# TCPD
## a TGEM Based Hybrid UV Photon Detector for Cherenkov Applications

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ALICE-Budapest and ALICE VHMPID Groups

# Outline

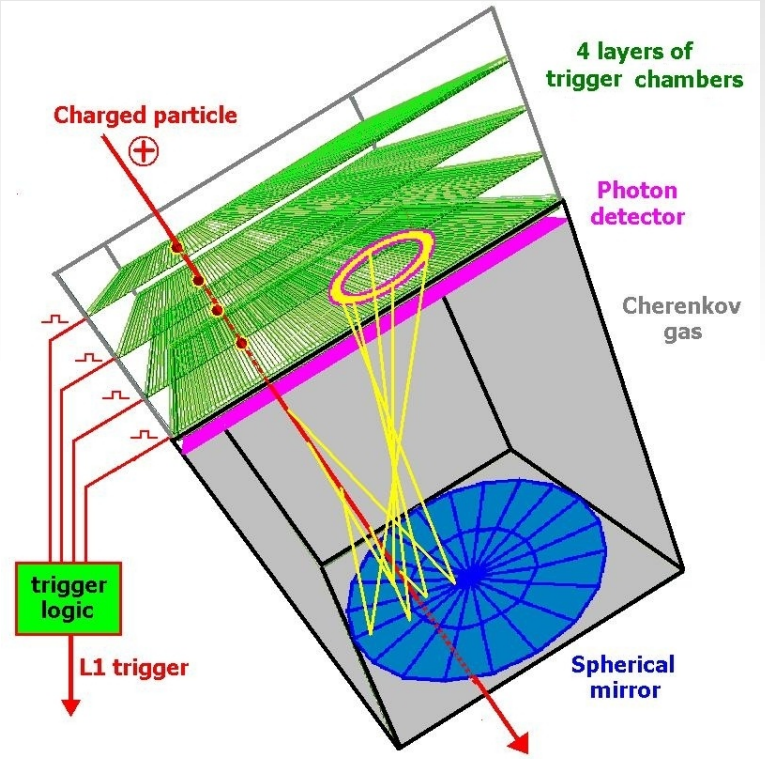
- **Motivation**
- **TCPD outline**
- **Laboratory setup**
- **Beam tests for RICH**
- **MIP Suppression**
- **Leopard**
- **Summary**

# VHMPID

## (Very High Momentum Particle Identification Detector)

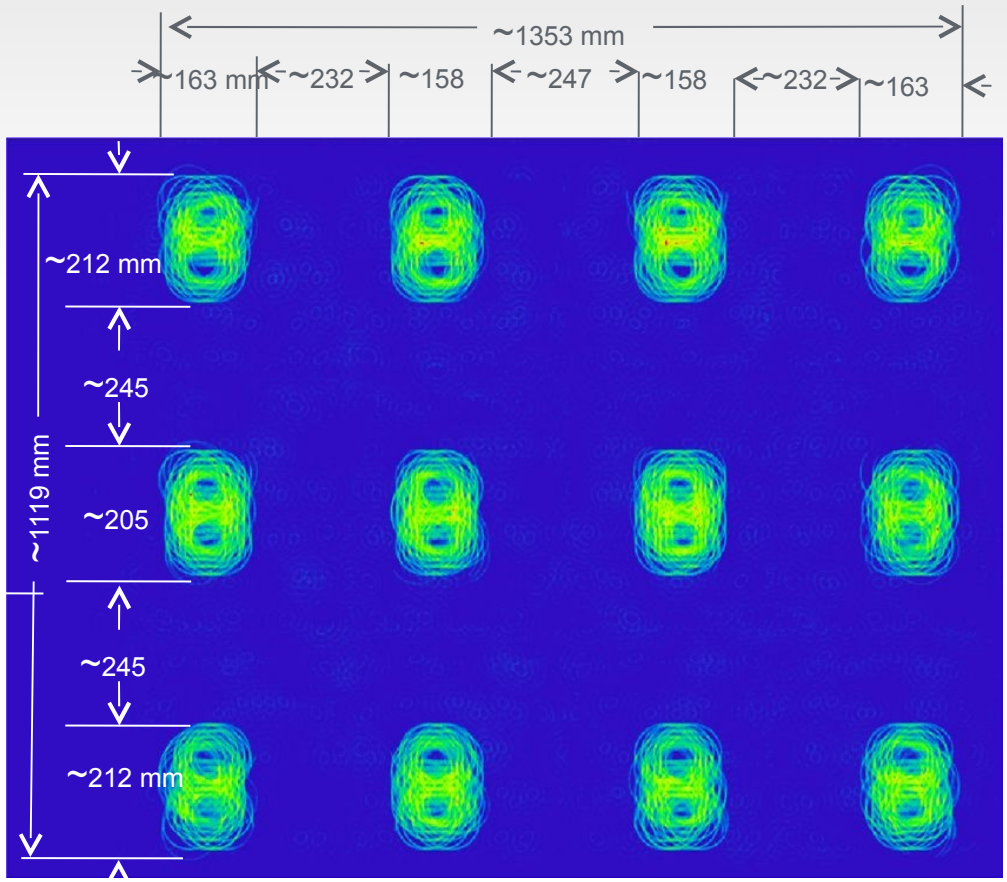
- ALICE R&D Project was.. :(
- Gaseous Cherenkov detector
- Mirrors to produce rings
- Photon detection
- Heavy-ion physics

  PID at high momenta track level,
  Jet suppression, Di-/Multi-hadron fragmentation function,
  Proton-pion anomaly,
  Correlations: photon-jet, hadron-hadron.



# VHMPID's Photon Detector

- Cherenkov photon detection
- Tilted focusing mirrors
- Several windows
  ~20x20 $cm^2$
  (quartz, $CaF_2$)
- CsI coating
- MWPC / TGEM /
  GEM / TCPD / ?

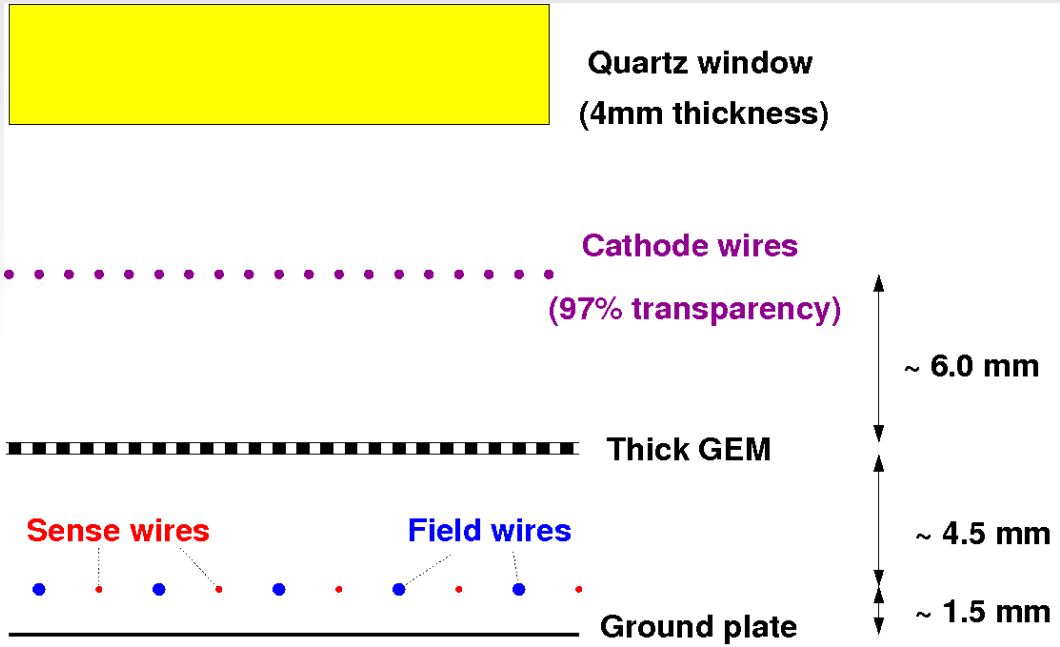


# Photon detection…

- **MWPC for photon detection**
  - (+) Full surface
  - (-) Ion backflow
  - (-) Feed-back photons
  - (-) Large MIP signal
  - (-) Mechanical precision
- **ThickGEM based photon detection**
  - (+) Reduced ion backflow
  - (+) No feed-back photons
  - (+) MIP suppression
  - (-) Multi-layers (2-3) raise cost
- **Close Cathode Chamber (CCC)** [ NIM A 648 (2011) 163]
  - (+) Mechanical tolerance, simple construction
  - (+) Low material budget

# TCPD Outline
## (ThickGEM+CCC Photon Detector)

- A known configuration applied for photon detection
- UV-transparent quartz window
- Wire plane for cathode
- ThickGEM, upper surface could be coated with CsI
- Standard CCC wire layout
- Padplane on ground




Combines most of the advantages of both technologies

Applied TGEM: 0.4mm thickness, 0.3mm hole diameter, 0.8mm pitch, 0.06mm rim.Typical gain : 10-100

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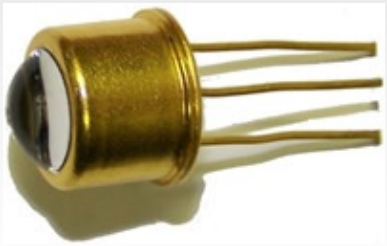
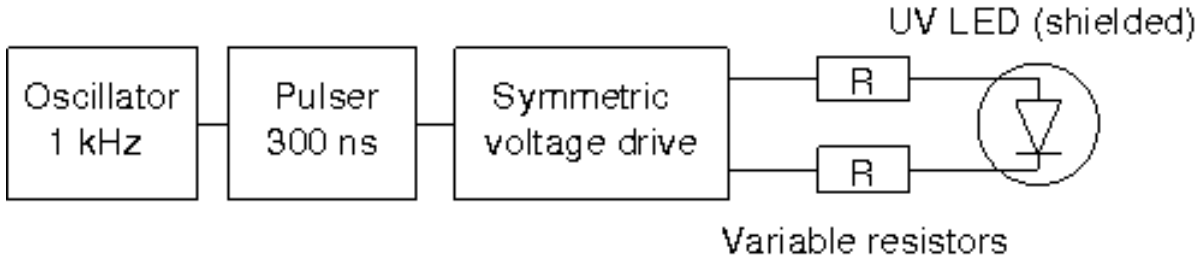
# Laboratory setup

- First prototype : 10cm x 10cm active area
- Gas: Ar/$CO_2$
- Beta source (Sr-90), triggering on scintillator
- Measure TGEM absolute gain in the low amplification regions as well via reversed / normal cathode field
- Single photo-electron response
  UV photons by pulsed LED
- Read out the connected wires / pads

# Photon Source : UV LED

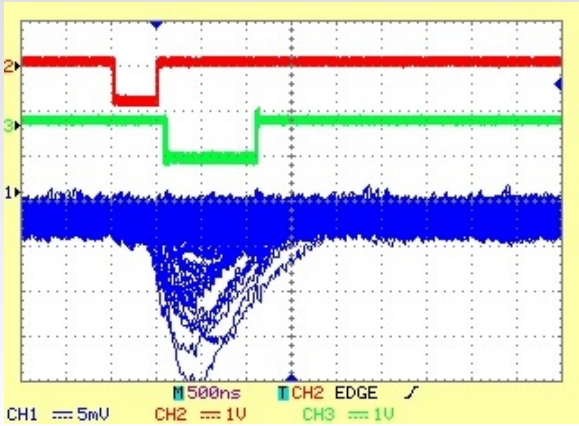
- SETi UV TOP 240
  - 245 nm peak;  10 nm width
  - Photo-electrons from gold surface
- UvLed Driver Unit
  - Home made for our specification
  - Short pulses (adjustable : 50-500 ns)
  - 1 kHz frequency (adjustable)
  - Intensity : adjustable with two resistors
- *Smooth change of PE yield over time in the hours scale*

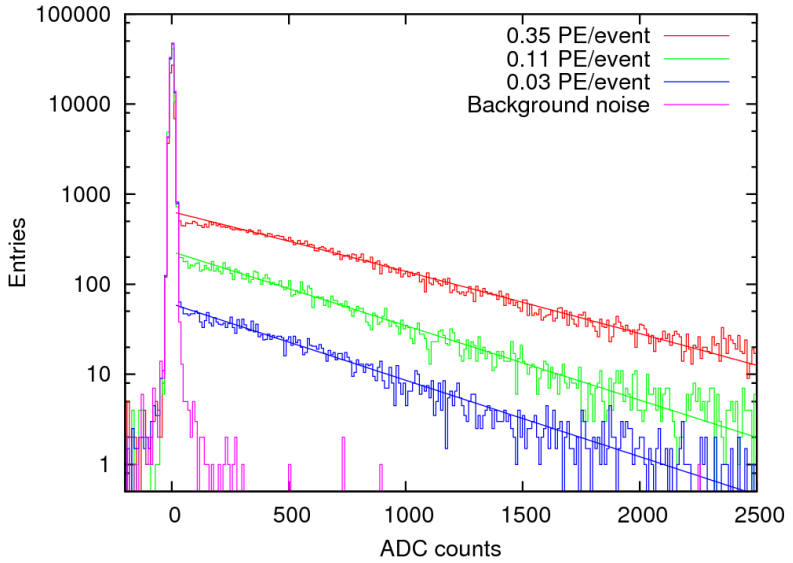




# Single Photo-electrons

- Swarm of photons,
  but low quantum efficiency
- Adjustable intensity
  --> average number of
  photo-electrons per pulse can be set
- Negligible multi-electron events
- Pulse-height spectra are similar
  for the different
  photo-electron yields



