High Resolution Scanner for Micropattern Based Cherenkov Detectors

(The "Leopard" System)

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REGARD

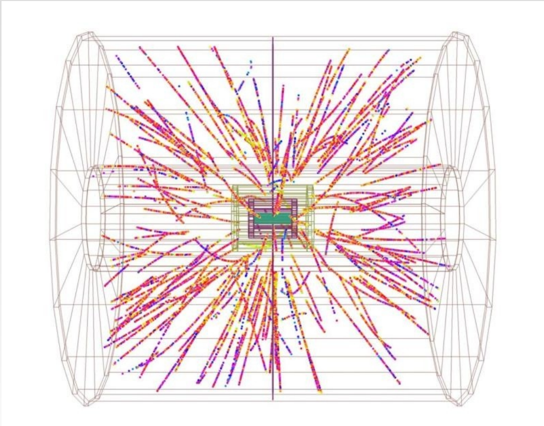
RMKI ELTE Collaboration on Gaseous Detector Research and Development

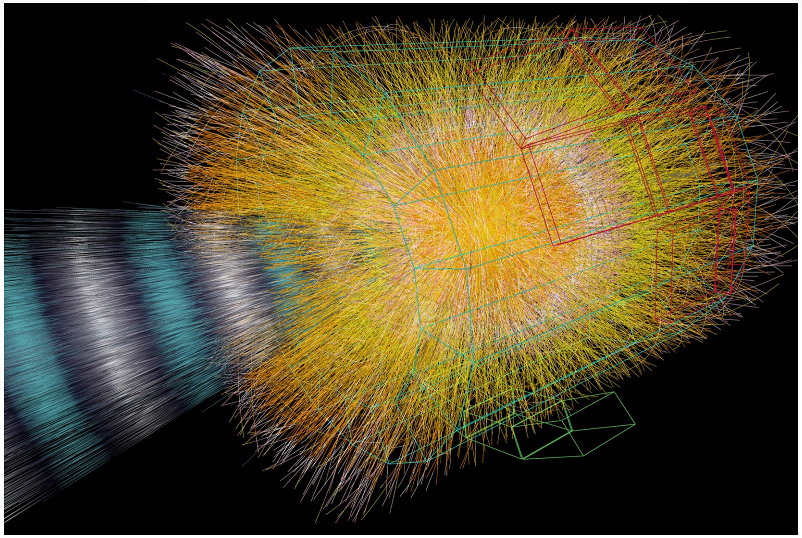
Outline

- **Gaseous detectors**
- **Micropattern technology**
- **Examining the microstructure:**
  the Leopard System
- **TGEMs : Yield maps, and the hole-gain**
  Drift field and Critical/Symmetry points
- **Applicability for thin GEM foil**
- **Summary and outlook**

Gaseous detectors

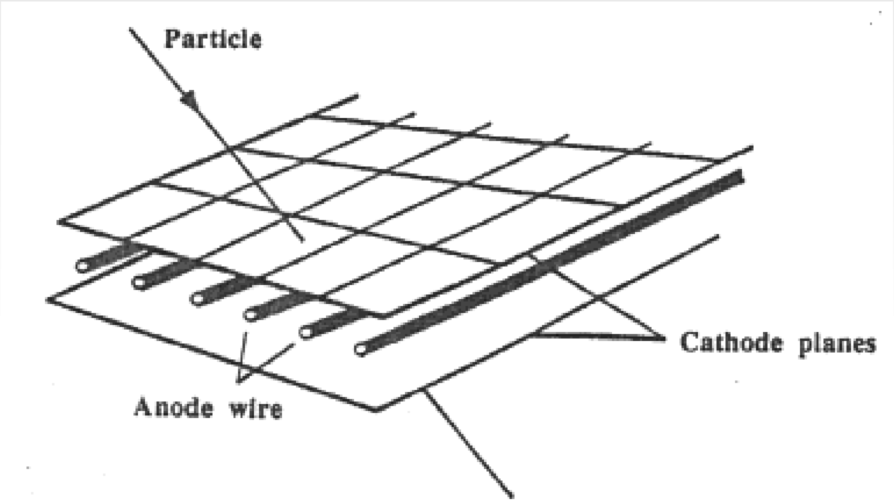
- GM, MWPC, TPC, ...
- Well known technique
- Capability for large volumes
- Excellent tracking even in 3D
  Two track resolution
- dE/dx information
  Particle identification
- Applicabe for RICH and TR detectors





Gaseous detectors

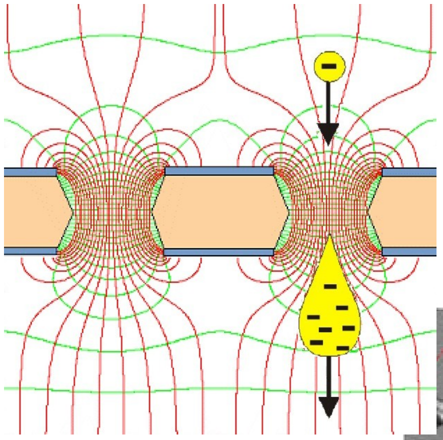
- Ionization of gas by charged particles along the tracklet
- Collection of electrons
- High electric field to
  produce electron avalanche
  (typically around a thin wire)

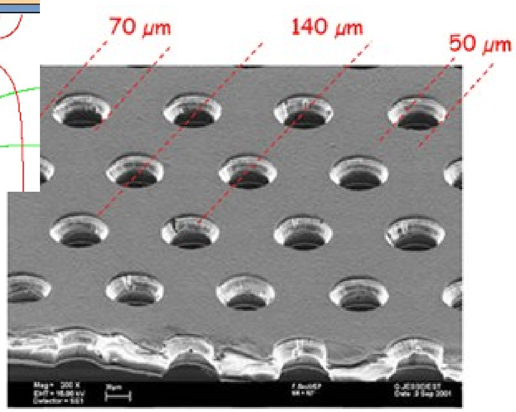


- Signal could be read out from
  neighbouring electrodes
  (eg. a segmented cathode)
- TPC : measurable drift time → 3D tracking
- Main advantages :
  Low material budet; Capability for large volume;
  Cost effective; Applicable for photon detection as well

Micropattern detectors

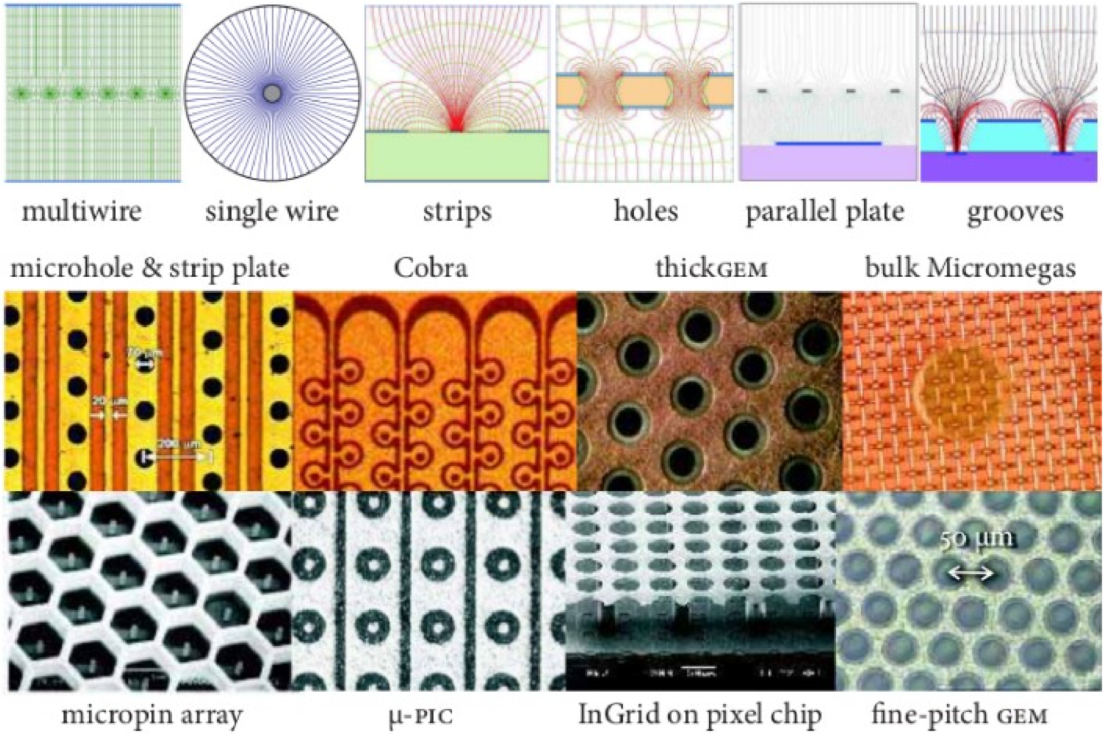
- Problems and limits of wire chambers
  gain uniformity, sagging, electronic force,
  strong frames, the wires, imperfections, planarity, ...
- Advancement of PCB- and industrial technologies
- High electric field NOT ONLY around wires



