Contribution ID: **36** Type: **Oral Contribution**

Towards high counting rate RPC-based neutron detectors: current state and perspectives

Tuesday, 11 February 2020 16:10 (20 minutes)

At LIP-Coimbra and in collaboration with the TUM-FRMII and ESS detector groups, we have been refining the concept of a novel type of position-sensitive neutron detector (PSND) based on resistive plate chambers with ¹⁰B₄C layers (¹⁰B-RPCs) as neutron converters. Our studies performed in the frame of SINE2020 (EU project 654000) have successfully proven the feasibility of this detection technology. We have demonstrated thermal neutron detection efficiency above 50% by using ¹⁰B-RPCs in a multilayer architecture and a spatial resolution better than 250 μm FWHM. The RPCs fast timing should also allow measurements of the neutron time-of-flight (TOF) with nanosecond resolution. RPCs also may offer very attractive practical properties such as low price per unit area, high modularity of the design and robustness. These manifold advantages render RPC-based neutron detectors a promising technology.
However, there are challenges which still have to be addressed such as, e.g. the counting rate capability limitation of these devices and which is narrowing the widespread use of this technology. Further decreasing the sensitivity of ¹⁰B-RPCs to gamma rays is also beneficial for applications requiring high signal-to-noise ratio.
Here, we present experimental results on the ¹⁰B-RPCs counting rate measurements when exposed to a thermal neutron beam. Several ¹⁰B-RPCs prototypes with anode plates made from float glass, low resistivity glass and low resistivity ceramics were built. The prototypes have been tested at V17 monochromatic neutron beamline at HZB-Berlin. For the RPC with the anode plate made from low resistivity glass, the counting rate did not show any non-linearity at the maximum flux available at this neutron beamline, reaching a value > 30 kHz/cm².
We also report results on the sensitivity of ¹⁰B-RPCs to gamma rays, measured using the angular correlations between the two annihilation photons of a ²²Na radioactive source, as well as a simulation study targeting the gamma sensitivity minimization, performed with GEANT4. The experimental results demonstrate that gamma sensitivity should be less than 10⁻⁶ and 10⁻⁵ for 0.511 and 1.27 MeV, respectively, for polarization voltages within the plateau for thermal neutrons.

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Session Classification: New Ideas