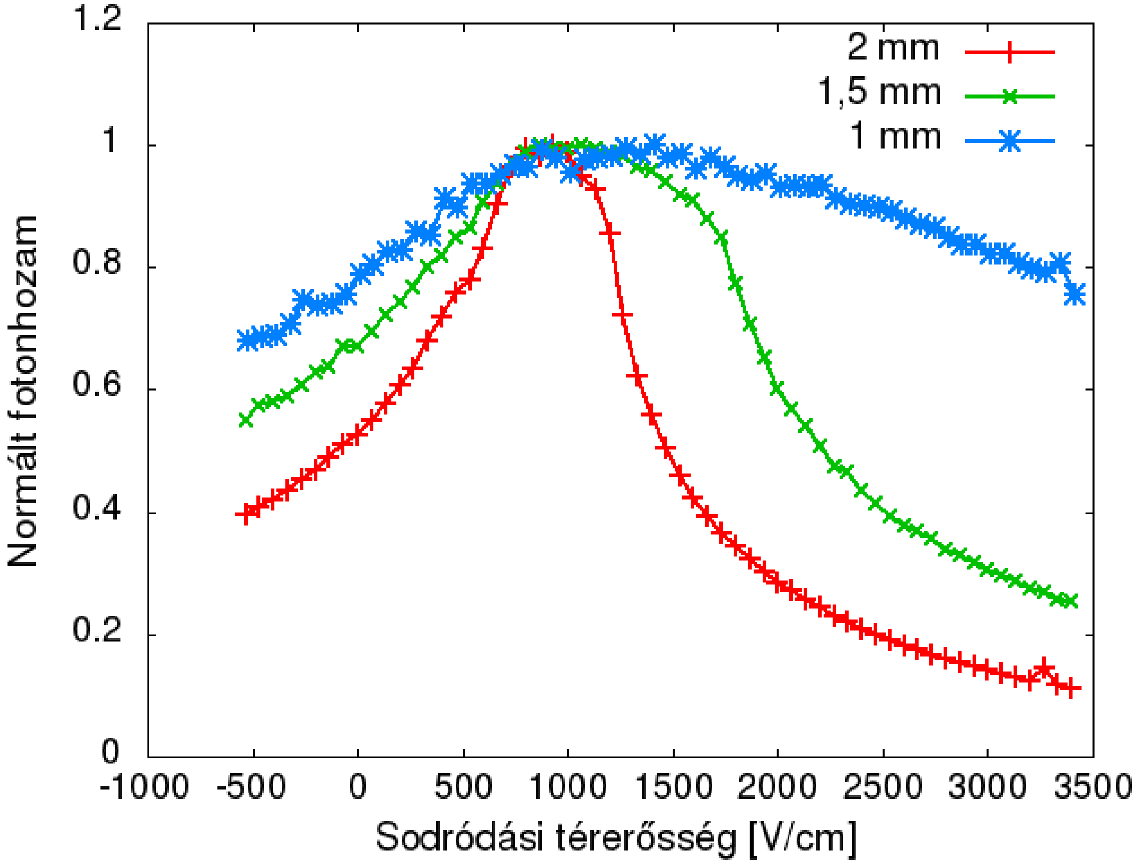
Examination of individual holes

1D scan



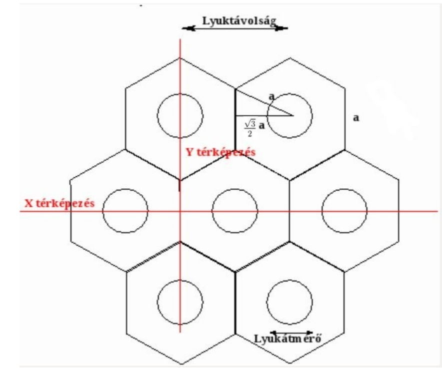
2D maps

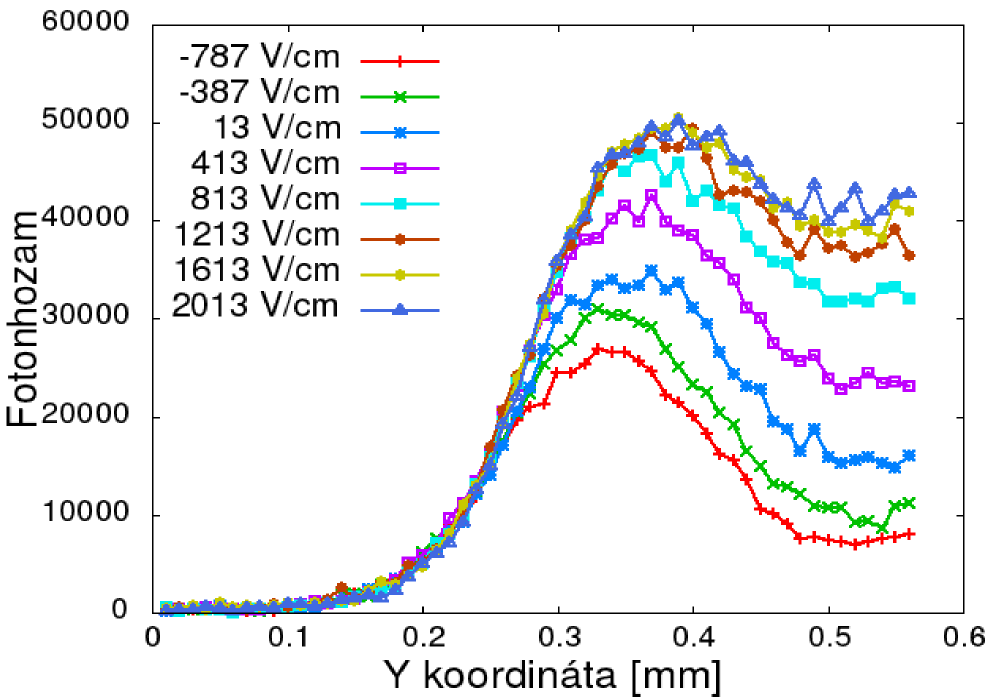


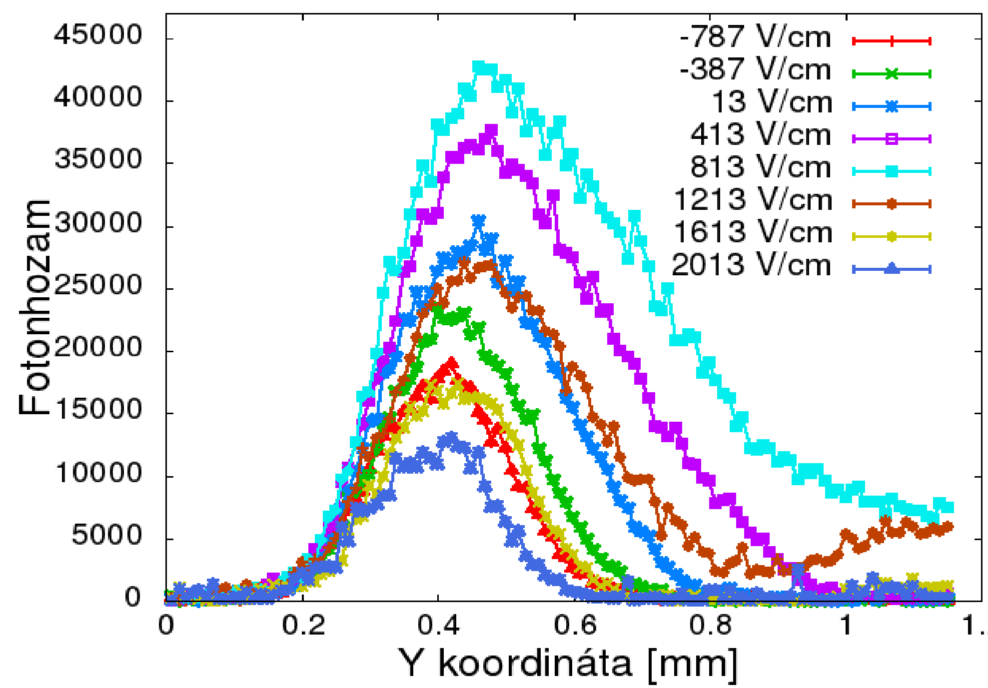


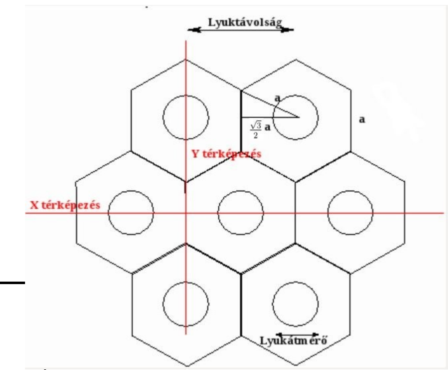
1.2
1
0.8
0.6
0.4
0.2
0
-1000
-500
0
500
1000
1500
2000
2500
3000
3500
Normált fotonhozam
Sodródási térerősség [V/cm]
