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The μ-RWELL technology for tracking apparatus in High Energy Physics

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ABSTRACT

The micro-Resitive WELL (μ-RWELL) is a Micro Pattern Gas Detector (MPGD) that inherits some of the best characteristics of existing MPGDs, like GEMs and MicroMegas, while simplifying the detector construction. A significant progress towards large-scale applications has been achieved through the consolidation and industrial cost-effective manufacturing of this technology. The μ-RWELL, showing excellent spatial performance, good time resolution and stability under irradiation, is proposed for several tracking apparatus for future experiments at future accelerators such as FCC (CERN), CEPC (China) and EIC (Brookhaven National Laboratory). The reduced impact in terms of material budget makes this technology suitable for the development of tracking devices in the muon spectrometer. In addition, the flexibility of the μ-RWELL base material makes this device suitable for the development of very light, fully cylindrical inner trackers at future high luminosity tau-charm factories, SCTF (China). We report in this paper some results in the development of 2D readouts for IDEA apparatus and the construction steps of a cylindrical μ-RWELL.

1. Introduction

The μ-RWELL technology [1] has recently found room for different applications due to its versatility. The R&D has made, according to the implemented charge evacuation scheme of the resistive stage, the technology suitable to be installed in harsh environments, with particle rates up to 10 MHz/cm^2 still operating at full efficiency [2]. The construction procedure of the detector starts with two parallel steps: the readout plane is built at ELTOS S.p.A while the base material (Cu-Apical-DLC) is realized at CERN. The readout plane can then be segmented in the most proper way for the wanted applications: for example, a pad-segmented readout is planned for fast detector response in LHCb (run 5–6) while strips are mostly employed for tracking purposes (ex. IDEA and EURIZON).

2. The IDEA apparatus at FCC-ee

The Innovative Detector for Electron–positron Accelerators (IDEA) is a general purpose apparatus considered for the installation at the interaction point of the Circular electron–positron Collider (CepC) [3]. This 4π apparatus can be divided in four regions; for two of them the μ-RWELL have been proposed: the pre-shower and the muon counters. Apart the challenge to cover huge areas (∼130 m^2 for the pre-shower and ∼1530 m^2 for the muon stations), in both regions the detectors must provide two-dimensional coordinates of the crossing point of the impinging particle. The layouts under investigation are sketched in Fig. 1: a double conversion gap with a common double-sided kapton cathode and the two 1D readout planes rotated of 90 degrees (left); the Capacitive-Sharing (CS) layout [4] (center), and the top-segmented readout (right), where the second coordinate is provided by a proper

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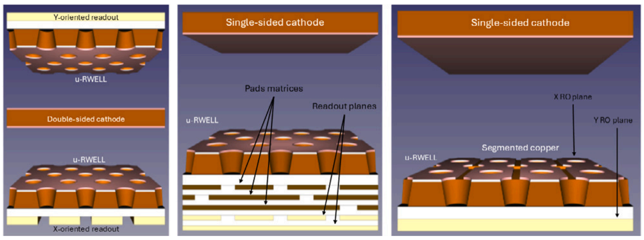

Fig. 1. Three layouts proposed for the 2D crossing point reconstruction: the common-cathode layout (left), the capacitive-sharing scheme (center) and the top-segmented readout (right).

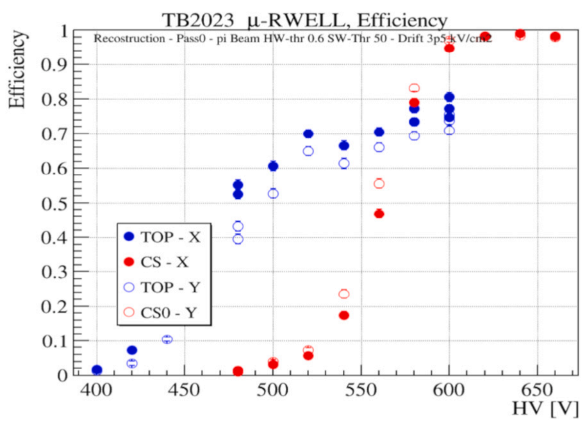

Fig. 2. Efficiency comparison between the CS and the top-segmented readout.

segmentation of the copper layer of the amplification stage. In the CS layout the charge is eventually divided between the planes hosting the orthogonal strips and then it requires a larger gain to achieve full efficiency, as can be seen is Fig. 2. The data have been collected at H8-SPS CERN North area; the detectors have been equipped with APV25-based front-end electronics (FEE) and flushed with Ar:CO_2:CF_4 45:15:40 gas mixture. Further studies are needed to optimize the detector response in case of two-dimensional readout plane.

