MPGD Photon Detector Upgrade for COMPASS RICH

Gergő Hamar

for the THGEM group of INFN Trieste

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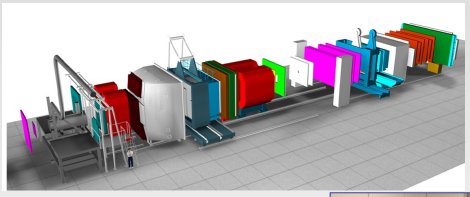
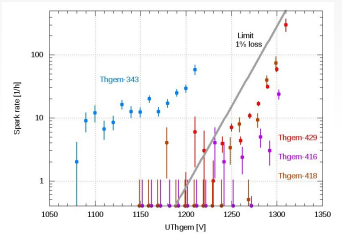
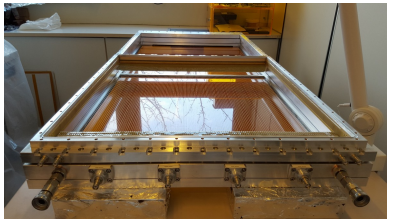
Instrumentation for Colliding Beam Phyisics
Budker INP, Novosibirsk, 2017

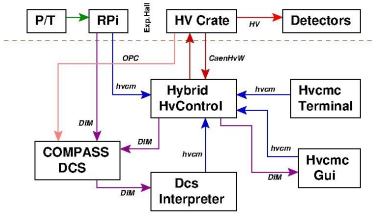
Outline

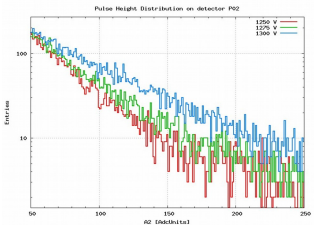
- COMPASS RICH1 Upgrade
- Detector structure : THGEM + MM
- Quality Assurance
- Construction + Installation
- HV system
- Commissioning Status











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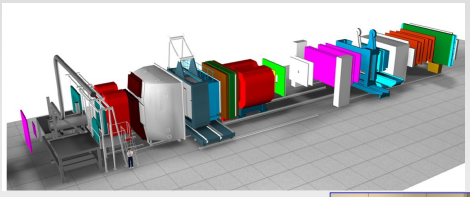

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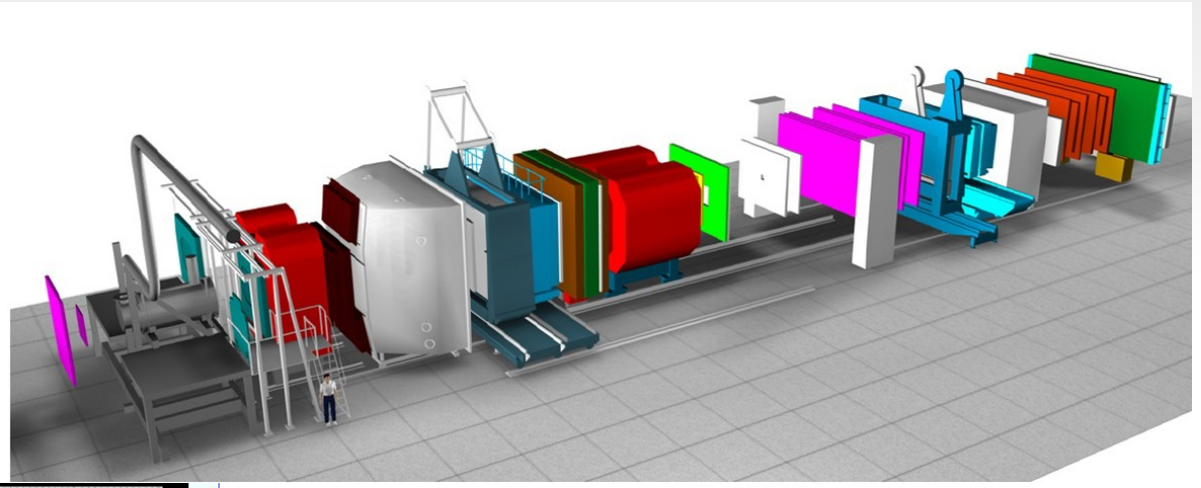
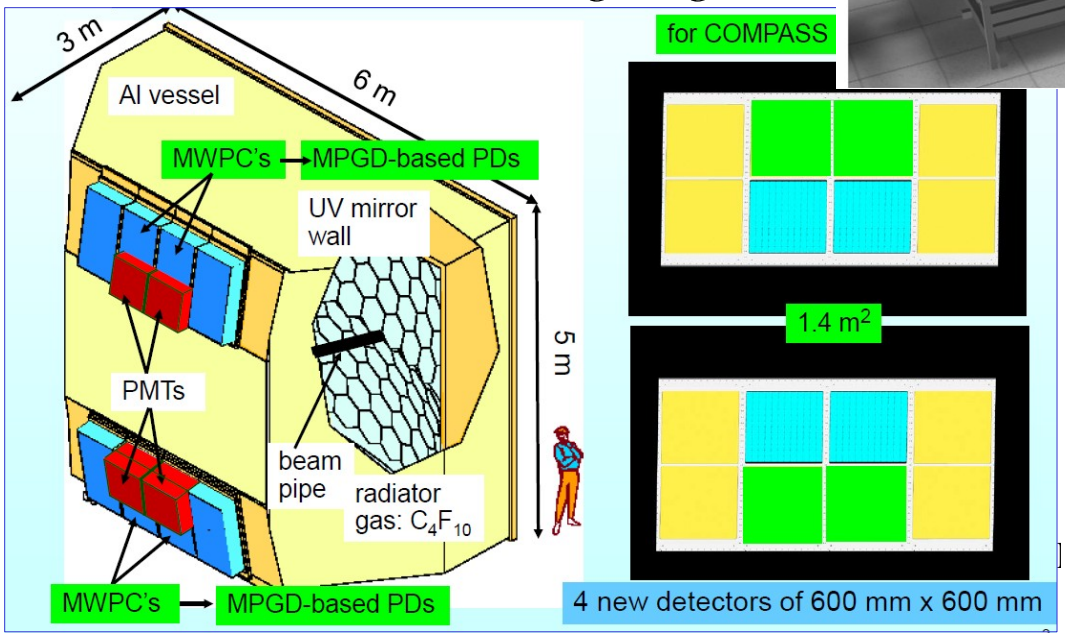
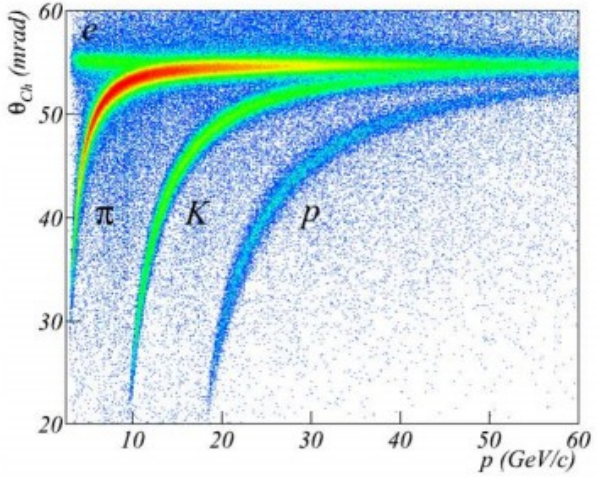
COMPASS RICH1

- **COMPASS at CERN SPS** : extension until 2025 under study
  Generalized PDF, Flavour separated SIDIS,
  Transvers momentum dependent PDF, QDC at low Q^2

- **RICH** for PID
  MWPC+CsI, MAPMT,
  MPGD Hybrid
  improve performance
  and overcome ageing



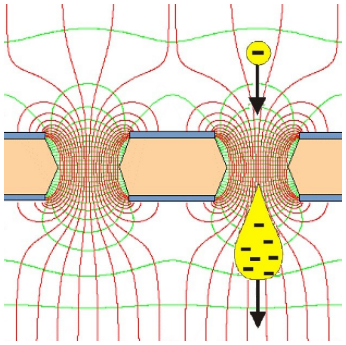




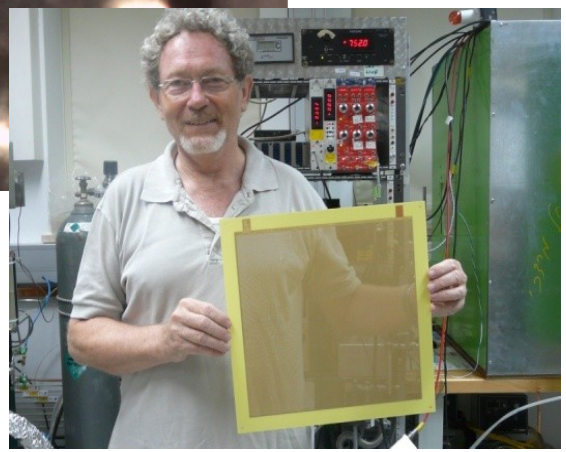
MicroPattern Gaseous Detectors

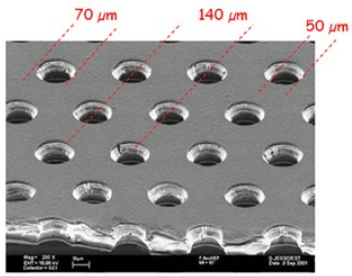
(Let me skip details, and refer to the morning session of today)

- Issues and limits of wire chambers
  gain uniformity, rate capability, wire sagging, planarity, strong frames, wire imperfections, electrostatic forces, ...
- Advancement of PCB- and industrial technologies
- GEM, **ThickGEM**, **Micromegas**, WELL, μPIC, InGrid, … → **RD51**

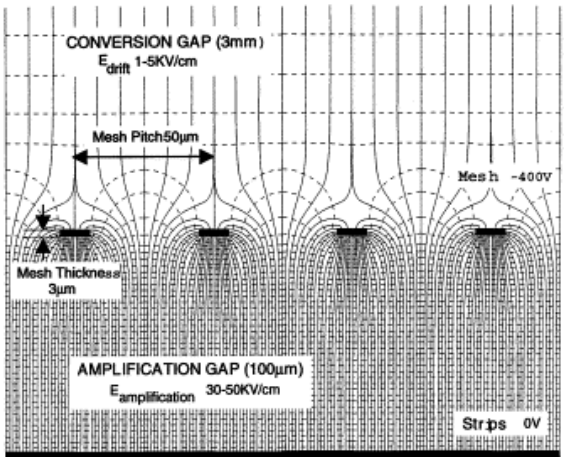


ThickGEM





GEM



MicroMeGas

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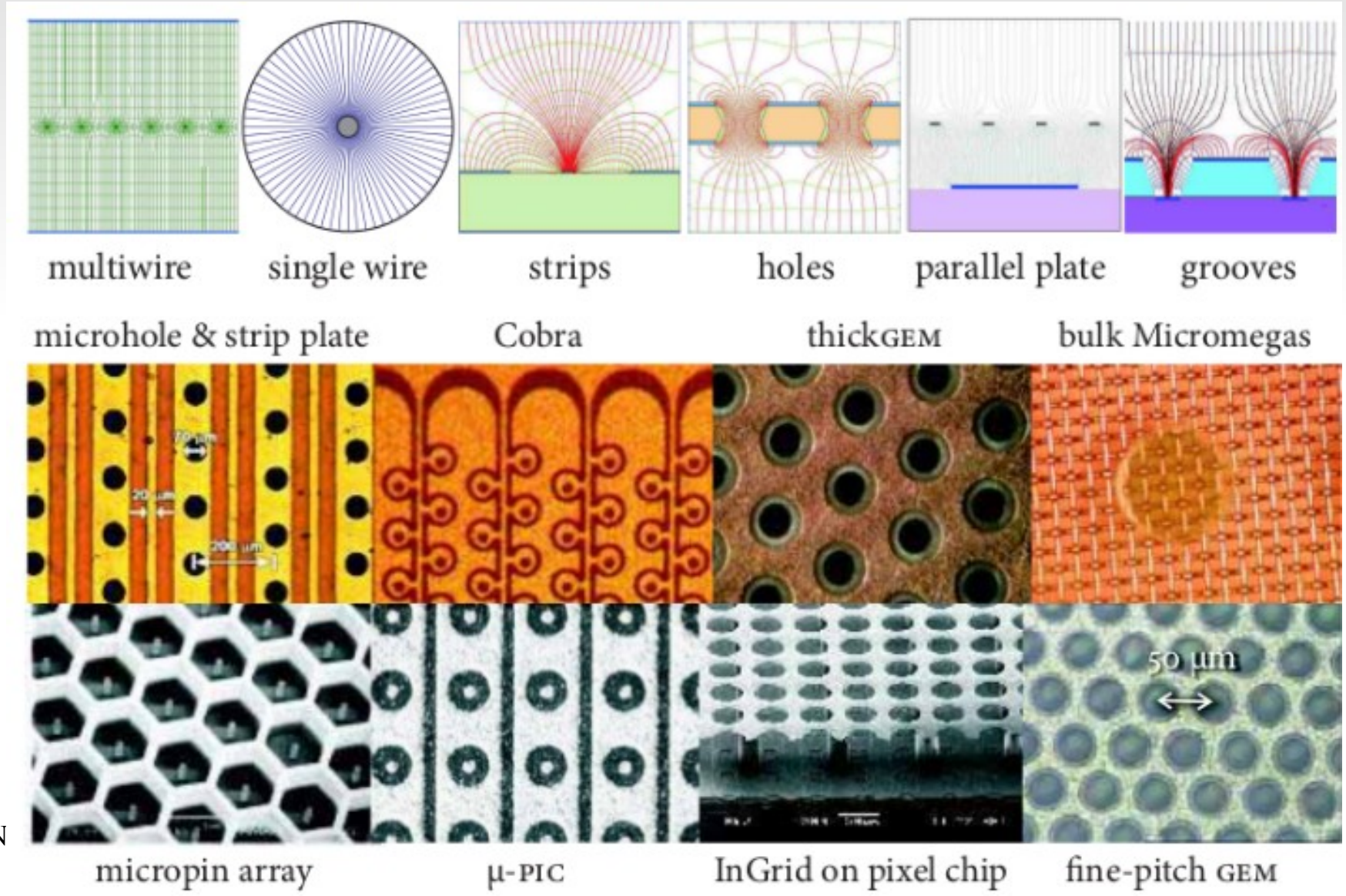
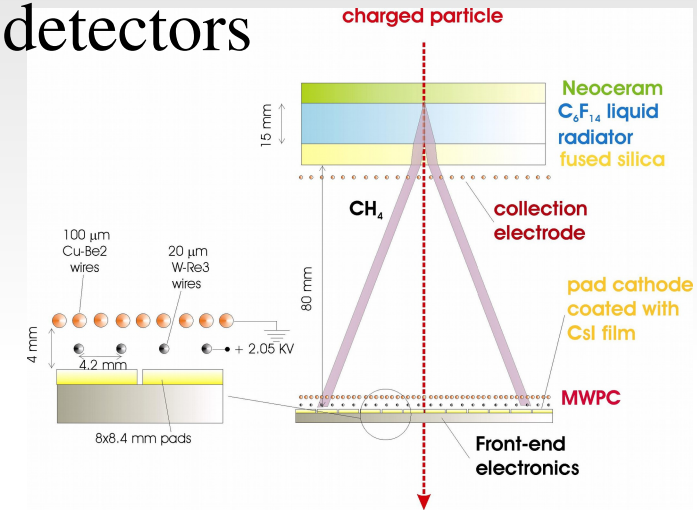
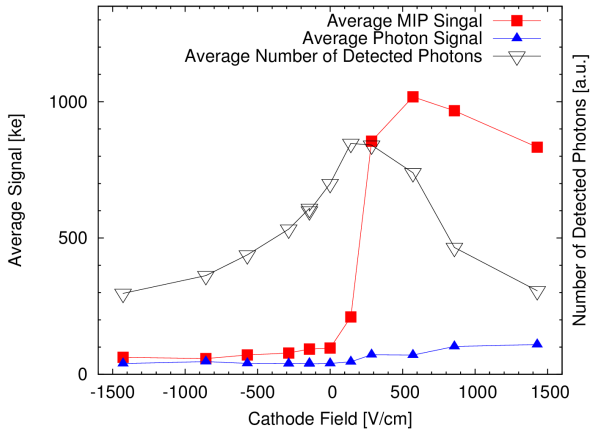