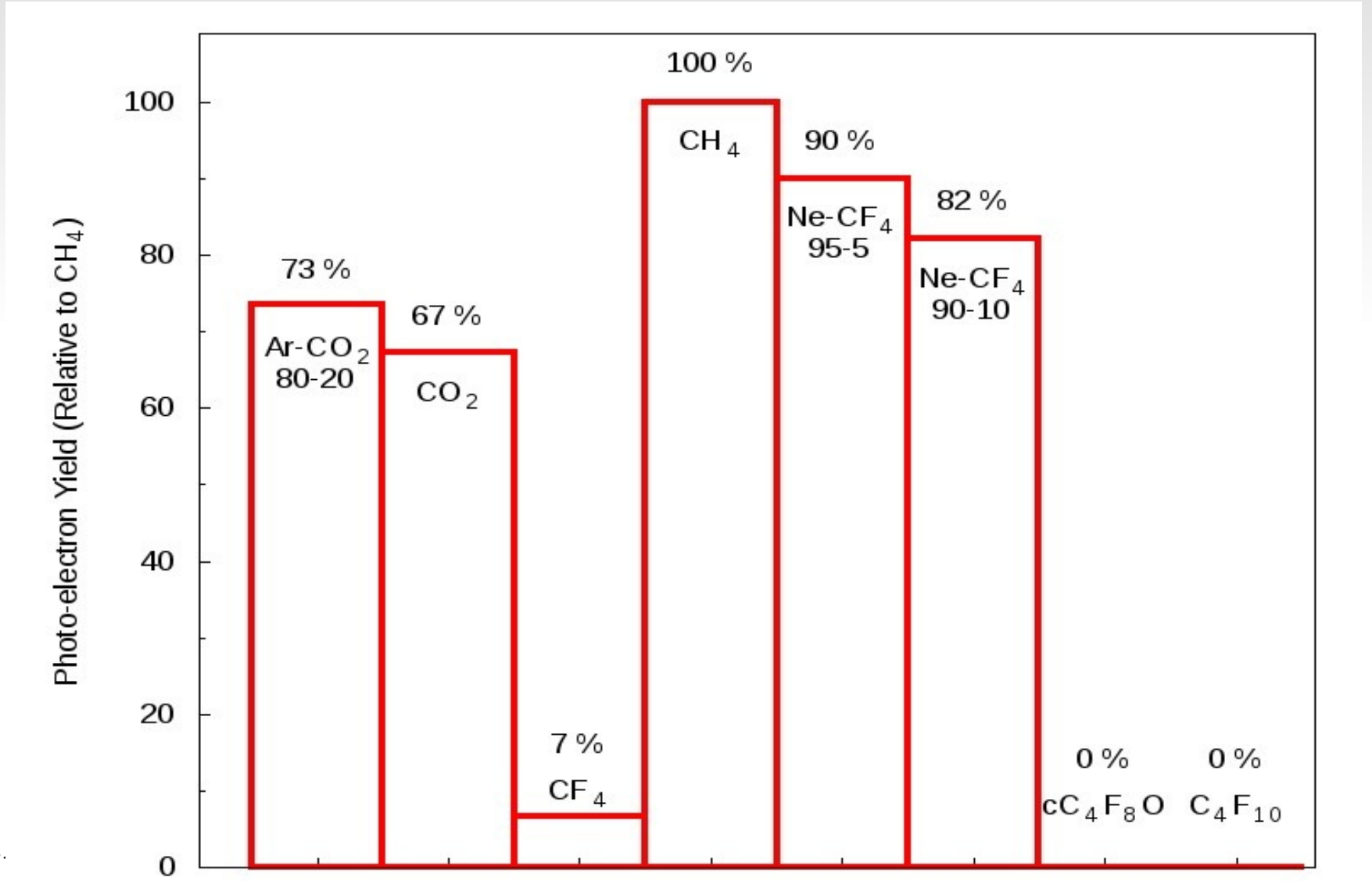



# Test of Different Gases

- Ar-$CO_2$, $CO_2$, $CH_4$, $CF_4$, Ne-$CF_4$, and the VHMPID radiator gas candidates: $C_4F_{10}$, $cC_4F_8O$ (windowless VHMPID operation)
- Read out the connected sense wires --> Camac ADC
- HV has been set to get the same gain in each gas
- Reference gas has been chosen : $CO_2$

  Each second measurement was with $CO_2$ to rule out the long term change of the UvLed's photon yield

# Photo-electron Yield in Different Gases



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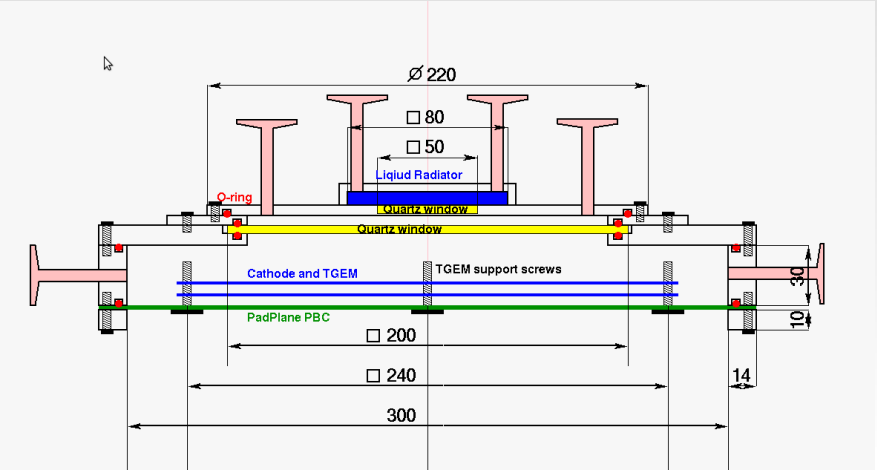
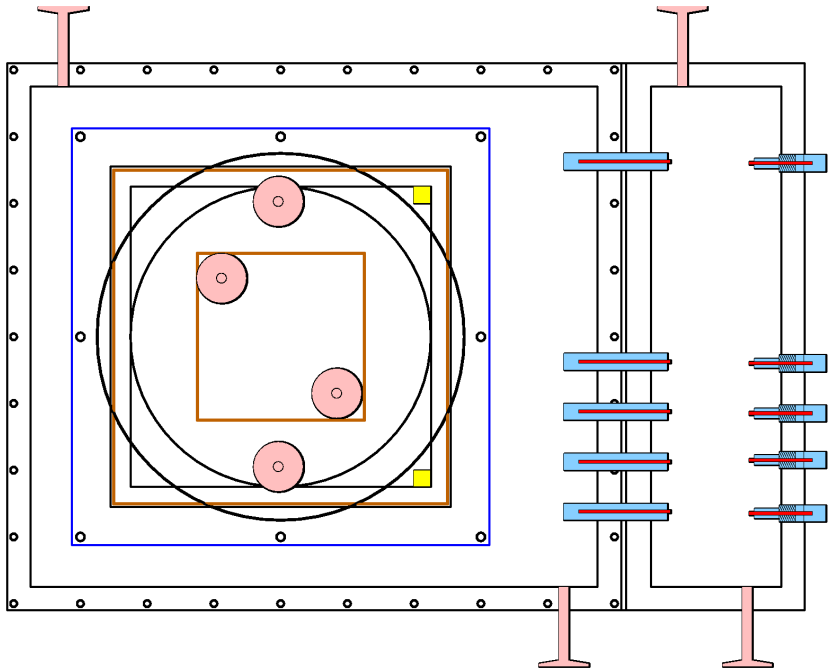
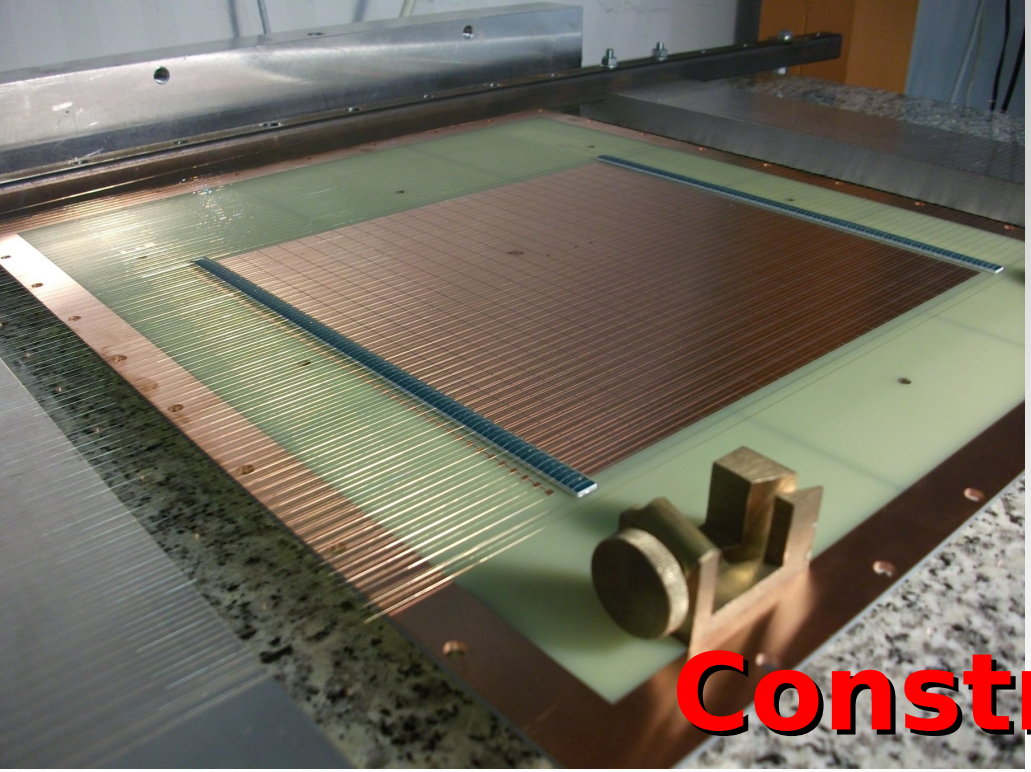
# TCPD-2 Chamber for Cherenkov photons

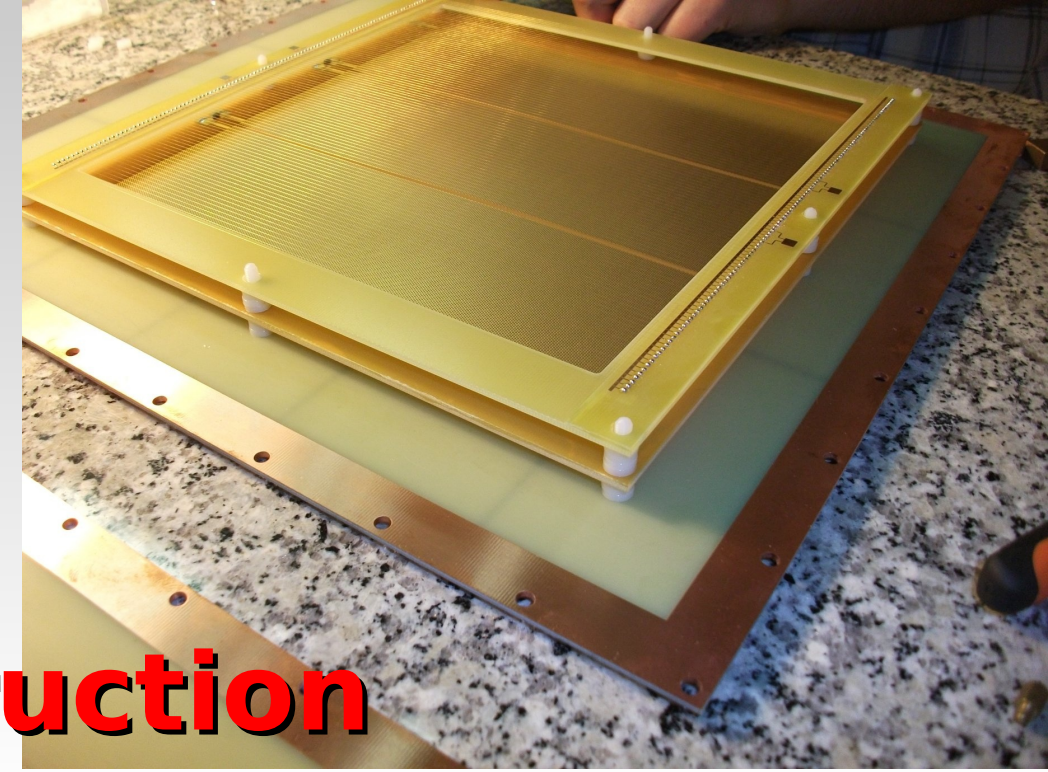
- TGEM 20x20 $cm^2$ active area (CERN, R.Oliveira, 2011)
- CsI cover (CERN, 2011)
- Humidity-free gas volume for the HV connection
- Large quartz window (20x20$cm^2$)
- Small monitoring window
- Detachable frame for the liquid radiator
- Pad structure : HMPID-like (8x8, 4x8, 4x4 $mm^2$)