2 mm
1,5 mm
1 mm

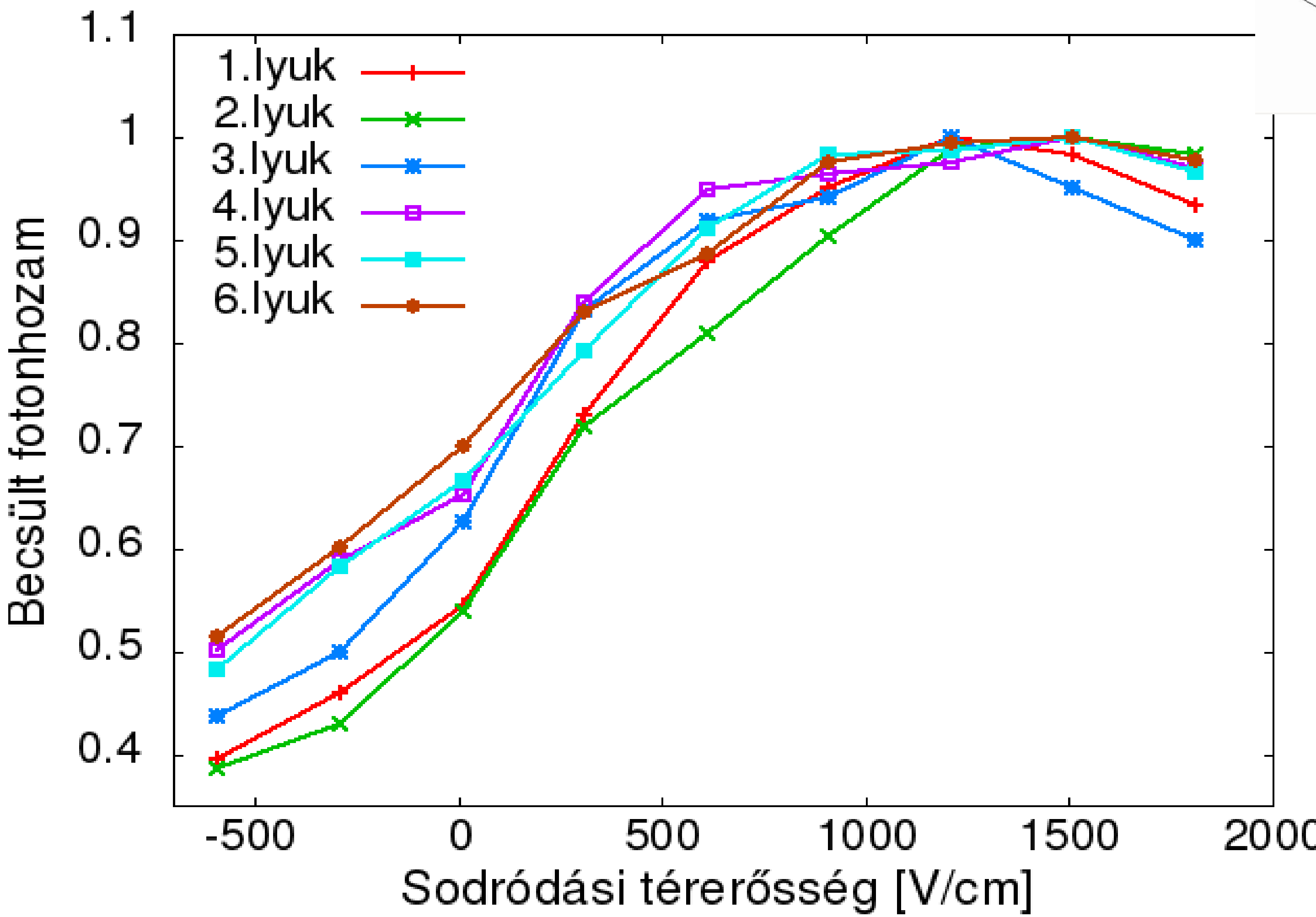
0,4


Lyuktávolság
Y térképezés
X térképezés
Lyukátmérő


-787 V/cm
-387 V/cm
13 V/cm
413 V/cm
813 V/cm
1213 V/cm
1613 V/cm
2013 V/cm
Fotonhozam
Y koordináta [mm]

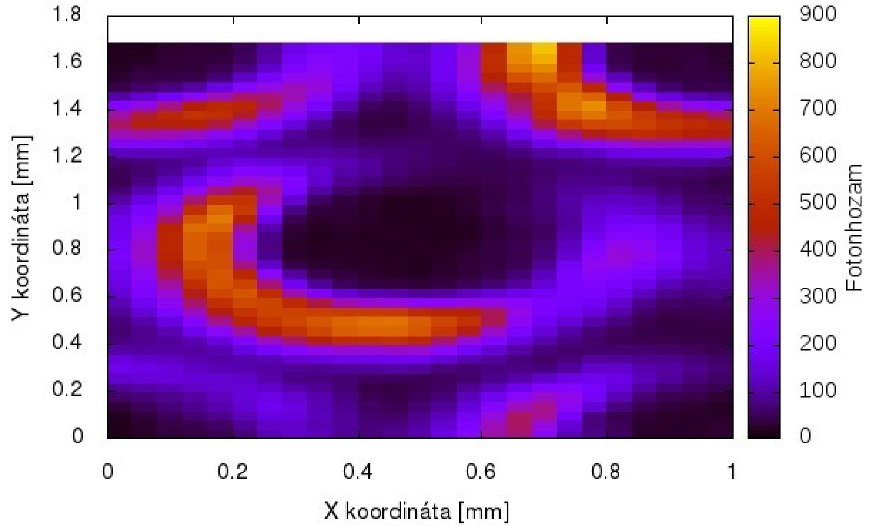

-787 V/cm
-387 V/cm
13 V/cm
413 V/cm
813 V/cm
1213 V/cm
1613 V/cm
2013 V/cm
Fotonhozam
Y koordináta [mm]


