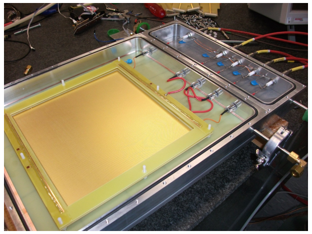
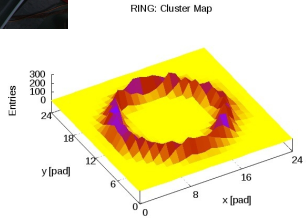
High Resolution Scan for Thick-GEM Based Photon Detectors

Gergő Hamar

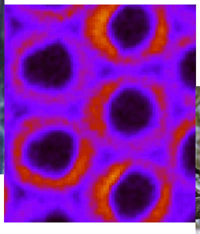
on behalf of the REGARD Collaboartion





Wigner RCP; ELTE

REGARD



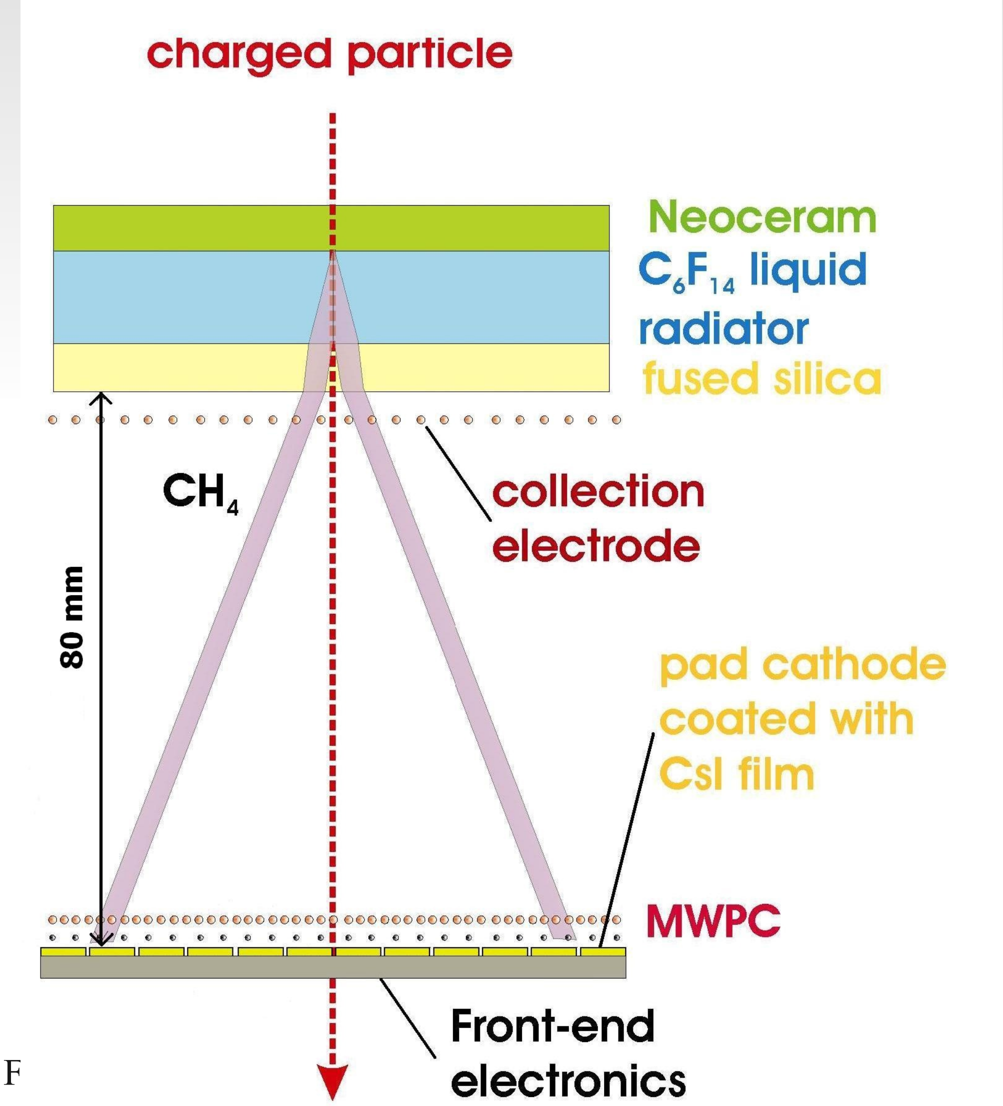
(Wigner **R**MI and **E**LTE Collaboration on **Ga**seous Detector **R**esearch and **D**evelopment)

Outline

- Gaseous photon detectors
  - How it works; Applications : eg. VHMPID
  - Micropattern detectors
- The TCPD detector
  - Single photon detection
  - Laboratory and test beam measurements
  - Cherenkov rings
- High resolution scans : the "Leopard" project
  - Optical setup, Focus
  - Efficiency and gain maps
- Outlook

Gaseous Cherenkov Photon Detectors

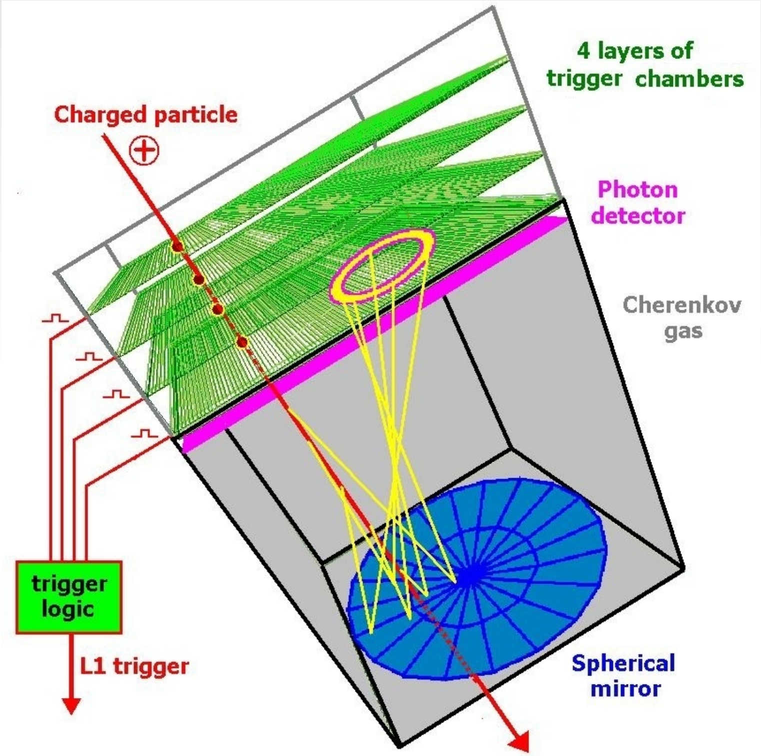
- Cherenkov radiator
- Photosensitive CsI
- Wavelength : VUV
- Single photoelectrons
- Position resolution from the gaseous detecotor (eg. MWPC)
- Ring imaging



VHMPID
(Very High Momentum Particle Identification Detector)

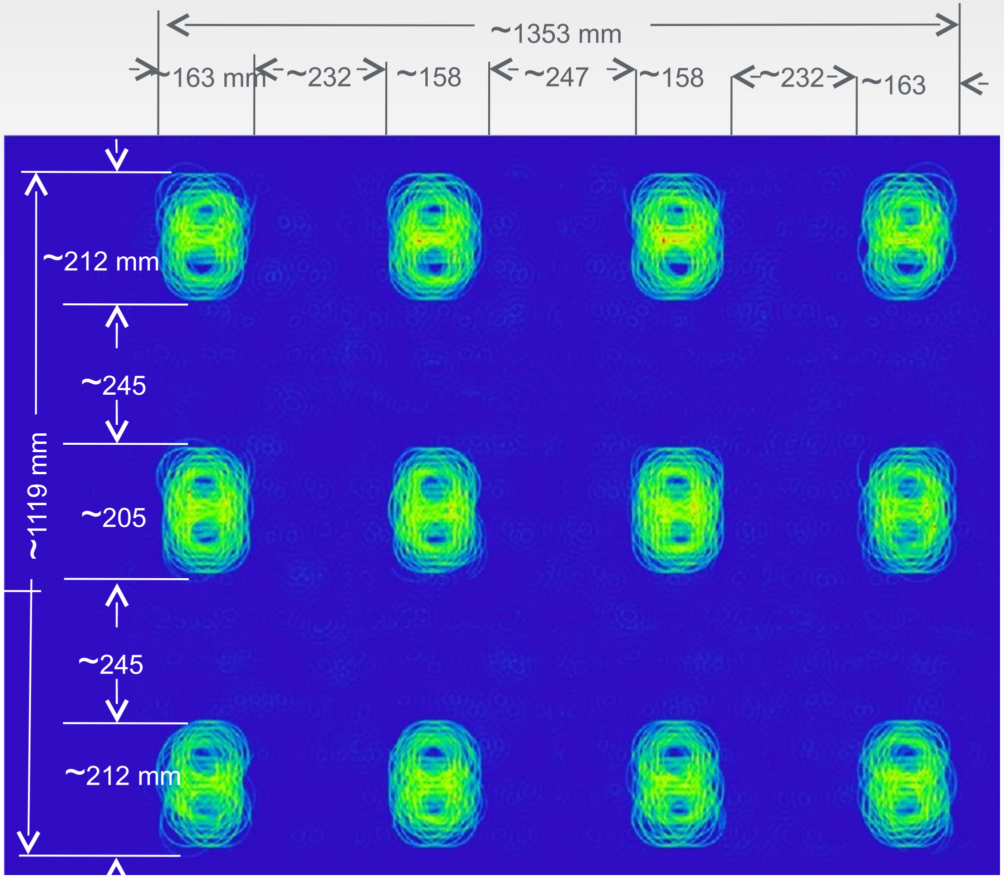
- ALICE R&D Project
- Gaseous Cherenkov detector
- Mirrors to produce rings
- Photon detection
- Heavy-ion physics

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

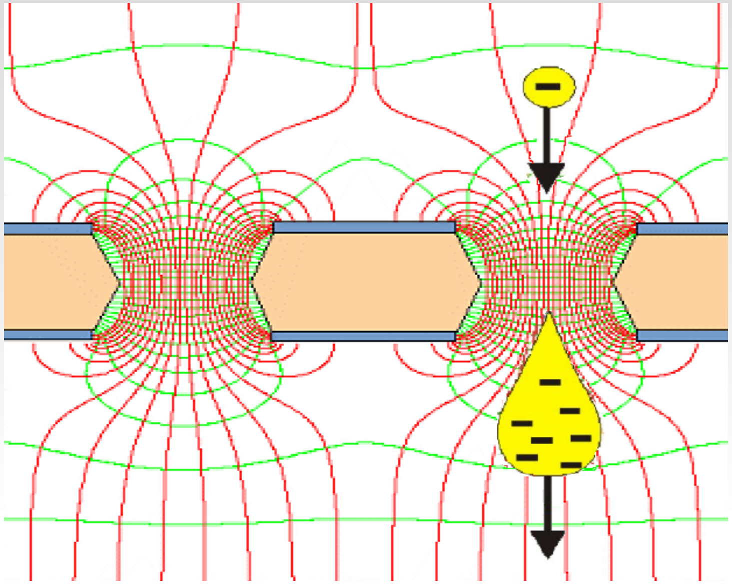


VHMPID's Photon Detectors

- Cherenkov photon detection
- Tilted focusing mirrors
- Several windows
  ~20x20 cm^2
  (quartz, CaF_2)
- CsI coating
- MWPC / TGEM /
  (like HMPID / V.Peskov et al.)
  GEM / TCPD ?



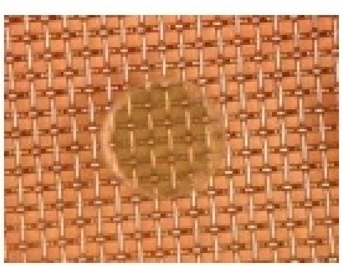
Micropattern Detectors

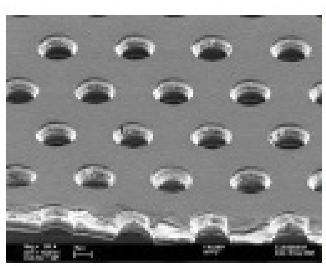


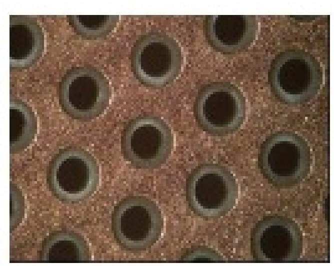
- **GEM (Gas Electron Multiplier)**
  - F.Sauli
  - Copper covered kapton foil with plenty of small hole (~50µm)
  - High voltage makes strong electric field inside the holes => electron avalanche: ~10-100
- Thick GEM (TGEM), Resistive TGEM (ReTGEM) (~600µm) spark tolerance, no clean room is needed
- Application for particle and nuclear physics, reactor technologies, medical imaging, environmental applications, ...

