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Timing RPC for thermal neutron detection with 3D position sensitivity

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Modern instruments for neutron science applications, such as, e.g., small-angle neutron scattering (SANS), reflectometry and macromolecular crystallography, require thermal neutron detectors with high detection efficiency, low sensitivity to gamma rays, high counting rates and high spatial resolution. At neutron spallation sources, due the pulsed nature of the beam, in most applications the capability of the detector to measure the neutron time of flight (TOF) is also required. This is particularly important to perform neutron wavelength-resolved measurements, and can easily be met with resistive plate chambers (RPCs), well known for their sub-ns time resolution. Moreover, it was also recently been shown that an RPC based thermal neutron detector can provide a high detection efficiency (> 50%) combined with sub-millimeter spatial resolution.
Here we will present a concept of a timing neutron detector aiming at four-dimensional readout capability (XYZ and time) and intended for TOF neutron diffraction and reflectometry, as well as other applications requiring readout of position and time, such as, e.g., wavelength resolved neutron imaging. The detector consists of a stack of neutron-sensitive double gap ¹⁰B-RPCs (RPCs lined with ¹⁰B₄C), oriented normally to the direction of the incident neutrons. Stacking RPCs is needed to achieve the detection efficiency of about 50%, and will also improve the counting rate capability nearly linearly with the number of RPCs. The neutrons TOF and the position of the neutron capture along of the stack (Z-coordinate) is obtained from the fast electronic component of the induced signal on the RPCs cathode. To determine the XY coordinate (plane parallel to the plates of the RPCs) of neutron events, two arrays of parallel metallic strips, orthogonal to each other and held by a thin film of polyamide, are placed between each neighbouring RPC. In this arrangement, gas gaps of adjacent RPCs share the same arrays of strips allowing to significantly reduce the number of readout channels. We will also report results of Geant 4 simulations targeting optimization of the detector design and providing the best trade-off between the detection efficiency, maximum count rate and the level of elastic neutron scattering on the detector components.

Primary author: Dr MARGATO, Luís (LIP-Coimbra, Departamento de Física, Universidade de Coimbra)

Co-authors: BLANCO, Alberto (LIP Coimbra); MOROZOV, Andrey (LIP-Coimbra); Mr SARAIVA, João (LIP--Coimbra); Mr LOPES, Luis (LIP-Coimbra); FONTE, Paulo

Presenter: Dr MARGATO, Luís (LIP-Coimbra, Departamento de Física, Universidade de Coimbra)

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