Lyuktávolság
a
a
X térképezés
Y térképezés
Lyukátmérő

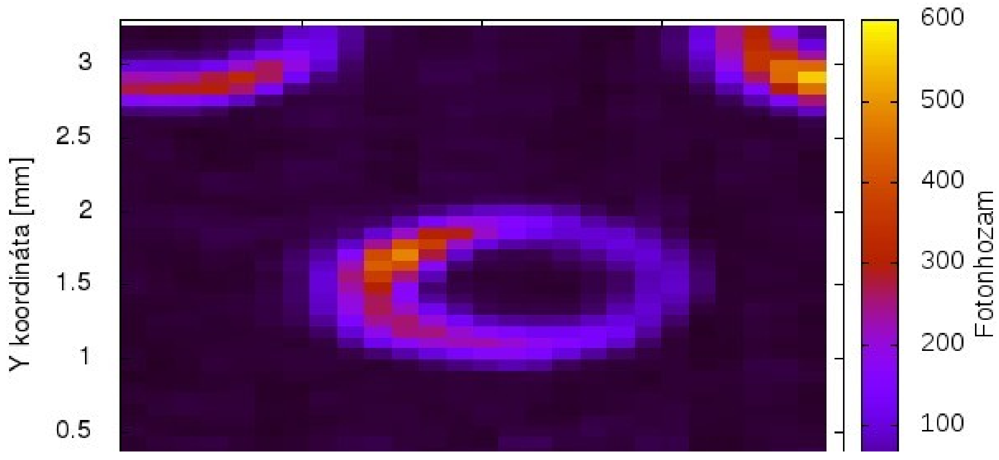

1.lyuk
2.lyuk
3.lyuk
4.lyuk
5.lyuk
6.lyuk
Becsült fotonhozam
Sodródási térerősség [V/cm]
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
-500
0
500
1000
1500
2000

1 mm

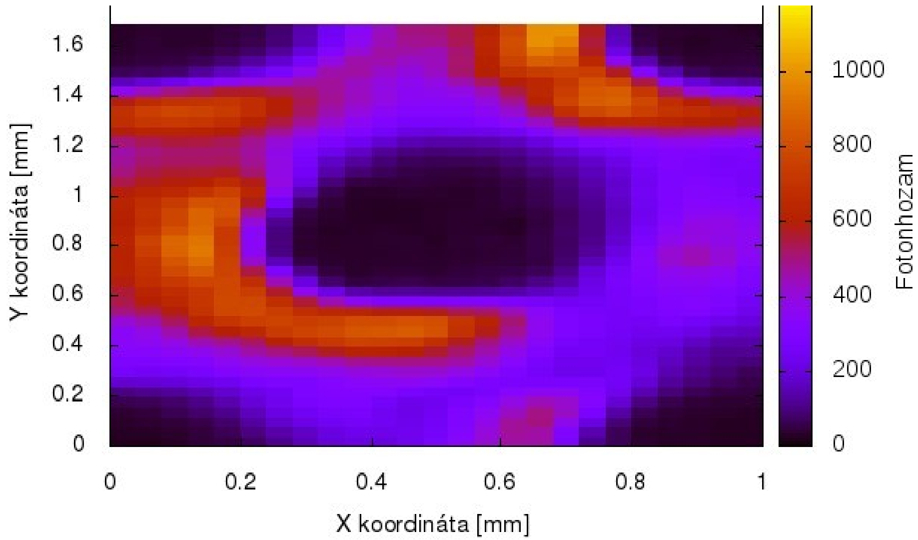
2 mm



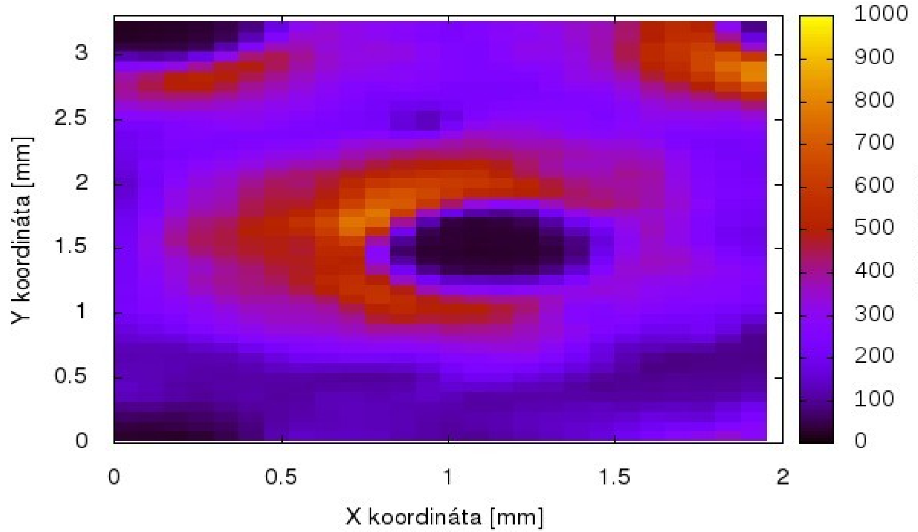
Y koordináta [mm]
X koordináta [mm]
Fotonhozam