MPGD Based Gaseous Photon Detectors

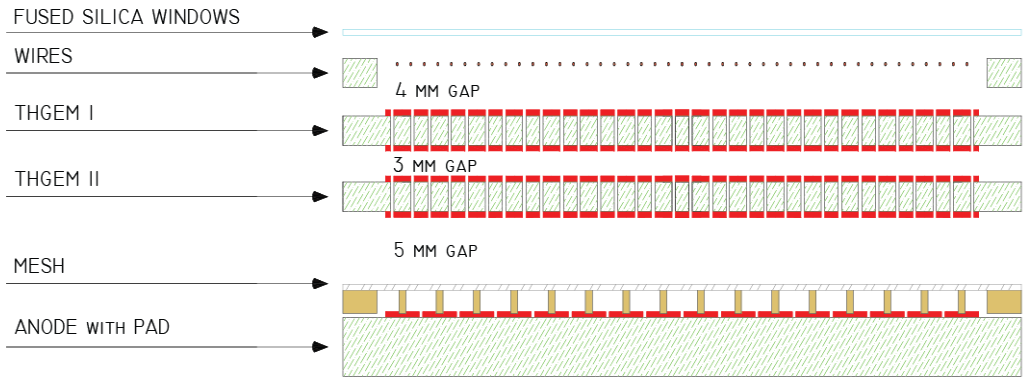
- Particle identification -> **Cherenkov detectors**
- Gaseous Photon Detectors for Cherenkov detectors
  - **Large area** at reasonable price
  - **CsI** cover for UV photon detection
- Advantages vs. MWPC based RICH
  - Reduction of ion back-flow
  - Fast response
  - High rate capability
  - Possibility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





The Hybrid Detector for COMPASS RICH

- **Double ThickGEM + Bulk Micromegas**
  - **Photo conversion** : first THGEM coated with CsI
  - **High gain** for single photo-electron detection
  - **Low Ion BackFlow** : MM + staggered THGEMs => ~ 2%
- THGEMs
  - Producer: ELTOS Italy ; Size: 600x300 mm^2
  - Parameters: thickness:400µm, pitch:800µm, hole:400µm, rim:10µm,
- Bulk MM
  - **Capacitive readout**, discrete resistors 500MOhm, Mesh on ground
  - Producer: PCB at TVR, bulk MM at CERN; Size: 600x300 mm^2
- Padplane: 8x8 mm^2 padsize
- Readout electronics: APV25 (+DAQ chain)



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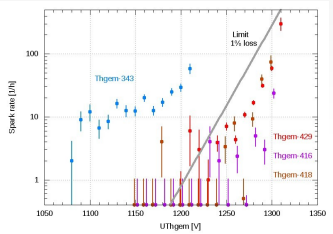
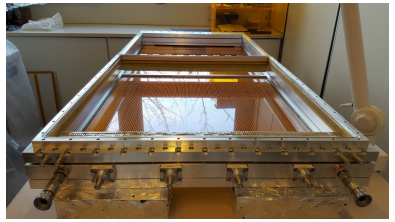
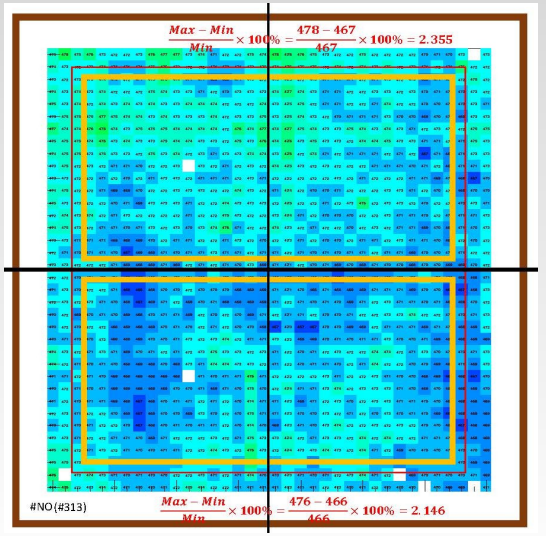
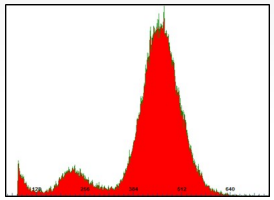


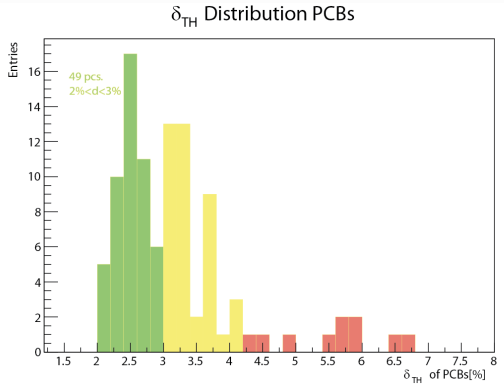


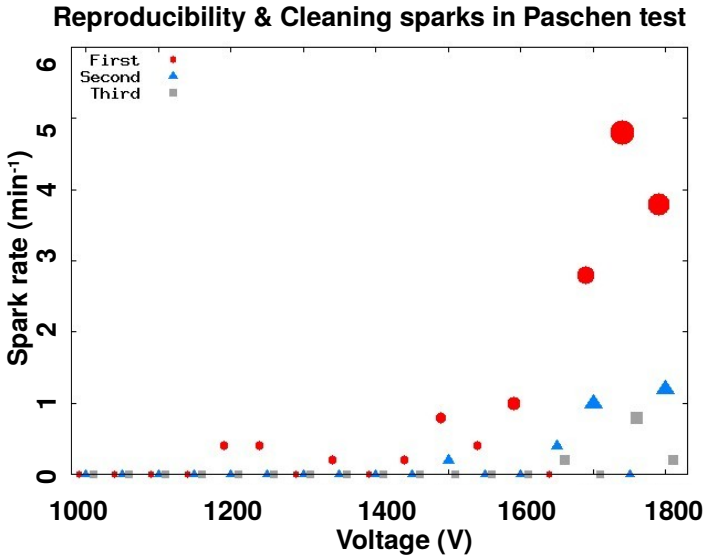
Quality Assurance

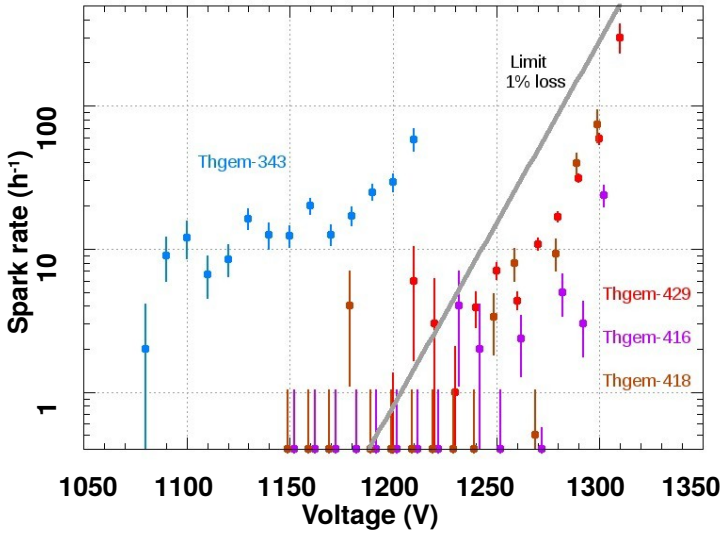
- ThickGEMs
  - Material selection → uniform thickness
  - Polishing → smooth copper edges
  - Paschen test in N_2
  - Discharge test in Ar-CO_2
  - Gain and unifromity measurements with X-rays
  - Test after gold plating
  - CsI coating's QE measurement
- Micromegas
  - Electrical check of HV pads
  - Gain and uniformity measurements with Fe-55

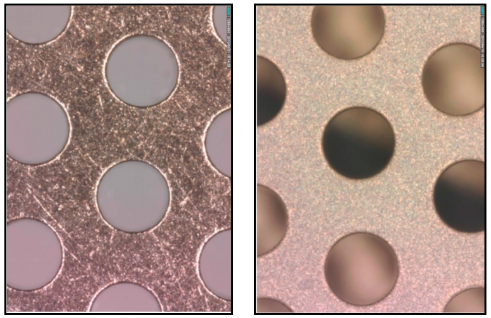












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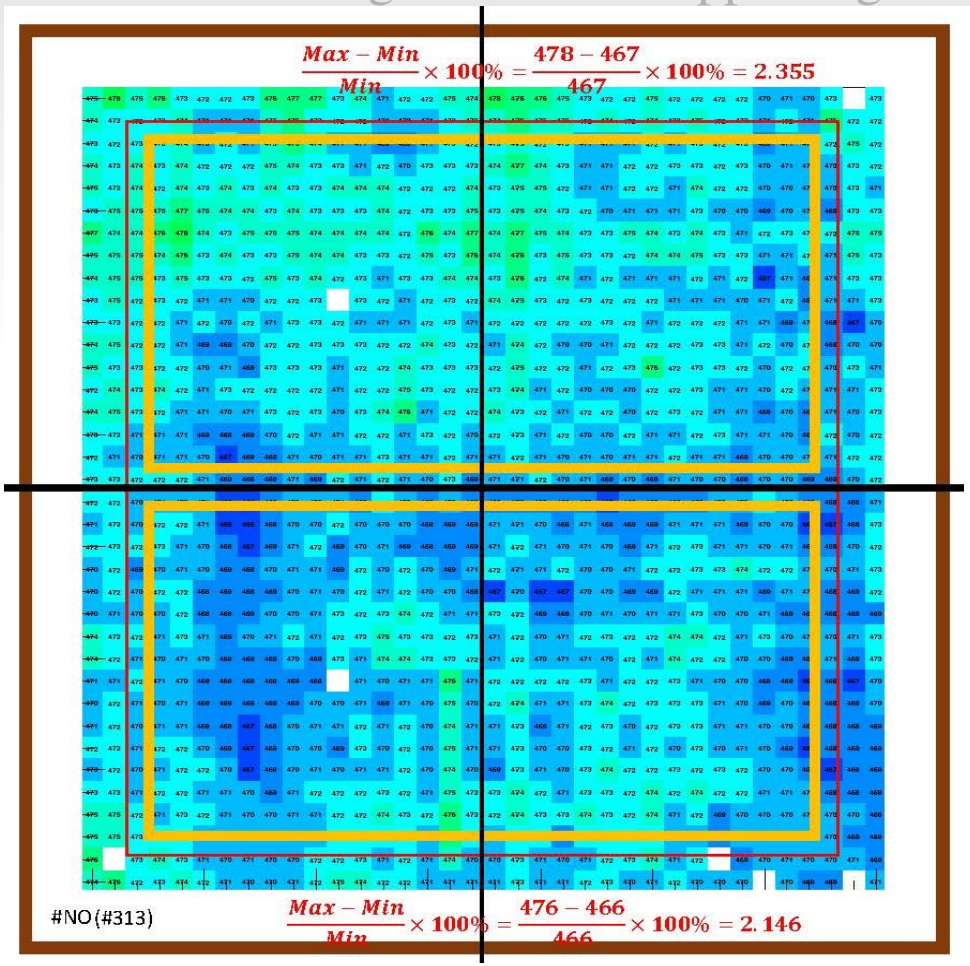
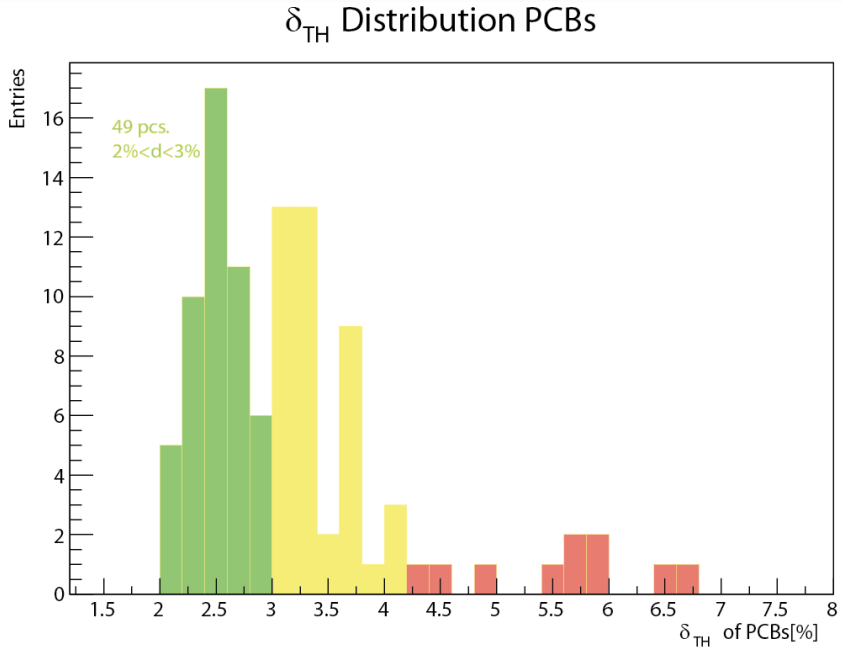
with X-rays