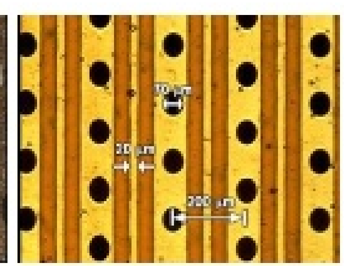
RD51

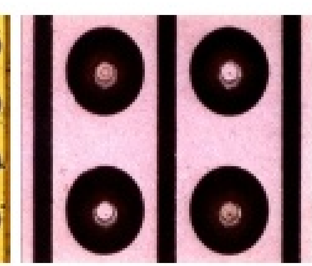
- New collaboration for MPGD R&D
- More than 25 countries, 80 institutes
- Common simulation, and test beam tools
- Small workshop for prototype production and technologiacal studies
- Several new micropattern technologies
- CMS, ATLAS, ATLICE, ITS TPC, COMPASS, ...

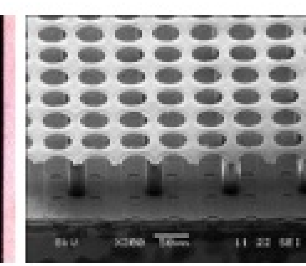

MicroMegas


GEM


THGEM


MHSP


microPIC

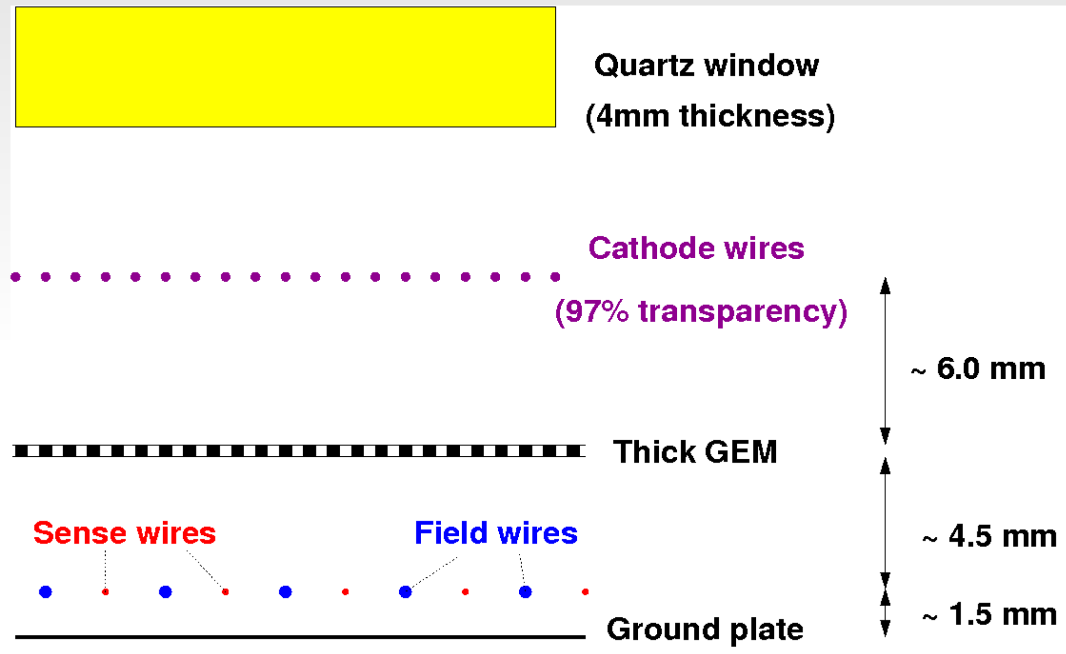

Ingrid

Several Possibilities for Photon Detection

- **MWPC for photon detection**
  - (+) Full surface
  - (-) Ion backflow
  - (-) Feed-back photons
- **ThickGEM based photon detection**
  - (+) Ion backflow
  - (+) Feed-back photons
  - (-) Multi-layers (2-3) raise cost
- **Close Cathode Chamber (CCC)** [NIM A 648 (2011) 163-167]
  - (+) Mechanical tolerance, simple construction
  - (+) Low material budget

TCPD Outline
(ThickGEM+CCC Photon Detector)

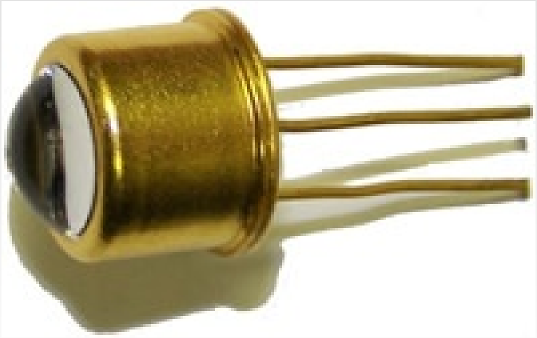
- A known configuration applied for photon detection
- UV-transparent quartz window
- Wire plane for cathode
- ThickGEM, upper surface could be coated with CsI
- Standard CCC wire layout
- Padplane on ground

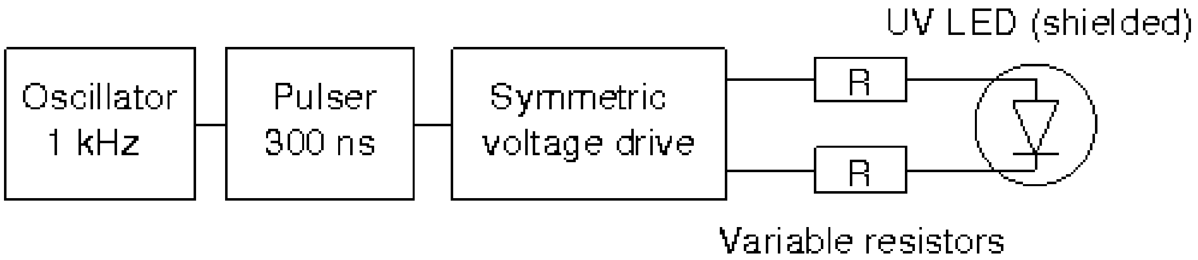


Combines the advantages of both technologies :
no feedback photons, small ion backflow, mechanical tolerance

Photon Source : UV LED

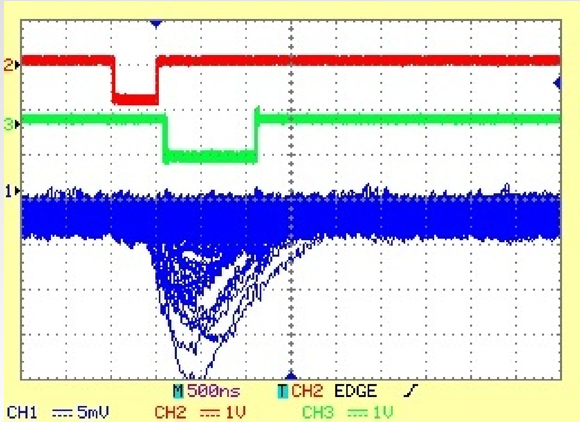
- SETi UV TOP 240
  - 245 nm peak; 10 nm width
  - Photo-electrons from gold surface
- UvLed Driver Unit
  - Home made for our specification
  - Short pulses (adjustable : 50-500 ns)
  - 1 kHz frequency (adjustable)
  - Intensity : adjustable with two resistors

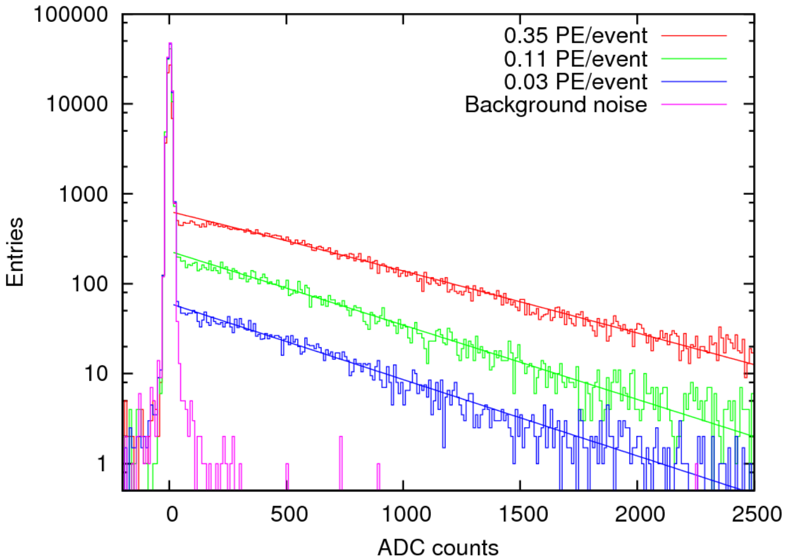




Single Photo-electrons

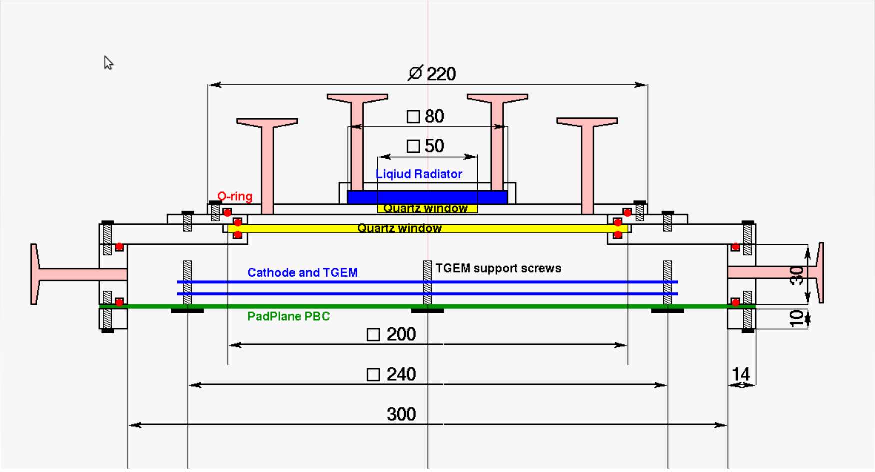
- Swarm of photons,
  but low quantum efficiency
- Adjustable intensity
  --> average number of
  photo-electrons per pulse can be set
- Negligible multi-electron events
- Pulse-height spectra are similar
  for the different
  photo-electron yields