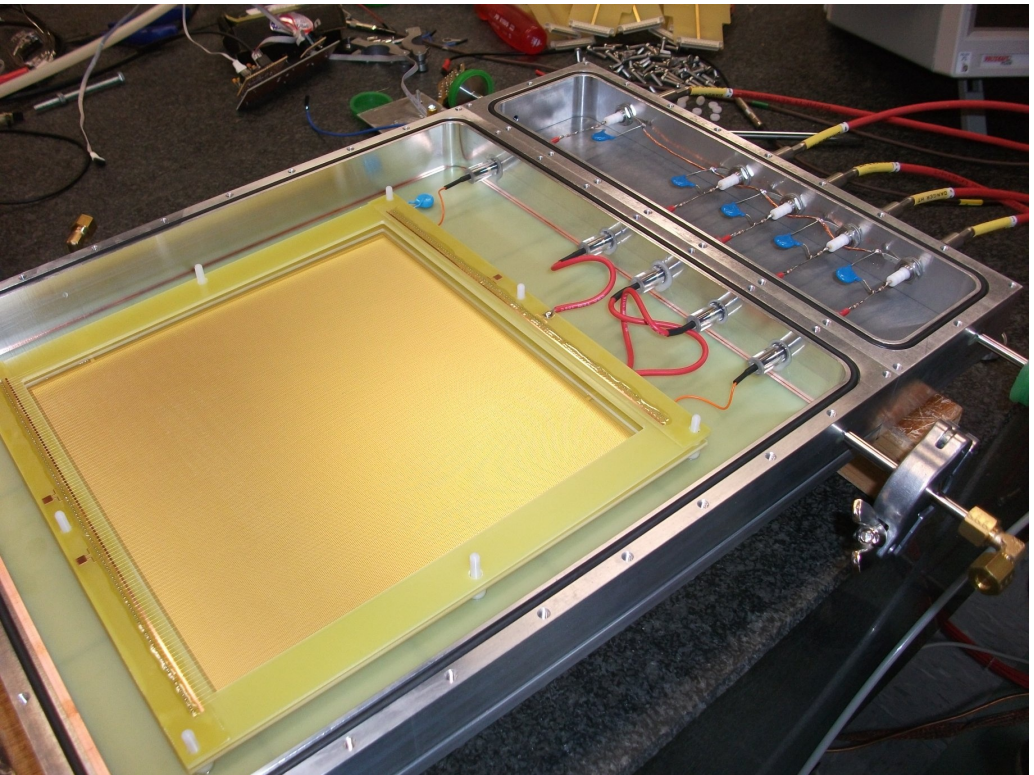


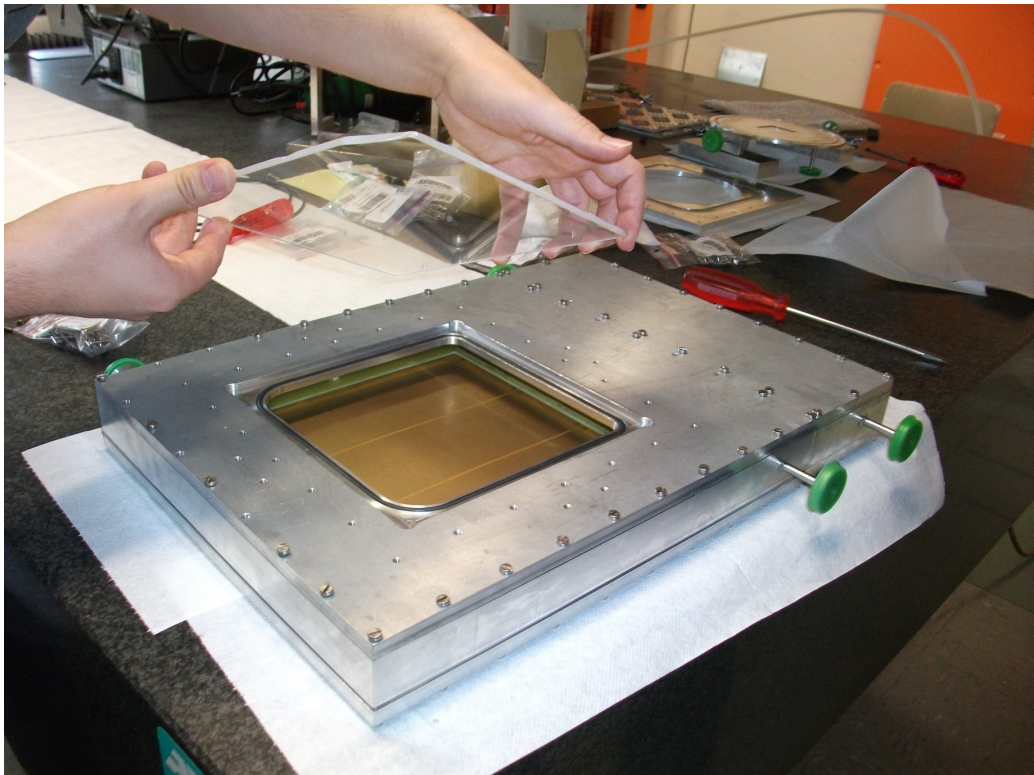



# Construction

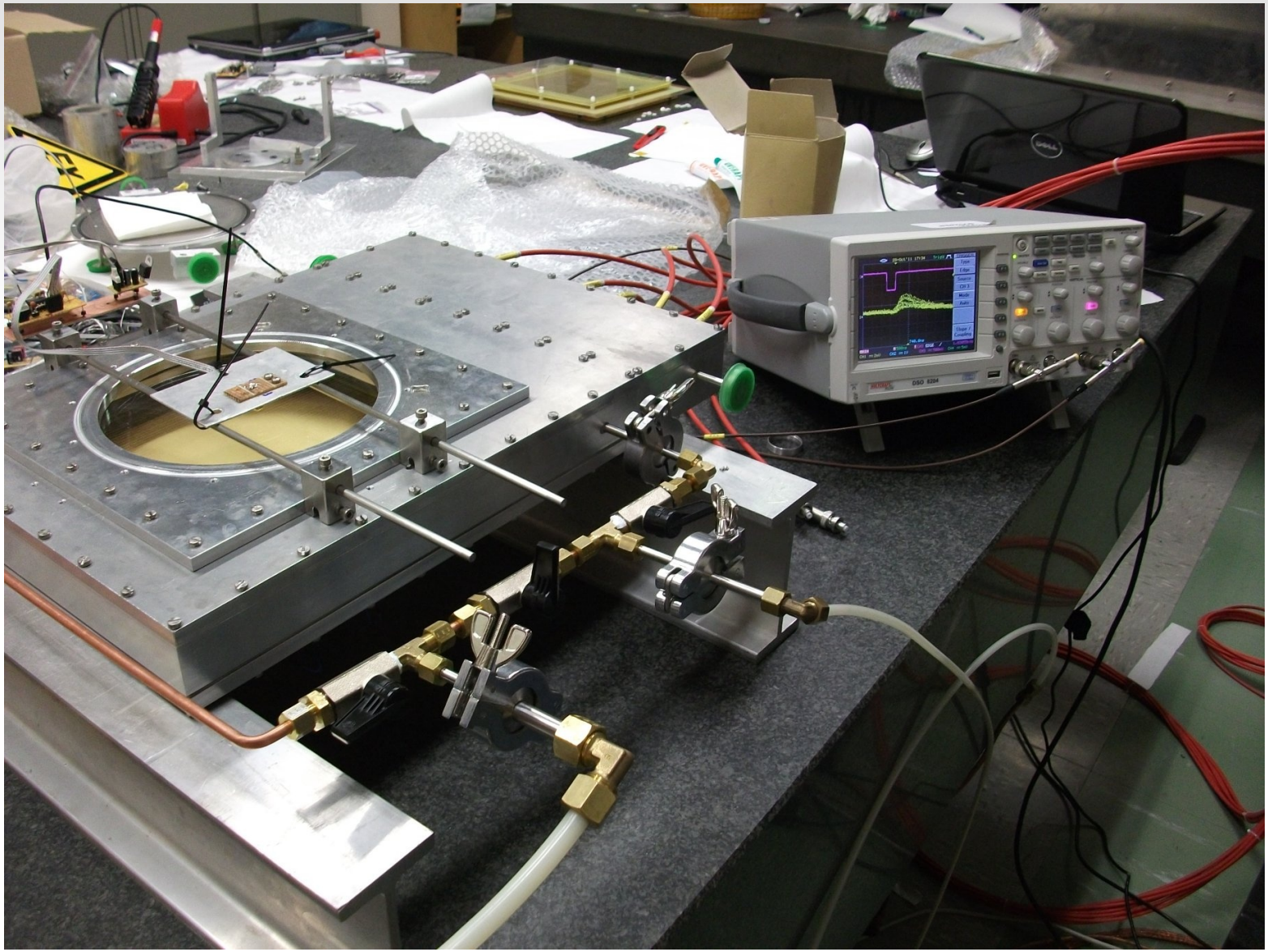






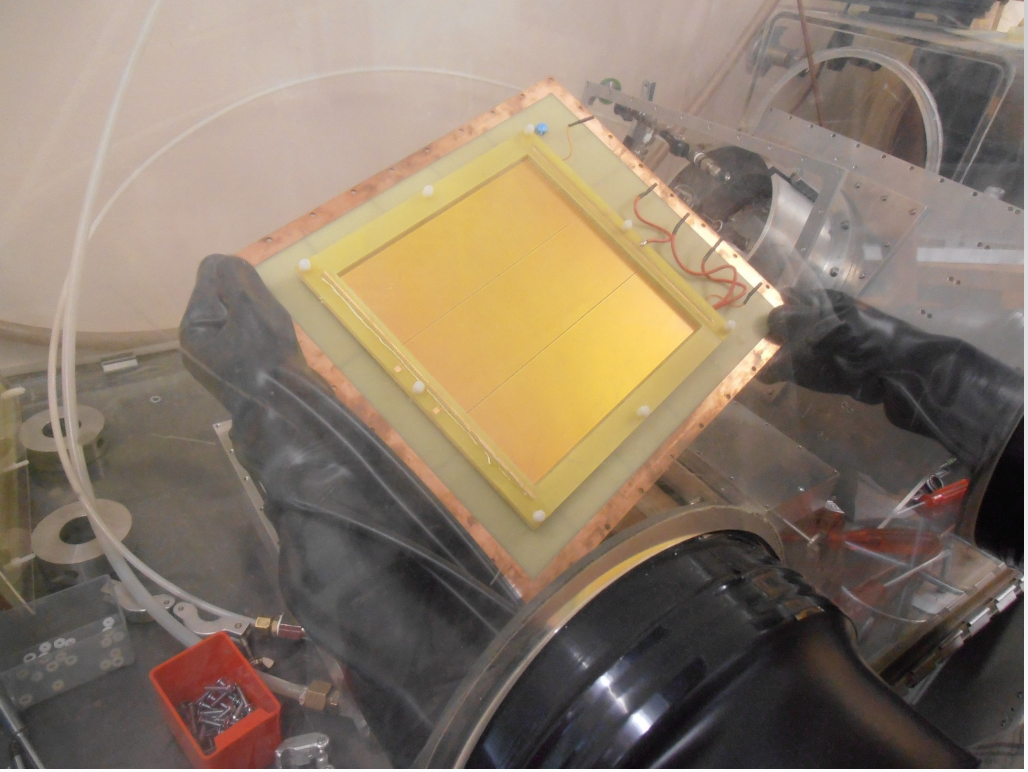


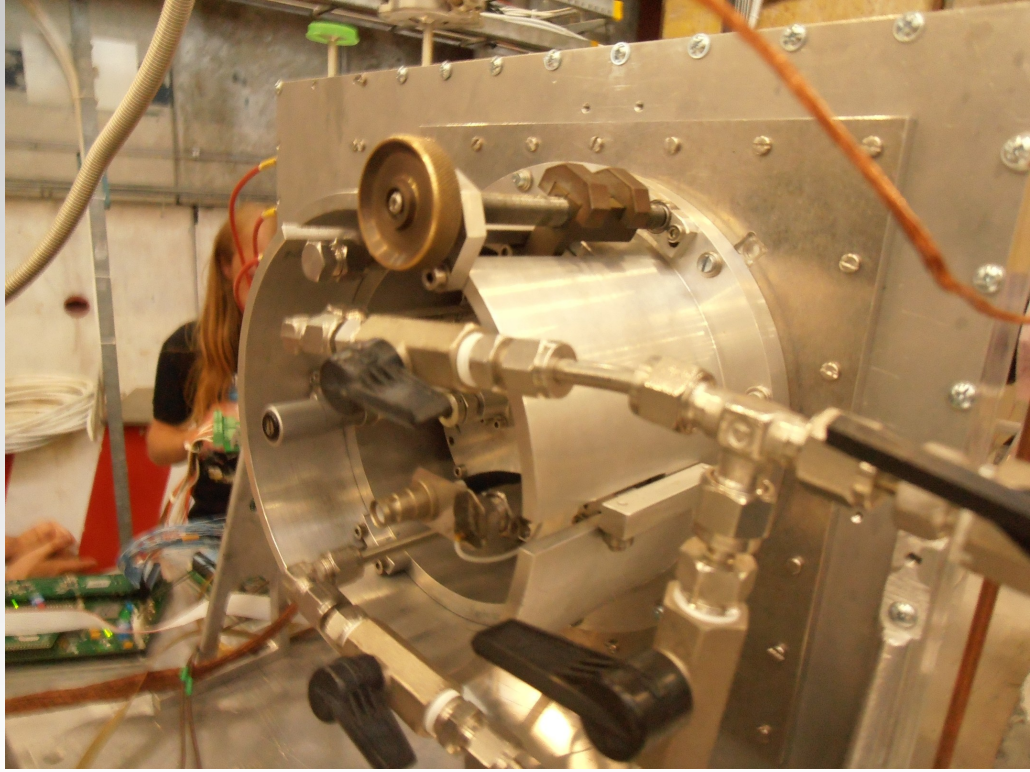
# First Photons with the 20cm Chamber

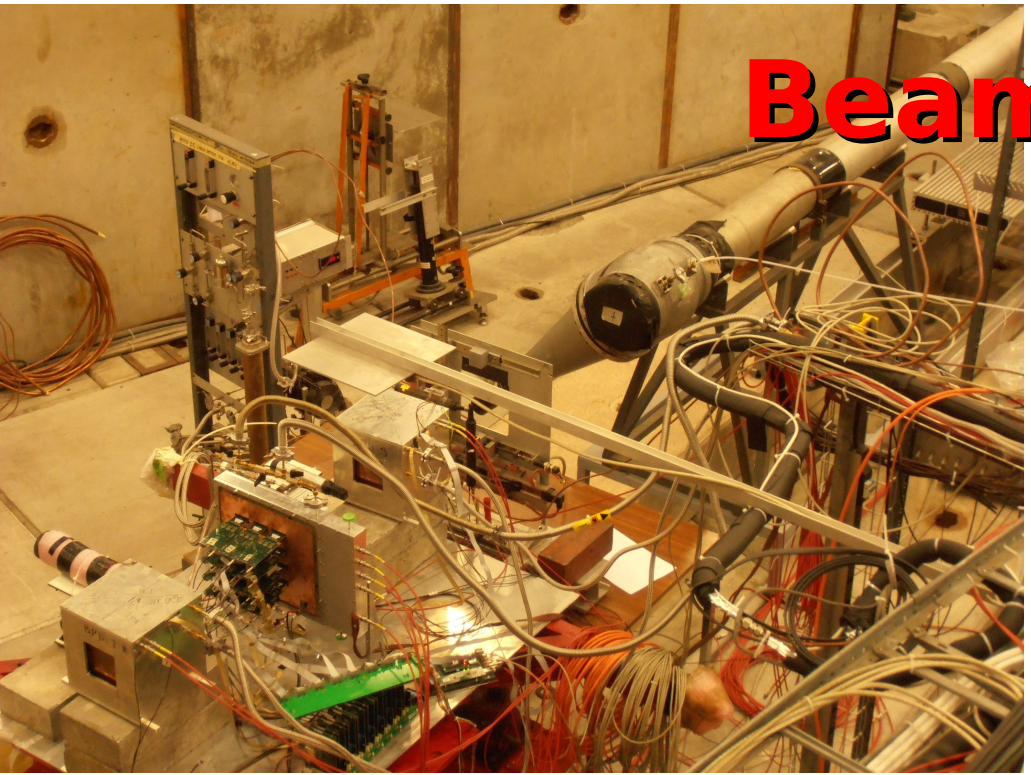


# Beam Test Setup

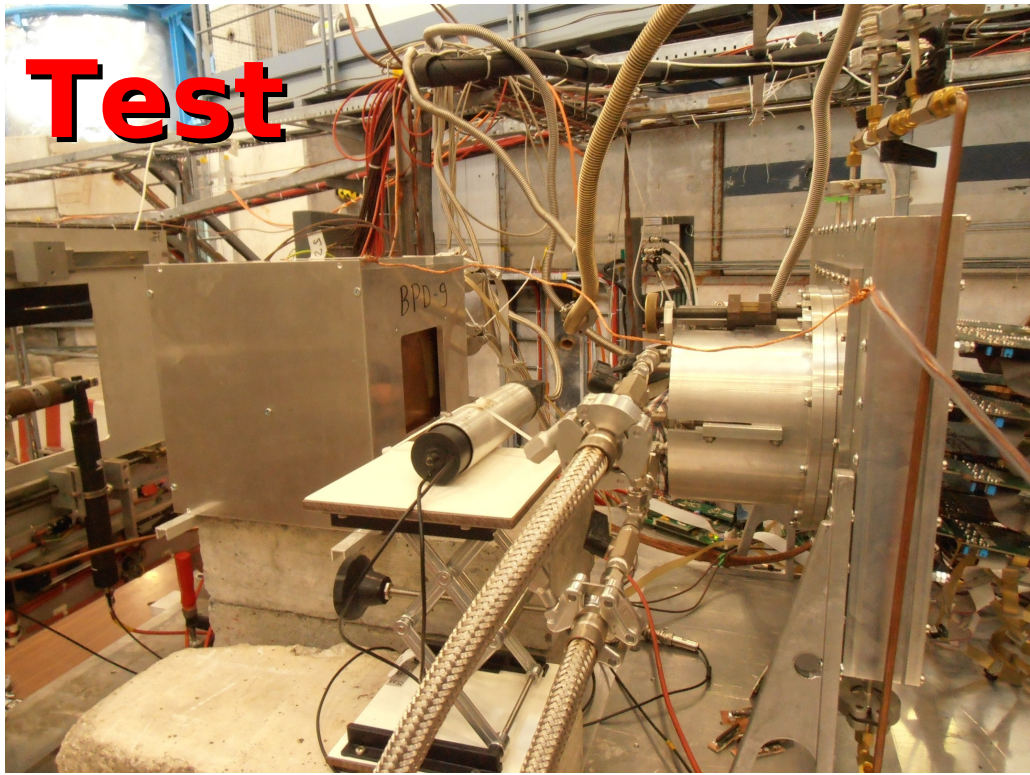
- In the 2011 beam test there was a problem with the window :(
- New beam test in September 2012. at CERN PS **T10**
- Four small scintillators to define a nice beam spot,
  Two large scintillators for beam and for muons
- Additional 2+2 BeamPositionChambers (**BPD**)
  read out by the same DAQ system
