Study of the μ-RWELL detector technology for the CMS forward muon system upgrade

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The μ-RWELL technology

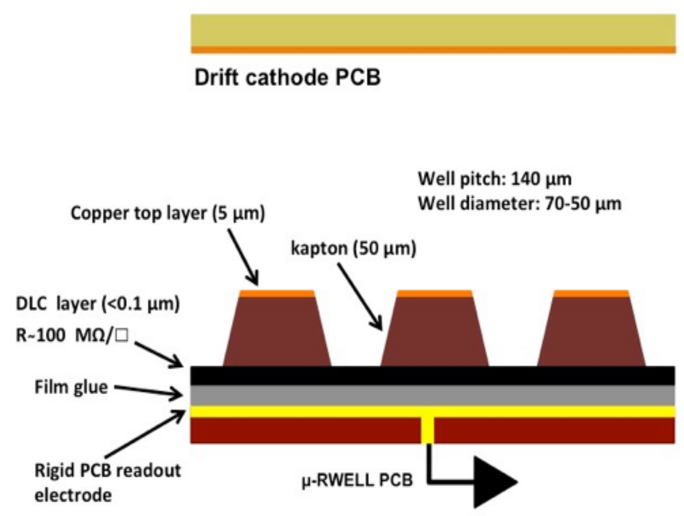
The micro-Resistive WELL (μ-RWELL) is a compact single amplification stage intrinsically spark protected Micro Pattern Gaseous Detector (MPGD)

The detector structure

The μ-RWELL detector is composed of only two elements: the **μ-RWELL PCB** and the **drift cathode**. They are separated by a drift gap of 4-7 mm.

The μ-RWELL PCB is the core of the detector and it is realized by coupling:

1. A **WELL patterned kapton foil** (50 μm) as single amplification stage: conical channels 70 μm (50 μm) top (bottom) in diameter and 140 μm pitch), created using a chemical etching process.
2. A **resistive layer** (R ~100 MΩ/□) for discharge suppression and current evacuation realized in the DLC (Diamond Like Carbon) technology (high mechanical and chemical resistant material).
3. A rigid **PCB readout** electrode.



The detector advantages

- High spatial and time resolutions
- High rate capabilities, spark safe
- Radiation hardness
- Single amplification stage
- Versatility:
  - ➡ Low-rate particle scheme (LR) about 100 kHz/cm^2 (CMS-Phase II upgrade, SHIP);
  - ➡ High-rate particle scheme (HR) > 1 MHz/cm^2 (LHCb Muon upgrade, FCC-ee/hh, CppC, CepC)
- Simple production and assembly procedure: mass producible by industry; no stretching of kapton foils
- Reduction of costs and time to realize large area detectors

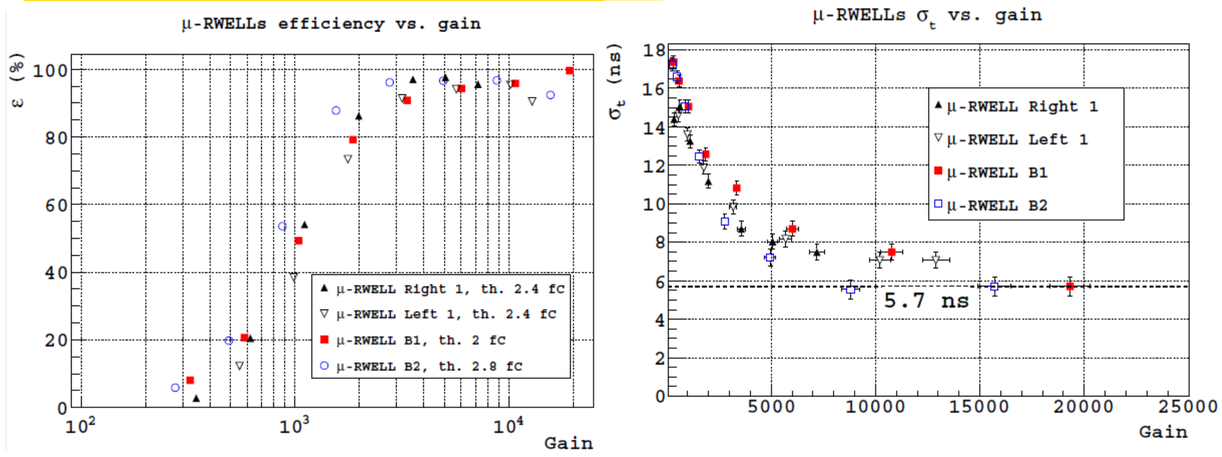
Beam tests @ CERN

CMS-GE1/1 size prototype

A CMS-GE1/1 μ-RWELL prototype was tested at the CERN H8 beam line during 2016 test beam campaign with 150 GeV/c muons and pions.

- ❖ Resistive DLC surface resistivity: about 70 MΩ/□ (LR configuration)
- ❖ Strips pitch = 800 μm
- ❖ Drift gap: 7 mm
- ❖ VFAT2 FE electronics
- ❖ Gas mixture: Ar/CO_2/CF_4 (45/15/40)

The results obtained from efficiency and time resolution tests have been compared with the performance of small μ-RWELL prototypes (10x10 cm^2, HR configuration): the behavior of all three prototypes is very similar.