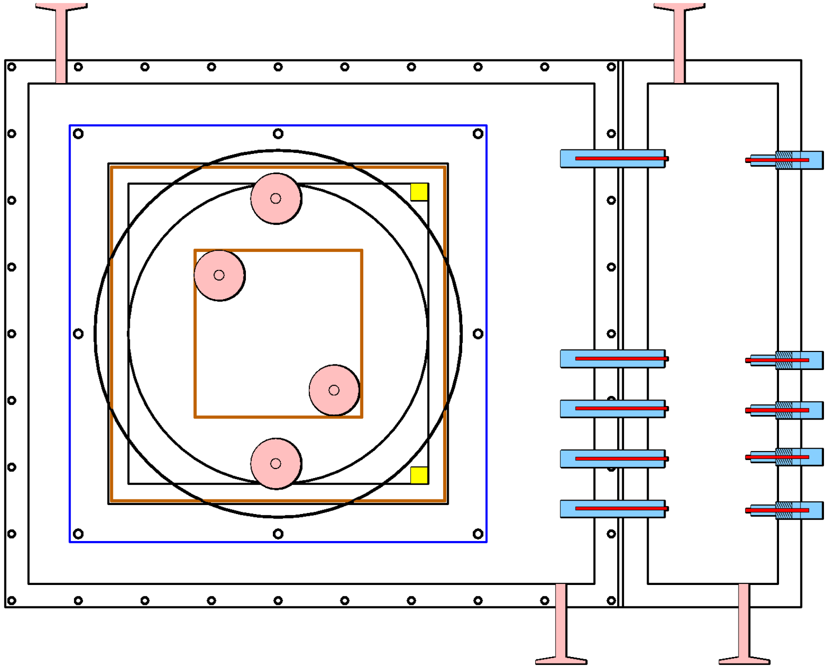




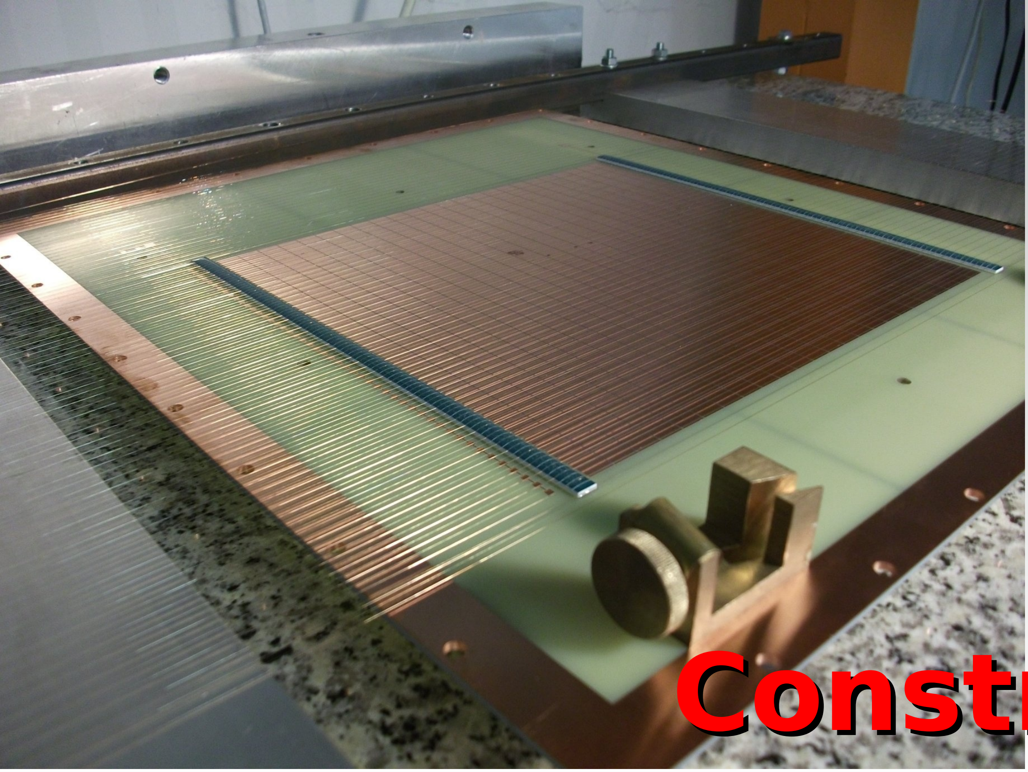
TCPD-2 Chamber for Cherenkov photons

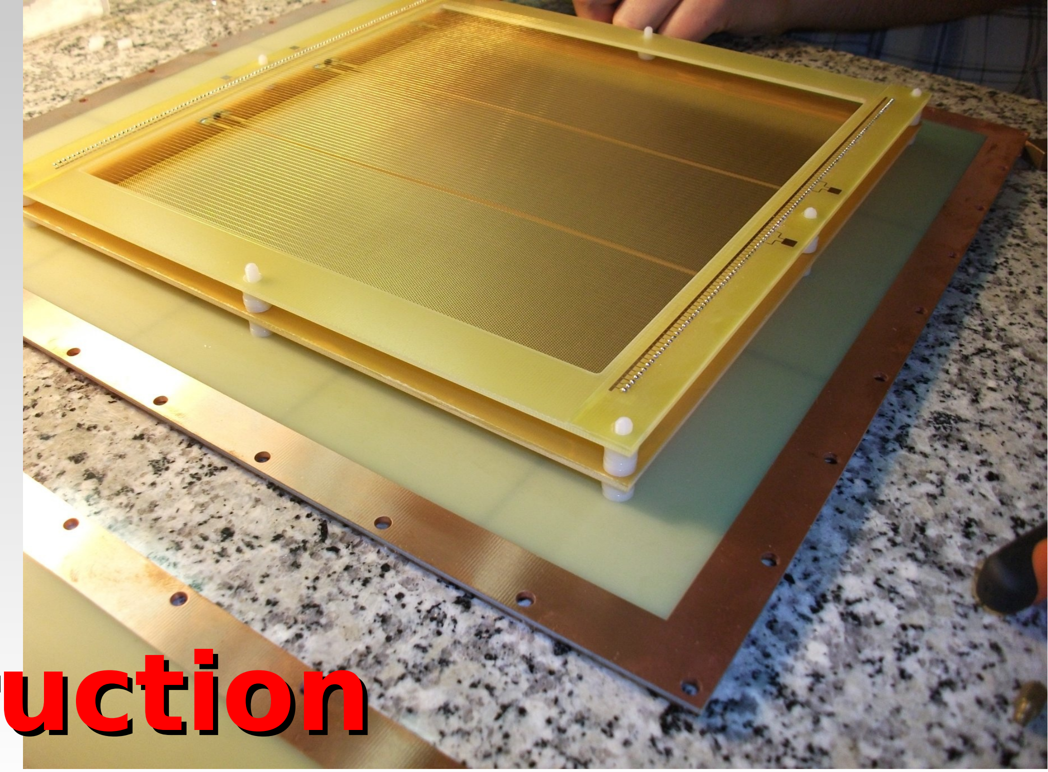
- TGEM 20x20 cm^2 active area (CERN, R.Oliveira, 2011)
- CsI cover (CERN, 2011)
- Humidity-free gas volume for the HV connection
- Large quartz window (20x20cm^2)
- Small monitoring window
- Detachable frame for the liquid radiator
- Pad structure : HMPID-like (8x8, 4x8, 4x4 mm^2)

