MPGD Photon Detector Upgrade for COMPASS RICH

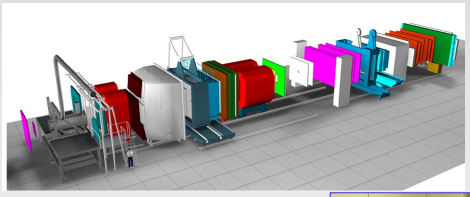
Gergő Hamar

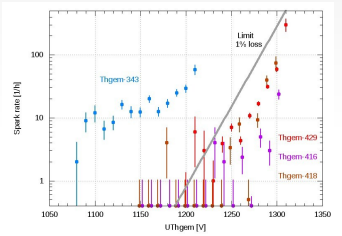
for the THGEM group of INFN Trieste
S. Dalla Torre, F. Tessarotto, S. Levorato,
S. S. Dasgupta, G. Hamar, C. Azevedo

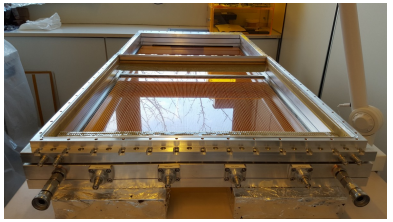
Instrumentation for Colliding Beam Phyisics
Budker INP, Novosibirsk, 2017

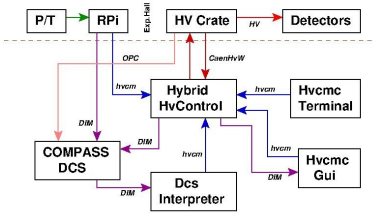
Outline

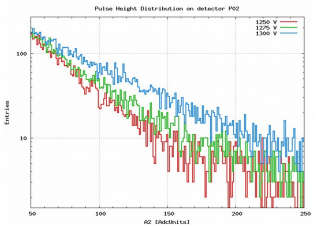
- COMPASS RICH1 Upgrade
- Detector structure : THGEM + MM
- Quality Assurance
- Construction + Installation
- HV system
- Commissioning Status











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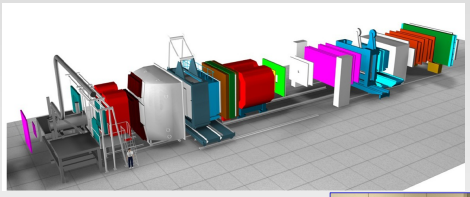

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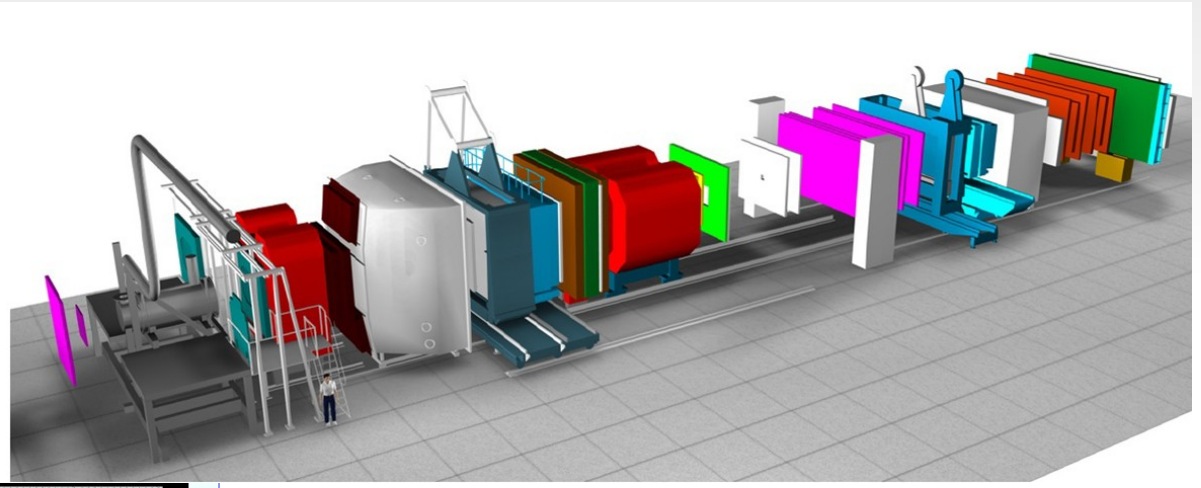
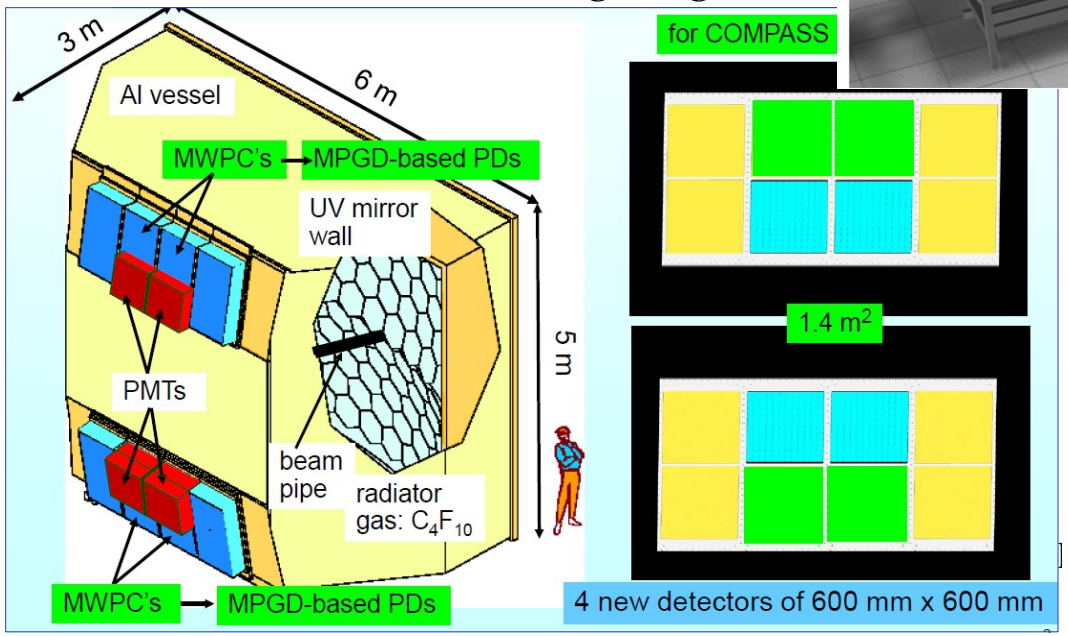
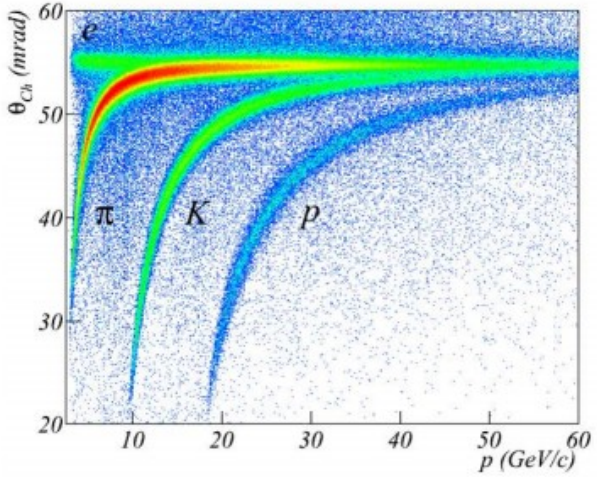
COMPASS RICH1

- **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



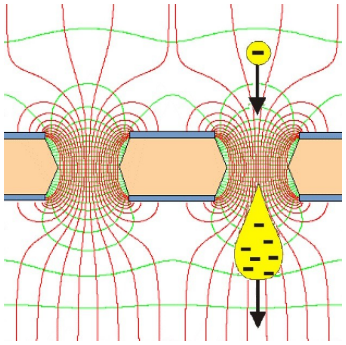




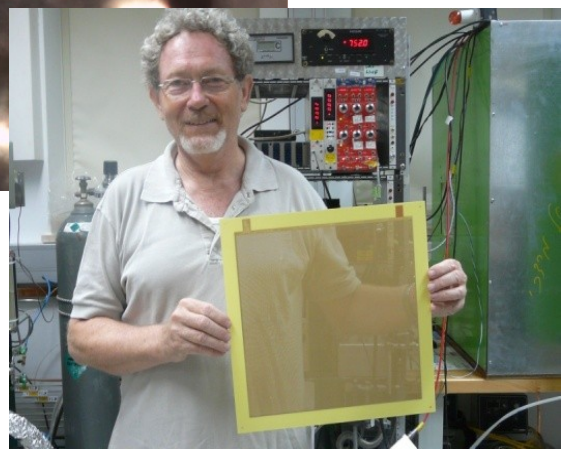
MicroPattern Gaseous Detectors

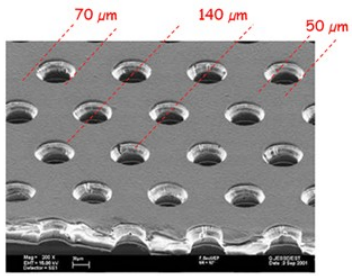
(Let me skip details, and refer to the morning session of today)

- 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**

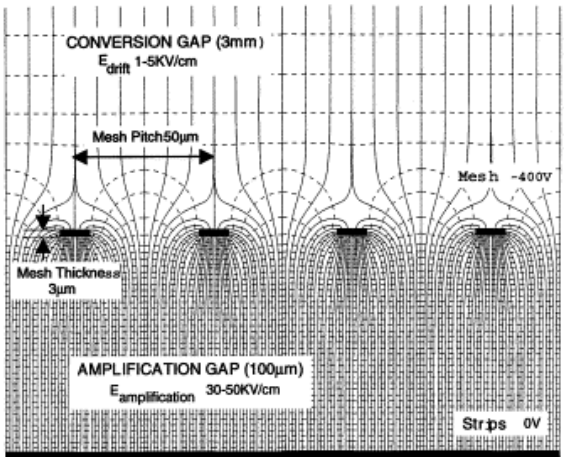


ThickGEM





GEM



MicroMeGas

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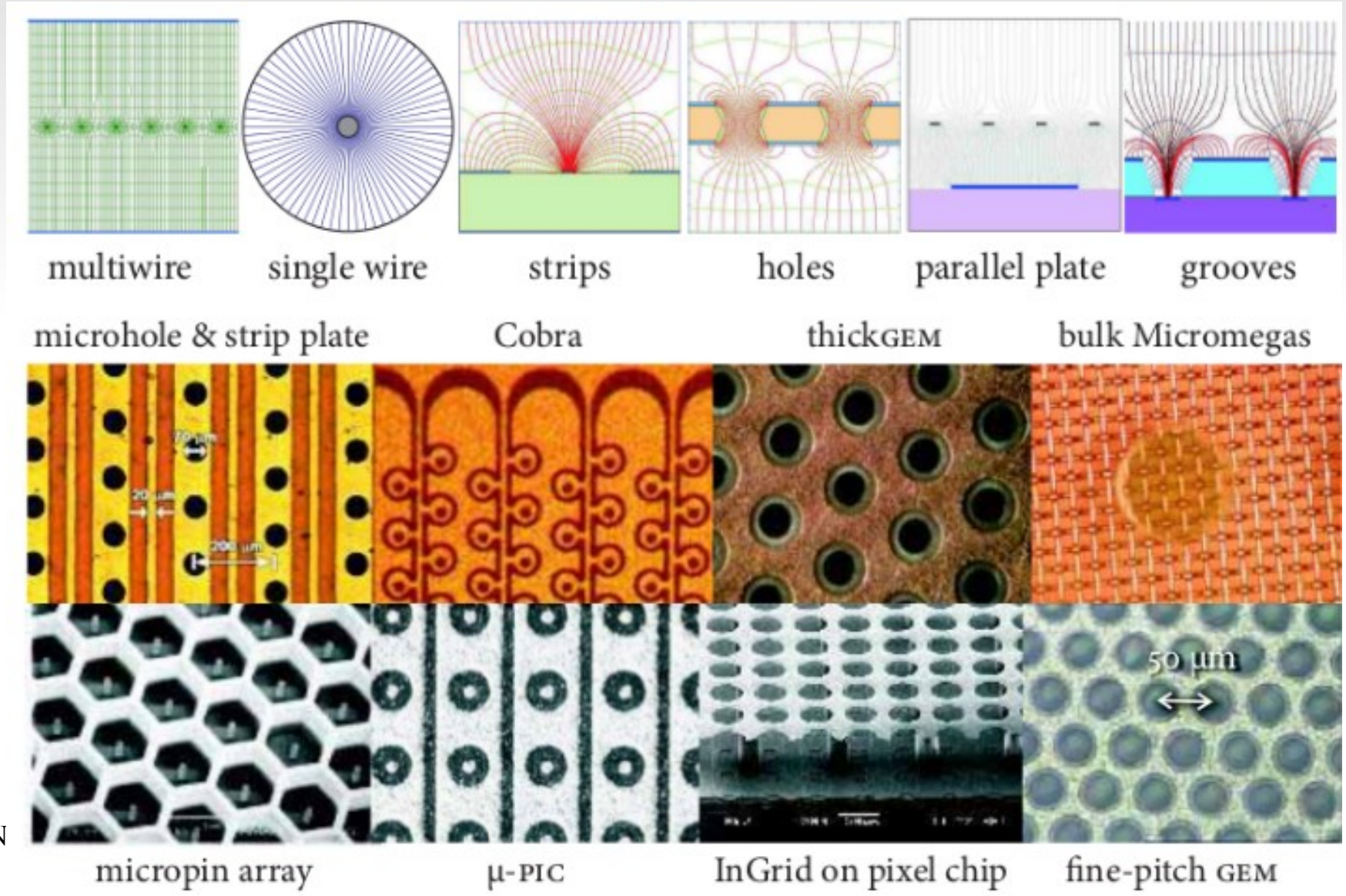
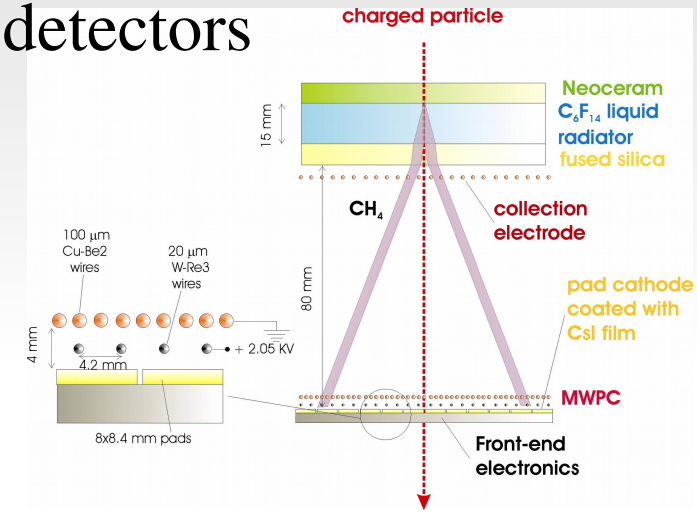
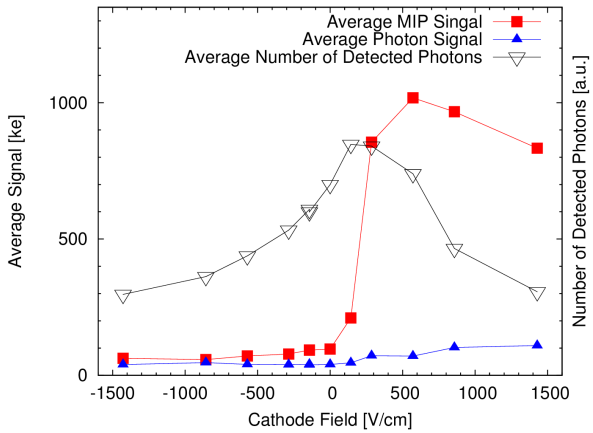


