The μ-Resistive WELL in HEP and beyond

G. Bencivenni[1], R. De Oliveira[2], G. Felici[1], M. Gatta[1], M. Giovannetti[1*], G. Morello[1], G. Papalino[1], M. Poli Lener[1]

1 Laboratori Nazionali di Frascati – INFN, Via Enrico Fermi 54, 00044 Frascati (RM), Italy
2 CERN, 1, Esplanade des Particules, Meyrin, Switzerland

Since the first prototype, introduced in 2014, the micro-Resistive WELL (µ-RWELL) has undergone significant and continuous evolution, leading to the realization of a detector intrinsically protected from discharges and with performance in terms of rate capability, spatial and temporal resolution comparable to that of other main MPGDs.

The µ-RWELL is a single amplification stage resistive MPGD based on the same Apical® foil used for the manufacturing of the GEM. The amplification stage is embedded through a resistive layer in the readout board. The resistive layer (typical surface resistivity 10-100 MΩ/□) is created by sputtering the back side of the Apical® foil with Diamond-Like-Carbon (DLC). On the top copper-coated side of the foil, a well matrix is created with conical blind holes (wells) 70 µm (50 µm) in diameter at the top (bottom) and 140 µm pitch. A cathode electrode, defining the gas conversion/drift gap, completes the detector mechanics.

The introduction of a resistive layer mitigating the transition from streamer to spark gives the possibility to achieve large gains (>10^4), while affecting the detector performance in terms of rate capability. Different detector layouts have been studied: the simplest one based on a single-resistive layer, with edge grounding has been designed for low-rate applications (few tens of kHz/cm2); more sophisticated schemes have been studied for high-rate purposes (>1 MHz/cm2). An overview of these different architectures, together with their performance, will be presented.

The presence of the resistive layer can affect the charge spread on the strips and consequently the spatial resolution of the detector: a systematic study of the spatial resolution obtained with the charge centroid (CC) method as a function of the impinging angle was made. For non-orthogonal tracks, the spatial resolution with CC method is compared with the performance obtained with the micro-TPC mode (µTPC): a readout approach that exploits the combined measurement of the ionization clusters time of arrival and the amplitude of the signals on the strips. Implementing the µTPC allows reaching an almost flat space resolution <100 µm for a wide angular range. The tracking performance of the detector as a function of the DLC resistivity, strip pitch, and width will be discussed.

The µ-RWELL technology is currently proposed for several nuclear and sub-nuclear projects: in LHCb for the upgrade of the innermost regions of the muon stations where the expected maximum particle rate is of the order of 1 MHz/cm2 a dense DLC grounding network layout has been proposed; in CLAS12 for the upgrade of the tracker spectrometer, and X17 where ultra-low-mass trackers are required; in TACTIC a semi-cylindrical version of the detector has been built and successfully operated; in URANIA a Boron-coated version of the detector has been developed as a thermal neutron device for Radiation Portal Monitor for homeland security applications. In addition, thanks to its flexibility, the technology has been exploited for the development of a low-mass full cylindrical inner tracker for Super-Tau-Charm Factories.

A Technology Transfer to ELTOS S.p.A., an Italian company leader in PCB production, is ongoing. ELTOS will produce the core of the µ-RWELL PCB while the final chemical treatment of the amplification stage will be performed at the CERN MPT-Workshop. Thanks to this collaboration, we expect to significantly reduce the detector cost, in view of possible mass production as foreseen by the experiments at the next generation colliders FCC-ee/hh and CepC.