- TCPD:pad readout DAQ,FEE : ALICE HMPID/VHMPID type
- Connected wires read out for scope monitoring
  and/or for simple data taking with CamacADC
- Radiator : $\mathbf{C_6F_{14}}$ (standard HMPID),
  **adjustable** eff. thichness and changeable distance from TGEM
- Base gas for operation : $\mathbf{CH_4}$
  + few days with Ar-$CO_2$ to compare with former lab results
- Study of pad-size dependance as well
  two padplanes: standard 8x8; and a mix with 4x4,4x8,8x8.



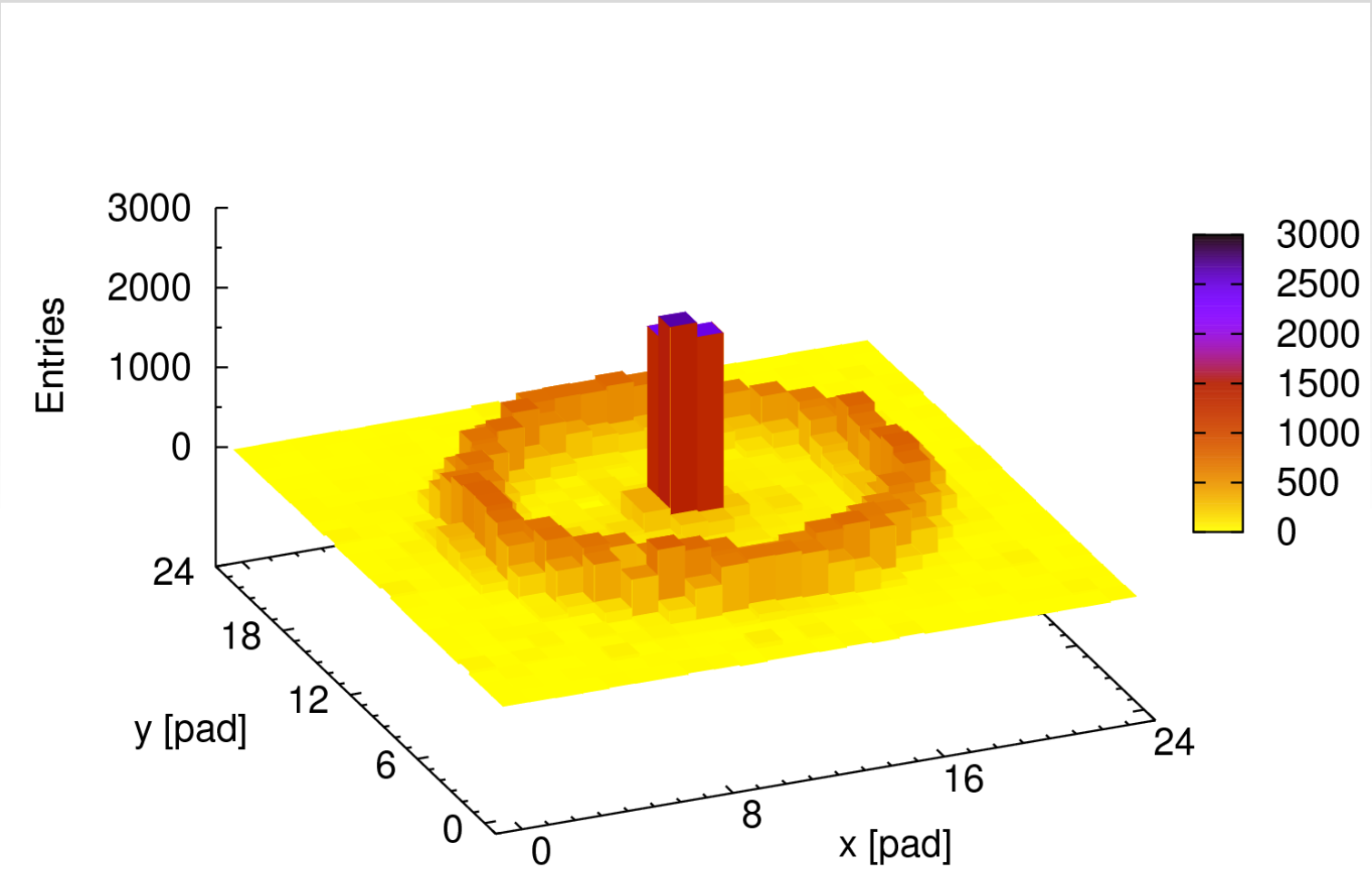




# Beam Test

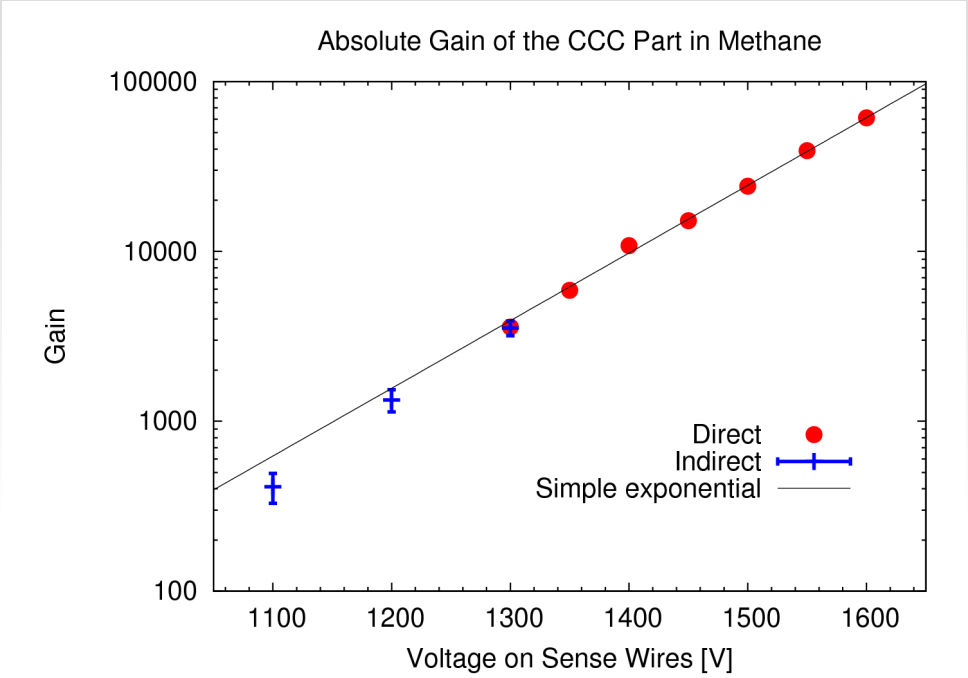


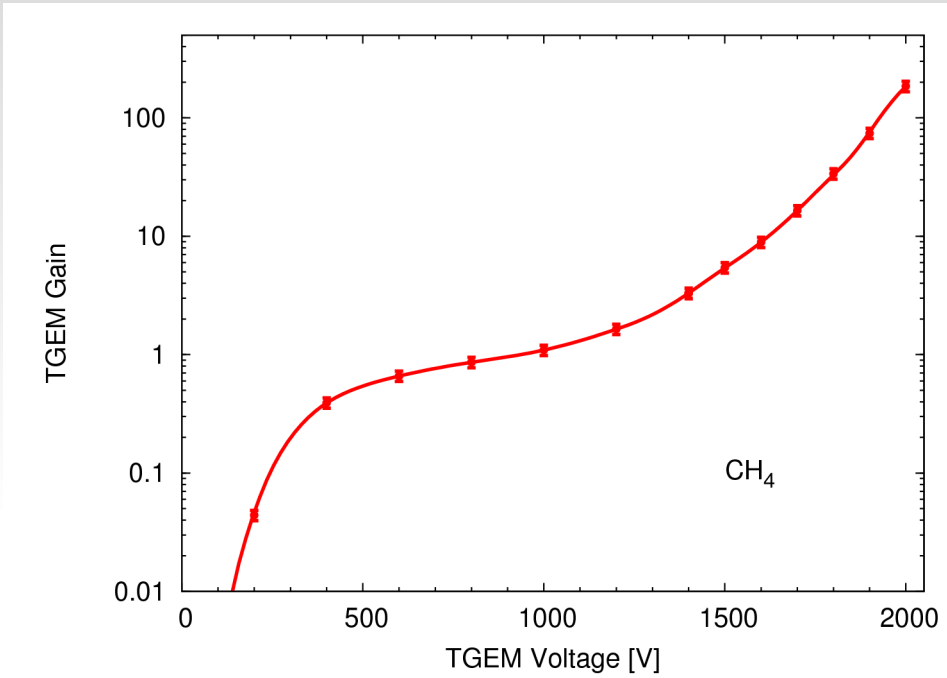
# It works !




- Cumulated Cherenkov rings from the firsts runs in Sept. 2012.