MPGD Based Gaseous Photon Detectors

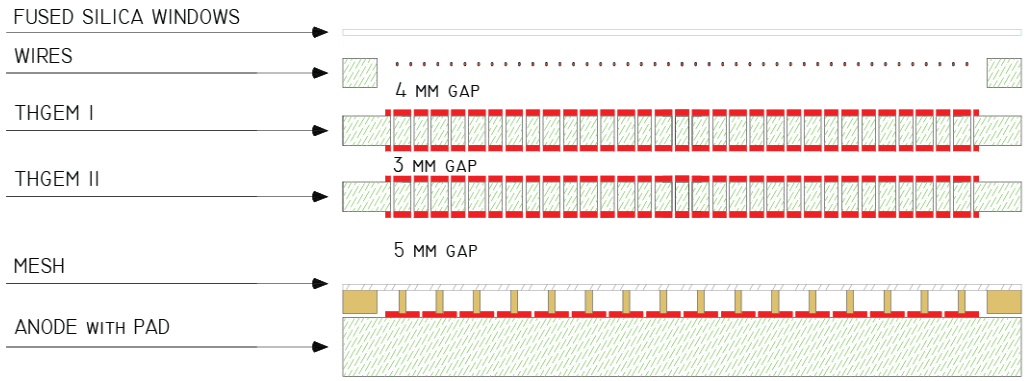
- Particle identification -> **Cherenkov detectors**
- Gaseous Photon Detectors for Cherenkov detectors
  - **Large area** at reasonable price
  - **CsI** cover for UV photon detection
- Advantages vs. MWPC based RICH
  - Reduction of ion back-flow
  - Fast response
  - High rate capability
  - Possibility 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)



D RICH

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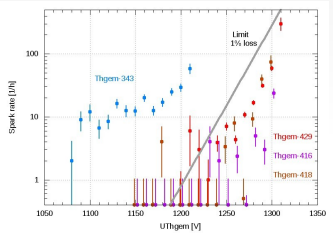
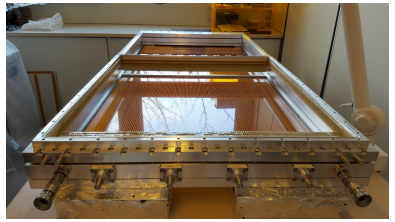
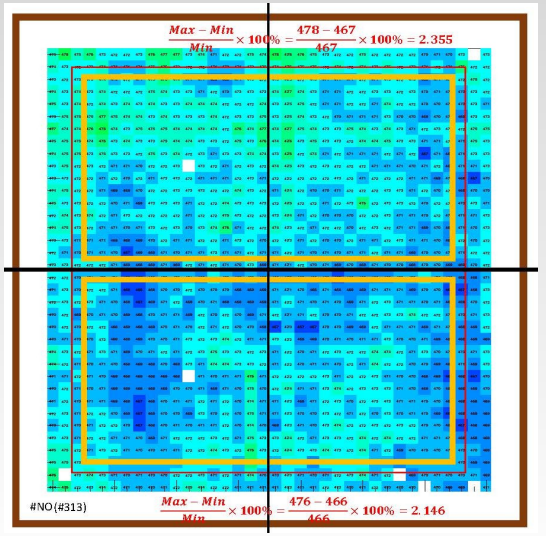
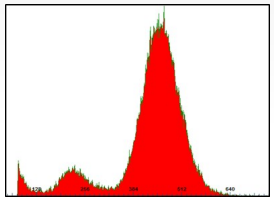


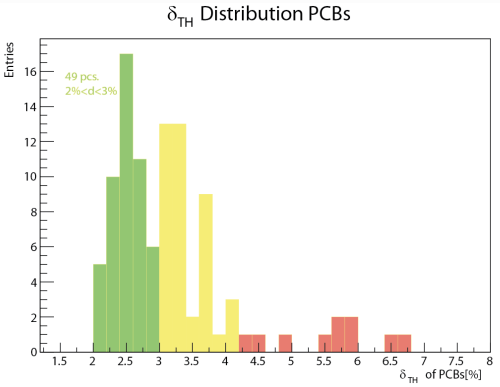


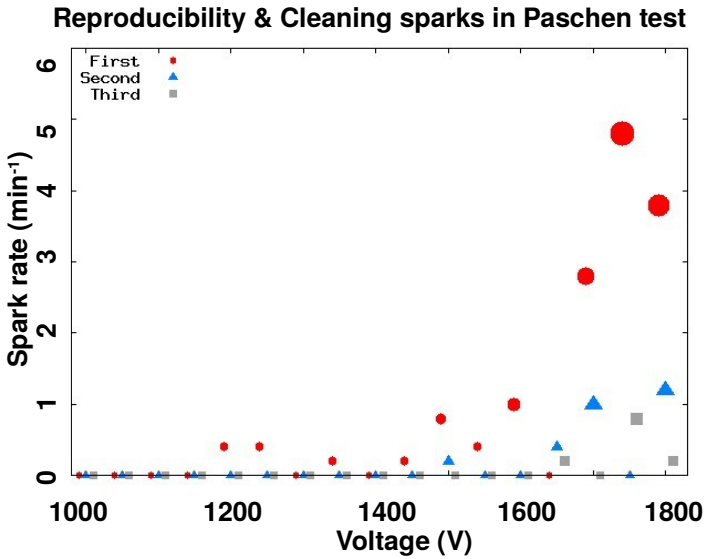
Quality Assurance

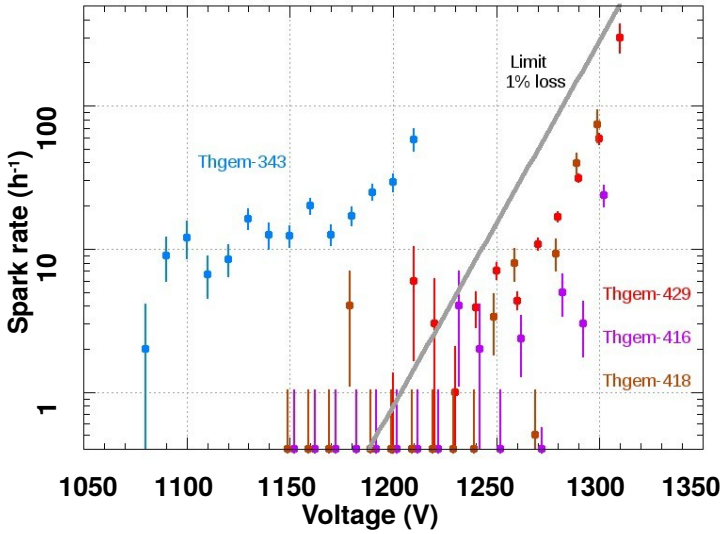
- ThickGEMs
  - Material selection → uniform thickness
  - Polishing → smooth copper edges
  - Paschen test in N_2
  - Discharge test in Ar-CO_2
  - Gain and unifromity measurements with X-rays
  - Test after gold plating
  - CsI coating's QE measurement
- Micromegas
  - Electrical check of HV pads
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

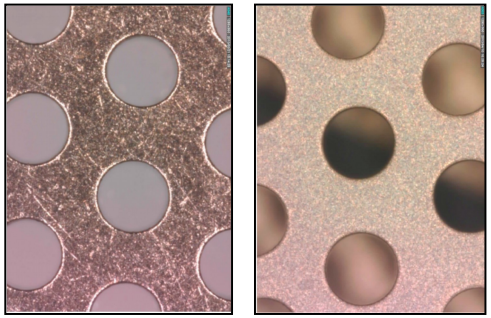












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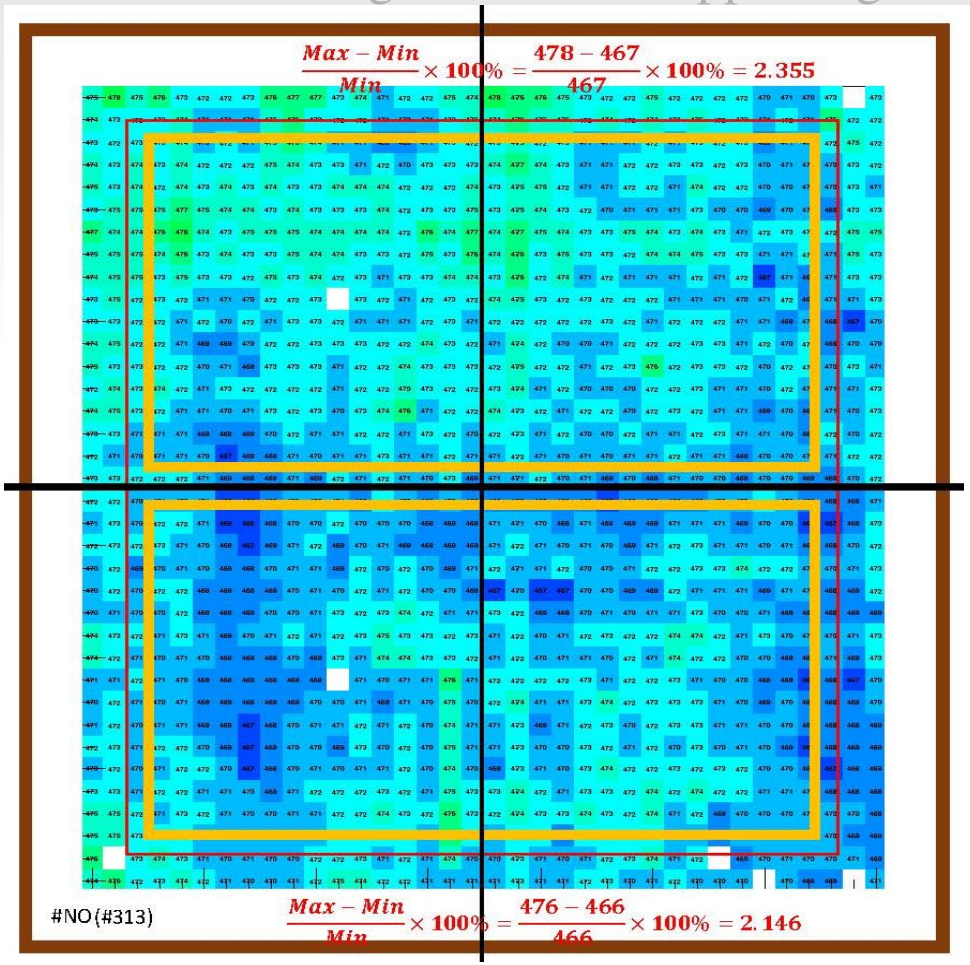
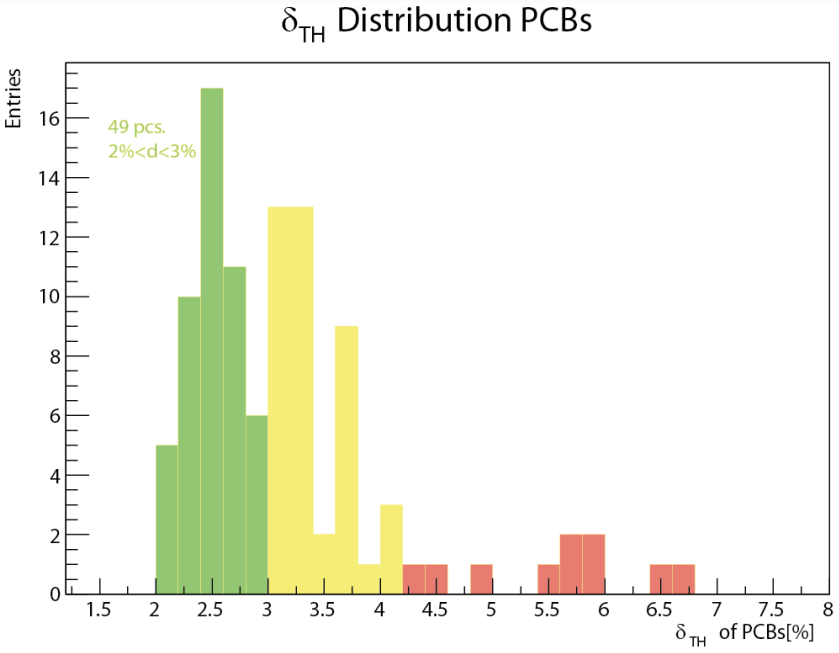


with X-rays



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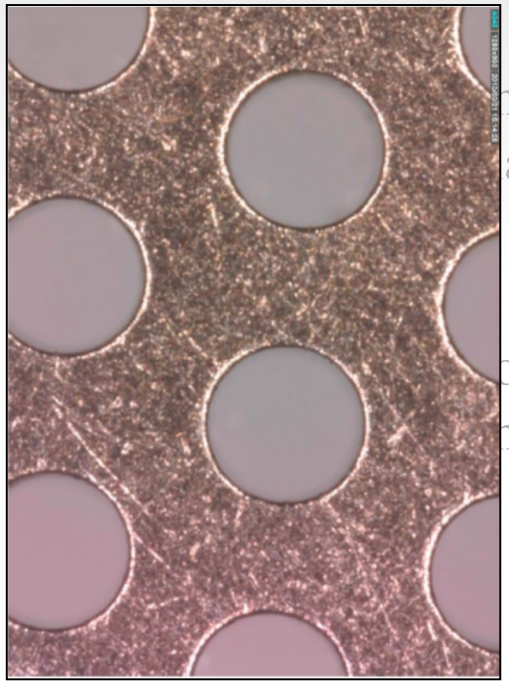