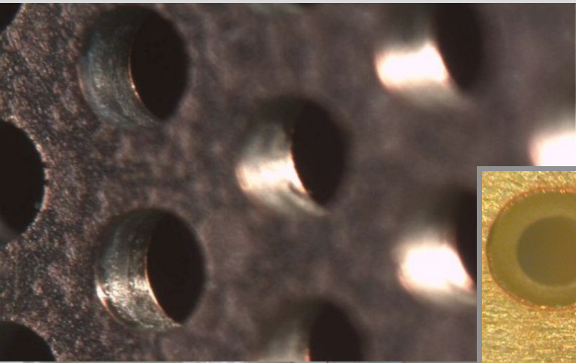


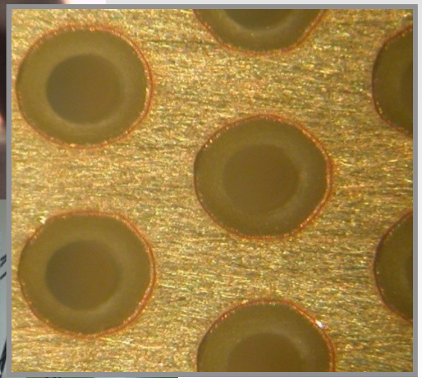
GEM

2015. June-July

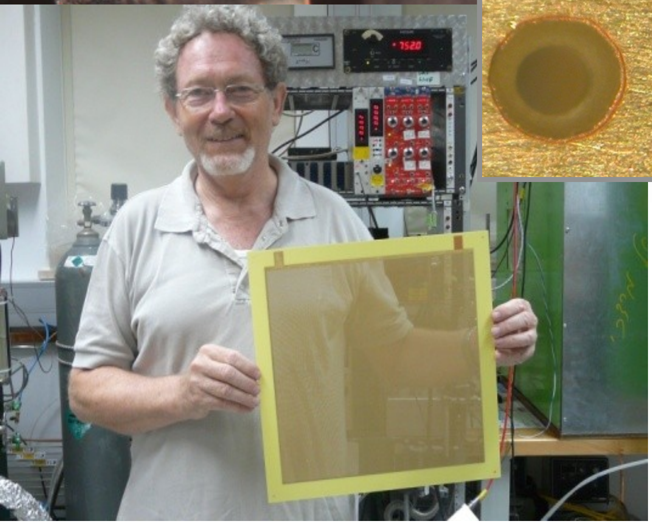


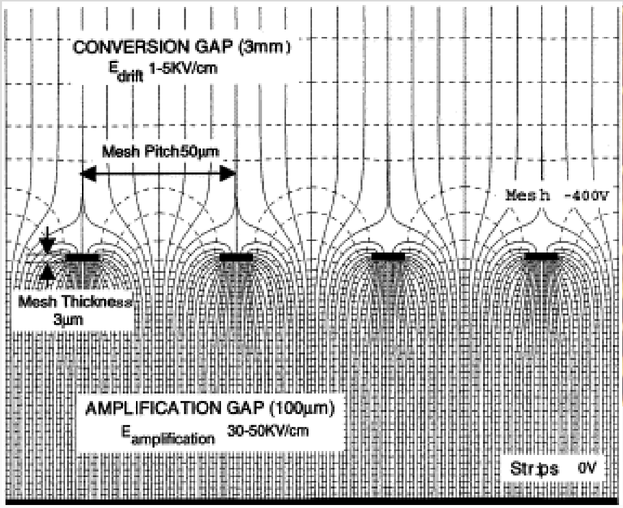
Micropattern detectors

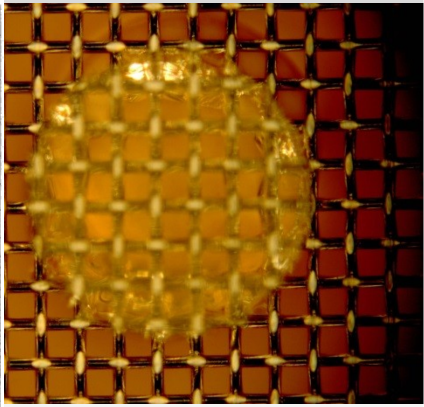




ThickGEM

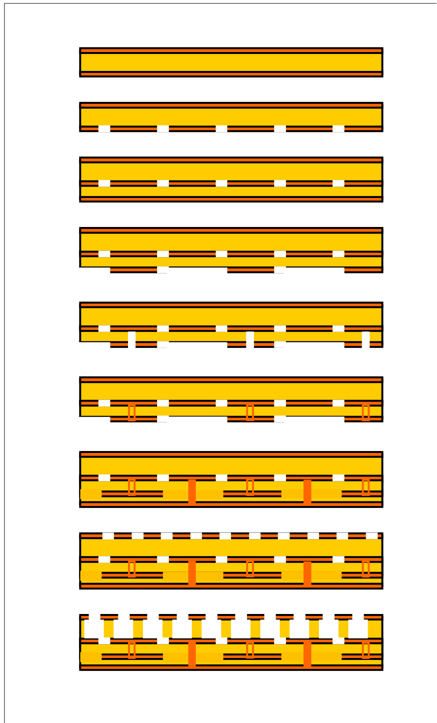




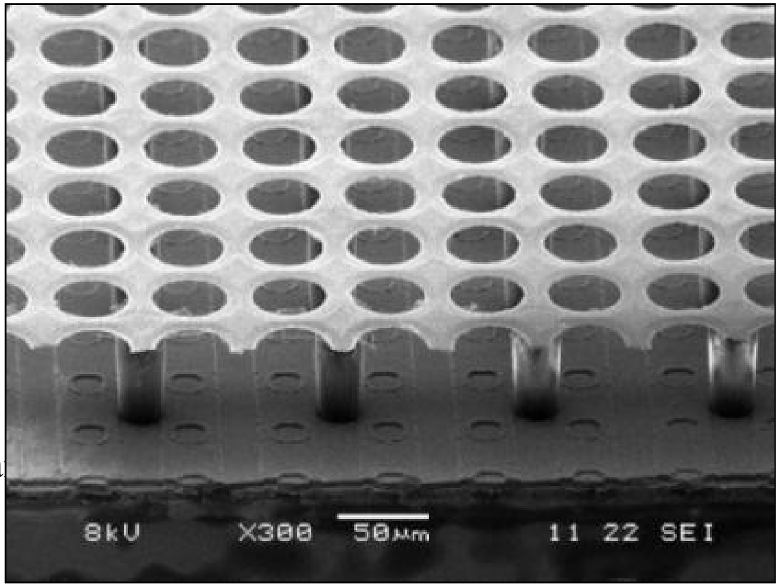


MicroMegas

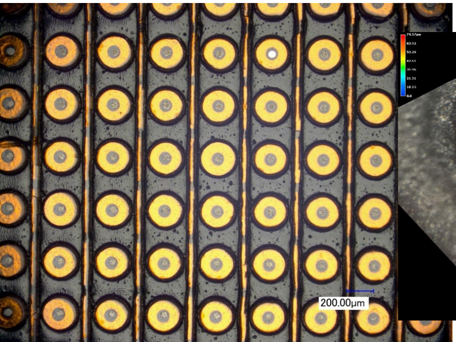
mbMM

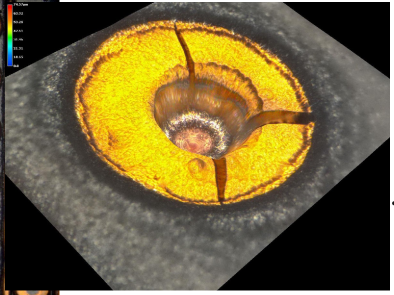


InGrid



µPIC





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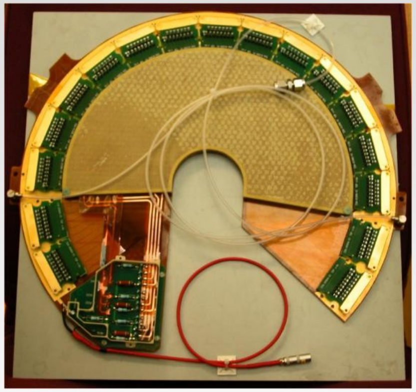
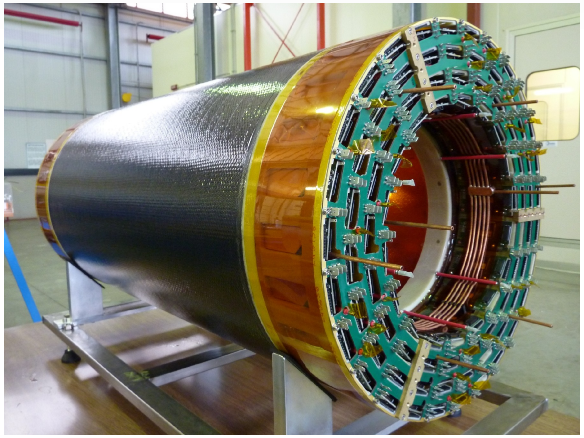
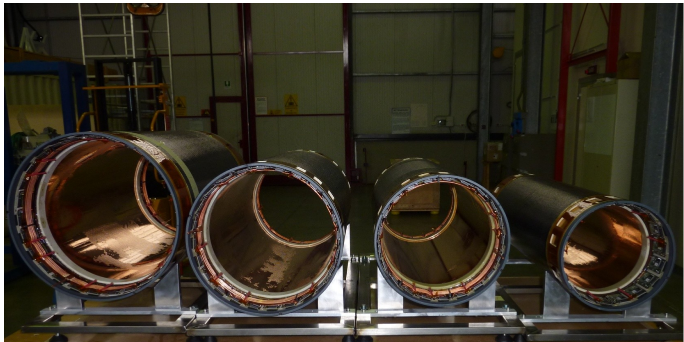
Advantages and Applications of MPGDs



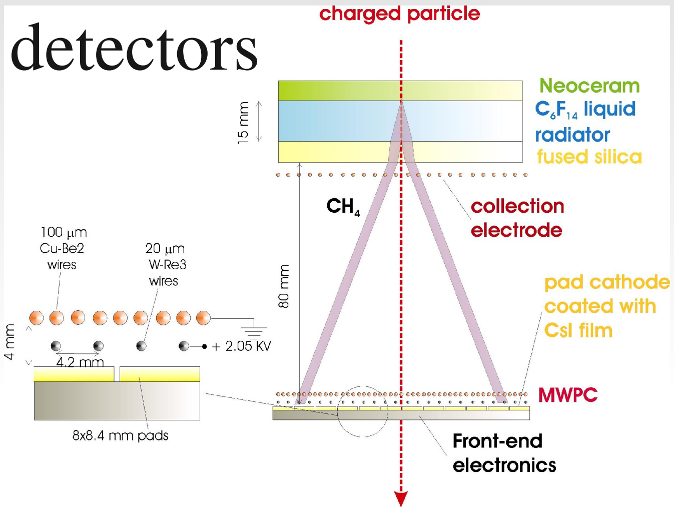
- Flexibility in geometries : tube, sphere, ...
- Higher rate capability !
  (CMS and ATLAS upgrades in the forward direction)
- Reduced ion backflow
  (ALICE TPC upgrade, COMPASS RICH upgrade)
- Fast signal
- Low material budget
- Producable by industry
- RD51 Collaboration
  (communication, know-how, production test facilities, simulation tools, SRS, ...)
- Examples: TOTEM GEM, KLOE2 CT, PHENIX HBD, FOPI GEM-TPC, ...

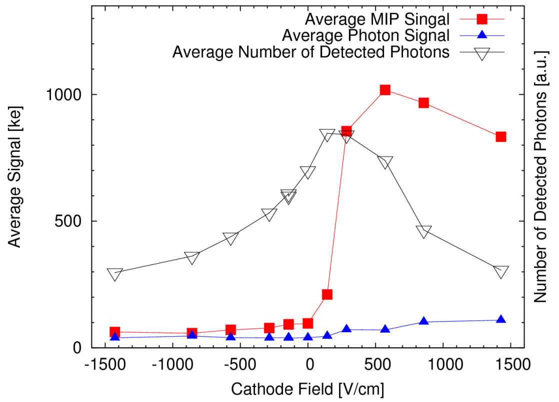




MPGD Based
Gaseous Photon Detectors

- Particle identification -> **Cherenkov detectors**
- Gaseous Photon Detectors for Cherenkov detectors
  - Large area at reasonable price
  - CsI cover for UV photon detection
- Advantages vs. MWPC based RICH
  - Reduction of ion back-flow
  - Fast response
  - High rate capability
  - Possibility for MIP suppression
  - No feed-back photons
- PHENIX, COMPASS, ALICE
- Triple GEM, TGEM, TCPD, TGEM+MM
  in all: GEM-type photoconverting plate
- Efficiency and microstructure ??





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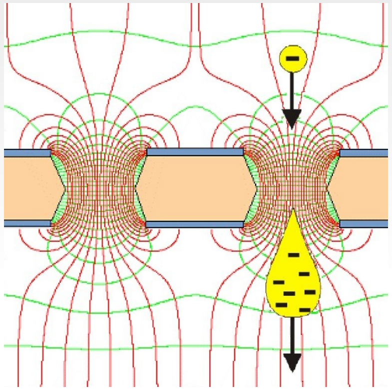
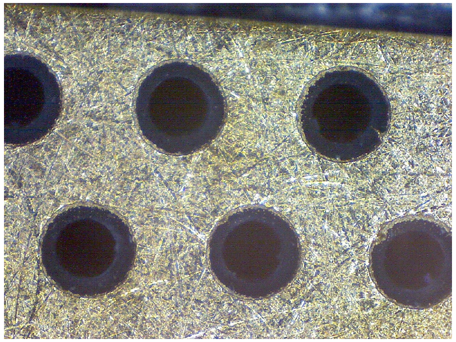
Microstructure of UV Sensitivity on ThickGEM Surface

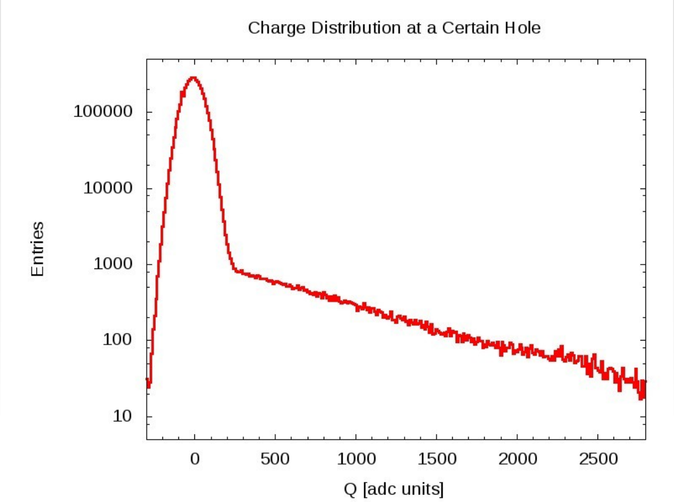
- Holes are definitely blind spots
- Inhomogenous extraction field
- Critical symmetry points (and lines)
- Side effects of MIP suppression ?
- Large range for all the geometrical parameters
  (diameter, pitch, rim, thickness)
- Choise of the filling gas
  (Methane vs non-flammable)





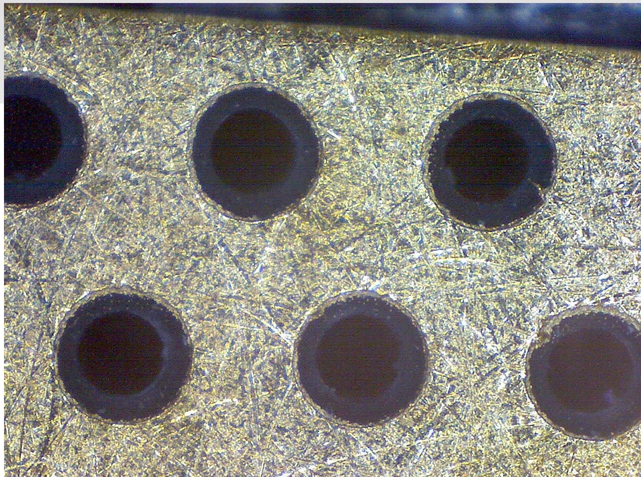
Strategy to Examine the Microstructure

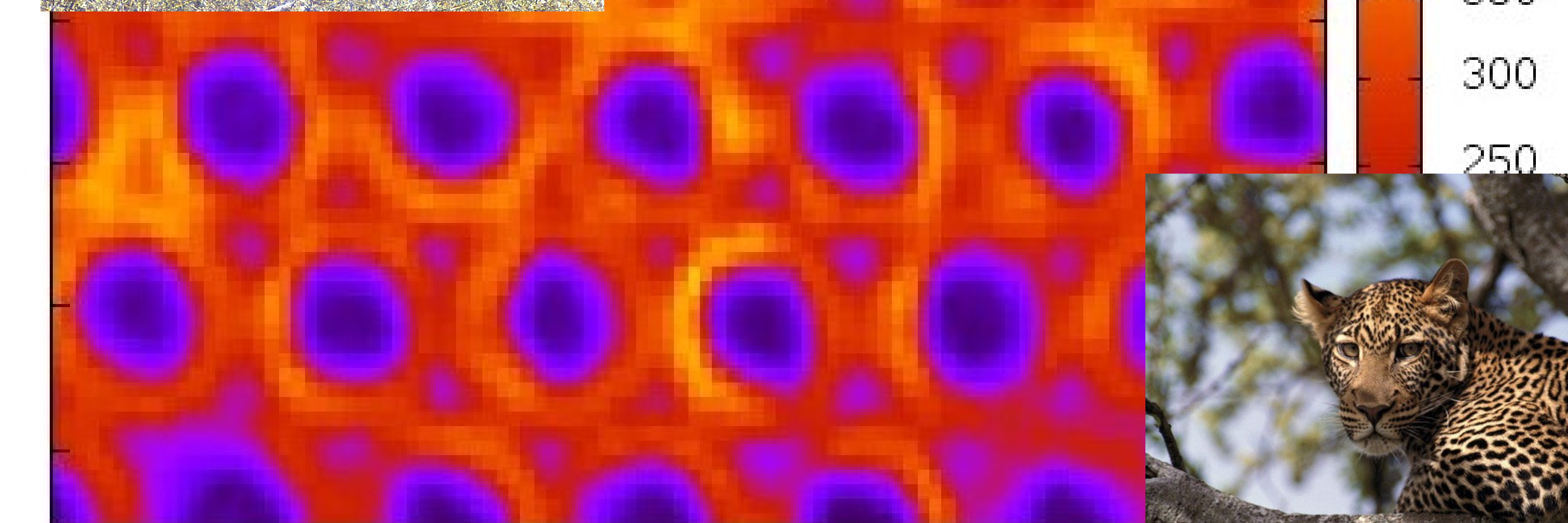
- Single photo-electrons :
  PE yield and gasgain separation
- Focused UV light
- High resolution mapping
- Combined data acquisition



- **Optimization** (and parametrization)
  (hole geometry, voltages, gas mixtures, ...)
- Fine tuning for **simulation**
- Quality assurance for **production**

What could be seen?



