Neutron detectors technologies required for the advanced neutron scattering instruments

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Abstract

It is well known that neutron scattering is an intensity limited technique. The brightness of modern neutron sources is many orders of magnitude lower comparing to the brightness of advanced synchrotron sources. However, the science which can be made with the use of neutron beams is in many cases unbeatable or even inaccessible for any other methods. This fact stimulates the upgrade of existing neutron sources and their instrumentation as well as construction next generation facilities for neutron research. The next generation neutron sources, like SNS in USA, JPARC in Japan, and coming soon ESS in Europe promise about one to two orders of magnitude increase in neutron flux depending on the type of the instrument. Meanwhile, advanced neutron optics, focusing systems and neutron detectors can potentially provide extra two orders of magnitude gain in efficiency of neutron spectrometers. Combination of both factors will lead to a quantum leap in performance opening new scientific horizons not feasible at present.

It is, therefore, evident why development of advanced neutron detectors and detector systems became at present one of the key issues. At the same time, for almost all instruments at the new neutron facilities the detectors are the limiting component. The moderator and guide systems will deliver more neutrons than the detectors can process. This shortcoming is magnified by the facts that even the most powerful neutron scattering facilities lack intensity for many experiments. Examples are real time parametric studies, high pressure experiments and measurements of microsamples etc.

Detecting neutrons is more complicated task compared to the detection of ionizing particles or ionizing radiation. Therefore, the variety of neutron detectors is much more limited. Meanwhile different types of neutron experiment pose specific and often contradictory requirements for detector characteristics. For experiments on the high intensity neutron sources the high counting rate is one of the key issues. This is very important for example for small angle neutron scattering and neutron reflectometry. For other experiments characteristics like detection efficiency, high position resolution, high time resolution, neutron/gamma discrimination, large-area imaging, or compactness are very important. Today also the cost of the detector became one of the most important factors. There is no single type of detector which satisfies all the above criteria. Therefore, compromise is inevitable and some of the characteristics are trade off in favor of others.

Present report gives an overview of the trends in detector systems development with the emphasis on the activities at the Frank Laboratory of Neutron Physics of the Joint Institute for Nuclear Research at Dubna.