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

HV is applied here through a resistor (mesh @ ground)

0.07 mm fiberglass

PCB

Resistor arrays

Connections for groups of 48 pads

Signals

60 x 60 cm² detectors formed by 30 x 60 cm² active elements
THE DETECTOR HV REQUIREMENTS

- Typical HV values
  - -300 V
  - -3400 V
  - -3200 V
  - -2000 V
  - -1700 V
  - -500 V
  - 0
  - +600 V

- HV segmentation
  - THGEM HV segmentation
  - MM HV segmentation

So far:
22 HV ch.s per detector, 4 detectors
HV distribution to the electrodes involved in multiplication

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

THGEM, top face (bottom is analogous)

MICROMEGAS, pos. HV supplied to each pad
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
- Field shaping electrodes in the isolating material protections of the chamber frames
- HV supply to the field shaping electrodes

Isolating material (Tufnol 6F/45) protection
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

<table>
<thead>
<tr>
<th></th>
<th>PD1</th>
<th>PD2</th>
<th>PD5</th>
<th>PD6</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>0,0, 13,0;</td>
<td>7,4, 1,1;</td>
<td>0,0, 0,0;</td>
<td>0,0, 2,0;</td>
</tr>
<tr>
<td>T2</td>
<td>0,3, 5,48;</td>
<td>77,86, 0,8</td>
<td>19,43, 11,0;</td>
<td>6,3, 3,3;</td>
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- N.Spark in app.10 min (in ArCO2) at 1175V

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<tr>
<td>T1</td>
<td>0,0, 0,*;</td>
<td>0,0, 0,0;</td>
<td>3,6, 2,1;</td>
<td>1,1, 1,1;</td>
</tr>
<tr>
<td>T2</td>
<td>0,51, 3,*;</td>
<td>* *, 0,4;</td>
<td>24,18, 34,2;</td>
<td>0,1, 0,3;</td>
</tr>
</tbody>
</table>

* could not reach voltage

→ 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**

- 1 step every 10’
  - dot size ~ N (n. of sparks)
  - Voltage decreased when N > 4

**ANALYSIS OF THE RESULTS**

- TIME at the given HV
- Number of sparks
- Spark rate (1/min)
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

Results OK

REPEAT THE MEASUREMENT
Identified feeble sectors have separate HV supply channel providing scaled HV.

Taking into account the feeble sectors.

Bad segment that matches with what observed during the 2016 run.

Repeated measurements.

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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
Gain stability vs P, T:
- \( G = G(V, T/P) \)
- Enhanced in a multistage detector
- \( \Delta T = 1^\circ C \rightarrow \Delta G \approx 12\% \)
- \( \Delta P = 5\text{ mbar} \rightarrow \Delta G \approx 18\% \)

THE WAY OUT:
- Compensate T/P variations by V
  \( \rightarrow \) Gain stability at 10% level

In total 136 HV channels with correlated values

- 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

HV control

GAIN MEASUREMENTS
ALTERNATING
W, W/O CORRECTION

A LONG MEASUREMENT
W CORRECTION

Residual gain evolution of the detector (~ 10%)
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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)

**BEAM INTENSITY from ppp on T6 (AVERAGE per h) x 10^{13}**

**Spark rate (h^{-1})**

Philadelphia, MPGD2017

HV for MPGD photon detectors.

Silvia DALLA TORRE
Our approach to resistive MMs and spark control

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

The HV of the non tripping pad is very limited affected:
2V drop → ~4% drop in G

R ~ 0.5 GΩ is preserving the non-tripping pads efficient all the time!
HYBRID DETECTORS: about MMs

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

[Graph showing current (µA) over time, with labels MM and THGEM]
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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
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.

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
     - Low-Pin-Count FMC connector

3. **Carrier (Commercial)**
   - Zed Board based on hybrid Xilinx Zynq commercial carrier including high throughput low-pin-count FMC
   - 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)
   - Programming on going, ADC already read at 500 MSPS

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

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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 $\geq 20$ 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)