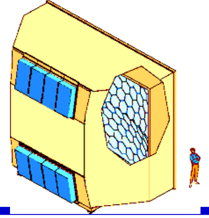
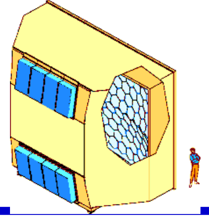


The high voltage system for the novel MPGD-based photon detectors of COMPASS RICH-1

S. Dalla Torre

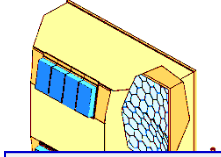
on behalf of the Trieste COMPASS group



OUTLINE

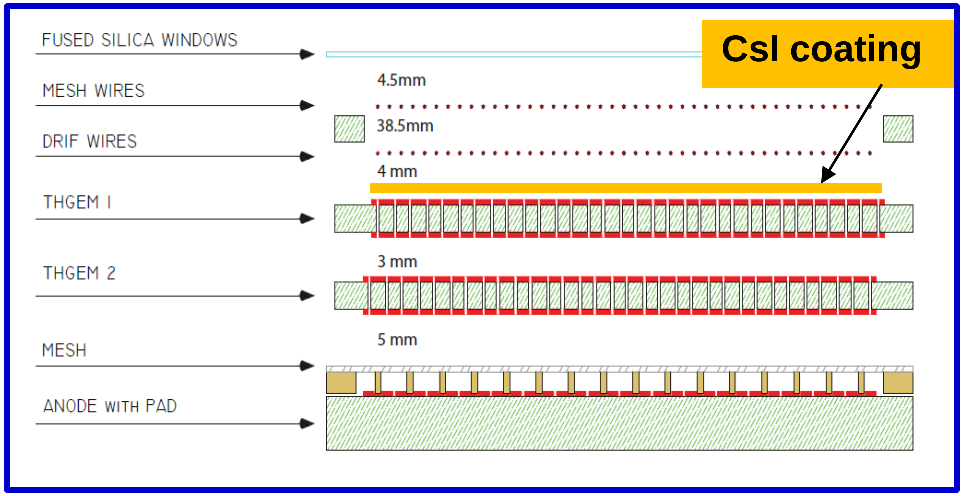
The HV system for MPGD photon detectors of COMPASS RICH-1

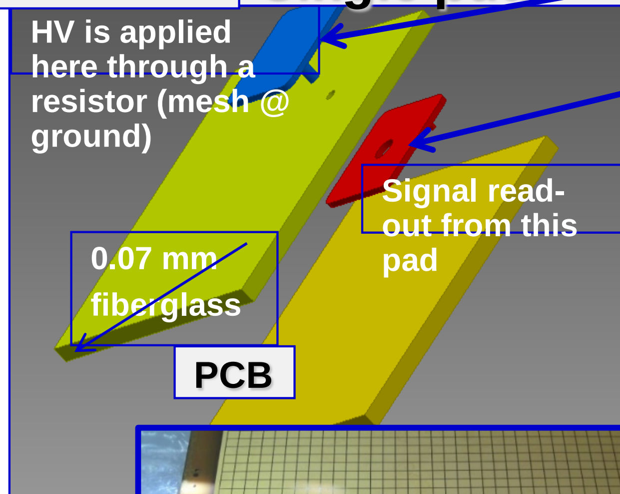
- ***The HV requirements for the novel COMPASS RICH photon detectors***
- ***The HV system and its control***
- ***HV performance of the hybrid MPGDs for COMPASS RICH-1***
- ***Future perspectives in Trieste for MPGD-dedicated HV systems***
- ***Summarizing***

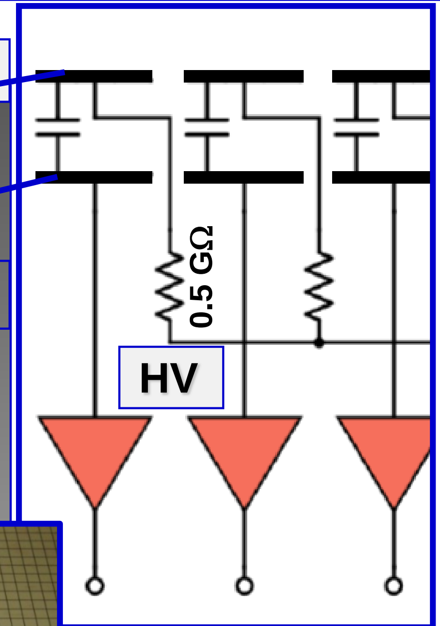


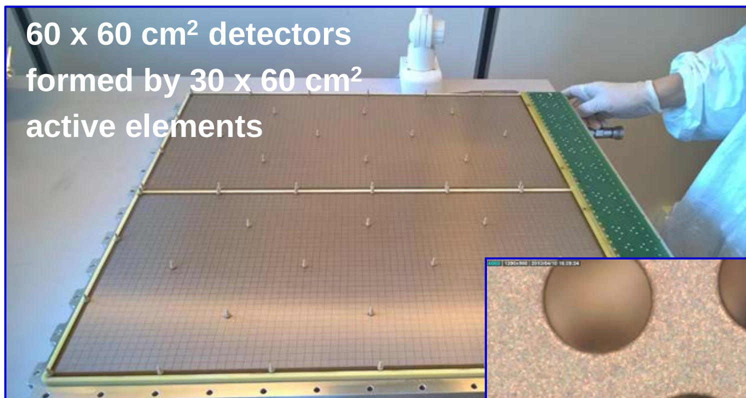
THE CONTEXT

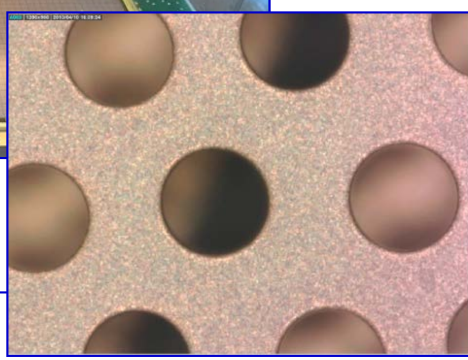
The novel photon detectors for the upgrade of the sensor system of COMPASS RICH-1