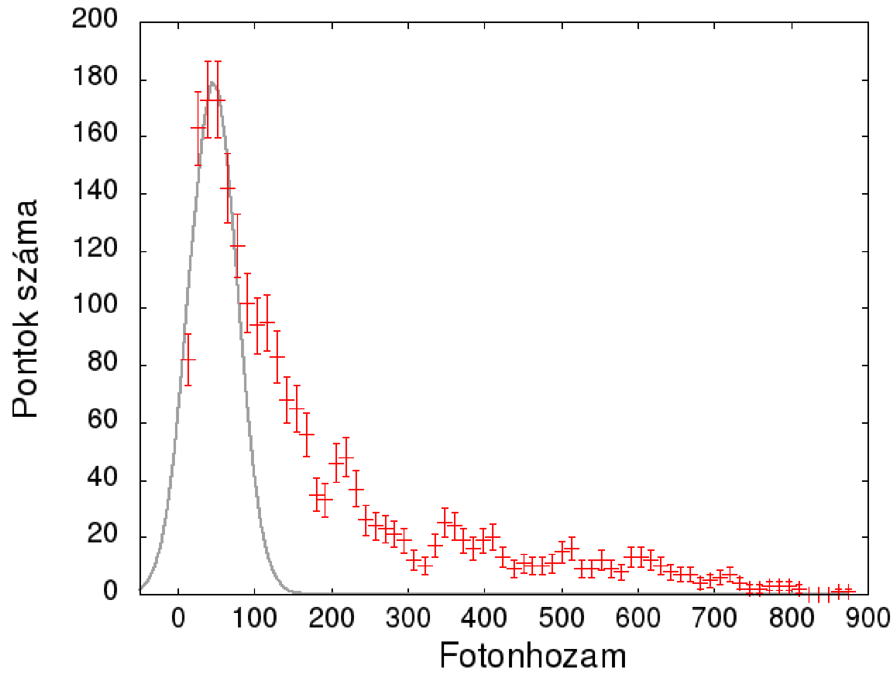
Y koordináta [mm]
Fotonhozam



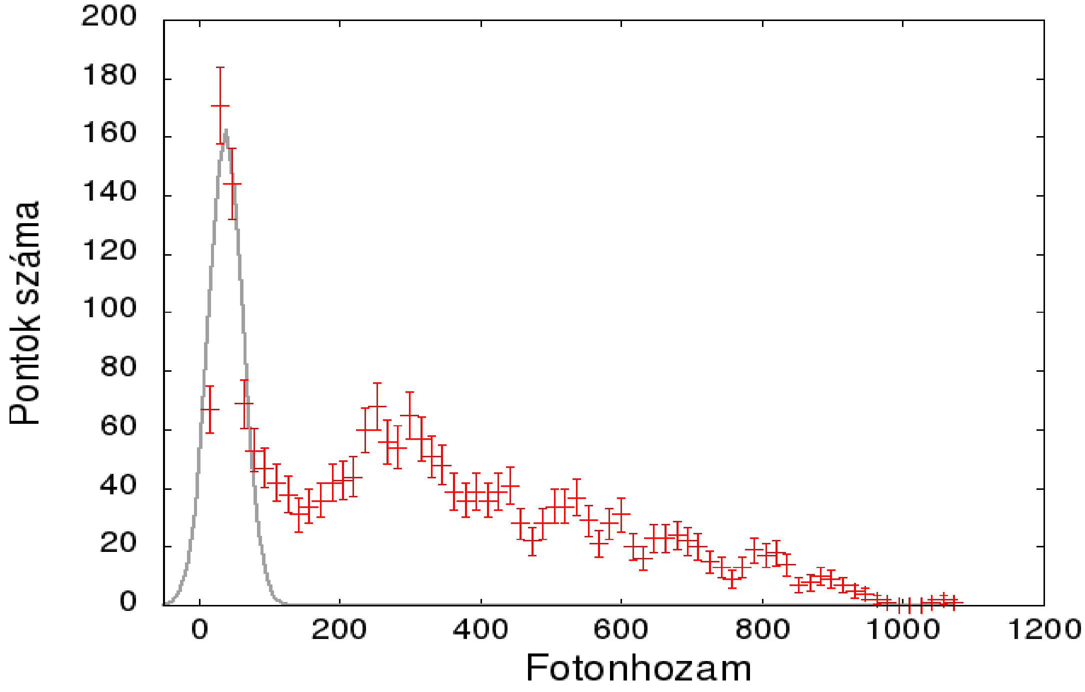
Y koordináta [mm]
X koordináta [mm]
Fotonhozam



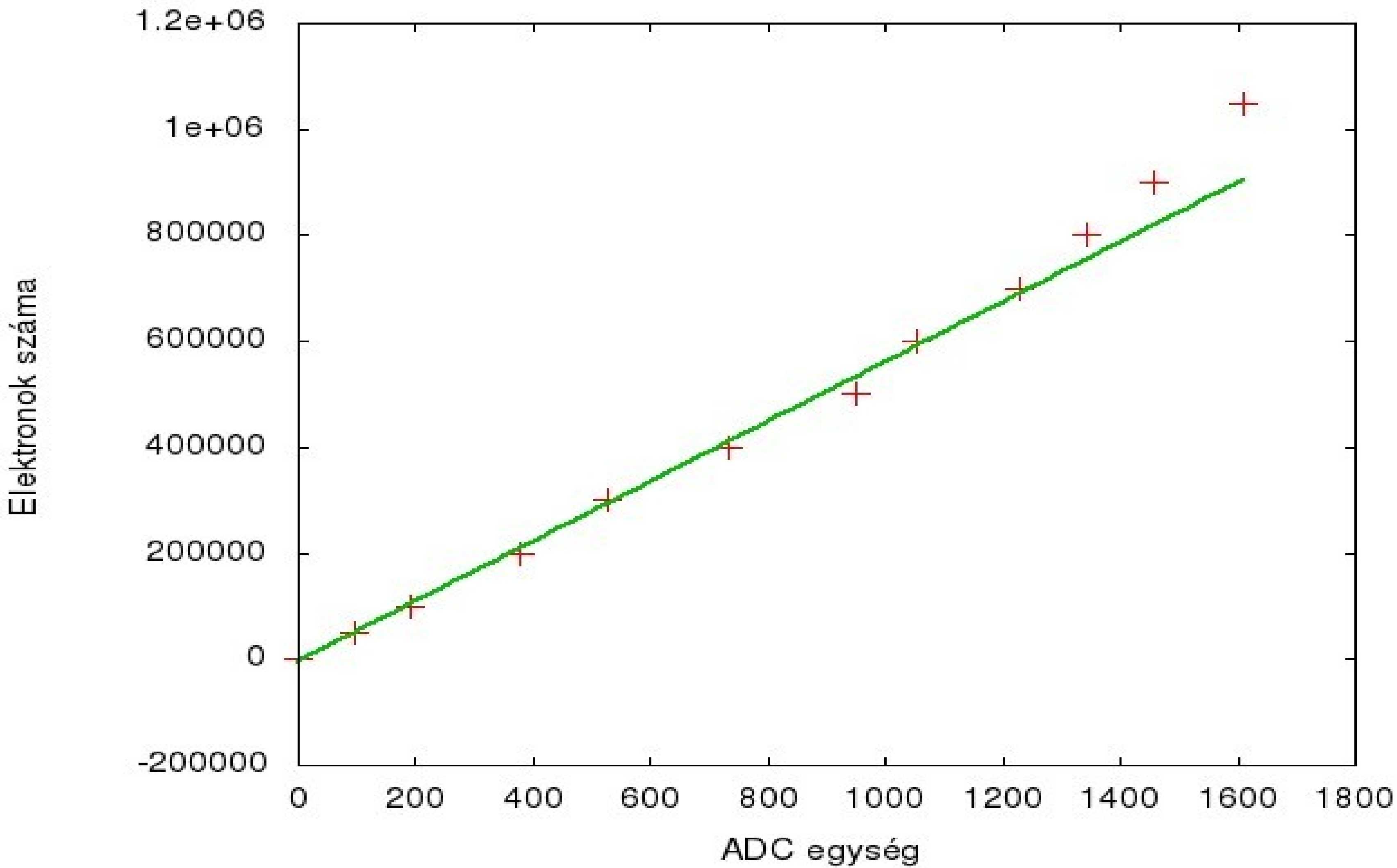
Y koordináta [mm]
X koordináta [mm]
Fotonhozam