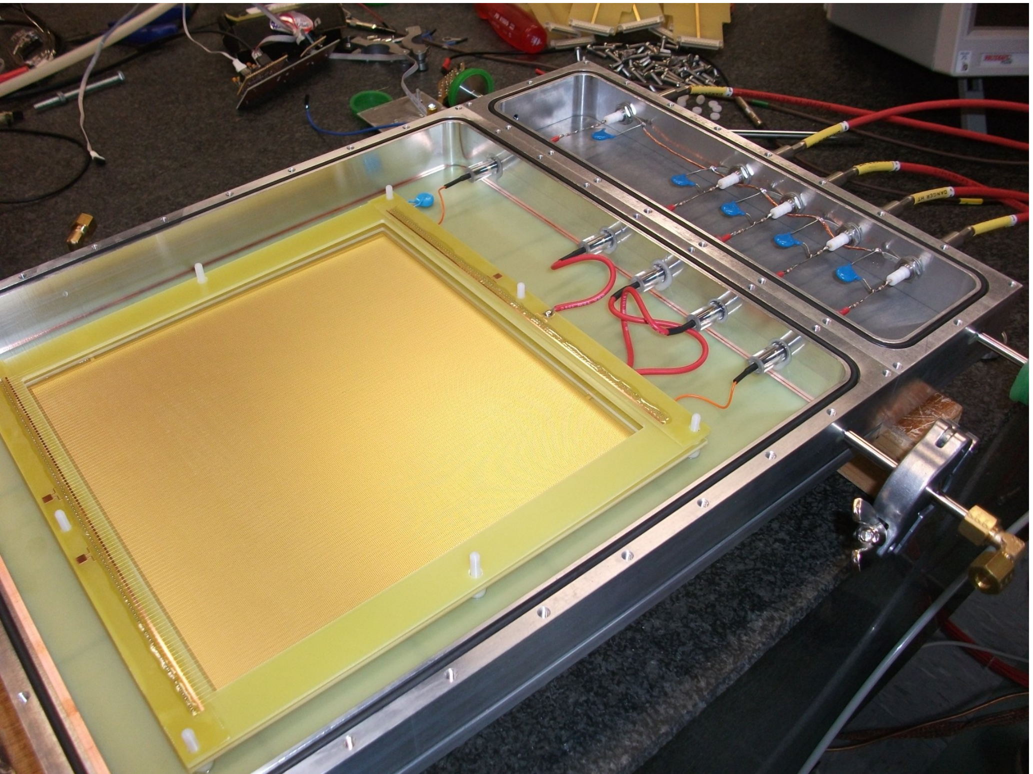


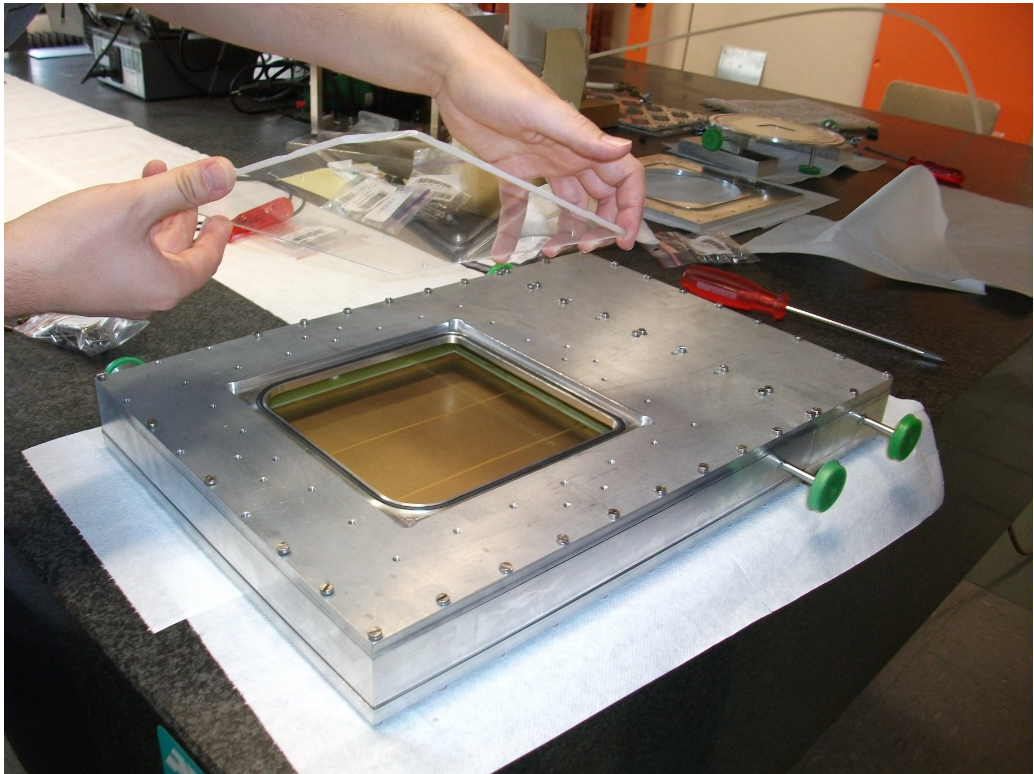


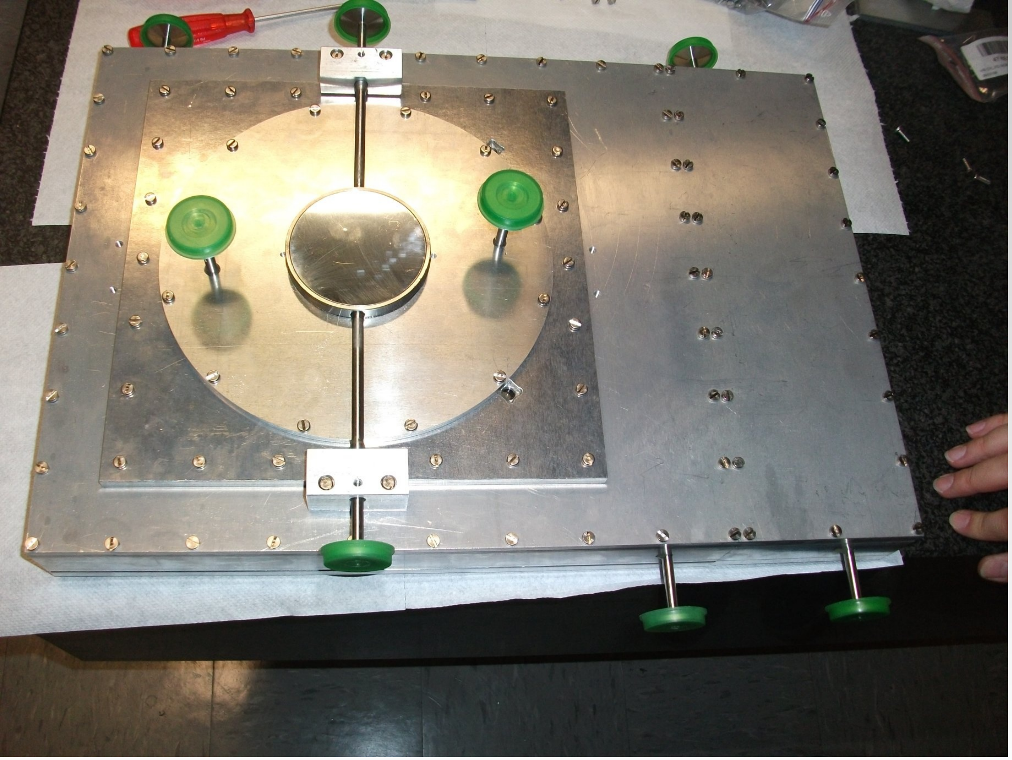
Construction

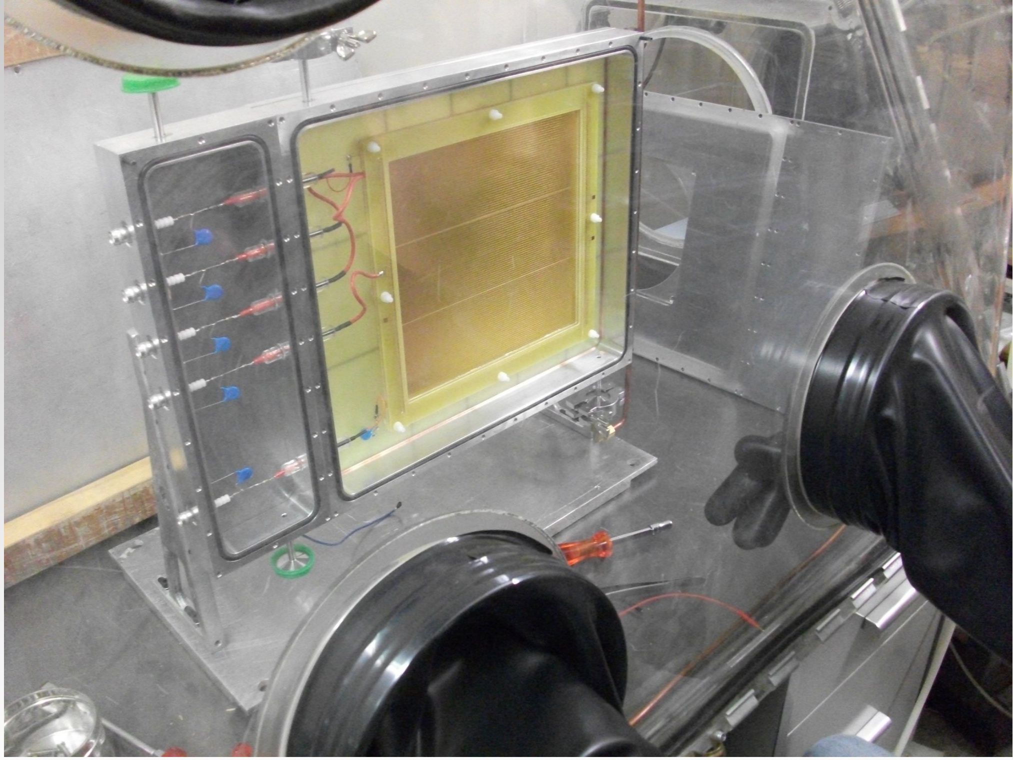






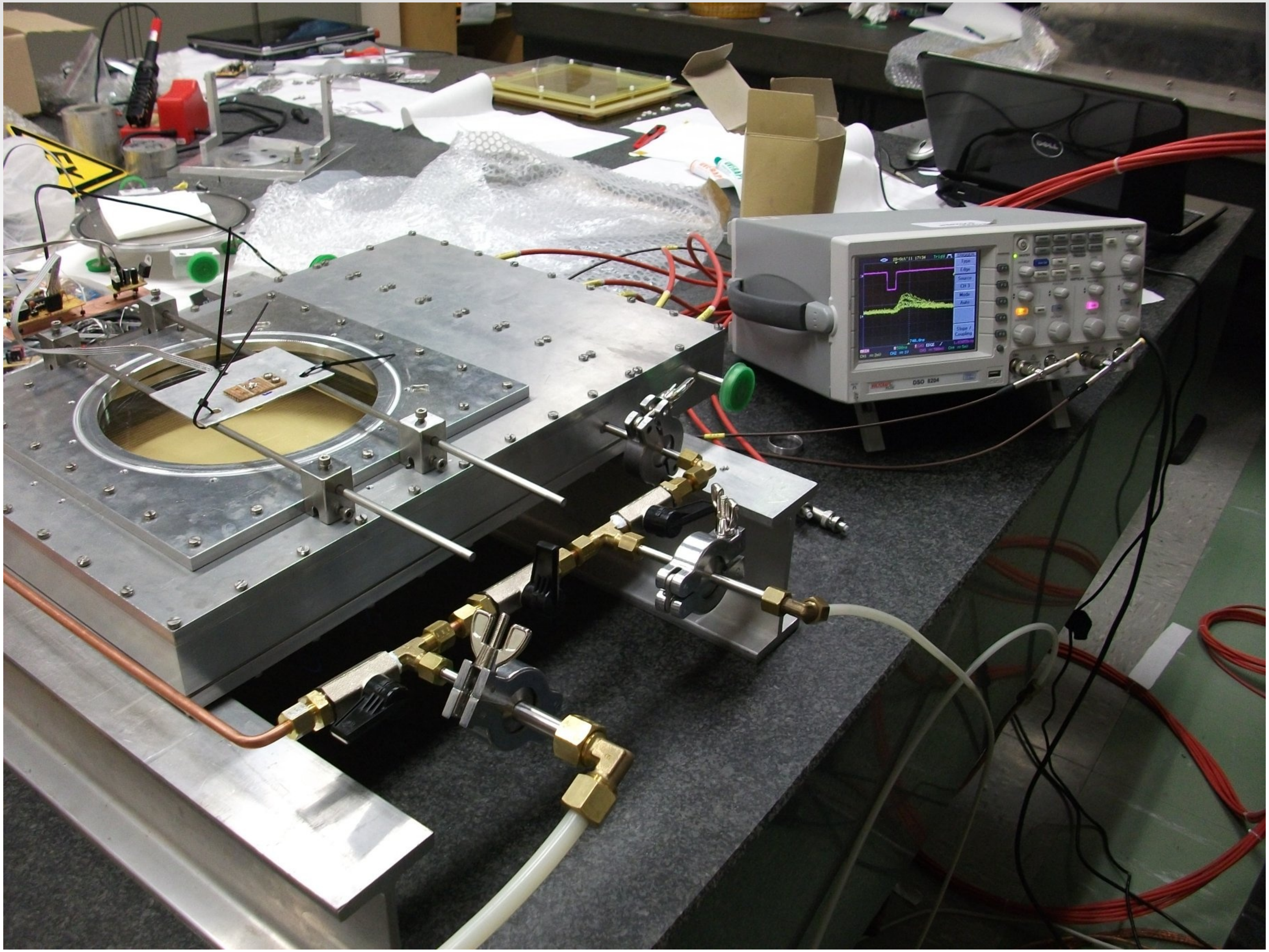






Beam Test

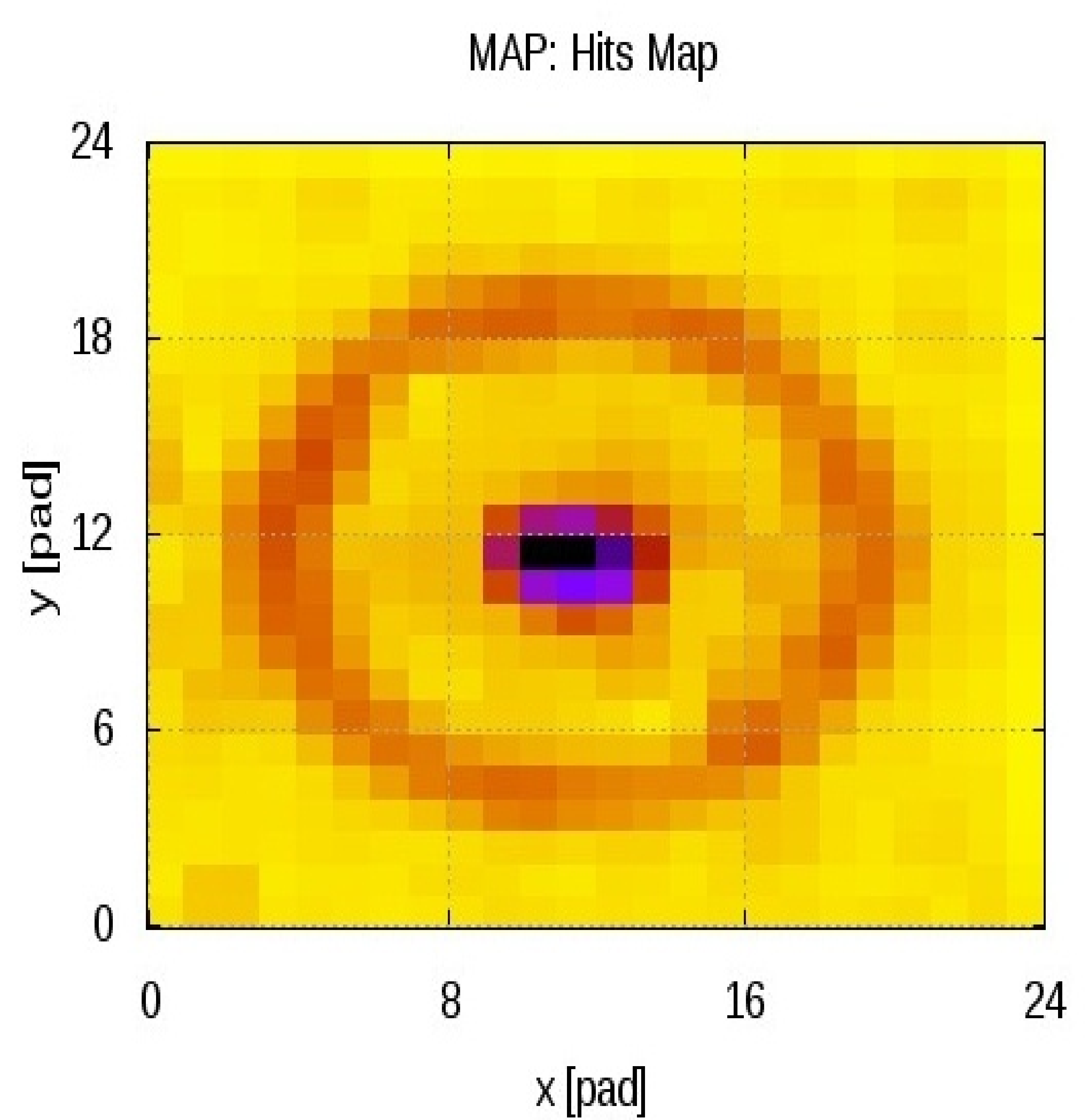
First Photons with the 20cm Chamber



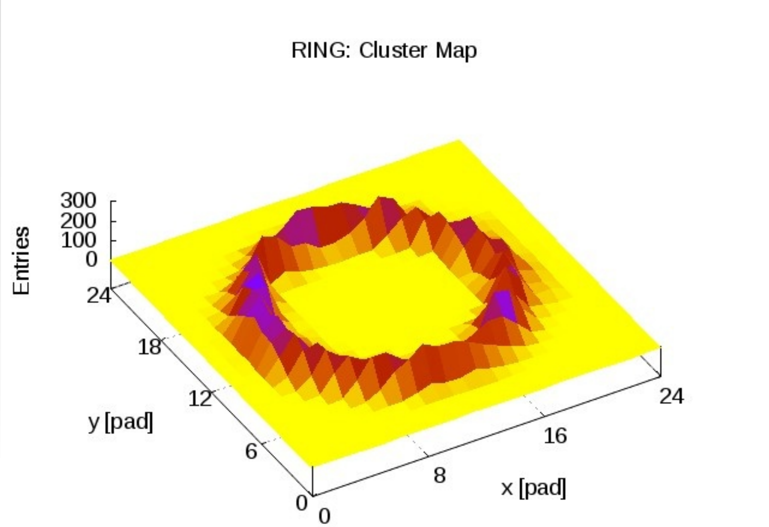
Beam Test Setup

- Beam test in 2011, 2012 at CERN PS T10
- Four small scintillators to define a nice beam spot,
  Two large scintillators for beam and for muons
- Pad readout DAQ,FEE : ALICE HMPID/VHMPID type
- Connected wires read out for scope monitoring
  and/or for simple data taking with CamacADC
- Radiator : C_6F_{14} (standard HMPID)
- Applied gases : Ar-CO_2, CH_4
- Study of pad-size dependance as well
  two padplanes: standard 8x8; mix 4x4,4x8,8x8.

