PROCEEDINGS OF SCIENCE

The micro-Resistive WELL detector for the phase-2 upgrade of the LHCb muon detector

M. Poli Lener*
Laboratori Nazionali di Frascati - INFN, Frascati, Italy
E-mail: marco.polilener@lnf.infn.it

G. Bencivenni, G. Felici, M. Gatta, G. Morello, E. Tskahadadze

Laboratori Nazionali di Frascati - INFN, Italy

R. De Oliveira

CERN, CH

A. Ochi

University of Kobe, Japan

The µ-RWELL is a new generation Micro-Pattern Gaseous Detector, composed of two elements: the cathode and the µ-RWELL_PCB including the amplification stage, realized with a polyimide structure micro-patterned with a blind-hole matrix, embedded through a Diamond-Like Carbon (DLC) resistive layer with the readout PCB. Different layouts of the resistive stage have been studied: the simplest one is based on a single DLC layer with edge grounding, suitable for low rate applications (30-40 kHz/cm^2). More sophisticated schemes are under study for high rate purposes (up to 2-3 MHz/cm^2). The high-rate versions are still under intense R&D in order to optimize the performance and the constructive process but this detector seems already a valid candidate to be used for the phase 2 upgrade of the LHCb muon detector. For this upgrade, the experiment is targeting a luminosity of $2x10^{34}$ cm^{-2} s^{-1}, with strong requirements on the robustness and detection efficiency of the muon system. We report on the ongoing R&D, showing also the latest measured performances of the new high rate versions of the detector.

The 39th International Conference on High Energy Physics (ICHEP2018)
4-11 July, 2018
Seoul, Korea

*Speaker.

PoS(ICHEP2018)536

1. Introduction

The LHCb experiment [1, 2] is a single-arm spectrometer dedicated to the study of the CP violation and other rare phenomena in the decay of Beauty particles. One of its feature is a fast and versatile trigger system to select the interesting events. The apparatus is designed like a fixed-target experiment due to the very forward peaked b-quark distribution at LHC. It is composed of five systems: vertex, tracking, ring Cerenkov detectors, the calorimeters and the muon system. Up to the end of 2017 LHCb has recorded a total luminosity of 7 fb^{-1} and in the next year, since LHC is going to increase its luminosity, the apparatus needs to upgrade its system. For the first phase only the replacement of the FEE will be done. For the phase 2, the detectors should show a rate capability up to 3 MHz/cm^2, an efficiency for single gap $> 95\%$ within 25 ns (BX), stability up to 6 C/cm^2 integrated charge in 10 y at G=4000. So we propose for this upgrade the micro-Resistive WELL.

2. The µ-Resistive WELL

The µ-RWELL has been invented at LNF [3] with the aim to simplify the detector assembly, avoiding time consuming operations (i.e. epoxy curing cycle) and to improve the operation stability under heavy irradiation. The detector looks very compact and merges the features of two well-known MPGDs (fig.1): it inherits from the GEM the amplification stage (50 µm Kapton® claded on one side with 5 µm Cu layer patterned with high density of holes) and from the MM the presence of a high resistive (10-200 MΩ/□) layer (DLC- diamond like carbon) above the readout plane. This layer mitigates the passage to the streamer region due to the drop of the amplification field strongly quenching the amplitude of the sparks. The surface resistivity must be optimized since features like the rate capability, the response speed and the spatial resolution are strongly dependent on the chosen application (HEP, neutron or gamma detection).

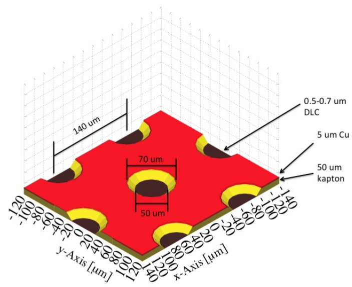

Figure 1: Sketch of a *upmu*-RWELL with the geometrical parameters.

3. The µ-RWELL and the TT

The realization of the µ-RWELL_PCB has been assigned to industry, with the aim to reduce the cost of the device. So far the very fruitful collaboration with the ELTOS S.p.A in San Zeno (AR, Italy) allowed the production of several µ-RWELL_PCB with 10x10 cm^2 active area as well as the production of large prototypes (about 0.5 m^2) for a proposal for CMS. The DLC sputtering has been instead done at Be-Sputter ltd sited in Japan, while the chemical opening of the amplification channels (blind holes) is done at the PCB-Workshop of CERN (by one of the authors). A collaboration is ongoing also with TECHTRA z.o.o. (POLAND).

4. Different layouts for different applications

The industrialization process requires a simpler layout, with a single resistive layer; such layout shows limitations strictly related to the rate [4], due to the same process leading to the charge amplitude quenching. In order to realize a product that can find room for an industrial production, with the purpose to reduce the costs, and that can stand up to high rate particles (O(MHz/cm^2) different charge evacuation schemes have been proposed, realized and tested, all with a single resistive layer: Silver Grid v1 (SGv1), Silver Grid v2 (SGv2) and Resistive Grid (RG) which features are reported in table 1.