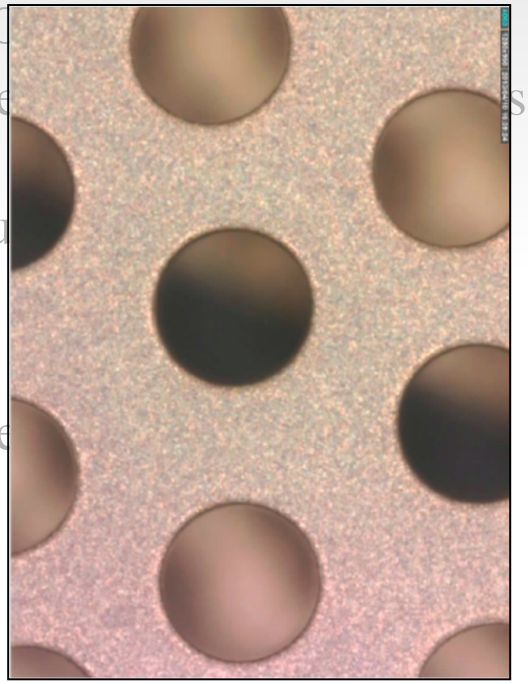

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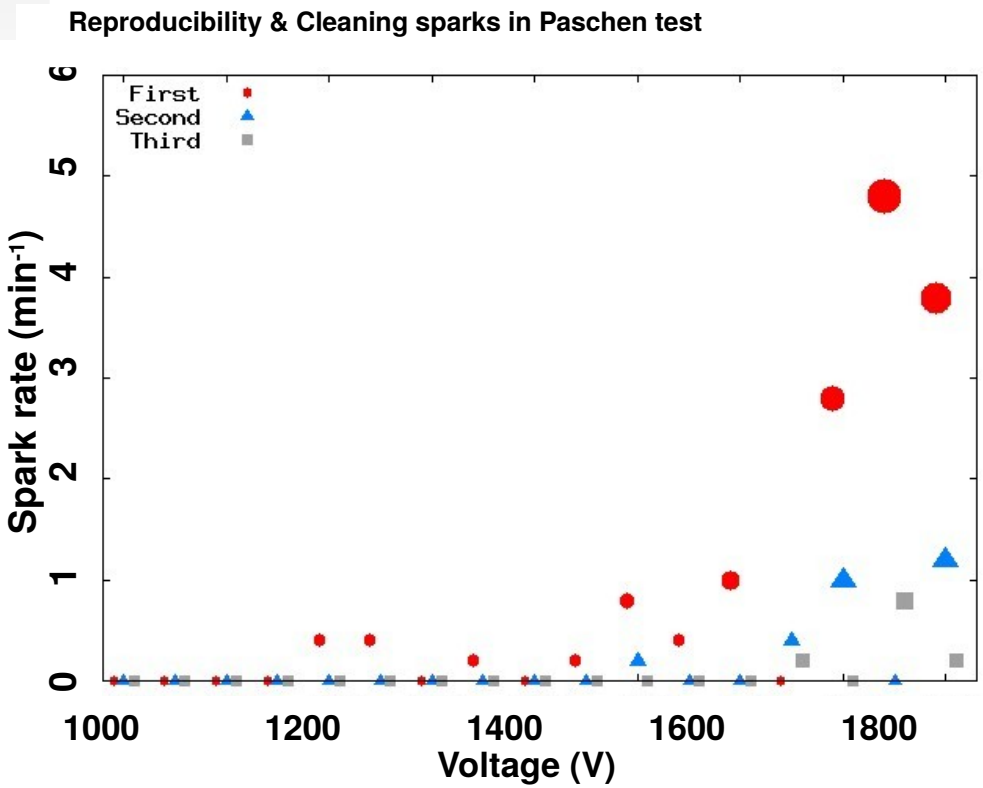

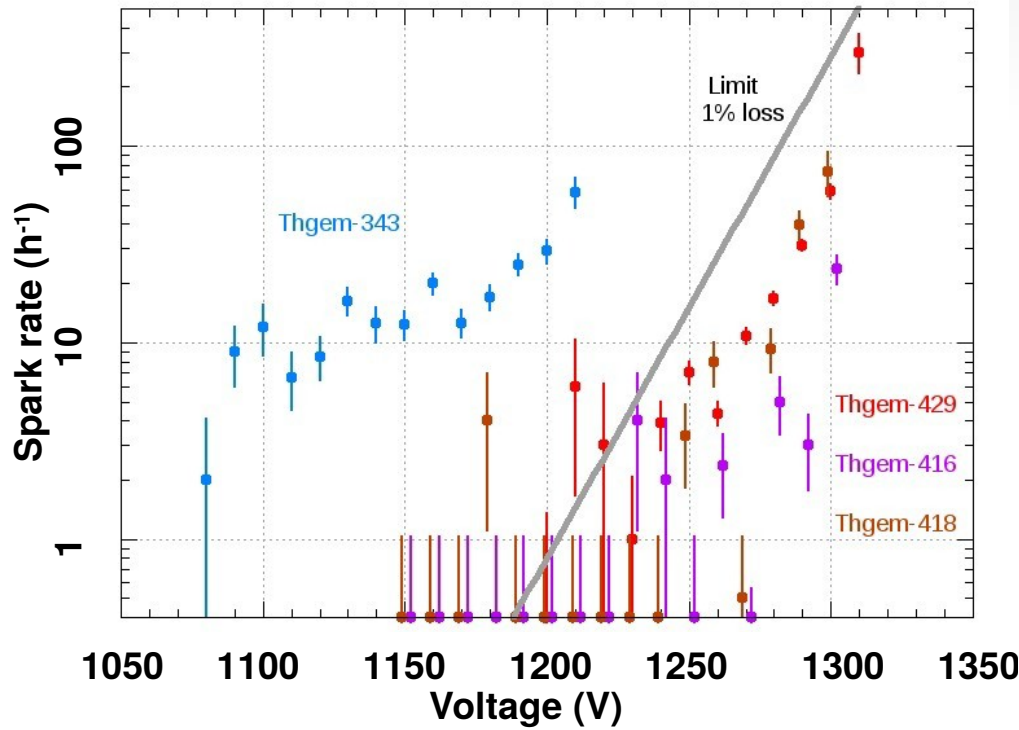

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  - Test after gold plating
  - CsI coating's QE measurement
- Micromegas
  - Electrical check of HV pads
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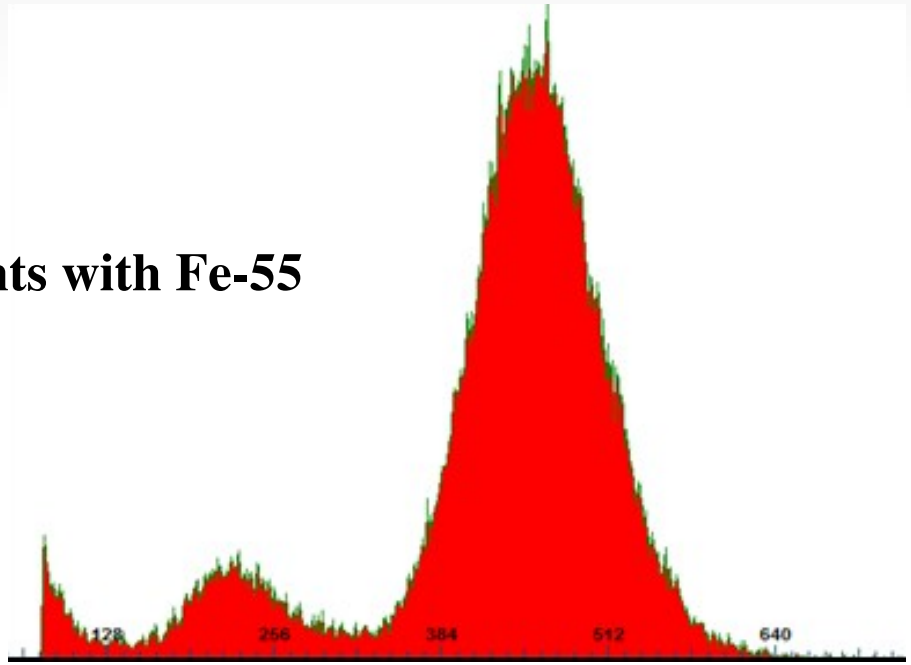

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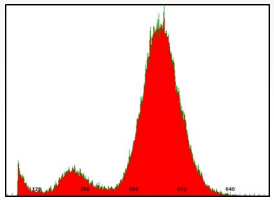

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  - Electrical check of HV pads
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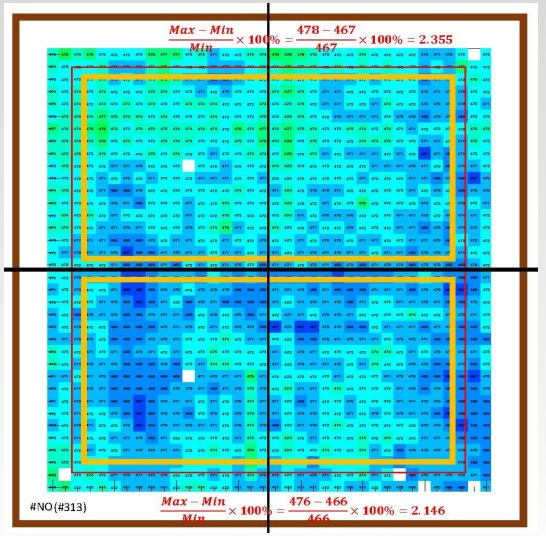
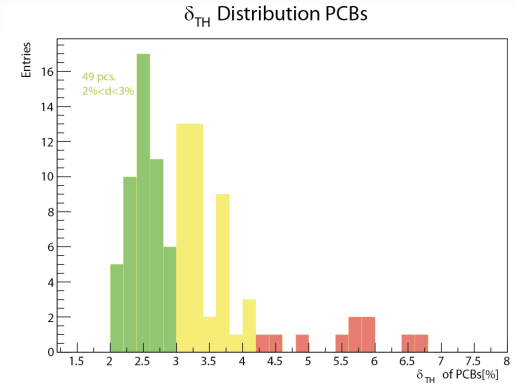
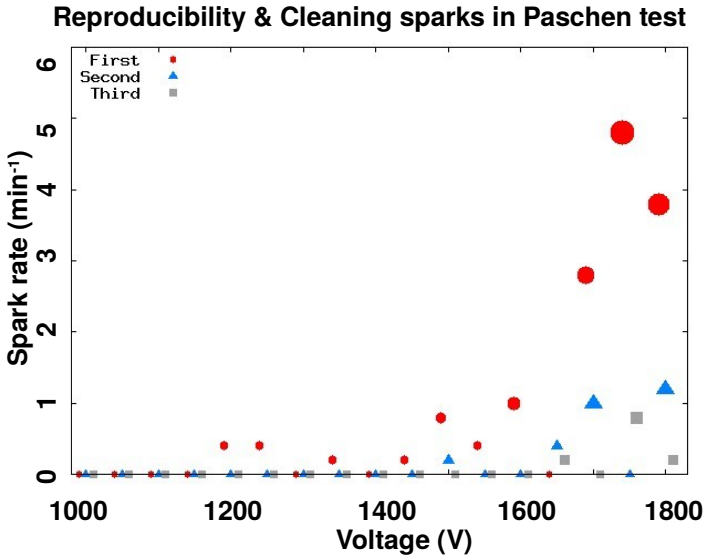
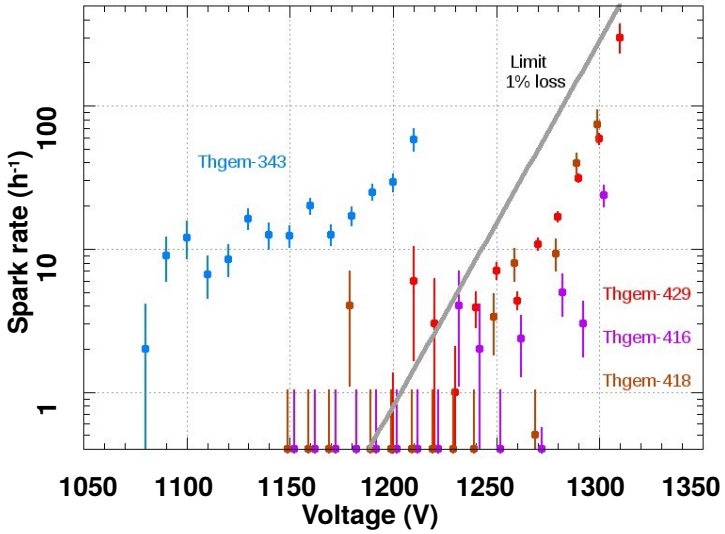
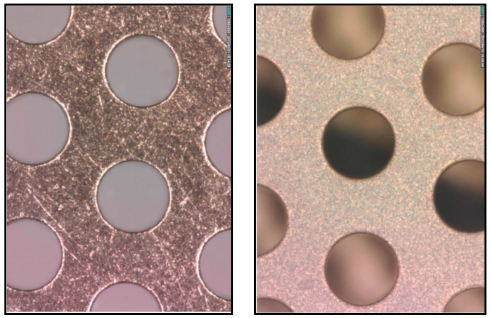