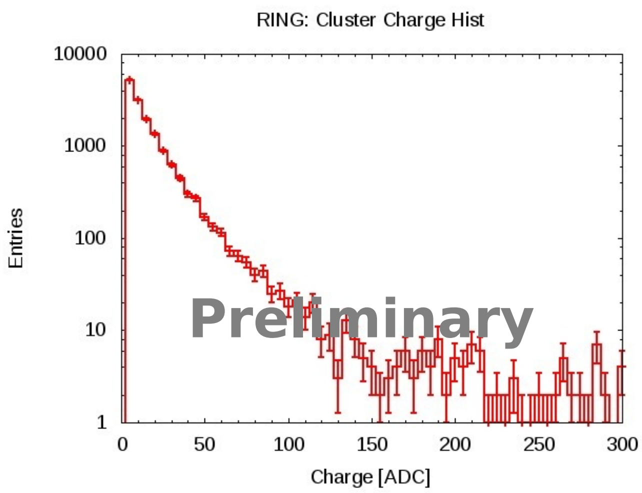
Cherenkov Rings

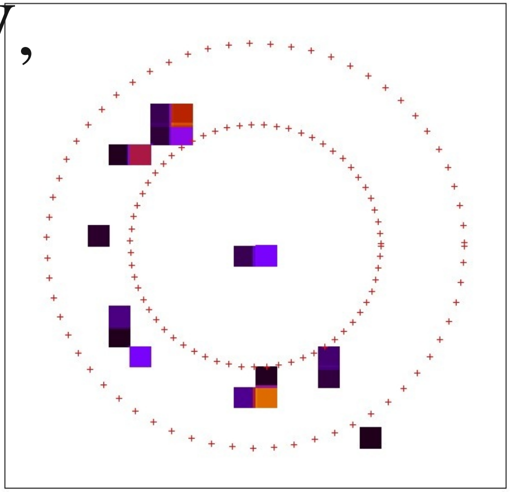


Cherenkov Rings



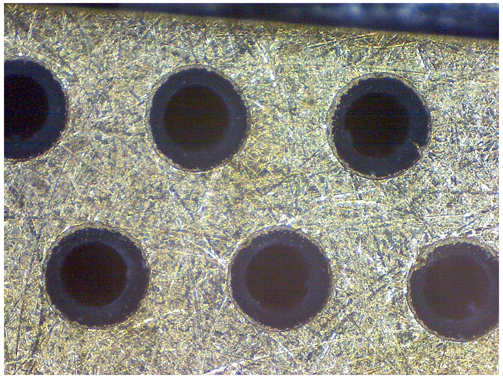
- Full Cherenkov ring with TGEM
- Cherenkov photon detection
- Problem with the windows
  (grooves were in it =>
  significant loss of the effective surface)
- Offline analyses is still ongoing
- Basic studies: HV,
  pad-size, rate,
  uniformity





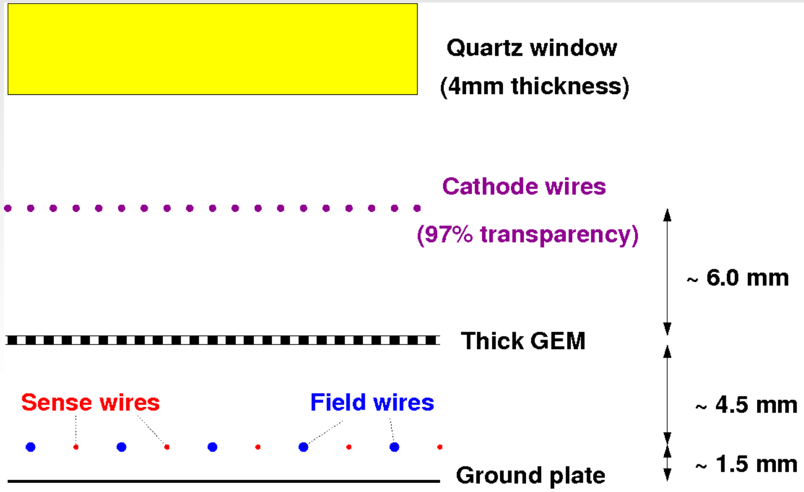
High Resolution Scan

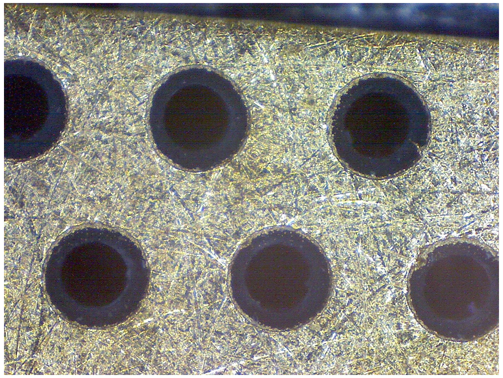
- Holes cannot be covered with CsI
- Loss of effective surface
- Inhomogen field for electron extraction
- Effect of MIP suppression ?
- Electrostatic calculations, simulations
- Symmetry points are crucial
- Is it measurable with good enough resolution?



TCPD

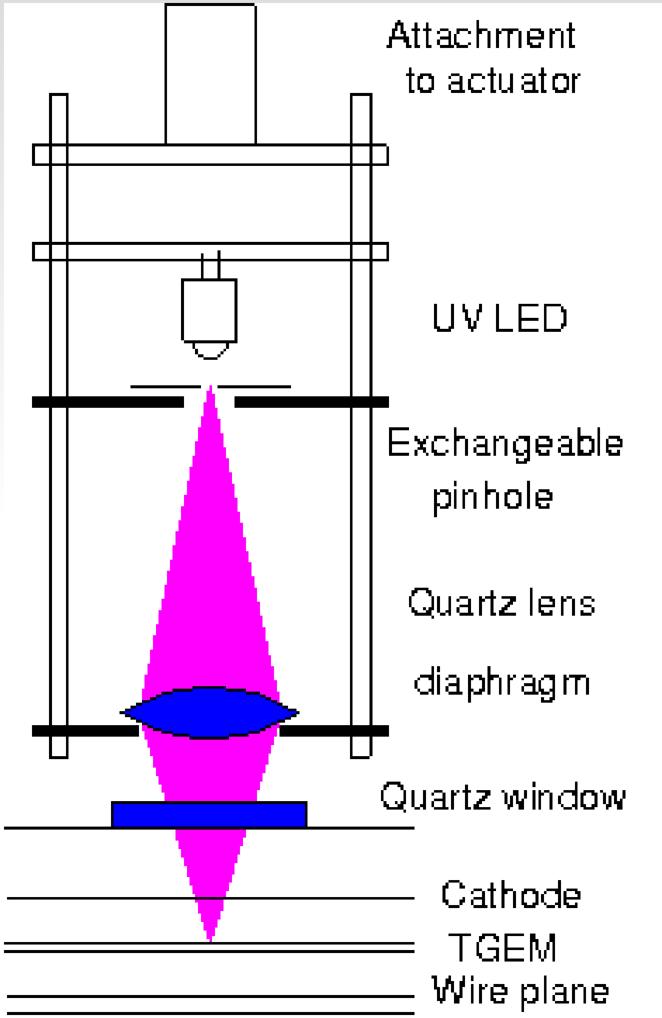
- **T**hickGEM + **C**CC **P**hoton **D**etector
  (former slides)
- Transparent cathode (via 30 µm wires)
- TGEM
  - Made in CERN by Rui in 2009
  - 10cm x 10cm
  - Hole: 300 µm, pitch: 800 µm, rim: 60 µm
- Close Cathode Chamber
  - 4 mm wire spacing
- Signal : from the connected sense wires



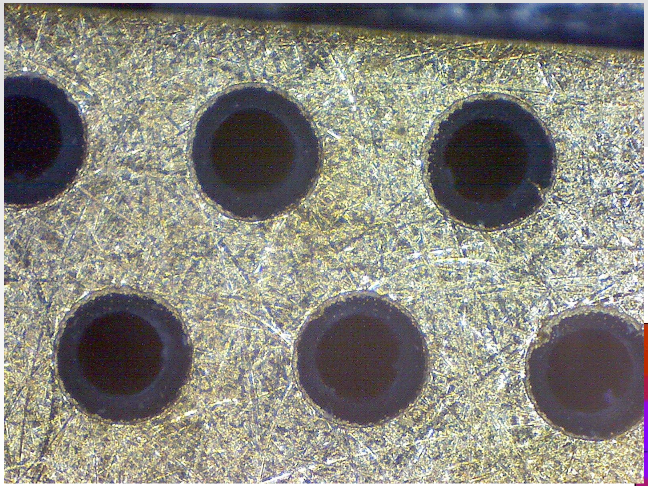


Optical Setup

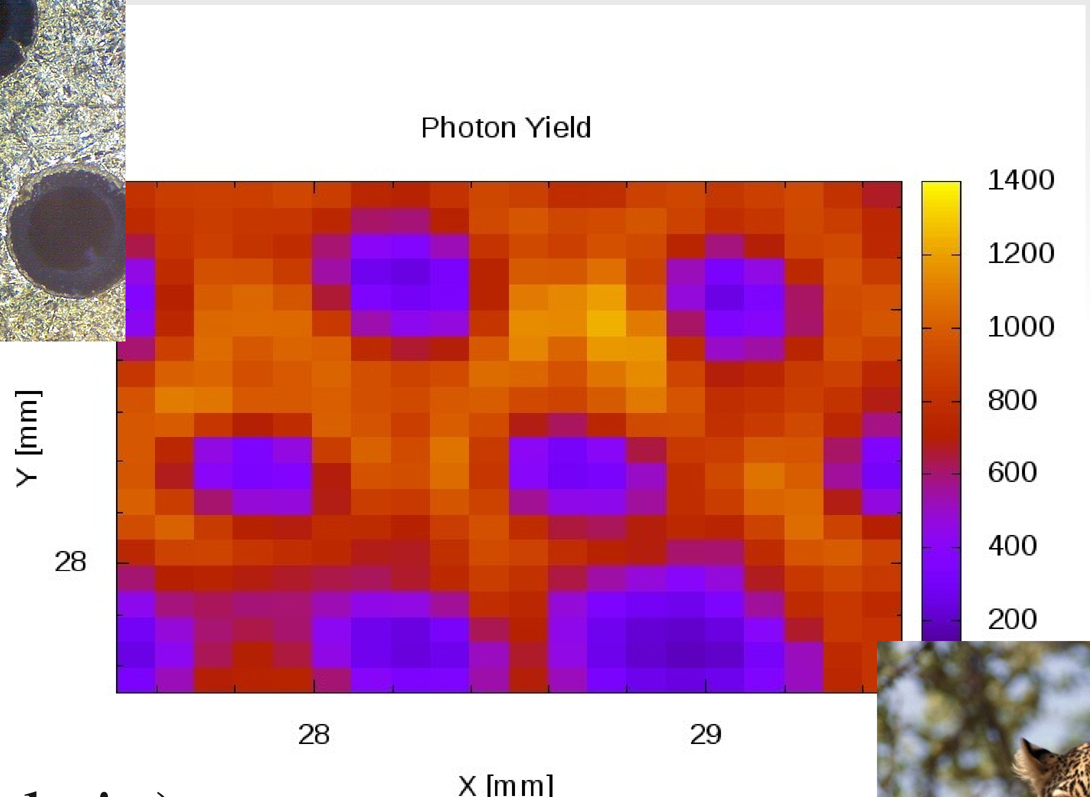
- Focusing setup :
  focus onto the TGEM surface
- Spot size? ~ pinhole size
  - 150, 300, 500 µm
- Motion table
  - 3 dim with stepping motors
  - Precision ~ 2.5 µm / step
  - Coordinated by the DAQ



First Pictures



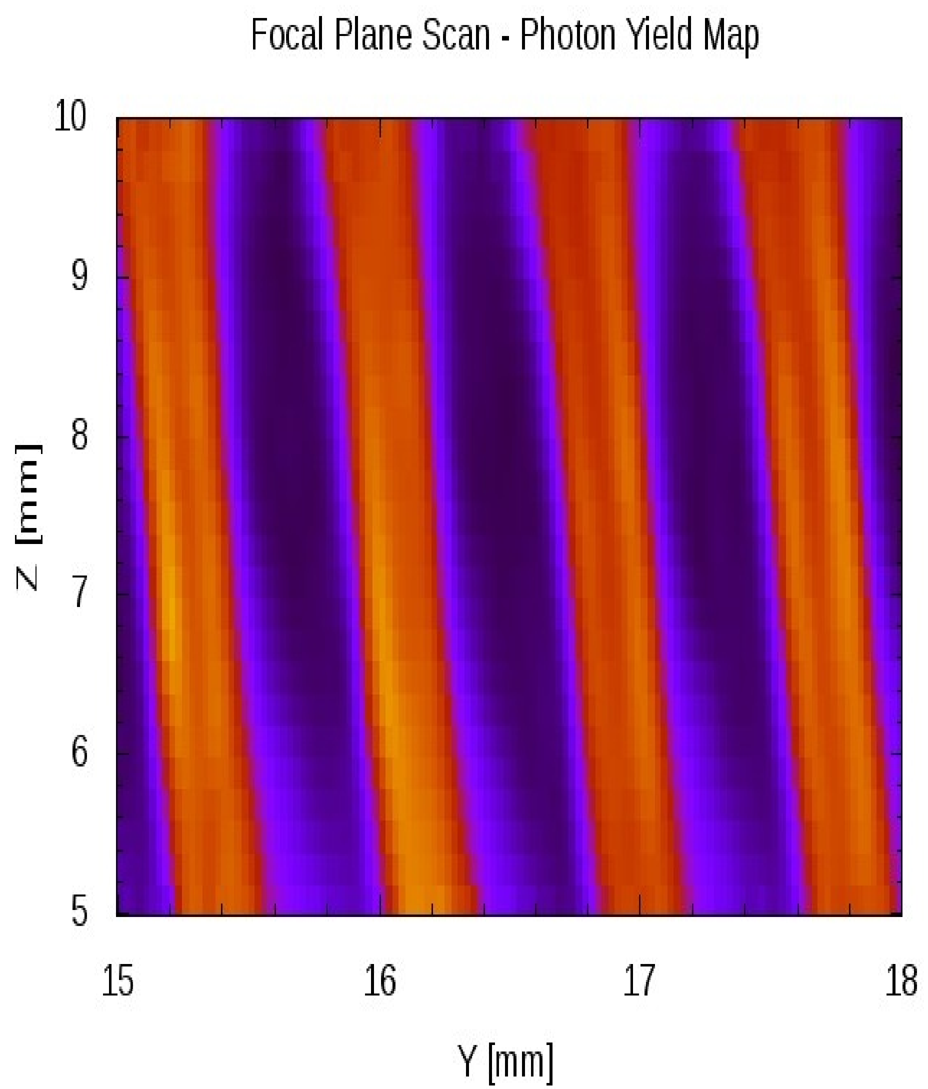
2 dim. photo-electron yield map



It works! :)