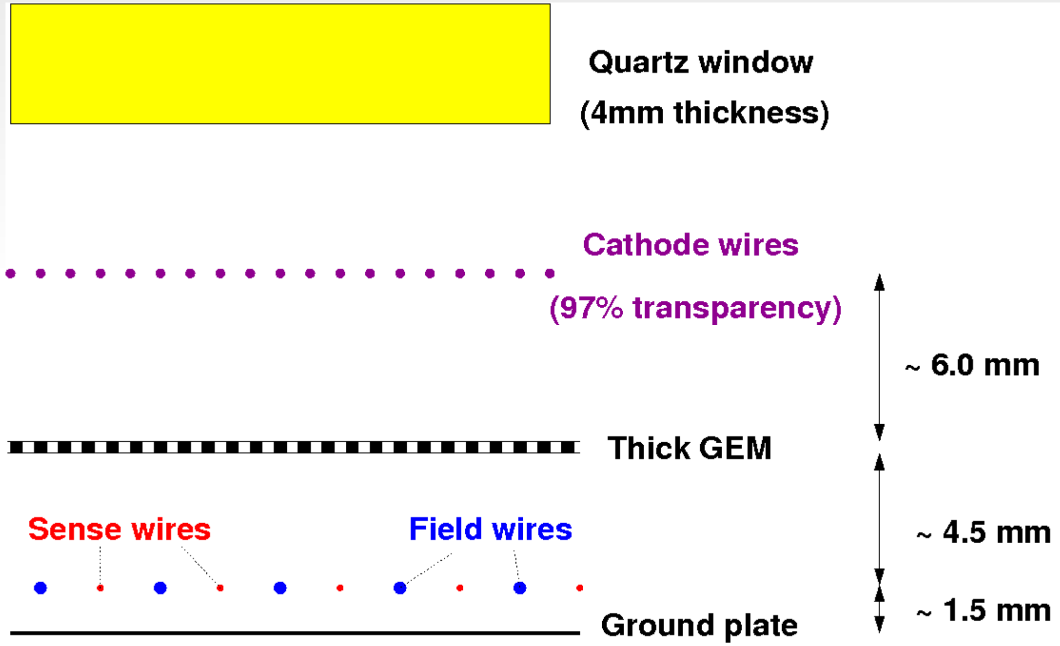


like a leopard...

Single ThickGEM Layer ? TCPD Outline

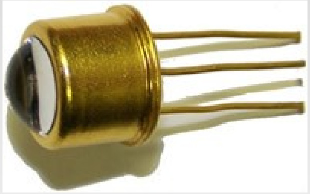
(ThickGEM+CCC Photon Detector)

- A known configuration applied for photon detection
- UV-transparent
  quartz window
- Wire plane for cathode
- ThickGEM
  Gold plated
- CCC: an optimized MWPC
  as high gain stage
- Padplane
- Read out : connected wires (or pads)

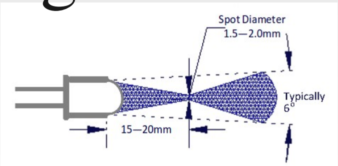


Optical Setup

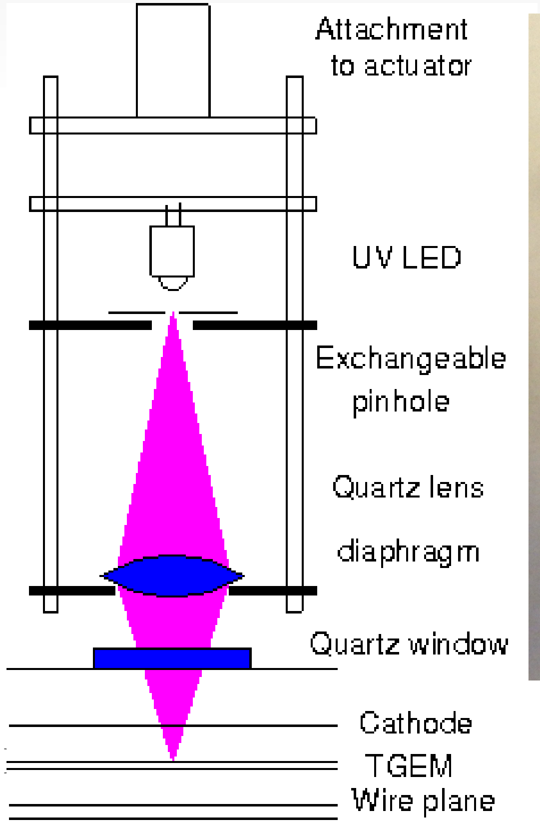
- Pulsed UV source : UV LED : SETI UVTOP240
  peak: 243 nm, widths: 10nm
  Photo-electrons from gold surface

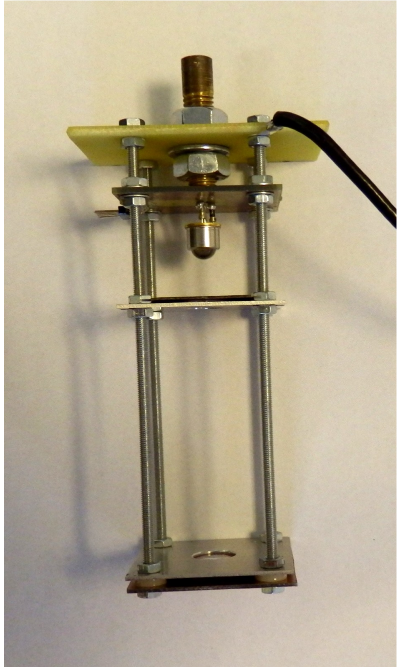


- Focusing ball lense cover



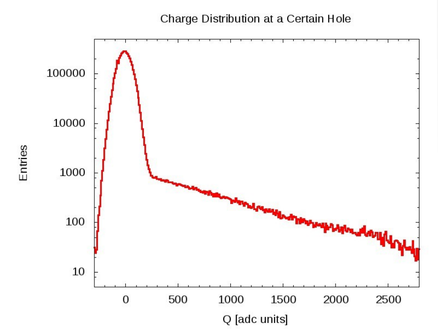
- Led Driver Unit
  adjustable oscillator
  trigger and LED output
- Pinhole (spot size x 2)
  150 μm => 70 μm spot
  Pinhole 30 μm became
  just usable
- Quartz window
- Further improvements
  are still underway





Challenges

- Optical system : 20-100 μm spot size
  => 10^4 - 10^6 points (spectra)
- Single photo-electrons:
  < 5% PE / event AND 100-1000 PE / point
  => thousands of events in each points

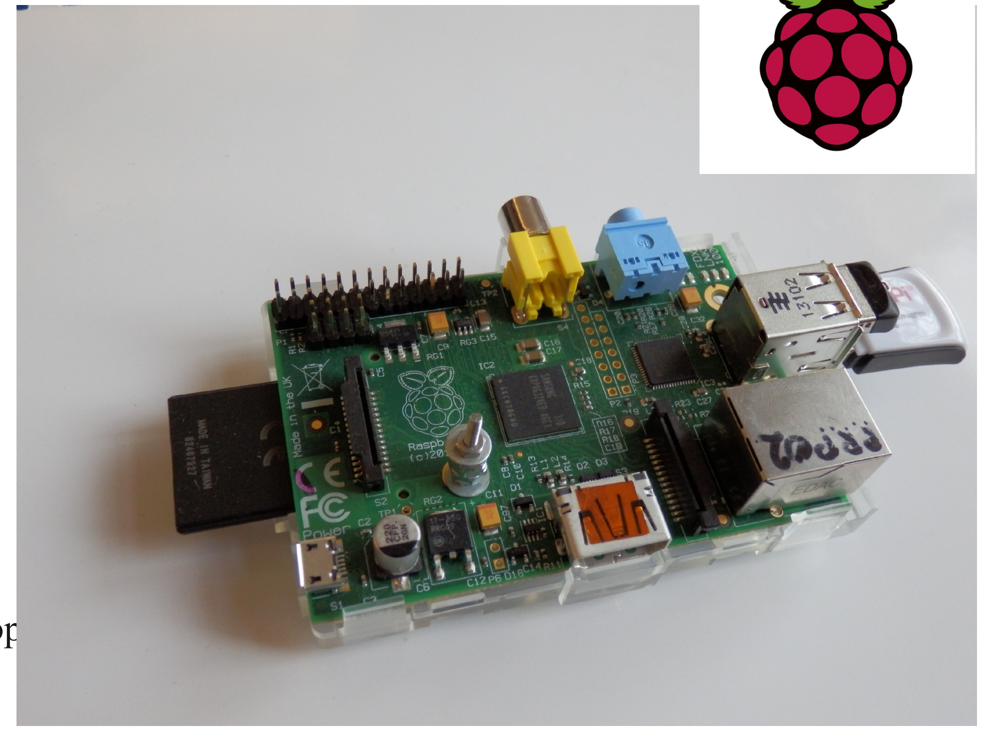


<u>Necessary system requirements :</u>

- Efficient focusing of pulsed UV light
- Actuator system (3D) : ~10 μm precision, 10ms response
- Fast ADC : >> 10 kHz
- Combined data acquisition system (ADC and actuator)

Data Acquisition : Machine

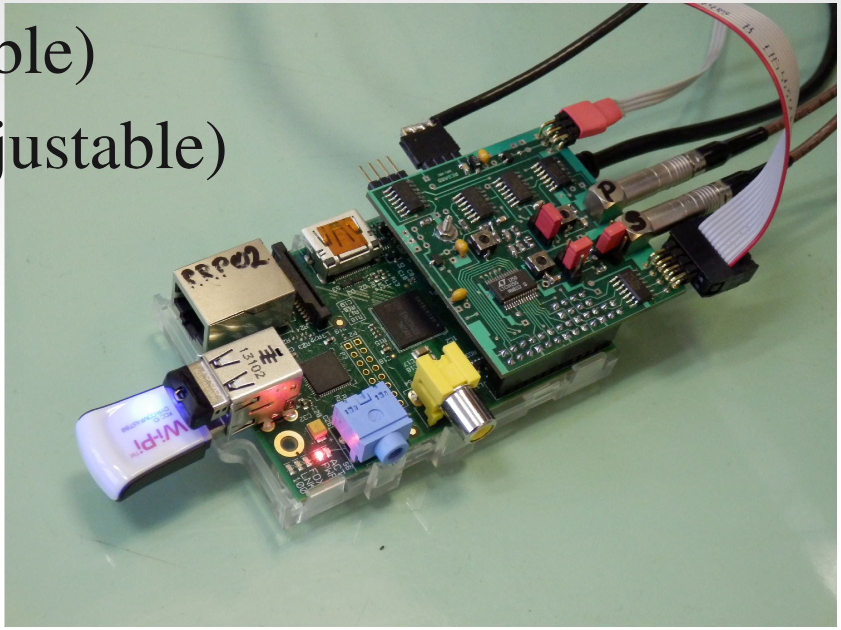
- Several options tested so far: Camac, PC+LPT
- Recent successfull implementation: RaspberryPi
- **Raspberry Pi** (is a tiny computer)
  - 700MHz ARM CPU + Broadcom 2835 chip
  - Periferials: USB, HDMI, SD, AV, Audio
- **GPIO pins (10MHz)**
- Low power consumption and low cost
- Raspbian **Linux** : Debian based OS
- WiFi connection



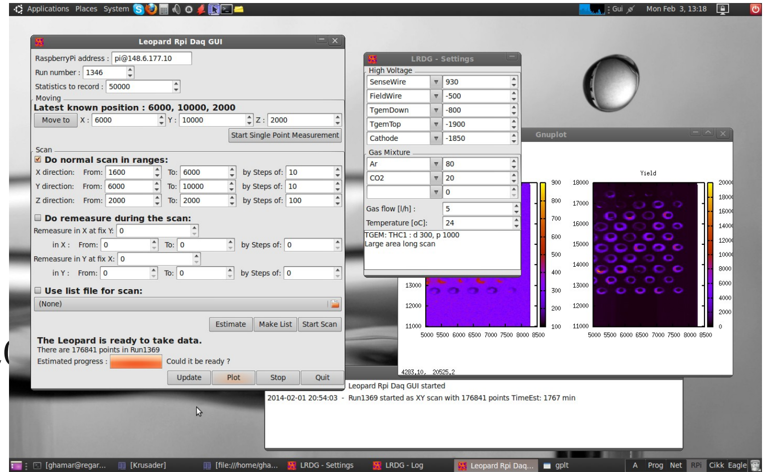
Data Acquisition : HW + SW

- Special **additional board**: fits to the GPIO pins
- Parallel-out single **ADC** (LTC1415)
- **Trigger** reciever and timing (adjustable)
- Signal shaping and amplification (adjustable)
- **Tagging** of rejected triggers
- **Direct actuator control**

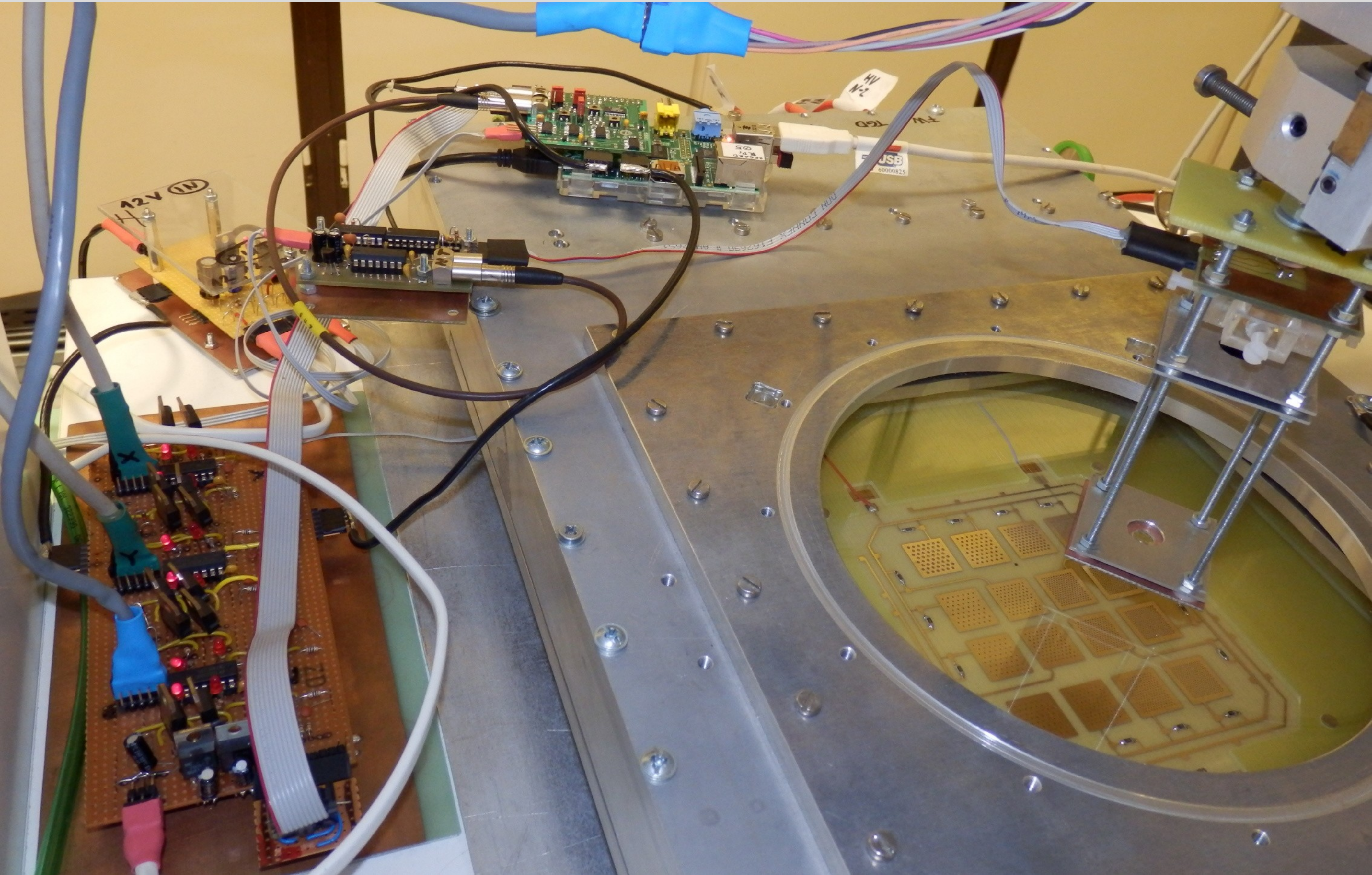
  (can be accomodated
  to any moving controls)