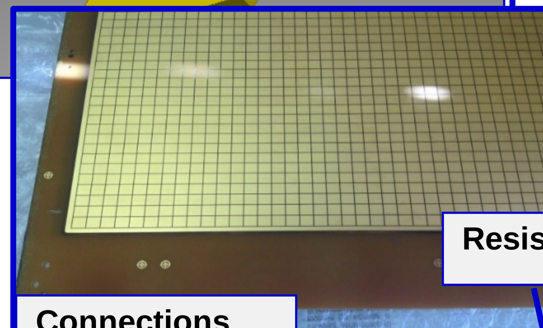


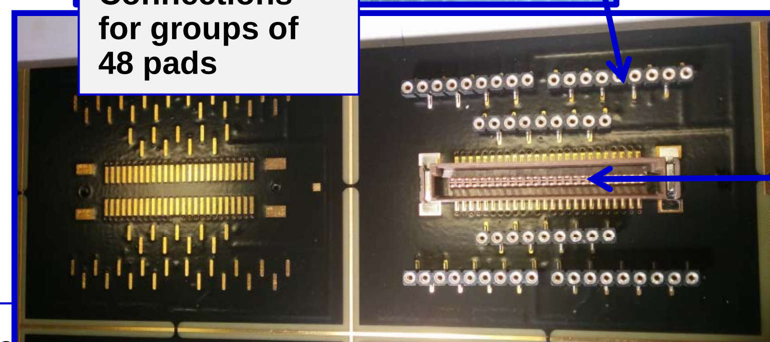




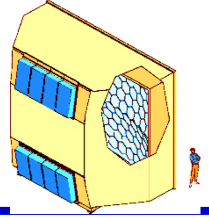






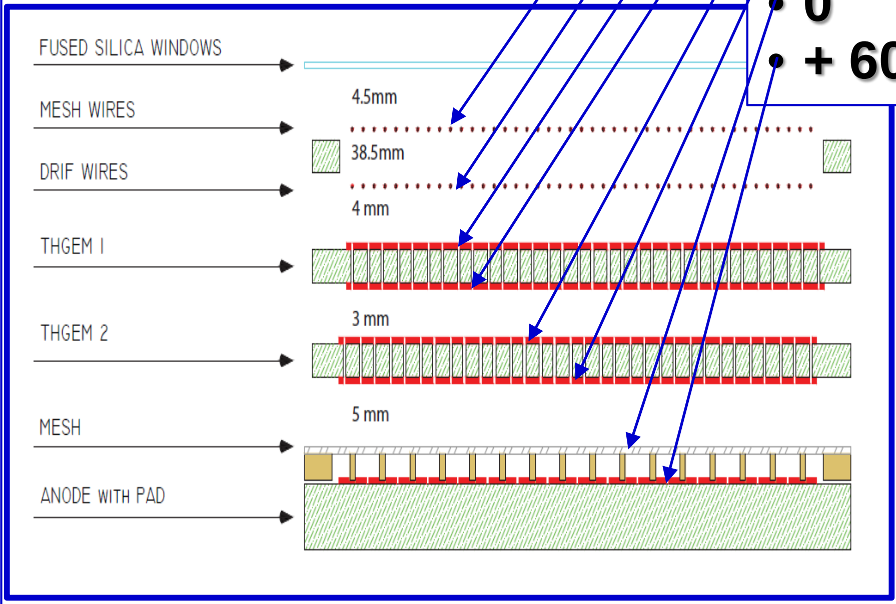


THE DETECTOR HV REQUIREMENTS

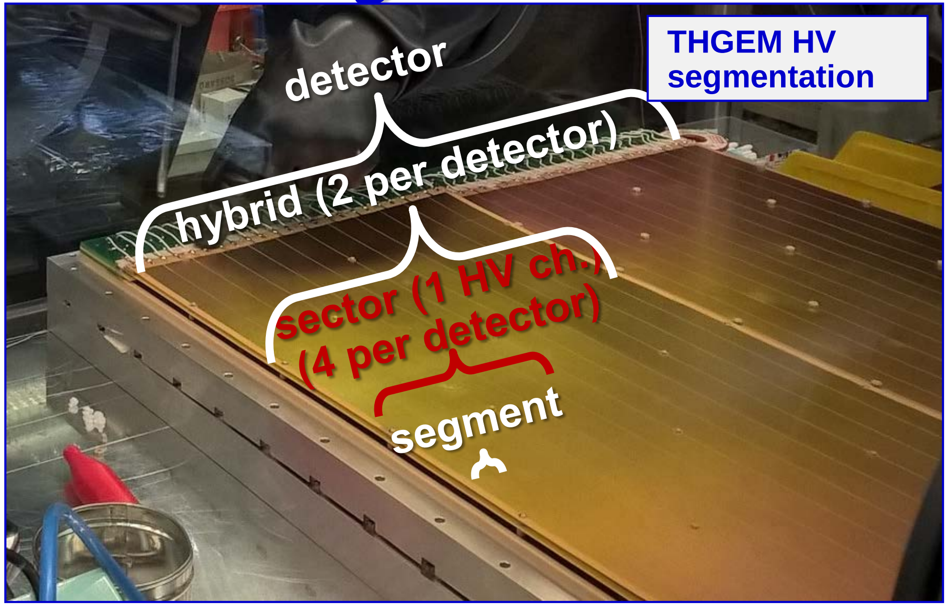


Typical HV values

- - 300 V
- -3400 V
- -3200 V
- -2000 V
- -1700 V
- - 500 V
- 0
- + 600 V

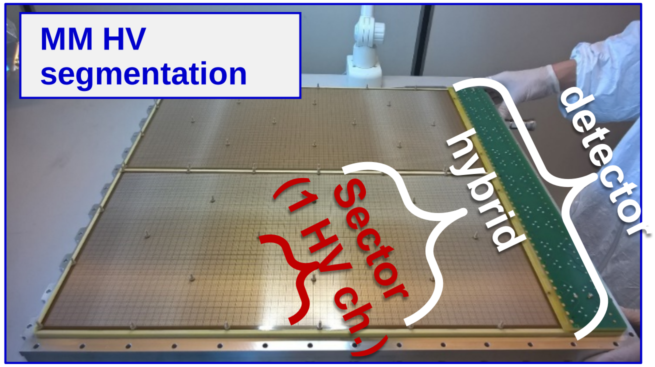


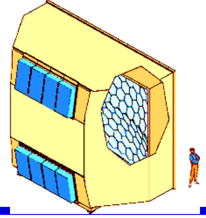
HV segmentation



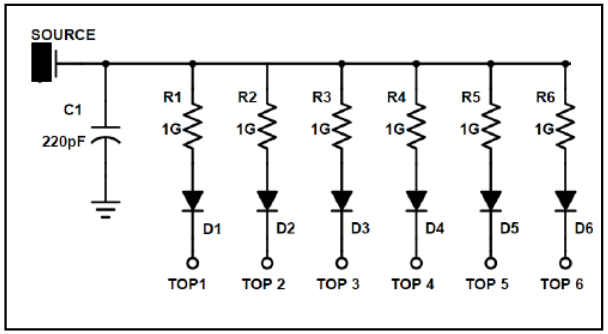
So far:

22 HV ch.s per detector, 4 detectors



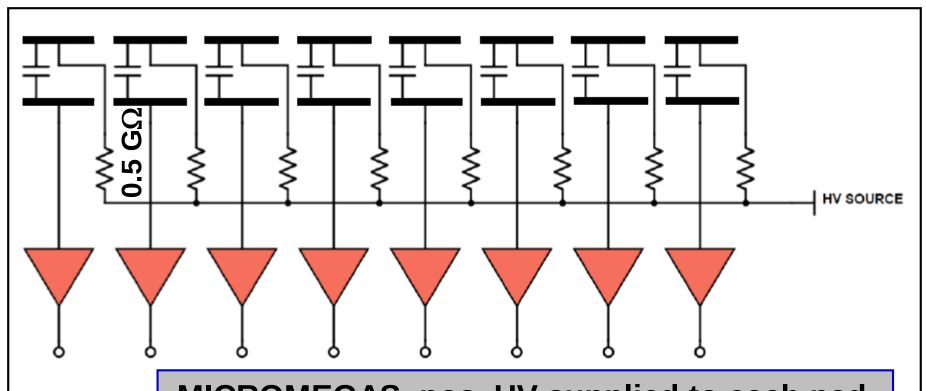


HV distribution to the electrodes involved in multiplication

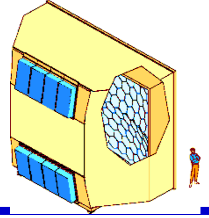


THGEM, top face (bottom is analogous)

- **HV supply to drift and field wires: standard**
- **THGEM faces are separately supply**
- **MICROMEGAS require positive HV**