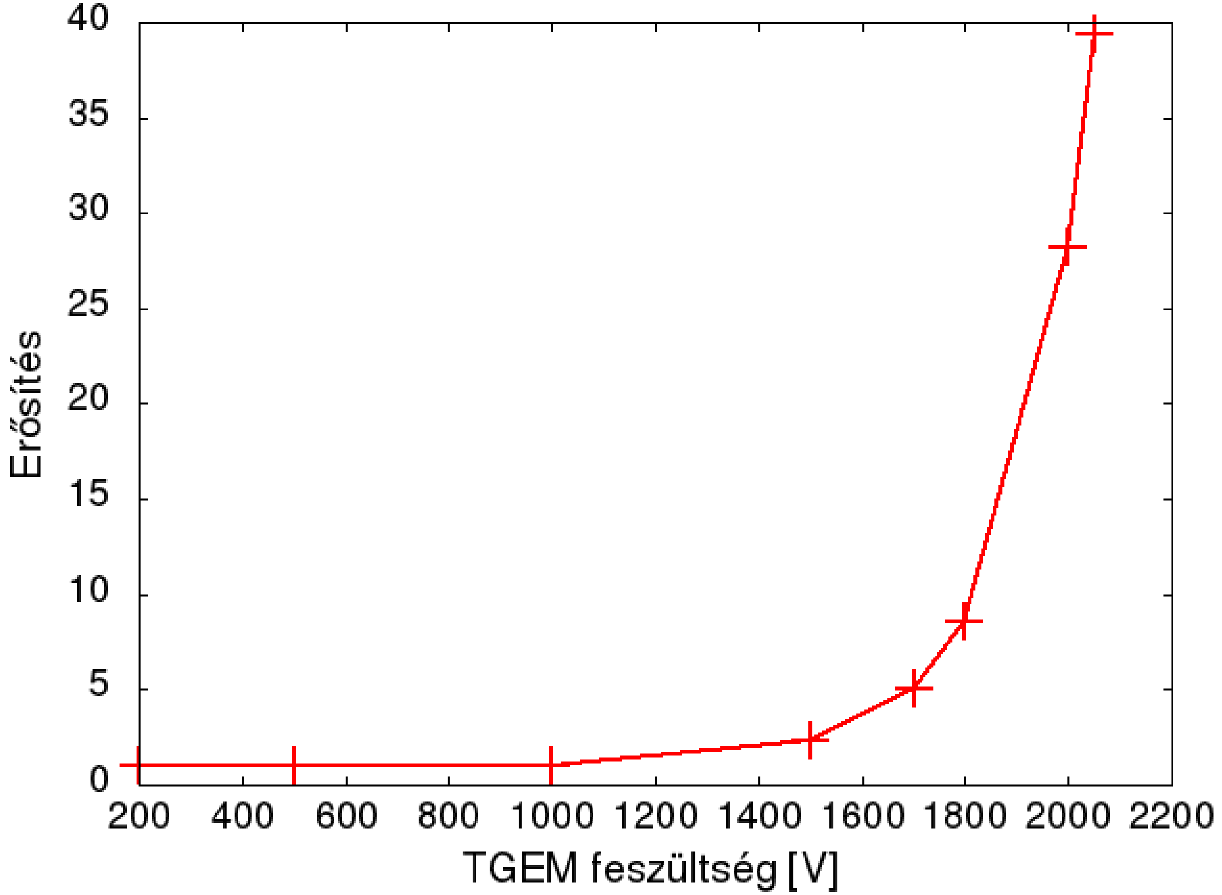


200
180
160
140
120
100
80
60
40
20
0
Pontok száma
0 100 200 300 400 500 600 700 800 900
Fotonhozam

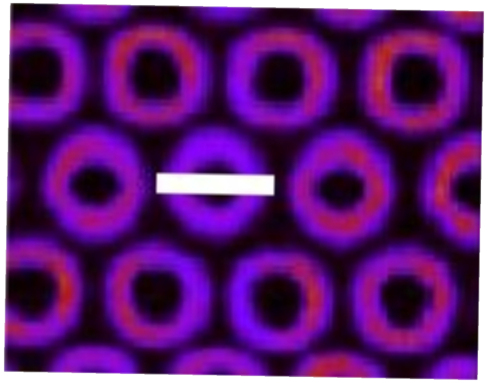


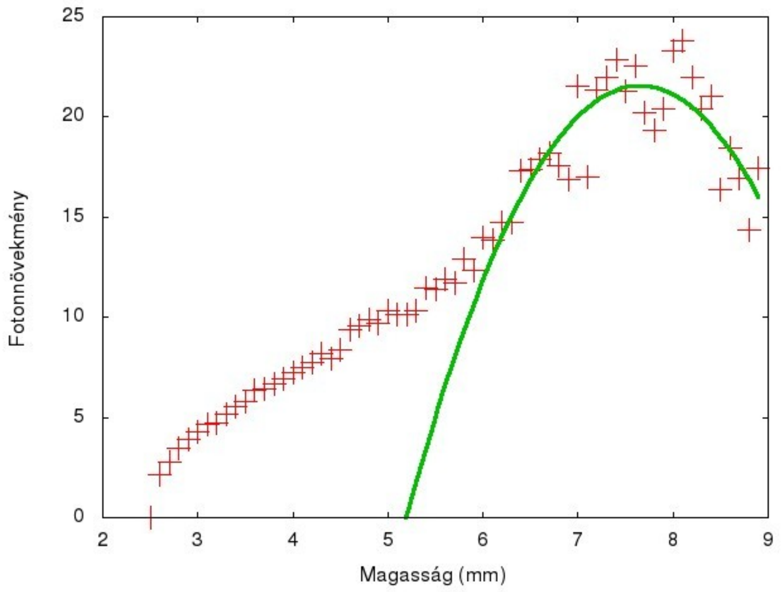
200
180
160
140
120
100
80
60
40
20
0
Pontok száma
0 200 400 600 800 1000 1200
Fotonhozam

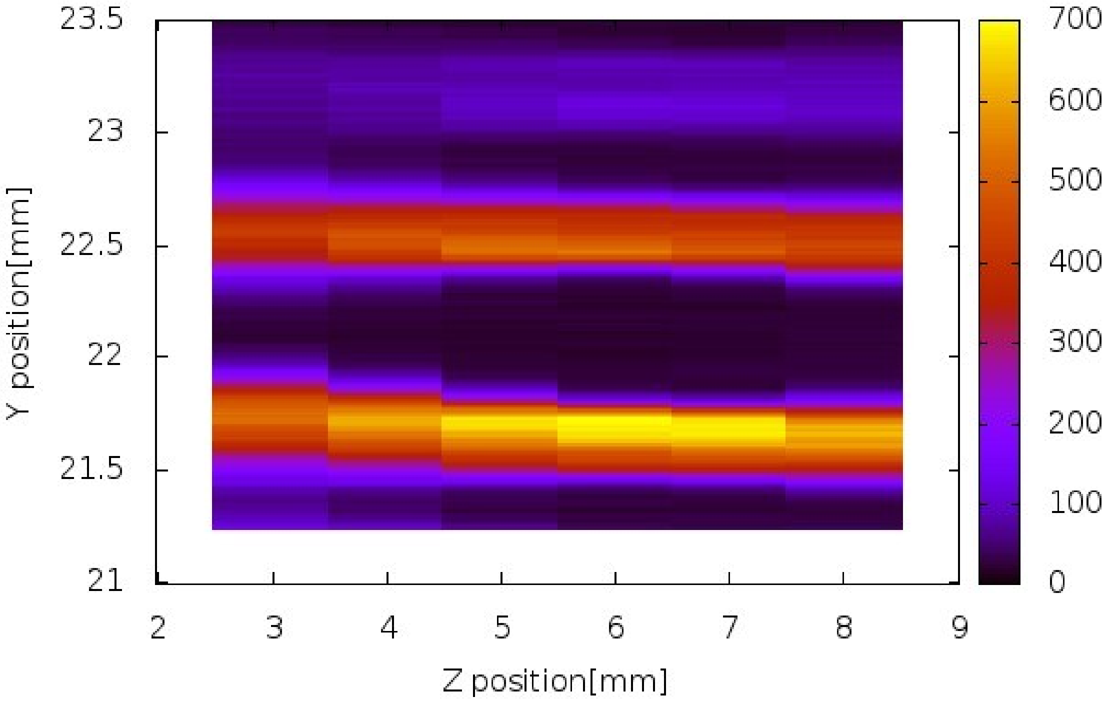

1.2e+06
1e+06
800000
600000
400000
200000
0
-200000
0
200
400
600
800
1000
1200
1400
1600
1800
Elektronok száma
ADC egység