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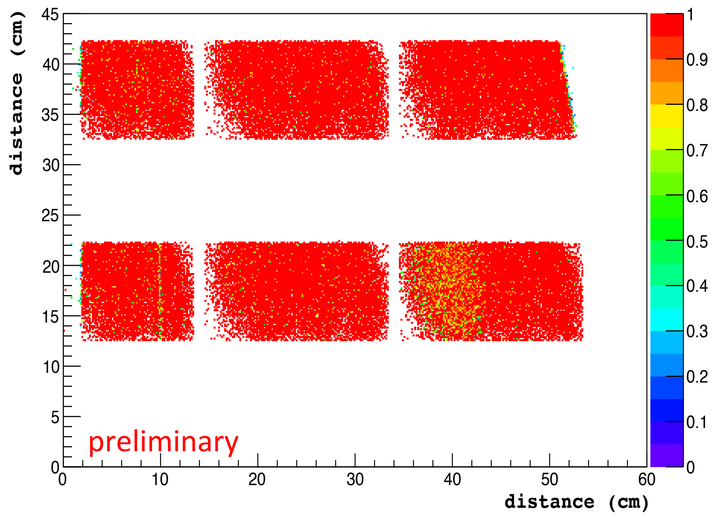
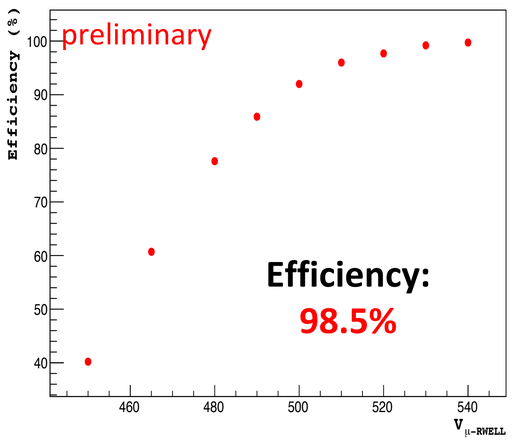
CMS-GE2/1 M4 size prototype

A CMS-GE2/1 20° sector equipped with two large area M4 μ-RWELL detectors was assembled and exposed to a 150 GeV/c muon beam at the CERN H4 beam line. The GE2/1 sector was flushed with an AR/CO_2 70/30 gas mixture. The detector was placed on a remotely controllable moving platform in order to allow to scan the surface of the detector across the muon beam.





Ageing tests @ GIF++

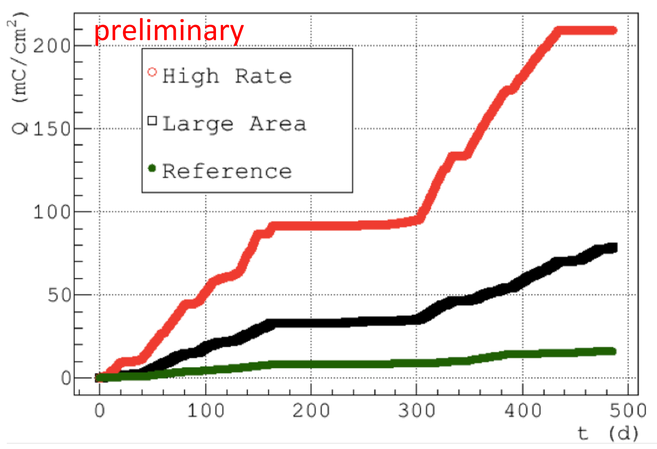
CMS-GE1/1 size prototype after beam test at H4: the goal is verify the behaviour of the μ-RWELL technology under high irradiation

From April 2017, the **GE1/1 size μ-RWELL** prototype (Ar/CO_2 70/30) has been exposed to the Gamma Irradiation Facility (GIF++) high-intensity source in the closest position to the source, together with two smaller prototypes:

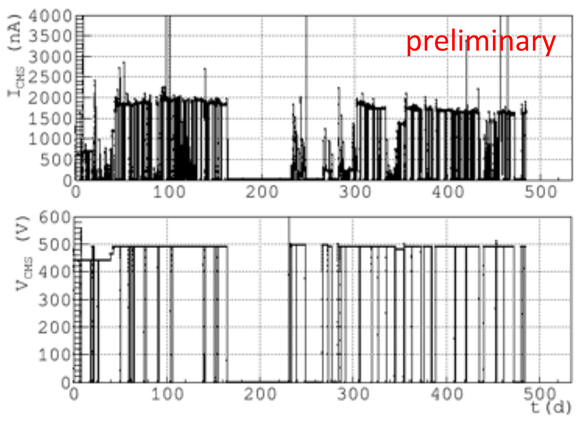
High Rate μ-RWELL (Ar/CO_2/CF_4) 10x10 cm^2
Reference μ-RWELL (Ar/CO_2) 5x5 cm^2

Up to now, the CMS-GE1/1 has integrated more than 75 mC/cm^2 without any relevant change in performances (expected dose for GE1/1 in 10 years HL-LHC with safety factor 3: 18 mC/cm^2)

Integrated charge vs time



Current and applied voltage vs time for the GE1/1 size



Conclusions

All the studies performed on the large area μ-RWELL confirm good performances in terms of efficiency, time and space resolution. Homogeneity of the detector response has been proved on the largest μ-RWELL ever build (GE2/1 M4) and detector hardness to radiation is still under study but up to now does not show any sign of ageing.