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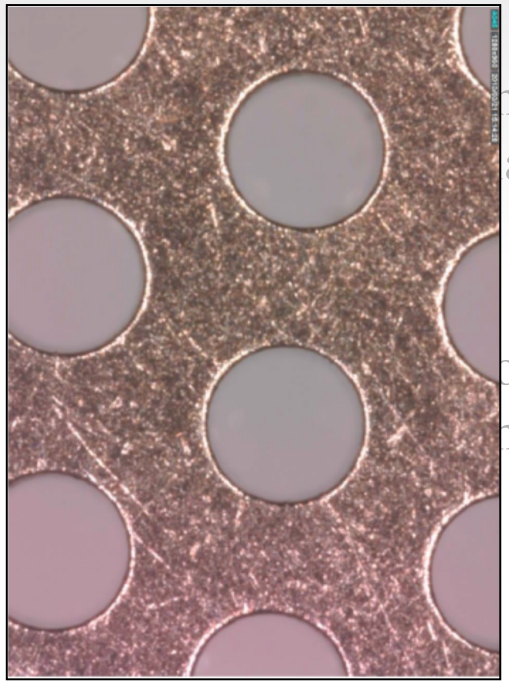

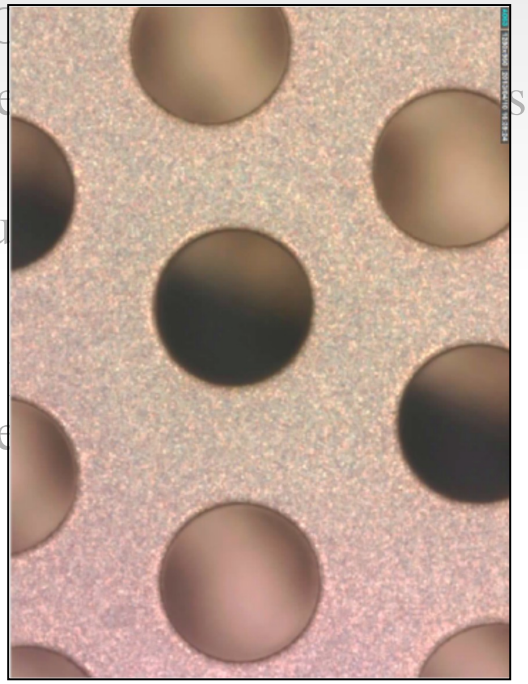

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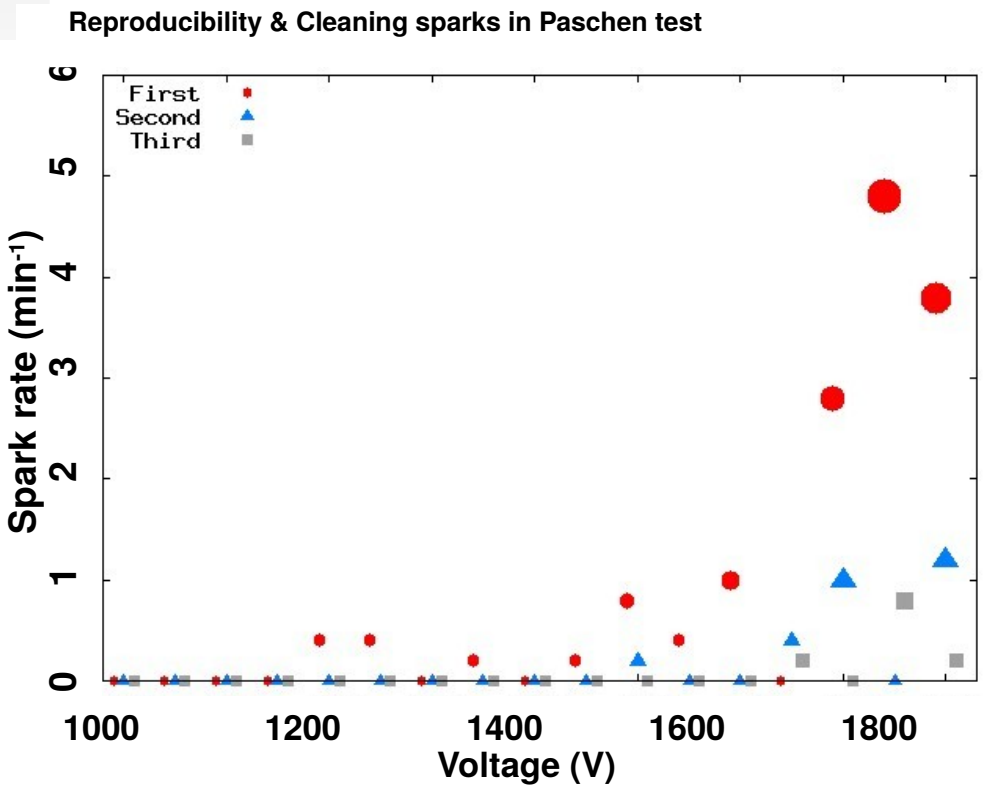

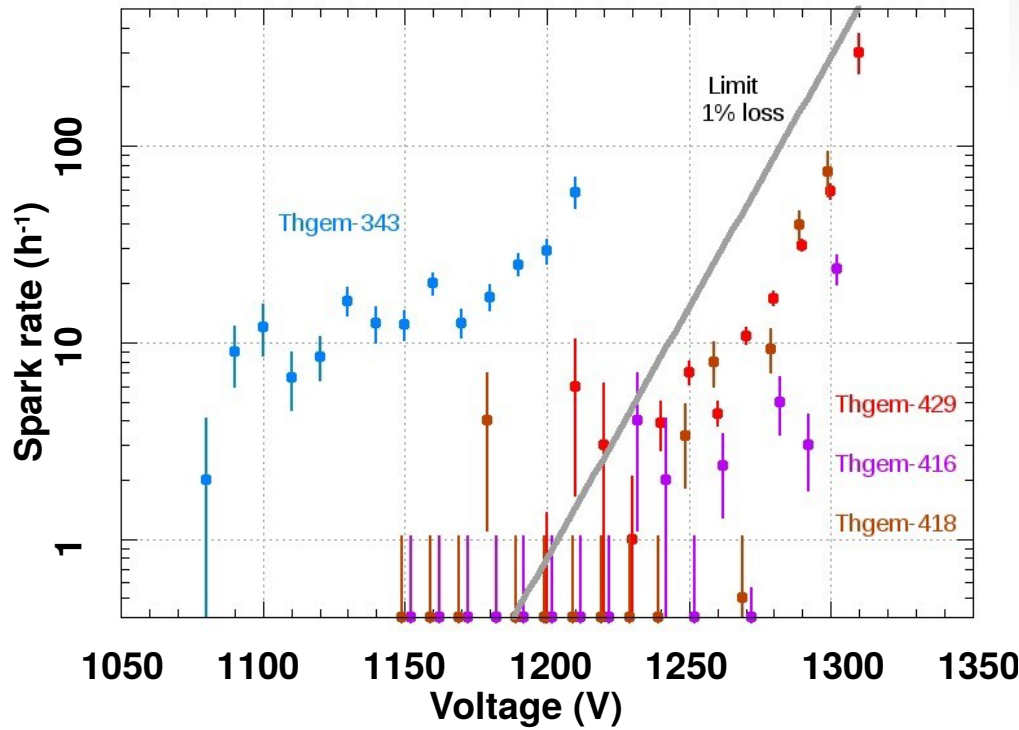

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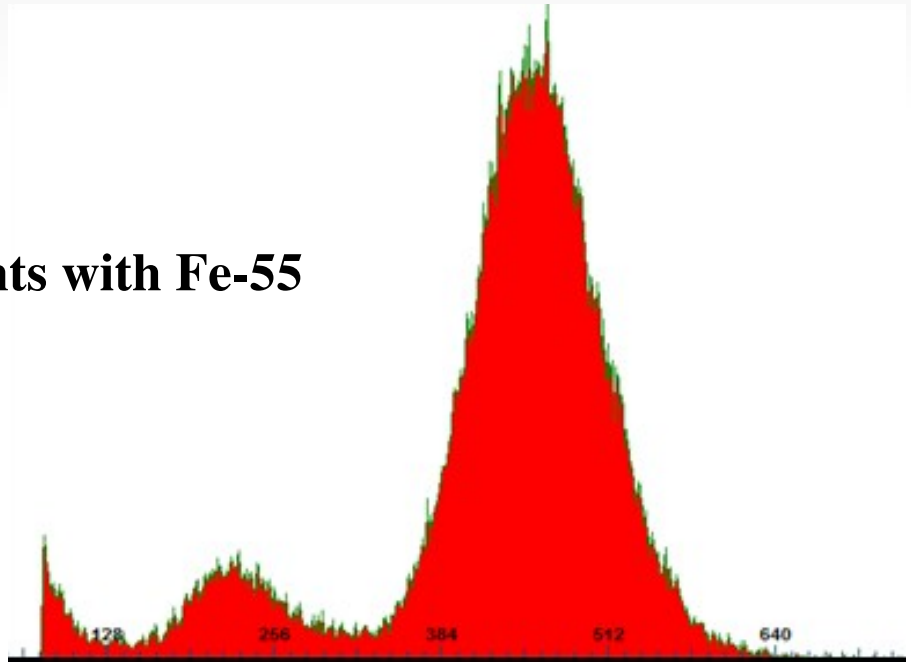

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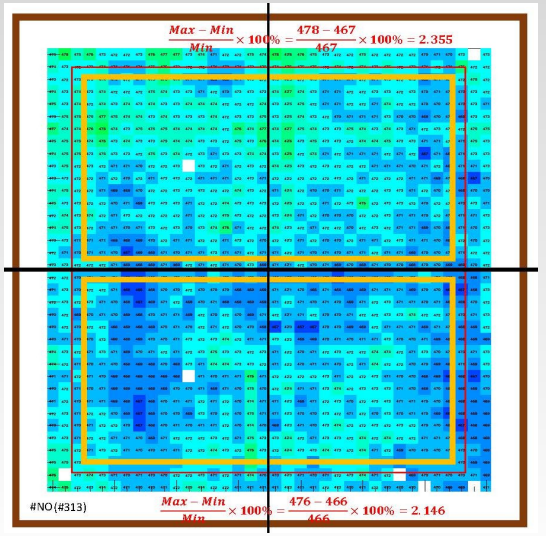
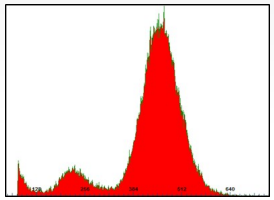
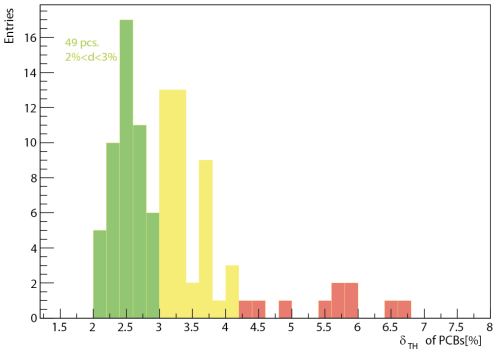
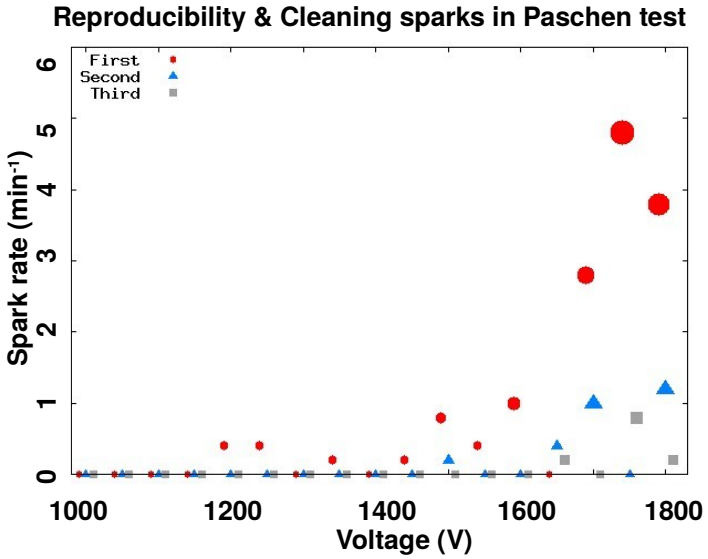
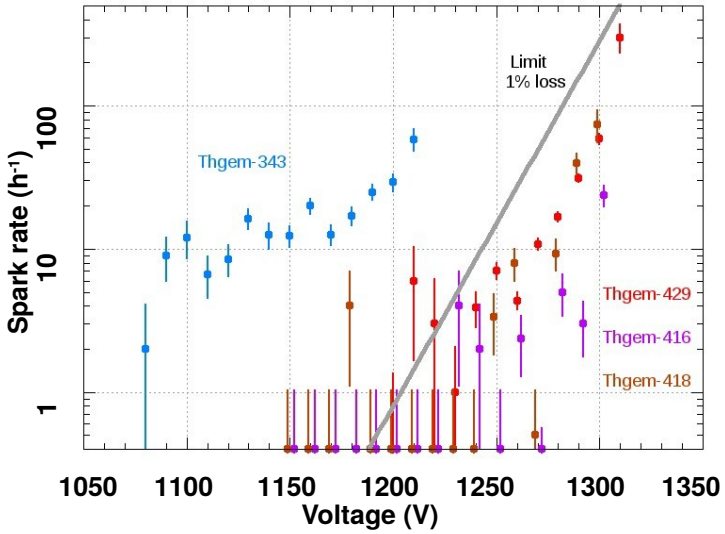