- Software: C,C++ runs on the RPi
- ADC (w DSP), save spectra
- Control 3D table and HV system
- GUI on remote PC (wxWidgets)



Presently Working Setup



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Setting the Focus

- Fine tuning from the data is essential

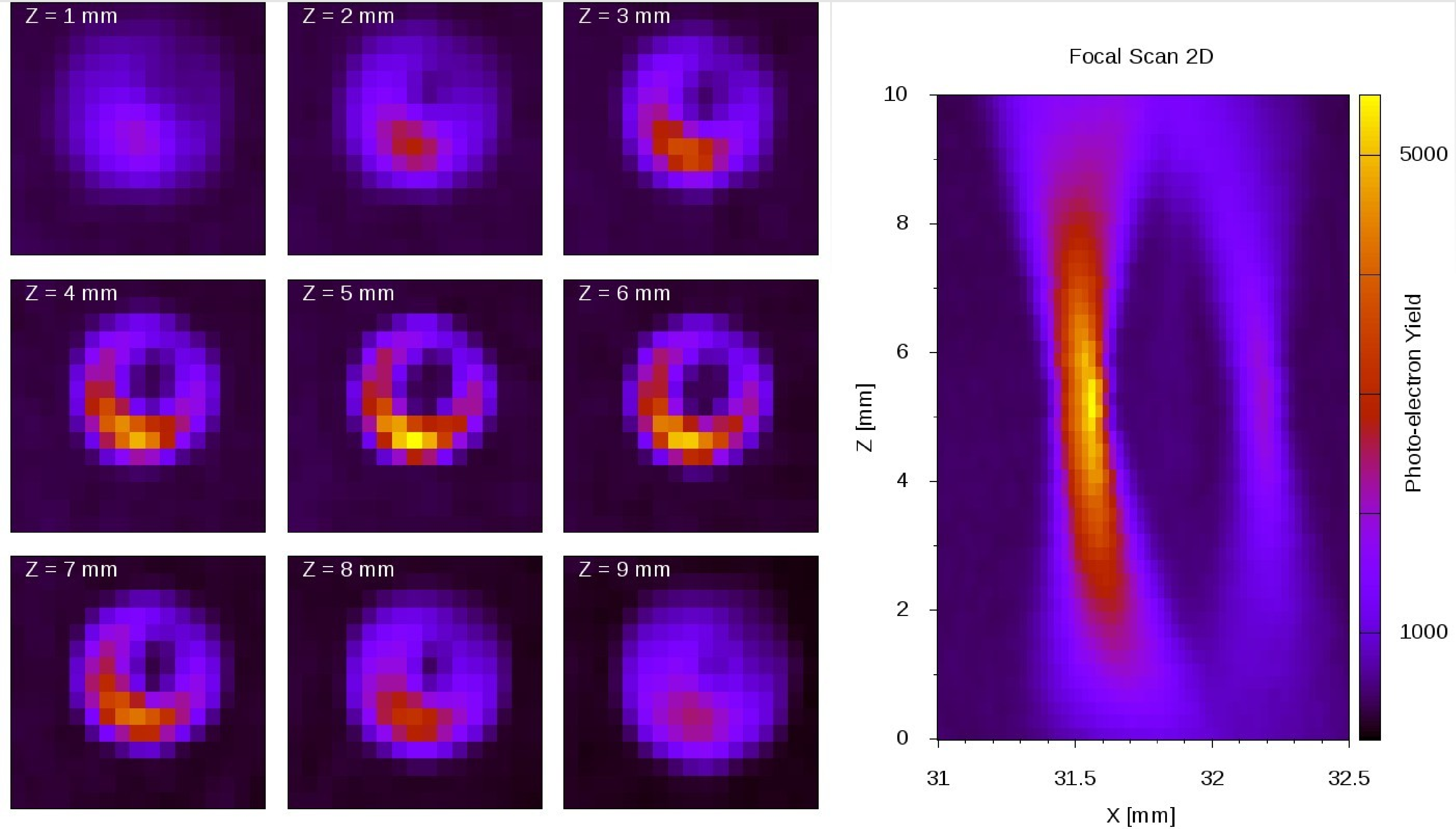
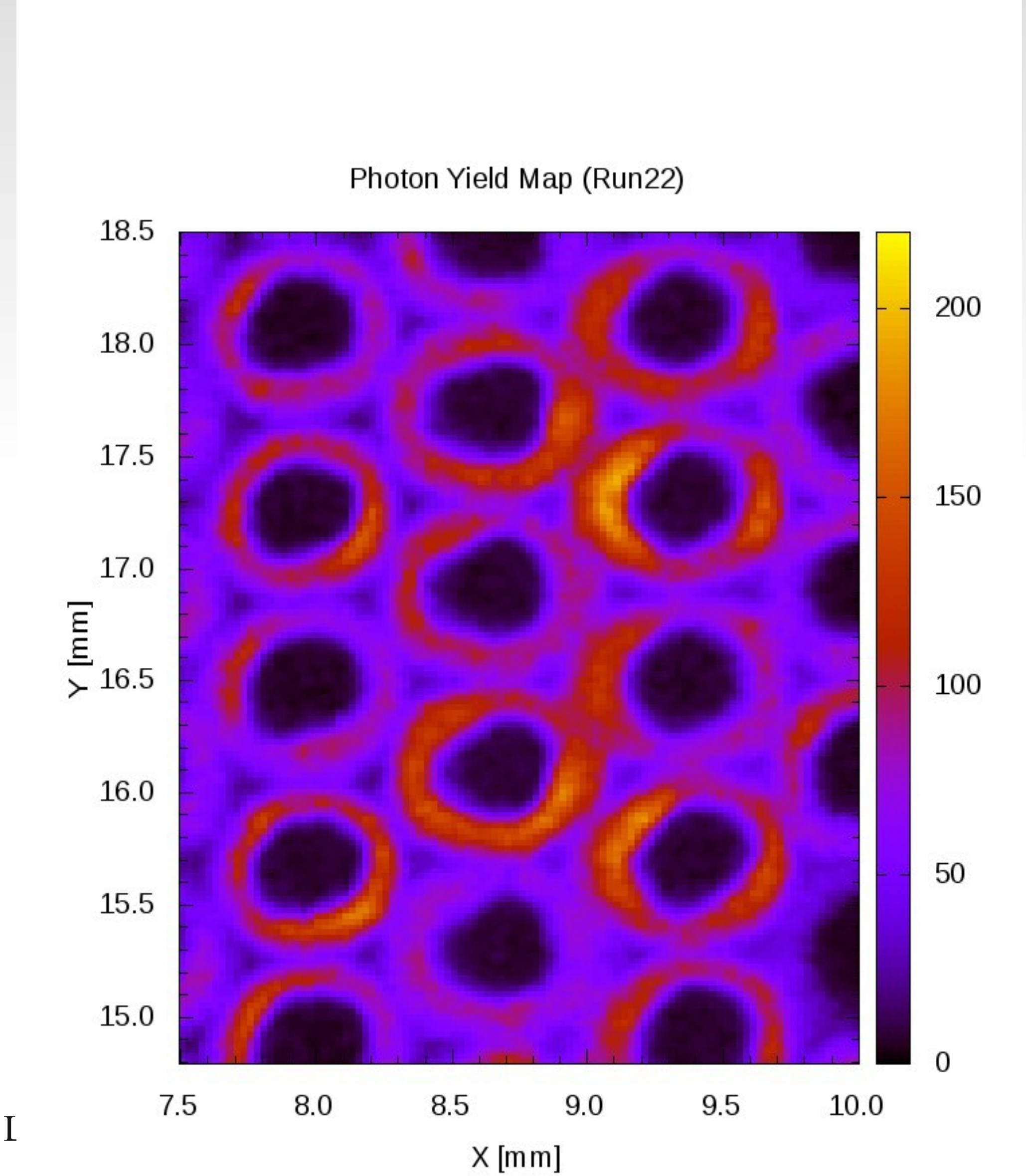


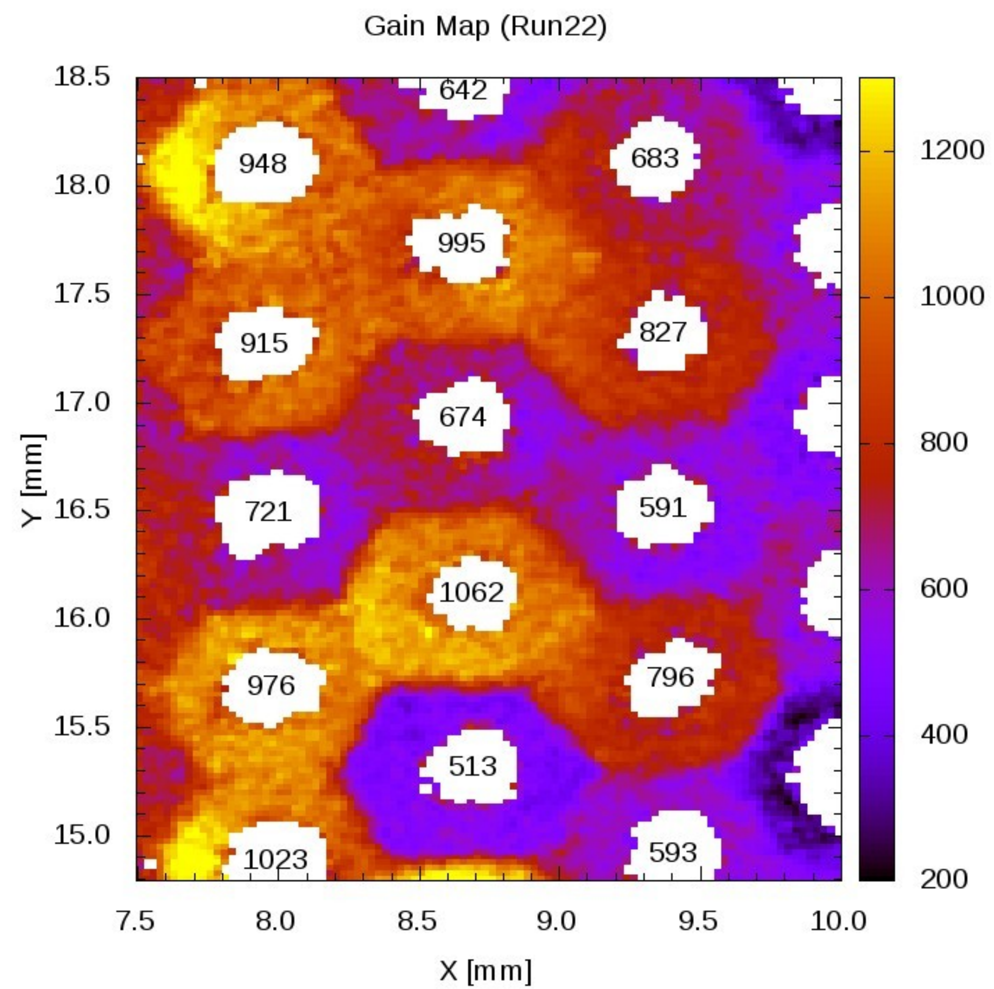
Photo-electron Yield Map

- Holes are visible
- Symmetry lines and points are **dark**
- **Ring-like** structure
- No azimuthal symmetry around the holes
- **Yield varies** from hole to hole (even by a factor of two)



Gain Map

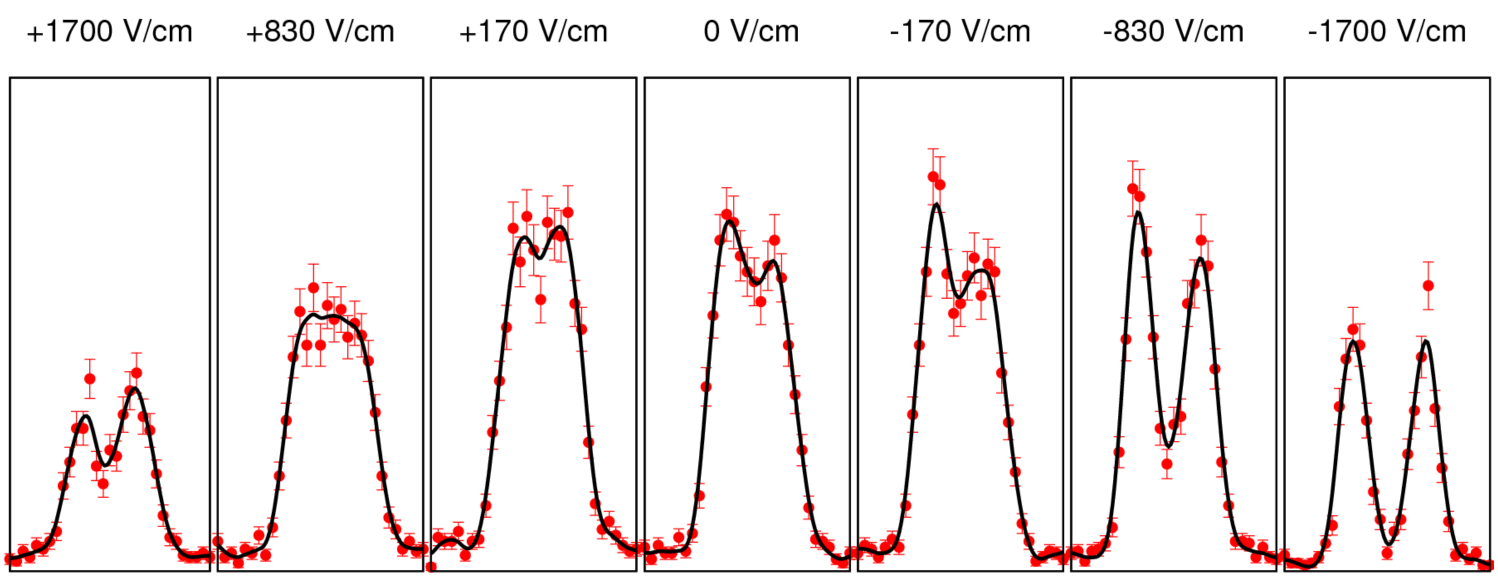
- Gain is measured for each measurement point
- Gain is constant in the hexagonal collection zone of a hole (**hole-gain**)
- Hole-gains vary a lot from hole to hole
- Only slightly correlates with the detected photon yields