MICROMEGAS, pos. HV supplied to each pad



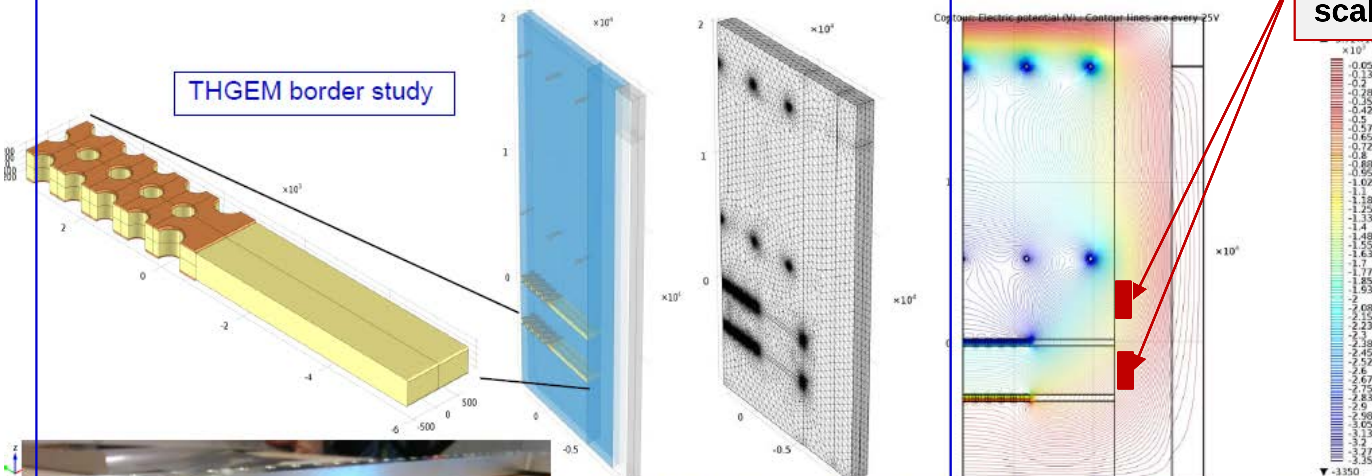
THE DETECTOR HV REQUIREMENTS

More electrodes needed to shape the electric field at the detector edges

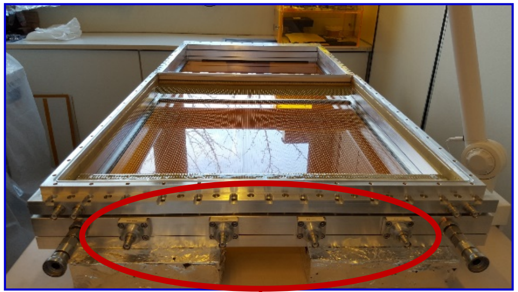
Field shaping electrodes :

The applied voltage must properly scale with the THGEM voltage !

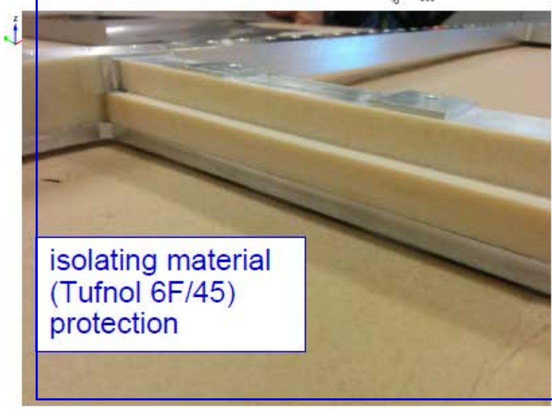
THGEM border study



large field values at the chamber edges and on the guard wires

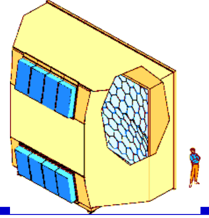


HV supply to the field shaping electrodes



isolating material (Tufnol 6F/45) protection

Field shaping electrodes in the isolating material protections of the chamber frames

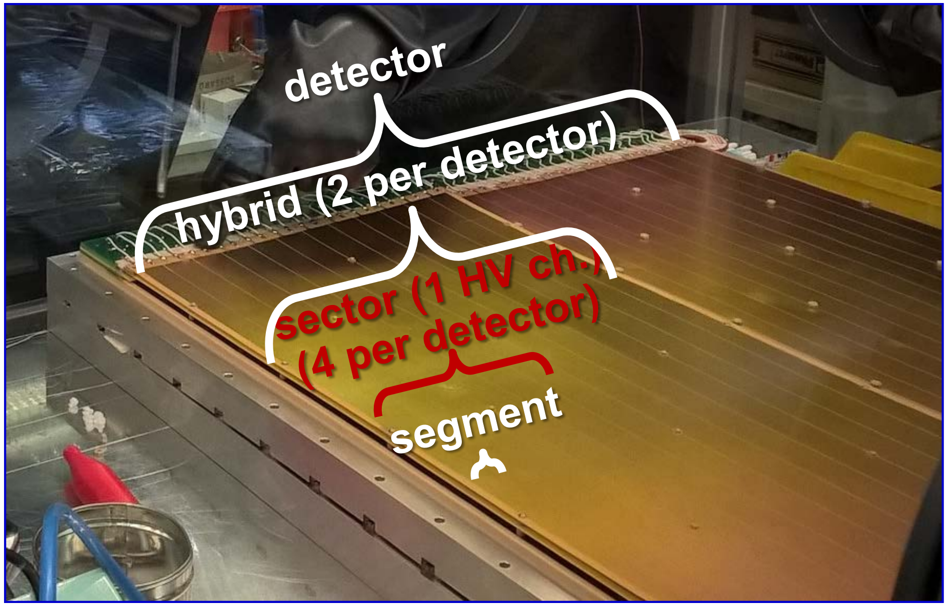


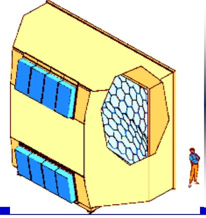
Taking into account the feeble sectors

- **THGEM HV distribution**
  - **1 chamber: 2 hybrids (detectors)**
  - **1 hybrid: 2 sectors**

    → 1 sector is 25% of a detector, i.e. 6 % of the total instrumented surface
  - **1 sector: 6 segments**

    → 1 segment is 4% of a detector, i.e. 1 % of the total instrumented surface





Taking into account the feeble sectors

- **First exercise to identify the feeble channels**
  - **only the THGEM1 (2) sectors on at high HV, with THGEM2(1) at lower HV**

- After run test
  high HV on one THGEM, low on the other
- N.Spark in 2 hours (in CH4) at 1300V

	PD1	PD2	PD5	PD6
T1	0,0, 13,0;	7,4, 1,1;	0,0, 0,0;	0,0, 2,0;
T2	0,3, 5,48;	77,86, 0,8;	19,43, 11,0;	6,3, 3,3;

- N.Sparks in app.10 min (in ArCO2) at 1175V

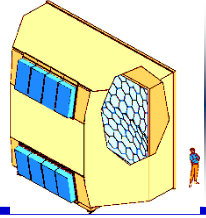
	PD1	PD2	PD5	PD6
T1	0,0, 0,*;	0,0, 0,0;	3,6, 2,1;	1,1, 1,1;
T2	0,51, 3,*;	*,*, 0,4;	24,18, 34,2;	0,1, 0,3;

bottom chambers (PD1, PD2) **top chambers** (PD5, PD6)