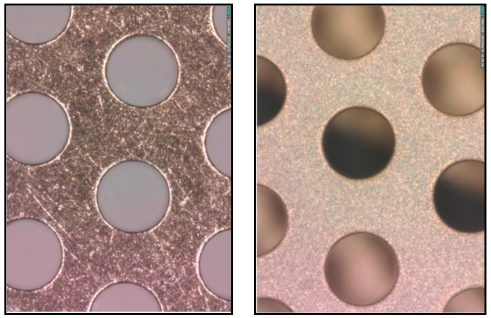


δ_{TH} Distribution PCBs



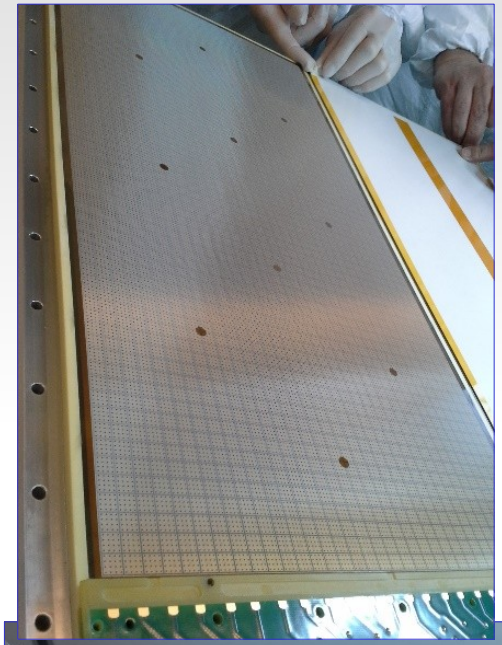


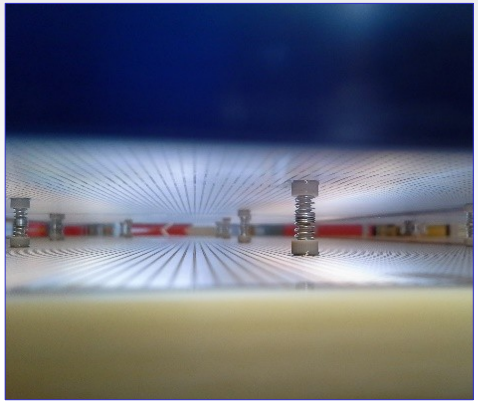


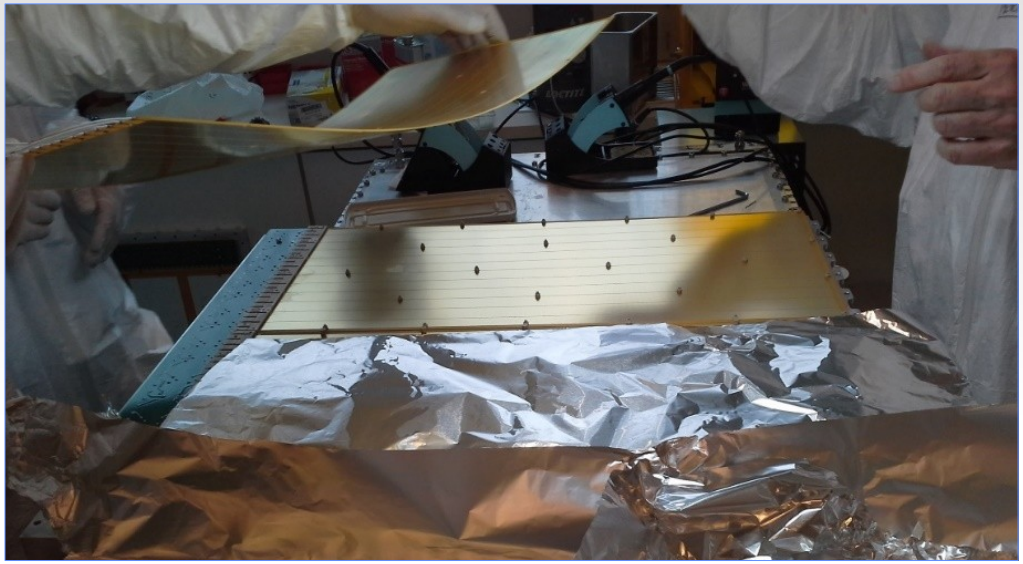


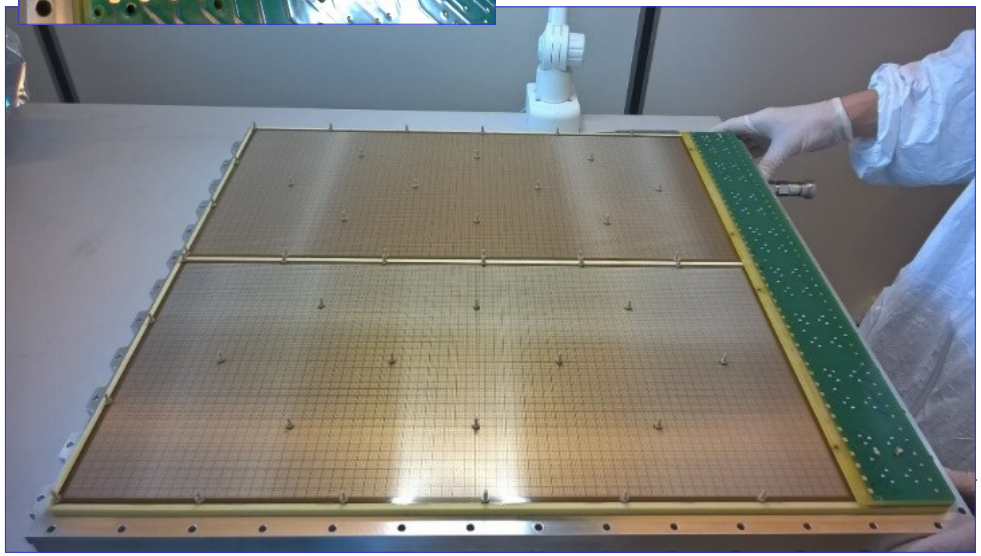
Assembly

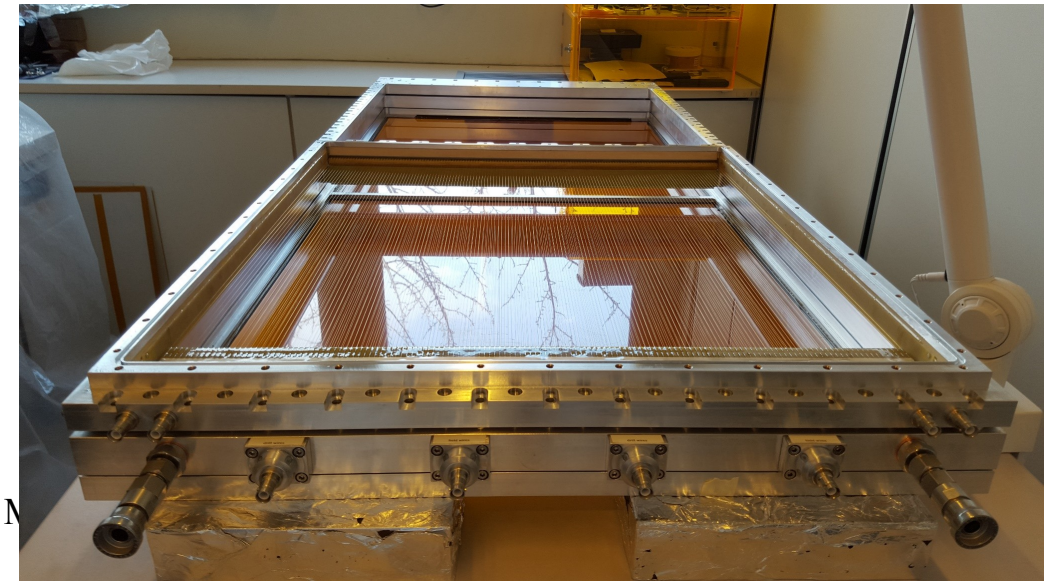
- Mostly Clean-room operation





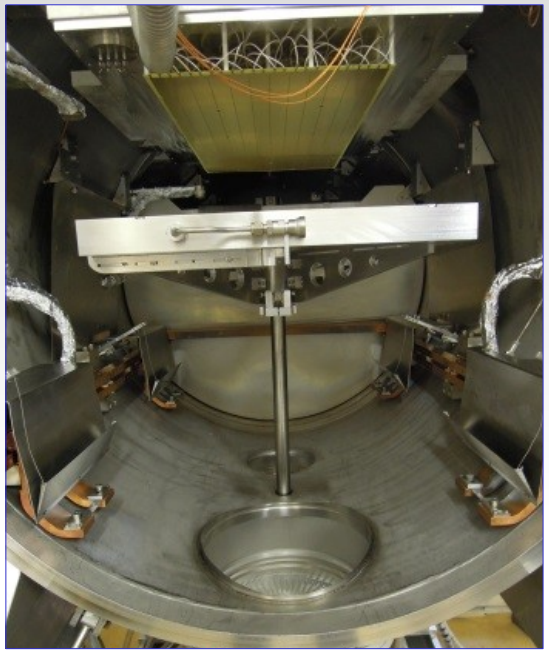


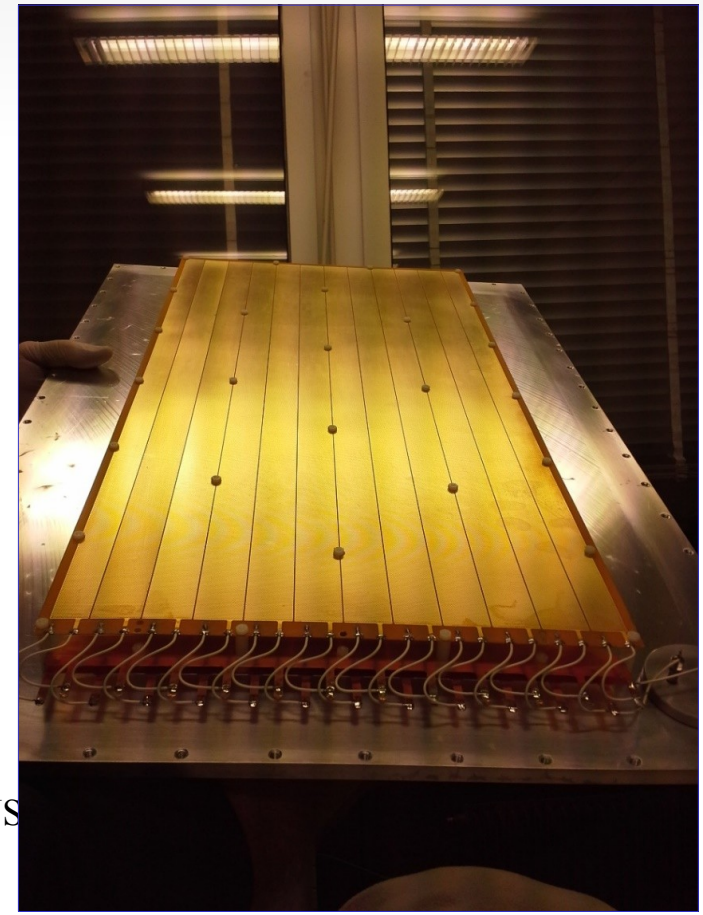


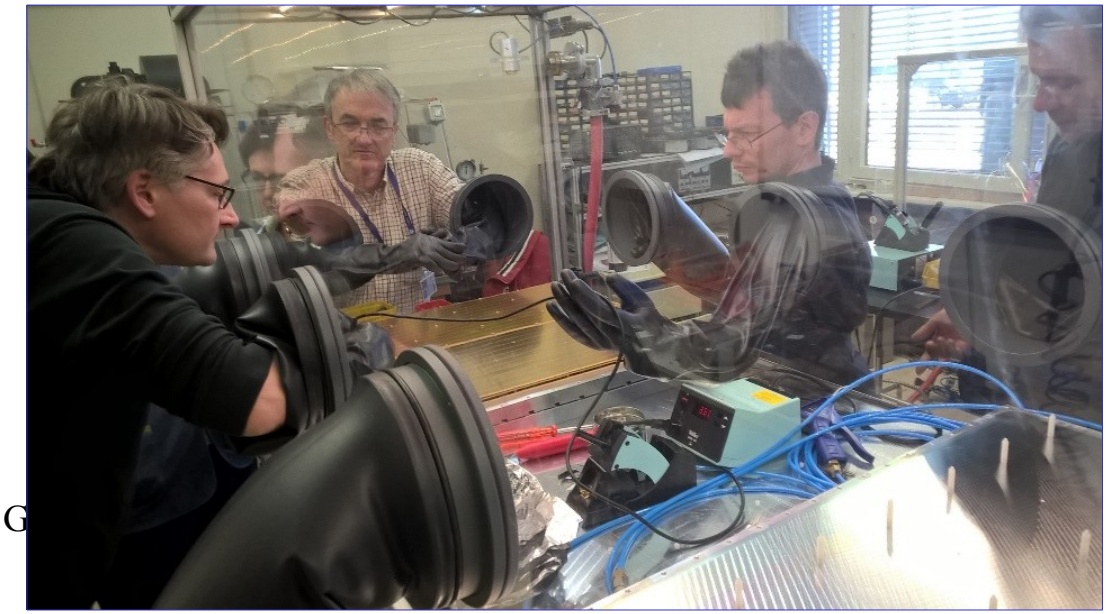


… and the CsI

- Revive the **CsI coating system** at CERN (non-trivial)
  proper gold surface, cleanliness, …
- Surface with holes in it …
- **Measured QE** ~ expected one x0.7-1.0
- Coated THGEMs assembled







Mounting

- MAPMT part remounted
- Hybrids: due to the CsI → mounting is a **golve box** operation
- + HighVoltage (new sytem)
- + Electronics (used system)
- + Cooling (upgraded)

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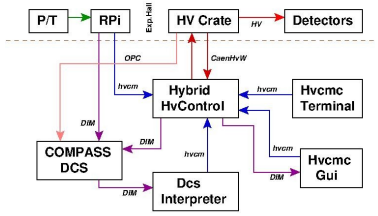
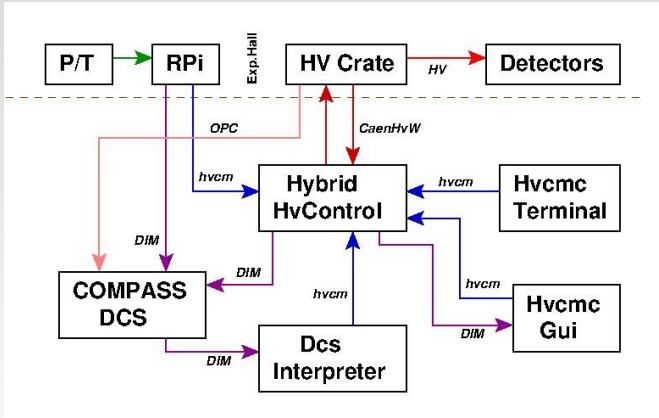
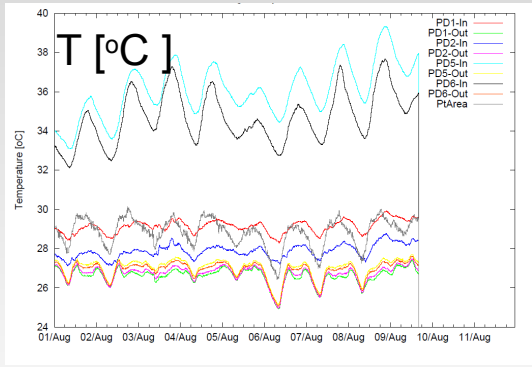
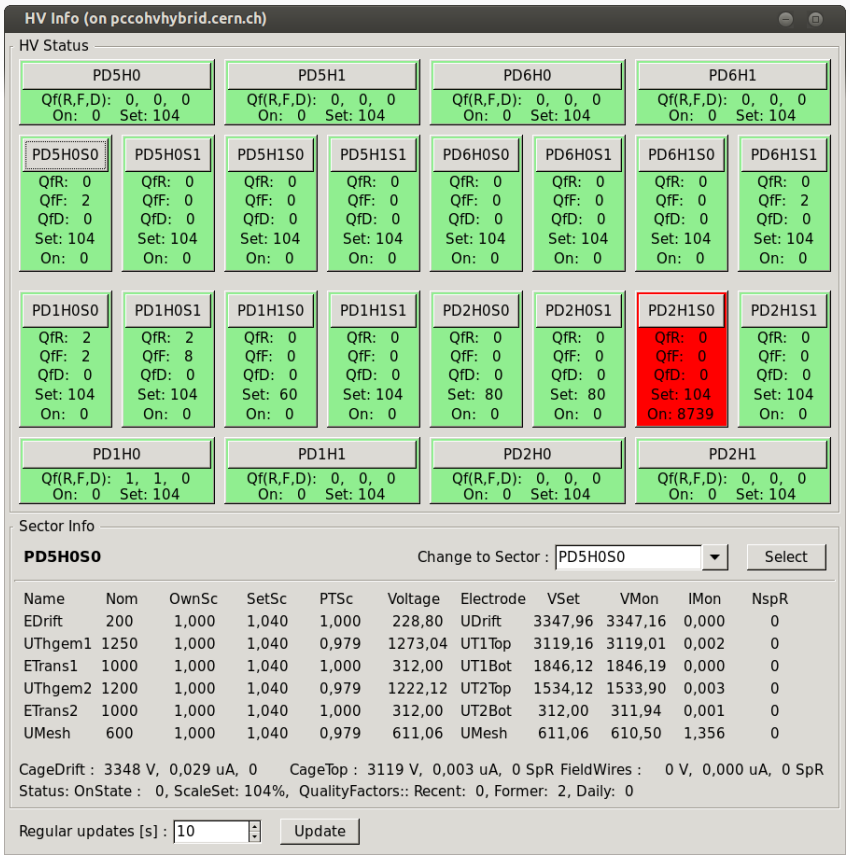