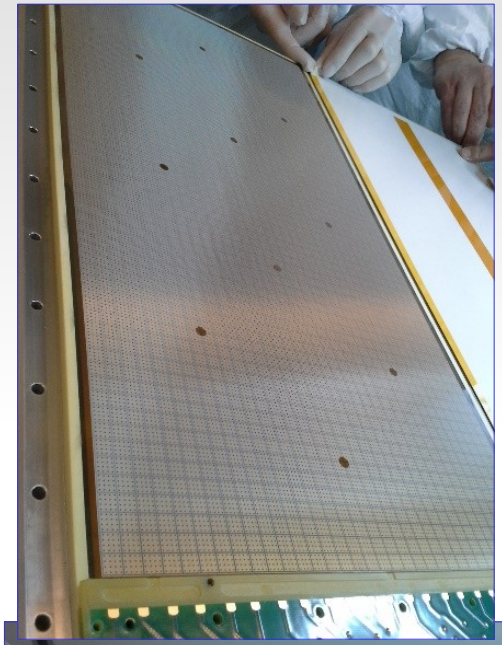


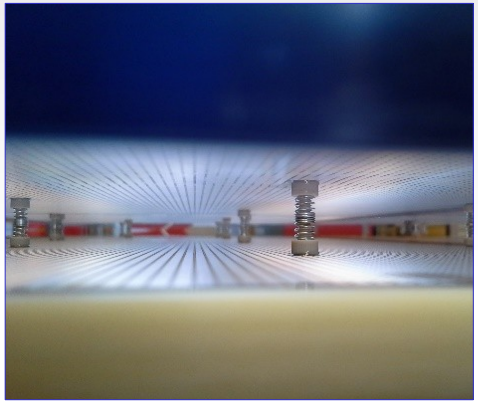


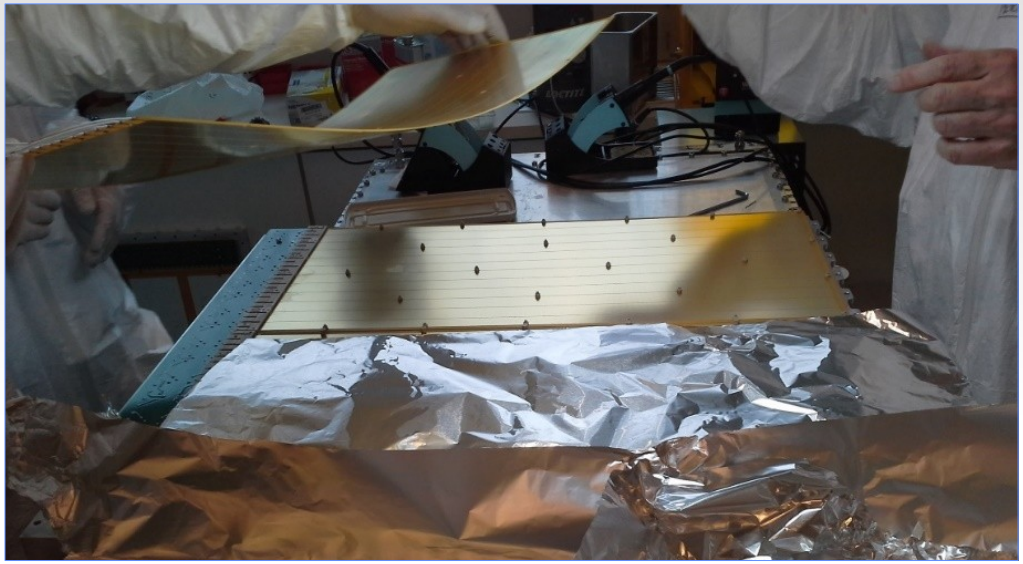


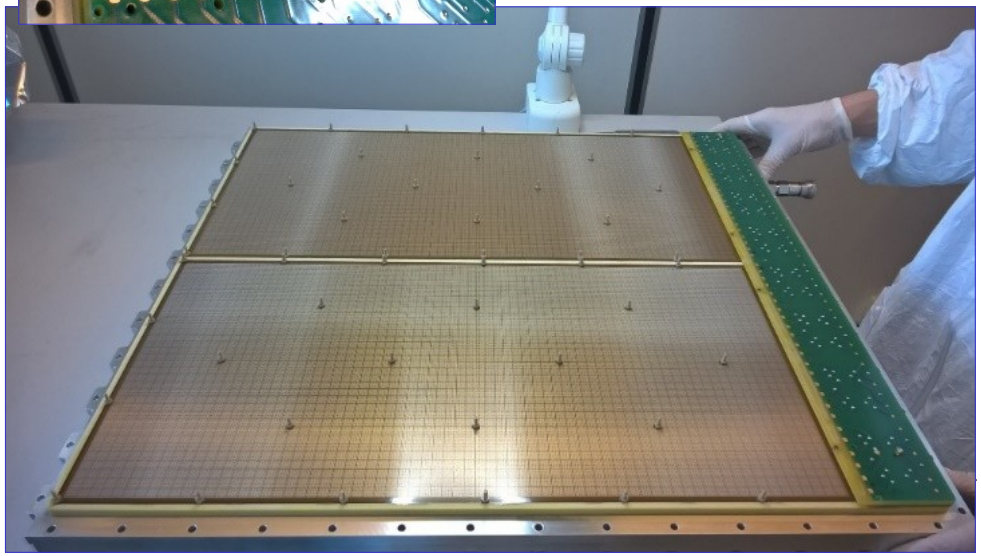
Assembly

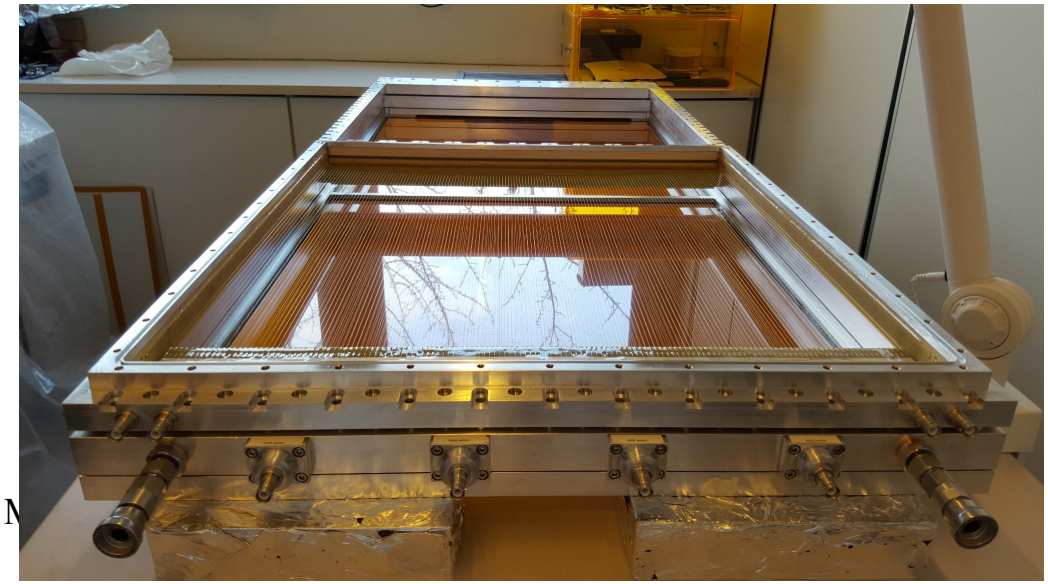
- Mostly Clean-room operation





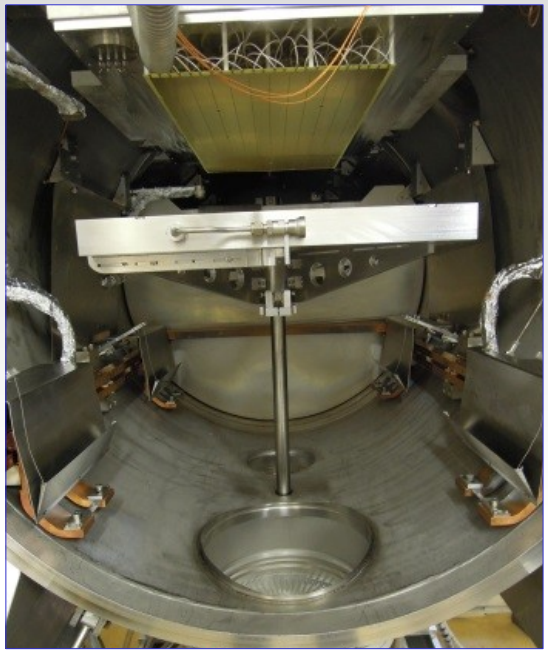


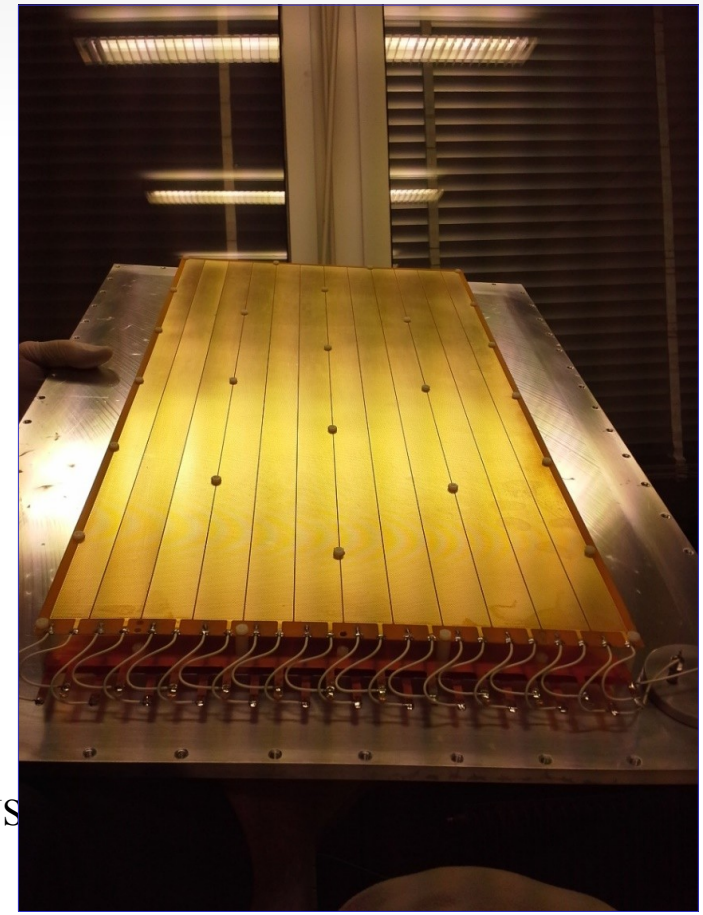


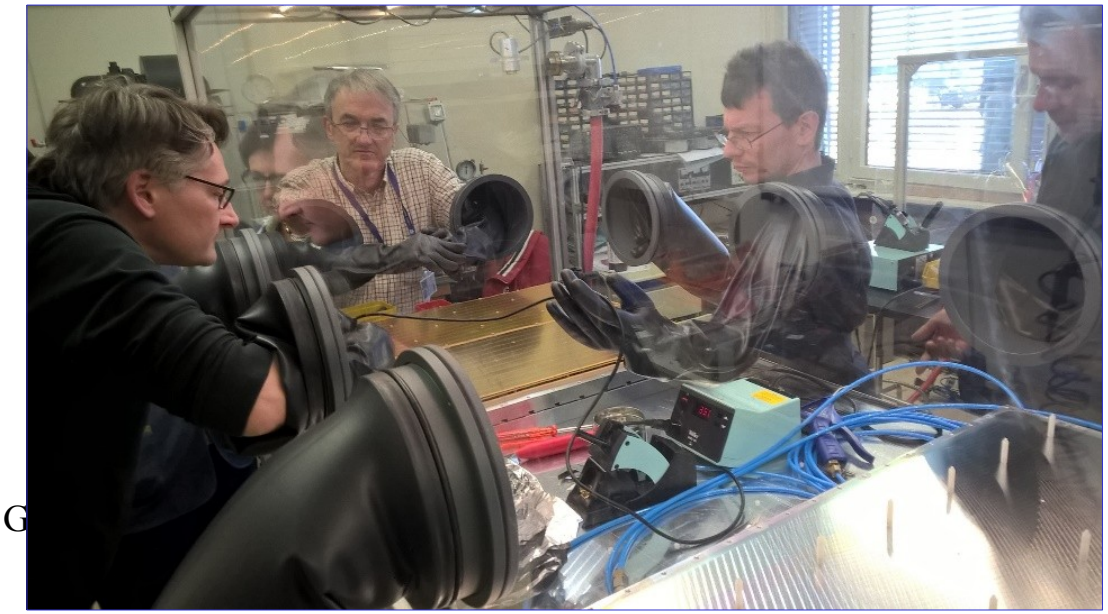


… and the CsI

- 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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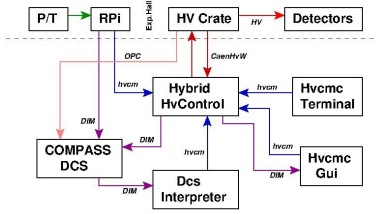
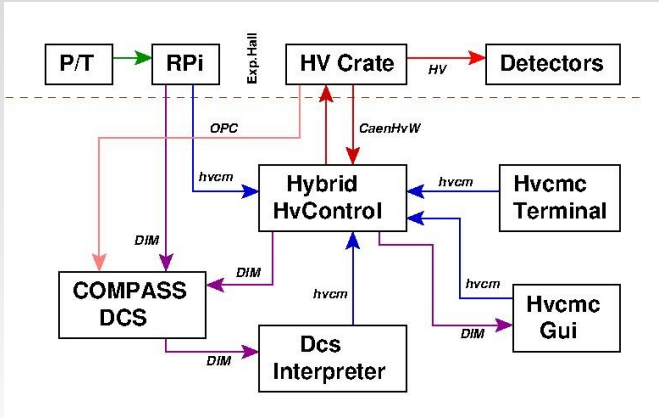
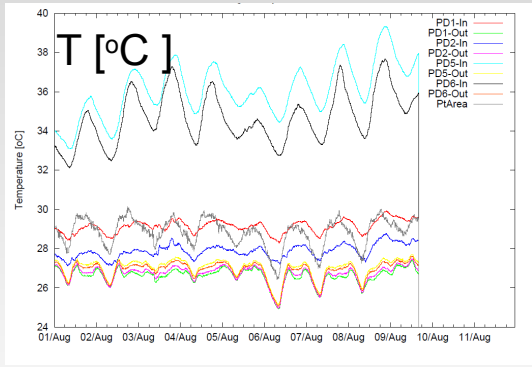
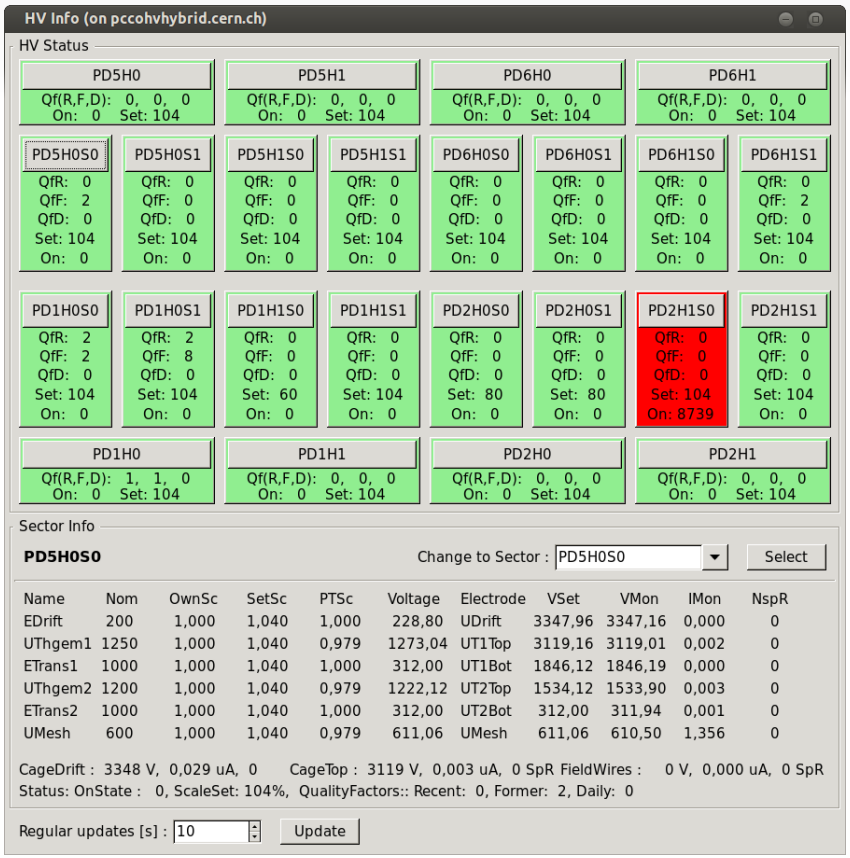


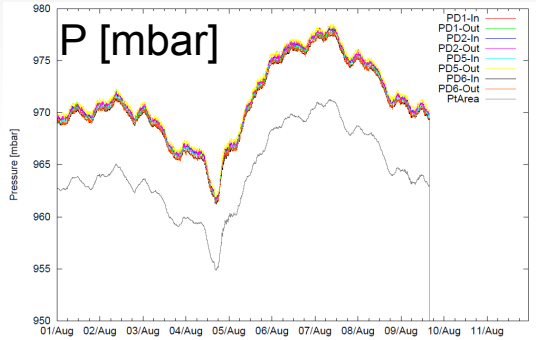
HV System

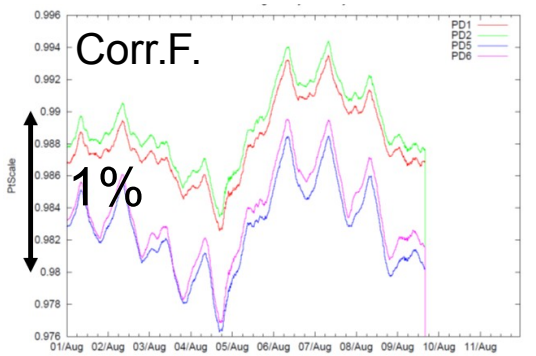
- **Custom made HV system**
  (C++,wxWidgets)
- Coop. with **COMPASS DCS**