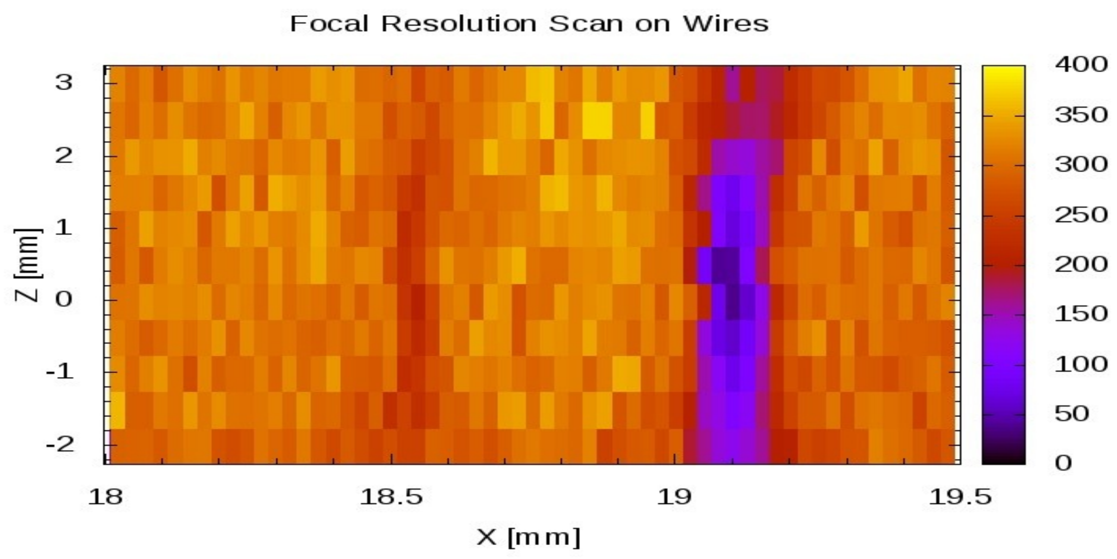
Searching for the Focal Plane

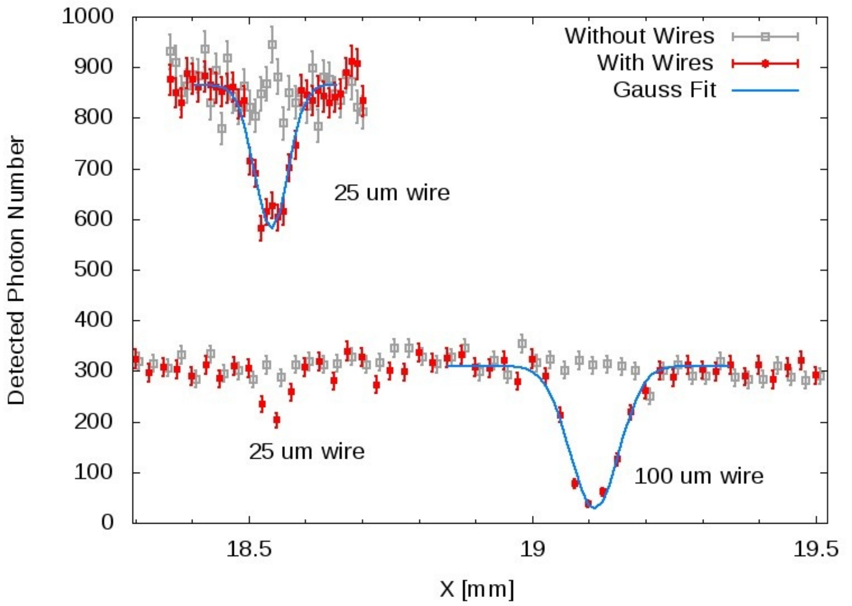
- 1 dim. scans
  at different heights
  through a line of holes
- Holes are visible
  (even symmetry lines are)
- Sharpest edges
  defines the focus
- Small asymmetry is visible
  due to the slight inclination
  of the UvLed (~ 2 degrees)



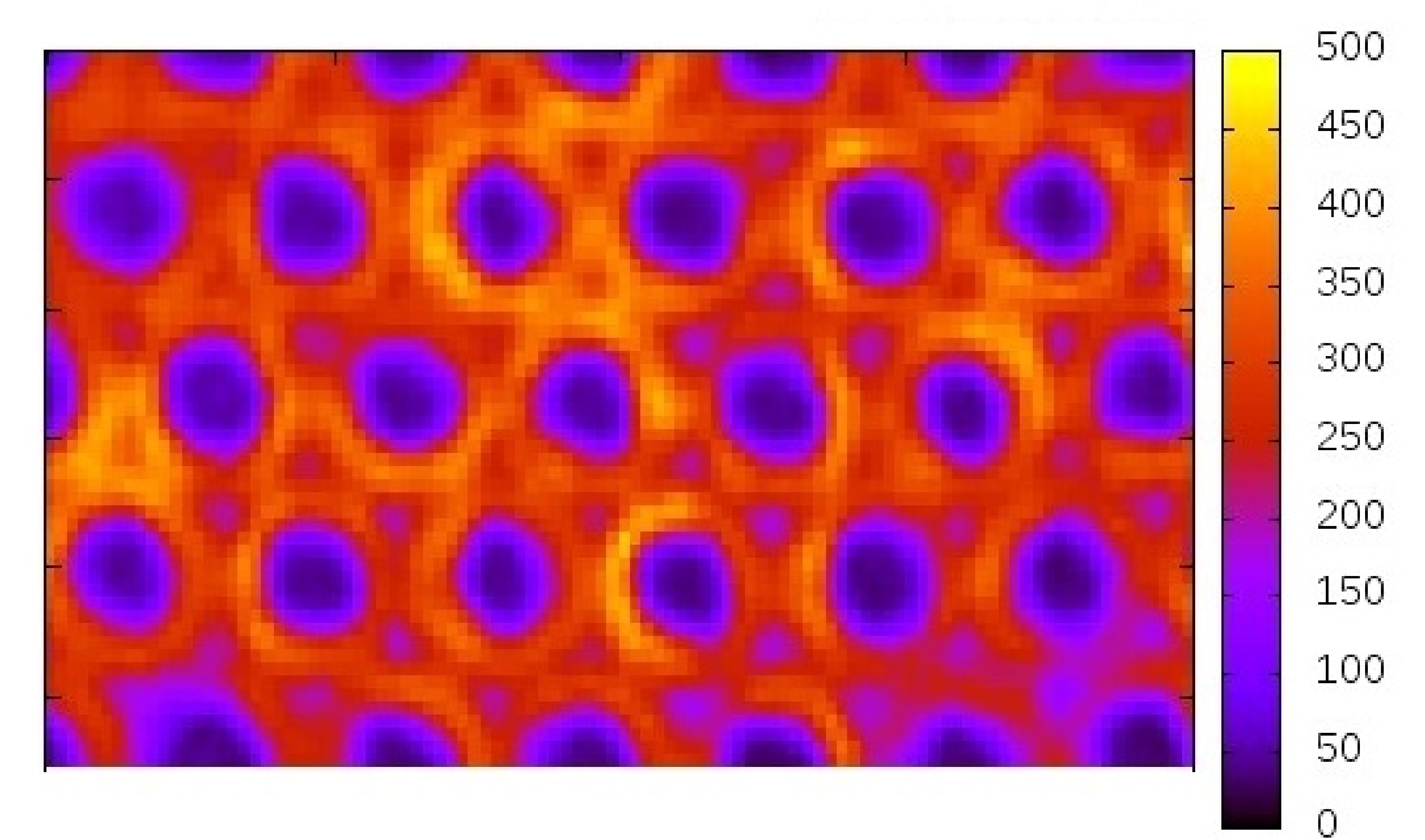
Measuring the focused spot

- Wires were placed onto the window
- 1D scan with different focus
- Spot from ∅150 µm pinhole is 70 µm FWHM