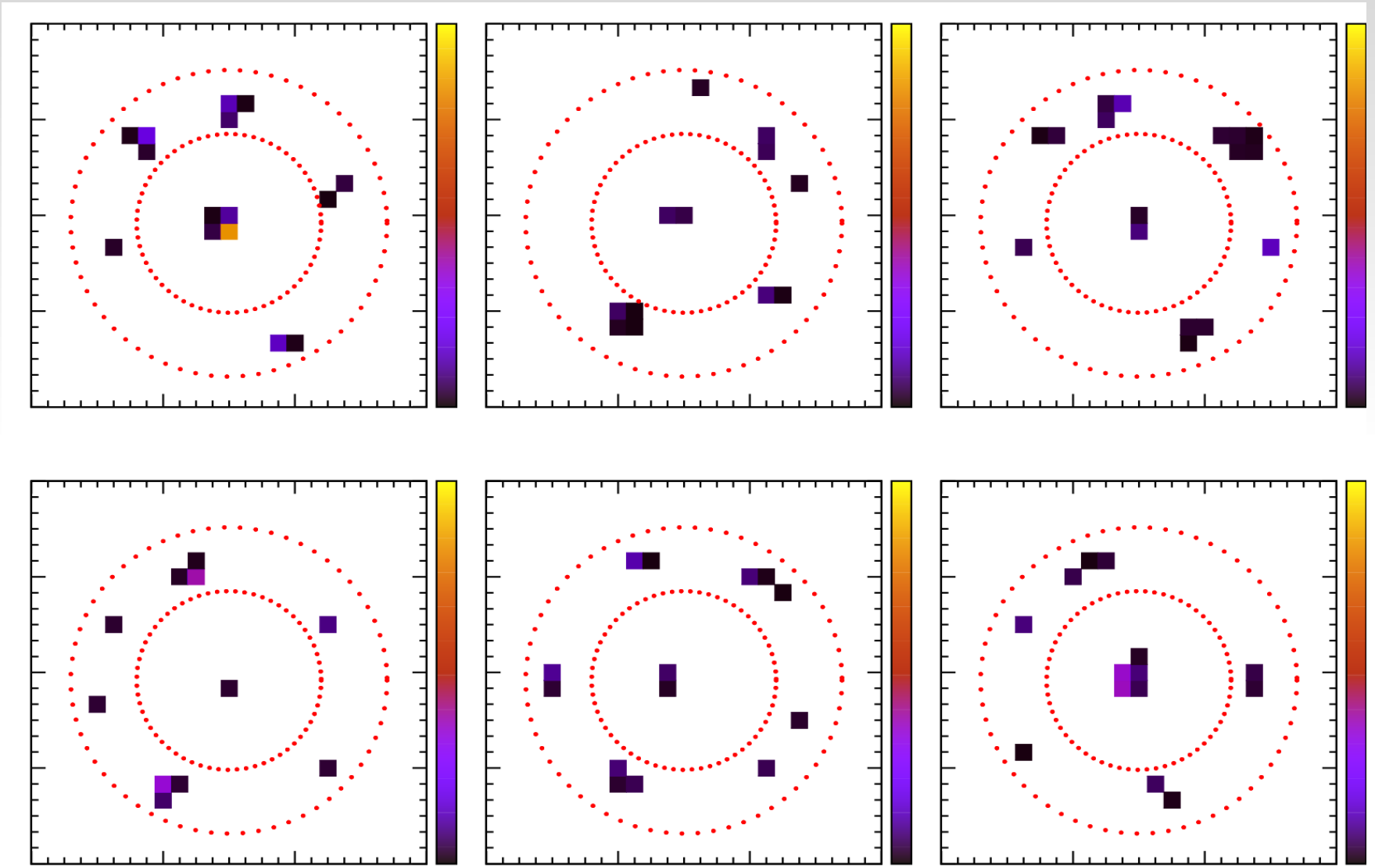
# Applied Gains



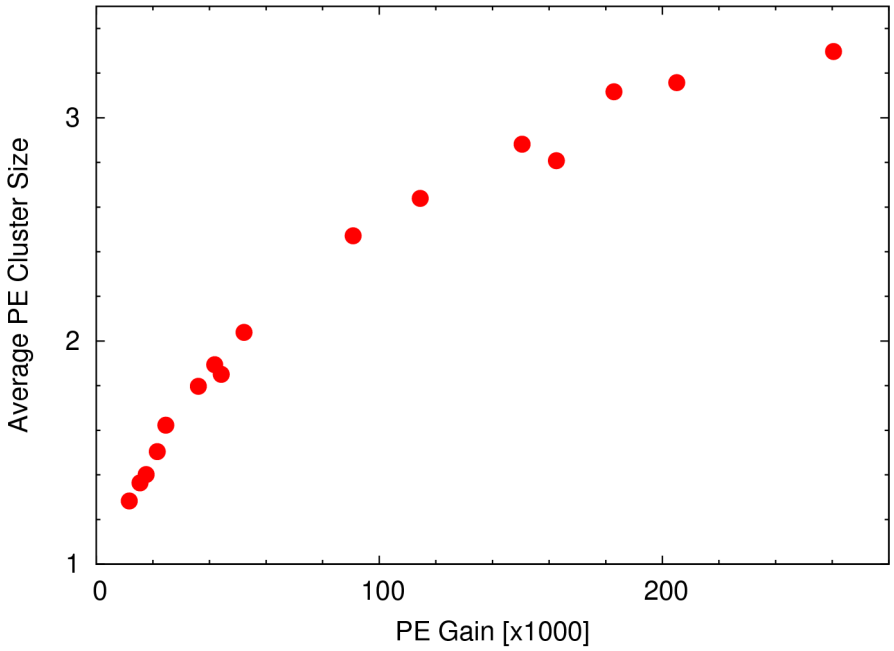

- CCC and TGEM gains were measured independently
- Typical gains : TGEM : 10 - 100;  Overall gain : $10^4$ - $10^5$
- No need for high gain on TGEM ensured stable operation
- Even with gain $3x10^5$  **no sparks** have been observed

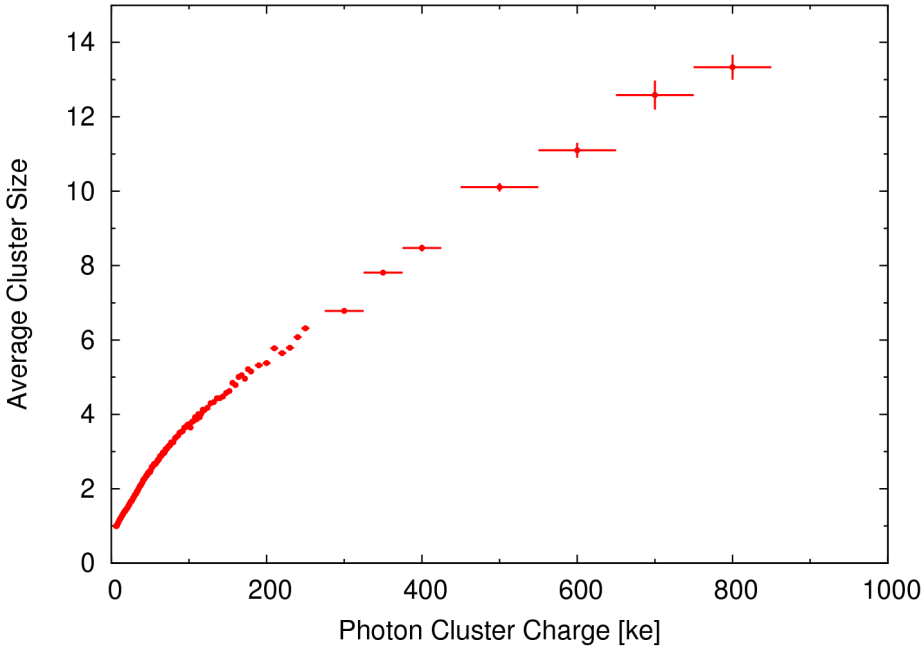
# Single Events



# Cluster Size Distribution

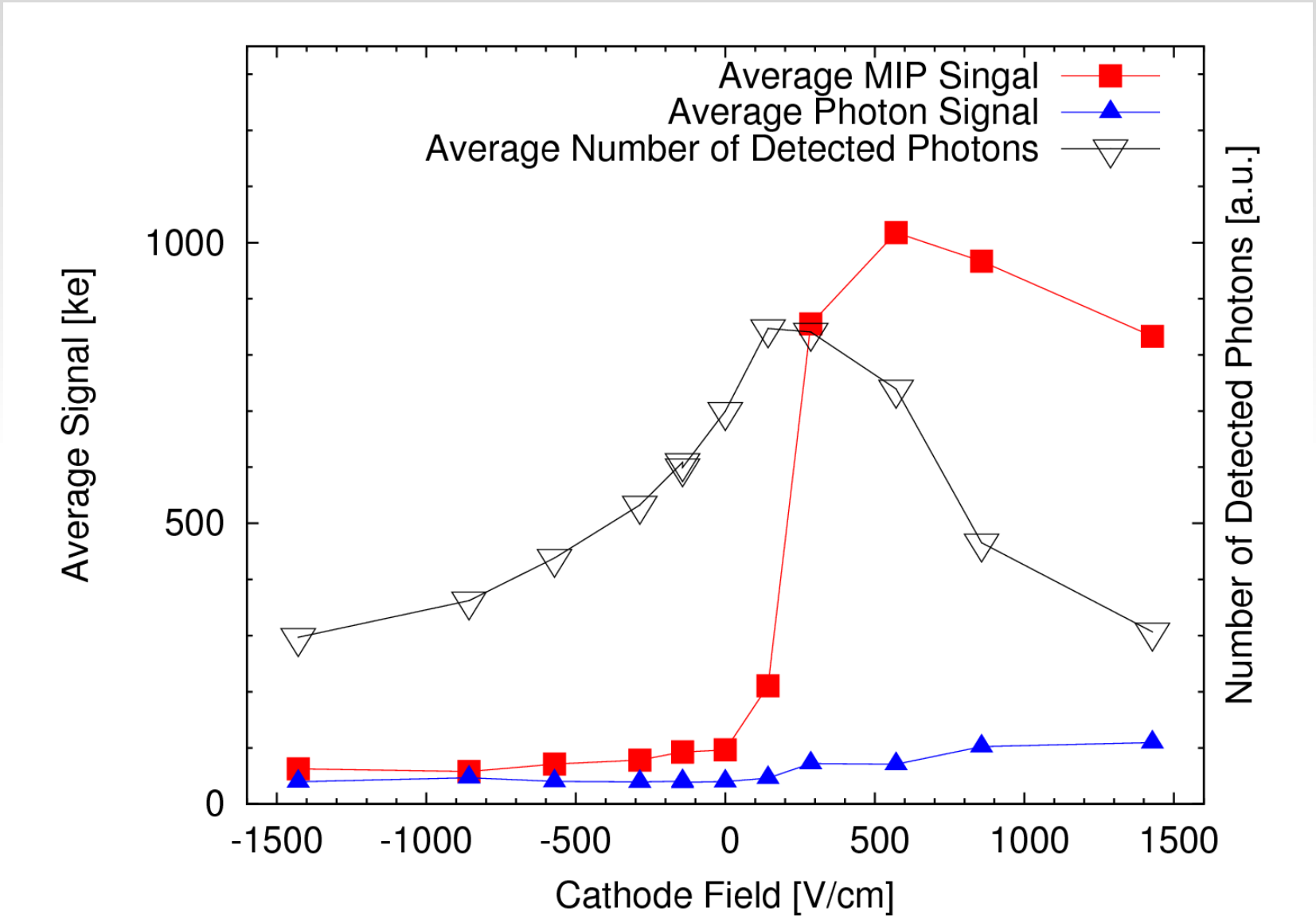
- Cluster size on the 8.0 x 8.4 $mm^2$ pads were measured in the ring region with photo-electron candidates
- Cluster size is crucial for padsize optimization in small diameter rings ( R < 7 cm )



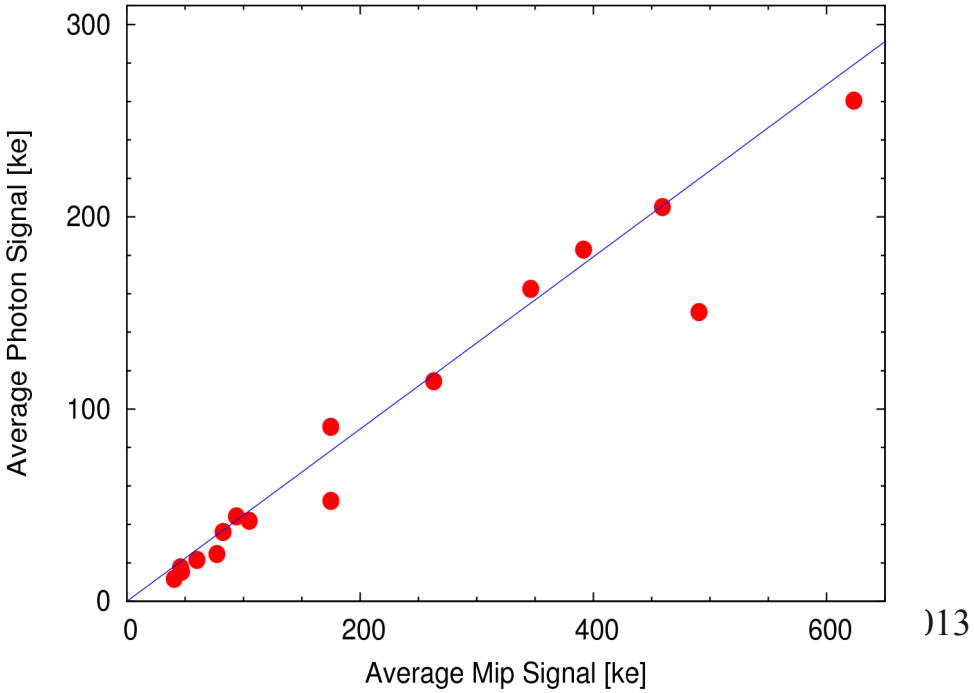

- Different gain distributions lies nearly on the same curve
- Even with gain $10^5$ the average cluster size is 2.5