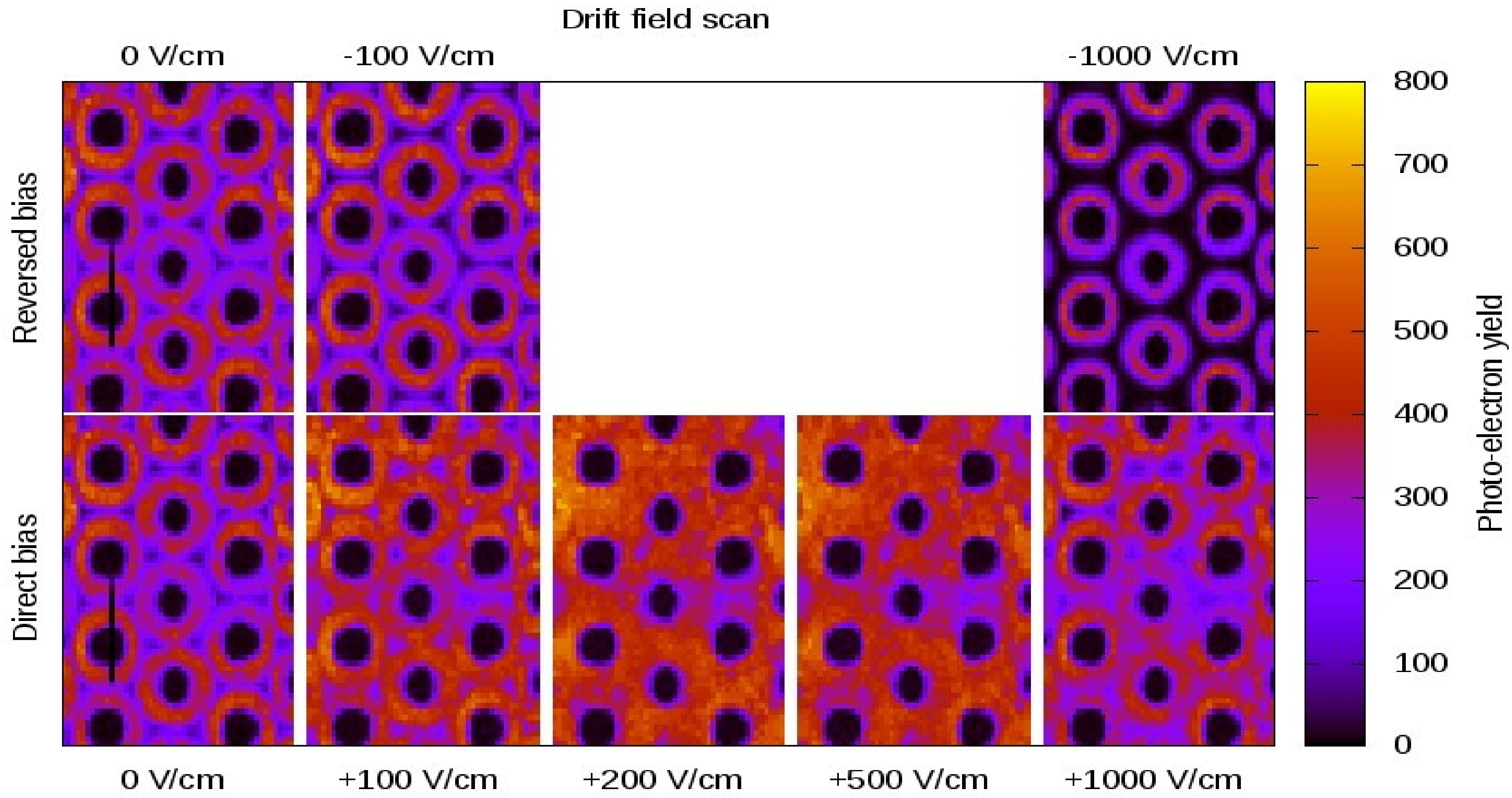
TGEM from CERN from 2009 !

The Role of the Drift Field

- High positive:
  electrons cannot leave the surface / pushed back
- High negative:
  electrons are drifting towards the cathode



The Role of the Drift Field



INFN Trieste + WignerRCP Budapest

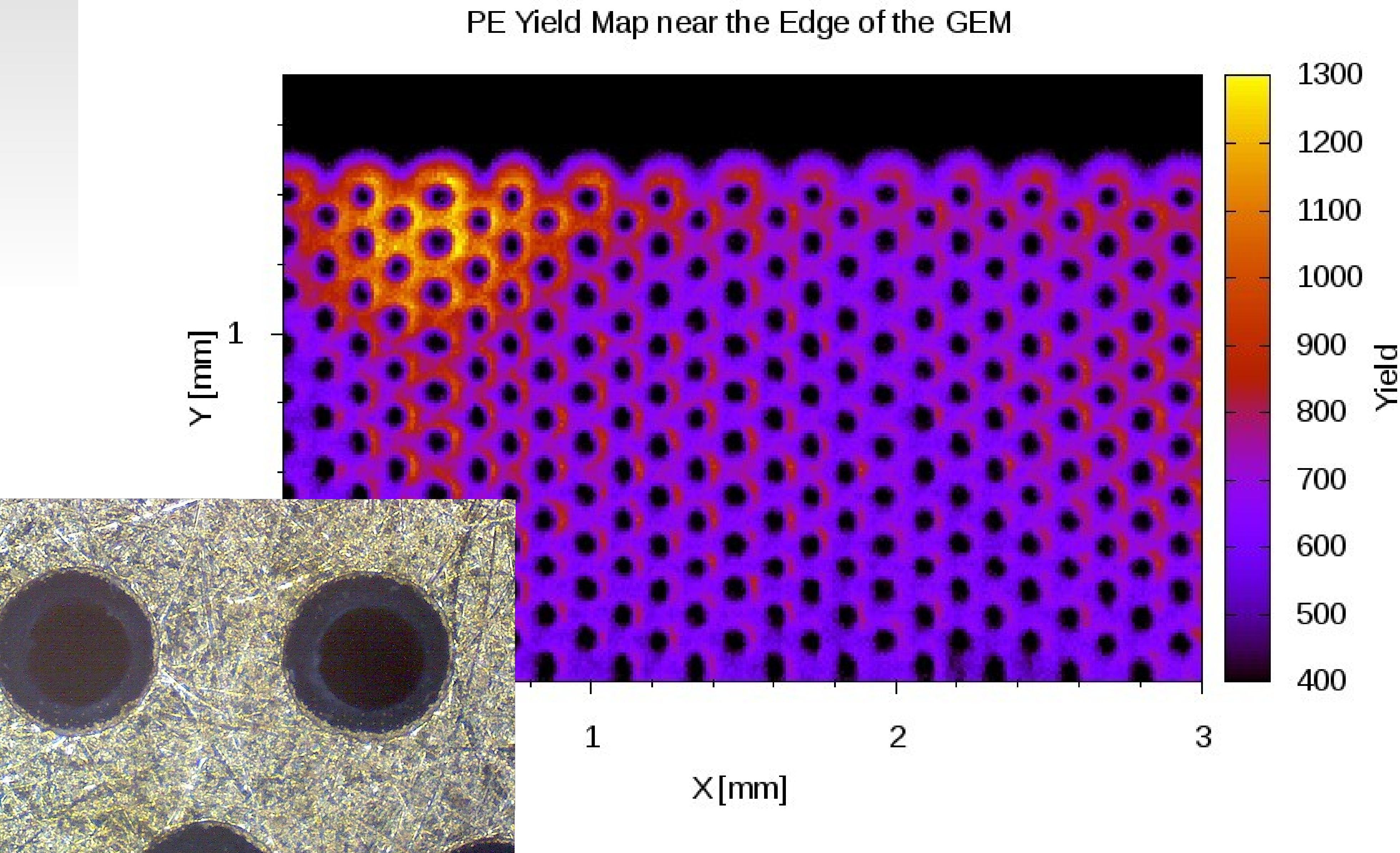
G.Hamar, F.Tessarotto, S.Levorato, S.Dalla Torre, S.S.Dasgupta, D.Varga

Normal GEM

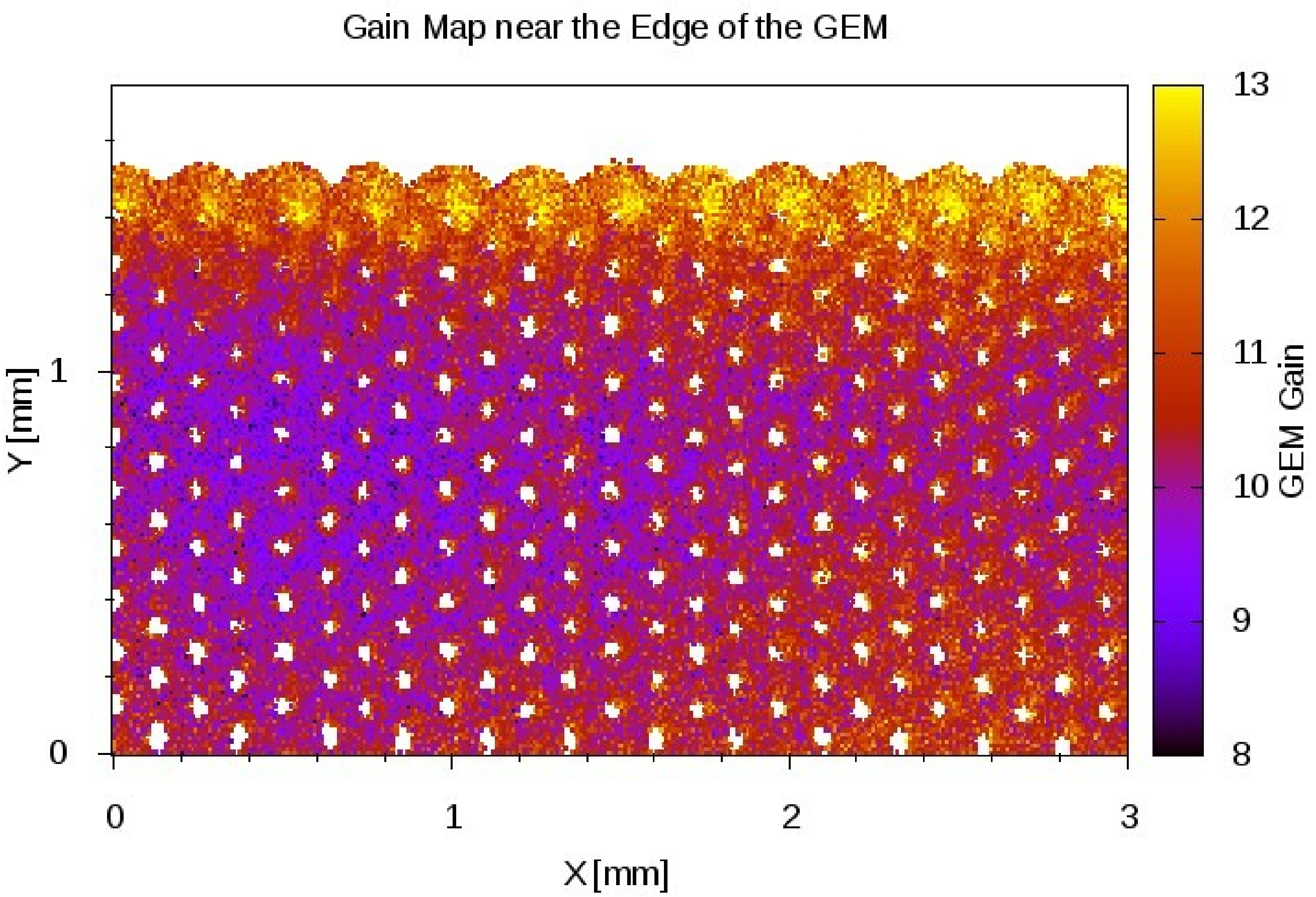
- Is it possible to study the microstructure of a normal thin GEM foil (with holes of 70µm) ?
- Precision of 10-20 µm is needed
- Is gold cover necessary?

- Pinhole of 30 um was installed
- Standard copper covered normal GEM has been checked for the first time ...