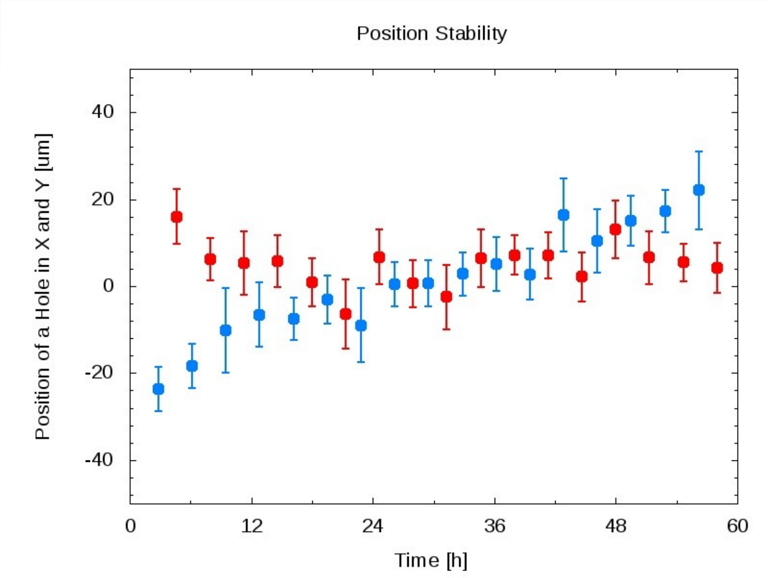


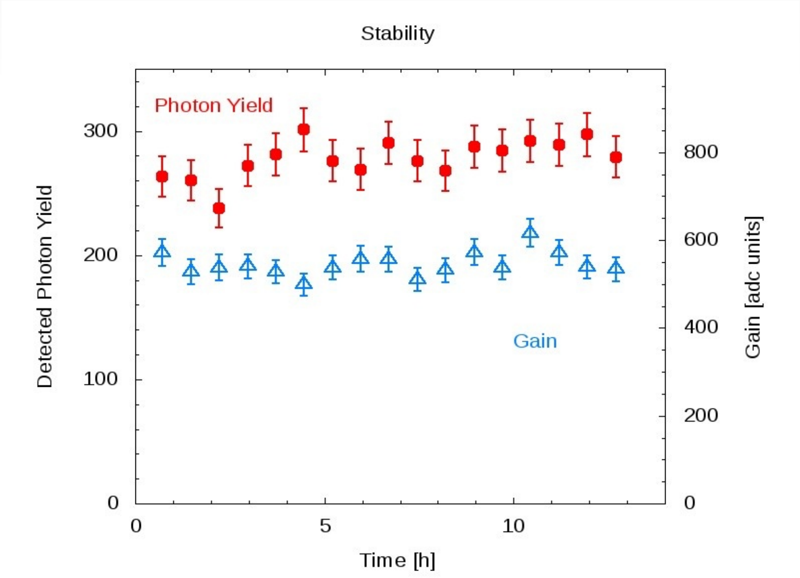
“Second” Pictures



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

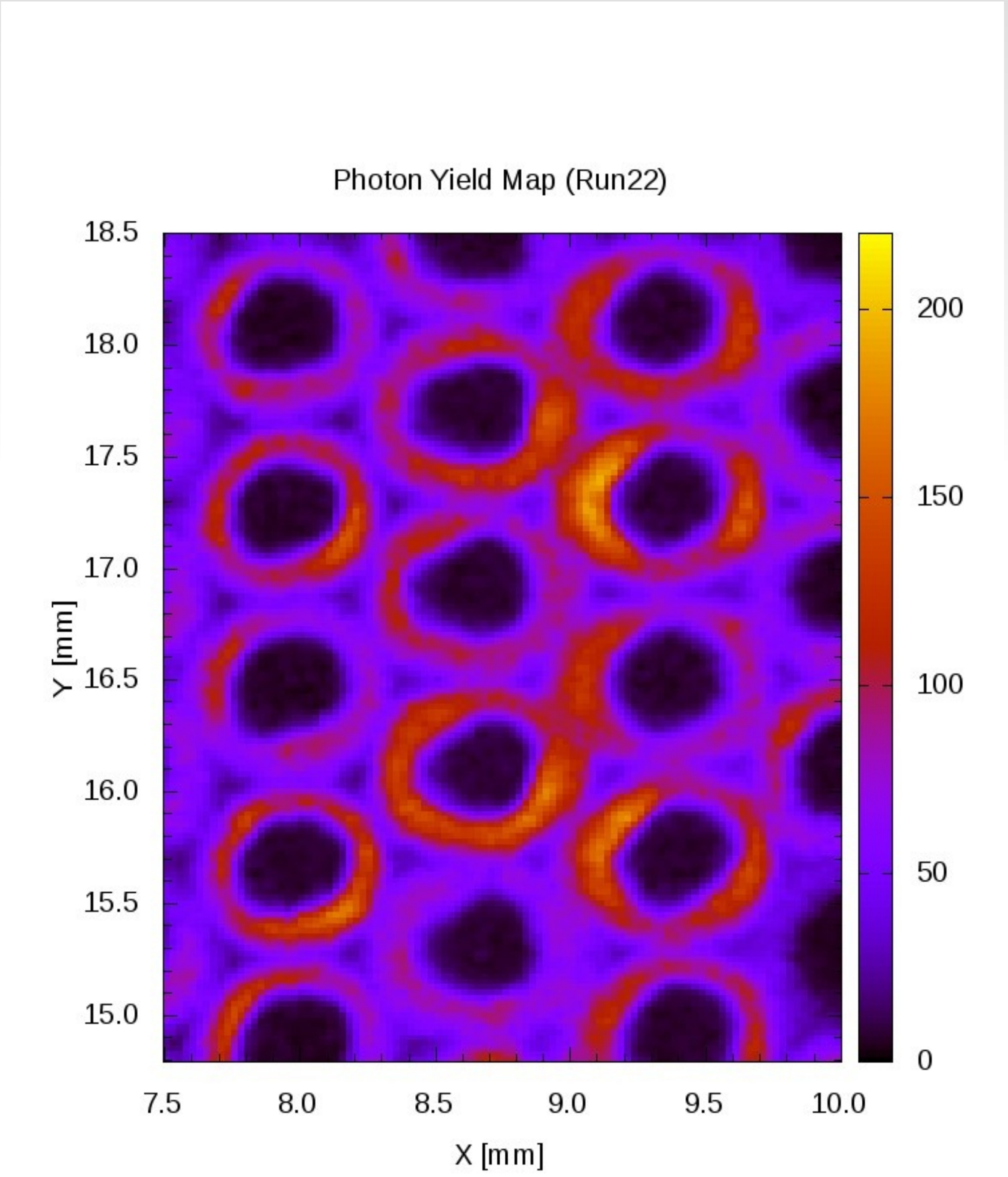




- **The system is stable enough to perform long measurements**

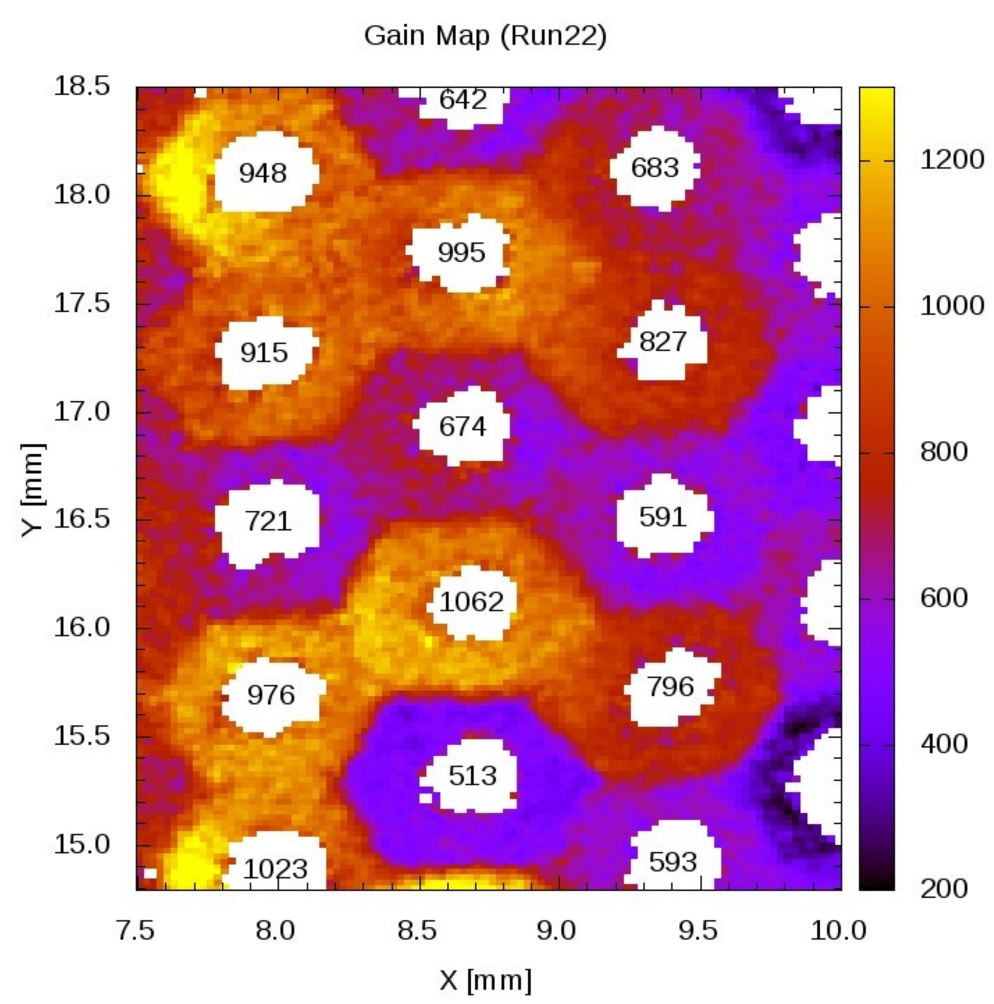
Photo-electron Yield Map

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



Gain Map

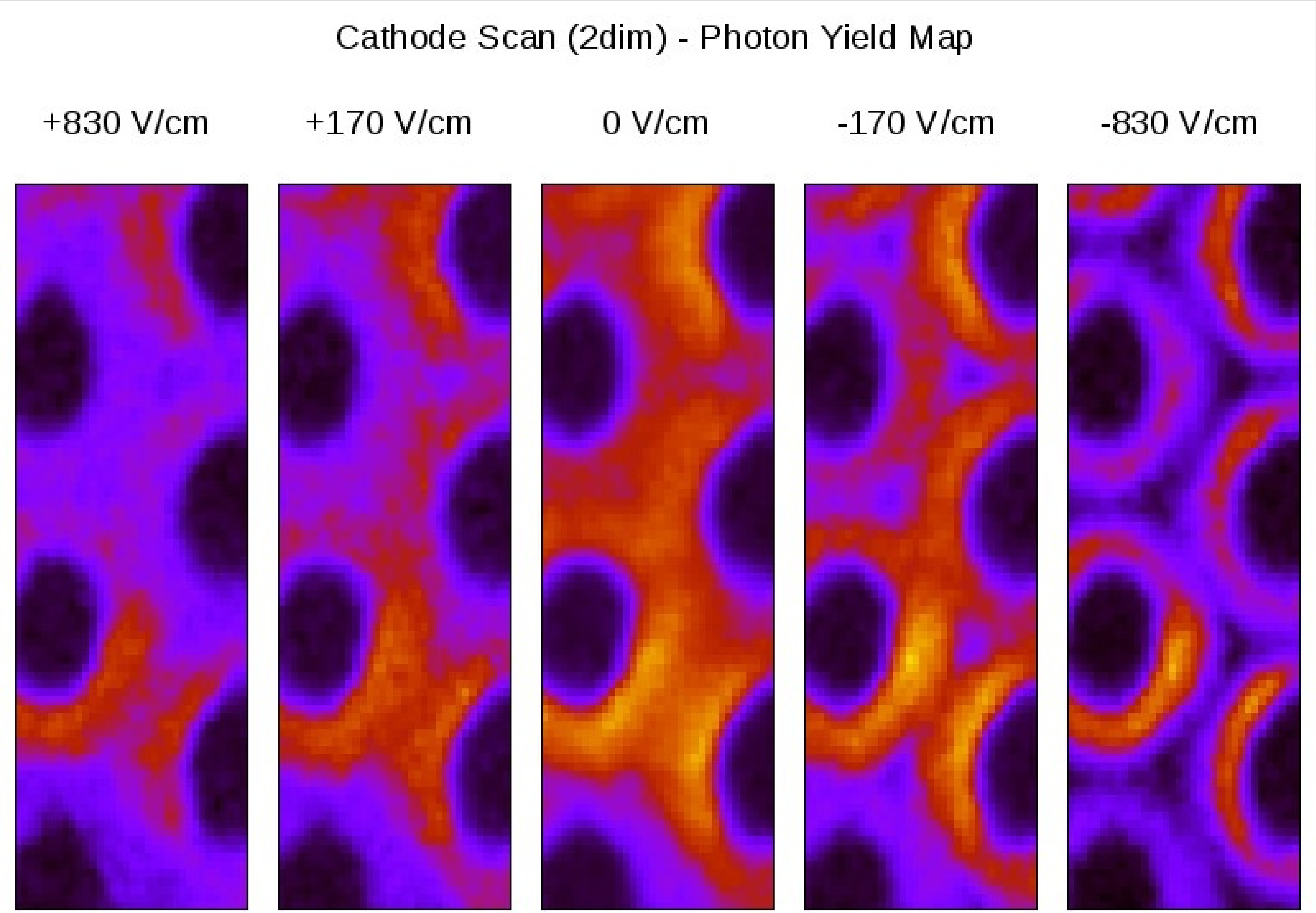
- Gain is measured for each measurement point
- Gain is constant in a hexagonal shape around a hole (**hole-gain**)
- Hole-gains vary a lot from hole to hole
- Only slightly correlates with the detected photon yields



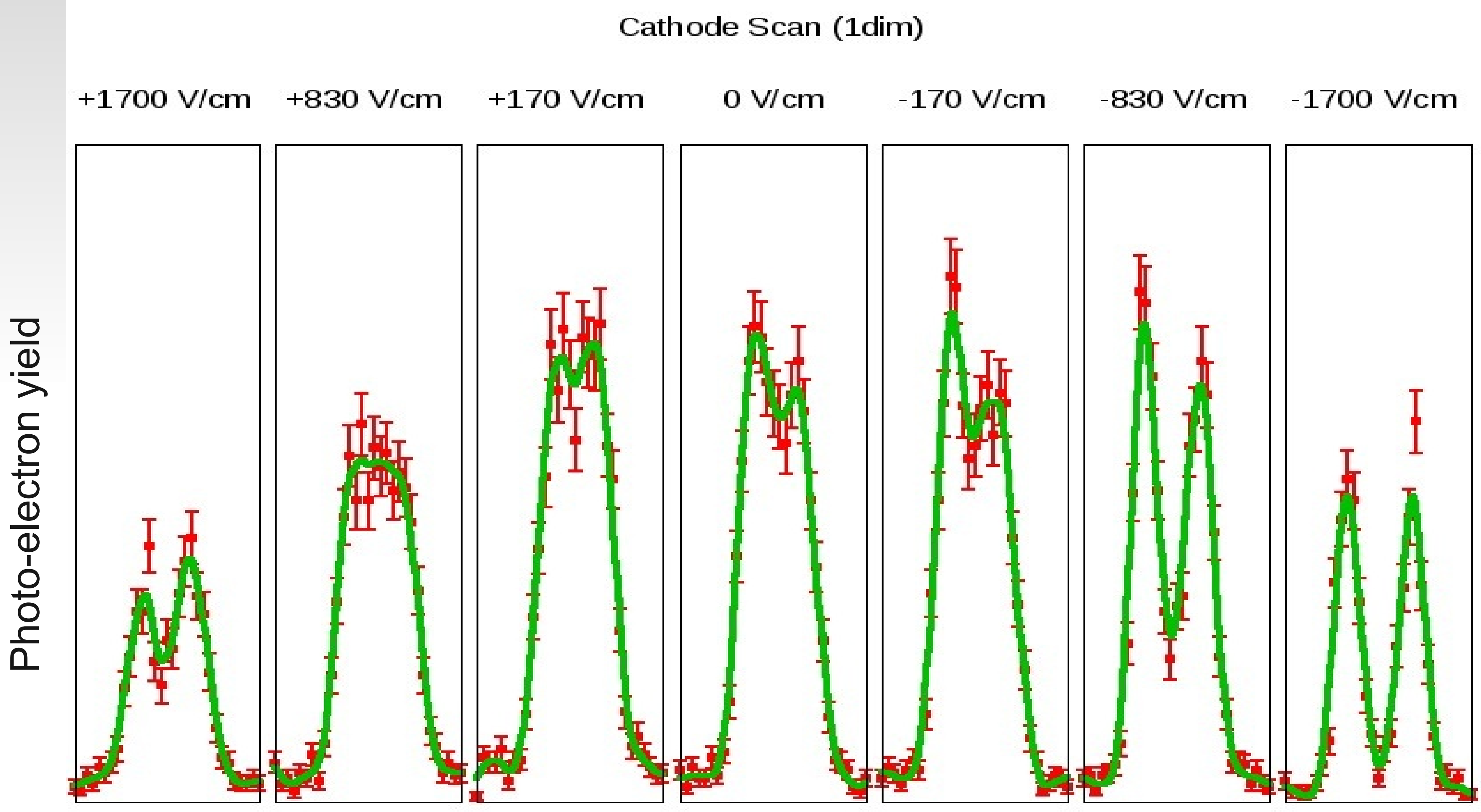
Cathode Field Scan

- Normal vs. reversed field
- Electric field lines between the TGEM-Up and the Cathode
- Overall efficiency
  - Peaks at 0 V/cm
  - Slowly decreases with higher fields, roughly symmetric
- High reverse field : from the symmetry lines and points the field line go to the Cathode --> loss in effective surface, more “ring-like” structure
- High normal field : at the symmetry lines and points the electrons are pushed back to TGEM surface; changes the holes' field configuration. --> loss of efficiency