- **Correction wtr P/T**
  in amplifier regions
- "OwnScale" to finetune
  for **uniformity**
- **Log** with 1 Hz
- **Spark detection**
- Autodecrease HV
  if too many sparks
- Interaction via: GUI,
  DCS, DIM, Msg
- Gain variation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







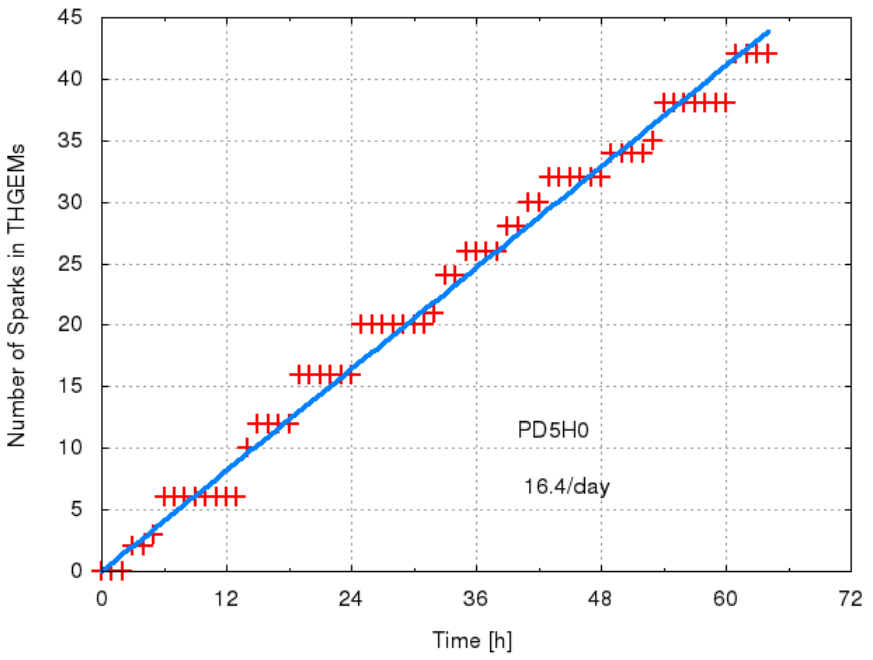


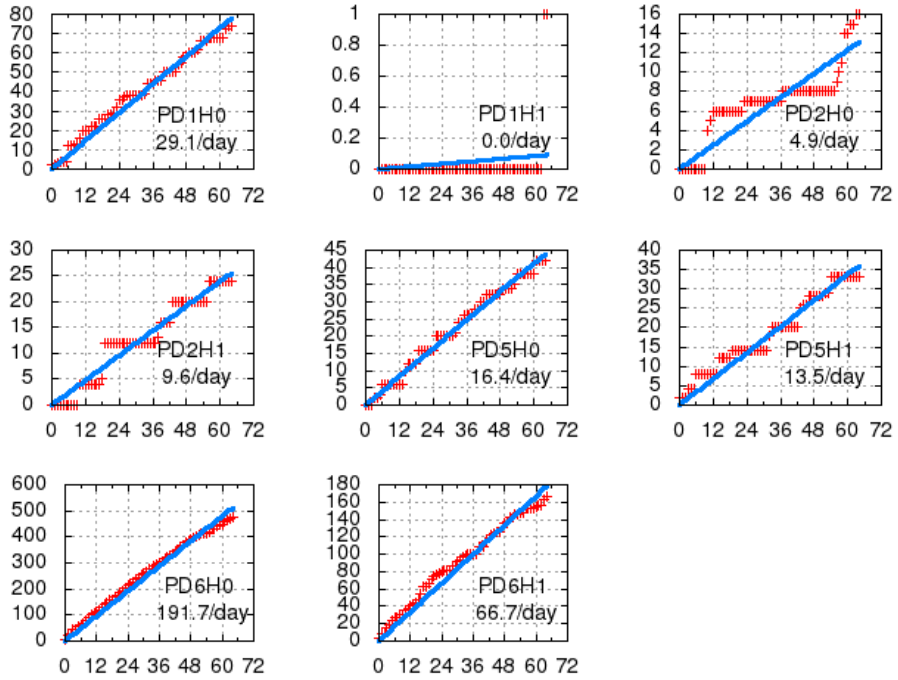


P/T: ~1% →
Gain: ~40%

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



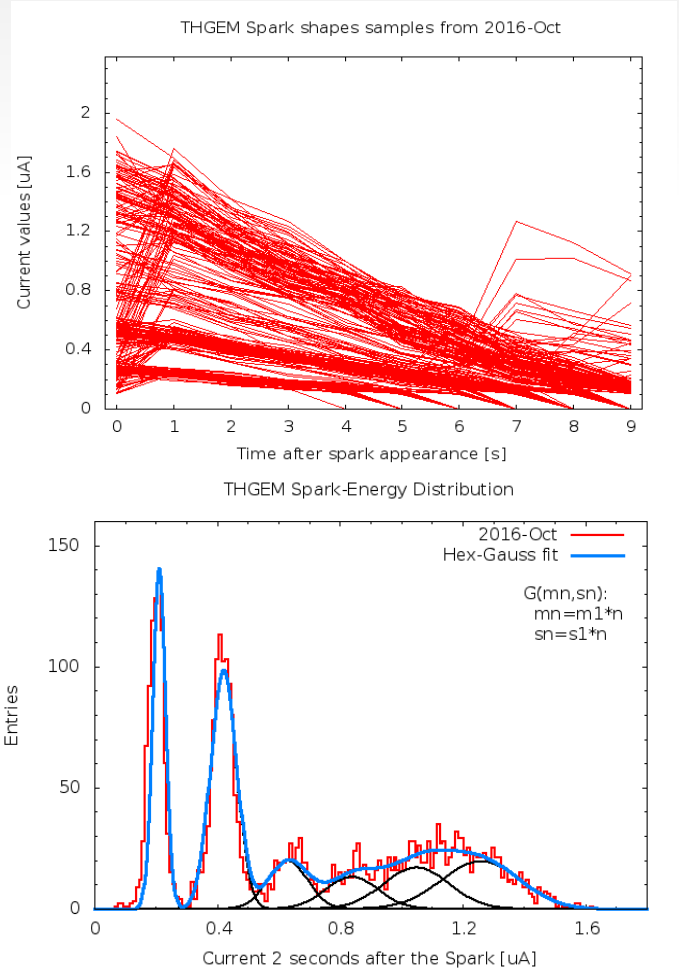


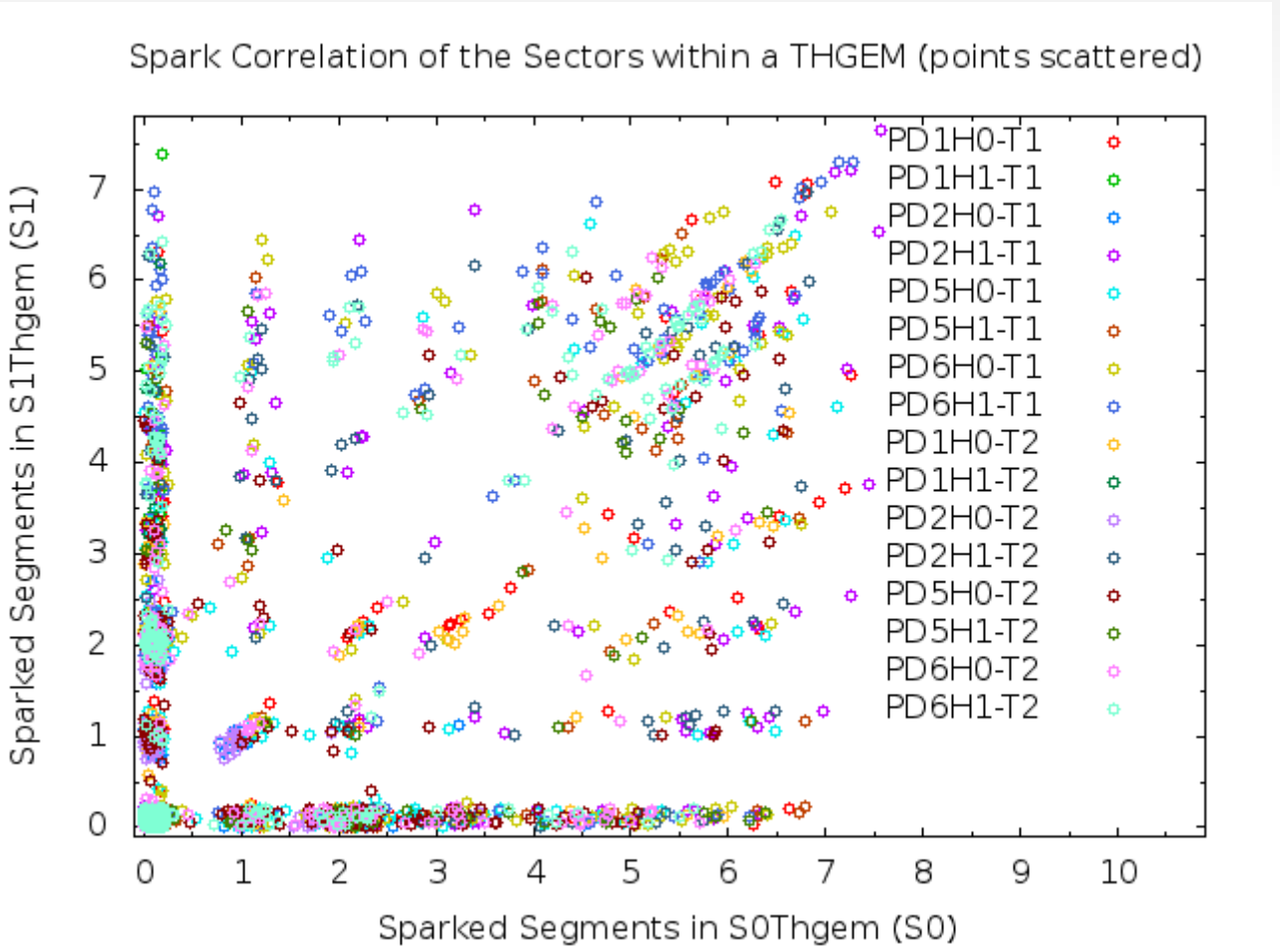
Sparks in the THGEMs

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

  between the two THGEMs of a Sector : always

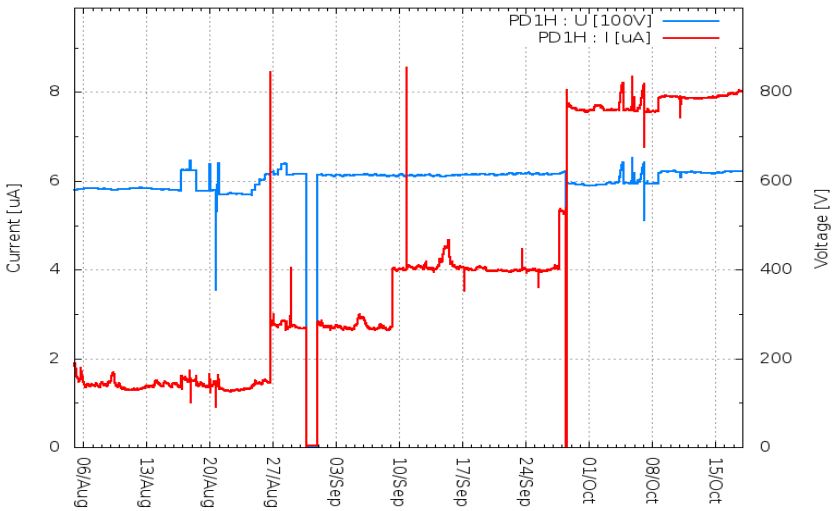
  between two sides of a THGEM (neighbouring Sectors)
- Mostly 1-2 segments, or the whole THGEM (showers?)