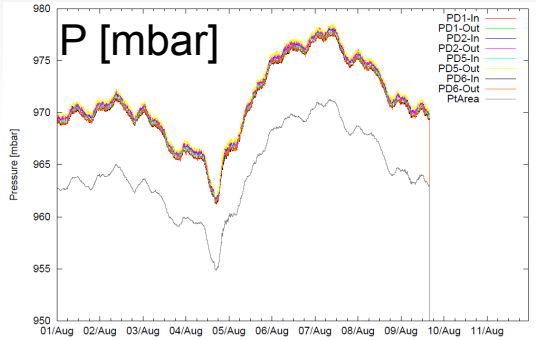
HV System

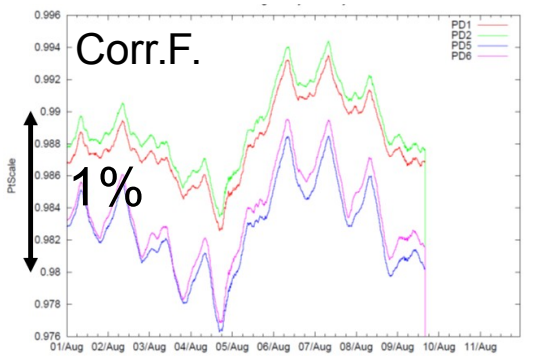
- **Custom made HV system**
  (C++,wxWidgets)
- Coop. with **COMPASS DCS**
- **Correction wtr P/T**
  in amplifier regions
- "OwnScale" to finetune
  for **uniformity**
- **Log** with 1 Hz
- **Spark detection**
- Autodecrease HV
  if too many sparks
- Interaction via: GUI,
  DCS, DIM, Msg
- Gain variation in lab
  40% → 10%
  Needs to be verified
  on the CompassData
- HV Units from CAEN
  SY2745 (x2): HvCrate
  A7030 (x2): +3kVx12ch
  A1561 (x8): -6kVx12ch







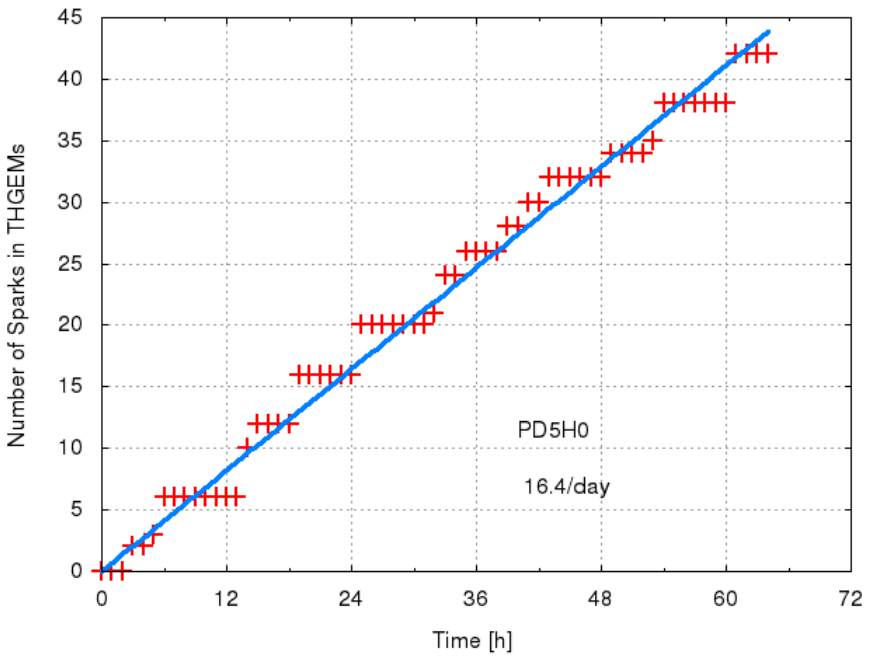


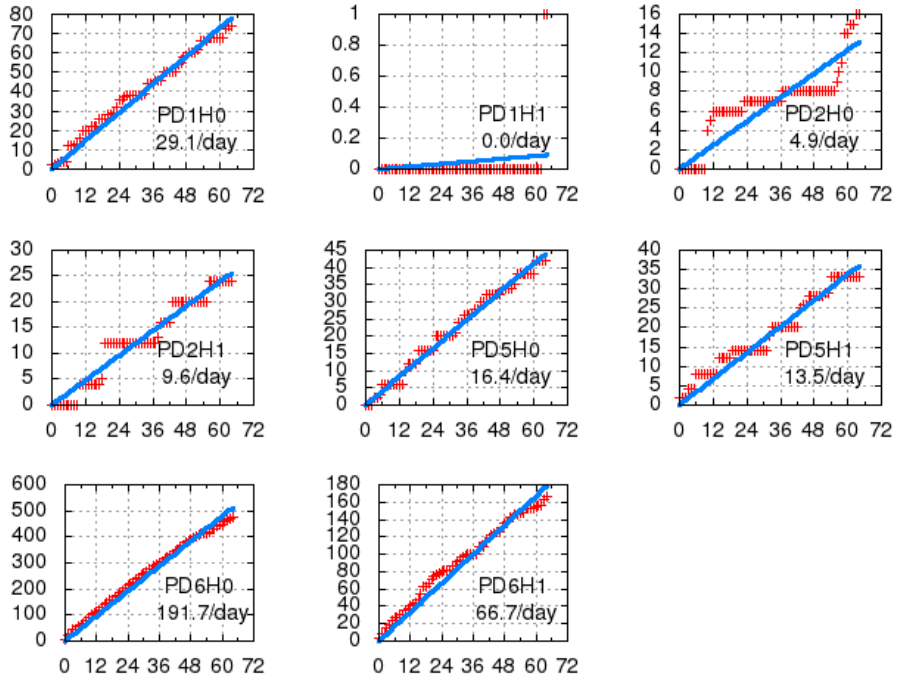


P/T: ~1% →
Gain: ~40%

Sparks in the THGEMs

- Log of HV and autodecrease worked well
- **Spark rate** seems to be **constant** on all Sectors (two half THGEMs)
- Bad sectors : three (3/16) cannot be kept at reasonable voltage for long segment-level investigation aftre the End of RUN
  Priority was the commissioning of the **working Sectors**
- Several correlated sparks on neighbouring sectors/chambers have been seen
  → most probably induced by cosmic showers



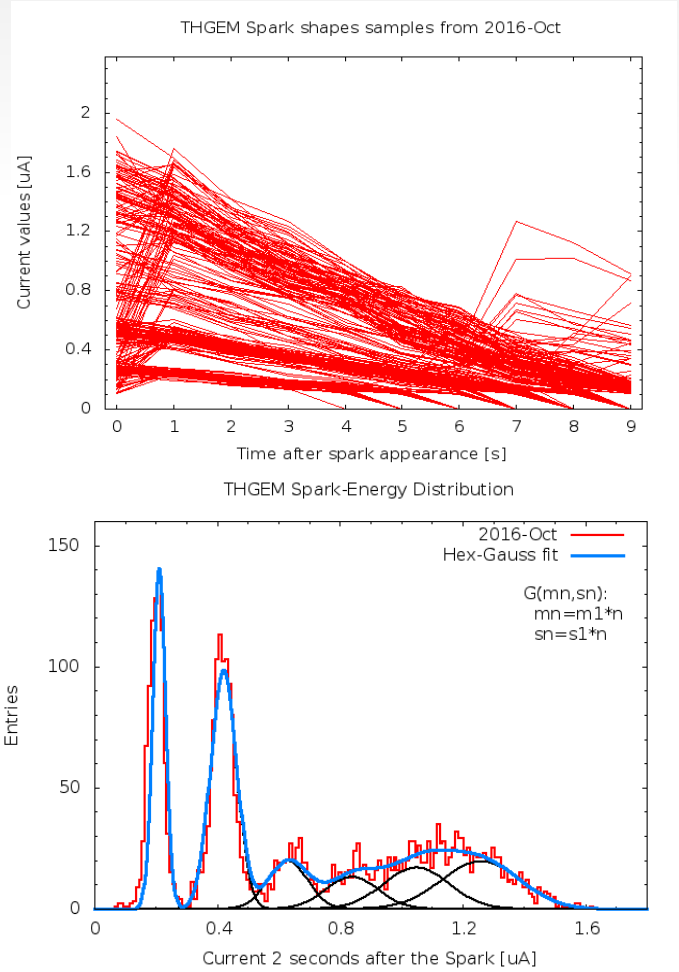


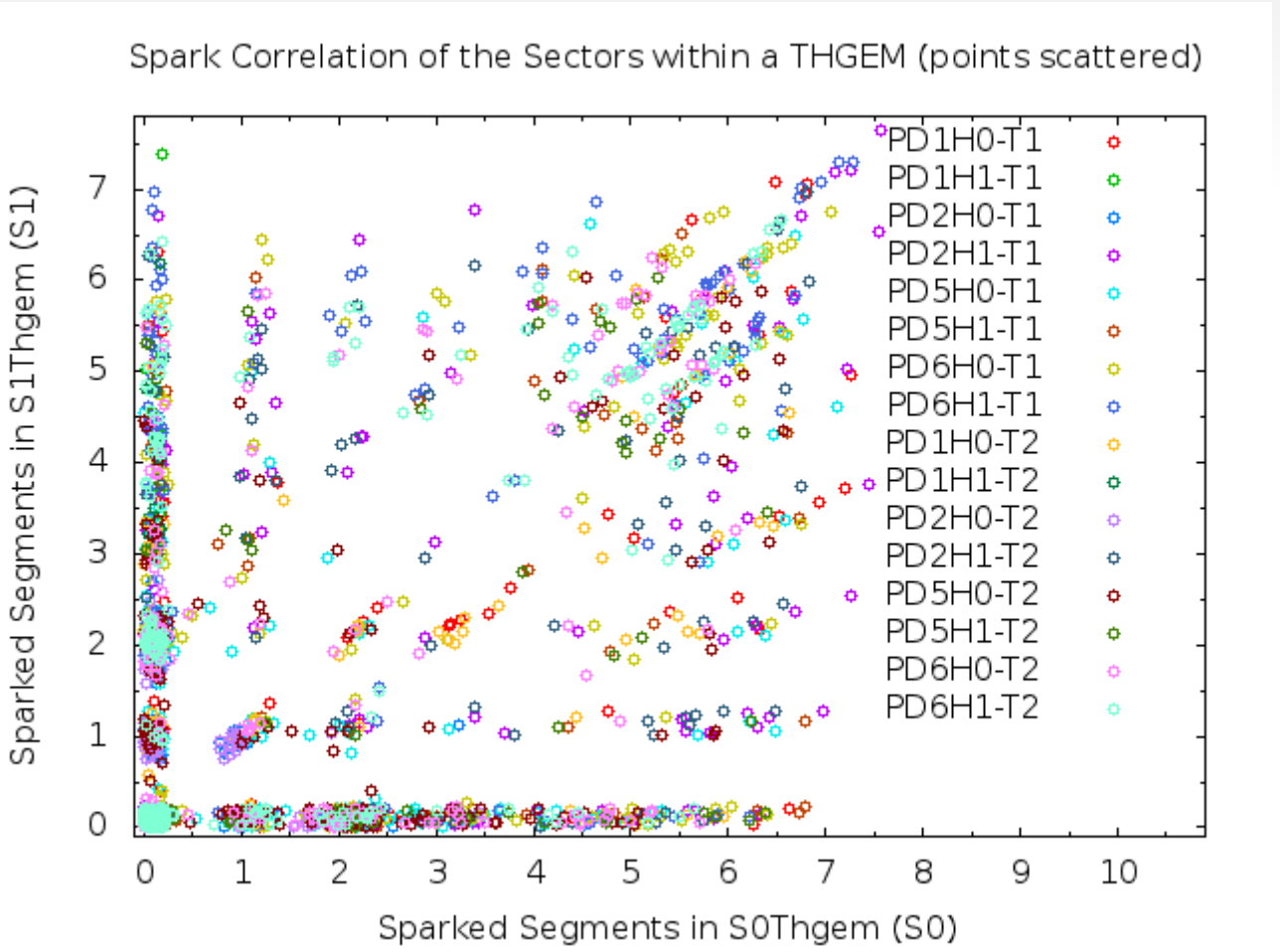
Sparks in the THGEMs

- **Spark energy** is measurable: is **discrete** → number of involnved **segments**
- **Spark correlations**

  between the two THGEMs of a Sector : always

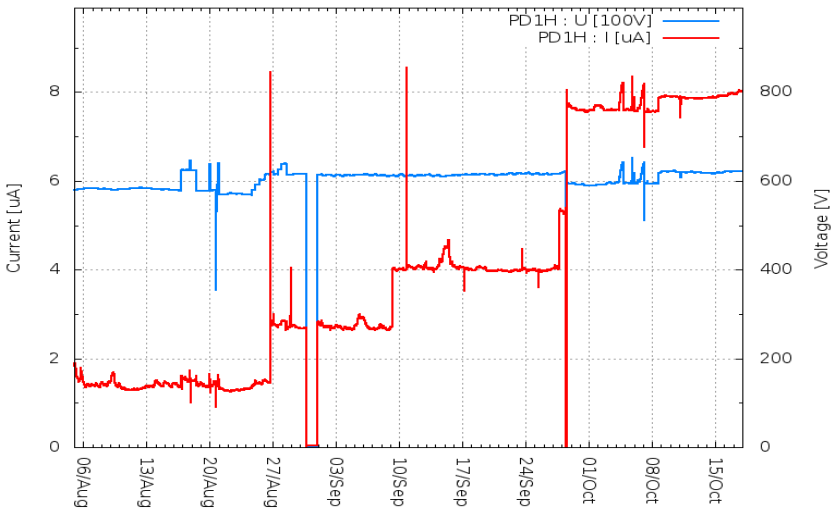
  between two sides of a THGEM (neighbouring Sectors)
- Mostly 1-2 segments, or the whole THGEM (showers?)