Normal GEM

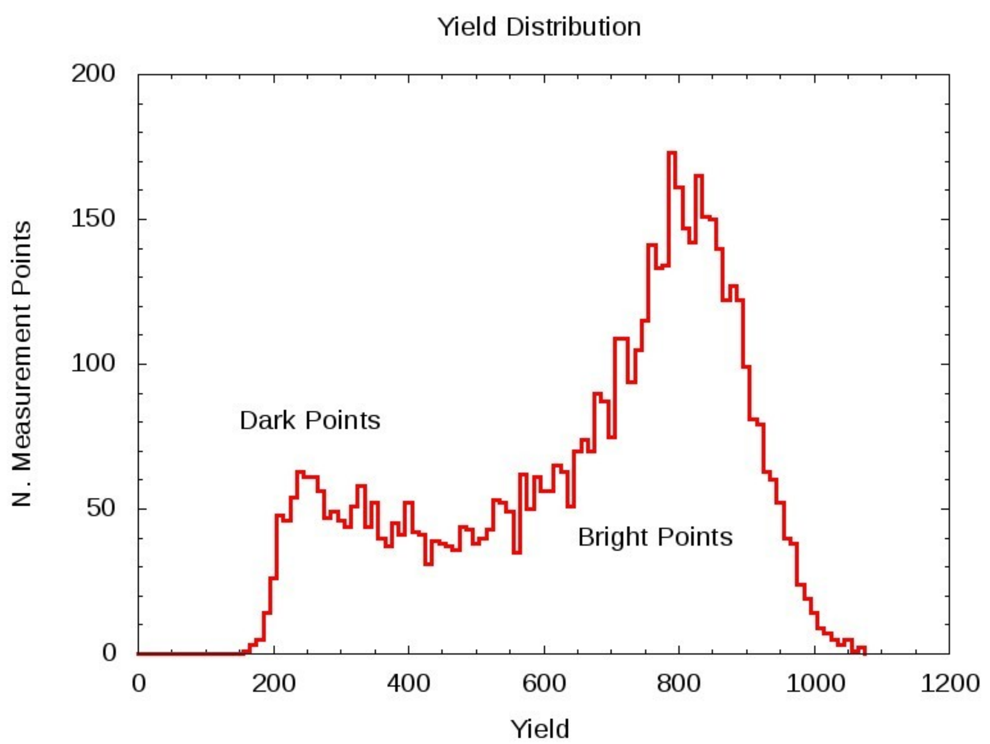

PE Yield Map near the Edge of the GEM
Y [mm]
1
X [mm]
1
2
3
1300
1200
1100
1000
900
800
700
600
500
400
Yield

Edge of the GEM



Defining Holes

- Same methodes as for TGEMs
- Define dark points
  (dark yield is shifted due to non negligible backgroud)
- Clusterize dark points (hole candidates)
- Define hole area
  (closest point)
- Compute "hole-gain"
  and/or other
  hole-level quantities



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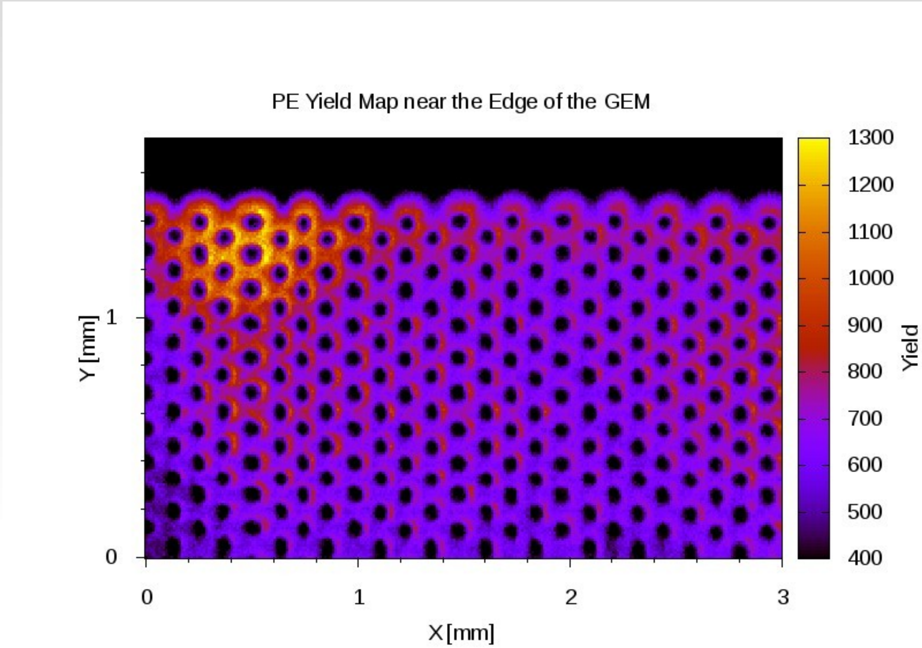
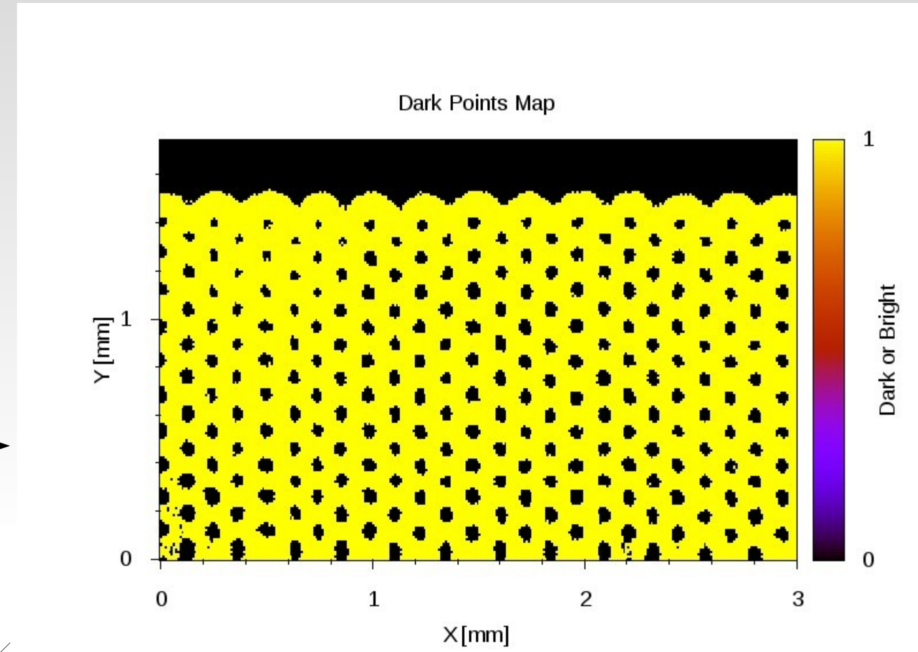
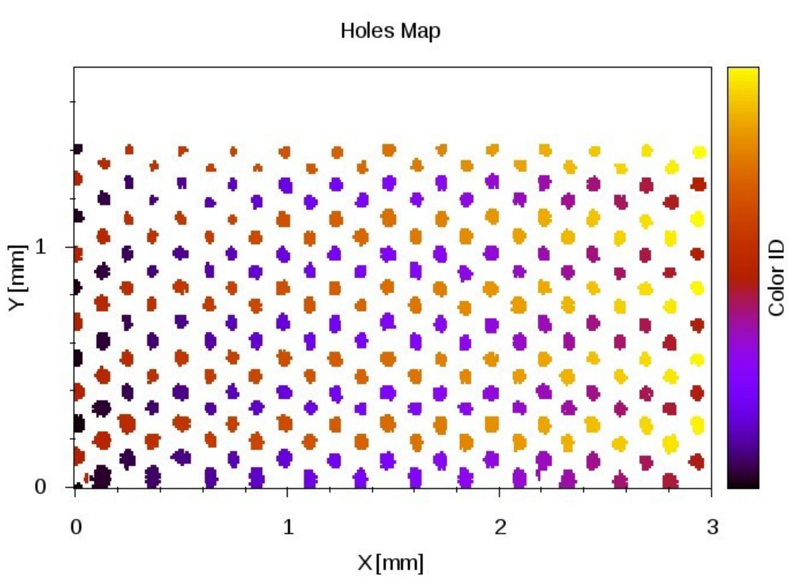
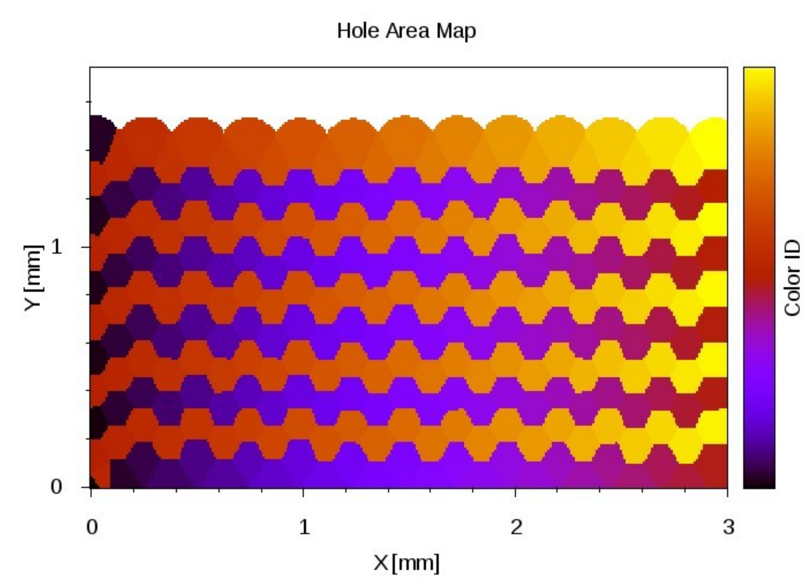






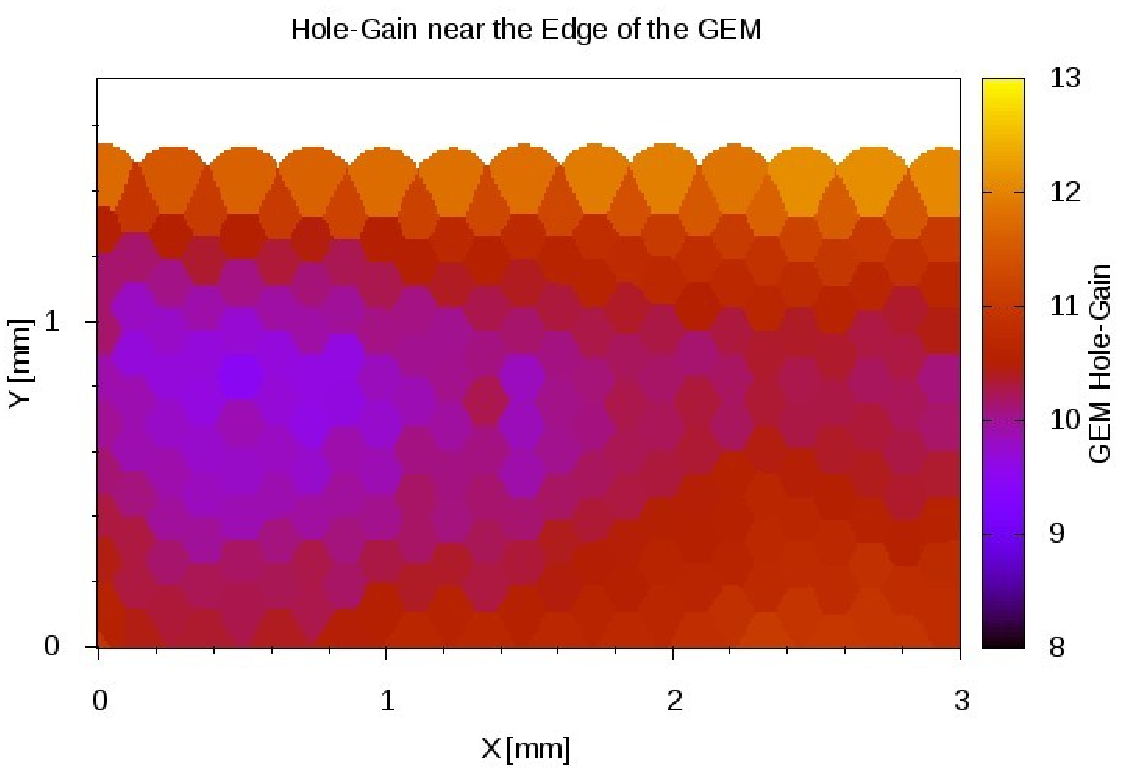
n GEM

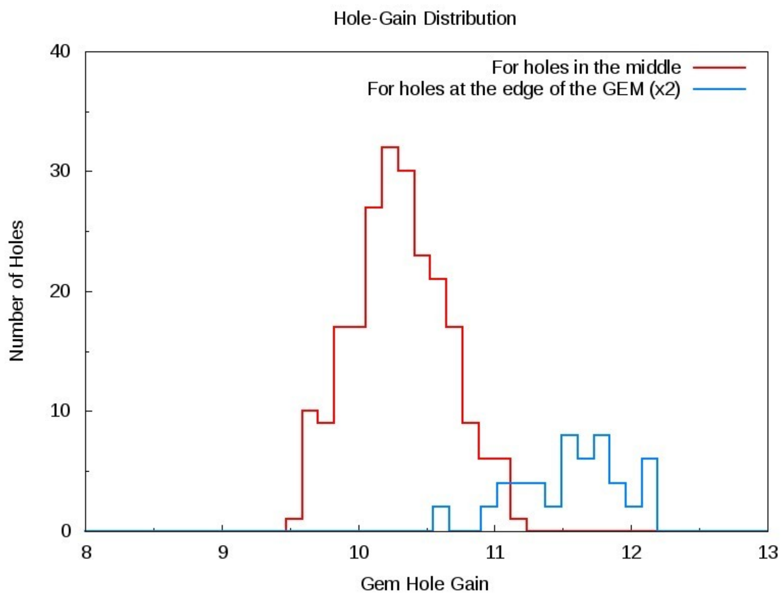


Hole-gain

- Hole-gain distribution : sigma < 5% in the sample
- Larger gain along the edge

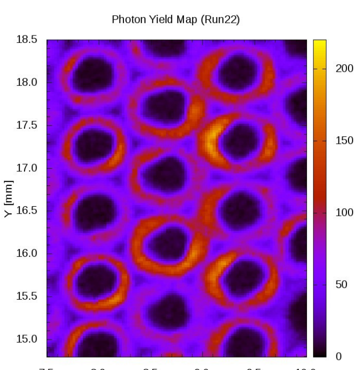
  (higher surface charge on the metal border?)