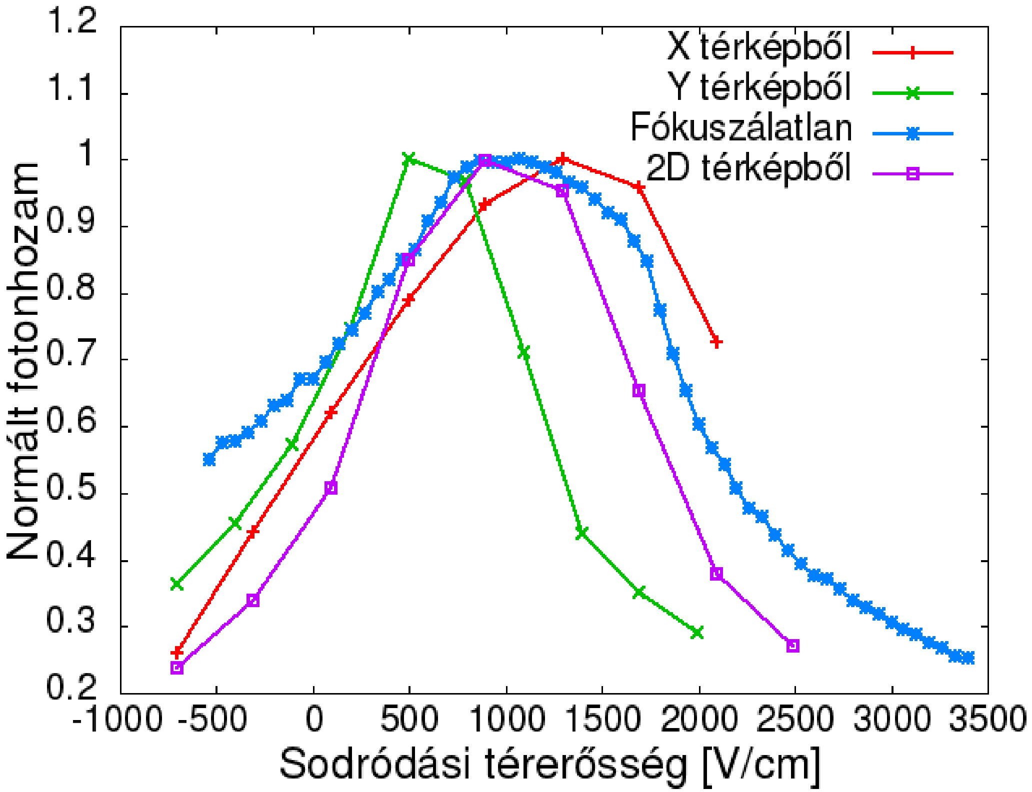

40
35
30
25
20
15
10
5
0
Erősítés
200 400 600 800 1000 1200 1400 1600 1800 2000 2200
TGEM feszültség [V]