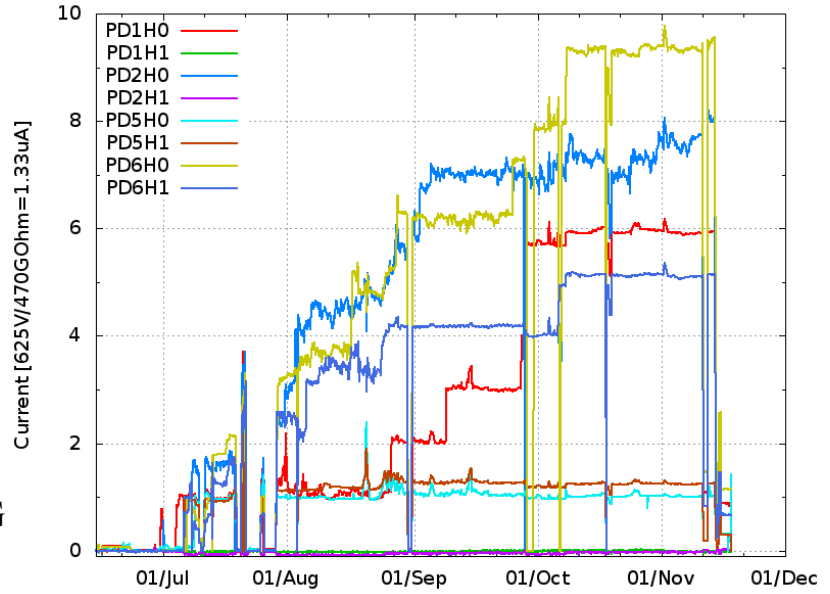




The Micromegas

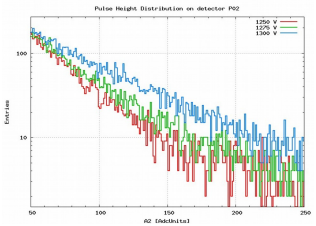
- **Shorts** have appeared during operation
  could be : inside the detector's gas volume / in the PCB material / resistor array
- **No pre-filter resistors** are used before the distribution to the HV-pads
  → **MM** is still **usable**, with high constant current (flowing to the shorted pad)
  no extra noise have been seen due to these shorts
- Close-to **discrete steps** in currents (proportional to the number of shorted pads?)
  $\Delta I \sim= 625V / 470M\Omega$
- The troublesome "super-cooling" (malfunction of a cooling regulator logic)
  too cold environment → huminidty got condensed: Issue solved asap
- Total number of affected pads: 30 (**0.15%**) + N_2 flux to resistors
  Stable for more than a month (no new shorts from the 7th of October)





Outline

- COMPASS RICH1 Upgrade
- Detector structure : THGEM + MM
- Quality Assurance
- Construction + Installation
- HV system
- **Commissioning Status**



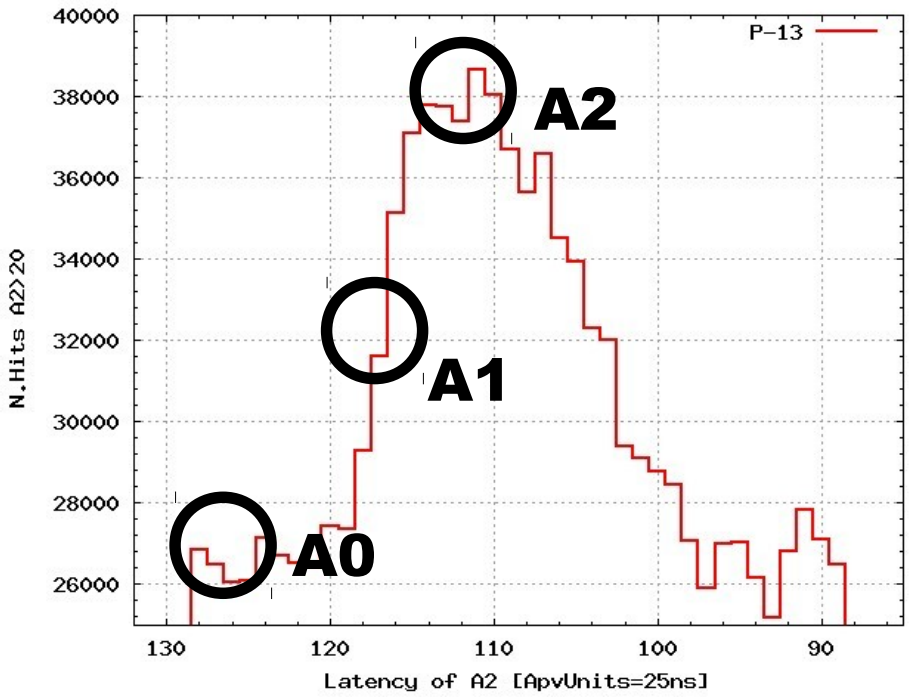
Commissioning
… is still ongoing

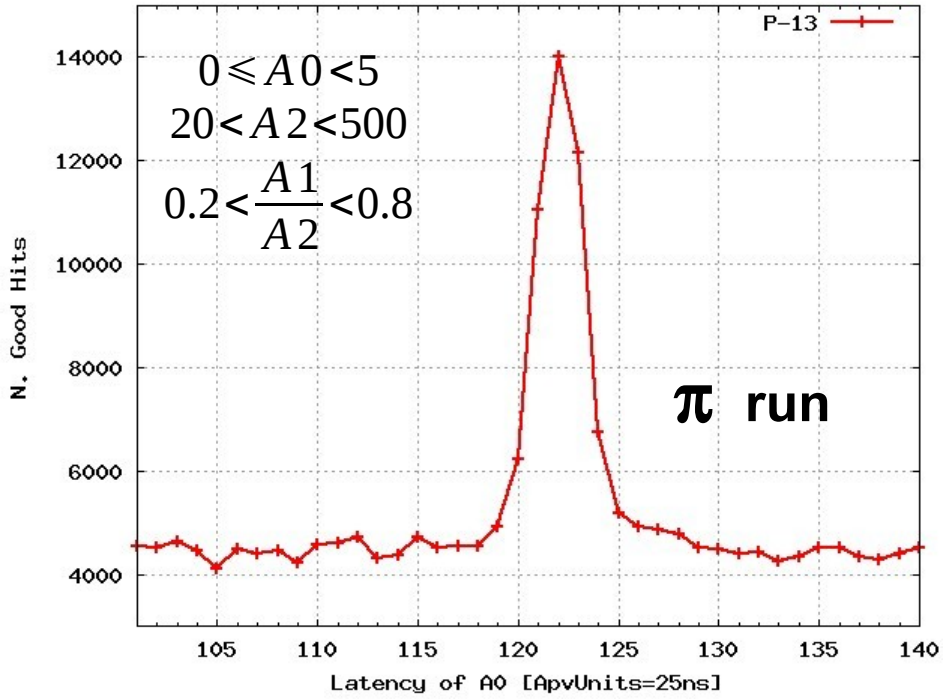
- Operation of the HV system
- Communication with DCS
- Stability, shorts, and sparking issues

- Operation of the FEE
- Communication with DAQ
- Photon signals ? Noise issues
- Signal timing (most crucial)
- Confirmation via laboratory type measurements
    - HV scan on MM
    - HV scan on THGEMs
    - Drift field scan
- Combining with tracking, PID

Readout with APV

- RICH FEE : **APV25** + DAQ chain
  → integration, shaping, sampling, pedestal subt., zero sup., send data
- Latency settings depends on trigger system and signal formation
- **Latency scan** with several configurations (HV and beam) [LatencyUnit=25ns]
- Amplitude measurement in 3 samples, separated by 150ns
  Baseline (A0), Rising edge (A1), Maximum (A2) [AdcUnit=300e]
- **Signal shape** is visible, short plateau at maximum, fast rise defines narrow timing
- **Clear indication on the presence of the signal !**





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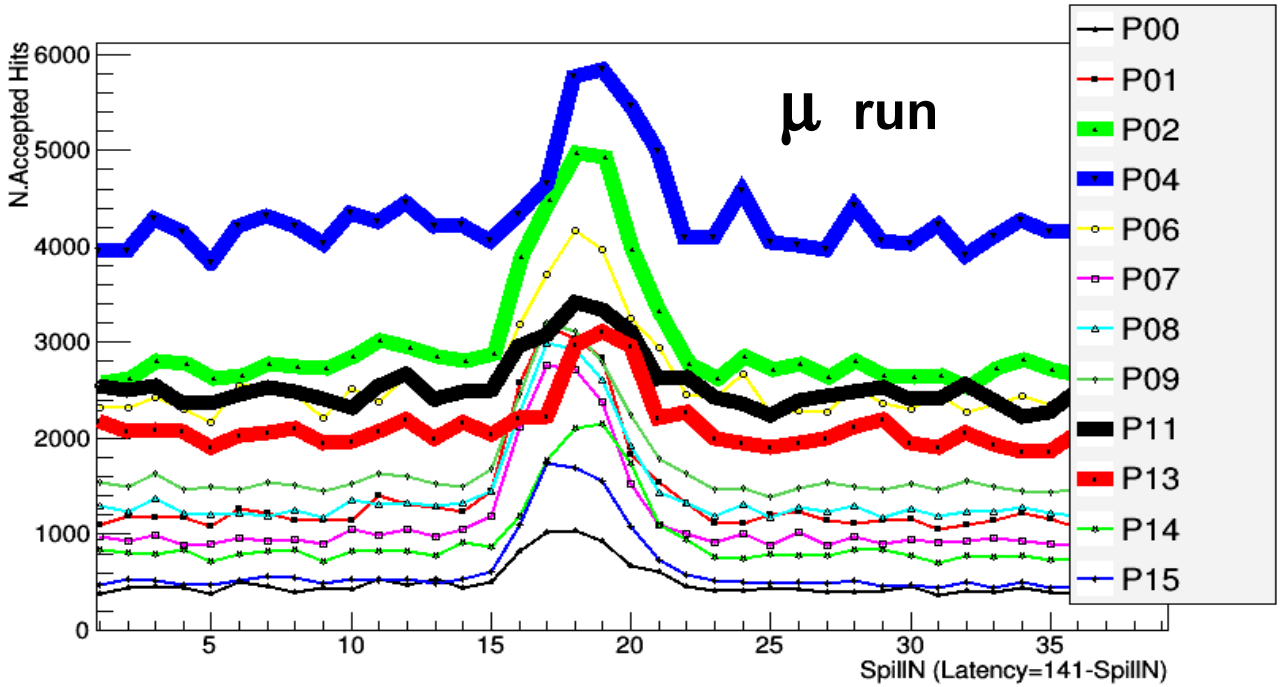
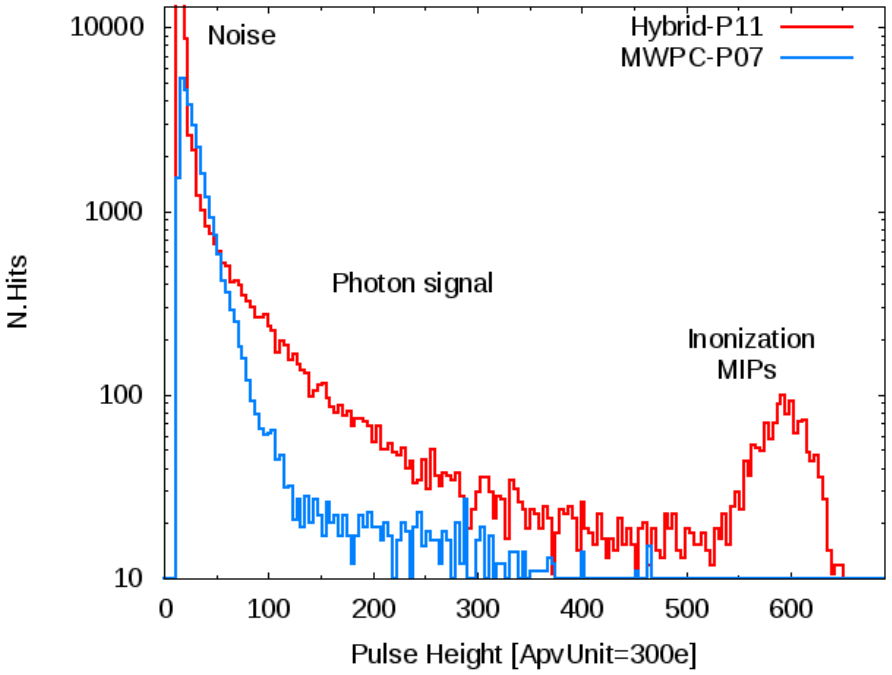
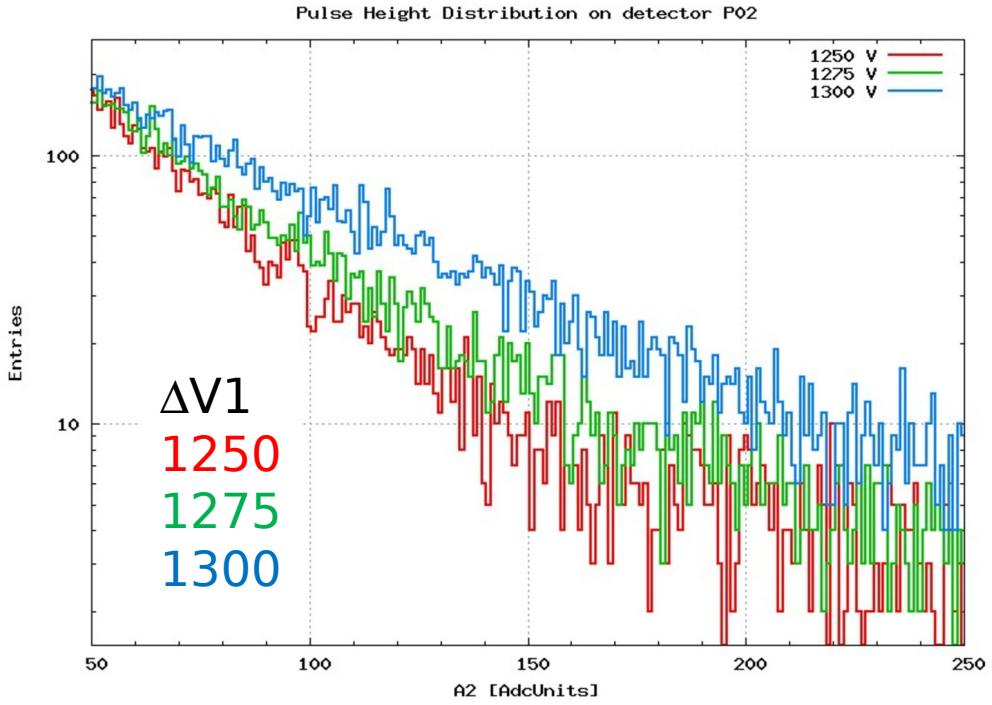
$$0 \leqslant A0 < 5$$
$$20 < A2 < 500$$
$$0.2 < \frac{A1}{A2} < 0.8$$