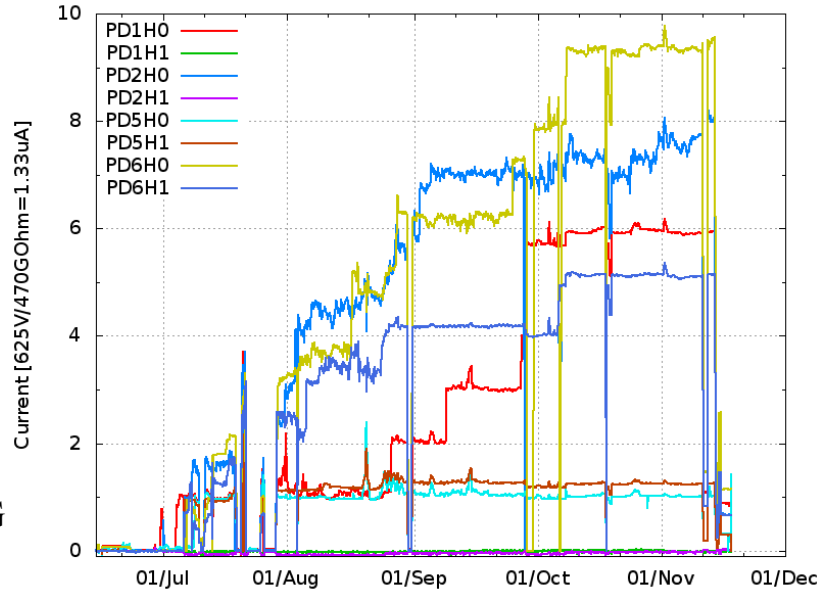




The Micromegas

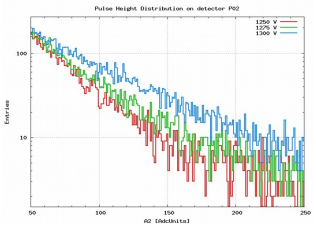
- **Shorts** have appeared during operation
  could be : inside the detector's gas volume / in the PCB material / resistor array
- **No pre-filter resistors** are used before the distribution to the HV-pads
  → **MM** is still **usable**, with high constant current (flowing to the shorted pad)
  no extra 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**



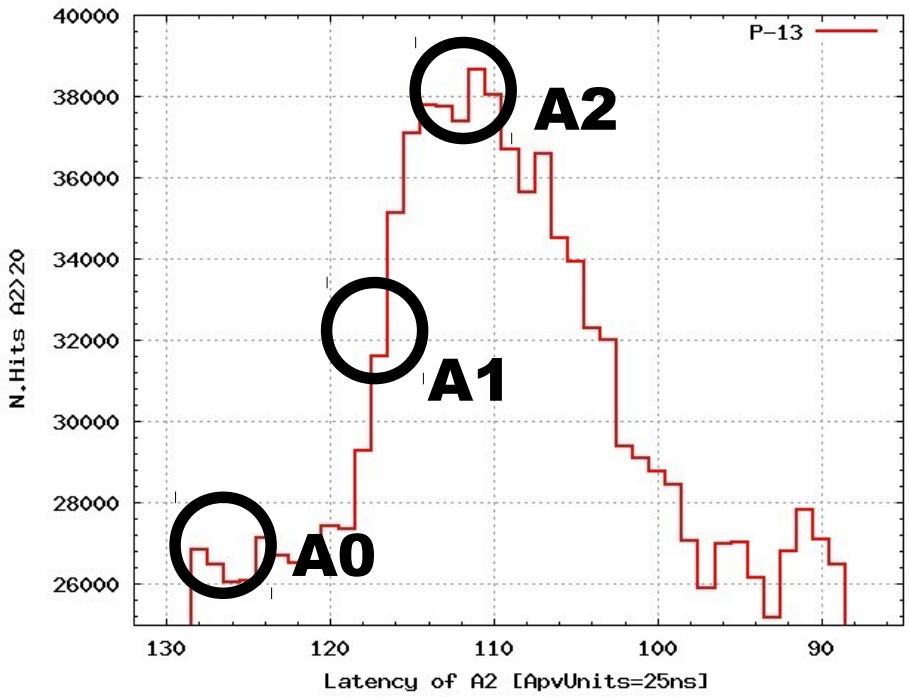
Commissioning
… is still ongoing

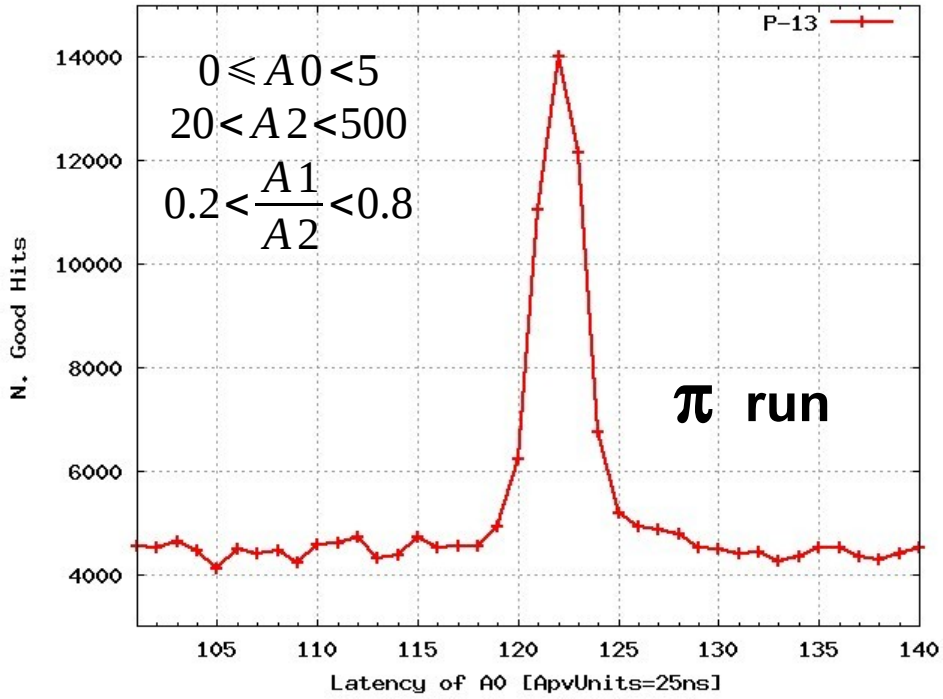
- Operation of the HV system
- Communication with DCS
- Stability, shorts, and sparking issues

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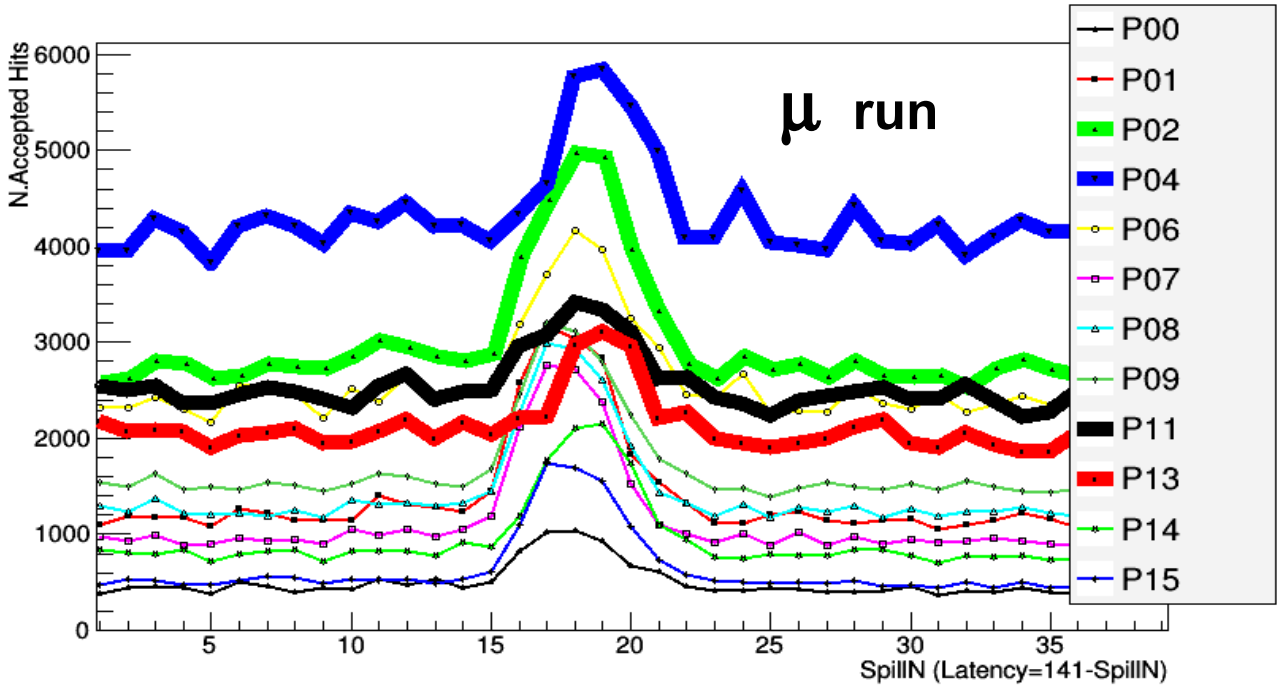
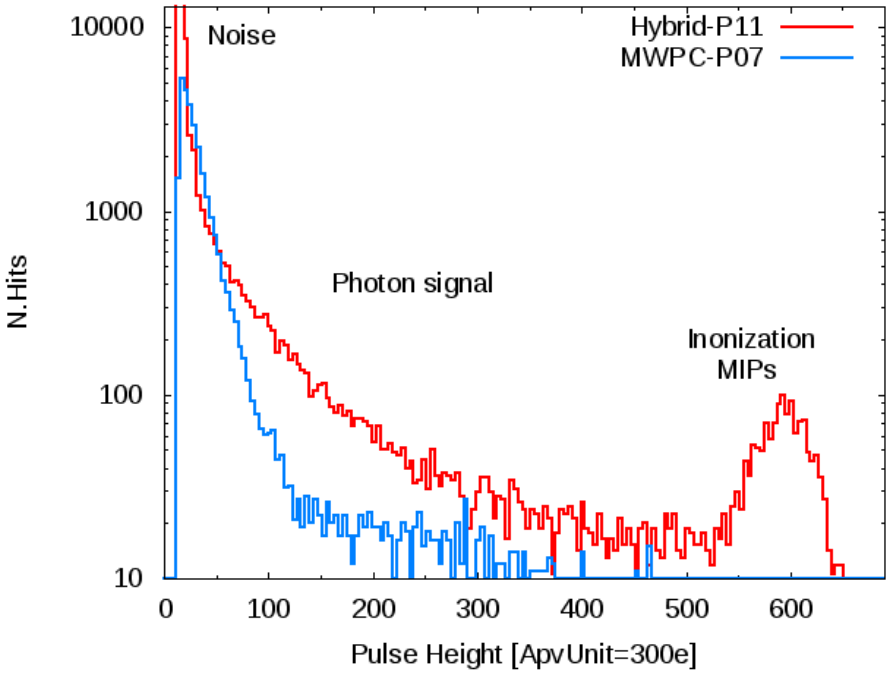
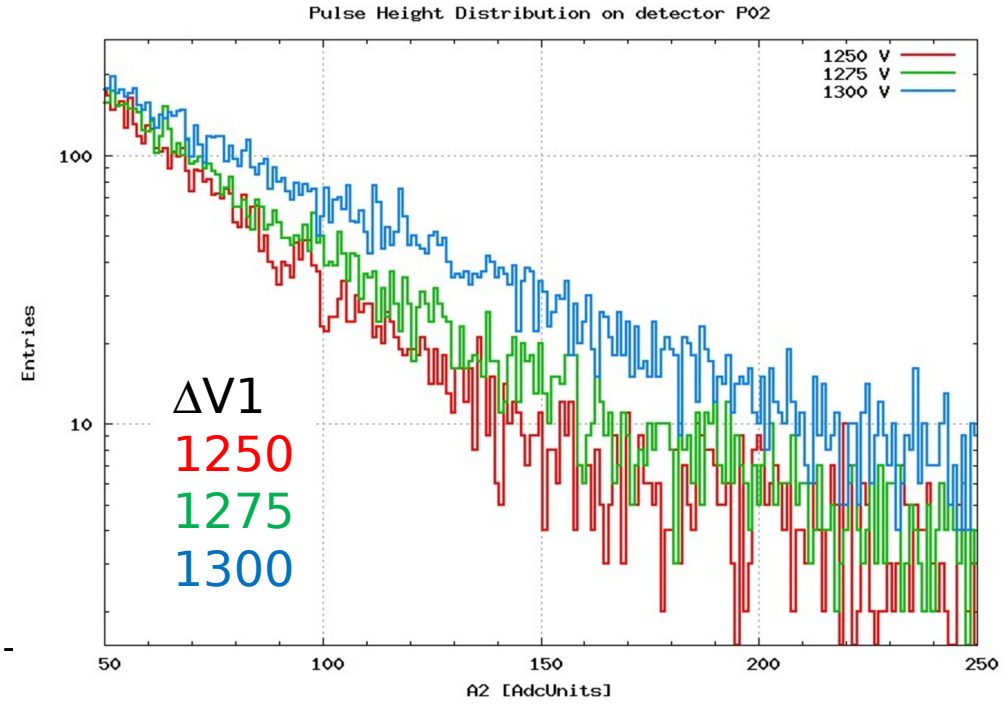
$$0 \leqslant A0 < 5$$
$$20 < A2 < 500$$
$$0.2 < \frac{A1}{A2} < 0.8$$



