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Neutron imaging with 10B4C-lined thin-gap RPCs: A multilayered architecture for high detection efficiency

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Recently LIP has introduced a new type of position sensitive thermal neutron detector (PSND) based on the combination of thin-gap RPCs (Resistive Plate Chambers) and solid-state neutron converters containing Boron-10. This detection technology offers a much lower cost per unit area compared to He-3 based detectors. The potential of this emergent detector technology is currently being evaluated for neutron scattering science in the framework of the SINE2020 project (EU project 654000).
One of the main challenges of using Boron-10 converters is to overcome the low thermal neutron detection efficiency of a single layer, which typically ranges from 5% to 10% depending on the neutron energy. Here we propose a PSND design with 10B4C-lined thin-gap RPCs in a multilayered architecture with the potential to achieve an overall detection efficiency above 50% for thermal neutrons.
To evaluate this multilayered architecture we have designed and constructed a detector prototype with a stack of 10 double-gap RPCs (DG-RPCs), having 20 layers of 10B4C in total. Each DG-RPC consists of two resistive anodes made of float glass and an aluminium cathode. The cathode is coated on both sides with a ≈1 micron thick layer of 10B4C.
To pick-up the induced signals, a thin multilayer polyimide PCB is inserted between each pair of DG-RPCs. The PCBs have three planes of metallic strips: The external ones are used to read the X coordinate for the events in the corresponding neighbouring DG-RPCs, and the middle plane of strips, which provides the Y coordinate, is shared by both adjacent DG-RPCs. The strips are read out individually by charge sensitive preamplifiers and the distribution of the induced charge is used to compute the event position by the centroid (CoG) algorithm. The cathodes, read individually, provide the signals to trigger the DAQ system and to identify the DG-RPC in which the neutron was converted (Z coordinate of the event).
Here we report preliminary experimental results obtained with the detector prototype in the TREFF neutron beamline (λ=4.7 Å) at FRM-II research reactor in Munich. The results are very promising: a detection efficiency > 50% and a spatial resolution below 0.35 mm FWHM (X and Y directions) were measured for 4.7 Å neutrons. We also present results of a Monte Carlo simulation study targeting optimization of the number of 10B4C layers and their thickness, as well as the impact of the neutron scattering by the detector materials on the detector performance.
The high detection efficiency, very good spatial resolution and fast timing capability (sub-nanosecond range) opens the possibility of applying the 10B4C lined thin gap RPCs in time-resolved or energy-resolved (TOF) neutron imaging.

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