HR scheme	n. layers	pitch	type	Dead area
SG v1	single	6 mm	cond. grid	33%
SG v2	single	12 mm	cond. grid	10%
RG	single	6 mm	resist. grid	-
DL	double	6 + 6 mm	cond. vias	-

Table 1: Summary of the features of the new single-resistive high rate versions of the µ-RWELL together with the Double Layer (DL), the first high rate-oriented µ-RWELL realized.

5. Detector performances

The mentioned detectors have been irradiated with X-rays at LNF. The detectors have been operated at a gain of 6300 and flushed with Ar:CO_2:CF_4 45:15:40. The rate capability over two orders of magnitude of estimated photon conversion have been measured and it is reported in fig. 2. The SGv1 can stand up to 3 MHz/cm^2 losing the 10% of the gain. But, as reported in table 1, this detector exhibits the largest dead area, so studies are ongoing to merge this rate capability with a smaller dead area. The detectors have been moreover exposed to the H8C pion/muon beam in order to evaluate the tracking efficiency and they have been equipped with an analog FEE: APV25 readout by the SRS system [6]. As shown in fig. 3 the RG and the DL prototypes reach full efficiency ($\sim$ 98% - No dead area in the amplification stage), while the SG 1 and SG2 show lower efficiency ($\sim$ 74% and $\sim$ 92% respectively), but higher than their geometrical acceptance (66% and 90% respectively), thanks to the efficient electron collection mechanism of the combines drift/amplification electric field, reducing the effective dead zone. A measurement of the time resolution has been performed equipping the detector with the VFAT2 FEE [7] and it is showed in fig. 3. The σ_t saturates at 5.7 ns due to the FEE. This value should be compared with the one measured by the LNF-LHCb-GEM group of 4.5 ns [9].

6. Conclusions

The µ-RWELL technology is very promising and its R&D is converging to a final resistive layout allowing to face up to 3 MHz/cm^2 (for LHCb purposes) limiting the efficiency losses. The

PoS(ICHEP2018)536

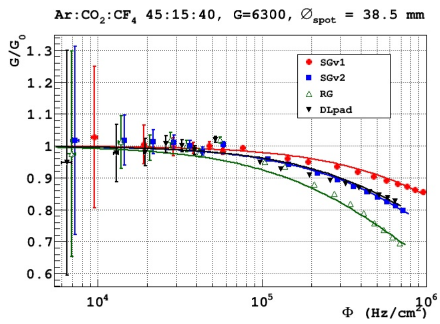

Figure 2: Rate capability comparison for the μ-RWELL high rate versions.

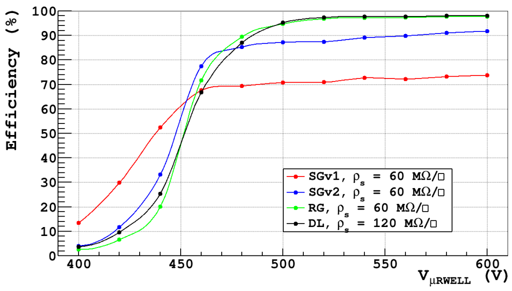

Figure 3: Tracking efficiency as function of the voltage applied to amplification stage for different μ-RWELL layouts.

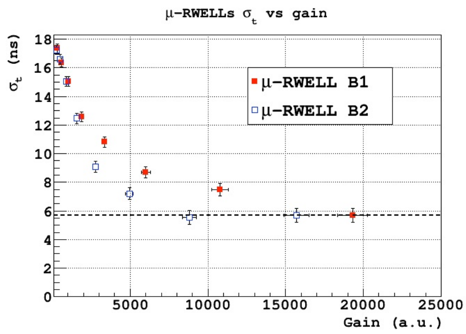

Figure 4: Time resolution as a function of the gain for a single resistive layer μ-RWELL.

detector performance, measured with the LHCb-GEM gas mixture, are very interesting: a time resolution of 5.7 ns with a FEE saturation effect and a tracking efficiency higher than 92% with the SG2 detector. A new detector layout, based on the Single Layer layout and with a lower dead zone (∼ 5%) has been produced and will be caracterized by the measurements with high intensity hadron beam. The cooperation with the companies (ELTOS, Be-Sputtering) is helping for a complete Technological Transfer of the detector technology.

References

[1] LHCb coll., CERN/LHCC 04 (1998)

[2] LHCb coll., CERN/LHCC 030 (2003)

[3] G. Bencivenni et al., JINST 10 (2015) P02008

[4] G. Bencivenni et al., NIM A 886 (2018) 36

[5] A. Alexoupulos et al., NIM A 617 (2010)

[6] L. Jones, https://cds.cern.ch/record/1069892/files/cer-002725643.pdf

[7] P. Aspell, https://cds.cern.ch/record/1069906/files/p292.pdf

[8] G. Bencivenni et al., PoS (BORMIO 2017) 002

[9] G. Bencivenni et al., NIM A 494 (2002) 156