HV Scans

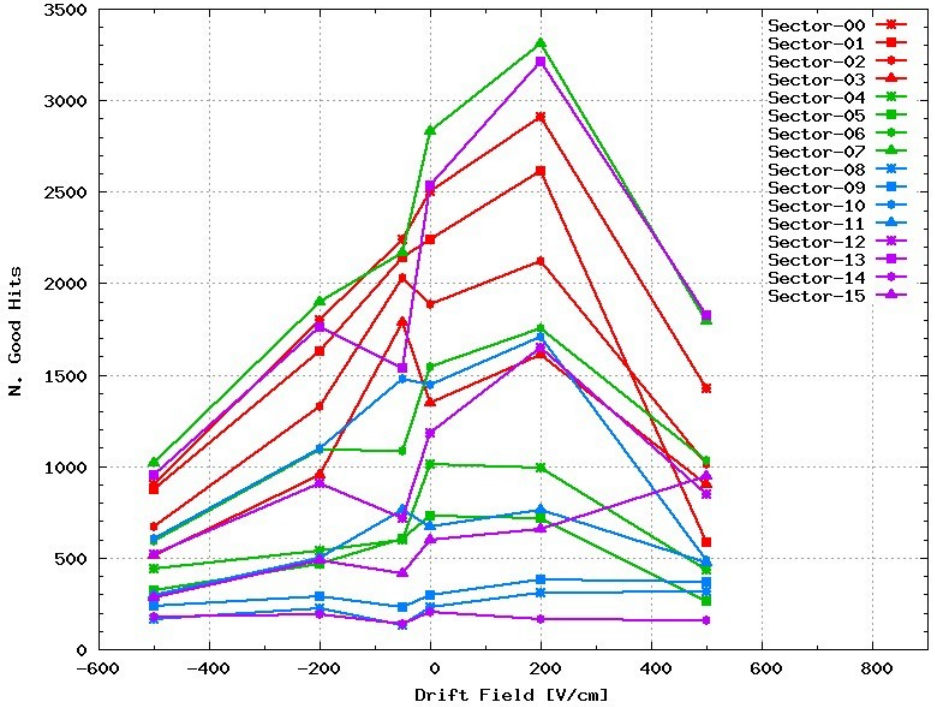
- **First characterization** steps during the commissioning
  reproduce simple laboratory scans, check for consistency
- **Gain scan** wrt voltage on MM and THGEMs were checked
  and influence of transverse fields, and gain sharing was studied as well
- Increase of the gain is **consistent** with the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



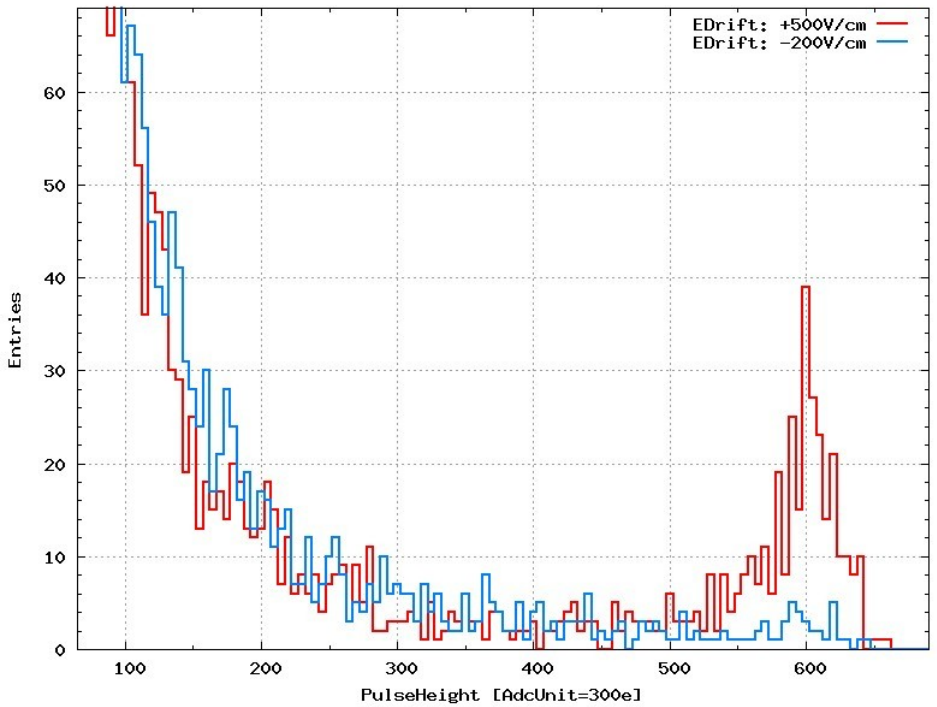


Drift Field

- **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



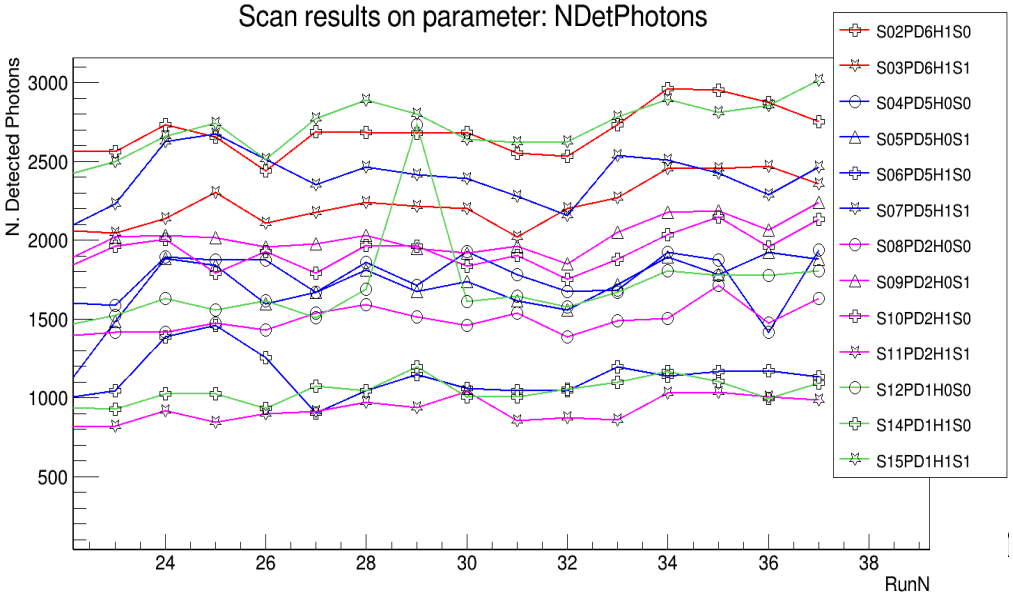
- MP(

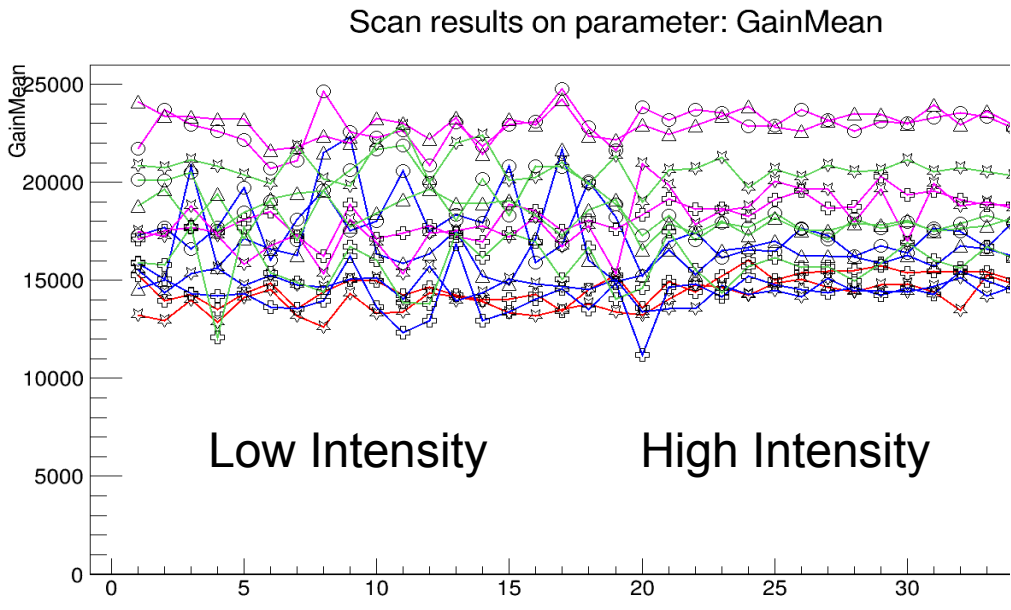


Stable Operation

- **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

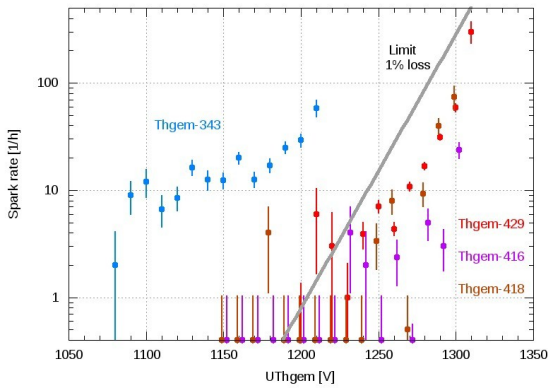
- Offline work is ongoing ...

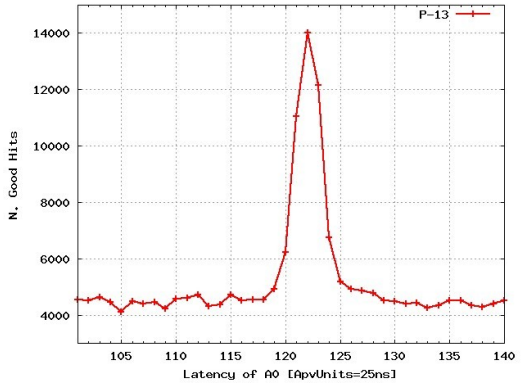


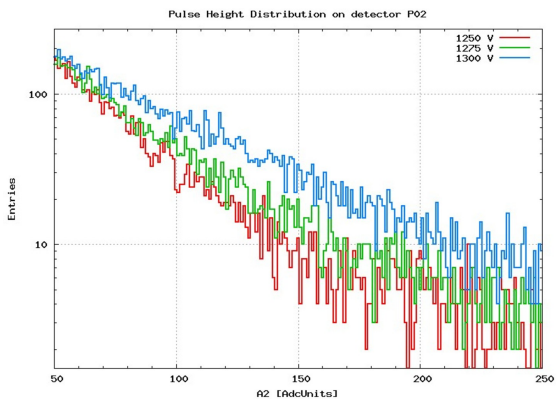


Summary

- **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 ...

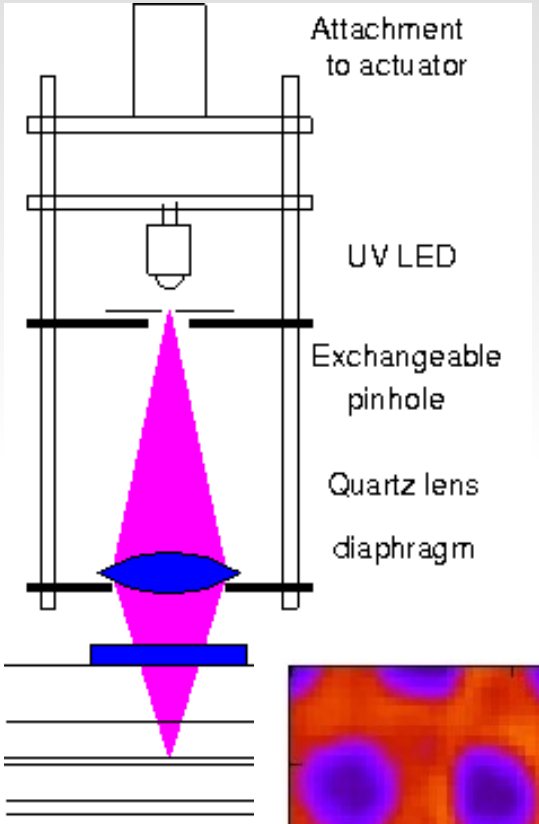




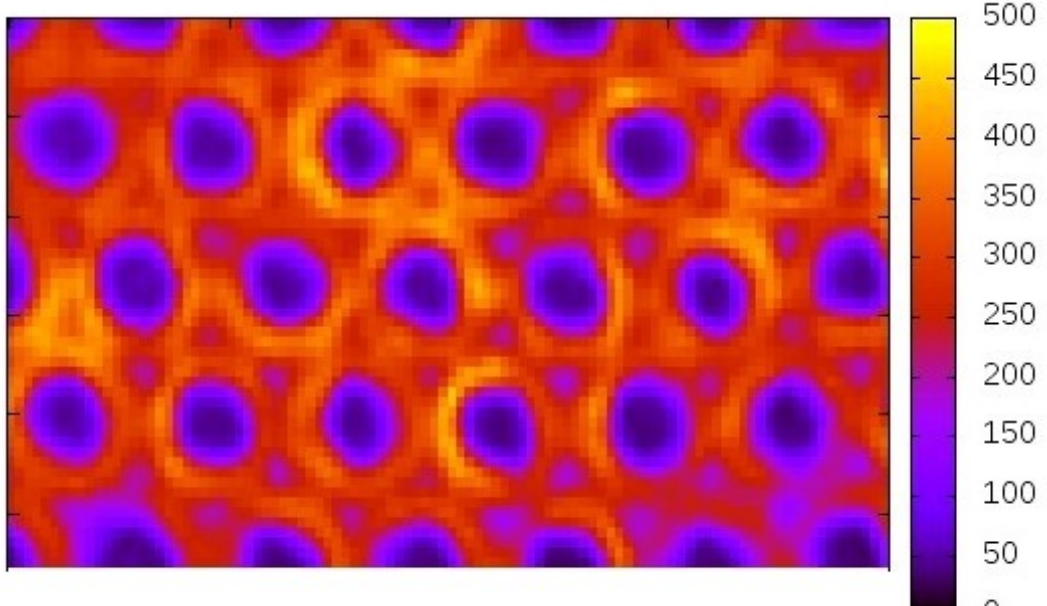


Backup Slides

The "Leopard"