Cathode Field Scan



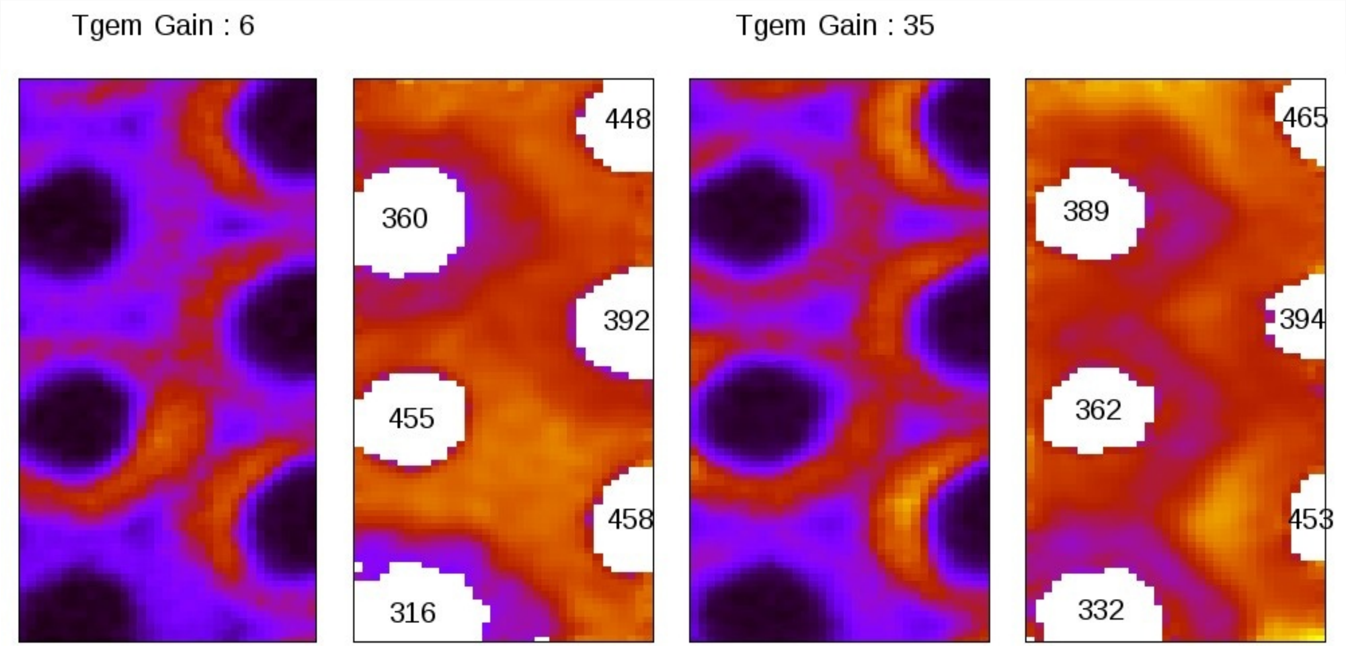
Cathode Field Scan



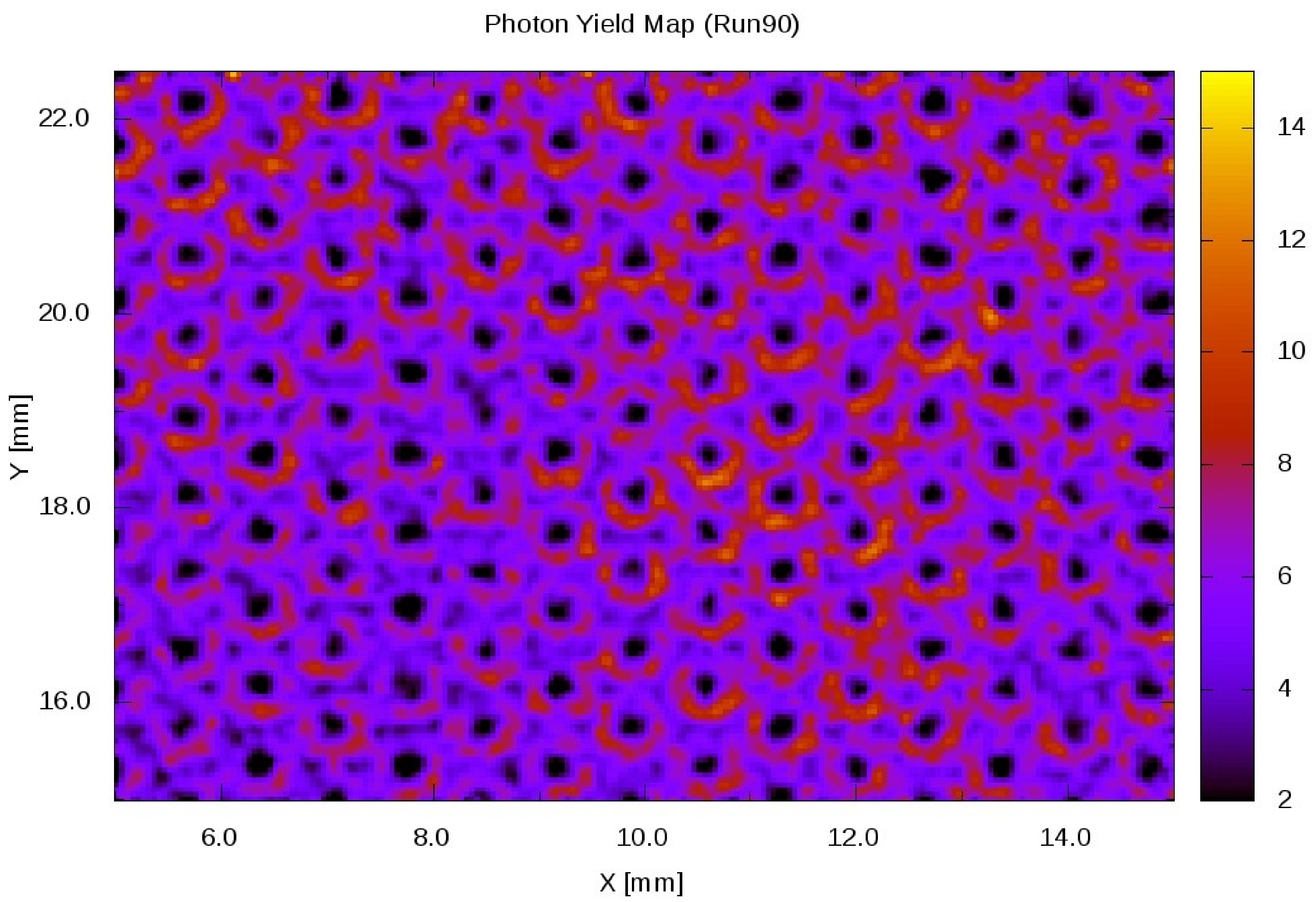
TGEM Gain Variation

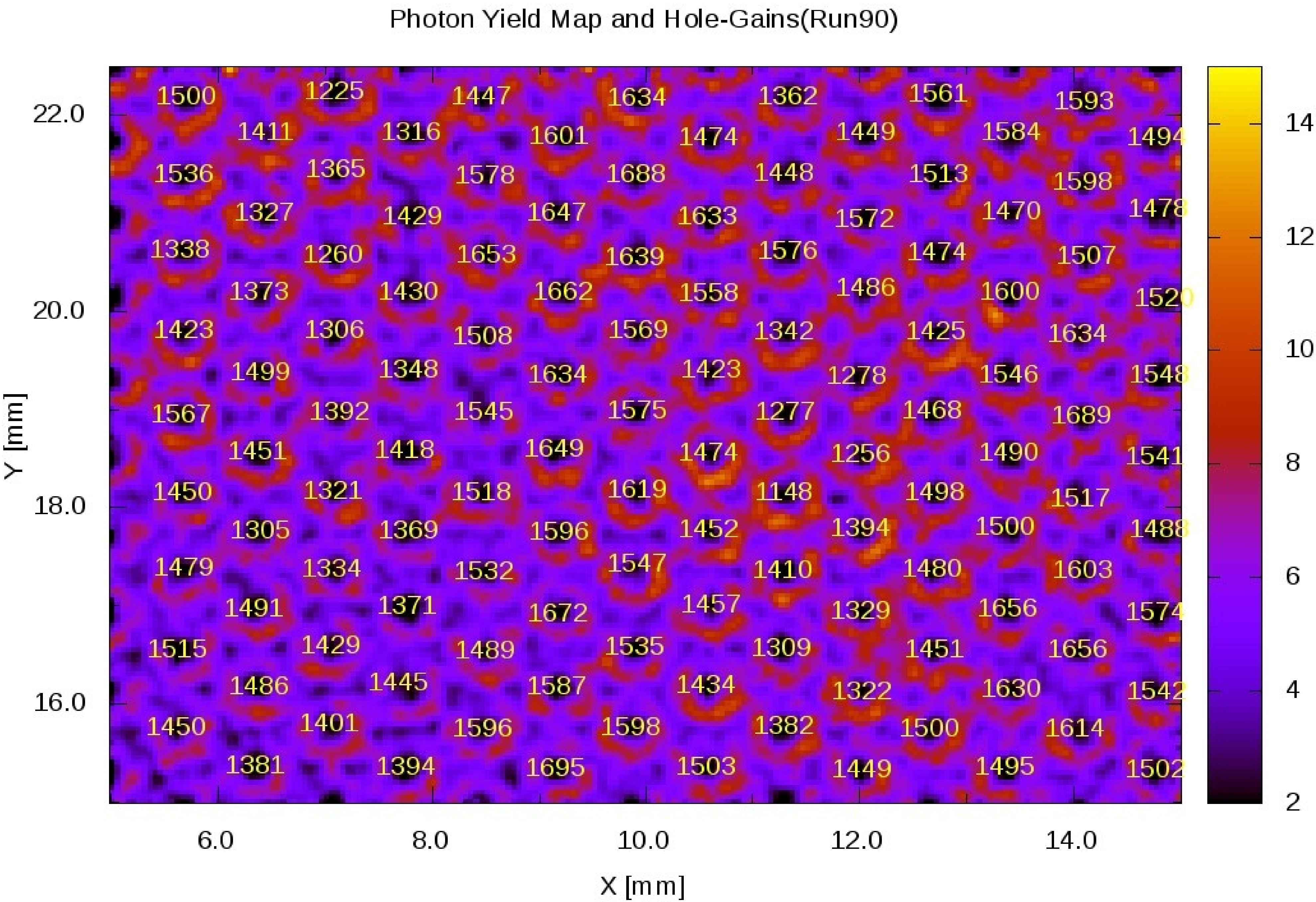
- **Same region at different TGEM voltages**
- TGEM gain has been measured with MIP-like beta source
- Overall photo-electron yield increases only a bit

Voltage dependance of the gain could be different from hole to hole (?)



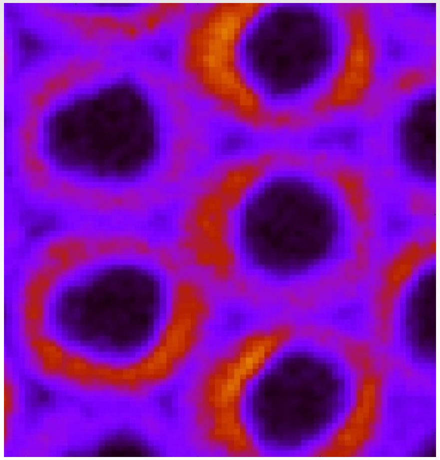
TGEM, made in 2011




Photon Yield Map and Hole-Gains(Run90)
1500 1225 1447 1634 1362 1561 1593
1411 1316 1601 1474 1449 1584 1494
1536 1365 1578 1688 1448 1513 1598
1327 1429 1647 1633 1572 1470 1478
1338 1260 1653 1639 1576 1474 1507
1373 1430 1662 1558 1486 1600 1520
1423 1306 1508 1569 1342 1425 1634
1499 1348 1634 1423 1278 1546 1548
1567 1392 1545 1575 1277 1468 1689
1451 1418 1649 1474 1256 1490 1541
1450 1321 1518 1619 1148 1498 1517
1305 1369 1596 1452 1394 1500 1488
1479 1334 1532 1547 1410 1480 1603
1491 1371 1672 1457 1329 1656 1574
1515 1429 1489 1535 1309 1451 1656
1486 1445 1587 1434 1322 1630 1542
1450 1401 1596 1598 1382 1500 1614
1381 1394 1695 1503 1449 1495 1502
22.0
20.0
18.0
16.0
Y [mm]
6.0
8.0
10.0
12.0
14.0
X [mm]
14
12
10
8
6
4
2

Summary

- Micropattern technology for future detectors/upgrades
- High energy PID -> Cherenkov -> Photon detection
  eg. ALICE VHMPID
- TCPD is a reliable candidate
- Surface scan with single photo-electrons
  Separation of efficiency and gain measurements
- Excellent tool to study TGEM's local behavior
- Leopard
  - Ring-like photo-effective area
  - Photo-electron efficiency fluctuations
  - Hexagonal hole-gain structure



Thanks to the Hungarian OTKA CK77719, CK77815 grants and the support of the REGARD, ALICE-Budapest and ALICE VHMPID Groups