3. EURIZON

The EURIZON project[1] aims to establish a collaboration among institutes for the construction of detectors for future tau-charm factories. The µ-RWELL technology has been proposed as a candidate for a cylindrical Inner Tracker. This task exploits the possibility to realize the amplification and the readout stages on flexible substrates (APICAL®). A first prototype has been built to validate the construction process. This prototype implements the idea to have a device that can be re-opened (no glue used for sealing) in order to substitute any malfunctioning part of the amplification stage. Indeed this latter is divided in three parts, each shaped as a rooftile. Each tile is composed by a cylindrical sheet of Millifoam® coupled with the flexible R/O and amplification stages. The choice of the material is a good compromise to cope with the rigidity of the µ-RWELL, in order to achieve the required curvature radius of the composite tile, and with the request of a low-mass detector (ρ_{Mlf} = 75 kg/m^3). The tile is then fixed by plastic screws on a rectified Millifoam® cylindrical support. Realized in natural PEEK, the flanges are glued on both sides of each electrode. They provide a mechanical reinforcement of the cylinders and they host the transition boards for the HV distribution and for the signal readout. The end-caps, also built in PEEK, have great importance as they have three tasks: hosting the o-rings for the sealing of the detector, hosting the gas inlets and outlets, maintaining the distance between the two electrodes. Once assembled (Fig. 3), the detector response has been studied under cosmic-ray muons. The readout has been divided in two halves around the horizontal plane. The efficiency and the spatial resolution are shown in Fig. 4. The limited efficiency plateau of the black dots in Fig. 4 (left) is due to the presence of a 2 mm dead area (the separation between two tiles) inside the trigger volume. The detector has been equipped APV25-based FEE and flushed with Ar:CO_2:CF_4 45:15:40 gas mixture. The readout plane has been segmented in axial strips, 650 µm pitch: this explains the spatial resolution plateau tending to a relatively large value. Nevertheless, the construction process has been validated opening the way for the application of this technology for future cylindrical detectors.

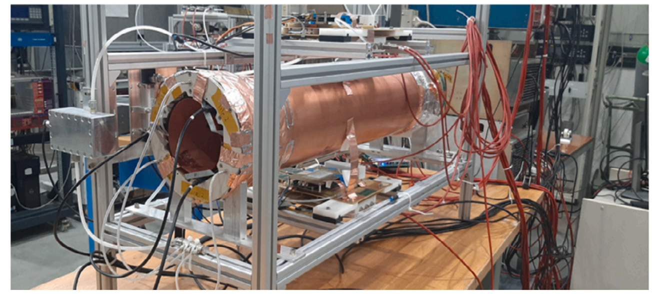

Fig. 3. The cylindrical µ-RWELL.

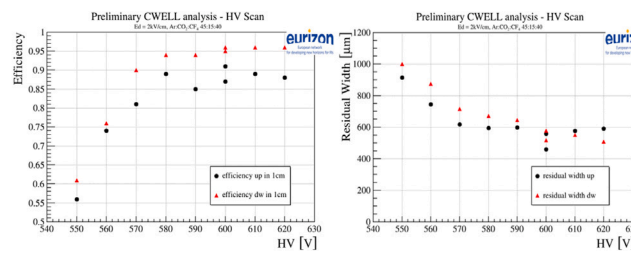

Fig. 4. Efficiency (left) and spatial resolution (right) measured with the cylindrical µ-RWELL. In both plots the black markers refer to the upper half of the detector, while the red to the inferior part.

4. Conclusions

The µ-RWELL is a technology suitable for tracking applications in HEP apparatus, although R&D on two-dimensional readout is still needed. The three layouts proposed for IDEA are actually under investigation to achieve a good compromise among the request to cover large areas, a full-efficient tracking capability and a limited amount of front-end electronics channels. In parallel, the technology can also be exploited for cylindrical detectors, thanks to the possibility to be realized on flexible substrate, as it has been done for the EURIZON projects. In this case the construction steps have been validated by a cosmic-ray muons data taking campaign.

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Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: G. Morello reports financial support was provided by European Union. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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