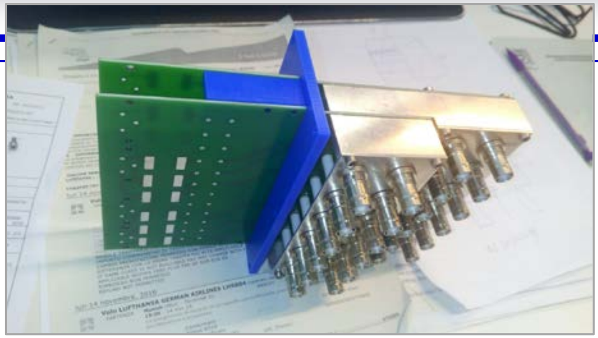
* could not reach voltage

3

→ **THGEM1's (CsI coated) are performing better !**



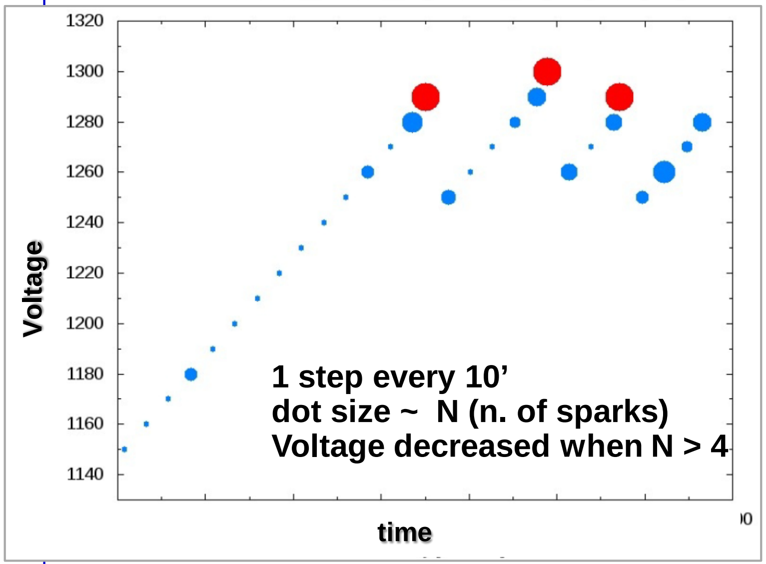
Taking into account the feeble sectors



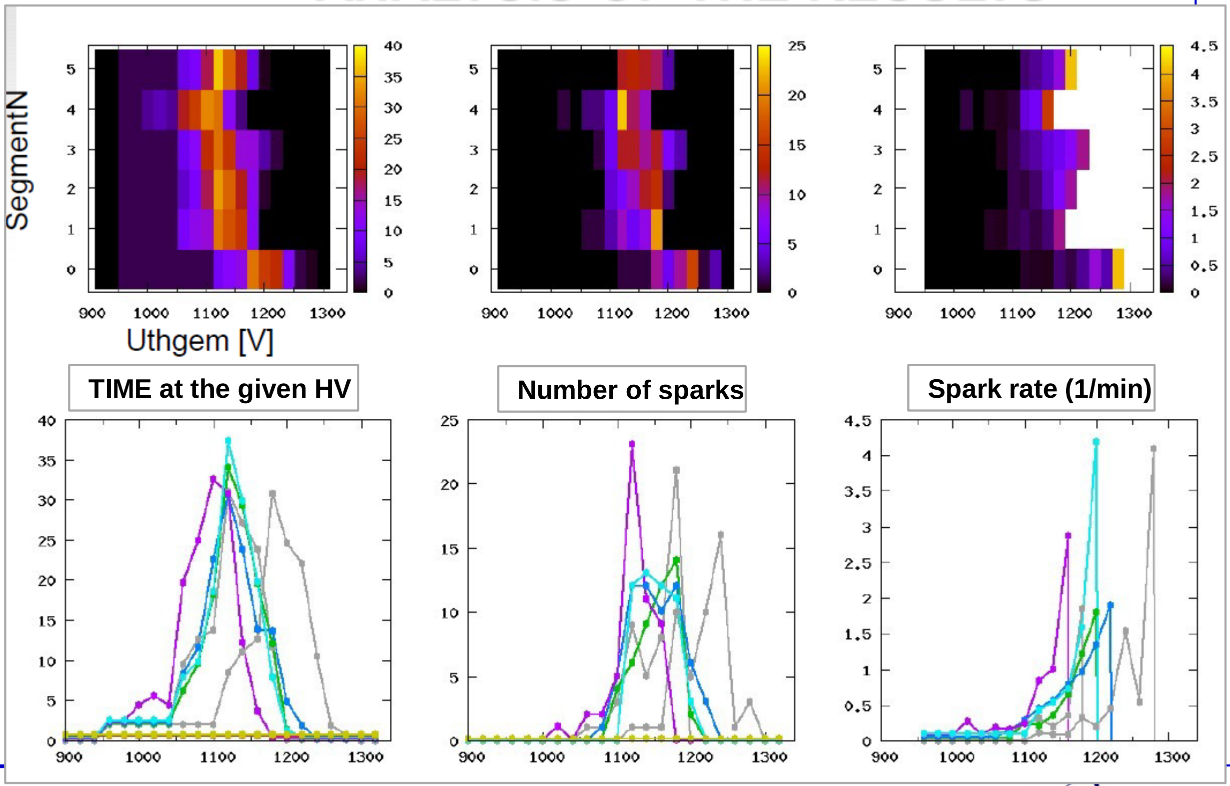
Studying segment by segment

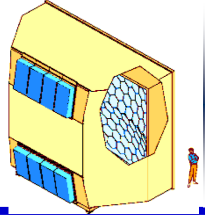
- 2 dedicated voltage distribution boxes built
  - 6 segments per box, independent HV supply
- Dedicated software control tool