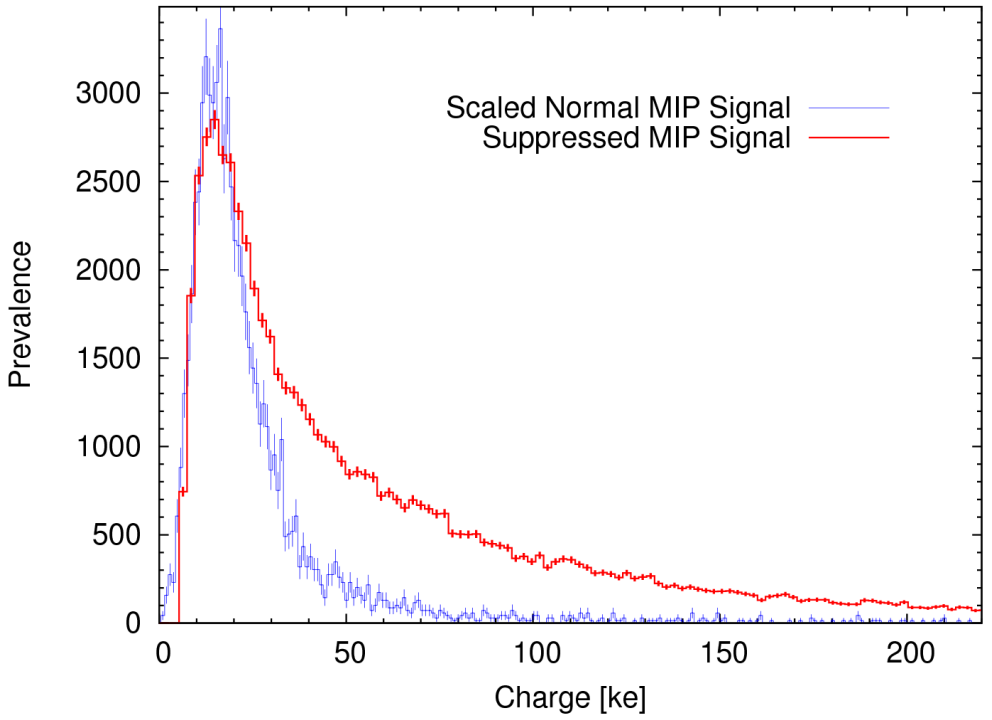
# MIP Suppression



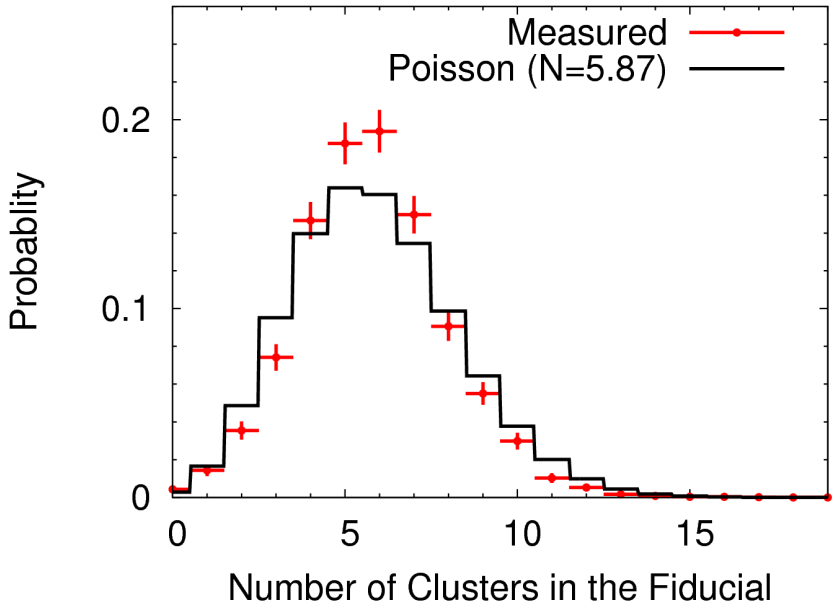
# MIP Suppression

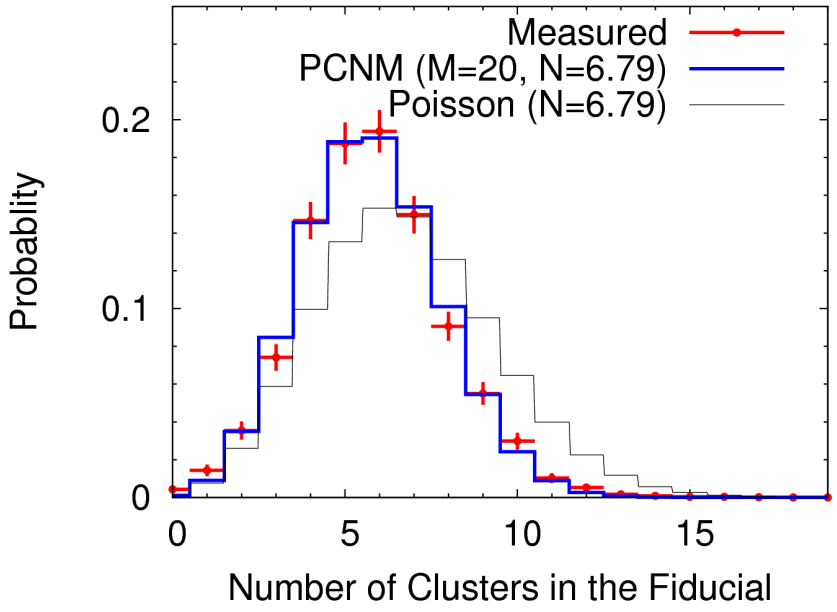
- Possibility for MIP suppression in MPGDs
- MIP signal in the order of the PE singal
- Small reversed cathode field is enough
- The cathode field approx. 0-100 V/cm is ideal for photon detection
- Suppressed MIP signal differs form the Landau curve
  due to the eventually deposited electron just above the TGEM



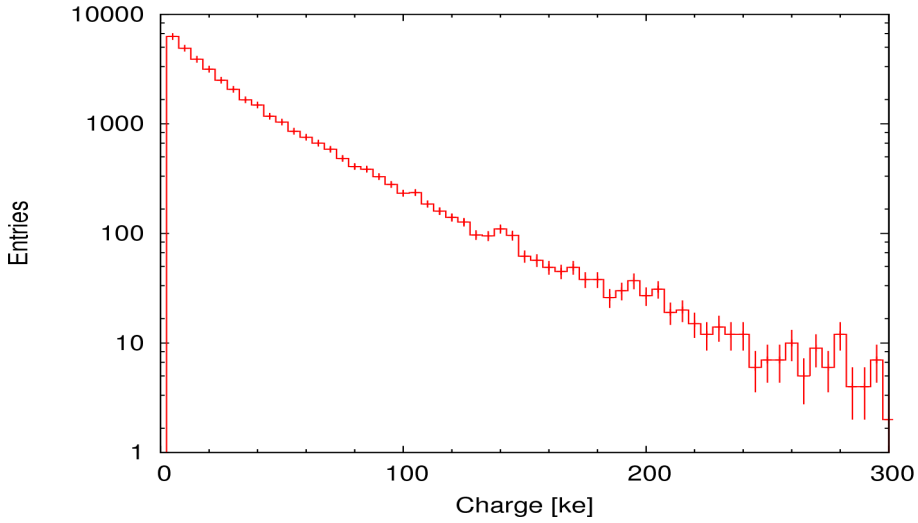



# Photon Yield




- With TGEMs there are blind areas for photons
- Hole configuration needs to be optimized for this purpose (-> "Leopard" like studies)
- With nonoptimized setup the photon yield was approx. 60-70 % of the desired
- Consistent with Leopard meas.



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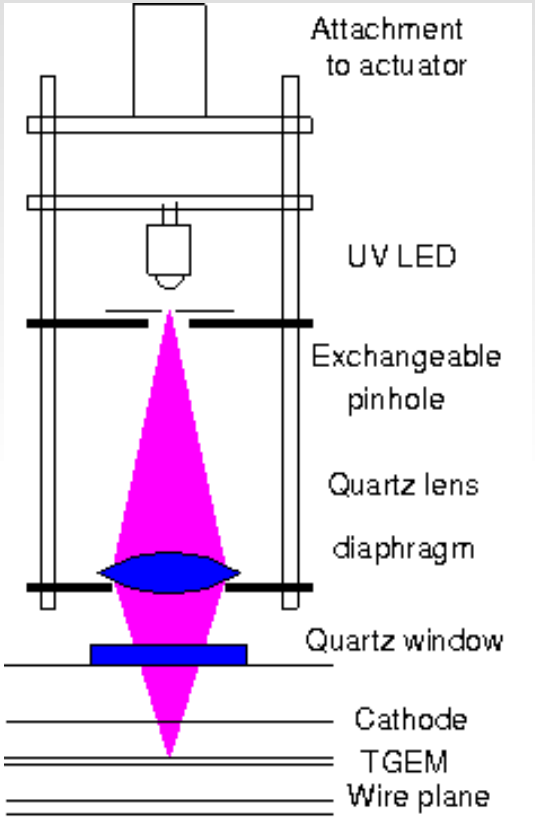
# Measurements and Optimization on Microscales

- What is the optimal hole configuration for photon detection?
- Holes are blind areas, but what about all the other parts?
- Quantify the loss around the critical/symmetry points
- Does the gain depend on the location of the emitted electron?
- ...
- Input for simulations

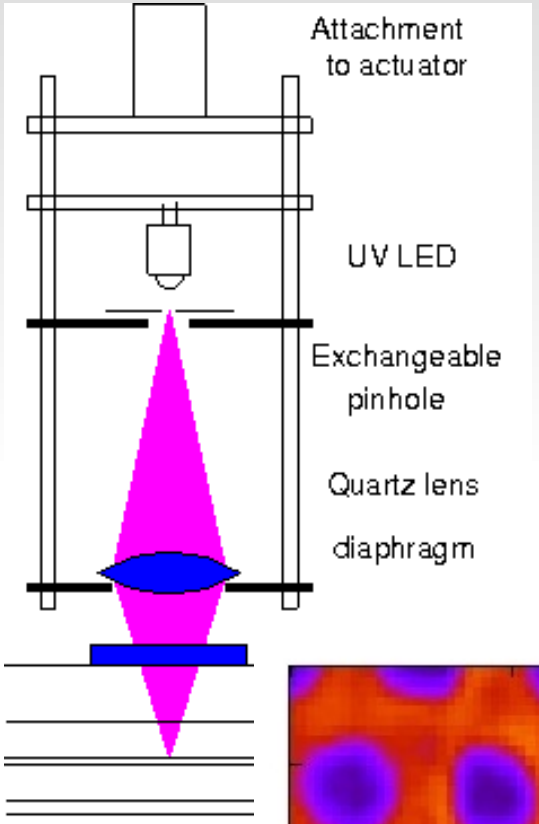
- How to measure these?
- With single photo-electrons of well known position...

# High resolution scan

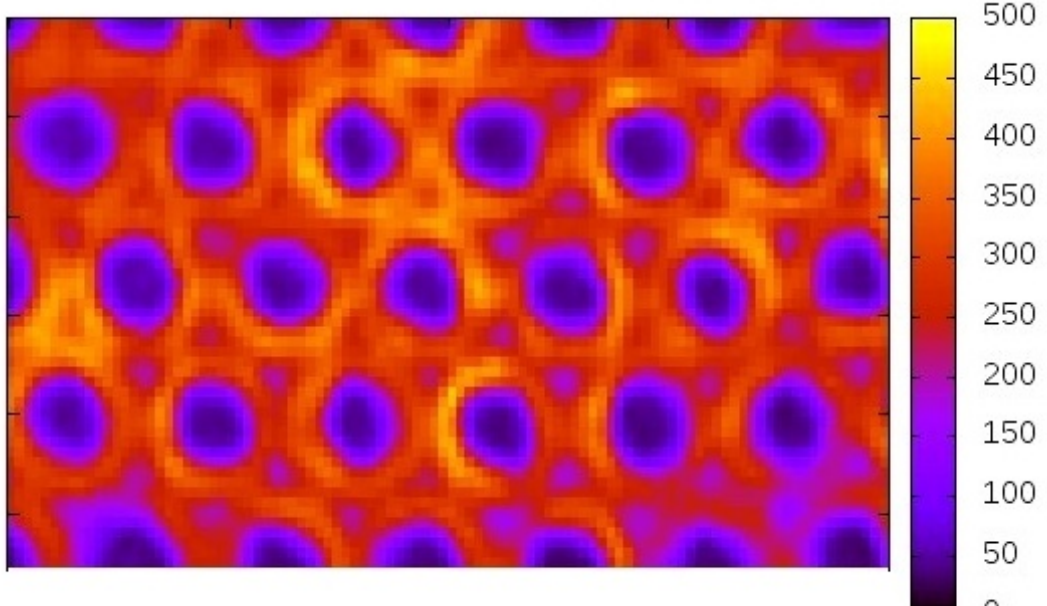



- Pulsed UV light focused to 70 μm spot onto the top of the ThickGEM
- Optical setup mounted onto a contolled 3D actuator system
- Fast DAQ...
- Single PE spectra at each point

# The "Leopard"

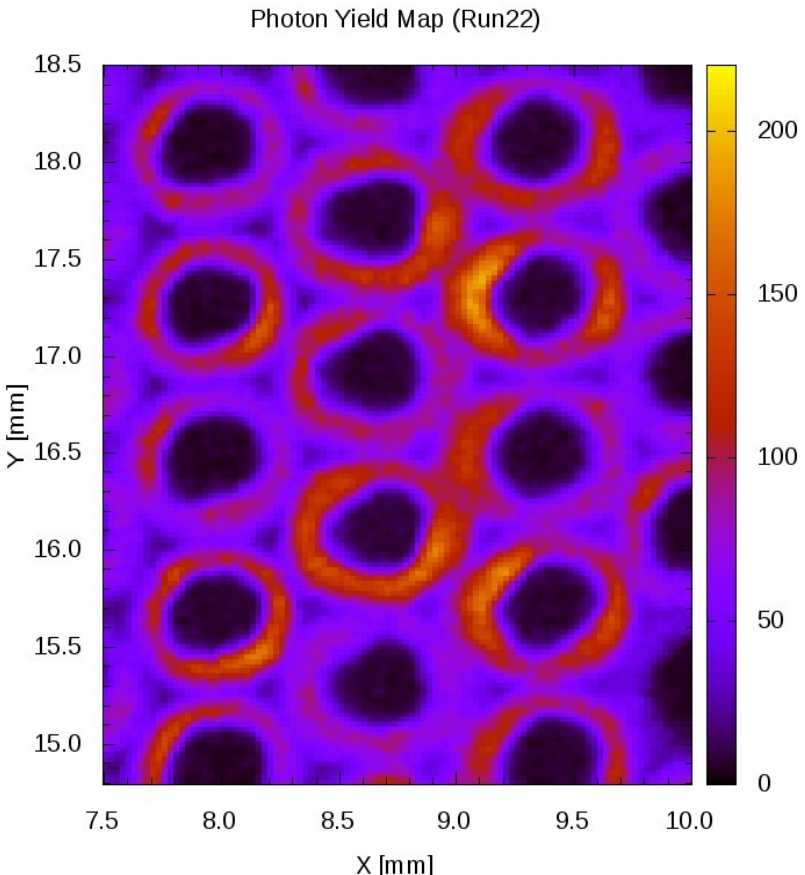



- Pulsed UV light focused to 70 μm spot onto the top of the ThickGEM
- Optical setup mounted onto a contolled 3D actuator system
- Fast DAQ...
- Single PE spectra at each point
  -> Photo-efficiency, and gain