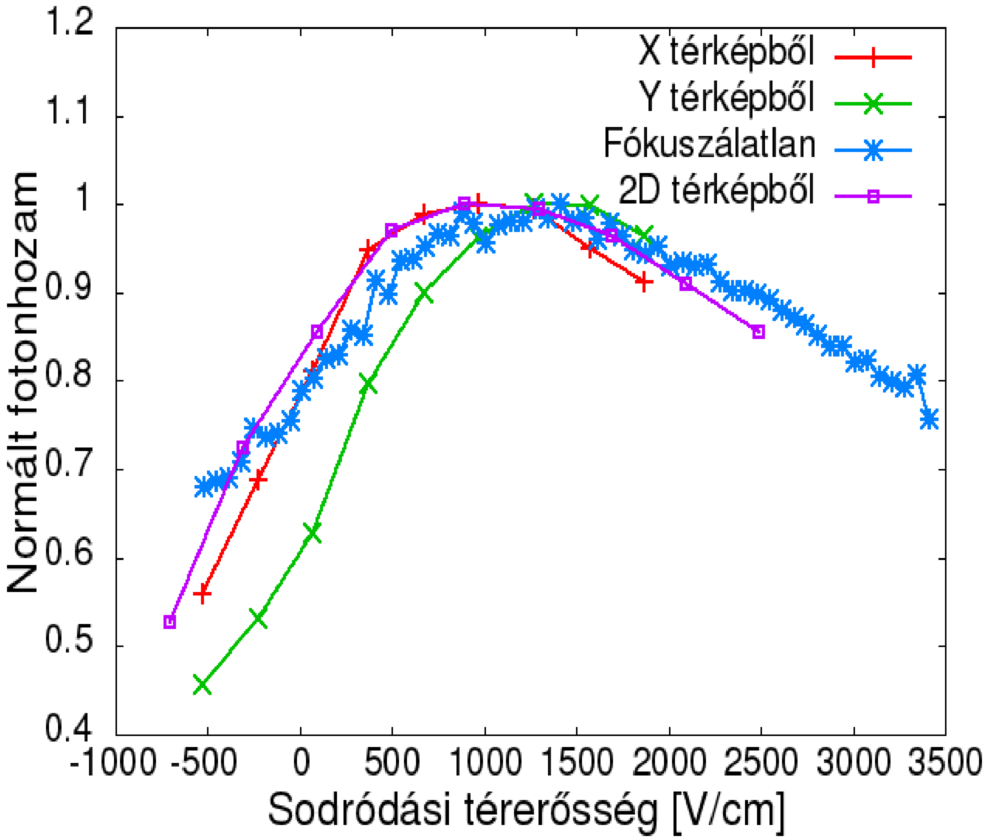
Focus

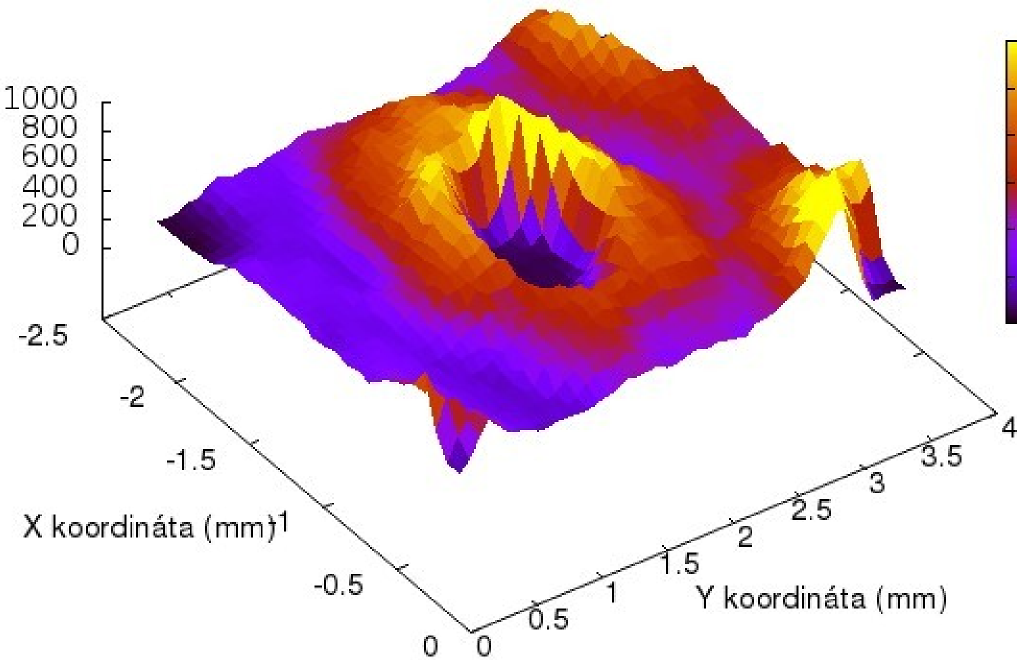


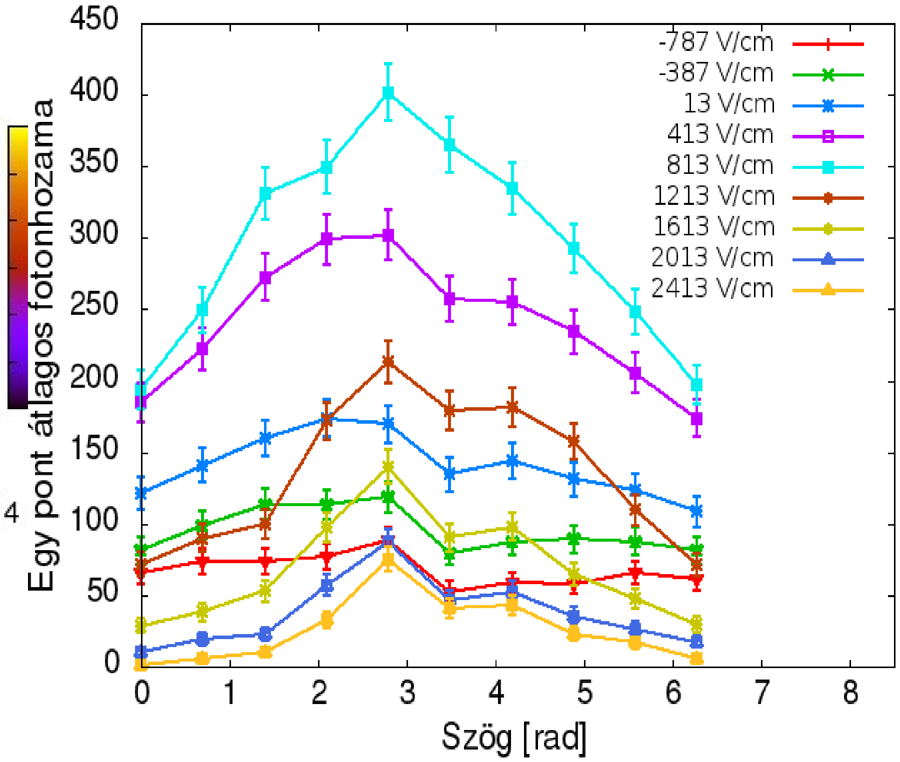

Fotonnövekmény
Magasság (mm)
0
5
10
15
20
25
2
3
4
5
6
7
8
9

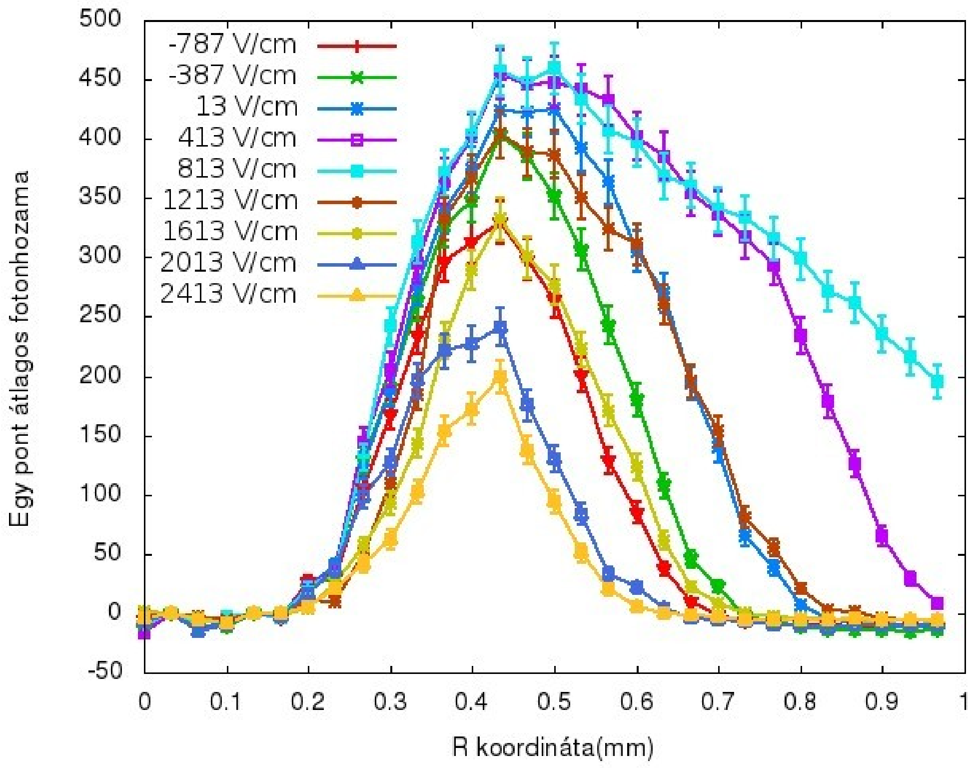

Y position[mm]
Z position[mm]
23.5
23
22.5
22
21.5
21
2
3
4
5
6
7
8
9
700
600
500
400
300
200
100
0


Normált fotonhozam
Sodródási térerősség [V/cm]
X térképből
Y térképből
Fókuszálatlan
2D térképből
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
-1000 -500 0 500 1000 1500 2000 2500 3000 3500

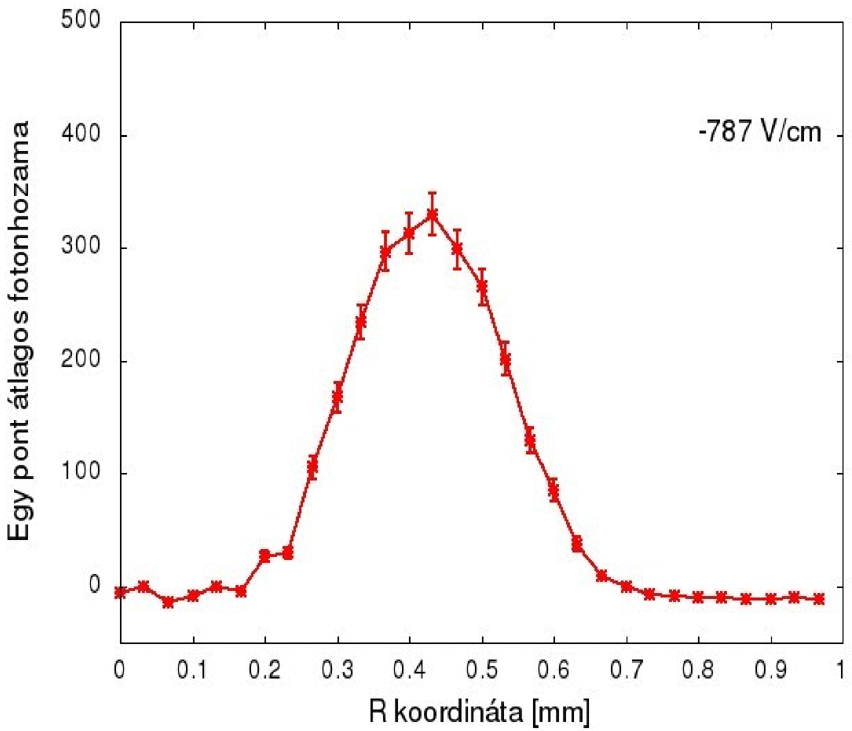

Normált fotonhozam
Sodródási térerősség [V/cm]
X térképből
Y térképből
Fókuszálatlan
2D térképből
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
-1000 -500 0 500 1000 1500 2000 2500 3000 3500


1000
800
600
400
200
0
-2.5
-2
-1.5
-1
-0.5
0
X koordináta (mm)
0
0.5
1
1.5
2
2.5
3
3.5
4
Y koordináta (mm)


Egy pont átlagos fotonhozama
Szög [rad]
-787 V/cm
-387 V/cm
13 V/cm
413 V/cm
813 V/cm
1213 V/cm
1613 V/cm
2013 V/cm
2413 V/cm
0
50
100
150
200
250
300
350
400
450
0
1
2
3
4
5
6
7
8