THE TEST LOGICS

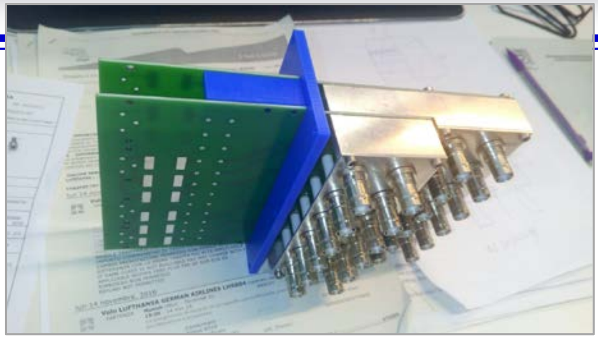


ANALYSIS OF THE RESULTS



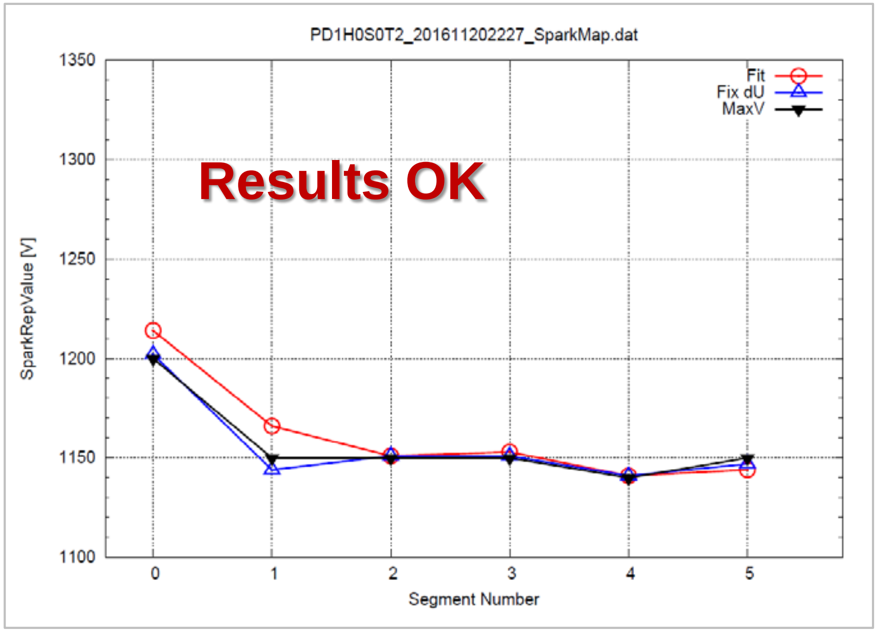


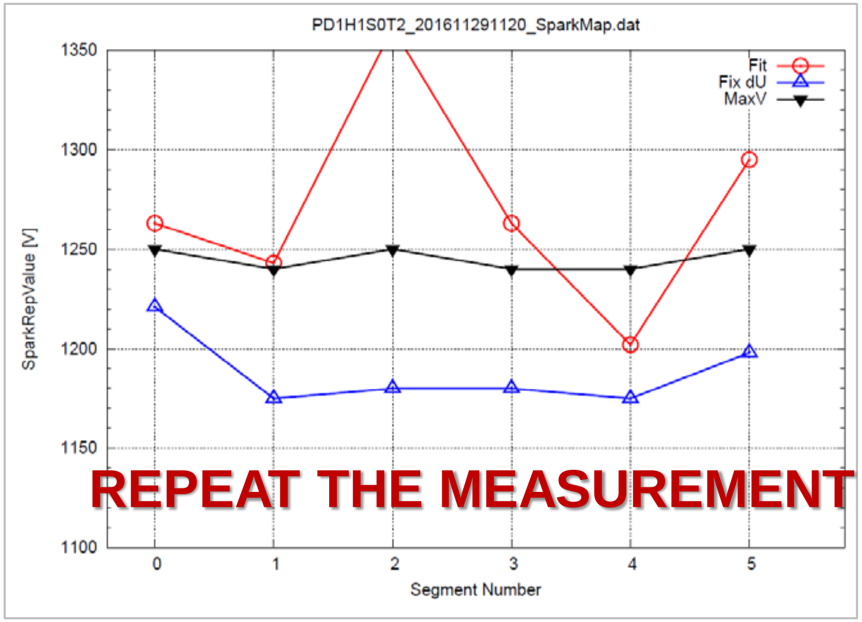
Taking into account the feeble sectors

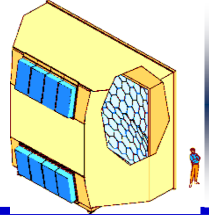


Parametrizing the test results via a single figure

- Extract it from the spark rate vs voltage
  - 3 algorithm used
    - When they give the same indication (LARGE MAJORITY OF CASES), use it
    - When they are at variance, repeat the measurement







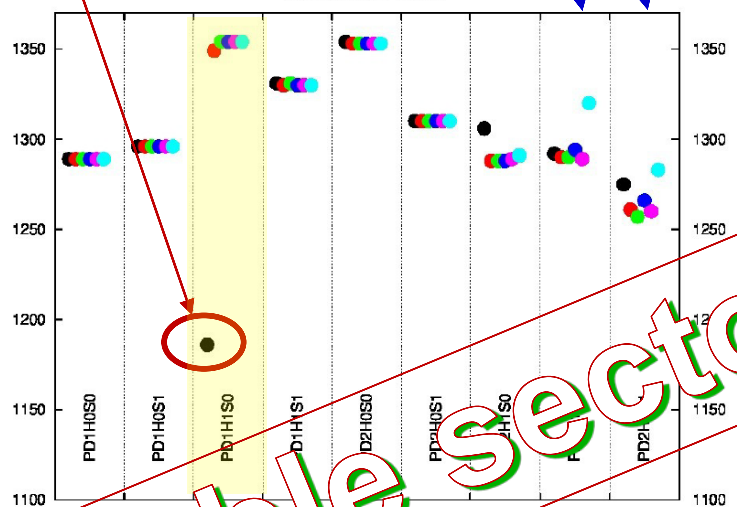
Taking into account the feeble sectors

Identified feeble sectors have separate HV supply channel providing scaled HV

Repeated measurements

Bad segment that matches with what observed during the 2016 run

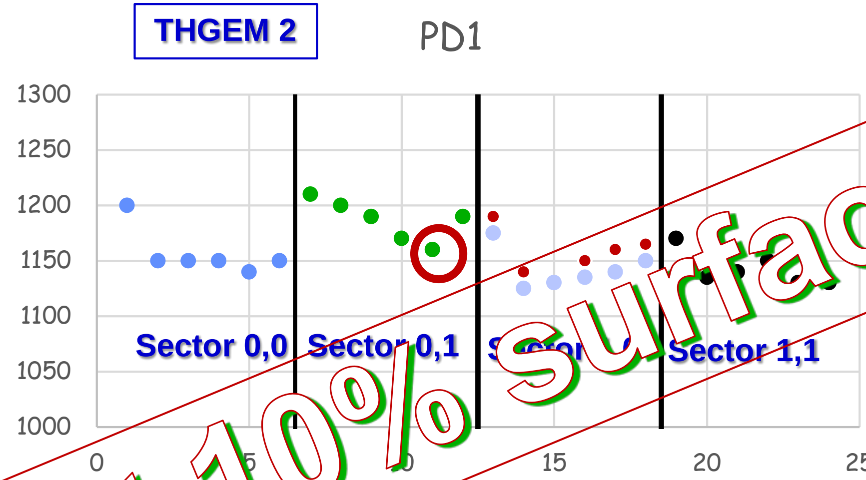
THGEM 1

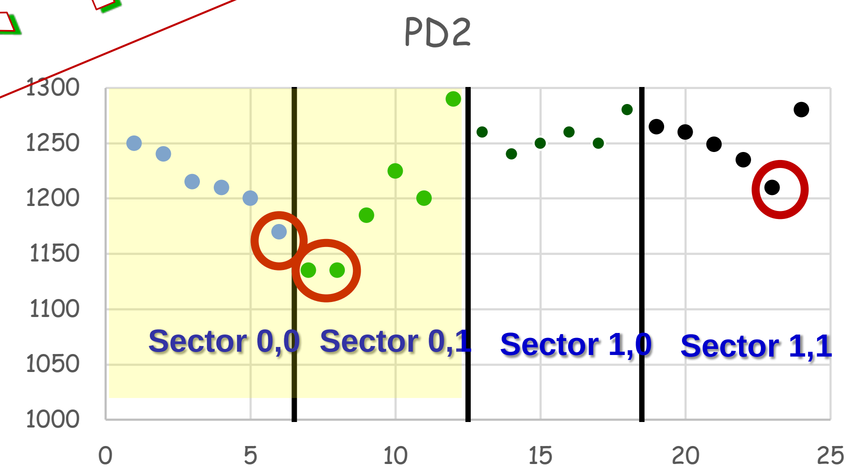


Chamber PD1

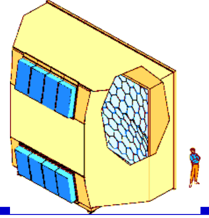
Chamber PD2

THGEM 2





Feeble sectors< 10% surface



OUTLINE

The HV system for MPGD photon detectors of COMPASS RICH-1

- *The HV requirements for the novel COMPASS RICH photon detectors*
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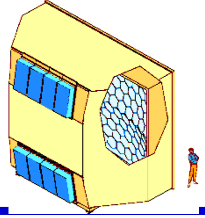
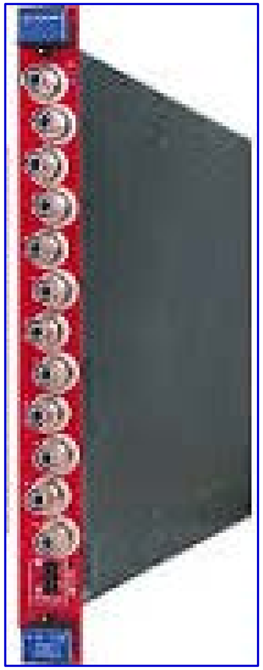