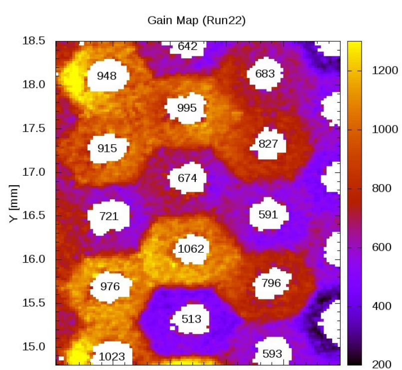


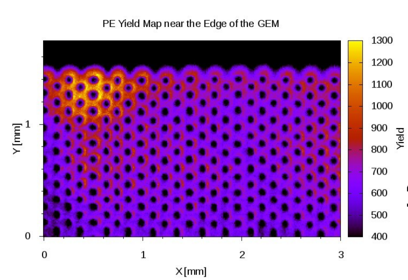


Summary

- **Micropattern based Cherenkov detectors**
- **Leopard System**
  - Single MPGD (with a postamplification stage)
  - Focused UV light mounted onto a moving table
    + a fast controlling and DAQ part with RaspberryPi
- **Detailed ThickGEM Studies**
  - Hole-by-hole variations, inhomogenities
  - Hole-gain structure, uniformity evaluation
- **Optimization** and **Finetune simulations**
  and **QA for production**
- **Normal GEM foils** became accessible



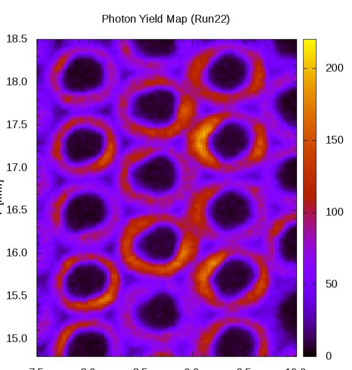


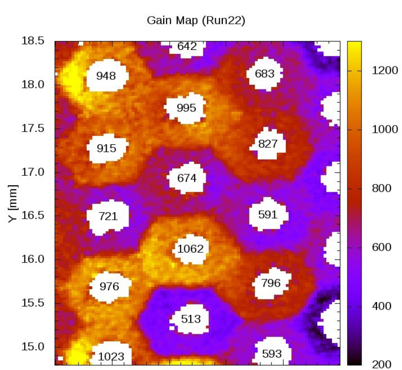


Backup slides

Future Plans

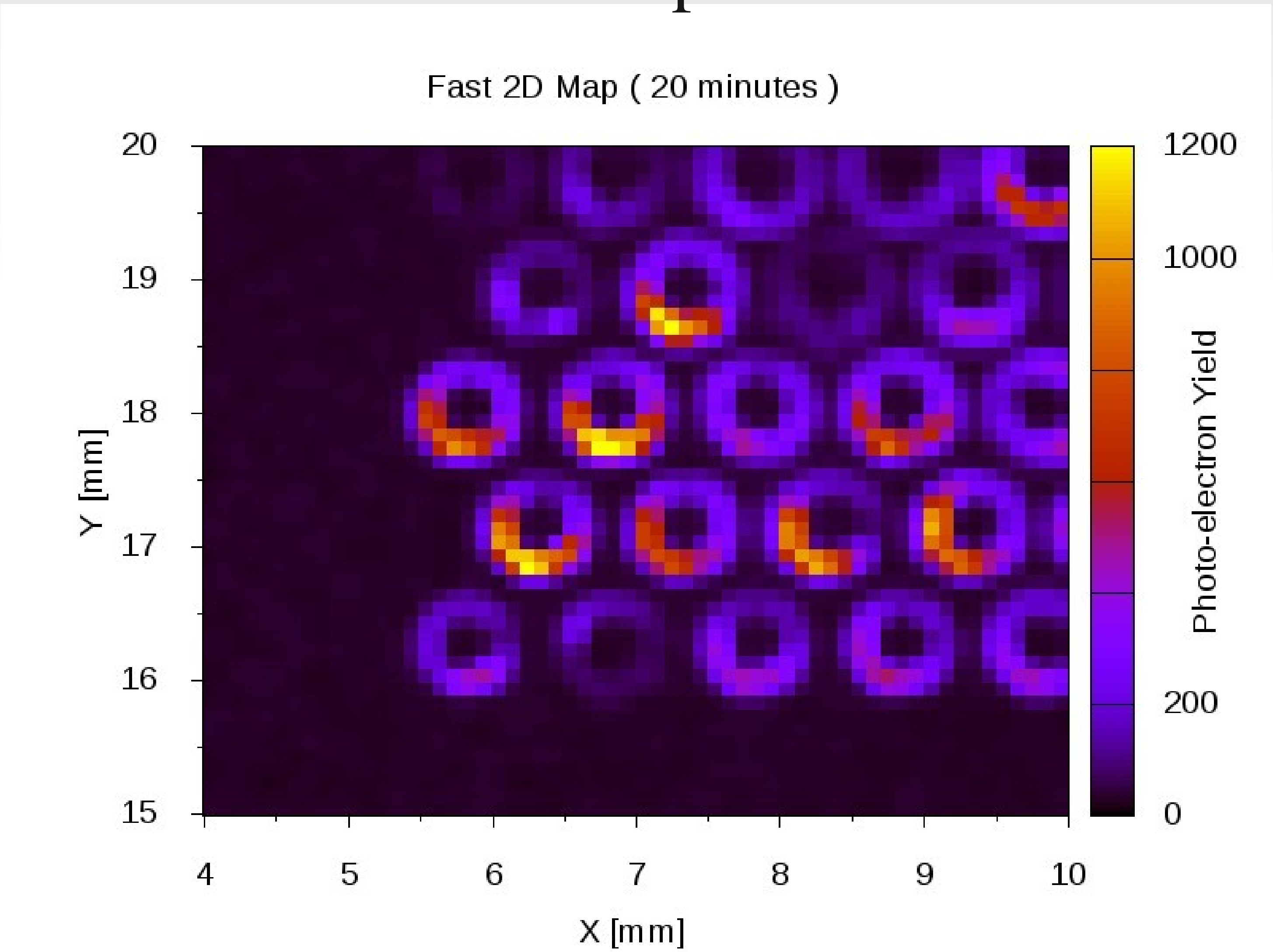
- Detailed studies on different geometries and applicable gases with TGEMs
- Correlation with optical checks, and with production procedures and failures.
  A new device for Quality Assurance ?
- Exploration of the microstructure on thin GEM foils
- Fine tuning input for simulations



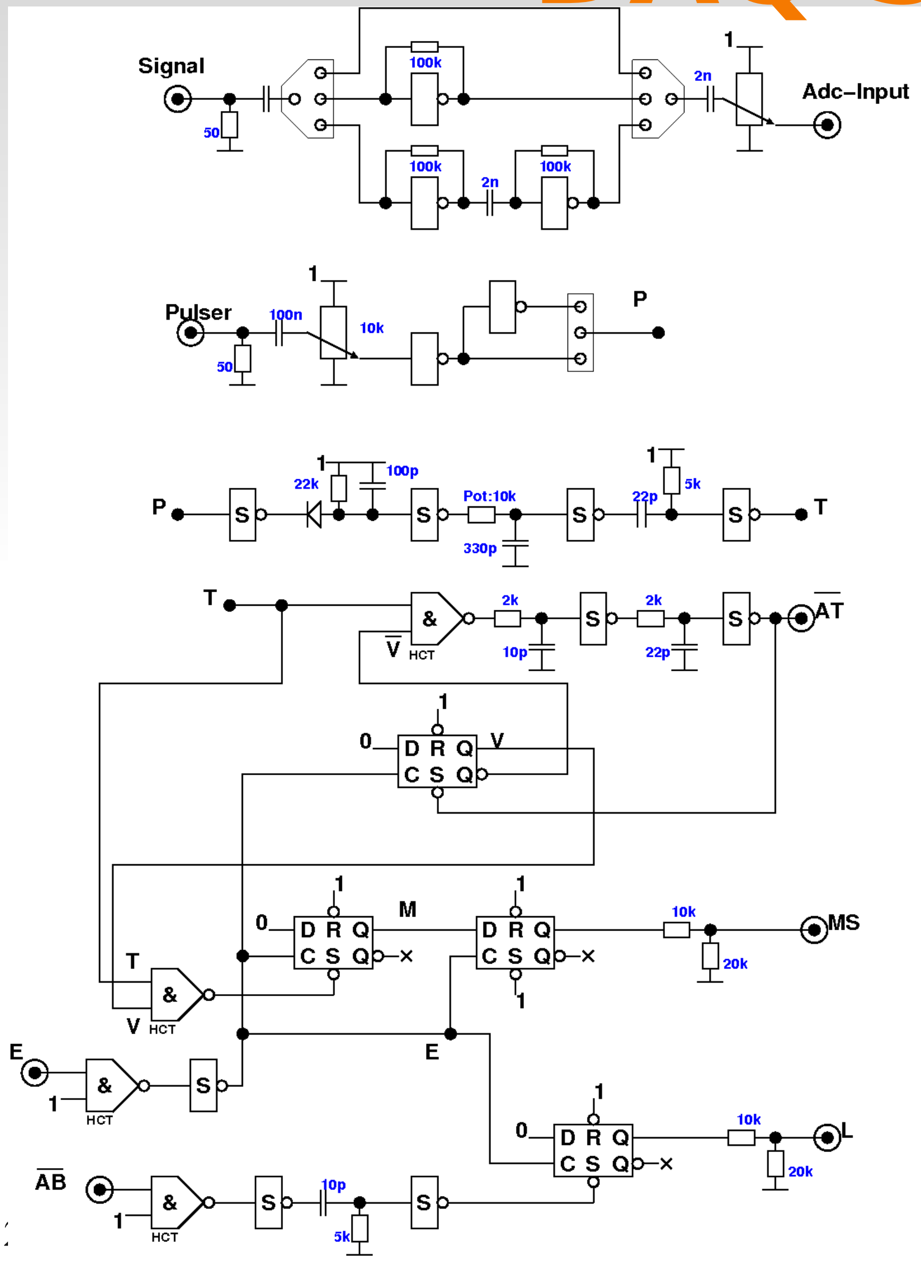


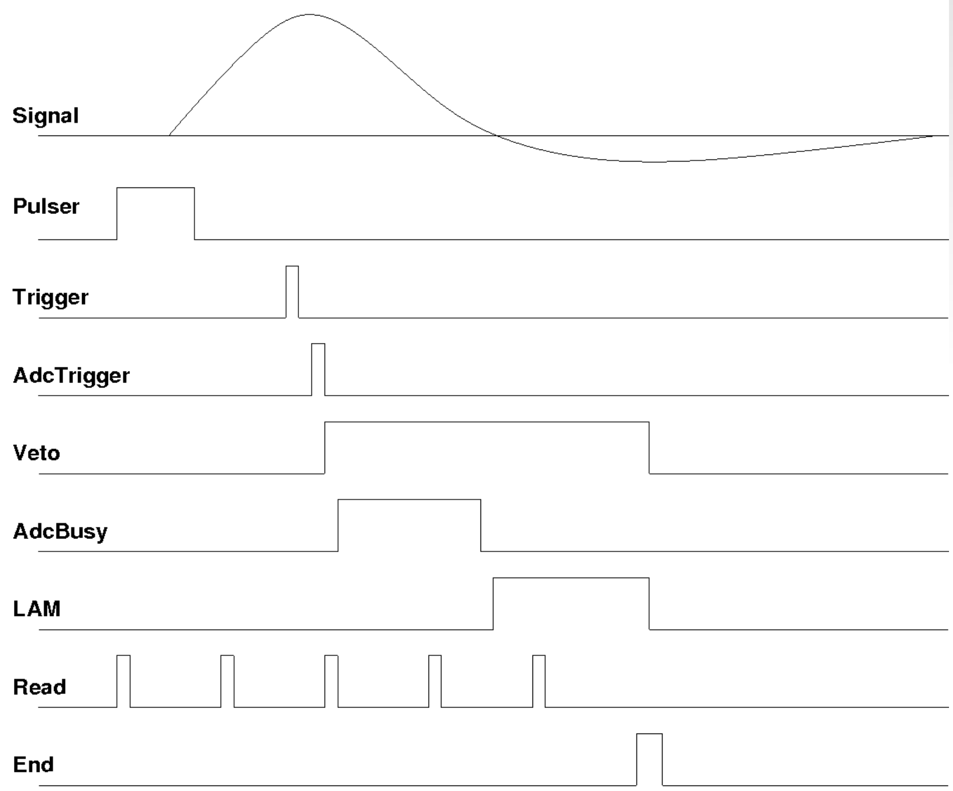
Speed : 20 min run

- DAQ rate : 120 kHz achieved
  with 99.5 % events accepted



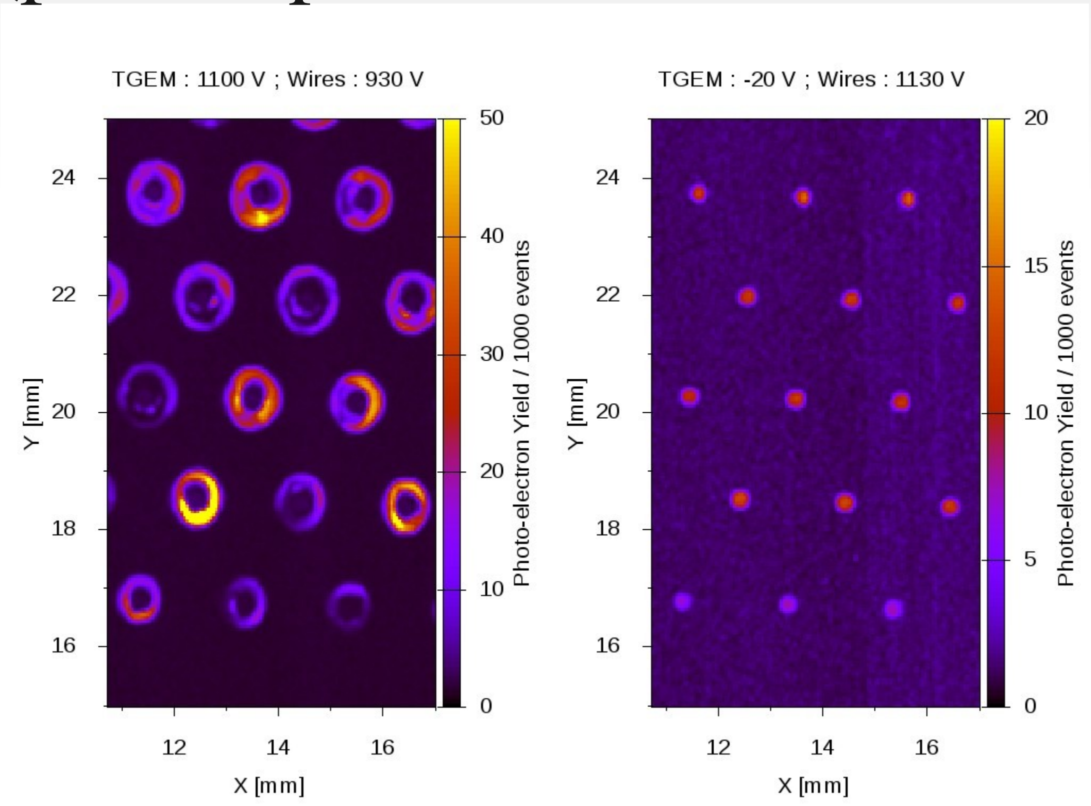
DAQ Scheme


Signal
50
100k
2n
1
Adc–Input
Pulser
100n
10k
P
22k
100p
Pot:10k
330p
22p
5k
T
&
V
HCT
2k
10p
AT
0
D R Q
C S Q
M
MS
20k
E
AB
L