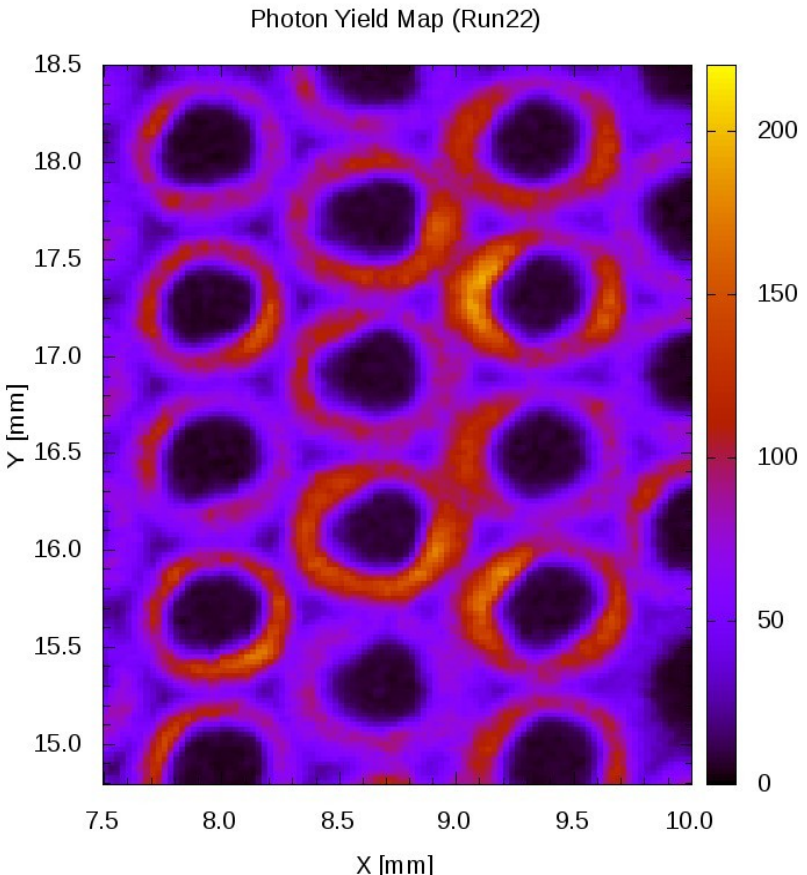


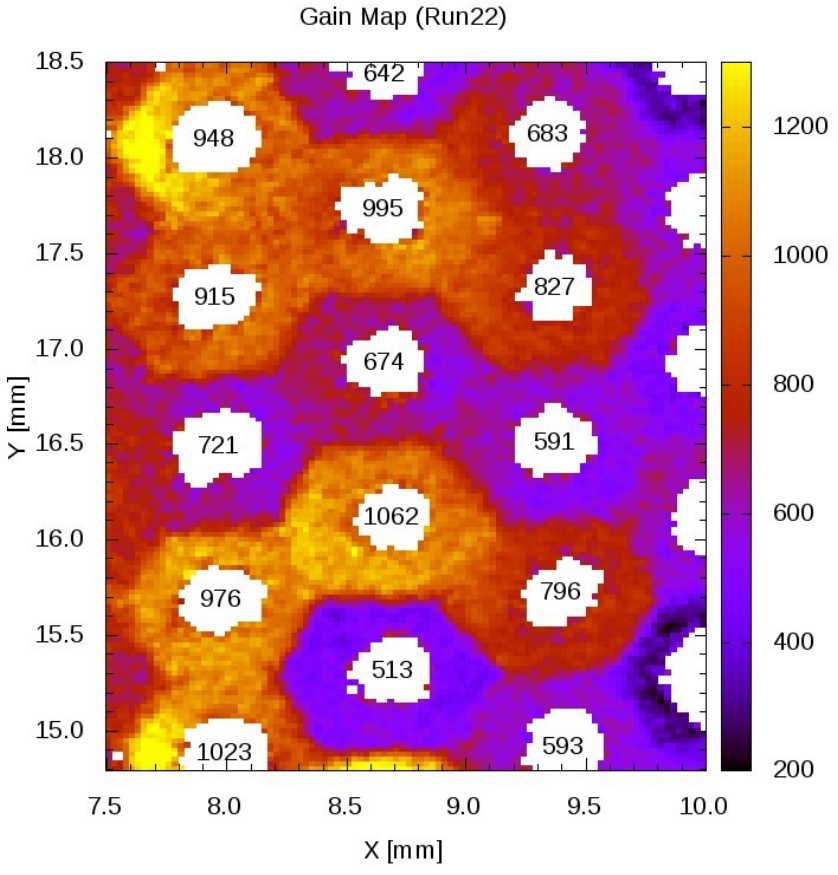
- Pulsed UV light focused to 70 μm spot onto the top of the ThickGEM
- Optical setup mounted onto a contolled 3D actuator system
- Fast DAQ...
- Single PE spectra at each point
  -> Photo-efficiency, and gain



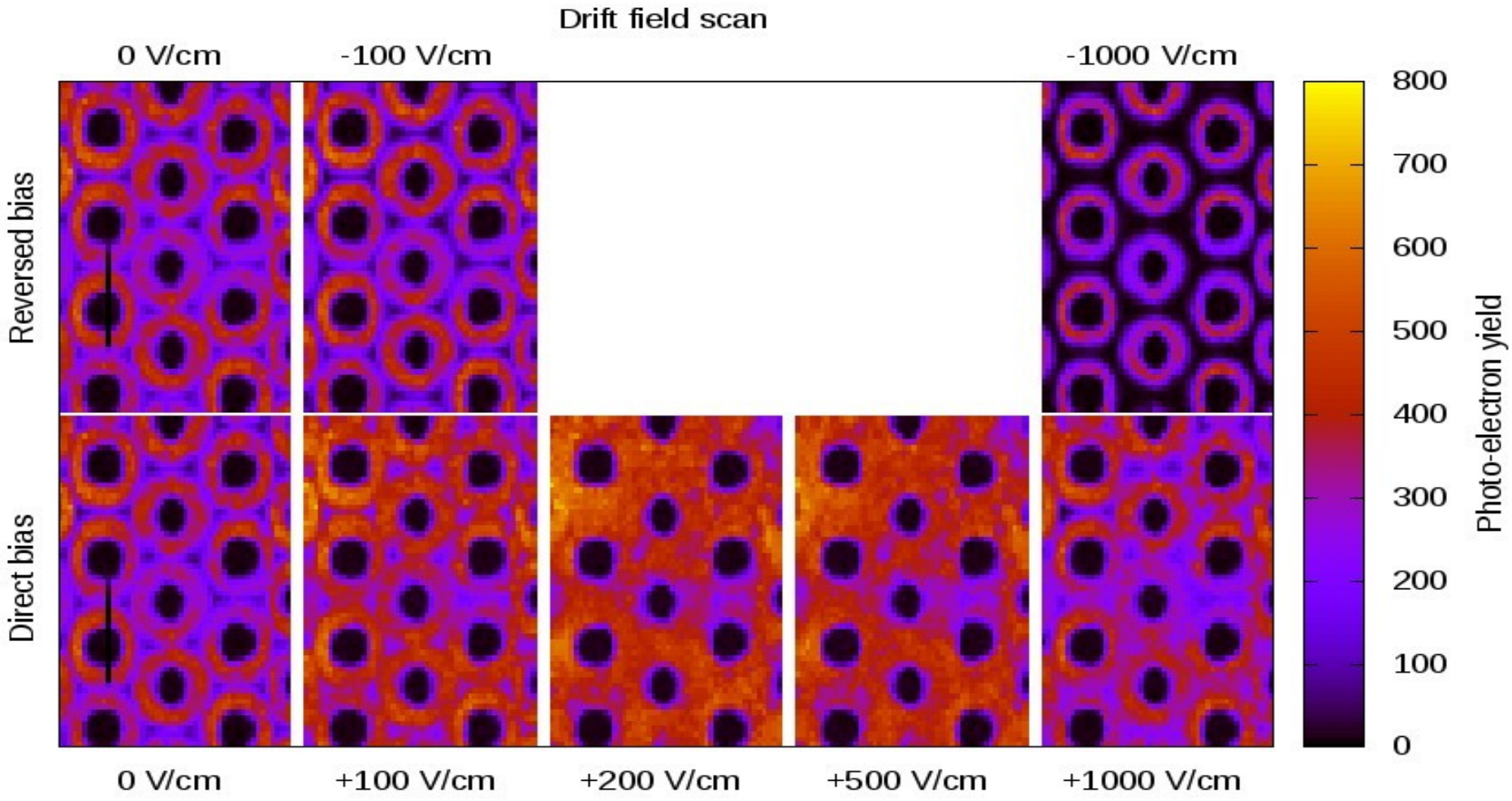
Maps of Yield and Gain

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



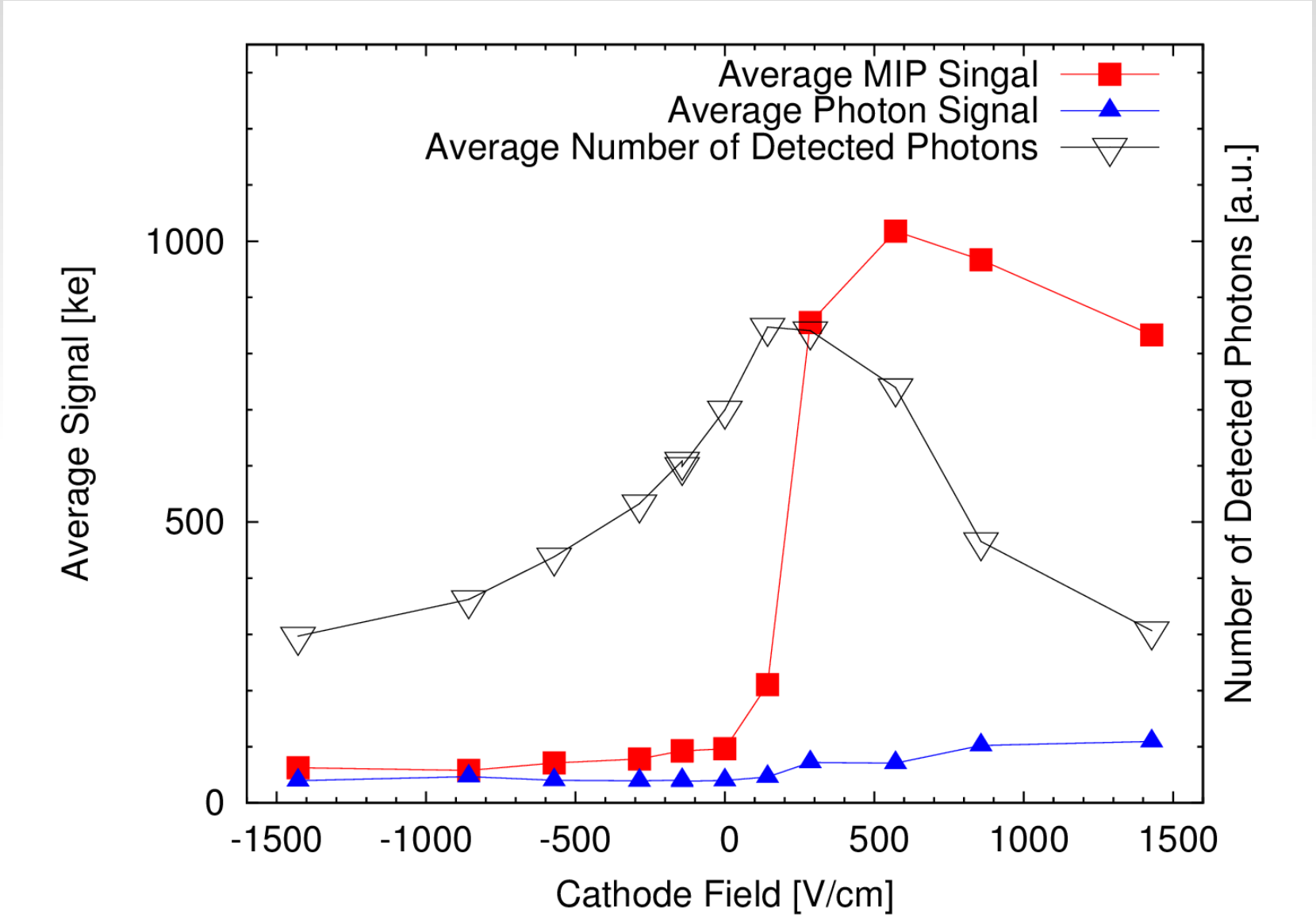


The Role of the Drift Field



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

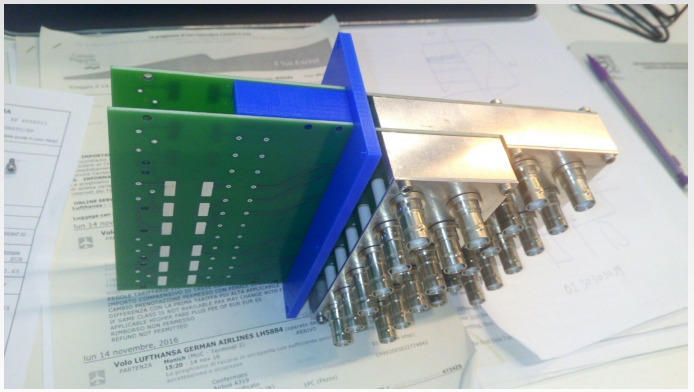
MIP Suppression



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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