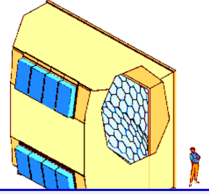
THE (commercial) HARDWARE

CAEN SY 4527 system

- THGEMs:
- CAEN A1561HDN, -6kV, SHV, 12 channels, 50 pA current monitor resolution
  - Fully satisfactory



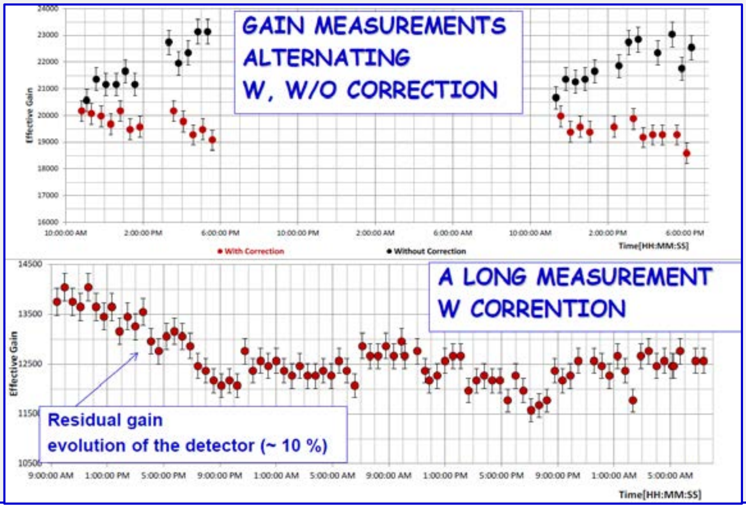
- MMs:
- CAEN A7030DP, +3kV, SHV, 12 channels, 2 nA current monitor resolution
  - Not enough current resolution, unstable current off-set



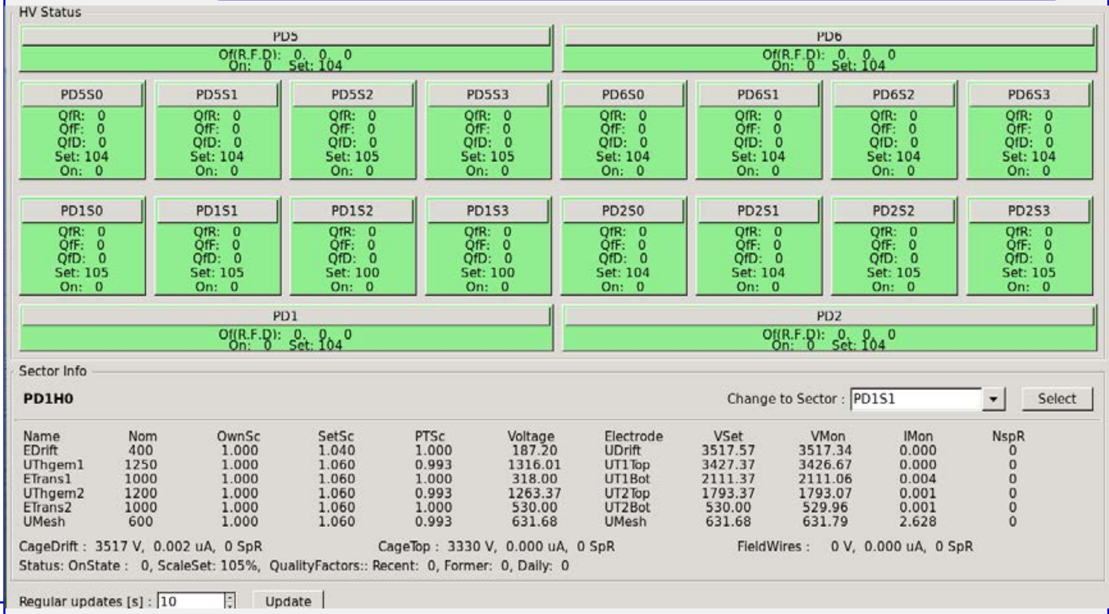
HV control

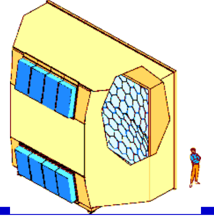
In total 136 HV channels with correlated values

- **Gain stability vs P, T:**
  - G = G(V, T/P)
  - Enhenced in a multistage detector
  - $\Delta T = 1^oC$ → $\Delta G \approx 12$ %
  - $\Delta P = 5$ mbar → $\Delta G \approx 18$ %
- **THE WAY OUT:**
  - Compensate T/P variations by V
    → Gain stability at 10% level



- **HV control**
  - Custom-made (C++, wxWidgets)
  - Compliant with COMPASS DCS (slow control)
  - "OwnScale" to fine-tune for gain uniformity
  - V, I measured and logged at 1 Hz
  - Autodecrease HV if needed (too high spark-rate)
  - User interaction via GUI
  - Correction wrt P/T to preserve gain stability





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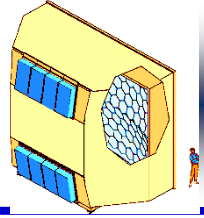
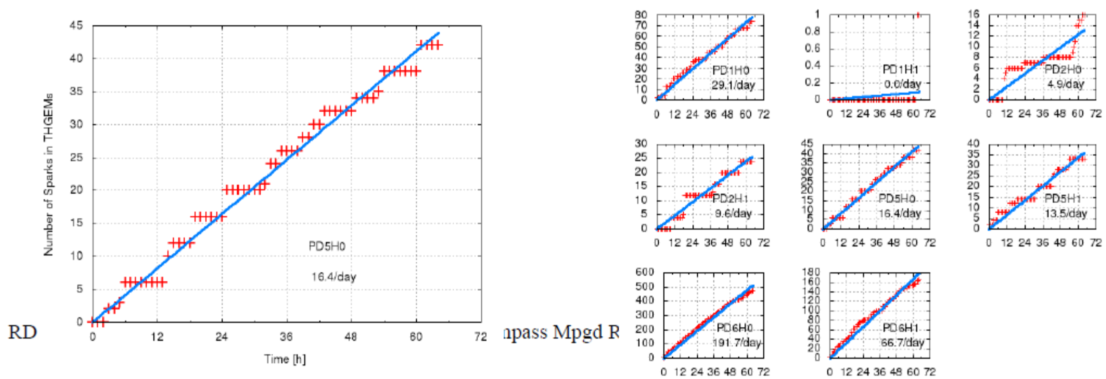
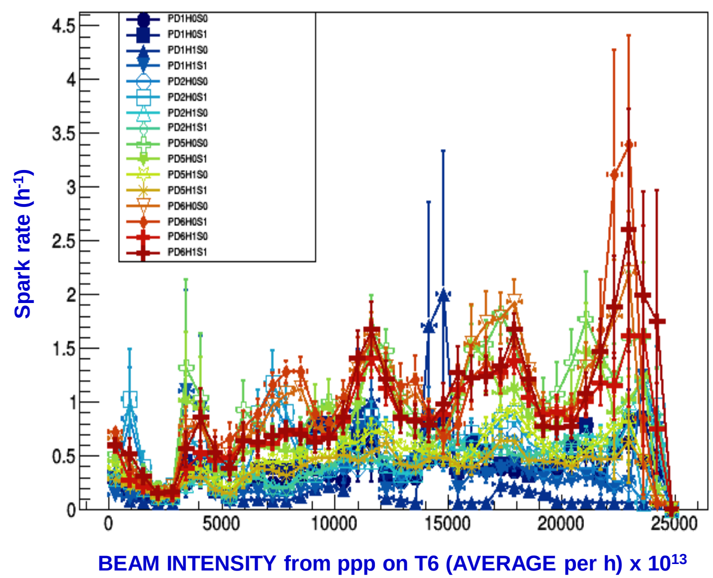