Signal
Pulser
Trigger
AdcTrigger
Veto
AdcBusy
LAM
Read
End

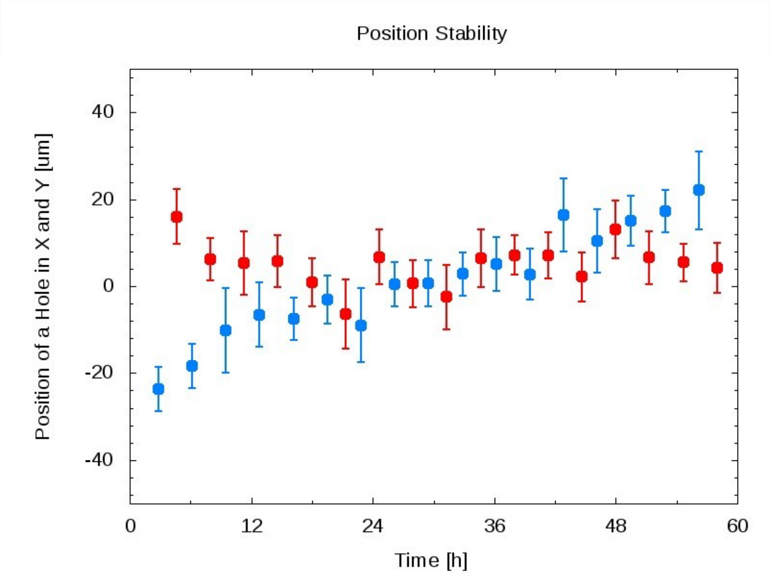
Gain calibration of the MWPC section

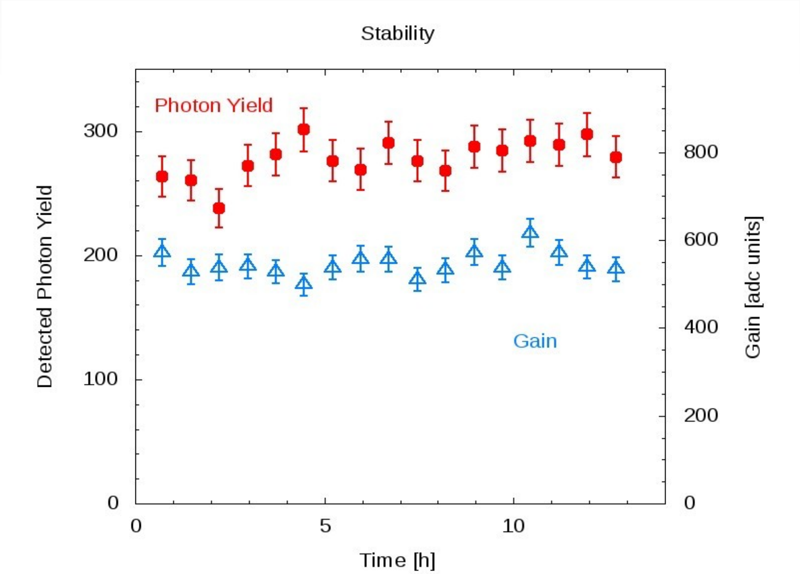
- Single TGEM exploration
- Underlying structure (post amplification MWPC stage) is measureable via shining **through the holes**



Stability

- **Regular remeasuring** of a given region near a hole
- UV LED yield slightly varies with time
- Gain roughly stable
- Actuator system : +/- 20 µm through a day, on a 1 mm range





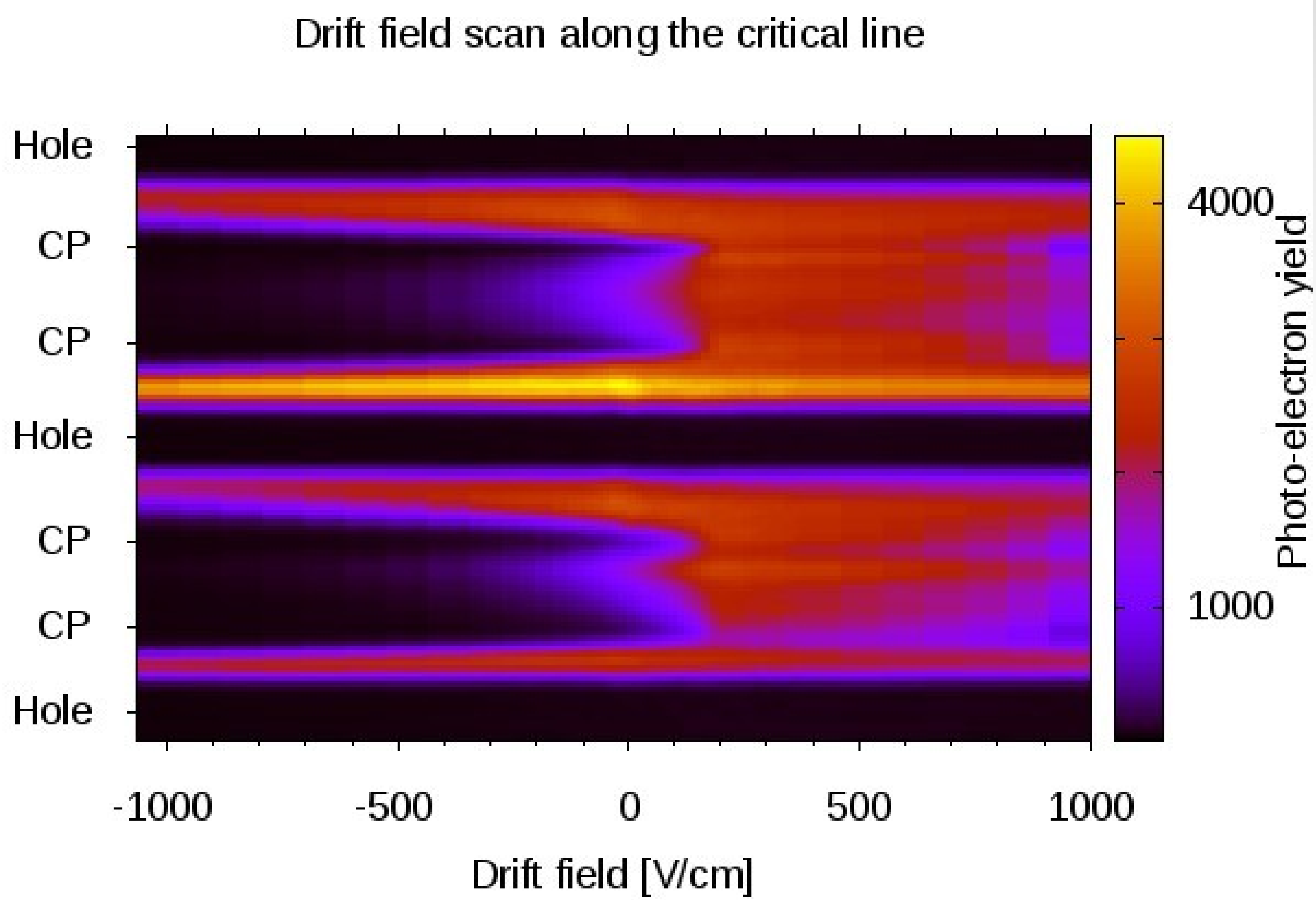
- **The system is stable enough to perform long measurements**

Budapest + Trieste measurements

- RD51 Common Project
- COMPASS RICH upgrade
- TGEM + MM Hybrid
  for low ion back-flow and high gain operation
- Study of candidated geometries in Ar/CH4 mixture
- Behaviour of the Critical/Symmetry Points

Crew: Gergő Hamar, Fulvio Tessarotto, Stefano Levorato, Silvia Dalla Torre, Shuddha Shankar Dasgupta, Dezső Varga

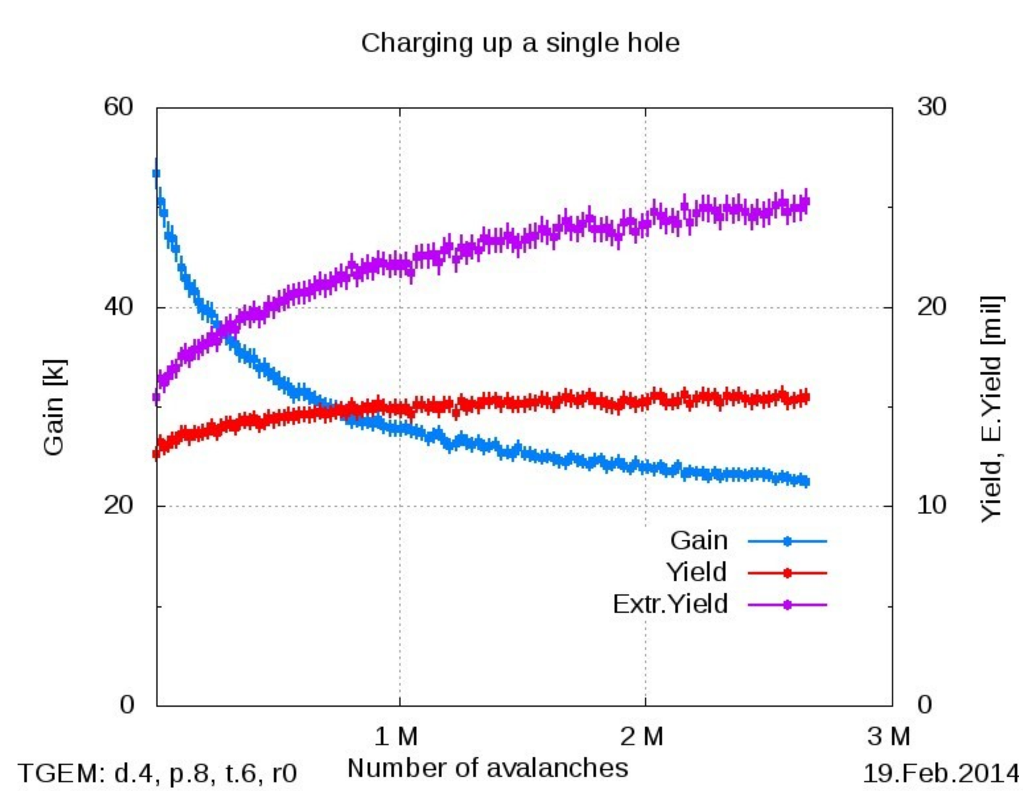
The Role of Drift Bias

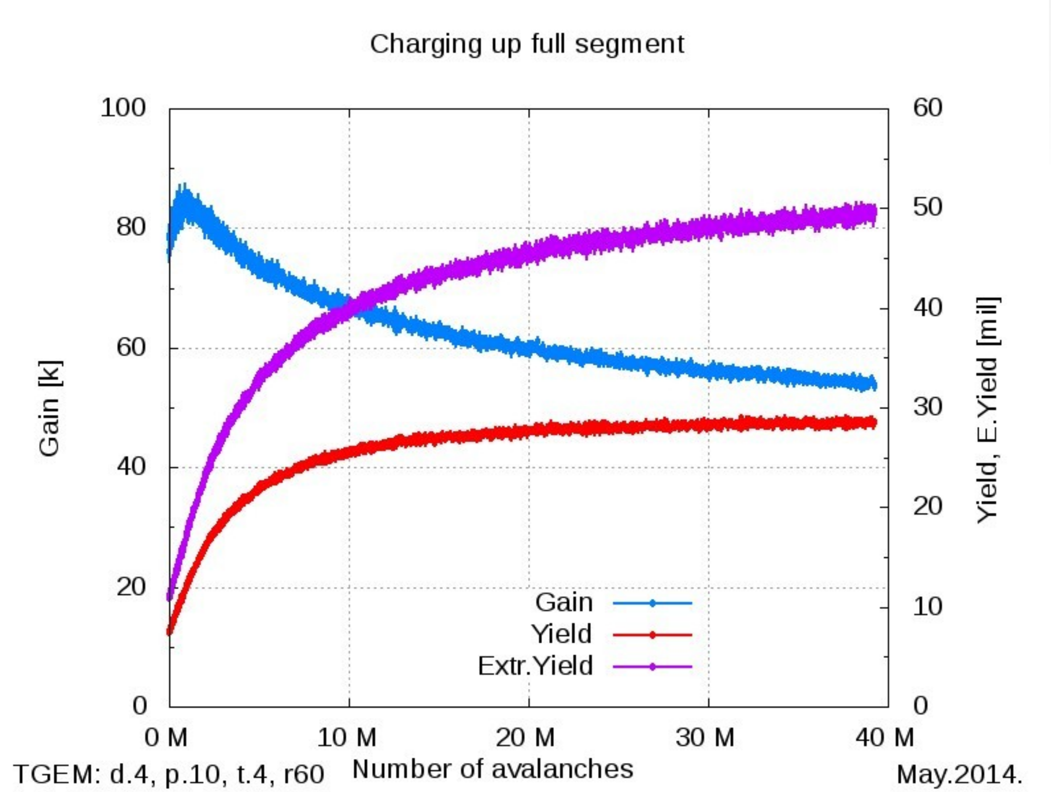


INFN Trieste + WignerRCP Budapest
G.Hamar, F.Tessarotto, S.Levorato, S.Dalla Torre, S.S.Dasgupta, D.Varga

Charge Up ...

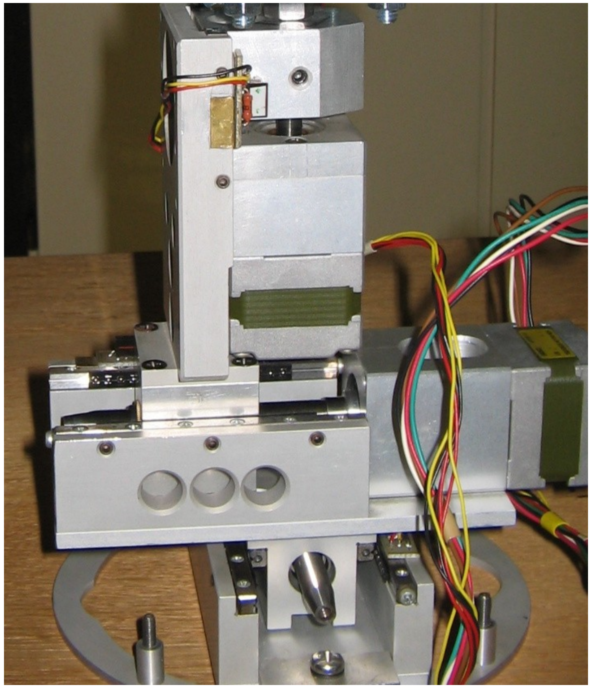
- Single hole charge up became possible
- Gain drops while PE yield increases !
- Effect on : single point / single hole / full segment ?
- Charge-up during scanning measurements





Actuator System

- Stepping motors for all axis
- Good resolution : 2.5 μm
- Direct control
- Mounted upside-down on
  a support table



Larger (20cm)
and faster version
became ready
recently