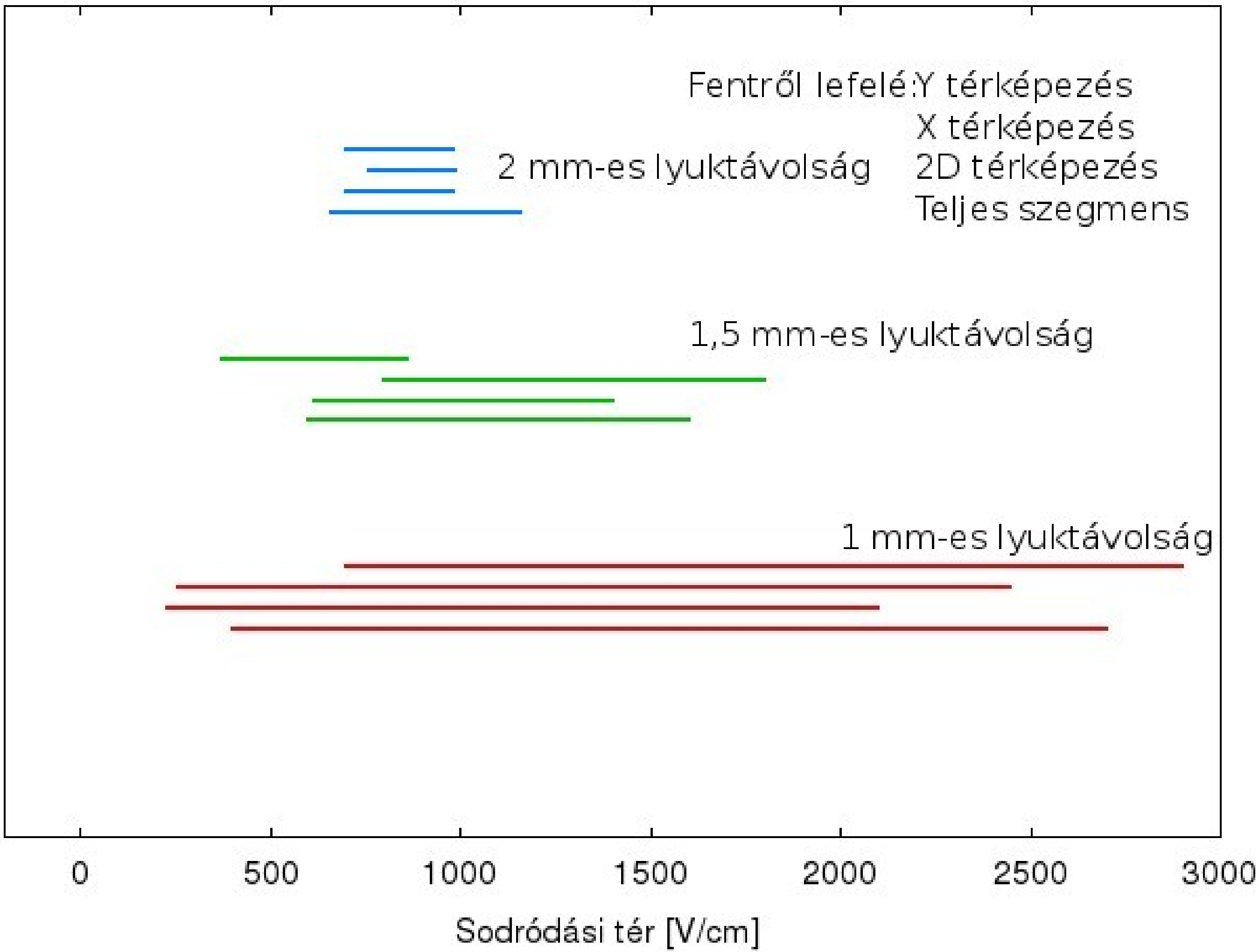


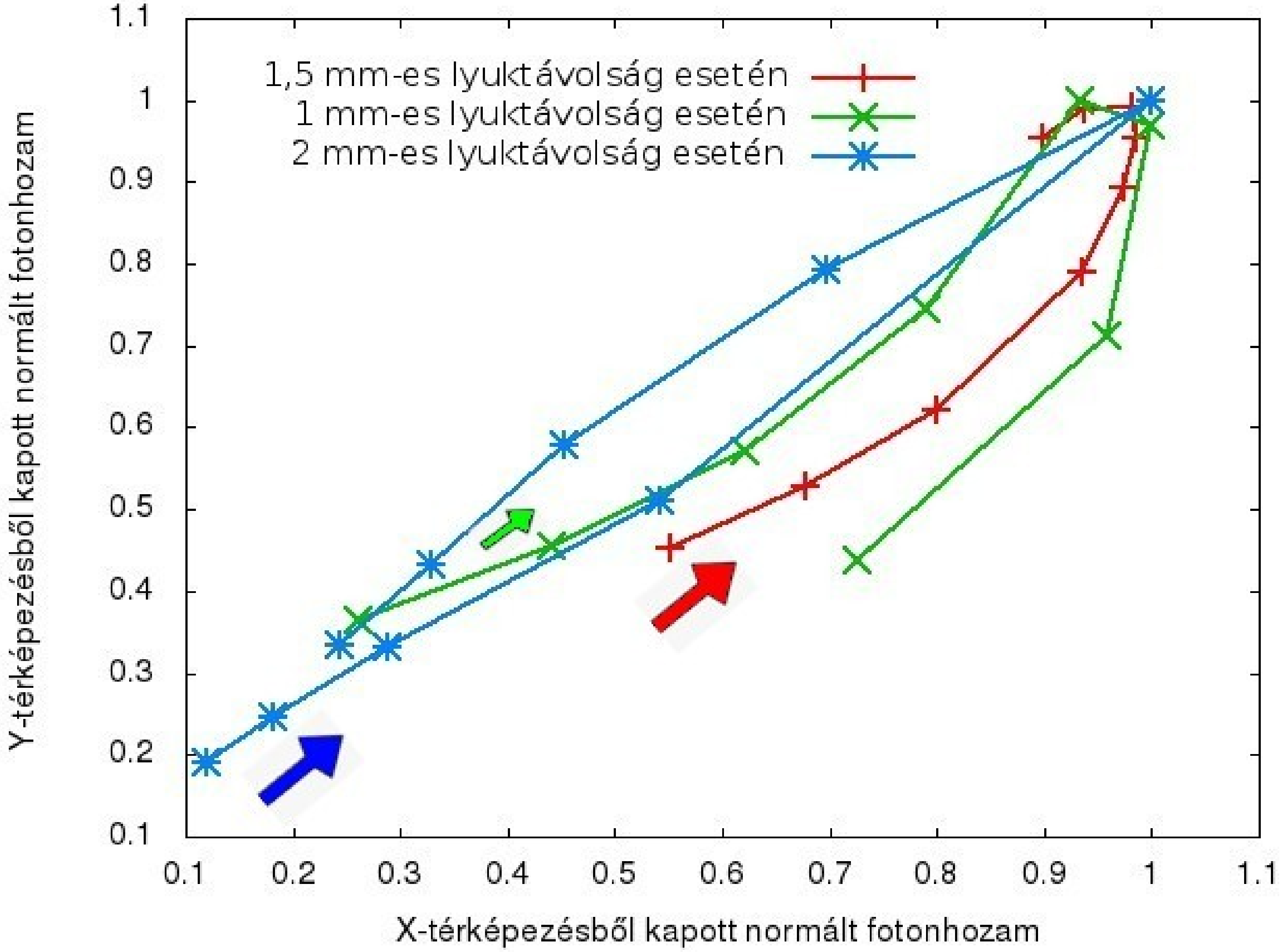
-787 V/cm
-387 V/cm
13 V/cm
413 V/cm
813 V/cm
1213 V/cm
1613 V/cm
2013 V/cm
2413 V/cm
Egy pont átlagos fotonhozama
R koordináta(mm)



-787 V/cm
Egy pont átlagos fotonhozama
R koordináta [mm]

Optimal drift field




1,5 mm-es lyuktávolság esetén
1 mm-es lyuktávolság esetén
2 mm-es lyuktávolság esetén
Y-térképezésből kapott normált fotonhozam
X-térképezésből kapott normált fotonhozam
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1