HV Scans

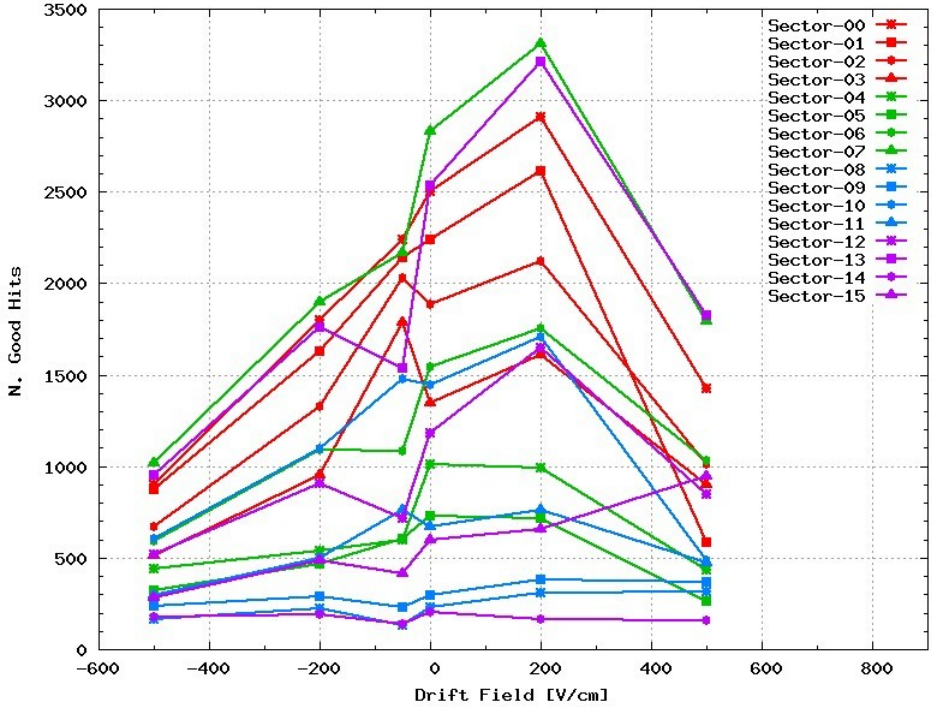
- **First characterization** steps during the commissioning
  reproduce simple laboratory scans, check for consistency
- **Gain scan** wrt voltage on MM and THGEMs were checked
  and influence of transverse fields, and gain sharing was studied as well
- Increase of the gain is **consistent** with the laboratory predictions
- **Gain of 10k-30k reached** (MWPC raw PH gain : 4-5k)
- Number of detected photoelectrons are similar as for MWPCs



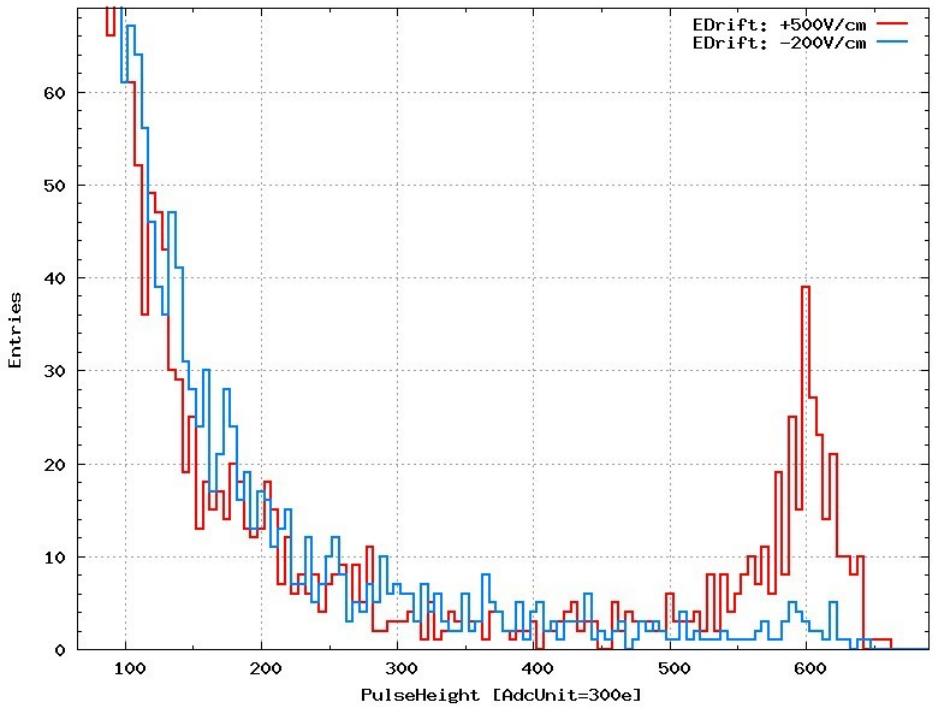


Drift Field

- **Drift field scan** was performed :
  crosscheck the laboratory results, define optimal field
- Effect on **photo-electron yield** as expected
  (thus even verifying that the photo-electrons were observed)
- **Suppression of MIP** (high charge) signal has been seen
  (can increase stability, and usable dynamic range)
- Optimum chosen at maximal photo-electron yield



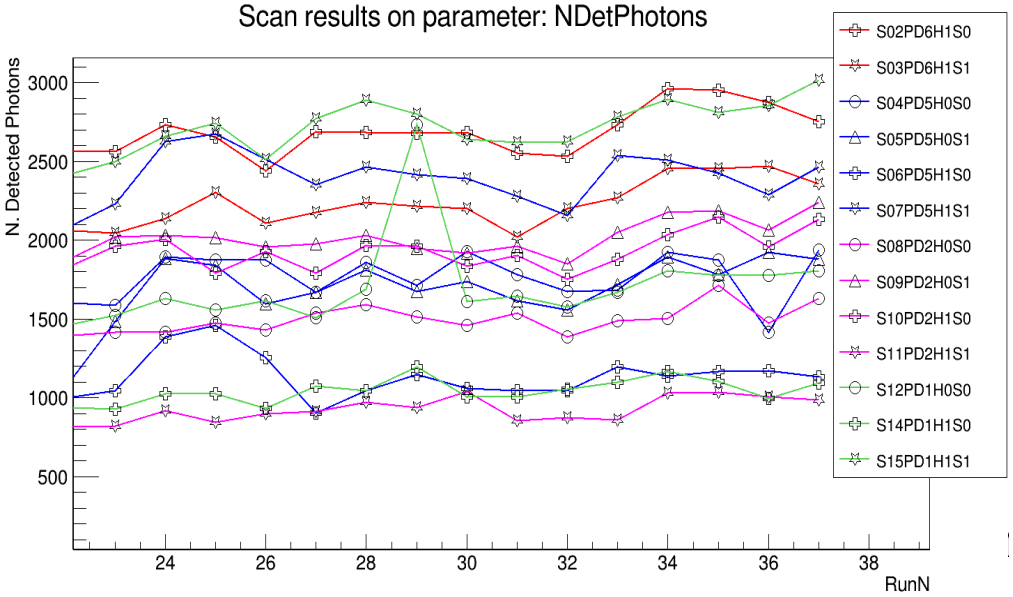
- MP(

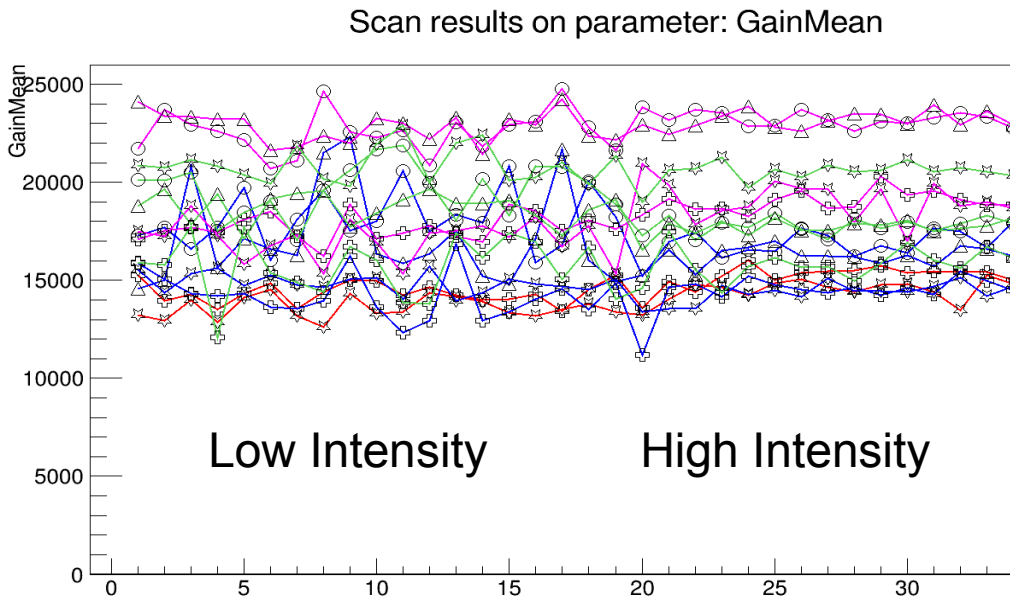


Stable Operation

- **Performance stability** investigation
  Stable operation (no parameter modification at all)
  for the last week of RUN2016
- Close-to optimal configuration (gain and stability)
- **Spark rate** in average was below **5 / day / Sector**
- **Stable** gain in Low/High intensity as well

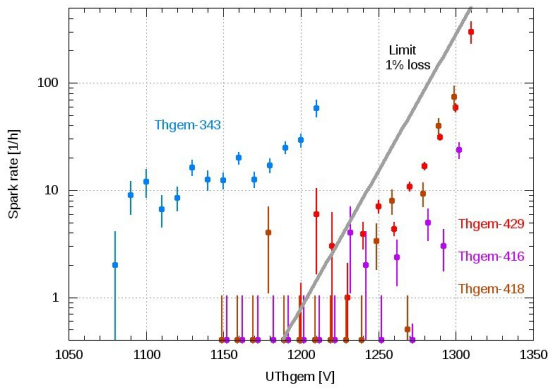
- Offline work is ongoing ...

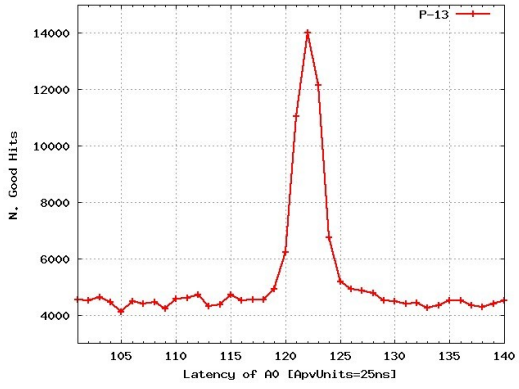


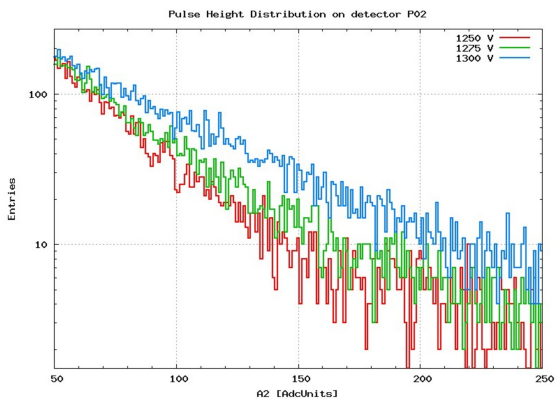


Summary

- **First Hybrid MPGD Ring Imaging Cherenkov Detector in operation**
  with double **THGEMs** and Bulk **Micromegas**
  photoconverter: CsI coating on the first THGEM
- Four detectors, each with 600x600 mm^2 surface (from two halves)
- **Construction**
  Detailed **quality assurance** and checks
  Assembly and **CsI** coating
  Installastion to COMPASS at CERN SPS was done.
- **Photon signal were seen !**
- Data analysis for finetuning is ongoing
  operational principles have been proven
- A lot more to come ...

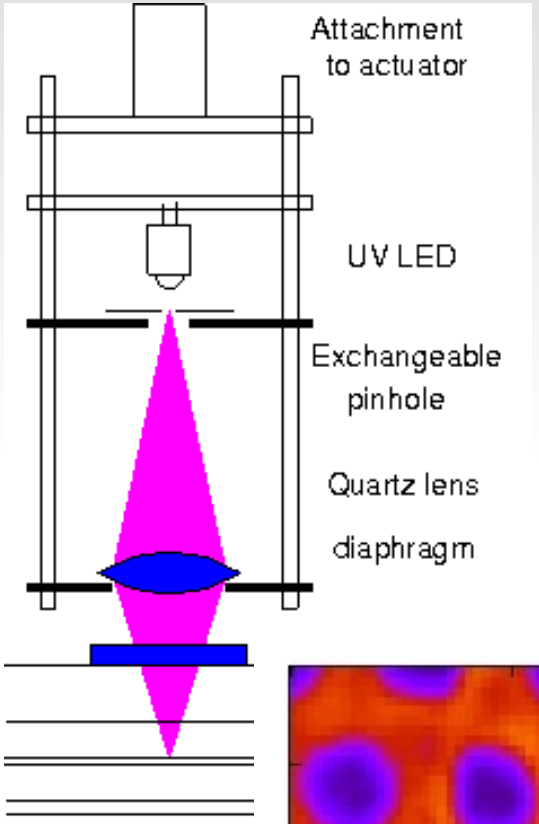




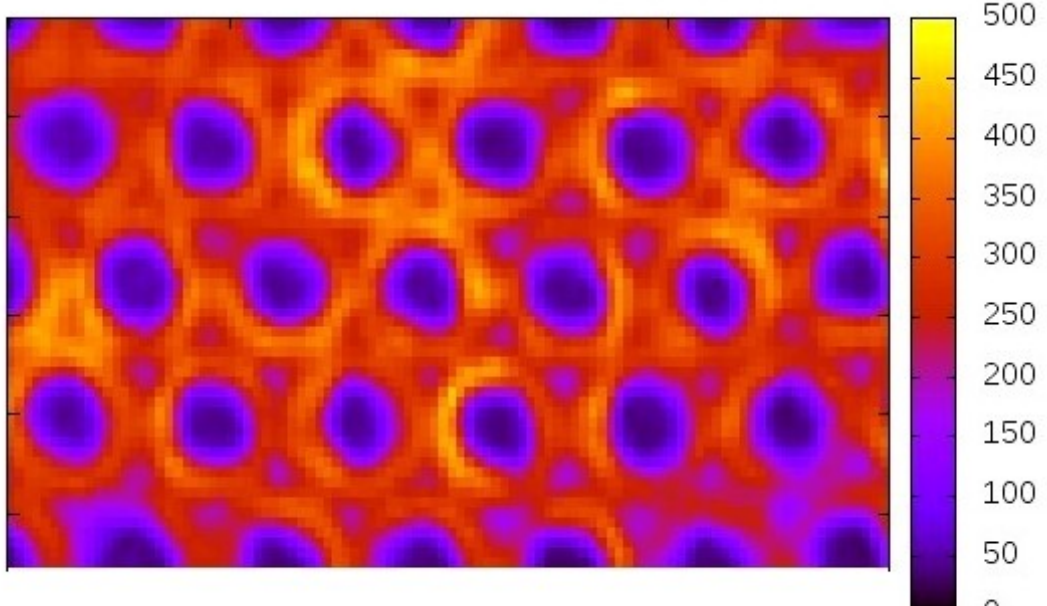


Backup Slides

The "Leopard"