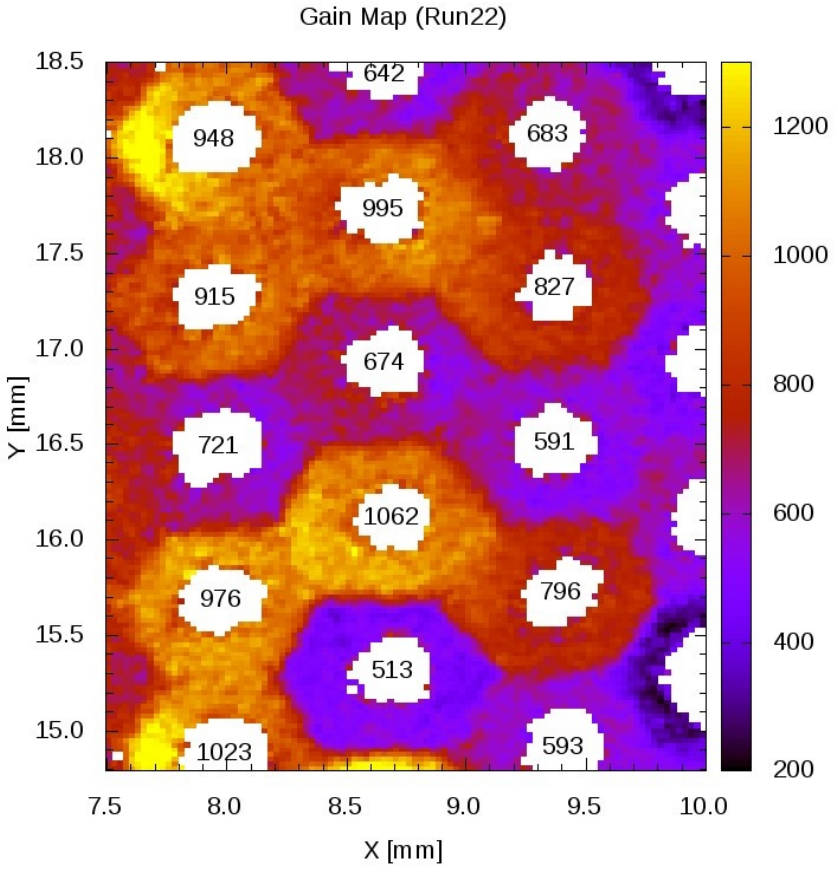



# Maps of Yield and Gain

- Microstructure of the photo-efficiency map
- Appearance of the "hole-gain"
- Non-uniformity on the hole-to-hole level





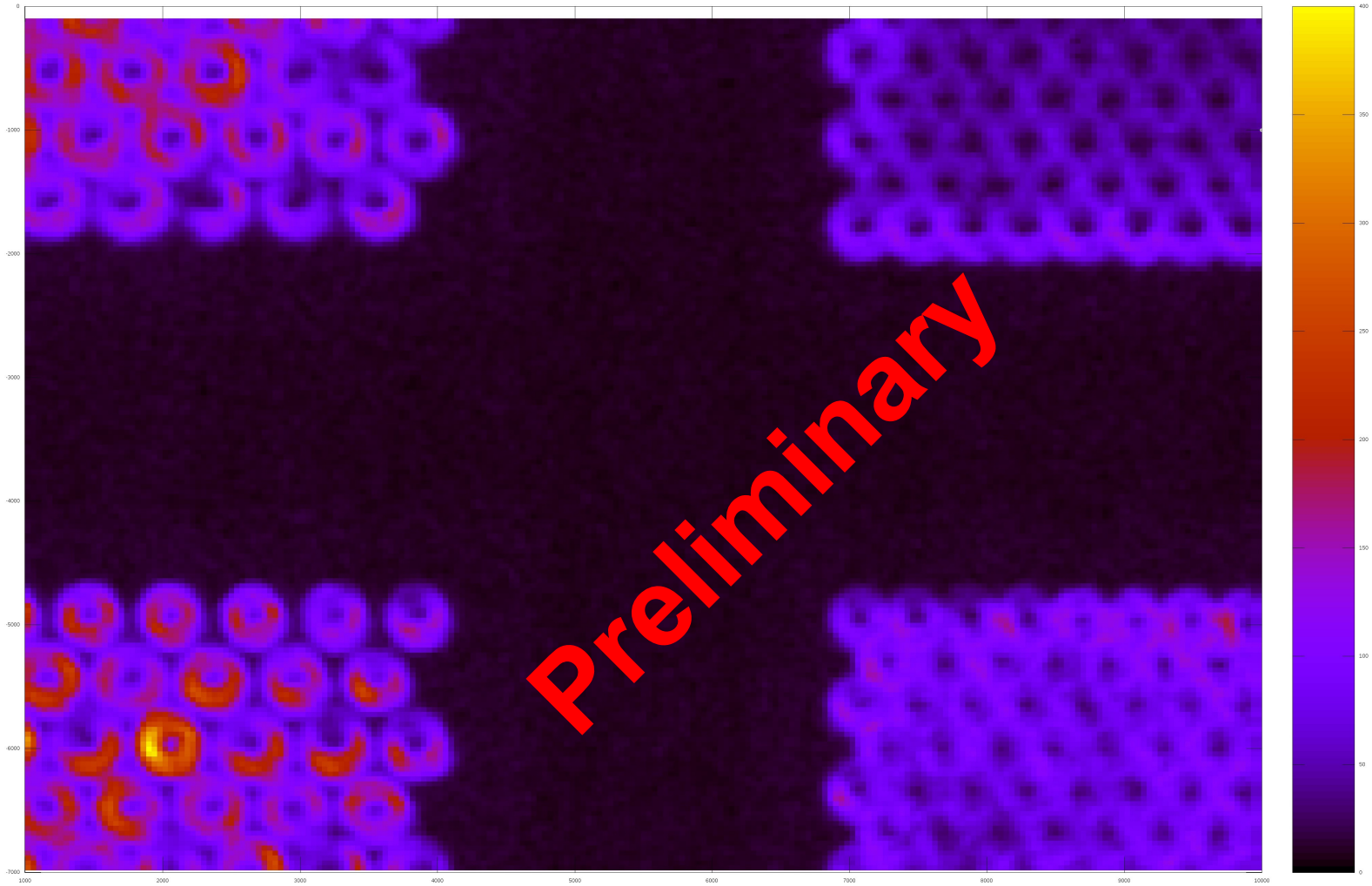
# Summary

- **TCPD** – nice combination of micropattern and wire based technologies for photon detection
- **Single photo-electron** studies with a UvLed were done
- Real **Cherenkov applicability** was demonstrated
- Full Cherenkov ring detection with one TGEM
- Stable operation even with **high gains**
- Moderate cluster size without technical difficulties
- Natural **MIP suppression**
- **Leopard** system for microscans serving optimization, simulation, QA, production advances
- *Leopard upgrades: faster DAQ, smaller spotsize (GEM?), and todo : check different hole configurations and gases.*


- Special thanks go to the test beam group
- And thanks to the Hungarian OTKA CK77719, CK77815 grants and the support of the REGARD, ALICE-Budapest and ALICE VHMPID Groups

**h: 0.5 mm; p: 1.5 mm**

**h: 0.5 mm; p: 1.0 mm**

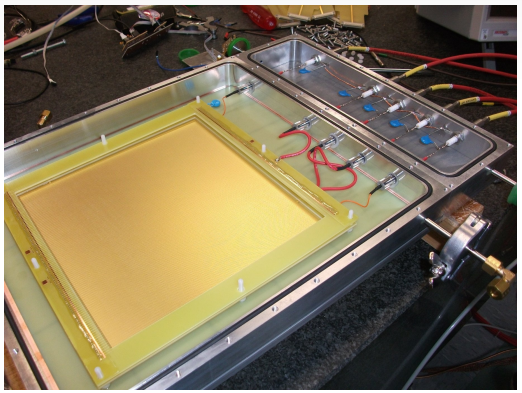


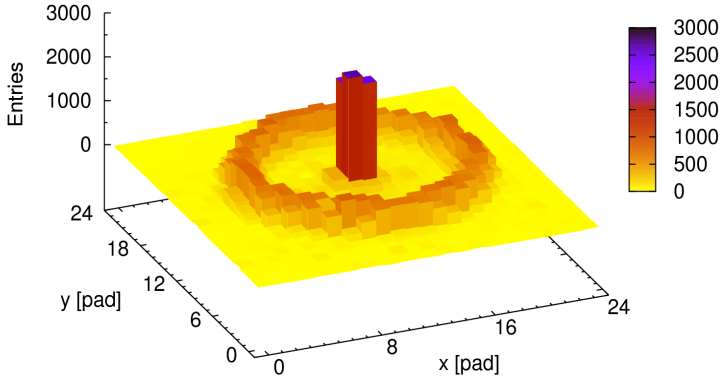

**h: 0.4 mm; p: 1.5 mm**

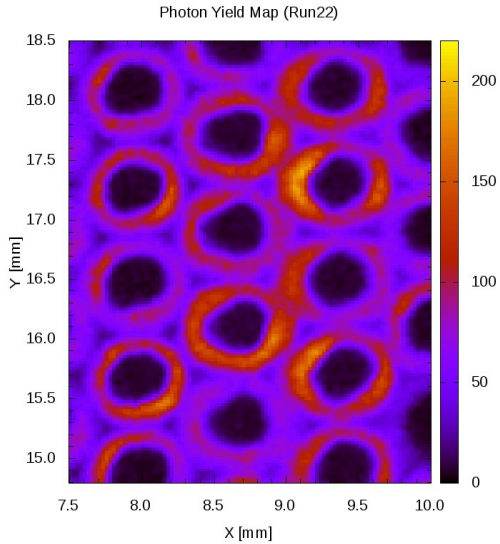
**h: 0.4 mm; p: 1.0 mm**

Outlook : systematic study of detection efficiency as a function of hole diameter and pitch

