Thermal neutron detection based on resistive gaseous devices

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

In the framework of the uRANIA-V (u-Rwell Advanced Neutron Imaging Apparatus) project, we are developing innovative thermal neutron detectors based on resistive gaseous devices such as micro-Resistive WELL (μ-RWELL) and surface Resistive Plate Counter (sRPC).

The μ-RWELL is a single amplification stage resistive MPGD developed for HEP applications. The amplification stage, based on the same Apical® foil used for the manufacturing of the GEM, is embedded through a resistive layer in the readout board. The resistive layer is realized by sputtering the back side of the Apical® foil with Diamond-Like-Carbon (DLC). On the coppery side of the foil, a well matrix is realized with conical blind holes (well) 70 μm (50 μm) top (bottom) diameter and 140 μm pitch. A cathode electrode, defining the gas conversion/drift gap, completes the detector mechanics. The deposition of a thin layer of 10B4C on the cathode surface allows the thermal neutrons conversion into 7Li and α ions, which can be easily detected in the active volume of the device. Results from tests performed with different detector layouts show that a thermal neutron (25meV) detection efficiency up to 7% can be achieved with a single detector. A detailed comparison between experimental data and the full simulation of the neutron physics and the detector behaviour has been performed.

In parallel, we are proposing the development of thermal neutron detectors based on a novel RPC concept. The sRPC is a revolutionary RPC based on surface resistive electrodes realized by exploiting the well-established DLC sputtering technology on thin (50μm) polyimide foils, the same used in the manufacturing of the μ-RWELL. The DLC foil is glued to a 2mm thick float-glass, which is characterized by excellent planarity. The 2 mm gas gap between the electrodes is ensured by spacers made of Delrin®, inserted without gluing at the edges of the glass supports. The electrodes sandwich is then inserted in a fiber-glass box that acts as a gas volume container. By replacing DLC with 10B4C sputtered electrodes, the device becomes sensitive to thermal neutrons. Three different combinations of 10B4C coated electrodes have been tested: Boron cathode - DLC anode; DLC cathode - Boron anode; Boron cathode - Boron anode. With these layouts, a thermal neutron detection efficiency of 4%, 2%, and 6% has been respectively achieved. The robustness, ease of construction, and scalability of the sRPC technology should allow the construction of cost-effective large area detector units as required by applications in homeland security (such as Radiation Portal Monitor).