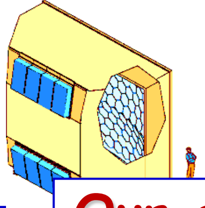
HYBRID DETECTORS: about THGEMs

- **Lessons about THGEMs**
  - Full correlation of discharges THGEM1 & THGEM2
  - Recovery time <10 s
  - Discharge rates: ~ no dependence on beam intensity and even beam on-off

- Several correlated sparks on neighbouring sectors/chambers have been seen
  → most probably induced by cosmic showers
- Spark uniformity has been seen (quantized in charge and duration, mostly single)



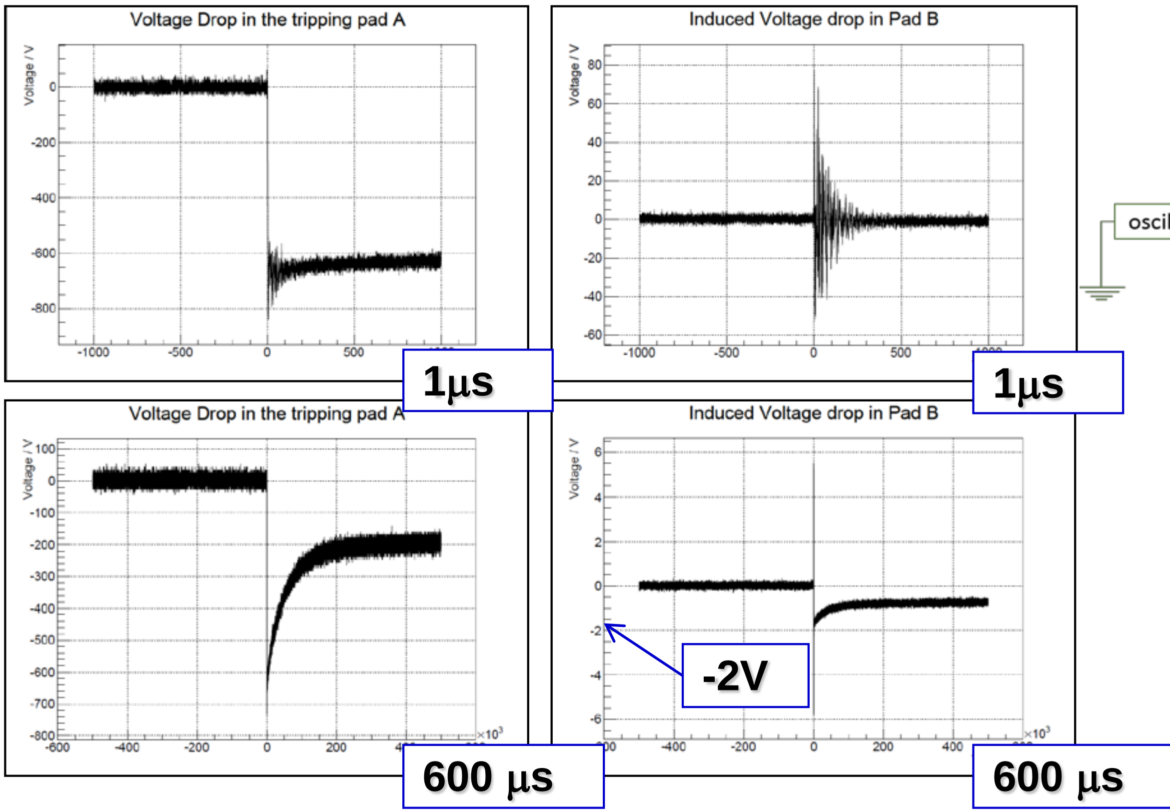


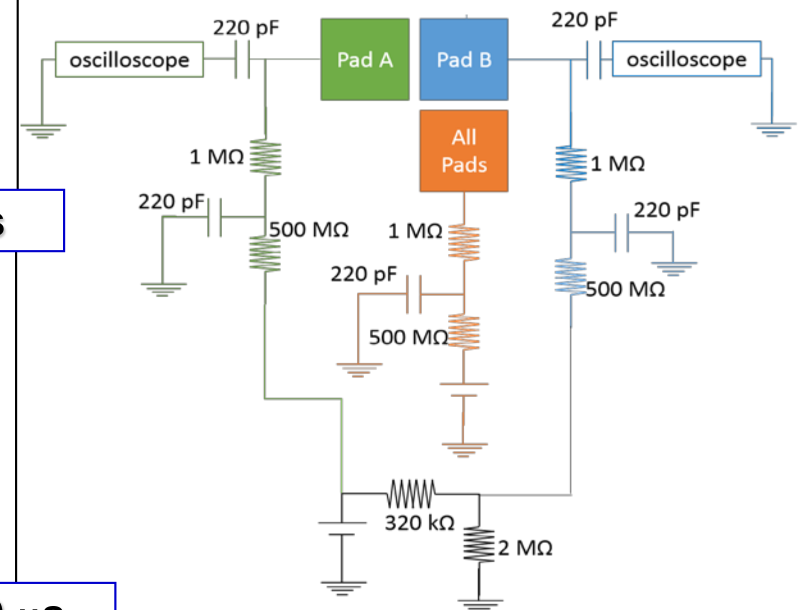


HYBRID DETECTORS: about MMs

Our approach to resistive MMs and spark control

Pads A & B (the two adjacent pads being studied) are powered <u>by the same PS</u>





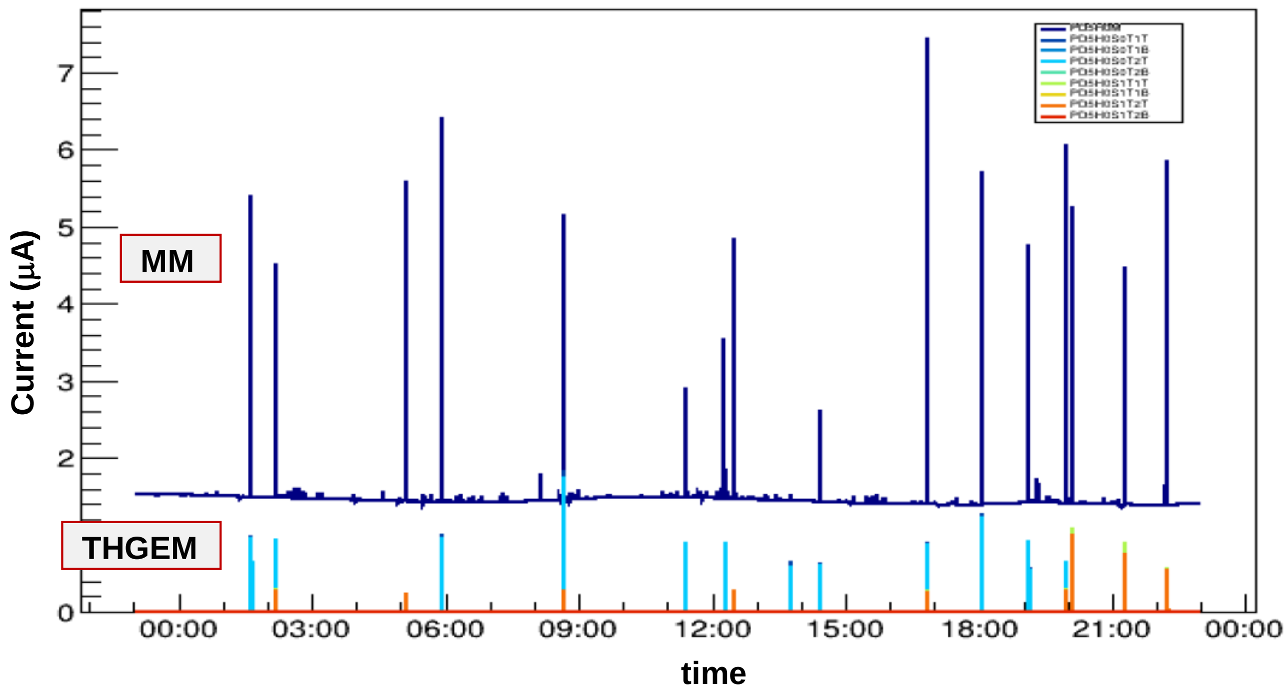
The HV of the non tripping pad is very limited affected:

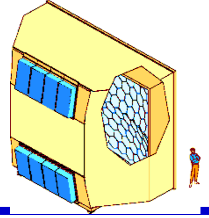
2V drop → ~4% drop in G

<u>R ~ 0.5 GΩ is preserving the non-tripping pads efficient all the time !</u>

HYBRID DETECTORS: about MMs

- **Lessons about MMs**
  - *A part 1 MM, full correlation between THGEM and MM sparks*
  - Recovery time ~1s





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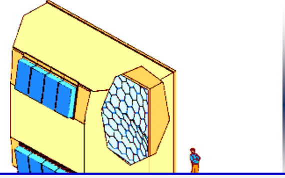


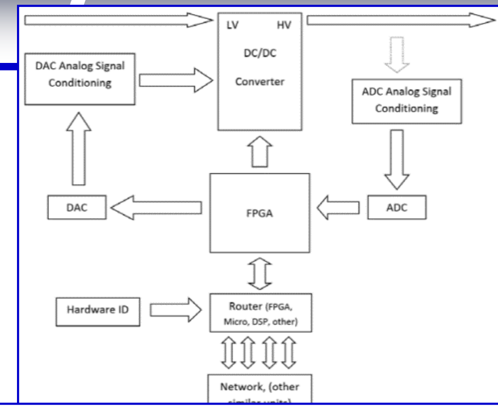
MPGD-dedicated HV system

Main goal: match the HV PS MPGD-requirements not commercially available

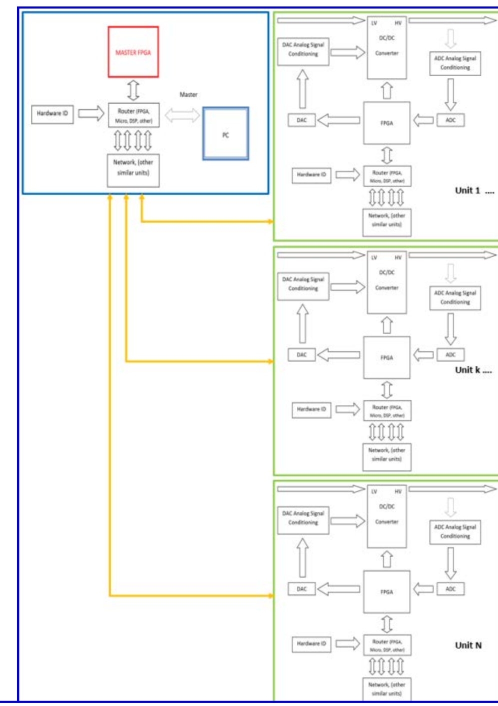
- true real-time monitoring of the main parameters (voltage, current)
- the fast control of the HV channels
- the use of local intelligence for the application of feedback protocols when pre-breakdown conditions are detected
- HV generated at the detector level: HV cabling, connectors, space constrains, **cost, accumulated charge** issues
- Modularity of the system: large size projects employing MPGDs may use a large number of channels (M/S architecture)
- **Compactness**

Goal parameters:

- **Time stamp resolution for current and voltage monitoring in the order of 10 ns or better**
- **High resolution voltage monitoring better than 0.5 Volt on several kVolt scale at sampling rate > 100 kHz**
- **Precise current monitoring at the level of 10 pA at sampling rate > 100 kHz**



Block diagram of the single HV module.



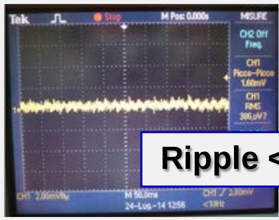
Block diagram of the architecture of the HV system

MPGD-dedicated HV system, R&S status

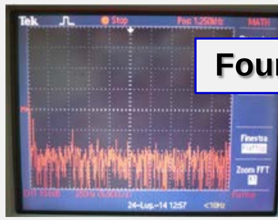
Activity grouped in 3 items completed/ongoing

1. Selection of the DC to DC converter (Commercial device)

by ripple measurements and response linearity



Ripple < 2 mV pp



Fourier transf.

ISEG
BP040105n12
PCB-HV-module of 4W BPS series
(now available also up to 6 kV)
V_{out} = 0 to -4 kV
Ripple & noise < 40 mVpp at full load

2. ADC Board FMC standard adopted, the custom-made Pico ammeter (Custom made, see poster)

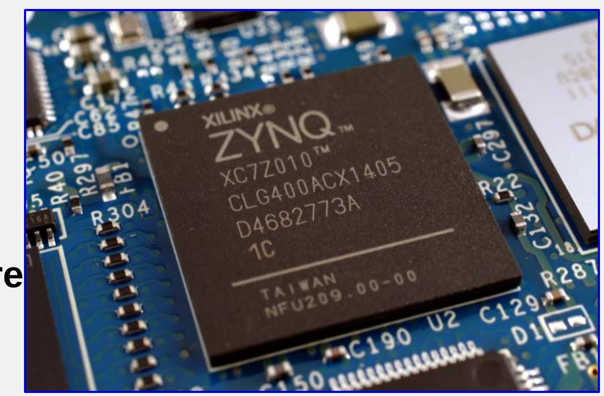
- **ADC selected:** 8-Bit 500 MSPS A/D Converter ADC08500
- **ADC board: custom design, built and successfully tested**
  - ADC self-calibration, multiple ADC synchronization capability
  - <u>Low-Pin-Count FMC connector</u>

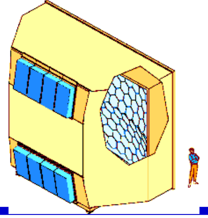
3. Carrier (Commercial)

Zed Board based on hybrid Xilinx Zynq
commercial carrier including high throughput <u>low-pin-count FMC</u>

Fully Programmable System-on-Chip (SoC) device combining a 'hard' dual core ARM processor (Cortex-A9) with an FPGA fabric (FPGA Artix-7 or Kintex-7)

<u>Programming on going, ADC already read at 500 MSPS</u>

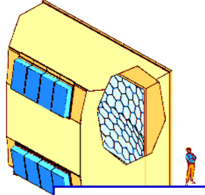




OUTLINE

The HV system for MPGD photon detectors of COMPASS RICH-1

- ***The HV requirements for the novel COMPASS RICH photon detectors***
- ***The HV system and its control***
- ***HV performance of the hybrid MPGDs for COMPASS RICH-1***
- ***Future perspectives in Trieste for MPGD-dedicated HV systems***
- *Summarizing*



SUMMARIZING

- **In spite of the complexity of hybrid MPGDs:**
  - The implemented HV system with sophisticated control allows for
    - Safety operation
    - Collection of information for understanding and monitoring the detector behavior
  - The electrical stability of the hybrid detectors is satisfactory at gains >/= 20 k
    - Not trivial: so far all MPGDs are operated in exp.s with gains < 10 k
- **A MPGD-dedicated HV system is under development in Trieste**
  - Main Features:
    - Generation of the HV at the detector
    - Real-time V, I information and handling
  - Goals:
    - Support to R&D activity
    - Tool for experiments (debugging, monitor, local feedback protocols)