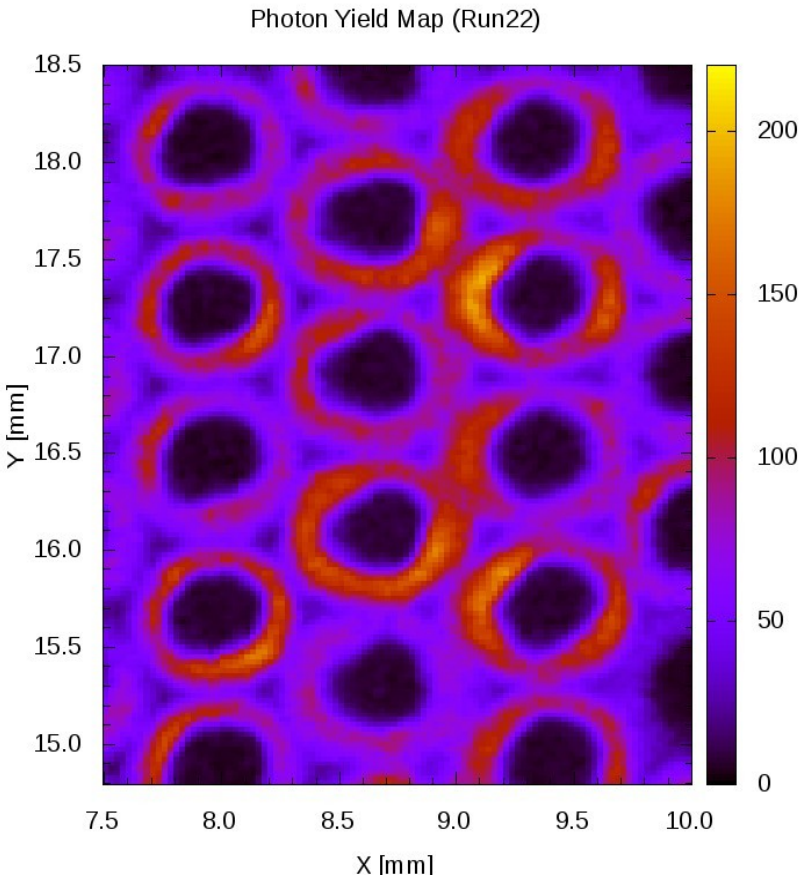


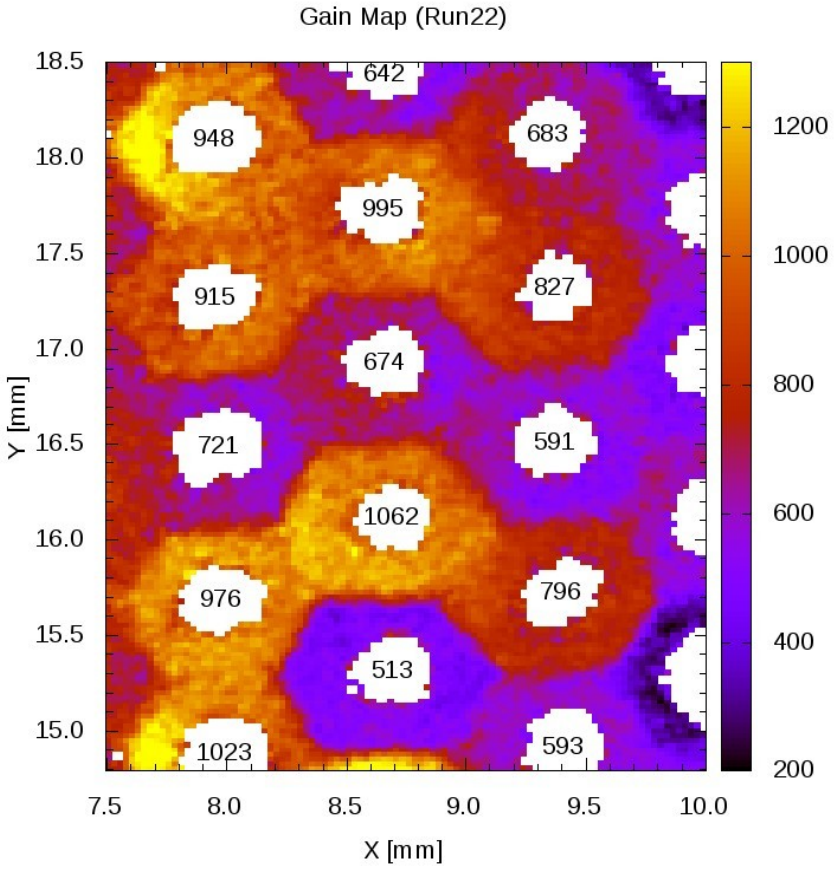
- Pulsed UV light focused to 70 μm spot onto the top of the ThickGEM
- Optical setup mounted onto a contolled 3D actuator system
- Fast DAQ...
- Single PE spectra at each point
  -> Photo-efficiency, and gain



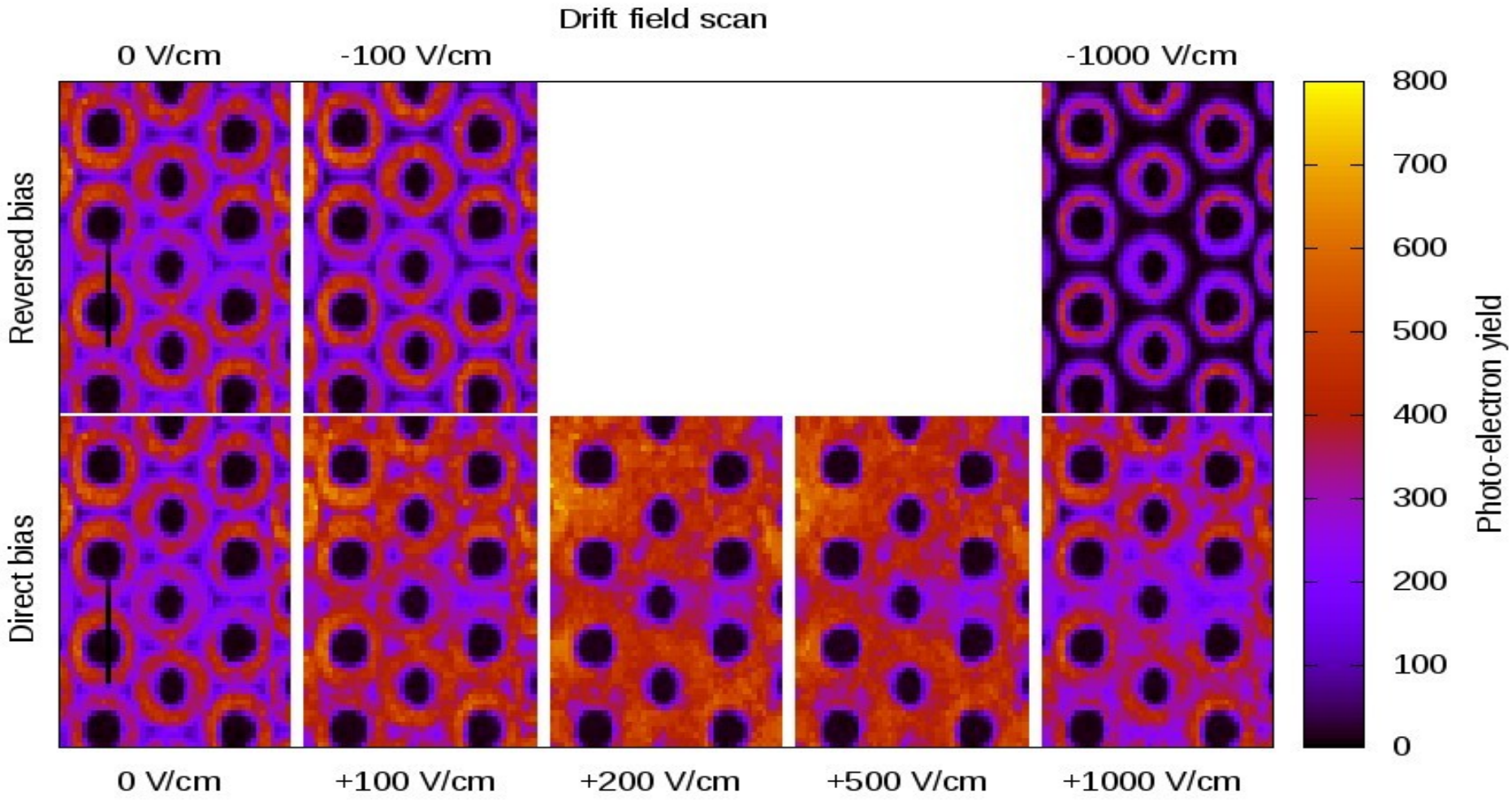
Maps of Yield and Gain

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



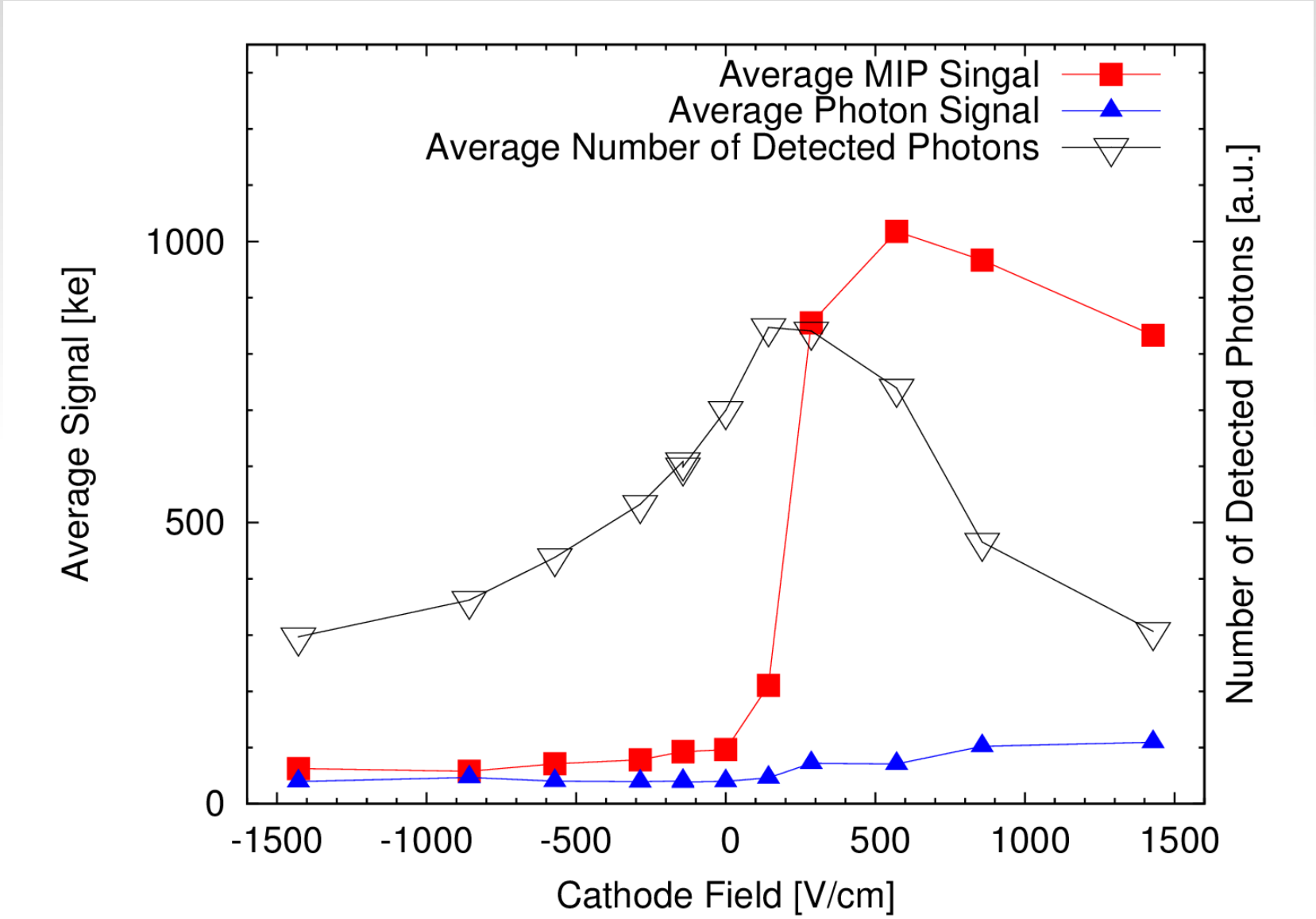


The Role of the Drift Field



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

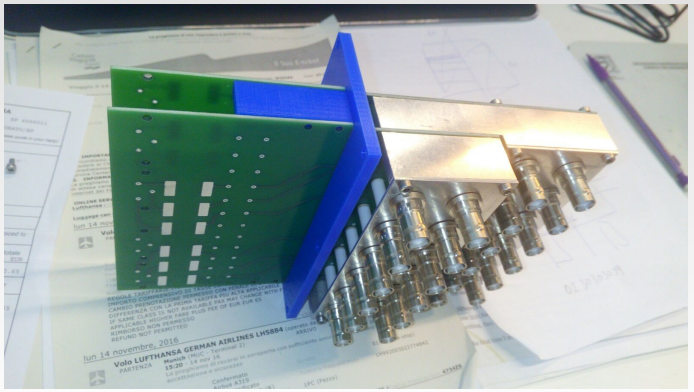
MIP Suppression



WignerRCP Budapest
G.Hamar, D.Varga

After End of RUN2016 Segment Check

- The feeble Sectors will be investigated
  Spark rate measurement at Segment level
  (24mm wide strips means 4% of a detector)
- **Weak segments** can be **identified**
  and later if needed eliminated
- Testing has been started, and foreseen
  to continoue during the next weeks



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