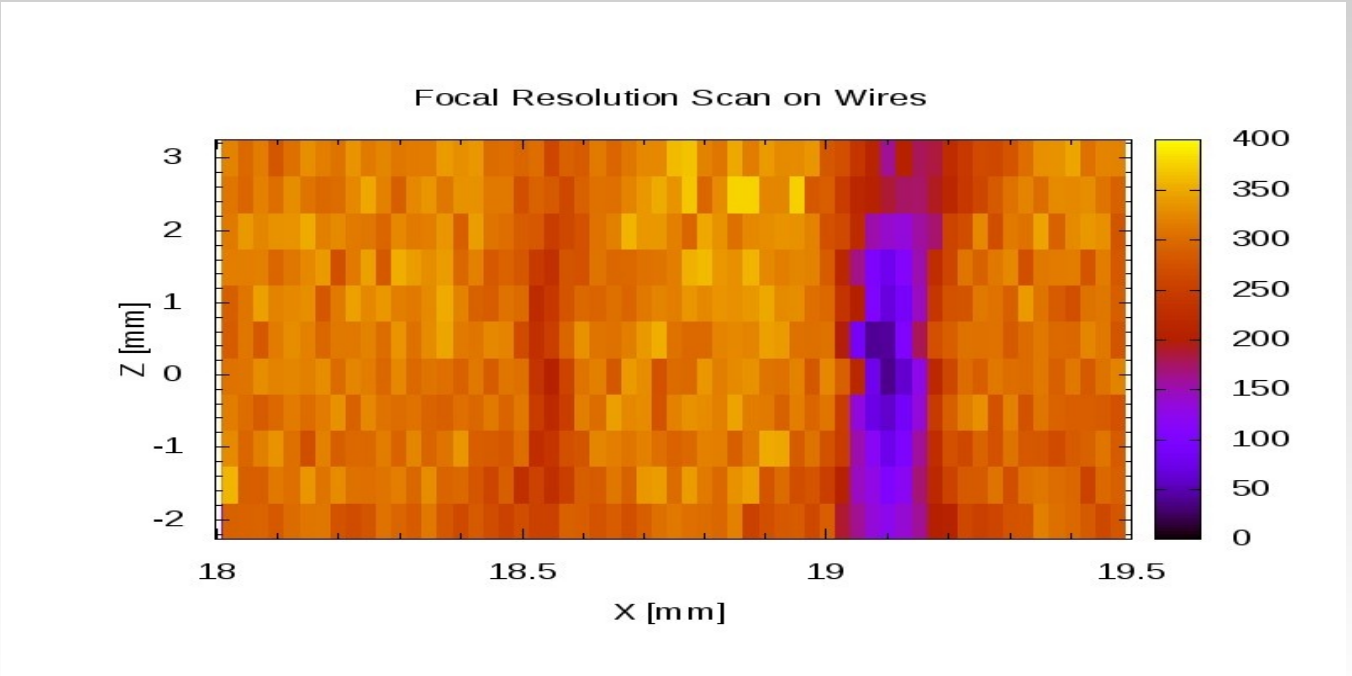
# Thank You
# for Your Attention

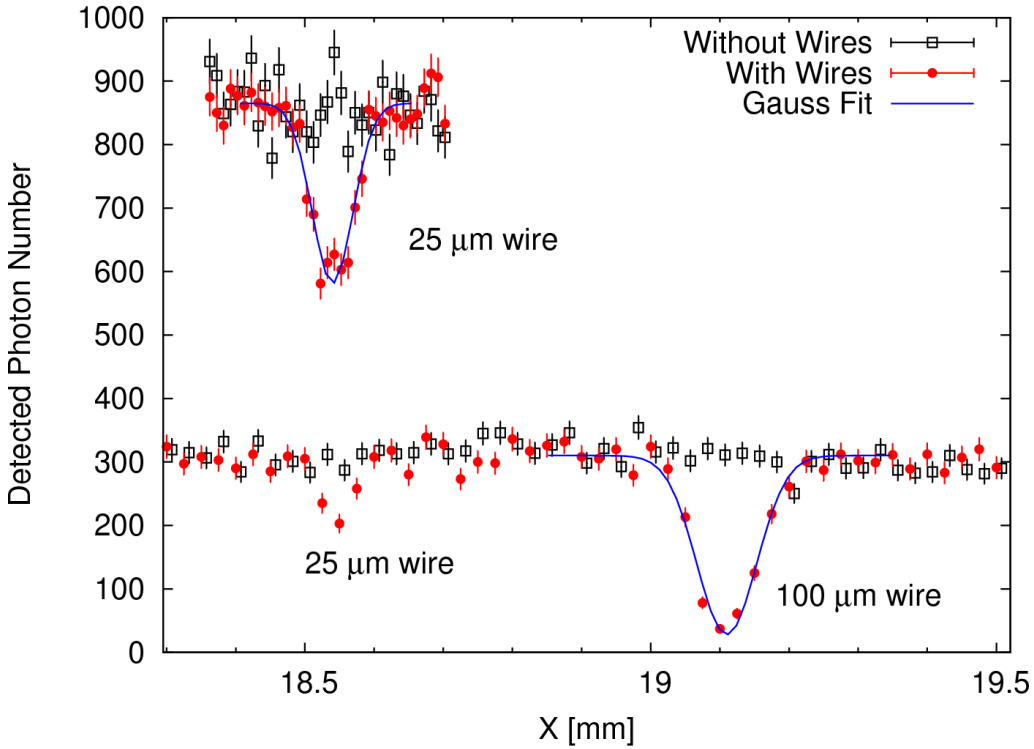


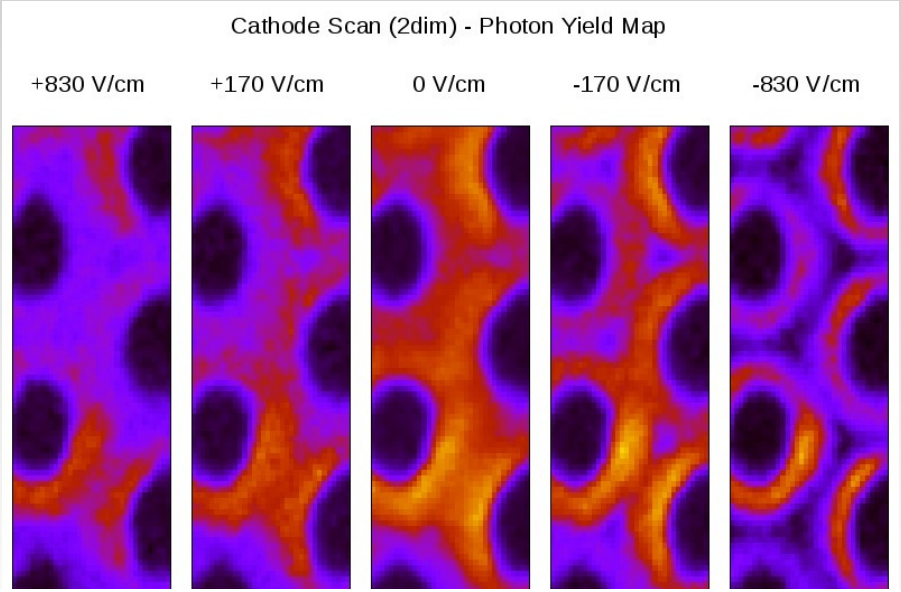


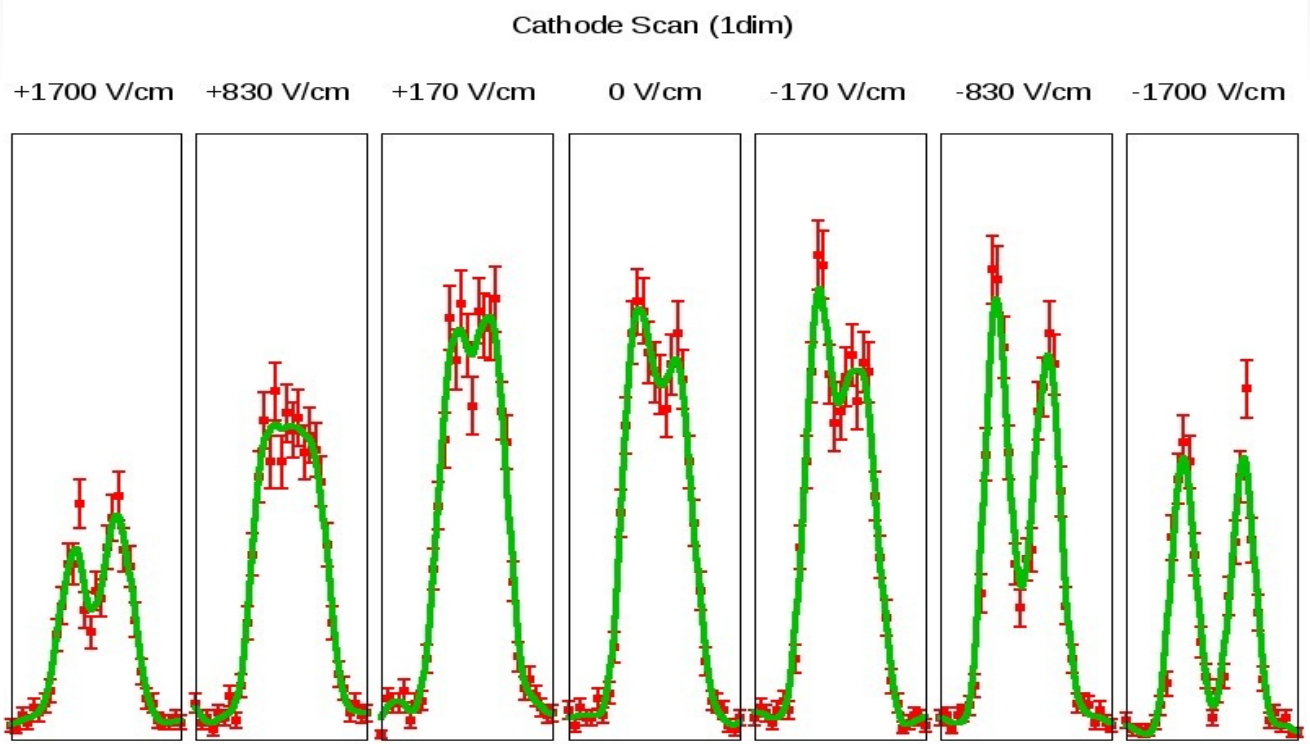



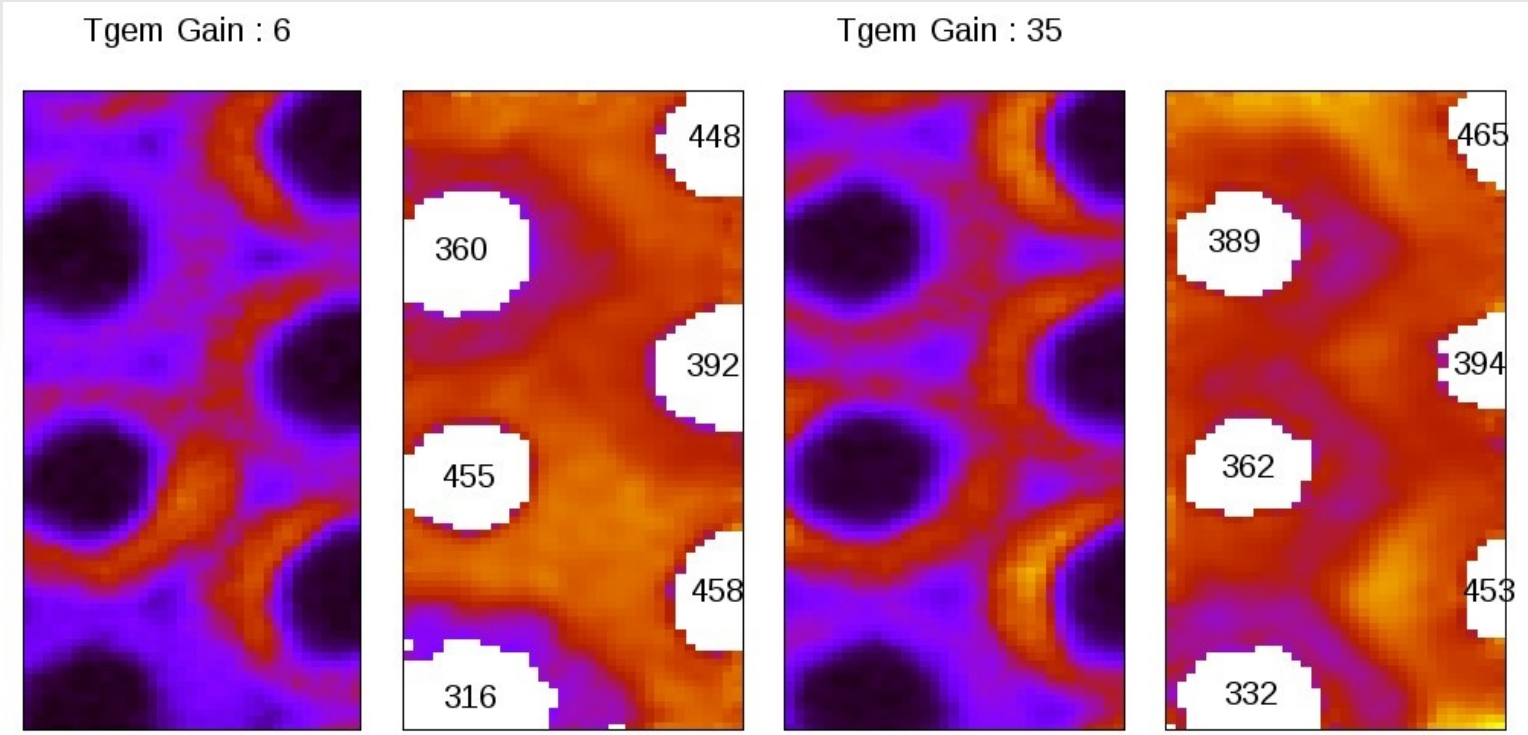
# Backup slides / plots

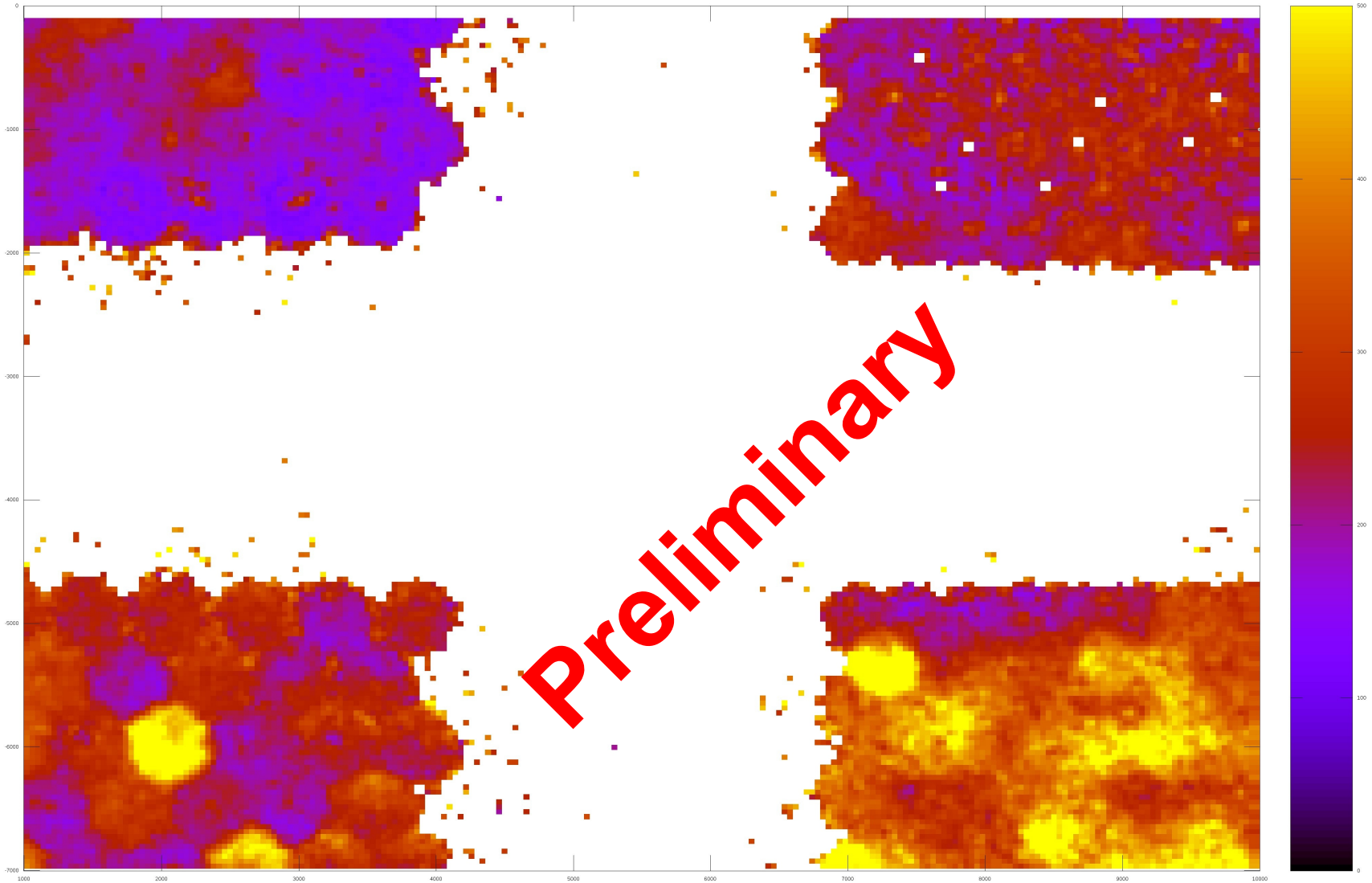

Focal Resolution Scan on Wires
Z [mm]
X [mm]
3
2
1
0
-1
-2
18
18.5
19
19.5
400
350
300
250
200
150
100
50
0


Without Wires
With Wires
Gauss Fit
25 µm wire
25 µm wire
100 µm wire
Detected Photon Number
X [mm]
1000
900
800
700
600
500
400
300
200
100
0
18.5
19
19.5


Cathode Scan (2dim) - Photon Yield Map
+830 V/cm
+170 V/cm
0 V/cm
-170 V/cm
-830 V/cm


Cathode Scan (1dim)
+1700 V/cm
+830 V/cm
+170 V/cm
0 V/cm
-170 V/cm
-830 V/cm
-1700 V/cm


Tgem Gain : 6
Tgem Gain : 35
448
360
392
455
458
316
465
389
394
362
453
332


0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
500
400
300
200
100
0
Preliminary